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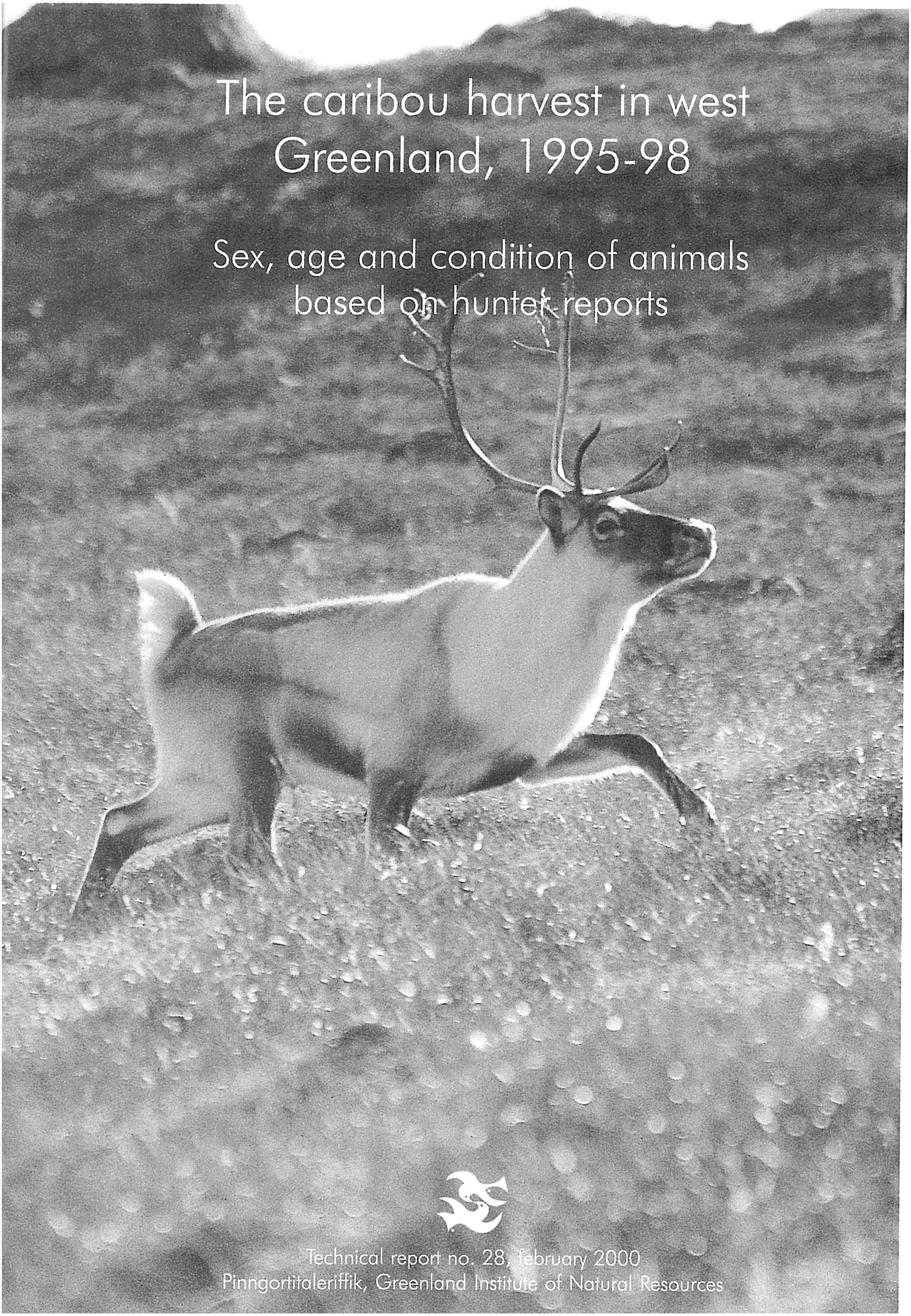
Sex, age and condition of animals based on hunter reports



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The caribou harvest in west Greenland, 1995-98

Sex, age and condition of animals based on hunter reports

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Eqqikkaaneq

1995-imili Kalaallit Nunaata kitaani tuttut (*Rangifer tarandus groenlandicus*) nunap immikkoortuini sisamaasuni piniarneqarnerat killilersugaasimavoq. Ukiut tamaasa tuttunniat qinnuigineqartarsimapput tuttut pisarisamik suiaassusaat, utoqqaassusaat peqqissusaallu (uppataasa tunnuisa issussusaat) nalunaarutigisaqqullugit. 1995-imilu tuttunniat tuttut pisarisamik allerui tunniussimavaat.

Sumiiffiit akornanni assigiinngissutsit annikinnerusut ukiullu eqqaassanngikkaanni tuttut pisarineqartut amerlanersaat tassaapput pannerit (>90:10). Tuttutat taama equngatigisumik suiaassutsinut agguataarnerat aqutsiniarnermut atatillugu aarlerinartortaqarpoq, tassami suiaassutsit agguataarnerat tuttut amerlassusaannik nikerartitsisinnaammat. Siunissaq eqqarsaatigalugu tamanna ungasinnerusoq isigalugu tuttutassat ikiliartornissaannik kinguneqaratarsinnaavoq.

Alleqqut takissusaat nunap immikkoortuini nikingassuteqanngillat. Utoqqalinerup nassataanik kigutit nungullarnerat immikkoortumi avannarlermi ersarinneruvoq (Sisimiut-Kangerlussuaq), tamannalu qularnanngitsumik peqquteqarpoq tamaani sioqqat seqummaarissut sumi tamaani siaruarsimanerat, immikkoortumi tassani naasunut aamma siaruarsimallutik. Tuttut peqqissusaat, uppataasa tunnuisa issussusaat aallaavigalugu, Kalaallit Nunaata kitaani tamani pitsaginarpoq, immikkoortuni nikingassuseqalaartarluni.

Inuussutissarsiutigalugu tuttunniat sunngiffimmilu tuttunniat tuttut pisarisaat angissutsimikkut nikinganeqanngillat, inuussutissarsiutigaluguli tuttunniat kulavannik amerlanerusunik pisaqarsimapput ulluinnarnullu sanilliullugu weekendini tuttunnerusimallutik. Tuttunniat pannerit kulavaallu utoqqaassusaannik naliliinerminni assigiimmik kukkussuteqartuarsimapput. Tuttut utoqqaat ukiui ikinaarneqartarsimapput, inuusunnerillu utoqqaanaarneqartarsimallutik.

Misissuineq taanna tunuliaqutaralugu naliliisinnaavugut tuttunniat paasissutissat katersaat siunissami tuttut taakku pillugit nakkutilliinermut iluaqutaajumaartut.

Resumé

Siden 1995 har jagten på rensdyr (*Rangifer tarandus groenlandicus*) i Vestgrønland været kvotereguleret inden for fire naturligt adskilte regioner. Hvert år er jægerne blevet bedt om at indsende oplysninger om køn, alder og kondition (tykkelse af rumpefedt) hos de nedlagte dyr. Desuden afleverede jægerne i 1995 underkæberne fra de nedlagte rensdyr.

Bortset fra mindre forskelle mellem områder og år var størstedelen af de nedlagte rensdyr voksne bukke (>90:10). Den ekstreme kønsfordeling i fangsten er en potentiel kilde til bekymring i relation til forvaltningen, idet kønsfordelingen kan fremme store svingninger i bestanden. På sigt kan dette få negativ betydning for en mere langsigtet bæredygtig fangst.

Længden af underkæberne varierede ikke i forhold til regionerne. Aldersspecifik tandslidtage var mere tydelig i den nordlige region (Sisimiut-Kangerlussuaq), hvilket sandsynligvis skyldes det fine sandstøv, der lægger sig overalt og dermed også på vegetationen i denne region. Rensdyrenes kondition, baseret på et rumpefedt-index, viser sig at være god i hele Vestgrønland, med små forskelle mellem regionerne.

Der var ingen forskel på størrelsen af de rensdyr, der blev nedlagt af hhv. erhvervs- eller fritidsjægere, men fritidsjægerne nedlagde en større andel simler og skød flere rensdyr i weekenden end på hverdage. Jægerne viste sig konsekvent at lave samme fejl ved vurderingen af alderen for både bukke og simler. Alderen for gamle dyr blev undervurderet, mens alderen for unge dyr blev overvurderet.

På baggrund af denne undersøgelse kan vi konkludere, at oplysninger indsamlet af jægerne fremover vil være nyttige i forbindelse med monitering af disse rensdyrbestande.

Summary

Caribou *Rangifer tarandus groenlandicus* have been harvested under a quota system since 1995 in four regions of west Greenland. In each year, hunters were asked to return information on the sex, approximate age, and body condition of animals harvested, and lower jawbones were collected from animals shot in 1995.

Despite small differences between regions and years, the harvest was strongly sex-biased (>90:10) towards adult males. This extreme male bias in the harvest is a potential source of management concern as it could favour the development of boom and bust dynamics in the population, which in turn could have adverse effects on the long term sustainability of the harvest.

Jawbone length did not vary among regions. Tooth wear was more pronounced in the northern region (Sisimiut-Kangerlussuaq), probably due to the fine soil dust which covers vegetation in the region. Based on a rump-fat index animal condition appears to be good all over west Greenland, with some slight but consistent differences among regions.

There were no differences in the size of the caribou killed by professional and recreational hunters, but recreational hunters harvested a higher proportion of females and shot more caribou at the weekends than during the week. Hunters appeared to make consistent errors in ageing both male and female caribou, underestimating the age of old animals and overestimating the age of young animals.

With further validation of hunters' information we conclude that data provided by hunters will be useful in monitoring these caribou populations.

