Coastal Marine Institute

University of Alaska

Radio Frequency Identification Tags for Grizzly and Polar Bear Research

Lori T. Quakenbush
Principal Investigator

Co-principal Investigators:
Richard Shideler
Geoff York

Final Report
OCS Study MMS 2009-004

July 2009

Minerals Management Service
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and the

School of Fisheries & Ocean Sciences

University of Alaska Fairbanks

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Abstract

Grizzly bears (*Ursus arctos*) and polar bears (*U. maritimus*) are important species for subsistence communities along the Beaufort Sea coast for food, fur, and for their cultural importance. Both species are important components of arctic terrestrial and nearshore ecosystems and they interact with existing oil and gas development in the central Beaufort Sea region, and are likely to interact with new offshore and onshore developments. Much of our current knowledge about bear populations, habitat use, movements, and interactions with oil and gas activities on the North Slope has been the result of repeated observations of telemetrically collared bears (VHF and satellite). For polar bears in particular, much of the information comes from females and subadults because adult male bears have a low retention rate for collars due to their neck anatomy. Application of existing and emerging Radio Frequency Identification (RFID) technology, currently used for military and commerce, has the potential to significantly increase the sample size of marked bears by decreasing the cost and providing a way to mark male bears. The goal of this research and development project was to test the feasibility of the RFID system for grizzly and polar bear research and management by modifying the tags so they could be attached to bear ears and by modifying the reader and antenna system for use in aircraft and land vehicles. RFID ear tags were placed on 52 polar bears and 22 grizzly bears in 2006 and 20 polar bears in 2007. Signals from tags were received from up to 500 m at ground level and up to 1.7 km from an aircraft at approximately 600 m altitude. Although RFID signal range exceeded our expectations, tag retention, especially for grizzly bear females with dependent young, was a major limitation. Due to the effective range of RFID tags other configurations (*e.g.*, subcutaneous implants) may provide a solution to tag retention. Future potential applications of RFID technology for bear research and management include monitoring wildlife in areas where collars are inappropriate and monitoring movements at specific sites of interest such as carcasses and work sites.

Introduction

Grizzly bears (*Ursus arctos*) and polar bears (*U. maritimus*) are important species for subsistence communities along the Arctic coast for food, hides, handicrafts, and for their cultural importance (Amstrup et al. 1986, Shideler and Hechtel 2000, Treseder and Carpenter 1989). These bears are also important components of Arctic terrestrial, nearshore and, in the case of polar bears, marine ecosystems. Polar bears were listed as threatened under the Endangered Species Act (Federal Register 73(95): 28212–28303) in 2008 due to the anticipation that the reduction in their sea ice habitat will reduce polar bear populations. Information on polar bear movements and habitat use will be increasingly important as the sea ice recedes. Both species use the North Slope oilfield region and will be affected, directly or indirectly, by future oil and gas development in terrestrial, nearshore, and offshore areas. Much of our current knowledge about bear populations, habitat use, movements, and interactions with oil and gas activities on the North Slope has been the result of repeated observations of radio-collared or satellite-tagged individuals (Amstrup et al. 2000, Shideler and Hechtel 2000, Amstrup et al. 2001).

Unfortunately, adult male bears have a low retention rate for collars because the largest circumference of their neck is larger than that of their head. Although adult male grizzly bears shed collars less frequently than adult male polar bears, 59% of male grizzlies in the North Slope Oilfield Grizzly Bear Project lost their collar at least once (Shideler, unpubl. data). Due to poor success with collars and implanted satellite tags on male polar bears (Amstrup et al. 2001); adult males have not been used in radio-tagging studies. Thus, much of what we know about the ecology of polar bears and interactions between polar bears and oil development is based on satellite tracks and relocations of female and subadult bears. Our knowledge of adult male grizzly bear ecology and interactions with oil development has been limited, although less so than that for polar bears.

