An Aerial Abundance Estimate of the Dolphin and Union Caribou (*Rangifer tarandus groenlandicus* x *pearyi*) Herd, Kitikmeot Region, Nunavut – Fall 2020

Government of Nunavut

Department of Environment

GN Technical Report Series – No: 01-2021

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1st February 2021

ABSTRACT

Between October 22 and November 2, 2020, we estimated the abundance of Dolphin and Union (DU) caribou on their fall range on Victoria Island and the Kitikmeot mainland, near the Coronation Gulf, Bathurst Inlet, and Kent Peninsula. We opted to diverge from the previous costal survey methods (conducted in fall 1997, 2007, 2015, and 2018) for three main reasons. Firstly, local hunters from the communities of Kugluktuk, Cambridge Bay, and Ulukhaktok believed current estimates of abundance, and DU caribou telemetry locations, were not representative of observed changes in DU caribou seasonal range use and migratory behaviors in recent years. Communities also reported recent declines but requested a larger survey effort to ensure changes in caribou behavior were not invalidating the coastal survey method. Secondly, only 4 collars remained from a 50-collar deployment program initiated in spring 2018. This lack of current telemetry data raised concerns that the low number of collars may not be representative of DU caribou fall distributions and movements, making the telemetry dependent coastal survey method less reliable. Thirdly, the need for a new estimate was considered urgent by stakeholders based on the 2018 survey reporting of a 78% decline in abundance between 2015 and 2018. During this period, DU caribou abundance declined from 18,413 (95% CI = 11,644 – 25,182; CV = 17%) caribou in 2015 to 4,105 (95% CI = 2,931 - 5,750; CV = 17%) in 2018. We used previous years' survey results, historical and current collar data, a spatial assessment of historical collar data, and local Inuit Qaujimajatuqangit (IQ) to develop abundance strata over a much larger area than covered in previous fall surveys. We used the double observer pair and distance sampling methods to visually assess caribou abundance. In total, we surveyed 130,187 km^2, of which 105,577 km^2 was on Victoria Island, representing half of the island's surface area. We observed 1,330 caribou within 209 groups on transect and 101 caribou that were off transect, 452 muskox within 47 groups, 30 moose within 13 groups, 28 wolves within 10 groups, and 2 wolverines. In total we estimated 3,815 (95% CI =

2,930–4,966, CV= 13%) caribou across all strata on both Victoria Island and the mainland, of which 3,579 (95% CI = 2,758-4,644; CV = 13%) caribou were estimated within Victoria Island strata, and 236 (95% CI = 57-980; CV = 74%) caribou within mainland strata. An assessment of the change in abundance between the fall 2018 and fall 2020 abundance estimates was not found to be significant, with confidence limits overlapping, thus yielding no quantitative conclusion that herd numbers had significantly changed between 2018 and 2020. However, the ratio of estimates between 2018 and 2020 suggests an overall reduction in herd size of 7% to 13%, which amounts to yearly changes between these two survey periods of 4% to 7%. Due to the importance of the Dolphin and Union herd to Inuit subsistence and culture, the implications of the decline are serious.

Key words: Caribou, Barren-Ground Caribou, Dolphin and Union Caribou, Aerial Survey, Fall, Visual Survey, Kitikmeot Region, Double Observer Pair Method, Distribution, Movements, Distance Sampling, Population Structure, Nunavut, *Rangifer tarandus groenlandicus x pearyi*, Population Survey, Caribou Fall Distribution.

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ᐅᑐᐱᕆ 22–ᒧ ᓄᕕᐱᕆ 2–ᒧ, 2020,–ᒥ ᐊᑯᓐᓂᖓᓂ, ᖃᔅᓯᐅᓇᓱᒋᓐᓈᓚᐅᖅᐳᒍᑦ ᐅᓄᕐᓂᖏᓐᓂᒃ ᐅᑯᐊ, ᑭᓪᓕᓂᐅᑉ ᑐᒃᑐᖏᑦ ᐅᑭᐊᒃᓵᒃᑯᑦ ᐃᓂᒋᕙᒃᑕᒥᓂ ᐅᕙᓂ, ᐃᖃᓗᒃᑑᑎᐊᑉ ᕿᑭᖅᑕᕐᔭᐊᖓᓂ ᕿᑎᕐᒥᐅᓂᒧ ᓄᓇᑉᐸᓯᖏᓐᓂᖓᓂ, ᐅᑯᐊ ᖃᓂᒋᔭᖏᓐᓂ, Coronation Gulf, ᕿᖓᐅᑦ, ᐊᒻᒪ Kent Peninsula. ᐊᑐᖐᕈᒪᔭᖃᓚᐅᖅᐳᒍᑦ ᑭᖑᓂᕐᑎᓐᓂ ᓯᓪᔭᖓᒍᑦ ᖃᐅᔨᓴᕐᓯᓂᕐᒍᑦ ᐊᑐᖅᑕᐅᕙᒃᑐᓂᑦ (ᑲᔪᓯᑎᑕᐅᓚᐅᖅᑐᓂᒃ ᐅᑭᐊᒃᓵᓂ ᐅᑯᓇᓂ, 1997, 2007, 2015, ᐊᒻᒪ 2018) ᐱᖓᓱᓂᒃ ᐱᔾᔪᑎᖃᓪᓗᐊᑕᖅᓗᑕ. ᓯᕗᓪᓕᕐᒥᒃ, ᓄᓇᓕᖕᒥᐅᓂᑦ ᐊᖑᓇᓱᒃᑎᒋᔭᐅᔪᑦ ᐅᑯᓇᙵᑦ ᓄᓇᓕᖕᓂᑦ, ᖁᕐᓗᖅᑐᖅ, ᐃᖃᓗᒃᑑᑎᐊᖅ, ᐊᒻᒪ ᐅᓗᒃᕼᐊᒃᑑᖅ ᐅᒃᐱᕆᔭᖃᓚᐅᖅᐳᑦ ᒫᓐᓇ ᖃᔅᓯᐅᓇᓱᒋᔭᐅᔪᑦ ᐅᓄᕐᓂᖓᓂ, ᐊᒻᒪ ᑭᓪᓕᓂᐅᑉ ᑐᒃᑐᖏᑕ ᓇᓃᓐᓂᖏᑦ, ᑭᒡᒐᖅᑐᐃᓚᐅᙱᓚᑦ ᑕᐅᑐᒃᑕᐅᔪᓂᑦ ᐊᓯᔾᔨᕐᓂᕆᔭᐅᔪᓂᑦ ᑭᓪᓕᓂᐅᑉ ᑐᒃᑐᖏᓐᓂ ᐊᕐᖀᒍ ᖃᖓᒃᑰᕐᓂᖓᓄᑦ ᐃᓂᒥᒃ ᐊᑐᖅᐸᖕᓂᕆᔭᖓᓄᑦ ᑕᓪᔪᐊᓂᕐᒧᓪᓗ ᐃᓕᖅᑯᓯᕆᕙᒃᑕᖏᓐᓂᒃ ᖃᖓᑦᑎᐊᓖᕐᓂ ᐊᕐᖀᒍᒋᔭᐅᔪᓂ. ᓄᓇᓖᑦᑕᐅᖅ ᐅᖃᐅᓯᖃᓚᐅᕆᕗᑦ ᖃᖓᑦᑎᐊᓖᖅ ᐅᓄᕈᓐᓃᕆᐊᕐᓂᕆᔭᐅᔪᓂᒃ, ᑭᓯᐊᓂᓗᑦᑕᐅᖅ ᐊᐱᕆᓪᓗᑎᒃ ᐊᖏᓂᖅᓴᒥᒃ ᖃᐅᔨᓴᕐᓂᖅᑕᖅᑯᓪᓗᒍ ᓇᓗᙱᑦᑎᐊᕈᒪᓂᕐᒍᑦ ᐊᓯᔾᔨᕐᓂᕆᔭᐅᔪᑦ ᑐᒃᑐᐃᑦ ᐃᓕᖅᑯᓯᕆᔭᖏᓐᓂ ᐊᑐᕈᓐᓇᐃᓪᓕᑎᑦᑎᙱᒃᑲᓗᐊᕐᒪᙲᑕ ᓯᓪᔭᖅᐸᓯᖕᒥ ᖃᐅᔨᓴᖅᓯᓂᕐᒍᑦ ᐊᑐᖅᑕᐅᔪᒥᒃ. ᐊᐃᑉᐸᖓᑦ, ᑎᓴᒪᐃᓐᓇᕐᓂᒃ ᖁᖓᓯᕿᕐᓂᒃ ᐊᒥᐊᒃᑯᑕᖃᓚᐅᖅᐳᖅ 50–ᓂᑦ ᖁᖓᓯᕿᓕᖅᑕᐅᓯᒪᔪᓂᒃ ᐱᓕᕆᐊᖑᓚᐅᖅᓯᒪᔪᒥᑦ ᐱᒋᐊᖅᑕᐅᓚᐅᖅᓯᒪᓪᓗᓂᓗ ᐅᐱᕐᖒᒥ 2018–ᒥ. ᑕᒪᓐᓇ ᐱᑕᖅᙱᓐᓂᖓ ᖃᖓᑦᑕᖅᑎᑕᐅᓯᒪᔪᒃᑯᑦ ᑎᑎᕋᖅᓯᒪᔪᓂᒃ ᓴᖅᑭᑎᑦᑎᓚᐅᖅᐳᖅ ᐃᓱᒫᓘᑕᐅᔪᓂᒃ ᐅᓄᙱᓐᓂᖏᑦ ᖁᖓᓯᕿᐃᑦ ᑭᒡᒐᖅᑐᐃᙱᑐᐃᓐᓇᓇᐊᖅᑲᖅᓂᖅᒋᓐᓂᒃᑭᓪᓕᓂᐅᑉ ᑐᒃᑐᖏᓐᓂ ᓇᓃᑉᐸᖕᓂᖏᓐᓂᒃ ᓇᒧᙵᖅᐸᓪᓕᐊᕙᖏᓐᓂᓗ, ᑕᒪᓐᓇ ᖃᖓᑦᑕᖅᑎᑕᐅᓯᒪᔪᒃᑯᑦ ᓯᓪᔭᒥᒃ ᖃᐅᔨᓴᖅᓯᕙᖕᓂᖅ ᐊᑐᖅᑕᐅᑎᐊᙱᓐᓂᖅᓴᐅᓕᖅᑎᑦᑎᓪᓗᓂ. ᐱᖓᔪᖓᑎᒍᑦ, ᐱᔭᕆᐊᖃᖅᓂᖅ ᓄᑖᒥᒃ ᖃᔅᓯᐅᓂᐊᖃᓱᒋᓐᓈᓂᕐᒥᒃ ᐃᓱᒪᒋᔭᐅᓚᐅᖅᐳᖅ

ᑐᐊᕕᕐᓇᕋᓱᒋᔭᐅᓗᓂ ᐱᖃᖃᑕᐅᔪᓂᑦ ᑕᒪᓐᓇᓗ ᑐᙵᕕᖃᖅᑎᑕᐅᓪᓗᓂ 2018–ᒥ ᖃᐅᔨᓴᕐᓂᐅᓚᐅᖅᑐᒧᑦ ᐅᖃᐅᓯᓕᖅᒧᑦ 78%–ᒥᒃ ᐅᓄᕐᑯᓐᓃᕆᐊᖅᓯᒪᓂᖏᓐᓂᒃ ᐅᓄᕐᓂᕆᔭᖏᑕ 2015–ᓗ 2018–ᓗ ᐊᑯᓐᓂᖏᓐᓂ. ᑕᒪᓐᓇ ᐊᑐᕐᓂᖓᓂ, ᑭᓪᓕᓂᐅᑉ ᑐᒃᑐᖏᓐᓂᒃ ᐅᓄᕐᓂᖏᑦ ᐅᓄᕈᓐᓃᕆᐊᓚᐅᖅᐳᑦ 18,413–ᓂᑦ (95% CI = 11,644 – 25,182; CV = 17%) ᑐᒃᑐᓂᒃ 2015–ᒥ 4,105–ᖑᓕᓚᐅᖅᓱᑎᒃ (95% CI = 2,931 - 5,750; CV = 17%) 2018–ᒥ. ᐊᑐᓚᐅᖅᐳᑦ ᐊᕐᕌᓂᐅᓚᐅᖅᑑᑉ ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᖃᓄᐃᓕᖓᓕᖅᑎᑕᐅᔪᓂᒃ, ᐊᑐᖅᑕᐅᕙᓚᐅᖅᑐᓂᒃ ᒫᓐᓇᓗ ᖁᖓᓯᕈᖅᓯᕗᖅᓂᕐᒧᑦ ᑎᑎᕋᖅᓯᒪᔪᓂᒃ, ᐊᒻᒪᓗ ᓄᓇᓕᖕᒥᐅ ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᖏᓐᓂᒃ ᐋᖅᑭᒃᓯᒪᓕᖅᑎᑦᑎᔪᒪᕐᓂᒧᑦ ᐅᓄᕐᓂᖏᓐᓄᑦ ᖃᓄᐃᓕᐊᓂᖏᓐᓂᒃ ᐊᖏᓂᖅᓴᒻᒪᕆᖕᒥ ᐃᓂᒥ ᖃᐅᓯᓴᖅᑕᐅᕝᕕᐅᕙᓚᐅᖅᑐᒥᑦ ᑭᖑᓂᑦᑎᓐᓂ ᐅᑭᐊᒃᓵᒥ ᖃᐅᔨᓴᕐᓂᕆᔭᐅᔪᓂ. ᐊᑐᓚᐅᖅᐳᑦ ᒪᕐᕈᐃᓕᖅᑲᖑᔪᒃᑯᑦ ᓇᐅᑦᑎᖅᓱᖅᑎᓂᒃ ᒪᕐᕉᖕᓂᒃ ᐅᖑᓯᒋᓗᐊᖅᓱᒋᓪᓗ ᖃᐅᔨᓴᖅᓯᓂᕐᒧᑦ ᐊᑐᖅᑕᐅᓇᔭᖅᑐᓂᒃ ᑕᐅᑐᒃᑐᒍ ᖃᐅᔨᓴᕋᔭᕐᓂᕐᒥᒃ ᑐᒃᑐᑦ ᖃᓄᖅ ᐅᓄᖅᑎᒋᓂᖏᓐᓄᑦ. ᑲᑎᕐᓱᒋᑦ, ᖃᐅᔨᓴᖅᓯᕝᕕᖃᓚᐅᖅᐳᑦ 130,187 km^{2}–ᓂᒃ 105,577 km^{2}–ᒋᔭᖏᓪᓗ ᑕᐃᑲᓂ ᐃᖃᓗᑦᑑᑦᑎᐊᑉ ᕿᑭᖅᑕᕐᔪᐊᖓᓃᕐᓱᑎᒃ, ᑕᒪᓐᓇ ᑭᒡᒐᖅᑐᐃᓪᓗᓂ ᓇᑉᐸᖓᓂᒃ ᑖᔅᓱᒪ ᕿᑭᖅᑕᐅᑉ ᐃᓂᐅᑉ. ᑕᑯᓚᐅᖅᐳᑦ 1,330–ᓂᒃ ᑐᒃᑐᓂᒃ, 209–ᓂ ᑐᒃᑑᖃᑎᒌᖕᓂ ᑐᑭᓂᕝᓕᐊᖅᑐᒥ, 101–ᓂᓪᓗ ᑐᒃᑐᑐᓂᒃ ᑕᒪᑐᒪ ᑐᑭᓂᐊᖅᑑᑉ ᓯᓚᑖᓂᑦᑐᓂᒃ ᑐᑭᓕᐊᖅᑑᑉ, 452–ᓂᒃ ᐅᒥᖕᒪᖕᓂᒃ 47–ᓂ ᐅᒥᖕᒪᐅᖃᑎᒌᒃᑐᓂ, 30–ᓂᒃ ᑐᒃᑐᕙᖕᓂᒃ 13–ᓂ ᑐᒃᑐᕙᐅᖃᑎᒌᓂ, 28–ᓂᒃ ᐊᒪᕈᕐᓂᒃ 10–ᓂ ᐊᒪᕉᖃᑎᒌᒃᑐᓂ, 2–ᓂᓪᓗ ᖃᕝᕕᓘᕐᔪᖕᓂᒃ. ᑲᑎᕐᓱᒋᑦ 3,815–ᐸᓘᓇᓱᒋᓐᓈᓚᐅᖅᐳᑦ (95% CI = 2,930–4,966, CV= 13%) ᑐᒃᑐᓂᒃ ᑕᒪᐃᓐᓂᓕᒫᖅ ᐃᓂᒋᕙᐅᔪᓕᒫᓂ ᑕᐃᑲᓂ ᐃᖃᓗᒃᑑᑦᑎᐊᒥᐅᑦ ᕿᑭᖅᑕᕐᔪᐊᖓᓂ ᓄᓇᕕᖕᒥᓗ, ᑖᒃᑯᓇᓂᓗ 3,579–ᖑᔪᑦ (95% CI = 2,758-4,644; CV = 13%) ᑐᒃᑐᐃᑦ ᐃᖃᓗᒃᑑᑦᑎᐊᑉ ᕿᑭᖅᑕᖓᑕ ᓄᓈᓃᕐᓱᑎᒃ, 36–ᖏᓪᓗ (95% CI = 57-980; CV = 74%) ᑐᒃᑐᐃᑦ ᓄᓇᕕᖕᒥ ᐃᓂᒋᔭᐅᔪᒦᕐᓱᑎᒃ. ᖃᐅᔨᓴᕐᓂᖅ ᐊᓯᔾᔨᕐᓂᕆᔭᐅᔪᒥ ᐊᓄᕐᓂᕆᔭᖏᓐᓂ ᐅᑭᐊᒃᓵᖑᓚᐅᖅᑐᒥ 2018–ᒥ ᐅᑭᐅᒃᓵᖑᓚᐅᖅᑐᒥᓗ 2020–ᒥ ᖃᔅᓯᐅᓂᖏᓐᓄᑦ ᖃᔅᓯᐅᓇᒋᓐᓈᓃᑦ ᖃᐅᔨᓴᐅᕝᕕᐅᓚᐅᙱᓚᖅ ᐅᔾᔨᕐᓇᕐᓂᖓᓂᒃ, ᐃᓱᓕᑦᑕᕐᕕᖏᒃ ᓇᓇᓗᙱᑦᑎᐊᕐᓂᓕᕐᒧᑦ ᖃᓪᓕᖃᑦᑕᐅᑎᓪᓗᑎᒃ,

ᑕᐃᒪᐃᓐᓂᖓᓄᑦᑐ ᓴᖅᑭᑎᑦᑎᙱᑦᕆᓂ ᓈᓴᒐᒃᓴᐅᔪᓂᒃ ᖃᓄᐃᓕᖓᓕᖅᑎᑕᐅᔪᓂᒃ ᑕᒪᒃᑯᐊ ᖃᑦᓯᐅᓂᖏᑦ ᐅᔾᔨᕐᓇᖅᑐᒪᓇᒃᑯᑦ ᖃᓯᔾᔨᖅᓯᒪᓕᓚᐅᖅᑐᑎᒃ 2018–ᒧ 2020-ᒧ ᐊᑯᓐᓂᖏᓐᓂ. ᑭᓯᐊᓂᒧᑦᑕᐅᖅ, ᖃᓅᓂᕆᔭᖏᑦ ᖃᑦᓯᐅᓇᓱᒋᔭᐅᔪᑦ 2018–ᒧ 2020–ᒧ ᐊᑯᓐᓂᖏᓐᓂ ᐃᒪᐃᑎᑦᑎᖅᑰᕗᖅ, ᐊᑕᖏᖅᑐᑎᒃ ᐅᓄᕈᓐᓃᓇᐊᖅᓯᒪᓂᖏᓐᓂᒃ ᓂᕐᔪᑎᐅᖅᑲᑎᑏᑦ ᐅᓄᕐᓂᖏᑕ 7%–ᒥᑦ 13%–ᒧᑦ, ᑕᒪᓐᓇᓗ ᐊᕐᕈᒍᑕᒫᑦ ᐊᓯᔾᔨᕐᓂᕐᓂᒃ ᐱᑕᖅᑲᖅᑎᑦᑎᑦᑐᓂ 4%–ᒥᑦ 7%–ᒧᑦ. ᐱᔾᔪᑎᖃᖅᑐᓂ ᐱᒻᒪᕆᐊᓘᓂᖏᓐᓂᒃ ᑭᑦᑕᓂᐅᒃ ᑐᒃᑐᖏᑦ ᐃᓄᐃᑦ ᐆᒪᔾᔪᑎᒋᕙᒃᑕᖏᓐᓄᑦ ᐃᑦᖅᑯᓯᖏᓐᓄᑦᑐ, ᖃᓄᐃᓕᖓᓕᕐᓂᓇᓱᐅᔪᑦ ᐅᓄᕈᓐᓃᓇᐊᕐᓂᖏᓐᓄᑦ ᐱᒻᒪᕆᐊᓘᕗᑦ.

ᐅᖃᐅᓯᐅᑦᑐᐊᑕᖅᑐᖅ: ᑐᒃᑐᑦ, ᓇᐹᖅᑐᖃᙱᑦᑐᒥ ᑐᒃᑐᑦ, ᑭᑦᑕᓂᐅᑉ ᑐᒃᑐᖏᑦ, ᖃᖓᑕᓄᓂ ᖃᐅᔨᓴᕐᓂᖅ, ᐅᑭᐊᒃᓵᖅ, ᑕᐅᑐᒃᑯᒍ ᖃᐅᔨᓴᖅᓯᓂᖅ, ᕿᑎᕐᒥᐅᓂ, ᒪᕈᓄᑎᒃ ᑕᐅᑐᒃᑎᐅᓄᑎᒃ ᐱᓕᓇᖃᑎᒌᒃᑐᒃ ᐊᑐᖅᑕᐅᕙᒃᑐᖅ, ᓇᓃᓐᓂᓇᔾᔪᑦ, ᓇᔪᙳᖅᐸᑦᓕᐊᕙᓐᓂᖏᑦ, ᐅᖓᓯᒋᖓᓄᐊᖅᑯᒋᑦ ᖃᐅᔨᓴᖅᓯᕙᓐᓂᖅ, ᖃᓯᐅᓂᖏᓐᓄᑦ ᖃᓄᖅ ᐋᖅᑭᒃᓯᒪᓂᖏᑦ, ᓄᓇᕗᑦ, *Rangifer tarandus groenlandicus x pearyi*, ᖃᓯᐅᓂᖏᓐᓄᑦ ᖃᐅᔨᓴᖅᓯᓂᖅ, ᑐᒃᑐᐃᑦ ᐅᑭᐊᖅᓵᒃᑯᑦ ᓇᓃᑉᐸᓂᓇᔾᔪᑦ.

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1.0 INTRODUCTION

Caribou are circumpolar in their distribution and occur in northern parts of Eurasia and North America. In Canada, caribou are represented by four subspecies; Peary (*Rangifer tarandus pearyi*), woodland (*R. t. caribou*), grant's (*R. t. granti*), and barren-ground (*R. t. groenlandicus*). However, a fifth grouping, known as Dolphin and Union caribou (*Rangifer tarandus groenlandicus* x *pearyi*), differ from both Peary and barren-ground caribou genetically, making them unique amongst North American caribou populations (McFarlane et al., 2016; Serrouya et al. 2012). Dolphin and Union (DU) caribou share traits from both barren-ground and Peary caribou in regards to their appearance and behavior. Generally, DU caribou are smaller bodied than barren-ground caribou, and lack the dark brown coloration which is typical of barren-ground caribou. While slightly larger bodied than Peary caribou, DU caribou are similar in coloration, with their characteristic lighter pelage (Poole et al., 2010). DU caribou tend to share the lighter slate grey coloration of their antler velvet with Peary caribou, while differing from the more commonly dark chocolate brown antler velvet of barren-ground caribou (Gunn et al., 1997). Behaviorally, DU caribou, like Peary caribou, spend their entire annual cycle in high arctic habitats, while their extensive seasonal migration across the sea ice to winter on the Nunavut mainland is reminiscent of the barren-ground subspecies (*groenlandicus*), with whom they seasonally mix.

DU caribou are known to occupy an annual range that encompasses the majority of Victoria Island, and the northern extents of the Nunavut mainland in the vicinity of the Coronation Gulf, Bathurst Inlet, and Kent Peninsula (**Figure 1**). Most collared DU caribou cows (from 1987 to 2020) have calved and spent their summer months on Victoria Island, at times mixing with Peary caribou within the central and northern extents of the island (Davison and Williams, 2019). Though named for the Dolphin and Union Straight where the DU caribou once commonly migrated during fall to their mainland seasonal winter range, most migratory DU caribou now migrate across the Dease Strait to their wintering grounds along, and inland from, the eastern shores of the Coronation Gulf, and in the vicinity of

Bathurst Inlet and Kent Peninsula (Gunn et al. 1997). Recent Inuit Qaujimajatuqangit (IQ), collected during pre-survey consultations, suggests that this annual cycle has changed in recent years with evidence of change in seasonal range affinity and migratory patterns (Roberto-Charron, 2020). Hunters from the communities of Cambridge Bay, Kugluktuk and Ulukhaktok are reporting larger numbers of DU caribou remaining year-round on Victoria Island, while mainland hunters have reported DU caribou in the vicinity of Contwoyto Lake mixing with the mainland herds within the last two to three years (**Figure 1**). Though DU caribou occupy a largely discreet winter range, there is overlap with barren-ground caribou, including the Beverly, and Bathurst herds, most pronounced in early fall and spring within the southern extents of the DU caribou known annual range (Campbell et al. 2012a; Campbell et al. 2012b) (**Figure 1**). Furthermore, the DU caribou overlap in range with Peary caribou (Campbell et al. 2012b; Davison and Williams, 2019; Gunn et al. 1997). Following a June 1994 calving survey across Victoria Island reported by Gunn et al. (1997), field biologists were concerned that all aggregations of DU caribou were not assessed, and that there was confusion between Peary caribou aggregations and DU caribou aggregations. Biologists at the time believed that to adequately assess DU caribou during calving, an island wide survey may have to be considered, and that consideration of such a survey, at that time, may not be logistically feasible. In response to this finding, a coastal survey methodology was developed and deployed in fall 1997 (Nishi and Gunn, 2004). This survey method had the advantage of dramatically reducing the survey study area. Additionally, it was completed when Peary caribou were largely separated from DU caribou, and it monitored the DU caribou during their pre-fall migration staging along the southern Victoria Island coast waiting for the sea ice to form just prior to their migration across the Dolphin and Union, and Dease Strait to the Nunavut mainland. When combined with an intensive satellite telemetry program, the method proved highly successful, and in 1997 the first complete abundance estimate of the Dolphin and Union herd was realized. Since 1997, the fall survey method has been implemented in 2007, 2015, and 2018.

Throughout the coastal survey history of the DU caribou population, the overall trend has indicated a statistically significant and steady decline (Gunn et al., 2011; Leclerc and Boulanger, 2019). DU caribou herd abundance has declined from 34,558 (95% CI = 27,757 to 41,359; CV = 12%) in 1997, to 27,787 (95% CI = 20,250 to 35,324; CV = 13%) in 2007 (19% decline), to 18,413 (95% CI = 11,644 to 25,182; CV = 17%) in 2015 (34% decline), finally plummeting to 4,105 (95% CI = 2,931 to 5,750; CV = 17%) by 2018. This indicates an overall decline of 78% between 2015 and 2018 and 4.2% per year and almost a doubling in the annual rates of decline since fall 1997. The annual rate of decline between 1997 and 2015 was 2.6% per year (Nishi and Gunn, 2004; Dumond and Lee, 2013; Leclerc and Boulanger, 2018). Reasons for this dramatic decline between 2015 and 2018 are yet unknown, however contributing factors likely involve a combination of factors including, but not limited to, predation, harvesting, forage quantity, quality and availability, changes in sea ice conditions, parasites and disease. Leclerc and Boulanger (2018), estimated collared female survival at 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. Regardless, the estimated survival rate of 0.72 indicated a declining population.

DU caribou status was originally assessed as a single unit with Peary Caribou, and together they were identified as Threatened in 1979. In 1991, the caribou populations were separated regionally and were reassessed as follows; Banks Island (Endangered), High Arctic (Endangered), and Low Arctic (Threatened) populations. In 2004, the populations were reassessed with the Banks Island and High Arctic populations combined and designated as Peary Caribou, and the Low Arctic population as Dolphin and Union caribou. At this time Dolphin and Union caribou were assessed as Special Concern. In 2017, the DU caribou population was re-assessed by COSEWIC as Endangered in Canada (COSEWIC 2004; Species at Risk Committee, 2013; COSEWIC, 2017).

The fall 2020 DU caribou abundance survey became a Nunavut Government priority. Both the Endangered status recommended by COSEWIC, and the reported declines from the 2018 survey, created an urgent need to re-assess the population and consider management actions aimed to prevent further decline. The coastal survey method has proven reliable in the past, and to this end aspects were retained in the development of the fall 2020 survey strata including the high coverage coastal strip strata. However, due to a lack of collared caribou cows, in combination with local observations on DU caribou overwintering on Victoria Island, and hunter observations of rutting DU caribou further inland away from the traditional coastal strip study areas, the survey design was greatly modified. In 2020, additional survey strata were drawn inland from the coastal strip strata and into the Northern extents of Victoria Island. Additionally, three mainland strata, representing early winter / post fall migration range, were established.

There were several reasons why the decision was made to modify the method. The main reasons for these modifications were driven by the loss of 46 collared DU caribou between spring 2018 and fall 2020, leaving only 4 collars active by fall 2020, while the global pandemic prevented any program maintenance in spring 2020. Without these additional collars, concerns over unrepresentative stratification, undocumented migratory movements, and punctuated movements between strata during the survey, were raised. Additionally, the communities of Cambridge Bay, Kugluktuk, and Ulukhaktok had concerns that the DU caribou herds’ annual movements, migratory patterns and fall distribution, have been changing (Roberto-Charron, 2020). Local hunters were concerned that their observations of DU caribou year-round on Victoria Island were consistent with the observations from the 1920s reported by Inuit elders, in the DU herd’s migration from Victoria Island to the mainland. It’s believed that severe winter storms, including icing events, led to a large-scale reduction in caribou abundance, which in turn led to the modifications in DU herd behaviour, and ultimately, range use (Roberto-Charron, 2020; Hughes, 2006; Poole et al., 2010; Hanke and Kutz, 2020). The reported declines in the 1920s persisted into the 1970s when Inuit harvesters began reporting the beginnings of a recovery on southern Victoria Island (Hughes, 2006). By the mid-1970s, small numbers of Dolphin and Union caribou were reported to be crossing the sea ice to the mainland, resuming their migratory behaviour (Hughes, 2006; Gunn et al. 1997).

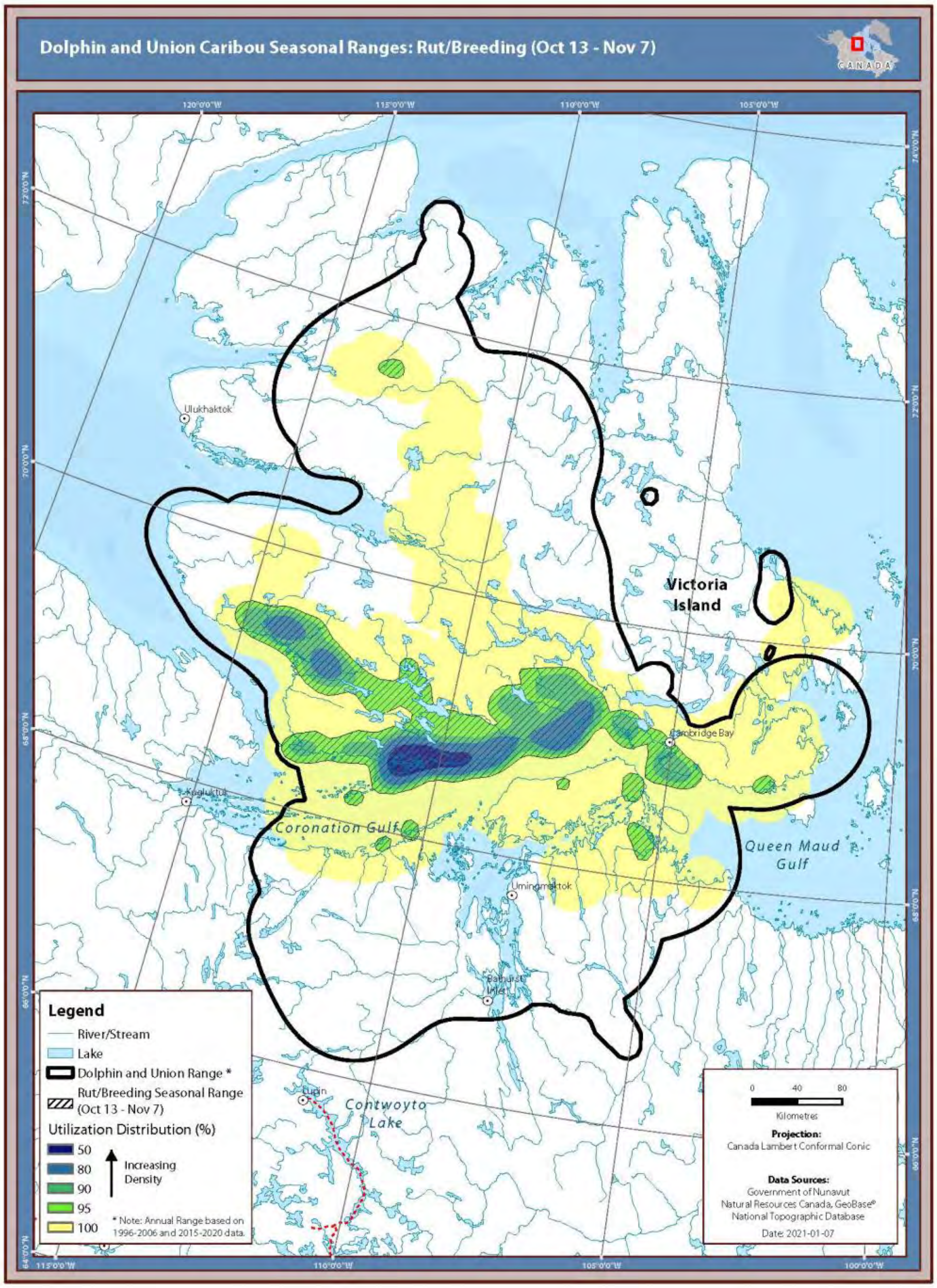

Figure 1. The Dolphin and Union (DU) caribou annual range and fall/rutting range (Oct. 13 to Nov. 7). Range extents developed using a kernel analysis of DU caribou cow telemetry data collected between 1997-2006 and 2015-2020 (**Appendix 8.1**). All core fall/rut seasonal range (green polygons) and annual range extents developed based on the 95% Utilization Distribution (UD). Yellow color represents fall/rut extents to the 100% UD. Red dashed line indicates a winter mining road.

2.0 STUDY AREA

The DU caribou herd annual range and fall/rutting seasonal range (October 13 to November 7) was estimated using a kernel analysis from the amalgamation of data from two satellite telemetry programs, the first running from 1997 through 2006, and the second running from 2015 to 2020 (Campbell et al., 2014). The estimated annual range of the DU caribou herd, based on satellite-collar location data collected between 1997 and 2020, is approximately 243,085 km^2. Of the entire annual range an estimated 157,147 km^2 (65%) lies on Victoria Island and 85,938 km^2 (35%) on mainland Nunavut. The full extent (100% UD) of the DU caribou herd fall/rutting range is estimated to cover 125,448 km^2, which represents approximately 52% of the herd's annual range. Of the fall/rut range, approximately 92,020 (73%) km^2 lies on Victoria Island, while an estimated 33,428 km^2 (27%) lies on the Nunavut mainland. As the survey was flown within the fall/rut period (October 13 to November 7), we focused survey effort within the fall seasonal range polygon (**Figure 2**). It is noteworthy that the fall/rut seasonal range extent includes the migratory period. All 2020 survey transects were flown prior to sea ice formation, therefore prior to the onset of the DU herds migration from Victoria Island south to the mainland extent of the fall/rut seasonal range.

The DU herd's annual range extends across both the Southern and Northern Arctic Ecozones (Environment Canada, 1995). From south to north, the range crosses 7 ecoregions including the Garry Lake Lowland, Takijuq Lake Upland, Queen Maud Gulf Lowland, Bathurst Hills, Amundsen Gulf Lowlands, Victoria Island Lowlands, and Shaler Mountains Ecoregions (Wiken, 1986; Environment Canada, 2001; Environment Canada, 1995) (**Figure 3)**. Much of the DU fall/rutting seasonal range runs through the Amundsen Gulf Lowlands, and to a lesser extent through the Victoria Island Lowlands.