Contents

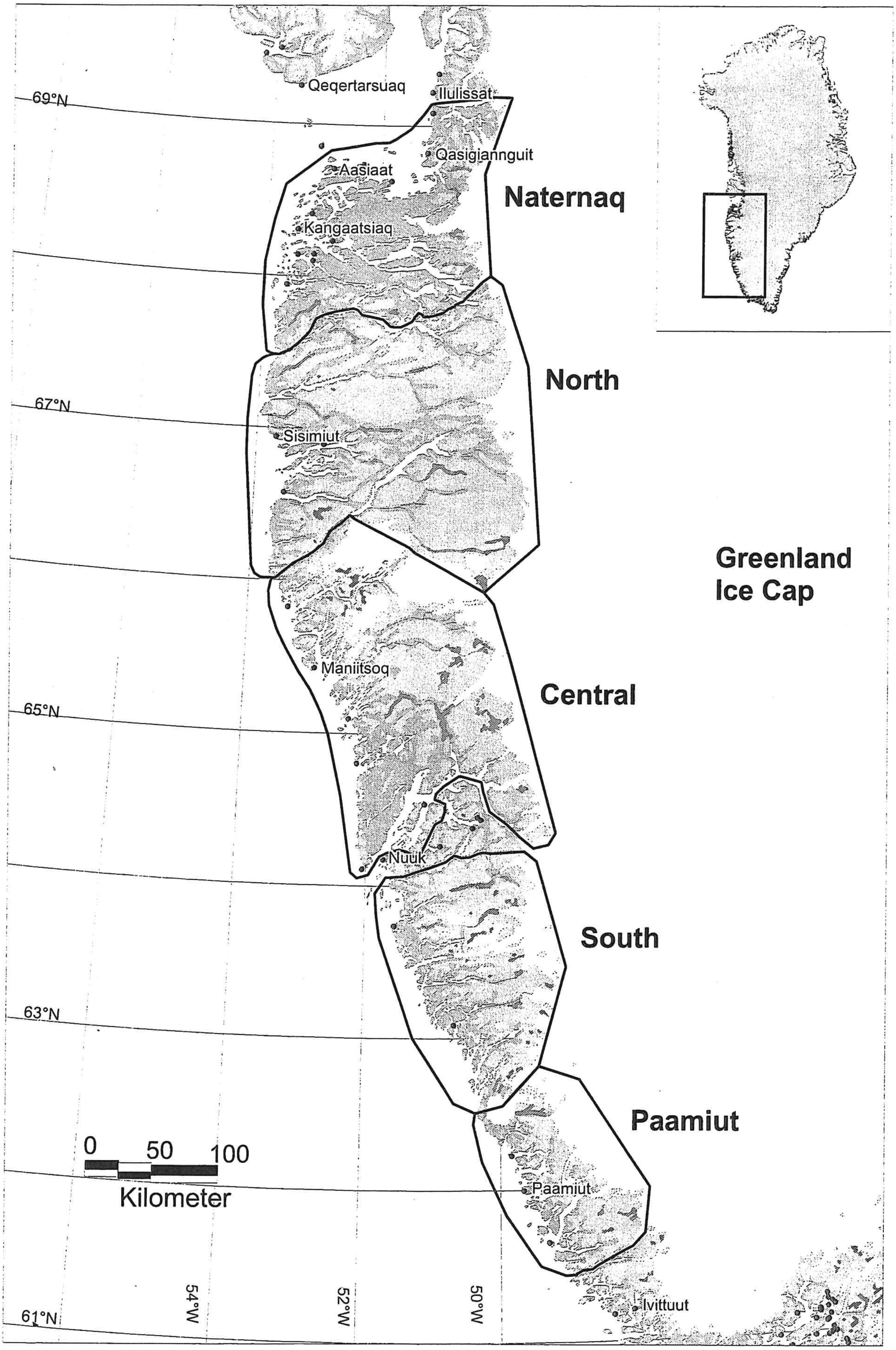

Figure 1. Map of West Greenland.

Background

Caribou *Rangifer tarandus groenlandicus* in western Greenland are an important game species both for recreational and professional hunters, and as such are of both economic and cultural importance (Kapel & Petersen 1982). Although they have not received as much attention as the marine mammals (Caulfield 1997), considerable controversy has surrounded caribou management during the 1990's (Sejersen 1998). Two years of protection (1993-94) followed the previous system of open-quota hunting, and has in turn been followed by a quotaregulated harvest from 1995 to the present. The sizes of Greenland's caribou populations have fluctuated widely during historic times, although it is uncertain as to relative roles that climate, resource-limitation and harvest have played (Jensen 1928, Vibe 1967, Strandgaard 1980, Strandgaard et al. 1983, Roby et al. 1984, Meldgaard 1986, Forchammer et al. in press). Against the background of these historic population fluctuations, the very poor base of scientific knowledge (Linnell et al. 1999), and the intrinsic difficulties of surveying and monitoring caribou in wilderness areas (Thomas 1998), it has been very difficult to make science-based recommendations concerning quota size. In order to improve the state of knowledge about these caribou populations it is necessary to utilise information from all sources. Information provided by hunters can be a valuable source of data to assist in monitoring wild ungulate populations (e.g. Jordhøy et al. 1997, Solberg et al. 1997, Langvatn 1997, Solberg & Sæther 1999, Ericsson & Wallin 1999). In this report we examine the value of information returned by the caribou hunters in west Greenland during the first 4 years of quota-regulated harvest.

Monitoring the condition and size of individuals in a population is a potential tool for assessing the interaction between populations and their environment. Decreasing condition of individuals may indicate high population density or unfavourable environmental conditions during some years (Skogland 1985, Kojola & Helle 1996). In order to improve the status of knowledge concerning individual condition and harvesting patterns for caribou in west Greenland, information on harvested animals has been collected since 1995. During these years, hunters reported the sex, the estimated age, the estimated condition and the location of all caribou killed. In addition, in 1995, lower jawbones were collected for measurement of precise age and toothwear. Using this information, we analysed the sex and age structure of the harvest and compared the size and condition of the caribou in different regions of west Greenland. We evaluated the possibility of using information provided by hunters as a population monitoring tool and discuss the longterm sustainability of the current harvest strategy.

Study site and species

The range of caribou in western Greenland has been separated into five, geographically distinct, management regions (see map, Figure 1). These are regions;

Naternaq (68-69°N): This population is north of Nordre Strømfjord. The population of caribou is so low here that it is not open for harvest.
North (66-68°N): Formerly referred to as the Sisimiut-Kangerlussuag herd (Thing 1984), this population is found between Nordre Strømfjord and Søndre Strømfjord and in Angujartorfiup Nunaa.
Central (64-66°N): This population is bounded by Godthåb fjord in the south and the Sukkertoppen glacier to the north, and includes the Akia/Nordlandet area.

South (62° 30′-64°N): This population is bounded by Ameralik Fjord in the north and Fredrikshåb Isblink glacier to the south, including the two subareas Uttoqqarmiut and Qeqertarsuatsiat.
Paamiut (62°N): This small population is bounded by the Frederikshåb Isblink to the north and the Sermiligaarsuk Fjord to the south..

The inland icecap forms the eastern border for all regions. Although all populations are within the low-arctic zone, local climate varies along north-south and coast-inland gradients, with coastal, and more southerly, areas receiving more precipitation (c. 800 vs 200 mm per year) and less extreme temperatures than northern, and more inland areas (Böcher & Petersen 1997). Because the area of icefree land is so broad in region North, the inland areas of this region are especially dry. This, together with periodic, dry föhn-winds, results in a very fine layer of sand/dust covering most vegetation. No potential predators of caribou are found in west Greenland (Dawes et al. 1986)

Data collected and analysis (Table 1)

Caribou were harvested during a short season every autumn from mid-August to mid-September. During the period 1995-98, the quota was not specific to region or age/sex, so hunters were free to take whatever category they chose anywhere in the four regions, apart from 1995 when they were not allowed to kill females.

For all years since quota hunting opened in 1995, hunters have been asked to report the location of death, the sex, and an estimated age for all caribou shot. From 1996 hunters were also asked to estimate the thickness of the rump fat. Age and rump fat thickness were then classified into categories (Table 2). In 1995, hunters also sent the lower jawbones to the Greenland Institute of Natural Resources. These animals were aged using the cementum layers in incisors, I_1 (Reimers & Nordby 1968). The total jaw length, the diastema length, and the length of the posterior and anterior part of the mandible, were measured with a digital calliper to the nearest mm. The height of the incisor was measured as an index of tooth wear (Appendix 2).

For each year, we calculated the percentage of females in the harvest and the percentage of animals shot in each region. The latter statistic may not be fully representative of the real geographical distribution of the harvest because not all hunters completely filled out their report cards. When an animal was reported with the information about its location of death missing (around 10% each year), we attributed this animal to the region corresponding to the municipality where the hunter lived. When the sex of the animal was missing, we did not include it in the analysis.

From 1996 to 1998, we could only analyse the age-distribution based on the age-classes reported by the hunters. For each year, we calculated the proportion of the harvest in each age-class for each sex with all regions combined. For males it was possible to break this down to specific regions but not enough females were shot to provide equivalent data. For 1995, we calculated a more accurate age-distribution of the harvest based on the precise tooth cementum layers age-determination. Based on this accurate age, we compared the age given by hunters to the actual age by calculating the percentage of animals misclassified by hunters for each age-class.

Table 1. Overview of the different parameters for which data were available from the different years.

