The significance of supplemental food to polar bears during the ice-free period of Hudson Bay

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Polar bears were studied near Churchill, Manitoba, to evaluate the possible importance of supplemental food. Once ashore, bears became segregated by age and sex; family groups and pregnant females moved inland into a denning area, while single bears, especially adult males, remained along the coast. Bears were inactive and fed little. Analysis of blood samples taken from bears in the denning area suggested that they also were not feeding. By remaining inactive, they are able to minimize energetic demands and the chance of hyperthermia. After 2 months ashore, some bears, mainly family groups and subadults, fed in the Churchill dump. The data indicated that individual needs and learning were major factors determining which bears used the dump. Adult males did not feed there even though they may have been there previously as cubs or subadults. Bears which fed in the dump were significantly heavier than those which did not. There was no evidence that bears using the dump gained either reproductive or survival advantages. We conclude that polar bears will use supplemental food sources which are available or if they have previously learned their location; however, it is not necessary for their survival.

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Les ours polaires ont fait l'objet d'une étude près de Churchill, Manitoba, dans le but d'évaluer l'importance d'une addition de nourriture au régime normal. Une fois hors de l'eau, les ours se séparent en fonction de leur âge et de leur sexe; les groupes familiaux et les femelles enceintes migrent vers l'intérieur des terres vers les régions où ils se font des repaires, alors que les ours seuls, surtout les mâles adultes, demeurent près de la côte. Les ours sont inactifs et se nourrissent peu. L'analyse des échantillons de sang d'ours regroupés dans la région de Denning permet de croire que les ours ne se nourrissent pas. En demeurant inactifs, ils parviennent à minimiser les demandes énergétiques et les chances d'hyperthermie. Après 2 mois à terre, certains ours, surtout des groupes familiaux et des subadultes, ont utilisé le dépotoir de Churchill comme source de nourriture. Les données indiquent que les besoins individuels et l'apprentissage constituent les principaux facteurs qui déterminent quels ours utilisent le dépotoir. Les mâles adultes ne se nourrissent pas à cet endroit, même s'ils l'ont déjà fait lorsqu'ils n'étaient que des oursons ou des subadultes. Les ours nourris au dépotoir étaient significativement plus lourds que les autres. Il n'a pas été possible d'évaluer si les ours qui utilisaient le dépotoir en retiraient des avantages relatifs à la reproduction ou à la survie. Il faut conclure que les ours polaires utilisent les sources de nourriture supplémentaires lorsqu'elles sont disponibles ou lorsqu'ils ont appris à les repérer auparavant, mais ces sources ne sont pas indispensables à leur survie.

[Traduit par le journal]

Introduction

Polar bears (*Ursus maritimus*) primarily prey upon ringed seals (*Phoca hispida*) and the larger but less abundant bearded seals (*Erignathus barbatus*) (Stirling and Archibald 1977; Smith 1980). They typically feed on the blubber (Stirling and McEwan 1975), a high-energy food source (Schmidt-Nielsen 1975). Polar bears are also opportunistic feeders and will scavenge on the carcasses of walrus (*Odobenus rosmarus*), beluga whales (*Delphinapterus leucas*), and bowhead whales (*Balaena mysticetus*) (Lentfer 1972; Uspenski and Kistchinski 1972; Christiansen 1981).

The subpopulation of polar bears resident in southwestern Hudson Bay spends several months ashore each year (Stirling *et al.* 1977). From mid-November to late July, all polar bears, except denning females, are out on the sea ice hunting seals. Family groups emerge from dens and move onto the sea ice in late February and March. However, from late July to mid-November, when Hudson Bay is ice free, polar bears are ashore along the coasts of Manitoba and Ontario (Russell 1975; Jonkel *et al.* 1976; Stirling *et al.* 1977). Thus, it is important for these bears to accumulate adequate fat reserves for the entire period they spend ashore, because there will probably be no adequate alternative food sources.

Russell (1975) documented food habits of polar bears during summer and autumn, but was unable to determine how often they fed. Latour (1981*a*) observed at Cape Churchill that while ashore, polar bears remaining inactive (70.8% of the observed time) and fed very little (1.25% of the observed time). Knudsen (1978) found that on the islands in James Bay, polar bears were inactive 86.8% of the observed time and fed for 3.2% of the observed time.