2.1 Northern Arctic Ecozone.

The Northern Arctic Ecozone primarily consists of low rolling plains covered by layers of glacial till and debris. Permafrost lies beneath the entire zone below a thin active layer that freezes in winter and thaws in summer. The constant freezing and thawing separate the substrate creating cell-like shapes known as patterned ground, which consequently cover much of the ecozone. Expansive flat coastal plains extending many kilometers inland typify much of the coastline within this Ecozone. Crustal recoil is active in the area and exemplified by inland beach ridges. Within the interior of this ecozone, broad plateaus are common, often showing deep V-shaped cuts along their shoulders where past and existing streams and rivers have cut through the sedimentary substrate on which they flow. Islands of this ecozone often display sheer cliffs along the edges of high plateaus making some coastline inaccessible. Within the DU annual range, this ecozone is represented by three ecoregions, the Amundesen Gulf Lowlands, Shaler Mountains, and Victoria Island Lowlands: (After Wiken, 1986; Environment Canada, 2001; Environment Canada, 1995) (**Figure 2**);

2.1.1 Amundsen Gulf Lowlands Ecoregion.

This ecoregion occurs predominantly on southern Victoria Island and to a minor extent on the mainland. The mean annual temperature is approximately -14°C with a summer mean of 2°C, and a winter mean of -28.5°C. The mean annual precipitation ranges from 100 to 200 mm. This ecoregion is classified as having a low arctic ecoclimate and is characterized by a nearly continuous cover of dwarf tundra vegetation. Dominant vegetation consists of dwarf birch (*Betula glandulosa*), willow (*Salix spp*.), northern labrador tea (*Ledum decumbens*), mountain avens

(*Dryas integrafolia)*, and ericaceous shrubs (*Vaccinium spp*.). Tall dwarf birch, willow, and alder (*Alnus spp*.) occur on warm sites, while wet sites are dominated by willow and sedge (*Carex spp*.). The terrain of the southern one-third of Victoria Island generally slopes gently to the southwest and is composed of stratified Palaeozoic carbonate rocks. Extensive areas of drumlinoid ridges bring a characteristic grain to the minor topography on the island. Turbic Cryosols are the dominant soils, developing on a variety of smooth, undulating glacial deposits. Deep, continuous permafrost with high ice content and abundant ice wedges are characteristic, although an area with continuous low ice content permafrost runs along the coast between Minto Inlet and Prince Albert Sound, west of the Shaler Mountains ecoregion. Common wildlife includes muskox, caribou, arctic hare, arctic fox, snowy owl, raptors, polar bear, seal, seabirds, and waterfowl (After Wiken, 1986; Environment Canada, 2001; Environment Canada, 1995).

2.1.2 Shaler Mountains Ecoregion.

This ecoregion covers the Shaler Mountains in central Victoria Island and is characterized by a 40-60% vegetative cover mixed with exposed bedrock materials. The mean annual temperature is approximately -15.5°C with a summer and winter mean of 1°C and -29.5°C respectively, with mean annual precipitation ranging from 100 to 200 mm. This ecoregion is classified as having a mid-arctic ecoclimate. Tundra vegetation includes purple saxifrage (*Saxifraga oppisitifolia*), mountain avens, and dwarf willow, along with alpine foxtail (*Hordium spp*.), wood rush (*Luzula confusa*), and other saxifrage (*Saxifraga spp*.). Wet areas have a continuous cover of sedge, cottongrass (*Eriophorum spp*.), saxifrage, and moss. The Shaler Mountains dissect Victoria Island and are composed of late Proterozoic stratified rocks intruded by gabbro sills that form cuestas and are capped by flat-lying volcanic rocks. The center part of the mountains reaches about 760 m ASL (above sea level). Turbic Cryosols developed on undulating to steeply sloping glacial deposits dominate the soils of this region, with surface bedrock common throughout the region. Continuous, low ice content permafrost occurs throughout the ecoregion. Common wildlife includes caribou, polar bear, muskox, arctic hare, arctic fox, snowy owl, other raptors, seal, whale, walrus, seabirds, and waterfowl (After Wiken, 1986; Environment Canada, 2001; Environment Canada, 1995).

2.1.3 Victoria Island Lowlands Ecoregion.

This ecoregion includes the northern two-thirds of Victoria Island. This ecoregion is classified as having a mid-arctic ecoclimate. The mean annual temperature is -14°C with a summer mean of 1.5°C and a winter mean of -29°C, with mean annual precipitation ranging from 100 to 150 mm. This ecoregion is characterized by a discontinuous upland vegetative cover dominated by purple saxifrage, mountain avens, and dwarf willow, along with alpine foxtail, wood rush, and other saxifrage species such as *Saxifraga tricuspidata*. Wet areas have a continuous cover of sedge, cottongrass, saxifrage, and moss. Remaining upland areas are largely devoid of vegetation, a distinguishing characteristic of this ecoregion. Smooth, undulating lowlands are formed on flat-lying Palaeozoic and late Proterozoic carbonate rocks that slope gently to the south and southwest. Extensive areas of drumlinoid ridges impart a characteristic grain to the minor topography. Elevations lie predominantly below 100 m ASL, except in central Victoria Island where elevations rise to over 200 m ASL. This ecoregion is underlain by continuous permafrost with medium to high ice content in the form of ice wedge polygons and massive ice bodies. Turbic Cryosols with Static Cryosols are the dominant soils, developing on a variety of smooth, undulating glacial deposits. Wetland areas are distributed mainly along the east coast of Victoria Island along M'Clintock Channel. These are composed of marshes, horizontal fens and low-center lowland polygon fens with small, elevated peat mound bogs. Common wildlife includes caribou, muskox, polar bear, arctic hare, arctic fox, snowy owl, other raptors, seal, whale, seabirds, and waterfowl (After Wiken, 1986; Environment Canada, 2001; Environment Canada, 1995).

2.2 Southern Arctic Ecozone.

The Southern Arctic Ecozone primarily consists of extensive glacial deposits of soil and rock debris often in the form of boulder moraines cut by long eskers extending up to 100 km, with occasional surface intrusions of granite bedrock. Outwash aprons of crudely sorted sands, gravels and raised beach ridges once forming the shorelines of preglacial lakes, occur less frequently. Glacial carried “erratics”, or large boulders carried by glaciers, can be found throughout this ecozone. Permafrost occurs continuously throughout this ecozone, which at times can be just a few centimetres under the surface. Soils are often waterlogged or frozen, and ponds and lakes numerous. The constant freezing and thawing separates the substrate creating cell-like shapes known as patterned ground, which, as in the Northern Ecozone, cover much of the Southern Arctic Ecozone. Within the DU caribou annual range, this ecozone is represented by four ecoregions, the Takijuq Lake Upland, Bathurst Hills, Queen Maud Gulf Lowland, and the Garry Lake Lowland: (After Wiken, 1986; Environment Canada, 2001; Environment Canada, 1995) (**Figure 2**).

2.2.1 Takijuq Lake Upland Ecoregion.

In this ecoregion, much of the upland surface is composed of unvegetated rock outcrops that are common on the Canadian Shield. The mean annual temperature is approximately -10.5°C with a summer mean of 6°C and a winter mean of -26.5°C, with mean annual precipitation ranging between 200 and 300 mm. This ecoregion is classified as having a low arctic ecoclimate. Numerous lakes form extensive coverage across the lowlands of this ecoregion. Vegetative cover is characterized by shrub tundra, consisting of dwarf birch, willow, northern Labrador tea, Mountain avens, and ericaceous shrubs. Depressions are dominated by willow, sphagnum moss (*Sphagnum spp*.), and sedge tussocks. Scattered stands of spruce (*Picea glauca*) occur along the southern boundary of this ecoregion. The geology of the region consists mainly of massive Archean rocks that form broad, sloping uplands, plateaus, and lowlands. Bathurst Hills form a prong of rugged ridges that reach about 610 m ASL and stand as much as 185 m above nearby lakes. Turbic and Static Cryosols form the common soils on thin discontinuous sandy morainal and fluvioglacial materials, and in association with rock outcrops, dominate the uplands. Organic Cryosols are the dominant soils in the lowlands. Permafrost is deep and continuous with low ice content throughout most of the region, although the ice content along the west side of Bathurst Inlet is low to medium. The ecoregion has high mineral development potential and considerable exploration activity has taken place. Common wildlife includes caribou, muskox, grizzly bear, hare, fox, wolf, raptors, shorebirds, seabirds, and waterfowl (After Wiken, 1986; Environment Canada, 2001; Environment Canada, 1995).

2.2.2 Bathurst Hills Ecoregion.

This ecoregion occurs along the mainland shore of Coronation Gulf and along the shores of Bathurst Inlet and adjacent offshore islands. The mean annual temperature is approximately -12.5°C with a summer and winter mean of 4°C and -28°C respectively. The mean annual precipitation ranges from 125 to 200 mm. This ecoregion is classified as having a low arctic ecoclimate and is characterized by a nearly continuous cover of shrub tundra vegetation. Dwarf birch, willow, and alder occur on warm, dry sites while sphagnum moss and sedge tussocks dominate poorly drained sites. Bathurst Hills are composed of down-faulted, folded sediments and sills that lie within, and extend south from, Bathurst Inlet between higher upland areas of massive granite rocks. The softer rocks, having been eroded in many places, lie submerged beneath bays and channels, leaving the harder deposits more than 300 m ASL. Marine silts and reworked deposits from marine sediments cover low-lying areas along the coast. Some rugged peaks reach 610 m ASL, standing as much as 185 m above nearby lakes. Rock outcrops and Turbic and Static Cryosolic soils developed on thin sandy glacial tills, are characteristic of the region. Permafrost is continuous with low to medium ice content, except in the northeastern part of the ecoregion on the Kent Peninsula, where it has medium to high ice content in the form of ice wedges. Common wildlife includes waterfowl, caribou, muskox, moose, red and arctic fox, snowshoe hare, arctic ground squirrel, masked shrew, lemming, wolf, lynx, weasel, snowy owl, shorebirds, seabirds, raptors, seal, whale, walrus, and polar bear (After Wiken, 1986; Environment Canada, 2001; Environment Canada, 1995).

2.2.3 Queen Maud Gulf Lowland Ecoregion.

The Queen Maud Gulf Lowland is classified as having a low Arctic ecoclimate and is characterized by a cover of shrub tundra vegetation, consisting of dwarf birch, willow, northern Labrador tea, mountain avens, and ericaceous shrubs. Tall dwarf birch, willow, and alder occur on warm sites while wet sites are dominated by sphagnum moss and sedge tussocks. Geologically the region is composed of massive Archean rocks that form broad, sloping uplands that reach about 300-m ASL in the south, and subdued undulating plains near the coast. The coastal areas are mantled by silts and clay of postglacial marine overlap. Bare bedrock is common, and turbic and static cryosols, developed on discontinuous, thin, sandy moraine, and level alluvial and marine deposits, are the dominant soils. Permafrost is continuous and deep with low ice content. The Queen Maud Gulf Lowlands are an important habitat for waterfowl and shorebirds, and the Queen Maud Gulf Bird Sanctuary covers most of the ecoregion (After Wiken, 1986; Environment Canada, 2001; Environment Canada, 1995).

2.2.4 Garry Lake Lowland Ecoregion.

This ecoregion extends across an extensive area of massive granitic Archean rocks, forming a broad, level to gently sloping plain that reaches about 300 m ASL. The mean annual temperature is approximately -10.5°C with a summer mean of 5.5°C and a winter mean of -26.5°C, while mean annual precipitation ranges between 200 and 275 mm. This ecoregion is classified as having a low arctic ecoclimate. The characteristic vegetation is shrub tundra commonly made up of dwarf birch, willow, and alder, on warm, dry sites, and willow, sedge, and moss on poorly drained sites. The lowland is composed of Turbic and Static Cryosol soils developed on discontinuous, thin, sandy moraine, with Organic Cryosolic soils on level high-centre peat polygons. Permafrost is continuous with low ice content throughout the ecoregion. This ecoregion provides breeding habitat for snow and Canada geese, and other waterfowl. Other common wildlife include caribou, muskox, moose, red and arctic fox, snowshoe hare, arctic ground squirrel, masked shrew, lemming, wolf, lynx, weasel, snowy owl, shorebirds, and other raptors (After Wiken, 1986; Environment Canada, 2001; Environment Canada, 1995).

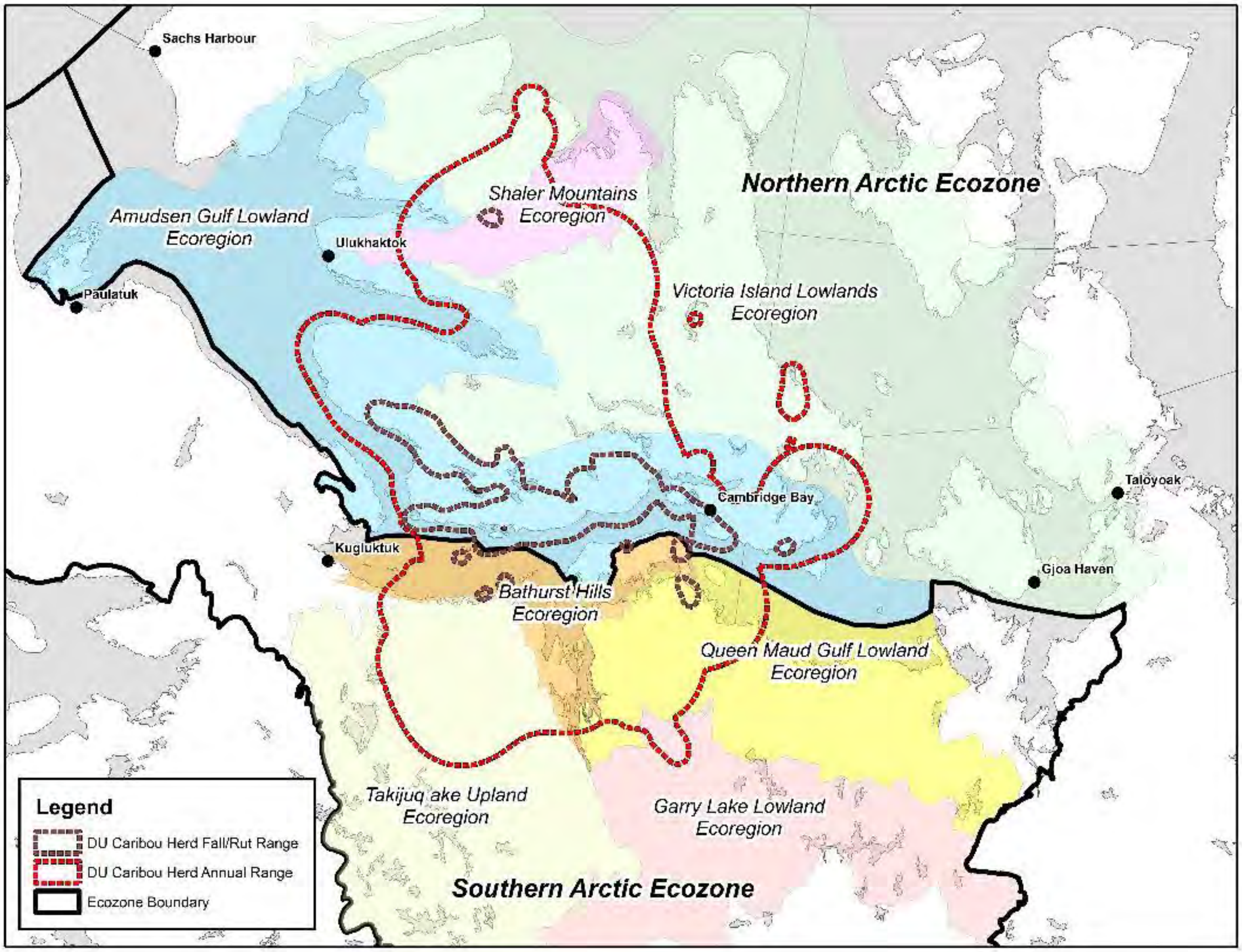

Figure 2. Ecozones and ecoregions of the Dolphin and Union caribou herds fall/rut seasonal range extents (brown dashed line) and annual range extents (red dashed line) (Ecozones and Ecoregions after Environment Canada, 1995). Fall/rut extents based on the 100% Utilization Distribution.

3.0 METHODS

The fall 2020 DU caribou distance sampling and double observer pair visual abundance survey was based out of the communities of Kugluktuk, Cambridge Bay, Nunavut, and Ulukhaktok, Northwest Territories. The survey was structured into two main components: 1) Pre-stratification using telemetry, past survey results and IQ collected during the pre-survey consultation process, and 2) Distance sampling double observer pair aerial visual survey methods.

We used telemetry data from past programs ranging from 1996 to 2020, to help define the fall/rutting period (October 13 to November 7) within which the survey was to be conducted. Initial survey stratification used both individual telemetry points and kernel analysis (KDE), to determine potential fall range and likely densities. Determining sea ice crossing dates was also important and was pre-determined to be the endpoint of survey efforts. We also examined the general vegetative characteristics and topography preferred by collared caribou and used the preferred habitats to help align survey strata and determine areas not represented by telemetry that may provide preferred habitat to DU caribou. All pre-selected fall 2020 survey strata were drafted using all these information sources, to ensure all likely caribou habitat was included in the survey effort. A summary of spatial methods, analysis, and results are provided in an appended summary analysis to this report (**Appendix 8.1 "Spatial Analysis"**).

3.3 Survey Area and Stratification

The establishment of the survey study area and the division of that study area into strata (or geographic areas) of similar relative densities of caribou was achieved prior to the October 2020 survey effort, using past aerial survey and telemetry findings, and a spatial analysis of historical telemetry data (**Appendix 8.1**), merged with local knowledge and/or IQ (Campbell et al., 2015; Roberto-Charron, 2020). The decision to diverge from the previously effective costal survey method used in fall 1997, 2007, 2015, and 2018, was due to 3 main factors:

1- Local hunters from the communities of Kugluktuk, Cambridge Bay, and Ulukhaktok believed the current collaring program was not representative of the entire DU fall range, reporting a component of the DU caribou population that in recent years has been wintering on Victoria Island. Additionally, concerns that the 2015 and 2018 mainland based collaring programs did not represent non-migratory DU caribou that spent their entire annual cycle on Victoria Island, were also raised.

2- Only four (4) active collars were remaining from a 50-collar deployment program initiated in spring 2018. This number is considered too small to develop robust strata that would be reflective of the entire DU caribou fall distribution.

3- The need for the survey was considered urgent by governments and stakeholders based on the results of a fall 2018 costal survey, which reported of a 78% decline in abundance from the previous fall 2015 coastal abundance survey. A decision to postpone the survey until a new collaring program could be initiated was deemed a high risk.

We used previous year's survey results (Leclerc and Boulanger, 2019), and collar data to develop initial strata (**Figure 3**). We then used spatially explicit polygons of the DU caribou fall/rut seasonal range, including strata based on previous surveys and telemetry data, as a starting point for the inclusion of IQ from Hunters and Trappers Organizations (HTOs) representing Cambridge Bay, Kugluktuk, Burnside, Omingmaktok, and Ulukhaktok. We planned three consultation meetings to engage local experts and knowledge holders in the further development of survey strata (**Table 3**), through the augmentation of survey and telemetry-based maps provided to all participants, with local IQ (Roberto-Charron, 2020) (**Appendix 8.2**). Following initial consultations, DOE staff amalgamated the two mapping products into several survey strata organized into 2 main options. These refined options were further discussed, and an agreement derived. With an understanding that severe fall weather, creating conditions of icing, fog, and heavy snow, would limit our total number of consecutive flying days, the working group opted for a two-tiered approach. Using this approach all very high (highest predicted caribou densities), high (high predicted caribou densities), and medium (medium predicted caribou densities) strata would be priority, with all remaining low-density (low predicted caribou densities) strata flown if conditions, time, and budget allowed (**Figure 4**).

We used the double observer pair method combined with distance sampling methods to visually assess caribou abundance across all strata. The merging of past survey observations and telemetry data, with the mapped density distributions from consultations, yielded 13 main survey strata including one very high density (VHD) stratum, one high density (HD) stratum, four medium density strata (MD), and 7 low density strata (LD) (**Figure 5**). Survey effort, measured as transect spacing, was then allocated across survey strata based on the following constraints. Strata with the highest estimated caribou densities for the proposed survey period would receive the highest level of coverage, with survey effort for the remaining strata proportional to derived relative densities of caribou, estimated weather windows, and budgetary constraints. Effective strip width (up to a maximum of 1,500 meters per side of the aircraft) could vary depending on sightability, which in turn was dependent on measured co-variates including visibility, snow patchiness, terrain ruggedness, percent snow cover, percent cloud cover, speed, and observer ability. Very high-density strata received the highest survey effort with transects spaced 4 km apart yielding a maximum stratum coverage of 75% (assuming perfect sightability (sightability=1) across the full 0-1500 m distance). The high-density stratum used a 5-kilometer spacing yielding a maximum coverage of 60%. Medium strata used an 8-kilometer transect spacing yielding a maximum coverage of 37%; while low-density strata used 10-kilometer transect spacing yielding a maximum coverage of 30% (**Figure 5**).

Financial and logistic constraints, Dolphin and Union caribou migratory behavior, and weather modeling of weather windows between October 15 and November 7 within the survey study area, dictated the survey window and total number of aircraft required to successfully complete the survey. The survey endpoint was dictated by the timing of the Dolphin and Union caribou migration from the southern shores of Victoria Island to the Nunavut mainland. All strata were surveyed using three high-winged aircraft with wing struts. The aircraft deployed included two Cessna Grand Caravan single turbine engine aircraft, and one Dehavillind twin-Otter, twin turbine engine aircraft.

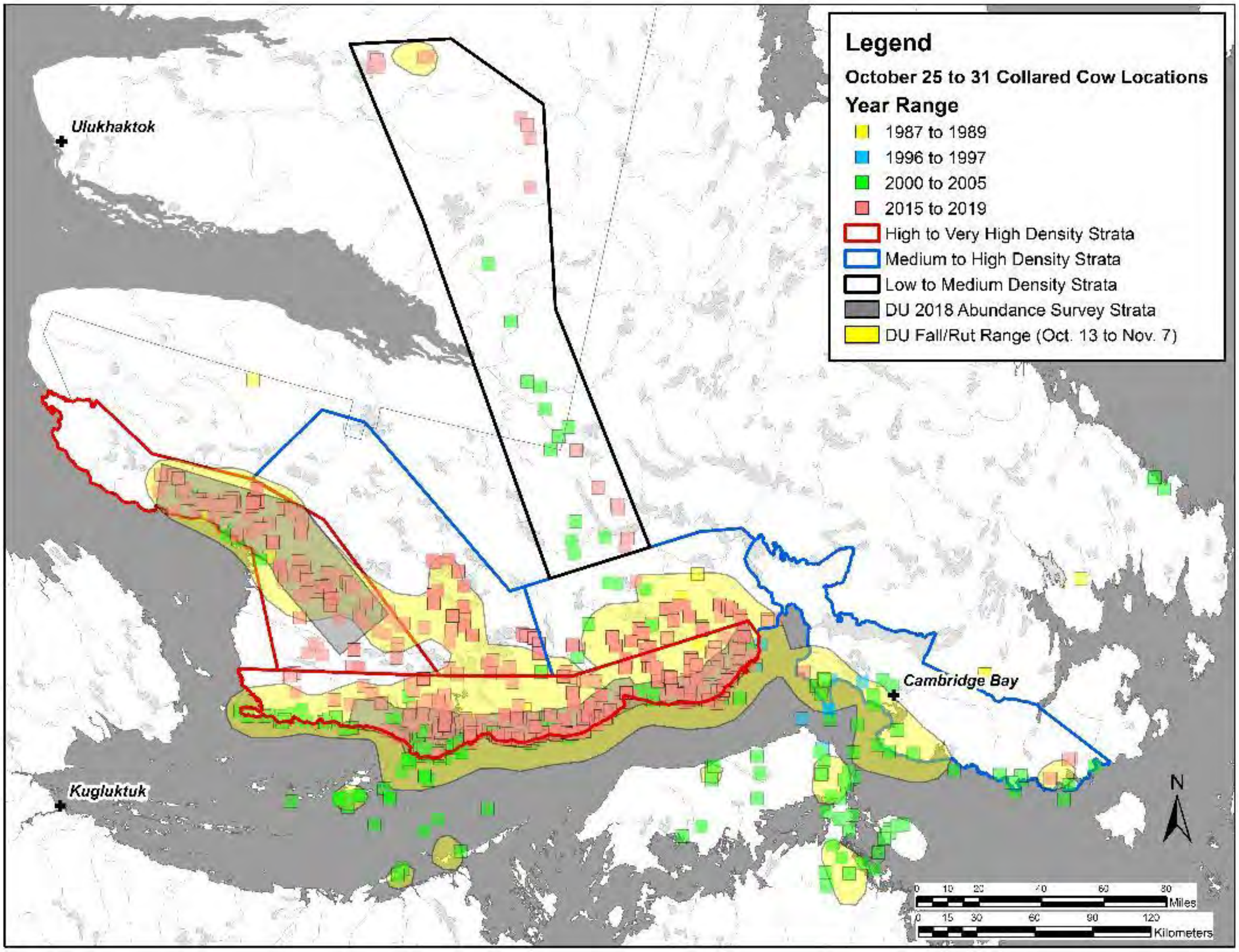

Figure 3. The initial DU fall 2020 survey stratification based solely on DU caribou telemetry data and the 2018 DU abundance survey strata. The DU fall/rut seasonal range extents (yellow) were developed using kernel analysis and based on a 95% utilization distribution using combined telemetry data from a 1997 to 2006 deployment, and a 2015 to 2020 deployment.

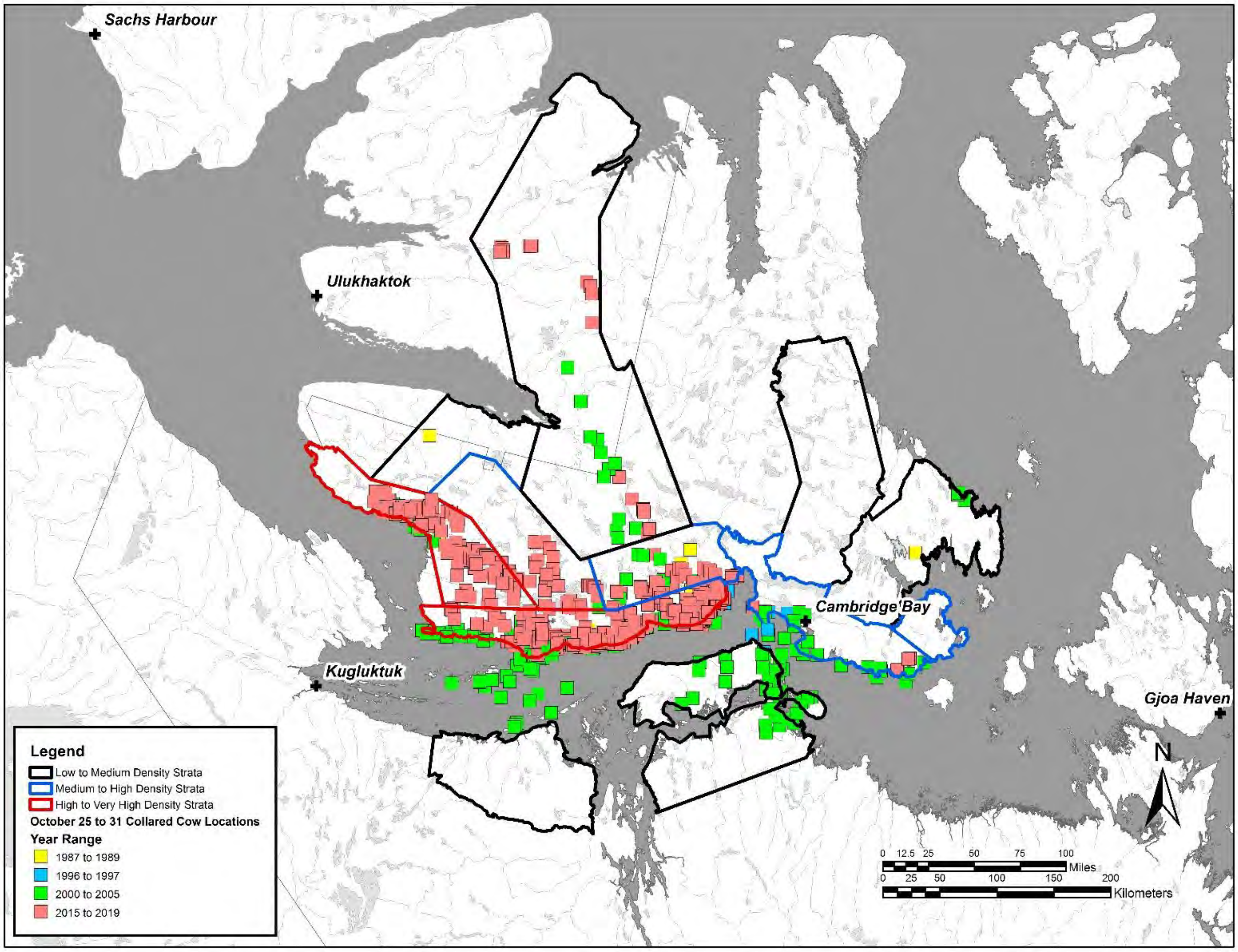

Figure 4. Final strata selection based on figure 1 above, and the inclusion of community-based IQ collected during the pre-survey consultation process.

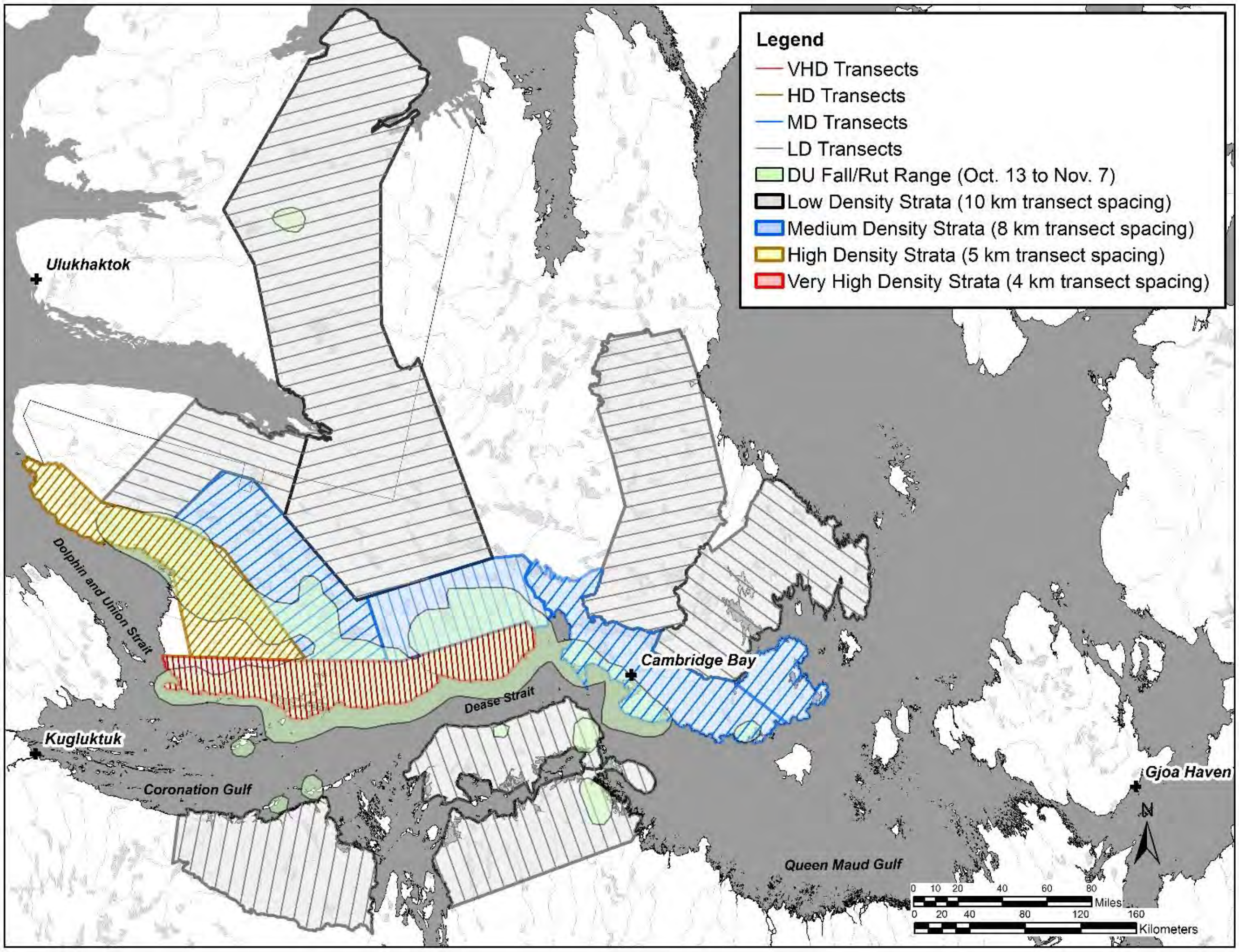

Figure 5. DU fall 2020 survey strata placement and transect effort relative to DU late fall range (October 13 through November 7). Strata and transect effort based on historic survey observations, cumulative caribou telemetry data, IQ from the communities of Cambridge Bay, Kugluktuk, and Ulukhaktok, predicted weather windows and budgetary constraints. The DU Fall/Rut seasonal range extents (green) are based on a 95% utilization distribution using a kernel analysis of combined telemetry data from a 1997 to 2006 collar deployment, and a 2015 to 2020 collar deployment.

Table 1. Dolphin and Union research and management consultation schedule and participating agencies. Dolphin and Union management concerns and survey design was discussed in meetings 1, 2, and 3. Initial survey results and reporting schedules were discussed in meetings 4 and 5.

Date & Time	***Meeting Type***	***Organizations Represented***	***# of Attendees & Reference***
1 September 16th, 2020 9:00 AM to 5:00 PM	In Person and virtually, in Cambridge Bay	Cambridge Bay HTO, Kugluktuk Angoniatit Association, Omingmaktok HTO, Burnside HTO, Kitikmeot Regional Wildlife Board, Ulukhaktok HTC, Nunavut Wildlife Management Board (NWMB), GN-Department of Environment (DOE), Nunavut Tunngavik Inc.(NTI), Wildlife Management Advisory Council (WMAC), GNWT-Environment and Natural Resources (ENR), Environment and Climate Change Canada (ECCC), University of Calgary (U of C), Kitikmeot Inuit Association (KIA).	42 Attendees (Roberto-Charron, A. 2020. Dolphin and Union Management Consultation. Summary report. 36 pp.)
2 October 2nd, 2020 9:00 AM to 12:00PM	Virtual Meeting	Cambridge Bay HTO, Kugluktuk Angoniatit Association, Omingmaktok HTO, Burnside HTO, Kitikmeot Regional Wildlife Board, Ulukhaktok HTC, Nunavut Wildlife Management Board (NWMB), GN-DOE,NTI, WMAC, GNWT-ENR, ECCC, U of C,KIA.	42 Attendees
3 October 8th, 2020 9:00 AM to 5:00PM 6:30 PM to 9:30 PM	In Person and virtually, in Cambridge Bay	Cambridge Bay HTO, Kugluktuk Angoniatit Association, Omingmaktok HTO, Burnside HTO, Kitikmeot Regional Wildlife Board, Ulukhaktok HTC, Nunavut Wildlife Management Board (NWMB), GN-DOE,NTI, WMAC, GNWT-ENR, ECCC, U of C,KIA.	42 Attendees
4 October 29th, 2020	In Person in Cambridge Bay	Cambridge Bay HTO, GN-DOE, NTI, KRWB	15 Attendees
5 October 30th, 2020	In Person in Kugluktuk	Kugluktuk Angoniatit Association, GN-DOE, NTI	17 Attendees

3.4 Aerial Abundance Survey

The fall 2020 Dolphin and Union caribou abundance survey applied a random, stratified, visual method, employing both distance sampling and double observer pair techniques (Boulanger, 2020; Boulanger et al., 2014; Campbell et al., 2012a). Transect spacing was allocated based on proportional densities as described in section 3.1 and flying effort allocated based on total available flying time (Heard, 1985; Boulanger, 2020). Transects within each stratum were aligned at right angles to the longitudinal axis of the stratum to maximize the total number of transects (N) in each stratum. In each abundance stratum, an initial transect was randomly placed perpendicular to the longest stratum boundary and the remaining transects systematically placed at regular intervals according to the allocation of survey effort (**Figure 5**). The entire aerial survey study area covered 136,889 km^2 and encompassed the known fall range extents and known migratory corridors of the Dolphin and Union caribou herd (**Figure 5**). In total, the survey included 326 transects with a mean transect length of 52.4 km, yielding 16,322 line kilometers, not including positioning and de-positioning. Transects were created using Environmental Systems Research Institute (ESRI) ArcMap Geographic Information System (GIS) software and were based on the World Geographic System (WGS) 1984 coordinate system projected into Canada Lambert conformal conic.