Data collected	1995	1996-1998
Date	x	x
Type of hunter	x	x
Location	x	x
Age estimated	x	x
Sex	x	x
Rump-fat index		x
Correct age	x	
Jawbone measurements	x	
Weight estimated	x	

Table 2. Age and rump-fat thickness categories. Five classes ranging from 1 to 5 were defined for the rump-fat and 4 classes ranging from 0 to 3 were defined for age.

Category	Reported fat (cm)	Reported age (years)
0		<1
1	<1	1-2
2	1-2	2-4
3	2-3	≥4
4	3-4	
5	≥4	

The age distribution in the harvest can be used to estimate, under some restrictive assumptions, the annual mortality. The assumptions are that (1) the population has a stable age distribution and is neither increasing nor decreasing, (2) there is no hunter selection for any criteria correlated to age, and (3) mortality rates are not age-dependent. The survival rate can then be deduced from the slope of the linear regression of the logarithm of the proportion in each age-class against age (Caughley 1977).

For each year and sex, we analysed the rumpfat index according to region and age-class, using ANOVAs when age-class was considered as categorical or ANCOVAs when age-class was considered as continuous. Then, we also tested for differences between sexes and years. We did not include the age-class 0 (calf) in these analyses because of the very low number that were harvested (less than 1%).

A series of strip-transect aerial censuses of all four regions were made between 1993-96 (Greenland Institute for Natural Resources, unpublished data). These were used to determine the relative distribution of caribou between the four regions, and indicated that in 1996, the total size of the west Greenland population was in the order of 22,000 caribou (95% confidence intervals 19,500 - 25,000).

All statistical tests are presented in Appendix 1 and are referred to in the text using "T" and the number of the test.

Hunting patterns and accuracy of age and sex estimated by hunters

Comparison between professional and recreational hunters in 1995-1998: timing of the hunt and sex selection.

The hunt is open from mid-August to mid-September. Most animals are shot during the second half of the hunting season by both professional and recreational hunters (percentage of the hunt completed in August was always smaller than percentage in September, see column "A vs S" in Table 3). The larger proportion of caribou shot in September may indicate that hunters have some selection criteria and are looking for animals fitting those. This pattern was more pronounced for females than males (T2, Table 3), suggesting that hunters have a preference for males and tend to shoot females only at the end of the hunt, perhaps after they have not been able to find the animal for which they were searching. Professional hunters shot caribou on every day of the week with equal pressure, while the recreational hunters tended to shoot most of their animals (45%) at the weekends (T3, Figure 2).

Recreational hunters shot a significantly larger proportion of females than professional hunters (T4). Indeed, depending on year, recreational hunters shot between 31% and 58% more females than what would have been expected if they had the same sex-selection pattern as professional hunters.

Table 3. Relative percentage of males and females shot in August and September by professional and recreational hunters. Because a few caribou were hunted outside the hunting period (<2 %), the percentage does not always add to 100.

		PROFESSIONAL					RECREATIONAL				
		Aug.	Sept.	A vs S[1]	N[2]	F[3] (%)	Aug.	Sept.	A vs S[1]	N[2]	F[3] (%)
95	Male	45%	55%	-	821		46%	54%	-	292	
	Female	42%	58%	-	48		35%	62%	-	26	
	F vs M[4]	-	+		869	5.5	-	+		318	8.1
96	Male	39%	59%	-	1,248		40%	60%	-	362	
	Female	33%	67%	-	123		37%	63%	-	76	
	F vs M[4]	-	+		1,371	9.0	-	+		438	17.3
97	Male	45%	54%	-	1,520		49%	51%	-	482	
	Female	41%	56%	-	116		31%	67%	-	67	
	F vs M[4]	-	+		1,636	7.1	-	+		549	12.2
98	Male	46%	53%	-	1,701		46%	54%	-	558	
	Female	39%	59%	-	118		29%	71%	-	65	
	F vs M[4]	-	+		1,819	6.5	-	+		623	10.4

[1] A vs S = August versus September: "-" indicates fewer caribou hunted in August than in September
[2] N = total number of caribou for which the sex and month of harvest were known
[3] F = percentage of females to males; proportion of females in the harvest
[4] F vs M = female versus male: "-" indicates a smaller proportion of females in the harvest

The mean size of the jawbone of males taken by professional and recreational hunters was similar (age accounted for), indicating that professional and recreational hunters do not differ much in their selectivity for size (T27). A more detailed investigation of the number of hunting trips made by hunters before they shot an animal and interviews about hunter preferences could confirm the existence of some selection profiles.

Classification into age-classes and sex determination

The data from 1995 allowed an evaluation of the age estimation made by hunters. The age obtained from the cementumlayer analysis of the incisor was assumed to be the real age. The distribution of the real ages and ages determined by hunters differs (T5, Figure 3) both for males and females. Indeed, nearly 30% of the males classified by hunters as being in age-class 2 (2 and 3 year-old males) were actually misclassified (Figure 4). The misclassified males were, in 93 % of the cases, really older than 3 years but had been mistaken for younger males. The error was even larger for age class 3 (4 and older), with 58 % of the males misclassified. Nearly 60% of the males thought to be 4 and older were actually 3 and younger (Figure 4). In the case of females, 30% and 56 % of the animals classified in age-class 2 and 3 respectively had been misclassified (age underestimated for age-class 2 females and age overestimated for age-class 3 females). In other words, hunters overestimated the age of young animals, and underestimated the age of old animals.

The age estimated by hunters can therefore only be taken as a rough estimate of age. Both body growth and antler growth were very variable among individuals of the same age. We found that males categorised in the oldest age-class were also the biggest (i.e. had the thick-

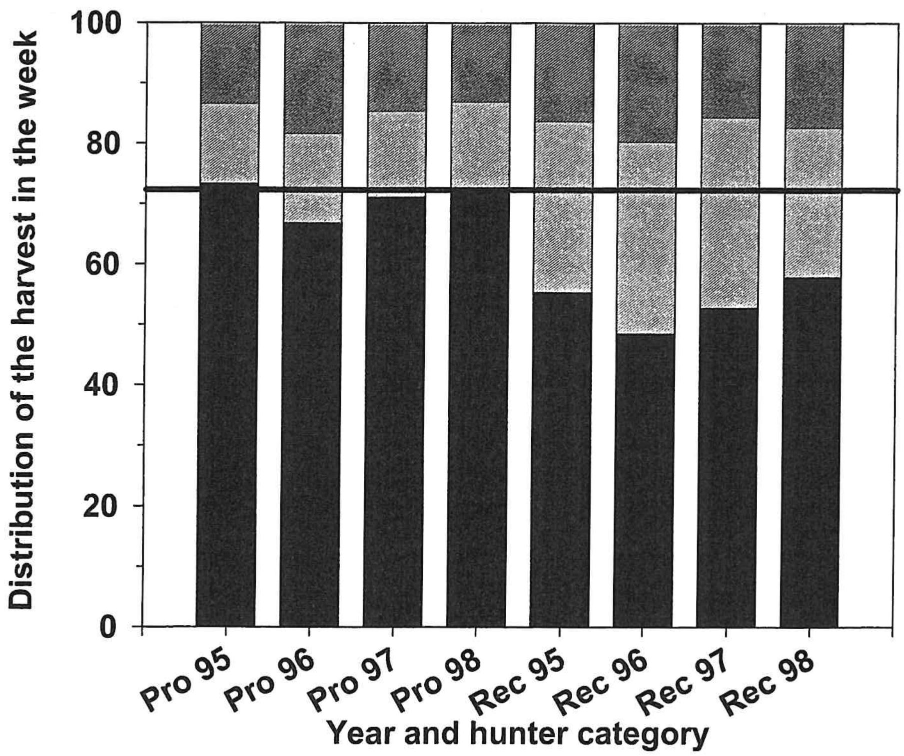

Figure 2. Percentage of animals killed during the weekdays (in black), during Saturdays (light grey) and Sundays (dark grey) for professional hunters (Pro) and recreational hunters (Rec) from 1995 to 1998. If hunters hunt equally each day, one would expect 71% of the animals to be hunted during the working day as indicated by the black line. This was the case for professional hunters, while a larger proportion of animals harvested by recreational hunters were shot during the weekends.

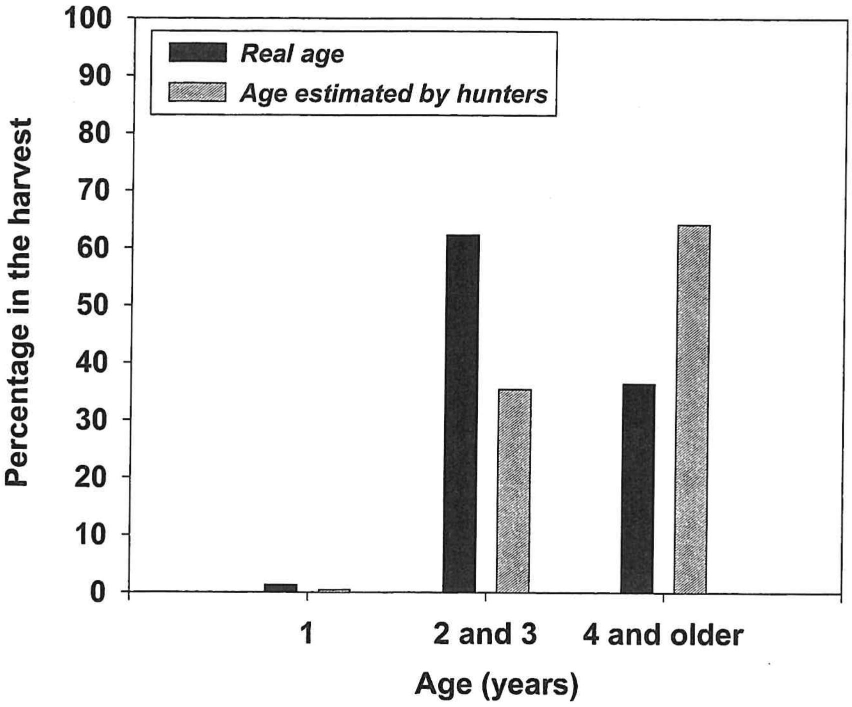

Figure 3. Difference in the age distribution of males as estimated by hunters and as determined by counting cementum annuli in incisors.

