FIELD TESTS OF POTENTIAL POLAR BEAR REPELLENTS

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Abstract: Field tests of potential repellents were made on free-ranging polar bears (*Ursus maritimus*) near Churchill, Manitoba, from 11 October through 12 November 1978. Polar bears were attracted to an observation/testing area with sardine baits at 11 sites. Commercial dog repellents and household chemicals were tested for their ability to keep bears from visiting baited sites, recorded sounds were tested for driving bears from a baited site, and a loud freon horn was tested in seminatural encounters with the observer. Bears made 294 visits to the chemical sites, 55 visits to the acoustic site, and the freon horn was tested 31 times. Most bears (81%) were repelled with the horn, but the behavioral reactions to the taped sounds varied. The chemical repellents did not prevent bears from visiting the baited sites, but bears spent significantly less time at the treated sites than at untreated controls. Bears stayed at the control sites for an average of 420 sec (SD = 335 sec), but left the treated sites after an average of 98–317 sec (SD = 87–370 sec) depending on the chemical.

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Activities of people in bear habitat often attract bears (Singer and Bratton 1980, Cushing 1983, Herrero 1983, Hoak et al. 1983), and each year bears injure people and damage property. As human visitation to bear habitat has increased, so have the injuries and damage caused by bears (Herrero 1970a, 1970b, 1976; Jonkel 1970; Mundy and Flook 1973; Schweinsburg and Stirling 1976). The increase of human encounters with grizzly (*U. arctos horribilis*) and black bears (*U. americanus*) has occurred primarily in national and provincial parks in the United States and Canada, but as oil and mineral exploration and exploitation have increased in the North, so have human populations, and damage by polar bears has increased (Schweinsburg and Stirling 1976).

To reduce the injuries and damage caused by bears we can reduce the number of encounters between bears and people, reduce the probability that such an encounter will result in injury, or both. Both directions of research have been pursued (Miller 1980; Stuart 1980; Wooldridge and Belton 1980; Stenhouse 1982; Williamson and Wheelan 1983; Hunt 1984; Rogers 1984; Stenhouse and Cattet 1984). By understanding the habitat and space requirements of bears, appropriate measures can be taken to direct campers, hikers, and workers away from areas where bears will be found (Stuart 1980, Williamson and Wheelan 1983). In addition, knowledge of what attracts bears allows us to educate people so they will not inadvertently draw bears to themselves, their campsites or work camps (Cushing 1983, Hoak et al 1983). Despite efforts not to attract bears, however, people still encounter them. When that happens, the behavior of the people involved is important in determining the outcome of the encounter (Tate and Pelton 1983, Jope and Shelby 1984, Jope 1985).

Electric fences can protect beeyards from black bear depredations (Storer et al. 1938, Gilbert and Roy 1977). Electric fences are not effective, however, for deterring polar bears (Stenhouse 1982, Wooldridge 1983, Stenhouse and Cattet 1984). The recorded sounds of barking dogs repel Yezo brown bears (*U. a. yezoensis*) but pile-hammer or jet plane sounds do not (Haga 1974). Aggressive sounds of male polar bears and synthetic imitations of those sounds repel captive polar bears, wild black bears, and captive brown bears with variable success (Wooldridge and Belton 1980, Miller 1983), but further tests are needed. Loud horns also repel captive grizzly and polar bears (Miller 1983, Hunt 1984). Furthermore, commercial dog repellents and ammonia are effective repellents when sprayed into the faces of grizzly or black bears (Miller 1983, Hunt 1984, Rogers 1984).

The purpose of this study was to test potential repellents and deterrents on free-ranging polar bears. I tested the ability of passive chemical deterrents to keep polar bears from visiting bait sites, the ability of recorded sounds to chase bears from a bait, and the ability of a loud freon-powered horn to repel polar bears in seminatural encounters with people.

