HIGH ARCTIC WOLF ECOLOGY
FIELD REPORT, SUMMER 2016

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Summary
Since summer 2014, 2-5 wolf packs have been tracked on Ellesmere Island's Fosheim Peninsula and eastern Axel Heiberg Island. This report provides an update on the 2016 field season and wolf movements and activities from fall 2015 until fall 2016. Collars were active on the eastern Axel Heiberg Island pack (W445, since July 2015), the Eureka pack (W444, since July 2015), and Hot Weather Creek pack (W443, since September 2014). Both W443 and W444 visited Axel Heiberg Island from their territories on the Fosheim Peninsula, and both W443 and W444 visited Axel Heiberg Island from their territories on the Fosheim Peninsula, and W444 made increasingly long and frequent visits, including to the Axel pack's den site. When we checked dens in May 2016, he was resting at the Axel den and appears to be the breeding male of that pack. Meanwhile, W445 had been making long off-territory movements to Stor Island and Strand Fiord as well as north and south along the eastern slopes of Axel Heiberg Island and the Schei Peninsula. In early May she crossed to Ellesmere Island's Raanes Peninsula and continued south, covering more than 1600 km to reach Dundas Harbor on southern Devon Island, where she remained until her collar dropped in early July.

Six active den sites were recorded this year: one on Axel Heiberg, one south of Slidre Fiord (Eureka pack) with another nearby (likely a second Eureka breeding female), one at Mount Lockwood, one east of Remus Creek, and one at Hot Weather Creek. The Hot Weather Creek den was attended by W443 and his mate in early June, but three wolves from another pack approached the den and killed the pups. The Eureka pack appears to have had 3 active dens – updated pack ad pup counts when the pack passes by the weather station in fall-winter 2016-17 will provide more insight regarding pack dynamics.

In total, since 2014 we have investigated 285 cluster sites and identified 44 muskox carcasses (kills or probable kills) and 1 seal, likely scavenged. This year accounted for 203 of those cluster visits. We found 34 muskox kills (one was likely a scavenge, 2 were unknown scavenge or kill, and three were observed kills rather than from clusters) and one seal carcass (likely scavenged), 6 dens, and 4 confirmed rendezvous sites. No caribou carcasses have been found recently during cluster searches, although we have found them incidentally and on searches in 2010, suggesting that they will be conspicuous if present.

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ᑕᐃᒪᙱᑦ ᐊᐅᔭᖓᓂᑦ 2014, ᒪᕐᕈᒡᓗ ᑖᓪᓕᒪᓪᓗ ᐊᑯᓂᖏᓐᓃᑐᓂᒃ ᐊᒪᖅᑯᓂᒃ ᖃᐅᔨᒪᔭᐅᔪᖃᐃᓐᓇᓚᐅᕐᒪᑦ ᑕᐅᕙᓂ ᐊᐅᓯᐃᑦᑑᑉ ᕿᑭᖅᑖᓗᐊᓐᑐᓂᒃ Fosheim ᓄᕗᐊᕐᔪᖏ ᐊᒻᒪᓗ ᑲᓇᖕᓇᖅᐸᓯᐊᓂ ᓇᐹᖅᑐᓕᐅᑉ ᕿᑭᖅᑕᐅᑉ. ᑖᕙᓂ ᐅᓂᒃᑳᓂ ᖃᐅᔨᑎᑦᑎᖕᒪᑕ ᒫᓐᓇᓕᓴᐅᓚᑎᒍᑦ 2016-ᒥ ᓯᓚᒥᑦᑎᐊᕐᓇᖅᑎᓪᓗᒍ ᐊᒻᒪᓗ ᐊᒪᖅᑯᑦ ᓇᒧᙱᐅᕙᓪᓕᐊᓂᖏᑦ ᐊᒪᓗ ᖃᓄᐃᓕᐅᖅᐸᓪᓕᐊᓂᖏᑦ ᐅᑭᐊᒃᓵᖓᓂᑦ 2015 ᑕᐃᑯᖓ ᐅᑭᐊᒃᓵᖅ 2016-ᒧᑦ. ᖁᖓᓯᕈᖏᑦᑎᒍᑦ ᓇᓗᓇᓚᐅᖏᑦᑐᑦ ᑕᐅᕙᓂ ᑲᓇᖕᓇᖅᐸᓯᐊᓂ ᐊᐅᓯᐃᑦᑑᑉ ᕿᑭᖅᑖᓗᐊᓂ ᐊᒪᕈᖃᑎᓖᑦ (W445, ᑕᐃᒪᙱᓂᑦ ᔪᓚᐃ 2015), ᔫᓇᑲᐅᓪᓕ ᐊᒪᖅᑯᖏᑦ (W444, ᑕᐃᒪᙱᓂᑦ ᔪᓚᐃ 2015), ᐊᒻᒪᓗ Hot Weather Creek ᐊᒪᖅᑯᖏᑦ (W443, ᑕᐃᒪᙱᑦ ᓯᑎᐱᕆ 2014). ᑖᒃᑯᐊᒃ ᑕᒪᕐᒥᒃ W443 ᐊᒻᒪᓗ W444 ᑕᐃᑯᙱᓚᐅᖅᑐᑦ ᐊᐅᓯᐃᑦᑑᑉ ᕿᑭᖅᑖᓗᐊᓄᑦ ᑕᐅᕙᙱᑦ ᓄᓇᒋᓯᒪᔭᒥᓂᑦ ᑕᐅᕙᓂ Fosheim Peninsula, ᐊᒻᒪᓗ W444-ᖑᔪᑦ ᑕᐅᕗᖓᐅᑯᑖᒃᐸᖕᓂᖅᑰᑎᒃ ᐅᐸᒍᑎᕙᒃᑰᑎᒃ, ᐱᖃᓯᐅᑎᓪᓗᒋᑦ ᓇᐹᖅᑐᓕᐅᑉ ᐊᒪᖅᑯᖏᑦᑕ ᑎᓯᖏᓐᓄᑦ. ᖃᐅᔨᓴᕋᑎᒍ ᑎᓯᖏᑦ ᒪᐃ 2016-ᒥ, ᑕᐃᑲᓃᓚᐅᖅᑐᖅ ᓇᐹᖅᑐᓕᐅᑉ ᐊᒪᖅᑯᖏᑦᑕ ᑎᓯᖏᓐᓂ ᐊᒻᒪᓗ ᓄᓕᐊᖅᑎᐅᔪᖅ ᓇᒍᑕᐅᓪᓗᓂ ᓇᓗᓇᕋᓂ ᑖᑯᓇᓂ ᐊᒧᕈᖃᓐᑎᖏᓐᓂ. ᐊᒪᐃᓛᒃ, W445-ᖑᔪᖅ ᑕᐅᕗᙱᐅᑯᑖᒃᐸᖕᓂᖅᑰᓂ Stor ᕿᑭᖅᑕᕐᒧᑦ ᐊᒻᒪᓗ Strand Fiord-ᒧᑦ ᐊᒻᒪ ᐅᐊᖕᓇᖓᓂ ᓂᒋᐊᓂᓗ ᓯᕙᖓᓂᐊᒍᑦ ᓇᐹᖅᑐᓕᐅᑉ ᕿᑭᖅᑕᐅᑉ ᐊᒻᒪᓗ ᑕᐅᕘᓇ Schei Peninsula-ᑯᑦ. ᒪᐃ ᐱᒋᐊᓕᓵᖅᑎᓪᓪᓗᒍ ᐊᕐᓇᐅᔪᖅ ᑕᐃᓐᓇ ᐊᐅᓯᐃᑑᑉ ᕿᑭᖅᑖᓗᐊᓄᖓᐅᓂᖅᑰᓂ Raanes Peninsula-ᑯᑦ ᐊᒻᒪᓗ ᑲᔪᓯᓐᓂᖅᑰᓂ ᓂᒋᕐᒧᑦ, 1600 ᑭᓛᒥᑐᓂᒃ ᐅᖓᓯᒃᑎᒋᔪᒥᒃ ᑎᑭᑰᓂ ᑖᓪᓗᕈᑎᓄᑦ ᓂᒋᐊᓂ ᑖᓪᓗᕈᑎᐅᑉ, ᑕᐃᑲᓃᖏᓐᓇᖅᑎᓪᓗᒍ ᖁᖓᓯᕈᑎᓂ ᑲᑕᐃᓐᓂᖅᐸ ᔪᓚᐃ ᐱᒋᐊᓕᓵᖅᑎᓪ ᓗᒍ. .