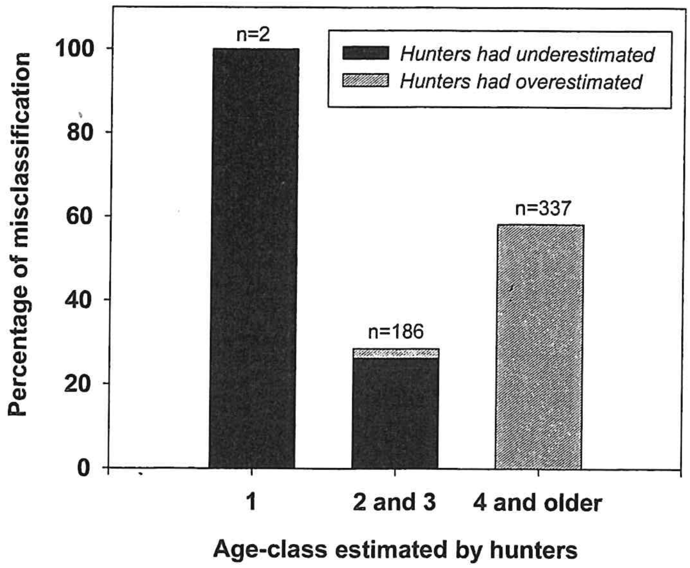

Figure 4. Percentage of males classified in a given age-class that were misclassified by hunters. The total number of males for which an age was reported by the hunter is given above each bar.

Table 4. Number of harvested and reported caribou per region and sex from 1995 to 1998 and percentage of females in the harvest.

Year	Region	Total	% Region	Male[1]	Female[1]	% Females
1995	North	319	25.4	290	16	5.2
	Central	547	43.6	501	30	5.6
	South	362	28.8	321	29	8.3
	Paamiut	27	2.2	21	2	8.7
	Total[2]	**1,314**		**1,135**	**77**	**6.4**
1996	North	841	42.2	766	68	8.2
	Central	390	19.5	350	27	7.2
	South	623	31.2	534	82	13.3
	Paamiut	141	7.1	107	31	22.5
	Total[2]	**1,995**		**1,757**	**208**	**10.6**
1997	North	1,086	44.0	997	80	7.4
	Central	643	26.1	601	42	6.5
	South	573	23.2	489	64	11.6
	Paamiut	164	7.7	140	21	13.0
	Total[2]	**2,472**		**2,227**	**207**	**8.5**
1998	North	1,264	42.6	1,123	80	6.0
	Central	730	24.6	639	36	5.3
	South	758	25.5	642	69	9.7
	Paamiut	214	7.2	148	33	18.2
	Total[2]	**2,966**		**2,552**	**218**	**7.9**

[1] The sum of the number of males and females does not equal the number in the column "Total" because some hunter reports did not indicate the sex of the animal.
[2] The sum of the region total does not always equal the total of a given year when neither the location of death nor the town where the hunter lives was reported.

Figure 5. Age structure (as estimated by cementum annuli in incisors) of the harvested males and females in 1995, all regions combined.

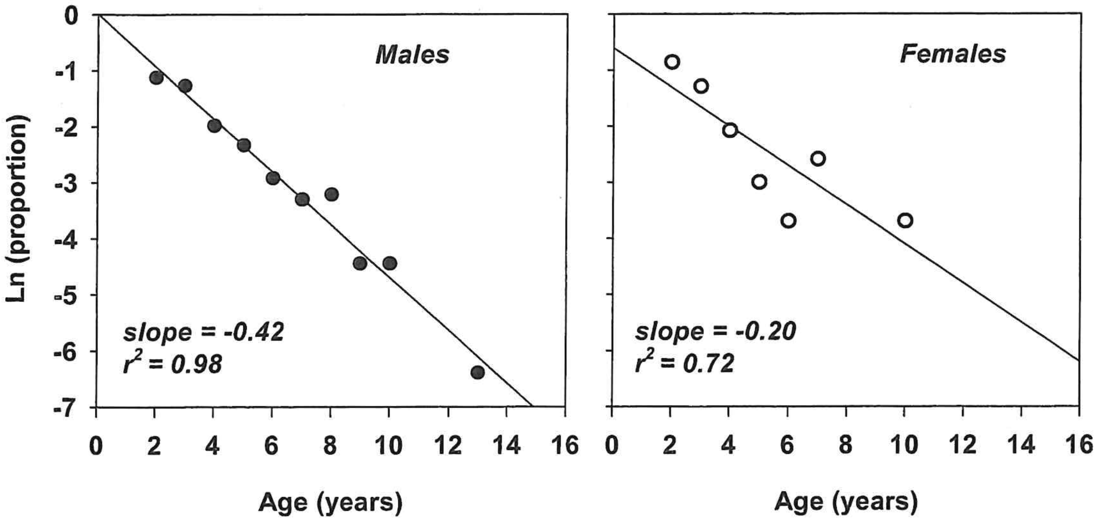

Figure 6. Proportion (Ln-transformed) of harvested males (left) and females (right) in each age-class (as estimated by cementum annuli in incisors), for all regions combined in 1995. Lines are regression lines between the Ln of the proportion, and age.

est rump fat layer, see next section), which supports the hypothesis that one of the criteria used by hunter to assess age is whether the male is big. Thereby, young males in relatively good condition, probably carrying relatively large antlers for their age-class, were susceptible to being misclassified as "old" males (age-class 3, males 4 year-of-age and older).

In 1995, the sex of 249 caribou had been checked based on their DNA, allowing comparison of the sex given by hunters to the "real" sex. The sex given by hunters was wrong in 7.6% of the cases (Jepsen 1999). Since sex is an easy character to recognise, these mistakes can probably be attributed to mistakes made by hunters when filling in reports, or to the fact that hunters were not allowed to shoot females in 1995, leading to a reluctance to write female on the report card. Another test of their ability to sex animals should be made now that they are allowed to harvest both males and females.

Biological results and discussion

Regional distribution of the harvest

From 1995 to 1998, the geographic distribution of the harvest among regions has been stable. The highest proportion of the harvest was in region North (about 45%), followed by regions Central and South (about 25% each), and finally the smallest proportion (<10%) in Paamiut (Table 4). The aerial surveys from 1996 (Greenland Institute of Natural Resources, unpublished data) indicated that the relative availability of caribou was 48%, 29%, 21% and 2% in regions North, Central, South and Paamiut, respectively. While there were no major discrepancies in the relative ranking of the spatial distribution of the animals and the spatial distribution of the harvest, the hunting pressure in the Paamiut region is relatively high for a population which probably estimated at only about 400 to 500 animals (Greenland Institute of Natural Resources, unpublished data). Based on this uneven pattern of animal distribution, as well as on other indications that the caribou population in Paamiut may be relatively heavily harvested, the Greenland Institute for Natural Resources recommended that quotas should be explicitly attributed to the different regions starting in 1999 (Linnell et al. 1999).

This was further justified by the fact that both genetic (Jepsen 1999) and satellite-telemetry data (Cuyler & Linnell unpublished) suggest minimal movement of caribou between regions.

Sex and age structure in the harvest

Mortality estimates based on actual ages in 1995

The age distribution of the numbers of males and females harvested (Figure 5) seems to indicate a relatively smooth exponential decrease of the proportion of animals in each age. This is confirmed when plotting the logarithm of the proportion of culled individuals against age as the relationship obtained is well described by a linear relationship (T11, Figure 6). This relationship did not differ between regions (T8), indicating that the age structure and the decrease of the proportion of each age class with age followed the same pattern within all regions.

The slope for all regions combined differed between sexes (T9) whereas the intercept did not (T10), indicating that the proportion of both 2-year-old females and males was the same, but that subsequent mortality rates differed. The slope was -0.417 ± S.E. 0.058 for males, giving an estimate of annual survival of 0.66, with a 95% confidence interval of 0.61-0.75. This means that, if assumptions are fulfilled, an average of 34% (95% CI: 26-39%) of males between 2 and 13 years of age die each year, either from the hunt or from natural causes. For females, the slope was -0.198 ± S.E. 0.051 (all regions combined), giving an annual survival rate of 0.82 with a 95% confidence interval of 0.71-0.91. Under the same assumptions as for males, an average of 18% (95% CI: 10-29%) of females between 2 and 10 years of age die each year.

The mortality rates estimated using the proportion of males and females in each age from the harvested sample of animals in 1995 has to be interpreted with caution as it is based on the assumption of a stable population and age structure. As emphasised above, the populations may have been in an increasing phase. If this is the case, it will have lead to an overestimate of the mortality rates. However, it was interesting to find that the plot of the logarithm of the proportion of males shot per age against age was so linear. This suggests that there is no selection for any specific age-category of males once they have passed their second birthday. This is not conclusive as a linear trend could also occur if hunter selection increases proportionally with age. The sex difference was consistent with the fact that most of the harvested animals were males. More information about mortality patterns and population dynamics based on independent data are required to further interpret these results.

Sex and age structure from 1996 to 1998 based on hunter assessments

The sex structure in the harvest was strongly biased towards males in all regions and all years. Comparing all years (1995-1998), the sex bias towards males was more pronounced during 1995 and the least during 1996 (T5). The hunters of the Paamiut region, and to a lesser extent hunters from region South, tended to shoot a relatively high proportion of females, when compared with hunters from the North and Central regions (T6, Table 4).

