



# Protocol Implementation Plan for Monitoring Muskox Sex-Age Composition in the Arctic Network

Natural Resource Report NPS/ARCN/NRR—2018/1795



**ON THE COVER**

Muskox in Bering Land Bridge National Preserve.  
(©QUINTIN SLADE)

---

# **Protocol Implementation Plan for Monitoring Muskox Sex-Age Composition in the Arctic Network**

Natural Resource Report NPS/ARCN/NRR—2018/1795

Joshua H. Schmidt  
National Park Service  
Inventory and Monitoring Program  
Arctic and Central Alaska Networks  
4175 Geist Road  
Fairbanks, AK 99701

Hillary L. Robison  
National Park Service  
Western Arctic National Parklands  
PO Box 1029  
Kotzebue, AK 99752

Scott D. Miller  
National Park Service  
Inventory and Monitoring Program  
Arctic and Central Alaska Networks  
240 W. 5<sup>th</sup> Ave.  
Anchorage, AK 99501

November 2018

U.S. Department of the Interior  
National Park Service  
Natural Resource Stewardship and Science  
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available in digital format from the [Arctic Network Inventory and Monitoring website](#) and the [Natural Resource Publications Management website](#). If you have difficulty accessing information in this publication, particularly if using assistive technology, please email [irma@nps.gov](mailto:irma@nps.gov).

Please cite this publication as:

Schmidt, J. H., H. L. Robison, and S. D. Miller. 2018. Protocol implementation plan for monitoring muskox sex-age composition in the Arctic Network. Natural Resource Report NPS/ARCN/NRR—2018/1795. National Park Service, Fort Collins, Colorado.

# Contents

|                                                                                                                          | Page |
|--------------------------------------------------------------------------------------------------------------------------|------|
| Figures.....                                                                                                             | v    |
| Tables.....                                                                                                              | v    |
| Abstract.....                                                                                                            | vi   |
| Acknowledgments.....                                                                                                     | vii  |
| Introduction.....                                                                                                        | 1    |
| History of the Cape Thompson muskoxen population in Cape Krusenstern National Monument and Noatak National Preserve..... | 1    |
| History of the Seward Peninsula muskoxen population in Bering Land Bridge National Preserve.....                         | 2    |
| History of Muskox Surveys.....                                                                                           | 2    |
| Conceptual Framework for Monitoring.....                                                                                 | 5    |
| Measurable Objectives.....                                                                                               | 6    |
| What is being Measured and How .....                                                                                     | 6    |
| Sampling Design and Monitoring Schedule .....                                                                            | 8    |
| Sampling Design .....                                                                                                    | 8    |
| Monitoring Schedule .....                                                                                                | 9    |
| Data Management, Analysis, and Reporting .....                                                                           | 10   |
| Data Management Life Cycle.....                                                                                          | 10   |
| NPS Standards .....                                                                                                      | 11   |
| Data Quality.....                                                                                                        | 11   |
| Freedom of Information Act.....                                                                                          | 11   |
| Records Management .....                                                                                                 | 11   |
| Core Functional Model .....                                                                                              | 13   |
| Roles and Responsibilities .....                                                                                         | 14   |
| Project Leader.....                                                                                                      | 14   |
| Data Manager .....                                                                                                       | 14   |

## Contents (contents)

|                                                    | Page |
|----------------------------------------------------|------|
| Data Collection .....                              | 14   |
| Overview .....                                     | 14   |
| Data Sensitivity Statement .....                   | 15   |
| Deliverables Schedule .....                        | 15   |
| Quality Assurance .....                            | 17   |
| Quality Control .....                              | 17   |
| Product Archival and Documentation.....            | 18   |
| IRMA Data Store.....                               | 18   |
| Public Muskox Website.....                         | 19   |
| Reports.....                                       | 19   |
| Certified Dataset.....                             | 20   |
| Resource Brief.....                                | 20   |
| Products Publication.....                          | 20   |
| Metadata .....                                     | 20   |
| Line of Sight.....                                 | 20   |
| Data and Information Security .....                | 21   |
| Closeout .....                                     | 22   |
| Certification .....                                | 24   |
| Budget.....                                        | 24   |
| Safety .....                                       | 26   |
| Standard Operating Procedures.....                 | 26   |
| References.....                                    | 28   |
| Appendix A: Field Data Deliverables Schedule ..... | 31   |

## Figures

|                                                                                                                                  | Page |
|----------------------------------------------------------------------------------------------------------------------------------|------|
| <b>Figure 1.</b> Survey areas for long-term monitoring of sex-age composition of muskoxen in the Arctic Network park units. .... | 2    |
| <b>Figure 2.</b> Long term monitoring project data management life cycle. ....                                                   | 10   |
| <b>Figure 3.</b> The ARCN/CAKN Core Functional Model overview. ....                                                              | 13   |
| <b>Figure 4.</b> Data products processing and flow diagram.....                                                                  | 15   |
| <b>Figure 5.</b> Standard ARCN Vital Sign Project reference architecture in the IRMA Data Store. ....                            | 19   |
| <b>Figure 6.</b> The muskox monitoring website draws information from the IRMA Data Store .....                                  | 19   |
| <b>Figure 7.</b> Each informational component informs and is informed by other components .....                                  | 21   |
| <b>Figure 8.</b> Example of reconciling published holdings with the protocol’s data deliverables schedule during closeout.....   | 22   |

## Tables

|                                                                                                                                           | Page |
|-------------------------------------------------------------------------------------------------------------------------------------------|------|
| <b>Table 1.</b> Factors affecting muskox populations within ARCN parks and measures for Vital Signs monitoring. ....                      | 5    |
| <b>Table 2.</b> Proposed schedule for conducting muskox sex-age composition surveys in northwest Alaska.....                              | 9    |
| <b>Table 3.</b> Muskox monitoring data deliverables schedule. ....                                                                        | 16   |
| <b>Table 4.</b> Estimated annual operating cost (based on FY2017 dollars) for implementation of the ARCN Muskox Vital Sign Protocol. .... | 24   |
| <b>Table 5.</b> Narrative documents and standard operating procedures for the ARCN muskox sex-age composition monitoring vital sign. .... | 27   |

## Abstract

Muskoxen are rare worldwide. Within the U.S. National Park system (NPS), muskoxen only occur in four park units, all within the Arctic Network Inventory and Monitoring program (ARCN): Bering Land Bridge National Preserve (BELA), Cape Krusenstern National Monument (CAKR), and Noatak National Preserve (NOAT). Occasionally, muskoxen are observed in Gates of the Arctic National Park and Preserve (GAAR). Key reasons for monitoring muskoxen are that muskox are: (1) an important subsistence species; and (2) an arctic obligate species and are therefore a good indicator of the condition in Alaska's arctic ecosystems. Muskox in the Arctic Network occur in two distinct populations. The northern population occupies CAKR and spreads north onto the north slope of Alaska and east into NOAT. The second population encompasses all of BELA and is found throughout the Seward Peninsula and to the east. The NPS surveys muskox in both populations in cooperation with the Alaska Department of Fish and Game (ADFG). Abundance and distribution of muskoxen is monitored with an adapted distance sampling technique (Schmidt et al. 2010, Westing 2011, Schmidt and Gorn 2013). Following the abundance survey, a second survey is conducted to gather information on muskoxen sex-age composition. The ADFG typically leads, with support from the NPS, the logistics for the abundance and sex-age composition surveys of the Seward Peninsula muskoxen population and consolidates the data gathered during the surveys. The NPS and ADFG analyze the data for the abundance and sex-age composition surveys, respectively. For the Cape Thompson muskoxen population, the NPS and ADFG share logistics for the abundance and sex-age composition surveys, and share consolidation of the data. The NPS and ADFG analyze the data for the abundance and sex-age composition surveys, respectively. As of this writing, the NPS participation in these surveys has been led by Western Arctic National Parklands (WEAR). Muskox sex-age composition surveys are the focus of this protocol implementation plan. Determination of muskoxen sex-age is a helicopter-supported ground-based survey that targets groups of muskox located during the aerial abundance and distribution surveys. Ideally, composition surveys are conducted less than a month after the completion of the abundance and distribution surveys to minimize movement of animals, and thereby minimize the need to search for muskox groups. Monitoring objectives of this protocol implementation plan are to: 1) Determine late winter muskoxen sex composition in the Cape Thompson and Seward Peninsula populations; and 2) Determine late winter muskoxen age composition in the Cape Thompson and Seward Peninsula populations.

## Acknowledgments

The National Park Service (NPS), Alaska Department of Fish and Game (ADFG), US Fish and Wildlife Service (FWS), and the Bureau of Land Management (BLM) have been cooperatively monitoring muskoxen in northwestern Alaska since the 1990s. Surveys are accomplished by sharing personnel, funds and aviation resources to first count and survey muskox populations, and then, to conduct a sex and age composition survey. Although this is a highly cooperative and mutually beneficial effort, the ADFG typically leads, with support from the NPS, the logistics for the abundance and sex-age composition surveys of the Seward Peninsula muskoxen population, consolidates the data gathered during the surveys, and ADFG and NPS analyze the data for the abundance and sex-age composition surveys, respectively. For the Cape Thompson muskoxen population, the NPS and ADFG share logistics for the abundance and sex-age composition surveys, share consolidation of the data, and ADFG and NPS analyze the data for the abundance and sex-age composition surveys, respectively. Given the close coordination between the NPS and ADFG, the development and execution of the protocols for monitoring muskoxen has been a joint effort with ADFG staff. In particular, ADFG Tony Gorn, Charlotte Westing, Bill Dunker, and Adam Craig have been instrumental in this process.

Within the NPS, monitoring of muskox is also a cooperative effort, in this case between Bering Land Bridge National Preserve, Western Arctic National Parklands, and the Arctic Network (ARCN). NPS partners share, fund and execute different aspects of the monitoring effort with the parks taking the lead in the population surveys, and the network taking the lead in the sex-age composition work and data analysis.