6-ᖑᔪᓂᒃ ᑎᓯᓂᒃ ᑎᑎᕋᖅᓯᓯᒪᔪᑦ ᑕᒪᑐᒪᓂ ᐊᕐᕋᒎᔪᒥ: ᐊᑕᐅᓯᖅ ᓇᐹᖅᑐᓕᖏ, ᐊᑕᐅᓯᖅ ᓂᒋᐊᓂ Slidre Fiord (ᔫᓇᑲᐅᑉ ᐊᒪᖅᑯᖏᑦ) ᐊᓯᐊᓂᒃ ᖃᓂᒋᔮᓃᑐᕐᑲᖅᑰᓂ (ᐃᒻᒪᖅᑲ ᑐᒡᓕᖏᑦ ᔫᓇᑲᒥ ᐃᕐᓂᐅᖅᑐᖅ ᐊᕐᓇᐅᓪᓗᓂ), ᐊᑕᐅᓯᖅ ᑕᐃᑲᓂ Mount Lockwood, ᐊᑕᐅᓯᖅ ᑲᓇᖕᓇᖅᐸᓯᐊᓂ Remus Creek, ᐊᒻᒪᓗ ᐊᑕᐅᓯᖅ ᑕᐃᑲᓂ Hot Weather Creek-ᒥ. ᑕᐃᓐᓇ Hot Weather Creek-ᒥ ᑎᓯᐅᔪᖅ ᐅᐸᒃᑕᐅᓯᒪᓐᓂᖅᑰᓂ W443-ᒧᑦ ᐊᒻᒪ ᐱᖃᑎᒌᔭᑕ ᔫᓂᖑᔮᖅᑎᓪᓗᒍ, ᑭᓯᐊᓂ ᐱᖓᓰᔪᓂᑦ ᐊᒪᖅᑯᓂᑦ ᐊᓯᖏᓂᖔᖅᑐᓂᑦ ᐅᐸᒃᑕᐅᓐᓂᕐᒪᑕ ᐊᒪᕈᐊᕋᖏᑦ ᑐᕐᑯᓴᖅᑕᐅᓐᓂᖅᑰᑎᒃ. ᔫᓇᑲᒥ ᐊᒪᕈᖃᑎᓖᑦ ᐱᖓᓯᐃᓂᒃ ᑎᓯᖃᐅᖅᑐᑦ ᐊᑐᖅᓯᒪᓵᖅᓯᒪᔪᓂᒃ – ᒫᓇᓕᓴᑦ ᐊᒪᖅᑯᑦ ᓇᓗᓇᐃᖅᑕᐅᑎᓪᓗᒋᑦ ᕿᑐᙵᖓᓂᑦ ᓇᐃᓴᐃᖃᓯᐅᔭᐅᔪᖃᖅᑐᖅ ᑕᑯᔭᐅᓂᕐᒪᑕ ᓴᓂᖅᑯᑦᑐᑦ ᓯᓚᓕᓇᕝᕕᐅᑉ ᓯᓚᑖᒍᑦ ᐅᑭᐊᒃᓵᖅ-ᐅᑭᐅᖅ 2016-17-ᒧᑦ ᐅᖃᐅᓯᓇᒃᑲᓐᓂᓚᖅᑕᕗᑦ ᖃᐅᔾᔭᒃᑲᓐᓂᕈᑎᒍ ᐊᒪᕈᖃᑎᓖᑦ ᖃᓄᐃᓕᖓᓂᖏᑦ.

ᑲᑎᕝᒍᒋᑦ, ᑕᐃᒪᙱᓂᑦ 2014-ᒥᑦ ᖃᐅᔨᓴᖅᓯᓯᒪᓕᖅᑐᒍᑦ 285 ᑲᑎᖓᖏᑦᑐᓂᒃ ᐃᓂᐅᓯᒪᔪᓂᒃ ᐊᒻᒪᓗ ᓇᓗᓇᐃᖅᓯᓯᒪᓪᓗᑕ 44-ᓂᒃ ᐅᒥᖕᒪᕕᓂᕐᓂᒃ ᑐᑯᔪᕕᓂᓇᓂᒃ (ᑐᑯᑕᐅᓂᑯᑦ ᐅᕝᕙᓘ ᐊᒪᖅᑯᓂᖅᑲᐃ) ᐊᒻᒪ ᐊᑕᐅᓯᖅ ᓇᑎᕕᓂᖅ ᓇᓂᔭᐅᓂᑯᔪᒃᓴᐅᔪᖅ. ᑕᒪᑐᒪᓂ ᐊᕐᕋᒎᔪᒥ ᖃᐅᔨᓯᒪᔭᕗᑦ 203 ᖃᖓᒃᑰᖅᑕᖅᑰᑎᒃ ᓇᕈᓇᖃᑦᑕᖅᑐᕝᕕᓃᑦ. ᓇᓂᓯᓪᓗᑕᓗ 34-ᓂᒃ ᐅᒥᖕᒪᕕᓂᕐᓂᒃ ᑐᑯᑕᐅᓯᒪᔪᓂᒃ (ᐊᑕᐅᓯᖅ ᓇᓂᔭᐅᓂᑯ, ᒪᕐᕉᒃ ᓇᓗᓇᖅᑰᑎᒃ ᓇᓂᔭᐅᓂᑰᓇᓯᒋᓪᓗᑎᒍ ᐅᕝᕙᓗᑭᐊᖅ ᐊᒪᖅᑯᓂᑦ ᐱᔭᓇᔭᐅᓂᑯᑦ, ᐊᒻᒪ ᐱᖓᓱᑦ ᖃᐅᔨᓴᖅᑎᓪᓗᑕ ᑐᑯᑕᐅᔪᑦ ᐊᕝᕕᒃᑐᖅᓯᒪᔪᓂᐅᖏᓐᓂᖅᓴᐅᔪᒃᓴᐅᔪᖅ) ᐊᒻᒪ ᐊᑕᐅᓯᖅ ᓇᑎᕕᓂᖅ (ᓯᓗᕕᓂᐅᔪᒃᓴᐅᔪᖅ), 6 ᑎᓰᑦ, ᐊᒻᒪ 4 ᓇᓗᓇᐃᖅᑕᐅᓯᒪᓪᓗᑎᒃ ᓄᓕᐊᕐᕕᐅᖃᑦᑕᕐᓂᖏᓐᓄᑦ. ᑐᒃᑐᕕᓂᕐᓂᒃ ᓇᓂᓯᔪᖃᓚᐅᙱᑦᑐᖅ ᖃᖓᑦᑎᐊᓗᒃ ᕿᓂᖃᑕᒃᑎᓪᓗᒋᑦ ᓇᓂᑕᕐᓂᐅᔪᓂᒃ, ᑭᓯᐊᓂ ᓇᓂᓯᖃᑦᑕᖅᓯᒪᓂᑰᔪᒧᑦ 2010-ᒥ, ᓇᓗᓇᐃᕈᑎᒋᓪᓗᓂᐅᒃ ᑕᑯᒃᓴᐅᓇᔭᕐᓂᖏᓐᓄᑦ ᐱᑕᖃᕐᓂᕈᑎᒃ.

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Introduction

Arctic wolves (*Canis lupus arctos*), a subspecies of grey wolf inhabiting the Canadian Arctic Archipelago, were classified in 1999 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Data Deficient due to insufficient information on populations, trends, and diet (Van Zyll de Jong and Carbyn 1999). To attempt to fill knowledge gaps for Arctic wolves and for the prey populations they depend on, we initiated a satellite telemetry study in 2014 on the Fosheim Peninsula and eastern Axel Heiberg Island. The accessibility of the area from the Eureka Weather Station makes it logistically feasible to ground-truth collar data, and the long history of the Eureka pack with humans at the weather station means they are easily approachable and can be observed from close range. It also makes them very attractive to film crews, who co-operate with researchers to provide additional behavioural observations and biological samples when they are filming in the area.

Over the last 3 years, we have deployed 8 satellite GPS collars on wolves in 6 packs. Movement patterns and home range use are consistent with a population that occupies discrete territories year-round, in contrast to tundra wolves farther south which follow migratory caribou herds. Wolf densities in the study area are on par with parts of the boreal forest and Rocky Mountains, at around 7 wolves/1000 km^2 (Anderson et al. 2016). Muskoxen and arctic hare are abundant; Peary caribou use the area but currently appear to be at low densities, despite large numbers being observed on eastern Axel Heiberg Island during spring 2007 surveys (Jenkins et al. 2011). Genetic signatures, movements of currently collared wolves, and the movements of the Eureka pack breeding male in 2009 confirm the interisland nature of the wolf population around Eureka Sound (Mech and Cluff 2011, Anderson et al. 2016).

The 2016 field season included den checks and cluster investigations in early June, followed by den checks, cluster investigations, and collar deployment in early July 2016. One film crew (Gulo Films, Hamberg, Germany, 4 people) visited the study site in April and returned from early June until July 30. They were positioned at the Hot Weather Creek den until the pups there were attacked and killed by another pack. They checked several of the cluster sites and previous den locations by ATV in an attempt to find a new filming location, before eventually moving to a second active den which they located during a July 9 helicopter flight. A second film crew (John Downer Productions, Bristol, England, 4 people) was stationed at the Eureka pack den when it was located on July 4, and remained there until July 27. Both crews were in regular communication with the researchers and were able to collect observations and samples.

Study Area

The study area is located on central Ellesmere Island’s Fosheim Peninsula and nearby areas of Axel Heiberg Island (Figure 1, 2). Although two dens south of the Sawtooth Mountains are known, no collars have been deployed south of the Sawtooths and the dens are not monitored there on an annual basis.

