Black Bears (Ursus americanus) in Northeastern Labrador.

by

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ABSTRACT

Ten black bears in the Voisey's Bay area of Labrador were studied in 1996 and 1997 using GPS and VHF radio telemetry. GPS collars recorded location and movement activity, but did not operate as long as expected. The short life span of the GPS collars was attributed to battery malfunction. General observations of bear ecology included information on feeding habits, den sites, den entry, spring emergence, reproduction, demographics, morphology, and daily activity. Age structure of captured subjects suggests an older population and female reproductive histories as determined through analysis of cementum annuli suggest delayed sexual maturity. Minimum Convex Polygon (MCP) home ranges were calculated and analyzed to determine if location sample sizes were adequate to estimate home range. Sample size was considered adequate for 2 subjects and borderline for 3 others. Post translocation point removals at discreet time intervals following each translocation event were used to determine if translocation inflated home range estimates. It appeared that translocation did significantly effect home range estimation for several subjects. Habitat selection for 3 adult females was analyzed using Chi-square goodness of fit. Two of the females preferred forested areas, although visual observations suggest that black bears use the barrens and forested areas, similarly. Funding for the study was provided by the Voisey's nay Nickel company.

ACKNOWLEDGEMENTS

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Special thanks go to P. Trimper for his help in securing funds and logistical support for the field component of this project, to J. Rowell of the Labrador Inuit Association for introducing me to the Voisey's Bay project, and to L. Cicnjak-Chubbs whose experience and advice as a black bear researcher greatly improved the quality of this study. Constructive review of the manuscript was provided by B. Napier and E. Young, of the Voisey's Bay Nickel Company (VBNC).

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Resources and Agrifoods, the Labrador Inuit Association, Acadia University, and Canadian Helicopters International. The research was completed as part of the environmental baseline characterization conducted by Jacques Whitford Environment Limited on behalf of the Voisey's Bay Nickel Company who provided 100% of the funding for this study.

APPROVAL TO USE COPYRIGHT MATERIAL AND PROPRIETARY INFORMATION

From: eyoung@inco.com
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Keith,

We have reviewed the potential journal articles that you sent and do not have a problem with you using them for your thesis. You also have permission to use the black bear technical data report for your thesis.

Elizabeth

PROLOGUE

The 1996 black bear (Ursus americanus) study was developed in anticipation of the Environmental Impact Statement (EIS) for the proposed Voisey's Bay mining development. Field work for the black bear project began in May 1996, continued through the summer and concluded following den emergence in 1997. The general objective of this study was to collect data on bear ecology in the Voisey's Bay area and prepare a report for the Voisey's Bay EIS (Appendix 1).

The Voisey's Bay Environmental Assessment panel concluded in 1998 and all EIS research is now available to the general public (VBNC 1998). The Voisey's Bay EIS, despite the criticisms identified during the review phase by consultants and public interest groups, may be the single most comprehensive document describing to the environment of Labrador. Fish and wildlife reports include: black bear, caribou, fur bearing mammals, char, marine mammals, avifauna, small mammals, and ecological land classification, in addition to several dozen engineering and sociological technical data reports. Unfortunately, the geographic scope of the EIS is limited to an area immediately adjacent to the proposed mine site (approximately 1600 km^2).

In 1997, I began work with Environment Canada and received assurance that education leave would be granted at a future date to complete my M.Sc. degree. When it came time to write the thesis and after discussing the matter with Dr. Bondrup-Nielsen, it was decided that the thesis would take the form of 4 chapters written in Journal style, each with its own study area, methods, conclusion, and citation sections and included the following:

Chapter 1. A brief account of the functioning and utility of GPS collars, recent technology rarely used in wildlife studies prior to 1996 (Rempel et al. 1995). The few studies that had employed GPS collars had not made their results available to the public. Given their cost and value in wildlife research, information on their performance was considered important. Chapter 2. Topics include denning, morphology, demographics, reproduction, food habits, etc. The paucity of historic information on black bear ecology in Labrador make this chapter especially important. Chapter 3. This chapter reports the results of a "pseudo experiment" that used point removal and random sampling of location data to evaluate required sample size and affect of translocation in calculating home range. Chapter 4. In the late 1980's black bears were observed occupying a region devoid of trees year round (Harrington 1994). This atypical behavior prompted my interest in habitat selection of black bears in Labrador, and was the main reason for selecting the black bear as a study subject. Appendix 1 is the black bear technical data report (TDR) that was submitted as part of the Voisey's Bay EIS. Although much of the information in the EIS document is presented in 4 chapters of this thesis, the TDR contains information that was not reported elsewhere, such as maps of: GPS and VHF home range, home range overlap, home range scale habitat use, black bear capture locations, unknown bear sightings, black bear den sites, density estimate calculations, and rooftop GPS collar "test" results.

GENERAL INTRODUCTION

Black bears (Ursus americanus) are free roaming omnivores (Banfield 1974) generally viewed as vegetarians (Kolenosky and Strathearn 1987). The black bear diet varies with season, geographic location (Holcroft and Herrero 1991) and human activity (Craighead and Craighead 1971). In Alberta, black bears feed on green plant matter and insects in spring, supplemented with raspberry (Rubus idaeus) and horsetail (Equisetum sp.) in summer, and berries and insects in the fall (Holcroft and Herrero 1991). Black bears in New Brunswick feed on grasses in the spring, and switch to blueberry (Vaccinium angustifolium) and raspberry in late summer (Zytaruk 1978). In insular Newfoundland, black bears feed on green vegetation in spring and summer (Day 1997), but prefer blueberry and bakeapple (Rubus chaememorus) in the fall (Day 1997, Payne 1978).

Barren ground black bears in northern Labrador have smaller bodies and a greater dependence on protein than their forest dwelling counterparts (Veitch 1992). This reliance on protein is apparently due to the absence of mast crops in the surrounding habitat (Veitch 1992). Although, Schwartz and Franzmann (1989) found that black bears in Alaska accounted for 80% of moose predation and 70% of moose mortality, moose predation was probably only a small component of the overall black bear diet. Day (1997) found that animal remains occurred in 33% of black bear stomach and scat samples in Newfoundland. In addition to ungulates and small mammals, fish and seals may be important components of the black bear diet at various times of the year.

Black bears are polygamous, male reproduction is influenced by geographic location, social status, photo-period and the female estrus cycle (Garshelis and Hellgren

1994). Estrus in females generally occurs from May to August with a peak during June and July (Garshelis and Hellgren 1994). Male black bears use scent trails to locate females (Kolenosky and Strathearn 1987). Black bears reproduce through delayed implantation and have low fecundity (Kolenosky and Strathearn 1987). According to Elowe and Dodge (1989), a female bear's ability to reproduce is dependent on food availability. They note that 10 out of 10 pregnant female black bears with low carbohydrate diets failed to produce young. Female black bears first give birth between the ages of 3-7 years, typically breed every 2-3 years, and produce 1-4 cubs during each birthing event (Banfield 1974). Black bear cubs are born between December and February while the mother is still in the den. The cubs generally weigh 0.3 kg at birth and grow to 30 kg by the age of nine months. Bear cubs stay with their mother until they are approximately 17 months old (Kolenosky and Strathearn 1987). These factors (low fecundity, parental care, iterated breeding) are indicative of a K-selected species (Begon and Mortimer 1986).

Black bear home ranges vary with gender, geographic location and resource availability (Harrington 1994, Klenner 1987, Fuller and Keith 1980). Male black bears generally have larger home ranges than female black bears which reflects the reproductive strategy of the male to mate with as many females as possible (Harrington 1994). Female black bear home range size can vary from 3 km^2 (Lindzey and Meslow 1977, Jonkel and Cowan 1971) to 1670 km^2 (Harrington 1994). The average home range for a forest dwelling female bear is 30 km^2 (Stirling and Derocher 1990), while the median home range (n=8) for a barren ground female bear is 360 km^2 (Harrington 1994). The average home range for a forest dwelling male is 80 km^2 (Stirling and Derocher 1990), but ranges as large as 9,500 km^2 have been recorded for barren ground male black bears in northern Labrador

(Harrington 1994). Home ranges may be used by more than one bear, but specific areas are seldom used at the same time (Kolenosky and Strathearn 1987). In Manitoba, Klenner (1987) observed up to 100% spatial and temporal home range overlap for bears, while in Alberta, Fuller and Keith (1980) reported only 12% overlap in female home ranges.

Many black bears exhibit habitat preference. In Alberta, black bears commonly use stands of spruce (Picea sp), open muskeg , and areas of mixed aspen (Populus tremuloides) and jack pine (Pinus banksiana) (Fuller and Keith 1980). Black bear movement in Manitoba appeared to be restricted to wooded areas, ravines and shelter belts (Klenner 1987). In New Brunswick, Zytaruk (1978) reported that black bears preferred areas of dense balsam fir, rather than open mixed forest, while Chamberland (2000) found that bears preferred habitats with high amounts of hiding cover and abundance of safety trees. Day (1997) found black bears on insular Newfoundland used non-forested areas less than expected, and showed preference for balsam fir forest, while Veitch (1992) reported that black bears in northern Labrador survive and persist in a non-forested ecosystem.

Daily activity patterns are a response to seasonal and daily variations in the environment (Nielsen 1983). Factors to consider when evaluating activity patterns include: environmental constraints, optimal foraging, and social activities (Lariviere et al. 1994). Black bears are generally considered diurnal (Armstrup and Beecham 1976, Lindzey and Meslow 1977, Lariviere et al. 1994). In Quebec, Lariviere et al. (1994) found that for most black bears activity began 30 minutes after sunrise and ended 2.5 hours after sunset.

Black bear denning usually occurs between September and November (Schooley et al. 1994, Harrington 1994, Tietje and Ruff 1980, Fuller and Keith 1980, Lindzey and Meslow 1977, Armstrup and Beecham 1976, Jonkel and Cowan 1971, Rogers 1970).

Timing of denning may be influenced by food availability, photo-period, temperature, snowfall, gender and pregnancy (Schooley et al. 1994, Tietje and Ruff 1980, Jonkel and Cowan 1971). Emergence from the den normally occurs during spring (April to May) and appears to be influenced by snow melt, photo-period, temperature, gender and reproductive status (Harrington 1994, Schooley et al. 1994, Fuller and Keith 1980). Snowstorms have been suggested as a stimulus for denning (Craighead and Craighead 1972), while low food availability in fall and inadequate body weight have been reported as the cause of delayed den entry (Schooley et al. 1994, Klenner and Kroeker 1990).

In northern areas where large hollow trees are uncommon, bears tend to use excavated dens which they line with plant material (Klenner and Kroeker 1990, Tietje and Ruff 1980, Fuller and Keith 1980). Tietje and Ruff (1980) concluded that the proportion of bears excavating dens is linked to lower winter temperatures and the need for increased insulation. Schooley et al. (1994) reported that females often construct dens within the confines of their summer range, while Tietje and Ruff (1980) reported that males used den sites far removed from their summer range. Pregnant females appear to den earlier than non-pregnant females (Klenner and Kroeker 1990) and barren ground females show a preference for dens at high elevation (Harrington 1994). The wide range of den types and habitats used suggest that den site availability does not limit certain bear populations (Klenner and Kroeker 1990).

Densities for black bears have been calculated in several locations throughout their North American range. Young and Ruff (1982) estimated 0.37- 0.62 bears/ km^2 for a hunted population of black bears in East Central Alberta, while Jonkel and Cowan (1971) reported densities of 0.25-0.40 bear/ km^2 for a population of black bears in Montana.

Dennis et al. (1996) report an estimated density of 0.11-0.15 bears/ km^2 in the Serpentine Lake area of Western Newfoundland.

There are no population estimates for black bears in Labrador and very little is know of their ecology. The following chapters report some of the first ever research of black bears in Labrador. The objective of this study was to describe the general ecology of black bears on the north east coast of Labrador.

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CHAPTER 1. BLACK BEAR (URSUS AMERICANUS) GPS COLLAR PERFORMANCE ON LABRADOR'S NORTHEAST COAST.

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Abstract: In support of an Environmental Baseline Characterization program at Voisey's Bay, Labrador, Global Positioning System (GPS) collars were deployed on 3 adult female black bears (*Ursus americanus*) during 1996. Collars were capable of differential correction, were equipped with a mercury tip-switch, and were on a 3 hour fix-acquisition schedule. All collars were activated on 20 June, 1996 and entered emergency mode, indicating collar malfunction on or before 13 August, 1996. The collars yielded a total of 204 geodetic fixes out of 1037 fix attempts. Mercury switch activations were averaged every 3 hours to provide a single count of activity for that 3 hour period. The collars yielded a total of 1037 activity counts from 1037 attempts.

Key Words: GPS, VHF, radio telemetry, black bear, *Ursus americanus*, activity switch, Labrador, Voisey's Bay.

Systematic, quantitative study of individual or population distributions, home ranges, habitat use and daily activity patterns are important in understanding the ecology of a given species. Over the years, remote sensing has provided valuable information on many of these variables. Historically VHF telemetry has been an integral component of most remote sensing systems. However, VHF telemetry

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requires the immediate presence of the researchers, and this is often limited by temporal and spatial constraints. Recently the development of Satellite and GPS technologies have allowed biologists to overcome some of the limitations of conventional VHF radio tracking.

In the last 5 years GPS collars have been deployed on various species including moose (Alces alces), caribou (Rangifer tarandus) and black bear (Rempel et al. 1995, Moen et al. 1996, Courturier pers. com). The results of these research efforts have not yet been synthesized into a comprehensive evaluation of the GPS system as it relates to animal tracking. However, the results of these individual studies do provide insight into the potential application of GPS technology in the study of wildlife populations. The following describes the performance of 3 GPS collars deployed on black bears (Ursus americanus) in northeastern Labrador during 1996 as part of the baseline ecological research conducted for the Voisey's Bay Environmental Impact Statement (VBNC 1997).

STUDY AREA

The centre of the study area (56° 20' N, 62° 06' W) was approximately 330 km north of Goose Bay, Labrador, in the vicinity of the Voisey's Bay mineral discovery. The study area was defined by the movements of animals captured near this point and comprised approximately 1,700 km^2 of rugged terrain with elevations ranging from 0 to 400 m above sea level. Steep cliffs were common in the west while low rolling hills were predominant in the east. The amount of forest in the study area varied with elevation; land at lower elevations were forested (some bog/fen peatlands), while higher elevations were predominately barren. The most common forest type in the study area was spruce-fir/dwarf shrub forest. This habitat consisted of spruce (Picea spp.) and fir (Abies balsamea) trees and was characterized by an open canopy (< 50% closure). The shrub layer was dominated by black berry (Empetrum nigrum), Labrador tea (Ledum groenlandicum), and tundra bilberry (Vaccinium uliginosum); ground vegetation was dominated by moss (Pleurozium scherberi and Dicranum scoparium). Bog/fen peatlands supported various species of vegetation including Sphagnum spp., bakeapple (Rubus chamaemorus), sedges (Carex spp.), Labrador tea, tundra dwarf birch (Betula glandulosa), and larch (Larix laricina) (JWEL 1997). The mean monthly temperatures for the study area ranged from -19° C in January to 10° C in July; the mean annual temperature is approximately -3° C. Mean annual precipitation has been calculated at 740 mm, with the highest rainfall occurring during July (79 mm), and maximum snowfall occurring in January (87 mm) (Environment Canada 1989).

METHODS

Bait stations (Johnson and Pelton 1980) were established near fresh black bear sign during May 1996. Sites with repeat black bear visits were used as snare locations. Aldrich leg snares (Lindzey 1987) were checked daily and deactivated after each capture event. Trapping commenced on June 21 and all GPS (Lotek Engineering Inc.) collars were deployed by 23 June, 1996. Subject bears were marked with Flex-Lok plastic ear tags (Ketchum Manufacturing) and were sedated with 4-7 mg/kg of Telazol (White et al. 1996) and given a penicillin injection to decrease chance of infection. Subjects were monitored for recovery from anesthetic and revisited 24-30 hours after capture. An intensive recapture program using leg snares and aerial darting from helicopter following procedures described by Baer et al. (1987), was initiated after final GPS collar failure on August 12 and all GPS collars were retrieved by 27 August, 1996. VHF mortality collars (manufactured by Lotek Engineering Inc.) were deployed on subjects in place of the GPS collars. VHF monitoring of these subjects continued until December 1996.

The GPS collars, each weighing approximately 1.36 kg, were capable of differential correction and were equipped with data loggers, mercury switches and VHF radio beacons transmitting in the 150-MHz band. The VHF beacons initialized on 20 June while the GPS unit, mercury switch and data logging components initialized on 25 June, 1996. The GPS collars attempted to record the following information every 3 hours: geodetic coordinates (latitude and longitude), activity counts, temperature, time, date, fix status, HDOP (horizontal dilution of precision), and convergence (distribution of satellites above the horizon) (Moen et al. 1996) for a total of 8 fix attempts/day. The GPS collars measured activity by counting mercury switch activation, these were summed every 10 minutes and averaged every 3 hours to provide a single activity count at the time of data logging.

The GPS collars were not capable of remote communication, and were retrieved during August 1996, and sent to Lotek Engineering Inc. for data down-loading and differential correction. Bears were tracked before and after GPS retrieval using standard VHF telemetry. Radio telemetry was conducted bi-weekly (Mech 1983, White and Garrott 1990), between June and November, 1996. Telemetry flights were conducted, using a Bell 206B helicopter with two side-mounted VHF antenna, at altitudes between 40 to 2,000 m above ground level (Gilmer et al. 1981, Mech 1983). Once a signal was isolated, an effort was made to obtain a visual fix (Gilmer et al. 1981, Mech 1983, White and Garrott 1990), or the subject's location was estimated. The helicopter's GPS provided geodetic locations of all observation events (both visual and non-visual). Locations obtained from the helicopter GPS were not differentially corrected and were assumed to have an accuracy of +/-100 m. Both the GPS collars and the helicopter GPS recorded geodetic data in World Geographic System (WGS) 84 Latitude/ Longitude.

RESULTS

Collar 3 slipped off its initial subject on 24 June, 1996 prior to GPS initialization (Table 1). Collar 3 was positioned in a location with an unobstructed view of the sky for 10 days (referred to as collar 3A) prior to being fitted on a new subject on 10 July (after which the collar was referred to as 3B). Technical problems related to the operation of Collars 1, 2 and 3B were encountered approximately 6-7 weeks after deployment. The VHF beacons of Collars 1 and 2 entered emergency mode on 12 August; Collar 3B entered emergency mode on 13 August (Table 1). An evaluation of the raw and post processed data revealed that the collars had been recording information based on Greenwich Mean Time and a 3 hour adjustment was necessary for all dates and times. Collars 1 and 2 each required nine days for initial geodetic fix (Table 1); collar 3A made its first fix seven days after GPS initialization (Table 1). Each GPS collar averaged 345 fix attempts over their 43-44 day lifespan; approximately eight fix attempts per day. The number of successful fixes however, averaged 1.6/day and were typically 2-dimensional (2-D) instead of 3-D fixes. The only exception occurred when Collar 3A was stationed with an unobstructed view of the sky. During this stationary period Collar 3A had the highest overall acquisition success rate (55%) and the highest 3-D success rate (88%) of any collar deployed. Collars 1, 2 and 3B had overall acquisition success rates of 16, 11, and 22 %, respectively (Table. 1).

Each collar produced an average of 345 activity readings during its lifespan. The collars appeared to record activity consistently but no efforts were made to quantify accuracy of the activity information. For reasons unknown, Collar 2 adjusted its recording interval halfway through the summer. Despite the change in the recording interval, the data logger recorded information at the same rate (8/day) and with the same period (3 hours) between successive recordings. However, after the interval change, the data logger came on-line 1 hour ahead of schedule.

DISCUSSION

The GPS collars worked for a significantly shorter period than expected and recorded locations 19.5% of the time that fixes were attempted. Collar 3 (A and B) was in the shadow of the largest cliff face in the study area and was assumed to have the most impeded view of the sky, yet it performed better in terms of 3-D and overall fix success, than collars 1 and 2. Collar 3A (which was stationary) produced more 3-D fixes than collars that were on actively moving bears. The success of collar 3A may be explained by the search pattern employed by the GPS units; which appeared to acquire fixes more readily and with greater accuracy if the available satellites were viewed from the same location at the time of each data logging event. Collar 3B had the fastest initial fix time; possibly because it was fitted to a subject that was captured within 200 m of that collars stationary rooftop location.

Collars 1 and 2 were least successful in terms of time to first fix and the number of 3-D fixes. The home range of the bear fitted with Collar 1 was characterized by gentle rolling hills and open forest. The author assumed that Collar 1 had the best exposure to the sky of all GPS collars deployed. The home range of the bear fitted with Collar 2 included some of the most rugged landscape in the study area and had the lowest number of successful fixes. The bears that were fitted with Collars 1 and 2 displayed more variation in daily movement (K. Chaulk unpublished data) and this could account for their lower performance (Moen et al. 1996).

CONCLUSIONS

The cause for collar malfunction was attributed to battery failure; apparently the batteries were unable to deal with energy drain caused by the repeated shut down and re-activation of the electronic system (T. Lewandowski pers. com). The cost of each collar after taxes was over $9,000 for a total of $27,000. The cost of all helicopter flights associated with this study (VHF telemetry, animal relocation, snare checking, etc...) has been estimated at approximately $49,000 (70 hours at approximately $700/hr). Comparisons in the quality and quantity of the VHF and GPS data are difficult and will depend, ultimately, on the objectives of the study. The GPS collars provided very good geographic and activity related information. However the GPS collars failed to live up to advertised expectations. Meanwhile the VHF tracking produced data over a longer period and provided researchers with a means to directly observe animal behaviour and habitat use. A decision to use a GPS system must be carefully made with full appreciation of its limitations.

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Table. 1 Summary of Black Bear GPS Collar Performance June-August 1996.

Collar I.D	Days to First Fix	Days Active	2-D[1] Fixes	3-D[1] Fixes	Total Fixes	Total Attempts	Overall Success (%)
1	9	43	31	19	50	319	15.5
2	9	43	27	13	40	353	11
3A	2	16	6	46	52	95	55
3B	0.5	28	34	25	59	270	22
Total			100	104	204	1037	
$\bar{x}$	5	32.5	24.5	26	50	259	25
Sd	4.5	13	13	14	8	115	20

[1] 2-D and 3-D refer to two dimensional and three dimensional fixes, respectively. 2-D fixes are a function of latitude and longitude, 3-D fixes record altitude as the third dimensional measure, 3-D fixes are considered more accurate and can be differentially corrected for selective availability error when base station information is available.

CHAPTER 2. OBSERVATIONS OF BLACK BEAR (URSUS AMERICANUS) ECOLOGY ON LABRADOR'S NORTHEAST COAST

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Abstract: Black bear (Ursus americanus) research in Labrador has been sparse and little is known about its regional ecology. Recent research conducted as part of the Voisey's Bay environmental impact assessment has changed this trend. Twenty-four black bears were captured, measured, marked and/or radio-collared and tracked in northeastern Labrador during 1996 and 1997. Black bears used sea ice for travel, coastal islands for denning, hunted adult caribou, and were the possible cause of moose calf mortality. Body sizes where similar to those reported for black bears further north in Labrador. The sex ratio of the 24 bears captured and handled was 1:1. The sex of 6 of the 7 known mortalities during 1996 and 1997 were male. Age structure of captured subjects suggested an older population. Female reproductive histories, as determined through cementum annuli analysis suggest delayed sexual maturity. Den entry was first observed during October in 1996; spring emergence occurred between 26 April and 27 May in 1997. Four of 6 radio collared females gave birth during the winter of 1997.

Key Words: black bear, Ursus americanus, Labrador, telemetry, home range, food habits, morphology, denning, Voisey's Bay, environmental assessment.

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Historically, the American black bear (Ursus americanus) has been a commonly studied mammal and over the years many research programs have investigated its ecology. This research has been conducted over a wide array of landscapes, from Atlantic to Pacific, and southern US to northern Canada. These studies have described an animal whose behavior (i.e., denning, foraging, habitat selection, etc) varies with local geography and environment. Although, the black bear has been studied throughout most of its range, it had been virtually ignored in Labrador. This changed in 1989, when a 5 year research program was initiated to document black bear ecology near Hebron Fiord in northern Labrador (Veitch 1994a).

The Hebron bears demonstrated atypical characteristics such as heavy reliance on animal protein, home ranges orders of magnitude larger than bears to the south, and preference for barren habitats, earning them the name "barren ground black bear" (Veitch 1994b). Shortly after the completion of the Hebron study, a large nickel deposit was discovered 190 km to the south, near Voisey's Bay, Labrador. The anticipated development of that deposit, and the associated environmental impact assessment prompted the present study on the ecology and life history of the black bear population of the Voisey's Bay area. This chapter will detail observations made during 1996 and 1997 and describe den sites, den entry, spring emergence, food habits, daily activity, morphology, and demographics.

STUDY AREA

The study area (56^{O} 20' N, 62^{O} 06' W) which comprises over 1600 km^2, approximately 360 km north of Goose Bay, Labrador, is rugged with elevations ranging from 0 to 400 m asl. Land at lower elevations is primarily forested (some wetland), while higher elevations are predominately rock barren. The main forest type is black spruce/lichen (Picea marianna/Cladonia sp.); other common habitat types include bog/fen peatlands, alpine heath, and dwarf birch (Betula glandulosa) thicket (JWEL 1997a). Weather and climate information collected by Environment Canada at the nearby community of Nain show that the mean monthly temperature varies from -19° C in January to 10° C in July, with a mean annual temperature of -3° C. Mean annual precipitation is estimated at 740 mm, with highest monthly rainfall recorded during July (79 mm) and maximum monthly snowfall occurring in January (87 mm). Snow and ice can persist until July (Environment Canada 1989). Day length varies in the study area from approximately 18 hours in June to 16 hours in August. On 25 June sunrise occurs at approximately 03:19 and sets at 21:03 Atlantic Daylight Savings Time (ADST); on 13 August the sun rises at 04:32 and sets 19:53 (ADST), based on an elevation of 400 m. These estimates vary from year to year and with elevation (Environment Canada 1998).

METHODS

Three methods of capture were used. Bait stations (Johnson and Pelton 1980) were established near fresh black bear sign during May 1996. Sites with repeat black bear visits were used as snare locations. Aldrich leg snares (Lindzey 1987) were checked daily and deactivated after each capture event. Culvert traps were used to capture bears that occurred near mineral exploration camps. Culvert traps were not pre-baited, and all bears captured in culvert traps were relocated by helicopter. Aerial darting was conducted from a helicopter following procedures described by Baer et al. (1987). All marked black bears were tranquilized with 4-7 mg/kg of Telazol (White et al. 1996) and were given a penicillin injection to decrease chance of infection. Subjects were monitored for recovery from anesthetic and were revisited 24-30 hours after being tranquilized.

Seven VHF collars (Holohil Inc.) and 3 Global Positioning System (GPS) collars (Lotek Engineering Inc. 1996, see also Moen et al. 1996, Rempel et al. 1995) were fitted on black bears between June and July, 1996. The batteries powering the GPS collars failed during August 1996 (Chapter 1); the bears were recaptured and the GPS collars were replaced with VHF mortality collars (Lotek Engineering Inc.). All collars transmitted in the 150-MHz band. Bears were also marked with Flex-Lok plastic ear tags (Ketchum Manufacturing). Captured bears were aged, weighed, sexed and their reproductive status (Coy and Garshelis 1992, Larsen and Taber 1980) were recorded at the time of capture; measurements were supervised by the author to reduce researcher variation (Eason et al. 1996). Weights were determined using a mobile weight scale. Age was estimated at time of capture based on pelage condition, body size, scarring and tooth wear. A premolar was extracted from each bear and sent to Matson's Laboratory (Montana, USA) for cementum annuli analysis, which were used to determine age and reproductive history (Coy and Garshelis 1992). Sex was determined at capture by size and condition of reproductive organs (i.e. testicles, vulva, mammary glands). The alpha-numeric identifier used in this report was formatted as follows: age class, sex, capture number (i.e., AMB01= adult male bear number 01). This format was chosen so the reader could use the ID tag to discern important demographic characteristics.

Telemetry flights were conducted between 24 June and 15 October, 1996 using a Bell 206B helicopter and followed procedures described by Gilmer et al. (1981), Mech (1983), and White and Garrott (1990). Aerial telemetry was conducted bimonthly; each bimonthly session was approximately 7 days long and radio collared bears were located approximately 3 times each session. Once a signal was localized to a small area (100 m radius), an effort was made to acquire a visual fix. When a visual fix was not possible, the subject's location was estimated. The helicopter's GPS was used to record the location of all observations (both visual and non-visual). Frequency of monitoring flights were reduced after October to one session in late November 1996. Four separate monitoring flights were flown between 10 April and 12 June, 1997. Ground telemetry was conducted when aerial telemetry or animal handling were not in progress.

Food habits were discerned through opportunistic field collection of bear droppings and visual observations of foraging behaviour (Hewitt and Robbins 1996) during ground telemetry. Den sites were located during ground and aerial telemetry. GPS coordinates, structural characteristics, and habitat type were recorded for each den site; occupied dens were not examined for structural characteristics. The timing of den entry and occupancy was determined from monitoring flights during the fall and winter of 1996. Known black bear dens were monitored for activity and emergence during the winter and spring of 1997.

Den sites were assigned to forest, shrub, and barren habitat types based on visual inspection of the surrounding landscape. Forest habitat was any area with canopy height exceeding 1 m, shrub habitat was any area with canopy height less than 1 m, and barren habitat was any non-wetland area with less than 5% canopy cover.

The GPS collars were programmed to record the following information every 3 hours: geodetic coordinate (latitude and longitude), activity count, temperature, time, date, fix status, HDOP (horizontal dilution of precision), and convergence (distribution of satellites above the horizon) (Moen et al. 1996, Rempel et al. 1995) for a total of 8 fix attempts/day. Activity, measured via mercury switch activations, were summed every 10 minutes and averaged every 3 hours to provide a single activity count at the time of data logging. Activity counts, parsed and sorted by time interval and date, were averaged for each bear to produce graphs of mean daily activity. Activity information was collected on 3 adult females using the 3 GPS collars from late June to mid-August.

All data were entered into File Maker Pro for information management and export to various software packages for analysis and desktop publication. GPS locations obtained from the helicopter and handheld GPS units were not differentially corrected and were assumed to have an accuracy of +/-100 m (Moen et al. 1996). The helicopter GPS recorded geodetic data in World Geographic System (WGS) 84 Latitude/Longitude, and were converted to Latitiude/Longitude, North American Datum 83 using MapInfo (1997a,b).

RESULTS

There were a total of 44 capture events of 23 black bears (11 were captured on more than 1 occasion) between June and November, 1996 (Table 1). Twenty black bears were marked with ear tags and/or radio collars, but no more than 10 radio collared bears were active at any given time. Culvert traps and leg snares accounted for 27 and 9 captures respectively, one bear was darted from helicopter (Table 1).

Forty-nine black bears were identified throughout the study area during 1996 and 1997; 23 were marked and 26 were unmarked. Of the 23 marked bears: 10 were male, 10 were female and 3 were of undetermined sex; 13 were adult, 8 were sub-adult and the ages of 2 were unknown. Of the 26 unmarked bears, 25 belonged to 7 distinct family groups, of these 7 were adult females, 18 were cubs. One bear was identified based on distinct pelage (50% blonde) no other bears were observed with this much non-black coloring. The mean ages of marked male and female bears at capture were 7 and 8 years, respectively. The oldest bear as determined from cementum analysis, was a 23 year old male (Table 1).

Four bears in the study set were shot by mining camp and department of wildlife officials in 1996: 2 were collared (AMB01 and SMB10), 1 was tagged (UUB19), and 1 was unmarked (UMB17). Three bears died during 1997: SFB16 (natural causes), SMB13 (shot by hunter), and SMB10 (shot by camp officials) (Table 1). Six of these 7 known mortalities were males. A post-mortem examination of AMB19 by the veterinary college in Prince Edward Island showed that the bear had previously been shot and had been suffering from lead poisoning for approximately 6 weeks prior to its death (F. Phillips pers. comm.). No black bears died as a result of capture or handling by the study team.

Two of 10 females were in estrus at the time of capture (AFB02 and AFB04). Two opposite-sex pairs of black bears were observed together for extended periods during July 1996 (AFB02 and AMB19; AFB06 and AMB01). Only 1 collared bear (AFB07) was actively caring for cubs during 1996; this family group was still intact at the time of emergence in 1997. According to reproductive histories compiled from cementum analysis, only AFB06 had given birth prior to 1996, at ages 6, 9, and 11 years, AFB06 also produced cubs for the fourth time at the age of 14 during the winter of 1997.

Radio tracking during the spring of 1997 showed that 4 collared females (AFB02, AFB06, AFB08, and AFB09) gave birth during the winter of 1997: AFB08 had 3 cubs, and AFB02, AFB06 and AFB09 produced 2 cubs each (Table 3). Of the 5 females for which reproductive histories were known, earliest and oldest age at first litter were 6 and 10 years, respectively. Incidental observations during 1996 identified 7 other distinct family groups within the study area. There were 25 bears in these 7 groups: 7 adults and 18 cubs. Five groups had 3 cubs each, while 2 groups had 2 cubs each. A total of 30 cubs was observed in 12 family groups during 1996 and 1997 (Table 3).

Between June and October 1996, weights and physical measurements were recorded for 20 bears. Weights ranged from 27 to 130 kg, ($\bar{x}$ =65 kg, n=23); some bears were measured on more than one occasion. One adult male and 3 adult female black bears were measured twice, between June and August, 1996, over which time all

3 bears gained 12-25 kg each. Median weight for these bears in June was 50 kg, median weight for the same bears in August was 69 kg, this represents a 38% increase in body weight, while median neck size and chest girth both increased by an average of 11% and 7% respectively for the same period. Total body length showed less change over the same period (Table 5).

Eighteen den sites, 7 in forest, 5 in shrub thicket, and 6 in barren were located during 1996, then entrance to all dens faced south or southwest (Table 6). Eight dens were unoccupied and were located prior to the start of fall denning; 10 additional dens were located after initiation of denning. Five of the 6 adult females selected higher elevation barren areas for den sites and 1 selected lower elevation forest (Table 6). Three of the radio collared females entered dens by mid-October, 1996. A mother with 2 cubs (AFB07) left her initial den site in late October and moved to a second den site. Four other bears (3 females and 1 male) entered their dens by late November, while 2 bears, AFB09 and AMB18 were still active on December 1, 1996 (Table 6).

In 1996, personnel associated with the Voisey's Bay mining exploration reported observing one black bear in March, and made regular reports of black bears by May. During May and June 1996, the study team observed 3 incidence of black bears walking on sea ice up to 2 km from shore. Monitoring flights conducted in 1997 found that all radio collared bears had emerged from their dens between 27 April and 27 May, 1997.

Field analysis of black bear scats showed a that scats were regularly composed of more than 90% berries (Empetrum sp., Arctostaphylos sp., and Vaccinium sp.) from June to mid-July, scat composition gradually changed to 90% green plant matter component between mid-July and mid-August. From mid-July to late-August black bears were observed on a number of occasions feeding on grass and seaweed (Fucus sp.). By late-August, scat composition changed again and berries once again became the main component. Barren habitats appeared to be the most productive areas for berries throughout the year. By mid-October, however berries were inaccessible in some areas due to snow cover, no scats were found in the field after mid-October.

Two incidences of ungulate predation/scavenging by black bears were observed during 1996. The first incident occurred in April and involved an unmarked adult male black bear attacking an adult caribou (Rangifer rangifer), which later died from its wounds and was eaten by the bear. This incident was photographed (Figure 1) by camp personnel (W. Montague, pers. comm.).

