ARCTIC
VOL. 66, NO. 2 (JUNE 2013) P. 139–146

An Improved Method of Documenting Activity Patterns of Post-Emergence Polar Bears (*Ursus maritimus*) in Northern Alaska

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(*Received 24 February 2011; accepted in revised form 18 July 2012*)

ABSTRACT. Throughout their circumpolar range, pregnant female polar bears (*Ursus maritimus*) create snow dens in which they give birth to altricial cubs. Because polar bear neonates are born in such an undeveloped state, their survival requires a long, undisturbed period of in-den development. To mitigate human impacts on denning bears, it is necessary to understand the chronology of denning, the behaviors of denning bears, and their sensitivity to human activities. Since 2002, we have studied the den emergence behaviors of polar bears in northern Alaska; however, we moved from using on-site observers (2002–03) to using autonomous video systems (2005–08). Here we compare the duration, activity budgets, and behaviors of polar bears to see whether observation methods affected their activities. Camera systems recorded nearly 10 times the data per den recorded by human observers (526 h/den and 57 h/den respectively). We found no difference between the two study periods in emergence dates, duration at den sites, abandonment dates, or activity budgets for polar bears. We observed a 16-fold reduction in the number of bear-human interactions when using cameras instead of human observers. There was, however, a marked increase in the intensity of response when using cameras (125 m) as compared to observers in blinds (400 m). An understanding of these activity patterns can be used to manage human activities near dens so as to minimize disturbance.

Key words: Alaska, behavior, den emergence, human disturbance, maternity den, North Slope, polar bear, post-denning, southern Beaufort Sea, *Ursus maritimus*

RÉSUMÉ. À l'échelle de leur aire de répartition circumpolaire, les ourses polaires (*Ursus maritimus*) en gestation se créent une tanière de neige pour donner naissance à leurs oursons à développement tardif. Puisque les nouveau-nés de l'ourse polaire naissent dans un état si peu développé, leur survie nécessite une longue période de développement non perturbé en tanière. Afin d'atténuer les incidences de l'être humain sur les ours en tanière, il est nécessaire de comprendre la chronologie de la mise bas, les comportements des ours en tanière et leur sensibilité à l'activité humaine. À partir de 2002, nous avons étudié les comportements de sortie des tanières des ours polaires du nord de l'Alaska, tout d'abord au moyen d'observations faites sur place (en 2002 et 2003) et ensuite, au moyen de caméras vidéo autonomes (de 2005 à 2008). Ici, nous comparons la durée, la répartition des activités et les comportements des ours polaires afin de déterminer si les méthodes d'observation ont influencé leurs activités. Les caméras ont enregistré près de dix fois plus de données par tanière que les observateurs humains (526 h/tanière et 57 h/tanière respectivement). Nous n'avons trouvé aucune différence entre les deux périodes à l'étude en ce qui a trait aux dates de sortie, aux durées de séjour en tanière, aux dates d'abandon ou à la répartition des activités des ours polaires. Lorsque nous avons utilisé des caméras par opposition à des observateurs, nous avons dénoté 16 fois moins d'interactions entre les ours et l'être humain. Cependant, nous avons remarqué une augmentation accrue sur le plan de l'intensité de la réponse lorsque nous nous sommes servis de caméras (125 m) comparativement aux observateurs dissimulés (400 m). La compréhension de ces modèles d'activités peut servir à gérer l'activité humaine à proximité des tanières afin de minimiser les perturbations.

Mots clés : Alaska, comportement, sortie de la tanière, perturbation anthropique, tanière de maternité, versant nord, ours polaire, après-séjour en tanière, sud de la mer de Beaufort, *Ursus maritimus*

Traduit pour la revue *Arctic* par Nicole Giguère.

INTRODUCTION

Across most of their range, pregnant female polar bears excavate dens in snow and ice in early winter (Harington, 1968; Lentfer and Hensel, 1980; Ramsay and Stirling, 1988; Amstrup and Gardner, 1994). They give birth in midwinter (Harington, 1968; Uspenski and Kistchinski, 1972; Ramsay and Dunbrack, 1986) and emerge from dens when cubs are approximately three months old (Amstrup, 1993). Polar bears of the southern Beaufort Sea initiate denning in

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late October through early December, at which time they excavate snow dens in areas with adequate accumulations (Durner et al., 2001; Amstrup, 2003).