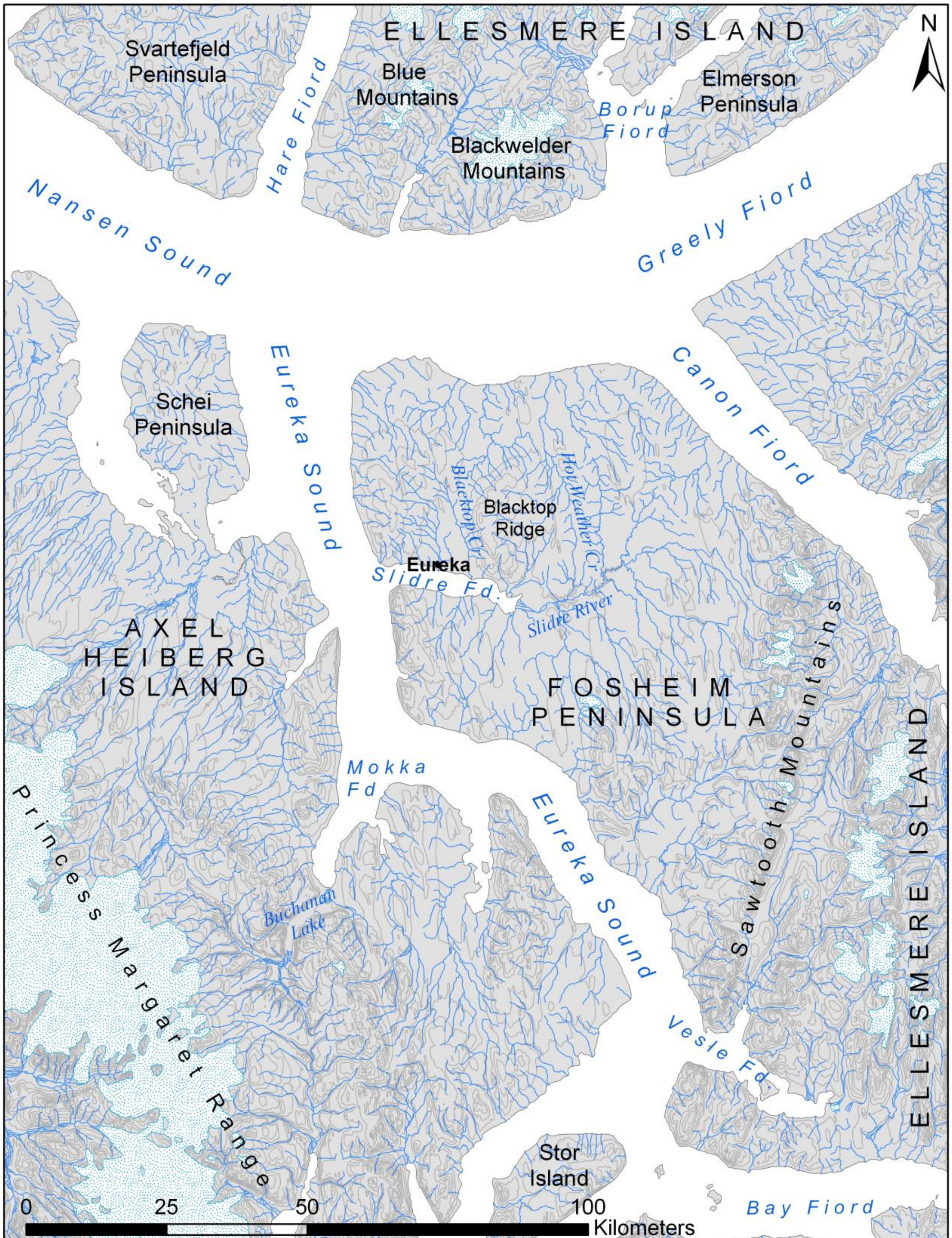


Figure 1. Major landmarks of the Fosheim Peninsula and Axel Heiberg Island study area.

Figure 2. Major landmarks of the Canadian Arctic Archipelago surrounding the study area.

Den Status
Thirteen dens or potential dens had been previously recorded by researchers and weather station staff. Four of those locations did not have a clear den entrance found despite repeated visits, so they were not checked this season. The Bay Fiord and Vesle Fiord dens, being the farthest away from Eureka, were not checked due to time constraints on aircraft. A total of 16 confirmed wolf dens are now known in the area. Several additional sites encountered opportunistically or during cluster searches were also checked in June and July 2016, including 6 fox dens, bringing the total known den sites and potential den sites to 30. This is a useful dataset for locating wolves when packs are not collared, to deploy new collars, count the pack, determine how many pups were produced, collect samples, or record behaviour. In total, 6 of the known dens were active in June/July 2016 (Figure 3).

Mount Lockwood
The only known den for this pack had one wolf present and some excavation when it was checked Jun 3, 4, and 8. In late June, there was one wolf and one pup seen at the den, and again on July 6, the breeding female and one pup were seen. The breeding male was the only wolf visible at the den on July 10. Several wolves (2 adults and 2 yearlings, one single, and a pair) were seen north of Blacktop Ridge and north of the Lockwood den on June 27 and 29, but it is not clear whether these wolves were associated with the Lockwood den or part of the Cañon Fiord pack. Although the Cañon Fiord pack was not located this year, the movement patterns of neighbouring W447 (Mt Lockwood) and W443 (Hot Weather Creek) suggest that there is still a defended territory along Cañon Fiord.

Hot Weather Creek
The Hot Weather Creek den was attended by a breeding female and W443, with 5 pups. On June 10, the pack howled and was answered by several distant wolves, but when the three new wolves approached (apparently a breeding female, very large breeding male, and another adult), it was clear they were not from the same pack. W443 left, and when the breeding Hot Weather Creek female failed to draw the new wolves away from the den area, she followed his retreat. The three adults, including a breeding female, approached the den, and the breeding female reached in, killed the pups with bites to the head and neck, and removed them from the den. Three pups were cached nearby and two were eaten before the attackers left. The Hot Weather Creek breeding female returned shortly after, ate one of the cached pups, and left.

Axel Heiberg Island
Only the den located in 2014 appeared to be occupied, of 3 dens known for this pack. We made 2 passes of the southern den by helicopter, on July 3 and July 9, but there was no evidence of recent activity (tracks, excavations, hair). A 2-person crew observed the active northern den from July 3-4 and confirmed W444 (who dispersed from the Eureka pack and appears to be the breeding male on Axel) with 5 other adults and 6 pups. We located a third potential den site in a broken cliff overlooking sedge meadows, south of the other two confirmed dens.

Eureka
The Eureka pack moved from their 2015 den site to an area used as a rendezvous site in summer 2015. At this den, we observed 5 adults and 3 pups. They had a second den 4 km north where the pack resettled in July. However, an additional den was also located 13 km north of this den, with one female, one male, and one male pup.W447 visited this den, socializing with the adult wolves and entering the den. Another den east of the Eureka den and north of the Slidre River was attended by 2 females, one male, and 7 pups. One female led the 4 larger pups away from the den and was not seen again, while the other females remained at the den with the other 3 smaller pups. The relationship between this den and the Eureka dens is less clear. Although W447 did visit the den based on the locations recorded by her satellite collar, no ground crew was present to determine the nature of the visit. Her movements were consistent with a wolf visiting the den, travelling to a kill site, and returningto provision the pups, but the kill site was not verified either. The Hot Weather Creek den was also at the northeastern edge of the Eureka pack territory, so it is possible that the Eureka wolves were responsible for destroying that litter, although this area was also along the southwest edge of the Cañon Fiord pack territory. On another occasion, Eureka wolves brought a dead pup from another location to the den site.

Pack and Litter Size

A film crew at the Eureka pack den was able to confirm 3 pups there, with another pup at another Eureka den. There were also another 7 pups at a nearby den, apparently with 2 breeding females. The limited field time reduced the number of incidental sightings of other packs and prevented searching for previously collared packs to update pack size. Table 1 summarizes the packs and pup counts from the summer, compared to 2014 and 2015.

Table 1. Pack and litter sizes for wolf packs monitored at dens from 2014-2016. The den north of Slidre Fiord was included as a Eureka den, although the pack affiliation has not been confirmed.

Pack/Area; Collared Wolf	2014 Adults (Pups)	2015 Adults (Pups)	2016 Adults (Pups)	Comments
Eureka; W444, W447	15-16	13 (3)	5 (3) 3 (7) 2 (1)	Up to 2 additional dens, one with a litter of 7 pups likely from 2 females, and another den within the territory visited by W447 but not directly observed to determine the nature of the visit.
Gibbs Fiord (Axel Heiberg); W440, W445, W444	7 (9)	9 (unk)	6 (6)	Only north den appears to be occupied.
Vesle Fiord; uncollared	3 (3)	5 (unk)	Unk (unk)	Den was not checked in 2016.
Hot Weather Creek; W443	2 (0)	Unk (0)	2 (5)	3 other wolves killed the pups and the adults left the area.
Cañon Fiord; W441	6 (3)	Unk (unk)	Unk (unk)	Pack wasn't located in 2016, but several observations north of Blacktop Ridge of 1-4 wolves suggest that the territory is still occupied.
Mount Lockwood; W446	5 (3)	Unk (unk)	2 (1)	Wolf observations north of Blacktop Ridge could be associated with Lockwood pack, but more than 2 wolves never seen at the den.
Bay Fiord; uncollared	2 (3)	Unk (unk)	Unk (unk)	Den was not checked in 2016.
Wolf Valley; W442	4 (4)	Unk (unk)	Unk (unk)	Den not located in 2014 or 2015, located in 2016 with fresh digging but no activity.

Although only one active den was found on Axel, that pack could have another litter that we are unaware of, as we only determined a second litter was present in 2014 when we counted them at a rendezvous site in late summer. The scattered dens on the Eureka territory attended by single wolves suggest that they may be additional Eureka dens, and observations from weather station staff over winter 2016-17 will provide us with updated pack and pup counts.

Collar Deployment

We used a Pneu-Dart rifle with brown .22 blank charges and barbed 3-cc dart fired from the shooting window of a Bell 206 helicopter. Although net-gunning is the preferred method, charges and a Y-pole were not were not available this season. Immobilization was with Telazol (7 mg/mL at 15 mg/kg). Once immobilized, wolves were measured, sampled, and fitted with Vectronic Vertex Iridium satellite collars, programmed for 1-hour fixes and a drop-off in summer 2018. Collared wolves are summarized in

Table **2**.

Table 2.GPS-collared wolf update for fall 2015, High Arctic wolf ecology project.

Wolf ID	Collar ID	Pack	Collar Duration	Sex	Age	Capture Latitude	Capture Longitude	Weight (kg)
W447	(Vectronic); 1-hr fixes	Eureka	06-Jul-16 to present	F	2 yr	79.822	-85.272	32 est.
W446	(Vectronic); 1-hr fixes	Mount Lockwood	06-Jul-16 to present	F	Adult	80.217	-86.163	27 est.
W444	18851 (Vectronic); 2-hr fixes	Eureka; dispersed to Axel	03-Jun-15 to present	M	Adult	79.991	-85.772	38.0
W445	18850 (Vectronic); 1-hr fixes	Axel Heiberg – Gibbs Fiord; dispersed	05-Jun-15 to 01-Jul-16; presume dropped	F	Adult	79.744	-87.858	32.0
W443	36137 (Lotek); 1-hr fixes	Hot Weather Creek	06-Sep-14 to present	M	Adult	80.12227	-84.5502	35.0
W442	36135 (Lotek); 1-hr fixes	Wolf Valley	06-Sep-14 to 28-Sep-14 (23 days); collar dropped	F	Adult	79.95317	-84.6779	27.0
W441	36136 (Lotek); 1-hr fixes	Canon Fiord	30-Jun-14 to 10-Dec-14 (164 days); collar dropped	F	2 yr	80.17695	-83.5726	29.5
W440	36134 (Lotek); 1-hr fixes	Axel Heiberg – Gibbs Fiord	15-Jul-14 to 03-Aug-15 (384 days); presume dropped	M	2 yr	79.89303	-88.3022	34.5
W410	Telonics GPS/Argos; 12-hr fixes	Eureka	09-Jul-09 to 12-Apr-10 (278 days); wolf died	M	Est. 9 yrs	Eureka		41.0

Dispersal and Long-distance Movements

Two of the collared wolves dispersed in spring 2016. W444, a Eureka male, made several forays to Axel Heiberg Island in February, March, and April 2016, and eventually settled there. His attendance and behaviour at the den suggests that he is the new breeding male of that pack.

