Population Estimate of the Dolphin and Union Caribou herd

(*Rangifer tarandus groenlandicus* x *pearyi*)

Coastal Survey, October 2018

and

Demographic Indicators

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Executive Summary

Dolphin and Union (DU) Caribou (*Rangifer tarandus groenlandicus* x *pearyi*) have a large distribution covering Victoria Island (Nunavut and Northwest Territory) and the northern region of the Canadian mainland in Nunavut. The DU Caribou calve and summer on Victoria Island, resulting in the sharing of the northwestern extents of their seasonal ranges with Peary Caribou (*Rangifer tarandus pearyi*). While Peary Caribou winter on Victoria Island, the DU Caribou generally display migratory behavior by crossing the sea-ice of the Coronation Gulf to winter on the Canadian mainland. Once on the mainland, DU caribou over-winter with other tundra-wintering caribou in the eastern part of their winter range. In addition to this specific movement and seasonal range, the DU Caribou can also be distinguished, with certainty, genetically from other caribou herds (Peary Caribou and Barren-ground Caribou), highlighting the conservation importance of this herd.

A coastal survey methodology, originally developed by Nishi (2004), has been used to estimate the DU caribou since 1997 as they physically separate from the Peary caribou in the fall. This methodology is based on hunter observations and *Inuit Qaujimajatuqangit* of Dolphin and Union Caribou gathering during rut into a narrow band on the southern coastline of Victoria Island. The caribou wait along this coastline (known as staging) as the sea-ice forms enough for them to resume their migration to the mainland. During this time, their daily movement rate is presumed to be relatively low and the method assumes that the majority of the herd is found along the coastline at the end of October. If these two assumptions are met, the method will provide a reliable population estimate. The same method was used in 1997, 2007, 2015, and 2018 surveys to generate population estimates, allowing trend analysis. In the fall of 2015, the total estimate of the final visual strata was 14,730 (SE=1,507, CV=10.2%, CI=11,475-17,986) caribou, resulting in an extrapolated population estimate of 18,413 (SE=3,133.8, CV=17%, CI=11,664-25,182). A statistically significant decline of 66% was observed between 2007 and 2015 surveys, which amounted to a 4% annual rate of decline. Given this rate of decline, an increase in the frequency of population monitoring was enacted to assess herd trend. The main objective of this study was to provide a new extrapolated population estimate, and access current trends for effective management.

The 2018 survey occurred between October 31 and November 4, 2018. A total of 38 collared caribou were monitored to assess location and movement relative to coastal strata. During the final visual survey, 89% of collared caribou were contained within survey strata; with 63% occurring in coastal strata and 26% in the two inland strata north of Read Island, accounting for the remaining collared caribou outside of the coastal strata. The 11% of collar not included in the final abundance survey was still included when calculating the extrapolated population estimate.

The collared caribou occurring in the two inland strata at the time of the survey still reached the coastline and started their sea-ice crossing in November, after the survey. Thus, the total estimated number of caribou in the final visual strata (89% of the collared caribou) was 3,673 (SE=595.5, CV=16.2%, Cl=2,660-5,073) caribou, which resulted in an extrapolated population estimate of 4,105 (SE=694.8, CV=16.9%, Cl=2,931-5,750). These results show an abrupt population decline between 2015 and 2018, with an annual change of 62%.

Vital rates were also examined to shed light on the demographic status of DU caribou. The yearly collared female survival estimate for 2018 was 0.62 (SE=0.07, CI=0.48-0.75), which included known hunting and natural mortality. If known hunting mortality was excluded from survival estimates, then survival increased to 0.72, providing compelling evidence to suggest that hunting mortality is likely contributing to the observed decline in demographic rates. These lower survival rates are consistent with survey findings of an observed decline in population. Other demographic studies (Boulanger et al., 2011) have indicated that cow survival rates need to be at least 0.80-0.85 for population stability (dependent on levels of recruitment) with higher survival rates needed for population increase (Adamczewski et al., 2019; Boulanger et al., 2019). Laboratory analysis of female feces, collected from collared caribou and hunter harvested sample kits, was done to determine the pregnancy rate of DU caribou. Though pregnancy rates from spring collared caribou samples seemed high with 94%, these samples are likely positively biased due to selection of fatter animals for collaring. Pregnancy rates from hunter sample kits which are likely more representative of the population over the same period suggested lower than expected pregnancy rates (69%). Low productivity combined with low survival, are further indicators of a declining population. Also, even if there was higher recruitment, this could not compensate for the low cow survival rates to maintain a stable population (Boulanger et al., 2011).

Contrary to previous assumptions that DU caribou stop migrating at low numbers, the current sample of collared DU caribou do not indicate that a substantial proportion of caribou are not migrating to the mainland each winter. From the 2015-2016 and 2018 collaring program, data generated from 35 and 49 DU collared caribou were available for analysis. Of these, there were only two instances of caribou not crossing to the mainland, which occurred during the winter of 2016-2017. However, Ulukhaktok hunters are reporting that more DU caribou are remaining on Victoria Island year-round. While the exact proportion of caribou remaining on the island is unknown, this survey result of migrating caribou should be of conservation concern for groups that hunt Dolphin Union caribou, regardless of the existence of a smaller group of non-migratory DU caribou that inhabit Northern Victoria Island, as it is unlikely that the sum total of these animals will offset the severity of the declines observed for the main, migrating proportion of the herd.

The DU caribou herd survey results, along with observed demographic indicators, indicate a continuing, significant and, in recent years, steep, decline. As a culturally and economically important herd to the Nunavut communities and harvesters of Cambridge Bay, Bay Chimo, Bathurst Inlet, and Kugluktuk and the Northwest Territory communities of Ulukhaktok and Paulatuk, the decline of the DU herd is particularly concerning for communities, hunters, and interjurisdictional partners. The results presented from this study highlight the risk to the herd and the urgent need to develop effective, inter-jurisdictional management actions aimed at stabilizing the decline and fostering recovery of DU caribou. Due to the uniqueness and importance of this herd, it is critical that co-management partners work together to address this decline through sustainable management. According to the approved Dolphin and Union Caribou Management Plan, at this low population level, more preventive management measures should be developed to conserve DU Caribou and support recovery of the herd.

ᐊᐅᓚᑦᑎᔾᔨᓂᖕᒫᖅᑐᑦ ᓇᐃᓈᖅᓯᒪᔪᖅ

ᕿᑭᖅᑖᓘᑉ ᑐᒃᑐᖏᑦ (*Rangifer tarandus groenlandicus x pearyi*) ᓇᓅᕈᓘᔭᖅᑲᑦᑕᖅᐳᑦ ᑮᓪᓕᓂᕐᒥᑦ ᐅᐊᖕᓇᖅᐸᓯᐊᓂᓗ ᓄᓇᒥᑦ ᑲᓇᑕᐅᑉ ᓄᓇᐃᓐᓇᖓᓂᑦ ᓄᓇᕗᒻᒥ. ᕿᑭᖅᑖᓘᑉ ᑐᒃᑐᖏᑦ ᓄᕐᖃᐅᖅᑲᑦᑕᖅᐳᑦ ᐊᐅᔭᒃᑯᓪᓗ ᑮᓪᓕᓂᕐᒦᑉᐸᒃᓱᑎᒃ, ᐅᐊᖕᓇᖅᐸᓯᐊᓅᑦᑐᐃᓐᓇᐅᓕᖅᓱᑎᒃ ᐊᕐᕌᒍᑉ ᐃᓚᐃᓐᓇᖓᓂ ᐊᔾᔨᒌᙱᑦᑐᑦ ᕿᑭᖅᑕᓂ ᑐᒃᑐᖏᓪᓗ (*Rangifer tarandus pearyi*). ᕿᑭᖅᑕᓂ ᑐᒃᑐᖏᑦ ᐅᑭᐅᒃᑯᑦ ᑮᓪᓕᓂᕐᒦᑉᐸᒃᑎᓪᓗᒋᑦ, ᕿᑭᖅᑖᓘᑉ ᑐᒃᑐᖏᓪᓕ ᑕᒡᕙᐊᒐᕙᖕᓂᖏᓐᓂᒃ ᓴᖅᑮᔭᖅᑲᑦᑕᖅᐳᑦ ᓯᑯᒃᑯᑦ ᐃᑳᖅᐸᒃᓱᑎᒃ Coronation Gulf–ᑯᑦ ᐅᑮᓕᔭᖅᑐᖅᓱᑎᒃ ᑲᓇᑕᐅᑉ ᓄᓇᐃᓐᓇᖓᓂ. ᓄᓇᐃᓐᓇᕐᒦᓕᖀᖕᒪᒥᒃ, ᕿᑭᖅᑖᓘᑉ ᑐᒃᑐᖏᑦ ᐅᑭᐅᒃᑯᑦ ᑕᐅᕙᓃᖅᑲᑦᑕᖅᐳᑦ ᐊᓯᖏᓪᓗ ᓇᑉᐹᖅᑐᖅᑲᙶᖏᑦᑐᒥᐅᑕᑦ–ᐅᑮᓕᕙᒃᑭᓪᓗᑎᒃ ᑐᒃᑐᐃᑦ ᑲᓇᖕᓇᖅᐸᓯᐊᓂ ᐅᑭᐅᒃᑯᑦ ᓇᔪᖅᐸᒃᑕᒥᓂᒃ. ᐊᒻᒪᓗᑦᑕᐅᖅ ᓇᓗᓇᐃᔭᖅᓯᒪᔪᑦ ᓇᒧᙵᐅᕙᖕᓂᖏᑦ ᐊᒻᒪ ᐊᕐᕌᒍᑉ ᐃᓚᐃᓐᓇᖓᓂ ᐊᔾᔨᒌᒃᐸᙱᓐᓂᖏᑦ, ᕿᑭᖅᑖᓘᑉ ᑐᒃᑐᖏᑦ ᐃᓕᓴᓇᔭᐅᕙᓇᓇᕗᑦ, ᓇᓗᓇᙱᑦᑎᐊᖅᑐᓂ, ᓯᕗᓪᓕᖅᓯᕈᑎᖏᑎᒍᑦ ᐊᓯᖏᓐᓂᒃ ᑐᒃᑐᖏᓐᓂᒃ (ᕿᑭᖅᑕᓂ ᑐᒃᑐᐃᑦ ᐊᒻᒪ ᓇᑉᐹᖅᑐᖅᑲᙶᖏᑦᑐᒥ ᑐᒃᑐᐃᑦ), ᓇᓗᓇᕈᓐᓃᑦᑎᐊᖅᑐᓂ ᑐᒃᑐᖏᑦ ᓄᖑᕋᓗᐊᖅᑕᐃᓕᒪᔪᓐᓇᐊᖅᑲᓪᓚᓐᓂᖏᓐᓂᒃ.

ᓯᒡᔭᖅᐸᓯᖓ ᓈᓴᖅᑕᐅᔪᑦ ᖃᐅᔨᓴᖅᑕᐅᕙᓪᓕᐊᔪᑦ, ᓯᕗᓪᓕᖅ ᓴᖅᑭᑕᐅᓚᐅᖅᑐᑦ ᓂᓯᒧᑦ (2004)–ᒥ, ᐊᑐᖅᑕᐅᖃᑦᑕᓚᐅᖅᐳᑦ ᕿᑭᖅᑖᓘᑉ ᑐᒃᑐᕆᓐᓄᑦ ᓇᓚᐅᑦᑖᕈᑕᐅᓪᓗᑎᒃ 1997-ᒥᑦ ᐱᒋᐊᖅᑐᓂ ᐊᕕᒃᓯᒪᓂᖅᑲᑦᑕᕐᒪᑕ ᕿᑭᖅᑕᓂ ᑐᒃᑐᕆᓐᓂᒃ ᐅᑭᐊᒃᓵᙳᒍᕿᖅᓯᓂᖅ. ᑖᓐᓇ ᖃᐅᔨᓴᕈᑕᐅᔪᖅ ᒪᓕᖅᑲᑦᑕᖅᐳᖅ ᐊᖑᓇᓱᒃᑎᓄᑦ ᐅᔾᔨᕆᔭᐅᔪᓂᑦ ᐊᒻᒪ *ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᖏᓐᓂ* ᕿᑭᖅᑖᓘᑉ ᑐᒃᑐᖏᑦ ᑲᑎᙵᓕᖅᑲᑦᑕᕐᓂᖏᓐᓂᒃ ᓄᓕᐊᓕᖅᑎᓪᓗᒋᑦ ᑐᐊᑦᑐᒃᑰᖅᓗᑎᒃ ᑮᓪᓕᓂᐅᑉ ᓯᑲᖕᓚᑕ ᓂᕆᖅᐸᓯᐊᒍᑦ. ᑐᒃᑐᐃᑦ ᓯᑲᖅᐸᓯᒥ ᐅᑕᖅᑭᖅᑲᑦᑕᖅᐳᑦ (ᑕᐃᔭᐅᕆᓪᓗᓂ ᑲᑎᙵᓚᖕᕙᖕᒪ) ᓯᑯᕙᓪᓕᐊᑎᓪᓗᒍ ᓄᓇᐃᓐᓇᕐᒧᑦ ᑕᕝᕙᐊᖅᐸᓪᓕᐊᓂᐊᖅᑎᓪᓗᒋᑦ. ᓯᑯᕙᓪᓕᐊᓂᖓᓂ, ᖃᐅᑕᒫ ᐃᖏᕐᕋᕙᓪᓕᐊᓗᐊᖅᑲᑦᑕᕐᖃᓯᕆᔭᐅᙱᑦᑐᑦ ᖃᐅᔨᓴᕈᑎᑎᔭᖕᓚᓄᓪᓗ ᐅᓄᕐᓂᖅᓴᐃᑦ ᑐᒃᑐᐃᑦ ᓯᑲᖕᓚᓃᓐᓂᖅᓴᖅᑕᐅᕙᒃᖢᑎᒃ ᐅᑐᐱᕆᐅᑉ ᓄᙳᐊᓂ. ᑖᒃᑯᐊ ᒪᕿᒃ ᑲᖕᕿᕆᔭᐅᔫᒃ ᒪᓕᒃᑕᐅᒃᐸᑎᒃ, ᖃᐅᔨᓴᕈᑎᖓᓄᑦ ᓴᖅᑭᑎᑦᑎᔾᔪᓐᓇᕐᓂᐊᖅᐳᑦ ᑐᒃᑐᕆᑕ ᖃᔅᓯᐅᓇᓱᒋᔭᐅᓂᖏᓐᓂᒃ. ᐊᔾᔨᙳᓂᒃ ᖃᐅᔨᓴᕈᑎᖃᖅᑲᑦᑕᓚᐅᖅᐳᑦ 1997-ᒥ, 2007-ᒥ, 2015-ᒥ, ᐊᒻᒪ 2018-ᒥ ᓈᓴᐃᑎᓪᓗᒋᑦ ᓴᖅᑭᑦᑎᓇᓱᒃᖢᒋᑦ ᑐᒃᑐᐃᑦ ᖃᔅᓯᐅᓇᓱᒋᔭᐅᓂᖏᓐᓂᒃ, ᖃᓄᐃᓕᖏᓪᓕᐊᓂᖏᓐᓂᒃ ᖃᐅᔨᓴᕈᓐᓇᖅᓯᓪᓗᑎᒃ. 2015–ᒥ ᐅᑭᐊᒃᓵᖑᑎᓪᓗᒍ, ᑲᑎᕐᔪᑦ ᖃᔅᓯᐅᓇᓱᒋᔭᐅᔪᑦ ᑭᖑᓪᓕᖅᐹᖅ ᑕᐅᑐᒃᑯᒍ ᓄᓇᒥ 14,730–ᖑᓚᐅᖅᐳᑦ (SE=1,507, CV)=10.2%, CI=11,475-17,986) ᑐᒃᑐᐃᑦ, ᓴᖅᑭᑎᑦᑎᓗᓂ ᖃᔅᓯᐅᓇᓱᒋᔭᐅᓂᖏᓐᓂᒃ 18,413–ᖑᓪᓗᑎᒃ (SE=3,133.8, CV=17%, CI=11,664-25,182) ᑐᒃᑐᐃᑦ (ᐊᔾᔨᙳᐊᖅ 1). ᓈᓴᖅᑕᐅᔪᑦ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᕙᓪᓕᐊᓚᐅᖅᐳᑦ 66%–ᒥᑦ ᑕᑯᔭᐅᔪᑦ 2007 ᐊᒻᒪ 2015 ᐊᑯᓐᓂᖓ ᓈᓴᐃᑎᓪᓗᒋᑦ, ᐃᒪᓐᓇᐃᓕᖅᑐᑎᒃ 4%–ᒥᑦ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᖅᑐᑦ ᐊᕐᕌᒍᓕᒫᖅ ᖃᔅᓯᐅᓂᖏᑦ. ᐅᓄᕈᓐᓃᖅᐸᓪᓕᖅᑐᑦ ᒪᓕᒃᖢᒋᑦ, ᑐᒃᑐᐃᑦ ᓇᐅᑦᑎᖅᓱᖅᑕᐅᓯᒪᔪᓂᖅᓴᐅᖁᔭᐅᓕᖅᖢᑎᒃ ᐱᒋᐊᖅᑎᑦᑎᓚᐅᖅᐳᑦ ᖃᓄᐃᓕᖏᓪᓕᐊᓂᖏᑦ ᖃᐅᔨᓴᖅᑕᐅᓗᑎᒃ. ᑐᕌᒐᒃᑐᐊᑦᑕᕐᓂᐊᖅᐳᑦ ᖃᐅᔨᓴᓕᖅᐸᑕ ᓄᑖᒥᒃ ᐅᓄᖅᓯᕆᐊᖅᓯᒪᔪᓂᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᕐᑯᑎᑦ, ᐊᒻᒪ ᓖᓐᓇ ᓇᒧᙵᖅᐸᓪᓕᐊᓂᖓᓂᒃ ᐱᓗᑎᒃ ᐊᐅᓚᑕᐅᑦᑎᐊᓕᕐᑯᑎᑦ.

2018–ᒥ ᓈᓴᐃᓚᐅᖅᐳᑦ ᐅᑐᐱᕆ 31 ᐊᒻᒪ ᓄᕙᐱᕆ 4, 2018 ᐊᑯᓐᓂᖓᓂ. ᑲᑎᕐᔪᑦ 38–ᓂᒃ ᑐᒃᑐᓂᒃ ᖁᖓᓯᕈᖅᓯᒪᔪᓂᒃ ᓇᐅᑦᑎᖅᓱᓚᐅᖅᐳᑦ ᓇᓃᓐᓂᕆᓐᓂᒃ ᓇᒧᙵᖅᐸᓪᓕᐊᓂᖏᓐᓂᒡᓗ ᖃᐅᔨᓴᖅᖢᑎᒃ ᓯᒡᔭᖅᐸᓯᖓᓃᑦᑐᓂᑦ. ᑭᖑᓪᓕᖅᐹᒥ ᑕᑯᒃᓴᐅᔪᓂᒃ ᖃᐅᔨᓴᖅᑎᓪᓗᒋᑦ, 89%–ᖏᑦ ᑐᒃᑐᐃᑦ ᖁᖓᓯᕈᖅᓯᒪᔪᑦ ᖃᐅᔨᓴᖅᑕᐅᖃᑕᐅᔪᓐᓇᓚᐅᖅᐳᑦ; 63% ᓯᒡᔭᖑᓃᕐᔪᑎᒃ ᐊᒻᒪ 26% ᒪᕿᕐᓂᒃ ᓄᓇᖅᐸᓯᖕᒥᕐᔪᑎᒃ Read Island ᐅᐊᖕᓇᖓᓂ, ᐊᒥᐊᒃᑯᕆᔭᐅᓪᓗᑎᒃ ᖁᖓᓯᕈᖅᓯᒪᔪᓄᑦ ᑐᒃᑐᐃᑦ ᓯᓚᑖᓃᑦᑐᑦ. 11% ᖁᖓᓯᕈᖅᓯᒪᔪᑦ ᐃᓚᓕᐅᔾᔭᐅᙳᕆᑦᑐᑦ ᑭᖑᓪᓕᖅᐹᒥ ᐅᓄᕐᓂᕆᓐᓂᒃ ᓈᓴᖅᑕᐅᔪᓂᑦ ᓱᓕ ᐃᓚᓕᐅᔾᔭᐅᓚᐅᖅᐳᑦ ᖃᐅᔨᓴᖅᑕᐅᓕᖅᑎᓪᓗᒋᑦ ᐃᓚᒋᐊᖅᓯᒪᔪᑦ ᐅᓄᕐᓂᖏᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᓂᑦ.

ᖁᖓᓯᕈᖅᓯᒪᔪᑦ ᑐᒃᑐᐃᑦ ᒪᕿᕐᓂᑦ ᓄᓇᖅᐸᓯᖕᒥᑦᑐᓂᑦ ᓈᓴᐃᑎᓪᓗᒋᑦ ᓱᓕ ᑎᑭᐅᑎᓚᐅᖅᐳᑦ ᓯᑯᒃᑯᓪᓗ ᐃᑳᖅᐸᓪᓕᐊᓪᓗᓂᒃ ᓄᕙᐱᕆᐅᑎᓪᓗᒍ, ᓈᓴᐃᕚᓂᑎᓪᓗᒋᑦ. ᑕᐃᒪᐃᒻᒪᑦ, ᑲᑎᕐᔪᑦ ᖃᔅᓯᐅᓇᓱᒋᔭᐅᔪᑦ ᑐᒃᑐᐃᑦ ᑭᖑᓪᓕᖅᐹᒥ ᑕᑯᔭᐅᔪᑦ (89% ᖁᖓᓯᕈᖅᓯᒪᔪᑦ ᑐᒃᑐᐃᑦ) 3,673–ᖑᓪᓗᑎᒃ (SE=595.5, CV=16.2%, CI=2,660-5,073) ᑐᒃᑐᐃᑦ, ᓴᖅᑭᑎᑦᑎᓗᓂ ᖃᔅᓯᐅᓇᓱᒋᔭᐅᓂᖏᓐᓂᒃ 4,105 (SE=694.8, CV=16.9%, CI=2,931-5,750)

ᑐᒃᑐᐃᑦ (ᐊᔾᔨᙳᐊᖅ 1). ᖃᐅᔨᓴᕈᑕᐅᔪᓂᑦ ᑕᑯᕗᒍᑦ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᕐᓂᖏᓐᓂᒃ 2015 ᐊᒻᒪ 2018 ᐊᑯᓐᓂᖓᓂ, ᐊᕐᕌᒍᓕᒫᖅ 62%−ᒥ ᐊᓯᔾᔨᖅᑐᓂ.