The ability to identify individual bears without having to recapture them would greatly improve the efficiency and safety of research operations. Capture and handling of bears in remote areas is expensive, and potentially dangerous for both bears and researchers. We often recapture apparently unmarked bears only to release them once their identity had been confirmed from lip tattoos. Currently, unless a bear is wearing an active VHF or satellite collar, the only way to confirm its identity is to capture it. The time, effort, risk, and cost required to recapture a bear that does not add significantly to the results of the study reduces the total number of bears that can be marked. A potential solution, Radio Frequency Identification (RFID) technology, has been used in military, commercial, and livestock applications. RFID technology has the potential to allow us to significantly increase the sample size of marked bears because RFID tags are inexpensive, and receiving equipment suitable for wildlife use is either commercially available or easily modified from existing sources. However, there had been no research into the efficacy of RFID technology applied to large mammals in remote areas where they are subject to extreme environmental conditions. Therefore, we proposed to test RFID transmitters applied as ear tags on bears, and antenna and reader systems that could be mounted on the same survey and capture aircraft that are used in grizzly bear and polar bear projects. We also wanted to test the RFID system with a ground-based radio-tracking system for grizzly bears.

The objectives of this study were to:

1. Develop and build 50 RFID ear tags suitable for attachment to wild, free-ranging grizzly and polar bears. Tags would be programmed to report an individual identification number.

2. Develop four RFID tag readers and antenna systems capable of identifying hundreds of individually coded RFID tags at a horizontal and vertical distance of more than 100 m. The reader must be compact, light-weight, and durable enough to allow easy operation in the cabin of a Bell 206 helicopter and Cessna 185 or similar aircraft. Receiving antennae must fit the helicopter or fixed-wing aircraft, be durable enough to withstand severe arctic conditions, and sensitive enough to identify the tags at the required distance in fog, rain, and snow. The reader-antenna configuration must also be portable enough that it can be used in a pickup truck or mounted on fixed poles or industrial antennae.

3. Test and evaluate the performance of the RFID system on 40 grizzly bears over the 2005 and 2006 field seasons. Grizzly bears can be captured and monitored more easily and inexpensively than polar bears, and the North Slope Oilfield Grizzly Bear Project has maintained a radio-marked sample of approximately 40–50 bears annually. RFID deployment would occur during capture operations for that project. The first summer (2005) would be deployment of tags and monitoring their fate. The following summer (2006) would be monitoring the fate of the tags after denning and especially after the breeding season when our experience indicates that radio-collars and ear tags are most likely to be lost during bear-bear interactions.

4. Test and evaluate the RFID system on 10 polar bears captured on or near shore in the fall of 2005. Monitor the tags through the following winter and summer.

Methods

RFID Development

We contracted with Integral RFID, Inc. of Richland, WA, an RFID systems integration team, who modified existing RFID components for use in bear research. We jointly developed specifications for the tags, reader, and antenna system based on our experience with bear capture, handling, and radio-tracking and based on Integral RFID's knowledge of the technology. As of early 2005, RFID tags were passive only (*i.e.*, tags did not transmit until the reader queried and energized them). By fall 2005, active RFID technology was available and Integral RFID, Inc. developed both a passive and an active prototype tag for testing. The active tag showed much greater range in laboratory tests, therefore we did not pursue the development of a passive tag.

Figure 1. First (left) and second (right) generation RFID ear tags developed for testing on grizzly and polar bears.

Ear Tag. The RFID tag was designed to transmit the tag identification number (incorporated in a beacon signal of 303.8 MHz) every two seconds. The tag in this configuration had a battery life of four years. To construct the ear tag, the electronics were housed in high-density polyethylene (HDPT), chosen because it was non allergenic, did not interfere with RF signals, was durable, waterproof, and flexible at extremely cold temperatures. The first tag design (Generation 1) weighed 17.7 g but the post was too short for attachment on larger grizzly bears that had thicker ear tissue (Fig. 1). The second tag (Generation 2) had a thinner housing, which resulted in lighter weight (16.1 g) and had a longer post for better attachment (Fig. 1). Both tags attached by sliding the post through a hole punched in the bear's outer ear. The post was inserted through the hole so that the tag was secured to the outside of the ear (Fig. 2). A plastic washer was placed on the inside of the ear and held in place with a spring steel interior-toothed lock washer that penetrated into the post (Fig. 3). It was necessary to leave sufficient space between the washer and the skin to allow aeration of the puncture wound in order to allow it to heal properly, and to prevent tissue necrosis that could be caused by contact pressure on the tissue. Figure 2 illustrates a Generation 2 RFID tag and colored ear flag attached to an adult female grizzly bear's left ear and a colored numeric ear tag and ear flag on the right ear. Few Generation 1 tags were deployed and we did not analyze their results separately.