Visual observations were recorded using distance sampling, where five observational strips or “bins”, were marked out on left and right fixed wing struts. The 5 distance bins were divided across the strut into 0 to 200 meter, 200 to 400 meter, 400 to 600 meter, 600 to 1,000 meter and 1,000 to 1,500 meter strips. Bin development followed a similar configuration used successfully during a 2014 survey of Baffin Island caribou and based on recommended guidelines for bin intervals (Campbell et al., 2015; Buckland et al., 1993). Total strip width was marked using attached streamers at 0 meter, and 1,500 meter strut markers, while 1/8-inch-wide black electrical tape was applied against a white strut background to visually separate the remaining bins. Bins were also numbered from 1 (0-200m) to 5 (1,000 to 1,500m) for bin identification when an observation is being called out. Strip widths or "bins" (w) were calculated using the formula from Norton-Griffiths (1978) (**Figure 6**).

$w = W * h/H$

Where:

W *= the required strip width or "bin"*

h *= the height of the observer's eye from the tarmac*

H *= the required flying height*

Strip width calculations were confirmed by comparing bin measurements between aircraft of the same make and model used in previous surveys where bin markers were confirmed by flying perpendicularly over runway distance markers at survey altitude, with strut measurements of the 2020 survey aircraft. Due to the high potential for patchy snow conditions, and seasonally low cloud, coupled with relatively flat terrain, the decision was made to reduce survey altitude to 92 meters (300 feet) from the more commonly used 122 meters (400 feet), to enhance caribou sightability. All aircraft were equipped with radar altimeters to ensure an altitude of 92 meters above ground level (AGL) was maintained precisely. Off-transect observations were not encouraged for the purposes of ensuring a more focused search of the demarked distance bin visual strips. Observed caribou were not classified into age and/or sex classes due to the potential of negatively affecting an observer ability to effectively search his or her bins.

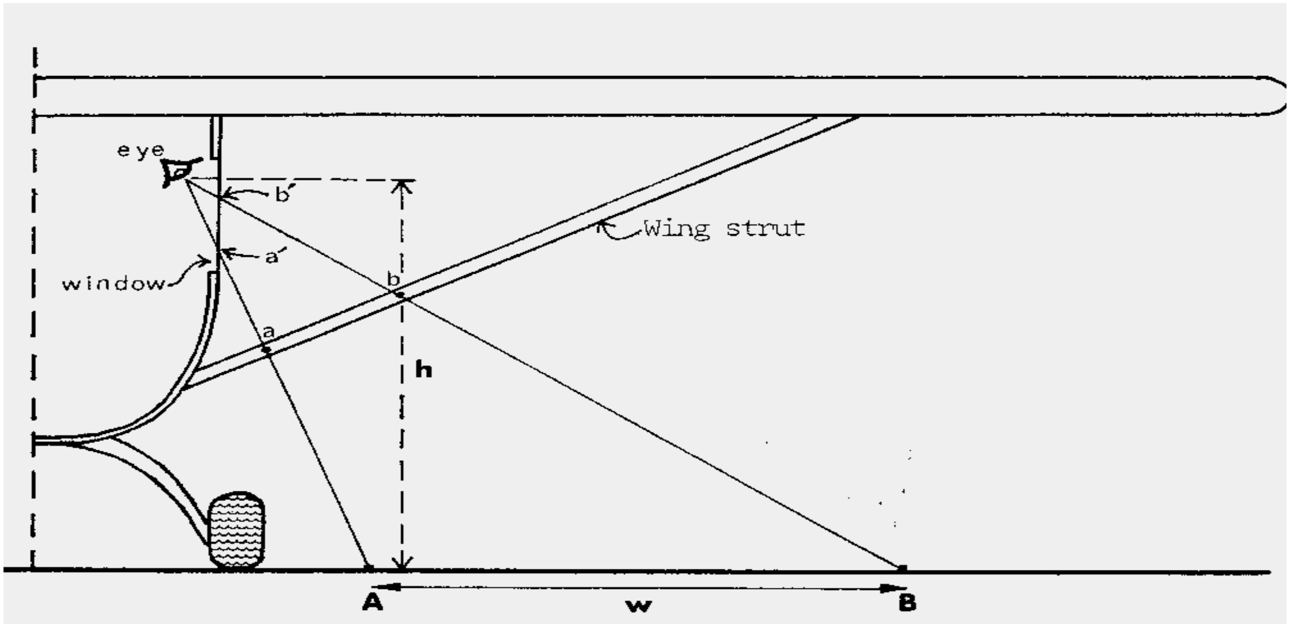

Figure 6. Schematic diagram of aircraft configuration for strip width sampling (Norton-Griffiths, 1978). W is marked out on the tarmac, and the two lines of sight a' – a – A and b' – b – B established. The streamers are attached to the struts at *a* and *b*, whereas a' and b' are the window marks (After Jolly, 1969).

The double observer pair method used two dedicated observers on each side of the aircraft and two additional observer/data recorders on each side of the aircraft. All caribou (target wildlife) called by the observers included the bin/strip number in which they were seen, an index of snow patchiness, and an index of snow cover. The observer/recorder recorded the species and number, the observation waypoint, air speed, percent cloud cover, an index of visibility, and an index of topographic ruggedness.

The topography index was a general assessment of elevation variation, expressed as a ratio of slope to ruggedness. Observers and/or data recorders assessed the overall degree of slope within the immediate area of observed individuals/groups and recorded these observations numerically as flat (1), moderate (2), or steep (3). Ruggedness was assessed using a visual sweep across a 1,000 square meter area surrounding the observation. Ruggedness assessments were also recorded numerically as flat (1), rolling (2), and mountainous (3) across the same area. For example, a topography index of 1 / 2 would indicate the observation was made in a flat area within rolling terrain.

A snow patchiness index was assessed numerically by the observers within an estimated 500 square meter buffer around the observation. Observations made in areas characterized by continuous ground cover received a value of one (1). Buffers characterized by checkerboard patches of snow and open ground estimated to be 1 to 5 meters in size or less, were given a value of two (2). Areas with checkerboard like patches 5 to 10 meters in size were recorded as a three (3), while observations made within areas representing checkerboard patches 10 to 50 meters in size were given a value of four (4). Finally, observations made within areas of contiguous snow cover with no exposed ground, were assessed as a five (5). Observations yielding a patchiness index of 2 to 4 (indicating a non-continuous snow cover) would be further assessed using snow cover estimates recorded by the recorder/observer. Snow cover was measured as a percentage of the ground covered by snow within an estimated 500 square meter area surrounding the observation. Cloud cover was measured as a percentage of sky that obscures blue sky within an estimated 2,000 square meter area around the aircraft and observation.

The visibility index was based on the cause of the reduced visibility, and its extent. Six main mechanisms of reduced visibility were used, and included rain (R), snow (S), fog (F), ice fog (I), dust (D), and smoke (SM). The degree to which visibility was reduced used 5 additional categories including: unrestricted (1), unrestricted within visual strut markers (bins) (2), partially restricted within strut markers (3), mostly restricted within strut markers (4), and completely obscured within strut markers (5). For example, visibility that is partially obscured in snow, within observation strut markers would be recorded as S/3.

3.5 Dependent Double Observer Pair & Distance Sampling Visual Method

The double-observer pair configuration was used within all fixed wing aircraft to maximize sightability out of each of the left and right side of the aircraft, by adding one additional observer to each side (Campbell et al., 2012, 2015, and 2018). Additionally, the double observer pair configuration allowed each aircraft to maintain a minimum of two experienced wildlife observers on each of the left and right side of the aircraft throughout the survey, while providing training opportunities for community-based representatives within the remaining seats. The method, as applied to the present work, involved two pairs of observers on each of the left- and right-hand sides of the aircraft in addition to one recorder/observer on each side of the aircraft (**Figure 7**). Of the dedicated observers, one “primary” or front observer sat in the front seat of the plane with a second “secondary” or rear observer seated immediately behind the primary. The method as it applied to the Dolphin and Union caribou abundance survey adhered to five basic steps:

1) The front (primary) observer called out all groups of caribou (number of caribou and location) including the observation bin number he/she saw within each of the 0 to 200, 200 to 400, 400 to 600, 600 to 1,000, and 1,000 to 1,500 meters distance bins. Front observers were instructed to call observations just after they passed the three o’clock (right) or nine o’clock (left) positions halfway between the front and rear (secondary) observer (approximately at the wing strut). This included caribou groups that were between approximately 12 and 3 o’clock for right side observers and 9 and 12 o’clock for left side observers. The main instruction to observers was that the front observer be given time to call out all caribou seen before the rear observer called them out:

2) The rear observer called out whether he/she saw the caribou that the front observer saw and observations of any additional caribou groups. The rear observer waited to call out caribou until the group observed passed halfway between observers (between 3 and 6 o’clock for right side observers and 6 and 9 o’clock for left side observer).

3) The observers discussed any differences in group counts to ensure that they had called out the same groups or different groups and to ensure accurate counts of larger groups.

4) The data recorders in the Cessna Grand Caravan, one in the right seat beside the pilot and the other on the rearmost seat on the left side of the aircraft, categorized and recorded counts of each caribou group into "front only", "rear only" and "both". The sample unit for the survey was "*groups of caribou*" not individual caribou. Recorders and observers were instructed to consider individuals to be those caribou that were observed independent of other individual caribou and/or groups of caribou. If sightings of individuals were within proximity to other individuals, then the caribou were considered a group. As the data recorders were also experienced observers, data recorder observations would also be recorded. The single exception to the above configuration involved the data recorders within the Twin Otter aircraft, both of whom took positions within the left and right seats in front of the left and right observers, and behind the pilots.

5) The observers switched places approximately halfway through each survey day (i.e., at lunch or halfway through a flight) to monitor observer ability. The recorder noted the names of the primary and secondary observers.

The method used a combined distance sampling and mark-recapture approach to estimate abundance for survey stratum during the DU caribou survey effort. The basic approach involved using mark-recapture to estimate the probability of detection of caribou at 0 distance from the survey plane, and distance sampling methods to estimate the decrease in probability of detection at greater distances from the plane. This approach ensured a more robust estimate than using distance sampling methods alone, which assume that the probability of detection of caribou groups at 0 distance from the plane is 1 (Borchers et al. 1998, Buckland et al. 2004, Laake et al. 2008a, Laake et al. 2008b, Buckland et al. 2010, Laake et al. 2012). The Huggins (Huggins 1991) mark-recapture model in program MARK (White and Burnham 1999) was used for initial model selection of dominant covariates that affect sightability in the vicinity of the survey plane. For this analysis, observations were restricted to those that occurred within 1,500 meters of the survey plane on each of the left and right sides. A removal model formulation of parameters was used to account for the dependence of front (primary) and rear (secondary) observers.

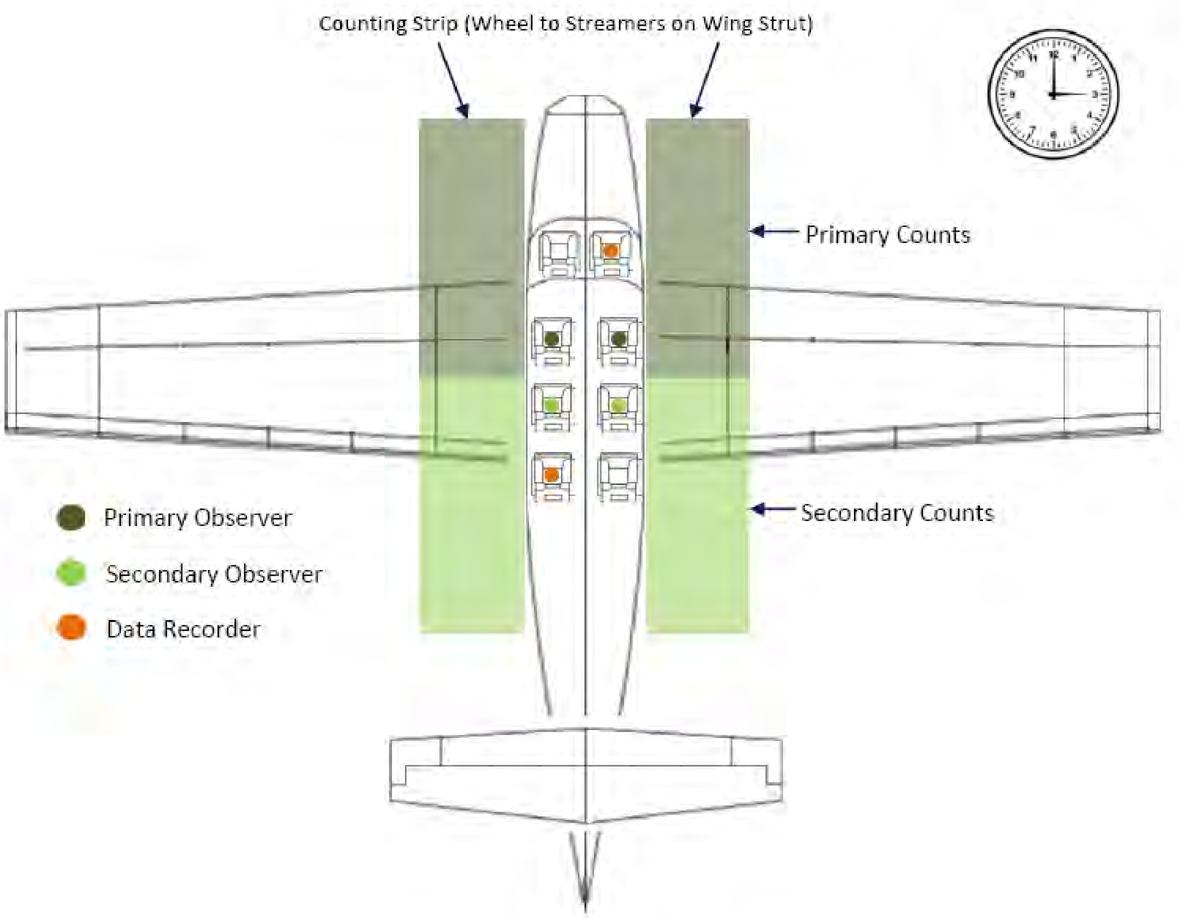

Figure 7. Observer and data recorder position for the double observer pair method employed on this survey. The rear (secondary) observer calls caribou not seen by the front (primary) observer after the caribou have passed the main field of vision of the front observer. The hour hand on a clock is used to reference relative locations of caribou groups (e.g., "Caribou group at 3 o'clock" would suggest a caribou group 90° to the right of the aircrafts longitudinal axis.). See 3.5 above for exceptions within the Twin Otter aircraft.

The main covariates used in the analysis are listed in **Table 4**. The *MRDS* R package (Laake et al., 2012) was used to build mark-recapture and distance sampling models. The approach was to initially build distance sampling models with the mark-recapture model parameters held constant and vice-versa for the double observer pair models. A composite model was then built using the most supported covariates from each of the component analyses. Estimates for strata were derived based on transect lengths and strata areas for the best fitting detection model. Estimates of variance were derived using estimators for a systematic sampling layout (Fewster, 2011).

The fit of the models was evaluated using the Akaike Information Criterion corrected for small sample size (AIC_c). The model with the lowest AIC_c score was considered the most parsimonious, thus minimizing estimate bias and optimizing precision (Burnham and Anderson, 1998). The difference in AIC_c values between the most supported model and other models (Δ AIC_c) was also used to evaluate the fit of models when their AIC_c scores were close. In general, any models with a Δ AIC_c score of less than 2 between them were considered to have equivalent statistical support. Overall model fit was also assessed using goodness of fit tests (Buckland et al. 1993; Buckland et al., 2004) as well as graphical comparison of detection functions with histograms of frequencies of observations from the survey. Analyses were conducted in program R (R Development Core Team, 2009) with plots being produced using the *ggplot* (Wickham, 2009) R package and maps produced in QGIS (QGIS Foundation 2020) using the simple features R package (Pebesma, 2018).

3.6 Trend Analysis

The DU caribou fall 2020 Victoria Island, mainland, and combined estimates were initially compared to the 2018 estimate using a t-test to determine if the two estimates were significantly different (Gasaway et al., 1986). Confidence limits on yearly change were estimated assuming log-normal distributions of abundance estimates. Log-linear models (McCullough and Nelder, 1989; Thompson et al., 1998; Williams et al., 2002) were used to analyze longer-term trends. 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.

Table 2. Covariates used to model variation in sightability for the dependent double observer analysis of the fall 2020 DU abundance survey results.

Covariate	Acronym	Description
Observer pair	obs	each unique observer pair
Data recorder observations	DRpair	Pairs who were assisted by the data recorder
	Recobs	Observations taken by data recorders
Group size	size	size of caribou group observed
	Log(size)	Natural log of group size
Snow cover	snow	snow cover (0,25,75,100)
	snowc	continuous
Snow patchyness	patch	Ordinal (1 to 6)
Visibility		Ordinal
Cloud cover	cloud	cloud cover (0,25,75,100)
	cloudc	continuous
Coastal/inland strata	Coast	Coastal strata vs inland areas

4.0 RESULTS

4.1 Observations and Survey Coverage

Though strata development used a combination of telemetry data from 1995 to 2019, as well as IQ reported through community consultations, we wished to assess strata coverage based on current telemetry locations of DU caribou. At the time of the DU caribou 2020 fall abundance survey, four (4) DU caribou collars remained active, and produced a total of 48 locations from October 23 and 24, and October 26 through 28, the interval within which all VHD, HD, and MD strata flights were completed. All collar locations were located within defined strata and as a result received complete coverage during the 2020 survey effort. We found that only 5 of those 48 locations (10%) collected during this survey period were outside of the Very High Density (VHD) strata, with 4 of the 5 (8%) within the Medium Density West stratum, and 1 of the 5 (2%) within the Medium density east stratum (**Figure 8**). Of note was the lack of any telemetry locations within the HD stratum during the survey. It is also important to note that following the completion of the survey, all collared caribou were located along the coast within the VHD stratum suggesting a general movement, throughout the survey, towards the coast. Of the 11 days taken to survey all strata, only one weather day (October 25) prevented all aircraft from flying. The VHD and HD stratum were completed in 1.5 days (October 26 and 27) and the MD west and MD east completed in 1.5 days (October 27 and 28) as well (**Table 5**).

We observed 1,330 caribou within 202 groups, 452 muskoxen within 47 groups, 30 moose within 13 groups, 28 wolves within 10 groups, and 2 wolverines. As an initial step, transects in the LD central and LD East were adjusted based on flight track logs (**Figure 9**). Of the strata flown, some strata did not have any caribou observed and were not considered further in estimates (**Figure 10** and **Table 6**). Most caribou were observed in the High Density and Very High-Density East strata. An estimated 97% of planned transects and associated strata were successfully flown during the fall 2020 survey effort.

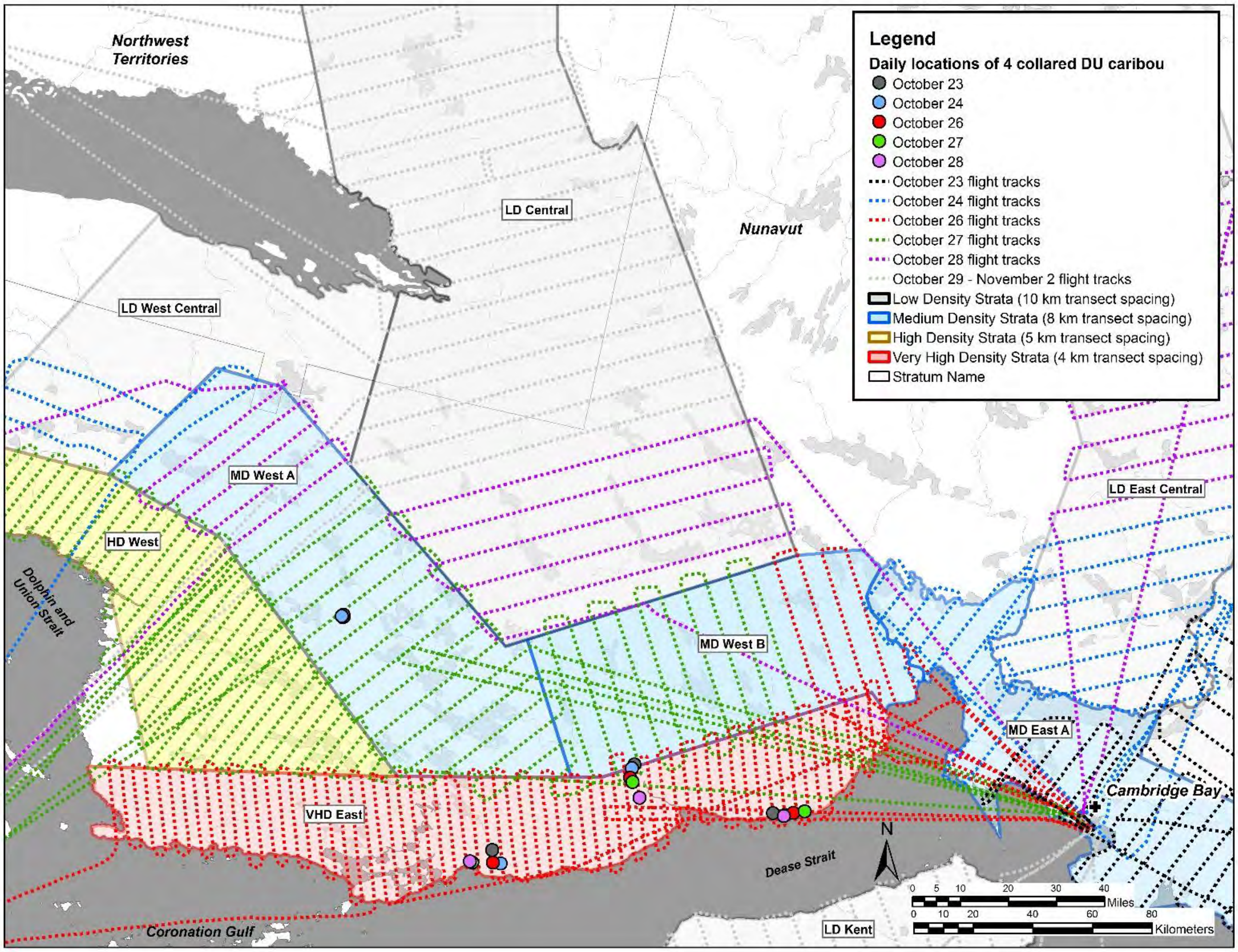

Figure 8. Daily flight tracks compared to daily collared caribou locations throughout the first 6 days of the fall 2020 DU abundance survey. Of the 48 locations collected from 4 collared caribou during the survey, only 5 were outside the VHD survey strata.

Table 3. Timing of abundance survey strata flights. Note the VHD and HD strata were flown consecutively and completed in under 2 days. Strata definitions; MDWa and MDWb = Medium density west a & b, MDEa and MDEb = Medium density east a & b, VHD = very high density, HD = high density, LDWC = low density west central, LDE = low density east, LDEC = low density east central, LDC = low density central, LDK = low density Kent Peninsula, LDSK = low density south Kent Peninsula, LDSW = low density south west mainland, and Recon = Reconnaissance flight.

DU-2020		Aircraft & Strata		
Month	**Day**	**GATH**	**FAFG**	**GNPS**
October	23	MDEb	MDEa	Weather
	24	LDE & LDEC	MDEa	Recon & LDWC
	25	Weather	Weather	Weather
	26	VHD & MDWb	VHD & MDWb	VHD
	27	HD & MDWb	MDWa & MDWb	HD & MDWa
	28	LDEC	LDC	MDWa
	29	LDSK	LDC	LDC
	30	LDK	LDC	LDSW
	31	Strata Complete	LDC	LDSW
November	1		LDC	LDSW
	2		LDC	Strata Complete
	3		Strata Complete	

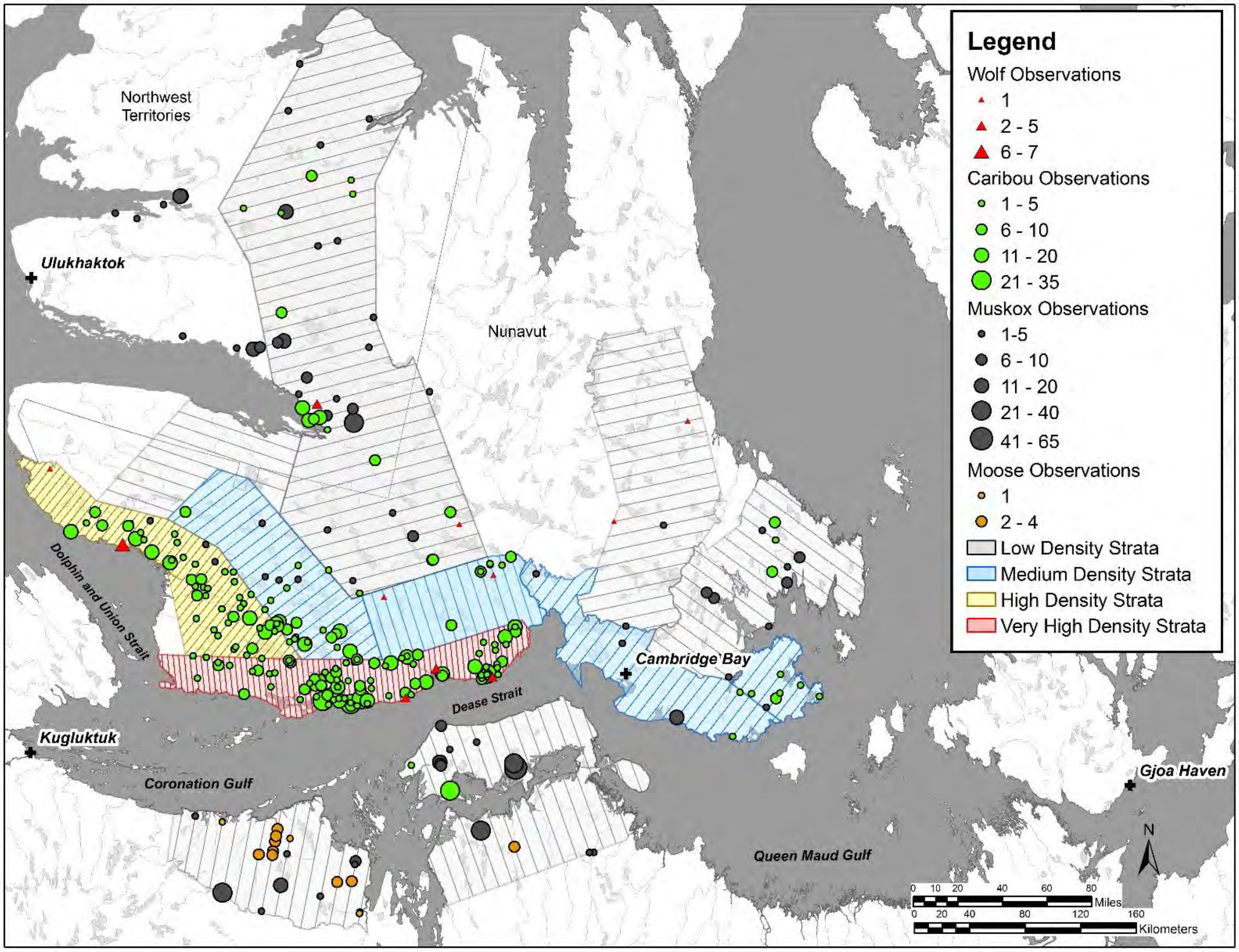

Figure 9 Caribou, wolf, muskox, and moose observations recorded during the Dolphin and Union fall 2020 abundance survey.

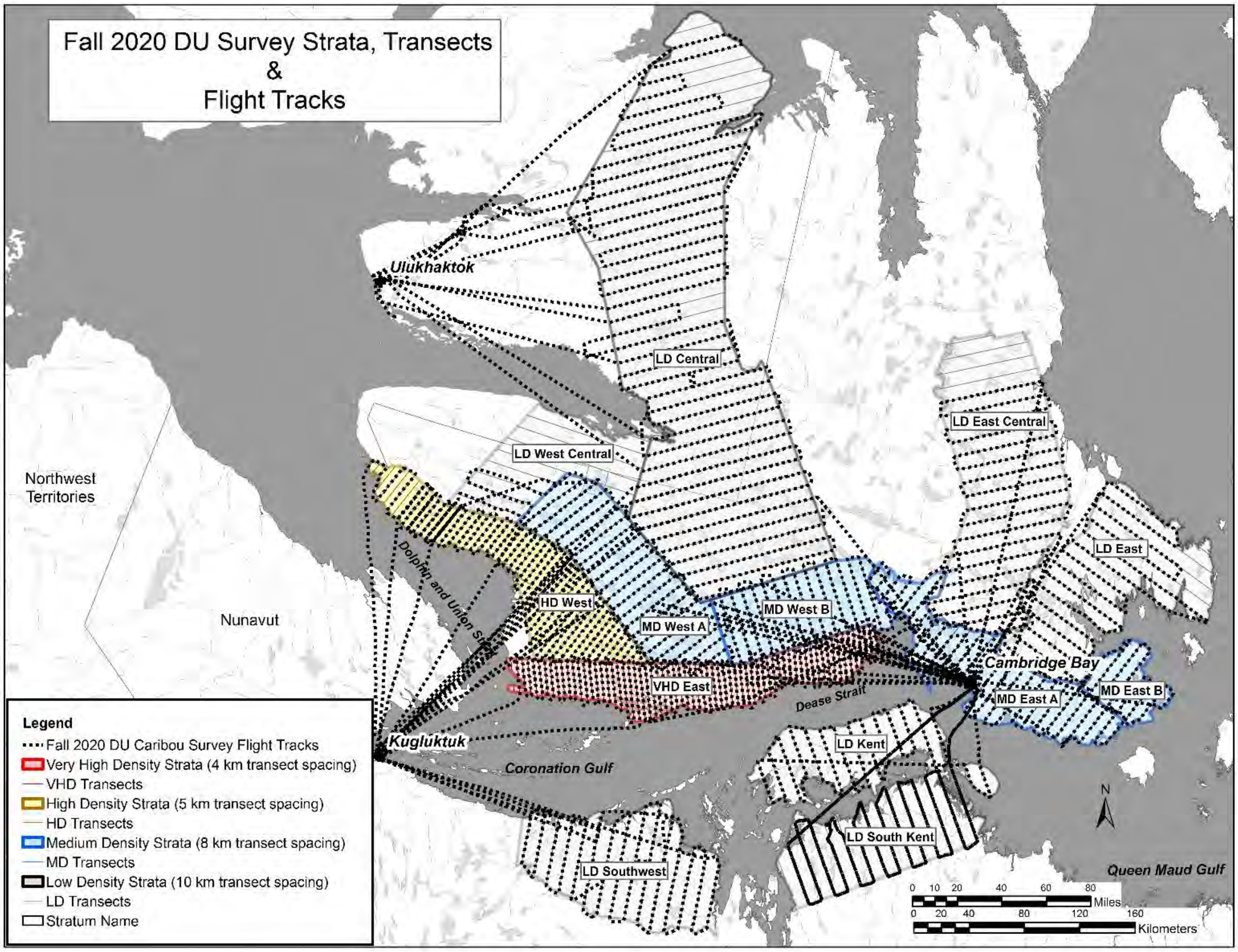

Figure 10. Actual flight tracks flown over delineated stratum and associated transects of the fall 2020 Dolphin and Union survey. Lines were shortened in the Low Density (LD)-east and LD-central strata based on actual flight paths (VHD = very high density, HD = high density, MD = medium density, and LD = low-density strata). An estimated 97% of all proposed survey transects and associated strata were successfully completed.

Table 4. Actual strata dimensions, number, and length of transects flown, and caribou observed on transect, for the DU fall 2020 aerial abundance estimate.

Strata	Strata Name	Strata_Area (km2)	No Trans	flown transect length	Total Transect Length	Caribou observed on transect
HDW	High_Density_West	8,540	50	1,709.17	1,709.17	262
VHDE	Very_High_Density_East	7,902	68	1,976.26	1,976.26	665
MDEa	Medium_Density_East_A	7,577	27	951.05	951.05	1
MDEb	Medium_Density_East_B	2,151	8	268.53	268.53	22
MDWa	Medium_Density_West_A	8,703	23	1,087.95	1,087.95	150
MDWb	Medium_Density_West_B	6,052	15	738.85	738.85	26
LDC	Low_Density_Central	40,174	40	3,732.90	4,028.41	124
LDE	Low_Density_East	11,064	15	1,028.70	1,103.42	14
LDEC	Low_Density_East_Central	14,898	22	1,506.97	1,506.97	0
LDKP	Low_Density_Kent_Penninsula	5,716	14	576.55	576.55	66
LDSK	Low_Density_South_Kent	8,248	17	807.84	807.84	0
LDSW	Low_Density_South_West	9,402	15	943.07	943.07	0
LDWC	Low_Density_West_Central	6,462	10	624.26	624.26	0

4.2 Distance and Double Observer Pair Data Summary

The distribution of caribou groups sighted relative to the distance bins marked on underwing struts was lower closest to the plane then increased as the bins moved further from the plane. Observations increased in the 200 to 400 and 400 to 600 meters bins before decreasing in the more distant bins (600 to1000 and 1,000 to 1,500 meters bin). Data recorders, especially in bins close to the plane (**Figure 11**), made a large number of observations. Additionally, the distribution of observations varied by whether strata were on the coastal or inland areas of the survey study area (**Figure 12**). Coastal strata (Very High Density East (VHDE), and High Density West (HDW)) in this case, were the two high-density strata while Medium density (MD) – East (MDEa) and MD East-B (MDEb) strata inland habitat and displayed fewer observations. Coastal VHD strata (VHDE) had a higher proportion of observations near the plane whereas inland MD strata (MDWa, MDWb, MDEa, MDEb) had a relatively high proportion of observations in the furthest survey bin. Observer data is summarized in **Table 7** by observer pairs. In addition, data recorder observations (caribou that were missed by the 2 observers but observed by the recorder) are listed for each observer pair. Single observer (p1x: 1-rear observer/total observations) and double observer ($1-(1-p1x)^2$) are listed. We note that these are for all distances rather than observations near the plane. For double observer only data, single observer probabilities average 0.9 with double observer probabilities of 0.99. When data recorder observations are added, single observer probabilities are reduced to 0.74 and double observer probabilities are 0.93. The main reductions occurred for pairs three (3), 6, and 7, which display double observer probabilities of 0.75 to 0.84 when data recorder observations are added. Most noteworthy is pair 7, where 22 (34%) of the observations were made by the data recorder. Double observer detection probabilities for pairs 2, 6, and 7, who accounted for 31 of the 37 additional data recorder observations, were modelled using the DRpair covariate.

The distributions of sightings also varied by observers with some pairs showing the more characteristic histogram shape with the most sightings near the plane, whereas the distribution of others was more dominated by sightings in the 200 to 400 meter bin (**Figure 13**). Data recorder observations occurred across all distance bins for many observers. Group size of caribou also influenced whether both observers sighted caribou. Once group size was greater than ten (10), both observers were likely to see a caribou group. Single caribou or smaller groups were more likely to be missed by single observers (**Figure 14**). Group size also influenced the shape of the detection function. Detection functions for smaller groups were dominated by higher frequencies in the closer bins to the plane whereas larger groups occurred in the further bins (**Figure 15**).

