

VARIABLE IMPACTS OF PEOPLE ON BROWN BEAR USE OF AN ALASKAN RIVER

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Abstract: A quantitative study of the behavior of brown bears (*Ursus arctos*) was undertaken at Brooks River in Katmai National Park and Preserve 1988-90 to determine whether human activity affected use of the area by females with young. Over the 3 fall seasons 862 hours of systematic observations were recorded or not (late Aug through mid-Oct salmon spawning period). Ten different females with young were observed, 4 of them over a complete reproductive cycle. Each female was classified according to human tolerance as "habituated" ($n = 5$), or "nonhabituated" ($n = 5$). The seasonal patterns of family group activity were examined according to habituation class. There was a direct relationship between the distribution of river use by nonhabituated family groups and proximity to Brooks Camp, while no relationship was found for habituated family groups. Use of areas by nonhabituated families increased near Brooks Camp late in the season, when human activity and noise in camp decreased. Availability of fish for bears was highest in areas near camp; however, nonhabituated females with young used these areas significantly less than habituated families.

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Recreational activity in Katmai National Park and Preserve (NPP) has increased more than 2-fold over the past 10 years; visitor use of the Brooks River area increased from >5,350 visitor days in 1981 to >10,750 visitor days in 1991 (D.C. Nemeth, Natl. Park Serv., unpubl. data). With the passage of the Alaska National Interest Lands Conservation Act (1980), Congress specified that Katmai NPP should be a National Park Service (NPS) unit where:

"...fish and wildlife may roam freely, developing their social structures and evolving over time as nearly as possible without the changes that human activities would cause" (Senate report 96-413 1980:137).

The potential effects of increased visitation on brown bear (*Ursus arctos*) activity, particularly on females with young, is of concern to park management, as specified in the park's General Management Plan (NPS 1986a) and Bear Management Plan (NPS 1986b). Braaten and Gilbert (1987) and Warner (1987) reported few observations of bear family groups through the peak visitor-use period of June through early September, and an appreciable increase in sightings after that period. They hypothesized that females with young may have been inhibited from using the river by the activities of people.

In this paper we examine the effects of human activity at Brooks River on females with young during the fall salmon spawning periods (late Aug through mid-Oct) of 1988-90. We compare the use patterns of females with young differing in their tolerance of people, and relate these use patterns to human activity in the area, as well as to the activities of conspecifics and salmon availability.

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STUDY AREA

Katmai NPP is located on the northern portion of the Alaskan Peninsula (Fig. 1). The Naknek drainage, of which Brooks River is a part, comprises 1 of the 4 most productive salmon drainages in the region.

Brooks River serves as a major migratory route and, to a lesser extent, spawning stream for sockeye salmon (*Oncorhynchus nerka*). The river is approximately 2.5 km in length, flowing from Brooks Lake into Naknek Lake, with a 2-m high falls midway. The upper river is generally bordered by a forest cover of alder (*Alnus* spp.), spruce (*Picea* spp.), birch (*Betula* spp.), and willows (*Salix* spp.). Near the mouth of the river the banks are low and more open, supporting marsh areas.

There are 2 main periods of bear activity at Brooks River. The first occurs during the first 3 weeks of July when large numbers of salmon pass through the river, most headed toward upper tributaries (Merrill 1964). Brooks River is the first river within the park at which significant numbers of salmon become available to bears. Bears gather at the 2-m high Brooks Falls, where fish are captured as they jump and school below the falls. The number of salmon moving up the river declines towards the end of July, when most bears move on to other food sources.

Bear activity increases again along Brooks River at the end of August, and grows through September and October. This second "season" of bear activity far surpasses the bear activity levels of July (Troyer 1980a,