Over the years, multiple fixed-wing and helicopter pilots have contributed to the safe collection of survey data. Likewise, multiple observers have participated in gathering data. Of particular note due to their long involvement and contributions to these surveys are Kate Persons, Jim Dau, Letty Hughes, Brad Shults, Kumi Rattenbury, Leanne Ayers, Marci Johnson, Andy Greenblatt, Sandy Hamilton, Eric Sieh, Jared Cummings, Russel Rowe, Troy Cambier, and Quintin Slade.

We also thank Tony Gorn, Bill Dunker, and Adam Craig for reviewing earlier drafts of this protocol.

# Introduction

Muskoxen (*Ovisbos moschatus*) are rare worldwide. Muskoxen are native to Alaska, but were extirpated in the state by the middle of the 19<sup>th</sup> century (review in Lent 1999). Muskoxen were re-established in Alaska in the 1930s. Currently, muskoxen populations occur in four locations in Alaska (AK), two of these ranges overlap park units in northwestern AK. Muskoxen were re-introduced on the Seward Peninsula and near Cape Thompson in the 1970s. Since their establishment, muskoxen have become an important subsistence food for local residents and are a highly prized hunting resource. Muskoxen tend to occupy small home ranges in comparison to migratory species so are good indicators for local environmental conditions, and meta-populations of this species are found throughout the year within the boundaries of the Arctic Network (ARCN) (e.g., residents). Muskox populations may have substantial effects on plant communities and by extension wildlife communities through effects on vegetation either directly through browsing and grazing or indirectly through biogeochemical cycling. Within the U.S. National Park system (NPS), muskoxen only occur in four park units: Bering Land Bridge National Preserve (BELA), Cape Krusenstern National Monument (CAKR), and Noatak National Preserve (NOAT). Occasionally, muskoxen are observed in Gates of the Arctic National Park and Preserve (GAAR). Key reasons for monitoring muskoxen are that muskox are: (1) an important subsistence species; and (2) an arctic obligate species and are therefore a good indicator of the condition in Alaska's arctic ecosystems.

## History of the Cape Thompson muskoxen population in Cape Krusenstern National Monument and Noatak National Preserve

The Alaska Department of Fish and Game (ADFG) translocated muskoxen to the Cape Thompson area just north of CAKR in 1970 (36 animals) and 1977 (34 animals). The muskoxen released at Cape Thompson were transplanted from the Nunivak Island herd that was originally established in 1936 from muskoxen captured in Greenland. Muskoxen have continuously occupied habitat within CAKR since 1979 and presumably immigrated from the two groups of muskoxen that were translocated. Based on aerial surveys and opportunistic observations, muskoxen occupy habitat from the mouth of the Noatak River northward through CAKR and as far north as the North Slope of Alaska (Figure 1). Muskoxen are also dispersed along the northern foothills of the Brooks Range from the coast and as far east as the eastern edge of NOAT. Although muskoxen are currently widely distributed, historically they were concentrated in a band of habitat that encompasses the coastal area and approximately 35 miles inland from the mouth of the Noatak River to Cape Lisburne. This area is referred to the "core" population area and has been consistently monitored for abundance, composition, and distribution since 1994. Beginning in 2011, survey efforts expanded to include the entire Cape Thompson muskox population including the lands comprising eastern NOAT and up to the North Slope. The population in the core area peaked in 2005 at 369 animals and then declined to around 220-230 animals in 2011. Recent analyses that include data from 2018 and estimates of survival show there was a 4% decline of the population in the core area between 2011-2018, which was primarily driven by a decrease in cow yearling survival. The population in the expanded area, however, remained relatively stable between 2011 and 2016, where it numbered 576 and 556 animals, respectively.

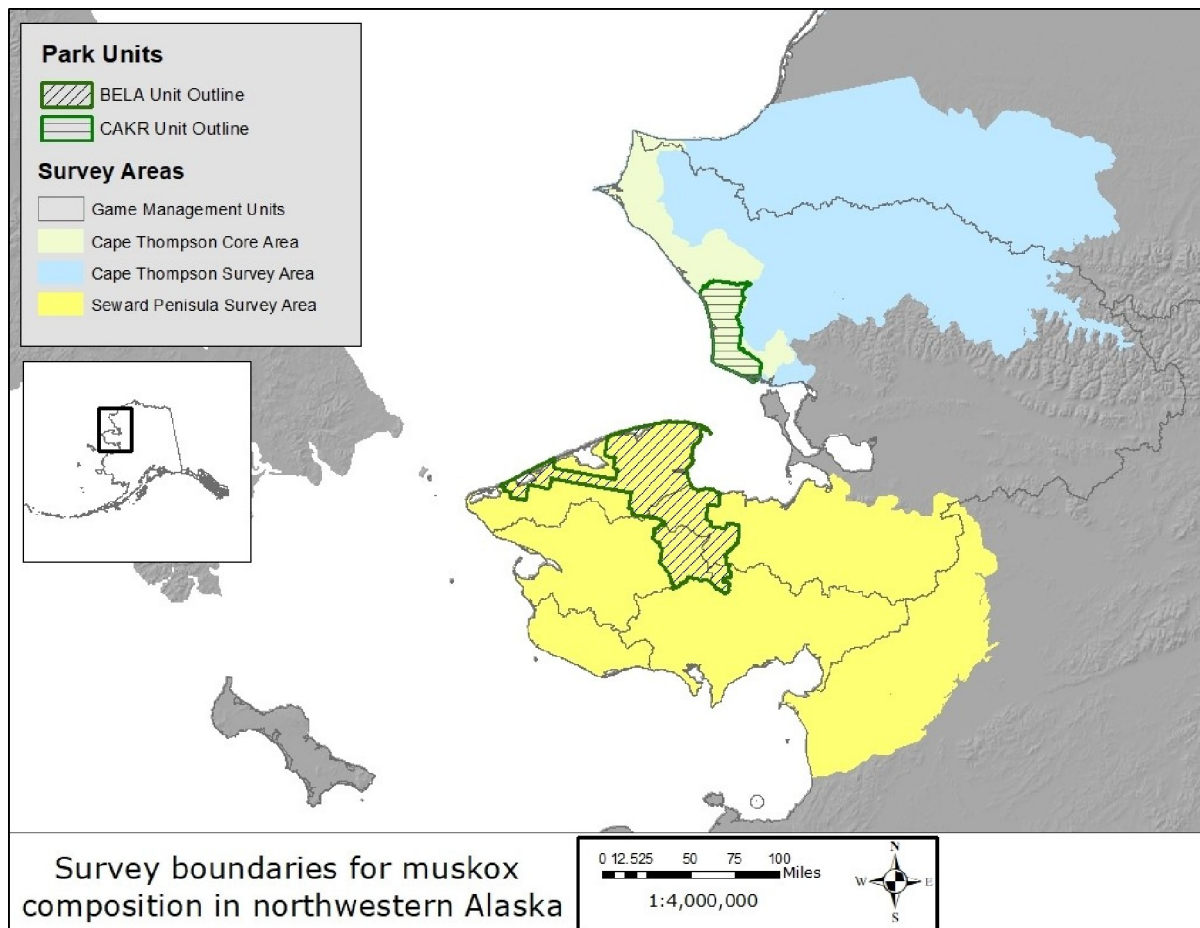


**Figure 1.** Survey areas for long-term monitoring of sex-age composition of muskoxen in the Arctic Network park units.

### **History of the Seward Peninsula muskoxen population in Bering Land Bridge National Preserve**

In 1970, 36 muskoxen from Nunivak Island were introduced to the southern portion of the Seward Peninsula (Grauvogel 1984). An additional 35 muskoxen from the Nunivak Island herd were translocated to the existing population in 1981 (Machida 1997). From 1970 through 2010, the population grew steadily and expanded its range northward and eastward throughout the Seward Peninsula (Gorn and Dunker 2013), including BELA. Muskox populations in the western portion of the Seward Peninsula grew steadily and peaked between 2007 and 2010. In 2010, the population on the Seward Peninsula peaked at 2,903 animals. The population declined slightly in 2012 to 2,223 animals and then stabilized around 2,353 animals between 2015 and 2017 with some variation in individual subunits (Gorn and Dunker 2015, Dunker 2017).

### **History of Muskox Surveys**

Abundance and distribution monitoring of muskoxen began in the 1970s with opportunistic, minimum-count, aerial surveys conducted by the ADFG. These surveys became more consistent starting in 1988. The NPS has contributed to ADFG's efforts both collaboratively and independently

since 1983. Minimum count surveys were replaced in 2011 for the Cape Thompson survey area and in 2010 for the Seward Peninsula population with an adapted distance sampling technique that provides abundance estimates with a measure of precision. Protocols for conducting these surveys and the associated analysis can be found in Schmidt et al. 2010, Westing 2011, Schmidt and Gorn 2013, Westing 2013, Gorn and Dunker 2013, and Hughes 2016. The ADFG typically leads, with support from the NPS, the logistics for the abundance and sex-age composition surveys of the Seward Peninsula muskoxen population, and consolidates the data gathered during the surveys. The NPS and ADFG analyze the data for the abundance and sex-age composition surveys, respectively. For the Cape Thompson muskoxen population, the NPS and ADFG share logistics for the abundance and sex-age composition surveys, and share consolidation of the data. The NPS and ADFG analyze the data for the abundance and sex-age composition surveys, respectively. As of this writing, the NPS participation in these surveys has been led by Western Arctic National Parklands (WEAR). Population estimates are crucial to managing muskoxen in northwestern Alaska including BELA and the WEAR parks (CAKR, KOVA, and NOAT). ARCN's role in these surveys is typically limited to providing statistical support.

Muskoxen sex-age composition are the focus of this protocol implementation plan. Muskoxen sex-age composition surveys have been conducted since 2004 on the Cape Thompson population, and since 2002 on the Seward Peninsula. Determination of muskoxen sex-age is a helicopter-supported ground-based survey that targets groups of muskox located during the aerial abundance and distribution surveys. Ideally, composition surveys are conducted less than a month after the completion of the abundance and distribution surveys to minimize movement of animals, and thereby minimize the need to search for muskox groups.