The proportion of males classified in age-class 3 (^{3}4 years old) based on teeth in 1995 was lower than the proportion of males classified in this age-class by hunters in 1996-1998 (T12, Table 5). This implies that hunters tended to misclassify males of age-class 2 into age-class 3 and *vice versa* in 1996-1998 as well as in 1995, assuming that the standing age structure of male did not change drastically between 1995 and 1996-1998. Misclassification of females was less pronounced in 1996-1998 than in 1995 (T12). However, the low sample of females precluded testing for any differences between years.

Table 5. Total number of animals aged, calves and yearling excluded, and percentage classified as age-class 2 (2-4 year-of-age) and age-class 3 (≥4 year-of-age) in 1995 versus 1996-98 combined. The ageing in 1995 is based on teeth whereas it was based on the hunter's own judgement from 1996 to 1998. Totals are for regions North, Central and South, combined.

	Females		Males	
	1995	1996-1998	1995	1996-1998
2 and 3 year-of-age	70.0	77.4	60.8	51.2
≥4 years-of age	30.0	22.6	39.2	48.8
Total	40	465	594	5,480

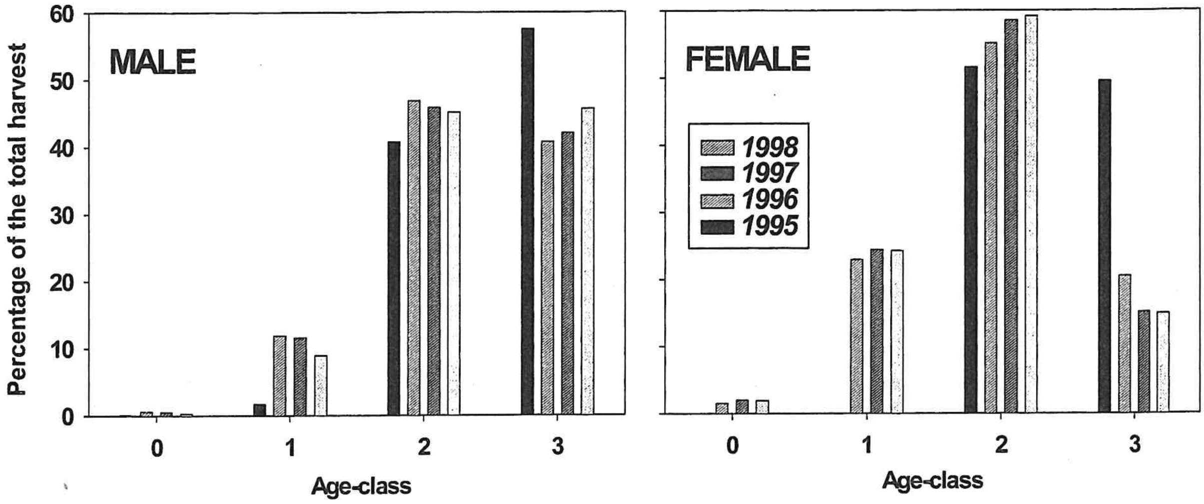

Figure 7. Percentage of the harvest in each age-class (as estimated by hunters), according to sex and year (1995-98).

The age structure for the female segment of the harvest was similar for all years (T14) with most animals belonging to the oldest age-classes, 2 and 3, (>2 years old, Figure 7), while it differed slightly (but significantly, given the large sample sizes) for males (T14), with less yearlings and more old adults in 1998 than during 1996 and 1997.

A higher proportion of young males (age class 1) and a lower proportion of older males (age-class 3) were represented in Paamiut than in the 3 other regions (T13, Figure 8), a trend that was consistent over years. Causes could include (1) a difference in the age structure of the standing population or (2) a weaker selectivity of the hunter for old males in Paamiut, or (3) it may also be due to the low density of the population that would limit the availability of preferred categories of animals, forcing hunters to shoot less preferred individuals. Data on age and sex structure of the standing population is needed.

Possible consequences of the sex biased harvest

The harvest is extremely sex-biased with more than 90% of harvested animals being males in most years. Males are often the preferred target for hunters when the strategy is to let the population increase, and when male trophies are sought (Ginsberg & Milner-Gulland 1994). A preference for males may be intrinsic in Inuit societies, since the main motivation for

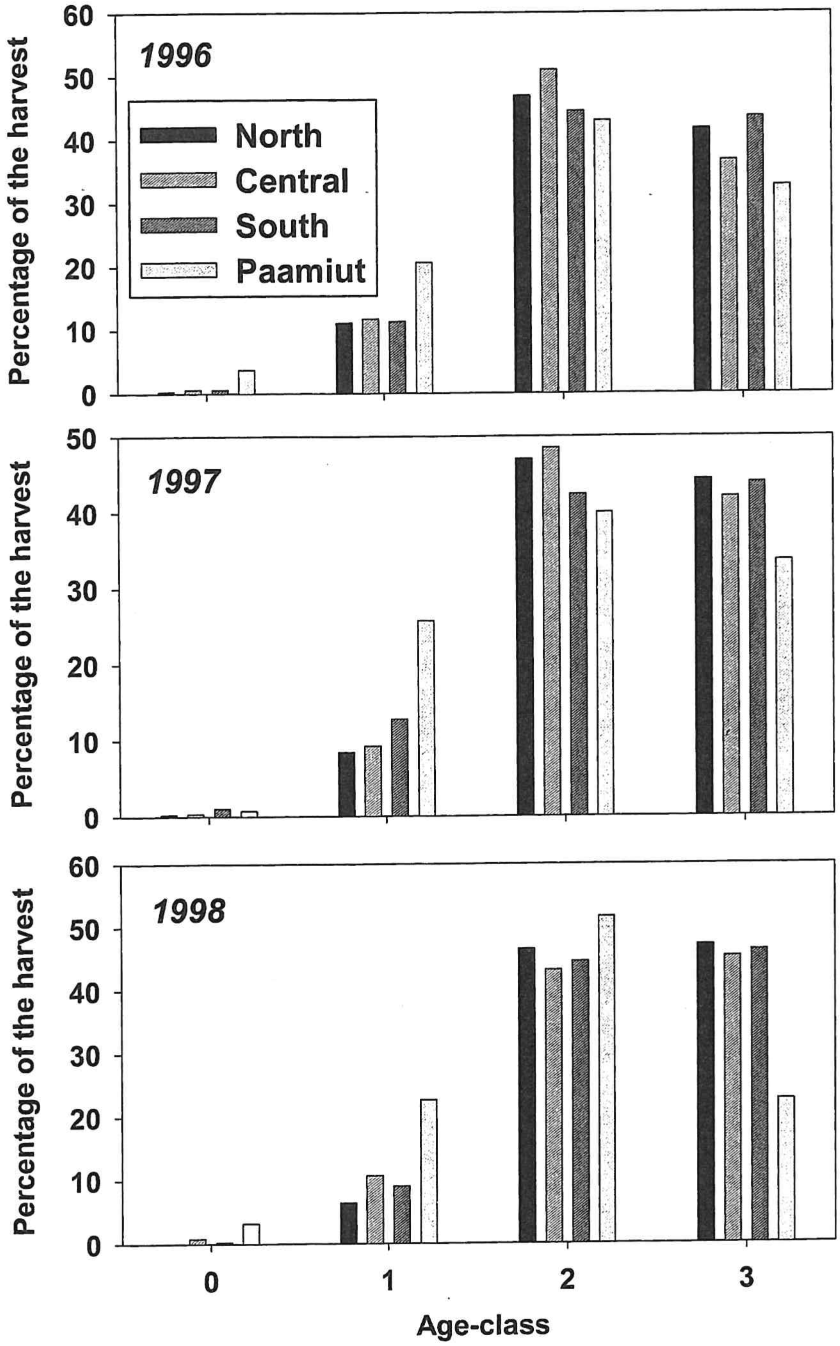

Figure 8. Percentage of males in each age-class (as estimated by hunters) according to region and year.

hunting is to obtain food (Condon et al. 1995, Gunn 1998), and males are larger and provide more meat (Holthe & Lassen 1984, Jingfors 1986, Thomas & Barry 1990). In general, the skew in the sex ratio of the standing population is usually assumed not to limit the reproduction of females because of the potential for a few males to impregnate many females in polygynous species like wild reindeer or caribou (Skogland 1989). In addition, for the same number of individuals shot, the population contains a higher proportion of females that produce a larger number of calves than if the sex-bias in the harvest was more balanced. Nevertheless, when conducted to an extreme and over the long-term, a male-biased harvesting strategy may not be without risks for the dynamics and genetics of a population (Ryman et al. 1981, Ginsberg & Milner-Gulland 1994). Although the aim of management in Greenland during the early 1990s has been to let the population increase after an apparent low in population