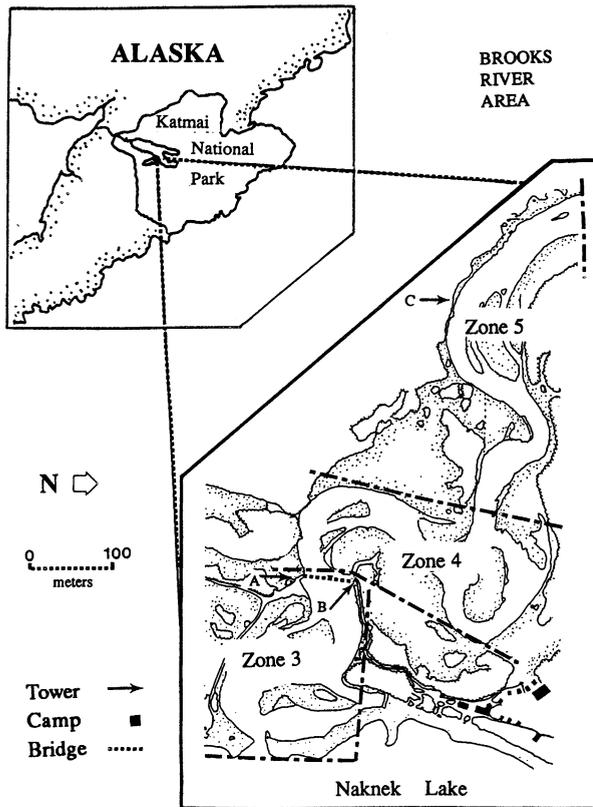


Fig. 1. Location of Brooks River in Katmai National Park and Preserve. Observation zones on Brooks River (below Brooks Falls) and tower locations (a = bridge tower 1988, b = bridge tower 1989-90, c = cutbank tower 1988-90) are indicated.

Braaten and Gilbert 1987, Warner 1987, Olson et al. 1990). Bears concentrate in the lower portions of the river during the fall as dead and dying, spawned-out salmon accumulate in backwaters, snags, and along the lakeshore.

Brooks River attracts many park visitors who come to fish, and to view and photograph bears. Brooks Camp, located on the north side of the river along the Naknek shoreline, provides facilities for park visitors and park and concessions employees (Fig. 1). The camp includes a lodge, visitor center, and park and concessions housing and support facilities. Beyond these buildings to the north is a 21-site campground. Brooks Camp is accessed by float planes and by boats, most originating in King Salmon, about 40 km to the northwest. The majority of planes land offshore from Brooks Camp and taxi to the shore at developed facilities.

Brooks Lodge closed on 10 September 1988-90. Closure of NPS and lodge facilities extended human activity in Brooks Camp to at least 10 days beyond closing of the lodge. Limited (2-4) NPS staff remained in Brooks Camp with reduced utilities through mid-October, and limited use of the NPS campground also continued through October. Use of the river in the fall by fly-in fishing groups increased over the years that the river was monitored, largely due to a change in NPS policy regarding use of the river by guided groups. In 1988 the river was closed to guided fishing after 10 September; in 1989 the upper river was open to guided groups, and in 1990 the entire river was open.

METHODS

Data presented were collected from 26 August to 12 October 1988, 1989, and 1990. Observations were taken only on the river below Brooks Falls to the mouth on Naknek Lake. This area was divided into 3 zones (Fig. 1):

- Zone 3: The river mouth, from the pontoon footbridge to Naknek Lake.
- Zone 4: The Oxbow, from the upper end of the Oxbow marsh to the pontoon floating bridge.
- Zone 5: The Cutbank, from the beginning of the rapids below Brooks Falls to the upriver end of the Oxbow marsh.

Observers viewed Zones 3 and 4 simultaneously from a 4-m tower of scaffolding. This tower was located on the south side of the river at the bridge in 1988, and on the north side of the river directly opposite its original location in 1989 and 1990. Comparisons of data collected from both locations showed no apparent effect on total bear minutes observed. Zone 5 was monitored from a 3-m tree stand on the south side of the river atop a 3-m eroding bank.

Observation sessions were scheduled systematically; the sampling regime produced balanced coverage through all daylight hours and across all observation zones within a consecutive 4-day sample period.

Records of identifying characteristics of individual bears were maintained. Many bears were recognized between study years (18/62); however, changes in physical appearance may have precluded reidentification of some individuals. Each female with young was classified as habituated or nonhabituated to people. However, it should be noted that each of these 2 categories encompassed a range of individual tolerances. Habituation was defined as consistent tolerance of people at 50 m or less with no significant change in behavior.

Complete record sampling (Slater 1978) and focal sampling (Altmann 1974) were used to record information regarding bear activity; scan sampling was used to sample human activity (Altmann 1974).