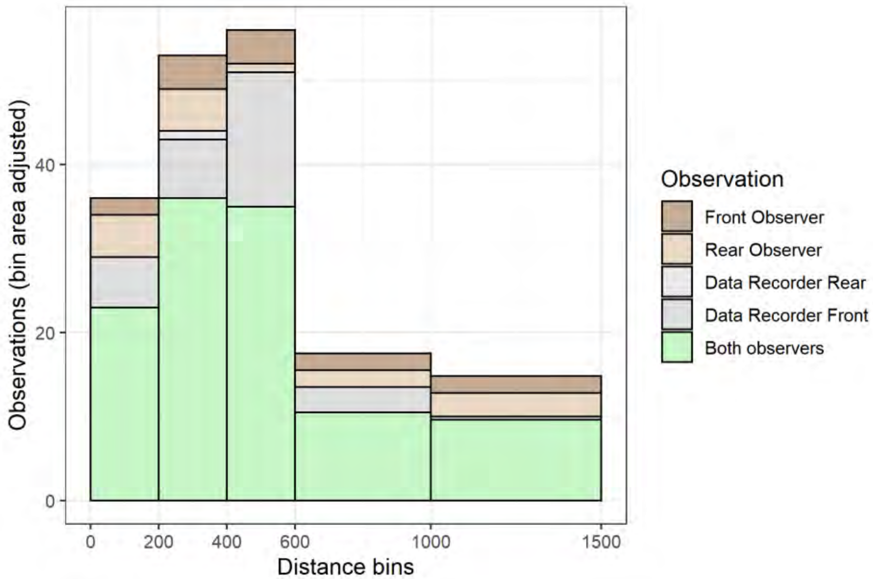

Figure 11. Histograms of detections as a function of distance from plane. Observations are also color-coded by observation type. Observation frequencies are adjusted based on bin widths.

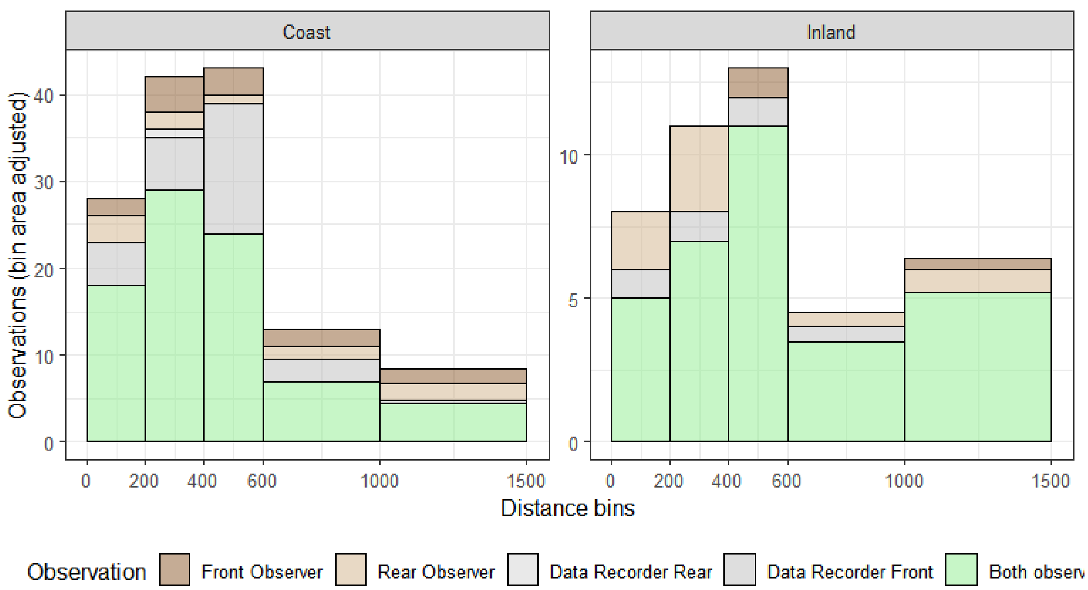

Figure 12. Histograms of detections as a function of distance from plane for coastal and inland strata. Observations are also color-coded by observation type. Observation frequencies are adjusted based on bin widths.

Table 5. Summary of double observer pair data; p1x is the single observer sighting probability and p2x is the double observer probability. Data is summarized for double observer only data and double observer with data recorder observations (DRobs: observations where only the data recorder saw a group of caribou).

Pair number	Double observer data						Data recorder (DR) + double observer data				
	front	rear	both	total	p1x	p2x	DR obs	2x+DR	Proportion DR obs	p1x	p2x
1	3	0	14	17	1.00	1.00	3	20	0.15	0.85	0.98
2	1	6	24	31	0.81	0.96	0	31	0.00	0.81	0.96
3	0	0	5	5	1.00	1.00	5	10	0.50	0.50	0.75
4	5	4	28	37	0.89	0.99	0	37	0.00	0.89	0.99
5	2	3	18	23	0.87	0.98	3	26	0.12	0.77	0.95
6	1	2	8	11	0.82	0.97	4	15	0.27	0.60	0.84
7	7	6	30	43	0.86	0.98	22	65	0.34	0.57	0.81
8	0	1	12	13	0.92	0.99	0	13	0.00	0.92	0.99
Sum/average	**19**	**22**	**139**	**180**	**0.90**	**0.99**	**37**	**217**	**0.17**	**0.73**	**0.93**

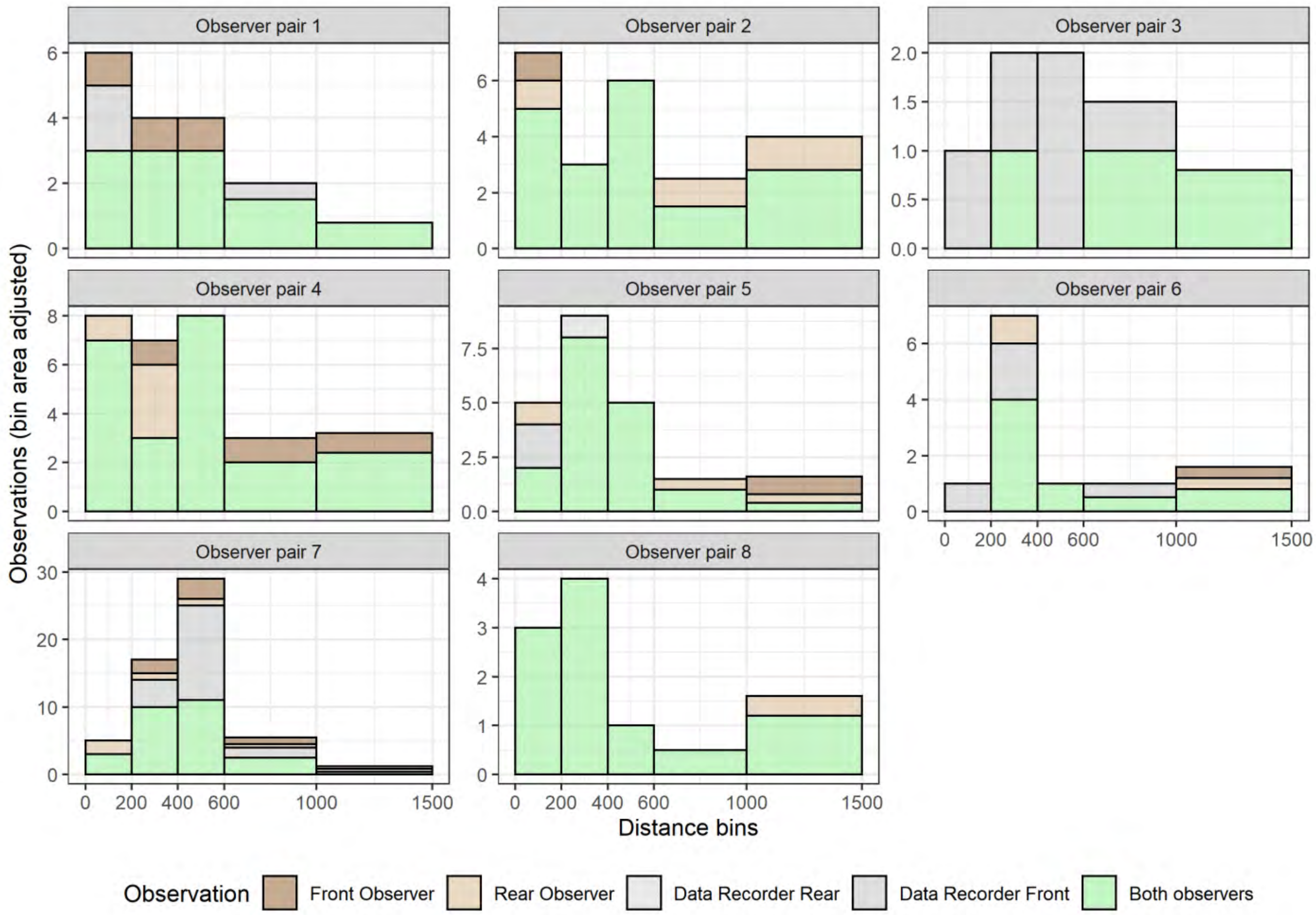

Figure 13. Histograms of detections as a function of distance from the plane for observer pairs. Observations are also color-coded by observation type. Observation frequencies are adjusted based on bin widths.

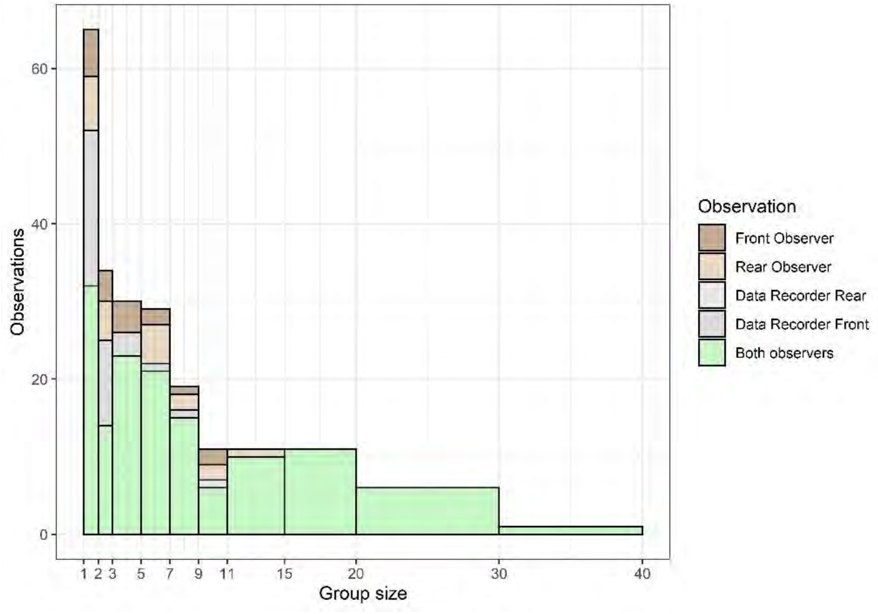

Figure 14. Histograms of detections as a function of group size. Observations are also color-coded by observation type. Observation frequencies are adjusted based on bin widths.

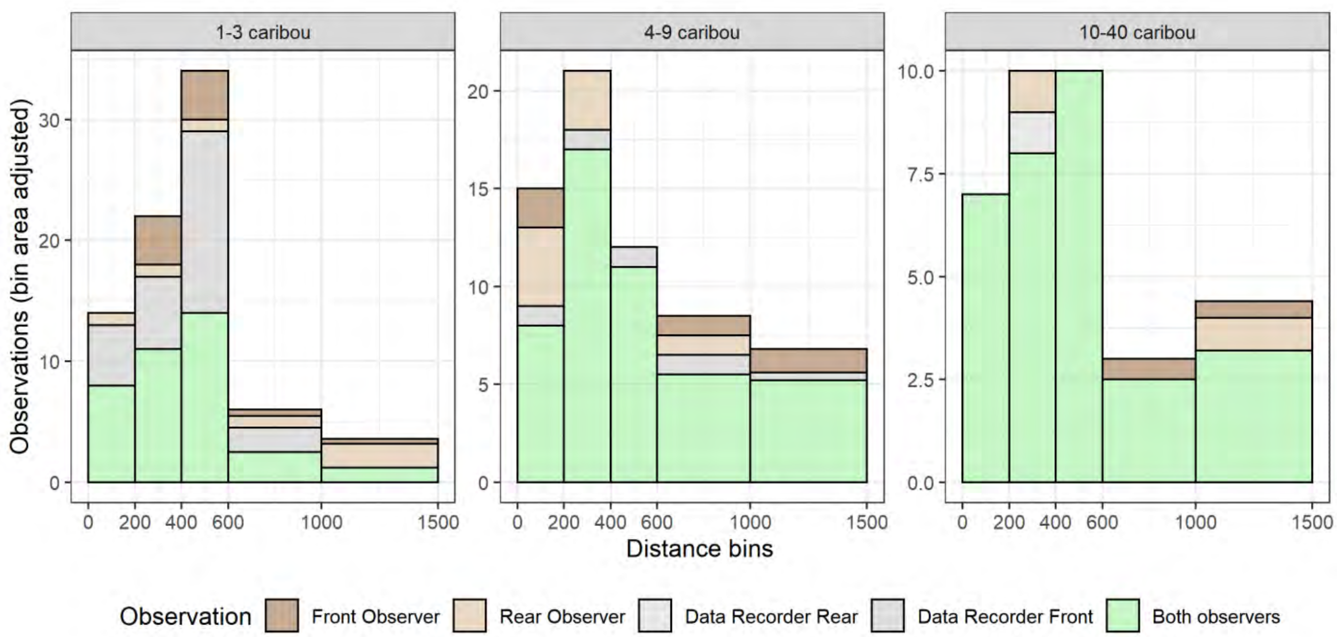

Figure 15. Histograms of detections as a function of group size and observation type.

Snow cover, snow patchiness, and cloud cover were also considered as covariates. Snow cover and snow patchiness was skewed towards high snow cover with 192 of 209 observations of caribou with snow cover over 90%, and 177 of 209 observations with snow patchiness scores of 4 or over indicating relatively continuous snow cover. Cloud cover was more variable with an average cloud cover 55% (s.d.=38.0, min=0, max=100, n=209). Each covariate was tested individually as part of the model selection procedure.

4.3 Model Selection

Initial distance sampling model selection focused on the choice of a detection function with a hazard rate function (**Table 8,** model 3) being more supported than a half-normal function. The coast/inland strata (coast) and cloud covariates were more supported than a constant model. We also considered the log-size covariate given the likelihood of size effects in the detection function (**Figure 15**). It was likely that size effect may become more relevant when double observer variation is modelled and therefore this covariate was also considered in composite models. Other covariates such as snow patchiness, elevation and visibility were less supported. Snow patchiness had low sample sizes in most classes (except 6) which created model convergence issues when modelled as a factor. Categories were pooled into low and high categories to confront this issue. In addition, recorder observations were also considered further in unison with other covariates.

The double observer/mark-recapture model selection used a hazard rate distance detection function with distance covariates held constant. The DRpair covariate which accounted for observer pair/data recorder pairing, was used as a structural covariate in all models. Observer pairs were initially modelled separately, however, this increased model complexity. A reduced observer pair model with the three pairs that showed higher frequencies of missed caribou (pairs 3, 6, and 7) were pooled, which held the highest support of models considered (**Table 9**, model 1). Also supported was group size (model 2).

The most supported distance and double observer covariates were then combined into composite models. Immediately, the combined models were more supported than models with constant distance sampling terms (**Table 10**, model 6) or constant double observer terms (model 9). The main double observer model considered was the DRpair + size model, which gave strong support for the associated covariates (**Table 9**). Combinations of the candidate distance sampling model covariates were considered with a model that had coastal strata (coast) and the log of group size (size) being most supported (**Table 10**, model 1). Models that also had cloud cover (model 2), and just coast and cloud (model 3) were also supported. The estimates from all 3 of the most supported models were compared in the sensitivity analysis detailed later in this report.

The pooled detection function for model 1 (**Table 10**) suggests that the detection of caribou on the line (distance=0) was 0.86 (SE=0.09) with a shoulder of constant detection to approximately 400 meters after which it declined to 0.2 at the furthest bin (1,000 to 1,500 meters) (**Figure 16**). Fit of the model was marginal in the initial 0 to 200 meter bin and the 600 to 1,000 meter bin, as indicated by chi-square tests (χ^2=16.2,df=0). The complexity of the model combined with the limited number of bins meant that there were no degrees of freedom for the distance sampling component of the chi-square test. Regardless, the mark-recapture component of the model did display adequate fit ((χ^2=16.2, df=7, p=0.21). The overall χ^2 for the model was 25.6, df=2, p<0.001). The main reason for lack of fit was poor fit to the initial 0 to 200 meter bin and the 600 to 1,000 meter bin. The main reason for lack of fit was most likely due to lower than expected frequencies in the 0 to 200 meter bin which was due to less attention to bins closest to the plane. Higher frequencies in further bins were more pronounced in the inland or medium density strata (**Figure 17**). Lower detection in the closer 0 to 200 meter bin was potentially dealt with using the double observer approach, which relaxes the assumption of perfect sightability close to the plane.

Table 6. Univariate model selection for distance sampling covariates. The distance sampling detection function (DF: HR-hazard rate, HN-Half normal) is shown along with distance and double observer models. Sample size adjusted Akaike Information Criterion (AIC_c), the difference in AIC_c between the most supported model for each model (ΔAIC_c), AIC_c weight (w_i), number of model parameters (K), and deviance is given. Constant models are shaded for reference.

No	DF	Distance model	MR/2x model	AIC_c	ΔAIC_c	w_i	K	LL
1	HR	CoastStrata	constant	963.30	0.00	0.45	4	-477.6
2	HR	cloud	constant	965.09	1.78	0.19	4	-478.4
3	HR	constant	constant	966.57	3.27	0.09	3	-480.2
4	HR	logsize	constant	967.27	3.96	0.06	4	-479.5
5	HR	Recobs	constant	967.51	4.21	0.06	4	-479.7
6	HR	snow	constant	967.97	4.67	0.04	4	-479.9
7	HR	size	constant	968.01	4.71	0.04	4	-479.9
8	HR	snowpatch	constant	968.49	5.18	0.03	4	-480.1
9	HR	Visibility	constant	969.49	6.19	0.02	6	-478.5
10	HR	Elevation	constant	970.98	7.67	0.01	7	-478.2
11	HN	constant	constant	969.79	35.04	0.00	2	-482.9

Table 7. Univariate model selection for double observer covariates. The distance sampling detection function (DF: HR-hazard rate, HN-Half normal) is shown along with the distance and double observer model. Sample size adjusted Akaike Information Criterion (AIC_c), the difference in AIC_c between the most supported model for each model (Δ AIC_c), AICc weight (w_i), number of model parameters (K), and deviance is given. Constant models are shaded for reference.

No	DF	Distance model	MR/2x model	AIC_c	ΔAIC_c	w_i	K	LL
1	HR	constant	DRpair+size	938.02	0.00	0.76	5	-463.9
2	HR	constant	DRpair+logsize	940.46	2.45	0.22	5	-465.1
3	HR	constant	DRpair+snowpatch	947.73	9.71	0.01	5	-468.7
4	HR	constant	DRpair+cloud	949.70	11.69	0.00	5	-469.7
5	HR	constant	DRpair	950.42	12.40	0.00	4	-471.1
6	HR	constant	DRpair+snow	951.60	13.58	0.00	5	-470.7
7	HR	constant	Drpair+coast	952.42	14.41	0.00	5	-471.1
8	HR	constant	observers	961.26	23.24	0.00	10	-470.1
9	HR	constant	constant	966.57	28.56	0.00	3	-480.2

Table 8. Combined distance sampling and double observer analysis. Sample size adjusted Akaike Information Criterion (AIC_c), the difference in AIC_c between the most supported models for each model (ΔAIC_c), AIC_c weight (w_i), number of model parameters (K), and deviance is given. Constant models are shaded for reference.

No	DF	Distance model	MR/2x model	AIC_c	ΔAIC_c	w_i	K	LL
1	HR	Coast + logsize	DRpair + size	934.75	0.00	0.28	7	-460.1
2	HR	Coast+ cloud +logsize	DRpair+ size	934.84	0.09	0.27	8	-459.1
3	HR	Coast + cloud	DRpair + size	935.34	0.59	0.21	7	-460.4
4	HR	RecObs + Coast+logsize	DRpair + size	936.72	1.97	0.10	8	-460.0
5	HR	Coast + logsize	DRpair + logsize	937.19	2.45	0.08	7	-461.3
6	HR	constant	DRpair + size	938.02	3.27	0.05	5	-463.9
7	HR	Coast + logsize	obs+size	946.60	11.85	0.00	13	-459.4
8	HR	Coast + logsize	size	947.68	12.93	0.00	6	-467.6
9	HR	Coast + logsize	constant	963.22	28.48	0.00	5	-476.5

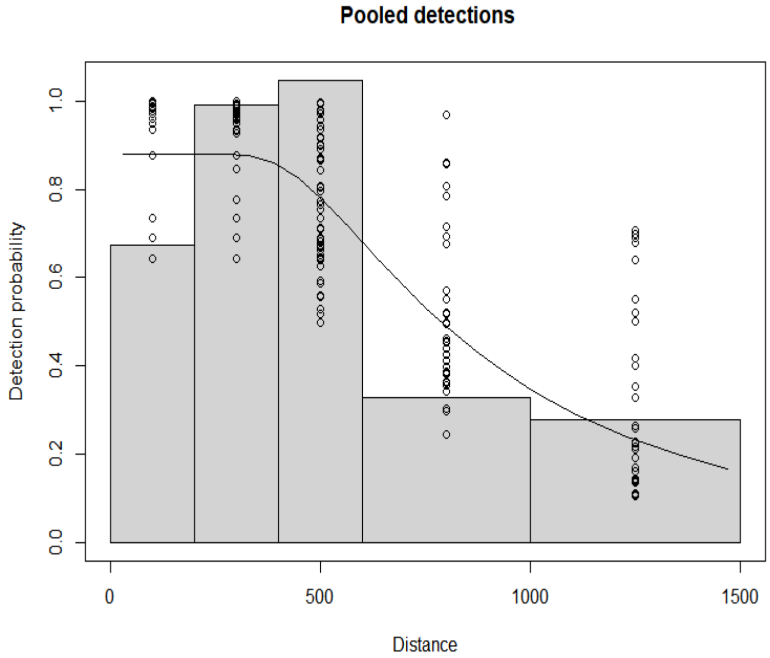

Figure 16. Fitted detection function for the most supported MRDS model.

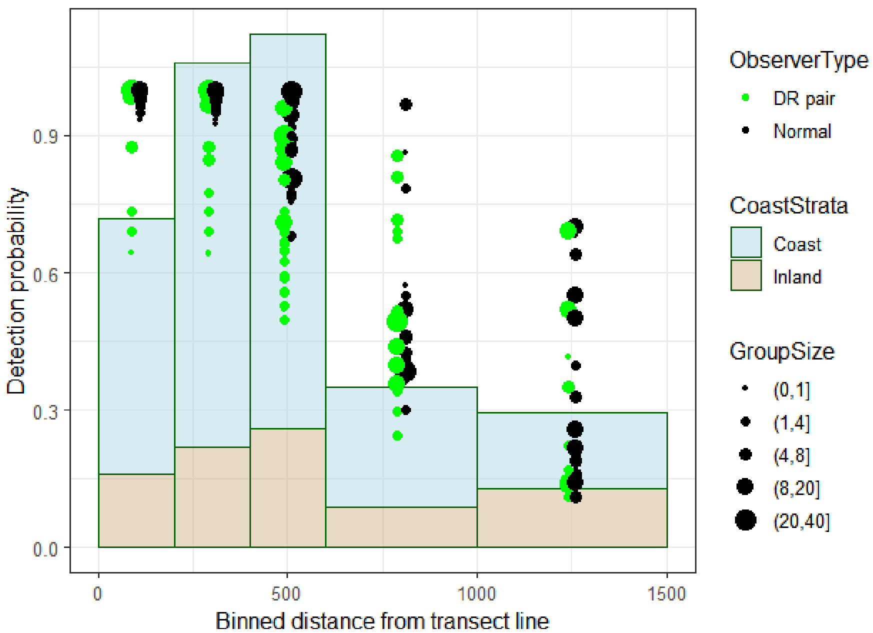

Figure 17. Fitted detection function showing coastal (HD and VHD strata) and inland (MD and LD) strata frequencies and observer type predictions.

4.4 Sensitivity Analysis

Sensitivity analyses were conducted to evaluate and estimate sensitivity to model selection uncertainty, fit of models to the detection function, inclusion of data recorder observers, and use of distance sampling and/or double observer data sets (**Table 11** and **Figure 18**). Estimates were contrasted against the estimate of the model 1 (3,815 caribou CI=2930-4966). In terms of model selection uncertainly, the three most supported models (models 1, 2, and 3) displayed similar estimates with an increase in estimates when log-size was not included in the detection function. This was likely due to the influence of larger group sizes, which will display higher sightability, at further distances. Given the evidence of group size sightability, the inclusion of group size was justified.

Model 1 was then run with observations from the primary (front) and secondary (rear) observers pooled for the 3 pairs that had data recorder assistance. Therefore, a group was only measured as a miss if both observers missed the caribou that the data recorder observed. This scenario basically assumed that the data recorder had the same sighting probability as the two observers combined (which was less likely). The resulting estimate was 3,694 which was 121 caribou less than model 1 (that treated the data recorder as an additional 2nd observer). Model 1 was also run with the data recorder observations removed, resulting in an estimate of 3,373. This reduction was presumably due to a loss of observations in the higher density strata where many of the data recorder observations occurred. The actual estimate was lower than the strip transect estimate (without a double observer) which is unlikely.

Model 1 was then run with the right bin (1000 to 1500 meters) removed to test for the effects of outlier observations in further bins. This increased the estimate to 4,072 caribou which was potentially because of outlier observations inflating estimates of sightability and therefore reducing abundance estimates. Left truncation of the left bin (0 to 200 meters), which would remove the effect of lower sightability near the plane, had less influence on the estimate but did reduce precision. Left and right truncation further reduced the estimate presumably due to a loss of data (the number of caribou sighted was reduced from 1,330 to 844 when both bins were removed).

Distance sampling only, which assumes sightability of 1 (100%) at the line, also showed a reduced estimate even when the 0 to 200 meter bin was truncated. This result was not surprising given that sightability on the line was estimated at 0.9 by the MRDS model. Strip transect sampling with a double observer model for sightability (*DRpair+size*) resulted in a similar estimate to model 1 but with lower precision. If the double observer model was removed, and sightability was assumed to be 1 (100%) then the estimate was reduced to 3,599. The strip transect estimate without a double observer can be considered the most conservative estimate, given that sightability is assumed to be 1 (100%), which is unlikely, with no further modelling of sightability. As shown in **Figure 18**, all the estimates from the sensitivity analysis fall in the general range of each other with an average estimate of 3,729 caribou. As discussed later, the best estimate is from model 1 given that it uses all the data sources available and accounts for most sources of variation. Likely differences between estimates all fall within the main range of confidence limits of all the estimators. Similarity between model 1 and the double observer strip transect estimate, which is used for most caribou surveys, is reassuring.

Table 9. Sensitivity analysis of the fall 2020 modeled estimates of Dolphin and Union herd abundance (Victoria Island and Mainland) using various model formulations and data sources. Model numbers refer to the models listed in Table 10.

Analysis	Caribou counted	Abundance N	SE	Conf. Limit		CV
Model selection uncertainty (MR models DRobs + size)						
model 1 (DS model: coast+logsize)	1330	3,815	513.7	2,930	4,966	0.13
model 2 (DS model: coast+cloud+logsize)	1330	3,770	495.6	2,914	4,877	0.13
model 3 (DS model: :coast+cloud)	1330	4,078	553.6	3,126	5,321	0.14
model 4 (DS model: :recobs+coast+logsize)	1330	3,794	503.4	2,926	4,920	0.13
Data recorder observations						
model 1: pool observers 1 and 2	1330	3,694	468.4	2,881	4,736	0.13
model 1: data recorder observations excluded	1226	3,373	510.5	2,509	4,536	0.15
Left and right truncation (model 1)						
Right truncate at 1000m	1079	4,072	538.9	3,138	5,285	0.13
Left truncate at 200m	1095	3,711	808.1	2,428	5,669	0.22
Both right and left truncate	844	3,542	521.4	2,650	4,734	0.15
Distance sampling only (DS model: coast+logsize)						
Left truncate at 200m	1095	3,445	540.7	2,534	4,683	0.16
Strip transect sampling (0-400 m)						
double observer (MR model: DRpair+size)	519	3,861	646.6	2,782	5,359	0.17
No double observer	519	3,599	533.0	2,689	4,818	0.15

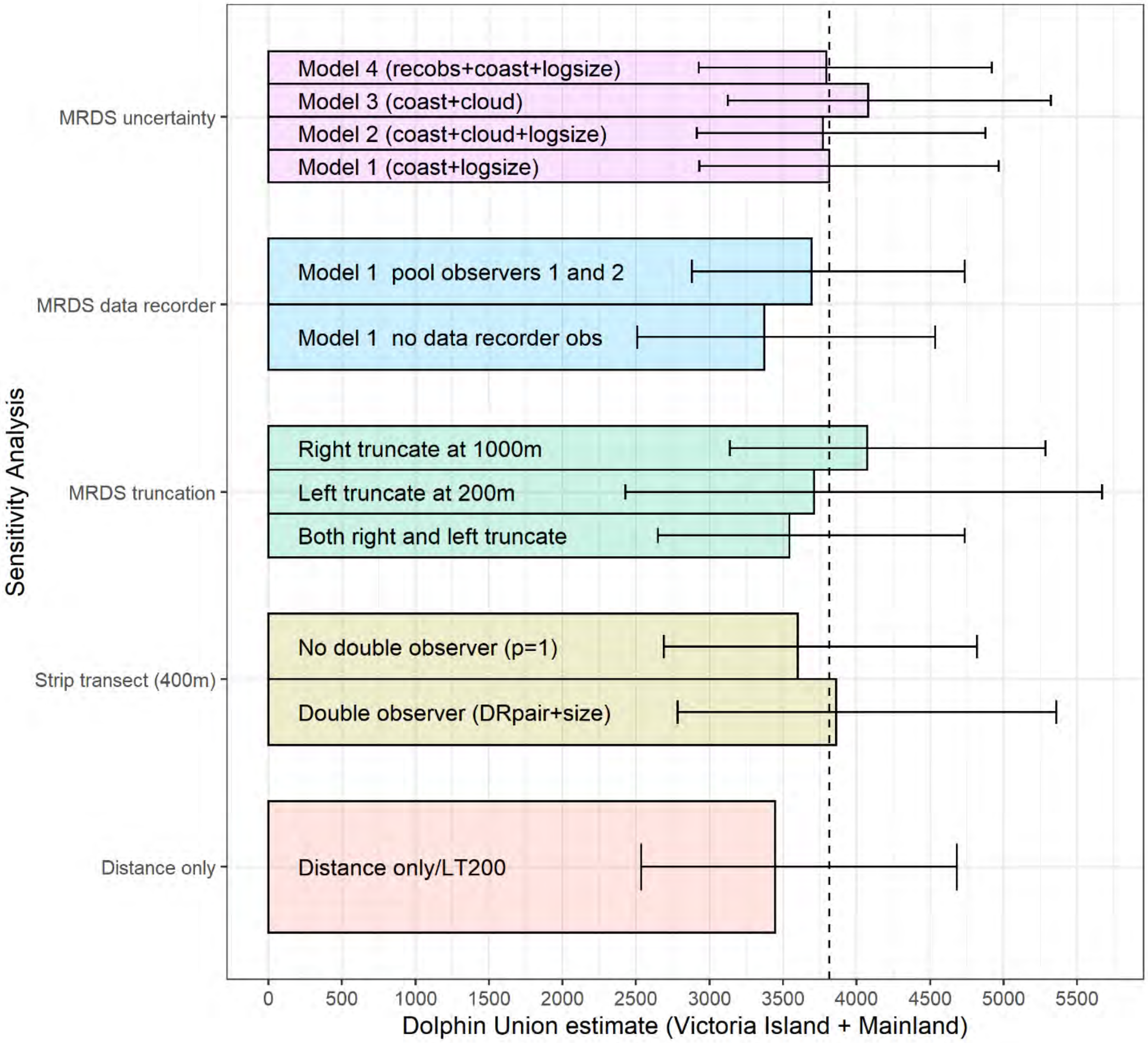

Figure 18. Graphical representation of sensitivity analysis estimates listed in Table 11. The estimate from model 1, used for full island estimates, is delineated by a dashed line for comparison purposes.

4.5 Estimates and Trend Analysis

4.5.1 Estimates

Estimates for strata from model 1 (**Table 10**) demonstrate that the highest densities of caribou were found in the Very High-Density East and High-Density West coastline strata, with moderate densities in the Medium West A (MDWa) stratum. Most other stratum had lower densities of caribou, resulting in lower estimates of abundance (**Table 12**). Two groups of caribou were sighted on the Kent Peninsula on the mainland (LDKP) resulting in an estimate of 236 caribou for all mainland strata. The inclusion of the mainland strata produces a total abundance estimate of is 3,815 (CI=2,930-4,966) caribou. If only the Victoria Island caribou are used, then the estimate is 3,579 (CI=2,758-4,644).

Table 10. Estimates for each strata from the most supported MRDS model (DS: CoastStrata+logsize, MR:DRobs+size, Table 10). The number of caribou counted on transect is given for each strata along with abundance estimates. Density is the abundance estimate divided by strata area X 100.

Strata	Strata_Name	Caribou counted	Abundance (N)	SE	Confidence Interval		CV	Density
Victoria Island strata								
VHDE	High_Density_East	665	1,487	275.3	1,034	2,139	0.19	18.82
HDW	High_Density_West	262	821	164.4	554	1,217	0.20	9.62
MDEa	Medium_Density_East_A	1	5	5.9	1	33	1.08	0.07
MDEb	Medium_Density_East_B	22	130	48.7	58	290	0.37	6.04
MDWa	Medium_Density_West_A	150	470	121.3	281	784	0.26	5.40
MDWb	Medium_Density_West_B	26	89	37.3	38	207	0.42	1.47
LDC	Low_Density_Central	124	511	140.5	297	879	0.27	1.27
LDE	Low_Density_East	14	65	41.5	19	225	0.63	0.59
LDWC	Low_Density_West_Central	0	0				0.00	0.00
LDEC	Low_Density_East_Central	0	0				0.00	0.00
	Total	**1,264**	**3,579**	**476.5**	**2,758**	**4,644**	**0.13**	**2.72**
Mainland strata								
LDKP	Low_Density_Kent_Penninsula	66	236	174.9	57	980	0.74	4.13
LDSK	Low_Density_South_Kent	0	0				0.00	0.00
LDSW	Low_Density_South_West	0	0				0.00	0.00
Victoria Island + Mainland								
Total	Victoria Island + Mainland	**1,330**	**3,815**	**513.7**	**2,930**	**4,966**	**0.13**	**2.79**

4.5.2 Trend Analysis

To determine the trend in Dolphin and Union herd abundance, we compared herd estimates from the fall 2018 and fall 2020 abundance surveys. We conducted this comparison for both the Victoria Island + mainland estimate, and Victoria Island only estimate, from the fall 2020 survey (mainland transects were not flown in fall 2018). While the Victoria Island + mainland estimate may be the best representation of the Dolphin Union herd, previous surveys only surveyed Victoria Island and therefore, it could be argued that the best comparison for trend is the Victoria Island estimate. In both cases, the difference between 2018 and 2020 estimates are not significant (**Table 13**). The ratio of estimates between 2018 and 2020 suggests an overall reduction in herd size of 7 to 13%, which amounts to yearly changes of 4 to 7% using the two estimates of herd size for the Dolphin union herd (**Table 14**). In all cases the confidence limits overlapped and therefore the change is not statistically significant, yielding no quantitative conclusions that herd numbers had significantly changed between 2018 and 2020.

A regression analysis of the data set suggests that a model with a trend term that corresponds to the fall 2007-2015 survey estimates, and the fall 2018-2020 survey estimates, with a single reduction from 2015-2018 estimates, describes the data adequately (**Table 15**). The slope term for year can be exponentiated to estimate a mean λ of 0.97. The year (2018) term describes the overall decrease in caribou abundance from fall 2015 to fall 2018 (23%) as also indicated in **Table 14**, where it is estimated as a 22% decline (**Figure 19**). This model suggests that the population may have declined between 2018 and 2020 at a rate similar to observed declines occurring prior to 2015. Similar results occurred using only the Victoria Island 2020 estimate for the trend analysis.

Table 11. Abundance estimates of the Dolphin and Union herd from fall 1997, 2007, 2015, 2018, and 2020. Both the Victoria Island + mainland (VI + Mainland) and Victoria Island only (VI only) are listed for the 2020 estimates.

