BEAR DETECTION AND DETERRENT STUDY, CAPE CHURCHILL, MANITOBA, 1982

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ABSTRACT

The second field season of the bear detection and deterrent research program was completed at Cape Churchill, Manitoba from 16 September to 5 November 1982. Polar bears (*Ursus maritimus*) were attractd to the study site by the use of beluga whale (*Delphinapterus leucas*) and ringed seal (*Phoca hispida*) carrion bait. Field tests were conducted on: microwave motion detection units, which were interfaced with audio sirens; a trip wire fence system; a recording of barking dogs; rubber batons; plastic slugs; and flare/scaring cartridges. Testing was carried out during daylight hours and, with the aid of an electric floodlight system, during periods of darkness. A capture/marking program enabled the return rates of 30 bears to be determined.

Two hundred and fifty seven polar bears were tested during the study. Microwave motion detection units were 100% successful in detecting approaching bears (N=187), however, the activated audio sirens did not deter bears from continuing their approach. The trip wire detection system was also 100% effective in detecting approaching bears (N=50).

The recording of barking dogs did not stop the approach of any of the bears tested (N=131). Rubber batons fired from a 38 mm anti-riot gun were 100% successful in deterring both experimental (N=131) and control (N=126) bears from the bait site. Rubber batons were not effective when fired from a pistol. Plastic slugs proved ineffective in deterring bears (N=25) from the bait site. Flare/scaring cartridges were successful in deterring the approach of 77% of the bears tested (N=75) while the field crew was engaged in equipment repair and maintenance operations.

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INTRODUCTION

Man/bear confrontations have resulted in damage to property and/or serious injury or death to man (Noris-Elye 1951, Herrero 1970, Manning 1973, Jonkel 1975, Stirling 1975, Pelton et al. 1976). In the last decade there has been an increase in the number of nuisance bears shot in defense of life or property in the Northwest Territories (N.W.T.) (Table 1). When reviewed in conjunction with legal harvest rates and the low reproductive potential of bears, it is possible that these additional "removals" could adversely affect resident bear populations which in turn could also affect the availability of quota animals to native hunters.

Perhaps the largest contributing factor to the increasing number of man/bear conflicts is the growing number of people living and working in bear habitat. With increased development (e.g., Norman Wells Pipeline, Beaufort Sea Development) and other types of human activity in bear habitat, more bear/man encounters can be expected.

Bear/man conflicts can occur under a variety of circumstances. They can involve small groups of individuals such as recreational hikers, campers and canoeists. They can also occur at scientific field camps, outpost camps, large industrial sites, explorations camps, and settlements. In each of these cases, bears are attracted by food and associated odours, garbage, or simply through curiosity. There have been a number of cases where man/bear encounters could have been avoided or reduced through more efficient handling of garbage and other wastes. In these

Table 1. Problem bear kills in the Northwest Territories (1972-1981).

Year	Black bears[a]	Grizzly bears[a]	Polar bears
1972	4	1	10
1973	2	-	10
1974	-	12	13
1975	8	4	18
1976	18	6	23
1977	36	24	13
1978	10	48	19
1979	2	14	34
1980	-	6	34
1981	29	8	40

a Data for black (*Ursus americanus*) and grizzly bears (*U. arctos*) are not as complete as data for polar bears. These data must be reviewed only in the context of *known* problem bear kills. It is likely that many kills are not reported.

cases, bears are being conditioned to expect food. Therefore, bears receive positive reinforcement (rewards) and become persistent. In addition, bears receiving positive rewards learn to associate other stimuli (e.g., human scent, buildings, noise, equipment, etc.) with obtaining food. Therefore, bears are attracted to even the cleanest camps or settlements. Elimination of this behaviour is a slow process; infrequent rewards can renew this behaviour.

In cases where negative reinforcement does not occur or where rewards are obtained, bears lose their natural fear of humans. These bears then become bolder and more aggressive towards man (Cross 1974, Martinka 1977, Stirling et al. 1977, McArthur 1980, 1982).

On the other hand, many bear/man encounters cannot be avoided and must be dealt with.

The equipment and techniques used widely to date (e.g., thunderflashes, airhorns, the firing of warning shots, banging pots, etc.) to deter bears have, in many cases, been ineffective. In addition, a number of other techniques and equipment types have been tested. Relocation programs (Cole 1972, Craighead and Craighead 1972, Pearson 1972, Craighead 1976, Miller and Ballard 1982), electrified fence studies (Gilbert and Roy 1975, Gunson 1980, Wooldridge 1980a), and food aversion experiments (Wooldridge 1980b) have all been completed and were relatively unsuccessful.

In 1981 the N.W.T. Wildlife Service initiated a Bear Detection and Deterrent Research Program in an effort to develop equipment and techniques designed to increase human safety in bear habitat and simultaneously reduce the escalating number of nuisance bears which are destroyed (Stenhouse 1982).

The goals of this program are:

1) to develop a variety of effective detection and deterrent programs that can be applied to each type of human installation whether it be a small exploration camp or a large industrial site or community;

2) to develop and implement education and training programs.

The short-term objective of this program is to evaluate the effectiveness of commercially available detection and deterrent systems on bears by:

1) documenting the behaviour of individual bears during approach and avoidance of deterrent systems;

2) developing objective criteria of detection and deterrence for free-ranging bears;

3) determining whether experienced bears respond with statistically significant different behaviour patterns than inexperienced bears.

This paper reports on the results of tests completed during the second field season at Cape Churchill, Manitoba from 16 September to 5 November 1982. Stenhouse (1982) summarizes past polar bear deterrent work, and results of the 1981 field season.

STUDY AREA

The study area is located at Cape Churchill, Manitoba (58°48'N, 93°14'W), (Fig. 1), within the coastal zone of the Hudson Bay Lowlands (Coombs 1954). The eastern half of the study area is composed chiefly of gravel beach ridges interspersed with freshwater lakes and ponds, and the western half is mainly a large, shallow brackish lake (Fig. 1). The inland waters were frozen by the third week in October. Vegetation in the area is typical of subarctic regions (Hustich 1975), mainly consisting of sedges (*Carex* spp.), willow (*Salix* spp.), mosses, lichens and forbs.

Study Population

Polar bears come ashore along the Manitoba and Ontario coasts when the Hudson Bay ice melts in early August. Females with cubs and pregnant females move 20-50 km inland, adult males congregate along the coasts, and subadults of both sexes are distributed inland between the males and females (Knudsen 1973, Stirling et al. 1977). On land polar bears utilize birds, mammals, carrion, and kelp (found on the tidal flats) as summer food (Nero 1971).

The bears gradually move north along the Manitoba coast from September through November. Accordingly, large numbers congregate in the Cape Churchill region during those months (Russell 1975, Latour 1980). At freeze-up, usually in mid-November, the bears disperse onto the new ice in search of seals.

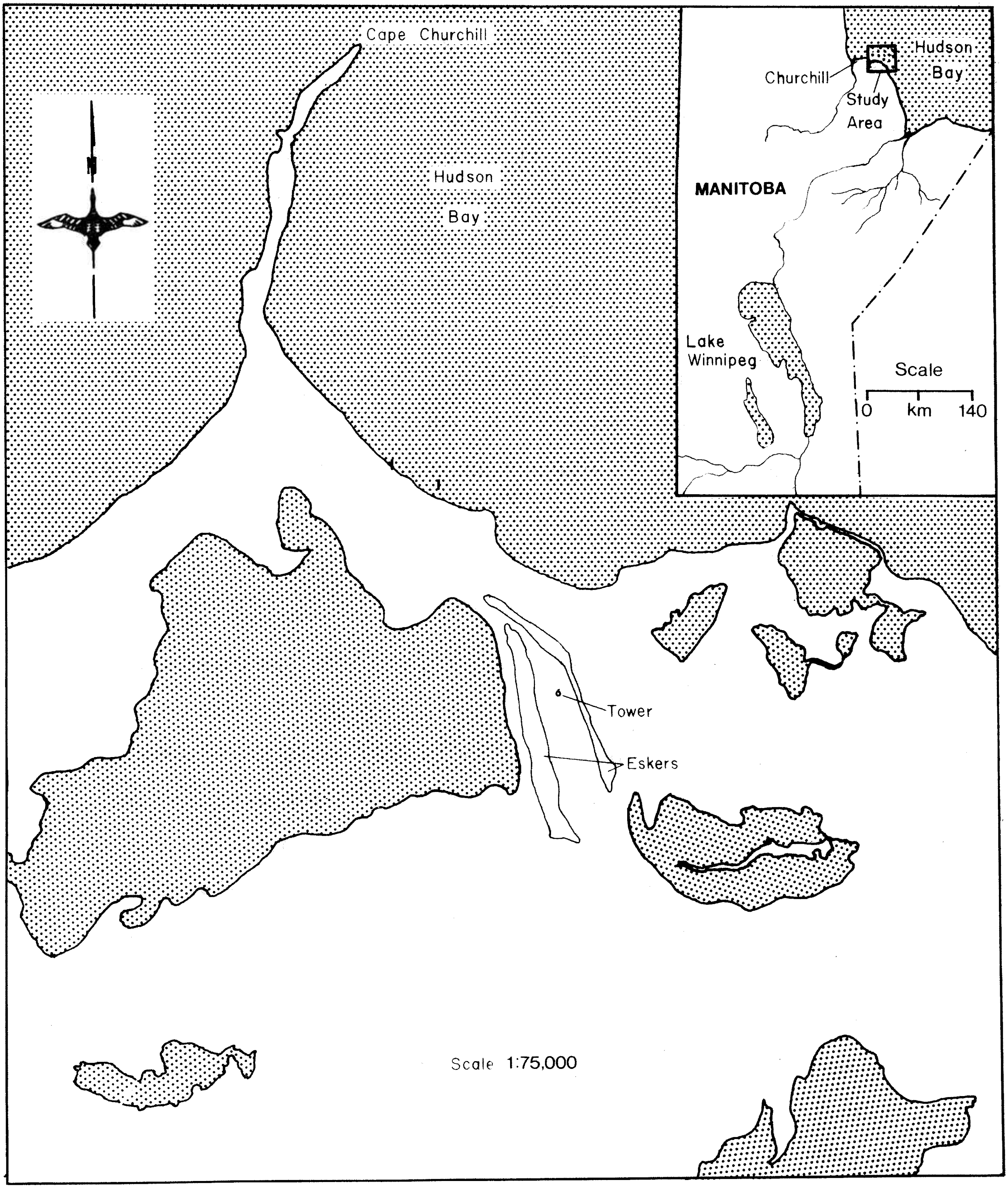


Figure 1. Location of the 1982 bear detection and deterrent study site at Cape Churchill, Manitoba.