Figure 2. Dorsal view of RFID ear tag (left) and ear flag on adult female grizzly bear.

Figure 3. Attachment mechanism for RFID ear tag for grizzly bears and polar bears

Reader. The reader decoded the signal from the tag and transferred it to a display device (*e.g.*, computer) that translated the signal. Our reader was modified from a Mantis II™ RFID reader manufactured by RF Code, Inc. and could be powered by a 12 v portable battery or from the aircraft or truck battery. The reader was connected to a laptop computer or Personal Data Assistant (PDA) to provide the visual display. Software developed by Integral RFID, Inc. allowed the reader to receive and display the individual identification numbers transmitted from the tags through the antenna. If the reader received signals from more than one tag, all tag identification numbers were displayed side by side on the screen. When the reader lost the signal from a tag, that identification number disappeared from the screen.

Antenna. We mounted one directional yagi antenna to the wing strut of a Cessna 185 airplane, oriented 90° to the direction of flight and downward at a 30° angle (Fig. 4). This allowed us to circle bears from a consistent altitude and horizontal distance while evaluating the RFID reader's reception ability. We also mounted two directional yagi antennas on a Eurocopter "A-Star" helicopter, one on each side forward and below the fuselage. We mounted one antenna in the horizontal and one in the vertical plane.

Figure 4. RFID (left) and conventional VHF (right) radio-tracking antenna array mounted on a Cessna 185 aircraft.

We recorded maximum and minimum vertical and horizontal distances for signal reception and temperature/precipitation if weather and visibility conditions allowed, and if the bears were not disturbed by multiple passes of the aircraft. We measured horizontal distances to the bear's location using the aircraft GPS and then circled that location at progressively greater distances until the tag was no longer displayed on the computer or PDA screen. We recorded flight altitude from the aircraft altimeter and calculated direct reception distances by applying the Pythagorean Theorem using the horizontal distance and altitude as known sides of the right triangle.

We tested the range of the tags from the ground by holding a single yagi antenna mounted on a short mast from the window of a truck. The antenna was approximately 2 m above the ground and we tested it in both the vertical and horizontal planes. We placed six tags on a 1.5 m-high post and drove progressively farther away from the tag until the tag display disappeared. We then drove toward the tag until the display reappeared. We recorded the number of tags displayed at each location and the distance to each tag using a Garmin 12XL™GPS receiver.

