



Activity patterns and time budgets of grizzly bears in the Swan Mountains of Montana
by Erik Alexander Wenum

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science Fish
and Wildlife Management
Montana State University
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Abstract:

The continued existence of many grizzly bear populations will depend on their ability to co-exist with man. Studies have indicated that grizzly bears are able to avoid direct conflicts with humans by either avoiding areas of predictable human use or by shifting their activity rhythms to periods of low human disturbance. There is a need for greater understanding of how and when bears alter their activity to avoid these potential conflicts and what role age, sex, reproductive status and season play in their ability or need for these adjustments.

The specific objectives of this study were: 1) determine seasonal activity budgets and patterns of 6 adult female grizzly bears, 2) determine, as possible, activity budgets and patterns among various age, sex and reproductive classes by season.

Activity data were collected using a LOTEK SRX400 telemetry scanner/receiver unit. Data were collected over 3 seasons, spring, summer and fall, during 1992, 1993 and 1994. A total of 5384.5 hours of activity data were collected from 19 different bears.

Following a period of post-denning lethargy, bears gradually increase the amount of time spent in an active state, reaching a spring mean percent time active (PTA) of 75.3%. Bears were most active during the summer season with mean PTA's as high as 88.3%. The high level of activity by all age, sex and reproductive classes is indicative of the hyperphagic activity bears enter during the berry season. In the early fall, bears continued this high level of activity, but this sharply declined as bears prepared for the upcoming denning season, with mean activity levels as low as 38%.

During the spring and summer seasons, bears began their active period at or near sunrise and were active through the day, with activity ending approximately 1.5 hours after sunset. During the fall, bears began their active period 1 -1.5 hours before sunrise, with near continuous activity ending 2 hours after sunset.

Although there were some differences by age, sex, reproductive status and season, grizzly bears in the South Fork were very active and highly diurnal in their activity patterns.

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

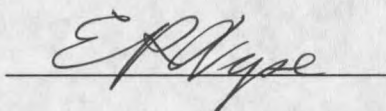
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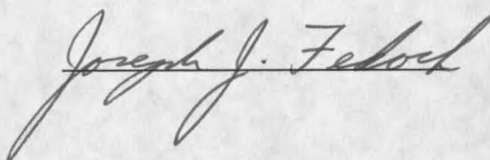
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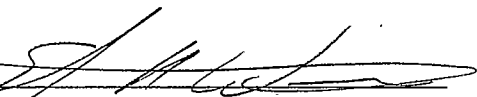
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ABSTRACT

The continued existence of many grizzly bear populations will depend on their ability to co-exist with man. Studies have indicated that grizzly bears are able to avoid direct conflicts with humans by either avoiding areas of predictable human use or by shifting their activity rhythms to periods of low human disturbance. There is a need for greater understanding of how and when bears alter their activity to avoid these potential conflicts and what role age, sex, reproductive status and season play in their ability or need for these adjustments.

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Although there were some differences by age, sex, reproductive status and season, grizzly bears in the South Fork were very active and highly diurnal in their activity patterns.

CHAPTER 1

OVERVIEW

Introduction

Currently, within the 48 contiguous United States, there are only 6 areas that contain remnant or self-perpetuating populations of grizzly bears (*Ursus arctos horribilis*) (Patnode and LeFranc 1987). All of these areas are experiencing a loss or degradation of habitat through resource extraction and/or human disturbance and development. Of these areas the Northern Continental Divide Ecosystem (NCDE) stands the best chance of retaining grizzly bears in the future. The NCDE includes parts of 5 National Forests (Flathead, Helena, Kootenai, Lewis and Clark, and Lolo), 4 designated wilderness areas (Bob Marshall, Great Bear, Mission Mountains, and Scapegoat), Glacier National Park (GNP), and state and private lands. While a large portion of the NCDE is protected from resource extraction (GNP and the wilderness areas), all of it is subject to the pressures of an increasing human population and human recreational pursuits.

With this increasing demand, the survival of many grizzly bear populations will depend on their ability to coexist with humans. Previous studies have indicated that grizzly bears are able to avoid direct conflicts with humans by either avoiding areas of predictable human use or by shifting their activity rhythms to periods of low human disturbance (Gunther 1991, McCann 1991, Aune and Kasworm 1989, McLellen 1989a,

1989b, 1989c, McLellen and Shackleton 1989a, 1989b, 1988a, 1988b).

There is a need for greater understanding of how and when bears alter their activity rhythms to avoid these potential conflicts and what role age, sex, reproductive status, and season play in the ability or need for this adjustment. Additionally, it is uncertain what cost these behavioral shifts may impose either from an energetics or forage efficiency and, ultimately, a reproductive fitness standpoint. This question is of importance for a wide variety of species due to the difficulty in associating behavioral disruptions to demographic consequences (Shank 1979).

The activity rhythms of a species are of interest for several reasons (Roth 1983). Once activity rhythms have been quantitatively described, they may be used to interpret the level of stress the population is experiencing. There are 2 aspects of an activity rhythm, activity budgets and activity patterns. Activity budget refers to the amount of the diel period spent in an active state. Activity pattern refers to the diel rhythms of activity.

Research on grizzly bear populations has been hampered by biological and logistical constraints. Grizzly bears exhibit complex individual and intraspecific behavioral patterns, have secretive habits, an aggressive temperament, and the ability to move long distances in a short period. They also inhabit mountainous and densely vegetated habitats which hampers observation. Grizzly bears also have lower reproductive rates and population levels relative to other species.

The Montana Department of Fish, Wildlife and Parks initiated the South Fork of the Flathead River Grizzly Bear Project (SFGP) in 1987 as a 10-year population dynamics and habitat selection study. A primary objective of the SFGP was to determine if current

ecological conditions within the study area are adversely affecting grizzly bear survival and, thus, population growth.

The specific objectives of this study were to:

1. Develop and validate a technique for the collection of continuous activity data.
2. Determine seasonal activity budgets and patterns of 6 focal adult female grizzly bears.
3. Determine activity budgets and patterns among various age, sex, and reproductive classes.
4. Determine if differences exist between activity budgets and patterns of 6 focal adult female grizzly bears when using roaded and unroaded habitats.

Study Area

The study area was located in the South Fork of the Flathead River drainage in northwestern Montana (48° 1' N 113° 43' W) and encompasses approximately 938 km² (Figure 1). The area extended from Pioneer Ridge south to the Bob Marshall Wilderness area boundary. The western and eastern boundaries were the Swan Valley and Hungry Horse Reservoir, respectively. The study area was primarily within the boundaries of the Flathead National Forest and was administered by Hungry Horse, Spotted Bear, and Swan Lake Ranger Districts.

Northwest Montana is influenced by Pacific maritime weather patterns, with average annual precipitation in excess of 80 cm, > 50% in snow. Temperature and precipitation, collected at the Hungry Horse Dam weather station, varied by season. Spring (8 May - 15 July) temperatures ranged from 2.8°C to 31.7°C with a mean of 14.8°C. Summer (16 July - 15 September) temperatures ranged from 1.1°C to 36.1°C with a mean of 19.1°C. Fall (16 September - 15 November) temperatures ranged from -6.1°C to 27.2°C with a mean of 6.8°C. Total precipitation for spring, summer and fall were 18.4 cm, 5.0 cm, and 17.4 cm respectively (NOAA 1994). At higher elevations weather conditions were more severe, with an average annual precipitation in excess of 250 cm (Manley and Mace 1992).

The South Fork of the Flathead is characterized by rugged mountainous topography, and elevations vary from 914 m in the Flathead Valley to over 2,736 m along

the Swan Mountain Divide. Complex local climates and the rugged topography create a mosaic of vegetation. Over 50% of the study area was closed timber, with the remainder broadly classified as cutting units, open ridges, parks, avalanche chutes, and rock land. The alpine zone of the Swan Mountains is of severely broken and jagged topography, resulting in the true alpine flora being dispersed with large expanses of intervening bedrock (Mace and Aune 1988).

Nearly every drainage in the western portion of the study area has a primary, secondary or tertiary road. Many of these roads are seasonally or permanently closed to vehicular traffic. Recreational activities in the study area include big game hunting, fishing, hiking, camping, wood cutting, berry picking, snowmobiling, and riding all terrain vehicles (ATV's).

Daily human intrusion during the spring and summer seasons is best characterized as light with the exception of the Jewel Basin Hiking Area and its access points, which experienced moderate recreational use, particularly during the summer season. During the fall, season human intrusion into the area is best characterized as moderate to heavy due to an increase in vehicular traffic, hiking, and stock use during the big game hunting season.



Figure 1. Study Area Map

Methods

There have been many studies using biotelemetry techniques to document activity rhythms of grizzly bears in both the United States and Canada and the brown bear of Europe (i.e. McCann 1991, Clevenger et al. 1990, Aune and Kasworm 1989, Bjarvall and Sandegren 1987, Harting 1985, Schleyer et al 1984, Aune and Stivers 1983, Roth 1983, Roth and Huber 1986, Schleyer 1983).

Advantages to remote sensing techniques include; 1) increased observer safety when studying potentially dangerous animals, 2) elimination of observer effects on the study subject, 3) elimination of the need for direct observation, which can be compromised by darkness, dense vegetation, inclement weather, topography, and the subject's mobility (McCann 1991). Disadvantages of remote sensing result from uncertainty in classifying an activity state based on a monitored variable. Some degree of uncertainty is often associated with the variable (i.e. signal strength or pulse rate) due to sudden changes in it's character. Additional uncertainty may result from procedural or system biases that favor a particular activity state (Jacobsen and Wiggins 1982).

Previous studies used either signal strength fluctuations of fixed pulse rate radio collars (Bjarvall and Sandegren 1987, Roth and Huber 1986, Harting 1985, Roth 1983) or radio collars equipped with tip switches that alternated the pulse between 2 rates depending on the vertical orientation of the collar (McCann 1991, Clevenger et al. 1990, Aune and Kasworm 1989, Harting 1985, Schleyer et al. 1984, Aune and Stivers 1983,

Schleyer 1983). Of those studies using tip switch collars, several had various reset times ranging from 0-5 minutes (McCann 1991, Clevenger et al. 1990).

Studies using signal strength to determine activity followed qualitative rules based on some change (an increase or decrease) of the signal strength to assign a classification of either active or inactive. When using tip switch collars to determine the activity state, the sample was generally classified as active or inactive based on the number of pulse rate changes per unit time.

Radio collars were monitored at set intervals for a predetermined sampling duration (time sampling). Both the interval between samples and the duration varied widely between studies. Instantaneous time sampling as defined by Jacobsen and Wiggins (1982) results in a sample being designated as active or inactive independently of the previous or subsequent samples. However, this becomes increasingly inaccurate as sample duration is decreased or the interval between samples is increased.

Continuous monitoring of an animal's activity rhythm offers a more accurate accounting of time expenditures and event sequencing than time sampling (Jacobsen and Wiggins 1982). Additionally, continuous monitoring may eliminate any observer effect on the animal's behavior. Altmann (1974) defines continuous monitoring as the continuous collection of focal animal samples, and involves recording all occurrences of the behaviors of interest performed by a specific or focal individual over a sample of known length. Such data are suited to studying the percent of time spent in various behaviors, behavioral sequences and durations of behavioral bouts (Altmann 1974). However, few studies have used a continuous monitoring approach due to the effort

required to collect such data.

In many previous studies, activity data was collected manually, resulting in small sample size, and in some cases (Schleyer 1983) relied on human auditory skills to distinguish even the subtlest of changes in signal strength. Further error may have resulted from a time sampling scheme, of the two studies where continuous monitoring was used to obtain activity data only McCann (1991) was able to collect a large sample.

McCann (1991) using a Rustrack dual channel strip chart recorder, collected 4,756 hours of activity data from 15 individuals, resulting in the largest sample of any previous behavioral research involving grizzly bears. However, McCann had to develop multiple rules for determining activity states. McCann used collars with differing reset times (5 second and 2.5 minute). Additionally, it was found that the speed of the strip recorder varied with ambient temperature and with the level of battery charge. Thus rules could vary greatly depending on the particular collar type, the temperature and rate of temperature change, and the battery charge and rate of charge decrease. Additional error may have resulted in reading the analog strip charts. Activity patterns were determined visually and strip speed was measured manually.

Field Procedures

Since fall of 1987, South Fork Grizzly Project (SFGP) personnel have captured 49 grizzly bears using snaring techniques described by Johnson and Pelton (1980). A premolar was extracted for age determination (Stoneberg and Jonkel 1966). Captured bears ≥ 1.5 years of age were fitted with motion-sensitive radio collars (Telonics Inc. Mesa, AZ.), with a cotton break-away splicer, allowing the collar to be dropped after 1-5 years (Hellgren et al. 1988). Each collar was equipped with a 10-degree mercury tip switch, which changed the emitted radio signal from a slow pulse rate of approximately 60 signals per minute to a fast pulse rate of approximately 90 signals per minute when the collar was tilted greater than 9 degrees from vertical. Reset to the slow pulse rate was instantaneous when the collar returned to the upright position.

Activity budgets and patterns were recorded using a LOTEK SRX 400 digital telemetry scanner/receiver unit (LOTEK Engineering Inc. Ontario, Canada) with a Telonics omni-directional whip antennae. This unit was capable of scanning multiple radio frequencies (scan interval = 3 seconds) and storing the following parameters: time, date, frequency, pulse rate and signal strength. Two, 12-volt dry cell batteries allowed the unit to continuously record for 10 days.

Activity data were collected during 3 seasons (spring, summer, and fall) in 1992, 1993 and 1994. Spring was defined as 8 May - 15 July (68 days) or from den emergence until the end of breeding season. Also signifying the end of spring was a change in food habits, from grasses and forbs, notably cow parsnip (*Heracleum lanatum*) and angelica (*Angelica arguta*) to globe huckleberries (*Vaccinium globulare*) and serviceberry

(*Amelanchier alnifolia*). Summer was defined as 16 July - 15 September (61 days) during which berry use was continuous (Mace and Manley 1990). Fall was defined as 16 September - 15 November (60 days) and began when food habits changed from huckleberries to mountain ash (*Sorbus* spp.) berries and gut piles from hunter kills (Manley and Mace 1991) and ended when denning occurred.

Bears ≤ 4.5 years of age were classified as sub-adults, and bears > 4.5 years of age were classified as adults. Due to the length of the study, several individuals changed from sub-adult to adult and/or changed reproductive classes, i.e. adult females with cubs of the year in 1992 were adult females with yearlings in 1993 and were solitary adult females in 1994. Bears that occurred in more than one classification over time were treated as independent individuals each year.

During the 1992 field season, 8 bears were monitored, representing 5 age, sex, and reproductive classes: adult females, adult females with yearlings, adult males, sub-adult males and sub-adult females.

During the 1993 field season, 13 bears were monitored, representing 4 age, sex, and reproductive classes: adult females, an adult female with 2 2-year olds, adult males, and sub-adult females. Bears were located through aerial telemetry flights twice per week, weather permitting, and ground telemetry efforts. Relocation flights generally occurred between 0700 and 1200 hours, with some occurring between 1700 and 2100 hours. Each location was plotted on a 1:24,000 orthographic photo map and Universal Transverse Mercator (UTM) coordinates, elevation, aspect and slope were recorded. Location information was used to determine which bear was in an accessible location in

which to deploy the LOTEK unit. Once deployed, the unit was checked by SFGP personnel periodically and was retrieved when the memory banks were full, the batteries had died, or the bear had left the area.

Sixteen bears were intensively monitored during the 1994 field season representing 5 age, sex, and reproductive classes: adult females, adult females with cubs of the year, adult males, sub-adult males and sub-adult females. Six adult females, 3 solitary and 3 with cubs of the year, were selected as focal animals. These individuals were selected based on the location of their home ranges relative to roads.

The study area was divided into 2 major habitat types: those that were "roaded" and those that were "unroaded". These 2 habitat groups were defined by road density (miles of road/km²) as described by Mace and Manley (1993). Revegetated roads were not figured into calculations of road density. Roaded habitats were defined as those geographic areas that exhibited road densities of greater than 0 km/km². Conversely, unroaded habitats were defined as those geographic areas that exhibited road densities equal to 0 km/km². Each focal bear had both roaded and unroaded areas within their home range (Figure 2). Home ranges were calculated using a 100% adaptive kernel model.

Focal bears were continuously monitored for a sampling bout of 72 hours. Focal bear sampling order was generated using a randomized block design. Each focal bear was monitored a minimum of 2 72-hr bouts per season. Other non-focal bears were monitored as available.

Bears were located through aerial telemetry flights twice per week, weather

permitting, and intensive ground telemetry efforts. Location information was plotted using the same methods used in 1992 and 1993. Location information was used to determine optimal location for the scanner/receiver unit. The unit was placed as close to the focal bear as possible in a location to optimize continuous monitoring without influencing bear activity. Location information was also used to determine the focal bear's location relative to the 2 habitat types (roaded, unroaded) and to other bears.

While monitoring bears in roaded habitats the LOTEK was checked at regular intervals. While monitoring bears in unroaded habitats the LOTEK was continuously attended for the entire 72-hour monitoring period.

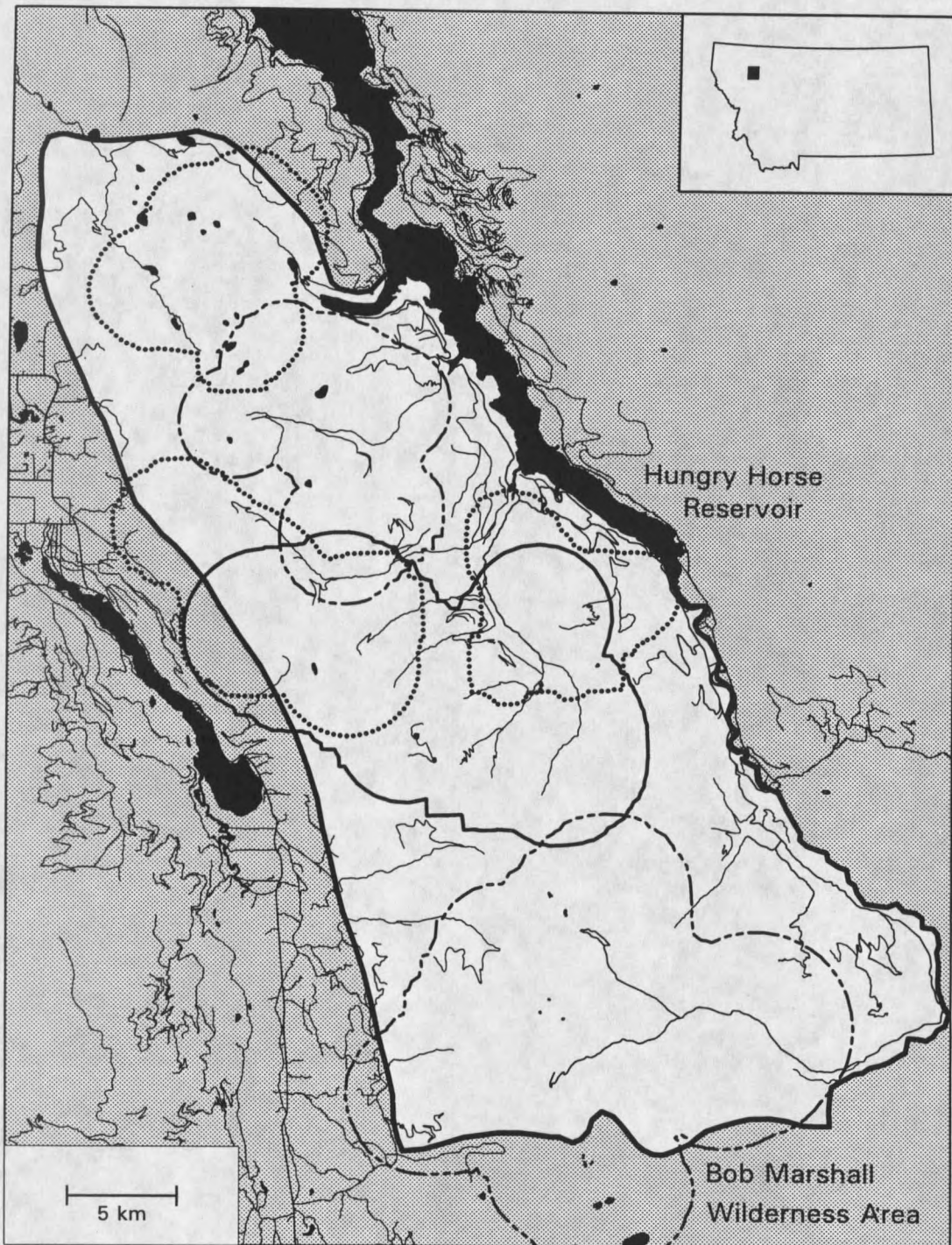


Figure 2. Home Ranges (100% adaptive kernel) of focal adult females relative to roads.

Determining Activity

Raw activity data (Appendix A) were downloaded in ASCII format to a laptop computer at the end of each sampling bout, then transferred into a database management program. Programs (Appendix B) written in dBASE III Plus (Ashton-Tate 1986) were used to edit and collate activity data. Radio collar pulse and modulation rates and signal strength were used to categorize data sets as active or inactive. During field testing of the LOTEK receiver, I determined that a stationary collar exhibits variable signal strength due to atmospheric and vegetative interference. I also determined that a signal strength standard deviation of < 10 could be used as a corrective factor for these atmospheric and vegetative variables. Consecutive activity data were combined into 15-minute blocks. For each 15-minute block, changes in modulation and signal strength were summarized. The pulse rate range (60-90 signals per minute) was divided into 3 quantiles, 60-70, 70-80 and 80-90 signals per minute. A 15-minute block was categorized as inactive if the mean pulse rate was between 60-70 or 80-90 signals per minute and the signal strength standard deviation was < 10 . Fifteen minute blocks were categorized as active if the mean pulse rate was between 60-70 or 80-90 signals per minute and the signal strength standard deviation was ≥ 10 or if the mean pulse rate was between 70-80 signals per minute regardless of the signal strength standard deviation. Activity data were collected from test collars to verify activity determination methods during each collection season. Grizzly bear activity data were validated through direct observations, when possible (Appendix C).