ᐊᑐᕐᓂᖃᖅᑐᒻᒪᕆᖕᓂᑦ ᖃᐅᔨᓴᓚᐅᕆᕗᑦ ᑐᑭᓯᐅᒪᓕᒃᑲᓐᓂᕐᑯᓪᓗᒋᑦ ᓇᒧᙵᖅᐸᓪᓕᐊᓂᖏᓐᓂᒃ ᕿᑭᖅᑖᔾᔫᑉ ᑐᒃᑐᖏᑦ. ᐊᕐᕌᒍᓕᒫᒧᑦ ᖁᖓᓯᕈᖅᓯᒪᔪᑦ ᐊᕐᓇᓪᓗᐃᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ 2018−ᒧᑦ 0.62 (SE=0.07, CI=0.48-0.75)−ᖒᓚᐅᖅᐳᑦ, ᐱᖃᓯᐅᔾᔭᐅᓪᓗᑎᒃ ᖃᐅᔨᔭᐅᓪᓗᑎᒃ ᐊᖑᓇᑦᑕᐅᔪᑦ ᐊᒻᒪ ᓄᓇᒥ ᑐᕐᑯᖓᔪᖅᓯᐊᖑᔪᑦ. ᖃᐅᔨᔭᐅᔪᑦ ᐊᖑᓇᑦᑕᐅᓪᓗᑎᒃ ᑐᕐᑕᐅᕙᒃᑐᑦ ᐃᓚᐅᑎᑕᐅᓚᐅᙱᑉᐸᑕ ᐊᓐᓇᒃᑐᓂᑦ ᓇᓚᐅᑦᑖᖅᓯᒪᔪᓂᑦ, ᑕᐃᒪᓕ ᐊᓐᓇᒃᓯᒪᔪᑦ 0.72−ᒧᑦ ᐅᓄᖅᓯᒋᐊᕋᔭᓚᐅᖅᐳᑦ, ᓇᓗᓇᐃᕈᑕᐅᔫᓇᖅᑐᓂᒃ ᓴᖅᑭᑎᑦᑎᓕᕐᓗᑎᒃ ᐊᖑᓇᑦᑕᐅᓪᓗᑎᒃ ᑐᕐᑯᑕᐅᕙᒃᑐᑦ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᕈᑕᐅᓂᖓᓂᒃ ᓇᒧᙵᖅᐸᓪᓕᐊᓂᖏᑦ ᖃᔅᓯᐅᓂᖏᓐᓂᒃ. ᐊᑦᑎᖕᓂᖅᓴᐃᑦ ᐊᓐᓇᒃᓯᒪᔪᑦ ᐅᓄᕐᓂᖏᑦ ᒪᓕᒃᐳᑦ ᓈᓴᖅᑕᐅᔪᓂᑦ ᖃᐅᔨᔭᐅᓚᐅᖅᑐᓂᑦ ᑕᑯᔭᐅᔪᑦ ᐅᓄᕈᓐᓃᖅᓯᒪᓂᖏᓐᓂᒃ. ᐊᓯᖏᑦ ᓇᒧᙵᖅᐸᓪᓕᐊᓂᖏᑦ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ (Boulanger et al., 2011) ᓇᓗᓇᐃᖅᓯᓚᐅᖅᐳᑦ ᑐᒃᑐᐃᑦ ᐊᓐᓇᒃᓯᒪᔪᑦ ᐅᓄᕐᓂᖏᑦ 0.80-0.85−ᖑᔭᕆᐊᖃᖅᐳᑦ ᑐᒃᑐᖏᑦ ᐊᑕᐅᓲᓐᓇᕐᒥᓐᓂᐊᕐᓗᑎᒃ (ᐅᓄᖅᓯᕗᓪᓕᐊᓂᖏᑦ ᑐᙵᕕᒋᓗᒋᑦ) ᐊᓐᓇᒃᓯᒪᔪᑦ ᖁᑦᑎᖕᓂᖅᓴᐅᔭᕆᐊᖃᖅᓗᑎᒃ ᑐᒃᑐᓄᑦ ᐅᓄᖅᓯᒋᐊᖅᑐᓄᑦ (Adamczewski et al., 2019; Boulanger et al., 2019). ᖃᐅᔨᓴᕐᕕᖕᒥ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᐊᕐᓇᓪᓗᐃᑦ ᐊᓇᖏᑦ, ᑲᑎᑕᐅᔪᑦ ᑐᒃᑐᓂᑦ ᖁᖓᓯᕈᖅᓯᒪᔪᓂᑦ ᐊᒻᒪ ᐊᖑᓇᑦᑎᓂᑦ ᑐᒃᑐᑕᐅᔪᑦ ᖃᐅᔨᓴᒐᒃᓴᖏᓐᓂᒃ, ᑕᐃᒪᐃᓕᐅᖅᑎᑦᑎᓚᐅᖅᐳᑦ ᑐᑭᓯᓇᑦᑐᓗᑎᒃ ᕿᑭᖅᑖᔾᔫᑉ ᑐᒃᑐᖏᑦ ᓇᔾᔨᕗᒃᑐᑦ ᐅᓄᕐᓂᖏᓐᓂᒃ. ᓇᔾᔨᔪᑦ ᐅᓄᕐᓂᖏᑦ ᐅᐱᕐᙱᒃᑯᑦ ᖁᖓᓯᕈᖅᓯᒪᔪᑦ ᑐᒃᑐᖏᑦ 94%−ᒥᑦ ᐅᓄᕐᓂᖅᓴᐅᖅᑰᔨᖓᓗᐊᖅᑎᓪᓗᒋᑦ, ᑖᒃᑯᐊ ᖃᐅᔨᓴᖓᒃᓴᐃᑦ ᐅᓄᕐᓂᖅᓴᐅᕗᑦ ᖁᐃᓂᓂᖅᓴᐃᑦ ᑐᒃᑐᐃᑦ ᓂᕈᐊᖅᑕᐅᖃᑦᑕᕐᓂᖏᓐᓄᑦ ᖁᖓᓯᕈᖅᑕᐅᓂᐊᖅᑐᑦ. ᓇᔾᔨᔪᑦ ᐅᓄᕐᓂᖏᑦ ᐊᖑᓇᑦᑎᓂᑦ ᖃᐅᔨᓴᒐᒃᓴᖅᑖᕆᔭᐅᔪᑦ ᐅᓄᕐᓂᖏᓐᓂᒃ ᑭᒡᒐᖅᑐᐃᑦᑎᐊᕐᓂᖅᓴᐅᕗᑦ ᐊᕐᕌᒍ ᐊᑐᖅᑎᓪᓗᒍ ᐅᓄᙱᓐᓂᖅᓴᐅᖅᑰᔨᕗᑦ ᓂᕆᐅᒋᔭᐅᔪᒥᑦ ᓇᔾᔨᔪᑦ ᐅᓄᕐᓂᖏᓐᓂᒃ (69%). ᕿᑐᙱᐅᓗᐊᙱᑦᑐᑦ ᐃᓚᖃᖅᓱᓂ ᐊᓐᓇᒃᐸᒃᑐᑦ ᐊᒥᓲᙱᓐᓂᖏᑦ, ᓇᓗᓇᐃᖅᓯᔾᔪᑕᐅᒃᑲᓐᓂᖅᐳᑦ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᐊᓂᖏᓐᓂᒃ. ᐊᒻᒪᓗᑦᑕᐅᖅ, ᐅᓄᖅᓯᕖᓪᓕᕋᓗᐊᖅᐸᑕ, ᑖᓐᓇ ᐃᑲᔫᑕᐅᓇᔭᙱᑉᐳᖅ ᑐᒃᑐᐃᑦ ᐊᓐᓇᒃᐸᒃᑐᑦ ᐅᓄᙱᓐᓂᖏᓐᓂᒃ ᓱᕋᙱᓐᓇᕐᓂᕋᐃᔪᓂᑦ (Boulanger et al., 2011).

ᑭᖑᓂᑦᑎᓐᓂᓕ ᑲᖏᒋᔭᐅᓚᐅᖅᑐᑦ ᕿᑭᖅᑖᔾᔫᑉ ᑐᒃᑐᖏᑦ ᑕᒡᔪᐊᕈᓐᓃᖅᑕᑦᑕᕐᓂᖏᓐᓂᒃ ᐅᓄᙱᑦᑐᑯᔾᔪᓪᓗᑎᒃ, ᒫᓐᓇ ᖃᐅᔨᓴᖅᑕᐅᔾᔪᑎᑦ ᖁᖓᓯᕈᖅᓯᒪᔪᑦ ᕿᑭᖅᑖᔾᔫᑉ ᑐᒃᑐᖏᓐᓂᒃ ᓇᓗᓇᐃᖅᓯᙱᓚᑦ ᑐᒃᑐᐃᑦ ᐅᓄᖅᑐᑦ ᑕᒡᔪᐊᖃᑦᑕᙱᓐᓂᖏᓐᓂᒃ ᓄᓇᐃᓐᓇᕐᒧᑦ ᐅᑭᐅᒃᑯᑦ. 2015-2016−ᒥᑦ ᐊᒻᒪ 2018−ᒥᑦ ᖁᖓᓯᕈᖅᓯᑲᑕᒃᑎᓪᓗᒋᑦ, ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᓴᖅᑭᑎᑦᑎᓚᐅᖅᐳᑦ 35-ᒥᑦ ᐊᒻᒪ 49-ᒥᑦ ᕿᑭᖅᑖᔾᔫᑉ ᑐᒃᑐᖏᑦ ᖁᖓᓯᕈᖅᓯᒪᔪᑦ ᐊᑐᐃᓐᓇᐅᓚᐅᕐᓂᖏᓐᓂᒃ ᖃᐅᔨᓴᖅᑕᐅᓂᐊᖅᑐᑦ. ᑖᒃᑯᓇᓂ, ᒪᕿᐃᓈᒃ ᐱᓕᕆᐊᖑᔫᒃ ᑐᒃᑐᖏᑦ ᓄᓇᐃᓐᓇᕐᒧᑦ ᐃᑳᙱᑦᑐᑦ, ᐅᑭᐅᖑᑎᓪᓗᒍ ᐊᑐᖅᑕᐅᓚᐅᖅᐳᖅ 2016-2017−ᒥ. ᑭᓯᐊᓂ, ᐅᓗᒃᕼᐊᖅᑑᖅ ᐊᖑᓇᑦᑎᖏᑦ ᐅᖃᓚᐅᖅᐳᑦ ᐅᓄᕐᓂᖅᓴᐃᑦ ᕿᑭᖅᑖᔾᔫᑉ ᑐᒃᑐᖏᑦ ᑮᓪᓕᕐᒦᖏᓐᓇᖃᑦᑕᖅᐳᑦ ᐊᕐᕌᒍᓕᒫᖅ. ᑐᒃᑐᐃᑦ ᖃᔅᓯᓪᓚᑦᑖᖑᓂᖏᓐᓂᒃ ᕿᑭᖅᑕᒦᑦᑐᑦ ᖃᐅᔨᒪᔭᐅᙱᒃᑲᓗᐊᖅᑎᓪᓗᒋᑦ, ᑖᒃᑯᐊ ᖃᐅᔨᓴᕈᑕᐅᔪᑦ ᑕᒡᔪᐊᖅᐸᒃᑐᑦ ᑐᒃᑐᖏᓐᓂ ᓄᖑᕋᐃᓗᐊᖅᑕᐃᓕᒪᓂᕐᒧᑦ ᐃᓱᒪᓗᑕᐅᔭᕆᐊᖃᖅᐳᑦ. ᐅᓄᙱᓐᓂᖅᓴᐃᑦ ᑲᑎᙵᔪᑦ ᐱᑕᖃᕋᓗᐊᖅᐸᑕ ᑕᒡᔪᐊᖅᐸᙱᑦᑐᑦ ᕿᑭᖅᑖᔾᔫᑉ ᑐᒃᑐᖏᑦ ᕿᓪᓕᓂᕐᒥᖃᑦᑕᖅᑐᑦ, ᑲᑎᕝᕙᒋᑦ ᑐᒃᑐᐃᑦ ᐋᖅᑭᐊᕈᑕᐅᓇᔭᙱᒻᒪᑦ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᕐᔪᐊᖅᑐᓄᑦ ᓄᓇᐃᓐᓇᒥ ᑕᑯᔭᐅᓯᒪᔪᑦ, ᑕᒡᔪᐊᖅᐸᒃᑐᑦ ᐃᓚᖏᑦ ᑐᒃᑐᐃᑦ ᑲᑎᙵᓐᓂᑦ.

ᕿᑭᖅᑖᔾᔫᑉ ᑐᒃᑐᖏᓐᓂᒃ ᖃᐅᔨᓴᕈᑕᐅᔪᑦ, ᐊᒻᒪᓗ ᑕᑯᔭᐅᓯᒪᔪᑦ ᓇᒧᙵᖅᐸᓪᓕᐊᓂᖏᓐᓂᒃ ᓇᓗᓇᐃᖅᓯᔾᔪᑎᑦ, ᓇᓗᓇᐃᖅᓯᕗᑦ ᑲᔪᓯᓂᖓᓂᒃ, ᐅᔾᔨᕐᓇᕐᓂᖓᓂᒃ ᐊᒻᒪ ᐊᕐᕌᒍᓂ ᐅᓄᙱᑦᑐᓂᒃ ᖄᖏᖅᑐᓂᒃ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᕐᓂᖏᓐᓂᒃ. ᐃᓚᖅᑯᓯᑎᒍᑦ ᑮᓇᐅᔭᓕᐅᕋᓱᖕᓂᕐᒧᓪᓗ ᐱᒻᒪᕆᐅᓂᖓ ᑐᒃᑐᐃᑦ ᓄᓇᕗᒻᒥᐅᑦ ᓄᓇᓕᖏᓐᓄᑦ ᐊᖑᓇᓱᒃᑎᓄᓪᓗ ᐃᖃᓗᒃᑑᑦᑎᐊᕐᒥᐅᓄᑦ, ᐅᒥᖕᒪᖅᑑᕐᒧᑦ, ᕿᙵᐅᒻᒧᑦ ᐊᒻᒪ ᖁᑦᓗᖅᑑᕐᒧᑦ ᓄᓇᑦᓯᐊᒥᐅᓪᓗ ᓄᓇᓕᖏᓐᓄᑦ ᐅᓗᒃᕼᐊᖅᑑᕐᒧᑦ ᐊᒻᒪ ᐸᐅᓚᑐᕐᒧᑦ, ᕿᑭᖅᑖᔾᔫᑉ ᑐᒃᑐᖏᑦ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᕐᓂᖏᑦ ᐃᓱᒪᓘᑕᐅᓗᐊᖅᐳᑦ ᓄᓇᓕᖕᓂ, ᐊᖑᓇᑦᑎᓂᑦ, ᐊᒻᒪ ᑭᒡᒐᖅᑐᐃᔨᐅᕝᕕᖃᖅᑐᑦ ᐱᓕᕆᔨᖏᓄᑦ. ᖃᐅᔨᓴᕈᑕᐅᔪᑦ ᐅᓂᒃᑲᐅᓯᐅᔪᑦ ᓇᓗᓇᐃᖅᓯᔾᔪᑕᐅᕗᑦ ᑲᑎᕆᓐᑦ ᐅᓗᕆᐊᓇᖅᑐᕕᓪᓕᕐᓂᖏᓐᓂᒃ ᐊᒻᒪ ᑐᐊᕕᕐᓇᖅᑐᒥᒃ ᐋᖅᑭᒃᓯᔭᕆᐊᖃᓕᖅᓗᑎᒃ ᐊᑑᑎᖃᖅᑐᒥᒃ, ᑭᒡᒐᖅᑐᐃᔨᐅᙵᖃᖅᑐᑦ ᐊᐅᓚᑦᑎᔾᔪᑎᒃᓴᖓᓂᒃ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᐊᑎᑦᑎᑦᑕᐃᓕᒪᔪᒥᒃ ᐊᒻᒪ ᐅᑎᖅᑎᑦᑎᕙᓪᓕᐊᑎᑦᑎᔪᒥᒃ ᕿᑭᖅᑖᔾᔫᑉ ᑐᒃᑐᖏᓐᓂᒃ. ᑲᑎᕆᓐᑦ ᐊᔾᔨᒋᔭᐅᙱᓐᓂᖏᓐᓄᑦ ᐱᒻᒪᕆᐅᓂᖏᓐᓄᓪᓗ ᐊᐅᓚᑦᑎᔨᐅᖃᑎᒌᑦ ᐱᓕᕆᖃᑎᒌᒋᐊᖃᓪᓚᕆᒃᐳᑦ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᐊᔪᑦ ᑲᒪᒋᔭᐅᓗᑎᒃ ᓄᖑᕋᐃᓗᐊᙱᓪᓗᑎᒃ ᐊᐅᓚᑦᑎᔾᔪᑎᒥᒃ ᐊᑐᕐᓗᑎᒃ. ᕿᑭᖅᑖᔾᔫᑉ ᑐᒃᑐᖏᓐᓂᒃ ᐊᐅᓚᑦᑎᓂᕐᒧᑦ ᐸᕐᓇᐅᑦ ᐊᖏᖅᑕᐅᔪᖅ ᒪᓕᒃᑐᒍ, ᑖᒃᑯᓇᓂ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᐊᔪᓂᑦ, ᓱᕋᖅᑕᐃᓕᒪᑎᑦᑎᓂᕐᒧᑦ ᐊᐅᓚᑦᑎᔾᔪᑎᒃᓴᓂᒃ ᓴᖅᑭᑕᐅᔪᖃᕆᐊᖃᖅᐳᖅ ᕿᑭᖅᑖᔾᔫᑉ ᑐᒃᑐᖏᓐᓂᒃ ᓄᖑᕋᐃᓗᐊᖅᑕᐃᓕᒪᓗᑎᒃ ᐃᑲᔪᖅᑐᐃᔪᓂᓪᓗ ᑲᑦᑎᕆᓐᑦ ᐅᑎᖅᐸᓪᓕᐊᕐᑯᓪᓗᒋᑦ.

Aulapkaijini Naittumik Uqauhiit

Dolphin and Union (DU) Tuktuit (*Rangifer tarandus groenlandicus* x *pearyi*) angijumik hanguviqaqtut piplutik Kiillinirmi ((Victoria Island) Nunavumi Nunatsiamilu) tununnganinganilu Kanadaup iluilingani Nunavunmi. Ukuat DU Tuktuit nurivaktut aujiplutiklu Kiillinirmi, pidjutiplutik atuqatigiingnikkut tununngani-ualirni nunani upakvigigijanun ukununga Peary Tuktuinni (*Rangifer tarandus pearyi*). Taimaatun Peary Tuktuit ukiivaktun Kiillinirmi, ukuat DU Tuktuit utiuvaktut ikaaqhugu tariup-hikua Coronation Gulf-mi ukiiplutik Kanadaup iluiliani. Iluilingmungaraangamik, DU tuktuit ukiivaktut katimaqatigiplugin aallat ukiuqtaqtumi-ukiivaktuni tuktuni uvani kivataani ukiivingmingni. Ilaupluni uumani taimaaqpiaq auladjutimun aujamilu najurvigijainni, ukuat DU Tuktuit ilitrijauttaaqtun, naunaitpiaqtukkut, timiutikkut aallanin tuktuinnin (Peary Tuktuit ukuallu Barren-ground Tuktuinnin), naunaiqtittugu nunguttailinikkut anginiqarniit ukunani tuktuinni.

Hinaanin naunaijarniq qanuriliuruti, hivulliqpaakkut piliuqtauhimajuq NIshi-min (2004), atuqtauhimavaktuq nalautinniaqhimaplugin DU tuktuit talvannga 1997min taimaatun qimakpakkamikkik Peary tuktuit ukiakhami. Una qanuriliurniq tunnganiqaqtuq anguniaqtinin tautukhimadjutainnin uvanilu I*nuit Qaujimajatuqanginnin* ukunani Dolphin and Union Tuktuinni katidjutainni majurhagaliraangamik tuattumi tikiraqmi hivuraani hiningani Kiilliniup. Tuktuit utaqqivaktun hinaani (lihimajaujuq nutqangajun) tariup-hikua ivjuhiqhiiplugu utiujaamingnik iluilingmun. Uvani, ubluq tamaat auladjutait aktilaangit ihumagijaujun hunguqpiangittun qanuriliurutilu ihumagijuq amigaitqijaujut tuktuit tautungnaqtun hinaani nunguliqtillugu October. Taimaatun ukuak malruuk ihumagijaujuk itquumakpata, qanuriliuruti tuniniaqtuq ihuarutiqaqtumik amigaitilaangitigun nalautinniarhimadjutinik. Aajjikkutaq qanuriliuruti atuqtauvaktuq 1997, 2007, 2015, 2018milu naunaijarnirni pijaami amigaitilaatigun nalautinniarhimadjutikhanik, pipkainikkut taimailiurutikkut qaujiharutikhanik. Uvani Ukiakhami 2015, tahapkunani tamatkiumayunik nalautakgutauvaktunik tahapkunani inirutauvaktunik ilidjuhinik nunauliuqhimayunik nalgungayunik malikgakhanik havakhikhimayunik 14,730 (SE=1,5071, CV=10.2%, CI=11,475-17,986) tuktunik, pidjutihimajuq itqurniarhimajunik amigaitilaanginnik nalautinniarhimajunik imaatun 18,41 (SE=3,133.8, CV=17, CI=11,664-25,182) tuktuinni (Naunaitkutaq 1). Nampaitigun angijumik ikiklijuummirutinik imaatun 66%-kut tautuktaujuq 2007min 2015mun naunaijarutinin, tamaitqiutiqaqtuq imaatun 4%mik ukiuq tamaat ikilijuummirutimik. Taimainningani aktilaangani ikiklijuummiqtirutimi, amigaitqijaujunik piqattarutinik amigaitilaanginni tuktuni amirinirni pivaktuq qaujihariami tuituinni qanuridjutilirininginni. Pilluarumadjutaa uumani naunaijarnirmi taimaatun tunijaami itqurniarhimanikkut amigaitilaanginni nalautinniarhimajuni, pijaamilu tadja qanuridjutilirininginni nakuumik aulapkaidjutikhanun.

Una 2018mi naunaijarniq pivaktuq akunngani October 31min November 4mullu, 2018. Tamatqiutihimajuni 38nik qunghuhinirmiaqaqtunik tuktut amirijauvaktun naunaijarumaplugu humiinninginnik auladjutainniklu pidjutinginnun hinaani nunani. Talvani kingulliqpaami takuhimanikkut naunaijarnirmi, 89%ngujut qunguhunirmiaqaqtuni tuktut iluaniittun naunaijarnikkut nunani; piqaqtuq 63%nik talvaniittun hinaani nunani imaalu 26%ngujun ittun malguungni tatpaani-nunami tununngani Qikiqtanajungmi, pidjutigiplutik kingulliinnik qunguhinirmiaqaqtunik tuktunik hilataani hinaani nunani. Ukuat 11%-ngjun qunguhinirmiaqaqtuni ilaliutihimangittun kinguqliqpaami amigaitilaanginni naunaijarnirmi huli ilaliuthimajun naunaijarutingani itqurniarhimanikkut amigaitilaanginni nalautinniarhimajuni.

Qunguhinirmiaqaqtut tuktuit tahamaniittun malguungni tatpaani-nunami naunaijaqtillugin tikittun hinaanun ikaaqtiliqhutiklu tariukkut Novembermi, iniriiktauhimaliqtillugu naunairjarniq. Taimaatun, tamatqiutihimajun nalautinnarhimajun amigaitilaanginnik tuktuni talvani kingulliqpaami takuhimanikkut (89%ngujut qunguhunirmiaqaqtuni tuktut) imaatun 3,673 (SE=595.5, CV=16.2%, Cl=2,660-5,073) tuktuit, pitjutilik itqurniarhimanikkut amigaitilaanginni nalautinniarhimajuni imaatun 4,105 (SE=694.8, CV=16.9%, Cl=2,931-5,750) tuktuni (Naunaitkutaq 1). Hapkuat naunaitkutit tautuktijun piqpiaqtunik amigaitilaangin ikiklijuummiqtun ukunani 2015min 2018mullu, pipluni ukiuq tamaat aallanguqtirnirmik imaatun 62%mik.