METHODS

Observations were made from a Canadian Wildlife Service (CWS) observation tower located 1.5 km south of the Hudson Bay coast (Fig. 1) at Cape Churchill, Manitoba. A wooden hut on top of the 13.5 m high tower served as the observation post/living quarters during the study period (Fig. 2). Figure 2 also shows a steel cage used to house the researcher while conducting deterrent tests with rubber batons and plastic slugs. In addition, electric lights (Crous-Hinds High Pressure Sodium NAC 1100) were mounted on the roof of the observation hut (Fig. 2) to allow testing during periods of darkness.

Baits comprised of ringed seal and beluga whale carrion and oil were placed at a site 35 m north of the steel cage. Pieces of this bait were placed both inside a collapsed 45 gallon steel drum and inside a piece of chain link fence, which was folded over the bait, chained and wired shut to form a "sandwich". The use of these containers prevented bears from easily removing the bait prior to the initiation of deterrent tests. The collapsed barrel and the piece of chain link fence were then anchored to a 45 gallon barrel, which was cut open and filled with rocks and gravel. Bait was put out as required, typically twice daily. A small quantity of naptha gas was poured into the collapsed barrel and ignited in order to heat the bait and generate odours to attract the bears.

Tests were conducted each day from 0800-2100. In addition, tests were completed in one of the following time blocks each night: 2100-0100, 0100-0500, and 0500-0800.

Figure 2. Observation tower/living quarters used during the bear detection and deterrent study, Cape Churchill, Manitoba, Fall 1982.

As in 1981, painted wooden stakes were positioned around the observation tower to form a series of concentric circles (Fig. 3), which were used as timing zones. The distance of the zones were 40 m, 60 m, 80 m and 175 m from the base of the observation tower. These zones were used to measure the approach and exit rates of each polar bear.

As bears approached the tower and bait site, they were randomly assigned to an experimental or control subject category. Data were collected on focal individuals approaching the tower and bait site as well as on focal groups of bears within the timing zone during this same period (Altmann 1974). It was therefore possible to test the reactions of numerous bears at the bait site during an experimental trial.

The approach and exit rates of bears passing through zones A (175-80 m) and B (80-60 m) were recorded in order to assess the speed with which they passed through these zones before and after deterrent tests.

As experimental bears entered the 60-40 m timing zone (Zone C) a recording of barking dogs was played as long as the bear remained in the zone. If the bear proceeded to the bait site in the 40-0 m zone, it was allowed to feed undisturbed for 1 to 2 minutes. Time spent at the bait site and the success in obtaining food was recorded. After this time, rubber batons or plastic slugs (Fig. 4) were fired at the bear from the ground by a researcher housed inside a steel cage in an attempt to deter the bear from the bait site, located approximately 35 m north of the cage. Plastic slugs were fired from a 12 gauge shotgun. The behavioural responses of the bear to each deterrent were recorded.

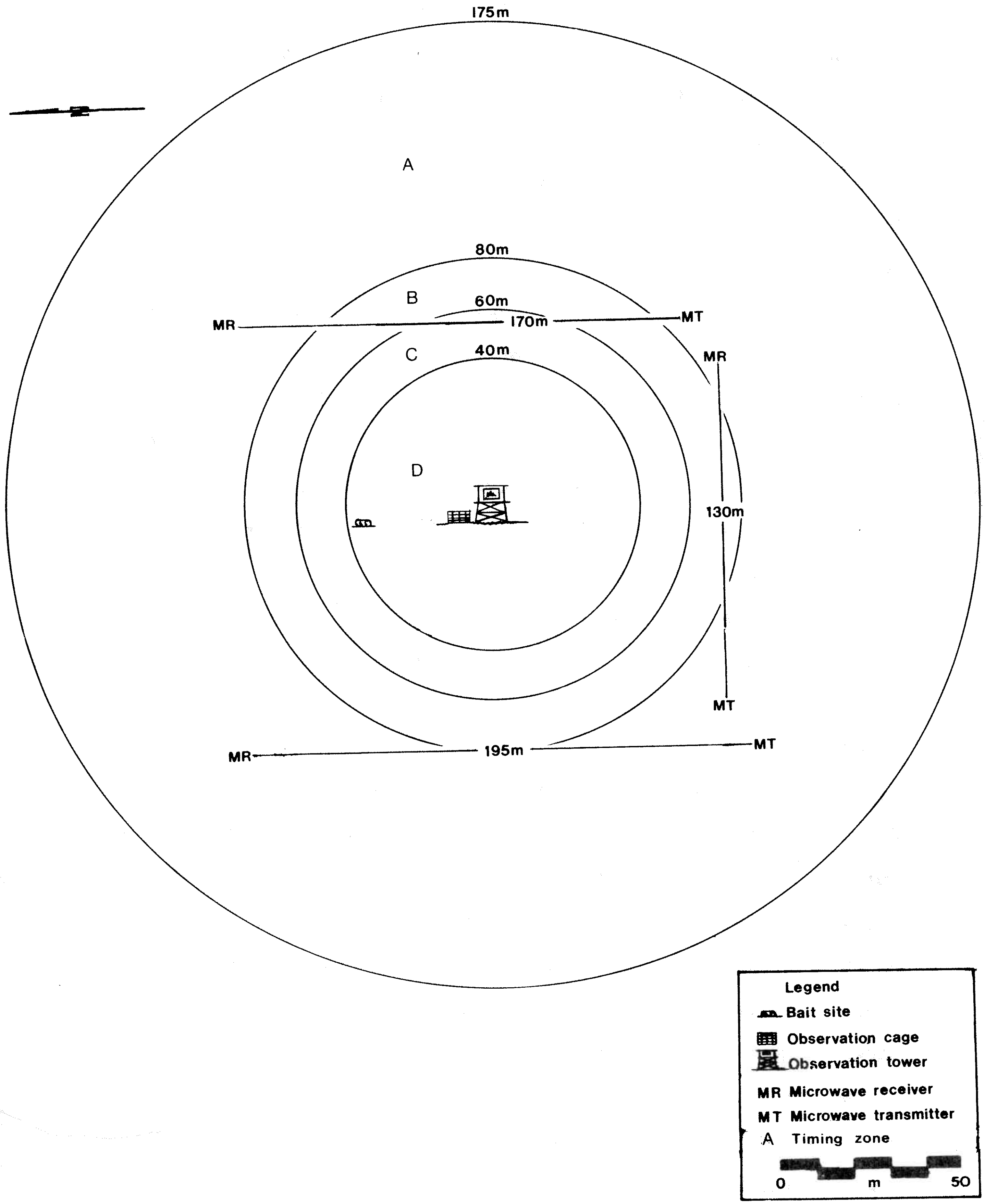


Figure 3. Location of timing zones, microwave detection units, bait sites, testing cage and observation tower at the study site, Cape Churchill, Manitoba, Fall, 1982.