To better understand the post-emergent ecology of polar bears in the southern Beaufort Sea, we initiated research in 2002 that documented den breakout times, length of post-emergence stay at den sites, activity budgets of post-emergent bears, and the frequency and intensity of bear-human interactions (Smith et al., 2007). We continued this work in 2005–08, but we used video camera systems rather than human observers to improve data quantity and quality while reducing bear-human interactions. With implementation of cameras we expected 1) a significant increase in observation time per den, 2) fewer bear-human interactions, 3) more intense bear-human interactions due to the close proximity of cameras to dens (125 m), 4) a longer stay at den sites due to less human disturbance, 5) a longer duration of stay outside the den and a shorter duration inside the den due to less disturbance, and 6) differences in behavior at the den site (e.g., walking, lying, or playing).

METHODS

We conducted this research along the coastal plain of northern Alaska (North Slope), with the focus north and east of Milne Point (Fig. 1). In the southern Beaufort Sea, terrestrial polar bear dens occur primarily along the cutbanks of barrier islands and the nearby coastal plain, although some bears have been documented denning as far as 50 km inland (Lentfer and Hensel, 1980; Amstrup and Gardner, 1994; Durner et al., 2003; Amstrup et al., 2004). This region lacks the steep topography associated with polar bear denning areas on Wrangel Island, Russia (Uspenski and Kistchinski, 1972), Herald Island, Russia (Ovsyanikov, 1998), and Svalbard, Norway (Larsen, 1985). Consequently, dens are restricted to coastal islands, riverbank bluffs, and landforms capable of holding sufficient snow for den construction (Durner et al., 2003). For the purposes of this study, we define a "den site" as the den cavity, entrance, and area within 25 m of the entrance. Before den breakout in late February to March, den sites are indistinguishable from the surrounding terrain. Although Durner et al. (2006) created a polar bear den habitat selection model that delimits the search area for denned bears, locating dens before breakout (spring opening) is still a significant challenge (Lentfer and Hensel, 1980). To locate dens for observation, we therefore used four methods: 1) radio-telemetry, 2) aircraft-based, forward-looking infrared imagery (FLIR) (FLIR Systems, Inc., Portland, Oregon), 3) hand-held FLIR, and 4) trained dogs. These methods are presented in detail in Smith et al. (2007).

We used digital video cameras (Sony TRV-480 Handycam®) for den site monitoring. Cameras were set to run 0.5 sec of videotape (15 image frames) every 30 seconds until the videotape was full, or for approximately 4.7 days of continuous runtime. Although this camera is sensitive to low light conditions, it does not have night vision capability, which limited our hours of observation from dawn to dusk. However, on moonlit nights with clear skies, cameras are capable of monitoring den sites. Cameras were housed in insulated containers (Igloo® 48-quart ice chests) containing two 100 ampere hour (aH), 12V gel cell batteries. Batteries provided power for both the camera and a heater, which maintained temperatures around 20˚C within the enclosure (Fig. 2). We positioned cameras at 125 m from dens and set the field of vision to include 25 m on either side of the entrance. After four days of continuous operation, each camera was checked for operational status and the videotape was replaced. Each site visit required about 10 minutes, and sites were accessed by snow machines. Whenever approaching a site, we would pause at approximately 1.6 km from the den and scan the area with binoculars to make certain the bears were not out. If the bears were out, we left and returned another day. We recorded all bear-human interactions that occurred during site visits.

Date/time stamps on each frame of the video enabled us to determine the timing and duration of specific events precisely. This method of data collection is known as instantaneous scan sampling (Altmann, 1974; Lehner, 1996), with each 0.5 sec of videotape comprising a single scan sample. We classified bear behavioral states (i.e., behaviors with measurable duration, such as walking and resting), events (i.e., activities without meaningful duration, such as den exit, den entry, and urination), and modifiers (i.e., scanning while resting), using definitions provided by previous researchers (Hansson and Thomassen, 1983; Larsen, 1985; Ovsyanikov, 1998). The term "den breakout" as used in this study refers to the first time that bears fully emerge from dens; this definition specifically excludes nose and head pokes from being breakout events. Polar bear activity budgets were derived by totaling the number of scans per behavior type and dividing the time in any one behavior type by the total time bears were observed. Comparisons of mother and cub activity budgets (e.g., time spent foraging, walking, or playing) were conducted using the Student's *t*-test for statistical significance.

