	فړ⊳⊂	╘∩L'⊀⊂⋗ ኇ ℃ ⁻ :	Լ՝∧Ն՞	Ϸσ╘ჼϽჼჼ:	⊲qa⊳au4e _® Ċ
9:00-9:05 ▷·≟°d ^c	1	╘∩∟σ΅∧Ր⊲ჼ∩⊂⊳σ∿Ⴑ		୰୳⋖⊳⊂ኈ	5 Γσ ⁻ γ ⁻
9:05-9:10 ▷-ċd ^c	2	ᡆ᠋ᠴᡆ᠘ᡃ᠈᠘᠋᠋᠋ᡔ᠋᠋ᢐ᠘ᡰ᠘ᡔᡗ᠋ᢕ᠋ᢧ᠋ᡔ᠋᠘ᡄ᠋᠌᠌ᠵ᠋᠋ᢧ᠘᠋᠋᠆ᡔ᠋᠉		∆ీగ≪⊳⊂ి	5 Γσ ⁻ Υ ⁻
9:10-9:15 ▷-ċ.ºd ^c	3	ᡖ᠋᠒᠋᠋᠄ᢣ᠋᠋᠋᠕ᡩᢄ᠋ᢄ᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆	1	ୢ∆୳୶⊳⊂ୢୄ	ϬͺϹϭϲ
		۵۹۵۰ - ۲ <u>۲</u> ۲ ۲۹٬۹۵ مه. ۲ کار <i>۵</i> ۰۶٬۲۹٬۹۰ مه ۲ کار			
9:15-10:00 ▷-ċ_*dc		╘∩Lネ ^Ⴝ ᠄₽ℾჼʔ⊲ჼℱ Դ ^ჺ ഛ໑⋟ ^ҫ Ⴑ≪Lነժ ^ҫ Ճ୵ᡫ᠆ϷʔՈՐԵՃ·Ⴍ΅Ϲʹ [ൣ] Ր·ჾ ⊲Ͻჼነለስ ഛ໑୬ ^ֈ ୮ ഛ൨ĊʔႶჾ ^ֈ ଏጎየʔሰ ^ҫ Ճ୬୦՞ԴዮჾႦ 5.3.24 ⊲ʹݑϟ·Ⴍჼჾჼ⅃ჼ ႠLՃ֊ჾ ^ֈ ԵՈ·ͻՐ ^ϲ Ͻ·ϽϒϷʹልϷϟ·Ⴍჼჾʹϒ·ͼႦ 42-ჾ ϹϷ≪ ^Ϟ Ⴑ ^ҫ Ճ୬Ճー՞ℾ ^ϧ Բ·ϲϭʹℾ୬ ʹ₽ႶჼჼℾϷჾ ϽჼϽʹϒ·ჾ [Ճ៸ᡶ᠆ϷʔϹϷϭʹϞ]	2	ᢆᠵ᠘᠊ᡟᡄ᠋ᡅᢣ᠄ᢣᠯ᠋ᡐᡃᡆᢅ ᠘ᡃᢐᡄ᠘ᢣᡃᢛᠬ᠋᠅ᡣᡄ ᠴᡆᢁ᠂᠋ᠴ᠘᠆ᡧ᠘᠋᠋᠂᠋ᠬ᠊ ^ᡄ	45 Γσ ⁻ ר ^{יכ}
10:00-10:15 ▷-ċ.ºd<					15 Гס ^{-ניכ}
10:15 ▷-ﻧﺪ [،] ط ⁻ 12:00 ▷-גיל		ϧϞϟͼ;ͺϧͺϧͻϥϧͺϲͺϫͺϲͺϫ ͼϫϫͺ;ͺϧϧϧϲϧϧͺ ;ͼ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;	2	᠌᠌᠌᠌ᠵᡄ᠋ᡘ᠈ᡷᡟ᠍ᠫᡟᡃᡆᡃ ᠘ᡃ᠋ᢐᡄ᠘ᡃ᠉ᠬ᠋᠋᠈᠋ᡏᡄᠴᢌ᠋ ᡁ᠊ᢦ᠋᠘᠕᠆ᠬ	⊲⊂⊳୵ ^ቈ 1 ∆ьˤϚ⅌ & 45 ୮σ ^{ͺϲ} ϳϲ
12:00-1:30 ▷·ċ.ºd<		۲۲۵٬۵۴ د ۲			
		ຉ֎৯֊ Ր«୮,۹֊Ն֊ Չ֎ՍՀՄչ֎֊Ը, Չ«ՍՀՄչ۹֊			
1:30-2:15 ▷>d ^c	5	ᠳ᠋ᠴ᠘᠆᠋᠋ᡫᠣ᠋᠋ᡨᡗᡗ᠋᠋᠋ᠶ᠅ᡔᢂ᠋᠋᠋᠉ᡩᢄ᠋᠅᠘ᡄ᠂ᠴᢩ᠆ᢓ᠕᠅ᢕ᠋ᠫ᠋ᠶ᠘ ᠆᠋᠘᠆ᢤᠣᢞᡗ᠆ᠣ᠋᠋[ᠳᢂ᠈ᠺᡊᡗᡊᠯ᠋ᡗ᠋ᡬ᠋	3	ےمع⊂ ل≪ل∆ ^د	45 Γσ ^{-ς,ic}
2:15- 2:45 Þ°-∍d ^c	6	ዹዾϷϹʹ ^ቈ ϹϷσ ^ͺ ዮና ለርጜኇ፝ኆዮና ጜ፟፟፟፟፟፟፞፞ጜ፞፝፝፝፝ ር∆ነ፟፟፟፟፟፟፟፟፟፟ ረሷነትϷ፝፝፝፝፝፝፝፝፝፝፝፝ ኣቨርϷ៹Ϸ ^ቈ ረበነ ጜϷኦልϷለLσ ^ͺ ዮና በΓ⊲Jና/⊲Ϸ ኄJና/ຼມፙ፞፞፞፞፞ቝኄͿ_ຼ϶ኇ DNA-ďና, ዹ<፟ ^ዹ Ͻຼー [ൣ] Γ ርረናΓ, ዋበኈΓϷσ, 2018-2019 [ዄϷኦበናበՐ⊲₽ሰና]	4	ےمے¢دا≪ل∆⊂	30 Гσ ^{-с} і ^с

		۷۵،۹⊃۲۳۶،۲۹٫۹۰ ۲۵۵ ۲۵۵ ۲۵۵ ۲۵۵ ۲۵۵ ۲۵۹ ۲۵۹ ۲۵۹ ۲۵۹ ۲۵۹			
2:45-3:15 ▷>d ^c	7	⊴⊳∟ና∩ም∿Ր∗ም՝ ഛ⊂໋ም՝ ϽኣႱჼኣՃና [℆⊳ትՈናՈՐ⊲₽Ոና]	5	᠘ᡃᢐᠴᡄᡅᢣ᠄ᢣᡐᡃᡉ	30 Гσ ^{-c} ί ^c
3:15-3:45 ▷°→d°	8	Ϸ՚ኦ ^ኈ ጋናበ⊲ናኇናፑ ለϷ៸ጜናኇናፑ ጋኄႱልጜናኇ ዮኄታኇ⊲ናኇጏና ፞፞፞፞፞፝ ዮኄጛ፟፟፟<՟ኇዻናኇኄ፝፞፝፝ጏ ለኄ፟፟፝ኄ፟፟፝፝፝፝፝፝፝ጜ፟፟፝፝ ጜዾኦኣናልϷ፟፟፝፝፝፝፟፝፝፝ኇዀኇዀ፝፝፝፝፝፝፝፝፝፝፝፝፝፝፝፝፝፝፝፝፝፝፝፝፝	6	᠘᠊᠋ᡃᠣ᠋ᠴ᠆ᠬᢣ᠈ᡃᠡ᠌ᠫᡃ᠆	30 Гσ ⁻ ۲ ⁱ⁻
4:00-4:15 ▷d ^c		ഛഀځ∿له∆∘۹۰۵			15 Гσ ⁻ לי ^ב
4:15-4:45 ▷d ^c	9	᠘ᡃᢐ᠋ᠴᡃᠫ᠊ᡣᢦ᠋ᡝᠣ᠘ᡃᢐ᠋ᠴ᠈᠕᠆ᡅᠦ᠋ᠮᡃ᠋᠊᠋᠋᠋᠋ᠫᢣ᠋᠋᠋᠋᠋ᡰ᠅᠘ᡩ᠘᠋ᢩ᠖᠋᠋	7	᠘ᡃ᠋ᢐ᠋ᠴᡄᡅᢣ᠈᠊ᡟᢦ᠋ᡃᢦᡄ	30 Гס ⁻ ר ^{יכ}
4:45-5:15 ▷-→d ^c	10	₽≪·ϲ·ℾΔ⅌⅃Ի۸ϲ℩ℴ·ℾ՝ ϽኣႱኣՃ՟ ໑Ϲ՟ [⅌⊳ᲞՈናՈՐ⊲₽Ո՟]	8	᠘ᡃᢐ᠋ᠴᡄᡅᢣ᠄ᢣ᠋ᡃᡐᡃᡄ	30 Гס ⁻ רי ^ב
5:15-5:45 ▷°♪°d°	11	<i>᠌ᡔᠻᢣᠳ᠋ᡐ᠋ᠵᢗᠵᠦ᠋᠊᠋᠋᠋ᠴ᠆<᠋ᢩᡆᡄ᠋ᡣᡬ᠂᠘᠆ᢣᡐ᠋᠋᠋᠋᠘᠆ᡆᡅ᠊ᡆ᠋᠋ᢐ᠖᠋ᢞᠬ᠆᠋ᠴᡄ᠘ᢞᠺ᠋᠍᠍ᢧ ᠋ᡃᢣᢄᡃᠶᢂ᠂ᡕᡤ᠂ᠳ᠕ᢣ᠋᠋᠋ᡒ᠋᠋᠂᠘umpfish [᠋ᠲ᠋᠌᠌᠌ᢂ᠋ᢄᡣᡗ᠋᠋ᠬ᠋᠋᠋ᠺ᠋</i>	9	᠘ᡃᢐᠴᡄᡅᢣ᠈ᡃᡕᢦᡃᡆᡃ	30 Гσ ⁻ ۲ ^{ic}
		ସ≪∩൳൩扵ՙଽ୵୶,ଵୢୄ ୵୵୶୰୷ୢ୵୵୷୶ଽ ୵୵୵୵୷୷୷୵୷୷୵୷୷୵୷୷୷୷୷୷୷୷୷୷୷୷୷୷୷୷୷୷୷୷			
5:45 ▷ئەط 5:15 كەنى ^م ە	12	᠋᠋᠋᠋᠋ᡔ᠋᠋᠋ᡨ᠋ᢄ᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆	10	ᠳᡒᢕᡄᡅᢣ᠈ᢩᢣᠿᢩ᠈ᡆ _ᠸ	30 Гσ ^{-c} י ^c
6:15: ▷°م°	13	ᲮᲘLԺ ^Ⴊ ՃᲫᲚ℠Ծ ^Ⴊ ᲮᲘLԺሲ℠ ℄ ^Ⴊ <ჼႠ [๛] ႱԺჼ ᲮᲘLԺోԻ RM004-2020-ℾჼ		୵୳୶⊳⊂ୢୄ	5 Гσ ⁻ ۲ ^{іс}

 \circ $PA^{\circ}i_{P}d^{\circ}$ is a $A^{\circ}c^{-}d_{J}$ in $A^{\circ}c^{\circ}$ is $PA^{\circ}d^{\circ}d^{\circ}$ in $A^{\circ}c^{-}d_{J}$

つうろく くらしょうかく しょうやく いっしょうやく 84%-シレントン 2015-Fr マート 88% 2016-Fr.

ጋናძናኈጋልσ⊳σኈՐ°σϧ, ⊳ഛኈՐ°σኁኣና ፈንᢣን;∩▷ ΔL°ฉ 11 ഛናհՃና 100-ഛና ⊲ና໑ና౨∿ഛና (0.11).

 $P^{T} = P^{T} + P^{$

- ൧ഄ൨൴൙൛൙ഄഀഀഺ൜ഺഀൎ൙ഺ

- 2015/2017-Γ ℅Ϸݤᢣᡪᠣᠵᡧ ᡣᠣ᠘ᡃᡗᠣ᠋᠋᠈ᢕ᠘᠖ᢣ᠋ᢁᢟᠳᡧ᠆ᡗᡆᡐᡥᠴᢈ᠂᠉ᠫ᠘ᡬ:

- 2016 ▷Ρ⊲ʰɨኣʰd< šʰъΔ<<<⊂⊲J∩^{*}Γ[®]σ[™] šʰ▷λኣ∠▷šィ∠ἰ≺
 2017-Γ ▷Λ^s^{*}ἰνd

۹٬۲۷۵٬۲۲۱ م، ۲۲۵۵٬۲۵ ۹٬۶۲۷ ۹٬۹۵۲ ۹٬۹۵۲ ۹٬۹۵۲ ۹٬۹۵۲ ۹٬۹۵۲ ۹٬۹۵۲ ۹٬۹۵۲ ۹٬۹۵۲ ۹٬۹۵۲ ۹٬۹۵۲ ۹٬۹۵۲ ۹٬۹۵۲ ۹٬۹۵۲ ۹٬۹۵۲

▷ናቴትርናቴስናቴትር ርጉና ጋበቱ 2015-Γ ናቴኦትትንበልσናም, ወሷዎΓና ሀዊደቂና ସዊበሮኪትምቦና (DOE)

27,787 ± 7,537 (20,250-35,324, 95% Cl) DDD Dda Dda CC 2015 bh. Dr Dainrade Diode $\Delta L^{\circ} = P \mathcal{C}^{\circ} U^{\circ}$ 18,413 ± 6,795 (11,664-25,182, 95% CI) $D^{\circ} \Delta L^{\circ} = \Delta^{\circ} d \cap 1$.

 $(\Delta L^{\circ} \Box P^{\circ} J)^{\circ} = 4.2\%$ $\forall i \in JCL^{\circ}$, $P d a^{\circ} U^{\circ} = 2007 \cdot \Gamma$ $P \Delta i \sigma^{\circ} \Gamma^{\circ} \sigma^{\circ} = \Delta i L \Gamma P D \sigma d \sigma^{\circ}$

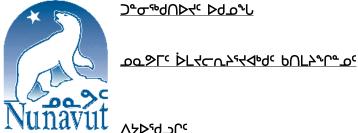
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 $\Delta C^{C} = (U^{C} - U^{C})$

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DVDL4UPVC

ΔረΓ⊂⊳5υ. X



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 $5^{6}PO(OJOPCP)$

- 2018-Γ^c ▷dϤ ^cd^b ͻ^bϽ^cΓ Ϥ^L Δ^cb ͻ^bϽ^cΠ⊲σ Ϥ^bu ζ^bΛ^c Λ^bd^c (HTO) Δb^c^bϽΔζL C^bϽ^c 50-σ C^c δ^e Ϥ^L ^cd^c (DU) Ͻ^bϽσ ^cd^bUζ²δζL(Γ^c Δ^c) 47-σ Ϥ^c Δ^c Δ^c 4^L 3 Ϥ^bUζ⁻Δ^c ^cd^bUζ²b^cΔ^cΠ⊲²^bα C^bζL^c Δ^c>²F 15-Γ^c 24-J^c, 2018.

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- $dP \subseteq CP \land L^{n} \cap D^{n} d^{1} \sqcup \land G^{n} \cup C^{n} \sqcup C^{n} \cup C^{n} \cup$
- \dot{L}° c Pape one construction of the terms of terms of the terms of te

- $\dot{d}\sigma$ 2020-F^c, $d \ll \Pi_c h^{b} d^{b} \mu^{c}$ For C $\Pi \cap G = P^{c} h^{c} h^{c$
- $4 \leq 2020$ - Γ' , $\Delta q \gg \Gamma'$ $\flat L < h < + 4 < b < L < h < + 4 < b < + h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < h < -$
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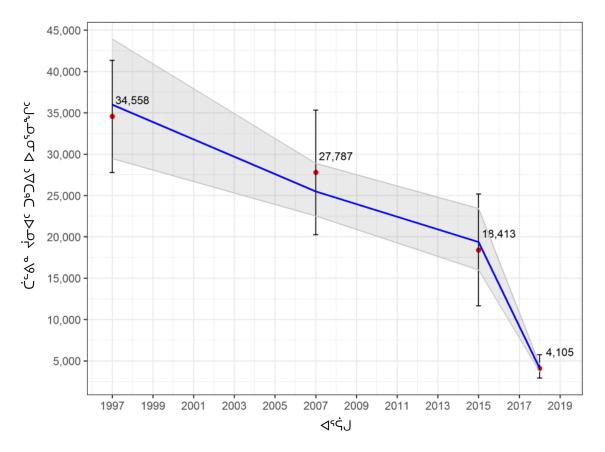
⊲∧⁵∕⁵ċ⁻:

- $P^{0}b \rightarrow P^{0}b' = P^$
- $P_{P_{2}}^{P_{2}}$ $P_{P_{2}}^{P_{2}}$ P_{P

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CLbd4 2020-J' \triangleright D'orthe D' all all the description of the descripti

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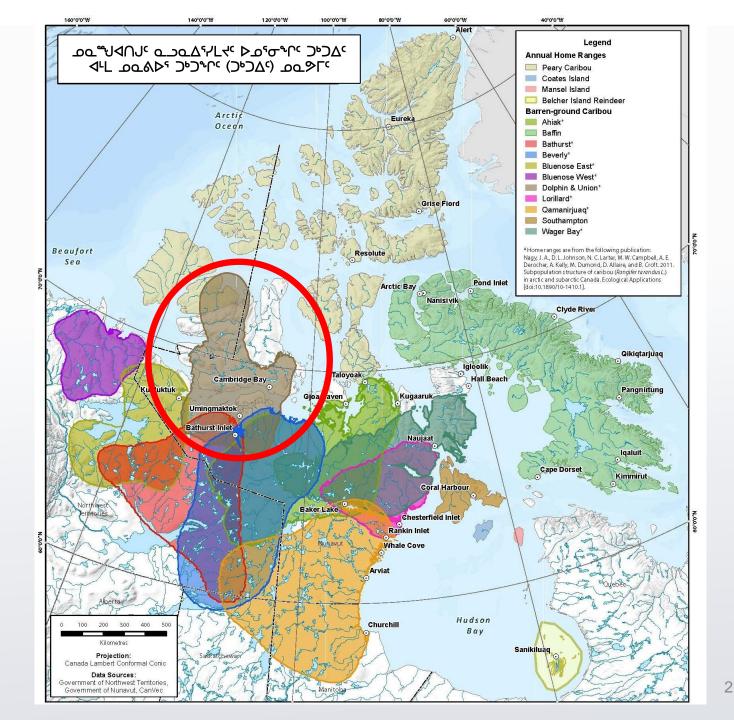
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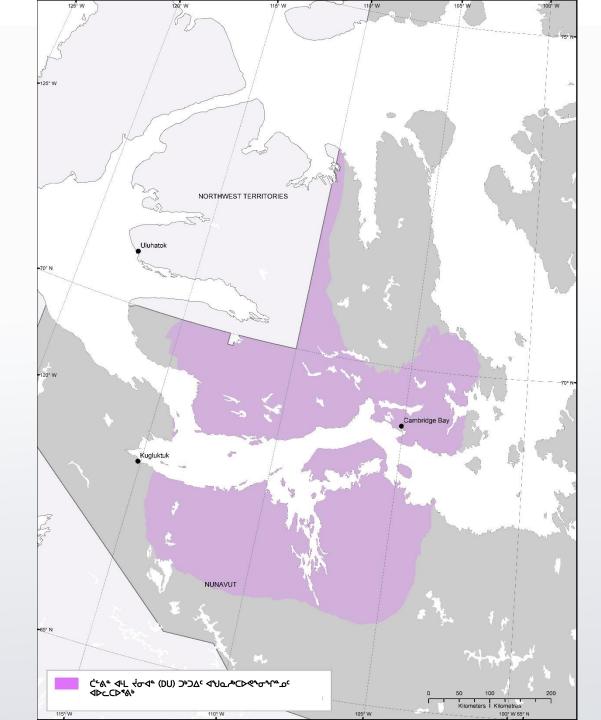
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Nunavut







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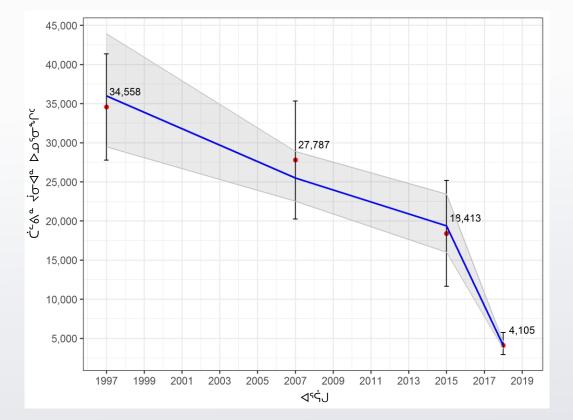
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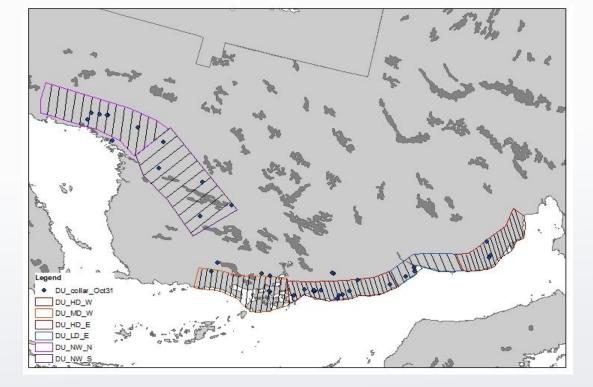
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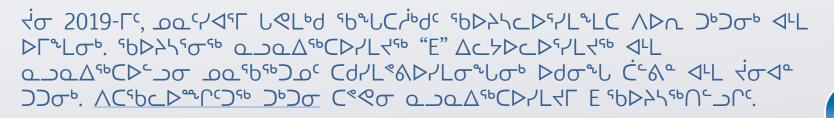


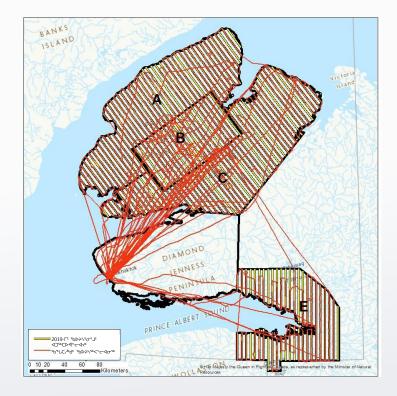


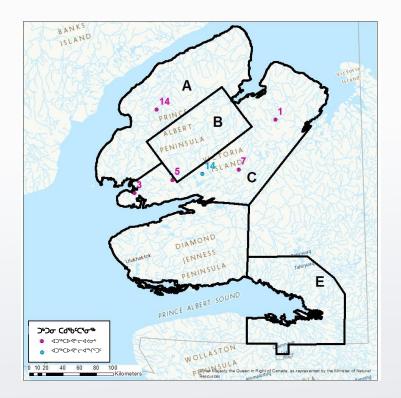
















- CLbdd 'dbd7bCDdt' ליםים Δ ' שיאל' 'd' לים'ם ליחרים (94%), שםיסיריחט ליחיסיג שבאיז' אדשסלסי ליםים יסי (69%).
- $4^{+}_{-}\Delta^{c} < 4^{-}_{-}\Delta^{c} < 2^{+}_{-}\Delta^{c} < 2^$
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- 2019 הרילייכדעל יפריזעיכדע יהשאליסעישרי

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⊳₽⊲ыׂג∿טס 2019	>کف ^ن ۵٬۰ ۹۰L ۹٬۵۵۲ ۵٬۵۵۲٬۵۰٬۵۰۵ ۵۰٬۵۰ ۵۰ ۵۰٫۵۲ ۵۰٫۵۰ ۵۰۲ ۲۰۵۰ ۵۰۲ ۲۰۵۰ ۵۰۲ ۵۰۲ ۵۰۲ ۵۰۲ ۵۰۲			
_∧െ 2019	᠋᠄ᡃ᠋᠋ᡋᡪ᠋ᢣ᠋᠌ᢄᢣ᠅᠘ᠺᢄᡩ᠅ᢕᢄᠴ᠋᠃᠆᠂ᡔᠳᡠᡄ᠋ᢙ᠋ᡃ᠙ᡩᡄ᠋᠋᠊᠋ᡧ᠋ᠺ᠂᠋᠘᠄᠋ᡃ᠋᠖ᡪ᠋᠋ᢣᢄᢣᡃᡆ᠋ ᠋᠋᠋᠋ᠺ᠋᠋᠋᠋᠋᠋᠋᠋ᢄ᠆ᠴᢕ			
በረለሲ 2019	᠌ᠴᡆ᠋᠀ᡏ᠋᠄᠌᠌᠌᠌᠔᠘ᡃᠧᡊ᠋ᢣᡝᡧ᠋᠋ᢀᡃᡆ᠋ᡝ᠖᠋᠘᠋᠋ᡅᢪ᠆ᠴ᠋᠄᠘᠋᠉ᡃ᠋ᠥ᠘ᢣ᠋᠉᠋ᢕ᠋᠋᠉᠋᠖᠘᠅᠘᠃᠋᠉ ᢄᠴ᠋᠋᠋᠊᠋᠋ᠴ᠋᠋᠋᠊᠆᠆᠘᠆᠋᠘			
∧Ր⊲Ⴀ๎๎๛ๅ๛ๅ 2020	ϳϿϤϔϿͻͽϥͺͶͿ;ϷϲͺϫϲϲϿϞͳϟ;ͺϷͶͼϧϤϹϷϟ;			
באל 2020	᠋ᡃ᠋ᡖ᠘ᡄ᠌᠌ᢂ᠋ᠽ᠋ᠫᡃᢑ᠋ᢨᠾᢪ᠋ᠳ᠋᠉᠕ᢉ᠊᠋ᡏ᠉ᢗ᠌᠌᠌ᡔ᠋ᢣ᠉᠕᠈ᡃᡕ᠋ᡣ᠋ᢉ᠆᠋᠋ᠴ᠕᠋ᠴ᠙ᡃᡕᠯᡐᡝ᠋ᡅ᠉᠆᠋᠋᠋ ᡩ᠋ᠳ᠕ᡃᡕᠯ᠋ᡗ᠋᠋ᠴᢁ			
LA 2020	ᠻᡃ᠋᠊᠋ᡃ᠆ᠭᢛᡬ᠂᠌ᡔᠦᡃᢂᢣ᠘ᠴᡆ᠋᠆ᢞᠴ᠂᠋᠕ᢂᡄ᠋᠋ᢉ᠋᠋᠋᠋ᠵ᠋᠕ᡔᡅ᠋᠋᠖ᢕᢣᠴ			
<i>≺ਂ</i> σ 18, 2020	ᢂ᠋᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆			
रंक २२, २०२०	ᡏᠦᡃᢗ᠊ᡣ᠋ᡣᡪᡃᢛᠫᢛ ᠴᡆᢩᢀᡏ᠋᠄ ᠌᠌ᢆᢣ᠘ᢣᡄᡅ᠋ᢣᡝᢣᢦᡃ᠋ᢦᡃ ᠋᠋ᡋ᠋᠘ᡶ᠉ᡥᠴ᠋ᢩᠥ᠂ᠺᢣ᠋᠋᠘᠆ᠴᠥ᠆ᡏᠦᡃᢗᡃᡆ ᡏ᠋ᢁᡄ᠋ᠺ᠋᠋᠋ᡊ᠋᠋᠋ᠴ᠋᠘ᡄ᠋ᢂ᠆ᡁ			
לב∆ 28, 2020	ᠴᡆ᠋᠀ᡏ᠋᠄ ᠌᠌᠌ᢆᢣ᠘ᢣᡄᡅᢣᡝᡧᢦᡰ᠋ᢦᡰ ᠋᠋᠋ᡋ᠘ᡶ᠋᠈ᢉ᠙᠋᠌᠌᠌ᢄ᠂᠋ᢄ᠂᠘᠘᠆᠘᠂ᠺ᠋ ᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆			





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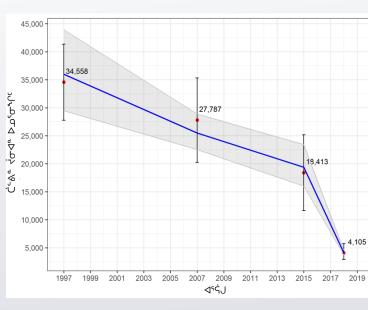




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^ទժ֊ԳԸ՝ՐԵ THANK YOU QUANAQUTIN MERCI

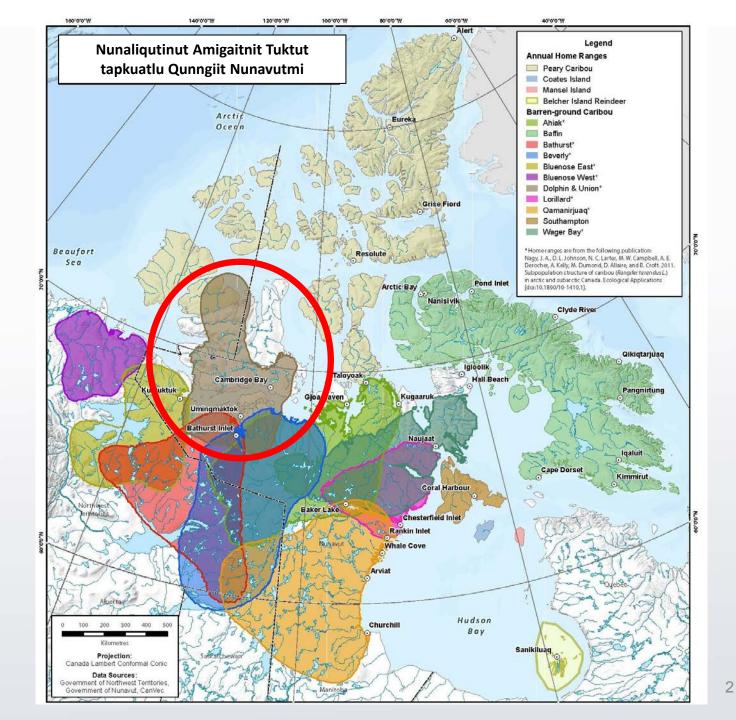




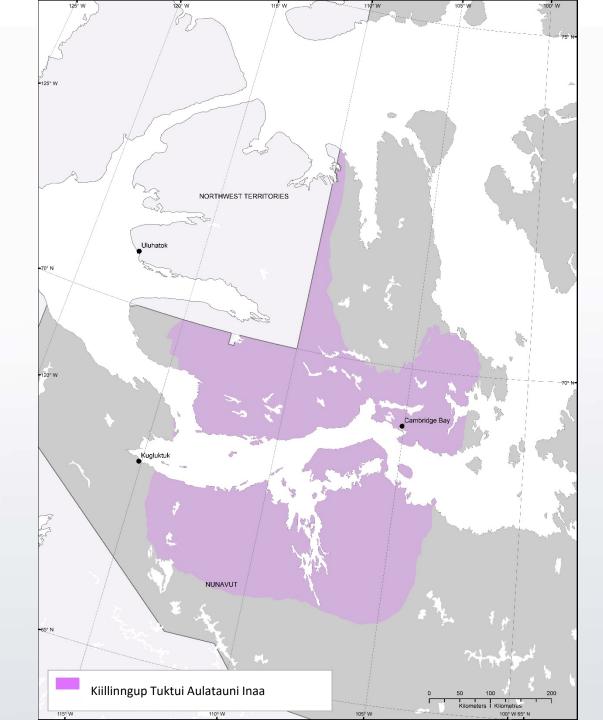
 $b \supset A \supset J_{a} > A \supset A \supset C > C$ Building Nunavut Together Nunavuliuqatigiingniq Bâtir le Nunavut ensemble

KIILLINNGUP TUKTUI NAUNAIYAQNI AULATAUNILU





Nunavut







Kiillinngup Tuktui Aulatauni: Atuqatigiktut Havariyat

- Amihut ilagit atuqatigiktut havariyainik aulaninut tapkuat Kiillinngup Tuktui
 - Nunavut Kavamanga
 - Nunatsiap Kavamanga
 - Inuit tapkuatlu Inuvialuit timingit aulattiqatigitlu katutyiqatigit
 - Kaanatap Kavamanga
- Tamna aulaninut pilaqtitiyit tiliuqtauyut tapkunanga Nunavut Angirutit tapkuatlu Inuvialuit Kingulliqpamik Angirutit
- Tapkuat amihuaqyuit havariyai Kavamatuqatkut tapkuatlu Kavamatkut Nunatsiaq uumayut hivuragiyauyunut piquyat





Qauyihaqninut Atuqhimani

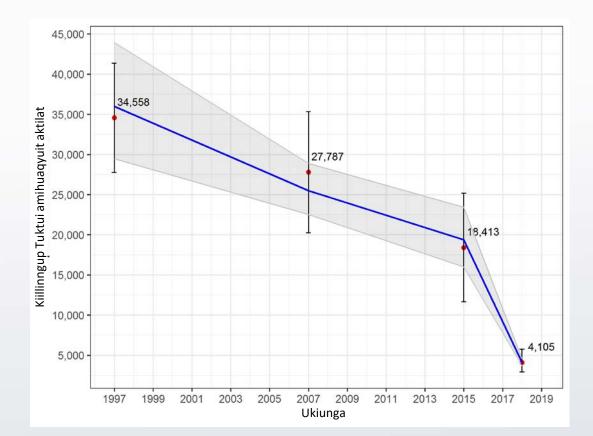
- Tamna naunaiyaqnia pingangnaa Kiilliniq Qikirtaq atuqtauyuq talvani Juni 1994 tamna havagutauyuq mikhautninut <u>14,539</u> tuktut
 - Tamna naunaiyaut naunaiqhimaitmagit tapkuat nuriuqvit hiamaumani tapkununga amihuaqyuit
 - Aturahuaquyauyut tingmitikkut naunaiyainiq hinaagut hivuani aulaqnit iluilikmun
- Hivulliq amigaitpiaqni naunaiyainiq atuqhugu hinaagut pityuhiq atuqtauyuq talvani 1997 qanuritnialu mikhautni tapkuat <u>34,558</u> tuktut
- 2007 amigaitpiaqni naunaiyainiq qanuritnialu mikhautni 27,787 tuktut
- 2015 amigaitpiaqni naunaiyainiq qanuritnialu mikhautni **18,413** tuktut
- 2018 amigaitpiaqni naunaiyainiq qanuritnialu mikhautni <u>4,105</u> tuktut





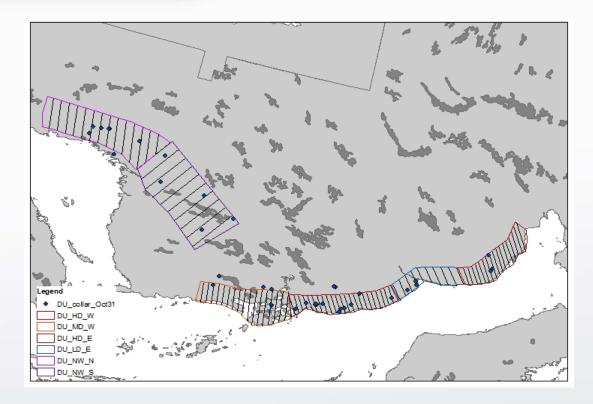
Tamna 2018 naunaiyainiq, tapkuat maliktat ayyikkuta pityuhiq hivuani pingahut naunaiyainit, qanuritnialu mikhautni tapkuat **<u>4,105</u>** tuktut

Piniarahugini Akunngani (2,931-5,750)





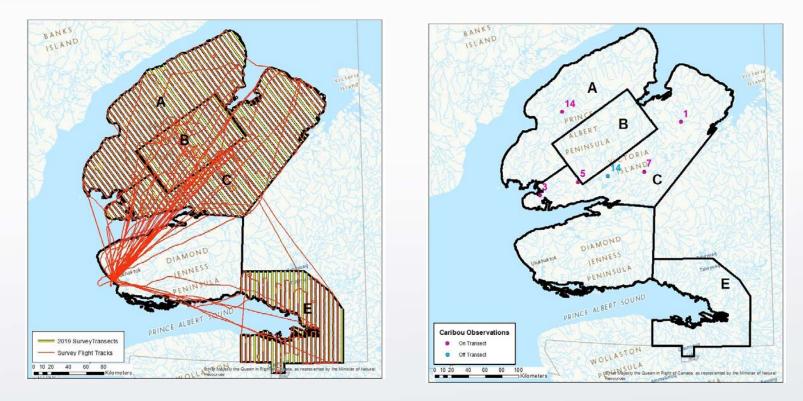




Tanma kingulliqpamik uuktut naunaiyainiq atuqtakhat taphumunga 2018 amigaitpiaqni mikhautni naunaiyainiq







Talvani Juni 2019, Kavamatkut Nunatsiaq (GNWT) atuqtat tingmitikkut naunaiyainiq tapkuninga Kingailaup tuktut tapkuatlu Umingmait. Tamna naunaiyaut atauttimun taiyauyuq "E" ilaliutiyauyuq naunaiqtauplunilu inaanut tapkuat nunalikni tautuktit taiyat nayuqpaktat tapkuat Kiillinngup Tuktui. <u>Piittuq tuktut</u> takuyauni tahamani inigiyani E atuqtitlugu tamna naunaiyaut.





Amigaitniriyai naunaipkutat

- Ikittut kulavait annaumani (62% tapkuat qunguhiaqtauhiqhimayut kulavait annaumayut talvani 2018)
- Pititlugu hingaiyut aktilat puqtuyut qunguhiaqtauhiqhimayuni kulavait (94%), tapkuat aktilat pukkitqiyauqpiaqtut angutayuni kulavait (69%).
- Pukkittut pangniit:kulavait avikhimani tapkununga 15 pangniit/100 kulavait Ukiakhani 2016 kititnit
- Pukkittut nurait:kulavait avikhimani tapkununga 11 nurait/100 kulavait tingmiyauyumi Upinngani 2017 kititnit







Hivuranaqnit

Amigaitni allanguqnit atuqpakhimayut pityutainut ilitquhiit utiqtakpaknit. Pityutit akhuqtilaqtat ikikligiaqni tamnalu/uvaluniit pittailini utiqtitni ilaliutyalat pityutit (katiqhuqni aktuanit) tapkuatlu ilaqalat:

- <u>Hilaup aadlangurninnga</u>
 - Pivigiya tariup-hikunia qiqinia hikuplu hunilaiqnia/nakuunia
 - Pityutaulaq ilagiaqni uvaluniit akulaiqpalliqni qayauyut qanurilitnit
 - Allanguqni uumatyutit (niriniagat nakuuni pilaqnilu)
- <u>Aaniarut, Kumaaqyuit, tapkuatlu Inungnit Huliniit</u>
 - Aaniarut tahapkuatut Qakuqtuliqtuqnit aktuanilgit tuktut aaniaqtailininut
 - Kumaqyuit ulapihaiyut pipkailat akhuqtitauninut tuktut
- <u>Tariuqni Aulaqnit</u>
 - Aktuaniqalat hiku ikaqtuqvini ilagiaqnilu qayauyut qanurilitnit





Hivuranaqnit

- <u>Angunahuaqtit Akiraqturiknitlu</u>
 - Amaqut angunahuaqtiulluaqtut
 - Nunalikni ilihimani takukhautitai tautuktailu ilagiaqni akhait amigaitnit
- <u>Angunahuarniq</u>
 - Tamna hivuranaqluarniqhaungittuq tapkununga amihuaqyuit kihimik amigaitnit tikitpata puqhiqpiaqninut, tamna hivuranaqnia pityutauyuq angunahuarninik anginiqhauyuq pityutaulaqlu ikiklivalianginnaqninut aktuanilu utiqtitaunit





Aulaninut Pigiarutit

- Nunaliuyut taihimayunik hugiaqtut tahapkuatut nutqaqtitni aliahutauplutik akiliqtuiyut angunahuarutit tapkunanga Kiillinngup Tuktui amihuaqyuit
- Timinga Avatiliqiyikkut qangahaq iniqtat havanguyuq tapkununga qalviit hiamaumanit tahamani Kitikmeot (tuhaqhitaut iniqtigauyuq) parnaktutlu nutamik akhait hiamaumanit pigiaqtukhaq talvani 2021
- Amaqut Naunaiyaqni Katitiqni Havagut
 - 151 naunaiqtutit tahamani Kitikmeot talvani 2019-20 ukiup ilaani (654 nunatagauyuq-tamaat)







Pityuhiq Pivikha

- Aktuupa 2018 naunaiyaut havaq inirtuq
- 2019 tuhagakhat qauyihaqni naunaiyautmun
- Ukiakhani 2019 Bluenose Akitnaani tapkuatlu Bathurst uqaqatigiknit huli ilagiarutai qauyihaqni ilayauyut tapkununga Dolphinlu Unionlu naunaiyautit
- Nuvipa 2019 Ransomware qaritauyakkurutit aihuilitigaunit Nunavut Kavamanga – uuktutit tuhaqhityutit qaritauyakkutlu tuhaumatyutit tammaini
- Tisaipa 2019 Nunavut Uumayuliqiyiqyuatkut Katimayiit havaktit hatqiqtitat amigaitnit mikhautnit inungnut
- Atulihaqniani 2020 qaritauyakkut titiqatlu utiqtitauyut
- Mai 2020 Kingulliqpaq tuhaqhitaut atuqatigigutauyuq nunaliuyunut aulattiqatigitlu katutyiqatigit





PITYUHIQ PIVIKHA		
Aktuupa 2018	Naunaiyainiq havaq inirtuq	
Atuqniqhaunianut 2019	Nampanik ihivriuqniq	
Ukiakhani 2019	Bluenose Akinnaani tapkuatlu Bathurst uqaqatigiknit iniqtut huli <u>ilagiarutit</u> <u>qauyihaqni ilayauyut tapkununga Dolphinlu Unionlu naunaiyaut</u>	
Nuvipa 2019	Ransomware qaritauyakkurutit ihuiqtitaunit – uuktut tuhaqhitautitlu tammaqtut	
Tisaipa 2019	<u>Nunavut Uumayuliqiyiqyuat Katimayit havaktit hatqiqtitat amigaitnit mikhautnit</u> <u>inungnut</u>	
Atulihaqniani 2020	Qaritauyat titiqatlu utiqtitauyut	
Matyi 2020	Pittailitit iliyauyut piplugu tamna Qalagjuarniq-19 Aaniaryuarniq	
Mai 2020	Kingulliqpamik tuhaqhitaut atuqatigigutauyuq nunaliuyunut tapkuatlu aulattiqatit katutyiqatigit	
Juni 18, 2020	Hivayautikkut katimaqatigini tapkuat Angutikhaliqiyit tapkuatlu aulattiqatigit katutyiqatigit	
Juni 22, 2020	Minihitauyuq tuyutigiya titiraq tapkununga Nunavut Uumayuliqiyiqyuat Katimayit tukhiqhugu Minihitauyuq Aulattiniqmun Pigiarut	
Julai 28, 2020	Nunavut Uumayuliqiyiqyuat Katimayit kiuyat tamna Minihitauyuq unniqhugulu pilaqnini taphuminga "Atullaktuq Ihumaliurut"	





Aulaninut Pigiarutit

- Tamna Minihitauyuq tapkununga Avatiliqiyikkut tuyurtuq titiqamik tapkununga Nunavut Uumayuliqiyiqyuat Katimayit talvani Juni 2020 tukhiqnia tamna Minihitauyuq Aulattiniq Pigiarut, piplugu nakataani 5.3.25 tapkunani Nunavut Angirutit. Tamna pityuta uuma piyut tahapkununga:
 - Tamna akhut ikikligiaqni tapkuat amihuaqyuit akungani 2015 tamnalu 2018
 - Hivulliqnik qanuritnit tapkunanga Pitquhit Ilihimanit naunaiyainiq tautuktat ikikligiaqnit
 - Tamna pilaitnia uqaqatigikniq talvani Upinngani 2020 parnautauniagut piplugu tamna Hilaqyuaqmi Aaniaqyuarniq piplugu tamna Hilaqyuaqmi Aaniaqyuarniq
 - Tamna ilagiaqnia akhurnaqnit tapkununga Kiillinngup Tuktui piplugu ikikligiaqni nalaani amihuaqyuit tapkuat Bathurst tapkuatlu Bluenose Akitnaani





Aulaninut Pigiarutit

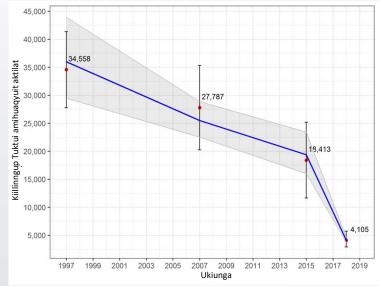
- Tapkuat Nunavut Uumayuliqiyiqyuat Katimayit kiuyat naunaiqtatlu tamna Minihitauyuq atulaita pilaqtitityutini malikhugu nakataani 5.3.24 tapkunani Nunavut Angirutit piplugulu atulaktuq ihumaliurut
 - Atullaktuq ihumaliurutit piyaulat piqarangat <u>irininaqtuq</u> (akhut ikikligiaqni amihuaqyuit) tamnalu <u>atuinangittut qanuritnit</u> (pilaitni malikni atuqpaknit uqaqatigikni ihumaliurnitlu pityuhiit piplugu hilaqyuaqmi aaniaqyuarniq)
- Tamna atullaktuq Katitlugu Pilaqtut Angunahuaqni tapkuat <u>42 tuktut</u> angitauhimayut Minihitauyunit atuqpaliayutlu tapkununga Kiillinngup Tuktui amihuaqyuit tahamani Nunavutagauyup Iluani
 - Tamna Katitlugit Pilaqtitat Angunahauqni 42 pityutauyuq tamna 1% angunahuaqni tapkuat amihuaqyuit





Uqauhikhat

- Pitquhiit Ilihimani tapkuatlu naunaiyainiq havat naunaiqtat ikikligiaqni tapkunani Kiillinngup Tuktui taimanga 1997.
- Piplugit tapkuat amigaitni qanuritni nunaliuyutlu piyaqaqni, hunat ilaliutyaqni pilaqagit tapkuat nunaliuyut piqaqtitni tapkunani tatya angunahauqni puqtunit?
- Tukliit Atuqtakhat:
 - Atuinaqni munaqhiniq
 - Nunavut Uumayuliqiyiqyuat Katimayit pityuhia
 - Havaqatiginia Nunatsiaq





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Munaqhityutit

- Tapkuat Timinga Avatiliqiyikkut pigiaqtat parnaiyainiq atuinaqninut munariyauni havagut kivgaqtutitnut tamaitnit atuqnilgit timiuyut aulattiqatigitlu katutyiqatigit.
- Tamna pigiarut aturahuaquyauyuq angiyunut aktilat ukiakhani 2020 naunaiyaqni ilaliutyaunit nunalikni ilihimanit attaqtuhigiaqninut naunaiyainiq inaa.
- Uqaqatigiktut pityutainut aktuanit naunaiyainiq inirtiqnianut tapkuat ilalgit: pilaqni maniktakhat, pilaqni tingmitit, pivikha pilaqni parnaiyainiq, hilamun kinguvaqnit, pukkittutlu qaphiuni qunguhiaqtautit huniumaittut amihuaqyukni.
- Piplugu puqtuyumik hivuranaqnia pilaitni iniqtiqni tapkuat titiratuqat uuktut naunaiyainiq, ahia atulaq mikitqiyamik aktilanga naunaiyainiq tamna 5-nik amihuiqtigini tapkunangaunganit 2018 naunaiyainiq niruaqtauyuq tapkunanga parnaiyainiq ilagiit.



^ՙժን՞գՐ՝՝ THANK YOU QUANAQUTIN MERCI





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DOLPHIN AND UNION MANAGEMENT CONSULTATION

Consultation on 2018 Survey Results and Interim Total Allowable Harvest

Summary Report

October 26, 2020

Amélie Roberto-Charron, Wildlife Biologist II - Kitikmeot Department of Environment Government of Nunavut Kugluktuk, NU

Executive Summary

Government of Nunavut (GN), Department of Environment (DOE) conducted a consultation with Burnside Hunters and Trappers Organization (BHTO), Omingmaktok Hunters and Trappers Organization (OHTO), Kugluktuk Angoniatit Association (KAA), and Ekaluktutialik Hunters and Trappers Organization (EHTO) on October 8th, 2020, regarding the Dolphin and Union caribou herd. Other stakeholders in attendance included Nunavut Wildlife Management Board (NWMB), Nunavut Tunngavik Inc. (NTI), Kitikmeot Regional Wildlife Board (KRWB), Kitikmeot Inuit Association (KitIA), Government of Northwest Territories (GNWT), Wildlife Management Advisory Committee (WMAC), Environment and Climate Change Canada (ECCC) as well as local elders and a local outfitter.

The intent of this consultation was to discuss the 2018 Dolphin and Union caribou abundance survey results and the interim Total Allowable Harvest (TAH) of 42, which was implemented in August 2020. The consultation was also intended as an opportunity to hear and better understand any concerns associated with the interim TAH and to ensure the affected Hunters and Trappers Organizations (HTOs) were well informed on all the most recent information for this subpopulation. The HTOs also provided further input on the Dolphin and Union abundance survey that took place from late October through to the beginning of November 2020.

The consultation included presentations from DOE on the 2018 survey, analysis, results, management decisions, and timeline since the survey was completed. There was also a presentation given by University of Calgary representatives on results of Traditional Knowledge and health monitoring studies. Each of the stakeholder groups in attendance was given an opportunity to ask questions and to provide input. There was consistent input from groups present that affected communities lack confidence in the results of the 2018 abundance survey. Many feel it was an underestimate of the population at that time and that it did not account for caribou from the Dolphin and Union caribou herd that are no longer migrating and are overwintering on Victoria Island or the Dolphin and Union caribou that remain trapped on the mainland after breakup and do not reach Victoria Island in the spring

Predators were identified by many of the consultation participants as one of the highest threats to the Dolphin and Union caribou herd and a main cause of observed population declines. There were concerns expressed about increased human activities such as industrial development and shipping, which are believed to have detrimental impacts on the health of the herd and sea-ice integrity for migration between Victoria Island and the mainland. There was consistent agreement between the HTO representatives that the interim TAH, which was based on a recommended 1% harvest rate, was too low and should be increased to at least 2% (84 caribou). A few people requested an additional 60 tags, which would increase the TAH to 102 caribou.

The feedback collected during this consultation will also aid the GN in future management and research of the Dolphin and Union caribou herd.

This report attempts to summarize the comments made by participants during the consultation.

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Aulapkaiyini Naittuq

Nunavut Kavamanga (GN), Avatiliqiyikkut (DOE) uqaqatigiiktut ukununnga Burnside An'nguhiqiitkut Timiqutigiyait (BHTO), Omingmaktok An'nguhiqiitkut Timiqutigiyait (OHTO), Kugluktuk Angoniatit Katimayiingit (KAA), ukuatlu Ekaluktutialik An'nguhiqiitkut Timiqutigiyait (EHTO) October 8-mi, 2020, uumuuna Tahiqpak Kanannangani tuktuit. Aadlat tigumiaqtuuqatauyut katimaqatauyut ilaliutiyut Nunavunmi Huradjanik Munarinigmut Katimayiingit (NWMB), Nunavut Tunngavikkut (NTI), Kitikmeot Avikturhimayuni Huradjanik Katimayiingit (KRWB), Kitikmeot Inuit Katimayiingit (KitIA), Nunatsiap Kavamanga (GNWT), Huradjanik Munariniqmut Uqaqatigiikniqmut Katimayiingit (WMAC), Avatinga Hilaup Aadlangurninnga Kaanatami (ECCC) ukuatlu inirniriinit talvannga qablunaaniklu angunahuaqtittiyuktunik.

Uqaqatigiiknahuarninnga uqariamiknik 2018-mi Tahiqpak Kanannangani tuktuit amihuuninngit naunaiyaininngit qanurittaakhaanik unalu tadjakaffuk Tamakpiangani Pidjutittaktunik Angunahuaknikmun (TAH) 42-mit, iliuraqhimayuq August 2020-mi. Uqaqatigiiktullu pivikhaqautikhamik tuhaagiamiknik nakuutqiamiklu kangirhigiamiknik ihumaaluutinik piyut tadjakaffukmut Tamakpiangani Pidjutittaktunik Angunahuaknikmun naunairiamilu ayurhaqtitauyut Anguhiqiitkut Timiqutigiyaits (HTO) nakuuqpiaqtumik naunaipkaqtauyut tamainnik nutaatqianik naunaitkutanik uumunnga ilagiyanga angitqiyauyunit. Annguhiqiitkullu tuniyullu aadlamik qanuqtut ihumagiyamiknik uumunnga Tahiqpak Kanannangani amihuuninnginnik naunaiyainiq piyait nunguliqtumi October atulihaaliqtumut November 2020.

Uqaqatigiikninnga ilaliutiyuq uqaqtakhamiknik Avatiliqiyiitkunnit 2018 naunaiyaininnganik, ihivriurninnga, qanurittaakhaanik, atan'nguyap ihumagiyaminik, unalu naunaipkainiq hulilukaarutinginnik hivulliqpaamit ublumimut taimaa naunaiyairuiramik. Uqaqtullu Iliharvikyuanganit Calgary havaktinginnik qanurittaakhaanik Qangaraaluknitamik Ilihimaniq unalu aaniaqtailiniqmut munariniqmut naunaiyainiq. Tamarmik tigumiaqtuuqatauyut katimayut ilauyut tuniyauyut pivikhaqautikhamik apirigiamiknik tunigiamiknilu qanuqtut ihumagiyamiknik. Pihimmaaqtuqlu qanuqtut ihumagiyamiknik katimayunit ayurhaqtitauyuq nunallaanut piqalluangittut ukpiriyamiknik qanurittaakhaanik 2018 amihuuninnganik naunaiyainiq. Amihut ihumagiyut amigaitpiaqtuq amihuuninnganit talvani pipkaidjutingittuq tuktut uumannga Tahiqpak Kanannangani tuktuit ikaungittut nurraliurvikmiknut ukiuyut Kiiliniqmi uumaniluuniit Tahiqpak Kanannangani tuktuit ikaalimaiqtut hikuiqmat tikingittullu Kiiliniqmut upin'ngakhami.

Aadlat huradjat angunahuaqtut ilitariyauyut amihunit uqaqtunit atauhiuyuq quulitqiyauyuq qayangnautigiyauyut ukununnga Tahiqpak Kanannangani tuktuit pilluarutigiyauyullu qun'ngiaqtauyut amihuangit ikikliyuumiliqtuq. Ihumaaluutigiyauyuqlu uqaqtauyuq amihunguqmat inungnik hulilukaaqtut havakviuliuqtut umiakkuuqtullu, ihumagiyauyuq piqaqtuq nakuungittumik pilaqutiyut qanurittaakhaanik amihuaryunganit tariup hikungalu nuutiqtitauniq Kiiliniqmit nunainnaqmiitut. Angirutiqaqtuqlu ukunanit Anguhiqiitkut havaktingit tamna tadjakaffuk Tamakpiangani Pidjutittaktunik Angunahuaknikmun, pihimayuq pitquyauyumit 1 pusantmit angunahuarniqmut nampanganik, mikivallaarmat angikliyuumiqtukhaq 2 pusantmut (84 tuktut). Qaffiuyut inuit apiriyut aadlamik 60 atatait, angikliyuumirniaqtait Tamakpiangani Pidjutittaktunik Angunahuaknikmun to 102 tuktut.

Uqaqtamiknik katitiqtait uqaqatigiiktillugit ikayurniaqtaa Nunavut Kavamanga hivuniqmi munarigiami ihivriuriamikniklu ukuninnga Tahiqpak Kanannangani tuktuit.

Una taiguagakhaq pinahuaqtuq ihivriuriamikni uqaqtangit katimaqatauyunit katimatillugit.

Preface

This report represents the Department of Environment's best efforts to accurately capture all of the information that was shared during a consultation meeting with Burnside Hunters and Trappers Organization (BHTO), Omingmaktok Hunters and Trappers Organization (OHTO), Kugluktuk Angoniatit Association (KAA), and Ekaluktutialik Hunters and Trappers Organization (EHTO) on October 8th, 2020.

The views expressed herein do not necessarily reflect those of the Department of Environment, or the Government of Nunavut.

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1.0 Report Purpose and Structure

This report is intended to collate and summarize comments, questions, concerns and suggestions provided by participants at the October 8, 2020 consultation in Cambridge Bay on Dolphin and Union caribou research and management. Representatives from the affected HTOs, DOE, the NWMB, NTI, and the KRWB attended the consultation in person.

Additionally, the following parties attended the consultation by phone: University of Calgary (U of C), GNWT, ECCC, KIA and WMAC.

2.0 Purpose of Consultation

The purpose of the consultation was to meet with the affected HTOs, including BHTO, OHTO, KAA, and EHTO, and other relevant stakeholders to discuss the results from the 2018 population abundance survey and the interim TAH of 42 and to receive their feedback. An overview of the results from the 2018 Dolphin and Union aerial survey was provided through a presentation given by DOE representatives and the results of Traditional Knowledge (TK) and health monitoring studies were presented by representatives from the U of C.

In addition, the meeting served to provide an opportunity for representatives from affected HTOs and co-management partners to provide their feedback, ask questions and obtain clarification on the 2018 survey results and current management actions. Clarification was provided on the process to change an interim TAH, the roles and responsibilities of NWMB, as well as an overview of the co-management process.

The consultation was also intended to ensure that the HTOs were well informed on all the most recent information and plans regarding the upcoming Dolphin and Union survey. The consultation allowed HTOs and community members to voice any requests they may have regarding the survey. It is important that all stakeholders work together to manage this subpopulation in the future.

2.1 Format of Meetings

The meeting was held on October 8th, 2020 and ran for approximately 9 hours. The meeting was facilitated and led by the DOE Kitikmeot Wildlife Manager, Kevin Methuen. The meeting began with opening remarks by Kevin Methuen, a prayer by James Eetoolook, and roundtable introductions. This was followed by a presentation by the Acting Manager of Wildlife Research, Caryn Smith. Questions took place during the presentation and participants were invited to ask questions, raise concerns, or provide advice following the presentation. A roundtable to allow feedback and input from the HTOs and KRWB followed. A presentation was given by Dr. Susan Kutz and students from the U of C, which provided an update on a Traditional Knowledge study and ongoing health monitoring research for Dolphin and Union caribou. KIA, NTI and NWMB were also given the opportunity to provide input. Questions were then asked regarding the process associated with the interim TAH and the upcoming survey, followed by closing remarks.

3.0 Summary of Consultation

The objectives of the consultation were made clear to the HTO members prior to and at the start of the meeting.

Date: October 8, 2020

Representatives in Person:

- GN-DOE
 - Acting Wildlife Research Manager Caryn Smith
 - Director of Wildlife Research Drikus Gissing
 - Kitikmeot Regional Manager Kevin Methuen
 - Kitikmeot Regional Biologist Amélie Roberto-Charron
 - Director of Wildlife Operations Jason Aliqatuqtuq
 - Kivalliq Regional Biologist Mitch Campbell
- NWMB
 - Marine Mammal Biologist Jordan Hoffman
 - Wildlife Director Denis Ndeloh
- Burnside HTO
 - Board member Sam Kapolak
- Omingmaktok HTO
 - o Chairman Peter Kapolak
- Kugluktuk HTO
 - Manager Amanda Dumond
 - Board member OJ Bernhardt
 - Chairman Larry Adjun
 - o Board member Bobby Anavilok
- Kitikmeot Regional Wildlife Board
 - o Coordinator Ema Qaqqutaq
 - o Coordinator Peggy Adjun
 - Chairman Bobby Klengenberg
- Cambridge Bay HTO
 - Chairman Bobby Greenley
 - Board member Clarence Kaiyogana
 - o Board member Peter Evalik
 - Manager Beverly Maksagak
 - Board Member George Hakongak
 - Board member George Angohiatok
 - Member Jimmy Hanikiak
 - Member Gary Maksagak
 - Member Richard Ekpakohak
 - Member (and translator) James Panioyak
- Nunavut Tunngavik Inc
 - Vice President James Eetoolook

- Director of Wildlife and Environment Paul Irngaut
- Resource Management Advisor Cheryl Wray

Representatives on Phone:

- University of Calgary
 - o Dr. Susan Kutz
 - PhD Candidate Andrea Hanke
 - MSc student Fabian Mabrot
 - Post-doctoral researcher Javier Fernandez
- GN-DOE
 - Baffin Regional Biologist John Ringrose
 - o Baffin Wildlife Technician Chris Mutz
- Wildlife Management Advisory Council
 - Biologist Rosemin Nathoo
- Nunavut Tunngavik Inc.
 - Assistant Director of Wildlife and Environment Bert Dean
- Government of NWT, Environment and Natural Resources
 - Regional Biologist Tracy Davison
- Ulukhaktok HTC
 - Board Member Joseph Haluksit
- Environment and Climate Change Canada, Canadian Wildlife Service
 - Species At Risk Biologist Isabelle Duclos
 - Species At Risk Biologist Rhiannon Pankratz

Summary of Comments and Questions:

- All HTOs expressed that predators are a main threat to the Dolphin and Union herd and are contributing to the population decline.
- Large male caribou are vulnerable to predators during the rutting season when they are physically exhausted.
- HTOs felt that the 2018 survey was flawed based on the following points:
 - \circ It was not made clear why certain observations were not recorded
 - It is believed that the population estimate from the 2018 survey is an underestimate
 - A coastal survey does not survey a large enough area
 - Dolphin and Union caribou that do not migrate are not being counted
- HTOs were unhappy that the results and report were delayed, and that the population number was not released earlier by the GN.
- HTOs felt there should have been more consultation regarding the 2018 results before the interim TAH was implemented.

- Being able to harvest caribou is important for more than just food. Inuit need to hunt caribou to pass on the hands-on knowledge of how hunt and how to use animals in traditional ways to their children and grandchildren.
- HTOs believe that other options were not explored before restricting Inuit harvesting and that the effect of predators needs to be considered, as well as effect of insects, thinning ice, and industry.
- Some caribou are not migrating because of industrial activity (e.g. too much blasting at the Hope Bay Mine).
- HTOs are appreciative of the improved collaboration and partnerships in the upcoming survey and commend the GN for making the survey a priority. HTOs appreciated being asked for their input in the design and planning of the upcoming survey work. Working together is very important.
- In response to questions on calf recruitment: The actual value that is used to index productivity is the number of calves to the number of cows. How many cows and calves are observed, and the ratio is important to herd health. This indicates whether the herd is going up, down or stable. Every herd is a little bit different but around 25-30 calves/100 cows seems to show stability.
- In response to questions on how to plan a survey without many collared animals: Collared cows are typically very representative, however, without collared caribou, local knowledge can help to locate groups of animals. Historical survey data, historical collar data, and tracks can also be used to determine priority survey areas. Without collars more searching is typically required.
- Collaring is important and should be maintained going forward to help with monitoring.
- Collaring for the Dolphin and Union caribou herd will take place in 2021 in either the spring or the fall.
- No harvest limits were implemented following the 2015 survey although a decline was noted as other actions were being explored such as increased collaring and increased survey effort.
- The Traditional Knowledge study results supported the science in that there is an observed decline in the herd. The science puts specific numbers to the decline while the TK indicates the trends and is able to show that the declines were observed at given times based on community perspectives.
- Communities want the sample kit program to continue to ensure the health of the herd is monitored.
- Most participants felt that a TAH of 42 was too stringent. A 2% harvest rate of the estimated population was recommended by several HTOs and NTI (total of 84 animals). A few people present requested an additional 60 tags which would result in a TAH of 102 caribou.

• A TAH of 42 will be hard to allocate between communities but the KRWB recognizes they have that role.

4.0 Summary

There was a consistent message from the HTOs that they did not trust the results of the 2018 Dolphin and Union caribou population abundance survey and believe the reported results to be an underestimate of how many caribou there were at the time. There is a firm belief among communities that some Dolphin and Union caribou are no longer migrating, and they are either staying on Victoria Island or not leaving the mainland. There was agreement that the herd is declining but the consensus among HTOs and co-management partners was that the interim TAH of 42 (1% harvest rate) is too low and that based on community needs and local Inuit knowledge of the herd status, the TAH should be increased to 84 (2% harvest rate). The HTOs and NTI feel that adequate consultation had not been done following the release of the final report on the 2018 survey and the interim TAH should not have been implemented without the proper consultation. HTOs feel it is important to recognize that predators are a main threat to the herd and are a main contributing factor to the population decline. Harvesting is not the cause of the decline.

On a positive note, all parties present felt the recent collaboration between the DOE and relevant stakeholders, on the 2020 Dolphin and Union population abundance survey, is a big step in the right direction for re-building relationships and trust in research. During the consultation, the DOE and NWMB representatives were able to communicate the next steps in the management decision process. The interim TAH of 42 will remain in place until the NWMB has been able to review the interim decision, based on the best available information, and make a new decision on the harvest of Dolphin and Union caribou.

Appendix

Dolphin and Union Meeting Transcript October 8th, 2020

9:14 AM Meeting call to order

Introduction and housekeeping by Kevin Methuen

Opening prayer James Eetoolook

Kevin: Changes to agenda: U of C presentation this afternoon

Note from Bobby Greenly regarding community elders present (will ask questions through him) Question from James regarding how best to provide lengthy remarks, interested in giving a statement from his organization

James: The agreement recognizes rights and wildlife harvest. Conservation in our minds when dealing with issues. NA recognizes self-governance. Limitations out in place if issues with conservation. NWMB and gov responsibility do not regulate harvest unnecessarily, infringement on Nunavut rights. NTI supports that they do not feel that appropriate consultation was done. Inuit need to be involved in all aspects of conservation. When placing TAH for other herds there was extensive consultation prior to placing, with DU, there was minimal discussion. Very important part of the law through the NA

Caryn Smith: Presentation

Bobby Greenly question: Threats doesn't include predators (and they should be the most problematic issue and should be the top of the list)

Caryn response: These are not listed in any particular order, and there are two slides

Bobby response: The wording made it seem like these should have been at the top here. We don't like to repeat ourselves, and our main concern is predation. And we want to make that clear.

Caryn response: They are in no particular order and all of them are being discussed as major threats. No threat listed is being discounted as a significant threat.

Presentation continued.

15 minute break.

10:36 AM meeting resume

House keeping: U of C bumped to after 3 PM to have time for questions. Given the primary goal of getting feedback on interim TAH of 42.

Start with KHTO for feedback.

Larry: All commercial hunting ended on BNE, Bathurst and DU. Here to discuss 2018 report. Statement to GN: 2018 survey was flawed in several ways. A mistake was made, and because of that one mistake we are here to discuss. Many hunters subsist on BNE, and DU, and the 10 tags for Bathurst are for subsistence for outpost camp by Contwoyto Lake. I'd like to hear more from Susan regarding health and reproduction for this afternoon. From our TK we have a healthier heard, and that may be dished out by Susan as compared to 2015. Pass off to Amanda.

Amanda: We've had a couple of meetings since numbers came out. Not from the GN, but from NWMB. These numbers were from 2018 survey. We understand ransomware and COVID, and the delays. We were not happy that this number didn't come from the GN. We were not happy that we could not consult our community. And it comes from out HTO bylaws. But with the 50-person limit from GN regarding COVID, we couldn't have our meeting and have quorum.

QUESTION FOR CARYN: why no later composition surveys since 2015 and 2017.

Caryn response: secondhand information, as I was not the manager during the surveys. Not 100% sure why we haven't had any between 2017 and present. Hoping to have some in the future, and to involve the communities.

Drikus: Could be because of the priority. Many projects are cut due to the fact that they aren't high priority.

Drikus comment on survey (response to Larry): We are aware of the distrust towards the 2018 results. We have sent many GN staff to speak to these results and are putting numerous resources to new surveys. We have a responsibility to Inuit to protect resources. We have a due diligence to act when we see a conservation concern. And this is a big food security issue. If we do not do our job, we are accountable. TAH of 42 is interim, not forever, depends on when the NWMB will be able to have a meeting to discuss.

Larry: commend GN on work towards the survey and the pooled resources from other regions in Nunavut. Commend GN on predator work (including the grizzly program)

Amanda: I don't think the GN has thoroughly explored other options before restricting Inuit harvesting. There's no evidence of other management options. Easiest way is to restrict our people. We know predators have a huge impact on caribou populations. No evidence that the GN is looking at other things, e.g. effects of insects, sea ice, etc. TK shows that when pops are low they no longer migrate. Observations of DU caribou on mainland and not on the island after breakup. These individuals not considered.

Bobby A.: Bring up surveys and how they are done. From 18 K to 4 K. Counters were asked not to count certain areas and certain caribou. Concerns that caribou were missed during the survey. Believe that 4K is an underestimate. Felt that if the concerns of people on the land are not being considers. Biologists need to step into the Inuit boots. Need more consistent and think empathetically. Almost 50% of caribou not counted, how can they have an accurate estimate of the population based on this survey?

OJ: DU caribou don't migrate all the time. There are island caribou near where I live, yet there is no sea ice. How did they get there? Last year. If you want to save the caribou, put the price up for predators. And that will make a big help. More harvesting of the predators.

Larry: Both directors are active hunters. OJ travelled to Bathurst inlet to hunt. Many hunters travelled to NWT for collaborative wolf hunts. Thank you to NTI for gas subsidy.

Amanda: Food security. The community of Kugluktuk has already seen a restriction for BNE. We're a growing community, how will the GN help to support the people of Kugluktuk? Funds for food security aren't enough. Struggling with fish population (ongoing studies with this). Moose harvest will be increasing this year. Another concern, traditional knowledge transfer. People learn by doing. I want to be able to teach my son how to hunt. You can't teach hunting by telling. I learned through my parents, and I want my son to learn too. How can I teach him if I can't hunt the caribou? And I feel for people who weren't fortunate enough to get a caribou this fall. And we're getting to a point where we may not be able to pass that knowledge on. You know, our ancestors were conservationists. Living on these lands for thousands of years. We should be able to manage our resources according to the Nunavut agreement. But I also believe in partnership and western science. And we're seeing that in the upcoming surveys, because we need a better perspective. Commending the GN for the upcoming survey. Thank you for asking for our input for the upcoming surveys. We need to keep working together.

Peter Umingmaktok HTO: question for Caryn how do you monitor how many calves are born to each cow?

Caryn response: Lucky that we have a very experienced regional biologist here, Mitch Campbell

Mitch: Thank you for the question. Depends on the timing of the survival survey done in the spring. Not sure how it's done here. In the Kivalliq, in June you can be sure how many calves each cow has. Later it's harder, confusing as there are aggregations of calves. For recruitment, we try and see how many calves there are per 100 cows. In the Kivalliq, we use collar data. We go to areas where there are collars, and we will spend 1 hour per each collar and count the number of young bulls, mature bulls, yearlings, calves (<1 year old) and cows. The actual value that we use to index productivity is the number of calves to the number of cows. How many cows and calves we saw and the ratio? This tells us whether the herd is going up, down or stable. Every herd is a little bit different. Around 25-30 calves/100 cows seems to show stability. Anything under 25 could indicate a decline. The more under 25 the steeper the decline, and everything over 30 could indicate an increase and same, the more over 30 could be a higher increase.

Peter: One more question, how do you know where to look for a herd without collared cows? There should be many groups without collared caribou that you missed during the survey.

Mitch response: We have found that the collars are very representative. But as you know they are not 100%, never really 100%, and we have also found for the bigger herds, that if you have them overwintering in different areas, quite often the cow/calf ratio could be different in different areas, so very important that we catch all the different areas. For the Baffin which doesn't have collars, we would use the local knowledge and we would always include local hunters recommended by HTO to go out with us. And any other kinds of information available to us (past collar data, and past survey data) to high grade, which simply means fly into these areas and search them thoroughly. In the spring we use tracks to indicate whether animals are there. The composition work we do in Baffin requires more time, as there is more searching when we do not have the collars to guide our work. It is important to be fairly confident that the areas you are surveying are representative of the herd. Because if you miss a location, and if it was a

good location where there were lots of calves, then that could really impact the result and could show a lower number of cows. Important to consider all main areas.

Peter: Thank you Mitch.

Sam Burnside HTO: We believe that there was not enough consultation put forth between communities and hunters before TAH implemented. We also believe that a costal survey is not enough. We have been observing that island caribou stay on the mainland. This past spring, I observed that the Beverly herd had DU caribou overwintering with it. And when they migrated east, the DU went with them. Unsure whether the DU summered with the Beverly herd. Not all DU caribou spend the summer on the island. They stay too long and get stuck on mainland. We would like to see the survey area increased, all the way to Contwoyto lake. We also know that not all caribou will be with the collared caribou. Which is why we want to see the area increased. One fall at Contwoyto, I saw hundreds of caribou every day, but I did not see one collared caribou. And on predation, we are seeing a great increase of number of grizzly bears, and number of eagles. We see eagles harassing caribou and that's a predator that we need to keep on the mind, as it's not considered.

Cam Bay HTO:

Booby Greenly: Thank you to everyone for coming. Big thanks to GN regarding the future survey. Going back to last week to discuss the survey, we picked the best option. I didn't get an answer last week regarding my suggestion. I made a suggestion to collar caribou in the spring. We have the collars available. I was wondering if that will be going forward in the spring.

Caryn response: we have been talking about collaring. It has been something that we have been discussing. We think collaring is very important, and we discussed it as an option in the fall but it will depend on the funds available, we need to ensure that we support research on Muskox, Polar Bears and other species. However, Drikus feels it will be likely. Something that we have been working on for a number of years, is that we want to run a good MX 11 survey. It is a priority for the region, so we can have a good understanding of the population of Muskox and have a better understanding of potential impacts if there is a shift to hunting more Muskox rather than caribou.

Drikus: I fully support Caryn's comment. But I want to reiterate, that this is likely the biggest conservation issue that we are dealing with because of all of the other declines that are being experienced with other herds. We are also supporting a Northeast Mainland caribou survey; we're hoping to count all of the caribou on the mainland to get a better idea of the caribou numbers and how they combine with DU. I can commit that the collars on DU will happen in the fall or in the spring, it will happen.

Bobby G.: Question about the 2018 survey. With the shoreline graph, with the proposed survey that was done, how much was actually completed? And with the collared caribou that are outside of those grid lines, were they actually counted?

Caryn response: I apologize I am not familiar with these results, and the biologist that did the analysis isn't here. I believe that most of the lines were flown. And the numbers of collars that aren't counted within the survey area are included in the analysis and are accounted for.

Bobby G.: We all knew the population was declining. We noticed a decline over a time, from 34 K to 27K, and from 27 K to 18 K. Why couldn't the biologist see the decline and act drastically sooner and act sooner.

Caryn: Following the communication from the 2015 survey, there was a recognized decline, but at the time the recommendations for management were to try and do other things rather than focus on the harvesting limits. The monitoring periods also got shorter. Recommendation to NWMB after the 2015 survey was that there was no need at that time for a TAH.

Bobby G.: Thank you for bringing other people together for the survey. And hopefully this will really improve future survey. Information from me, sea-ice crossing and what our HTO has done. We looked at this closer and we wanted to look at the starting and ending of when the crossing should be limited near Cam Bay, unless there is an emergency. There are a few people who have comments on behalf of Cam Bay HTO.

George: the history of our people in the north, and how our elders dealt with situations like this. We grew up in a time where we didn't have caribou and muskox. My grandfather told me of a time when many caribou and muskox were available to our people. And I couldn't imagine a time with that many animals, but I couldn't imagine a time where there were that many animals. I asked what happened to all those animals. He explained that there was a time when we were could walk in any direction and see animals. My grandfather said they would come back. In the 1980s, I saw animals near cam bay. I suspect that these animals were from northern Victoria Island, they were all white, no brown on them. These animals come and go. When the population gets too high, they will have disease, run out of food, and they will die off. My grandfather gave the example of lemmings and foxes. This is the same for the larger animals, like with caribou and with predators. The decline is because the numbers are too great, sickness spreads out, and when you have too many animals you eat all the food, and you need to move elsewhere. Caribou are moving but aren't dying off. Having said that, the numbers of predators being so large. When you get a large number of predators because of a boom of caribou, they teach their children like we do, how to hunt caribou. I blame predators for the lack of calves that I have seen. And in the fall times, I see dead bull caribou after the rut. And sometimes I see them sleeping. I can walk up to them with my wife and I touched them, and they got up. After breeding the caribou are exhausted and have no energy to defend themselves against predators. Previous thought was to harvest the animal because you don't know when you will see them next. But the current government is saying leave these animals when you don't know the population. It's not the hunters' fault that the numbers are down, but we're always the first impacted.

Peter: First I would like to comment, I respect that the GN is taking action to help preserve our resources, but are these the correct actions that the government is imposing on Inuit? I don't think a TAH should have been imposed without a proper consultation. We were provided a 100-page report and given 1-2 months to provide edits, but that wasn't enough time. The land claims agreement is not being properly followed. Our community could harvest 150-300 caribou annually, would this really have a negative impact overtime?

Caryn response: Several things to consider. Given the declining trend. We don't know what the number of the herd is right now. The number could be lower. If your community takes 150-300 that's around 5%, and if Kugluktuk does too, that's over 10%. But we are currently unsure of the numbers, which is why we're trying to be cautious. Touch back on NA, and when the results were released, we weren't able to fully consult, we also didn't know how long that could last. We didn't know we could travel here, and we need to make sure we do due diligence.

Peter: We only harvest what we need to make sure to conserve our own resources

Break for lunch

Meeting resumed at 1:10 PM.

Bobby G.: When we talked about this in the past, but why was the harvest set at 1%? I brought up the suggestion of 2%, and it was shot down pretty quick, and why was that

Caryn response: That's not off the table. We're here today to discuss options and we're asking for your thoughts and your input on the TAH of 42. We're really welcoming of any recommendations and thoughts that you might have.

Bobby G.: With other herds, 2% harvest rates are common. Why not have a standard? 2% was used for Baffin and other herds. If we keep it as a standard at 2%, would it make a large difference on the herd?

Caryn response: When we think about proposed rates of harvest, we try and be consistent, but there are other factors that we also try and take into account. Some of the bigger difference, if we were to compare Baffin with DU, one of the factors that we noted is that the DU tends to be more vulnerable to harvest, based on the nature of the migration, they aggregate close to communities, whereas Baffin tend to spread out and be less accessible. That being said, it's important to take into consideration community needs. At the end of the day, we would be remiss if we applied a blanket percent because there are herd specific challenges and differences that we need to consider.

Jimmy: I'd like to comment in regard to the caribou, my comment would be more in regards to the elders and the proposed 42 tags on DU is not very consistent seeing that we never had a collar tag system before. In the 1960s, we didn't have any caribou around this area at all. This is not the first time that the caribou has come and gone or has moved away. I want to pass on some traditional knowledge, wildlife in general from what I've been advised, you can't always predict what's going to happen to them They come and go, but you need to manage our animals and our wildlife. And in regard to our elders, how are we going to survive is something I've always thought about since the 42 has been mentioned. How am I going to go out hunting without a tag? With elders, we can't go out to the areas where the caribou are, it's far from the community. And elders need to be part of the decision-making process, and as an elder I do not agree with the 42 tags. These are the food that we put on the table for our families, and the government says that we need to stop because the caribou are declining. But the government doesn't think about how it impacts our people. And what we need to do is come to a decision on what we need to do. My father, and my grandfather have always told me that we need to manage our wildlife and take only what you need. 42 tags is really minimal to feed our families. I totally disagree with the government deciding that we will only have 42 tags. The government always putting into place management plans without proper consultations in the communities. As well we harvest the Muskox, and the caribou. But it seems that the elders are always forgotten when restrictions are put on wildlife. We need more tags so that we can bring it around so that people can have enough to eat. Also, we had no consultations from the government as to why they want a tag system. We have to manage our wildlife because it provides for our families. The wildlife are depleting, but caribou move away when the habitat is no longer good for them. This is happening near Cam Bay; the caribou are moving away. We go hunting for days, and sometimes we find caribou, sometimes we don't. What am I going to do? Break the

law and go hunting without a tag. I need to feed my family. So, what we need to do is work together to decide on a number if we are going to use a tag system.

Richard: Caribou survey history done in 2018. We had firsthand look at why that number is so low. We went out with Lisa and the survey grid we were supposed to do was never completed. And we saw a lot of caribou, but she told us not to count them. She told us not to count them because if you can't recognize if they are male, female or calves, don't count them. This figure here, just with the grid we were supposed to do, this is about 40% of what we saw. In the air, we could see caribou on both sides, but she said, just count the side close to the airplane. Myself, I thought, that we would reach the hill to count them. When we got to where we were going, we were skipping lines. The actual grids that we did, I outlined them and gave them to Beverly, and they were very low. And going off of what Bobby G. said, 42 is very low. And 65 more caribou would be good. With climate change and the ice being formed much, much later. Would you the government rather see the caribou drown on the ocean than we the Inuit harvesting them for our food? It would be better be that the people eat them than have them going to waste in the ocean. Because it will be way more than 65 that will drown. There have been people that see in the ice the antlers, where the caribou have drowned. It would be better to have the number up rather than 42, so that at least the people have caribou meat to eat, rather than drowned in the ocean. People don't waste food. But when we're told not to harvest, then those animals are wasted. They drown. I know that the caribou will rebound, because there is no sport hunting anymore. And the big males are not being disturbed to mate. And I know they will rebound, and in the survey grid shown here, most of it, we did not do. I was out last weekend, and I was at Ferguson Lake, and there were caribou there going eastwards. But the wind was coming from the northwest, and I could smell the caribou. The reason why they are not migrating through Kent Peninsula, is because there is too much blasting from Hope Bay mine. There's too much blasting and the ground shakes. They know it's dangerous, and they don't go there. I thank you for listening.

George: Good afternoon. I have been operating out of Barin Bay as an outfitter for ten years, and I have seen the numbers dwindled year by year. After 2016 I cut off all sport hunts for Muskox, and this year I was supposed to have two hunters, but it was shut down because of Covid. We were there mid-August to late-August, and we counted only 25 caribou. But in the time that I have worked out of there, I've noticed an increase in grizzlies. I have seen in separate years I have seen sows with three cubs of the year. I have seen sows with year old and two-year-old cubs, and that is very disturbing. I started noticing grizzlies on this side of the island in the mid-nineties. Seven miles north of camp, there is a wolf den. This year, we counted six wolves. Their numbers are coming up. I have been on a rescue mission on Hadley bay. I have crossed many many wolf tracks all going up to Hadley Bay. And that's quite concerning. And those two are the biggest predators for Muskox and caribou. And when a bull caribou expends his energy, he can't defend himself. Is there going to be a survey to determine the number of grizzlies on the island? And for the migration pattern on the caribou, the caribou that are being harvested in King William Island, are those DU?

Drikus response: We have to prioritize what we do with our annual budget. We receive 2-3 million dollars for all of Nunavut, not just for the Kitikmeot, and we need to prioritize. We are launching a grizzly bear project near Kugluktuk, on the mainland, but not on the island. Later this month we will have a survey for DU. As for the caribou on King William Island, I don't know.

Beverly: In our modern world, there are limitations to technology. I understand the ransomware issues, but I recommend having a paper trail. In our culture, the elders teach us. And with Bobby G.'s remark, with the declines, they were seen many years ago, why wasn't anything

done? Our land claim agreement is our laws, put into place by our elders. The predators have been discussed many, many years, we feel that it's not the harvesters that are taking down the caribou, it's the predators. My question for the GN is will they look over the food subsidy, now that you are proposing a TAH on the one species that we rely on for our nutrition? Because it's our elders and our youth that are losing that nutrition from our lands. And as HTOs, we would like more resources to be able to better support our board and provide the best information that we can. We as managers struggle to keep on top of wildlife, specifically caribou. But let's not forget that there is other species that we rely on. But my question is will the GN look over the food subsidy?

Drikus: Thank you we anticipated this concern would come up. After the Baffin decline, a system was put into place to help with the decline. It's not our department, which is easy for me to say, but that's for an MLA to bring up those concerns.

James P.: Thank you for this opportunity to speak on behalf of our community. Thank you to everyone for participating in this issue. It's good to see all the familiar faces. What I listened to around the table, is very accurate information. The government continues to listen, but a lot of times what we discuss, what we say as a community representative, the government doesn't seem to understand the real struggles that we have. And caribou issues have been topics for a long time. For as long as we've been at the table. And in the Kitikmeot region, our people really struggle. Our concerns aren't heard, because we don't give enough push. We are too passive. Having said that, we need to get stronger, and push the government and tell them to listen. This is what we are struggling with. Caribou is our mainstay as far as putting food on the table. And it's very concerning that the government can one day say we're putting a TAH on your caribou harvest. You wake up one day, and you see on social media that this is happening today. Caribou that we depend on, on the island, its being put to halt, because the government says the caribou are being depleted. But it's not just the caribou. For years, even our polar bear subpopulations were a concern on the island with the Umingmaktok channel at the time, the government pushed for a moratorium on our polar bear population in one day. Our oral history tells us that. Without consultation this was done. It was a real struggle at the time. They put a moratorium when our hunters knew that the numbers weren't decreasing. But the shocking fact. was that the TAH was put into place without consultation. We have to abide by the land claims agreement, and the government is not doing that. We need to work together. I think right now is a good start, as Bobby G. said, we need to work together and have common ground. But I really thank our elder Jimmy for speaking about his traditional knowledge. And it's nice to see young faces at the table. And I just want to say, we need to stop being passive and fight for what we have, because that's the only way the government will listen to us. And thank you all for coming to speak about this sensitive topic. As far as I'm concerned, my grandsons and granddaughter, have asked me the same question that our elder raised. Why am I not going to go caribou hunting? And that's something that we have no control over, unless we fight it. We have leaders around the table who are willing to stand and fight this. And I hope that we can agree with the government for the sake of our people. 42 tags isn't enough for one community, let alone the 4 communities that are around the table. We can agree with the government that the numbers are decreasing, but we need to agree to a good number where we can put food on the table for our families. And one more thing, if we are going to use a tag system, then we need to have the government step up. We need the government to step in and provide subsidies. Where the hunters can have subsidies for their gas and ammunition or something that the government can put on the table, for the sake of our elders and our youth.

Kugluktuk HTO:

Larry: Reiterate, since 2007 Kugluktuk has stopped all sport hunts. Only Muskox is being sport hunted. We have tried in the last two years, to try for more grizzly tags, but it's been shut down by NWMB and the GN. Grizzly bear incentive: \$100 for a sample. Could you go above and beyond that like you do for polar bear. Are we getting a new incentive for grizzly bears and for wolves? Are we going to run another incentive program like we do for BNE and Bathurst? We need to put our foot down as the KHTO. I have 4 herds that I need to deal with inter-jurisdictionally. What is the next step with MX 11? Are they going forward with the MX 11 survey that was supposed to be done last year?

Caryn response: First question about sample programs for grizzly. There's a big difference between the grizzly and polar bear samples. We're just starting to increase the amount of information that we can collect for grizzly, whereas for polar bears there is mandatory reporting process. And those samples aren't only used for health, but the DNA is also used to identify abundance estimates. So that when our polar bear bios do surveys, the also use the harvester info for population estimates. Currently there is no harvest limitation on grizzlies, we are just looking at trends. For muskox, MX 11, its really unfortunate that it's taken us a couple of years to get that going. The biggest hurtle we had on this was getting the permits from the federal government, without getting that permit we would've missed about 20% of the management unit and we wouldn't have been able to get a good estimate for that population. The good news is that now the legacy contaminated site has now been cleaned up. That should mean that the ability to get permits, should no longer be an issue, and the survey will be proposed for this year. We see this as a priority, because in having as much information in alternate species, is important so we don't have a negative impact on those species.

Drikus: Incentives question: Subsidies program is a government issue and budgetary issues and it's interdepartmental when those decisions are made. When it comes to the subsidies program, we needed to take budget from research to pay for the wolf funds. The samples are used for research, so some of the samples programs can be enhanced, but others can't.

Amanda: We're sitting here today to discuss a TAH of 42 based on the 2018 report and survey. It's very disconcerting. Before that survey there was a plan to collar 50 females and that the collars would last for three years. Why do we only have 4 now? What happened to the males that were collared.

Caryn: I don't have all the numbers for the collars right now. In 2018, 6 were harvested. The others that were taken were natural causes. Since, there was natural mortality. The male collars, I don't know the current status. But when I requested information in 2019, they had survived the winter. We have access to the collar data, and we can provide a table with all the fates of the collars.

OJ: When you make the grids, you could colour the grids, so you could see the migration of the routes.

Caryn: One of the preparations that Mitch has done for the survey, is the position of the collared caribou. We can present some of this after the break if you're interested.

Larry: In the past, Lisa gave us collar locations for each month from April to June. That's what I got (holds up single map) and last week we got this (holds up multiple maps with routes per month). And this was considered proper reporting. And this is what I want to see. I want proper reporting from this survey.

Caryn: When the maps were sent out they were sent out as they came in, so the ones that Mitch sent out were previous maps all at once. Currently we only have 4 collars on the ground, so we won't be able to provide maps with locations immediately (fewer animals are currently tagged). We have had internal discussions regarding whether we should share heat maps or real time locations. This is a discussion we need to have internally as to what we are willing to share.

Amanda: Question about samples and sample kits. Because of COVID we haven't been able to pick up sample kits. What I'd like to see is mandatory sample kits for DU. You know, I don't know why we're here discussing a TAH from a report we don't believe in. We're looking at 1% harvest from a population number that we don't believe. Things have been missed. What else has been missed. We're concerned about a disconnect between HTO and the government. There's distrust there. Sometimes it's really really hard. Regardless, we try our best to pass the information back and forth. But I worry about what the future working relationship will be. And we're using a report that we really don't like. And I wonder what the number really is. And what 1% of that is.

Bobby A.: Climate change, crossing from Richardson islands to the river. I saw a herd of caribou. Lots and lots of lots, and when I got closer, most of them were bulls, very few females. The government has many resources. I don't want to get to herding reindeer. But it gets to the currents, the currents are changing too. They're changing direction. That's going to do something to the ice where the caribou cross. That's something for the government to look into to. We are the people that get out on the field. We know where all the dangerous ice is. We stay away from it, but the caribou don't know. Having all the technology, we need to know more. Climate change is only getting worse.

KRWB:

Bobby K.: Where to start. Covid. DU caribou decline within three years from 18 K to 4 K. What happened to the 14 K? Speaking to the TAH of 42 between 5 communities. In reality we have 3, bay chino and Bathurst, we're all living in Kugluktuk or cam bay. 42 tags in 3 communities. You have 14 per community. There's about 6 people in one household. How long will that last? A couple days? Earlier mention that only 40% of survey was done in 2018. And you were supposed to do MX 11. Hasn't been done. Funny that you were concerned about doing the survey missing 20% because of Queen Maud Gulf, yet a member of our community says you only did 40% during the 2018 survey. Maybe something to bring up for the next survey, at the last grid line, do you see any additional caribou beyond the survey area? Have a general idea of what caribou is left rather than don't count those.

Peggy: We all know that caribou are being knocked by the wolves, it's part of the natural thing that wolves do? Is it not possible for the surveys to add wolf counters? Where the caribou are, the wolves are. For the survey, keep a close count on the TAH, to have mandatory reporting.

Kevin: my understanding is that all species are counted during surveys, not just the specific species. We will be making sure that the programs are in place to monitor DU caribou.

Ema: We don't have the same herds in the east as is in the west. I can't imagine being given a TAH for the Ahiak herd that we hunt. It's scary to be told that you can't hunt. I've listened about the survey and not being consulted. I can't remember the last time the survey was run, and Lisa piggybacked on KRWB to deliver the survey results. I wasn't here for some of her reports to the HTOs. I've heard some things on how the survey results were given to the communities. The

GN in the past month has agreed to do a 5X larger survey, and the HTOs are happy with that. But imposing a TAH on how past information given to the HTOs, I don't think that's fair to the harvesters because of how the information was delivered. Many of us spent several days away from home to deliver our AGM, because Lisa asked KRWB to deliver the results. I would hardly consider that a consultation. It was only information sharing. So, I'm hoping that future biologists will work with the HTOs.

Bobby K.: I remember we had one conference call, there was really short notice, TAH of 42 put out of nowhere. I don't think our HTOs were notified by the survey results. It sure would've been nice to know that this was coming rather than just one conference call out of the blue. Sometimes harvesters are out on the land and may be doing something illegally without knowing. We Inuit should always be informed of every little thing happening on our lands. This coming out of nowhere was like a slap in the face. Like we don't matter. I'm hoping that in the long run the government will change their ways in communicating before putting on a TAH. Is there any way that we can remove the TAH until the next survey?

Drikus: there is no way to remove it, it needs to run through the NWMB system. This 42 is an interim for this harvest season but could change this harvest season. Denis can inform on the process later. This 42 will change based on a public hearing process, and the survey that Mitch is planning.

Ema: KRWB met around the second week of September to inform me that they will not be distributing the 42 TAH, but we acknowledged in the September 15 letter to Drikus, but later on they met, and acknowledged that there is a decline and we need to deal with it and stressed that we will distribute them after today's meeting, and the board passed a motion working this out. They also mentioned that they didn't just want to distribute the 42 to the different communities with an uncertain survey number. I still don't know when we will be distributing the 42 TAH, but we will. Just uncertain when.

2:51 PM Break

3:12 PM Meeting resumed

Susan: Susan Kutz presentation.

Question from George: Cow being skinned had testicles, what could cause that

Susan response: Hermaphrodites occur periodically in all mammal species, and that sounds like that was the case here.

Presentation resumed- Pass off to Andrea Hanke

Question by Bobby Greenly: With the predation part of it, if you look at the number of predators, matches the decline that was presented in the 2018 report.

Question by Peter Evalik: Does the TK knowledge support western science that has been presented today?

Response by Andrea: In general, TK and western science do support one another, and declines are occurring. Same trends are being observed. The surveys give numbers and TK gives us the information from the past. What's really interesting that's brought by TK, is that the peaks and

the declines started at different times. Starting in Kugluktuk in 2003, but if we look at the curve from Cam Bay, then the peak was in the 2000s and dropped in the mid-2000s. Don't think the populations surveys would've showed that spatial variation.

Presentation resumed- Pass off to Fabian Mavrot

Presentation resumed- Pass off to Javier

Larry question: I find it interesting that the population is 'healthy' yet our population is decreasing

Response Xavier: We should be careful in interpreting these results are. We are talking about body condition and cortisol, which may not relate to population health.

Amanda question: I wanted to ask about sample kits and the number of samples coming in. What would be the implications of a lower sample size on your work?

Javier response: Lower sample size is problematic from a scientific perspective. The smaller sample the lower reliability there is in the results. However, samples can occur from other work, including collaring and other programs.

Amanda question: Clarify, know whether the number of sample kits will have an implication on the study? Kugluktuk had 0 spring of 2020, and now there will be a maximum of 42 samples with the TAH.

Susan response: We won't have any data from spring 2020 to compare the previous years. Sample size per community will be smaller. Fabian also mentioned annual interviews, so even if people weren't harvesting caribou, harvesters and community members can still provide observations and important information from being on the land.

Larry question: FYI Kugluktuk does reporting volunteering of any other species to the wildlife officers.

Putting up maps of collared data by Mitch

Question from Jimmy: Wondering about other migratory caribou that migrate from King William Islands?

Mitch response: Survey strata has not been included for the King William islands. Unknown for right now.

Response from Jimmy: I'd really like to see the area to be included. I know this because I have seen this movement. And so have others near Gjoa Haven.

Mitch response: With that information, another thing that we can do, is potentially discuss collaring animals that could be representative of that movement and possibly genetic scat samples on King William Island to get an idea of how many animals and what species would be occurring there.

Kevin adds: Officer in Gjoa Haven was told by chair of HTO that he harvested animals that seemed to be DU animals.

Bobby Klengenberg question: Did a trip down to Ellis river, spotted DU caribou with Ahiak caribou on Ellis river

Mitch adds: Heard from Baker Lake hunters that they believe that they are at times capturing DU caribou in that area. We have asked for genetic samples for these animals. Caribou do move quite far distances.

4:58 PM break for dinner

Resume meeting 6:30 PM

Attima KIA: I am here on my own, not on behalf of KIA. Everybody here knows that hearing the information from GN about caribou. With that, their population is down, but I don't think it's that, they just moved from where the food is available to them. We are being penalized for the number of tags given.

Peter KIA: Thanks to Caryn for the presentation and overview on the present situation. In 2007 the number started to go down in the past there's been discussion about use of threats calculator (used in 2014). During that period where the numbers were going down, 2007 and 2015, went down to 18 K. Quite a drastic decline. Were threat calculators and other management tools used to identify priorities with the decline?

Caryn response: if you're referring to a threats calculator being used during the listing process, no we did not use this process. However, we did include more collars on the ground, and increased the monitoring on the herd and the DU caribou became a higher priority.

Peter KIA: This tool used by many jurisdictions for wildlife management planning. Leading up to 2018 when it was identified that the pop survey was going to take place, was there any indication of any indication of caribou collars, how many were on the ground in 2015 and 2018.

Caryn response: Over 30 collars were used to inform the 2018 survey.

Peter: the threats calculator is used by other organizations to better understand threats of a species. Proposed program to collar will give more confidence in the data. We need to have higher confidence level in the data.

Bobby G.: The way the collaring system started was in 2014, we weren't keen on the collaring system, we went with 25 collars. After seeing how the animals would react after the first year or so, we added an additional 25 collars. Which gave a total of 50 collars.

Peter KIA: Needs to be clear that all research activities requires collaring, so it's crucial that animals get collared.

NTI:

James E.: Pleasure to know the history of the herd. Dates back to 1950s, and George talked about it. It's a history as well. Regulations are good, but when you don't assess whether it's working the way it's supposed to be working. For example, Muskox, the Canadian government banned the hunt of Muskox, and they thought they were doing a good job. But Inuit were eating the Muskox anyways. They knew that the animal would run in circle. The nature created them,

so let the nature care for them. You need to harvest part of the animals so that the animals are healthy. If the population grows too large the sickness kicks in, therefore reduces the population of the animal. The survey history in 1984 to 1997 they increased 20 K animals and from there it drops. We always say we want less invasive method research, and here we are talking about collaring again. What happened to the consultations before you set the 42? But in the NA you need to consult before a TAH is imposed. I think that's against the Canadian constitution agreement. I think the figure 42 is too small. I don't think you can put a dent in the population with an extra 60 animals. The nature created them for Inuit to feed on them, and that 42 is not enough and I think based on faulty research in 2018. Like the elders said, they saw a number of animals and they were told not to count them. In your mind you have to ask that question: how does that system work. I think there is a better system that estimating the number where we harvest less even though the numbers are needed. I think you have to change your thinking are you going to be popular or unpopular. You're here to work with the people.

Paul: What they said really shows the knowledge that is being passed on and that they have been working with the caribou for a long time, and it shows that they have respect for the animal. We were clearly told that you do not waste. That's one of the unwritten laws of the Inuit. Inuit aren't just going to waste animals they depend on them and we all know that. As for the interim TAH that was put into place it clearly states that you need to tell Inuit that will be impacted before you put it in place with meaningful consultation with the communities. And it was encouraging that you want to hear from people and to make changes. We have already heard from Bobby G. that 2% would be better that 1% and it makes sense they rely on the caribou. So what I'm asking is would you be able to agree to 2% rather than 1% until the next survey is done? When the survey indicates the next number we can revisit it again, but my question is then, if you were to come up with a higher number, would that just be for Nunavut or would you have to share it with NWT? And also, I don't know whether many of the people here understand the system, but I'll ask anyways, how long will this interim TAH be in place, is it until the next survey? As we know, Arctic knowledge is improving. You say it's expensive, and it's true! It is, but with the technology that we have today, like drones, they can do surveys and what not, would that be cheaper, and that's an option that we can really look into. We would like to support the people of Cambridge bay and Bay Chimo on their request to have the TAH increased to 2%. Thank you.

Kevin: My understanding of the jurisdiction of our minister is that any TAH would only be applied to the herd in NU, not in NWT. In terms of the timeline and then when a new TAH would be in place, that would be up to when NWMB to have a meeting, so I would ask NWMB to comment on that.

Denis: I will add comments when NWMB provides comments.

Question from Richard: I was born in Wellington bay, our ancestors didn't go looking for the caribou, they would wait for the caribou. They had drives where they would drive the caribou. When the Europeans came there was a lot of running around and even now. Lots of movements, airplanes, snowmobiles, and mines. The mines make noise, and the caribou run away from the noise. But a long time ago when our ancestors used to wait for the caribou. They didn't make noise. It would scare the caribou. They would use sign language say, get ready they're coming. But now? What are we doing? We're running after the caribou rather than waiting for them. They spook them. I just want to thank NTI for the comments that they make that are very true. Thank you very much.

James P.: All of us here are here to listen and make comments on what we think, It never a pleasure to impose any restrictions or how much you can get to a hunter that can service for 10 thousand year on it. But we are very conservative as well. But we will be here for quite a while, the future generations. Thank you.

George: When you were mentioned on the phone UHTC, they might be on the phone. What is their plan if there are any there for the management for the DU herd? That would be an important piece to know. Not only for them but for us as well. Especially if we have to live with the TAH for months of for years.

Kevin: It is an important question which is why they were included in the meeting today, along with other partners from across the border, but I do not believe that they are currently on the phone.

George: And if they aren't on the phone it would be nice to know how their information is spread.

Bobby Greenly: I can answer a little bit for you there, we have a working group with our HTOs here and Uluhoktok and Paulatok. It's new, and it's something we should have done long ago given what is going on with our shared herd. They mentioned possibly doing an aerial survey and ground-based surveys. We have been working closely with the other HTOs and we have been communicating very very well. But I can't answer anymore, but hopefully that helps a little bit.

Drikus: I can also provide some additional discussion on inter-jurisdictional interactions. Our minister shared the results with GNWT and wrote a letter that identified our concerns. The NWT minister wrote back saying that they were willing to work with us. Ultimately there needs to be discussion as it is a shared herd. Technically the 42 should be a shared TAH, however the time that we feel the herd is the most vulnerable is when they aggregate in the spring and in the fall. Most of the harvest from what I've seen has been in Nunavut. But there will need to be more discussion. There will hopefully be a ministerial meeting that will be bringing together the ministers together soon.

Mitch: there have been initial discussions with the GNWT and affected HTCs and although the plans are still tentative the GNWT is looking to charter their own aircraft, and the remaining three would be the GN and the community members here. And the priority strata that have been discussed would be surveyed. To compliment the surveys, the GNWT hope to run land surveys in areas that wouldn't be possible to be surveyed. Hopefully we will be successful, and the information can be brought together to get a better idea on the herd.

Bobby Greenly: The GN has no jurisdiction in the NWT, but then you mention that the 42 should be shared. So, are you trying to combine the NU and the NWT? I just want to get that clear.

Drikus: The interim decision is just for NU, but when the NWMB makes a decision on the TAH the NWMB needs to consider the harvest in other jurisdictions as well. So, there should be meetings with different jurisdictions. With BNE there was a discussion, and that needs to happen with this herd too. We didn't expect it to be this steep and we didn't feel that we needed a TAH. And the new population was a shock. Which is why we redid the analysis. But at the end of the day, it will be up to the board. When NWT put a moratorium on Bathurst, NU had a harvest for many years after that.

Larry: I wanted to make a comment on the inter-jurisdictional wildlife board. We have an opendoor concept to deal with all our shared herds. We give them our information and they give us theirs. We work together on a specific herd. And in the past, they tried to impose, and we fought back. We are involved on three working groups, for three different herds, and eventually we'll likely see one for Beverly and Ahiak.

James P.: Wanted to follow up regarding what was asked with the GNWT delegates and the participation. For your information when I was still with KRWB we did have a working group with NWT. As well NTI was present. We had a meeting in Edmonton discussing many of the same topics. And the GN and GNWT were present. And we came to a consensus where we wanted to work together and this was the exact same discussions, where we talked about TK and how the communities need to be more involved and representatives from both governments all agreed that it was a good idea to have a good working relationship and have a co-management working group and that's where we left it. UHTC there mentioned that they had never been involved in that level of discussions and I'm sure that the department of environment should have records of that. And the GN biologists were involved. And so, any information from that meeting should have been brought up to the attention of the Inuit government. And both sides agreed that they would be working with the working group. But it has come to this! Now we're talking about an interim TAH. We want a request for a public hearing about this. We can make that request through KRWB.

NWMB:

Denis: 8 months ago, we were all seated around this table, and Jorgen one of our board members that has since passed said: do you know your mandate. I would first start with that, let's start with the clarification of NWMB's mandate. The role of the board is to facilitate or to integrate Inuit input into the government decision making process. And most decisions are suggested by government, but the final decision is also implemented by the government and our role is to make sure that Inuit input is included. On July 18, 2020, we received a letter from the GN to implement an interim TAH of 42. In September, when the board considered the GN proposal, the board reviewed this request and came to two conclusions: 1. Inuit had not been considered, and 2. The board even that it's a tribunal doesn't have any powers with 5.3.24. If the government decides that there is an emergency, then the NA gives you the power to make an interim decision. However, when you do, we will review this decision as soon as practical. So, the minister later confirmed that they would then implement the TAH of 42. So, the position of board is to now gather information. This consultation is a key piece of that process. To answer Paul's question, this item will be on the board agenda in December 2020, whether or not they think that they will have enough information for this, it's up to them to make that decision. But I heard some comments from the government that I would like to clarify, which will help us as we try to analyze and come up with options for the board. The GN said that the interim TAH will be in place until consultations and until more information is present. So, my first question to the GN is, what plans do you have in terms of management decision for DU?

Drikus: Our next steps are, this is a consultation of the 2018 survey, you will receive the 2018 consultation record which will include all of the information that we have received from this meeting. We hope to run a 2020 survey. You can choose to make a decision now, or you can wait until the new results. The process now is to be based on the 2018 result. From a government perspective you have enough information to proceed. We can't tell you what to do. The only concerns after that, is how long it takes to get the report. It could take 6 months or a year. And if the weather is bad, we may not even be able to conduct our survey.

Denis: My next question is about the decision to set a TAH of 42. As I said the GN has full authority to do what they have done. But I have a question of the motivation of urgent and unusual. And this is because I have heard two lines of argument here. So, the urgent and unusual threats, were these related to urgent threat to the species and the unusual threat to Inuit. Was it the threat to caribou that was urgent? Or was it the delay that was caused by COVID?

Caryn: I don't think it's fair to say that the decision was based on one of the other, I think it was based on both. There was an urgent need for conservation of the species, and the unusual circumstance was the global pandemic. If we had waited and not acted, we don't know how bad the situation would've gotten. This wasn't an easy decision, but many factors were taken into consideration when the situation was faced.

Denis: The last question I have is if you can go to slide 13 (slide with the timeline). On December 2019, stated that NWMB staff released population estimates to the public. My question is, when was the intended date for this information to be released to the public? The NWMB provides funding to the government to conduct research on wildlife in NU, and according to the process of administrating that grant, the government researchers have to provide a result to the NWMB one year after the project. We supported the 2018 DU survey and the final results were due September 19, 2019. So, we got a report from Lisa-Marie. After that, in December, we need to inform our board members on the status of our caribou herds. So, we took the information from the report from the GN on the status of the DU. And at that meeting, the board invited the KHTO. And apparently at that meeting, it was the first time that the KHTO heard the results of the 2018 DU survey results. When was the GN intending to release that information?

Drikus: I personally have no issues releasing preliminary information to the community. And we can say that the information is preliminary, and that we are still working on it, but there will be a confirmation and a report to follow up. However, in 2015 preliminary results were released and they were used as part of the COSEWIC process, and the federal agents suggested the listing of DU under SARA. So when we had preliminary results when it went from 18K to 4K, we realized that if we release this information, DU could get listed as Endangered federally. We were criticized by NTI in 2015, and we didn't want to be further criticized. When NWMB released the number, there was no criticism from NTI. Which was interesting. Our intent was to release the number when the final report was submitted.

Peter Evalik: The question I have is if a change can't be made today on the interim TAH, how long will it take for a change to be made? When I asked the GN whether a change can be made, and the GN said no it's up to NWMB, but Denis just said that the decision was made by the GN. So I'm asking for clarification here.

Caryn: What we are saying today is that the interim TAH was made by the GN, given that the normal process couldn't be run. But we're picking up where we left off. We're now going through consultation and providing information to NWMB, and then NWMB will make a formal decision on the TAH. And it is their role to formally decide on a TAH and submit it to our minister.

Drikus: Caryn is 100% correct. And maybe there is a confusion. The minister made this decision, but he can't reverse it like that. When he makes a decision, he takes it to cabinet and it needs to go into legislation as an order for it to go forward. So, our minister presented to cabinet, and cabinet decided on the interim decision. And that can only be changed when the board makes a decision. And this can happen quickly. However, it can also take more time. We

have heard that people are interested in a public hearing, that could take longer. However, it still needs to be taken through the board. The board can decide to have a meeting tomorrow.

