September 1994

POLAR BEARS

Peter L. Clarkson
Wolf/Grizzly Bear Biologist, Renewable Resources, Government of the N.W.T.

Ian Stirling
Polar Bear Biologist, Canadian Wildlife Service

Peter L. Clarkson
Wolf/Grizzly Bear Biologist
Renewable Resources
Government of the N.W.T.
Inuvik, Northwest Territories
Canada X0E 0T0

Ian Stirling
Polar Bear Biologist
Canadian Wildlife Service
Edmonton, Alberta
Canada T6H 2S5

POLAR BEARS

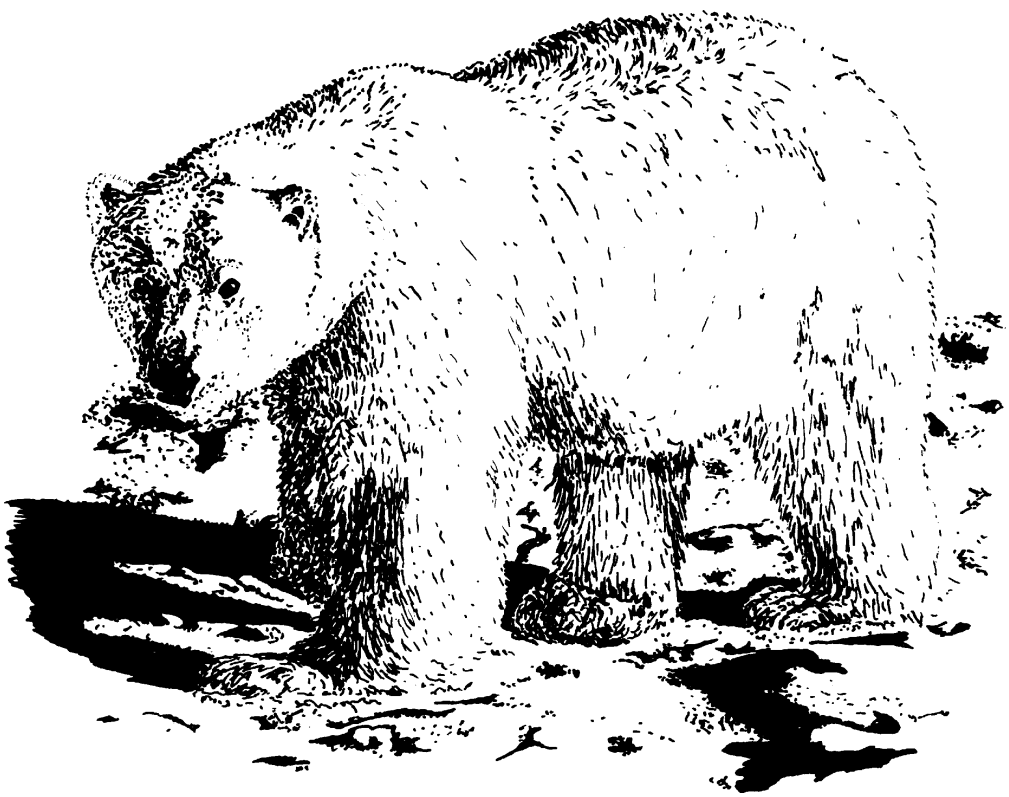


Fig. 1. Polar bear, *Ursus maritimus*

Damage Prevention and Control Methods

Exclusion

Heavy woven-wire fences (minimum 6 feet [2 m] tall).

Specifically designed electric fences.

High metal walls (offshore oil rig caisson or drilling ship).

Sturdy metal buildings and iron cages.

Cultural Methods

Remove snow around buildings and work areas to increase visibility.

Install good lighting in areas where it is essential to detect bears that may be in the vicinity.

Store garbage, human waste, food, and other products in areas not accessible to bears.

Deterrents and Frightening Devices

Loud noises, vehicle engines, cracker shells, rifle shots, barking dogs, and air horns.

Trained bear dogs.

Employ trained bear monitors with firearms and deterrents to protect communities, industry camps, and work places.

Nonlethal firearm deterrents such as 12-gauge plastic slugs and 1 1/2-inch (38-mm) rubber bullets.

Vehicles, heavy construction equipment, snowmobiles, and helicopters can be used to chase polar bears away from work and living areas.

Detection Systems

Dogs, bear monitors, trip-wire fences, and electronic (infra-red, microwave, modulated light beam) alarm systems.

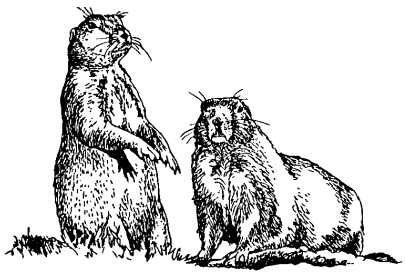
Constant vigilance of personnel working at the site.

Repellents

Capsaicin spray.

Toxicants

None are registered.



PREVENTION AND CONTROL OF WILDLIFE DAMAGE — 1994

Cooperative Extension Division
Institute of Agriculture and Natural Resources
University of Nebraska - Lincoln

United States Department of Agriculture
Animal and Plant Health Inspection Service
Animal Damage Control

Great Plains Agricultural Council
Wildlife Committee

Fumigants

None are registered.

Trapping

Live traps (culvert and barrel traps) and snares (Aldrich foot snares).

Shooting

Twelve-gauge shotgun and rifled slugs at close range.

High-powered rifle of .30-06 caliber or larger at close or long range.