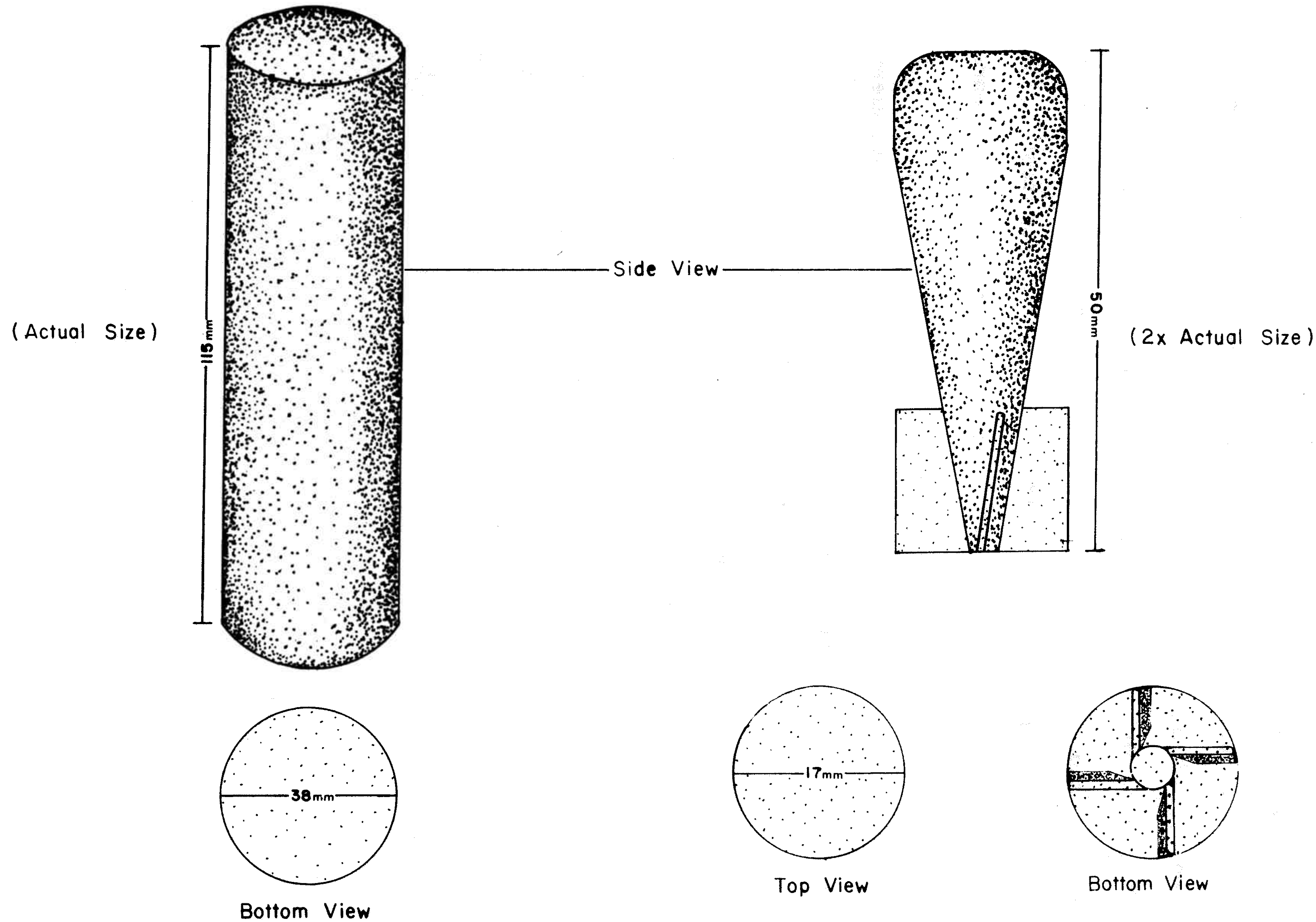


Figure 4. Rubber baton and plastic slug tested during the 1982 bear detection and deterrent study site, Cape Churchill, Manitoba.

After testing and observing the responses of approximately 100 polar bears to rubber batons from within the cage, I completed the tests from outside the cage. Shots were again fired from a distance of approximately 35 m.

Rubber batons were also fired from a 38 mm signal pistol during this study. The signal pistol is commonly used to fire batons at closer range than the 38 mm riot gun. For tests with this weapon, bait was placed 20 m north of the cage and bears feeding at this site were tested.

During the course of daily activities and equipment maintenance operations at the study site, there were many bear/man encounters. In a great many of these situations flare/scaring cartidges were tested for their deterrent effectiveness. Tests were not structured and therefore simulated a typical man/polar bear encounter in a field setting.

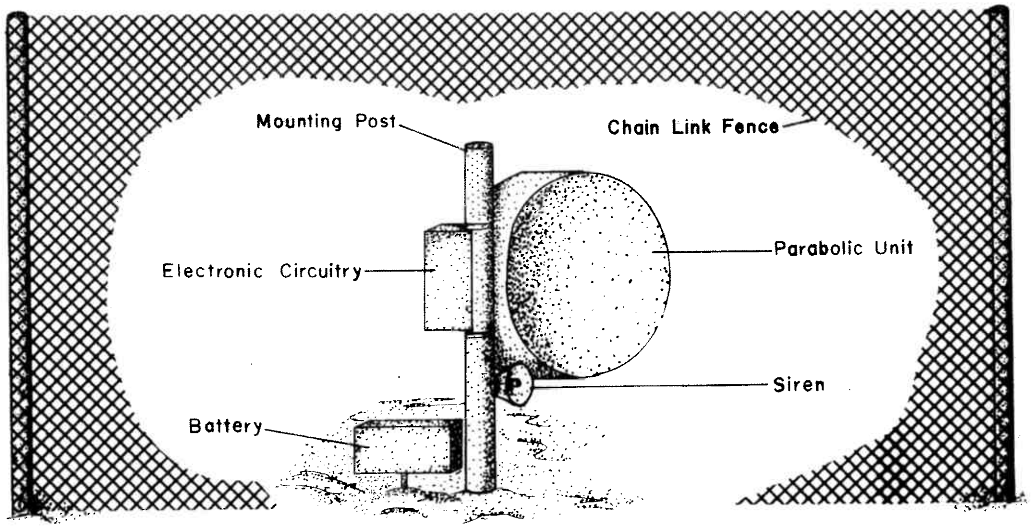
Control bears were not subjected to any deterrents for a 15 minute period. After 15 minutes, tests were conducted with rubber batons or plastic slugs in an attempt to deter them from the bait site. This permitted more bears to approach the bait site and be tested, thereby increasing the sample size. Accordingly, these bears were studied as controls during approach and as experimentals during exit from the site.

In addition, both experimental and control bears were used to test two types of detection systems. The first system was comprised of microwave motion detection units, and were positioned to the east, west and south of the observation tower (Fig. 3). The location and separation distance between these units was dictated by the topography of the terrain at the study site. Elevation variations along the north perimeter precluded the use of microwave motion detection units. Each of the three receiver units was synchronized with a horn shaped audio siren secured to the mounting post under the parabolic unit of the receiver (Fig. 5). When the microwave beam was broken by an approaching bear the siren emitted a loud (115 dB @ 1 m from siren) rise and fall audio alarm. The microwave units situated south of the observation tower were enclosed by chain link fence (Fig. 5) in an effort to prevent damage by curious polar bears (Stenhouse 1982). The microwave units to the east and west of the observation tower were not enclosed by any fencing. This was done in order to determine if bears investigated the fenced versus nonfenced systems to any greater degree.

The second detection system was comprised of a trip wire fence positioned around the outside of the steel cage (Fig. 6). If a bear approached the cage and broke or dislodged one of the fence wires, an audio alarm was activated.

The following data were recorded on cassette tapes for each bear entering the study area:

1) date, time, wind speed and direction and temperature;
2) direction of approach and exit;
3) tag, mark number or identifying characteristics, sex and age of the bear if known;
4) approach and exit times in each zone;
5) responses to triggered detection systems;
6) responses to acousitic repellent (barking dogs);
7) amount of time at the bait site;



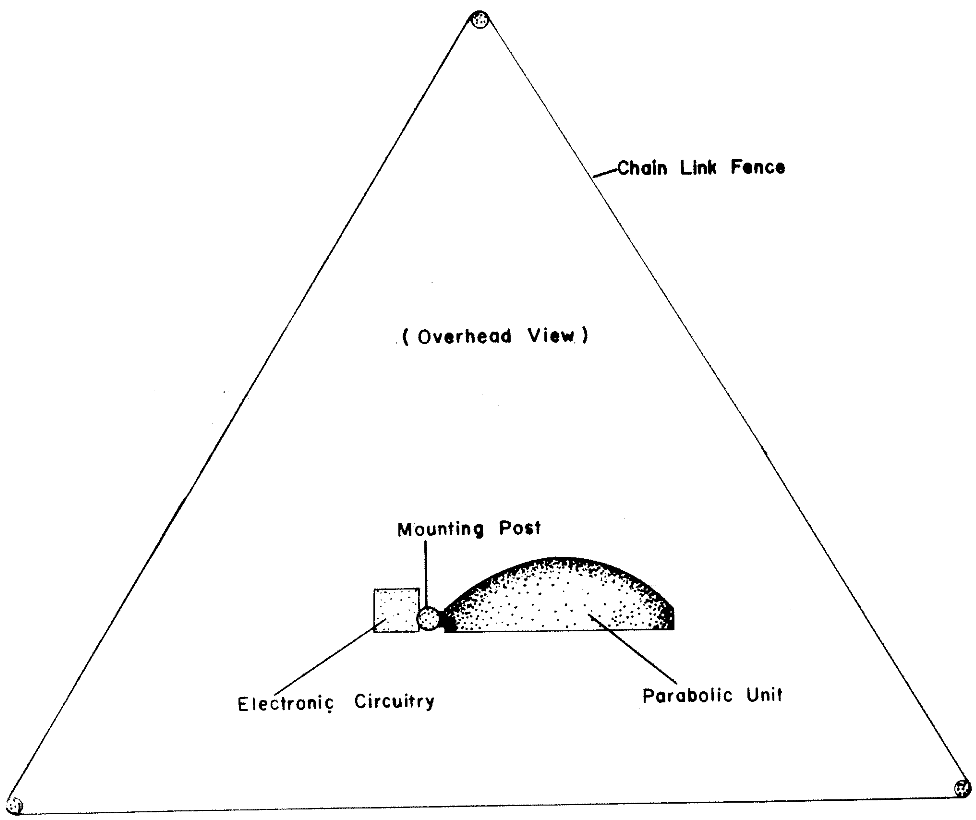


Figure 5. Racon microwave detection unit and chain link fence enclosure at the 1982 bear detection and deterrent study site, Cape Churchill, Manitoba.