The U.S. Bureau of Ocean Energy Management, Regulation and Enforcement maintains five meteorological monitoring sites within 50 km of the dens we studied. Wind speed (m/s) and temperature (˚C) were recorded as hourly averages. Precipitation was also recorded hourly. Wind chill was calculated using the following formula:

$$\text{Wind chill temperature (˚C)} = 13.12 + 0.6215T_a - 11.37V^{0.16} + 0.3965T^{a}V^{0.16}$$

where T_a is the air temperature in ˚C and V is the airspeed in km/h (Osczevski and Bluestein, 2005). For each day, we calculated the total time bears were observed out of den and compared it to the average wind chill for the same day using the Spearman's rank correlation test. The test statistic for Spearman's is *S*, and the measure of correlation is ρ (rho), which ranges from 0 (not correlated) to 1.0 (perfectly

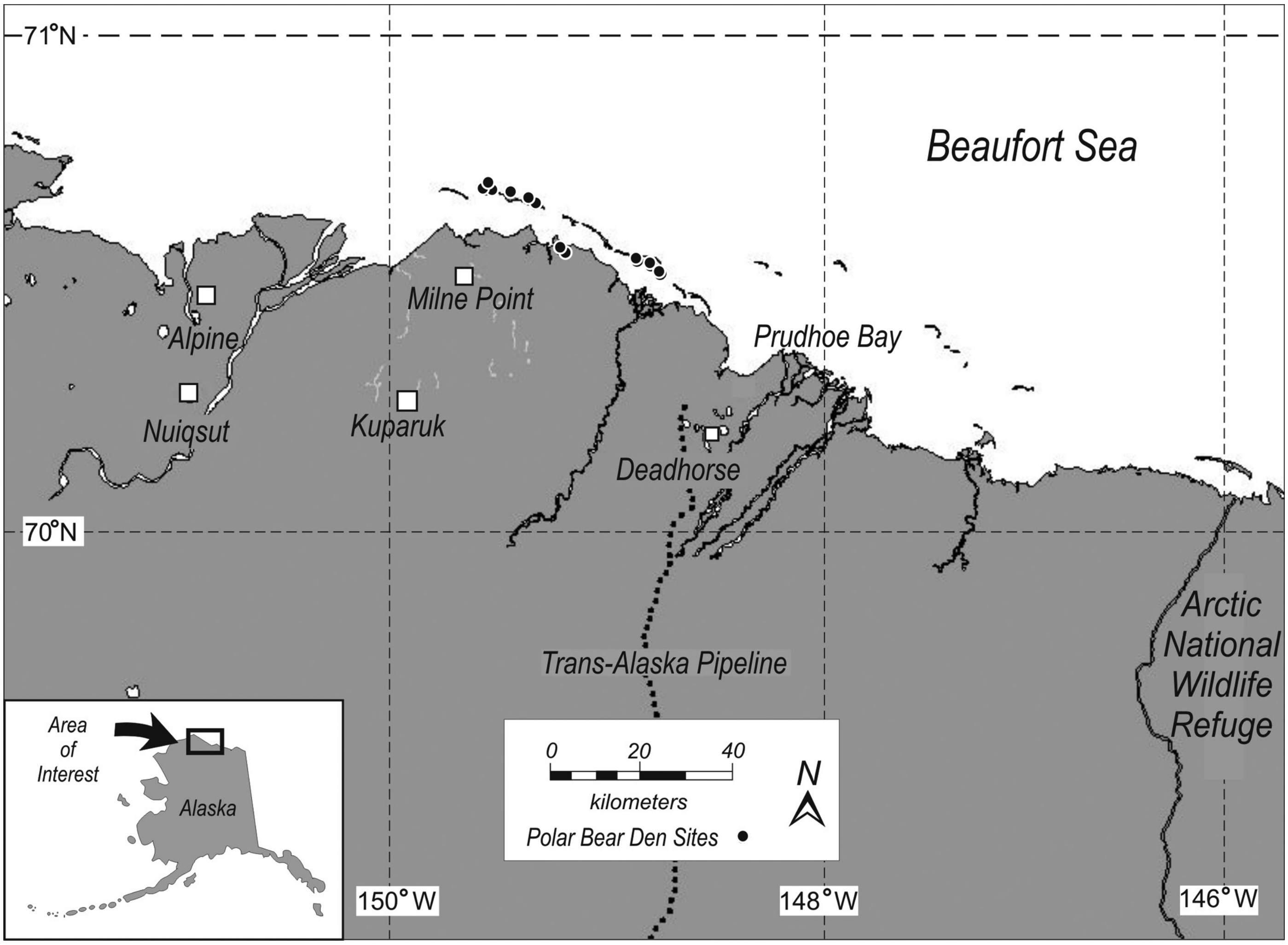

FIG. 1. Location of the polar bear dens within the maternal den study area, North Slope, Alaska, in 2005–08.