Other Methods

Drugging and immobilization with Telazol (safest and most reliable drug) administered by a dart gun or jabstick. Other drugs can be used with suitable care.

Identification

The polar bear (Fig. 1) is the largest member of the family Ursidae. Males are approximately twice the size of females. On average, adult males weigh 500 to 900 pounds (250 to 400 kg), depending on the time of year. An exceptionally large individual might reach 1,320 to 1,760 pounds (600 to 800 kg). Adult females weigh 330 to 550 pounds (150 to 250 kg) on average, although a pregnant female just prior to going into a maternity den could be double that weight.

Polar bears have a heavy build overall, large feet, and a longer neck relative to their body size than other species of bears. The fur is white, but the shade may vary among white, yellow, grey, or almost brown, depending on the time of year or light conditions. The pelage consists of a thick underfur about 2 inches (5 cm) in length and guard hairs about 6 inches (15 cm) long. Polar bears have a plantigrade gait and five toes on each paw with short, sharp, nonretractable claws. Females normally have four functional mammae. The vitamin A content of the liver ranges between 15,000 and 30,000 units per gram and is toxic to humans if consumed in any quantity.

Fig. 2. Polar bear distribution map.

Range

Polar bears are distributed throughout the circumpolar Arctic. In North America, their range extends from the Canadian Arctic Islands and the permanent multiyear pack ice of the Arctic Ocean to the Labrador coast and southern James Bay. The southern limit of their distribution in open ocean areas such as the Bering Sea or Davis Strait varies depending on how far south seasonal pack ice moves during the winter (Fig. 2).

Habitat

From freezeup in the fall, through the winter, and until breakup in the spring, polar bears are dispersed over the annual ice along the mainland coast of continental North America, the inter-island channels, and the shore lead and polynia systems associated with them. Polar bears are not abundant in areas of extensive multiyear ice, probably because of the low density of seals there.

Polar bears use a variety of habitats when hunting seals, including stable fast-ice with deep snowdrifts along pressure ridges that are suitable for seal birth lairs and breathing holes, the floe edge where leads are greater than 1 mile wide (1.6 km), and areas of moving ice with seven-eighths or more of ice cover. Bears may be near the coast or far offshore, depending on the distribution of these habitats. Ringed seals (*Phoca hispida*) and sometimes bearded seals (*Erignathus barbatus*) maintain their breathing holes from freezeup in the fall to breakup in the spring. Bears can hunt more successfully in areas where wind, water current, or tidal action cause the ice to continually crack and subsequently refreeze.

During winter, bears are less abundant in deep bays or fiords in which expanses of flat annual ice have consolidated through the winter. In places

where the snow cover in the fiords is deep, large numbers of ringed seals give birth to their pups in subnivean lairs in the spring. Consequently, polar bears in general, but especially females with newborn cubs, move into such areas in April and May to hunt seal pups.

During summer, the response of the bears to the annual ice melts varies depending on where they live. Bears in the Beaufort and Chukchi seas may move hundreds of miles to stay with the ice. Bears in the Canadian arctic archipelago make seasonal movements of varying distances depending on ice conditions. Polar bears travel seasonally to remain where ice is present because they depend on the sea ice for most of their hunting.

In Hudson Bay, James Bay, parts of Foxe Basin, and the southeastern coast of Baffin Island, the ice melts completely in the summer and there are no alternate areas with ice close enough to migrate to. In these areas the bears may be forced ashore as early as the end of July to fast on land until November. Some bears remain along the coast while others move inland to rest in pits in snow banks or in earth dens in areas of discontinuous permafrost. By late September or early October, bears that spent the summer on land tend to move toward the coast in anticipation of freezeup. Many conflicts with people occur in the fall when bears are waiting along coastal areas for the sea ice to form.

Food Habits

Polar bears feed on ringed seals and to a lesser degree on bearded seals. About half of the ringed seals killed during the spring and early summer are the young of the year. These young seals are up to 50% fat by weight and are probably easy to catch because they are vulnerable and inexperienced. Less frequently taken prey include walrus (*Odobenus rosmarus*), white whales (*Delphinapterus leucas*), narwhals (*Monodon monoceros*), and harp seals (*Pagophilus groenlandicus*). Polar bears also eat small mammals, bird eggs, sea weed, grass, and other vegetation, although these food sources are much less common and probably not significant.

Polar bears are curious animals and will investigate human settlements and garbage. They have been observed to ingest a wide range of indigestible and hazardous materials, such as plastic bags, styrofoam, car batteries, ethylene glycol, and hydraulic fluid.

General Biology, Reproduction, and Behavior

Polar bears mate on the sea ice in April and May. Implantation of the embryo is delayed until the following September. The adult sex ratio is even, but because females normally keep their young for about 2 1/2 years, they usually mate only once every 3 years. This creates a functional sex ratio of three or more males per female that results in intensive competition among males for access to estrus females.

Maternity dens are usually dug in deep snow banks on steep slopes or stream banks near the sea by late October or early November, depending on the availability of snow. In the Beaufort Sea, a large proportion of the females den on the multiyear pack ice several hundred miles (km) offshore. On the Ontario and Manitoba coasts of Hudson Bay, female polar bears may have their maternity dens 30 to 60 miles (50 to 100 km) or more inland, though this is quite unusual elsewhere in polar bear range.