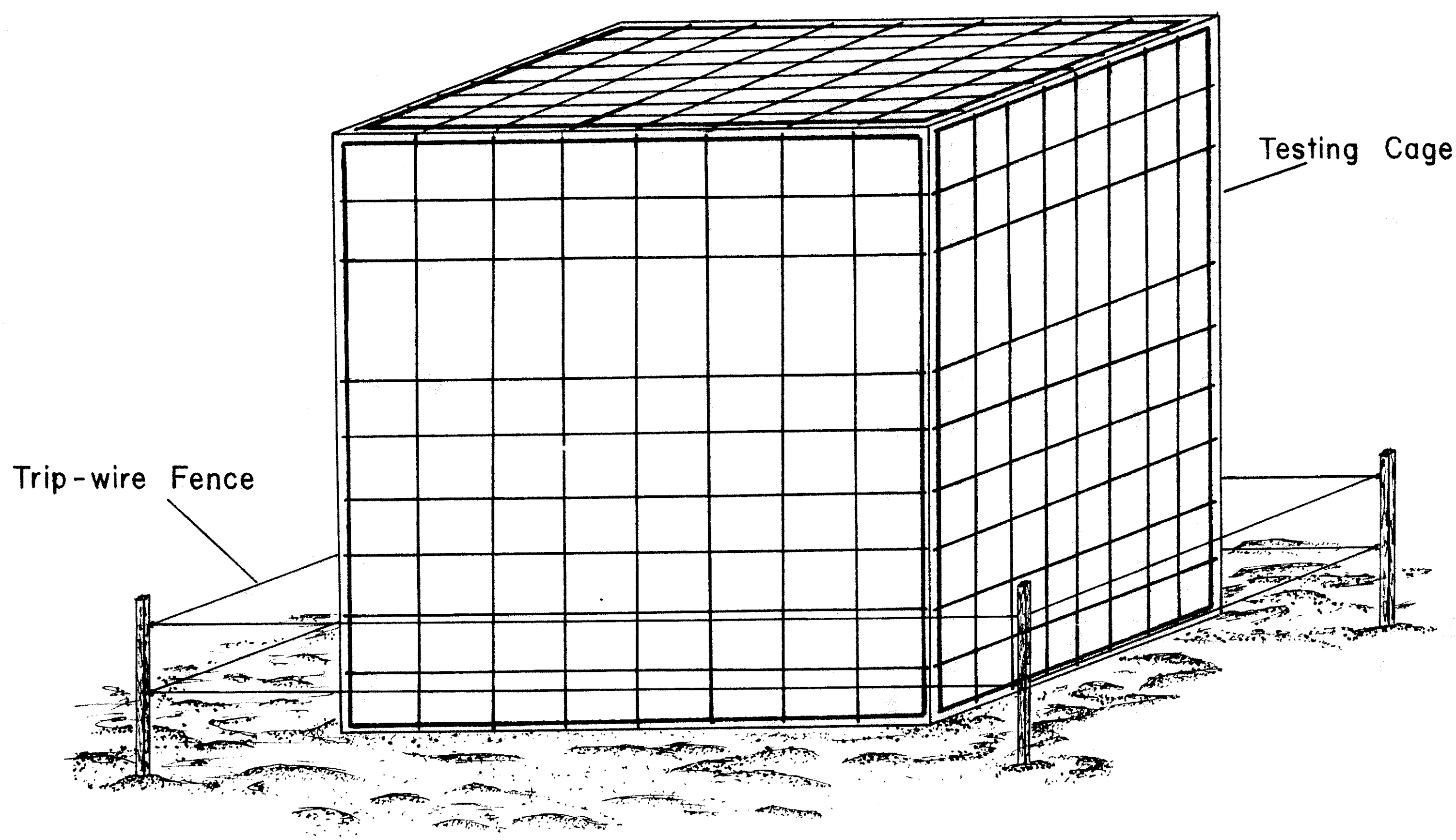


Figure 6. Location of trip wire fence system around the testing cage during the 1982 bear detection and deterrent study site, Cape Churchill, Manitoba.

8) number and marks of other bears within the study area;

9) number of shots fired at the bear(s) at the bait site;

10) responses of bears which were struck;

11) simultaneous responses of other bears within the study area.

Those data were transcribed onto coded sheets for computer analyses. Detailed behavioural responses were extracted from 16 mm film (via Bolex H-16), which were recorded during some of the tests.

Data were analyzed on a Hewlett-Packard 3000 computer. Statistical tests were conducted using Statistical Package for the Social Sciences (SPSS) (Nie et al. 1974). SPSS programs were used to conduct analyses of variance and to test selected data; a Mann-Whitney U test and the Wilcoxen test for matched subjects were also used.

Behavioural Catalogue

Based on observations made during the 1981 field season (Stenhouse 1982) a behavioural catalogue was compiled and utilized during the 1982 field season (Table 2). No new behavioural states were observed during the 1982 field season.

As in 1981, observations once again focused on behavioural states and frequency of occurrence to analyze behavioural sequences.

Table 2 does not include social, sexual or hunting behaviour categories, and therefore, does not represent the full behavioural repertoire of the polar bear.

Table 2. Behavioural catalogue of experimental and control polar bears observed during the 1982 bear detection and deterrent study, Cape Churchill, Manitoba.

Behavioural Catalogue	
<u>Lying and resting</u>	<u>Exploring/curiosity</u>
lying stretched	lateral head shift
lying curled	stand on hind legs
sitting	sniff - air
	sniff - substrate
	head-up-down
<u>Agonistic</u>	<u>Comfort Movements</u>
charge/rush	roll
lip smack/snarl	scratch
snort	lick
head-up-down	shake
	defecate
	urinate
<u>Locomotion</u>	<u>Ingestion</u>
walk	drink
trot	chew
gallop	tear
	lick

Identification of Individuals

Polar bears were captured and marked in cooperation with the CWS polar bear research team. Polar bears in the vicinity of Cape Churchill were darted and immobilized from a helicopter and each bear was markked with a tattoo on the upper lips, ear tags and a numeral or a letter painted on the back with a commercial hair dye (Lady Clairol). In addition, each bear was sexed, weighed and a premolar tooth was extracted for ageing.

The objectives of the marking program were:

1) to facilitate the collection of data on the behaviour and return rates of individual bears, and
2) to determine whether age and/or sex had an important effect on the behavioural responses of bears to deterrents.

In addition to the marked bears, 16 other bears were identifiable because of unique morphological characteristics and/or their involvement in social units (e.g., females with cub[s]).

MATERIALS

Microwave Motion Detection Units

Three sets of Racon 14000-06 Outdoor Perimeter Motion Detection Units were used in this study. These units are designed as high security protection systems for nuclear power plants, prisons, industrial sites, and various types of government installations.

The model 14000-06 is a cold weather system tested and certified to operate at -40°C. These operate as bistatic systems, which means that the transmitter and receiver are set up at opposite ends of the protected area. An RF signal is continuously transmitted to the receiver, thus creating an invisible "fence". When an intruder passes between a receiver and a transmitter, the RF signal is disrupted. This disruption causes signal variations, which trigger an alarm relay. This system has an effective operating range of 456 m on level terrain. The effective range is reduced if the terrain is irregular. Gravel beach ridges precluded the use of the microwave system north of the tower. Therefore, the systems were established along the east, west, and south perimeters (Fig. 3).

Installation of the microwave units was accomplished by digging a 1 m hole in the substrate, placing a 8.2 cm (O.D.) x 1.8 m steel pipe into the hole and back filling with gravel. The pipe was then frozen in place by pouring water around the base. The receiver or transmitter was then bolted to the pipe (Fig. 4). Once secured, antennae adjustments were made with a multimeter and the operation of the system was tested. A dual sound electronic siren (Safe House 49-488B) was mounted below the parabolic on each receiver unit and interfaced with the alarm relay mechanism. The units were powered by 12 volt D.C. power supplies (Delco 625 amp.), which were recharged every second day.

When a reduction or break in the signal occurred (e.g., a polar bear passed between a transmitter and a receiver), the electronic siren was activated, which could be heard from any location within the study area.

The microwave units located south of the observation tower were enclosed by 10 gauge chain link fencing, erected in a triangular configuration (Fig. 4). The fence was 1 m in front of the parabolic units and did not interfere with the transmission or reception of the RF signal. This fence was erected to determine if it would prevent bears from damaging the microwave units.

The microwave detection systems were operated on a 24 hour basis, and voltage checks on the power supplies were made every day. Visual confirmations of a warning of an approaching bear were made during the daylight hours and when night observations were being conducted.

Audio Recording of Eskimo Dogs

Recordings of six eskimo dogs were made at the Eskimo Dog Research Foundation, Yellowknife, N.W.T. A raw polar bear hide was placed in their pen and a recording made of the dogs responses to the hide. These recordings were made with a Uher 4000-L recorder and Grampion parabolic reflector. At the study site these recordings were broadcast through four University Sound wide-angle paging/talkback speakers (CFID 32-8), which were mounted on each of the four observation tower legs 4 m agl. A 60 watt power amplifier (Sony XM-120) and a cassette player (Sony XK-21), mounted inside the observation tower, generated the sounds. This sound system was also powered by a 12 volt D.C. automotive battery (Delco 625 amp.). Sound levels for all trials were 110 dB, measured on a sound meter 1 m from the speaker.

Rubber Batons

Anti-riot rubber batons (38 mm) (rubber bullets) were tested during the study. These projectiles were fired from a single shot 38 mm riot gun. The ballistics data on these projectiles and the background data on the 38 mm riot gun are presented in Stenhouse (1982). All rubber batons were fired by a ground-based researcher.

Cage

A 2.4^3 m steel cage was constructed at the study site and located at the north base of the observation tower (Fig. 6). The frame of the cage was assembled from 6 cm angle iron, which had 1 cm holes drilled at 8 cm intervals along its length. The floor and roof of the cage consisted of two 1.2x2.4 cm steel mesh panels which were bolted to the frame. The walls of the cage were made from 2.4x2.4x0.4 cm strips of iron which were interwoven and then bolted in place. The finished weight of the cage was 1 ton.

This cage was used as a safety precaution while firing rubber batons and plastic slugs at polar bears feeding at the bait site 35 m north of the cage.

Plastic Slugs

In addition to testing rubber batons from the cage, tests were also conducted with "Ferret" practice rounds or plastic slugs. The plastic slug consists of a 5 cm solid plastic tapering projectile with four tail fins (Fig. 4). This projectile is housed inside a standard 12 gauge shotgun shell. This cartridge has a muzzle velocity of 550 ft/sec when fired from a 12 gauge shotgun.