The Churchill dump is one reliable source of food available to polar bears in northeastern Manitoba during the period they spend on land. This food source is used by approximately 1% of the total population and primarily from October to mid-November. The use of dumps as food sources by both black bears (*Ursus americanus*) (Rogers *et al.* 1976; Young and Ruff 1982; Herrero 1983) and brown bears (*Ursus arctos*) (Craighead and Craighead 1971; Mundy and Flook 1973; McCullough 1982) has been well documented in the literature.

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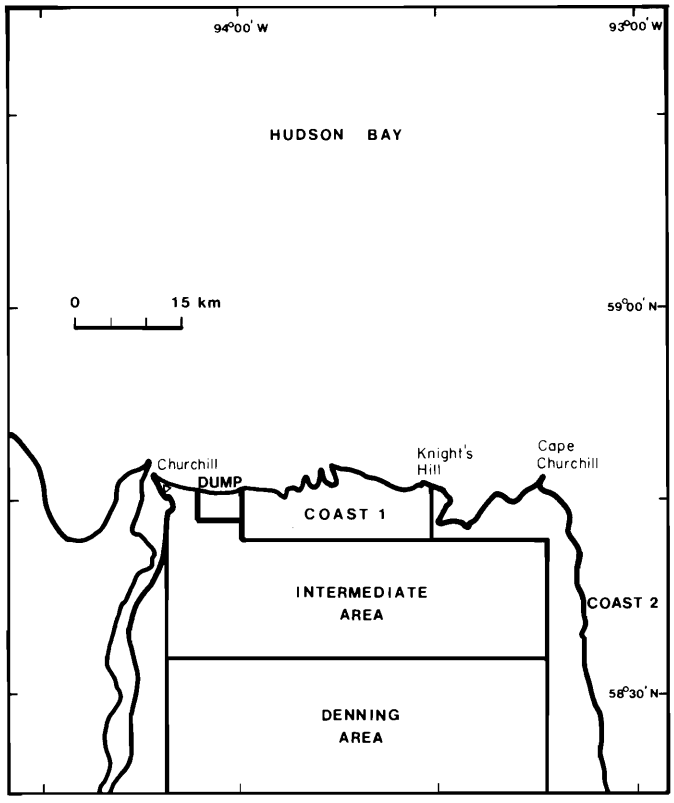

FIG. 1. Locations of the major areas within the entire study area (after Stirling *et al.* 1977).

This study compares polar bears that used food from the dump while ashore to those that did not. It evaluates the nutritional and behavioral strategies which polar bears have evolved to enable them to spend an extended period of time away from primary food sources.

Materials and methods

Research was conducted along the western coast of Hudson Bay in northeastern Manitoba. Patterns of ice formation and breakup on Hudson Bay have been documented (Larnder 1968; Danielson 1971). The study area lies within the Hudson Bay Lowlands (Ritchie 1962) and was divided into five parts: denning, coast 1, coast 2, intermediate, and dump areas (Fig. 1). The topography, flora, and fauna of these areas have been described (Stirling *et al.* 1977; Lunn 1985). The width of the coastal strip was arbitrarily set at 5 km. Limited access to the coastal areas by track and all-terrain vehicles extended as far east as Knight's Hill. As the effect that limited human activity may have on polar bears was unknown and there were few observations of bears in this area, the coastal region was divided into two: coast 1 and coast 2. The dump area was arbitrarily defined to encompass the area within a 3 km radius of the town garbage dump. The dump was created in the 1960's and is now approximately 150 m long, 75 m wide, and 20 m high.

Since 1966, the Canadian Wildlife Service and the Wildlife Branch of the Manitoba Department of Natural Resources have been involved in ecological studies of polar bears in Manitoba (Ramsay and Stirling 1982). Many polar bears have been tagged and the resultant data are in the national data base stored by the Canadian Wildlife Service in the University of Alberta computer. Using preexisting computer programs, information pertaining to the age-classes and sex classes of polar bears, previous capture histories, weights, and other information on all polar bears captured by researchers, killed as problem bears, or shot by Inuit hunters could be extracted. The data were analyzed using the Michigan interactive data analysis system (MIDAS; Fox and Guire 1976). Field observations were divided into two seasons, summer (July–September) and fall (October–December), as polar bears did not typically feed in the Churchill dump until October.

