

HABITAT SECURITY FOR ALASKAN BLACK BEARS AT KEY FORAGING SITES: ARE THERE THRESHOLDS FOR HUMAN DISTURBANCE?

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Abstract: We examined the distribution, individual diversity, and fishing activity of black bears (*Ursus americanus*) in relation to human activity on an Alaskan salmon (*Oncorhynchus* spp.) stream to determine the impacts of wildlife viewing on bear foraging behavior. We logged 622 observation hours in 1994 and 1995 at 2 falls on Anan Creek, southeast Alaska. The lower falls was open to the public, whereas the upper falls was closed. We identified 14 adult males and 10 adult females at Anan Creek common to both years of the study. We observed 17 recognized bears 75–100% of the time at the upper falls; only 2 females fished solely at the lower falls. Five of 8 bears that fished exclusively at the upper falls (all large males) appeared wary of researchers upon their arrival. Based on quantile regression analyses, we found that visitor numbers acted as a ceiling on fishing duration of black bears at the lower falls of Anan Creek in 1994 and 1995. Furthermore, 2 habituated bears seen frequently at the lower falls spent less time in view (maximum values) as visitor group size increased. We found little relationship between visitor numbers and other indices of black bear activity and diversity at this site. Whereas the upper falls received more use by bears due to superior fishing opportunities and increased security, we suspect that some bears restricted their fishing to this site to avoid high human activity at the lower falls. Bears fishing at the lower falls were more tolerant of people; however, they exhibited sensitivity to larger group sizes as evidenced by shorter fishing bouts. These results are a conservative estimate of human impacts on bears as they reflect threshold levels of the most tolerant bears in a population.

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Key words: anthropogenic disturbance, black bear, habituation, regression quantiles, southeast Alaska, *Ursus americanus*, wildlife viewing

Wildlife viewing is rapidly becoming an economically dominant use of natural resources by the public (Edington and Edington 1986, Flather and Cordell 1995, Larson 1995). In particular, viewing programs that feature charismatic megafauna such as bears, in their natural environment, are in high demand (Swanson et al. 1992). Most of the well known bear-viewing sites are located in Alaska, where bears aggregate at salmon streams to feed on spawning and migrating fish. During the past 10 years, these areas have experienced dramatic increases in human visitation, some doubling each year (Aumiller and Matt 1994, Fagen and Fagen 1994, Olson and Gilbert 1994, Chi and Gilbert 1996). Although some viewing programs (e.g., McNeil River State Game Sanctuary) capped visitor numbers at their inception (Aumiller and Matt 1994), others lacked clearly defined management objectives to address continued growth in visitor use (Titus et al. 1994).

A prevailing concern to biologists and wildlife managers is the potential negative effects that unprecedented expansion of viewing programs may have on bears. Wildlife viewing has been categorized as non-consumptive, implying negligible effects on the resource. This assumption, however, needs evaluation because contrary evidence is well documented in the literature (Gutzwiller 1993, HaySmith and Hunt 1995). Whereas some animals habituate to people and their activities (Frame and Frame 1980, Jones and Swartz 1984, Aumiller and Matt 1994), others remain wary, avoiding areas of high human use and development (Jope 1985, Nadeau 1989, McCutchen 1990). Furthermore, studies on bear-human

interactions at established viewing sites indicate that the mere presence of human observers poses significant disturbance to some bears (Warner 1983, Braaten 1988, Olson 1993, Fagen and Fagen 1994, Olson and Gilbert 1994). In Katmai National Park, Alaska, the temporal and spatial distributions of nonhabituated brown bears (*Ursus arctos*) were better explained by the location, intensity, and timing of human activity than salmon availability (Olson and Gilbert 1994, Olson et al. 1997). These findings are corroborated by Warner (1987) and Reinhart and Mattson (1990). Over-winter survival and reproductive success of bears depends on their ability to build up fat for hibernation (Miller 1994, Noyce and Garshelis 1994). Consequently, displacement of non-habituated bears from critical foraging areas will invariably affect individual fitness if alternative food sources are unavailable (Archibald et al. 1987, Gilbert 1989, McCutchen 1990, Gilbert and Lanner 1992).

Moreover, in the absence of restrictions on visitor numbers and human behavior permitted at wildlife viewing sites, disturbance may exceed the thresholds of even the most tolerant bears. Several studies suggest subtle shifts in diel activity patterns of habituated bears in response to peak visitor use during midday hours (Olson et al. 1998, Chi and Gilbert, 1996, Final report: Human-bear interactions at Anan Creek, Tongass National Forest Alaska, Utah State University, Logan, Utah, USA). To establish a balance between resource protection and public access at wildlife viewing sites, managers need a basis for predicting impact thresholds on both habituated and non-habituated bears.

This study investigated the potential impacts of wildlife viewing on black bears at Anan Creek. Rapidly becoming known as an exceptional black-bear viewing location, Anan Creek experienced an upsurge in visitation since 1990 (U.S. Forest Service 1996). This stream is unique as it is one of the few places where both black bears and brown bears can be observed fishing relatively closely. The objectives of our research were 2-fold: (1) to test the hypothesis that visitors do not affect the distribution, diversity, or fishing activity of black bears at Anan Creek; and (2) to recommend appropriate management strategies that maximize bear use of Anan Creek while facilitating recreational viewing.