Arrival and departure times and individual identities were recorded for all bears seen during an observation session. Frequency of fish capture and duration of fishing and consumption were also recorded for a subsample of the individuals using the monitored area. Since portions of dead salmon were retrieved by bears, these were recorded to the nearest quarter.

The total number of people present within the observation zone was recorded at 10-minute intervals throughout the observation session. During each 10-minute period the number of engine sounds (and other loud disturbances) was tallied.

Bear activity over the fall sample period was summarized by observation zone using consecutive 4-day blocks, corresponding with the sampling regime. Observed levels of bear activity, total bear minutes (tbm), and human activity, total people (tp), are reported as rates (tbm/tom and tp/ts) calculated using total sample minutes (tom) or scans (ts) as the divisor. Fish capture rates (e.g., fish caught per fishing hour [f/fh]) were derived from the individual bear fishing data, using total fishing hours (fh) as the divisor. Fish capture rates served as an index to salmon availability in each of the observation zones. Because total sample period times between zones and years were slightly different, percent-use figures by zone were derived using activity rates adjusted by total sample time.

Visual inspections of the distributions of use by bears and people across the fall sample periods showed remarkable similarity among years. A Kruskal-Wallis (K-W) 1-way layout indicated no significant differences in use of each observation zone by individual habituated and nonhabituated bears among years ($P > 0.10$); dates of regular river use (third Julian dates seen) by these individuals were also similar among years (K-W $P > 0.10$). Mann-Whitney 2-sample rank tests comparing rates of bear activity and human activity in each zone and year prior to and following lodge closure also demonstrated similarity (Table 1). We therefore pooled the data across the 3 years for most analyses.

A Poisson model (Frome 1983, Baker 1985) of fish capture rates was used to evaluate differences in catch rates among zones through the fall sample period. Standard nonparametric data procedures followed Zar (1984). $P < 0.05$ was considered significant.

RESULTS

Approximately 950 hours of systematic observation

time were recorded over the 3 fall periods. Time periods and locations not comparably sampled between years were removed prior to data analysis, leaving 862 hours of observation reported here (1988 = 283 hr, 1989 = 297 hr, 1990 = 282 hr).

Eleven different females with young were identified. Ten of these females were classified according to habituation status: 5 as habituated and 5 as nonhabituated. Limited observation time for 1 female (19 min on 1 occasion) precluded classification of her tolerance of proximity to people and she was not included in comparisons presented here.

Fish Capture Rates

A Poisson model of bear fish capture rates summarized by 4-day sample periods for each zone showed a significant interaction between zone and sample period ($P = 0.01$). Examination of the residuals from a model without the interaction term indicated that lack of fit was restricted to 2 sample periods; fish capture rates showed an otherwise similar pattern of gradual increase in each zone through the fall. Rates in Zone 5 were consistently lower than those in Zones 3 and 4. Median rates of fish capture were 19 fish/fishing hour in Zone 3, 19 f/fh in Zone 4, and 11 f/fh in Zone 5.

Seasonal Use Patterns by Zone

Human Activity.—Human activity on the river declined substantially after the lodge closed on 10 September (Fig. 2d). Winterizing activities by lodge and NPS staff led to continued activity in Brooks Camp through at least 22 September. The number of people observed on the river varied across sample years due to a change in policy that allowed guided fishing in the zones sampled in 1990. Across the 3 years, the maximum number of people counted in any one scan in Zone 3 was 37 (1989), in Zone 4 was 9 (1990), and in Zone 5 was 25 (1990). Overall, 52% of human activity was recorded in Zone 3, 3% in Zone 4, and 45% in Zone 5. Activity in Zone 3 involved largely photographers, bear viewers, and staff (75%), while Zone 5 was used principally by anglers (79%). Human use showed 2 noticeable declines: one following lodge closure 10 September, the other at the beginning of October when fly-in fishing groups stopped using the river (Fig. 2d).

Noise occurrence rates declined through the fall sample period as human use decreased (Fig. 2). Lowest rates were recorded in Zone 5, the observation area farthest from camp.