Year	N	SE	Conf. Int		CV	df	t-test	df	p-value
1997	34,558	4283.0	27,757	41,359	0.12	38			
2007	27,787	3613.0	20,250	35,324	0.13	21	-1.21	58.09	0.2318
2015	18,413	3133.8	11,644	25,182	0.17	55	-1.96	53.02	0.0553
2018	4,105	694.8	2,931	5,750	0.17	54	-4.46	60.39	0.0000
2020 (VI + Mainland)	3,815	513.7	2,930	4,966	0.13	326	-0.34	123.08	0.7377
2020 (VI only)	3,579	476.5	2,758	4,644	0.13	379	-0.62	113.18	0.5337

Table 12. Estimates of overall change and yearly change (λ) in Dolphin Union estimates.

Year	Overall change	SE	Conf. Int.		Yearly change (λ)	SE	Conf. Int.	
2007	0.80	0.15	0.57	1.14	0.98	0.02	0.94	1.01
2015	0.66	0.14	0.43	1.00	0.95	0.03	0.90	1.00
2018	0.22	0.06	0.14	0.36	0.61	0.05	0.52	0.71
2020 (VI + Mainland)	0.93	0.21	0.61	1.42	0.96	0.10	0.78	1.19
2020 (VI only)	0.87	0.19	0.58	1.33	0.93	0.10	0.76	1.15

Table 13. Regression trend analysis using log-linear regression methods. Results are given for analyses using the 2020 Victoria Island + Mainland estimate, and the Victoria Island only estimate.

Regression terms					**Estimates of change**			**Significance**	
Term (β)	**β**	**SE**	**Conf. Int**		**change**	**Conf. Int**		**statistic**	**p-value**
2020 Victoria Island +mainland estimate									
(Intercept)	10.49	0.07	10.35	10.63				148.09	0.0000
year	-0.03	0.01	-0.05	-0.02	0.97	0.95	1.01	-5.88	0.0278
Year (2018)	-1.45	0.09	-1.62	-1.27	0.23[1]	0.20	1.10	-15.92	0.0039
2020 Victoria Island only estimate									
(Intercept)	10.51	0.10	10.31	10.70				105.30	0.0001
year	-0.04	0.01	-0.05	-0.02	0.96	0.01	0.95	-4.39	0.0482
Year (2018)	-1.46	0.13	-1.71	-1.20	0.23	0.13	0.18	-11.25	0.0078

[1]this is an estimate of overall change from 2015-2018

Victoria Island + mainland 2020 estimate

Victoria Island only estimate

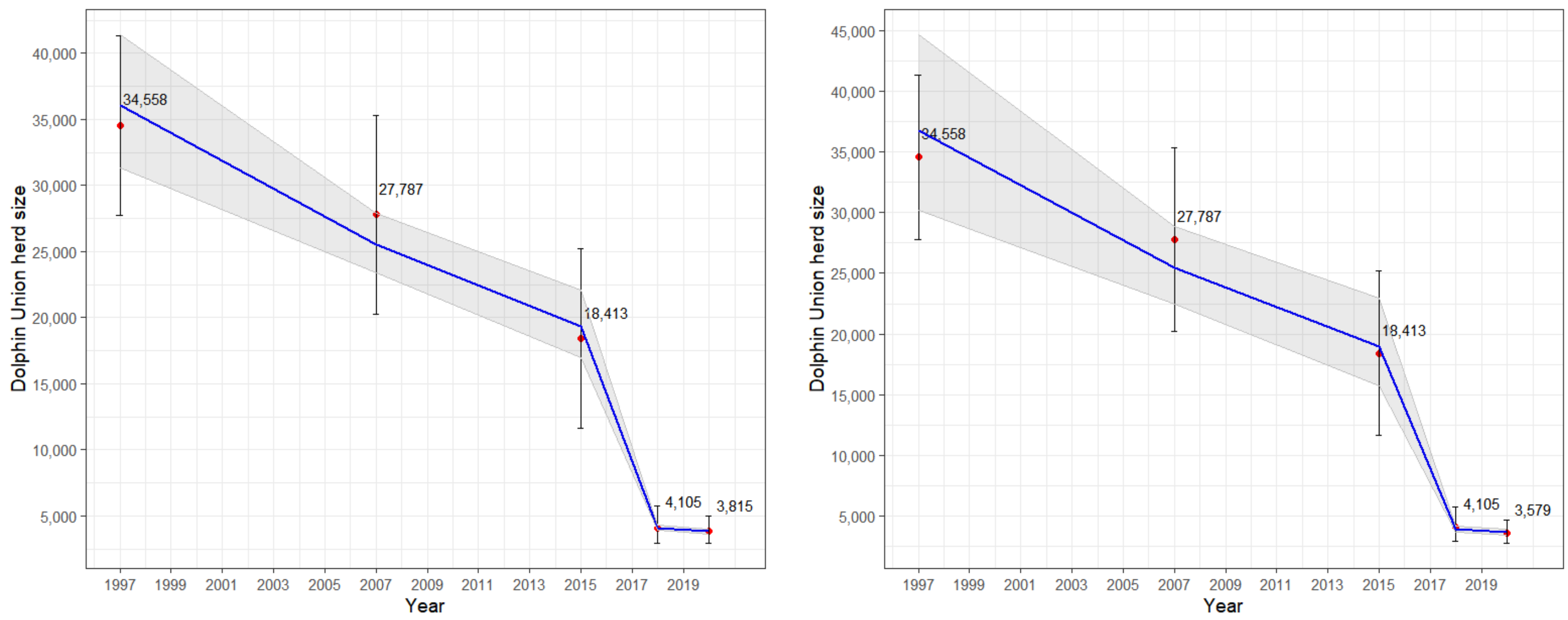

Figure 19. Population estimates and estimated trends for the Dolphin Union caribou herd using the 2020 Victoria Island + mainland estimate (left) and the Victoria Island only estimate (right).

5.0 DISCUSSION

5.1 Population Demography & Threats

The results from this survey validate the decline concluded from the 2018 Dolphin and Union survey and support the conclusion that the population declined substantially between 2015 and 2018. Although this survey used a different methodology without reliance on collared caribou, it arrived at a similar estimate, suggesting that the overall estimate is robust to methodologies employed. The implications of this decline are serious as the herd is of significant importance for Inuit subsistence and cultural needs for several communities in the western Kitikmeot and in the northeastern extent of the Beaufort Delta.

Similar declining trends have been observed in other caribou herds in Northern Canada and Alaska. For example, Bathurst herd has declined from an estimated 470,000 animals in the 1980s to an estimated 8,210 animals in 2018 (Adamczewski et al. 2019), and the Bluenose East herd has declined from an estimated 121,000 to 123,000 in 2010 to an estimated 19,160 in 2018 (Boulanger et al. 2019). Traditional Knowledge and scientific research indicate that caribou populations have historically experienced cycles of highs and lows, however, these widespread declines are concerning, particularly in the context of global change and local access to healthy country food.

Reasons for these declines are unclear but may be linked to natural and human factors, some of which may be exacerbated by climate change. Specifically, natural factors such as predators, hydrological shifts, insect harassment, stochastic weather events, changes in wildfire regime, and extreme temperature fluctuations, all represent threats to barren-ground caribou populations. Research conducted on the Bathurst and Bluenose East herd has indicated that very high drought and warble fly indices in 2014 resulted in low percentages of breeding females in June 2015

(Boulanger and Adamczewski 2017). Anthropogenic factors, including changes in harvesting practices, ice breaking practices, habitat fragmentation through landscape modification, and other effects of industrial activities, also have a detrimental impact on caribou movement and behavior (Dumond and Lee, 2013). Recent research conducted by Wilson et al. (2016) and Boulanger et al. (2020) has demonstrated the aversion of barren-ground caribou to road crossing. Additionally, these threats may be having cumulative effects, and may synergistically be having negative impacts on barren-ground caribou productivity and long-term viability.

Dolphin and Union caribou are facing many of the same threats as barren-ground caribou, as well as population specific threats. Due to their migration across the Coronation Gulf, the Dease Strait, and Queen Maud Gulf, to winter range on the mainland of Nunavut, Dolphin and Union face unique threats. Most notably, DU caribou are reliant on sea ice (Poole et al. 2010, COSEWIC 2017; Hanke and Kutz, 2020). Ice breaking practices and declining periods of ice cover, cause unpredictability in sea ice condition and connectivity for this species' unique sea ice migrations in the fall and spring. Due to the DU herds reliance on sea ice, climate change may also pose a serious threat to Dolphin and Union caribou (Poole et al. 2010, COSEWIC 2017). Another threat to the herds status is possible emigration events into neighboring barren-ground caribou herds on the Nunavut mainland. In recent years, traditional knowledge has reported that Dolphin and Union caribou are being seen with barren-ground caribou year-round, and outside of their known annual range extents. Additionally, small groups of DU caribou have been observed joining larger barren-ground caribou herds during fall migration. It is unclear how regularly this may occur, and if DU caribou are also joining barren-ground caribou on their rutting grounds, which if confirmed, suggest these emigrants are no longer reproductive members of the DU herd, but rather of the Barren-ground caribou herd within which they are mixing. Traditional Knowledge also indicates that during previous population lows, the herd ceased migration, an observation consistent with both recent reports, and current population declines. It is unclear how any, or all of these possible behavioral shifts could impact the health or survival of individuals into the future. The factors driving the current declines in Dolphin and Union caribou need further investigation to effectively quantify decline mechanisms to model and manage the population effectively into the future.

5.2 Survey Methods and Challenges

One challenge with this analysis was the higher proportion of data recorder observations. These observations do not fall into the usual double observer model framework and therefore had to be further considered. We addressed this issue by pooling the second recorder and data recorder observations into a single observer for the pairs that had substantial data recorder observations. We then modeled the double observer probabilities for the pairs of observers that had data recorder assistance separately, then modeled the other observers (without data recorder assistance) using the DRobs covariate. This allowed the inclusion of the substantial data recorder observations in the analysis, where and when they occurred. We further tested the sensitivity of treating the data recorder as a third observer by running a sensitivity analysis where observations from the front and rear observers were pooled as a single session, and the data recorder observations treated as a second observer/session. The resulting change in the estimate was minimal (121 caribou) suggesting that the analysis was robust to how observations from the data recorder were treated. We note that if these observations are not used, then the estimate of abundance from the MRDS model is less than that from strip transects (that are likely biased low due to low sightability near the plane). It would be possible to model data recorder observations more directly as a third observer; however, this capability is not included in the MRDS package. To develop a new triple observer estimator for a third data recorder observer, would require substantial programming likely using a Bayesian MCMC approach (Kery and Schaub, 2012) and is beyond the scope of the current effort. It is likely that the amount of change in estimates due to differences in how data recorder observations are modelled, would not be substantial in the context of the overall range of estimates produced by the sensitivity analysis (**Figure 18**).

The dependent double observer pair method assumes equal sightability between observers as well as reasonably high individual sighting probabilities, to be effective as an estimator of sightability. If individual sighting probabilities become too low so that a substantial proportion of caribou are missed, it is likely that the double observer estimator will be biased low due to inefficiencies of the removal estimator used for modelling dependent observers. An independent observer method (where the two observers do not communicate) is more effective and efficient but more difficult to implement (Buckland et al. 2010) when observer probabilities are variable and lower (Laake et al. 1997, Laake et al. 2008a, Laake et al., 2008b). We suggest that in future surveys, observer pairs who have many data recorder observations, are moved or separated throughout the survey to avoid the additional assumptions of inclusion of data recorder observations in the analysis. If this is not possible, then independent observer methods, which are more robust to these issues, should be implemented if the wildlife being observed is of a low enough density as to provide consistently independent groupings geographically.

Distance sampling allowed the inclusion of observations that were further from the usual 400-meter strip width. This was advantageous for some strata (Kent Peninsula and low density east) where all the observations were beyond 400 meters and therefore, the estimate for these strata using strip transects was 0. However, the challenge of distance sampling is ensuring that data is collected to meet the general assumptions of the method. The main assumption is that observer attention is focused on bins closest to the plane so that detection in these bins is close to 100%. The shape of the detection function suggested that observers were not adequately sighting caribou in the first survey bin at 0 to 200 meters, which would bias the distance sampling analyses. One potential reason for lower detections near the plane could have been the lower survey altitude (300 feet) that reduced the size of the front to back survey window and subsequent time that surveyors had to spot caribou closer to the plane. Other distance sampling surveys on Southampton Island (Campbell et al., 2020) and Baffin Island (Campbell et al., 2015) that flew at the usual higher survey altitude (400 feet) did not have reduced observations in the closer survey bin with higher (>0.95) estimated sighting probabilities in the first (0 to 200 meters) bin. The double observer method helped account for this issue by estimating the probability of sighting caribou in the 0 to 200 meter bin at 0.86. Comparison of the standard strip transect estimate (assuming sightability of 1) of 3,599 compared to the strip transect double observer estimate of 3,861 (**Table 10** and **Figure 19**) indexes the relative sensitivity of estimates to sightability near the plane. Flying at the lower survey altitude for the Dolphin Union survey had the advantage of being less affected by cloud cover and therefore it was an advantageous method. However, we suggest that if this method is employed again, a double observer method is used to estimate sightability to account for lower sighting probabilities in areas closer to the plane.

The other potential issue was caribou in the further bin being called as on transect when they were off-transect, due to difficulties of calling caribou at the furthest, narrowest (by way of observer perspective) bin. If this occurred, then the estimate might show a negative bias of a few hundred caribou as indicated when the furthest bin is reduced. Because fixed-wing distance sampling data is typically binned, it is not possible to trim off smaller amounts of data at further distances such as in usual distance sampling analyses, that records all observations, and then measures all observations from the transect line to the observation or group. We suggest that if distance sampling is to be used in fixed wing platforms that do not measure group distances from the transect, it should be, as in the present work, accompanied by double observer methods to allow estimation of sightability on the transect.

The 2020 survey did not use satellite collared caribou to identify areas of high aggregation and instead conducted an extensive survey of all areas that were likely to have caribou. The similarity of estimates between the fall 2018 and fall 2020 surveys suggests that the coastal survey method, when in concert with a collaring program of between 25 and 50 collars, was and remains a robust survey method. However, evidence of caribou outside of the coastal strips typically used during the coastal surveys, were reported by local hunters from the communities of Cambridge Bay, Kugluktuk, and Ulukhaktok, and verified by the fall 2020 survey effort, suggesting that future coastal survey efforts should ensure that more inland strata are sampled, regardless of collar distribution. During the fall 2020 survey effort, inland strata and associated transects, including areas that have never been sampled using the coastal survey method, made up an estimated 30% of all on transect observations of caribou (403 caribou). Though there were only 4 active collars during the 2020 survey effort, only one was outside of high-density survey strata.

5.3 Recommendations

Future research on the Dolphin and Union herd should be focused on identifying mechanisms for the observed trends so that the causal factors can be addressed to aid in the effective management of the herd. Population abundance should be carefully monitored, and the frequency of surveys should remain high when the population is in the declining phase. Additionally, obtaining accurate predator and human harvest rates and other forms of anthropogenic mortality, will be key to the effective modelling of herd specific mortality and its effects on abundance trends (Boulanger et al. 2019). This information will be necessary to confirm the effectiveness of current management actions.

The collaring of animals is also a key requirement to effective abundance survey stratification, as well as the monitoring of possible changes in movement related behavior and seasonal range use. Future surveys should also be expanded beyond the historically conducted coastal survey to, at minimum, include both inland and mainland strata. Although not statistically significant, the inclusion of the mainland strata in the 2020 survey effort did find caribou aggregations on the mainland consistent with community observations, suggesting that this could be something more pervasive in the future and for this reason alone, should be monitored. Additionally, given the number of observations made further inland, future surveys should at minimum consider areas 50 to 100 km inland from the south central and south western coast of Victoria Island, and/or as collars indicate.

5.4 Public Confidence

During the September and October stakeholder consultations, it became evident that community-based wildlife management organizations were unsatisfied with efforts to include IQ into caribou research planning and deployment. This is an issue that has challenged biologists, managers, and Inuit Organizations alike across the Territory. Though we are all working hard to come together to find a way of improving this situation, much work remains to be done. The DU caribou fall 2020 survey findings confirmed that HTO concerns that DU caribou fall distributions went beyond the constraints of the previously surveyed narrow coastal strata characteristic of the telemetry driven coastal survey method, were valid. Additionally, considering the history of the DU caribou Herd having halted their mainland migration from Victoria Island during times of low abundance in the 1970s, we suggest that hunter observations of overwintering DU caribou on Victoria Island coupled with the current declines estimated in recent years is consistent with this possible change in migratory behavior, and should be considered in any future research planning (Roberto-Charron, 2020; Hanke and Kutz, 2020). These observations can have far reaching implications to the effectiveness of research programs. DU caribou overwintering on Victoria Island would have important implications for effective and representative collar deployment. A split in collar deployment between the mainland and Victoria Island would provide better overall representation of the herds contemporary use of its range, and therefore should be factored into any future collaring program. Furthermore, hunter observations of DU caribou in the Contwoyto Lake area, well outside of their known annual range, also raises concerns that the DU herd may be in flux. These extralimital observations could explain possible mechanisms governing the dramatic decline observed between 2015 and 2018 and should be explored further. We suggest that future research in Nunavut would greatly benefit from a more shared approach to the development of research programs through a more effective and meaningful inclusion of IQ in research planning. In the case of the fall 2020 DU caribou abundance survey, the inclusion of IQ into the survey plans was pivotal in the successful completion of the survey. Working together to better understand the complex relationships between caribou and their environment will lead to better research results, and more effective management of this species. Through collaborative work, we can improve the scientific, political, and public confidence in research results, and in turn, the effectiveness and acceptance of the management actions developed, by all stakeholders.

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7.0 ACKNOWLEDGEMENTS

The success of any large-scale wildlife survey initiative is completely dependent on the quality of the team assembled to complete the task. Our team was of the highest quality. In total, 20 individuals representing the communities of Cambridge Bay, Kugluktuk, and Ulukhaktok took part as observers in the survey effort. Our most sincere thanks go out to the Cambridge Bay observers including Mable Angohiaktok, Richard Ekpakohak, George Hakongak, Jimmy Haniliak, Allen Kapolak, Peter Kapolak, and Gary Maksagak; the Kugluktuk Observers including Regan Adjun, Albert Anavilok, OJ Bernhardt, Darian Evyagotalilak, Jeffery Niptanatiak, Jonathan Niptanatiak, and Antoin Nivingalok; and the Ulukhaktok Observers including Patrick Akhiaktak, Tiffani Akhiaktak, Tom Harvey, Jack Kataoyak, Susie Memogana, and Allen Pogotak. We would also like to thank Amanda Dumond (Kugluktuk Angoniatit Association), and Larry Adjun (Kugluktuk Angoniatit Association), Bobby Greenley and Beverly Maksagak (Ekaluktutiak HTO), Connie Kapolak (Bathurst Inlet HTO), Bessie Inuktalik (Olokhatomiut HTC), Rosemin Nathoo and (WMAC), Marsha Branigan (GNWT). I would also like to take this opportunity to thank Jason Shaw and Robin Kite from Caslys consulting for their always exceptional GIS support and quick turn-around times often at very short notice. I would also like to thank Drikus Gissing and Caryn Smith for their behind the scenes efforts to keep the survey effort alive and on track despite the many speed bumps encountered, this survey could not have been completed without that support. Finally, I would like to thank David Lee for his advice and encouragement throughout the survey process.

Simple thanks cannot adequately express our immense appreciation to all those involved in this survey from the observers to the charter companies, pilots, and hotel staff that safely carried and accommodated our team. We would like to extend a special thanks to Air Tindi (Discovery Air) and their highly skilled pilots Ted Duinker, Shawn McKnight, Gabriel Vaughan Vianna, and Ames Rae whom in many ways carried this project through to its safe and successful completion. We also thank Bob Schnurr for his experience and expertise (and patience!) in assembling the aircraft and experienced staff at such short notice, and John Paton and Sam Tilley for again going far beyond their required duties to ensure aircraft were secured for this large survey effort. These efforts represent a small miracle considering the global pandemic amongst other challenges.

8.0 APPENDIX

8.1 Consultation Maps

Figure 20. A map of the 2020 fall DU caribou survey area and probable caribou distributions based on submissions from Ulukhaktok, NWT.

Figure 21. A map of the 2020 fall DU caribou survey area and probable caribou distributions based on submissions from Ulukhaktok, NWT.

Figure 22. A map of the 2020 fall DU caribou survey area and probable caribou distributions based on submissions from Cambridge Bay and the Ekaluktutialik HTO, NU.

Figure 23. A map of the 2020 fall DU caribou survey area and probable caribou distributions based on submissions from Kugluktuk, NU.

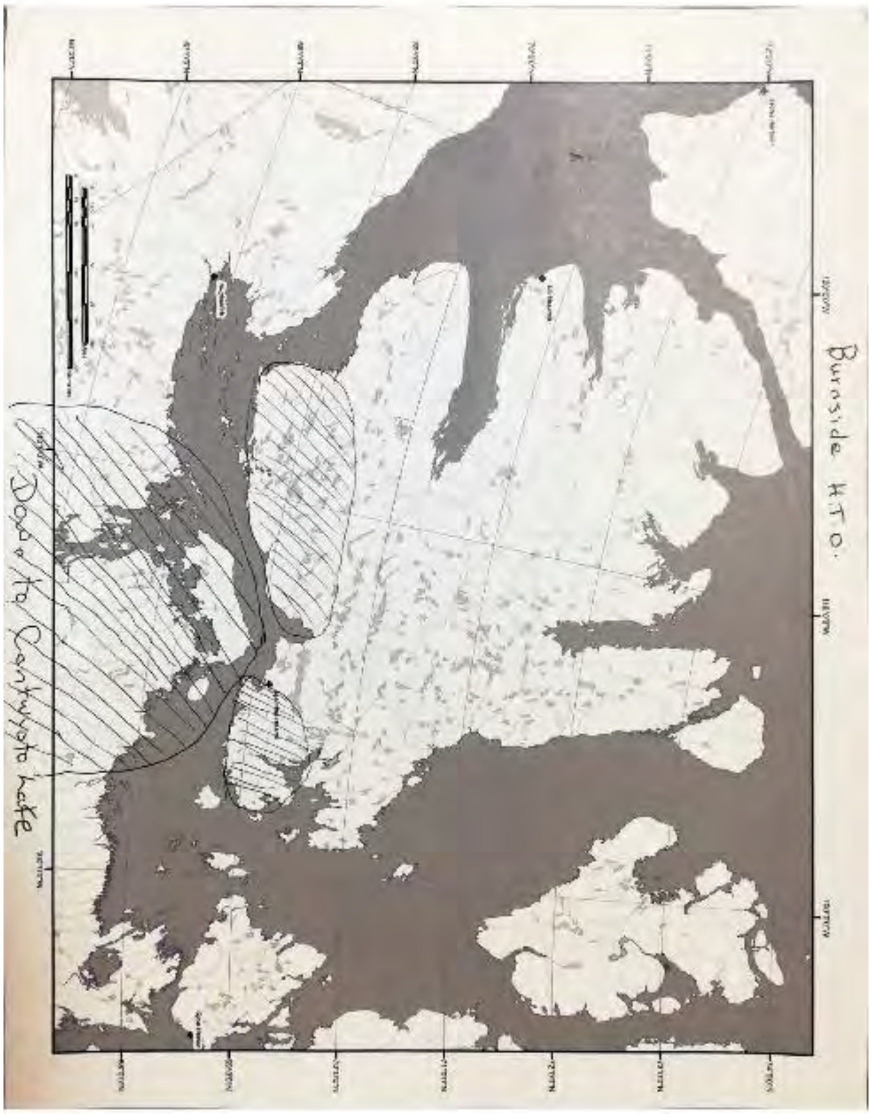

Figure 24. A map of the 2020 fall DU caribou survey area and probable caribou distributions based on submissions from Burnside HTO, NU.

Figure 25. A map of the 2020 fall DU caribou survey area and probable caribou distributions based on submissions from Omingmaktok, NU.

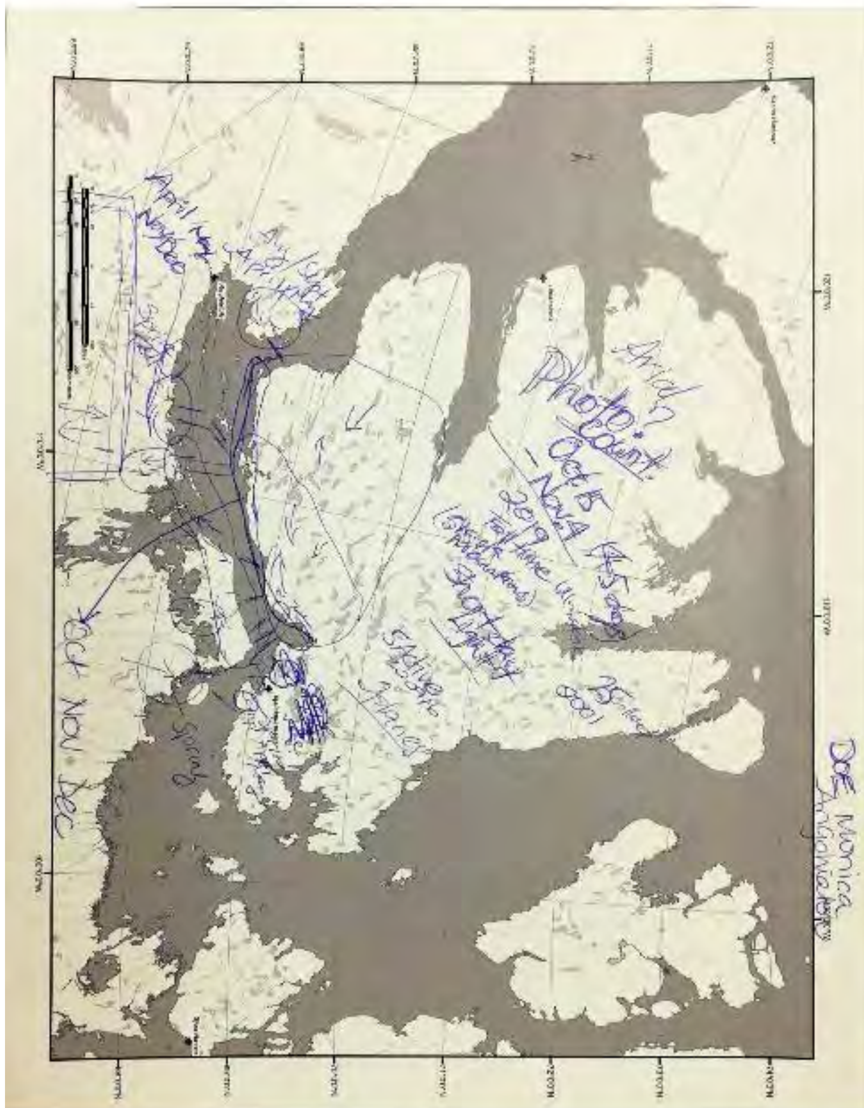

Figure 26. A map of the 2020 fall DU caribou survey area and probable caribou distributions based on submissions from DOE, Wildlife Officer Report, Cambridge Bay, and Kugluktuk.

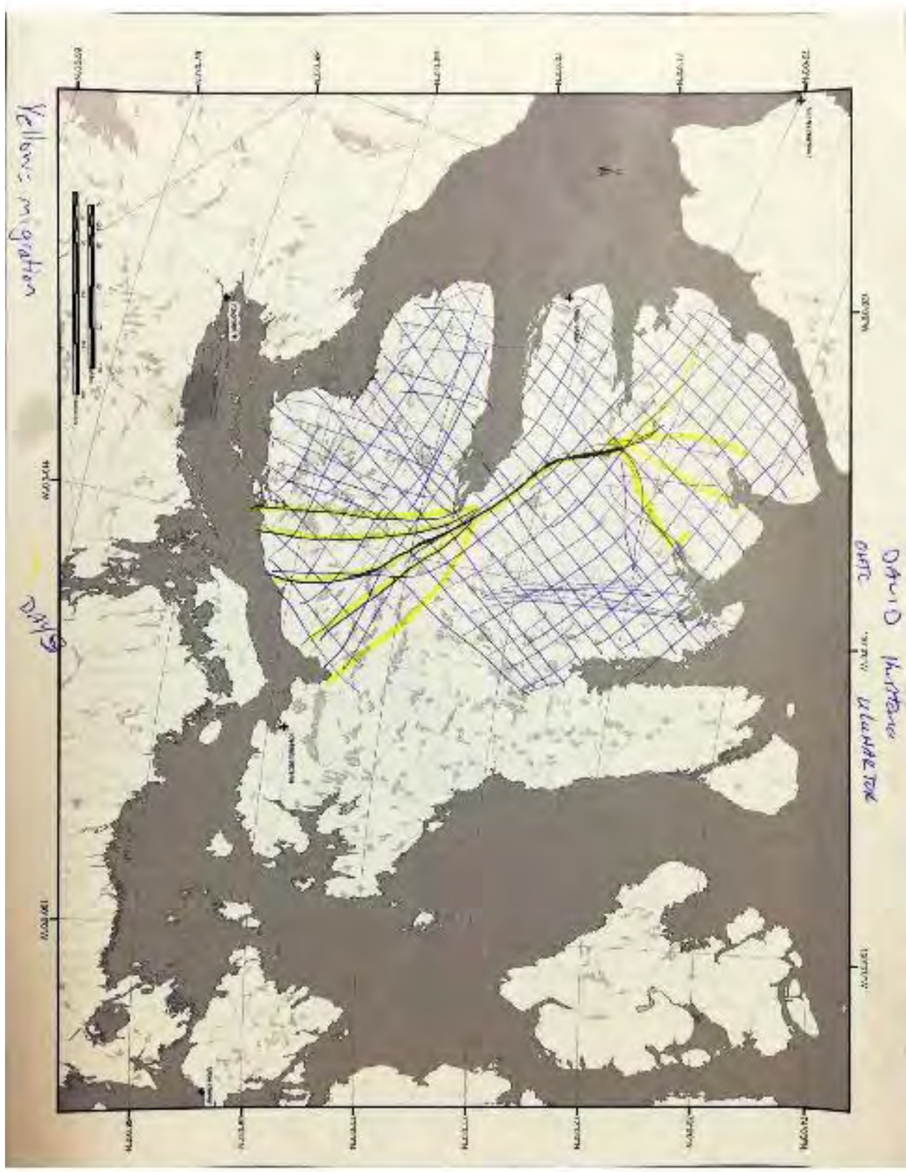

Figure 27. A map of the 2020 fall DU caribou survey area and probable caribou distributions based on submissions from Ulukhaktok, NWT.

8.2 Dolphin and Union Caribou Herd Landscape Stratification Analysis – Methods and Results Summary.

Dolphin and Union Caribou Herd Landscape Stratification Analysis – Methods and Results Summary

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January 2021

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1.0 DATA AND METHODS.

The following sections describe the data incorporated into the landscape stratification analysis along with the methods applied.

1.1 Caribou Telemetry Data

Telemetry points were collected from three telemetry programs, the first deployed between 1987 and 1989 maintaining a mean of 6 collars annually, the second between 1996 and 2006 maintaining a mean of 11 collars annually, and the third between 2015 and 2020, maintaining a mean of 27 collars annually (Table 1). The GPS locations from these programs were imported into an Access database, normalized into a common data structure, and attributed based on previously developed seasonal range date extents (Campbell et al., 2014) for the analysis. All pre-deployment and post-mortality locations were removed from the data, along with any collars deployed on non-Dolphin and Union caribou (determined through genetic analysis of captured caribou).

1.2 Annual Range Analysis Methods

Data were split into two groups for the annual range analysis: telemetry locations collected between 1996 and 2006 and current telemetry locations collected between 2015 and 2020. Data from 1987-1989 were excluded from the annual range analysis as sample sizes of collared caribou were relatively low. The annual range for 1996 to 2006 pooled data across years and used kernel density estimation (KDE) to generate a utilization distribution characterizing annual range use for that period. The bandwidth applied in the KDE (i.e., 29 km) was estimated using reference bandwidth (*href*) approach and the range boundary defined as the 95% utilization distribution contour (Calenge 2011).

The annual range boundaries for the current telemetry data, were defined on a year-to-year basis rather than as a pooled dataset due to the large sample sizes available. Utilization distributions were generated for each year using KDE and the 95% contour used to define the range boundaries. The bandwidth used to generate the utilization distributions (i.e., 28 km) was calculated by averaging the *href* estimated for each year.

To generate an annual range boundary that captured both historical and current range use, the 95% utilization distribution polygons for each period (i.e., 1996-2006, 2015, 2016, 2017, 2018, 2019, and 2020) were merged and any overlapping boundaries dissolved.

1.3 Seasonal Range Analysis Methods

Seasonal range boundaries were generated for both low movement and high movement seasons using a similar approach to the annual ranges. Telemetry locations for all years were attributed with the seasonal date ranges defined by Nagy 2011. For each low movement season, data were pooled across years and a utilization distribution was generated using KDE with a seasonally specific bandwidth estimated using the *href* method (Table 2). The seasonal range boundaries were defined as the 95% utilization distribution contour.

For the high movement seasons, yearly migration corridors were derived from transect kernel densities for each of the migration seasons. The bandwidth for the corridor analysis was 20 kilometers. To bring the individual migration density layers to a common scale, they were reclassified into the utilization distribution classes 50%, 80%, 90%, 95%, and 100%. The reclassified corridor layers were weighted according to the number of collars for each year giving more weight to years with more collars. The layers were added together to identify consistently high use areas year to year. These consistently used areas were used to define the extent of the migration corridors.

Table 14. Summary of telemetry data available for the annual and seasonal range analyses.

Year	Number of Collars
1987	6
1988	7
1989	5
1996	3
1997	1
1998	1
1999	19
2000	20
2001	18
2002	12
2003	20
2004	14
2005	9
2006	3
2015	17
2016	29
2017	16
2018	44
2019	33
2020	20

Table 15. Estimated bandwidth radii for low movement seasons.

Season	**Bandwidth Radius (km)**
Calving	24
Post- Calving	28
Summer	25
Late Summer	29
Rut	22
Winter	17

1.4 Landscape Stratification Methods

A land cover classification for Victoria Island was completed to support survey planning for the Dolphin and Union subpopulation. The classification was based on a fused 20 metre Landsat and Sentinel 2 best pixel composite satellite image generated from imagery collected between July 1 to August 31, 2017 to 2020 (**Error! Reference source not found.**). The classification was performed using a supervised classification method based on visual interpretation. Training sites were collected for ten classes based on a previous ecological landcover classifications completed for the Kivalliq region: water, wet graminoid, graminoid heath tundra, heath upland, rock/heath upland, sand/gravel, boulder, rock, and snow/ice (Campbell et al. 2012). The resulting classification was intersected with caribou telemetry locations collected between 2015 and 2020 to investigate seasonal land cover use patterns demonstrated by caribou on Victoria Island.

Additionally, a topographic position index (TPI) surface was generated using the Arctic HRDEM (20 metres) obtained from Natural Resources Canada. TPI is calculated by comparing the elevation for a given cell in a DEM to the mean elevation calculated over a specified spatial neighbourhood (Weiss 2001). As TPI is scale dependent, we calculated surfaces for three spatial neighbourhoods: 500 metres, 1500 metres, and 3000 metres. Smaller neighbourhoods highlight extreme terrain changes (e.g., narrow ridge lines and narrow valley bottoms) while larger spatial neighbourhoods provide a more generalized characterization of landform features. Dolphin and Union telemetry locations were intersected with the TPI results and summarized by season to explore terrain feature use patterns for caribou on Victoria Island.

Figure 28. Landsat and Sentinel 2 Fused Satellite image covering Victoria island.

2.0 RESULTS AND DISCUSSION

The following sections describe the results of the landscape stratification analysis in relation to the survey strata, telemetry locations and caribou observations from the survey.

2.1 Annual Range

The annual range boundaries generated for this project closely resemble those proposed by Nagy 2011. The Dolphin and Union annual range boundaries encompass the majority of Victoria Island and extend south to the mainland covering the areas around Bathurst Inlet, Umingmaktok, and the Kent Peninsula (**Error! Reference source not found.**).