Polar bears were captured using methods described by Lentfer (1968), Stirling *et al.* (1977), and Stirling *et al.* (1980). Blood samples were collected from some individuals and analyzed for urea and creatinine levels by Dr. R. Nelson at the Carle Foundation Hospital, University of Illinois, Urbana, IL. Nelson *et al.* (1973) and Nelson *et al.* (1983) found that mean urea:creatinine ratios of nonfeeding black bears during winter sleep were <10, while those for feeding black bears were >10. For the purposes of determining whether polar bears were feeding, we also used 10 as the critical value. A premolar was extracted for age determination using methods similar to Thomas and Bandy (1973). Based on this age, each bear was placed in one of the following classes: (*i*) cub of the year (COY), less than 1 year old; (*ii*) yearling, between 1 and 2 years old; (*iii*) subadult, ages 2–4 years; (*iv*) adult, 5 years or older.

Adult females not accompanied by cubs of any age were classified as solitary, whereas adult females and accompanying offspring were classified as family groups. Up to 40% of the adult female polar bears in Manitoba show a 2-year breeding cycle as opposed to the more usual 3-year cycle in more northerly populations (Ramsay and Stirling 1982); therefore, a number of yearling bears may be on their own. These bears were classified as independent yearlings. Any bear without cubs that had no known age was placed in the category "unknown." Activities of bears that were handled were not recorded until 3 days after capture to minimize the chance that their observed behavior could be influenced by drugs.

Activities of polar bears were observed over 2.5 years. We observed bears in the coast 2 area from 11 July to 8 August 1982 and from 27 July to 24 august 1983. We spent 26 days (24 September to 19 October) in the coast 2 area during the fall of 1983. We also observed bears at the Churchill dump for three successive fall periods: 5 October to 11 November 1981, 24 September to 14 November 1982, and 12 September to 23 September and 20 October to 4 November 1983.

Most polar bears in the coast 2 area were observed from either a 13.5-m tower at Cape Churchill or from a 6-m tower situated 12 km south of Cape Churchill. We also observed polar bears from the ground after we had located them by travelling along gravel beach ridges on all-terrain cycles. Observations were made using Leitz Trinovid 10 × 40 binoculars of Bausch and Lomb 15–60× zoom spotting scopes. In the dump area, bears were observed from a vehicle parked 200 m to the northwest. As all observations were made between 0700 and 1930, the data were biased towards daylight hours.

Observed activities were placed into one of the following categories. (*i*) Foraging: feeding or looking for food within a 100 m area. (*ii*) Travelling: walking or running through an area without stopping, except for short (<1 min) rests or swimming over 10 m in one direction. (*iii*) Resting: lying, standing, sitting, or walking or swimming less than 10 m in one direction. (*iv*) Aggressive interactions: hissing, charging, locking of jaws, or swiping with front paws with or without contact. Less overt aggression was not detectable, therefore, aggression may be underrepresented in the time budgets. (*v*) Nonaggressive interactions: social play, such as described by Latour (1981*b*), between two or more bears.

An arc sine transformation was used to make comparisons between time budgets (Sokal and Rohlf 1981).

Results

Once ashore, polar bears tended to segregate by age-class and sex class. Throughout the summer and fall, adult males were found mainly in the coast 2 area and solitary adult females were found in the denning area. Subadult females were more evenly distributed, while subadult males tended to be found in the coast 2 and dump areas. Although family groups were found primarily in the denning area, some were in the dump area. However, a significantly greater number (G-test,

TABLE 1. Percentage of time bears engaged in each activity during the summers of 1982 and 1983 and the fall of 1983 in the coast 2 area

Group (*n*)	FO	TR	RE	AG	NA	Total (min)
Family groups (7)	2	21	77	0	0	3 085
Independent yearling females (1)	<1	22	78	0	0	832
Subadult males (2)	1	10	88	0	0	1 392
Subadult females (1)	0	43	57	0	0	218
Adult males (4)	1	5	90	0	4	5 985
Solitary Adult females (1)	0	9	91	0	0	402
Unknown bears (175)	<1	5	95	0	<1	40 288

NOTE: FO, forage; TR, travel; RE, rest; AG, aggressive interactions; NA, nonaggressive interactions.