Both subsistence and sport hunting are allowed in BELA and NOAT. Subsistence hunting by Federally Qualified Subsistence users is allowed in CAKR. The cooperative approach between ADFG and federal land management agencies has allowed muskox herds in Northwestern Alaska to be managed as naturally occurring wildlife populations rather than populations based on agency boundaries. Cooperation has resulted in sharing of resources for a more comprehensive biological data set as well as enhanced conservation, and has allowed a coordination of harvest allocation to both State of Alaska sport and subsistence programs as well as a federal subsistence program.

The purpose of this document is to describe the means by which long-term trends in the sex-age composition of muskoxen populations that overlay three NPS units in Alaska will be collected, managed, and reported. Parks units covered by this protocol implementation plan (PIP) are BELA, CAKR and NOAT. Muskoxen also occasionally occur in GAAR and KOVA, but the animals in these two units are dispersed and thus, are not covered by this PIP. All five parks are part of the ARCN Inventory and Monitoring Program. The Inventory and Monitoring Program (I&M) was established in 2001 as part of the NPS's strategy to better understand and manage parklands using scientific information. Nationally, 32 networks were established that shared geographic similarities, common natural resources and resource protection challenges. ARCN is one of four such units in AK. All I&M networks are responsible for selecting and monitoring key physical, chemical, and biological resources and processes in their park units and to design and implement long-term protocols that can

detect changes in network ecosystems. ARCN coordinates inventory and monitoring of natural resources within GAAR, NOAT, KOVA, CAKR and BELA.

Muskoxen are one of 28 vital signs selected for long-term monitoring by ARCN. The prioritization of the muskox vital sign by ARCN was based on park management priorities. Herd sex-age composition provides critical information for understanding population trends. With composition data, herd productivity can be correlated with environmental conditions, habitat conditions, predation, harvest patterns, and management strategies. Muskox sex-age composition are important for managing sport and subsistence hunting. In addition, muskoxen population trends and sex-age composition can be used to investigate linkages with other vital signs including climate, snow and ice, terrestrial vegetation, and other herbivore and predator species (Lawler et al. 2009). For park visitors, muskoxen can be a reliably viewed large mammal because they are non-migratory and relatively sedentary in comparison to other arctic ungulates (i.e. caribou). The NPS is mandated by the Alaska National Interest Lands Conservation Act (ANILCA 1980) to “provide the opportunity for continued subsistence uses” (Section 801 (4)); and (3) “[conserve] natural and healthy [wildlife] populations” (Section 814(1)).

A peer-reviewed journal article presented the means by which ARCN will collect muskox sex-age composition data and reports the results obtained from surveys conducted from 2002 - 2012 on the Seward Peninsula, AK (Schmidt and Gorn 2013). ARCN will follow the sampling strategy outlined in the Schmidt and Gorn (2013) publication with minor modifications that will be outlined in this PIP. The PIP will also detail how the data collected from this effort will be managed and reported by the NPS. Additional detail for field and data processing procedures are provided in the Standard Operating Procedures (SOPs). The SOPs used for this protocol are adopted from the ARCN-CAKN Dall’s sheep SOPs and ARCN moose SOPs. Modifications to these SOP are summarized below and fully described in renamed ARCN Muskox SOP versions (Table 5). The Dall’s sheep and moose SOPs are published as stand-alone documents and are available on the ARCN website (<http://science.nature.nps.gov/im/units/arcn/>) and in the NPS Data Store (see ARCN Dall’s sheep and Moose monitoring projects (<https://irma.nps.gov/DataStore/Reference/Profile/2214983> and <https://irma.nps.gov/DataStore/Reference/Profile/22351856> for Dall’s sheep and moose, respectively. This PIP will be implemented by the ARCN in collaboration with the Alaska Department of Fish and Game.

## Conceptual Framework for Monitoring

Muskoxen are a circumpolar arctic species. Within the NPS system, they are only found in Parks in the ARCN. In the past few decades, climate change has been affecting the northern latitudes more than any place on earth. As a region, Alaska has warmed more than twice as rapidly as the rest of the United States over the past 60 years, with average annual air temperature increasing by 3°F and average winter temperature by 6°F (Chapin et al. 2014). Climate warming is leading to major changes in arctic ecosystems, including significant increases in woody vegetation cover (Pearson et al. 2013). Implications for an arctic ungulate, such as the muskox are substantial. In addition to changes in climate and ecosystems, muskox populations may be impacted by hunting (Schmidt and Gorn 2013). Given the NPS's mandate to provide the opportunity for continued subsistence uses and to conserve natural and healthy wildlife populations (ANILCA 1980), understanding muskox population levels and sex-age composition is of vital importance for management (Table 1).

**Table 1.** Factors affecting muskox populations within ARCN parks and measures for Vital Signs monitoring.

| Category               | Issue                                                                                                                                                                                                                                                                              | Measure                                                                                                                                                |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| Climate Change         | Anticipated long-term climate change is predicted to alter both vegetation species-ranges and community composition and structure in ARCN parks.                                                                                                                                   | <i>Change in muskox population numbers and distribution in northern Alaska.<sup>1</sup></i>                                                            |
| Extreme Weather Events | Extreme weather events are predicted to increase in northern Alaska with increasing temperatures. This may lead to increased icing events related to freeze-thaw cycles or rain-on-snow events. Increases in icing events would impact forage availability to northern herbivores. | <i>Rapid changes in muskox populations and distribution.<sup>1</sup></i> <b>Potential changes in sex-age distribution in muskox herds.<sup>2</sup></b> |
| Human Harvest          | Human harvest may lead to changes in muskox population numbers and distribution and may selectively remove specific sex and age classes.                                                                                                                                           | <i>Changes in muskox populations and distribution.<sup>1</sup></i> <b>Potential changes in sex-age distribution in muskox herds.<sup>2</sup></b>       |

<sup>1</sup> Measures are addressed through other monitoring initiatives by NPS or partners (also in italics).

<sup>2</sup> Measures have been selected for inclusion in the ARCN muskox monitoring effort (also bolded).

## Measurable Objectives

To measure changes in muskoxen sex-age composition, the following two objectives will be addressed by this PIP across two populations in northwestern Alaska. One population occurs north of Kotzebue, AK and radiates to the north and east encompassing CAKR and a portion of NOAT. The second occurs on the Seward Peninsula and encompasses BELA (Figure 1):

- 1) Determine late winter muskoxen sex composition in the Cape Thompson and Seward Peninsula populations.
- 2) Determine late winter muskoxen age composition in the Cape Thompson and Seward Peninsula populations.

Parks in ARCN and the ADFG are also responsible for separate but related monitoring objectives for muskoxen in northwestern Alaska. The two most relevant to this PIP have to do with population numbers and trends:

- 1) Estimate late winter muskoxen abundance in the Cape Thompson and Seward Peninsula populations.
- 2) Determine late winter muskoxen distribution in the Cape Thompson and Seward Peninsula populations.

All the objectives listed above will be addressed cooperatively with the ADFG. ARCN relies on the ADFG and park biologists for information on current muskox locations and distribution in order to plan the logistics for sex-age composition surveys (Schmidt and Gorn 2013; Gorn and Dunker 2013). Historically, population survey efforts have been supported by park base funds and from financial support from ADFG, US Fish and Wildlife Service, and the Bureau of Land Management.

## What is being Measured and How

The ARCN will be monitoring muskox population sex-age composition using the methods presented by Schmidt and Gorn (2013) and further described by Gorn and Dunker (2015). Locations of muskox groups are recorded during the survey-unit wide population survey or during pre-composition surveys designed to locate the majority of the groups within the survey unit. Population surveys are conducted during March and April, and composition surveys are initiated within one month after the population survey is completed and prior to calving. Sex-age composition surveys are conducted from the ground using a helicopter (or snowmachine) to access groups of muskox. Trained observers use spotting scopes and binoculars to classify individual muskox into seven sex-age classes based on body size, hair length and horn characteristics: bulls 4-years-or older, 3-year-old bulls, 2-year-old bulls, cows 4-years or older, 3-year-old-cow, 2-year-old-cows, and yearlings. Mature bull to 100 cow ratios (MB:100 C) are calculated using the number of mature bulls (4-years-or-older) per cows > 3 years-old. Yearling to 100 cow ratios (Y:100 C) were calculated using the number of yearlings per 100 cows > 3 years-old. ). Composition proportion estimates were calculated for MB ( $\hat{p}_{MB}$ ) and SY ( $\hat{p}_{SY}$ ) and reported with 95% confidence. Percent recruitment was calculated as the number of short

yearlings per all muskox sampled excluding calves  $[SY/(N-\text{calves})]$  (Gorn and Dunker 2015). Multiple resources are available to help train new observers in classifying muskoxen including Olesen and Thing (1989) and two online publications by the ADFG (Alaska Department of Fish and Game. No date).

# Sampling Design and Monitoring Schedule

## Sampling Design

Muskox sex-age composition are collected following the methods outlined by Gorn and Dunker (2013). Muskox groups that are located during aerial surveys are relocated during muskox composition surveys. In brief, for the Seward Peninsula population (including BELA) the list of muskox groups that are located during the survey-unit wide population survey are divided into 3 classes based on group size: small (1-16), medium (17-33), and large (>33). The sample is comprised of a number of individuals from each group size-class in proportion to the distribution of size-classes in the encountered groups. Groups from each class are randomly selected and sampled in order until  $\geq 150$  individuals have been sampled within each given management area (i.e., Game Management Unit; GMU). If  $< 150$  animals are observed in a GMU all groups are included. Due to the small size of the Cape Thompson population all groups are sampled if possible. This was consistent with the sample size recommendations for composition surveys proposed by Czaplewski et al. (1983).

In summary, sampling effort is done in proportion to the numbers and types groups observed during the population survey. Sampling objectives are:

- 1) Sex and age  $\geq 150$  individual muskox per management area (GMU);
- 2) The  $\geq 150$  muskox that are sexed and aged should be allocated proportionally to the proportion of group in each size class (small, medium, and large) encountered in each management area;
- 3) Groups that are chosen for composition determination should be randomly distributed throughout a subunit.

