02 KORTRAPPORT/BRIEF REPORT SERIES
NORSK POLARINSTITUTT, TROMSØ 2005

Magnus Andersen and Jon Aars

Behavioural response of polar bears to disturbance by snowmobiles

Kortrapportserie nr. 2

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Norsk Polarinstitutt 2005

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Cover photo:	**Magnus Andersen, Norsk Polarinstitutt**
Technical editor:	**Gunn Sissel Jaklin, Norsk Polarinstitutt**
Design/layout:	**Audun Igesund, Norsk Polarinstitutt**
Printed:	**November 2005**
ISBN:	**82-7666-219-6**
ISSN:	**1502-0924**

Abstract

Snowmobile use in Svalbard, Norway, has increased significantly during the last 15 years. In the current study the distance at which polar bears detected and actively responded to approaching snowmobiles was measured. The responses were categorized according to the intensity and persistence of the reactions, and given numbers 1 to 4, where 4 was the strongest response. Polar bears were detected on the sea ice using telescopes and binoculars. Undisturbed bears were continuously observed and their behaviour recorded, while two snowmobiles approached them. Distances between the bear(s), the observer, and the snowmobiles were monitored while approaching the bear(s) using GPS positions. Wind direction at the time of the observation was recorded. Data on the behavioural response was collected for 20 encounters. Polar bears were detected at an average distance of 2475 m (range 141 – 6260 m). On average the bears detected the snowmobiles at a distance of 1164 m (range 141 – 4903 m). Polar bears responded to the approaching snowmobiles at 326 m (SE=341 m) (adult males); 164 m (SE=638 m) (adult females); 1534 m (SE=451 m) (females with cubs); and 1313 m (SE=341 m) (single medium sized bears of unknown sex). There was a statistical tendency for a difference in responses to the snowmobiles among age and sex categories: adult males: 2.4 (SE= 0.27), adult females: 3.0 (SE=0.51), females with cubs: 3.5 (SE=0.36), single medium sized bears (sex unknown): 3.4 (SE=0.27). Wind direction contributed significantly to the fit of the model. Although data are limited in the current study the results indicate that there is large variation in how polar bears respond to disturbance from snowmobiles, and that some bears react at particularly long distances and show strong responses. Long term consequences of snowmobile disturbance on the population dynamics of polar bears are currently unknown.

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Introduction

The polar bears are some of the largest predators in the Arctic marine ecosystem. They are closely associated with sea ice, which they use as substrate for both hunting and movement (Mauritzen 2002). Polar bears mainly feed on seals, although carrion, birds and bird eggs can be important food items during the ice free period in summer and autumn (Derocher et al. 2002). The world population of polar bears is currently believed to be in the range 22,000-27,000 animals that can be divided into 20 populations throughout the circumpolar Arctic (Lunn et al 2002). The Barents Sea population is one of these. It covers the geographic regions of Svalbard, the Barents Sea and Franz Josef Land. The size of this population is estimated to be between 2300 and 4100 animals (Aars et al., unpublished data).

Photo: Magnus Andersen

Humans are fascinated by big predators, and the polar bear is a mythical species that has received and still receives a lot of public attention. They are present in Inuit myths and art and have been one of the most valuable preys for trappers in the Arctic. In more recent times polar bear hunting has been the ultimate challenge for safari hunters. Polar bears still have a special place in people's minds today, and modern tourism has given a large number of people the opportunity to see this animal in the wild. Although polar bears are not over-harvested any more, as they were before the protection, they are still vulnerable to human impact and presence (Lunn et al 2002). It is through recreational activities (tourism, camping trips etc) that a large part of the polar bear–man encounters occurs, at least in the Svalbard area.

Photo: Magnus Andersen

Both tourism and the local use of motorized vehicles have increased in Svalbard during the last 15 years. Tourist activities include summer cruise ship traffic, snowmobile traffic and a more modest use of dog sledge expeditions. Of these, snowmobile traffic is the activity that has greatest potential to have a direct effect on polar bears, as a large part of the driving in Svalbard is done on sea ice, due to the steep and mountainous terrain. As a response to the increasing activity and with the aim to reduce potential negative impact on wildlife, regulations concerning the use of snowmobiles in Svalbard were enacted in 2002. The regulations reduced the area in Spitsbergen where visitors could travel freely on snowmobiles. In the eastern part of Spitsbergen restrictions were also put on motorized traffic by Svalbard residents (for Regulations on off-road motor traffic and the use of aircraft and The Tourist Regulations, see http://www.sysselmannen.svalbard.no).