Trip Wire Fence System

A two strand trip wire fence, originally designed and constructed by D. Wooldridge (1980), was tested during the study. Four 1 m wooden posts (2"x2") were erected 2 m from the outside of each corner of the steel testing cage. Two nylon eyelets were stapled to each of the posts at heights of 0.5 m and 1.0 m. A length of 20 gauge plastic coated electrical wire was strung through the eyelets to form a two strand fence around the outside of the cage (Fig. 6). The 20 gauge wire leads were attached to the alarm terminal board and the leads from this board were fed to the audio alarm unit situated in the cabin on top of the observation tower.

Flare/Scaring Cartridges

A cartridge designed to scare birds from civil and military airfields was tested (bird scaring cartridges, Pains Wessex, England). These 12 gauge cartridges weigh 22 g, and when fired from a liner-fitted signal pistol will travel 120 m. Each cartridge emits a yellow flare trace, and explodes (110 dB) to produce a bright white flash.

RESULTS

The 1982 study period extended from 16 September to 5 November. During this time 257 bears were observed. Of this number, 131 served as experimental subjects and 126 were control subjects. A total of 862 hours of observations were recorded during the study period; 505 hours of observation were completed during the daylight hours and 357 hours during darkness.

Marked Bears

Forty two polar bears were captured and individually marked during the study period (Fig. 7). The marked sample included 36 males and 6 females. Of the marked bears 62% (N=26) were subadults under 5 years of age and 38% (N=16) were adults ($\geq$ 5 yrs) (Fig. 8).

In addition to these marked bears, 16 unmarked polar bears had unique morphological characteristics which enabled field researchers to identify them on a consistent basis. The sex of these 16 bears was ascertained (14 males, 2 females) by the presence of penile hairs or urine stains around the vulva during trial periods.

Zone A (175-80 m) and Zone B (80-60 m)

There were no significant differences in the amount of time experimental (N=131) and control bears (N=126) spent in zone A ($t=0.08$, $P>0.05$) or zone B ($t=0.37$, $P>0.05$) during approaches to the tower (Table 3). However, experimental bears spent

Figure 7. Marked bears at the bait site during the 1982 bear detection and deterrent study site, Cape Churchill, Manitoba.

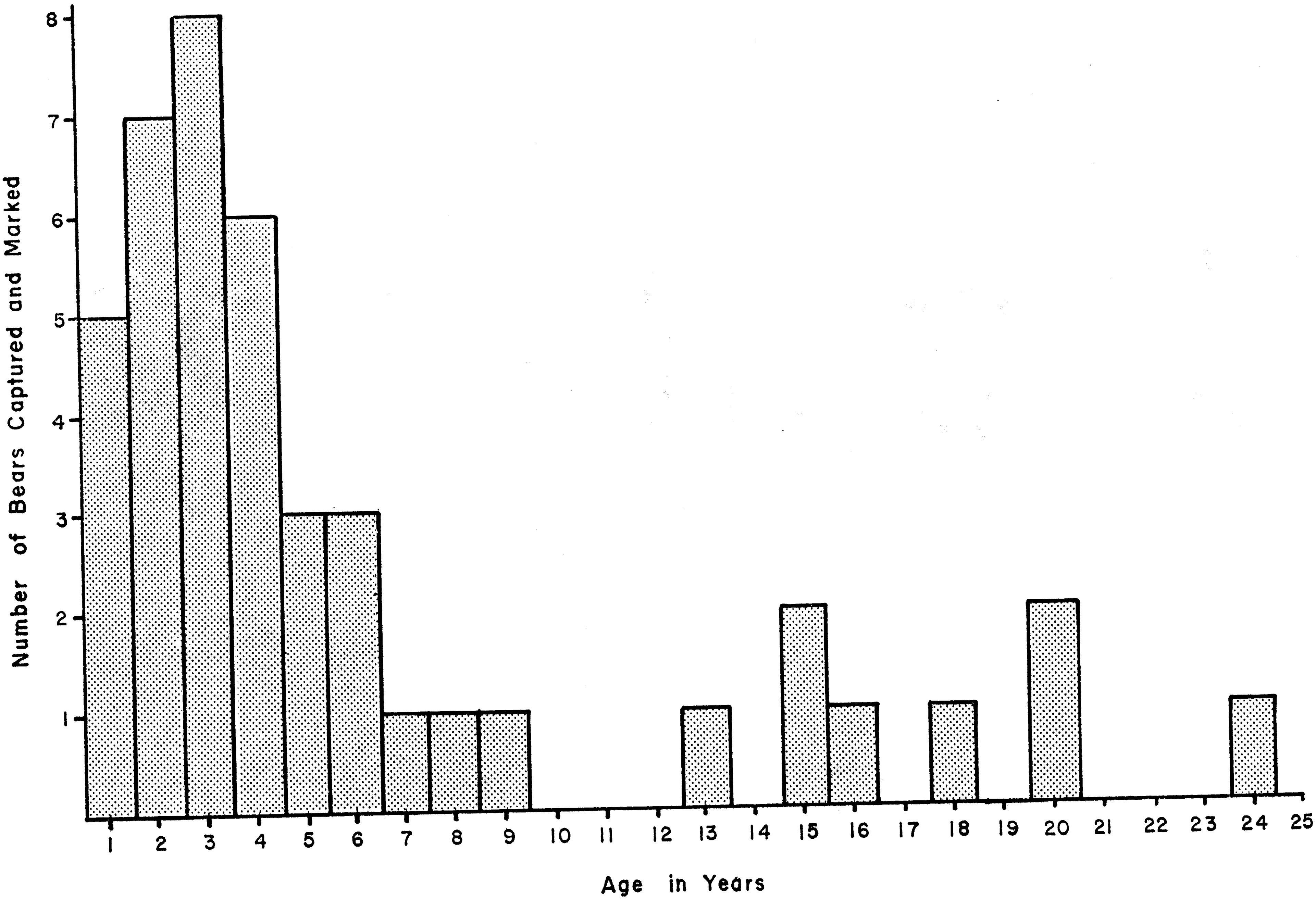


Figure 8. Age of bears captured and marked during the 1982 bear detection and deterrent study site, Cape Churchill, Manitoba.

Table 3. Summary of the time spent in each experimental zone during the 1982 bear detection and deterrent study, Cape Churchill, Manitoba.

	Test Zone							
Subject type	Approach				Exit			
	A (175-80m)	B (80-60m)	C (60-40m)	D (40-0m)	D (after shot)	C (40-60m)	B (60-80m)	A (80-175m)
Experimental								
Mean($\bar{X}$)	3:21[2]	1:12	:32	1:51	:05	:09	:24	1:53
Variance(s^2)	10:04	:52	:10	2:19	:12	:04	:18	:46
Confidence interval[2]	:27	2:04	:15	1:23	:06	:02	:08	:15
Sample size (N)	131	131	131	131	131	131	131	131
Control								
Mean($\bar{X}$)	3:17	1:08	:34	17:36	:05	:12	:29	2:06
Variance(s^2)	9:52	:41	:12	2:03	:14	:02	:14	:39
Confidence interval[2]	:26	:46	:19	1:43	:05	:05	:10	:20
Sample size (N)	126	126	126	126	126	126	126	126

1 All times given in minutes:seconds.

2 Significance level is $p = 0.05$.

significantly less time exiting through zone A ($U=0.36$, $P<0.01$) and zone B ($U=0.09$, $P<0.001$), than was spent during approaches to the tower. This same result was demonstrated for control bears (zone A, $U=0.61$, $P<0.05$; zone B, $U=0.29$, $P<0.01$). These results suggest that the deterrents utilized in the inner zones altered the bears' rate of movement to a significant degree. When the rate of movement (meters/sec) was calculated and compared for experimental and control bears exiting through zones A and B there was a significant difference found ($U=1.25$, $P<0.05$) in the rate of movement through these zones. Deterred bears moved faster through zone B than zone A. No significant difference was found in the approach rate of experimental and control bears while moving through zones A and B.

The occurrence of behavioural categories of experimental and control bears during approach and exit through the four timing zones is presented in Table 4. These data were compiled by recording the amount of time each focal animal engaged in each of the five behavioural categories in each timing zone. The data in Table 4 represents the number of focal bears spending the majority (>50% of the time in that zone) in the various behavioural categories. These data indicate that focal bears spent most of their time both during approach and exit periods engaged in locomotor activities. Also, sleeping/resting took place only in the two outer timing zones (A and B) during approach. Bears demonstrated agonistic behaviour in the bait zone (Zone D). Agonistic behaviour was displayed through interspecific threat postures and short charges. Of the bears observed in Zone D, 37%

Table 4. Occurrence of behavioural categories during approach and exit of directly approaching bears through the four timing zones during the 1982 bear detection and deterrent study, Cape Churchill, Manitoba.

	Behavioural Category				
Zone and subject type	Sleeping/ resting	Agonistic	Locomotory	Curiosity/ investigatory	Comfort movements
Zone A (approach)					
Experimental (N=131)	24	0	99	2	6
Control (N=126)	18	0	96	1	11
Zone A (exit)					
Experimental	0	0	123	5	3
Control	0	0	117	2	7
Zone B (approach)					
Experimental	1	0	124	6	0
Control	3	0	119	4	0
Zone B (exit)					
Experimental	0	0	124	6	0
Control	0	0	121	2	3
Zone C (approach)					
Experimental	0	0	125	5	1
Control	0	0	124	0	2
Zone C (exit)					
Experimental	0	0	131	0	0
Control	0	0	126	0	0
Zone D (approach)					
Experimental	0	18	59	37	17
Control	0	23	12	59	32
Zone D (exit)					
Experimental	0	0	128	0	3
Control	0	0	117	0	9

displayed curiosity/exploratory behaviours. These behaviours were related to the bears investigating the bait barrels and attempting to extract pieces of meat. Bears approaching in zone D also displayed more comfort movements than observed in any of the other timing zones. A total of 93.6% of these comfort movements involved bears licking seal and whale off their front paws after being at the bait site for varying lengths of time.