On May 3, W445 was on the southeast coast of Axel Heiberg Island, after several forays out of the main pack territory, including to Stor Island (April 21-22) and Strand Fiord (Mar 15-17). On May 8 between 13:00-14:00, she crossed to Stor Island, crossed the island in 2 hours, and crossed to the Raanes Peninsula in another 2 hours. By May 9 15:00 she was at the south tip of the Raanes Peninsula and headed east to the Svendsen Peninsula. She crossed Vendom Fiord on May 11 at 19:00 and went southeast, crossing Makinson Inlet May 12 13:00-15:00, and skirting south along the ice caps. She arrived at the south coast of Ellesmere Island at Fram Fiord on May 14 at 17:00. She continued south across the sea ice to Smith Island at 23:00, but returned to Ellesmere Island at King Edward Point shortly thereafter. She continued northeast to the Stewart Islands off the east coast of Ellesmere Island (May 17 15:00) and Coburg Island (May 17 20:00). She nearly circumnavigated Coburg Island and returned to Ellesmere on May 19 17:00. She then headed west, crossing an ice cap May 20 01:00 and more or less following the southern shore of Ellesmere Island past Grise Fiord (where she was behind the airport May 23 17:00-22:00). W445's movement past the hamlet of Grise Fiord was not noticed by any residents, but it also coincided with the fishing derby weekend when people were at the fishing lakes at Truelove Lowlands on Devon Island (Iviq Hunters and Trappers Association, pers. comm.). She arrived at the west coast of Ellesmere Island, at Hell Gate (a polynya between Ellesmere, Nort Kent, and Devon islands) on May 28, turned north briefly then doubled back south and retraced her path east to Cape Storm on May 31 04:00. Here, she crossed Jones Sound to Truelove Inlet, Devon Island, on May 31 16:00. She continued south across Devon Island to Burnell Inlet, arriving on the south coast of Devon Island on June 3 and continuing east to Croker Bay, where she arrived on June 5. She stayed on the west side of the inlet, moving north and south, before crossing on June 9, and spent the next day between Croker Bay and Dundas Harbour. She continued east on June 10 until she turned back at a glacier that extended from the Devon Ice Cap to Lancaster Sound. She returned to Dundas Harbor and continued north along Croker Bay, crossing on June 13 to the west shore. On June 14 she crossed east again and continued to the glacier, which she crossed June 16. She returned on June 18 to the Croker Bay/Dundas Harbour area, where she remained until her collar became stationary July 1. This was the scheduled drop-off time, but since we were not able to retrieve the collar this season, it's also possible that W445 died while still wearing the collar. Collar retrieval will be attempted in summer 2017.

The areas where W445 doubled back, at Coburg Island and Hell Gate, are open water year-round. Lancaster Sound, south of Devon Island, is also open, limiting her movements the south coast of Devon Island. However, there are also high densities of muskoxen on Devon Island, including at Croker Bay and Dundas Harbour, which could have been an attractive resource (Anderson 2016). Figure 4 shows W445's path and hourly locations.

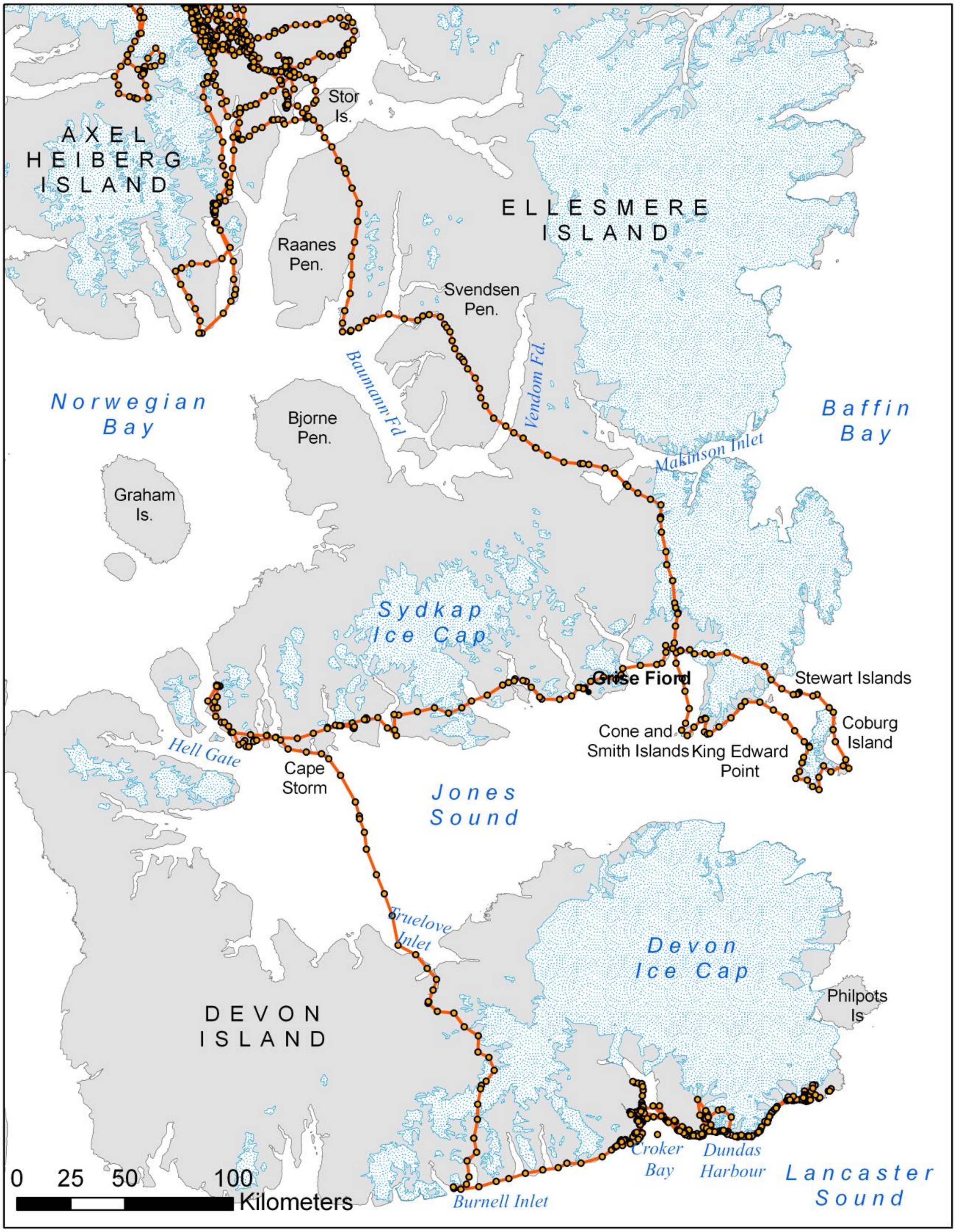


Figure 3. Route taken by W445 during dispersal from Axel Heiberg Island to southern Devon Island, May-June 2016.

Home Range
We calculated minimum convex polygon (MCP) home ranges using the R user interface 'rhr' (Signer and Balkenhol 2015), which relies on several R packages, for reproducibility of home range estimators. MCPs are a simple, intuitive way to represent and compare home ranges. They are particularly useful for comparing to historic home ranges, calculated before quantity and quality of data allowed the development of other home range estimators. However, MCPs do not provide any indication of intensity of use within a home range. MCP home ranges are shown in Figures 5 and 6. The north-south orientation is partly due to several forays south of the territories, for example, W444 travelled to the south tip of Axel Heiberg Island and returned. In the case of Axel Heiberg Island, most movement is constrained north-south between the ice sheets and Eureka Sound. The consistent north-south orientation could also partly be an artefact of the MCP calculation.

To assess within-territory space use, we calculated Brownian bridge movement model (BBMM) home ranges using the R package 'adehabitat' (Calenge 2006) in R (R Core Development Team 2013). Unlike kernel methods, which calculate a utilization distribution based on locations only, BBMMs assume a Brownian motion random walk between successive locations, with the probable path influenced by the time elapsed and the distance between successive points (Bullard 1999, Horne et al. 2007, Kie et al. 2010). The greatest positional uncertainty is halfway between known location points. The method works best with short intervals between successive locations, like the 1-hour fix interval used on these collars, and since it takes the time between points into consideration, autocorrelation is not an issue (unlike in kernel methods, which assume locations are independent). They also avoid problems associated with large datasets, which are becoming increasingly common in telemetry studies (Hemson et al. 2005, Kie et al. 2010). BBMM home ranges are sensitive to 2 smoothing parameters, one based on the GPS positional accuracy (taken here conservatively as 30 m, Loveless 2010, although retrieval of dropped collars will give us a better estimate for our system) and one based on the distribution of locations (i.e. the animal's behaviour and movement) and estimated here with the liker function in adehabitat. BBMM home ranges are shown in Figures 7 and 8.

[Note: adehabitat is not supported in newer versions of R and the package adehabitatHR now provides the home range functionality.]