Data Totals

Distribution of Data

A total of 5,384.50 hours of grizzly bear activity data were collected for 19 different bears between 1992 and 1994, resulting in 21,538 quarter hour observations. A total of 9,863 quarter hours (2,465.75 hours) of activity data were collected for adult females, 5,276 quarter hours (1,319.00 hours) for adult males and 6,399 (1,599.75 hours) were collected for sub-adult bears. Over 47 percent (10,249 quarter hours or 2,562.25 hours) of the data were collected during the 1994 field season when monitoring was most intensive.

During 1992 a total of 4,478 quarter hours (1,119.50 hours) of activity data were collected on all age and sex classes. Over 52 percent (2,330 quarter hours or 582.50 hours) of the data collected were for adult females (Table 1).

Table 1. Total quarter hours of activity monitoring during 1992.

Classification	Spring	Summer	Fall	Total
Adult Female ^a	65	1298	390	1753
Adult Female ^b	467	-	110	577
Adult Female Total (n= 5)	532	1298	500	2330
Adult Male Total (n= 1)	3	48	33	84
Sub-adult Total (n= 2)	819	644	601	2064
TOTAL	1354	1990	1134	4478

^a = accompanied by 1 or more yearlings^b = solitary female

During 1993 a total of 6,811 quarter hours (1,702.75 hours) of activity data were collected on all age and sex classes (Table 2).

Table 2. Total quarter hours of activity monitoring during 1993.

Classification	Spring	Summer	Fall	Total
Adult Female ^a	83	-	-	83
Adult Female ^b	1150	730	33	1913
Adult Female Total (n= 7)	1233	730	33	1996
Adult Male Total (n= 4)	539	816	1441	2796
Sub-adult Total (n= 2)	-	1414	605	2019
TOTAL	1772	2960	2079	6811

^a = accompanied by 2 2-year olds

^b = solitary female

During 1994 a total of 10,251 quarter hours (2,562.75 hours) of activity data were collected on all age and sex classes. Over 54 percent (5,537 quarter hours or 1,384.25 hours) of the data collected were for adult females (Table 3).

Table 3. Total hours of activity monitoring during 1994.

Classification	Spring	Summer	Fall	Total
Adult Female ^a	1290	948	907	3145
Adult Female ^b	987	862	543	2392
Adult Female Total (n= 6)	2277	1810	1450	5537
Adult Male Total (n= 4)	642	407	1347	2396
Sub-adult Total (n= 6)	963	729	624	2316
TOTAL	3882	2946	3421	10249

^a = accompanied by 1 or more cubs of the year

^b = solitary female

CHAPTER 2

ACTIVITY BUDGETS

Introduction

Studying an animal's activity budget has frequently been suggested as a means of exploring the relationship between a population or class of individuals (varying sex, age or reproductive classes) and their environment (Roth 1983, Jacobsen and Wiggins 1982, Boy and Duncan 1979, Eberhardt 1977). There are 2 certainties about mammals: 1) they use energy to perform activities and, 2) they use time to collect energy (Bunnell and Harestad 1989). The amount of time spent collecting energy is dependant on how tightly an animal's activity budget is constrained by existing environmental conditions.

Quantifying the activity budget of a species or population under varying environmental conditions may allow some activity parameter(s) to be used as an indicator as to the level of stress the population is experiencing (Roth 1983). Additionally, seasonal variation of an animals activity budgets may be indicative of critical periods during the life history of the species in question. To be of use, however, these baseline data must include or account for variations based on sex, age, reproductive status and season.

Previous studies of grizzly bear activity budgets have been hampered by small sample size of either the number of bears monitored or the total time monitored or both (McCann 1991). These small samples have for the most part prevented an in-depth

investigation of the effects of these various classes. This chapter describes the total time spent in an active state of differing age, sex and reproductive classes by season.

Analysis

The statistical analytical procedures were selected after in-depth consultation with the Montana State University Department of Statistics as well as other individuals. It was concluded that these analytical procedures represented the best approach to summarizing the data.

Quarter hour activity data for like age, sex and reproductive class were pooled overall and by season. Mean proportional activity levels and their confidence intervals were calculated. Any box-whisker plots with overlap or correspondence in either confidence limits will not be significantly different (McGill et al. 1978). Conversely, box-whisker plots with non-overlapping confidence limits will be significantly different. All tests were completed at $p = 0.05$.

Results

Comparisons of overall percent time active (PTA) indicated there were significant differences between all 4 sex and age classifications when pooled regardless of season or reproductive class. Sub-adult males were the most active class with an average PTA of $86.3 (\pm 1.9)$. Adult females were the second most active class with an average PTA of $79.0 (\pm 1.9)$. Adult females were the second most active class with an average PTA of $79.0 (\pm 0.8)$. Sub-adult females were in an active state $73.0 (\pm 1.2)$ percent of the time, while adult males had the lowest overall PTA of $60.9 (\pm 1.3)$. All age and sex classes had extremely tight confidence intervals with all 4 being less than $\pm 2.0\%$ (Figure 3).

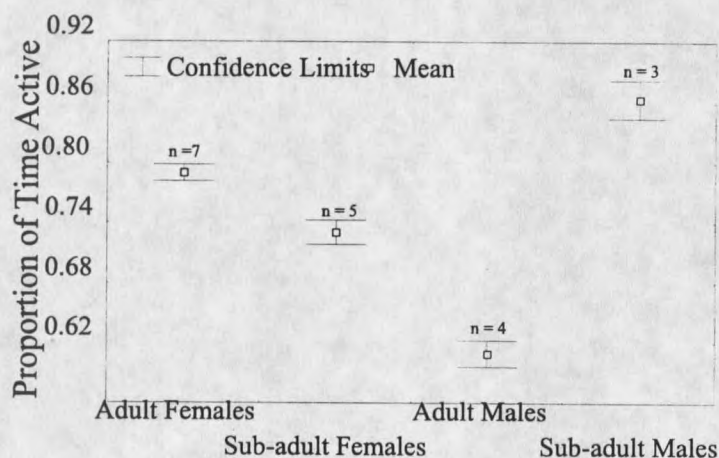


Figure 3. Overall proportion of time spent in an active state by age and sex class, 1992 - 1994.

Age and Sex by Season

During the spring period, sub-adult males were the most active class, with an average PTA of $85.3 (\pm 3.5)$, additionally sub-adult males were significantly different from the other 3 age and sex classifications (Figure 4). Adult females with an average PTA of $76.5 (\pm 1.3)$ were not significantly higher than the PTA of adult males, $73.5 (\pm 2.5)$. Sub-adult females had the lowest PTA of $66.1 (\pm 2.5)$ and were significantly lower than the other classifications.

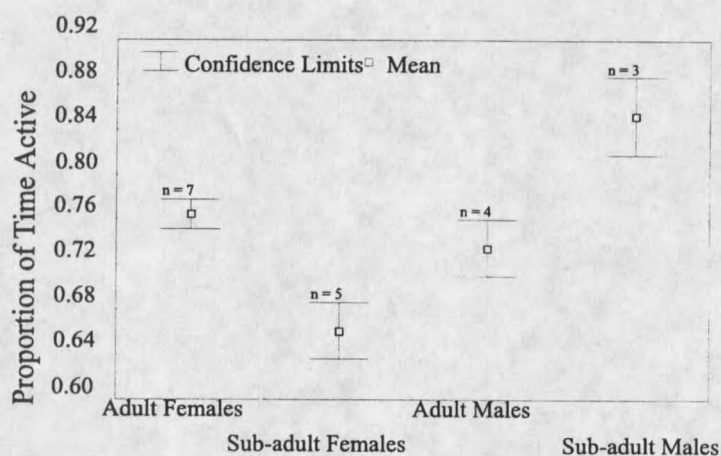


Figure 4. Proportion of time spent in an active state by age and sex class during the spring season (8 May - 15 July), 1992 - 1994.

During the summer season, sub-adult males were the most active class with a PTA of $88.5 (\pm 3.8)$ but were not significantly different from the $84.1 (\pm 1.2)$ PTA of adult females. Sub-adult females had a summer PTA of $75.5 (\pm 1.7)$. Adult males had the lowest summer PTA, $70.6 (\pm 2.5)$. All possible classification pairings were significantly different with the exception of adult females and sub-adult males (Figure 5).

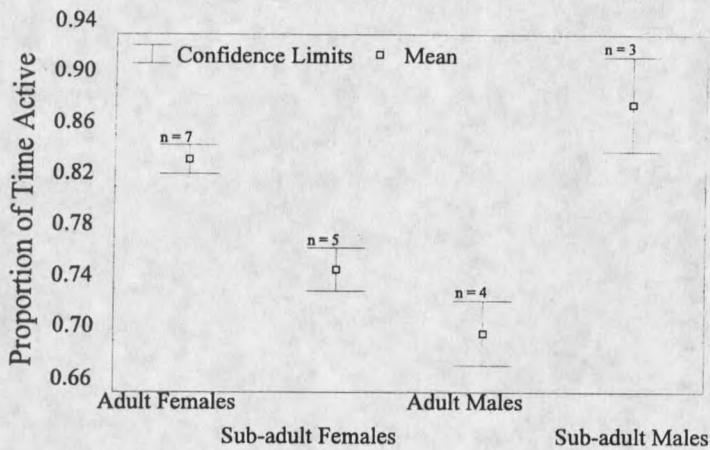


Figure 5. Proportion of time spent in an active state by age and sex class during the summer season (16 July - 15 September), 1992 - 1994.

During the fall sub-adult males were the most active class with a PTA of 86.0 ($\pm$ 2.8). Adult females and sub-adult females were similar in their fall PTA, 72.4 ($\pm$ 2.3) and 75.8 ($\pm$ 2.4) respectively. Adult males had a much lower PTA, 51.3 ($\pm$ 1.9), relative to the other classifications. All possible classification pairing were significantly different with the exception of adult females and sub-adult females (Figure 6).

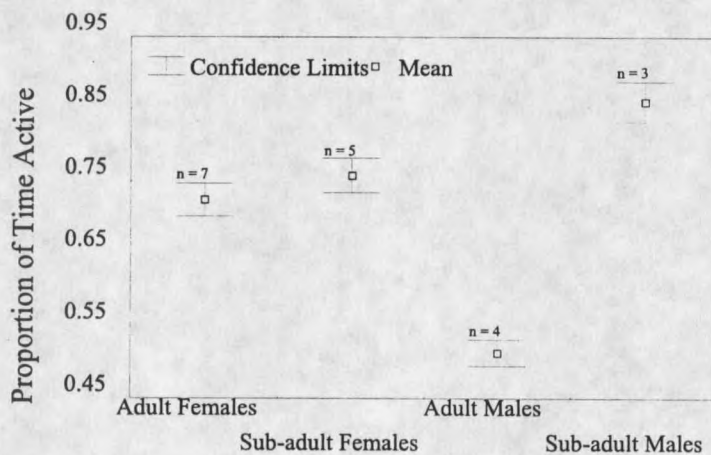


Figure 6. Proportion of time spent in an active state by age and sex class during the fall season (16 September - 15 November), 1992 - 1994.

Reproductive Status by Season

There were few significant differences based on the 3 possible reproductive classes, solitary females, females with cubs and females with yearlings. Overall females with yearlings were the most active class, PTA $81.3 (\pm 1.8)$, but were not significantly different from solitary females, PTA $79.0 (\pm 1.2)$. Additionally, females with cubs, PTA $77.6 (\pm 1.5)$, were not significantly different from solitary females, they were however, significantly lower than females with yearlings (Figure 7).

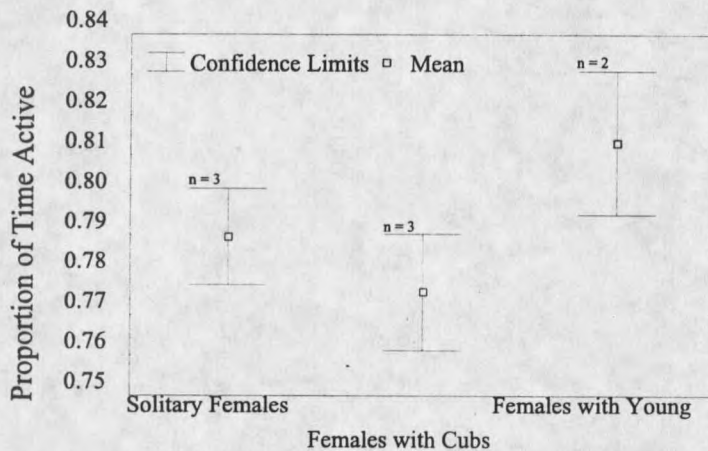


Figure 7. Overall proportion of time spent in an active state by reproductive class, 1992 - 1994.

There was no significant difference between the 3 reproductive classes during the spring season (Figure 8). Solitary females were active $77.5 (\pm 1.6)$ percent of the time. PTA for females with cubs and females with yearlings were $74.2 (\pm 2.4)$ and $77.7 (\pm 6.8)$ respectively.

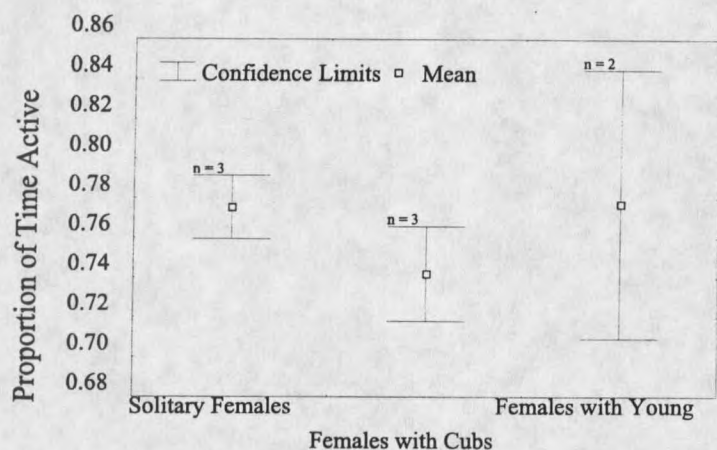


Figure 8. Proportion of time spent in an active state by reproductive class during the spring season (8 May - 15 July), 1992 - 1994.

During the summer season solitary females, PTA $82.0 (\pm 1.9)$, were not significantly different from females with cubs, PTA $84.4 (\pm 2.3)$. Additionally, females with cubs were not significantly different from females with yearlings, PTA $86.6 (\pm 1.9)$. Females with yearlings were however, significantly higher than solitary females (Figure

9).

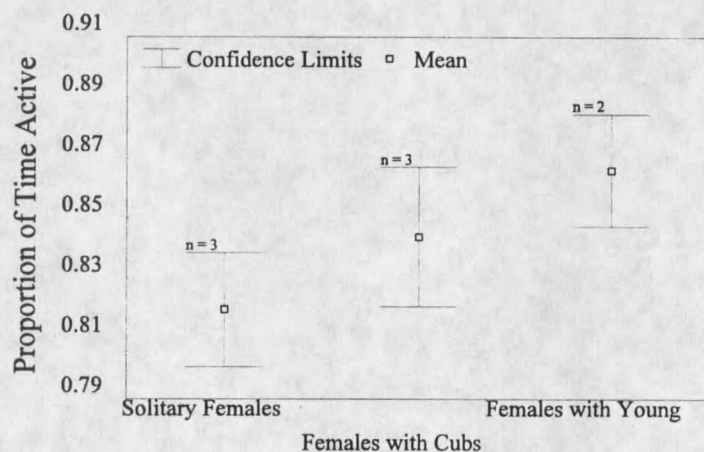


Figure 9. Proportion of time spent in an active state by reproductive class during the summer season (16 July - 15 September), 1992 - 1994.

The fall season showed no significant difference between solitary females, PTA 73.2 (± 6.5), and females with cubs, PTA 75.3 (± 2.8), nor was there significant difference between solitary females and females with yearlings, PTA 65.1 (± 4.8) (Figure 10). There was however, a significant difference between females with cubs and females with yearlings.

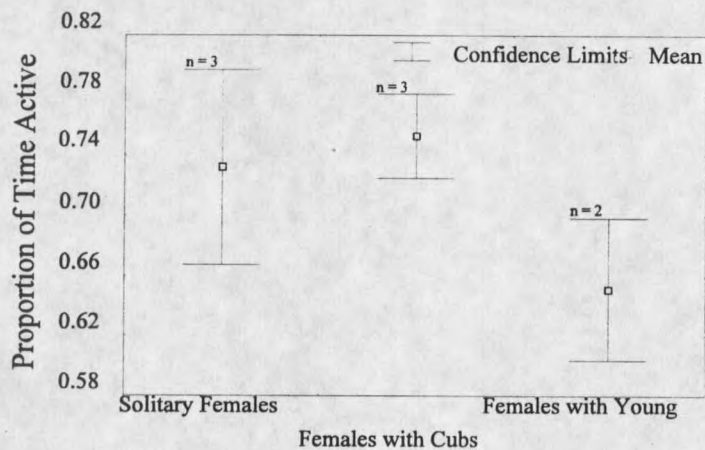


Figure 10. Proportion of time spent in an active state by reproductive class during the fall season (16 September - 15 November), 1992 - 1994.

Seasonal Variation

When adult females are pooled regardless of their reproductive status, all 3 seasons (spring, summer, fall) were significantly different (Figure 11). Adult females had a spring PTA of $76.4 (\pm 1.3)$. Adult females exhibited the highest PTA, $84.1 (\pm 1.2)$, during the summer, while fall had the lowest, $72.4 (\pm 2.3)$.

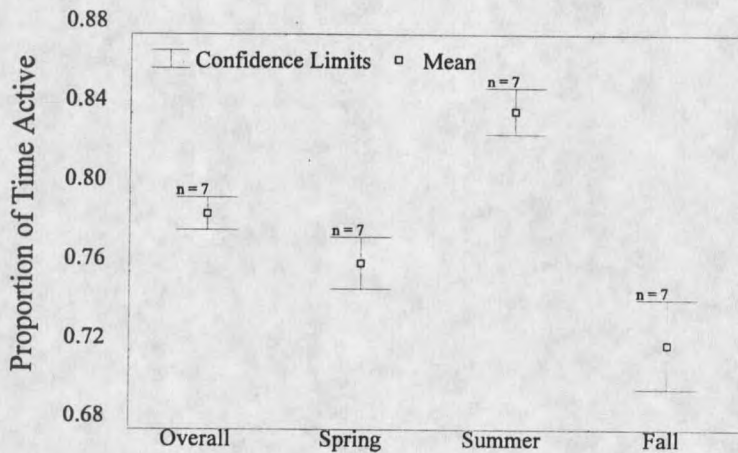


Figure 11. Proportion of time spent in an active state for adult females by season, 1992 - 1994.

Solitary females were most active during the summer season with a PTA of $82.0 (\pm 1.9)$. There was no significant difference in their activity level during spring, PTA $77.5 (\pm 1.6)$ and fall, PTA $73.2 (\pm 6.5)$ (Figure 12).

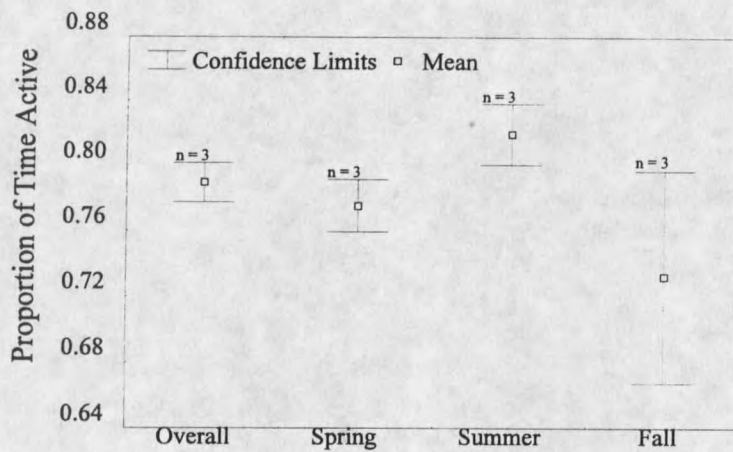


Figure 12. Proportion of time spent in an active state for solitary females by season, 1992 - 1994.

Females with cubs exhibited no significant difference between spring, PTA 74.2 (± 2.4) and fall, PTA 75.3 (± 2.8). The summer activity level, PTA 84.4 (± 2.3), was significantly higher (Figure 13).

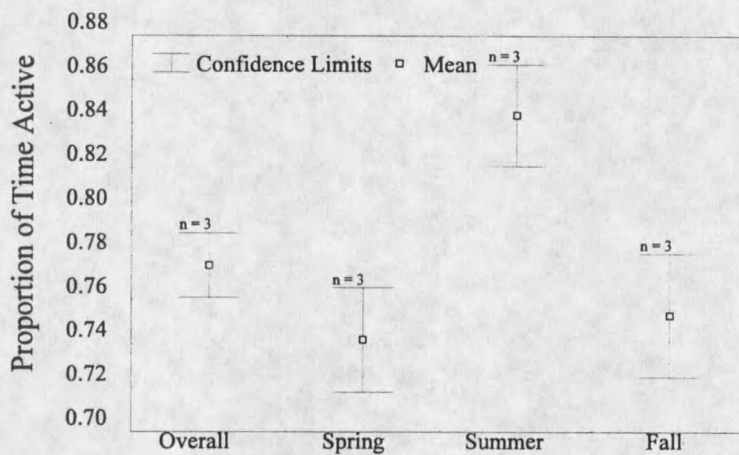


Figure 13. Proportion of time spent in an active state for females with cubs by season, 1992 - 1994.

Females with yearlings were significantly different during all 3 seasons (Figure 14). Spring had a PTA of $77.7 (\pm 6.8)$, while summer had the highest activity level, PTA $86.6 (\pm 1.9)$. Fall had the lowest activity level, PTA $65.1 (\pm 4.8)$.

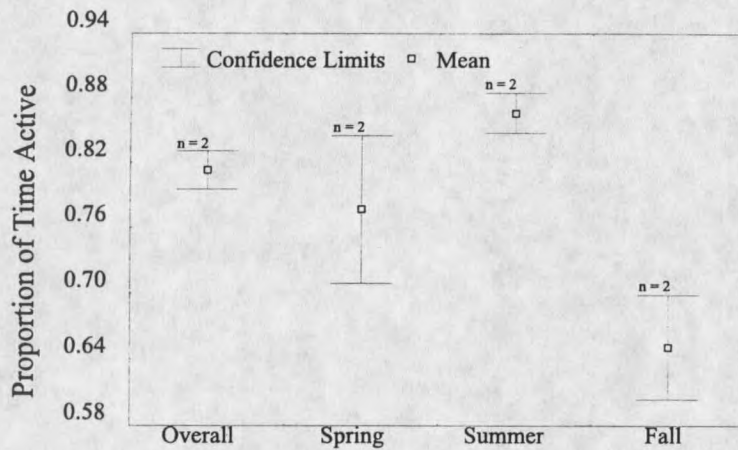


Figure 14. Proportion of time spent in an active state for females with yearlings by season, 1992 - 1994.