For example, during the 2015 Seward Peninsula survey there were 12 transects in GMU 22E where muskox were detected. The types of muskox groups observed on these 12 transects were:

- 7 Small groups with the number of individuals ranging from 1 to 16
- 3 Medium groups with the number of individuals ranging from 17 to 32
- 2 Large groups with the number of individuals ranging from 33 and higher

The approximate composition of groups expected in GMU 22E would be:

- Small groups ~60%
- Medium groups ~25%
- Large groups ~20%

Therefore, a fairly representative sample of 150 muskoxen in GMU 22E will comprise approximately 90 individuals coming from small groups, 38 coming from medium groups, and 30 coming from large groups. Locating and classifying approximately 8 or 9 small groups, 2 or 3 medium groups, and 1 large group would be the expected workload for GMU 22E. The number of groups required will vary somewhat depending on the actual size of the groups encountered.

It is important to allocate the sample in proportion to the different group size categories as closely as possible. In the example given above, if 8 small groups are sampled, and 3 medium groups are sampled to meet the objective of having 60% and 25% of the animals classified from small and medium groups, respectively, and a total of 152 muskoxen have been sex-aged, the survey should not end. There is still a need to sample a large group to ensure the large group size is represented in the sample. Results from previous surveys indicate this sampling design will provide sex-age proportion estimates that are  $\pm 5\%$ -10% at a 95% level of significance.

### Monitoring Schedule

Muskox composition surveys are conducted in March and April within 1 month of completing the survey-unit wide population survey. Muskox sex-age composition data will be collected every 2 years alternating between the Cape Thompson core survey area and the Seward Peninsula survey area. Every fifth year, the Cape Thompson survey will include both the core area as well as the expanded area (Table 2).

**Table 2.** Proposed schedule for conducting muskox sex-age composition surveys in northwest Alaska.

| Survey Area                 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|-----------------------------|------|------|------|------|------|------|------|------|------|------|
| Cape Thompson Core Area     | X    | X    | X    | –    | X    | X    | X    | –    | X    | –    |
| Cape Thompson Expanded Area | X    | –    | –    | –    | X    | –    | –    | –    | X    | –    |
| Seward Peninsula            | –    | X    | –    | X    | –    | X    | –    | X    | –    | X    |

# Data Management, Analysis, and Reporting

## Data Management Life Cycle

Data management for the muskox monitoring program will proceed through an ongoing life cycle as shown in Figure **Error! Reference source not found.2** (NPS 2008a). Major stages of the life cycle include data collection, data entry and import, quality control, data product documentation and archival, seasonal closeout, dataset certification, and data analysis and reporting (NPS 2008b).

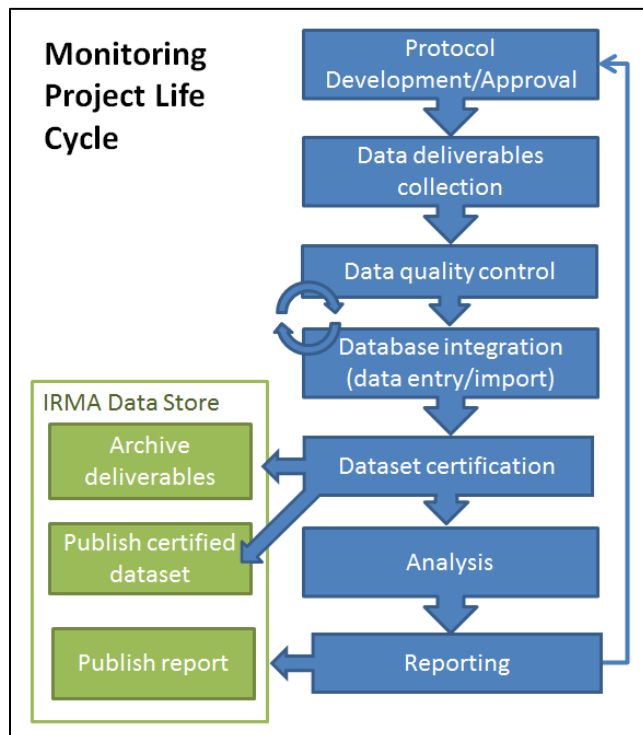


**Figure 2.** Long term monitoring project data management life cycle.

An overview of major components of the muskox monitoring data management life cycle follows. Specific procedures given in standard operating procedures.

# NPS Standards

## Data Quality

Director's Order #11B mandates a high level of information quality from the service's scientific programs:

*The National Park Service will ensure that information it releases will be developed from reliable data sources and will otherwise ensure information quality at each stage of information development. The NPS's methods for producing quality information will be made transparent, to the maximum extent practicable, through accurate documentation, use of appropriate internal and external review procedures, consultation with experts and users, and verification of the quality of the information disseminated to the public. The NPS will also keep users informed about corrections and revisions.*

*Information will be developed only from reliable data sources based on accepted practices and policies utilizing accepted methods for information collection and verification. It will be reproducible to the extent possible. Influential information will be produced with a high degree of transparency about data and methods. The information should include all pertinent information to allow the public to understand the park's legislative authorities, mission, activities, organization, strategic plan, performance plan, and performance accomplishments.*

Director's Order #11A section 5.8: Data Integrity Standards outlines the NPS policy for accuracy, completeness and review:

*All information owners will maintain all official NPS records and data in a manner which meets the highest data integrity standards, including timeliness, accuracy and completeness (also see DO #11D). Each information owner will take what ever steps necessary to ensure that NPS systems have sufficient data quality reviews and audits from both an internal system perspective, as well as externally thorough control reviews.*

Adherence to the data management procedures in this monitoring protocol will ensure compliance with DO#11.

## Freedom of Information Act

The Network will comply with all Freedom of Information Act restrictions regarding the release of data and information as instructed in NPS Director's Order #66B.

## Records Management

Direction for managing physical and digital materials is provided in NPS Director's Order 11D.

*The NPS has a strong business need for excellent records management, in that the Service's mission is to care for natural and cultural resources so that they are left "unimpaired" for future generations. This requirement for managing resources in perpetuity sets a high standard for record keeping. No resources can be managed well in the future without*

*complete records of how they were managed in the past. Because the NPS manages some of America's most significant cultural and natural resources, the public also has a significant interest in our records. Section 1.9.2 of NPS Management Policies 2006 (NPS 2006) states that the future of the Service depends on the availability, management, dissemination, and preservation of information, and directs the agency to implement professional quality programs to manage information resources.*

## Core Functional Model

Data generated by the muskox monitoring program are managed according to the Core Functional Model described in Figure 3 **Error! Reference source not found..**

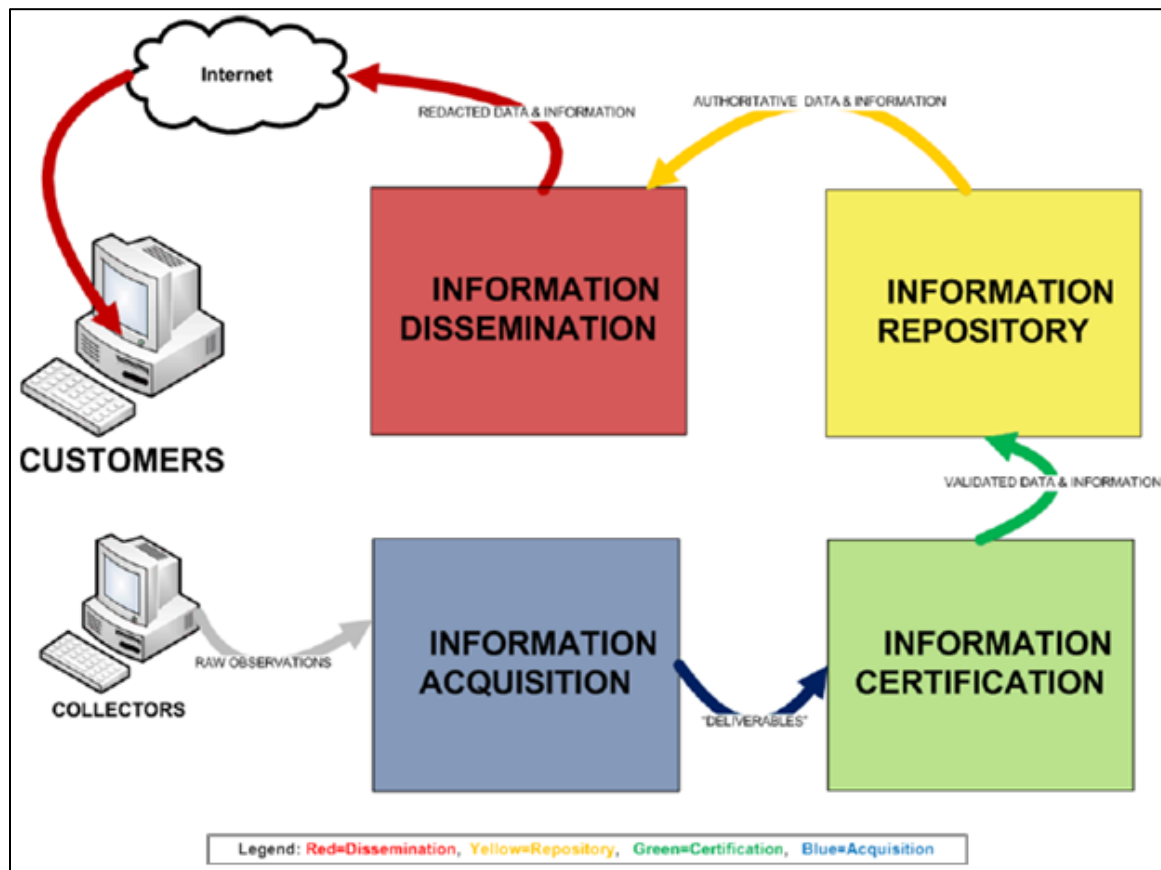


**Figure 3.** The ARC/CAKN Core Functional Model overview.

Dissemination services (red, Figure 3) provide all deliverables to all customers using internet web sites and web services through the NPS Integrated Resource Management Applications (IRMA) Data Store. Repositories (yellow) store the certified inventory and monitoring products called for in the protocols. Certification processes (green) assure repositories have the highest quality data and that sensitive items are restricted to authorized users. Data acquisition processes (blue) led by park staff and cooperators include a wide array of tasks, ranging from collecting raw data to composing reports on long-term trends.