Peter: If the results of the survey show favourable, can the TAH be removed almost instantly? We could have a daily report coming from Mitch on how many caribou are being counted daily, would we still need to have a TAH in place?

Caryn: Of course if we get high numbers compared to the 2018 survey, we would put together the recommendation for a different management strategy. But what if that survey comes back and it's not good news. Well then, we'll need to deal with that. Regardless of what that number is, we'll need to address it and make recommendations. We will need to make sure to involve all the co-management into the recommendations.

Peter: Drikus mentioned that the results, they want them to get out there. So, I don't know how you deal with counting caribou. But it would be valuable to know whether Mitch sees 8K caribou a day or 100 caribou a day.

Denis: So first to bring you back to the role of NWMB, the board will begin it's review of the interim decision in December. By that time, they will have provided the board with minutes from this meeting. So, the board will have the 2018 survey report and these minutes, that will detail everything that was said in this room. They may say that we have heard enough to make a decision, or they may decide that we need to hear more from the Inuit and that we need another meeting, ultimately it'll be all up to them. They can make up their mind with what they want to do.

Peter: So, with RWOs and our chairman KRWB, will they have that opportunity to be present to speak what we would like for the board to see? Based on what was said here today. You know, the survey that we don't trust, no proper consultation. I guess, will KRWB and the chairman of the other HTOs affected, could they participate.

Denis: Yes, they are always welcome. But all the co-management partners are important members and can be part of the discussion. What can also help, for the written record, an RWO and an HTO can write in their position on the issue and can be added to the record.

Paul: When GN was created, Inuit had a lot of expectations that they would be represented by this government. So, when you are making recommendations to the board you need to reflect both sides, Inuit knowledge and science in your submission. And that's what Inuit are expecting from their government to be represented. You mentioned that you will be making internal recommendations to the minister, and you heard from these consultations the thoughts from these RWOs, HTOs, and their thoughts are that 2% are more accurate to the needs of the community. So, my question is when you make your recommendations to the minister, will you include this information?

Drikus: Yes, we will. We get the results from the survey, we consult, and then we will do our best to accommodate, then we submit to the board. There is an IQ report as well that will be included in this submission as well.

Paul: Will you recommend 2%?

Drikus: I can't say yes, in case the minister says no.

Paul: Going back to my question and the representation of the minister. Will you relay that information to the minister?

Drikus: Yes.

Mitch: Just a quick addition to the survey talk, there is a process for getting formal results. And there's a method we use, and that's called line counts. And we've done it to other surveys. We look at how the results will compare to the previous year. So, we will do that and we will be able to make decisions pretty fast.

Peter: So, with the lines, will they be the same as the last survey? or will it be the 5X larger areas

Mitch: Yup, we're shooting for an area that is 5X greater than the 2018 survey. Even though we are surveying more area and we expect more information, we expect we will see most of the animals in the coastal areas. We can also compare the same areas that were surveyed in 2018 to the upcoming survey, and we can take that information to know whether it will be higher or lower than the previous year. So we can relay to all stakeholders whether we think that the population estimate will be higher or lower than the 2018 survey.

Kevin: Can you speak to the urgent need for observers

Mitch: We are hoping to have 4 planes. One will be staffed by GNWT, but the other three will be staffed by GN staff and community members. In three planes, we'll need a minimum of 12 observers, and maybe a few backups in case someone is no longer able to attend. If we can get the most experienced hunters and observers that would be ideal. We will be in a day early to go over the methodology with the observers, and we want a lot of community involvement.

Kevin: In terms of logistics I can be a primary point of contact for this. Myself and Amelie can be a point of contact for this.

Mitch: At the start we hope to have two planes in Kugluktuk and two in cam bay and surveying the high priority strata, and then we will go to the option 1 areas, and then we will keep going if we are lucky with weather.

Bobby Greenly: what is the max number of days?

Mitch: 4.5 days for option 2, 7 days for option 1. But if there are any weather days or any turnarounds we will need to adjust for that. Another concern is how many caribou we could possibly be missing because of poor sight ability. If we get poor visibility and poor weather, we'll need to go to the next step. However, we're going to hope for good weather, but we'll be pulling out all the stops. We have a couple methods to know whether all the caribou are being counted, and we'll be doing that.

Rosemin: Have the strata in option 1 been prioritized?

Mitch: Yeah, they have. As soon as it's done I will send it to everyone, and if anyone wants a higher priority area, that's easy, just let me know and I can change it around.

Peter: Being a treasurer for the HTO, I'm always thinking money. I'm assuming that the GN will compensate.

Mitch: Yeah, absolutely. They will be.

Peter: Bev don't forget to sharpen your pencil.

Attima: After the survey is done, who will be writing up the IQ report, is it the same as the scientists?

Caryn: The traditional knowledge study was just completed by Andrea Hanke from U of C and those results were shared with the communities and co-management partners.

Rosemin: I would like to provide an update for today. Just so all the communities are aware, we are working with the GNWT to do ground-based surveys. So, we will be also collecting information in that way. So, we just spent the afternoon with the HTC to discuss the information there, and will share information as soon as available.

Mitch: reminder to please share letters of support, this survey requires full community support.

8:26 PM short break then closing remarks

Closing remarks:

KIA:

Peter: We appreciate getting to participate in the discussion. Thank you.

Rosemin: I have no comments because I missed most of the meeting, but I look forward to reading the minutes. I didn't have much to say. Thanks.

U of C:

Andrea: Thank you for letting us participate and to Kevin for moderating.

NTI:

Burt: I don't have anything to add.

James E.: Thank you Kevin. I'd like to say that all of us represent the same population and we need to make a sound decision by working together, and I'm hopeful that the upcoming survey will be done properly. There's lots of times that research being done isn't done the way it should be. And the outcome is negatively imposed on harvesters. And we don't want to see that. Let us see more accurate rather than estimate of population counting. We're going to be here and we are the consumers of our wildlife and we will be for quite some time in the future. And I would like to thank all of you for taking part, the more the better. I just came back from a round table discussion of the biggest project yet in Nunavut that is being proposed by Baffinland. It's a big project that will be affecting almost the whole north, and I think we need to be listened to, the people. You need people. Especially harvesters when something like this is being imposed on them, we need to do our part, but most of us have been saying that what you are suggesting is unacceptable and that it's based on faulty information. All of us are working for the same

people, and we need to make sure that we're representing those people. Is it really a conservative estimate, we need to know. And we need to work together. Have a good trip back home. Hopefully the NWMB will make a sound decision on behalf of the people they represent. Thank you.

Paul: Thank you elders for your wisdom. You've lived with caribou for a long time. And you've experience living without it. I have full confidence that the survey will be done with Mitch, he's a good man. He can get the job done properly. I expect that we will hopefully see different numbers, good numbers with the proper survey being done. This is a public government we need to be consulted. Hopefully, that will be done in the future too. Meaningful consultations. There may be times in the future where this happens again, but consultations are important. They build trust. We expect our government to do proper consultations. It's a tough job for NWMB, they need to balance both TK and science, but they can do it they've done it before. Thank you and thank you for having me.

Bobby Greenly: Thank you to everyone who participated today. Thank you to our elders and interpreters. These types of situations are difficult. But we're discussing and hopefully we're moving forward with getting better numbers and a better count. But the trusting is a big thing. And I think it'll work out to everyone's favour. Like the elders say that we all have to work together. I've learned so much in the last 7 years as chair. And that's with everything. Going out on the land, you learn as you go, you learn lots. Every time you go out you learn something new. Meetings are the same. At every meeting, we learn new things. I'd like to say a big thank you to everyone in this room that participated today.

George: Thank you everyone. I do have mixed feelings hearing everything that I have heard today. You know when we come across problems in our life, we dig down to reach those problems, we're not doing that here. Hunters who have the least impact on these animals are being targeted, but they aren't the problem. You know that you need to go directly to the problem. In this case, predators. We're being targeted as the impact of the decline, and that's not right. I feel badly about having to work with it this way. I have explained that over the years elders have told us there will be rises and falls. I have seen the caribou and the Muskox come and go. It's a cycle. Mother Nature controls that cycle. And for us to impede that is wrong. We shouldn't be penalizing hunters. They're not the direct cause. Thank you.

Peter: Thank you to all of the people here. They have all the science but the TK knowledge that's just as important as the western science. Thank you for the clarity. I'm just a young guy in comparison to these elders.

Bobby K.: Thank you to everyone for coming. I'm not used to this large group gathering anymore. But getting used to it. I'm not happy with the 42. We would like it to be increased by 60 tags. Growing up all my life. I have seen the caribou migrate all my life. And for my whole life they have been crossing. The DU out of all caribou have the largest ocean to cross, all other caribou cross lakes, but the DU cross the ocean. When the DU cross, they usually have a couple inches of ice. But for caribou if the wind breaks up the ice they can't go anywhere. That could be the major cause for the caribou decline. The migration route changes. Elders tell us that. But putting the tag of 42 without consultation, it hurts. Regardless of whether you hear our voices or our opinions nothing can be changed. I hope that the next survey results are better. For 40 years I've seen the caribou move through there, and I think that this survey will be the most populated survey with caribou. My issue nowadays is predators, and I'm hoping that in the long run we can minimize the predators and get funding through our HTOs to help with the gas costs and other costs. Our own locals can go and take care of predators in these remote areas. It hurts to know that we need to divide 42 tags. It causes issues and conflict between people and communities. And on that note, I'm hoping that it can be increased another 60 until the next count is done. Thank you very much.

Ema: Thank you for inviting KRWB. Good to be here and to listen to concerns. I hope that from here we can work closer, this is not an easy subject to talk about and I hope that we are more informed next time around. Thank you.

Larry: Thank you for this meeting. As everyone has stated, I am quite certain that the next survey will be done properly. It is hard for Inuit. I'm talking for the largest Inuit community in the Kitikmeot. I have a lot on my mind but thank you everyone for participating and I look forward to going to Iqaluit for the NWMB meeting. Thank you.

OJ: This is my first survey and thank you for having me.

Amanda: We need action on past surveys. We need to look at other factors that are impacting our herds. I'm always happy and proud to speak on behalf of our board. I speak for our community members and I speak for our elders and our youth. I speak for my dad and for my son. I hear from my dad, speak from what you know. Speak from the heart. So thank you.

Bobby K.: Meeting objectives were going in the right direction. Shows that we can communicate and work things out. I think one thing we need to deal with is climate change that we can do nothing about.

Larry: Thank you to Cheryl for her work on Kugluktuk Community Management Plan.

Peter: Thank you for the invitation. And I want to echo what has been said about Mitch. I think he'll do a good job. I have worked with him in the past, and he works hard, and I want to commend him on his hard work.

Sam Kapola Burnside HTO: Thank you for inviting me. And thank you to Cam bay for hosting us. The Inuit are being pointed at as the cause for the decline.

Attima: I have experience working with NWMB, and it's mostly Inuit working with the board even though the chair isn't an Inuk. We always want to hear about the IQ knowledge. For caribou declining there's a lot of issues that touches the decline. Predators are still a concern. When the population is low, we maybe use .2% of the population. In December meeting, I hear that will be a conference meeting. Which is too bad, but we have to stay healthy.

Jordan: thank you to cam bay, and we will be taking all the information that was shared today and other documents.

Kevin: I easily learn more one day than spending an entire day behind my desk. I think it's very important for the co-management to work together.

Drikus: Thank you very much to everyone who took the time to come today. In my view, this is a great example of the co-management process. We may not always agree, but I feel that we will have a way forward. This was a very constructive meeting. We're very committed to working together and I just wanted to make sure that the people are aware of our responsibility. We have a commitment according to the Nunavut agreement.

Caryn: I don't have a lot more to add, but I would again, like to say thank you. Thank you for allowing us to come here and for coming here to chat with us and help us move forward. We just want you to know that we will do everything we can to make this process go smoothly.

Jimmy.: Just for caribou, we only have discussion on caribou, and I don't really like the TAH as an elderly person. But we have to work together and the staff who are listening you need to take into consideration the advice of our elders. Their advice is still important and we need to pay attention to it. Seeing that caribou are declining, myself I have seen the caribou activities in my area. You also need to remember the ancestors' advice; those are the ones that we shouldn't forget. Their advice is on the spot. Thank you all.

Richard: I just want to thank you for the opportunity to voice my opinions and what we have done today and faced fear. Because if you don't face fear it will overtake you. And what we are doing here is overcoming the fear of the caribou declining. But we need to work together and have faith. But this number is too low. We need to have faith with the people that have done the survey. I have worked with Mitch before and I know we will get good results. We need to think positive. Thank you.

Naikok Hakongak: We as Inuit know how many caribou are out there but we don't usually count them. We say we see few or a lot. But I look forward to seeing how the scientists will count these caribou. If I go out there and they say, don't count outside the lines. I'll bring a notebook and count outside the lines and I will count all of the predators that I see. Safe travels to all those going home. And thank you for inviting me.

Cheryl: Thank you to everyone for their time and their honesty today. I wanted to add a bit of context to a question that George had with our working relationship with the NWT. We do have an active working group. Our working with the HTCs is facilitated by NTI and by YMAC, and it's a form where we can share our conservation concerns. We do have that working group face to face. And again, thank you it's a pleasure to see you all face to face after a number of months, and good luck with the upcoming surveys.

Mitch: I just want folks to know that I'm very honored to be part of this working group. I've learned early on that the success of any survey relies on Inuit knowledge. If there's any ability that I have to work on these surveys has been by listening to the Inuit throughout my career. Throughout this process I hope that people will be free to continue sharing that knowledge. People around the table may be involved and I hope they can share their knowledge during their survey. We will do the very best we can, and we hope we can get a result that people can feel we can work forward with. Thank you so much.

Jason: thank you very much I'd like to speak in Inuktitut. Thank you for letting me be part of your meeting. I haven't spoken but I have listened. As you have a big concern, and I am listening. Although we have different roles, although I am coming from the GN we have one common goal. We have a concern because wildlife is our prime resource for providing for our families. Although we have differences and different opinions, we don't want to see that come between us. We need to move forward although it's a difficult task. We know that this will not only happen now but again in the future. We have listened to your concerns and what you don't like about the process, but what I'm saying is that we need to work together as well. That's what I want to talk about. Although we have different views different concerns, we have a common goal and we need to work together for a common solution. I'm hoping that we can work together. Thank you very much for welcoming us. I hope that when we meet again, we'll have a better solution for our people. Thank you very much.

James P.: Thank you everyone who was seated here today. I also appreciate all the comments. I'm very happy for all of your presence. Listening to the elders, I appreciated it. I appreciate the presence of the HTOs. We can see that you are trying to help your people. And for our younger generation we have to have that too. And of course, people have concerns. I'm aware of that as to how to put food on the table for their family. However, everyone has to work together. And we need to listen to our elderly people. Thank you everyone. I give you my appreciation for the ability to speak and express my concerns, but my heart feels a bit better even if I don't like the TAH. We need to have better working groups and working relationships and we need to improvise those needs for our younger relationships. Have a good and safe trip home. Thank you to all.

Attima: Update the meeting in December will be in person!

Closing prayer James E. Meeting ends at 9:30 PM.



Population Estimate of the Dolphin and Union Caribou herd

(Rangifer tarandus groenlandicus x pearyi)

Coastal Survey, October 2018

and

Demographic Indicators

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> NUNAVUT DEPARTMENT OF ENVIRONMENT WILDLIFE RESEARCH SECTION KUGLUKTUK, NU

Executive Summary

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

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

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

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

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

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

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

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יףףייכה שיטיריהי פרסילישליטליטל כים יטפאלרכפליי גריטיכייאי סטבאהטר פיאראסלהי סי \dot{P} ር $\sigma P^{<}$ /ሥታ ሀር $\sigma P^{(n)}$ ረላ) እንጋ $\Delta^{(n)}$ /ሥታ የረገር PC የሪካ (ር Δ አ $P^{(n)}$ - σ b $D^{(n)}$ ሀ የ $\Delta^{(n)}$ ᢗᡃ᠋ᢣᠯᢀ᠋᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆ ᠘ᡐᡄ᠆ᡏᢕ᠆ᢆᠫ᠋ ᠣᡆ᠘ᠳᠳᡗ ᠘ᡐᡄ᠋᠆ᡏ᠘ᡐ ₅P⊃Ci Δ° Γ° Λ° Λ° $2018-\Gamma \quad \text{inverse} \quad \text{inver$ հահեր 14,730- Cl=11,475-17,986) $D^{b}D^{c}$, Cl=11,475-17,986) $D^{b}D^{c}$, ቴካሪዮል የምምም 18,413-୬୮୦ (SE=3,133.8, CV=17%, CI=11,664-25,182) ጋ₽ጋ∆ና (ፈንግህፈጭ 1). aher C P de C P dΔL°QΔς%ጋቡ 4%–Γ' ϷϿዮჾჼ<< ና%ጋ' ላናና JcĹ% ነь አሥራምቦ'. ϷϿዮჾჼ< ና%ጋ' Lー・ጋቦ', ブンΔ'

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Aulapkaijini Naittumik Uqauhiit

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

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

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

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

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

Malingittumik hivuagun ihumagijauhimajuni taapkuat DU tuktuit utimuujungnaiqpaktun ikikligaangata, una tadia naunaijarutait gunguhinirmiagagtuni tuktuni ilitturipkaingittug amigaittun ilanginni tuktuni utimuungittun iluilingmun ukiunguraangat. Talvannga 2015-2016min 2018millu qunghuhinirmiaqturnirmi pinahuarutimin, ilitturipkaidjutikhat pijun taapkunannga 35nin ukunanngalu 49nin DU gunguhinirmiagagtunin tuktuinnin hailihmajun naunaijarnirnun. Hapkunannga, malruunginnaujuk pidjutik tuktuinni ikaangittun iluilingmun, pivaktuq uvani ukiumi 2016-2017mi. Kihimi, Ulukhaktokmin anguniaqtit unniutihimajun amigaiqjuummiqtun DU tuktuit tahamaniiraanginnaliqtun Kiillinirmi (Victoria Island) ukiuqtamaat. Taimaitkaluarhuni nalautpiaqhimajuq amigaitilaangin ilanginni tuktuinni tahamaniittun gikigtami ilihimajaungittug, una naunaijarnig naunaitkutaa utiuvaktuni tuktuni pidjutiujukhag ihumaaluutaujukhaq anguniaqpaktunun nunguttailinikkut Dolphin Union tuktuinnik, ihumagingillugin tahamaniittun ikittun katimajun utiujuittun DU tuktuit najuqtaat Tununganiani Kiillinirmi, taimaittungittunarhingmat amitaitilaakkut tamatgiutikkut hapkunani tuktuinni ilangautilimaittun gajangnagtukkut ikiklidjutainnik tautukhimajun taapkunaulluagtuni, utiujuktuni amigaitilaanginni tuktuinni.

Ukuat DU tuktuinni naunaijarnikkut pidjutainni, ukuallu tautukhimajuni amigaitilaakkut naunaitkutini, naunaiqtittun aularaanginnaqtumik, anijumik taimaalu, qangannuani ukiumi, angaugpiagtug, ikiklijuummirnig. Taimaatun pitguhikkut piangaijarnikkullu anginigagtukkut tuktuinnik ukununga Nunavunmi nunallaani anguniaqtinullu Iqaluktuuttiami, Omingmaktomi, Kingaonmi, Kugluktumilu Nunatsiamilu nunallaani Ulukhaktomi Paulatumilu, ikiklijuummirnig DU tuktuinni ihumaalungnaqpiaqtuq nunallaanun, anguniagtinun, naliinnilu-nunagijaujuni paannarijaujuni. Taapkuat pidjutait tunihimajun uumannga naunaijarnirmi tautuktitait qajangnarutait tuktuinni umanilu ihariagijauqpiaqtuni pivallialiurnikkut nakuujunik, naliinninunagijaujunin hanaqidjutikhanik ingattagtailinikkut aulapkainikkut turaangajun ikiklijuummirutainnik pipkainikkullu amigaiqtirutainnik DU tuktuinnik. Pidjutainnin aallanganikkut anginiqarnikkullu tuktuinni, anginiqaqpiaqtuq atauttikkutuumani aulapkaidjutikkut paannariit havagatigiiktukhat kiujaami ikiklijuummirnig talvuuna aularaanginnaqtukkut aulapkaidjutinik. Malikhugin angiqtauhimajun Dolphin and Union Tuktuinni Aulapkainikkut Hivunikhami, uvani ikittuni tuktuinni, amigaitgijaujun nunguttailinikkut ganuriliurutikhat pivallialiugtaujukhat tammagtailinikkut DU Tuktuit ikajurlunilu annaktihimanikkut tuktunik.

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Introduction

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

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

In 1994, Nishi and Buckland used the barren-ground calving ground population survey methodology in a study area, which represented 63% of Victoria Island. The study area included the entire west side of the island, from the south coast to the north including Prince Albert Peninsula, all the way west of Hadley bay. They established five strata of uniform coverage in all strata (10% coverage). The survey was run during calving season from June 5 to 14 and resulted in an estimate of $14,529 \pm S.E.$ 1,015 caribou. This assessment underestimated the total number of the DU Caribou herd or the total number of caribou on Victoria Island (Peary Caribou and DU Caribou), since an unsystematic aerial search in the eastern portion of Victoria Island confirmed additional female and calf pair sightings outside of the study area from the Collinson Peninsula up to Storkerson Peninsula (Nishi and Buckland, 2000). The inadequacies of this survey method indicated that the DU Caribou herd should not be surveyed based on the traditional calving ground methodology, as these caribou seem to have an individualistic and dispersed calving ground strategy (Bergerud, 1996). In addition, the estimate from the Nishi and Buckland (2000) survey most likely included the Peary caribou herds mix in the summer range is not fully understood. In response to the inability to effectively delineate a specific calving ground, due to the DU Caribou individualistic calving strategy, a new survey method was developed by Nishi and Gunn (2004). To develop this new methodology, hunters provided valuable input to identify when would be the best time to survey this herd, during a time when they are not mixing with the Peary Caribou. Based on hunter observations and local Indigenous Knowledge, the survey was designed to survey the DU Caribou when both sexes were known to gather during the rut within a narrow band (10 km from the shoreline) on the southern coastline of Victoria Island. The caribou wait along this coastline (known as staging) as the sea-ice forms enough for them to resume their migration. During this time, their daily movement rate is presumed to be relatively low and assumes that the majority of the herd are found along the coastline at the end of October.

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

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

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

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

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

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

Methodology

Study area

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

species, such as the purple saxifrage. The lakes are surrounded with sedge, cotton grass, saxifrage and moss (Environment Canada, 1995).

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

Collar deployment 2018

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

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

Population Estimate

Integration of Local Knowledge in the Survey Design

On September 28, 2018, a month prior to the survey, the relevant Nunavut co-management partners including the affected Hunters and Trappers Organizations (HTOs) of Cambridge Bay and Kugluktuk, Nunavut Tunngavik Inc. (NTI) and the Government of Nunavut Department of Environment (DOE) met to review the survey design and include additional local observations and co-management partners' recommendations. Scientific information, such as the 2018 collar distribution locations that show consistency between the previous two collaring years and the distribution of DU Caribou collar data as

of September 09, 2018, was made available for discussion. Based on the available collar distribution and the recent observations, it was agreed that the survey effort should be concentrated to the west side of Victoria Island as all the collars were located west of Wellington Bay in September. Since 15 collars out of the 50 collars were captured on the east side of Bathurst Inlet the previous spring, the HTO members stipulated that these collars were not representative of the proportion of the DU Caribou herd that are known to summer east of Cambridge Bay. Therefore, it was recommended that the reconnaissance survey also include the east side of Victoria Island, as it was done in 2015. It was also decided that the inland collar locations would be investigated by flying to the collar and determining the number of caribou in the group associated with it. In the event that the number of animals was greater than 50, the area around the collar would be stratified and included as a separate inland visual stratum in the final count. For the reconnaissance survey, it was recommended that the transect lines were extended 20 km inland to account for additional caribou groups between the collared caribou, to ensure the main distribution of DU caribou was captured and incorporated into the estimate.

Collar caribou movement and survey design

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

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

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

Once a portion of the collared caribou reached the coast, the systematic reconnaissance survey was flown on the southern coastline of Victoria Island, from Read Island to Parker Bay, allowing stratification of the final visual coastal survey, while collared caribou outside the coastal area continued

to move toward the coast. Caribou that spend the summer farther north, west of the Shale Mountains, arrive later at the coast. Thus, enough time to survey the final visual strata was allocated before the first collar began to cross the sea-ice. Sea-ice formation is known to occur earlier on the eastern side (Dease Strait) than on the western side (Coronation Gulf), which also influences the pattern of the caribou migration and the chronological order in which the final visual coastal survey strata was surveyed. If two or more collars had started to cross the sea-ice before the specific final visual coastal strata was surveyed, the survey would have been cancelled.

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

Aircraft configuration

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

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

Where, W= the required strip width; h = the height of the observer's eye from the tarmac; and H= the required flying height (Figure 1).

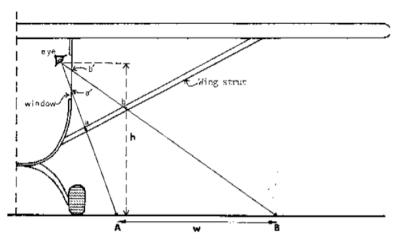


Figure 1: Schematic diagram of aircraft configuration for strip width sampling North-Griffiths (1978). W is marked out on the tarmac, and the two lines of sight a'-a-A and b'-b-B establish, whereas a'- and b' are the window marks.

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

Final visual coastal strata estimate

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

$$\widehat{N} = RZ = Z \frac{\sum_{i} y_{i}}{\sum_{i} z_{i}}$$

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

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

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

Extrapolated Population estimate

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

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

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

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

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

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

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

Overall Trend

The 2018 estimate was initially compared to the 2015 estimate using a t-test to determine if the two estimates were significantly different (Gasaway et al., 1986). Log-linear models (McCullough and Nelder 1989; Thompson et al., 1998; Williams et al., 2002) were then used to analyze trends from 1997 to 2018. A primary emphasis of this analysis was to test if the trend from 2015 and 2018 surveys

differed from previous surveys. This model assumed an underlying quassi-Poisson distribution of estimates with population change occurring on the exponential scale. Survey estimates were weighted by the inverse of their variance therefore giving more weight to the more precise estimates. A log-link was used for the analysis therefore allowing direct estimates of yearly rate of change as one of the regression β terms. Additive terms were used to determine if the trend from 2015 to 2018 was different than previous years.

Population demography

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

Cow survival rate

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

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

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

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

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

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

Pregnancy rate

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

Spatial analysis

Annual home range between 2015 to 2019

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

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

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

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

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

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

Average Href: 28383.69667

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

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

Results

Collar Deployment 2018

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

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

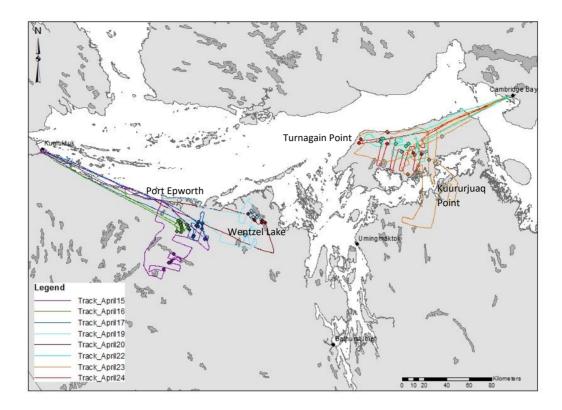


Figure 2: Map of Bathurst Inlet showing the 50 Dolphin and Union caribou collaring locations and flight tracks between April 15 to 24, 2018, on the west side of the Inlet and on Kent Peninsula.

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

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

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

mortality, a site examination would have to have been performed, which is expensive and logistically challenging.

Body condition of captured caribou in 2018

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

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

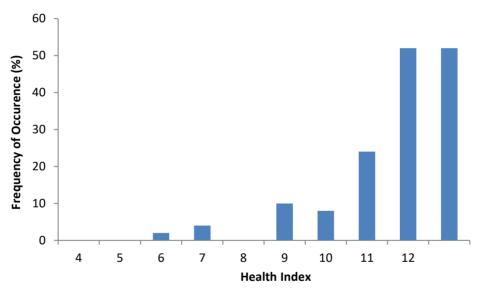


Figure 3: Average body score condition displayed as frequency of occurrence (%) of captured Dolphin and Union Caribou in 2018 (n = 50). The index score scale range from 4 to 12, where low numbers represent unhealthy caribou and high numbers represent healthy caribou.

Population estimate

Dolphin and Union collar 2018 fall distribution

From October 15 to December 15, 2018, the collar locations of 38 available DU Caribou on Victoria Island were closely monitored. An overview of each collar path during this period was plotted on a map for visualization (Figure 4). All the collars were located west of Wellington Bay and not farther north of Read Island. Progressively, between Lady Franklin Point and Cape Peel, the collars crossed to the Canadian mainland to their wintering ground, north-west of Bathurst Inlet. On November 3, 2018, one

mortality event off the coast of Byron Bay (DU-181-2018), likely due to drowning, happened during the survey and this collar was no longer monitored or included in the extrapolated population number.

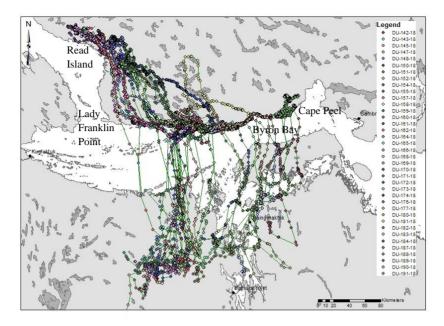


Figure 4: Overview of the movement pattern of 38 collared Dolphin and Union Caribou from October 15 to December 15, 2018.

Systematic reconnaissance survey

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

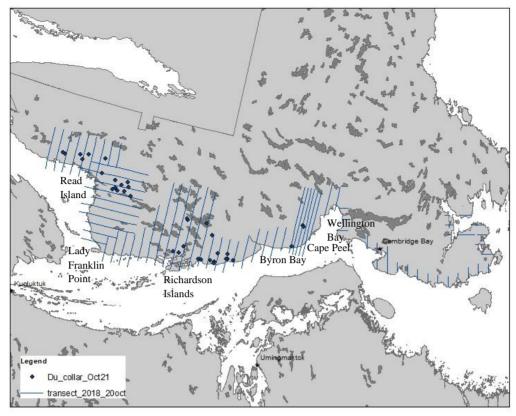


Figure 5: The reconnaissance survey design, based on collared caribou locations (n = 38) on October 21, 2018, in relation to the coastal study area extending from the shoreline to 10 km inland on the East side to over 20 km inland on the West side of Wellington Bay.

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

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

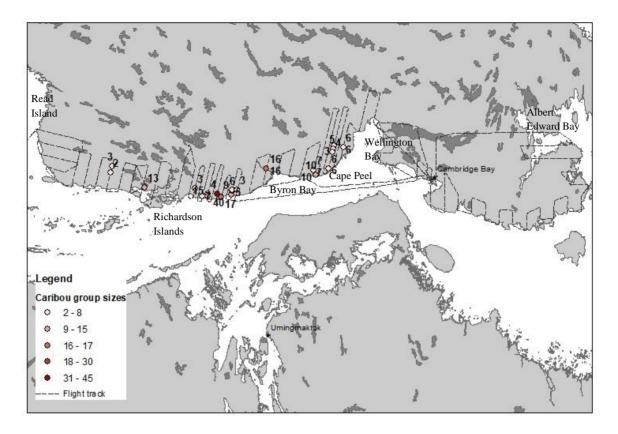


Figure 6 :Reconnaissance survey lines flown based on the locations of 38 Dolphin and Union caribou from October 21, 24 and 25, 2018 in relation to the coastal area extending from the shoreline to 10 km inland the East to over 20 km inland west of Wellington Bay. The dots represent caribou observations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

Final systematic visual surveys

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

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

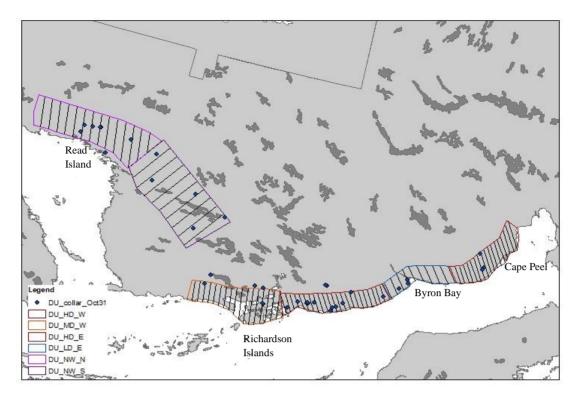


Figure 7 :Final visual stratification layout showing all strata for the 2018 coastal survey of Dolphin and Union caribou. Low density east (LD_E, blue), medium density west (MD_M, orange), a high density east (HD_E, red) and a high density west (HD_W, red), and the two inland strata in the northwest: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

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

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

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

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

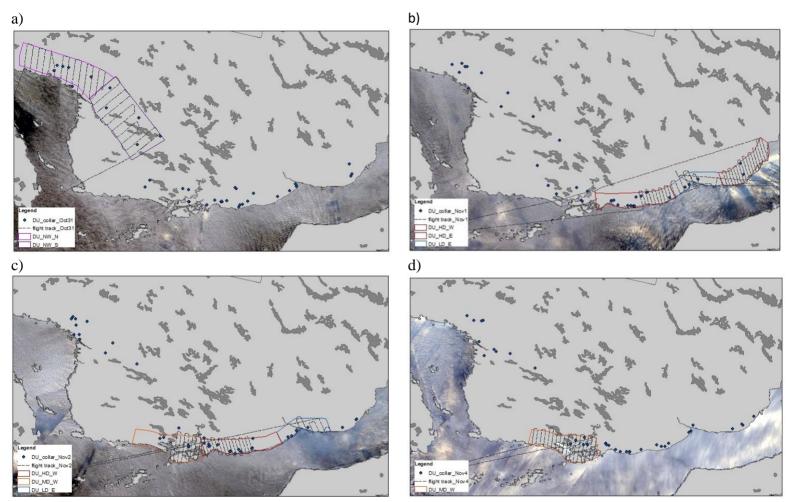


Figure 8: Daily location of Dolphin and Union collared caribou in relation with the final visual stratum surveyed (flight track) and sea-ice formation for a) October 31, b) November 1, c) November 2, d) November 4.

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

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

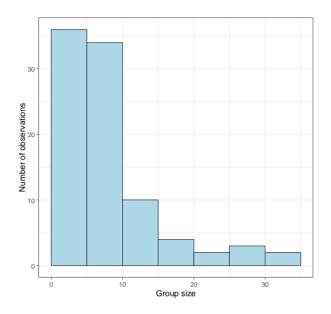


Figure 9: Distribution of caribou group sizes observed during the final visual surveys for Dolphin and Union caribou on October 31, November 1, 2, and 4, 2018.

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

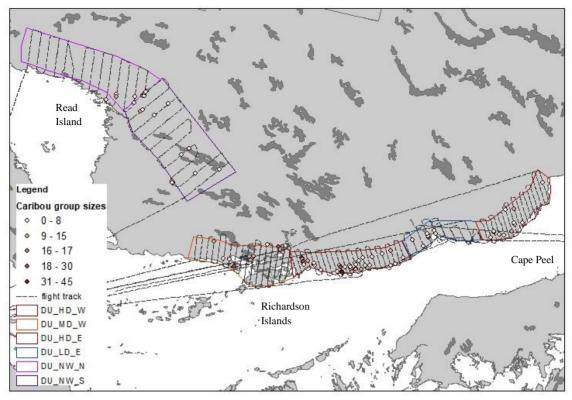


Figure 10: Distribution of Dolphin and Union caribou based on the location of the groups observed during the final visual stratification. Flight tracks flown from October 31 to November 4 are also shown for reference.

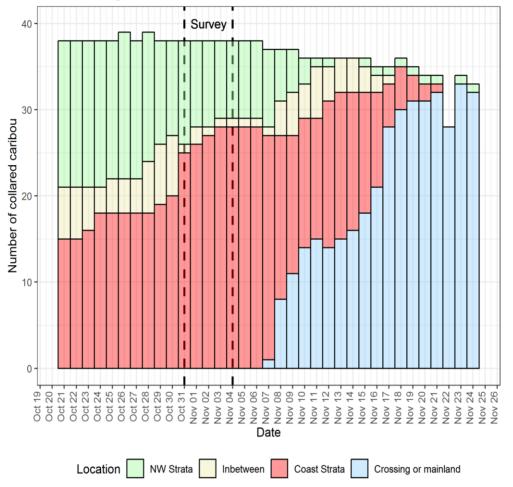
The final estimates from the six visual strata are given in Table 4. The highest density of caribou was observed in the HD_W stratum with 1.8 caribou per km² and the lowest density was found in NW_N strata with 0.22 caribou per km². Two-thirds of the population was estimated in the HD_W strata. The resulting estimate of 3,673 (SE= 595.5, CV= 16.2%, CI= 2,660-5,073) caribou was relatively precise with a coefficient of variation of 16.2%.

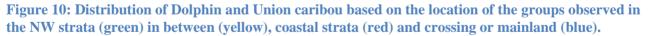
Strata	Caribou counted on transect	Density (Caribou per km ²)	Estimated caribou (\widehat{N})	Standard Error (\widehat{N})	Coefficient of variation
HD_E	74	0.34	259	81.7	31.6%
LD_E	63	0.73	389	187.2	48.2%
HD_W	395	1.76	1,460	443.0	30.3%
MD_W	123	0.50	550	157.5	28.7%
NW_S	62	0.27	622	190.4	30.6%
NW_N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

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

Collar caribou movement and survey design

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





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

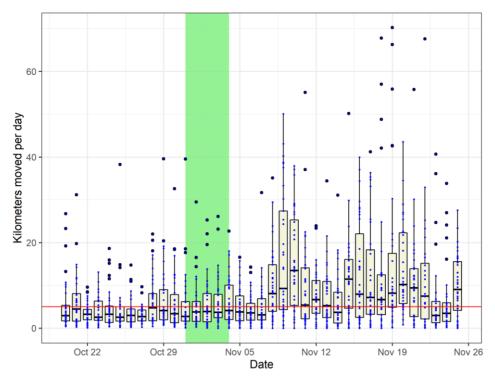


Figure 11: The daily movement rate of the caribou during the final visual strata survey. The dates the survey was conducted are delineated by a green band.

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

Collar		Surv	ey date		Colla	r present		
	10/31/18	11/01/18	11/02/18	11/04/18	4/18 All strata Coasta			
DU-142-18	NWN	NWN	NWN	NWS	1	0		
DU-143-18	NWN	NWN	NWN	Out	1	0		
DU-145-18	HD2W	HD2W	HD2W	HD2W	1	1		
DU-147-18	MD_W	MD_W	MD_W	MD_W	1	1		
DU-148-18	NWN	NWN	NWN	NWN	1	0		
DU-150-18	MD_W	MD_W	MD_W	MD_W	1	1		
DU-151-18	HD2W	HD2W	HD2W	HD2W	1	1		
DU-152-18	Out	MD_W	MD_W	MD_W	1	1		
DU-154-18	HD2W	HD2W	HD2W	HD2W	1	1		
DU-155-18	NWS	Out	Out	MD_W	1	1		
DU-157-18	HD2W	HD2W	HD2W	HD2W	1	1		
DU-158-18	HD2W	HD2W	HD2W	HD2W	1	1		
DU-159-18	MD_W	MD_W	MD_W	HD2W	0	0		
DU-160-18	NWN	NWN	NWN	NWN	1	0		
DU-161-18	NWN	NWN	NWN	NWS	1	0		
DU-162-18	NWN	NWN	NWN	NWN	1	0		
DU-164-18	NWN	NWN	NWN	NWN	1	0		
DU-165-18	HD2W	HD2W	HD1W	HD1W	0	0		
DU-166-18	HD1W	HD1W	HD1W	HD1W	1	1		
DU-168-18	HD_E	HD_E	HD_E	HD_E	1	1		
DU-169-18	NWN	NWN	NWN	NWN	1	0		
DU-170-18	MD_W	MD_W	MD_W	MD_W	1	1		
DU-171-18	LD1E	LD2E	LD2E	HD_E	1	1		
DU-172-18	NWS	NWS	NWS	NWS	1	0		
DU-173-18	NWS	Out	MD_W	MD_W	1	1		
DU-174-18	HD2W	HD2W	HD2W	HD2W	1	1		
DU-176-18	HD2W	HD2W	HD2W	HD2W	1	1		
DU-177-18	HD2W	HD2W	HD2W	HD2W	1	1		
DU-180-18	HD2W	HD2W	HD2W	HD2W	1	1		
DU-181-18	LD1E	LD1E	LD1E	LD1E	1	1		
DU-182-18	MD_W	MD_W	HD2W	HD2W	1	1		
DU-183-18	HD2W	HD1W	HD2W	HD1W	1	1		
DU-184-18	HD2W	HD2W	HD1W	HD1W	0	0		
DU-187-18	NWS	NWS	NWS	NWS	1	0		
DU-188-18	HD1W	HD1W	LD1E	LD1E	0	0		
DU-189-18	HD_E	HD_E	HD_E	HD_E	1	1		
DU-190-18	LD1E	LD1E	LD1E	LD2E	1	1		
DU-191-18	HD_E	HD_E	HD_E	HD_E	1	1		
				Total	34	24		
				Mean	0.89	0.63		

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

Extrapolated population analysis

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

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

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

Overall trend

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

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

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

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

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

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

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

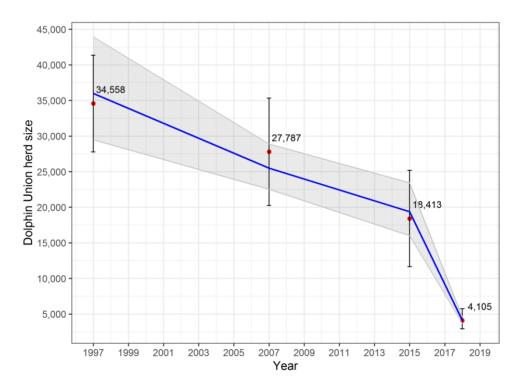


Figure 12: Estimates of herd size for the Dolphin and Union caribou herd from the 1997 survey (Nishi and Gunn 2003), 2007 survey (Dumond and Lee 2013), the 2015 survey (Leclerc and Boulanger, 2018) and 2018 survey. The blue line represents the log linear model estimates of herd trend (Table 7) and confidence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

Population demography, 2018

Collared caribou movements and survival rates

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

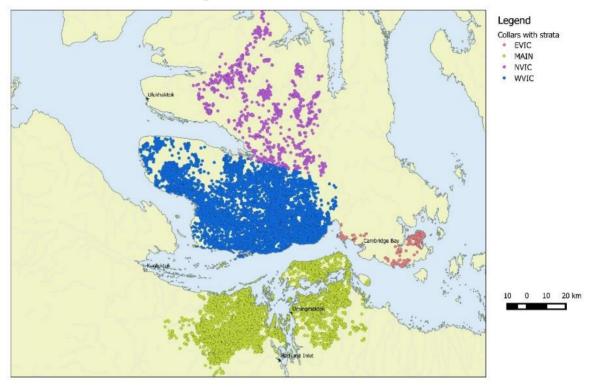


Figure 13: Assignment of Dolphin Union caribou collar locations groupings into specific areas within the herd's range: East Victoria Island (EVIC, blush), Mainland (MAIN, green), North Victoria Island (NVIC, purple) and West Victoria Island (blue).

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

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

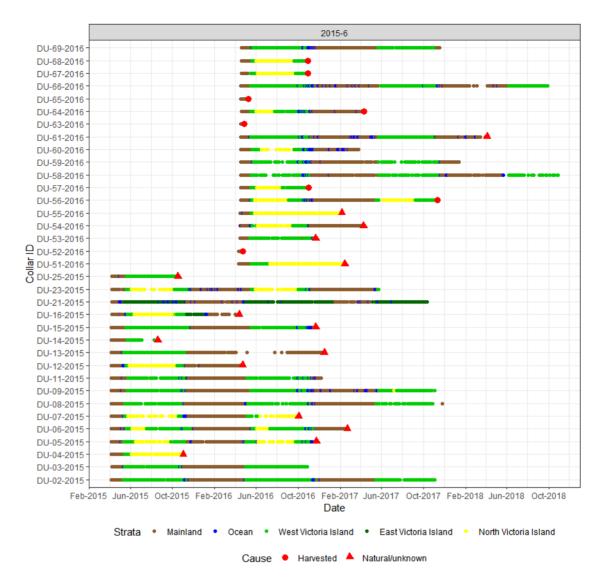


Figure 14: Collar histories for 35 collars deployed in 2015 and 2016. The location of collars for each month is given relative to Victoria Island or the mainland or ocean (crossing). Fates are given for known mortalities. If no mortalities are denoted (by a red symbol) then it is assumed the collared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

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

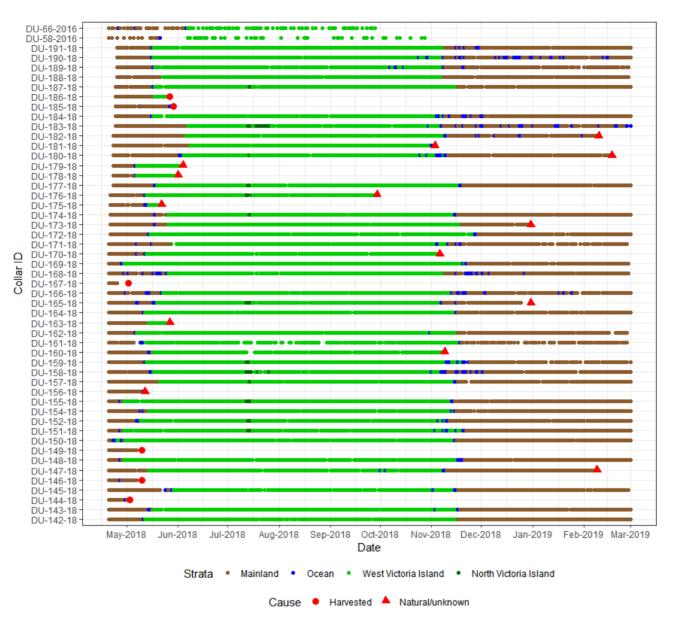
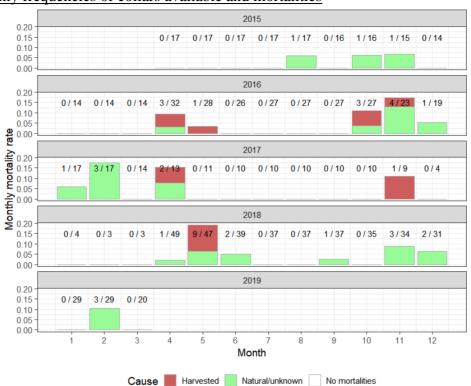


Figure 15: Collar histories for 49 (46 F and 3 M) collars monitored in 2018 and two collars from previous deployment (DU-66-2016 and DU-58-2016) from late April 2018 to March 2019. The location of collars for each month is given relative to Victoria Island or the mainland or ocean (crossing). Fates are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

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



a) Monthly frequencies of collars available and mortalities

b) Mortality locations (2018)

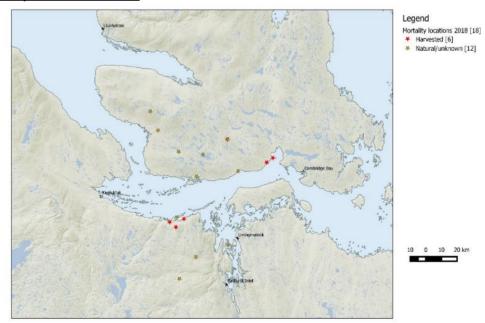


Figure 16: a) Summary of monthly active collared caribou and mortalities from 2015 through 2019, for collared Dolphin and Union caribou, with monthly mortality rate given as a ratio (number of deaths per total number of active collars), b) Dolphin and Union caribou mortality locations in 2018, categorized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

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

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

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

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

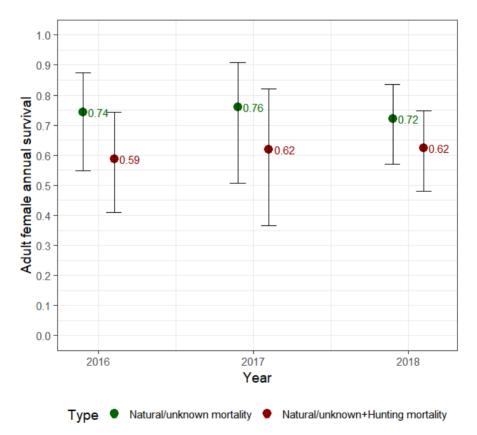


Figure 17: Estimates of yearly survival of Dolphin and Union caribou from 2016 through 2018 with the mean number of collars monitored per month, by type of mortality, with survival rates given next to data points.

Pregnancy rate

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

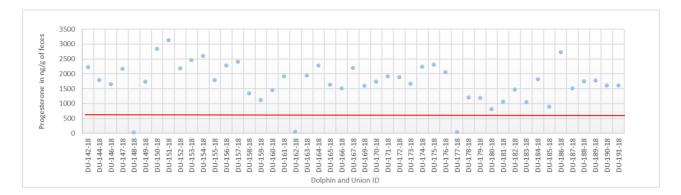


Figure 18: Progesterone level in feces (ng/g) for each female Dolphin and Union caribou collared. Levels below 600 ng/g were considered as non-pregnant.

Spatial analysis

Annual home range between 2015 to 2019

Based on telemetry data from collared caribou tracked between 2015 and 2019, the annual home range of DU caribou progressively constricted and shifted to the western part of the range (Figure 19). The annual home range went from 198,704 km² in 2016-2017 to 128,803 km² in 2017-2018, which represents a decrease of 35%. This was observed as a lower number of caribou using their usual summer range in the northwestern part of Victoria Island, as well as the eastern part of the range around Cambridge Bay.

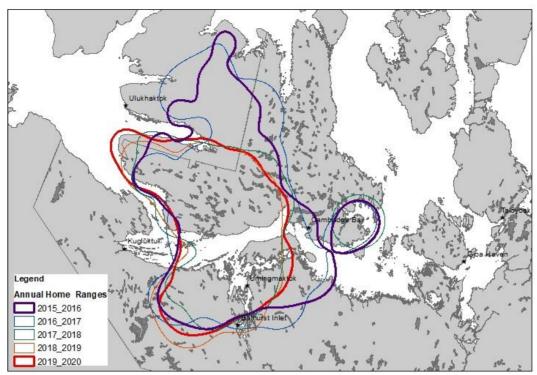


Figure 19: Variation of annual home range of the Dolphin and Union caribou showing a contraction between 2015-2016 (purple) and 2019-2020 (red).

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

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

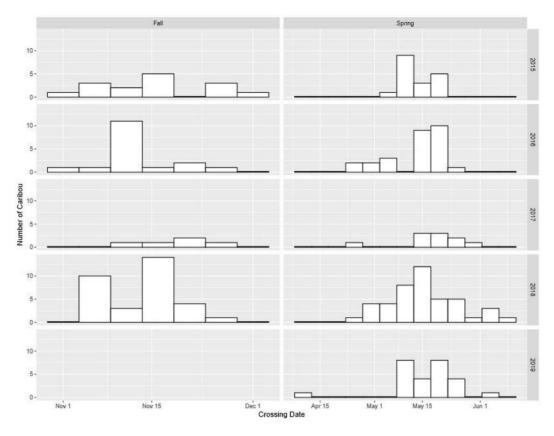


Figure 20: Number of Dolphin and Union caribou crossing the sea ice between Victoria Island and the mainland during fall and spring migration, per season and per year, from April 2015 to June 2019.

Discussion

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

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

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

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

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

contained within all the survey strata (inland and coastal strata), which is a higher proportion of collars than was included in the survey area in 2015 (79%) (Leclerc and Boulanger, 2018).

For the first time, the DU Caribou herd survey included two inland strata (NW_N and NW_S) in the final survey strata. The decision to include these was based on the fact that 10 collared caribou were located in a defined area with the presence of additional caribou groups, between observed collar locations considered likely. During the 2018 survey, no collared caribou were observed in the middle or North of Victoria Island and investigations of this area were therefore not performed. The highest density of caribou was found in the HD_W strata with a density of 1.76 caribou per km². This high density stratum is considerably lower than high density of caribou per km² in 1997 and 3.85 to 5.84 caribou per km² in 2015 in the high density stratum at that time (Nishi and Gunn, 2004; Leclerc and Boulanger, 2018).

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

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

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

Collar data suggests (Figure 14 and 15) that all the collared caribou migrated in the Fall of 2018 (figure 15). In the winter of 2016-2017, two animals (DU-51-2016 and DU-55-2016) of 35 caribou monitored did not migrate in the fall and stayed in northern Victoria Island before both became mortalities in the middle of the winter, (February 2017). It is possible that these two animals could have either spent the entire winter on Victoria Island or migrated at a later time, however this is unlikely given that they were

still in northern Victoria Island in February. Late migrating caribou were also recorded in the fall of 2015, where a collared individual migrated in December (Figure 20). While the population was declining in numbers, no change in migratory behaviour amongst the majority of collared caribou to non-migrating animals was observed in any particular collared individual that was followed for more than a year and for an entire winter (Figure 14). If the observed decline was related to a change in migratory behaviour, than it would be expected that a proportion of the migratory collared caribou would stop migrating. Thus a change in migratory behaviour is unlikely contributing to the current, observed decline. The continuation of the migration between 2015 to 2019 (Figure 20) also suggests that the DU Caribou migration is, in fact, not currently population size or density driven. The 2018 extrapolated population estimate (4,105) has fallen well below the 1980 estimate of 7,936 caribou at a time that the herd was assumed not to migrate due to the low number of caribou (Gunn and Fournier, 2000).

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

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

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

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

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

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

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

The reproduction rate is one of the most important parameters used to monitor the growth potential of a population (Bergerud et al., 2008). Pregnancy rates are usually established by udder counts in June or calves at heel during the peak of calving. However, this would be an expensive method to determine pregnancy rate for the DU Caribou herd due to their independent, dispersed calving strategy spread across Victoria Island. Thus, pregnancy rates were determined by measuring the level of fecal progesterone in collared caribou cows. Pregnancy rates of the collared DU Caribou herd, were considered relatively high at 94%. During the 2018 collaring, a total of 40 Dolphin and Union sample kits were also collected by harvesters on the ground. The pregnancy rate from the harvester sample kits

(n=29) provided a different pregnancy rate. The pregnancy rate from the available Dolphin and Union caribou sample kits resulted in nine individuals being non-pregnant and a pregnancy rate of 69% (Fernandez. pers. comm.). The caribou sampled from the harvesters might be more representative of the pregnancy rate of this herd because captured caribou were biased toward fatter and healthier looking caribou based on CARMA criteria, with the net effect of biasing collared caribou to more likely being pregnant (Figure 3). For the George River Caribou Herd, a pregnancy rate of 89% to 100% was needed for the herd to increase, while pregnancy rates from 59% to 78% were recorded when the herd was in decline in the early 1990s (Bergerud et al., 2008). In any case, adult female survival rates are low and need to increase to allow herd stabilization or increase, regardless of pregnancy rates.

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

Conclusion

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

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

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Kitikmeot Traditional Knowledge Studies on Dolphin and Union Caribou, 2003 and 2018-2020

(Rangifer tarandus groenlandicus x pearyi, island tuktu)

Research update



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Roles of researchers and other contributors:

2003 Ekaluktutiakmiut and Kugluktukmiut Traditional Knowledge Study on Dolphin and Union Caribou

Kugluktuk Angoniatit Association: Amanda Dumond and the board of directors reviewed project deliverables. Results were presented at the Kugluktuk Angoniatit Association's annual general meeting in January 2019.

Ekaluktutiak Hunters' and Trappers' Organization: Beverly Maksagak and the board of directors reviewed project deliverables. Results were presented at the Ekaluktutiak Hunters' and Trappers' Organization annual general meeting in January 2019.

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University of Calgary: Andrea Hanke led the interview analysis and reporting with input from all partners, including co-supervisors Susan Kutz and Cindy Adams, in 2018-2020.

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Government of Nunavut: Lisa-Marie Leclerc provided input on the project design and took part in the interview analysis. Terry Milton contacted Kugluktukmiut knowledge keepers to schedule interviews and reviewed transcripts. Provided honoraria costs, in-kind office space, and technical expertise. Kate England, Lisa-Marie Leclerc, and Caryn Smith reviewed project deliverables.

University of Calgary: Andrea Hanke led the project design, implementation, interview analysis, and reporting with input from all partners, including co-supervisors Susan Kutz and Cindy Adams, in 2018-2020. Juliette Di Francesco assisted during the focus groups and feedback sessions.

EXECUTIVE SUMMARY

Dolphin and Union (DU) caribou (*Rangifer tarandus groenlandicus x pearyi*, locally referred to as island tuktu) were recently assessed as Endangered by the Committee on the Status of Endangered Wildlife in Canada in 2017. The recorded DU caribou history includes a limited collection of Western knowledge and Traditional Knowledge studies. In this project, we thematically summarized Traditional knowledge on DU caribou from interviews in 2003 with Ekaluktutiakmiut (15) and Kugluktukmiut (15) and interviews in 2018-2020 with Kugluktukmiut (33). The information gained provides important insights on the history, abundance, distribution, and health of DU caribou.

Methods in brief: This report presents Kitikmeot Traditional knowledge of DU caribou documented in two separate projects. The Government of Nunavut, Department of Environment initiated the first project in 2003, and it involved structured, individual interviews and participatory mapping. The second project began in 2018 as a collaboration among the Kugluktuk Angoniatit Association, Government of Nunavut, and the University of Calgary. The 2018-2020 project involved semi-structured individual interviews, focus groups, feedback sessions, and participatory mapping, involving 56 points of contact with 33 Kugluktukmiut over 2 years. We analyzed the interview transcripts using a qualitative analytical method, thematic analysis, to find patterns within and across the interview accounts in each individual project. We digitized and analyzed the participatory maps within ArcMap (Esri) using built-in geoprocessing tools to illustrate and summarize the Traditional knowledge keepers' (TKK) mapped DU caribou ranges and hunting areas (DU caribou hunting areas in 2003; general and DU caribou hunting areas in 2018-2020). We used the term 'Kitikmeot Traditional knowledge' in accordance with the requests from Kugluktukmiut involved in the 2018-2020 study.

Context of Observations: TKKs explained that their observations of DU caribou distribution and abundance depended on their personal spatial areas of expertise and observation. A key theme from the interviews was that DU caribou and people used the land in accordance with annual and seasonal variations. They said that the lives of DU caribou are dynamic and that they are constantly adapting to the changing environment around them.

Distribution and Abundance: TKKs mapped the past and present distribution of DU caribou and their hunting ranges. Of the DU caribou range mapped in 2003, approximately 24% mapped by Kugluktukmiut fell outside of the current ECCC (2018) range map for this herd. The total hunting range area in 2003 had decreased to approximately 1/3 of the total historical hunting area for both communities. However, based on the 2018-2020 interviews, Kugluktukmiut hunting range had increased since the early 2000s.

TKKs described fluctuations in DU caribou abundance over time with very low numbers in the 1920s to 1950s. Recent declines in abundance appear to have occurred at different times in different communities. For Kugluktukmiut, the herd peaked in approximately the mid-to late 1980s and had since declined to approximately 40% of that abundance peak by 2020. The western boundary of the DU caribou distribution, historically extending far west of Kugluktuk on the mainland, progressively shifted eastward from Kugluktuk and towards Ekaluktutiak. This was coincident with an abundance decline in the west (confirmed in narratives and mapping). Today, Kugluktukmiut mapped similar total area for the herd's range per decade (1980-2010). While no new interviews were done in 2018-2020, previous participatory interviews in 2014 by Tomaselli et al. (2018) indicated that the herd peaked near Ekaluktutiak from 1990s to mid-2000s and had since declined to approximately 20% of this abundance peak by 2014.

In interviews from 2003 and 2018-20, TKKs indicated that DU caribou could be found on both the mainland and Victoria Island year-round. Further, the 2003 TKKs said that not all DU caribou would make the migration back to Victoria Island and more caribou were migrating off the island near 2003 than had previously. They said the timing and likelihood of migration was influenced by DU caribou abundance and the timing of sea-ice formation. Severely delayed sea-ice formation was observed to result in DU caribou crowding staging grounds, poorer body condition, and moving eastward while waiting for the sea-ice to form. TKKs described progressively riskier fall travel seasons for DU caribou. They described that unstable sea-ice formation resulted in more DU caribou falling through thin ice and drowning, becoming hypothermic, receiving injuries, and/or experiencing increased energy loss compared to previously.

Health and concerns: In 2003, TKKs described or named conditions consistent with brucellosis and tapeworm cysts in the muscles in DU caribou. However, Kugluktukmiut emphasized more concern about DU caribou health conditions than Ekaluktutiakmiut did in 2003. TKKs said sick DU caribou were more frequently observed during the spring when the caribou were the skinniest. Kugluktukmiut in 2018-2020 expressed concerns about the following impacts on DU caribou well-being and as possible causes of declines: poorer hunting practices of inexperienced harvesters (caribou herds and predators); increased non-renewable resource exploration and traffic; climate changes; increasingly unstable sea-ice, and increasing insect harassment (intensity and diversity). TKKs said that predator harvesting was not as common nor practiced the same today compared to the past. This has resulted in increased predator abundance. In the 2003 interviews, TKKs said the introduction of rifles in the 1920s resulted in more successful caribou hunts, but that more caribou mortalities had resulted from harmful sea-ice encounters and severe ground freezing that prevented access to vegetation.

Management Recommendations: Kugluktukmiut were asked in 2018-2020 what could be done to help protect DU caribou. They advocated for education opportunities for inexperienced harvesters as the most feasible, short-term action to mitigate pressure on the DU caribou herd for long-term outcomes. People suggested this could include pairing together inexperienced hunters who want to learn with experienced hunters who want to teach, and that this could be done through a coordinated effort between the Kugluktuk Angoniatit Association and the Government of Nunavut. TKKs did not agree whether the Kugluktuk Angoniatit Association or the Government of Nunavut should implement a restriction similar to a Total Allowable Harvest, but they emphasized that such a strategy would need to adapt alongside changes in the DU caribou abundance.

Conclusion: The Traditional knowledge interviews in 2003 and 2018-2020, together with those done by Tomaselli et al. (2018) in 2014, have provided critical insights into the abundance, distribution, and health trends of the DU caribou. TKKs' concerns for DU caribou were brought forward and they provided management recommendations. Key findings demonstrate that the cumulative historic DU caribou range is much broader than their current distribution, and that seasonal distribution and migration is perhaps more variable than previously documented. Considering the full and cumulative extent of the DU caribou range within current management plans is critical to manage landscape-use if a full recovery of the herd to historical numbers and range use is desired. The community-based knowledge on DU caribou distribution, abundance, and health was nuanced and complementary within and between Ekaluktutiakmiut and Kugluktukmiut accounts. Specifically, the different spatial and seasonal use of the land and interactions with the caribou by Ekaluktutiakmiut and Kugluktukmiut provided critical insights at different times in the life of DU caribou. This highlights the critical importance of involving multiple communities and TKKs from across the DU caribou range to understand the full life history of DU caribou, including seasonal and spatial variability, and to develop effective herd-level conservation approaches.

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OVERALL INTRODUCTION

This report presents information documented during two separate Traditional knowledge projects focused on Dolphin and Union (DU) caribou. The first project started in 2003 with Ekaluktutiakmiut and Kugluktukmiut, and the interviews were not analyzed fully until 2020. The second project was done in 2018-2020 with Kugluktukmiut. Research ethics boards at the University of Calgary (REB17-2427) and the Nunavut Research Institute (#04 003 19R-M) approved both projects in 2018. The teams involved in these projects come from diverse backgrounds, including experts in caribou health and social science methodologies and methods at the University of Calgary, Ekaluktutiak Hunters' and Trappers' Organization (EHTO), Kugluktuk Angoniatit Association (KAA), and the Government of Nunavut, Department of Environment (DOE). The results of these studies are presented below, starting with (1) the 2003 Ekaluktutiakmiut and Kugluktukmiut Traditional Knowledge Study on DU Caribou.

For context, the Traditional knowledge keepers (TKK) involved in these studies colloquially referred to DU caribou as island tuktu or as a crossbred caribou between Peary and barren-ground caribou. Harvesters consistently distinguished DU caribou from Peary and barren-ground caribou. In Ekaluktutiak, the accessible barren-ground caribou herds include the Bathurst and Beverly herds. In Kugluktuk, the accessible barren-ground caribou herds include the Bluenose East, Bathurst, and, some years, the Beverly herds. Although TKKs were specifically asked about DU caribou, it is possible that some TKKs' comments could, on occasion, refer to their experience with these other herds rather than DU caribou. DU caribou are traditionally harvested by Kugluktukmiut on the mainland in the fall and spring, on southwestern Victoria Island in late summer before the rut, and on the southern shoreline of Victoria Island when they start their fall migration. Ekaluktutiakmiut also harvest DU caribou on the southern shoreline of Victoria Island when they start their fall migration.

2003 Ekaluktutiakmiut and Kugluktukmiut Traditional Knowledge Study on DU Caribou

BACKGROUND & METHODS

In 2003, the DOE initiated Traditional knowledge study on DU caribou because of concern about DU caribou drowning, unknown harvesting rates, and to document Traditional knowledge on DU caribou distribution and movement. The project involved structured, individual interviews with Ekaluktutiakmiut (15) and Kugluktukmiut (15). The interviews explored historical DU caribou abundance trends, spatial and temporal migration trends, and trends in body condition and abundance when the herd migrated and times when it did not migrate (see *Appendix A* for interview guide). There was an assistant present during each interview who, when needed, translated back and forth between Inuinnaqtun and English and completed the transcriptions from the audio-recordings. Each TKK created a participatory map comprising DU caribou seasonal locations (summer and winter), migration movements (spring and fall), and DU caribou hunting areas that they used in the past (before 2003, no exact years indicated) and present (2003). No monthly detail was recorded for the participatory maps. In 2017, analysis of these data started with a collaboration with the Kutz Research Group at the University of Calgary, Faculty of Veterinary Medicine, in 2017.

We base the following results on an analysis led by Andrea Hanke, PhD student, University of Calgary. We used a specific philosophical approach, an interpretivist paradigm and critical realism ontology, to help negotiate the differences between Traditional and Western knowledge (Maxwell and Mittapalli 2011). We digitized and analyzed the participatory maps using geoprocessing tools in ArcGIS (Esri software). Then, we incorporated these maps to the narrative analysis and compared the mapping summaries to the ECCC (2018) range map for DU caribou. We analyzed the interview transcripts by community (two separate analyses) using a qualitative analytical method, thematic analysis. This allowed us to use coding strategies to assign labels to the data in order to find patterns within and across the interview accounts (Braun and Clarke, 2006). We used two different coding strategies for the thematic analysis: a holistic strategy which focuses on clumping topics within the data and organizing subcategories within those topics and an in vivo strategy that focuses on assigning labels to the data using the exact words of the TKKs (Saldaña, 2013). Following the coding, we used concept mapping to help visualize the interactions amongst the codes. We presented the initial results at the EHTO's and KAA's annual general meetings in January 2019 as a chance for the community to provide feedback on the analysis. After incorporating this feedback, we presented the results at the DU caribou user-to-users working group meeting in May 2019 and the EHTO's special meeting with Transport Canada that focused on ship icebreaking in October 2019. The results presented here will focus on population, health, distribution, and habitat of caribou as documented by the TKKs.

RESULTS

Thirty people, nine older than 55 and six younger than 54 from Ekaluktutiak and eight older than 55 and seven younger than 54 from Kugluktuk, were interviewed for this study. All 30 interviews were transcribed, and all 30 individual participatory maps were digitized.

Participatory Maps (Fig. 1&2a,b&c)

The participatory maps depicted DU caribou seasonal ranges, DU caribou migration routes, and TKK's DU caribou hunting ranges (*Fig. 1&2a,b&c*). Four hundred and eight polygons denoted summer (64) and winter (67) caribou ranges, past (pre-2003) (146) and "current" (2003) (131) DU caribou hunting ranges, and 524 polylines denoted fall (265) and spring (259) migration routes. The DU caribou range mapped by the TKKs represented approximately 52% of the total ECCC (2018) DU caribou range. Divided by community, Ekaluktutiakmiut covered approximately 37% and Kugluktukmiut covered approximately 32% of the total ECCC (2018) DU caribou ranges were approximately 81% inside and 19% outside of the ECCC (2018) DU caribou range (*Table 1*). Of their total DU caribou range mapped in 2003, approximately 4% mapped by Ekaluktutiakmiut and 24% mapped by Kugluktukmiut fell outside of the current ECCC (2018) range map for this herd.

DU Caribou Range by TKKs	Inside ECCC (2018) Range	Outside ECCC (2018) Range
Both Communities	81%	19%
Ekaluktutiakmiut (total)	96%	4%
Summer	95%	5%
Winter	100%	0%
Kugluktukmiut (total)	76%	24%
Summer	93%	7%
Winter	71%	29%

Table 1. Comparison between TKKs' DU caribou range maps and ECCC (2018) management plan range.

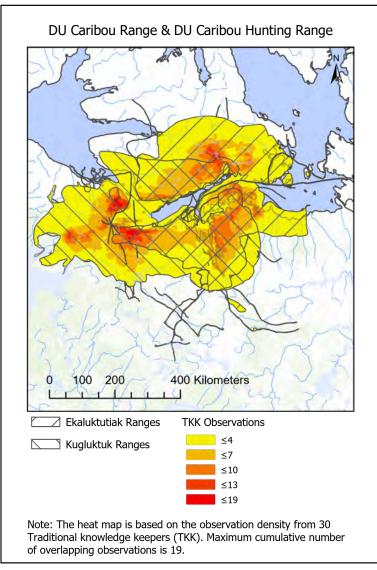
Changes in hunting areas

Kugluktukmiut mapped ranges extended further west and south than those delineated by Ekaluktutiakmiut. Ekaluktutiakmiut mapped ranges extended further east and north than those delineated by Kugluktukmiut (*Fig. 1*). For both communities, the area (km²) covered by "current" (2003) DU caribou hunting ranges declined to approximately 1/3 the area of those used in the past (pre-2003) (*Table 2; Fig. 3a&b*). There was no explanation why these changes occurred nor a defined a time period for the past hunting (pre-2003).

Table 2. DU caribou range and DU caribou hunting range summarized, as mapped by TKKs in 2003. The only values that consider overlapping areas is the community overlap column.

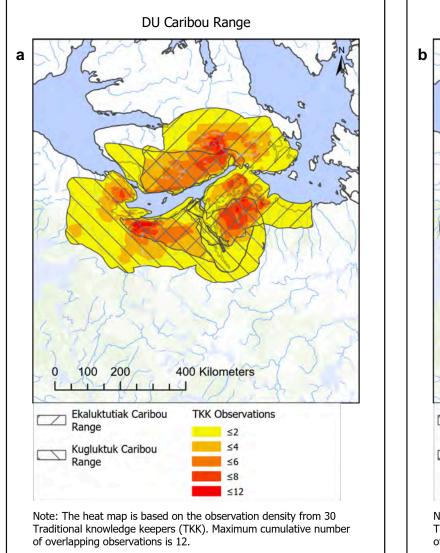
Range Type	Total Area	Ekaluktutiakmiut Area	Kugluktukmiut Area	Community Overlap
All Mapping	277 100 km ²	173 700 km ²	193 100 km ²	89 700 km ²
DU Caribou	248 200 km ²	149 100 km ²	164 200 km ²	65 000 km ²
(% of all mapping)	(90%)	(86%)	(85%)	(72%)
Summer	170 800 km²	121 100 km ²	78 300 km ²	28 600 km ²
(% of total DU caribou)	(69%)	(81%)	(48%)	(44%)
Winter	189 900 km²	98 600 km ²	138 900 km ²	47 700 km ²
(% of total DU caribou)	(76%)	(66%)	(85%)	(73%)
DU Caribou Hunting	165 300 km ²	80 200 km ²	107 100 km ²	22 000 km ²
(% of all mapping)	(60%)	(46%)	(55%)	(25%)
Past (pre-2003)	150 300 km²	67 200 km ²	104 200 km ²	21 100 km ²
(% of total DU caribou hunting)	(91%)	(84%)	(97%)	(96%)
"Current" (2003)	58 100 km ²	26 200 km ²	32 400 km ²	400 km ²
(% of total DU caribou hunting)	(35%)	(33%)	(30%)	(2%)

Figure 1. Combined DU caribou range and DU caribou hunting range as reported by Ekaluktutiakmiut and Kugluktukmiut in 2003. Colour gradient is based on the density of observations.

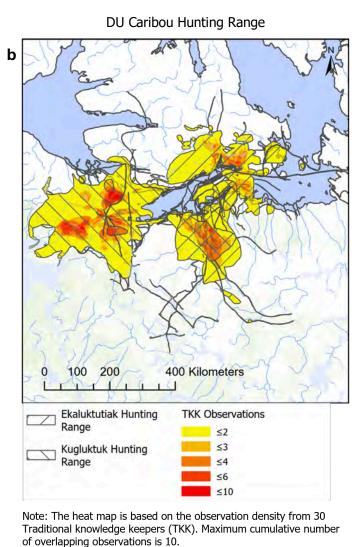


Base Maps Source: Esri Canada, Canadian Community Maps contributors; NRCAN Hydro, Land Coordinate System: NAD 1983 UTM Zone 12N Projection: Transverse Mercator

Figure 2. Summaries of DU caribou range (a), DU caribou hunting range (b), and DU caribou migration routes (c) as reported by Ekaluktutiakmiut and Kugluktukmiut in 2003. Colour gradient is based on the density of observations.



Base Maps Source: Esri Canada, Canadian Community Maps contributors; NRCAN Hydro, Land Coordinate System: NAD 1983 UTM Zone 12N Projection: Transverse Mercator



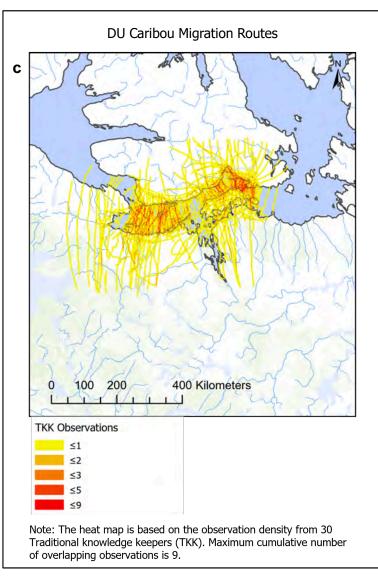
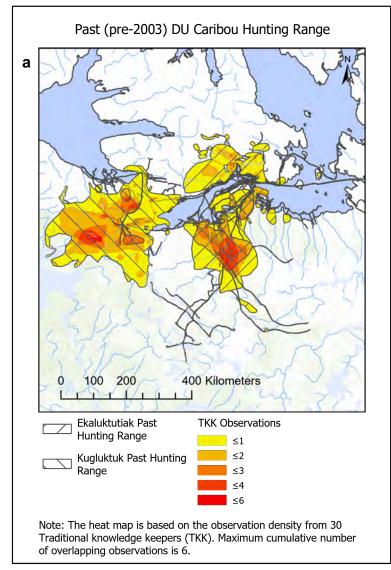
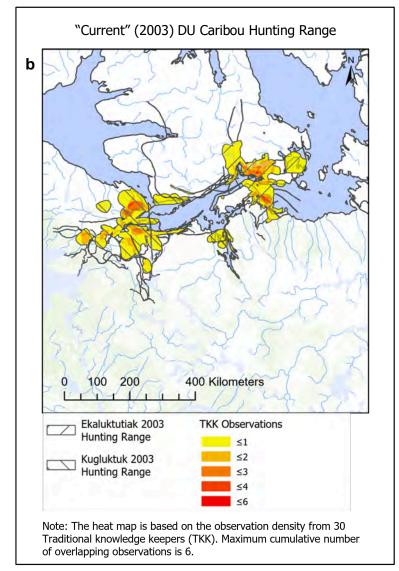


Figure 3. DU caribou hunting range in past (pre-2003) (a) and "current" (2003) (b) as reported by Ekaluktutiakmiut and Kugluktukmiut in 2003. Colour gradient is based on the density of observations.



Base Maps Source: Esri Canada, Canadian Community Maps contributors; NRCAN Hydro, Land Coordinate System: NAD 1983 UTM Zone 12N Projection: Transverse Mercator



DU Caribou Behaviour

Related to abundance (Fig. 4a,b)

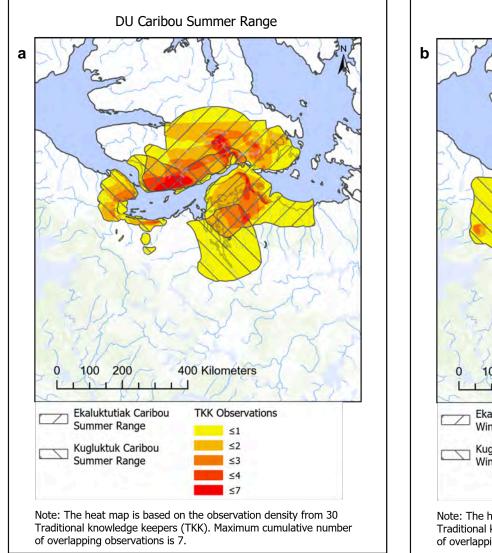
TKKs described variations in DU caribou behaviour that were expected and related to abundance. They said that when the number of caribou fell below the 'migration threshold', DU caribou did not migrate and remained on Victoria Island for the winter: "the herd never used to migrate to [the mainland] long ago. Long ago in Victoria Island there were hardly any caribou." (Kugluktuk TKK 3). TKKs found that when the DU caribou abundance was increasing but not yet migrating, there were many DU caribou gathering on the southern shore of Victoria Island: "more than 20 years ago, there were many [nonmigrating] caribou on the south side of Victoria Island" (Kugluktuk TKK 10). They said when the DU caribou abundance exceeds the 'migration threshold', the caribou migrated to the mainland for the winter. TKKs agreed that there normally would be some DU caribou that stay on Victoria Island throughout the winter regardless of abundance. They did not indicate the proportion of the herd that would remain on Victoria Island. This appeared to have recently changed near the time of the 2003 interviews, as TKKs described an abnormal change in migrating behaviour where DU caribou "seemed to migrate right onto the mainland, right off [Victoria] Island" (Kugluktuk TKK 6) and further south than observed previously. Further, some TKKs said that not all DU caribou return to Victoria Island; some speculated that DU caribou are migrating too far south to make the migration back across the sea-ice. TKKs said the DU caribou abundance also influences the duration of the migration. When there are fewer migrating caribou, the migration is completed quicker and vice versa.

Related to sea-ice conditions

TKKs described changes in climate and weather that influenced the timing of seasonal changes and the presence of wind, snow, and sea-ice. They said that wind was more problematic, snow quantity was reduced, and sea-ice formation was later in 2003 than in the past. The accounts linked temperature and wind observations with sea-ice formation, such that hotter and windier conditions limited sea-ice formation by delaying appropriate freezing temperatures and breaking-up any pack sea-ice that had formed. TKKs reported snowmobile trails that had disappeared "in a couple of days from the wind. No more ice; the ice we just travelled on is all open water from the wind" (Ekaluktutiak TKK 3).

TKKs explained that these changes in climate and weather had delayed freeze-up of sea-ice and impacted DU caribou during migration by increasing the risk of mortality events. Some DU caribou would fall through the sea-ice; some of these caribou could get out of the water, but this caused "a lot of the energy loss from the body, [leaving] hardly any fur on them; the front legs totally no hair on them. Patches of ice on their back, all matted on backs, chunks of ice hanging. I've seen them die of hypothermia" (Kugluktuk TKK 6). DU caribou also drowned after falling through the sea-ice. TKKs said that delays in sea-ice formation also caused changes in DU caribou staging and migrating behaviour (*Fig. 5a&b*). They explained that when the sea-ice formed later in the year, the lack of sea-ice acted as a barrier to migration and this resulted in DU caribou crowding their southern Victoria Island staging range and moving further east in search of suitable ice to initiate migration. More so, TKKs said the longer DU caribou waited for the sea-ice to form, the more "the animals seemed to get leaner" (Kugluktuk TKK 6). As the delays continued, TKKs reported some DU caribou would abandon migrating behaviour: "some of the caribou didn't migrate because they were looking for a place to cross. The ones that didn't cross they just turned around and went back inland, stayed on the island" (Ekaluktutiak TKK 2).

Figure 4. DU caribou range in the summer (a) and winter (b) as reported by Ekaluktutiakmiut and Kugluktukmiut in 2003. Colour gradient is based on the density of observations.



Base Maps Source: Esri Canada, Canadian Community Maps contributors; NRCAN Hydro, Land Coordinate System: NAD 1983 UTM Zone 12N Projection: Transverse Mercator

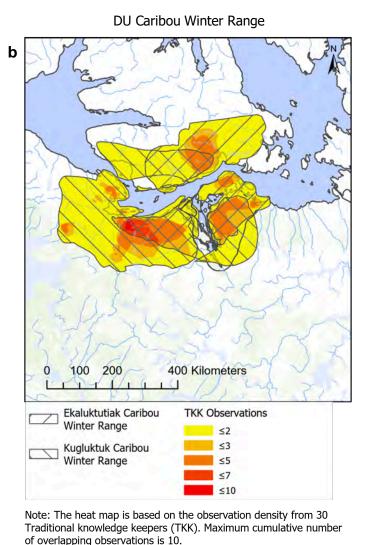
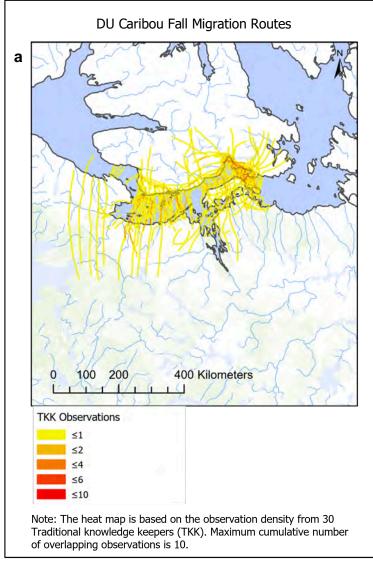
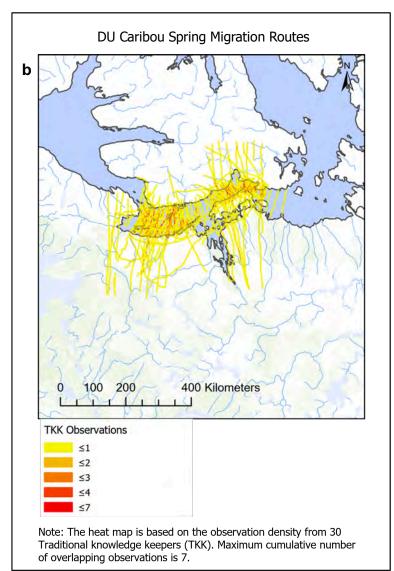


Figure 5. Migration routes for DU caribou in the fall (a) and spring (b) as reported by Ekaluktutiakmiut and Kugluktukmiut in 2003. Colour gradient is based on the density of observations.



Base Maps Source: Esri Canada, Canadian Community Maps contributors; NRCAN Hydro, Land Coordinate System: NAD 1983 UTM Zone 12N Projection: Transverse Mercator



DU Caribou Health *Disease syndromes*

TKKs described or named conditions consistent with brucellosis, such as "watery joints", "joints really three times the leg size", "swollen joints" and tapeworm cysts (likely caused by *Taenia* spp.), such as "small white round cysts", "right in the meat, little cysts, look like pearls" (Kugluktuk TKK 6). They said that while some caribou were very healthy, these disease syndromes were more frequently observed during the spring when the caribou were the skinniest.

In addition, Kugluktukmiut described rashes and hairless legs, green meat, broken jaws, "funny bones", lungs stuck to the chest cavity, "spleen and stomach stuck together", and enlarged spleens. Ekaluktutiakmiut described "a few [sick caribou] over the years" (Ekaluktutiak TKK 1) with big stomachs, green meat/puss, irritated spleens, hoof problems, antlers stuck together, and sick caribou when calving. When contrasting Ekaluktutiakmiut and Kugluktukmiut observations, Kugluktukmiut emphasized more concern about DU caribou health conditions than Ekaluktutiakmiut.

Body condition

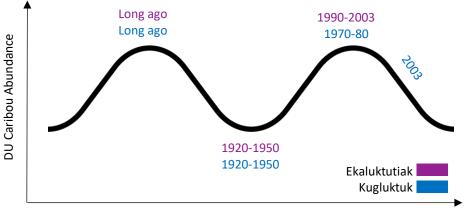
TKKs indicated that DU caribou body condition changed according to the seasons. They said caribou were "really fat" (Ekaluktutiak TKK 9) during the summer and fall, not bad during the winter, and skinny during the spring. The accounts associated migration and rut with having the greatest influence on body condition, with Ekaluktutiakmiut primarily reporting on the influence of rut and Kugluktukmiut primarily reporting on the influence of migration. During the summer and fall, TKKs said DU caribou recovered the accumulated nutritional debt incurred from these energetically costly life stages of the previous year.

TKKs explained that extreme temperatures (hot and cold), rough snow conditions, and rain during snow seasons could further reduce body condition. They said extreme heat during the summer resulted in skinny caribou, but they did not indicate the mechanisms that caused this to happen. TKKs also said hard winters, which could include extreme cold, deep and/or hard snow, and/or rain during snow seasons, resulted in skinny caribou. One TKK explained that "when the snow is [very] hard" (Ekaluktutiak TKK 10) it is difficult for caribou to access the vegetation during the winter. Similarly, they reported that rain during snow seasons created a layer of ice over the vegetation that blocked access to food. TKKs associated rain during snow seasons with massive declines in caribou, where "all the caribou died off from thick rain" (Kugluktuk TKK 15). People said that extreme rain-on-snow events starved caribou to death in the 1920s because they could not break through the ice to access the vegetation.

DU Caribou Abundance Trends

TKKs described a general abundance cycle for DU caribou, where there were times that they would "go for days and days and never see a single live animal" (Ekaluktutiak TKK 1) to times when there were so many they were "lining up outside the houses" (Kugluktuk TKK 7). From both communities, TKKs described a decline in caribou numbers from 1920 until the 1950s, after which the DU caribou became more abundant. Kugluktukmiut described many DU caribou

through 1970s and 1980s, where "there were lots of caribou right in town, migrating through" (Kugluktuk TKK 7). This trend shifted and by 2003 people noted that DU caribou were no longer found around the airport: "the caribou used to come behind the airport, now there is hardly any caribou" (Kugluktuk TKK 14). Conversely, Ekaluktutiakmiut described many DU caribou from the 1980s to 2003, "back to the way it used to be long ago today" (Ekaluktutiak TKK 10) and that "every year now, caribous come [...] right to town" (Ekaluktutiak TKK 3). *Figure 6* illustrates the details of the DU caribou abundance cycle.



Time (year)

Figure 6. Trends in abundance of DU caribou as described in interviews from 2003. The purple (top) time-intervals represent observations from Ekaluktutiakmiut, and the blue (bottom time-intervals represent observations from Kugluktukmiut.

SUMMARY

The 2003 interviews with Ekaluktutiakmiut and Kugluktukmiut contained important similarities and differences within the Traditional knowledge. For both communities, the "current" (2003) hunting range area used by TKKs' in 2003 had decreased when compared to the past (pre-2003) hunting ranges, yet no reason was given for this change. There are various reasons that could be implicated in the hunting range change, from changes in the range of the DU caribou herd to changes within the communities; drawing causality is beyond the scope of this research. However, the mapped DU caribou ranges and the narratives around DU caribou location and abundance suggest that the western boundary of the DU caribou distribution moved eastward approximately between 1980 to 2003. The hunting range swould logically follow this range shift. TKKs from both communities also linked DU caribou range and migration, with migration happening only once an abundance threshold was reached. Both communities explained that even when migration occurred, some DU caribou were present on both Victoria Island and the mainland in all seasons. DU caribou were also reported on the mainland during the summer in Tomaselli et al. (2018).

In addition to distribution, differences in community observations are important to acknowledge for herd status. Ekaluktutiakmiut, described a stable abundance with healthy DU caribou close to the community in 2003 and emphasized rut when discussing body condition. Kugluktukmiut accounts described a declining abundance with sick DU caribou far from the community in 2003 and emphasized migration when discussing body condition. These observations in body condition by each community are consistent with the seasons the communities interact with DU caribou, and the further descriptions of seasonal body condition are consistent with expected results from Western knowledge (Åhman and White, 2018) and other documented Traditional knowledge (Parlee et al., 2013). Altogether, these differing observations on the same herd that were documented in the same year highlight how Traditional knowledge is embedded in place. This is particularly critical to consider in a species like caribou that are migratory across a vast geographic range. It is important to consider Traditional knowledge from multiple communities throughout the range to develop a spatial and temporal herd-level understanding of DU caribou.

This analysis was based on archived Traditional knowledge: interviews from 2003. These historical data have provided important insights into DU caribou ecology, health, and variability over space and time. The Traditional knowledge accounts described changes in DU caribou health, abundance and annual and seasonal distribution. Considering the full seasonal and historical extent of the DU caribou range as described through these accounts is critical for managing landscape use that accommodates full recovery of the herd to historical numbers and range use.

2018-2020 Kugluktukmiut Traditional Knowledge Study on Dolphin and Union Caribou

BACKGROUND

We started this project in response to community concerns about the status of the DU caribou herd and the desire to increase Traditional knowledge representation and guidance in co-management discussions. The research built on an existing partnership among the KAA, DOE, and the University of Calgary. These partnerships were for hunter-based sampling and monitoring for muskoxen and DU caribou and a previous Traditional knowledge study in Ekaluktutiak that included documenting Traditional knowledge on the health, demographics, and trends of DU caribou (Tomaselli et al., 2018).

METHODS

We used three sets of interviews with Kugluktukmiut to understand the health and population status of the DU caribou. These included individual interviews, focus groups, and formally held and dropin feedback sessions (Finlay and Ballinger, 2014; Tomaselli, 2018). Each part followed a semi-structured interview guide, was audio-recorded (excluding the drop-in feedback sessions) and was held at the KAA office (see *Appendix B* for interview guides). To ensure the involvement of DU caribou experts, we invited people to take part in the research based on recommendations by the KAA (purposive sampling) and recommendations given by the TKKs during the interviews (snowball sampling) (Finlay and Ballinger, 2014; Tomaselli, 2018). As each interview set evolved, new TKKs were added to the groups. After the formal feedback sessions, we presented the results at the KAA's annual general meeting in February 2020 as a chance for the community to provide feedback on the results and interpretation.

The individual interviews explored the meaning of DU caribou to TKKs, contemporary health and population status, spatial distribution, and concerns about the status of DU caribou and potential ways to address these concerns. We designed the focus groups to generate semi-quantitative data using participatory epidemiology activities such as proportional piling and mapping (Tomaselli et al., 2018). These activities generated data on population abundance, population demography, distribution, and occurrence of disease syndromes. We brought the analyses from the individual interviews and focus groups back to TKKs during the feedback sessions as a chance for everyone to ensure that interpretation of the interviews was accurate, clear up confusion, and add in missing details.

For the participatory mapping activities, we used paper maps that we generated in ArcGIS with guidance from the KAA. We photographed or scanned (depending on resources available), georeferenced, and digitized the participatory data on the paper maps after the interviews. The individual interviews and focus groups both used a single map and colour codes to differentiate attributes (type of observation, year, season). Each feedback session used 11 different maps to document further spatial and temporal details: one for 'What parts of the land do you know really well?', and two sets of five for 'Where do people see DU caribou?' that covered time-intervals from 1980 to 1989, 1990 to 1999, 2000 to 2009, 2010 to 2017, and 2018 to 2020 (i.e. 'today').

We completed proportional piling exercises for population trends as described in the following steps. First, the interview facilitator asked TKKs what year they saw the most DU caribou; this became the 100% mark and was represented by a two-cup pile of beans. Second, the interview facilitator asked TKKs to use the beans to represent proportionately how many DU caribou they saw in 2019 compared to the peak time (100%). Then, the interview facilitator measured that amount of beans with a two-cup liquid

measuring cup to create a percent ratio from peak caribou (100%) to the amount of caribou in 2019 (XX%). If the TKKs had information prior to the time of peak population (100%), it was added using the same steps. The interview facilitator and TKKs then drew a line that connected the data points on a paper chart. Once drawn, the interview facilitator measured, verified, and adjusted the percentage every five years according to the guidance of the TKKs. During the feedback sessions, the TKKs had the chance to amend or re-pile the abundance data.

We followed the same interview analysis employed in the 2003 project (described on pg. 3) to analyze the interview narratives on abundance trends, spatial trends, and TKKs' concerns for DU caribou. As such, we followed an interpretivist paradigm, critical realism ontology, and thematic analysis framework with holistic and in vivo coding to find patterns and themes in the interviews (Braun and Clarke, 2006; Maxwell and Mittapalli 2011; Saldaña, 2013). Although, in the 2018-2020 study, we did not compare between communities because this study was only done in Kugluktuk. In addition, we completed this analytical process after each interview set and then returned the preliminary results in the subsequent interview set. The analysis of DU caribou health and demography and still in progress. The results presented here will focus on DU caribou distribution, abundance, and TKKs' concerns and their solutions.

RESULTS

We interviewed nine Elders and six adults in September and October 2018, facilitated seven focus groups that engaged nine Elders and seven adults in January 2019, and held four formal feedback sessions with 11 Elders and seven adults along with a few rolling drop-in sessions to allow people with scheduling conflicts to participate in February 2020 (five Elders and two adults). Elder designation was based on self-identification by the TKK (as an Elder or adult) and confirmed by the KAA. In total, we had 56 points of contact over two years with 33 TKKs.

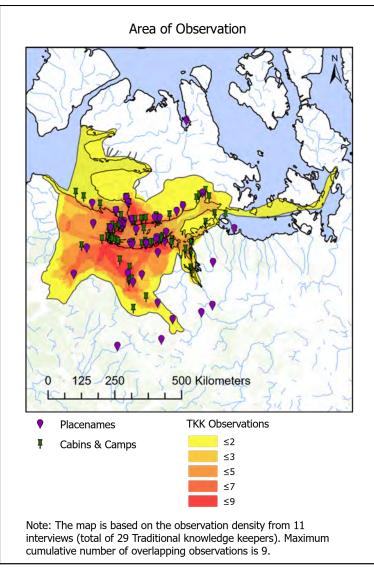
Variations in Experience

TKKs emphasized that how people and DU caribou experience the land is expected to vary by season and year. Harvesters travel on the land differently depending on the season (ATV, snowmobile, boat) and the year (weather conditions, etc.), and DU caribou also change depending on the season and the year. TKKs said they never expect to see DU caribou in the same locations every year. They said interpretation of DU caribou changes requires consideration of expected seasonal and annual variations.

Participatory Maps

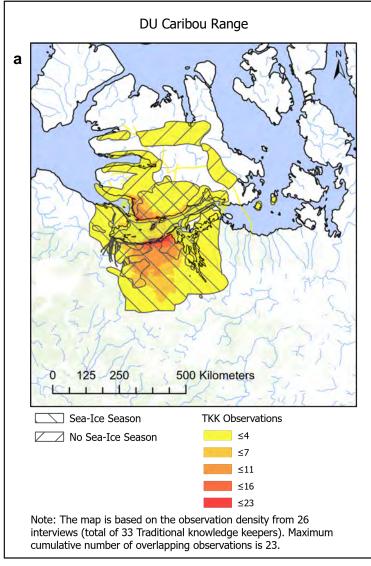
Altogether, the TKK's participatory maps covered 286 200 km² of land that they considered knowing well. This comprised of travel and general hunting areas (*Fig.* 7). They also mapped 240 400 km² as DU caribou range (*Fig.* 8a), 33% of which laid outside the land considered known well. TKKs mapped 138 700 km² of land they used to hunt DU caribou (*Fig.* 8b), 8% which lie outside the land considered known well. The summarized participatory mapping data suggest an increasing trend in DU caribou hunting range area since the early 2000s (*Table* 3). TKKs described a gradual change in DU caribou locations, where harvesters had to travel further east on the mainland and further inland (northeast) on Victoria Island to see and hunt DU caribou over the years. These changes are detailed through maps and interview narratives.

Figure 7. Area of observation as reported by Kugluktukmiut in 2018-2020. Includes Kugluktumiut travel and general hunting ranges, camps/cabins, and placenames used throughout the interviews. Colour gradient is based on the density of observations.



Base Maps Source: Esri Canada, Canadian Community Maps contributors; NRCAN Hydro, Land Coordinate System: NAD 1983 UTM Zone 12N Projection: Transverse Mercator

Figure 8. DU caribou range (a) and DU caribou hunting range (b) as reported by Kugluktukmiut in 2018-2020. Colour gradient is based on the density of observations.



Base Maps Source: Esri Canada, Canadian Community Maps contributors; NRCAN Hydro, Land Coordinate System: NAD 1983 UTM Zone 12N Projection: Transverse Mercator

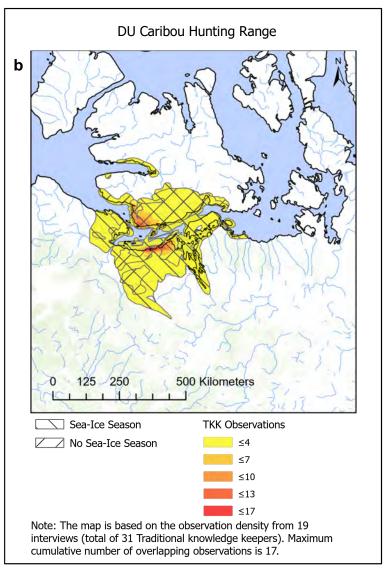


Table 3. DU caribou range and DU caribou hunting range summarized by decade from 1980-2020, as mapped by TKKs in 2018-2020. The values reflect absolute areas and do not consider overlapping areas. % of Total indicates the percent of the related 1980-2020 interval range (maximum) represented in the specific year interval. % Change indicates the percent change in area from the previous decade.

Range Type	Year Interval	Total Area	% of Total	% Change
DU Caribou Range and DU Caribou Hunting Range	1980-2020	247 200 km ²	100%	n/a
DU Caribou	1980-2020	240 400 km ²	100%	n/a
	1980-1989	122 800 km ²	51%	n/a
	1990-1999	158 300 km ²	66%	29%
	2000-2009	133 300 km²	55%	-16%
	2010-2020	156 200 km²	65%	17%
DU Caribou Hunting	1980-2020	138 700 km ²	100%	n/a
	1980-1989	66 400 km²	48%	n/a
	1990-1999	64 500 km²	47%	-3%
	2000-2009	77 600 km²	56%	20%
	2010-2020	93 700 km ²	68%	21%

1980s (Fig. 9a) & early 1990s (Fig. 9b)

TKKs said DU caribou were abundant in the 1980s and 1990s near Kugluktuk and were found both east and west of the community during the winter and summer. They said people would see DU caribou on the small islands between the mainland and Victoria Island during the summer. TKKs describe the most recent abundance peak in the 1980s and early 1990s and when people did not have to travel far to find and hunt DU caribou.

Late 1990s & early 2000s (Fig. 9c)

TKKs described the late 1990s and early 2000s as a time of change for DU caribou. They said DU caribou were not as abundant on the mainland west of Kugluktuk, and there were fewer reports of DU caribou crossing the Dolphin and Union Strait. Instead, they saw DU caribou more frequently on the mainland east of Kugluktuk, moving towards Tree River. TKKs familiar with the PIN3/Rymer Point/Read Island area on Victoria Island said that there were fewer DU caribou seen in this area during the summer/fall hunt, but still enough for hunting purposes.

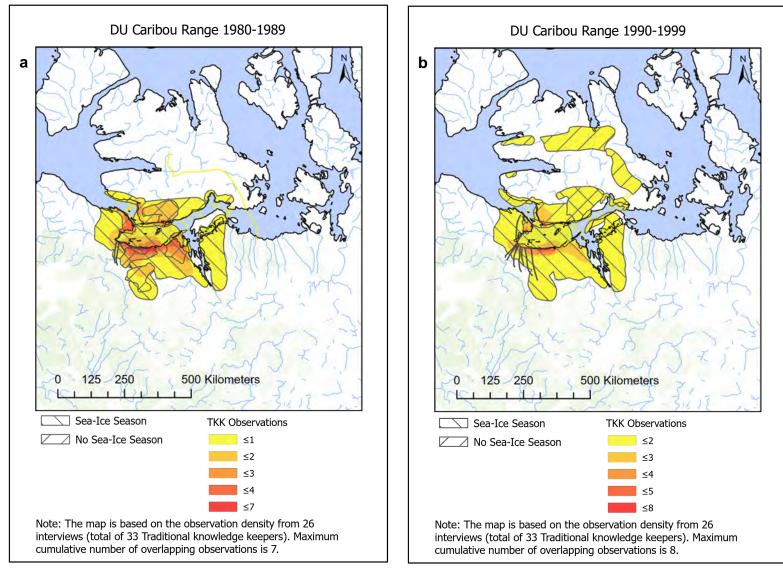
Late 2000s & early 2010s (Fig. 9d)

TKKs said people continued travelling further east on the mainland to find DU caribou, now mostly between Tree River and Grays Bay. Those familiar with the PIN3/Rymer Point/Read Island area on Victoria Island said this time period was when they started travelling further inland to find DU caribou and needed to plan their hunting trips later in the season to match the DU caribou movements.

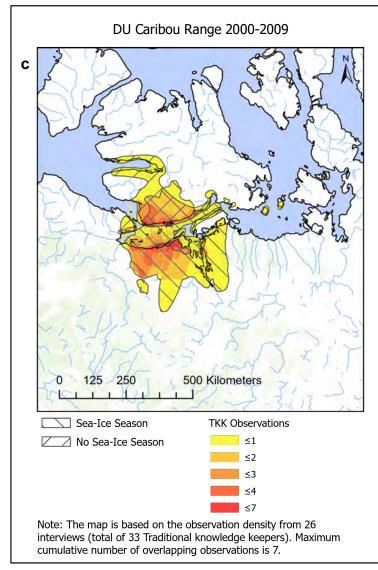
Late 2010s & today

TKKs said people continued travelling further east on the mainland to find DU caribou, now mostly travelling to Grays Bay, Wenzel River, and beyond into Bathurst Inlet. Those familiar with the PIN3/Rymer Point/Read Island area on Victoria Island said that during this time period, even though they are travelling further inland to find DU caribou, they find fewer DU caribou than the late 2000s and early 2010s.

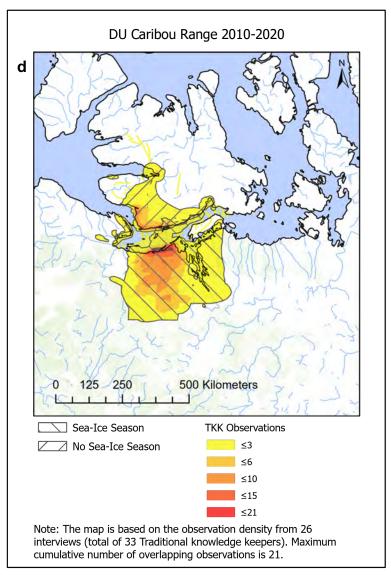
Figure 9. DU caribou range per decade as reported by Kugluktukmiut in 2018-2020, including 1980-1989 (a), 1990-1999 (b), 2000-2009 (c), and 2010-2020 (d). Colour gradient is based on the density of observations.



Base Maps Source: Esri Canada, Canadian Community Maps contributors; NRCAN Hydro, Land Coordinate System: NAD 1983 UTM Zone 12N Projection: Transverse Mercator



Base Maps Source: Esri Canada, Canadian Community Maps contributors; NRCAN Hydro, Land Coordinate System: NAD 1983 UTM Zone 12N Projection: Transverse Mercator



Abundance Trends

The proportional piling activities were done in 2019 with seven focus groups (two to three people per group; *Fig. 10a&b*). Focus group five elected to skip the activity, leaving data from six focus groups. One group had observations beginning in 1965, one beginning in 1970, and the rest beginning between 1980-1990. The group from 1965 described peak abundance then with a decline observed starting in 2005, whereas the 1970 group described an increase in abundance from 1970-1985 and a decline observed by 1995. The remainder of the groups described peak abundance at the beginning of their observation period, and the decline noticed between 1990-2005. All groups agreed that the herd's abundance had declined substantially by the time of the interviews. Each focus group either described or drew annual variation in the abundance curves, explaining that the caribou abundance does not smoothly change but increases then decreases (or vice versa) in a jagged line with a general increasing or decreasing trend.

For the feedback sessions, we used a smoothed quadratic linear model to illustrate the collective trends in the proportional piling data for abundance (Tomaselli et al., 2018). The model, supported by the narratives, indicated that the DU caribou abundance peaked in 1986 and the lowest abundance percentage occurred in 2019 at 40%. *Figure 11* was presented back to the TKKs during the feedback sessions. All TKKs during the feedback sessions agreed with the trends of increase and decrease with no amendments, but some TKKs who were not originally involved in the focus groups did not want to comment on the percentages associated with the trends. TKKs explained that the abundance percentages were associated with distribution of the animals and location of the TKKs. For example, people who were more familiar with the western range. This accounts for some variability within the dataset.

Concerns for DU Caribou Status and Suggested Management Actions

TKKs identified concern about five main issues that potentially impact the status of DU caribou (*Fig. 12*).

Hunting practices

TKKs expressed concerns around hunting practices, including DU caribou subsistence and sport hunting, and predator harvesting (hunting and trapping). Changes in DU caribou subsistence hunting practices included poor meat management (ex. spoiling meat, feeding meat to dogs, not knowing what meat is safe to eat or not), lack of proper sharing practices, and inadequate hunting practices of inexperienced hunters (ex. harvesting the wrong type of animal for the season, approaching the animals directly rather than on an angle). TKKs related these changes to education barriers between youth and Elders. They also related the changes to insufficient knowledge transfer about these topics with the public, including youth and adults. As a potential solution to this, TKKs indicated a desire for more educational opportunities for inexperienced hunters who want to learn about DU caribou hunting. This would include, but would not be limited, to selecting appropriate animals in regard to the season and population status, safe butchering and handling of the harvested animal, how to recognize what is safe to eat, etiquette around meat sharing, quantity of harvest, as well as general camping skills, such as collecting safe drinking water and safe land and water travelling. TKKs said these programs should include support and/or coordination by/between the DOE and KAA. Further, they said it is important to include hands-on learning, such as through on-the-land camp programs that connects those who want to learn with those who want to teach.



Figure 10a. Proportional piling activity with an Elder focus group in January 2019. Photograph includes Roger Hitkolok, Andrea Hanke, Juliette Di Francesco, John Kapakatoak, and Larry Adjun (left to right).

Figure 10b. Image shows an example of bean piling, where all the beans together represented 100%, and the smaller pile of beans on the right represented the number of caribou seen in 2019.

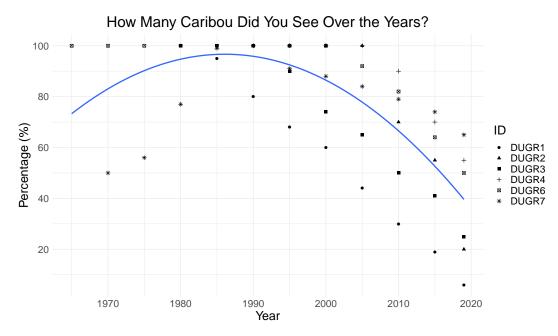


Figure 11. Collective DU caribou abundance trend created during proportional piling activities and based on Kugluktukmiut knowledge. ID represents each focus group that participated in the piling exercises (note: group 5 elected to not complete the activity). The blue line represents a smoothed quadratic linear model and was reviewed and accepted during feedback sessions in 2020 with Kugluktukmiut as the DU caribou abundance trend from Kugluktukmiut perspective.

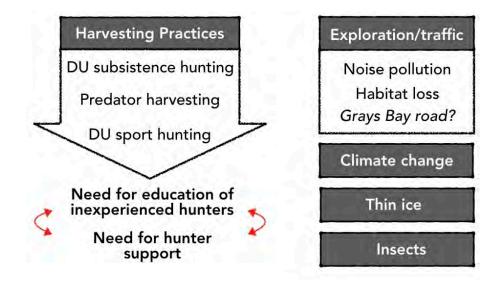


Figure 12. Five main issues that TKKs identified might impact DU caribou status. They identified hunting practices as the most important for immediate action, through increasing opportunities for educating inexperienced hunters and providing support (financial, resources, education, etc.) for hunters to maintain presence on the land and pressure on predators. Other concerns included rate of exploration and traffic, climate change, presence of thin ice, and increased burden from insects.