TABLE 2. Percentage of time bears engaged in each activity during the falls of 1981 and 1982 in the dump area

Group (*n*)	FO	TR	RE	AG	NA	Total (min)
Family groups (7)	48	14	38	<1	0	25 473
Independent yearling males (3)	49	21	24	6	0	191
Subadult males (4)	62	14	13	<1	10	4 800
Subadult females (2)	17	9	70	0	4	2 728
Adult males (2)	21	16	52	<1	11	3 049
Unknown bears (44)	30	19	44	<1	6	4 752

NOTE: FO, forage; TR, travel; RE, rest; AG, aggressive interactions; NA, nonaggressive interactions.

$0.025 < p < 0.05$) of family groups were caught in the dump area in the fall than in the summer. Only 17% (7 of 41) of family groups caught during the summers from 1966 through 1983 were in the dump, whereas in the fall, 33% (42 of 127) of family groups were caught there.

As we did not observe activities of any bears in the intermediate area and only 27 bears have been caught there since 1966, we did not include this area in any analyses.

Female bears caught in the denning area were significantly older (*t*-tests, $p < 0.001$) than females caught in any other area. The mean ages of females caught in the coast 1 ($n = 60$), coast 2 ($n = 64$), and dump ($n = 102$) areas were 4.5 ± 3.9, 5.4 ± 5.0, and 5.4 ± 5.1 years, respectively. However, the mean age of females caught in the denning ($n = 113$) was 10.4 ± 5.5. Males caught in the coast 2 or denning areas were significantly older (*t*-tests, $p < 0.001$) than those caught in the dump or coast 1 areas. Mean ages of males caught in the coast 1 ($n = 63$) and dump ($n = 118$) areas were 3.6 ± 3.3 and 3.4 ± 2.9 years, respectively; while in the coast 2 ($n = 165$) and Denning ($n = 33$) areas, the mean ages of males caught were 7.2 ± 5.5 and 7.5 ± 5.1 years, respectively.

A significantly greater number (*G*-test, $p < 0.001$) of females than males caught in the dump area were over 6 years of age. Of all females caught there, 30% (31 of 102) were older than 6 years. By contrast, only 7% (8 of 118) of males were older than 6 years.

In the coast 2 area, a total of 299.7 h of activity was observed on 100 polar bears during the summers of 1982 and 1983 and 570.6 h of activity was observed on 91 bears in the autumn of 1983 (Table 1). There were no observations of independent yearling males in this area. Resting was the most dominant activity. While resting, most bears lay in daybeds in the grass along the coast. A daybed was an area of flattened grass, approximately 2 m × 1 m, formed by the weight of a lying bear. Family groups moved more than single bears. After about 1 week ashore, family groups began to move inland. Cubs were usually active and thus probably caused their mothers to travel. Most other bears made short movements between daybeds once or twice each day. Members of family groups were the only ones observed feeding, mostly on moss and the seed heads of grasses. Even so, feeding accounted for only 2% of their total activity. Although numerous flocks of flightless geese were present in the coast 2 area throughout the summer, no polar bears were observed attempting to capture them. No bears, including members of the same family group, were observed interacting aggressively or nonaggressively.

It was not possible to observe the behavior of polar bears in the denning area. However, it was possible to determine if they were feeding by the analysis of samples of blood collected from bears captured in this area and comparing these results with those from bears in areas where activities of bears have been observed. The mean urea:creatinine ratio was significantly higher (*t*-tests, $p < 0.001$) for bears feeding in the dump than in other areas. The mean urea:creatinine ratio for bears in the dump area ($n = 16$) was 22.0 ± 12.9 and suggested they were feeding. Direct observations of bears in this area confirmed this. Mean urea:creatinine ratios of bears in the denning ($n = 60$) and coast 2 ($n = 75$) areas were 9.0 ± 5.3 and 7.9 ± 4.5, respectively, and were not significantly different (*t*-test, $0.1 < p < 0.2$). These means suggested that bears in these two areas were not feeding. Observations in the coast 2 area also supported the conclusion drawn from the blood analysis. We concluded, by inference, that bears in the denning area also did not feed to any great extent.