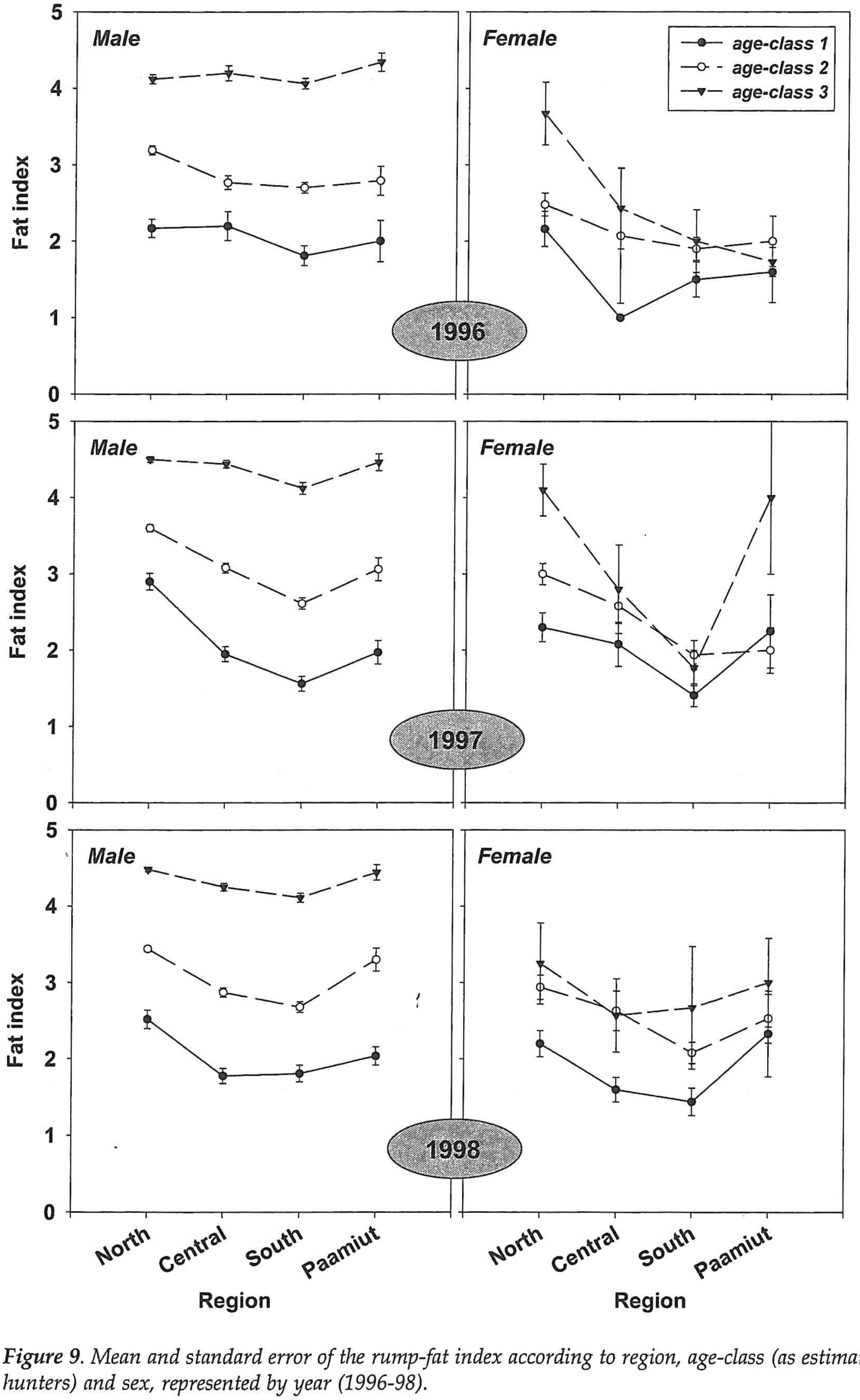

Figure 9. Mean and standard error of the rump-fat index according to region, age-class (as estimated by hunters) and sex, represented by year (1996-98).

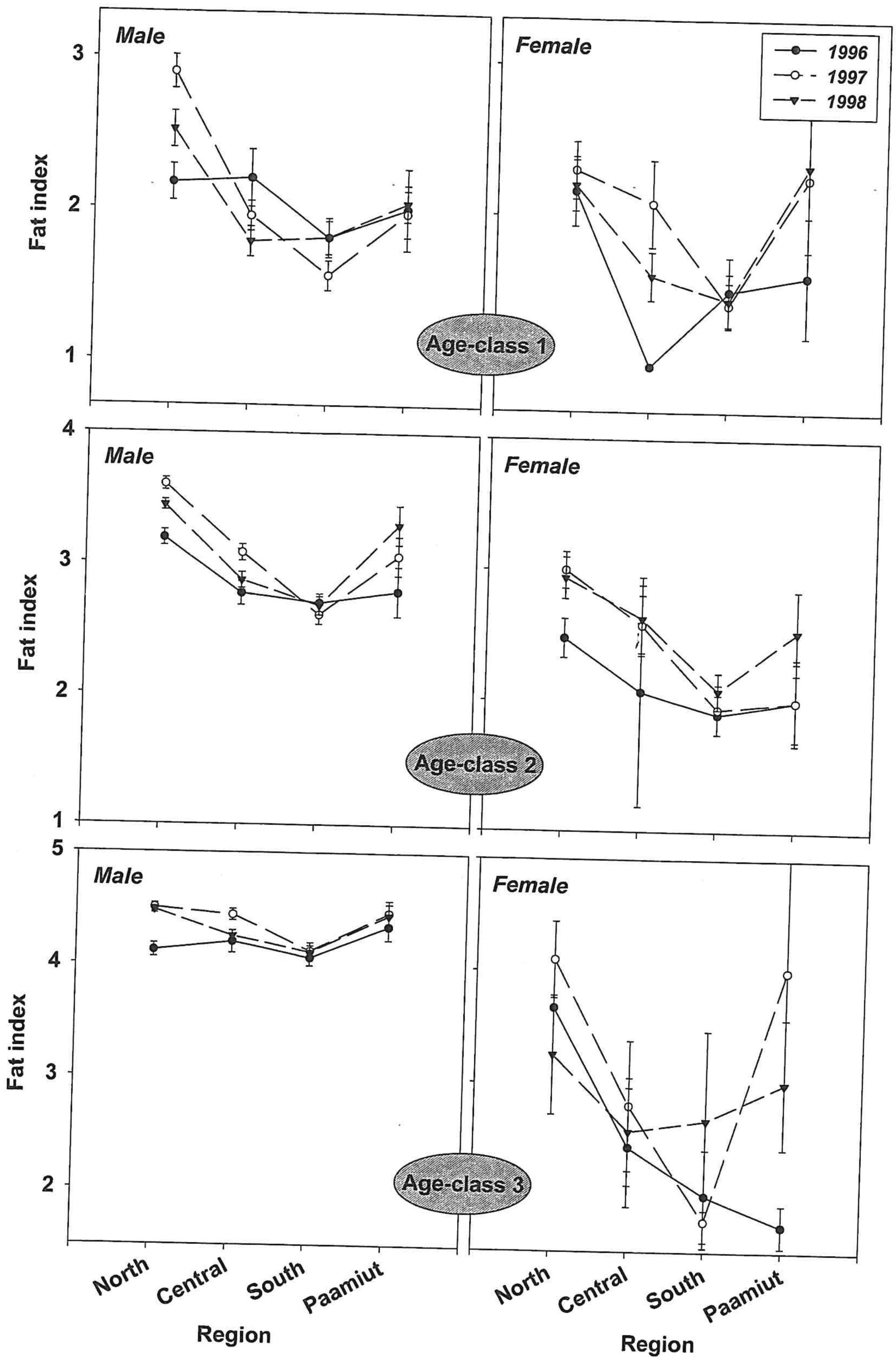

Figure 10. Mean and standard error of the rump-fat index according to region, year and sex, represented by age-class (as estimated by hunters).

Figure 11. Mean and standard error of the rump-fat index according to age (as estimated by hunters) and sex, all regions and years (1996-98) combined.

size, both managers and hunters are also concerned by the potential of boom and crash dynamics to develop (Klein 1968, Swanson & Barker 1992, Mallory & Hillis 1998). A male biased harvest can promote boom and crash dynamics because growth rates are kept very high. A more conservative strategy would be to harvest a higher proportion of females to keep population growing, but at a lower rate (Jordhøy et al. 1997).

Individual condition based on the rump-fat index, 1996 to 1998

Sex, age, year and region differences

For males, the rump-fat index differed widely according to age-class, with males from age-class 3 being fattest (T15, Figure 9). This age effect on fat index was apparent for all years. The same results hold for females (T16). In addition, male and female fat indices differed between region within each year (T17, T18). In males, the region effect interacted with the age effect (T19), meaning that differences among regions were not the same for each age-class (Figure 10). There was nevertheless a trend for region North and Paamiut to have fatter males than regions Central and South, this trend being however less obvious in 1996 and for age-class 3 in general (Figure 9). For females, the region effect was similar across age-classes (T20), except in 1997, due to exceptionally large fat indices for age-class 3 females in regions North and Paamiut. Females in the region North tend to be fatter on average than females in other regions (Figure 10).

The fat index differed widely between sexes (T21), females having a consistently lower fat index than males. This difference increased with age (T22, Figure 11). The mean difference between sexes, when accounting for year and region effect, was 0.246 ± S.E. 0.097 for age-class 1, 0.657 ± S.E. 0.059 for age-class 2 and 1.617 ± S.E. 0.106 for age class 3.

Differences among years were highly significant in both sexes (T23). In males, the year effect was however not the same in each region (T24), as illustrated on Figure 10 (e.g. there is no year effect in region South for age-class 2 whereas for all other regions, males in age-class 2 had a lower fat index in 1996). However, there was a general pattern for the fat index in 1996 being slightly lower than in the two other years (1996 *vs* 1998: -0.161 ± S.E. 0.031). In addition, there was a very slight tendency for animals to be fatter in 1997 than 1998 (1997 *vs* 1998: 0.090 ± S.E. 0.029), however, this was not consistent over age-classes and regions (see Figure 10).