TKKs also explained that Total Allowable Harvest (TAH) restrictions for Bluenose East and Bathurst caribou herds had created unbalanced harvesting pressure on DU caribou, since this herd has no TAH restrictions. Some TKKs suggested that it could be useful to have DU caribou on a similar system until they recover. There was disagreement amongst people about whether the KAA or DOE should implement a restriction similar to the TAH. TKKs emphasized that if it was implemented, such a strategy would need to adapt alongside changes in the DU caribou abundance. Some TKKs said people would not follow the restrictions, and others further clarified that it would make food security too difficult to achieve. Some TKKs said that emphasizing education on proper hunting practices would be more beneficial than TAH restrictions for long-term change. However, they also indicated that an annual or seasonal restriction, like a TAH, may be needed for short-term change.

TKKs considered predator harvesting pressure as one of their top concerns for DU caribou. They explained that predator harvesting requires extensive time, resources (gas, food, equipment, repairs), and expert knowledge (safety, technical). They also said predator harvesting had an insufficient return reward that did not act as an incentive to engage in the process. Further, TKKs said that predator harvesting was not as common nor practiced the same today compared to the past. As a result, they said there are more predators today than in the past. TKKs indicated a desire to have more support for people to take part in these activities so they could maintain presence on the land and pressure on the predators. This could be in the form of resources and financial support, and/or with educational opportunities. For example, the educational opportunities could cover what incentive and educational resources already exist and additional programming that reviews requisite expertise and safety knowledge specific to predators.

TKKs also expressed concern about DU caribou sport hunting and its undue pressures on the most important breeding caribou. Some TKKs were conflicted about this concern because they understood the sport hunts as good employment opportunities. Other TKKs were conflicted as they did not know how much impact the limited sport hunts could have at a herd-level. The TKKs' suggested solution was to pause DU caribou sport hunts until the herd recovers.

Exploration/traffic

TKKs described an increase in noise pollution over time, with more helicopters, planes, and snowmobiles around today than in the past. Some TKKs expressed concern about potential mining, roads, and port developments as they would take up important caribou habitat. Also, some TKKs indicated concern about municipality contributions to pollution in the area, for example dump smoke during routine burning. There was a lot of discussion and conflicting views about the potential Grays Bay road and port project, and this was not covered in depth nor was there agreement among the TKKs. One suggested solution was to have stricter, or more enforced, regulations or restrictions around aircraft, developments, and/or municipalities to limit their potential impact on DU caribou. TKKs also suggested that more public education regarding those regulations would be useful so people understand what is being done and the reasons behind those actions.

Climate changes

TKKs described many changes in climate, including rain, wind, temperature, moisture, vegetation, sun, and timing of season changes. Linked to these climatic changes were rain-on-snow events that formed layers of ice over the vegetation, making it more difficult for DU caribou to access their food. TKKs also linked climatic changes with changes in sea-ice formation. There were no specific weather events mentioned that were directly connected to the recent abundance decline.

Sea-ice

TKKs explained that the sea-ice formed earlier in the eastern portion than the western portion of the DU caribou range. They explained that this has contributed to the changing DU caribou distribution. Also, TKKs frequently discussed thin ice and said that DU caribou often fall through near islands or fast currents. When the caribou fall through the sea-ice, they said DU caribou either drown, freeze on land, or have balls of ice attached to them (for example, on the legs or back). They said that the sea-ice is thawing before all DU caribou migrate north to Victoria Island in the spring, leaving some portion of the DU caribou on the mainland for the summer. Some TKKs said that this happened once in a while in the past, and others said that this is happening more now because the caribou are migrating further south than before and are taking longer to return to the mainland shoreline.

Insects

TKKs also mentioned changes in insect intensity and diversity, and that they are worse with hot and wet summers. They said this impacted caribou by preventing rest and eating. TKKs also mentioned insects in relation to climate change, but they talked extensively about insects and this warranted it as a stand-alone concern.

SUMMARY

The 2018-2020 Kugluktukmiut interviews documented an eastern shift in the western range boundary and a decline in abundance for the DU caribou herd from 1980 to 2020. TKKs explained and illustrated that they had to travel progressively further east on the mainland and further inland on Victoria Island to find DU caribou over the years. The participatory mapping and interviews narratives demonstrated that the DU caribou distribution is different today (2010 to 2020) compared to the 1980 to 1989. TKKs also said that there are fewer caribou today (2018 to 2020) compared to 2010, even when they travel further east and inland. Through the participatory proportional piling exercises and within the Kugluktukmiut spatial areas of observation, the DU caribou population in 2019 was estimated at approximately 40% of what it was in the 1980s. This collective Kugluktukmiut perspective is an important

account to consider, along with accounts from other communities within the DU caribou range, for future herd management.

In addition to herd status, TKKs identified concern about potential threats to DU caribou and suggested management actions. The concerns included harvesting practices (DU caribou subsistence hunting, predator hunting, predator trapping, and DU caribou sport hunting), exploration/traffic, climate change, thin ice, and insects. TKKs generated a list of suggested solutions to help mitigate these threats, and most of the suggestions addressed a need for hands-on education of inexperienced harvesters. TKKs advocated for the prioritization of inexperienced harvester education, covering topics from proper harvesting techniques, etiquette around meat sharing, and specialized predator knowledge. While TKKs indicated that there is increased importance on DU caribou harvesting since the harvesting restrictions on the neighbouring caribou herds, some TKKs emphasized that overall harvest of DU caribou has not increased as a result. Not all TKKs agreed about implementing a TAH for the DU caribou herd, but they agreed that if one were implemented, the harvest restrictions would need to adapt alongside changes in the DU caribou. The TKKs identified concerns for DU caribou were identified in the ECCC (2018) management plan and warrant due consideration in management discussions.

OVERALL DISCUSSION

Abundance

The 2003 and 2018-2020 Traditional knowledge studies on DU caribou provided critical information about this herd's population trend. The 2018-2020 study used individual interviews, focus groups, and feedback sessions to document Kugluktukmiut Traditional knowledge around DU caribou. Results from this study demonstrate an eastward shift in the western boundary of DU caribou distribution and an increase in DU caribou hunting ranges since 2000s, coincident with a substantial abundance decline to 40% of the prior mid-1980s peak. The range shifts and abundance decline are consistent with those identified in the 2003 interviews with Ekaluktutiakmiut and Kugluktukmiut. This suggests that the decline recognized by Kugluktukmiut in 2003 was real and had continued until present day, with the abundance peak occurring around the mid-to late 1980s. These results are congruent with observations by Ekaluktutiakmiut and local knowledge keepers in 2014 (Tomaselli et al., 2018). There, Ekaluktutiakmiut and local knowledge keepers reported that the DU caribou population had declined to 20% of its prior 1990s to mid-2000s peak. They associated the decline with smaller group sizes, smaller proportions of juveniles, poorer body condition, and a larger proportion of sick animals (Tomaselli et al., 2018). The population survey conducted in 2018 reported a 38% annual decline since 2015 (4 105 animals), along with fewer groups, smaller group size, lower stratum density, and low survival rates (0.62) (Leclerc and Boulanger, 2020). The 2018 survey result represents 12% of the 1997 survey result (34 558 animals) (Leclerc and Boulanger, 2020). A remaining DU caribou population of 12% since 1997 could be consistent with the Traditional knowledge near Ekaluktutiak in 2003 and by Tomaselli et al. (2018). However, it is a greater decline than that derived from the Kugluktukmiut accounts.

Leclerc and Boulanger (2020) reported a recent western range shift for DU caribou based on collar locations and in correspondence with an Ekaluktutiakmiut decrease and Ulukhaktokmiut increase in recently observed DU caribou. Meanwhile, the Kugluktukmiut perspective suggests an eastward shift in the western boundary of DU caribou distribution in both the 2003 and 2018-20 studies. The variability in the abundance and distribution accounts may be influenced by three points of interpretation. (1) The Kugluktukmiut knowledge refers to the 1980s and the survey baselines refer back to 1997. This may create a temporal scale issue that could be influencing the results, as has been reported in other studies (Neis et al., 1999; Armitage et al., 2011). (2) Seasonal harvesting locations and access to the land have been shown to change the reported relative abundance by the communities (see Ferguson et al., 1998, Neis et al., 1999, Kendrick and Manseau, 2008). Unpacking spatial scales among Traditional knowledge studies and population surveys may help facilitate understanding across the research. (3) The Traditional knowledge from 2003 and 2018-20 indicated that DU caribou behaviour changes in response to abundance and seaice. An Ulukhaktok community member reported freezing rain in Prince Albert Sound area in fall/winter of 2018 and that DU caribou might have turned back from their fall migration (F. Mavrot, pers comm). This weather event that may have influenced a change in behaviour could have impacted the number of DU caribou congregating along the southern shore of Victoria Island during the survey period (for similar accounts, see Parlee et al., 2013, Gurarie et al., 2019). These three points require further investigation in order to best understand the different information sources.

Distribution

Caribou abundance is known to fluctuate through time (Ferguson et al., 1998; Bergerud 2008). Population decreases are often accompanied by range contractions while population increases are often accompanied by range expansions (Ferguson et al., 1998; Bergerud 2008). Since TKK accounts are

specific to their land-based knowledge, a reported decrease in caribou sightings is locally based and needs to be interpreted in relation to, and combination with, observations from other areas. As such, a locally observed abundance decrease in one location does not necessarily mean a population decrease (Ferguson et al., 1998). Drawing on our results and previously published peer-reviewed and grey literature, we get a fairly detailed account of the DU caribou dynamics and range over time. Thorpe et al. (2001) describe a Kiillinik caribou herd in the Bathurst Inlet region as a herd of small, white caribou that come from Victoria Island to spend the winter. Elders explained that the Kiillinik caribou (DU caribou) started to come further south in the 1970s and mixed with the Ahiarmiut caribou (barren-ground caribou) (Thorpe et al., 2001). From this account, it seems the southern boundary of the DU caribou distribution shifted southward to include the Umingmaktok and Bathurst Inlet regions in the 1970s. This corresponds with the time Kugluktukmiut from the 2003 study said DU caribou peaked by their community (further refined to the 1980s in the 2018-2020 study). Ulukhaktokmiut reported a decline DU caribou abundance in 1990s (Ulukhaktok TK interviews 2011-2013, as cited in ECCC, 2018). Thorpe et al. (2001) reports that DU caribou became progressively more abundant near Ekaluktutiak from the 1980s to 2000s, Bates (2006) reports regular hunting of DU caribou twice a year by Ekaluktutiakmiut in 2000, and Tomaselli et al. (2018) recorded the peak for DU caribou from 1990s to mid-2000s by Ekaluktutiak. This is consistent with the Kugluktukmiut observed eastward change in the DU caribou distribution starting in the late 1990s and early 2000s. These data suggest that the boundaries of the DU caribou distribution fluctuate alongside population abundance. The Traditional knowledge alongside the most recent population survey (Leclerc and Boulanger 2020) further suggest that DU caribou have contracted its western and eastern boundaries to create a narrower distribution.

Hunting Range

The extent of DU caribou hunting ranges appeared to contract when DU caribou were abundant near the community and expand when DU caribou were far from the community. The 2003 study showed an approximate 65% decrease in DU caribou hunting range from the past (pre-2003) to 2003, transitioning from a period of very few DU caribou in 1920-50s to many DU caribou in 1970-2003. The 2018-20 study showed a 45% increase in hunting range area from 1990-1999, including 21% increase since 2000-2009, to 2010-2020. This period is transitioning from many caribou in the 1980s to early-1990s to a period of fewer DU caribou in 2020. Increases in hunting ranges have been reported during other wildlife declines, linked to increases in search intensity and further travel distances (Neis et al., 1999, Kendrick and Manseau, 2008). The overall area accounted in the participatory mapping was greater in the 2018-20 study than the 2003 study.

Concerns & Management Suggestions

The identified Kugluktukmiut concerns for the DU caribou herd are similar to concerns previously voiced by Indigenous communities about this caribou and other caribou herds (Dumond, 2007; Sangris, 2010; Padilla & Kofinas, 2014; Tomaselli et al., 2018). Foremost, they advocated for education for inexperienced harvesters with a strong hands-on learning component. Future development of this type of education initiative could draw from the Aqqiumavvik Society, such as their young hunters, mentoring young men, and culture of cooking programming (Aqqiumavvik Society, n.d.). Kugluktukmiut in the 2018-20 study and in Dumond (2007), indicated concern over the decrease in predator harvesting today compared to the past and the recent increase in predator numbers. The DOE Wolf Sample Program has been supporting Kitikmeot wolf harvesters since November 2018 (Legislative Assembly of Nunavut, 2019), and the Government of Northwest-Territories recently expanded their North Slave Wolf Harvest

Incentive Program to include Nunavut harvesters in 2019 (ENR, n.d.). In addition to the wolf initiatives, the DOE is currently analyzing data on wolverines and is planning a grizzly bear study (Government of Nunavut, 2020). The KAA is also planning a Traditional knowledge study on grizzly bears (A. Dumond, pers comms).

OVERALL CONCLUSION

Together, the 2003 and 2018-20 studies detail the history, distribution, abundance trends, and concerns for DU caribou. The discussion of these results together with other studies like Tomaselli et al. (2018) and Leclerc and Boulanger (2020) have highlighted the importance of having information from multiple sources and times in order to weave together the complex ecology, distribution, and population trends of DU caribou. Further, the diversity of available information can allow for better consideration of the different data limitations (Bates, 2007). The expressed concerns for DU caribou declines and the suggested management actions can help guide future decisions for this herd. Considering the full and cumulative extent of the DU caribou range within current management plans is critical to manage landscape-use if a full recovery of the herd to historical numbers and range use is desired. The community-based knowledge on DU caribou distribution, abundance, and health was nuanced and complementary within and between Ekaluktutiakmiut and Kugluktukmiut accounts. This reflects the TKKs' varied spatial and seasonal use of the land and interactions with the caribou. These studies have highlighted the critical importance of involving multiple communities and TKKs from across the DU caribou range to understand the full life history of DU caribou, including seasonal and spatial variability, and to develop effective herd-level conservation approaches.

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Appendix A. Interview Guide for Ekaluktutiakmiut and Kugluktukmiut Traditional Knowledge Study on DU Caribou In 2003

- 1. When were you born?
- 2. Where were you born?
- 3. Where do you live?
- 4. Where did you live when you were a kid? A young adult? Now where do you live?
- 5. Who are your parents? Brothers? Sisters?
- 6. Did you hunt caribou when you were a young adult?
- 7. Do you hunt caribou a lot?
- 8. Where did you hunt caribou long ago?
- 9. Where do you hunt caribou now?
- 10. Did you travel a lot when you were a young adult?
- 11. Do you travel a lot now?
- 12. Between the 1920's and the 1970's the Dolphin-Union herd was believed to be extinct by biologists. Do you know what happen during this period?
- 13. What effect did the introduction of riffles have on the herd in the 1920's into the 1970's?
- 14. Historical trends in the abundance of the Dolphin-Union herd? (In the past was the herd in numbers where there were many caribou or less caribou?)
 - a. When you were young/the place?
 - b. When you were a young adult/the place?
 - c. When you became an adult/the place?
- 15. Temporal trends in the abundance of this herd? (Any short term difference in numbers of this herd, for example in a certain year there were many caribou or less caribou)
 - a. When you were young/the place?
 - b. When you were a young adult/the place?
 - c. When you became an adult/the place?
- 16. Migrations, areas where the caribou traveled through. Can you mark them on the maps?
- 17. Have you ever seen the herd to not migrate? (What reasons do you think caused that to happen?)
 - a. What year(s)?
 - b. Weather conditions?
 - c. Amount of snow?
 - d. Were there lots of caribou?
 - e. Were the caribou in groups or spread out?
 - f. Were the caribou healthy?
 - g. Over harvest?
- 18. Was it because they were not coming around your camp or because there were less caribou?
- 19. Nowadays, the herd is migrating to the mainland in winter and comes back to the island for calving. Was it always like that?
- 20. Trends in abundance of caribou when the caribou migrate or did not migrate? (Were there a difference in number of caribou when the caribou migrated to mainland and when the caribou did not migrate).
- 21. Seasonal locations (spring, summer, fall and winter). Can you mark them on the maps?
- 22. Trends in body condition when the caribou migrate or did not migrate?
 - a. Body condition, when the herd did not migrate was the caribou healthy?
 - b. When the caribou migrated were the caribou healthy?

- c. Were they skinny and shown any signs of illness when they stayed on Victoria Island?
- d. Were they skinny and shown any signs of illness when they went to the mainland?
- 23. What did the caribou eat? (Spring, summer, fall and winter). Did you noticed some changes along the years? Were there differences when migrating or not?
- 24. What have you seen, body condition of the Dolphin-Union caribou through out the year?
- 25. Do you have anything you would like to tell me in general about your knowledge or experience with the Dolphin-Union caribou herd?
- 26. Do you know of any stories passed on knowledge on this caribou herd from your father/mother, grandfather/grandmother, uncle/aunt, or any elderly person in general?

Appendix B. Interview Guides for Kugluktukmiut Traditional Knowledge Study on Dolphin and Union Caribou in 2018-2020

Dolphin and Union Caribou Health Monitoring Program

Individual Interview Guide

Interview #:

Date:

**As with any qualitative interview guide, these questions are suggestions of what will be discussed in the interview. Prompts are included under the bolded questions to be used as needed for guiding the discussion.

Italicized writing indicates the use of a participatory research tool. **

Hello! Thank you for agreeing to be interviewed. As you already know the purpose of this study is to collect traditional and local knowledge about DU caribou in order to inform a program for monitoring DU caribou health.

Go over consent form with participant

I have an outline of questions I would like to ask you and I will be taking some notes during our discussion. Are you okay if I audio-record the interview?

Please feel free to add any comments whenever you wish. Is there anything you would like to ask before we start?

INTERVIEW QUESTIONS:

A. General/Demography

First of all, I would like to ask you some general questions about yourself.

1. Personal information:

- a. Interviewee: Elder Hunter Outfitter Other:
- b. Inuit identity: Inuit non-Inuit
- c. Active Hunter: Yes No
 - a) <u>If yes</u>, do you hunt DU, Peary or Bluenose caribou? Muskox?
 - b) If no, were you a hunter before? Until when? For how long?
- d. Gender: Male
 - Female

		You don't Prefer not	-	otion that applie	es to me.	I ident	ify as _	
	e.	Age yea	rs					
	f.	Are you part of the HTO?	Yes	No				
	g.	Where were you born?						
	h.	How many years have you	u lived in I	Kugluktuk?		_ years		
2.		u hunt/handle DU caribo	u? Yes	No				
		nunt	DI I	2				
		When did you start to hun				Comm	mitre	Smart (ag a
	D.	What kind of hunts do yo guide)	u participa	te in? Subsis	stence	Comm	unity	Sport (as a
	c.	About how many DU cari	•		•			
		Subsistence # _ Community # _		when				
		Sport #		when when				
	d.	Where do you normally h						
		Mapping						
	e.	Where did you used to hu	nt DU cari	bou?				
		Mapping						
	f.	What type of animals do	ou hunt?					
		Subsistence		Type: adult	young	calf	male	female
		Community		Type: adult	young	calf	male	female
		Sport	<u></u>	Type: adult	young	calf	male	female
	g.	What do you do after you	hunt a DU	caribou?				
		a) How do you pailand?	rocess the	carcass in the fi	ield and	what de	o you le	eave out in the
		b) What type of h	unt is it fr	om? (subsistend	ce/comm	unity/s	sport)	
	Ifl	nandle		× ·		2	1 /	
	a.	When did you start to han	dle DU ca	ribou?				
	b.	Who hunts the DU caribo	u that you	handle? From v	which typ	pe of h	unt do 1	hese caribou
		come from?						
			mmunity	Sport				
	c.	How many caribou do you	-					
				when				
		Community # Sport #		when				
	d.	What kind of caribou do y	vou handle	?				
		· · ·		Type: adult	young	calf	male	female
		a i		Type: adult	young	calf	male	female
		Sport		Type: adult	young	calf	male	female

B. <u>Community Importance</u>

Now, I would like to talk to you about what DU caribou mean for your community.

- 1. Tell me, what do DU caribou mean to you?
 - a. Compared to other caribou herds? Muskox?
 - b. How has this changed over time?
- 2. What parts of DU caribou do you eat? How?
 - a) Cooked, raw, dried?
 - b) How do you store DU caribou meat?
 - c) Tell me about any concerns you have about butchering, handling or eating DU caribou.

D. <u>DU Caribou Health</u>

Now, I would like to talk to you about what you see in <u>DU caribou</u>.

- 1. What is a good DU caribou? What is a bad DU caribou?
- 2. How do you think the DU caribou herd is doing?
 - a. Can you describe this further?
 - b. Why do you think this is?
- 3. In the past, were there fewer DU caribou or more DU caribou then now? *Timeline, proportional piling*
 - a. When you were young/young adult/adult? Before 2003, in 2003, and now?
 - b. Does the number of DU caribou change year-to-year?
 - c. Descriptive probing for details
 - d. If mortality events are mentioned, ask for details (season, year, location, number of animals, composition of animals)

4. Tell me about any changes you've noticed in DU caribou.

Refer to timeline, seasonal calendar

- a. Can you describe these further?
- b. When did you start to notice the changes?
- c. Why do you think this has happened?
- d. Is this related to changes in the lands or other animals?
- e. Do you think these changes are impacting how the DU caribou herd is doing? How?
- 5. Can you mark on the map the seasonal locations of DU caribou and the areas they travel through?

Mapping (summer and winter locations & fall and spring migration routes)

a. Have these changed from when you were young/young adult/adult? Before 2003, in 2003, and now? *Refer to timeline*

6. Tell me about the movement of DU caribou.

a. Today, do DU caribou move from the mainland to the island?

a) If so,

Does the whole herd move or just some animals?

How many animals migrate together? What is their composition

(calves/adults, females/males)

When do you see the DU caribou migrate?

Refer to map

b) <u>If not</u>, why do you think this has happened?

What year(s)?

Weather conditions?

Amount of snow?

Number of caribou?

Were caribou in groups or spread out? What size were the groups?

Were they good caribou? Bad caribou?

Did harvesting or predation have an effect?

- b. Is the movement today different from the past? *Refer to timeline*
 - a) Locations, timing, group size, group composition
 - b) When did this change? *Refer to timeline*

7. Throughout the year, when are DU caribou fat, fair, or skinny?

Seasonal calendar

- a. Why does the fatness of the animal change?
- b. Are there things that happen which make the animal become fatter or skinnier?
- c. Does the time DU caribou get fat/skinny change year-to-year?
- d. How does today's body condition compare to 2003 and before? *Refer to timeline, seasonal calendar*

8. What do DU caribou eat?

- a. Spring, summer, fall and winter?
- b. Have the DU caribou changed what they eat? When you were young/young adult/adult? Before 2003, in 2003, and now? *Refer to timeline, seasonal calendar*
- c. Are there any places the DU caribou always go to eat?
 - a) Some animals risk their lives to go lick roads, mud or dirt, etc. They do this because they need the minerals, or nutrients, to be healthy. Is there anything like that for the DU caribou? *Refer to map, seasonal calendar*

E. Disease

Now, I would like to ask you some questions about diseases of DU caribou.

- 1. Tell me about any common diseases that you know of in DU caribou.
 - a. Could you describe them further?
 - b. Do these diseases go by any other names?
 - c. Do you see these diseases in today's DU caribou?
 - d. Have these diseases changed? Refer to map, timeline, seasonal calendar

2. Have you ever seen dead DU caribou in the wild? Yes No

- a. When (year and season) and where? *Refer to map, timeline, seasonal calendar*
- b. Can you describe what you saw?
- c. How many animals did you observe dead?
- d. What kind of animals? adult young calf male female
- 3. When you were out in the land, have you ever thought a DU caribou was sick? Yes
 - No
 - a. Could you tell me more?
 - a) Can you indicate the location on the map and when it happened? *Refer to map, timeline, seasonal calendar*
 - b) Can you describe what you saw?
 - c) How many animals did you observe?
 - d) What kind of animals? adult young calf male female
 - e) Do you have a name for this sickness?
- 4. What about the animals that you hunted so far? Have you observed any strange things when you butchered them? Yes No
 - a. Could you tell me more?
 - a) Can you describe what you saw?
 - b) Where and when was that?
 - c) What kind of animals? adult young calf male female
 - d) Is this a common finding in the animals you hunted, so far? Yes No
 - e) Have you observed any changes over time in the animals? *Picture prompts, timeline, proportional piling, seasonal calendar*

F. Wrapping Up

- 1. Are there any stories you would like to share about DU caribou?
- 2. What things are important to monitor for the DU caribou herd?
 - a. What are ways that you think we can find out how the DU caribou are doing?
 - b. What is important for monitoring the health of DU caribou?
- **3.** Anyone else you would recommend for this study? Someone else who is really knowledgeable about DU caribou?
- 4. Anything else you would like to share?

Thank you very much for taking the time to participate in this project. If you have any concerns, please contact me (<u>andrea.hanke1@ucalgary.ca</u>). I'll be in touch with you to go over the results from this interview and to set up the group interview.

Dolphin and Union Caribou Health Monitoring Program

Group Interview Guide

Interview #:

Date:

**As with any qualitative interview guide, these questions are suggestions of what will be discussed in the interview. Italicized writing indicates the use of a participatory research tool. **

Hello! Thank you for agreeing to be part in this small group interview. As you already know the purpose of this study is to collect traditional and local knowledge about DU caribou in order to inform a program for monitoring DU caribou health. In this second phase, we will have a group discussion and we will do some exercises to further explore some of the findings.

We will use the map to indicate location, we will create a seasonal calendar and temporal line to create a sort of DU caribou health history and finally we use some tables to show association of factors.

During the group discussion, I will be taking some notes. Feel free to add any comments whenever you wish. Is there anything you would like to ask before we start?

First of all, I will summarize for you the findings from the analysis of the previous interviews

Summary of the findings from INDIVIDUAL INTERVIEWS

Do you agree with that? Would you like to add anything else?

Start the activities:

Theme1. Participants' area of observation & DU caribou range (confirmation)

Exercise

Mapping

- Overall hunting area & confirmation of DU ranges from individual interviews 2. DU caribou demography
 - a. Relative abundance

Drawing exercise

Timeline exercise; adjust timeline span as appropriate but maintain proportionality; may develop pre/post-decline phases b. Relative decline Proportional piling As relates to the timeline phases. Divide counters (rep. pre-decline phase) to current population size. c. Group size and distribution Categorization exercise Number of animals in a group and the average distance between the groups d. Group sex and age structure Proportional piling Divide counters: adults vs juveniles, adults into female vs males, juveniles into calves vs yearlings 3. DU caribou body condition Proportional piling Divide counters into very fat, fat, not bad, and poor for observed or hunted animals 4. DU caribou morbidity and mortality a. Relative morbidity and mortality Proportional piling Divide into healthy, diseased and dead animals b. Relative prevalence of disease Proportional piling Divide counters (rep. whole population) into prevalence of each disease before and after decline. Probe for intensity and presentation, season, age/sex, location Warbles Nose Bots Biting flies: mosquitoes, horseflies/bulldogs, blackflies, ticks Hair coat: Face, neck Besnoitia Joints: Brucella, keep in mind Erysip Meat: Taenia Lungs: Stuck, Echinococcus Abdomen: Liver (Taenia, white spots/other), Guts stuck, any worms in abdomen? (Setaria) Hooves: changes Antlers: changes Add new ones to the list if it's not there. c. Causes of mortality Proportional piling Continuing from 4a), divide the counters that represent 'dead caribou' into 'predation', 'acute deaths' and 'undetermined/other causes'. Further divide 'predation' into the predator species thought to be involved. 'Acute deaths' was defined as the presence of one or more carcasses lying on the ground within the same geographical area, with the following specific characteristics: carcass/es intact or only minimally scavenged, death/s occurred recently (within few weeks), and not attributable to predation or hunting. Further define the 'undetermined/other

causes'.

Show a picture of a caribou dead from predation/hunting.

- 5. Patterns of DU caribou disease outbreak
 - a. Sex and age characteristics *Proportional piling* Refer back to 4a) 'acute morality' pile. Divide counters according to adults vs juveniles (calves plus yearlings) and then adults into females vs males.
 - b. Spatio-temporal distribution & Seasonality *Mapping* Map the locations of the 'acute moralities'. Mark down number dead, age, year, and season.

Is there anything else that comes to mind that you would like to talk about?

On the behalf of my team at the University of Calgary, thank you very much for taking the time to participate in this group discussion. If you have any concerns, please contact me (<u>andrea.hanke1@ucalgary.ca</u>).

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> حص⊃ח© Department of Environment Avatiliqiyikkut Ministère de l'Environnement

DOLPHIN AND UNION CARIBOU

Teleconference with Hunters and Trappers Organizations and Co-Management Partners

Meeting Minutes and Speaking Points



June 18, 2020

Government of Nunavut

Meeting started at 11:15 am EST

- Attendees:
 - Kevin Methuen (GN-DOE)
 - Caryn Smith (GN-DOE)
 - Drikus Gissing (GN-DOE)
 - Denis Ndeloh (NWMB)
 - Jordan Hauffman (NWMB)
 - Bert Dean (NTI)
 - Beverly Maksagak (EHTO)
 - Amanda Dummond (KHTO)
 - Arlene Hokanak (KHTO)
 - Andrea Hanke (UofC)
 - Javier Aguilar (UofC)
 - Cheryl Wray (NTI)
 - George Angohiatok (EHTO)

- Jason Aliqatuqtuq (GN-DOE)
- Jon Neely (GN-DOE)
- Jason Akearok (NWMB)
- Kate England (NWMB)
- Kyle Ritchie (NWMB)
- Bobby Greenly (EHTO)
- Bobby Klengenberg (KRWB)
- Bobby Anavilok (KHTO)
- OJ Bernhardt (KHTO)
- Susan Kutz (UofC)
- Connie Kapolak (Burnside HTO)
- Clarence Kaiyogana (EHTO)

*Peter Kapolak was not able to call in; Kevin will send him a summary afterwards via CO III and seek input

Presentations

- Caryn Smith presented overview of the results from the 2018 population survey and current status of the Dolphin and Union Caribou (Appendix A)
- Andrea Hanke presented overview of TK study methods and results from 2003 and 2018-2020 (Appendix B)
- Susan Kutz presented overview of caribou sampling and health assessment program (Appendix B)
- Kevin Methuen presented the next steps and management recommendations (Appendix A)
- Break from 11:55-12:05 PM EST

Kugluktuk HTO Comments and Questions

- Amanda Dummond wants to know about a collar from early 2020 that stayed on Victoria Island
 - \circ $\,$ Caryn will check on that collar and get back to HTO $\,$
- Amanda Dummond where did you get the information to indicate that there has been a significant harvest from DU caribou?

- Caryn Smith it was stated at March public hearings that there is more harvest pressure on DU caribou due to BNE and Bathurst declines and there were reports from harvesters of harvest happening in the Spring of this year (2020).
- Amanda does not think the word "significant" should be used and that it is misleading.
- Amanda Dummond Why is there no Predator control and what is the government planning for predator control?
 - Drikus Gissing there are no new programs being proposed for predator control but the current support for active harvesters has been very effective. We are increasing efforts on predator research, such as Grizzly Bear research, and continuing the wolf sample program
 - Drikus Gissing added more insight into where the reports of continued harvest have come from and why the harvest levels are concerning and are significant in his opinion
- Amanda Dummond their board would not be comfortable with interim TAH being
 implemented July 1st. They need more time to meet with community and have more HTO
 consultation. They feel they need more time with the report and time to meet with the
 community. Question to the NWMB on whether the interim decision can be implemented
 without consultation.
 - Jason Akearok the Minister of Environment has the authority under the Nunavut Agreement to implement an interim management decision as per 5.3.24 in the agreement (for urgent and unusual circumstances).
- Amanda Dummond wants to know what the position of the other co-management partners is at this point, especially the other jurisdiction.
 - Drikus Gissing the GN has sent a letter to the GNWT Minister to relay the results and indicate that we need to initiate discussions on the shared management of this herd. We would like to have a collaborative process but we cannot force them to go faster in their process. We hope that they will start to implement a harvest restriction in their jurisdiction as well. The GN has no role in allocation but we can help facilitate the discussion between the appropriate organizations.
 - Drikus Gissing also pointed out that the GN does not like to implement harvest restrictions, especially through this method, but we feel the need to initiate this due to the conservation concern and with an expedited process of consultation. We are looking for guidance from the HTOs on how they want the consultation process to start. It is correct that the decision will not be in place by July 1 as it will take some time for the decision to go through the proper process before implementation. If there are mistakes in the current status of this herd we will likely pick it up in the next survey process. We will be making it a priority to gather more information to inform whether the harvest limitations should be adjusted to better reflect the population status.

- Amanda Dummond their community did not expect the current status. The harvesters out there do not believe the number. They want more time to review the report and get their thoughts together. They won't be ready for a while. It is unacceptable that the report took so long to be shared with the communities. They recognize the decline but to wait two years for the report.
 - Caryn Smith In early 2019 there was some outside concerns with the methodology of the survey so the DOE initiated additional spatial analysis and included additional data from genetics to ensure that the results presented in the report were as strong as possible and the most accurate with the available information. The additional analysis strengthened the report an improved scientific confidence in the results. Unfortunately there was the blackout period at the end of 2019 caused by the Ransomware attack on the GN, which delayed progress, and the workplace changes due to Covid-19 caused a another slight delay just before it was finalized.
- Bobby Anavilok has questions about the number and the survey methods. There were huge areas that were not looked at or caribou that were not counted. The timing of the survey may not be appropriate. The biologist that is coordinating the survey is responsible for that. Maybe because the biologist doesn't eat meat.
 - Caryn Smith there is typically misunderstanding between composition survey and population survey. Also the methodology has been the same since 1997 and been consistent. The methodology for this survey was developed because the traditional calving ground survey was not a good fit for Dolphin and Union Caribou since their calving behaviour is spread out over Victoria Island but they do gather in large numbers just before crossing the ice in fall and for the rut. The survey has been done the same way and time of year so because of that it should be more effective in capturing a trend. If we used a different method in 2018 and tried to compare it to 2015 the change in method could easily be used to say the decline might not be that accurate. If you walk into a room the same time every day and there is fewer people each time, you know its likely because there are less people and not because of how and when you walked into the room. The collars are still showing movement over the sea ice so the bulk of the herd is still moving to the coast and into the survey area at that time of year.
 - Bobby Anavilok worries about the survey and whether many of the animals are not being counted
- Amanda Dummond mentioned the chairperson, Larry, could not attend. They want more time with the report and the information. They don't think they are ready for a decision to be made.

Cambridge Bay HTO Comments and Questions

• George Angohiatok – questions about the methodology used to do the study. From a distance it is hard to tell what the animals are. Growing up they watch their animals. They have noticed there is a change and they know it has happened. When you start to look at ways to fix that

problem you should go directly to the cause of the program. The harvesters take a very small proportion of the animals when compared to the predators. The wolves take a large number of calves in the spring. When any living thing runs out of food they have to move. We have a lot of work to do as an HTO on what we want to see and sharing our concerns with the community. We don't agree with some of the methods you are using. We don't think the numbers are necessarily going down, they are likely moving into different areas. My grandparents said that you can't control the numbers, they will go up and down. They are not ready to make a recommendation. He thinks the methods being used a waste of time. We need to look at this more realistically and meet face to face. The Kugluktuk concerns are their concerns too. What can be done? Making the hunters pay by not harvesting, instead of looking at the direct cause of the decline, the predators is not right. The GNWT looks at predators, but not in NU. Two different approaches. The key people who make these decisions need to look at this. We need to look at this. We need to look at what our priorities are.

- Bobby Greenly in looking at the letter signed and sent by Drikus. They have concerns about the recommendation of 42. We have a population of close to 2000 people with 80% Nunavut Inuit, the same applies to the other communities. I know it was mentioned to do a 1% harvest of the 4,205 caribou that is left. Is this going to be submitted to the NWMB for a decision? It is going to be very difficult to keep traditional ways going with such a low harvest limit. Is this automatically going to be submitted to the NWMB without consultation?
 - Kevin Methuen acknowledged that issues around food security are very important right now and that is certainly something that gets considered by the Minister when making these decisions. The intention and purpose of the interim decision is to address the situation until a fuller process can be completed. The GN will be submitting the interim recommendation to the NWMB now with the intention to fulfil the process of consultation and another formal recommendation to the NWMB
 - Drikus Gissing (re-joined the call after audio problems) this is an interim decision and we know that it does not really meet the basic needs level of the communities. The GN has an obligation to address conservation concerns and if we did not act on this we would not be fulfilling our mandate. We are following a process that is outlined in the Nunavut Agreement. We want to go through this process as soon as possible to have proper consultations and formal submission to the NWMB, which could require a public hearing as well, just as for Bluenose East and Bathurst caribou. When you review the report, pay attention to the survival rates as indicated by the collars. Many of the collared animals were harvested or died due to other reasons. We also have a TK report that has basically confirmed that there are declines in this herd.
- Bobby Greenly they all care about the wildlife but if this is going to be an interim decision, they would like to see the number a bit higher even though he knows that it is the harvest rate that was agreed upon in the Management Plan. They only take a maximum of 200 caribou each year. He's glad to see there is a previous process such as the Baffin population and TAH process. He understands that there are 10 communities in Baffin. It is frustrating but they would like to see the interim number a bit higher as it is too low.

- Susan Kutz wanted to make a clarification that the decline in the TK results is not as drastic as the decline indicated by the survey results.
- EHTO member (name was hard to hear when question was posed) interested to know what NTI has to say about this.
 - Bert Dean him and Cheryl have been involved in this file and the big concern NTI has is 0 in and around the survey methodology so there are concerns about the migration back to the mainland. Ulukhaktok is actually seeing an increased harvest so it is important that it is an inter-jurisdictionally shared herd and we need to acknowledge that they are seeing more caribou in their area. They would like to know what the more recent harvest information is. There may have been some recent harvest of a couple hundred but there has not been a harvest study and there is no complete information on that. There are a lot of thing we should be looking at such as information from hunters. The information on Brucellosis is also concerning. Has there been a change in distribution, has there been issues with the sea-ice crossing and the quality of ice, shipping, and harvest. What kinds of management actions would the communities like to see? Working together is going to be difficult. It's not a matter of picking sides or having that debate, are there some actions that the communities would be interested in doing? Communication is a big issue. When we started conversations about Bluenose East and Bathurst, NTI was involved in getting the communities involved in the conversation. Kugluktuk had been hunting more Dolphin and Union caribou a few years ago because there had been more caribou around. This information is important for the NWMB for when they make decisions on this. Cheryl may have more to add. ECCC is also involved because they want to list this subspecies as Endangered and there were issues with how the results were shared a few years ago.
- Bobby Greenly mentioned that for his comments about the 1% harvest for the interim decision, even if we have community consultation and public hearings, if this was a 2.5% harvest it would give us 105 tags which would be more significant than 42 caribou. Is that something that would be possible?
 - Drikus Gissing this was not an easy decision and there were several formal meetings with the Minister. There were even discussions on implementing a moratorium. Based on our consultation with our Minister, 42 is the best recommendation we could present. It might not even have to be for a year, it could be for less time depending on how quickly the process of consultation and submission to the NWMB goes. The harvest limit could go up or down based on that process. The change won't come until after the formal consultation. He agrees with some of the points made by Bert Dean in that there is a need for more information, community input, and more survey information to be collected. NTI has not made any alternate suggestions. We hope that we can meet with you in the next month or two, if not sooner so that we can speed up the process.
 - Bert Dean wanted to add that NTI's focus has been on what the HTO or community supports and that is why they have not come forward with an alternative suggestion. He

pointed out that the Coral Harbour community worked together to support a lower HTO and all the co-management partners were on the same page. I don't know how much harvest there would be. Is it a critical time when the herd aggregates on the coastline? We need to acknowledge that this harvest has to be shared. If the significant part of the herd is migrating to a different area how do we address that issue? There would have to be discussion on allocation.

- Denis Ndeloh had a question and clarification on the process that the GN is trying to go
 through with this process. Your letter says that at this time the GN is recommending an interim
 decision as outlined by 5.3.24 of the Nunavut Agreement. I understand you are bringing a
 recommendation to the board after this process. Why are we saying we are going to the NWMB
 if we want to use 5.3.24, we do not need to involve the Board before the interim decision is
 made.
 - Caryn Smith and Drikus Gissing we will be making a Ministerial Management Initiative recommendation to the Board as outlined by 5.3.25 of the Nunavut Agreement before making a decision under 5.3.24. This gives the board the opportunity to make a decision before we move forward with a Minister's Interim Decision.
- Bobby Greenly doesn't really have any more questions but wants to point out that he doesn't agree that thousands of caribou are being harvested and that he does not think the limit of 42 is appropriate and would like to see it a bit higher.

Burnside HTO Comments and Questions

• There were no comments of questions from the Burnside HTO

Kitikmeot Regional Wildlife Board Comments and Questions:

Bobby Klengenberg – he was out in the field when the survey was done and the caribou were starting migrating down at that time and it was only a small portion of where the caribou were. I know things won't change from what was said this morning. If the survey is repeated I would like to see more areas added to the survey. You might get better numbers if you add more areas. We have more communities involved so it would be great if the number was a little higher.

NTI Comments and Questions

 Bert Dean – NTI will be willing to work with the communities to help figure out what approach they think would be the most appropriate in this situation. They also have a call soon with Inuvialuit Game Council. Cheryl has been working with the KHTO to set up meetings with Inuvialuit. We will just continue to work with the communities.

NWMB Comments and Questions

- Jason Akearok he can see that this is considered an urgent issue for the GN, but given the suggestion put forward by EHTO of a higher TAH, is there a possibility of considering a higher number before submitting to the NWMB.
 - Drikus Gissing at this point, based on the evidence we cannot consider a different recommendation. Also, there has been almost 2 years since the survey so the overall population may be lower. The NWMB is able to consider other information in their response, such as Traditional Knowledge. As you know, additional information is collected through the consultation process. We hope that all the information collected through consultation can help direct a harvest management decision that is reflective of the best available information.

University of Calgary Comments and Questions

• Susan Kutz – they are there just to provide additional information to all the organizations.

*Omingmaktok HTO Comments and Questions

• Peter Kapolak *(provided after the teleconference) – In Bathurst Inlet, in May or April, we see the Dolphin and Union caribou going with the Ahiak caribou, going to the east, they're traveling with the Beverly herd. Quite a few caribou going east. Maybe that's why the numbers are down.

Closing Remarks

- Caryn Smith We want to work with communities and follow their lead on how the consultations should proceed. We are looking for direction from the HTOs on the best time and method for holding formal consultations. It's important that we work closely on this as we know the consultation step in this process is very important.
- Bobby Greenly wanted to make a suggestion that now that we are able to travel, if you come to the community very soon while it's warm we could do this outside and maintain distance. Like setting up speakers. He suggests we deal with this right away and ASAP before people are going out on the land.
- Bobby Anavilok how did the government come up with 42? I don't think it was a serious
 matter for the government but it was a serious matter for us. This is going to create a problem
 for us. We don't believe the proof of the survey. Can't just go by assumptions or guessing. We
 have to get the real numbers. Have to get the real numbers from the people of the North and
 not the people from the South.
 - Caryn Smith the DOE will be putting a lot of effort into ensuring there is adequate involvement from the communities before and during the survey work. There will need to be meetings with HTO and local harvesters before the survey to ensure that the

survey area represents the best amount of coverage and best areas to survey the most amount of animals. We will also be sure to include HTO/community members on the actual survey as well.

- Bobby Greenly in the past they have pushed to make sure that someone from their community was on the survey flights and he wants assurance that they will be represented on the upcoming survey.
- Drikus Gissing assured Bobby that they will involve the HTOs in the survey and if they feel they are not being involved properly to contact him directly.

Meeting adjourned at 1:55 pm EST

Appendix A

Scientific Survey Results and Management Recommendations Speaking Points for Dolphin and Union Teleconference with Co-Management Partners Thursday, June 18, 2020

Scientific Survey Results

- The Dolphin and Union caribou herd has been surveyed, using the coastline methodology, in several years including 1997, 2007, 2015, and now in 2018.
- Prior to the most recent survey, the population trend was showing a slight decline, representing about 34% over an 8-year period (4.2% annually on average) between 2007 and 2015.
- The results of the 2018 population survey have indicated that herd is experiencing a drastic decline, which represents a serious conservation concern for the future recovery of this herd.
- The 2018 population estimate is 4,105 caribou, which is a continued decline from the estimate of 18,413 caribou in 2015, 27,787 caribou in 2007, and 34,558 caribou in 1997.
- There has been substantial harvest from the herd since the 2018 survey, partly as a response to the declines of neighbouring Bluenose East and Bathurst caribou herds, and that harvest could have resulted in further declines to the herd.
- The currently declines are not due solely to harvest but with very few animals, the risk posed by overharvest is significant and could result in continued population decline and/or extirpation on some parts of the traditional Dolphin and Union range.
- Climate-related changes, timing of the sea-ice freeze-up, shipping, predation, and competition with other species are also considered main threats to the survival of the herd.
- Demographic indicators such as low calf to cow ratios, low female survival, low pregnancy rates in harvested females, and low bull to cow ratios are also concerning factors for the sustainability of this herd.
- All collars that were deployed in 2018 continued to cross to the mainland in both 2018 and 2019 winters. Based on historical assumptions and some Traditional Knowledge, the herd will stop migrating if the population gets too low. The population may be near that level so it is critical that it is maintained, especially for all communities to maintain access to the herd.
- Your communities and your HTOs have been leaders in the stewardship of your wildlife populations. You have taken measures that should absolutely be commended, such as cancelling sport hunting and working with the GN on the wolf sample program.

• Research on wolverine in the Kitikmeot is in the analysis stage and will be followed by results and a final report to be shared with communities. Plans for grizzly bear research in the Kitikmeot are in the early planning stages but faced some delays due to Covid-19 restrictions.

Management and Recommendations

- Considering the population estimate of 4,100 in 2018 and TK study results, we need to discuss the Next steps, and management recommendations
 - GN is recommending an Interim TAH of 42, representing a 1% harvest of the population
- This Small harvest would help preserve cultural and traditional harvest practices
- This interim recommendation reflects the severe recent decline, and it is critical that this is implemented as soon as possible so we are reaching out to the NWMB to address this interim recommendation outside of their regular quarterly meetings.
- The GN is looking to implement for the upcoming harvest season and meet as soon as possible afterwards for a consultation.
- We would like to know how HTOs want to proceed with full consultation in the coming months. The interim decision does not mean there can't still be a change in the TAH after the interim decision is implemented. Consultation will be held, and a new recommendation submitted to the NWMB that incorporates all the information gathered through consultation.
- More important than ever, that all co-management partners acknowledge this decline and we come together to protect the herd so that it can persist on the landscape for future generations of harvesters.
- We are hoping this short-term sacrifice will allow us to realize the long-term goal of ensuring this herd is sustainable for future generations of harvesters.
- We Need HTOs to relay this urgency to their members and work closely with conservation officers to implement and adhere to the TAH as a protective management measure
- I'd like to thank all HTOs for the existing measures they have taken , like suspending sport hunts, and for closely working with us to date on voluntary harvest reporting and sampling
- The next survey is a high priority for our department, we would like HTOs to be highly involved. Fall 2021 at the latest

Appendix B

Traditional Knowledge and Health Monitoring Speaking Points for Dolphin and Union Teleconference with Co-Management Partners Thursday, June 18, 2020

TK points (Andrea Hanke)

- Methods description
 - In 2003, Monica Angohiatok led Traditional knowledge interviews with Ida Kapakatoak. Together, they interviewed 15 harvesters in Ekaluktutiak and 15 harvesters in Kugluktuk (total of 30 harvesters). Then, I analyzed these interviews and brought the results back to both communities in 2019 during their HTO AGMs (January), the User-to-Users meeting in Kugluktuk (May), and the Ice-Breaking meeting in Ekaluktutiak (October).
 - As Amanda Dumond and Larry Adjun know well, I've been working really close with the KHTO and GN to hold new TK interviews in Kugluktuk (just here due to constraints in resources). This started with 15 individual interviews in the fall of 2018, where Amanda graciously had me in her office for two months. Then, I returned in January 2019 to discuss the initial results with harvesters and complete some more activities. This happened in 7 group interviews with 16 people in total. Then, I returned in January 2020 to finalize the results with harvesters and to modify or clarify any of interpretations from our previous interviews. For this, we had 4 formal group meetings and 7 meetings where people dropped in to the HTO to go over the results with me (25 people in total). It has been a very collaborative process and engaged a total of 33 harvesters.
- <u>Interpretation point</u>: Hunters expect variation from annual/seasonal changes (ex. weather) and harvester/caribou locations (ex. harvesters' camps and caribou aren't expected to use the exact same locations every year).
 - Results are specific to the communities and harvesters they're informed by as people are familiar with different parts of the land and different times of the year (2003/2018)
 - Reports on abundance are tied to location of harvesters (2003/2018)
- Caribou story

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- Kugluktukmiut perspective
 - 1. Kugluktukmiut said that the DU caribou abundance peaked ~1980 (2003/2018)
 - Near this time, between 1980 to early 1990s, Kugluktukmiut in the 2018-2020 study said DU caribou were found both east and west of the community during the winter and summer. People did not have to travel far to find and hunt DU caribou.
 - 3. Harvesters said the late 1990s and early 2000s was a time of change for DU caribou. They said DU caribou were not as abundant on the mainland west of Kugluktuk, and there were fewer observations of DU caribou crossing the Dolphin and Union Strait. Instead, they saw DU caribou more frequently on the mainland east of Kugluktuk, moving towards Tree River. On southwestern Victoria Island, harvesters also said there were fewer caribou, but still enough for hunting purposes so they didn't have to travel any further. This decline was also reported in the 2003 study, where people were seeing fewer DU caribou and more sick caribou in 2003 than they had in the 1980s.

- 4. Moving to the late 2000s and early 2010s (2018-20 interviews), harvesters said people continued travelling further east on the mainland to find DU caribou, now mostly between Tree River and Grays Bay. Near southwestern Victoria Island, harvesters said this time period was when they started travelling further inland to find DU caribou and needed to plan their hunting trips later in the season to match the DU caribou movements.
- 5. From late 2010 to today, harvesters said people continued travelling further east on the mainland to find DU caribou, now mostly travelling to Grays Bay, Wenzel River, and beyond into Bathurst Inlet. Harvesters familiar with the southwestern Victoria Island area said this time period was when, even though they are travelling further inland to find DU caribou, they find fewer DU caribou than the late 2000s and early 2010s.
- 6. Today, Kugluktukmiut from the 2018-2020 study said there are approximately 40% DU caribou left today. To get this number, we used a pile of beans to represent the most DU caribou people have seen (the peak). When asked how many DU caribou they see today, harvesters moved the portion of beans they thought represented the approximate portion of DU caribou they see left today compared to the peak. We did this with the 7 group interviews in 2019 and the abundance trend was approved in 2020 with harvesters.
- o <u>Ekaluktutiakmiut perspective</u>
 - 1. Ekaluktutiakmiut reported peak abundance between 1990-2003, also the time when they said DU caribou were close to the community.
- Summary:
 - From the <u>Kugluktukmiut perspective</u>, the DU caribou abundance peaked ~1980s and were close to the community. Then DU caribou started to move away from Kugluktuk in late 1990s and early 2000s, and today they are the furthest from Kugluktuk with ~40% of DU caribou present today compared to the population peak around 1980.
 - The Kugluktukmiut perspective differs in some timing and details from the Ekaluktutiakmiut perspective. In Ekaluktutiak, caribou numbers peaked later (1990s-2003) and fewer sick animals were seen in 2003 compared to Kugluktuk. To understand DU caribou at the herd level, it'll be important to consider TK from all communities within the DU caribou range as they inform on different times of the year and different geographic regions.
- TKK concerns for DU caribou and management suggestions from Kulguktukmiut 2018-2020
 - Kugluktukmiut were concerned about the impact of harvesting practices (caribou herds and predators), exploration/traffic, climate change, thin ice, and insects have on DU caribou status (2018)
 - Formation of sea-ice impacts the location of caribou and safety during migration (2003)
 - They advocated for education for inexperienced harvesters as the most feasible, short-term action to mitigate pressure on the DU caribou herd for long-term outcomes (ex. Pairing those who want to learn with those who want to teach). Education about the supports already available could be useful too (including supports available for predator harvesting). (2018)

Caribou Sampling (Susan Kutz & Javier Fernandez Aguilar)

- <u>Goal</u>: Understand the health, condition, pregnancy rates of animals through samples from harvested and captured caribou
- <u>Why</u>: Individual health reflects how they are doing that year and may help predict future population trends, also tells us if the caribou are safe to eat
- Samples 2015-2019, 209 in total

- Harvester sampled: Kugluktuk=97, Cambridge Bay=49 and Ulukhaktok=4 (does not include samples from CB [18) and Kug [7] in fall 2019)
- Captured and collared for population monitoring purposes by the Government of Nunavut (n=85).
- <u>Genetics</u> in progress, but 3 from hunted near Ulukhaktok in Dec 2018/Jan 2019 were tested and confirmed as DU. These were given high priority to test because it was a bit unusual to harvest DU caribou in high numbers near Ulukhaktok in the winter.
- <u>Blood</u> on filter paper testing for various diseases found several that can affect reproduction, but this is 'normal'
- One finding that is a of importance is high occurrence of **brucellosis** (14%)– animals with that are less likely to be pregnant (92% vs 63%), are in poorer body condition, and survival may be reduced. This disease can also affect people.
- Hair tested for <u>trace minerals</u> lower than other caribou populations especially Selenium which is important for growth and reproduction
- Hair tested for stress hormones 2018-19 lower stress levels than 2015-17
- Higher overall pregnancy rates compared to 2 other studies (1987-91, 2001-2003) (combined pregnancy rates for harvested and captured caribou are: 2015=88.2%, 2016=87.5%, 2018=85.5% and 2019=96.3%).
- Higher body condition compared to samples from 1987-91 when the herd was either at its peak or just beginning to decline, depending on location
- These findings of higher pregnancy rates, declining stress levels, and higher body condition in the last few years suggest a few good years recently for the DU caribou. BUT
 - we don't know actual calving rates or calf survival (could be affected by some of the diseases, low selenium, as well as weather, predators, etc)
 - Brucellosis is affecting reproduction, condition, and survival
 - Trace minerals may be low cause ongoing problems in reproduction and calf survival
 - Ongoing monitoring will help to determine if there is a trend in individual health improving, or if it is only a few good years.



Ekaluktutiak Hunters & Trappers Organization P.O. Box 1270 Cambridge Bay, Nunavut, X0B 0C0 Telephone #: (867) 983-2426 or 983-2428 Facsimile #: (867) 983-2427 Email: cambay@krwb.ca

October 28, 2020

Nunavut Wildlife Management Board PO Box 1379 IQALUIT NU X0A 0H0

RE: Submission for Total Allowable Harvest (TAH) of 42 Tags on the Dolphin and Union Herd

Thank you for taking the time to review Ekaluktutiak Hunters and Trappers Organization's (EHTO) submission of the TAH of 42 Tags on the Dolphin and Union Herd.

We understand there is a decline but to put a TAH on our main country food source was a shock to our membership. The season is upon us to harvest caribou for the long winter a head. Our Elders and youth are the ones affected by the imposed TAH.

Department of Environment (DOE) did NOT have Community Consultation with our membership before the TAH was imposed. That clearly goes against the Nunavut Land Claims Agreement. DOE did NOT include Traditional Knowledge in their reports on the Dolphin and Union Herd and again that goes against the Nunavut Land Claims Agreement.

42 tags (1% of 4,200) for Cambridge Bay, Kugluktuk, Bay Chimo and Bathurst Inlet is very low for our Community population. Therefore, EHTO is requesting NWMB to increase tags from 42 to 210 tags (5% of 4,200).

here / Regards,

Bobby Greenley Chair



Ekaluktutiak Hunters & Trappers Organization P.O. Box 1270 Cambridge Bay, Nunavut, X0B 0C0 Telephone #: (867) 983-2426 or 983-2428 Facsimile #: (867) 983-2427 Email: cambay@krwb.ca

Tattiarnaqtuq 28, 2020

Nunavut Uumajuliqijirjuat Katimajit Titiqqiqivia 1379 IQALUIT NU X0A 0H0

MIKHAAGUT: Tunijakhat haffumani Atauttimuuqtut Anngutikhanut (TAH) hapkuat 42 Nalunaijainingit ukunanngat Ikirahak Amihuarjuit Tuktungit

Quanaqqutit hamna qimilruaqhimagangi Ekaluktutiak Anguniaqtit Timingat (EHTO) tunihimajangit haffumani TAH hapkuat 42 Nalunaijainingit ukunganngat Ikirahak Amihuarjuit Tuktungit.

Kangiqhihimajavut ikivalliajut kihimi pinahuariami ATAUTTIMUUQTUT ANNGUTIKHANUT niqituavut quglungnaqtuq taimaa katimajikput. Hamna hilaqutivut anguniariami tuktumik ukiuraalungmi hivuani. Inutuqavut inuuhuktuutivullu tadja ihuiluutigijaat uvanngat ATAUTTIMUUQTUT ANNGUTIKHANUT.

Avatiliqijit Havagviat (DOE) Nunalingni KATIMADJUTIGIHIMANNGITTUT katimajivut hamna ATAUTTIMUUQTUT ANNGUTIKHANUT akhuuqpiaramik talvuuna. Taamna tutqittiaqhimajuq malikhimaitpiaqtaat Nunavut Nunataarvingat Angirutaat. Avatiliqijit Havagviat (DOE) ILAGINNGITPIAQTAAT Iuit Qaujimajatuqait Maligaut unipkaaqhugit uvunga Ikirahak Tuktu Amihuarjuit taamna iliginngitpiaqtaat Nunavut Nunataarvingat Angirutaat.

42 nalunaijainigt (1% haffumani 4,200) Iqaluktuuttiaq, Qurluqtuq, Umingmaktuuq unalu Qingauk ikitpiaramik Nunalingni amihuuningit. Talvanngat, EHTO tukhiqhimajaat NWMB angiklijakhaat nalunaijainingit uvanngat 42 mit 210 mut nalunaijainingit (5% haffumani 4,200).

Ukpiqtatka,

Bobby Greenley Ikhivautaq

すうく 28, 2020

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C. P. 2410 Igaluit, Nunavut X0A 0H0

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> ՐԺ՝C ସ≪Ո⊂ռծ՝ժ°⊅° Minister of Environment Ministaat Avatiligiyitkut Ministre de l'Environnement

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> רסי⊂ ⊲≪∩רתאילים⊂ Minister of Environment Ministaat Avatiliqiyitkut Ministre de l'Environnement

Mr. Daniel Shewchuk Chairperson, Nunavut Wildlife Management Board PO Box 1379 Igaluit, NU X0A 0H0

June 22, 2020

Re: Dolphin and Union Caribou – 2018 Survey Results and Management

Dear Mr. Shewchuk,

In October 2018, the Government of Nunavut (GN) Department of Environment (DOE) conducted an aerial survey of the Dolphin and Union caribou herd using the fall shoreline methodology established and used since 1997. Additional survey analysis was completed to include new genetic information, and to ensure the results included all available information following some external concerns with methodology. The additional analysis delayed the completion of the final report, but the results and the final report are now completed and have been shared with Hunters and Trappers Organizations (HTOs), co-management partners, and with management authorities in the Northwest Territories.

The results of the 2018 population survey and a recent Traditional Knowledge study (report in progress) have indicated the Dolphin and Union caribou herd is experiencing a drastic decline, which represents a serious conservation concern for the future recovery of this herd. The current population estimate is 4,105 caribou, which is a continued decline from the estimate of 18,413 caribou in 2015 and 34,558 caribou in 1997. Traditional knowledge studies conducted in 2003 and 2018-2020 also indicate that there have been significant declines in the herd around the communities of Cambridge Bay and Kugluktuk since peaks around the 1980's to 2019. There has also been substantial harvest from the Dolphin and Union caribou herd since the 2018 survey as a response to the declines of neighbouring Bluenose East and Bathurst caribou herds. Concerning demographic indicators of this herd such as low calf to cow ratios, lower pregnancy rates in harvested animals, and a low bull to cow ratio, have also shown a need to take action for the protection of this herd. The current decline is not due solely to harvest but with very few animals, the risk posed by harvest is significant and could result in continued population decline and/or extirpation on some parts of the traditional herd range.

It is more important than ever that we work together to conserve this herd for future generations of users in both jurisdictions by doing everything we can to help facilitate recovery. The communities that harvest from this herd have been leaders in the stewardship of their wildlife populations. There have been some measures taken by HTOs in Nunavut that should be commended, such as cancelling sport hunting on the herd, but given the drastic decline of this herd, additional measures are needed to support recovery before it is too late.

My Department had intended to consult in the spring of 2020 with the affected HTOs, comanagement partners, and relevant users and management authorities in the Northwest Territories, but the travel restrictions in place due to COVID-19 have delayed this process. Due to the seriousness of the herd status and given the possible delays in completing a fulsome consultation process, my Department is recommending an interim decision for urgent and unusual circumstances, as outlined in section 5.3.24 of the *Nunavut Agreement*. I request that the Nunavut Wildlife Management Board (NWMB) make a decision on this matter in time for implementation prior to the start of harvesting in the Fall of 2020.

The recommendation is for a 1% harvest limit (42 caribou) herd-wide while the consultation process is being completed and until new information is available, including results from a new population survey. Maintaining a small harvest would help to preserve cultural practices and traditions. As this is a shared herd with users in the Northwest Territories (NWT), we are initiating discussions within Nunavut and the NWT to determine how to appropriately share the suggested harvest of 42 caribou. The Kitikmeot Regional Wildlife Board would be the responsible agency for the allocation of the harvest to the relevant Nunavut Communities. Given the seriousness of the decline in this herd, a new population survey is tentatively planned for 2021. This recommendation is also in line with the Management Plan that was approved by the NWMB.

Management actions should be enacted as soon as possible in order to reduce the risk of further significant declines and/or extirpation from some parts of the Dolphin and Union caribou herd range. There will need to be an expedited process to develop a plan forward for a fair shared allocation of the harvest between the jurisdictions and users. An adaptive management approach is recommended including regular monitoring to advise changes to harvest restrictions so that actions reflect population size and trajectory. The DOE will work to ensure they replace lost collared animals due to mortalities and start the planning of the new population survey as soon as COVID-19 restrictions permit these activities.

DOE believes the above noted recommendation is the best balance based on the current available scientific information and Traditional Knowledge/*Inuit Qaujimajatuqangit* to ensure harvest is set to a sustainable level and could help support a recovery of Dolphin and Union caribou.

I know the NWMB members and staff are committed to ensuring the valuable resources of Nunavut, such as this important caribou herd, are managed successfully for future generations. I look forward to working together to ensure this herd's recovery and sustainability.

Sincerely,

Hon. Jce Savikataaq Minister of Environment

Cc: Jimmy Noble Jr., Deputy Minister of Environment Steve Pinksen, Assistant Deputy Minister of Environment Drikus Gissing, Director of Wildlife Research

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August 10, 2020

Mr. Daniel Shewchuk Chairperson Nunavut Wildlife Management Board P.O Box 1379 Iqaluit, NU X0A 0H0

Re: NWMB Decision on the Government of Nunavut's Proposal to Establish an Interim Total Allowable Harvest for the Dolphin and Union Caribou Herd

Dear Mr. Shewchuk,

Thank you for your decision letter, dated July 28, 2020, concerning the proposed interim Total Allowable Harvest (TAH) for the Dolphin and Union caribou herd.

To reiterate the decision of the Nunavut Wildlife Management Board (NWMB):

 RESOLVED, that the Board inform the Government of Nunavut that the Board will review the matter should the Government of Nunavut use its Nunavut Agreement section 5.3.24 authority to establish an interim Total Allowable Harvest for the Dolphin and Union caribou herd.

Due to the urgent conservation concern for the Dolphin and Union caribou herd, I intend to move forward with the interim decision and implement a TAH of forty-two (42) caribou until the consultation process with affected Hunters and Trappers Organizations, and other co-management partners is completed and additional information is collected to inform a new management recommendation.

I know the NWMB members and staff are committed to ensuring the valuable resources of Nunavummiut, such as this important caribou herd, are managed successfully for future generations. My Department will make certain your Board staff are well informed of the consultation planning and process. I look forward to working together to ensure this herd's recovery and sustainability.

Sincerely,

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Hon. Joe Savikataaq, Minister of Environment

Cc. Jimmy Noble Jr., Deputy Minister of Environment Steve Pinksen, Assistant Deputy Minister of Environment Drikus Gissing, Director of Wildlife Research



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Гज[∿]⊂ ⊲≪∩⊂∿ి⊸^с Minister of Environment Ministaat Avatiliqiyitkut Ministre de l'Environnement

Mr. Daniel Shewchuk Chairperson Nunavut Wildlife Management Board P.O Box 1379 Iqaluit, NU X0A 0H0

September 4th, 2020

Dear Mr. Shewchuk:

Re: NWMB Decision on the Government of Nunavut's Proposal to Establish an Interim Total Allowable Harvest for the Dolphin and Union Caribou Herd

As a follow up to my letter on August 10, 2020, I want to inform the Nunavut Wildlife Management Board (NWMB or Board) that as per section 5.3.24 of the *Nunavut Agreement*, I have implemented a Total Allowable Harvest (TAH) of forty-two (42) caribou for the Dolphin and Union caribou herd, effective immediately. This decision was not made lightly and was in response to the urgent conservation concern for this herd.

In addition, Department of Environment staff are planning in-person consultation with the affected Hunters and Trappers Organizations (HTOs) and relevant co-management partners in early October to discuss the interim TAH, future management recommendations, and ongoing monitoring of this important caribou herd. Department staff are also investigating options and the availability of resources to run a population estimate survey of the Dolphin and Union caribou herd as early as possible.

My Department will work with your staff to ensure you have what is needed to conduct a Board review of this interim decision, as outlined in section 5.3.24 of the *Nunavut Agreement*. I look forward to working together to ensure this herd's recovery and sustainability.

Sincerely

Yoe Savikataaq, Minister of Environment

Cc. Jimmy Noble Jr. - Deputy Minister, Department of Environment, Government of Nunavut (GN)

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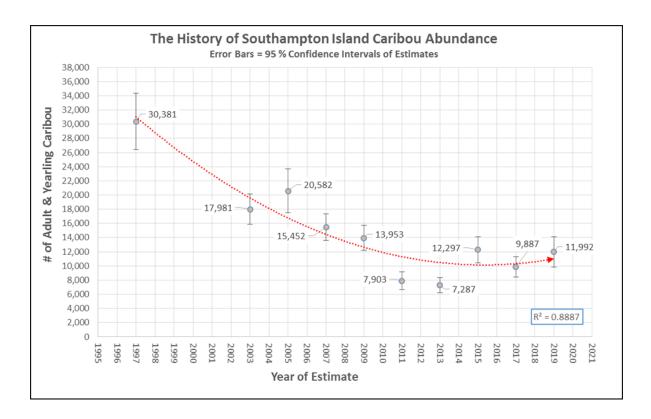
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⊲'ት 1. - ኄዾ∆⊂▷ናምዮና ኣ፦ሮናና ጋካጋ∆ና ⊲Γ√σዮና.



⊲≪∩⊂∩≻⁵d⊂ Department of Environment Avatiliqiyikkut Ministère de l'Environnement

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⊲>°σå^ь 10, 2020

؋َڡ؞ ᠆؞۩>؞, ٩«٠᠆،۲۲ ص٬۲۸ ۲۵، ۵۷>۰, ۹«۰᠆،۲۲ ÞL۲ ۵۵٫۵۵ ۵۵۵ میه۵ ۱۹۲ ۲۵٫۵۵۲ ۲۰

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1.0 ב∆ב [®] ۲L ל [®]	.1
2.0 ጋየረባናባኖች	.3
3.0 Þσ≦ἑ< ለንጘ∩∿Ⴑ ⊲୳L⊃ ╡⅌₽⊳Lσ∿Ⴑ	.4
4.0 ∧'⊀∩∿Ն ⊳ʻճʻճ∩ʻճʻʻσʻ⅃ʿ ⊳ ^៲ ௨Ϛʻσ∿Նʿ	.4
4.1 ዄ⊿ፊ℃σ℃ Ҍ∩L∩ና∩ႫႺ	.4
5.0 ኣʿຕፕˤ ÞLᠯᡣᡅᢣᢦᡄᡃᠯ᠋᠋᠄ ᲮᲘLᢦᢩᡥ᠈᠘ᠯ᠋ᡃ᠉᠁᠁᠁᠁	.5
6.0 ∩∩ኈዞ୮° Ճᡄ▷ጚኈ 1	.8
7.0 ∩∩ჼႱ⅃՟ Ճഺ൳⊳ՈỉLํ∜ 2 (ႱႶLነํႵႶ՟)	.9

ϷΓLϲ_Ωσ⁵J^c Ϸⁱ_σ^bⁱ_σ^bⁱ_σ^bⁱ_σⁱ_σ^bⁱ_σⁱ_σⁱ_σⁱ_σⁱ_σⁱ_σⁱⁱ_σⁱ_σⁱⁱ

⊴'ል⊴ና, በዖና'ᢣ⊴ኈ, ᲮኍՐኈቍኇዀ, ኈLዏናጋ⊲ዀ, ᠘ᢣᠴᡄᡶᡝᡧ, ᡆĎᠨᢆና Ϥᡃ᠘ᠴ ᢣᡄ᠋ᡝ᠋ᡗ ᠌ᢃᡥᠣᢁᡃᡫᠣᡄ $\forall P^{\sigma} \sigma \delta^{\flat} (\delta P \triangleleft n) 5 \forall L \supseteq 24, 2020 - \Gamma^{c}, D \triangleleft P^{L} U \triangleleft L^{\flat} d^{\circ} \Gamma^{c}, \Delta \sqcup P^{c} \supseteq \Omega^{\flat}$ ۹۳۰۵ کرد ومحدد مربطهم ۷۹ مارت ۵۹ مربطه که مربطه م ⊂ کھکھا ا^ے کے ل احد کے کے محد کے کے کے ل احد کے کہ کے ل احد کے ک . ٢٤ خصه حاله مان المان المان المانية المحالية المحالية المحالية المحالية المحالية المحالية المحالية المحالية الم ᠵᢁ᠆ᡔ᠘ᢤᢕ᠙᠆ᡐ᠘ᠿᡩᡐᡆ᠖ᢐᡃᢐᠲᡘᡆᢐ᠙ᢧ᠘ᠿᡄᢂᡩ᠘᠘ᡩᠴ᠘᠅᠆ᡔᢌ᠘ᡩ ▷Γ∿LΔ⊆L℆Δ<&ՐՆ⊆℃℃℃℃~ም⊆, Δ/LΓ۶℃~ጏ ∧፫ኪ⊲ኪ⊀L۶<⊂ 2020-21-Γ⊆Γ℆ℶ⊆ ϤL⊃ ۲۹۹۹۵۰ کے ۲۹۹۹۵۹ کے ۲۹۹۹ کے ۲ \forall ለ⊲ቍና∩⊲∟⊳ኈ⊃ኈ ⊲୳∟⊃ ՃᲮላՃቍዄኈンቍ CLՃჾኴና Ճ୯⊳ጘኴና ጘኈዮና∩ኈLና ⊳ኦለሲኦዄናቍናℾ» $\Delta \Delta \Delta \delta^{*} / \delta^{*} > \delta \delta (\delta > \Delta c) > \delta^{*} - \delta^{*} / \delta^{*} - \delta^{*} / \delta^{*} = \delta^{*} / \delta^{*} - \delta^{*} / \delta^{*} / \delta^{*} / \delta^{*} - \delta^{*} / \delta^{*}$

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Δ /L^u\^w/DPMC/DC/ Δ ^w \leq CL^u, P/ $d\sigma$, d^{w} PC d^{w} / d^{c} MX-10-C^c DC^uL- σ d^{c} d^{c}

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- Δካፈውር▷< ጋ⊦ርጐሁ: Ċσ Å</p>
- ∘ ∆۲۹۶۲۵۵ : أ۲٬ م1ذ™

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- Ⴑ≪LጋჼႦჼⅆჼႫჼ ᲮႭႠႠჼ ႫჼႵႶຉჼ ለትჼႶና∆ϟჼݸና, ϷLႵႻႭ Ͻሲኣ Ⴀჼჼჼ

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⊳<_יי: ⊲≫°σ&° 10, 2020

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ᠴᡆᢁᡃᡏ Ⴑ֎Ľᡃݸ᠊᠊᠍᠌᠌ᡐᢪᡄᡄᢂ᠋᠅ᠫ᠋ᡄ᠋ᡃᡄ᠋ᡄ᠋ᡘ᠈ᡧᢕ᠋ᡬᡆ᠖ᢕ᠋ᢄ᠅ᢕ᠅᠋ᢕ᠅᠋ᢕ᠅ᢕ᠅᠋ᠥ ᡃ᠋ᡋ᠋᠒ᡶ᠋ᡃᡠ᠋ᡃᢐᢗ᠌᠌᠌᠌ᡄᢄ᠂᠋ᡦ᠅ᡗ᠅ᠴ᠋ᢩᡄ᠉ᡃᠮ Ⴑ֎Ľᡃݸ᠋ᠳ᠘᠋ᡗᠮᡃ, ᢆᡠᠺᡏᡃ, ᡤ᠋᠋ᡗᡃ᠂᠍᠋᠋ᠬᡃ᠋᠘᠋ ᢗ᠋᠍᠍᠍᠍᠆᠋ᢧᡃᡃ᠋ᢣ᠋᠋ᢐ᠅᠋᠋ᢉ᠋᠊᠋ᢌ᠆ᡄᢂ᠋᠆᠆᠘᠆᠆᠘᠘᠋᠆᠆᠆

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⊲d♂▷∩Ր♂[∿]し: L'?ં' ଘ[<]<'∿'',ン♂ ∆'∿'ናഛ^c

৬೧L೭ ৬՝Ը՝ ՃᲮᲙႪጋՃᲙ ԿႪՐՐJՈ՝ MX-14 ϷՐ՞L ຉ ዮ ᠆ϷᲙℾ՝ King William ՙՔԲႪԸՐ՚.

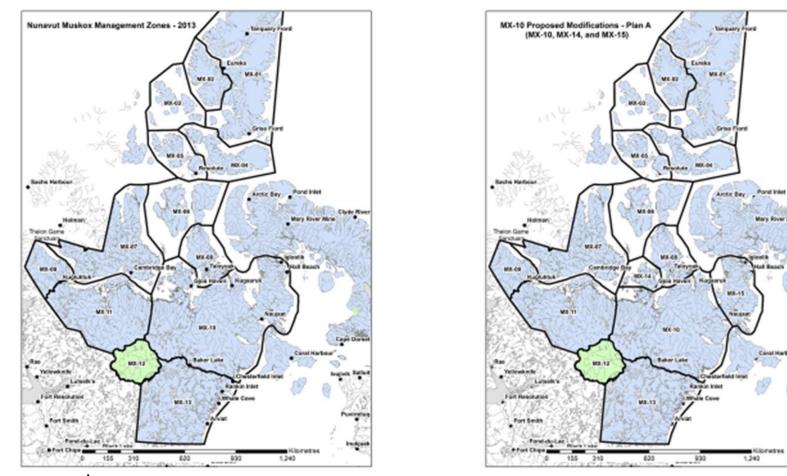
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<u>**ԽLᠯᡄᡊᢣ᠍ᠯᡄ᠈ᡩ᠘᠒᠘ᡷ᠋᠄᠋᠆᠉ᠫ᠋᠋᠋᠆ᡘ᠆ᡔ᠉᠆ᡧ᠘᠋᠖᠘ᢧ᠋ᠮ᠘ᢋ᠋ᡀ᠋᠉᠖᠘᠘᠀᠋᠉</u> ᢗᡆᡗ᠋᠊᠋ᡄ᠉᠋᠋᠋ᡊ᠆ᠳ᠋ᡏ᠋᠋᠋᠋᠋᠋᠃᠋᠋᠋᠋᠘᠆᠉᠆᠃᠘᠋᠁᠆᠆᠆᠆

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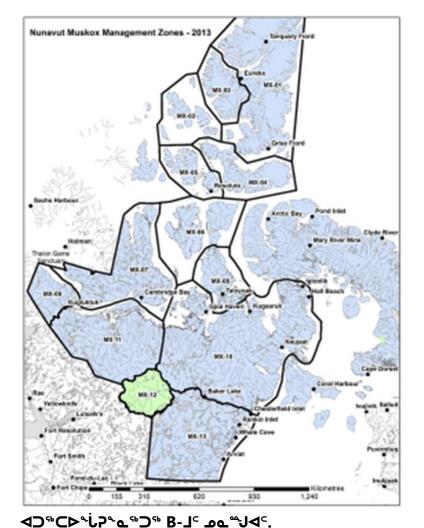
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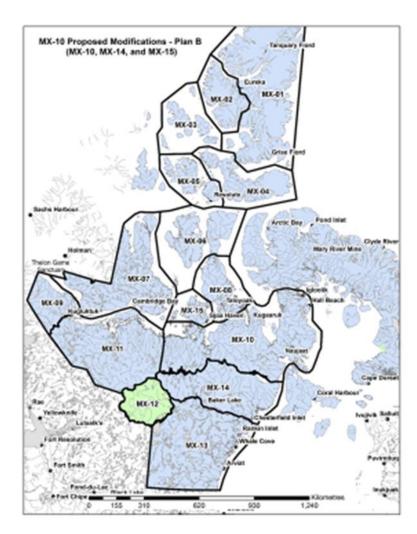
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> ⊲⊲∩רת¢לש Department of Environment Avatiliqiyikkut Ministère de l'Environnement

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₽≪੶**⊂**᠂ᡗ╴ᢩᡄᡄ⊳**ᢕ᠈**ݸ᠊᠋᠋ᠫ᠈⊃ᡄᡅᠣ᠅

Ϸ**ϭ·**ʹϷϷ**៸Ϸϭ**ʹϞͿ; የ≪·ϲʹΓϚ ʹϐϷ**ϟኣϪϭ·ʹΓ**՝ Ϸ≦ͻϹϳϲʹͽϽϪϭʹͽͺϤϞLͻͺϪϲת⊲ʹϞͿϞͰϞϚ Ϲ**ϭ**ϽϚϽ; Γϛ; ϳ· ϪΓ⊲ʹͽʹϞͺ; 7:02

ጋየተበናበታና Δ^ϧሃ «ϷϹ^ͼ - Ρ^ϧህ «^ͼͺͻϹ ΛΓϤϚʹϹ, Ϥ^ͱL_· Ͻ^ϧϽ/Ϸ^ィልቦቼናϹ^៳Γ[,] ͻ</mark>በJ^c ቼLσ^ィלϤ^ቴ Ϸ[<]«..................... < ァー Ͻ^ϧϽϓ^c, ቼ^kϓዖL۶ ^j c⁻ dϤ^t ϫⁱL^t<^c? Γ^{cⁱ} ϳⁱ>- - ϳ, ϹΔLαΔ^cϽα^t^sϽJ^c.

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⊂Δbσ.

 $\Gamma^{c'}\dot{b}^{b}$ - $4^{c'}\dot{b}^{c'}$

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°PP°°⊂Γ°.

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 $\dot{C}\sigma\dot{A} - \Im D\Delta^{c} \Im \Delta^{c}\dot{D}h^{c}C^{c}, \dot{\Phi}\sigma = \Phi \Im^{c}\Delta^{c} \Delta^{c} + \Delta^{c}\Delta^{c} + \Delta^{c}\Delta^{$

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- \triangleright b'd''\c^J \supset $) \rightarrow LC \dot{\triangleright} \supset$ G''C \triangleright b' \supset G''C \triangleright b' \supset G''C \triangleright c.
- $a a a a^{+}/(b c P^{+})^{+} D^{-} a a^{-}/(a^{+}) = a^{+}/(b^{+}) = a^{+}/(b^{+})$
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- 11,992 ∿∩⊆⊂

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 $P \leftarrow A^{b} adc^{b} - A > {}^{b} O^{c} a^{c} O O^{c} A^{c} O^{c} O^{c} A^{c} O^{c} O^{c} A^{c} O^{c} O$

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የ·≟Λ^ϧ ჲժ≟^ᢑ - ᠘᠘ᡶᠯᢗϷ᠋ᡗ᠋ᠬᡪᡃ᠉᠋ᠫ᠉. Γ^ϲʹϳϧ·>· - Ͻ᠈Ͻσ^ϧ ϫ៶᠉ϹʹႶ^ݒσ· Ͻσ⊀^ݒϫʹσϤͽϹʹϒ, ϫϲϷ·ϹʹͽϹϷϟϫϧ<u></u>ʹʹϒ·Ͻͽ የϒϤσ ϹʹϭϤ

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⊳⊲<∪₅⁻

⊲ч⊥⊃ ⊲ґ°℃∽ቍ℃▷ቍ ๒೭Ⴊ℃Ҁና℃. ∧┌Ⴂ⊲ખ∖┌чLႢ▷Ⴊ℃℃ႪϽӈ.

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Γ^ϲʹͺϳϧ·>·ͺͺ·ͺͽϲϒϷϿͺ;ͺͼϷϷϞϷϽϲϷͼϹͽϲͺϭϥͱʹϹϧͼͺʹϥϲϧͺͺͺϭͺϲϧͺͺͺͼ ϧͻϫϲϫ;

▷ርኈየኦሲ⊲ዄኈጋሇ Ľዏ፟ኍዾና ለኊፘኯዾዄኇ፞ኇ ርኈየቍ, ዄጘለዾዏኁዮና ጋካጋ∆ና ለJናበሇ ⊲୮ሥ ጋካጋርሲኦ▷ተレር ⊲σሇኊፙዀጋና. ዄጘለዾኇኁዮና ለ₽ኦበቦሇናበሆ ለኦዹፇዀጋኈ.

P·≟Λʰ ჲd≟ኈ - Ϸኄ₽Lᠯ∿Ⴑ ϽʰϽσʰ ኄϷᢣኣΔσϷ< Γʰኣ໋ഛˤ, ኄϷᢣኣΔσኈ Λ⊲σʰ<Ϛ,

 $\mathsf{Pd^{<}Hd^{}}-\mathsf{L}\mathsf{B}\Delta\dot{\cap}^{\mathsf{c}}\mathsf{C}\Delta\mathsf{B}\mathsf{}^{\mathsf{h}}\mathsf{C}^{\mathsf{h}}\mathsf{C}\mathsf{}^{\mathsf{h}}\mathsf{C}^{\mathfrak$

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 $\exists \mathsf{L}^{\mathsf{h}} \triangleleft \mathsf{L}^{\mathsf{h}} \mathsf{L}^{\mathsf{h}}$

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- [・] ΔbጘΔdF חΔ^{*} ΔLP^{*} Δ^{*}dND^{*} ℔σϹ^{*}しσ⁻ ΔHΔd^{*}-J⁻ Δ^{*}L₋ D^{*}dd^{*}\-^{*}J⁻ • ΔbጘΔdF በበ^{*}bF⁻ Ͻ^{*}Z^{*}D⁻ ĎLጘールオベニ^{*}イ^{*}σ⁻ 25 Ⴆ^{*}ל^{*}ל^{*}D⁻ D^{*}dd^{*}\-^{*}F⁻ Ͻ^{*}Ͻω⁻
- 35 ℅Lσᆟ⊲℠ ϽϧϽϧϹͺ;ϥϧϤϧϧϲϷͼϹϷϚϘͼϲϷ
- ▶₽₽∿ነ⊀[™] ነd∿나?
 ™ጏ∆ⁱi[™] Ր՟ጋJ՟ ጜLσⁱ ⊀⊲[™] Ͻ[™]Ͻ[™] Ր՟σ⁻.

₽≪₋⊂ኄL_⊂ ⊃,⊃**௨**, ₽⊳۶≀⊽௨。

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- L°ċ ⊂ 5-15

NEM ኄ⊳ኦኣ∆ፚኈ

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- ኄ▷ዖጘሬጘሪ ኣናሮና ⊲∠ዖዾና ⊲ናሪበቦካ ⊲ጋኄናርናಒ∿i⊂ ⊃ካጋኴና ፚዸጐዮና Lኄፚሰና
- ᠄▷ᡃᠫᡃᠣ᠊ᢦ᠋᠋ᡃ᠋᠅ᡔ᠋᠋᠅᠘ᡩ᠘ᡩ᠘᠘ᡃᡆ᠘᠆ᢂ᠋᠉
- ႦႫႠႱႫ^c ჃᡃL⊃ Ҏ≪·ႠϷ[<] ႫႶႳႫ^c. • ぱႫႠჼႶჼႶჼ╣ႶႫჼ ⊲ჂႱϷჼჁჂჼ. LჼႶႠϷႶႫჼ ⊲ჂႱϷჼႦჂჼ ჼႻႠႠĴႠჼႠჼ
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⊲L⅌ⅆ**ℴ** ℯՇ⊳Ս_৽۹_c Ք⊳۶ィՋՉ֎

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- ኄ▷ኦኣኈ∩ፖ▷ኄጛጏና ዾኈጉ፨๙ኇናና ኄዾላፐና ኄ▷ኦኣፚኇዾኇዻኈጋጏና ዾ॰ፚና-୮ና (ᠯσ)
- 2011-Г^с ┓∟▷^cĊ[™]⊂▷⊀^c 71,430

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᠌᠌᠉᠂᠔᠊ᡆ᠋᠉᠊ᢗᡔ᠋᠋᠉ᡩᡄᢂ᠉ᠫ᠉᠂᠋᠕ᢩ᠆᠋᠄᠔᠘᠕᠉ᢣᡆ᠋᠉ᢣᠳᠺ᠘᠅ᢕᡄᢂ᠉ᠫ᠘᠋᠕᠋᠅᠘᠆᠕᠅ᡁᢕᡄ ᠕᠋᠋᠉ᠫ᠅ᢕ᠋᠋᠋᠉ᡩᡄ᠘᠉ᠫ᠅ᡔ᠙᠅ᢕᡄ᠂ᠴᡆ᠈ᡃᡆ᠋ᢆᢓᠬ᠋᠅ᡶ᠂᠘ᠴ᠅᠊ᠥ᠂ᢕ᠋ᠯ᠉᠋᠋᠋᠘᠋᠒᠋᠋᠄᠋ᠺᠰ᠉᠋ᢕᠥᡃ

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 $\Gamma^{c'}\dot{b}^{L}$ - L'?' PPP \triangleleft - \neg - \square^{c} - L'P \neg - \square^{c} - L'P \neg - \square^{c} - L'P \neg - \square^{c} - \square^{c

᠋᠄ᡃ᠋᠋᠋₽ᠻᡃ᠋᠖᠊᠋᠆᠋ᡬ᠊᠖ᠳᢕ᠋᠋᠋᠋᠆ᢄ᠂ᢞ᠋᠘᠋᠋ᢄ᠆᠆᠘᠋

Γ^ϲ՝ ϧϳ·<- - ϹϥͿϐϲ ϹϥϧϘϲ ⊲ͽϧϲϿͺͽϽ ͽϿϧͺ· ϳϞ, ͼϥϚͽ - Ψ₂ϒϧϤϲϿ;ϿϿϘϲ ϫϥ;ϥͺϧϫ, ϹϥϚϿͽϽϯ ϭϿϷϫ, Somerset

۲^ﺩ٬ ﺁﻧ<╴ - ﺩﻟﻪﮪ ﺧ^៲ﻟﻪﻙ». ᲙՀ٬ ﮪᲫᲚ - ᲮᲠᲞᲘ⊲Ლ،Კ ﺩ ﺩᲙᲙ~Ლ,ᲙᲙ Facebook-Კ ﺩᲙᲠﺩᲚ,Დ๛ ᲑﻪᲑ ﺩᲠᲑംჂ ᲠᲮᲠ८८-

ح&^₅ل⊂ٰם⊂.

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Γ^ϲʹ ϳͼϳʹϚͷͷϫͷϲ;;ͺϫϲ;ϫϲ;ͺϫϲ;ϫϲ;

σϷል⊲ʰኣኈኈ·Ϲኄኒኂር? Ċσ λ - ຼຉ៹៹[∿]⅃⊲ኈር΅Ր·Ͻ·.

CLP∿レϷϽΔ·ϫჼ<C ጋነጋለϷʹᠴՌ. ₽Ϥʹ ዘϤJ - CL·ϫ ጋየለ·ϫ·ናበϤኈጋኈ ጋϤልϫኈ<ና, የለϤϭ Ϲ·ኣ ለቦሃለ Ϥ·Lᠴ Ϲ·ϹʹͰͰ<C ΔለLኈለኈጋለ ጋσ⊀LJ՜ለϷነ Δϫʹϒ·ϭ· Ͻϭ⊀L΅ϒ·ͿϭʹϒϷ·ʹ϶·ϭ·ና. ቴϷኦLልለ Ϲ·«΅Ⴑና ኣ·ϲ·ና⅃ና ϭ·የϭ·

 $P \leftarrow A^{b} \ adde b = A^{c} + A^{c} d A^{b} A^{c} - A^{c} d A^{c} A^{c} - A^{c} d A^{c} A$

ᡔ᠗^ᢏᡶ᠋Ċ᠋ᡃᢆᡃᠥᡅ᠊᠍᠋⊲ᡄᡃ^ᡄ.

<u>/ '</u>ݸГᅂ∩♂▷√[®]. ϽϞϨ[<]ϟ, ℔ϷϟႶϹϷϭ⊲[®]≫[®] ϽϨΔ ⊲^ͱL_→ ϨϤ[<] ℔ϷϟኣΔϟ~</sup>ͼʹϭͺϤ[®]Ͻ·.

ʹየዺጔႱ^ቈィϷ^ቈンՈ^ֈ Ϥ^ֈLച Ͻ^៲Ͻʹϐ·Ϲ^ͼϽ^៲\Ϸϟ^ϲ. Γ^ϲ[,] ϳ·>· - ϹΔL_° Δ^cϹሲϤʹϐ^៳ʹΓ^cϽ^c, σϤ¹</sub> ႱϹⁱ¹⁶ ¹², σ^c ¹², σ^c ¹², ¹² ¹²,

የ፦ᡄᠰᡃ ᠌᠊ᡆ᠔᠋ᡄ᠉᠂᠘᠘᠋ᢩᢣᢉ᠋ᡃ᠋᠖᠋ᡅ᠋᠋᠊᠋᠋ᢙᢐ᠉ᠺᢗ᠄ᡏ᠋᠋ᡗᢪᢗ᠋᠋ᢩ᠆᠆ᡘ᠉᠂ᡗᠵ᠋᠋᠋᠆ᡘ᠉᠂ᡗ ᢗᡃᢁ᠋᠋᠋᠋᠋᠆᠘᠘ᢣ᠋᠋ᡩᡗ᠆ᠳ᠈᠋᠋᠋᠋᠆ᢧᢐᡘᡶ᠋᠋ᡬ᠖ᢞᡗᠵᢗ᠋᠋᠋ᢗ᠘᠌᠋᠉᠋᠘᠋᠋ᢄ

ﺎᲙ୳ ﻣـﺎﺧﻪ - ᠫ᠈ᠫ≦ᡣ᠅ᡔ᠉᠊᠖ᠴᢀ᠉᠆᠆ᠺ᠘᠘᠅ᠫ᠘ᠻ᠉ᠫ᠘ᢣ᠋ᡗᢄᢂ᠘ᡐᠣ᠅ᡗ᠉᠊ᠳᡄ᠊ᠫ᠈ᠫ᠘᠋ᡗ᠄ᡩᢪ᠉ᡬᠴ᠋

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LONG-TERM TRENDS IN ABUNDANCE AND DISTRIBUTION OF THE SOUTHAMPTON ISLAND CARIBOU HERD

1978-2019

Report

October 2020

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Abstract:

Barren-ground caribou (Rangifer tarandus) were introduced onto Southampton Island (SHI) from Coats Island, in the Kivalliq Region of Nunavut, in 1968, following their extirpation from SHI in the early 1950s. This demographic study illustrates large fluctuations in abundance and distribution of caribou on SHI since its reoccupation. The SHI caribou herd grew from the 48 animals introduced in 1968 to an estimated population of 30,381 animals (+/- 3,982, 95% CI) by June 1997, with an annual rate of increase of approximately 23%. The SHI herd supported a subsistence harvest beginning in 1978, and a largescale commercial harvest beginning in 1993. After nearly 30 years of growth, herd abundance declined from the estimated 29,245 in June 1997 to 21,277 (95% CI = 18,098-24,896, CV=0.080) in June 2005, to 14,389 (95% CI = 12,684-16,325; CV=0.064) in June 2007, to 13,651 (95% CI = 12,091-15,412; CV=0.061) in June 2009, to 8,442 (95% CI = 7,171-9,937, CV = 0.082) in June 2011, and then to 7,287 (95% CI = 6,255-8,490, CV = 0.073) in May 2013. By May 2015, the population had increased again to 12,368 (95% CI = 10,518-14,542, CV = 0.081). However, by 2017, the population had declined again to 9,200 (95% CI = 7,755-10,915; CV = 0.087). During the decline caribou distribution gradually concentrated into a core area within the south-central portion of the Island in the vicinity of the Kirchoffer River. In 2019, herd size was estimated at 12,255 (95% CI = 10,106-14,861, CV=0.097), which was similar to the 2015 estimate. Harvest estimates over the same periods varied widely. Following the 2011 survey, an annual Total Allowable Harvest (TAH) of 1,000 caribou was applied over the 2012, 2013, and 2014 harvesting seasons. Following the population increase detected in 2015, the TAH was increased to 1,600 caribou annually then dropped by the community of Coral Harbour to 1,000 caribou following the 2017 estimated declines. Susceptibility to disease and parasites due to low genetic heterogeneity has been a concern since the introduction of caribou to SHI and was a likely catalyst to the widespread infection of caribou with *Brucellosis suis* first detected in the population February 2000.

Prevalence of Brucellosis climbed from 1.7% in February 2000 to 58.8% in March 2011 and this increase is thought to have contributed to decreased pregnancy rates over the same period. Pregnancy rates dropped from a high of 93.1% in February 2001 to a low of 37% in March 2011. Trend analysis suggests that the SHI caribou population has been decreasing at a rate of 9% per year since the 1997 survey up to 2013 followed by an immigration event in 2015. Since 2015, trend analysis suggests relative stability of the herd. A genetic analysis and local knowledge confirmed the occurrence of a movement event between the mainland and SHI between the winters of 2014 and 2015 which likely increased the population. While the herd appears to have been stable between 2015 and 2019, it is still below historic levels. The recent estimates suggest that perhaps the rate of decline has been reduced, and herd size is stable albeit much lower than 1997 levels. Given the reliance of users on this population for subsistence and commercial harvesting purposes, continuation of the current TAH is recommended to maintain stability and promote recovery over the next 2 to 3 years, at which time a reassessment of herd abundance and TAH levels should be undertaken.

Key words: Commercial harvest, barren-ground caribou, caribou, *Rangifer tarandus*, Southampton Island, Coral Harbour, Kivalliq, disease, *Brucellosis suis*, Nunavut, population survey, demographic studies.

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1.0 Introduction

Following the extirpation of caribou from Southampton Island (SHI) in the early 1950s, there was much discussion regarding their re-introduction as well as recognition of the careful husbandry that must go hand in hand with any such program (MacPherson, 1967). Discussions continued up until 1967 at which time Northwest Territories Commissioner Stuart Hodgson along with D.S. Munro, Director of the Canadian Wildlife Service (CWS), made the decision to move forward with the reintroduction of caribou to SHI. The target group for the source population was the Coats Island Herd, due to its close proximity and ecological and environmental similarities to Southampton Island. Regional Superintendent A. G. Loughery and Research Supervisor A.H. MacPherson began implementation of the program on June 7th, 1967. The very first animals on Southampton Island following their extirpation, were these 48 animals captured and transported from Coats Island.

From their start on Southampton Island, caribou were watched closely by wildlife officials. The first evidence of the success of the introduction was communicated by the game Management Officer Ed Bowden who estimated between 100 and 125 caribou ranging over the southern half of the island in the winter of 1971 (Game Management Files, 1971, 1972, 1973). The success of the re-introduction was soon realized and an aerial survey to estimate the population planned for June 1978. From 1978 to 1999 the Government of the Northwest Territories managed the progress of the 1948 reintroduction of caribou. With its formation in 1999, the Government of Nunavut (GN) took over this responsibility. The current GN management strategy follows a management plan developed in partnership with the Coral Harbour HTO and consists of a program relying upon regular aerial surveys and an extensive health monitoring program. Due to confirmed declines following the 2011 population estimate, the health monitoring component of population monitoring of the SHI herd, which included a one hundred animal

harvest for the assessment of health and condition, has been suspended to allow all available tags to go to the hunters of Coral Harbour.

The introduced caribou had steadily increased to an estimated population of 30,381 animals (95% CI=3,982; CV=0.066) in 1997, which represented the highest number of caribou ever recorded on the island. The 1997 estimate suggested a rate of increase of 23% between survey periods. However, the potential for a founder effect for this introduced population, leading to low genetic variability and increased susceptibility to disease and parasites was a concern. In February 2000, the reproductive disease Brucellosis suis was detected and grew to a prevalence of 58.8% by February 2011. High rates of *Brucellosis* in the population are thought to have been the main catalyst behind later declines observed following the June 1997 survey (Campbell, 2015). An aerial population survey conducted in 2003 detected the first decline of caribou since their introduction, showing a population estimate of 17,981 + 2,127 (95% CI=2,127; CV = 0.06) animals. The population remained relatively stable, or increased slightly, between June 2003 and a follow-up survey flown in June 2005. The June 2005 abundance survey estimated 20,582 +/- 3,056 (95% CI=3,056; CV=0.075), but the observed increase from 2003 results was not found to be statistically significant. The first evidence of a significant drop in abundance was recorded between June 2005 and June 2007 when survey results estimated 15,452 (95% CI=1,858; CV=0.06) caribou. This suggested a 14% decline from the June 1997 estimate (Campbell, 2015). The SHI caribou population continued its decline to 13,953 (95% CI=1,790; CV=0.07) in 2009, and to 7,902 (95% CI=1,261; CV=0.08) in June 2011. Following the introduction of a Total Allowable Harvest (TAH) by the 2012 harvesting season, the decline slowed and by May 2013, abundance was statistically stable at an estimated 7,287 (95% CI=1,045; CV=0.07) caribou (Campbell, 2015). Since 2015, trend analysis suggests relative stability of the herd. A genetic analysis and local knowledge confirmed the occurrence of a movement event between the mainland and SHI between the winters of 2014 and 2015 which likely increased the population. While the herd appears to have been stable between 2015 and 2019, it is still below historic levels. The recent estimates suggest that perhaps the rate of decline has been reduced, and herd size is stable albeit much lower than 1997 levels.

Health studies conducted up to Spring 2015 suggest body condition did not change significantly, with the exception of a condition study in February and March of 2011 which showed that the Southampton Island Herd was in the poorest condition reported since the initiation of the health monitoring program in March 1993 (Campbell, 2015). During the winters of 2010 and 2011, hunters reported numerous freezing rain events and extensive icing across the island. These icing events likely made winter forage less accessible to caribou (Tyler, 2010). Icing events that reduced accessibility to food could also have been associated with observed declines in condition, which further reduced reproductive success (Cameron et al. 1993, Gerhart et al. 1997). Support for this hypothesis stemmed from numerous local reports of starving and dead caribou during mid to late winter 2011 (Campbell, 2015).

Along with severe weather events, reproductive disease is thought to be a major contributor to overall population declines. Pregnancy rates declined from approximately 80% in 1997, to 60% in 2003, reaching a low of 36.3% in 2008, then climbing to 55.6% in 2010 only to decline again to 37.0% in 2011 (Campbell, 2015). The reproductive disease *Brucellosis suis* (Brucella) was first detected in February 2000 at a rate of 1.7% and by March 2011, rates of infection had risen to 58.8% by March 2011 (Campbell, 2015). High Brucella infection rates raised concerns regarding human health, as well as the ability of the SHI caribou herd to sustain and recover from substantial commercial harvesting and subsistence harvesting pressures.

Brucellosis and icing events are not the only issues threatening the SHI caribou population. Over-harvest has become a dominant threat to the long-term sustainability of this population. In particular, a growing export market within Nunavut territory, driven in large part through caribou meat sales via social media, had been driving harvest levels beyond sustainable limits into to the 2012 harvesting season. Elements of the unrestricted sale of caribou meat are also driving increased harvest pressure on breeding females: customers on social media offer higher payment for fat caribou, which during the winter and spring seasons are predominantly pregnant females.

In this report we summarize the findings of over 20 years of monitoring on the SHI caribou herd and discuss trends in abundance, disease, harvest, and other long-term threats to the herd and their implications for management of this population.

2.0 Study Area

At 43,000 km², Southampton Island is the largest island in Hudson Bay. The island is divided into the Northern and Southern Arctic ecozones. The Northern Arctic ecozone covers White Island, and the northeastern third of Southampton Island including northern Bell Peninsula and can be further divided into the Boothia-Foxe Shield eco-province and then the Wager Bay Plateau ecoregion (**Figure 1**).

The Wager Bay Plateau ecoregion covers the northeastern Kivallig Region, extending westward from the northern portion of Southampton Island on Hudson Strait to Chesterfield Inlet in the south, and as far west as the Back River (Wiken, 1986; Natural Resources Canada, 2001). The mean annual temperature is approximately -11°C with a summer mean of 4.5°C and a winter mean of -26.5°C. The mean annual precipitation ranges from 200 to 300 mm. This ecoregion is classified as having a low Arctic ecoclimate and is characterized by a discontinuous cover of tundra vegetation, consisting mainly of dwarf birch (Betulaglandulosa), willow (Salix northern Labrador spp.), tea (Ledumdecumbens), mountain avens (Dryas integrafolia), and Vaccinium spp. Taller dwarf birch, willow, and alder (Alnusspp.) occur on warm sites, while wet sites are dominated by willow and sedge (Carex spp.). Lichen-covered rock outcroppings are prominent throughout the ecoregion. This ecoregion is composed of massive Archean rocks of the Canadian Shield that form broad, sloping uplands, plains, and valleys. It rises gradually westward from Chesterfield Inlet to 600 m ASL (above sea level) elevation, where it is deeply dissected. Turbic and static cryosols developed on discontinuous, thin, sandy moraine and alluvial deposits are the dominant soils in the ecoregion, while large areas of regosolic static cryosols are associated with marine deposits along the coast. Permafrost is continuous with low ice content. Naujaat and Baker Lake are the main settlements within the ecoregion (Wiken, 1986; Natural Resources Canada, 2001).

The Southampton Island Plain ecoregion includes the remainder of Southampton Island and all of Coats and Mansel Islands (Figure 1). The mean annual temperature is approximately -11°C with a summer mean of 3°C and a winter mean of -24.5°C. The mean annual precipitation ranges from 200 to 300 mm (Wiken, 1986; Natural Resources Canada, 2001). This ecoregion is classified as having a low Arctic ecoclimate and is characterized by a nearly continuous cover of low Arctic shrub tundra vegetation, consisting of dwarf birch, willow, northern Labrador tea, mountain avens, and Vaccinium spp. Wet sites are dominated by willow, sedge, and moss. The region is composed of the partly submerged blanket of flatlying Paleozoic carbonate rocks and is generally less than 90 m ASL in elevation. Bedrock outcrops are common. Static and turbic cryosols developed on level to undulating morainal and marine deposits are the dominant soils. The maritime influence is limited to the late summer and early fall. Coastal ice and fog persist for long periods in the summer when the sea ice is absent. The ecoregion is underlain by continuous permafrost with medium ice content composed of ice wedges. Coral Harbour is the largest settlement within this ecoregion (Wiken, 1986; Natural Resources Canada, 2001).

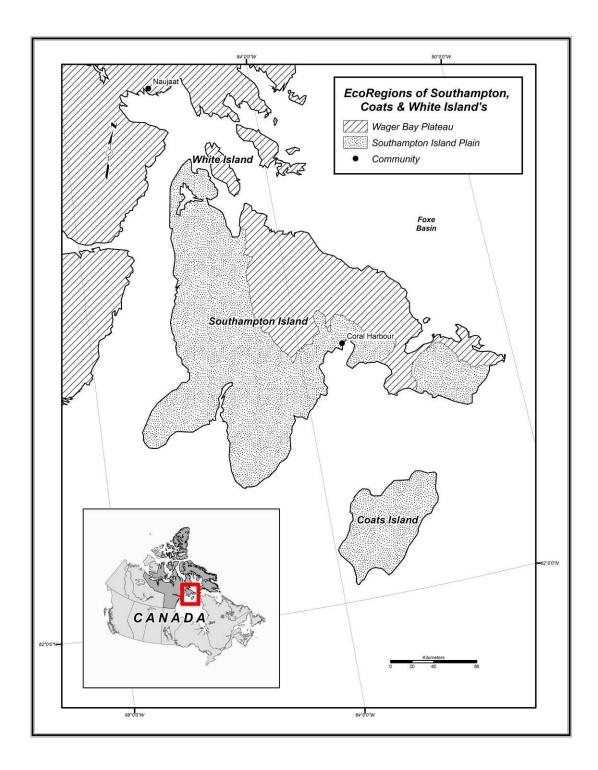


Figure 1 Ecoregions of the Southampton Island, Coats Island and White Island study areas (Wiken, 1986; Natural Resources Canada, 2001).

3.0 Methods

3.1 Caribou Introduction (1967) – An Historical Account:

Caribou reintroduced to Southampton Island from the Coats Island Herd were initially immobilized from a G2 helicopter using a CO2 gas-operated Palmer 'Capchur' gun and both 2 cc and 5 cc darts. The darts used during the initial capture contained a pre-measured dose of crystalline succinylcholine ('Anectine') dissolved in isotonic water at a concentration of 5mg/cc and administered at a rate of 5 mg per 100 pounds (Eskimo 1968). The tranquillizer 'Largactil' at a concentration of 25 mg/cc and a dosage of 125mg per 100 pounds was used to maintain immobility. Up to seven animals were captured in this way, per day. Captured animals were taken to a base camp with an enclosure on Coats Island, where they were weighed, medicated with Vitamin E and Selenium, as well as an antihistaminic and anti-biotic, injected into the shoulder. Animals were held for up to one week. From the enclosure, animals were re-captured for transport by roping or tackling, tied up in slings, tranquillized and placed in single and twin Otter fixed wing aircraft for their final transport and release onto Southampton Island, in the vicinity of the airport. In total, 66 caribou, comprising 12 bulls, 26 cows (one pregnant), and 10 calves (8 male and 2 female), were captured and released onto Southampton Island. Of the original 66, 18 animals died, two from dart wounds, two from broken legs, and six from what appeared to be capture myopathy (CWS) correspondence, 1969; Eskimo 1968). Reasons for the remaining eight deaths do not appear in the records examined. In total, 48 animals survived the reintroduction and make up the founding group of Southampton Island's reintroduced caribou herd.

3.2 Aerial Surveys (1978-2012):

Following their reintroduction onto Southampton Island, caribou were monitored periodically by both local and Government wildlife officials, primarily using groundbased methods. Kraft's aerial survey flown in November 1978 was the first scientific population estimate made since their re-introduction (Kraft, 1981). Kraft used a stratified transect survey method to cover 3 strata that were believed to represent the full extent of the Southampton Island Herd's distribution. The survey was flown between November 22nd and 25th, 1978 and utilized one observer on each of the left and right side of the single engine high wing DE Havilland Otter aircraft. Transects were placed 6.44 km apart for a total of 12.5 % coverage of the entire survey area. Effective strip width was a total of 800 meters, 400 meters out each side of the aircraft, while survey elevation was 122 meters AGL (above ground level) with a mean survey speed of 140 Kph (Kraft 1981). Population estimates were derived by calculating the density of caribou observed for all transect strips and multiplying density by the total stratum area.

3.3.2 Random Block Survey Method:

A second survey method was employed in June 1986 and consisted of a stratified random block survey design (Heard and Grey, 1987). The census zone was divided into 5 strata which received differential coverage ranging from 11% to 54%. The stratification into census zones was based on a pre-survey reconnaissance, habitat and range preference (Parker, 1975), and recent observational data from both local hunters, wildlife service personnel, and previous survey observations of caribou. A Bell 206B helicopter was used as the survey vehicle at variable speeds and altitudes. The survey personnel consisted of two rear seat observers, a front left seat navigator, and a pilot. Sightings from all personnel were recorded. Each animal observed was approached and circled so that its sex and age could be determined. Heard and Grey also attempted to determine sightability through the re-surveying of portions of three blocks at three times the initial survey intensity and determining the differences recorded between these surveys. This method of

determining sightability was, however, unsuccessful due to the movement of animals between surveys. A third survey flown June 1991 aimed at improving the 1987 survey effort. The June 1991 survey followed, for the most part, the same methodology employed in 1987 by Heard and Grey (Ouellet, 1992). The main modifications made to the 1987 methods were made to ensure complete coverage of the island and involved the delineation of two strata defined as low density which were surveyed using an aerial strip transect survey flown with a Cessna 337 fixedwing aircraft. Sampling intensity varied from 11% to 51% over 48 transects and/or blocks flown.