# Roles and Responsibilities

## Project Leader

- Ensures that the muskox monitoring protocol and all of its standard operating procedures are current and up to date. If methods must be changed the project leader ensures that the standard operating procedures remain in sync with actual data management operations. The project leader ensures data is collected, processed and published consistently and strictly according to the specifications and methods described in the standard operating procedures.
- Performs an annual closeout with the Network program manager and data manager.
- Performs analytical procedures and reports on findings
- Arranges technicians and budgets for data management costs, such as data entry and processing.

## Data Manager

- Provides for the security, longevity and accessibility of the monitoring dataset (NPS 2008a).
- Maintains software and hardware for file backups and security, databases, custom and proprietary applications and Geographic Information Systems tools.
- Guides personnel in data processing techniques, metadata generation and product archival in NPS data stores and enterprise databases.
- The data manager is not responsible for data entry, processing, metadata generation or archiving data deliverables.

# Data Collection

## Overview

The muskox monitoring program creates and maintains specific data deliverables (Table 3 and Appendix A). Raw data deliverable files are collected during surveys and processed for quality. Processed files are certified by the project leader and analyzed. During seasonal closeout the raw deliverables are archived in private Data Store references while certified data files are archived in the muskox monitoring program's authoritative, public certified Dataset (Figure 4).

Each deliverable is disseminated directly from the IRMA Data Store, the single authoritative source for Network products. In the event that a data product ever diverges from that in the IRMA Data Store the latter version should be considered authoritative.

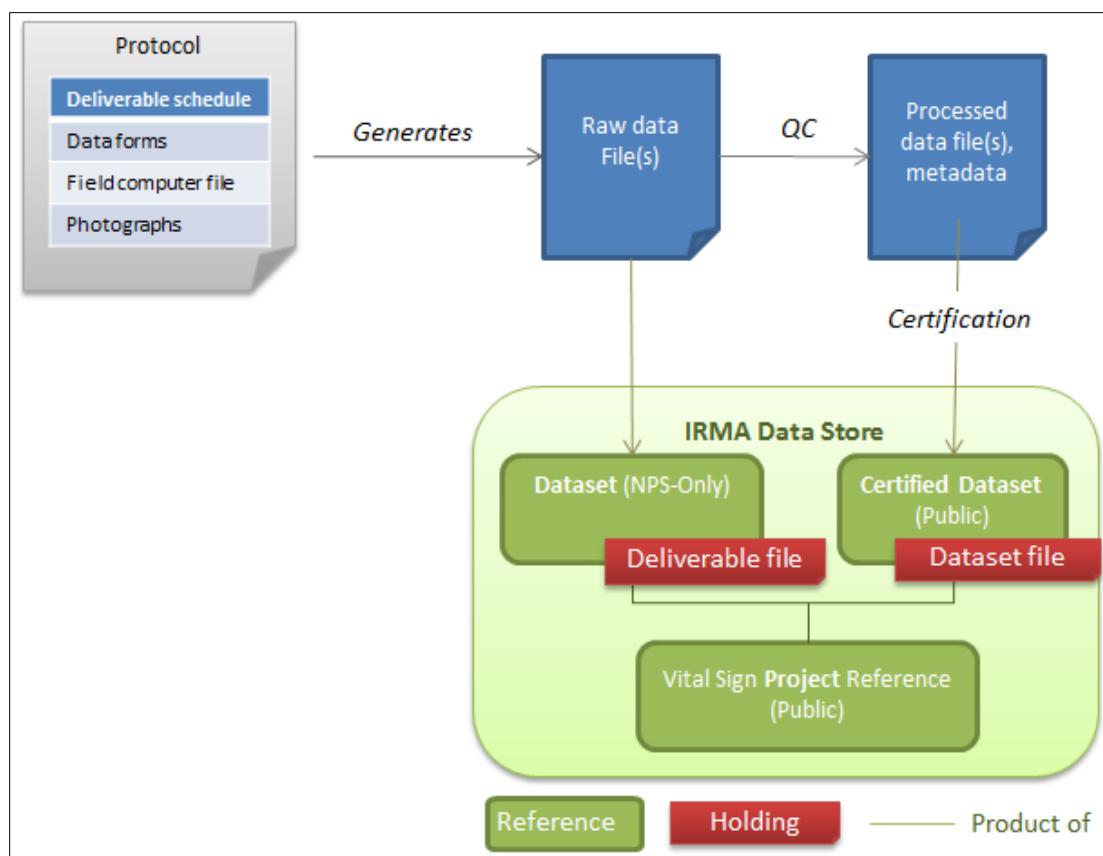


**Figure 4.** Data products processing and flow diagram. Data deliverables are collected on a cycle, processed to analytical quality, certified, and published to the IRMA Data Store. Raw deliverables are retained in private Dataset references.

### Data Sensitivity Statement

The ARCN muskox monitoring protocol defines the collection of sensitive data and requires special handling procedures. The justification for this declaration of sensitivity is that the data deals with ‘rare, threatened, endangered, or commercially valuable species’ (National Parks Omnibus Management Act [1998], NPS 2002).

Network staff will ensure that all references to protected information are removed or obscured in any reports, publications, maps, or other public forum. Following the standard for Freedom of Information Act (FOIA) requests, the Network will segregate the non-releasable information and where practical will not withhold associated releasable information. Metadata for that dataset and the IRMA citation will also be updated to reflect that the associated data are sensitive.

The project leader is responsible for maintaining the security of data released to any NPS dataset catalog and ensuring confidentiality agreements are in place before sharing data with any non-NPS entity.

### Deliverables Schedule

The muskox monitoring program will create and maintain the data products shown in Table 3.

**Table 3.** Muskox monitoring data deliverables schedule.

| Identifier | Deliverable                | Description              | Schedule            | Responsibility* |
|------------|----------------------------|--------------------------|---------------------|-----------------|
| M1         | Survey units with metadata | Shapefile and text file, | As needed           | PI              |
| M2         | Data collection forms      | Paper forms              | Sample date +1 year | PI              |
| M3         | Survey data with metadata  | Shapefile and text file, | Sample date +1 year | PI              |
| M4         | Data collection form scans | Portable document file   | Sample date +1 year | PI              |

\*PI = Principal Investigator

The deliverables in Table 3 are described in more detail in Appendix A.

## Quality Assurance

The muskox monitoring protocol assures high data quality by proactively deploying a system of administrative procedures and technological safeguards including:

- Standard operating procedures designed to minimize the introduction of errors during data collection and processing.
- Apprenticeship of new field crew under an experienced observer.
- Standard database security and integrity functions and data integrity constraints (Frakes et al., 2015) to enforce compliance with the Vital Sign's logical data model.
- Application level data entry checks and business rule enforcement.

## Quality Control

Ensuring high data quality as a high priority for the Muskox Vital Sign. Quality control procedures focus on verifying data as well as identifying and correcting errors in final data products. Quality control safeguards include:

- Data verification and/or double data entry procedures.
- Spot checking.
- Automated programmatic range, domain or impossible value checking.
- Graphical and visual exploratory data analysis
- Statistical error or outlier identification.
- Data quality audits and reporting.
- Dataset certification.

## Product Archival and Documentation

Director's Order 11D states that all records of natural and cultural resources and their management are considered mission-critical records (necessary for fulfillment of the NPS mission) and must be permanently archived. Mission critical deliverables are considered to be archived when they are uploaded to the IRMA Data Store. With few exceptions IRMA is the only authoritative repository for mission critical I&M products.

Data archiving is done in concert with seasonal close out and data certification (ARCN/CAKN DMSOP-1, Miller 2017). All data are archived in the following ways:

- IRMA Data Store. Formats may include:
  - Raw and processed data files described in this protocol's deliverables schedule.
  - Human readable text file of all muskox monitoring databases. A SQL script is built that can recreate the entire database and all the data within it.
- Network file server

Muskox monitoring program data are maintained on a network file share in the Fairbanks Administrative Center (FAC) in Fairbanks, Alaska and backed up to off-site storage at the NPS Natural Resource Stewardship and Science Directorate (NRSS) in Denver, Colorado and a separate NPS facility in Fairbanks. The NRSS and FAC use enterprise-level business continuity processes to maintain data security. In the event of catastrophe at one site, the original data may be restored from the other.

### IRMA Data Store

The NPS IRMA Data Store is the primary organizational repository and publication platform for information related to the muskox monitoring program. The muskox Vital Sign has a single master IRMA project reference (<https://irma.nps.gov/DataStore/Reference/Profile/2219896>) to which all products are related (**Error! Reference source not found.Figure 2 and Figure 5**). Product publication and reference architecture in the IRMA Data Store is covered in more detail in ARCN/CAKN/DMSOP-1 (Miller 2017).