Management authorities and advisers in mainland Norway and Svalbard have sought after knowledge of the effect of snowmobile traffic on polar bears in the Svalbard area, and reports have been presented where the current available literature has been examined (Persen 1986; Reimers 1991; Overrein 2002). A large part of the knowledge available is based on sporadic observations and personal experiences, which are valuable, when nothing else exists. Until present no attempts have been made to measure quantitatively how bears are affected by snowmobile traffic. The scientific literature on human disturbance of wildlife elsewhere is, however, extensive – including behavioural and physiological studies on ungulates (Calef et al. 1976; Eckstein et al 1979; MacArthur et al 1979; Freddy et al. 1986), marine mammals (Kelly et al. 1988; Born et al. 1999), seabirds (Dunnet 1977; Gabrielsen and Smith 1995), carnivores (Amstrup 1993; Eid et al. 2001; Creel et al. 2002) and vegetation (Babb and Bliss 1974; Chapin and Shaver 1981). The effects of motorized vehicles (aircraft, snowmobiles, heavy industrial vehicles, tundra buggies and boats) are most frequently the aim of the studies, but the effects of humans on foot and stationary industrial installations have also been investigated (e.g. Colman et al. 2001).

It is not plausible to do studies on effects of disturbance on demographic traits with limited resources. It is however possible to study the immediate behavioural responses of the bears, and, based on our knowledge about their biology, say something about the likelihood of these responses having more serious population effects. In this study the main mission was to quantitatively measure the distance at which polar bears typically detect approaching snowmobiles, the distance at which they actively react, and to categorize the type of reaction. Secondly, we wanted to test the prediction that mothers with juveniles are more sensible to disturbance. We hypothesize that the reaction of mothers with juveniles are more likely to have effects on the populations than that of other animals, as juvenile survival is much lower than for adult bears and thus probably much more vulnerable to stress.

Material and Methods

The fieldwork was conducted from 28 April to 5 May 2004 and from 1 to 10 April 2005 after a pilot study where methods were tested out in May 2003. The Van Keulen fjord on the east coast of Spitsbergen (15º 30'E, 77º 30'N), Svalbard (Figure 1), was chosen as study area, due to the high number of polar bears known to stay in or move through the area during this time of the year (Norwegian Polar Institute, unpub. data).

Polar bears were detected on the sea ice with the use of a high quality telescope (Swarovski HD-ATS 80) with up to 60X magnification (Swarovski Eyepiece 20-60x Zoom) mounted on a tripod or handheld binoculars (Swarovski 8.5X42). Most bears were detected from an elevated point, either a height above the shore, an ice berg or the roof of the base cabin at Dahlgrenodden (Slettebu). Some of the bears were observed from the snowmobiles, while the observers travelled on the fjord ice. When bears were detected their behaviour was evaluated, and only those who appeared not to be aware of our presence at the time, were included in the experiment. On a few occasions the bears were detected when moving away from the approaching snowmobiles or from the cabin, and these observations were not included in the study.

When a polar bear, unaware of us, was detected, one person observed the bear continuously, while two snowmobiles moved towards the bear in a straight line at a speed between 30 and 40 km/h. The heading of the snowmobiles were, as far as possible, held towards the point where the bear was first seen, and was not changed if the bear moved to one side. VHF-communication between observer and persons on the snowmobiles ensured that these were aware of the behaviour of the bear at all times as they approached it. To enable measurement of different distances between the bear and the observer and the approaching snowmobiles, GPS positions along the track towards the bear were taken (Figure 2). The following snowmobile positions were recorded: (A) bear detected (B) observation of bear starts (and snowmobiles start to approach the bear), (C) bear detects approaching snowmobiles, and (D) bear reacts to approaching snowmobiles (by running or walking). The position of the polar bear at the time when it reacted to the snowmobiles, was recorded (E). The position where the bear reacted to the approaching vehicle was determined by interpretation of the tracks at the location. The snow was soft and left good tracks throughout the whole study period. On one occasion the distances were measured with a handheld laser range finder (Opti-Logic 800 XL). The vehicles used during the study were Arctic Cat, Bearcat WT snowmobiles with 660 ccm four stroke engines.