During the autumns of 1981 and 1982, a total 683.2 h of observations was made on 82 polar bears (Table 2). Resting was not as common in the dump area as it was in the coast 2 area, which may reflect a tendency for polar bears not to rest in the same areas where they feed. As expected, foraging accounted for a much greater percentage of the observed activities of bears in this area. Garbage was delivered around 1100 and 1500 on 4 days. Most bears that foraged in the dump arrived between 0800 and 1000 and left between 1700 and 1900. After they left each afternoon, individual bears tended to select specific resting sites within a 2 km radius of the dump. These resting areas were used throughout the fall.

The mean duration of all nonaggressive encounters was 19 min ($n = 32$) and varied in length from 2 to 66 min. These interactions usually involved two bears, although on two separate occasions three bears were involved, and primarily occurred in the grassy areas adjacent to the dump.

Aggressive interactions did occur in the dump area. They

TABLE 3. Percentage of time bears engaged in each activity during the fall of 1983 in the dump area

Group (n)	FO	TR	RE	AG	NA	Total (min)
Family groups (4)	35	11	48	<1	6	13 812
Independent yearling females (2)	61	9	29	0	<1	1 821
Subadult males (6)	45	11	36	<1	8	6 337
Subadult females (4)	40	9	49	0	1	4 063
Adult males (2)	39	9	48	0	3	4 088
Unknown bears (9)	10	9	74	<1	7	1 806

NOTE: FO, forage; TR, travel; RE, rest; AG, aggressive interactions; NA, nonaggressive interactions.

accounted for less than 1% of the activity budget for all groups but one. We considered a bear to have won an interaction when the other bear ceased interacting and moved away. Aggressive interactions were brief, their mean duration (n = 52) was 1.2 min, and ranged from 1 to 3 min. Except for one encounter, all were inititated by adult females with cubs. Aggression usually resulted from contact between a female's cubs and other bears. Family groups won all but 1 of the 51 bouts they initiated and were the most dominant bears.

In 1983, bears came into the dump more than a month earlier (late August compared with early October) and there were about twice as many (20 vs. 10–11) as in the previous 2 years. We observed 27 bears for a total of 532 h of activity (Table 3). There was a significant difference (G test, $p < 0.05$) in the percentage of time accounted for by each activity between 1981–1982 and 1983 for bears of each age-class and sex class observed in the dump area, except for subadult males and females. Family groups and unknown bears foraged less and rested more during 1983 than in 1981–1982. Adult males foraged more in 1983 than in 1981–1982. All groups of bears travelled less in 1983 than in the previous two autumns. Except for family groups, the percentage of nonaggressive interactions remained the same or decreased from 1981–1982. The mean duration of all nonaggressive encounters (n = 44) was 18 min and varied from 2 to 50 min. Although family groups did not engage in nonaggressive interactions in 1981–1982, in 1983 this activity accounted for 6% of their time budgets. The percentage of aggressive interactions decreased in 1983. The mean duration of these encounters (n = 11) was 1 min and ranged from 1 to 2 min. As in the previous two seasons, family groups were dominant, as they won all 10 bouts.

Since 1966, 33 individual adult females, caught and tagged in the Churchill dump, have brought 57 litters (101 offspring) there. Thirty-nine percent (13 of 33) of these adult females have returned to the dump in subsequent years with different litters. One female has returned with four different litters and one has returned with five different litters. Once weaned, 21% (15 of 72) of the offspring were known to have returned to the dump. One female cub that went there with her mother subsequently returned with two different litters of her own.

Since 1966, 207 individual bears have been captured in the Churchill dump; of these, 67 (32%) have been recaptured there in years subsequent to their first capture. One female caught there in 1967 has returned almost every other year over the past 16 years. Two females have each returned to the dump over a 10-year time span, while three females have returned over an 11-year period. However, males did not return as often as females even if they were in the dump as cubs. A total of 23 cubs and subadults that were originally caught in the dump have not returned there but have been recaught as adults elsewhere. Of this total, 2 males (9%) and 2 females (9%) were recaptured in the Denning area, while 17 males (74%) and 2 females (9%) were recaptured along the coast.