STUDY AREA

Anan Creek is approximately 40 km southeast of Wrangell in southeast Alaska (56°11'N, 131°53'E) on the Tongass National Forest (Fig. 1). The region is char-

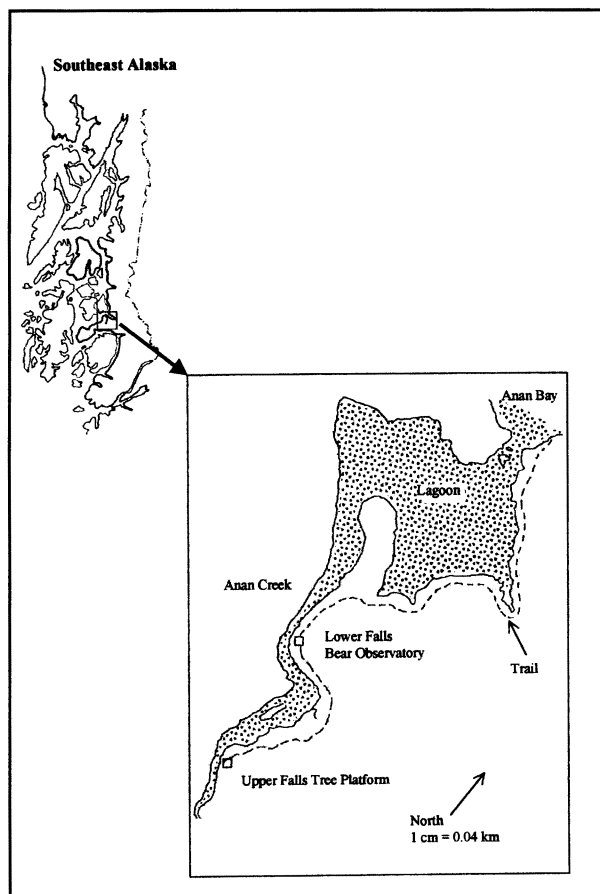


Fig. 1. Map of the study area, Anan Creek, Tongass National Forest, Alaska, 1994-95.

acterized by coastal forests of Sitka spruce (*Picea sitchensis*) and western hemlock (*Thuja plicata*) interspersed with alder (*Alnus* spp.) and black cottonwood (*Populus trichocarpa*) along riparian zones. The left fork of Anan Creek is wide and flat, providing suitable spawning habitat for as many as 250,000 pink salmon (*Onchorhynchus gorbuscha*). Large boulders constrain the stream channel in 2 locations, creating a series of small waterfalls and a labyrinth of rock caves and crevices. From early July through September, both black bears and brown bears aggregate at these falls, below which salmon accumulate in large numbers along side-pools of the creek making them more vulnerable to capture by bears.

In 1965, the U.S. Department of Agriculture Forest Service (USFS) constructed a bear-viewing observatory on the north side of the creek 12 m above the lower falls. This structure has been modified and expanded since then to accommodate more people; currently it is 15 m long and as wide as 8 m. A 9-m² section of the observatory is covered, providing shelter from the rain and sun. From the observatory, bears can be viewed en route to or fishing for salmon 10-40 m away. Additionally, there is a fish pass 12 m below the observatory and 8 m from the other side of the creek. This pass has a 25 m² platform that was covered with a tarp in 1994 and 1995 to conceal human observers. Bears have been observed fishing for salmon directly across from this structure as well as beside it.

Anan Creek is accessible only by floatplane or boat. Visitors are dropped off at the trailhead near the mouth of the estuary and follow a boardwalk trail about 0.8 km to the lower falls. USFS interpreters are present at the trailhead and observatory to provide information on natural history and safety issues related to human-bear encounters. However, human behavior is not highly regulated and there are few restrictions on visitor numbers on site.

The upper falls, about 0.4 km upstream from the lower falls, has been closed to research and the public since 1992 due to several incidents between people and bears. Since the trail to this area has not been maintained for public use and human activity is limited, we selected the upper falls as our control site.

USFS staff (2-3 people) were housed in 2 small administrative cabins approximately 75 m north of the trailhead. A Forest Service recreational cabin (capacity 5-6 people) 0.3 km north of the trailhead was the only on-site accommodation available for public use.

METHODS

Bear Identification

During 23–31 July 1993, Alaska Department of Fish and Game (ADF&G) personnel captured bears, fitted them with radiocollars, ear-tagged them with small multi-colored Floy fish tags (Floy Tag, Inc., Seattle, Washington, USA), and lip-tattooed them as part of a population demographics study. We differentiated between individual bears by natural markings, morphological characteristics, and ear tags. We took photographs of bears (front view and profiles) and sketched distinguishing physical characteristics. We determined sex of individuals from observation of genitals, urination posture, or the presence of cubs. We used our photographs and sketches to compile detailed identification records on bears and continuously updated these records as coat condition changed and new scars were acquired. We used binoculars and spotting scopes to facilitate bear identification.

Data Collection

We collected data on black bear activity and behavior between 16 July–3 September, 1993, 3 July–27 August, 1994, and 3 July–3 September, 1995. In early July, we sampled between 0600 and 2200 hours, dividing each day into eight 2-hour periods. In mid-July, we omitted the last session (2000–2200 hours) as decreasing light made observations difficult and return from sites hazardous. To simplify logistics, we systematically assigned sampling sessions each day to ensure complete coverage of all periods at both sites each week. Observations were made from the bear observatory at the lower falls and from an elevated tree platform and blind on the north bank of the creek at the upper falls.

We used a form of focal animal sampling (Altmann 1974) to collect data on black bear activity. During observation sessions we recorded the following information on all bears seen: species, sex–age class, identification or description, bear location, arrival and departure time, fishing attempts, fish caught or scavenged, and where fish were consumed. In addition, we documented all detectable responses exhibited by individual bears to our arrival or to the presence of USFS personnel. We used instantaneous scan sampling (Altmann 1974) to monitor visitor numbers at the lower falls. Upon the sound of the timer (set at 10-minute intervals), the observer visually scanned the designated zone and recorded the number of people present at the observatory.