Pihimajun amigaitilaangit ihivriuqtauvaktullu naunaijarumanikkut amigaitilaanginnik qanurinninginnik ukunani DU tuktuinni. Ukiuq tamaat qunguhinirmiaqaqtuni arnarlungni annaumajuni nalautinniarhimajun 2018mun unaujuq 0.62 (SE=0.07, CI=0.48-0.75), ilaqaqtuq ilihimajaujunik anguniarutinik nunami tuqudjutikkullu. Taimaatun ilihimajaujun annguniarnikkut tuqudjutit piirhimakpat annaumajuni nalautinniarhimajunin, taimaatuttauq annaumajuni amigaiqjuummiqpaktuq uumunga 0.72, tuniutipluni taimaitpiarnikkut naunaitkutinik kangirhidjutikkut anguniarnikkut tuquvaktun piqpiarutiungnarhijuq tautungnaqtuni ikiklijuummiqtirutini amigaitilaanginni. Hapkuat ikitqijaujut annaumajuni amigaitilaangiq aajjikkiigutijun naunaijarnirmi ilitturihimajuni tauktuknaqtuni ikiklijuummirutini amigaitilaanginni. Aallat amigaitilaakkut qaujiharniit (Boulanger etal., 2011) naunaiqtihimajait kulavait annaumanikkut amigaitilaangit pijukhauhimajun mikinikhaanun kiklinganun imaatun 0.80-0.85 amitaitilaanginnun auladjutikhaanun (pidjutilgit qanuqtun amigaiqjuummirutainni) taimaalu qulvanitqijaujunik annaumanikkut amigaitilaanginnik ihiariagijaujun amigaitilaangit amigaiqjuummirianginni (Adamczewski et al., 2019; Boulanger et al., 2019). Qaujiharvingmin naunaijarutit arnarlungnin anainnin, katitiqhimajun qunguhinirmiaqaqtunin tuktunin anguniaqtunillu anguhimajunik naunaijarutinin, havakhimajuq naunaijariami najjihimanikkut aktilaanginnik ukunani DU tuktuinni. Taimaitkaluaqhuni najjihimajun aktilaangit taapkunannga upingaami qunguhinirmiaqaqtunin tuktuni naunaijautini qulvahiktutun ittuq imaatun 94%ngupluni, hapkuat naunaijautit taimaittuujungnarhijun nakuunirnun ihumaliuriiqhimanikkut pidjutainnik puvalatqijaujunik tuktunik qunguhiniarmialiktaujukhanik. Najjihimanikkut aktilaangit taapkunannga anguniaqtunin naunaijarutinin taimailluarungnarhijun naunaittiarutiuplutik tuktuinni talvani aajjikkiiktumi hivitunirni naunaihimajunik atpahilluamik talvannga niriuktaujumin najjinikkut aktilaanginni (69%). Atpahiktun nauvaktun ilauplutik ukununga atpahiktuni annakhimajuni, naunaiqjuummiqtidjutaujullu uumani ikiklijuummilqtumik tuktuinnik. Taimaalu, piqaraluaqqat qulvahitqijaujunik nauvaktunik, una pidjutiulimaittuq atpahiktunik kulavanik annakhimanikkut aktilaanginnik aulapkaidjutikkut aularaanginnaqtukhamik tuktuinnik. (Boulanger et al., 2011).

Malingittumik hivuagun ihumagijauhimajuni taapkuat DU tuktuit utimuujungnaiqpaktun ikikligaangata, una tadja naunaijarutait qunguhinirmiaqaqtuni tuktuni ilitturipkaingittuq amigaittun ilanginni tuktuni utimuungittun iluilingmun ukiunguraangat. Talvannga 2015-2016min 2018millu qunghuhinirmiaqturnirmi pinahuarutimin, ilitturipkaidjutikhat pijun taapkunannga 35nin ukunanngalu 49nin DU qunguhinirmiaqaqtunin tuktuinnin hailihmajun naunaijarnirnun. Hapkunannga, malruunginnaujuk pidjutik tuktuinni ikaangittun iluilingmun, pivaktuq uvani ukiumi 2016-2017mi. Kihimi, Ulukhaktokmin anguniaqtit unniutihimajun amigaiqjuummiqtun DU tuktuit tahamaniiraanginnaliqtun Kiillinirmi (Victoria Island) ukiuq-tamaat. Taimaitkaluarhuni nalautpiaqhimajuq amigaitilaangin ilanginni tuktuinni tahamaniittun qikiqtami ilihimajaungittuq, una naunaijarniq naunaitkutaa utiuvaktuni tuktuni pidjutiujukhaq nunguttailinikkut ihumaaluutaujukhaq anguniaqpaktunun Dolphin Union tuktuinnik, ihumagingillugin tahamaniittun ikittun katimajun utiujuittun DU tuktuit najuqtaat Tununganiani Kiillinirmi, taimaittungittunarhingmat amitaitilaakkut tamatqiutikkut hapkunani tuktuinni ilangautilimaittun qajangnaqtukkut ikiklidjutainnik tautukhimajun taapkunaulluaqtuni, utiujuktuni amigaitilaanginni tuktuinni.

Ukuat DU tuktuinni naunaijarnikkut pidjutainni, ukuallu tautukhimajuni amigaitilaakkut naunaitkutini, naunaiqtittun aularaanginnaqtumik, anijumik taimaalu, qangannuani ukiumi, angauqpiaqtuq, ikiklijuummirniq. Taimaatun pitquhikkut piangaijarnikkullu anginiqaqtukkut tuktuinnik ukununga Nunavunmi nunallaani anguniaqtinullu Iqaluktuuttiami, Omingmaktomi, Kingaonmi, Kugluktumilu Nunatsiamilu nunallaani Ulukhaktomi Paulatumilu, ikiklijuummirniq DU tuktuinni ihumaalungnaqpiaqtuq nunallaanun, anguniaqtinun, naliinnilu-nunagijaujuni paannarijaujuni. Taapkuat pidjutait tunihimajun uumannga naunaijarnirmi tautuktitait qajangnarutait tuktuinni umanilu ihariagijauqpiaqtuni pivallialiurnikkut nakuujunik, naliinni-nunagijaujunin aulapkainikkut hanaqidjutikhanik turaangajun ingattaqtailinikkut ikiklijuummirutainnik pipkainikkullu amigaiqtirutainnik DU tuktuinnik. Pidjutainnin aallanganikkut anginiqarnikkullu uumani tuktuinni, anginiqaqpiaqtuq atauttikkut-aulapkaidjutikkut paannariit havaqatigiiktukhat kiujaami ikiklijuummirniq talvuuna aularaanginnaqtukkut aulapkaidjutinik. Malikhugin angiqtauhimajun Dolphin and Union Tuktuinni Aulapkainikkut Hivunikhami, uvani ikittuni tuktuinni, amigaitqijaujun nunguttailinikkut qanuriliurutikhat pivallialiuqtaujukhat tammaqtailinikkut DU Tuktuit ikajurlunilu annaktihimanikkut tuktunik.

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Introduction

In the early 1900s, two different types of caribou were observed on Victoria Island. A small portion of caribou that were smaller and whiter remained on Victoria Island year-round, whereas other caribou were seen migrating across the Dolphin and Union Strait in the fall, to winter on the mainland (Manning, 1960). Due in part to their distinct wintering strategy and physical appearance, the migrating caribou were called the Dolphin and Union (DU) Caribou herd (*Rangifer tarandus groenlandicus x pearyi*) based on the name of the strait the caribou were then crossing (Gunn and Fournier, 2000). The other resident caribou were called the Minto Inlet Caribou as they are known to be found year-round close to the Minto Inlet area. The Minto Inlet Caribou appear most similar to caribou on Banks Island and were later known to be Peary Caribou (*Rangifer tarandus pearyi*). Later, the DU Caribou herd, was found to be genetically distinct from other caribou herds, but they also share haplotypes with neighbouring Barren-ground Caribou herds (Zittlau 2004; Eger *et al.*, 2009; McFarlane *et al.*, 2009) and Peary Caribou, which suggests a certain degree of inter-breeding.

In the first half of the century, it was assumed that the DU Caribou migration was density-dependent and driven by their population size; when the herd declined to low levels, they halted their migration to the Canadian mainland (Godsell, 1950). In the 1970s and into the early 1980s, hunters reported an increase in sightings of caribou on southern and central Victoria Island, which suggested an increase in abundance (Gunn, 1990). In the summer of 1980, Jakimchuk and Carruthers flew systemic transect lines on the western side (6.25% coverage) and central part (3.313% coverage) of Victoria Island for a polar gas project. With their relatively low survey effort and coverage, they most likely underestimated the caribou number at 7,936 ± 1,118 animals (Gunn and Fournier, 2000). Still, at this point in time and with this caribou number, the DU Caribou herd was assumed, by some, not to migrate. Then in 1993, DU migration was documented with thousands of caribou found migrating from the mainland back to Victoria Island in the spring (Gunn, *et al*., 1997). Researchers at the time suggested this indicated an increase in DU caribou numbers and triggered the development of a more strategic method to effectively survey this herd.

In 1994, Nishi and Buckland used the barren-ground calving ground population survey methodology in a study area, which represented 63% of Victoria Island. The study area included the entire west side of the island, from the south coast to the north including Prince Albert Peninsula, all the way west of Hadley bay. They established five strata of uniform coverage in all strata (10% coverage). The survey was run during calving season from June 5 to 14 and resulted in an estimate of 14,529 ± S.E. 1,015 caribou. This assessment underestimated the total number of the DU Caribou herd or the total number of caribou on Victoria Island (Peary Caribou and DU Caribou), since an unsystematic aerial search in the eastern portion of Victoria Island confirmed additional female and calf pair sightings outside of the study area from the Collinson Peninsula up to Storkerson Peninsula (Nishi and Buckland, 2000). The inadequacies of this survey method indicated that the DU Caribou herd should not be surveyed based on the traditional calving ground methodology, as these caribou seem to have an individualistic and dispersed calving ground strategy (Bergerud, 1996). In addition, the estimate from the Nishi and Buckland (2000) survey most likely included the Peary caribou that are known to be in the Prince Albert Peninsula area, where the degree to which the two caribou herds mix in the summer range is not fully understood.

In response to the inability to effectively delineate a specific calving ground, due to the DU Caribou individualistic calving strategy, a new survey method was developed by Nishi and Gunn (2004). To develop this new methodology, hunters provided valuable input to identify when would be the best time to survey this herd, during a time when they are not mixing with the Peary Caribou. Based on hunter observations and local Indigenous Knowledge, the survey was designed to survey the DU Caribou when both sexes were known to gather during the rut within a narrow band (10 km from the shoreline) on the southern coastline of Victoria Island. The caribou wait along this coastline (known as staging) as the sea-ice forms enough for them to resume their migration. During this time, their daily movement rate is presumed to be relatively low and assumes that the majority of the herd are found along the coastline at the end of October.

The first population survey of the DU Caribou following the development of the coastal survey method, was flown in fall 1997 and resulted in an estimate of 27,948 ± SE 3,367 caribou in the final survey strata on the coastline (Nishi and Gunn, 2004). The DU Caribou herd was next surveyed in 2007 following the same methodology. Dumond and Lee (2013) estimated 21,753± SE 2,343 caribou in the final survey strata on the coastline. Both the 1997 and 2007 surveys did not have any collar location data available, to determine with precision when the majority of caribou had reached the shoreline to start the count of the final visual strata. Thus, to determine the proportion of caribou that were outside the coastal survey strata, Dumond and Lee (2013) used satellite collar data from previous years to later extrapolate the proportion of latent caribou that had not yet reached the coast at the time of the aerial survey and then applied the same analysis to the 1997 estimates. This resulted in a revised extrapolated estimate of 34,558 ± Cl 4,283 caribou in 1997 and 27,787 ± Cl 3,613 caribou in 2007. Statistically, the difference between the 1997 and 2007 population estimates were not significant and the conclusion was made that the population remained, at best, stable, over the decade (Dumond and Lee, 2013). Nonetheless, local Indigenous Knowledge affirmed that the DU Caribou herd had started to decline over the same period (Tomaselli et al., 2018)

In 2014 and early 2015, a Traditional Indigenous Knowledge study conducted by Tomaselli et al., (2018) in Cambridge Bay concluded that the DU Caribou reached their peak numbers at some point between 1990 and 2005, then the herd started to decline in the mid-2000's. Interviewees that participated in the study indicated that they were seeing about 80% less caribou around Cambridge Bay compared to what they observed in the 1990s. Since the decline began, Tomaselli's findings suggest that hunters observed a decrease in the number of yearlings and calves, observations of poorer caribou body condition, and increased observations of caribou with abnormalities or diseases (Tomaselli, 2018). This information triggered the need for the 2015 Dolphin and Union population survey.

To accurately determine when the majority of DU Caribou (defined as more than 75%) have reached the coastline (final survey strata), and the proportion of latent caribou (outside the final survey strata), collars were deployed (17) on the mainland in the spring of 2015, to be used to determine the timing of the coastal population survey in the fall of 2015. The same coastal survey methodology was used to allow for comparison with previous surveys and to establish a trend. When the final visual strata were flown, the majority (79%) of the collared caribou had reached the coastal survey area, and a small number were starting to cross the sea-ice. The fall 2015 survey resulted in an estimate of 14,730 (SE=1,507, CV=10.2%, CI=11,475-17,986) caribou on the coastline, resulting in an extrapolated population estimate, including the latent caribou (outside the survey strata), of 18,413 (SE=3,133.8, CV=17%, CI=11,664-25,182) by using real time collar location. At the time of the survey, only one collared caribou was located east of Cambridge Bay and few groups were observed off transect, confirming the recent Indigenous Knowledge that 80% less caribou had been observed around

Cambridge Bay. The observed decline between the 2007 and 2015 estimates was statistically significant which resulted in a recommended increase of the monitoring schedule to every 3 years. This herd is the central herd for all Western Kitikmeot communities: Cambridge Bay, Kugluktuk, Bay Chimo, and Bathurst Inlet (Nunavut) and for Ulukhaktok in Northwest Territory. The decline of the DU Caribou creates concerns related to food security, cultural identity, and way of life of the Inuit across the range that depend on this herd.

With a decreasing DU Caribou population, there is an assumption, based on historical information and limited collar information, that the population will reach a threshold in which the herd will change its behavior by halting its sea-ice crossing to the mainland to instead winter on Victoria Island. Despite the presumption that the herd did not migrate to the mainland in the late 1980s, the DU Caribou were still observed on the southern coastline of Victoria Island in the fall, as this is the area where both sexes aggregate for the rut (Gunn pers. comm). Based on this observation, the coastal survey method could still be applicable to determine the population estimate of the DU Caribou herd past the population threshold in which they are believed to stop migrating. However, the timing in which the DU Caribou cross the sea-ice seems later, year after year, due to delayed sea-ice formation (Poole et al., 2010). How this delay is affecting the start of the migration inland, the migration pattern, or the physiological impact of a potentially longer period of staging at the coastline is currently unknown.

This project aimed to establish a new population estimate from the 2018 survey results, monitor demographic indicators (cow survival rate and pregnancy rate of collared caribou), and assess spatial changes in home range and change in sea-ice crossings. In addition, collars were deployed (50) and were used during the population survey to indicate that the majority of caribou (>75%) had reached the coastline and ensure the final visual survey was completed before caribou started to cross the sea-ice to the mainland. The information generated in this study are intended to inform the sustainable management of DU Caribou and the application of management recommendations to address their ongoing decline.

Methodology

Study area

The Dolphin and Union range encompasses Victoria Island and the Canadian mainland. Victoria Island is mainly characterized with undulating lowlands formed on flat-lying Palaeozoic and late Proterozoic carbonate rock that slope gently, and where the maximum elevation is 200 meters (Environment Canada, 1995). The land is covered with low rocky promontories, scattered eskers, and numerous ponds and small lakes. Victoria Island is part of the Northern Arctic Ecozone and made up of three ecoregions, the Wager Bay Plateau, Victoria Island Lowlands, and the Shaler Mountains (Environment Canada, 1995). The willows in southeastern Victoria Island are also found to be greater than further north on the island (Eldun, 1990). The southern coast of Victoria Island is part of the Wager Bay Plateau ecoregion. Some sites are characterized by taller dwarf birch and alder, but the vegetation is mostly characterized with a discontinuous cover of willow, northern Labrador tea, *Dryas* ssp., and *Vaccinium* spp. In the Wellington Bay region (southeastern), eight vegetation classes were distinguished and the presence of *Dryas* and *Salix* in many habitat classes suggests a wide capacity for environment tolerance (Schaefer and Messier, 1993). The Victoria Island Lowlands ecoregion, which constitute two-thirds of Victoria Island, is mainly dominated by arctic willow, alpine foxtail, wood rush, and other saxifrage species, such as the purple saxifrage. The lakes are surrounded with sedge, cotton grass, saxifrage and moss (Environment Canada, 1995).

Between Tree River and The Queen Maud Gulf Bird Sanctuary lay Bathurst Inlet within the Canadian Shield. Its northern location, above the tree line, place it within the southern border of the Arctic tundra. Uplands occur on either side of the inlet; to the east the Buchan and Bathurst Drift Uplands; and to the west, the Contwoyto Plateau, Wilberforce Hills and the Tree River Uplands (Bird and Bird, 1961). The vegetation in the river valley is lush where shrubs, birch, and the willow can reach up to 2 -3 meters (Cody et al., 1984). The Uplands are characterized by a rock desert cover with a patchy distribution of cushion plants, prostrates shrubs, lichens, and bryophytes. The winter conditions are among the most severe in the Arctic and the summer is relatively mild at the head of the inlet (Maxwell, 1981).

Collar deployment 2018

The DU caribou have been wintering on the Canadian mainland. As the spring approaches, the caribou move to the coast of the mainland, concentrate to feed and rest (staging), and start to cross back to Victoria Island in April (Gunn et al., 1997; Bates, 2006). At this time, they are found near the coastlines and collars can be deployed from Tree River to Hope Bay area. In mid to end of April 2018, consistent with the deployment areas of 2015 and 2016, 50 collars were deployed on DU Caribou between Kugluktuk and the Kent Peninsula.

The caribou were targeted and collared with Lotek GPS Globalstar Lifecycle satellite collars following the capture methods involving tangle net and net gunning team from a helicopter (TAEM, 1996). The caribou capture work was performed by an experienced capture crew: net gunner and one handler, under a fixed time. The time between the beginning of the pursuit (which was kept under 1 minute) to the animal being released did not exceed 10 minutes. This was done in order to keep stress levels to a minimum and thereby increase the survival rate post-collaring. To further decrease post-collaring mortality, collars were deployed at outside temperatures above -25° C to avoid freezing the lung tissue of the caribou while running. Though adult cows were targeted, males were also captured as by-catch and collared during the course of this capture program. Once a caribou was immobilized, hair samples from two different body locations (rump and neck), feces, blood samples, and photographs (teeth, body and eye) were taken. By palpitation of the shoulder, ribs, and hips/spine, a body condition score was given according to CARMA's protocol level 2 for live animals (CARMA, 2008) to determine overall fatness. All noticeable anomalies were recorded. The scat samples were sent to a laboratory for pregnancy testing and genetic analysis under the standard set of 18 microsatellite markers to confirm the specific genetics signature of the DU caribou, similarly to what has been done in past caribou projects from across Canada (Serrouya et al., 2012).

Population Estimate

Integration of Local Knowledge in the Survey Design

On September 28, 2018, a month prior to the survey, the relevant Nunavut co-management partners including the affected Hunters and Trappers Organizations (HTOs) of Cambridge Bay and Kugluktuk, Nunavut Tunngavik Inc. (NTI) and the Government of Nunavut Department of Environment (DOE) met to review the survey design and include additional local observations and co-management partners' recommendations. Scientific information, such as the 2018 collar distribution locations that show consistency between the previous two collaring years and the distribution of DU Caribou collar data as of September 09, 2018, was made available for discussion. Based on the available collar distribution and the recent observations, it was agreed that the survey effort should be concentrated to the west side of Victoria Island as all the collars were located west of Wellington Bay in September. Since 15 collars out of the 50 collars were captured on the east side of Bathurst Inlet the previous spring, the HTO members stipulated that these collars were not representative of the proportion of the DU Caribou herd that are known to summer east of Cambridge Bay. Therefore, it was recommended that the reconnaissance survey also include the east side of Victoria Island, as it was done in 2015. It was also decided that the inland collar locations would be investigated by flying to the collar and determining the number of caribou in the group associated with it. In the event that the number of animals was greater than 50, the area around the collar would be stratified and included as a separate inland visual stratum in the final count. For the reconnaissance survey, it was recommended that the transect lines were extended 20 km inland to account for additional caribou groups between the collared caribou, to ensure the main distribution of DU caribou was captured and incorporated into the estimate.

Collar caribou movement and survey design

The DU Caribou survey methodology is based on the assumption that at the end of October the majority of caribou gather within a very narrow band along the shoreline to rut, while waiting for the sea-ice to freeze in order to continue their migration to the mainland. At this time, the Peary and the DU Caribou herd are separated and use different parts of the island. Both sexes of DU caribou aggregate along the southern coast allowing for a herd estimate of the DU herd through a survey of the coastal area (Nishi, 2000; Nishi and Gunn, 2004; Poole *et al*., 2010), and their daily movement rate would be low (< 5 km/day) as the migration stops while caribou are staging. Changes in daily movement rates of collared cows were assessed to determine the movement rate during staging.

In 2018, to help determine the specific timing in which most caribou are in the coastal area, 38 available radio collared DU caribou on Victoria Island were tracked daily to index the distribution of the caribou herd relative to three specific areas: inland, in the coastal study area, and on the sea-ice. To better track caribou movement, the daily fixes were increased to six per day during the survey period. Using real-time collar locations to define the study area and estimate the population is meant to help support the assumption that the collared caribou distribution is representative of the herd distribution. The location of the caribou during the survey was further categorized into four different categories (North west strata, in-between, coastal, and crossing or mainland) to determine if the timing and spatial extents of the final visual survey effectively met the assumptions of this coastal survey method.

The survey was structured into two main components 1) a systematic reconnaissance survey that was used to delineate the distribution and the density of caribou on the coastal study area and 2) the systematic final visual coastal survey strata that was used to generate the coastal population estimate. In particular, previous survey results suggested that the final survey strata should include a minimum of 10 transects per stratum with closer to 20 transects being optimal for high density areas. Generally, coverage should be at least 15% with higher levels of coverage for high density strata. In the context of sampling, increasing the number of lines in a stratum provides insurance that it minimizes the influence of any one line on estimate precision. As populations become more clustered, a higher number of transect lines is required to achieve adequate precision (Thompson, 1992; Krebs, 1998).

Once a portion of the collared caribou reached the coast, the systematic reconnaissance survey was flown on the southern coastline of Victoria Island, from Read Island to Parker Bay, allowing stratification of the final visual coastal survey, while collared caribou outside the coastal area continued to move toward the coast. Caribou that spend the summer farther north, west of the Shale Mountains, arrive later at the coast. Thus, enough time to survey the final visual strata was allocated before the first collar began to cross the sea-ice. Sea-ice formation is known to occur earlier on the eastern side (Dease Strait) than on the western side (Coronation Gulf), which also influences the pattern of the caribou migration and the chronological order in which the final visual coastal survey strata was surveyed. If two or more collars had started to cross the sea-ice before the specific final visual coastal strata was surveyed, the survey would have been cancelled.