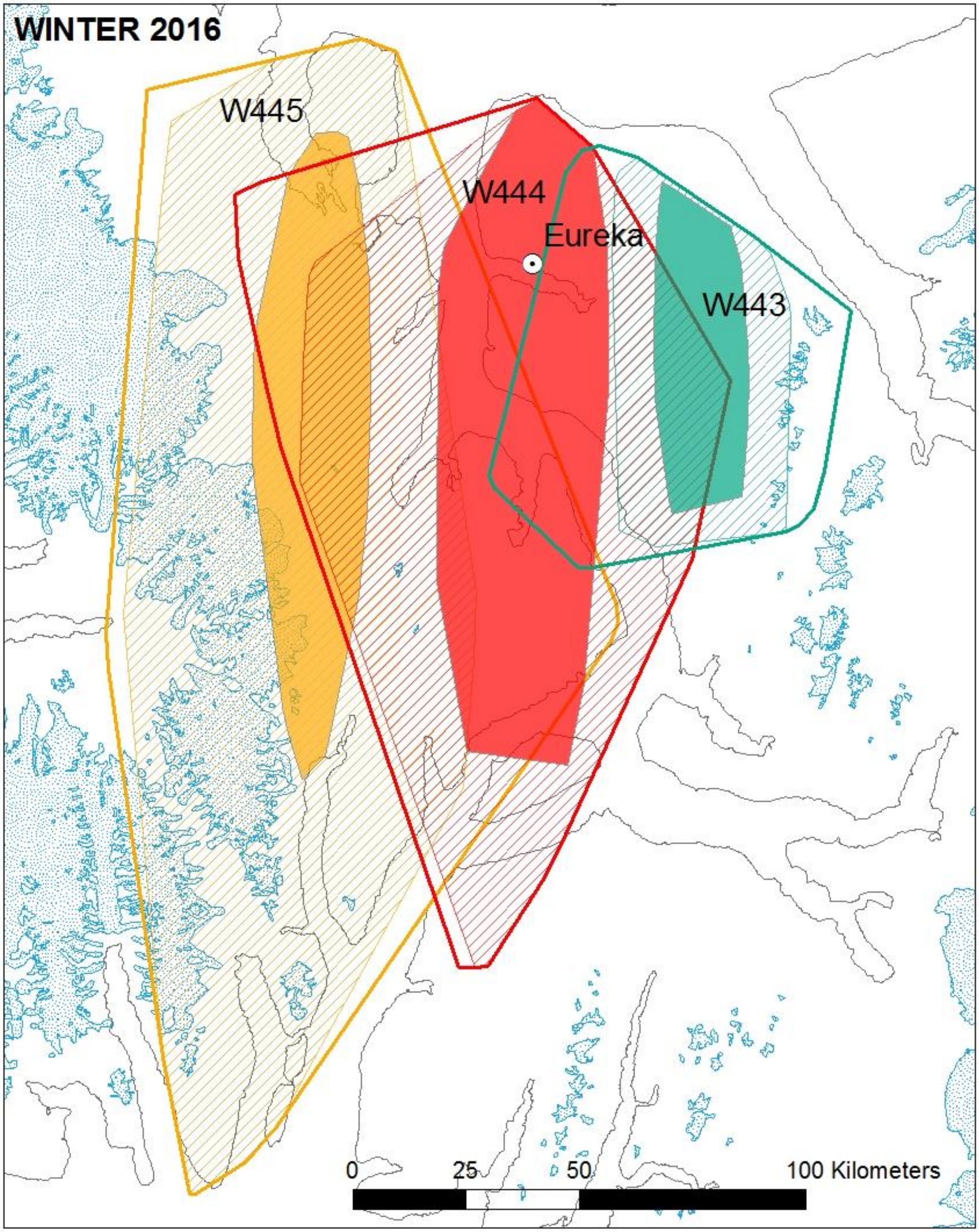


Figure 4. Home ranges for collared wolves in winter (Oct 1, 2015-May 31, 2016). Since W445 dispersed, the locations for her winter home range were Oct 1 – May 2, prior to her Stor Island crossing and continued movement south. Hollow outlines are 100% minimum convex polygons (MCPs), hatched areas are 95% MCPs, and solid areas are 50% MCPs. Stippled blue areas are glaciers and icefields.

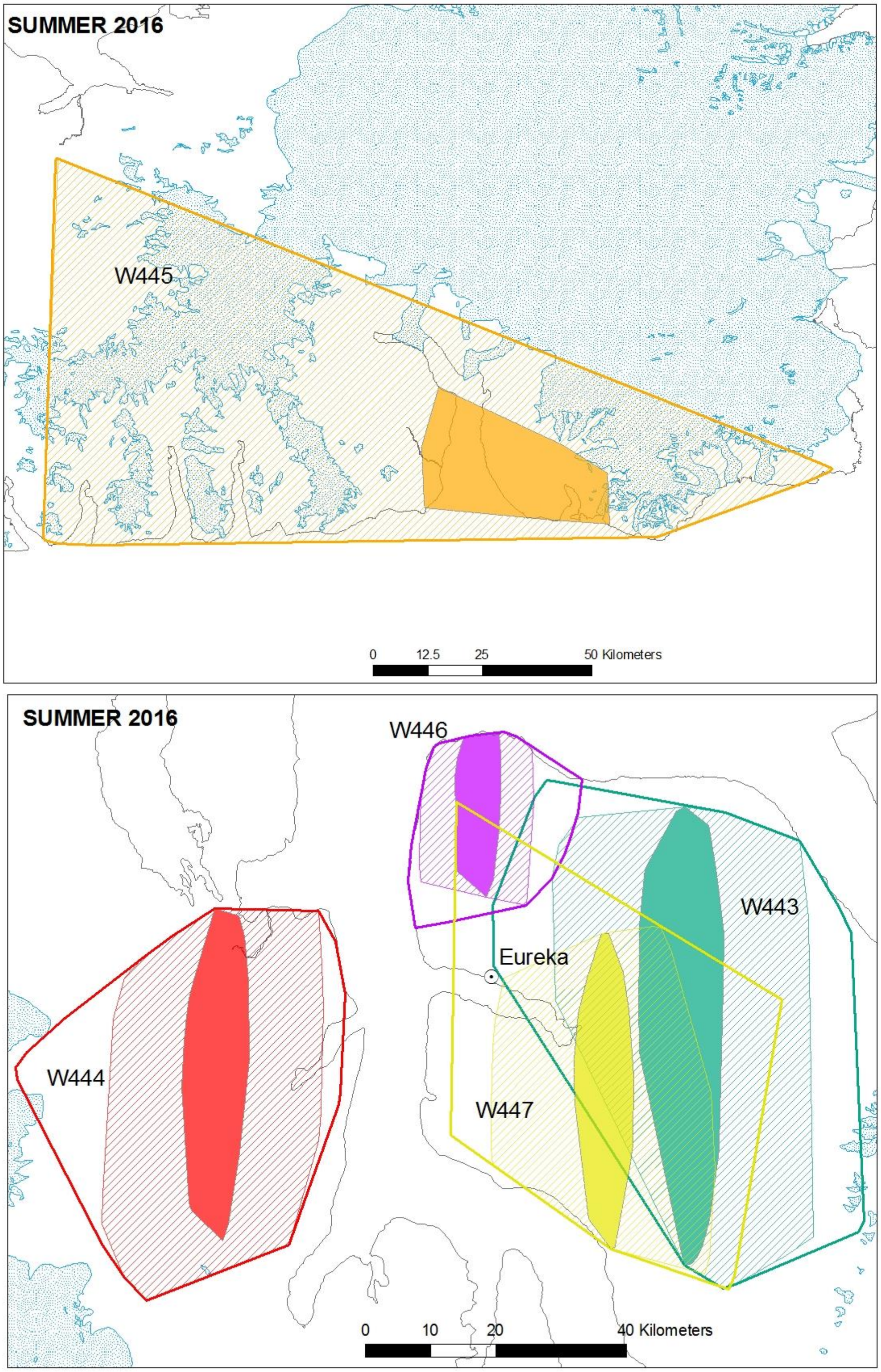


Figure 5. Home ranges for collared wolves in summer (Jun 1-Sep 30). W445 dispersed and it is not clear whether she had established a new home range when her collar stopped moving July 1. Hollow outlines are 100% minimum convex polygons (MCPs), hatched areas are 95% MCPs, and solid areas are 50% MCPs. Stippled blue areas are glaciers and icefields.