Bear Activity.—Adult males favored use of Zone 4,

Table 1. Median rates of habituated and nonhabituated family group activity (tmb/tom) and human activity (tp/ts) recorded prior to (Pre = 26 Aug-10 Sep) and following (Post = 11 Sep-12 Oct) lodge closure.

| | Zone 3 | | | Zone 4 | | | Zone 5 | | |
|---|--------|-------|-------|--------|-------|-------|--------|-------|-------|
| | 1988 | 1989 | 1990 | 1988 | 1989 | 1990 | 1988 | 1989 | 1990 |
| Habituated Family Group Use ^a | | | | | | | | | |
| Pre | 0 | 0.006 | 0.106 | 0.047 | 0.165 | 0.182 | 0.027 | 0.122 | 0.088 |
| Post | 0.194 | 0.412 | 0.426 | 0.152 | 0.189 | 0.344 | 0.078 | 0.218 | 0.109 |
| <i>p</i> ^b | * | ** | ** | | | | | | |
| Nonhabituated Family Group Use ^a | | | | | | | | | |
| Pre | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Post | 0 | 0 | 0 | 0.089 | 0.018 | 0.068 | 0.392 | 0.354 | 0.270 |
| <i>p</i> ^b | c | c | c | * | * | * | ** | ** | ** |
| Human Use | | | | | | | | | |
| Pre | 3.84 | 7.32 | 4.84 | 0.02 | 0.26 | 0.15 | 2.81 | 4.22 | 4.16 |
| Post | 0.58 | 0.40 | 0.71 | 0.01 | 0 | 0.11 | 0.16 | 0.12 | 2.74 |
| <i>p</i> ^b | ** | ** | ** | | * | | * | ** | * |

^a Within each use category, significant differences within columns are indicated as * ($P < 0.05$) or ** ($P < 0.010$).

^b Based on Mann-Whitney 2-sample rank tests, each with $n_{pre} = 4$ $n_{post} = 8$.

^c Rates were not tested as they were virtually all (32/36) zeroes.

with 49% of all male minutes observed in this zone. Use of Zones 3 and 5 by males was approximately equal (26% min Zone 3, 26% min Zone 5). Use of Zone 3 was primarily by 2 habituated males (75% min); upriver these 2 males accounted for less of the total male use (Zone 4 = 50% min, Zone 5 = 32% min). The median number of adult males observed during the fall was 11. Greatest use by other bears was in Zone 5 (39% min), followed by Zone 4 (35% min), and Zone 3 (27% min); a median of 17 different individuals was observed each year.

Habituated family groups were already using the river when sampling began 26 August, while nonhabituated family groups were not observed using the river until 10 September. The arrival of nonhabituated family groups each year consistently coincided with a substantial reduction in visitor numbers due to closure of the lodge. All 5 habituated family groups were observed on the river by 15 September; 4 were regularly using the river by the first week of September. Three of the 5 nonhabituated family groups were first sighted after the second week of September.

Zone 3, the zone closest to Brooks Camp, was used almost exclusively by habituated family groups (98% total family group min recorded) (Fig. 2a). Activity in this zone by habituated family groups increased through

September and reached its highest level of 0.60 tmb/tom 5-8 October. The small amount of activity by nonhabituated family groups occurred in October, after human use and noise had reached their lowest levels.

Both habituated and nonhabituated family groups used Zone 4; however, habituated family groups again accounted for a higher percentage of the total family minutes observed (72%). Nonhabituated family groups showed a gradual increase in use through September. Rates of activity by these bears during October averaged a 10-fold increase over periods of activity in September. This marked increase in use coincided with lowest rates of noise occurrence and human activity (Fig. 2b). Use of Zone 4 by nonhabituated females was largely by 2 individuals (97% Bear #13 and Bear #38).

Habituated family groups showed variable levels of activity in Zone 5, and with declining use rates by October as accumulations of dead salmon increased downriver. In contrast, nonhabituated family groups increased use through the first 4 days of October, and use rates were still at their highest levels as they declined the last week of sampling (Fig. 2c); these high levels of use coincided with decreased use of Zone 5 by anglers and an overall decline in human activity and noise occurrence. Nonhabituated family groups accounted for 62% of the minutes recorded in Zone 5.