Sub-adult females exhibited a significantly lower PTA during the spring season, $66.1 (\pm 2.5)$. Summer and fall PTA's did not significantly differ, $75.5 (\pm 1.7)$ and $75.7 (\pm 2.4)$, respectively (Figure 15).

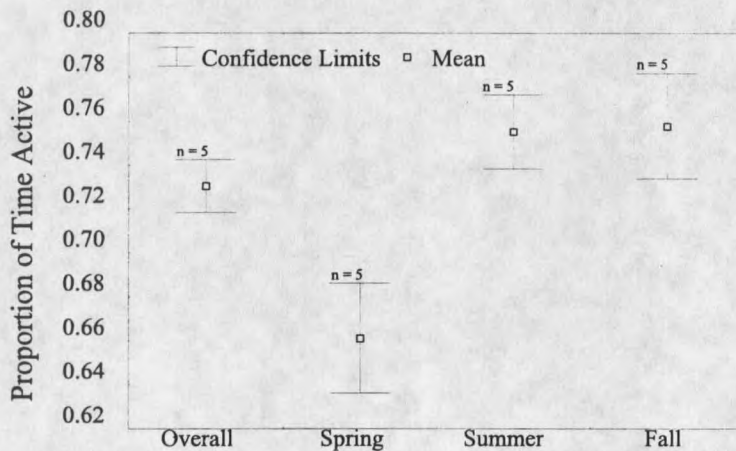


Figure 15. Proportion of time spent in an active state for sub-adult females by season, 1992 - 1994.

Spring and summer PTA's for adult males did not significantly differ, 73.5 (± 2.5) and 70.6 (± 2.5) respectively. The fall PTA however, was significantly lower, 51.3 (± 1.9) (Figure 16).

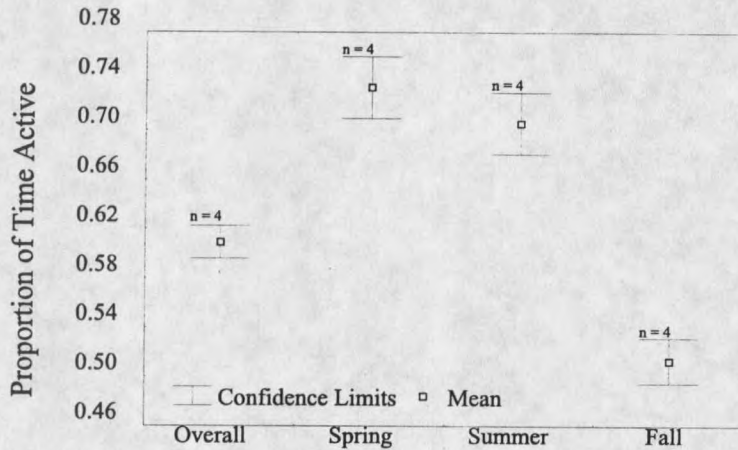


Figure 16. Proportion of time spent in an active state for adult males by season, 1992 -1994.

There were no significant differences between season for sub-adult males (Figure 17). PTA's for spring, summer and fall were 85.3 (± 3.5), 88.5 (± 3.8) and 86.0 (± 2.8) respectively.

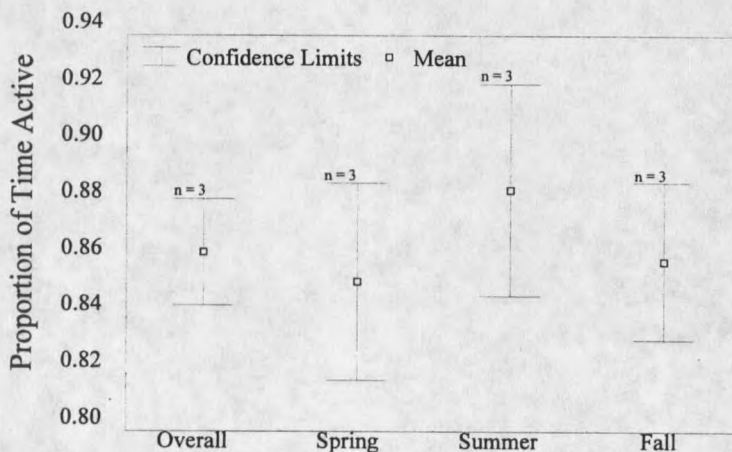


Figure 17. Proportion of time spent in an active state for sub-adult males by season, 1992 -1994.

Discussion

The amount of time spent on various activities is dependent on factors such as the animals, social system and rank, breeding strategies, body size and metabolic demands, all of which, particularly metabolic demands can vary seasonally (Herbers 1981). With bears, size and/or dominance related differences relative to food availability may help explain differences in activity budgets between age and sex classes. Potential foraging inefficiencies along with higher energetic demands may also be important to sub-adults, regardless of sex (Bunnell and Gillingham 1985).

Previous studies of grizzly bear activity budgets reported average annual levels of activity ranging from 33.3 - 77.5 percent time active. Schleyer (1983) determined that Yellowstone grizzly bears had an average annual activity level between 33.3 - 50% (8 -12 hours per day). Clevenger et al. (1990) found that an adult male brown bear in Spain was active 37% of a ten month non-denning period. Roth (1983) reported an overall activity level of 47% for European brown bears. Roth and Huber (1986) found that 2-year-old females were active 61% of the time and that 4-year-old males were significantly lower (49%). Aune and Kasworm (1989) found East Front grizzly bears were engaged in 'vigorous' activity 10 - 15 hours (41.7 - 62.5%) of a 24 hour period. Grizzly bears in Alaska were reported to have annual activity levels ranging from 64.0% (Gebhard 1982)

to 77.5% (Phillips 1987). However, Hechtel (1985) found annual activity levels as low as 40%.

McCann (1991) was the only other researcher to collect an adequate sample to report overall average annual percent time active of grizzly bears by sex and age groups. McCann (1991) reported an overall average percent time active for adult females (54.3), sub-adult females (55.1), adult males (47.3) and sub-adult males (55.3) inhabiting the upper portions of the North Fork of the Flathead River drainage. This study found that grizzly bears inhabiting the middle and lower portions of the South Fork of the Flathead River drainage had higher overall PTA, (adult females 79.0, sub-adult females 73.0, adult males 60.9, and sub-adult males 86.3), but they had similar patterns with the sub-adult males having the highest PTA and the adult males having the lowest. Reviewing mammalian activity budgets, Bunnell and Harestad (1989) found a general tendency for adult males to be less active across species.

Comparisons of activity levels by season are difficult due to differing definitions of seasons amongst studies. These difficulties stem from differing food resources and plant phenology typically used to define seasons. Nelson et al. (1983) described 4 physiological stages exhibited by bears; hibernation, walking hibernation, normal activity, and hyperphagia. These 4 stages also make cross study comparisons difficult since some studies reported these stages by month rather than by a defined season.

A synopsis of previous studies reveals that in most instances bears were

most active in the summer or berry season and least active during both the spring and fall seasons. Alt et al. (1976) found that adult male black bears increased their activity level throughout spring until mid summer at which time the level declined continuously until denning occurred. McCann (1991) found that bears were most active during the berry season (64.4%) and early summer (58.7%) and had the lowest PTA during the spring (41.0%) and fall (44.1%) seasons. Schleyer (1983) reported activity levels for Yellowstone grizzlies as low as 10 - 20% (2.4 - 4.8 hours per day) during the early spring and fall. Harting (1985) reported Yellowstone grizzly bears to have a probability of activity between 0.64 - 0.71 during the summer season and 0.52 during the fall months.

During the spring period, bears gradually increase the amount of time spent in an active state. Bears that have been out of the den for a short time may experience a post-denning lethargy period, "walking hibernation". During this period, lasting several days, bears gradually increase their activity levels until such time that the bear leaves the den site. As this lethargy period ends, bears continue to increase the amount of time they spend in an active state until they reach "normal activity".

Hyperphagia is best described as that period where an animal is on an unrelenting search for food. Bears exhibit this hyperphagic period during the summer and fall seasons when mast crops are at their height and the bears begin preparation for the upcoming denning period. This hyperphagic period is that time when bears are experiencing the greatest weight gain per unit time over the

course of a year. As den entrance approaches, bears again exhibit "walking hibernation" during a short pre-denning lethargy period as their metabolism and other systems begin to slow. This is reflected by a substantial decrease in activity levels.

As with the overall PTA, sub-adult males had the highest spring PTA, sub-adult females had the lowest. The 3 female reproductive classes showed no significant difference, although females with cubs had the lowest mean activity level. After a brief post-den lethargy period, all adult females, regardless of reproductive status, displayed a comparable level of "normal activity". Adult males were considerably more active in the spring than any other season due to the increased activity level corresponding to the onset of the breeding season.

All age, sex, and reproductive classes with the exception of adult males and sub-adult females were most active during the summer season. This high level of activity may be reflective of a hyperphagic state during the berry season. Nelson (1980) and Gebhard (1982) found bears were active 20 hours per day (83.3%) during the fall hyperphagic period. Clevenger et al. (1990) reported the bear was most active during the period between July and November (42 -48%). The lower activity of adult males might be an artifact of their ability to secure those areas of highest berry production, therefore, decreasing their need for extensive travel between food sources. Sub-adult males, the most active class, were moving extensively between berry patches, probably due to their low social standings and corresponding inability to secure quality food production sites.

In the early portion of the fall season, all classes of bears were highly active due to continued hyperphagic activity. Sub-adult females were most active during the fall, and sub-adult males continued their high level of activity. Sub-adult females, being the most social and least dominant class of bears, continue their hyperphagic activity for a longer period and perhaps in the least productive habitats. Additionally, these lesser quality habitats are those same areas that tend to put bears at the highest risk of man-caused mortality (i.e. road sides or at a greater distance to any available escape cover). As the fall season progressed the PTA level decreased as more bears prepared for the onset of the denning period. This decrease in PTA may be due in part to bears entering a pre-denning lethargy period prior to den entrance.

Activity levels of the 3 female reproductive classes did not follow an expected energetics curve of females with cubs being the most active class. Females with yearlings were more active than solitary females, but despite higher energetic costs incurred with lactation, females with cubs had the lowest overall activity levels. While it is possible that females with cubs limit activity following an energy conservation strategy, it is more likely an artifact of the cubs limited mobility.

Solitary females were most active during the summer season and least active during the fall. The fall decrease in activity I observed was due to an extended pre-denning lethargy period and early den entrance, in one case as early as 3 October. Alt et al. (1976) found solitary female black bears generally denned

before the other age and sex classes. Solitary adult female grizzly bears in the South Fork were consistently the first class to den. Two solitary adult females displayed a decreasing PTA, from 66% to 38% over a 5-day period as they neared den entrance. Percent time active dropped to zero in both bears after they had remained in the den for 24 hours..

Females with cubs of the year were most active during the summer season and least active during the spring. As spring progressed their activity level increased, peaking during the summer season. Alt et al. (1976) found females with cubs gradually increased activity through the summer, peaking in September. Activity levels in the fall were similar with that of spring, possibly due to early denning and the corresponding pre-denning lethargy period.

Females with yearlings did not differ significantly from solitary females during the spring or fall seasons. During the summer season, females with yearlings exhibited the highest activity level of the 3 reproductive classes. This may be indicative of the higher mobility and higher energetic demands of the yearlings.

Overall, data from this study indicate a seasonal trend for most age and sex classes and all reproductive classes, with the summer season having the highest level of activity and the spring and fall having the lowest. This trend is consistent with that of previous studies and the 4 physiological phases described by Nelson et al. (1983).

CHAPTER 3

DIEL ACTIVITY PATTERNS

Introduction

Geist (1971) suggested that mammals inhabiting areas of high human use avoid interactions with humans by switching their activities to those times of minimal human disturbance. Spatial avoidance of areas of human activity has been documented for several grizzly bear populations (Archibald et al. 1987, Mattson et al. 1987, and Harding and Nagy 1980), and results in the loss of potentially productive habitat and travel routes. Temporal avoidance until such times of low human disturbance makes these habitats available for exploitation by bears. Servheen (1981) suggested that darkness may provide sufficient cover for bears to utilize otherwise unavailable habitats. Previous studies of grizzly and brown bear activity have indicated an increase of nocturnal behavior in areas of elevated human use (Clevenger et al. 1990, Aune and Kasworm 1989, McLellan and Shackleton 1988b, Bjarvall and Sandegren 1987, Roth and Huber 1986, Roth 1983). While most research indicates bears are generally crepuscular and even nocturnal in their behavioral pattern, this is not the case for all populations. This chapter describes the activity patterns of differing age, sex and reproductive classes over the 24-hour diel period by season.

Analysis

Quarter hour data for like age, sex and reproductive classes were pooled by season. Mean proportional activity levels and their ($\alpha = 0.05$) confidence intervals were calculated. A best fit polynomial line (line A, Figure 18) and its confidence intervals ($\alpha = 0.05$) were then plotted. The overall seasonal PTA for the appropriate age, sex, and reproductive class was then overlaid (line B, Figure 18). The intersection of the upper confidence limit of the quarter hour and the lower confidence limit of the overall PTA (point I1, Figure 18) define the beginning of the active period. Conversely, the intersection of the upper confidence limit of the quarter hour and the lower confidence limit of the overall PTA (point I2, Figure 18) concludes the active period.

Mean sunrise and sunset times by season (Mountain Standard Time) MST were calculated using an algorithm from the United States Naval Observatory (1987) for a central point in the study area ($48^{\circ} 1' N 113^{\circ} 43' W$). Mean sunrise and sunset times defined the daylight period (line C, Figure 18) within the 24-hour diel period as depicted along the 'x' axis.

A vertical line drawn between line A and the 'x' axis (line D, Figure 18) indicates that time within the 24-hour diel period that activity began (point I3, Figure 18). A vertical line drawn between point B and the 'x' axis (line E, Figure 18) indicates the time at which activity concluded (point I4, Figure 18).

The period of time between the 2 vertical lines represents the duration of activity.

If the vertical line intersects the 'x' axis before the beginning of the daylight line, activity began prior to sunrise, conversely if the vertical line intersects the 'x' axis after the beginning of the daylight line activity began after sunrise.

If the vertical line intersects the 'x' axis before the end of the daylight line activity ceased prior to sunset, conversely, if the vertical line intersects the 'x' axis after the end of the daylight line, activity continued after sunset.

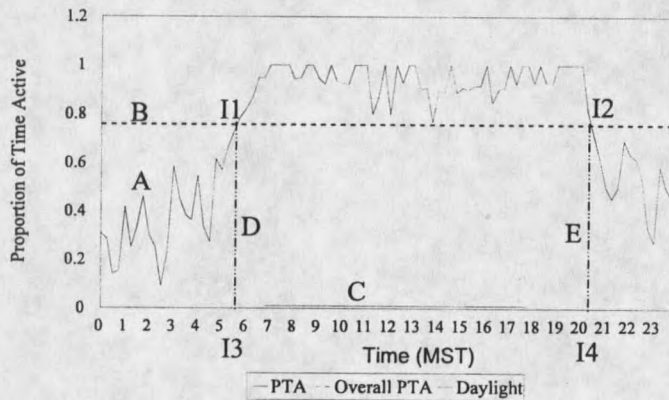


Figure 18. Example activity graph.

Kruskal-Wallis one-way analysis of variance tests were performed to determine if there were significant differences between the active period start time and sunrise as well as between the end of the active period and sunset. Additional tests were completed to determine if there were differences in the active period length both between classes and season. Significance was determined at $p < 0.01$.

Results

Overall

Overall, all age and sex classes were strongly diurnal in their activity patterns.

Adult females became active at 0515 hours (hrs) $\pm$ 15 minutes (min), with activity ending at 2145 hrs ($\pm$ 15 min), resulting in 16.5 hrs ($\pm$ 0.5) of near continuous activity (Figure

19). Sub-adult females became active at 0545 hrs ($\pm$ 15 min), with activity ending at 2100 hrs ($\pm$ 15 min), resulting in a 15.25 hrs ($\pm$ 0.5) of continuous activity (Figure 20).

Overall, adult males had weak bimodal activity patterns, with the active periods from 0545 - 1115 hrs and 1630 - 2315 hrs (Figure 21), resulting in 12.25 hrs of activity over the 24 hour diel period. Sub-adult males became active at 0515 hrs ($\pm$ 15 min), with activity ending at 1945 hrs ($\pm$ 15 min), resulting in a 14.5 hrs ($\pm$ 0.5) of near continuous activity (Figure 22).

All possible pairings, except for sub-adult females and sub-adult males, were significantly different in the length of the active period.

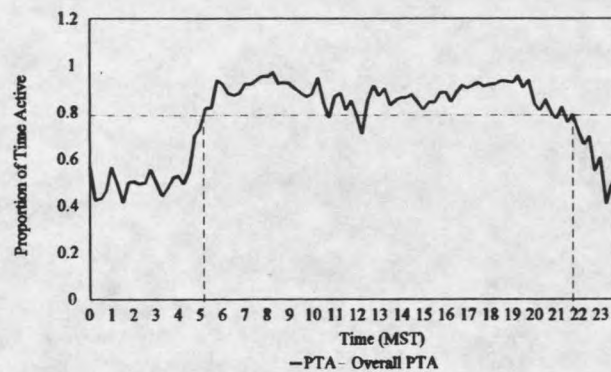


Figure 19. Overall diel activity pattern of adult females.

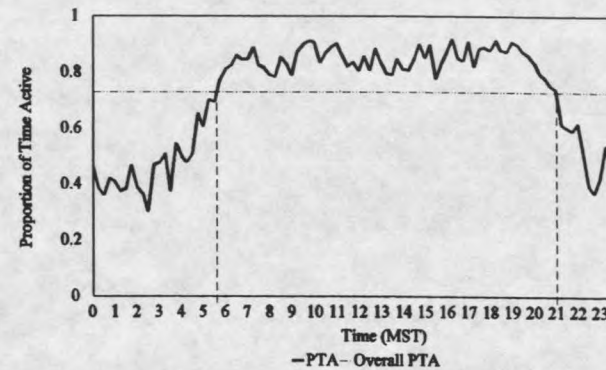


Figure 20. Overall diel activity pattern of sub-adult females.

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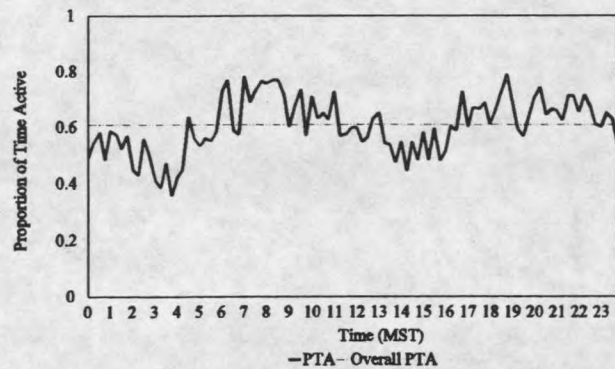


Figure 21. Overall diel activity pattern of adult males.

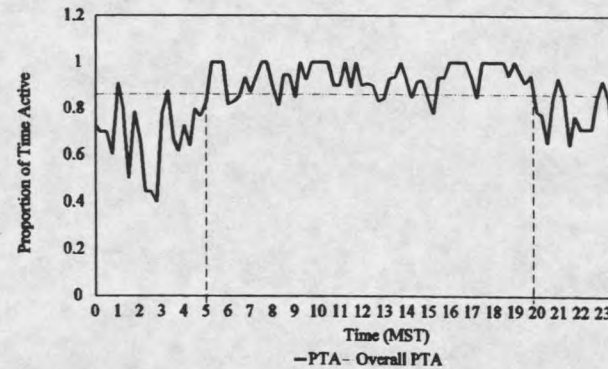


Figure 22. Overall diel activity pattern of sub-adult males.

Spring (8 May - 15 July)

During spring, the start of the active period was strongly correlated with sunrise (0445 hrs). The cessation of activity, however, does not appear to be as strongly related to sunset (2015 hrs). Adult females, when pooled, began the active period at sunrise (± 15 min) and ending at 2200 hrs (± 15 min), 1.75 hrs after sunset, resulting in 17.25 hrs (± 0.5) of activity (Figure 23). Adult females plotted by reproductive class, though differences exist, show similar patterns. Solitary females had the longest activity period (17.25 hrs, ± 0.5), with activity starting at sunrise (0445 hrs, ± 15 min) and ending 1.75 hrs after sunset (2200 hrs, ± 15 min) (Figure 24). Females with cubs had a significantly shorter active period (16 hrs ± 0.5) than the other reproductive classes, starting at 0545 hrs (± 15 min), 1 full hour after sunrise and ending at 2145 hrs (± 15 min), 1.5 hrs after sunset (Figure 25). Females with yearlings began their active period at sunrise (0500 hrs, ± 15 min) and ended 1.75 hrs after sunset (2200 hrs, ± 15 min) resulting in 17 hours (± 0.5) of continuous activity (Figure 26). Sub-adult females had the same activity patterns as females with cubs, with activity starting well after sunrise (Figure 27). Adult males exhibit weak bimodal activity patterns during the spring. The morning bout of activity was difficult to define; however, there were several peaks between 0500 and 1200 hrs. The level dropped from 1200 hrs until 1700 hrs when activity became near continuous until 2130 hrs (Figure 28). Interestingly, sub-adult males display activity patterns more similar to those of females with young than adult males. Activity for sub-adult males began at 0500 hrs (± 15 min) and ended at 2215 hrs (± 15 min), resulting in 17.25 hrs (± 0.5) of near continuous activity (Figure 29).