To account for the collars that were far inland and had not reached the study area during the reconnaissance survey, the methodology was to fly to the collar location to determine the group size of animals associated with specific collared individuals, as well as to determine the presence or absence of other groups of caribou in the area. If the group size associated with that collar was higher than 50, or the number of collared caribou inland was greater than 5 in a cluster, an inland stratum would be included in addition to the final visual coastline strata. For groups lower than 50, the collar locations relative to when the final visual strata were surveyed were summarized to determine the proportion of collared caribou that were within the survey area and outside the survey area at the time of the final visual survey. This percentage of collars estimated to be outside the survey area was used to extrapolate a population estimate while taking into consideration the proportion of latent caribou in the final herd estimate. This survey methodology provides two estimates 1) the final survey strata estimate (number of DU Caribou on the coastline) and 2) the extrapolated population estimate (DU Caribou on the coastline and outside the coastline/inland).

Aircraft configuration

The reconnaissance survey and the systematic final visual coastal survey strata were both flown with a fixed-wing aircraft, a Twin Otter. The transect lines were surveyed at an average speed of 160 km/hr and at an altitude of about 121 meters, which was maintained with a radar altimeter and due to the mostly flat relief of the study area. A radar altimeter was used to keep the aircraft at the proper survey altitude to keep the survey area consistent. A pre-determined transect width of 400 meters was set on each wing based on a calculation using the formula of Norton-Griffiths (1978) and others (Gunn and Patterson, 2000; Howard, 2011; Nishi and Gunn, 2004; Dumond and Lee, 2013).

$$w = W\left(\frac{h}{H}\right)$$

Where, *W*= the required strip width; *h* = the height of the observer's eye from the tarmac; and H= the required flying height (Figure1).

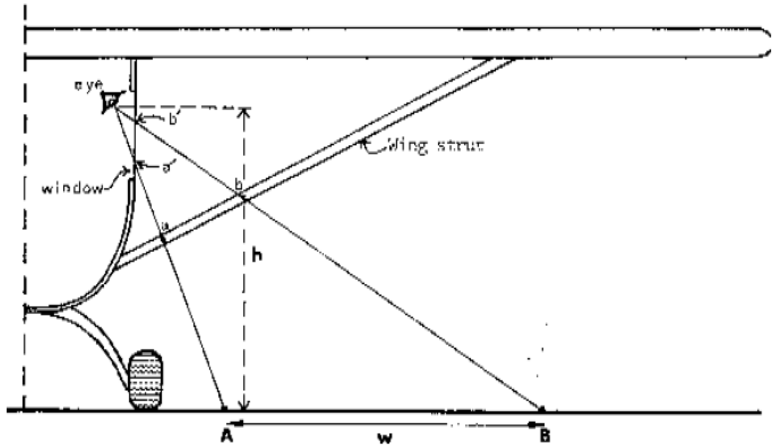


Figure 1: Schematic diagram of aircraft configuration for strip width sampling North-Griffiths (1978). W is marked out on the tarmac, and the two lines of sight a'-a-A and b'-b-B establish, whereas a'- and b' are the window marks.

The survey utilized a dependent double-observer pair method. The typical configuration was comprised of the pilot, two data recorders (rear left and front right) and four observers (two on the left side of the aircraft and two on the right side). Only caribou observed within the strip, as defined by the inner and outer streamers attached to the left and right struts of the aircraft, were recorded (Campbell et al. 2012). As per Campbell et al., (2012) two observers were used on each side of the plane to ensure higher sighting probabilities and fewer missed observations. Double-dependent observer methods assume that sighting probabilities of each observer were equal. To help meet this assumption, primary and secondary observers switched position during the survey. Sighting and caribou counts on transect were recorded on a touch screen tablet computer with software commonly used in other barren-ground caribou surveys in both Nunavut and the Northwest Territories. As each caribou group (observation number) was recorded with the number of caribou composing the group, a real-time GPS waypoint was generated, allowing geo-referencing of the survey data. The use of the field tablet increased the data entry speed, accuracy, and reduced the time required to perform preliminary analysis of the reconnaissance data for stratification required in the final visual coastal survey.

Final visual coastal strata estimate

Caribou abundance in each coastal strata was estimated using standard formulas for aerial surveys (Jolly 1969; Krebs 1998). The population estimates for fixed-width strip sampling using Jolly's Method 2 for uneven sample sizes are derived from the following equation:

$$\hat{N} = RZ = Z\frac{\sum_i y_i}{\sum_i z_i}$$

Where $\hat{N}$ is the estimated number of animals in the stratum, R is the observed density of animals (sum of animals seen on all transects $\sum_i y_i$ divided by the total strata area$\sum_i z_i$), and Z is the total strata. The variance for each strata is given by:

$$Var(\hat{N}) = \frac{N(N-n)}{n}\left(s_y^2 - 2Rs_{zy} + R^2 s_z^2\right)$$

Where N is the total number of transects required to completely cover stratum Z, and n is the number of transects sampled in the stratum. s_y^2 is the variance in counts, s_z^2 is the variance in areas surveyed on transects, and s_{zy} is the covariance. The estimate $\widehat{N}$ and variance $Var(\widehat{N})$ are calculated for each stratum and summed. The Coefficient of Variation (CV = $\sigma/\widehat{N}$) was calculated as a measure of precision.

Extrapolated Population estimate

The extrapolated population estimate is influenced by the known movement of latent DU Caribou (percentage of collar caribou not in the final visual strata) to the coastal area after the caribou have started to migrate across the sea-ice. The aim is to determine the potential size (extrapolated estimate) of the DU Caribou if all the caribou (100% of the collar) occurred on the final coastal survey strata at the time of the survey. Thus, the Lincoln Peterson estimate of herd size was calculated based on the proportion of collared caribou observed within and outside the survey area when the survey occurred. The extrapolated estimate of the herd was calculated as:

$$N_{LP}= (((M+1)*(C+1))/(R+1))-1$$

with M equal to the number of collared caribou, R equal to the number of collared caribou detected in survey strata, and C equal to the estimate of herd size from the strata survey ($\widehat{N}$) (Seber 1982, Krebs 1998).

The estimate of variance from just the Lincoln Petersen estimator was modified to account for sampling variation in both the strata estimate and the collar-based estimate of proportion caribou in the strata area. This was done using the variance estimator, proposed by Innes et al., (2002) that considers both sources of variance as follows:

$$var(\,N_{LP}) = N_{LP}^2(\,CV^2(p_{LP}) + CV^2(\widehat{N}\,))$$

where CV^2=(var(x)/x^2). The variance of the Lincoln Petersen estimate of capture probability (p_{LP}) was estimated based on the hypergeometric probability distribution, which is assumed with the Lincoln Petersen estimator (Thompson 1992). Confidence limits were calculated using the t-statistic from strata surveys.

The estimate derived from the availability estimator of Innes *et al*., (2002) was similar to the Lincoln Petersen estimator given that it uses the same general method to estimate detection probabilities of caribou in the study area. The main difference between the two estimators was that the Lincoln-Petersen formula adjusts the herd estimate for small sample sizes of marked animals. The Lincoln-Petersen estimator also assumes a representative distribution of collared caribou relative to caribou within the herd, so that the ratio of caribou within the study area indicates the detection probability of caribou within the herd (Rivest et al., 1998).

Overall Trend

The 2018 estimate was initially compared to the 2015 estimate using a t-test to determine if the two estimates were significantly different (Gasaway et al., 1986). Log-linear models (McCullough and Nelder 1989; Thompson et al., 1998; Williams et al., 2002) were then used to analyze trends from 1997 to 2018. A primary emphasis of this analysis was to test if the trend from 2015 and 2018 surveys differed from previous surveys. This model assumed an underlying quassi-Poisson distribution of estimates with population change occurring on the exponential scale. Survey estimates were weighted by the inverse of their variance therefore giving more weight to the more precise estimates. A log-link was used for the analysis therefore allowing direct estimates of yearly rate of change as one of the regression β terms. Additive terms were used to determine if the trend from 2015 to 2018 was different than previous years.

Population demography

Demographic indicators for the DU population, the cow survival rate and pregnancy rate, were investigated in 2018. The interaction between these various indicators can be difficult to interpret, but they nonetheless help to provide a better understanding of the herd population demography (Boulanger et al., 2011) to determine the future trajectory of the herd.

Cow survival rate

One of the most critical demographic parameters for caribou is adult female survival (Bergerud, 2008; Boulanger et al., 2011). However, this is one of the most difficult parameters to estimate given limitations on sample size as well as assumptions in the estimation of survival. Traditional survival analysis from collared caribou makes a set of stringent assumptions on the data set which include:

- The fate of every collared caribou is known during the time that the caribou is collared. So for every time interval (month in the case of this analysis) we know the number of collared caribou that are alive and the number that have died.
- It is assumed that collar censoring (due to collar drop off or failure) is independent of fate. Basically this means that the fate of each caribou needs to be determined when its is dropped from the data set.
- It is assumed that collared caribou are a sample of the larger population of interest (adult female caribou in this case) so that their survival reflects the larger survival of this part of the population.

From the time the collar was deployed until a mortality notification was received, the data generated from the DU collared caribou were monitored. The fates of the DU collared caribou were determined by receiving the mortality notification once the collar stopped moving for 720 minutes, which was then recorded as mortality. Due to the logistical challenge of accessing the collar location sites after the notification was received to perform a necropsy in a timely fashion, a determination of the cause of death (predation, disease, natural) was not possible. However, caribou locations of caribou recorded as mortalities were assigned a specific location (North, East, West Victoria Island and the Mainland). Additionally, it was impossible to rule out the possibility of collar failure or device drop-off providing a source of bias (if a collar that drops off is called a mortality or a collared caribou that dies is not noted as a mortality in the data set assuming the collar dropped off). This estimate of survival from collared caribou may be negatively biased if a substantial proportion of collars that were reported as mortalities were actually failures. To reduce this source of bias, the collar drop-off was set to be activated after two and half year after deployment on the third week of October, well before the battery life expired. The only known failure was that a collar did not drop-off as scheduled and the collar kept collecting data until the battery died.

Kaplan-Meir survival rates (Pollock et al., 2004) were estimated using the survival package in the program R (R Development Core Team 2009) as:

S_{month}= 1 - (number of monthly mortalities) / (number of alive caribou each month)

The yearly survival is then the product of the 12 monthly survival estimates. Variances were calculated using formulas in Pollock et al., (1989) with confidence intervals constructed on the logit-scale.

Pregnancy rate

The pregnancy rate of female caribou is determined at the peak of calving by counting the number of females that have a calf at their heel. However, the DU calving ground is undefined and spread over Victoria Island making the identification of the DU cow/calf pairs problematic to determine (Nishi and Buckland, 2000). From the DU females collared in 2018, fresh fecal samples were collected. The samples were kept frozen until they were sent to the Toronto Zoo's Reproductive Physiology Laboratory for analyses. Immediately upon thawing, fecal pellets were mixed together, 0.5 g of feces was weighed into a glass vial, and 5 ml of 80% methanol in distilled water (v:v) was added to each vial. Samples were briefly vortexed and extracted overnight in a sample rotator. Samples were then centrifuged for 10 minutes and the supernatants were transferred to a clean glass vial for storage at -20C until analysis. Progesterone concentrations in the extracts were quantified using a progesterone enzyme immunoassay (CL425 from C. Munro, UCDavis) and 96-well microtiter plates were coated with progesterone antibody (CL425) and incubated overnight. Progesterone standards, fecal extracts and HRP-labelled progesterone were diluted in assay buffer and loaded onto the microtitre plates in duplicate. Binding of the HRO was detected using ABTS and the colour reaction measured using a spectrophotometer. Female caribou with > 600 ng/g progesterone were categorized as pregnant and caribou with 0.20-200 ng/ g of progesterone were categorized as non-pregnant (Morden et al., 2011).

Spatial analysis

Annual home range between 2015 to 2019

The GPS locations of telemetry points, collected between April 2015 and January 2020 were imported into an Access database and normalized into a common data structure and attributed appropriately for the analysis. Each collar was attributed with the life-cycle year, which starts at the beginning of the Spring Migration (collaring) and goes until the end of the Winter season (April 25th to April 24th the following year). Only collars with at least three months of data were included in the analysis to ensure that the resulting annual ranges were representative of DU caribou distributions. Barren-ground and DU caribou male collars were also excluded from the analysis. A total of 63 unique collars that were included in the analysis and the yearly breakdown can be seen in Table 1.

Table 1: Summary of telemetry data included in the annual range analysis of Dolphin and Union caribou from 2015 through 2020.

Life Cycle Year (Apr 25 – Apr 24)	Number of Collars	Number of Locations
2015-2016	17	3437
2016-2017	25	4189
2017-2018	8	882
2018-2019	35	11010
2019-2020	21	5116

The telemetry data were analysed for each life cycle year. Density maps, derived from a kernel density analysis on the location data (points), were developed using a search radius (bandwidth) of 28 km. The 28 km bandwidth represents the average bandwidth value calculated from annual reference bandwidths (href) for 2015-2016, 2016-2017, and 2018-2019. Life cycle years 2017-2018 and 2019-2020 were left out of the average, as they were missing data for the latter half of the year (i.e. fall and winter seasons). Since href values are generated using the standard deviations of x and y coordinates, including href values for datasets that were not representative of DU Caribou distributions for a complete year would have introduced a bias into the average value (Table2). The same bandwidth value (i.e. 28 km) was used to generate each of the annual utilization distributions so that changes in range size could be compared through time. Using a constant value for the bandwidth ensures that changes in range size reflect changes in caribou distributions and not changes to analysis parameters, year-to-year. Range boundaries were defined as the 95% utilization distribution contour. All annual range analyses were performed using the adehabitatHR package in R (Calenge, 2006).

Table 2: Summary of telemetry data included in the annual range analysis of Dolphin and Union caribou from 2015 through 2019.

Life Cycle Year (Apr 25 – Apr 24)	Number of Collars	Number of Locations	Href	Comments
2015-2016	17	3437	31273.24	
2016-2017	25	4189	31618.3	
2017-2018	8	882	34123.75	* This year may not be representative of range use especially later in the year: Fall- Winter. Left out of average.
2018-2019	35	11010	22259.55	
2019-2020	21	5116	24183.98	*This year missing info for winter Feb-Mar. Not included in the average
		Average Href:	28383.69667	

Timing of the Fall sea-ice crossing from 2015 to 2019

To explore the timing of ice-crossings, collared caribou movements were intersected with the Dolphin and Union Strait and Coronation Gulf. Movements were defined using walk-lines generated from successive telemetry locations. Movements that intersected Dolphin and Union Strait and Coronation Gulf represent ice crossings and were manually reviewed to identify the crossing start and end dates for each collar. As a result, an ice-crossing dataset was generated that attributed each collar that crossed to, or from, Victoria Island with specific ice crossing start and end dates. To explore variation in ice crossing dates through time, results of the analysis were visualized graphically by year and season (fall, spring) using histograms.

Results

Collar Deployment 2018

Target locations for caribou captures were based on past information on winter distribution, local observations and Inuit Traditional Knowledge (TK) to capture a representative sample of the herd. Collar deployment began on April 15, 2018 from Kugluktuk. On April 15, a search for caribou started inland, south of Port Epworth (Figure 2). Five groups of caribou were seen and one collar per group was deployed. On April 16, 10 collars were deployed around the same area. Small groups of caribou were aggregating at close proximity to each other. Following the extent of this distribution, the deployment team moved west on April 17, and deployed an additional nine collars. From those successful collar locations, the search progressed closer to the coastline, but no caribou were seen farther north. On April 18, the weather conditions were too poor to collar. The next day, the team continued their search in the direction of Wentzel River. Only one group of caribou was seen, and one collar was deployed. The next important aggregation of caribou was located around Wentzel Lake. On April 19th and the following day, six and five collars were deployed respectively at this location. No caribou were seen by the shore line during the non-systematic search on the west side.

To deploy the remaining 15 collars on the east side of Bathurst Inlet, the helicopter was re-located to Cambridge Bay on April 21. As the time approached late April, the team focused on deploying the collars on the Kent Peninsula contrary to the north shore of the Canadian mainland, as at this time the caribou migration was likely well underway. On April 22, the team was able to collar seven caribou on the Kent Peninsula south-east of Turnagain Point and no caribou were seen east of this location. On April 23, an extensive search was begun, aiming to collar caribou south on the Kent Peninsula around half-way cabin and Kuururjuaq Point. The team collared three caribou, before searching on the mainland in areas where caribou were previously collared in 2015 and 2016. However, no caribou were seen on the mainland. Late in the afternoon, the team flew by the north shore of the Kent Peninsula and collared two additional caribou. Having four collars left to deploy on April 24, the team had to search within the previous collar area in a more systematic way to try to find new groups of caribou. A first fly over of any observed group was done to make sure that the group did not already include any collared caribou moving north. If one caribou within the group was collared, the group was immediately left and the search continued. During the collaring, no caribou were seen on the east side of the Kent Peninsula. Figure 2 shows the specific locations where the collared caribou were collared.

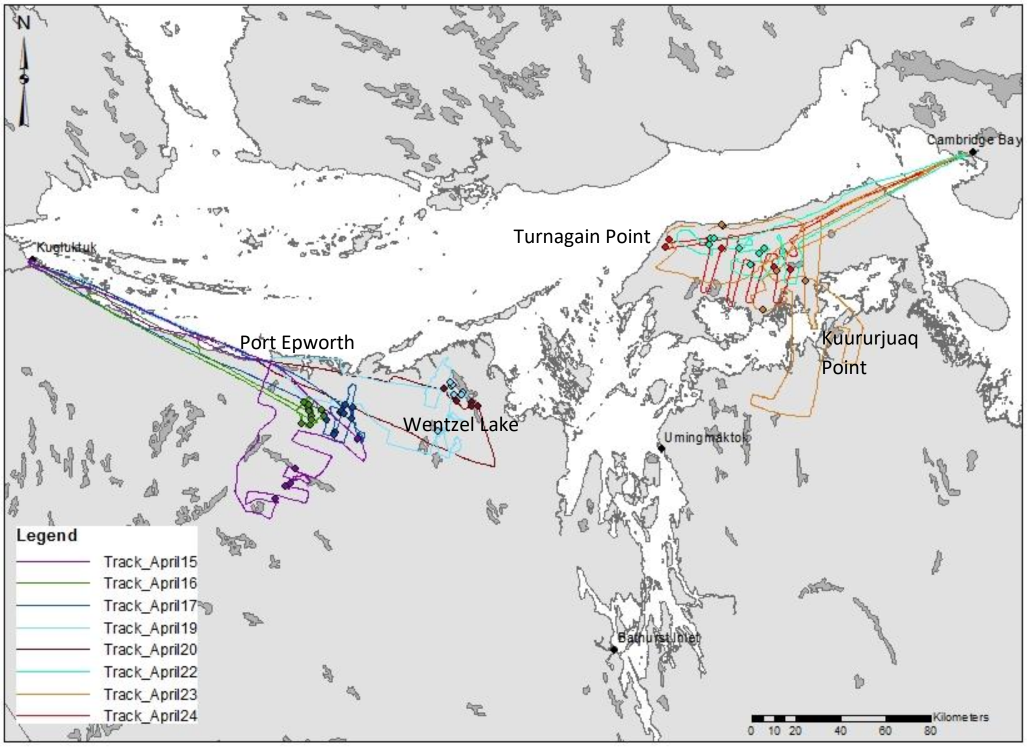


Figure 2: Map of Bathurst Inlet showing the 50 Dolphin and Union caribou collaring locations and flight tracks between April 15 to 24, 2018, on the west side of the Inlet and on Kent Peninsula.

Of the 50 collars, 35 were deployed on the west of Bathurst Inlet and 15 on the Kent Peninsula. Forty-seven (47) collars were deployed on female caribou and three (3) were deployed on males (DU-143-18, DU-145-18 and DU-168-18). Specific precautions, such as setting the collar on a bigger setting, were taken when collaring male caribou to ensure those three caribou were not harmed by the collars during the rutting season when their necks tend to get bigger. As of March 2019, all three males were still active and alive.

Two mortality events occurred during the collaring program. At the Kent Peninsula (68.58562N, -107.23687W), a 2015 collar was spotted on a caribou, and a decision was made to re-capture the animal to remove the collar, as the drop off mechanism had failed. As the net was being removed from the animal, the female caribou died. The old collar was collected (DU-16-2015) and the animal was sampled (DU-192-2018). The second mortality also occurred on Kent Peninsula (68.52082N, -106.89381W). As the caribou was running, it broke its front leg. The animal was euthanized for humane reasons and samples were collected from the animal (DU-193-2018). In both cases, the caribou were dressed on site, the meat was properly prepared for consumption, and given to the Cambridge Bay food distribution bank. The Cambridge Bay Hunters and Trappers Organization was notified immediately of both mortality events.

Within a month after collaring, six collared caribou were harvested by local hunters and the collars were returned to the nearest Conservation Officer. One collar stopped transmitting five days after deployment, which might indicate a malfunction of the collar and/or a post-collar mortality due to stress (DU-153-2018). This collar was not included in the survival analysis. To determine the cause of natural mortality, a site examination would have to have been performed, which is expensive and logistically challenging.

Body condition of captured caribou in 2018

Body condition was assessed according to CARMA's *Rangifer* Health & Body Condition Monitoring Protocol Level II, section 3. Palpation of animals was undertaken during collaring of captured caribou as a health index. Shoulders, ribs, hips and spine were felt using bare hands to determine the general fat coverage and then scored on scale of 4 through 12, with four being considered very bony with grooves between ribs and no back fat present, while 12 being very broad in the shoulder, ribs nearly flush with tissue between them, and hips well padded. Figure 3 shows the body condition index for the captured 50 caribou.

The body index condition was partially biased toward healthy caribou as healthier caribou were targeted for the collaring program. Healthy animals will have a better chance to resist disease, harsh winter conditions, outrun predators, and mostly survive for the entire duration of the collar life (estimated 3 years). Thus, 52% of the caribou had a health index of 12, with very few caribou having a lower index than 8 suggesting that overall collared caribou were above average condition (Figure 3).

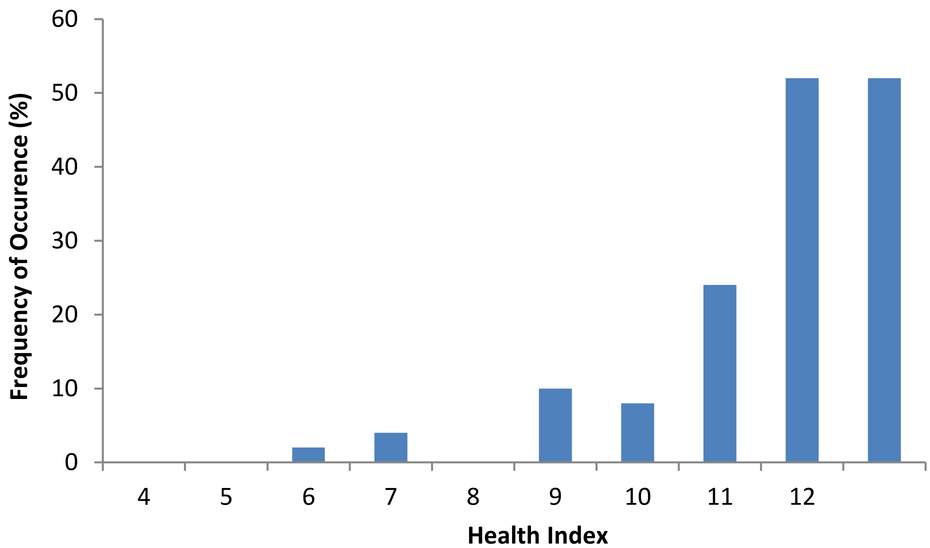


Figure 3: Average body score condition displayed as frequency of occurrence (%) of captured Dolphin and Union Caribou in 2018 (n = 50). The index score scale range from 4 to 12, where low numbers represent unhealthy caribou and high numbers represent healthy caribou.