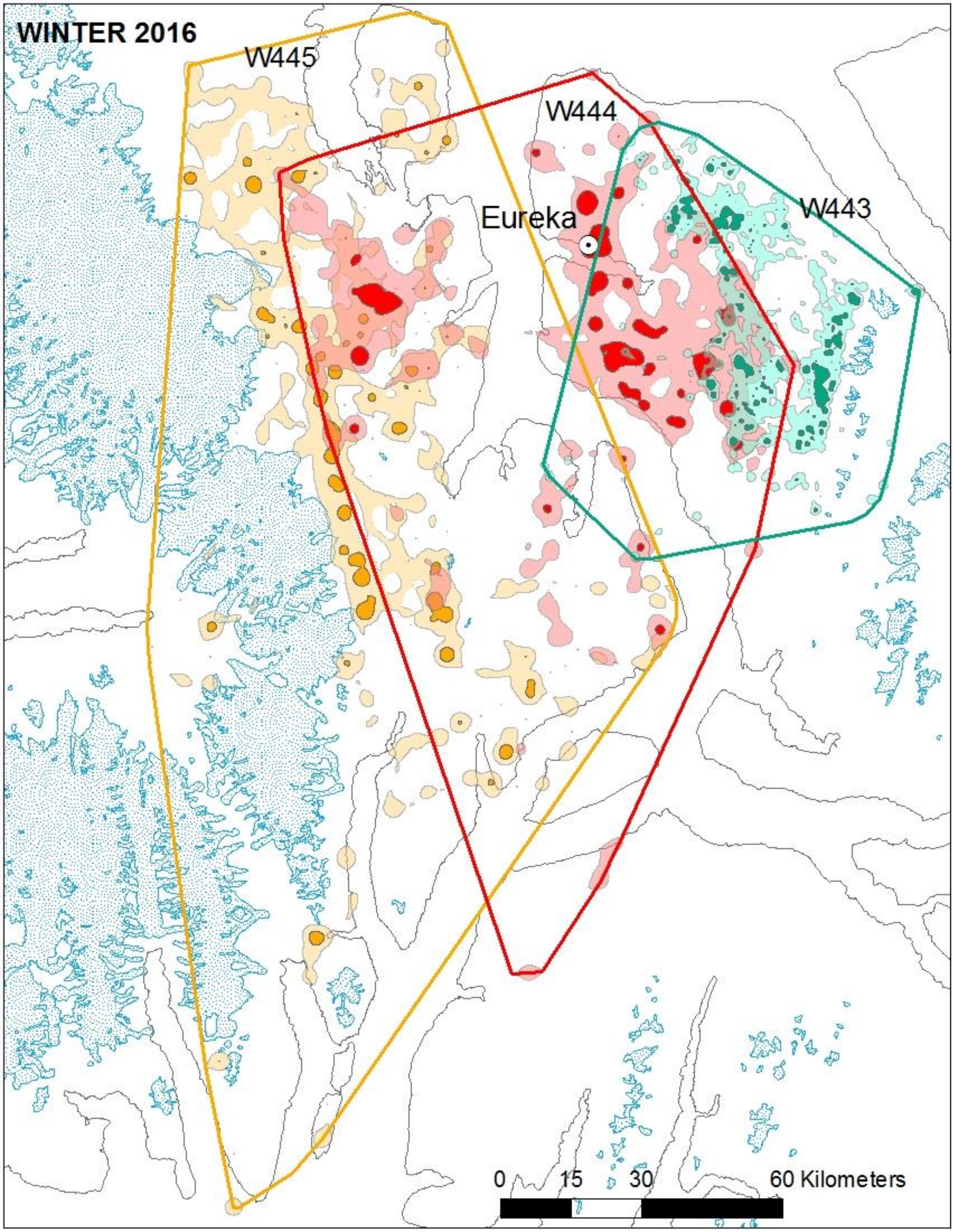
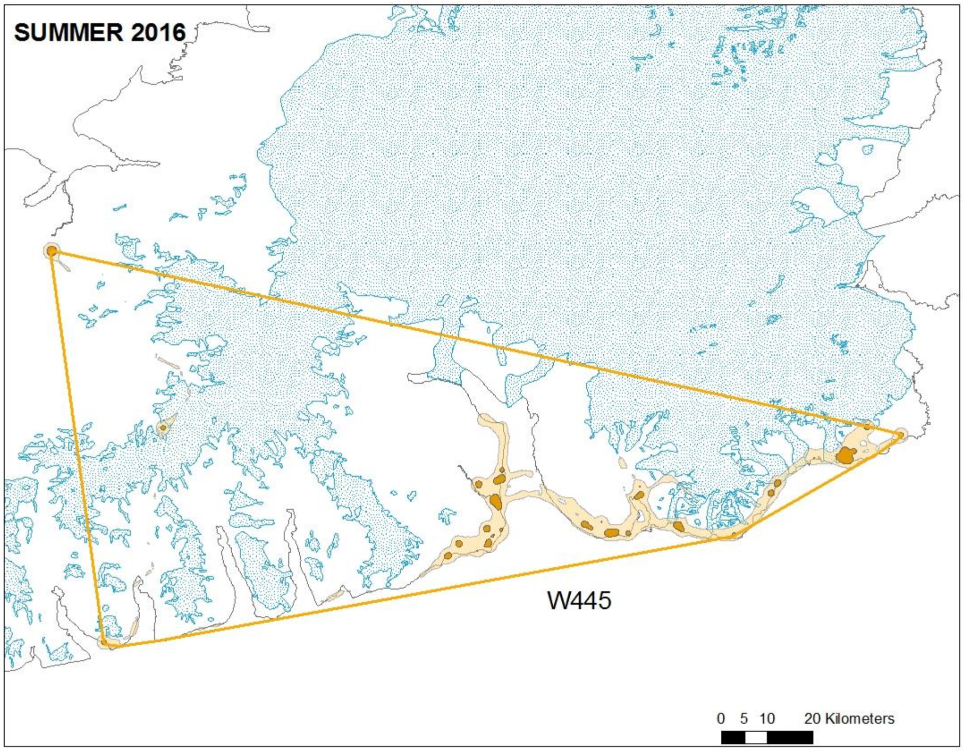


Figure 6. Home ranges for collared wolves in winter (Oct 1, 2015-May 31, 2016; May 2 for W445 prior to her dispersal). Hollow outlines are 100% minimum convex polygons, transparent polygons are 95% Brownian bridge movement model (BBMM) home ranges, and solid polygons are 50% BBMM core areas. Stippled blue areas are glaciers and icefields.



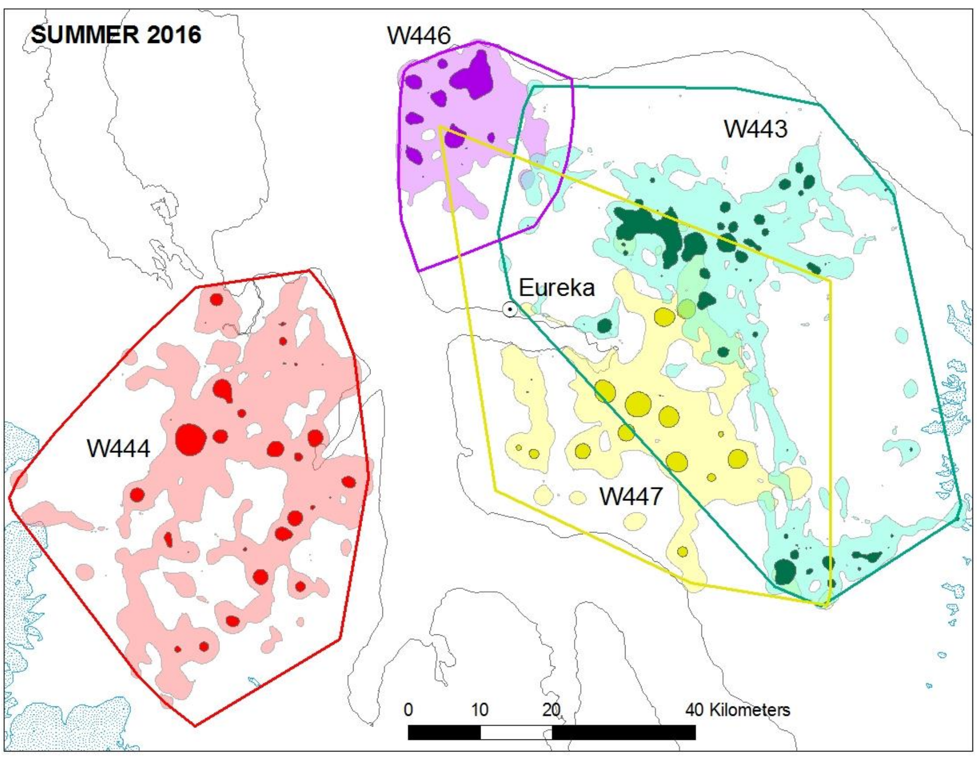


Figure 7. Home ranges for collared wolves, summer 2016 (Jun 1-Sep 30). W446 and W447 were collared July 6, 2016, and W445 may not have established a new home range prior to her collar becoming stationary on July 1. Hollow outlines are 100% minimum convex polygons , transparent polygons are 95% Brownian bridge movement model (BBMM) home ranges, and solid polygons are 50% BBMM core areas. Stippled blue areas are glaciers and icefields.

Overall, the space use of the wolves collared from 2014-2016 is that of a population maintaining year-round territories. The movements of W410 over winter 2009-2010 suggested that a large area was required to maintain the pack (Mech and Cluff 2011). It is possible that some of the long movements made by W410 (and presumably the pack) were forays off their territory. Interestingly, W444 visited some of the same areas outside the main Eureka territory as W410 had visited 5 years ago. Densities of prey may have been different during that study, but no quantitative estimates are available – especially for arctic hare. Mech (2005) did suggest that unusually early snow resulted in a muskox die-off in 1997, although muskoxen were at high densities in 2006 (Jenkins et al. 2011). Muskoxen on south Ellesmere also experienced a die-off in the early 2000s and in 2005, from which the population has since recovered (Taylor 2005, Campbell 2006, Jenkins et al. 2011, Anderson and Kingsley 2015). The implications for predation dynamics are vastly different if wolves are territorial than if they exist in a nomadic state when not denning, and this could change depending on available prey resources.

Table 3. MCP and BBMM home range sizes for wolves collared from summer 2014 to summer 2016. Areas were calculated with a North Pole Lambert azimuthal equal area projection centered on the study area (latitude of origin 80°N and central meridian -92°W).

Wolf	Season	Collar Days	Collar Locations	100% MCP (km^2)	95% MCP (km^2)	50% MCP (km^2)	95% BBMM (km^2)	50% BBMM (km^2)
W440	Summer 2014	78	1832	1794	1182	77	621	24
	Winter 2014-15	212	5803	8803	6026	1457	1886	125
	Summer 2015	64	1519	2232	1719	396	705	21
W441	Summer 2014	93	2180	1111	816	506	392	16
	Winter 2014-15	71	1683	1867	1260	213	402	48
W442	Summer 2014	23	531	809	688	164	311	22
W443	Summer 2014	25	568	1798	1424	369	417	54
	Winter 2014-5	212	5808	2768	2125	618	826	122
	Summer 2015	122	2902	3301	2669	468	947	47
	Winter 2015-16	243	5855	5156	2809	1256	1092	141
	Summer 2016	122	2198	3108	2285	685	883	101
W444	Summer 2015	120	1247	9506	4728	1236	1750	210
	Winter 2015-16	243	2925	12644	11094	4591	2873	296
	Summer 2016	122	2580	2091	1666	394	958	61
W445	Summer 2015	118	2538	2124	1613	382	623	15
	Winter 2015-16	243	5747	18332*	14336*	2746*	3428*	237*
	Summer 2016	30	719	9041**	9018**	868**	567**	56**
W446	Summer 2016	86	2087	597	399	147	325	47
W447	Summer 2016	86	2075	2425	1394	323	638	59

*Until May 2, prior to dispersal.

**This likely includes continued dispersal, but since the collar stopped moving July 1, any delineation of W445's new home range on Devon Island (or continued dispersal) is not possible.