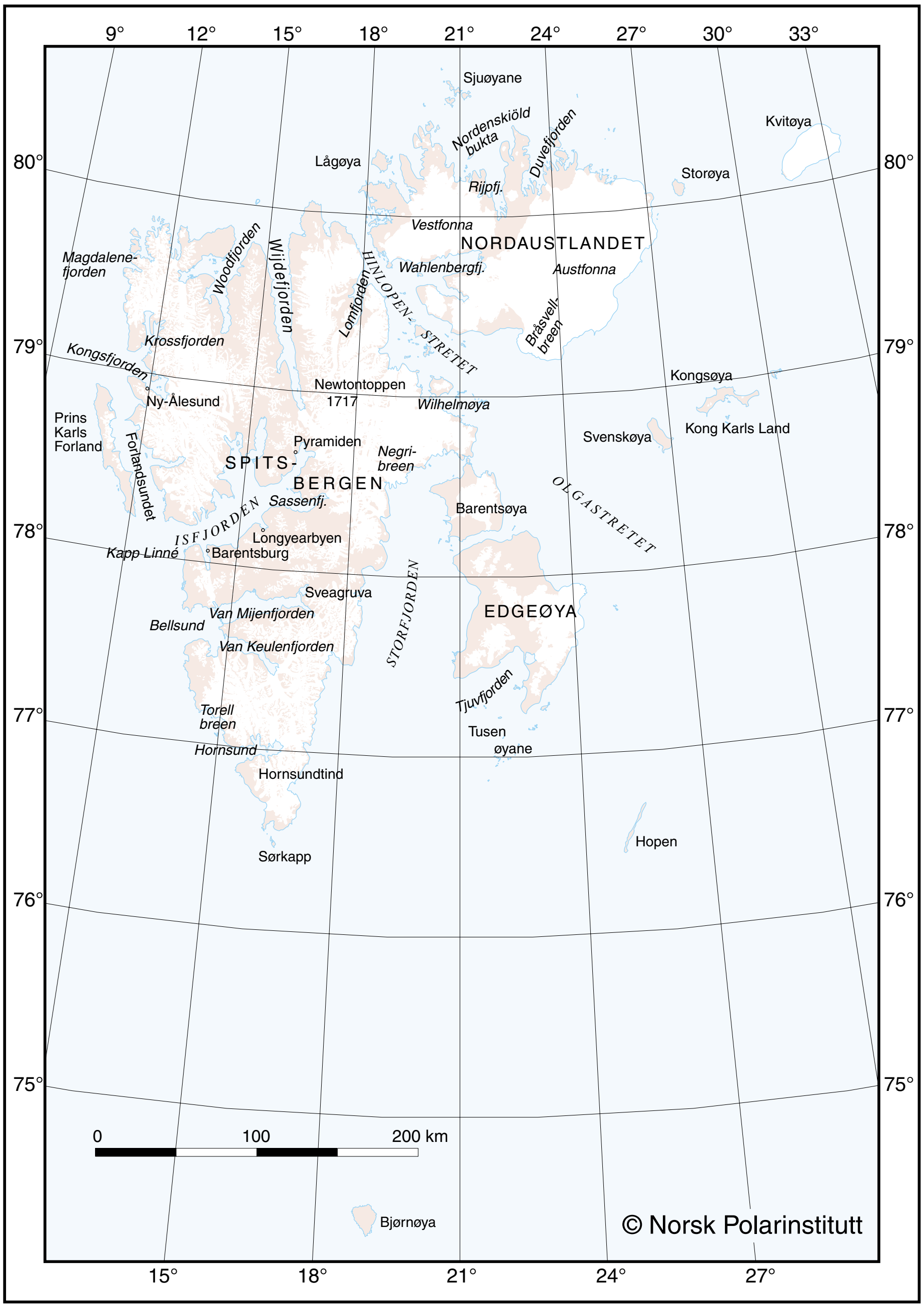


Figure 1. Map of the Svalbard archipelago

The behaviour of the polar bear was described prior to, during and after it detected the approaching vehicle. Prior to the disturbance, the behaviour of the bear was described as walking, lying down, sitting (at seal hole), and if the bear obviously was hunting, this was recorded. Further, the reaction of the bear to the disturbance was rated from 1 to 4 (Table 1) based on the intensity and persistency of the response (e.g. change of course, change of pace, showing curiosity, trying to hide, aggressive reaction, moving onto land or up in a mountain side etc.).