3.3.3 Single Observer Pair Method:

The November 1978, March 1990, June 1995, 1997, 2003, 2005, 2007, and 2009, surveys were flown using a single observer pair stratified systematic aerial strip transect method while the June 2011, May 2015, 2017, and May 2019 surveys were flown using a dependent double observer pair stratified aerial strip transect method. Little of the method has been documented for the March 1990 survey that was undertaken to estimate the SHI caribou population and distribution (Ouellet, 1992). The March 1990 survey was flown using a Cessna 337 fixed wing aircraft at 120 meters above ground level (AGL) at various speeds between 100 and 120 knots. The survey crew included two rear seat observers, a front right seat navigator, and the pilot. The strip width on each side of the aircraft was 400 meters. The survey covered the entire Island using 18 transects, which yielded 4% coverage, leading to low survey intensity and precision, resulting in an estimate of 9,319 (95% CI=6,341) caribou (Ouellet, 1992). Because of the low precision of the 1990 estimate, the survey was repeated in 1991 utilizing a different quadrat method. The 1991 survey estimated 13,676 (95% CI=3,105; CV=0.12), and being of greater precision, should be the relied upon estimate. A single observer pair stratified systematic aerial strip transect survey was flown in late June and early July of 1995, but there were serious problems of sightability as caribou were extremely hard to see due to their darker summer coats. Surveyors consider their population estimate result from the 1995 survey of 18,275 +/- 1,390 (95% CI) to be a major underestimate, and these results are therefore excluded from this report. Due to the sightability issues with the 1995 survey, a specific recommendation was made to conduct surveys earlier in June or before, prior to moulting (Mulders, pers. comm.). The survey to re-estimate the population was later flown in June 1997 and resulted in a population estimate of 30,381 (95% CI=3,982; CV=0.066).

Survey efforts in June 1997, 2003, 2005, 2007, 2009, 2011, 2012, May 2013, 2015, 2017, and 2019 utilized a stratified systematic aerial strip transect method flown with a high wing single engine turbine or gas, fixed wing aircraft. In 2013 surveys were moved from early June to mid-May as weather modelling indicated more "flyable" days during May. Additionally, the month of May provided more continuous snow cover for improved sightability, while maintaining distributions within June based strata. These findings lead to a permanent change in survey scheduling to May. Reconnaissance surveys used to delineate strata extents were flown in June of 1997, 2003, 2005, and 2007 (Figure 2). Although densities of caribou declined between 1997 and 2013, strata remained consistent with an even drop in relative densities across all survey strata, with the exception of White Island (Figure 3), where caribou abundance declined disproportionately more than on Southampton Island. Though strata remained similar between surveys, transect spacing did increase with decreasing relative densities within the Bell Peninsula and White Island strata. The largest single modification to strata occurred within the Low South strata in 2005 as a result of extensive flooding along the Boas River, which travels through the strata. In this case transects over the Boas River area were shortened to avoid flooded areas where caribou would not be found. Strip width (w) for all surveys were established using streamers or dowels attached to the wing struts, based on calculations described in Norton-Griffiths (1978) (Figure **4**), and as follows:

w = W * h/H where: W = the required strip width;
h = the height of the observer's eye from the tarmac; and
H = the required flying height

Strip width calculations were confirmed by flying perpendicularly over runway distance markers or other fixed distance markers periodically throughout the survey. The strip width area for all abundance surveys was 400 meters per side.

Standardized reconnaissance transects with a total observation strip of 800 meters (400 meters per side) were flown during the June 1997, 2003, and 2005 surveys and used to stratify caribou into areas of similar relative densities, used later to allocate effort for the abundance phase (Heard 1987). A stratified random transect method was then used during the abundance phase of all surveys (**Figure 5 to 8**). Attempts were made to maintain a constant altitude of 400 ft. during the 1978, 1990, 1995 and 1997 surveys. A radar altimeter was employed during the 2003, 2005, 2007, 2009, 2011, 2012, 2013, 2015, 2017, and 2019 surveys to increase altitude precision between transects and survey years. The first transect within each of three strata (Low, Medium and High) was randomly placed along a line of latitude or otherwise randomly selected, with each sequential line being evenly spaced.

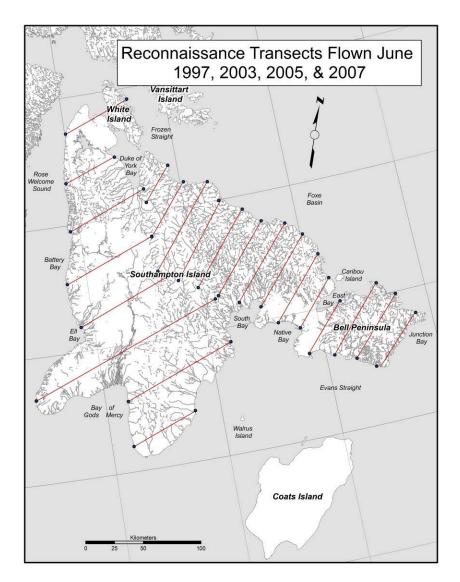


Figure 2. Reconnaissance transects flown in June of 1997, 2003, 2005, and 2007, to delineate abundance strata used to estimate Southampton Islands (including White Island) caribou population.

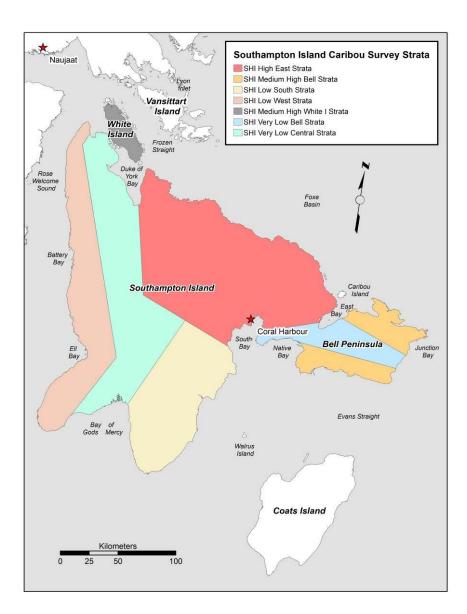


Figure 3. Abundance strata initially delineated using reconnaissance flights to map relative densities of caribou. As caribou distribution changed little across all survey years, these strata were utilized for all surveys post-2007.

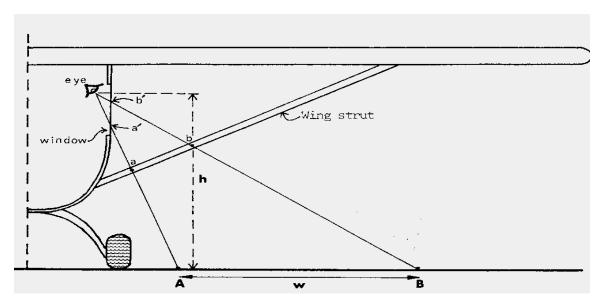


Figure 4. Schematic diagram of aircraft configuration for strip width sampling (Norton-Griffiths, 1978). W is marked out on the tarmac, and the two lines of sight a' – a – A and b' – b – B established. The dowels/streamers are attached to the struts at *a* and *b*. a' and b' are the window marks.

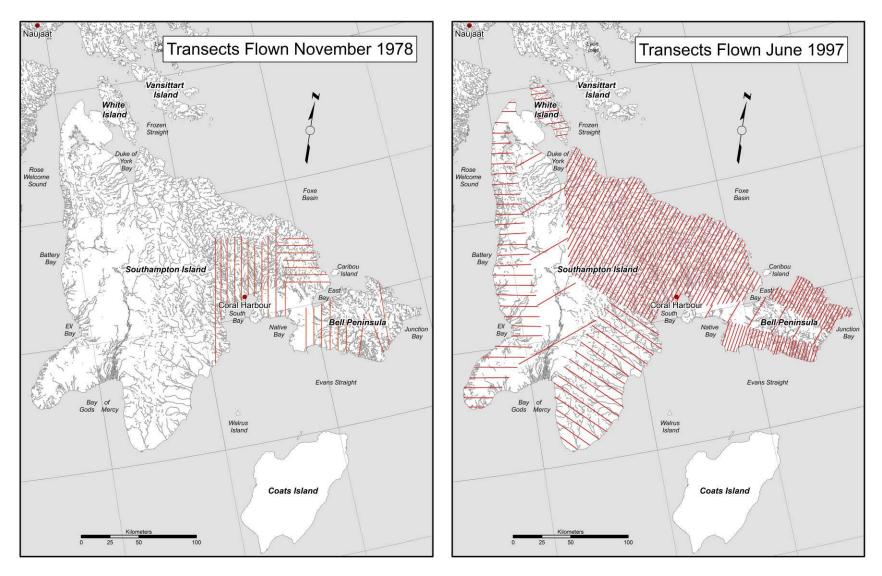


Figure 5. Stratified random transect surveys flown in November 1978 and June 1997.

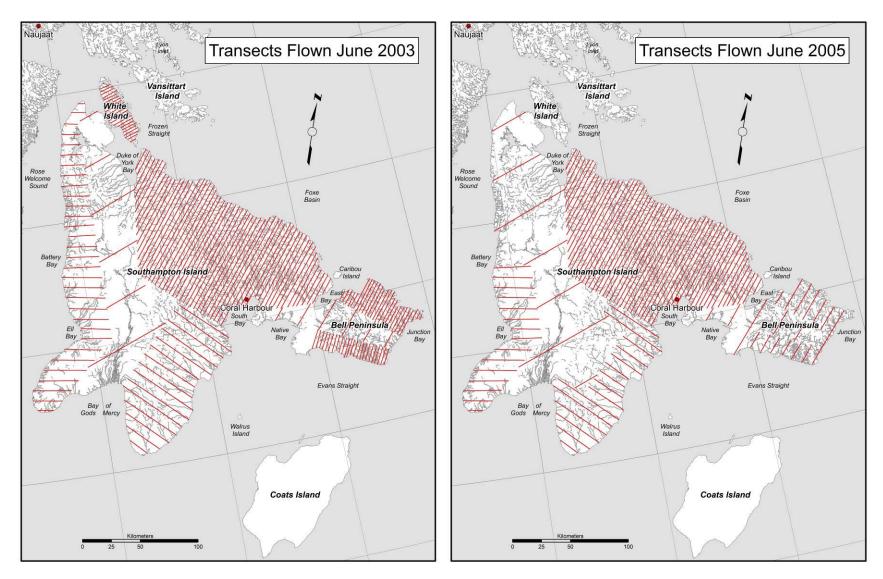


Figure 6. Stratified random transect surveys flown in June 2003 and 2005.

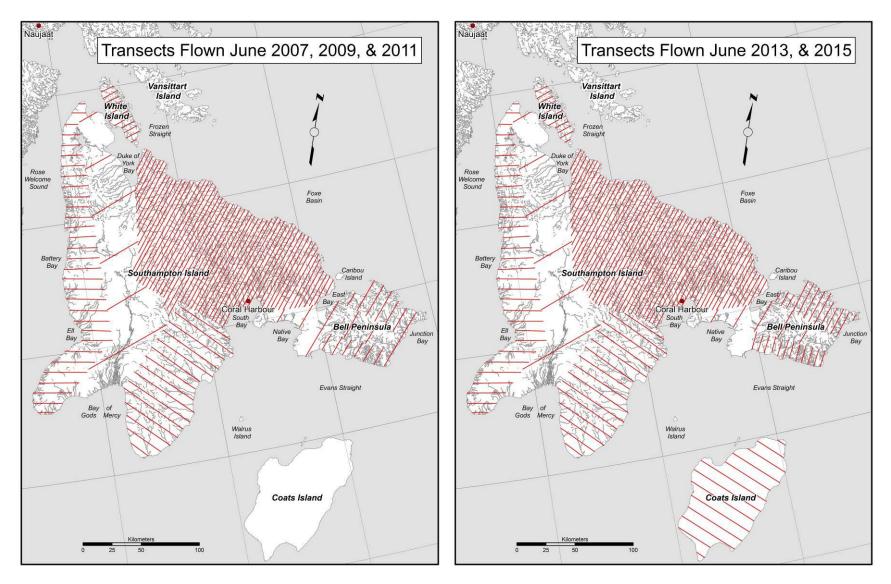


Figure 7. Stratified random transect surveys flown in June 2007, 2009, 2011 and May 2013 and 2015.

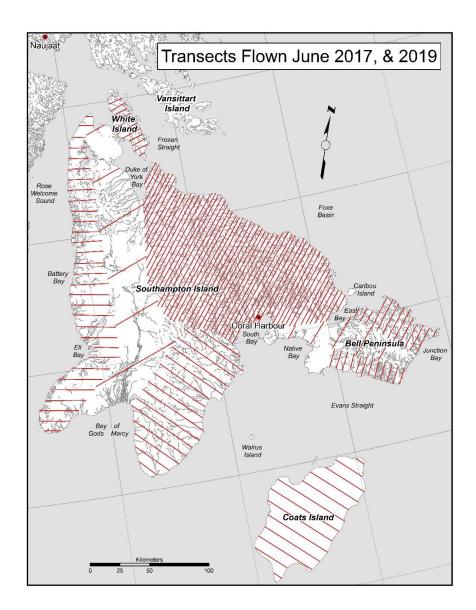


Figure 8. Stratified random transect survey flown in May 2017, and 2019.

During the 1978, 1997, 2003, 2005, 2007, and 2009 population estimates the survey crew included a pilot (front left seat), a data recorder/navigator (front right seat), a left rear seat observer and a right rear seat observer. The pilot monitored air speed and altitude while following transects pre-drawn on 1:250,000 topographic maps (November 1978) or shooting waypoints on a Trimble GPS (June 1995, 1997). During the 2003, 2005, 2007, 2009, 2011, 2012, 2013, 2015, 2017, and 2019 surveys, transects were navigated using cloned pre-programmed routes on two Garmin C-176 (203 through 2013) and Montana 650T (2015 and 2017) geographic positioning system (GPS) units set to WGS 1984 datum and true north. The data recorder/navigator was responsible for assisting in the navigation of transects (1978 and 1997), and monitoring a second identically programmed GPS unit for the purposes of double-checking the position, altitude, distance from transect, and ground speed (2003, 2005, 2007, 2009, 2011, 2012, 2013, 2015, 2017, and 2019). Geographic coordinates (waypoints) and numbers of adult and calf caribou were either recorded on compact tape recorders with associated positions marked on a map (1997), or recorded on both maps and data sheets (1978), or recorded on data sheets (2003, 2005, 2007, 2009, 2011, 2012, 2013, 2015, 2017, and 2019). The responsibilities of the left side and right side observers was to monitor their 400 meter strips and call out numbers of caribou separated by adults and calves, both on and off transect as indicated by wing strut markers. The 2003, 2007, 2009, 2017, and 2019 air crews remained the same throughout the survey, while during the 2005, 2011 and 2015 surveys, one observer was changed part way through the survey. Information on the 1978, and 1997 surveys concerning consistency in air crews is lacking. All observational data including position were archived in a digital database and are included in Appendix 1.

Survey data from all surveys were initially analyzed using Jolly's Method 2 for unequal sample sizes (Jolly 1969 *In* Norton-Griffiths 1978). Only counts of adults and yearlings were used for the final population estimates as calves are not considered fully recruited into the population until they have survived their first

winter. Lake areas were not subtracted from the total area calculations used in density calculations.

3.3.4 Dependent Double Observer Pair Method:

The June 2011, May 2013, 2015, 2017, and 2019 surveys were marked by a change in visual survey method. An additional 2 observers and one data recorder were added to the survey crew increasing the crew to 7 individuals including the pilot. The method has been adopted to all Kivalliq regional ungulate surveys. Pilot studies conducted on Muskox abundance in 2010 and barren-ground caribou abundance in 2011, confirmed fewer animals were being missed while using this new configuration. Additionally, more HTO representatives could be involved in the survey while maintaining two experienced observers covering each side of the survey aircraft. The new method is termed a dependent double observer pair visual method and is set up with two left side observers and two right side observers with a data recorder for each.

The dependent double-observer pair method involves one "primary" (front) observer who sits in the front seat of the plane and a "secondary observer" (rear) observer who sits behind the primary observer on the same side of the plane (**Figure 9**). One data recorder sitting to the right of the pilot was assigned the right primary and secondary observers while the second data recorder, sitting on the rear left side was assigned the left primary and secondary observers. The method adhered to five basic steps; **1** - The primary observer called out all groups of caribou (number of caribou and location) he/she saw within the 400 meter wide strip transect before they passed halfway between the primary and secondary observers and 9 and 12 o'clock for left side observers. The main requirement was that the primary observer called them out; **2** - The secondary observer called out whether he/she saw the caribou that the first observer saw and observations of any <u>additional</u> caribou

groups. Both the primary and secondary observers waited to call out caribou until the group observed passed half way 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 are calling out the same groups or different groups and to ensure accurate counts of larger groups; **4** - The data recorder categorized and recorded counts of caribou groups into "primary only", "secondary only", and "both", entered as separate records; **5** - The observers switched places approximately half way through each survey day (i.e. during re-fueling) to monitor observer ability. The recorder noted the names of the primary and secondary observers.

The sample unit for the survey was "*groups of caribou*" not individual caribou. This created problems for the data recorder trying to determine when a group of caribou differed from individual caribou that were separated by short distances. To resolve this issue, 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 through an estimated separation of 100 meters.

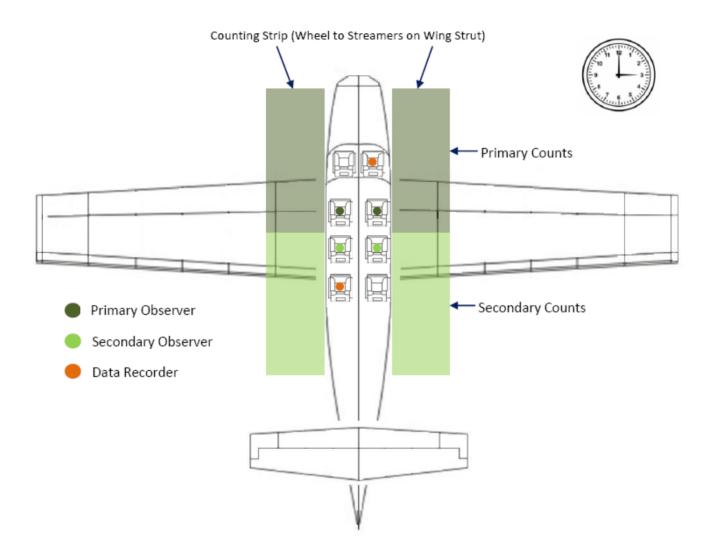


Figure 9. Observer position for the dependent double observer pair method employed on the 2011, 2013, 2015, 2017, and 2019 Southampton Island caribou abundance surveys. The secondary observer calls caribou not seen by the primary observer after the caribou have passed through the main field of vision of the primary observer. The small 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.).

3.3 Distribution:

Distribution maps were developed to graphically summarize survey data for survey observations up to and including June 2007. The distribution maps were generated through an interpolation which provided an estimate of the number of animals present at un-sampled locations based on the known values gathered at surrounding locations. This type of analysis generates a surface consisting of cells, each with an attribute (in this case, population density), used to interpret the spatial distribution of geographic points and then convert them into a continuous distribution reflecting estimates of point densities. In this study an Inverse Distance Weighted (IDW) interpolation technique was used within ArcMap's Spatial Analyst extension. IDW is an effective means of interpolating scattered data points. It assumes that the resulting interpolated surface should be influenced most by the nearby points and less by more distant points. It estimates values by calculating a weighted average. The farther a sampled point is from the cell being evaluated, the less weight it has in the calculation of the cell's value (Watson and Phillip, 1985).

To account for null data, all survey observations were first buffered to ten kilometers. To account for nil records those portions of the transect not covered by the observation buffers were then divided into 5 kilometer segments with the first starting 5 km from the edge of the nearest buffered observation or transect starting point. At each division between 5-km segments, a point with an observed value of zero was inserted. The analysis was then run using the survey observation values as well as the newly populated zero values. The analysis requires that a series of parameters be defined. The parameters, along with a description and the settings used are summarized in **Table 1**.

The resulting surfaces were themed by the population density attribute and overlaid on a base map of Southampton and White Islands to develop the figures.

Density class or "bins" are developed to reveal the most visual information and highlight and estimate distributional changes between surveys. As area estimates of relative densities on Southampton Island are mostly aggregated in the 0 to 5 caribou/km² class, the bins were developed to accentuate these lower relative densities.

Table 1.Inverse distance weighting (IDW) analysis parameters employed in the analysis
of Southampton Island caribou densities from 1978 through 2007.

Parameter	Description	Settings
Z Value Field	The Z value is the attribute being used to derive the interpolated surface.	The population attribute stored in the field Number.
Power	The higher the Power value, the greater the influence of values closest to the interpolated point. The most common value for the Power parameter is 2.	A value of 2 was selected.
Search radius type	The search radius can be either variable or a fixed distance.	As the sample points were not evenly distributed, a variable search radius was used that assessed the data points nearest to the particular cell of interest.
Search radius setting	The search radius setting specifies either the maximum distance of a fixed radius search or the number of points for a variable type. The number of the analyses was 1	
Output cell size	The resolution (or cell size) of the grid (the surface) resulting from the analysis.	An out cell size of 100 m2 was specified resulting in a population density of animals per hectare.

3.4 Statistical Analysis of Abundance and Trend:

3.4.1 Strip transect surveys (1997-2019):

The standard Jolly estimator (Jolly 1969, Krebs 1998) was applied to the strip transect data for all years with an assumed strip with of 800 meters for all years except 2015 where the strip width was 918 meters. Strip transect data for 2017 was created using the first 2 bins of the distance sampling data which amounted to an 800 meter strip. Strata were estimated separately and then combined for a total estimate for the Island. Coats Island was also surveyed in 2013, 2015, and 2017 and was excluded from the South Hampton Island estimate. Log-normal confidence limits were generated on the estimates (Thompson 1992).

3.4.2 Double observer/strip transect analyses (2011, 2013, 2015, 2017, and 2019): Given that this method assume equal sightability between observers it is essential that the observers switch seats over the course of the survey (Cook and Jacobsen 1979). Estimates of herd size and associated variance were measured using the mark-recapture distance sampling (MRDS) package (Laake et al. 2012) in the program R (R Development Core Team 2009). In MRDS, a full independence removal estimator which models sightability using only dependent double observer pair information (Laake et al. 2008a, Laake et al. 2008b) was used making it possible to derive dependent double observer pair strip transect estimates. Strata-specific variance estimates were calculated using the formulas of Innes et al. (2002). Data were explored graphically using the ggplot2 (Wickham 2009) package in R.

3.4.3 Modelling of sighting probability variation:

One assumption of the dependent double observer pair method is that each caribou group observed had an equal probability of being sighted. To account for differences in sightability we also considered the following sightability covariates in the MRDS analysis (**Table 2**). Each observer pair was assigned a binary individual covariate and models were

introduced that tested whether each pair had a unique sighting probability. Previous analyses (Campbell et al. 2012; Boulanger et al. 2014) suggested that the size of the group of caribou had strong influence on sighting probabilities and therefore we considered linear and log-linear relationships between group size and sightability (**Table 2**). Cloud and snow cover were recorded by data recorders as they changed and were included in the analysis as ordinal rankings. We suspected that sightability was most likely lowest in mixed snow cover conditions and therefore we considered both categorical and linear models to describe variation in sightability caused by snow cover. Cloud cover could also influence sightability by causing glare, flat light, or variable lighting. We used the same basic strategy to model cloud cover variation as we did for snow cover variation.

The fit of 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.

3.4.4 Distance sampling analyses (2017):

For the 2017 survey, distances of caribou groups from the survey planes were binned into intervals (0-200m, 201-400m, 401-600m, 601-1000m, and 1001m-1500m), based upon markers on wing struts of the survey plane, as was done in the 2014 Baffin Island caribou survey (Campbell et al. 2015). In addition, the dependent double observer pair also assessed sightability of caribou in the 0-200 meter strip closest to the aircraft.

A combined distance sampling and mark-recapture approach was used to estimate abundance for the 2017 data set. The basic approach involved using mark-recapture analytical methods 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).

As with the dependent double observer pair analysis, the MRDS R package (Laake et al. 2012) was used to build mark-recapture and distance sampling models. The general approach used was to build distance sampling models with the mark-recapture model parameters held constant. Once a parsimonious distance sampling model was identified, the mark-recapture model was built to further assess sightability of caribou in immediate proximity to the aircraft. The same general set of covariates used in the dependent double observer pair analysis (**Table 2**) were used for both the dependent double observer pair analysis, AIC methods were used to assess model fit. Overall model fit was also assessed using goodness of fit tests as well as graphical comparison of detection functions with histograms of frequencies of observations from the survey.

3.4.5 Trend analyses:

We used log-linear models to analyze trends for the increase and decrease phase of the caribou abundance dataset (McCullough and Nelder 1989, Thompson et al. 1998, Williams et al. 2002). Our models assumed an underlying quasi-Poisson distribution of estimates with population change occurring on the exponential scale. Abundance 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 allowing direct estimates of yearly rate of change as one of the regression β terms. Additive terms were used to estimate phase-specific trends and the effect of a possible immigration event, likely occurring between May 2013 and May 2015, on SHI herd trend.

Table 2. Covariates used to model variation in sightability of caribou for the dependent double observer pair analysis conducted on the 2017 abundance survey of the Southampton Island caribou herd.

Covariate	Acronym	Description
Observer pair	observers	each unique observer pair
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
Cloud cover	cloud	cloud cover (0,25,75,100)
	cloudc	continuous

3.5 Condition and Disease Sampling:

The health and condition of SHI caribou condition was monitored through the collection of harvest samples, beginning in 1995 (Campbell, 2015). Variables measured included a ratio of bare kidney to kidney fat index, the recording and sampling of any apparent disease and/or diseased tissue, the recording and sampling of parasitic infections, the measurement of back fat, bone marrow condition (in some years), pregnancy rates, fetal sex (in some years), and age through the analysis of cementum-annuli from the sampling of I-1 (the first incisor) from the lower jaw. In the case of the GN health studies, all anatomical components of an individual caribou being sampled and/or measured were recorded along with a common tag number and the associated harvest year. This common tag number allowed for the pooling of analysis results to provide a comprehensive description of the health, age and sex of the individual being sampled. From 1995 through 1999, approximately 400 animals per year were sampled in this way. Sampling across February and March 2000 through 2009 was reduced to approximately 200 to 300 animals (excluding 2001, 2002 and 2003). Prior to 2009, all sampling was carried out in conjunction with the commercial harvest, which ran from mid-February through to early April in most years. Following the cessation of the commercial harvest in 2009, harvest numbers in 2010 and 2011 were reduced to 100 animals. Following the 2011 survey results and subsequent application of a total allowable harvest (TAH) in 2012, the community of Coral Harbour requested that the 100 animals harvested for body condition be suspended so that all TAH allocations could be provided to the community. The suspension of the condition sampling harvest has remained in effect to-date.

The kidneys sampled for the kidney fat index (either left or right) were selected based on the amount of fat surrounding the kidney. In all cases the fatter of the two was chosen. The thickness of back fat was measured along a line 5 to 10 centimeters from the base of the tail, perpendicular to the spine. Measurements were taken from the thickest fat deposits on the rump (one to two inches to the left and right of the base of the tail) on mainly the left side but also on the right side when left-side fat was obviously removed during the skinning process.

As a standard protocol, the Canadian Food Inspection Agency (CFIA) randomly collected between 300 and 400 blood samples from commercially harvested animals from 1993 through 2007. From 2007 to 2011, blood samples were collected by GN biologists from animals collected for health and condition harvests, from remaining ventricular and/or arterial blood. Sampled blood was drained into red topped vacutainers, left to stand approximately two hours at between five and ten degrees Celsius, then spun down in a centrifuge for approximately ten to fifteen minutes to separate the serum from cellular material. Individual serums were poured off into new sterile, red-topped vacutainers, carefully packed and allowed to freeze at approximately -20° to -30° degrees Celsius. Frozen blood serums were then transported first to labs in Lethbridge, Alberta for Brucellosis, and Tuberculosis screening then to the CFIA lab in Ontario for further disease testing. Adult female reproductive tracts were also collected in 2005 for the purposes of identifying reproductive stress and/or disease. All sampling pre-2009 was carried out in conjunction with the commercial harvest which ran from mid-February to early April. The GN did not have access to all CFIA test results.

3.6 Genetic Analysis – Movement:

Over the winter of 2014, Coral Harbour hunters reported caribou tracks crossing the ice from the mainland across to the northwestern extents of SHI. Though no estimates of the total number of caribou involved in this crossing were communicated beyond "hundreds", local hunters had observed more calves in June 2014 and increased densities of caribou in the following harvesting year, compared to preceding hunting seasons. Results from the May 2015 abundance survey estimated a significant increase in SHI caribou abundance of both adults and calves, compared with 2013 results. This population increase was theorized by both the community of Coral Harbour and Wildlife officials' to be related to the

immigration of mainland caribou onto SHI. We set out to further investigate this hypothesis using population genetics.

We engaged Wildlife Genetics International (WGI) to pursue this question using the clustering programs Structure and Genetix, which produce accessible visual summaries of the results (Paetkau, 2015). Caribou tissue collected on SHI in 2004, and 2014, as well as tissue samples collected from hunters in the Naujaat (Repulse Bay) area, were compared for assessments of ancestry. Additionally, WGI used archived samples from the Qamanirjuaq caribou herd for added comparative analysis with the SHI herd. WGI used GeneClass2 to assess ancestry hypotheses, explicitly. Initial explorations included data from South Baffin Island, Melville Peninsula, and Ahiak/Beverly, but these explorations did not identify any associations of relevance to SHI.

Genotyping was performed by Wildlife Genetics International (WGI) using a standard set of 18 highly variable microsatellites that they had consistently employed for other caribou genetic analyses in Nunavut, Northwest Territories, British Columbia, and Alberta. The analysis proceeded in two rounds of 9 markers (including gender markers), as all 18 markers cannot be loaded into a single sequencer lane. After completing a first pass with all 18 markers, WGI did a round of reanalysis ('cleanup') of individual data points that were scored with low confidence (1) during the first pass (Paetkau, 2015). This reanalysis used 5 µL of DNA per reaction, up from the 3 µL used for first pass. In some cases, multiple attempts were made to confirm problematic data points. At the end of the cleanup phase, 6 samples from SHI still had low-confidence scores in their genotypes (Paetkau, 2015). In total, WGI was able to successfully genotype complete 18-locus genotypes for 37 samples from Naujaat, and 131 from SHI. With genotyping completed, WGI defined an individual for each unique multilocus genotype, taking identifiers from the first sample to be assigned to each individual, of which 37 samples from Naujaat were assigned to 34 individuals (10M:24F), and the 131 samples from SHI in 2014 were assigned to 127 individuals (76M:51F). None of these animals had previous detections in the greater Nunavut dataset including samples from the 2004 harvesting season. Paetkau (2015) then used resampling in the software GeneClass2 to generate 10,000 simulated mainland and island genotypes and plotted the distribution of the island/mainland likelihood ratio to produce critical values for statistical testing (Paetkau *et al.* 2004 *Mol. Ecol.*). By way of example, 99% of simulated island genotypes had a log likelihood ratio in excess of 9.

4.0 Results and Discussion:

4.1 **Population Distribution:**

In discussing changes in distribution of caribou on Southampton Island, it is important to note that although an island population, some exchange with the mainland likely occurred on a very small scale during winters when an ice bridge had formed across Roes Welcome Sound (Local Knowledge). According to island residents, during most winters, Roes Welcome sound does not freeze over completely creating an effective barrier to caribou movement. If such a change was to occur however, this exchange would most likely have been with the Wager Bay population of caribou occupying the Lyon Inlet area due to its closer proximity to SHI. Though tracks have been observed of caribou on the ice of Roes Welcome Sound in late winter (going both east to the island and west from the island) there has been no documented evidence of a successful crossing.

Between 1968 and 1978, the first ten years of caribou occupancy on SHI following re-introduction, monitoring was mainly conducted using ground observations. During this period observations of caribou taken during patrols whether by ground or by air suggested caribou had spread considerably across the Island (Figure 10). Kraft's aerial survey in November 1978 was the first to estimate the population since its re-introduction. Both transects and points of observation were digitized off report figures and used with IDW to produce an estimate of abundance of the newly introduced Southampton Island Caribou herd (**Figure 11**). At this time, caribou were largely aggregated in the shoulder area east and northeast of Coral Harbour, the south shore of Bell Peninsula, and along the coast just south of the town of Coral Harbour. No animals were observed by either hunters nor during aerial reconnaissance conducted in previous years, anywhere further north nor west of the areas indicated.

After the examination of all available observational data up to 1987, Heard and Gray (1987) concluded that there always appeared to be caribou in the core areas of Bell Peninsula and the Kirchoffer River uplands, northeast of Coral Harbour (Heard and Grey, 1987). These observations made during their 1987 aerial population estimate showed an expansion of the herds distribution further north and west, and throughout the coastal strip encompassing Bell Peninsula. Unfortunately, point data are not available from this survey. Caribou distribution estimated on SHI in June 1991 was similar to that recorded in 1987. Oullett (1992) suggested that caribou range did not appear to expand between 1987 and 1991 even though their numbers increased substantially. Oullett (1992) found that to accommodate growth, densities simply increased within the existing range. Once again, point data is not available for either of Oullett's 1990 or 1991 surveys.

All surveys conducted from 1997 to present have point data, from which to base the analysis. The 1997 results also showed little in the way of distributional change since Oullett's observations in 1992, although densities had continued to increase significantly (**Table 3 & 4**) (**Figure 12**).

An examination of distributional change following introduction was made using IDW with ground and aerial survey point data (**Figures 12, 13, 14, and 15**). These analyses suggests that caribou distribution increased across the Island from the point of introduction, up to the 1987 survey year, at which time the now rapidly increasing population stopped expanding its range, suggesting that the herd had reached full occupancy of usable caribou habitat on the island. Caribou had occupied the southern portions of the island including Bell Peninsula and inland toward the central portions of the island along the Kirchoffer River watershed by as early as 1983. As observed by Oullett (1992) densities increased over the same geographic areas from 1987 up until a period between 1998 and 2002, at which time densities over the same areas decreased significantly. The most dramatic decrease in densities was in Bell Peninsula between the 2005 and 2007 surveys (Figure 14 and 15). Caribou had all but abandoned the area, likely as a result of overgrazing from years of higher relative densities. Today the central portion of

the island remains the most highly used habitat by SHI caribou. Ecologically, this area is where the western flats meets the eastern highland, creating an ecotone between the Wager Bay Plateau and Southampton Island Plain Ecoregions.

Observed distributions from the 2003 survey indicated little change from distributions observed during previous surveys though localized densities had decreased. The first distributional change was recorded in June 2005, at which time, there was a noticeable decrease in the numbers of caribou occupying Bell Peninsula (**Figure 14, and 15**). According to survey density estimates, this declining trend in Bell Peninsula continued through June 2007, and was also reported by local hunters.

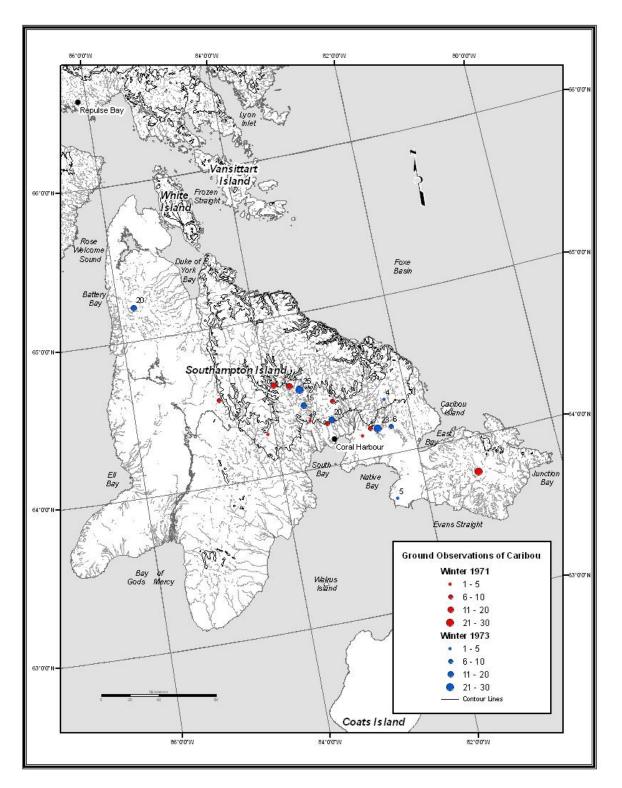


Figure 10. Observations of caribou on Southampton Island (1970 to 1973).

Table 3. Inverse distance weighting (IDW) values for the entire Southampton Island study area including White Island and Bell Peninsula showing changes in adult caribou density through time. Results from June 2005 were removed as White Island was not surveyed in that year.

Ca	1978		1997		2003		2007		% Change			
Caribou/km²	km²	Percent	km²	Percent	km²	Percent	km²	Percent	1978 to 1997	1997 to 2003	2003 to 2007	1997 to 2007
0-1	43,471	98.5%	31,591	71.6%	32,674	74.0%	36,514	82.7%	-26.9%	2.4%	8.7%	15.6%
1-2	345	0.8%	4,535	10.3%	4,741	10.7%	3,862	8.8%	9.5%	0.4%	-1.9%	-1.5%
2-5	230	0.5%	4,836	11.0%	5,190	11.8%	3,248	7.4%	10.5%	0.8%	-4.4%	-3.6%
5-8	58	0.1%	1,680	3.8%	1,202	2.7%	434	1.0%	3.7%	-1.1%	-1.7%	-2.8%
>8	22	0.0%	1,484	3.4%	319	0.7%	68	0.2%	3.4%	-2.7%	-0.5%	-3.2%
Total	44,126	100.0%	44,126	100.0%	44,126	100.0%	44,126	100.0%				

Table 4. Inverse distance weighting (IDW) values for the entire Southampton Island study area including White Island and Bell Peninsula showing changes in the density of observed calves through time.

Cai	2003		2005		20	07	% Change			
Caribou/km²	km²	Percent	km²	Percent	km²	Percent	2003 to 2005	2005 to 2007	2003 to 2007	
0-1	43,276	98.1%	44,062	99.9%	44,042	99.8%	1.8%	-0.1%	1.7%	
1-3	801	1.8%	60	0.1%	82	0.2%	-1.7%	0.1%	-1.6%	
>3	49	0.1%	4	0.0%	2	0.0%	-0.1%	0.0%	-0.1%	
Total	44,126	100.0%	44,126	100.0%	44,126	100.0%				

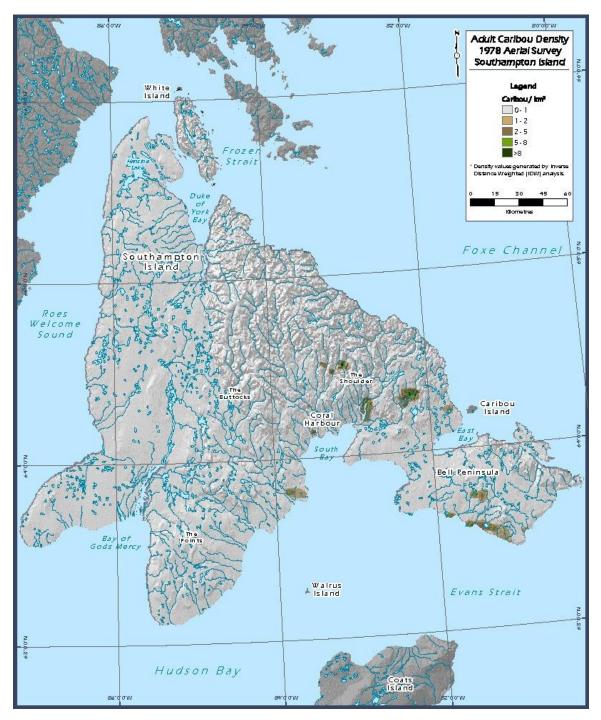


Figure 11. Results of the inverse distance weighted (IDW) interpolation technique applied to November 1978 abundance survey observations showing relative density of barren-ground caribou (*Rangifer tarandus*) on Southampton Island.

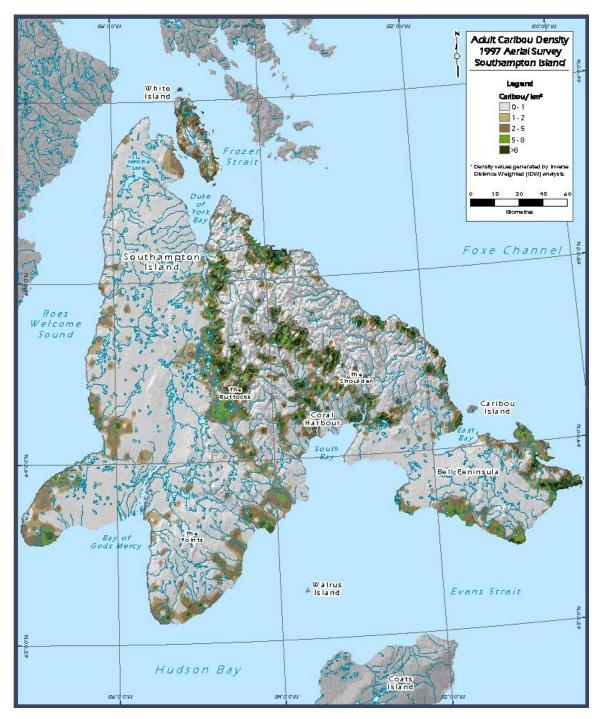


Figure 12. Results of the inverse distance weighted (IDW) interpolation technique applied to June 1997 abundance survey observations showing relative density of barren-ground caribou (*Rangifer tarandus*) on Southampton Island.

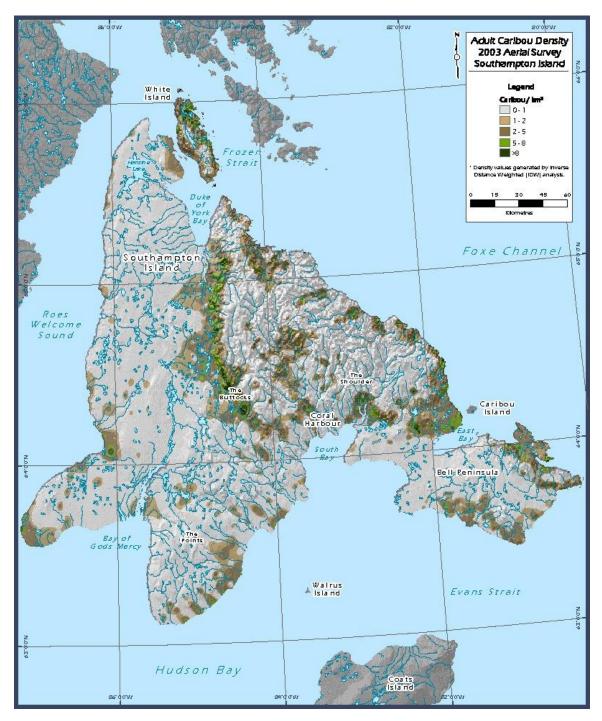


Figure 13. Results of the inverse distance weighted (IDW) interpolation technique applied to June 2003 abundance survey observations showing relative density of barren-ground caribou (*Rangifer tarandus*) on Southampton Island.

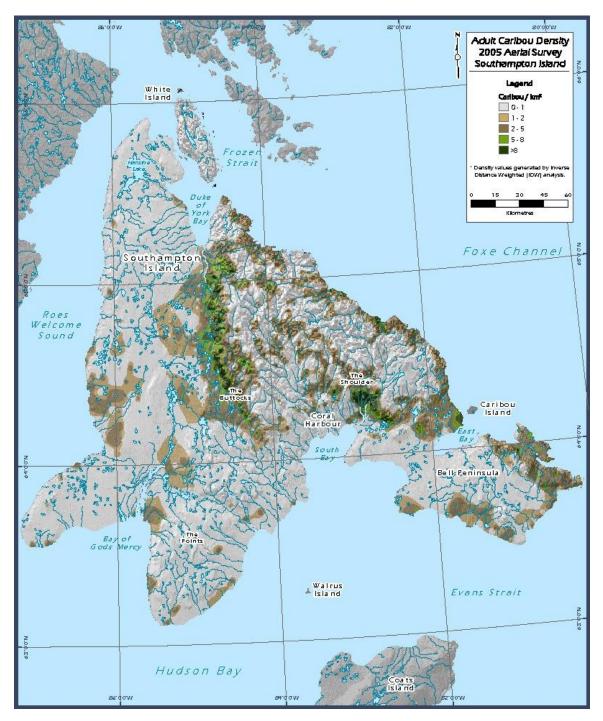


Figure 14. Results of the inverse distance weighted (IDW) interpolation technique applied to June 2005 abundance survey observations showing relative density of barren-ground caribou (*Rangifer tarandus*) on Southampton Island.

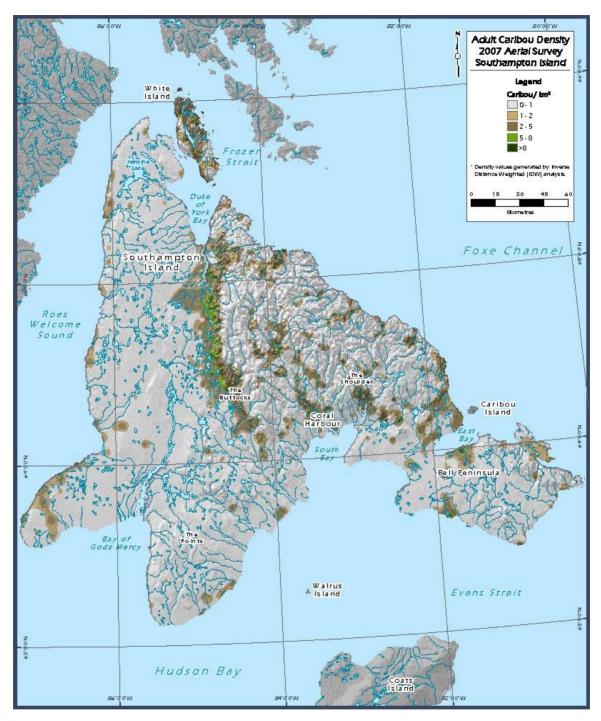


Figure 15. Results of the inverse distance weighted (IDW) interpolation technique applied to June 2007 abundance survey observations showing relative density of barren-ground caribou (*Rangifer tarandus*) on Southampton Island.

4.2 Strip Transect Surveys:

Overall, population abundance estimates from 1997 to 2019 were reasonably precise, with Coefficients of Variation (CVs) of less than 10% in all years (**Table 5**, **Figure 16**). **Figure 16** displays the estimates from **Table 5** and strata-specific estimates are shown in **Figure 17**. A tabular listing of estimates is provided in excel worksheets with this report. Coats Island is included in **Figure 17**; however, it was not included in overall Southampton Island estimates. Population declines occurred in all strata from 1997 to 2013, and again from 2015 to 2017 followed by an increase to 2015 levels in 2019. The use of different scales on the graph in **Figure 17** aids in interpretation of stratum-specific trends but it is also misleading in terms of the relative abundance of caribou in each stratum. For this reason, the same estimates of caribou numbers are plotted on the same scale (**Figure 18**), clearly indicating that the majority of caribou on SHI occurred on the High Eastern SHI strata, in all years.

Table 5. Strip transect estimates of caribou on Southampton Island, showing the number of strata sampled each year, the number of caribou counted on transect, and population estimates with descriptive statistics (SE = standard error, CV = coefficient of variation) are given for each year of surveys from 1997 through 2019.

	•		•				
Year	Strata	Caribou	Strip	transect est	timates		
	sampled	Counted	Ν	SE	Confider	ice Limits	CV
1997	7	5777	29,425	1622.5	26,375	32,827	5.5%
2003	7	3833	18,479	1099.8	16,420	20,797	6.0%
2005	6	4079	21,227	1701.8	18,098	24,896	8.0%
2007	7	2689	14,389	914.6	12,684	16,325	6.4%
2009	6	2521	13,651	833.1	12,091	15,412	6.1%
2011	7	1667	7,937	580.4	6,861	9,182	7.3%
2013	7	1597	7,284	525.3	6,307	8,413	7.2%
2015	7	3068	12,319	931.6	10,591	14,328	7.6%
2017	7	1685	8,436	680.8	7,184	9,906	8.1%
2019	7	2551	11,944	1080.8	9,972	14,305	9.1%

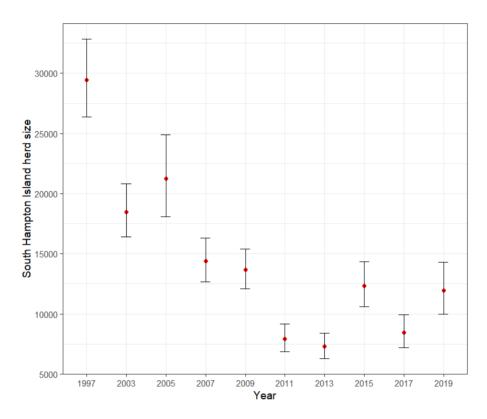


Figure 16. Population abundance estimates of the Southampton Island caribou herd using a strip transect estimator, according to strata listed in Table 5.

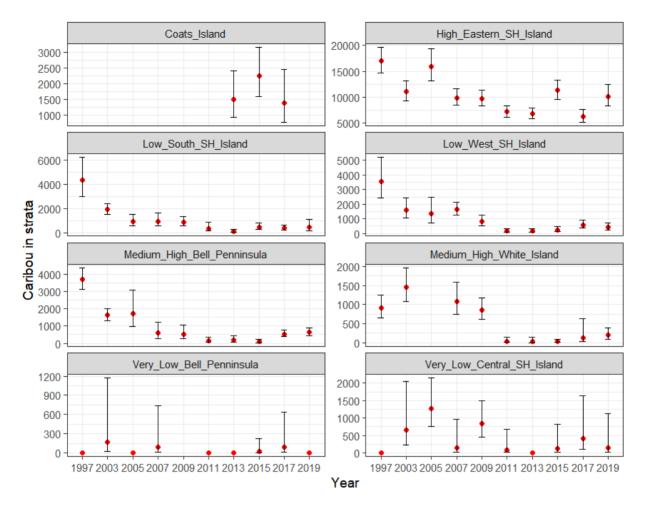


Figure 17. Strata-specific estimates of strata sampled using a strip transect estimator. Note that the y-scales are different for each graph.

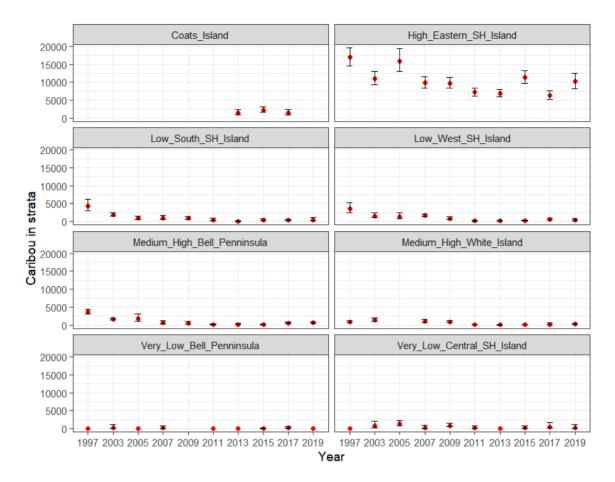


Figure 18. Strata-specific estimates of strata sampled using a strip transect estimator with the same scale used on each graph.

4.2.1 Dependent double observer analyses (2011-2015 and 2019): Dependent double observer pair data were collected using fixed-wing aerial surveys in 2011, 2013, 2015, 2017, and 2019. In 2017, we used binned distance markers on wing struts to allow for distance sampling methods, as described in the methods section of this report. Survey conditions, group sizes, and observer efficiency varied between each survey year. These data were explored graphically to help assess dominant forms of variation prior to identifying a statistical model for population estimates derived from the dependant double observer pair method. The distribution of group sizes was relatively similar during each survey year with larger groups observed in 2015 (**Figure 19**).

In general, smaller group sizes were more likely to be seen only by a single observer. Observers were placed into 18 pair combinations, of which 10 pairs switched between primary and secondary roles, and 8 did not. The assumption of the dependent double observer method is that the two observers have similar sighting probabilities and therefore, estimates may be biased when observers do not switch places during the survey. The sighting probability of pairs varied between observers for some pairs (i.e. in particular for pair 7) showing a higher relative frequency of only one observer seeing a group of caribou (**Figure 20**). A detailed listing of observer pairs is given in Appendix 1.

Between 1997 and 2011, all surveys were flown in early June close to or during the onset of spring melt. From 2013 to present, survey deployment was changed to early to mid-May (see methods) though no detectable variation in relative densities and their related strata were found. Regardless, snow cover varied each survey year with 2011 having a full range of snow cover and other years showing primarily high snow cover particularly 2013 and on following the change in survey timing to May. Sighting probabilities were lower in 2011 as shown by higher frequencies of single observer sightings (**Figure 21**). Cloud cover also varied for each year (**Figure 22**), with no discernable patterns.

Dependent double observer pair model selection, performed by sequentially calculating differences in Akaike's information criterion (AICc), suggested that sighting probabilities varied according to a combination of observer, year, size of caribou groups observed, and cloud categorized in 25% intervals, and an interaction of snow cover and group size (Table 6). Two models were supported by differences in AICc values of less than 2. The support for year as a sightability term suggested that there were year-specific factors affecting sightability that were not accounted for by other covariates. Observer pairs in the analyses were reduced to the main pairs that exhibited lower sighting probabilities, given that a model with all observer pairs parameterized did not converge. Using this strategy, the main observer pairs that displayed lower or higher probabilities were accounted for with other observer pairs set to a mean value. The predictions of the most supported model (model 1 in **Table 6**) are shown graphically, demonstrating that sightability was lower in 2011 and 2019, for both observer pairings and as a function of cloud and snow cover (Figure 23 and 24). Estimates from dependent double observer methods are compared to those from strip transects in a later section of the report.

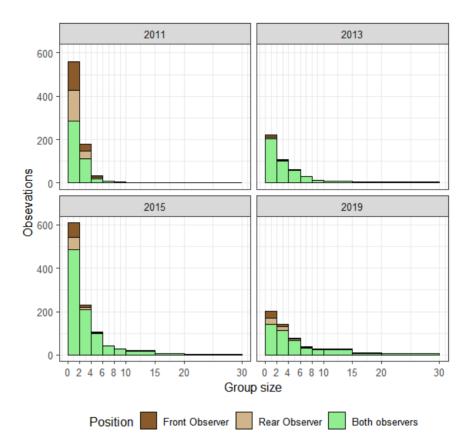


Figure 19. Group sizes of caribou observed each year for surveys conducted in 2011, 2013, 2015, and 2019 with frequency of sightings made by front, rear, and both observers.

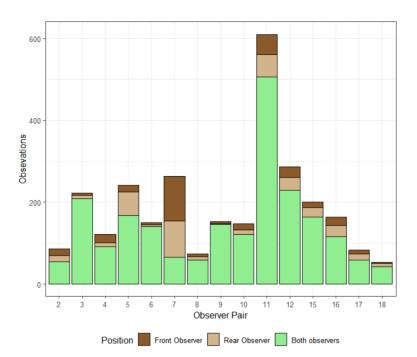


Figure 20. Observer pairings with frequencies of sighting by front, rear, and both observers.

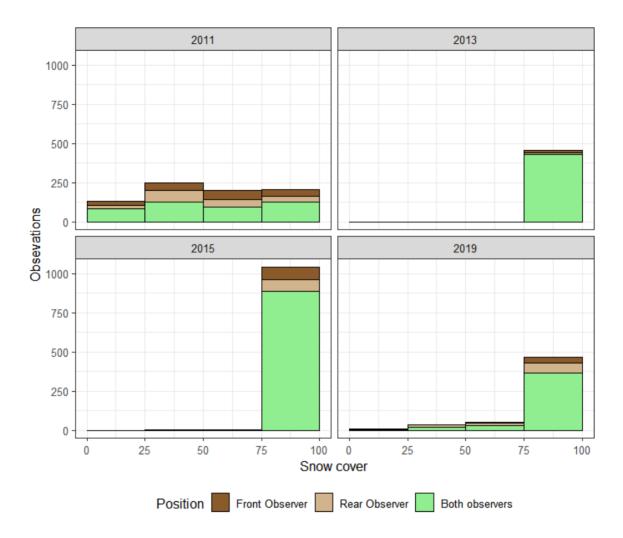


Figure 21. Snow cover during each year of the survey with frequencies of sightings by front, rear, and both observers.

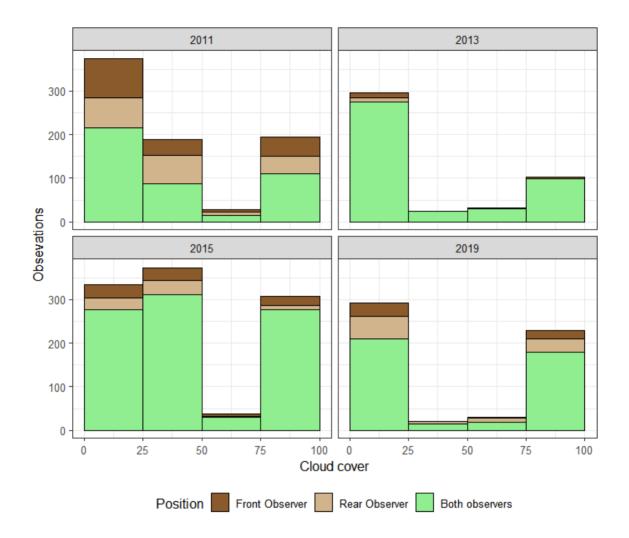


Figure 22. Cloud cover during each year of the survey with frequencies of sightings by front, rear, and both observers.

Table 6. Dependent double observer model selection results. Sample size adjusted Akaike Information Criterion (AICc), the difference in AICc between the most supported model. For each model (△AICc), AICc weight (wi), number of model parameters (K), and deviance is given. See Table 1 for covariate definitions

No	Model	AICc	Delta_AICc	AICcWt	К	LL
1	observers (reduced) +Year + size + cloud +snowc*size	1916.82	0.00	0.47	16	-942.3
2	observers (reduced) +Year + size + cloud	1917.00	0.19	0.43	15	-943.4
3	observers (reduced) +Year + size + cloud+Year*size	1919.93	3.11	0.10	18	-941.8
4	Year + size + cloud + snow	1946.30	29.48	0.00	11	-962.1
5	observers (all)	2007.52	90.70	0.00	15	-988.7
6	size + snow + cloud	2018.84	102.02	0.00	4	-1005.4
7	YearF	2020.53	103.72	0.00	8	-1002.2
8	snow + cloud	2049.87	133.06	0.00	7	-1017.9
9	snow	2060.00	143.18	0.00	4	-1026.0
10	snowc + cloudc + snowc * cloudc	2092.56	175.74	0.00	4	-1042.3
11	size	2132.15	215.33	0.00	2	-1064.1
12	logsize	2138.00	221.18	0.00	2	-1067.0
13	cloud_factor	2166.28	249.46	0.00	4	-1079.1
14	constant	2180.59	263.78	0.00	1	-1089.3

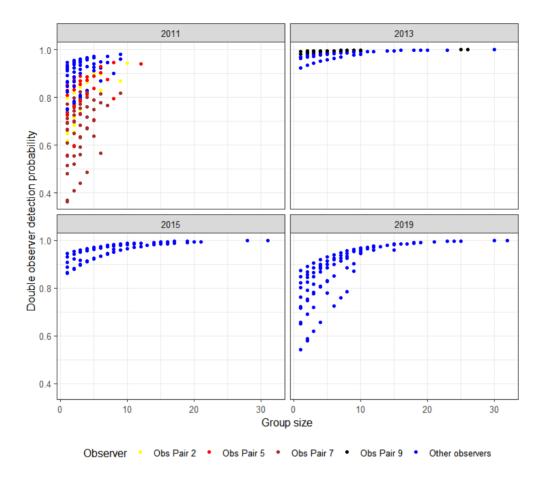


Figure 23. Dependent double observer detection probabilities as a function of year, group size, for selected observer pairs.

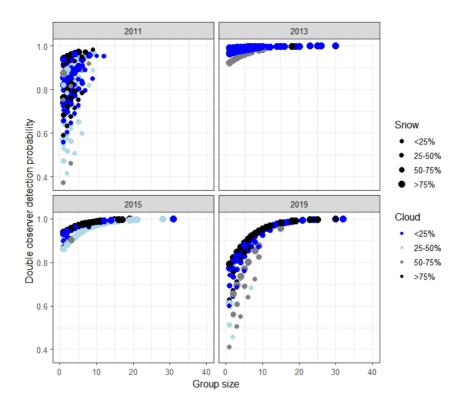


Figure 24. Dependent double observer probabilities as a function of year, group size, snow and cloud cover.

4.2.2 Distance sampling/double observer pair sampling in 2017:

During the 2017 survey, frequencies of observations by distance bins revealed different detection probability curves between observer pairs 1 and 2. Observer pair 1 had a higher frequency of observations near the aircraft whereas observer pair 2 had a higher frequency away from the plane. Compared to previous years of dependent double observer pair sampling, there was a higher frequency of observations from data recorders in 2017, suggesting a higher level of observation experience by the data recorders. To utilize these recorder observations, we categorized them as single observer observations and assumed that the data recorder had similar sighting probabilities to the other observers (**Figure 25**). Snow cover was greater than 50% in the area of most observations, and the results of the 2017 observations suggested that sightability was lower when snow cover conditions were below 50% (**Figure 26**).

Model selection proceeded by building distance sampling models with the markrecapture model parameters held constant, and by initially comparing half normal and hazard rate models. Of these, the hazard rate model was the most supported, with observer pair and snow (continuous cover) as covariates. Once this model was selected, dependent double observer pair mark-recapture models were compared with observer pair and snow, as well as the most supported covariates. Group size (log transformed) was also supported as a distance sampling covariate (Model 1, **Table 7**). Goodness-of-fit for model 1 was marginal (chi-square=19.8, df=7,p=0.006), however most of the lack of fit came from the 600-1,000 meter distance bin which would have less influence on estimates given low observation frequency rates in this bin (Figure 27). An additional analysis was conducted, which used the first 2 distance bins of data to fit dependent double observer pair only models to the data, without the distance component (Table 8). The same suite of dependent double observer pair models was applied to the data set as used in previous years analysis and as listed in Table 7. According to this subsequent analysis, a model with observer, snow (continuous) and the log of

group size was most supported. Population abundance estimates from this model were thus compared to the distance sampling and strip transect estimates.

4.2.3 Comparison of estimates from strip transect, dependent double observer pair, and distance sampling:

Comparison of strip transect, dependent double observer pair, and distance sampling estimates suggests reasonable agreement between estimates, with the confidence intervals from each method all overlapping. Estimates from the dependent double observer method when compared with the single observer jolly estimator were 6% higher in 2011, similar in 2013 and 2015, and 4% higher in 2017. In 2017, distance sampling estimates were 9.1% higher than strip transect estimates and 5% higher than dependent double observer pair estimates suggesting that distance sampling was better able to accommodate observations where one observer may be over sampling further distance bins (**Table 9**, **Figure 28**).

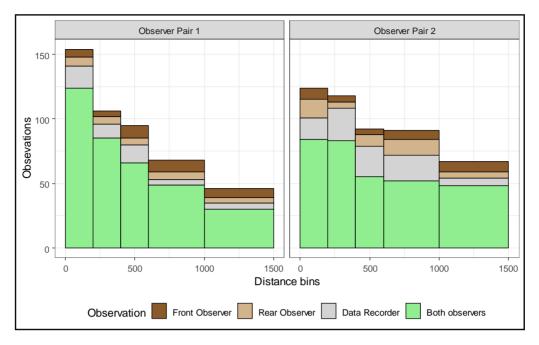


Figure 25. Frequencies of observations by distance bin for the 2 observer pairs in May 2017.

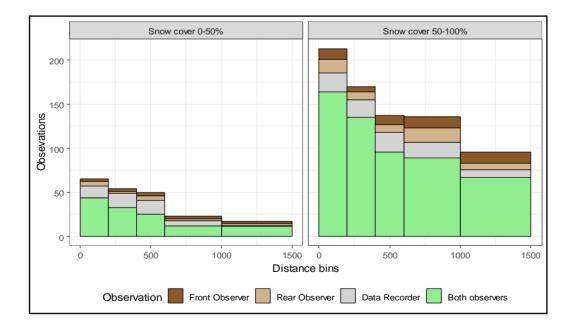


Figure 26. Frequencies of observations by distance bin for 2 levels of snow cover.

Table 7. Dependent double observer model selection results. Sample size adjusted Akaike Information Criterion (AICc), the difference in AICc between the most supported model for each model (△AICc), AICc weight (wi), number of model parameters (K) and deviance is given. See Table 1 for covariate definitions.

		Distance sampling	2x observer		Mo	del fit		
No.	DF	Distance covariates	covariates	AICc	ΔAIC _c	Wi	К	LL
		Distance /Double						
		observer models						
1	HR	obs+snowc+log(size)	obs+snowc	4000.0	0.00	0.95	8	-1992
2	HR	obs+snowc+log(size)	obs+snow	4006.6	6.59	0.04	10	-1993
3	HR	obss+snowc+size	obs+snow	4009.3	9.24	0.01	10	-1994
4	HR	obs+snowc	obs+snow	4010.8	10.75	0.00	9	-1996
5	HR	obs+log(size)	obs+snowc	4012.7	12.66	0.00	7	-1999
6	HN	obss+snowc+logsize	obs+snow	4019.2	19.16	0.00	9	-2000
7	HN	obs+snowc	obs+snow	4019.8	19.71	0.00	8	-2001
8	HR	obss+snowc	obs	4020.1	20.04	0.00	6	-2004
9	HR	obss+snowc	size	4028.0	27.94	0.00	6	-2008
		Distance sampling	•	1				
		models						
10	HR	obss+snowc	constant	4031.2	31.14	0.00	5	-2010
11	HN	obss+snowc	constant	4040.2	40.11	0.00	4	-2016
12	HN	obs+snowc+size	constant	4040.2	40.15	0.00	5	-2015
13	HR	obs	constant	4041.7	41.66	0.00	4	-2016
14	HN	snowc	constant	4045.3	45.28	0.00	3	-2019
15	HR	size	constant	4047.0	46.96	0.00	4	-2019
16	HR	constant	constant	4047.3	47.27	0.00	3	-2020
17	HN	obs	constant	4061.1	61.09	0.00	3	-2027
18	HN	constant	constant	4067.3	67.22	0.00	2	-2031
19	HN	size	constant	4067.9	67.89	0.00	3	-2031

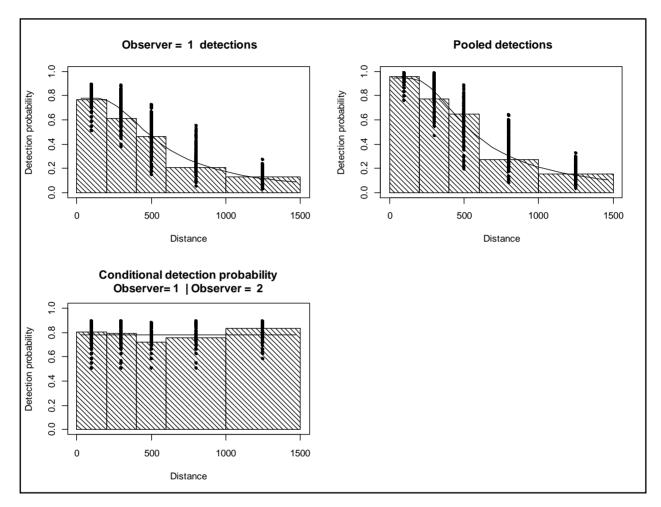


Figure 27. Graphical representation of goodness-of-fit of the most supported double observer model (Model 1, Table 7).

Table 8. Dependent double observer model selection results. Sample size adjusted Akaike Information Criterion (AICc), the difference in AICc between the most supported models for each model (ΔAICc), AICc weight (wi), number of model parameters (K), and deviance is given. See Table 1 for covariate definitions

No	Model	AICc	ΔAIC _c	Wi	К	LL
1	obs+snowc+log(size)	1,193.0	0.00	0.40	4	-592.5
2	obs+snowc+size	1,193.1	0.07	0.38	4	-592.5
3	obs+snowc	1,194.7	1.70	0.17	3	-594.3
4	obs+snow_factor	1,197.8	4.75	0.04	5	-593.8
5	obs+snow_factor+cloud_factor	1,200.3	7.26	0.01	8	-592.0
6	constant	1,208.7	15.73	0.00	1	-603.4

Table 9. Comparison of estimates of Southampton Island caribou using strip transect, double observer, and distance sampling/double observer (2017 only)

Year	Method	Caribou counted	Ν	SE	Cont	f. Limit	CV
2011	Strip transect	1667	7,937	580.4	6,861	9,182	7.3%
2011	2x Observer strip transect	1667	8,442	691.9	7,171	9,937	8.2%
2013	Strip transect	1597	7,284	525.3	6,307	8,413	7.2%
2013	2x Observer strip transect	1597	7,287	557.2	6,255	8,490	7.6%
2015	Strip transect	3068	12,319	931.6	10,591	14,328	7.6%
2015	2x Observer strip transect	3068	12,368	1002.6	10,518	14,542	8.1%
2017	Strip transect	1685	8,436	680.8	7,184	9,906	8.1%
2017	Distance 2x observer	1653	9,200	796.4	7,755	10,915	8.7%

2017	2x Observer strip transect	1665	8,752	759.5	7,365	10,399	8.7%
2019	Strip transect	2512	11,521	1063.3	9 <i>,</i> 583	13,852	9.2%
2019	2x Observer strip transect	2512	12,255	1185.4	10,106	14,861	9.7%

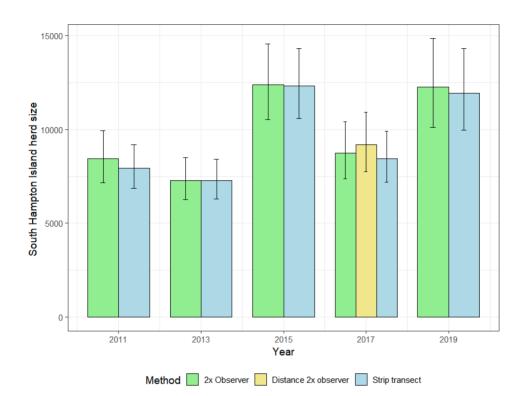


Figure 28. Comparison of Southampton Island caribou herd abundance estimates from strip transect, dependent double observer, and distance sampling/double observer analyses (2017).

4.3 Trend estimates:

Our trend analyses cover two separate phases of Southampton Island caribou abundance: prior to 1997 when herd abundance was increasing, and from 1997 to 2017 when the herd was declining. Prior to 1997, and since their reintroduction, the abundance of the SHI caribou herd was increasing. Despite a statistically significant increase between the May 2013 and May 2015 survey estimates, the SHI herd has exhibited an overall decline since 1997.

4.3.1 Trend from 1997 to 2017 (the decline phase):

Data from 1997 to 2017 included strip transect, dependent double observer pair, and distance sampling surveys. The use of different methods had minimal effects on the overall abundance trends identified. However, the best estimates for 2011, 2013, and 2015, based on model fit and lowest CV's, were dependent double observer pair estimates which accounted for sightability, especially in 2011. For 2017, the distance sampling estimate was least biased because of observer error. For this reason, we used strip transect data for estimates from surveys up to 2009, followed by dependent double observer pair estimates for 2017.

T-tests were used to compare the significance of the difference between sequential estimates (**Table 10**). Of the 8 survey estimate comparisons the 1997 to 2003, 2005 to 2007, 2009 to 2011, 2013 to 2015, 2015 to 2017, 2017 to 2019 periods showed statistically significant change. Of these comparisons, only the 2013 to 2015, and 2017 to 2019 estimates showed a statistically significant increase in the SHI caribou population, all others displaying significant declines. Annual change in population size, based on a year to year comparison of estimates (expressed as ratios), varied between 0.79 and 1.30. SHI caribou abundance estimates from 1997 to 2017 are shown graphically in **Figure 29**. To estimate the effect of a potential immigration event on the overall trend, prior to the 2015 survey, an

additive term was applied to model use to generate the 2015-2017 survey estimates. This term basically assumed that the SHI population was increased by a constant amount during this time due to immigration. These terms were both found to have a significant effect on the trend in caribou abundance (**Table 11**). The year term provided an estimate of long-term annual rate of change for the SHI population (0.91 CI=0.89-0.94) which was not, overall, affected by the immigration event. This translates to a 9% (CI=6-11%) decline in caribou abundance each year, from 1997 through 2017. A trend term for the period of 2015 to 2019 was not significant.

A plot of model predictions reveals good fit of the model to estimates with predictions intersecting the confidence limits of all 10 estimates (**Figure 30**). Namely, the model suggests that the herd declined at a constant rate from 1997-2014, followed by an immigration event sometime between May 2013 and May 2015 (Patkeau, 2015), and then continued to decline at a similar rate as it had previously, from 2015-2017 (**Figure 30**). Using this model, and assuming a constant rate of decline (9%) over the period, we estimated that approximately 5,024 caribou would have had to immigrate to SHI between May 2013 and May 2015 to account for the increased number of animals observed in May 2015. If the immigration event had not occurred, and the population continued to decrease at the 9% rate, then there would be approximately 4,200 caribou remaining on the island as opposed to the 9,200 estimated in the 2017 survey.

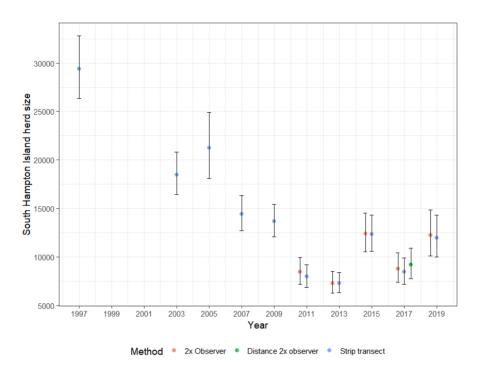


Figure 29. Comparison of strip transect, dependent double observer pair, and distance sampling/double observer pair estimates (2017).

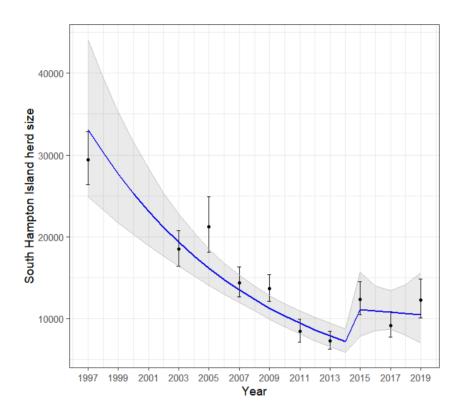


Figure 30. Predictions of herd size of the Southampton Island caribou population from the log-linear model (Table 11), which assumes a constant decline in population size with an immigration event that occurred before the 2015 survey. Confidence limits are provided as shaded regions on the plots.

Year	method	Ν	SE	CV	df	t-test	df	p-value	Gross change	Annual change
1997	Strip transect	29,425	1622.5	5.5%	93					
2003	Strip transect	18,479	1099.8	6.0%	90	-5.58	163	0.0000	0.63	0.93
2005	Strip transect	21,227	1701.8	8.0%	76	1.36	132	0.1774	1.15	1.07
2007	Strip transect	14,389	914.6	6.4%	88	-3.54	117	0.0006	0.68	0.82
2009	Strip transect	13,651	833.1	6.1%	80	-0.60	168	0.5514	0.95	0.97
2011	2x Observer	8,442	691.9	8.2%	73	-4.81	151	0.0000	0.62	0.79
2013	2x Observer	7,287	557.2	7.6%	59	-1.30	131	0.1960	0.86	0.93
2015	2x Observer	12,368	1002.6	8.1%	59	4.43	92	0.0000	1.70	1.30
2017	Distance 2x	9,200	796.4	8.7%	134	-2.47	133	0.0146	0.74	0.86
	observer									
2019	2x Observer	12,255	1185.4	9.7%	64	2.14	122	0.0344	1.33	1.15

Table 10. Estimates used for the 1997 to 2017 trend analysis of Southampton Island caribou abundance, with the results of t-tests comparing the estimates of successive surveys. Also shown are estimates of gross and annual change based on the ratios of successive estimates.

Table 11. Log-linear model parameter estimates for trend analysis (1997-2017).

Term	β	SE (β)	t	p-value	Conf. limit	
Intercept	36218.82	0.15	72.04	0.0000	26964.44	47761.37
Trend λ (1997-2015)	0.91	0.01	-7.75	0.0001	0.89	0.94
Immigration (2015)	0.30	0.18	-6.78	0.0003	0.21	0.43
Trend λ (2015-9)	0.99	0.08	-0.18	0.0000	0.85	1.15

4.3.2 Trend from 1978 to 1997(the increase phase):

The historic data set (1978-1991) was added to the analysis to obtain an estimate of trends in the SHI caribou population during the phase of increase that occurred from 1978 to 1997. This was accomplished by adding terms to account for the decrease phase, which allowed us to estimate an annual rate of increase of 1.18 (CI=1.12-1.25), or, 19% (CI=16-22%), from 1978 to 1997 (**Table 12**). A plot model for these predictions is shown in **Figure 31**.

4.3.3 Sampling effort and error

A comparison of strip transect, dependent double observer pair, and distance sampling estimates suggest that the assumption of perfect sightability on the 400 meter survey strip was met in 2013 and 2015 with estimates being close for dependent double observer pair and strip transect estimates (Figure 28). In 2011, variability in observers and snow cover reduced the strip transect estimates compared to the dependent double observer pair estimates. In this context, the dependent double observer pair method provided a test of assumptions of the strip transect method and corrected estimates when the assumption of perfect sightability was violated. In 2017, distance sampling estimates were higher than dependent double observer pair and strip transect estimates. This may have been due to one of the observer pairs not putting enough survey effort to the distance bins closer to the aircraft (Figure 25), as indicated by different shapes of the detection histograms for the two observer pairs. This would have caused a negative bias in both strip transect and dependent double observer pair estimates and illustrates a potential issue with distance sampling; observers spending too much time looking out at further bins which are often easier to view than the closer bins. In the case of conditions of excellent sightability, this can lead to a significant overestimate. The dependent double observer pair method partially accounted for this by also estimating the sighting probabilities of observers near the survey line. The dependent double observer pair method assumes that the two observers in a pair have equal sighting probabilities. It is therefore essential that observers switch places half-way through the day to ensure robust estimates from this method. Of the 14 observer pairings on surveys, 7 switched places which may have affected the overall quality of the dependent double observer estimates. If observers cannot switch places, then an independent observer method should be considered especially when caribou density is not high.

4.3.4 Overview of Abundance and Trend Analysis:

Overall, trend analysis suggests that the SHI population has been decreasing at a rate of 9% per year since the 1997 survey. An immigration event in 2015 increased the population, however, comparison of the 2015 and 2017 survey estimates suggests approximate stability after 2015 with the herd rebounding to 2015 levels in the 2019 survey. A trendline with minimal slope intersects the confidence limits of the 2015, 2017, and 2019 estimates suggesting that stability is statistically possible despite the difference in the 2017 and 2019 estimates (**Figure 30**). A model with trends from 2015 to 2017 and from 2017 to 2019 was not statically supported.

Term	β	SE (β)	t	p-value	Conf. Limit	
(Intercept)	927.28	0.24	28.56	0.0000	561.30	1,439.17
Trend (1978-1997)	1.18	0.03	6.36	0.0002	1.12	1.25
Decrease-intercept	214.32	0.46	11.55	0.0000	85.46	530.08
Trend (1998-2014)	0.77	0.03	-8.76	0.0000	0.73	0.82
Immigration (2015)	0.10	3.20	-0.73	0.4854	0.00	52.42
Trend (2015-9)	0.98	0.08	0.93	0.3786	0.92	1.26

Table 12. Log-linear model parameter estimates for trend analysis (1978-2017).

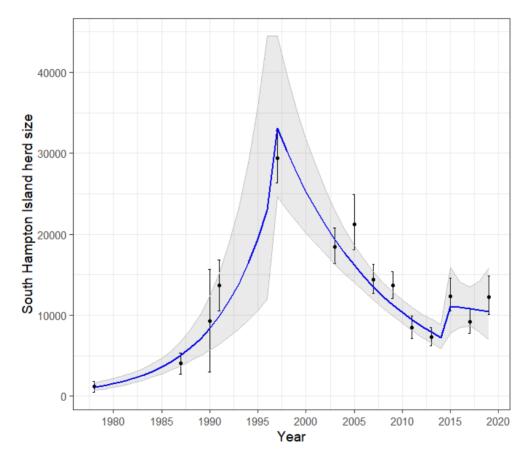


Figure 31. Predictions of herd size of the Southampton Island from the log-linear model (Table 12) which assumes a constant decline in population size after 1997 with an immigration event that occurred before the 2015 survey.

4.4 Effect of Disease on Abundance:

Brucellosis is an infectious disease caused by the Bacteria Brucella. Many different animal species including humans can become infected. The form of Brucellosis that occurs in wild caribou is *Brucella suis* Type IV. In caribou these bacteria occur primarily within tissues of the reproductive system but also commonly occurs within leg joints (Williams et al. 2001; CDC 2016; Corbel, 2006). The bacteria can also be found in the milk, blood, urine, and semen of infected animals (CDC 2016; Corbel, 2006). Animals can get the bacteria by either oral ingestion, direct contact with the mucus membranes of the eyes, nose, or mouth, or through breaks in the skin. Brucella can also be transmitted by contaminated objects (fomites) (Corbel, 2006). Some animals are carriers and can have the bacteria without showing signs of the illness. Animals in these cases can shed the bacteria into the environment for long periods, infecting other animals in the herd. Brucellosis can cause reproductive problems such as abortions, still birth and infertility. Other signs can include arthritis, swelling of the joints and testicles, and udder infections (mastitis) (Williams et al. 2001; CDC 2016; Corbel, 2006). Tissues and fluids associated with abortions, drainage of fluid from swollen joints, vaginal discharge, fetal fluids, and semen can be highly infective and can spread the bacterium into the immediate environment where uninfected animals can become infected through the ingestion of infected tissues and objects such as plants. The potential for environmental concentration of this disease makes Brucellosis a density-dependent disease. Areas of concentration such as migratory corridors, rutting areas and, particularly, calving grounds would represent some of the higher risk areas for the spreading of this disease (Williams et al. 2001; CDC 2016; Corbel, 2006). Predation and scavenging of diseased tissue can also contribute to the bacterium's spread throughout the environment.

Health monitoring of the SHI barren-ground caribou had its beginnings in 1988 when Heard (departmental correspondence) sampled 20 cows in March to determine their reproductive status and general condition. These small condition studies continued through 1991 (Adamczewski and Heard data) at which time the condition studies ceased. The analysis of condition was started up again in February 1996 in association with the initiation of the large-scale commercial harvest in March 1993. Due to the small sample sizes in the early condition data, for the most part, these were not included in this analysis. The first samples did, however, give results that were consistent with hunter reports of caribou on SHI in excellent health and condition at this time. By 1995, the condition and productivity of the herd had changed little, an assessment that would remain up until the 2000 harvesting season when CFIA random blood testing identified the beginning of what would become a rapid induction of the bacterial disease *Brucella suis* serovar 4 in the SHI caribou herd (**Figure 32**). There is no evidence of this disease within this population prior to the 2000 harvesting season.

Concurrent with the decline from the 1997 to 2005 survey estimate, there were at first subtle, then more dramatic shifts in range use by 2005. Range use changed significantly as densities dropped in most areas, with the exception of the north central portions of the islands where use remained consistent between years although densities slowly dropped up to present (Figure 12 and 13). In addition, the first cases of *Brucella suis* were reported during the 2000 harvest year (1.7% of 400 animals tested) and had reached a prevalence of 19.5% in 2003, 28.6% in 2005, 48.8% by 2007, 39.1 % by 2009 and 58.8 % by 2011. Pregnancy rates, which are affected by Brucellosis, initially dropped from 93.1% in 2001 to 37.9% in 2005, and then increased to 64.4% in 2007. The hopes that the disease was declining in the population were dashed when a 2009 screening showed pregnancy rates dropping further to 44.3%. The last major condition study conducted in March 2011, prior to the application of a TAH, recorded pregnancy rates of 37% (**Figure 32**).

In 1992 the Canadian Polar Commission released a status report on Brucellosis in the Circumpolar Arctic (O'Reilly, 1992). In the report, O'Reilly summarized the incidence of Brucellosis across the Circumpolar arctic (**Table 13**). Brucellosis prevalence within the Southampton Island population reached a high of 58.9% in 2011 which represents the highest prevalence amongst any caribou and/or

reindeer populations' worldwide (O'Reilly, 1992). Currently levels are unknown due to a cessation of the annual caribou condition harvest. With the human health issues associated with Brucellosis through either the consumption or handling of infective tissues, Coral Harbour residents are concerned over the future of their caribou herd.

4.41 Brucellosis and heard trend:

Concurrent with the rising prevalence of the reproductive disease *Brucella suis* was the reported declines in abundance from 1997 through 2013 (**Figure 32**). It appears clear that Brucellosis was a contributing factor to the steady declines observed in this population of caribou. However, with high commercial harvest rates of the SHI herd up to 2009, it is likely that both commercial hunting pressure and disease together, contributed significantly to a declining trend in caribou abundance. By 2003, three years following the first confirmed cases of Brucellosis in SHI caribou, pregnancy rates were still over 85% and the population was still over the hypothesized carrying capacity of the island of an estimated 15,000 animals (Oulett et al. 1996). With Brucellosis being a density dependent disease, it was decided by all co-managers that a further reduction in caribou abundance would be beneficial to the long-term viability of the SHI population. In the meantime, continual monitoring and population assessments every 2 years would provide an early warning system, should the decline steepen.

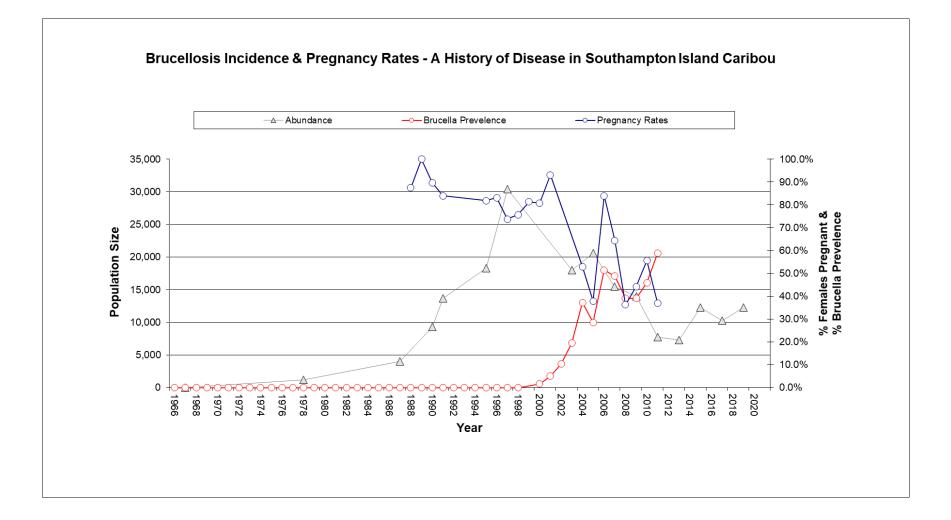


Figure 32. A history of abundance, pregnancy rates and *Brucellosis suis* prevalence for the Southampton Island caribou herd originally introduced onto the island from Coats Island in 1968.

Herd	Incidence Date		Remarks	Source		
	(%)					
Southampton	Not Present	1990	75 samples	(NWT Wildlife notes)		
Qamanirjuaq	4%	1966-68		(NWT Wildlife notes, 1983)		
Beverly	< 2%	1983	118 samples	(Goldfarb, 1990)		
Bathurst	Present	1981-1983	3 samples	(NWT Wildlife notes, 1983)		
Baffin Island	14-35%	Mid-1980s	N Baffin highest	(O'Reilly, 1992)		
Melville/Boothia	20-35%	1980s	17 samples	(O'Reilly, 1992; Gunn et al. 1991)		
Ahiak	?					
Porcupine	15-20%	1980s	?	(O'Reilly, 1992)		
Central Arctic	15-20%	1980s	?	(O'Reilly, 1992)		
Western Arctic	= 30%</td <td>1960-1980</td> <td>?</td> <td>(O'Reilly, 1992; Neiland et al. 1968)</td>	1960-1980	?	(O'Reilly, 1992; Neiland et al. 1968)		
Nechina	1-6.5%	1962-65	?	(Neiland et al. 1968)		
George River	Not Present	1987-88	?	(Forbes 1991; Greenberg et al. 1958)		
QEI Peary	Present	1980s	1 sample (P. of W. Island)	(Forbes, 1991)		

Table 13. Circumpolar Incidence of Brucellosis in barren-ground Caribou and
Reindeer across arctic North America (after O'Reilly, 1992).

4.5 Harvest:

Throughout the reintroduction of barren-ground caribou to SHI, wildlife managers of the time were vigilant in their on-going management of the herd. Management recommendations were, in all cases, based on research results, and particularly quantitative population estimates. In February 1978, the first caribou hunt since the 1968 introduction, was carried out on SHI. The quota was set at 25 bulls and was based on observations from a reconnaissance survey flown in 1977 that sighted a total of 172 caribou, 79 of which were adult males, 54 adult females, and 39 yearlings, suggesting a sex ratio skewed towards males (Kraft, 1978) (**Table 14**) (**Figure 33**). In August 1979, the TAH (quota) for bulls was increased to 50 largely based largely on the findings of the November 1978 population survey. Early in 1983 the first cow harvest was approved with a TAH set at 20. Regulations were developed along with this new TAH stipulating that 10 cows be harvested in the spring and the remaining 10 in the fall. The TAH was then raised from 50 to 250 bulls, and from 20 to 50 cows, based on recommendations generated following the 1987 population estimate (Heard and Grey, 1987).

During the 1988 harvesting year, concerns regarding the accidental harvesting of females seem to have led to the removal of the female quota and an increase in the male quota to 300 animals sometime in 1988. At this time, it was clearly indicated in the regulations that; "hunting zone J/2 (Southampton Island) was restricted to 300 male caribou." In 1989 recommendations to increase the TAH to 400 caribou, of which 100 could be female were made. These recommendations were supported by Doug Heard who indicated the proposed increases were based on sound ecological principles (Renewable Resources Official Correspondence 140 007 005 & 150 001 005, October 1989). Seasons for this new quota were recommended to be from October 1st to October 31st for males and April 1st to May 31st for females. By 1993, and in response to rapid population growth reported by Oullett in 1991, the TAH was removed (Oullett, 1992) (**Table 15**).

From 1993 up until the 2012 harvesting season subsistence harvest was not accurately monitored. In Nunavut monitoring of caribou harvest in the absence of a TAH is not mandatory. Although the 1991 NWMB Harvest Study attempted to assess wildlife harvest through hunter interviews, it is generally agreed that the final estimates are best guesses and may be misleading in some cases. For SHI, however, accurate records of harvest numbers and sex ratios (for most harvests) were kept as part of commercial harvests running consecutively between the harvesting years of 1992 through to 2007 and including 2009.

The first commercial quotas were established in 1992 and were set at 250 animals (gender breakdown unknown) (Junkin, 2003) (Table 16) (Figure 33). Despite the 1992 commercial allocation, it was not until 1993 that the first five caribou (of unknown gender), harvested for commercial purposes was reported since the herd's reintroduction from Coats to Southampton Island. Commercial quotas continued to rise to 1,000 animals in 1993, 5,000 in 1994 and 6,000 by 1997 (Junkin, 2003). Since 1993 there have been annual commercial harvests up to and including the 2009 harvesting season. Interestingly, a non sex-selective subsistence quota of 1,000 animals was re-instated in 1994 in an effort to offset an increase in the commercial quota from 1,000 to 5,000 over the same period (Junkin, 2003). By 1997, in response to survey results indicating the continued rapid growth of the population to 30,381 animals (Mulders, 1997), concerns about the caribou population having exceeding the Islands hypothesized carrying capacity of 15,000 caribou were being realized (Oullett et al 1994, Oullett et al 1993). In response to these concerns, the wildlife regulations were once again amended to allow an unlimited subsistence harvest and a non sex-selective commercial quota of 6,000 caribou.

Overall, the commercial harvest was successful in reducing the population to the estimated carrying capacity of the Island of 15,000 caribou (Oulett et al. 1996). Current concerns however, are that continued high harvest rates, in excess of 6,500 caribou over the 2006 and 2007 harvesting seasons would drive the population too low to sustainably maintain the estimated subsistence harvest rate

of 1,500 to 2,000 caribou annually. Additionally, there was the concern of rising Brucella prevalence and its observed impact on the reproductive potential of the SHI herd. The continued decline of SHI caribou following the 2003 survey estimate only heightened these concerns, and by 2007, when the population had dropped further to an estimated 14,389 adult and yearling caribou, discussions on ending the commercial harvest had begun. However, the harvest employed many local people and the political will to continue the harvest was high. Despite these pressures the harvest was cancelled by the Coral Harbour HTO in 2008 and only a small harvest of 843 was undertaken in March 2009. Between 1978 and 2009 an estimated total of 27,400 caribou had been harvested for subsistence purposes and 42,000 for commercial purposes yielding a total harvest of 69,400 caribou, of which 61% were taken for commercial purposes (**Table 16**). Since 2009 there has been no commercial caribou harvest. Results from the 2009 aerial abundance estimate showed no significant change between survey periods suggesting that the cessation of the harvest was having the net effect of slowing or stabilizing the population decline. But, over the same period, annual condition and disease monitoring tracked a steady increase in Brucellosis prevalence and a corresponding reduction in reproductive productivity (Figure 32).

Unfortunately, the stabilizing effect lasted only a short period and by June 2011 estimates of population abundance dropped further to 8,442 adults and yearlings. With the commercial harvest having been stopped and the subsistence harvest remaining relatively constant at an estimated 1,500 to 2000 caribou annually, the reasons for this rapid decline appeared to now be related to the reported high prevalence of the reproductive disease Brucellosis. By March 2011, Brucellosis disease prevalence had reached a troubling 58.8% and spring pregnancy rates had plummeted to 37% (**Figure 32**). In addition to high rates of disease, around this time and despite the cessation of the commercial harvest, a new method of selling country foods was gaining popularity and increasing harvests of SHI caribou. This new harvest pressure was developing from the growing demand for the sale of caribou meat on social media. A ripe market had opened up on Baffin Island where Baffin communities were struggling with declining caribou

populations as well. When sales of caribou from SHI on social media began, 24,764 kilograms of caribou meat was sold and shipped from SHI in the first 8 months of sales, representing an estimated 710 caribou (**Figure 34**). Unfortunately the data provided by the airline was cut off in January 2012 thus removing our ability to assess the internet sales and harvest totals, through export traffic, for the months of heaviest harvest (March, April, and May).

4.51 Harvest Management and Planning 2011 to present:

Meetings in the summer and fall of 2011 between the GN Department of Environment and the Coral Harbour HTO, and additional meetings with all stakeholders in the winter of 2012, led to a formal request by the Coral Harbour HTO to the GN and the NWMB to apply a TAH of 4 caribou per household (1,000 caribou) in an attempt to stabilize the decline through harvest management. Additionally, the annual condition harvest of 100 animals, used to assess Brucellosis prevalence and pregnancy rates amongst other health and condition indicators, was discontinued in order to move all harvesting opportunities to local Inuit.

Another product of these meetings was the development of the *Southampton Island Barren-ground Caribou Population Management Plan* (2012), which was submitted to the NWMB for decision in March 2012. The plan outlined an agreement to establish a TAH of 1,000 caribou and a Non-Quota Limitation (NQL) protecting cow/calf pairs. Also, in the plan was the specification of continued harvester-supported monitoring, and the continued assessment of SHI caribou population abundance every 2 years. The urgency of the situation led to the NWMB supported and community requested establishment of a Ministerial Management Initiative (through the Nunavut *Wildlife Act*) to immediately assign a temporary TAH.

By May 2013, the herd had further declined to an estimated 7,287 adult and yearling caribou, prompting the GN to recommend a further reduction to 2 caribou per household (500 caribou) with 100 caribou held back for the HTO to use as

deemed appropriate, for a total of 600 caribou. The community rejected this recommendation, preferring to wait until the May 2015 abundance estimate had been made, to make a final decision. The community based its decision on hunter observations of reduced signs of Brucellosis within their catch and a general thought that herd health and pregnancy rates were improving. Continued reports of healthy caribou, fewer signs of disease, several reports of a possible movement of caribou onto the Island over the winters of 2014 and 2015, and a noticeable increase in calves in June 2014, preceded the May 2015 abundance survey. Consistent with community reports, the 2015 survey estimated a significant increase in adult and yearling caribou. In two years, the population had increased by 5,081 animals to 12,368 caribou, an estimate far higher than could be accounted for by reproduction alone. The community of Coral Harbour was not surprised with the result, attributing the increase to what they believe was the movement of a large group of caribou from the mainland onto the north end of the island. In an attempt to verify these accounts, the GN conducted a genetic analysis using SHI hunter provided tissue samples from 2014 and then comparing them to SHI samples from 2004 and samples collected on the mainland in the vicinity of Naujaat.

Table 14. History of the Southampton Island assigned subsistence harvest quotas (TAH) from 1978 to 1991. Harvest management prior to the first commercial allocation in 1992 (subsistence harvest estimated using government reports, HTO correspondence and personal communications with wildlife staff).

	Regulated Quotas (TAH)							
¥		Subs	istence	Comm	tal A arve:			
YEAR	Female (#)	Male (#)	No Sex Selection (#)	Total (#)	No Sex Selection (#)	Total	Total Allowable Harvest (TAH)	
1978	0	25	0	25	0	0	25	
1979	0	50	0	50	0	0	50	
1980	0	50	0	50	0	0	50	
1981	0	50	0	50	0	0	50	
1982	0	50	0	50	0	0	50	
1983	20	50	0	50	0	0	50	
1984	20	50	0	50	0	0	50	
1985	20	50	0	50	0	0	50	
1986	20	50	0	50	0	0	50	
1987	50	250	0	250	0	0	250	
1988	0	300	0	300	0	0	300	
1989	100	300	0	300	0	0	300	
1990	0	400	0	400	0	0	400	
1991	0	400	0	400	0	0	400	

Table 15. History of the Southampton Island harvest assigned commercial and subsistence Quotas (TAH) from 1992 to present (subsistence harvest estimated using government reports, HTO correspondence and personal communications with wildlife staff).

	Regulated Quotas (TAH)						
ΥĒ		Subsi	stence	Comm	tal A arve:		
YEAR	Female (#)	Male (#)	No Sex Selection (#)	Total (#)	No Sex Selection (#)	Total	Total Allowable Harvest (TAH)
1992	0	400	0	400	250	250	650
1993	no limit	no limit	no limit	no limit	1,000	1000	no limit
1994	NA	NA	1,000	1,000	5,000	5,000	6,000
1995	NA	NA	1,000	1,000	5,000	5,000	6,000
1996	NA	NA	1,000	1,000	5,000	5,000	6,000
1997	no limit	no limit	no limit	no limit	6,000	6000	no limit
1998	no limit	no limit	no limit	no limit	6,000	6000	no limit
1999	no limit	no limit	no limit	no limit	6,000	6000	no limit
2000	no limit	no limit	no limit	no limit	6,000	6000	no limit
2001	no limit	no limit	no limit	no limit	6,000	6000	no limit
2002	no limit	no limit	no limit	no limit	6,000	6000	no limit
2003	no limit	no limit	no limit	no limit	6,000	6000	no limit
2004	no limit	no limit	no limit	no limit	6,000	6000	no limit
2005	no limit	no limit	no limit	no limit	6,000	6000	no limit
2006	no limit	no limit	no limit	no limit	6,000	6000	no limit
2007	no limit	no limit	no limit	no limit	6,000	6000	no limit
2008	no limit	no limit	no limit	no limit	6,000	6000	no limit
2009	no limit	no limit	no limit	no limit	6,000	6000	no limit
2010	no limit	no limit	no limit	no limit	6,000	6000	no limit
2011	no limit	no limit	no limit	no limit	6,000	6000	no limit
2012	NA	NA	1,000	1,000	0	0	1,000
2013	NA	NA	1,000	1,000	0	0	1,000
2014	NA	NA	1,000	1,000	0	0	1,000
2015	NA	NA	1,000	1,000	0	0	1,000
2016	NA	NA	1,600	1,600	0	0	1,600
2017	NA	NA	1,600	1,600	0	0	1,600
2018	NA	NA	1,000	1,000	0	0	1,000
2019	NA	NA	1,000	1,000	0	0	1,000

Table 16. A history of the Southampton Island actual harvest from 1992 to present. Harvest estimates include actual commercial harvest and estimated subsistence harvest (subsistence harvest estimated using government reports, HTO correspondence and personal communications with wildlife staff).

	Actual Harvest								
	Subsistence (Values Estimated)					Comn		Tot: (Es	
YEAR	Female (#)	Male (#)	Unknown (estimated)	Total (estimated)	Female (#)	Male (#)	Unknown	Total (#)	Total Harvest (Estimated)
1992	0	400	0	400	0	0	0	0	400
1993	?	?	500	500	?	?	5	5	505
1994	?	?	500	500	500	500	1,000	1,000	1,500
1995	?	?	1,000	1,000	?	?	2,356	2,356	3,356
1996	?	?	1,000	1,000	?	?	1,839	1,839	2,839
1997	?	?	1,500	1,500	2,356	1,009	0	3,365	4,865
1998	?	?	1,500	1,500	2,069	887	0	2,956	4,456
1999	?	?	1,500	1,500	514	580	0	1,094	2,594
2000	?	?	1,500	1,500	1,170	996	0	2,166	3,666
2001	?	?	2,000	2,000	2,070	1,626	0	3,696	5,696
2002	?	?	2,000	2,000	959	2,875	0	3,834	5,834
2003	?	?	2,000	2,000	3,403	1,602	0	5,005	7,005
2004	?	?	2,000	2,000	?	?	3,200	3,200	5,200
2005	?	?	2,000	2,000	2,766	1,272	0	4,038	6,038
2006	?	?	2,000	2,000	2,892	1,136	0	4,028	6,028
2007	?	?	2,000	2,000	1,446	1,129	0	2,575	4,575
2008	?	?	2,000	2,000	0	0	0	0	2,000
2009	?	?	2,000	2,000	322	521	0	843	2,843
2010	?	?	2,000	2,000	0	0	0	0	2,000
2011	?	?	2,000	2,000	0	0	0	0	2,000
2012	?	?	1,000	1,000	0	0	0	0	1,000
2013	?	?	1,000	1,000	0	0	0	0	1,000
2014	?	?	1,000	1,000	0	0	0	0	1,000
2015	?	?	1,000	1,000	0	0	0	0	1,000
2016	?	?	1,600	1,600	0	0	0	0	1,600
2017	?	?	1,600	1,600	0	0	0	0	1,600
2018	?	?	1,000	1,600	0	0	0	0	1,000
2019	?	?	1,000	1,000	0	0	0	0	1,000
Grand Totals			40,600				42,000	82,600	

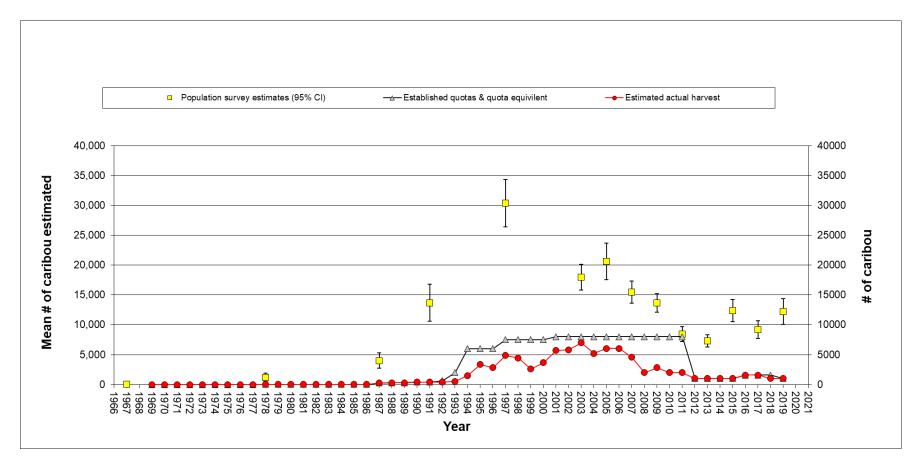


Figure 33. An examination of quota adjustment and actual harvest based on population estimates (Quota equivalents = estimated maximum subsistence harvest substituted for "no-limit" quota allowance values, Tables 1 and 2).

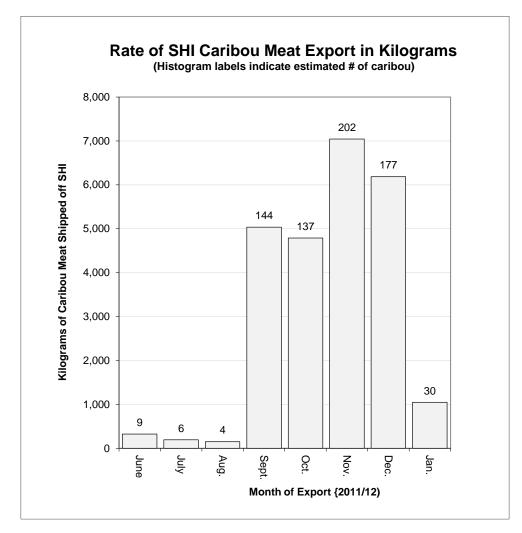


Figure 34. Caribou exports off Southampton Island primarily to Baffin Island communities. Data collected over an 8-month period in 2011/12.

4.6 **Population Genetics:**

The 2015 abundance survey results showed a statistically significant mean increase of 5,081 caribou from the previous survey in 2013, an increase that cannot be entirely accounted for by reproductive rates alone. The GN, in partnership with the Coral Harbour HTO, set out to try and confirm the possible mechanism of this increase. Based on information collected over two meetings with the Coral Harbour HTO, the primary mechanism forwarded by the HTO was the movement of caribou onto SHI. Hunter reports of many tracks coming onto the Northwest end of the island from across the sea ice suggested immigration was likely a behind the increase in caribou abundance. We sought to verify these observations through a genetic analysis of SHI tissue samples from 2014 (collected just following the reported movement) and 2004 (collected a decade prior to the suspected movement). Both these samples would then be compared with archived Qamanirjuag caribou samples collected in 2012, and 2015 caribou samples collected in the vicinity of Naujaat, on the Kivalliq mainland. We employed Wildlife Genetics International (WGI) to analyze the results and test the validity of such a movement of caribou onto the Island.

Using Qamanirjuaq and Naujaat (Repulse Bay) samples to represent the mainland population, and starting out by using only the Southampton data from 2004 to start, WGI noted that the dramatic separation of mainland and island populations was not perfectly reflected across all individuals, even in 2004 (Paetkau, 2015) (**Figure 35**). Specifically, Qamanirjuaq individual C45 (partially red bar in group 2) and SHI individual 155 (partially green bar in group 4) were estimated to have ~ 35% ancestry in the 'wrong' population. These unusual individuals were previously dismissed as outliers, but that may have been premature: the stark differences in allele frequencies should have allowed accurate assessments of ancestry using 18 markers (Paetkau, 2015). Upon examining the 2014 samples, WGI found a marked shift between the 2004 and 2014 SHI genotypes, with 3% of the 2004 caribou being estimated to have < 90% SHI ancestry, versus 35% of individuals

collected between 2013 and 2015 having < 90% SHI ancestry. Assuming that this shift is not the result of a change in sampling location — the NW region of SHI might show more mainland influence than the south — this change in the genetic composition of the population over the course of a decade is dramatic (Paetkau, 2015).

According to Paetkau (2015), the temporal shift was strong enough to leave little doubt that geneflow had occurred from the mainland to the island. To address the question of ancestry, Paetkau (2015) calculated the likelihood (Paetkau *et al.* 1995 *Mol. Ecol.*) that each genotype in the dataset would have been drawn from either the mainland (using Qamanirjuaq and Naujaat caribou herd DNA samples for allele frequencies) or the Southampton Island group (using 2004 data for SHI) (**Figure 36**). Paetkau concluded that with P < 0.01 that any genotype with a lower ratio did not have pure island ancestry, while ratios in excess of -7.8 (P < 0.01) had ancestry other than pure mainland.

With consideration to the number of tests conducted and associated hypothesis testing framework, WGI assessed the risk that the outliers are simply Type I errors. Having tested 86 individuals from the mainland, and 58 SHI individuals from 2004, a correction for multiple tests indicated critical values of 0.0006 and 0.0009, respectively, in order to achieve an 'experimentwise' P = 0.05, suggesting a genotype with a more extreme P than those that would be expected to occur through Type I error in 5% of similar datasets (Paetkau, 2015). The P-values estimated by GeneClass2 for C45 and 158 were 0.0003 and 0.0000, respectively, so these 2004 outliers cannot be explained by chance, even after correcting for the number of individuals tested (Paetkau, 2015). Paetkau therefore concluded that the evidence of movement in both directions (onto and off of the mainland) by 2004, was statistically meaningful. Indeed, both SHI individuals are statistically excluded as purebred members of either source population (mainland or island), indicating that they are members of the F1, or subsequent, hybrid generation (Paetkau, 2015).