The second incident occurred during an attempt to dart a black bear from a helicopter on the Ikadlivik river in June 1996. The black bear was observed retrieving a dead moose calf (Alces alces) near the river bank, it then proceeded to run, approximately 50m, with the carcass in its mouth, then dropped the carcass and ran into the forest. An adult female moose was seen within 200 m of the carcass. The carcass was retrieved, and closer examination revealed that the calf had recently died and had been partially eaten.

Other evidence of ungulate predation was found in a number of black bear scats. One scat contained 95% Cladonia sp., with intermittent bone shards. The remains of a dead caribou were found near the location of this scat, suggesting the bear had scavenged the caribou's stomach contents (i.e., the source of the Cladonia). Approximately one dozen old bear scats composed of more than 90% caribou fur were found throughout the summer of 1996. Small mammal densities were low during 1996 (JWEL 1997b) and little evidence of this potential food source was found in bear scats. Local river systems were walked to determine whether black bears were fishing during 1996. The study team observed 2 black bears that appeared to be fishing, although the team was unable to determine if fish were caught. Although arctic char (Salvinus alpinus) were plentiful in study area rivers (JWEL 1997c), no fish bones or scales were found in bear scats.

Activity data from the 3 collars were averaged and graphed to represent mean daily activity (Figure 2). Lowest activity occurred at 23:00 hours, just after sunset, while peak activity was observed at 17:00 hours. Activity was relatively constant across all other time intervals. The 95% confidence intervals for the median of the data show similar pattern in daily activity (Figure 2).

DISCUSSION

In 1996 and 1997, 49 black bears were identified in the study area. Of the 23 bears that were captured in the study area during 1996, 10 were male, 10 were female, and 3 were of undetermined sex. Seven had died by 1997, and of these, 6 were male. Of these 6 males, 5 mortalities resulted from human-bear interaction at Voisey's Bay mineral exploration facilities. Although, no estimates for the local black bear population were obtained, due in part to the short time frame of the study, black bear density in the study area appeared to be high. The study did, however, record other aspects of local bear ecology such as home range size, denning period, and food habits.

Human-bear interactions often result in the destruction of bears during developments in the north (Bromley 1985, Follmann and Hechtel 1990). Although nuisance bears were a problem at Voisey's Bay camp in 1996 and 1997, there were no known bear mortalities at camp facilities in 1998 (P. Blanchard pers. comm.).

A black bears diet varies with season, geographic location (Holcroft and Herrero 1991) and human activity (Craighead and Craighead 1971), leading some researchers to characterize them as omnivores (i.e., Banfield 1974) and others to characterize them as vegetarians (Kolenosky and Strathearn 1987). In Alberta, black bears fed on green plant matter and insects during the spring, added raspberry (Rubus idaeus) and horsetail (Equisetum sp.) to their diet in the summer, and turned to berries and insects during the fall (Holcroft and Herrero 1991). In New Brunswick, bears fed on grasses in the spring, and switched to blueberry (Vaccinium angustifolium) and raspberry in late summer (Zytaruk 1978). In insular Newfoundland, black bears have been found to feed on green plant matter, berries and animals (Day 1997, Mahoney 1985, Payne 1975). In northern Labrador, small mammals were a common component in the barren ground black bears' diet; green vegetation and berries were also important (Harrington 1994). Schwartz and Franzmann (1989) found that black bears in Alaska accounted for 80% of moose predation and 70% of moose mortality; however, even there, moose predation provided only a small proportion of the overall black bear diet.

Opportunistic field analysis of black bear scats in this study during 1996 revealed that black bears were mainly vegetarians. Berries were the main dietary component in late spring; residual berries were abundant on the barrens during the initial collaring in June, and almost all fresh black bear scats encountered during this period were composed of berries and associated plant matter. By mid-July, berries appeared to become scarce and green plant matter became the main food source. Green plant matter was readily available in most habitats throughout the study area. Berries became more common in scats as fall progressed. The high dietary plant component of the summer diet was similar to black bear food habits in other regions, although the noticeable lack of insects in the scats was not compatible with findings in other areas of Canada.

Two incidental observations of ungulate predation/scavenging during 1996 corroborate findings in Alaska (Schwartz and Franzmann 1989), Labrador (Veitch and Krizan 1994), and Newfoundland (Dennis et al. 1996). No small mammal remains were found in black bear scats during 1996; small mammal numbers were reported to be low in the study area in 1996 (JWEL 1997b). There were also no observations of black bears successfully catching fish in the study area in 1996, although black bears were seen fishing on 2 occasions. Black bears were suspected of killing some radio tagged fish in the study area, but these mortality could also have been caused by river otter (Lutra canadensis) (JWEL 1997c).

Black bears usually den between September and November (Rogers 1970, Lindzey and Meslow 1977, Tietje and Ruff 1980, Harrington 1994, Schooley et al. 1994) and den entry may be affected by food availability, photo-period, temperature, snowfall, gender, pregnancy and body weight (Craighead and Craighead 1971, Tietje and Ruff 1980, Klenner and Kroeker 1990, Schooley et al. 1994). This agrees with what observations in the study area, as most bears entered their dens after the first snowfall in October and almost all were in their dens by November. Pregnant females are reported to den earlier than other females (Klenner and Kroeker 1990), but this was not substantiated in this study area.

In northern areas where large hollow trees are uncommon, bears tend to use excavated dens which they line with plant material (Fuller and Keith 1980, Tietje and Ruff 1980, Klenner and Kroeker 1990). All dens in the Voisey's Bay study area were excavated and none made use of pre-existing structures (i.e., caves, hollow trees). Tietje and Ruff (1980) concluded that the proportion of bears excavating dens is linked to lower winter temperatures and the need for increased insulation. Dens in the study area were found in three habitat types: spruce forest (Picea sp.), shrub thicket and the barrens. One bear left the mainland in late summer and took up residence on a large coastal island where it denned for the winter underneath a shrub thicket. All dens within the forest and shrub thickets were excavated. The den roofs were often supported by the root systems of the adjacent vegetation. The entrance to all dens faced south or southwest, possibly to minimize exposure to north winds and increase exposure to sunlight and were found in slightly elevated areas, possibly to reduce the chance of flooding during spring melt. Barren ground female black bears show a preference for denning at higher elevations (Harrington 1994). In the Voisey's Bay study area, 5 of 6 females denned at higher elevation in barren areas. The author speculates that female black bears in Labrador may den at higher elevations to avoid heavy snow cover. This denning strategy would allow females early exit to replenish fat supplies, if additional food reserves were required to feed new born young.

Schooley et al. (1994) reported that females often construct dens within the confines of their summer ranges. In Alberta, Tietje and Ruff (1980) reported that males often used den sites far removed from their summer range. Analysis of MCP's based on GPS collar data showed that at least half of the females in the study set denned in their summer home range (unpublished data). Spring emergence for bears in the study area occurred between 26 April and 27 May 1997, this is similar to emergence periods reported elsewhere (Fuller and Keith 1980, Harrington 1994, Schooley et al. 1994). Some researchers have reported that dens may be used repeatedly by the same bear (Tietje and Ruff 1980), and although the short duration of this study did not allow the authors to detect such behavior, two unoccupied dens were found with signs of recent use by porcupine (Erithizon dorsatum).

Black bears can range from 57 to 272 kg with males about a third larger than females in a given area. The largest black bear found in North America came from Manitoba, Canada and weighed 365 kg (805 pounds) (The Bear Den 1998). Subjects from our study area were considerably smaller with the largest male weighing 125 kg. The mean weight of adult females in early July was 54 kg. Our weights are similar to those reported in northern Labrador (A. Veitch pers. comm.). Three adult females were weighed twice during 1996, once in late June and again in mid August. The median weight gain was 22 kg, typical for black bears as they build up fat reserves for the on-coming winter.

Black bear productivity in the study area seemed quite high. Nineteen cubs from 8 different family groups were observed in the study area between June and December 1996. Three of 6 adult females collared in 1996 produced cubs in 1997.

The productivity of bears in the Voisey's Bay area is similar to that reported by Klenner in Manitoba, but much higher than the productivity reported by Veitch (pers.comm.) in northern Labrador. Age structure of captured bears suggest an older population (i.e. low adult mortality) and female reproductive histories as determined through cementum annuli analysis, suggest delayed sexual maturity. Both of these factors may be indications that the population is stable, and near carrying capacity (Begon and Mortimer 1986).

Daily activity patterns arise in a response to seasonal and diurnal variations in the environment (Nielsen 1983). Black bears are generally considered diurnal, a view substantiated by Armstrup and Beecham (1976) in Idaho, Lindzey and Meslow (1977) in Washington, and Lariviere et al. (1994) in Quebec. Lariviere et al. (1994) found that black bears from Gaspesie National Park commenced daily activity approximately 0.5 hours after sunrise, and ceased activity approximately 2.5 hours after sunset. These results are similar to those observed in this study area. The activity sensors revealed greatest activity at 5:00 pm, with least activity near sunset. Unfortunately the short life span of the collars prevented analysis across seasons.

CONCLUSIONS

Despite its status as a game animal, the black bear in Labrador, has received little attention from wildlife managers. There are no scientifically valid data to verify the belief held by the public that the black bear population in Labrador is stable, or possibly increasing. In 1996 and 1997, the local black bear population was very productive, but this productivity may have been offset by high adult and sub-adult mortality. Although the number of reported cases of human-induced bear mortality appeared to decline in 1997, human/bear conflicts continue. With many growth industries (i.e., hydro, forestry, mining, and tourism) on Labrador's economic horizon, a population census would provide an invaluable baseline on the status of this species.

PERSONAL COMMUNICATIONS

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Table 1. Capture Information for Black Bears in the Voisey's Bay, Labrador study area, 1996-1997

ID	Age	Sex	No. Captures	Culvert Trap (96)	Leg Snare (96)	Air Dart (96)	Deaths (96)	Deaths (97)	Comments
SMB00	3	M	3	3					First bear ear tagged
AMB01*	10	M	3	1	1		1		Destroyed**
AFB02*	7	F	3	1	1	1			GPS collar replaced August (96)
AFB03*	7	F	1		1				GPS collar fell off June (96)
AFB04*	6	F	2		2				GPS collar replaced August (96)
AMB05	8	M	1	1					Disappeared June (96)
AFB06*	13	F	1	1					
AFB07*	10	F	1		1				
AFB08*	6	F	3	2	1				GPS collar replaced August (96)
AFB09*	8	F	2	2					
SMB10*	2	M	3	2				1	Destroyed**
SMB11	3	M	2	1			1		Destroyed**
AFB12*	16	F	4	4					
SMB13*	2	M	2	1				1	Killed ***
SFB14	3	F	1		1				
SMB15	3	M	1		1				
SFB16	4	F	3	2				1	Died ****
UMB17		M	1				1		Unmarked, Destroyed**
AMB18*	23	M	1	1					Last bear collared, oldest bear
AMB19	9	M	3	2			1		Lead poisoned, Destroyed**
SB-A20	4		1	1					First bear captured, not marked
SB-A21	3		1	1					Captured by camp officials
UB-V22			1	1					Captured by camp officials
Count	21	20	23	17	8	1	4	3	
Sum			44	27	9	1	4	3	
Median	6		1						
$\bar{x}$	7		2						
Sd	5		1						
Min	2		0						
Max	23		4						
Range	21		4						

* Ages based on cementum annuli; **destroyed by camp officials; ***killed by local hunters;
**** died of natural causes

Table 2. Black Bear Demographics for the Voisey's Bay, Labrador study area 1996-1997 .

	Sex			Age Class		
	Male	Female	Unknown	Adult	Sub-adult[1]	Unknown
Marked	10	10	3	13	8	2
Unmarked		7	19	7	18	1

[1] All bears less than 5 years old, includes cubs.

Table 3. Black Bear Productivity in the Voisey's Bay, Labrador study area, 1996 and 1997.

ID	Age (96)	Cubs (96)	Cubs (97)	Age at first birth[1]	Comments
AFB02	7		2	8	In estrus June (96)
ADB04	6				In estrus June (96); non-productive (96-97)
AFB06	13		2	6	Cubs at age 6,9,11, & 14
AFB07	10	2		10	Two cubs at time of capture in June (96)
AFB08	6		3	7	
AFB09	8		2	9	
Unmarked		3			
Unmarked		3			
Unmarked		3			
Unmarked		3			
Unmarked		3			
Unmarked		2			
Unmarked		2			
Count	6	13	4	5	
Sum		21	9		

[1] Age at first birth determined through analysis of cementum annuli (Coy and Garshelis 1992).

Table 4. Summary of average physical measurements for black bears, near Voisey's Bay, Labrador 21/06-19/10, 1996.

Measurement Period	Sex	N	Age		Weight (kg)		Neck (cm)		Chest (cm)		Head (cm)		Body Length (cm)	
			$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
June-July	F	6	8	3	54	11	53	4	89	8	31	2	156	6
July-August	F	5	9	4	61	13	56	4	85	5				
June-August	M	5	3	1	55	15	47	6	79	8	30	2	150	17
June-October	M	5	12	6	111	16	66	5	106	5	36	2	188	8

Table 5. Percent change[1] in physical measurements of 4 black bears from the Voisey's Bay, Labrador, study area between 21/06-27/08, 1996.

ID	Age	T1-T2[2]	Weight (kg)	Neck (cm)	Chest (cm)	Length (cm)
AFB02	7	67	50 (25)	13 (7)	2 (2)	
AFB04	6	55	38 (17)	28 (13)	7 (5)	3 (5)
AFB08	6	38		5 (2)	8 (7)	5 (8)
AMB01	10	56	14 (12)	10 (6)		2 (3)
median	7	56	38 (17)	11 (7)	7 (5)	3 (5)
$\bar{x}$	7	54	34 (18)	14 (7)	6 (5)	3 (5)
sd	2	12	19 (7)	10 (5)	3 (3)	2 (3)

[1] All changes were positive, percent change for each variable were calculated by dividing absolute change by first measurement of the season (not shown), percent values are the first value in the column and absolute values for change are shown in brackets.

[2] Represents the number of days between measurement 1 (T1) & measurement 2 (T2).

Table 6. Den Information for black bears in the Voisey's Bay, Labrador study area, 1996-1997.

ID	Habitat	Approximate Den Entry (1996)	Approximate Emergence (1997)	Comments
AFB02	Forest	11/29	05/27	
AFB04	Barren	10/18	05/27	
AFB06	Barren	10/17	05/27	First bear to den in '96
AFB07	Barren	10/18		Moved to 2nd den by 11/04/96
AFB07	Barren	11/04	05/27	Stayed in this den for rest of winter
AFB08	Barren	11/29	04/26	First bear to emerge in '97
AFB09	Forest	11/03	05/27	Moved to 2nd den during the winter
SFB16	Barren	11/04	05/27	Died shortly after emergence
SMB10	Shrub	11/29	05/27	Denned on Kikkertavak Island
AMB18	Shrub		06/12	Still active on 11/30
Unoccupied Den	Forest			
Unoccupied Den	Forest			
Unoccupied Den	Forest			
Unoccupied Den	Forest			
Unoccupied Den	Forest			
Unoccupied Den	Shrub			
Unoccupied Den	Shrub			
Unoccupied Den	Shrub			
Count	18	9	9	
Range (Days)		43	47	

Figure 1 Adult black bear attacking caribou, near Voisey's Bay in 1996.

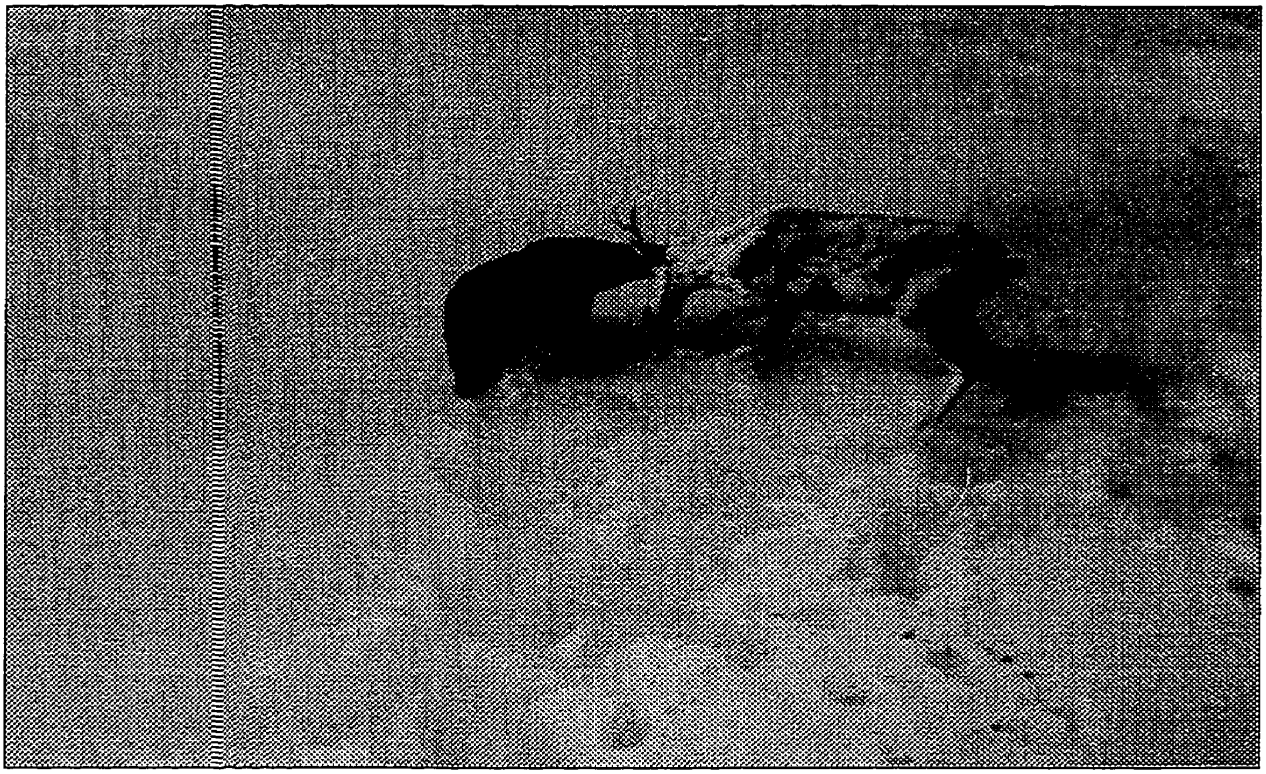
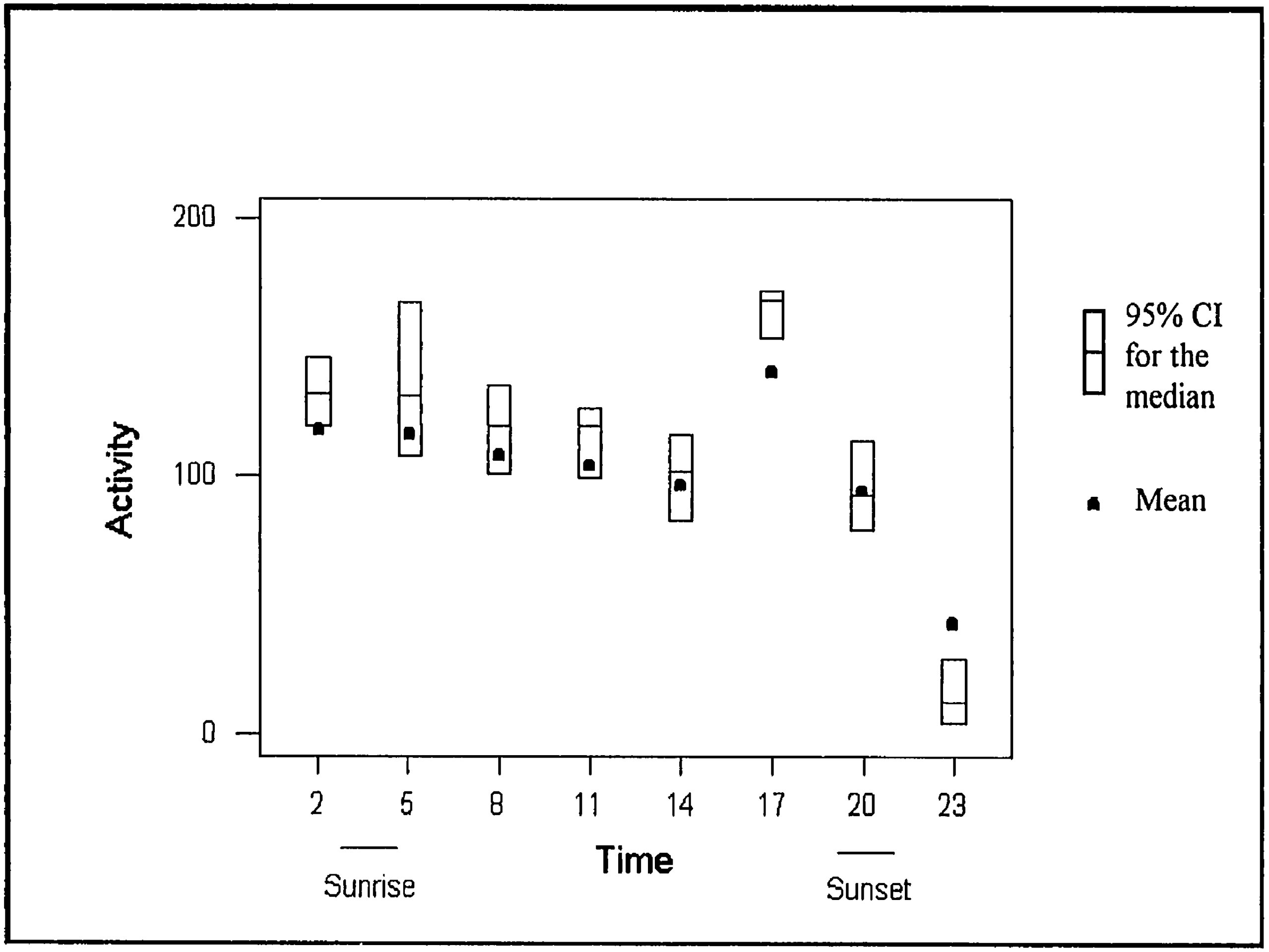


Photo courtesy of Wayne Montague

Figure 2. Mean daily activity of three female black bears near Voisey's Bay, Labrador June-August 1996.



CHAPTER 3. CALCULATING BLACK BEAR (URSUS AMERICANUS) MCP: EVALUATING TRANSLOCATION, HOMING, POINT REMOVAL AND SAMPLE SIZE

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Abstract: Ten black bears were tracked near Voisey's Bay, Labrador, using VHF and GPS telemetry during the summer and fall of 1996. Eight subjects were translocated during this study, and in an attempt to reduce the effects of these artificial outliers, location information was parsed and sorted by point removal treatments which were based on 5 post translocation time categories. Locations from each treatment were randomly selected at various levels of N, and used to generate approximately 1100 Minimum Convex Polygons (MCP). One-way ANOVA with Tukey's post hoc test for multiple comparisons and two-way ANOVA were used to detect differences due to point removal. Asymptotic non linear regression was used to determine if location sample size was sufficient to estimate MCP. Sample size was considered sufficient to estimate MCP for 2 subjects, and was borderline for 3 other subjects. Data suggest that post translocation point removal and random sampling can: a) reduce the effects of artificial outliers and b) detyermine if sample size is sufficient to estimate MCP.

Key Words: black bear, Labrador, telemetry, MCP, Range Manager, sample size, asymptote, translocation, geodetic outliers, point removal.

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Home range is typically defined as the area used by an individual during routine activities such as feeding, mating, and rearing young (Burt 1943, Samuel and Garton 1985, Larkin and Halkin 1994). Efforts have been made to standardize home range estimation procedures and a number of methods are currently available, including harmonic mean (Dixon and Chapman 1980), adaptive kernel (Worton 1989), minimum convex polygon (Mohr 1947), and bivariate normal ellipse (Jennrich and Turner 1969). All of these methods are found as functions within various computer programs (Larkin and Halkin 1994, Range Manager 1998), each producing slightly different size estimates (Larkin and Halkin 1994). So while home range measurements are often cited as a comparative measure within a species, the lack of standardization can often lead to arbitrary results (Schoener 1981). Although a number of authors have attempted to describe home range software (Larkin and Halkin 1994) and explore the mathematics behind estimation procedures (Van Winkle 1974, Samuel and Garton 1985); unfortunately, some of these models are very complex. For many, the minimum convex polygon (MCP) is the most intuitive home range estimator, and MCP is commonly reported for species such as black bear (Mares et al. 1980, Tietje and Ruff 1980, Young and Ruff 1982, Brody and Pelton 1989, Dennis et al. 1996, Day 1997, Chamberland 2000). However MCP has a number of drawbacks including sensitivity to geodetic outliers (Schoener 1981, Samuel and Garton 1985) and location sample size (Van Winkle 1974, Bekoff and Mech 1984).

After a review of the limitations of home range estimation, the author decided to quantify the effects of those factors most likely to have influenced MCP home range calculation for the current black bear data set. In 1996, 8 of 10 radio collared black bears were translocated after they had interacted with mineral exploration camps in the study area. Given that black bears possess the ability to home (McArthur 1981, Rogers 1986), the author attempted to minimize the artificial inflation of MCP by systematically removing location data at discreet time intervals following each translocation event. This exercise produced several point removal treatments for each bear. Multiple random samples at various levels of N were drawn from these treatments, and MCP's were calculated based on this random sampling. If homing had occurred and translocation events affected home range estimation the author predicted that as the time interval following translocation increased, MCP would decrease and stabilize, indicating that inflation due to translocation had been reduced.

In addition to investigating the effects of translocation, the author evaluated the effects of location sample size on MCP. It has been suggested that $N \geq 30$ are required to estimate MCP (Mech 1983, Klenner 1987) while others have suggested that N can inflate estimates (Van Winkle 1974, Bekoff and Mech 1984). Given that $N=30$ is commonly used as a threshold for MCP estimation, the author asked if MCP could be reasonably estimated at $N < 30$ and if so, what method could be used to gauge the accuracy of MCP. The author used data generated during the point removal procedure, and calculated 95% asymptotes for each point removal treatment. If location sample size was greater then the calculated value (i.e., 95% asymptote), then home range was assumed to have been accurately estimated.

STUDY AREA

The study area (56° 20' N, 62° 06' W) of over 1600 km^2, was rugged with elevations ranging from 0 to 400 m above sea level. Land at lower elevations was primarily forested (some wetland), while higher elevations were predominately rock barren. The main forest type was black spruce/lichen (Picea marianna/Cladonia sp.); other commonly found habitat types included bog/fen peatlands, alpine heath, and dwarf birch (Betula glandulosa) thicket (JWEL 1996). Weather and climate information collected by Environment Canada from the nearby community of Nain indicated the following normals: mean monthly temperature of -19° C in January to 10° C in July, with a mean annual temperature of -3° C. Mean annual precipitation is estimated at 740 mm, with highest monthly rainfall recorded during July (79 mm) and maximum monthly snowfall occurring in January (87 mm). Snow and ice can persist in the study area as late as July (Environment Canada 1989).

METHODS

Black bears were captured using leg snare, culvert trap and aerial darting between June and October, 1996. Black bears captured in culvert traps near mineral exploration camps were translocated using helicopter and sling. Seven VHF collars and 3 Global Positioning System collars were fitted on black bears between June and September, 1996. Telemetry flights were conducted every 2 weeks between 24 June and 15 October, 1996. Bimonthly sessions lasted approximately 7 days and subjects were located 3 times each session. The frequency of monitoring flights was reduced after 15 October 1996, with only two sessions through November, 1996. Ground telemetry was conducted when aerial telemetry or animal handling were not in progress. Alpha-numeric identifiers were assigned to individual bears using the following format: age class, sex, capture number (i.e., AMB01= adult male bear number 01).

Location data were parsed and sorted by bear ID, date and time and grouped into point removal treatments: MZ = all data used, MT = translocation point omitted, M24 = points 24 hours post-translocation omitted, M48 = ..., and M72. Serial numbers were assigned to the location data in each treatment and these were randomly sampled with replacement using a uniform probability distribution producing 6 random subsets/ per N_i, where N_i = 5, 10, 15, 20, 25, 30, 40, 50, and 60 these were run through RANGE MANAGER, a MAPBASIC shareware application, with MCP set at 100% (Range Manager 1998). Error in sampling procedure (i.e., sampling with replacement) was recognized after the majority of home ranges were calculated, and actual sample sizes were determined post hoc. Effect of point removal treatment on MCP were tested within-subject using MINITAB's one-way ANOVA with Tukey's post-hoc test for multiple comparisons. Effects of treatment were also tested across subject using a general linear model (MINITAB two-way ANOVA) with treatments MZ, MT, and Mmax, where Mmax was equivalent to the maximum point removal category for a given subject (i.e., AMB01 Mmax = M24, AFB02 Mmax = M72). A $\log_{10}$ transformation was applied to stabilize the variance of the residuals from the general linear model. Effects of location sample size (N) were tested in SPSS using a non-linear asymptotic regression model of the form

$$hr = b_1(1 - e^{(-N/b_2)})$$

In this model, the parameter b_2 is interpreted as 1/3 of the sample size necessary to reach approximately 95% of the asymptotic home range (Cressie, 1991). The reader should note that a number of asymptotic models were applied to fit the data, and Acadia's consulting statistician recommended use of $hr = b_1(1 - e^{(-N/b_2)})$ (Cressie 1991).

Homing behaviour and rates of return to capture site were calculated based on translocation distance information and re-sighting period. Homing was assumed to have occurred when a bear returned to an area within 1 km of initial capture location. return rates were estimated for 10 subjects, 7 of which were radio collared.

RESULTS

Between June and November, 1996, there were 44 capture events in the study area, involving 21 black bears, 15 of which were translocated a total of 25 times. Known homing periods were calculated at least one time for 11 subjects (Table 1). Estimated return periods from translocation point to capture site ranged from 1-55 days ($\bar{x}$= 18 days, sd = 19 days); return rates varied from 0.5 km/day to 6.5 km/day ($\bar{x}$ = 3 km/day, sd = 2 km/day) (Table 1). Location information was collected throughout the duration of the study with the majority of observations occurring in July and August 1996 (Table 2). The majority of locations were collected in June and July ($\bar{x}$ = 28), with the fewest locations collected in October and November ($\bar{x}$ = 6). The number of locations per animal ranged from 15-104 ($\bar{x}$ = 46, sd. = 32). In total, 1080 MCP's were calculated for 10 subjects ($\bar{x}$ = 108, sd. = 77, range 39-271) (Table 2).

Mean home range size in response to location sample size and treatment was graphed for some subjects to illustrate the relationship between point removal and location sample size. AMB01 (Figure 1) was a translocated bear and visual analysis suggest neither decline in MCP due to point removal nor stabilization of MCP due to location sample size. AFB02 (Figure 2) was also a translocated bear, although visual analysis does not suggest decline in MCP due to point removal, MCP appeared to stabilize at middle values of location sample size. AFB04 and AFB07 (Figure 3) were not translocated. Visual analyses suggests that MCP stabilized for AFB04, but not AFB07. Visual analysis of AFB06 (Figure 4) suggests a decline in MCP due to point removal and stabilization of MCP due to location sample size.

Two way ANOVA was performed using a general linear model to test for total differences due to point removal ($F = 9.53$, $DF = 2$, $p = 0.003$). One way ANOVA with Tukey's test for multiple comparisons was used to evaluate the effects of point removal within subject. Six subjects showed statistically significant declines due to point removal (Table 3). Asymptotic non-linear regression was used to evaluate the effects of location sample size, and the estimates of the 95% asymptote are presented in Table 4. Two subjects (AFB02 and AFB04) had location sample sizes greater than the 95% asymptote. Three subjects (AFB06, AFB08, and AFB09) had actual location sample sizes that fell within the lower limits of the 95% CI for the 95% asymptote. The remaining subjects had actual sample sizes below the estimated 95% asymptote and associated 95% CI (Table 4).

DISCUSSION

Homing was observed in most translocated subjects, the data support the idea that homing is common in black bears and explains why translocation is not viewed as an effective method of bear control (McArthur 1981, Bromley 1985, Follmann and Hechtel 1990). The homing behaviour illustrated by subjects in the study set, led the author to attempt to quantify the effects of translocation on home range.

To address the issues of translocation, homing and home range estimation the author systematically removed location data at discreet time intervals following each translocation event. Similar procedures have been used by researchers to evaluate the accuracy of home range estimates (Bekoff and Mech 1984, Seaman et al. 1999). By selecting multiple random samples from each treatment and using these random samples to calculate multiple MCPs, location sample size was constant within-subject and across treatments. Two-way ANOVA suggested that point removal does significantly deflate MCP. One-way ANOVA using Tukey's post hoc multiple comparisons revealed that point removal deflated MCP estimates for 6 subjects. Tukey's multiple comparison suggest that declines were not likely to continue in 5 subjects. ANOVA provided no mechanism to determine if the mean MCP's were accurate, or if location sample size was sufficient to estimate home range.

To ascertain whether location sample size was sufficient to estimate MCP home range, the author used a non-linear asymptotic regression model. This analysis produced a 95% Confidence Interval for the 95% asymptote. If actual sample size approximated the 95% asymptote then location sample size was assumed to be sufficient to estimate home range. The reader should note that other values of the asymptote could have been used (i.e., 90% asymptote); the author employed the SPSS default value (i.e., 95% asymptote). The asymptotic estimates of sample size reported here are substantially below those reported elsewhere (Laundre and Keller 1984, and Bekoff and Mech 1984), where location sample size of several hundred were suggested as necessary to estimate MCP home range.

Based on the results from the non-linear regression model it appeared that two translocated bears had sufficient location sample size to estimate home range, while three translocated bears subjects were borderline. When more than one point removal treatment approximates the asymptotic value for location sample size, the investigator may be required to make a subjective judgement as to which treatment to use to calculate MCP, taking into account what question is being asked. For example, if home range is to be used as a basis for habitat selection (McCall 1979), the investigator may want to maximize the number of locations. Furthermore using mean home range size as a measure of behaviour may preclude the use of home range shape (i.e., shape is difficult to average), and shape may be important when investigating habitat use in relation to landscape characteristics.

CONCLUSION

Many factors can influence black bear home range estimation, including gender, geographic location, resource availability, and population density (Harrington 1994, Klenner 1987, Fuller and Keith 1980). The analyses presented in this paper did not consider these factors. The results from the analyses suggest that no specific number or threshold value exists for estimating MCP, and given the number of variables that one must consider when calculating home range area (i.e., age, sex, topography, habitat, population density, location error, computation method), it may be impossible to describe home range consistently. The author calculated approximately 1100 MCP's, and in essence he could have chosen any single MCP as a home range estimate for a given subject. MCP results varied considerably within subject, and since there is no accepted method to determine which data set to use, any single MCP estimate could have been justified as correct (or argued as incorrect). This leaves the door of criticism wide open, and the reproducibility of results may be nearly impossible with single data set home range estimates.

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Table 1. Summary of black bear capture, translocation and homing in the Voisey's Bay, study area during 1996.