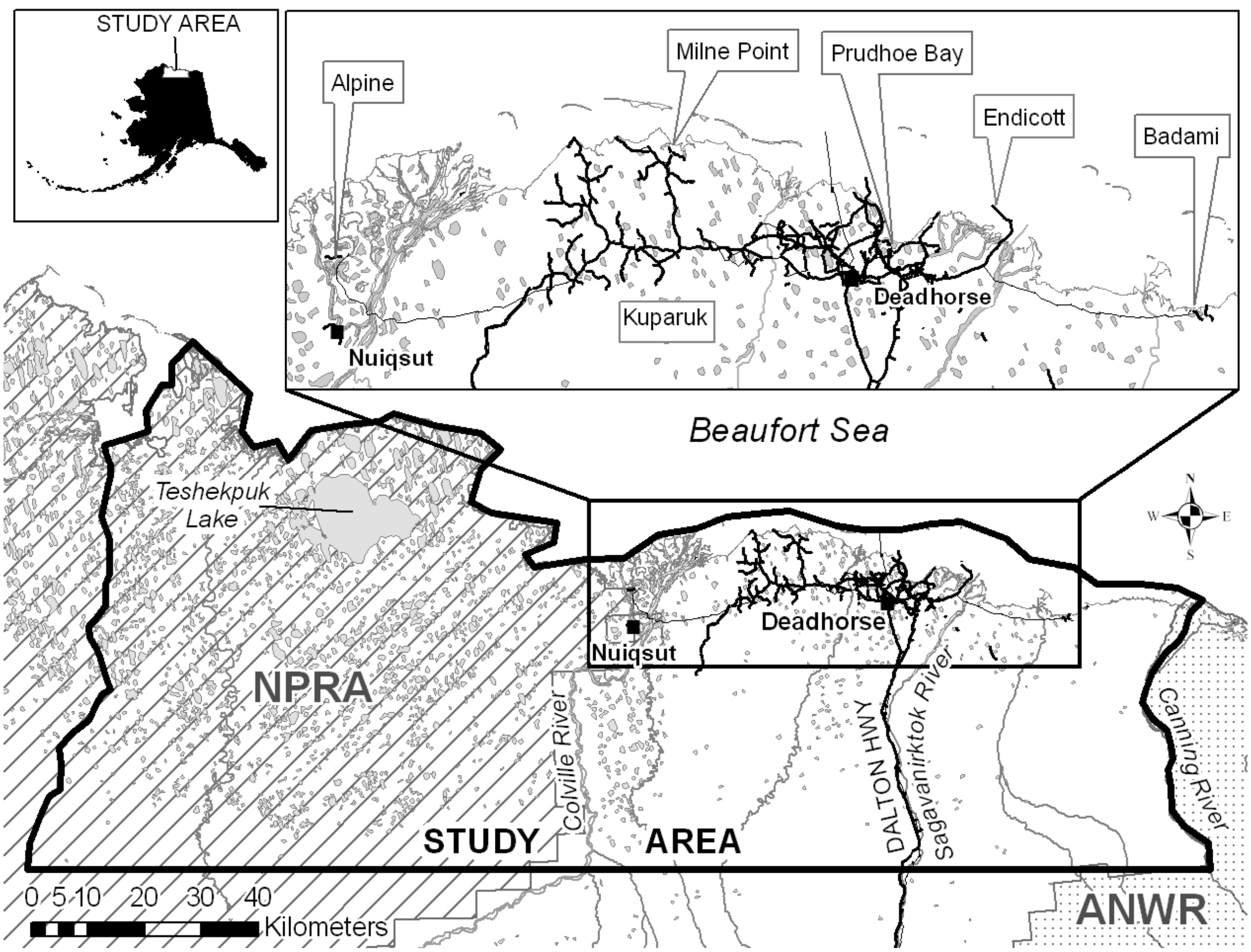

Figure 5. North Slope oilfield grizzly bear study area.

Field Testing

Grizzly bears. RFID tags were attached to grizzly bears that were radio-collared as part of the North Slope Oilfield Grizzly Bear Project (Fig. 5). Most grizzly bears were captured from a helicopter using immobilizing darts fired from a Palmer Cap-Chur® gun. We also used culvert traps to capture bears accessible from the oilfield road system. We captured adults (>5 years old) and independent subadults (1–5 years old) only. We used Telazol® (Fort Dodge Laboratories) as the anesthetic. We marked each bear with a unique combination of colored ear flags attached by numbered plastic tags (Jumbo Rototag®, NASCO, Modesto, CA). We also tattooed an identification number on the upper lip, and attached a VHF collar (Telonics, Mesa, AZ). Most collars were modified with a double canvas spacer designed to rot and release the collar after two years. In most cases, the white RFID tags were placed on bears that had either white or yellow ear flags to minimize interference with the ear flag color. We attached RFID ear tags on either the left or right ear, depending on flag color or condition of the ear.