Repelling bears from baited sites using passive chemical deterrents or recorded sounds is analogous to repelling them from a campsite or work camp that may be attractive to them. In these cases no encounter with humans is necessary. In contrast, repelling bears with a hand-held horn requires the bear and human to meet. The ability to repel a curious or even a charging bear without injuring it would significantly reduce the injuries caused by bears. At the time of this study little research had been done on the problem of repelling polar bears, so I tested a broad range of potential repellents. Furthermore, I focused on

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materials that are usable without special permits or training.

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STUDY AREA

Observations were made from Klein Tower, 40 km east of Churchill, Manitoba, from 11 October through 12 November, 1978 (Fig. 1). The tower is 6 m high and commands an excellent view of the area. The area has little relief, and the vegetation consists of low shrubs, grasses, sedges, and small forbs and lichens. All the lakes in the area were frozen for the duration of field observations. Hudson Bay remained clear of ice until about 28 October when it began to freeze gradually. By 12 November, shore-fast ice extended offshore for several kilometers.

Each fall many polar bears congregate along the shores of Cape Churchill (Fig. 1) and remain there in high densities until the ice forms on Hudson Bay (Stirling et al. 1977). Large adults dominate the areas closest to the cape and force most of the subadults inland or along the coast away from Cape Churchill. In addition, the adults are usually fat from hunting the previous winter and spring, whereas subadults have depleted fat reserves (Bukowsky and Kearney 1978). Klein Tower is not close to the preferred beach areas near Cape Churchill, and many more subadults than adults visit the area. Both the ease of observation and the large number of bears make the area a good site for conducting field tests of potential repellents.

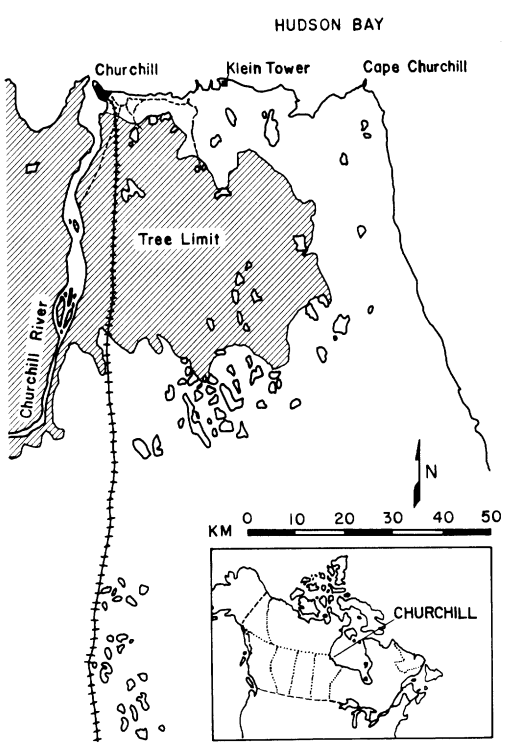

Fig. 1. Map of the Cape Churchill area.

METHODS

On 11 October, 11 sites were marked 100–500 m from the tower; the east unit (1E–5E), the west unit (1W–5W), and the acoustic site (AS) (Fig. 2). About 100 ml of a mixture of mashed sardines and cooking oil was poured over a conspicuous rock at each site. In addition to my 11 sites, 2 additional sites were baited with sardine mash/cooking oil for a concurrent study conducted by the Northwest Territories (NWT). All the sites were rebaited daily as safety permitted. The 1st 2 weeks of observation were considered control observations and the sites were left untreated.

On 27 October, a loudspeaker was placed 5 m from the bait at the acoustic site, and the remaining 10 bait stations were sprayed with dog repellents or household chemicals (Table 1) so the uncontaminated sardine mash bait was surrounded by the test chemical. Sites 1E and 1W received Halt, 2E and 2W received Chaperone, 3E and 3W received Bear Trail, 4E and 4W received Git, and 5E and 5W received Scram. Enough chemical was used to wet the area around the bait. Once tests began, the appropriate chemicals were replenished daily at each rebaiting. After a week of observations on the treated sites there was a 4-day hiatus in baiting. Ammonia was then tested at sites 1E, 3E, 1W, and 3W and Pine Sol was tested at sites 2E, 4E, 2W, and 4W. Scram was continued on 5E and 5W.