Microwave Motion Detection Units

A total of 187 polar bears was detected (and visually confirmed) crossing through the three microwave detection zones between 16 September and 28 October. The microwave systems were dismantled and removed on 28 October as a result of weakening power supplies, which required charging daily to maintain an adequate power level.

All microwave systems were investigated by polar bears. Bears occasionally misaligned the non-enclosed microwave units during exploratory behaviour and damaged the audio sirens. Realignment of the receiver and transmitter units and siren repairs were required. Misalignment and "tampering" by bears always caused the siren to be activated. In addition, when battery voltages dropped below 10 volts D.C. the detection system triggered and the siren was automatically activated. This triggering warned the research team that the power supplies required charging.

Bears also investigated the chain link enclosed detection system. There were 47 observed cases of bears investigating this system but it was not misaligned or damaged by bears until 22 October. On that date, a bear gained access to the detection units by pushing in the fence.

Of the 187 polar bears detected, 14 (7.5%) were startled and walked slowly back when the audio siren was activated. All of these bears then proceeded to investigate the source of the sound. Since each siren was only mounted on the receiver, a bear crossing the microwave beam near the receiver obtained the loudest stimuli. All of the startled bears passed within 3 m of the receiver, which perhaps accounts for their responses. Of the remaining 173 (92.5%) detected bears, 151 (87.3%) did not exhibit a change in behaviour when the siren sounded; they all continued on to the bait site. However, 22 (12.7%) bears stopped and looked towards the sound source ($\bar{x}$=8.2 sec, S.D.=1.4) when the microwave beam was broken.

The microwave motion detection systems were not adversely affected by snow, rain, or fog during the study period.

Zone C (60-40 m)

A recording of barking eskimo dogs was played when experimental bears entered this timing zone. There were 131 experimental bears tested with this recording, of which 126 (96.2%) continued to move directly to the bait site without any observable change in behaviour. Five (3.8%) marked bears, which had undergone previous testing, displayed a change in behaviour on repeat visits to the bait site (see following section on the return rates of marked bears). Although these five bears did exhibit a change in behaviour when the recording of the dogs was activated, all five bears proceeded towards the bait site ($\bar{x}$=46 sec, S.D. = 24) after the recording ceased. No significant differences ($T=0.05$, $P>0.05$) were found between the amount of time experimental and control bears spent in zone C during approach. Additionally, no significant differences ($t=1.00$, $P>0.05$) were found in the amount of time spent in zone C by these two groups during exit periods. However, significant differences were found ($U=0.18$, $P<0.01$) in the amount of time spent in zone C between these two groups of bears during exit and approach. Both control and experimental bears spent significantly less time in zone C during exit than during approach.

Zone D (40-0 m)

Bears entering this timing zone moved directly to the bait site. Experimental bears were allowed to feed for between 1 and 2 minutes and were then hit with a rubber baton or a plastic slug. Control bears were allowed to feed for approximately 15 minutes and were then hit with a rubber baton or a plastic slug. No control bears left the bait site without administration of a deterrent.

There were 131 experimental bears hit in the hind quarters with rubber batons after being allowed to feed at the bait site. Of these, 119 (90.8%) galloped from zone D when struck with a single rubber baton. Eight experimental bears (6%) required two "hits" before trotting from zone D, three (2.2%) bears trotted after three hits, and one bear (0.7%) walked from zone D only after being hit with four rubber batons in succession. No correlations were found between the number of shots required to move a bear from the bait site and the amount of time a bear had been feeding, its age, sex, or body weight.

In addition, 126 control bears were struck with rubber batons after feeding at the bait site for the alloted time of 15 minutes. Of these, 122 (96.8%) galloped from zone D after being struck with one rubber baton; four (3.2%) bears required two "hits" before trotting from zone D. Once again, no correlation was found between the amount of time a control bear was feeding and the number of rubber batons required to drive it from the bait site.

All bears receiving multiple hits with rubber batons (experimental and control) displayed a typical behavioural response. This response had the following components:

1) flinch when struck;
2) smell, lick or snap at area of contact;
3) move away from the bait approximately 2 to 4 steps;
4) look towards person firing the weapon;
5) move back towards the bait site maintaining visual contact with the ground based observer.

This sequence of behaviour usually lasted approximately 10 seconds. No signs of vocal or postural aggression were displayed towards the person firing the rubber baton by any of the 257 polar bears tested, irrespective of whether the shots were fired from inside (N=112) or outside (N=145) the steel cage.

No significant differences (t=0.0, P>0.05) were found in the amount of time experimental or control bears spent in zone D after being struck by a rubber baton. Since the bait site was approximately 10 m from the 40 m timing stake and the mean exit time was 5 seconds, the bears struck by a baton moved at a rate of 2 m/s out of zone D. All bears deterred with rubber batons moved directly out of the study area.

Based on the rubber baton tests on 257 polar bears the accuracy with which I struck the bears was 89%. While it is impossible to account for each "miss" the following variables did have an effect:

1) flinching while pulling the trigger;
2) a bear turning or moving quickly prior to shooting;
3) on 2 days, strong gusting crosswinds altered the baton's trajectory.

During the rubber baton testing trials, 106 additional bears entered the study area. The distance between focal bears and additional bears was divided into the following categories: 80-60 m, 60-40 m, 40-0 m, and at the bait site (Table 5). When the focal animal was struck with a rubber baton, the initial behavioural response of other bears within these zones were recorded. Table 5 indicates that the only behavioural responses of these additional bears fall into the locomotor activity category; none of the 106 bears moved towards the bait site or the sound source. A significant difference was found (X^2=81.12, P<0.001) in the behavioural responses exhibited by these bears based on their distance from the focal animal once the rubber

Table 5. Behavioural responses of non-focal bears to discharge of rubber batons, during the 1982 bear detection and deterrent study, Cape Churchill, Manitoba.

Initial behaviour response*	Distance from focal animal				N
	at bait site	0-40 m	40-60 m	60-80 m	
Gallop	26	17	3	0	46
Trot	6	7	10	2	25
Walk	0	1	11	23	35
	32	25	24	25	106

* All movements were away from the bait site.

baton had been fired. The data in Table 5 suggests that bears closer to the sound source and focal animal were much more likely to gallop from the area when a rubber baton was fired than were those further away.

Bears within the study area during testing of a focal bear did return to the bait site; 85 (80.2%) bears returned within 2-4 hours ($\bar{x}$=2:37), and three (2.8%) returned within 4-6 hours. No correlation was demonstrated between the distance of exposure and the amount of time before a bear returned to the bait site. Clearly, exposure to the audio stimuli in association with the discharge of the anti-riot gun was not an adequate deterrent to keep these bears away from the bait site.

In addition, 29 plastic slugs were tested using the same techniques employed with the anti-riot gun. Of 25 experimental bears struck with plastic slugs, three (12%) trotted away and stopped 10 to 15 m from the bait site and looked towards the researcher who had fired the slug. Within 2 minutes after being struck, all three bears approached the bait site and resumed feeding. The remaining 22 (88%) bears flinched when hit, but continued to feed. One bear was struck four times with a plastic slug in the right flank within approximately 10 seconds; however, the bear flinched and continued feeding after being struck with each slug. None of the bears struck with plastic slugs displayed aggression towards the person firing the weapon, whether the shots were fired from inside (N=12) or outside (N=17) the cage. All plastic slugs fired hit the target (accuracy = 100%).

Tests were conducted using a 38 mm signal pistol to fire rubber batons. A total of 20 bears was attracted to bait located 20 m north of the steel cage. Thirty two rubber batons were fired but no bears were struck (accuracy = 0%), consequently tests were discontinued.

Other Factors Affecting Approach and Exit Rates

An analysis of variance (ANOVA) was performed on the two groups of bears (experimental and control), which approached and exited through the four timing zones during this study. In this 12 way ANOVA, the dependent variable was the amount of time spent in each zone. The independent variables included: day in study period; time; wind speed; wind direction; ambient temperature; direction of approach; duration of exit (Fig. 9); amount of time at the bait site; number of other bears within the study area; number of shots fired at the focal animal; the sex; and, the age of marked bears (where possible).

Results of this analysis demonstrated that none of the independent variables had a significant effect ($P>0.10$) (including all possible interactions) on the time spent in zones A, B, C or D during approach or exit for the experimental or control bears.

Marked Bears Receiving Experimental Testing

Of the 42 captured and tagged polar bears, 25 (59.5%) underwent experimental testing. In addition, 16 bears with unique and recognizable morphological characteristics were tested. Therefore, a total of 41 readily identifiable bears was tested.