Population estimate

Dolphin and Union collar 2018 fall distribution

From October 15 to December 15, 2018, the collar locations of 38 available DU Caribou on Victoria Island were closely monitored. An overview of each collar path during this period was plotted on a map for visualization (Figure 4). All the collars were located west of Wellington Bay and not farther north of Read Island. Progressively, between Lady Franklin Point and Cape Peel, the collars crossed to the Canadian mainland to their wintering ground, north-west of Bathurst Inlet. On November 3, 2018, one mortality event off the coast of Byron Bay (DU-181-2018), likely due to drowning, happened during the survey and this collar was no longer monitored or included in the extrapolated population number.

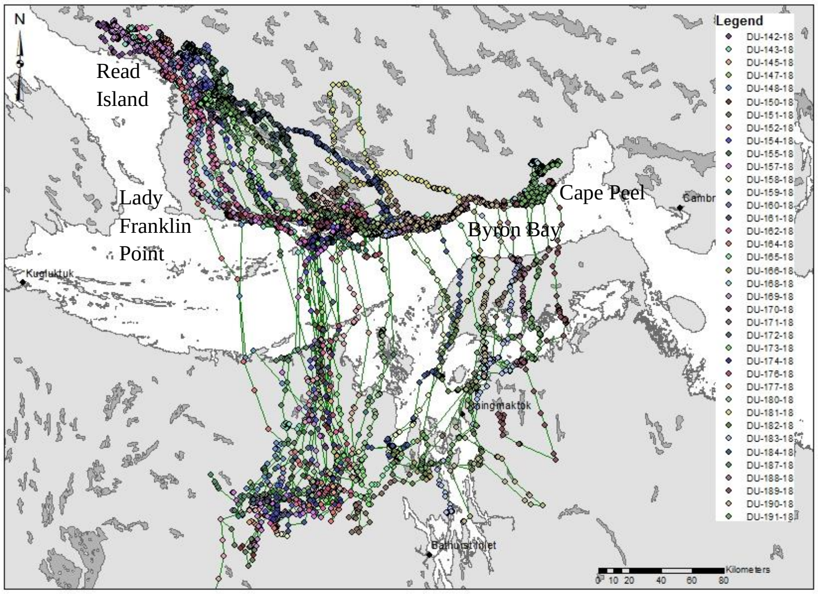


Figure 4: Overview of the movement pattern of 38 collared Dolphin and Union Caribou from October 15 to December 15, 2018.

Systematic reconnaissance survey

The reconnaissance and the visual survey were timed according to the distribution of the collared caribou relative to the study area, before caribou had initiated their migration over the sea-ice. In the circumstance that two of the collars started to cross, the survey would have been cancelled and postponed to the following year. The reconnaissance survey design was based on the assumption that the distribution of the 38 collared caribou characterized the distribution of the herd. The reconnaissance survey transect lines were spaced 10 km apart, except in areas of known caribou aggregations based on local observation and where the majority of fall harvest took place, since 2015 (Cape Peel). Where caribou were expected to occur, the spacing of transects was set at 4 km to increase the chance of detecting as many caribou groups as possible, in-between tracked collar locations (Figure 5). The reconnaissance survey transects were oriented perpendicular to the coastline to reduce potential bias due to the known distribution of caribou parallel to the coastline. The survey area was extended to 20, and up to 30, km inland West of Wellington Bay, as requested by the Hunters and Trappers Organizations, and 10 km inland East of Wellington Bay. As of October 21st collared caribou were still slowly moving South toward the shoreline. The transects East of Wellington Bay were the same transects as were flown during reconnaissance surveys in 2015. Even though there were no collared caribou at this location, effort was still allocated to flying these areas and ensuring no significant aggregations of caribou were missed in the East.

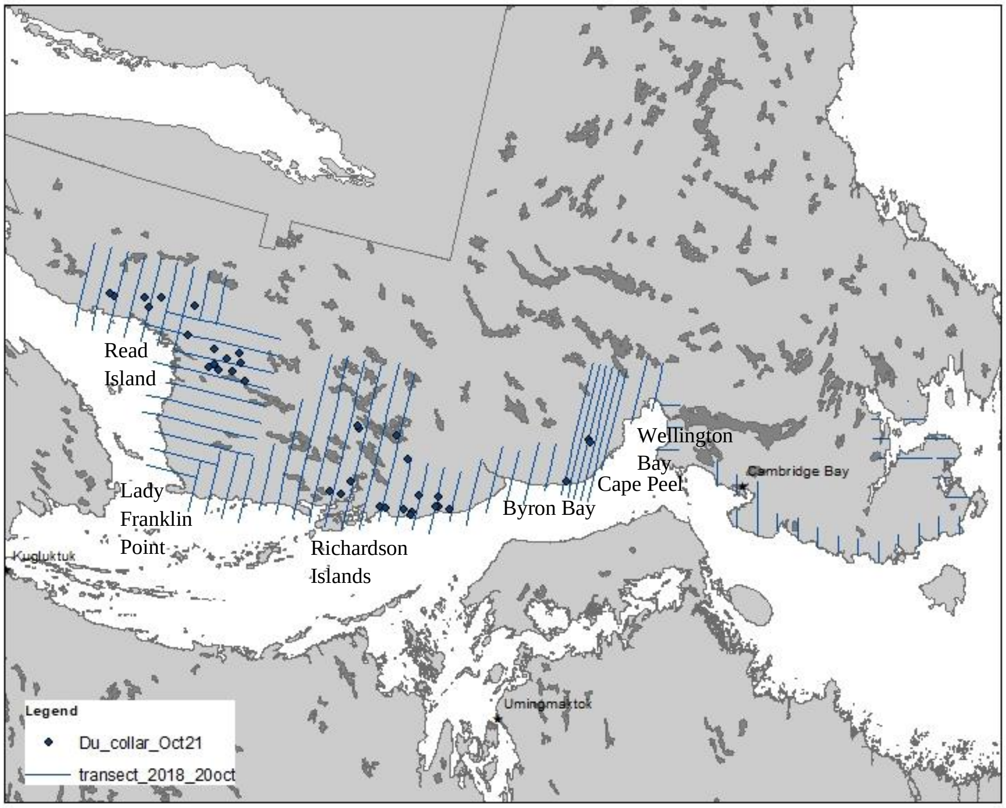


Figure 5: The reconnaissance survey design, based on collared caribou locations (n = 38) on October 21, 2018, in relation to the coastal study area extending from the shoreline to 10 km inland on the East side to over 20 km inland on the West side of Wellington Bay.

The reconnaissance survey was done over three days, October 21, 24, and 25, 2018, from North of Lady Franklin to North of Albert Edward Bay (Figure 6). Collared animals were distributed in the vicinity of Read Island Freezing rain and ice fog conditions between October 26 and October 30 prohibited further reconnaissance survey work of this area. During this period, the remaining proportion of collars around Read Island were closely monitored to capture any movement south toward the coast line. The low observed movement rate (< 5km/day) of the collared caribou combined with the closeness of the start of migration date, led us to stratify the Read Island area into two inland strata (northwest north (NW_N) and a northwest south (NW_S) that were to be surveyed as part of the final systematic survey.

Information on the locations of caribou groups seen along the South shore of Victoria Island during the reconnaissance survey were used to allocate survey effort for the final visual survey. To the East of Wellington Bay, on October 24, no caribou were observed on transect. South of Read Island, North of Lady Franklin Point, no caribou were observed on transect (Figure 6). These two areas were not surveyed further during the final visual survey, given the extremely low observed density of caribou, lack of caribou occupancy, and the absence of collars. The observations from the shoreline reconnaissance survey (October 21, 24, 25) suggested that the higher density of animals (groups of < 45 caribou) were East of Richardson Islands and Cape Peel.

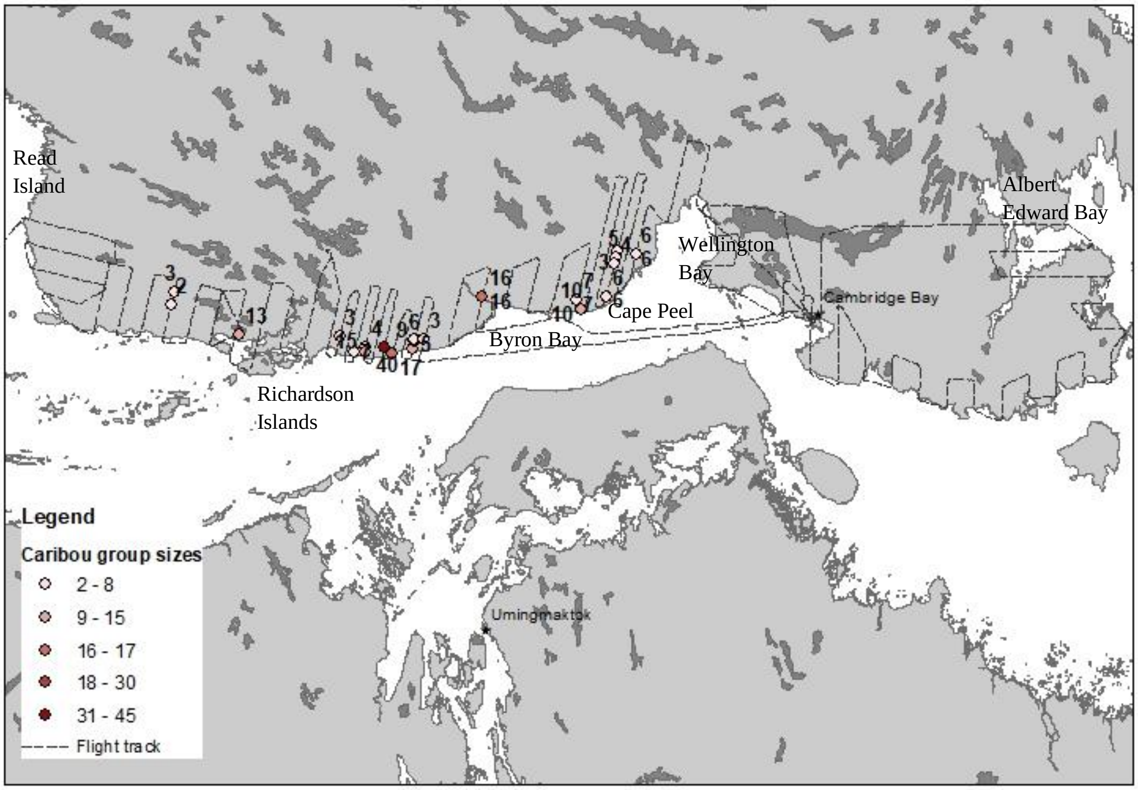


Figure 6 :Reconnaissance survey lines flown based on the locations of 38 Dolphin and Union caribou from October 21, 24 and 25, 2018 in relation to the coastal area extending from the shoreline to 10 km inland the East to over 20 km inland west of Wellington Bay. The dots represent caribou observations on transect.

Final systematic visual surveys

Strata were delineated to increase the survey effort where the density of caribou were found to be the highest, based on location and number of caribou per group observed during reconnaissance surveys and collar location (Figure 6). In the fall, freezing rain, fog and low cloud cover generally halt the survey work. Given challenging weather conditions, individual strata were designed to be flown as much as possible in a single survey flight to try to avoid issues with partially sampled strata. The amount of coverage (the proportion of area that each strata that was sampled) was based on optimal levels determined from previous surveys of Dolphin Union (Leclerc and Boulanger, 2018).

Four visual strata were defined along the coast line: low density east (LD_E), medium density west (MD_M), a high density east (HD_E) and a high density west (HD_W) and the two inland strata northwest: northwest south (NW_S) and northwest north (NW_N) (Figure 7). At the time of the design, five collars were located outside the final delineation of the strata, two north of the HD_W and three north of the MD_W. Since these collars were within 5 km of the strata, it was presumed that they would move south to within the final survey strata at the time of which the respective strata would be surveyed (Figure 7), and these caribou did move into strata when the strata were flown. The final coverage for each stratum varied from 28.6% for the high density (HD_E) stratum to 10% for the low density (NW_S) stratum (Table 3) based on optimal allocation from the reconnaissance survey data.

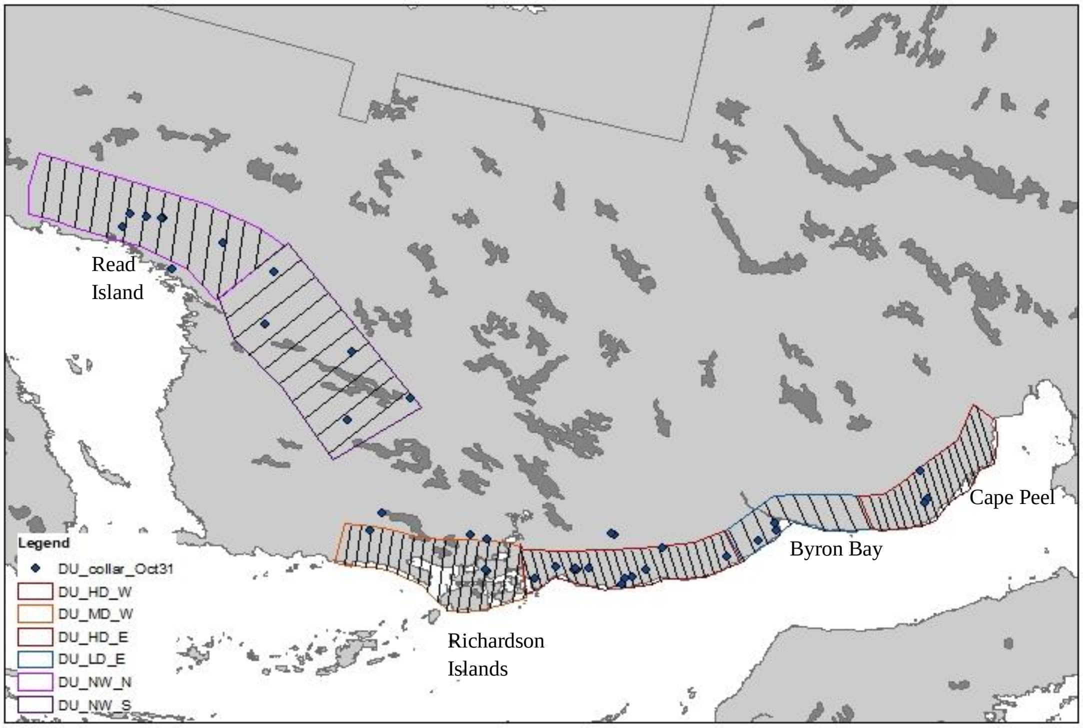


Figure 7 :Final visual stratification layout showing all strata for the 2018 coastal survey of Dolphin and Union caribou. Low density east (LD_E, blue), medium density west (MD_M, orange), a high density east (HD_E, red) and a high density west (HD_W, red), and the two inland strata in the northwest: northwest south (NW_S, purple) and northwest north (NW_N, light purple). Dark blue dots represent the October 31 collar locations at the time of stratification.

Table 3: Strata dimensions for the Dolphin and Union 2018 abundance survey and coverage allocation.

Strata	Area of strata (km^2)	Baseline (E-W) distance (km)	Total transects possible	Number of transects sampled	Transect area sampled (Km^2)	Coverage
HD_E	764.2	60.5	48.4	17	218.6	28.6%
LD_E	531.9	54.3	43.4	10	86.2	16.2%
HD_W	829.8	83.5	66.8	23	224.5	27.0%
MD_W	1109.8	72.5	58	17	248.4	22.4%
NW_S	2268.0	84.6	67.7	10	226.0	10.0%
NW_N	1803.8	104.1	83.3	14	229.2	12.7%

The final visual survey was conducted on October 31, November 1, 2 and 4 when the highest proportion of collars (89%) were in the survey strata, which also coincided with peak numbers of collared caribou in the survey strata (Figure 8). The LD_E and MD_W were surveyed on November 1 and November 2 (Figure 8 b) and c)) The MD_W stratum was surveyed partially on November 2 as the weather (fog) and the restricted day light prohibited continued surveying for that day. Weather conditions (snow, mist, and fog) prohibited continued surveying of the coastal area on November 3, and the survey finally resumed on November 4. At this time the entire MD_W stratum was re-surveyed completely with improved weather conditions and sightability to make sure we lower the chance to miss any caribou.

The November 4 data was used for the final estimates (Figure 8 d)). The total kilometers flown on transect was 1,541 km.

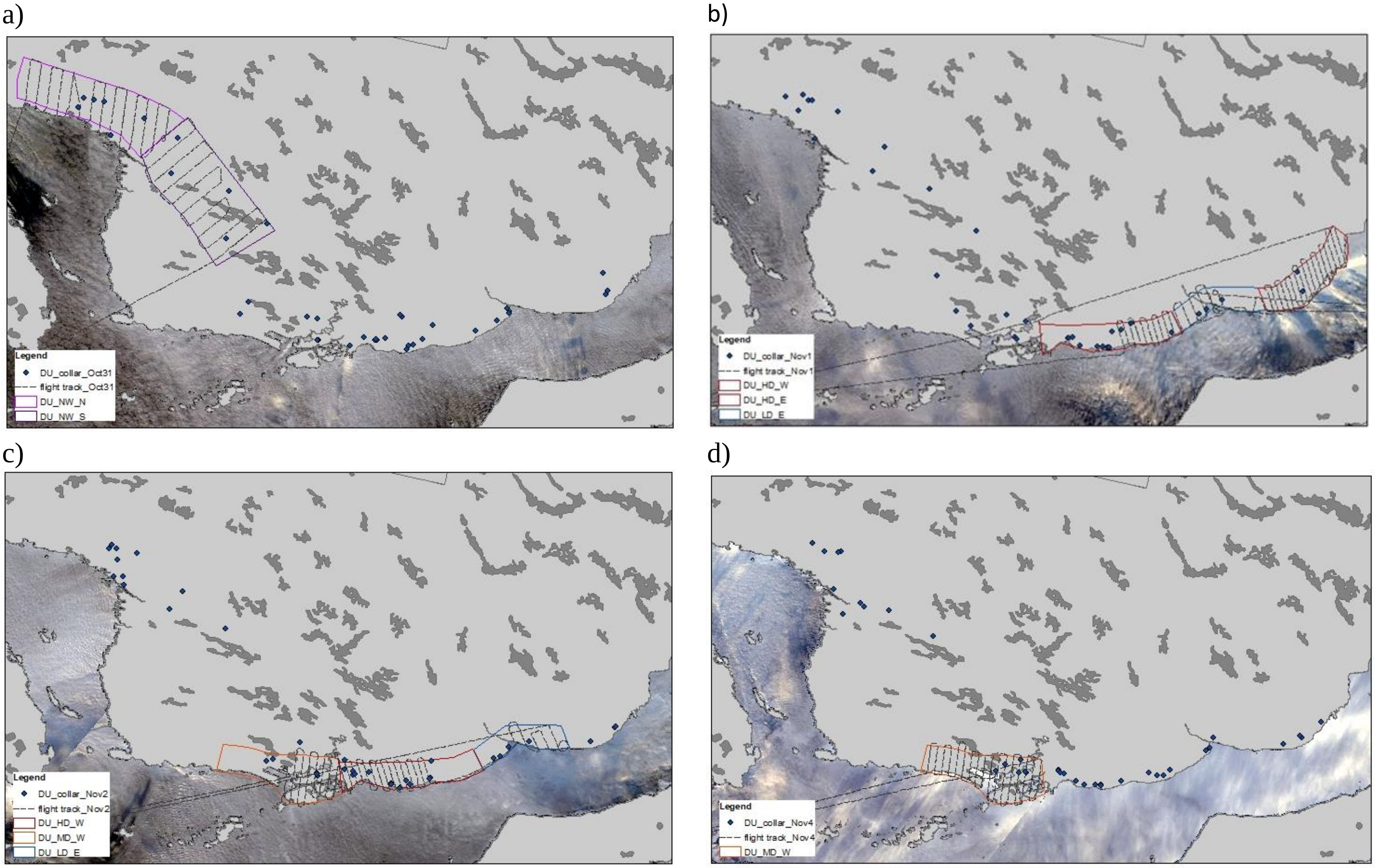


Figure 8: Daily location of Dolphin and Union collared caribou in relation with the final visual stratum surveyed (flight track) and sea-ice formation for a) October 31, b) November 1, c) November 2, d) November 4.

During the visual survey 767 caribou were counted in 91 groups (Figure 9, Table 4). The mean group size was 8.4 caribou (median=6, std. dev=7.3, min=1, max=35, Figure 9). No group of caribou larger than 35 were seen.

A dependant double observer pair platform was used during the visual survey, with the data recorder being the 2nd observer for 55 of the 91 total observations. With this method, the two observers communicate the number of caribou seen and the 2nd observer called out caribou groups not seen by the first observer. An approximate estimate of the single observer sighting probability for all observers was gained by subtracting one minus the frequency of observations seen only by the 2nd observer. Data from the 91 observed groups thus resulted in a sighting probability for a single observer of 1-10/91=0.89. The sighting probability for 2 observers is thus $1\text{-}(1\text{-}0.89)^2=0.99$, which basically means that observers saw 99% of the caribou on-transect. Using this estimate, there is little evidence that a substantive proportion of caribou were missed within strata during the survey. It is possible to estimate abundance with sightability accounted for as is done in calving ground surveys (Campbell et al., 2012), however, given the high double observer sighting probabilities, it is likely that there would be minimal difference between standard and double observer estimates. Additionally, the low sample size of observations was a challenge for substantive modelling or estimation using double observer methods, with this data set.

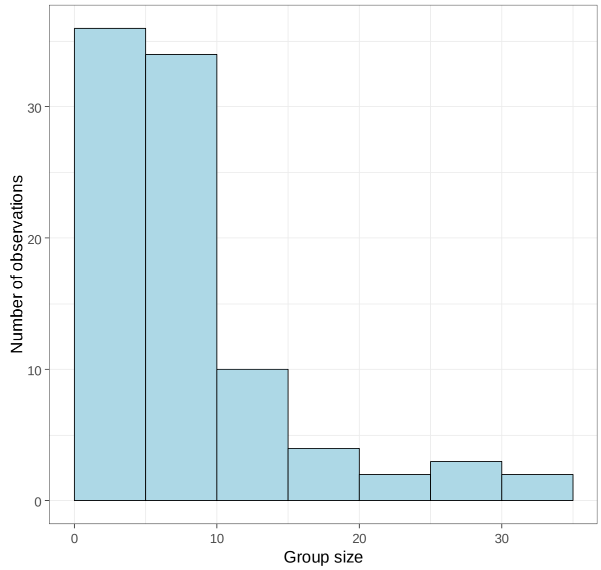


Figure 9: Distribution of caribou group sizes observed during the final visual surveys for Dolphin and Union caribou on October 31, November 1, 2, and 4, 2018.