Polar bears. RFID ear tags were attached to polar bears by the USGS polar bear group during capture activities in the southern Beaufort Sea. Polar bears were captured by injecting Telazol® with projectile syringes fired from helicopters (Larsen 1971, Schweinsburg et al. 1982, Stirling et al. 1989). An RFID ear tag was attached to the right ear when possible (Fig. 6). If the right ear was compromised in some way, the left ear was used. No ear flags were used on polar bears. Capture activities and relocations of bears with RFID tags were conducted using fixed-wing or helicopter which was limited to ~160 km of shore.

Figure 6. RFID ear tag on polar bear.

Results

RFID Tag Performance

Grizzly bear. We attached 22 RFID ear tags on 18 female and four male radio-collared grizzly bears during August and early September 2006 (Table 1). During radio-tracking flights in October 2006 we located 21 tagged bears of which 16 (76%) had RFID tags that were still transmitting (Table 1). During flights in November 2006 we located 16 bears of which 11 (69%) were still transmitting. During a polar bear capture operation in April 2007 we located four grizzly bears denning near the coast and two had functioning RFID tags. During June 2007 we conducted three aerial surveys (on 6, 13, and 26 June) and were again able to locate 21 of the tagged bears including one that had been killed. During June the proportion of functioning tags on bears known to be alive declined from 42% to the final proportion on June 26 of 30% (6 of 20). During the last June survey we received a signal from a tag (#56927) that had not been heard on any survey and had apparently been lost shortly after deployment in August 2006. The tag was lying on the ground in the study area. In two instances (#59527 and #55887), we located bears whose tags were not received on one survey but were received on the subsequent survey.

Visual inspection of several of the bears suggested that tags were missing, rather than present but failing to transmit. Conventional ear tag loss is highest in females with cubs and breeding adult males (Shideler, unpubl. data). By the end of the study, none of the females that were accompanied by cubs in both years had functioning ear tags; however three of six females that had cubs in only one year had functioning ear tags as did three of four females that had no cubs. Of the six tags still on bears and transmitting, three were females with new cubs and three were females without offspring.

None of the four males had functioning ear tags at the end of the study. Three of four RFID tags on males were still transmitting in November 2006, but only one (#54399) was received in early June and none after that (Table 1). That adult male was observed on the subsequent flight and was accompanying a female. His ear flag appeared to be missing suggesting that the RFID tag may have been pulled out during aggressive encounters with other males or during mating activities.

Detection distances for RFID ear tags on grizzly bears ranged from 200 m to 2,600 m (Table 2). We also detected the tags of 13 grizzly bears that were in earthen dens, although the horizontal distances were minimal even from altitudes as high as 1500 m (Table 2). This was consistent with our experience tracking with VHF equipment in that signals are strongly directional with a narrow reception angle when bears are in earth dens.

In spring 2007, to further test the RFID system we loaned the antenna and reader to Alaska Department of Fish and Game (ADF&G) personnel studying coastal brown bears in southeast Alaska. They deployed 20 RFID ear tags on adult brown bears and were able to detect some tags from an aircraft at approximately 1.6 km. They also experienced problems with tag retention but believe some of it may have been washer failure as some ear holes were not torn. They are planning to put out another 25 RFID tags in spring 2008. They are going to add a pin and epoxy to secure the washer to see if that improves tag retention. Recapture of RFID tagged bears is believed to be likely during this study because the proportion of tagged bears in this area is high (L. Beier, ADFG, pers. comm. 2008).

Table 1. Status of RFID tags on grizzly bears deployed in 2006 and monitored in 2006 and 2007. N = non-functioning tag, F = functioning tag, F* = functioning tag in den, -- = bear not found on survey, C = cub-of-the-year, Y = yearling, T = 2-year-old.