Lastly, we kept detailed records of all events in which people displaced bears from either the lower or upper

falls. We classified the outcome of bear avoidance responses to people as (1) displaced to the surrounding forest or a cave for the entirety of the observation session (DZ), or (2) initially avoided but activity resumed following the episode (RA).

Analyses

To determine how different bears allocated their fishing efforts between the lower and upper falls, we calculated activity rates of individuals as the total time each bear was observed at each site divided by the number of observation sessions. We used 3 indices as overall measures of black bear activity (individuals pooled): (1) bear minutes (i.e., the amount of time bears spent in view of the observer), (2) the number of bear visits, and (3) mean bout length (Chi and Gilbert 1996). These 3 measures identified how bear activity varied because the first index (bear minutes) was a function of the latter 2 (visits and visit duration). In addition, we used individual richness (number of different bears seen) and Simpson's D (a function of richness and evenness) as measures of black bear diversity. Simpson's D was calculated as $H = 1/\sum P_i^2$, where P_i = the number of bear minutes for individual i divided by the total number of bear minutes for that session. Data collected from 10 habituated individuals at the lower falls (i.e., lacked response to people and extensive use of the lower falls) were analyzed separately. We calculated visitor activity at the lower falls, represented as people per scan, by dividing the total number of visitors counted for all scans by the number of instantaneous scans taken (typically 12) for each observation session.

We constructed bivariate scatterplots to examine the relationships between the independent variable (visitor numbers) and the dependent variables (black bear activity, diversity, and individual fishing time). Our purpose was to determine whether high levels of human activity constrained the individual diversity and activity of bears fishing at the lower falls. When a ceiling rather than a controlling effect is of interest, ordinary least squares (OLS) estimators, which model the center of data distributions (means) and assume homoscedastic variance (Cade et al. 1999) may not accurately portray the nature of the relationship between the independent and dependent variable (Maller et al. 1983, Blackburn et al. 1992, Terrell et al. 1996, Thomson et al. 1996, Garvey et al. 1998, Scharf et al. 1998, Cade et al. 1999).

For quantifying the slope of upper bounds in scatterplots, regression quantiles have been proposed as superior models to OLS regression (Koenker and Bassett 1978, Gutenbrunner and Jureckova 1992, Terrell et al. 1996, Scharf et al. 1998). A quantile is defined as “a

plane that splits a frequency distribution into parts" (Terrell et al. 1996:109) such that there are Nq observations below the q^{th} quantile, where N is the number of observations. In quantile regression models the parameters of interest include the intercept (β_0) and slope (β_p , $P \geq 1$) of the θ^{th} ($0 < \theta < 1$) quantile. These models have unbiased medians rather than means, are less sensitive to outlier contamination than OLS models, and accommodate heteroscedasticity in the estimates (Scharf et al. 1998, Cade et al. 1999). We fitted the 75th and 90th regression quantiles to model upper limits of bear activity (bear minutes, visits, and mean bout length), diversity (individual richness and diversity of bear activity), and individual fishing time as functions of visitor number. Constraining effects are indicated by 75th or 90th regression quantile slopes (Terrell et al. 1996) being steeper than the 50th regression quantile slope. Significance tests of quantile slopes were based on regression rank scores (Gutenbrunner et al. 1993, Koenker 1994) and conducted using S-Plus (B. Cade, U.S. Geological Survey, Fort Collins, Colorado, USA, personal communication, 1997).

Cade and Richards (1996) found that while regression quantiles were not as sensitive to outliers of the dependent variable as OLS regression, they did, however, respond similarly to the effects of leverage points (outliers

of the independent variable). For this reason, we removed 1 leverage point from the data set of overall black bear activity and diversity.

RESULTS

Individual Black Bear Distribution at Anan Creek

The first field season (1993) served to develop a protocol for reliable identification and recognition of individual bears and to refine data collection methods. Our results are based on the 1994 and 1995 field seasons during which we sampled 340 and 282 hours at the lower falls and upper falls, respectively. Each year we individually identified approximately 19 male and 13 female adult black bears at Anan Creek. However, we observed only 14 male and 10 female black bears both years of the study. These were individuals that were frequently seen or had distinguishing markings, thereby making it easier to differentiate them. Consequently, our sample may be biased toward more visible and, possibly, more tolerant individuals. However, time spent on the river by these individuals accounted for 71% and 83% of all adult bear activity observed in 1994 and 1995, respectively. Based