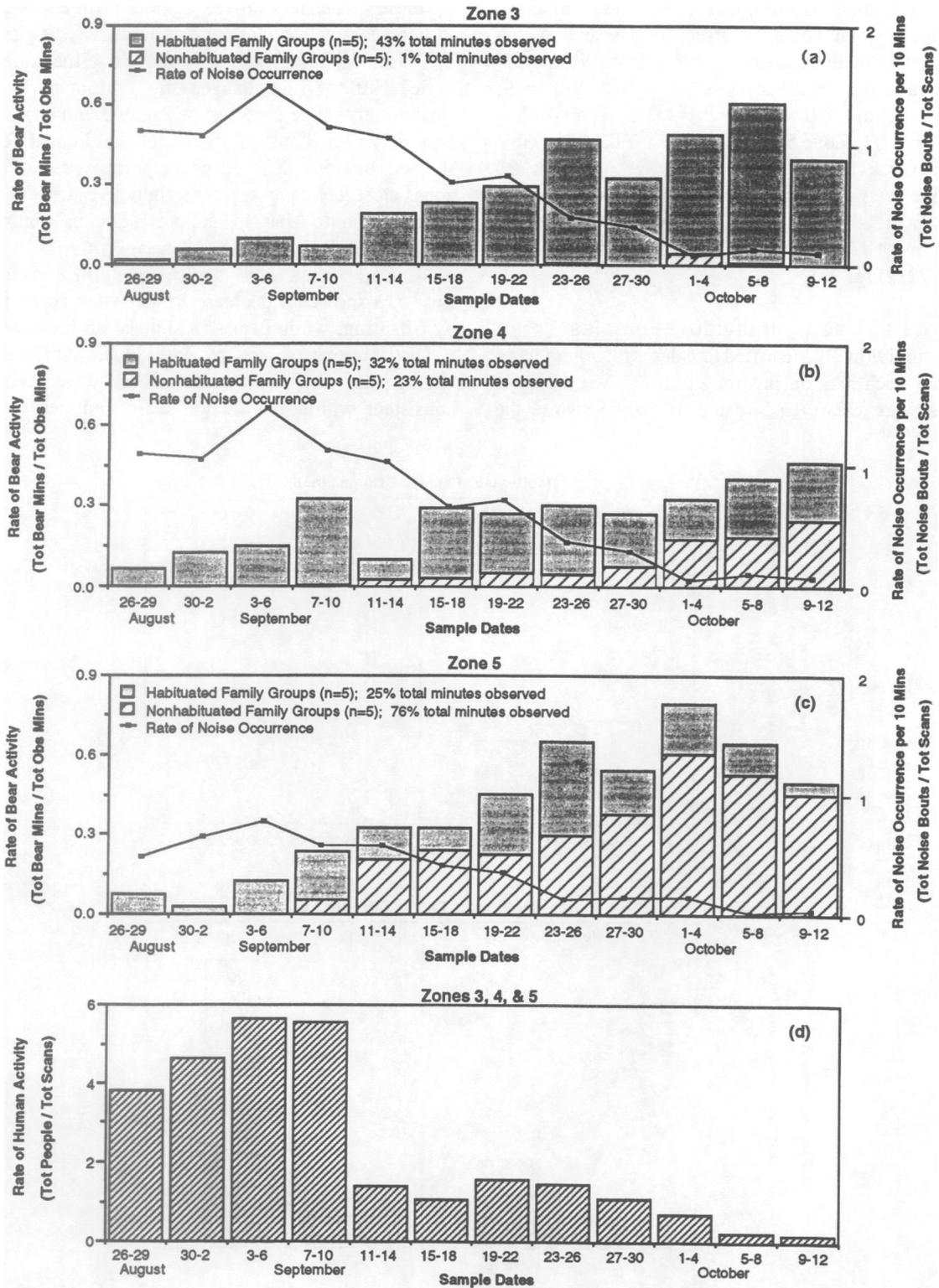


Fig. 2. The seasonal pattern of rates of noise occurrence and bear family group activity by observation zone. Human use is summarized across all 3 zones.

A significant increase in use by nonhabituated family groups was apparent in Zones 3, 4, and 5 after 30 September, when noise occurrence rates and human activity were at their lowest levels (Mann-Whitney 2-sample rank tests ≤ 30 Sep vs. >30 Sep, $n_{<30} = 9$, $n_{>30} = 3$: Zone 3 $U = 50.0$ $P = 0.05$, Zone 4 $U = 45.0$ $P = 0.02$, Zone 5 $U = 45.0$ $P = 0.02$) (Fig. 3b). Increased use by habituated family groups after 30 September was apparent only in Zone 3 (≤ 30 Sep vs. >30 Sep, $n_{<30} = 9$ $n_{>30} = 3$: Zone 3 $U = 47.0$ $P = 0.04$, Zone 4 $U = 58.0$ $P = 1.00$, Zone 5 $U = 61.0$ $P = 0.72$) (Fig. 3a).