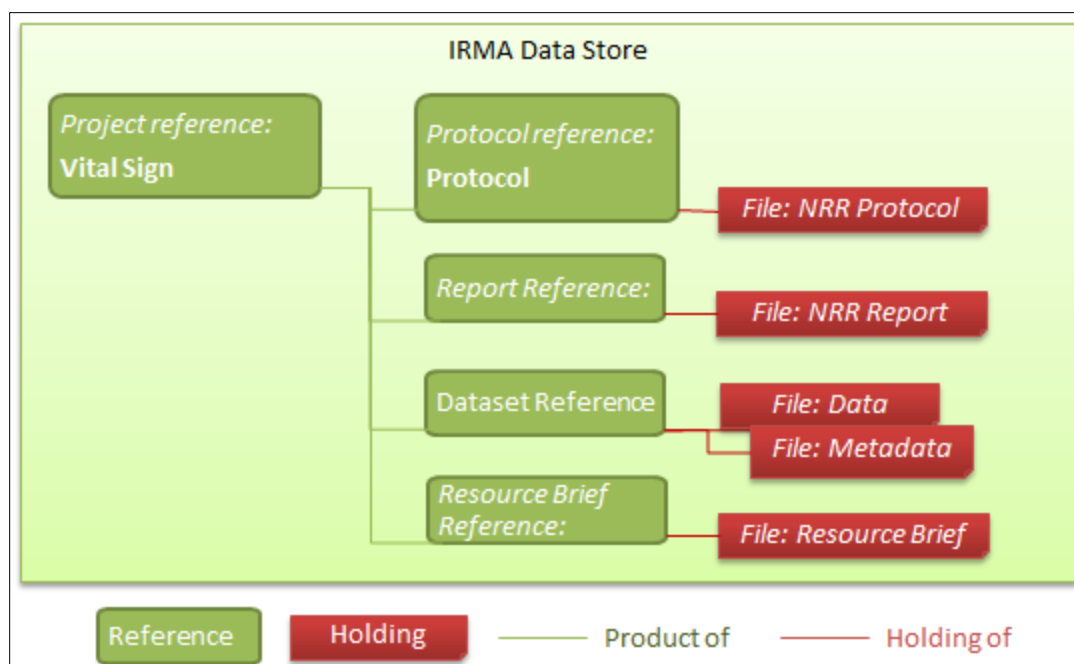


**Figure 5.** Standard ARCN Vital Sign Project reference architecture in the IRMA Data Store.

### Public Muskox Website

Arctic Network publishes products generated by the muskox monitoring through a website available at <https://www.nps.gov/im/arcn/muskox.htm>. This web profile will publish the releasable contents of monitoring reports, journal articles, datasets and related products. The website draws data from the IRMA Data Store via web services (Figure 6). Products published to Data Store automatically cascade to the muskox website. It is the joint responsibility of the project leader and the data manager to keep the system of related IRMA Data Store references up to date.

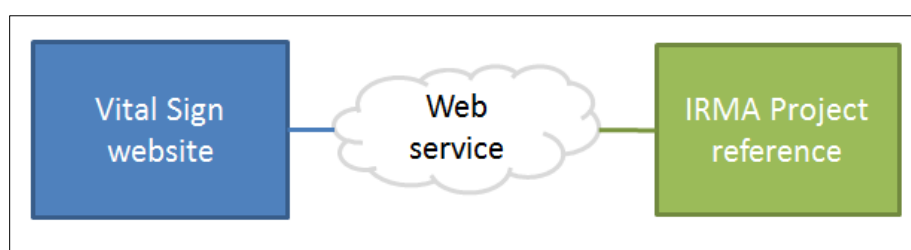


**Figure 6.** The muskox monitoring website draws information from the IRMA Data Store. Products published to Data Store automatically cascade to the muskox website.

### Reports

Reports are published in the NPS Natural Resource Report publication series (<https://www.nps.gov/im/publication-series.htm>) in collaboration with the ADFG. (<http://www.adfg.alaska.gov/index.cfm?adfg=librarypublications.wildlifemanagement#muskox>) or in professional journals. Reports and journal articles reporting analytical results will be published in tandem with the dataset that was used.

Natural Resource Reports are automatically tracked and announced to Network program managers and data managers but journal articles are not. The PI will create Data Store references for journal articles related to monitoring, link them to the Vital Sign's IRMA Project reference (Figure 5), and notify Network staff of their presence.

### **Certified Dataset**

All reports providing statistical results will also publish the data on which they were based. Metadata will be provided as well as a link to the certified original dataset (NPS 2005). Data are made available through IRMA in machine readable formats according to Director's Order #11A and as mandated by the Federal Open Data Initiative (Executive Order No. 13642).

### **Resource Brief**

The I&M resource brief is the primary outreach document for the muskox monitoring program. The principal investigator will revise any existing resource brief after new findings to reflect current understanding of the resource's trend and implications for park management. Resource briefs are made available on the Network web site through an IRMA Data Store Resource Brief product reference that is attached as a product of the main Vital Sign Project reference (**Figure 5**).

### **Products Publication**

Reports, datasets and other monitoring products are published through NPS websites using the Vital Sign's master Data Store Project reference via web services exposed by the IRMA Data Store. Authoritative products will only be distributed through the IRMA Data Store (Figures 5 and 6).

### **Metadata**

All project datasets, including spatial and non-spatial data, are archived in the IRMA data store with metadata (NPS 2005, **Figure 5**). The mandate for adequate metadata comes from Director's Order #11A:

*All NPS data systems will develop data dictionaries and conform to available NPS organization-wide dictionaries. Geographic Information and Metadata must meet all Federal standards, DOI standards and NPS standards.*

Preferred metadata formats include Federal Geographic Data Committee (FGDC) and Ecological Metadata Language (KNB 2017).

### **Line of Sight**

Line of Sight is the informal name given to the I&M program's philosophy that every datum should be inextricably linked to the standard operating procedure and protocol version that guided its collection (Figure 7**Error! Reference source not found.**). This custodial chain is maintained through metadata columns in the main monitoring database coupled with metadata maintained in each protocol and standard operating procedure's IRMA reference. A data consumer will be reliably able to access a data record and discover the standard operating procedure version that defined its collection and processing.

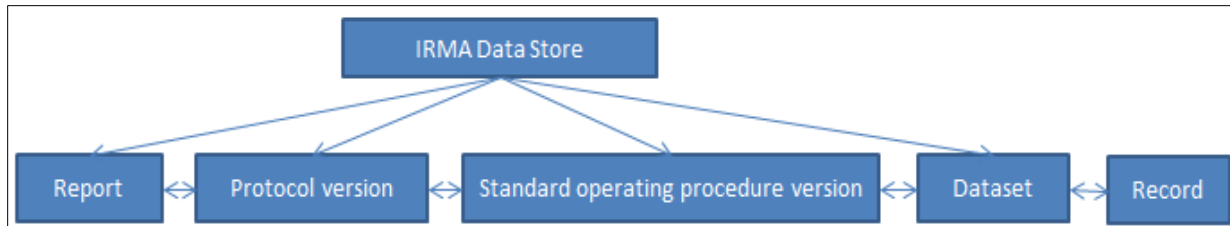


**Figure 7.** Each informational component informs and is informed by other components. Discovery of one component leads to discovery of all other components in a formalized data management chain of custody.

### **Data and Information Security**

Digital products produced by the muskox monitoring program will be stored in the IRMA Data Store and the ARCN network file server. Under no circumstances will any mission-critical information reside on individual I&M staff computers whether they are assigned to monitoring personnel by the NPS or not. Project materials will be secured and available on I&M servers at all times. The data manager, in conjunction with IT staff at FAC and with the Network support office in Ft. Collins, CO is responsible for backups, security and longevity of monitoring data.

## Closeout

Closeout is the part of the muskox monitoring data management life cycle through which seasonal data collection files (deliverables, **Error! Reference source not found.** and Appendix A) and certified data are archived in the IRMA Data Store (**Error! Reference source not found.**Figure 4 and Figure 5). The muskox monitoring program will follow the procedures described in ‘Product Archival, Seasonal Closeout and Dataset Certification Procedures for the Arctic and Central Alaska Inventory and Monitoring Networks: ARCN/CAKN Data Management Standard Operating Procedure #1 (Miller 2017).

Closeout happens after a remeasurement cycle when data files have been collected, processed and certified. Deliverables and the certified dataset are archived as holdings of private and public Dataset References in Data Store (Figure 4 and Figure 5, Miller 2017). Closeout is complete when seasonal Dataset holdings reconcile with the deliverables schedule (Figure 8).

After closeout, all permissions are removed from references except for the project leader and data manager. The references are then linked to the main muskox monitoring IRMA Project reference so that it becomes discoverable.

**Monitoring Protocol**

Table 1 shows the field data deliverables that will be collected seasonally.

**Table 1. Data deliverables schedule**

| Identifier | Deliverable           |
|------------|-----------------------|
| D-01       | Field database file   |
| D-02       | Field data collection |
| D-03       | Survey Photos         |
| D-04       | Tracklogs             |
| D-05       | Waypoints             |
| D-06       | NRDS Report           |

Seasonal closeout is complete when the deliverables from the protocol's deliverables schedule are available in the IRMA Data Store

**REFERENCE: 2173037**

**IRMA Portal Integrated Resource Management Applications**

[Portal](#) > [Home](#) > [IRMA Applications](#) > [Data Store](#) > [Profile](#) >

Scientist, A. 2017. 2016 Vital Sign Field Data Deliverables Dataset. Dataset. National Park Service Inventory and Monitoring Program. Fairbanks, AK. Generic Dataset-2222131.

Reference Status as of 07/31/2015: Active  
Visibility: Internal

**Holdings**

|                                                              |
|--------------------------------------------------------------|
| D-01 FieldDatabase.zip (.shp, 134kb)                         |
| D-02 Field data collection forms (pdf, 340kb)                |
| D-03 SurveyPhotos-2011.zip (.jpg, Compressed archive, 300Mb) |
| D-04-05 Tracklogs-Waypoints.zip                              |
| D-06 NRDS Report (link)                                      |

**Figure 8.** Example of reconciling published holdings with the protocol's data deliverables schedule during closeout. Data deliverables are defined in the monitoring protocol. These deliverables are archived in Dataset references in the IRMA Data Store. Closeout is complete when the holdings in the Dataset reference reconcile with the deliverables in the deliverables schedule.

The closeout method described above will ensure that all data objects collected during a remeasurement cycle are accounted for, documented and available for perpetuity should the need arise to revisit the data.

## Certification

Certification is the phase of the muskox monitoring data management life cycle where the principal investigator formally confirms that the Vital Sign's dataset is ready for analysis (NPS 2016).

Certification also affirms the scientific, administrative and technical integrity of the program:

- The protocol and standard operating procedures are current. All technical changes are up to date and documented.
- Raw and intermediate data deliverables have been processed via quality control procedures, have been integrated with the vital sign's database or data management system and have been archived and documented appropriately for posterity.
- Each data record is traceable to the protocol version and SOP version that guided its collection.
- All closeout activities have been performed.
- The certified database or data files have been published to the Vital Sign's public Dataset reference in the IRMA Data Store.
- The Vital Sign's IRMA Data Store references and cross-links are complete.
- The dataset is of sufficient quality that analyses may be performed on it and the results published.