TABLE 4. Mean (±SE, n in parentheses) weights (kilograms) of bears caught in nondump areas from 1966 to 1983

	Summer	Autumn	t-test	p[a]
Adult females	193±31(29)	159±28(61)	5.197	S
COY females	54±13(18)	41±10(36)	3.803	S
COY males	57±7(11)	44±13(27)	3.238	S
Yearling females	116±21(6)	93±20(13)	2.337	S
Yearling males	110±25(5)	112±15(21)	0.237	NS
Independent yearling females	112(1)	85±34(22)		
Independent yearling males	118±22(4)	107±26(14)	0.800	NS
Subadult females	171±46(12)	144±33(51)	2.356	S
Subadult males	224±46(18)	178±43(88)	4.136	S
Solitary adult females	226±20(4)	227±57(33)	0.031	NS
Adult male	323±72(15)	310±70(102)	0.668	NS

[a]S, significant; NS, not significant.

Except for COY females, there were no significant differences (t-tests, $p > 0.05$) between weights of bears in the dump and other areas in the summer. COY females in the dump area were significantly heavier (t-test, $0.01 < p < 0.02$) than those not there. It appeared that bears of each and sex class came ashore in comparable nutritional condition. By autumn, nonfeeding bears had lost weight. Six groups of bears that did not feed in the dump were significantly lighter (t-tests, $p < 0.05$) in the autumn than they were in the summer (Table 4). By contrast, there were no significant differences (t-tests, $p > 0.05$) between summer and autumn weights of bears feeding in the dump. From these data, it was clear that there was a nutritional benefit to some groups of bears that fed in the dump.

To examine benefits to individuals, some bears were captured twice in 1 year. Except for one subadult female, bears in the coast 1 and coast 2 areas (n = 16) lost between 0.3 and 0.4% of their total initial body weight per day. Bears in the denning area did not lose weight (n = 1) or lost (n = 5) between 0.1 and 0.8% of their total initial body weight per day. In contrast, individual bears foraging in the dump gained (n = 26) between 0.1 and 0.6% of total initial body weight per day or showed no weight loss (n = 3).

It appeared that once ashore, all bears lost weight. Bears that foraged in the dump were able to replace the lost weight prior to going back onto the sea ice. However, this nutritional benefit did not appear to translate into a reproductive benefit. There

was no significant difference (t-test, $0.5 < p < 0.9$) between the mean litter size of bears that foraged in the dump ($\bar{x} \pm$ SE, 1.8 ± 0.7; $n = 58$) and those that did not forage there ($\bar{x} \pm$ SE, 1.7 ± 0.6; $n = 152$).

It was not possible to get an accurate estimation of survivorship; however, a crude value based on recapture was determined. Of the total number of polar bears that have fed in the dump and could have been recaptured, 49% (89 of 183) were recaptured throughout the entire study area in subsequent years. Essentially 100% of bears in the dump are captured each year; therefore, it was necessary to weight those bears caught in other areas but never in the dump, as they had about a 30% chance of capture. We weighted one-third of these bears (33) by a factor of 3 1/3 to compensate for this capture bias. The weighted recapture rate was 43% (176 of 410). Although the method was admittedly subjective, there appeared to be no advantage or disadvantage, in terms of survivorship, to those bears that fed in the dump.

One bear that fed in the dump was found dead within 200 m of the site. Two pieces of lead batteries were found in the stomach. We concluded that this bear probably poisoned itself. There was no way to determine how many bears poison themselves while feeding in the dump, but the large number of tagged bears that have returned in subsequent years suggested that accidental poisonings were rare.

Each autumn, some polar bears enter the town of Churchill, cause problems, and have to be destroyed. A significantly higher number of tagged bears that have fed in the dump have been destroyed as problems (G-test, $p < 0.001$). Of 207 tagged bears that have fed there, 12% (24) have been destroyed as problem bears compared with only 2% (11 of 496) of tagged bears that have not fed there. Of the 24 "dump" bears that were destroyed, 19 were subadult males.