Patterns of Use by Individual Females

Four individually identified females with young were observed each fall during the study. Two of these females were clearly habituated to people, while the

other 2 were nonhabituated. A comparison of zone use by these 4 females showed distinct differences related to both habituation class and reproductive status (Fig. 4). Use of Zones 3 and 4 by the 2 habituated females varied little with changes in reproductive status (maximum change in % use of Zones 3 and 4 = 9% by Bear #7). In contrast, the 2 nonhabituated females showed obvious differences in percent use of the 2 zones closest to camp when reproductive status changed from single to that of supporting cubs (maximum change in % use of Zones 3 and 4 = 37% by Bear #38). The change in use was different for each female: Bear #13 showed a decrease in use when accompanied by offspring, while Bear #38 showed an increase.

Distributions of use by individual family groups among the 3 observation zones were relatively consistent within habituation class and across years

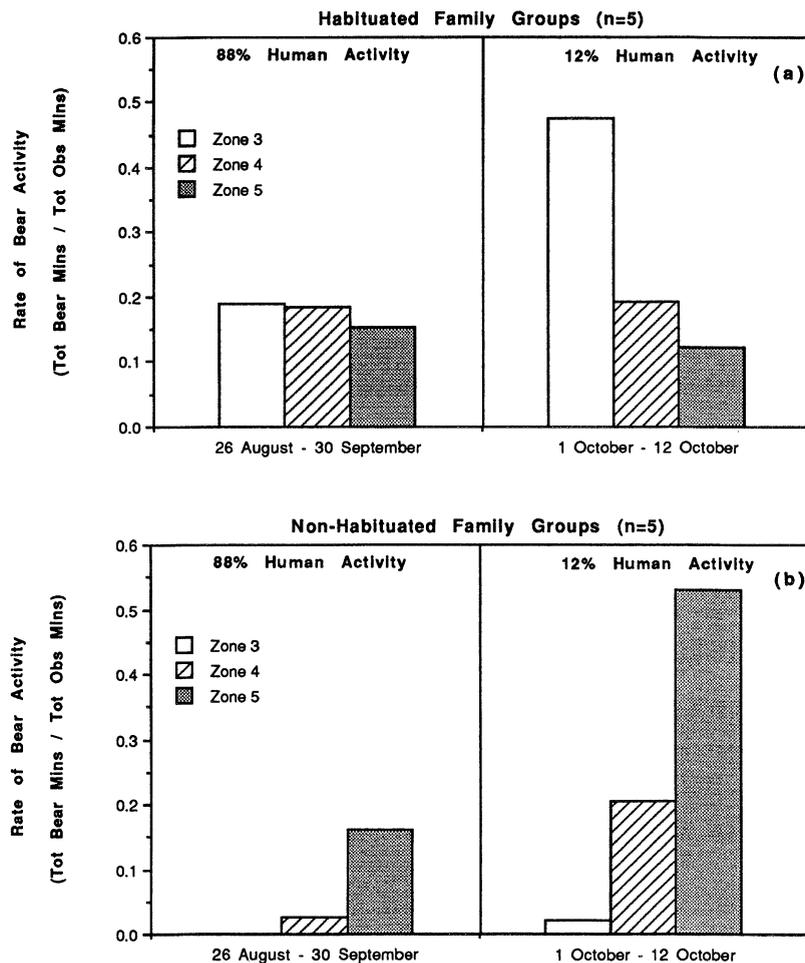


Fig. 3. A comparison of activity levels by zone of habituated and nonhabituated family groups during August-September (high human use) and October (low human use).