Table 1. Categories and descriptions of polar bear responses to disturbance by the approaching snowmobiles during observational sessions.

Response	Category	Description of polar bear behaviour
1	No reaction	Did not pay any attention to the snowmobiles
2	Light reaction	Walks away from snowmobiles or adjusts heading as a response to the snowmobiles, stops, lifts head, looks towards the snowmobiles, continues with same pace
3	Medium reaction	Runs away from snowmobiles, often interrupted by periods of fast walking. Determined to get away from the snowmobiles
4	Strong reaction	As 3, but runs heavily for an extended period of time

Photo: Petter Wabakken

The direction of the wind was recorded in relation to the direction of approaching snowmobiles, and was described as; no wind (N), wind from the snowmobiles and towards the bear (T), wind from the bear and towards the snowmobiles (F) and wind from the side relative to the heading of the snowmobiles towards the bear (C) (Table 2).

The movement towards the polar bear was immediately stopped when a response from the bear was recorded.

All positions were entered into a GIS (ArcMap 9.0), and distances were determined using a measuring tool in the programme. Maps showing all the observed bears, positions and distances were also produced in ArcMap.

Analysis of variance (ANOVA) was run to evaluate the responses of the different categories of animals to disturbance (adult female with cubs, adult male or single animal of unknown sex). The SAS statistical package (SAS Institute Inc. Cary, NC, USA, 1989) was used for analyses of data, and model based standard errors (SE) are provided as measure of variance.