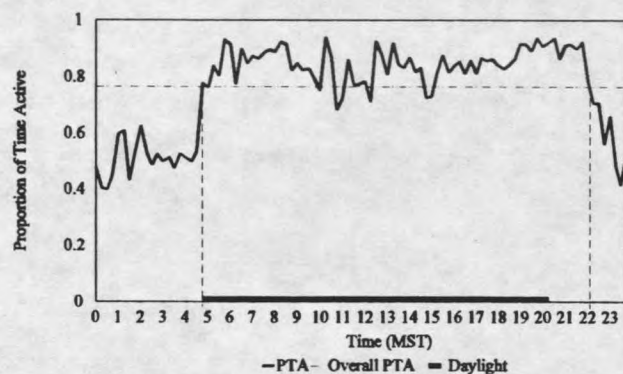


Figure 23. Diel activity pattern of adult females during the spring season (8 May - 15 July).

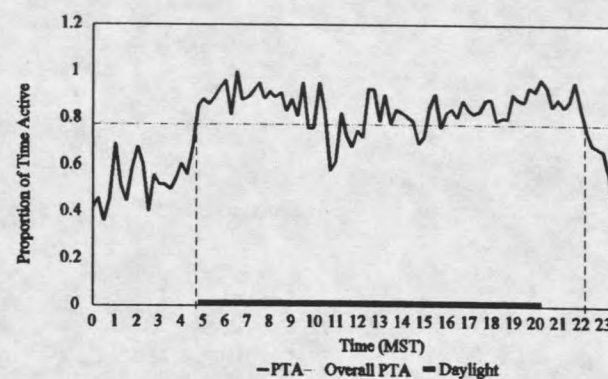


Figure 24. Diel activity pattern of solitary females during the spring season (8 May - 15 July).

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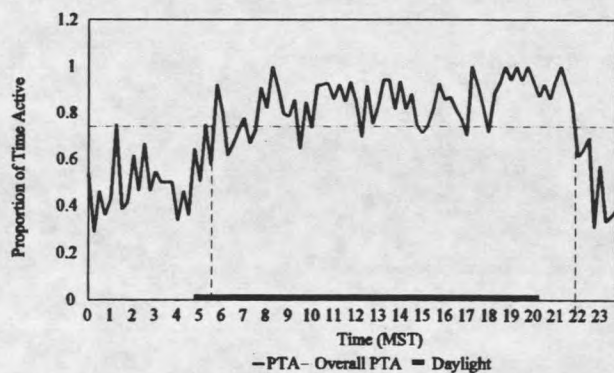


Figure 25. Diel activity pattern of females with cubs during the spring season (8 May - 15 July).

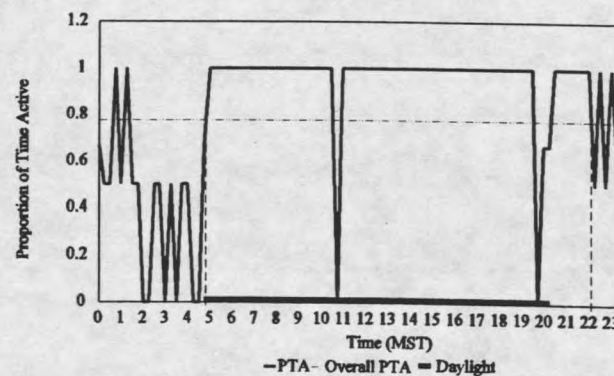


Figure 26. Diel activity pattern of females with yearlings during the spring season (8 May - 15 July).

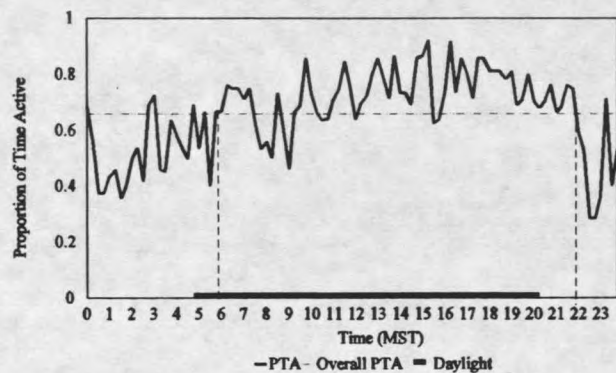


Figure 27. Diel activity pattern of sub-adult females during the spring season (8 May - 15 July).

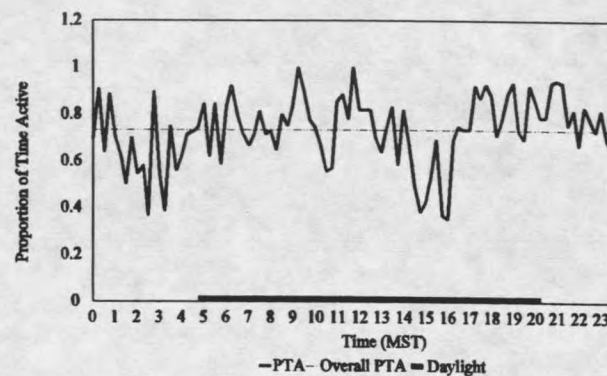


Figure 28. Diel activity pattern of adult males during the spring season (8 May - 15 July).

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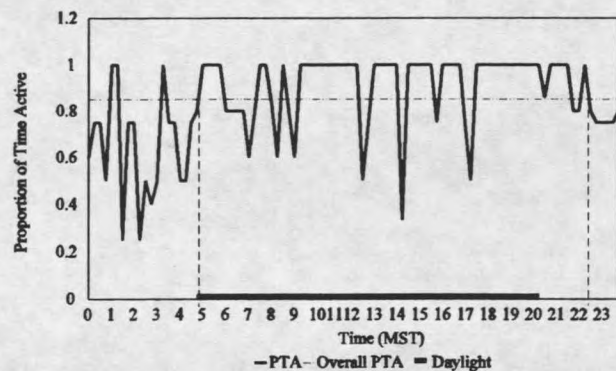


Figure 29. Diel activity pattern of sub-adult males during the spring season (8 May - 15 July).

Summer (16 July - 15 September)

During the summer the active period for all age, sex and reproductive classes began at or before sunrise (0530 hrs) and continued at least 1.25 hrs after sunset (1930 hrs). All age, sex and reproductive classes displayed periodic decreases in activity at approximately 1200 hrs. In most cases, this decrease did not last longer than 15 minutes before full activity resumed. Adult females, when pooled regardless of reproductive status, began activity just before sunrise (0515 hrs, ± 15 min) (Figure 30). Activity was near continuous for 16.25 hrs (± 0.5) until 2130 hrs (± 15 min), ending 2 hours after sunset. Solitary females had the shortest active period of the 3 reproductive classes spending 15.75 hrs (± 0.5) in an active state. The active period of solitary females began (0445 hrs, ± 15 min) and ended (2045 hrs, ± 15 min) earlier than any other class (Figure 31). During the summer the active period for females with cubs was longer than that of any other class (17 hrs, ± 1.0) (Figure 32). Additionally females with cubs had more periodic midday decreases in activity. Females with cubs became active at sunrise (0530 hrs, ± 15 min) and ended 3 hours after sunset at 2230 hrs (± 15 min). Females with yearlings became active just before sunrise (0500 hrs, ± 15 min) and ended 2 hours after sunset (2130 hrs, ± 15 min) after 16.25 hrs (± 0.5) of near continuous activity (Figure 33). There was no significant difference in activity length between the 3 reproductive classes.

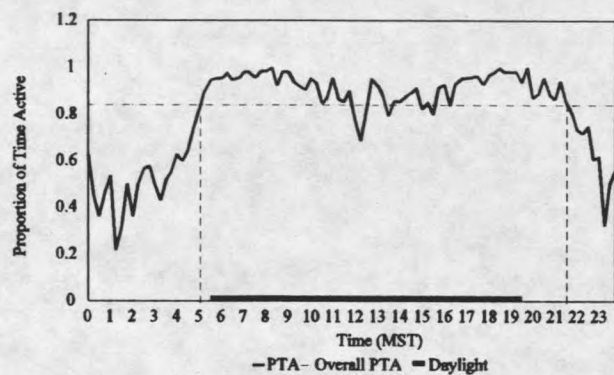


Figure 30. Diel activity pattern of adult females during the summer season (16 July - 15 September).

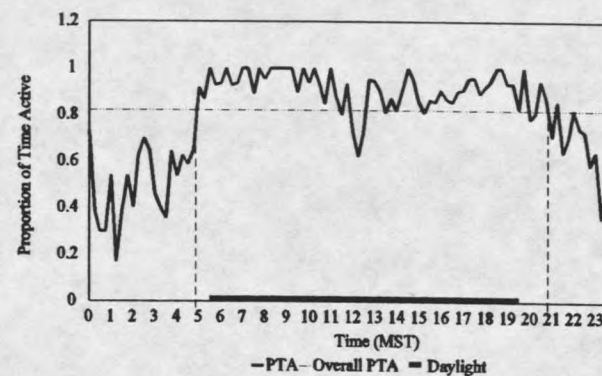


Figure 31. Diel activity pattern of solitary females during the summer season (16 July - 15 September).

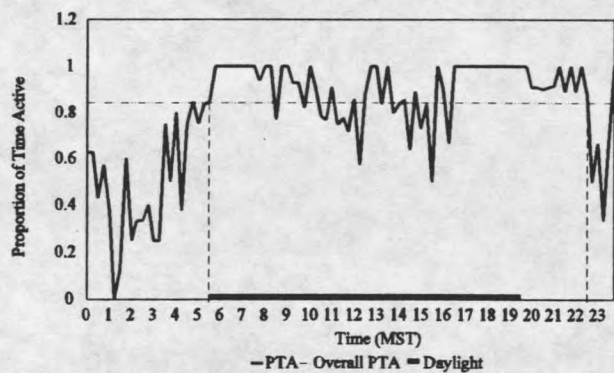


Figure 32. Diel activity pattern of females with cubs during the summer season (16 July - 15 September).

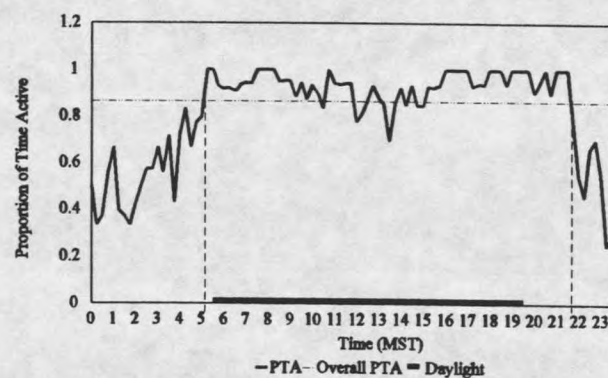


Figure 33. Diel activity pattern of females with yearlings during the summer season (16 July - 15 September).

Sub-adult females had the shortest active period of all the classes (15.5 hrs, ± 0.5). Activity began at sunrise and ended 1.5 hours (± 0.25) after sunset at 2100 hours. Adult males, had a defined active period during the summer, with activity beginning at sunrise and ending at 2200 hrs (± 15 min). There was however, a period of decreased activity midday (Figure 35). Sub-adult males were active for 16.75 hrs (± 1.0) of the 24 hour diel period. Activity began just before sunrise (0515 hrs, ± 15 min) and ended 2.5 hours after sunset at 2200 hrs (± 15 min) (Figure 36). There was no significant difference in active period length among any of the age, sex or reproductive classes.

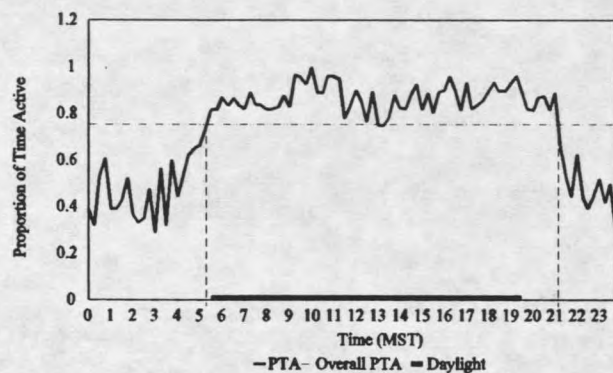


Figure 34. Diel activity pattern of sub-adult females during the summer season (16 July - 15 September).

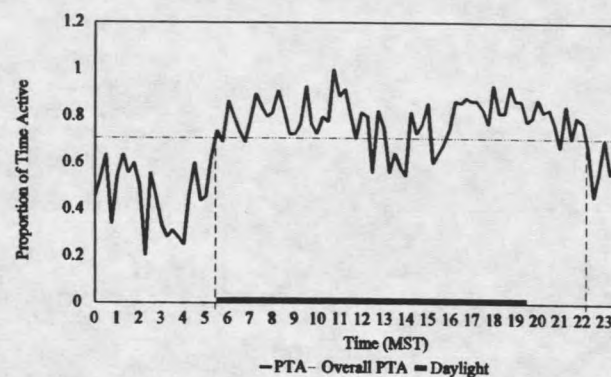


Figure 35. Diel activity pattern of adult males during the summer season (16 July - 15 September).

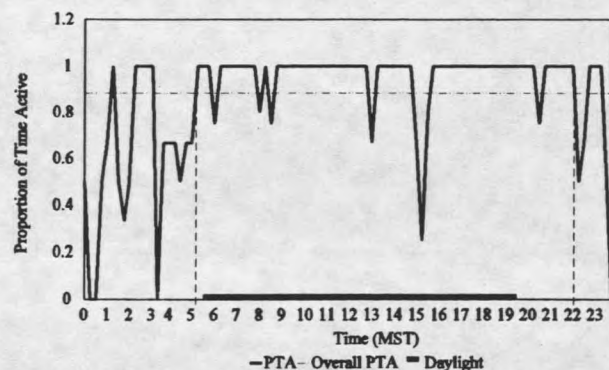


Figure 36. Diel activity pattern of sub-adult males during the summer season (16 July - 15 September).

Fall (16 September - 15 November)

During fall, there was a general decrease in the amount of time spent in an active state. The strong diurnal pattern however, continued for all age, sex and reproductive classes with the exception of adult males. In most cases activity began 1.0 - 1.5 hours before sunrise (0645 hrs) and ended 1.75 - 2.5 hours after sunset (1745 hrs). Pooled adult females became active 1 hour before sunrise at 0545 hrs (± 15 min) and had continuous activity for 14 hours (± 1.0) ending at 1945 hrs (± 15 min), 2 hours after sunset (Figure 37). During the fall, solitary females had a significantly shorter active period than all other age, sex and reproductive classes (12.0 hrs, ± 0.5). While all other classes began activity prior to sunrise, solitary females did not become active until sunrise. The active period of solitary females ended significantly earlier than that of other classes (1900 hrs, ± 15 min) (Figure 38). Females with cubs became active at 0545 hrs, 1 hour (± 15 min) before sunrise. Activity continued for 13.75 hours (± 0.5) ending at 1945 hrs (± 15 min) (Figure 39). Females with yearlings were active a total of 14.25 hrs (± 0.5) of the 24 hour diel period. Activity began at 0530 hrs and continued until 1945 hrs (Figure 40).

Sub-adult bears of both sexes had the longest active periods of the fall season (14.5 hrs, ± 1.0) (Figures 41 and 43). Sub-adult females became active 1 hour before sunrise at 0545 hrs (± 0.5) and had continuous activity until 2015 hrs (± 0.5). Sub-adult males became active at 0515 hrs, 1.5 hours before sunrise and continued activity until 1945 hrs.

As with the spring season, adult males have peaks of activity beginning at sunrise and lasting through the late morning hours, ending at approximately 1100 hrs. There was

a second period of activity beginning at sunset and continuing though sporadic until 2330 hrs (Figure 42).

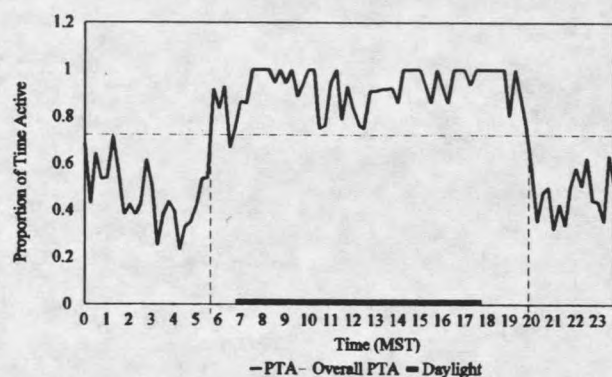


Figure 37. Diel activity pattern of adult females during the fall season (16 September - 15 November).

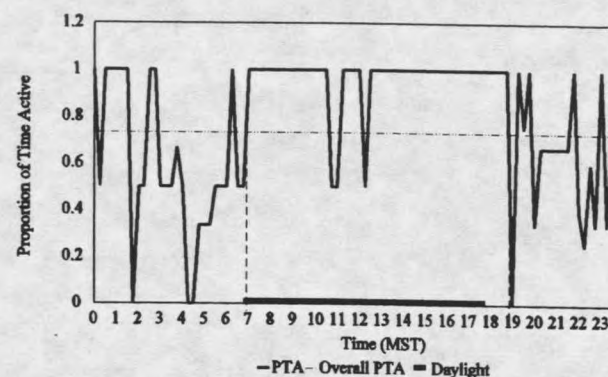


Figure 38. Diel activity pattern of solitary females during the fall season (16 September - 15 November).

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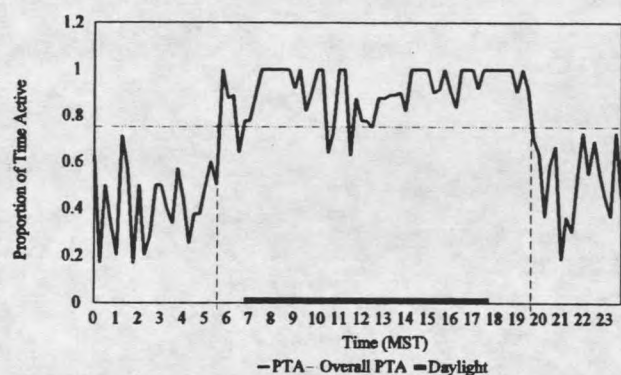


Figure 39. Diel activity pattern of females with cubs during the fall season (16 September - 15 November).

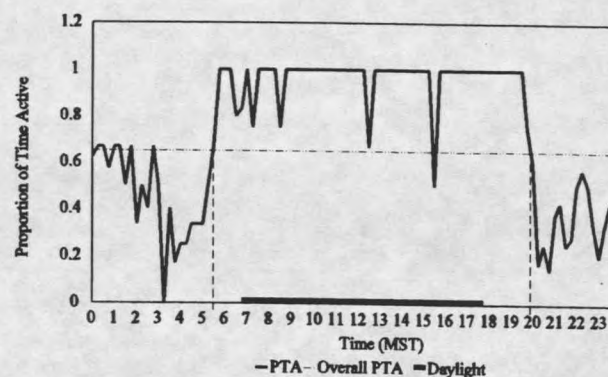


Figure 40. Diel activity pattern of females with yearlings during the fall season (16 September - 15 November).

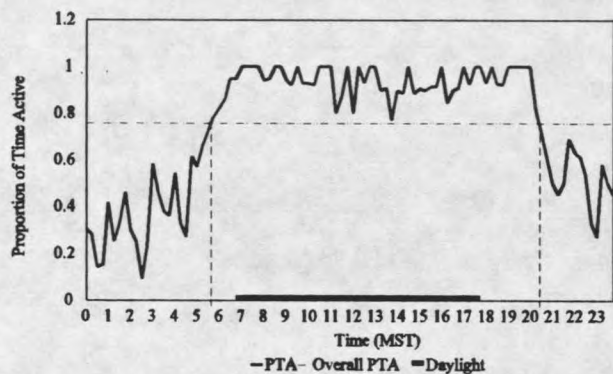


Figure 41. Diel activity pattern of sub-adult females during the fall season (16 September - 15 November).

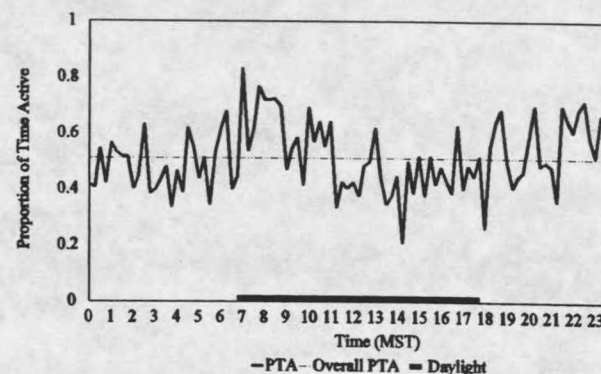


Figure 42. Diel activity pattern of adult males during the fall season (16 September - 15 November).

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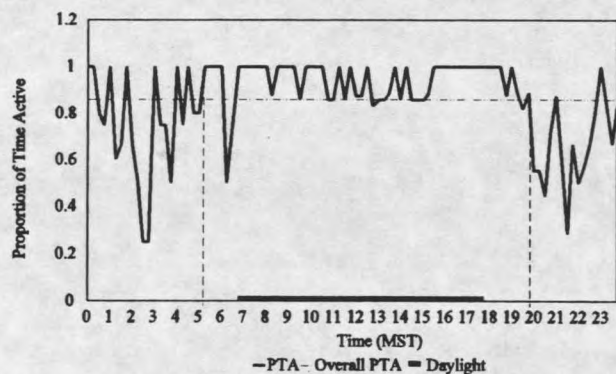


Figure 43. Diel activity pattern of sub-adult males during the fall season (16 September - 15 November).

Discussion

Research publications on grizzly bear activity patterns generally describe bears as crepuscular and in some cases nocturnal (Clevenger et al. 1990, Gunther 1990, Aune and Kasworm 1989, Phillips 1987, Roth and Huber 1987, Roth and Huber 1986, Aune and Stivers 1985, Harting 1985, Roth 1983, Schleyer 1983). However, where data were available, these studies found very different seasonal patterns. Harting (1985) and Schleyer (1983) found that Yellowstone bears were more diurnal in the spring and fall than during the summer. Conversely, Sizemore (1980) found bears in the Flathead to be more nocturnal during the spring and summer seasons. Clevenger et al. (1990) and Roth and Huber (1986) found brown bears were more diurnal in the fall and winter seasons.

Interestingly, those studies that describe bears as primarily crepuscular and nocturnal were those that used a time sampling approach to obtain the activity data. Both this study and McCann (1991) using continuous monitoring to obtain activity data found bears to be diurnal, overall and across seasons. While McCann did find some bears to exhibit crepuscular peaks, this study found bears to be highly diurnal.