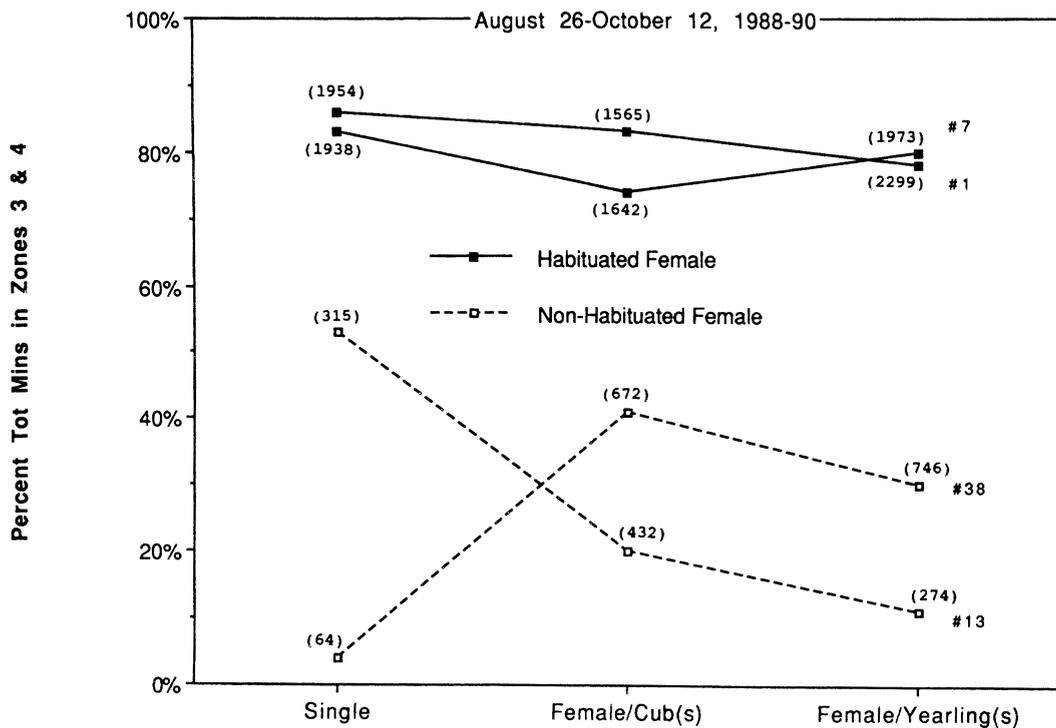


Fig. 4. A comparison of reproductive status with percent use of Zones 3 and 4 by individual females recognized across all years of the study. The total minutes each female was observed is indicated in parentheses.

(Fig. 5). Four of the 5 habituated females used Zones 3 and 4 significantly more than Zone 5 (Wilcoxon matched-pairs signed-ranks test: $T = 1.0$, $n = 7$, $P = 0.04$; medians: Zones 3 and 4 = 0.17, Zone 5 = 0.06), while nonhabituated females all showed significantly greater use of Zone 5 ($T = 0.0$, $n = 7$, $P = 0.02$; medians: Zones 3 and 4 = 0.03, Zone 5 = 0.12). The distributions of use by nonhabituated family groups appeared relatively consistent across sample years, even as human use of Zone 5 increased in 1990.

DISCUSSION

Our impression was that the scan counts of people present were not entirely representative of the degree to which human activity affected each zone. Indirect exposure to people occurred in Zones 3 and 4, due to the proximity of Brooks Camp. Limited staff and visitors remained in Brooks Camp and Campground through the end of sampling each year, and in 1988 and 1990 a small stand-by generator was in constant operation.

After the pontoon footbridge was removed in mid-September, motor-boats and canoes were frequently used to cross to the south side of the river in Zone 3.

Most planes continued to land on Naknek Lake, taxiing to shore at Brooks Camp. Although we tallied the number of noise bouts heard during 10-minute intervals, the relative intensity of any noise bout was unmeasured. For example, a plane landing on Naknek Lake had greater impact in Zone 3 (river mouth) than in Zone 5 (upriver), but it was recorded by an observer in either zone as 1 noise bout.

Differences in area between observation zones made counts of people difficult to evaluate. When both nonhabituated family group(s) and people were present within an observation area, they were almost invariably observed at greater than 100 m from each other, sometimes as much as 450 m. Potential spacing between bears and people was most limited in Zone 3 due to the developed area on the north side of the river. Zone 4 provided more alternative routes to bears; however, the developed area on the north side of the river again placed some limits on where a female with young could travel and still remain far from people or the Brooks Camp site. Zone 5 had the most alternative routes for bears due to the large size of the zone, and because there were no developed areas on either side of the river.