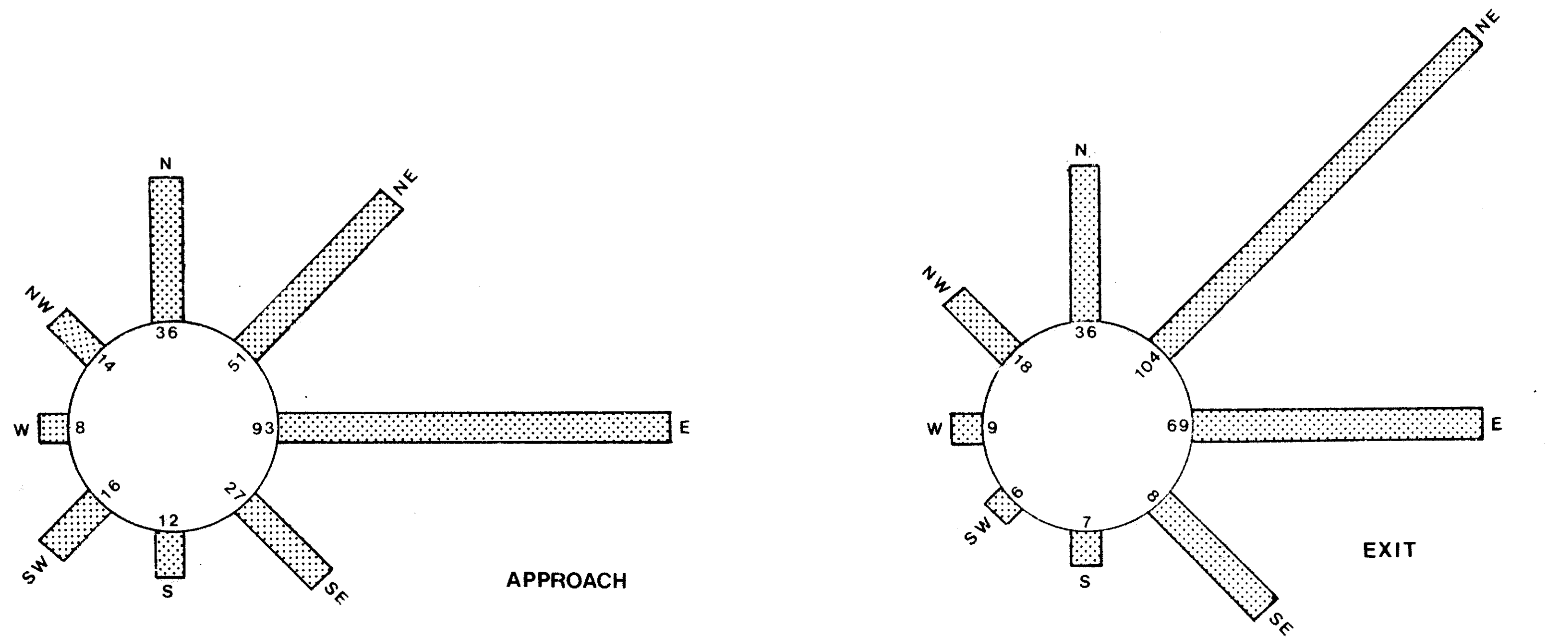


Figure 9. Direction and frequency of approach and exit of experimental and control bears during the 1982 bear detection and deterrent study, Cape Churchill, Manitoba.

Return Rates and Behaviour of Marked Bears

Tests were conducted for an average of 16 hours/day. Approximately 7 hours of night observation and testing was completed during each 24 hour period. Since observations were not carried out "around the clock" the return rates presented represent observed return rates. We did notice that bears which were bedded down outside the testing area during the night testing periods did come into the bait site once the lighting systems were turned off, and testing stopped.

Of the 41 marked bears tested, 30 (73.2%) were tested once; 11 (26.8%) returned to the bait site more than once. Seven (17.0%) returned twice, two (4.9%) returned four times, one (2.4%) bear returned five times, and one (2.4%) bear returned thirteen times to the bait site. The times between each approach and visit to the bait site are presented in Table 6. Although the sample size of multiple-visit experimental bears is relatively small (N=11) it appears that these bears began to spend more time away from the bait site after each test with rubber batons.

In addition, no signigicant differences were found in the approach rates through timing zones A or B and exit rates through zones D, C, B and A between repeat-visit and single-visit experimental bears. However, significant differences in the amount of time spent during approach through zone C ($U=2.08$, $P<0.05$) and zone D ($U=3.19$, $P<0.05$) were found between repeat-visit and single-visit experimental bears. Repeat-visit bears spent significantly more time in zone C and zone D than did single-visit bears.

Table 6. Amount of time[1] between repeat visits to the bait site by marked experimental bears, 1982 bear detection and deterrent study, Cape Churchill, Manitoba.

Number of approaches to bait	Bear #										
	P	17	L	18	15	14	44	500[2]	503[2]	Y	A
2	0:4:18:21	0:7:38:06	0:12:49:12	1:8:15:31	3:2:31:57	0:2:16:24	0:6:35:06	0:5:12:38	0:18:04:03	0:9:51:18	0:14:30:22
3								0:13:08:11	0:19:12:31	1:02:37:12	0:18:16:34
4								2:11:22:17	1:17:51:28	0:22:19:41	1:04:37:18
5										2:19:11:25	1:21:08:15
6											2:06:39:15
7											2:03:12:39
8											2:14:43:17
9											3:14:12:27
10											4:18:38:15
11											2:17:35:08
12											2:22:41:19
13											3:01:15:36

1 Days: hours: minutes: seconds.

2 Identified by morphological characteristics.

Five of the repeat-visit bears made lateral movements in zone C when the recording of barking dogs was activated, however, after 6-21 seconds, all five bears moved directly towards the bait site. Once repeat-visit bears entered zone D they displayed more hesitation behaviour (e.g., sniffing air and substrate, standing on hind legs, and lateral head shifts) than exhibited by single-visit bears. In addition, the multiple-visit bears oriented their bodies at the bait site so that they could maintain visual contact with the ground based researchers. Six of these bears began feeding from a lying position, a behaviour we observed only once in control bears (N=126). When these six bears did lie down to feed, they always positioned the bait barrels between themselves and the researchers. Every 3-5 seconds each of these bears would look at the researcher.

Trip Wire Detection System

The supply of bait was stored inside a reusable 45 gallon drum housed inside the steel testing cage. Accordingly, bears were often attracted to the cage. This provided an opportunity to test a trip wire detection system. Bears that approached the steel cage broke the electrical wire and activated an audio alarm inside the observation tower.

A total of 50 bears tested the trip wire system and all bears activated the alarm. None of the bears attempted to step through the two strand fence, they simply walked through it.

No false alarms were registered as a result of strong winds or frost loadings during the testing period.

Flare/Scaring Cartridges

A total of 75 flare/scaring cartridges were tested. All of these cartridges ignited when fired and travelled approximately the same distance (120 m). In 62 (82.6%) cases polar bears were approaching the field crew during ground-based equipment maintenance and repair operations. In 13 (17.3%) instances the cartridges were used to determine if a bear was approaching during periods of darkness.

The behavioural responses of bears to these cartridges (Table 7) show that the majority (77.3%) of these bears trotted or walked away and did not approach the field crew while we finished our task. However, 14 (18.6%) bears did approach after initially moving away from the research team. While the exact distance bears moved off before returning was difficult to determine from the ground, it was estimated to range from 5-25 m.

It is also very important to note that three (4.0%) bears showed no observable behavioural response to the flare/scaring cartridges, and continued moving directly towards the research team.

Table 7. Behavioural responses of bears to flare/scaring cartridges during the 1982 bear detection and deterrent study, Cape Churchill, Manitoba.

Behavioural response	Number of bears	
Trotted away - no approach	27	(36.0%)
Walked away - no approach	31	(41.3%)
Trotted away - approached	5	(6.6%)
Walked away - approached	9	(12.0%)
No response - continued approach	3	(4.0%)
Total	75	(100.0%)

DISCUSSION

Detection Systems

Racon Motion Detection Systems

The racon microwave units were 100% successful in detecting approaching polar bears during both the 1981 and 1982 studies. The interfaced audio sirens warned researchers of an approaching bear but did not deter bears. Thus it appears that the audio sirens are useful as a warning system for personnel working in the vicinity of bears.

The chain link fence enclosure around one of the Racon systems was useful in preventing bears from damaging or misaligning the detection system. However, the design and construction of the enclosure did not prove totally adequate. It is felt that by increasing the size and strength of the enclosure, bears would be unable to make contact with the detection units. Chain link fence can be used since it has no adverse effect on the transmitted microwave beam.

The Racon microwave motion detection units are useful in providing a permanent or semi-permanent camp with a highly effective bear detection system. This system would be particularly useful in northern latitudes where men work outside during the winter months, where darkness prevails for long periods, and where visibility is reduced. The cost to enclose a small camp with this system would be approximately $10,000.

The following practical considerations are relevant:

1) irregular terrain will reduce the system's effective range;

2) unless alternating current (A.C.) is available, low temperatures will reduce battery (D.C.) life and thus make the system more labor intensive;

3) daily "walk" tests must be conducted on a regular basis to ensure the system's operational status.

These systems are relatively simple to install, can be maintained and operated with only a basic knowledge of electronics, and are not affected by rain, snow or fog. However, they have not been tested under severe arctic conditions.

Trip Wire Fence System

The trip wire fence system tested was effective in detecting intruding bears. This system is simple to set-up and operate, and does not require any specialized testing equipment. However, it must be reset after each intrusion. This type of detection system is practical for relatively small mobile field camps, since there are limitations to the area which can be enclosed by the trip wire. The trip wire system does not require a large number of materials, e.g., tent poles, or jerry cans could serve as corner posts.

In order to overcome difficulties encountered by earlier researchers, we developed a new tripwire fence system which incorporated the following features:

1) an improved and simplified electronic circuitry with multiple channel capabilities;

2) external battery hook up to alleviate cold weather problems;

3) an all-weather housing.