While crepuscular is best defined as active at and around sunrise and sunset, there is no defined time period surrounding either solar event. Those studies (McCann 1991, Aune and Kasworm 1989, Harting 1985, Roth 1983, Schleyer 1983) that did find bears that exhibited diurnal patterns, either individually or collectively, may be best described as having bimodal patterns. These bimodal increases in activity generally occurred after

sunrise and prior to sunset, with extended periods of lower activity through the day.

In the South Fork, all age, sex, and reproductive classes with the exception of adult males during the spring and fall seasons displayed very strict diurnal rhythms. Overall, adult females, sub-adult females and sub-adult males began activity at 0530 hrs and continued until 2045 hrs, resulting in 15.5 hrs of diurnal activity. Although adult males show little if any discernable pattern during the spring and fall seasons, there is a tendency to describe the data as weakly bimodal during the diurnal period.

During the spring season, the start of the active period was strongly correlated with sunrise, with the exception of females with cubs, sub-adult females and adult males, all classes became active at sunrise (0445 hrs). Females with cubs and sub-adult females became active 1 hour after sunrise (0545 hrs). The active period for all age, sex and reproductive classes ranged between 16.0 - 17.25 hrs of near continuous activity. For all classes of bears, the active period ended between 2145 - 2215 hrs, 1.5 - 2.0 hours after sunset.

During the summer all age, sex and reproductive classes except for females with cubs began the active period at approximately 0515 hrs, 0.25 - 0.5 hrs prior to sunrise. Females with cubs became active at sunrise (0530 hrs). The active period lasted between 15.5 - 17.0 hours for all age, sex and reproductive classes. Although all classes displayed a slight decrease in activity at approximately 1300 hrs, this decrease was not long enough in duration (generally <30 min) to describe the pattern as bimodal. The active period ended at 2130 hrs, 2 hours after sunset (1930 hrs) in most instances, females with cubs however, continued activity for 3 hours after sunset ending activity at 2230 hrs.

Females with cubs may have the longest post sunset activity period due to their longer (2 hrs) period of inactivity midday. This longer midday rest period may be required due to the lesser stamina of the cubs. The summer season was the only time adult males displayed true diurnal activity patterns. This may be a function of the increased forage efficiency associated with daylight conditions in response to hyperphagic activity.

During the fall season, all classes except solitary females, began activity 1.0 - 1.5 hours (0515 - 0545 hrs) prior to sunrise (0645 hrs). Solitary females began activity 0.25 hrs after sunrise. Activity ceased for all classes between 1945 - 2015 hrs, 2.0 - 2.25 hours after sunset. This resulted in near continuous activity for 12.75 - 14.5 hrs.

Although all classes extended activity beyond sunset during each of the 3 seasons, this is best described as a continuation of diurnal behavior, rather than nocturnal activity. Activity was initiated during the daylight period and was simply extended. The only activity that was truly nocturnal (i.e. initiated during the night), occurred during the fall. Solitary females did display some nocturnal activity, which may be in response to their shorter diurnal activity period (12.5 hrs). This nocturnal activity occurred during the early morning hours (0030 - 0130) and was of short duration.

Adult males, however, did have extended periods of activity beginning shortly after sunset. Though short in duration (approximately 30 min) at first, there was an extended period (2.5 hrs) beginning at 2115 hrs. This nocturnal behavior may be a response to the physiological changes from the hyperphagic activity of the summer season. Adult males have the greatest fall weight gain of all age and sex classes.

Switching to nocturnal behavior may be the best method to avoid excessive body heat build up, associated with heavy body fat. Interestingly, adult males do have diurnal activity during the fall; however, this ceased at 1100 hrs, when temperatures began to approach midday highs.

Many authors (Aune and Stivers 1985, Bjarvall and Sandegren 1987, Roth and Huber 1986, Roth 1983) report that bears are more active during the daylight hours in areas with lower human disturbance. In the South Fork, human intrusions are generally limited to roaded environments. Even in these areas, human activity tends to be highly localized to the immediate area surrounding the road. Only during the fall hunting season was there extensive travel away from the roads, but there were no overt changes in activity patterns during this time. The Jewel Basin Hiking Area was the only area that received extensive use during the late spring and summer, and only 1 (#96) of the 6 focal adult females had portions of the Jewel Basin encompassed within their home range. Number 96 did not display any change in her activity pattern during any season when she was within the Jewel Basin.

It has been suggested that a shift to a nocturnal activity pattern may be a behavioral adaptation to reduce stress associated with human activities. Although humans are the chief cause of mortality, behavioral information indicates that the grizzly bear population inhabiting the South Fork may not be experiencing the same levels of stress from human intrusion as other populations.

CHAPTER 4

ACTIVITY BOUT LENGTHS

Introduction

Daylength or the time period available for activity is an important resource for diurnal animals (Herbers 1981). An animal's energetic status is determined by its time-energy budget (McCann 1991). Procurement of energy and energy expenditure are the central elements of time-energy budgets (Herbers 1981). The amount of time spent foraging, energy procurement, is dependant on individual specific factors, i.e. age, sex, reproductive status and weight. These factors also determine an individual's energetic requirements (energy expenditure), additionally these factors determine an individuals ability to acquire energy through both social dominance and foraging experience. Foraging bout length is also related to an individual's ingestion and digestion rates and gut size (Bunnell and Gillingham 1985).

While other activities (travel, breeding, etc.) occur while an animal is active, most of an animal's active period is spent foraging. Conversely, most of an animal's inactive period is spent resting and digesting. The amount of time spent in each phase is influenced by the animal's gut size and rate of passage. Within a species gut size and rate of passage are related to an individual's size. One significance of being larger is that the total energy cost per unit weight decreases with increasing body weight (Kleiber 1975).

One consequence of this relationship is that smaller individuals must have higher rates of passage (Demment 1983) or have the ability to secure higher quality foods.

Dominance and the ability to secure the highest quality foods are a function of age, sex, and size. With grizzly bears, males are larger than females, and adults are larger than sub-adults. Overall, adult males are the largest and sub-adult females typically the smallest. Adult males have the greatest ability to secure the highest quality foods, yet have the lowest energy costs per unit weight. Adult females also have relatively low costs per unit weight, provided they are not incurring the additional costs associated with gestation or lactation (Lloyd et al. 1978). Sub-adults of both sexes have the highest cost per unit weight due to higher growth requirements (Lloyd et al. 1978). Sub-adults may also have the lowest forage efficiency due to inexperience (Bunnell and Gillingham 1985) and smaller bite size.

When using broad classifications based on age and sex and therefore size, the significance of being smaller should be expressed by the need for more, not longer, foraging bouts. Larger bears that are experiencing higher costs, are able to reduce the need for more foraging bouts simply as a function of larger gut capacity. The length and sequence of alternating active and inactive bouts are a function of the rate at which an animal fills and empties its gut.

This chapter describes the interspersions and lengths of active and inactive bouts during the diurnal and nocturnal periods by age, sex, reproductive status and season.

Analysis

Data from individual bears was investigated for continuous blocks of like activity.

A continuous block of activity was described as having a period of 2 or more quarter hours of the same activity value (0 = inactive, 1 = active) before ending when the activity category changed. Bout lengths were pooled for like activity category by age, sex, reproductive class, season and time period (diurnal, nocturnal). Mean bout lengths and their confidence limits ($\alpha = 0.05$) were calculated. Kruskal-Wallis one-way analysis of variance tests were completed to determine if significant differences existed between bout lengths of the same activity category by bear classification, season and time periods.

Significance was determined at $p < 0.01$.

Results

Spring (8 May - 15 July)

During diurnal periods in spring, there were no significant differences between bout lengths of activity for any of the age, sex and reproductive classes (Figure 44). Duration of bouts ranged from 62 - 93 minutes. Sub-adult males had the longest bout lengths, while adult males had the shortest. Periods between active bouts, had a duration of 23 - 42 minutes. There was a significant difference between inactive period lengths of sub-adult females and all classes of adult bears (Figure 45). Sub-adult females had the longest inactive periods (42 min). Excluding sub-adult females, the range of the remaining classes was only 7 minutes (23 - 30 min).

During the spring nocturnal period, there were no significant differences between either the active or inactive bout lengths (Figures 46 and 47). Bears were inactive for 32 - 36 minutes before any activity occurred. Nocturnal activity bout lengths were 33 - 58 minutes in duration and usually occurred during the early portion of the nocturnal period. This reflects the continuation of the diurnal activity patterns described in Chapter 3. Once this continuation of diurnal activity ended, inactive bout length duration increased to a minimum of 147 minutes for the remainder of the nocturnal period.

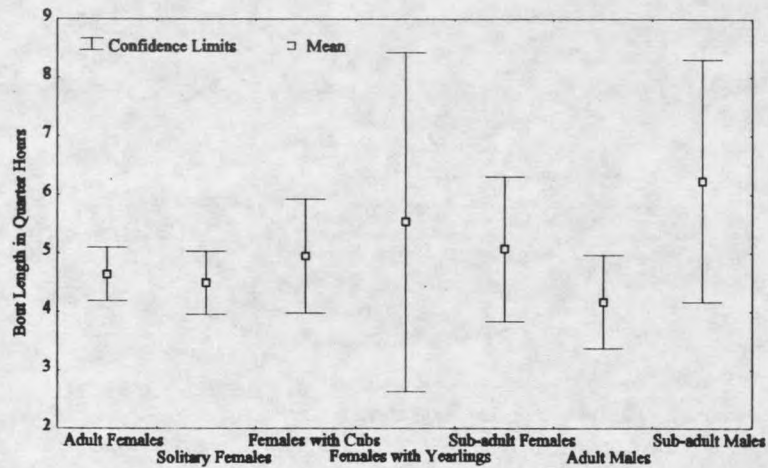


Figure 44. Active bout lengths during the spring (8 May - 15 July) season diurnal period.

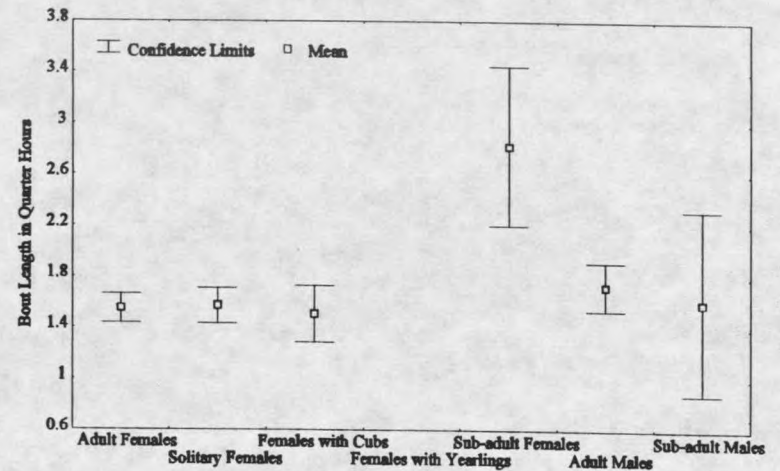


Figure 45. Inactive bout lengths during the spring (8 May - 15 July) season diurnal period.

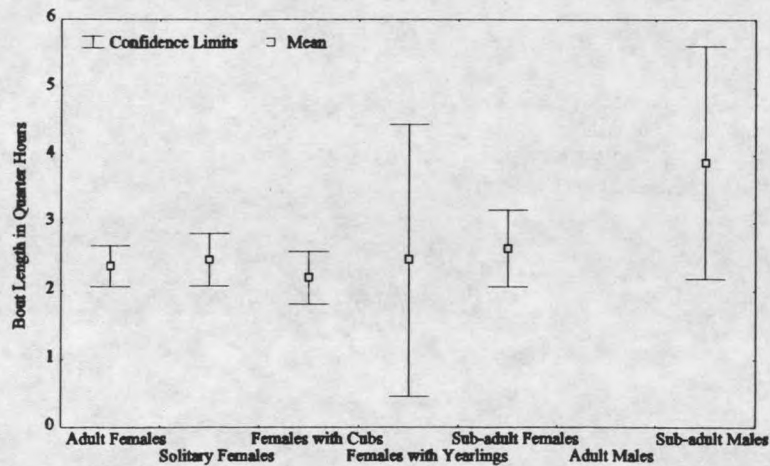


Figure 46. Active bout length during the spring (8 May - 15 July) season nocturnal period.

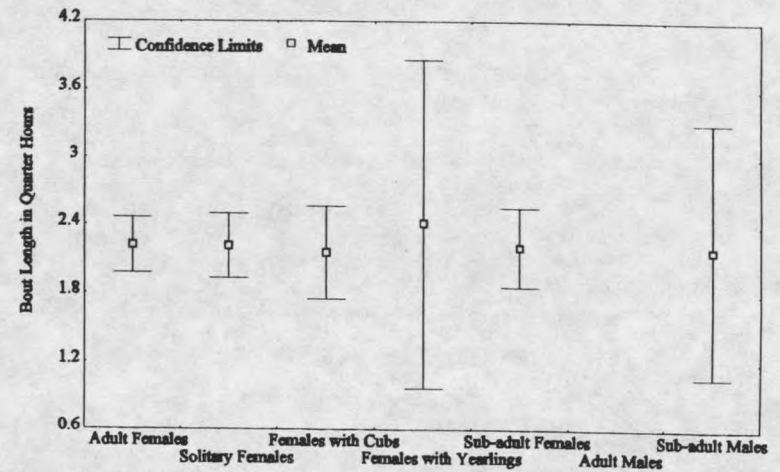


Figure 47. Inactive bout lengths during the spring (8 May - 15 July) season nocturnal period.

Summer (16 July - 15 September)

During the summer season diurnal period, sub-adult females and adult males had significantly shorter active bout lengths than did pooled adult females. Although not significantly different from the remaining classes, adult males and sub-adult of both sexes did have the shortest bout lengths (Figure 48). Active bout lengths ranged from 55 - 80 minutes in duration. The duration of the inactive periods during the diurnal period ranged from 19 - 26 minutes and were not significantly different by age, sex or reproductive class. Adult males, however, did have the longest inactive period (Figure 49).

During the summer nocturnal period, there were no significant differences in the bout lengths of either activity or inactivity. Sub-adult males displayed the longest active bout length (56 min), while for all other classes active bout length was between 33 - 38 minutes (Figure 50). The inactive bout length during the early nocturnal period ranged between 27 - 37 minutes for all age, sex and reproductive classes (Figure 51). However, after the continuation of the diurnal activity patterns ended, bout length increased to 123 minutes of continuous inactivity for the remainder of the nocturnal period.

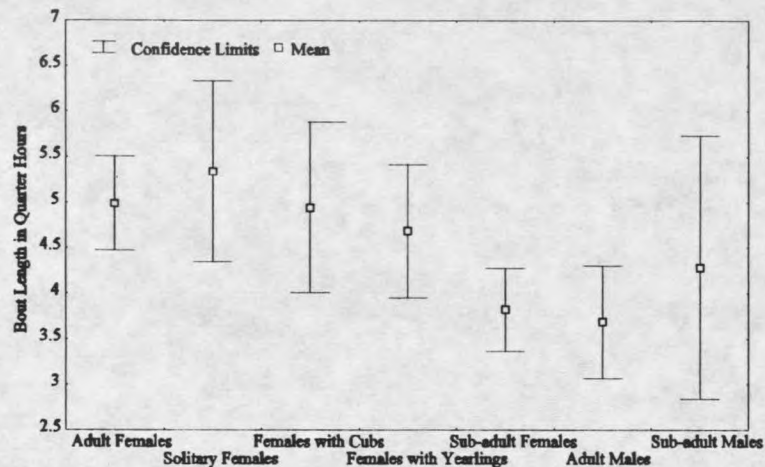


Figure 48. Active bout lengths during the summer (16 July - 15 September) season diurnal period.

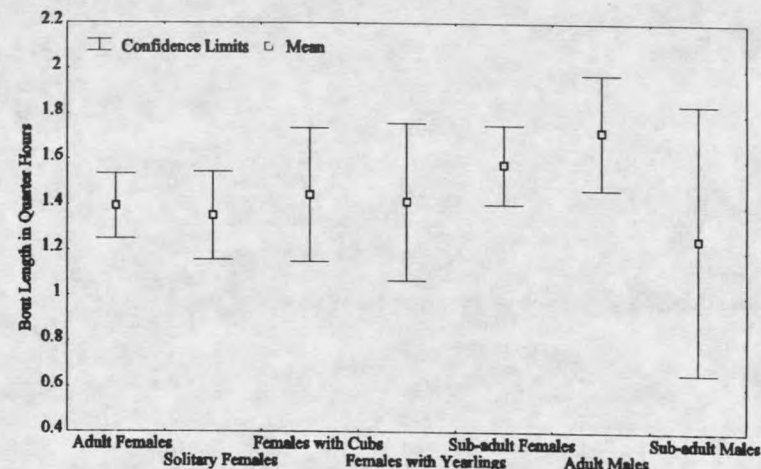


Figure 49. Inactive bout lengths during the summer (16 July - 15 September) season diurnal period.

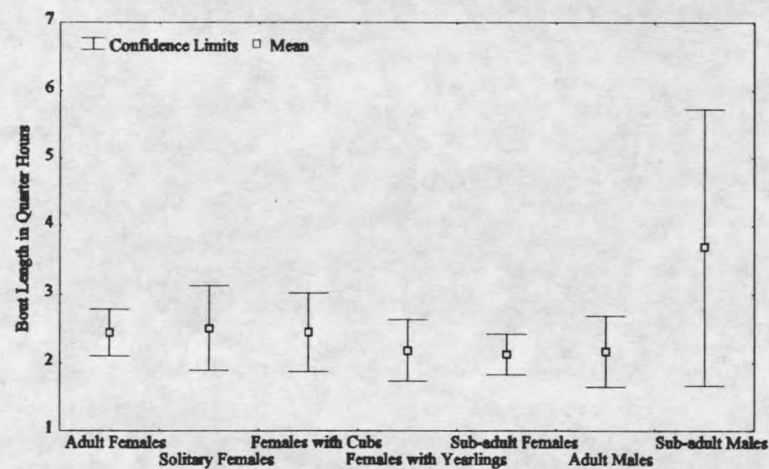


Figure 50. Active bout lengths during the summer (16 July - 15 September) season nocturnal period.

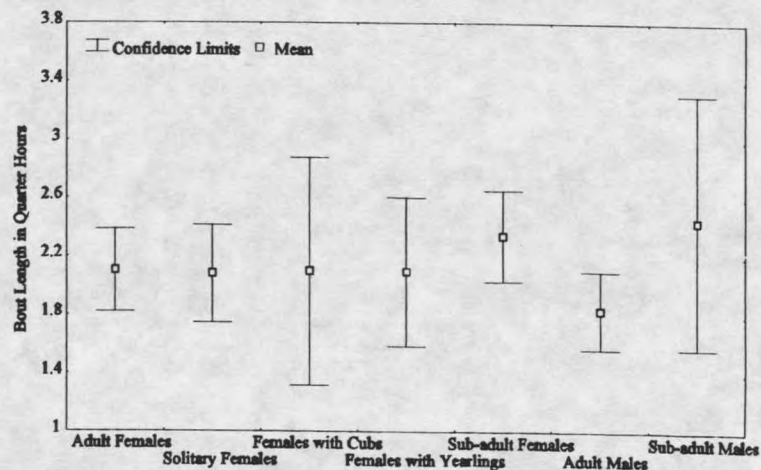


Figure 51. Inactive bout lengths during the summer (16 July - 15 September) season nocturnal period.

Fall (16 September - 15 November)

During the fall, diurnal period active bouts ranged from 28 - 118 minutes in duration. The active bout length of adult males was significantly shorter (28 min) than most other classes (Figure 52). All other classes ranged between 66 - 118 minutes. Inactive bout lengths were the inverse of active lengths with adult males having significantly longer (28 min) bouts of inactivity than most other classes (19 - 23 min) (Figure 53).

The active bout lengths during the nocturnal period were not significantly different and ranged between 31 - 52 minutes in duration (Figure 54). The inactive bout length during the early nocturnal period ranged between 26 - 58 minutes for all age, sex and reproductive classes. There were significant differences between sub-adult males and both sub-adult females and females with young (Figure 55). Females with young had the longest inactive periods (58 min) while sub-adult males had the shortest (26 min). However, after the continuation of the diurnal activity patterns ended, all classes had a minimum of 184 minutes of continuous inactivity for the remainder of the nocturnal period.

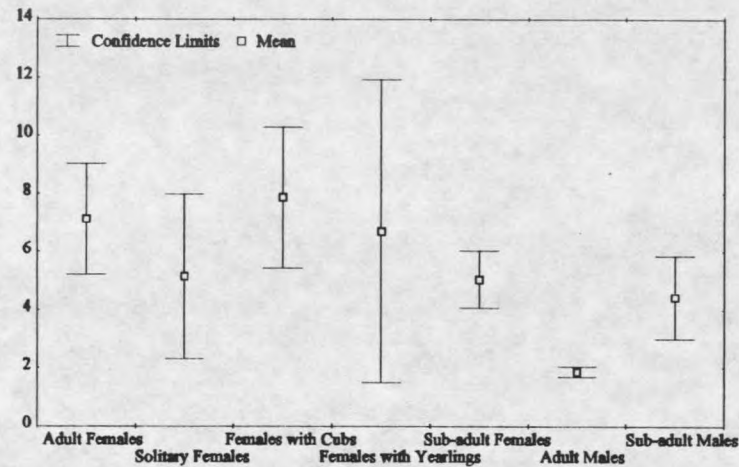


Figure 52. Active bout lengths during the fall (16 September - 15 November) season diurnal period.