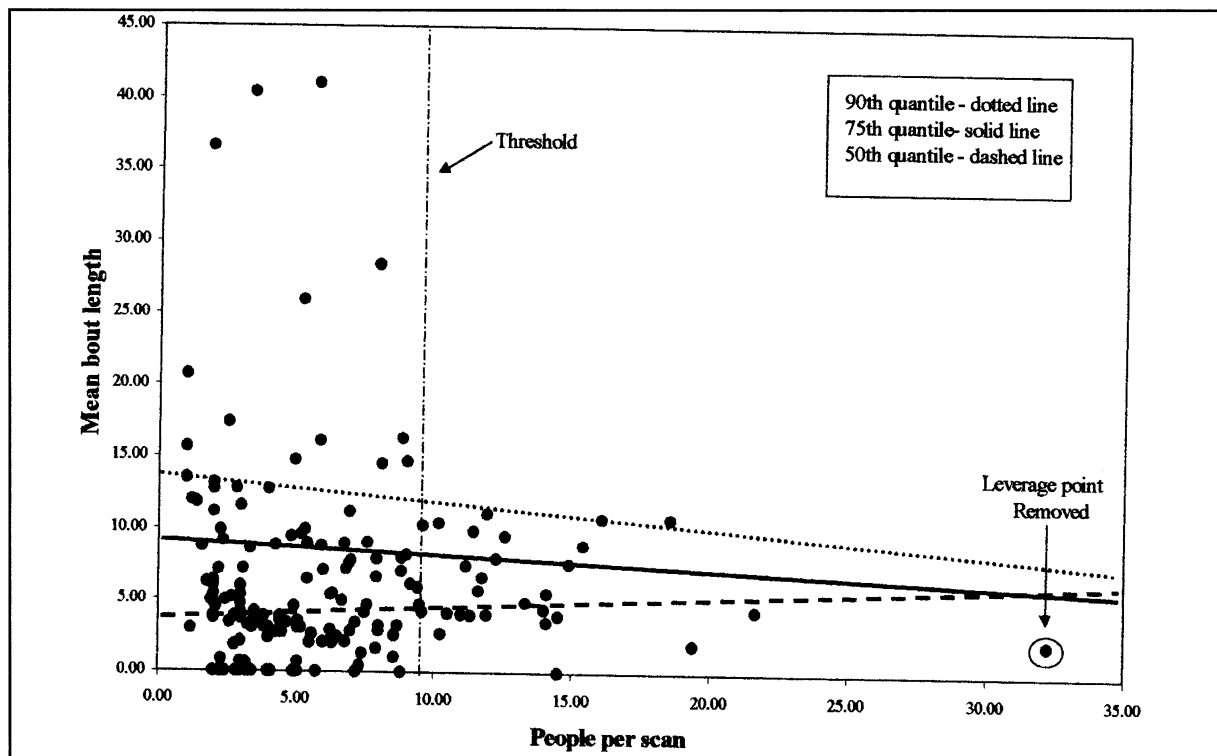


Fig. 2. Quantile regression lines (50th, 75th, and 90th) depicting the relationship between visitor activity and mean bout length of black bears at the lower falls, Anan Creek, Tongass National Forest, Alaska, 1994–95.

on these statistics, we believe this sample to be representative of the majority of bears that consistently fished at the lower and upper falls of Anan Creek.

We found substantial variation between individuals within each sex class in the spatial distribution and total amount of fishing time. Seven of 14 male black bears recognized both years of the study fished exclusively at the upper falls, and another 6 spent >75% of their fishing time at this site. We observed 4 of 10 identified female black bears only at the upper falls and 2 only at the lower falls. Activity ratios for 4 females seen at both falls ranged from 30:70 to 70:30 (lower falls:upper falls). These individual patterns of bear activity were consistent across years with few exceptions. One adult male spent 45% of his fishing time at the lower falls in 1994 but was not sighted there in 1995. Two females spent 70–75% of their fishing time at the lower falls during the year they were accompanied by dependent young but reversed this pattern the year they were without cubs.

Further, 1 small lone female used only the upper falls in 1994 but was seen on 2 occasions along Anan Creek the following year when she had cubs of the year.

Black Bear Activity and Diversity at the Lower Falls

We found no constraining effects by people on bear minutes, fishing bouts, individual richness, or diversity of bear activity. However, mean bout length became progressively limited as visitor numbers increased (Fig. 2); slope of the 90th quantile was negative, greater in magnitude than that of the 50th quantile, and differed from 0 ($P < 0.10$, Table 1). Bout lengths decreased substantially beyond a threshold of 9 people/scan. This threshold value equates to a maximum of 15 people on the observatory at a time (Chi and Gilbert 1996:102). Although not significant, the number of bear visits increased as visitor numbers increased, a result inconsistent with patterns noted for the other indices.

Table 1. Slope (β), confidence interval, and test statistic for the 50th, 75th, and 90th quantile models of the relationship between indices of bear activity and diversity and visitor numbers for Anan Creek, Tongass National Forest, Alaska, 1994–1995.

Indices	50 th quantile			75 th quantile			90 th quantile		
	β	90% CI	χ^2	β	90% CI	χ^2	β	90% CI	χ^2
Bear minutes	1.68	0.84–3.49	5.61 ^a	1.89	-1.91–8.92	0.04	-1.82	-6.88–1.69	1.15
Visits	0.41	0.16–0.71	8.63 ^a	0.14	-0.08–0.67	0.59	0.29	-0.38–0.97	0.05
Mean bout length	0.09	-0.03–0.30	0.30	-0.11	-0.28–0.22	0.00	-0.17	-0.44–0.13	2.96 ^b
Individual richness	0.23	-0.04–0.26	8.37 ^a	0.07	-0.22–0.37	1.43	0.00	-0.17–0.34	-0.17
Diversity of activity	0.13	0.06–0.19	8.49 ^a	0.03	-0.01–0.15	2.05	-0.03	-0.07–0.14	0.22

^a 1 df, $P < 0.05$

^b 1 df, $P < 0.01$

Table 2. Slope (β), confidence interval, and test statistic of 50th and 75th and 90th quantile regression models of the relationship between bout length and visitor numbers for 10 individual black bears observed frequently at the lower falls for Anan Creek, Tongass National Forest, Alaska, 1994–1995.