ID	No. Captures	No. Translocations	Translocation Date	Translocation Distance (Km)	Known Return Period to Capture site (days)[1]	Rate of Return Km/day
SMB00	3	3	06/19	1	1	1
			08/19	30		
			10/08	26		
AMB01[2]	3	1	08/02	13	2	6.5
AFB02[2]	3	1	07/29	31	6	5.17
AFB03	1					
AFB04[2]	2					
AMB05	1	1	06/23	25		
AFB06[2]	1	1	06/23	12	22	0.55
AFB07[2]	1					
AFB08[2]	3	2	07/10	12	5	2.4
			08/22	23	8	2.88
AFB09[2]	2	2	07/31	16	10	1.6
			08/11	56		
SMB10[2]	2	2	07/31	13	4	3.25
			08/31	52		
SMB11[2]	2	1	08/01	20	55	0.36
AFB12	4	4	08/01	27	7	3.86
			08/08	56	9	6.2
			08/18	32	33	0.97
			09/20	42		
SMB13	1	1	08/02	26		
SFB14	1					
SMB15	1					
SFB16[2]	2	2	08/26	26		
			10/05	18		
UMB17	1					
AMB18	1	1	10/21	13		
AMB19	3	2	08/27	35	48	0.73
			10/18	23	46	0.5
SUB20	1	1	06/19	18		
Count	21	15			14	14
$\bar{x}$	2	1			18	3
Median	2	1			9	2
Sd	1	1			19	2
Range	1-4	1-4			1-55	0-7

[1] Based on estimated return date to capture site, some subjects may have returned sooner than indicated.
[2] Radio collared subjects

Table 2. Summary of location and MCP home range data based on radio collared black bears, tracked using VHF and GPS telemetry in the Voisey's Bay study area during 1996. Random MCP were generated based on random sampling of treatment. The number of non-random MCP is equivalent to the number of Point Removal treatments for each subject.

ID	No. Locations (N)				No. MCP Generated			
	Total	Period			Random		Non-Random	Total
		Jun-Jul	Aug-Sep	Oct-Nov				
AMB01	15	6	9		36		3	39
AFB02	94	58	29	7	266		5	271
AFB04	72	50	18	5	60		1	61
AFB06	38	14	17	7	119		4	123
AFB07	37	37	24	6	64		2	66
AFB08	104	52	43	9	219		4	223
AFB09	26	3	17	6	75		4	79
SMB10	22	2	15	5	72		4	76
SMB11	27		23	4	63		3	66
SFB16	22		16	6	72		4	76
Count	10	8	10	9	10		10	10
$\bar{x}$	46	28	21	6	105		3	108
Median	32	26	18	6	72	4	4	76
Sd	32	24	9	1	76	1	1	77
Min	15	2	9	4	36	1	1	39
Max	104	58	43	9	266	5	5	271
Range	89	56	34	5	230	4	4	232

Table 3. Summary of one-way ANOVA (Tukey's multiple comparisons) [1] of black bear MCP home range estimates by point removal treatment and subject. Treatments MZ, MT, M24, M48, M72 were based on post translocation point removal. MZ = no data points removed, MT = translocation point removed, M24 = all points 24 hours after a translocation removed, M48 =..., M72, etc.

Bear ID	Point Removal Treatment	# MCP Calculated	Mean MCP Size (km^2)	Sd.	Pooled Sd.	p-value
AMB01	MZ[a]	13	47	23	24.18	0.142
	MT[a]	13	49	24		
	M24[a]	13	31	25		
AFB02	MZ[a]	54	126	48	44.58	0.134
	MT[a]	55	118	44		
	M24[a]	54	108	42		
	M48[a]	55	109	45		
	M72[a]	53	108	45		
AFB06	MZ[a]	31	67	29	24.28	0.000
	MT[a,b]	31	65	32		
	M48[b]	30	50	22		
	M72[c]	31	26	7		
AFB08	MZ[a]	85	66	34	28.01	0.000
	MT[b]	85	54	28		
	M48[c]	83	44	21		
AFB09	MZ[a]	19	236	203	126.30	0.000
	MT[b]	11	92	40		
	M24[b]	12	68	46		
	M72[c]	12	55	39		
SMB10	MZ[a]	13	343	214	112.80	0.000
	MT[b]	13	98	54		
	M24[b]	13	69	29		
	M72[b]	13	69	35		
SMB11	MZ[a]	19	84	33	26.11	0.000
	MT[b]	13	48	18		
	M72[b]	13	47	20		
SFB16	MZ[a]	13	221	39	55.56	0.000
	MT[b]	13	148	75		
	M48[b]	13	156	59		
	M72[b]	13	111	41		

[1] Within subject treatments with identical superscripts were not significantly different when tested using Tukey's multiple comparison.

Table 4. Summary statistics asymptotic non-linear regression to determine if location sample size was sufficient to estimate MCP home range by point removal treatment and subject. Treatments MZ, MT, M24, M48, M72 were based on post translocation point removal. MZ = no data points removed, MT = translocation point removed, M24 = all points 24 hours after a translocation removed, M48 =..., M72, etc.

Bear ID	Point Removal Treatment	Location Sample Size	95% Asymptote[1]	Standard Error	95% CI		R^2
					Lower	Upper	
AMB01	MZ	15	65	85	-124	253	0.49
	MT	14	51	68	-99	200	0.39
	M24	13					
AFB02	MZ	94	69	16	37	101	0.63
	MT	92	81	16	49	112	0.71
	M24	86	64	16	31	96	0.56
	M48	85	55	16	24	86	0.47
	M72	83	64	18	27	101	0.50
AFB04	MZ	72	32	3	27	37	0.85
AFB06	MZ	38					
	MT	37	194	206	-224	613	0.66
	M48	36	54	34	-16	123	0.37
	M72	35	46	10	27	65	0.79
AFB07	MZ	37					
AFB08	MZ	104	144	57	31	258	0.47
	MT	99	120	38	44	197	0.58
	M48	95					
AFB09	MZ	26					0.37
	MT	23	20	18	-19	60	0.29
	M24	21					0.30
	M72	19					0.46
SMB10	MZ	22					0.46
	MT	20					0.62
	M24	19					
	M72	18	60	83	-117	236	0.38
SMB11	MZ	27					
	MT	25	87	81	-85	258	0.53
	M72	24	126	161	-212	465	0.59
SFB16	MZ	22	59	34	-13	131	0.75
	MT	20					
	M48	19	85	91	-108	277	0.62
	M72	18					

[1] estimated location sample size required to reach 95% asymptote from the model $hr_i = b_1(1-e^{(-Ni/b2)})$, calculated as $b_2 * 3$.

Figure 1. Comparison of Point Removal Treatments for AMB01

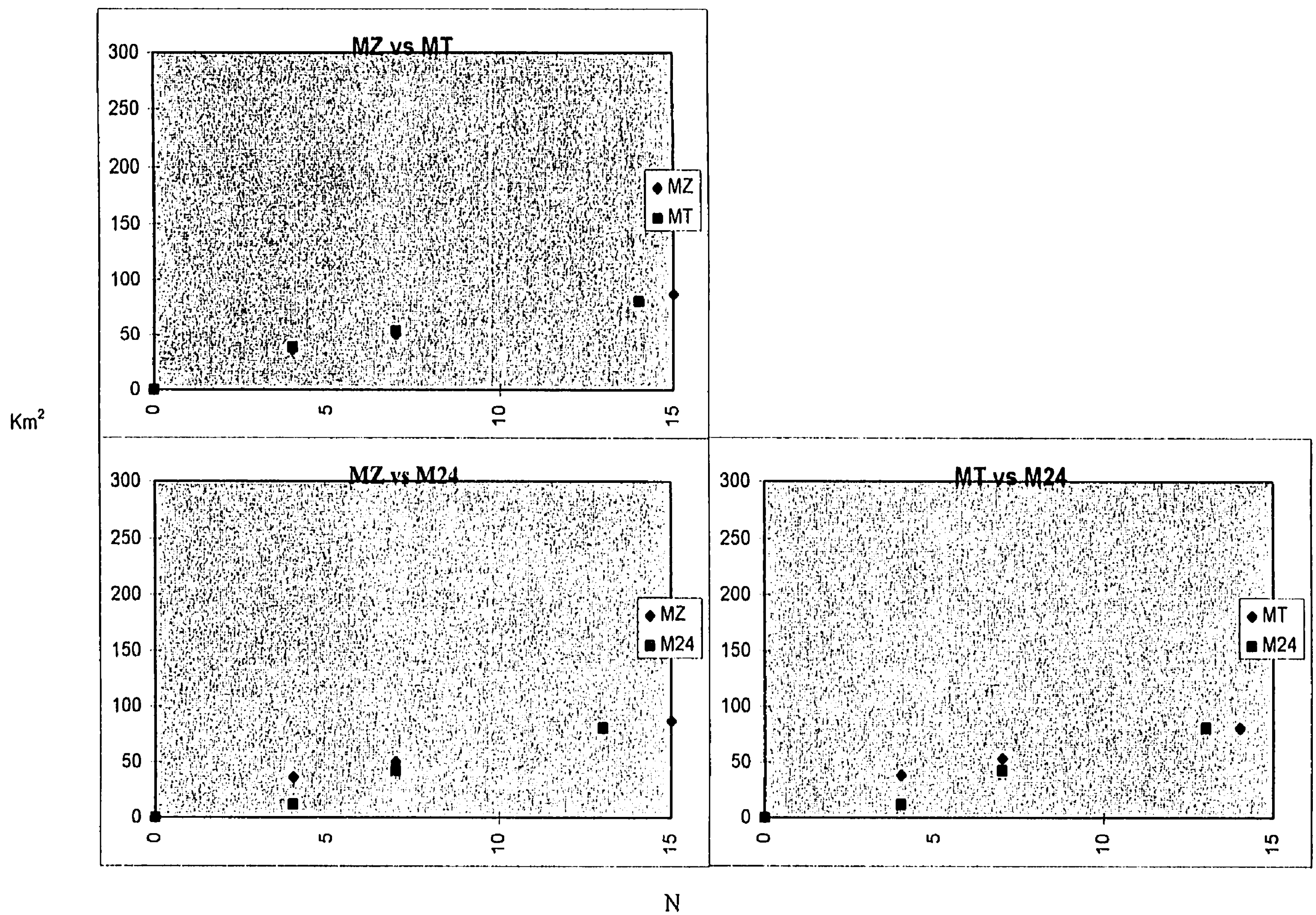


Figure 2

Comparison of Point Removal Treatments for AFB02

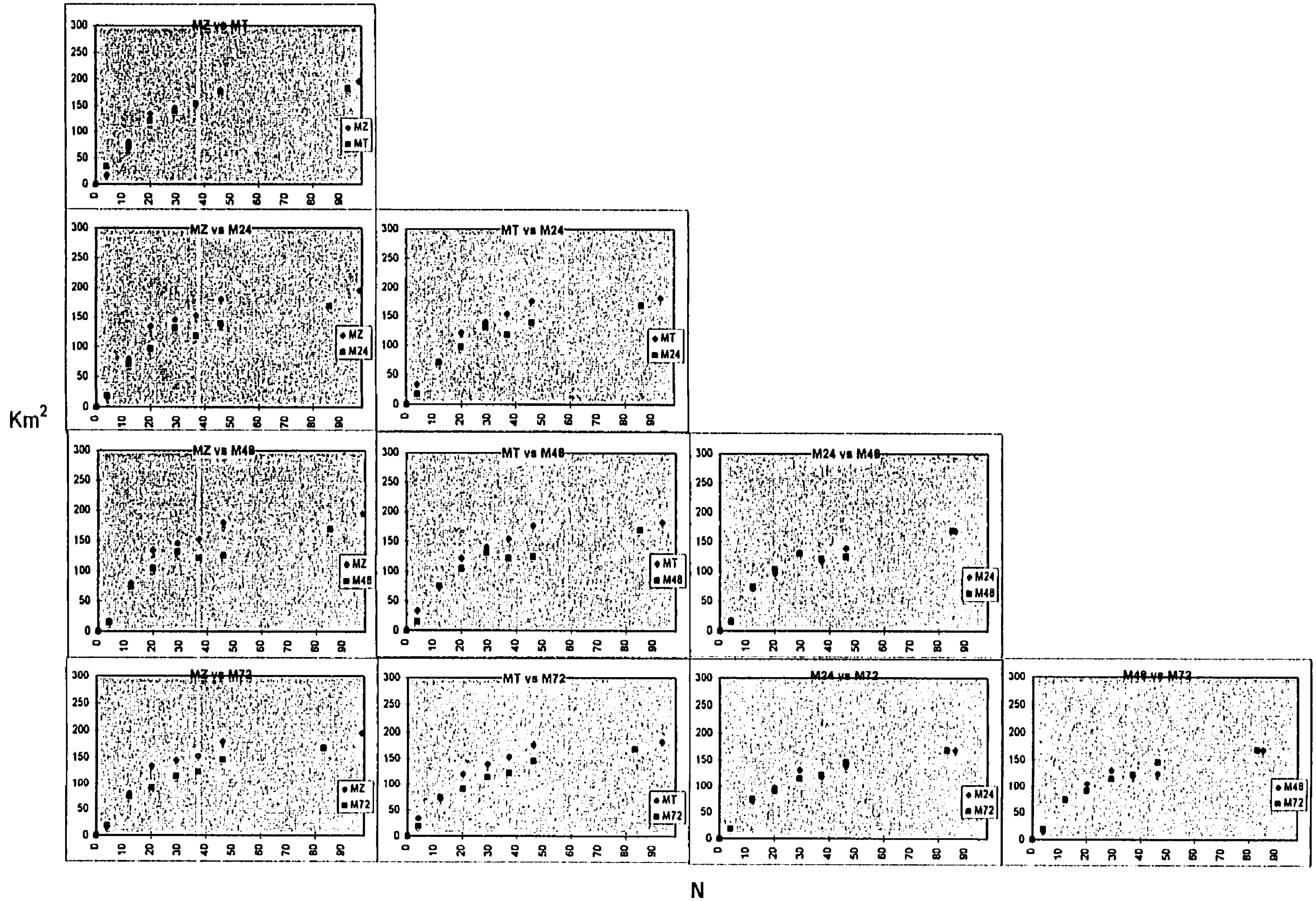


Figure 3 Comparison of Treatment MZ for non-translocated subjects AFB04 AFB07

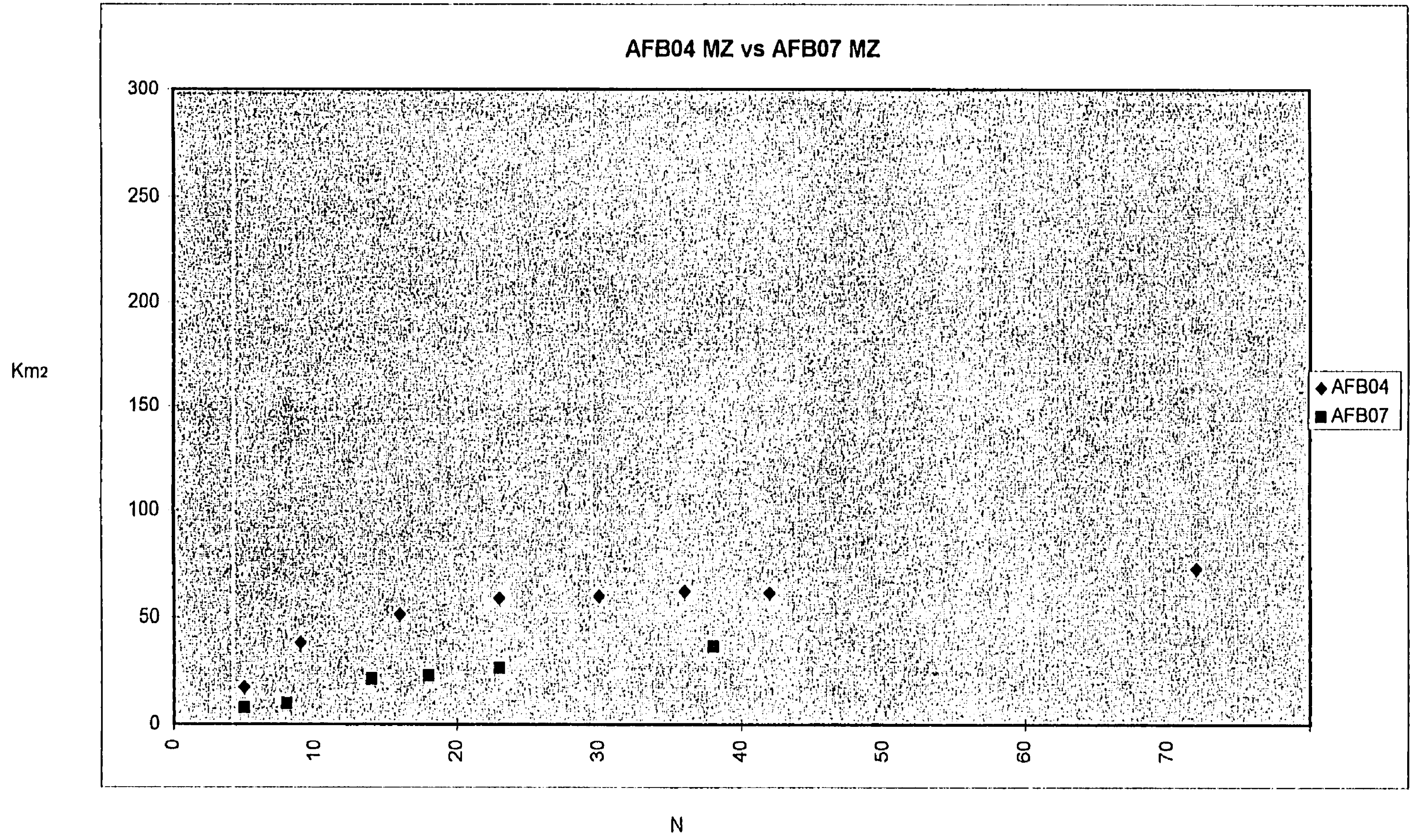
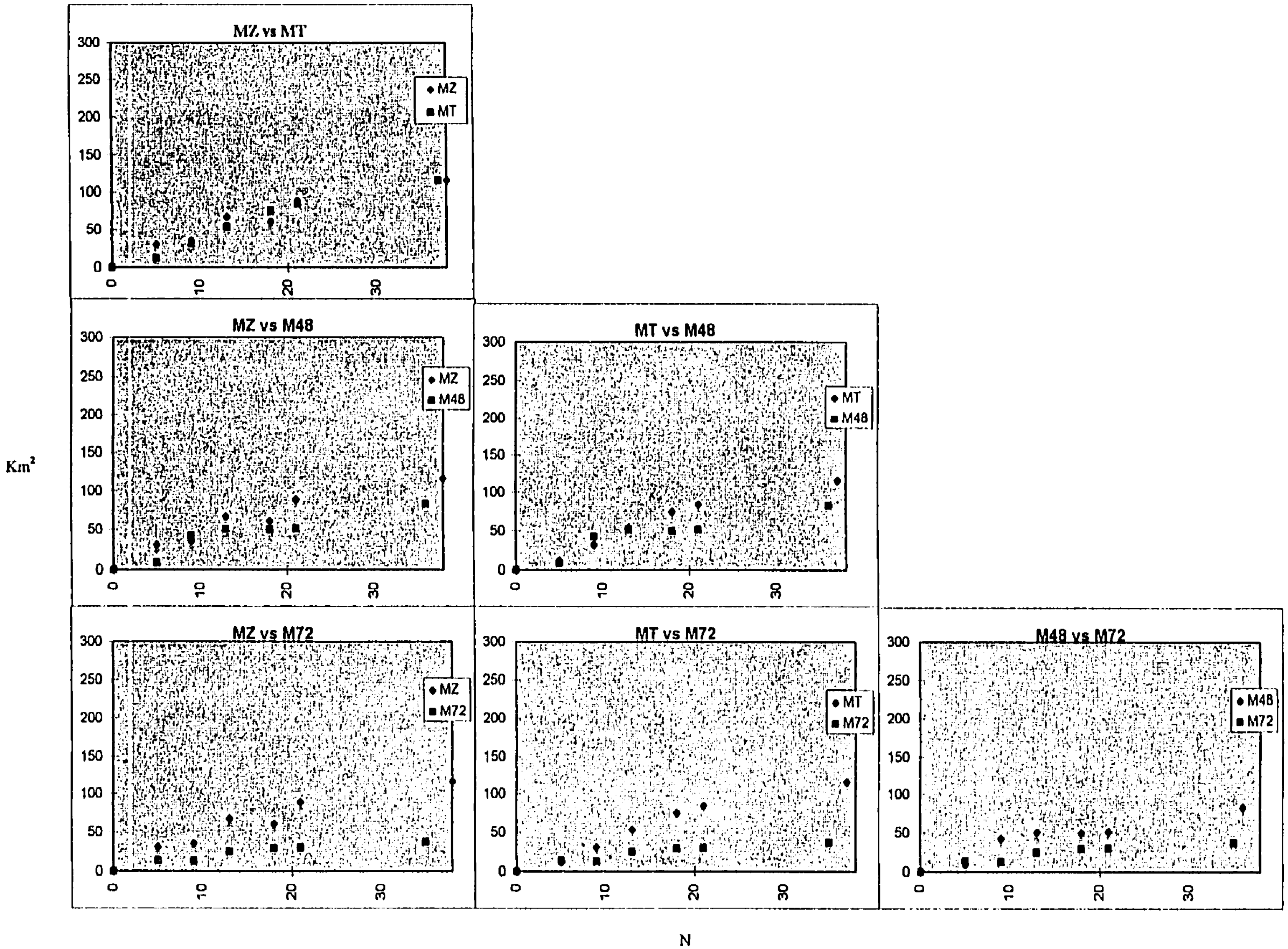


Figure 4

Comparison of Point Removal Treatments for AFB06



CHAPTER 4. BLACK BEAR (URSUS AMERICANUS) HABITAT SELECTION ON THE NORTHEAST COAST OF LABRADOR

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Abstract: Visual observations of habitat use, GPS locations and vegetation maps were used to evaluate black bear (Ursus americanus) habitat use in northeastern Labrador. GPS location data were limited to a 1.5 month period in the summer of 1996 with 3 adult female black bears. Chi-square goodness-of-fit testing was used to evaluate habitat selection. If the test was significant, availability was compared to the 95% confidence interval for that habitat. The 95% CI was based on the normal approximation to the binomial distribution, with a Bonferroni correction for multiple testing. Two of the females appeared to prefer forest ($p < 0.05$), and avoid barren. Visual observations of habitat use by radio collared subjects (n=10) occurred over a period of 5 months during 1996. Visual observations of habitat use by radio collared bears were not tested statistically but suggest that barren areas are used almost as much as forest. Habitat maps (1:20,000) based on aerial photography were used to determine habitat availability.

Key Words: black bear, Ursus americanus, habitat selection, aerial photography, Voisey's Bay, Labrador, GPS, telemetry, chi-square.

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The black bear has long been thought of as a forest dwelling species. This assumption has been supported by many researchers, most notably Jonkel and Cowan (1971). Fuller and Keith (1980) reported that black bears in Alberta used stands of spruce (Picea spp.), open muskeg, and areas of mixed aspen (Populus tremuloides) and jack pine (Pinus banksiana). Klenner (1987) reported that black bears in Manitoba appeared to be restricted to wooded areas, ravines and shelter belts. Zytaruk (1978) noted that bears in New Brunswick preferred areas of dense balsam fir rather than open mixed forests. Chamberland (2000) reported that black bears in New Brunswick preferred habitats with high amounts of canopy cover and safety tree density. Sampson and Huot (1998) reported use of beech-maple forests in core areas of black bear home ranges in southern Quebec, while in Gaspesie National Park, black bears were found primarily in the forest and were rarely observed occupying barren habitats (Boileau et al. 1994). Day (1997) found that black bears in Newfoundland were found in non-forested areas less then expected and actually showed a preference for stands of balsam fir.

During the late 1980's, a small population of black bear was observed occupying an area devoid of forest year-round on Labrador's north east coast (Veitch 1991 & 1992, Harrington 1994). It was not known if these bears preferred barren areas or if they simply made due without forested habitats. In 1994, a large nickel deposit was discovered near Voisey's Bay, Labrador, approximately 190 km south of the area occupied by the "barren ground" black bear. As a result of the nickel discovery, a program was initiated to study the ecology of black bears in the proposed development area. The Voisey's Bay development area was composed of many habitat types: forest, barren, shrub thickets, bog/fen peat land, etc. As the Voisey's Bay area was relatively close to the region occupied by the 'barren ground' black bear, and offered a variety of alternative habitats, the author questioned if black bears, given the opportunity, would select forest over barren habitat types. The objective this paper is to determine if black bears did use barren areas and, if so, to test for extent of habitat selection relative to habitat availability.

STUDY AREA

The center of the study area (56^{O} 20' N, 62^{O} 06' W) was approximately 35 km southwest of Nain, Labrador, 330 km north of Goose Bay, in the vicinity of the Voisey's Bay mineral discovery. The study area was defined by a 1:20,000 ecological land classification compiled by Jacques Whitford Environment Limited and comprised approximately 364 km^2 of rugged terrain with elevations ranging from 0 to 650 m asl (JWEL 1997). Steep cliffs were common in the west while low rolling hills were predominant in the east. The study region was composed of three basic land regions: Western Plateau, Central Ranges, and the Fraser River lowlands (JWEL 1997). Elevations in the Western Plateau ranged from 350 to 650 m. The topography was relatively flat, with the main habitat types being heath and rock barrens. The Central Ranges were typified by rounded topography, valleys and depressions. The main habitat types were also heath and rock barrens. The eastern portion of the study area was typically classified as the Fraser River land region, and was characterized by low-lying coastline, sheltered river valleys, and rolling hills. Elevations in the Fraser River land region ranged from 0 to 400. The main habitat types in this region were spruce forest and bog/fen peatlands (JWEL 1997).

Weather and climate information collected by Environment Canada from the nearby community of Nain show the following: mean monthly temperature ranged between -19^{o} C in January to 10^{o} C in July; mean annual temperature was -3^{o} C; mean annual precipitation was estimated at 740 mm. The highest monthly rainfall was recorded during July (79 mm) with maximum monthly snowfall during January (87 mm). Snow and ice can persist in the study area as late as July (Environment Canada 1989).

METHODS

Seven VHF collars and 3 Global Positioning System (GPS) collars (Lotek Engineering Inc. 1996, see also Moen et al. 1996, Rempel et al. 1995) were fitted on adult female black bears between June and September, 1996. All collars transmitted in the 150-MHz band. Bears were also marked with Flex-Lok plastic ear tags. Telemetry flights were conducted every 2 weeks between 24 June and 15 October, 1996. Bimonthly sessions lasted approximately 7 days and subjects were located 2-3 times each session. The frequency of monitoring flights were reduced after 15 October 1996, with only two sessions through November, 1996. Ground telemetry was conducted when aerial telemetry or animal handling were not in progress. The alpha-numeric identifier used in this report was formatted as follows: age class, sex, capture number (i.e., AMB01= adult male bear number 01).

The GPS collars were capable of differential correction and were equipped with data loggers; each collar weighed approximately 1.36 kg. The VHF beacons initialized on 20 June while the GPS unit, mercury switch and data logging components initialized on 25 June, 1996. The GPS collars attempted to record the following information every 3 hours: geodetic coordinates (latitude and longitude, WGS 84), activity counts, temperature, time, date, fix status, HDOP (horizontal dilution of precision), and convergence (distribution of satellites above the horizon) for a total of 8 fix attempts/day. The GPS collars were retrieved by mid-August 1996, and were sent to Lotek Engineering Inc. for data down-loading and differential correction. Two dimensional data points produced by the GPS collars were assumed to have an error radius of less than 50 m; differentially-corrected GPS data were assumed to have an error radius of less than 10 m (Moen et al. 1996), only 3 dimensional (3-D) fixes were differentially corrected. GPS location data were parsed by subject and a 100% MCP was calculated for each individual; these polygons were used to derive habitat availability.

Digital habitat maps (1:20,000) were developed based on interpretation of aerial photography. Habitat maps were prepared by Jacques Whitford Environment Limited, as part of the environmental baseline research for the Voisey's Bay Environmental Impact Statement; methods used to compile the habitat maps are presented in JWEL (1997). Nineteen habitat classes were differentiated, including Bog/Fen Peatlands, Salt Marsh, Rock Barrens, Heath Barrens, Gravel Barrens, Coastal Barrens, Dune, Stream Swamp, Alder Thicket, Birch Thicket, Spruce-Fir/Dwarf Shrub Forest, Fir-Spruce-Birch/Rich Herb Forest, Spruce/Sphagnum Forest, Rich Swamp Forest, Black Spruce/Lichen Forest, Birch Forest, Tuckamore, Lake and River (Table 1). Two additional "non-habitat" classes were identified: Ground Obscured by Cloud, Ground Obscured by Shadow. Specific habitats classes that were delineated on the 1:20,000 vegetation maps were grouped into barren, forest or other;

Observed versus expected use based on GPS collar location information was tested for evidence of selection using Chi-square goodness of fit test (Neu et al. 1974). If the test was significant, availability was compared to the 95% confidence interval for that habitat. The 95% CI was based on the normal approximation to the binomial distribution, with a Bonferroni correction for multiple testing (Neu et al. 1974). Visual observations of radio collared black bear habitat use were recorded in the field, and habitats were classed as either forest, barren or other. Visual observations have been used to determine habitat use in other studies (Palma et al. 1999). Visual observations reported in this study were not tested for selection because many of the observations occurred outside the area described by the 1:20,000 digital vegetation maps, where habitat availability could not be calculated.

RESULTS

Ten black bears were tracked using VHF telemetry between June-October 1996, two of these subjects were tracked until December 1996. Habitats were classed visually as either forest, barren, or other. A total of 185 observations were made of black bear habitat use: subjects were observed in forest $\bar{x} = 54\%$ (median = 60.4, sd = 21.5), barrens $\bar{x} = 40\%$ (median = 32.2, sd = 25.7), and other $\bar{x} = 6\%$ (median = 4, sd = 7) (Table 2). Three adult female black bears were tracked using GPS collars from July-August, 1996. Location information (n=125) downloaded from the 3 GPS collars was plotted on 1:20,000 vegetation maps. Bear locations most commonly occurred in Spruce/Fir/Dwarf-Shrub, Birch Thicket, Black Spruce Lichen, and Tuckamore (Table

3). Chi-square analysis of gross habitat use were performed on the location data from each of the 3 GPS collared bears. AFB04 and AFB08 occupied habitats differently from availability ($p < 0.02$) and appeared to prefer forest more then any other habitat. AFB02 appeared to use gross habitats in accordance with availability (Table 4).

DISCUSSION

Researchers often assume selection has occurred if a resource is used more than suggested by availability (Neu et al. 1974, Thomas and Taylor 1990, Rosenberg and McKelvey 1999). Most definitions of availability assume uniform habitat distribution (Neu et al. 1974, Rosenberg and McKelvey 1999), but these assumption may be false due to landscape characteristics, and territorial behaviors, etc. (Rosenberg and McKelvey 1999). A number of statistical tests exist to analyze resource/habitat selection, including the chi-square goodness-of-fit test (Neu et al. 1974) and the rank method (Johnson 1980). Alldredge and Ratti (1992) report that observation weighting (i.e., all observations are equal), test suitability, and the hypothesis itself, influence outcomes of statistical testing. Alldredge and Ratti (1986) found that the chi-square method controlled Type I errors, and Type II errors when the number of habitats being tested were small, and locations/animal > 50. The Neu method (Neu et al. 1974) is a very simple test, which ignores possible confounding factors such as competition between animals, etc (C. Thompson pers. comm.).

Deciding which habitats are available to an individual or group is a major obstacle in studying resource selection (Rosenberg and McKelvey 1999, Thomas and Taylor 1990), because availability determines expected values. A number of techniques exist to determine availability: Schaefer and Messier (1995) suggest analyzing habitat at varying spatial scales; Arthur et al. (1996) suggest drawing an availability radius around each location; while Hjermann (2000) suggest using a continuous availability function for a given radius around a location.

The most commonly used method to determine availability is the home range estimate (Boileau et al. 1994, Thomas and Taylor 1990, McCall 1979, Lindzey and Meslow 1977), where the home range boundary represents the edge of available habitat. For this paper, the author used MCP home range as the parameter to determine habitat availability for each subject. MCP is commonly used in habitat selection studies (Carter et al. 1999, Young and Ruff 1982, Fuller and Keith 1980).

At least 2 adult females occupied habitats disproportional to their availability during the period July-August. These 2 black bears preferred forested habitat. For the 3 GPS collared females, the most commonly used habitat classes appeared to be Spruce/Fir/Dwarf Shrub, Birch Thicket, Black Spruce/Lichen, and Tuckamore. However, subject sample size (n=3), location sample size (n=126), time frame (1.5 months), and geographical extent of base mapping, place restrictions on generalizing black bear habitat selection behavior. If black bears in the study area prefer forest to barren it is not supported by visual observations. Some researchers have speculated that black bears are restricted to forested areas, especially females with cubs (Young and Beecham 1983, Chamberland 2000). However, the highest recorded use of barrens in 1996 was by females; one (AFB07) was caring for cubs. A number of possible explanations exist why the visual information (Table 2) contradict the data from the GPS collars (Table 4):

1) Visual observations, n= 10 subjects of varying age and gender; GPS observations, limited to 3 adult females.
2) Visual observations covered a period of 5 months; GPS observations, 1.5 months.
3) Visual observations were collected bi-weekly between 08:00-20:00; GPS observations were collected daily, 24 hour/day.
4) Visual observations occurred outside the 1:20,000 habitat base map; GPS observations occurred inside.
5) Un-quantified territorial behavior may have forced some subjects into non-preferred habitats.
6) GPS and mapping errors (JWEL 1997, Moen et al. 1996) might have decreased GPS observation location accuracy.

If we assume the data presented in Tables 2 & 4 are correct, the contradictory information contained in them may be explained by any combination of 1-5. From early to late June, almost all fresh black bear scats contained high levels of berries (Vaccinium spp., Empetrum nigrum). These berries could have been residuals that survived from the previous berry season. For most of July and August, scats were primarily composed of grasses; by late August, berries once again became the main fecal constituent (Chapter 2). Berries were readily available on the barrens in the spring and fall of 1996, but in summer green plant matter was more common in the forest (Chapter 2). Shifts in black bear foraging behavior due to changing food availability have been reported by many researchers (Sampson and Huot 1998, Schooley et al. 1994, Elowe and Dodge 1989), and may explain discrepancies between visual and GPS data.

CONCLUSION

Black bears are omnivores and many non-plant food sources existed in the study area, including small mammals, char, caribou, moose, seal, bear, shellfish, and insects. The extent to which bears fed on these non-plant species was not quantified. In fact, identifying the factors influencing black bear habitat selection was beyond the scope of this study. The primary reason for investigating habitat selection was to see if general habitat selection behaviour differed from black bears elsewhere (are black bears a forest dwelling species only). The limited sample size and number of observations preclude generalizations to other areas. Visual observations to determine habitat use were not subjected to statistical testing. In addition to visual observations of radio collared subjects, many unknown black bears were observed on the barrens. The tendency to observe bears on the barrens could have been the product of observer bias, and/or increased visibility. This was not the reason for the relatively high number of observations on the barrens by radio-collared subjects, which were located using VHF radio beacons. Black bears in the Voisey's Bay area do make use of both barren and forested areas. Further research is required to identify factors (i.e., age, sex, food availability, food preference, reproductive status, season, etc) that influence habitat selection for bears in this region.

PERSONAL COMMUNICATIONS

C. Thompson. Consulting Statistician. Acadia University, Wolfville, N.S.

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Table 1. Summary of Habitat Types and Plant Species Composition for Voisey's Bay study area, 1996 (source JWEL 1997).