Figure 10 shows the location of groups counted on transects during the final visual survey. The majority of caribou were distributed between Richardson Islands and Cape Peel (Figure 10). Observations were assigned to strata and transect lines within strata for estimation of caribou within each stratum.

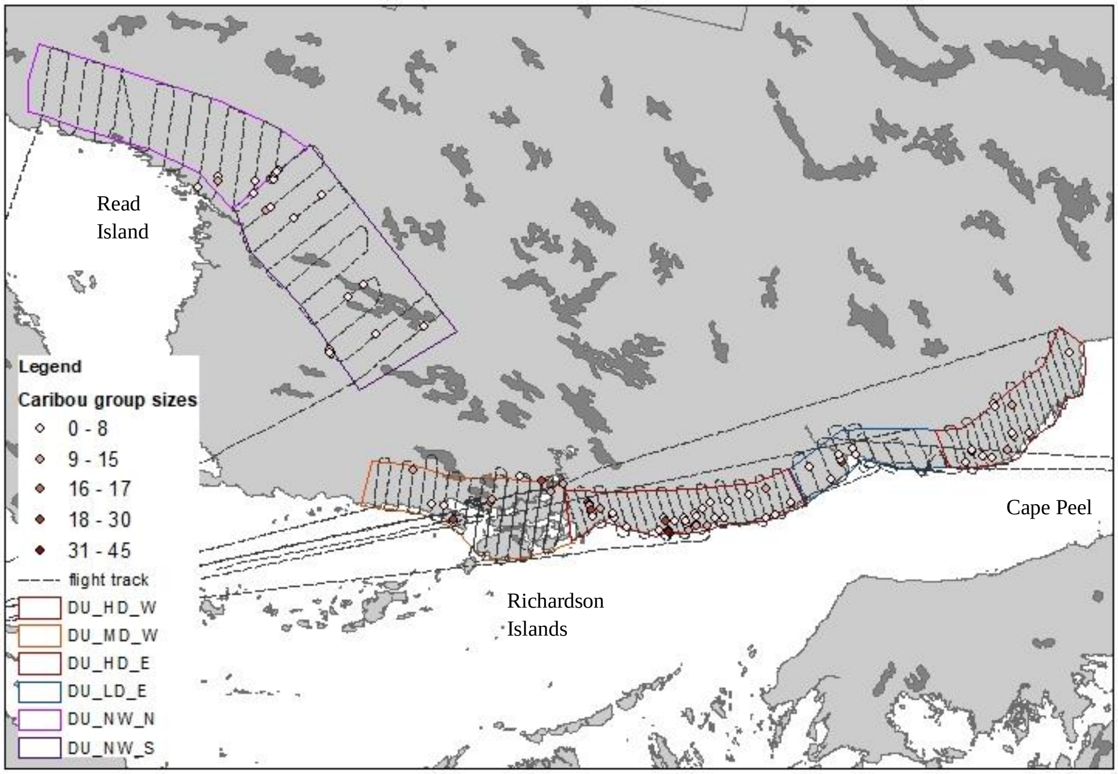


Figure 10: Distribution of Dolphin and Union caribou based on the location of the groups observed during the final visual stratification. Flight tracks flown from October 31 to November 4 are also shown for reference.

The final estimates from the six visual strata are given in Table 4. The highest density of caribou was observed in the HD_W stratum with 1.8 caribou per km^2 and the lowest density was found in NW_N strata with 0.22 caribou per km^2. Two-thirds of the population was estimated in the HD_W strata. The resulting estimate of 3,673 (SE= 595.5, CV= 16.2%, CI= 2,660-5,073) caribou was relatively precise with a coefficient of variation of 16.2%.

Table 4: Estimate of Dolphin and Union caribou observed in visual survey strata during the aerial survey conducted on October 31, November, 1, 2, and 4, 2018.

Strata	Caribou counted on transect	Density (Caribou per km^2)	Estimated caribou ($\hat{N}$)	Standard Error ($\hat{N}$)	Coefficient of variation
HD_E	74	0.34	259	81.7	31.6%
LD_E	63	0.73	389	187.2	48.2%
HD_W	395	1.76	1,460	443.0	30.3%
MD_W	123	0.50	550	157.5	28.7%
NW_S	62	0.27	622	190.4	30.6%
NW_N	50	0.22	393	235.7	59.9%
Total	**767**		**3,673**	**595.5**	**16.2%**

Collar caribou movement and survey design

From October 19 to November 26, the location of collars relative to inland (NW strata), in between, coastal strata, and crossing or mainland is represented in Figure 10. The survey occurred between October 31 and November 4 at which time most caribou were located within the survey strata, no caribou were on the sea ice, and a minimal number of caribou (1 to 2) were in-between strata. Caribou started crossing to the mainland on November 7, 3 days after the survey was completed. By November 21 most caribou were crossing to the mainland, or on the mainland.

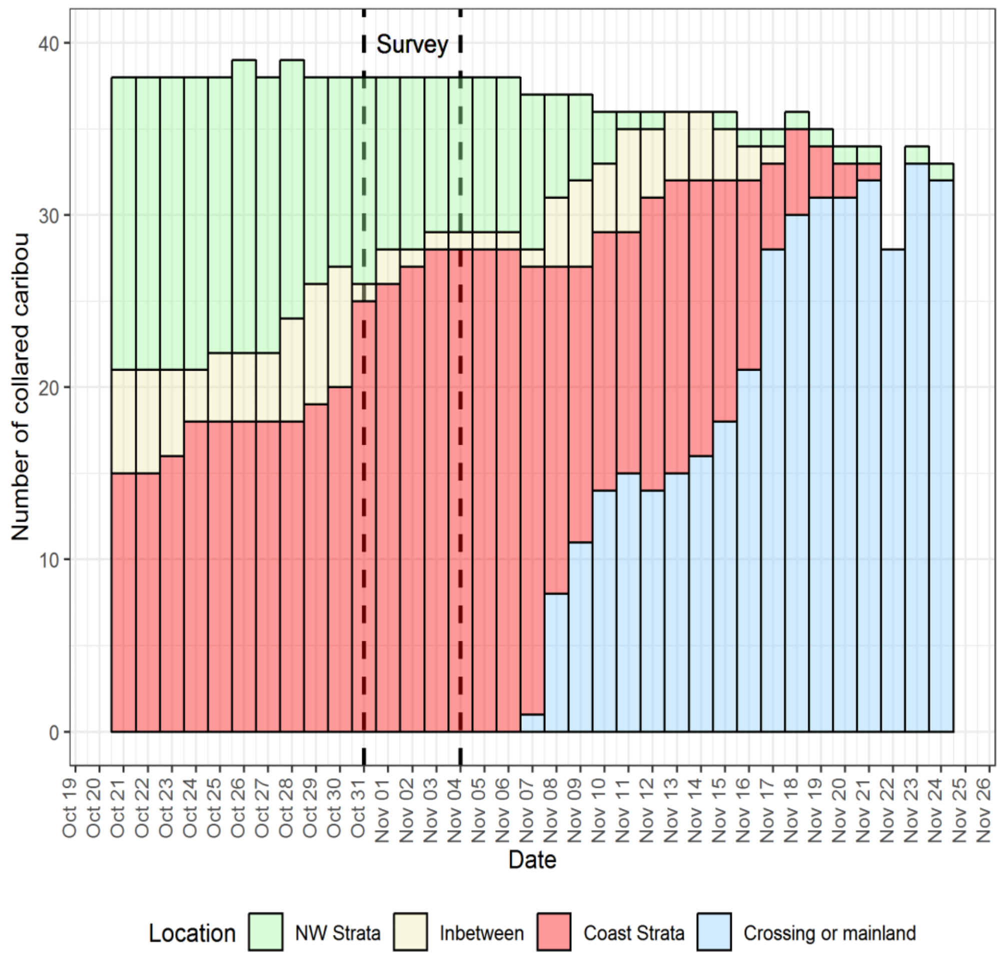


Figure 10: Distribution of Dolphin and Union caribou based on the location of the groups observed in the NW strata (green) in between (yellow), coastal strata (red) and crossing or mainland (blue).

The daily movement rate showed a consistent below 5 km/day movement rate for all collared animals from October 20 to November 7 (Figure 11) during staging. The 5 km/day movement rate is one of the triggers used for commencement of visual and photographic calving ground surveys (Campbell et al., 2012; Adamczewski et al., 2019). The survey is indicated by the green area in Figure 11 at which time the majority of movements were below 5km/day. Once the DU caribou started to cross over the mainland (Figure 11), the daily movement rate increased above 5 km/day (Figure 11).

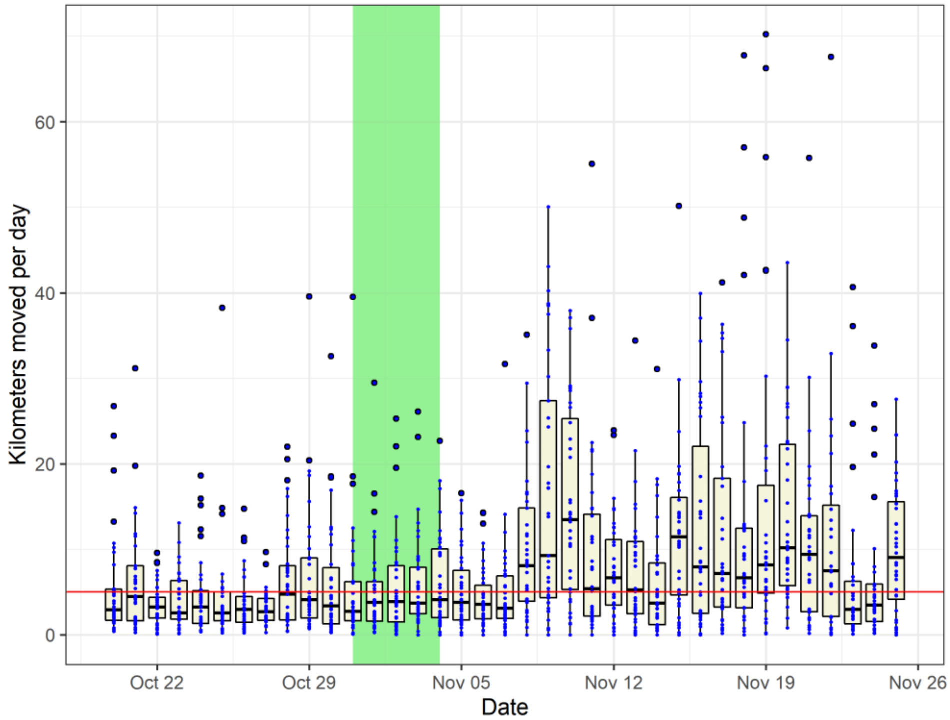


Figure 11: The daily movement rate of the caribou during the final visual strata survey. The dates the survey was conducted are delineated by a green band.

Table 5 provides the location of each collared caribou relative to the final visual survey strata at the time of the final visual survey. The HD_W and LD_E were surveyed on November 1 and 2, 2018. For this analysis, these strata (HD_W and LD_E) were subdivided based on the day they were flown and renamed HD1W and LD1E for areas flown on November 1 and HD2W and LD2W for strata areas flown on November 2. Cells are shaded if the given strata were flown for each survey date. The location of caribou in all strata, and then again only the coastal strata was tabulated as follows: if a collared caribou was present, or not, in the final visual strata, they were coded as included (1) or not included (0) (Table 5). This allowed for determination that 89% of all collared caribou were included in all survey strata (inland and coastal strata) and 63% were included in the coastal strata.

Table 5: Summary of 38 collared Dolphin and Union caribou locations relative to the visual survey dates flown(grey shaded) indicating presence as included (1) or not included (0), in all strata and coastal strata.

Collar	Survey date				Collar present	
	10/31/18	11/01/18	11/02/18	11/04/18	All strata	Coastal strata
DU-142-18	NWN	NWN	NWN	NWS	1	0
DU-143-18	NWN	NWN	NWN	Out	1	0
DU-145-18	HD2W	HD2W	HD2W	HD2W	1	1
DU-147-18	MD_W	MD_W	MD_W	MD_W	1	1
DU-148-18	NWN	NWN	NWN	NWN	1	0
DU-150-18	MD_W	MD_W	MD_W	MD_W	1	1
DU-151-18	HD2W	HD2W	HD2W	HD2W	1	1
DU-152-18	Out	MD_W	MD_W	MD_W	1	1
DU-154-18	HD2W	HD2W	HD2W	HD2W	1	1
DU-155-18	NWS	Out	Out	MD_W	1	1
DU-157-18	HD2W	HD2W	HD2W	HD2W	1	1
DU-158-18	HD2W	HD2W	HD2W	HD2W	1	1
DU-159-18	MD_W	MD_W	MD_W	HD2W	0	0
DU-160-18	NWN	NWN	NWN	NWN	1	0
DU-161-18	NWN	NWN	NWN	NWS	1	0
DU-162-18	NWN	NWN	NWN	NWN	1	0
DU-164-18	NWN	NWN	NWN	NWN	1	0
DU-165-18	HD2W	HD2W	HD1W	HD1W	0	0
DU-166-18	HD1W	HD1W	HD1W	HD1W	1	1
DU-168-18	HD_E	HD_E	HD_E	HD_E	1	1
DU-169-18	NWN	NWN	NWN	NWN	1	0
DU-170-18	MD_W	MD_W	MD_W	MD_W	1	1
DU-171-18	LD1E	LD2E	LD2E	HD_E	1	1
DU-172-18	NWS	NWS	NWS	NWS	1	0
DU-173-18	NWS	Out	MD_W	MD_W	1	1
DU-174-18	HD2W	HD2W	HD2W	HD2W	1	1
DU-176-18	HD2W	HD2W	HD2W	HD2W	1	1
DU-177-18	HD2W	HD2W	HD2W	HD2W	1	1
DU-180-18	HD2W	HD2W	HD2W	HD2W	1	1
DU-181-18	LD1E	LD1E	LD1E	LD1E	1	1
DU-182-18	MD_W	MD_W	HD2W	HD2W	1	1
DU-183-18	HD2W	HD1W	HD2W	HD1W	1	1
DU-184-18	HD2W	HD2W	HD1W	HD1W	0	0
DU-187-18	NWS	NWS	NWS	NWS	1	0
DU-188-18	HD1W	HD1W	LD1E	LD1E	0	0
DU-189-18	HD_E	HD_E	HD_E	HD_E	1	1
DU-190-18	LD1E	LD1E	LD1E	LD2E	1	1
DU-191-18	HD_E	HD_E	HD_E	HD_E	1	1
				Total	34	24
				Mean	0.89	0.63

Extrapolated population analysis

The estimate of caribou (3,763) in all strata was divided by the proportion of collared caribou in all strata (0.89) to obtain an extrapolated estimate of 4,105 animals (Table 6). An alternative estimate which used only the caribou estimated in the coastal strata (2,657) divided by the proportion collars in the coastal strata (0.63) was also derived. This estimate 4,207 was very close to the all strata estimate, 4,105, but was less precise given the lower proportion of collars included. The closeness of the 2 estimates suggests that most caribou were covered in the coastal and all strata. The best estimate in this case is the all strata estimate, which uses all the data available and has the lower coefficient of variation (16.9%).

Table 6: Extrapolated estimates of Dolphin and Union caribou herd size (N (estimate)) based on the proportion of collared caribou in the survey area (P) and number of caribou estimated to have occurred in the survey strata (N (strata)) at the time of the survey, for all strata, and coastal strata only.

Type	Strata N		GPS collars	Proportion		Collar-based estimate				
	N (strata)	CV	In strata	P	CV	N (estimate)	SE	CV	Conf. Limit	
All strata	3,673	16.2%	34	0.89	4.9%	4,105	694.8	16.9%	2,931	5,750
Coastal strata only	2,657	19.3%	24	0.63	6.9%	4,207	861.9	20.5%	2,789	6,348

Overall trend

A significant decline in the DU herd is suggested by the estimate based on the 2018 population survey, in comparison with previous population estimates for the herd. The difference between the 2015 estimates (18,413) and the 2018 estimate (4,105) was significant ($n = 2$, $t = -4.46$, $p<0.01$).

Table 7: Comparison of previous estimates of the Dolphin Union caribou population sizes with the 2018 estimate using t-tests.

Year	N	SE	Confidence Interval		CV	t-test	df	P-value
1997	34558	4283.0	27,757	41,359	12.4%			
2007	27787	3613.0	20,250	35,324	13.0%	-1.21	58	0.232
2015	18413	3133.8	11,644	25,182	17.0%	-1.96	53	0.055
2018	4105	694.8	2,931	5,750	16.9%	-4.46	60	0.000

The trend between 2015 and 2018 surveys was then estimated and compared to previous surveys using log-linear models. Log-linear models show that the trend between 2015 and 2018 was significantly different than the trend from 1997-2015 with this period having an estimated annual change of 0.97 (3% decline each year CI=2-5%) compared with the more recent period (2015-2018) having an annual change of 62% (38% decline each year, CI=33-43%, Table 8, Figure 12).

Table 8: Log-linear model estimates of trend in Dolphin and Union caribou herd numbers from 1997-2018. Estimates are given on the exponential scale. The Annual change from 2015-2018 was derived from the gross change additive slope term.

Term	Estimate	SE	t	p.value	Confidence interval	
Intercept	35,983	0.10	102.82	0.006	29,237	43,627
Annual change (1997-2015)	0.966	0.01	-4.02	0.155	0.950	0.983
Gross change (2015-18)	0.235	0.13	-11.20	0.057	0.183	0.305
Annual change (2015-8)	0.617				0.568	0.673

Figure 12 shows the extrapolated population estimates for the last four surveys. Note that the 1997 and 2007 survey results, 34,558 (SE=4,283, CI=27,757-41,359) and 27,787 (SE=3,613, CV= CI=20,250-35,324) animals, respectively, were generated based on collar data not directly pertaining to the time period that the survey was occurring. However, for the two most recent surveys, real-time collar data were made available to confirm with greater precision the number of collars included, and not included, in the final visual strata. The 2015 and 2018 survey resulted in estimates of 18,413 (SE=3,133.8, CV=17%, CI=11,664-25,182) and 4,105 (SE=694.8, CV=16.9%, Cl=2,931-5,750) animals, respectively. Note that the log linear model estimates a decline of 3% per year (CI=2-5%) between 1997 and 2015, and shows an abrupt decline between 2015 and 2018 of 38% (CI=33-43%) per year.

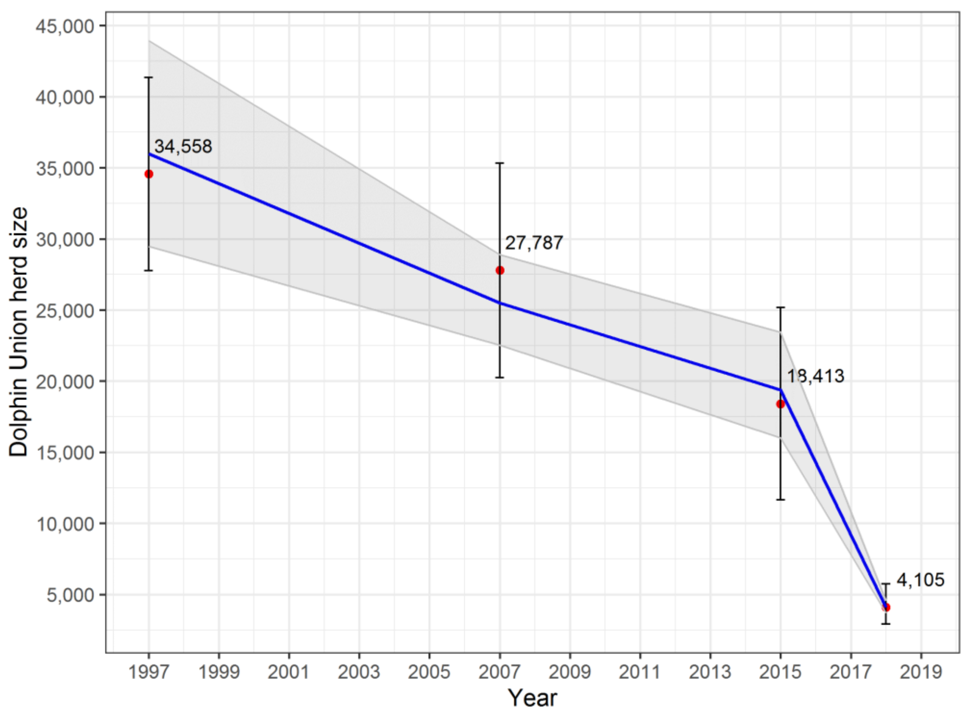


Figure 12: Estimates of herd size for the Dolphin and Union caribou herd from the 1997 survey (Nishi and Gunn 2003), 2007 survey (Dumond and Lee 2013), the 2015 survey (Leclerc and Boulanger, 2018) and 2018 survey. The blue line represents the log linear model estimates of herd trend (Table 7) and confidence intervals are depicted by grey shaded areas.

Population demography, 2018

Collared caribou movements and survival rates

As a first step in estimating cow survival for DU caribou, the 2015 to 2019 caribou locations were assigned a specific area based on locations on Victoria Island; North (NVIC), East (EVIC) or West (WVIC) or the mainland (MAIN, Figure 13).

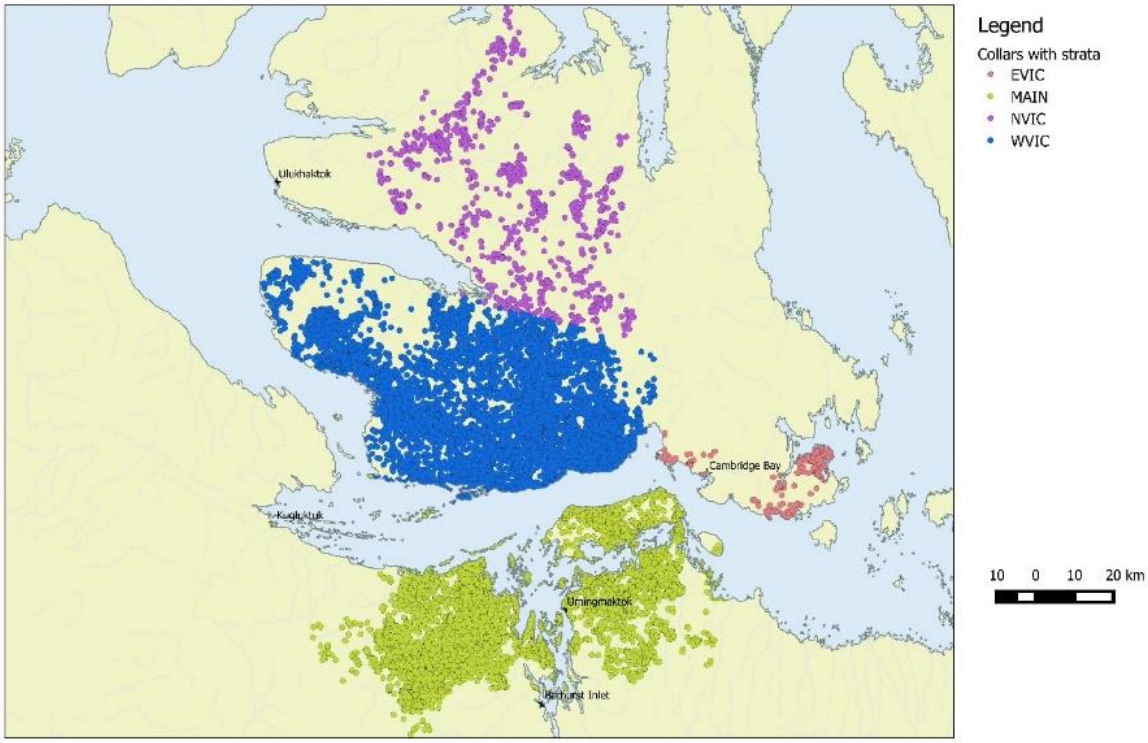


Figure 13: Assignment of Dolphin Union caribou collar locations groupings into specific areas within the herd's range: East Victoria Island (EVIC, blush), Mainland (MAIN, green), North Victoria Island (NVIC, purple) and West Victoria Island (blue).