Pregnant females normally have 2 young between about late November and early January. At birth, cubs weigh about 1.3 pounds (0.6 kg), have a covering of fine hair, and are blind. They are nursed inside the den until sometime between the end of February and the middle of April, depending on latitude. When the female opens her den, the cubs weigh 22 to 26 pounds (10 to 12 kg). The family remains near the den, sleeping in it at night or during inclement weather for up to another 2 weeks while the cubs exercise and acclimatize to the cold, after which they move to the sea ice to hunt seals.

The mean age of adults in a population is 9 to 10 years and average life expectancy is about 15 to 18 years. Maximum recorded age of a male in the wild is 29 years. Few male polar bears live past 20 years because of the intense competition and aggression among them. The oldest age recorded for a wild female polar bear is 32 years.

Depending on the age and sex class, polar bears spend 19% to 25% of their total time hunting in the spring and 30% to 50% of their time hunting in the summer. Polar bears capture seals mainly by stalking them, by waiting for them to surface at a breathing hole or, in the spring, by digging out seal pups and sometimes adults from birth lairs beneath the snow. When a polar bear kills a seal it immediately eats as much as it can and then leaves. Polar bears do not cache food and normally only remain with a kill for a short time. In the case of a large food supply such as a dead whale or a garbage dump, individual bears may remain in an area for several days or even weeks.

Polar bears sleep about 7 to 8 hours a day. They tend to be more active at "night" during the 24-hour daylight that prevails in the summer months, and to sleep during the day. Within 1 or 2 hours after feeding, they will usually sleep, regardless of the time of day. Before sleeping, females with cubs often move away from areas where other bears are active, probably to reduce the risk of predation on the cubs by adult males.

Damage and Damage Identification

Threat or damage from a polar bear differs from that of other bears because it can occur at any time of the year. Conflicts are commonly referred to as "threat to life or property" (TLP) or "defense of life or property" (DLP). Although polar bears are the most predatory of the three North American bears, their threat to human life has

been low. Historically, northern people (Inu, Inuit, Inuvialuit, and Inupiat) were aware of the threat posed by polar bears. Legends and artwork portray conflicts between northern people and polar bears. In recent times, polar bears have injured or killed people living and working in the Arctic. Fleck and Herrero (1988) provide a detailed discussion of polar bear-people conflicts in the Northwest Territories and other areas. The Bear-People Conflict Proceedings (Bromley 1989) includes several papers on handling and preventing encounters with bears.

Damage to property can be serious in the remote and sometimes harsh arctic environment, where food and shelter may be essential to survival. Most property damage occurs at small semi-permanent hunting camps, industrial camps, and in communities. Damage includes destruction of buildings and their contents, predation of tied dogs, destruction of snowmobile seats and other plastic or rubber products or equipment, and raiding of food caches.

Legal Status

Polar bears are protected in Canada and the United States. In Canada, polar bears are legally hunted. Seasons, protected categories, and quotas apply. In Alaska, polar bear hunting is not legal, but native people may kill animals for subsistence. In Russia and Svalbard, polar bears are completely protected. In Greenland, polar bears are legally harvested by Inuk hunters. Females with cubs in dens are protected.

Deterring polar bears in Alaska is restricted to wildlife officers because polar bears are protected by the Marine Mammal Protection Act. This policy is being questioned because it does not allow companies or private individuals to deter a bear in a problem situation. It is, however, legal for anyone to shoot a bear in defense of life. In Canada it is legal for anyone to attempt to deter, and if necessary destroy, a bear in defense of life or property. Any bear killed in either jurisdiction must be reported to the nearest wildlife office.

Damage Prevention and Control Methods

Preventing Polar Bear-People Conflicts

Preventing bear-people conflicts has been given considerable attention in the Canadian and Alaskan Arctic since the mid-1970s. Reducing the number of polar bear-people conflicts has increased the safety of people living and working in the Arctic and reduced the number of polar bears killed in problem situations. An active public information and education program will help inform people how to prevent bear problems. Most wildlife agencies in bear country have a variety of public education materials available that are specifically designed to help people prevent bear problems and better handle any that may occur. Special information and training workshops have been developed by the Department of Renewable Resources, Northwest Territories, and adopted by wildlife agencies and industry in other jurisdictions. The workshops instruct people on how to prevent bear conflicts. Two publications to assist workshop instructors are available (Clarkson and Sutterlin 1983, and Clarkson 1986a). The *Safety in Bear Country Manual* (Bromley 1985, Graf et al. 1992) has been used as a reference text for most workshops.

Many bear problems occur at industry camps and work sites. When designing and setting up camps, the number of conflicts can be reduced by considering the potential bear problems. Keeping a clean camp and reducing the number of attractants will reduce bear problems. Once a bear has received a food or garbage reward from a camp, it will quickly associate the camp with available food. Most bears that are habituated to human food or garbage are destroyed in a problem bear situation. To reduce the number of problems and problem bear deaths, careful planning and precautions should be taken.

A "Problem Bear Site Operations Plan" was developed to help industrial operations better plan and prevent bear problems (Clarkson et al. 1986b). The plan helps camp safety officers, team leaders, and managers locate and design facilities and programs that are site specific. It contains information and emergency contact telephone numbers, site design, personnel responsibilities, and techniques to detect and deter bears. The plan can be included in the *Safety in Bear Country Manual* as an additional chapter. Problem Bear Site Operation Plans have been developed for polar bear concerns at the arctic weather stations and for oil exploration activities in the Beaufort Sea. Each plan deals with being prepared for and preventing polar bear problems at specific sites.