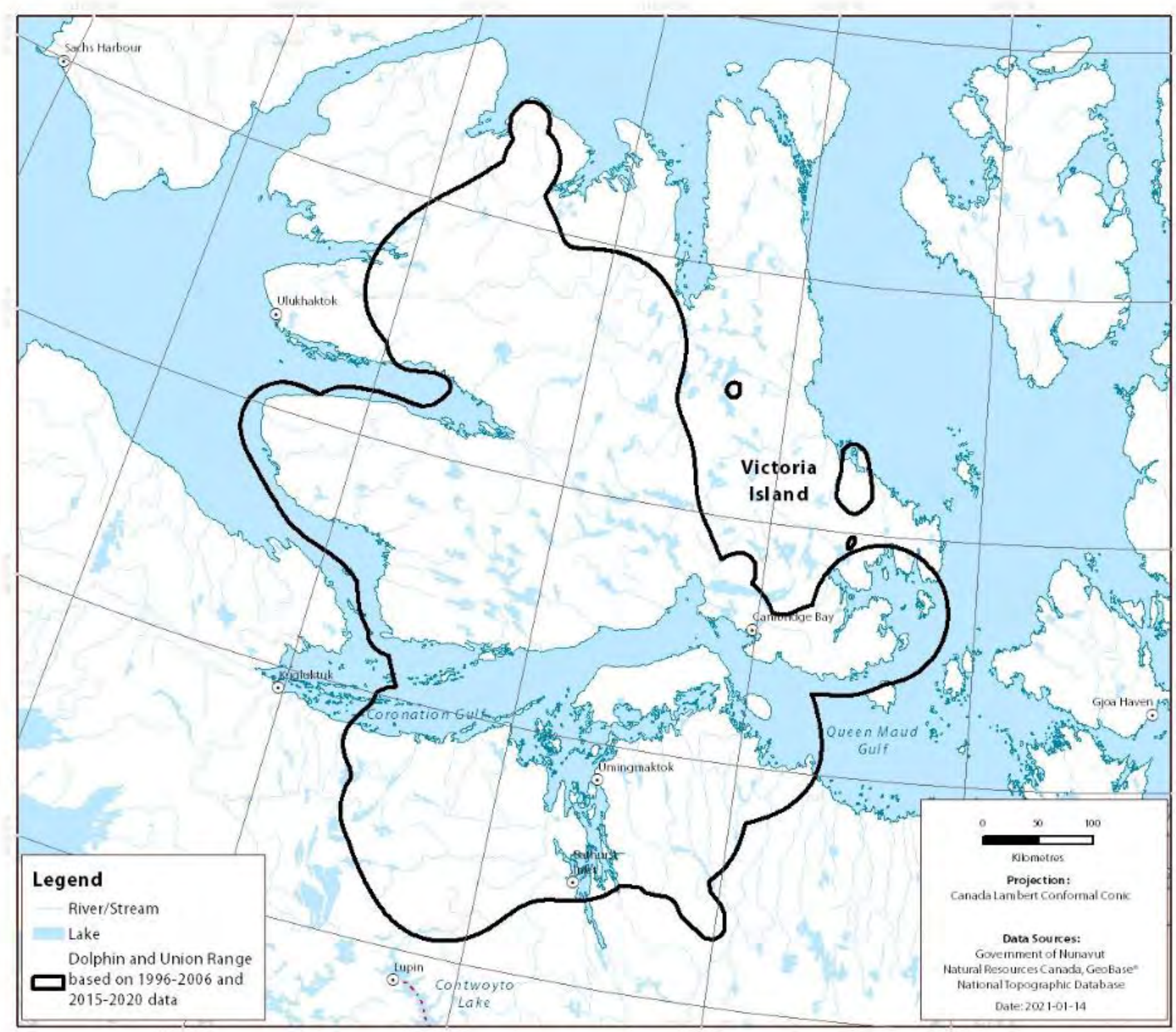

Figure 29. The Dolphin and Union (DU) annual range.

2.2 Seasonal Ranges

The seasonal range boundaries generated for Dolphin and Union reflect the variation in habitat use driven by annual biological and ecological cycles. Spring migration corridors are located between the mainland coast and Victoria Island with the highest use areas falling across the Kent Peninsula and to the West of Bathurst Inlet. The location of these corridors capture the movement of the caribou from their winter ranges on the mainland to the calving and summer ranges located on Victoria Island (**Error! Reference source not found.**).

The calving, post-calving, summer and late summer ranges all occur primarily on Victoria island with the highest use areas located in the southwest and south-central portions of the island (**Error! Reference source not found.**– **Error! Reference source not found.**). Scattered pockets of high use also occur in the north-central region of the island, around Cambridge Bay, and on the Kent Peninsula. There is a slight shift north by Dolphin and Union caribou throughout the snow free months resulting in no range use occurring on the mainland or Kent Peninsula for collared DU caribou after the calving season has finished.

Movement corridors associated with the pre-breeding period of the fall migration reflect the movement of caribou towards the southern coastline of Victoria Island (**Error! Reference source not found.**).

The rut occurs primarily along the southern coast of Victoria Island, as the caribou wait for suitable ice conditions to return to the mainland for the winter (**Error! Reference source not found.**).

The post-breeding fall migration corridors are located between Victoria Island and the mainland coast with the highest use areas falling across the Kent Peninsula, mouth of Bathurst Inlet, and in the region west of the Inlet. The location of these corridors reflects the timing of caribou movements from Victoria Island across the sea ice to their winter ranges on the mainland (**Error! Reference source not found.**).

The Dolphin and Union winter range is located south of the Kent Peninsula, around Umingmaktok, and to the west of Bathurst Inlet. High use areas occur primarily in the region between Kikerk Lake and Bathurst Inlet (**Error! Reference source not found.**).

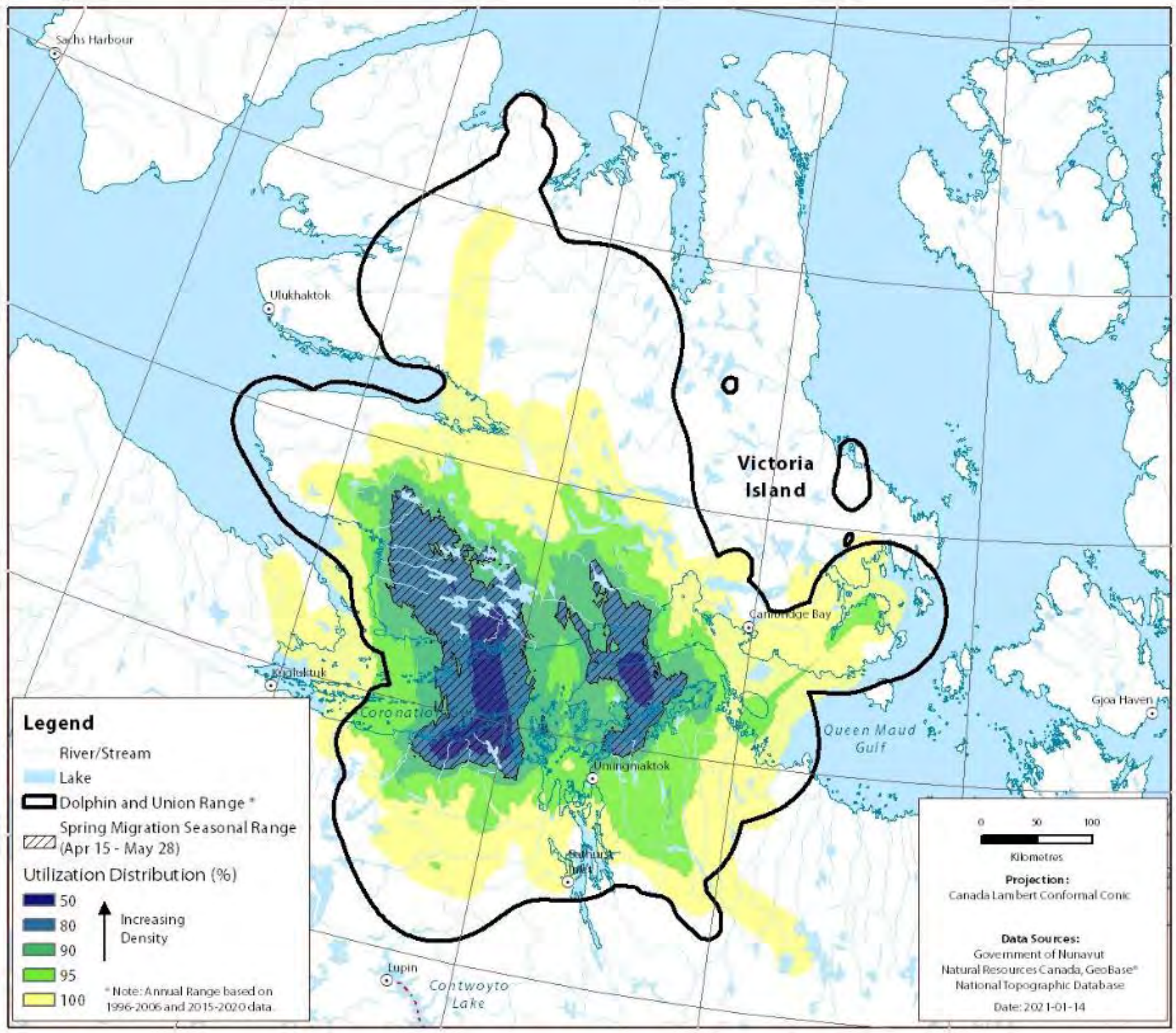

Figure 30. The Dolphin and Union (DU) annual range and spring migration seasonal range.

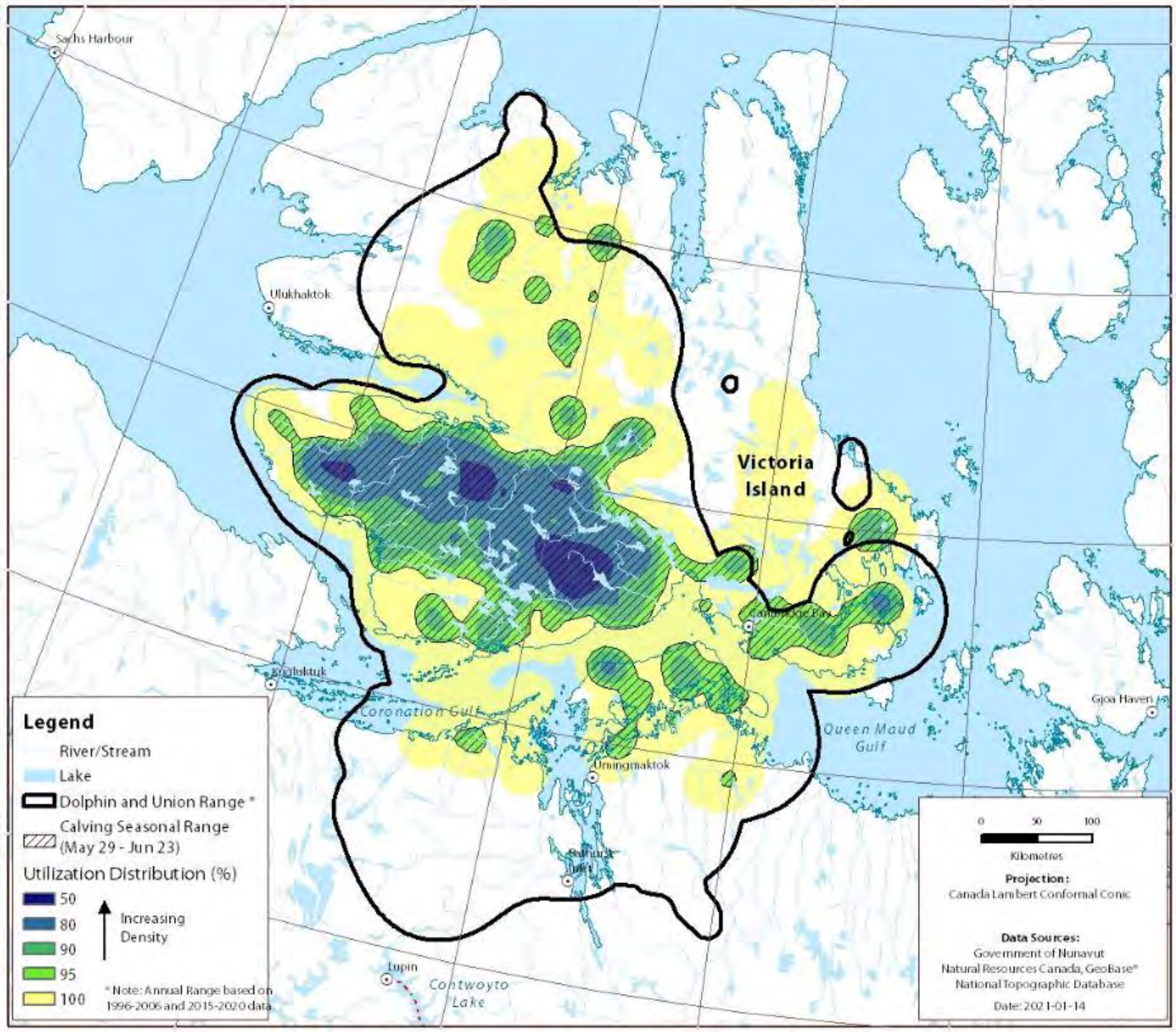

Figure 31. The Dolphin and Union (DU) annual range and calving seasonal range.

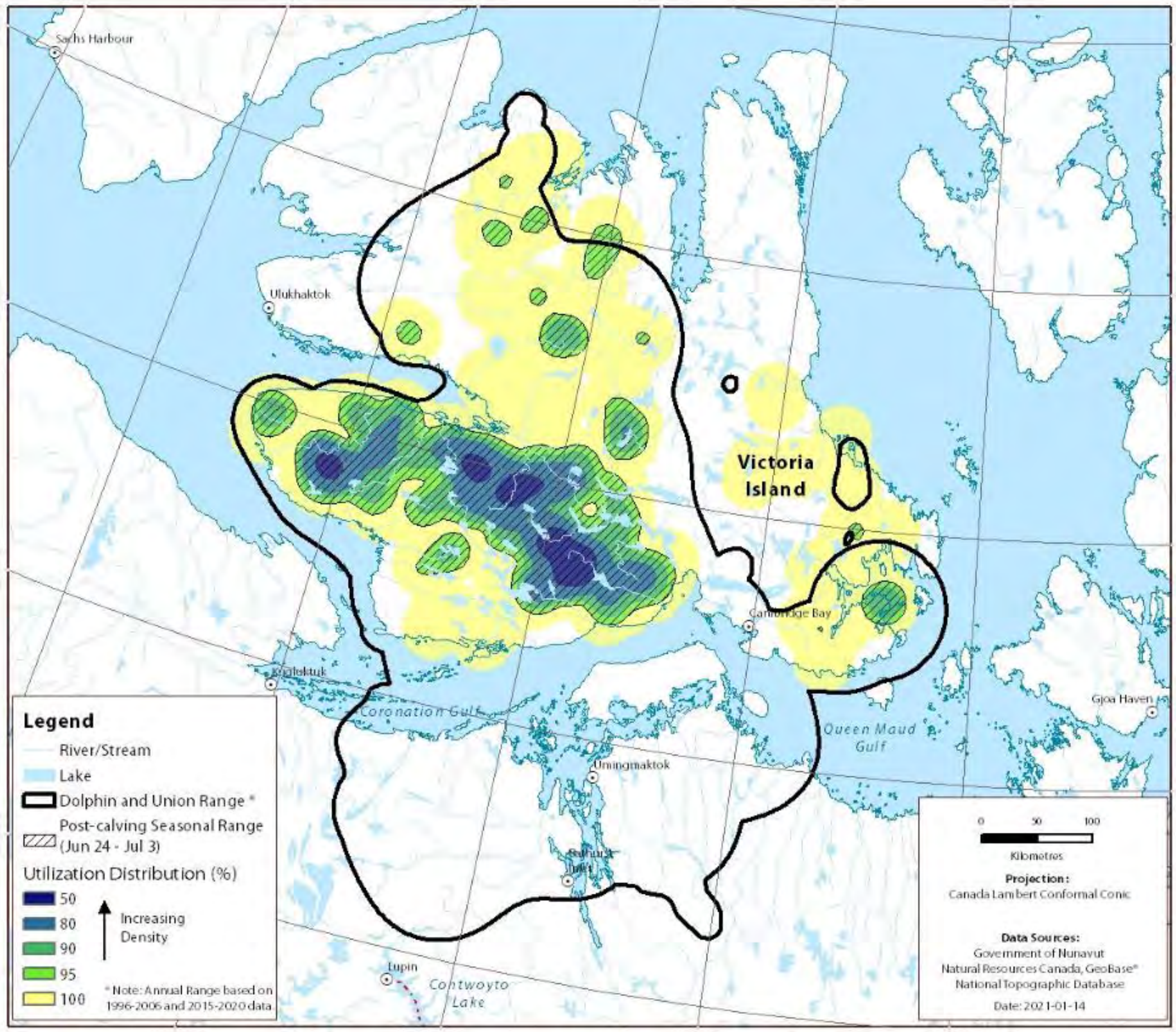

Figure 32. The Dolphin and Union (DU) annual range and post-calving seasonal range.

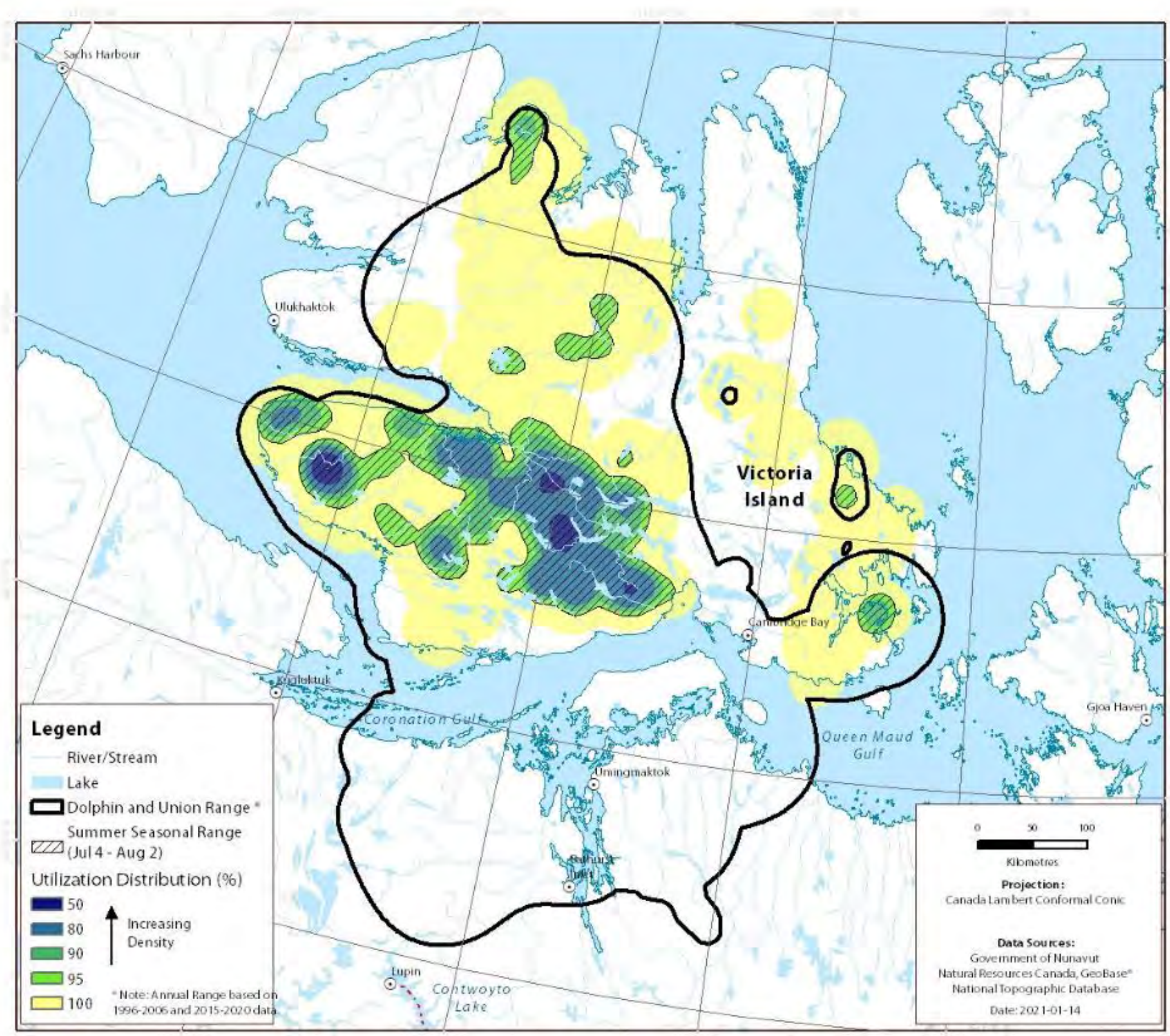

Figure 33. The Dolphin and Union (DU) annual range and summer seasonal range.

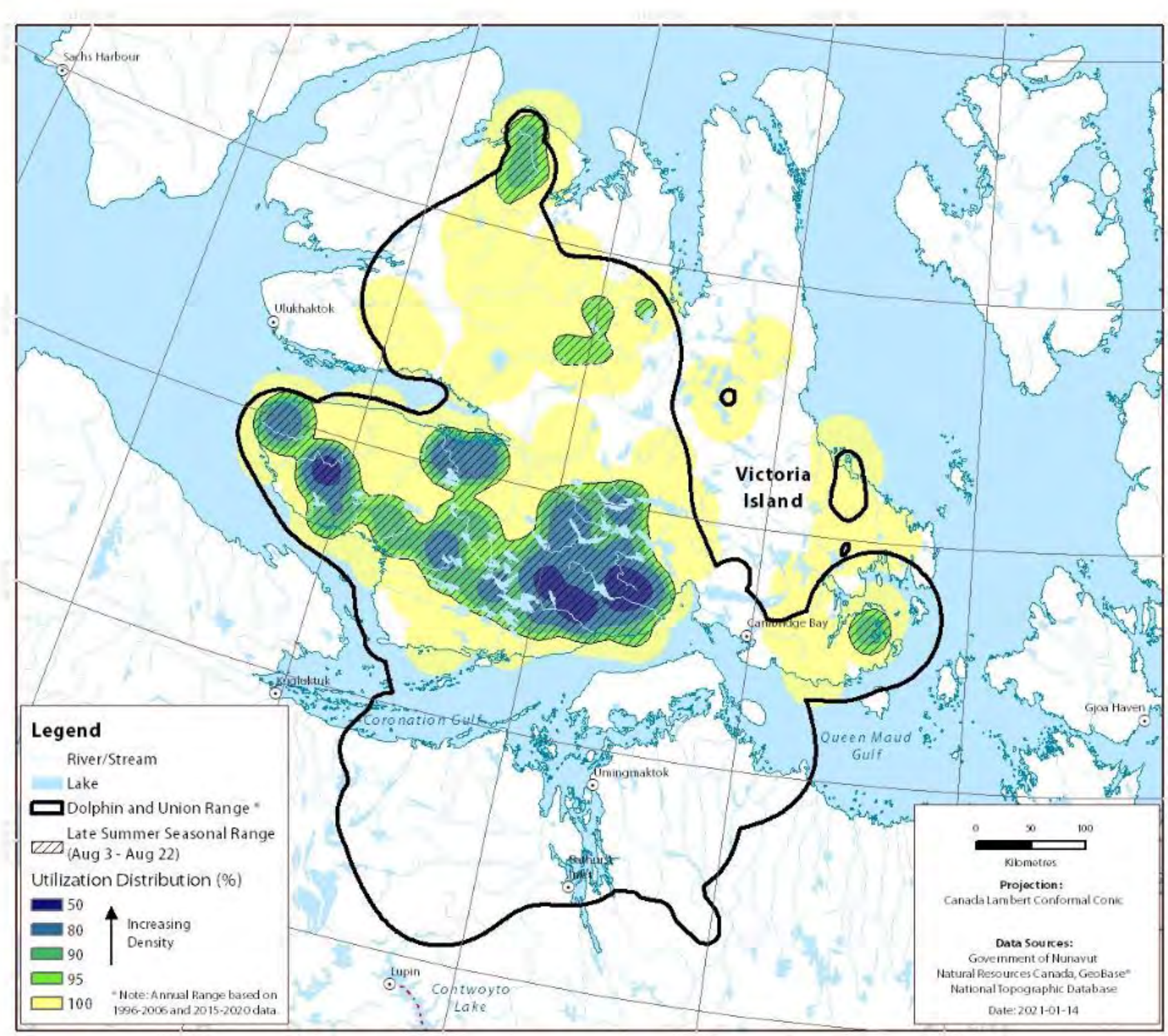

Figure 34. The Dolphin and Union (DU) annual range and late summer seasonal range.

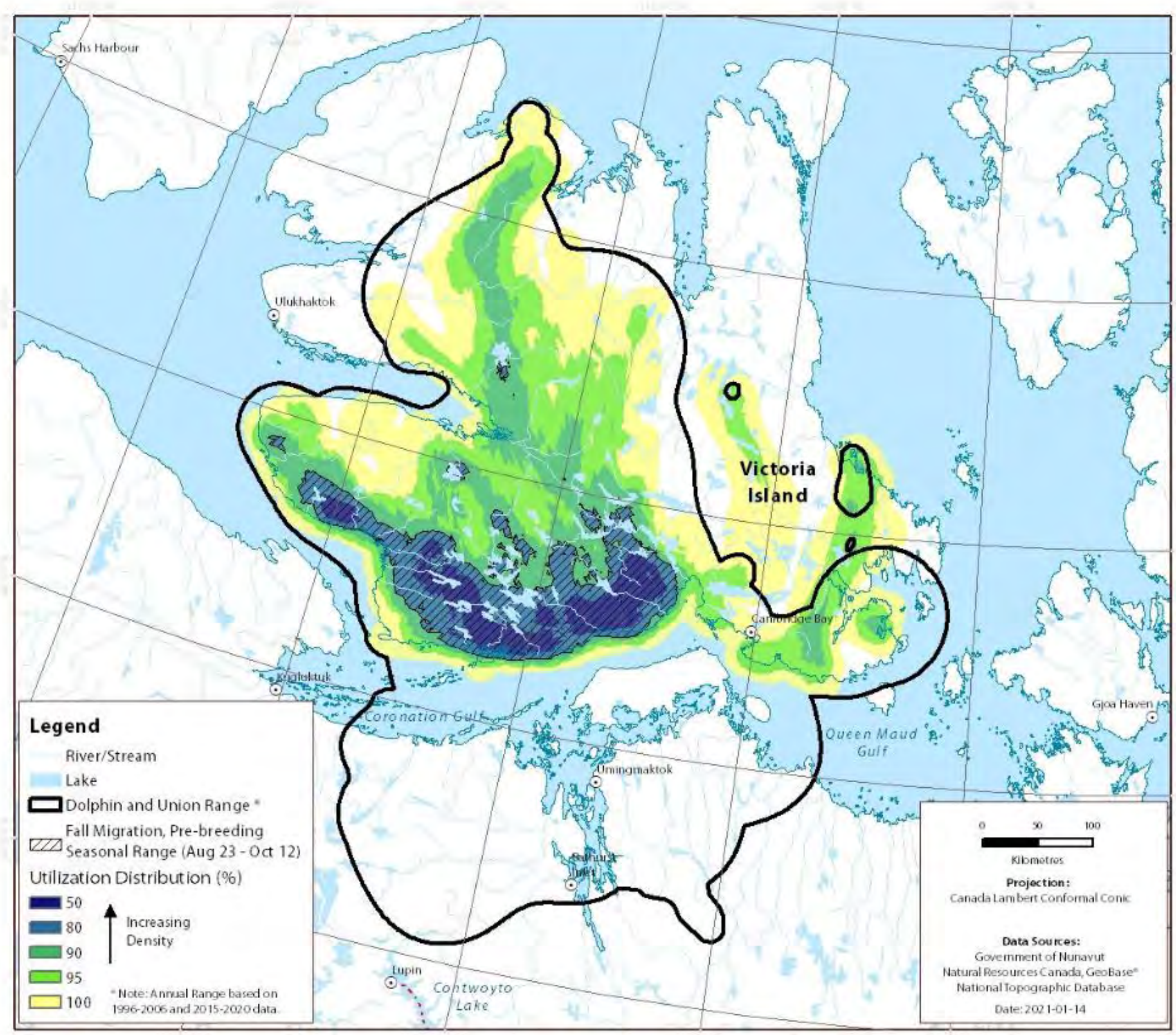

Figure 35. The Dolphin and Union (DU) annual range and fall migration, pre-breeding seasonal range.

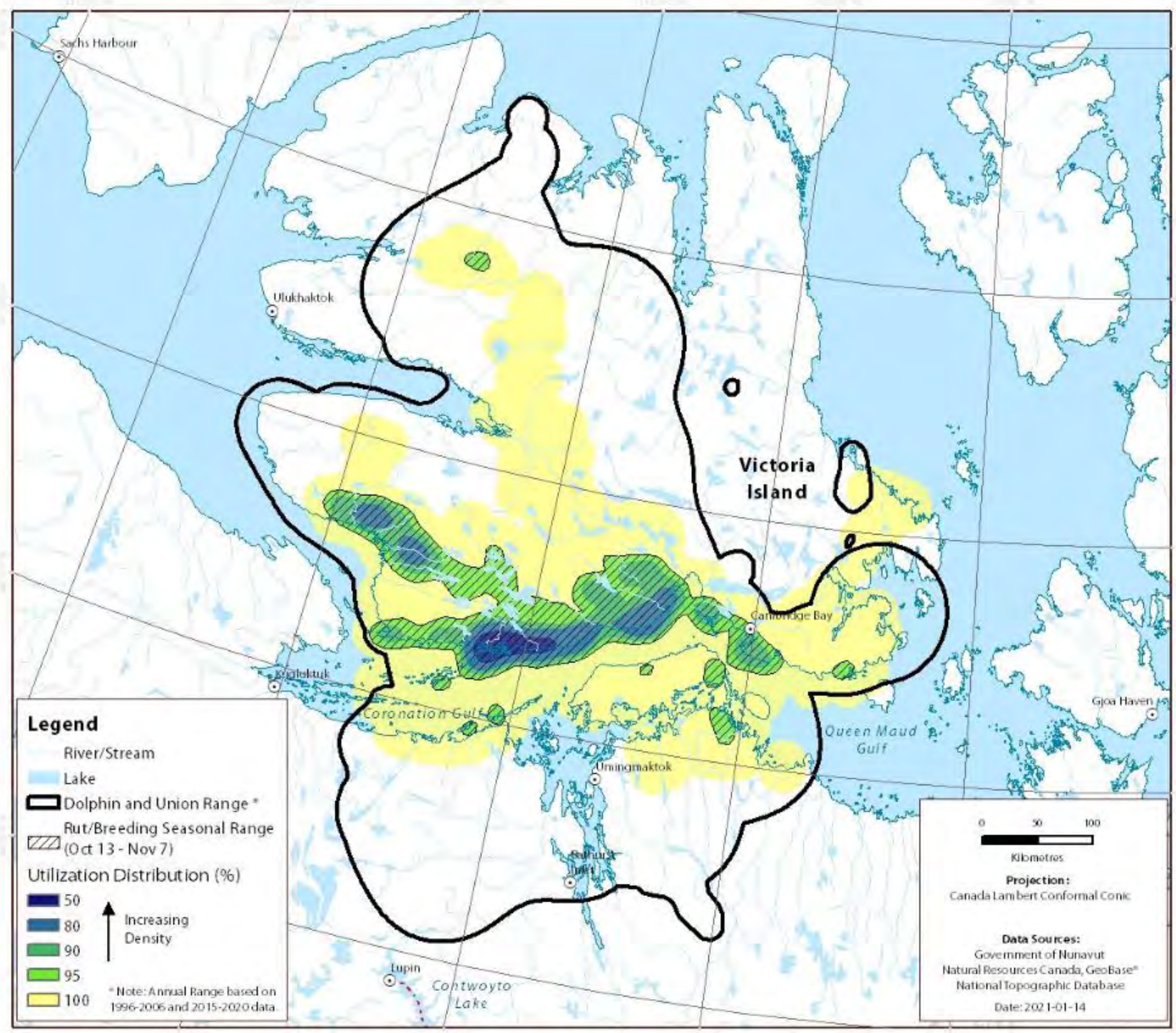

Figure 36. The Dolphin and Union (DU) annual range and rut/breeding seasonal range.

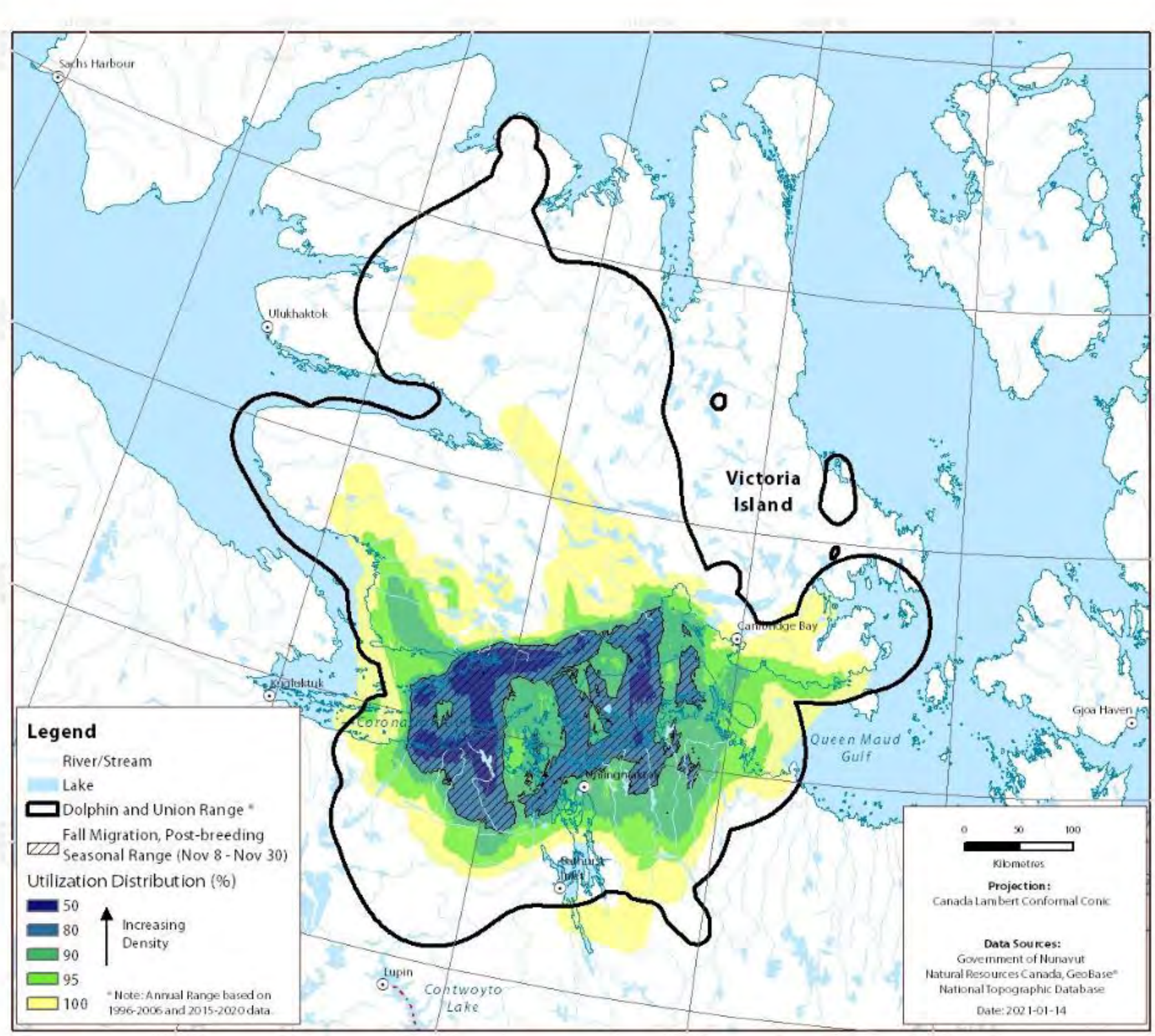

Figure 37. The Dolphin and Union (DU) annual range and fall migration, post-breeding seasonal range.