The collar histories, depicted in Figure 14 and 15, were summarized by deployment years with monthly points categorized by strata and with mortalities denoted at the end of each collar history. If a mortality was denoted it was either recorded as harvested (red dot) or natural/unknown (red triangle), if a mortality was not denoted then it is assumed the collared caribou survived. Between 2015 and 2019, of 43 mortalities, 14 were due to harvest and 29 were unknown, or due to natural causes (Figure 14 and 15).

In 2015 and 2016, 35 collared caribou were monitored (Figure 14). The collared caribou appeared to have summered at both North and South Victoria Island, occupying a large summer range. Migration between the mainland and Victoria Island was observed for all caribou, except for two animals (DU-51-2016 and DU-55-2016). Observation of the tracks of these two animals shows that they moved to the Northern Victoria Island after collaring in April 2016, but did not migrate south in the fall of 2016. They stayed north of Victoria Island (West of Ulukhaktok), before both becaming mortalities in February 2017.

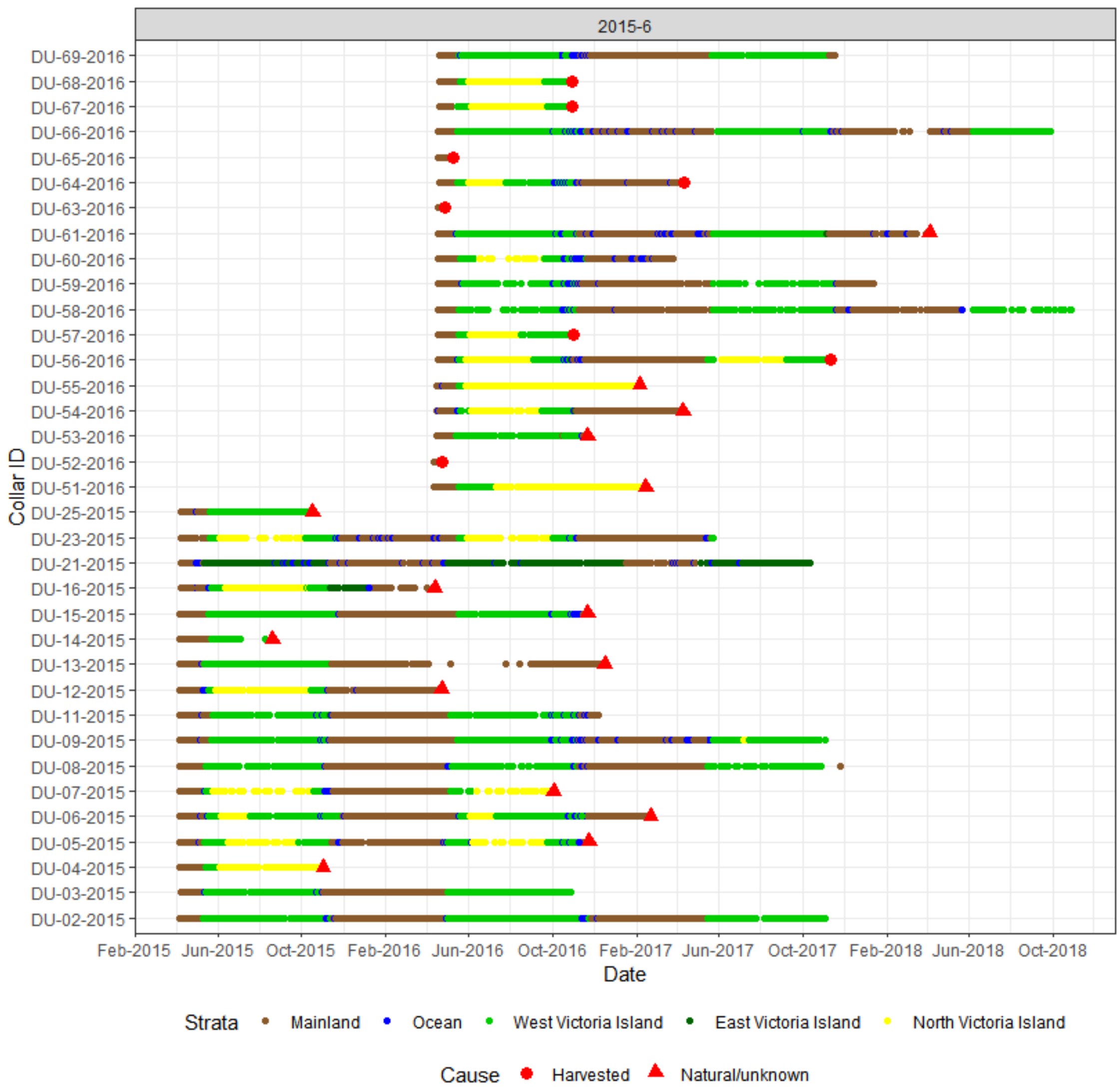


Figure 14: Collar histories for 35 collars deployed in 2015 and 2016. The location of collars for each month is given relative to Victoria Island or the mainland or ocean (crossing). Fates are given for known mortalities. If no mortalities are denoted (by a red symbol) then it is assumed the collared caribou survived (collar dropped with the release mechanism at the end of the collar battery life).

In 2018, 50 collared caribou were deployed and 49 were monitored from April 2018 to March 2019 (Figure 15). In addition, 2 collared cows from previous deployments were still alive after April 2018 and are shown in Figure 15. The collar histories show that five collars were mortalities before crossing to Victoria Island in May of 2018, while all the remaining collared crossed successfully. During the summer, most collared caribou occurred in Southern Victoria Island, with few observed collar locations in Northern Victoria Island. All of the remaining collars (38), that were not mortalities during the summer of 2018, crossed to the mainland in November 2018 as indicated in Figure 10.

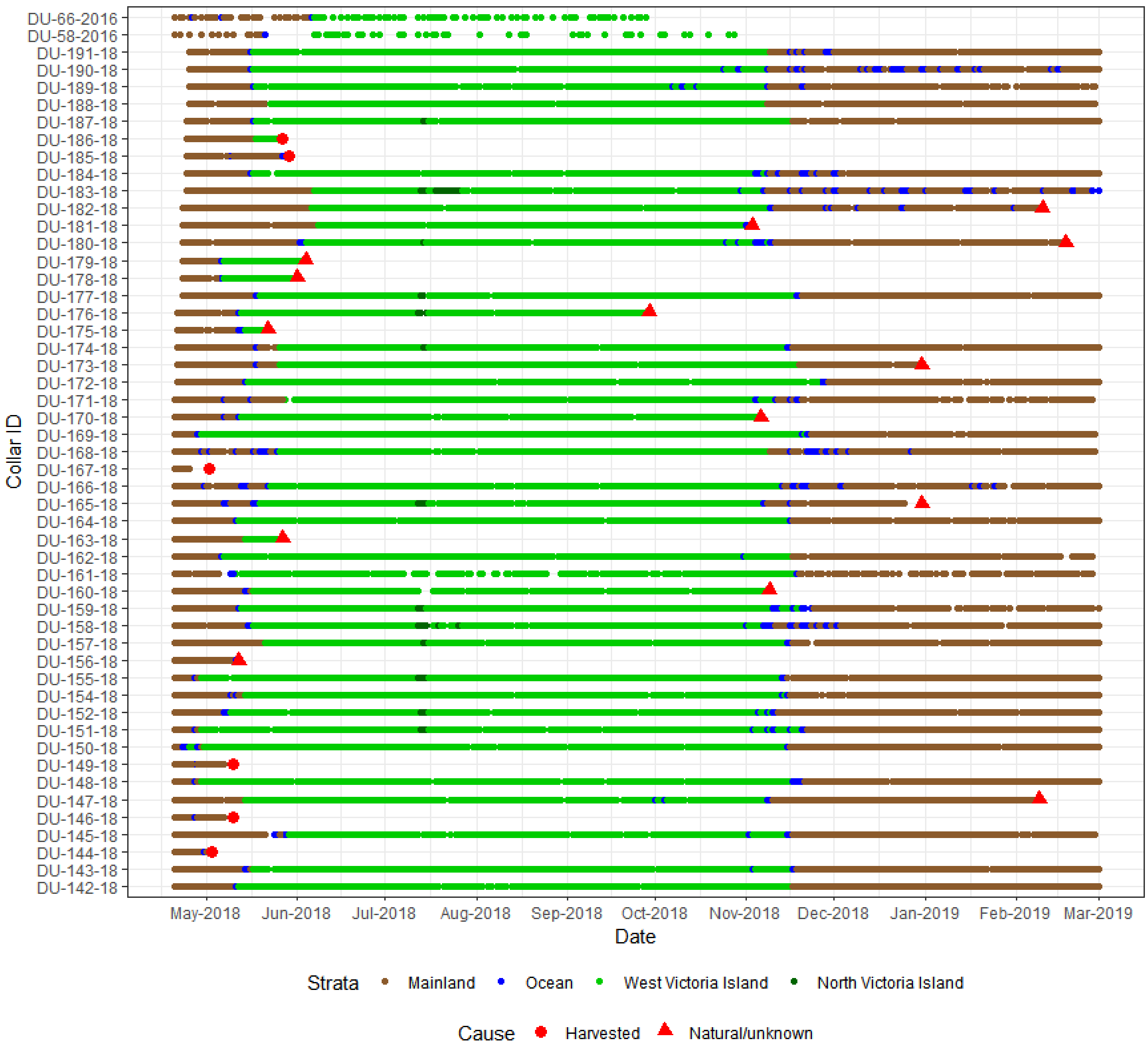
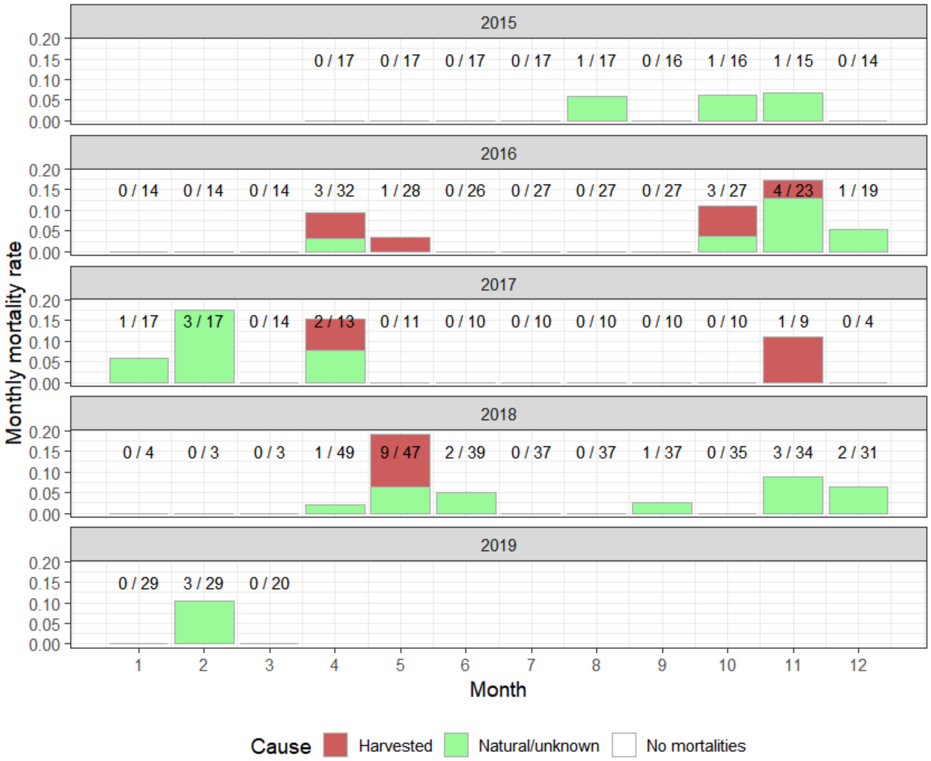


Figure 15: Collar histories for 49 (46 F and 3 M) collars monitored in 2018 and two collars from previous deployment (DU-66-2016 and DU-58-2016) from late April 2018 to March 2019. The location of collars for each month is given relative to Victoria Island or the mainland or ocean (crossing). Fates are given for known mortalities. If no mortalities are denoted, then it is assumed the collared caribou survived (collar dropped or expired). The three collared males are shown here (DU-143, DU-145, and DU-168) but were not included in the cow survival analysis.

Summaries of the monthly numbers of collars, compared to mortalities, suggest that mortalities often occured in the fall and spring time, relative to when the caribou are more accessible to harvesters and closer to communities (Cambridge Bay and Kugluktuk, Figure 16a)). A plot of mortality locations for 2018 shows that mortalities that were attributed to harvest (collars returned to Conservation Officers) indeed occurred along the coastlines, whereas natural/unknowns mortalities occurred in areas further inland , where access to the herd by harvesters is more challenging (Figure 16 b)). The initial sample size of collars in April of 2018 included two collars that had survived from previous deployments, 46 females and three males collared in April of 2018.

a) <u>Monthly frequencies of collars available and mortalities</u>



b) <u>Mortality locations (2018)</u>

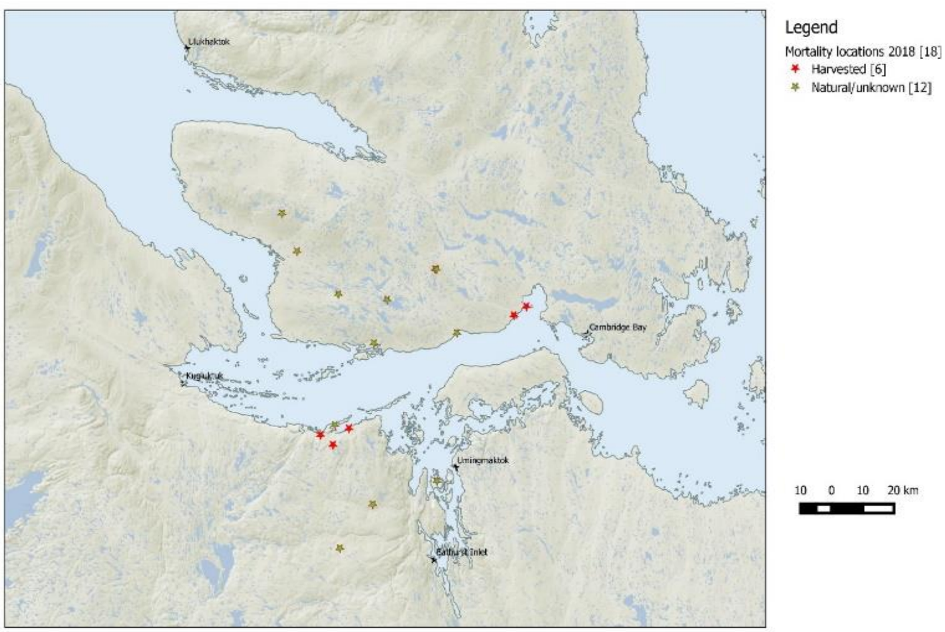


Figure 16: a) Summary of monthly active collared caribou and mortalities from 2015 through 2019, for collared Dolphin and Union caribou, with monthly mortality rate given as a ratio (number of deaths per total number of active collars), b) Dolphin and Union caribou mortality locations in 2018, categorized by mortality type. The furthest south harvest mortality has 2 locations which appear as 1 due to the proximity of the locations.

Yearly survival rates were generated from 2016 to 2018, which had sample sizes of collars for all the months of a year (Table 9 and Figure 18). As a full year of data was not available, the 6 mortalities that occurred in 2015 and 2019 were not considered in the analysis. The total mortalities for this analysis was 37. The highest sample size of collars was obtained in 2016 and 2018 and therefore, survival estimates from these years are the most reliable.

Table 9: Estimates of yearly survival of Dolphin and Union caribou cows for years in which collars were on caribou for all months of the year. Also given are numbers of total mortalities, total Alive Months (total caribou monitored per month across the entire year), mean number of caribou alive each month. The count of mortalities due to harvest are given in parentheses in the Total Mortalities column.

Year	Survival	SE	Conf. Limit		Total Mortalities	Alive Months	Mean Alive	Min Alive	Max alive
2016	0.61	0.09	0.43	0.76	12 (5)	278	23.17	14	32
2017	0.58	0.12	0.34	0.79	7 (3)	135	11.25	4	17
2018	0.62	0.07	0.48	0.75	18 (6)	356	29.67	3	49

The survival estimates were relatively similar across years in 2016, 2017, and 2018 (Figure 17). If known mortalities due to harvest are removed from the analysis, then the survival rate for 2018 increases to 0.72 (CI=0.57-0.84) with estimates in other years increasing to 0.74 and 0.76 (Figure 17).

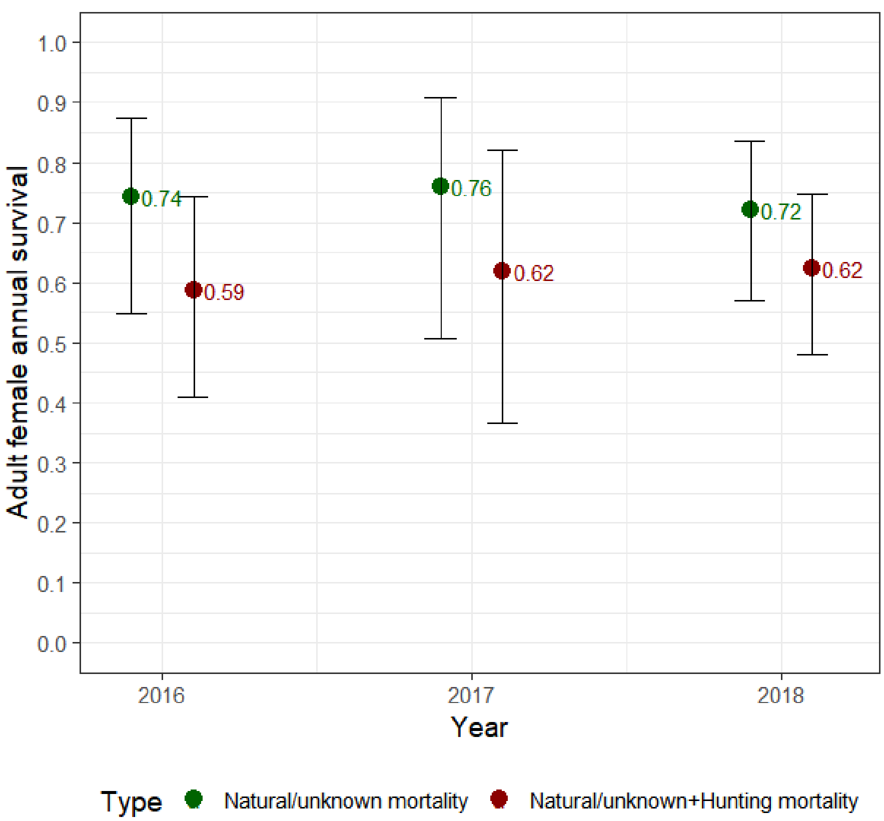


Figure 17: Estimates of yearly survival of Dolphin and Union caribou from 2016 through 2018 with the mean number of collars monitored per month, by type of mortality, with survival rates given next to data points.

Pregnancy rate

Fecal samples of 47 female DU collared caribou were collected and all were successfully analysed for progesterone levels to indicate the pregnancy rate. Individual caribou were confirmed as pregnant if the level was more than 600 ng/g wet feces of progesterone and non-pregnant if this level was below 200 ng/g wet feces (Figure 18). From the samples, only three females were barren, representing a pregnancy rate of 94% for DU caribou in Spring, 2018.

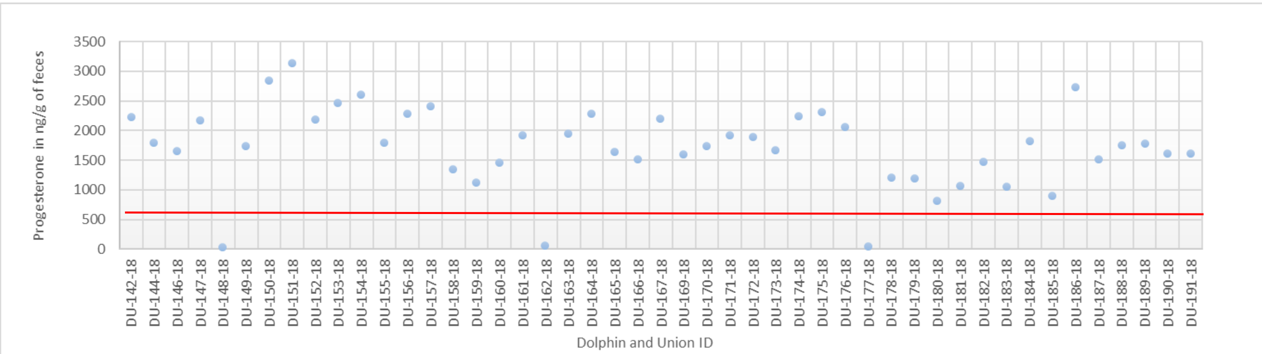


Figure 18: Progesterone level in feces (ng/g) for each female Dolphin and Union caribou collared. Levels below 600 ng/g were considered as non-pregnant.

Spatial analysis

Annual home range between 2015 to 2019

Based on telemetry data from collared caribou tracked between 2015 and 2019, the annual home range of DU caribou progressively constricted and shifted to the western part of the range (Figure 19). The annual home range went from 198,704 km^2 in 2016-2017 to 128,803 km^2 in 2017-2018, which represents a decrease of 35%. This was observed as a lower number of caribou using their usual summer range in the northwestern part of Victoria Island, as well as the eastern part of the range around Cambridge Bay.