Evaluation of hunter assessment of rump fat thickness

The fat thickness given by hunters, and classified into categories *a posteriori*, appeared to capture some general patterns found in other caribou populations (Dauphiné 1976, Holte & Lassen 1984, Crête et al. 1993) in that the fat index increased with age for males and was larger for males than for females. Fat deposits have been shown to vary seasonally in caribou (Dauphiné 1976) and to be at a maximum in September-October for caribou males and females. This means that measuring the fat deposit during these months is likely to give a measure that will be the most sensitive to year-to-year and region-to-region variation in summer grazing conditions. The data presented here suggested that animals had slightly less fat in 1996 and that animals from region South have less fat than animals from other regions, although we cannot explain these differences with current information on temporal and spatial variation in range quality.

Were the caribou in good condition?

Because the mean we studied was calculated from the fat index categories, we cannot directly transfer these numbers into centimetres. However, considering that category 1 corresponded to a fat layer less than 1 cm, and that the following categories corresponded to increments in fat thickness of 1 cm until category 5 that corresponded to more than 5 cm of fat, we can approximate the real fat thickness by subtracting 0.5 cm (half of the 1 cm range for category 1 to 4) from our average to obtain a rough estimate of the real fat thickness. This estimate may represent an underestimation because it assumes that animals classified in the fat index category 5 had a fat thickness of 5.5 cm while it actually groups all animal having an estimated thickness of 5 cm and more. Nevertheless, we approximated the rump fat thickness to be 2.6 cm for males 2-4 years old, 3.8 cm for older males, 1.9 cm for females 2-4 years old and 2.1 cm for older females. This is more than was reported for males and females harvested in region North in 1977-1978 (Holte & Lassen 1984), where the mean for males >2 year-of-age was 2.4 cm rump fat and the mean was 0.7 cm and 1.7 cm for lactating and non-lactating females >2 years-of-age, respectively. Values reported for the Kaminuriak population in northern Canada (Dauphiné 1976) are of the same order of magnitude, with the mean fat layer of adult females (>2 years-of-age) being 1.5 cm and the fat index of males increasing with age for males, from 1.3 cm, to 2.4 cm, 2.8 cm and 4.0 cm for males aged 2, 3, 4 and >5 years-of-age, respectively. The fat thickness of Greenland caribou in all regions surveyed is within the normal range of variation reported for caribou and indicates that the animals were in good condition during the 1996-98 harvests.

Individual size based on jawbone measurements and tooth wear, 1995

Regional differences

Jawbone length for males increased with age until 5 years of age and then stabilised (a slight increase in the mean can be detected but is not significant, T26). The jawbone length did not differ among the regions (T25, Figure 12). The mean jawbone length for adult males (5 year-of-age and older) is 262.1 ± S.E. 1.2 mm (see Table 6 for mean per age-class and region).

The diastema length increased both with age (T29) and jawbone length (T30) meaning that for a given jawbone length, the older animals have the longest diastema (Figure 13). Dias-

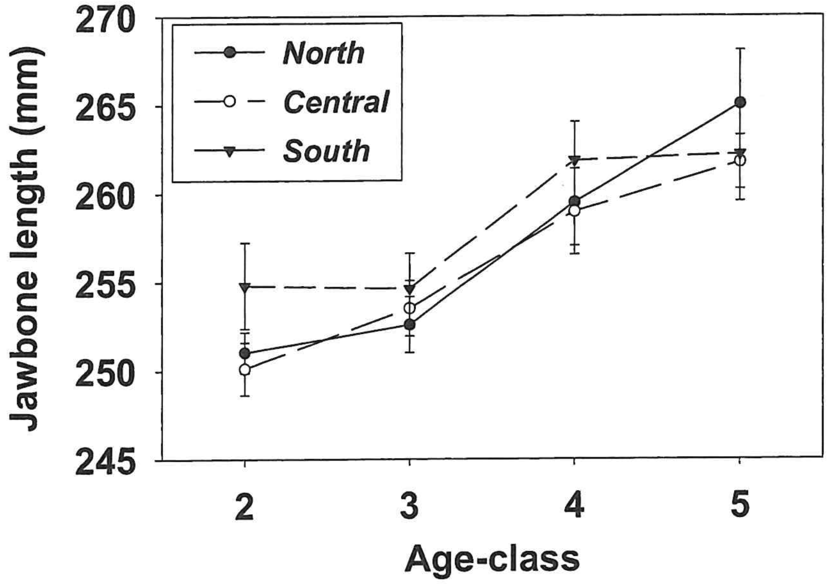

Figure 12. *Male jawbone length according to region and age-classes estimated by cementum annuli in incisors. Age-classes are one year wide, i.e., age-class 2 are 2 to 3 years old, age-class 3 are 3 to 4 years, etc. Age-class 5 groups all males over 5 years old.*

Table 6. *Jawbone length per region and age-class (sample size, mean and standard error of the mean). Age classes 2 to 4 correspond to ages 2, 3 and 4 year-of-age respectively, while age-class 5 groups animals 5 years and older.*

Region	North			Central			South		
Age-class	N	Mean	SE	N	Mean	SE	N	Mean	SE
2	58	251.02	1.61	90	250.11	1.48	35	254.80	2.43
3	48	252.59	1.58	59	253.51	1.56	43	254.62	2.01
4	23	259.48	2.44	31	258.96	2.43	21	261.84	2.19
5	20	265.04	3.04	62	261.75	1.52	42	262.20	2.66

tema length differed among regions (T28), with males coming from region North having a shorter diastema than males coming from region Central and South.

The jawbone proportion also differed among regions (T31) and depended on the jawbone length (T33) more than age (T34). Indeed, for males in region South, jawbones had a shorter posterior part than males in other regions, even for the same total jawbone length (Figure 13). The growth of the posterior and anterior part of the jaw may occur during different stages of the animal growth (Langvatn pers. comm.) and may therefore indicate that the timing of the availability of food during growth was different in the different regions. This hypothesis requires further investigation

Incisor length is a measure of tooth wear. It varied with age (T35) but not with jawbone length for a given age (T36): the older the animal, the shorter the incisor (Figure 13). The rate of decrease in the incisor length with age was faster for region North than for the two other regions (T34). Not enough animals were available from Paamiut to include in the analysis.

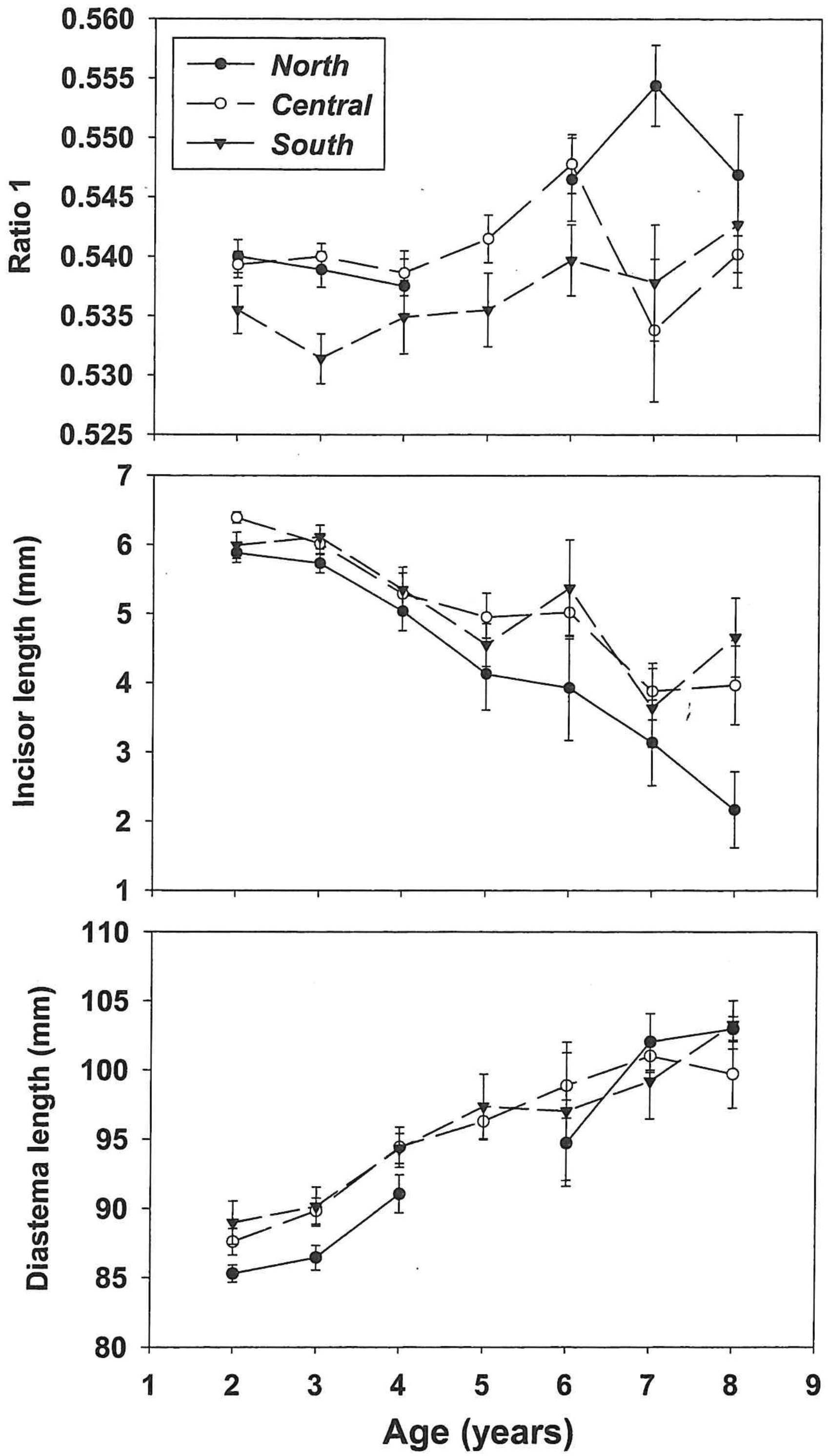

Figure 13. Diastema length, incisor length and the ratio of the posterior length of the jawbone to the total length of the jawbone, according to age (as estimated by cementum annuli in incisors) and regions.