			Cubs in 2006			Radio-tracking Date		Cubs in 2007		Radio-tracking Date			
RFID #	**Age**	**Sex**	**No.**	**Age**	**Tagging Date**	**10/10/06**	**11/25/06**	**No.**	**Age**	**4/23/07**	**6/6/07**	**6/13/07**	**6/26/07**
56927	Adult	F	2	C	8/15/06	N	N	2	Y	N	N	N	N
56679	Adult	F	2	Y	8/15/06	F*	--				Dead		
58191	Adult	F	2	C	8/9/06	F	F*	2	Y		N	--	N
55743	Adult	F	2	C	8/16/06	F	F*	2	Y		--	N	N
57815	Adult	F	2	C	8/17/06	N	N	2	Y	N	N	N	N
49663	Adult	F	2	C	8/9/06	F	--				--	N	--
60815	Adult	F	2	C	8/17/06	F	F*	2	Y	F*	--	N	N
60567	Adult	F	2	C	8/18/09	N	N	2	Y		N	--	N
59479	Adult	F	3	Y	9/7/06	F	N	1	T		--	N	N
55479	Adult	F	2	C	9/7/06	F	N	1	Y		--	N	N
57143	Adult	F			9/7/06	F	F*	2	C	F*	F	--	F
58911	Adult	F			8/17/06	F	F*	3	C		F	--	F
52159	Adult	F			8/8/06	--	--	2	C		--	N	N
55887	Adult	F			8/15/06	F	F*	3	C		--	N	F
54311	Adult	F			8/9/06	N*	--				N	--	N
57807	Adult	F			8/16/06	F	F*				F	--	F
57047	Adult	F			8/15/06	F*	--				--	F	F
53807	Adult	F			8/8/06	F*	F*				--	F	F
55967	Subadult	M			8/8/06	F	F*				--	--	N
54399	Adult	M			9/7/06	F	F*				F	--	N
58383	Adult	M			8/8/06	F	--				N	--	N
59527	Subadult	M			8/9/06	N	F*				N	--	N
					#F/n	**16/21**	**11/16**			**2/4**	**5/12**	**2/11**	**6/20**
					Percent function	**76%**	**69%**			**50%**	**42%**	**18%**	**30%**

Polar bear. In spring 2006, we put RFID ear tags on 52 polar bears (31 females, 21 males). Detection distances for RFID ear tags on polar bears were measured for five polar bears as the helicopter lifted off of the newly tagged bears (Table 2). Distances ranged from 330 m to 1,300 m (Table 2). In another test, signals from polar bear ear tags were received from the helicopter at an altitude of 152 m for a distance of more than 400 m. Several bears were re-sighted within days of capture and appeared to be wearing the tags well. In spring 2007, we deployed 20 tags on 12 females and eight males. In 2007, we encountered six bears that had RFID tags in 2006. Two females and one male still had functioning ear tags while one female and two males did not. A polar bear harvested in Canada was also reported with an RFID ear tag. The tag was functioning when it was returned to USGS during the summer of 2007.

In September and October 2006 and 2007, we loaned the antenna and reader to U.S. Fish and Wildlife Service (USFWS) Marine Mammals Management personnel conducting a study of polar and grizzly bear use of bowhead whale remains after subsistence whaling near Kaktovik. The receiving system was used from a truck parked within 100 m of the remains. None of the grizzly bears observed were collared or ear flagged, and none of the marked polar bears that were observed had RFID tags. No RFID tags were observed nor signals received from any of the bears monitored during the study (S. Miller, USFWS, pers. comm., 2007).

Reader Performance

The reader performed well in airplanes, helicopters, and the truck, however because the reader and display was visual only, it required that the observer be looking at the screen in order to determine when signals were received. Signals could be missed if the observer was distracted during a survey.

Antenna Performance

The antenna functioned well during RFID operations from fixed-wing and helicopter for both grizzly and polar bears in the extreme conditions encountered in this region. The installation and operation of the yagi antenna was similar to antennas used for VHF tracking. The cable and connectors used were SMA connectors (typically used for Wi-Fi and other wireless applications) and they were not as robust in winter conditions as the BNC connectors and arctic cables used for VHF tracking.

We tested a dual-antenna system capable of switching from an antenna mounted on the right side to an antenna mounted on the left side of the aircraft (similar to that used for conventional VHF radio-tracking) to see if the RFID signals were directional enough to use for tracking. The test failed because the RFID reader cannot detect differences in signal strength, which is a critical requirement for radio-tracking.