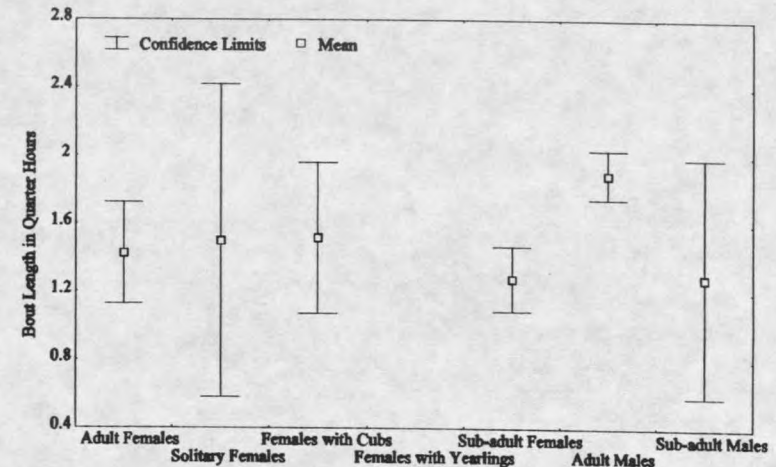


Figure 53. Inactive bout lengths during the fall (16 September - 15 November) season diurnal period.

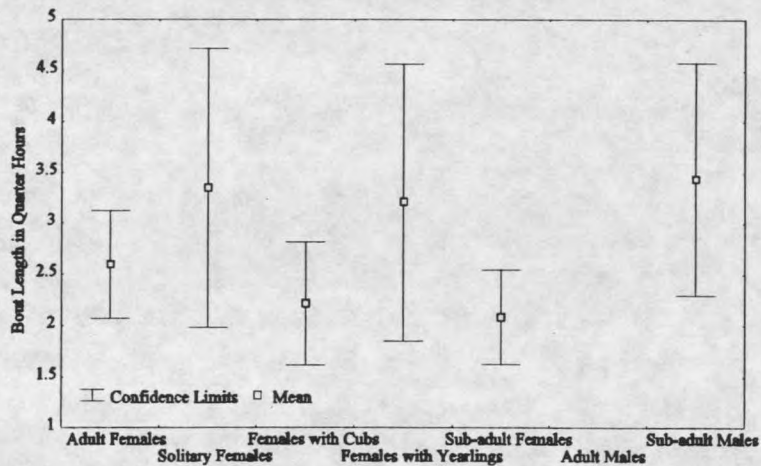


Figure 54. Active bout lengths during the fall (16 September - 15 November) season nocturnal period.

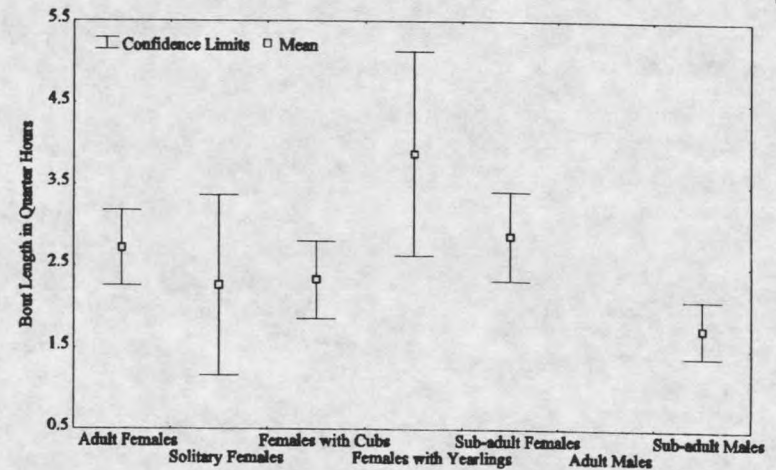


Figure 55. Inactive bout lengths during the fall (16 September - 15 November) season nocturnal period.

Discussion

Animals of the same species but of differing age, sex, reproductive status, and dominance classifications are faced with differing environmental and physiological constraints. It is hypothesized that dominant animals are able to decrease the amount of time spent foraging and increase the amount of time spent in other activities (i.e. breeding) simply through their ability to claim quality food sites. Subordinate animals must make up for their inability to secure or retain quality food sites by extending foraging periods in lower quality areas. Analyzing bout length data may indicate how animals in different classes respond to these constraints, overall and by season.

McCann (1991) found that by season, bears had shorter active bout lengths during the summer and increasing lengths during the fall. Inactive bouts showed the opposite trend with fall having shorter bouts and spring having longer bouts of inactivity. McCann (1991) found this to be particularly true of adult bears.

Grizzly bears that inhabit the South Fork follow similar bout length patterns. On average, diurnal activity bout lengths were longest during the fall season (82 min) and shortest during the summer season (68 min). This pattern held true for the nocturnal inactivity bout lengths, with the summer season having the shortest (123 min) and the fall season the longest (184 min). The diurnal inactive bout lengths, however, displayed a different pattern. Fall and summer inactive bouts were equal in length (21 min) but the spring season had longest periods of inactivity (28 min).

Along with forage efficiency levels, body size and the corresponding gut capacity, differing food types also influence the length of active and inactive bouts. Phillips (1987) and Schleyer (1983) found that bears feeding on carcasses had longer bouts of inactivity than bears utilizing other food types.

The summer season represents a period of high quality foods (globe huckleberries) that are passed through the gut relatively quickly. This faster passage time allows bears to have shorter inactive periods (digestion time) before feeding resumes. Highly productive berry patches permit a rapid filling of the gut. The importance of maximizing intake opportunities was best displayed by adult males. Adult males had the shortest active bout lengths during the summer season, perhaps due to their ability to secure those sites with the highest food production. Adult males also had the longest inactive bout lengths, possibly due to the time needed for their gut to digest the larger quantity of berries due to their higher gut capacity. Sub-adults of both sexes had the second shortest active bout lengths during the berry season; this, however, may be a function of a decrease in the time needed to fill their smaller gut, even when foraging in lower quality sites. Sub-adult males had the shortest inactive bout lengths, perhaps due to a decrease in the time needed to digest smaller quantities. The cost of these shorter bouts is reflected in them having the highest percent time active, resulting in a higher total number and more frequent feeding and resting bouts.

During the fall season, bears had longer diurnal active bout lengths and shorter inactive bout lengths than during the other 2 seasons. This may be due to bears attempting to maximize foraging activity during the shorter daylight period.

Additionally, bears had much longer nocturnal bouts of inactivity than during any other season. This may be indicative of bears beginning preparation for the upcoming denning season.

CHAPTER 5

MANAGEMENT IMPLICATIONS

Previous studies have demonstrated that human activities can dramatically impact grizzly bear populations. Direct impacts tend to be immediate and extreme, often resulting in mortality. Indirect impacts, though difficult to measure and quantify, tend to have the greatest long term effects. Monitoring a population's demographics may help define these long term effects and allow for some mitigation. Additionally, alterations of activity budgets and patterns may be an early indicator that the population is experiencing some form of human disturbance related stress.

If adequate habitat is available without having to utilize areas of high human use, bears are not likely to expose themselves to the risks associated with these areas, and spatially avoid high human use areas rather than altering their behavioral patterns. If disturbed habitats are limiting in some fashion, animals will attempt to alter their activity patterns to allow for these areas to be utilized.

Objective 4 of this study was to determine if differences existed between activity budgets and patterns of six focal adult female grizzly bears when using roaded and unroaded habitats. I was unable to measure a response in activity because focal bears spatially avoided areas with high road densities. Although some bears did utilize these roaded environments, use was of short duration. Use of these areas was never long

enough to document any shift in behavioral patterns that would have allowed for extended use of these areas, i.e. a shift to a more nocturnal rhythm. This may indicate that there is adequate habitat available for the existing population level under current cover conditions and rate of human intrusion.

Although human-caused mortality is the greatest form of mortality for the grizzly bear population inhabiting the South Fork, these bears do not demonstrate the same behavioral patterns as those populations inhabiting other areas. This may indicate that although these bears are experiencing the pressures of human disturbance, it is not currently at a level great enough to force them to switch their activity patterns to avoid periods of high human use. However, if human use continues to increase and road building and the subsequent resource extraction alter ever increasing expanses of the habitat, a change in activity patterns to a nocturnal rhythm might occur. Once this change has occurred, additional human use and habitat modification may make these areas of little or no use. At some threshold level, even altering behavioral patterns will not allow for the population to maintain its current level and the population will begin to decline, possibly to the point of non-recovery.

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APPENDICES

APPENDIX A

AN EXAMPLE OF RAW ACTIVITY DATA (1 HOUR)

Table 4. An example of raw activity data (1 hour).

Event_Log Data from Receiver #0					
LotekDate	Time	Frequency	Rate	Strength	Antenna
34485	"12:00:20"	164.185	63	82	"M0"
34485	"12:00:26"	164.185	63	92	1
34485	"12:00:31"	164.185	63	92	2
34485	"12:00:37"	164.185	63	102	3
34485	"12:00:43"	164.185	63	99	4
34485	"12:00:49"	164.185	63	100	5
34485	"12:00:54"	164.185	63	94	6
34485	"12:01:00"	164.185	63	130	7
34485	"12:01:06"	164.185	63	131	7
34485	"12:02:30"	164.185	63	80	"M0"
34485	"12:02:38"	164.185	48	59	1
34485	"12:02:44"	164.185	63	55	2
34485	"12:02:50"	164.185	63	93	3
34485	"12:02:55"	164.185	63	86	4
34485	"12:03:01"	164.185	63	77	5
34485	"12:03:07"	164.185	63	79	6
34485	"12:03:13"	164.185	63	87	7
34485	"12:03:18"	164.185	63	91	7
34485	"12:04:38"	164.185	76	71	"M0"
34485	"12:04:43"	164.185	63	78	1
34485	"12:04:49"	164.185	63	66	2
34485	"12:04:56"	164.185	52	61	3
34485	"12:05:02"	164.185	63	65	4
34485	"12:05:07"	164.185	63	70	5
34485	"12:05:13"	164.185	63	68	6
34485	"12:05:19"	164.185	63	85	7
34485	"12:05:25"	164.185	63	74	7
34485	"12:06:44"	164.185	92	136	"M0"
34485	"12:06:49"	164.185	70	140	1
34485	"12:06:54"	164.185	94	128	2
34485	"12:06:59"	164.185	67	149	3
34485	"12:07:05"	164.185	63	147	4
34485	"12:07:11"	164.185	63	155	5
34485	"12:07:16"	164.185	78	93	6
34485	"12:07:23"	164.185	66	65	7
34485	"12:07:29"	164.185	57	90	7
34485	"12:08:57"	164.185	93	88	"M0"

Table 4. Continued.

34485	"12:09:33"	164.185	71	90	5
34485	"12:09:37"	164.185	89	85	6
34485	"12:09:43"	164.185	56	88	7
34485	"12:09:48"	164.185	76	127	7
34485	"12:11:07"	164.185	89	61	"M0"
34485	"12:11:12"	164.185	63	115	1
34485	"12:11:17"	164.185	73	130	2
34485	"12:11:21"	164.185	89	145	3
34485	"12:11:26"	164.185	71	141	4
34485	"12:11:31"	164.185	82	147	5
34485	"12:11:35"	164.185	82	148	6
34485	"12:11:40"	164.185	72	130	7
34485	"12:11:45"	164.185	87	119	7
34485	"12:13:05"	164.185	94	110	"M0"
34485	"12:13:10"	164.185	63	131	1
34485	"12:13:16"	164.185	64	124	2
34485	"12:13:26"	164.185	78	81	4
34485	"12:13:38"	164.185	59	100	5
34485	"12:13:42"	164.185	88	83	6
34485	"12:13:47"	164.185	78	92	7
34485	"12:13:51"	164.185	94	73	7
34485	"12:14:26"	164.525	62	117	"M0"
34485	"12:14:32"	164.525	62	129	1
34485	"12:14:37"	164.525	62	118	2
34485	"12:14:43"	164.525	62	120	3
34485	"12:14:49"	164.525	62	115	4
34485	"12:14:55"	164.525	62	118	5
34485	"12:15:02"	164.525	52	119	6
34485	"12:15:07"	164.525	62	119	7
34485	"12:15:13"	164.525	62	117	7
34485	"12:15:57"	164.185	94	83	"M0"
34485	"12:16:03"	164.185	59	72	1
34485	"12:16:22"	164.185	47	62	4
34485	"12:16:28"	164.185	93	90	5
34485	"12:16:32"	164.185	78	79	6
34485	"12:16:36"	164.185	94	89	7
34485	"12:16:41"	164.185	64	107	7
34485	"12:17:16"	164.525	62	120	"M0"
34485	"12:17:22"	164.525	62	124	1
34485	"12:17:28"	164.525	62	125	2

Table 4. Continued.

34485	"12:17:34"	164.525	62	117	3
34485	"12:17:40"	164.525	62	124	4
34485	"12:17:46"	164.525	62	121	5
34485	"12:17:52"	164.525	52	121	6
34485	"12:17:58"	164.525	62	122	7
34485	"12:18:04"	164.525	62	121	7
34485	"12:18:48"	164.185	85	143	"M0"
34485	"12:18:52"	164.185	87	114	1
34485	"12:18:56"	164.185	87	130	2
34485	"12:19:00"	164.185	94	123	3
34485	"12:19:04"	164.185	86	141	4
34485	"12:19:09"	164.185	72	144	5
34485	"12:19:15"	164.185	63	139	6
34485	"12:19:20"	164.185	75	92	7
34485	"12:19:24"	164.185	94	115	7
34485	"12:20:51"	164.185	66	125	"M0"
34485	"12:20:58"	164.185	50	86	1
34485	"12:21:04"	164.185	63	99	2
34485	"12:21:10"	164.185	54	66	3
34485	"12:21:15"	164.185	77	72	4
34485	"12:21:21"	164.185	52	78	5
34485	"12:21:27"	164.185	63	95	6
34485	"12:21:33"	164.185	63	91	7
34485	"12:21:40"	164.185	49	84	7
34485	"12:23:05"	164.185	94	83	"M0"
34485	"12:23:09"	164.185	94	90	1
34485	"12:23:13"	164.185	94	93	2
34485	"12:23:17"	164.185	94	100	3
34485	"12:23:22"	164.185	73	89	4
34485	"12:23:28"	164.185	54	73	5
34485	"12:23:32"	164.185	92	82	6
34485	"12:23:38"	164.185	66	74	7
34485	"12:24:18"	164.525	62	122	"M0"
34485	"12:24:24"	164.525	62	124	1
34485	"12:24:32"	164.525	44	123	2
34485	"12:24:41"	164.525	44	118	3
34485	"12:24:47"	164.525	62	123	4
34485	"12:24:53"	164.525	62	120	5
34485	"12:25:01"	164.525	51	128	6
34485	"12:25:43"	164.525	51	121	7

Table 4. Continued.

34485	"12:28:07"	164.185	94	96	"M0"
34485	"12:28:11"	164.185	86	97	1
34485	"12:28:18"	164.185	63	74	2
34485	"12:28:25"	164.185	63	87	3
34485	"12:28:40"	164.185	45	65	4
34485	"12:28:45"	164.185	68	83	5
34485	"12:28:51"	164.185	63	83	6
34485	"12:28:56"	164.185	75	70	7
34485	"12:29:05"	164.185	53	97	7
34485	"12:29:44"	164.525	50	115	"M0"
34485	"12:30:22"	164.525	56	115	2
34485	"12:30:30"	164.525	45	128	3
34485	"12:30:42"	164.525	63	123	5
34485	"12:30:46"	164.525	89	121	6
34485	"12:30:51"	164.525	74	118	7
34485	"12:30:57"	164.525	64	123	7
34485	"12:31:41"	164.185	94	73	"M0"
34485	"12:32:00"	164.185	41	84	1
34485	"12:32:07"	164.185	92	80	2
34485	"12:32:11"	164.185	94	88	3
34485	"12:32:18"	164.185	72	72	4
34485	"12:32:28"	164.185	63	65	5
34485	"12:32:36"	164.185	45	66	6
34485	"12:32:42"	164.185	65	132	7
34485	"12:32:47"	164.185	74	138	7
34485	"12:34:06"	164.185	82	120	"M0"
34485	"12:34:16"	164.185	59	100	1
34485	"12:34:20"	164.185	90	97	2
34485	"12:34:28"	164.185	47	69	3
34485	"12:34:32"	164.185	78	83	4
34485	"12:34:38"	164.185	59	84	5
34485	"12:34:50"	164.185	67	74	7
34485	"12:34:57"	164.185	48	77	7
34485	"12:36:16"	164.185	88	63	"M0"
34485	"12:36:29"	164.185	94	73	2
34485	"12:36:32"	164.185	94	72	3
34485	"12:36:36"	164.185	94	80	4
34485	"12:36:40"	164.185	90	79	5
34485	"12:36:46"	164.185	60	64	6
34485	"12:36:52"	164.185	60	71	7

Table 4. Continued.

34485	"12:36:56"	164.185	84	89	7
34485	"12:38:18"	164.185	81	106	"M0"
34485	"12:38:22"	164.185	91	141	1
34485	"12:38:27"	164.185	75	114	2
34485	"12:38:31"	164.185	92	75	3
34485	"12:38:36"	164.185	64	107	4
34485	"12:38:41"	164.185	69	113	5
34485	"12:38:48"	164.185	55	125	6
34485	"12:38:59"	164.185	63	84	7
34485	"12:40:21"	164.185	85	90	"M0"
34485	"12:40:26"	164.185	67	116	1
34485	"12:40:32"	164.185	65	105	2
34485	"12:40:37"	164.185	75	112	3
34485	"12:40:42"	164.185	63	150	4
34485	"12:40:48"	164.185	63	131	5
34485	"12:40:54"	164.185	63	125	6
34485	"12:40:59"	164.185	63	140	7
34485	"12:41:12"	164.185	66	66	7
34485	"12:42:39"	164.185	48	71	"M0"
34485	"12:42:55"	164.185	94	103	1
34485	"12:42:59"	164.185	94	91	2
34485	"12:43:03"	164.185	94	116	3
34485	"12:43:07"	164.185	94	107	4
34485	"12:43:11"	164.185	94	82	5
34485	"12:43:14"	164.185	94	82	6
34485	"12:43:18"	164.185	94	80	7
34485	"12:43:23"	164.185	67	60	7
34485	"12:44:45"	164.185	94	82	"M0"
34485	"12:44:49"	164.185	94	91	1
34485	"12:44:53"	164.185	94	82	2
34485	"12:44:57"	164.185	94	83	3
34485	"12:45:00"	164.185	94	71	4
34485	"12:45:04"	164.185	94	75	5
34485	"12:45:08"	164.185	94	79	6
34485	"12:45:12"	164.185	94	74	7
34485	"12:45:16"	164.185	94	70	7
34485	"12:46:34"	164.185	94	86	"M0"
34485	"12:46:38"	164.185	94	89	1
34485	"12:46:42"	164.185	94	68	2
34485	"12:46:46"	164.185	78	76	3

Table 4. Continued.

34485	"12:46:50"	164.185	94	92	4
34485	"12:46:54"	164.185	94	107	5
34485	"12:46:58"	164.185	94	84	6
34485	"12:47:02"	164.185	94	91	7
34485	"12:47:05"	164.185	94	95	7
34485	"12:48:28"	164.185	46	80	"M0"
34485	"12:48:35"	164.185	77	68	1
34485	"12:48:48"	164.185	49	70	2
34485	"12:48:53"	164.185	94	86	3
34485	"12:48:57"	164.185	94	89	4
34485	"12:49:02"	164.185	69	93	5
34485	"12:49:06"	164.185	91	97	6
34485	"12:49:11"	164.185	67	91	7
34485	"12:49:15"	164.185	94	80	7
34485	"12:50:33"	164.185	94	82	"M0"
34485	"12:50:37"	164.185	94	93	1
34485	"12:50:41"	164.185	94	84	2
34485	"12:50:45"	164.185	94	94	3
34485	"12:50:48"	164.185	92	97	4
34485	"12:50:53"	164.185	87	79	5
34485	"12:50:57"	164.185	89	86	6
34485	"12:51:01"	164.185	91	79	7
34485	"12:51:07"	164.185	50	77	7
34485	"12:52:26"	164.185	85	72	"M0"
34485	"12:52:31"	164.185	75	95	1
34485	"12:52:35"	164.185	94	97	2
34485	"12:52:38"	164.185	94	103	3
34485	"12:52:42"	164.185	94	98	4
34485	"12:52:46"	164.185	94	87	5
34485	"12:52:50"	164.185	94	87	6
34485	"12:52:54"	164.185	94	84	7
34485	"12:52:58"	164.185	78	77	7
34485	"12:54:24"	164.185	58	99	"M0"
34485	"12:54:28"	164.185	94	102	1
34485	"12:54:31"	164.185	94	104	2
34485	"12:54:35"	164.185	94	90	3
34485	"12:54:40"	164.185	78	94	4
34485	"12:54:43"	164.185	94	99	5
34485	"12:54:51"	164.185	42	83	6
34485	"12:54:57"	164.185	63	67	7

Table 4. Continued.

34485	"12:56:41"	164.185	82	78	"M0"				
34485	"12:56:23"	164.185	91	75	1				
34485	"12:56:27"	164.185	94	71	2				
34485	"12:56:31"	164.185	77	76	3	.185	77	90	4
34485	"12:56:36"	164.185	85	81	5				
34485	"12:56:46"	164.185	71	76	6				
34485	"12:56:51"	164.185	91	101	7				
34485	"12:56:55"	164.185	82	89	7				
34485	"12:56:59"	164.185	79	82	"M0"				
34485	"12:59:38"	164.185	92	68	1				
34485	"12:59:46"	164.185	89	75	2				
34485	"12:59:50"	164.185	89	85	3				
34485	"12:59:54"	164.185	79	78	4				
34485	"12:59:58"	164.185	56	66	5				
34485	"13:00:04"	164.185	66	67	6				
34485	"13:00:10"	164.185							

APPENDIX B
DATA COLLATING PROGRAMS (dBASE)

Table 5. Data collating programs written in dBASE.