Avoiding and responding to close encounters with polar bears is addressed by Bromley (1985), Fleck and Herrero (1988), Stirling (1988a), and Graf et al. (1992). While each polar bear encounter is different, the chance of a serious or fatal bear problem can be reduced by keeping alert and being informed and prepared to deal with any bear problems that may arise.

Exclusion

Heavy woven-wire fences are effective in keeping bears out of an area. Fences must be constructed of sturdy materials and properly maintained to prevent bears from entering the exclosure. The fence should be a minimum of 6 feet (2 m) high, and the bottom should be secured to the ground or a cement foundation to prevent bears from lifting the fence and crawling under the wire. Keep fence gates closed when not in use to prevent bears from entering the area.

Electric fences have been tested on polar bears with limited success; grounding problems during winter months have been the primary obstacle. Davis and Rockwell (1986) describe an electric fence they used to protect a camp during the summer months along the Hudson Bay coast.

The use of high metal platforms, such as oil rig caissons, or offshore drilling ships, prevents bears from getting access to work and living areas. Sturdy metal buildings and iron bar cages

have been successfully used to store food and equipment, and prevent polar bear access.

Cultural Methods

Regular snow removal from work and living areas in polar bear habitat will help make these sites safer by reducing potential hiding spots and increasing visibility for personnel. Install lighting around the work site to increase visibility and staff safety. Proper design and set-up of work and living sites will help reduce potential problems. Regular camp maintenance and proper handling and storage of food, wastes, and oil products will help reduce bear problems.

Deterrents and Frightening Devices

Nonlethal deterrents are used on polar bears in an attempt to scare them away rather than destroy them. Deterrents range from snowmobiles and vehicles to 12-gauge plastic slugs and cracker shells. Choosing an appropriate deterrent will depend on the type of problem and specific location (Table 1). Regardless of the type of deterrent used, all encounters with bears should be supported by an additional person equipped with a loaded firearm.

Graf et al. (1992) reviewed several deterrents that are useful for polar bears. Clarkson (1989) recommends the use of a 12-gauge shotgun and a "three-slug system" (cracker shell, plastic slug, and lead slug). Deter bears from a site as soon as they are seen in the area, to prevent them from approaching closer and receiving some type of food or garbage reward. Figure 3 identifies the appropriate distances for deterring versus destroying a bear. Each bear deterrent situation is different, and depends on the bear's behavior and safety options available at the site. When deterring a bear with a plastic slug, aim for the large muscle mass area in the hind quarters (Fig. 4). The neck and front shoulders should be avoided to minimize the risk of hitting and damaging an eye.