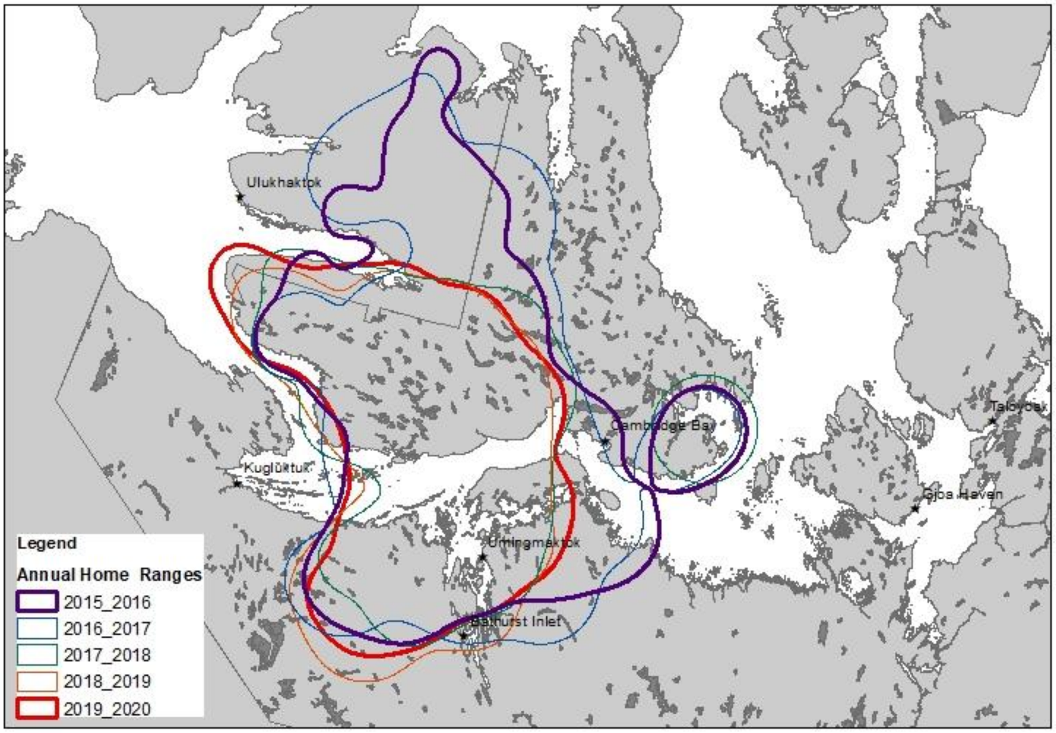


Figure 19: Variation of annual home range of the Dolphin and Union caribou showing a contraction between 2015-2016 (purple) and 2019-2020 (red).

Timing of the Fall sea-ice crossing from 2015 to 2019

Sea-ice crossing was analysed from October 2015 to June 2019 (Figure 20). The objective of the population surveys is to count caribou while staging and before they cross. The timing of the survey at the end of October/early November, has been appropriate to meet this objective. The timing of fall crossing takes place generally from the end of October to December, as in 2015 when caribou were still migrating to the mainland in late December. Collar data, since 2015, shows that the fall migration has continued even while the DU population was declining. Spring migration ranged from April to early June, where in 2018 and 2019 caribou were still crossing after June 1.

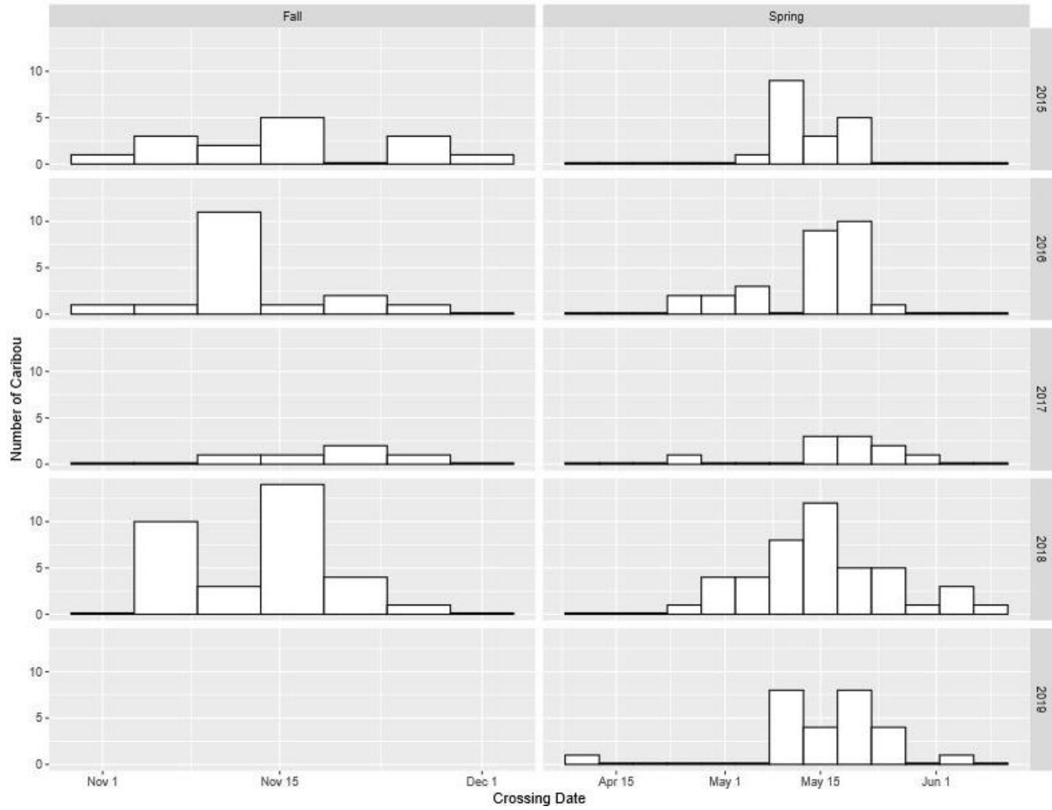


Figure 20: Number of Dolphin and Union caribou crossing the sea ice between Victoria Island and the mainland during fall and spring migration, per season and per year, from April 2015 to June 2019.

Discussion

Since the DU Caribou survey methodology is based on the assumption that the collared caribou distribution is representative of the entire herd distribution during the coastal survey, great attention was given to where the collars were deployed. Collaring took place from April 15 to 24, before the start of the migration to Victoria Island (Figure 2). Unlike the 2015 and 2016 collar deployment years, the 2018 collaring started from the West side of Bathurst Inlet to ensure that animals did not start to migrate before collaring occurred, as caribou in these areas are known to cross earlier than the animals on the East side of Bathurst Inlet (Poole et al., 2010). In addition, a larger number of collars (50) was deployed in 2018 compared with previous years, on both sides of Bathurst Inlet, to capture individuals that would be representative of overall DU caribou herd movement. Additional effort was also made to deploy collars based on the skewed proportion of animals in the winter range on both sides of the Inlet. On the West side of Bathurst Inlet, hunters reported observing more animals (35/50 collars deployed in this area), as the number of caribou on the eastern part of the range is known to have simultaneously decreased, based on Traditional Knowledge (TK; deployed 15/50 collar) (Tomaselli et al., 2018). This low density on the East side of the Inlet was also observed during the intensive search effort made on the Kent Peninsula from April 22 to April 24, 2018 and reflected by the difficulty to find different caribou groups to deploy the remaining 15 collars (see Figure 2). As in previous years, DU Caribou were pre-selected for collaring based on their general appearance of fatness, as healthy caribou have a better chance of survival during the collar life (three years). This intentional bias is explained in the skewed health index toward caribou in good condition (Figure 3).

DU caribou on the East side of Bathurst Inlet are known to mix with Barren-ground caribou on the Canadian mainland, which can make it more complicated to ensure that the collaring targets DU caribou. However, in 2018, genetic analysis confirmed that all 50 collars were deployed on the DU herd. This suggests that the DU and the Barren-ground caribou herds segregate during migration at the end of April and the Barren-ground caribou range is less likely to extend onto the Kent Peninsula at that time.

Male and female DU caribou are known to gather on the South coast of Victoria Island in the fall to rut and to stage before they resume their migration to the Canadian mainland. Wildlife biologists have been able to take advantage of this herd specific migratory behavior to maximize survey estimate reliability while minimizing survey logistics and cost. This being said, the timing of the final visual abundance survey cannot guarantee all collars will be within the survey area, but rather does assume that the majority of the collars and associated caribou will be represented within visual strata.

When accounting for weather days, and the fact that the coastline survey takes usually three to four days to complete, the DU coastal survey remains feasible but challenging. Figures 10 and 11 show that the timing in which most of the collars are in the survey strata in 2018 was limited to a short window of seven days and the timing of the final visual survey fell within this time frame (Figure 10). This was also paired with a daily movement rate of caribou below 5 km/day (Figure 11), which limited caribou movement between the final visual strata. To test the assumption that the collared caribou distribution was representative of the distribution of the entire herd, the reconnaissance survey area was extended to the entire south coast based on historical staging and crossing sites and as the DU caribou have the possibility to cross to the mainland from the Dolphin and Union Strait to Dease Strait, even though some areas had no collared caribou (Lady Franklin Point, and East of Wellington Bay) (Figure 6). Observations made on October 21, 24 and 25 confirmed that where there were no collars and no groups of caribou were observed on transect. Therefore, these areas of very low caribou density were no longer considered for the final visual survey.

The 2018 population estimate was complicated by low sample sizes of groups observed during the final visual survey, as only 91 groups of caribou were observed. This is considerably lower than the number of groups observed during the 1997 DU caribou survey with 322 groups (Nishi and Gunn, 2004), and in 2015 with 210 groups observed (Leclerc and Boulanger, 2018). The mean group size also showed a temporal decrease in size, with 15.8 in 1997, 15.2 in 2015 (median=10, std. dev=16.7, min=1, max=135), and 8.4 in 2018 (median=6, std. dev=7.3, min=1, max=35, Figure 10) (Nishi and Gunn, 2004; Leclerc and Boulanger, 2018). Analysis of double observer frequencies suggest that this was not due to poor sightability, and therefore likely consistent with a density-dependent effect of the observed decline. Another factor that could have reduced caribou counts was harvest activity in the high density East (HD_E) strata that occurred between October 21 and October 28 at Cape Peel, just prior to the final visual survey. Collar data suggests that caribou turned around and headed down the coast into the edge of the other strata (LD_E) during this time. No caribou were observed in the eastern part of this stratum (LD_E) when it was surveyed, but snowmobile tracks and five gut piles from harvested caribou were observed. However, the survey of the low density East (LD_E) strata showed that no caribou were located on the East side of the strata, indicating that this movement was contained within the HD_E strata. Thus, this would suggest that although movements of caribou occurred between the reconnaissance survey and the final visual survey, no caribou moved out of the final visual survey area during the caribou count. Regardless, the survey area coverage was adequate based on the number of collars detected within the survey area at the time of the final visual survey, with 89% of collars contained within all the survey strata (inland and coastal strata), which is a higher proportion of collars than was included in the survey area in 2015 (79%) (Leclerc and Boulanger, 2018).

For the first time, the DU Caribou herd survey included two inland strata (NW_N and NW_S) in the final survey strata. The decision to include these was based on the fact that 10 collared caribou were located in a defined area with the presence of additional caribou groups, between observed collar locations considered likely. During the 2018 survey, no collared caribou were observed in the middle or North of Victoria Island and investigations of this area were therefore not performed. The highest density of caribou was found in the HD_W strata with a density of 1.76 caribou per km^2. This high density stratum is considerably lower than high density of caribou previously observed during coastal surveys with 9.79 caribou per km^2 in 1997 and 3.85 to 5.84 caribou per km^2 in 2015 in the high density stratum at that time (Nishi and Gunn, 2004; Leclerc and Boulanger, 2018).

The extrapolated estimate of the DU herd was calculated using two approaches. First, the estimate of caribou in all strata (3,763) was divided by the proportion of collared caribou in all strata (0.89) to get an extrapolated population estimate of 4,105 caribou. Using only the caribou estimated in the coastal strata (2,657), divided by the proportion of collars in the coastal strata (0.63) resulted in an extrapolated population estimate of 4,207 caribou. The closeness of the two estimates is a demonstration of the reliability of the method of including the proportion of caribou that have not yet reached the final survey strata by estimating the detection probabilities of caribou based on the collar distribution (included/present or not included/not present in the strata). Thus, the most accurate extrapolated population estimate (4,105) remains the one that included all strata (inland and coastal strata), the largest proportion of collared caribou within the survey area (0.89), and the lowest coefficient of variation (16.9%).

An extrapolated population estimate of 4,105 DU Caribou (SE=694.8, CV=16.9%, Cl=2,931-5,750) is very concerning. It could be disputed that the survey only targeted the portion of the DU Caribou herd that was migratory and there are other DU caribou that do not migrate and remained further north on Victoria Island. Following the 2018 fall survey, three generically confirmed DU Caribou were harvested West of Ulukhaktok on December 05, December 24 and on January 09 (Mavrot, pers. comm). Though local harvesters have indicated concern regarding the 2018 survey exclusion of an inland group of the DU caribou herd in this survey, we still believe that number of these animals was low and does not pertain to the majority of the Dolphin Union herd which show migratory behavior.

In early 2019, Ulukhaktok hunters were reporting that the DU Caribou were wintering on the Island. In May 2019, a muskox and Peary Caribou survey was conducted by the Government of the Northwest Territories on Northwest Victoria Island. The Olokahktomiut Hunters and Trappers Committee identified an additional area (survey block E) to be surveyed at the head of Prince Albert Sound based on local knowledge. The survey block E was surveyed between May 8 to May 24 before the migratory portion of the DU herd reached this area. No caribou were observed on and off transect in this survey block. In addition, in the historical survey area, five group of caribou were seen on transect for a total of 30 animals, and one group of 14 off transect (Davison and Williams in prep).

Collar data suggests (Figure 14 and 15) that all the collared caribou migrated in the Fall of 2018 (figure 15). In the winter of 2016-2017, two animals (DU-51-2016 and DU-55-2016) of 35 caribou monitored did not migrate in the fall and stayed in northern Victoria Island before both became mortalities in the middle of the winter, (February 2017). It is possible that these two animals could have either spent the entire winter on Victoria Island or migrated at a later time, however this is unlikely given that they were still in northern Victoria Island in February. Late migrating caribou were also recorded in the fall of 2015, where a collared individual migrated in December (Figure 20). While the population was declining in numbers, no change in migratory behaviour amongst the majority of collared caribou to non-migrating animals was observed in any particular collared individual that was followed for more than a year and for an entire winter (Figure 14). If the observed decline was related to a change in migratory behaviour, than it would be expected that a proportion of the migratory collared caribou would stop migrating. Thus a change in migratory behaviour is unlikely contributing to the current, observed decline. The continuation of the migration between 2015 to 2019 (Figure 20) also suggests that the DU Caribou migration is, in fact, not currently population size or density driven. The 2018 extrapolated population estimate (4,105) has fallen well below the 1980 estimate of 7,936 caribou at a time that the herd was assumed not to migrate due to the low number of caribou (Gunn and Fournier, 2000).

To determine the proportion of DU Caribou that do not migrate, future collaring efforts should also target caribou on Northern Victoria Island, in an attempt to further determine the potential proportion of non-migratory DU caribou relative to resident Peary Caribou. Nonetheless, this likely small group of caribou ranging across central and northern Victoria Island have not been accounted for during any previous DU Caribou surveys, therefore, they are unlikely to have influenced the nature of the current trend.

Recent observation from Ulukhaktok indicate that a small portion of DU caribou stay on Victoria island in the winter or are very late in their migration. However, current collar data doesn't indicate any change in migratory behavior nor that a significant proportion of the herd is wintering on Victoria Island. If caribou failed to migrate, the collar data seems to imply that they might become a mortality.

The small number of caribou groups seen on transect, the decrease in caribou density on the coastline, and the decrease in the mean group size are all used to derive the extrapolated population estimate of 4,105 DU Caribou (SE=694.8, CV=16.9%, Cl=2,931-5,750). Coastline surveys have been employed over time (past 23 years), for monitoring the portion of the DU herd that is migrating and likely most vulnerable to harvest, as most harvest occurs during their migration (Figure 16). As DU caribou constitutes a traditional food source for the communities of Cambridge Bay, Bay Chimo, Bathurst Inlet, Kugluktuk, and Ulukhaktok, their conservation is critical. Measures aimed at conservation of DU caribou thus need to account for the vulnerability of the entire herd, the portion of the herd to be the most vulnerable to harvest and other mechanisms of mortality, regardless of the small non-migratory or migratory DU caribou group.

The extrapolated population estimate of 4,105 DU Caribou (SE=694.8, CV=16.9%, Cl=2,931-5,750) is very concerning and there is a sense of urgency to ensure the appropriate conservation measures are implemented on the DU Caribou herd in light of the alarming rate of decline, over the last three years. The overall trend in 2018 suggests a large-scale decline in the DU herd even if considering a small proportion might not have been assessed. The log-linear model estimates a decline of 3% per year between 1997 to 2015, when the population reached 18,413 animals. However, this rate of decline climbed to 38% per year from 2015 to 2018, resulting in a population estimate of 4,105 animals. Trend analysis suggests that this decline cannot be attributed to variance in the survey estimate alone. The annual rate of change (62%, which translates to a 38% decline each year) is more severe than the decline of the Bathurst herd that occurred between 2006-2009 in which the rate of change was 76% (or a rate of decline of 23% each year) (Nishi et al., 2010).

In 2016, a Total Allowable Harvest was implemented on the declining, adjacent herds of the Bluenose-East and Bathurst caribou. The harvest restrictions on the Bluenose-East and Bathurst caribou herds may have resulted in shifting local harvest pressure onto the DU Caribou herd, to sustain each community's need for country food. Similar shifts have been noted on the Qamanirjuaq and Southampton Island caribou herd in the wake of declines documented on Baffin Island and associated harvest restrictions, One of the causes for the accelerated decline of the Bathurst caribou herd was found to be a constant harvesting pressure on a declining population (Boulanger et al., 2011; Boulanger et al., 2014). The survival rate estimate of DU caribou cows in 2018 of 0.62 (CI=0.48-0.75) is similar to the Bathurst herd in 2009 of 0.67, which was reduced by substantial harvest pressure on a declining population (Boulanger et al., 2011). Thus, an increased harvesting rate on the already declining DU herd would likely have contributed to exacerbating the existing, observed decline in DU Caribou.

Harvest appeared to be a significant source of mortality for DU caribou from 2015 to 2019, with 14 of 43 mortalities of collared caribou having occurred due to harvesting. Harvesting of DU caribou occurs twice a year in Nunavut; in the spring (April) from the Canadian mainland, as caribou migrate back to Victoria Island, and in the fall (October-November) on the south coast of Victoria Island (Figure 16b). If these mortalities are removed from the analyses, the survival estimates increase to levels between 0.72 and 0.76 (Figure 17) suggesting a harvest effect. This level of natural survival is lower than that estimated for the Bathurst herd in 2017 (0.82 CI=0.69-0.92, (Adamczewski et al. 2019), but similar to the Bluenose-East Caribou herd (Boulanger et al 2019; 0.72, CI=0.60-0.83) and Dolphin Union herd from 1999 - 2004 of 0.76 (Poole et al., 2010). In 2017, the Bathurst Caribou herd had minimal harvest pressure and the Bluenose-East herd also had relatively low harvest levels (323 caribou in 2018 out of herd size of 19,294 adults (CI=12,042-16,249) (Boulanger et al. 2019) and therefore estimates of survival for these herds are likely not influenced substantially by harvest. Of significance is the increase in mortality rates for the DU caribou herd following harvest restrictions on the Bluenose-East and Bathurst caribou herds.

Similarity in natural survival levels between the DU and Bluenose-East herd further suggests that harvest levels are additive to other mortality sources leading to reduced survival rates (Figure 17: 0.62 with harvest compared to 0.72 without harvest in 2018), given the currently low herd size of the DU Caribou herd, combined with the level of current harvest. At the current herd size (4,105 caribou) it is possible that even a moderate level of harvest could affect caribou survival and herd demography especially if harvest is focused on females (Boulanger and Adamczewski, 2016). There is general agreement that harvest mortality is additive rather than compensatory in caribou populations (Bergerud et al., 2008). Regardless, the estimated adult female survival level of 0.62 is far below the levels of 0.80-0.85 which are needed for population stability (Haskell and Ballard, 2007; Boulanger et al., 2011) and coincides with the decline observed in the DU Caribou herd. In this context, the DU Caribou herd is very likely experiencing a demographic decline. This independent result further supports the observed declining trend based on population surveys.

The reproduction rate is one of the most important parameters used to monitor the growth potential of a population (Bergerud et al., 2008). Pregnancy rates are usually established by udder counts in June or calves at heel during the peak of calving. However, this would be an expensive method to determine pregnancy rate for the DU Caribou herd due to their independent, dispersed calving strategy spread across Victoria Island. Thus, pregnancy rates were determined by measuring the level of fecal progesterone in collared caribou cows. Pregnancy rates of the collared DU Caribou herd, were considered relatively high at 94%. During the 2018 collaring, a total of 40 Dolphin and Union sample kits were also collected by harvesters on the ground. The pregnancy rate from the harvester sample kits (n=29) provided a different pregnancy rate. The pregnancy rate from the available Dolphin and Union caribou sample kits resulted in nine individuals being non-pregnant and a pregnancy rate of 69% (Fernandez. pers. comm.). The caribou sampled from the harvesters might be more representative of the pregnancy rate of this herd because captured caribou were biased toward fatter and healthier looking caribou based on CARMA criteria, with the net effect of biasing collared caribou to more likely being pregnant (Figure 3). For the George River Caribou Herd, a pregnancy rate of 89% to 100% was needed for the herd to increase, while pregnancy rates from 59% to 78% were recorded when the herd was in decline in the early 1990s (Bergerud et al., 2008). In any case, adult female survival rates are low and need to increase to allow herd stabilization or increase, regardless of pregnancy rates.

Spatial analysis of the DU Caribou annual home range, based on 2015 - 2020 collar data, shows a progressive contraction and shift to the western part of the range (Figure 19). This range contraction is also consistent with a declining trend in herd size and likely also correlated with the declining trend in DU numbers (Bergerud et al., 2008). A Traditional Indigenous Knowledge study conducted in 2015 in Cambridge Bay indicated that the number of caribou around the community had declined by 80% (Tomaselli et al., 2018). However, recent local observations from the community of Ulukhaktok (west of the DU caribou range) have indicated an increase in DU Caribou sightings. The disparity between the local observations of these two communities across the DU Caribou herd range can be reconciled and explained by the range shift toward the west described by the collar data. Further evidence of this shift is indicated by observations of collared caribou south of Ulukhaktok, and none East of Cambridge Bay, in the fall during the 2018 population survey.

Conclusion

This project aimed to establish a new population estimate from the 2018 survey results, monitor demographic indicators, and analyze spatial distribution and range of the DU herd. The results of this study demonstrate a significant population decline from 18,413 (SE=3,133.8, CV=17%, CI=11,664-25,182) in 2015 to 4,105 (SE=694.8, CV=16.9%, Cl=2,931-5,750) in 2018 that cannot be discounted based on a small portion of DU caribou assumed to be missed based on community-based observations in northwestern Victoria Island. The estimated annual rate of change (62%, which translates to a 38% decline each year) is alarming and represents a major conservation concern. These findings are corroborated by lower cow survival rates of 0.62 and low pregnancy rates from harvester samples of 69%. Calf production and recruitment rates remain unknown. Cow survival is comparable to the Bathurst herd in 2009, which was attributable to a substantial harvest pressure on a declining population. This decline in DU caribou numbers was also reflected in a shift in the annual home range to the west, and an accompanying range contraction. Although more effort is needed to determine the percentage of the herd that might be non-migratory, significant non-migratory behaviour has not been observed in any of the DU population surveys or collar data since 1997, and thus does not explain the current decline.

To mitigate this significant and steep decline, it is recommended that more preventive management measures are developed with co-management partners in Nunavut and the Northwest Territories to conserve the DU Caribou herd and to support herd recovery as prescribe in the approved Dolphin and Union management plan. Joint efforts and close collaboration between jurisdictions is necessary to support the overall recovery of this herd.

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