Moving forward a decade, Paetkau (2015) found that 19 of the 127 new 2014 SHI caribou had a likelihood of P < 0.01 that they were from "pure" SHI caribou as represented by the 2004 samples. According to Paetkau 23 individuals produced a P between 0.05 and 0.01 which individually could be explained as outliers (Type I error). As a group, however, Paetkau believed there were too many outliers to be so easily dismissed, as Type I error for a dataset of 127 pure SHI animals. In total, Paetkau observed 19 individuals beyond the critical ratio for P = 0.01, and 42 beyond P = 0.05 suggesting a substantial mainland influence present in 2014 but not present in 2004.

Though the results do not support that a pulse of mainland individuals had moved onto Southampton Island recently, they also do not support that genetic isolation of the island herd has been maintained. Paetkau (2015) points out that samples collected on SHI between 2013 and 2015 did not appear to include any F0 (parental generation) immigrants from the mainland. Paetkau concluded that the analysis has documented that a large proportion of 2014 SHI caribou samples (about 1/3 of the current set) are of F1 (offspring generation) or subsequentgeneration hybrid ancestry.

One possible explanation of the absence of apparent F0 immigrants from the mainland could be that such individuals arrived at the northwest corner of the island and took a generation or more to reach as far south as the region where the hunter samples were collected, which is more towards the southcentral extents of SHI. This, however, cannot explain the statistically significant increase in caribou abundance along with the local reports of mainland caribou migrating onto SHI between the May 2013 and 2015 surveys. Possible reasons for this finding could be related to a sampling bias whereby hunter samples collected from early 2014 could have missed an immigration event occurring later in the winter. Though unlikely, consideration must also be given to the mainland comparative samples. Most of the samples were collected from areas close to Naujaat creating a second

possible sampling bias that could have excluded more northern groups of caribou as potential source populations, such as caribou in the vicinity of Lyon Inlet. Clearly, additional genetic analysis needs to be undertaken to determine the cause of the hybridization event clearly documented more accurately sometime between 2004 and 2015. Overall, we suggest that local hunter knowledge, and scientific evidence to date, all point to the arrival of a large contingent of caribou onto SHI from an area or areas not covered by SHI aerial survey extents.

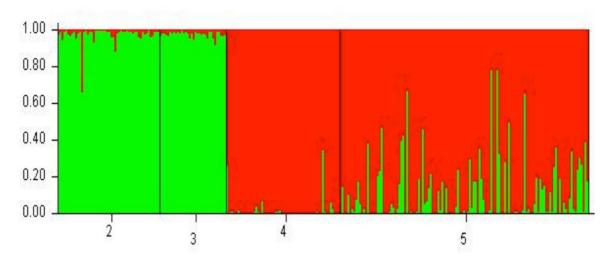


Figure 35. Structure results. Each column represents an individual, with its estimated proportion of mainland ancestry coded green, and SHI ancestry red. The 'populations' are Qamanirjuaq (2; w9741), Repulse Bay (3; g1616), SHI 2004 (4; w9741) and current SHI 2014 (5; g1616) (Paetkau, 2015).

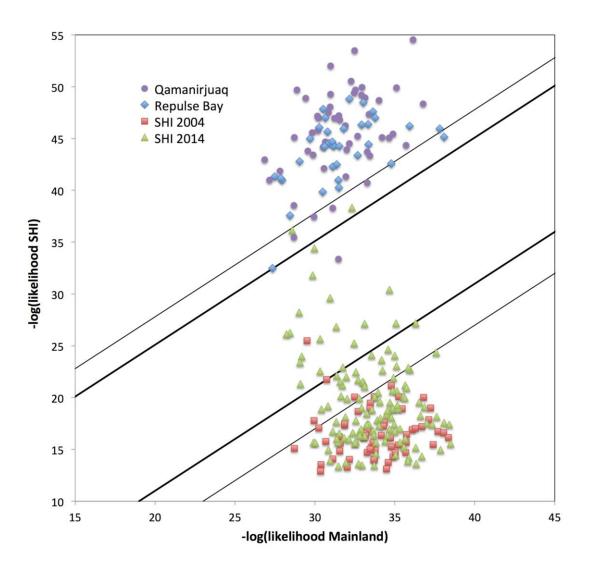


Figure 36. Likelihoods of occurrence based on mainland and (2004) island allele frequencies of caribou according to genetic analysis from different populations and years. Resampling in GeneClass2 indicated that 95% of purebred individuals are expected to have likelihood ratios outside the light lines, while 99% should sit beyond the heavy lines. Individuals between the heavy lines, including C45 (purple circle) and 155 (orange square) have genotypes that are rarer than 99% of individuals of either pure mainland or pure island ancestry. These include seventeen 2013–2015 SHI caribou (Paetkau, 2015).

5.0 Conclusions & Recommendations:

5.1 Aerial Survey Methods:

Overall, survey efforts from 1997 to 2019 were relatively precise (CV = 0.055 to 0.087) and were able to track two decades of decline followed by a period of stability within the Southampton Island caribou population. Methods changed over the period, namely from single observer pair configurations from 1997 through 2007, to dependent double observer pair configurations in 2009 to 2015, and 2019, and to a composite of dependent double observer pair and distance sampling configurations, in 2017.

The dependant double observer pair configuration proved to be the most advantageous methodology, given that front and rear observers switch positions half way through each survey day, and that both front and rear observers are given the prescribed opportunities (see methods) to see the groups while flying along transects. The method reduced sightability errors common to the single observer pair method and provides more precise estimates of wildlife populations. This method was the most effective at correcting estimates when the assumption of perfect sightability was violated. The dependant double observer pair method had other advantages. Incorporating more involvement of community members in research, builds local support for the method and survey results, increases training opportunities for observers, improves research capacity in the territory, and incorporates co-management partners in research aspects of wildlife management.

Although the addition of distance sampling methods can further improve survey precision, the task of the observers becomes more challenging, and problems can arise when using observers with limited experience. In 2017, distance sampling estimates were higher than dependent double observer pair and strip transect

estimates. This may have been due to one of the observer pairs not putting enough survey effort to the bins near the aircraft (**Figure 25**) as indicated by different shapes of the detection histograms for the 2 observer pairs. This would cause a negative bias in both strip transect and dependent double observer pair estimates. This illustrates a potential issue with distance sampling, observers spending too much time looking out at further bins which are often easier to view than the closer bins, rather than surveying one strip more thoroughly. The dependant double observer pair method partially accounted for this by also estimating the sighting probabilities of observers near the survey line. In the 2017 case, the observer was identified using dependant double observer records and the error addressed.

Based on our analyses and experience, we suggest that the dependant double observer pair method is the most appropriate method to meet the rigours of quantitative assessment while promoting collaboration with co-management partners. Distance sampling methods, though exceptional in many respects, should only be deployed when experienced observers occupy all observer positions, and, in combination with the dependant or independent double observer pair configuration. If abundance were to decline further on Southampton Island, greater consideration should be given to incorporating distance sampling into survey methods. This may mean working closer with community HTOs to ensure only experienced observers are chosen, to reduce errors which contradict the assumptions of statistical models used in population estimates.

5.2 Herd Trend:

The SHI caribou population peaked sometime between 1995 and 2000 and has, since then, declined by an estimated 9% annually, up until the 2017 survey estimate. A probable immigration event sometime between May 2013 and May 2015 significantly increased abundance by an estimated 5,082 caribou, however,

by May 2017 the population trajectory seems to have fallen back into the 9% annual rate of decline trend that was documented up until 2013. This decline turned around between May 2017 and May 2019, when abundance increased to levels similar to 2015 results suggesting stability across the period. Reasons for the decline detected in May 2017 are likely related primarily to three separate mechanisms including harvest, Brucellosis prevalence, and icing and its effects on forage availability during some winters. The increases detected in May 2019 were likely related to the HTO directed reduction in harvest over that period, and possibly a second immigration event, though studies have yet to confirm such an event. Conditions over the 2-year period were favorable with no indications of icing or other extreme weather events. Any one or part of these metrics could have led to the increases observed in 2019.

Brucellosis likely had little influence on abundance trend until 2004 when disease prevalence reached an estimated 40%. As a result, we believe harvest was the main mechanism of decline between 1997 and 2004. One must keep in mind, however, that the reduction in abundance was the goal during this period, as the population was believed to be well beyond the island's carrying capacity of 15,000 caribou (Oullet, 1993). Since 2004, both the reproductive disease Brucellosis and harvest were likely the main mechanisms of decline. Unfortunately, at this point we are unable to ascribe which may have had the greater effect on the abundance of SHI caribou. This being said, by 2005, abundance was still above the hypothesized carrying capacity of SHI (Oulett, 1993), so the management goal of reducing abundance remained unchanged. By 2007, herd estimates were below the estimated carrying capacity of 15,000 caribou, however, declines in abundance seemed to slow between 2007 and 2009, based on survey results. Additionally, Brucellosis prevalence was declining by 2009 and, based on hunter reports, general condition/health was increasing. As Brucellosis prevalence had been steadily decreasing from 2006 through 2009, and the declines over the same period were slowing, the management goals were amended by the Coral Harbour HTO to reduce the Islands commercial harvesting. Agreement was reached amongst all co-management partners to suspend the commercial harvest after 2009, in an attempt to further stabilize the decline and maintain an abundance that could support the subsistence harvest. Between 2009 and 2011, however, the caribou population significantly dropped by 5,209 animals, the greatest observed decline over any 2-year period. During this period trends in Brucellosis prevalence reversed and climbed to the highest recorded, and pregnancy rates dropped to below 40%, the second lowest recorded since 2000. Additionally, the unanticipated sale of caribou meat through social media, a new form of commercial harvesting protected as a right under the Nunavut Agreement, beginning in 2010, reached levels estimated to have exceeded the subsistence harvest over the 2011/2012 harvesting season. It appears that during this period, disease and harvest together were driving the population down. With the formal commercial harvest already stopped in 2009, the Coral Harbour HTO and GN had little option but to apply a TAH to reduce the subsistence harvest as an attempt to control the sale of caribou meat, primarily to Baffin communities, through social media.

The statistically significant increase in the SHI caribou population between May 2013 and May 2015, subsequent decline of an estimated 9% between 2015 and 2017, and 9% increase between 2017 and 2019, has been difficult to explain quantitatively. Genetic studies conducted as a follow-up to hunter observations suggesting a large group of mainland caribou had come onto the island from, the mainland sometime between 2013 and 2015, have yet to provide a conclusive answer regarding whether a migration event was the key mechanism of both the increases between 2013 and 2015, and 2017 and 2019. However, the genetic work did indicate that sometime between 2004 and 2015, a significant mixing of mainland and SHI caribou occurred. More analysis comparing consecutive years of SHI genotypes, with a more geographically broad collection of caribou genetic samples from coastal areas bordering SHI, will be necessary in order to more effectively explore possible mainland connections and reduce potential sampling bias that may be masking actual events. Although it is only a remote possibility, we believe that SHI caribou reproductive potential alone is unlikely to have

accounted for the 41% increase estimated between 2013 and 2015, though would not be out of the realm of possibility to have accounted for the increases observed between 2017 and 2019.

5.3 Future Management:

Another survey will be planned to further assess the maintenance of the detected stability between May 2015 and May 2019. Should a renewed decline be observed, discussions with the Coral Harbour HTO and other stakeholders regarding the consideration of a further reduction in TAH will have to be arranged shortly following the surveys completion, in an attempt to try and safeguard against further decline and associated hardship to the residents of Coral Harbour. Should survey results suggest continued stability, or an increase in caribou abundance, discussions on maintaining the current TAH (in the case of stability), or increasing and/or removing the TAH, (wholly dependent on the magnitude of any detected increase), will be discussed with all stakeholders.

The mechanisms driving the changes in abundance observed over the entire survey history of the Southampton Island caribou population are multiple, and difficult to isolate and quantify, suggesting that further research is required. It appears that the main drivers have been the disease *Brucella suis* Type IV, harvest (with emphasis on the sale of caribou meat through social media), and potentially poor winter weather in some years. The need to continue monitoring disease prevalence in SHI caribou is required if we are to understand present day infection rates and associated productivity for the herd. Recently, hunters have reported fewer caribou with signs of disease, and a noticeable increase in the number of calves observed in 2015 through 2017, which suggests that disease prevalence may be decreasing. If this is the case, and Brucellosis no longer represents a primary mechanism of decline, then harvest, along with weather and condition monitoring should become the focus of future monitoring for the SHI herd.

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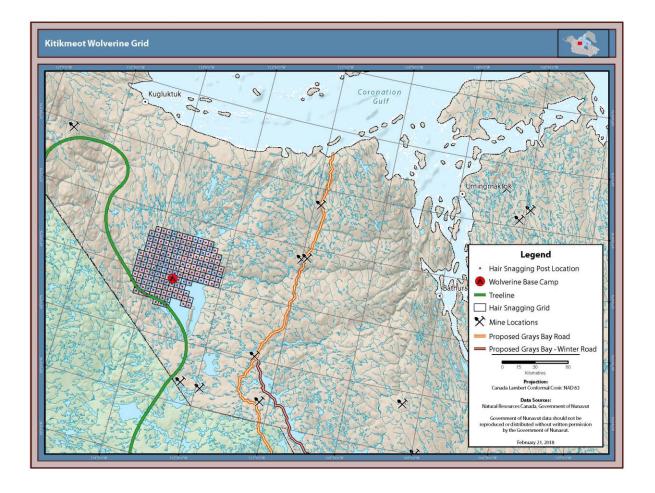
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⊲⊲∩⊂∩ک[⊮]d^c Department of Environment Avatiliqiyikkut Ministère de l'Environnement

ESTIMATES OF WOLVERINE DENSITY FROM MARK-RECAPTURE DNA SAMPLING

Napaktulik Lake, Kitikmeot Region, Nunavut 2018-2019

Final Report

September 2020

Malik Awan Department of Environment Igloolik, Nunavut X0A 0L0 Murray Efford Dunedin, New Zealand John Boulanger Integrated Ecological Research Nelson, BC

Summary

This report presents results for a wolverine (*Gulo gulo*) DNA mark-recapture study conducted near Napaktulik Lake, Kitikmeot region, Nunavut, to establish baseline population abundance and density estimates for long-term regional monitoring. In addition, monitoring of the wolverine population is also important as part of predator research and management as it informs caribou management. Wolverines are listed as a species of Special Concern under the federal Species at Risk Act (SARA) and are an important cultural and economic resource traditionally harvested by Inuit. This project was done collaboratively with the Kugluktuk (Angoniatit Association) Hunters and Trappers Organization (HTO). Genetic analysis was used to identify sex and individual wolverines from DNA in hair samples collected non-invasively by a science-driven study design and logistics facilitated by local hunters. From early March through late April 2018 and 2019, the field team sampled a grid of 154 posts baited with caribou (*Rangifer tarandus groenlandicus*) and Muskox (*Ovibos moschatus*) legs and scent lures. The posts were spaced in 5x5 km (25 km²) cells for three 10-day sessions within a 4,000 km² area northwest of Napaktulik Lake.

In total, 22 individual wolverines (11F:11M) were detected in 2018 and 27 wolverines in 2019 (13F:14M), including 10 individuals (6F:4M) identified first in 2018 and then recaptured in 2019. Spatially explicit capture-recapture (SECR) methods were used to estimate population density. Wolverine density was estimated as 3.10 wolverines/1,000 km² (95% CI: 2.00–4.78) in 2018 and 4.14 wolverines/1,000 km² (95% CI: 2.78–6.18) in 2019, with no significant difference between years. These SECR yearly density estimates pertain only to wolverines with home range centers within the DNA sampling grid. Our results suggest that the population of wolverines in the proximity of the grid varies spatially and temporally in its usage of the grid area, which may be responsible for the apparent inter-annual variation in density estimates. There was little difference between sexes in the extent of movements on the grid in 2018, but a clear separation in 2019. Median observed range length of detected males (24 km) was similar to that of detected females (23 km) in 2018, but consistently larger in 2019.

Wolverines in the region exist at low densities and are being exposed to increasing levels of human activity through mining and subsistence harvest. Our results, which contribute to baseline data for wolverine ecology, could be used to provide a quantitative basis to establish future sustainable harvest limits and could support input to the Nunavut Impact Review Board (NIRB) review process. DNA based surveys offer a practical and cost-effective method to monitor wolverine populations in tundra situations. For a better understanding of wolverine population in the area, we

recommend long term monitoring by involving local HTOs and industry. This study demonstrates the efficiency of joint research projects to inform wildlife management.

Key words: density estimates, DNA, *Gulo gulo,* Napaktulik Lake, Kitikmeot, Nunavut, spatially explicit capture-recapture, wolverine.

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Naitumik titiraqhimayuq

Una ilitugidjutikhaq naunairutiqaqhimayuq qalvingnik (Gulo qulo) DNAnik nanigiaqvakhimayut aulatiffaaqhimayunlu nunamun ihivriudjutikharnik talvani Napaktulik Tahiani, Kitikmeot, Nunavunmi, aulatitihimayut naunairutikharnik amihuaryuit unalu amihuaryungit nallautiqhimayunik hivutunigaalukmik avikturvingmi munagidjutikharnik. Ilauhimayuq, munagidjutikharnik qalvingnik amigaitilaangat akhurnaqturlu ilagigamiut angitiugamik huraadjanik munagidjutikharnik ihiviudjutikharnik naunaiyaivakami tuktunik Qalviit naunairutigaqtun huraadjat Ihumagiyauyukharnik talvuuna munagidjutikharnik. kanatami Huraadjat Ayungnautiqaqtun Maligaq (SARA) unalu akhurnaqtun pitquhiqaqtun maniliurutikharnik ilitguhigaghimayut anguniagtauvakhimayut Inuinarnik. Una havaaghag havakpakhimayuq havaqatigiikhuta Kugluktuk Anguniaqtuliqiyit Katimayiingit (HTO). Atugpaktugut idjuhigharnik kangikhidjutikharnik ganurimangaangit nanminigiyauyuniklu ilitagidjutikahrnik qalvingnik taima DNAnik amiinik naunaitkutikhagpakhutik pukuktauvakhimayut ilaungitunik talvuuna nallunagtunik ilituginahuarnikkut aulayut ihivriudjutikharnik naunaitkutikharnik aulatitivakhimayut nunalaani anguniaqtiuyunik. Qigailrug atulihaaligtiluni talvuuna Qitiggautiyurmun 2018mi - 2019mun, hanigaini pukukpakhimayut hunavalungnik hanigarni 154nik napaqutingnik havagatigiiktunik niqihiqhimayunik tuktunik (Rangifer tarandus groenlandicus) Umingmakniklu (Ovibos tipigikhautiqaqtunik moschatus) kanaarnik upautauyaanganik. Tapkuat napagutit ungahiqtilaaqaqtun taima 5X5nik kmnik (25 km²) avatilgit pingahunik 10nik ublunik upautauyukharnik talvuuna 4,000 km^{2nik} hanigaini avatilgit tunnganirmi Napaktulik Tahiani.

Talvuuna atautimiitun, 22nik galvingnik talvani (11F:11M) ilauvakhimayut talvuuna malrungnik ukiunganik ihivriudjutikhaqaqpakhimayut, 2018 ilauplugitlu 27nik qalvingnik 2019mi (13F:14M) ilitagiyauvakhimayut hivulirpaarmi 2018mi taimalu nangiaqtauvakhimayut 2019mi. Inikhavikhangit nanigiaqtauvingani (SECR) hanaqidjutikhangit atuqtauvakhimavuq nallautigianganik amigaitilaangat nunagiyainik. Qalviit nunami nayugaini angiktilaangit 3.10nik qalviinguyut/1000nik ungahiktilaaqaqtun (955 CI: 2.00-4.78) 2018mi unalu 4.14nik qalvingnik/1000nik ungahiktilaaqaqtun (95% CI: 2.78-6.18) 2019mi, taima allanguqtivyaangitumik talvuuna ukiungnanik. Ukuat SECRngit ukiuk tamaat nallautiqhimayut aulaniaqtun talvuunaluaq qalvingnun aihimavikhaqaqtunik nayugaini talvani DNAnik ihivriudjutikharnik avatiligagtunik. Naunaitkuhighimayaptingnik naunairutigagtun taima amihuaryungit qalviit talvani nayugaaniitunik avatiliqarvingmi naunairutiqakhimayuq amihuaryuingit hanigaini talvanilu atuqtauvinganik talvani avatiliqirmi nayugaani, taima munagidjutiqarniaqtun talvuuna ukuingani nallautirutikharnik nunami nayugainik nallautighimayunik. Allatgiinigagtunlu talvuuna anguhaluit arnarluitlu talvuuna aulaviingit nayugarni naunaiyagiikhimayunik 2018mi, kihimi naunailuaqhimavakhimayuq 2019mi.

Naunairutikhangit qunngiaktauhimayut aulavingit anguhaluit (24nik ungahiktilaaqaqtun) aadjikiivyaktumik naunaiqhimayuq arnarluit (23nik ungahiktilaaqaqtun) 2018mi, kihimi angikliyumiqhimaliqhuni 2019mi.

Qalviit talvani avikturviangani hanigainiitun aulainaqtun taima mikinirmi amihuaryungit taimalu naunairutigaligtun amigairyumiktumik gullirutigaligtun inungnik hulilukaaktunik talvuuna uyaraghiugtunik anguniagtaunginagtuniklu. Taima naunaitkutikhangit, uminga ihivriudjutikharnik, naunaitkuhigtitivakhimayug naunairutikharnik talvuuna galviit nayugainik, atugiaqaqtun taima tuniyaangat amigaitunik naunairutikharnik piqagianganik hivunikharnik anguyauyukhat kiklivikharnik ikayuutiginiagtunlu naunairutikharnik tapkuninga Nunavut Ayungnautiqaqtunik Ihivriuqtiuyut Katimayiinun (NIRB) ihivriudjutikharnik hanaqidjutingnik. DNAnik naunairutigagtunik ihivriudjutikharnik aituihimaarniaqtun ihuaqtumik akiligiaqaqtuniklu hanaqidjutikharnik munagiyaangat qalviit amihuaryuingit nunamiitunik aulahimaaqtunik. Taima ihuaqtumik ilitugidjutikharnik qalvingnik amihuaryuingit talvani hanigarni, atuquniaqtugut hivutunigaalukmik munagidjutikharnik ilauniqarniaqtun nunalaani HTOngit havagvingitlu. Una ihivriudjutikhag naunairutigarniagtug ihuagtumik aulavikharnik ilaugatigiiktukharnik ihivriudjutikharnik havaaghangit naunaiyaiyaanganik uumayuligiyingit munagtiuyunik.

Naunaitkutikhangit taiguangit: amihuaryuingit nallautiqhimayut, DNAngit, *Gulo gulonik*, Napaktulik Tahiani, Nunavut, hanirangit nanigiaqtauvingit aulaqtiffaaqhimayutlu, qalvik.

Sommaire

Ce rapport présente les résultats d'une étude de capture-recapture de carcajous (Gulo qulo) aux fins d'ADN menée près du lac Napaktulik dans la région du Kitikmeot au Nunavut. L'étude visait à établir les renseignements de base sur la taille de la population et sa densité à des fins de monitorage à long terme. De plus, le monitorage des populations de carcajou est important, car il fait partie de la recherche et la gestion des prédateurs, et contribue à la gestion du caribou. Les carcajous ont été placés sur la liste des catégories préoccupantes en vertu de la Loi fédérale sur les espèces en péril et constituent une ressource traditionnelle économique et culturelle récoltée par les Inuits. Ce projet a été réalisé en collaboration avec l'Association des chasseurs et trappeurs de Kugluktuk (Angoniatit Association). L'analyse génétique a été utilisée pour identifier le sexe et les individus au sein de la population à partir de l'ADN provenant des échantillons de poil recueillis de manière non invasive, et selon le concept et la logistique d'une étude scientifique en collaboration avec les chasseurs locaux. Du début mars à la fin avril 2018 et 2019, l'équipe de terrain a pris des échantillons d'une zone quadrillée de 154 pieux dotés d'appâts composés de pattes et d'odeurs de caribou (Rangifer tarandus groenlandicus) et de bœuf musqué (Ovibos moschatus). Les pieux étaient répartis en cellules de 5 km sur 5 km (25 km²) durant des périodes de 10 jours, et disposés sur une aire de 4 000 km² au nord-ouest du lac Napaktulik.

Au total, 22 carcajous individuels (11 femelles; 11 mâles) ont été recensés en 2018, et 27 (13 femelles; 14 mâles) en 2019, dont 10 individus (6 femelles; 4 mâles) déjà répertoriés en 2018, puis recapturés en 2019. Des méthodes spatialement explicites de capture-recapture (SECR) ont été utilisées pour estimer la densité de population. La densité des carcajous fut estimée à 3,10 carcajous par 1 000 km² (95 % Cl : 2 à 4,78) en 2018 et 4,14 carcajous par 1 000 km² (2,78 à 6,18) en 2018 par 1 000 km² (95 % Cl : 2,78 à 6,18) en 2019, sans différence significative entre les années. Ces estimations annuelles SECR de densité ne portent que sur les carcajous dont le territoire est concentré au sein de la grille d'échantillonnage d'ADN. Nos résultats suggèrent que la population de carcajous à proximité de la grille varie spatialement et temporairement quant à l'usage de la zone grillagée, ce qui pourrait expliquer l'apparente variation annuelle des estimations de densité. Il y eut peu de différence entre les sexes quant à l'étendue des déplacements au sein de la grille en 2018, mais une séparation claire en 2019. L'étendue du territoire médian observée chez les mâles (24 km) était similaire à celui détecté chez les femelles (23 km) en 2018, mais systématiquement plus grand en 2019.

La population de carcajous de la région est de faible densité et est exposée à un accroissement des activités humaines, les mines et la chasse de subsistance notamment. Nos résultats, lesquels participent aux données de base de l'écologie des carcajous, pourraient être utilisés

pour procurer une base quantitative afin d'établir d'éventuelles limites de récolte durable. Ils pourraient aussi servir à enrichir les processus d'évaluation de la Commission du Nunavut chargée de l'examen des répercussions. Les études fondées sur l'ADN offrent une méthode pratique et efficiente pour assurer le suivi des populations de carcajou dans les zones de toundra. Pour une meilleure compréhension de la population de carcajous dans la région, nous recommandons l'implantation d'un monitorage à long terme en collaboration avec les OCT et l'industrie. Cette étude démontre l'efficacité de projets de recherche conjoints pour soutenir la gestion de la faune.

Mots clés : estimation de la densité, ADN, *Gulo gulo*, lac Napaktulik, Kitikmeot, Nunavut, capture-recapture spatialement explicite, carcajou

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Table 6. Estimates of wolverine population density from capture–recapture studies. Methods SECRspatially explicit capture–recapture, CR closed population, JS Jolly-Seber.28

1.0 INTRODUCTION

In Nunavut, the wolverine (*Gulo gulo*) is listed both as a furbearer (Schedule 5.2) and a big game species (Schedule 5.1) under the Nunavut Agreement. The wolverine is a solitary carnivore of the Arctic tundra and is an important cultural and economic resource traditionally harvested by Inuit. Nunavut represents the north-eastern edge of wolverine distribution in Canada. There are limited baseline data on wolverine distribution and density within Nunavut. Currently, there is no quantitative limit on their harvest by Inuit. Nevertheless, wolverine densities are believed to be moderate in the western mainland of Nunavut but low on the Arctic islands and in the eastern mainland (Slough 2007, Species at Risk Committee 2014). Inuit observations and recent harvest reports suggest that wolverine numbers in Nunavut are either stable or slightly increasing, and the species may be expanding its range eastward and northward (Awan et al. 2014, COSEWIC 2014, Awan 2020).

The wolverine was assessed as a species of Special Concern in Canada by the Committee on the Status of Endangered Wildlife in Canada in 2014 and listed as Special Concern under Schedule 1 of the Species at Risk Act (SARA) in 2018. While there are no associated effects on Inuit harvest in Nunavut, under SARA a national management plan must be developed within three years of being listed to prevent a species from becoming threatened or endangered. Habitat fragmentation and loss due to development and climate change were considered the primary threats during the SARA listing process. While this is true for most parts of the species' southern range and for western North America, the range fragmentation and habitat loss issues that affect southern or western populations may have limited application to wolverines in Nunavut. However, there has been an increase in wolverine-human conflicts associated with mineral development projects (Agnico Eagle Mines 2014, 2018; Mulders 2019) and there have been substantial declines in wolverine numbers in the central barrens (Boulanger and Mulders 2013, Species at Risk Committee 2014, Efford and Boulanger 2018). Wolverine-human conflicts can be expected to escalate in Nunavut with the amount of development projects growing over time (NIRB 2012).

Arctic climates and ecosystems are changing at the fastest rates on Earth (McLennan et al. 2012). It is believed that wolverines are demographically susceptible to impacts from climate change (Inman et al. 2012, GRRB 2014). Compared with other species adapted to cold, snowy environments, wolverines are particularly sensitive to the impacts of predicted warming trends on snowpack (McKelvey et al. 2011). While climate change impacts are preeminent in the southern part of the wolverine range, they are expected to amplify northward (Inman et al. 2012). McKelvey et al. (2011) hypothesized that the geographic extent and connectivity of suitable wolverine habitat in western North America will decline with continued global warming, and Heim et al. (2017) suggest that cumulative effects of climate and landscape change can limit species local adaptation and dispersal capabilities. Conversely, Webb et al. (2016) described that wolverines may be more flexible in their habitat selection and likely developed local adaptations depending on habitat type and resource availability. Various studies have highlighted wolverine's requirement of persistent snow cover for denning, birth, caching food and reproductive success (Lee and Niptanatiak 1996, Copeland et al. 2010, Peacock 2011, McKelvey et al. 2011). Magoun and Copeland (1998) noted that at least 1 m of snow, distributed uniformly or accumulated in drifted areas, should be present throughout the denning period (February until May). However, in northern Sweden, Aronsson and Persson (2017) found that the wolverine population expanded and colonized into areas without persistent spring snow cover. How climate change might influence spring snow cover and affect larger ungulates remains uncertain (COSEWIC 2014). Recent ecological studies of the impact of diminishing snow cover in Labrador suggest a negative impact on boreal caribou survival due to enhanced predation by wolves, which can more easily access their prey with the loss of deep snow in winter (Schmelzer et al. 2020).

The wolverine is both a scavenger and opportunistic predator throughout its range, caching food in boulder fields, snowbanks, or bogs for later use (Banci 1987, Mulders 2000, Mattisson et al. 2016, van der Veen et al. 2020). Within the Arctic ecosystem, caribou (*Rangifer tarandus groenlandicus*) is an important prey species sustaining much of the tundra biodiversity, and trends in their numbers are important in the structure and

functioning of the tundra ecosystem (Gunn et al. 2011). Arctic wolverines rely predominantly on migratory caribou (Mulders 2000, Awan et al. 2012, L'Hérault et al. 2016), although diet composition changes according to available resources (Mattisson et al. 2016). Since wolverine breeding propensity is likely limited mostly via winter food availability (Persson 2005), the recent decline in caribou abundance and substantial contraction of their range in the Canadian north (Gunn et al. 2011, Adamczewski et al. 2015) is expected to affect wolverines in Nunavut, but any effects are difficult to identify or quantify since the demographic response of resident wolverine populations to variation in prey abundance is unknown (Dalerum et al. 2009).

Baseline population data for wolverines remain scarce throughout their circumboreal range, including most of Canada (Barrueto et al. 2020). Nunavut contributes substantial numbers to the national harvest even though ecological data for tundra wolverine are sparse, especially in the north-eastern edge of distribution. Similar to other northern parts of the wolverine range, the Nunavut mainland is comprised of large undisturbed areas away from communities harvesting range. These areas with no or limited harvest act as reservoirs or refugia (source) to maintain or repopulate hunted populations (sink) of wolverines near communities (Mulders 2000, Cardinal 2004, Krebs et al. 2004, Golden et al. 2007, Species at Risk Committee 2014, Gervasi et al. 2016). As these areas (refugia) become more accessible due to resource development and increased use of highly efficient snowmobiles by local hunters, populations of wolverines become more susceptible to overharvesting and disturbance. Having baseline information for wolverines allows for future monitoring of population trends as the ecosystems and harvesting pressures change over time.

Wolverine typically occur at low densities (Mulders 2000, Royle et al. 2011, Efford and Boulanger 2018, Awan et al. 2018), maintain large home ranges (Mulders 2000, Dumond et al. 2012), and have long dispersal movements (Inman et al. 2012). Numerous survey methods have been used to estimate wolverine population density, abundance or trends, including telemetric monitoring (Magoun 1985, Banci 1987), monitoring natal dens (Landa et al. 1998), identifying individuals using deoxyribonucleic

acid (DNA) from hair collected at bait sites (Mulders et al. 2007, Boulanger 2012, Efford and Boulanger 2018, Fisher et al. 2013, Awan et al. 2018), motion-detection cameras (Lofroth and Krebs 2007, Royle et al. 2011) and aerial (Becker 1991, Becker et al. 1998, Golden et al. 2007) and ground (Golder 2007) snow track surveys. Using DNAbased mark-recapture in the Lac de Gras region, Boulanger and Mulders (2008) estimated density for females from 2.7 to 6.2 and for males from 1.3 to 4.5 wolverines/1,000 km². Using DNA-based mark-recapture in the Kivalliq region, Awan and Boulanger (2016) and Awan et al. (2018) estimated density from 1.6 to 4.4 wolverines/1,000 km². However, in the Kitikmeot region, there is little information about wolverine abundance and ecology, making it difficult to make pro-active recommendations for harvest management (Lee and Niptanatiak 1993).

Similar to other large carnivores, live-capture and tracking of wolverine in the remote tundra is expensive and difficult (Dumond et al. 2012, Efford and Boulanger 2018). The Nunavut Agreement established Hunters and Trappers Organizations (HTO) and Regional Wildlife Organizations with specific roles and authorities, and through these organizations, Inuit are co-partners in Nunavut wildlife management, including wildlife research. In Nunavut, harvest of wolverine and other furbearers for clothing and income is a seasonal and traditional activity, where opportunity for other employment is scarce. Inuit community concerns over wildlife handling has led to the implementation of culturally acceptable, non-invasive research approaches. This study uses DNA-analysis with a field method that integrates the use of local Inuit hunter's skills and capacities (Inuit Tapiriit Kanatami 2016), and provided local employment and training. Boulanger and Mulders (2008) and Golder (2007) argue that DNA-based methodologies are more powerful and robust for monitoring wolverine populations than track count methodologies. The hair-snagging sampling technique in a mark-recapture framework is feasible in the tundra habitat for both wolverine and grizzly bear (Ursus arctos) (Mulders et al. 2007, Dumond et al. 2012, 2015; Awan and Boulanger 2016; Efford and Boulanger 2018; Awan et al. 2018), and this approach was selected to estimate density and monitor wolverine population trends in the Kitikmeot region of Nunavut.

1.1 Objectives

Our primary objective was to estimate wolverine density and develop protocols that could lend to community-based monitoring. The use of culturally acceptable (non-invasive) scientific methods and local knowledge was a priority in study design and implementation. This project aimed to be the basis for long-term monitoring of the species in Nunavut.

The specific objectives of the study were to:

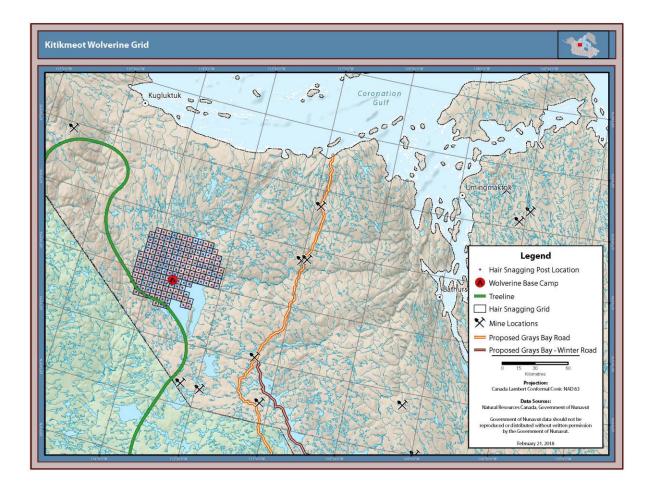
- Estimate wolverine density within the Napaktulik Lake study area;
- Establish baseline wolverine population data which can be used for long-term population monitoring; and
- Provide training for local field staff, facilitate knowledge transfer between study participants, ensure meaningful Inuit involvement in wildlife research, and improve collaboration between the GN and co-management partners.

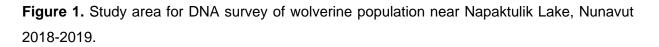
2.0 METHODS

2.1 Study Area

We used two approaches to establish a regional long term DNA sample plot to monitor representative wolverine densities over the long-term. First, we interviewed 10 wolverine hunters and elders from Kugluktuk to identify wolverine habitat and distribution and hunter harvest patterns, as well as caribou and muskox distribution. Second, we considered future mineral resource development, potential linear developments, and long-term patterns of wolverine harvest in the Kitikmeot region. The selected study site comprised ~4,000 km² area in the vicinity of Napaktulik (aka. Takijuq) Lake (66° 29'. 21N, 113° 28'.45W) in the Kitikmeot region of Nunavut, approximately 170 km southeast of the community of Kugluktuk (Fig. 1). The study area consisted of snow covered tundra with shrubs protruding above the snow, numerous frozen small lakes, elevations ranging from 400 to 600 m with high ridges blown free of snow, and dense fields of boulders.

The study area lies in the Takijuq Lake Upland Ecoregion of the Southern Arctic Ecozone. The area of the ecoregion is characterized by cool summers and very cold winters. Mean summer and winter temperatures are 6°C and -26.5°C, respectively, and mean annual precipitation ranges 200-300 mm. The ecoregion is classified as having a low arctic eco-climate, with massive Archean rocks that form broad, sloping uplands, plateaus, and lowlands. The ecoregion has high mineral development potential and substantial exploration activity has taken place (Ecological Framework of Canada 2019). The vegetation is characterized as shrub tundra, consisting of dwarf birch, willow, northern Labrador tea, Dryas spp., and Vaccinium spp., a ground cover of mosses and lichens with scattered stands of spruce along the southern boundary (Ecological Framework of Canada 2019).





The study area overlaps with the summer range of the Bluenose-east caribou herd (Boulanger et al. 2019) in the west, with the Dolphin and Union caribou herd winter range in the east (Environment and Climate Change Canada 2018), and within the annual range of Bathurst caribou herd (Virgl et al. 2017, WFATWG 2017), with light hunting activity. The study area is part of a traditional travel route by snowmobile from the Kugluktuk to the Contwoyto Lake area (Lee and Niptanatiak 1993). During the summer months, this area is accessible only by aircraft.

In 2018 March/April, we observed no caribou or tracks of caribou in the study area during the sampling period. However, during the 2019 sampling period we encountered

caribou and caribou tracks daily. The Beverly herd wintered in the vicinity of the study area in 2019 (J. Adamczewski pers. com. to Kugluktuk HTO in Feb 2019) and caribou and wolves were harvested around Napaktulik Lake by Kugluktuk hunters. Human caused mortality was higher for wolverine and wolves in 2019 winter as wolves and wolverine followed the group of Beverly caribou herd as they wintered in the area. A Government of Nunavut wolf sample collection program was put in place in 2019 to improve research efforts on wolves. The program led to increases in the level of wolf harvest in the region. Caribou gut piles and wolf carcasses attracted wolverines and high wolverine harvest happened in the study area. Five years (2014-18) of reported annual average wolverine harvest from the study area was 3 wolverines, with zero reported harvest in 2017, 2018 and 2020. However, in 2019, 24 wolverines were reported killed by hunters in the early winter between the 2018 and 2019 genetic mark-recapture survey. Most of the wolverine harvest occurred in conjunction with caribou and wolf hunting during early winter. We asked hunters to report the day and location of kill and return the skull for age determination.

Low densities of muskoxen (*Ovibos moschatus*) live year round in the area (Leclerc 2015) and may provide food to support wolverine through the winter. Smaller prey species include Arctic hare (*Lepus arcticus*), Arctic ground squirrels (*Spermophilus parryii*), voles and lemmings (Muridae), ptarmigan (Lagopus spp), and migratory bird species (Mulders 2000, Samelius et al. 2002, Dalerum et al. 2009, Awan et al. 2012). Other carnivores in the area included Arctic fox (*Vulpes lagopus*), red fox (*V. vulpes*), wolf (*Canis lupus*), and grizzly bear.

2.2 Field methods

We conducted DNA sampling during early spring in 2018 and 2019 following the noninvasive procedure developed by Mulders et al. (2007) and updated methods of Awan et al. (2018). This study was designed to involve local hunters in the collection of samples, with 3 Kugluktuk HTO members hired as part of the field research team. The DNA grid (Fig. 1) was sampled from March 8 to April 20, 2018 and March 9 to April 22, 2019. The actual posts sampled in the DNA sampling area varied by year. Low snow depth in 2018 resulted in the dropping of 17 of 160 bait posts proposed for sampling in the original design, and 6 bait posts in 2019 were dropped due to lack of access. Snow in the south west corner (near tree line) of the sampling grid was soft and deep and made snow machine travelling difficult. We sampled, 143 bait posts in 2018 and 154 in 2019 (Fig. 2) in a systematic sampling grid within 5x5 km grid cells, each hosting a post in the cell centre.

2018	2019
H1 I1 J1 K1 L1 M1 V1 O1 P1 Q1 R1 G1 H2 I2 J2 K2 L2 M2 N2 O2 P2 Q2 R2 G2 H3 I3 J3 K3 L3 M3 N3 O3 P3 O3 R3 G3 H4 I4 J4 K4 L4 M4 N4 O4 S3 G3 H4 I4 J4 K4 L4 M4 N4 O4 S3 G5 H6 I6 J6 K6 L6 M6 N6 O6 S5 T4 G6 H7 I7 J7 K7 L7 M7 N7 O7 P7 Q7 R7 S6 T5 G7 H8 I8 J8 K8 L8 M8 N8 O8 P8 Q8 R8 S7 G9 H10 I10 J10 K10 L10 M10 M10 M10 M10	H1 I1 J1 K1 L1 M1 N1 O1 P1 Q1 R1 G1 H2 I2 J2 K2 L2 M2 N2 O2 P2 Q2 R2 S1 G2 H3 I3 J3 K3 L3 M3 N3 O3 P3 Q3 R3 S2 G3 H4 I4 J4 K4 L4 M4 N4 O4 V S3 T2 G4 H5 I5 J5 K5 L5 M5 N5 O5 P5 Q5 R5 S4 T3 G5 H6 I6 J6 K6 L6 M6 N6 O6 P6 Q6 R6 T5 T5 G7 H8 I8 J8 K8 L8 M8 N8 O8 P8 Q8 R5 T6 G8 H9 J9 K9 L9 M9 N9 O9 P9 I I I I I I <td< th=""></td<>
K14 L14 M14	K14 L14 M14

Figure 2. Locations sampled for wolverine DNA in 2018 (143 posts) and 2019 (154 posts). Each location has an alphanumeric label (G1 etc.). Sampling of some marginal sites only in 2019 resulted in a slight change in the area surveyed.

Each hair snare bait post was ~1.6m long, 10x10 cm wide, wrapped with barb-wire to trap wolverine hair, and anchored in packed snow (Appendix 3). We attached bait (~250g caribou or muskox leg bone) and a combination of commercial lures (Beaver Castor and Long Distance Call, O'Gorman Lures, Montana, USA) to the top of each post with haywire. We used frozen caribou/muskox leg bones, which we cut in chunks, drilled a hole in the bone, and wired the bone to the top of the post. There were numerous gut piles of hunter-killed caribou and wolf carcasses during the 2019

sampling period. We recorded the GPS position of each bait post. We used snowmobiles to visit each post 3 times at about 10-day intervals. At each visit, we collected all visible hairs from the barbed wire, post, and from the ground around the post. We used a propane torch to remove any remaining hair. Each individual clump of hair was removed from the post and placed in a labeled individual coin envelope (post number, location on post and date) for storage. We installed a fresh set of bait and lures after every check. We recorded the number of muskoxen, and other prey species sighted or wildlife signs observed during the post set-up and while driving between posts.

We installed 12 motion triggered digital cameras (Reconyx PC-800 Hyperfire Professional IR, Holmen, WI) facing bait posts to capture wolverine activity. We programmed cameras at high sensitivity, 5 images per trigger, one second apart. The cameras documented wolverine sighting date and time of the visit and time spent at the hair snagging post, and captured images of other animals visiting the post.

2.3 Laboratory methods

We sent hair samples to Wildlife Genetics International (WGI), Nelson, BC for individual wolverine identification. We analyzed two samples per collection event (post/session combination) when there was more than one sample of suitable quality available. If possible, we selected the two samples from different sides of the post and used an average of 5.6 guard hair roots per extraction — counting underfur as 0.2 guard hair roots. DNA was extracted using QIAGEN DNeasy Tissue kits, aiming to use 10 clipped guard hair roots, when available. In 2018, we identified individual wolverines using a ZFX/ZFY gender marker and the 7 microsatellite markers, applied to other wolverine projects in the tundra (Mulders et al. 2007, Awan and Boulanger 2016, Awan et al. 2018). After 2018 DNA analysis we observed slightly low genetic variability of wolverines in the Kitikmeot region (0.68 across 7 markers, compared to 0.71 in the Kivalliq region, Awan and Boulanger 2016, Awan et al. 2018), and to compensate for this we used 9-locus analysis (8 microsatellites plus ZFX/ZFY for sex) to identify

individual wolverines in 2019. The quality assurance methods of Paetkau (2003) were used to ensure the accuracy of individual identifications.

A tooth (lower canine) was removed and submitted for aging to Matson Laboratory (Montana, USA) using cementum annuli from wolverines reported killed by hunters in the early winter between the 2018 and 2019 DNA survey. Following Banci and Harestad (1988) and Vangen et al. (2001) individuals were then grouped into three age classes: juvenile (0-1 year, date of birth is set to March 1st), yearling (1-2 years) and adult (\geq 2 years).

2.4 Data analysis

We summarized the number of wolverines detected as a function of active posts each session. In addition, we plotted the approximate paths of wolverines based upon unique post detections per session.

2.4.1 Spatially explicit capture-recapture

We used spatially explicit capture–recapture (SECR), an extension of conventional capture–recapture methods specifically for estimating the density of spatially distributed populations (Efford 2004, Borchers and Efford 2008, Royle et al. 2014). SECR avoids most of the concerns about geographic closure that featured in earlier analyses using conventional closed-population methods (e.g., Mulders et al. 2007).

The data for SECR are spatial detection histories; each history is a record of the particular sites (posts) at which each individual was detected. The detected individuals are a selection of those centred in the surrounding area – the chance of being detected declines with distance. By fitting a curve for the decline in detection probability with distance we are able to estimate both (i) parameters of the curve, and (ii) the density of activity centres (including animals that were not detected). SECR has developed over

the last 18 years and now exists in two main types characterised as 'maximumlikelihood' (Borchers and Efford 2008, Efford 2018) and 'Bayesian' (Royle et al. 2014).

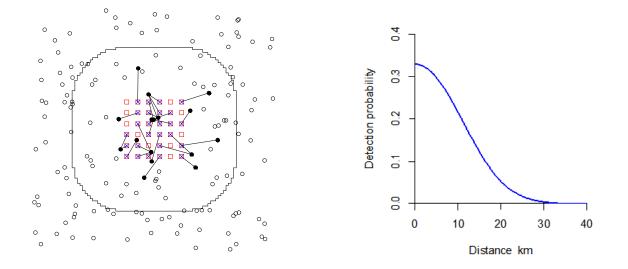


Figure 3. Spatially explicit capture–recapture conceptual model. Animal activity centres (dots) are distributed across the wider landscape. Animals centred near a post (red squares) have a high probability of detection (blue crosses; see also hypothetical distance-detection function on right). The centres of animals detected at least once are shown as filled dots (a single sampling interval is shown). Animals centred beyond an arbitrary outer perimeter (solid line) have such low probability of detection that they can be ignored in model fitting.

For SECR the population is thought of as a distribution of animal activity centres in 2 dimensions (open circles in Fig. 3). We can ignore centres that are very far from detectors because these animals stand negligible chance of detection, and this has computational benefits. Using the method of maximum likelihood it is necessary to integrate the probability of detection over space (the potential locations of activity centers). This is easier when space is finite and can be discretized as many small pixels.

The criterion for ignoring distant animals is usually a buffer of a certain width around the detectors (represented by the perimeter line in Fig. 3). The area within this boundary becomes the area of integration for maximum likelihood or the 'state space' of centres in Bayesian models e.g. Royle et al. (2014) (the term 'habitat mask' is used in R package 'secr').

Where habitat extends indefinitely in all directions, as appears to be the case for mainland Nunavut wolverines, the placement of the boundary is arbitrary. The area should merely be large enough that enlarging it further has no effect on density estimates because only un-detectable animals are added. This is achieved by using a buffer around the posts that is large compared to the radius of home ranges. Whether the buffer is large enough can be tested once pilot values are available for σ , the spatial scale (width parameter) of the blue detection curve in Fig. 3.

2.4.2 SECR modelling of wolverine data

SECR models were fitted with the R package 'secr' version 4.2.2 (Efford 2020). A 50km buffer was used to define the habitat mask; lakes and other areas of water were included in the mask as these were frozen during the sampling period.

The hazard of detection was modelled as a function of distance considering possible sex effects, differences between years, and different shapes of detection function (halfnormal vs negative exponential). For this phase of the analysis a conditional likelihood model was used, avoiding the need to specify a model for density (Borchers and Efford 2008).

For density estimation we used a 'hybrid mixture' model in which sex was used to define mixture classes; this allowed the individual covariate 'sex' to be included in models for density.

The best model among various possibilities was selected by Akaike's Information Criterion (AIC) – smaller values of AIC indicate a better model. We used a likelihood ratio test where a hypothesis test was needed to distinguish between two nested models (number of degrees of freedom equal to the difference in number of estimated coefficients).

2.4.3 Population turnover

The turnover parameters phi (apparent survival (ϕ): the probability that a wolverine that was in the sampling area in 2018 was still in the sampling area in 2019) and f (recruitment: the number of new wolverines in 2019 per wolverine in 2018) were estimated from non-spatial and spatial robust-design forms of the Pradel–Link–Barker model (Efford and Schofield 2019) using the R package 'openCR' (Efford 2019). We note that apparent survival will include death as well as emigration of wolverines from the sampling area and recruitment will include both births of wolverines and immigration of wolverines into the sampling area between 2018 and 2019. These estimates describe the turnover between summer 2018 and summer 2019.

3.0 RESULTS

3.1 Summary of data

In 2018, we collected 175 wolverine hair samples, 12 (7%) lacked suitable material for analysis and 24 (14%) failed during genotyping. We successfully analyzed 123 hair samples which were assigned to 22 individual wolverines (11F:11M). In 2019, we collected 220 wolverine hair samples, 75 (34%) lacked material suitable for analysis and 21 (10%) failed during genotyping. We assigned 106 successful samples to 27 wolverines (14F:13M; Table 1), of which 10 (6F:4M) were 'recaptures' from 2018 sampling. No individuals from this study area matched to any individual from other Arctic datasets or study areas (D. Paetkau, WGI, unpubl. data). The DNA samples from harvested individuals will be processed and incorporated into future analyses.

In both years, more DNA samples (detections) were collected in later sessions, while the number of newly detected individuals tended to decline suggesting sampling was effective in sampling wolverines on the grid and surrounding area.

Table 1. Summary statistics for DNA sampling of wolverines near Napaktulik Lake, Nunavut, in 2018 (143 posts at 5-km spacing) and 2019 (154 posts at 5-km spacing).

				Year of s	ampling			
2018 2019								
Session	1	2	3	Total	1	2	3	Total
Detections	15	33	44	92	26	30	41	97
New animals	9	6	7	22	13	9	5	27

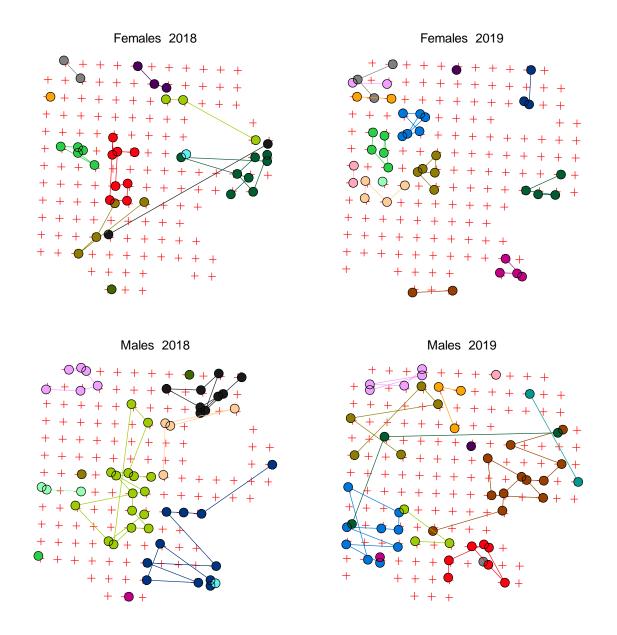


Figure 4. Detection locations of wolverines on grids of posts (red crosses) near Napaktulik Lake in 2018 and 2019. Known locations of an individual are joined (individuals distinguished by colour with the same colors used for individuals detected in both 2018 and 2019).

3.2 Sex differences

Approximately equal numbers of male and female wolverines were detected in each year. The 22 wolverines detected in 2018 comprised 11 males and 11 females; the 27 wolverines detected in 2019 comprised 13 males and 14 females (see also Table 2). The distance between the most extreme locations of each animal (observed range length) is a convenient individual-level summary of the extent of movements. The raw data (Appendix 2) suggest little sex difference in observed range length in 2018, but a clear separation in 2019 (Fig. 5). Median observed range length was similar for females in 2018 (23 km), males in 2018 (24 km) and males in 2019 (22 km), but noticeably different for females in 2019 (10 km). The longest observed range (67 km) belonged to a male detected 3 times in 2019. It is unclear whether the difference between years was due to altered behaviour or to differences in age structure or random effects. However, the evidence suggests that detection should be modelled separately in the two sexes.

Sex		Sess	ions														
Female																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
2018	3	2	2	1	1			2									11
2019	2	4	2	3	2	1	•	•	•	•	•	•	•	•	•	•	14
<u>Male</u>																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
2018	5		1	1		1			1		1					1	11
2019	4	1	3		2	•	1	•	1		•	1					13

Table 2. Number of detections per wolverine, by sex and year. Zero shown as "."; excludes repeat detections at a site within a session.

The number of detections per individual influences the observed range length (Fig. 5). Interpretation of SECR detection parameter and detection function plots provides a way to assess the movement of wolverines that is independent of sampling intensity, as we show later.

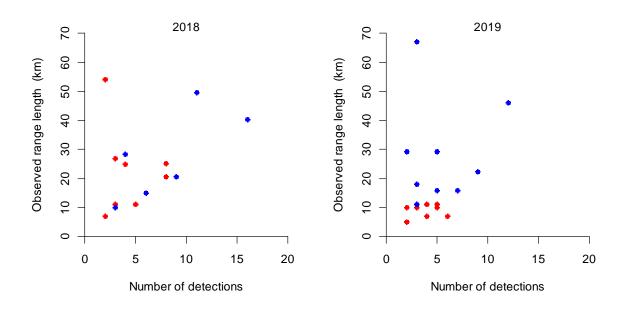


Figure 5. Observed range length (maximum distance between detections) for individual male (blue) and female (red) wolverines.

3.3 Selection of detection model

A negative exponential detection model had substantially lower AIC than a halfnormal model (Δ AIC = 40.5; Appendix 1). This is commonly the case when there are occasional long-distance movements (Fig. 4) and we used the negative exponential detection function for all subsequent models.

Models that included sex differences in detection were preferred by AIC, especially when the sex effect was allowed to differ between years (Appendix 1). An additive post-specific learned response (lambda0~Sex*Year+bk) gave a small reduction in AIC compared to the Sex*Year model (Appendix 1), but the effect on density estimates was negligible (<2%; details not shown) and learned responses were not included in further models. The number of detections appeared to increase across sessions within a year (Table 1) and models with a temporal within-year trend fitted better than those without

such a trend (Appendix 1). However, including a temporal trend in lambda0 had almost no effect on the density estimates (Appendix 1) and one was not included in subsequent models.

3.4 Modelling to estimate wolverine density

A model with differing density in 2018 and 2019 did not fit better than a constant-density model (LRT = 0.95, 1 df, P = 0.33). We report estimates from the full year-specific model in Table 3, noting that the change in density between years is not significant. A model with differing sex ratio did not fit better than a model with differing density and constant sex ratio (LRT = 0.017, 1 df, P = 0.90).

Estimates of density and detection parameters are given in Table 3.

Table 3. Estimates of wolverine density and parameters $\lambda 0$ (intercept) and σ (spatial scale) of
the negative exponential spatial detection function in 2018 and 2019.

Metric	Year					
	<u>2018</u>	<u>2019</u>				
Density/proportion females						
Density (wolverines / 1000 km ²)	3.10 (2.00–4.78)	4.14 (2.78–6.18)				
Proportion females	0.510 (0.373–0.646) (hel	d constant across years)				
Detection parameters						
<u>Females</u>						
Detection at home range center (λ_0)	0.354 (0.182–0.691)	0.967 (0.526–1.778)				
Scale of movement (σ ; km)	4.76 (3.50–6.47)	2.50 (1.93–3.25)				
Males						
Detection at home range center (λ_0)	0.717 (0.414–1.242)	0.249 (0.140–0.443)				
Scale of movement (o ; km)	5.40 (4.27–6.83)	7.78 (5.70–10.62)				

Detection function plots based on detection parameters (Table 3) reveal a wider range of movement related to sites for males (Fig. 6). Detection at home range center increased for females in 2019 but decreased for males. Conversely, scale of movement decreased for females but increased for males in 2019.

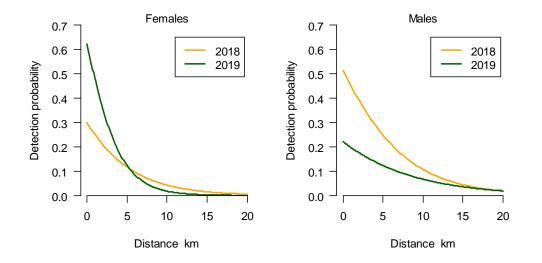


Figure 6. Modelled probability of detection as a function of distance, by sex and year based on detection parameters listed in Table 3.

3.5 Population size

There was no natural boundary to the sampled wolverine population, so the nominal population size depends on the area chosen. We present population size estimates in Table 4 for two arbitrary areas, 20-km and 50-km buffered areas around the post array.

Table 4. Estimated numbers of wolverines	ithin different distances of post locations (annual
difference not statistically significant).	

Buffer around posts	Year	
	2018	2019
20-km buffer (9495 km ²)	29	39
50-km buffer (22936 km ²)	71	95

3.6 Harvest

Reported wolverine harvest for Napaktulik Lake area was zero in 2018. Hunters reported killing 24 wolverines around Napaktulik Lake in 2019 winter, including 20 males and 4 females (Fig. 7), most were harvested (n = 20) before the first session of the DNA trapping. Twenty two were aged including 6 juveniles (27%), 9 yearlings (41%) and 7 adults (32%). Wolverine harvest locations suggest wolverine harvest occurs in conjunction with caribou and wolf hunting. The male:female ratio of the harvest was highly biased towards males (Fig 7). The age distribution of the killed wolverines was weighted more towards sub adult animals.

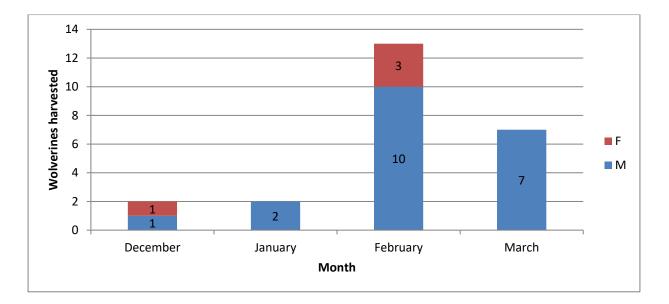


Figure 7. Monthly reported wolverine harvest in the study area during winter 2018-19.

The reported harvest locations of wolverines killed between the 2018 and 2019 surveys were concentrated in the southeast of the post grid, particularly around the northeast end of Napaktulik Lake (Fig. 8).

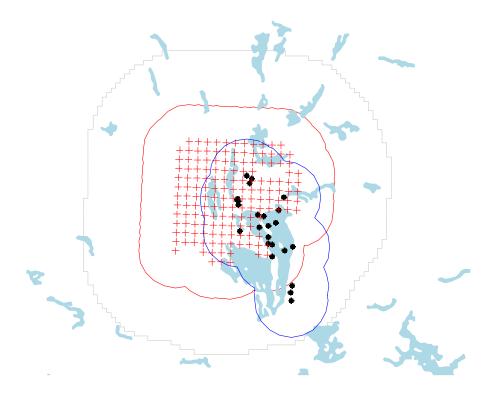


Figure 8. Harvest locations (black dots) of 24 wolverines killed in the winter (December 2018 to March 2019) between the 2018 and 2019 DNA surveys. Locations jittered slightly to reduce overlap. Red crosses mark post locations. The red and blue lines mark a 20-km buffered area around the posts and the harvest locations, respectively. These indicate the catchments from which post-detected and harvested animals were drawn with high probability (95%): the catchments overlap substantially but not completely. Outer grey line is 50-km buffered area used for SECR modelling of post data; a small minority of detected wolverines were likely centred between the red and grey lines.

3.7 Changes between 2018 and 2019

Wolverines that were detected in both 2018 and 2019 remained in essentially the same locations (Fig. 9), suggesting that they were resident of the area. Estimates of apparent survival and recruitment from a spatial robust-design Pradel–Link–Barker (PLB) model (Efford and Schofield 2019) were similar to those from a non-spatial model, but confidence intervals were wide (Table 5). The estimated population growth rate (λ relative change in density over the duration of sampling – unrelated to lambda0) is the sum of apparent survival and per capita recruitment, and may also be estimated directly

by fitting a PLB model parameterized with λ . Direct estimates of λ were 1.23 (0.80–1.89 95% CI) from the non-spatial model and 1.21 (0.78–1.86) from the spatial model.

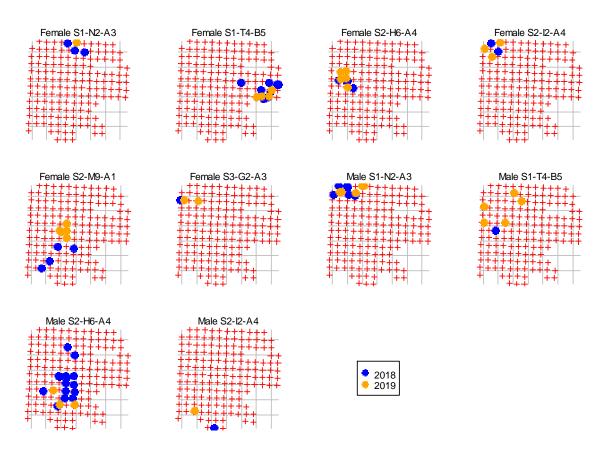


Figure 9. Locations of wolverines detected in both 2018 and 2019. Female S2-M9-A1 and male S3-K11-C3 appeared to shift their centres of activity between years.

Table 5. Estimates of detection and demographic parameters from robust-design 2-year open population models. The parameter for the magnitude of detection is 'p' for the non-spatial (Pradel–Link–Barker) model and 'lambda0' for the spatial model. Sigma (spatial scale of detection) is not estimated in the non-spatial model.

Model	Detection paramet	ers	Demographic parameters			
			Apparent	Per capita		
	lambda0/p sigma		survival	recruitment		
Non-spatial	0.56 (0.46–0.65)	_	0.50 (0.28–0.71)	0.73 (0.37–1.43)		
Spatial	0.12 (0.10–0.16)	8.9 (8.1–9.9)	0.52 (0.30–0.73)	0.69 (0.35–1.38		

Camera data showed that wolverine visited the bait posts on average 7 days (SD = 4.2, n = 15) after deployment, compared to the Henik Lake study, done in the Kivalliq region of Nunavut, where estimate was 3.6 days (Awan et al. 2018). While visiting the baited post, wolverine spent on average 22.8 minutes around the post. Wolverines visits and activity at the posts was equally distributed during day and night.

3.8 HTO Participation

Ground-based surveys, which can involve local HTO and community participation, are a labour intensive but a cost-effective methodology for studying wolverines. The necessary land skills needed for this type of fieldwork were attained by hiring three experienced hunters from the Kugluktuk HTO as field technicians. The field technicians were very knowledgeable on the local area and wildlife, actively participated in the field work, and learned standardized wildlife survey techniques (sampling protocol, hair collection and data recording). The skills acquired by the field technicians increased chances that those individuals could participate in running this program in future years with minimal supervision and technical assistance. The skills acquired by the field technicians also makes them more qualified to work as technical staff (e.g. wildlife monitors) with other organizations such as exploration/mining camps.

The study generated about 400 person-days of employment to local hunters and elders. This seasonal employment to local hunters helps alleviate some pressures due to the high cost of living in the North, and offsets expensive maintenance costs for hunting equipment needed to carry out subsistence harvesting activities and traditional lifestyle (Stevenson 1996). The project also helped the local HTO to build technical expertise, experience, and monitoring capacity for future HTO-led projects or collaborations with co-management partners. The baseline information collected within the socio-cultural framework will be used for future monitoring and wolverine management. HTO board members reviewed, discussed and contributed to the proposed research project and field methods, provided guidance throughout the project, and in turn obtained increased awareness about the species status at the national and international level. The involvement of hunters and the HTO in the study improved their collaborative

relationship with the GN and may be a mechanism to increase local interest and involvement in wildlife management. The project provided opportunity to hunters to use their land skills and wildlife knowledge, which enhanced study results. The lead biologist and other participating GN staff had the opportunity to improve their land skills and learn more about how HTO/community members want to be involved in scientific studies and conservation in Nunavut. Local participants acted as stewards of the land on a daily basis and provided guidance to GN staff to ensure the fieldwork was completed and accomplished safely.

4.0 DISCUSSION

Our estimates of density and the average number of wolverines with home-range centres on the sampling grid at a single time varied between 2018 and 2019. The estimated population density increased (non-significantly) between 2018 and 2019. We note a theoretical possibility that the baited-post survey methodology or wintered caribou herd in the Napaktolik Lake area in 2019 may have induced a change in late winter wolverine distribution. The presence of wintering caribou in the study area likely resulted in higher wolverine density, high wolverine harvest, and higher male wolverine movements in 2019, consistent with Krebs et al. (2007) that winter food resources influence habitat selection in wolverines. Arctic wolverines rely predominantly on migratory caribou (Mulders 2000, Dalerum et al. 2009, L'Hérault et al. 2016) and Magoun et al. (2018) documented that wolverines pursuing caribou over long distances on snow covered tundra The telemetry study findings suggested that wolverine repeatedly visited and spent more time in areas with larger prey in winter (Inman and Packila 2015, Scrafford and Boyce 2018). This suggests an increased density of wolverines in 2019, possibly by transient wolverines. Similarly, Stoner et al. (2013) demonstrated that the transient segment of the cougar (*Puma concolor*) population swells during livestock production and Hayes et al. (2016) documented that distribution of tundra wolves depends on where caribou are in any given year. Further, wolf carcasses and caribou gut piles in the area by hunting activity attracted more wolverines into the study area in 2019 –see Mulders 2000).

Several studies have emphasized the importance of caribou in sustaining the tundra biodiversity, its central role in the lives of Inuit (Ljubicic et al. 2018), and as a common proportion of the diet of predators and scavengers (Dalerum et al. 2009, Gunn et al. 2011). Caribou wintered less frequently in the Napaktulik Lake area, which is likely due to low caribou numbers in the region since the early 2000s (Adamczewski et al. 2009) and subsequent reduction in their annual range (Virgl et al. 2017). The area has, therefore, not been frequented as much by Kugluktuk hunters during this period. Comparatively, high wolverine and wolf harvest occurred in the past out of Kugluktuk

when caribou herds wintered nearby (Hayes et al. 2016), because hunters spent more time on the land to hunt caribou. While hunting caribou, harvesters usually pursued wolverine when they saw wolverine or found fresh tracks., (Awan 2020). In 2018, wolverine harvest was zero, which was apparently due to the absence of wintering caribou in Napaktulik Lake area. According to collaring data and local knowledge, the Beverley caribou herd has not been wintered in Napktulik Lake area in recent years. However, in 2019 a group of Beverley caribou wintered in this area (J. Adamczewski pers. com. to Kugluktuk HTO in Feb 2019). Arctic wolverines are known to follow (Magoun et al. 2018) and eat caribou (Mulders 2000, L'Hérault et al. 2016). Thus, wintering caribou attracted more predators and hunters in the area near the study site. Along with prey abundance over winter in 2019, higher hunting activity (gut piles and wolf carcasses) and availability of vacant wolverine territories due to high harvest in early winter, likely resulted in higher wolverine density and larger male wolverine movements in 2019.

In northern Sweden, Aronsson and Persson (2018) observed high fidelity at total wolverine territory level, however, they found that more intensively used core areas varied among years with resource availability. Royle et al. (2011) described a shift in home ranges due to resource variability in multi-year studies.

In many carnivores, annual variation in prey availability and environmental conditions can change animal distribution, density, and shift home range size and location, including grizzly bears (McLoughlin and Ferguson 2000, McLoughlin et al. 2003); wolverine (GRRB 2014, Efford and Boulanger 2018, Olsson 2020) and wolves (Hayes et al. 2016). Moorhouse and Boyce (2016) associated yearly variation in SECR density estimates of grizzly bears in Alberta with change in home-range centers. Our results reflect a snapshot of wolverine status in early spring over 2 years. The apparent interannual variation in density estimates highlights the need for multi-year monitoring to better determine spatial and temporal drivers of local abundance and how wild populations change over time (Harris et al. 2005, Mulders et al. 2007, Morehouse and Boyce 2016).

We compared the present estimates with other estimates of wolverine density from capture–recapture studies (Table 6). The estimated wolverine density near Napaktulik Lake was similar to that from Henik Lake in the Kivalliq region (Awan et al. 2018) and slightly higher than that from Aberdeen Lake (Awan and Boulanger 2016).

Locality	Year	Density	Proportion	Method	Source
Locality	i cai	(per 1000km ²)	females	Wiethou	Jource
Nunavut		(per 2000km/)	Ternales		
Aberdeen Lake	2013	2.36 (2.09–2.33)	0.57	SECR	Awan & Boulanger 2016
	2014	1.66 (1.12–2.53)	0.61		0
Henik Lake	2015	4.42 (3.29–5.93)	0.43	SECR	Awan et al. 2018
	2016	3.38 (2.89–3.96)	0.49		
Napaktulik Lake	2018	3.10 (2.00-4.78)	0.51 ¹	SECR	This study
	2019	4.14 (2.78–6.18)	0.51 ¹		
<u>NWT</u>					
<u>Daring, Ekati, Diavik</u>	2014	3.32 (2.62–4.20)	0.56	SECR	Efford &
					Boulanger 2018
British Columbia					
Omineca	1996–97	6.5		JS	Lofroth & Krebs
					2007 ²
Columbia	1997–98	5.8			
<u>Alaska</u>					
Tongass NF	2008	9.7 (5.9–15.0)		SECR	Royle et al. 2011 ³

Table 6. Estimates of wolverine population density from capture–recapture studies. Methods SECR spatially explicit capture–recapture, CR closed population, JS Jolly-Seber.

^{1.} Proportion female assumed constant across years

^{2.} Ear tagging and transmitter implants

^{3.} Camera trapping with identification by pelage differences

Higher wolverine densities were estimated in the central Arctic (6.85 wolverines/1,000 km² at High Lake in 2008 and 4.80/1,000 km² at Izok Lake in 2012; Poole 2013), however, both of these study areas have very limited wolverine harvest and this higher density was likely associated with comparatively higher caribou numbers in the region in 2010 and 2012. Around our study area, with wolverine tracks, Lee and Niptanatiak (1993) estimated density as 1/136-226 km². Estimated average wolverine density at the three sites in the central barrens (Daring Lake, Diavik and Ekati) declined by about 40%

between 2005 and 2014, from an average of 5.57 wolverines/ 1,000 km² to 3.32/1,000 km² (Efford and Boulanger 2018), concurrent with declines in the Bathurst caribou herd. Gervasi et al. (2015) described that population properties, such as density or survival rates, often vary due to uneven spatial distribution of resources and mortality risks. Similar to grizzly bears, it has been generally assumed that wolverine densities are higher in the West Kitikmeot and lower to the north and east (Slough 2007), and that population density is driven by productivity and seasonality (McLoughlin 2001). In North America, wolverine densities vary across ecological areas and habitat quality, to a maximum of about 5-10 wolverines/1,000 km² (COSEWIC 2014, Species at Risk Committee 2014).

Effect of harvest

The estimated population density increased (non-significantly) between 2018 and 2019. There is therefore no evidence that the harvest reduced the population between 2018 and 2019, but an impact cannot be ruled out owing to the statistical uncertainty in the estimates. It is also possible that the population was increasing naturally, and that density estimates would have increased even more without harvest.

The relatively high harvest in our study area during the winter of 2019 was primarily attributed to a wintering caribou herd in the area. About a third of harvest locations lay outside the perimeter of the post grid. Thus, while most harvested wolverines would have been detectable at posts, some likely had peripheral home ranges with low probability of detection at posts as indicated by the harvest high-probability catchment area (blue) outside the post catchment area (red) in Fig. 8. This component of the harvest would therefore not be expected to impact on the measured population density.

Localisation of harvest effort in the southeast of the study area was linked to caribou hunting opportunities. In the southeast, it is easy to chase caribou and predators by snow machine on the frozen lakes. In the north and western portion of sampling grid, the terrain is comparatively steep and rugged, providing escape features for wolverines to avoid being chased by snow machines and shot. There was no evidence for higher wolverine density in the southeast of the post grid, but we cannot exclude the possibility that density was higher away from the grid to the southeast. A hypothetical pocket of high density there, possibly coupled with rapid replacement of harvested males by immigrants, may have existed to the southeast of the post array; this may help explain the apparent inconsistency between the SECR and harvest data. Alternatively, the SECR estimates may underestimate the overall population density, perhaps because some component of the population (perhaps young animals) was under sampled.

Estimates of apparent annual survival were low (0.5) for this study (Table 5) compared to the Daring Lake study (Efford and Boulanger 2018) where estimates were 0.73 (CI=0.66-0.80) and 0.67 (CI=0.59-0.75) from 2004-2014. Per capita recruitment was much lower in the Daring Lake study (females 0.19, CI 0.13-0.28; males 0.27, CI 0.20-0.35) and as a result the population there declined substantially over time. The comparison should be viewed cautiously given the short time series (2 years) for the Napaktulik Lake data set. Wolverines that were detected in both years (n = 10) generally showed fidelity to mean capture areas (Fig. 9), therefore the apparent lower survival may be due to either true low survival or emigration of younger wolverines to other areas. It is likely the harvest of wolverines between yearly sessions increased mortality rates of wolverines therefore reducing apparent survival. Krebs et. al. (2004) reported higher survival rates in non-harvested populations. Like other mammals, high malebiased dispersal (Pusey 1987) and intersexual home range overlap is reported in wolverine populations (Vangen et al. 2001, Dalerum et al. 2007, Bischof et al. 2016). Others have reported long dispersal movements in yearlings from their natal area before reaching sexual maturity (Copeland 1996, Mulders 2000, Vangen et al. 2001, Inman et al. 2012) and migration of wolverines from areas with lower mortality to those with higher mortality (Gervasi et al. 2015, 2016). It is likely that the Napaktulik Lake population is part of a source and sink dynamic, with emigration from outside areas replenishing harvested animals or sustaining the harvest through immigration (Mowat et al. 2020). This apparent low survival may be due, in part, to dispersing transient wolverines that spend only a portion of time on the grid, as also described by Mulders et al. (2007) in the central Arctic. This is consistent with the 2014 COSEWIC assessment, which

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indicates that a sizeable proportion of the wolverine populations, normally sub-adults, are transient at any given time.

Sex differences in movement

The movements of males were noticeably greater than those of females but only in 2019. Other studies have reported consistently greater movements of males (Efford and Boulanger 2018). We speculate that harvest in 2019 may have affected movement patterns. The harvest in the study area was in winter (54% in February), when juvenile and yearling wolverine dispersal typically begins in January, and males dispersing more commonly than females (vangen et al. 2001, Gervasi et al. 2015). Of the animals harvested between 2018 and 2019 (Fig. 7), 83% were males. The harvest of subadults (68%) around the study area was slightly higher than the Kitikmeot regional harvest (59%, Awan 2020). The actual sex ratio in the population is 1:1, however, male biased harvest sex ratio reflects immigration and enhanced harvest availability of young males in the study area or difference in vulnerability to harvest by sex.

Kukka et al. (2017) describe the high proportions of young males in the harvest, because vacant areas created by the harvest of resident animals may be filled by dispersing young males (Magoun 1985). Others have reported long dispersal movements in yearlings from their natal area before reaching sexual maturity (Copeland 1996, Vangen et al. 2001, Inman et al. 2012). The high harvest of younger males (61%) may have resulted in vacant male territories and dispersal to nearby vacant territories likely led the higher male movement. Long distance dispersals are documented in Arctic wolverines, especially dispersing juvenile wolverines from un-hunted areas fill the voids left by harvested animals (Mulders 2000). Various studies have documented vacant territories (Kortello et al. 2019). In mammals, emigration (and therefore immigration) most often occurs in juveniles, especially young males (Adamczewski et al. 2009).

Power to detect change in density

The estimates of wolverine density from Napaktulik Lake may be used in future as a baseline against which to assess change. Statistical power to detect such a change depends (in part) on the precision of the density estimates. We estimate the precision of the 2018 estimate by its relative standard error (RSE), also known as its CV. The 2018 Napaktulik Lake density estimate ($3.10 / 1000 \text{ km}^2$) had RSE(D) = 0.225. A single later survey using the same methodology could be expected to yield a similar RSE, except for changes in sample size due to changed density. Efford and Boulanger (2019) gave a method¹ for predicting the statistical power of a 2-survey comparison with RSE constant except for density effects. We used their method to predict that a repeat survey would meet the threshold of 80% power to detect a 64% reduction or 95% increase in density, given a relaxed type-I error rate $\alpha = 0.1$. Changes of lesser magnitude would not be expected to show a significant difference, as for the 2018–2019 comparison in the present study. This emphasises the difficulty of monitoring such a sparsely distributed species. Other studies on wolverine (Efford and Boulanger 2018, Awan et al. 2018) provide further guidance on survey intervals and study design.

We note that the estimate of trend from this project should be interpreted very cautiously given that it is based on 2 years of sampling with a substantive harvest in between sampling years. To establish longer-term demographic trend would require a multi-year survey effort. Multiple surveys would provide estimates of the process variation – possibly random components of annual variation in density unrelated to long-term trend – while also accumulating information on trend itself, thereby leading to greater statistical power. Conversely, the presence of process variation complicates both study design and interpretation. We can only speculate on the magnitude of process variation in the Napaktulik Lake wolverines – it seems unwise to extrapolate from the Daring Lake population whose dynamics were apparently quite different. We note that removal of

¹ The method is implemented on the Power tab of the online app secretsign

⁽https://www.stats.otago.ac.nz/secrdesignapp/). Adjust the alpha level on the Options page.

harvested individuals between sampling complicates estimation of trend. Genotyping of harvested wolverines which is underway would assist in determining the relative impact of harvest on trend in the sampling grid.

Analysis of microsatellite DNA allows individuals to be identified from hair, given adequate samples. A hair sample can fail in an individual identification if it is too small (less hairs) or degraded (Long et al. 2008). The sample quality, estimated from the genotyping success rate was variable in both years. In both years, we set aside samples that contained no guard hairs with roots and <5 underfur (classed "Xinadeguate"). In 2018, only 7% (n=12) samples lacked suitable material for analysis, while in 2019, 34% (n=75) samples were too small, having only few snagged hairs and deemed unsuitable for analysis — indicating a reduction in guality relative to 2018. The number of guard hair roots per successful sample was down to 3.8 in 2019, from 5.6 in 2018. This could be explained by a factor like wind, but maybe the capacity of wire to pluck hair goes down over time because the same wire (posts) was used in 2004-05 for a wolverine study around Kugluktuk (Dumond et al. 2012). Another factor that might have contributed to the quantity of snagged hairs in the samples was the presence of caribou (alternate source of food) in the area during the sampling period (March/April). We believe that one reason our hair samples in 2018 had more snagged hairs, was due to the fact that there were no caribou in the vicinity of the study area during the 2018 sampling period. The absence of caribou during the sampling period may have caused wolverines to be more interested in visiting the baited posts and lures. Apparently, hungry wolverines were spending more time on the posts in an attempt to remove the bait and left additional hair samples. With abundant caribou and wolf carcasses available in 2019, wolverines in the study area were probably not interested in bait on the posts. Wolverines may have been distracted by scattered gut piles from harvested caribou and possibly less attracted by baited posts. Therefore, they were visiting and climbing up on the posts to explore scent lures, but wolverines were possibly less hungry and not sufficiently enticed by bait to remain for a longer time on the posts in order to leave more hairs. In other words, wolverines with less access to prey species would likely be more interested in visiting the baited posts (R. Mulders pers. comm. March, 2019).

Among the successful samples (having more hairs with roots), sample quality and genotyping success was good, with 2018 samples resulting in 86% success, compared to 83% in 2019, up from 81% in 2015 (Awan et al. 2018) and 82% in 2012 (Poole 2013) in comparative Arctic tundra wolverine density studies. These are all solid numbers, and do not suggest problems with collection or storage methods. This >80% success rate was still at the high end of the rates in projects that use remote sampling. (Paetkau 2019 unpublished data). We recommend replacing barb wire on the wood posts to snag wolverine hairs and continuing with the use of 9 microsatellite markers to identify individual wolverines in future projects. Genotypes from harvested wolverines from the study area to incorporate mortality data in the future analysis.

In summary, our results contribute to knowledge of wolverine ecology in the study area and can be used for future monitoring and to generate very rudimentary regional population estimates. This could inform the evaluation of current harvest in Nunavut and future management recommendations for sustainability. A database containing "DNA fingerprints" of individual wolverine has been established for Nunavut, which will be used for population delineation. We suggest genotyping of wolverine harvest samples from Kugluktuk for future demographic analysis. Our study can be used to refine and optimize DNA sampling methods for future wolverine studies on the tundra.

Wolverine is a culturally and economically important furbearer for Inuit. There is currently no wolverine monitoring program at the mines in Nunavut, so potential effects of industrial development are unknown. Given the low density, yet high occurrence of wolverines at the mine sites (Agnico Eagle Mines 2018), we recommend multiple years of DNA sampling to accurately determine population trends, mitigation and monitoring needs by involving the industry through the Nunavut Impact Review Board (NIRB) and the HTOs.

5.0 FIELD TEAM

Malik Awan, GN Department of Environment OJ Bernhardt, Kugluktuk HTO member (2018) Eric Hitkolok, Kugluktuk HTO member (2019) Perry Klengenberg, Kugluktuk HTO member Jonathan Niptanatiak, Kugluktuk HTO member

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8.0 APPENDIX

8.1 Appendix 1. Comparison of detection models.

Tables use these abbreviations: npar number of parameters, logLik log-likelihood, AIC Akaike's Information Criterion, dAIC difference in AIC from best model, AICwt AIC model weight.

LambdaO and sigma are parameters of the detection model. The notation \sim 1 indicates a model with constant

1. Halfnormal vs negative exponential detection model, sexes pooled.

model	npar	logLik	AIC	dAIC	AICwt
lambda0~1 sigma~1 exponential	2	-576.8	1157.5	0.0	1
lambda0~1 sigma~1 halfnormal	2	-597.0	1198.0	40.5	0

2. Sex and year effects on detection, negative exponential.

model	npar	logLik	AIC	dAIC	AICwt
lambda0~Sex*Year, sigma~Sex*Year	8	-551.6	1119.3	0.0	0.992
lambda0~Sex, sigma~Sex	4	-560.4	1128.9	9.6	0.008
lambda0~Sex+Year, sigma~Sex+Year	6	-558.9	1129.8	10.5	0.000
lambda0~1, sigma~1	2	-576.8	1157.5	38.3	0.000

3. Site-specific learned response (bk) and within-year temporal trend (T), on top of sex and year effects, negative exponential (AIC not directly comparable to above because sessions not collapsed)

model	npar	logLik	AIC	dAIC	AICwt
lambda0~Sex*Year+T, sigma~Sex*Year	9	-722.9	1463.9	0.0	0.615
lambda0~Sex*Year+T+bk, sigma~Sex*Year	10	-722.4	1464.8	0.9	0.385
lambda0~Sex*Year+bk, sigma~Sex*Year	9	-729.5	1477.1	13.2	0.000
lambda0~Sex*Year, sigma~Sex*Year	8	-731.8	1479.6	15.7	0.000

Density estimates (wolverines / 1000 km²) from the top model (Sex*Year and within-year temporal trend in lambda0) and the 95% CI were almost the same as estimates of year-specific density from one without a temporal trend:

model	2018	2019
D*Year lambda0~Sex*Year+T, sigma~Sex*Year	3.095 (2.003–4.784)	4.139 (2.772–6.178)
D*Year lambda0~Sex*Year, sigma~Sex*Year	3.091 (1.999–4.779)	4.144 (2.776–6.187)

Female	year				Males	year			
id	2018	2019		.019 id		2018		2019	
	ORL	n	ORL	n		ORL	n	ORL	n
S1-N2-A3	11.2	3		1	S1-G1-A5	15	6	15.8	5
S1-T3-A3	54.1	2		0	S1-Q2-A4	20.6	9		0
S1-T4-B5	25	8	11.2	4	S2-G11-A3		1		0
S2-H6-A4	11.2	5	11.2	5	S2-N4-A4	28.3	4		0
S2-I2-A4	7.1	2	11.2	3	S3-G7-A3	10	3		0
S2-M9-A1	25	4	10	5	S3-I7-A6		1	29.2	5
S2-N3-A3	26.9	3		0	S3-K11-C3	40.3	16	18	3
S3-G2-A3		1	10	2	S3-L14-A3		1		1
S3-K14-		1		0					
GROUND					S3-M12-A4	49.5	11		0
S3-L6-A4	20.6	8		0	S3-O1-C6		1		0
S3-O6-GROUND		1		0	S3-Q10-				
					GROUND	1		0	
S1-G1-A2		0	10	2	S1-G9-A3		0	22.3	9
S1-J5-A3		0	7.1	6	S1-L10-A3		0	46.1	12
S1-K14-A2		0	10	2	S1-N5-A3		0		1
S2-H8-A2		0	11.2	4	S1-S3-A2		0	67.1	3
S2-I8-A4		0		1	S2-012-A2		0		1
S2-P12-A1		0	7.1	4	S3-M2-A2		0	11.2	3
S2-Q3-A7		0	10	3	S3-01-A2		0		1
S3-G6-A2		0	5	2	S3-P12-A1		0	15.8	7
					S3-Q2-A3		0	29.1	2

8.2 Appendix 2: Observed range lengths (ORL) of individual wolverines detected in 2018 or/and 2019.



8.3 Appendix 3: Wolverine hair snagging posts.

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 b∩いつい 17,520 kg (38,625 lbs) b∩いつい ▷はL△・のいい つういつい く・のいうい ∆ኄዾጏ⊂ኊልኈレዾ ⊲⊳ኑኈሁσ 2020. Ė७d⊲ ∆⊆Ր՟ጏσՐና ኄጛሮጉነ<ጏኈՐ°σ 200 kg b∩ናጋቦና $P(dL\Delta^{\circ}\sigma^{\circ}\Gamma)$ ($\Delta(P = D^{\circ})$) ($\Delta P = 2020$ PPPbd ($\Delta(P = D^{\circ})$), bride ($\Delta(P = D^{\circ})$)

LJALP[%]ጋ[®] 4⁴/γ 3. 2020 4⁴L 4PLσ⁶bLP[%]D[%] Λ⁶bJσ⁶ ΛαJ47/⁶σ⁶. 6bσ/⁶b⁶σ⁶ $36 \Delta^{5}$ አካታሪፈምስና Δ^{5} አካታሪ የድርጉምጋና ላይሥላና Δ^{5} አካታሪ ላዲ Δ^{5} አካታሪ የሆኑ Δ^{5} $\Delta L \Delta^{c}$.

2) <°σ∿⊃Γ ∆℃b⊃⊂∩σ™</p> CLDJ∿U ⊲ናሩJJ' 2020/21, Δናb⊃°σ' ⊲▷ፇød' Δናb⊃σ∩σ% <°σ%) Δρ°Uσ

⊲L ib>>\icCσi_L. <u> 16-24:</u> 1) $\sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{i=1}^{n} \sum_{i=1}^{n} \sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{i=1}^{n} \sum$

، هدى مەركەتكە ھەھەرە ئەھەرەھەرە ئەھەرە ئەھەرە / ئەرەپەرە، ئەلەرە كەرە

 $2^{+}-2^{$ איירי אריסרי ארידער אריסרי Δ רידער איירי (שבייכער א איטאיער) איירי איטאאאיי ᠴ᠋᠋᠔᠋᠋᠋᠋᠋᠘᠋᠋᠋ᡎᡗᢕ᠋᠋ᠴᡄ᠄ᢆᢣ᠘ᢣ᠋ᠺᢞᠳ᠋ᠵ᠘᠋ᢆ᠆ᢧ

 $< \Delta^{\circ} \Delta^$ 5) $\flat L \prec \flat C \triangleright \prec \sigma \lor$ $\Box \land \flat h \lor C \lor \sigma \lor$

 $d^{\circ}\sigma d a^{\circ} J$ $P^{\circ}\sigma b^{\circ} D D \sigma^{\circ} P^{\circ} a^{\circ} \Delta b d d^{\circ} D J \sigma d D c (n^{\circ} D n^{\circ} C a^{\circ} A c a^{\circ} b n^{\circ} P^{\circ} a^{\circ} a^{\circ} b a^{\circ} b a^{\circ} b a^{\circ} b^{\circ} b^{\circ} a^{\circ} a^{\circ} b^{\circ} b^{\circ}$

ፈናልσናገና ጋዮ/ቦላ2/በσና ላጊ የኦንትራና ΔΓίΓροσηληθως. «Τώς βρηγαιαι το αγώς αι το αγώς αι το αγώς αι το αγώς αι το αγώς τ ኦጋንትናክበሶ∿ቦና ናክ⊳ኦበና∩∠⊳ናክጋና ∆LናΓ⊳ር⊂ኪጶነቄዋና ▷ኃ∧ኪ 29 ሮካd ५୯୯ 2020−Jና

ΔL'ΓΡΟσηλιά Ρίδρινο Ρανίζαν στο στο 2021 στο στο 2021

4) ⊲ˤṡ́ˤ

Ρϑ·ϲ·Γ ϧΛͿσ⊳ϳͽϽͽ ΛγΛϥ.

ביכ⊳רדי טריבו אוייער איידע א

<<p>< <<p

ΓΑ-ΟΘΟ ΔΔΕΓΡΟΟ ΑΔΕΓΟΟ ΥΡΟΥΤΟΟ ΤΟ ΛΟΥΤΟ ΜΑΙ ΑΔΕΓΟ

- D_{1}^{6} DIC 5 CP 5 Δ_{2}^{6} $\Delta_$

⊳'ے'ل: فھ∧∩ 02, 2020

<u>Ͻϭϟ⊳ϟͺ</u>Ϸͽ_៓Γ

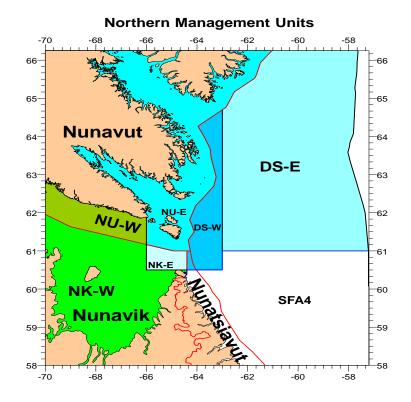
<u>ا∿م⊳⊿</u>

<u>ריאלאללל: X אלגר⊳יסי: ⊲⊃ריאלאלי:</u>

Λ'ተ∩∿Ն: ቴ⊳ኦLஉժ≗σ'⅃ʿ ⊲⊃໊⊂Ϸσ∻Ն ኣஉተLσ∻Ր՟ ϷየϷ⊂໊⊃Γ՟ ዮϞJੱ<Δ՟ (*Pandalus borealis*) ላ'L 'ዮ∍σ໊⊃Ċ՟ ዮϞJੱ<Δ՟ (*P. montagui*) ዮϞJΔ՟ Λ∿Ն⊧**ℶ**՞Նσ ላ'L Ხ**ℶ**≗**ℶ**՞Նσ ⊲ϷኦϞʹልϷ⊀Γ՟ ዮϲ՟Ր՟

<u>_____J⊲.</u>:

ጋ⁻ህל^ቈጋ⁻ – bፈ^{_}ፈ୮ ⁻ህኦነል▷ל^ቈ ዖ·<u>-</u>Ն ጋ⁻ህየ2ኛጋ⁻ – ለ⁻ህ-ፈ⁻ህԺ ⁻ህኦነል▷ל^ቈ ዖ·<u>-</u> ⁻ህ





 $\triangleright P \triangleright \subset D \cap J < \Delta C (Pandalus borealis)$



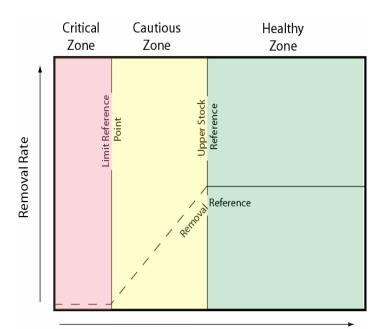
'ዮኈኇኈ፝ጋ፦ ° ይ፞፞፞<<ዾ (*Pandalus montagui*)

<u>ᡆ᠋᠆ᡆ᠘ᡃ᠋᠋᠋᠅᠘ᢧ᠆ᡘ</u>

L⁻ L⁻

ϽϞϷͺL^{*}ťብՐሃϷ៸ϟͺϞ[®] ϧብͺͰϟϫ[°], ΔͺL^CΓϷϹϲͺϲϟ^{*}d[°] ϧ_ϤϹΓ (DFO) ϧϞ[°]Υϟͺϟ[°] Ϟ[®]PΛ^cΩ_→Ω Ϥ^L ϤϽϲ[®]Ͷ^cΩ_→Ω ϒ₂^ΦσϤ^C Ϥ^C_Δ[®][°]⁴^C^Δ[®]²[°]⁴^C^P⁸[°]⁴²[°]⁴⁴[°]

Lლውቴ[®]ጋበና *Δቴചলኪው፤ታ ሏለLლውም፤ታ* ኣ<u>ዉለ</u>*Lምሌ አቴለውነትላ[®] ለውማላታ ፋናርዉ∆[®]ለLም፤ታ ⊲ጋ[®]<i>C*▷ለፓና(DFO, 2006), Δ∟JC-ച⊲ርኪኦዮና ⊲ጋው PA ኣሏለLምዮና ለቴለኦኦትው⊲[®]ጋና ቴኦኦስና⊲ናልውና ແລ⊾Δና⊃Րና ∧[°]ህራ Δቴ⊃Δና ቴወΔሮ[°]ሁውዮዮ_°ውና ዮናሮዮና: ቴወΔዮՐ∩⊲[®]ጋና, ቴኦኦLኦሲ⊲ጵና ⊲^L ለ^Lቢኦላና ዮናሮና (⊲'ኦ°čJ⊲[®] 1).



Stock Status

CSAS 'የΓ'?ኇ፞፞፞፞ጏ^c ለ«፦<ዻኇ፞፟፟፟፟፟ ለሰላፈኦኈጋኈ ኦለኁ፟ኒ፟ኄታ 2020 ኣኈየበናበጔበ ወር፟ኇ LRPs ኦժቇኄ *P. montagui* ላ፟ *L P. borealis* ኦ «ኖ WAZ ላጊ ጋየተሰላዖበኈ በናበጋኇ ቪቄፈኦተና LRPs ርነፊኈኄ ልኈጋ° ጋ°

DFO ΔαΓ΄Ϟὑ΅Ͻϭ· ϤϷϲ·ϚͶϭ·Ϳ· Ϟ΅ϒϒϒϚϤϒͰϚ ϷϒϷϹ΅ϽͿ· ϒͽϭϤͿ· Ϥ·ϹϫϪ΅ϒͰϭ·Ϳ· ϤϽ΅ϹϷϟϹ· ΛϲͺϞͻϛ· (NPAWG), ϽϚͰͺϧʹϒϲʹϧ΅ϒ΅ϒϾϚϤͰͺ ϤϽϲ·ϭͰϫϿͶ ΔϲͺͿϹϽͽͺϧʹʹϒϲ WAZ ϤͰ ΕΑΖ ΡΑ ϞϫϲͰϲϭʹϒ·ϼϛ, ΛϫϤ΅ϽϹϲ, USRs ϤͰ HDRs. ΔϲͺϒϷϷϞ· NPAWG ΛʹϐϲϒϷʹϞϟͼ DFO ʹϐϷϟϞ΅Ͷϭͼ ϤͰ ϼϫϹʹϞʹϾʹϽϭϛ ϤϷϲͼʹͶϭͼʹͿϲ, ϤϐͼϽ΅ϲͰϟϭͼ Ͱ«ϤΔϲ, ϼϫʹϐ·ϐͼʹϲͰͺϒϲ ͶϹϷϞͼ, ΛϲϥͺϐϷϞͼ Ϸ·ͰͽϽΔϟͼ ϤͰϫͻʹϹϷʹͽ ϧͶϲϳϟϛ ϪϐϧϫϪ;ʹϧʹϳ

NPAWG ለ~ሲላትሆናላъ "ጋምና ለ~ሲላቴምላ "ጋና ለቦላና ጋም ኦዮላካት ሁም 2020 በዖናበጋበ ጋና ሆኖምና. Δεቦላና ጋЈ ጋም / ምና ፲ና ወትሁለ ልዮምና ፲ና ላኦሮ በምና ፑና, ኣ "ዖበናበሁ / ላና ምኦኖ PA ኣፈ / Lምትሁ ወ ልቴ ጋዮ ምም WAZ, ለቴ/ኦቦ - ጋበ Δ "ቴሬ ፊት ህና ዉጋዉ ልና ጋቦና ቴኦኦቦላናልኦ የሚሞንና, ሮ የምትር ርኦበቦ ላና ጋላምቴና ጋበ ቴ ወል ምስቦላ ምና ፊኒና ባና ሰበኦምና ፲ና ዉጋላል የሆኖ ነና ልቴ ጋምና ፲ና.

⊲ር°ᡤᢣᡃ᠋᠆ᡩ᠙ᡃ᠋᠋ᡥᠬ᠊ᠦ᠊᠖ᢂ᠋ᢣᡪ᠋ᠳᢂᢣᠮ᠕ᢉ᠊᠍ᠬᡆᠣᢦ᠋᠉ᠫ᠉ᢂᠴ᠌᠅᠘*P. borealis* ላᡃ᠘*P. montagui* ᢂፈᠥ WAZ ላᡃ᠘ EAZ ልቃ⊲ሲℾ 2021, ኣ°₽ՈናՈϞና LRPs ⊲ጋኈሮϷϭ⊲ኈጋና ፊbϞናኌႶ ΓነኣϷኣናሮϷኌႶ ₽ϞͿΔና ቼኴ᠘ᆕ∿Ⴑም^ᢏՐ֊ഛና

DFO ዄレንትፈና በዖናበራፕና ՆርጐዮዀጋΓና PA ኣፈረፈራՆ レቃՆ WAZ ላጊ ጋዖረቦላዖሰና ኦቃՆ EAZ PA ኣፈረፈራՆ ኣዀዖራላዀጋና ላርራ ለልኣኣዄኌላጐናናጋΓና. የረላራር, ላርጐዮዀጋቦና PA Δሬሀርጐዮና ዖህሩሮዀሩ ዻዀየናርኮጐናሩር ፌኒሬጮጋንሪና ላጋዀርኮኌራ 2021-22 bበናጋቦና ዖህናሩናርኮላጐዹዀጋና Δረፈራኮናዎላና, ኣዀዖበናበላና LRPs ለርዄዀበናበራላዀጋና ፈጋፈሬዀሪሀበΓ ላጊ ጋዖሀላዖበΓና ኌህኣΔጐዮናጋራና Δረፈራኮናዎላታና ላርጵናጋና ለኒሲኮላΓና ፈናርፈዖኈሏበናበኛው የህናሩጋና.

- •----۵∧ ۵٫ 2020 ك∿

ΔϲͿϹʹϒʹ

ΔϲͺͿϹʹᡫ Α – ዹጏዹΔፇ^ŵґLσ[^]^{C°} DFO. 2020. ኄ⊳ኦ\ኄ∩ຼິ ▷ኄ⊳ኦነዖጘ⊲σ^ናነິ ዮ֊ሮኄ[®]∩ር⊳לσ^c ኄ⊳ኦՐ⊲ናል[°]Ր[®]σ ▷ዖ⊳ር[®]ጋΓ ዮኂ[<]<ຼ[°] (*Pandalus Borealis*) ላ^ιL ኁዎፍ[®]C[÷][°] ዮኂ[<]<Δ[°] (*Pandalus Montagui*) ኦሬ[°] ሬ[°]¹ レ[°]¹ [°]¹ [°]¹

ΔϲͺͿϹʹͺͰ Β – ͺϤϹʹ·ϒʹϐʹϽՈ^ϲ ៶ʹϐϷϐͶϹϷϞʹ: DFO. 2020. ʹϐϷϟ៶ʹϐͶϼͼʹϷʹϐϷʹϟϒϤϭ·ʹͿͼ ϷϲϲʹϐϐͶϹϷϞϭͼ ʹϐϷϟϒϤʹϐʹϒͼϭ ϷϷϷϹʹϐʹϽϜ ϷʹͿʹ<ʹϼͼ (*Pandalus Borealis*) Ϥ^ͱL ʹ⅌ϭʹϐϹϲϲ ϷʹႮʹ<Δ^ϲ (*Pandalus Montagui*) Եգ՝ գ՞Նϭ Ϥ^ͱL Λ՞Ն՝ գ՞Նϭ ϐϷϟϞʹϭϷϞϜ Ϸ·ϲʹʹϒ·ϭ. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/053.

• ΡΑ ϞϿϷϒΓϤʹϐʹϒϚ ϷϭͷʹϞυ WAZ ϤʹL ΕΑΖ ϞϿϷϒϞʹͽϹϷϧ·ϭϲͺϤϲ·ʹ ϤΓϟͼʹϓ·ϫϼϚ ϤϽʹʹϒϹϷ;ϞʹϫͺʹͽʹϽϚͺϒͽϷͼͶϹϷͿϭͺϷʹʹͼϫϳ··ͼϚʹϞͽΔϫϳʹϧϲϹϷͶϭ·ϔϚϷʹϟͿϚϘϚϷʹϟϲϷʹͽʹ ϤʹL ϤͼͶϲϲϭʹͿϚϷʹʹͼϫϳ·ʹͼϚϤͼͶʹϞͷϚʹϒϞͶʹϧʹʹͶϹϔʹϲʹϤʹϹʹʹϫϤϹʹʹϿϭϚͺϒͽϷͽͶϹϷϫͶ ϞϿϲϤͿͶϷϫͶ

- LRPs ϤʹL ϽʹϒʹϚʹህϚ USRs Ͻ·ϭ·ϬʹϐʹϽϚ ΛϷʹϲϭϚ ϤϽΔ·ͼϷϟϭϚ ʹϐϷϟϞʹϐʹͶϭϚ ϽϷϟϒϤϨͶϭϚ, ϷϟϤϭ ΛʹϐϟϷϟϡʹϒϚϽϚ ϤϫͶϲͺϲϭ·ʹͿϚϷͺϠϫͺϿ·ϭϚ ϤϫͶʹ·ႱϣϚ ΛʹϞͶϬϐʹͶͶϚͶϚʹϤʹϐϷʹϟϭʹϓ·ϣϚ. ϽϷϟϒϤϨͶϚ ΛʹϞϥʹϐʹϐʹϽϚ Ϲʹ·ϐͷͽʹ·ϧʹϐϷϟϞʹϐͶͻϷϟϛʹϐϒϷϟϫϾ ΛϹʹϐϚͶϤʹʹϒϚϽϚ.
- EAZ-F^c, ▷-」F」^{*}して[®]∩C▷/L⁴^c LRP ▷P▷C[®]⊃F P^{*}J⁴<_D^c (⁶J^{*} ペ_ת⊲[®])^c 15,800 ▷≪^{*}^{*}U^c 6,800 t) Ϥ^L D^{*}J⁴^k^{*} USR (⁶J^{*} ペ_ת⊲[®])^e ∩P^c⊃J 31,600 ▷≪^{*}U^c 18,200 t) D^{*}^kUσ[®])^c 11-Ϥ^{*}GJσ Ϥdσ▷σ[®][®]Dσ^c (2009–2019). Ϥ^{*}PC▷^kDσ[®])^c LRP Ϥ^L D^{*}J⁴^k^{*} USR ^{*}P^{*}σ[®]C^{*}C^{*}D^c ▷^K^{*}D^c ▷^KP∩^c∩L^{D^{*}}D^{*} 3,100 t (▷^K ペ_ת⊲[®])^{*} ▷ ≪^{*}U^c 2,300 t) ⊲^kL 6,100 t (⊲/^{*})^k^{*}C^{*}D^{*}), D^{*}C^kC^{*}D^c.
- WAZ-F^c, ^ΔC[™] \[™]P[™]∩CÞϚC[™]/L⁴[™] LRPs ÞPÞC[™]⊃Г P^{*}J[<]<^Δ^c for (4,100 t) d^ιL [™]P[™]σ[™]C[←]C[™] P^{*}J[<]<Δ^c (12,300 t) [¬]^{*}Uσ[™]D^C 6-dⁱ¢Jσ ddσÞσ^{*}Γ^c (2014–2019). dⁱ^λ<[¬]dσσ, ^ΔC^{*}J^{*}[™] [¬]J^{*}APCP^{*}[™] d^c∩σ[™]\Γ P^{*}J[<]<^Δ [™]D^A^{*}A^{*}Γ^c (USR) ∧C[™]DCP^{*}^c d[¬]Dσ [¬]L⁴D^c (8,200 dⁱL 24,600 t, P^{*}J^c[⊥]C[∩]D^c).
- (EAZ) ኣ^ቈP^ቈበር⊳֊⊳^ቈሃLէ^ቈ 2009–Γ^ϲ ጋ[∞]ህ፞σ^ቴ^b^ቈጋቦ^c ላ^cϤJ^{Δ^c} ለ⁵U/J^{Δ^c} ቴ⊳ኦኣσ^sJ^c ጋዖሃቦ ላੋዖበσ^c ላ^LL ^ቴ_DΔ^cσ_Lኦ^{*}^c^{*}^c σ^dL ²^c²^c²^c</sup> ላ²^c²^c²^c²^c²^c²^c²^c²^c²^c²^c²^c²^c²^c²^c²^c²^c²^{c²^c²^{c²^c}}

ℶℶℶ∆۶^ւսՐ՟

ϧͺϹϹͳʹϐϷϷϞϞ^ͺϐϽϲϷʹϐϷ[;]ϷϹ⊲ϭͺͳϲͺͺ;ϷϷϞϒ_ʹϧϢϲͺ;ϿϲϷ;ϷϲϫϲͺͳϲϷϫ.