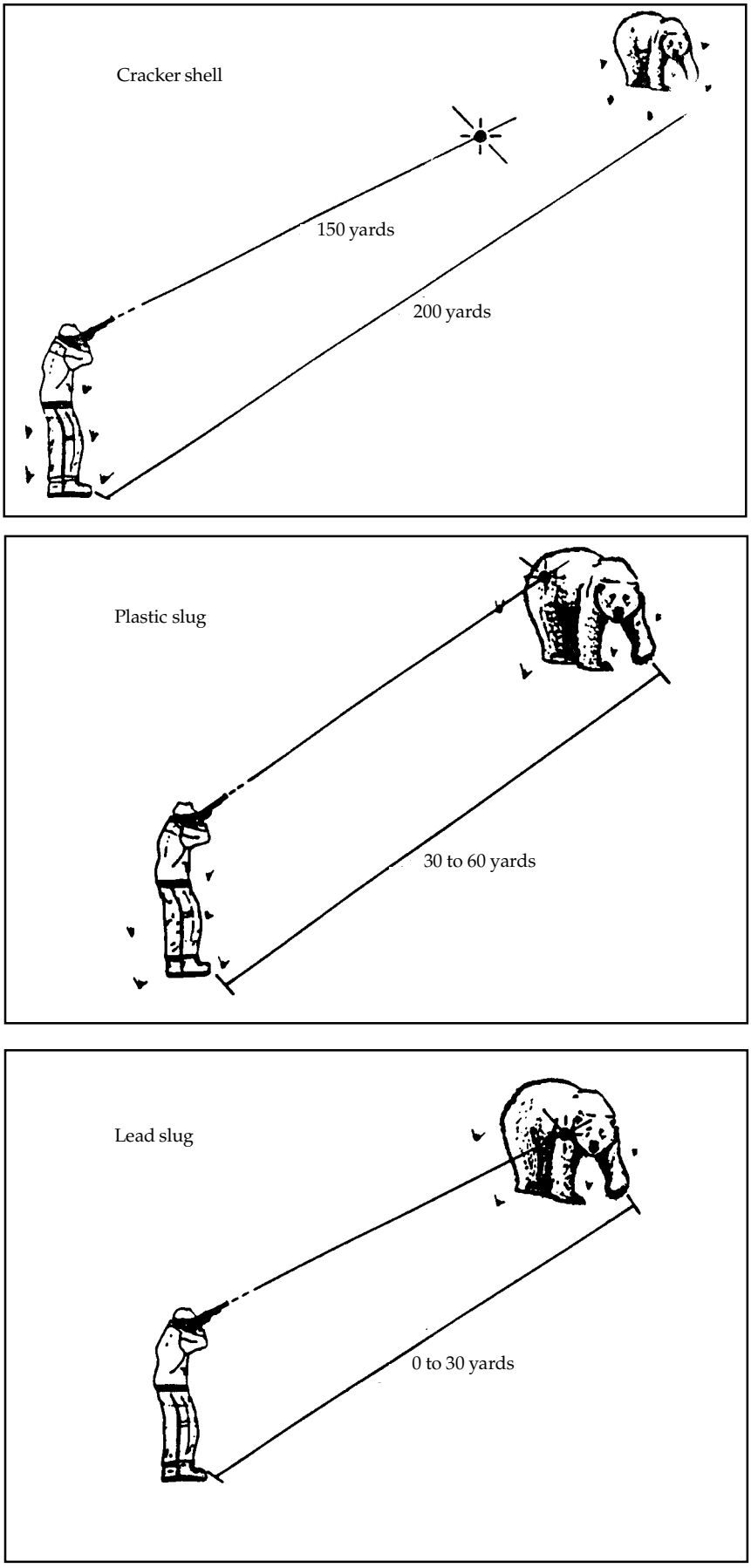


Fig. 3. Deterring and destroying a bear with a 12-gauge shotgun.

Table 1. Review of deterrent methods.

Method	*Effectiveness*	*Practicality*	*Advantages*	*Limitations*
Warning shots	-will not scare some bears -repeated use may decrease effectiveness	-practical for most situations where portable, short-term deterrent is needed	-readily available -easy to use -portable	-may injure bear, if not carefully placed
Cracker shells	-same as for warning shots -should not be relied on for personal protection	-same as for warning shots	-same as for warning shots	-improper storage and/or old stock can misfire -may be a fire hazard
Blank pistol Screamer/banger	-same as for cracker shell	-same as for warning shots	-safe -loud, unusual, and prolonged noise -long range 100+ yards	-may be a fire hazard
Pencil flare gun	-same as for cracker shell	-same as for warning shots	-same as for warning shots	-same as for cracker shells
Propane cannon	-will protect livestock and apiaries	-practical as immediate response to emergency situations	-easy to set up and use -portable	-restricted to isolated areas as sound carries long distance
12-gauge plastic slugs	-very effective though some bears not deterred	-suitable for most problem bear situations	-can be fired from a 12-gauge shotgun -portable	-may injure bear if used at a range closer than recommended
Rubber bullet (38 mm)	-very effective	-useful in most situations when a Renewable Resource Officer or R.C.M.P. can be contacted	-bears do not react aggressively	-use limited to renewable resource officers and R.C.M.P. in Canada -intensive training and practice necessary -may injure bear if shot not placed properly -special gun required
Electric fence	-fence built to proper specifications will keep out polar bears	-suitable for temporary, semi-permanent, and permanent installations	-permanent deterrent method -24 hours protection	-effort required for installation -regular maintenance required
Capsaicin sprays	-effective for polar bears in some circumstances -should not be relied on for personal protection	-portable -useful as a backup for other deterrent methods -useful while traveling or in small camp areas where other deterrents not allowed	-readily available -portable -easy to use	-may not be useful in all situations (wind) -limited range (6-8 yards) -not reliable in sub-zero temperatures
Vehicles (snowmachines, all terrain vehicles, helicopters)	-engine noise often frightens bears away -chasing bears for a short distance is effective	-useful while traveling or in small camps where vehicles or helicopters are used	-easy if vehicle is accessible	-may be hazardous to persons and bears if not used properly
Air horns (boat horns)	-same as for warning shots and cracker shells	-same as for warning shots	-same as for warning shots	-not reliable in cold temperatures -may provoke aggressive or curious reaction -source of noise is from person
Dogs	-specially trained dogs may be effective in some cases -not reliable	-suitable for camps of all sizes	-easy	-untrained dogs can aggravate a bear and/or lead it back to camp -dogs can be killed -require a responsible handler
Bear monitors	-can be highly effective if experienced with bears, deterrents, and firearms	-especially useful at large, established camps	-flexible	-need several monitors for 24-hour protection -need good communication

Table 2. Review of bear detection systems.

Method	*Practicality*	*Effectiveness*	*Advantages*	*Limitations*
Trip-wire fence	-small or temporary camps	-100% successful in field tests	-small, light, portable -24-hour protection -inexpensive -easy to set up and operate -requires minimal equipment	-may be triggered by other animals -must be reset manually
Microwave motion detection system	-large, semipermanent, and permanent camps	-100% successful in field tests	-24 hour protection -easy to install and maintain -resets automatically -powered by AC current or 12V batteries	-perimeter limitation of 450 yards for single unit -may be triggered by other animals -relatively expensive -not easily moved -site levelling may be required -units must be "bear-proofed"
Dogs	-most situations (requirements for dogs must be met, refer to text)	-inconsistent results	-simple -inexpensive -portable	-protection may be inconsistent -dog may be mauled or killed -dogs may attract bears -some risk involved until you have seen a dog's reaction to bears
Bear monitors	-medium to large semi-permanent and permanent camps	-effectiveness depends on experiernce and training of monitor	-flexible -provide protection as well as warning	-thorough training necessary to obtain maximum effectiveness
Infra-red system	-potentially useful for large sites	-100% successful in preliminary field tests	-24 hour protection -flexible -useful where unstable ground/ice conditions exist -portable	-expensive -must be operated by trained personnel -poor functional operating distance -poor video image
Conventional security system	-potentially useful for most situations	-have been successfully used for detecting people -have not been field-tested on bears	-easy to use -portable -flexible	-effectiveness to detect bears has not been determined -some systems are expensive

Detection Systems

Detecting a polar bear that is approaching a work or living area is an important part of handling bear problems. Bear detection systems range from a simple tripwire to more technical electronic monitoring devices (Table 2). If a bear is approaching a work or living area, the personnel on site should have time first to ensure their safety and second to prepare to deter the bear. Detection systems must be properly installed and maintained to be effective. If bear problems are rare, a system that is too technical or difficult to maintain will soon be neglected. Bear monitors and dogs should have previous experience with bears. An experienced bear dog can act both as a detection and deterrent system.