Ground testing of tags not deployed on bears resulted in detection ranges of approximately 400–450 m but only if the antenna was held in the horizontal plane (Table 3). A vertical antenna orientation was much less effective. Although some tags could be read at distances of up to 500 m there was considerable variability (Table 3). We were not able to test the reception system from the ground on grizzly bears as we intended because no RFID ear tagged bears were present in the vicinity of the road system while we were present.

We also tested the angle of reception of static tags with the antenna held at approximately 2 m above the ground at distances of 50 and 210 m from the tag. At 50 m we could detect the tag at a horizontal angle of 70º either side of centerline to the tag for a total reception angle of 140º. At 210 m the reception angle was narrower; 60º either side of centerline.

Table 2. RFID tag reception distances from aircraft. Horizontal distances and altitude were approximated from GPS and altimeter readings, respectively. Direct distance was calculated as the hypotenuse of a right triangle using the Pythagorean Theorem.

RFID #	Horizontal Distance (m)	Altitude (m)	Direct Distance (m)
Grizzly Bears-Active Season (n=22)			
55743	10	200	200
57143	10	240	240
57047	410	170	440
57807	410	230	470
54399	10	620	620
55479	10	620	620
55967	10	780	780
59479	10	780	780
60815	820	160	840
55887	820	165	840
53807	820	230	850
57807	820	330	880
55887	820	400	910
49663	820	470	950
55967	820	470	950
59527	500	820	960
57143	1640	230	1660
58911	1650	330	1680
58191	1530	720	1700
58911	1640	500	1720
58383	1750	620	1860
49663	10	2600	2600
Grizzly Bears In Dens (n=13)			
57143	10	30	35
57143	10	70	70
60815	10	70	70
56679	10	160	160
58911	10	160	160
55887	10	260	260
58191	10	360	360
57807	10	390	390
57047	10	420	420
55967	10	550	550
55743	10	710	710
59527	970	160	980
53807	10	1520	1520
Polar Bears-Active Season (n=5)			
20446	10	330	330
20847	10	330	330
20678	10	430	430
20865	10	430	430
20864	10	1300	1300

Table 3. RFID tag reception distances from the ground using six tags placed 1.5 m above the ground using an antenna 2.0 m above the ground in horizontal and vertical orientation.

	Number of tags received	
Distance (m)	Horizontal	Vertical
230	6	3
260	6	6
270	6	0
280	2	3
280	4	0
350	6	1
400	6	0
400	6	1
420	6	1
420	2	0
450	6	0
470	1	0
500	0	2
500	0	0
550	0	0
600	0	0

Discussion

Our study was designed for deploying RFID ear tags on grizzly bears in two field seasons (2005 and 2006) during the ongoing North Slope Oilfield Grizzly Bear Project; however funding was not available in time for the RFID tags to be developed and deployed during the 2005 season. Only 22 of the proposed 40 RFID tags were deployed on grizzly bears in 2006 and there was no opportunity to capture grizzlies in 2007. We were however, able to deploy 72 tags on polar bears instead of the proposed 10 because USGS purchased tags for testing and was engaged in a major capture effort.

We accomplished our objectives to build RFID ear tags and reader systems that could be used from various tracking platforms. Reception from the air exceeded our expectations and supported our conclusion that RFID technology can be a useful tool for grizzly and polar bear research and management. Even reception from the ground exceeded our criteria of >100 m, but the maximum range of ~400 m limits many applications. We found no effect of weather conditions on tag signal reception during the normal range of spring and fall radio-tracking weather.