Gross Habitat	Habitat Name	Ground vegetation	Shrubs	Trees
Barrens	Rock Barrens	Parmelia saxatilis, Crutose lichen, Rhacomitrium lanuginosum	Vaccinium uliginosum, Empetrum nigrum, Ledum decumbens, V. vitis-idaea	
	Heath barrens	Betula glandulosa, Empetrum nigrum, Vaccinium uliginosum, Ledum decumbens	Ptilidium ciliare, Cetraria islandica, C. nivalis, Cladonia stellaris	
	Gravel Barrens	Carex bigelowii, Cetraria spp.,	Betula glandulosa, Empetrum nigrum, Salix uva-ursi	
	Coastal barrens	Carex bigelowii, Cetraria islandica	Empetrum nigrum, Vaccinium uliginosum, Salix arctophila, Gale palustris	
	Dunes	Elymus arenarius, Festuca rubra	Empetrum nigrum	
Forest	Stream Swamp	Carex bigelowii, C. aquatilis, Epilobium latifolium, Eriophorum scheuchzeri, Lonicera villosa, Solidago macrophylla, Pleurozium schreberi	Alnus crispa, Salix planifolia,	Picea mariana, Larix laricina
	Alder thicket	Dryopteris spinulosa, Solidago macrophylla	Alnus crispa, Betula glandulosa, Ribes glandulosum	
	Tuckamore	Cladonia stellaris, Pleurozium schreberi	Picea mariana, Ledum groenlandicum	
	Birch Thicket	Sphagnum spp., Cladonia stellaris, Pleurozium schreberi, Polytricum commune	Betula glandulosa, Vaccinium uliginosum, Ledum groenlandicum, Empetrum nigra	Larix laricina, Picea mariana
	Spruce/Fir Dwarf-Shrub	Pleurozium schreberi, Chamaepericlymenum canadense, Peltigera apthosa	Empetrum nigra, Abies balsamea, Picea mariana, Ledum groenlandicum, Vaccinium uliginosum	Picea glauca, P. mariana, Abies balsamea, Larix laricina,
	Spruce/Fir/Rich Herb	Pleurozium schreberi, Gymnocarpium dryopteris, Chamaepericlymenum canadense	Alnus crispa	Picea glauca, P. mariana, Betula papyrifera, Abies balsamea
	Spruce Sphagnum	Sphagnum spp., Rubus chamaemorus, Equisetum sylvaticum	Empetrum nigra, Ledum groelandicum, Vaccinium uliginosum	Picea mariana, Larix laricina
	Rich Swamp Forest	Pleurozium schreberi, Sphagnum spp.	Betula glandulosa, Ledum groelandicum, Empetrum nigra	Larix laricina, Picea glauca, P. mariana
	Black Spruce Lichen	Cladonia stellaris, C. mitis, Pleurozium schreberi	Empetrum nigrum, Ledum groenlandicum	Picea mariana, Larix laricina
	Birch Forest	Chamaepericlymenum canadense, Dryopteris spinulosa, Solidago macrophylla	Alnus crispa, Ribes glandulosum	Betula papyrifera, Picea mariana, P. glauca
Other	Bog/Fen Peatlands	Sphagnum spp., Carex aquatilis, C. rariflora	Ledum spp., Betula glandulosa, Salix arctophila, S. pedicellaris	
	Salt Marsh	Puccinella phryganodes, Triglochin palutris, Potentilla anserina, Carex bipartita, C. rariflora	Salix humilis	
	Lake, River, Ground Obscured by Cloud, Shadow			

[1] Only the most abundant plant species are presented.

Table 2. Visual observations of habitat use. Percent habitat use by radio collared black bears (n=10) near Voisey's Bay Labrador, from June to November, 1996. Habitats were visually classed as either barren, forest, or other by the author at time of data collection.

Bear ID	N	Barren (%)	Forest (%)	Other (%)
AMB01	11	27.3	63.6	9.1
AFB02	27	40.7	51.9	7.4
AFB04	28	85.7	14.3	0.0
AFB06	19	26.3	73.7	0.0
AFB07[1]	22	68.2	31.8	0.0
AFB08	20	10.0	80.0	10.0
AFB09	17	11.8	70.6	17.6
SMB10	14	28.6	57.1	14.3
SMB11	14	35.7	64.3	0.0
SFB16	13	69.2	30.8	0.0
$\bar{x}$		40.4	53.8	5.8
Median		32.2	60.4	3.7
Sd		25.7	21.5	6.8
Total Observations	185	80.0	95.0	10.0

[1] AFB07 was caring for 2 cubs in 1996.

Table 3. Summary of habitat use by 3 adult female black bears near Voisey's Bay, Labrador, in 1996. Habitat use was based on location information from 3 GPS collars. Area measurements for each habitat were calculated based on the entire ecological land classification area that was described through interpretation of aerial photographs at the 1:20,000 scale.

Gross Habitat	Habitat Name	Area km^2	Observed
Barrens	Rock Barrens	37.67	7
	Gravel Barrens	20.22	6
	Heath Barrens	28.52	5
	Dunes	0.24	1
	Coastal Barrens	0.57	0
Forest	Spruce Fir/Dwarf Shrub	89.60	32
	Birch Thicket	47.79	30
	Black Spruce Lichen	49.57	10
	Tuckamore	7.46	10
	Alder Thicket	6.59	7
	Spruce Sphagnum	17.88	6
	Stream Swamp	1.59	2
	Spruce Fir/Rich Herb	0.29	0
	Rich Swamp Forest	1.70	0
	Birch Forest	0.99	0
Other	Bog/Fen Peatlands	21.72	5
	Lake	25.45	4
	Ground obscured by cloud	1.48	1
	Salt Marsh	1.18	0
	River	1.64	0
	Ground obscured by shadow	1.76	0
Total		363.88	126

Table 4. Summary of Chi-square goodness of fit test for evidence of selection. The 95% CI were based on the normal approximation to the binomial distribution, with a Bonferroni correction for multiple testing. MCP home range was used to delineate habitat availability.

Bear ID	Habitat	Area (Km^2)	Observed	Expected	$(obs-exp)^2/exp$	95% CI Lower	95% CI Upper	% Availability
AFB02								
	Barren	10.07	5	8.23	1.27	-0.00	0.22	0.18
	Forest	35.97	32	29.38	0.23	0.55	0.87	0.65
	Other	9.05	8	7.39	0.23	0.04	0.31	0.16
	Total	55.09	45	45				
	Chi-stat				1.73			
	Df				2			
	P-value				0.46			
AFB04								
	Barren	8.91	6	10.42	1.87	0.05	0.53	0.43
	Forest	8.61	17	10.07	4.78	0.63	1.03	0.42
	Other	3.01	1	3.52	1.80	-0.06	0.16	0.15
	Total	20.53	24	24				
	Chi-stat				8.45			
	Df				2			
	P-value				0.01			
AFB08								
	Barren	13.37	7	17.23	6.08	0.02	0.23	0.31
	Forest	27.65	48	35.63	4.29	0.75	0.97	0.64
	Other	2.43	1	3.14	1.68	-0.02	0.06	0.06
	Total	43.45	56	56				
	Chi-stat				12.05			
	Df				2			
	P-value				0.00			

GENERAL CONCLUSION

The black bear (Inuit - Aklak, Innu - Mashku) is found throughout Canada, (Banfield 1974) and continues to occupy about 90% of its historic range. Veitch (1992) suggested that black bears have recently extended their range in Labrador to include barren ground habitats as far north as Nachvak fiord. The 1996 black bear study was initiated to collect baseline information on the ecology of black bears in the Voisey's Bay area with the intent of applying this information to what was then the anticipated Voisey's Bay EIS. To achieve this goal a number of bears were captured, marked with ear tags and fitted with VHF or GPS radio collars and subsequently tracked using radio telemetry.

The 3 Global Positioning System (GPS) collars produced a substantial amount of information during their short life span in 1996. Data from the 3 GPS collars was the basis for Chapter 1, and contributed to Chapter 4 and Appendix 1. Though the GPS collars failed to meet lifespan expectations, they provided valuable insight on black bear ecology in Labrador. Black bears are generally considered diurnal (Armstrup and Beecham 1976, Lindzey and Meslow 1977, Lariviere et al. 1994). Lariviere et al. (1994) found that activity began 30 minutes after sunrise and ended 2.5 hours after sunset. This diurnal behaviour was also observed in the study area; reduced activity at sunset and increased activity in early evening was recorded by the GPS collars in 1996.

Opportunistic field analysis of black bear scats in the project area during 1996 revealed that black bears were mainly vegetarians. Berries were the main dietary components in late spring, late summer, and in the fall. Residual berries from the previous year were abundant on the barrens during the initial collaring in late June, and almost all black bear scats encountered during the initial collaring were composed of berries and associated plant matter. By mid-July berries appeared to become scarce and green plant matter became the main scat constituent. Green plant matter was readily available in most habitats throughout the project area. The high dietary plant component corresponded with black bear food habits in other regions, but the noticeable lack of insects in the scats was not compatible with findings in other areas of Canada.

Two incidental observations made in the project area during 1996 corroborate findings of ungulate predation in Alaska (Schwartz and Franzmann 1989) and Newfoundland (Dennis et al. 1996, Mahoney 1985, Day 1997). No small mammal remains were found in black bear scats during 1996. This finding is compatible with low, small mammal population numbers observed during 1996 (JWEL 1997a). There were no observations of black bears successfully catching fish in the project area in 1996. The two incidences of potential fishing behavior suggest that black bears may have been the cause of some radio-tagged fish mortalities, although these may have been caused by a river otter (Lutra canadensis) (JWEL 1997b).

Black bears use a variety of habitat types for den sites, and selection can vary with geographic location and winter severity (Tietje and Ruff 1980). Dens in the study area were found excavated in three habitat types: white spruce forests, shrub thickets and on the barrens. All dens within the forest and shrub thickets were excavated with the roofs supported by the root systems of adjacent trees and shrubs. All dens found had the entrance facing south or southwest, possibly to minimize exposure to north winds and increase exposure to sunlight. All dens were found in slightly elevated areas, possibly to reduce the chance of flooding during spring melt.

Translocating nuisance black bears is a common bear control method (McArthur 1981, Bromley 1985, Follmann and Hechtel 1990). However, it is generally accepted that translocation is not an effective control method since black bears often return to the capture site (Bromley 1985, Follmann and Hechtel 1990). Rogers (1986) reported that black bears were able to return to home ranges from release distances of greater than 60 km. The data from the 1996 black bear study also support the idea that homing is common in black bears (Chapter 3) and the results of point removal analysis suggest that it may be possible to use the homing behaviour of bears to correct for the inflation effects of translocation when calculating home range.

None of the bears for which home ranges were calculated had areas as large as those reported by Harrington (1994) in northern most Labrador, even though a number of home ranges were known to have been inflated as a result of bears being moved (Chapter 3 and Appendix 1). The largest home range documented during 1996 was 193 km^2 (Appendix 1). Taking into consideration the effect of moving bears, home range areas of the radio collared bears within the project area appear to be similar in size to those noted by Stirling and Derocher (1990). Home range areas of adult females that were not moved corresponded with the home range areas of adult female forest dwelling bears elsewhere in Canada (Klenner 1987, Stirling and Deroucher 1990).

There was a high degree of home range overlap between radio collared black bears in the 1996 study (Appendix 1). Based on the population density estimate, the amount of overlap may be higher when unknown bears are factored into the analysis. However, many of the home range overlaps were caused by moving radio collared bears. Observations made after a bear was moved were included in the home range analysis (Appendix 1), and may have skewed the home range calculations and inflated the number of estimated overlapping home ranges.

A number of females were in estrus during the initial collaring in June 1996. During June and July, up to four adult males where observed in close proximity (less than 15 m) to adult females on the barrens. This period corresponds with the mating period reported elsewhere in Canada, and suggests that barren areas may be important in the mating behavior of black bears in this region. Barren areas may facilitate mating, because odors which are thought to aid in attracting potential mates, are readily dispersed on the open landscape. Many of the subjects that were captured were adults. This finding along with the late sexual maturity suggested by cementum annuli, likely indicates a stable population that is near carrying capacity. K-selected populations often are found in constant or seasonally predictable environments (Begon and Mortimer 1986). Some characteristics of K-selected populations include delayed maturity, fewer young, larger size, longer life, iterated breeding and parental care (Begon and Mortimer 1986).

Reports of black bear activity from Voisey's Bay continue to come in, mainly from the helicopter pilots that worked on the 1996 black bear study. A recent report suggest that one radio collared bear had new cubs in the spring of 2000. The 3 females for which testing of habitat selection was performed demonstrated preference for forested habitats, but visual observations of habitat use suggest that this may not have entirely been the case (Chapter 4). In terms of resource selection, black bears in the project area during 1996 may have exhibited a transitional behavior displaying habitat selection characteristics common to both barren ground black bears and forest dwelling black bears.

This black bear study was a first attempt to understand the ecology and life history of black bears on Labrador's northeast coast. It suffered from a short study time frame, limited sample size, inadequate base mapping, and lack of control area. Much more work is required to obtain a clear picture of black bear population dynamics, range extension, habitat selection and food habits in Labrador.

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APPENDIX ONE

VOISEY'S BAY

1996 ENVIRONMENTAL BASELINE

TECHNICAL DATA REPORT

BLACK BEAR

Jacques Whitford

Consulting Engineers
Environmental Scientists

Recycled Paper

VOISEY'S BAY
1996 ENVIRONMENTAL BASELINE
TECHNICAL DATA REPORT

BLACK BEAR

JWEL PROJECT NO. 1048

VOISEY'S BAY
1996 ENVIRONMENTAL BASELINE
TECHNICAL DATA REPORT

BLACK BEAR

PREPARED FOR

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November 18, 1997

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1. INTRODUCTION

1.1 Background

Voisey's Bay Nickel Company Ltd. (VBNC) is proposing to develop a nickel-copper-cobalt mine and mill at Voisey's Bay in northern Labrador, 35 km southwest of Nain, 79 km northwest of Utshimassits and 330 km north-northwest of Happy Valley-Goose Bay (Figure 1.1). The approximate coordinates of the main orebody (the Ovoid) is latitude 56°15'N and longitude 61°15'W.

The majority of the site lies within a sheltered north-south oriented valley that connects Anaktalak Bay and Voisey's Bay. The surrounding terrain is rugged with elevations ranging up to 400 m above sea level. Land at lower elevations is forested while higher elevations are predominantly barren rock. The climate is subarctic with short summers and long winters.

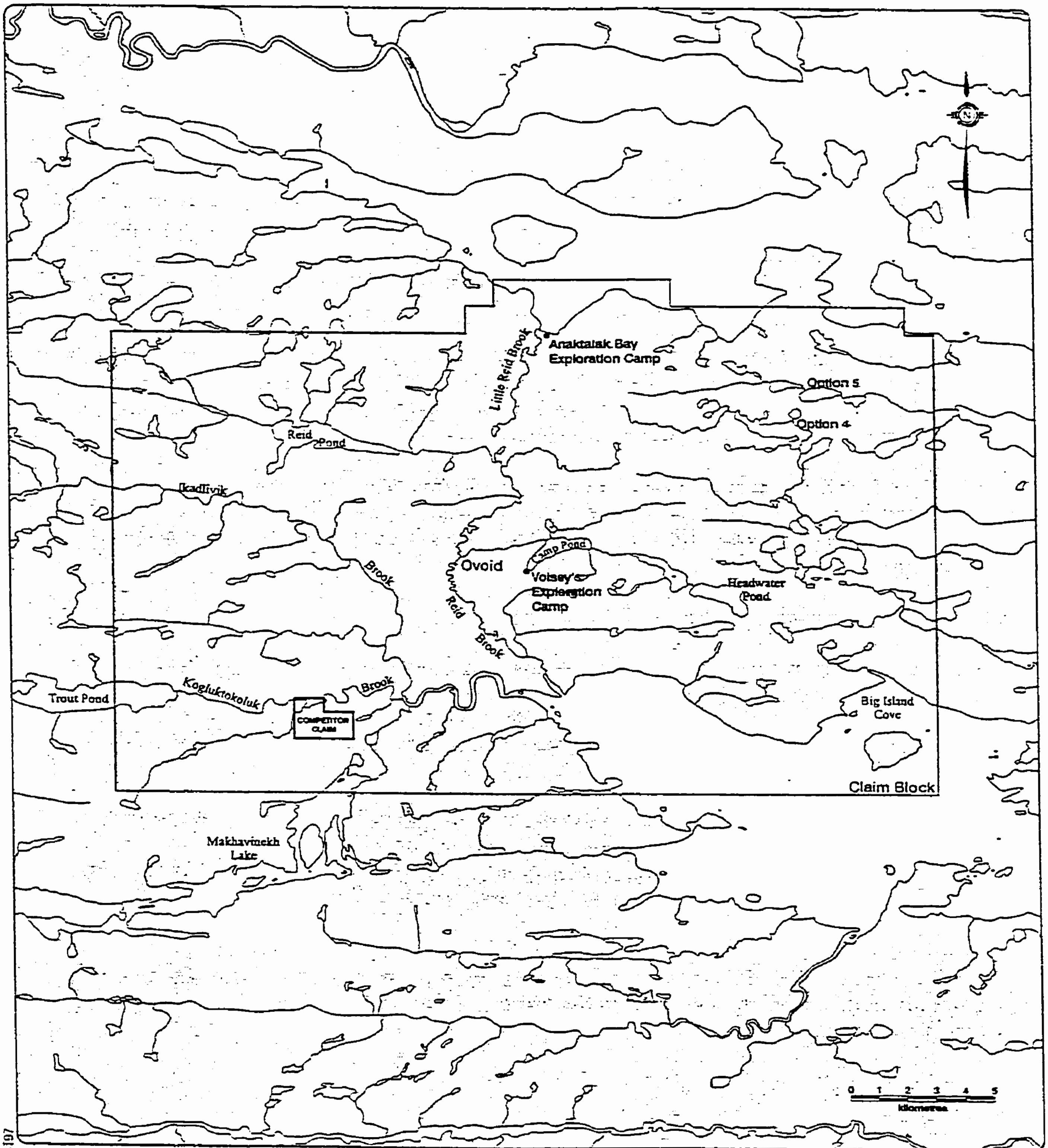
Since 1995 VBNC has conducted a program of field surveys intended to provide an environmental baseline characterization in the area of the proposed mine and mill project. This report includes all of the data collected to date and is one of a series which provides results of the study program.

1.2 Study Scope and Intent

Black bears are an important ecosystem component in Labrador, particularly in northern Labrador where the black bear has special status in both the Innu and the Inuit cultures (Brice-Bennett 1977). As a result, black bears were considered an important study component in the 1996 environmental baseline characterization program. Other factors supporting the black bear study component include:

- black bears occur year round in the development area (Harrington 1994; Brice-Bennett 1977);
- little is known about the ecology of the black bears common to the area; and
- information relating to anthropogenic disturbance is sometimes contradictory (Herrero 1992; Olson and Gilbert 1992; Follmann and Hechtel 1990; Brody and Pelton 1989).

The purpose of the study was to provide baseline data on black bear ecology within the study area. The specific objectives of the black bear study were to determine black bear demographics, abundance, distribution, habitat use and movement, and develop a biological profile including general body condition.



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Jacques Whitford
Environment Limited
Environmental Scientists
Consulting Engineers

VOISEY'S BAY NICKEL
COMPANY LIMITED

Figure 1.1

VOISEY'S BAY CLAIM BLOCK

1.3 Study Area

The geographic boundary for the black bear study area was determined by the habits of the black bears that move through the study area throughout the year.

The study area is 1,686 km^2 and is centered around the area between Voisey's Bay in the south and Anaktalak Bay in the north (Figure 1.2).

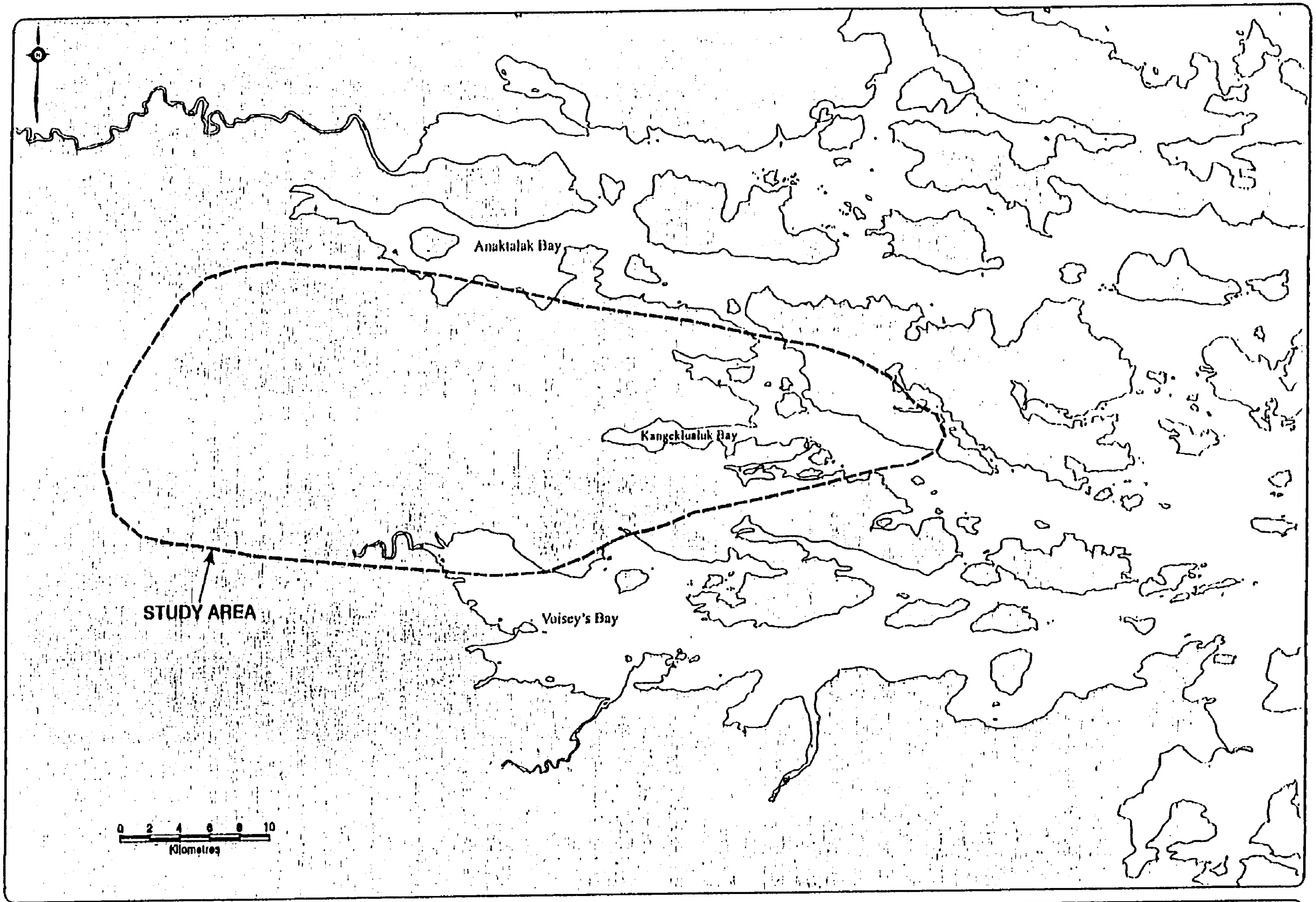
The terrain in the study area is rugged with elevations ranging up to 600 m above sea level. Land at lower elevations is forested with some wetlands, while land at higher elevations is predominately rock barren. The main forest type is Black Spruce/Lichen. Other dominant habitats in the area are Bog/Fen Peatlands, Alpine Heath and Birch Thicket (JWEL 1997a). The climate is harsh with mean monthly temperatures for Nain ranging from -19° C in January to 10° C in July. The mean annual temperature is approximately -3° C. Mean annual precipitation for Nain is 740 mm with the maximum monthly rainfall occurring in July (79 mm) and maximum monthly snowfall in January (87 mm). High winds from the west and northwest are frequent during the fall and winter. Prevailing wind direction switches to the east and northeast between April and August (Environment Canada, n.d.).

1.4 Study Team

The black bear study team included three scientific authorities, a field biologist, two field technicians, five field assistants and a data management team (Table 1.1). Dr. Jim Schaefer, Bill Duffett, Doug Blake and Frank Phillips from the Wildlife Division, Department of Forest Resources and Agrifoods also provided assistance during the black bear study.

Table 1.1 Black Bear Study Team

Field Study	Role	Personnel
Black Bear	Scientific Authority	Dr. Lidija Cicnjak-Chubbs
	Scientific Authority	Dr. Soren Bondrup-Nielsen
	Scientific Authority	Dr. Fred Harrington
	Biologist, Data Analysis and Management, Lead Writer	Keith Chaulk
	Field Technician	Morgan Michelin
	Field Technician	Bruce Mactavish
	Field Assistant	John Flowers
	Field Assistant	Bobbi-Jo Campbell
	Field Assistant	Dwayne Chaisson
	Field Assistant	Cameron Anderson
	Field Assistant (Volunteer)	George Chaulk
	Data Management	Dave Hiscock
	Digital Mapping	Brian Johnson



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VOISEY'S BAY NICKEL COMPANY LIMITED

Figure 1.2

BLACK BEAR STUDY AREA

1046-035.CDR 17NOV97

The following biographical statements highlight the roles and responsibilities of the black bear study team members.

1.4.1 Scientific Authority

Lidija Cicnjak-Chubbs, D.V.M., M.Sc., is an ecologist and veterinarian with previous experience in brown and black bear research. For the terrestrial component of the environmental baseline studies, Dr. Cicnjak-Chubbs was the scientific authority for the black bear and body burden studies, biologist for the black bear study, lead writer for the caribou, furbearer, small mammals and body burden studies, and a member of the field team for the avifauna, black bear and caribou studies. She was selected for these roles based on her academic training and experience conducting field research on bears and avifauna. Dr. Cicnjak-Chubbs has conducted various wildlife studies including: studying the European brown bear and American black bear; inventorying and mapping wetland habitat; preparing wetland management plans; restoring wetlands; collecting samples and analyzing data on Canada Geese, Mallard Ducks and Trumpeter swans; and monitoring fish populations and analyzing data collected. Prior to accepting a position with JWEL, she was an Environmental Health Officer with the Newfoundland Department of Municipal and Provincial Affairs where she was responsible for administering and regulating environmental programs in Labrador, environmental and health pollution control, and inspecting PCB storage and waste disposal sites, and fuel storage areas.

Soren Bondrup-Nielsen, Ph.D., is a zoologist specializing in spatial population dynamics and factors affecting home range size and use, and population dispersal. Dr. Bondrup-Nielsen was a scientific authority for the black bear study and also participated on the field team. He was selected for this role based on his academic training and experience. Dr. Bondrup-Nielsen is an Associate Professor of Wildlife Biology at Acadia University, Co-Director of the Center for Wildlife and Conservation Biology also at Acadia University, and a Honorary Adjunct Professor at the School for Resource and Environmental Studies at Dalhousie University. He has taught courses in biology, ecology and wildlife management at the university level for over 10 years and supervised both honours and masters level students. Dr. Bondrup-Nielsen has published numerous refereed articles in various scientific journals, co-authored two books and several reports and presented a number of papers on his research.

Fred Harrington, Ph.D., is a biologist specializing in neurobiology and behavior. Dr. Harrington was a scientific authority for both the caribou and black bear studies, and part of the field team for the caribou study. He was selected for this role based on his academic training and experience. Dr. Harrington has conducted extensive research on caribou and black bears in Labrador and Northern Quebec. He has 20 years experience teaching at the university level and is currently a professor with the Department of Psychology at Mount Saint Vincent University. His primary research interests are caribou and black bear behavior.

1.4.2 Field Study Team

Keith Chaulk, B.Sc., is a terrestrial biologist. Mr. Chaulk was the principal biologist for the black bear study, as well as a member of the caribou, avifauna, small mammal and furbearer field teams. He was responsible for developing the study design, implementing field protocols, collecting and analyzing data, and preparing maps. Mr. Chaulk was selected for this role based on his academic training and previous field experience. His experience includes: research on the Newfoundland Pine Marten for the Western Newfoundland Model Forest; waterfowl surveys for the Canadian Wildlife Service; and carrying out silviculturalist duties with the Department of Forestry.

Morgan Michelin is a field technician with JWEL's office in Happy Valley-Goose Bay. Mr. Michelin helped coordinate project logistics, data collection and field safety. Mr. Michelin was chosen for this role based on his education and work experience. Mr Michelin has a Resource Technician diploma and over 10 years experience in conducting biological research. He has worked for the provincial Wildlife Division, Department of Fisheries and Oceans, Canadian Wildlife Service and University of Maine.

Bruce Mactavish was a member of the black bear study team, senior technician for the caribou study and field crew leader for the avifauna studies. Mr. Mactavish was selected for these roles based on his experience in conducting field surveys, particularly in northern Labrador. He has conducted a variety of aerial and ground surveys for caribou, moose and avifauna throughout northern Labrador for the Department of National Defense, numerous site surveys for avifauna and other wildlife to support various environmental assessments in Labrador and on the island of Newfoundland, and fish and avifauna monitoring programs. In addition, Mr. Mactavish is a widely recognized authority on avifauna distribution and identification in eastern Canada with over 25 years of experience in conducting avifauna studies.

David Hiscock is responsible for computer systems at JWEL's Happy Valley-Goose Bay office. Mr. Hiscock provided technical support in data collection and analysis for the terrestrial study teams. Mr. Hiscock has a Bachelor of Commerce degree and has been working professionally with computer systems and data analysis for 6 years. He has extensive experience with data collection, validation and reporting and uses a variety of software packages to help the science team achieve their objectives. Mr. Hiscock has been with JWEL for two years and has worked in both the Happy Valley-Goose Bay and St. John's offices.

Brian Johnson is a computer drafting technician. Mr. Johnson was responsible for preparing and presenting the field data for the avifauna, small mammal, furbearer, black bear and caribou studies in a digital format. He also participated in the field studies for caribou, furbearers and small mammals. Mr. Johnson was selected for this role based on his training in computer drafting, and previous experience developing digital base maps, drawings and overlays for the 1995 Voisey's Bay environmental baseline characterization program. Mr. Johnson also participated in the field surveys for caribou, avifauna and other wildlife as part of the 1995 environmental baseline characterization program, and prepared digital maps for the 1995 Raptor Monitoring Program for the Department of National Defence.

Cameron Anderson from Makkovik, **Bobbi-Jo Campbell** and **George Chaulk** from North West River, **Dwayne Chaisson** from Happy Valley-Goose Bay and **John Flowers** from Nain were field assistants for the black bear study. They assisted the biologist and field technicians with sample and data collection, and routine logistics.

Seven helicopter pilots participated in the radio telemetry flights between May 25, 1996 and December 1, 1996: Henry Blake; Leo Callahan; Stephanie Chagnon; Matt Davis; Mike Hogan; Craig Mayo; and Kirk Nielsen.

1.5 Project Quality Assurance And Quality Control

A quality assurance and quality control (QA/QC) plan is a necessary part of an environmental study. QA/QC planning ensures that high quality data are produced and substantiated. An effective QA/QC plan includes organization, record keeping and standard operating procedures (SOPs) for such tasks as field surveys and data management.

The QA/QC plan for the 1996 environmental baseline characterization is on file at the VBNC office in St. John's. The plan included detailed work plans and SOPs for each of the individual studies undertaken. The work plans outlined the study design and tasks to be completed, while the SOPs identified the personnel and equipment required for the study, potential hazards and precautions, permits required and the various tasks to be carried out. Specific directions were provided for conducting the various field surveys, and the information to be recorded on the data sheets and how it was to be recorded.

The work scope of the black bear study was reviewed and approved by Dr. S. Bondrup-Nielsen, Dr. F. Harrington and Newfoundland and Labrador Wildlife Division representatives. A permit to conduct black bear research in the Voisey's Bay area was issued by the Wildlife Division (Appendix A). The black bear study methodology was based on proven and accepted techniques used by Wildlife Division and consultation with J. Schaefer of the Wildlife Division. All black bears were handled according to the division's animal handling guidelines and capture techniques were consistent with the division's capture protocols (B. Duffett, pers. comm.). Representatives from the Wildlife Division supervised and assisted all black bear captures, and were responsible for teeth removal (for aging purposes) and other aspects of handling. Each field study team was entirely or largely (two out of three members) composed of experienced individuals. Dr. L. Cicnjak-Chubbs monitored all field work for consistency and scientific validity, and frequently reviewed all data collected for accuracy and completeness.

All field information was copied as soon as possible after a period in the field and stored separately for future analysis. A FileMaker Pro database and data sheet were developed for the black bear study (Appendix B). All data were entered in the database by the field team with data entry being monitored periodically for accuracy and consistency. The database provided a means for validating data as the study progressed.

Base maps and location information were standardized by converting latitudes and longitudes into North American Datum 1983 (NAD 83) using the CALHOME software (Kie et al 1994). Location data were validated by comparing field and computer generated maps.

2. METHODS

In 1995, the on-site environmental monitors kept a daily log of black bear encounters, captures and mortality. Bears within or near the exploration area were the responsibility of the camp operator. Records kept during this period were limited to encounters at the Voisey's Bay exploration camp. The total black bear captures and mortality recorded during this period were accurate; however, the actual number of black bear encounters at the camps was considered to be much higher than recorded numbers. The 1996 study involved a more rigorous research program that involved capturing, and radio-collaring and tracking a number of black bears within the study area.

2.1 Capture Methods

Three capture methods--leg snares, culvert traps and aerial darting--were used for the black bear study in 1996. Leg snares and culvert traps were used for initial black bear capture, measuring and radio collaring. Aerial darting was only used to recover a failed Global Positioning System (GPS) collar. As discussed in Section 1.5, black bear captures were consistent with the Wildlife Division's capture protocols and were supervised by division personnel.

2.1.1 Leg Snares

In order to determine the best leg snare locations, twenty potential snare sites (baiting stations) were established near fresh black bear signs (i.e. droppings, tracks and foraging activity) in different habitats within the project area during May 1996. As described by Johnson and Pelton (1980), each site was pre-baited with sardines. Sites with repeat black bears visits were used as snare locations. Aldrich leg snares (Lindzey 1987), provided by Margo Supplies, were set at these sites and baited with sardines and meat scraps. A cubby (i.e. a structure that directs the snare safely onto the leg of a captured animal) was built for each snare (Figure 2.1). The snares were checked daily. Snare sites were only used once, so after an animal had been captured the site was deactivated. All snares were removed by June 25, 1996.

Leg snares were also used during August 1996 in an effort to replace three failed GPS collars from bears captured and collared earlier in the summer. Nine leg snare sites were established, according to the procedures discussed previously, in the area where the three bears were located. Two of the three bears were caught by the leg snare method.