correlated). We used the Student's *t*-test to compare den emergence dates, length of stay at dens, bear behaviors, and weather variables for significance, and one-way analysis of variance to explore activity patterns within and between polar bear family groups (R Development Core Team, 2010). Statistical significance was set at $\alpha = 0.05$.

RESULTS

In March of 2005 to 2008, we observed 11 dens for a total of 241 days, or an average of 22 days per den (Table 1). Camera monitoring was continuous until bears abandoned dens; however, we were able to document nighttime activity on only five nights, when the moon was up and skies were clear. Inclement weather, periodic camera malfunctions, and nighttime interrupted continuous data collection. The mean date of den emergence was 13 March (range of 1–22 March, SD ± 7.7 d, $n = 11$), and the mean date of den abandonment was 19 March (range of 13–29 March, SD ± 7.8 d, $n = 11$; Table 1). Following initial emergence, polar bear families remained at den sites for 2 to 18 days (mean = 6.6 ± 4.5 d, $n = 11$). During the 1406 hours when cameras were monitoring the 11 dens, adult females remained in the den for 97.5% of the time, and cubs for 98.8% of the time (Table 2). For adult females, the average length of stay in dens between emergent, active periods, 2.25 h ($n = 124$), was significantly longer than the average time spent outside dens, 0.20 h ($n = 176$, Student's $t = -13.29$, $p < 0.001$). The comparable figures for cubs were 2.57 h ($n = 66$) in den and 0.27 h outside ($n = 40$, Student's $t = -7.45$, $p < 0.001$).

Activity data for dens studied in 2002–03 ($n = 8$, Smith et al., 2007), and dens observed in this study ($n = 11$) is presented in Figure 3. For all 19 dens, the mean breakout date was 15 March (range of 1–26 March, SD ± 7.4 d, $n = 19$), and the mean abandonment date was 21 March (range of 2–31 March, SD ± 7.8 d, $n = 19$).

Daily out-of-den activity data for all polar bear families (Fig. 4, $n = 11$) show no specific diurnal activity pattern; hence, a bear can be expected to emerge anytime during the daylight hours. Bears were rarely active during the twilight and dark hours of this study. Bears were observed out of den on 184 occasions, but they were active in low light conditions (i.e., civil twilight) on only six occasions (3% of exits):

FIG. 2. The camera system used for recording polar bear activity at den sites. The person is positioning the camera by using an external monitor attached to the activated camera.

two at dawn and four at dusk. Cameras captured bear activity that continued into darkness on two occasions. On five of 108 nights (5%), ample moonlight made it light enough to detect activity, but bears were not active outside the den. Bears did not range farther than 100 m from den entrances during this study, as documented on videotape and by post-abandonment track analysis. Polar bear tracks remain visible for weeks. By encircling den sites and following tracks with our snow machines, we were able to follow departing families for hundreds of meters as they moved away. Videotape and track censuses confirmed that movements were direct and northward away from den entrances, with no bears returning once they had gone more than 100 m.

Adult females and dependent cubs exhibited different patterns of activity with regard to frequency and order of appearance when exiting dens. We observed adult females exiting dens a total of 176 times, whereas their cubs exited 65 times, or approximately one-third as often. Adult females emerged from their dens unaccompanied 67% of the time, with cubs lagging in their exit up to several minutes. When cubs exited dens, 26% of the time their mothers preceded them. In 7% of all den exits observed, mothers and cubs exited together. Cubs exited alone in only two of 184 exit events (< 1%), during which they remained outside for 1–2 minutes. Mothers and cubs significantly varied in the mean number of exits per active day, with mothers averaging 2.3 exits per day and cubs 1.0 exits ($n = 22$, Student's $t = 3.17$, $p = 0.002$). A comparison of the time mothers and cubs spent out of den as they approached den abandonment did not show any trends; that is, mothers and cubs did not spend increasingly longer periods outside as den abandonment approached (adult females: $p = 0.180$, cubs: $p = 0.796$).