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ቴ⊳ኦኣኈ∩ኇ╴⊳ቴ⊳՚ኦՐ⊲ʔ╴የ֊ሮቴኈ∩ና∩ኇኄገ ለ∩⊂⊳ጘኇ╴⊳የ⊳ርኈጋ୮ የኈጏናሏና (*PANDALUS BOREALIS*) ⊲୳L የኈጏና≺ሏና (*PANDALUS MONTAGUI*) ԵፈኁፈኈႱኇ ⊲୳L ለኈႱኁፈኇ ቴ⊳ኦኣናልቦኦ⊳ጘኇና

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ለነላበ∿し: ΔĽ σ⊲C σ ∩ ²⁶ baCF - <u>Δ</u> ⁶ <u>J</u>⁶ <u>Λ</u> ⁶ <u>J</u>⁶

∆℔**⅃**⊂൩൙ք՟Շഀ ⊲⊳ԸշՍչ⊀ՍԳշ ϽለՉշለշ։

- \dot{P}_{a} P_{a} P_{a}
- L=CDN \triangleleft L=CN \triangleleft C \land CN \land CN
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∆ ^ی ار⊸۲ (⊂∆J/∿ل)	⅊ℶ⅁ϞϲϷϨՈϚⅆϹ℀Ⴑ Քℶ⅃Ϛⅎℰ, Ϸն⅃Δ·ϭʹϒϚ	⊃ڶڮ؇ڮ ڮ؆ڮڮڮ ڮٵڔڋڡ ڮۥٵڗ	2020 ԲՎԵՆ-ԵՇՈ ՉՆՆԵՀ- ԵՆՂՀԻՉ- ԵՉՐԾ-ՇՆԵ	2020 % مے°°⊂⊃۲L⊀° ⊲۲L d⊂∿L	2020 % _
۵۵-۵ ^ی) (۵۶-۱۵ مد)	20.000	17.418	14496.63	73	83
H_ልʰ (30 L∆⊂)	5.000	4.899	4917.58	98	100
ל∆d	17.000	13.063	11133.61	66	85
<⊂ ^₅ ⊀⊲ʰ (Ả∩ ḋʰ)	9.100	8.709	7826.65	86	90
౬ు౬ా ఛో. (<∆౸ా <∆)	9,100 (*5,000)	᠘ᡃᠳ᠘᠘ᢞ᠕ᡔ᠋᠂ᢕ	᠘ᡃᠳ᠘ᢞ᠕ᠺ᠋᠂ᡘ᠘	_	_
یاتے۔ ۹۳ ما مع	56,100	44,089	38,374	81	90

2020 单๔₽ን๓₽?∩๙゚◁゚Jን゚Ր゚ჾ゚∧₋→⊲⊂∆゚

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- దిశంవాంగ్లి శ్వండాంగ్లి స్టార్ స్ స్టార్ స్ట్

∤⊾⊃∆⁵ഘˤσˤ ኄ⊳ᢣ\ˤσ⊂**൩**σᡥ:

*_``J`\$L_1+D~t^& d`C~L

ϤϷ·ϹϞʹϚ≟᠊*σ*· ΛϹʹቴʹ<mark>Ⴑ</mark>ͺͺͺͺϧϲϟϭϲͺͽϷϟϞͽϹϷϟϲϞϭϲͺͽϥͼͶϲϷͽϽϲͺϤϷϟϷͶͱϿͿϟϲ ϫϿͼϪͽϹϷͿϥϲϲ

∠bting d) < C) ∧rdsc r g b j 2020, r p d l a d'ta "

Cd^c\D∩^c∩≪^c⊃∩^b P^c⊂σ^b Δ⊂^eσ⊲^cδ^lΓ (Lⁱⁱ) 2020).

___^e_ ኄ⊳ኦነኈናርታ⊲ኈጋታና ጘ⊳ናሮቢ[«]ል⊦ር

<u>∟</u>` ዘ⊲ኪ՝ – /ݠ⊃∆⁵ݠჼႫ^с ኄ⊳ዖ\ነ₢ႠኪႫ^ቈ

⊂کے کو جو حلال الے کاکھ – 26 کو کو کے کہ کھی کہ کو کے کہ کو کہ کے کہ کو کہ کے کہ ک

ለጋΔ·൶Ϸኈዮነ⊀በኈዮና ኣኈዮፈϷኈበ·ፈዮና.

⊲⊳∟⁻∩ஏ∿):

2020).

⊳י_י: ⊳י⊃∧ר 28, 2020

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∆^ւթ⊃**∟**սելեն Հիշեն Հրանան հերհերուն հ

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- Δኄᠴᡄᠬᠦᡗᡏ᠋᠊᠊᠋ᢂᠵᡄ᠋ᡗᠬᢣᢂ᠋᠅ᠺᡄᡅ᠋᠖᠋᠖ᡄᢂ᠋᠖᠆᠙ᡧᡄ᠅ᢂ᠋᠙ᢂ᠋ᡩᡄᠺ᠋᠄ Foods), ᡧ᠘᠖᠒᠋᠖ᡣ᠖᠅<ᡗ᠋ᡣᡅ᠋᠘᠋ᠮᠥ᠋ᠺ᠅᠘᠘᠘ᡶᠯᠥ᠋ᡗ᠕ᡄ᠘᠋ᡬᢋ᠋ᠮ᠋ᠺ ᠺ᠋ᡊ᠋ᡩᠯ᠋᠊ᡧ᠋ᠮᠴ᠘᠖ᠴᡄᡅᢩ᠋ᡭᢌ᠋ᡶ᠋᠋᠋ᡄᢆᡆᢂ᠅᠘᠋᠘᠋ᠮᢧᢁᠺᠫᡅ᠅᠘ᡄᢂᡔᡇᡗᢕ᠋

- P⁵JJJJC
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- ቴኦኦኒሊላቴናምዮዮምና Δቴንጋሬና ላፑላዎዮዮምና ወዲተቴናልኦና ላቁበላምና ለኦኦፖዚተምና ፈንፈልፕሮኦሬኦምንና ሃቃናተኦኦኦቦላቴናምዮዮምና ዴተናጋቦና ኦቴኦፖኦፖዚቲና ኦሬቲናምላበነፅና Եንኦቴበሶዮዮምና የሢቴጋሏትምና, ላጊናሮኦቴ ፈኦኦም Δቴንሪሥምነፅና ሶፈኦኦሮኦንዮሚናኦኚኒሲር. ሮዴዮፌ ለናንጋ, ቴውቴንተሬኦዬንና ሃቃጋላቦላናፅኦኦጋበኑ ሃቃናተኦኦኦቲኒቲና, ላሏናለፕሮኦንም ወዲተም ቴኦኦኒናምኦቲቴ ለቦላቴበሮኦሬኦቴንና ላፍጏጋና 2020 ሮፊዮፌምናኒኦንጋበኑ ፈኦኦምና ላጊ ቴዮዮምና Δቴንሪሥምተመናና. ላኪልሬኑ, ለኦተረላቴበናበዲሬኦቴንና ወላናበዲናጋምና Δቴንግምና ቴኦኦኒፕሮኦቲናኒምና ለቴፖኦንኦንጋበኑ Δንዮፌቦኑ ፌናዮዮና, ልሬዮዮም ምምዮር ላጊ ላናጋላተምና Δቴንታርዮና ለቴፖኦንኦንስላ ፊንዮፌቦኑ ፌናዮዮና, ልሬዮዮም ምምዮሶሮ ላጊ ላናጋላተምና
- 50-σ^c ኻ▷ኦኣ^ቈ⊂▷ላ^cኣσ^c ⊲ጋσ ∧∠▷^ቈϽ^c ∩ኣL▷ላ^ቈϽσ^c (8) ΔLϲ^eσ^c ϤⁱL 50-σ^c
 ኻ▷ኦኣ^ቈ⊂▷ላ^cኣσ^c ⊲Ͻσ ∩ኣLσ^c (4) ΔLኻ^sል^eσ^c ⊿^c∩ል▷∠▷^ቈϽ^c ᡆ▷^jσ^c ϤⁱL ኻ^s∩^sc^c σ^c
 ⊲<∩^{*}∩^eσ^c ⊲Ͻσ. ኻ▷ኦኣ^ቈ⊂▷ላ^cⁱ^c ⊲▷^c ^a∩⊂▷∩⊲^{i^c}▷ Δc⁻<ΔⁱJ^c ϤⁱL σⁱP∩⊲^c^c^c^c^c^c^c</sub>
 ⊲ⁱL ida^sP_i<sup>c^s^c^c</sub> ኻ▷ኦኣ^ቈ⊂▷∩<sup>i^c^c^c^c</sub> ^D<sup>c^s^c^c</sub>
 </sup></sup></sup>

- Ρ«·ϲ΅ ͽͼϲʹͽʹ&Նσ ΔʹͽϿϲϲϭͼϓϛ ϷΩLέʹͼϭʹͽϽͶ <ʹͼϷͶͽʹϿϛ 2021-Γ, Λ/ϞͶϒ·ϿͿ ͽ«·Ϟϭʹͼ΅-19 ϭʹϽϭϞʹ ͽͼϲϷʹ ϭϟϭ϶ϿϭϥϭʹͽʹϔϯϟͶϷϞʹ ϭϽϷͼʹͽͶϹϷϭ΅<Ϲ.
 ϭϽͶϷͼϟϭͽϽͽ ϷͶͰͼ·ϭϚ ΛϲϲϞϞͶϲϲͼϔϚ ϟϤͰͽͶϹϷͿͰ·ϿͶ ͽϷϟϞϷϟͰϞϛ 2020-Γ ͽͼϲͼ ͽϷϷϟϳϚϞͼϛ ͽϷϟϞʹͼϷϲϷͽϽϹϛ ϭͰͰ ͼϿͼΔϟΔͿͰ;ϿͶ ͽϷϟϞͽϹϷϹϭϲͼ ϭͰͰ

∩∩ናჼ⊃ჼჼ:

▷└: ▷ʰ⊃∧∩ 28, 2020

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ճոՋշ⊃ԳℯՐ։

᠘ᡄᡃᢣᠵ᠋᠋ᢐᡕᢣᠣ᠒᠍᠆ᡆ᠋᠋᠋᠆ᡥᢣ᠋ᠴᡏ᠋᠋᠘᠅ᡁ᠅᠆᠋᠕᠘ᢞᡄᠴ᠈᠒᠒ᡪᢡᢕ᠋ᠵ᠘᠘ᠴᢄᡩ᠘᠘ᠴᢄ᠘᠘ᢁ᠘᠘᠘᠉ᢕᡄᢁᢕᡄ

ϽͿϧϧϽϞͽͺϿϭͽϧͺͺϷϳϒϲϤϟ;ϥϤͼͺϼͶϯϧͺϹͺͶϺϺΒ) ϼϢϯϩϲͺϧϹͼϫͺϽϳϲͺͽϽͽͺ

ϷͿϟͼ ϷϭʹϹϹ (COSEMIC-۹ͼ) ͽϷϧϞϷϢϹ϶ͺͽ, ϭϝͳϽ ϿͰϽ϶ͺϽϧϞϫϭϧͺ ∿_۲۲-¬ه

רױֹ∟[ַ] (*Cyclopterus lumpus*) (⊲יֹץ"ט⊲∿ 1). ᢆᡰᡄᢂᡔᡄᢂ᠋ᠫᡄᢂ᠆ᠴ᠋ᡣ᠈᠘᠋ᡃᢐᠴᡄᡅ᠋᠋ᠴ᠋᠋᠆ᡆᢂᢣᢂᢁ᠋ᢄ᠘ᡧᠼ᠉᠆ᠺᢂ᠆᠖᠘ᢕ᠆

58-> $L \simeq \sigma^{1} \Delta^{1} b T > C \Delta^{2} = 0$ $\mathcal{D}^{\mathcal{D}}$ $\Lambda \subset \mathcal{A} \subset \mathcal{A$

⊴Гℰ<u>վ</u>ГԽ-Շՙ&Րጋ∆-ՇՄՉԹ_"ՀՇ, ՀՇ-Շ՝

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ΟΠϚ[®]CϷϟLϟ[®] 5.2.34 (f)–[®]υσ ϼϥϹ^{*}σ^{*}J^c Ϥ[®]ϒ[®]ϴΠ[†]JΠΓ Ϸ[®][®]ϟLϟ[®] NWMB–d^c ΔLΔ[®]σ⊲_LϤ[®]^P^e^{*}, ΔϟLΓϟ[®]^P^c^LC[®]⁻, Ϥ[®]^P[®]^C^P^A^{*} ΛC[®]_L₂^A², Δ^Δ[®]², Δ^Δ^{*}, Δ^Δ[®]², Δ^Δ^{*}, Δ^{*}, Δ^{*},

∧۲۰۵۹۲۵ ۵۲۲۳۵۲۵۵ ۵۲۵۵۲۵۲۵ ۸۲۵۹۲۵ ۸۲۵

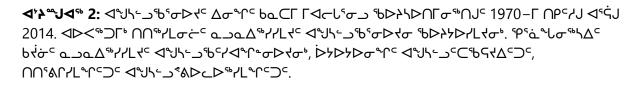
ኽϷትንϷለLኆ ϷϿሲ⊲ႭჼϿᡤႶናለውႭჼჂႽ ՉኂኣኁϿናኮ ለፈለϷႶኆ ΔኽϿႱለዺናቃϷ«ናጋჼ, ፈለንትჼናሩ፦ፈምኄ Δምዮር ፈዛሬን >፦ሬና፴ና ኽϷትኣንርϷ«ናጋና. Δምናምጅዮጋላቸጋና ፈኂኣኁጏሏና ምዋቦንϷቭና ክለና≟ႭჼჂႠჼ ፴ና ΔLናΓϷϹ፴ና, ፈዛሬጋ የJበሮჼ፴ና የለጋሏ՞Ⴍናም ምዋሮჼ፴ና ኣჼለኽჼለበჼ. የJበጵና ኣჼለኽჼንና ፈዛሬጋ ፈናቭና ምዋኽቭና ሏምናቃዮለም ፈኂኣኁጋዮም ሏምናቃድሮንም የለፈም ኽϷትሬንϷ՞ዮናጋჼ ለዛሬና ርሬነፈ፴ኄႱ ምዋቦንዾኽለϷႶዛሬሲር.

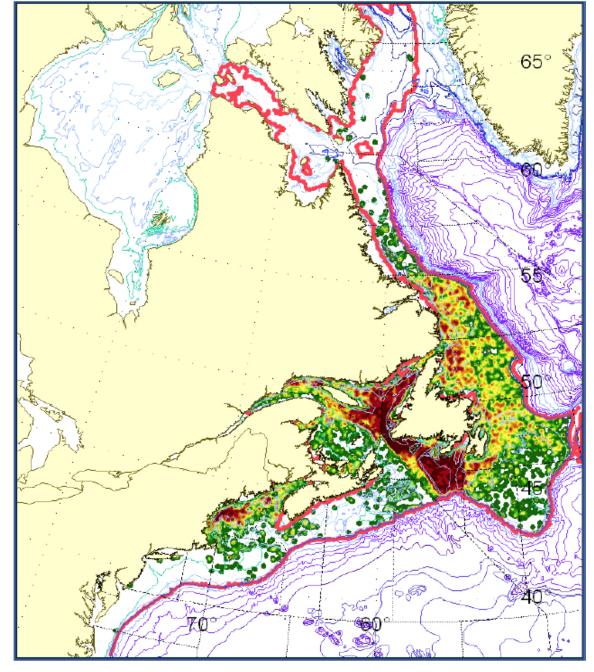
 Λ P $\dot{}$ " L^{C} C δ P $\dot{}$ Λ P $\dot{}$ " L^{C} C δ P $\dot{}$

$$\begin{split} & L \in \mathcal{A}^{c} \Delta^{\circ} b^{\circ} \Gamma^{\circ} \delta^{\circ} b^{\circ} b^{\circ} b^{\circ} h^{\circ} \sigma^{\circ} \delta^{\circ} b^{\circ} h^{\circ} \sigma^{\circ} \sigma^{\circ} b^{\circ} b^{\circ$$

→Γ ℃
ΛΓϤʹͼʹʹͺϤϭ 1969, Δʹϧͻϲͺϲϭ·Γ / «°σ° ΛΓϤʹͽʹΠϹΓσ΅ σϷ «Ϸ°ἐ、Γ ΔͽΔ、ʹϲ-Γ·ͻΓ^c
ϹͺϷʹΓϷϹϷʹϓ^cϽ^c 、ϷϭϚ、ϲ^c / «°ΥϹ ΛϷϘ«σ°Γ^c (Acipenseridae) ϤΓ/^c / «Δ^c
ΛϷϘͼʹΠ·ͻΓ^c ͽͼͺʹϞϤΓ ϹʹϷϤ ϷʹϞʹϐϷʹϷʹϚ ϚϷϭϚ、ϲ / «°Γ^c σϷϐϤʹϚϷ«σϤΠ·ͻΓ^c.
ϷͼϹ / ͽ·ϷϹʹ^sϽΓσ΅ σϷϐϤʹϚʹϐʹϷϾϲϭ·Γ^s ϤʹϞͿ、·ͻ^c / «°Γ^c σ^s Ϥ^c Δ^c
ϤʹϞ, ⁵ (Ϸͺ-ΛϷϘͼʹϽ^s Ϥ^c L / «°Γ^c ΛϷ^s Λ^s ^c ^c.

⊃Բ∿Ր





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√ أ`⊃ ً ≪ 12, 2020

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- σ⁵¹⁵¹/₂σ⁶ bacc bld⁵δ⁶. Δσσ⁶ CLσ 100km δ⁵¹/₂σ²¹/₂σ⁶ σ¹/₂σ⁶

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רבי∿: ⊳⊃∧∟ 22, 2020

ΠΠና[®]C[°]Γ' Ϲ΄ϟĽ: Cσቴ HÞL[®], Δ[°]ϟ≪ϷϹϷ[<]–Ͻ[°]ΓϲϤ, σ[°]Γ[°]υσ⁵J' ϤϷϲ[°]Π⁵ԵΠ⁶[°]σ⁵J' ԵΠL²5[°]σ⁶ <u>Danica.hogan@canada.ca</u>

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NINGINGANIQ NATIONAL WILDLIFE AREA

Management Plan for NWMB Approval



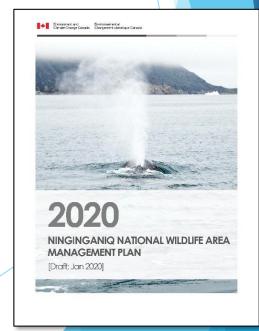
בפר ׂ⊳Lל⊂תליל⊲^c אר^c, ∆יש⊃∆^c 02 חר∧ת 2020

NWMB, Iqaluit, 02 Dec 2020

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- Information on protected areas in Nunavut
- Show you the content of the Management Plan





$\begin{array}{c} \label{eq:2.1} & \neg \dot{\Box} & \neg \dot{\Box}$

Information on National Wildlife Areas and Migratory Bird Sanctuaries in Nunavut

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Purpose of Network

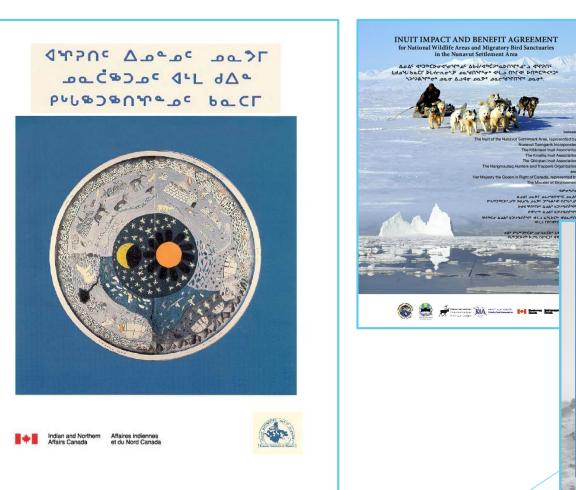
- Conservation
- Research
- Interpretation

National Wildlife Areas (NWA) Migratory Bird Sanctuaries (MBS)

National Wildlife Areas Réserves nationales de faune (54) Migratory Bird Sanctuaries (92)

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	MBS	NWA	
Protection Focus	Migratory birds	All wildlife	
Protection Period	Nesting/breeding season	Year-round	
Legal Basis	Migratory Birds Convention Act	Canada Wildlife Act	



2016 TO 2023 INUIT IMPACT AND BENEFIT

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> Environment and Climate Change Canada Changement climatique Cana

దంద్ ఈ⊃్రిటర్గిం నేందిం ఈం గాంం (2008; 2016) Inuit Impact and Benefit Agreement (2008; 2016)

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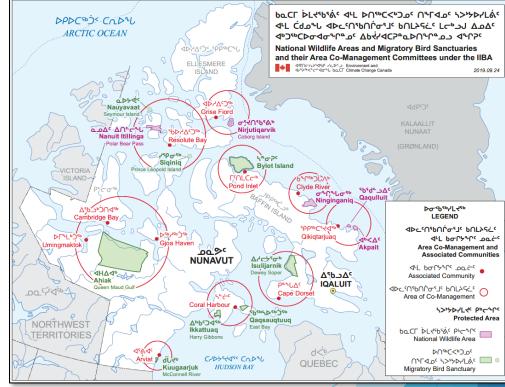
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- Decisions for Migratory Bird Sanctuaries and National Wildlife Areas strongly influenced by Inuit Qaujimajatuqangit
- Guarantees comanagement of Migratory Bird Sanctuary and National Wildlife Areas Important feature: Area Co-Management Committees

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 ⁶ D⁴ C⁴ D⁴
 ⁶ D⁴ C⁴ D⁴
- 9 ACMCs were created in Nunavut to co-manage the 13 protected areas
- Made up of 5 people from the associated community and 1 from Canadian Wildlife Service (Environment and Climate Change Canada)





 1 member from Canadian Wildlife ᡏᡄᢂ᠘᠘ᡩ᠘ᢋᡄ᠘᠊ᡁᢄ᠉᠆ᠳᢄ᠕᠆᠕᠆᠕ ∧൳൨ል[ൣ]ႱႫ Ხ∩Lϟ℅൨୭[֊]: Ⴀ<mark>ႫႱ ዘ⊲⊳Ⴑ</mark>ჾ (**⊃**∿∩⊂∿)

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- Ninginganiq ACMC was formed in 2009
- 5 members from Clyde River

James Qillag

- - Sam Palituq (Chair)

Enuusiq Jaypoody

Service: Danica Hogan (Vice-Chair

Jaysie Tigullaraq

Leah Tassugat



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ACMC will:

- advise the Minister on all aspects of MBS/NWA management
- review permit applications
- develop Management Plans

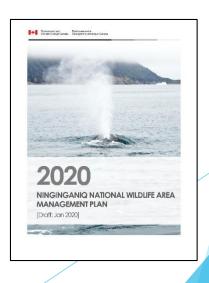




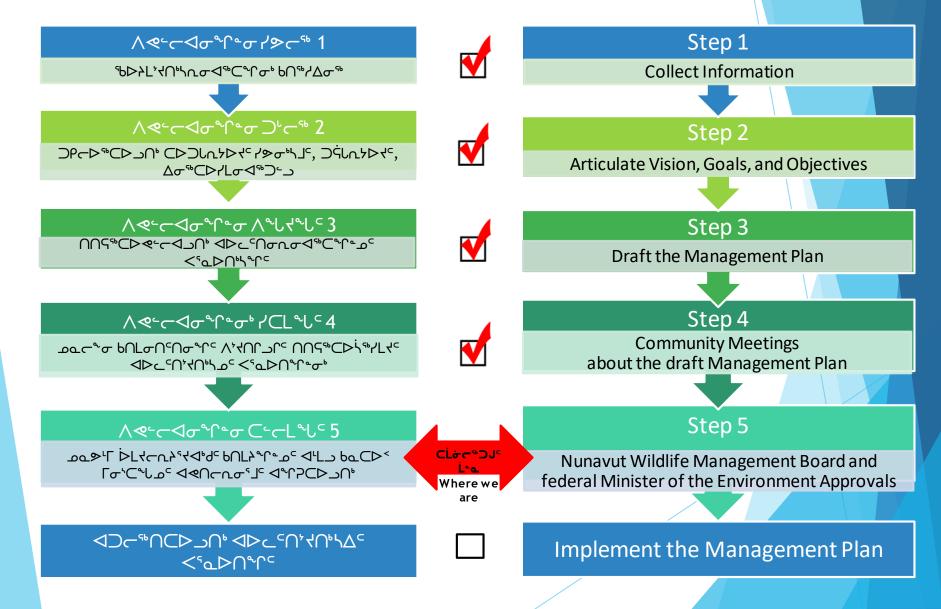
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- Allows the Area Co-Management Committees to share their vision of the protected area
- Guides decision making for the protected area
- Describes important cultural and environmental aspects
- States which activities are permitted and not permitted



<٢٩هه الك^٢ ح^يمك الم² Management Plans: *Steps*



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Management Plan Preparation and Approval

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- 3.5.4 ∩∩๑๖๐๖๖∩๖ ๔๎ฅ๖๙๖๐๖๖∩๖ ๔๖๔๓๖๙๓๖๖๔ ๙๔๖∩๑, ๖๗๔ ๔๖๔๓๖๓๓ํ๛๓๖๔ ๖๓೭๖๓๔ Ճ๙೭๓๓๙๖๔๖๓๔ ๛๔ ๖๖๖೭๖๖๖๖๙๓ ๖๛๗๐๖๙ Ճ๔๓๖๖๙๙.
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MANAGEMENT PLAN PREPARATION

- 3.5.4 In preparing Management Plans, the ACMCs shall carefully consider any *Inuit Qaujimajatuqangit* brought forward by a member.
 - 3.5.5 The ACMC shall consult the relevant RIA, and NTI, before completing the draft Management Plan.
 - 3.5.6 Subject to its work plan and budget, the ACMC may prepare the Management Plan according to whatever process it deems appropriate and it may consult as it deems appropriate.

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(e) ▷੶᠋ᠴ᠋᠋ᠬᡗ᠊᠊ᢦ᠋᠋ᢕᡄ᠋᠉ᡣᡄ ᢦ᠋ᢕᡄ᠉ᡣᡄ ᢦ᠋ᢕᡄ ᢀᡄᡄ᠋ᠬ᠈ᡃᠯᢕᠵᡰᡄ <ᠮᡆᢈ᠋ᠺᡢᠶ ᢐᠴ᠘ᡄ᠌ᠵ᠉ᢕᠵᢦ᠍ᢁᠫᡄ᠙ᡃᠥᠬᡄ. 3.5.7 The Management Plan shall include a description of:

(a) the purposes of the NWA or MBS;

(b) management goals and objectives;

(c) the natural and cultural history and the context within which the NWA or MBS operates;

(d) policies that will guide the management of the NWA or MBS;

(e) a schedule to implement Management Plan action items.

దందం అ⊃ాంగిందం నేందిందిందిందం Aంగాం Inuit Impact and Benefit Agreement

3.5.8 Where an NWA or MBS includes IOL, the Management Plan shall reflect and address any special issues arising from the presence of the IOL.

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MANAGEMENT PLAN APPROVAL

3.6.1 The ACMCs shall recommend completed Management Plans to the NWMB for approval in accordance with sections 5.2.34(c) and 5.3.16 of the NLCA.

3.6.2 The ACMC shall provide the relevant RIA and NTI with a copy of the completed Management Plan when it sends the Plan to the NWMB.

దందం అ⊃ాంంగిందం నేందిందిందిందం Aంగాం Inuit Impact and Benefit Agreement

3.6.3 ⊂∆L→, L←^L→J ⊲എറാ∩് 5.2.34(c) ⊲പ് 5.3.17 ∩₽- العافية عام 15.3.23 مرف 12° לי ୰୳୵୵୲୰୳୵୰୵୵୰ <u>ک۲۹-۷-۶،۲۹،۵۲ کام</u> ظُنُهُ∾<۲۹, כב۲۲ ⊳°هن⊶خ۲ کرے∿ل, ⊲⊳ഺ൳൱ൢ൛ഺഄഺഀ

3.6.3 If, in accordance with the decision-making process set forth in subsection 5.2.34(c) and sections 5.3.17 through 5.3.23 of the *NLCA*, the NWMB or the Minister rejects, in whole or part, a completed Management Plan and the Plan is returned to an ACMC for reconsideration, the relevant ACMC shall reconsider the Plan and re-submit it to the NWMB.

∆ందం అి⊃ాందించిందం నతందెందం చింగెం Inuit Impact and Benefit Agreement

3.6.5 $\subset \Delta L \supseteq \Gamma \sigma' \subset \triangleleft^{\circ} \Gamma^{\circ} < J$ $\triangleleft \triangleright \subseteq^{\circ} \cap^{\circ} \dashv^{\circ} \land \circ \leq^{\circ} \boxdot \wedge \Gamma^{\circ}, \Gamma \sigma' \subset$ $\wedge \Gamma \triangleleft^{\circ} \cap^{\circ} \sigma \dashv^{\circ} \subset^{\circ} \cup \lor \dashv^{\circ} \wedge \neg \land^{\circ} \subset^{\circ} \dashv \dashv$ $\triangleleft \supseteq \cap^{\circ} \boxdot^{\circ} \dashv \supseteq \subset^{\circ} \subset \triangleright \cap \dashv \subset^{\circ}$ $<^{\circ} \sqcup \land^{\circ}$. 3.6.4 In accordance with section 8.4.13 of the *NLCA*, approved Management Plans shall be based on the recommendations of the relevant ACMCs, taking into account the recommendations of other interested persons or bodies.

3.6.5 Once the Minister has accepted a Management Plan, the Minister shall proceed forthwith to do all things necessary to implement the Plan.

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Content of the Draft Management Plan for the Ninginganiq National Wildlife Area

کے ح^مر کے ح<u>ک</u>ر میں کے کار کے Content of the Management Plan

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- CDJLᡅᢣᢂᡩ, ᠫᡬ᠘ᡅᢣᢂᡩ᠘ᠴ ᠕ᡄᡅ᠋᠋᠕ᡩ᠘ᡆᢖ᠘ᠳᡏ᠖᠉ᠫ

- Description of the National Wildlife Area
- Ecological resources
- Cultural resources
- Vision, goals and objectives
- Management
 Considerations things to consider in managing the National Wildlife Area







దురాి^c <్ ఎండ్ గింగర్ సింగ్ Content of the Management Plan

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- Management Approaches what we will do to achieve the goals and objectives
- Authorized Activities and Access

 what activities require a
 permit, who requires a permit
- Management Plan implementation and collaboration



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- Established as a National Wildlife Area in 2010 to protect Bowhead Whales and their habitat.
- Community-based initiative (started in 1983)



ຼຼຼຼຼຼຼຼຼຼຼຼຼຼຼຼ Landscape

- 3,362 km2 b∩ິJ: ᠘⊆՟Եື⊃σ, 2,832 km2 ΔL&ື ⊲L∆ື 530 km2 ໑໑
- Λ⁵brD∩-_J ΔLc⁵⁵ <⁵Lσ McBeth b⁶C⁵⁵ >⁶Lr⁶σc¹J² 12 nm P⁶c⁶Lσ⁶

- 3,362 km² total: includes 2, 832 km² of marine waters and 530 km² of land
- Includes Isabella Bay from mouth of McBeth Fiord out to 12 nm limit
- Includes all islands within the bay and land located within ~ 1km of the shoreline
- Rugged land, especially on the south side of the bay





ຼຼຼຼຼຼຼຼຼຼຼຼຼຼຼຼ Landscape

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- Mostly federal crown land and federally controlled marine waters
- 4 parcels of Inuit
 Owned Land (surface rights)



⊲≪∩∿لۍ ہے۲⊳⊂∆ نے کلا∠ے ∧⊂∿b Ecological Resources

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- 5 ה∠לב עלבים לארלי
- Important feeding area for Bowhead Whales in Canada-up to 147 whales at one time
- Polar bear summer and denning habitat
- 15 species of mammals
- 43 species of birds
- Important staging/moutling site for King Eiders, Long-tailed Ducks, and Dovekies
- Diverse marine community of fish and invertebrates
- 5 species at risk



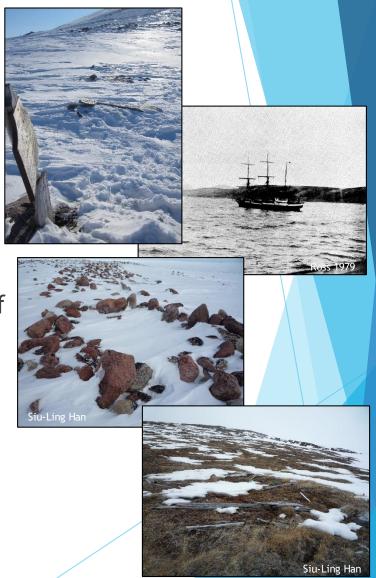


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Inuit have used Ninginganiq for thousands of years

- Several known archaeological sites, cultural features & artifacts in the area
- Include Thule, modern Inuit, and European whaling sites
- Likely many unregistered sites in the area



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 b⁶JΔ^c Γⁱ 」 L°σ⁶Γ°σ^c

- ۵۵-د٬۲۲۵۰

- Hunting- seals, whales, polar bears, birds, some terrestrial mammals
- Egg collection- especially goose and eider
- Trapping- foxes and wolves
- Fishing- mostly Arctic Char
- Camping



⊂∆^ہ′Lσ ⊃⊶⊂⊃ ⊲۲^۰∩^c مو Past and current other land uses

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- Research
- Tourism- Cruise ships, sailboats





⊲▷ຼ<∩∽ˤϤ< ΔϟL⁵Ϟ⁵²</p>P∩⁵ϞΔManagement Considerations

Management considerations are things we need to be aware of within, and surrounding, the protected area in order to effectively manage it



⊲⊳_⊆∩∽ˤ⅃⊆∆∠L⁵ኣ∿∠>∩⁵ኣ∆⊆ Management Considerations

۵۲^ناعو در ۲۵-۲۵ م. ۳۰ م. ۲۷انام ۲۹ م. ۲۹ م. ۱۹ م. ۲۹ م. ۲۹ م.

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No significant or immediate threats, but:

- 1. Harvest of Wildlife
 - need to work with management authorities to make sure harvest is sustainable
- 2. Tourism
 - Likely to increase in future
 - Need guidelines for tourism vessels





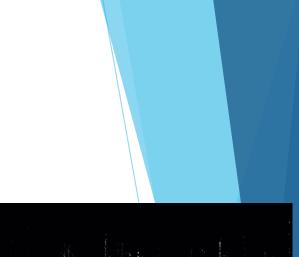
⊲⊳ے ^c∩ σ ^c 」^c ∆ ∠ L^b ∖^{cb} ∠ ⊃ ∩^b ∖ ∆^c Management Considerations

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3. Noise

- Need to better understand how noise from humans impacts whales in area.
- 4. Ship Collisions
 - Ships likely to increase
 - Need to protect whales from collisions







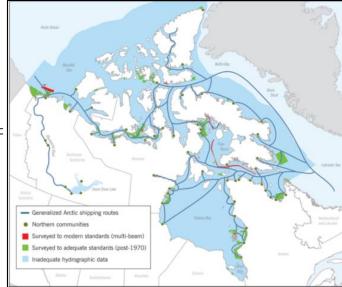
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Management Considerations

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5. Pollution

- None now, but could increase with more ships
- 6. Commercial Fishing
 - None now, but could increase in future
 - Risk of entanglement
- 7. Climate Change
 - Can't control, but need to document changes
 - Could increase marine traffic and predation by killer whales



CD⊃しんりD∀^c, ⊃GしんりD∀^c, △σ^{sb}CD∀L∀^c」 Vision, Goals, and Objectives

ϹϷϽႱͺͻϷ**Ϟ**^ϲ Ϸϭ·ϳͽ·Ͻ·ͺͺϲϷ·ϭ^ϲ ៶>·ϭϭʹ·ϹϷϭϭʹ**Ͱ**ͺ· ΔϲϹͺͺͻϷϞ^ϲ ៶>·ϭϭʹ·ϹϷ៸Ͱϭ·ʹϒ^ϲ

Vision A description of what the protected area should be Incorporates the protected area's purpose

Management Goals Statements that provide targets for how the vision will be met and maintained

2

Management Objectives Provide direction on how to achieve each goal

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2.i

ପେର୍କୁ କିମ୍ବ ସର୍ଦ୍ଦେର୍ଦ୍ଦ Vision for the NWA



$$\begin{split} \mathcal{A} \supset \mathcal{A}$$

The long-term vision for Ninginganiq NWA is protection of Bowhead Whales and other wildlife, conservation of the marine and terrestrial habitats on which they depend, and protection of the traditional Inuit use of the area. The NWA will also serve as a key site for research on Bowhead Whale ecology, the marine ecosystem of Isabella Bay, and the historical ties of the Inuit to traditional and commercial whaling. Research outcomes will provide a sound basis and infrastructure for management, education, and eco-tourism projects and programs.

⊲⊳ے ۲۵ مح Management Goals



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The long-term vision for Ninginganiq NWA is protection of Bowhead Whales and other wildlife, conservation of the marine and terrestrial habitats on which they depend, and protection of the traditional Inuit use of the area. The NWA will also serve as a key site for research on Bowhead Whale ecology, the marine ecosystem of Isabella Bay, and the historical ties of the Inuit to traditional and commercial whaling. Research outcomes will provide a sound basis and infrastructure for management, education, and eco-tourism projects and programs.

Protect Bowhead Whales and other wildlife using Ninginganiq NWA, and the marine and terrestrial habitat they depend on, from harm by human activities.

Conserve and protect the cultural and historical elements of Ninginganiq NWA, especially with regard to traditional and commercial whaling.

Increase public awareness of, and appreciation for, the natural and cultural resources of the area, particularly Bowhead Whales and other wildlife.

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Management	Objectives



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Protect Bowhead	Make organizations with a mandate to regulate activities outside the jurisdiction of ECCC aware of the conservation goals and objectives of the Ninginganiq NWA.
Whales and other wildlife using Ninginganiq NWA, and the marine and terrestrial habitat they depend on, from harm by human activities.	Control, supervise, and monitor access to Ninginganiq NWA.
	Effectively enforce regulations to prevent threats to Bowhead Whales, other wildlife, and their habitat; work with relevant regulatory agencies, as required.
	Monitor the terrestrial and marine ecosystems to establish baselines and monitor change in these baselines over time.

Empower Inuit to play a leadership role in documenting environmental conditions and changes.



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Conserve and protect the cultural and historical elements of Ninginganiq NWA, especially with regard to traditional and commercial whaling.

Control, supervise, and monitor access to Ninginganiq NWA

Empower Inuit to play a leadership role in documenting archeological sites and artifacts.

Conduct research on cultural and historical elements to identify areas of archeological importance.

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Increase public awareness of, and appreciation for, the natural and cultural resources of the area, particularly Bowhead Whales and other wildlife.

Create promotional and educational materials and make them available to the public.

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Management Approaches outline ways to address the Management Challenges, while meeting the Management Goals

> Cultural Resources Management Wildlife and wildlife habitat Management Monitoring and Research Public Awareness and Information Management

⊲⊳ౖౖంం∿ౕం ు∆్ిరం Management Approaches

Cultural Resources Management

Ensure preservation of archeological sites through the permitting process and add to knowledge through inventory, research, and mapping projects.

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Wildlife and wildlife habitat Management

- Control human activities in the NWA through the permitting process- do not permit activities that are incompatible with the conservation objectives of the area (e.g., commercial fishing, oil and gas, etc.)
- Ensure other regulatory agencies are aware of the NWA vision, goals, and objectives and consider them in their decision making processes.
- Create guidelines to mitigate human impacts on wildlife, especially whales.

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Monitoring and Research

- Support ongoing research and monitoring, document archaeological sites
- Improve knowledge of ecological and cultural resources in the NWA
- Improve knowledge of vessel traffic and noise in and around the NWA.

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Public Awareness and Information Management

develop education and outreach materials to inform Canadians about the cultural and ecological significance of Ninginganiq NWA.

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- Inuit do not require a permit to enter the NWA for traditional activities, including harvesting, removal of carving stone, setting up camps (Nunavut Agreement and IIBA)
- Inuit do not require a permit to enter the NWA when working as a hunting or fishing guide





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Authorized Activities and Access

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- All non-Inuit do require a permit to enter and conduct any activities in the NWA (land or water) including non-Inuit sport hunters, researchers and tourists
- All commercial or business activities (Inuit and non-Inuit owned businesses) do require a permit-except for Inuit hunting and fishing guides.



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ec.cwspermitnorth-nordpermisscf.ec@canada.ca

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- Persons who require a permit to enter the NWA can apply for a permit from the Canadian Wildlife Service:

ec.cwspermitnorth-nordpermisscf.ec@canada.ca

Iqaluit office: 867-975-4642

The Ninginganiq ACMC reviews all permit applications and provides recommendations to the Canadian Wildlife Service on whether the permit should be issued or not.

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for 'L<< a>D
- Permits may be issued if:
 - ▶ The activity is scientific research relating to wildlife or habitat conservation
 - ► The activity benefits wildlife and their habitats
 - ► The activity contributes to wildlife conservation
 - ▶ The activity is consistent with the purpose of the NWA and the management plan

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Management Plan Implementation

- Implemented as resources (time and money) allow
- Plan will be reviewed after 5 years, and then every 10 years after that

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The Ninginganiq ACMC recommends the Ninginganiq NWA Management Plan to the NWMB for approval

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Contact Information: Ninginganiq Area Co-Management Committee c/o Vice-chairperson Danica Hogan <u>danica.hogan@canada.ca</u> (867) 669-4754

Consultation Record for Ninginganiq NWA Management Plan

Organization	Contact	Date sent	Invited to Meeting?	Response received?	Comments?
Department of Fisheries and Oceans (Science)	Steve Ferguson Research Scientists- Marine Mammals <u>Steve.ferguson@dfo-</u> <u>mpc.gc.ca</u>	Nov. 8, 2019	N	Y- E-mail Nov 29, 2019	N
McGill University- Department of Geography	George Wenzel Professor of Geography (Clyde River history/culture focus) george.wenzel@mcgill .ca	Nov. 4, 2019	N	Y- Email Nov. 14, 2019	Ŷ
Department of Fisheries and Oceans (Oceans)	Joel Ingram Manager, Protected Areas Joel.Ingram@dfo- mpo.gc.ca 204-983-5006	Jan. 14, 2020	Y	Y- Email Feb.7, 2020 (reviewed by Charlotte Sharkey)	Y
Nunavut Tunngavik Incorporated	Pacome Lloyd plloyd@tunngavik.co m Qilak Kusugak <u>qkusugak@tunngavik.</u> <u>com</u>	Jan. 13, 2020	Y	Y-Email Feb.7, 2020 acknowledged reminder to provide input	N
Qikiqtani Inuit Association	Jovan Simic IIBA Implementation Manager Jsimic@qia.ca	Jan. 13, 2020	Y	Y- Email Feb 20, 2020	Y
Clyde River Hamlet	Angela (<u>reception@clyderiver</u> <u>.ca</u>) 867-924-6220	Phone call Jan. 14, 2020 Jan. 14, 2020	Y	N- Note that mayor attended Clyde River community meeting Angela sent to mayor for review- requested in English Angela agreed to	N
				post flyer for the community meeting	

				and also provide a copy of the plan to anyone wanting to read it in the community-flyers indicate hard copies available at the hamlet.	
Clyde River HTO (Nangmautaq HTO)	Listed number 867- 924-6202 is no longer in service. <u>htoclyde@qiniq.com</u> <u>clyde@baffinhto.ca</u> (from Qikiqtaaluk Wildlife Board Website and QWB secretariat Kolola Pitsiulak)	Jan. 21/22 2020- ENG	Y	N- Note that representative attended Clyde River community meeting Feb.10, 2020 - requested presentation- sent to HTO Feb.11, 2020	N
Qikiqtaaluk Wildlife Board	Kolola Pitsiulak Nunavut Inuit Wildlife Secretariat Executive Director- Qikiqtalluk Region <u>kpitsiulak@niws.ca</u>	Jan. 22, 2020	Y	Y- Email Jan 22 2020 acknowledged receipt of plan	N
Clyde River Community	Flyers in hamlet office, airport, Northern Store, etc. Radio Invite- Mayor and ACMC members Facebook posts- Clyde River News and Clyde River Sell/Swap Feb. 10, 2020 Community Meeting @Parish hall 7pm- 10pm	Feb.10, 2020 Community meeting Flyers and available for reading since Jan.14, 2020 (Hamlet)	Y	Y	Y- See community meeting summary
Government of Nunavut- Wildlife, North Baffin	Scott Johnson Manager Wildlife, North Baffin <u>sjohnson2@gov.nu.ca</u>	Jan. 17, 2020	Y	Y- Email Jan. 17, 2020, Email Feb. 17, 2020	N

	867-899-7360 Markus Dyck Polar Bear Biologist <u>Mdyck1@gov.nu.ca</u>				
Government of Nunavut – Culture and Heritage	Sylvie LeBlanc Territorial Archaeologist <u>SLeBlanc1@gov.nu.ca</u> Phone: (867) 934-2040	Jan. 14, 2020	Y	Y- Email Feb.20, 2020	Y
Inuit Heritage Trust	William Beveridge Executive Director <u>wbeveridge@ihti.ca</u> Lynn Peplinski Traditional Place Names Manager <u>Ipeplinski@ihti.ca</u>	Jan. 14, 2020	Y	N	N
CIRNAC	Erik Allain Director of Lands <u>erik.allain@canada.ca</u> Phone: (867) 975-4295	Jan. 14, 2020	Y	N	N

NOTE: Comment period extended to Feb.21, 2020- reminder sent to all those that did not provide comments by Feb.17, 2020.



January 14, 2020

DRAFT MANAGEMENT PLAN FOR NINGINGANIQ NATIONAL WIDLLFIE AREA

The <u>Ninginganiq National Wildlife Area</u> is located ~100km south of Clyde River and was established in 2010. As required by the *Nunavut Agreement*, an <u>Inuit Impact and Benefit</u> <u>Agreement for National Wildlife Areas and Migratory Bird Sanctuaries in the Nunavut</u> <u>Settlement Area (IIBA)</u> was first concluded in 2006 and renegotiated in 2016. Nunavut Tunngavik Inc., the three Regional Inuit Associations, and the federal Minister of the Environment, Environment and Climate Change Canada signed the *IIBA*. The *IIBA* created comanagement committees for these protected areas in Nunavut. Inuit from Clyde River, and Environment and Climate Change Canada co-manage the Ninginganiq National Wildlife Area through the Ninginganiq Area Co-Management Committee (ACMC).

Part of the Ninginganiq ACMC's mandate is to write a management plan for the National Wildlife Area. The ACMC completed the draft management plan and is holding a community meeting **10 Feb 2020 in Clyde River at the Parish Hall from 7pm-10pm** to discuss the plan content and get feedback. Everyone is welcome!

We realize that not everyone can attend this meetings. The Ninginganiq ACMC is also welcoming input on the management plans via email. We ask that you provide all written input by **9 February, 2020** to Danica Hogan, Vice-Chair of the Ninginganiq ACMC (danica.hogan@canada.ca; 867-669-4754).

Sincerely,

Sam Palituq Chair, Ninginganiq ACMC

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14, 2020 - المعط



Hogan, Danica (EC)

From: Sent: Subject: Hogan, Danica (EC) February 17, 2020 11:46 AM Ninginganiq National Wildlife Area draft Management Plan- final call for comments Feb.21 2020

Hello,

You previously received an email inviting your organization to provide comments (in- person or in writing) on the Ninginganiq National Wildlife Area draft Management Plan. The Ninginganiq Area Co-management Committee (ACMC) held their community meeting in Clyde River, NU on Feb.10, 2020 to receive in-person comments. The deadline for providing written comments was Feb.9, 2020.

I am touching base with you now to provide you with one final opportunity to provide written comments on the plan. The ACMC will extend the comment period to Feb. 21, 2020, after which date the comment period will be closed.

Please feel free to get in touch should you have any questions about the plan or how to provide written comments.

Have a wonderful day,

Danica

Danica Hogan, M.Sc.

A/Shorebird Biologist, Northern Region, Canadian Wildlife Service (Yellowknife) Environment and Climate Change Canada / Government of Canada <u>danica.hogan@canada.ca</u> / Tel: 867-669-4754

A/Biologiste des oiseaux de rivage, Région du Nord, Service canadien de la faune (Yellowknife) Environnement et Changement climatique Canada / Gouvernement du Canada <u>danica.hogan@canada.ca</u> / Tél. : 867-669-4754

Community Meeting

about the draft management plan for Ninginganiq National Wildlife Area



- See the content of the draft Management Plan and provide your input
- Meet the Ninginganiq Area Co-Management Committee members
- Refreshments will be served

- Share your knowledge and stories about Ninginganiq
- Learn more about the National Wildlife Area
- Door Prizes
- Plan available to read at Hamlet office

Everyone welcome!

Where: Parish Hall

When: February 10: Open House 7pm with presentation at 7:30pm

~ For more information call or e-mail Danica Hogan- <u>danica.hogan@canada.ca</u> or 867-669-4754

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Community Meeting Notes: Feb 10 2020

7pm- 10pm

Parish Hall, Clyde River, NU

ACMC Participants:

Present: Sam Palituq (Chair) Leah Tassugat Danica Hogan (Vice Chair) Jaysie Tigullaraq

Shauna Seeteenak (Inuit Learning and Development Program with CWS) Lisa Pirie-Dominix (Protected Areas Head, Northern Region, CWS)

Regrets: Enuusiq Jaypoody (absent for medical reasons), James Qillaq (NWB meeting)

Others Present: Jerry Natanine (translation)

Proceedings:

Meeting started at 7pm

- 1. Open house to view posters, meeting the committee, get snacks
- 2. 7:30pm Opening Prayer and Chair and Vice-Chair Opening Remarks (Sam Palituq and Danica Hogan)
- 3. 7:45pm-8:30pm Management Plan Presentation (Presented by Danica Hogan)
- 4. 8:30pm-9pm BREAK and Door Prizes
- 5. 9pm-10pm Open floor open for questions and comments
 - a. Community Member Comment/Question: General comment about growing up there and hearing stories about the area from father

b. Community Member Comment/Question: Why has it taken so long to make the management plan? Where is the lodge that was talked about? Community has been talking about this since 1990s. Asking because he is envious of other communities that have areas like Ninginganiq and they employ people for tourism purposes. Where is the tourism?

ACMC Response: Danica indicated that the plan has taken a long time partly due to logistical circumstances in the ACMC (deaths, changes in members, etc.) and partly due to the fact that the committee really wanted to make sure they had all of the available information when writing it, and really wanted to take their time to make sure the plan was done right. Sam added to this reiterating the responsibility the committee members felt to go slowly to make sure the plan really reflected what was best for the area and community.

c. Community Member Comment/Question: Why on the map is the area marked all the way up to the shoreline and some land is included in the boundary?

ACMC Response: Danica indicated that the boundary was established with the community of Clyde River/ the old steering committee before the area was designated in 2010. Sam indicated that the boundary was made to include up to about 1 mile of land around the bay to ensure that tourists/researchers couldn't just camp on the land at the edge of the bay to do work in the area.

- d. Community Member Comment/Question: Educating the public about this is good. Thank you for making things so clear.
- e. Community Member Comment/Question: Why isn't CWS here? They negotiated with the HTO, so we should see more of them since our ancestors negotiated with them. It seems like all of the old work is being forgotten or changing. Why aren't there more meetings in Clyde River?

ACMC Response: Danica clarified that the ACMC works directly with CWS and that she is part of the ACMC as the CWS member. The management plan was created with the committee and CWS, as was agreed upon in the IIBA, and was based on all of the old work with the HTO/Steering Committee that established the NWA- the old work is not being forgotten or changed, the ACMC is the continuation of the work. Sam indicated that all of the ACMC meetings are held in Clyde River and that the management plan was created from documents and interviews that resulted from all of the old work

f. Community Member Comment/Question: I'm from the HTO and I got the copy of the draft management plan that the ACMC sent us, but could you please share the presentation you just gave as well?

ACMC Response: Danica promised to send a copy of the presentation to the HTO the next day (NOTE: Presentation sent via email Feb.11, 2020).

g. Community Member Comment/Question: When will the draft be finalized? Asking because TINMCA only took 2 years.

ACMC Response: Danica indicated that the draft will undergo edits once all of the comments from reviewers/this meeting are addressed, then it goes to NWMB and the Minister of ECCC for approval. Can't give a definitive date that it will be due, but ACMC wants to try to have it finalized by end of 2020. TINMCA is going through a different process, so it is not necessarily comparable to the ACMC process.

h. Community Member Comment/Question: I want this to be finished while our elders are still alive. Make it happen as fast as you can so we can see it become real while they are still alive. I am glad that we can talk face to face.

6. Closing comments and Final Door Prizes 10pm

SIGN IN SHEET

EVENT: NINGINGANIQ ACMC COMMUNITY MEETING	LOCATION: PARISH HALL
DATE: Feb.10 2020	9 A
LIST OF	ATTENDEES
NAME (PRINT FIRST AND LAST NAME)	NAME (PRINT FIRST AND LAST NAME)
1 Mary Tatatourile	25
2 - TP < -	26
3 Trans, Atra Dia	27
4 202 0 67	28
5 5 0206	29
6 Sampeta Vilteta	30
7 The Part	31
8 5008 455	32
9 (Domie Rook	33
10 Fene Quila	34
11 Janel Jaypooty	35
12 199 Jane 100	36
13 SIANDY KAUTUR	37
14 Mike Jaypoody	38
15 Annie Igy WEyerk	39
16 Tine April	40
17 MAGGE Q	41
18 INUTER TRAPPIELS	42
19 Procesie Pallag	43
20	44
21	45
22	46
23	47

Organization	Comments	ACMC Response
Department of Fisheries and Oceans (Oceans)	Ninginganiq NWA	Changed to "their"
	In Nunavut, Nunavut Inuit, as per the	
	Nunavut Agreement (NA), can hunt wildlife,	
	including the collection of migratory bird eggs	
	and feathers, for his or her economic, social,	
	and cultural needs.	
	This sentence doesn't read well, as Inuit is	
	plural and then it switches to singular, 'his or	
	her'. Could change to "In Nunavut, a Nunavut	
	Inuk, as per the NA" or change his or her to	
	their.	
	p. 1	Changed, as suggested.
	Isabella Bay is also classified as an	
	'Ecologically and Biologically Significant Area'	
	by the Department of Fisheries and Oceans	
	Canada (DFO 2015b).	
	Suggest changing 'classified' to 'identified'.	
	р. б	Spelling corrected. Answer to question about
	-I usually see Kangiqtugaapik spelled with one	shore lead is unknown.
	'n'.	
	-curious to know how frequently 'exceptional	
	years' occur, when Baffin Island shore lead	
	opens early, and whether increased	
	frequency is predicted.	
	р. 7	Nangmautaq refers to the name of the HTO
	-Clyde River HTO is used but Nangmautaq	in Clyde River, while the Clyde River HTO
	HTO is used below in the document.	refers to the organization in Clyde River-I've
	-Kimmirut (then Lake Harbour) and Iqaluit	clarified this in the text. Added information
		about old name (Lake Harbour).
	p. 11	Changed, as suggested.
	- -Tunit should be plural: Tuniit	

Comments Received by the Ninginganiq ACMC Regarding the Draft Ninginganiq NWA Management Plan

Polar Bears are present throughout Baffin	
Bay and Davis Strait with apparently stable,	
or according to Inuit, increasing populations	
(Dowsley 2007, Peacock et al. 2013).	
Could be more objectively phrased like this:	
'with apparently stable, according to	
scientists, or increasing, according to Inuit,	
populations.'	
p. 25	Changed to Kuuktannaq, as this is the official
, Kuuktanaq – there are three different	spelling on the map.
spellings of this in the document (assuming	
it's the same river): Kuuktanaq, Kuuktaanaq	
and Kuuktanaag.	
-the NWMB is the main instrument of wildlife	Changed, as suggested. Information
management in the NSA; it doesn't just	regarding clarification of the process for
manage harvest of wildlife by Inuit, but also	changing harvest rates also noted in the
by non-Inuit.	
,	management plan.
-the NWMB and Government of Nunavut co-	C'astronomic fully Day has discussed as the train
manage terrestrial wildlife (including polar	Significance of the Bowhead hunt to Inuit is
bears), and the NWMB and DFO co-manage	already discussed elsewhere in the
marine wildlife (excluding polar bears).	management plan.
Suggest change to "DFO, NWMB and	
Regional Wildlife Organizations Wildlife	
Management Boards under the NA co-	
manage Bowhead hunting. In 2015, NWMB	
and DFO increased the total allowable	
harvest of Bowhead Whales in the NSA from	
three to five Bowheads per year, which is	
well below the calculation of harvest that the	
ECWG bowhead whale population can	
support (DFO 2015a)."	
-DFO 2015a provides scientific advice on	
harvest levels. DFO takes this scientific advice	
to NWMB and requests a decision from the	
to inversion and requests a decision non the	

NWMB on modifying the total allowable harvest. The NWMB makes a decision and the Minister of DFO accepts it (in this case). So 2015a is not really an appropriate reference for the TAH being increased, which was a management decision that considers the best available information including the scientific advice, but does not have to correspond to the scientific advice. It is an appropriate reference for the scientific advice itself, which I've added in above. -could add some perspective on significance of these hunts to Inuit.	
The ACMC suggests that visitors follow recognized whale-watching guidelines and regulations -may want to list some examples of these guidelines and regulations? ECCC should develop additional guidelines for visitors, -is this something that ECCC plans to do? Something that's been recommended by the ACMC? Can this be said in a different way from what 'should' be done.	Changed to will be done- the plan is written by the ACMC, so the ACMC is saying that ECCC may create these guidelines as information becomes available for the NWA.
-Tourism – add that a permit must be obtained to conduct tourism in the NWA	Not added here, as this section is simply talking about management considerations for CWS management of the area. Section 7 speaks to the need for visitors to obtain any required non-CWS permits.
p. 31 Generally, whales in Ninginganiq NWA show little reaction to vessel passages, but	This is IQ. No specific reference, just what Inuit from Clyde have observed.

sometimes when ships approach closer, the	
whales move into shallow waters.	
Is there a reference for this?	
Ship collisions – it's my understanding that a	Yes, a permit is required, but this does not
permit must be obtained to transit through	mean that permitted ships cease to be a
the NWA? So why would we expect increased	threat.
risk of collisions when whales are feeding in	
Isabella Bay, i.e. in the NWA	
Pollution – may want to mention the	Thanks! This is a good suggestion. I have
Strategic Environmental Assessment (SEA) in	added text referencing the report.
Baffin Bay/Davis Strait to assess the potential	
impacts of possible future offshore oil and	
gas activity and inform decision-making.	
On July 31, 2019 the Nunavut Impact Review	
Board submitted a final report and	
recommendations for the SEA in Baffin Bay	
and Davis Strait. It can be accessed on their	
public registry at	
https://www.nirb.ca/project/125087. The	
three volumes of the final report appear	
under the 'Documents' tab at the top of the	
page.	
Commercial fishing is an activity that is likely	Added this reference to showcase Greenland
to grow in Nunavut waters as climate	Halibut importance.
changes (Church 2011).	
I think this sentence sets the wrong tone, as	
commercial fishing is already huge in	
Nunavut waters. See Integrated Fisheries	
Management Plans for Greenland halibut and	
Northern shrimp. Suggest something more	
like what's stated with respect to Greenland's	
fishery: Greenland Halibut and Northern	
Shrimp are important fisheries off Baffin	
Island.	

http://www.dfo-mpo.gc.ca/fisheries-	
peches/ifmp-gmp/groundfish-poisson-	
fond/2019/halibut-fletan-eng.htm	
In 2017, the Division 0B [the Canadian side of	
Davis Strait] Total Allowable Catch [for	
Greenland halibut] increased to 7,575 t for	
the 2017 and 2018 fishing seasons.	
Subsequent TAC increases in OB have been	
implemented by the Minister and can be	
found at the following website.	
[The Division 0A (the Canadian side of Baffin	
Bay) TAC for Greenland halibut] increased to	
8,575 t for the 2017 and 2018 fishing	
seasons. Subsequent TAC increases in OA	
have been implemented by the Minister and	
can be found at the following website.	
The Subarea 0 [Division 0B + Division 0A]	
Greenland Halibut fishery adds significant	
economic value to Northern communities.	
The landed value average for Nunavut	
Enterprises from 2011-2017 was around \$90	
million per year. The fishery is also	
considered to be the most lucrative Atlantic	
groundfish fishery with the largest Greenland	
Halibut TAC in domestic waters.	
Offshore catches are taken using either	
bottom otter trawl (single and twin trawl) or	
bottom set fixed gear (longline, gillnet).	
http://www.dfo-mpo.gc.ca/fisheries-	
peches/ifmp-gmp/shrimp-crevette/shrimp-	
crevette-2018-002-eng.html	
-also I don't think that Arctic Char would be	
fished "offshore", but rather along the coast	
(local fish harvesters would know best)	

	Health & Safety – it's my understanding that if it's necessary for safety purposes, a vessel may transit the NWA without a permit, and the incident is then reviewed afterwards, to ensure it really was necessary for safety purposes. There is nothing to this effect discussed in this section.	Yes, but this is part of other regulations, not CWS regulations. Even the NOTMARS for this area does not state this.
Government of Nunavut – Culture and Heritage	Referring to Section 2-This section appears to be limited to general background information, culture history and include a few know locations. However, it does not address a management plan for the protection, management and conservation of cultural and heritage resources. As a reference see the this below: https://www.pc.gc.ca/en/docs/pc/guide/gra- mar/index	Management of the NWA and it's resources is addressed in Sections 4-10.
	Pg. 14 Identified sites need to be recorded and reported to the Territorial Archaeology Office to be entered in the territorial site database.	These are sites already recorded by the Prince of Whales Northern Heritage Center.
	Pg. 34- The investigation and recording of archaeological sites requires a permit that is issued by the Government of Nunavut. The visitation of archaeological sites by tourists also require a Class 1 archaeology permit.	We added a paragraph in section 6.1 making reference to protection of archaeological and cultural heritage sites under the IIBA, the Nunavut Archaeological and Palaeontological Sites Regulations, and Article 33 of the Nunavut Agreement as follows:
	Needs to refer to Nunavut Legislation.	"In accordance with s. 2.1.7 of the IIBA, the archaeological and cultural heritage of Inuit must be protected in the management of Ninginganiq NWA. This includes protection

	and conservation of archaeological sites,
	artifacts, and cultural sites of importance to
	Inuit. All activities within the NWA must
	comply with the requirements of the
	Nunavut Archaeological and Palaeontological
	Sites Regulations and Article 33 of the
	Nunavut Agreement. If an archaeological site,
	specimen or artifact is encountered which
	has not been previously identified, it should
	be photographed and the geographic
	coordinates recorded. This information must
	then be provided to the Government of
	Nunavut's Department of Culture and
	Heritage, the Inuit Heritage Trust, and NTI as
	soon as reasonably practicable."
Section 11.2 Remove: "and Heritage develops	Changed, as suggested. Clarified that the
and implements policies, programs and	ACMC provides advice about CWS permits,
services aimed at strengthening the culture,	where applicable, to avoid potential
language, heritage and physical activity of	confusion surrounding permits issued by the
Nunavummiut. The Department of Culture	GN.
and Heritage maintains close working	
relationships with the professional	
archaeology and palaeontology communities,	
with Nunavut communities, with the Inuit	
Heritage Trust, and with other territorial and	
federal government agencies." And Replace	
with "The GN Department of Culture and	
Heritage is the government agency	
responsible for the management and	
protection of archaeological and	
palaeontological sites in Nunavut. This is	
done through regulations, legislation, and	
policy. These regulations include obtaining	
authorization from the GN, in the form of a	

	normit to conduct any type of activity at an	
	permit, to conduct any type of activity at an	
	archaeological or paleontological site,	
	whether it is research, resource	
	development, or tourism."	
Qikiqtani Inuit Association	Objective 1.4 is closely tied to Objective 1.5 –	The co-management structure of the NWA
	in other words, monitoring should be Inuit	ensures that Inuit are actively involved in all
	led – not just based on science, but also Inuit	management aspects of the NWA, however,
	knowledge.	the ACMC explicitly wanted to state that Inuit should play a role in the
	Similarly, objective 2.3 is closely linked to	documenting/monitoring of values in the
	objective 2.2 – research needs to be based on	NWA- hence Objectives 1.5 and 2.2. The
	IQ principles and have heavy Inuit	reason for this is that while management of
	involvement.	the area will always involve Inuit (through the
		ACMC), outside research may not always
	Maybe that's what's understood by	involve Inuit. The listed objectives are an
	objectives 1.4 & 2.3, but I figured I would	explicit expression from the ACMC that we
	mention it, as Inuit involvement on some of	will encourage Inuit involvement in all
	the objectives is explicitly mentioned. It	monitoring/documenting of values.
	might just be a consistency thing.	6, 6
	5 - j	
	"During the period when the whales are	The ACMC recommended we put this in the
	present in the NWA (i.e., usually from early	plan so whales are not disturbed in the NWA.
	August to late October), any subsistence	Ultimately, the plan cannot keep Inuit from
	harvest of marine mammals is strongly	hunting whenever and whatever they want in
	discouraged in the NWA, particularly in the	the NWA (see section 7), which is why this is
	shallow area beside Nuvuktiapik and the	worded as a discouraged activity and not a
	deep feeding troughs."	prohibition. And yes, the HTO has had an
	Did this come out of consultations with	opportunity to provide input on the plan.
	HTO? This basically means that during the	
	main hunting season Inuit are discouraged	
	from using the area. Sorry, this is more of a	
	question as I am still familiarizing myself with	
	the file.	

	6.4 Research – There is significant concern expressed with activities that might have negative impacts on the Bow Head Whales, even to a point of discouraging traditional use of the area (see my comment above). Has there been any thought put into what impacts research activities might have?	Collection of any information should be conducted by qualified individuals- the ACMC is recommending/identifying priorities for monitoring in the management plan, but it will not necessarily be CWS or the ACMC that performs this monitoring. Research activities have to be approved by the ACMC through the CWS permitting process. Generally speaking, the ACMC considers any potential impacts that any permitted activity might have on the NWA during the permit review process. Almost any activity will have an impact on something, so part of the ACMC's job is to weigh the potential impacts and benefits of an activity when deciding whether to recommend a permit be issued by CWS.
	Once again, I apologize for mostly asking questions rather than providing comments, as I try to catch up with the history of this file	No problem! Questions are great! And if you ever have other questions about the ACMC or Ninginganiq NWA, please feel free to get in touch!
George Wenzel	On p23/T3, I was surprised by the inclusion of beluga and no mention of narwhal. If my memory serves, narwhal are far more abundant and more frequently encountered in the Clyde area, including Isabella Bay, than beluga. I took a quick look at the Clyde 5yr totals in the NWMB and beluga seem indeed to be rare visitors. You might check about narwhal v. beluga with Sam and the committee crew.	Checked this with the committee-keeping the Beluga on the list.

Draft Management Plan Ninginganiq National Wildlife Area

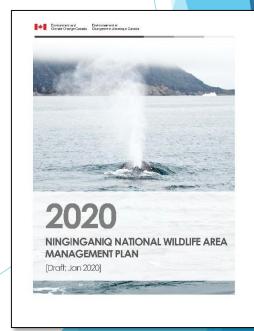


لح∿™⊃لٰ∧⁵, à≤∽⊲⊂ 10, 2020 Clyde River, February 10, 2020

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- Information on protected areas in Nunavut
- Show you the content of the Draft Management Plan
- Get your input and comments on the Draft Management Plan





Information on National Wildlife Areas and Migratory Bird Sanctuaries in Nunavut

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Purpose of Network

- Conservation
- Research
- Interpretation

National Wildlife Areas (NWA) Migratory Bird Sanctuaries (MBS)

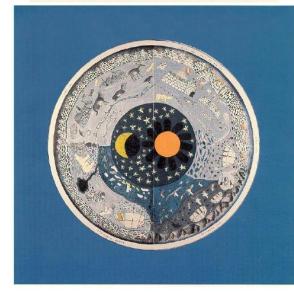
National Wildlife Areas Réserves nationales de faune (54) Migratory Bird Sanctuaries Refuges d'oiseaux migrateurs (92)

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	MBS	NWA
Protection Focus	Migratory birds	All wildlife
Protection Period	Nesting/breeding season	Year-round
Legal Basis	Migratory Birds Convention Act	Canada Wildlife Act

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Affaires indiennes et du Nord Canada



INUIT IMPACT AND BENEFIT AGREEMENT for National Wildlife Areas and Migratory Bird Sanctuaries in the Nunavut Settlement Area

2016 TO 2023 INUIT IMPACT AND BENEFIT



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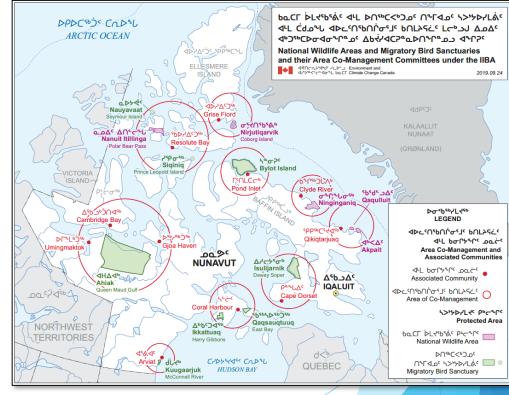
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- Decisions for Migratory Bird Sanctuaries and National Wildlife Areas strongly influenced by Inuit Qaujimajatuqangit
- Guarantees comanagement of Migratory Bird Sanctuary and National Wildlife Areas Important feature: Area Co-Management Committees

⊲▷∟⊆∩ኑ▷⁵ⴰ⊂▷☞ˤ⅃⊆ ⴰ∩և⊦ʕ∟⊆ Area Co-Management Committees (ACMCs)

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- 9 ACMCs were created in Nunavut to co-manage the 13 protected areas
- Made up of 5 people from the associated community and 1 from Canadian Wildlife Service (Environment and Climate Change Canada)





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- Ninginganiq ACMC was formed in 2009
- 5 members from Clyde River
 - Sam Palituq (Chair)

 - James Qillaq
 - Enuusiq Jaypoody
 - Jaysie Tigullaraq
 - Leah Tassugat
- 1 member from Canadian Wildlife
 Service: Danica Hogan (Vice-Chair)



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ACMC will:

- advise the Minister on all aspects of MBS/NWA management
- review permit applications
- develop Management Plans





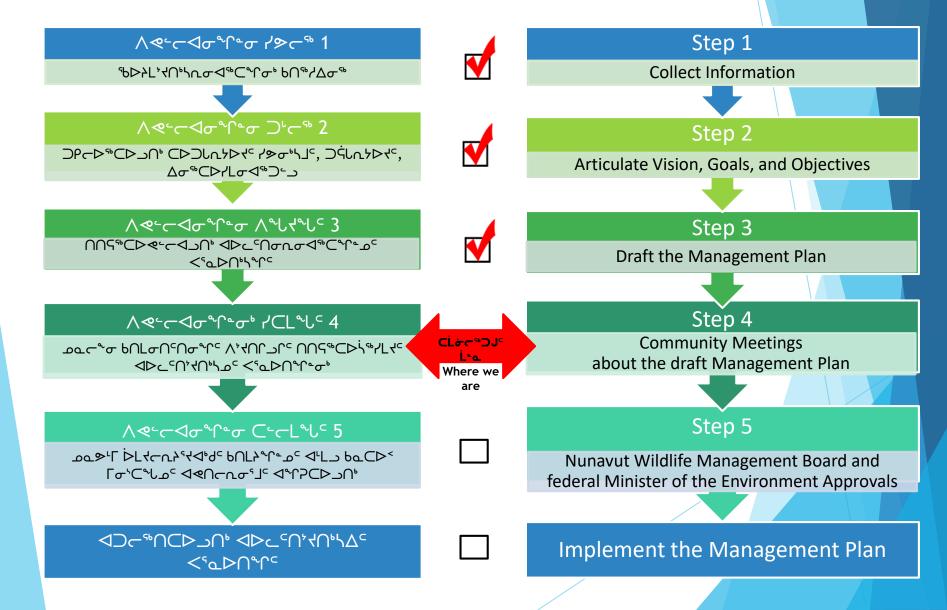
لامە LC مەردە كەرە <ئە كەرە <ئە What is a management plan?

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- Allows the Area Co-Management Committees to share their vision of the protected area
- Guides decision making for the protected area
- Describes important cultural and environmental aspects
- States which activities are permitted and not permitted



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Content of the Draft Management Plan for the Ninginganiq National Wildlife Area

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- Description of the National Wildlife Area
- Ecological resources
- Cultural resources
- Vision, goals and objectives
- Management
 Considerations things to consider in managing the National Wildlife Area







దురాిగం చెంది చెంది చెంది చెంది చెంది Content of the Management Plan

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- Management Approaches what we will do to achieve the goals and objectives
- Authorized Activities and Access

 what activities require a
 permit, who requires a permit
- Management Plan implementation and collaboration



^కం∿ ∧≪్⊂⊲∩⊲్∟ం ి7L°L°Ĺ Historical Background

- ۵۵-۵۰۲۰ ۸۵-۲۹۲۰ ۵۰-۵۰۲۰ ۸۵-۵۰۰ (۸۲۹۵۰ ۲۰۰۰)
- Established as a National Wildlife Area in 2010 to protect Bowhead Whales and their habitat.
- Community-based initiative (started in 1983)



ຼຼຼຼຼຼຼຼຼຼຼຼຼຼຼຼ Landscape

- 3,362 km2 b∩ິJ: ᠘⊆າວັດ, 2,832 km2 ΔL໖ ປີ__ 530 km2 ໑໑
- Λ钻イレハーンJ Δしーいづい くいし McBeth しいいう レッレイ・ワーム 12 nm Pーー レック

- 3,362 km² total: includes 2, 832 km² of marine waters and 530 km² of land
- Includes Isabella Bay from mouth of McBeth Fiord out to 12 nm limit
- Includes all islands within the bay and land located within ~ 1km of the shoreline
- Rugged land, especially on the south side of the bay





ຼຼຼຼຼຼຼຼຼຼຼຼຼຼຼຼ Landscape

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 ጜ፟∿しዾ^c ∧ᠯ°ዺ▷∩ጜ₽⊂▷ᠯ^c)
- Mostly federal crown land and federally controlled marine waters
- 4 parcels of Inuit
 Owned Land (surface rights)



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- Important feeding area for Bowhead Whales in Canada-up to 147 whales at one time
- Polar bear summer and denning habitat
- 15 species of mammals
- 43 species of birds
- Important staging/moutling site for King Eiders, Long-tailed Ducks, and Dovekies
- Diverse marine community of fish and invertebrates
- 5 species at risk





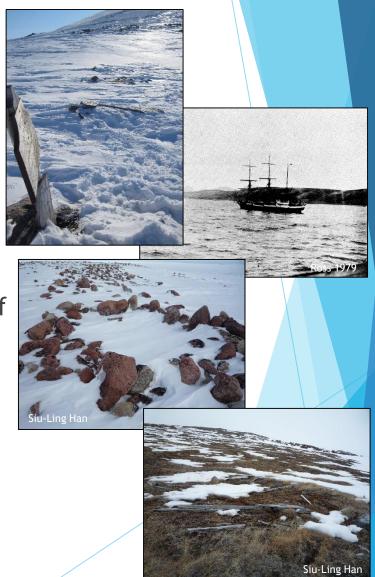
⊲≪∩∿لۍ ے۔ آک⊂∆ نے اُک∟√∆ پی ∧⊂∿⊃ ⊂Ld Cultural Resources

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Inuit have used Ninginganiq for thousands of years

- Several known archaeological sites, cultural features & artifacts in the area
- Include Thule, modern Inuit, and European whaling sites
- Likely many unregistered sites in the area



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- Hunting- seals, whales, polar bears, birds, some terrestrial mammals
- Egg collection- especially goose and eider
- Trapping- foxes and wolves
- Fishing- mostly Arctic Char
- Camping



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- Research
- Tourism- Cruise ships, sailboats





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Management considerations are things we need to be aware of within, and surrounding, the protected area in order to effectively manage it



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No significant or immediate threats, but:

- 1. Harvest of Wildlife
 - need to work with management authorities to make sure harvest is sustainable
- 2. Tourism
 - Likely to increase in future
 - Need guidelines for tourism vessels





⊲⊳ے ^c∩ σ ^c 」^c ∆ ∠ L^b ∖^b ∠ ⊃ ∩^b ∖ ∆^c Management Considerations

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3. Noise

• Need to better understand how noise from humans impacts whales in area.

4. Ship Collisions

- Ships likely to increase
- Need to protect whales from collisions



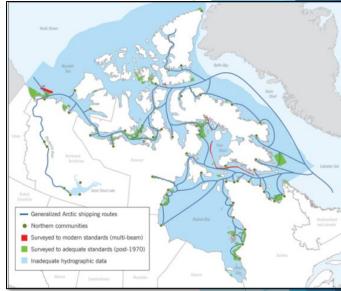


Management Considerations

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- 5. Pollution
 - None now, but could increase with more ships
- 6. Commercial Fishing
 - None now, but could increase in future
 - Risk of entanglement
- 7. Climate Change
 - Can't control, but need to document changes
 - Could increase marine traffic and predation by killer whales



CD⊃LLלC, ⊃GLLלC, ∆σ^{Sb}CD√LלC, ∆σ^{Sb}CD√LלCVision, Goals, and Objectives

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Vision

A description of what the protected area should be Incorporates the protected area's purpose **⊲⊳ຼິ∩ଟ໌⅃ິ ⊃ൎഀ഻ഀՐ** ⊳ഀҌҎ∩҆ ີ ໑຺ຉ໑∆۶∆൳໊ ⊃ൎ൨൨ഀ۶⊳๙൳ഀ ⊂⊳⊃Ⴑ൨ഀ۶⊳๙ ⊲ഀ഻L₂ ഀ๖ຉ໊ ⊲ഀഄL۶⊳൳⊲ഀഀLഀ഻C ൎഀഀ₽⊳L∩⊂⊳_∩഻_

Management Goals Statements that provide targets for how the vision will be met and maintained

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Management Objectives Provide direction on how to achieve each goal

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Cdୁଟ୍ଟୁ ମୁସ୍ଟୁ CDମମ୍ଦୁ Vision for the NWA



The long-term vision for Ninginganiq NWA is protection of Bowhead Whales and other wildlife, conservation of the marine and terrestrial habitats on which they depend, and protection of the traditional Inuit use of the area. The NWA will also serve as a key site for research on Bowhead Whale ecology, the marine ecosystem of Isabella Bay, and the historical ties of the Inuit to traditional and commercial whaling. Research outcomes will provide a sound basis and infrastructure for management, education, and eco-tourism projects and programs.

⊲⊳∟⊆∩ஏら」⊂ ⊃Ġし∿∩⊂ Management Goals



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The long-term vision for Ninginganiq NWA is protection of Bowhead Whales and other wildlife, conservation of the marine and terrestrial habitats on which they depend, and protection of the traditional lnuit use of the area. The NWA will also serve as a key site for research on Bowhead Whale ecology, the marine ecosystem of Isabella Bay, and the historical ties of the Inuit to traditional and commercial whaling. Research outcomes will provide a sound basis and infrastructure for management, education, and eco-tourism projects ۲>٬۶ک⊃∩۰ ح٬ݸ< ح۲۰۲۰ کے ک۲۹ حکک ۲۰۵۰ ح۲۰ ح ۲۵ کی ۲۰۱۲ میں ۲۰۹۵، حکت کی ۲۰۱۲ میں کی کو کی کو کی کو کی کو کی کو ۱۹۵۲ میں کو ک

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Protect Bowhead Whales and other wildlife using Ninginganiq NWA, and the marine and terrestrial habitat they depend on, from harm by human activities.

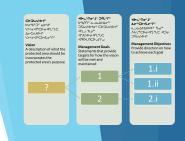
Conserve and protect the cultural and historical elements of Ninginganiq NWA, especially with regard to traditional and commercial whaling.

Increase public awareness of, and appreciation for, the natural and cultural resources of the area, particularly Bowhead Whales and other wildlife.

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Protect Bowhead Whales and other wildlife using Ninginganiq NWA, and the marine and terrestrial habitat they depend on, from harm by human activities.	مے ۵ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲
	Control, supervise, and monitor access to Ninginganiq NWA. Effectively enforce regulations to prevent threats to Bowhead Whales, other wildlife, and their habitat.
	Monitor the terrestrial and marine ecosystems to establish baselines and monitor change in these baselines over time.

Inuit play a leadership role in documenting environmental conditions and changes.

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Conserve and protect the cultural and historical elements of Ninginganiq NWA, especially with regard to traditional and commercial whaling.

Control, supervise, and monitor access to Ninginganiq NWA

Inuit play a leadership role in documenting archeological sites and artifacts.

Conduct research on cultural and historical elements to identify areas of archeological importance.



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Increase public awareness of, and appreciation for, the natural and cultural resources of the area, particularly Bowhead Whales and other wildlife.

Create promotional and educational materials and make them available to the public.

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Management Approaches outline ways to address the Management Challenges, while meeting the Management Goals

> Cultural Resources Management Wildlife and wildlife habitat Management Monitoring and Research Public Awareness and Information Management

Cultural Resources Management

Ensure preservation of archeological sites through the permitting process and add to knowledge through inventory, research, and mapping projects.

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Wildlife and wildlife habitat Management

- Control human activities in the NWA through the permitting process- do not permit activities that are incompatible with the conservation objectives of the area (e.g., commercial fishing, oil and gas, etc.)
- Ensure other regulatory agencies are aware of the NWA vision, goals, and objectives and consider them in their decision making processes.
- Create guidelines to mitigate human impacts on wildlife, especially whales.

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Monitoring and Research

- Support ongoing research and monitoring, document archaeological sites
- Improve knowledge of ecological and cultural resources in the NWA
- Improve knowledge of vessel traffic and noise in and around the NWA.

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Public Awareness and Information Management

develop education and outreach materials to inform Canadians about the cultural and ecological significance of Ninginganiq NWA,

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- ۵۵۵^۰ **حکم ک^۳ ۲۰۵** ۲ ۸ ۲۰ ۲۰ ۲۰ ۵۵^۰ ۵۵۲ ۱۹۵۰ ۲۰ ۲۰ ۲۰ ۲۰ ۵۰ ۲۰ ۵۰ ۵۶۰ ۲۰ ۲۰ ۲۰ ۲۰ ۲۰ ۲۰ ۲۰ ۲۰ ۲۰ ۲۰ ۵۶۰ ۲۰ ۲۰ ۲۰ ۲۰ ۲۰ ۲۰ ۲۰ ۲۰
- Inuit do not require a permit to enter the NWA for traditional activities, including harvesting, removal of carving stone, setting up camps (Nunavut Agreement and IIBA)
- Inuit do not require a permit to enter the NWA when working as a hunting or fishing guide





Authorized Activities and Access

- All non-Inuit do require a permit to enter and conduct any activities in the NWA (land or water) including non-Inuit sport hunters, researchers and tourists
- All commercial or business activities (Inuit and non-Inuit owned businesses) do require a permit. Except for Inuit hunting and fishing guides



ec.nupermisscf-cwspermitnu.ec@canada.ca

∆ౕరి౨~౮ ∆ౕరి ౖ∆౪ౕనిం: 867-975-4642

- Persons who require a permit to enter the NWA can apply for a permit from the Canadian Wildlife Service:

ec.nupermisscf-cwspermitnu.ec@canada.ca

Iqaluit office: 867-975-4642

The Ninginganiq ACMC reviews all permit applications and provides recommendations to the Canadian Wildlife Service on whether the permit should be issued or not.

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- Permits may be issued if:
 - ▶ The activity is scientific research relating to wildlife or habitat conservation
 - ▶ The activity benefits wildlife and their habitats
 - ▶ The activity contributes to wildlife conservation
 - ▶ The activity is consistent with the purpose of the NWA and the management plan

Management Plan Implementation

- Implemented as resources (time and money) allow
- Plan will be reviewed after 5 years, and then every 10 years after that

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⊃P۲Ր⊲ీరర్'విఏసి: **రార్రాతి ఎండ్గిరింర్ చ్రిగిగించ్ం** ఎదిగింగి ఎఎదిగిందిందిందిందిందిందిందిందిందిందింది <u>danica.hogan@canada.ca</u> (867) 669-4754

Contact Information: Ninginganiq Area Co-Management Committee c/o Vice-chairperson Danica Hogan <u>danica.hogan@canada.ca</u> (867) 669-4754

ריֹץ בעלים ⊃\PLלט⊂ We want to hear from you!

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- Your comments and input are very valuable to us
- What do you think of the content of the management plan?
 - Are you comfortable with the content of the management plan?
 - What are you not comfortable with in the management plan?
- Do you have any knowledge about the NWA that you want to share so it can be included in the management plan?

From:Hogan, Danica (EC)Sent:January 14, 2020 4:05 PMTo:'erik.allain@canada.ca'Subject:Ninginganiq NWA Draft Management Plan for ReviewAttachments:Draft Ninginganiq NWA MP meeting invite and review_EN.pdf; Ninginganiq NWA
Management Plan - DRAFT Jan 2020.pdf

Dear Mr. Allain,

Please find attached an invite from the Ninginganiq Area Co-Management Committee to provide written or in-person comments on the Ninginganiq National Wildlife Area draft Management Plan. If your organization wishes to provide written comments on the plan, please return them to me via e-mail by **Feb.9**, **2020**.

Please feel free to get in contact if you have any questions regarding the above.

Have a fantastic day,

Danica

Danica Hogan, M.Sc.

Protected Areas Specialist, Northern Region, Canadian Wildlife Service (Yellowknife) Environment and Climate Change Canada / Government of Canada <u>danica.hogan@canada.ca</u> / Tel: 867-669-4754

From:Hogan, Danica (EC)Sent:January 14, 2020 4:28 PMTo:'reception@clyderiver.ca'Subject:Ninginganiq NWA Draft Management Plan for ReviewAttachments:Draft Ninginganiq NWA MP meeting invite and review_EN.pdf; Ninginganiq NWA
Management Plan - DRAFT Jan 2020.pdf

Hi Angela,

As per our phone chat earlier today, please find attached an invite to provide written or in-person comments on the Ninginganiq National Wildlife Area draft Management Plan. If your organization wishes to provide written comments on the plan, please return them to me via e-mail by **Feb.9**, **2020**.

Please feel free to get in contact if you have any questions about the draft plan or how to provide comments.

For now, please just send this to the appropriate person at the Hamlet. As discussed, I will send different files to provide to the community later this week.

Thanks very much for your help with this!

Sincerely, Danica

Danica Hogan, M.Sc.

Protected Areas Specialist, Northern Region, Canadian Wildlife Service (Yellowknife) Environment and Climate Change Canada / Government of Canada <u>danica.hogan@canada.ca</u> / Tel: 867-669-4754

From:	Hogan, Danica (EC)	
Sent:	January 21, 2020 1:15 PM	
То:	'htoclyde@qiniq.com'	
Subject:	Ninginganiq NWA Draft Management Plan for Review	
Attachments:	Draft Ninginganiq NWA MP meeting invite and review_EN.pdf; Draft Ninginganiq NWA	
	- MP meeting invite and review_ه_∩⊃ ^c .pdf; Ninginganiq NWA Management Plan.	
	DRAFT Jan 2020.pdf	

Hello,

Please find attached an invite to provide written or in-person comments on the Ninginganiq National Wildlife Area draft Management Plan. If your organization wishes to provide written comments on the plan, please return them to me via e-mail by **Feb.9**, **2020**.

We are currently providing the English version of the plan as we are waiting on Inuktitut translation of the document. We can provide the Inuktitut version of the plan, when it becomes available, if this is preferred. Please let me know if you would like an Inuktitut copy of the plan.

Please feel free to get in contact if you have any questions about the draft plan or how to provide comments.

Sincerely, Danica

Danica Hogan, M.Sc.

Protected Areas Specialist, Northern Region, Canadian Wildlife Service (Yellowknife) Environment and Climate Change Canada / Government of Canada <u>danica.hogan@canada.ca</u> / Tel: 867-669-4754

From:	Hogan, Danica (EC)	
Sent:	January 14, 2020 3:45 PM	
То:	'Ingram, Joel'	
Subject:	Ninginganiq NWA Draft Management Plan for Review	
Attachments:	nents: Draft Ninginganiq NWA MP meeting invite and review_EN.pdf; Ninginganiq N	
	Management Plan - DRAFT Jan 2020.pdf	

Hi Joel,

I hope this finds you well and your new year is off to a good start!

Attached is the draft Ninginganiq NWA management plan for DFO's review. This plan has already been sent for review to Steve Ferguson, as a DFO marine mammal expert, but we'd like to provide an opportunity for the Oceans Program to provide comments/input as well. Please provide any comments back to myself by **Feb.9**, **2020**.

The Ninginganiq Area Co-Management Committee will also be holding a community meeting in Clyde River on Feb.10, 2020 from 7pm-10pm at the Parish Hall. Everyone is welcome to attend this meeting (please see attached letter).

Feel free to get in contact if you have any questions about the draft management plan or the community meeting!

Thanks, Danica

Danica Hogan, M.Sc.

Protected Areas Specialist, Northern Region, Canadian Wildlife Service (Yellowknife) Environment and Climate Change Canada / Government of Canada <u>danica.hogan@canada.ca</u> / Tel: 867-669-4754

From:Hogan, Danica (EC)Sent:January 14, 2020 4:16 PMTo:'SLeBlanc1@GOV.NU.CA'Subject:Ninginganiq NWA Draft Management Plan for ReviewAttachments:Draft Ninginganiq NWA MP meeting invite and review_EN.pdf; Ninginganiq NWA
Management Plan - DRAFT Jan 2020.pdf

Dear Ms. LeBlanc,

Please find attached an invite to provide written or in-person comments on the Ninginganiq National Wildlife Area draft Management Plan. If your organization wishes to provide written comments on the plan, please return them to me by **Feb.9, 2020.**

Please feel free to get in contact if you have any questions about the draft plan or how to provide comments.

Sincerely, Danica Hogan

Danica Hogan, M.Sc.

Protected Areas Specialist, Northern Region, Canadian Wildlife Service (Yellowknife) Environment and Climate Change Canada / Government of Canada <u>danica.hogan@canada.ca</u> / Tel: 867-669-4754

From:Hogan, Danica (EC)Sent:January 17, 2020 9:36 AMTo:'sjohnson2@gov.nu.ca'Subject:Draft Ninginganiq National Wildlife Area Management Plan For ReviewAttachments:Draft Ninginganiq NWA MP meeting invite and review_EN.pdf; Ninginganiq NWA
Management Plan - DRAFT Jan 2020.pdf

Hi Scott,

Thanks for the chat this morning! As discussed, please find attached an invite to provide written or in-person comments on the Ninginganiq National Wildlife Area draft Management Plan. If your organization wishes to provide written comments on the plan, please return them to me via e-mail by **Feb.9**, **2020**.

I will provide the plan to Markus Dyck as well, as per your suggestion.

Please feel free to get in contact if you have any questions about the draft plan or how to provide comments.

Thanks and have a fantastic day!

Danica

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From:	Hogan, Danica (EC)	
Sent:	January 14, 2020 4:20 PM	
То:	'wbeveridge@ihti.ca'; 'lpeplinski@ihti.ca'	
Subject:	Ninginganiq NWA Draft Management Plan for Review	
Attachments:	Draft Ninginganiq NWA MP meeting invite and review_EN.pdf; Ninginganiq NWA	
	Management Plan - DRAFT Jan 2020.pdf	

Dear Mr. Beveridge and Ms. Peplinski,

Please find attached an invite to provide written or in-person comments on the Ninginganiq National Wildlife Area draft Management Plan. If your organization wishes to provide written comments on the plan, please return them to me via e-mail by **Feb.9**, **2020**.

Please feel free to get in contact if you have any questions about the draft plan or how to provide comments.

Sincerely, Danica Hogan

Danica Hogan, M.Sc.

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From:Hogan, Danica (EC)Sent:January 13, 2020 10:21 AMTo:'Plloyd@tunngavik.com'; 'qkusugak@tunngavik.com'Subject:Ninginganiq NWA Draft Management Plan for NTI ReviewAttachments:!Ninginganiq NWA Management Plan - DRAFT Jan 2020.pdf

Hi Pacome and Qilak,

I'm the Vice-Chair of the Ninginganiq Area Co-Management Committee in Clyde River and I've been told that you are the folks I should contact to provide NTI an opportunity to review the Ninginganiq National Wildlife Area Management Plan.

Attached is an English version of the Draft Management Plan for Ninginganiq National Wildlife Area. I'd like to take this opportunity to invite you to provide comments/feedback on the Draft Management Plan by **Feb.9, 2020**. The ACMC will be holding a community meeting at the Clyde River Parish Hall on **Feb.10 between 7pm-10pm** to allow folks in Clyde River to provide feedback about the draft plan as well. This is an open meeting that you are welcome to attend.

In addition to the community meeting, the ACMC will be holding ACMC Meetings during the days of Feb.11 and 12, to discuss all of the comments and feedback received about the Draft Management Plan.

We are currently waiting on Inuktitut translation of the draft plan (it has taken longer than expected), but I can send you that version once I've received it, if you would like to review the plan in Inuktitut as well. Please let me know if this is the case.

Thanks very much, and please feel free to get in contact with me should you have any questions about the meetings or management plan!

Danica

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From: Sent: To: Subject: Attachments: Hogan, Danica (EC) January 13, 2020 10:13 AM 'Jsimic@qia.ca' Ninginganiq NWA Draft Management Plan for QIA Review !Ninginganiq NWA Management Plan - DRAFT Jan 2020.pdf

Hi Jovan,

I'm the Vice-Chair of the Ninginganiq Area Co-Management Committee in Clyde River and I've been told that you are the contact for all things ACMC-related at QIA.

Attached is an English version of the Draft Management Plan for Ninginganiq National Wildlife Area. I'd like to take this opportunity to invite QIA to provide comments/feedback on the Draft Management Plan by **Feb.9, 2020**. The ACMC will be holding a community meeting at the Clyde River Parish Hall on **Feb.10 between 7pm-10pm** to allow folks in Clyde River to provide feedback about the draft plan as well. This is an open meeting that you are welcome to attend.

In addition to the community meeting, the ACMC will be holding ACMC Meetings during the days of Feb.11 and 12, to discuss all of the comments and feedback received about the Draft Management Plan. You are welcome to attend these meetings as well.

We are currently waiting on Inuktitut translation of the draft plan, but I can send you that version once I've received it, if you would like to review the plan in Inuktitut. Please let me know if this is the case.

Finally, the ACMC would like to provide a few written copies of the plan in Clyde River, prior to the meeting on February 10. The ACMC members suggested that the CLO in Clyde may be able to keep a few copies that people could go check out. In the past, I have always asked whomever occupies your position if I can approach Nina for help. Do you think this is something that Nina would be willing to help us with?

Thanks very much, and please feel free to get in contact with me should you have any questions about the meetings or management plan!

Danica

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From:	Hogan, Danica (EC)	
Sent:	January 22, 2020 12:56 PM	
То:	'kpitsiulak@niws.ca'	
Subject:	FW: Ninginganiq NWA Draft Management Plan for Review	
Attachments:	Draft Ninginganiq NWA MP meeting invite and review_EN.pdf; Draft Ninginganiq NWA	
	- MP meeting invite and review_ه_∩⊃ ^c .pdf; Ninginganiq NWA Management Plan.	
	DRAFT Jan 2020.pdf	

Hello Koloka,

I am hoping to provide some information to the Qikiqtaaluk Wildlife Board concerning the draft management plan for the Ninginganiq National Wildlife Area, located south of Clyde River. The Nunavut Inuit Wildlife Secretariat website seems to indicate that you are the person to contact to get this information to the QWB. Is this correct? If so, please see below. If you are not the correct person to contact, could you please direct me to the right person?

Also, I have found several e-mail addresses for the Clyde River HTO on various websites. Are you able to confirm what e-mail address the HTO is best reached at? I wish to send the HTO the same information that I am sending the QWB.

Thanks very much!

Danica

For the QWB:

Please find attached an invite for the Qikiqtaaluk Wildlife Board to provide written or in-person comments on the Ninginganiq National Wildlife Area draft Management Plan. If your organization wishes to provide written comments on the plan, please return them to me via e-mail by **Feb.9**, **2020**.

We are currently providing the English version of the plan as we are waiting on Inuktitut translation of the document. We can provide the Inuktitut version of the plan, when it becomes available. Please let me know if you would like an Inuktitut copy of the plan.

Please feel free to get in contact if you have any questions about the draft plan or how to provide comments.

Sincerely, Danica

Danica Hogan, M.Sc.

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From:	Ferguson, Steve <steve.ferguson@dfo-mpo.gc.ca></steve.ferguson@dfo-mpo.gc.ca>
Sent:	November 29, 2019 11:49 AM
То:	Hogan, Danica (EC)
Subject:	RE: Who counts Bowhead Whales?

Hi Danica,

Sorry for the delay, but I looked over a number of sections and nothing jumped out as in need of changing. It looked like a nice job. Thanks

Steve

From: Hogan, Danica (EC) <danica.hogan@canada.ca> Sent: November 8, 2019 5:08 PM To: Ferguson, Steve <Steve.Ferguson@dfo-mpo.gc.ca> Subject: RE: Who counts Bowhead Whales?

Hi Steve,

I hope this e-mail finds you well!

The Ninginganiq Area Co-management Committee is finally at the stage where we are ready to have some external folks review our management plan for Ninginganiq NWA. I realize that it has been a while since I asked you if you were available to review this document, but if you are still willing, the committee would love to receive any input/comments you have to give.

I have attached the draft management plan; as it is in draft form, please do not share it with anyone else.

The main sections that we'd love your input on are: Section 3.2: Wildlife species, Section 4: Management Considerations, Section 6: Management Approaches. However, please feel free to provide comments on any and all parts of the plan.

If you are able to provide your comments by Nov. 25, it would be much appreciated, as we will be sending the plan for translation into Inuktitut shortly after.

Thanks very much in advance and please let me know if you have any questions regarding the plan,

Danica

Danica Hogan, M.Sc.

Habitat Specialist, Northern Region, Canadian Wildlife Service (Yellowknife) Environment and Climate Change Canada / Government of Canada <u>danica.hogan@canada.ca</u> / Tel: 867-669-4754

From: Ferguson, Steve <<u>Steve.Ferguson@dfo-mpo.gc.ca</u>> Sent: February 1, 2018 7:08 AM To: Hogan, Danica (EC) <<u>danica.hogan@canada.ca</u>> Subject: RE: Who counts Bowhead Whales?

HI Danica,

Yes, I am able to help you out with information related to the East Canada-West Greenland bowhead population. The last abundance estimated were from an aerial survey in 2013 and a genetic mark-recapture done at the same time. We plan to update the genetic estimate later this year.

We have been conducting bowhead field research out of Pangnirtung in the Cumberland Sound area – but not directly in Isabella Bay. However, our tagged whales have used that area.

I am available to assist with a review of your management plan.

Steve

Steven Ferguson

204 983 5057 | facsimile 204 984-2402

Steve.Ferguson@dfo-mpo.gc.ca

Research Scientist/ Chercheur scientifique Marine Mammal Research Program/ Programme de recherche sur les mammifères marins Arctic Research Division / Division de la recherche sur l'Arctique Central & Arctic Region / Région du Centre et de l'Arctique Fisheries and Oceans Canada / Pêches et Océans Canada

501 University Crescent, Winnipeg, Manitoba, R3T 2N6 Government of Canada / Gouvernement du Canada

From: Hogan, Danica (EC) [mailto:danica.hogan@canada.ca]
Sent: January 31, 2018 3:51 PM
To: Ferguson, Steve
Subject: RE: Who counts Bowhead Whales?

Hi Steve,

I'm the vice-chair for the Ninginganiq Area Co-management Committee and I am working to update the info about the bowhead whale population using the NWA in our management plan. To that end, I am hoping that you can tell be about any recent work on bowheads in Isabella Bay or the surrounding area? The most recent info I have found thus far is a survey done in 2015 (which I think you were involved with). Has there been anything more recent?

I also wanted to ask you if you would be amendable to reviewing some sections of our management plan using a bowhead whale lens? We are not quite at the review stage yet, but I think having a bowhead whale expert provide us with some input would be beneficial to the plan.

I realize that this is probably coming out of left field for you, and think a phone call would probably be a great way to chat a bit more about all of this. Do you have some time in the next little while for a call?

Thanks very much for your time!

Danica

Danica Hogan

Habitat Specialist, Northern Region, Canadian Wildlife Service (Yellowknife) Environment and Climate Change Canada / Government of Canada <u>danica.hogan@canada.ca</u> / Tel: 867-669-4754

Spécialiste de l'habitat, Région du Nord, Service canadien de la faune (Yellowknife) Environnement et Changement climatique Canada / Gouvernement du Canada <u>danica.hogan@canada.ca</u> / Tél. : 867-669-4754

From: Postma, Lianne [mailto:Lianne.Postma@dfo-mpo.gc.ca]
Sent: January 19, 2018 2:51 PM
To: Hogan, Danica (EC)
Cc: Treble, Margaret; Ferguson, Steve
Subject: RE: Who counts Bowhead Whales?

Hi Danica,

You should contact Steve Ferguson, who I have cc'd here.

Thanks, Lianne

From: Hogan, Danica (EC) [mailto:danica.hogan@canada.ca]
Sent: January-19-18 2:53 PM
To: Postma, Lianne
Cc: Treble, Margaret
Subject: RE: Who counts Bowhead Whales?

Hi Lianne,

Any direction you could give about who to contact regarding bowhead whale research in the North would be very much appreciated! Have a great weekend!

Danica

From: Treble, Margaret [mailto:Margaret.Treble@dfo-mpo.gc.ca]
Sent: January 16, 2018 11:43 AM
To: Ingram, Joel; Hogan, Danica (EC)
Cc: Postma, Lianne
Subject: RE: Who counts Bowhead Whales?

Hi Joel and Danica,

I will let Lianne Postma, Section Head for Stock Assessment, respond. I'm not sure who in her group has been assigned the bowhead file.

Cheers, Margaret

From: Ingram, Joel Sent: January 15, 2018 10:04 PM To: Hogan, Danica (EC) Cc: Treble, Margaret Subject: RE: Who counts Bowhead Whales?

Hi Danica, Suggest you contact Margaret Treble Treble, Margaret.Treble@dfo-mpo.gc.ca (204) 984-0985

She is Acting Head of the Science group and should be able to provide direction.

Joel

From: Hogan, Danica (EC) [mailto:danica.hogan@canada.ca] Sent: January-12-18 12:23 PM To: Ingram, Joel Subject: Who counts Bowhead Whales?

Hey Joel,

I hope your 2018 is off to a great start! Mine has been cold and full of mini-car deaths thus far, but otherwise it has been lovely. ③

I have a random question for you: I can't seem to find the right DFO person to talk to about Bowhead whales in Nunavut and I'm wondering if you know if there is one person that heads research on that species, or is there a group of people? Any of the papers I've come across have indicated folks out of your Winnipeg office, but there's not one person that stands out as "the Bowhead Whale person". No worries if you don't know, I just thought I'd check before I go randomly emailing a whack-load of people.

Thanks!

Danica

PS- Garth sent me a lovely email indicating that you two met up before Christmas and that the cargo was intact...thanks for getting it to him safely!

Danica Hogan

Habitat Specialist, Northern Region, Canadian Wildlife Service (Yellowknife) Environment and Climate Change Canada / Government of Canada <u>danica.hogan@canada.ca</u> / Tel: 867-669-4754

Spécialiste de l'habitat, Région du Nord, Service canadien de la faune (Yellowknife) Environnement et Changement climatique Canada / Gouvernement du Canada <u>danica.hogan@canada.ca</u> / Tél. : 867-669-4754







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Environment and Climate Change Canada Public Inquiries Centre 7th Floor, Fontaine Building 200 Sacré-Coeur Boulevard Gatineau QC K1A 0H3 ▷ˤḇᡄ▷Ċ: 819-997-2800 ◁Ρˤḇལ∿Րናづ☜ ▷ˤḇᡄáལ∿☜: 1-800-668-6767 (ḇལⵎལལོོ)) ˤḇ⌒ঌ▷৮ʰdˤ: ec.enviroinfo.ec@canada.ca

Environment and Climate Change Canada – Canadian Wildlife Service Northern Region 933 Mivvik Street, 3rd Floor P.O. Box 1870 Iqaluit, NU X0A 0H0 トゥレートン・ 867-975-4642 ットロートントゥd^c: ec.nupermisscf-cwspermitnu.ec@canada.ca

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Environment and Climate Change Canada Public Inquiries Centre Fontaine Building, 12th Floor 200 Sacré-Coeur Boulevard Gatineau, QC K1A 0H3 PsbcDC: 819-997-2800 マPsbcDC: 819-997-2800 マPsbcCC5b PsbcAC5b: 1-800-668-6767 (bcCAcc5r) 5bcDPbdC: ec.enviroinfo.ec@canada.ca

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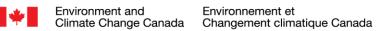
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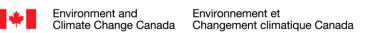
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ᢀᡄ᠋ᢩ᠈ᡣ᠋᠋ᡃᠣ᠒ᡥᢩᠣ᠋᠋᠆ᡆ᠋ᡃ᠘ᠴᢩ᠕᠋᠋᠈ᡥ᠋ᠺᠵ᠘᠘ᡩ᠋ᠵ᠅ᠺᢂ᠋᠈

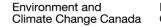
L°σርሊላ?°ฉʻንʻʻdσ?፦C?°ฉ፦ንՈ՟୬ Δ≪ልՐ≪ՙCጐՐ°σ ՈѷГՎʹ, ĊŀdϤ İʿฉÞᠵᡄÞ?ՈՐᲡሥ՞σՎʿ୬Ր՜, Δঌ৾৽ᲮՈՐ๋ঌʻ Ճ൳፦bdᢣንʻsbʰd՟୬ ◀ንሊՎʻbʔσՐ՜. Δ૭ঁ°ฉՈ՞ ໓ฉ୭୮ϷϹϷ֊Ր՟Ͻ՟ Ճ໓Ճՙ, ୕୵ᢞᡆϷՈĊႢՎൎᡄ՟ ◀ንՃ°ฉʻbʔLJጦ Ϸኖ≪೨՞°ċ՟ ՙb໓ՃႠϷʔL°σ?Ո ՙb໓ንՃ°ฉʻrՎጭ σ֊Ր֊Ⴑσ፦ ់ዾL๙ʻbʻል֊Ⴑσ. ୕୵ᢞᡆϷՈ৽Ქ՟ ՙb໓ՃႠϷʔr՛፡ L൳ʻrՎႢՎċ ՀϷ፦rኣⅆჾ֊⅃՟ Հու՟ԸϷฉ๗ՉჇL๙σ՟ ຝϷϲ՟Ⴖσ֊⅃՟ <ʻฉϷႶσ ฉ୬ฉՃናϷჇłL๙σ՟.