I observed all animals within view from dawn to dusk every day from 11 October through 12 November 1978 (except 4 Nov). At half-hourly intervals the number and activity of the bears were recorded. The bears were classified as inactive when lying down and active when sitting, standing, or moving. Bears were categorized as adults, subadults, or family groups. An adult was any bear estimated to weigh 200 kg or more. Subadults weighed less than 200 kg and were

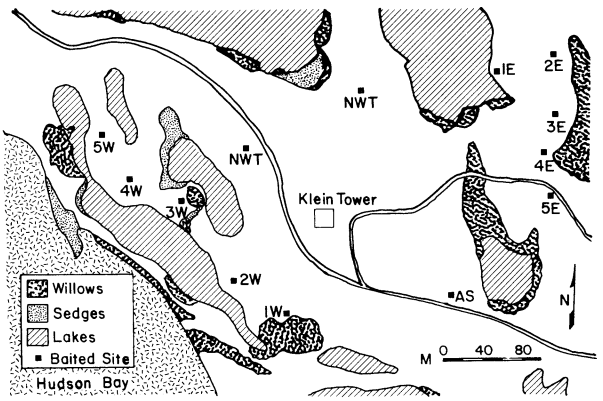

Fig. 2. Map of the observation area. The baited sites are labelled 1–5E (east unit), 1–5W (west unit), AS (acoustic site). The 2 baited sites labelled NWT were used for a concurrent study by the Northwest Territories.

not accompanied by another adult. Family groups were treated as a single unit and included any group with 1 adult (assumed female) and 1 or more cubs that were significantly smaller than the adult. Several bears in the area had been captured and marked with conspicuous numbers for a Canadian Wildlife Service study and some others could be recognized individually by natural marks. Except for a few extremely large adults that were assumed to be males, the sex of unmarked individuals was not determined. When a bear approached the sites, its identity (if possible), behavior, and the length of time that it spent at each baited site were recorded.

At the acoustic site, the subject was allowed to remain at the bait for 10 sec. After that time, an acoustic stimulus (Table 1) was played through the remote speaker from a cassette tape player in the tower. The duration of the stimulus varied with the type of sound and the length of the tape. If the initial sound did not repel the bear, a 2nd sound was tested after waiting 2–5 minutes.

The reactions of the bears to the acoustic stimuli were classified into 4 categories: repel, orient, no effect, and approach. A bear's reaction was classified as repel if the bear stopped licking the bait and then moved away from the bait while the sound was playing, even if the bear returned to the bait as soon as the stimulus ended. Orient signified that the bear shifted its position enough to face the speaker but did not leave the bait. The bear usually stopped eating and stood over the bait looking toward the speaker with its ears directed forward and its neck slightly lower than horizontal with its nose near the ground. The bears frequently extended their upper lips, but I could not hear if they also hissed aggressively. The categories no effect and approach are self-explanatory.

Finally, the freon horn was hand-tested whenever a bear approached the tower or when I was carrying it while rebaiting sites. A test consisted of pointing the horn at the bear until it was aware of me, then blasting the horn once or twice for 3–5 sec each time. Control tests were similar except that I did not blast the horn. A test was classified as a repel if the bear turned and moved away 5 m or more.

RESULTS

Bear Visitation

In the 4 weeks of observation, 16 identifiable bears visited the area 51 times and 63 visits were made by unmarked animals or family groups. The unmarked animals could be followed within a single day, but their identity was not maintained from 1 day to the next. If 16 marked bears visited the area 51 times it was assumed that the 63 visits by unmarked bears were made by 20 different bears. Therefore, an estimated 36 bears made 114 visists to the observation area.

Table 1. Repellent stimuli[a] and controls tested on free-ranging polar bears.