Cluster Site Investigations
Some early season visits to cluster sites were possible, but unfortunately snow prevented us from determining with certainty whether clusters were definitively not associated with prey remains. When possible, we revisited these sites later in the season to confirm. We used the same cluster algorithm developed by Knopff et al. (2009) for cougar predation that we used in 2014 and 2015, with clusters defined as 2 or more points within 175 m (Knopff et al. 2009) to locate potential kill sites. Cluster investigations were carried out mostly incidentally during capture activities and den searches, with a 4-day ground-based search on Axel Heiberg Island July 5-9, 2016 (Table 4, Figures 9 and 10). In total, we visited 203 cluster sites, recorded 34 muskox kills (one was likely a scavenged carcass, 2 were unknown

scavenge or kill, and three were observed kills rather than from clusters), one seal (likely scavenged; frozen in the ice on Slidre Fiord), 6 dens, and 4 confirmed rendezvous sites.

Table 4. Kill cluster investigations for summer 2016. Clusters were determined from the Knopff et al. 2009 algorithm, with the most recent clusters prioritized for investigation. Multiple visits by a wolf to kill sites and dens resulted in several clusters for some sites.

Wolf ID	Date Range	Total Clusters	Clusters Checked	Clusters associated with kills (# of kills)	Clusters associated with dens (# of dens)
W440	Nov-Dec 2014	161	35	10 (5 muskoxen)	
	Jan-Feb 2015	139	24	7 (4 muskoxen)	
	Mar-May 2015	201	32	2 (1 muskox)	3 (1); 1 fox den
W441	Sep-Oct 2014	180			
W442	Sep 2014	59			
W443	Nov-Dec 2014	214			
	Jan-Feb 2015	201			
	Mar-Apr 2015	216			
	May 2015	108			
	Jan-May 2016		40	2 (1 muskox)	
	Jun 2016		9		1 (1)
W444	Jun-Dec 2015		20	1(1 muskox)	3 (1); 3 rendezvous
	Jan-Jun 2016	327	57	16 (14 muskoxen, 1 seal frozen in ice)	4 (2)
W445	Jan-Jun 2016	232	36	5 (2 muskoxen)	2 (1)
W447	Jul 2016		41	17 (13 muskoxen; also 3 observed kills)	1 (1); 11 revisits to 1 rendezvous site

Since the satellite collars are also outfitted with accelerometers, we will be able to refine the kill cluster algorithm to more accurately identify kill sites. Even incorporation of basic accelerometer data (sum of activity over cluster locations) provides marked improvement over algorithms based only on location information (Moffatt 2012). Wolf behaviour at kill sites is different from behaviour at rendezvous sites, bed sites, and dens, so we expect to be able to further refine the kill cluster algorithm as the dataset improves. Preliminary analyses suggest an initial burst of high activity at kill site clusters, followed by a series of smaller activity peaks and low activity periods (Shipp 2016). In total, since 2014 we have investigated 285 cluster sites and identified 45 muskox carcasses (kills or probable kills) and 1 seal, likely scavenged. The conspicuous hair mats at the carcass sites suggest that, even when bones are almost completely consumed, kill sites can still be detected. However, the near complete consumption of several adult muskox carcasses that we located underscores the importance of searching either soon after the cluster is created or once all snow has melted out and the hair and rumen pile are not obscured. No caribou kill sites have been found during recent investigations, but one was found in 2010 at a cluster site and one was found incidentally during backtracking in 2014, confirming that the obvious white hair mats can be detected.

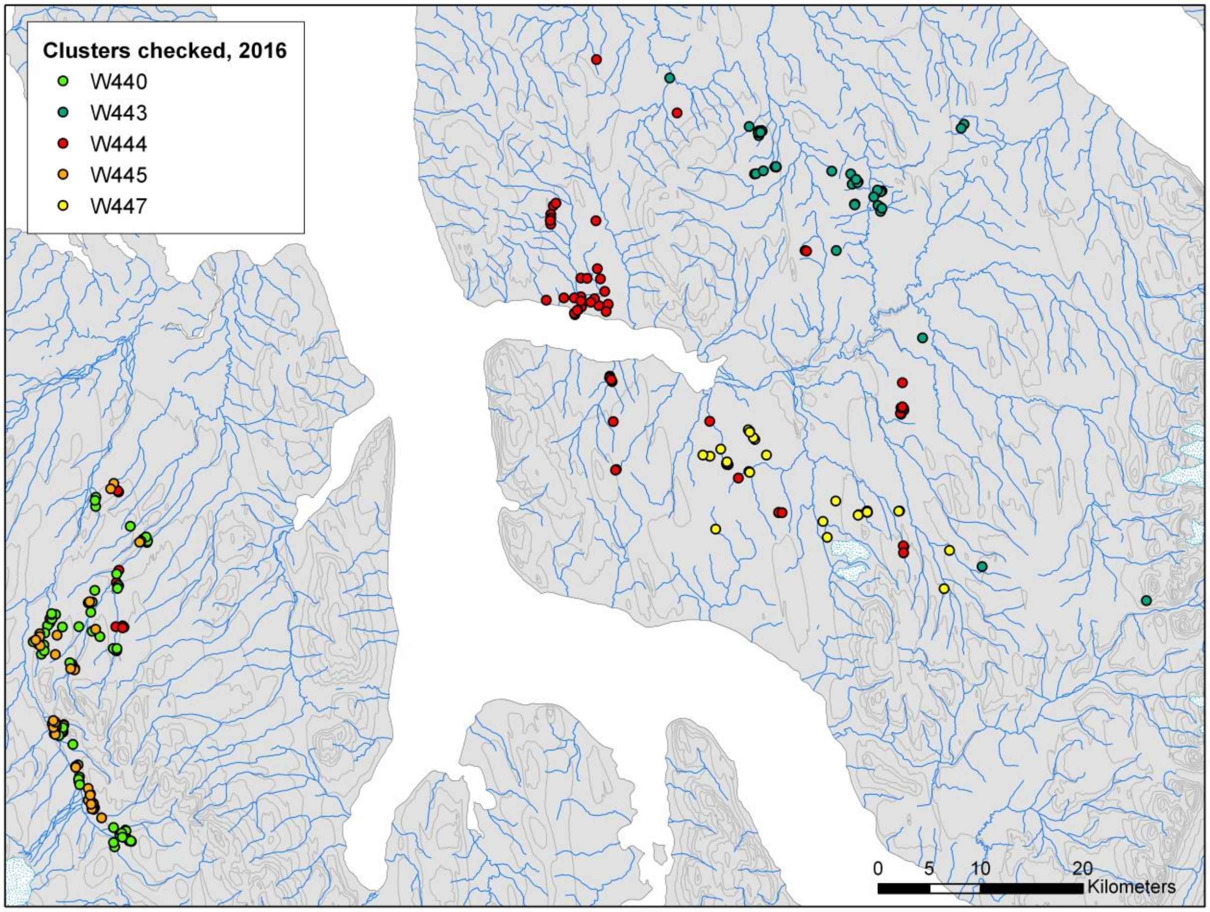


Figure 8. Locations of clusters investigated in summer 2016, colour-coded by wolf ID.

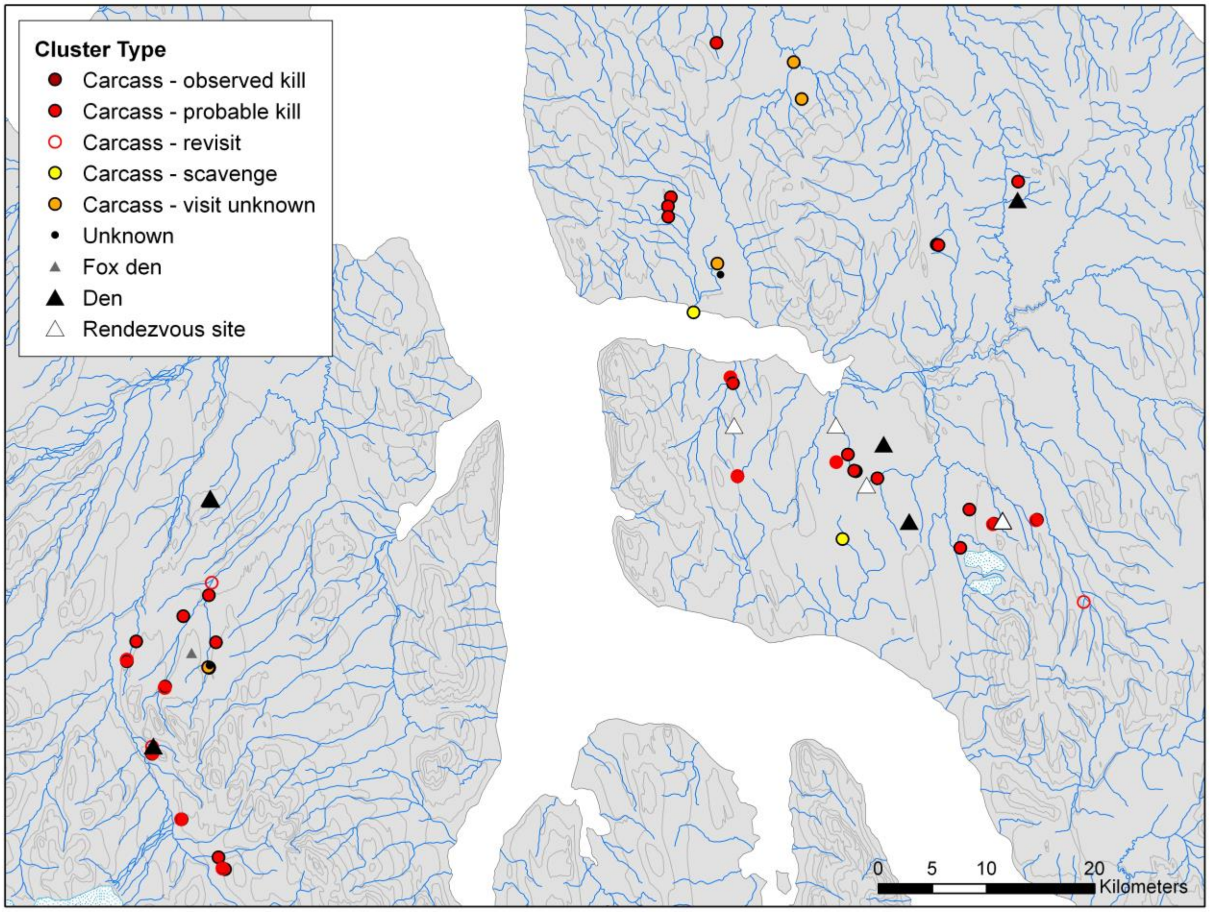


Figure 9. Results of cluster site investigations, summer 2016. Clusters that were visited but which had no evidence of a kill, den, or rendezvous site are not shown.