	50 th quantile			75 th quantile			90 th quantile		
	β_1	90% CI	χ^2	β_1	90% CI	χ^2	β_1	90% CI	χ^2
Males									
LIM	0.24	-0.41 – 0.16	1.95	-0.71	-1.16 – 1.98	0.86	-1.25	-1.57 – 21.46	0.67
T	0.71	0.15–0.96	2.86 ^a	2.4	0.65 – 2.78	4.58 ^b	2.14	1.75 – 3.89	4.37 ^b
PAT	-0.51	-0.57 – 0.23	1.83	-1.03	-1.48 – 1.40	0.02	-0.98	-3.51 – 0.29	2.92 ^a
SHA	0.53	-1.87–1.36	0.54	-1.32	1.89 – 0.47	0.7	-0.12		
ZIP	-0.06	-0.18 – 0.10	0.32	-0.06	-0.31 – 0.39	0.15	-0.7	-1.01 – 8.13	0.39
Females									
DEU	-0.20	-0.38 – -0.11	6.73 ^b	-0.45	-0.71 – 0.13	6.14 ^b	-0.43	-0.82 – 0.07	0.95
JUA	-0.13	-0.16 – 0.11	0.29	-0.04	-0.17 – 0.27	0.2	-0.46	-0.56 – 1.12	0.37
SHI	-0.10	-0.13 – 0.01	1.31	-0.16	-0.28 – 0.10	1.33	-0.32	-0.65 – 0.08	1.96
SMA	-0.01	-0.09 – 0.03	0.03	0.25	-0.34 – 1.05	0.05	1.24	-0.14 – 2.08	2.64
WIS	0.02	-0.11 – 0.22	0.03	-0.07	-0.28 – 0.17	0.02	-0.08	-0.54 – 0.51	1.19

^a $P < 0.10$

^b $P < 0.05$

Bout Lengths of Individual Bears (Lower Falls)

We observed 10 of the 24 bears identified in both 1994 and 1995 (5 males and 5 females) frequently enough at the lower falls to be individually analyzed (Table 2). We categorized these bears as habituated because they rarely, if ever, noticeably avoided people on the observatory. Slopes of the 75th and 90th quantiles for 7 of these bears were negative and greater in magnitude than that of the 50th quantile, indicating a ceiling effect of visitor numbers on time the bears spent in view (Table 2). However, slopes of the 75th (Fig. 3a) or 90th (Fig. 3b) quantiles for only 2 of these 7 bears differed significantly from zero. Interestingly, for 1 bear (Fig. 3c) there was a significantly positive relationship between visitor numbers and maximum bout length, indicating his visits were longer when larger visitor groups were present.

Displacement of Individual Bears

In 19 instances, 10 bears were displaced from the stream by people at the observatory. These bears did not return during that session (DZ). Nine bears resumed activity (RA) that was initially disrupted by visitors. The majority of displacements at the lower falls were surprise encounters with female and subadult bears at close range (2–15 m) on the trail near the observatory. At the upper falls, we observed 61 (91%) displacements (DZ) and 6 (9%) cases of temporary avoidance (RA), all because of researcher or USFS personnel arrival or presence. Most displaced bears at the upper falls were adult males (47%) and unknown adults (39%); 5 of 8 adult males that avoided people at this site never frequented the lower falls.

DISCUSSION

We identified almost 50% more adult male than adult female black bears at Anan Creek both within and across years. This outcome may reflect the relative ease of identifying males; they were typically larger and bore numerous scars, making it easier to distinguish between individuals (Herrero 1983). Adult females were smaller and in the absence of cubs could more easily have been mistakenly categorized as subadults (Olson 1993). However, we believe this bias was minor. The proportion of male bears observed at Anan Creek ($\approx 60\%$) was well within the range expected based on other studies of black bear population dynamics and composition (Beecham 1980, Kelleyhouse 1980, LeCount 1980, Kolenosky 1986, Kasworm and Their 1994, Miller 1994, Sellers and Aumiller 1994).

During both years at Anan Creek, most male black bears appeared to prefer the upper falls where human activity was minimal; the same generalization could not be made about females. Earlier work by Chi and Gilbert (1996) indicated that the upper falls provided more fishing opportunities and secure locations where bears could retreat to eat fish (i.e., rock caves and crevices). These 2 characteristics, in addition to limited human disturbance, likely made the upper falls a highly attractive fishing location. Our results agree with other bear foraging studies, which indicate that adult males typically secure the most productive feeding sites (Egbert and Stokes 1976; Luque and Stokes 1976; Rogers et al. 1976; Rogers 1987, 1989; Kearney 1989). Further, they are an under-represented cohort in areas frequented by people (Mattson et al. 1992) and appear more wary of people (Egbert and Stokes 1976, Warner 1987, Aumiller and Matt 1994).

Females and subadult bears, on the other hand, often select less optimal habitat in an effort to avoid the threat and competition presented by large males (Rogers 1989, Wielgus and Bunnell 1994a). Our results provide more evidence of this phenomenon as several females at Anan Creek, when accompanied by dependent young, seemed to segregate themselves from males. These females shifted their fishing efforts from the upper falls to the lower falls when they had cubs. Although seen frequently at the upper falls in 1994, another female completely avoided both falls in 1995 when accompanied by cubs-of-the-year. It appears that the lower falls functions as an alternative fishing location for females attempting to avoid large males at the upper falls.

Distribution Relative to Human Activity

We rejected the hypothesis that wildlife-viewing activities do not affect where bears fish on Anan Creek. Approximately half of all bears of both sexes fished exclusively at the upper falls, which was closed to the visiting public, and >71% spent >75% of their time there. Only 8% of our sample of bears (2 females) restricted their use only to the lower falls. Some large males, seen only or primarily at the upper falls, were consistently displaced when research or USFS personnel arrived. Although some reappeared after we entered the tree blind, others were not seen again until the next day. However, we acknowledge that any visitor effect was confounded by important differences in fish accessibility and availability of cover between the lower and upper falls of Anan Creek. For this reason, we restricted our inferences to individuals that exhibited obvious avoidance of people at the upper falls.