Photo: Jon Aars

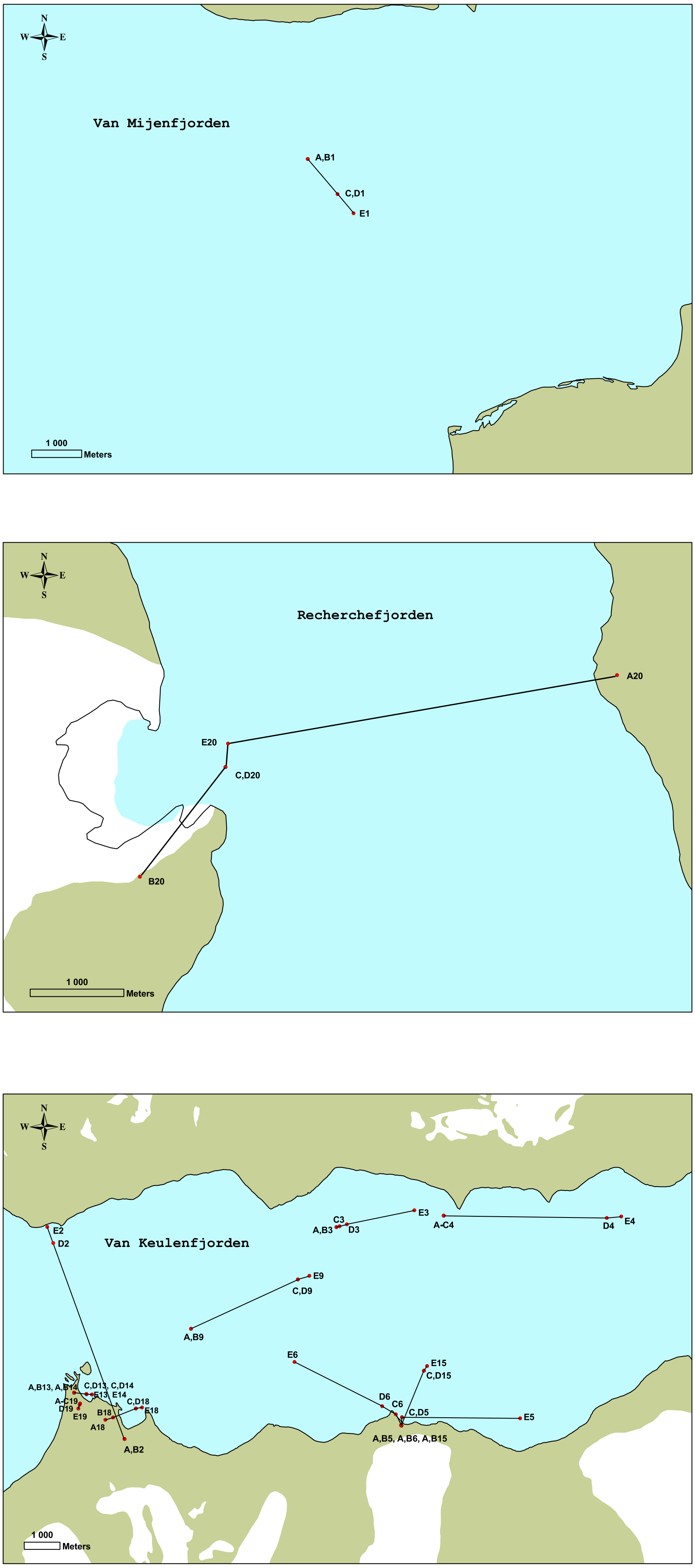
Photo: Magnus Andersen

Photo: Magnus Andersen

Results

During the fieldwork in May 2004 and April 2005 we had a total of 20 situations where data on the behavioural response of polar bears to snowmobiles could be collected (Figure 2, Table 2). Based on size and various marks on the bears, in addition to track measurements, it was concluded that a minimum of 18 different polar bears or groups of bears (families) where involved in the study. For two of the individual bears it could not be determined if it was a new bear or one observed on an earlier occasion. Polar bears were categorized as adult females with coys (cubs of the year), single adult females, adult males and single bears of middle size with undetermined sex and age (Table 2).

Polar bears were detected at distances between 141 and 6260 m, with an average of 2375 m, and with two exceptions all observations of their behaviour were made from the point where the bears were first detected. There was a large variation in the distances at which the polar bears became aware of the approaching snowmobiles. The average distance was 1164 m, but the longest was as much as 4903 m and the shortest only 141 m. Most bears reacted to the approaching vehicles at distances that were similar to or slightly shorter than where they detected the snowmobiles. One bear was, however, obviously aware of the snowmobiles at 4903 m, but did not show an evident response until the vehicle was only 410 m away. The variation in the distances at which the bears showed response (DE) was large (range 141 to 3272 m) in the current study, with an average of 1241 m. The mean DE was 326 m (SE= 341 m) for adult males; 1534 m (SE= 451 m) for adult females with cubs; 164 m (SE= 638 m) for two adult females without cubs and 1313 m (SE= 341 m) for single medium sized bears (Figure 2, Table 2). Due to the large within group variance, these differences were not significant ($F_{3,19}$= 2.21, p-value= 0.126).



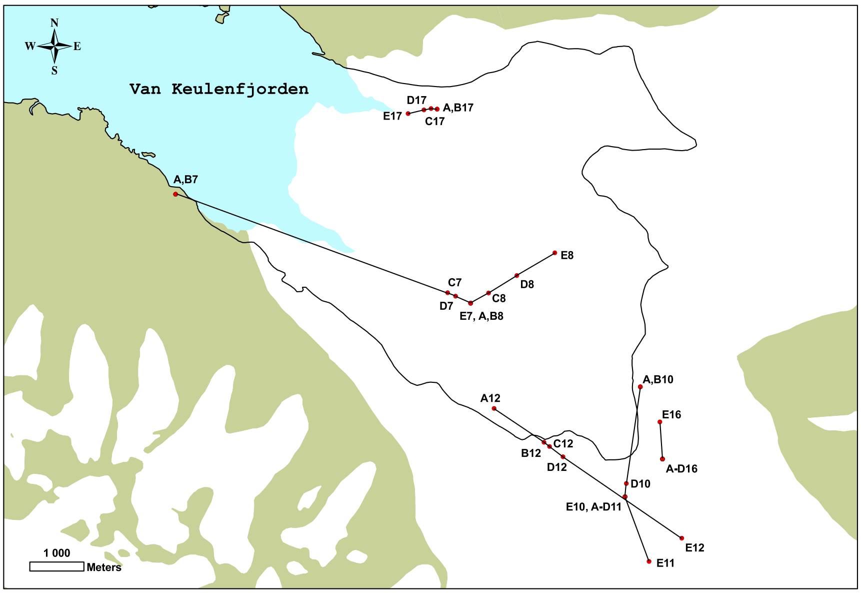


Figure 2. Maps showing the study area and GPS positions recorded during the observations of the polar bears in the current study. The letters A – D correspond to the following snowmobile positions: (A) bear detected, (B) observation of bear starts, (C) bear detects approaching snowmobiles, (D) bear reacts to approaching snowmobiles by running or walking. The letter E is the position of the polar bear at the time when it reacted to the snowmobiles. The numbers given in the maps correspond to bear numbers (1-20). Note: the glaciers in the study area has retreated in recent years, and the current maps are not updated.