Incidental Reports

Two wolves were seen during a refueling stop in June on Stor Island. Given the movement of W445 across Stor Island to the Raanes Peninsula, and the barren nature of the island, these two wolves may have been off territory or dispersing.

On June 27, a group of 4 wolves was travelling north of Blacktop Ridge, apparently 2 adults and 2 yearlings. One of the adults left the group and was seen later, alone. On June 29, a pair of wolves and a single wolf were seen in the same area. It is not clear if these represent part of the Mount Lockwood pack, part of the Cañon Fiord pack (which we did not locate this year, but which is likely still active based on collar locations of neighboring packs) or other wolves.

Wolf sightings at the Eureka weather station this summer were relatively infrequent and generally only one or two wolves were seen at a time. In early July, five wolves were seen along Blacktop Creek, and these may have been the Eureka pack (which was not yet collared). The pack did not make regular visits to the station. Wolves were occasionally seen at the weather station while the Eureka pack was at the den south of Slidre Fiord.

Management Implications and Future Work

The knowledge gaps in the muskox-caribou-wolf system have been brought up by the Peary Caribou Recovery Strategy Science Assessment Team (most recently at All Chairs Meeting in Yellowknife, Feb 17-19, 2015 and during Dec 2, Dec 8 2015 conference calls to review the knowledge assessment) and by COSEWIC during the Peary caribou status assessment (threat assessment conference call Sept 12, 2014). Certainly communities in the Northwest Territories, like Sachs Harbour and Ulukhaktok, and in the Kitikmeot, like Cambridge Bay, have mentioned increasing wolf populations as a threat to Peary caribou recovery (Peary Caribou Recovery Strategy consultations, Feb 26-28 and Mar 4-5, 2013 and All Chairs Meeting in Yellowknife, Oct 22-24, 2013, teleconferences Dec 2, Dec 8 2015). Although a classic apparent competition scenario could exist, it has not been investigated to present (Miller 1993, confirmed at more recent Peary caribou Recovery Strategy discussions). The mechanism of caribou decline when muskoxen are abundant (a pattern that community members often notice and that is also known through Inuit qaujimajatuqangit) is unknown. The draft Peary Caribou Recovery Strategy identifies predator-prey interactions as a priority for research and monitoring.

Three years of data on 8 wolves in 6 packs have already started to address some of these pressing questions. We have established that wolf populations in parts of the High Arctic exist at relatively high densities, comparable to the boreal forest and even approaching or exceeding Bergerud's (1988) wolf density threshold for caribou persistence (although the relevance of that threshold is unknown for Peary caribou in the High Arctic). We have also found that wolves remain on territories year-round, which means that there is not a time when wolf territories present a significantly lower predation risk due to wolves moving away. This could be an important factor in Peary caribou distribution and movement, particularly if they employ a 'spacing away' tactic to minimize predation risk, like woodland caribou. Wolves do not use their territories uniformly, however, so predation risk will still vary across the landscape.

Although previous locations from W410 in 2009 showed movements between the Fosheim Peninsula and Axel Heiberg Island, the additional location information from the Eureka pack crossing to Axel Heiberg, the dispersal of W444 to join the Axel pack, and the genetic similarity between W440 of Axel Heiberg and a previously genotyped Eureka wolf confirms that the area functions as an interisland population. The lack of locations south of the Sawtooth Mountains suggests that the mountain range may form more an effective barrier to most movement, but the topography south of the Sawtooths is also generally more rugged and prey densities may be lower. There is was an area of high muskox density along river valleys flowing into South Bay based on a 2006 aerial survey (Jenkins et al. 2011), but this is isolated by mountains and icefields.

Movements of collared wolves in 2015 and 2016 suggest that there may be more connectivity with wolf populations farther south than with populations to the north. W444 and the Eureka pack, as well as W445 and possibly other Axel pack members, travelled to Glacier Fiord and Hyperite Point on southern Axel Heiberg Island. Both W410 in 2009, and W444 and W445 in 2016, crossed to the Raanes Peninsula. W445 dispersed as far south as Dundas Harbor on Devon Island. There are wolves in the Tanqary-Lake Hazen corridor north to Alert, but none of the collared wolves have travelled north. Greely Fiord and Nansen Sound are wider than Eureka Sound, but they would be a much shorter ice crossing than the Jones Sound crossing of W445.

From an ecosystem monitoring standpoint, the project continues to provide baseline information on den/territory occupancy, pack size, and litter size for wolves in an area of development interest for coal. Although Canada Coal retracted its Nunavut Impact Review Board application to develop coal licenses held on the Fosheim Peninsula in 2013, the abundance of high-grade thermal coal at the surface, and potential for metallurgical coal, will likely continue to draw attention from developers as the arctic becomes increasingly accessible and developments becomes more economically feasible.

Acknowledgements

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Literature Cited

Anderson, M. 2016. Distribution and abundance of Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) on Devon Island, March 2016. Nunavut Department of Environment, Wildlife Research Section, Status Report 2016-01, Igloolik, NU. 37 pp.

Anderson, M. and M. C. S. Kingsley. 2015. Distribution and abundance of Peary caribou (*Rangifer tarandus pearyii*) and muskoxen (*Ovibos moschatus*) on southern Ellesmere Island, March 2015. Nunavut Department of Environment, Wildlife Research Section, Status Report, Igloolik, NU. 46 pp.

Anderson, M., D. MacNulty, H. D. Cluff, and L. D. Mech. 2016. High Arctic wolf ecology field report, summer 2014. Submitted to meet requirement of Wildlife Research Permit WL 2014-048. Government of Nunavut Status Report 2016-01, Igloolik, NU. 26 pp.

Bergerud, A. T. 1988. Caribou, wolves, and man. Trends in Ecology and Evolution 3(3): 68-72.

Bullard, F. 1999. Estimating the home range of an animal: a Brownian bridge approach. MSc thesis. University of North Carolina, Department of Statistics, Chapel Hill, NC: 27.

Calenge, C. 2006. The package adehabitat for the R software: a tool for the analysis of space and habitat use by animals. Ecological Modelling 197: 516-519.

Campbell, M. 2006. Estimating Peary caribou (*Rangifer tarandus pearyi*) and muskox (*Ovibos moschatus*) numbers, composition and distributions on Ellesmere Island, Nunavut. Government of Nunavut, Department of Environment, Status report 19, Iqaluit, 12 pp.

Hemson, G., P. Johnson, A. South, R. Kenward, R. Ripley, and D. MacDonald. 2005. Are kernels the mustard? Data from global positioning system (GPS) collars suggests problems for kernel home-range analyses with least squares cross-validation. Journal of Animal Ecology 74: 455-463.

Horne, J. S., E. O. Garton, S. M. Krone, and J. S. Lewis. 2007. Analyzing animal movements using Brownian bridges. Ecology 88: 2354-2363.

Jenkins, D., M. Campbell, G. Hope, J. Goorts, and P. McLoughlin. 2011. Recent trends in abundance of Peary Caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) in the Canadian Arctic Archipelago, Nunavut. Department of Environment, Government of Nunavut, Wildlife Report No. 1, Pond Inlet, Nunavut. 184 pp.

Kie, J. G., J. Mattiopoulos, J. Fieberg, R. A. Powell, F. Cagnacci, M. S. Mitchell, J.-M. Gaillard, and P. R. Moorcraft. 2010. The home-range concept: are traditional estimators still relevant with modern telemetry technology? Philosophical Transactions of the Royal Society B 365: 2221-2231.

Knopff, K. H., A. A. Knopff, M. B. Warren, and M. S. Boyce. 2009. Evaluating Global Positioning System telemetry techniques for estimating cougar predation parameters. Journal of Wildlife Management 73(4):586–597.

Loveless, K. 2010. Foraging strategies of eastern wolves in relation to migratory prey and hybridization. MSc thesis. Trent University, Department of Environmental and Life Sciences, Peterborough, ON. 73 pp.

Mech, L. D. 2005. Decline and recovery of a high arctic wolf-prey system. Arctic 58(3):305-307.

Mech L. D., and H. D. Cluff. 2011. Movements of wolves at the northern extreme of the species' range, including during four months of darkness. PLoS ONE 6(10): e25328. doi:10.1371/journal.pone.0025328.

Mech, L. D., L. G. Adams, T. J. Meier, J. W. Burch, and D. W. Dale. 1998. Wolves of Denali. University of Minnesota, Minneapolis. 231 pp.

Miller, F. L. 1993. Status of wolves in the Canadian Arctic Archipelago. Technical Report Series 173. Canadian Wildlife Service, Prairie and Northern Region, Edmonton, AB. 63 pp.

Moffatt, S. 2012. Time to event modelling: wolf search efficiency in northern Ontario. MSc thesis. University of Guelph Department of Integrative Biology, Guelph, ON. 57 pp.
R Core Team. 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/
Shipp, H. 2016. Using accelerometer data to remotely assess predation activity of Arctic wolves. Undergraduate honors thesis, Utah State University, Department of Wildland Resources, Logan, UT. 30 pp.
Signer, J., and N. Balkenhol. 2015. Reproducible home ranges (rhr): a new, user-friendly R package for analyses of wildlife telemetry data. Wildlife Society Bulletin 10.1002.wsb.539
Taylor, A. D. M. 2005. Inuit Qaujimajatuqangit about population changes and ecology of Peary caribou and muskoxen on the High Arctic Islands of Nunavut. MA Thesis. Queen's University, Kingston ON. 123 pp.
Van Zyll de Jong, C. G., and L. N. Carbyn. 1999. COSEWIC status report on the grey wolf (*Canis lupus*) in Canada. COSEWIC, Ottawa.