Repellents

Capsaicin (oleoresin of capsicum or concentrated red pepper) spray has been tested and used on black and grizzly bears (Hunt 1984), but has not yet been tested on polar bears. It may become more popular where restrictions on firearms are in place. Capsaicin needs to be scientifically tested before it can be formally recommended for polar bear protection.

Toxicants

No toxicants are registered for use on polar bears.

Fumigants

No fumigants are registered for use on polar bears.

Trapping

Live traps used to capture polar bears include culvert or barrel traps and foot snares. Both have been used to capture all three bear species in North America. The culvert trap has been used to capture polar bears at Churchill, Manitoba, and in the eastern Northwest Territories. It can also be used for short-term holding and transporting of captured polar bears. Foot snares were used in polar bear research in the early 1970s and are useful in some situations today. A

detailed description of using the culvert trap and foot snare is found in the **Black Bears** chapter in this handbook. In the early to mid-1900s, large leghold traps were used along the Arctic coast. These are no longer used today.

Shooting

Unfortunately, some bear-people conflicts require that problem bears be shot. Polar bears can be aggressive in attempting to obtain food, especially if they are in poor condition and near starving. If it is necessary to destroy a polar bear, it should be done as efficiently and humanely as possible. The 12-gauge pump action shotgun with lead slugs is an effective weapon for destroying a bear at close range (less than 100 feet [30 m]). It can also be used to deter a polar bear. High-powered rifles of .30-06 or larger caliber are also effective in destroying bears. A rifle used for bear protection should be equipped with open sights for close-range use.

Generally, if a bear is beyond 150 feet (45 m), destroying it is not necessary because the bear can be deterred before it comes closer. If it is necessary to destroy a bear beyond 100 feet (30 m), a high-powered rifle will be more accurate and have more penetration energy. Whether a shotgun or rifle is used, bears should be shot in the chest/vital organ area (Fig. 4). Handguns are not recommended for bear protection or for destroying problem bears. Proper training and practice is necessary to effectively use a firearm for bear protection or for destroying a bear.

Other Methods

Drugging/Immobilization. Polar bears are often immobilized in problem situations. Bears can be drugged while free ranging by darting them from the ground or from a helicopter, or darting after capture in a culvert trap or foot snare. Darts can be fired from a rifle or pistol. A jab stick can be used to immobilize bears captured in a culvert trap, but is not recommended for bears in a foot snare.

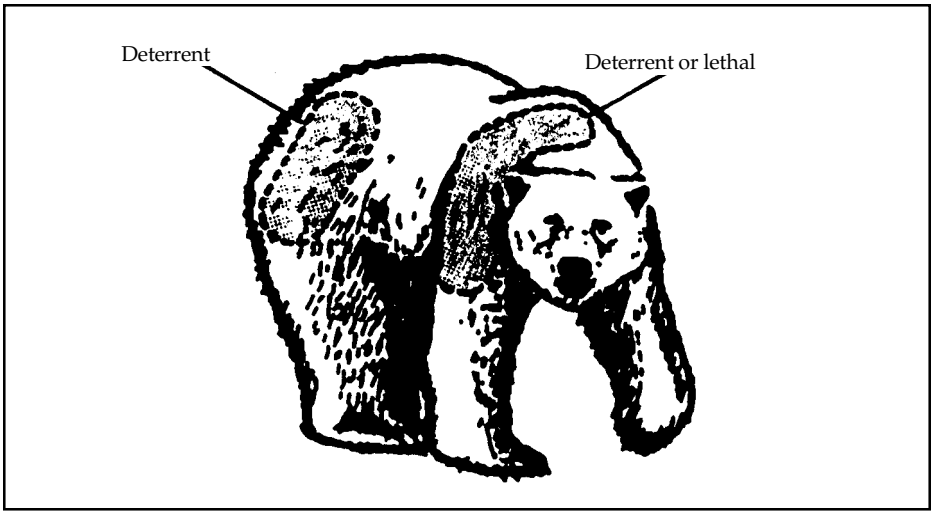


Fig. 4. Recommended deterrent and lethal hit locations on bears.

Darting from a helicopter (Bell 206 Jet Ranger or similar size), has been used for research and problem bear management. The helicopter should be equipped with a shooting window and have sling capabilities for moving bears. The helicopter should slowly approach the bear from behind at an altitude of 20 to 30 feet (6 to 10 m). Shooting distance from a helicopter is usually less than 30 feet (10 m). Bears should be darted in the large muscle areas of the neck, shoulder, or upper midback. Several immobilizing drugs have been used on polar bears in the past, however, Telazol is presently considered the most effective. Telazol is a safe and predictable drug to work with because there is a wide range of tolerance to high dosages, the reactions of darted bears can be easily interpreted, and the bears are able to thermoregulate while immobilized. Dosages of 8 to 9 mg/kg or greater are usually necessary to fully immobilize a polar bear for measuring and tagging. Immobilization time for adult bears depends on the injection site and weight of the bear. On the average, a bear will be immobilized in 4 to 5 minutes after the first injection of Telazol. Cubs of the year can be immobilized by hand or with a jabstick after being captured on or near their immobilized mother.