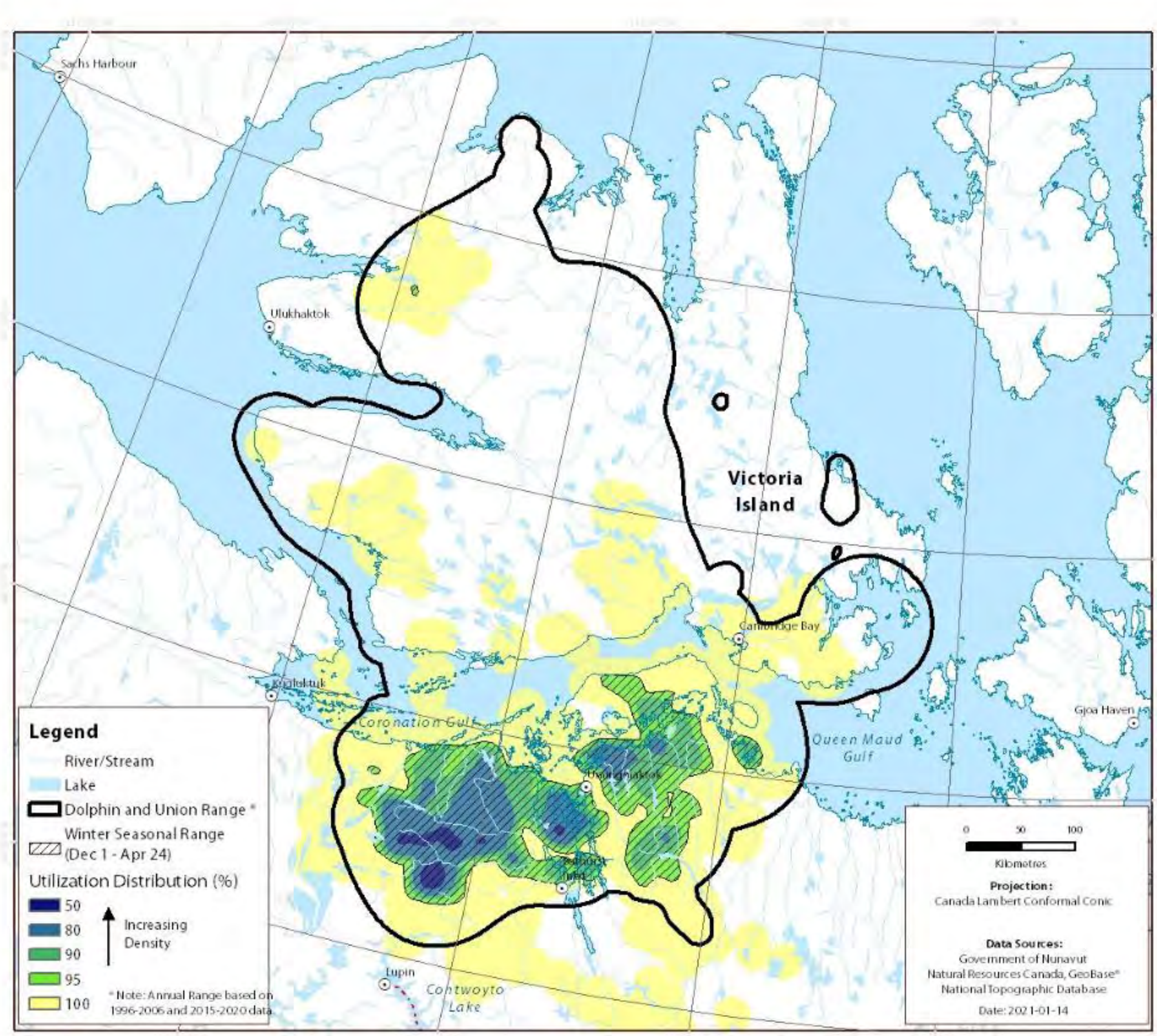

Figure 38. The Dolphin and Union (DU) annual range and winter seasonal range.

2.3 Land Cover

Since Dolphin and Union caribou spend much of the snow free months located on Victoria Island, the land cover classification was focused mainly on Victoria Island (**Error! Reference source not found.**). As such, the survey strata located on the mainland do not have complete coverage and are not included in the summary of results.

When considered as a whole, the principal land cover types present on Victoria Island are heath tundra and heath upland with graminoid, wet graminoid, and water making up a much smaller proportion of the total (**Error! Reference source not found.**). However, the results of the classification show considerable north-south variation in land cover types with less variation east to west. The southern coastline of the island is dominated by the graminoid class and lakes with smaller areas of both the heath tundra and upland classes. Heath upland becomes the dominant land cover type in the central region, while the graminoid and heath tundra classes are present but only in small discrete patches. The central area also has large sandy regions and many lakes. The northern portion of the island is characterized by the presence of large rocky areas of heath upland with some patches of wet graminoid and graminoid classes occurring in the northwest. Unlike the other two regions of the island, the northern portion has only a small number of lakes.

The land cover composition for the individual stratum mirror the north-south variation observed. Strata along the southern coastline have a large graminoid content, but as the strata get further from the coast, they become increasingly dominated by heath upland and heath tundra classes (**Error! Reference source not found.**). As such, the very high density and high density strata are characterized by high levels of the graminoid classes (Figure 13) and medium and low density strata by lower levels of graminoids and increasing levels of heath tundra and upland cover types (Figure 14 – Figure 15). The areas of Victoria Island not covered by strata are similarly composed of high levels of heath tundra and heath upland classes along with a higher proportion of rock, sand, and gravel than evident within stratified areas (Figure 16).

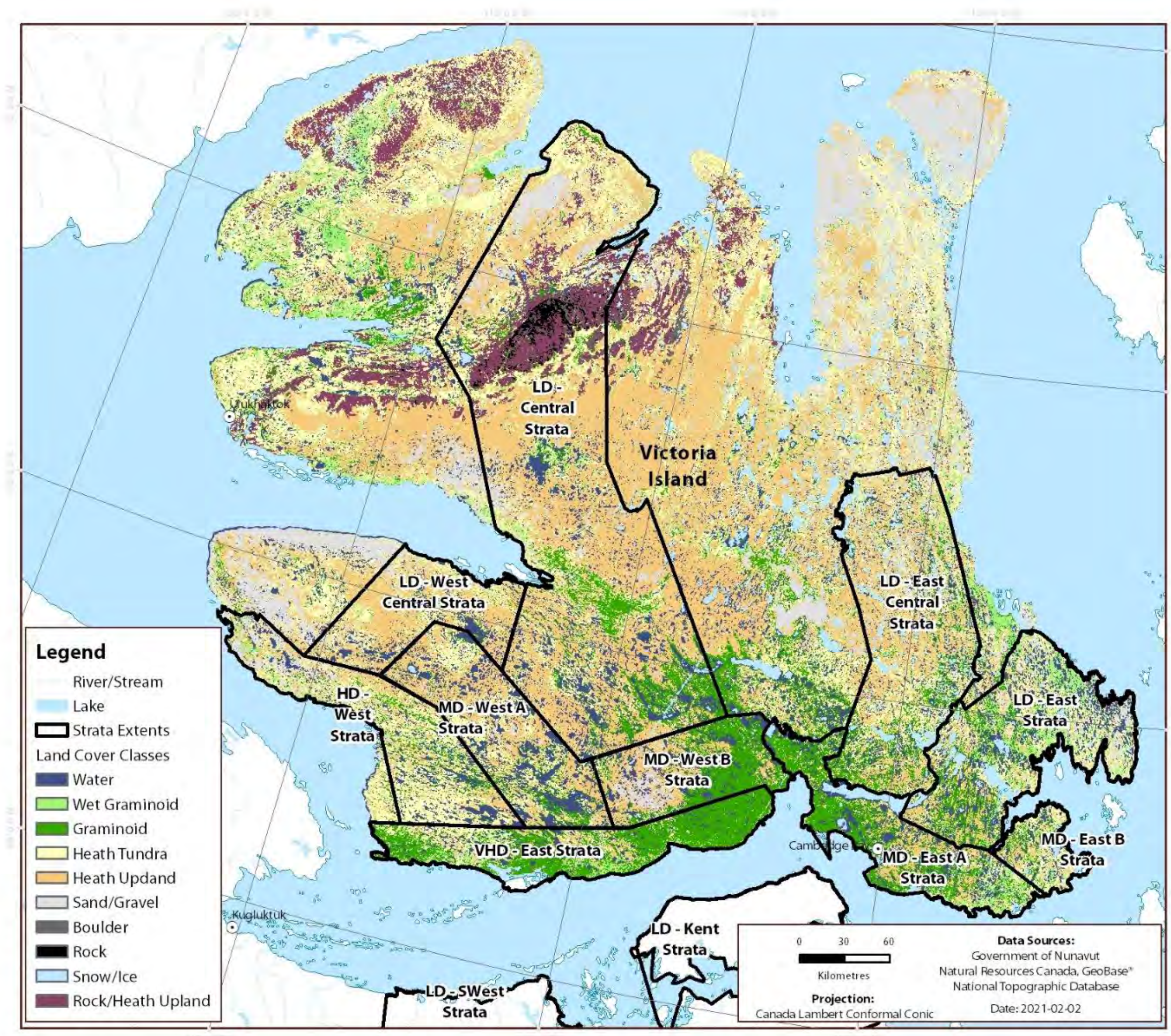

Figure 39. Land cover classification for Victoria Island.

Table 16. Land cover summary for Victoria Island and survey strata.

Strata Name	Water	Wet Graminoid	Graminoid	Heath Tundra	Heath Upland	Rock/Heath Upland	Boulder	Rock	Sand/Gravel	Snow/Ice
Victoria Island - Outside Strata	6.5%	7.4%	6.9%	25.1%	28.1%	8.3%	0.8%	0.6%	10.4%	5.8%
VHD East	13.9%	15.6%	41.1%	15.1%	10.1%	1.6%	0.3%	0.3%	1.4%	0.6%
HD West	14.6%	10.7%	12.4%	30.0%	21.9%	1.7%	0.0%	0.2%	8.1%	0.5%
MD East A	19.4%	12.4%	29.2%	15.0%	13.7%	1.8%	0.4%	0.4%	0.9%	6.8%
MD East B	16.2%	15.1%	14.4%	26.4%	17.4%	4.6%	0.1%	0.5%	2.4%	3.0%
MD West A	23.7%	7.7%	12.3%	22.7%	27.7%	2.9%	0.0%	0.2%	2.3%	0.5%
MD West B	18.4%	7.7%	29.3%	12.8%	21.1%	3.3%	0.1%	0.5%	6.3%	0.7%
LD Central	10.5%	5.3%	9.2%	21.4%	33.9%	9.6%	1.4%	2.0%	5.0%	1.7%
LD East Central	13.1%	9.0%	12.3%	23.0%	26.6%	2.9%	0.0%	0.3%	2.1%	10.8%
LD East	18.8%	16.7%	13.8%	21.2%	15.0%	2.9%	0.0%	0.3%	4.7%	6.5%
LD West Central	13.4%	5.2%	6.7%	25.9%	39.5%	2.3%	0.0%	0.2%	6.5%	0.3%

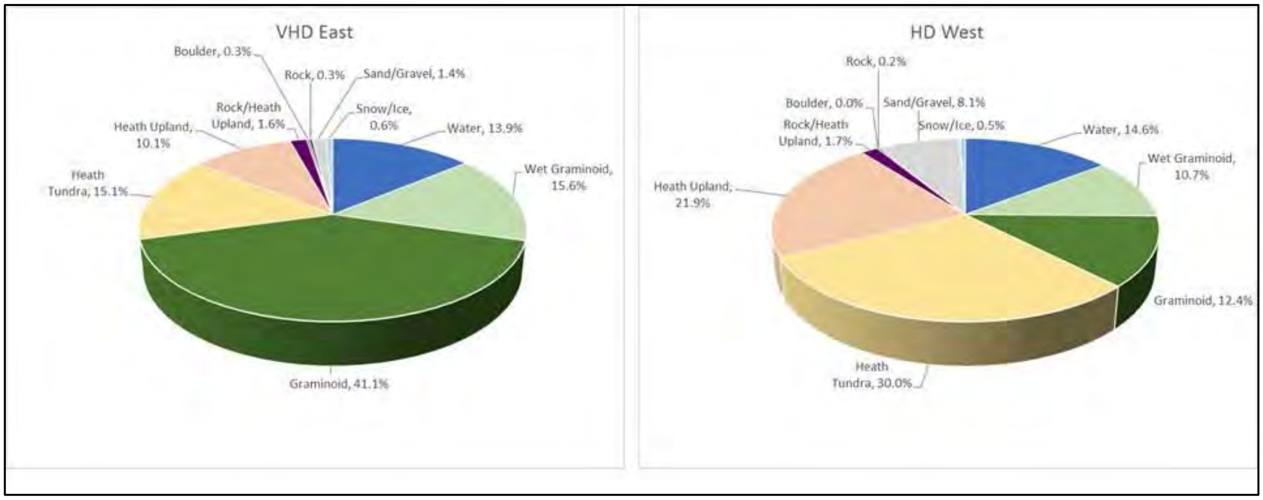

Figure 40. Land cover class percentages for very high and high density strata

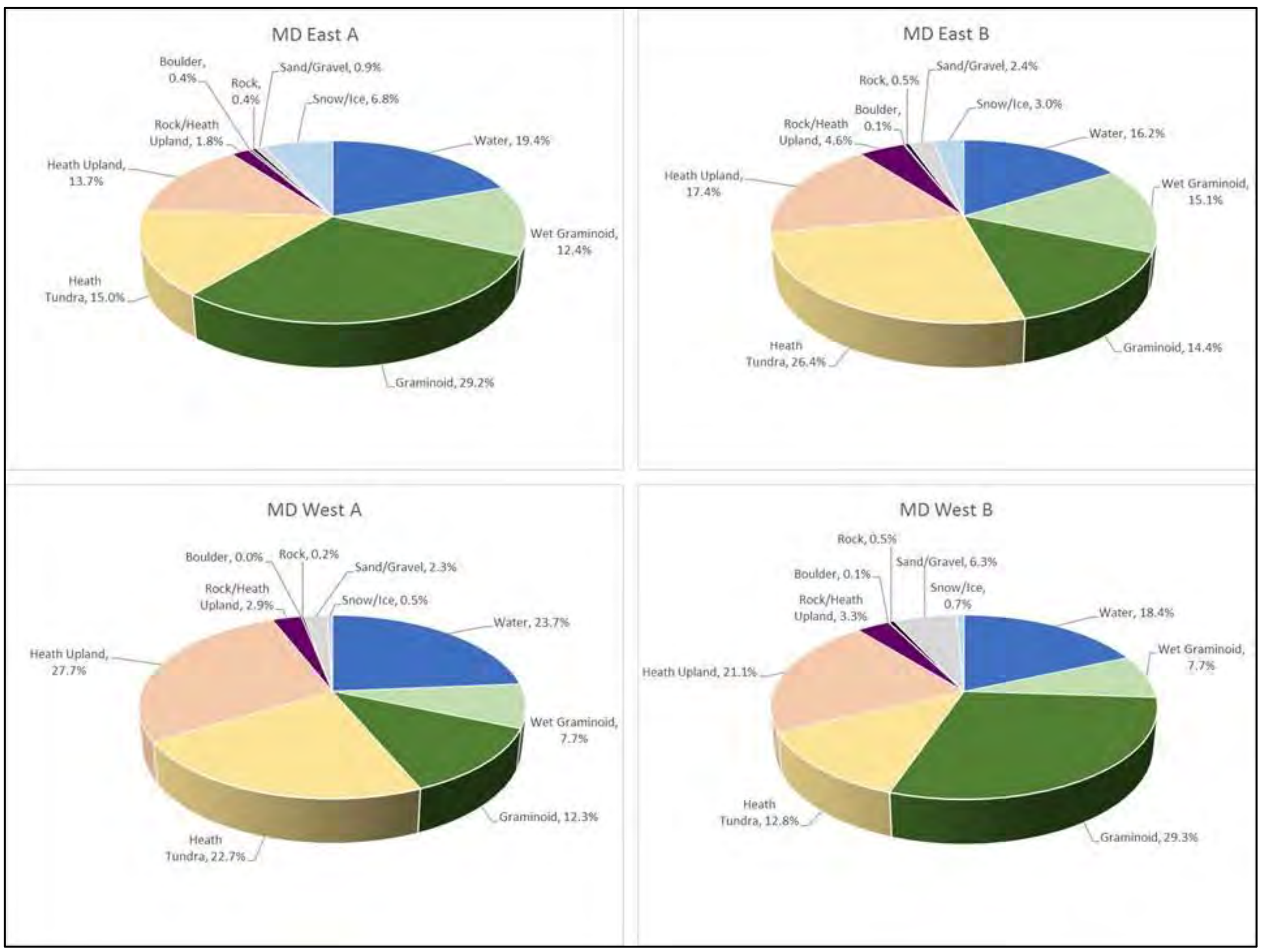

Figure 41. Land cover class percentages for the medium density strata

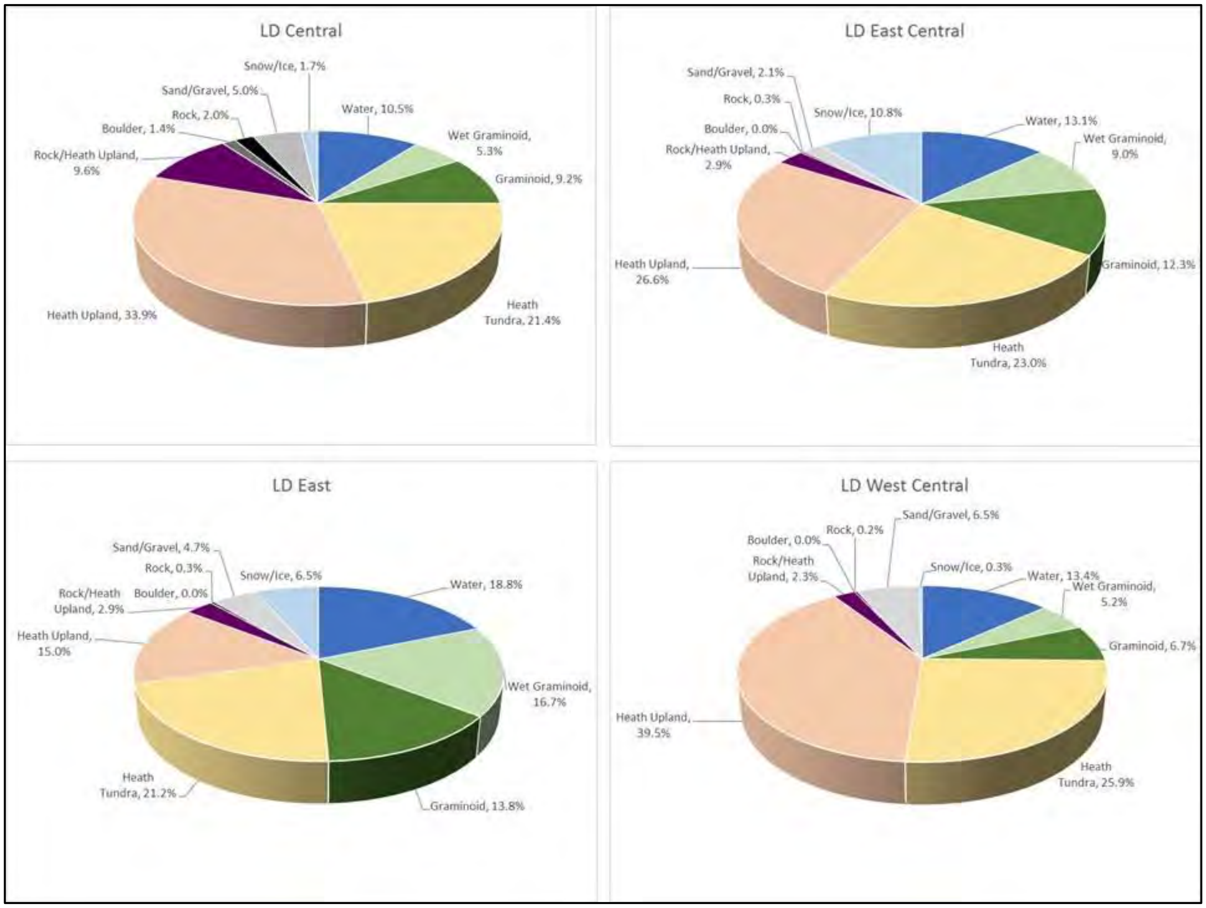

Figure 42. Land cover class percentages for low density strata

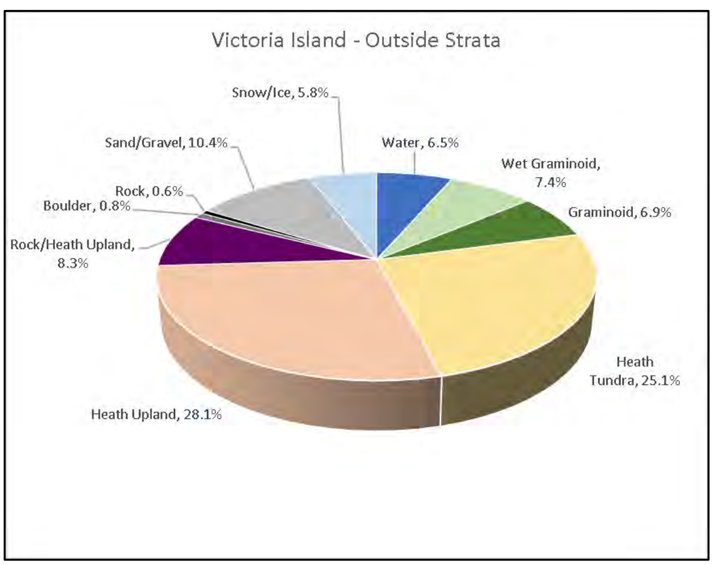

Figure 43. Land cover class percentages for areas of Victoria Island not covered by the strata

2.4 Topographic Position Index (TPI)

Generally, there exists very little variation in terrain on Victoria Island with the majority of the region being flat with rolling hills. However, similar to land cover, there appears to be a change in terrain type as you move north across the island. The south and central portions of the island are characterized by relatively flat terrain with occasional areas of higher elevation; while the north, has a distinct band of rough terrain and higher elevation that separates it from the rest of the island (Figure 17).

The TPI results highlight these trends by classifying terrain types into four general classes: ridges, slopes, valleys, and flat areas. Changing the scale of the TPI analysis did not change the spatial patterns present in the results, but did generalize terrain features as the spatial neighbourhood size increased (Figure 18). Across all analysis scales, large ridges and valleys were far more prevalent on the northern part of the island than in the central or southern areas; while the central and south were characterized by large flat areas interspersed with smaller ridge and valley features (**Error! Reference source not found.**).

The terrain for the individual strata is fairly consistent between survey areas with the flatland class being dominant across all three density designations (Figure 19 – Figure 21). The percentages for the four terrain classes were much more balanced for the areas of Victoria Island outside the survey strata, as these were generally located in the north where there exists much more natural terrain variation (Figure 22).

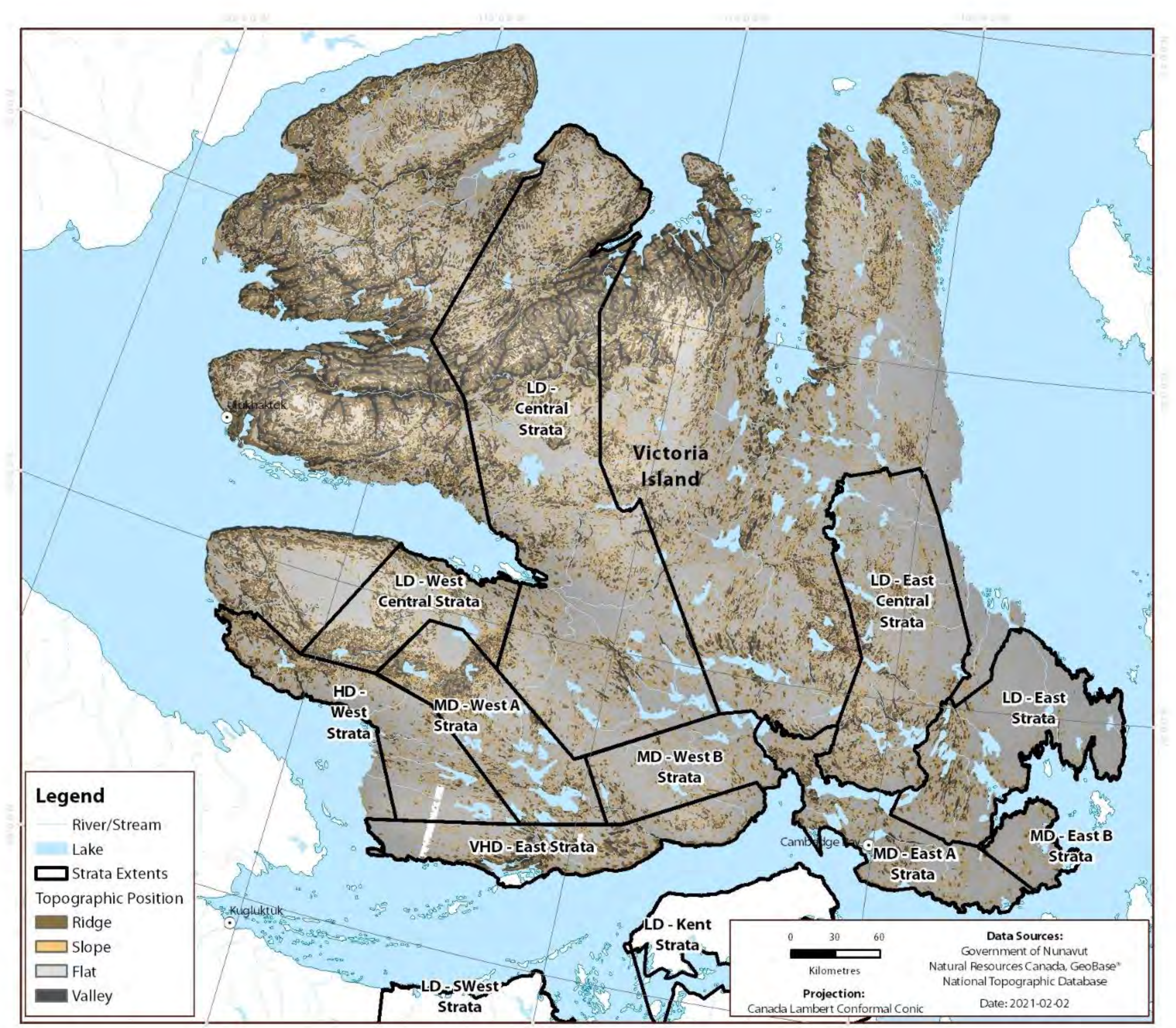

Figure 44. TPI for Victoria Island

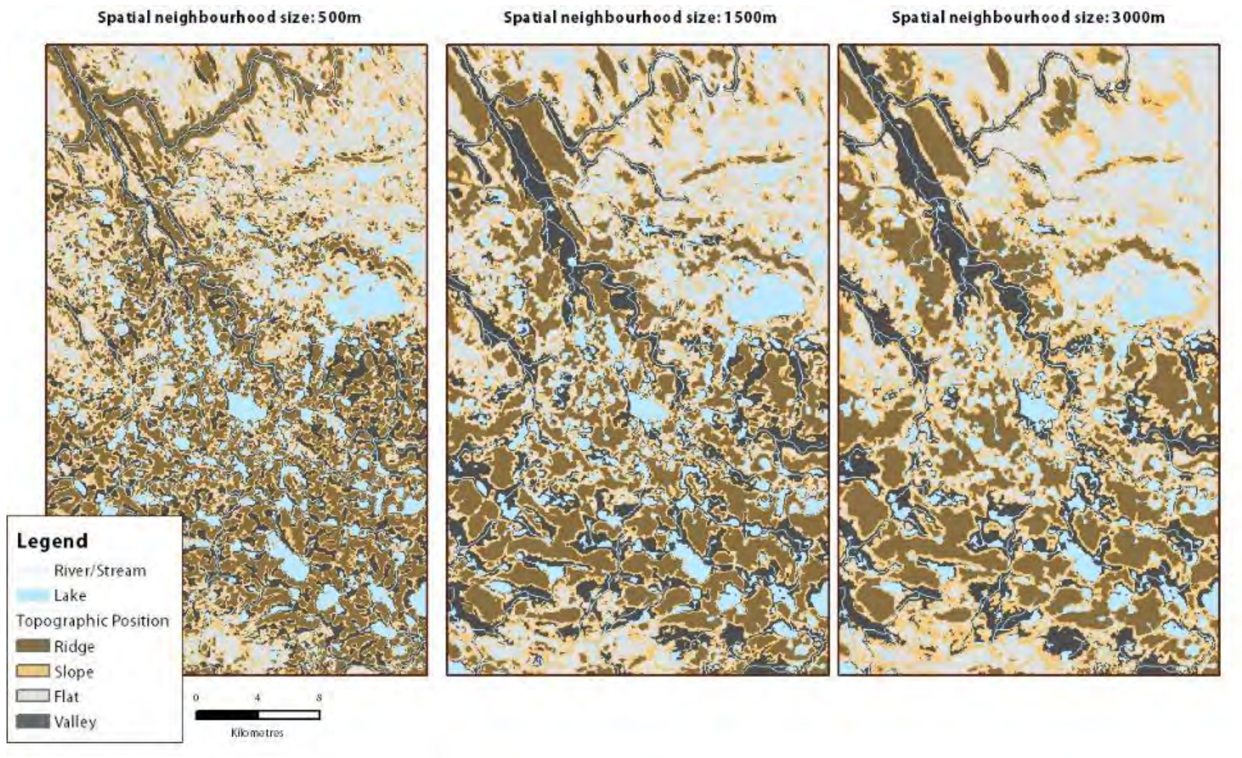

Figure 45. TPI results at the three analysis scales: 500m, 1500m and 3000m

Table 17. TPI summary for Victoria Island and survey strata

Strata Name	Flat	Ridge	Slope	Valley
Victoria Island - Outside Strata	43.3%	17.1%	23.5%	16.2%
VHD East	54.2%	12.0%	23.1%	10.7%
HD West	58.7%	8.5%	25.8%	7.0%
MD East A	67.4%	6.6%	21.9%	4.1%
MD East B	82.9%	2.2%	14.7%	0.2%
MD West A	50.4%	11.8%	27.4%	10.4%
MD West B	71.3%	3.8%	21.9%	3.0%
LD Central	47.7%	14.2%	24.2%	13.9%
LD East Central	67.1%	6.8%	21.7%	4.4%
LD East	79.6%	4.1%	13.8%	2.5%
LD West Central	41.4%	16.5%	27.5%	14.7%

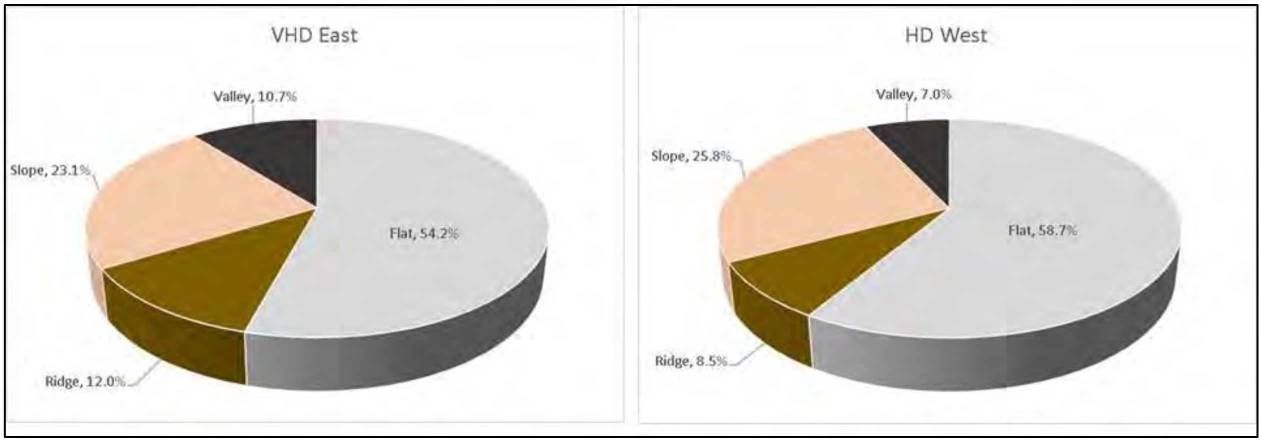

Figure 46. Terrain class percentages for the very high and high density strata

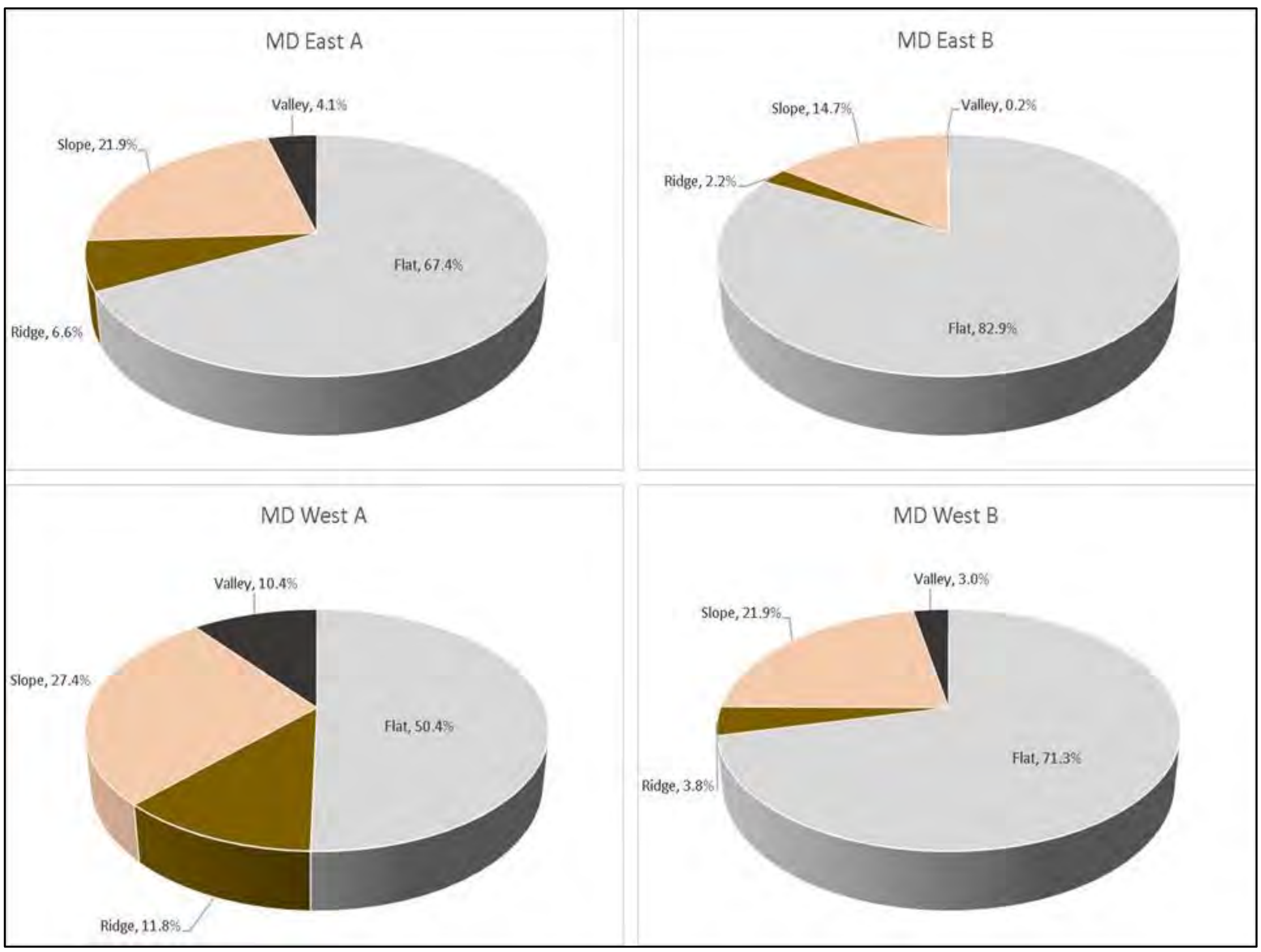

Figure 47. Terrain class percentages for the medium density strata

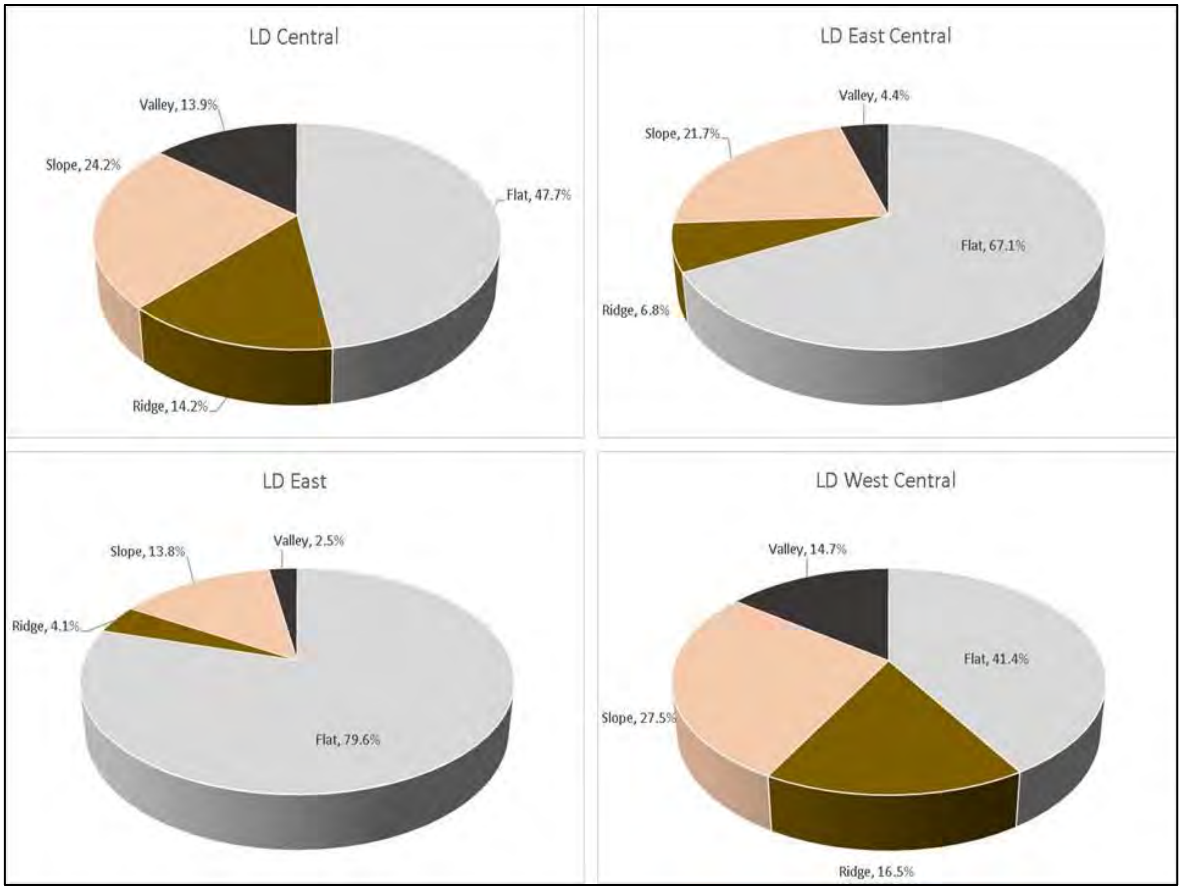

Figure 48. Terrain class percentages for the low density strata

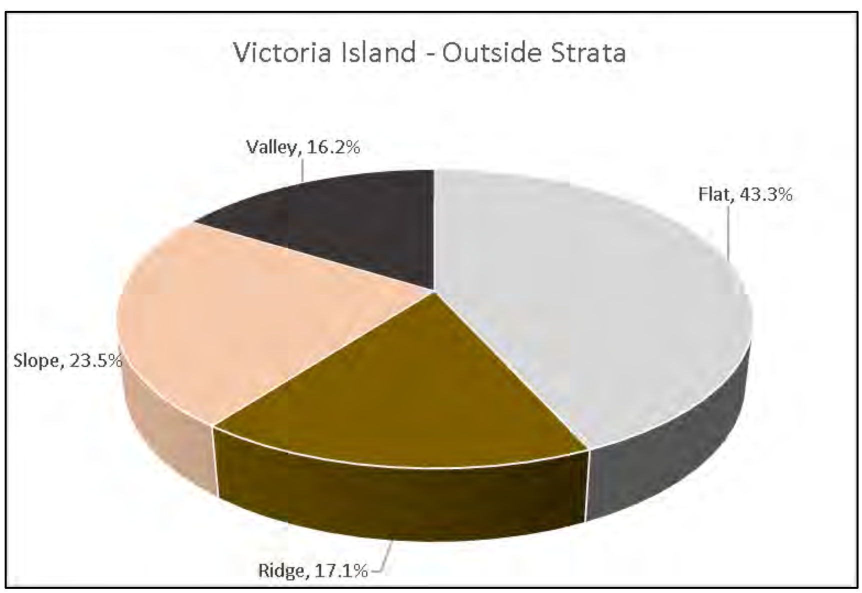

Figure 49. Terrain class percentages for areas of Victoria Island not covered by the strata

2.5 Land Cover Summaries for Telemetry Locations.

2.5.1 Vegetation

Intersecting the telemetry locations for Dolphin and Union caribou with the land cover classification revealed that the graminoid class appeared to be the preferred land cover class across all seasons, except for calving when the heath upland class was preferred (Figure 23). The heath tundra and heath upland were important classes during the spring and summer seasons (Figure 24); however, they became less important through the fall and winter (Figure 25). These results supported the density designations assigned to the breeding season survey strata as the high density areas were dominated by the preferred graminoid class; while low density areas were dominated by the less preferred heath tundra and upland classes.