Standing was the most prevalent adult female behavior (25.2%), followed by walking (21.7%), rolling in the snow (10.4%), sitting (8.6%), digging in the snow (6.2%), nursing (4.4%), resting (3.9%), and running (0.1%). No foraging behavior was observed. Because of the camera's fixed field of view, adult females were unobservable 19.8% of the time, having moved out of range. Adult female polar bears were active (e.g., walking, rolling, digging, or nursing) 42.7% of total observable time while out of the den and spent the balance of time inactive (e.g., standing or resting). Cubs engaged in walking more than any other behavior (31.6%), followed by standing (11.8%), nursing (10.7%), playing (10.35%), sitting (2.5%), resting (2.1%), and rolling in the snow (0.2%). No foraging behavior was observed. Cubs were unobservable 30.8% of the time because they moved out of the camera's view or were obscured by the mother. Cubs were active (e.g., walking, nursing, playing, or rolling) 52.8% of the observable time while out of the den.

Only weak relationships between polar bear activity patterns and weather were observed. When we compared the amount of time bears spent out of the den with the ambient temperature, a positive, but weak correlation was found ($r^2 = 0.0513$). Mean temperature for den breakout days across years was -32˚C, which was not significantly different from the mean temperature for March across years (range = -44 to -19˚C; mean = -28.9˚C, $t = -1.17$, $p = 0.13$). Den breakout events occurred as early as sunrise (6:13 a.m.) and as late as mid-afternoon (2:21 p.m.), with a mean around midday (mean = 10:12 a.m.). The amount of time spent out of the den daily was slightly correlated with the mean wind chill temperature (Pearson correlation coefficient = 0.227, $r^2 = 0.051$).

We logged 458.8 hours of den observations, for an average of 57.4 hours per den, when using blinds in 2002–03 (Smith et al., 2007). Using video cameras in 2005–08, we logged 5784 hours of den observations, for an average of 526 hours per den—or roughly ten times the data gathered using blinds—and with much less effort. We compared bear activity profiles generated by the two data collection methods (direct observation and video cameras) to see if they differed. With regard to the number of bear-human interactions associated with each method, we recorded 32 interactions during the 2002–03 study (16 per year) and four interactions in the 2005–08 study (one per year). The mean intensity of response to human activity was recorded as 1 = no overt response, 2 = moderate response (a brief change in behavior), and 3 = strong response (such as running or den entry). In 2002–03, the mean intensity of response was 1.3 ± 0.64 SD, whereas in 2005–08, it was 2.5 ± 1.0 SD. There was no significant difference between the two studies

TABLE 1. Location dates and observational data for 11 polar bear maternal den sites on the North Slope, Alaska, observed in March – April of 2005 to 2008.

Year	Dates observed	Location	Total observation days[1]	Den breakout	Den abandonment	Number of days at den[2]	Number of cubs at den	Adult total time out of den (hours)	Cub total time out of den (hours)	Number of adult observation sessions	Number of cub observation sessions
2005	11 Mar – 9 Apr	Staging Pad	30	12 Mar	29 Mar	18	2	12.3	8.8	50	35
2005	3 – 17 Mar	Pingok West	15	4 Mar	13 Mar	10	2	3.2	1.3	28	7
2006	3 – 24 Mar	Pingok East	22	22 Mar	24 Mar	3	2	2.4	1.2	11	9
2006	3 – 24 Mar	Pingok North	22	20 Mar	24 Mar	5	2	4.0	0.1	21	2
2007	15 – 23 Mar	Pingok East	9	16 Mar	21 Mar	6	2	2.0	0.1	28	5
2007	12 – 28 Mar	Pingok West	17	14 Mar	17 Mar	4	2	3.0	1.0	9	13
2007	10 – 22 Mar	Cottle West	13	11 Mar	20 Mar	10	2	3.1	1.9	23	4
2007	13 – 26 Mar	Cottle East	14	16 Mar	20-Mar	5	2	0.6	0.1	7	1
2008	5 – 25 Mar	Cottle	21	6 Mar	9 Mar	4	2	1.9	0.8	6	1
2008	1 Mar – 13 Apr	Pingok West	44	1 Mar	2 Mar	2	2	1.7	2.4	12	6
2008	1 Mar – 3 Apr	Staging Pad	34	26 Mar	31 Mar	6	2	0.6	0.3	6	3
		Totals	**241**	–	–	**73**	**22**	**34.8**	**18.0**	**201**	**86**
		Average	**22**	**13 Mar**	**19 Mar**	**6.6**	**2**	**3.2**	**2**	**18**	**8**

[1] Total days camera was observing den site.
[2] Number of days bears were at den site from breakout to abandonment.