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Environnement et Changement climatique Canada

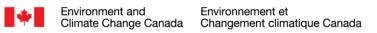
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АСМС	⊲⊳⊂‹ՈՙᲮՈՐԾ∿⅃ՙ ᲮՈԼネ‹
CIRNAC	ႱペLጋʻҌ๒ํdʿ-ഛգ・Ҍҹ҄Ҍ҅ҹ҄上էᡃᠫ᠕ᡔ᠋ᡅ᠋᠖᠋᠕ᡔᡅ᠖ᡅᢕ᠋ᡬᡆ᠋ᡬ᠘ᠴ᠘ᠴ᠘᠋᠘᠘᠘᠘
CLARC	ᠫᡆᡄᠲᠦ᠋᠋ᠴᡆᡄ᠋᠆᠋ᡄ᠘᠆ᡎ
CLO	שפ⊂°שנ אא⊳רוווא
COSEWIC	>>ר פיכשליכדלי אורדאיני (גישאימו)
CWA	baCT PLtcnoil Nidti
CWS	
DIAND	᠔᠋ᠴ᠋᠋᠋᠆᠘ᠴ᠆᠋᠘ᢣ᠋᠋ᢧᠳᡥ᠙
DFO	ϷϣϹϷʹ ΔͰʹΓϷϹϲʹͺϞϷϭͼ
ECCC	ϼϭϹϹ ⊲ፌႮᡄ୰ϧϧϲʹϲʹϧϧϧͺϫϲϧϧϿͺϥϧϧͺ
GN	»։ Ն«Լ [֊] Նՙ
GNWT	ב-גלק, ףעריףנ הפראפר, הארי
нто	⊲ᡷᡃᡆ᠋᠋᠘᠆᠋ᢣ᠈ᠳᢕ᠋᠔᠈ᡩ᠋᠑᠋ᢕ᠅ᡗᡅ᠅᠋ᡬ᠘ᡧᢐ᠆᠋᠕᠆ᡧ
IIBA	ΔΔΔ΄ Φ'Ͻ [;] ϷϹϷσ [·] ϔΓ [°] ϼϚΔbϞϟϘΡΛϤϧϼʹϧ Ϙ ϒΡΛ΄ baCΓ ϷLϞʹ·bʹ·δ°-ϼʹ Ϟ>Ϟλϐʹ·Γ°-ϼϚϘϤʹL _ʹ ͻͺͶʹϒΓϭʹϷͶʹϷϹ<ʹϽϚϞ>ϞλϐʹϒϼʹϼϲϼʹϾϼͼͺϿͼͺʹϞ
інт	ዾ፞ዾፚ‹ ለነብሥራት ወራለጋ፨џ‹
IOL	ᡘᠴ᠋ᢩ᠕᠅ᡣᡛ
IQ	᠘ᠴ᠘᠋ᡗ᠄᠔ᡐ᠘ᢣᠫ᠋᠂᠋ᢐᢞᡗ
IUCN	ᠴᡄ᠋ᠮᢣ᠋ᠫ᠈ᢣ᠋᠋ᢐ᠐ᡤ᠂ᠴᠴ᠋᠋ᡗᢦᢗ᠋᠋᠋᠋ᢣ᠋ᡔᠬᢣᢂ᠋ᡔ᠋᠋᠉ᢕᢣ᠖᠋᠋
МВСА	$ \Pi^{*}\Gamma \not a^{c} P \Pi^{*}C \lt O^{c} \Lambda \imath d + \iota^{c} $
MBS	ϷႶჼϷϹ<ʹϽϼ·ͺႶϞΓ⊲ʹ·ϸʹልϷ
NIRB	ወወይ ገሬ የግግራ ምር የግግ የ የ የ የ የ የ የ የ የ የ የ የ የ የ የ የ የ
NA	Δα& Δ [*] ΓΡΛ [*] υ ΔΔΔ' Δα [*] υσ'ΓΡ' Δ ^L Δ ΔΔ Ρ ^ι υ Σ [*] CP' Δσ baCJ'
NCLA	Δα&Γ ΔαĊίσι ΔενίδΛΥλ
NPC	orsh <eotype< th=""></eotype<>
NSA	ᠴᡆ᠋᠋ᢁ᠅ᠴᡆᢗᡃ᠋ᡃᡟ᠘ᡃᡕᢛ
NTI	ዾዹቝና ጋ፝፝፞፞፝፞፞፝፝፝፝፝፝፝ዾጜኯ፟፟፟፝፝፝፝፝
NWA	ba_CL þr≼piġ
NWMB	ᠴᡆ᠀᠋ᡏ᠌᠌᠌ᢄ᠘ᡃᡄ᠋᠋᠋ᠵᢣ᠋᠄ᢣᡏᡏ᠖᠋᠘᠘ᡷ᠋᠂ᡗ
NU	D0%



QIA	ͼνρͼσ ΔϿδͼ ρͻϧϧͼρυμ
QWB	᠄ᡏ᠋᠋ᡗ᠉᠆ᡗᢄ᠘ᢣ᠆ᠬᢣ᠋᠈᠂᠐᠘ᢣ᠈᠋ᢉ
RCMP	᠂ᡃᡆᡗ᠋᠋ᠣ᠋᠂ᡩ᠋᠆ᠳᢧᡄ᠋᠋᠘᠆ᠵᡄ᠋᠆ᡘᡃᡆ᠙
RIA	ላል፡ጋ፣ተLፚዾላታና ወጋንት፣bበሰኈቦና
SARA	$\dot{P}L \prec \Delta \Delta \Delta \dot{\neg} = \Delta \eta \prec \eta \wedge
ТС	$\Delta^{*}r^{i}S^{i}b^{i}C^{i*}\mathcal{I}_{\mathcal{C}}$

1 ५>᠈ᢣል⊳< ⊳σෳḃ∿Ⴑ







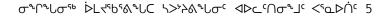
⊲>>°ህ⊲™ 1: σ°∩∿しσ™ ዾL๙๒ናል∿し

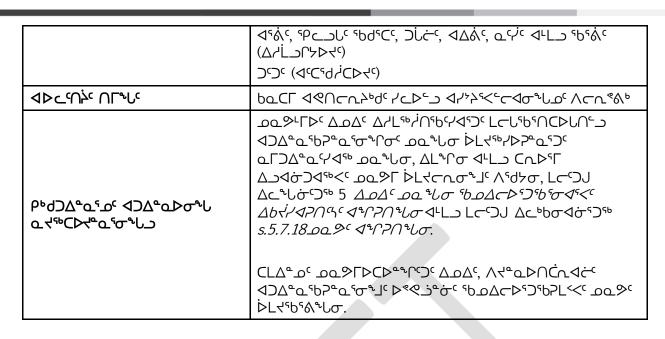




<u></u> α_αΔ℃	ϧϭͻϲϹͺ ϷͳϞͺϩ	
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ወዉ ^ቈ ህ⁄ቀൾ ጋቦታ ኣσታ <i>ጋ</i> ዉσሦቡ	69°50'N / 67°00'W	
Ⴤልጋۍኯ	3,362 km² ⁰⊂ ^ᡤ ᢗ ^ᡕ ᠙<ᡬᡅ᠋ᠫᠴᡏᠫ	
	 ▶ ዾニ゙σ^c ⊲^s𝔄 ዾ^c ບ≺し^s ΔL^s U (<i>Balaena mysticetus</i>) boCΓ. 	
<u></u> ዉ_ጋዉΔ℃Ϙ/L . « ኣ>ኦትል፞፡ L <i>ᠸ</i> Ⴑኈቦ፡	 ΔL[*]υ 4ⁱδω^c σ^cⁱδΔ[*]νⁱδδ⁻ωσ⁻ α^dυ^v 	
	 ΔL[*]υσ ϷL⁺[*]⁻ Δ⁻ Δ⁻ Δ⁻ Δ⁻ Δ⁻ Δ⁻ Δ⁻	
ᢣ᠌᠌>᠈ᢣ᠌ᢄ᠆᠘ᢣ᠋ᠣᡗ	Α. Ϸʹͺͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺ	
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٥٩٢٢ ٥/٢٢ ٩/٢٩ م٥	P.C. 2010-705	
^ና ነውንትርላናል፦ የወርው <u>ረ</u> ዮሬጉልም መ ወሻህርት የዲዮ (DEBL) ማብረ	21601	
Ⴑᢣ᠈᠋᠌ᢄ᠈᠋ᠳᡄ᠋᠋ᡶ᠋᠂᠔ᠿ᠃ᡗ᠊ᠦ ᢂ᠆᠆᠃᠋	2010	
ᡧ᠈ᡃᡂ᠅ᡤ᠂᠋ᡄ_ᠣᢩ᠘ ᠋ᡃᡘᡃᢣᢗᡋ᠈᠘ᢞ	ᡏ᠙ᡣᡄ᠋᠋ᡶ᠋᠋᠅᠋᠘ᢣ᠋᠋᠋᠄ᠫ᠘ᡩ᠋ᠴ᠋᠂ᡏ᠋᠋᠋ᠫ᠋᠋ᠬ᠋᠋᠄᠋ᡦᡄ᠋ᡘ᠂᠋ᡦᠧ᠘᠋᠋᠋ᢞ᠋᠋ᡫ᠄᠘᠘᠋᠋᠄᠘᠘᠋᠋ᠮᢄᠸᡄᡅᢣ᠋᠈᠋ᢉ	
፟ዾ ^៲ Lጚዄዾኁ ለዖኁጋኄዾኯኇኊኯዾኁ ለ፟፟፟፟፟፝፞ለኯዾኇኯ	ዾዾ፟፞፞፞፞፞፞ፚ፞፟ጜዾኯ፟፟ዾዾዸዾ	
ዻ፞፞ዾጞ ዾኯኯኯኯኯ	᠕᠋᠋᠋ᢗ᠋᠋᠋᠋ᢉ᠋᠋	
ዾר _ל כלקלי	ዻበናታኦተLኆ baCኦ ሀዲኬቴጐጮ ኦLኆ ሏ/፟L_ንዮኦኦሮን ለ ፣dኦኄፓ (ኣና): ዉዾና, ቦ፡ሀልፈናኆ (ሏ/Ľ_ንዮኦኦሮናጋና) ዉኦታጵና (ወኄውታፈና/ቦኦኦኆ) ዉኦታና (ፈናርናፈ/ርኦሮናጋና)	
	^ና ϷϷϞ·ϹϷϟͰͼʹͺϼ·ϧϧϲϤϲϧϧϷϫͺϷͳϲϫͺϷϭϹϹ ͼϷϿϘϹϧϒϲͼͳϧϳϹͺϷͶͳϧͽͺϲͽͺ(ϼϞϨͼϙ;;	











1.1 **ላካጋንካረታው / ታሳንላራካኒካ**

σ°ቦኈႱσኈ ዾLሩኄኄጜ∿Ⴑ ᠄₽ዖኈĊጏ< ዾኈ፞d⊲፞፞፞፞σናጋኈ ረ፞፞፞፞፞ዾጜ, Δ²Lኄb 100 ዖᡄቮርσና ዾኈႱሥኇ፝፝፝፝፝፝፝፝፝ ΔϲϲϷϧϷϞΓϞͼ Ϟͽϧϧ ͽϧϧͺͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫ 7^{+} לבישה אישריהראיי: 22.2 פברכי). בכאסיש (530 פברכי פאלה-באיסי) אישראידעאי 'የዖኈር፝፝፝፝ር ር ዾረፇኈኒታኄጏፚና ፈዛሬ ጋ Δዛሬ ካ በ ደር ኮርምና ዾኈኒሥራትና ረሷኈኒዎና . መኈቦኈኒመኈ ϷLϞʹϧͽͽϧͺϹͺϹͷϷϧϼͺ332 km² ϧϲϳϲͺϧͺϫͺϫͺϫͺϫͺϫͺϫͺϫ Δ L&P< Δ በσ^{*}υ 560 Γ΄C. $\dot{}$ ^{*}υ<** C/P+^{*}υC <^{*}*</4σ P/4σ Δ^{*}b'</ti> ィるフσch くっしਰ ΔιLib ΔΛσch 200σc 260ρc Γ΄Cρc (Finley et al. 1986, Finley 1990). パFいとしいいしょう マピーク (Gilbert 1985).

Crbs^c, dL→ r^{ss}F^sb^s⊃σ r⊂ (Sutherland 1853, Ives and Andrews 1963). Loc^sU $D = \Delta^{c} + C^{c}$ (Davis et al. 2006). אייך אייך שבי $\Delta^{c} + C^{c} + C^{c}$ $(\sim 900 \ \Box C \sigma^{c} > D^{o} \sigma^{c})$ ≪L__ σ`_ሥ<ናጋ™ -29.1 C イዾ`イላ` ້፟፟ຽ°__</br> ГсҐСσ^с ^sb^eσ^Sd^c^{S^b} (Environment and Climate Change Canada 2019).

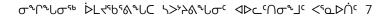
ەلەھەھەخ ئىلاچ مەخد ھەرەبىھە كەللالەيە ھەرەپكۈلەي كەرەپكۈلەي (ھەرەپكۈلەي). ئەۋەپۈخ بۈپ ᠘ᡃ᠋᠋᠘ᡃ᠋᠋᠋ᡰ᠘᠐᠙ᡄᡏᢗᠣ᠋᠄᠌᠉᠋ᢑ᠕᠆ᡊ᠅᠘ᠸ᠋᠅᠋᠋᠋ᠵ᠋ᡗ᠄᠈᠘᠆᠖᠋᠕᠘᠆᠖᠘᠖᠘᠘᠘᠘ σ°°°しσ[®] ĎLベ⁶δ[®]しJ^c ĎLベイD[®]D^c Δ⁶b^c⊂d⁶D^c D^c Sanguya and Gearheard 2014, Government (Government of Nunavut 2014).

レインタン5b% (Nunami Stantec 2018)、 σ°C°しσ% らしくいいる いし イトレッ いちのつう つく (▷◊⊃∩∩∍∩, ▷∞/⊲∍ じィ ⊲∟ے じィッ、 ७∩°∿しく ⊲⊂▷‹ィ୮) ๒๔°๔∿ႱԺ Ժ∿ՐѷႱԺ๛ ▷L๙๒ነል∿ႱႠ $\Gamma^{\circ}\sigma$ $\cap D^{<}\Delta L^{\circ}U\sigma$ (National Energy Board 1994, Nunami Stantec 2018).

ڶィイトシン むしゃつくこつい むいくくえの いりやしうく ひやらかして タレン ひゃりかして わしゃうく

DΓ ٬ه۳۲٬۶۰٬۶۰٬۵۰٬۵۲٬۹۲٬۹۵٬۶۰٬۶۰٬۹۰٬۹۰٬۹۰٬۹۰٬۹۰٬۹۰٬۹۰٬۹۵٬۹۰٬۹۵٬۹۰٬۹۰٬۹۰٬۹۰٬۹۰٬۹۰٬ ハケヘタフンダ^{いして} ム^いしらるしてすい (Canadian Ice Service 2011, Reeves et al. 2014). ふらしゃつ ∆د؈٩٦٢، ٢٩، ١٩٤ خ` +فسل ٩٩، ٩٨، ١٩٩ خَلام، أنهاد خَلام، أنهاد ماييا ٩٩، منه المنهاد المعالية المعالية الم ל>ילא⁶לשי (Pizzolato et al. 2016).

 $\wedge e^{-4}$ ᠄ᡃ᠋᠋᠋᠋᠋ᡃ᠋᠋ᡏ᠋᠋᠋᠋᠊᠆ᠴ᠋᠋᠋᠄᠋᠘᠆ᡁ᠆᠕᠆ᠴ᠕᠄᠘᠆᠕᠆᠕᠆᠕᠂᠘᠆᠕᠂᠘᠆᠕᠂᠘᠆᠘᠂



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P℃& (Nunavut Wildlife Management Board 2000).

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bo_CΓ (CIRNAC).

 $\Delta \Delta \Theta \subset \Delta \Delta \Theta$ שביטכ ש $PP^{*}C^{+}$ (CR-02): P_{+} $\Lambda^{+}U^{\prime}$ בם $P_{+}C^{+}C^{-}$ $P_{+}C^{+}C^{-}$ $P_{+}C^{+}C^{-}$. ዾLጚና/ዾናልዾቦላናb°ኈቦናጋና bዉርዾና ሀペLካďኈቦ°ጔና ኣ>ን፟ዾጚና ርኪዾኈሁσ (ጋኣናበና/ፈዾናጋና Δ ና>? 25, 2019 UNGS). CAL 2 a sadic of Lilc as a point of the set of the CL^{+} כילאכארי אוש ישאאיאיארי אבש ישאיאיארי בידי. בידי דיכיאכאריארישיים ישאאיאיאידי ארש אראיאי ጋር $C^{\delta}(\Gamma^{\circ} \cap \Gamma^{\circ} \cup \sigma^{\circ} \cap \Delta \Delta \Delta^{\circ} \cup \sigma^{\circ}

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 \mathcal{P} $b_{QC} > b_{QL} = σ° ቦ°ບσ[®] ዾLሩ'ጛ'ል°ບσ ኣ>ንኦልናኣΓና ወሷዎΓ 'ዋዖ°°Ćጏ< ረሷ°ບປና: σ°°ቦ°ບσ°°. «ረΔና. «Lጋ 'bነd' ጋΔና. 'የዖኈĆ ጋኁ: σኁቦኈሀ σኈ, Φ<Δና ላዛ L ጋ 'bነd' ጋΔና. Δ Δ Δ Φ Φ Ͻኈር Ϸ σኁቦ° Δ ና $\Delta b \dot{\ell} / d P \cap b \Delta b \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} / d P \cap b D \dot{\ell} = \Delta b \dot{\ell} + \Delta b \dot$ bጋንትናbበሶ^ኈቦ[°] $_{2}$. ናዖዖ፣ b $_{2}$ $b \cap L^{\circ} \cap \mathfrak{s}^{\circ}$ (HTO), $\mathcal{A} \cap \mathcal{s}^{\circ}$ b $\mathcal{C} \cap \mathcal{s}^{\circ}$ b $\mathcal{C} \cap \mathfrak{s}^{\circ}$ b $\mathcal{C} \cap \mathfrak{s}^{\circ}$ b $\mathcal{C} \cap \mathfrak{s}^{\circ}$. ϷLϞϲႢσჼͿͼ ΓϲႱͽͶϳͼ ϤϷϲͼϞͱϞϥͼ ͶͼϿͼͶϲϞͼϲͼϞϽϹϷϲϷͼϽͼ ͶͽϥϷͼ ϒͻͽ϶ϗͼϞϭͼ ϷϲϹϹ . ዾLጚኄ፟፟፟፟፝፞ዾጚጜዀዀዀዀዀዀዀዀዀዀዀዀዀዀዀዀዀዀዀዀዀዀዀዀዀዀዀዀዀ

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<u>δαCL pF4CU5,446 V564,000 απΓο Φσας υσυαγραφορια στα δασκαστα στα δασκαστα στα δασκαστα στα δασκαστα στα δασκασ</u> ϤL_> しペL^c idcic Δbt^w∩DibN^c^wσ^bd^c dDc^cΩJΩ^c d^bC^cD^c dd^bC^bD^c 1994Γ^c ᠘ᠴᡄ᠋ᡅᢣ᠋ᠫ᠋᠋ᡝ᠋bʰdʰᢉᠣ᠋ᡗ bᡆᢗᢂ᠂ᡏ᠙ᡣᡄᡅᢣᡃᡆ᠋ᢥᡥᠴ᠋᠋ᢧ᠄᠋ᡗ᠋996᠋ᡃ᠋᠋᠋᠋ᡣ᠋᠋᠆ᢣᠴ᠕᠋᠋᠄᠋ᡃᢞᠴᢦᡅ᠋᠋1998ᠮ. ᡩ᠋᠋₽₱ᡃᡃᢛᢗᠣ᠘ᠴ᠘᠋᠋

σ[∿]Γ[∿]しσ>[<] ϷL⊀⁶δ[%]UC ⁵2³δ[%]U₂⁶ ⁶⁶C[%]U.

Lናዖ<ናበኈጋበና Δ ር°σ</2 መንገራ አንባ 1992ህበና $_{J}$, Δ ር°σ</2 መንገራ መንግሥራ የእንና መንግሥራ የ $\dot{\mathsf{D}}$ L<δδ $\dot{\mathsf{D}}$ L<δδ $\dot{\mathsf{D}}$ L
 $\dot{\mathsf{D}}$ L
L 3^{+} אאיאטרישי פיראסבאישי שפר שי שאראסר שי שירש אייאטרישט אייאטרישט אייאטרישט אייאטרישט אייאטרישט אייאטרישט אייאט άμεργρέωσ οιταρηθυίαμο το 1994 θητων. Σταπαιατικά αθηθορια αι τη ται τη ται τη τ



᠂ᢑᠴ᠘ᡃ᠋᠅᠘᠊᠋᠅᠘᠆᠕᠂ᢣ᠘ ᠔ᡔᡄ᠈ᢣᡣᡝ	∆თ∿ს	ᠴ᠋᠋ᡆᠮᡗᡄᠮ

3D). P_{A}^{*}

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• Λ° u/dr Δ° ascibistication of Coordinate Coo

>⁶) σ^{0} , \dot{J}^{0} , \dot{J}^{0} , d

• ፖኮናንረላዖፖኈ ኦርኈዖኦናልቦታንኄኮ ላናሚታላናስና ናዖ፝ ህርኒናልኄሁ ላናልታና. «ዚጋናርኦኦኄሪቲናና

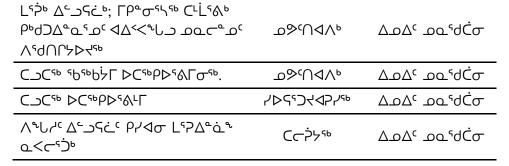
 σ° 1. $a _a Δ^{i} + L^{i} Δ _a^{e} _a^{i} < A^{i} + L^{i} + L^{$

1.4 Δ^{$-}_3ⁱdhⁱ d ₂ⁱdhⁱ Δⁱdhⁱ</sup>$

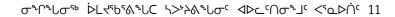
᠆ᡧ᠋᠊᠘᠋᠊᠕ᢞᡆᢩᢂ᠋᠖᠋ᡃᡗ᠂᠘ᡄ᠆ᡪ᠋᠘᠆᠅᠘ᢞᢐᡃᢐ᠋᠊ᢛ᠆ᠺ᠘᠆᠕ᠰᡆ᠋ᢂ᠋ $\Lambda P^{sb} d^{2}C P a d^{s} D \sigma^{c}$.

- $\alpha \Gamma \Box \Delta^{\circ} \alpha \Box A^{\circ} \Delta \alpha \Gamma$, $\Delta L \delta^{\downarrow} \Gamma \Box \dot{D} L \forall b \delta^{\circ} b \sigma$;

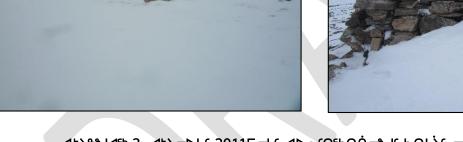








ላ›كَ ئَامَ 3: مَامَحَكَ 2011٢-٢٠ مَاكَ مَانَ مَانَ مَانَى مَانَى مَانَى مَانَى مَانَى مَانَى مَانَى مَانَى مَان المان مَانَ مَانَى مُ C. _>>ν∩⊲∧чΓ Δ՟_>ናረ፡; D. _>>ν∩⊲∧чΓ ▷C™₽ኦነልν C_C™











С

Environment and Environmement et Climate Change Canada Changement climatique Canada



2 ᠘᠆᠋᠂᠈ᠪᡗ᠋᠂᠘᠘᠂᠕᠘

2.1 Δ⊂[™]dゲη, Υ≫⊂ησ[™]ύ, Ο΄

'రరా'ర్ రాగాంగ్రా స్దీరి స్రాంగ్రా సందారింగ్ సందారింగ్ సంగాంగ్రా సంగాంగ్ సంగాంగ్రా సంగాంగ్ సంగాంగ్రా సంగాంగ్ సంగాంగ్రా సంగాంగ్ సంగాంగ్రా సంగాంగ్ సంగాంగ్రా సంగాంగ్ సంగారా సంగారా సంగాంగ్ సంగాంగ్ సంగారంగారా సంగారా సంగారా సంగారా సంగారా సంగారాగారం సంగ

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 $\triangleleft \cap \triangleright \cap i^{i_{i_{i_{j}}}} LC \Gamma^{i_{i_{j}}} d\Delta \succ \subset \Lambda \cup \Gamma$ (Fortune et al. 2017).

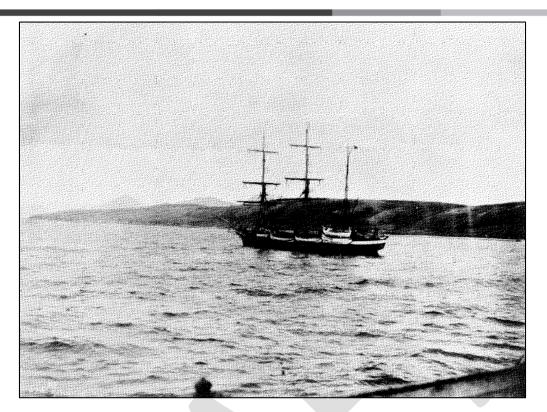
"b▷L™d∩ጔና. ▷™ረና∩?በናኣጋና. ≪L_> ▷⊲ኣ▷∩⊂▷?በናኣጔና (Kugler 1980. Ross 1993). ליפס⊲ת⊲כב⊳יץנלי יףף™כֹבֹל ∆ףקל״טכ יטסריֹס ∧רפיסחי ∆אככיהרבחי 1600°רי פעב ለ_d CarleCa®aናጋበና ፈናዊናbናCerebናጋና 1719°ቦσ, ርናኑኮኦና ፈናዊσፈናሰና ، خلەت سەرەر ھەتەركەھەكەركەھەكەنىڭ (Ross 1979)، ھەت 1820، ئەلمەت 1820، ئەلمەت كە Γ° Γ Δ° Γ Finley በዮጋJ 1800 ነዖበላσና Δረ<_∿Ր°ຼ໑ና (Higdon 2008; **ላንት°ህላ∿ 4**). >በነ d∆° ຼຼ໑໑∿ႱσናΓ⊳ና 'የዖኈĊጏ< ΔዖናኣኈႱσ ላ፣ペσላ፣በ▷፫ኪ°ጋቦና በቦናጋሀ 1900ኈቦ°_ውና, የረላσ፫, Γላ፫ႱናΓኦና \square שבילפירססשיםתישרי ליפססילי באכשסד Holland 1970, Ross 1979, Higdon 2008). ፈናራው ፈንጉ ወንጋር 1800 በር Δረላውና በዮጋህ 1911 በ ወንጋር እናለ የሰላ ር μን የ (Woodby and

'ዕ⊳ትペ'ር⊲ታГσ^ъ b∩^ւνረΔίδር⊂▷ናኈႱና Wenzel (2008) ▷ንት?ሥσ⊂▷ናጋኈ ነδና/Եና⊂└Ĺሲና

- ילריے חףיכט לפחי ילרי כירנים משמי) שישיכבאיסי מטריכוי אמייטשי $\nabla \nabla \sigma c' < \nabla \sigma c'$







⊲ኦዶ∿ህ⊲ኈ 4: ሥ፱ራገጋና ▷Γ⊲Γσኈ ዻና≪σ⊲ና∩ጔና, Cイ▷≻ናΓ (1903), Γና∩LCϲ∽Γ (Ross 1979)

2.2 በበና፣ር⊳ረLኆ ዾዺፚ ለ፟፟፟፟፞፞፞ለ፟፟፟፟፟፟፟፟፟፟፟፟፟፟፟፟፟

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- 2. ዾፇናበላለ⁶ 'የዖ⁶'ር⁵ህ. ጋለ⁶ልΓờ^ና ለዖ⁵ር^ና ላ⁴L₂ 'የ⁶ታልờ^ና (ጋσΓσ⁵ ዾ' ל⁹ሮ⁵ ሮ⁵ ዾ Δ⁴Lσ⁴J⁵b²Δ⁵), 'b⁴LΓờ⁶ ለጋ⁵b⁴d⁴s²Δ⁴, 4⁴L² ጋσልờ⁶ 'b⁴LΓσ⁵Γ'; Cd²Γ' **ላ³ λ⁶⁵**J**4⁶ 5**A ⁵²D¹C⁴U/L⁴.

ᡣᡣᡥᡃ᠋᠑᠋᠄ᡃ᠌᠌᠖᠅ᢁ᠘ᢞᡃ᠂ᢗᡆᡃ᠋ᢣ᠋᠋ᡗᡃ᠋᠖ᡃ᠋ᡭ᠅ᡫᡠᡃ᠑᠂ᢂ᠆᠅᠘ᡧᠥ᠂ᠴᡅ᠋᠋᠖᠋᠕᠋ ᡄᠴᡆ᠘᠋᠋ᡝᢣ᠘ᢞ᠂᠋᠋᠋᠋᠆ᡘ᠆᠅ᢕ᠅᠘ᡔ᠋᠋᠅ᢄᡶᢞᡃ᠖ᡃ᠋ᡭ᠅ᡫᠦᡃ᠄

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⁵PP⁶C₂ > P⁶d4 ⁵bP⁴L²C⁴D⁵ αΓ²D⁶ αΓ²D⁶ α²P⁶C⁴U⁶ ⁵P⁶C⁴U⁶ ⁵D⁶ α⁴C⁴U⁶ ⁵D⁶ α⁴C⁴ ⁵D⁶ α⁴C⁴ ⁵D⁶ α⁴C⁴ ⁵D⁶ α⁴C⁴ ⁵D⁶ α⁴C⁴ ⁵D⁶ α⁴C

4 (أجاب 1818 PT (أجاب 2000) (أجاب 2





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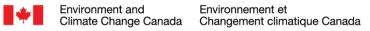




⊲ነት°ህ⊲™ 5: ⊲ነት⊂ዾሁና ለዛሬሲዾቦታዾኆ Δዛሬσኁጋጭ ወቂዀናልቦታና σግቦኄውዀ ዾ፟Lጘዄናልኄሁσ. Α. ም°σልታና

చిటి సింగాం సంగాం స

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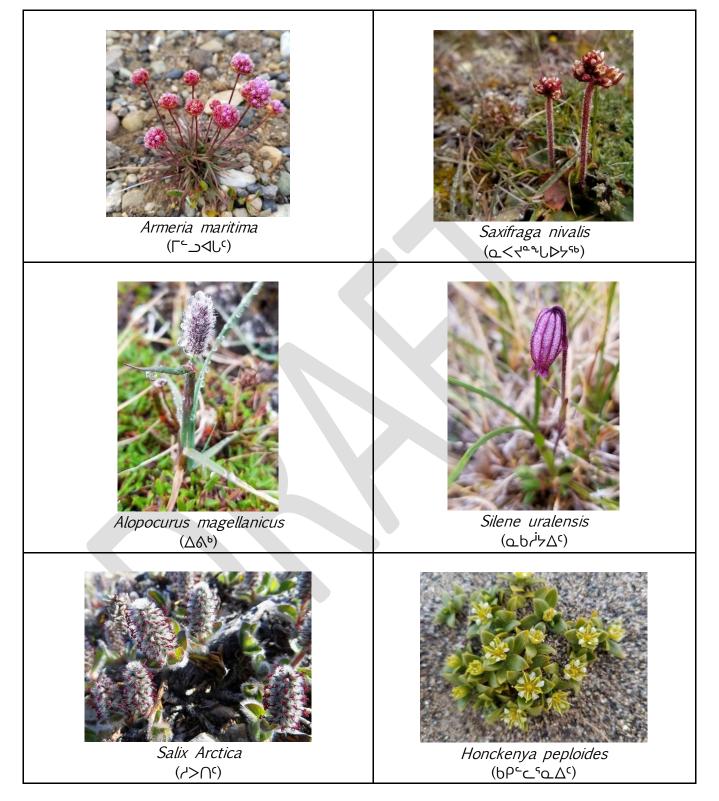
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 $σ^{h}$ ^h υσρ^k γ₂^hυ μ_c^h σρ^k) Δ^h αⁱ^hυ^k σ^k γ₂^hν αρ_k^hυ^k σ^k γ₂^hν αⁱ^kυ^k σ^k γ₂^hν αⁱ^kν α

(**⊲ንት°ህ⊲™** 1). Cイ⊳ታ∿し Δዛሬኻ 30 km ዖ⊆Րርና ፖልጋσ∿し ኣσ_ሪና <∿しσ ≪ዜጋ Δ∩σ™<፞ህσ∿し 260 m ר כסיסס (Finley 1987, Finley 1990). כאסאיער באיער איריבילא אסאלאיסדי, אר ה $\dot{}$ $\mathcal{L}^{\circ\circ}\dot{\Gamma}^{\circ}$ ם רס \mathcal{L}° ס (Finley 1987, Finley 1990). ביר \mathcal{L}° ס \mathcal{L}° ס \mathcal{L}° ס (Finley 1987, Finley 1990). ביר \mathcal{L}° ס \mathcal{L}° al. 1994, Northern Environmental Marine Organization 2003). $\Delta^{b}b^{\circ}\sigma^{b}b \Delta b c^{\circ} (\dot{b} \dot{c}) \cap b d_{c}$ <30 m $\dot{\mathsf{FC}}$ \mathcal{O} \mathcal{O} σφωνλοδωναφοισ δωσασοι σουτία Δωριά σύματας (Finley 1990, Aitken and Fournier) 1993). אים אי פאשרעיטי ארייט אריט אין געריט געריט געשי געריט געריט געריט אין אין אין 1993. איז אין 1993, σΓィ」 ΔLD< Δ^{*}Γίςσ^{*}υ ίρρ^{*}C₂Γ΄^{*}ΰς⁵ Δ^{*}Δ^{*}σ^{*}υυ Δ^{*}Γίςσ^{*}υC₂ μοσ^{*}υ Δ°Γςσςγδαςσα μοΔσςγδαςσσυ ΔΛσευ Δααιυ αρεείςσευ ، イdˤbʔ°ởˤᠠ᠘bΔ°ݥˤᢣᡃᢉᡤ᠋ᠴJ (Fissel et al. 1982, Finley 1990). CĹσ Δ∿ᡤᠭᠬ᠋ᠴJ (Fissel et al. 1982, Finley 1990). Λσιζίσιυσι, ϷϿϤϷ< Ψιδυαιρείας, ϤΓ⊃ ΔΓΑ< Ζωριαιριας συραιας σρασισειρα $\Delta \cup \subset \odot'$ ישלי איר שראלישלי (Finley et al. $\Delta \cup \subset \odot'$ 1994).

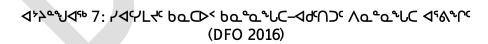


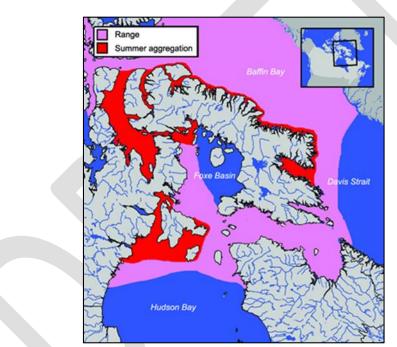
ద్ఘట్ ద్యార్థిల్ దిండాల్లో సంకాండాలు దిండాల్లు సంకాండాలు దిండాలు దిండాలు ఉండాల్లు ఉండాలు ఉండుం అండాలు ఉండాలు ఉండాలు ఉండాలు అండాలు అండాలు ఉండాలు ఉండాలు ఉండాలు అండాలు

⊲ነት°ህ⊲ኈ 6: Ϸ΄כֹֹוֹ בּםַרֱליָטלגל ס∿ר∿נסኈ ϷׁL๙וּהַאָּטָס (לוֹאָבשׁנייר: ח. אוֹשׁניי).

[•] δοργιώς διαθαία δατό μαι διαθαία διαθαία τη διαθαία διαθεία διαθεία διαθεία διαθεία διαθεία διαθεία διαθεία δια CPትዮጵር የሚገሩ የሚያገሩ የሚ and Botkin 1993). איפסאולי סאידארטילי, באלכבאיעראי אראכאיר 1900 איני 1900 «Γζήνανμαντισιας 100 αήμας Δυασ (Finley 2001). μας το ματικο μαιά το ματικο μ αποικο ματικο μ et al. 2006, Doniol-Valcroze et al. 2015, Frasier et al. 2015). ΔΔΔ^c Dσ^b COJ^c d^cÅ^c





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3.2.1 Jid'

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ΡϑϚᡄ᠈ᢣ᠋᠋ᠣᡪᡃ᠋ᠸᠣ*Calanus*, σᠻᡄᠴᢦᢗ°ᡣ (Finley et al. Finley et al.1986, Finley et al.1994, Finley et al. 1998, Lowry 1993, Nunavut Wildlife Management Board 2000, Laidre et al. 2004, Laidre et al. 2007). b/いイレー いっぽうし Cムケレペン "*Calanus* Pじらこ」 マイペ" (Finley et al. 1998). ^sd۵^c∩۲Lー^c^c^c^c^c ^dAPPt^e ^o^c ^{(Bradstreet and Cross 1982, Finley et al. 1986, Dueck and} Δυς ΄΄. Δίδι σαλαύς και μαια το μαια τ ᠋᠋᠋ᠻᡃ᠋ᡃ᠋᠋᠋ᡃᠫ᠆᠘᠋᠋᠋᠋᠋᠆ᡩ᠘ᢞ᠋ᢕ᠖᠘᠋᠋᠋᠆ᡩ᠘᠖᠕᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘ ለ血゚血゚しር ዻናል゚ቦσና ናዕዾትናዕረው/ጋና ዮኒჼ፦<ዾσናኣσና ዻናዖላዖኑርንና (Mvsis oculata) סיֹףרי⊲ליΩCiΓLC (Pomerleau et al. 2011).

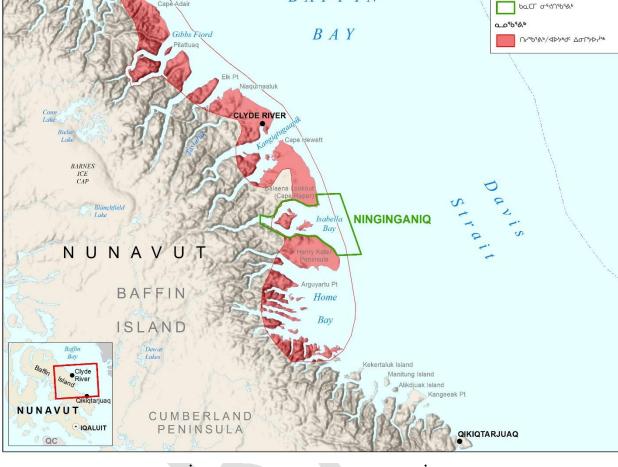


నిసిగిరాంట్ "*Calanus* Pిచినండాం రిగిజిగిదింగాం" Lరారార్గిని గారార్ సిందిందింది. 1994). సPPిండ్పాగ్ ఎళి గెరిదిజినరాగం, సింపునినికే పెరారారు పరిగిరించేరారు సినింగాం చిందింది. విశిందం రాస్పారా, సిగితిందా గెరింటి సిరించింది. ఎగ్ సిరింగి పెరి సిరింగాం 1983గి ఈ ఓు 1992గి, విశ్యీ సినిందం రాస్పార్ సినితింగాందు.

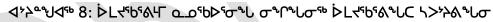
حدره، المعام، المعاد المعالية المحالية محالية محالية محالية المحالية المحالية محالية محاليمحالية محالية محالية محالية 7) すっしょう (Rugh et al. 1992, Schell and Saupe 1993, COSEWIC 2009). ふっかつゃ Ĺናċኈዮና, ΔιLib ΛነፈርϷ՟ン⊲Ciul ሎbΔናጋΓና Ϸ∩ιν<՟σ⊲ciPፈና (Mitchell and Reeves 1982, Reeves and Mitchell 1988, George et al. 1994, Finley 2001, Moshenko et al. 2003, Higdon et al. 2011). Ροῦμασια σιὰς Δυσῦτς το θορσμασια σια σια σιάς αιτο αιάς $d^{r} + d^{r} = \Delta^{r} + d^{r} = \Delta^{r} + d^{r} + d^{r$ Finley 1990, George et al. 1994, Northern Environmental Marine Organization 2002, Reinhart ˤƤĹۿᠺᡃ᠋ᡪ᠖ᡔ᠋°ᡠ᠌ᡝ᠋ᢙ᠈᠘ᢁᢅᡃᡆᠯ᠙ᡩᡄᢀ᠋ᠣᢩᢈ᠓oshenko et al. 2003, Higdon et al. 2011, IPCC 2014). ነካጋጋሪ° Δ^{c} Δ^{c} مرلاح ملاح Lycon مالاح (Finley et al. 1986, Philo et al. 1992, Finley 2001, COSEWIC 2009).

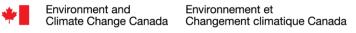
3.2.2 ANTCADTOC > DA

anadagc. Jula a



BAFFIN







ద్గీ రవిది అర్గించింగ్ చింగ్ చేస్తులు రాంగించింగా సిర్లీ సిర్లీ సిర్లీ (Government of Nunavut 2014). రిస్ట్ సిలిస్ట్ సిల్లించింది సిర్లింగ్ సిర్లం సిర్లింగ్ సిర్లం సిర్లం సిర్లింగ్ సిర్లం సిర్లింగ్ సిర్లం సిర్లం సిర్లింగ్ సిర్లం సిర్లింగ్ సిర్లం
ΔቃΔና ቃቂዮና ቂ៩ሁዮዮኇና ኦበሎሪውዎራውናሪ የትርሞ የኦቦሎጋቪሊተር በበናናረርተር ላህታዎዲንርታና ኦርኖ ላժዮኖትሁም 1923Γና በዮንጋ 1974ጋና (Milton Freeman Research 1976). በበናናረርተና ኦሮቴው ርሏር የላር ፍተባሰና ላቲናና ላጊ ላጊ የአንድ የዲጋላም የኦቦሎጋና ናትሁምሁናንና ርረውታዎምናለምጋ, ለየኦርዮር ላይታዎስና መሬና ላጊ የሚጋላም የኦሮም የኦንምና ላውታዎስና ነው እንዲ ለየኦርዮር አልኮዲናንም. አቀር የህቂራና የኦሮር ኦዮትሪና ኦናንምና ላውታዎስና ነው እንዲ ለሆኖንም ለልኮዲናንም, የተርጉትህም ሆምና ልቃልና ኦናዮምሪር ኦናትዮናላልናንስላትሁ ልሁኖናንና ላዲጋላ, ኦቦዮትሁምና አውዲር ኦሞ ለህልናት የኦሮቦታም.

3.2.3 CLDTDC APT 42 DL + BDM

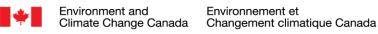
దటడార్స్ ద్రహాంత్ దిశార్ దిశార్ దిశార్ దిశార్ దిశార్ దిశార్ దిశార్ దిశార్లు ఆటు దిశార్లు ఆటు దిశార్లు దిశార్ల

3.2.4 *∩°*୮√



 σ Γ⁽γ4[\] $b\sigma$ Δb- $\dot{D}^{<}$ (Finley and Evans 1984). ⁽b⁽d⁻)Δ⁽ (Fulmarus glacialis)) ⊲ ∿Ր σ (Finley 1987, Finley 1998). L כ יכו שם ינס ינסאנאסלי, ליט (*Chen caerulescens*) Λ C⁶b⁵⁵ ΔLc[·]⁵ Dd^ea^{*}Lσ, \square P⁶(\square AN⁶ ba^ea^{*}e²/dσ, LΔΓ $\frac{1}{2}$ σΓ \square (Government of Nunavut grylle), σና፦ (Branta canadensis), የዮንሀሩ፦ (Somateria mollissima), ወኦታልንተል (Larus *hyperboreus*), ベレン うってくく (*Gavia immer*) (Northern Environmental Marine Organization 2003). «/ግግ ΔLˤΓϷϹˤ / ϹϧϷˤΓϷϹˤ በϞΓϤˤ ϧϞቡͽϽὑΛιΤ<ናϽና ϤペンϤσン LdϤ: ΔΓͽϲͿΔϲΔς (Sterna paradisaea), ^sd^c (*Charadrius hiaticula*), こ ひっん^c (*Larus glaucoides*), こ ひっや^c (*Pagophila*) eburnea), ⊲^LL → ⊲^b<∆^c (Uria lomvia) (Sale 2006, McKinnon et al. 2009, Gaston 2011, Government of Nunavut 2014, Richards and Gaston 2018).







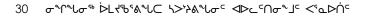
3.2.5 ÞL ~ Arn

 $\label{eq:approximation} \label{eq:approximation} \label{eq:approx} \label{eq:approx} \label$

ΔቃΔና ቃቂጐቦና ቂኆ፦<ናሮጐቦምናጋ ቂጋቂΔናጋΔሬሥንንና ኮዮዮንጋኒሊና በበናሬሥንንና ኆህቂሥኖልምና ኦሬናቴክበሶና ለተናላማትሬኒኒር ሬሮናንቦና ለበፋንጋታ 1923Γና በΡናጋታ 1974ታና (Milton Freeman Research 1976). ኦምቴም በበናናለሬና ጋናንና ኮዮኖሎ<ናንና ሬማፍሥታኖ ላኖሎ። ፈኮለሬንፈጋፈጋና (ኦሬኖቂጐህር ለቂኖቂጐህልና), ቂምኦቦሪናንና ቂሞኦኦሮም ወጅናበጐቦር.

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- 4. ההיכארגי 'בשבאיכארגי', 'כאאאליט'בשאי', אישטאיבעי', אישטאיבאי', אישטאיבעי', אישטאיבעי' אישטאיבעי' אישטאיבעי'
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	مام	᠔᠆᠈᠋ᡃ᠋᠐ᢗᢂ᠋᠘᠈ᢆᡃ᠘			
᠕ርʹᡃ᠋᠖ᡪᢞᡃ᠋ᠫᡃ᠋᠉᠂᠘᠆᠘ ᠖ᢂ᠆᠕᠂ᠬ᠘᠕᠆ᢁᡬ	եսշլ		൧൨൭ഺ	᠆ ᠆ ℃dᢣ▷ィL杙 ▷∜④≟°ở	
⊲∩ [∞] CÞ/L≮	<i>Ϋς</i> 1	<i>ነና</i> ¹ ይላ⊗г ፈጋፈ∆⊎ď³		ᢗ᠔ᡃᠺ᠋ᠫ᠘ᡨᡆᡅ᠍᠍ᡧᡄ᠄ᡧ	
∩∿ר⊲י	•				
ᡗ৽᠘ᡧ᠋ᠺᢦ᠄ᢣᢈ	۵؍ڶٵڮڡ؞	∆ہلےےمٸ٢٢٦٢ (2017)	᠕ᢗ᠋᠋᠂ᢅᡉ᠌᠌᠉᠆ᠬ	CdኑÞrL⊀	
م٥۶ کلار	٩٠Cıqųcb4	⊲د⊂و۹۹ب⊂۲۵	᠕ᢗ᠋᠋ᠻᡉᢩᢞ᠋ᡗᠬ᠋᠋ᠫ᠋᠋᠋᠄	ϹϥϞϷͱϞϨͼϽͼ	
مەلەر	᠊᠋ᠴᡃ᠋ᠲᠣ᠊᠋᠋᠊᠋᠋᠆ᡔᡐᠮ	᠊᠋ᠴᡃ᠋᠍ᠣᠳ᠋᠋ᠳ᠋᠋ᠳᠺᡘ᠋	᠕ᢗ᠋᠋ᡪ᠋ᢧ᠋ᢩ᠆ᡷ᠙ᢕ	CqAPPrAcDc	
ᡃᡪᢂ᠋ᠮ	ᠫ᠆᠋ᠴ᠋ᡃᠣᠳ᠋ᠺᡘ᠋᠆᠘᠆ᡁ	᠊᠋ᠴᡃ᠋᠍ᢪᠣ᠋᠊ᢦ᠋᠋ᠳᠺᠠᡗᡃᢣᢂᢞ	᠕ᢗ᠋᠋ᡪ᠋ᡌᢦ᠋ᡐᡗᠬ᠋ᠫ᠋ᢛ	᠕ᢗ᠋᠋᠋ᡃ᠋ᡋ᠘ᡱᡆᡅ᠋᠍ᡧᡄᡃ	
⊳۲۲، م۵₀،UV					
⊲∆ۿ۬‹, ۥ۬ڟ‹ؠڹػڶڹػۥ	ᡆ᠋᠋ᠴᡆ᠘ᡃᢗᢂᢞ᠘᠋᠈ᡗᠬ᠋᠌᠌	۵'nĹIJſ۶Þť	᠕ᢗ᠋᠋ᡪ᠋ᢧᢨ᠋᠈ᢕᡗᢌ	CqAPAqAp	
ڡؚۮڹؙۮ	ᡆ᠋᠋ᠴᡆ᠘ᡃᢗᢂ᠘᠅ᡗᠬ᠋ᢅ᠌ᠵ	۵،۲۲۵۲۴	᠕ᢗ᠋᠋ᡪ᠋ᢆᡉ᠋ᢩᡷᡊ᠋ᠫ᠋ᢛ	Cq4D4T4c	
^ና ₽౬౨౿ౕౕbdౕౕ౿ౕౕౖఀ, Þౕ⊌dౕΓÞఁౕdఁ≀Ċఄ – ᢣᠳᢓ∩Ϸౕ౨ౕ₽౬౨৬ఄఄ٢ఁ	ᡆ_ᢣᡆ᠘ᡃᢗ᠌᠋ᡔᠨ᠘ᢩ᠈ᡤ᠑᠈	᠘ᡤ᠘᠋ᠴᢉᡃᢣᢂᢞ	᠕ᢗ᠋᠄ᢅᡃᡉᢩᢞᠶᡃᡗᠫ᠋᠋ᡃ	CdኑÞbưረፖሪ	
⊲'ል́‹, bჲር▷′ bჲ°ჲ∿Ⴑơ - ⊲d₽ጋ'౨ ∧ჲ°ჲ∿Ⴑơ	ᡆ_ᢣᡆ᠘ᡃᢗ᠋᠋ᠵ᠘ᢩᢣᢕ᠈	∆≁Ĺ∍Րᢣ⊳⊀	᠕ᢗ᠋ᡝ᠋ᡉᢩᢩ᠈ᠧ	Ϲϭϧ⊳ϞΓϞ	
Ͻ·Ͻ· (LσϚ·ΓϷϹ·)	ᡆ᠋᠋ᠴᡆ᠘ᡃᢗᢂ᠆ᢥ᠙᠑ᡃ	٩،٩،٩٩	᠕ᢗ᠋᠋᠂ᢅᡃᡉ᠋᠋᠅ᡥᢗ᠋᠋᠋ᠵᢑ	᠕ᢗ᠋᠋᠋ᡃ᠋ᡋ᠘᠋ᠳᡆᡅ᠋᠍᠆ᠵ	
^ډ ٩دےل ^ر ﮐﻠﺨ ^ﺮ (،٩٩ܡ،৬૮۲, ៤ﺩ᠆ۥٵؚ؇	ᡆ᠋ᠴᡆ᠘ᡃᢗ᠋᠋ᠺᡃ᠆ᠺ᠅ᢕᠶ	۵۲Ĺᠴᢉᢣᢂᢞ	᠕ᢗ᠋ᡝ᠋ᡉᢩᢩ᠈ᢕᡗᠫ᠋᠌	ϹϭϧϷϞΓϞϲ	
مـەر	ΔλΓγρκ	Διέσιγρα	᠕ᢗ᠋᠋᠂ᢅ᠋ᡌ᠆᠋᠈ᠺ	Cd♭⊳rL⊀c	
۶۵۶ġc	ΔιΪωργο	Διΐωργο	᠕᠋᠋ᢗ᠋᠄ᢅᡃᡉᢩ᠉ᢕᢗ᠋᠋ᠫ᠋ᢛ	∧Cౕb⊃∆ిౖౖ∩⊲⊂ి (Awan and Szor 2012)	



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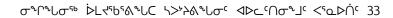
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4.1 ϷLᠯ^ҁσ⁵





ィタσィハσ (Harsem et al. 2015), የイタσϲ, ▷ዀイタ」やプロ・レイントン・シーヴィ $P_{2} = P_{2} = P_{2$

⊲ጋቢĴ≗ዹ՟ሩሲ≗ዏኈሁ >⊀ኄጋΓና ረዖ፣ሷናጋና σ∿ቦኈሁσዀ ዾ፞ዾ⊀ኈ፟፟፟፟፟፟፟፟፟፟ዾዀዀረ ⊲ペበናረላኈሁσ ٥٦٩٢خمخ»،أحداد م، ما، محد به محد المعلم الم المعالم المعالم المعالم المعالم المعالم المحد المحد المحد المحد الم ح°م& ک (COSEWIC 2009, Beyer et al. 2016, Blanken et al. 2017, Bone 2018, د- م v Ω Nevalainen et al. 2018, Vergeynst et al. 2018). $\Delta^{\circ}\Gamma^{\varsigma} \prec \sigma^{\varsigma} \to \sigma^{\varsigma} \to \sigma^{\circ} \to$ $d \otimes \cap \mathcal{C} \otimes \mathcal{C}$ ᠴᡆ᠋᠋Γᡃ᠄᠈᠋᠉ᡃᡁᢞᠣ᠋᠋᠋ᡪ᠋ᢣᠵ᠋ᢕ᠋ᡗ᠄ᡃ᠋ᢧᠣ᠋᠂ᡄ᠋ᢗ᠘ᡄᢉᢦ᠋᠋ᡄ᠋ᡃ᠋᠋᠋᠋᠋ᠴ᠋᠋ᢧ᠋᠋᠋᠋᠋᠋᠋᠋ ⊳∿טכ<u>ֿ</u>ר 400 כ<u>°</u>י.

4.4 **Þ**Γ⊲⁵√4 ⊲,>∩σ⁵∩ יטסאאסיטיביעלי סאירי אייאלי סאייכסאייטיגר (Kraus 1990). ארסילסי סביאפירסרי<כ, ᡏᢗ᠋᠋ᡄ᠋ᡝᢣ᠋ᢡ᠆ᡏᠫ᠘ᢩ᠖ᡆᢓ᠋᠋᠆ᡆ᠋᠋᠄᠋᠋᠉ᡶᢗ᠋᠋᠄ᡩᡬ᠄᠋᠋᠋ᡏ᠘᠋᠋᠋ᡝᢕ᠋ᡝᡃ᠋ᡶ᠋ᠴ᠋ᢦ᠋᠋᠋᠋᠋᠋᠋ᢉ᠂᠋ᠳᠺᡄ᠋᠋᠋᠆ᠮ᠂ᡧ᠋ᡬ᠖᠆ᡧ᠋ᡗᢂᢞ᠋ᡅ᠄᠋᠋᠋᠋ σ^{μ} የረላσሮ. ጳጋበσሲႱታኈርኈቦና ዾΓላናጚላና ጳኦበ°σኈ፟፟፟፟፟ አርጐ፝፝፝ዾና ሲዾናታጋኈርዾታሲላሮ፦

 $4.5 > 4^{5} - 7^{5} - 7^{5}$

የረላውሮ ላንትሶ<<∿ቦ⊾୮៩ ላናልና ላጋው, ላናናህ୮ጔ ኄዮሁ▷<<ና, ላ⊾__ ውናዮናኣን▷ናልኈሁ (Richardson and (Marshall Macklin Monaghan Ltd. 1982, Nickels 1992, Stewart et al. 2011, Stewart et al. 2013). P^{P} P^{P} P^{P} P^{P} P^{P} CALADA^ea^s<^c ームシングでいっていっしょう (Paxian et al. 2010, Pizzolato et al. 2016, Dawson et al. 2018).

4.3 σΛċ⁻

 L_{C}^{-} / - የወይ የመረሻ የመሬት የአንት የሚያስት የመሬት የሚያስት የመሬት የሚያስት የ ՈየፖLԾֆՐԾ.

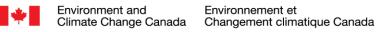


4.7 ረር ላ/ንትና<ና ላ ፊ የ

᠊᠋ᡊᢂ᠋ᠴ᠋ᢄ᠉᠆᠕ᡧᡄᡆ᠋ᠫᢨᡆ᠋᠋᠂ᠳᡆᡐ᠋᠋᠘᠋᠋᠋ᢣ᠘᠋᠋᠘᠆᠘᠆ᡐ᠋᠋᠘᠋᠆᠘᠆᠘᠆᠘᠆᠘ $\Delta L^{b} U \sigma$, $\Delta L^{c} \sigma = \Delta L^{c} \Delta L^{c} \Delta L^{c} \sigma$ (Church 2011, Government of Nunavut 2016, Bone 2018, ΔLⁱΓ C C Λ^b dⁱ 2020), ⁱb c i c Λⁱ Λ^b Δⁱ Λ^b Δⁱ Λ^j Δⁱ Δⁱ Λ^j Δⁱ Λ^j Δ^j ΔυσιόΓ. Δενρί σριργικα διοσυγγικα αγράγια τη αγράτη αραγικά τη αραγική αραγικά τη αραγική αραγική αραγική αραγ (ዾ፞ናጋበቦጔJ. bclነጔና 'bcናc°σďንና). ርΔLΔ<<ና ፞ ፈረሁኄሁ ኣኈለዽና σናዋናኣናዖናልጋላኄሁ Δ ሩለቦታኦሮና<ር ለኦሥቦσና «ኮጋ Δ σናኑን» Δ ና። /ሮቴኦሮም, ኦጋና/«ትርላሩር Lናቡናርኦበጋና Management Board 2000). Leoc, ibp>いい ΔμιδιΣ Σide C בכ, ibp> ᡏ᠋ᢗᢛᡆᠯᢗᢂ᠋᠆᠘᠖᠆᠘᠘᠆᠆ᡧᡌ᠒᠆᠕᠋᠕᠆᠆᠆᠕᠋᠕᠘᠆᠕᠋᠕᠆᠆᠘᠘᠘᠆᠕᠋᠕᠘᠘᠘᠘᠘᠘᠘᠘᠘ Pበ⁶< ⁶ ር ላው ⁶ የ ⁶ 1 ⁶ σ° \dot{D}







5 ጋናሀዔ ለታሲና ወረተታ

5.1 Ϲ┫·ᡆ᠂∿ͿϤʹϹϷϯϹϯʹ

ለዾኈረዻኈርዾጋσ ርሲዾና ወዲቦጋ ዉረሁኈቦና ዻ፝፞፞፞፞ዉዾዾነ፟ጚብቦ፟፟፟፟፝፞ በራይ አንንኦዾጋσ Δ፞፞፞ዾልና ለኈdィጋናьናгሪ ወዉГ°ወና ላውናሩ፣ለL&ቦሚናርኈሁ. σኈቦኈሁσኈ ዾ፞L๙ኈъጜኈሁ ጋኈbርናልውσላናг๙ኈ 'bPP/2 4?ጋውና ፈናልና ፈሬሀብዋው ወዲናርስቦ, የቦርረን< ርጥይ،ቦር ፈሬሀብና ብዙቦን የተበጋይ ውደ የወንዲ

5.2 ጋናሪና ለታሲናር አዲቲ ጋ

 Δ^{\prime} ለህሥበላσላናጋና ጋግኒሀልናክናጋቡና Δርግሀσ 2.1 ላግቦፖርኦርኦናጋσ Δρ Δ^{\prime} «ጋጮርኦσግቦግልና $\Delta b \dot{\prime} / d 2 \Omega^{c}$ $\Delta b \dot{\prime} / d 2 \Omega^{c}$

 $\Lambda = \Lambda^{\circ} C D + L + \sigma = \sigma^{\circ} C^{\circ} L + \sigma^{\circ} D + \sigma^{$

 \mathbf{D} ሳሪ% 1: እንታ ጋበ ላናልና ላሥር \mathbf{D} ኮር ላ \mathbf{D} ጋና \mathbf{D} የ \mathbf{D} የ \mathbf{D} እና \mathbf{D} የ \mathbf{D}

ちしつとしてくいしし ヘアジノタティン つらしめ ヘタウト シンティー ひょう ひょうちょう ひょうちょう ひょうちょう

 $\dot{D}L \prec 5b 5h UC 4> 2A UD 47A UD 47$

 Λ biscover 1.3: Let control Let Concover and Atlantic A Arr DLt ALD attr Arababish CLDI& JEELT LCLONN $\forall D \subset \Omega^{\dagger} + \Omega \subset \Lambda^{\dagger} = \Omega^{\dagger} = \Omega^{\dagger} + \Omega^{\dagger} = \Omega^$

 Λ μάτοντι 1.4: Δ ργτωντο μαγραγιστικό τη ματροματική τη μαρικη ματροματική τη ματροματική τη μαρικη ματροματική τη μαρικη ματροματική τη μαρικη μ

 \Box ሩ Δ^{1} \wedge P \rightarrow D^{1} \wedge P \rightarrow D^{1} \wedge P \rightarrow D^{1} \wedge D^{1}$

 Λ νάς Δ ν $\forall D\Delta^{e} \Delta^{e} \Delta^{e} D \Delta^{e} \sigma^{e} \sigma^{e} D \Delta^{e} \Delta^{e} \Delta^{e} D \sigma^{e}$

Lc^cጋቦ^c በበናና/Lσ^{*}ν^c 2.1.7 ব^{*}ν^c^sbn^c^jJnσ^c IIBA, Δ^cC^sσ^s^s^dN^{*}ν^c 4^L Δc^s^b^d^s^b^d^s^b^d^s^b^d^s^b^d^s^b^d^s^b^d^s^b^d^s^b^d^s^b^d^s^d

۵.1 <u>Δ⊂</u>[®]dłϽ[®]i∩J^c Λⁱd∩Ͻ[®]ht>לσ^c ⊲⊳∟^c∩Jⁱ^c

6 ⊲⊳⊂د∕ابٰر

<P><P><P><P><P><P><P><P><P><P><P><P>

5.3 ፡ዦΓ፡ዖσኈ

ለታሲናር >< L ላ ን ነ ፡፡ ለ ግን ነ ፡፡ ለ ግን ነ ፡፡ እ ግን

ϽϚʹႱჼ᠈ᢃ᠄ ᠌᠌ ᠌᠌ ℙၑႝϽΔ°Ⴍჼ ᡝ᠋ᡃ᠋᠔Ϸᢣ᠘ᡣᢗϷ᠋᠋᠋ᡔᡣᡝ, ᠊᠋ᡶᡃᡃᢣᢆᡆ᠌᠌᠌᠌᠌ᢄ᠆ᡘ᠋ᡝ᠋ᢉ᠋ᠴ᠋ᡝᡄᠴ, ᠴᡆ᠋᠋ᠵ᠘°ᡆᢩ᠅ᢞ᠊᠋᠋᠋ᢛ᠋ᡝ᠘°᠅ᢉᡗ᠉ ᠘᠆᠋᠋᠋᠋᠋᠋᠘᠆᠋ᢧᡶ᠋᠆ᡩᠣ᠋᠋᠋᠘ᢣᢄᢣ᠘ᠺᢄᡔᠴ᠘᠋᠋ᡬ᠘᠋᠊᠋᠋

 $\Lambda + i C D + L + 2.3$: b D + h = D + f = D + f = D + L + D + h = D



۵‹ርናኇኣኈ ኄኯኯኯኯሩ‹ ۲۶٬∿ႱႱ‹ مےم۵፦Cኯዸኇ፟፟፟፟፝ዯናጋኈ, ላኯኯኯኯኯኯኯኯኯኯ ዾฉ[๛]ปจกม ห่งกจระL^{*}เม مےم۵፦C>ש กก๛กม. כיטס סרארעל ጋσንኮቦବኄተናን፦ጋና שמפי נפנטר מכײַטלרבתאש מ׳מיכז־גאשש, משמי ለነሪበጐሞው מדירס፦በשי, פובש שמפי סײַנאשי הדינרשי גנרידארמרסילדשר.



বংব্রেয় বংশস্বর্ন্যুন্ ব>প্ত র্ জ্যু	ϽϚϳͺͼͺϒϧϔϹϷϞͿϲ;ͺϿ	ϤϷ ϲ᠊ᠻᡃ᠈ᢣᠯϷ ᠳ ᡏᠫᡃ	ለ
>८९᠑ᠧᡣᡏ ^ᢑ	D $\dot{\mathbf{f}}$ U \mathbf{f} 1 : \mathbf{h} > \mathbf{h} > \mathbf{h} > \mathbf{h}	 (Φ) C (Υ) (Υ) (Υ) (Υ) (Υ) (Υ) (Υ) (Υ) (Υ) (Υ)	 Δ.Ξ⁶ Q.Π^c DQ P Γ P C P[%] (P^c) ΔDΔ^c σ P^s P L K^c ΛK⁶ Q P N⁶ b L K⁶ S^h U σ. bQ C F P L K σ L⁵ S^h U σ. bQ C F P L K σ^c L C U C P S S^h O^c Δ^k P^c C P L K σ^c L C U C P S S^h O^c Δ^k P^c C P L K σ^c L C U C P S S^h O^c Δ^k P^c C P L K σ^c L C U C P S S^h O^c Σ C S^c O^c Λ σ^h V G^s D L K⁶ S S^h U σ N K⁶ Q P N C S L⁴ D C C P S S^h O^c O^k C D C S^k O^k D L K⁶ S S^h U σ N K⁶ Q P N C S L⁴ S^h S S^h U σ N K⁶ Q P N C S S^h O^k D L K⁶ S S^h U σ N C S^h C D C K⁴, S^h U σ S^h D L K⁶ S S^h U σ N C S^h C D C S^k S^h S^h S^h O^k O^k O^k O^k O^k D S S^h S^h O^k O^k O^k O^k O^k S^h S^h S^h O^k



ঀ৾৾৽৻৽৾৾ ঀ৾৾৽৻৴৾৽ ঀ৾৾৴৻ঢ়৾৵৾৾৴	ϽϚϤͼϫϫϫ	᠊᠋ᠺ᠋ᢂ᠆ᠺᡃ᠈᠆ᠺᢂ᠆ᠺ	٨ペ፦ᠵ᠊᠋ᡆᠣ᠋᠋᠋ᠬᠥ᠈᠄ᡃᠥᠵ᠘ᢣᡕᡤ᠙(᠄ᡇ᠋᠋᠋ᠮ᠄ᡔᢝᢩᠴᡗ᠄ ᡏ᠄ᡩ᠍᠍᠊᠘᠂ᡄ᠘᠈᠋᠘ᢣᡪ᠘᠆<ᢕ
>∟ና᠑ᢅᡣ᠕ᡏ	\mathbf{J} Ġ \mathbf{b} w 2 : Λ \mathbf{b} ^c \mathbf{b} ^c \mathbf{w}	Δ ^L Lσ ^L Ͻ ^S b ^C ^D σ [*] h [*] Lσ [*] ÞL ⁴ b ^S δ [*] Lσ ^C ^D ^C ^L LΔ ^D σ [*] h ² σ ^C 6. ^{S⁴} P ^G ^D ^C ^S ^D ^C ^S ^D ^C ^D ^D ^C ^D ^D ^C ^D ^D ^C ^D ^D ^C ^D	 Φ°ση, νον το δημορού το δημορού το δημορού το το δημορού το /li>



ঀ৾৾৽৾ঢ়৾ ঀ৾৾৽৴৽৾৵ ঀ৾৾৴৽ঢ়৾৾৵	ϽϚϤͼͶͻͼ	ᢀ᠋᠆᠆ᡘᡃ᠈᠆ᡧᢂᡔ᠋ᡏᠫᡃ	٨ペ-באסלירסי ישאאנאלי (יאדיאלי (אדיאלי אילטי כ-בני טאקאלאלט ו
ÞL≺ [«]	$J\dot{c}lv^{b}$ 1: $L > b > b > c < b < b < b < b < b < b < b < b < b <$	 ΔΡωίησι Ι΄ Λωλάροντι 1-7 'dώσ. Ο Ο ΝΡΙ ΝΠΓΥ άζι Ο Γ΄ Ο ΔΙαινιστία Δαίυσι αρωτής το Γ΄ Ο ΔΙαινιστία αίμος αρωτής το Γ΄ Ο Γ΄ Αριγαία σι Γ΄ Εμταλία τη Γ΄, Δαρ Γ΄ Εμταλία τη Γ΄, Δαρ Γ΄ Εμταλία της σι Γ΄ Εμταλία της σι Γ΄ Εμταλία της σι Γ΄ Εμταλία της σι Γ΄ Εμταλία της αίμος της αίμος της αίμος της αίμος της αίτος Γ΄ Αμαία Αμιδι Αμάία Αμαία Αμαία Αμαία Αμαία Αμαία	 7. ϽϞϷͺͺͼϧͺϷϲͺͼϟͼ Δα[*]υσ ϤϷϲͺͼϟͼ ϧημεκικά δημεκικά



√د∽ۍ	 ϽϚႱჼ Λϧሲϧ·ϹϷϞͿͺϞʹʹ_	᠊ ᡏᢧᡄᠺᡃ᠈ᢋᡟᢧᠦᡏ᠑ᡃ	∧ ኖ-⊂⊲ም∿ምና የ₽₽₽୮⊀ሀኑ (የይደንም~⊃ሆ
⊲دبحوري			۹٬خ۶ ۲-۲۰ م۲۹۵٬۰۷
<u>م>۲۵۵</u> هک			
σΛċ ^ϲ	ጋናしኈ 1: ५>ፇ⊳_ጋጦ ላኁል፞ና ላፖኄՐ՟_ጋ ዾL⊰ና		
⊳L⊲₁≺⊲₁	⊲ጋና⊃Րና	⊲⊳∟ና∩σኁ⅃ና ∧⊾⊦⊲₽ር⊳๙ 1-8	9. bጋኦኦኄበሶ ለነብትጋር
4>℃	∧نظ۶٬, ط٤∟ ⊂ת⊳۲۲ שפךے פלו∿רי	^ہ dخح.	ᢣ᠋᠋ᢨᡕᢕ᠋᠋ᠳ᠋᠋ᠶ᠋ᡗ
کلات، ک	ᠳ᠋᠋ᡏ᠋᠙ᢣ᠋ᡪᢣ᠌ᢂ᠋ᢣ᠋ᡗ, ᡥ᠋᠔᠋᠋᠘ᠳ᠋᠋᠋ᠴ᠋		ᡏᡃᡗ᠘᠋᠋ᡦ᠖ᠴ᠘ᡱᡆ᠋᠘ᡩᡄ
᠘ᡃ᠋ᡃᠦ᠋ᠴᡄ᠋ᡅᠣ᠋ᡃᡃ	ᡠᠴ᠘᠆ᢂᠫ᠋ᠮᠣᡝᠵᡃᠺ	᠋᠋᠋᠋᠋᠋ᠴ᠋᠋᠋᠋᠋᠋᠋᠋᠋᠋᠋᠋	ᠳ᠋᠈ᡣ᠋᠈᠘ᡔ᠋᠋᠉᠄᠘ᢣ᠋ᡃ᠋᠋᠋᠋ᢣ᠋᠋᠋᠋ᢆᢣ᠘᠆᠋᠋᠋᠋
		₽۲۹،₽۵۰۹۵۵ ۵۵۲ ۵۵۹	ᠫᠣᢣ᠌᠔ᢞ᠘ᡄᡃᢅᠫᡝ᠊ᢂ᠋ᢩᢂᡄ᠋᠋ᢉᢙ᠋᠋᠅᠋
	$\Lambda \flat \dot{\alpha} \flat \imath c arphi \kappa \prime t$.1: $b J^{\flat} \dot{\lambda} \imath b \Omega \dot{\Gamma} \iota \Omega - \flat arphi \kappa L \kappa \prime$	᠆᠋᠈ᡅᢣᡅ᠈ᡅ᠘ᢥ᠙᠘᠉ᡷᠺ᠘᠉᠕᠕᠕᠕ᢁ	᠆᠋᠋᠋᠄ᡆ᠌᠌᠌ᢂ᠋᠅᠋ᢩ᠘᠉᠘᠘
		ᢣ᠋᠋᠋᠋᠋ᡥᠧ᠋ᠴᡗ	
		ᡏ᠔᠘ᡆ᠋ᡃ᠋ᠣ᠘ᡩᠣᡅ᠕᠆ᡄᠳᠥ᠋᠂ᠳ᠋ᡞ᠘ᡆ᠋᠋	
	$\dot{\mathcal{P}}L \prec \mathcal{D} \mathcal{D} \mathcal{T}$	᠋᠋ᡩᡄ᠋ᢨ᠈᠋ᢉ᠋᠋᠋ᡰ᠋᠋᠋ᢧᠴ᠋᠋᠋᠆᠋ᡗ᠅ᠴ᠋᠋ᠳᢉᡃ᠋᠋᠋ᢆᠳᡄᢄ᠆ ᠘᠋᠋᠋᠋᠋᠋᠘᠋᠋᠋᠋ᠮᢄ᠋᠆ᠸ᠋᠋ᡘᡷ᠅ᢉ᠋᠋᠄᠋ᢧᡆᢗᢂ	
	ΛΥΛΥ ^{CD} Lt 1.2: ADCCDDN.		
	$P \triangleleft \Omega \mathcal{U} \mathcal{U} \mathcal{U} \mathcal{U} \mathcal{U} \mathcal{U} \mathcal{U} \mathcal{U}$		
	$\sigma^{*} \ell \sigma^{*} \dot{\rho} L \tau^{*} \delta^{*} L C + 2^{*} \lambda^{*} \ell \rho^{*}$		
	$\sqrt{2\Delta^{\circ}a^{\circ}b^{\circ}L^{\circ}}$	5 ነር 0 , 11 ርጋ 1 ነር ርር ነር ዕበLትኈቦና,	
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	$\Lambda \neq \dot{\alpha} \neq \varsigma \land \sigma \neq 1.3$: $L = \varsigma \land \sigma \neq 0 \neq 0 \neq 0$		
	$L \subset C \land C$		
	$\forall r^*r' \rightarrow \dot{P}L'' \forall L \rightarrow a d b^*r'$		
	AL SCALLET A NOISDER - OC		
	Λ۶άβ ⁽ CDxLx ^{(1,4} : αΡΥ ⁽) ⁽ CD) ΔαΓΡΟ ⁽ CαΡ ⁽ ΓΡΟ ⁽) 48Ω-Ϊ ³ υ		
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	$16DAAadbcs\Delta < C$		
	<i>᠕ᢣ᠋᠋ᡅᢣ᠋ᡃᢗ᠌ᢂᠵ᠋ᠮ᠄᠋.5:</i> ᠘ᠴ᠘᠋᠋᠋᠂᠋ᡗ᠀᠋᠆᠋᠋ᡣ᠙		
	ᡣ᠋ᡣᡪ᠋᠋᠋ᡏᡄᢂ᠋᠋᠊᠋ᡔ᠅ᡗᠣ᠋᠃ᢙᡧᢕᢂ		
	᠋ᠮᡃᡅ᠋᠘ᢩ᠆᠆᠆᠕ᠴ᠋᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆		



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ᡃ᠘᠆ᢂ ᠘ᡃ᠈ᢣ᠋᠈᠆ᠺ᠆ᡄ᠋᠕ᠳ᠈᠘	ϽϚႱႪ 1: ᢣ>᠈ᢣᠵ᠋᠆ᡣ ᡏᢠᢆ᠄ᡏᡘ᠅ᡣᡄᠴᢆᢂ ᠯᠫ᠋᠄ᠫᡗ᠄᠋ᠳ᠈᠂ᠬ᠅᠖ᠴ᠅ᢂ᠘ᢋ᠋᠖ᡘ᠅᠘ᠸ ᠺ᠄ᠬᢣ᠄ᡘ᠘ᠴᢗ᠋ᡅᢂ᠄ᠮ᠌ᠴᡆ᠋ᠮᠴᡆᡶ᠅ᡗ ᡦ᠋ᡏ᠋᠙᠋᠋ᡪ᠋ᠬᢂᢤᡗ᠋᠄ᠺ᠖ᡩᠧ ᠄ᠳᠴ᠘᠆ᢂ᠂ᠫ᠖ᢐ᠋᠆᠄	Cd⊃ጦ ⊲Þᡄᡢᠥ᠋ᠮ ∧ႭჄ⊲₽CÞᢞ 7୮ 10⊐ ថἐᡠ᠑.	
	ΛϟͺϧϟϚϷϞͰͺϞ·1.4: ͺϼϷϘʹ϶Ͻͽ·ϹϷͺͻϽ· ϼϛΓϷϹ· ϹͺϼϷϚΓϷϹ·ʹͻ ϤϘϽϲͺͰϞ ϐϷϷϞϚϹϷΓϤ΅ϞͿʹͻϭͺϐϷϷͰͰϞϹϷϭϤͽϽϭ· Ϥ·ͰͺͻͺͺϼϷϘʹͽϽͽϲϹϷͽϾͼϛͽϽϚϤϒϷϷϚϲϲϤϞ ϐϷϷϞϧͺͺϤϐϲϲϧϪʹ<Ϲ		
	<i>ለኦሲኦናር⊳ላL๙ 1.5:</i>		



6.2 בלל^גרסי דססתיליי

ΦΡΞΥΥΚΙΎ ΦΈΔ ΕΞΕυδο ΠΟΡΚ΄ δο ΔΞΡδΑΡΟΔΞΡΟΚΑΤΟΥ ΔΕΓΟΥΤΕΊΕ ΑΝΤΟΝΟΥ ΑΝΤΑΝΟΥ ΑΝΤΑΝΟΥ ΑΝΤΑΝΟΥ ΑΝΤΟΝΟΥ ΑΝΤΟΝΟΥ ΑΝΤΟΝΟΥ ΑΝΤΑΝΟΥ ΑΝΤΟΝΟΥ ΑΝΤΑΝΟΥ ΑΝΤΟΝΟΥ ΑΝΤΟΝΟΥ ΑΝΤΟΝΟΥ ΑΝΤΟΝΟΥ ΑΝ

ርΔL፫ Δυ፫ናጋጭ ϷሬቲናႦናፖላናጋላጋትሬና ርሲϷችሁ ላዊበላጋ, Δεሬናው Ϸ۵ዮጵዮጵና Δናራሳት Δናውጋሪቶ መንግ ርሬሥት የሬድናጋና የህመት ሀናበው. Δናውጋሪቶ መጭ መኑንበናአጋና ማናውንሪውና ኮሬኖና ውና ዉቲሁ የጋና መትዮህመም ϷሬቲናႦናልችሁ, ሬዲሞላና ለዉረላሲላናውቶ የናጋና መትዮህመም ϷሬቲናႦናልችሁር አንትልችሁው.

6.3 ĎLליסי Γ⊲σ∿σ‰

- 2. ϽΡΥΡΤ>ΚΝΥΤΑς ͽΡΑΦΚΑΙΞΟ ϽΡΥΡΤΦΑΔΑΙΟ ͽΡΟΓ Υσενου Ακτορού Ακτορο

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ዾ᠈ᢣ᠌᠋᠋ᡔᢞ᠊᠋ᠳ᠌᠌ᡔᡣᡅ᠕᠋᠂᠋᠋᠋᠋ᡋᢣᢣ᠋ᠵ᠘᠊ᡧ ᢗᢞᡇᠣ ᠋ᡅ᠌ᢩᢄ᠈᠋᠖ᢕ᠋ᠺᢙᡄᡃ.

ﻣﻪﻧ새ንሲላናbσዀ ለሥበም >Δ>ምኑጋ ላዊበላምኑጋ ላጋበናbናም፦ሩ፟ህናbCPምላናጋጮ ላሥሩናበሀበናካም ምትቦኈሀምዀ ዾ፞L፟፟ጚናbናልኈሀም. ፈምናምናሩንህጋም ኣ>ንኦኦምምኑቦና ላናልና, ላሥዮኑጋ ዾ፞L፟ጚናbበቦና, ዉ፟፝ጚሁዮዮጋ ፲ểዉ๒៤ና ዖንህምኈሀናበምጋ ዖንፈንዉና ወና ኦሩናርኦናሁናርምናሩና ናbኦንኣናርኦናፈልጐሁሲላትና ናክጋልምኈዮቴጋላናደኈሀር ላናልና ላዊበላምጋ ዉናሁኈሁ ናክጋልምኦምኖተላጐዮቴጋላናደኈሀና.

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⁶ ΙοΔ⊂ΡͽϽͽϧΔ<<
 ⁶ ΙοΔ
 ⁶ Γ³



ᡏ᠋ᠫ᠘ᢩ᠂᠋ᡆ᠋᠄ᡃᡉ᠌᠘᠊᠋ᢣ᠋ᡔ᠋᠄ᡔ᠋᠋᠆᠆᠄ᢣ᠋᠆ᡷ᠘᠆᠋᠋᠆᠆᠄

᠘ᠴ᠘᠋᠄᠂ᡧᠫᡃ᠋᠅᠊ᢗ᠌᠌ᡔᠳ᠋᠋᠈ᢚ᠘᠋᠋ᠦᢣᠯᢣᡏᡘᠺ᠋ᡩᠴ᠂ᡘᡃᡲᠬ᠋᠋᠌ᢓᠺᡫᠣ᠊ᠴᡆᢩᢀ᠋ᢄᢣᠳ᠋᠋᠈᠘ᢩ᠈᠆᠋ᡘ᠅᠘᠘᠅᠋᠘᠘ ᡏ᠋᠘ᡱᡆ᠋᠄ᡋᢪᡆ᠋᠋᠂ᠳ᠋᠈ᡏ᠋᠋᠋᠈᠕ᢞᡆᢩᢂ᠋᠄᠋᠋᠖᠆᠋᠉᠈᠆ᡘ᠅᠘᠋ᡬ᠘᠋᠘᠘᠘᠘᠘᠘

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 $C\Delta\dot{L}^{*} \rhd b^{*}b^{*}L^{L}L^{*} \square a \mathscr{P}^{*} \mathscr{A}^{*}P \cap^{*}U \sigma \ \ \ \mathscr{A}^{*}L^{*}b^{*}b^{*} \cap \mathscr{A}^{*}\mathcal{D}^{*}\mathcal{P}^{*}C \mathcal{P}^{*}C \mathcal{P}^{*}C \mathcal{P}^{*}\mathcal{D}$

. ዾLላσና ወላጮርኈレርጔ ବଡ଼∩ବୁଟ୍.

∖>ኦ≥ልኈႱσ.

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7.1 **Ճґ**ዖˤᡅ᠋᠃̂∩⊂⊳∿ՐႺϽϤ

. ዾLኆ፞፞፟፟፝፞፞ዾናልኈሀር ኣ>᠈፟፟፟ትልኈሀഛ

7 ኣ°ኈቦσˤၑˤႶርϷᢞ ᠕᠋᠋ᢗ᠘᠆ᡠᡝ᠊᠋





ჼႦϷትLታϷՐ⊲Ⴀ፦: ჼႦഛጋ∆°ႭናჄჃჼჼ ჃჼჂႶჼ°ႫჀႶ<くႠ ჂኣናናኣჼdႶዎና ϷႫჼႦႭϷჄჄL๙ ႠჼႻႭႫ ႶႶჼჼႦႫ ჃႾჂ ჼႦϷჂჼႦϷႠϷჄႾ๙ ኣჼჼႼႠϷႫď ႠႫჼႠჂჼ, ჼႦϷჂჼႦϷႶჼႱ ኣ°ჼႶႫჼჼኣϷႫჃჼჂჼჼ.

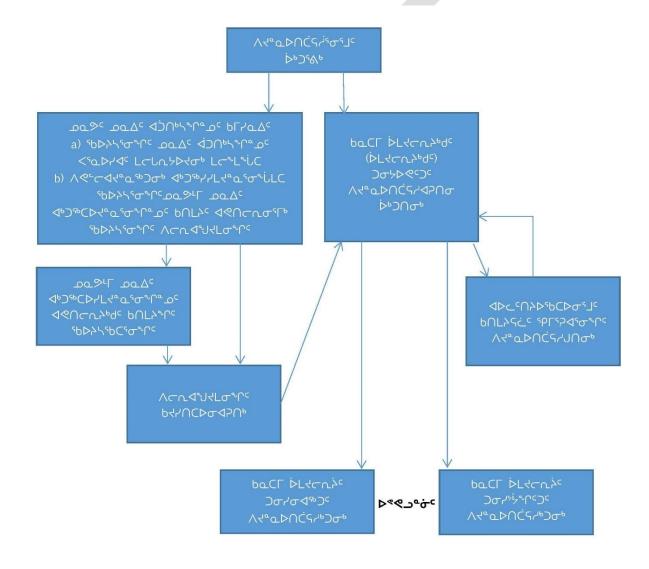
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ጋና/ና?LጋΔ°ႭႢላႠჼ CLΔ°σϲͺĹና/ላჼ CCႶႢላႠ°σჼ ላჼቦჼჼCϷϟĽჼϟႶႫჼͺჂ°Ⴋჼ ႶႶჼჼႦჼď ጋና/ናႢላႠჼ ϷdႭჼႱ ጳϷჼႺჼႶϹϷჂႶჼ ጋና?ႶჼႱႭჼ ჼႦႢჽϷჼႻჼ ჂჼႫჼ ႶႶናჼልቦჂႱ:

Environment and Climate Change Canada – Canadian Wildlife Service Northern Region 933 Mivvik Street, 3rd Floor P.O. Box 1870 Iqaluit, NU XOA 0H0 Pらしこと:: 867-975-4642 56へムマナッdC: ec.nupermisscf-cwspermitnu.ec@canada.ca

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ϽσϧϷϽϤ;<
ΛξαϷϦͼ Λζεσμικος
Ληνομικος
Ληνομικ



ል/Lቦ՟ጔJ ኘኴወበቦ ለペ՟ርላኦሊላኘႦኚኒኄር ላኦጮህላ፣ 10–୮, ጋና/ናዖL୯ ጋና/ናዖበኑቦσና ጋσ//Lቦላ፦ ዮሮቴካናበርኦሮ σኑቦኄሁው፣ ኦLቲቴናልኄሁσ ለሮሊሀደረው ለቦላዖLናናር ላσ 1–୮ ላዛሬው ኦንሮሚ 31–୮ ጋና/ናና/Lቦላ፦ ልኖዎላሲ 1. ላፖኑቦሮ ላናና ጋና Δውላσ, ጋና/ናዖLሞ ለሞዉኦበርዖደሮ ጋσ//Lቦላ፦ ጋና/ናኦበኑቦም ር፣ኑዮ በኣደና ፖምናኔሆ ለቦላሬኦዮቦምኄሆው ኦሮውኄሆው ለሮሲላቢታኔህር.





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ec.nupermisscf-cwspermitnu.ec@canada.ca

- bacr ϷLϞϲϞϷLϞ· ΛϷ·Ϟ·ϚϷLϞ·σϭ·ΛϷϭ· (אשמער Δ·אירי ϷLϞ·σϭec.dalfnord-wednorth.ec@canada.ca

ዾዹፚ ሀሀሪ፥ጘ୮ና ዺናፍ&∿ቦ₅፞፞፞ኯ

ᢄ᠋᠋ᡃ᠔᠆ᡩᡉ᠘ᡧᡆ᠋ᠴ᠘ᡱ᠋ᢩᡆ᠉᠊᠋᠆᠅᠘ᡔ᠉᠂ᡬ᠘ᢞ᠋ᡃ᠋᠖᠋ᡭᢌᡶᠣ᠂ᡃ᠋ᠳ᠘᠆ᢞ᠋᠖ᡔ᠉᠘ᢞᢐ᠘ᢞ᠋ᢩᡆᡗ᠋

σ^ͺዮ^ͺႱσ^ͺϷL⊀^៲ϧͽͺ</sup>υϹ ϒ>ኦᢣል_៓ႱႻ

baCF \flat L

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C[٬]d٩ᡅ٩ᡄᡃ.

ΡﻮϽΔ°ﻮ[·] >ċᡅᡏᡃᡗ᠉ ><ኌ∿ႱΔ·ϟͺϤϲϤϲϷ >∿Ⴑϟ·Ͻσ∿Ⴑϼ·, ϟϲ?ϟ·ϧ·Ϲ·σ∿Ⴑϼ·, ϟͿ·ϿϽΔ°ﻮᡅᠯ᠖᠂σ∿ႱϹ, ϤͰͺϿͺϤ·ϹͼϽΔ°ﻮᡅᠯ᠖·∿ႱィʹϿϭ·ͽϲ Ϥϟ∿Րϼ·Ͽ ϷͰϟ·ϼ· ΠΡϚ·ϚϷϤ·ͽႱϹ. ϤϷ·ϲ·ϟͰͿϟϲ ϟϥϧϥͶ·Ͽ ϷϧႱϟ·ϽͿϲ ϤϷ·ϲ·ϟͰϭϥ·ϿϭͺϤϽͶ·ϧϨͽϥ·Ͻϭϲ

- ዻ፟ኈዖቦዻናርዾጏቡና ረፍናብናረደሩ ኌ፝፞ኇፚ ፚኄጏፍሬና አ፟ታናርዾጏቡና ዾፇኯባላላኑΓ;

ᢄ᠂᠋᠋ᡤᢆ᠋᠆᠋ᠴ᠘ᡩ᠋ᡥᡊ᠑ᡄᡅᠣ᠋᠋ᢛ ᢦ᠙ᢗᡅ᠋᠋᠋ᠶ᠋ᡤ᠋᠋᠋᠋ᠮ᠋᠋᠋᠋



᠘ᡃ᠋ᢛ᠋᠊᠋ᠫ᠊᠋ᠺᡃ᠋᠆ᢞ᠍᠍᠊᠋᠋ᡃ᠋᠋ᠮ

- *bLt^c Δ_DΔ^c J^cda^C Λ^cd^{yc}*
- $b \Delta C \Gamma \dot{P} L \prec C \Lambda \sigma^* J^{c} \Lambda \delta \sigma^*$, and $\dot{P} L \prec^{c} b^{c} \Lambda^{c} \Lambda \delta \sigma^* J^{c} \Lambda \delta \sigma^* J^{$

- $a^{-} = a^{-} = a^$
- b໑C▷< <፦ሥዕኈቦና bኈቦኈጋቪ∧ኑ୮, ຼ໑໑୭ና: 867-924-0123, or 867-924-1111 ጋ⊲໖ና໑ና⊃ናຩና∩-ຉJ



ለታናላና	⊲ ^ډ ¢J 1	⊲٩̈ĠJ 2	⊲ ^ډ ¢J 3	ଏ ^ଽ ၎୕J 4	⊲ ^₅ द॑J 5	⊲ ^ډ ¢ر 6	⊲ ^ډ ¢J 7	⊲₅ċ٦ 8	⊲ ^₅ द॑J 9	⊲ ^₅ ¢J 10
ᠪᡃᡲᠡᡣᢗᢂ᠋᠅ᡗᢪ᠋ᢩᡆ᠋ᠶᠴᠦ ᠕ᢞᡆᢩᢂ᠋᠋ᡃ᠋ᡋ᠋ᡅ᠋᠋᠕ᡃᢪᡆᢄ᠋	х	х	x	х	x	х	х	x	х	х
ᢤᡃᡃᢆᡟᠥ᠘ᡕᡝ᠕᠅᠋ᢆᡨᢕᡆᡃᠴᡳ ᡏᢣᡤᡄᡃᠬᢗ᠌᠌᠌ᢦ᠈ᢣᡤᡄ᠋᠋ ᠺᢞᡆᢩᡅᠺ᠕ᢤ᠋ᡆᢄ᠆ᡣᢦᡄᡃ	Х	х	×	x	×	X	х	х	х	х
<ᠮᡆᡐᡣᡄ᠈ᠫ ᠘᠆᠋ᡁᢐ᠋ᡏ ᠘ᡄ᠋᠋᠋ᡗᡊ᠈᠋ᢣᡐᠦ᠍ᡏᠫᠥ	x	х	х							
᠆ᡬᡃᢛᡠ᠋ᠴᠺ᠂ᠴ᠋ᢩᠣᡄᡃᡃ᠋ᢐ᠋᠘ᡤᠴ ᠈᠋ᠮᢧ᠋᠄᠗᠄᠋ᡃ᠋ᡳ᠋ ᠂ᠳᠴ᠘᠆ᢂ᠈ᠫ᠋᠂ᡦᡠᡄᢩ᠂ᠵ	х	×	×							
ᡬᠯᡃᡃᢆᢦ᠋᠘ᡕ ᢣ᠋ᡃᢛ᠋᠋᠋₽ᡷ᠋ᡪᠬᠻᠡ᠋᠘ᢕ᠋ᠳ᠋᠋ᡗ ᠘ᡄᢪᠦ᠋ᡏᢓ᠋ᠺ᠋᠋᠋ᡗ᠋ᠺᡆᠮᠴ				х	х	х				
ᡅᢩ<∠᠘᠋᠋᠋᠆ᠺ ᢣᢛ᠋᠋ᡗᡷᠫᢩ᠄ᢣᠦ᠋ᢩᡝ ᠘ᡄᡨᠣᢩᢦ᠋᠋ᠻᠬᡗᠨᢕᠦᡃ᠋ᠴ ᠴᡆ᠋᠋Г				х	х	х				
ᢣᡃᢛ᠋᠋₽ᡃᢆᠶ᠋ᡗᡊ᠈ᢙᠧ᠋ ᠆᠘ᢞᠬ᠋ᠬᠫ᠘ᢝᢩ᠋᠋᠋᠋᠋᠋᠆᠘ ᡏ᠔᠋᠌᠋᠌᠌ᢂ᠆ᡘᠴᡗᠵᠺ	x	Х	х	х	х	х	х	х	х	х
ϥʹͼϷϳϿͶϲ ϽϤϐͺͼϲͻϽͼϷͼϲͼ ͼϷϽϲϲϷͼϽͼϒϷͼͳϧϳϹ							х	х	х	х
ᢃᢣ᠌᠌ᢂ᠘ᡃᡅ᠍᠍ᡏ᠖᠆ᡪ᠘ᢩ ᠆ᡩᡃᡁᡅ᠋ᢝᠫᡄ᠋ᡅᡷᡃ	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х

ዉጋዉ∆ካቻ 5: ▷<ጋ∿ሀΔናር▷ፖሬሩ ▷ናጋናፖ▷ቦነቻ ⊲ጋርናበር▷ቦ⊲ሩና σ∿ቦኈሁσዀ ▷ሬናቴል∿ሀው ⊲▷ሬናበሀበዔና <ናዉ▷በኍና.

ראיניליטירבוי פבפעיכ⊳יראי **פבם∆יטי ד**.

10 <፣ሷዾሰ・ ላጋር-ነበርዾታ ዮ





ϧϽ;ϧ;ϼϢϧϧϲ Ͽ;ϷϹͶϲϞ _ͼ ϭͺͽϽϲ										
ൎdᡝᡃᢆᢛᡠ᠋᠋ᠴᡣ ᡄᠴᡆ᠘ᠮᠡ᠌᠔ᠺᡃᡪᠺ᠋᠋᠋ ᡆᠳᡘᡃᡲᡃ᠋᠋ᡋᡝᢌ᠋᠋᠋ᡏᠦᡃᠦ ᠘᠋ᢗᢗᡝᠳᢣᡝᡈ᠌᠋᠌ᢦᡗᡔ᠋ᡗ				х	х	х				
ᡏᡄ᠋᠂ᡣᡆᡷ᠋ᠴ᠄᠆ᡣᡄ᠉᠋ᠴ᠙ ᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆ ᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆	х	Х	х	х	х	Х	Х	х	х	х

10.1 ⊲⊳∟°∩σ∿⅃ິ\°℃σ൩ን⊳ጘ°∩ຕን⊳ነጘ∩഻₋⊃

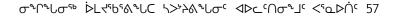
10.1.1 baCF
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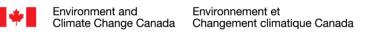
⊲⊳∟ና∩σኈ⅃ና ኣኈኈՐσ൩ᢣ⊳ኆ σኈՐኈႱσኈ ቓ፞Lኆ፞፞፞Ҍጘልጔና ጋ°ኈႱልኁҌናጋና *bႭር୮ ቓ፞L๙⊂Ⴂσኈ፟⅃ና ለናdፇኈ* ⊲ၬ*ጔ ቓ፞L๙፧Ҍጘልና ለናdፇኈ*Ⴑና

10.1.2 ΦΑ ΌΨL τσ ΦΕ ΠΕΕΡσε Ο ΕΛΕΡΓΕ (ΦΕ ΠΕΛΓσε ΕΛΕλΟ

ዾኄዾኦትቦላሲኆንና ፑσኑርፑና ላኆበሩሲሥዕഛና ዉሥዕሩ፟ዸናኯላጭ ላቅዾናበሀታው ውኑዮኄሁውጭ ፟ዾዚናቴናልኄሁር ኣ>ኦትልኄሁഛና, ርΔLΔናርሲላኄቴናፑ ላኄዮንበቦታደኦኄዮና Δ፴Δና ጭጋኈርዾውኄዮኈഛና Δቴጚተላንበናኣጐጋ ላኄዮንበኄሁሆና.

10.1.3 Δα ΘΓ Ελάσηλικά ΕΛλληγ (Ελάσηλικά)





10.2 ⊲⊳∟‹∩σ∿⅃' <ና⊾⊳ᡤ・ ኁ₽Γኁ₽ኦ⊳σ∿Ր・

ዾዹፇ< ႱペĽ๒ďゃႶႠ ⊲ペႶႠჀჂჾďゃႶ< − ĎĹႵႠჀႣゃჂſ ⊲⊅ႠናႶჂჾႻ ႾႠႱჼႶႮჼ ႶႠჂႦႵႾႵჼ *᠕᠄᠔ᡃᢣ᠋᠋᠋᠋ᡃ᠘ᠸ*ᡣᢣᡃᠣᡝ ᢀ᠋ᡄ᠋᠋᠄ᡣᢣ᠋᠈ᡴᢗ᠕ᠸᡅ᠋᠋᠋᠋᠋ᠵ᠋᠕ᡷᡀ᠋᠖ᢣ᠘᠒᠋᠋ᡗᢣ᠘᠖᠋᠘᠘᠘᠘᠘᠘᠘ ᠄᠈᠘᠊᠋ᡃᡝᠳ᠋᠄᠘ᡄᢉᠫ᠍᠍᠘᠊᠋ᠴᡆ᠌᠌᠌᠌ᡐ᠋᠋᠋ᢉ᠋᠆᠒᠋᠋᠋᠋᠋᠅᠘ᡄᢉᡃᠵᢄ᠆ᠴᠣ᠊᠋ᠫ᠋᠋᠋᠋ᡃᡬ᠋᠋᠋᠘᠋᠋᠋ᡬ᠘᠋᠁ ᢄ᠘ᢣᡄ᠋ᡊ᠊᠋ᢐ᠋᠊᠆᠘᠆ᡩᠴᢉ᠘᠆ᡩᠴᢉ᠘᠆ᡩ᠘᠋ᠧ᠘᠘ᡩ᠘᠘ᡩ᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘ ᠘ᠴ᠘᠋᠋᠋᠄᠊᠋᠋᠋ᡰᢣ᠋᠋ᡔ᠋ᢄ᠋᠋᠋᠋ᡷ᠋᠋ᢣ᠘᠋᠋᠋᠋᠋ᡬ᠖᠋᠋᠋᠋᠖᠆᠘ᠴ᠀᠋᠘᠋᠘᠋᠆᠘᠘᠋᠋᠘᠋᠆᠆᠘

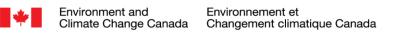
11.2 _____ ሀሬጉስ

᠘᠋᠋ᡰᢣ᠋᠋᠋ᢙ᠋᠋ᡰ᠋ᢙ᠋᠋᠋ᢄ᠆᠘᠆ᡧ᠘ᠴ᠘᠆ᡁ᠘᠆ᡱᡄᡄ᠄᠘᠆ᠴ᠖᠆ᠴ᠆ᡓ᠆᠘᠆ᠴ᠘᠆᠘᠆᠘᠆᠘᠆᠘᠆᠘᠆᠘᠆᠘᠆᠘ ᠂ᡃ᠋ᡃ᠋ᡋᢄ᠆ᢣᡗ᠘ᢣ᠋᠋᠋ᡃ᠖᠂ᠳ᠖᠘ᢣ᠋᠋᠋

Ď᠘ᢞ᠋᠋ᢐᡝ᠋᠋ᢐᡲᡶ ᠌ᠫᢣ᠋᠋᠋᠋ᠫᢣ᠘᠆᠘᠆᠖᠈᠖᠖᠖᠘᠖᠖᠘᠖᠘᠖᠘᠖᠘᠖᠘᠖᠘᠖᠘᠖᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘᠘ ϼͼϲϐϭͺͺϤϷϲ;Ϣ;ϷϹϷϞ;ͺϷͶͿϯͽϧϲϫͺͺϒͼͽϧϲͽ;Ϸ;Ͻϲ;ͺʹ ϧϽͽ϶ϧͶϥϧϧͺϫϲͺϫ;ϫͷϫϫϫϫϫϫϫϫϫϫϫϫϫϫϫϫϫϫϫϫϫϫϫϫϫϫϫϫϫ ክበሬንግር. ወወይΓ ኦլፈርሊን፣ፈላና ክበሬንግር ለአናካናኮና ጋላርና∿ሀር ኦլፈናምና ላውርናበንውውንΓና ወወይΓ ᠕᠋᠋ᡃᡋᢣᢣ᠋ᠵ᠘ᡃ᠋᠋ᠴᢉ᠂᠋᠕᠋ᡃᢣ᠋᠋ᡃᢣ᠋᠋᠋᠂ᠴᡆᡐᡃ᠋ᠴᡆ᠋᠋ᡃ᠋ᠯ᠘ᡃ᠋ᢆᠥ᠃᠕ᠰ᠋᠋ᡞ᠋᠘᠋᠋ᢣᢣ᠋ᡃᠥᢕᢝᡆ᠋᠋᠋ᠮ᠊ᡧᡃ᠊᠋ᠥᡄᢂ

11 P^{ν} υς Δυζωρικός 11 P^{ν} υς ματηρικός 11 P^{ν} υς 11

יער ארכן ר-קראריכא יעד אדע דער 11.1 עראר אינער אינער אינער אינער אינער אינער אינער אינער אינע אינע אינער אינע





12 אסישכליטרגי ישאאראי אראי די

Aitken, A. E., and Fournier, J. 1993. Macrobenthos communities of Cambridge, McBeth and Itirbilung Fiords, Baffin Island, Northwest Territories, Canada. Arctic 46(1): 60-71.

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⊴∩∿เ	᠋᠄ᡃᠣᢂ᠋ᢣ᠋᠋᠋ᠮᠬ᠘ᡄ᠋᠋ᠴᡗ᠂᠋᠊ᡏ᠋᠋ᠬ᠖᠋ᠮ᠋ᢕᢄᡔ᠋᠋᠋᠆	∆⊅⁰∩ጋና ⊲∩∿Ⴑ
BlackGuillemot	Cepphus grylle	٨٩٩٢
Thick-billed Murre	Uria lomvia	$\triangleleft_{P} \lessdot_{P}$
Dovekie	Alle alle	$4^{b} < -4^{c}$
Canada Goose	Branta Canadensis	ᠳ᠋ᠸᠮᡃ
Snow Goose	Chen caerulescens	₽ჟო
TundraSwan	Cygnus columbianus	ჺႳႱຌჾ
CommonEider	Somateria mollissima	٩٩٠لذره
KingEider	Somateria spectabilis	$d \Box D \subset d^{cb}$
Long-tailed Duck	Clangula hyemalis	LUep
Red-breasted Merganser	Mergus serrator	₽₺₽₽Ĵ₽₽
R o ck Pt armigan	Lagopus muta	᠆᠆᠆᠆
WillowPtarmigan	Lagopus lagopus	ব৽ঢ়৸৸৻৸
CommonLoon	Gavia immer	$\dot{\supset} \overset{\text{\tiny c-l}}{\leftarrow} \overset{\text{\tiny d}}{\triangleleft} \overset{\text{\tiny b}}{\rightarrow}$
PacificLoon	Gavia pacifica	₅₽₽₽₽ ₽₽₽₽₽
Red-throated Loon	Gavia stellate	₅₽₅₽₽₽
Northern Fulmar	Fulmarus glacialis	᠄ᡋ᠈ᢅ᠆᠆᠉
Great Shearwater	Puffinus gravis	CUrrectore CURRECTOR
Sand hill Crane	Grus canadensis	ڮ؞ؚۮڔۥ؞
American Golden Plover	Pluvialis dominica	ᠮ᠔᠆᠋ᠬᠯ᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆᠆
CommonRingedPlover	Charadrius hiaticula	⊃ℰℰℿ⅃ℯℯ⅁⅀ℯ
RuddyTurnstone	Arenaria interpres	ᢞᡃᢣ᠘᠋ᠫᢩᠮᠵᡃᡃ



PurpleSandpiper	Calidris maritima	ᠠᡃᡃᢣᡅᢩᢂ᠋ᡃᢑ
Semipalmated Sandpiper	Caldiris pusilla	৸⊳৽৾৾৾ঀ৽
Red Phalarope	Phalaropus fulicaria	
Iceland Gull	Larus glaucoides	۶дрчр
HerringGull	Larus argentatus	ᡆ᠌᠋᠋᠋ᠵ᠕ᡃᠵᠯᡏᢛ,᠂ᠮᡕ᠋᠌᠌ᡕ᠘ᢂᡃ
Glaucous Gull	Larus hyperboreus	᠕ᡃᡗᡅ᠋ᠵ᠅
Black-legged Kittiwake	Rissa tridactyla	٩٥
Ross'Gull	Rhodostethia rosea	٩٥
lvoryGull	Pagophila eburnean	᠔᠋᠋Ӷ℠᠔ᢗ᠘ᡄᢩᠬ
Arctic Tern	Sterna paradisaea	۵۲ ^{۵۵} ۹۲
Long-tailed Jaeger	Stercorarius longicaudus	∆۲۵۹۵۲ے۵
Pomarine Jaeger	Stercorarius pominarus	₽₽₩₹4₫₫₽
Snowy Owl	Bubo scandiacus	₽ᲡᲡଈ⊲⁵ᠵᡃᡃ
Peregrine Falcon	Falco peregrinus ssp. tundrius	₽Ს₲₺
Gyrfalcon	Falco rusticolus	⊃ಲ್
CommonRaven		
	Corvus corax	ۥٛ٩ڮڂڔڹۥٝڂ
Horned Lark	Corvus corax Eremophila alpestris	ᢐ₽ᢪᡄᡶ᠋ᠮᡪᢞ ᢐᠯᠵᡅ᠌ᢩ᠕᠄ᠵᢪ
Horned Lark Northern Wheate ar		
	Eremophila alpestris	ⅆ≻²⊳൨≻Ե²
Northern Wheate ar	Eremophila alpestris Oenanthe oenanthe	⁵ძ<൧⊲⁵≺Ҍ ₅₽∆ಽ∿ൎႱᢑ
Northern Wheatear American Pipit	Eremophila alpestris Oenanthe oenanthe Anthus rubescens	⁵d<൧⊲⁵≺Ҍ ₅₽₽₽₽₽₽ ₽₽₽₽₽₽
Northern Wheatear American Pipit Lapland Longspur	Eremophila alpestris Oenanthe oenanthe Anthus rubescens Calcarius lapponicus	^٢ d<౨٩ ^٢ ₹ ⁶ ٢৳Δ ^{٢%} ڶ ⁵⁶ ٢d<౨٩ ^{٢6} Δ౨ ⁶ ∩⊃٢ ⊲౧%৳

2016**Г**^с 20231

 $\Delta \Box \Delta^{c}$ ᢀᠫ᠋᠋᠋ᠳᡄ᠘ᡓᡆ ᠕ᢟᡃ᠋᠆᠋ᠵ᠘ᡔᠴ ⊲∿∩⊇∩⊂

٥٩٢ ٢ ٢٢ ٥٩٢ ٢٢ ٥٩٢ ٢٢ ⊳∩∿⊂<∽⊃⊸ ∩∿Г⊲⊸ 5>5076% JO466 مےم⊿∿<>>C>۲۲۵% β >d⊲ ∆o∆ odidUL,oc ₽ᲡᲡ⁵Ხ⊃ˤᲮ⊂▷ʿ⊐∩Ს ॼᡆᢀᢗ Ͻ°∿Ⴑል^ϧ ∩Γ₂, ⁶Ρ∩⁶Γ>⁶ Δ_ΩΔ⁶ ϧϽϧϟͼϼϢϧϧϲ ΑσΨε ϧϽϧϞͼϘϤϧͼϲϫ $d\Delta^{\circ} \wedge \forall^{\circ} \Delta^{\circ} \sigma^{\circ} \cup b \Delta C\Gamma,$ $\Delta C \nabla A \nabla D \nabla P$

2016 TO 2023 INUIT IMPACT AND BENEFIT AGREEMENT FOR NATIONAL WILDLIFE AREAS AND MIGRATORY BIRD SANCTUARIES IN THE

NUNAVUT SETTLEMENT AREA

The Qikiqtani Inuit Association

represented by Nunavut Tunngavik Inc.