Tag loss appeared to be the greatest limitation on the application of RFID ear tags on bears. Although our ability to evaluate the tags on polar bears was limited due to the low re-sighting rate it appears that their tag retention may be better than that of grizzly bears. Four of seven (57 %) polar bears retained their tags after one year, while only 6 of 20 (30%) grizzly bears did. Polar bears did not have ear flags deployed with the RFID tag and we cannot rule out that the ear flags made it more likely for an ear tag to pull out of grizzly bears. We expect, however that most of the tags were lost by cubs grabbing them while playing with their mothers. Loss appears to be from being torn from the ear by other bears rather than failure of the attachment mechanism or the electronics. There may be ways to improve tag retention, such as modifying the tags for subcutaneous implantation. Although this may result in some reduction in reception range, it may be an acceptable trade-off if tag retention is improved.

Several improvements can be made to the system that would make it more powerful and easier to use. There is no audible signal associated with the reader/display device; therefore the operator must visually monitor the screen at all times during a survey. A signal could be missed if the operator were distracted from the screen. Adding an audible signal to the system could assist the operator and free him to do other tasks while monitoring. The system was not designed to measure signal strength; however, if signal strength could be monitored it may be possible to use the system for tracking. And finally, although our ground-based test was a realistic simulation of common wildlife operations, modifications should be tested that could improve range (*e.g.*, a taller antenna mast).

If tag loss can be overcome, RFID tags could be used for bears in areas where visible collars or other methods of marking are not desirable, such as near communities, in wildlife viewing areas, or on park lands. Subcutaneous implants of RFID tags could provide an inexpensive yet functional way to meet this goal without visible markings on the bear.

RFID tags can be used to monitor tagged bears near oil and gas facilities or other areas of interest in order to determine the number of bears using the area, their movements, and their den sites. Bears wearing RFID tags could be monitored as they move past RFID readers mounted on poles, buildings, or other existing structures in the oil field or near seasonal aggregations or movement areas. The presence and movements of RFID tagged bears could be monitored without the need for humans to be present, and without the potential disruptions of that presence. This type of information can aid in planning the locations for temporary and permanent facilities and in developing effective mitigation measures.

Greater numbers of polar bears have been observed nearshore and on land in recent years, possibly due to changes in sea ice. Documentation of polar bear numbers and movements onshore could assist in assessing effects of climate change on polar bears (Stirling and Derocher 1993, Stirling et al. 1999). Although the oilfields have attracted bears for the last 15 years (Shideler 1993) there has been an increase in polar bear use of habitats in and around North Slope oilfield facilities and bears are congregating near villages where the remains of bowhead whales are available (Evans et al. 2007). Questions regarding these recent concentrations include: a) are bears becoming food-conditioned to these sites, b) are the same bears using sites repeatedly, c) what component of the population is involved in these concentrations, d) are bears moving among these locations, or are they faithful to one area, and e) are more bears attracted to onshore and nearshore oil and gas development as a result of obtaining food at these sites?

Grizzly bears are also attracted to bowhead whale carcasses frequented by polar bears near Kaktovik (Shideler, pers. obs.) and at West Dock in the Prudhoe Bay oilfield (Shideler and Hechtel 2000). The same questions about polar bear use of these carcasses apply to grizzly bears.

In conclusion, although retention of the ear tags was not ideal, the tag and receiver technology showed great potential and we believe that with some additional research and development RFID tags could be a valuable tool for use in research. Our recommendations include:

1. Incorporate more durable and cold-tolerant cables and connectors, such as those used in VHF telemetry.
2. Improve the reader by adding audible alert when new signals are detected.
3. Modify the receiver to monitor RFID signal strength to allow tracking capabilities.
4. Develop stationary readers to monitor tagged bear movements.
5. Develop and test an RFID tag that can be subcutaneously implanted.

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Study Products

Presentations

Quakenbush, L. 2006. Radio frequency identification tags for grizzly and polar bear research. Presentation to the North Slope Borough Fish and Wildlife Management Committee, December. Barrow, AK.

Quakenbush, L. 2008. Radio frequency identification tags for grizzly and polar bear research. Annual presentation to CMI, February. Fairbanks, AK.

Quakenbush, L. 2008. Radio frequency identification tags for grizzly and polar bear research. Presentation to Indigenous People's Council of Marine Mammals, January. Anchorage, AK.

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Royalty Management Program** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principals of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.