The use of tooth wear as an index of population condition

Tooth wear measured by the height of the incisors appeared to be well correlated to age in a linear fashion, a result found earlier in caribou from North America (Miller 1974). This might be a useful measurement for classifying animal into age classes or at least, to provide an extra indication of animal's age, although the height of the incisor may not be the most sensitive to age changes. Miller (1974) showed that the third premolar and the first molar height were the best teeth to correlate with age. Any tooth measurement would have to be calibrated for each region as there was a clear regional difference in the rate of decline in incisor height. This may be due to different food quality or to the nature of the substrate in each region. In region North, where teeth wear more quickly, a fine layer of sand or dust deposited by wind covers the vegetation. Skogland (1988) showed by comparing two Norwegian populations, that more rapid tooth wear was associated with higher population density, lower quality of winter forage, and lower individual physical condition (measured by kidney fat). In our data, there was no indication that the quicker tooth wear in region North was associated with a lower body condition of animals as males were relatively fatter here than in the other regions.

Conclusions

The data presented here show the value of information that can be contributed by the "users" of a wildlife resource (Table 7). It is highly recommended that hunters continue to provide such information. Their participation is a prerequisite for the success of future monitoring of the west Greenland populations. However, in order to realise their full potential a number of improvements to the system could be made;

(1) The accuracy of the rump-fat measures reported by hunters needs to be validated.
(2) By studying the criteria that hunters actually use to estimate an animal's age it should be possible to develop guidelines to allow them to improve these estimates.
(3) The addition of a question concerning number of antler points may provide an additional indicator to age and individual condition.
(4) The addition of a question concerning hunter effort (e.g. the number of active hunting days required to shoot a caribou) may provide an effective index for monitoring changes in population density and distribution.

The data on age specific tooth-wear and mandible-length from 1995 provides a baseline from which changes in condition may be monitored. Periodic collections from different areas in the future will be of value. In this context a collection from region North has been made in 1999.

From a biological perspective, the main conclusions are (see also Table 7);
(1) The caribou appear to have been in good body condition throughout the period (1995-98).
(2) Differences between the populations exist. Although these were not large, they emphasise the need to monitor and manage the populations on a region specific basis.
(3) The harvest is extremely biased towards males. This bias is a potential source of concern, although the extent of its effect on the population will not be clear until population structure counts are made.

Acknowledgements

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Table 7. Synopsis of the results.

Questions	Answers	Fig.	Tab.	Tests
Are professional hunters more selective regarding animal size than recreational hunters?	NO			T27
Are professional hunters more selective than recreational hunters regarding sex?	YES		3	T4
Are professional hunters and recreational hunters hunting during (a) the same hunting period and (b) during the same day of the week?	(a) YES (b) NO	2	3	T1, T2, T3
Do hunters estimate age accurately?	NO	3, 4	5	T7
Did the sex structure differ among (a) year, or (b) regions?	(a) YES (b) YES		4	T5, T6
Did the age structure estimated by hunters differ among (a) year, or (b) regions?	(a) YES (b) YES	7, 8	5	T13, T14
Did the size (jawbone length) differ among regions?	NO	12	6	T25
Did the condition (rump-fat index) differ among (a) regions, (b) years, (c) age-classes, or (d) between sexes?	(a) YES (b) YES (c) YES (d) YES	9, 10, 11		T15 to T24

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Appendix 1

Statistical tests corresponding to effects discussed in the results. F stands for females, M for males, Rec for recreational hunter, Pro for professional hunter. Tests with a grey background are <u>not</u> significant. The level of significance is 0.05.

	Tests on:		
T1	**Timing**	Month effect (August vs September) (all years combined)	M, Pro: $\chi^2_{(1)}$=8.94, P<0.001
			M, Rec: $\chi^2_{(1)}$=3.64, P=0.056
			F, Pro: $\chi^2_{(1)}$=4.97, P=0.026
			F, Rec: $\chi^2_{(1)}$=5.53, P=0.019
T2		Sex effect on monthly timing (all years combined)	Pro: $\chi^2_{(1)}$=5.02, P=0.025
			Rec: $\chi^2_{(1)}$=13.34, P<0.001
T3		Week-end effect, pro. vs rec. hunters	$\chi^2_{(1)}$=181.61, P<0.001
T4	**Sex structure**	Professional vs recreational hunters	1995: $\chi^2_{(1)}$=2.81, P=0.094
			1996: $\chi^2_{(1)}$=23.81, P<0.001
			1997: $\chi^2_{(1)}$=14.00, P<0.001
			1998: $\chi^2_{(1)}$=10.41, P<0.001
T5		Year effect (regions combined)	$\chi^2_{(3)}$=26.53, P<0.001
T6		Region effect (years combined)	$\chi^2_{(3)}$=95.56, P<0.001
T7	**Age structure**	1995: accurate vs estimated age	M: $\chi^2_{(1)}$=, P<0.001
			F: $\chi^2_{(1)}$=, P<0.001
T8		1995: Region effect on mortality rates	$F_{2,35}$=0.048, P=0.953
T9		1995: Interaction of age and sex on mortality rates	$F_{1,35}$=13.994, P=0.001
T10		1995: Sex effect on mortality rates	$F_{1,35}$=2.196, P=0.109
T11		1995: Age effect on mortality estimates	$F_{1,35}$=110.642, P=0.001
T12		1995 vs (1996-1998) (age-class 2 and 3)	M: $\chi^2_{(1)}$=18.13, P<0.001
			F: $\chi^2_{(1)}$=1.15, P>0.05
T13		Paamiut vs other regions	M: $\chi^2_{(3)}$=75.93, P<0.001
T14		Year effect (1996 to 1998)	M: $\chi^2_{(6)}$=16.50, P=0.011
			F: $\chi^2_{(6)}$=1.01, P>0.05
T15	**Fat Index**	Age effect for males	1996: $F_{2,1708}$ = 382.662, P < 0.001
			1997: $F_{2,2155}$ = 494.770, P < 0.001
			1998: $F_{2,2457}$ = 512.808, P < 0.001
T16		Age effect for females	1996: $F_{2,186}$ = 6.277, P = 0.002;
			1997: $F_{2,177}$ = 8.113, P < 0.001;
			1998: $F_{2,2155}$ = 494.770, P < 0.001
T17		Region effect on fat index for males	1996: $F_{3,1708}$ = 7.589, P < 0.001
			1997: $F_{3,2161}$ = 60.803, P < 0.001
			1998: $F_{3,2463}$ = 58.576, P < 0.001
T18		Region effect for females	1996: $F_{3,186}$ = 8.062, P < 0.001
			1997: $F_{3,183}$ = 18.093, P < 0.001
			1998: $F_{3,196}$ = 6.877, P < 0.001

Continued....

Appendix 1 continued....

T19		Interaction between age and region on fat index for males	1996: $F_{6,1702} = 3.254$, $P = 0.003$ 1997: $F_{6,2155} = 61.505$, $P < 0.001$ 1998: $F_{6,2457} = 4.517$, $P<0.001$
T20		Interaction between age and region for females	1996: $F_{6,180} = 1.607$, $P = 0.147$ 1997: $F_{6,177} = 2.265$, $P = 0.039$ 1998: $F_{6,190} = 0.350$, $P = 0.909$
T21		Sex effect accounting for age and region effects	1996: $F_{1,1894} = 99.408$, $P < 0.001$ 1997: $F_{1,2344} = 58.853$, $P < 0.001$ 1998: $F_{1,2662} = 75.777$, $P < 0.001$
T22		Interaction sex and age, accounting for region effect	1996: $F_{2,1894} = 13.383$, $P < 0.001$ 1997: $F_{2,2344} = 11.999$, $P < 0.001$ 1998: $F_{2,2662} = 14.383$, $P < 0.001$
T23		Year effect, accounting for region effect	M: $F_{2,5766} = 10.207$, $P<0.001$ F: $F_{2,517} = 5.411$, $F = 0.005$
T24		Interaction between region and year	M: $F_{6,5766} = 5.672$, $P < 0.001$ F: $F_{6,511}=1.535$, $P=0.165$
T25	**Jawbone length**	Region effect	$F_{2,523}=1.232$, $P=0.293$
T26		Age effect	$F_{6,523}=11.438$, $P<0.001$
T27		Hunter category effect, accounting for age (2 to 8) and regions	$F_{1,510}=2.015$, $P=0.156$.
T28	**Diastema length**	Region effect	$F_{1,522} = 1050.753$, $P < 0.001$
T29		Age effect	$F_{1,522} = 110.629$, $P < 0.001$
T30		Jawbone length effect	$F_{2,522} = 15.776$, $P < 0.001$
T31	**Posterior jaw**	Region effect	$F_{2,523} = 14.686$, $P<0.001$
T32		Age effect	$F_{1,523} = 2.864$, $P = 0.091$
T33		Jawbone length effect	$F_{1,523} = 3496.290$, $P < 0.001$
T34	**Incisor length**	Region effect	$F_{2,489} = 9.868$, $P = 0.001$
T35		Age effect	$F_{1,489} = 168.298$, $P < 0.001$
T36		Jawbone length effect	$F_{1,488} = 0.937$, $P=0.334$

Appendix 2

Mandible lengths measured included the diastema and lengths K-M, K-L and L-M. The height of the first incisor, indicated as i_1, was measured from the gumline to the top of the tooth crown.