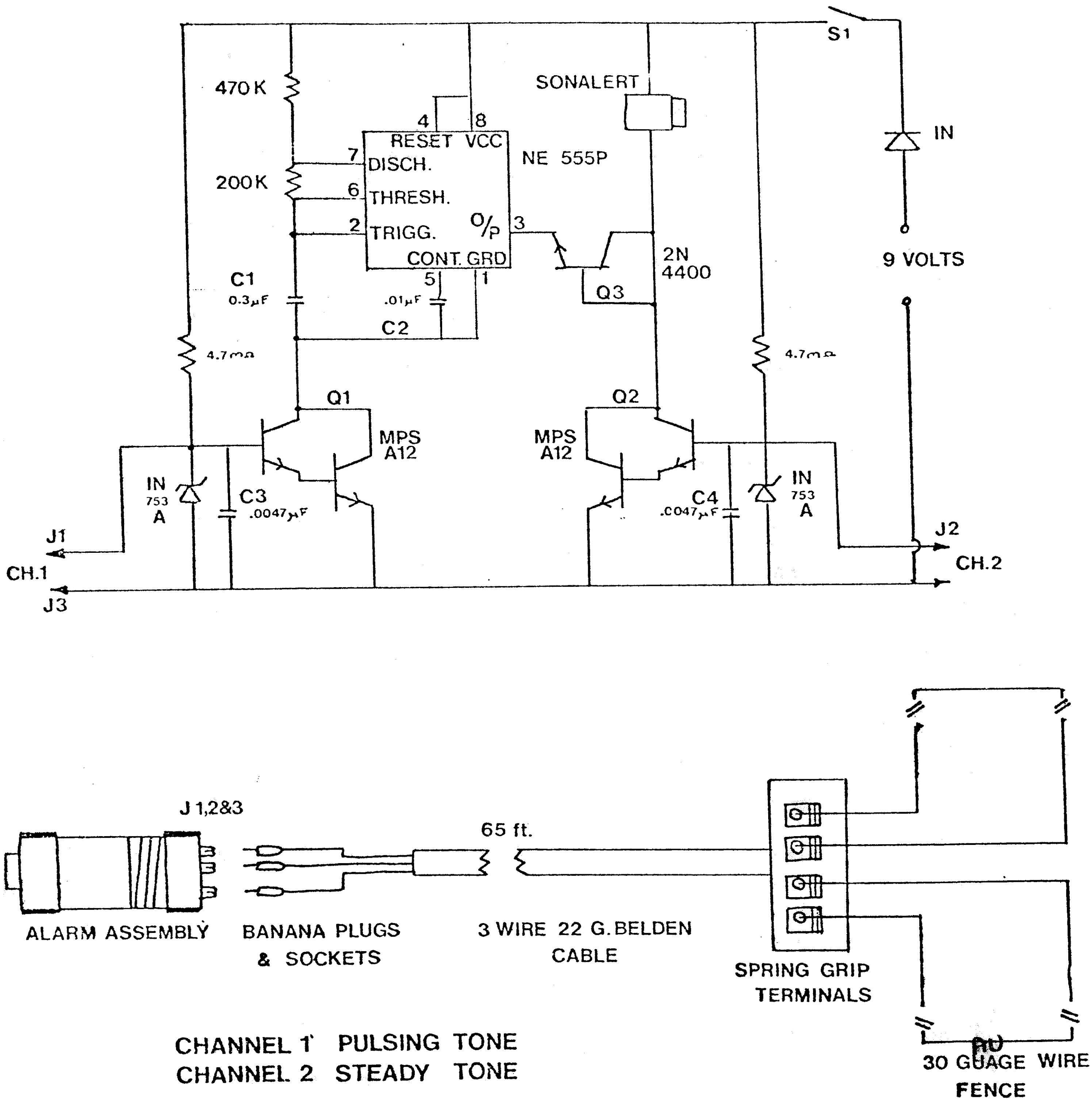


Figure 10. Electronic circuitry of a new trip wire detection system.

The trip wire system is small, portable, and most importantly, inexpensive. The new circuitry design is presented in Figure 10. It is estimated that these units could be produced for $30 to $40.

Deterrent Systems

Recording of Barking Dogs

After testing 131 experimental bears, no differences were found between the amount of time experimental and control bears spent in the test zone. This suggests that the recording had no observable deterrent effect on the polar bears tested. The results of the 1981 detection and deterrent tests also showed that a recording of barking eskimo dogs was not effective in deterring approaching polar bears. I feel that bears will not be deterred simply with an audio component.

Rubber Batons

A total of 257 polar bears was tested with rubber batons fired from the ground in 1982. In all cases, this technique was successfully used to drive bears from the bait site. The majority of bears left the bait site after a single application, however, some did require additional hits. The return rate could be a function of hunger motivation. This same explanation may account for 27% of the marked bears, which returned more than once to the bait site.

An important result is that none of the 257 polar bears hit with rubber batons charged or displayed any aggression towards the researcher who was approximately 35 m from the bears when they were struck.

The 38 mm anti-riot gun does require intensive training before a fair degree of accuracy can be assured. It is also important to remember that this weapon is not a toy and that it has the potential to kill and/or seriously injure people and bears if not used properly.

Plastic Slugs

The plastic slugs tested were ineffective in deterring experimental polar bears from the bait site. I feel that the shell as currently available is too light in weight to be effective in deterring polar bears, although it may be useful in deterring black bears. The use of the plastic slugs has three major advantages over the 38 mm rubber batons:

1) they have a high degree of accuracy;
2) they do not require a special weapon;
3) they have a lower cost per shell.

As a result of these advantages, we are redesigning these cartridges in conjunction with the manufacturer and plan to conduct additional tests during 1983.

Flare/Scaring Cartridges

These cartridges proved to be a useful system in deterring 77% (N=58) of the bears tested. But it is important to note that

18.6% (N=14) of the bears tested approached the researchers. Clearly this system is not totally effective in deterring bears. However, all the cartridges tested did ignite and travel approximately the same distance. The cartridge has a major advantage over other commercially available "cracker" shells, namely the flare component.

This cartridge was used a number of times during darkness to determine if a polar bear was approaching. When the shell explodes at the end of its trajectory, the flare component ignites and illuminates an area of approximately 15 m in diameter for approximately 3-5 seconds. This gives the user additional information on whether there is a bear or bears approaching as well as their location. I feel this cartridge would be extremely useful in areas where bears are encounterd during periods of darkness.

CONCLUSIONS

Before reviewing the conclusions of bear detection and deterrent research that can be drawn from the past 2 years of study, it is important to look at the research goals from a broader perspective.

The major goal of this research is to develop and test a system(s), device(s), or technique(s) which will deter black, grizzly and polar bears. Ideally deterrents will be effective against all bears in all possible field situations where there are bear/man encounters. From a practical, safety-oriented standpoint, it is unwise to consider a deterrent 100% effective, regardless of its success in the field.

A most important question relates to the definition of a deterred bear. Is it a bear that moves away from the area of human habitation for an hour, 10 hours, a day, or 10 days? Clearly a "deterred" bear will mean different things to different individuals, depending on the problems encountered and their previous experience with bears.

A large percentage of the nuisance bear complaints received in the N.W.T. during the last 2 years have been linked to food, the primary source of attraction. The broad category of food includes: human waste, garbage, food and cooking odours, improper food handling and storage, and poorly located and constructed meat caches. When a bear locates a food source, it is highly likely that it will return to utilize that food source as long as it is available. By returning and being successful at these food sources, the bear receives positive reinforcement. In such cases, one is faced with the challenge of altering a learned behaviour which has been positively reinforced a number of times (McCullough 1982). In these cases the ideal deterrent would produce one trial learning, which would inhibit the nuisance bear from returning to the area. However, previous animal learning studies (Marler and Hamilton 1966, Scott 1958, Thorpe 1956) clearly indicate that one trial learning is extremely difficult to obtain even in tightly controlled laboratory environments. Additionally, to reverse learning that has occurred from multiple positive-reinforcement is even more difficult. I am not aware of any animal studies which have totally eliminated an undesired positively reinforced behaviour with one trial learning. Therefore, it seems likely that in cases where a nuisance bear has been successful in obtaining food, multiple exposures to a deterrent system will be required.

In cases where bears approach camps for the first time, it is possible that one exposure to a deterrent system may produce the desired result, negative reinforcement.

The results of the past 2 years of research of bear detection and deterrent techniques have shown that there are detection and deterrent systems available which will increase human safety and decrease the number of nuisance bear kills.

The Racon microwave motion detection system and the trip wire fence system will detect an approaching bear if these systems are properly installed and maintained. Both of these detection systems will afford personnel the opportunity to find safety (e.g., get inside a building) or take steps to prevent or reduce the impact of a bear/man encounter.

To date, the 38 mm rubber batons have proven to be the most effective deterrent technique tested. However, rubber batons must be used in association with a support person who is in possesion of a loaded firearm.

To effectively use any of the detection or deterrent systems mentioned, personnel must be adequately trained. It is important that this training not be limited strictly to the use of detection and deterrent systems. Individuals must be schooled in order to understand bear habitat, bear habits and behaviours, and ways to minimize the probability of bear/man encounters through proper camp design, location, and proper maintenance procedures.

In light of this need, and in view of the results of the present research program to date, the N.W.T. Wildlife Service has begun to prepare a comprehensive bear detection and deterrent education and training program. It is our intention that the final education and training program will be utilized by all people living and working in areas where the possibility of bear/human encounters exist.

RECOMMENDATIONS

1) Tests with rubber batons, plastic slugs, flare/scaring cartridges, microwave motion detection units, and trip wire fences be conducted on black and grizzly bears.

2) Rubber batons be tested on actual nuisance bear complaints, and data be collected on the results of the deterrent.

3) Continue with research, development, and testing of plastic 12 gauge slugs on all three species of bears.

4) Continue development of a preliminary training program on bear deterrent and detection techniques.

5) Begin preparation of a comprehensive education and training program on bear behaviour and bear deterrent and detection techniques for all personnel living and working in bear habitat.

6) Continue investigating and testing other possible detection and deterrent systems, (e.g., redesigned plastic slugs, trip wire detection systems integrated with deterrent techniques and commercial dog repellants).

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Steve Moore drafted all the figures, and Ellen Irvine patiently processed the many drafts of this report.

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