TABLE 2. Activity budgets of adult female polar bears ($n = 11$) and dependent cubs ($n = 22$) observed at their den sites in northern Alaska, March 2005 to 2008.

Activity	Total observation hours		Percent total observation time		Percent time outside[1]	
	Females	Cubs[2]	Females	Cubs	Females	Cubs
In den	1371.0	1389.0	97.5	98.8	–	–
Nursing	1.8	1.8	0.1	0.1	6.5	15.7
Walking	6.9	5.2	0.5	0.4	24.9	45.7
Digging	2.4	0	0.2	0	8.7	0
Play	0	1.5	0	0.1	0	13.3
Generally active[3]	3.9	0.2	0.3	0	14.0	0
Generally inactive[4]	12.8	2.9	0.9	0.2	45.9	25.3
Unobservable	7.1	5.3	0.5	0.4	–	–
Totals	**1405.9**	**1405.9**	**100.0**	**100.0**	**100.0**	**100.0**

[1] Time when bears were outside the den and visible to observers.
[2] Total observation time of cubs outside the den is less as females emerged from the den unaccompanied 67% of the time.
[3] Includes rolling in snow and running.
[4] Includes sitting, standing, and resting behaviors.

in the mean dates of emergence (18 March in 2002 – 03 and 13 March in 2005 – 08; Student's $t = 1.2433$, $p = 0.116$, df = 16; Fig. 3) and den abandonment (24 March in 2002 – 03 and 19 March in 2005 – 08; Student's $t = 1.3435$, $p = 0.0989$, df = 16; Fig. 3). Nor did the two studies differ significantly in the bears' mean length of stay post-emergence (8.0 d in 2002 – 03, 6.6 d in 2005 – 08; Student's $t = 0.6309$, $p = 0.268$, df = 16). Maternal groups remained outside the den for longer periods during the 2002 – 03 study (mean = 17.2 min) than during the 2005 – 08 study (mean = 11.8 min, Student's $t = 1.7685$, $p = 0.039$). Adult bears also spent more time inside the den during the 2002 – 03 study (mean = 206.1 min) than during the 2005 – 08 study (mean = 133.1 min, Student's $t = 2.669$, $p = 0.001$). Bears also spent a greater percentage of total observation time outside the den during the 2002 – 03 study (8.2%) than during the 2005 – 08 study (5%). The mean number of exits per day was 2.11 in 2002 – 03, compared to 2.75 in 2005 – 08. Behaviorally, bears partitioned time similarly during the two study periods, except they occasionally foraged on vegetation in 2002 – 03 and were not seen doing this during 2005 – 08.

DISCUSSION

Our observations of post-denning polar bear activity on the North Slope are consistent with studies done elsewhere, in that a) denning polar bears at this latitude emerged in the month of March, b) bears spent the majority of their time inside their dens, c) bears did not appear to be active at night, d) bears remained at dens for variable lengths of time (2 – 18 days in this study), and e) bear out-of-den activity was positively correlated with wind chill (e.g., the colder it was, the less bear activity).

Polar bear family groups in this study and those of Herald Island, Russia (at 70˚ and 71˚ N, respectively) emerged predominantly in the month of March (Herald Island: mean = 25 March ± 1.5 days, $n = 7$; Ovsyanikov, 1998). Given