The caribou observation data collected during the Fall 2020 survey were also intersected with the land cover classification to further validate the seasonal habitat preferences determined using the telemetry data. According to both data sources, the graminoid class was preferred during the breeding season while heath tundra and upland classes were less preferred (Figure 26). One notable difference is the apparent higher use of water indicated by the observation data. The increase in the water class could be due to a few factors: the resolution of the land cover classification versus the resolution of the GPS devices used to capture the field coordinates, or differences in lake ice conditions between the telemetry collection period (2015-2019) and the survey (2020).

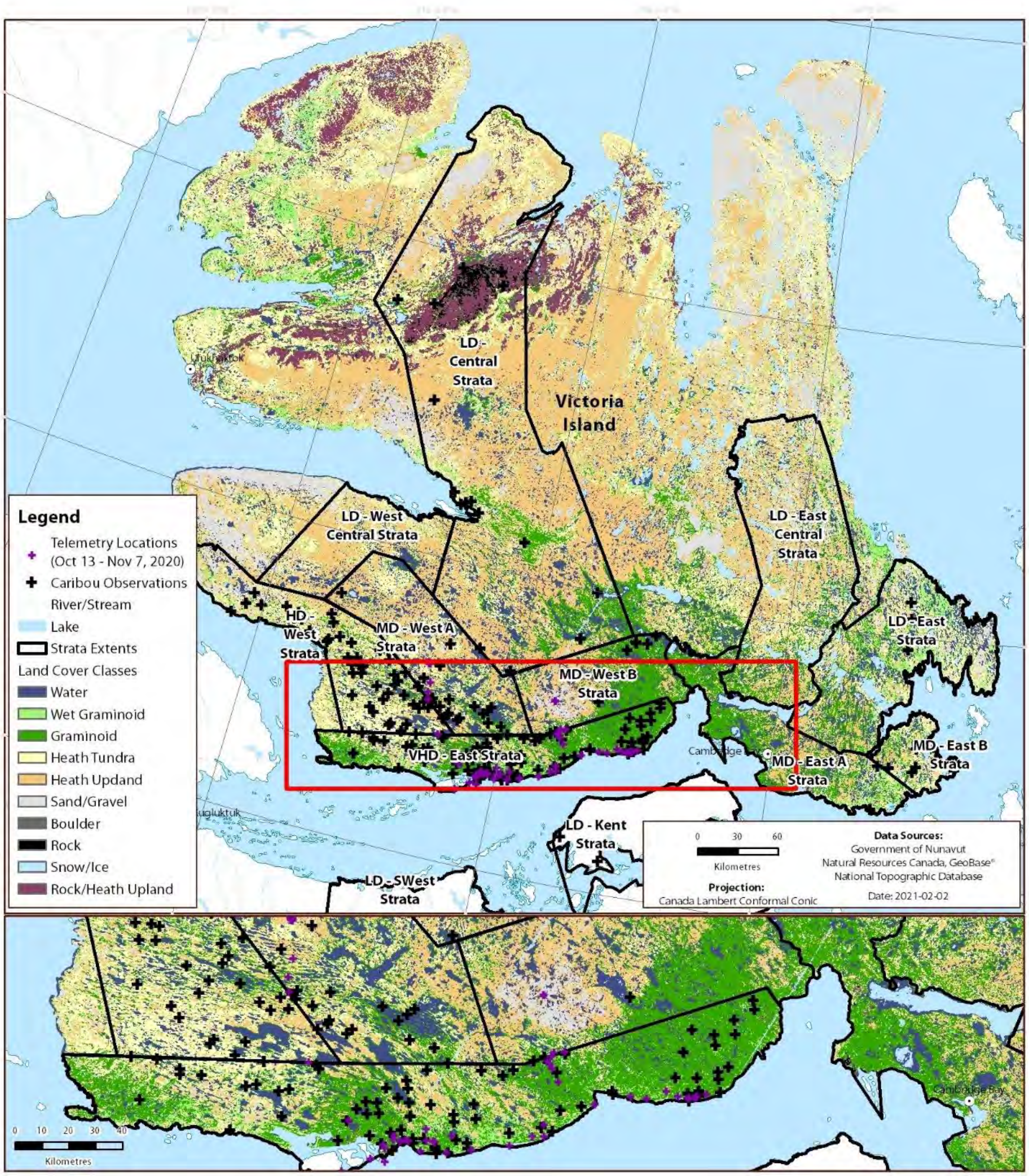

Figure 50. Landcover classification of the DU fall/rut range into 10 cover types. Telemetry data collected between 2015 and 2020 were used to assess habitat use. It is noteworthy that the survey extents cover much of the graminoid classification extent

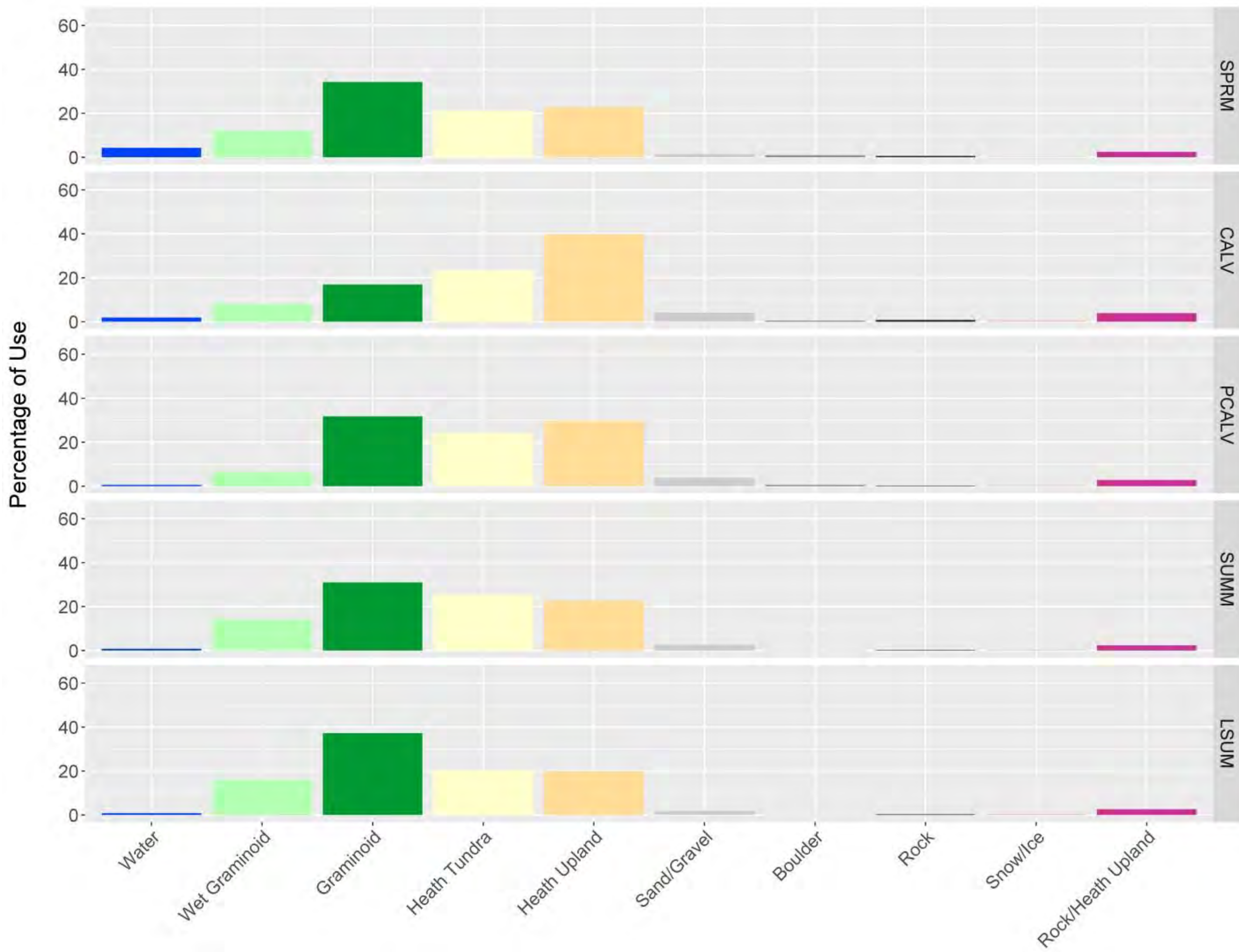

Figure 51. Land cover summaries by season for telemetry locations (Spring- Late Summer)

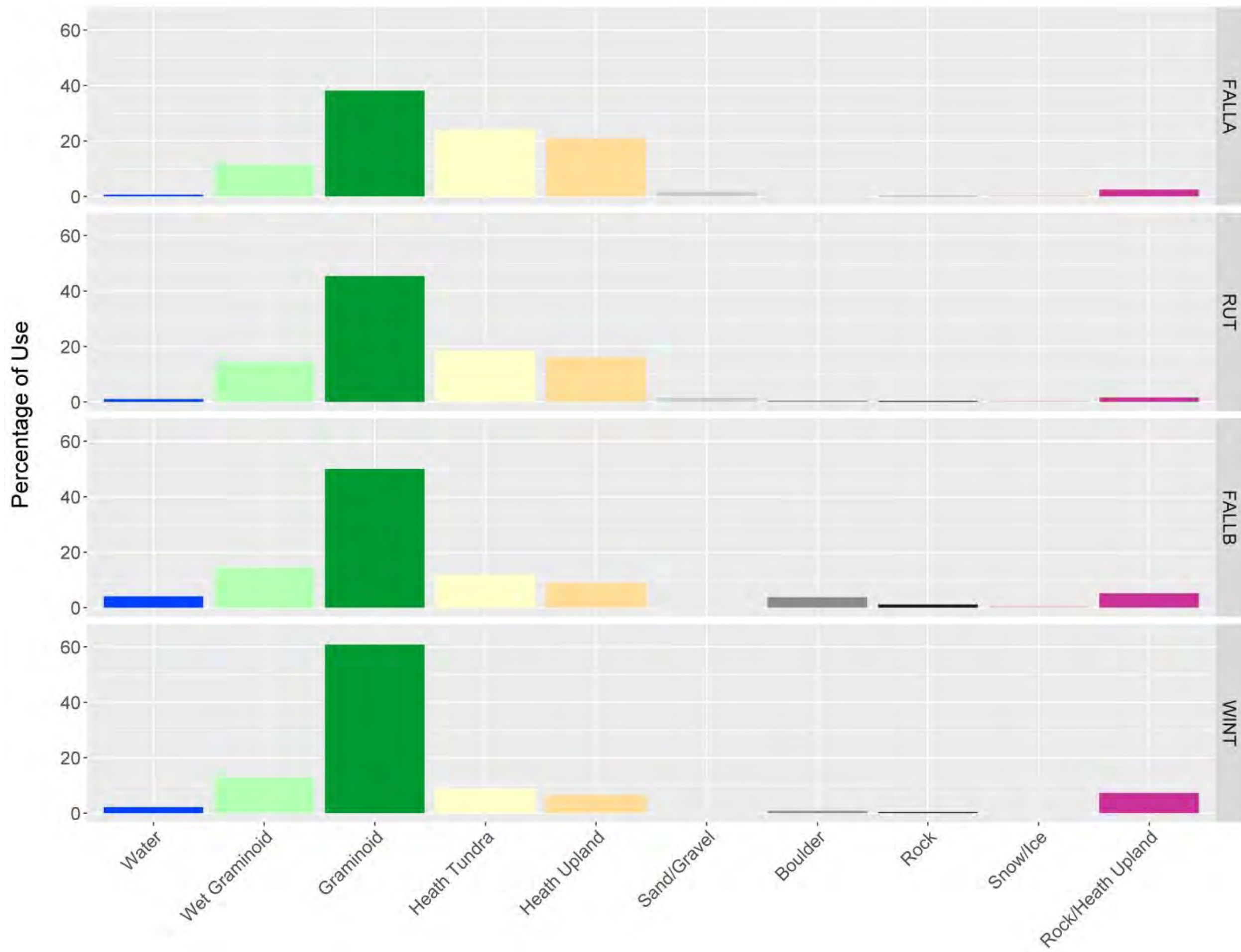

Figure 52. Land cover summaries by season for telemetry locations (FallA- Winter)

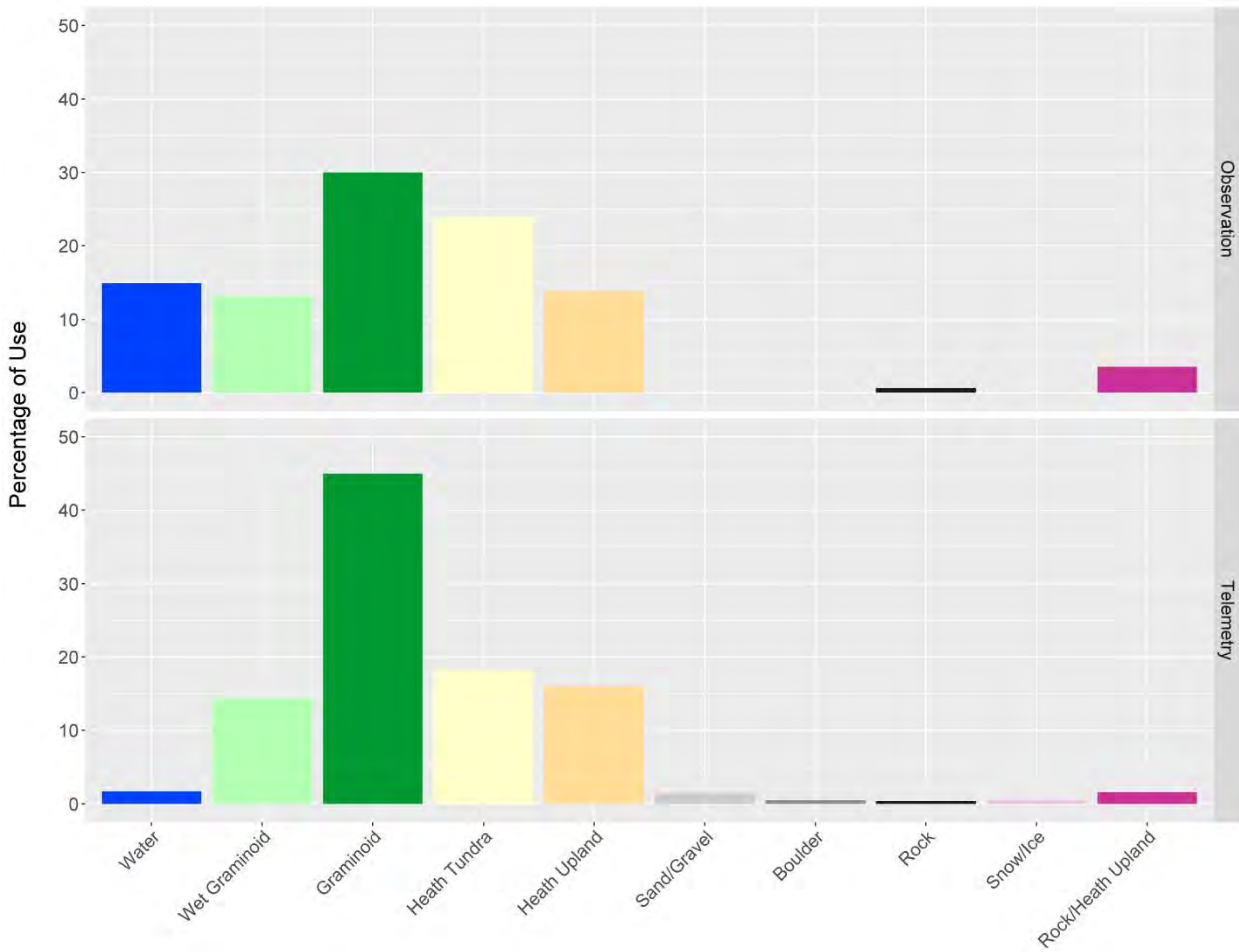

Figure 53. Comparison of land cover class use from telemetry and observation data.

2.5.2 Topography

Summarizing telemetry locations by TPI also revealed seasonal trends in terrain use with flatlands being preferred in all seasons (**Error! Reference source not found.**). During the post-breeding fall migration and winter seasons, flatlands appeared to be preferred, however, not as strongly as in the other seasons (Figure 28 – Figure 29). This decrease in use may be related to differences in terrain types on the mainland, as Dolphin and Union caribou have returned or are returning to their wintering range during these time periods. The observation data also showed similar trends in terrain use to the telemetry data during the rut (Figure 30). According to both data types, flatlands are preferred followed by slopes.

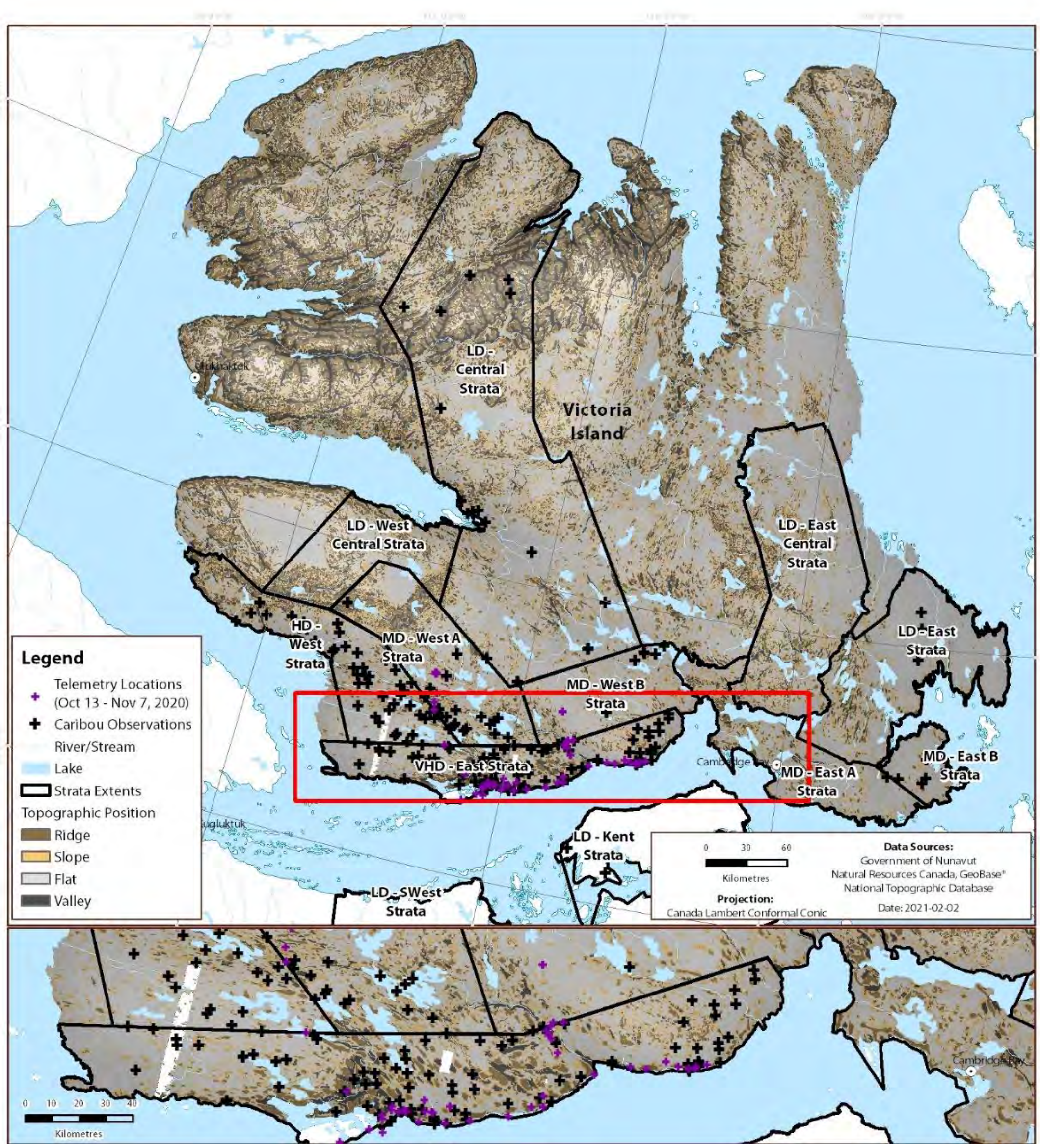

Figure 54. Topographic classification of the DU fall/rut range into 4 general topographic features characteristic of the range. Telemetry data collected between 2015 and 2020 were used to assess use of ridged, sloped, and flat topographic features as well as valleys.

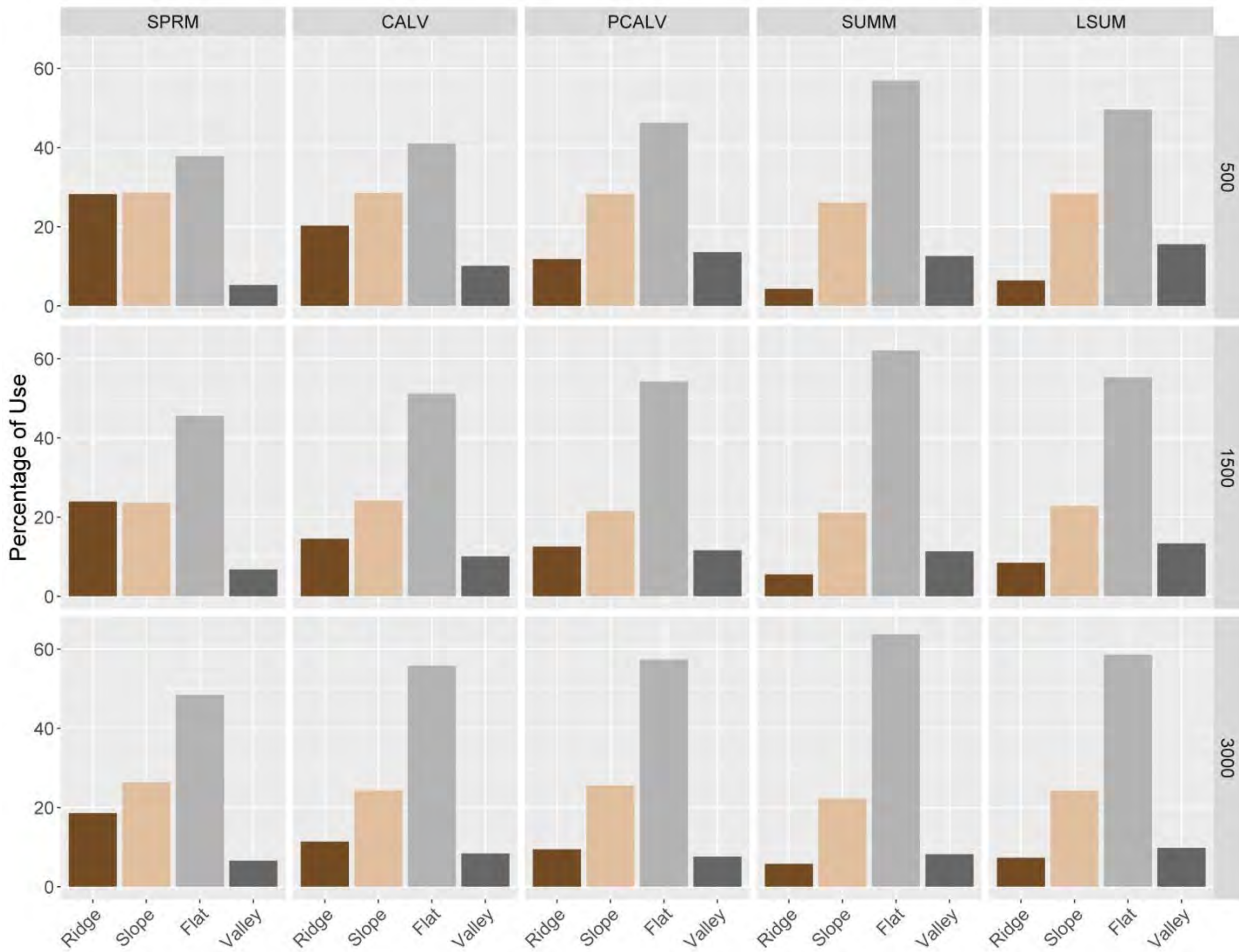

Figure 55. TPI summaries by season for telemetry locations (Spring- Late Summer)

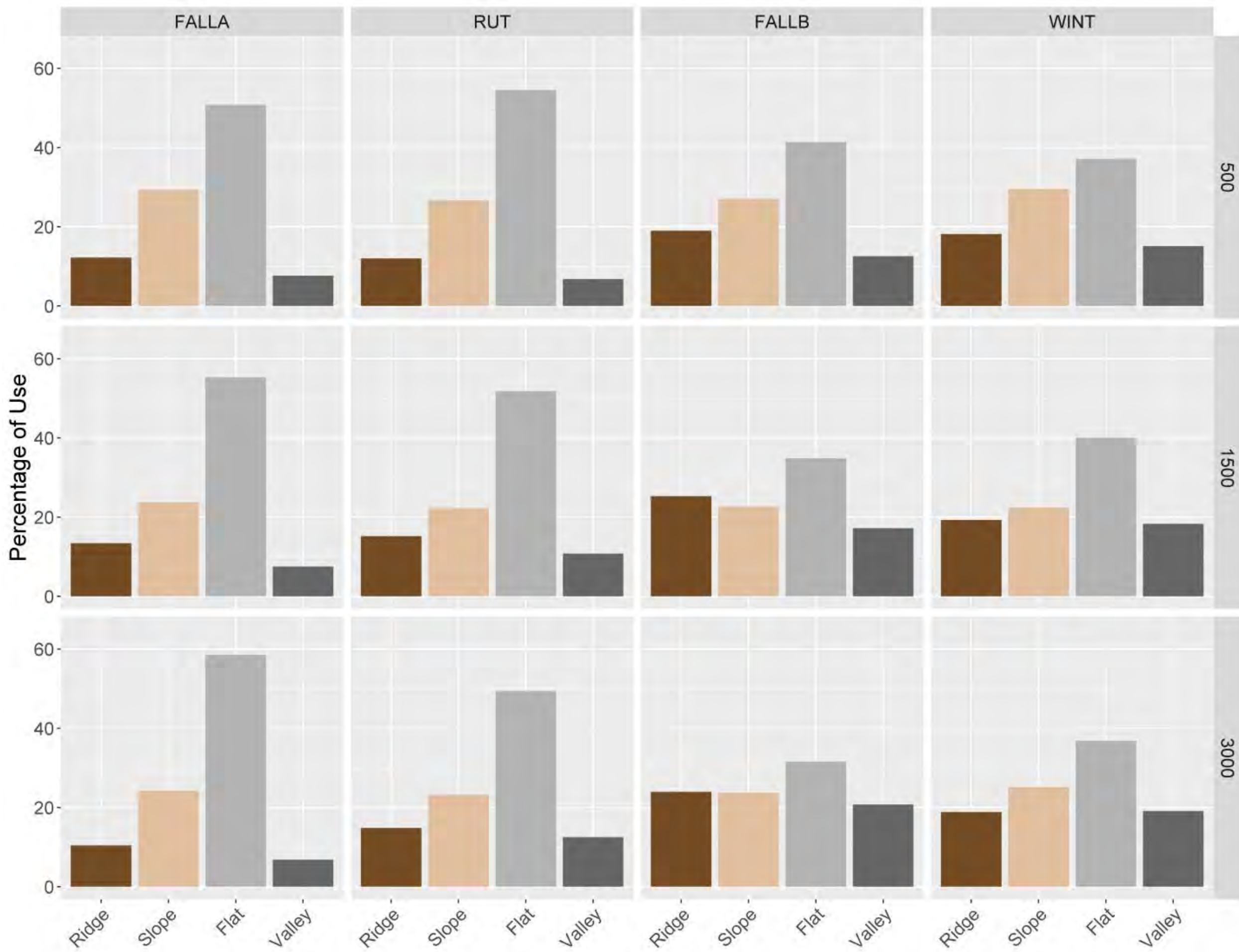

Figure 56. TPI summaries by season for telemetry locations (FallA- Winter)

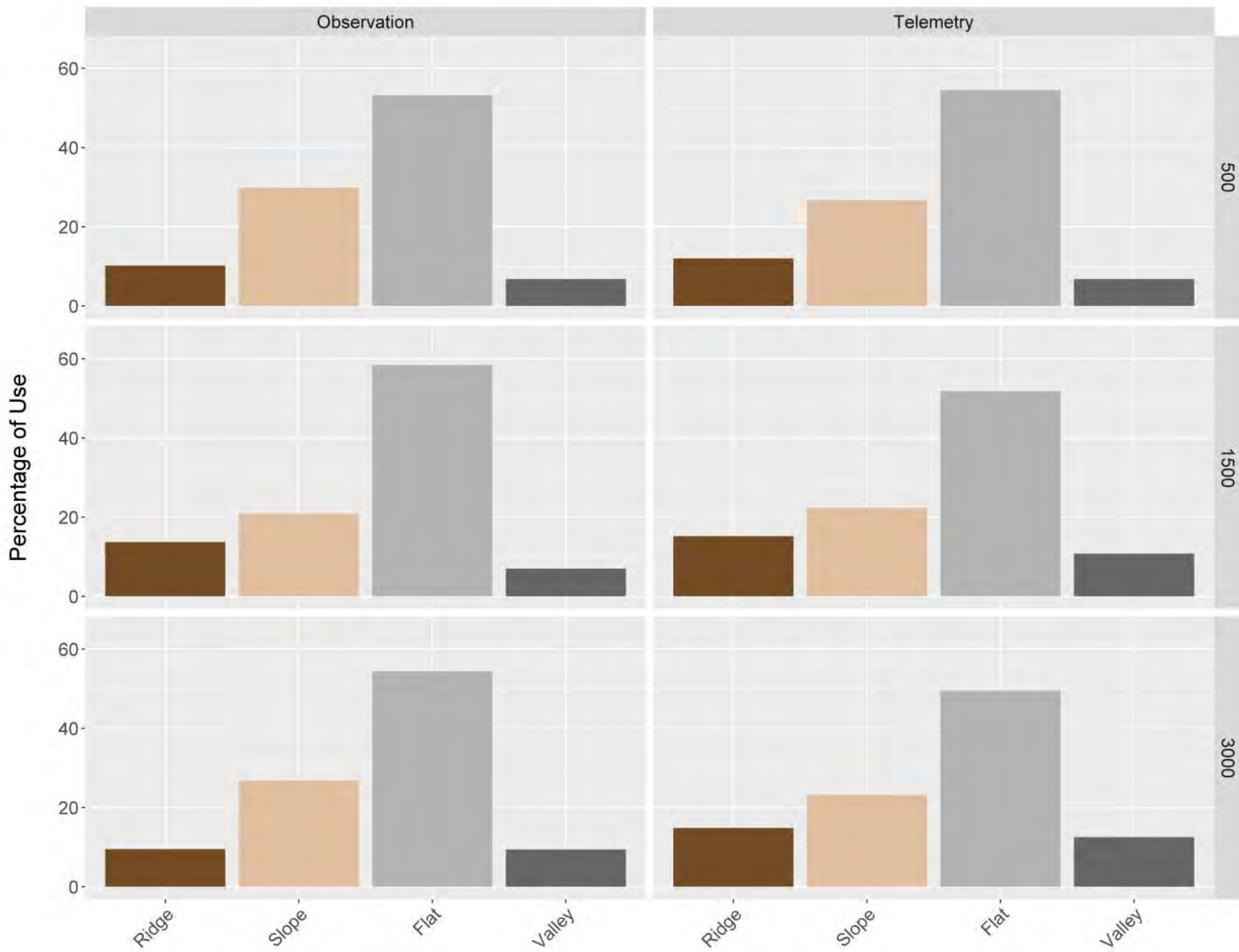

Figure 57. Comparison of terrain use from telemetry and observation data

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