The responses of the polar bears to the snowmobiles were categorized as 1, 2, 3 or 4, according to the nature of the reaction. The intensity of the reaction was the main criterion used, but the persistence of the response was also taken into consideration. No bears were given response category 1, six bears were given category 2, seven were given category 3 and seven were given category 4 (Tables 1 and 2). There was a statistical tendency for a difference in type of response between the different groups ($F_{3,19}$= 2.86, p-value= 0.0696) (adult males: 2.4 (SE= 0.27); adult females with cubs: 3.5 (SE = 0.36); adult females without cubs: 3.0 (SE= 0.51) and other single bears 3.5 (SE= 0.27).

Wind direction was determined for all observations, with four having wind towards the bear from the snowmobiles, ten had wind from the bear towards the snowmobiles, two had the wind from the side relative to the heading of the snowmobiles towards the bear and during four observations there was no wind (Table 2). Wind direction contributed to the fit of the model (F= 5,74, df= 3, p-value= 0,010), indicating that weather conditions can have a significant impact on the responses of the different bear categories to disturbance by snowmobiles (Table 2).

Table 2. Polar bears included in the study, distances recorded during the experimental sessions, responses by the bears to the snowmobiles and wind direction during the observational trial. The distances are described in the material and methods section and in Figure 1. Responses are on a scale from 1 (No reaction) to 4 (Strong reaction). Wind directions are: F (from the bear), T (towards the bear), C (sideways relative to the snowmobiles heading towards the bear) and N (no wind). Sexes are: F (female), M (male) and U (unknown).

Polar bear	Year	Sex	Age/size category	Accompanied by	Distance (m) A-E	Distance (m) B-E	Distance (m) C-E	Distance (m) D-E	Response	Wind direction
12	2004	F	Adult	2 coys	4188	3084	2958	2644	4	F
3	2004	F	Adult	2 coys	2222	2222	2130	1916	4	T
7	2004	F	Adult	2 coys	5777	5777	465	307	4	F
11	2004	F	Adult	2 coys	1270	1270	1270	1270	2	N
8	2004	M	Adult	alone	1800	1800	1422	810	2	C
1	2004	M	Adult	alone	1415	1415	496	496	2	N
13	2005	M	Adult	female	497	497	153	153	3	F
15	2005	M	Adult	alone	1769	1769	162	162	3	F
17	2005	M	Adult	alone	530	530	425	293	2	F
19	2005	M	Adult	alone	141	141	141	112	2	T
20	2005	M	Adult	alone	4138	1674	255	255	3	F
14	2005	F	Adult	male	497	497	153	153	4	F
18	2005	F	Adult	alone	1052	838	175	175	2	F
10	2004	U	Mid size	alone	2039	2039	246	246	3	N
6	2004	U	Mid size	alone	3444	3444	3176	2726	4	T
2	2004	U	Mid size	alone	6260		470	470	4	F
9	2004	U	Mid size	alone	3594	3594	329	329	4	F
5	2004	U	Mid size	alone	3290	3290	3272	3272	3	N
4	2004	U	Mid size	alone	4903	4903	4903	410	3	T
16	2005	U	Mid size	alone	670	670	670	670	3	C
				Mean	**2475**	**2077**	**1164**	**843**		
				Range	**141 - 6260**	**141 - 5777**	**141 - 4903**	**112 - 3272**		

Discussion

The current study has shown that polar bears in Svalbard react to snowmobile disturbance at long distances, but with large variability between individuals. Except for adult males, the bears typically also had a rather pronounced response where they frequently ran fast and far away from the approaching snowmobiles. The sample size in this study is limited, but the data indicate that females with juveniles and middle sized single animals react stronger to disturbance than other animals. Also, wind direction seems to affect the responses of the animals to the disturbance. More data will be needed before firm conclusions can be made about these relationships. However, the main result of bears detecting snowmobiles at long distances, up to almost 5 km, and reacting by moving away from it at distances above 3 km and on average more than 800 m, is valuable information. It means that bears frequently can be chased away from fjord ice also in cases where the drivers of the snowmobiles do not see the bears. The results from the current study are in agreement with the general experiences of people spending considerable amounts of time in the field in Svalbard.