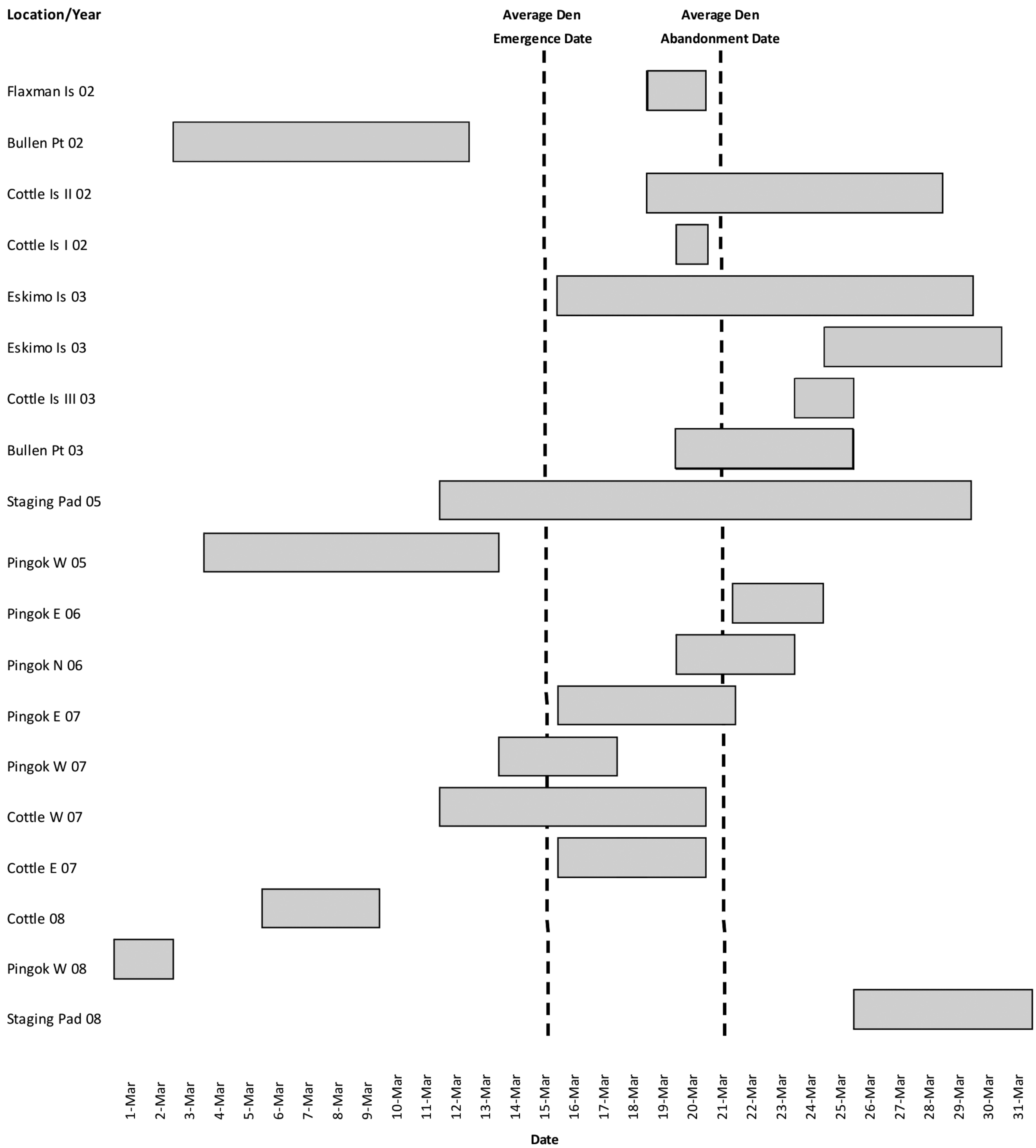

FIG. 3. Den emergence and abandonment dates for 19 dens studied on the North Slope, Alaska, 2002–03 and 2005–08.

the significant changes in sea ice extent and thickness during the period of this study (Comiso et al., 2008; Comiso, 2010), one might expect changes in the timing of den breakout. However, an analysis of 19 den breakout dates failed to reveal any significant trend (ANOVA, $R^2 = 0.0728$).

From den breakout to abandonment, polar bears rarely emerge from their dens in this or other studies (Norway = 80.6% of the time in-den for adults and 85.5% for cubs, Hansson and Thomassen, 1983; Russia = 94.9% of the time in-den for adults, no data for cubs; Ovsyanikov, 1998). We did not record any bear activity out of the den during the five nights when observation was possible. This finding is consistent with observations made on Wrangel Island over a 20-year period, during which time a bear was never observed outside at night (N. Ovsyanikov, pers. comm. 2006). The mean length of stay at dens post-emergence for

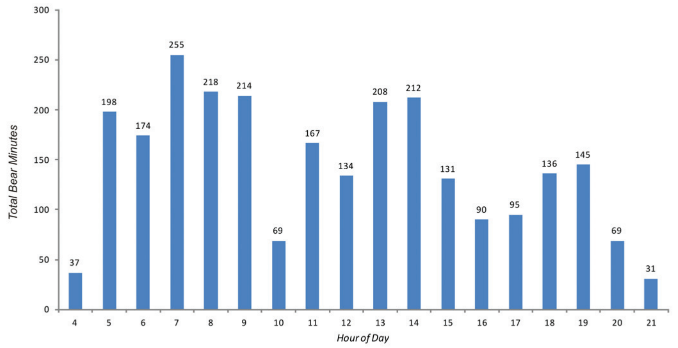

FIG. 4. Daily out-of-den activity patterns for 11 polar bear families observed on the North Slope, Alaska, in 2005–08.