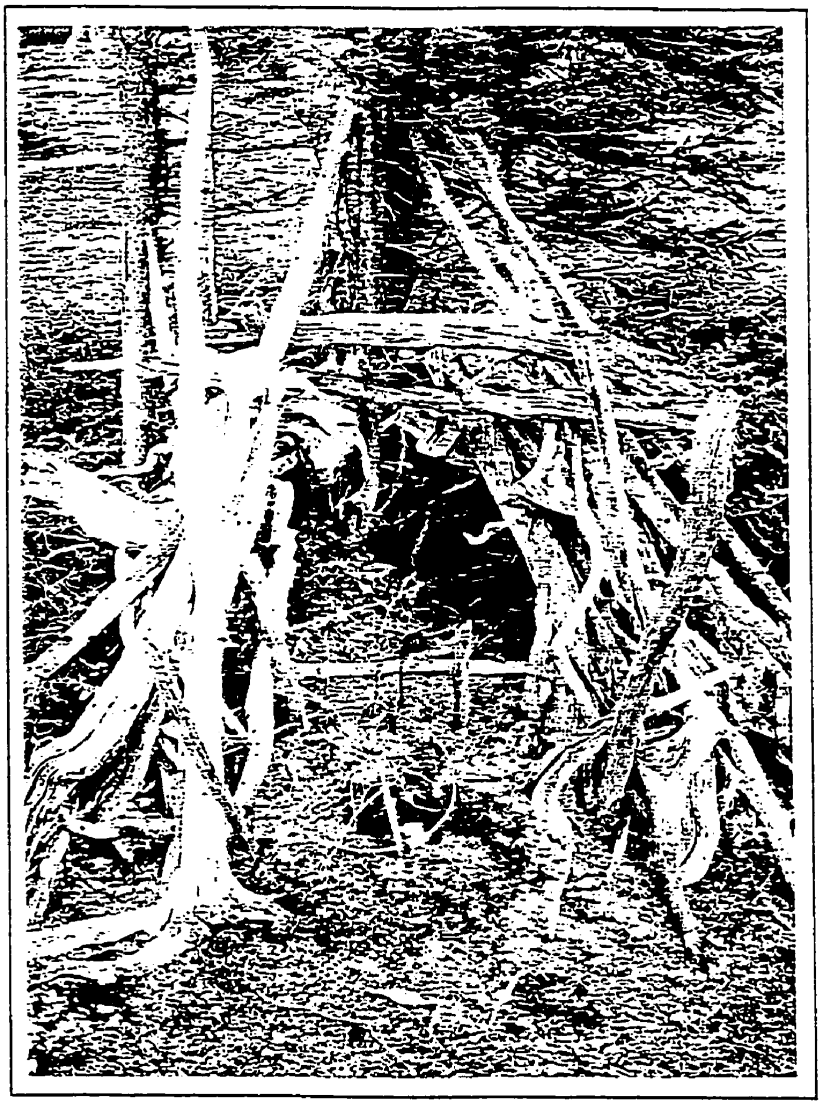

Figure 2.1 Leg Snare Cubby

2.1.2 Culvert Traps

Culvert traps were only used for capturing and radio-collaring bears at the Voisey's Bay and Anaktalak Bay camp sites. The traps used had been constructed, according to Wildlife Division specifications, by Archean Resources in 1995 as a control and safety measure (A. Turpin, pers. comm.). This series of safety measures was distinct from the black bear study.

The culvert traps were not pre-baited during the initial collaring period and were only activated when a bear came within 50 feet of the trap. After the initial collaring was completed, the decision to activate a culvert trap was left to the discretion of camp security.

2.1.3 Aerial Darting

Aerial darting was investigated as a capture technique; however, it was never used as a means for the initial capture and collaring of the bears. Aerial darting was only used when collars needed replacing or maintenance. It was carried out from an Aerospatiale Twin-Star (A-Star) helicopter according to the procedures described by Baer et al. (1987). The technique involved close collaboration between the helicopter pilot, Wildlife Division representative and field leader. The GPS collared bears were located through the still functioning radio telemetry component of the system. During the initial collaring period in June 1996, three attempts were made to recover the collars by aerial darting but all attempts were aborted due to poor flying conditions (i.e. terrain and wind). Only one GPS collar was recovered by aerial darting in late August 1996. As noted in Section 2.1.1, the other two collars were recovered by using leg snares.

2.2 Black Bear Handling

The initial radio-collaring period was in June 1996. The majority of black bears were captured, measured, tagged and radio collared during this period. However, some captures occurred at a later period in the study. These captures were primarily for recovering failed radio-collars and collaring new black bears for the study. At any given time during the study, there were ten radio collared black bears; however, they were not necessarily the same ten bears.

Black bears captured in the leg snares were tranquilized with 4-7 mg/kg of Telazol (White et al 1996) prior to any handling and radio-collaring. Wildlife Division personnel administered the tranquilizer through an air pistol dart. As discussed in Section 1.5, the bears were handled according to the Wildlife Division's animal handling guidelines with all handling supervised by division personnel.

A series of data was recorded for all the black bears captured in leg snares and all were marked with a Flex-Lok plastic ear (Ketchum Manufacturing) tag. Only adult bears were fitted with color coded Very High Frequency (VHF) and GPS radio collars transmitting in the 150-MHz band (Holohil Inc. and Lotek Engineering Inc.). All bears that were tranquilized and handled were injected with penicillin to minimize the risk of infection and all were released at the snare site.

During the initial collaring period of June 1996, only adult black bears caught in the culvert traps were tranquilized, marked with ear tags, fitted with a radio collar (if the quota of 10 animals had not been completed at that time) and moved away from project activities. As with bears captured in the leg snares, the tranquilizer was administered by Wildlife Division personnel, a similar series of data was recorded and each bear received a penicillin injection. Sub-adults, yearlings and black bears already marked with ear tags that were captured in the culvert traps were not tranquilized and were moved away from project activities.

An A-Star helicopter was used to move the black bears captured in culvert traps away from the camp site, while a Bell-206 Jet Ranger was used to transport the study team to the release location. Two helicopters were used since Canadian Helicopters' policy prohibits passengers onboard a helicopter during a slinging event (H. Blake, pers. comm). All culvert traps were equipped with eye hooks for attaching the slinging apparatus. Trap doors were securely fastened to minimize the chance of injury to the bears during the move. At the release location, culvert traps were carefully lowered to the ground and both helicopters landed behind the culvert trap so that the trap door pointed away from the study team. A two person team released the bear. One person opened the trap door, while a second person stood by with a firearm in case of an attack. The study team monitored the black bear's recovery from the tranquilizer at the release site and revisited all bears within 24 hours of being anesthetized.

Standard measurements and information, including neck, head and paw size, total length, weight, age, gender and reproductive status, were recorded for all bears captured (Eason et al. 1996; Coy and Garshelis 1992; Larsen and Taber 1980). Recording physical measurements was supervised and monitored by the field biologist in order to reduce researcher variation (Eason et al 1996). Weight was estimated based on physical appearance or by a mobile weight scale. Age was estimated based on physical characteristics such as pelage, scarring and tooth wear. Based on field estimates of age at the time of capture, the captured bears were grouped into one of four age classes (cub, yearling, sub-adult and adult). Gender was determined in the field by observing reproductive organs (i.e. testicles, vulva, mammary glands).

A premolar was extracted from each bear by Wildlife Division personnel and sent to Matsons laboratory for cementum annuli analysis. Cementum analysis is a highly reliable method used to establish black bear age and reproductive history (Coy and Garshelis 1992; Rodgers 1975).

Food habits were determined through opportunistic field analysis of bear droppings and visual observations of foraging according to procedures described by Hewitt and Robbins (1996). Den sites were located during the ground and aerial radio telemetry work, and the GPS coordinates for each den site were recorded along with structural information and the habitat type in which it was located.

2.3 Radio Telemetry

Two types of radio telemetry--VHF and GPS--were used for the black bear study. The first system involved Very High Frequency (VHF) radio collars that emit a radio pulse approximately every 0.5 seconds. VHF pulses were detected using a VHF receiver and an unidirectional antennae. The antennae direction indicated the azimuth to the collar, while the pulse strength indicated the distance to the collar.

The second method involved collars equipped with GPS and data logging technology. GPS technology is time-based and required three or more satellites in order to determine a geodetic location (i.e. latitude and longitude). When a location is determined. the associated information is stored in a data logger for downloading after the collar is retrieved.

Seven VHF collars (Mech 1983, Klenner 1987, White and Garrott 1990), manufactured by Holohil Inc., were placed on black bears between June and July 1996, and three GPS collars (Lotek Engineering Inc.) were placed on bears in June 1996. The GPS collars were later removed and replaced with VHF collars provided by the Wildlife Division and manufactured by Lotek Engineering Inc. during August 1996.

The VHF system allowed the study team to locate VHF and GPS radio collared black bears. Visual observations of black bears were made for over 80% of the VHF signals received. These observations have an accuracy of <100 m.

The GPS collars recorded the following information every three hours: geodetic coordinates (latitude and longitude); activity counts; temperature; time; date; fix status; HDOP (horizontal dilution of precision); and convergence (distribution of satellites above the horizon) (Rempel et al. 1995; Moen et al. 1996; Obbard et al. in press; Lotek Engineering Inc. 1996). The GPS collars were also equipped with a VHF beacon which allowed VHF radio telemetry to be carried out over the same period. Geodetic data from the GPS collars were differentially corrected by Lotek Engineering Inc. and have an accuracy of <100 m.

Both aerial and ground tracking was conducted in bi-weekly sessions between June 1996 and October 1996 (Mech 1983, White and Garrott 1990). Each bear was located approximately three times during each session. Ground tracking was conducted during periods when aerial tracking or animal handling were not in progress.

Two ground tracking methods were used. The first method involved the study team being set down by a helicopter, locating a radio-collar signal from the ground and making successional fixes from different observer locations to triangulate the bear's location (Mech 1983). However, radio-collar signals were often disrupted by the rugged terrain in the study area so this method was abandoned (Garrott et al 1986, Springer 1979). The second and preferred method involved locating the signal from the helicopter and the study team being set down approximately 1-2 km down wind of the bear. From this location, the two-person team observed the subject black bears for extended periods noting movement, habitat use and foraging behaviour.

Bear locations were mapped in the field, and GPS coordinates and habitat information (i.e. associated land types such as forest, barren and marsh) were recorded on data sheets (Appendix C). When the black bear denning period started, radio-telemetry flight frequency was reduced in order to minimize disturbance. Aerial surveys for den sites of radio collared bears were carried out between mid-October 1996 and late-November 1996.

Between June 24, 1996 and October 15, 1996, 23 monitoring flights were conducted using a Bell 206B helicopter with two side-mounted VHF antenna. The receiving system consisted of a set of headphones (Telonics Inc.) and a VHF scanning receiver (Telonics Inc.) connected by coaxial cable to the VHF antennae. A switch box (Telonics Inc) enabled the observer to select various antennae settings and aided in locating the signal source (Gilmer et al. 1981, Mech 1983). Monitoring flights were conducted at altitudes of 1,000 to 3,000 m. Subject locations were determined by flying towards a signal and systematically turning to eliminate areas providing no signal (Gilmer et al. 1981, Mech 1983, White and Garrott 1990). When a signal was isolated within a 100 m radius, an effort was made to obtain a visual fix on the bear (Gilmer et al. 1981, Mech 1983, White and Garrott 1990). When a visual fix was not possible, the location was estimated using the helicopter's GPS system.

2.4 Data Management and Analysis

As discussed in Section 1.5, data sheets were completed for all bears captured and all information was entered in the FileMaker Pro database. The database was used for calculating basic statistics and exporting data. Data was exported to CALHOME for the home range analysis, Excel, Quattro Pro, and/or Minitab for advanced statistical analysis, AutoCAD and SPANS for mapping and geographic analysis, and Microsoft Word for generating report tables and figures.

2.4.1 Home Range Analysis

A home range is defined as the area traversed by an animal during its normal feeding, mating and cub rearing activities (Burt 1943). The 1996 black bear study relied on a 100% Minimum Convex Polygon (MCP) method for estimating home ranges. It was acknowledged at the start of the study that the MCP method calculates larger home range areas as the sample size increases (Bekoff and Mech 1984). However, bivariate normal analysis of the geodetic data produced larger home range estimates than the MCP method. With this in mind and for comparison with other studies, the MCP method was chosen as the home range estimator.

MCP home ranges (Samuel and Fuller 1996; White and Garrott 1990) were calculated for 10 VHF radio collared black bears and three GPS collared black bears using the software package CALHOME (Larkin and Halkin 1994; Kie et al 1994). The home range calculations were based on VHF telemetry observations between June and November 1996, and GPS telemetry observations between June 25, 1996 and August 13, 1996.

Observations used in the VHF home range calculation were assumed to have an error radius of <100 m and were considered independent since these observations were separated by a minimum of 24 hours (Reynolds and Laundre 1990). Release coordinates for bears moved away from the project area were omitted from the home range calculation.

Observations used in the GPS home range calculation were assumed to have an error radius of <100 m due to differential correction (Moen et al 1996; Obbard et al in press). Locations recorded on capture and release days were omitted from the GPS home range calculation. Observation independence was not a criteria for the GPS home range calculations. It was discarded in order to maximize the number of samples in the data set and optimize compatibility with the Geographic Information System (GIS) habitat analysis.

Home range overlap was determined by analyzing the spatial distribution of black bear home ranges. Home range perimeters (calculated using CALHOME) were exported to AutoCAD and each perimeter was mapped on a separate layer. The area of overlap was then calculated for all interactions. Bears were grouped on the basis of gender and age class, and count and average area of overlap was then calculated on the basis of these groupings.

2.4.2 Habitat Use

VHF field observations and a GIS were used to analyze the habitat composition of black bear home ranges. The VHF field observations of bear locations used data from the 100 % VHF-MCP home range calculations. Habitat was subjectively determined based on a visual assessment of four broad categories--forests, barrens, marshes and other--that had been identified at the start of the summer. Forests were classified as areas with substantial canopy cover. Barrens, included shrub thickets, and were classified as alpine areas with no canopy cover. Marshes were classified as low altitude wetlands

The GIS involved analyzing the habitat in each black bear's home range and Landsat Imagery for this area of Labrador (Clark et al. 1993; Butler et al. 1995; Leckenby et al 1985). In order to maximize compatibility with classifications used in the VHF method, five habitat types--barrens, forests, shrubs, fens and water--were identified and delineated at the end of the GIS analysis.

2.4.3 Daily Activity

Daily activity was determined for three GPS collared bears between June 25, 1996 and August 13, 1996, using activity counts measured by a mercury-tip switch built into each GPS collar (Bevins et al. 1988; Moen et al. in press; Relyea et al. 1994)). Total mercury-tip switch activations were recorded every ten minutes and averaged to determine a single value for a three hour period. These counts were then averaged for each time interval and plotted to reflect daily activity.

2.4.4 Population Density

According to Lindzey (1987), there is no satisfactory method for estimating the size and monitoring the changes in black bear populations. Miller et al (1997) have outlined a method to estimate black bear densities using grid searches and radio collared subjects. This technique requires a pre-marking period of at least one year prior to attempting the density estimate (Miller et al 1997). For the 1996 black bear study, a crude population estimate was derived based on the number of known individuals (marked or otherwise identified) within the study area.

3. RESULTS

The records of black bear observations at the Voisey's Bay exploration camp during 1995 provide some information about the black bears in the vicinity of Voisey's Bay. The records indicate that black bears were observed near the exploration camps until mid-November 1995. The greatest amount of bear activity was recorded in July 1995 with at least one bear being observed near the exploration camps each day.

In 1995, captured bears that were removed from the area were not tagged, so subsequent identification was not possible (Figure 3.1). As a result, it was possible that the 27 observations included repeat observations of the same bears. For example, one family group (a mother with two cubs) was observed in the Reid Brook Valley on a number of occasions during 1995.

In 1996, greater than 150 encounters and observation of black bears were documented, including 41 live captured and 4 nuisance bears that were shot at the camp (Note that 3 were shot in 1995).

3.1 Black Bear Captures

Between June 18, 1996 and November 28, 1996, there were a total of 41 capture events involving 23 different black bears. The bears were captured at the Anaktalak Bay Camp, Voisey's Bay Camp, Ikadlivik River, Reid Pond/Brook, Otter Pond, Kangeklualuk Bay and the Macmillan site (Appendix C). Twenty-seven bears were captured in the culvert traps, nine in the leg snares, one by aerial darting and four were shot and killed (two by Wildlife Division personnel and two by Archean camp personnel). Eleven bears were captured on more than one occasion (Table 3.1).

Twenty of the 23 captured black bears were marked with ear tags and/or radio collars. Three bears were released without marking. No black bears died as a direct result of handling during this study.

The largest adult male (B05) disappeared early in the study. This may have been due to radio collar failure, bear mortality or the bear having moved out of the study area. Aerial surveys of the study region were unsuccessful in relocating this bear.

There were 17 different black bears involved in the 27 culvert trap events (Appendix C). All black bears caught in culvert traps were moved away from the project area and, except for three bears (B05, B13, and B18), all returned to the site after their first move. The return rate varied from two days (B08) to two or more weeks (Limpy), while the distances ranged from 0.5 km (B00) to 45 km (B13). In 1996, 15 km was the average distance that a radio collared black bear was moved.

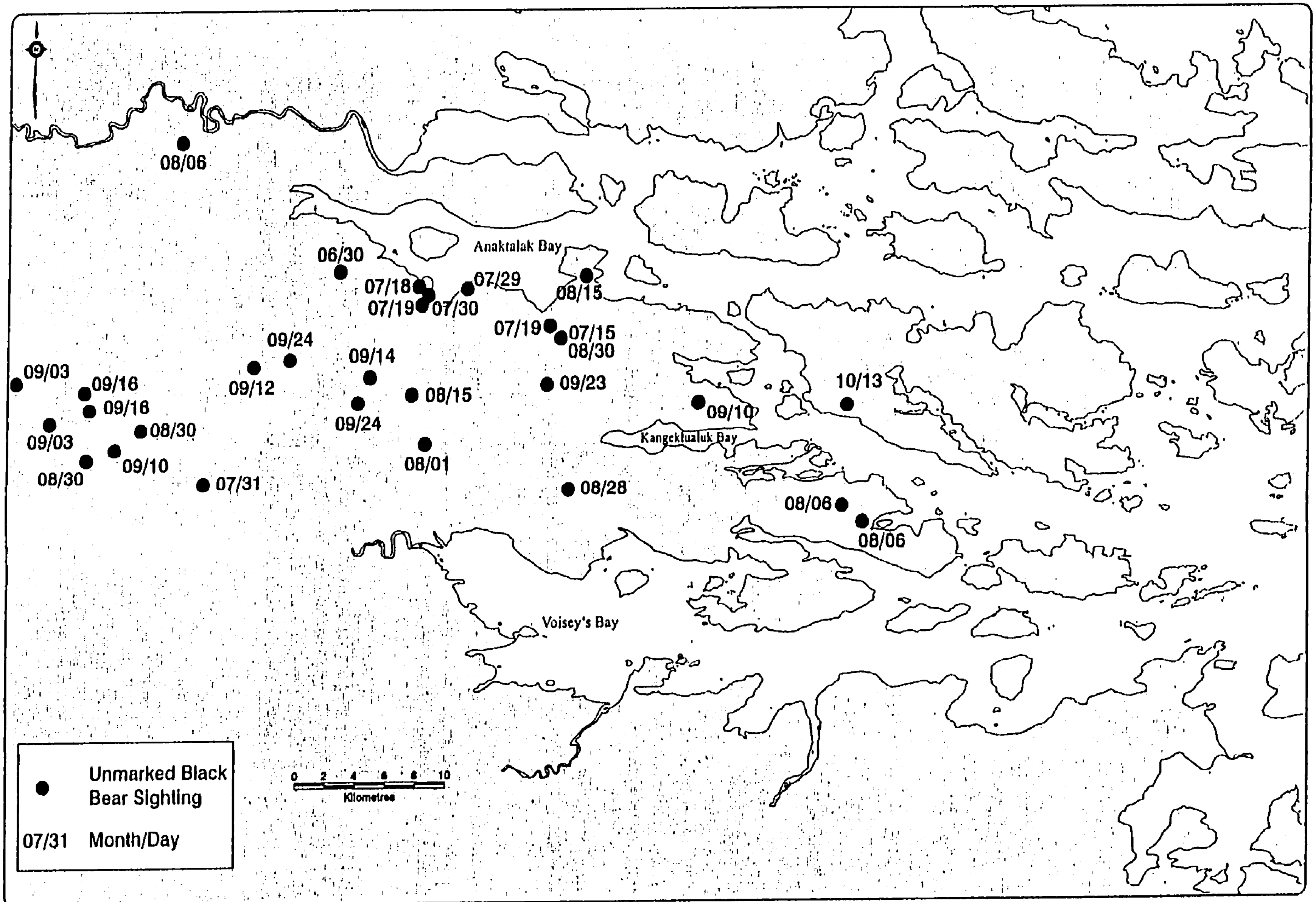

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Figure 3.1

UNMARKED BLACK BEAR SIGHTINGS IN THE STUDY AREA, 1996

Table 3.1 Black Bears Captured in the 1996 Study Area*

Bear ID	Age Class	Age+	Sex	Weight++ (kg)	Collar Type	Captures
00	Sub-adult***		Male	49		3
01**	Adult	10	Male	88 100	VHF	3
02**	Adult	7	Female	50 75	GPS/VHF	3
03	Adult	7	Female	70	GPS	1
04**	Adult	6	Female	45 64	GPS/VHF	2
05	Adult***		Male	130	VHF	1
06**	Adult	13	Female	70	VHF	1
07**	Adult	10	Female	45	VHF	1
08**	Adult	6	Female	45	GPS/VHF	3
09**	Adult	8	Female	40	VHF	2
10**	Sub-adult	2	Male	61	VHF	2
11**	Sub-adult***		Male	78	VHF	2
12	Adult	16	Female	68		4
13	Sub-adult	2	Male	45		1
14	Sub-adult***		Female	27		1
15	Sub-adult***		Male	36		1
16**	Sub-adult***		Female	60	VHF	2
17	Unknown		Male	Unknown[1]		1
18	Adult	23	Male	125	VHF	1
Limpy	Adult	9	Male	114		3
A-Bay 1	Sub-adult***		Unknown	41		1
A-Bay 2	Sub-adult***		Unknown	Unknown		1
V-Bay 1	Unknown		Unknown	Unknown		1
Billy+++	Unknown		Unknown	Unknown[2]		

* Blank cells indicate that information was not available or not applicable.
** Home range calculated
*** Based on field estimates of age
\+ Based on cementum analysis (all ages had the highest possible reliability indicators).
++ Black bears were weighed at different times throughout the year based on date of capture. Note that sub-adults weighed in the fall may weigh more than adults weighed during June.
+++ Not captured but identifiable because of distinct pelage
[1] Unknown was recorded for bears captured and released by others than our study team and two bears that were destroyed.
[2] Bear named that was easily recognizable due to its cinnamon coloured fur.

3.2 Demographics and Physical Characteristics

Of the 23 black bears captured in the 1996 study, the sex of three bears was unknown, ten were male, and ten were female (approximately 1:1 sex ratio). Nine black bears captured were sub-adult (39%), while 12 were adults (52%) and the age class of 2 (9%) was not known (Table 3.1). Weights varied by age, sex and season from 27 kg to 130 kg. The five heaviest bears were males (78-130 kg). Five females were lighter (64-75 kg), and the lightest (27 kg) bear was a sub-adult female (B14). Three adult bears were weighed twice during the year: B04 weighed 45 kg on June 22 and 65 kg on August 16; B02 weighed 50 kg on June 21 and 75 kg on August 27; and B01 weighed 88 kg on June 18 and 100 kg on August 18 (Table 3.1 and Appendix C).

Premolars were extracted from 14 black bears, these teeth were sent to Matsons Laboratory for analysis. Cementum analysis revealed that the oldest bear in the 1996 study set was 23 years old (B18), the second oldest bear was 16 (B12) (Table 3.1). Two bears were age 2 (B10 and B13), the remaining black bears were between 6 and 13 years of age (Table 3 .1).

Incidental observations during 1996 identified at least five distinct family groups within the study area. There was a total of 17 black bears in the five groups: five adults and 12 cubs. Two of the family groups had three cubs each, while three family groups had two cubs each. Only one of the family groups (B07) was radio collared. One sub-adult male (B10) originally caught at the Voisey's Bay camp, migrated to Kikkertavak Island and was observed in the company of a larger black bear from September 1996 to October 1996. It was speculated that B10 and its companion were a sub-adult and its mother. If so they would comprise a sixth family group in the study area.

3.3 Population Density

In 1996, 18 black bears were identified within a 40 km^2 area between the Anaktalak and Voisey's Bay camps (Reid Brook Valley) indicating a minimum of 0.45 bears/km^2 within the Reid Brook Valley (Appendix D). Three unmarked bears (A-Bay 1, A-Bay 2 and V-Bay 1) were omitted from the calculation since it's not certain whether they were marked at a later date in the study. If these bears were included in the density calculation, the minimum population density for the Reid Brook Valley increases to 0.52 bears/ km^2.

This area is part of the Fraser River Ecoregion (Lowlands Ecodistrict) covering 3207 km (17.3%) of the Landscape Region. If a conservative density of 0.05 bears/km^2 is attributed to the remaining terrestrial Ecodistricts (15,294 km^2 or 82.7%), the population for the Landscape Region would be estimated at 2200 black bears.

3.4 Mating and Reproduction

Captured bears were examined for signs of reproductive status during late June. Only two bears were in estrus at time of capture (B02 and B04). B02 and Limpy (adult male), as well as B01 (male) and B06 (female), were observed together for an extended period during the mating season. Only one collared bear (B07) was actively caring for cubs during 1996. Four collared females (B02, B04, B06, and B09) could potentially have cubs by the time they emerge from their den in the spring of 1997. In addition to B07, which currently has cubs, cementum annuli analysis revealed only one other female (B06) that had previously given birth. According to the cementum analysis B06 has given birth three times, at ages 6, 9, and 11.

3.5 Home Range Analysis

3.5.1 VHF Data Set

Home ranges were calculated for ten black bears based on the data collected from the VHF radio telemetry (Table 3.2). Three of the four largest home ranges were associated with females: B16 (193 km^2), B02 (147 km^2) and B09 (111 km^2). The second largest home range (163 km^2) was associated with B10, a sub-adult male. Males had larger average home ranges (101 km^2) than females (88 km^2) (Appendix E). Only one bear (B07) had a home range that did not interact with the project area. The only adult male in the study set (B01) had a home range of 81 km^2. The three smallest home ranges were also associated with adult females: B08 (21 km^2), B07 (22 km^2) and B04 (43 km^2), in contrast the two largest home ranges were occupied by sub-adults (B10 and B16). (Table 3.2 and Appendix E). The average home range of adults (n=7) was 72 km^2, while the average home range of sub-adults (n=3) was 138 km^2.

Of the ten VHF radio collared black bears, 8 were moved away from the project area (Table 3.2). This was considered the main reason for the large home ranges of B16, B10, B09 and B02. However, in contrast, B08 was moved on two occasions, but had one of the smallest home ranges in the study set. B04 and B07 were the only black bears in this study set that were not moved during 1996.

Table 3.2 100% MCP Home Ranges for Collared Black Bears

Bear ID	Age Class	Sex	Home Range (km^2)	Number of Times Moved
B01	Adult	Male	81	1
B02	Adult	Female	147	1
B04	Adult	Female	43	0
B06	Adult	Female	76	1
B07	Adult	Female	22	0
B08	Adult	Female	21	2
B09	Adult	Female	111	2
B10	Sub-adult	Male	163	2
B11	Sub-adult	Male	59	1
B16	Sub-adult	Female	193	2
Total (n=10)			917	12

3.5.2 GPS Data Set

As noted earlier, only three black bears were fitted with GPS collars (B02, B04 and B08). One of these three collars slipped off its initial subject (B03) and was placed in a known location for 10 days to act as a control for evaluating collar performance (Appendix F) This GPS collar was eventually placed on B08.

The simultaneous VHF monitoring of GPS collars allowed a comparison of the home ranges for the three GPS collared black bears. Computer mapping of the results revealed that the data collected by the two systems yielded locations within a 100 m radius.

The GPS-derived home range for B02 (162 km^2) was similar to the VHF-derived home range (147 km^2) with respect to size, configuration and home range placement (Appendices G and E). The GPS-based home range for B04 (65 km^2) was larger than the VHF-based home range of 43 km^2, but was similar with respect to shape and placement (Appendices G and E). The GPS-derived home range for B08 was also larger (40 km^2) than the VHF-derived home range (21 km^2), but was similar with respect to placement (Appendices G and E).

3.5.3 Home Range Overlap

All radio collared black bears had some degree of spatial overlap with other similarly marked bears. The highest degree of potential interaction occurred with B16 (a sub-adult female) whose home range overlapped with the home ranges of seven other radio collared black bears. The home range of B01 (an adult male) overlapped six other home ranges. The home ranges of two adult females (B04 and B07) overlapped with only one home range each (B16) (Figure 3.3).

3.6 Daily Activity

Two main activity patterns were evident around the exploration camps. Generally, black bears were most likely to visit the camps in the early morning and at dusk. On hot days in July and August, the number of black bears observed around the camps was low. The reduced sightings during these periods suggested that the black bears were inactive and using the forest as shelter from the heat and sunlight.

For example, average daily activity counts for the adult female (B04, B02 and B08) revealed a bi-modal activity pattern (Appendix H). The highest average activity counts were recorded at 0500 hours and 1700 hours. The lowest activity was recorded between 2000 hours and 0200 hours with a second smaller reduction in average activity around midday.

However, variability was observed in daily activity patterns such as B04. This bear revealed that the highest average daily activity was recorded at 1000 hours and 1900 hours. The lowest average daily activity counts were recorded at 1600 hours and 0400 hours (Appendix H)

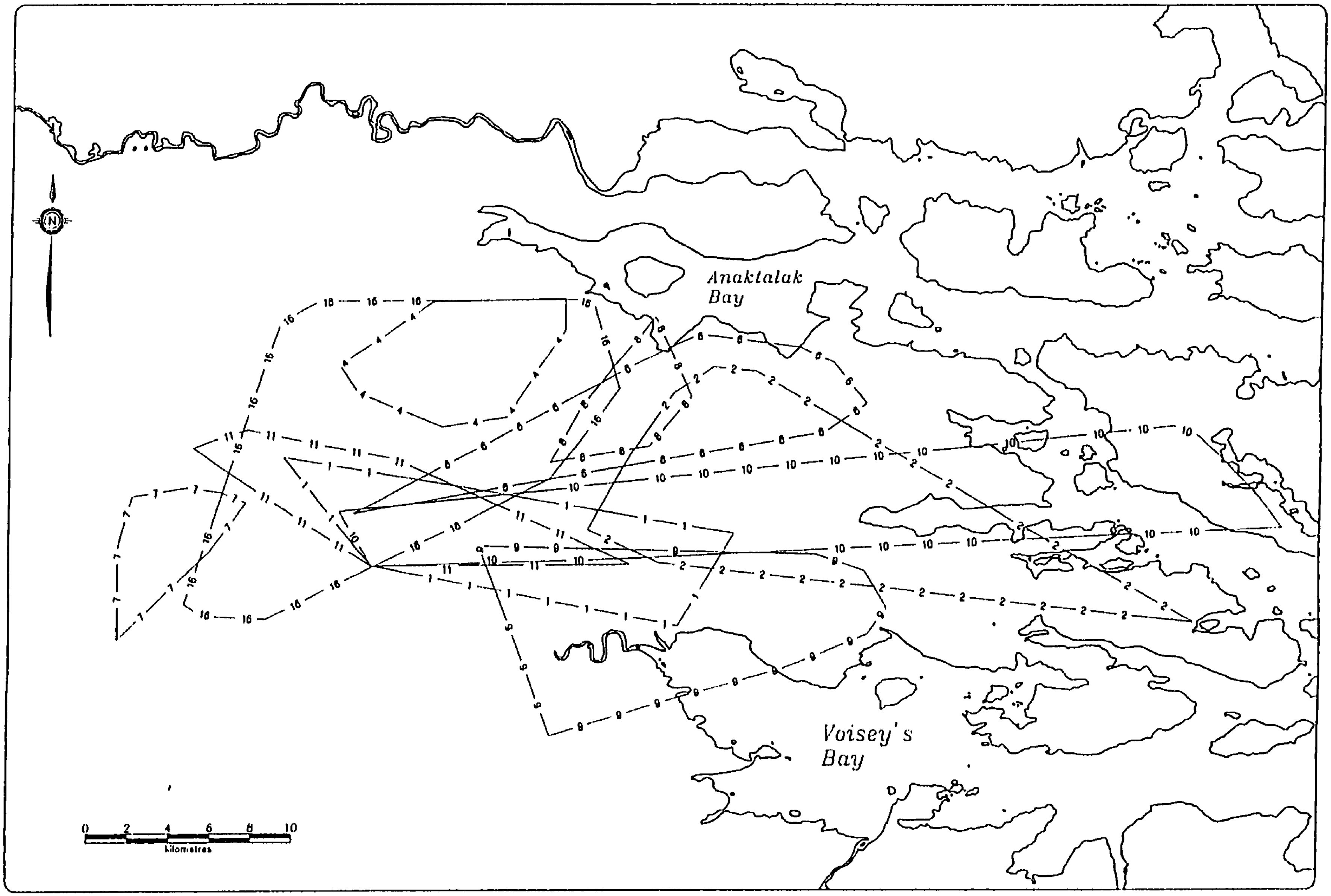

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FIGURE 3.2

HOME RANGE OVERLAP
RADIO COLLARED BLACK BEARS (N = 10)

VHF DATA SET

HOME RANGE CALCULATION = 100% MCP

FIG_3-2.DWG 19NOV97

3.7 Habitat Use

3.7.1 Field Observations VHF MCP Data Set

Only observations used in the home range calculations are discussed in this section in order to facilitate comparison with the GIS analysis of home range habitat composition (Section 3.7.2).

A total of 185 VHF field observations were used in the calculation of the home ranges for the ten radio collared bears in 1996: 95 in the forest (51%), 80 on the barrens (43%), 7 on the marshes (4%) and 3 (2%) in undefined habitats. Sub-adults, and adults used habitat in identical proportions (51 % forest and 44% barren), while males and females used the forest and barren in similar proportions. All groups were observed more frequently in the forest than any other habitat type (Table 3.3, Table 3.4, and Appendix H).

Table 3.3 Observed Habitat Use by Age Class*

Age Class	Habitat Type	Observed Use
Adult (n=7)	Forest	74
	Barren	62
	Marsh	6
	Other	2
Sub-adult (n=3)	Forest	21
	Barren	18
	Marsh	1
	Other	1
Total		185

• Based on VHF-MCP data set

Table 3.4 Observed Habitat Use by Gender*

Gender	Habitat Type	Observed Use
Male (n=3)	Forest	28
	Barren	21
	Marsh	2
	Other	1
Female (n=7)	Forest	67
	Barren	59
	Marsh	5
	Other	2
Total		185

* Based on VHF MCP data set

3.7.2 GIS Habitat Analysis of VHF MCP Home Range Data Set

The predominant habitat types in the black bear study area are forest (35%) and barren (32%) (Table 3.5). The remainder of the study area habitat consisted of water (16%), fen (13%) and shrub (5%).

Table 3.5 Habitat Composition of the Black Bear Study Area

Habitat Type	Area (km^2)	Percent
Forest	584.36	35%
Barren	540.29	32%
Fen	214.47	13%
Water	264.59	16%
Shrub	82.49	5%
Total	1686.2	100%

Home range habitat composition was similar for adults, males and females (Table 3.6). The home range composition for sub-adults was slightly different with less forest and more barren. The home range habitat composition for all categories combined was approximately forest (42%), barren (26%), fen (16%), water (11%), and shrub (4%). The main habitat types for both males and females were forest, barren and fen. Males had slightly higher barren composition and lower forest composition than females. Overall, home range habitat composition was different than the habitat composition of the larger area (Tables 3.5 and 3.6). This difference reflected the barren western landscape of the project region and the relatively easterly distribution of radio collared black bears.

Table 3.6 Average Home Range Habitat Composition (%)

Habitat Type	Female (n=7)	Male (n=3)	Adult (n=7)	Sub-adult (n=3)
Forest	42	43	46	37
Barren	27	24	22	30
Fen	16	16	17	15
Water	10	14	10	13
Shrub	5	3	4	5

3.7.3 GIS Habitat Analysis of GPS-MCP Home Range Data Set

The habitat composition of GPS-based home ranges for B02, B04 and B08 were different from the VHF home range habitat composition (Table 3.7). At least two habitat categories differed by a minimum of 10% for each bear (i.e., B02 GPS barren = 20% while VHF barren = 8%) (Table 3.7).