The muskox monitoring program will follow the dataset certification procedures described in 'Product Archival, Seasonal Closeout and Dataset Certification Procedures for the Arctic and Central Alaska Inventory and Monitoring Networks: ARCN/CAKN Data Management Standard Operating Procedure #1' (Miller 2017).

## Budget

NPS staff associated with the muskox vital sign include the ARCN/CAKN Biometrician, the WEAR and BELA Wildlife Biologists, and the ARCN/CAKN Data Manager. Cost of this protocol to the NPS I&M program are primarily associated with helicopter aviation time (Table 4).

**Table 4.** Estimated annual operating cost (based on FY2017 dollars) for implementation of the ARCN Muskox Vital Sign Protocol.

| Category  | Item                         | Costs (FY 2017) | Notes      |
|-----------|------------------------------|-----------------|------------|
| Personnel | ARCN/CAKN Biometrician       | \$5,157         | 1 PP GS-12 |
|           | WEAR/BELA Wildlife Biologist | \$8,822         | 2 PP GS-12 |
|           | ARCN/CAKN Data Manager       | \$4,133         | 1 PP GS-11 |
|           | <i>Total Personnel Costs</i> | <i>\$18,112</i> | –          |

**Table 4 (continued).** Estimated annual operating cost (based on FY2017 dollars) for implementation of the ARCN Muskox Vital Sign Protocol.

| <b>Category</b>                         | <b>Item</b>                                                                  | <b>Costs (FY 2017)</b>              | <b>Notes</b>                         |
|-----------------------------------------|------------------------------------------------------------------------------|-------------------------------------|--------------------------------------|
| <b>Aviation Survey Area*</b>            | Cape Thompson core area only (includes ferry time from Nome)                 | \$18,500                            | —                                    |
|                                         | Cape Thompson core area and expanded area (includes ferry time from Nome)    | \$30,000                            | —                                    |
|                                         | Cape Thompson core area and Seward Peninsula (includes ferry time from Nome) | \$30,000                            | —                                    |
|                                         | <i>Total Aviation Costs</i>                                                  | <i>\$18,500 - \$30,000 per year</i> | —                                    |
| <b>Travel</b>                           | 1 person Fairbanks to Kotzebue for 1 week (\$1,200/person x 1)               | \$1,200                             | Lodging at NPS bunkhouse in Kotzebue |
|                                         | <i>Total Travel Costs</i>                                                    | <i>\$1,200</i>                      | —                                    |
| <b>Equipment and Supplies</b>           | Field Supplies, cargo, iridium phone charges                                 | \$500                               | —                                    |
|                                         | <i>Total Equipment Costs</i>                                                 | <i>\$500</i>                        | —                                    |
| Total Project (without personnel costs) | —                                                                            | \$20,200 – \$31,700                 | —                                    |
| <b>Total Cost (including personnel)</b> | —                                                                            | <b>\$38,312 – \$49,812</b>          | —                                    |

\*Only one of these surveys will be completed in a given year.

## Safety

A primary goal of the ARCN is to ensure the safety of staff and partners while conducting inventory and monitoring activities in parks. Conducting fieldwork in Arctic Alaska with a helicopter during late winter has inherent risks and staff need to be aware and committed to ensuring that all monitoring activities are conducted safely. NPS personnel who participate in the muskox sex-age composition survey must be able to safely work in and near helicopters and be appropriately equipped and dressed to work in cold temperatures. NPS personnel receive training on NPS safety procedures, incident reporting, and emergency response prior to fieldwork. Project level safety information is presented in SOP 2.

Briefly, training for NPS personnel involved in muskox monitoring follows into 2 basic categories: field and safety policy and procedures and aviation. All safety procedures follow national, regional and park specific policies. Field based training includes CPR and basic first aid training as well as park specific training on satellite phone operation, and emergency contact procedures. All aviation based fieldwork in northern Alaska is vetted through the Northern Hub Aviation Manager (NHAM) (<https://sites.google.com/a/nps.gov/northern-aviation-hub/home>). The project PI submits a detailed project aviation safety plan to the NHAM (SOP 2) for approval. The NHAM checks the overall safety of the planned aviation work as well as the training record of those involved. Once the plan is approved, the PI can then file a flight plan and itinerary to the Alaska Region Communication Center (ARCC) (<https://sites.google.com/a/nps.gov/arcc-region/home>). The staff of the ARCC are on call 24 hours a day/7 days a week to answer and respond to radio or satellite phone calls. The ARCC staff flight follows the muskox composition crew while they are in flight and establish a call in schedule for the crew while they are on the ground sexing and aging muskox.

## Standard Operating Procedures

To ensure consistent implementation of this protocol over time, the following Standard Operating Procedures (SOPs) have been identified (**Table 5**). To the greatest extent possible, SOPs are adopted from procedures approved and implemented programmatically through the NPS Inventory and Monitoring program. The approved SOPs are available through the IRMA Data Store. The latest approved versions of operational SOPs are published as part of the annual deliverable schedule for each network <https://irma.nps.gov/>.

**Table 5.** Narrative documents and standard operating procedures for the ARCN muskox sex-age composition monitoring vital sign.

| Subject                                                   | SOP | Citation                                                                                                                                                                                                                                                                                                         | Notes                                                                               |
|-----------------------------------------------------------|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Preparing for muskox sex-age composition survey           | 1   | Schmidt, J.H., H.L. Robison, and S.D. Miller. 2018. Muskox Sex-Age Composition Monitoring Protocol Implementation Plan for the Arctic Network. Standard Operating Procedure (SOP) #1: Preparing for muskox se-age composition survey, Version 1.0. National Park Service, Fort Collins, Colorado.                | Pre-survey tasks to execute survey                                                  |
| Safety                                                    | 2   | Schmidt, J.H., H.L. Robison, and S.D. Miller. 2018. Muskox Sex-Age Composition Monitoring Protocol Implementation Plan for the Arctic Network. Standard Operating Procedure (SOP) #2: Safety Considerations, Version 1.0. National Park Service, Fort Collins, A Colorado.                                       | Required aviation training, planning and safety forms                               |
| Conducting a muskox sex-age composition survey            | 3   | Schmidt, J.H., H.L. Robison, and S.D. Miller. 2018. Muskox Sex-Age Composition Monitoring Protocol Implementation Plan for the Arctic Network. Standard Operating Procedure (SOP) #3: Conducting a muskox sex-age composition survey Version 1.0. National Park Service, Fort Collins, Colorado.                 | Outlines typical process used to gather sex-age composition data from muskox herds. |
| Data management for the muskox sex-age composition survey | 4   | Schmidt, J.H., H.L. Robison, and S.D. Miller. 2018. Muskox Sex-Age Composition Monitoring Protocol Implementation Plan for the Arctic Network. Standard Operating Procedure (SOP) #4: Data Management for the muskox sex-age composition survey, Version 1.0. National Park Service, Fort Collins, A Colorado    | Outlines data handing while in the field and post survey                            |
| Analysis and reporting muskox sex-age composition survey  | 5   | Schmidt, J.H., H.L. Robison, and S.D. Miller. 2018. Muskox Sex-Age Composition Monitoring Protocol Implementation Plan for the Arctic Network. Standard Operating Procedure (SOP) #5: Analysis and reporting of muskox sex-age composition survey, Version 1.0. National Park Service, Fort Collins, A Colorado. | Outlines analysis and reporting of muskox sex-age data                              |
| Revising the Protocol                                     | 6   | Schmidt, J.H., H.L. Robison, and S.D. Miller. 2018. Muskox Sex-Age Composition Monitoring Protocol Implementation Plan for the Arctic Network. Standard Operating Procedure (SOP) #6: Revising the Protocol Implementation Plan and SOPs, Version 1.0. National Park Service, Fort Collins, Colorado.            | Describes the process for revising the protocol                                     |

## References

- Alaska Department of Fish and Game. No date. Muskox: A guide to identification, hunting and viewing. Available from <https://www.adfg.alaska.gov/static/species/speciesinfo/muskox/pdfs/muskoxguide.pdf> (accessed 12 December 2017).
- Alaska Department of Fish and Game. No date. Muskox: Information on identification and hunting. Available from [https://www.adfg.alaska.gov/static/hunting/muskoxhunting/pdfs/muskox\\_information.pdf](https://www.adfg.alaska.gov/static/hunting/muskoxhunting/pdfs/muskox_information.pdf) (accessed 12 December 2017).
- Alaska National Interest Lands Conservation Act (ANILCA). Public Law 96-487. December 2, 1980.
- Chapin F III, S. F. Trainor, P. Cochran, H. Huntington, C. Markon, M. McCammon, A. D. McGuire, and M. Serreze. 2014. Ch. 22: Alaska. *In* J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe (eds.). *Climate change impacts in the United States: The Third National Climate Assessment*, U.S. Global Change Research Program, 514-536. doi:10.7930/J00Z7150.
- Cochran, W. G. 1977. *Sampling techniques*. John Wiley and Sons. New York, New York.
- Czaplewski, R. L., D. M. Crowe, and L. L. McDonald. 1983. Sample sizes and confidence intervals for wildlife population ratios. *Wildlife Society Bulletin* 11:121-128.
- Dunker, W. 2017. 2017 Seward Peninsula muskox population survey summary. Alaska Department of Fish and Game, Division of Wildlife Conservation, Nome, Alaska.
- Frakes, B., S. Kingston, and M. Beer. 2015. Inventory and Monitoring Division database standards: September 11, 2015. Natural Resource Report NPS/NRSS/NRR—2015/1035. National Park Service, Fort Collins, Colorado.
- Gorn, T., and W. R. Dunker. 2013. Unit 22 muskox. Pages 17-51 *in* P. Harper (ed.). *Muskox management report of survey and inventory activities 1 July 2010 - 30 June 2012*. Species Management Report ADF&G/DWC/SMR-2013-2. Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, Alaska.
- Gorn, T., and W. R. Dunker. 2015. Unit 22 muskox. Chapter 2, pages 2-1 through 2-44 *in* P. Harper and L. A. McCarthy (eds.). *Muskox management report of survey and inventory activities 1 July 2012 - 30 June 2014*. Species Management Report ADF&G/DWC/SMR-2015-2. Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, Alaska.
- Grauvogel, C. A. 1984. Muskoxen of northwestern Alaska: Transplant success, dispersal and current status. Pages 57-62 *in* D. R. Klein, R. G. White and S. Keller (eds.). *Proceedings of the First International Muskox Symposium*. Biol Pap. Univ. Alaska Spec. Rep. 4. May 22-25, 1983. University of Alaska, Fairbanks, Alaska.