Alaskan bears was comparable to that of Hudson Bay bears (Lunn et al., 2004; mean = 8.7 ± 1.8 d), but significantly shorter than that of bears on Herald Island (Ovsyanikov, 1998; mean = 15.5 ± 6.3 d).

We found that the time a polar bear spent outside its den was weakly correlated with wind chill. This observation is consistent with Blix and Lentfer's (1979) finding that cubs have a lower critical temperature of -30˚C, below which they are intolerant of wind chill and curtail outside activity. However, den breakout on the North Slope occurred at colder temperatures (-44˚C to -19˚C; mean = -28.9˚C) than those reported for den sites on Svalbard (Hansson and Thomassen, 1983) and Wrangel Island (Belikov et al., 1977), where temperatures ranged from -25˚C to -20˚C. Hansson and Thomassen (1983) suggested that temperature should not normally be a limiting factor in den breakout, and indeed den breakout occurred across a wide range of temperatures in this study.

We found that using camera systems instead of blinds was a great improvement. Camera systems increased data capture by nearly an order of magnitude, while significantly reducing our time in the field. Although the use of cameras reduced the number of bear-human interactions from 16 to 1 per year, the intensity of interactions increased, presumably because cameras were closer to bears than human observers (125 m vs. 400 m). Nonetheless, the use of cameras did not appear to affect the duration of stay at dens post-emergence. Whether bears were observed by people or by cameras, their activity budgets were unaffected. Camera systems were a trade-off: better quantity and quality of data at the cost of being more disruptive to bears.

MANAGEMENT IMPLICATIONS

Information from this study may be useful to those planning industrial activity on Alaska's North Slope. Polar bears in this region spend only a small percentage of time outside their dens between breakout and den abandonment, and when they do emerge, it is for very short periods. The fact that bears were not observed exiting at night in this study or another long-term den observation study (in Herald Island, Russia) suggests that human activity could be restricted to nighttime until bears abandon dens. In our study, bears did not stray more than 100 m from dens before abandonment. Finally, we did not observe any bears returning to dens once the mother and cubs had wandered more than 100 m and remained beyond that distance for a few hours. These facts could be used to help reduce or mitigate disturbance to polar bears when industrial activity occurs in close proximity to their dens.

ACKNOWLEDGEMENTS

We would like to thank three anonymous reviewers for their thoughtful comments regarding this manuscript. We would also like to thank the following persons for assisting data collection: S. Partridge, T.D. DeBruyn, J. Wilder, T. Evans, S. Schliebe, C. Perham, R. Shideler, B. Jessop, and J. Whiting. C. Perham and R. Shideler were always very helpful in locating dens and pleasurable to work with, as were Riley and Kavik, R. Shideler's tireless and talented Karelian bear dogs. Additionally, we thank W.J. Streever and D. Sanzone of British Petroleum Exploration (BPX) for their support and assistance, without which this project would not have been possible. Wilson Cullor and Tatyana Venegas (also at BPX Alaska) were important for their endless logistical support. S. Umatum, and N. Hermon of Alaska Clean Seas and K. Thomas-Ford and D. Heebner of BP Environmental provided invaluable assistance at the BPX Milne Point facility. We extend special thanks to D. Herron and J. Thompson of the BP Thermographics Division for providing access to the FLIR cameras. We also thank J. Allen, D. Kruger, J. Michaels, and Chief "Ski" plus a number of mechanics and other personnel at the BPX Badami facility for their support and assistance in keeping our gear operational and our project on track. Polar Bears International (PBI) has played an increasingly important role in supporting this work. Specifically PBI president Robert Buchanan and wife Carolyn have been instrumental in keeping us going, for which we are deeply grateful. We extend our deepest thanks to the entire PBI family as well. Funding for this work was provided in part by the U.S. Fish and Wildlife Service, the U.S. Geological Survey, British Petroleum Exploration–Alaska, and Polar Bears International.

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