Table 3.7 Comparison of GPS and VHF Home Range Habitat Composition (%)

Bear ID	Type	Forest	Barren	Fen	Water	Shrub
B02	GPS	42	20	19	17	3
	VHF	40	8	27	20	5
B04	GPS	32	37	13	11	7
	VHF	16	31	23	20	10
B08	GPS	48	24	14	8	7
	VHF	59	9	18	7	8
Average	GPS	40	27	15	12	6
	VHF	38	16	22	16	7

3.8 Den Sites and Denning

Active black bears have been observed in northern Labrador as early as April (A. Veitch, pers. comm.). During April 1996, a black bear was photographed attacking an adult caribou near the Anaktalak Bay camp (W. Montague, pers. comm). Both Anaktalak Bay and Voisey's Bay camp personnel (Archean Resources, Canadian Helicopters, and JWEL) began to observe black bears on a regular basis by May 1996. In May and early June 1996, the black bear study team observed black bears walking on sea ice. Spring surveys for black bear conducted during early April 1997 revealed that all radio collared bears were inactive and continued to occupy fall dens.

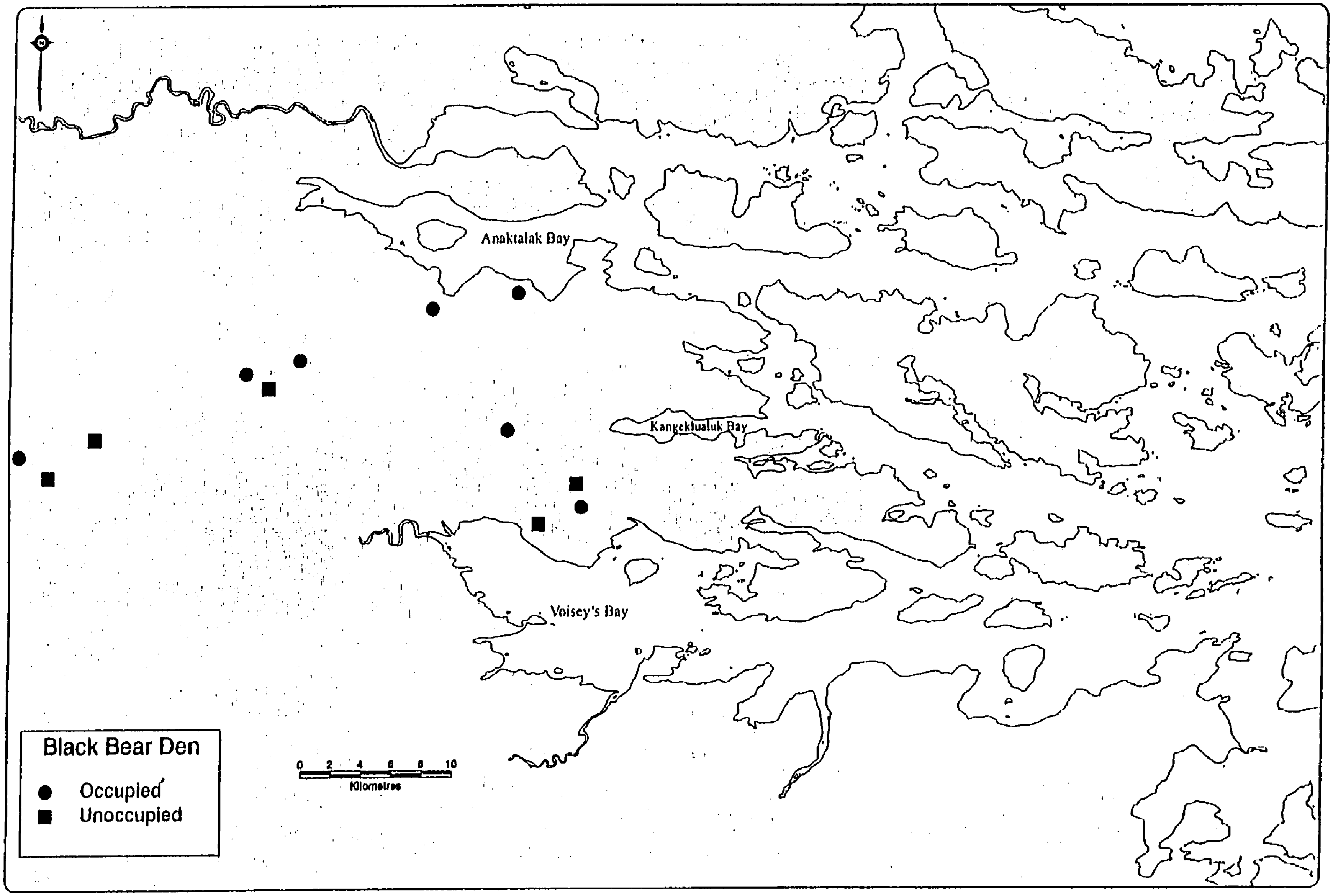
Eight unoccupied den sites were located prior to the start of denning (Figure 3.4). Five den sites were found in spruce forest and three in shrub thicket, and all were oriented with the entrance facing south or southwest.

Three radio-collared females had entered dens by mid-October 1996. A mother with cubs (B07) had left her initial den site by late October and moved to a second nearby den site. Four other bears entered their dens by late November. One adult male (B18, age 23, a recent addition to the study set) and one adult female (age 8) were still active as of December 1, 1996. A black bear survey conducted during early April 1997 revealed that both of these bears had denned in the forest. In total, four denning bears were found on the barrens, and three were found denning in shrub thicket and two were located in forest habitat.

3.9 Food Habits

Field analysis of black bear scat revealed a high berry component *(Empetrum spp, Arctostaphylos spp. and Vaccinium spp.)* from early to mid-summer, and a high green plant component after this period. From mid to late summer, black bears were observed on a number of occasions feeding on grass and seaweed (*Fucus spp.*). By late summer, scat composition changed again and berries became the main fecal component. By mid-October, berries were inaccessible in some areas due to snow cover. Barren habitats appeared to be the most productive areas for berries *(Empetrum spp., Arctostaphylos spp. and Vaccinium spp.)*. No scats were found in the field after mid-October.

Two cases of ungulate predation/scavenging by black bears were observed during 1996. The first case occurred in April and involved an adult male attacking an adult caribou which later died from its wounds (B. Price, pers. comm.). The second case occurred during an attempt to aerial dart a black bear on the Ikadlivik River. The black bear was observed retrieving a dead moose calf from a cache and running with the carcass in its mouth. The bear ran for approximately 50 m, at which time the bear dropped the carcass and ran into the forest. At the time of this incident, an adult female moose was observed within 200 m indicating that the calf had recently died. The carcass was retrieved and used for bait at a snare location. Closer examination of the carcass revealed that it had been partially eaten. Other evidence of ungulate predation was found in a number of black bear scats. One scat was composed of 95% *Cladonia spp.* with intermittent bone shards. The remains of a dead caribou were found near the location of this scat suggesting that the black bear had scavenged the caribou's stomach contents. Old scats with a high caribou fur component were found occasionally throughout the summer.



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Jacques Whitford Environment Limited
Environmental Scientists
Consulting Engineers

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Figure 3.3

KNOWN BLACK BEAR DEN LOCATIONS WITHIN AND NEAR THE STUDY AREA

In addition to evidence of ungulate predation, local river systems (Reid Brook, Koglutukoluk and Ikadlivik River) were walked to determine whether black bear were catching fish. None of the black bear scats encountered revealed evidence of fish bones or fish scales. However, the study team observed two black bears that were displaying potential fishing behavior, but no fish were caught in either case.

4. DISCUSSION

4.1 Population Density

Densities for black bears have been calculated in several locations throughout their distribution. Young and Ruff (1982) estimate 0.37-0.62 bears/1 km^2 for a hunted population of black bears in east central Alberta, while Jonkel and Cowan (1971) reported densities of 0.25-0.40 bear/ km^2 for a population of black bears in Montana. Dennis et al. (1996) report an estimated density of 0.11-0.15 bears/ km^2 in the Serpentine Lake area of western Newfoundland.

The relatively high population density (0.45 to 0.52 bears/km^2) estimated for this study may have resulted from the attraction to human activity at the Voisey's Exploration and Anaktalak Bay Exploration Camp

4.2 Demographics and Morphology

The sex ratio for known black bears in the study area was approximately 1:1. This is within the range of sex ratios reported elsewhere (Poelker and Hartwell 1973; Jonkel and Cowan 1971; Erickson et al. 1964). The oldest bear captured and aged through cementum analysis was 23 years old (B18). This is near the maximum life expectancy of 20-25 years (Kolenosky and Strathearn 1987). Generally speaking captured black bears appeared to be in good physical condition. In fact the excellent body condition and small size caused the study team to incorrectly estimate the ages of some bears. The study team incorrectly classified two bears as sub-adults based on field observations, due to the excellent condition of the teeth, and fur, combined with light weight and small body size. Similarly age estimates for some adult bears were incorrect, once again light weights and excellent body condition caused the study team to classify bears as being younger than the actual age. Veitch and Harrington (1994) have reported small body sizes for barren ground bears, suggesting that as a rule black bears in northern Labrador may be on average smaller than black bears elsewhere in Canada.

4.3 Mating and Reproduction

Black bears are polygamous. Male reproductive biology (as measured through serum testosterone levels) is influenced by geographic location, social status, photo-period and the female estrus cycle (Garshelis and Hellgren 1994). Estrus in females generally occurs from May to August with a peak during June and July (Garshelis and Hellgren 1994). Male black bears use scent trails to locate females (Kolenosky and Strathearn 1987). Black bears reproduce through delayed implantation and have low fecundity (Kolenosky and Strathearn 1987).

Female black bears first give birth between the ages of four and seven, and typically breed every two to three years. One to four cubs may be born during each birthing event (Banfield 1974). Black bear cubs are born between December and February while the mother is still in the den. The cubs generally weigh 0.3 kg at birth and grow to 30 kg by the age of nine months. Bear cubs stay with their mother until they are approximately 17 months old (Kolenosky and Strathearn 1987). According to Elowe and Dodge (1989), a female bear's ability to reproduce is dependent on food availability. They note that 10 out of 10 pregnant female black bears with low carbohydrate diets failed to produce young.

A number of females were in estrus during the initial collaring in June 1996. Throughout June and July, a number of adult males were observed in proximity (less than 15 m) to adult females. This period corresponds with the mating period reported elsewhere in Canada. During this period two adult pairs were observed on the barrens. The barren areas may be important in the mating behavior of bears in this region because odors, which are thought to aid in attracting potential mates, are more readily dispersed on open landscapes.

Only one bear in the study set was known to have cubs during 1996. This adult female (B07) had the smallest home range of all radio tracked bears and appeared to use the barrens more often than the other bears in the study set. Cementum annuli analysis revealed that only one female other than B07 previously had cubs. B09 had given birth three times in the past at ages 6, 9, and 11. The initiation of birth for B09 (age 6) is within the range reported elsewhere (Kolenosky and Strathearn 1987) but the age at time of the first litter for B07 (age 10) is considered old. Two family groups with 3 cubs each were observed during 1996. Many of the incidental family group observations occurred on the barrens. This may reflect family group habitat selection, but may also be due to increased visibility and observer bias.

4.4 Home Range

Black bear home ranges vary with gender, geographic location and resource availability (Harrington 1994; Klenner 1987; Fuller and Keith 1980). Male black bears generally have larger home ranges than female black bears which reflects the male bear's reproductive strategy of mating with as many females as possible (Harrington 1994). Female black bear home ranges can be as small as 3 km^2 (Lindzey and Meslow 1977; Jonkel and Cowan 1971) or as large as 1670 km^2 (Harrington 1994). The average home range for a forest dwelling female bear is 30 km^2 (Stirling and Derocher 1990), while the median home range (n=8) for a barren ground female bear is 360 km^2 (Harrington 1994). The average home range for a forest dwelling male is 80 km^2 (Stirling and Derocher 1990), but ranges as large as 9,500 km^2 have been recorded for barren ground male black bears in northern Labrador (Harrington 1994).

None of the bears for which home ranges were calculated had home ranges as large as those reported by Harrington (1994), even though a number of home ranges were known to have been inflated as a result of bears being moved. The largest home range documented during 1996 was 193 km^2. Taking in to consideration the effect of moving bears, home range areas of the radio collared bears within the project area were similar to these noted by Stirling and Derocher (1990). Home range areas of adult females that were not moved corresponded with the home range areas of adult female forest dwelling bears elsewhere in Canada (Klenner 1987; Stirling and Derocher 1990).

Kolenosky and Strathearn (1987) indicate that home ranges can sometimes be used by more than one bear, but specific areas are seldom used at the same time. Fuller and Keith (1980) observed only 12% overlap in female home ranges in Alberta, while Klenner (1987) observed 100% spatial and temporal home range overlap in Manitoba.

There was a high degree of home range overlap between radio collared black bears in the 1996 study. Based on the population density estimate, the amount of overlap may be higher when unknown bears are factored into the analysis. However, many of the home range overlaps were caused by moving radio collared bears. Observations made after a bear was moved were included in the home range analysis, and may have skewed the home range calculations and inflated the number of estimated overlapping home ranges.

4.5 Habitat Use

Black bears exhibit preferences for certain habitats. In Alberta, black bears commonly use stands of spruce (*Picea* sp), open muskeg , and areas of mixed aspen (*Populus tremuloides*) and jack pine (*Pinus banksiana*) (Fuller and Keith 1980). Black bear movement in Manitoba appeared to be restricted to wooded areas, ravines and shelter belts (Klenner 1987). Zytaruk (1978) noted that black bears in New Brunswick preferred areas of dense balsam fir instead of open mixed forests. Black bears in northern Labrador have been able to persist in the absence of a forested ecosystem (A. Veitch, pers. comm.).

Home range habitat composition was similar for all black bears for which home ranges had been calculated. Forest was the major habitat type in each home range calculated. Adults, sub-adults, females, and males all used the forest slightly more than the barrens. It should be noted that in other areas of Canada, black bears do not appear to use the barrens even when they are available. In terms of resource selection, black bears in the study area during 1996 may have exhibited a transitional selection behavior, displaying habitat selection characteristics common to both barren ground and forest dwelling black bears. Use of the barrens by study set black bears during 1996 may have been due to the high residual berry crop on the barrens during spring and the large berry crop on the barrens during late summer and early fall.

4.6 Food Habits

Black bears are free roaming omnivores (Banfield 1974); however, according to Kolenosky and Strathearn (1987), black bears are primarily vegetarian. The black bear diet appears to vary with season, geographic location (Holcroft and Herrero 1991) and human activity (Craighead and Craighead 1971). During the spring, they feed on emerging plant matter and insects, but switch to berries during the summer and fall.

In Alberta, black bears feed on green plant matter and insects during the spring, and add raspberry (*Rubus idaeus*) and horsetail (*Equisetum sp.)* to their diet in the summer. Berries and insects are their main food during the fall (Holcroft and Herrero 1991). Black bears in New Brunswick feed on grasses in the spring, and switch to blueberry (*Vaccinium angustifolium*) and raspberry in late summer (Zytaruk 1978).

In insular Newfoundland, black bears use blueberry and bake-apple (*Rubus chaememorus*) as sources of caloric energy during the pre-denning period (Payne 1978). According to Veitch and Harrington (1994), barren ground black bears in northern Labrador have smaller body sizes and a greater dependence on protein than their forest dwelling counterparts. According to Harrington (1994), small mammals are the major meat component in the barren ground black bears diet. This reliance on protein is apparently due to the lack of mast crops (e.g. acorns) in the surrounding habitat (Veitch and Harrington 1994). Schwartz and Franzmann (1989) found that black bears in Alaska accounted for 80% of moose predation and 70% of moose mortality; however, moose predation was probably only a small component of the overall black bear diet. In addition to ungulate and small mammal predation, fish and seals may be important components of the black bear diet at various times of the year in Labrador.

Opportunistic field analysis of black bear scats in the project area during 1996 revealed that black bears were mainly vegetarians. Berries were the main diet components in late spring, late summer, and in the fall. Residual berries were abundant on the barrens during the initial collaring in late June, and almost all black bear scats encountered during the initial collaring were composed of berries and associated plant matter. By mid-July berries appeared to become scarce and green plant matter became the main scat constituent. Green plant matter was readily available in most habitats throughout the project area.

The high dietary plant component corresponded with black bear food habits in other regions, but the noticeable lack of insects in the scats was not compatible with findings in other areas of Canada. Two incidental observations made in the project area during 1996 corroborate findings of ungulate predation in Alaska (Schwartz and Franzmann 1989) and Newfoundland (Dennis et al 1996). No small mammal remains were found in black bear scats during 1996. This finding is comparable to the low population numbers observed by the small mammal study (JWEL 1997b). There were no observations of black bears successfully catching fish in the project area in 1996. The two incidences of potential fishing behavior suggested that black bears may have been the cause for some radio tagged fish mortality. However, these mortalities were more likely caused by a river otter (*Lutra canadensis*) (JWEL 1997c).

4.7 Denning

Black bear denning usually occurs between September and November (Schooley et al. 1994; Harrington 1994; Tietje and Ruff 1980; Fuller and Keith 1980; Lindzey and Meslow 1977; Armstrup and Beecham 1976; Jonkel and Cowan 1971; Rogers 1970). Denning may be affected by food availability, photo-period, temperature, snowfall, gender and pregnancy (Schooley et al. 1994; Tietje and Ruff 1980; Jonkel and Cowan 1971).

Emergence from the den usually occurs during spring (April to June) and appears to be influenced by snow melt, photo-period, temperature, gender and pregnancy (Harrington 1994; Schooley et al. 1994; Fuller and Keith 1980). Snowstorms have been suggested as a stimulus for denning (Craighead and Craighead 1972), while low fall food availability and inadequate body weight have been reported as the cause of delayed den entry (Schooley et al. 1994; Klenner and Kroeker 1990).

In northern areas where large hollow trees are uncommon, bears tend to use excavated dens which they line with plant material (Klenner and Kroeker 1990; Tietje and Ruff 1980; Fuller and Keith 1980). Tietje and Ruff (1980) concluded that the proportion of bears excavating dens is linked to lower winter temperatures and the need for increased insulation. Schooley et al (1994) reported that females often construct dens within the confines of their summer range, while Tietje and Ruff (1980) reported that males often used den sites far removed from their summer range. Pregnant females appear to den earlier than other females (Klenner and Kroeker 1990) and barren ground females show a preference for denning at high elevations (Harrington 1994). The wide range of den types and habitats used suggest that den site availability does not limit certain bear populations (Klenner and Kroeker 1990).

Bears use a variety of habitat types for den sites, and selection seems to vary depending on geographic location and winter severity (Tietje and Ruff 1980). Dens in the study area were found in three habitat types: White Spruce forests, shrub thickets and on the barrens. All dens within the forest and shrub thickets were excavated with the roofs supported by the root systems of adjacent plant life (i.e. trees and shrubs). All dens found had the entrance facing south or southwest, possibly to minimize exposure to north winds and increase exposure to sunlight. All dens were found in slightly elevated areas, possibly to reduce the chance of flooding during spring melt. Two unoccupied black bear dens were found with recent signs of porcupine (*Erithizon dorsatum)* use. Active black bear dens in the study area were located using radio telemetry. In order to minimize bear disturbance, occupied den structures were not examined during 1996.

4.8 Moving Black Bears and Homing

Moving black bears is a common method of bear control (Bromley 1985; Follmann and Hechtel 1990). However, it is generally accepted that it is not an effective control method since black bears often return to the capture site (Bromley 1985; Follmann and Hechtel 1990). Rogers (1987) reported that black bears were able to return to home ranges from release distances of greater than 60 km. In addition to being ineffective, the chance of injuring a black bears increases during a move event.

4.9 Daily Activity

Daily activity patterns arise in response to seasonal and diurnal variations in the environment (Nielsen 1983). Factors to consider when evaluating activity patterns include: environmental constraints; optimal foraging; and social activities (Lariviere et al 1994). Black bears are generally considered diurnal (Armstrup and Beecham 1976; Lindzey and Meslow 1977; Lariviere et al 1994). Lariviere et al (1994) found that activity began 30 minutes after sunrise and ended 2.5 hours after sunset. These results correspond to those observed in the study area during 1995 and 1996. According to the activity monitors built into the three GPS collars black bears were least active for the three hour period before midnight. Generally speaking the highest levels of activity occurred at 5 am and 5 pm (Appendix H).

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Appendix A

Black Bear Study Permit

GOVERNMENT OF
NEWFOUNDLAND AND LABRADOR

Department of Forest Resources & Agrifoods
Wildlife Division

Mr. Perry Trimper
Jacques Whitford Environment
367 Hamilton River Road
P.O. Box 274, Station C
Goose Bay (Labrador)
A0P 1C0

16 May 1996

Re: Scientific Permit – Voisey's Bay Black Bear Research

Dear Mr. Trimper,

Please be advised that this letter has the effect of a Wildlife permit for the study of the ecology of black bears as described in your protocol (memorandum of 3 May 1996).

You are hereby authorized to monitor the movements, habitat use, and food habits of ten (10) radio-collared black bears, June - December 1996, in the vicinity of Voisey's Bay. The authority also extends to those persons identified in your protocol (Keith Chaulk and his advisors and field assistant). It is understood that the Wildlife Division staff must be directly involved in the immobilization and handling of all such black bears, and that all radio-collar frequencies must be coordinated with the Senior Biologist of the Wildlife Division. It is further understood that all data and reports from this study will be made available to the Wildlife Division within a reasonable period after completion of the fieldwork.

Please note that this permit does not represent, in any regard, an endorsement by the Wildlife Division of the nature or scope of studies that might be required as part of an environmental assessment of mineral developments in Labrador.

I wish you the best with this research.

Sincerely,

James Schaefer

James Schaefer, Ph.D.
Senior Wildlife Biologist

cc. Derek LeBoubon, Regional Wildlife Manager
Charlie Butler, Environmental & Wildlands Biologist
Shane Mahoney, Chief of Research & Inventories

P.O. Box 3014, Station B, Goose Bay (Labrador), A0P 1E0, Canada Telephone (709) 896-2732 Telefax (709) 896-0188

Appendix B

Sample Black Bear Data Sheet

BLACK BEAR COMPONENT STUDY - JACQUES WHITFORD ENVIRONMENT

CAPTURE DATE | C TIME | C SITE | C LOCATE N | C LOCATE E

ELEASE DATE | R TIME | R SITE | R LOCATE N | R LOCATE E

BEAR ID | SEX ☐M ☐F | OBSERVERS | CEMETUM AGE

RECAPT ☐Y ☐N | CAPT METHOD ☐air ☐snare ☐culvert ☐shot | FIELD AGE

TAGGING DATA

	OLD #	NEW #	TAG LOCATION	COLOR	TRANSMITTER ID	FREQUENCY
1						
2						
3						
4						
5						

OTHER 1

DRUG DATA

		DOSAGE	INJECTION SITE	RESPONSE
DRUG 1				
DRUG 2				

OTHER

TIME DATA

BEGIN	CHASE	INJECT 1	INJECT2	IMMOBILIZED	ANTIDOTE	RELEASE

PHYSICAL CONDITION

BODY ☐E ☐G ☐F ☐P | PELAGE ☐E ☐G ☐F ☐P

REPRODUCTIVE CONDITION | BODY TEMP | RESPIRATION BPM | HEART RATE PPM | NASAL DISCHARGE ☐Y ☐N

ECTOPARASITES ☐Y ☐N | TYPE

STANDARD MEASUREMENTS (METRIC)

	HEAD	F	FOOT H	TAIL	EAR	TOTAL
LENGTH						
WIDTH						

			SHOULDER HEIGHT	ESTIMATED WEIGHT	WEIGHT
CHEST		NECK			

REMARKS

RADIO TELEMETRY DATA SHEET

Date | Time | Observers | Bear ID | Lat | Long | Heading | Activity
☐ Moving ☐ Stationary

Observation Type ☐ Bear ☐ Capture ☐ Kill ☐ Den ☐ Other Wildlife ☐ Aerial ☐ Ground ☐ Visual ☐ No Visual

Habitat Type ☐ Forest ☐ Marsh ☐ Barren ☐ Other... Number Of Bears ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4

Triangulation ☐ Yes ☐ No Error Polygon ☐ Yes ☐ No Map Point ☐ Yes ☐ No

UTM N UTM E

COMMENTS

Date | Time | Observers | Bear ID | Lat | Long | Heading | Activity
☐ Moving ☐ Stationary

Observation Type ☐ Bear ☐ Capture ☐ Kill ☐ Den ☐ Other Wildlife ☐ Aerial ☐ Ground ☐ Visual ☐ No Visual

Habitat Type ☐ Forest ☐ Marsh ☐ Barren ☐ Other... Number Of Bears ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4

Triangulation ☐ Yes ☐ No Error Polygon ☐ Yes ☐ No Map Point ☐ Yes ☐ No

UTM N UTM E

COMMENTS

Date | Time | Observers | Bear ID | Lat | Long | Heading | Activity
☐ Moving ☐ Stationary

Observation Type ☐ Bear ☐ Capture ☐ Kill ☐ Den ☐ Other Wildlife ☐ Aerial ☐ Ground ☐ Visual ☐ No Visual

Habitat Type ☐ Forest ☐ Marsh ☐ Barren ☐ Other... Number Of Bears ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4

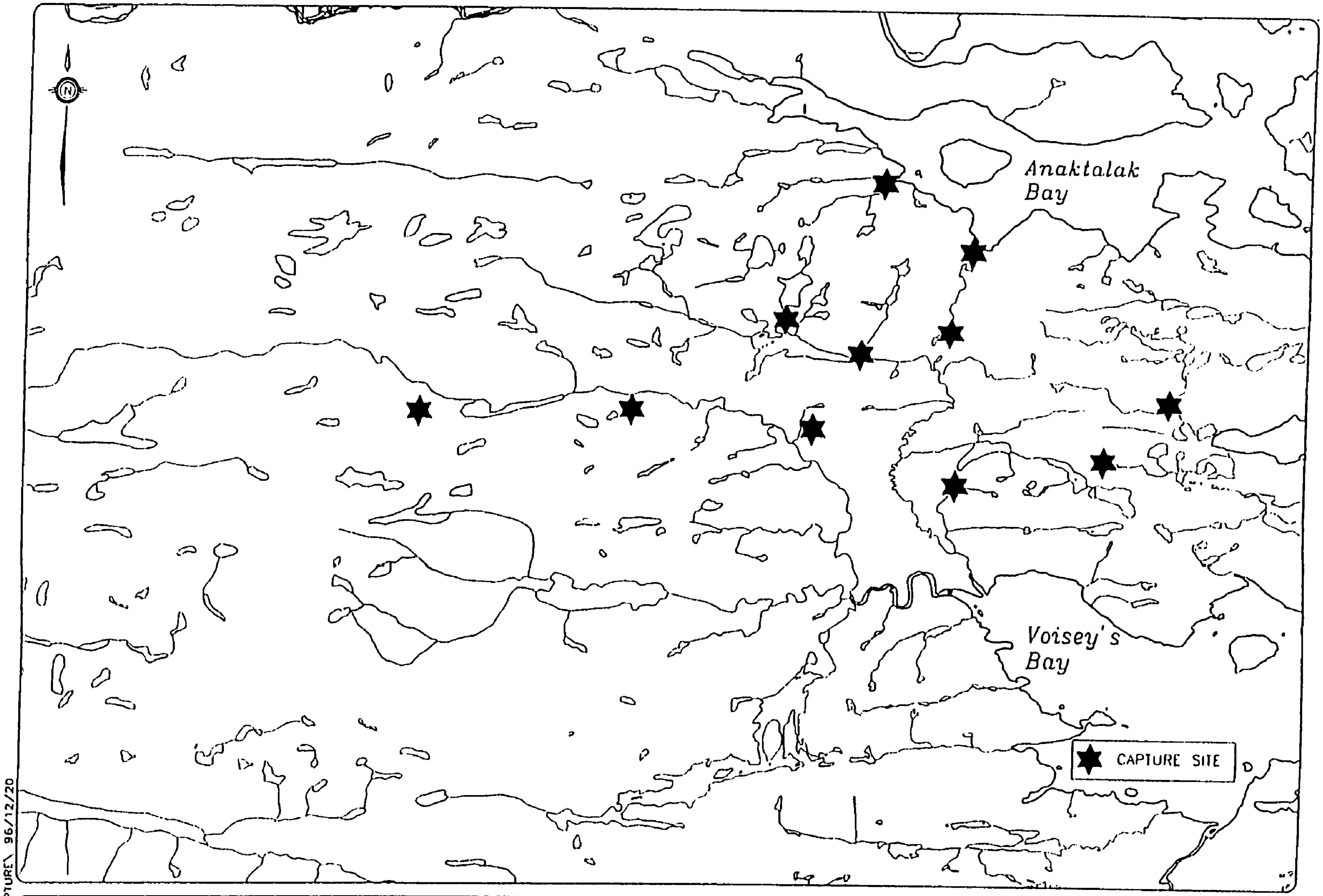
Triangulation ☐ Yes ☐ No Error Polygon ☐ Yes ☐ No Map Point ☐ Yes ☐ No

UTM N UTM E

COMMENTS

Appendix C

Black Bear Capture Data for 1996



R:\823\62009\CAPTURE\ 96/12/20

JACQUES WHITFORD ENVIRONMENT
ENVIRONMENTAL SCIENTISTS
CONSULTING ENGINEERS

VOISEY'S BAY NICKEL COMPANY LIMITED

FIGURE 1
BLACK BEAR CAPTURE LOCATIONS
1996

SUMMARY OF BLACK BEAR CAPTURE DATA 1996

ar I D	Sex	Estimated Age	Cementum Age	Weight
00	m	3		49

ATE	06/18/1996	SITE	ANAKTALAK CAMP	METHOD	CULVERT
ATE	08/18/1996	SITE	ANAKTALAK CAMP	METHOD	CULVERT
ATE	10/08/1996	SITE	ANAKTALAK CAMP	METHOD	CULVERT

UMBER OF TIMES CAPTURED 3

ear I D	Sex	Estimated Age	Cementum Age	Weight
01	m	12	10	88

DATE	06/21/1996	SITE	IKADLIVIK RIVER	METHOD	SNARE
DATE	08/02/1996	SITE	VOISEY'S CAMP	METHOD	CULVERT
DATE	08/16/1996	SITE	VOISEY'S CAMP	METHOD	SHOT

UMBER OF TIMES CAPTURED 3

ear I D	Sex	Estimated Age	Cementum Age	Weight
02	f	6	7	50

DATE	06/21/1996	SITE	KANGEKLUALUK BAY	METHOD	SNARE
DATE	07/28/1996	SITE	VOISEY'S CAMP	METHOD	CULVERT
DATE	08/27/1996	SITE	NEAR SARAH	METHOD	AIR

UMBER OF TIMES CAPTURED 3

SUMMARY OF BLACK BEAR CAPTURE DATA 1996

Bear I D	Sex	Estimated Age	Cementum Age	Weight
03	f	6	7	70

DATE 06/22/1996 SITE IKADLIVIK RIVER METHOD SNARE

NUMBER OF TIMES CAPTURED 1

Bear I D	Sex	Estimated Age	Cementum Age	Weight
04	f	6	6	45

DATE 06/22/1996 SITE MACMILLAN METHOD SNARE

DATE 08/16/1996 SITE OPTION 8 METHOD SNARE

NUMBER OF TIMES CAPTURED 2

Bear I D	Sex	Estimated Age	Cementum Age	Weight
05	m	8		130

DATE 06/23/1996 SITE ANAKTALAK CAMP METHOD CULVERT

NUMBER OF TIMES CAPTURED 1

SUMMARY OF BLACK BEAR CAPTURE DATA 1996

ar I D	Sex	Estimated Age	Cementum Age	Weight
06	f	7-8	13	70

ATE 06/23/1996 SITE ANAKTALAK CAMP METHOD CULVERT

MBER OF TIMES CAPTURED 1

ar I D	Sex	Estimated Age	Cementum Age	Weight
07	f	6	10	45

ATE 06/24/1996 SITE IKADLIVIK RIVER METHOD SNARE

MBER OF TIMES CAPTURED 1

ar I D	Sex	Estimated Age	Cementum Age	Weight
08	f	3.5	6	45

ATE 07/10/1996 SITE ANAKTALAK CAMP METHOD CULVERT

ATE 08/17/1996 SITE CAPTURE NEAR HALFWAY HILL METHOD SNARE

ATE 08/20/1996 SITE ANAKTALAK CAMP METHOD CULVERT

JMBER OF TIMES CAPTURED 3

SUMMARY OF BLACK BEAR CAPTURE DATA 1996

Bear I D	Sex	Estimated Age	Cementum Age	Weight
09	f	3.5	8	40

DATE 07/30/1996 SITE VOISEY'S CAMP METHOD CULVERT

DATE 08/10/1996 SITE VOISEY'S CAMP METHOD CULVERT

NUMBER OF TIMES CAPTURED 2

Bear I D	Sex	Estimated Age	Cementum Age	Weight
10	m	3.5	2	61

DATE 07/30/1996 SITE VOISEY'S CAMP METHOD CULVERT

DATE 08/10/1996 SITE VOISEY'S CAMP METHOD CULVERT

NUMBER OF TIMES CAPTURED 2

Bear I D	Sex	Estimated Age	Cementum Age	Weight
11	m	3.5		78

DATE 08/01/1996 SITE VOISEY'S CAMP METHOD CULVERT

DATE 10/19/1996 SITE VOISEY'S CAMP METHOD SHOT

NUMBER OF TIMES CAPTURED 2

SUMMARY OF BLACK BEAR CAPTURE DATA 1996

Bear I D	Sex	Estimated Age	Cementum Age	Weight
12	f	5	16	68

DATE	08/01/1996	SITE	VOISEY'S CAMP	METHOD	CULVERT
DATE	08/08/1996	SITE	VOISEY'S CAMP	METHOD	CULVERT
DATE	08/17/1996	SITE	VOISEY'S CAMP	METHOD	CULVERT
DATE	09/20/1996	SITE	VOISEY'S CAMP	METHOD	CULVERT

NUMBER OF TIMES CAPTURED 4

Bear I D	Sex	Estimated Age	Cementum Age	Weight
13	m	3	2	45

DATE	08/02/1996	SITE	VOISEY'S CAMP	METHOD	CULVERT

NUMBER OF TIMES CAPTURED 1

Bear I D	Sex	Estimated Age	Cementum Age	Weight
14	f	3	[illegible]	27

DATE	08/16/1996	SITE	REID POND	METHOD	SNARE

NUMBER OF TIMES CAPTURED 1

SUMMARY OF BLACK BEAR CAPTURE DATA 1996

Bear I D	Sex	Estimated Age	Cementum Age	Weight
15	m	3		36

DATE 08/17/1996 SITE NEAR OTTER POND, TRAP STATION #1. METHOD SNARE

NUMBER OF TIMES CAPTURED 1

Bear I D	Sex	Estimated Age	Cementum Age	Weight
16	m	4		60

DATE 08/24/1996 SITE ANAKTALAK CAMP METHOD CULVERT

DATE 10/04/1996 SITE VOISEY'S CAMP METHOD CULVERT

NUMBER OF TIMES CAPTURED 2

Bear I D	Sex	Estimated Age	Cementum Age	Weight
17	m			

DATE 08/22/1996 SITE ANAKTALAK CAMP METHOD SHOT

NUMBER OF TIMES CAPTURED 1

SUMMARY OF BLACK BEAR CAPTURE DATA 1996

Bear I D	Sex	Estimated Age	Cementum Age	Weight
18	m		23	125

DATE 10/19/1996 SITE VOISEY'S CAMP METHOD CULVERT

NUMBER OF TIMES CAPTURED 1

Bear I D	Sex	Estimated Age	Cementum Age	Weight
A-bay 1				41

DATE 06/17/1996 SITE ANAKTALAK CAMP METHOD CULVERT

NUMBER OF TIMES CAPTURED 1

Bear I D	Sex	Estimated Age	Cementum Age	Weight
A-Bay 2		3		

DATE 07/01/1996 SITE ANAKTALAK CAMP METHOD CULVERT

NUMBER OF TIMES CAPTURED 1

SUMMARY OF BLACK BEAR CAPTURE DATA 1996

Bear I D	Sex	Estimated Age	Cementum Age	Weight
Limpy	M	5	9	

DATE	08/27/1996	SITE	ANAKTALAK CAMP	METHOD	CULVERT
DATE	10/14/1996	SITE	ANAKTALAK CAMP	METHOD	CULVERT
DATE	11/28/1996	SITE	VOISEY'S CAMP	METHOD	SHOT