Passive chemical deterrents
Control (sardine mash/cooking oil)
Halt[b]
Chaperone[c]
Bear trail[d]
Git[c]
Scram[c]
Pine Sol
Ammonia
Taped sounds
Control (no sounds played)
77PB (adult female polar bear)
Shout (human shouting)
GBark (grizzly bear "barking")
ORCA (killer whale sounds)
RADIO (random radio noise)
Guen (subadult polar bear)
HHiss (human hissing like polar bear)
HBark (human barking like grizzly bear)
Other
Freon-powered horn
Control (observer without blasting horn)

[a] See Miller (1980) for a detailed description of all stimuli.
[b] Dog repellent designed to stop an attacking dog.
[c] Dog repellent designed to keep a dog out of a specific area.
[d] Artificial bear scent used to train dogs to track bears.

After the 1st week with 4 visits, the number of bears visiting the area increased. There were 23 visits in the 2nd week, and 44 and 38 visits in the 3rd and 4th weeks, respectively. Stable shore-fast ice on Hudson Bay increased dramatically over 7 and 8 November, and by 12 November no bears visited the observation area.

The wind was usually from the north. On the 3 most active days, however, it blew across the observation area to the nearest shoreline on Hudson Bay (ESE wind). On those days that the wind blew the odors of the baits toward shore, more bears visited the observation area.

Subadults accounted for 86 (75%) visits to the study area. With just 2 exceptions, adult bears who visited 20 (18%) times and family groups who visited 8 (7%) times only came to the observation area after the 2nd week. Subadults, on the other hand, visited the area from 13 October through 11 November.

Subadults were active 91% of the time, whereas the adults and family groups were active 78% and 70% of the time, respectively. When subadults were in the area, they were constantly moving and frequently encountered the baited sites. Lone adults walked more slowly and determinedly through the area and did not show as much interest in the baited sites. Adult females with cubs acted similarly to single adults except that they spent more time resting with the cubs.

Passive Chemical Deterrents

Of 294 visits by bears to the 10 chemical deterrent/bait sites, 248 (84%) were by subadults, 20 (7%) by single adults, and 26 (9%) were by family groups. Subadults and family groups made more visits to the baited sites, and lone adults made fewer visits than expected from the number of bear-hours each group-type was observed ($X^2 = 598$, df $= 2$, $P < 0.001$).

One marked subadult female, bear 6, made 77 visits to bait sites, whereas another subadult of unknown sex, SURE (identified by a large Scratch Under the Right Eye), visited sites 63 times. These 2 bears accounted for 48% of all visits to the bait sites. Two other subadult bears, LOLE (Line Over Left Eye), and bear 10 (female), visited sites 28 (9.5%) and 19 (6.5%) times, respectively. The remaining 107 visites were divided fairly evenly among the other 23 bears.

There were only 5 cases where the presence of the chemical at the bait station caused obvious behavioral reactions or unusual behavior. Typically a bear walked around the area until it passed downwind of a site; then it turned and walked upwind to the bait. When a bear arrived at the site, it usually spent a few seconds sniffing the ground around tha area before licking the rock that was baited. At treated sites, bears always licked the uncontaminated bait before licking the repellent.

Bears were repelled from chemically treated sites just 5 times out of 294 visits (2.6%). Pine Sol was the chemical in each case, and 2 different subadults of unknown sex were involved, SURE and BE (Big Ears). BE approached site 4E on 8 November. After 9 sec of typical licking behavior, BE quickly raised its head and backed away. BE then turned and trotted away from the site. The remaining 4 cases of repellency involved SURE on 9 November. SURE approached each site and stayed 12–187 sec before being repelled. In the most vigorous case, SURE jumped away from the site, trotted 4 steps, then stopped and shook its head several times, making vigorous licking movements in the air. There were 10 additional cases in which bears behaved unusually while traveling between sites, 3 more cases after having just visited sites treated with Pine Sol, and 7 cases after visiting sites treated with ammonia.