Bears at the upper falls might appear more sensitive to human disturbance because nonhabituated bears are cat-

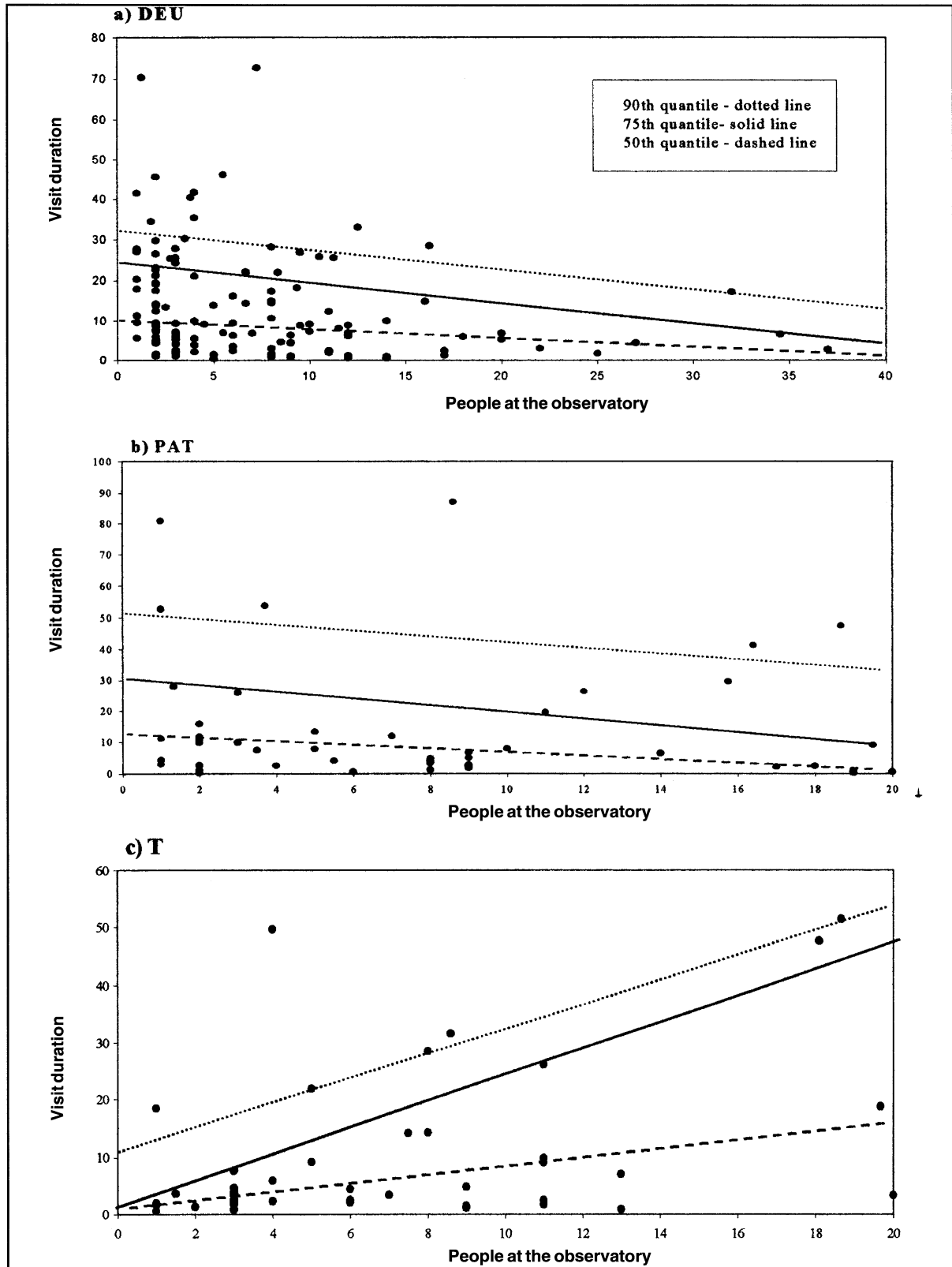


Fig. 3. Quantile regression lines (50th, 75th, and 90th) depicting significant relationships between duration of visit and the number of people at the observatory for 3 habituated black bears (DEU, PAT, T) at the lower falls, Anan Creek, Tongass National Forest, Alaska, 1994–95.

egorized based on their tendency to avoid people (Warner 1987, Mattson et al. 1992, Olson 1993, Olson et al. 1998). Olson et al. (1997) found that some nonhabituated family groups delayed their arrival at Brooks River by a week when concessionaire activities (fishing lodge) were extended a week beyond the usual closing date. Grizzly bears in Yellowstone National Park used front-country streams less during weeks of high visitor use despite a peak in the trout run (Mattson et al. 1992). At Anan Creek, the upper falls provided an alternative fishing locale for bears not habituated to or tolerant of people. This behavioral predilection is likely sustained because bears at this site have little opportunity for habituation due to limited human access.

In addition, bears appear to be more tolerant of people and their activities where interactions are expected and innocuous (Craighead and Craighead 1971, Herrero 1983, Jope 1985, Craighead et al. 1995). In a field study on black bear foraging, Rogers and Wilkers (1990) found that their study subjects, which were habituated to researchers (<2 m), exhibited wariness and avoidance upon unexpectedly encountering those same researchers. At Anan Creek, human presence at the upper falls has been low for several years; this area was closed to the public from 1993–95 for research purposes and for portions of the 1991 and 1992 field seasons due to encounters with brown bears. Furthermore, access to the upper falls is difficult because the trail is not maintained and, thus, hazardous, especially in heavy rain. Therefore, encounters with people present a relatively novel experience to which bears may react more strongly. The behavior of a large, relatively wary male is consistent with this hypothesis. He tolerated but was vigilant to visitors at the lower falls on a few occasions in 1994. But throughout the study he consistently fled to the security of a rock cave or surrounding forest upon detecting our arrival at the upper falls.