Her Majesty the Queen in right of Canada, as represented by the Minister of the Environment

BETWEEN











Environnement et Changement climatique Canada

Environment and Climate Change Canada

2016 ΔΔΔς ΦϽͽϹϷϭϤϳϭϧϹϧϿϲ ϒϭ;ϤΓϽϘ; ϤϧͺͿͻͺϳ ͷͺϗͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫͺϫ ͷͺϫͺϫͺϫͺϫͺϫͺϫͺϫ
ג>יל>לבאי שפשי פשפ∆™כדרשיני
Δς ^ω υ 1 - CΔjμ ^ω ρ ^c
∆c∿l 2— ᠭ᠋b_D)∆°a™ L⊂ʰ/L⊁∩.⊲⊂ˤ10
∆⊆ [°] U 3— ⊲⊳⊂°∩°b∩ ^{†°} 18
Δ C U 4 - Δ D Δ C D Δ G Λ C
Δ፫% 5 – ΔϿΔና ለኆ፝፝፝፝፝፝ፚኇ፟፝ዮና ዻ፝፝፝Lጛ ዻጋኈሮዾነ፟፝፝፝፝፝ፘኯ፟ኯኇ b፬ሮ୮ ዾ፝Lጘ፞፞፝፞፝፝፝ጜጜ፞ና ዻ፟፟፝Lጛ ዾበኈሮ<ናጋጔና በኈፐዻጔና ኣ>ንኦዾ/Lልኈ
Δ ב $b = 2$ של אדער איז
Δ ב δ 7 – >בק δ כתס δ 4L לאר מ δ ר ב δ ר לשל לשל Δ
Δ c b $-\Delta$ D Δ b b $-\Delta$ D \dot{b} $-\Delta$ \dot{b} $-\Delta$ \dot{b} $-\Delta$ \dot{b} $-\Delta$ $-\Delta$ \dot{b} $-\Delta$ $-\Delta$ $-\Delta$ $-\Delta$ $-\Delta$ $-\Delta$ $-\Delta$ $-\Delta$
᠘ᡄ᠋᠋᠋᠋᠊᠘᠆᠋᠋᠆᠋ᠴ᠘᠋᠋᠋᠋᠋᠋᠋᠋᠘᠋᠋᠋ᢑ᠘᠋᠋᠋ᢑ᠘᠋᠋᠋ᢑ᠘᠋᠋᠋᠋
∆ლ∿ს 10— ჼხ⊳გ\ჼσ [௷]
∆ር∿Ს 11 — ∆൧ഀ൧ഀഺ൨ഀഺ൨ഀഺഺ൨ഀഺഺഀ ๙ഺഀഀ൧ഺ൮ഀഀ൴ഺഀഺഀ
∆⊆∿⊎ 12 — σʻ≺∩ʻbʻ& ^c
∆دِى 13 — ⊲۲٬۶⊳∩، Ċ⊌dَمى ⊳∩ыс<٩كە، ∩∿ר⊲ە، ג>۶۶ארגע ⊲۲ב bacr ÞL⊰ыśś66
Δ c $14 - >$ c Δ 2° a C° C 4° a 32° a C° C C° C $14 - 2^{\circ}$ a 2° a 2° c 2°
Δ Δ $15 - 4$) $- 4$) $- 5$ $-$
∆ლ∿ 16— ⊲∆≪⊳∩⊰ഛ Ⴢ₽Ċ₽∩°
⊳∆ט™ I— ჾ∿∩∿Ⴑჾ™ baCF ⊳L√טיאֹ ^c
⊲∩⊂⊳∿⊃⊂

 $\Delta L \Delta^{L}L^{c}$, $\Delta \Delta^{S^{c}}$ \mathcal{D}^{s} U Δ^{s} Δ^{s}

᠙ᡃ᠋ᡰ᠖ᢛ᠋᠋᠋ᡔᢛ᠋ᡔᡄᢄᡆ᠋ᡄᢂᡧ᠘ᢛᠿᢄ᠄ᢙ᠋᠋

ΔLΔ^LL^c, Γσ^νC ϤϨΠϲͺλ^bdϿ^{to} Λ۶^bν^{to}b^{to} δαCP^s LcbcP^sΠ^vΓ^aΩ^c Λ^cϽΓ^c bαCΓ ϷLϟ^tδ^tδ^c Ϥ^LϽ ϷΠ^{to}C<^cϽΔ^c Π^vΓϤΔ^c ^λ>^bϷΖLδ^b Ϥ^LΔ ϤΠCP^{to}Z^{to}ΔΔ^c Φ^bϽ^{to}CPσϤ^{to}σ^vΓ^aΩ^c Λ^d^cCPCP^{to}α^{to}ϽΔ^c Δ^vΓ^bZ^{to}C^bα^{to}Δ^{to}Δ^c

 $\Delta L \Delta^{L}L^{c}$, L- c^{-} , D 9.3.2 4^L 9.3.7 $\rho a \beta^{L} f$ $\rho a c^{2} / \rho a^{-}$, bacc $\rho L + \delta^{c} a^{-} \rho a^{-}$ $\rho L + \delta^{c} a^{-} \rho a$

 Δ LA^LL^c, L^c^L₂)^C 9.4.1 4^L₂ 8.4.4 <u>a</u>a<u>9^L</u> <u>a</u>a<u>C</u>²*P*A^S 4^{*}*P*P</sub>*P*^C, NFD^K 4³×⁶bnhJnP^S A Δ ado Δ aa^C 4^bS^KCPod^Go^KP^S A A^K^C 7CP^K a^KD^S a^K*P*A^C baC bLK^Kb^Kd^KL² bN^KCCPod^Go^KP^S A 2008 Δ aa^C 4^bS^KCPod^Go^KP^S A Δ ^KCo^KS^KD^K L^C 31, 2014, 4^LL² L^C₂ J 8.4.7 <u>a</u>a<u>9^L</u> <u>a</u>a<u>C</u>²*P*A^S 4^KPPO^C, 4^LL³ 15.6.2 C^C dao 2008 Δ aa^C 4^bS^KCPod^Go^KP^S A^C A^CCPCP^K a^KD^S a^KPO^C, 4^LL³ 15.6.2 C^C dao 2008 Δ aa^C 4^bS^KCPod^Go^KP^S A^C A^CCPCP^K a^KD^SD^S a^KPO^C, 4^LC³ 4³×⁶Dn¹JCPb⁶ σ^C a^N ba Δ aa^C 4^bS^KCPod^Go^KP^S A^C CPCP^K a^KD^SD^S a^KPO^C, 4^LC³ (A^KCPCP^K a^KD^S a

 $\Delta L\Delta^{LC} \land C J^{C} \land C A^{C} \land C$

ΔLΔ^LLና ኣናΡCÞσѷՐና baCF ÞL๙Ⴆናልና Þ°≪೨೫ ኦՈѷC<ናጋውና ՈѷГ⊲ውና ኣ≫ᡟኦϷィLልჼ ΔィL⊂⊲ヘኦϷσ⊲ѷ⊃ѷ ΔbϞႶѷՐ°σჼ Ϥၬ೨ Ϥ°σѷィJ°ฉѷჂና ϤንΔ೨೧ჼ Δውѷσჼ; ϤL೨

 $\Delta L \Delta^{L} L^{c} bacc \dot{P} L + 56 \dot{A}^{c} + 59 C P L^{b} L^{c} d\dot{C} bacc \dot{P} L + c \sigma^{c} J^{c} \Lambda^{c} d + 5 d^{c} \Lambda^{c} d + 2 d^{c} \Lambda^$

 $\label{eq:constraint} \below

"bacr \flat Ltc...or'l' Λ "db'td"" \square P'b"D" bacr \flat Ltc...or'l' Λ "db'td", Λ 'db'c' d"L... acd \square bt'' \square dc' dt'' Lc." Λ Ltc bacr \flat Lt'b's' c:

"«Φωιθημένως»
«Φωιθημένως»
«ΔοΔί / υθμένως»
(Δαμεί τη δυλειτημεί τη δυλεί τη δυλειτημεί τη δυλεί τη δυλειτημεί τη δυλειτημεί τη δυλειτημεί τη δυλειτημεί τη δυλειτημεί τη δυλεί τη δυλειτημεί τη δυλεί τη δυλειτημεί τη δυλειτημα τη δυλειτημα τη δια τη διαδική

- 1.1 $\Box P^{h}P^{c} P^{b}P^{c} C Q Q Q^{h}P^{c} Q Q^{h}P^{c} Q^{h} Q^{h}P^{c} Q^{h} Q^{h} Q^{h} Q^{h$

$\Delta c^{u} l - C \Delta j r^{u} r^{c}$

 $\Delta \Box \Delta^{c}$ $\Gamma^{c} d \Gamma^{c} D^{c} D^{c} \Delta^{c} \Gamma^{c} D^{c} \Delta^{c} \Gamma^{c} d \Gamma^{c} \Delta^{c} \Lambda^{c} \Omega^{c}

 $2^{2} - 2^{$

ΔΔΔ^c 4^b)^{5b}CPσ4^sσ^bC^bσ^c Δ^c Δ^c Λ^c^c^c²CP^c^bα^bD^c Δ^c² 4)^{c^sh</sub>CPσ4^bD^c P^c P^c² D^c^bb^bD^c P^c² D^c²}

" $\Delta \Delta \Delta^{c} \triangleleft^{b} \Box^{b} C \triangleright \sigma \triangleleft^{c} \sigma^{c} \cap^{c} \Delta^{c} \wedge \langle^{c} - P C \triangleright \vee^{c} \Delta^{c} \Delta^{c} \partial^{c} n \rangle$ $D^{b} b^{b} \Box^{b} \Delta \Delta \Delta^{c} \triangleleft^{b} D^{b} C \triangleright \sigma \triangleleft^{c} \sigma^{c} \cap^{c} \Delta^{c} \wedge \langle^{c} - P C \triangleright \vee^{c} \Delta^{c} \partial^{c} D \rangle$ $a_{\Delta} a \Delta^{c} \cap \triangleleft^{b} \ell L \prec^{b} \triangleleft^{c} \sigma^{c}$

"Ρινδιάτυδη Ος" Οριδιόσις Καταντίας δας Γ΄ Ρίκιδιας Ραμάτας ΡΠιοςςομός Πιταμός Κολογιας αςύς *δαςΓ΄ Ρίκατασίμο Λιαρικάται* Ραμότας *Γιας ΡΠιοςομός Λιταραγρ*ως *Λιαρι*άτας

۹٬۲۰٬۵۲۷ ۵٬۲۵۵ ۵٬۰۰۵ ۵٬۰۰۰ ۵٬۰۰۵ ۵٬۰۰۰ ۵٬۰۰۵ ۵٬۰۰۰ ۵٬۰۰۵ ۵٬۰۰۰ ۵ ۵٬۰۰۰ ۵٬۰۰

"ላጋበየታናልሌ ኦሮጋዬ" ጋዮየዮምጋዬ ኦሮጋዬ ኦሮ ፊይላና ሞጋዬርኦታላም እ ለኆርጉርኦቶሚምጋድር ላዮቦስና ላጋበየታናምበናርህ ርቀታሌ የወርΓ ኦሬናዮናልና ኦኖዲጋታና ኦበምርሩናጋድ በዮርላይና ኣራንኦኦፖሬሌ ሬሮኒጋህ 2.2.3;

"Δርናσርলಒゃሪ ለኦረጋንኮሮኪሎሪ" ጋዖንኮምጋ በኦሮጋላሮው ሁዲኮሪ Δርናσርলಒゃሪ ለኦረጋንኮሮኪሎሪ ፋዜጋ ዉሮላጋΔ°ዉኈ ላርሩ ርካፈው, በΓነሪበጐቦ ኦኖዲጏዮውና ላኦሬናለጭቦና ለኦካናኮምጋና Δርናውርንኮምጋው ወዉΓ ላዛሬጋ Δርናውርው;

ርኮሀውኒ, bL&ቦ՟ጔ, በΓነሀበጐቦና ኦ««ጋይታና ላኦሬና ላኦሮ ለኦኦናቴምጋና bacr ኦደናቴናልና ላዛሬጋ ኦበምር<ናጋውና በትርላውና ኣንኦኦፖሬል።

"שברר שבאישיאלי" אישראישישיש שברר שבאישיאלי אישראיבי שבשי ששבאייכדיש אלטי שליש שליד שברר שבאייכאישיא

"▷∩ႪႠ<ናጋഛና ∩ჀႠႯഛና ኣ>ჾႦႦჄႾ&ჾ" ჂႼჾႦჾჂჾ ▷∩ႪႠ<ናჂჅና ႶჀႠႯჅႽ ኣ>ჾႦჄႾ&ჾ ჾႭႪና ႭჂႭႭႪႠႦჄႾႻჀ ჃႠ๋Ⴑና *ႶჀႠჃႽ ▷∩ႪႠ<ႦჂႭႽ ヘჾႵႠႦႻჼႶჼ๛Ⴝ ^ና*ჾႦჾ:

"▷በኈር<ናጋຼຼຼຼຼ በኊ୮ଏຼຼຼຼ ५>ኦኦ▷ፖLልኑ" ጋዖኄᲮኈጋኈ ▷በኈር<ናጋຼຼຼຼ በኊ୮ଏຼຼຼ ኣ>ኦኦ▷ፖLልኑ ଏଠିଟ ጋዖ⊂▷ኈፖLፈኈ;

"היראי אהיכליטעי אילכאסירישי אילאי" איזאיט אילכאס אילכאסיירישי איזאי איזאיזאי איזאין איזאיזאין איזאיזאין איזאיזאין איזאין איזאיזאין איזאאין איזאין איזאין איזאיזאין איזאין איזאין איזאין איזאיזאין איזאי

"የፖሪሬ ምር" ጋዮቴኬጋኈ የፖሪሬ ምር ውልፐኦርልና ለዛኒሌኦሩ ልውኑውና ኦሪሬ ነዋርኦፖሬ ላኁየፖስσ ልርኄሁ 6.4 በዮርጋሀ 6.7;

"ΔΔΔϚ >ᡄϚናႶϿϚ ᲮLᢣϷᢣᡃᢉ᠉ᢆ᠋Ͻᠻᡃᢐᡃᡃ᠉ᠫ᠉ ΔϿ৽ Ϸ《ᡧ᠋ᡱᡩᡠ ΔΔΔϚ ႶℾჼⅆႶѷՐ ϽσϟϟLϟϚ,Ϸ《ペᡱᡩᡠ ϽσϟϟLϟLϟϚ, ۸ჼⅆႶႫჼ Ϸ《ᡧᡱᢡᡠ ለኦናႶናϷႶႫჼ >ᡄናႶϿና;

"Δ $\Delta\Delta$ ' ⁵b>λL>)5b°/") ጋ የ5b°)5 ▷dd Λ>λ)55°C, Ű Δ > dL) CL57▷ Δ Δ C d)Λ°/C, ▷▷Λ Δ >°C, d)5°L>°C, C>C)°/C d·L) 5b>λL>°C Λ° Δ C d? (d?), CL°dd) Δ a, Δ L°, σ5d)C d·L) Δ Δ ΔC, CL>°U Δ Δ C ΔC/>>> d?(), CC)500 (d)200 (d)2

"᠘ᠴ᠘᠋ᡗ᠊ᢂ᠋᠖ᠯᢣ᠘᠋᠉ᢆ᠋᠋᠋᠋᠋᠋ᡗᠻ᠖᠋᠋᠋᠋᠋ᡊ᠅᠘ᠴᡅ᠋ᢕ᠋ᢄ᠙᠙᠋ᡱ᠅ᡠ᠋ᡗ᠘ᠴ᠘ᠲ᠋ᢩᡆ᠉ᠫᠭ ᢗ᠘᠋᠋᠋ᢩᡄ᠔ᢣᡅ᠊᠋᠋ᡏ᠖ᢛᢕ᠆᠋᠋᠋ᢕ:

">ዾኈጋር" ጋዖናbኈጋኈ ዖዺጋΔ°ዺኈ, ር፟፟ዸ፞፞፞፞፞፞፟፟፟፟፟፟ዸዾኯኯኯኯኯኯኯኯ ፚኈቦናናበናበሩና, ፚረኈጋና ዾ፝፞፝፝፝፝፝ዾ፟፝፝፝፝፝ፚ፝፝፝ ዾበኈር<ናጋዾና በኈፐዻዾና ኣ>ንኯኯዸል, ዾ፞፟፝፝፝፝፝ዾ፞፞፞፞፞፞ኯፘፘ፧

"σᠻᠯᡣᠣ᠋ᡗ᠘᠘᠘᠆᠋ᠺ᠈ᡩᢂ᠆᠉᠑᠖᠖᠕᠈ᡬᡆᢣ᠉᠑ᠻᡃ᠋᠖᠉᠑᠉᠂ᠳᠯᡣᠣ ᠘᠘᠋᠆ᡗᢣ᠌ᢂ᠆᠅᠋᠆᠖᠕᠈ᡬᠯᢣᢛ,᠕᠈ᠯᢣᡪᡄ᠋᠅ᡴ᠋ᡗ᠕᠋᠘᠆ᡆᡄᢦ᠑᠘ᡨᡆ᠅ ᠘᠆᠋ᡶ᠖᠕᠔ᢕᠯ᠋᠉᠄

 $(46)^{1} + 26)^{1} + 100^{1} + 100^{1} + 100^{1} + 100^{1} + 100^{1} + 100^{10} + 1$

"የሪዮትናምበ" ጋዮናራምጋም ፈጋና ለኆዾኦበርምረተም የሪዮትናምረውረምጋም ፈጋላታ የሥርግሞው ዕឧር୮ ኦርቲምናልና ኦኖペጏውና ኦበምር<ናጋውና በግዋወና ኣንንኦዮረርል።

"ላልኦጋጐረLሩና ሏውሏና ኦጋንኦናኦበሶጐቦና" ጋዖናኦጭጋጭ ናዖበናፐኦና ሏውሏና ኦጋንኦናኦበቦና ዮኖ ዮኖ፦ ላውሏና ኦጋንኦናኦበሶጐቦና ኦኖሮ ንዮዮኈርው ሏውሏና ኦጋንኦናኦበቦና በበናኈረLውՆ ርሏL°ዺኦኦሊላናኦናቦና ጋህ;

"שם \mathcal{P}^{C} כרילא חריל" כרילים שם כרילא חריל;

- (a) ዾዾ▷ ▷° ペン[◦] ᡠ^c ዾ⊂[∿]ሁ ነbC[™]ህበ[™]ሁ Δ[∿]Γⁱ^Gⁱ^b^b^C Δⁱ^o;
- (b) PaDA^aa^b d^aualuabhic^brLt^b At^aa^c σ c^b dCd^c 5.7.34 C^bda σ Dablt^b DaCPhD^c d^aCPhS;
- (d) ˤb⊳≻հᢑ∩.

"σፕረበኘቴሜጋና ወඛና ለዛLሊÞማና Δውጐወና" ጋዮቴሜጋሜ ወඛልና ለዛLሊÞረና Δውጐወና σፕረበኘቴፕLC ላዛሬጋ ላፖጥዮሙ ለኦረበናቴሜጋና ወጋወልሜፖLነጋበቱ ላዮቦዖበ 6.4.3 ላዛሬጋ 6.4.4.

$\Lambda c^{\circ} U 2 - \delta O \Lambda^{\circ} O^{\circ} I - \delta U + O A C^{\circ}$

2.1 ჂႰႱჁჃႶჿ

2.1.6

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- 2.1.1
- 2.1.2 **ΔΟΓ ΑΓΑΝΙΑΝΑΙ ΑΓΕΛΑΝΙΑΝΑΙ ΑΓΕΛΑΝΙΑ ΑΓΕΛΑΝΙΑΝΑΙ ΑΓΕΛΑΝΙΑΝΑΙ ΑΓΕΛΑΝΙΑΝΑΙ ΑΓΕΛΑΝΙΑΝΑΙ ΑΓΕΛΑΝΙΑΝΑΙ ΑΓΕΛΑΝΙΑΝΑΙ ΑΓΕΛΑΝΙΑΝΑΙ ΑΓΕΛΑΝΙΑΝΑΙ ΑΓΕΛΑΝΙΑΝΑΙ ΑΓΕ** σ \mathcal{A} $\mathcal{A$ $\mathsf{L}_{\mathsf{C}}^{\mathsf{L}} \to \mathsf{L}_{\mathsf{C}}^{\mathsf{L}} \to \mathsf{L}_{\mathsf$ የረላσ L<</p> Λ^{*}
- 2.1.3
- 2.1.4 on $id \cap \mathcal{P}^{(1)}$ ALAS $4H \rightarrow A^{1} \mathcal{P}^{(2)}$ Constants on CE ALAS $4H \rightarrow \mathcal{P}^{(2)}$
- 21.5
- חידסבי א>יא>לגאי גכיחסיבחי מבמי סיטבאישירי סכטי בפאידי

- LOG^PDS A°CPDS

 $\wedge A^{i}b^{i} \cap C P^{c} \cap A^{i} \cap A^{c} \cap A^{c} \cap A^{c} \cap A^{i} \cap A^{c} \cap A^{$ 2.1.8 $\wedge \dot{\otimes} = 2 \nabla \dot{\otimes} =$

Δεσισσοιδιάς αιμω Αργοιδιδιάς Δωδως Κοιμαριο Κιροργμωριο αιμω $\Delta P \subset P$

- 2.1.9 $\Delta D = \Delta
- 2.2 ∧a.rⁱ∩°

- 2.2.4 $Pace = 4^{2}PA = 4^{2}Pace = 4^{2$

- 2.4 ĂˤΡᡤ�ˤσˤь

2.4.2 PadifPade Action Pade Action
- 2.5.1 Ρσα ΔοΔς Φροιο αιστιστημος Λάτροραιο αιροιο
- 2.5.4 $\Lambda C^{\circ} D^{\circ} D^{\circ} D^{\circ} \Delta D \Delta^{\circ} = \Delta D \Delta^{\circ} \Delta^{\circ} D^{\circ} D^{\circ} D^{\circ} D^{\circ} \Delta^{\circ} D^{\circ} D^{\circ} \Delta^{\circ} D^{\circ} D^{\circ$

- 2.5.9 ΡΟΟ ΛΊΟΥς, ΔΟΥΓ ΟΊΕΟ ΡΔΟ ΚΟΥΣ Ο ΕΛΟΙΝΟ ΔΟΔ ΦΟΝΟΡΟΟΙΟΥ ΛΕΊΕΛΟ ΑΝΟΓΙΑΝΟ ΑΝΟΓΙΑΝΟ ΑΝΟΓΙΑΝΟ ΟΡΥΓΕ Ο ΕΛΑΝΟΓΙΑΝΟ ΑΝΟΓΙΑΝΟ ΑΝΟΓΙΑΝΟ ΟΡΕΊΝΑΙ ΑΝΟΓΙΑΝΟ ΑΝΟΓΙΑΝΟ ΑΝΟΓΙΑΝΟ ΑΝΟΓΙΑΝΟ ΟΡΕΊΝΑΙ ΑΝΟΓΙΑΝΟ ΑΝΟΓΙΑΝΟ ΑΝΟΓΙΑΝΟ ΑΝΟΓΙΑΝΟ ΟΡΕΊΝΑΙ ΑΝΟΓΙΑΝΟ ΑΝΟΓΙΑΝΟ ΑΝΟΓΙΑΝΟ ΑΝΟΓΙΑΝΟ ΑΝΟΓΙΑΝΟ ΑΝΟΓΙΑΝΟ ΟΡΕΊΝΑΙ ΑΝΟΓΙΑΝΟ ΙΑΝΟ ΑΝΟΓΙΑΝΟ ΙΑΝΟ ΑΝΟΓΙΑΝΟ ΙΑΝΟ ΑΝΟΓΙΑΝΟ ΑΝΟ ΑΝΟΓΙΑΝΟ ΑΝΟΙΑΝΟ ΑΝΟΙΑΝΟ ΑΝΟΙΑΝΟ ΑΝΟΙΑΝΟ ΑΝΟ ΑΝΟΙΑΝΟ ΑΝΟΙΑ ΑΝΟ ΑΝΟΙΑ ΑΝΟΙΑ ΑΝΟ ΑΝΟΙΑ ΑΝΟ ΑΝΟΙΑ ΑΝΟΙΑΝΟ ΑΝΟ ΑΝΟΙΑ ΑΝΟΙΑ ΑΝΟΙΑΝΟΙΑ ΑΝΟ ΑΝΟΙΑ ΑΝΟΙΑΝΟ ΑΝΟ ΑΝΟΙΑ ΑΝΟΙΑΝΟ ΑΝΟ ΑΝΟΙΑ ΑΝΟΙΑ ΑΝΟ ΑΝΟΙΑ ΑΝΟ ΑΝΟΙΑ ΑΝΟ ΑΝΟΙΑ ΑΝΟΙΑΝΟ ΑΝΟ ΑΝΟΙΑ ΑΝΟΙΑ ΑΝΟ ΑΝΟΙΑ ΑΝΟ ΑΝΟΙΑ ΑΝΟ ΑΝΟ ΑΝΟ ΑΝΟ ΑΝΟ ΑΝΟΙΑ ΑΝΟ ΑΝΟ ΑΝΟ

- 2.5.19 ኦላ Δቃሬና «ኮጋ»ርኦታላናም ይና ለ«ትርትርኦት መንጋድ ጋ «ኮንስና ፊዮቭናበላህጋቡ «ዛሬጋ ኦበሌሀናበጋቡ ለፈረላናኦበሶም «ዛሬጋ ዮብናበትቦታላምርግዮም «ዛሬጋ ለርሲትቦታላምርግዮም.
- 2.5.17 CAL రాసం గర్గాలు రాష్ట్ర రాష్ట్ర సింగ్ స

- 2.5.14 ΔΕΓΥΡΚ[™] ΒαΟΡ΄ UQL[™]Β[™]ΔΟΡσΔ[™]Γ^CΣ[™] Δε[™]υσ Ρ[®]Q[™]σ[™] CLDL[™]U^C ΔαΔ^C Φ[™]Σ[™]CPσΔ[™]σ[™]Γ[™]α[™]Λ[©]CPC[™]Δ[™]D[™]α[™]D[™]CPσ[™] Δβτ²2200[™] J Cl[™]U[™]D[™]

- 2.5.11 $C\Delta L^{\circ} \Delta D \cap \cap \Delta A^{\circ} \sigma A^{\circ} \cap D^{\circ} D = \Delta a^{\circ} A^{\circ} \cap A^{\circ} D = \Delta a^{\circ} A^{\circ} \cap A^{\circ} D = A^{\circ} A^{\circ} O = A^{\circ$
- ላጐየንሰና ፚዸጚ፞በዾႱሥጋና ጋዮ⊂ዾንበՐኁጋቦና ∆ዾ∆ና ላ▷ጋኈርዾσ∢ናጐኯኇ ለኆ፦፫ንርዾኆ፝፞፞፞፞፞ፚ፨ጋዾኁጋ ∢ጐየንበናበዮσ.

2.6.2 \land አንትኒቴትንር 'የΓናንፈቴስቦቦጋቦ' ΔውΔና, ແጋሲሏት/Lዎ' ኦዕሲσ ΔውΔ' ላኮጋኈርኦσፈናምንቦ ው \land ላትርንዮርኦታ ፈኑቦንሶ, Δርቴትናጋσ, ኦጋጋሬ የጉጋቦ:

- (a) $\Delta r^{1} \Gamma^{2} L^{1} \Gamma^{1} \Gamma^{2} \Lambda^{1} \Gamma^{1} L^{1} \Gamma^{1} \Lambda^{1} \Lambda^{$
- 2.6 2\\\~_\P` \PT\?<

- 2.5.20 ΛΟΊΡΥΡΟΊ ΛαΖαΊΡΟΓΟ ΦΟΊΡΟΠΟΝ Δ΄ ΟΥΤΟΔΟΔΟΝ ΑΝΗΓΥΦΗΝΟΝ ΑΝΑΥΝΟΝΟ ΔΟΛΔΊΡΥΟ ΔΟΊΡΟΝΑ ΔΟΥ ΦΟΊΡΟΝΟΔΙΟΥ ΑΝΗΓΥΦΗΝΟΥ ΔΥΡΛΟ ΔΟΊΡΟΝΟ ΦΟΊΡΟΝΟ ΑΝΟΥΝΟΝΟ ΔΥΡΛΟ ΔΟΊΡΟΝΟ ΑΝΟΥΝΟΝΟ ΔΟΊΡΟΝΟ ΔΟΊΡΟΝΟ ΑΝΟΥΝΟ ΔΟΊΡΟΝΟ ΔΟΊΡΟΝΟ ΑΝΟΥΝΟ ΔΟΊΡΟΝΟ ΔΟΊΡΟ ΔΟΙ ΔΟΊΡΟ ΔΟΊΡΟ ΔΟΙ ΔΟΊΡΟ ΔΟΊΡΟ ΔΟΙ ΔΟΊΡΟ ΔΟΊΡΟ ΔΟΊΡΟ ΔΟΙ ΔΟΊΡΟ ΔΟΊΡΟ ΔΟΙ ΔΟΊΡΟ ΔΟΙ ΔΟ

- (b) Δ_ΦΛϽϲ[™]CP_Λ[®] Ϥ^L ϽΡ/ϥ[®] ΛCP_Λ[®] ΔϽΛ⁶ Δ^D CΔL[®] α P τ Δ⁶ δ[®] 3[®]; 4^L
- (c) Prad Δ ארכאת אריכ ארכי הישט הישט הישט אריט אריער אריער אריער אריער אריער ארי ארישט אריער אין ארישט ארישט ארישט ארישט אין אין ארישט איגעע אישט איגעע אווען איגעע איגעע איגעע איגעעע איגעעע איגעעע איגעעע איגעעע איגעעע איגעעע איגעעעע איגעעע איגעעע איגעעע איגעעע איגעעעעע איגעעעע איגעעע איגעעעע איגעעעע איגעעע איגעעע איגע
- 2.7 <u>לי</u>ףיחסיטרי סכתסיטרי 2.7
- 2.8 ጋኁና∩ና∩σ™
- 2.8.1 Prod drais bibiecprline of data the product of the product

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 2.8.4 CΔL೨ ዾኄጜሇ

 2.8.4
 CΔL೨ ዾኄጜጜ

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٥٩٢ ኦሬቲሬ ሲዲሞ አንት አስም አንት አስም	የወርጉምር ወወርር
1. ⊲▷<Δ ^c baCΓ ϷLϞ ^s b ^s δ ^c	᠄ᡝ᠋᠋₽₽᠋᠋᠋৽ᢑᢕ᠋ᡪᢣ᠋᠕ᡷᢑ
2. ኣ°σʔˤ ÞՈჼ◊C<ˤጋϿˤ ՈჼΓϤϿና ኣ>ʲᢣϷፖLል◊	LCCP
3. Δϟϲʹϧʹϭϧ ϷͶͽϲ<ϚϽϿϲ ͶͼϹϭͻϲ ϒ>ͽϷϟϹϨͽ	Peallc
4. የᲮ₠Ხ₽₠₺ጛ፞ኈ ▷∩ኈႠ<ናጋഛና ∩∿୮⊲ഛና ५>ᡟᢣ▷ィLል▷	ᡃ᠆᠆᠆᠋
5. Δ৬ሩጋላኈ ኦበኈር<ናጋຼຼຼ በኈ୮ላຼຼຼຼ ኣ>ንኦኦረLልኑ	ᡃ᠆᠆᠆᠋
6.	b°°∩°₅ب¢ن∧₀
7. ΰႱናሎ ▷∩ჼ└<ናጋዾና ∩ჼГ◁ዾና ኁ>ኦን▷ፖሬልካ	ଏ ^s ଈସ ^c
 8. σ⁻ⁱ≺∩ⁱbⁱδⁱ b_ΩCΓ ⁱbLⁱ√ⁱbⁱδⁱ 	$\Box \land \Box \land$
9. ፓ•ጋলላ፣ልÞ< ፈኈ፟፟፝፝፝፞፞፝ ፈኈ፟፟፝፝፞፞ baCF σኁ፟፟לበዾና ዾፈኁ፞፞፞፞dႶኈዮና	᠋ᠳ᠔᠘ᠺᠫᠬ
10.	ᠮᡃ᠋bÞᢣ᠋᠘᠋ᡗ᠋ᠶᢛ, ᠘ᢑ᠕᠕ᠮᡪᢣ᠋ᠥ
11. ˤbˤdʿ∟Δˤ bᡆϹΓ Ϸ̃Lɬˤbˤἀˤ	$PP^{Sb}C^{S} \neq A^{Sb}$
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 - (c) CΔbσ ϤϷϲʹϚʹͽϷΛΓϷʹϭ·ʹͿʹ ϷΛLϷϚϲʹ Ϸ·Ⴑ·ͽϽͽΛʹͼϷϽ· ϤϹϷϲϷϫϷʹϚϽΓϷ ʹϷσΓϷʹϞυσ ΔαϲʹϚ, ϷʹͼϷʹͰͺϞͽ ΛΛʹϷσ 3-1, ΔϲΓϷϷϞʹ Δαϲʹ ΔαʹϭΛʹϷʹ ΔαΓϷϹʹͽΔʹͻ ϷΛLϷϚϲʹ Ϸʹ≪Ͽʹϭʹ Δαϲʹϭ ϤʹϒΡΛΔͼ ΛϟͼΔϷΛϲ ΔαʹϞυσ΄ CLΔ°σϲ ϤϹϟΔͼ Δαϲʹͽϲ ϤϞʹϷϚϽϚ ΛϞϤΔϷΛϲ ϤϷϲʹϚϷΛΠϷʹϭͼʹͿϾ ϷΛLϷϚϲʹ ϤͰΔͻ ϾϭϤ ϤϷϲͼϚϐͶΛʹϷϭͼʹͿϾ ϷΛLϷϚϲ ϷϤϤ ΔϲʹͼϷϐͼϭϤʹͽϽͼ ϤϹϷϲʹΓϷ Ϸ·Ⴑ·ͽϽͽ·ΛͼϿϽͼ ϤϽϭ ϤϹϟϭͼ Δαϲ ΔαʹͼͿϷϐʹϭϭϤͽϽͼ ϤϹϷϲʹ; ϤͰΔ ϤϷϲϚΛϟͼΔϷΛϲͼ ΔαʹϞυσͼ; ϤͰΔ
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- 3.2.15 CΔLン CL'Γ⁶ ϤϷϲ·ʹΛʹϧΟΛ⁶ σ΄ Ϥ ϷΛLϷϚϲ΄ ϷΛLσʹ⁶ ϷΛLσϤ⁶Ͻ⁶ ϤΟΡλϤ⁶ Ϸϥ ϤϹσʹϞυσ ΔΔΔ⁶ Ϥ⁶Ͻ⁶CϷσϤ⁶σ⁶Γ⁶Δ⁶ Λ⁴⁶ ϲ⁶⁶ϽΔ⁶ Δ⁶Γ²Γ⁴

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- 3.2.26 CLⁱΓ^b Δ/cⁱChⁱłĊⁱ d)σ υ≪L^bd^c dⁱċJdσ, d)σ dÞcⁱChⁱbChⁱ^bσⁱJ^c bOL^jζ^c NNSⁱJ^b Þσ^bbF^bσ^b CΔⁱJ^c dⁱċJΓ d)^bCF^bσ^c habF^bσ^c sibDh^bδ^b dⁱLJ d/^bC^bσ^b bibDh^bδ^b CΔLJ dDcⁱChⁱbOhⁱ^bσⁱJ^c bOL^jS^c d)σ dDcⁱChⁱbOh^{ib}σⁱJ^c bOL^jS^c Jσ^jJ^b Dσ^bbσ^b C^bdd Ac^jdⁱbO^bC^c iPΓⁱPdⁱσd^{ib}C^bC^bσ^b dⁱS^jJΓ ibDAcD^{ib}CD^j8σⁱσ^b dC^jJ Δc^bb 15.4.

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- - (d) $\forall \mathcal{A}^{c} \land \mathcal{A$
- 3.2.31 Λ Κ L Π΄ Δ Γ΄ Β Δ C Γ΄ Ρ L Κ Γ Λ Ρ Κ Κ Λ Δ Δ Υ΄ Δ Υ

- 3.3.1 Let J 9.3.7 Codes Δαβίτο Δαβίτο Δαβίτος Κάτρης, αραιτικός στη δημορικής τη τη δημορικής τη δημορική
- 3.3.3 $\dot{\mathsf{d}}^{\mathsf{i}}\mathsf{P}^{\mathsf{i}}\mathcal{A}^{\mathsf{i}$

- (c) (c) (Δω⁶ ΔωΔ^c Δ^j^j^kⁱ
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- (k) >ċ``\ D^{c}
 - 3.3.6 Λ΄ ΔΓ΄ ΡΊΦΡΊ ΑΊ ΚΑΊ Κ΄ Λ΄ ΔΙ ΔΑΝΟΊΝΤΑΚ ΔΟΔ΄ ΟΟΥΥΊΟΛΙΝΟ ΔΟΚΝΑΥΡΛΟ΄ ΛΚΡΩΡΛΟ΄ ΡΊΟΛΟ΄ ΔΟΊ 4.3.2 ΟΡΙΔΝΟΓΊΝ ΔΟ΄ 4.3.3, ΔΡΟΓΛΊΟΛΙΝΟ ΟΠΕΛΕΊ ΡΊΦΡΥΔΟΝ ΓσΎΟΙ ΛΟΎ ΓΟΥΔΗΝΟΝ ΠΟΓΊΥΙΚΟ 3.3.7-Γ.
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- 3.4.6 \dot{P}_{Δ} አሳት ላጋ የርቅ አስት የሚያስት የሚ

- 3.5.1 CLⁱΓ^b bacΓ bL⁴^bⁱÅ^c b[®]^e bⁿ^bC²^c²^o^c ⁿ^bΓ4^{o^c} ^k^jb²^k^b²^k²^{k²^k²^{k²^k²^{k²^k²^{k²}}}

- 3.5.5 Pdd dP = (nbnibmed for bold for
- 3.5.6 LCΓαΦ ϞΔϟϷσϭჼϿσ <ჼሏϷΛσ ϤͰͺͺϷἀϷϟͽϿΛσ, ϷϭϤ ϤϷͺͼΛϳϧΛϳͼ ϧΛͿϞϳͼ ΛΩ;σϭͽϿ ϭϳϷϟΔϿΛ ϤϷϲͼͶ;ϥͿͼϞϿ ϚͼϷͶͼ Ϳϲ·ϿͿ ϳϧϿϪͼϫ Λ≪ϲϭσͼϭͼϹͿͼ ϤϿͶϞϭ ϤͰͺͻ ϳϷΓϳϨϭϳϧͶΓϿΓ ϷϳϧϧͶΓϿΓ ͼϤϧϿͼ ϤϽΛϳϧͽϽϼ.

- - (c) $\square \square^{+} \square \land \square^{-} \square^{+} \square^{-}

 - (e) $P^{-} \mathcal{P}^{-} dD = \mathcal{P}$
 - (f) Pr™C a_a∆™rL≫c d™PP∩σ 14.2.2 dL_ 14.4.1.
- 3.5.9 ΟΔbσ Ρα ϤΡϲ·ϚͿϞϹϷϞ΅ <ናαΡΛ ΛϚϧά΅Ͽ΅ ϾͼϭϿϞ ϧαϹΓ ϷͰϞϧ;ϫ Ϸ«ϤϿͼ ϷϹͼϹϲϿͼ ϹϧϲϤϿͼ ϒϿ;ϷϷϞͰϐͼ, ϷϭϤ ϤϷϲͼϹͿͼϴϽͼ, ͼϷϲͽϲͼ ͼϷϲͼ ϲϫϿ ϲ ϲͼϿϤ 3.6, ϤϽϲͽϹϷ;Ϥ϶ͽͼ ϤͼϷϲϭͽϫ ϲͼϷΛ άμμοͿͼ.
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- 3.6.2 Ρdd ΔΡΕίΠιδηΓίδοι ΕΝΕΡΑΕ΄ Οσλοσίος ΔΟΛΑΡ Δαδογλεία ΔοΔς βολλιθημος Δίτο σοδς ορώδα ΝΕώς Κίσα Αγάιαλης ΔΡείΠιδημος Κίσρης Ρddο ΔΡείηδοη Κίσρης σοδιτ ΡΓκανίζανδας.

- 3.6.4 Let by 8.4.13 שם שירי שם כ'אראי מיראר, בי-Let be able of the set of t

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- (e) Δ is the and a condition of the c

- a) ዻ፞፞፞፞፝፝የ፡በዻኈ፞፝፝፝፝፝፝፝፝ዾዹ[፟]ንዾዹ^ንዾዹ¹ ዾd⊲ ዾ∩ኈכ<ንך ישבר⊳כ∆ና ለኦל∩⊾ሏና ዻኈבײּשײּד ב¢עליאי ישביר וֹאַנלייָ;
- a) ᡩ᠋ᡗᡏᡗ᠕᠋᠋᠋᠉ᡔ᠘᠋ᢕᡄ᠋ᠴ᠋ᡄ᠆ᠴᡆ᠋᠋᠋ᠺᢄᠺ᠋ᠺ᠈ᢣ᠋ᠿ᠋ᢂ᠋ᢣ᠘᠋ᡗ᠂᠕ᢩᢛᢑ᠖᠋᠉᠋ᡔ᠘ᠴ᠘ᡗ᠂ᠴᡆ᠋ᠮᠣᡘᡥ᠋ᠸ
- 4.1.1 ▷ 𝔄 𝔄 Δ

 $\mathcal{D}PC^{\mathsf{sb}} \subset \mathcal{D}^{\mathsf{b}} \subset \mathcal{D}^{\mathsf{b}}$

כ I¹⊳

- $(a) \quad (b) 5^{+}
- (e) $a \subset d \supset \Delta^{e} a^{h} i i \cup O \cap D \supset d^{h} b \supset b^{h} \cup d \subset J^{e} 4.3.8 d^{L} a \subset d \supset \Delta^{e} a^{h}$ $\Delta C J^{c} 4.3.9$

- Λ^{L}

- (iv) $CP\sigma^{U}$ $b_{D}\Delta CD^{Gb}CDZ^{Gb}$:
- (ii) $ab^{a}\sigma^{b}u \wedge a^{b}u \wedge$
- (i) $pacis d^{L}$ is a defined to d^{L} .

 $\Lambda c \ \Gamma b D^{c} \ c \ D^{b}$

 $\Delta \neq L \rightarrow \Gamma \rightarrow D \rightarrow C$

4.3.1 Λ^{\prime}

∆ረ∟⊂⊲∿ን₽ን የደጋር የ₽₽₽

4.3 5>40 CT DI 260 ST States

᠘᠋᠘᠘᠆᠋ᢄ᠕ᡧ᠘᠆ᠺ

- 4.3.4 Ρα Φανοιντίε Δαδς δουνδηγίες Δρενγγής Λεαρηας Ροόη, Λίδηιδιου ασαισσαια δρέπες - Δρενγγής Λεαρηας Ροόη, Αιδηίδιου ασαισσαια δρέπες Αστάστος Αργίας Αργγίας Αμαρίας Αργγής Αμαριας Αργγίας Αργγής Αμαρηας Γαραιας Αργγής Αμαρηας Γαραιας Αργγίας Αμαρηας Αργγίας Αργγής Αμαρηας Αργγίας Αργγίας Αμαριας Αργγίας Αργγίας Αμαριας Αργγίας Αργγίας Αμαριας Αργγίας Αργγία Αργγίας Αργγίας Αργγίας Αργγία Αργγίας Αργγίας Αργγία Αργγίας Α

- 4.3.8 CAL, ALLCONCONSTRUCT ON CONSTRUCT ON

- 4.3.9 ርΔL, Δ/LΓናΠϤϲϷͽͻͿ Ϟ∿ႱͽΠΓͼΠናΠϞͽ Ϸσͼϳͽ Ϥϲϳϲ ΠΠϚͽ/LϞͽ 4.3.8, ϷͿϤ ΔΔΔς ϤϐͽϽͽ/LϞͼ ϧϽ;ϷͼϦΓͼ ϤϽ2LϧͽΓͼ ΛϲϲϤϞͿσͽϧϿͼ ϧϟͶ϶ͻͿ ΔΔΔͼ ϧϽ;ϷͼͶΓͼϲ - ΔϧϞͽϒϿϔ ΛϞͼϫϷͶϿͼ ϷͽϽϾ, ϽϷϲϷϨͶͼϷϿͽ ϷͽϽϺϧ ϲʹϲͿϫϧ ϤͽϧͼͽϧϧϿͼ ϤϐͽϽͽϒͿͺϞͼ ΔΔΔͼ ϧϽ;ϷͼͶΓͼ ΓσʹϹͿ, ϲͼͿϤͻ ϲΔL, ϲͿϪϐϭͼ ϫϲͿϹϧϷϿͶͼ ͼϧϧͼϧϧϧϧϧ ϧͶϧͻϽϻ ϷͼϣϿͼϭͼ ϷϭϧͻͶͼͼ ϧϽͰ

- 4.3.14 Pł⊲σ℃▷™ ⊲∿ՐዖՈ 1.2, ▷ሲ "Γσ℃` ⊲∿Րዖ⋂σ 4.3 (c) ⊲ዛሬ 3.8
 ∩ℙ֊ンJ 4.3.11 ϽΡኘႦ♡™ Γσ℃ Ϲ°ሲ▷™ዮ℃™ Γσ℃⅃ና Δሲ∿ՐⅈՎዴ™. ኘႦ▷ኦና∩⊲ჼンJ,
 ▷ሲ 4.3.8, ▷ሲ "Γσ℃" Ͻዮኘъ™ጋ™ Γσ℃ ▷ኘႦႯႾና∩ჼンJ ኣ∿ႱჼႦႶՐԽՈና∩σჼΓ
 ▷σႪႦჀσ Ͻσϧ▷σ⊲ႪϽჼ Ϲ·ϟ⅃Ⴠ "Γσ℃⅃ና" ⊲∿ՐዖႶσ 4.3.8 Ͻዮ⊂▷ሲፈ೬™ዮ℃ን™ ▷ሲ
 Γσ℃ Ρィ⊲σ ΔሲペՐረ೬™ዮ℃ን™ Δϲ▷ႱϧႪჂჼ ኣჀჼႦႶՐԽϽσ ΛϲჀϧ▷Ϟσ.

4.4 CL۵° م

ϤϞͺϫͺϽϭϟϷͺϫϽϷͺϹϷϭϫϧͺͺϤϐϷϽͽϟϲϭͺ*ϫϫϫ*ͺ ϤϷϲͼͶͽͶͶ;ϫͼ;

- 4.6.1 Let 21 21.5.4 C°R ac P'F ac Crac Arran - 4.6.2 Lc-2J 21.5.7 C°&G ΔαβΥΓ' ΔαĊΡΛΔ' Δ'ΥΡΛ', ΔΥΎΟΡΗ Δ΄ ΔΟ Δαίσηγος Čοσυνο βαζΕ ΒΕΚσλίκαι ΔώβαΔικη Δ'ΥΟΡΗΔ' σίκησι αραίηζορκι αμω σίκησι ιρρλιώνη ανροριστου δεκολικόνου αραγιζ δεκολικόνου αραγιζ

4.6.4 לעל אילטל אילטל אינעלי כראילטל אינעלי כראיגעלי כראיגעטל אינעלי אינעלי כראיגעט אינעלי נעלי אינעליאינעלי אינעלי אינעלי אינעליאנעלי אינעלי אינעליאנעלי אינעלי אינעלי אינעליאינעלי אינעלי אינעליאנעלי אינעלי
4.7 $\Delta r^{c} C D \prec^{c} \Delta \Box \Delta^{c} \Box \Delta^{c} \Delta \Box \Lambda^{c} \Gamma^{c}$

4.7.1 ΡΟΥ ΚΟΥΔΥ ΔΟΎΡΟ Α.3 ΟΊΡΟΟΥΝΟΥ ΛΥ ΔΡΠΟΥΤΟΥ ΟΥ ΔΟΥ ΒΟΥΥ ΡΕΚΤΑΥΥΟΥ ΔΟΥΝΟΥΝΟΥ Α.3 ΟΊΡΟΟΥΝΟΥ ΑΝΟΥΥΥΝΟΥ ΑΝΟΥ ΡΕΚΤΑΥΥΩΝΟΥ ΔΟΥΝΟΥΝΟΥ ΑΝΟΥΝΟΥΝΟΥ ΑΥΡΑΥΤΑΥΝΟΥΝΟΥΝΟΥΝΟΥ ΑΥΡΑΥΝΟΥΝΟΥΝΟΥΝΟΥΝΟΥ ΑΝΟΥΝΟΥΝΟΥΝΟΥΝΟΥΝΟΥ ΑΝΟΥΝΟΥΝΟΥΝΟΥΝΟΥ ΑΝΟΥΝΟΥΝΟΥΝΟΥΝΟΥ ΑΝΟΥΝΟΥΝΟΥΝΟΥ ΑΝΟΥΝΟΥΝΟΥΝΟΥ ΑΝΟΥΝΟΥΝΟΥΝΟΥ ΑΝΟΥΝΟΥΝΟΥ ΑΝΟΥΝΟΥΝΟΥ ΑΝΟΥΝΟΥΝΟΥ ΑΝΟΥΝΟΥΝΟΥ ΑΝΟΥΝΟΥΝΟΥ ΑΝΟΥΝΟΥ ΑΝΟΥ ΑΝΟΥΝΟΥ ΑΝΟΥ ΑΝΟΥΝΟΥ ΑΝΟΥΝΟΥ ΑΝΟΥΝΟΥ ΑΝΟΥΝΟΥ ΑΝΟΥ ΑΝ

$\Delta \texttt{C}^{\text{L}} 5 - \underline{A} \texttt{D} \Delta^{\text{C}} \underline{\wedge} \texttt{A}^{\text{C}} \texttt{C}^{\text{L}} \mathbf{A}^{\text{C}} \underline{\wedge} \texttt{A}^{\text{C}} \mathbf{A}^{\text{C}} \underline{\wedge} \texttt{A}^{\text{C}}

5.1.1

5.2

5.2.1

5.2.2

5.2.3

5.1 $\mathcal{PC}^{\mathsf{S}}$

 $\bigcap^{\circ} \Gamma \triangleleft \circ^{\circ} \triangleleft \supset^{\circ} \lor \supset^{\circ} \lor \lor$

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 $\mathcal{A}^{\mathcal{V}} \mathcal{C} \mathcal{O}^{\mathcal{V}} \mathcal{C} \sigma.$

5>>>レ

(a) $\Delta \subset \Delta \Delta C$ $\Delta \Delta C$ ΔC ΔC ΔC ΔC

(c) $\wedge \mathcal{A}^{e} \Delta^{e} \Delta^{e} \wedge \mathcal{A}^{e} \Delta^{e} \Delta^{e} \nabla^{e} \nabla^$

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 $\Delta / L^{\circ} / C^{\circ}$

 $\Delta \subset \Gamma \succ D^{\circ} \cup C^{\circ} \Delta^{\circ} \cup C^{\circ} $\forall \dot{C} \downarrow^{c} 5.7.34$ $\square a P^{L} \square a \dot{C} P \square a^{*} P \square a \Delta L^{*} a P^{*} a^{*} D^{*}, \Delta \neg \forall \sigma b a C \Gamma$

 $\Lambda^{i}d_{5} = \sigma^{i}d_{5} = \sigma^{$

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 $P \cap C < D \land A' + C P \sigma^{C} \rho^{C} \land A' + C P \sigma^{C} \rho^{C} \rho^{C}$

5.4 ለ፞^ፍር>ረ°ଦ°ቦ^ፍኦ ኦሪታሪ

- 5.3.2 Leb b Leb

 $L \subset \mathcal{D} \land \Delta \subset \mathcal{D}$

5.3.1

5.2.5 'Pరెడ్ సిలిగ్ స్లార్ స్లా స్లార్ స్లా

ے בַסְיָּלְחִיּרָשָ אַשִיירָס אַבַרָ אַגאָיאָגי אַיּגש אַראָשער אַראַשי אַאָאָאַראַגאי

- 5.4.2 $\Delta \dot{o}^{<} 4$ $\Delta \dot{o}^{<} 4$ $\Delta \dot{o}^{<} 4$ $\Delta \dot{o}^{<} 4$ $\Delta \dot{o}^{<} \dot{o}^$
- 5.4.3
 5.4.3
 5.4.3
 4°
 4
- 5.4.4 Let 2^{1} $2^$
- 5.5 ھن ک 5.5
- 5.5.2 $dP \subset C^{+} dP \subseteq C^{-} dP$
- 5.5.4 Ley 7.2.2 Codes south souther
5.5.5 CAL> baCF $PL(CL)^{4}(4d^{6} PD)(CP)^{1} Pdd > CAC^{6} PC)^{1} Pd^{6} Pd$

6.3.1 LლンJ 4°PPN 15.2.1, baCF ÞL⊀ლሊኦናጳጳጳ ጋσፖσፋႪንና ሮካፈውኒ ውልዎና ጋ°ኒሬៃ በՐኒ ሮካሪሮኒ Ճውሬ ቀንምርኦσፋናግሮውና ለኆሮፖዖርኦቶስንውን ፈዮየንሰና ፈንሮምበርኦኖሮፈσፋምንውና ዸ፞ሏኦታኒሬና ቴናፖርሬኦዎግና ፈንፈልምፖሊና በበናምፖሊና 3 4ኒጋ 4 ፈዮየንበσ ኦሏሪም 15-1 ለσሲσፋንውና የፖና ፈኒጋ ՃውበኃሮምፖLቦፋሮ ንዮሮኦሲፋሮና ውልምና ንግኒሬስ በՐኒ ፈንሲፋቴምሮኒና ፈርታ Ճሬኒ 6.4 በዮኒህ 6.8 Lლንና የፖፈር ይልዮነናቴንቦስ.

- 6.3 ACUARTE 60 PARA
- 6.2 ∆∆°⊂ا∿د_

- (c) ኣናዮና∩ჂႶჼ ჂዮረฉჼჄႶና∩ჄႾႵႫჼ ႶႶႽჼჄႾႵႫჼ ΔႦႵႶႫႳჼႦჂႫჼ >ႠჽႶჾ ኦժ⊲Ⴢ ჼႦፚムჼዮናჂና ႠჼჾႱႦႦႱ ႦႦႠႠ ႦႾႵჼႦჼჽና ႯႾჂ ႦႶჼჼႠ<ჼჂჿና ႶჼႠႯჿና ኣჂჼႦႦჄႾჽჼ:
- (b) $a_a \Delta^{c} \Delta^{c} \Lambda^{c} \Delta^{c} \Delta$
- (a) ΠΠና¹ν/L⁴ ΔC¹σC⁴, Δ⁻C¹σC⁴, Δ⁻C⁴σC⁴, Δ⁻L³ Δ⁻L³
 ΠΠς¹ν/L⁴¹ CL¹σC⁴ δαCF δL⁴δ¹δ² Δ⁻L³ δΠ¹C⁴C⁵ Δ⁻L³
 Δ²ν³ν³ν³ν³
- 6.1 ጋዖር፞ኈ<ኁርላኦረቡኑኁና

 $\Delta c^{b} 6 - 25 PLO^{c} O^{5b}, OOS^{5b}/L4^{5} dO^{b}C^{c} 4^{L} \Delta^{b} S^{5} dO^{b}C^{c}$

6.4 ለነፈበጐቦ ለነፈበካኑና ለዛLሲኦረና Δጔኈጔና: CLΔ°ጔና LඌCኦቦላሮና

- - (d) Δ৮៩ ጋՐ ለኖር «በርቅም በ አውበጋና ወሏልና «በግቦና ሮካፈውህ, bacr ኦሬና የሰኛ, ኦበምር<ናጋውና በግር ላን አንትዮረል። «ዚጋ ወልቦንዮሩ Δጋላም.
- - (b) a a a Δ^{th} / L+C 4+L a P / j \sigma^{th} C straight of a a a a finite of the set of

Δ℃ σ C b s A C L A J J C

- 6.5.2 Λ૯૫૨૮૯ Δ°ΦϽʻԽΔϤ ϤϹϟϹϤ ϷϘϲ΅ϭϤ ϤϽϦ·ϧϤϞͽϽϤ ϹͼϤϿϢ ΔϿΔͽ Λαλαίδημος σαοδαίταρος ναίτος Κάρκανος ακτουρά Σσομά Λαίδιημος Ραδίηδησίος ακτουδιάτους
- (d) ᠘᠊᠋᠋᠋᠊᠋᠋ᡘ᠆ᡏ᠘ᠴ᠋᠋᠈ᡩᠣ᠋᠋᠋᠃ᡗ᠅᠕᠋ᢄ᠆ᡘ᠆ᡘ᠕᠅᠘ᡣᢄ᠆ᡘ᠘ ᡔ᠋᠄ᢣ᠋ᢉ᠖ᡃᢐᢂᡔᢞᡄ᠋ᠴᡆ᠘ᡕ᠕ᡃ᠘ᠧᢂᡩ᠘ᠴᡱᠴᡄ
- దించింది? ఈటు 'PF'?ల్ ఎంగి లినించింది? గిగినింగిని ఉందిని రాజిలి గిగిని సిగిది 6-1 bacf Þlళుశ్వం ఈటు Þగిళ్లంలో గిళ్లేల్ నిసింధిల్లి లేగుకుల్ లిగిళిల్లంలో కిరింగినిగి రిగ్రాంతాగా దడాక్ ఎంగి, కులినించిందిని దిగ్రాంకింగారా:

(a) Δ^{L} שלעם אירי Δ^{L} (b) Δ^{L} (c) Δ^{L}

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6.6

bበ $L^{c} < 4^{L}$ $ac^{c} & \Delta a^{c}$. CL^{c} $\Lambda'd$ $C\Delta L^{a}a^{b} \wedge A^{c}b^{b}$ $\Delta C' = \Delta ϼͼϪϚ, ͼϿͼϪϐϹϷϟͰ;ϲͺͼϷϹͼͻϤϐϦͶ·ϿϽͽϪϫϟϽͽϷϲϫϞͼϲ, ϤϷϲͼϽͼϷͶϔϫͼ; ϷͶͰϒ;ϳͼͺϤͱϹϿͺϼͼϲ΅ϭͺϪͽϪϲͺͺϳͼͼϷ;ϐͺϤϽͽϹϷ;ͼͺͶϾͼϷͽϽͼͺͶͼϤϲϿ ͼϷϷϞͼ;ϻϹϷϲͶϥϟͰ;ͼͺͼϷϭϲϧϲϲ;ͳ;ϳϹͺϪϲϹ;ϿϥͺϹϹϽͳͼϧͺϒϷϭϧͷ

- 6.6.2 $C\Delta b\sigma \wedge d + D = 0$ $\Delta a \sigma \wedge d = 0$ $\Delta b \sigma \wedge d = 0$ $\Delta b \sigma \wedge d = 0$ $\Delta d = 0$ $\Delta d \sigma \wedge d = 0$ $\Delta d = 0$ $\Delta d =$
- 6.6.3 ΔαΘς ϽͼϞϤϐϷ ΠΓϞυ ϷϿϚϷϟϟϹϿΛϷ ϷΠϹϭϤʹϞϹϛ ΛΓϤϲϷσͼϒϭͼϞϭ ϤϞϹϿ ΛϞϲʹϷϚϹ ΔϹʹϭϹϲϲϭϛʹͿϛ ϞαϞϷϞϛ, ϹϷϤϤ ϤϷϲϛϚͱͽͶϦϔϭϛʹͿϛ ϷͶϹϟϛϛ ϤϞϹϿ ϤϽͶϞͽ ϿαϲͼͼϭϞϾͽϽͽ, ϽϞϳϚ϶Ͻϲ ϒϛϿͿ ΛϳϤϹͼ ϤϞϹϿ ;ϷϷϟαϟͼͶϤϳϭͼͼϚ ϷϳϷϷͶϞϷͼͶϤϳϿϽϷ ϒϛϿͿ ΔϭϹͼϟͼϲͼͼ ͼϷϷϟϞϳϿϽϷ ϞͽϐϷϭϤͽϿϛ, ϤϞϹϿ ϷϭϷϲϤϲϿϳϛ ϤϳϷϷͶϞϭͼ ϞαϟͼϾͽ
- 6.7 בשיחסי סח״רי מח״רי מח״רי סר״כ<יסשי ח״רסשי ל>ילאלגמי, bacc גישימי סיגשי בביים מעי כנשיסי

- 6.7.3 రైవిల్ సినిగా రాజులు సింగా స

6.8 ጋየጋናኮዮሮም በበናኈረርረና

- 6.8.3 ወඛዎና ጋ°∿ሁልኮ በ୮∿ሁ ኣኘዋናበጋበኮ ΔLΔሮ∿ሁን‹CÞơላႪጋዀ Ϸddጋ, ΔםΔ^ና >ﺩჼႦናጋႠჀን₽ሩና ϷኛዊኌዮႫና ፈላዮዮና ΔםΔና ϷኛዊኌዮႫና Δዛ୮ႫႪჇႪጋዀ ፈንኦበፈጐሁም ለႠჀჃႾჃ ፈጋ፣ጋቦና ዋሷϷንሥአΔና ዉጋዉΔႪჇႾሩና 6.8.1. ϷdϤ ΔLΔሮሎሁንፈርϷႫፈႪጋና Lሮናበፈናጋበኮ ለንፈበጐዮሮም ϷናႦႪჇႾჃና 6.8.2-୮, ፈዛሬጋ Δርፖሬዮፓጋበኮ ርΔL°ዉϷአჀፈናႦႪበርϷჃႫ ለአϷჇႾჃና ዋዉϷአካጜም ሲዛሬካፖሬዮሩና ፈላጐዮኖሮ ለበርϷናጋበኮ.
- 6.8.4 $DPD^{5}b^{h}c^{\bullet}\sigma^{\bullet}$ $DD^{5}b^{h}c^{\bullet}\sigma^{\bullet}$, $A^{*}dD^{5}b^{*}d^{-}D^{*}b^{-}b^{-}d^{-}b^{-}d^{-}b^{-}d^{-}b^{-}d^{-}b^{-}d^{-}b^{-}d^{-}b^{-}d^{-}b^{-}b^{-}d^{-}b^{-}b^{-}d^{-}b^{-}$
- 6.8.5 bacf $\dot{P}L + ch^{3} + 4 d^{6} \Delta_{3} d\sigma \Delta_{3} d^{6} h^{6} h^{6$
- - (a) ଏମଂ୮୧ ଏଧି ଅର୍ଟମିନିମ୍ ଧିକ୍ଧି ୨୦୧୦୦୯୬୧ ଏଠିଟ ଏଟିଏକ ଜୁଟ୍ର ଅଟନ୍ମାନ ଜୁସଙ୍କୁ ଅନ୍ମାର୍କ ଅନ୍ମ ଅନ୍ମାରକ ଏଠିମ୍ହାରୁ ଅଞ୍ଚାନ୍ମାମ୍ଭ ଅବସ୍ଥରେ ସେହାପାର୍ନ୍ତ:
 - (b) ᠋᠂ᡃᠣᡄ᠋ᠴ᠋ᡄ᠋ᡣ᠋᠋᠋ᡔᡄ᠆᠘᠋ᢩᠣᡢ᠋᠋᠋ᠴ᠋᠋᠋᠋᠋ᡔᡄ᠘᠋᠋ᠨᡝ᠋ᢄ᠂ᢑ᠖᠋᠋᠉ᢕᡐᢕ ᡏ᠋᠋ᠴ᠋᠘᠆᠙᠘᠆᠙᠘᠆᠙᠘᠆᠙᠘᠆᠙᠘᠆᠙᠘᠆᠙᠘᠆᠙᠘᠆᠙᠘᠆

ዾ፞፞ፚር୮ ዾ፞L፞፞፞፟ጜፄ፞ጜ፞ጜ ዻ፟፟፝፞፞፞፞ዾጏ ዾበኈር<ናጋ፞ዾ በኈ୮ዻ፞ዾና ኣ>ንኦዾ፞፞፝፝፝፞ኯLል፝	የ እንግ የትግር እ
1. ⊲⊳<Δς ραζΓ ⊳ΓΥεβάς	᠄ᡗ᠋᠋᠋₽ᠮᢑᢕ᠋ᠮᡶᢂᡪᢑ
2. ኣ°σʔˤ Þብኈር<ናጋຼຼຼຼິ୦ በ∿୮ଏຼຼ໑ና ኣ>ኦϧϷረLልષ	Lc-
3.	₽º%U∆C
4. የዕኈ፟፟፝፝ዾዀጛ፞ዀ ዾበኈር<ናጋዾና በኈፐዻዾና ፟፟፝፝፞፞፞፞ጜኯኯዾኯዾ በኈፐዻዾናበዖ<ኈጋዾና ፟፟፟፟፝፝፝፞፞፞፞ዾኇዻ፧ልና	ڔۮڔ۬ۮ
5. Δ γሩጋላኈ ÞՈኈር<ናጋຼຼຼິ୦ በኈΓ⊲ຼຼຼຼິດ ኣ>ንኑÞፖLል፦	Ϥϲ
6. σ∿∿∿υσ bჲCΓ ϷLᢣˤbˤἀϤ	₽∿₽∿₽ڬ٨٩
7. ϳϳῦᡪᢞ ϷႶჼ᠈ᢗ<ናጋݐና ႶჼΓϤݐና ᢣ>᠈ᡃᢣϷჄĹልჼ	ସଂ&ସ ^c
8. σήληινταν βαζΓ ΡΓλιβάς	⊲⊳⊣∆⊂⊃∿
9. ጋ▷ጋ⊂⊲ናል▷< ዹኈኻኈሁ baCT ▷L៩ናbናልና ውዉናd∩ኈቦና	ͼϼϧϥͲϲϽ _ͼ Ϸ
10.	$^{c}b \triangleright \mathcal{A}^{c} \supset ^{sb}, \Delta^{b} \land \triangleleft ^{s} \mathcal{A}^{b}$
11. ˤbˤdʿ⊃Δˤ bϱCΓ Ϸ̃L⊰ˤbˤἀˤ	^ϛ ΡΡ ^{;ϧ} Ϲ [;] ϟϤ ^{;ϧ}
12. אֹש⊄ ⊳∩™כ<יכשי ח״רסשי א>יא⊳ארמש	$\Delta^{\varsigma} b \lrcorner^{b} \dot{\supset}^{c} \triangleleft^{\varsigma_{b}}, D^{\varsigma_{b}} \dot{\nearrow}^{\varsigma_{b}}, D^{\Gamma^{s}} L^{b} \dot{\supset}^{\varsigma_{b}}$

6.9 סשיסיש שפר״סי פ<לייכאראש

(d) $\forall A'^{c} \forall \dot{\Box} \cap A' \Box \nabla \dot{b} \subset A' \Box \dot{\Box} \cap A' \Box \dot{b} \subset A' \Box \dot{b} \Box \dot{$

- (i) $\bigcap \bigcap G^{G} \sigma^{G} \dot{P} \Delta D b^{G} \Delta C D^{G} D$
- 7.2.2
- 7.2.1 ለትናበናρης. Lender 15.2.1-F, bact bldentsdup Jody Jody Color

7.2

- (g) $\Delta b \dot{\ell} \Lambda \mathcal{C} \to \Lambda^{\circ} \Delta^{\circ} \Delta^{\circ} \Delta^{\circ} \Delta^{\circ} \Lambda \mathcal{C} \to \Lambda^{\circ} \Lambda \to \Lambda^{\circ} \Lambda \mathcal{C} \to \Lambda^{\circ} \Lambda \to \Lambda^$
- . ϷLϞʹϧϧϗͺͺϤϝϹϿͺϷϽͽϲͺϽͽϲͺͶϧͺϫϿͼͺϒͻ;Ϸϧϲ;ϫϯϹϿ

- (b) ለ«፦ ٩٤ ﻓﻪﺭך Þ٦
כ>א משמה אונש אכלה מכר הדאימי אונש

- 7.1.1

$\Box PC'^{Sb} < C < C < D^{b} < C$ 7.1

 $\Lambda < L > \sigma \land > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h > c < h$

 $\Lambda^{c}\Omega^{c}\Lambda^{c}$

 $\Lambda \neg \Lambda \neg \Lambda$

7.2.3

7.2.4

(v) ወዖኑንፖሊσ⁶ >ሬናናበ 4ጋጮርኦσላ⁶ጋσ⁶ bበ⁶ሀረσ 4^L 4/⁶C⁶σ⁶

(vi) $d^{c}P^{c} \Delta^{c} \Delta^{$

በኈፐላຼຼວና ኣ>ን≻>ተLልካ, ▷°ኖረጏዮጵና ኣ>°σላናልና በኈፐላው ▷°ኖረጏዮጵና

 5^{+}

۲۰۲۵ ۵۰ ۵۰۲۵ ۵۰ ۵۰۲۵ ۵°¢ ۵°¢ ۵°¢ ۵°¢ ۵°¢ ۵°¢ ۵°¢

 Δ^{1}

- (i) ఠీరిపీ గిశిష్ ఎ దుతర ÞCÞ/శి 12-CiPT, గండరాం గిళింగి/ఓళ రాంట్లం శ్విత్తించింది. గిళింగిల్లు గిలిండింది. గిళింగిల్లు ఉండిందిందింది. గిళింగిల్లు కార్లు కార్లు కార్లు రద్దిందిందిందిందింది.
- (c) ᡆ᠋᠋᠂ᡏᠣ᠋ᡝᡆᡣ᠋ᡝᡖ᠉᠘ᡩᡆ᠋᠉᠆ᡩᡄᢄ᠉᠆ᡩᡄᢂ᠂᠋ᡬ᠕᠅ᡁ᠖᠉᠘᠃᠘᠃᠘᠃᠕᠅᠘᠃ᡬ᠕᠅᠘᠃᠘᠉᠆᠅᠘᠃
- (ii) b°つらい Characteristic
 (iii) b°つらい
 (iii) ないので、
 (iiiii) ないので、
 (iii) ないので、
 (iii) ないので、
- (i) L⊂^bつ^{sb} つ^c しす^c 60 ΔΔ^b トロペ^c σ^c して ⊲^s Ġ UF; ▷^e ペ j^c Ġ^c

- 8.2.1 <u>Λνל</u>חרי_ר כֹילשיט Δביטם^כ:
- 8.2 ጋዖኈՐና
- (b) $A D Z \dot{C}^{-1} C \Delta C \dot{C}^{-1} C \dot{C}^{$

- 8.1 ጋዖር፞ኈ<፦<<ላንፈበሥላ

 $\mathsf{CL}^{\mathsf{F}}\mathsf{b}^{\mathsf{C}}\mathsf{D}^{\mathsf{C}}\mathsf{c}^{\mathsf{C}}\mathsf{C}\mathsf{L}^{\mathsf{C}}\mathsf{c}^{\mathsf{C}}\mathsf{d}^{\mathsf{C}}\mathsf{c}^{\mathsf{C}}\mathsf{d}^{\mathsf{C}}\mathsf{c}^{\mathsf{C}}\mathsf{d}^{\mathsf{C}}\mathsf{C}}\mathsf{d}^{\mathsf{C}$ 8.3.4 LOG7°P 2005

- 8.3.3 $0^{\circ} \Gamma \sigma^{\circ} h^{\circ}) 0$
- Prince .3.2 $C\Delta L^{\circ} \Delta D^{\circ} 4^{1}
- 831 مه می می ۵۰ میل میل
- 83 b°JĠ¢ dÞcCÞơ°°°
- (e) " $\Delta \Box^{\flat} \dot{b}^{\bullet} \Box^{\dagger} C \Box^{\diamond} D^{\circ}$ " $D^{\circ} b^{\circ} D^{\circ} \Delta \Delta^{\flat} D^{\circ} C \Delta \Delta^{\circ} \Delta^{\circ} C \Delta \Delta^{\circ} \Delta^{\circ} C \Delta^{\circ} D^{\circ} D$

- Δ^{L} Δ^{L} Δ^{C} Δ^{S} Δ^{S}
- (i) \dot{b} $\dot{b$
- (d) " \dot{b} $\dot{$ $\bigcap^{\circ} \Gamma \triangleleft_{D}^{\circ} \lor_{D}^{\circ} :$

- 8.3.6 Þa act Lerator so safe-atribnidhe-all for a safe so a saf

- 8.4.5 CΔbσ bαCΓ ϷLϞϲͺλϞϞϤϤ ϷϿϚͼϞʹϷϹʹLC CLϷʹϥ ϥʹͳσ·ϤϺʹϷͽϽϼ ΛልʹϷʹͶϚͶσʹͽ ϷʹʹϘʹ϶·ϭ· ϷϥϷϧϲϷϨͶΓϥϟͿ϶ϥͽϹʹ·ΓϿϛ, ϽϞʹͶϚͶσϤͽϽϛ ϤϽͶϟσ ͶϲϧϷϟLϞ ΔϿΔϛ ϤϷϲϛϟϡʹϒϿϛ ͶͶϚϳϿͶ.

- 8.5 dicle ipripatecode
- 8.5.1 4° $4^{$

- 9.1 ጋዖር፞ኈ<ኁርፈኑረቡኑና
- - (d) $b > L > D \cap \Delta \Delta \Delta^{c} \Delta C > \sigma^{c} + S^{c} \sigma^{c} + C + L < \Delta^{b} b a \Delta^{c} + C = \sigma^{c} \sigma^{c} + C + L < C = \sigma^{c} \sigma^{c} +

9.2 Δ_ውъ ለኦሆው። ለኦሆው። 3.5

- 9.2.1 bacf \dot{P} Lton \dot{P} Control \dot{P}
- 9.2.2 bacf blkcapidde Δ%badinfalm, Λiapidde A%badinfalm, Λiapidde
- 9.2.3 bacf Þlkcaðikade οσγγίσαιος αιάμοις δαιδαιός όμανο ααρε οριών Πρω Cloru Δαύσι Δείσαιος του καιαιός διαδιάτου Δεισαίος ίδαδείος αίμας ασ Λοιδααίδιος, Δβκίορκιαος Cidalus ααρε οριών στις αίμας ανόπκε ανότης αυαδικήμου Λεασαίοση Δεισαίσαιος.

- 9.3 $\Box C \Delta^{\circ} \Box^{\circ} T^{\circ} \Box^{\circ} \Box$
- - (b) $\Delta^{b}bab \leftarrow 1^{c}n^{c}n^{c}d\sigma^{c}dc^{b}c^{b}dc^{b}dc^{b}dc^{c}dc^{b}dc^{c}dc^{b}dc^{c}dc^{b}dc^{c}dc^{b}dc^{c}dc^{c}dc^{b}dc^{c}dc^{c}dc^{b}dc^{c}dc^{c}dc^{b}dc^{c}dc^{$
- 9.3.2 bacf blkclfgda Δccbnlbgabch bda dóg nnsblk βργλασαβςμοίαμο Δεβαλίκη βλαταστοιση ασδοίσαβηγος αμο Δλαδιδησο Δεβαλίκηο σαρίας σαίας

 - (c) $\forall D^{b} D^{\sigma}, \Delta D^{b} D^{2} \Delta^{c} \Delta^{c}$
 - (d) $b > L = C^{2} = A^{2} C^{2} = A^{2} A^{2} A^{2} = A^{2} A^{2} = A^{2} A^{2} A^{2} = A^{2} A^{2} = A^{2} A^{2} A^{2} = A^{2} A^{2} A^{2} = A^{2} A^{2} A^{2} A^{2} A^{2} = A^{2}

 - (f) $b > L > C \ a > C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a < C \ a <$
- 9.3.4 Δ badycinche dodi in description description of the set
- 9.4 $\Box \Delta^{\circ} \Box \Delta^{\circ}$
- 9.4.1 CΔL°ΦΡ/L°L° ασασΔ°Φ° Δ°νδαΔγσηΓοση Ο΄ Ο΄ αναγγάτους αμο Δγοστάτος Δ°νδαΔγνησι, αμο Ποροτορη Αςτοιατότους ΔρΔς, Δ°νδαΔγνος δνατοιατότος Δεδαδάτος, δοηρησιατότους Αςτοιατότους Δνατοιατότους Αςτοιατότους Δνατοιατότους Αςτοιατότους Δνατοιατότους Αςτοιατότους Δνατοιατότους Αςτοιατότους Αςτοιατότους Αταγγάτους Αταγγάτου Αταγγάτους Αταγγάτους Αταγγάτου Αταγγάτου Αταγγάτου
- 9.4.2 $Pdd \Delta c^{\circ} \sigma d^{\circ} c^{\circ} \Delta b a \Delta \dot{b} a \sigma d^{\circ} c c^{\circ} d^{\circ} c d^{\circ} \Delta b \alpha \Delta \dot{b} \alpha d^{\circ} c
 - (a) $P i \sigma^{C} \Delta^{b} b \Delta b^{b} \Delta' P C P d \sigma d^{L} \Delta d \sigma D d \sigma \Delta^{b} C \Delta^{b} c \Delta^{b} c \Delta^{b} c \Delta^{b} C c^{L} \Delta^{c} D P D A d^{b} C \sigma; d^{L} \Delta^{c}$
 - (b) ϷʹϽͽϞϹ;ϫͽͺϒϲϫϲϹ·ϿϭͺϪϷϞϿϹͼͺϪͽϷϲϫ϶; ΔϲͼϭϥͽϲͼͺϒͽϷϲϪ϶ϲϭϥͽϲϹͼͽͼͺͶϷϷͶϲϥͼϲϲ
- 9.4.3 ΔΔΔΔC
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 - (b) $\Delta = \Omega^{c} P^{e} A^{c} + C^{c} A^{c} + C^{c} A^{c} A^{c$
 - (c) ${\Bar{A}}^{\circ}$ ${\A}^{\circ}$ ${\A}^{$
- - (a) $\square P^{-} J = d D^{-} D^{-} \Delta C^{-} \sigma d (\square C D^{-} D^{-} \Delta D^{-} D^{-} D^{-})$
- 9.4.5 Ρ΄ΔΡϧϧͺϚϤϽϧϤͽϧͼϲϲϤϽͽϭϤͽϿϲϲϿͼϪͽϟϹϟϚϪϲͽϧ 9.3 ϤͰϹϿ 9.4 ΛδρσϤͼϧϲϿϲϪϲϭϧϿͼϹϷϭϥͼϫϧϾͽϲͺϒϭͼϲ϶ϲϷϽͼ϶ϿϤϧϲͿ ϤϽϲͽͶϹϷϭ;ϲϤϞϿϲϷͻϷϫϪ

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- (c) $\Box \sigma \Box r c$ $C^{c} C^{c} \Delta D^{b} O^{c} U^{c} O^{c} \Delta D^{b} O^{c} U^{c} O^{c} \Delta D^{c} O^{c}
- (a) \bigcap $G^{(3)} \cap G^{(3)} \cap G^{(3)$
- 10.2.2 $Do {}^{5}DD + 5^{5}O$
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- 10.2
- (g) $\forall b D^{a} \cap C D P \cap d^{a} \cap L C D^{a} \oplus \dot{C} \cap D P \cap d^{a} \cap L C$

- **᠄᠔᠌᠋᠌ᡔ᠘᠊᠋᠋᠋ᡔ᠋᠋ᢧ᠋᠋᠃᠋᠘᠋᠘᠘**ᡬ᠌᠌ᢄᡔᠲᢆᡈᢉᢁᢐ᠋᠘᠘᠘ᡩᡄ᠋᠋᠋᠋ᠴᠧ᠋ᠴ᠖᠘᠘᠋᠕᠘ᠴ᠋᠁

- 10.1.1

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- - (a) $\Delta^{(6)}baabena \Delta^{(6)}chabena
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- 10.3.3 bacf $\dot{P}L + c_{\Lambda} + 4 d^{c} CL \Delta^{c} \sigma^{b} \dot{A} + L_{\Delta} h^{b} \dot{P} + L_{\Delta} h^{c} \dot{P} + L_{\Delta} h^{$

- 10.5.2 b > 10.5.2 b > 10.5.2 b > 10.5.2 b > 10.5.1 b > 10.5.
- (b) Ρ/ϲͺ៶Ϟ/Ո°Ր° ϤϞϷʹϷ°ΓͺͻϤʹΠϹΔϲͺLͺͻΓ° ʹϧϷϷϞϽϹϷϞʹ ΔͻΔ° ϤϽϨϟʹϷʹͽ Ϥ·Lͺͻ ʹϭͿϐϤϟͿΠΓϨͽʹϹʹϷʹϼϚ ϷϥϹΓ ϷͿͺϟʹϧʹϳϗϚ Ϥ·Lͺͻ ϷΠʹͽϹϚʹϽϼϚ Π°ΓϤϼϚ ϞϿϞϷϷϟLϗͽ, ΔϲͺΓϞϷʹ·ͻΠͽ ϤϽϲ·ʹϭͿϞϷϞʹ ϷʹϨͺ϶ʹ϶ʹϭ· ϤϟʹͽΠϹϷϭϤʹͽϽϚ, ϹΔϷϭ ϹΔL°ϥϷϞʹϥͺͽʹͶʹ·ͻͿ, ʹϧϷϷϞϧͽͶϚ ϤϽʹͻϭϞϟ ϷϥϹΓ ϷͿͺϟʹϧϳϗϚ ϷʹϨͺ϶ϭ· ϷΠʹͽϹϚʹϽϼϚ Π°ΓϤϼϚ ϞϿϞϷϟͰϗϐ.
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- (b) $\Delta c^{P} \Delta A r^{P} a^{S} \Delta h$ (b) $\Delta c^{P} a^{S} \Delta h^{P} a^{S} a^{S} b^{S} b^{S} b^{S} a^{S} b^{S} b^{$
- (a) $\Delta r^2 a^3 r^2 \Delta b c L b^2 25 a^2 2$
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- 11.2 ጋቦኈቦና
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 - (a) "Δ^cC^sσC^c Λ^sdΠ^c" CΔL^eα^cCΔ^eα^s ϽΡ_C D^sνL^s CΔbσ <u>ρα</u>*P*^c ΔC^sσC_cπσ^s ^dL₂ D^sS^sU^sνL^sσ^s Δσ^sΓρ^c Λ^sd^sS^c;
 - (b) "ΔC⁵σC^C P²σ⁶η^C" CΔL⁶α^CΔ⁶α⁶ ϽΡ⊂⁵⁶γL⁴⁶ CΔbσ <u>σα⁹</u>Γ⁶ σα^C2Ω⁵ 4⁶η²Ω⁶;
 - (c) " $\Delta C^{\circ} \sigma C^{\circ} \Delta \sigma^{\circ} \Gamma^{\circ}$) $P^{\circ} b^{\circ} D^{\circ} \Delta \dot{\sigma}^{\circ} \Delta \sigma^{\circ} L \prec^{\circ} \sigma D \Delta^{\circ} \Delta^{\circ} \sigma^{\circ} \Delta^{\circ} \Delta^{\circ} \sigma^{\circ} \Delta^{\circ} \Delta^{\circ} \sigma^{\circ} \Delta^{\circ} \sigma^{\circ} \Delta^{\circ} \sigma^{\circ} \Delta^{\circ} \sigma^{\circ} \sigma^{\circ} \Delta^{\circ} \sigma^{\circ}

- 11.3.1 Λαλαιδημές Δαιγάντας δα Γσίς Δώλαλιδας αιζο ΔοΔ Λίσηριδημός αρεγιδιά αχηρίαδος αιζο σαιστηθιός του του Δίδος Δαιβοίος Δαίδης Δαίδης Δουστοίος του του Δείστος Λίσης Δαίδης Δουστοίος στηθιός σαιστηθιάτου Προστοίος του Γιστος του Γιστο

- 11.3.4 CAL, 40రెస్ ఎంగ్ సంకరారి, దోరంచరికోగిళ్లి 4టు ర్రీస్రిగిట్ ందిని ఉనిగిళి వోరిస్టిలింది దిల్లింగ్ సంకర్ణం సంస్థించింది. సింగ్లిలిలి ఉని సింగ్లిలింది. సింగ్లిలిలిలి సింగ్లిలిలి సింగ్లిలిలి సింగ్లిలిలి సింగ్లిలిలి సింగ్లిలిలి సింగ్లిలిలి సింగ్లిలిలి సింగ్లిలి సింగ్లిలిలి సింగ్లిలిలి సింగ్లిలి సింగ్లిలి సింగ్లిలి సింగ్లిలిలి సింగ్లిలి సింగ్లి సింగ్లిలి సింగ్లి సింగ్లి సింగ్లిలి సింగ్లిలి సింగ్లిలి సింగ్లిలి సింగ్లిలి సింగ్లిలి సింగ్లి సింగ్లిలి సింగ్లిలి సింగ్లిలి సింగ్లి సింగ్లి సింగ్లి సింగ్లి సింగ్లి సింగ్లిలి సింగ్లి సింగ్లి సింగ్లి సింగ్లి సింగ్లి సింగ్లిలి సింగ్లిలి సింగ్లి సింగ్లు సింగ్లి సింగ్లి సింగ్లు సింగ్లి సింగ్లు సింగ్లు సింగ్లి సింగ్లు సింలు సింగ్లు సింలు సింగ్లు సింలు సింగులు సింలు సింలు సింలు సింగ్లు సింలు సింగ్లు సింగ్లు సింగ్లు సింలు సింగి సింలు సింగి సింగి సింగ్లు సింగ్లు సింలు సింగ్లు సింగ్లు సింగి సింలు సింగి సింగి సింగ్లు సింగిలు సింగిలు సింగి సింగ్లు సింగి సింగ్లు సింగి సింగి సింగి సింగ్లు సిలిలు సి సింగ్లు సింలు సింలు సింగి సింలు సింలు సింలు స
- 11.3.6 baCF \dot{P} L+Ch \dot{Y} +4d^G h \dot{Y} +Gfine iPFiPAIshofts as a bet of the set of
- 11.3.7 CΔbσ 'bΔΔ'ϽʻbʻſſʻIJ ĊbdQσ ΔCʻσC Δσ^{*}ſ' Ϸ°&Ͽ°Ⴋ' ΛϷϟϽʻbʻbʻ&Ϸϟ^c Δσ^{*}ſ' Λ^LLΛϷϟ' ΔϿ^{*}Ͽ' ΔJϤႫ'Ͻ' ΔΔΔ' ΔQʻdſ^{*}ſ'C, bQCΓ ϷLϟϲΛϷʹϟϤϤ' ϷʹbϷΛϟLσϤ^{*}C^{*}ſ' ϤⁱϽΛϟ'Ϥ&ⁱϽ^{*}ϟLϟ' ΔΔΔ' ϷϽ^{*}ኦ⁵ϷΛΓ^{*}Λ' CLΔ^{*}σ^b ⁵bΔαϷ^{*}CϷϟσⁱ ϷϤϤϽ ΛϲΛϷϷϟ' ϷL ϤϹσ Δα^{*}υσ Ϥ^{*}Γ?Λ'.
- 11.3.9 $\Delta C^{(1)} + C^{$

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- 12.2 דיל<u>ח</u>שי אדבי<u>חילכדלי</u>
- 12.2.1 $ext{partial}$ xt
- 12.2.2 ΡΥΡΑΥΤΟΝ ΑΟΠΑΡΑΤΟΝ ΑΟΓΑΡΑΓΑΝΟΝΑ ΑΝΤΑΝΤΑΝΑ 12.2.2 ΡΥΡΑΤΑΝΑ ΑΟΓΑΡΑΤΑΝΑ ΡΟΓΑΡΑΤΑΝΑ 12.2.2 ΡΟΓΑΡΑΤΑΝΑ ΝΟΓΑΡΑΤΑΝΑ ΝΟΓΑΛΑ ΝΟΛΑ ΝΟΛΟ

- (c) 'bb>\\`\A'_`\C \Doc\L' - 12.2.4 LCΓ45655 4°Γ2Λς 4.6.1 4Ρς Λίγλος ΛΓ4ςΡ°ΥΓσΥΓσ ΔοΛΓΓΛ45ς ΔΔΔς Δαίθη Γς LC-ΔΝο Δςυ 12.2.3, Ρ44 βαCΓ ΡΓκαλίκα Οληγοατος αόλιδτος αδοστημες ΔΔΔς βοιριστικός βαστ ΡΓκαλίκας Ρσιδορίσης ατόμος μαιατικός Γκαλαμαίας Γιατικός Γκαλαμαίας Γιατικός Γκαλαμαίας Γιατικός Γκαλαμαίας Γκαδιστίας Γιστιστιστιστιστιστιστιστη Γιστισ

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- 12.3.4 $C\Delta L_{2}$, $A \not h \dot{h}^{h} h^{-} \square bacc \dot{P} L + ch^{2} + 4 d^{2} 4 P P h^{b} L + ch^{2} \square 12.3.3$, $A P - P - h^{b} D^{b} \dot{P} h^{2} \dot{P} h^{2} D^{b} \dot{P} h^{2} \dot{P} h^{2$
- 12.3.5 $\Delta = 4 = 30 P^{-} = \Delta^{c} \wedge P^{+} + e^{-} + e^$
- 12.3.7 ርΔLΔ፫∿ሁ<ና ÞdϤ ഛୁ୭ና ሁ≪Lʰdና ϤϽϤሁ∿ ▷ኖ≪୬ዮጵና ഛୁ୭ና ሁ≪Lʰdና ΔϼΔና ጋዮዖናክበሶ በበናጭፖL⊀ም ጋዮዖናክበሶሀበዮጐና ጳዮርታላናና ፌውዮ ጋናፅርኦናና ጳዮጋσሙካኮ \$20,000, baccr ኦL⊀ርኪኦና⊀ጳፅና ጳዮሮውቦ ጳዮጋሲላጭፖLውቦ ፌውሬና ላዛሬው ላካርΔና ጋናፅርኦኖና Lcトッህ ኦል ላኾዮንበ ፊሮ∿.

- 12.4 ΔՐC▷ˤᲮˤ<ַ_∩ʰ ◁̇̀∩ˤʰʰ͡∿⊃ˤ σˤḋ∩&ởˤ
- 12.5 ዾኄዾዾጚፈጋርና
- 12.5.1 4 (4) (1)

- (b) ᠉᠕᠃ᢗᠵᡃ᠋ᡕ᠉᠘᠃᠉᠕᠃᠘᠃᠉᠕᠃᠘᠃᠉᠕᠃᠘᠃᠉᠕᠃᠘᠃᠉᠕ ΔΟ»
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- (a) "いちちょうくいしん いっちょう マンション ロンション (10%) いっしょう (10%) いっしょ - 13.2.1 ▷
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- (e) ϽσϿΓς ϤϚͶϞΓϤͽϽς ϤͰͺϿ ϔͽϹϷϿΛͽ ϷΛͽϹϚ;ϽϿς ΛͽΓϤϿς Ϟ>ϞϷϟL&ͽ ϤͰͺϿ ϷϤϹΓ ϷLϞͽϳϫς ϤͰͺϿ ϤϔͽϦΛͼϧϿͼ ϹϷͽϟϿϲ ΔϿΔς ϿϤϳϤϽͽϲ Γεφακώ ΔϿϤϔ;Ͻς ϷΛͽϹϚ;ϽϿς ΛͽΓϤϿς Ϟ>ϞϷϟL&ͽ ϤͰͺϿ ϷϤϹΓ ϷLϞͽϳϫς.
- (c)
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- (b) ጋσጋቦና ΔΔΔና 4ዛሬጋ ሀዲኮሬና ጋኣኦደታሊላናክምርዮቦኖም ለኦተበካኣም ለርናክናታምጋና ጋቅረናምርኦቲና ርደጋጋኄሁ ኣናዖናበσላጭጋፊና, ላዮቦዮሮቦላናσላጭጋፊና ላዛሬጋ ናክወልሮዮሁσሊንቦኮ ላታናትናσላጭጋፊና, ላዛሬጋ ናክኦኦሬናበላናጋσ ኦዕላ ልፖሬቦታኦናበላጭፖሬና ለቦላሬኦዮዮቦም ኣናዖናበσላጭጋፊና, ላዮቦዮሮቦላናσላጭጋፊና ላዛሬጋ ናክወልሮዮሁσሊንቦኮ ላፖናትናσላጭጋፊና ልፖሬሮላኬንሪና;

13.1 JPC⁶⁶<⁻C4³

کرے 13 – ۲۹۵۹ کا ۵۹٬۵۵ کا ۵۹٬۵۵ کا ۵۹٬۵۵ کا ۵۹٬۵۷ کا ۵۰ کالے 6017 کا ۲۹٬۵۶

- 13.4.1 Lሮቦላቴኬንቴ 13.4.6, ንአናርኦቴዮዮሮ ሲኖላንጋልዲቴ ኣየደበታላቴጋና, ላъጦሮቦላቴታላቴጋና, ኦኖዲቌዮሮ ቴኦኦሮኒውኒ ላፖኑቴጋቴ ሮቴፊኔኒ ውወይና ኦደተሮሴኑቲላቴፊና, ኦፈርቦ ኦደተሮሴትቲላሪና የቦቴንላቴስናቴንግዮ ላጋበተም በቦኦተም ርደጋፊኒ ፊኦሬና ቀንቴርኦታላቴዮዮድና ለጵኖሮፖርኦቶሲቴንጋድ ላъቦፖስና ላቲጌ ላፖዮና
- 13.4 ለነረበኮኑና የዕቅትንቅፈረናበላጭ ጋበኮ

13.3.3

በፑਰበጐጦው, ላዛሬ ጋ ሬርቦላንኬንጭ 9.4.1 ላዛሬ ጋ 9.4.2 ሮካਰਕਰ ወል*ዎዛፑ ወልርንበው ላጐቦንበ*ና, ለলռፈውቍቦው ልድናላውንጋልግልጭ ኣናዖናበውላጭጋና, ላጐጦሮቦላናውላጭጋና, የክወልሮ ህመን ላንናትምንጭ ኦኖሚታውና ፑሮቦላጭርኦቶም ለኦሲጭበና ጋህ ላጋበናክሮናልጐሀር ኦናጋላ, bacr ኦሬተሮቪዮላላሪ ላዛሬ ጋ ላጋበናክጭጋና ልወልና በፑናਰበጐቦና ላቅናክበሰህበቦ ጋቦና ሮኮਰሙህናታላጭ ለኦተበቦና ጋቦና ልተሮናበሞናሮላሙህ ላጋበተውና ላናዖቦላጭጋውና ሮኮਰውህ ልወልና ላኮጋምርኦውላናሙጥ ልና ለሞናሮርኦቶግልን ውና ጋ ላጐቦንሰና.

- 13.3.2 'bP>ಎಸ್೧៧ಅ೧೯ bNL>೯ bನಸ೧೯೧೮ PZD& aDF AvdP5 'bP>>Paಸ್Gate bNL>೯ àLL'd>೧೯, P5b%ZLನ್ AC% 13.4, AP4CP%Pono baCF bLನದನ್ನನರ್ DP6%ZL>%Peno afoto SP6Nod%DC, d%P6CP4'od%DF P%&೨°ರ೯ 'bDAc%bo%b dx62%D% Codo%b DaP4F bLನದನ್ನರ್ಅdas.

- (g) "ናႦጔ᠘ႠჀႱჾჀ ፈჄሩჂႪጋႪ" ጋዮႪႪጋႪ ናႦኴፚႠჀႱႠჼჾჀჁ ዖረንႪჄႱჾჀჁ ႠႱჃ ዾႶႪႠ<ႽჂჿ ႶჀႠჃჿ ኣჂჾႦჄႱል ႠႱჃჀჼჂႶႦ ႦႭႠႠ ႦႱႵႪჽჿ.

- (d) "אילס 2 ישראבאירראשרטיער איר אירשאר אירשאר אירשאר אירשאר אירשאר אירשאר (d) איליס 2 ישראבאיר אירשאר אירש אירש אירש אירש איירש איירע איירש איירע איירש איירש איירש איירע א

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- (h) <code>ibpplcndiiin</code> <code>pdd adfpdc CLDLibc Nidniii</code> <code>ibpplcndiiin</code> <code>pdd adfpdc CLDLibc Nidniii</code> <code>ibppldiii</code> <code>pdd adfpdc in</code> <code>pdd adfpdiii</code>

- (e) Paby 560 100 -

- (a) $b > \Delta^{-1} = \Delta^$

13.4.2 Let all ipperparent is a set of the
ႱペႾჾႺ ႶႬჼჃႶჼჁႺ ለႠႡႵႠ ႠႠჂႠჼႱ ለነႵႶჾჄႺ ჼႦႦჄჄႦႭႵႺႶႯჼჼჂႶჁ ႠჾႻჂჼ ለჄႦႵႾႵჂႺ ჄჼႦႺႮႻჅჂႠ, ႻჼჁႱႠႶႯჼႫႯჼႦႠ, ჁჼペჂჼႫႺ ჼႦჂႭႠჼႱႫჼႱ ႻჄႠჂჼႦჂჼ.

- ∧<<p>C>+C>+C>+C>+C>+C>+C>+C>+C>+C>+C>+C>+C>+C>+C++

- \triangleright $\forall h$ $h \in \mathbb{R}^{2}$ $h \in \mathbb{R}^{2}$ $\Delta L^{\circ} a \triangleright \sigma \triangleleft^{\circ} \mathcal{D}^{\circ}$, $P^{\circ} P^{\circ} a a \triangleright^{\circ} \mathcal{D}^{\circ} a^{\circ} a$
- $P \ll 13.5.1$ $P \sim 24$ COMMENT L COMMENT COMMENT COMMENT COMMENT COMMENT COMMENT COMMENT COMMENTAL COMMENT COMMENT COMMENT COMMENT COMMENT COMMENTAL COMMENT L COMMENT COMMENTAL COMMENT COMMENT COMMENTAL COMMENT COMMENT COMMENTAL COMMENT COMMENTAL COMME 1353
- <u>በበናነጋቦ፣ ለተተኛ ርቀላው ንግን የግብ ማስምር ንግን የቀላይ የቀላን አግራ የስትን አግራ የስትን የሰብ እንግ እንግ የ</u> 13.5.2
- $\triangleright^{\circ} \heartsuit^{\circ} \overset{\circ}{\sigma}
- 13.5

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13.4.4

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13.5.1

13.5.4

13.4.5

13.5.5 ΟΡΥΔΕΊΛΑΡΦΤΟΤΑΊΣς, ΆγΨΟΡΦΥΓΔΕ Ρ«Φ.) ΔΕΥΔΕΊΛΑΡΔΕ ΑγάΨ<Γ ματηρίας Αγάλατης Αγάλατης Αγάλατης Αγάλατης Ανάψου Αγέλατης Αγάλατης Αγάλατης Ανάματης Αγάλατης Αγάλατης Ανάματης Αγάλατης Ανάματης Αγάλατης Ανάματης Αγάλατης Ανάματης Ανάμτης Ανάμτης Ανάματης Ανάμτης Ανδια Ανάμτης Ανάμτης Ανάμτης Ανάμτης Ανάματης Ανάμοτης Ανάμτης Ανάματης Ανάματης Ανάμτα Ανδιστη Ανάματης Α

- 13.6.2 Let J 11.5.9 Codes $aa\beta'F' accircle 4^{r}PRG'$, to be the set of the

- 13.7.1 bacF bLtchittdd Δchalf σtrong for bdd atradations and a section - 13.7.2 bacf \dot{P}_{L} and \dot{P}_{A} and $\dot{P}_{$

- $\bigcap^{\circ} \Gamma \triangleleft_{\mathcal{D}}^{c} \lor_{\mathcal{D}}^{\flat} \lor_{\mathcal{D}}^{\flat} \land \mathcal{D}^{\flat} \lor_{\mathcal{D}}^{c} \circ_{\mathcal{D}}^{\flat} \land \mathcal{D}^{\flat} \circ_{\mathcal{D}}^{\flat}
- $P \cap C < D \cup C \cap C$
- $\label{eq:label} \mathsf{A}^{\mathsf{L}}
- 14.2.2
- 14.2.1 $\mathsf{PC}^{\mathsf{D}}^{\mathsf{C}} \to \mathsf{C}^{\mathsf{C}}^{\mathsf{C}} \to \mathsf{C}^{\mathsf{C}} \to$
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- 5^{b}

- 14.1.1
- $\Box PC'^{Sb} < C < C < D^{b} < C$ 14.1

d^LL⊃ σⁱdΩ^c.

 $\wedge c ~ (14 -) \dot{c}

- 14.2.5 CΔbσ, Δ/LΓ'>Γ[®]σ^b Þdd bαCΓ ÞL
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- 14.3 ጋኣኅበናበσኈ >ዾ፞ኈበጋና
- 14.3.1 రందర్ స్రీటిలింది స్పర్సింగా స్పర్సించింది. సిందర్ స్పర్సింగా స్పర్సిల్ స్పర్సింగా స్పర్సిల్ స్పర్సింగా స్పర్సింగా స్పర్సిల్ స్పర్సిల్లం స్పర్సిల్లం స్పర్సిల్లం స్పర్సిల్లం స్పర్సిల్లం స్పర్సిల్లం స్పర్సిల్లం స్పర్సిల్లం స్పర్సిల్లం స్పర్సిల్ల స్పర్సిల్లం స్పర్సిల్ల స్పర్సిల్లం స్పర్సిల్ల స్పర్సిల్లలో స్పర్సిల్లలో స్పర్సిల్లలో స్పర్సిల్లలో స్పర్సిల్లలు స్పర్సిల్లలు స్పర్సిల్లలు స్పర్సిల్లు స్పర్సిల్లలు స్పర్సిల్లలు స్పర్సిల్లలు స్పర్సిల్లలు స్పర్సిల్లలు స్పరిల్లలు స్పరిల్లలు స్పరిల్లలు స్పరిల్లలు స్పరిల్లలు స్పరిల్లలు స్పరిల్లలు స్పరిల్లలు స్ స్పర్సిలో స్పర్సిల్ స్పరిల్లలు స్పరిలు స్పర్సిల్లలు స్పరిల్లలు స్పరిల్లలు స్పరిల్లలు స్పరిల్లలు స్పరిల్లలు స్పర
- 14.3.3 Ρα 4& ">""" L

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- - (a) $\square \square \Delta^{c} \square \square / \square^{e} \square^{c} \square^{c} \square \square^{c}

15.2.2 Ley J 4°PPN 15.2.1, bacf blter blter berged or Jorden Science
- ᠔᠅᠆ᡗ᠉᠊ᠣ᠈ᠧᠴ᠋᠆ᠫ᠆᠘ᡆ᠘᠋᠆ᡣᡄ᠈ᠫᡆᢛ᠊ᡩᡣᡣᠾᡤᡣᡆ᠈ᡩᢑ ᠕᠅᠆ᡔ᠘ᡔᢞᡆ᠋ᠫ᠆ᡷ᠘᠘᠂᠋
- (c) $b + l + l^{h} P + b + b h^{h} \Delta_{D} \Delta^{c} < 4^{h} D^{h} C b d^{c} A^{h} C b + b^{h} \Delta^{c} + a^{h} D^{h} D^{h} D^{h} \Delta^{c} + a^{h} D^{h}

- 15.1 <u>ጋ</u>₽Ċˤჾ<՟ϲ⊲᠈ᢣᡣᢑᡪ

(a) $P^{1}2^{5} \Delta \Delta \Delta^{2} \Phi^{5} \nabla \Phi^{1} \Phi$

15.4.1 $\wedge | \circ \circ \vee \sigma \triangleleft \circ \circ)^{c}$

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- 15.2.5 $PPP^{\circ}C^{\circ}DT$ $b_{D}AC^{\circ}U\sigma^{\circ}C^{\circ}DC$, $CAb\sigma$ $P^{\circ}\sigma^{\circ}C^{\circ}D\sigma$ $b_{D}C^{\circ}U\sigma^{\circ}C^{\circ}D\sigma^{\circ}D\sigma^{\circ}C^{\circ}D\sigma^{\circ}D\sigma^{\circ}C^{\circ}D\sigma^{\circ}D\sigma^{\circ}C^{\circ}D\sigma^{\circ}D\sigma^{\circ}C^{\circ}D\sigma$ $\forall \lambda^{n} = \nabla \Delta^{n} \lambda^{n} + \nabla \Delta^{n} ᢀ᠋᠋ᠫᡃ᠋᠆ᢕ᠋ᠵᡆ᠋ᡝᠳᡅ᠋ᡄ᠕᠅᠆᠆᠘᠘ᡧᢆᠣ᠉ᠫᠴ᠋ᠴ᠕᠋ᢥᡗᢓᡤ.
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- (d) $\Delta / L^{c} \Omega^{4} \square^{c} \square^$

- 15.6.1 Prad at the Correction of the Correctio
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- 15.7.1 Ρα ΔοΔς ΦΌ⁶CΡσσ⁴σ⁶Γ⁶ος Λ⁴ς⁶CΡCΡ⁴α⁶⁶Ο⁵ος Δ⁶ΓΡΛ¹ Ρίσσ ο⁵δ⁶ΠCΡJσ ΠΠ⁵δΠJ² σ⁶Γ⁶CΡ²Loσ CLΔ⁶σ² Λαίδη⁶σ⁶ Ρ⁸⁴σ⁵δ² Ρίσσ Δα⁶Γ⁶CΡJσ ο²C³ΔοΔ² σ⁵⁶CΡσσ⁴σ⁶Γ²ο² Λ⁴σ²CΡ⁴α⁶O⁵ος σ⁴Γ²Γ²
- 15.7.3 Þda Λα/4ౕ⁵DN^{ic} ᡩΡΓᠻᠯᢋᡝᠴ᠍ᢣ ΔϼΔ^c ϤʹϽʹ⁶CÞσϤʹϭʹʹϺ^eϼ^c ΛૡʹʹϲϝϨϹϷϟ^eϥ^{is}Ͻϼʹͻ ϤʹϒϔͶ^c ϤϽϲʹ^{is}ΝϹϷϟ^c Ϸσⁱδ^k^c ΠΝϚ^{is}ϟͰϟ^c Ͱϲⁱ₂Ω^k 15.6.2, Ċⁱda^tⁱ^c Ͻⁱδ^k²αΓ^kσ^c, ⁱbϷϟαμⁱ₂Ω^k Ϥ^{is}bNⁱJCϷⁱδ^cσ4ⁱL^kⁱ^c Ϸ[®]«ૐ^c Ϥⁱ²PAⁱσ4ⁱL^kⁱ^c ΔρΔ^c Ϥ^{is}²^kCϷσ4ⁱσ^k²^a²</sub> Λάⁱ²ΓΣϷϟ^aϥ^{is}²^k.

᠕ᢩ᠕᠂᠘᠘ᡩ᠘ᡩ᠘ᢕᠳᠿᡲᠳᢞᡗᢛ᠊ᢅᠤᡄ᠕ᢤ ᠅ᡬᡗᠵ᠓ᡬᡆᢄᢣᡃᢐᠧᡲᡢᡸᠿᡲ᠊᠕᠅᠅	ᠶᢞᡗᠳᢧᡄ᠕ᢤ	ر_^_م_م ⁺ 0_م ⁺ 0_م ⁺ 0_م √∿∿۲٦٦٦ 15-1 (لحل⁵ ⁴ 15.2.1)	رےمرح ^ہ ے باصا) 1-1	^{4b} 15.2.1)				
	⊲°ċJ 1	⊲°ن 2	⊲°نٰ ع	4 ل∻ک	⊲°نْئ 5	⊲₅نٰ 6	ح لغ∙⊳	٥٩م℃م
1. ⊲⊳رد∩₅⊳∩∿أم∟ b∩رجزد	\$350,000	\$350,000	\$350,000	\$350,000	\$200,000	\$200,000	\$200,000	\$2,000,000
2. ΔΔΔ ^c ϷϽϞϡϞϧͶϔ ΔϞϔϞϛϟϺϞϔͼ (ϤϷϲϲϺϞϧϺϞϔσͺͿϲ ϧϺͰϚϲʹϾϿ ^c)	\$25,000	\$25,000	\$25,000	\$25,000	\$20,000	\$15,000	\$15,000	\$150,000
3. ^D^Jbc^a ^{sb} J ^c ^*{D ^b L ^c	\$300,000	\$300,000	\$200,000	\$150,000	\$150,000	\$150,000	\$150,000	\$1,400,000
אראָכ ^א באלאאליש, 10, 20, 2	c \$57,142	\$57,142	\$57,142	\$57,142	\$57,142	\$57,142	\$57,148	\$400,000
5.	\$2,300,000	\$300,000	\$300,000	\$300,000	\$300,000	\$300,000	\$300,000	\$4,100,000
6. ∆ם∆ ^כ <⊲ ^כ ∩ז∿רי_ס ^כ ∆לח ^כ	\$64,285	\$64,285	\$64,285	\$64,285	\$64,285	\$64,285	\$64,290	\$450,000
7. ∆ۍ∿ۍ ^c ∆⊂⁴ح⇔⊲⁵₀∩ ^c ∩ځے ^c LơL⊀ ^{۹۵ װ}	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$350,000
8. לבי"ס מאראסר האראס ^ר	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$350,000
ݥ ݥ ݲ	\$3,196,427 \$1,196,427		\$1,096,427	\$1,046,427	\$891,427	\$886,427	\$886,438	\$9,200,000
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- - (a) ליררשר, איררשלד, איררשלד, איררשלד, איררשלד, איררשלישרש אירששליש אירששליש אירששליש אירששלישרש אירששלישרש אירששלישרש אירששלישרש אירששלישרש אירששלישרש אירשש
- 16.2 ጋዖኈՐና
- - (a) "ኣጐሁቴስበሶኮበናበσጭ" ጋዖቴሪጭጋጭ ጋዖłፈረቴዕበሶጐσጭ ሮቴሪላ ለፈረፋቴስበሶና ԵበL೨ጦ ላዛሬጋ ለሮሲፈሥርΓኈ፝ዾና, ሏይሩጭርϷ୬ጦ ኣጐሁቴስበሶኮበናበኦጦ, ፈናምረጋጦ ለኦፈርϷፈው ፈናምረዳ ፈናሮበና ጋቦና ፈናዮ ወና; ላዛሬኃ

16.3 ⊲∆≪⊳רלים כאכיריי

- 16.3.1 ΛαΓ Ρ⁵δ⁶γL< 4Ċσ Δ

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 16.3.1 ΛαΓ Ρ⁵δ⁶γL

 4Ċσ Δ

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 - (c) CAL \land A \land

2.3

ርልL೨ Δ୬° ዮርጋኈ Ϸ«ዲ୬ ዮና Δ୬° ዮርጋኈ ዉን୮ኇ፞፝፝ዀዀን፦ Ϸንጋጽ ወዉዎና ዉጋዉΔኈርϷረLσኄ ለኆዉϷႶርናሥጋም ጳϷናሬንኑትረLσላናጋም Ϸ«ዲ୬ዮ ጳϷናሬንትረLσናΓ ለታሲϷኈኣበናበσላናጋσ σቦኄሁσ ወዉዎና ዉጋዉΔኈርϷረLσኄ, ϷdϤ bዉርΓ ϷLϞϲሲትናϞላና ጋσσላኈርኄር ኁ₽ጮርσΔ ሏልና Ხጋኑትኄበሶኈቦና Ϸ«ዲ୬ዮጵና ሏዉኈሶረL๙ኈ ለኆዉϷႶℾ፦ ጳኄႦჇៃ፯ነጋቡ ለኆዉϷႶርናሥጋም ለϲሲታኈጋኈጋም ጳንትበፋሁσ ርካፈውኄ ዉጋዉΔኈረL๙ና ሏቇኈዮርጋልና Ϸንጋሴዮኖ.

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- 1.3 bacf blkclike arthreads are solved and the second states of the se

- 1.0 <u>A</u>_A <u>a</u>'d<u></u>^

- 2.6 CAL ΥΡΡ[®]Cσ ΔοΔ^c bϽϞδbΛΓάዮ Ϸ«< ϶ͼ Δα^{*}Γ΄λL<[®] ϽσϟͿσ Ρ[®]ህ«[®][®]Γ[°] σ ϤL ά^LLΓϞϷ^cΛϤ^sσσ ϷͻϽ[®]^b ϷLϞϲ Δ⁶ bLϞϲ δ³ b δ³ b δ³
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