NUMBER OF TIMES CAPTURED 3

Bear I D	Sex	Estimated Age	Cementum Age	Weight
V-Bay 1				

DATE	07/27/1996	SITE	VOISEY'S CAMP	METHOD	CULVERT

NUMBER OF TIMES CAPTURED 1

TOTAL NUMBER OF CAPTURE EVENTS 41

Appendix D

Population Density Calculation

Black Bears Used in Density Calculation (n=18)*

Bear ID	Age Class	Sex
00	Sub-adult	Male
01	Adult	Male
02	Adult	Female
05	Adult	Male
06	Adult	Female
08	Adult	Female
09	Adult	Female
10	Sub-adult	Male
11	Sub-adult	Male
12	Adult	Female
13	Sub-adult	Male
14	Sub-adult	Female
15	Sub-adult	Male
16	Sub-adult	Female
17	Unknown	Male
18	Adult	Male
Limpy	Adult	Male
Billy	Unknown	Unknown

18 bears divided by 40 km^2 = 0.45 bears /km^2
18 represents a minimum number of bears within the Reid Brook Valley during 1996

*If bears known as A-Bay 1, A-Bay 2 and V-Bay 1 are included in the calculation the density increases to 21 bears divided by 40 km^2 = 0.52 bears /km^2

Appendix E

Black Bear Home Range Areas
in 1996 (Based on VHF Data Set)

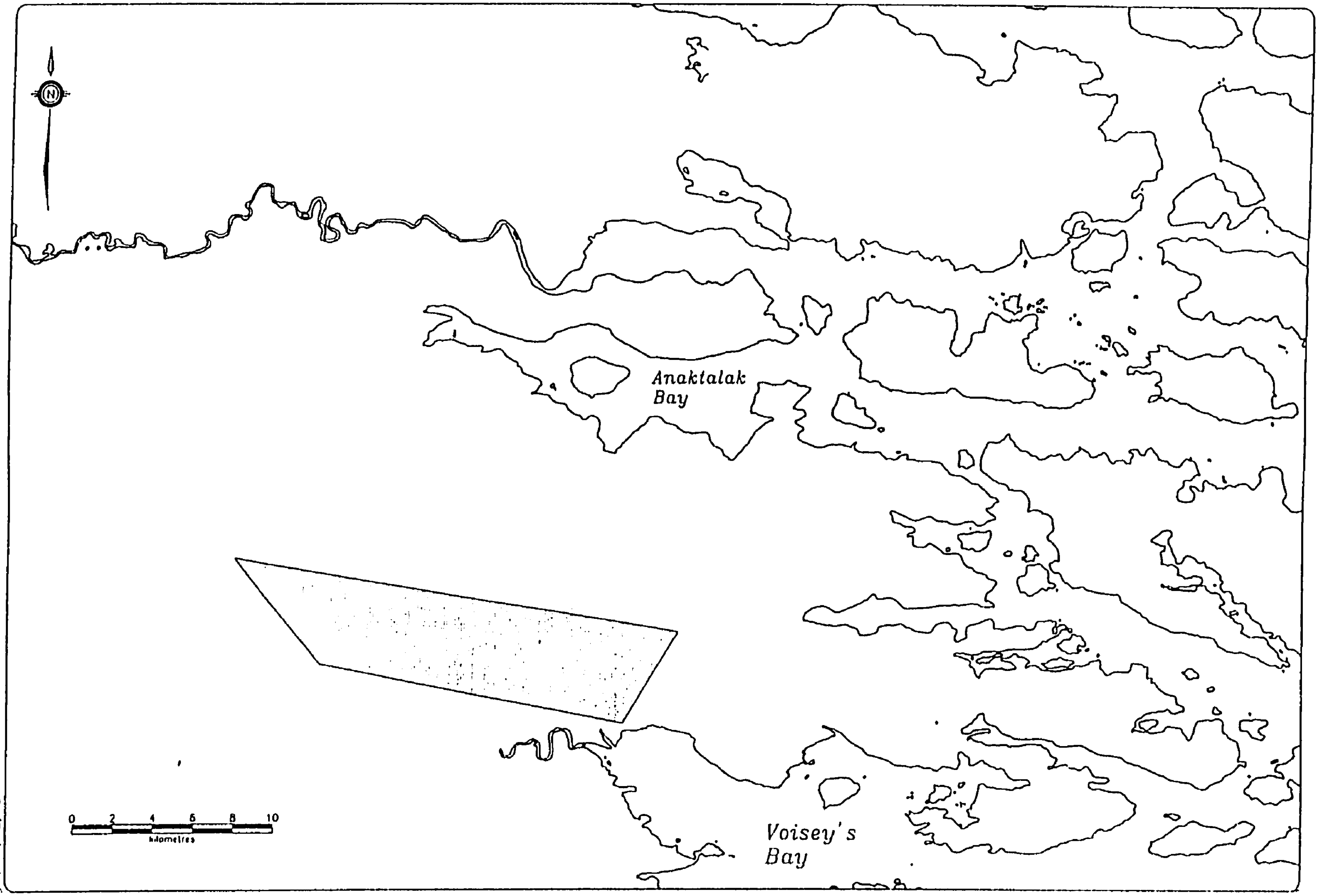


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FIGURE 1

Black Bear B01 Adult Male
Home Range Area = 81 Km^2

PROJECT No.823-62009

VHF Data Set

Home Range Calculation = 100% MCP

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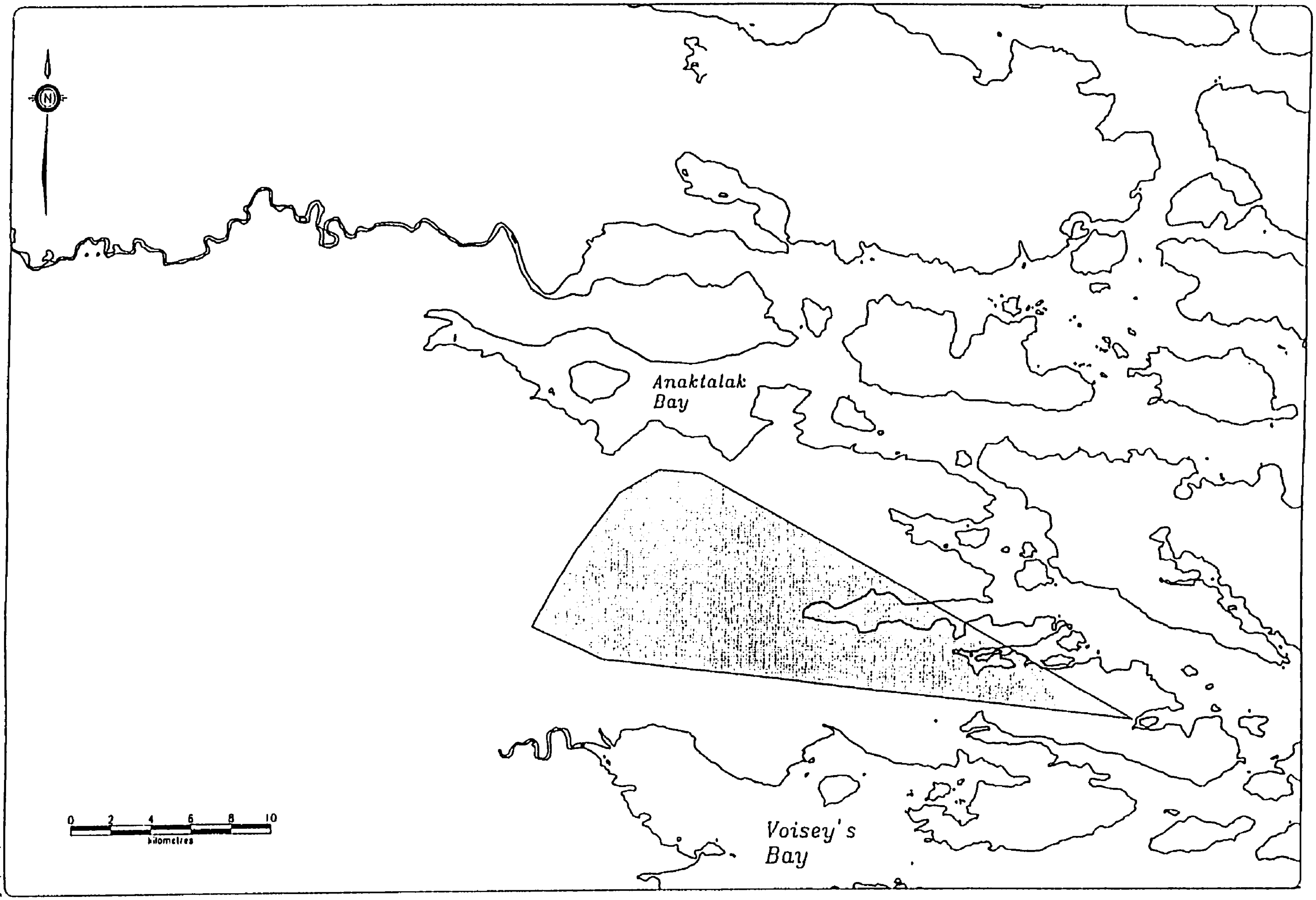

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PROJECT No.823-62009

FIGURE 2

Black Bear B02 Adult Female
Home Range = 147 Km^2

VHF Data Set

Home Range Calculation = 100% MCP

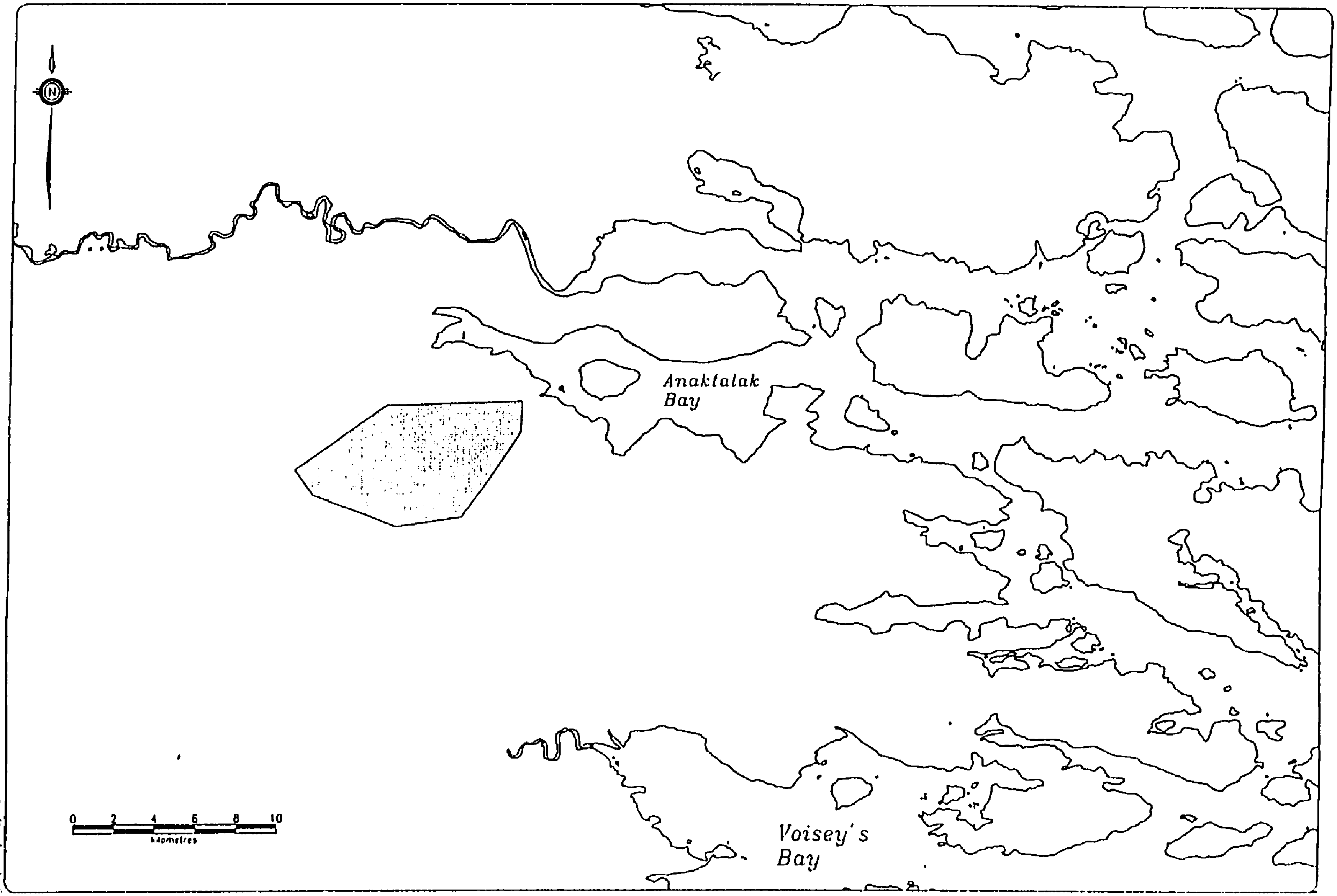

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FIGURE 3

Black Bear B04 Adult Female
Home Range = 43 Km^2

PROJECT No.823-62009

VHF Data Set

Home Range Calculation = 100% MCP

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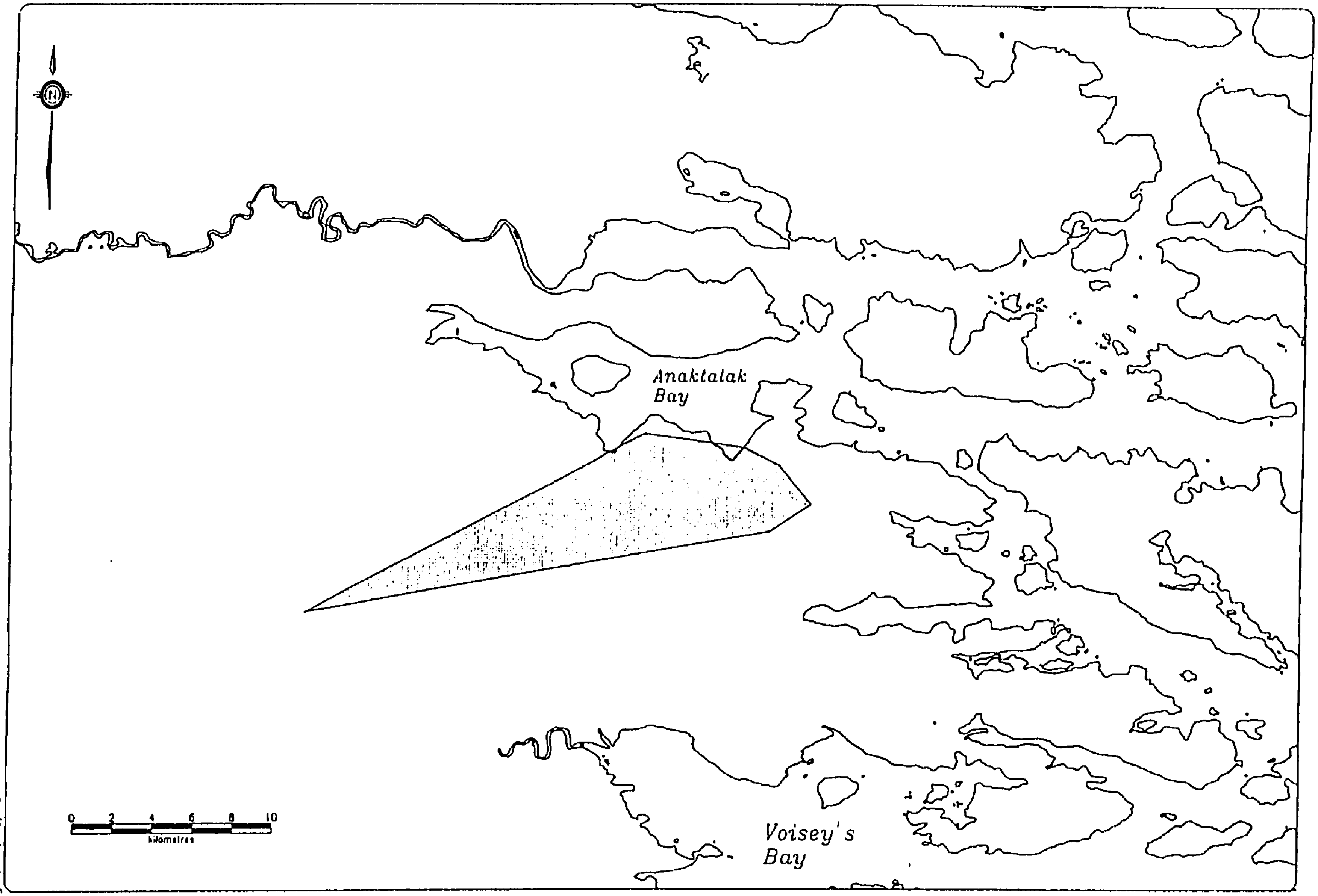

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PROJECT No.823-62009

FIGURE 4

Black Bear B06 Adult Female
Home Range = 76 Km^2

VHF Data Set

Home Range Calculation = 100% MCP

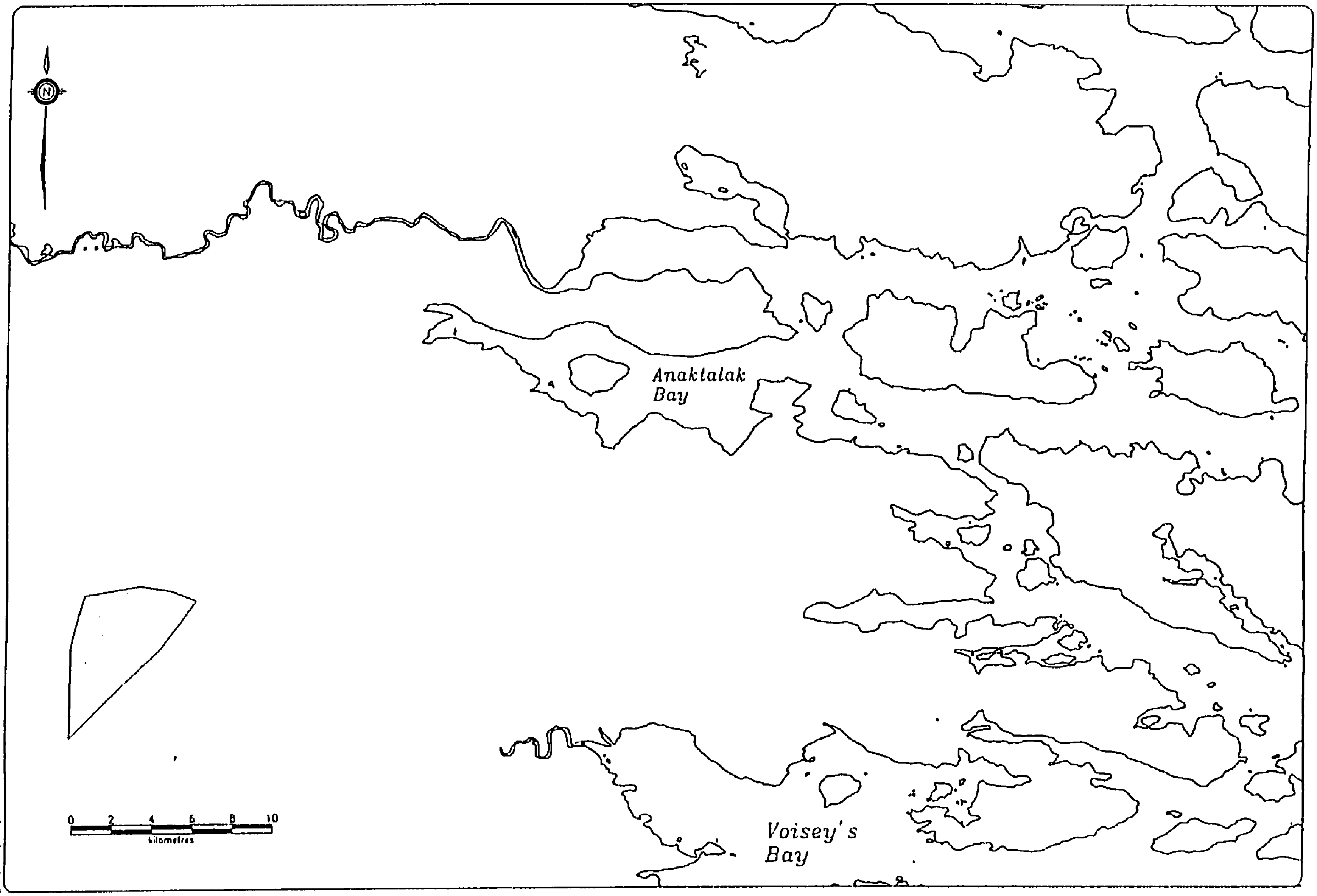

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FIGURE 5

Black Bear B07 Adult Female
Home Range = 22 Km^2

PROJECT No.823-62009

VHF Data Set

Home Range Calculation = 100% MCP

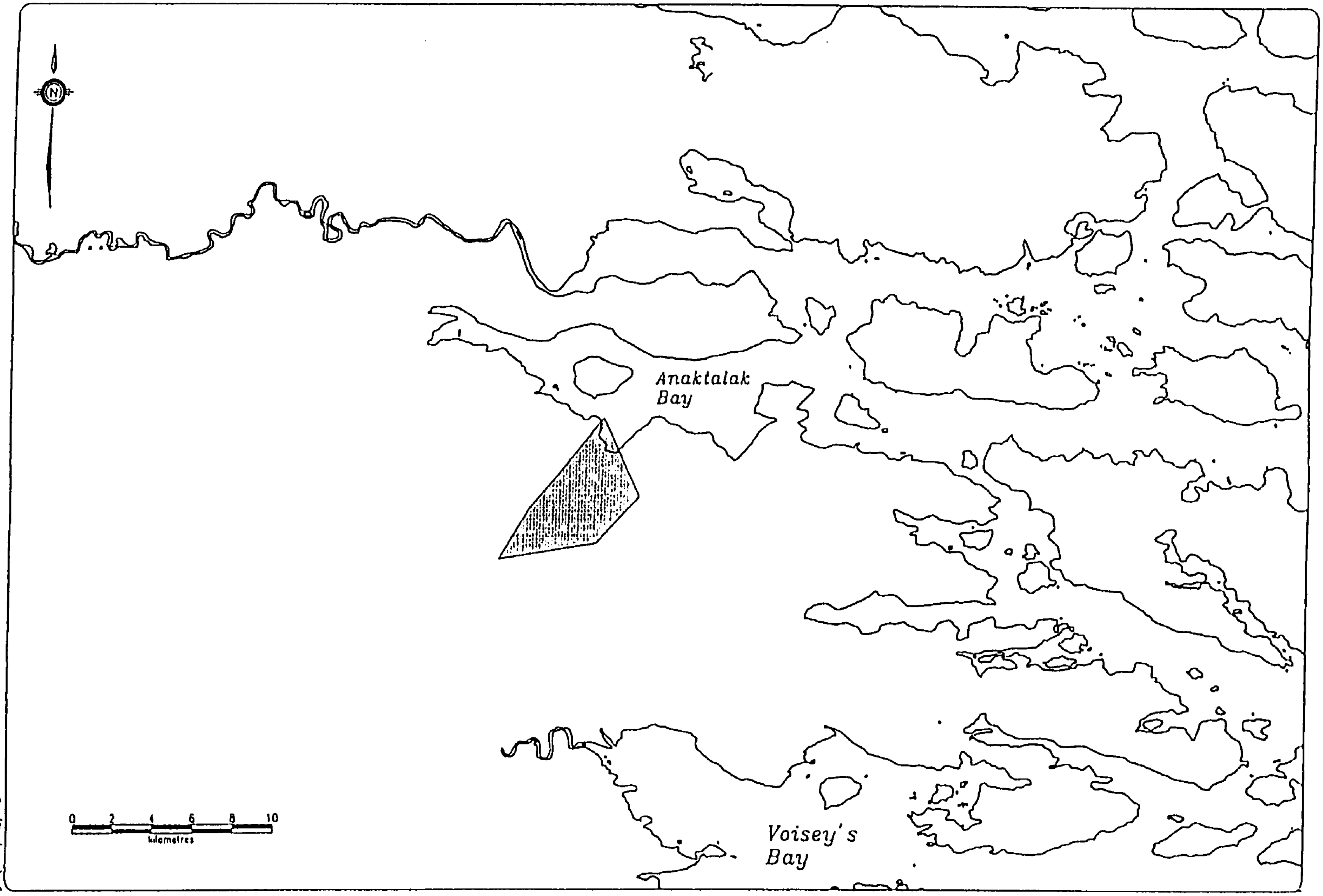

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FIGURE 6
Black Bear B08 Adult Female
Home Range = 21 Km^2

PROJECT 823-62009

VHF Data Set

Home Range Calculation = 100% MCP

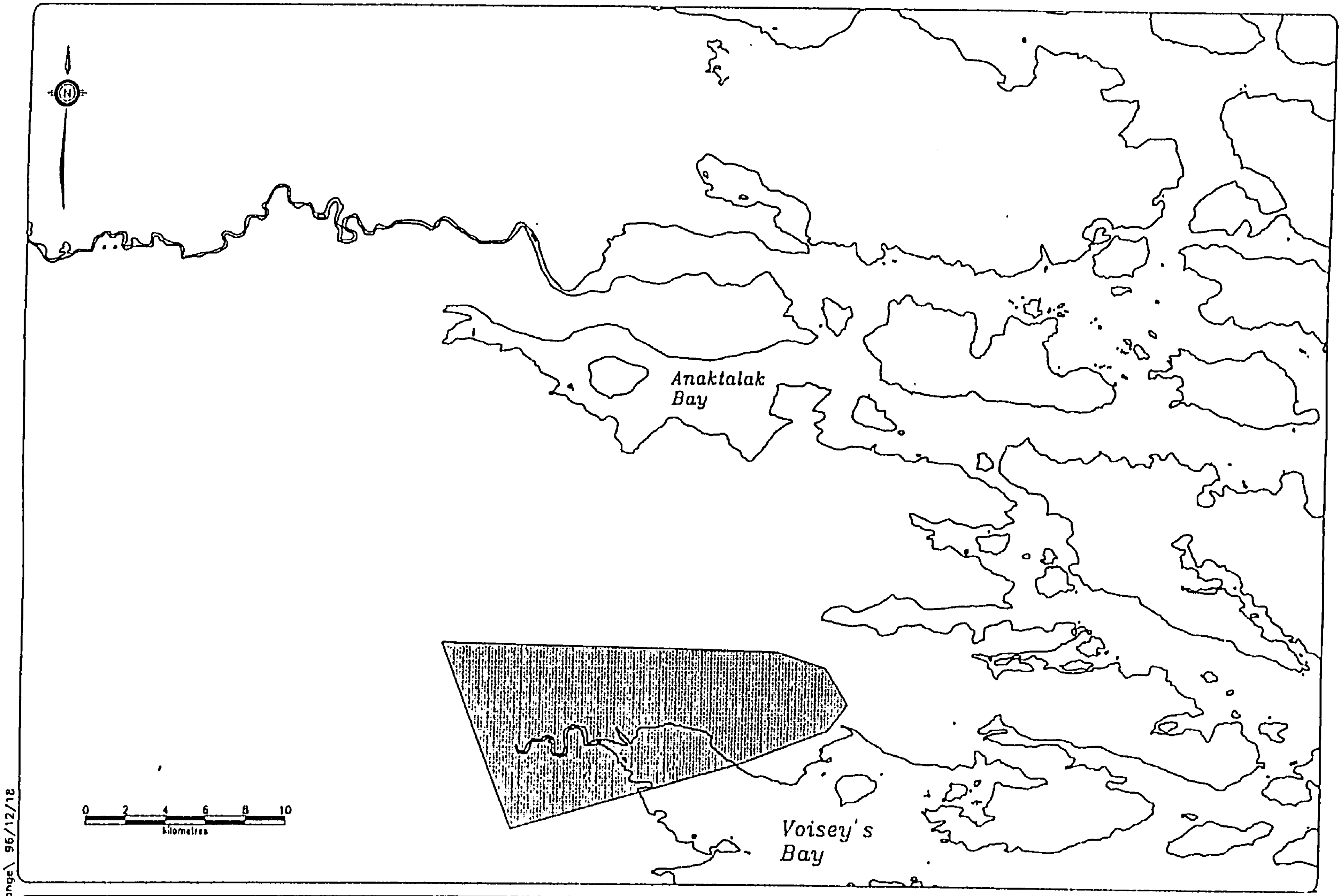

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FIGURE 7

Black Bear B09 Adult Female
Home Range = 111 Km^2

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VHF Data Set

Home Range Calculation = 100% MCP

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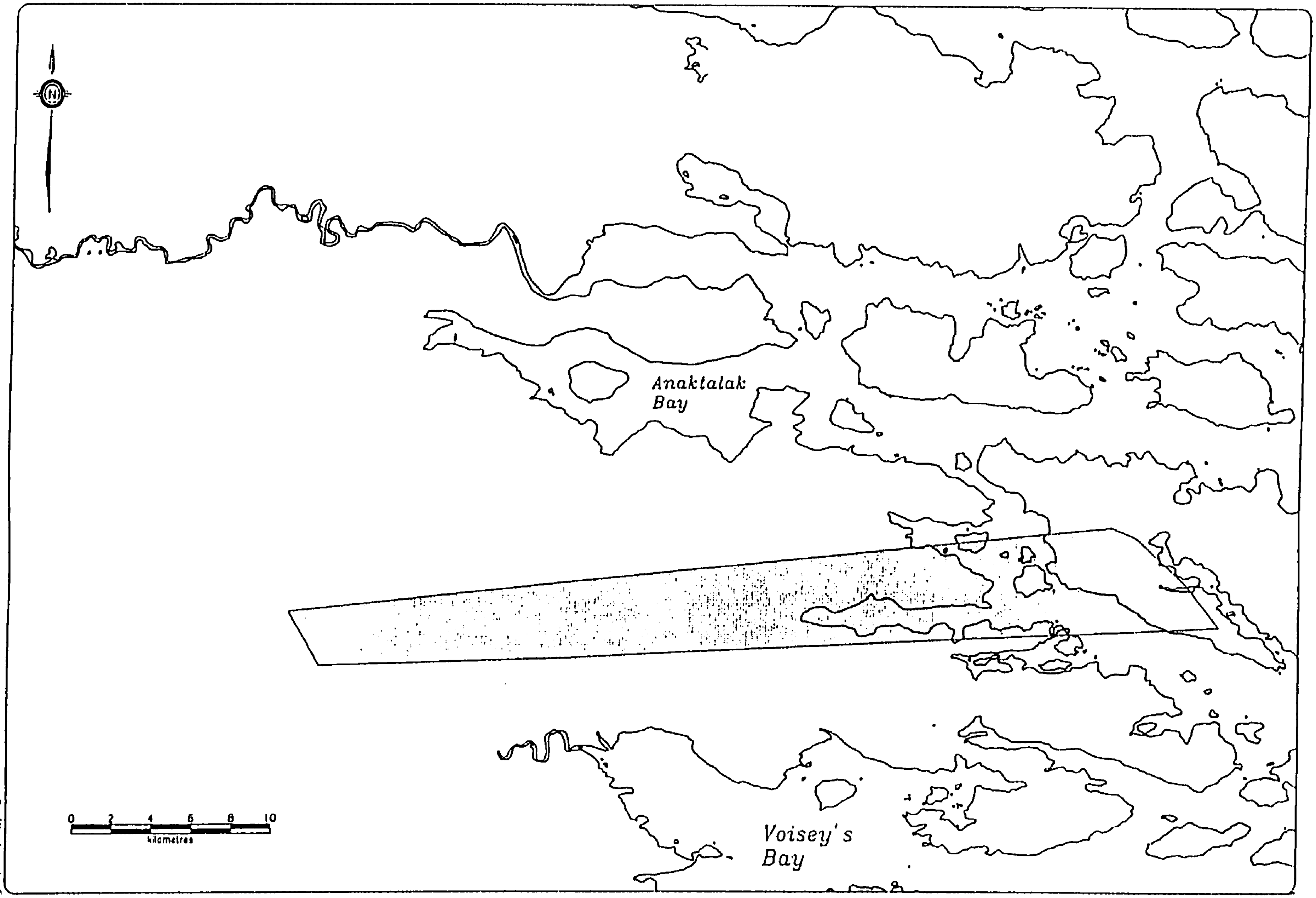

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FIGURE 8

Black Bear B10 Subadult Male
Home Range = 163 Km^2

PROJECT No.823-62009 | VHF Data Set | Home Range Calculation = 100% MCP

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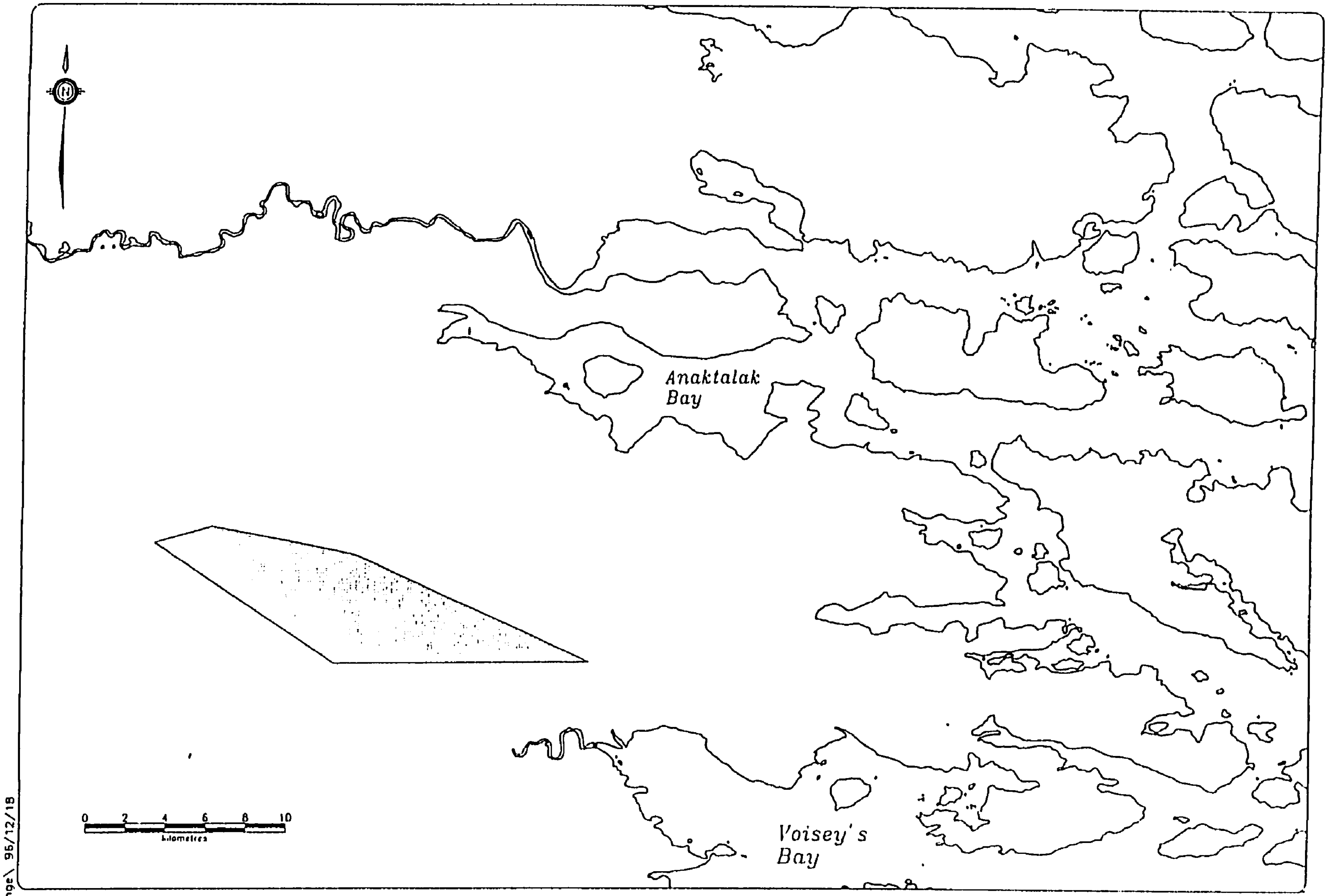