When Hudson Bay freezes, polar bears move north along the Keewatin coast, where some are hunted by Inuit from several communities. A significantly higher number of tagged polar bears that have fed in the dump were harvested (G-test, $p < 0.001$). Of 496 tagged bears not feeding in the dump, 4% (19) have been shot, while 8% (17 of 207) of tagged bears that have fed in the dump have been killed. As before, most of these "dump" bears were subadult males.

Discussion

Segregation did not appear to result from competition for resources, as no interactions were observed between any bears. This may be based on the avoidance of males by family groups. Intraspecific mortality of polar bears has been reported (Russell 1975). Intraspecific mortality caused by adult male black bears (Kemp 1976; Rogers 1977; Beecham 1980) and brown bears (Troyer and Hansel 1962; McCullough 1981; Stringham 1983) has also been reported, but some cases involved trapped animals. Therefore, the extent to which it occurs in these species under natural conditions is still unclear.

Over shorter distances, female polar bears with cubs are probably able to outrun adult males; however, over longer distances cubs may tire. Though adult females will defend their cubs, it is probably a better strategy for the survival of family groups to move inland.

Both Knudsen (1978) and Latour (1981*a*) documented that while ashore, polar bears were mainly inactive and fed very little. Over the past 20 years, scientists have conducted research on geese in the coast 2 area. M. Gillespie (personal communication) indicated that bears had been observed walking through flocks of flightless geese many times but no attempts were made to capture them.

Polar bears are inefficient walkers (Best 1982; Hurst *et al.* 1982) and are subject to hyperthermia during the warm season (Øritsland 1970; Best 1982). Hurst *et al.* (1982) studied polar bear locomotion and derived the following equation to measure oxygen consumption:

$$[1] \quad V_{O_2} = 0.62e^{0.06v^{1.5}}$$

where V_{O_2} is oxygen consumption in millilitres of O_2 per gram per hour, e is the base of the natural log (2.718), and v is walking speed in kilometres per hour. Using this equation and the body composition of female lesser snow geese (*Anser caerulescens*) (Ankney and MacInnes 1978), it was estimated that a 320-kg bear running at 20 km/h would have to catch a goose in approximately 12 s to be energy efficient. We assumed that (*i*) bears only used fat as an energy source, (*ii*) body composition of geese in Churchill was similar to that of geese at the McConnell River, N.W.T., and (*iii*) bears would only feed on protein and fat reserves as was observed at the dump. Chasing geese would also increase the chance of hyperthermia by increasing the amount of metabolic heat to dissipate.

As a large and reliable food source, the Churchill dump has existed since the early 1960's (Stirling *et al.* 1977). In this relatively short period of time, some polar bears have learned its location and have shown a high degree of seasonal fidelity. An individual may learn the location of a particular resource from its mother, from other bears, or by positive reinforcement of investigative behaviors (McCullough 1982). The number of cubs that have returned to the dump, once weaned, suggests that these bears have learned the location of the Churchill dump from their mothers.

Bears, in general, are opportunistic feeders and are adept at locating food sources by smell. Polar bears that investigate dump smells will be rewarded. By continuing to feed there, an individual may learn its location and return in subsequent years. Other studies have shown that black and brown bears learn locations of food sources and return in subsequent years (Craighead and Craighead 1971; Luque and Stokes 1976; Rogers *et al.* 1976; Rogers 1977; McCullough 1982).

On the sea ice, independent yearlings, subadults, and family groups may be displaced from their kills by larger, more dominant bears (Stirling 1974). Consequently, these bears may have more difficulty maintaining adequate fat reserves. In addition to basal metabolic needs, smaller bears have energetic costs associated with growth and females with cubs have energetic costs of milk production. Therefore, once ashore, they are more likely to become nutritionally stressed than bears that do not have these added costs. Any bear that has learned the location of a food source, such as a dump, might be expected to use that source if it becomes nutritionally stressed.