Photo: Magnus Andersen

Questions about the effect of different types of vehicle or industrial disturbance on wildlife are frequently asked by management authorities, and a large number of field studies on several species have been conducted that address these questions (see the introduction chapter for references). One limitation that is seen in many of these studies, that also applies to the current study, is that the effect which is measured is on an individual level and has a short duration. Population level effects are difficult to assess in most wild populations, and particularly in a long-lived and mobile species as the polar bear.

Although no such studies have been performed on polar bears until present, several authors have studied the behavioural or physiological response of various other species to snowmobile related disturbance.

McLaren and Green (1985) studied the reaction of muskoxen (*Ovibos moschatus*) on Melville Island, North West Territories, Canada, to an approaching snowmobile. They found that 50% of the animals in the herds reacted to the disturbance at distances ranging from 87 to 645 m. Further they found that the measured distances were positively correlated with wind speed, and that the maximum reaction level was positively correlated with herd size. Adult females were more frequently the first to react to the disturbance compared to other animals in the herds. To assess habituation, two herds were approached multiple times, and although sample sizes were low, a tendency of the herds to have lower reaction levels in the later approaches was seen. The authors experienced (during travel to, from and within the study area, during other fieldwork in the region etc.) that muskoxen herds were alerted to their activity at distances much greater than the ones measured during the experimental trials, and based on their results and experiences recommended that herds were not approached closer than 1 km either by motorized vehicles or people on foot.

In a study of mule deer (*Odocoileus hemionus*) response to human disturbance, Freddy et al. (1986) found that no response was seen until persons afoot and snowmobiles were on average 334 and 470 m away, respectively. A locomotor response was, however, seen at minimum distances of 191 m for persons and 133 m for snowmobiles, and in addition the responses to persons were longer in duration and more frequently involved running. Freddy et al. (1986) also evaluated how the disturbance may have affected mortality and fecundity of the deer in the study, and they found no clear effect. They suggest that the disturbance level may have been too low, or that the animals may have been able to compensate for the increased energetic output by changing their activity patterns.

A study similar to Freddy et al. (1986) was conducted on Svalbard reindeer (*Rangifer tarandus platyrhunchus*) in Svalbard, Norway, by Tyler (1991), where the responses of 101 groups of reindeer to disturbance from a snowmobile were recorded. Tyler (1991) found that the flight response was group co-ordinated, and that the median reaction distance was 640 m, whereas the median flight distance was 160 m. Further the author examined how the disturbance may have affected the energy expenditure and grazing time of the animals, using energy and time budget models. It was concluded that the energy expenditure increased by 0.4%, while the grazing time was reduced by 0.4%, and that no major negative effects from snowmobile disturbance on the Svalbard reindeer population was detected, based on the current level of traffic.

The three studies referred to here recorded short term behavioural responses of ungulates to snowmobile disturbance. Creel et al. (2002), however, evaluated long-term snowmobile inflicted stress on elk (*Cervus elaphus*) and wolf (*Canis lupus*) populations in Yellowstone National Park, USA, through the analyses of glucocorticoid (a stress hormone) levels in faeces. Elevated levels were found to correspond to areas and times of heavy snowmobile activity. Although stress responses were found, the authors could not determine whether the levels of snowmobile traffic in the area at the time did affect the population dynamics of elk or wolf.

Problems concerning direct human disturbance of polar bears have received relatively little scientific attention, but some studies have been conducted that can shed some light on the issue. Dyck and Baydack (2004) studied the effect of wildlife viewing from tundra vehicles at Churchill, Canada, on polar bear behaviour in the area. The activity has been going on for more than 20 years, and the main aim is to give tourists a possibility to observe undisturbed polar bears in their natural habitat. The authors studied vigilance activity in polar bears when tundra vehicles were present and when they were not. They found that the vigilance behaviour of male bears increased when one or more vehicles were present, whereas the pattern was opposite for females. Further they found that more vehicles did not result in a higher vigilance activity in male bears. Dyck and Baydack (2004) suggest that this kind of studies can be used in monitoring of wildlife behaviour in the context of wildlife viewing activities. In some parts of the Arctic, industrial activities have caused concern with regard to polar bears and their habitat use. Blix and Lentfer (1992) investigated the noise and vibration levels inside polar bear dens during petroleum exploration and development activities, with the aim to determine whether such disturbance would have a negative effect on denning females. It was concluded that such activities would not disturb denning females, given that the disturbance did not take place within 100 meters of the den. The nature of the typical snow conditions was shown to effectively dampen both vibration and noise to a low level. These results are in agreement with the findings of Amstrup (1993), who concluded that denning female polar bears in Alaska tolerated high levels of activity in the vicinity of their dens.