* This program replaces appropriate fields with corret information.

```
SET TALK OFF
SET ECHO OFF
DO QUART.PRG
DO BEARID94.PRG
DO DATE.PRG
DO LOCATE.PRG
```

* This program replaces time with quarter hours.

```
REPLACE ALL QUART WITH 0.1 FOR HOUR=0.AND.MIN<15
REPLACE ALL QUART WITH 0.2 FOR HOUR=0.AND.MIN>14.AND. MIN<30
REPLACE ALL QUART WITH 0.3 FOR HOUR=0.AND.MIN>29.AND. MIN<45
REPLACE ALL QUART WITH 0.4 FOR HOUR=0.AND.MIN>44
REPLACE ALL QUART WITH 1.1 FOR HOUR=1.AND.MIN<15
REPLACE ALL QUART WITH 1.2 FOR HOUR=1.AND.MIN>14.AND. MIN<30
REPLACE ALL QUART WITH 1.3 FOR HOUR=1.AND.MIN>29.AND. MIN<45
REPLACE ALL QUART WITH 1.4 FOR HOUR=1.AND.MIN>44
REPLACE ALL QUART WITH 2.1 FOR HOUR=2.AND.MIN<15
REPLACE ALL QUART WITH 2.2 FOR HOUR=2.AND.MIN>14.AND. MIN<30
REPLACE ALL QUART WITH 2.3 FOR HOUR=2.AND.MIN>29.AND. MIN<45
REPLACE ALL QUART WITH 2.4 FOR HOUR=2.AND.MIN>44
REPLACE ALL QUART WITH 3.1 FOR HOUR=3.AND.MIN<15
REPLACE ALL QUART WITH 3.2 FOR HOUR=3.AND.MIN>14.AND. MIN<30
REPLACE ALL QUART WITH 3.3 FOR HOUR=3.AND.MIN>29.AND. MIN<45
REPLACE ALL QUART WITH 3.4 FOR HOUR=3.AND.MIN>44
REPLACE ALL QUART WITH 4.1 FOR HOUR=4.AND.MIN<15
REPLACE ALL QUART WITH 4.2 FOR HOUR=4.AND.MIN>14.AND. MIN<30
REPLACE ALL QUART WITH 4.3 FOR HOUR=4.AND.MIN>29.AND. MIN<45
REPLACE ALL QUART WITH 4.4 FOR HOUR=4.AND.MIN>44
REPLACE ALL QUART WITH 5.1 FOR HOUR=5.AND.MIN<15
REPLACE ALL QUART WITH 5.2 FOR HOUR=5.AND.MIN>14.AND. MIN<30
REPLACE ALL QUART WITH 5.3 FOR HOUR=5.AND.MIN>29.AND. MIN<45
REPLACE ALL QUART WITH 5.4 FOR HOUR=5.AND.MIN>44
REPLACE ALL QUART WITH 6.1 FOR HOUR=6.AND.MIN<15
REPLACE ALL QUART WITH 6.2 FOR HOUR=6.AND.MIN>14.AND. MIN<30
REPLACE ALL QUART WITH 6.3 FOR HOUR=6.AND.MIN>29.AND. MIN<45
REPLACE ALL QUART WITH 6.4 FOR HOUR=6.AND.MIN>44
```

Table 5. Continued.

REPLACE ALL QUART WITH 7.1 FOR HOUR=7.AND.MIN<15
 REPLACE ALL QUART WITH 7.2 FOR HOUR=7.AND.MIN>14.AND. MIN<30
 REPLACE ALL QUART WITH 7.3 FOR HOUR=7.AND.MIN>29.AND. MIN<45
 REPLACE ALL QUART WITH 7.4 FOR HOUR=7.AND.MIN>44
 REPLACE ALL QUART WITH 8.1 FOR HOUR=8.AND.MIN<15
 REPLACE ALL QUART WITH 8.2 FOR HOUR=8.AND.MIN>14.AND. MIN<30
 REPLACE ALL QUART WITH 8.3 FOR HOUR=8.AND.MIN>29.AND. MIN<45
 REPLACE ALL QUART WITH 8.4 FOR HOUR=8.AND.MIN>44
 REPLACE ALL QUART WITH 9.1 FOR HOUR=9.AND.MIN<15
 REPLACE ALL QUART WITH 9.2 FOR HOUR=9.AND.MIN>14.AND. MIN<30
 REPLACE ALL QUART WITH 9.3 FOR HOUR=9.AND.MIN>29.AND. MIN<45
 REPLACE ALL QUART WITH 9.4 FOR HOUR=9.AND.MIN>44
 REPLACE ALL QUART WITH 10.1 FOR HOUR=10.AND.MIN<15
 REPLACE ALL QUART WITH 10.2 FOR HOUR=10.AND.MIN>14.AND. MIN<30
 REPLACE ALL QUART WITH 10.3 FOR HOUR=10.AND.MIN>29.AND. MIN<45
 REPLACE ALL QUART WITH 10.4 FOR HOUR=10.AND.MIN>44
 REPLACE ALL QUART WITH 11.1 FOR HOUR=11.AND.MIN<15
 REPLACE ALL QUART WITH 11.2 FOR HOUR=11.AND.MIN>14.AND. MIN<30
 REPLACE ALL QUART WITH 11.3 FOR HOUR=11.AND.MIN>29.AND. MIN<45
 REPLACE ALL QUART WITH 11.4 FOR HOUR=11.AND.MIN>44
 REPLACE ALL QUART WITH 12.1 FOR HOUR=12.AND.MIN<15
 REPLACE ALL QUART WITH 12.2 FOR HOUR=12.AND.MIN>14.AND. MIN<30
 REPLACE ALL QUART WITH 12.3 FOR HOUR=12.AND.MIN>29.AND. MIN<45
 REPLACE ALL QUART WITH 12.4 FOR HOUR=12.AND.MIN>44
 REPLACE ALL QUART WITH 13.1 FOR HOUR=13.AND.MIN<15
 REPLACE ALL QUART WITH 13.2 FOR HOUR=13.AND.MIN>14.AND. MIN<30
 REPLACE ALL QUART WITH 13.3 FOR HOUR=13.AND.MIN>29.AND. MIN<45
 REPLACE ALL QUART WITH 13.4 FOR HOUR=13.AND.MIN>44
 REPLACE ALL QUART WITH 14.1 FOR HOUR=14.AND.MIN<15
 REPLACE ALL QUART WITH 14.2 FOR HOUR=14.AND.MIN>14.AND. MIN<30
 REPLACE ALL QUART WITH 14.3 FOR HOUR=14.AND.MIN>29.AND. MIN<45
 REPLACE ALL QUART WITH 14.4 FOR HOUR=14.AND.MIN>44
 REPLACE ALL QUART WITH 15.1 FOR HOUR=15.AND.MIN<15
 REPLACE ALL QUART WITH 15.2 FOR HOUR=15.AND.MIN>14.AND. MIN<30
 REPLACE ALL QUART WITH 15.3 FOR HOUR=15.AND.MIN>29.AND. MIN<45
 REPLACE ALL QUART WITH 15.4 FOR HOUR=15.AND.MIN>44
 REPLACE ALL QUART WITH 16.1 FOR HOUR=16.AND.MIN<15
 REPLACE ALL QUART WITH 16.2 FOR HOUR=16.AND.MIN>14.AND. MIN<30
 REPLACE ALL QUART WITH 16.3 FOR HOUR=16.AND.MIN>29.AND. MIN<45
 REPLACE ALL QUART WITH 16.4 FOR HOUR=16.AND.MIN>44

Table 5. Continued.

REPLACE ALL QUART WITH 17.1 FOR HOUR=17.AND.MIN<15
REPLACE ALL QUART WITH 17.2 FOR HOUR=17.AND.MIN>14.AND. MIN<30
REPLACE ALL QUART WITH 17.3 FOR HOUR=17.AND.MIN>29.AND. MIN<45
REPLACE ALL QUART WITH 17.4 FOR HOUR=17.AND.MIN>44
REPLACE ALL QUART WITH 18.1 FOR HOUR=18.AND.MIN<15
REPLACE ALL QUART WITH 18.2 FOR HOUR=18.AND.MIN>14.AND. MIN<30
REPLACE ALL QUART WITH 18.3 FOR HOUR=18.AND.MIN>29.AND. MIN<45
REPLACE ALL QUART WITH 18.4 FOR HOUR=18.AND.MIN>44
REPLACE ALL QUART WITH 19.1 FOR HOUR=19.AND.MIN<15
REPLACE ALL QUART WITH 19.2 FOR HOUR=19.AND.MIN>14.AND. MIN<30
REPLACE ALL QUART WITH 19.3 FOR HOUR=19.AND.MIN>29.AND. MIN<45
REPLACE ALL QUART WITH 19.4 FOR HOUR=19.AND.MIN>44
REPLACE ALL QUART WITH 20.1 FOR HOUR=20.AND.MIN<15
REPLACE ALL QUART WITH 20.2 FOR HOUR=20.AND.MIN>14.AND. MIN<30
REPLACE ALL QUART WITH 20.3 FOR HOUR=20.AND.MIN>29.AND. MIN<45
REPLACE ALL QUART WITH 20.4 FOR HOUR=20.AND.MIN>44
REPLACE ALL QUART WITH 21.1 FOR HOUR=21.AND.MIN<15
REPLACE ALL QUART WITH 21.2 FOR HOUR=21.AND.MIN>14.AND. MIN<30
REPLACE ALL QUART WITH 21.3 FOR HOUR=21.AND.MIN>29.AND. MIN<45
REPLACE ALL QUART WITH 21.4 FOR HOUR=21.AND.MIN>44
REPLACE ALL QUART WITH 22.1 FOR HOUR=22.AND.MIN<15
REPLACE ALL QUART WITH 22.2 FOR HOUR=22.AND.MIN>14.AND. MIN<30
REPLACE ALL QUART WITH 22.3 FOR HOUR=22.AND.MIN>29.AND. MIN<45
REPLACE ALL QUART WITH 22.4 FOR HOUR=22.AND.MIN>44
REPLACE ALL QUART WITH 23.1 FOR HOUR=23.AND.MIN<15
REPLACE ALL QUART WITH 23.2 FOR HOUR=23.AND.MIN>14.AND. MIN<30
REPLACE ALL QUART WITH 23.3 FOR HOUR=23.AND.MIN>29.AND. MIN<45
REPLACE ALL QUART WITH 23.4 FOR HOUR=23.AND.MIN>44
REPLACE ALL QUART WITH 24.1 FOR HOUR=24.AND.MIN<15
REPLACE ALL QUART WITH 24.2 FOR HOUR=24.AND.MIN>14.AND. MIN<30
REPLACE ALL QUART WITH 24.3 FOR HOUR=24.AND.MIN>29.AND. MIN<45
REPLACE ALL QUART WITH 24.4 FOR HOUR=24.AND.MIN>44

Table 5. Continued.

* This program replaces bearid based on collar frequency.

```

REPLACE ALL BEARID WITH 18 FOR FREQUENCY=164.230
REPLACE ALL BEARID WITH 71 FOR FREQUENCY=164.525
REPLACE ALL BEARID WITH 22 FOR FREQUENCY=164.705
REPLACE ALL BEARID WITH 45 FOR FREQUENCY=164.185
REPLACE ALL BEARID WITH 48 FOR FREQUENCY=164.370
REPLACE ALL BEARID WITH 17 FOR FREQUENCY=164.580
REPLACE ALL BEARID WITH 19 FOR FREQUENCY=164.999
REPLACE ALL BEARID WITH 96 FOR FREQUENCY=164.450
REPLACE ALL BEARID WITH 14 FOR FREQUENCY=164.532
REPLACE ALL BEARID WITH 36 FOR FREQUENCY=164.565
REPLACE ALL BEARID WITH 49 FOR FREQUENCY=164.795
REPLACE ALL BEARID WITH 149 FOR FREQUENCY=164.860
REPLACE ALL BEARID WITH 69 FOR FREQUENCY=164.481
REPLACE ALL BEARID WITH 7 FOR FREQUENCY=164.600
REPLACE ALL BEARID WITH 8 FOR FREQUENCY=164.720
REPLACE ALL BEARID WITH 15 FOR FREQUENCY=164.470
REPLACE ALL BEARID WITH 50 FOR FREQUENCY=164.931
REPLACE ALL BEARID WITH 136 FOR FREQUENCY=164.960
REPLACE ALL BEARID WITH 29 FOR FREQUENCY=164.260
REPLACE ALL BEARID WITH 62 FOR FREQUENCY=164.625
REPLACE ALL BEARID WITH 65 FOR FREQUENCY=164.060
REPLACE ALL BEARID WITH 94 FOR FREQUENCY=164.545

```

* This program replaces LOTEK date with real date.

```

S=34238
D=92793
REPLACE ALL DATEA WITH D FOR STARTDATE=S
RETURN
S=34238
D=92793
REPLACE ALL DATEA WITH D FOR STARTDATE=S
REPLACE ALL DATEA WITH D+100 FOR STARTDATE=S+1
REPLACE ALL DATEA WITH D+200 FOR STARTDATE=S+2
REPLACE ALL DATEA WITH D+300 FOR STARTDATE=S+3
REPLACE ALL DATEA WITH D+7200 FOR STARTDATE=S+4
REPLACE ALL DATEA WITH D+7300 FOR STARTDATE=S+5

```

Table 5. Continued.

```

REPLACE ALL DATEA WITH D+7400 FOR STARTDATE=S+6
REPLACE ALL DATEA WITH D+7500 FOR STARTDATE=S+7
REPLACE ALL DATEA WITH D+7600 FOR STARTDATE=S+8
REPLACE ALL DATEA WITH D+7700 FOR STARTDATE=S+9

```

* This program uses lotek database files by individual bear and creates files which record activity by date and half-hour blocks.

```

COPY TO BPTEMP
USE BPTEMP
DO CLEANUP
SET TALK OFF
DO WHILE .NOT. EOF()
DAY=STARTDATE
F=QUART
WR=0
WP=0
WP2=0
N=0
DO WHILE STARTDATE=DAY.AND.QUART=F
P=POWER
R=RATE
WR=WR+R
WP=WP+P
WP2=WP2+(P*P)
N=N+1
SKIP
ENDDO
MR=WR/N
Q=WP2-WP^2/N
D=N-1
S2=Q/D
S=SQRT(S2)
SKIP -1
REPLACE MEANRATE WITH MR
REPLACE SDPOWER WITH S
REPLACE NUMBER WITH N
IF .NOT.EOF()
SKIP +1
ENDIF

```

Table 5. Continued.

```
ENDDO
GO TOP
USE ACTJR
APPEND FROM BPTEMP FOR NUMBER>9
IF B=5
USE AP5
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP5
DELE ALL
PACK
ENDIF
IF B=14
USE AP14
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP14
DELE ALL
PACK
ENDIF
IF B=18
USE AP18
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP18
DELE ALL
PACK
ENDIF
IF B=22
USE AP22
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP22
DELE ALL
PACK
ENDIF
IF B=19
USE AP19
APPE FROM BPTEMP
ERASE BPTEMP.DBF
```

Table 5. Continued.

```
USE BP19
DELE ALL
PACK
ENDIF
IF B=49
USE AP49
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP49
DELE ALL
PACK
ENDIF
IF B=50
USE AP50
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP50
DELE ALL
PACK
ENDIF
IF B=45
USE AP45
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP45
DELE ALL
PACK
ENDIF
IF B=48
USE AP48
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP48
DELE ALL
PACK
ENDIF
IF B=69
USE AP69
APPE FROM BPTEMP
ERASE BPTEMP.DBF
```

Table 5. Continued.

```
USE BP69
DELE ALL
PACK
ENDIF
IF B=71
USE AP71
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP71
DELE ALL
PACK
ENDIF
IF B=96
USE AP96
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP96
DELE ALL
PACK
ENDIF
IF B=149
USE AP149
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP149
DELE ALL
PACK
ENDIF
IF B=7
USE AP7
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP7
DELE ALL
PACK
ENDIF
IF B=8
USE AP8
APPE FROM BPTEMP
ERASE BPTEMP.DBF
```

Table 5. Continued.

```
USE BP15
DELE ALL USE BP8
DELE ALL
PACK
ENDIF
IF B=15
USE AP15
APPE FROM BPTEMP
ERASE BPTEMP.DBF
PACK
ENDIF
IF B=17
USE AP17
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP17
DELE ALL
PACK
ENDIF
IF B=136
USE AP136
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP136
DELE ALL
PACK
ENDIF
IF B=29
USE AP29
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP29
DELE ALL
PACK
ENDIF
IF B=62
USE AP62
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP62
```

Table 5. Continued.

```

DELE ALL
PACK
ENDIF
IF B=65
USE AP65
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP65
DELE ALL
PACK
ENDIF
IF B=94
USE AP94
APPE FROM BPTEMP
ERASE BPTEMP.DBF
USE BP94
DELE ALL
PACK
ENDIF
RETURN

```

* This program replaces the activity field in the activity .dbf file.

```

FILE WITH 0 FOR INACTIVE AND 1 FOR ACTIVE
SET TALK OFF
USE ACTJR
REPLACE ALL ACTIVITY WITH 1 FOR
BEARID=22.AND.MEANRATE>73.AND.MEANRATE<83
REPLACE ALL ACTIVITY WITH 1 FOR
BEARID=22.AND.SDPOWER>9.AND.MEANRATE<74.OR.BEARID=22.AND.SDPO
WER>9.AND.MEANRATE>82
REPLACE ALL ACTIVITY WITH 0 FOR BEARID=22.AND.ACTIVITY=0
REPLACE ALL ACTIVITY WITH 1 FOR
BEARID=19.AND.MEANRATE>69.AND.MEANRATE<80
REPLACE ALL ACTIVITY WITH 1 FOR
BEARID=19.AND.SDPOWER>9.AND.MEANRATE<70.OR.BEARID=19.AND.SDPO
WER>9.AND.MEANRATE>79
REPLACE ALL ACTIVITY WITH 0 FOR BEARID=19.AND.ACTIVITY=0
REPLACE ALL ACTIVITY WITH 1 FOR

```

Table 5. Continued.

BEARID=45.AND.MEANRATE>73.AND.MEANRATE<83
 REPLACE ALL ACTIVITY WITH 1 FOR
 BEARID=45.AND.SDPOWER>9.AND.MEANRATE<73.OR.BEARID=45.AND.SDPO
 WER>9.AND.MEANRATE>82
 REPLACE ALL ACTIVITY WITH 0 FOR BEARID=45.AND.ACTIVITY=0
 REPLACE ALL ACTIVITY WITH 1 FOR
 BEARID=18.AND.MEANRATE>75.AND.MEANRATE<86
 REPLACE ALL ACTIVITY WITH 1 FOR
 BEARID=18.AND.SDPOWER>9.AND.MEANRATE<76.OR.BEARID=18.AND.SDPO
 WER>9.AND.MEANRATE>85
 REPLACE ALL ACTIVITY WITH 0 FOR BEARID=18.AND.ACTIVITY=0
 REPLACE ALL ACTIVITY WITH 1 FOR
 BEARID=49.AND.MEANRATE>77.AND.MEANRATE<89
 REPLACE ALL ACTIVITY WITH 1 FOR
 BEARID=49.AND.SDPOWER>9.AND.MEANRATE<78.OR.BEARID=49.AND.SDPO
 WER>9.AND.MEANRATE>88
 REPLACE ALL ACTIVITY WITH 0 FOR BEARID=49.AND.ACTIVITY=0
 REPLACE ALL ACTIVITY WITH 1 FOR
 BEARID=48.AND.MEANRATE>71.AND.MEANRATE<81
 REPLACE ALL ACTIVITY WITH 1 FOR
 BEARID=48.AND.SDPOWER>9.AND.MEANRATE<72.OR.BEARID=48.AND.SDPO
 WER>9.AND.MEANRATE>80
 REPLACE ALL ACTIVITY WITH 0 FOR BEARID=48.AND.ACTIVITY=0
 REPLACE ALL ACTIVITY WITH 1 FOR
 BEARID=50.AND.MEANRATE>56.AND.MEANRATE<65
 REPLACE ALL ACTIVITY WITH 1 FOR
 BEARID=50.AND.SDPOWER>9.AND.MEANRATE<57.OR.BEARID=50.AND.SDPO
 WER>9.AND.MEANRATE>64
 REPLACE ALL ACTIVITY WITH 0 FOR BEARID=50.AND.ACTIVITY=0
 REPLACE ALL ACTIVITY WITH 1 FOR
 BEARID=71.AND.MEANRATE>71.AND.MEANRATE<81
 REPLACE ALL ACTIVITY WITH 1 FOR
 BEARID=71.AND.SDPOWER>9.AND.MEANRATE<72.OR.BEARID=71.AND.SDPO
 WER>9.AND.MEANRATE>80
 REPLACE ALL ACTIVITY WITH 0 FOR BEARID=71.AND.ACTIVITY=0
 REPLACE ALL ACTIVITY WITH 1 FOR
 BEARID=96.AND.MEANRATE>68.AND.MEANRATE<77
 REPLACE ALL ACTIVITY WITH 1 FOR
 BEARID=96.AND.SDPOWER>9.AND.MEANRATE<69.OR.BEARID=96.AND.SDPO
 WER>9.AND.MEANRATE>76

Table 5. Continued.