As males reach the age of 5 or 6 years, they approach adult size and would be expected to have less energetic demands than other age-classes and sex classes of bears. As they are older and larger, probably more experienced and competent hunters, and more capable of defending their kills than younger bears; therefore, they may feed more often. Once ashore, adult males appear to have sufficient fat reserves to draw upon throughout the summer and therefore may not become nutritionally stressed. This differs from what has been observed for both black bears (Rogers *et al.* 1976; Rogers 1977) and brown bears (Craighead and Craighead 1971; Stonorov and Stokes 1972; Luque and Stokes 1976), where males continued to use supple-

mental food sources, whether natural or artificial, regardless of their age.

The limited amount of observed aggression between polar bears and the dominant status of females with cubs differs from studies of black bears at dumps (Rogers 1977; Herrero 1983) and brown bears (Stonorov and Stokes 1972; Egbert and Stokes 1976) at salmon streams where, typically, adult males are dominant because of their larger size. This difference probably occurs because few adult males use the Churchill dump and polar bears have different energetic requirements than do other bear species at this time of year. As black and brown bears den in the fall, it is important that they build up adequate fat reserves for use during the winter denning period (Rogers 1976; Beeman and Pelton 1980; Nelson *et al.* 1983). Therefore, black and brown bears may be more aggressive at concentrated food sources in an effort to maximize the amount of stored fat reserves that they build up before denning. Polar bears move back onto the sea ice and begin hunting seals by the end of November, except for pregnant females which have already denned and do not feed in the dump anyway. Therefore, it is not critical for polar bears to build up fat reserves prior to going back onto the sea ice.

There are potential advantages to using a supplemental food source. First of all, bears feeding in the dump were significantly heavier than their nonfeeding counterparts. Other studies of supplemental feeding have shown similar results. For example, Rogers *et al.* (1976) reported that black bears feeding in garbage dumps in northern Michigan were significantly heavier than their counterparts not feeding in dumps. Populations of white-tailed deer (*Odocoileus virginianus*) (Ozoga and Verme 1982) and Japanese monkeys (*Macaca fuscata*) (Sugiyama and Ohsawa 1982) that received supplemental feed were significantly heavier than populations that did not.

Another advantage of a supplemental food source is the potential of increased survival of nutritionally stressed individuals. Although we demonstrated that bears lost weight once ashore and that bears in the dump were able to replace this lost weight, no increased survival of dump bears was found.

A third potential advantage is that female bears that feed while ashore may be able to produce more offspring per litter than bears that do not. Adult females that feed should be able to maintain higher levels of stored fat that can be used to meet the energetic needs of raising offspring. Rogers (1976) reported that female black bears that did not gain sufficient weight prior to denning usually failed to produce cubs. We found that there was no apparent reproductive advantage, as measured by litter size, to females that fed in the dump.

Black bears that fed in dumps had significantly higher mean litter sizes than nondump bears (Rogers *et al.* 1976). However, these data need to be put into perspective. Female black bears that feed in dumps den and give birth to cubs within 3–4 months. Any reproductive advantage is realized within a relatively short time after feeding. Female polar bears in the dump go out onto the sea ice during the winter, mate, and, at the earliest, would den 12 months later. During that time span, all pregnant females, regardless of whether they fed or not while ashore, have had the opportunity to feed on seals and built up fat reserves prior to entering dens and giving birth.

Individual need probably determines when and if bears use the dump. Bears of each age-class and sex class were of similar weight when they came ashore. Those bears with higher energetic demands should use up their reserves faster. Although it was not possible to determine when bears became nutritionally stressed, it may have occurred around the onset of their use of the dump at the end of September. Major movements of bears back towards the coast do not begin until the end of October. Therefore, most bears that fed in the dump did not do so as a result of an overall movement back towards the coast. The lack of adult males in the dump, a group that should be the least nutritionally stressed, further suggested that the nutritional condition of individual bears was important in determining when it was used.

Polar bears will use supplemental food sources if they are available, or if they have learned their locations, but most bears do not have to. As most bears probably catch seals within a few days of returning to the sea ice, the nutritional advantage that polar bears feeding on shore have over nonfeeding bears does not appear to be critical. It appears that polar bears are well evolved to deal with a 3- or 4-month period with little or no access to food.

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