Responses of Habituated Bears

Habituated bears are characterized by a lack of response to human presence or activity (Jope 1985, Olson 1993, Aumiller and Matt 1994). Where bears and people come into frequent, benign contact, habituation alleviates negative human impacts on some bears (Jope 1985, McLellan 1990) by allowing them to utilize common resources (Gilbert 1989, Gunther 1990). A stable relationship based on mutual recognition of individual boundaries between people and bears can be fostered where human activity is consistent and predictable (e.g., McNeil River State Game Sanctuary). Under such viewing conditions, bears will pass within an arm's reach of viewers while en route to the falls; brown bear females have been seen nursing their

cubs within 5 m of observers (Aumiller and Matt 1994). A similar adaptive syndrome existed at Anan Creek for a small subset of bears that regularly frequented the lower falls.

We tested several hypotheses concerning the effect of visitor numbers on the fishing activity of habituated bears at the lower falls. We found no declines in several measures of black bear activity (bear minutes, visits, diversity, different individuals) observed at this site in relation to visitor numbers, indicating that these bears are fairly resilient to relatively high levels of human disturbance. Furthermore, due to the placement of the observatory next to bear trails, bears approaching the creek on the north side passed regularly within 5–10 m of people on this platform. We frequently encountered the same few bears at very close distances (<15 m) on the trail where they slowly detoured around us without sign of distress.

However, we did reject the premise that visitor numbers do not affect overall fishing duration of bears at the lower falls. We found that bout lengths decreased as the number of people on the observatory surpassed a threshold of 15, indicating a subtle change in behavior in response to larger group sizes. Similarly, we found that 2 habituated bears spent less time in view as visitor numbers increased. To maintain total fishing time under high disturbance conditions, bears may be making more visits of shorter duration (incurring an additional energetic cost) to and from the creek.

We attribute the effect of high visitor numbers on fishing duration in part to a change in human social behavior we refer to as the cocktail hour effect. Small groups of people at the observatory were more engrossed in wildlife viewing whether a bear was out fishing or not. As visitors increased, the tendency for humans to interact socially with others also increased. People talking so loudly as to be heard over the roar of the falls resulted in greater disturbance to bears. Furthermore, movement by large groups of people on the observatory probably distracted or disrupted bears attempting to fish while, at the same time, remaining vigilant for other bears. Because time lost fishing equates to lost feeding opportunities, visitor group sizes larger than the threshold may have negative energetic consequences even for habituated bears.

As visitors were most numerous during midday hours, one might argue that temperature rather than large numbers of people was responsible for shorter fishing bouts. This seems unlikely. First, bout lengths at the upper falls (control site) were not of shorter duration during midday hours (Chi and Gilbert 1996). Second, local weather variation influenced midday temperatures more than did the time of day. Finally, we did not find that

more people visited Anan Creek on hot days; guided groups were scheduled in advance and arrived as planned unless travel was not possible due to lack of visibility or storms.

Brown Bear Activity at Anan Creek

Although it was not the focus of the research presented in this paper, the impact of brown bears on black bear foraging patterns at Anan Creek deserves mention. Brown bears prey on both cubs and adult black bears and pose a potential threat wherever they are sympatric (Miller 1985, Ross et al. 1988, Kasworm and Manley 1990, Mattson et al. 1992). Habitat use patterns of these 2 species have been documented under field conditions (Reinhart and Mattson 1990, MacHutchon et al. 1998). Black bears avoid areas or periods during which brown bears are active resulting in a temporal or spatial resource partitioning (MacHutchon et al. 1998).

At Anan Creek, we identified 10–15 individual brown bears each field season. Brown bears fished at both falls and thus did not deter black bears from utilizing these prime locations. However, based on all observations made between 0400–2300 hours, these 2 species appeared to be active at different times of the day. Brown bears were seen most frequently in the early morning (0400–0700) and evening (2000–2300), whereas black bears fished throughout the day (D. Chi, unpublished data). MacHutchon et al. (1998) found that where black and brown bear habitat overlapped with human recreational use, the location and timing of human disturbance influenced brown bear use patterns which, in turn, dictated when and where black bears were active. At Anan Creek, we suspect a similar cascading effect, as brown bears appeared more easily disturbed by people than black bears. Most visitors arrived between 0800 and 1800 hours; brown bears may have concentrated their fishing efforts around this window to avoid people, thus allowing black bears more diurnal use of the stream.

Regression Quantiles in Characterizing Effects of People on Black Bears

Recent ecological papers have emphasized the need for quantitative methods that model relationships between biological response variables and limiting environmental factors (Blackburn et al. 1992, Kaiser et al. 1994, Terrell et al. 1996, Thomson et al. 1996, Garvey et al. 1998, Scharf et al. 1998, Cade et al. 1999). In such relationships, a dependent or response variable may be influenced by any number of factors when it falls below a particular threshold for another factor (Kaiser et al. 1994).

For example, Cade et al. (1999:312) examined the relationship between species biomass (biological response variable) and habitat conditions (limiting environmental factor). They state that “changes in species biomass (Y) do not exceed limits imposed by habitat conditions (X) but can be reduced by nonhabitat factors (Z)”. Several methods have been used to quantitatively describe this type of relationship (e.g., partitioned regression, logistic slicing, tests for lopsidedness, regression quantiles; Thomson et al. 1996). However, regression quantile analysis is one of the few techniques whereby hypotheses can be statistically tested.