- Hughes, L. J. 2016. Unit 23 and 26A muskox. Chapter 3 Pages 3-1 through 3-19 *in* P. Harper and L. A. McCarthy (eds.). Muskox management report of survey and inventory activities 1 July 2012 - 30 June 2014. Species Management Report ADF&G/CWC/SMR-2015-2. Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, Alaska.
- KNB. 2017. Ecological Metadata Language (EML). Knowledge Network for Biocomplexity. Available online: <https://knb.ecoinformatics.org/#external/emlparser/docs/index.html>. Retrieved 2017-03-06.
- Lawler, J. P., S. D. Miller, D. M. Sanzone, J. Ver Hoef, and S. B. Young. 2009. Arctic Network vital signs monitoring plan. Natural Resource Report NPS/ARC/NRR—2009/088. National Park Service, Fort Collins, Colorado.
- Lent, P. C. 1999. Muskoxen and their hunters. University of Oklahoma Press, Norman, Oklahoma.
- Machida, S. 1997. Muskox survey-inventory management report. Pages 16-20 *in* M. V. Hicks (ed.). Annual report of survey-inventory activities, muskox. Federal Aid in Wildlife Restoration Progress Report Grant W23-4, W-23-5, Study 16.0. Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, Alaska.
- Miller, S. D. 2017. Product archival, seasonal closeout and dataset certification procedures for the Arctic and Central Alaska Inventory and Monitoring Networks. Standard Operating Procedure. National Park Service Arctic and Central Alaska Inventory and Monitoring Networks. Fort Collins, Colorado.
- NPS. 2002. Endangered Species Management. Reference Manual RM 77-8. National Park Service. Washington, DC.
- NPS. 2005. Director's Order #11A: Information and technology management. National Park Service. Available online: [http://www.nps.gov/policy/DOrders/DO\\_11A.pdf](http://www.nps.gov/policy/DOrders/DO_11A.pdf). Retrieved 2015-08-20.
- NPS. 2005. Director's Order #11B: Ensuring Quality of Information Disseminated by the National Park Service. National Park Service. Available online: <http://www.nps.gov/policy/DOrders/11B-final.htm>. Retrieved 2015-12-08.
- NPS. 2005. NPS REFERENCE MANUAL RM 66B: HANDLING PROTECTED INFORMATION. Unpublished Draft Policy. National Park Service. Washington, DC.
- NPS. 2006. Management Policies 2006. National Park Service. Washington, DC.
- NPS. 2008a. Data management guidelines for inventory and monitoring networks. Natural Resource Report NPS/NRPC/NRR—2008/035. National Park Service, Fort Collins, Colorado.
- NPS. 2008b. Data and information management plan: Arctic Network Inventory and Monitoring Program. Natural Resource Report NPS/ARC/NRR—2008/053. National Park Service, Fort Collins, Colorado.

- NPS. 2012. Director's Order #11D: RECORDS AND ELECTRONIC INFORMATION MANAGEMENT. National Park Service. Available online: [http://www.nps.gov/policy/DOrders/DO\\_11D.pdf](http://www.nps.gov/policy/DOrders/DO_11D.pdf). Retrieved 2015-12-08.
- NPS. Information Quality – Ensuring Objectivity, Utility, and Integrity of Information Used and Disseminated by the National Park Service. Available online: <http://www.nps.gov/policy/DOrders/DO11B--Update.htm>.
- NPS. 2016. Certification Guidelines for Inventory and Monitoring Data Products. National Park Service, Inventory and Monitoring Division. Fort Collins, CO.
- Olesen, C. R., and H. Thing. 1989. Guide to field classification by sex and age of the muskox. Canadian Journal of Zoology 67(5):1116-1119. Available online: <https://doi.org/10.1139/z89-159>.
- Pearson, R. G., S. J. Phillips, M. M. Loranty, P. S. A. Beck, T. Damoulas, S. J. Knight, and S. J. Goetz. 2013. Shifts in Arctic vegetation and associated feedbacks under climate change. Nature Climate Change 3:673–677.
- Schmidt, J. H., T. S. Gorn, and C. Westing 2010. Using distance sampling to estimate muskoxen population abundance on the Seward Peninsula, Alaska. Summary report prepared for Seward Peninsula muskox census participants, April 27, 2010 (unpublished). National Park Service, Fairbanks, and Alaska Department of Fish and Game, Nome and Kotzebue, Alaska.
- Schmidt, J. H. and T. S. Gorn. 2013. Possible secondary population-level effects of selective harvest of adult male muskoxen. PLoS One 8(6):e67493.
- Westing, C. 2011. Unit 23 muskox. Pages 48-62 in P. Harper (ed.). Muskox management report of survey and inventory activities 1 July 2008-30 June 2010. Alaska Department of Fish and Game, Division of Wildlife Conservation, Federal Aid in Wildlife Restoration Project 16.0, Juneau, Alaska.
- Westing, C. 2013. Unit 23 muskox. Pages 52-74 in P. Harper (ed.). Muskox management report of survey and inventory activities 1 July 2010-30 June 2012. Species Management Report ADF&G/DWC/SMR-2013-2. Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, Alaska.

## Appendix A: Field Data Deliverables Schedule

| Identifier | Deliverable                | Format                   | Schedule            | Responsibility* |
|------------|----------------------------|--------------------------|---------------------|-----------------|
| M1         | Survey units with metadata | Shapefile and text file, | As needed           | PI              |
| M2         | Data collection forms      | Paper forms              | Sample date +1 year | PI              |
| M3         | Survey data with metadata  | Shapefile and text file, | Sample date +1 year | PI              |
| M4         | Data collection form scans | Portable document file   | Sample date +1 year | PI              |

\*PI = Principal Investigator

### Deliverable M1: Survey units

**Description:** Polygon shapefile of survey units used for the muskox abundance survey

**Schedule:** As needed

**Responsibility:** PI

**Format:** Shapefile and text file, with metadata

**Specifications:** Deliverable M1 consists of a spatial dataset of polygon survey units, with coordinates in WGS1984 Geographic Coordinate System. File formats include a spatial data layer and a duplicate exported human and machine readable text file format such as comma separated values with spatial data in Well Known Text format, or GeoJSON.

**File naming scheme:** Deliverable M1 filenames will be prefixed by 'M1\_SurveyUnits' followed by any other arbitrary file naming information.

**Example:** M1\_SurveyUnits.shp, M1\_SurveyUnits.csv, M1\_SurveyUnits.xml

**Archival plan:** Each survey season during closeout this deliverable will be archived with all the other deliverables as holdings of a private seasonal deliverables Dataset reference in the IRMA Data Store. This Dataset reference will then be linked as a product of the master muskox monitoring Project reference (<https://irma.nps.gov/App/Reference/Profile/2219896>).

### Deliverable M2: Data collection forms

**Description:** Paper data collection data forms

**Schedule:** Sample date +1 year

**Responsibility:** PI

**Format:** Paper forms

**Specifications:** Ordered and annotated.

**File naming scheme:** N/A

**Archival plan:** Each survey season during closeout deliverable M2 will be archived with the project leader. Photocopies will be archived with the Network data manager and with regional curation.

**Deliverable M3: Survey data**

**Description:** Point spatial data layer of muskox group GPS waypoints and composition attributes.

**Schedule:** Sample date +1 year

**Responsibility:** PI

**Format:** Shapefile and text file, with metadata

**Specifications:** Deliverable M3 consists of a spatial dataset of point survey waypoint observations with associated muskox composition count data. Coordinates must be in WGS1984 Geographic Coordinate System. File formats include a spatial data layer and a duplicate exported human and machine readable text file format such as comma separated values with spatial data in Well Known Text format, or GeoJSON.

**File naming scheme:** Deliverable M3 filenames will be prefixed by 'M3\_SurveyData' followed by any other arbitrary file naming information.

**Example:** 'M3\_SurveyData.shp', 'M3\_SurveyData.csv', 'M3\_SurveyData.xml'

**Archival plan:** Each survey season during closeout this deliverable will be archived with all the other deliverables as holdings of a private seasonal deliverables Dataset reference in the IRMA Data Store. This Dataset reference will then be linked as a product of the master muskox monitoring Project reference (<https://irma.nps.gov/App/Reference/Profile/2219896>).

**Deliverable M4: Data collection form scans**

**Description:** Muskox survey data form scans in pdf or Tag Image File Format files

**Schedule:** Sample date +1 year

**Responsibility:** PI

**Format:** Portable document file

**Specifications:** Deliverable M4 consists of all field data collection forms, ordered and annotated, scanned into a single PDF document and named appropriately.

**File naming scheme:** Deliverable M4 will be a single PDF document. The filename will be prefixed by 'M4\_ScannedDataForms' followed by any other arbitrary file naming information.

**Example:** M4\_ScannedDataForms\_2018MuskoxSurvey.pdf

**Archival plan:** Each survey season during closeout this deliverable will be archived with all the other deliverables as holdings of a private seasonal deliverables Dataset reference in the IRMA Data Store. This Dataset reference will then be linked as a product of the master muskox monitoring Project reference (<https://irma.nps.gov/App/Reference/Profile/2219896>)



The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 953/149279, November 2018

**National Park Service**  
**U.S. Department of the Interior**



---

**[Natural Resource Stewardship and Science](#)**

1201 Oakridge Drive, Suite 150  
Fort Collins, CO 80525