Holding, Transporting, and Relocating. Problem polar bears that are captured or immobilized and not destroyed are usually held in a culvert trap or other suitable facility. Bears can be transported from a problem site with a culvert trap and released at another location if a road system exists. Road systems are limited in the arctic and relocating problem bears with culvert traps is usually not an effective option. In most cases, captured and immobilized bears need to be relocated by helicopter. Take precautions to ensure that bears are not injured or suffering from hyperthermia when transporting them in a cargo net below a helicopter.

In Churchill, Manitoba, polar bears are captured in or near the town limits, held in a polar bear holding facility and then flown out to an area north of Churchill and released. Capturing and holding the bears in the "polar bear jail" prevents these bears from causing problems while they are waiting for the ice to form on Hudson Bay. Bears kept in a holding facility can be given water, but food is not recommended because the bears may begin to associate people and the holding facility with food. Although an expensive program, the polar bear jail at Churchill has reduced the number of polar bear problems and polar bear mortalities.

Relocating problem bears usually does not solve the problem since they often return, sometimes from considerable

distances. Polar bears that are waiting along a coastline for ice to form should be moved in the general direction they would normally travel. Most of the polar bears released north of Churchill travel out on the sea ice and do not return to the townsite.

Economics of Damage and Control

No specific studies or reports have documented the economic costs of polar bear damage in the Arctic. Past polar bear problems have ranged in cost from nothing to several thousands of dollars. With the remote locations of camps and communities and the expense of transporting food and products in the Arctic, replacement costs are high. Lost work time of personnel and programs can also be substantial because of polar bear problems. In September 1983, Esso Resources Canada had to suspend drilling until a wildlife officer could drug and remove a bear that had happened onto the artificial island, costing Esso about $125,000. A similar incident occurred in 1985, and cost Esso approximately $250,000 in lost work time.

Hiring bear monitors can cost up to $250 per day to protect personnel, a camp, or an industrial site from polar bears. The cost of government staff and programs that are responsible for handling polar bear problems will depend on the number of problems. Churchill, Manitoba, has the most intensive government program to handle polar bear problems. This program costs the Manitoba government approximately $120,000 per year (M. Shoesmith, pers. commun.).

Purchasing detection and deterrent equipment and educating people on the proper procedures to prevent and handle bear problems will cost companies and agencies. These costs, however, are minimal when compared to personnel safety, replacement costs of property in the Arctic, and long-term polar bear conservation concerns.

Acknowledgments

We gratefully acknowledge the following for their continued support of our research on bears in general, and polar bears in particular: the Northwest Territories Department of Renewable Resources, the Canadian Wildlife Service, Polar Continental Shelf Project, Manitoba Department of Natural Resources, World Wildlife Fund (Canada), Northern Oil and Gas Assessment Program, and the Natural Sciences and Engineering Research Council of Canada. All people, organizations, government departments, and industry previously involved in the Northwest Territories' "Safety in Bear Country Program" are thanked for their past concern and support. L. Graf and K. Embelton assisted in word-processing and editing.

Tables 1 and 2 were adapted from Graf et al. (1992).

Figure 1 drawn by Clint Chapman, University of Nebraska.

Figure 2 was adapted from Sterling (1988) by Dave Thornhill, University of Nebraska.

Figures 3 and 4 are from Clarkson (1989).

For Additional Information

Amstrup, S. E. 1986. Research on polar bears in Alaska, 1983-1985. Proc. Working Meeting of the IUCN/SSC Polar Bear Specialist Group. 9:85-108.

Arco Alaska, Inc. 1990. Fireweed No. 1 exploratory well. Polar Bear/Personnel Encounter and Monitoring Plans. 16 pp.

Banfield, A. W. F. 1974. The mammals of Canada. Univ. Toronto Press, Toronto. 438 pp.

Bromley, M. 1985. Safety in bear country: a reference manual. Northwest Territ. Dep. Renew. Resour., Yellowknife. 120 pp.

Bromley, M., ed. 1989. Bear-people conflicts. Proc. Symp. Manage. Strategies Northwest Territ. Dep. Renew. Resour., Yellowknife. 246 pp.

Calvert, W., I. Stirling, M. Taylor, L. J. Lee, G. B. Kolenosky, S. Kearney, M. Crete, B. Smith, and S. Luttich. 1991. Polar bear management in Canada 1985-87. Rep. to the IUCN Polar Bear Specialist Group. Proc. IUCN/SSC Polar Bear Specialists Group. IUCN Report No. 7:1-10.

Clarkson, P. L. 1986a. Safety in bear country instructors' guide. Northwest Territ. Dep. Renew. Resour., Yellowknife. 32 pp.

Clarkson, P. L. 1986b. Eureka and Mould Bay weather stations problem bear site evaluation and recommendation. Northwest Territ. Dep. Renew. Resour., Yellowknife. 42 pp.

Clarkson, P. L. 1989. The twelve-gauge shotgun: a bear deterrent and protection weapon. Pages 55-59 *in* M. Bromley, ed. Bear-people conflicts. Proc. Sym. Manage. Strategies. Northwest Territ. Dep. Renew. Resour., Yellowknife.

Clarkson, P. L., and P. Gray. 1989. Presenting safety in bear country information to industry and the public. Pages 203-207 *in* M. Bromley, ed. Bear-people conflicts. Proc. Sym. Manage. Strategies. Northwest Territ. Dep. Renew. Resour., Yellowknife.