We believe that regression quantile analysis was a valid method for depicting the limiting effect people had on bear activity at Anan Creek. We had some concerns, however, regarding the computations and statistical tests. First, slopes of 90th regression quantiles for mean bout length and 3 habituated bears (DEU, WIS, and JUA) were much lower than expected based on a cursory inspection of the patterns. Cade et al. (1999) found that truncating zero counts (which made up 50% of observations) from a data set resulted in more highly negative slopes that differed significantly from zero. Our lack of more attenuated slopes may be due to the large number of zero or low values relative to the range we had for indices of bear activity, especially when fewer people were present. Moreover, it is possible that nonlinear quantile models would have better depicted patterns for a few of the individual data sets (DEU and JUA), as well as for mean bout length (B. Cade, U.S. Geological Survey, Fort Collins, Colorado, USA, personal communication, 1998).

Second, for 3 bears (LIM, SHA, and ZIP) the confidence intervals were excessively large and inconsistent with the test statistic or the slope of the 90th regression quantile. A resampling permutation test run on one of these data sets revealed that the sampling distribution of the rank score test statistic was bimodal and positively skewed (B. Cade, U.S. Geological Survey, Fort Collins, Colorado, USA, personal communication, 1998). This statistical anomaly may be due to discrete data groupings of the independent variable found in all 3 of these data sets. More observations along all values of the independent variable (visitor numbers) is needed to avoid this problem. Caution should be exercised when interpreting such conflicting results, as significance tests against the null model under these conditions may be inaccurate. Further experimentation with the rank scores and alternative permutation procedures on a variety of distributions is necessary to identify which approach is most appropriate for particular data sets (Koenker 1994).

CONCLUSIONS

Our results indicate that wildlife-viewing activities affect bears fishing at Anan Creek. We found that, although fish were accessible from both sites, some bears never used the lower falls and were displaced from fishing upon encountering people at the upper falls. At the lower falls, the duration of visits by tolerant bears decreased as visitors at the observatory increased. These results are a conservative estimate of human disturbance to bears at Anan Creek. Bears intolerant of people may have completely abandoned the area as the popularity of this site increased, leaving a remaining population composed of individuals able to habituate to various degrees of human disturbance. If so, we were relegated to documenting the outcome with no baseline reference for comparison.

MANAGEMENT IMPLICATIONS

In southeast Alaska, Anan Creek harbors one of the largest runs of pink salmon, an exceptional source of fat and protein for both black bears and brown bears. As the demand for wildlife-viewing opportunities grows, it becomes increasingly important to monitor and mitigate effects on wildlife, the resource upon which this activity depends. We discuss the applicability of our findings at 4 scales as proposed by Knight and Temple (1995).

Spatial.—Our data document the importance of having alternate foraging zones where bears can fish in the absence of human disturbance or distraction. At Anan Creek, the upper falls provided a refuge from visitor disturbance as well as superior fishing opportunities. Displacing bears from such ecologically significant micro-sites such as the upper falls could have negative consequences at a population level (Gilbert and Lanner 1992, Wielgus and Bunnell 1994b). Consequently, the natural integrity of this site should be maintained and anthropogenic disturbances kept to a minimum.

The lower falls may be attractive to subordinates and more importantly, to females with young as an option to avoid the threat large males pose to cubs at the upper falls. We noted one episode in 1995 when high water made fish inaccessible at the upper falls to all but a few bears for several days. During this time, some upper falls users were sighted at the lower falls while others abandoned the stream for the remainder of the season (Chi and Gilbert 1996). Hindering food acquisition by bears, particularly pregnant or lactating females, could contribute to reduced recruitment and affect population growth (Archibald et al. 1987, McCutchen 1990, Gilbert and Lanner 1992). For this reason, managers should set limits on the magnitude and duration of human dis-

turbance that results from wildlife-viewing activities at the lower falls.

Behavioral.—Large numbers of visitors on the observatory (>15) affected maximum fishing time of habituated bears. Placing restrictions on group size and providing education on appropriate viewing etiquette could reduce disturbance (Aumiller and Matt 1994, Fagen and Fagen 1994).

Temporal.—Although some bears were quite tolerant of people, we suspect that others did not fish at the lower falls due to the presence of people. Increasing the predictability and consistency of human activity by establishing fixed visitor hours might facilitate use by less tolerant bears (Fagen and Fagen 1992, Aumiller and Matt 1994, Herrero and Wiggins 1994).

Visual.—Our arrival to the upper falls consistently disrupted the fishing activity of bears, frequently resulting in their immediate displacement from the area. At either site, screening viewers from bears using blinds or hidden platforms and enclosed walkways would reduce distractions resulting from movement and would mask the sound.

At Anan Creek, there is a limited understanding of the movement patterns of black bears within and beyond this watershed. We need more information on larger spatial scales. Where do these bears go, what is the availability of other food sources, and how much do they utilize the upstream areas? This lack of information increases in importance as future timber cuts on the Cleveland Peninsula near the Anan Creek drainage are proposed and initiated. The degree to which bear populations depend on unique salmon runs like Anan Creek and availability of alternative forage opportunities throughout the season must be determined to better predict human impacts on bears (Titus et al. 1994).

The variation in individual behavior of highly intelligent organisms argues against use of statistical means of activity patterns to provide acceptable predictive capability. Examination of the causes of variation amongst individuals is best understood through long-term studies. Despite the constraints imposed by typical funding cycles, insights will only be revealed through commitment to these studies. Identifying behavioral syndromes could be useful to managers for generating predictions regarding human effects on population scale dynamics. Future research should address the challenge of developing models that incorporate individual variation (the range) and the frequency of behavioral phenotypes in a population to predict population level dynamics. This undertaking, although complicated with dynamics of habituation as well as the constant replacement of nonhabituated bears by more tolerant generations

(Aumiller and Matt 1994, D. Stonorov, Alaska Department of Fish and Game, Anchorage, Alaska, USA, personal communication, 1995), shows promise of developing realistic models and scenarios for resolving wildlife-human conflicts.

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