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FIGURE 9

Black Bear B11 Subadult Male
Home Range = 59 Km^2

VHF Data Set

Home Range Calculation = 100% MCP

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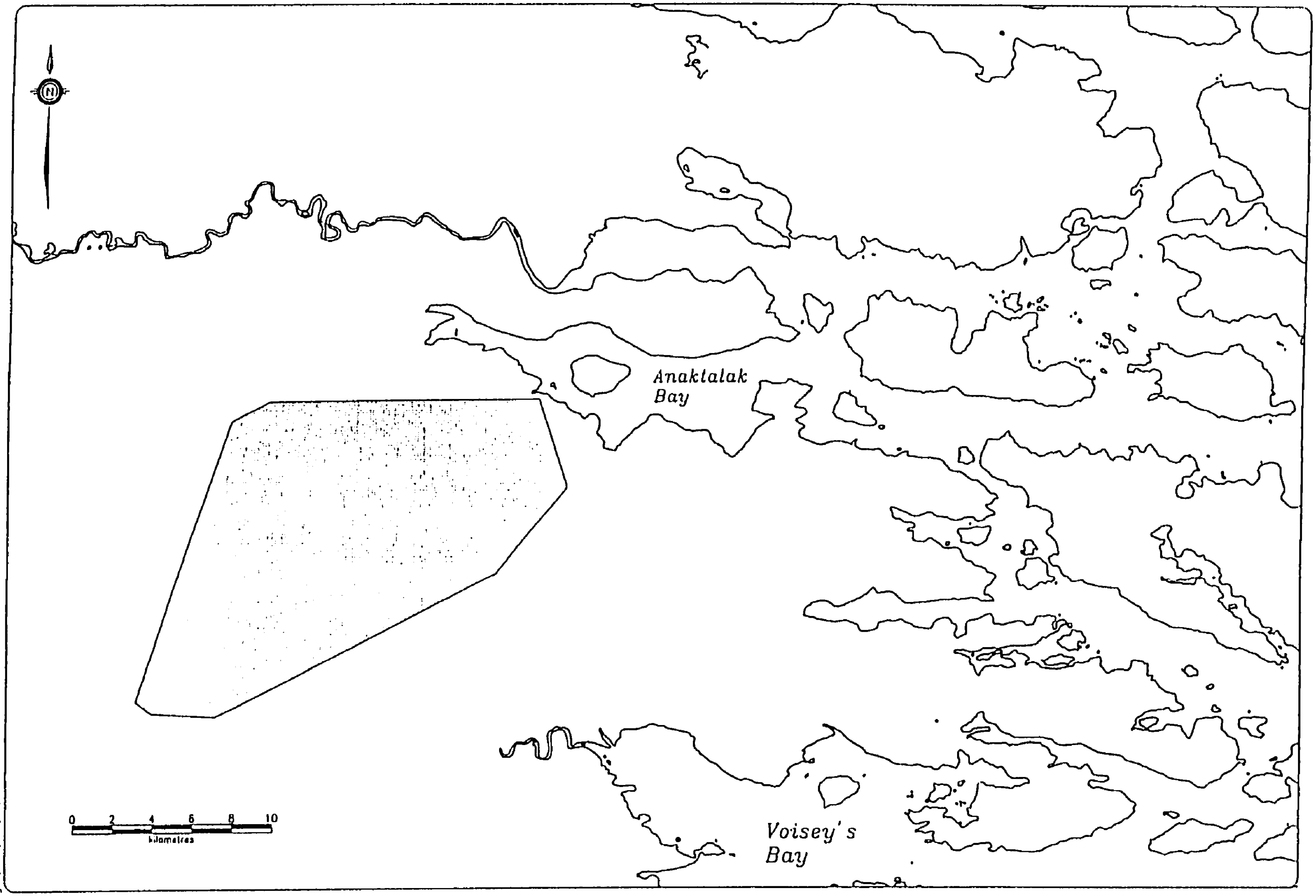

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FIGURE 10

Black Bear B16 Subadult Male
Home Range = 193 Km^2

PROJECT No.823-62009

VHF Data Set

Home Range Calculation = 100% MCP

R:\B23\62009\homrange\ 96/12/18

Appendix F

Roof-top GPS Collar Test

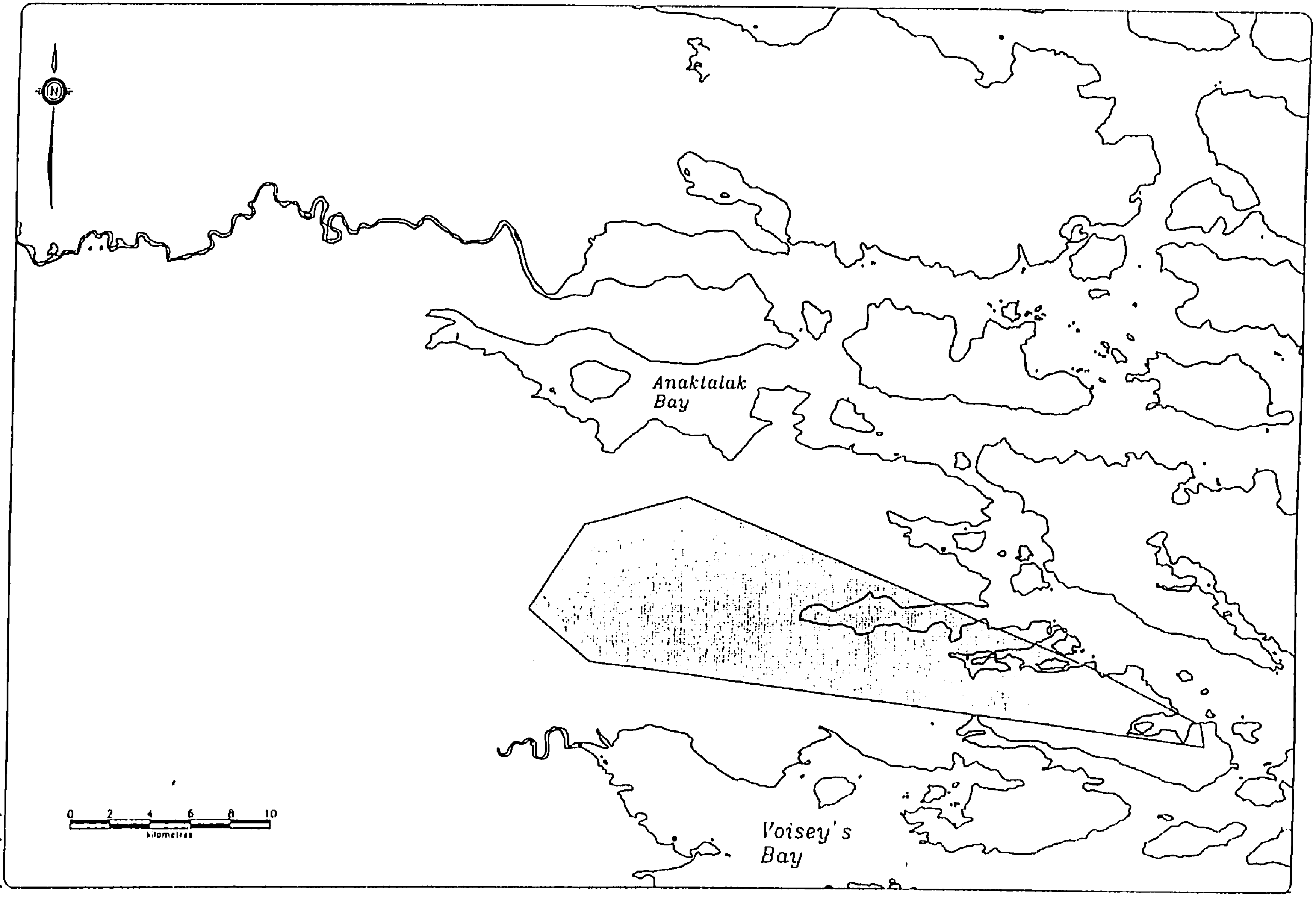
Roof-top GPS Collar Test Results

Date	Time (24 hr clock)	Lat.	Long.	DOP	Fix Status	Temp.	Activity	Convergence
6/30/96	2:02:10				Acq Sat	8.5	0	
6/30/96	5:02:12				Acq Sat	10	0	
6/30/96	8:02:11				Acq Sat	12.5	0	
6/30/96	11:02:12				Acq Sat	11.5	0	
6/30/96	14:02:12				Acq Sat	12	0	
6/30/96	17:02:11				Acq Sat	13	0	
6/30/96	20:02:12				Acq Sat	13.5	0	
6/30/96	23:02:13				Acq Sat	13.5	0	
7/1/96	2:02:11				Acq Sat	14	0	
7/1/96	5:02:11				Acq Sat	14	0	
7/1/96	8:02:11				Acq Sat	14	0	
7/1/96	11:02:10				Acq Sat	13.5	0	
7/1/96	14:02:10				Acq Sat	11.5	0	
7/1/96	17:02:11				Acq Sat	10	0	
7/1/96	20:02:11				Acq Sat	11.5	0	
7/1/96	23:02:10				Acq Sat	11	0	
7/2/96	2:02:12				Acq Sat	11.5	0	
7/2/96	5:02:12				Acq Sat	12	0	
7/2/96	8:02:06	562470	620472	1	2D Fix	11	0	26
7/2/96	11:02:11				Acq Sat	13	0	
7/2/96	14:02:11				Acq Sat	17	0	
7/2/96	17:02:11				Acq Sat	15	0	
7/2/96	20:02:12				Acq Sat	10.5	0	
7/2/96	23:02:11				Acq Sat	8.5	0	
7/3/96	2:02:11				Acq Sat	8	0	
7/3/96	5:01:41	562468	620480	1	3D Fix	10.5	5	26
7/3/96	8:01:41	562488	620500	1	3D Fix	14	0	26
7/3/96	11:02:00	562467	620480	5	3D Fix	12.5	0	26
7/3/96	14:01:59	562468	620480	3	3D Fix	13.5	0	26
7/3/96	17:02:10	562468	620480	3	3D Fix	6.5	0	24
7/3/96	20:01:44	562490	620500	3	2D Fix	4.5	0	28
7/3/96	23:02:11	562468	620480	4	3D Fix	3.5	0	26
7/4/96	2:01:51	562468	620480	1	3D Fix	4	0	16
7/4/96	5:01:44	562468	620480	2	3D Fix	9	0	28
7/4/96	8:02:00	562467	620480	1	3D Fix	16.5	0	26
7/4/96	11:02:11	562468	620480	5	3D Fix	14.5	0	26
7/4/96	14:01:44	562468	620480	3	3D Fix	11.5	0	28
7/4/96	17:01:44	562468	620483	4	3D Fix	6.5	0	26
7/4/96	20:01:59	562468	620480	1	3D Fix	3.5	0	26
7/4/96	23:02:11	562468	620478	2	3D Fix	2.5	0	26

Date	Time (24 hr clock)	Lat.	Long.	DOP	Fix Status	Temp.	Activity	Convergence
7/5/96	2:01:44	562468	620480	1	3D Fix	4	0	28
7/5/96	5:01:45	562468	620480	4	3D Fix	6.5	0	30
7/5/96	8:01:44	562468	620480	1	3D Fix	8	0	28
7/5/96	11:01:59	562468	620480	3	2D Fix	7	0	26
7/5/96	14:01:41	562468	620480	3	3D Fix	4.5	0	26
7/5/96	17:01:45	562468	620480	3	3D Fix	2.5	0	28
7/5/96	20:02:05	562468	620480	3	3D Fix	2	0	26
7/5/96	23:01:44	562468	620480	2	2D Fix	2	0	28
7/6/96	2:01:41	562468	620480	5	3D Fix	2.5	0	26
7/6/96	5:01:41	562468	620480	4	3D Fix	4	0	26
7/6/96	8:01:44	562468	620480	1	3D Fix	7.5	0	28
7/6/96	11:01:45	562468	620480	3	3D Fix	8	0	28
7/6/96	14:01:41	562468	620480	3	3D Fix	5.5	0	26
7/6/96	17:01:49	562468	620480	3	3D Fix	3.5	0	26
7/6/96	20:01:41	562468	620480	2	2D Fix	3	0	26
7/6/96	23:01:59	562472	620483	4	3D Fix	2.5	0	26
7/7/96	2:01:41				Acq Sat	2	0	
7/7/96	5:01:41	562468	620478	2	3D Fix	5.5	0	26
7/7/96	8:01:44	562468	620480	6	2D Fix	10.5	0	28
7/7/96	11:01:41	562468	620480	5	3D Fix	15	0	26
7/7/96	14:01:41	562468	620480	3	3D Fix	16.5	0	26
7/7/96	17:01:44	562468	620480	4	3D Fix	5	0	28
7/7/96	20:02:14	562468	620480	1	3D Fix	0	0	28
7/7/96	23:02:49	562468	620480	4	3D Fix	-2	0	70
7/8/96	2:01:59	562468	620480	2	3D Fix	6.5	0	26
7/8/96	5:01:44	562468	620480	2	3D Fix	25	0	28
7/8/96	17:01:41	562467	620482	4	3D Fix	7	0	26
7/8/96	20:02:14	562468	620480	2	3D Fix	0	0	28
7/8/96	23:02:14	562468	620480	2	3D Fix	-1	0	28
7/9/96	2:01:44	562468	620480	4	3D Fix	7	0	28
7/9/96	5:01:44	562468	620480	3	3D Fix	24.5	0	28
7/9/96	8:01:41	562468	620480	4	3D Fix	34	0	26
7/9/96	17:01:41	562468	620480	2	3D Fix	13.5	0	26
7/9/96	20:01:56	562468	620480	1	3D Fix	9.5	0	22
7/9/96	23:01:55	562468	620480	4	3D Fix	7	0	26
7/10/96	2:01:45	562468	620480	4	3D Fix	9	0	28
7/10/96	5:01:44	562468	620480	3	3D Fix	19	0	28

Appendix G

Black Bear Home Range Areas in 1996 (Based on GPS data Set)



R:\B23\62009\homrange\ 96/12/18

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FIGURE 1

Black Bear B02 Adult Female
Home Range = 162 Km^2

PROJECT No.823-62009

GPS Data Set

Home Range Calculation = 100% MCP

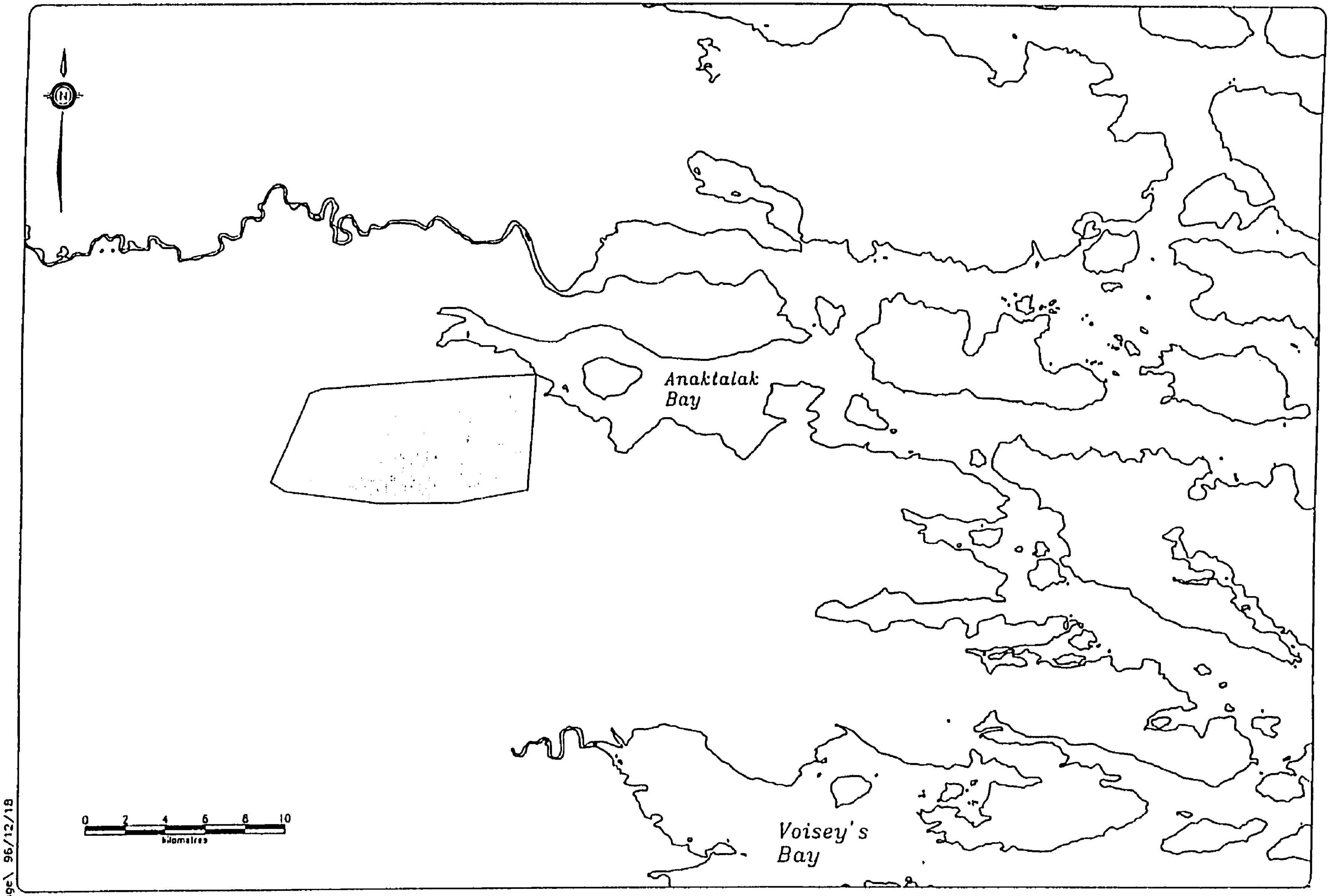

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FIGURE 2

Black Bear B04 Adult Female
Home Range = 65 Km^2

PROJECT No.823-62009 | GPS Data Set | Home Range Calculation = 100% MCP

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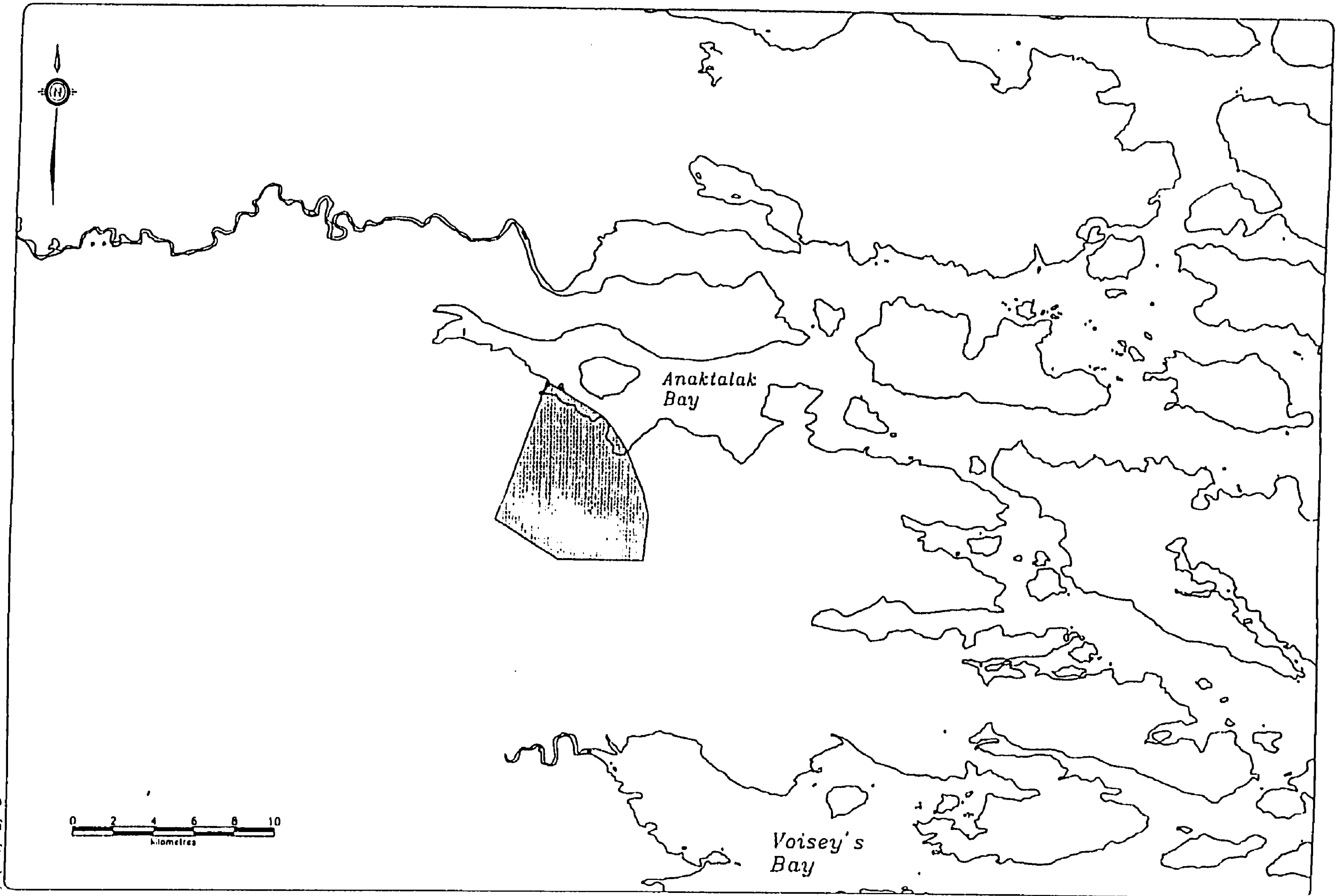

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PROJECT 823-62009

FIGURE 3
Black Bear B08 Adult Female
Home Range = 40 Km²

GPS Data Set

Home Range Calculation = 100% MCP

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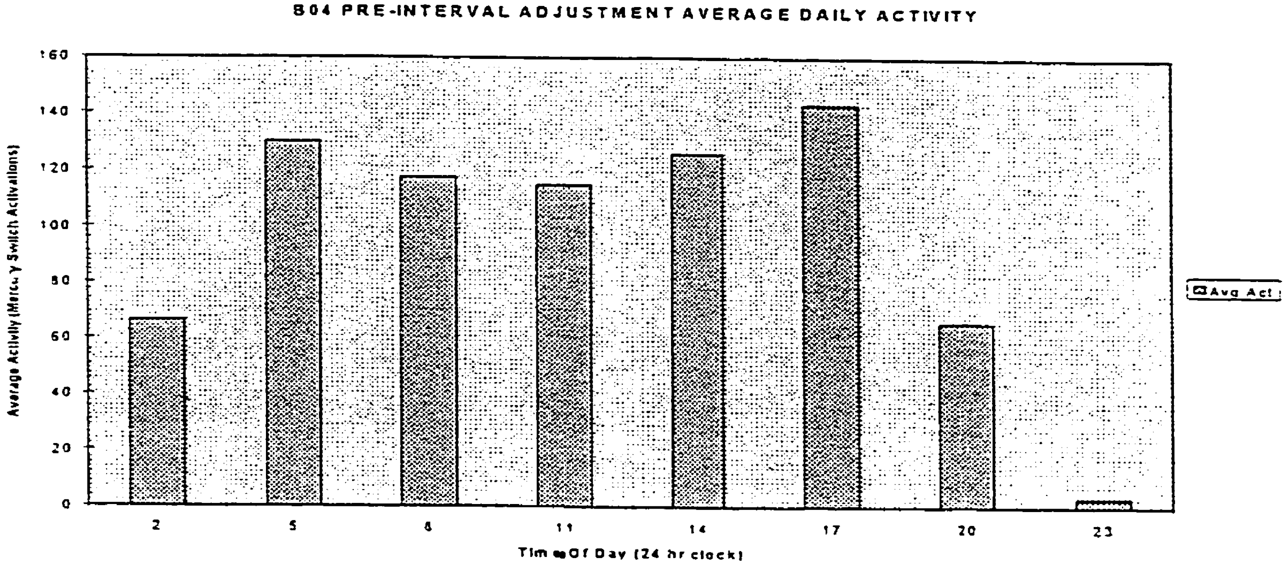
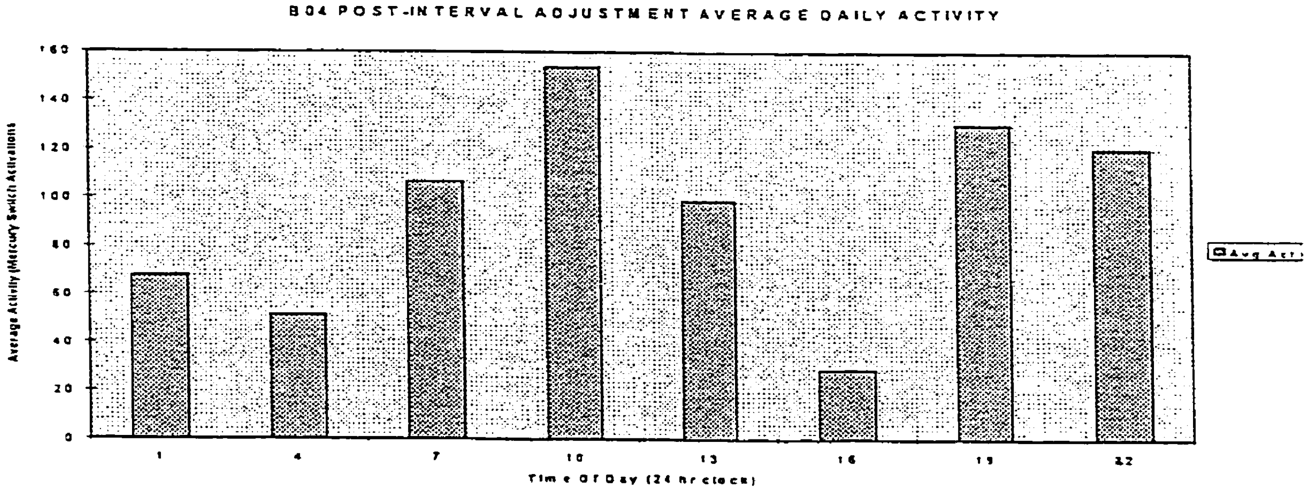
Appendix H

Records of Individual Black Bear Habitat Use and Activity

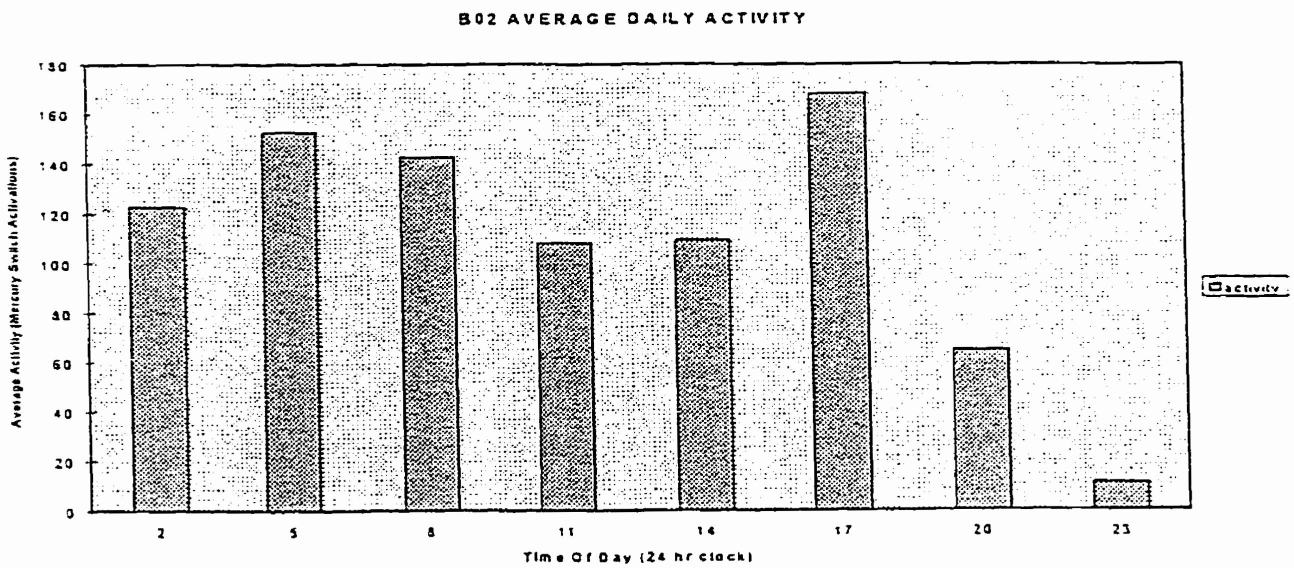
B04 (Adult Female) Average Daily Activity Pre-Interval Adjustment.
June 25, 1996 to July 25, 1996



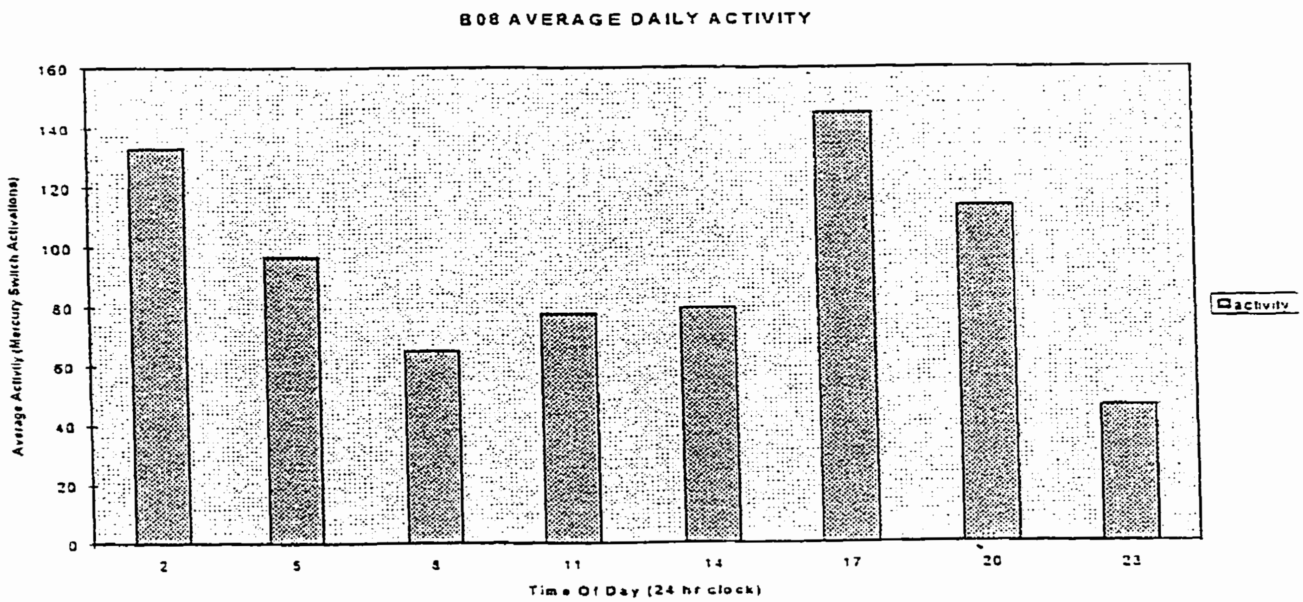
B04 (Adult Female) Average Daily Activity Post-Interval Adjustment,
July 25, 1996 to August 8, 1996



B02 (Adult Female) Average Daily Activity, June 25, 1996 to August 13, 1996



B08 (Adult Female) Average Daily Activity, June 25, 1996 to August 13, 1996



INDIVIDUAL HABITAT USE BASED ON THE VHF-MCP DATA SET

BEAR ID 01 ADULT MALE

	HABITAT TYPE	SIGHTINGS
	Barren	3
	Forest	7
	Marsh	1
VHF SIGHTINGS IN VICINITY OF CAMP		5
TOTAL OBSERVATIONS		11

BEAR ID 02 ADULT FEMALE

	HABITAT TYPE	SIGHTINGS
	Barren	11
	Forest	14
	Marsh	1
	Other	1
VHF SIGHTINGS IN VICINITY OF CAMP		2
TOTAL OBSERVATIONS		27

BEAR ID 04 ADULT FEMALE

	HABITAT TYPE	SIGHTINGS
	Barren	24
	Forest	4
VHF SIGHTINGS IN VICINITY OF CAMP		0
TOTAL OBSERVATIONS		28

INDIVIDUAL HABITAT USE BASED ON THE VHF-MCP DATA SET

BEAR ID 06 ADULT FEMALE

HABITAT TYPE	SIGHTINGS
Barren	5
Forest	14
VHF SIGHTINGS IN VICINITY OF CAMP	1
TOTAL OBSERVATIONS	19

BEAR ID 07 ADULT FEMALE

HABITAT TYPE	SIGHTINGS
Barren	15
Forest	7
VHF SIGHTINGS IN VICINITY OF CAMP	0
TOTAL OBSERVATIONS	22

BEAR ID 08 ADULT FEMALE

HABITAT TYPE	SIGHTINGS
Barren	2
Forest	16
Marsh	1
Other	1
VHF SIGHTINGS IN VICINITY OF CAMP	4
TOTAL OBSERVATIONS	20

INDIVIDUAL HABITAT USE BASED ON THE VHF-MCP DATA SET

BEAR ID 09 ADULT FEMALE

HABITAT TYPE	SIGHTINGS
Barren	2
Forest	12
Marsh	3
VHF SIGHTINGS IN VICINITY OF CAMP	1
TOTAL OBSERVATIONS	17

BEAR ID 10 SUBADULT MALE

HABITAT TYPE	SIGHTINGS
Barren	4
Forest	8
Marsh	1
Other	1
VHF SIGHTINGS IN VICINITY OF CAMP	1
TOTAL OBSERVATIONS	14

BEAR ID 11 SUBADULT MALE

HABITAT TYPE	SIGHTINGS
Barren	5
Forest	9
VHF SIGHTINGS IN VICINITY OF CAMP	2
TOTAL OBSERVATIONS	14

INDIVIDUAL HABITAT USE BASED ON THE VHF-MCP DATA SET

BEAR ID 16 SUBADULT MALE

	HABITAT TYPE	SIGHTINGS
	Barren	9
	Forest	4
VHF SIGHTINGS IN VICINITY OF CAMP		0
TOTAL OBSERVATIONS		13

TOTAL NUMBER OF OBSERVATIONS 185