The current discussion has shown that several species have varying responds to snowmobile traffic and other motorized vehicles and types of disturbance. The question of habituation in relation to such disturbance is only briefly discussed in most studies, mainly due to the lack of relevant data (e.g. McLaren and Green 1985). This is also the case in the current study. During the pilot project in 2003, however, one observation was made that we believe illustrates that polar bears may get habituated to snowmobile traffic and human presence. In April and May 2003 a female polar bear with a one year old cub stayed within a small area (5x10 km) in Tempelfjorden (17º 20'E, 78º 20'N) on the west coast of Spitsbergen, Svalbard, for at least three weeks during the peak snowmobile season. She spent most of her time along the 3 km glacier front in the bottom of the fjord. This particular place is one of the most visited sites in Svalbard by snowmobile tourists during this time of the year, and during the peak season as many as 100 - 200 snowmobiles visit daily, mainly as part of organized trips from Longyearbyen. The female was observed nursing her cub with approximately 50 snowmobiles present within a minimum distance of 100 meter, and this happend while vehicles entered and left the area. Only when one snowmobile approached her (as close as 25 m), she responded by moving closer to the glacier front and hid among broken glacier ice. Along the glacier front remains of both successful and unsuccessful seal hunting was found and it was obvious that the area was a good hunting habitat for her, and she chose to stay there despite the daily disturbance and sporadic harassment.

Polar bears are extremely mobile animals, that can move several thousand kilometres each year, and we believe that polar bears will move out of an area if sufficiently disturbed. Many polar bears have large home ranges, and these individuals will have no problem finding areas where disturbance is low. Other bears, however, have been shown to have very small home ranges, and these may be more vulnerable if the area experiences heavy disturbance. However, studies referred to earlier (Blix and Lentfer 1992; Amstrup 1993 and Dyck and Baydack 2004) have showed that polar bears are fairly robust when considering some types of disturbance.

On a large scale polar bears are very mobile, but when considering small scale movement behaviour (such as within a fjord) polar bears have been shown to perform quite restricted movements. Stirling (1974) described the behaviour of polar bears on the sea ice at Devon Island, Canada, through direct observations. He found that polar bears spent 66.6% of their time inactive (sleeping, lying and still-hunting), while 25% was spent walking. Only a few observations of short bursts of running by bears were made by Stirling (1974), all in connection with meetings between unrelated polar bears. In our study we observed polar bears that ran for at least 1 km after being disturbed by snowmobiles, and several of the bears left the ringed seal breathing hole where they were still-hunting when the vehicles approached. It is reason to believe that repeated disturbance leading to running and interrupted hunting could lead to increased energetic stress on the animals. Further, in extreme situations, overheating from running can lead to death of the animal. Polar bears are not adapted to movement at high pace over longer distances, and large individuals in particular may overheat if pursued over time (Øritsland 1970).

When reviewing literature on wildlife disturbance, studies rarely assess effects on survival or reproductive success or other effects on the population level. This is a problematic shortcoming, since this is the most important piece of information needed for authorities to make sound management decisions. With increasing tourism in many Arctic regions it is important to gain more knowledge about such issues. Such studies would however be extremely demanding both regarding resources and effort, and we will therefore probably have to depend on studies of effects on behaviour and maybe physiological responses. This can, however, be valuable as long as we know much about polar bear biology and thus can make plausible interpretations about how these responses may link to demographic processes.

Conclusion

The current project has shown that polar bears, and especially females with small cubs, have a potential to get disturbed by snowmobiles because they react on relatively long distances. Their reactions are often profound, even though the disturbance inflicted in this study was relatively mild. What the long term behavioural responses to snowmobile disturbance are and if there are negative effects on the population dynamics of polar bears is, however, still unknown.

Acknowlegements

This project was funded by The Governor of Svalbard and the Norwegian Polar Institute. We would like to thank Petter Wabakken and Øystein Overrein for assistance in the field and for constructive discussions about the current project.

Photo: Magnus Andersen

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