Clarkson, P. L., P. A. Gray, J. E. McComiskey, L. R. Quaife, and J. G. Ward. 1986a. Managing bear problems in northern development areas. Northern Hydrocarbon Development Environment Problem Solving. Proc. Ann. Meeting Int. Soc. Petroleum Ind. Biol. 10:47-56.

Clarkson, P. L., G. E. Henderson, and P. Kraft. 1986b. Problem bear site operation plans. Northwest Territ. Dep. Renew. Resour., Yellowknife. 12 pp.

Clarkson, P. L., and L. Sutterlin. 1983. Bear essentials: a source book and guide to planning bear education programmes. Faculty Environ. Design, Univ. Calgary. 69 pp.

Davis, J. C., and R. F. Rockwell. 1986. An electric fence to deter polar bears. Wild. Soc. Bull. 14:406-409.

DeMaster, D. P., and I. Stirling. 1981. *Ursus maritimus*. Mammal. Species 145:1-7.

Fleck, S., and S. Herrero. 1988. Polar bear conflicts with humans. Contract Rep. No. 3. Northwest Territ. Dep. Renew. Resour., Yellowknife. 155 pp.

Graf, L. H., P. L. Clarkson, and J. A. Wagy. 1992. Safety in bear country: a reference manual, rev. ed. Northwest Territ. Dep. Renew. Resour., Yellowknife. 135 pp.

Gray, P. A., and M. Sutherland. 1989. A review of detection systems. Pages 61-67 *in* M. Bromley, ed. Bear-people conflicts. Proc. Symp. Manage. Strategies. Northwest Territ. Dep. Renew. Resour., Yellowknife.

Hunt, C. L. 1984. Behavioral responses of bears to tests of repellents, deterrents, and aversive conditioning. M.S. Thesis. Montana State Univ., Bozeman. 136 pp.

Hygnstrom, S. E. 1994. Black bears. *in* S. E. Hygnstrom, R. M. Timm and G. E. Larson, eds. Prevention and Control of Wildlife Damage. Coop. Ext., Univ. Nebraska, Lincoln.

Lewis, R. W., and J. A. Lentfer. 1967. The vitamin A content of polar bear liver: range and variability. Compar. Biochem. Physiol. 22:923-926.

Lunn, N. J., and I. Stirling. 1985. The significance of supplemental food to polar bears during the ice-free period of Hudson Bay. Can. J. Zool. 63:2291-2297.

Meehan, W. R., and J. F. Thilenius. 1983. Safety in bear country: protective measures and bullet performance at short range. US Dep. Agric. For. Serv. Gen. Rep PNW-152. 16 pp.

Rodahl, K. 1949. Toxicity of polar bear liver. Nature 164:530.

Ramsay, M. A., and I. Stirling. 1988. Reproductive biology and ecology of female polar bears *Ursus maritimus*. J. Zool. London. 214:601-634.

Schliebe, S. 1991. Polar bear management in Alaska. Report to the IUCN Polar Bear Specialist Group. Proc. IUCN/SSC Polar Bear Specialists Group. IUCN Rept. No. 7:62-69.

Schweinsburg, R. E., L. J. Lee, and P. B. Latour. 1982. Distribution, movement, and abundance of polar bears in Lancaster Sound, Northwest Territories. Arctic 35:159-169.

Stenhouse, G. B, L. J. Lee, and K. G. Poole. 1988. Some characteristics of polar bears killed during conflicts with humans in the Northwest Territories. Arctic 41:275-378.

Stirling, I. 1975. Summary of a fatality involving a polar bear attack in the Mackenzie Delta, January 1975. Can. Wildl. Serv. Polar Bear Proj. Spec. Rep. 89. 2 pp.

Stirling, I. 1988a. Polar bears. Univ. Michigan Press., Ann Arbor. 220 pp.

Stirling, I. 1988b. Attraction of polar bears *Ursus maritimus* to offshore drilling sites in the eastern Beaufort Sea. Polar Record 24(148):1-8.

Stirling, I., and A. E. Derocher. 1990. Factors affecting the evolution and behavioural ecology of the modern bears. Int.. Conf. Bear Res. Manage. 8:189-204.

Stirling, I., and M. A. Ramsay. 1986. Polar bears in Hudson Bay and Foxe Basin: present knowledge and research opportunities. Pages 341-354 *in* I. P. Martini, ed. Canadian Inland Seas. Elsevier Sci. Publ., Amsterdam. 494 pp.

Stirling, I., D. Andriashek, and W. Calvert. 1993. Habitat preferences of polar bears in the western Canadian Arctic in late winter and spring. Polar Record 29:13-24.

Stirling, I., C. Spencer, and D. Andriashek. 1989. Immobilization of polar bears *Ursus maritimus* with Telazol in the Canadian Arctic. J. Wildl. Diseases. 25:159-168.

Struzik, E. 1987. Nanook: in the tracks of the great wanderer. Equinox Jan.-Feb. 1987. pp. 18-32.

Urquhart, D. R., and R. E. Schweinsburg. 1984. Polar bear: life history and known distribution of the polar bear in the Northwest Territories up to 1981. Northwest Territ., Dep. Renew. Resour., Yellowknife. 69 pp.

Uspenskii, S. M. 1977. The polar bear. Nauka, Moscow, 107 pp. (English trans. by Canadian Wildl. Serv., 1978).

Editors

Scott E. Hygnstrom
Robert M. Timm
Gary E. Larson