Although there were only 5 obvious repellent cases, bears spent significantly less time at the experimental sites than at the untreated sites (Table 2). There was no indication that the bears avoided particular sites, but the significantly less time spent at experimental sites indicates repellency. Bears spent the least amount of time at the Pine Sol sites, the repellent that elicited the few strong behavioral reactions. Seven other cases of unusual behavior occurred after bears visited ammonia sites, the site with the next shortest duration of visits. Bears were affected by the chemicals at the sites.

Acoustic Repellents

Eleven different polar bears visited the acoustic site for 55 trials. Fourteen of the trials were controls, in which no sounds were played to the animals. The stimulus for 16 of the tests was a recording of an adult female polar bear in a culvert trap (77PB). Another 9 tests were with a recording of a human shouting as if at a bear (Shout). These 2 recordings made up 61% of the tests. The other 6 acoustic stimuli (Table 1) were used for the remaining trials.

The 55 trials were divided among unaccompanied adults (2), family groups (1), and subadults (52). As

Table 2. Summary of visits and duration of visits at passive chemical deterrent sites.

Bait	Number of visits[a]				Seconds at bait (SD)	Mann-Whitney U-test[b]	
	SA	A	FG	Total		U	*P*
Control	35	0	0	35	420 (335)	—	—
Halt	34	3	6	43	188 (171)	1372	<0.002
Chaperone	34	7	5	46	133 (157)	1395	<0.001
Bear trail	31	2	4	37	317 (370)	1182	0.029
Git	20	0	3	23	162 (163)	468	<0.001
Scram	35	0	5	40	198 (234)	1203	<0.001
Pine Sol	30	3	2	35	98 (87)	829	<0.001
Ammonia	29	5	1	35	115 (116)	880	<0.001
Total	248	20	26	294			

[a] SA = subadult, A = adult, FG = family group.
[b] For Mann-Whitney U-tests, N_1 = 35 and N_2 = the number of times the treated site was visited.

in the passive chemical tests, single adults visited the acoustic site less than expected and subadults more than expected from the number of bear-hours of observation (X^2 = 7.98, df = 2, P = 0.025). One subadult, SURE, visited the site 22 (40%) of the 55 total visits. This bear frequented the observation area for the last 13 days of observations and made many visits to all the sites.

Nine bears were repelled 17 (42%) times, 19 (46%) tests on 4 bears were classified as orient, 4 (10%) tests on 1 subadult, SURE, had no effect, and 1 (2%) test attracted the bear (Table 3). The single approach was a startling reaction. The stimulus was "Shout," a recording of a human shouting. When the tape began, the unidentified subadult looked up quickly and trotted to the speaker. The bear turned the speaker on its back and stuck its nose into the face of the speaker until the shouting ended. When the tape finished, the bear returned to the bait and remained for several minutes. All 4 tests that elicited no apparent response involved SURE.

When considered separately, some stimuli were more effective than others (Table 3). The radio stimulus was 100% effective (N = 2), whereas 77PB and GBark (adult male grizzly bear "barking") were 50% effective (N = 16, N = 4). The remaining 5 stimuli were no better than 33.3% effective at repelling bears (Table 3).

Freon-powered Horn

The hand-held freon horn was tested 41 times, including 10 control tests. All but 3 of the tests were performed from the balcony of the tower, 6 m above the ground. Tests were performed on an estimated 15 different bears. There were 33 tests on subadults,

Table 3. Results of acoustic site trials.[a]

Stimulus	Frequency of occurrence				Total	Percent repel
	Repel	Orient	No effect	Approach		
Control	0	0	14	0	14	0
77PB	8	7	1	0	16	50
Shout	3	5	0	1	9	33.3
GBark	2	2	0	0	4	50
ORCA	1	3	0	0	4	25
HHiss	1	2	1	0	4	25
RADIO	2	0	0	0	2	100
GUEN	0	0	1	0	1	0
HBark	0	0	1	0	1	0
Total	17	19	18	1	55	

[a] Acoustic stimuli are described in Table 1 and Miller (1980).