BEARID=17.AND.SDPOWER>9.AND.MEANRATE<69.OR.BEARID=17.AND.SDPOWER>9.AND.MEANRATE>77
 REPLACE ALL ACTIVITY WITH 0 FOR BEARID=17.AND.ACTIVITY=0
 REPLACE ALL ACTIVITY WITH 1 FOR BEARID=136.AND REPLACE ALL ACTIVITY WITH 0 FOR BEARID=96.AND.ACTIVITY=0
 REPLACE ALL ACTIVITY WITH 1 FOR BEARID=15.AND.MEANRATE>69.AND.MEANRATE<79
 REPLACE ALL ACTIVITY WITH 1 FOR BEARID=15.AND.SDPOWER>9.AND.MEANRATE<70.OR.BEARID=15.AND.SDPOWER>9.AND.MEANRATE>78
 REPLACE ALL ACTIVITY WITH 0 FOR BEARID=15.AND.ACTIVITY=0
 REPLACE ALL ACTIVITY WITH 1 FOR BEARID=17.AND.MEANRATE>68.AND.MEANRATE<78
 REPLACE ALL ACTIVITY WITH 1 FOR .MEANRATE>62.AND.MEANRATE<72
 REPLACE ALL ACTIVITY WITH 1 FOR BEARID=136.AND.SDPOWER>9.AND.MEANRATE<63.OR.BEARID=136.AND.SDPOWER>9.AND.MEANRATE>71
 REPLACE ALL ACTIVITY WITH 0 FOR BEARID=136.AND.ACTIVITY=0
 REPLACE ALL ACTIVITY WITH 1 FOR BEARID=62.AND.MEANRATE>70.AND.MEANRATE<78
 REPLACE ALL ACTIVITY WITH 1 FOR BEARID=62.AND.SDPOWER>9.AND.MEANRATE<71.OR.BEARID=62.AND.SDPOWER>9.AND.MEANRATE>77
 REPLACE ALL ACTIVITY WITH 0 FOR BEARID=62.AND.ACTIVITY=0
 REPLACE ALL ACTIVITY WITH 1 FOR BEARID=149.AND.MEANRATE>65.AND.MEANRATE<73
 REPLACE ALL ACTIVITY WITH 1 FOR BEARID=149.AND.SDPOWER>9.AND.MEANRATE<66.OR.BEARID=149.AND.SDPOWER>9.AND.MEANRATE>72
 REPLACE ALL ACTIVITY WITH 0 FOR BEARID=149.AND.ACTIVITY=0
 REPLACE ALL ACTIVITY WITH 1 FOR BEARID=7.AND.MEANRATE>72.AND.MEANRATE<82
 REPLACE ALL ACTIVITY WITH 1 FOR BEARID=7.AND.SDPOWER>9.AND.MEANRATE<73.OR.BEARID=7.AND.SDPOWER>9.AND.MEANRATE>81
 REPLACE ALL ACTIVITY WITH 0 FOR BEARID=7.AND.ACTIVITY=0
 REPLACE ALL ACTIVITY WITH 1 FOR BEARID=8.AND.MEANRATE>74.AND.MEANRATE<84
 REPLACE ALL ACTIVITY WITH 1 FOR

Table 5. Continued.

```

BEARID=8.AND.SDPOWER>9.AND.MEANRATE<75.OR.BEARID=8.AND.SDPOW
ER>9.AND.MEANRATE>83
REPLACE ALL ACTIVITY WITH 0 FOR BEARID=8.AND.ACTIVITY=0
REPLACE ALL ACTIVITY WITH 1 FOR
BEARID=69.AND.MEANRATE>65.AND.MEANRATE<75
REPLACE ALL ACTIVITY WITH 1 FOR
BEARID=69.AND.SDPOWER>9.AND.MEANRATE<66.OR.BEARID=69.AND.SDPO
WER>9.AND.MEANRATE>74
REPLACE ALL ACTIVITY WITH 0 FOR BEARID=69.AND.ACTIVITY=0
REPLACE ALL ACTIVITY WITH 1 FOR
BEARID=94.AND.MEANRATE>72.AND.MEANRATE<82
REPLACE ALL ACTIVITY WITH 1 FOR
BEARID=94.AND.SDPOWER>9.AND.MEANRATE<73.OR.BEARID=94.AND.SDPO
WER>9.AND.MEANRATE>81
REPLACE ALL ACTIVITY WITH 0 FOR BEARID=94.AND.ACTIVITY=0
REPLACE ALL ACTIVITY WITH 1 FOR
BEARID=14.AND.MEANRATE>00.AND.MEANRATE<02
REPLACE ALL ACTIVITY WITH 1 FOR
BEARID=14.AND.SDPOWER>9.AND.MEANRATE<00.OR.BEARID=14.AND.SDPO
WER>9.AND.MEANRATE>01
REPLACE ALL ACTIVITY WITH 0 FOR BEARID=14.AND.ACTIVITY=0
GO TOP
USE ACTIVITY
APPE FROM ACTJR
USE ACTJR
DELE ALL
PACK

```

* This program appends desirable records to AP files the program uses the dumped file that has been converted to a .dbf file.

```

SET TALK OFF
SET ECHO OFF
DO LOTEK94.PRG
ERAS TEMP.DBF
COPY TO TEMP.DBF
USE TEMP.DBF
DO CLEANUP
Z=1

```

Table 5. Continued.

```
DO WHILE Z<21
  IF Z=1
    B=5
  ENDIF
  IF Z=2
    B=7
  ENDIF
  IF Z=3
    B=8
  ENDIF
  IF Z=4
    B=14
  ENDIF
  IF Z=5
    B=15
  ENDIF
  IF Z=6
    B=17
  ENDIF
  IF Z=7
    B=18
  ENDIF
  IF Z=8
    B=22
  ENDIF
  IF Z=9
    B=136
  ENDIF
  IF Z=10
    B=19
  ENDIF
  IF Z=11
    B=49
  ENDIF
  IF Z=12
    B=50
  ENDIF
  IF Z=13
    B=45
  ENDIF
```

Table 5. Continued.

```

B=94
ENDIF
IF Z=19 IF Z=14
  B=48
ENDIF
IF Z=15
  B=62
ENDIF
IF Z=16
  B=69
ENDIF
IF Z=17
  B=71
ENDIF
IF Z=18
  B=96
ENDIF
IF Z=20
  B=149
ENDIF
IF B=22
  USE BP22
  APPE FROM TEMP FOR
  BEARID=22.AND.ANTENNA<>'M0'.AND.RATE>63.AND.RATE<93
  DO CLEANUP
  DO QUARTA94
  DO ACTREP94
  ENDIF
  IF B=45
    USE BP45
    APPEND FROM TEMP FOR
    BEARID=45.AND.ANTENNA<>'M0'.AND.RATE>62.AND.RATE<94
    DO CLEANUP
    DO QUARTA94
    DO ACTREP94
    ENDIF
  IF B=18
    USE BP18
    APPEND FROM TEMP FOR
    BEARID=18.AND.ANTENNA<>'M0'.AND.RATE>64.AND.RATE<98

```

Table 5. Continued.

```
DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
IF B=48
USE BP48
APPE FROM TEMP FOR
BEARID=48.AND.ANTENNA<>'M0'.AND.RATE>60.AND.RATE<91
DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
IF B=5
USE BP5
APPEND FROM TEMP FOR
BEARID=5.AND.ANTENNA<>'M0'.AND.RATE>63.AND.RATE<99
DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
IF B=71
USE BP71
APPE FROM TEMP FOR
BEARID=71.AND.ANTENNA#'M0'.AND.RATE>60.AND.RATE<92
DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
IF B=49
USE BP49
APPEND FROM TEMP FOR
BEARID=49.AND.ANTENNA#'M0'.AND.RATE>64.AND.RATE<102
DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
IF B=96
USE BP96
APPEND FROM TEMP FOR
BEARID=96.AND.ANTENNA#'M0'.AND.RATE>58.AND.RATE<87
```

Table 5. Continued.

```
APPEND FROM TEMP FOR
BEARID=14.AND.ANTENNA#'M0'.AND.RATE>59.AND.RATE<91
DO CLEANUP
DO QUARTA94 DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
IF B=69
USE BP69
APPEND FROM TEMP FOR
BEARID=69.AND.ANTENNA#'M0'.AND.RATE>55.AND.RATE<86
DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
IF B=14
USE BP14
DO ACTREP94
ENDIF
IF B=50
USE BP50
APPEND FROM TEMP FOR
BEARID=50.AND.ANTENNA#'M0'.AND.RATE>47.AND.RATE<74
DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
IF B=19
USE BP19
APPEND FROM TEMP FOR
BEARID=19.AND.ANTENNA#'M0'.AND.RATE>58.AND.RATE<91.
DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
IF B=136
USE BP136
APPEND FROM TEMP FOR
BEARID=136.AND.ANTENNA#'M0'.AND.RATE>52.AND.RATE<83
DO CLEANUP
```

Table 5. Continued.

```
DO QUARTA94
DO ACTREP94
ENDIF
IF B=149
USE BP149
APPEND FROM TEMP FOR
BEARID=149.AND.ANTENNA# 'M0'.AND.RATE>55.AND.RATE<83
DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
IF B=7
USE BP7
APPEND FROM TEMP FOR
BEARID=7.AND.ANTENNA<>'M0'.AND.RATE>62.AND.RATE<92
DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
IF B=8
USE BP8
APPEND FROM TEMP FOR
BEARID=8.AND.ANTENNA<>'M0'.AND.RATE>64.AND.RATE<95
DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
IF B=15
USE BP15
APPEND FROM TEMP FOR
BEARID=15.AND.ANTENNA<>'M0'.AND.RATE>59.AND.RATE<90
DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
IF B=17
USE BP17
APPEND FROM TEMP FOR
BEARID=17.AND.ANTENNA<>'M0'.AND.RATE>58.AND.RATE<88
DO CLEANUP
```

Table 5. Continued.

```
DO QUARTA94
DO ACTREP94
ENDIF
IF B=62
USE BP62
APPEND FROM TEMP FOR
BEARID=62.AND.ANTENNA#'M0'.AND.RATE>60.AND.RATE<88
DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
IF B=65
USE BP65
APPEND FROM TEMP FOR
BEARID=65.AND.ANTENNA#'M0'.AND.RATE>57.AND.RATE<89

DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
IF B=94
USE BP94
APPEND FROM TEMP FOR
BEARID=94.AND.ANTENNA#'M0'.AND.RATE>62.AND.RATE<92
DO CLEANUP
DO QUARTA94
DO ACTREP94
ENDIF
Z=Z+1
IF Z<21
LOOP
IF Z=21
RETURN
ENDIF
ENDDO
SET TALK ON
```

Table 5. Continued.

* This program checks for single entries for each half hour and deletes them from the file.

```

SET TALK OFF
SET ECHO OFF
DO WHILE .NOT. EOF()
DAY=STARTDATE
Q=QUART
N=0
DO WHILE STARTDATE=DAY.AND.QUART=Q
N=N+1
SKIP
ENDDO
IF N=1
SKIP -1
DELETE
IF .NOT.EOF()
SKIP +1
ENDIF
ENDIF
ENDDO
GO TOP
PACK
RETURN

```

* This program locates records that may be faulty in LOTEK.PRG.

```

LOCA FOR RATE=0.OR.BEARID=0.OR.DATEA=0

```

* This program replaces quarter hour values.

```

replace all quart with 0.0 for quart = 0.1
replace all quart with 0.25 for quart = 0.2
replace all quart with 0.5 for quart = 0.3
replace all quart with 0.75 for quart = 0.4
replace all quart with 1.0 for quart = 1.1
replace all quart with 1.25 for quart = 1.2
replace all quart with 1.5 for quart = 1.3
replace all quart with 1.75 for quart = 1.4

```

Table 5. Continued.

replace all quart with 2.0 for quart = 2.1
replace all quart with 2.25 for quart = 2.2
replace all quart with 2.5 for quart = 2.3
replace all quart with 2.75 for quart = 2.4
replace all quart with 3.0 for quart = 3.1
replace all quart with 3.25 for quart = 3.2
replace all quart with 3.5 for quart = 3.3
replace all quart with 3.75 for quart = 3.4
replace all quart with 4.0 for quart = 4.1
replace all quart with 4.25 for quart = 4.2
replace all quart with 4.5 for quart = 4.3
replace all quart with 4.75 for quart = 4.4
replace all quart with 5.0 for quart = 5.1
replace all quart with 5.25 for quart = 5.2
replace all quart with 5.5 for quart = 5.3
replace all quart with 5.75 for quart = 5.4
replace all quart with 6.0 for quart = 6.1
replace all quart with 6.25 for quart = 6.2
replace all quart with 6.5 for quart = 6.3
replace all quart with 6.75 for quart = 6.4
replace all quart with 7.0 for quart = 7.1
replace all quart with 7.25 for quart = 7.2
replace all quart with 7.5 for quart = 7.3
replace all quart with 7.75 for quart = 7.4
replace all quart with 8.0 for quart = 8.1
replace all quart with 8.25 for quart = 8.2
replace all quart with 8.5 for quart = 8.3
replace all quart with 8.75 for quart = 8.4
replace all quart with 9.0 for quart = 9.1
replace all quart with 9.25 for quart = 9.2
replace all quart with 9.5 for quart = 9.3
replace all quart with 9.75 for quart = 9.4
replace all quart with 10.0 for quart = 10.1
replace all quart with 10.25 for quart = 10.2
replace all quart with 10.5 for quart = 10.3
replace all quart with 10.75 for quart = 10.4
replace all quart with 11.0 for quart = 11.1
replace all quart with 11.25 for quart = 11.2
replace all quart with 11.5 for quart = 11.3
replace all quart with 11.75 for quart = 11.4

Table 5. Continued.

replace all quart with 12.0 for quart = 12.1
replace all quart with 12.25 for quart = 12.2
replace all quart with 12.5 for quart = 12.3
replace all quart with 12.75 for quart = 12.4
replace all quart with 13.0 for quart = 13.1
replace all quart with 13.25 for quart = 13.2
replace all quart with 13.5 for quart = 13.3
replace all quart with 13.75 for quart = 13.4
replace all quart with 14.0 for quart = 14.1
replace all quart with 14.25 for quart = 14.2
replace all quart with 14.5 for quart = 14.3
replace all quart with 14.75 for quart = 14.4
replace all quart with 15.0 for quart = 15.1
replace all quart with 15.25 for quart = 15.2
replace all quart with 15.5 for quart = 15.3
replace all quart with 15.75 for quart = 15.4
replace all quart with 16.0 for quart = 16.1
replace all quart with 16.25 for quart = 16.2
replace all quart with 16.5 for quart = 16.3
replace all quart with 16.75 for quart = 16.4
replace all quart with 17.0 for quart = 17.1
replace all quart with 17.25 for quart = 17.2
replace all quart with 17.5 for quart = 17.3
replace all quart with 17.75 for quart = 17.4
replace all quart with 18.0 for quart = 18.1
replace all quart with 18.25 for quart = 18.2
replace all quart with 18.5 for quart = 18.3
replace all quart with 18.75 for quart = 18.4
replace all quart with 19.0 for quart = 19.1
replace all quart with 19.25 for quart = 19.2
replace all quart with 19.5 for quart = 19.3
replace all quart with 19.75 for quart = 19.4
replace all quart with 20.0 for quart = 20.1
replace all quart with 20.25 for quart = 20.2
replace all quart with 20.5 for quart = 20.3
replace all quart with 20.75 for quart = 20.4
replace all quart with 21.0 for quart = 21.1
replace all quart with 21.25 for quart = 21.2
replace all quart with 21.5 for quart = 21.3
replace all quart with 21.75 for quart = 21.4

Table 5. Continued.

replace all quart with 22.0 for quart = 22.1
 replace all quart with 22.25 for quart = 22.2
 replace all quart with 22.5 for quart = 22.3
 replace all quart with 22.75 for quart = 22.4
 replace all quart with 23.0 for quart = 23.1
 replace all quart with 23.25 for quart = 23.2
 replace all quart with 23.5 for quart = 23.3
 replace all quart with 23.75 for quart = 23.4

* This program replaces diel values based on quarter hours.

replace all diel with 2 for quart = 0.0
 replace all diel with 2 for quart = 0.25
 replace all diel with 2 for quart = 0.5
 replace all diel with 2 for quart = 0.75
 replace all diel with 2 for quart = 1.0
 replace all diel with 2 for quart = 1.25
 replace all diel with 2 for quart = 1.5
 replace all diel with 2 for quart = 1.75
 replace all diel with 2 for quart = 2.0
 replace all diel with 2 for quart = 2.25
 replace all diel with 2 for quart = 2.5
 replace all diel with 2 for quart = 2.75
 replace all diel with 2 for quart = 3.0
 replace all diel with 2 for quart = 3.25
 replace all diel with 2 for quart = 3.5
 replace all diel with 2 for quart = 3.75
 replace all diel with 2 for quart = 4.0
 replace all diel with 2 for quart = 4.25
 replace all diel with 2 for quart = 4.5
 replace all diel with 2 for quart = 4.75
 replace all diel with 3 for quart = 5.0
 replace all diel with 3 for quart = 5.25
 replace all diel with 3 for quart = 5.5
 replace all diel with 3 for quart = 5.75
 replace all diel with 3 for quart = 6.0
 replace all diel with 3 for quart = 6.25
 replace all diel with 3 for quart = 6.5
 replace all diel with 3 for quart = 6.75

Table 5. Continued.

replace all diel with 3 for quart = 7.0
replace all diel with 3 for quart = 7.25
replace all diel with 3 for quart = 7.5
replace all diel with 3 for quart = 7.75
replace all diel with 1 for quart = 8.0
replace all diel with 1 for quart = 8.25
replace all diel with 1 for quart = 8.5
replace all diel with 1 for quart = 8.75
replace all diel with 1 for quart = 9.0
replace all diel with 1 for quart = 9.25
replace all diel with 1 for quart = 9.5
replace all diel with 1 for quart = 9.75
replace all diel with 1 for quart = 10.0
replace all diel with 1 for quart = 10.25
replace all diel with 1 for quart = 10.5
replace all diel with 1 for quart = 10.75
replace all diel with 1 for quart = 11.0
replace all diel with 1 for quart = 11.25
replace all diel with 1 for quart = 11.5
replace all diel with 1 for quart = 11.75
replace all diel with 1 for quart = 12.0
replace all diel with 1 for quart = 12.25
replace all diel with 1 for quart = 12.5
replace all diel with 1 for quart = 12.75
replace all diel with 1 for quart = 13.0
replace all diel with 1 for quart = 13.25
replace all diel with 1 for quart = 13.5
replace all diel with 1 for quart = 13.75
replace all diel with 1 for quart = 14.0
replace all diel with 1 for quart = 14.25
replace all diel with 1 for quart = 14.5
replace all diel with 1 for quart = 14.75
replace all diel with 1 for quart = 15.0
replace all diel with 1 for quart = 15.25
replace all diel with 1 for quart = 15.5
replace all diel with 1 for quart = 15.75
replace all diel with 1 for quart = 16.0
replace all diel with 1 for quart = 16.25
replace all diel with 1 for quart = 16.5
replace all diel with 1 for quart = 16.75

Table 5. Continued.

```

replace all diel with 1 for quart = 17.0
replace all diel with 1 for quart = 17.25
replace all diel with 1 for quart = 17.5
replace all diel with 1 for quart = 17.75
replace all diel with 2 for quart = 18.0
replace all diel with 2 for quart = 18.25
replace all diel with 2 for quart = 18.5
replace all diel with 2 for quart = 18.75
replace all diel with 2 for quart = 19.0
replace all diel with 2 for quart = 19.25
replace all diel with 2 for quart = 19.5
replace all diel with 2 for quart = 19.75
replace all diel with 2 for quart = 20.0
replace all diel with 2 for quart = 20.25
replace all diel with 2 for quart = 20.5
replace all diel with 2 for quart = 20.75
replace all diel with 2 for quart = 21.0
replace all diel with 2 for quart = 21.25
replace all diel with 2 for quart = 21.5
replace all diel with 2 for quart = 21.75
replace all diel with 2 for quart = 22.0
replace all diel with 2 for quart = 22.25
replace all diel with 2 for quart = 22.5
replace all diel with 2 for quart = 22.75
replace all diel with 2 for quart = 23.0
replace all diel with 2 for quart = 23.25
replace all diel with 2 for quart = 23.5
replace all diel with 2 for quart = 23.75

```

* This program counts for activity by quarter hour.

```

set echo off
set talk off
select b
  use x.dbf
select a
  use 96s.dbf
  recnum = recno()
  nq = 0

```

Table 5. Continued.

```

na = 0
q = quart
count for quart = q to nq
count for activity = 1 .and. quart = q to na
goto top
select b
  replace quart with q
  replace nquart with nq
  replace nact with na
  do while .not. eof()
select c
  use y.dbf
select a
  skip
  do while q = quart
  skip
  enddo
  recnum = recno()
  q = quart
  nq = 0
  na = 0
  count for quart = q to nq
  count for activity = 1 .and. quart = q to na
  goto recnum
select c
  replace quart with q
  replace nquart with nq
  replace nact with na
  use
select b
  append from y.dbf
select a
  goto recnum
  loop
  enddo
  return

```

APPENDIX C

CASE HISTORIES VALIDATING ACTIVITY STATE
THROUGH DIRECT OBSERVATION

While these are not the only cases of activity state being validated through direct observations, they do represent each of the 4 possible collar signal strength and pulse rate combinations. The 4 possible combinations include; a constant signal strength with a constant pulse rate, a constant signal strength with a modulating pulse rate, a changing signal strength with a constant pulse rate and a changing signal strength with a modulating pulse rate. In all instances of direct observation, processed data was examined to assure it accurately indicated the observed activity state.

Case History 1

Adult Female #96

1509 hours 14 June 1994

I watched #96 (approximately 25 minutes) in a day bed at the base of an avalanche chute in Graves Creek. Number 96 did not move at all for the first 7 minutes observed, at 1516 hours #96 made a comfort movement that caused her collar to modulate for 30 seconds then it returned to a constant (slow) rate. Monitoring the LOTEK, other than the comfort movement both the collar's signal strength and pulse rate remained unchanged, indicating inactivity. At 1535 hours #96 rose and moved into the vegetation where she apparently bedded again as her signal strength and pulse rate returned to a constant state.

Case History 2

Adult Female # 94 accompanied by 1 cub of year (COY)

1800 hours 10 October 1994

I watched #94 and COY (approximately 1.25 hours) digging on the side of Kah Mountain. Number 94 appeared to be intently digging for glacier lily or lomatium bulbs. While occasionally digging in mimic of #94, the COY did so with what seemed to be limited enthusiasm, suffering easily from distraction. Monitoring the LOTEK, #94 collar's signal strength remained fairly constant, however the pulse rate was continually alternating between slow and fast. Indicating that the bear was in a continual active state although her total distance traveled was less than 20 meters.

Case History 3

Adult Male #149

1710 hours 04 June 1994

I watched #149 (approximately 17 minutes) walking up the divide between the Middle Fork of Bunker Creek and Warrior Creek until he crossed through the saddle between Warrior and Tranquil mountains. Monitoring the LOTEK, the pulse rate remained in the fast mode, except during a brief (< 30 seconds) pause the bear made to smell the ground, at which time it modulated then returned to a fast rate as the bear, keeping his head at the same upright position, continued up the ridge. The signal strength however, continued to decrease until the signal disappeared as the bear passed through the saddle into Warrior Creek.

Case History 4

Adult Female #96

Adult Male #71

0925 hours 17 May 1994

I watched both #71 and #96 (approximately 50 minutes) in an avalanche chute in lower Aeneas Creek. Monitoring the LOTEK, the signal strengths and the pulse rates of both collars were continually changing. Number 96 spent most of the time digging and feeding (appeared to be glacier lilies), other activity #96 engaged in was the occasional confrontation with and escape from #71 who between feeding bouts was attempting to breed. Although #96 repeatedly foiled his mounting attempts by either turning and confronting or by jumping away, #71 was persistent in his breeding attempts. After each mounting attempt #71 would feed for several minutes, then he would again approach #96 and either attempt to smell or mount her.

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