4 tests on lone adults, and 4 tests on family groups. There was no difference between the number of tests done on the different sex and age groups and the number of bear-hours each group was observed ($X^2 = 1.32$, df = 2, $P = 0.26$).

When a test was performed, the bear was already aware of my presence and oriented toward me. The bears were 5–50 m away for the trials ($\bar{x} = 20$ m). When the horn blasted, the animal nearly always startled before reacting further. If the animal did not turn and move off faster than a walk, the horn was blasted a 2nd time. Nine of the 31 experimental tests involved more than 1 horn blast. Animals that were repelled, trotted or ran various distances before continuing on their way. These bears usually extended their upper lips and hissed. Tests were classified as no repel if the bear continued what it was doing before the test at approximately the same intensity—even if it startled and paused when the horn blasted.

Bears were repelled in 25 (81%) of the 31 experimental trials and in 5 (50%) of 10 control tests. The number of repels from the freon horn was significantly greater than from the control tests (Fisher exact test, $P = 0.005$). In contrast, there was no difference in the intensity of the reactions (measured by the distance the bear ran) between bears that were repelled from experimental and control tests (Mann-Whitney U-test, U = 109, $N_1 = 5$, $N_2 = 25$, $P = 0.24$). Finally, some comment can be made about how individual bears reacted to multiple experiences. Five subadult bears were involved in 3 or more trials (tests and controls combined). Bear 6 was repelled in 3 tests and 1 control consecutively, SURE was repelled in the middle 3 of 5 tests, bear 10 was repelled in 2 tests then not repelled in a control trial, bear 27 was repelled in a test and a control trial then not repelled in a 2nd control trial, and BE was repelled in 2 tests then not repelled in 2 succeeding control trials. No tendency for the horn to be more effective in earlier trials was apparent, but the sample was very small and no conclusions regarding habituation could by made.

DISCUSSION

This study extended a previous study (Miller 1983) in which many of the same stimuli were tested on captive animals. The focus of that study was on stopping a bear after a charge was started. My earlier study and others since then (Stenhouse 1982, Hunt 1984, Rogers 1984, Stenhouse and Cattet 1984) have had encouraging results for repelling bears that are nearby or charging. This study, however, focused on preventing the encounter as well as preventing bears from charging. Passive chemical deterrents and the taped sounds can be used to reduce the chances that bears and people will encounter one another, and the freon horn was tested as an active repellent.

The results of these tests must be interpreted in light of the nature of the tests and the previous experience of the bears. Churchill, Manitoba, bills itself as the polar bear capital of the world for good reason. Many polar bears that come ashore along the western coast of Hudson Bay visit the town and the town's dumpsite (Stirling et al. 1977). Consequently, many of the bears tested in this study have had prior experience with people. Only 1 of the bears, bear 8R, was known to have been in Churchill in the fall of 1978 because it was captured and marked there. None of the other marked bears were known to have visited Churchill that year, though all of the marked bears had been handled at least once. McCullough (1982) has suggested that 1 reason for the recent increase in bear problems has been the habituation of bears to people—especially in parks where bears frequently are able to feed on human food or garbage. McCullough (1982) suggests a program of hazing bears whenever they are encountered to make them more wary of people; some successful attempts at aversive conditioning have been made with black bears (Greene 1982) and polar bears (Wooldridge 1980). The view that habituation to humans is a cause of current bear problems was disputed by Jope (1985), whose analysis of human encounters with bears in Glacier National Park indicates that habituation of bears to humans may reduce the probability that an encounter will lead to an attack.

At first consideration, 5 obvious reactions of 2 subadult bears out of 294 visits to passive chemical deterrent sites seems neglible, but several aspects of the tests are worthy of discussion. The bears were able to discriminate between the bait and the chemicals. They often sniffed around the baited rock for some time, but they always began licking where there was bait but no chemical. Furthermore, the few repels and other behavioral manifestations of having licked test sites indicate that some of the chemicals tested (Pine Sol and ammonia) were indeed noxious to the bears. Hunt (1984) obtained similar results testing ammonia-treated baits on black bears at a dump in Montana. Noxious chemicals did not prevent bears from visiting sites, but the bears spent significantly

less time at treated sites. If a garbage container or other attractant were treated with Pine Sol or ammonia and bears shortened their visits, the probability of an encounter with humans would be reduced accordingly. The effectiveness of the chemicals may be expected to increase as the bears make more visits to the sites and never attain the expected reward without punishment. I did not observe such a learning process, and longer-term experiments would be needed to examine that aspect of bear behavior. This study tested 7 potential chemical deterrents. Future tests should be conducted with fewer chemicals that have shown promise in these and other tests (Hunt 1984).

Biologically significant sounds also can be effective in repelling bears. The results of my acoustic tests on polar bears cannot be generalized to all bears or all circumstances. The exploratory nature of these tests meant that 8 different stimuli were tested. Although some sounds can be effective repellents, no unaccompanied adults and only 1 family group were tested. The family group was repelled by 77PB, and all other tests were on subadults. The general lack of repellency for the acoustic stimuli was probably partly due to the nature of the tests. When a bear approached the site and the stimulus was played, the bear nearly always reacted. Only 4 of 55 trials elicited no obvious response, but 19 of the reactions were classified as orient. When the test sound began, the bears startled and faced the speaker in all but the 4 cases of no response. In many cases the bear was uncertain of the threat and looked out beyond the speaker for the source of the sounds. There was no visual stimulus that could easily be recognized as the source of the threat, and once the bear had satisfied itself that there was no immediate danger it would return to the bait. Further tests might be improved by completing the illusion of a threatening encounter. This could be done by having the observer as part of the stimulus, using models of bears, or something as simple as hiding the speaker so that when the bear orients it cannot easily confirm that nothing is there.

The most promising of my tests were those of the freon horn. Using an operational definition of repel in which the bear must turn around and move away at least 5 m, the horn repelled polar bears in 81% of the tests; control trials were effective only 50% of the time. In contrast to the recorded sounds of the acoustic trials, the horn produced a very loud, directional sound and I was part of the stimulus so there was less ambiguity to the bears. Despite the high probability of repelling a polar bear with a freon horn, the bears ran only 5–40 m ($\bar{x}$ = 20 m) before they slowed to a walk. If the victim of a bear attack wanted to be safe, he or she would have to act immediately to increase that distance without inducing further attack.

Both the recorded sounds and the horn are subject to the problem of habituation. A frightening stimulus that is not followed by an appropriate or painful stimulus might soon become meaningless to the bears. Reacting appropriately to a biologically significant sound such as an aggressive bear, however, should be resistant to habituation. None of the animals that were tested more than 3 times showed a tendency to be repelled more often in the earlier trials, but more testing should be done to be confident with that result.

The obverse of the results of the freon horn trials is that 19% of the bears were not repelled. A repellent that is not 100% effective will always have some risk. In my observations on free-ranging polar bears, there were a few bears that disregarded all my efforts to repel them. The use of chemical sprays such as capsaicain at close range would add another defense that has been tested on bears with excellent results (Miller 1983, Hunt 1984, Rogers 1984). Other research with rubber batons shot from a 38 mm riot gun or plastic bullets is very promising (Stenhouse 1982, Stenhouse and Cattet 1984) but such a method requires permits, special equipment, and training that are not available to campers, hikers, or residents. Such bear repellents will be valuable, however, for parks, work camps, and towns where the equipment could be used by authorized trained individuals. Some bears, however, probably cannot be repelled without being harmed.

The best repellent without resorting to explosives or firearms may prove to be a device that combines different kinds of stimuli, such as a combined horn and chemical. The horn would be used on bears still some distance away. If the bear approached or charged, a chemical spray such as capsaicin extract could be used.

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