Considering the degree to which indirect sources of

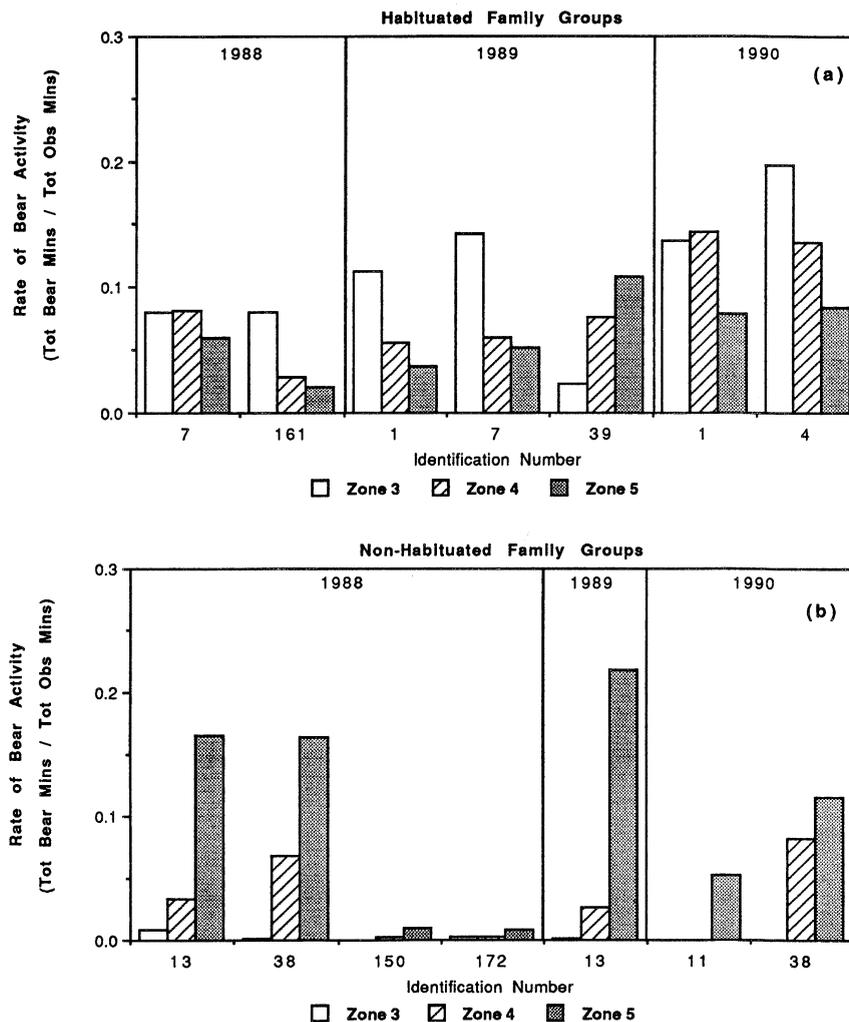


Fig. 5. Distribution of use among the three observation zones by individual habituated and nonhabituated family groups.

human use from activity in Brooks Camp affected Zones 3 and 4, we divided the lower river into 3 observation zones based on the following levels of human exposure:

- Zone 3: Greatest human impact
- Zone 4: Intermediate human impact
- Zone 5: Least human impact

Habituation and Distributions of Use

Females with young have been reported to be underrepresented at McNeil River (Stonorov and Stokes 1972, Egbert and Stokes 1976), particularly when salmon appeared accessible to family groups away from the concentration of bear activity at the falls. We did not observe such a lack of use by family groups at Brooks River between 1988 and 1990. Activity by

bears at Brooks during the fall was, however, far less concentrated than at McNeil, due to the distribution of salmon carcass accumulations throughout the river, so females with young may have been able to feed effectively and still maintain distance from other bears. Also, feeding on spawned-out salmon occurs later than fishing at McNeil, so bears were presumably more satiated.

Nonhabituated Family Groups.—The distribution of nonhabituated family group activity across zones demonstrated a stronger response to human activity than to fish availability. Their use was concentrated in Zone 5, the area of lowest fish capture rates. Increased use of Zone 4, where fish capture rates were higher, was observed in late September and October. This activity was largely by 2 of the 5 nonhabituated families, and

coincided with both decreased human activity and noise occurrence rates. The females who did use Zone 4 may also have responded to the accumulation of salmon carcasses downriver late in the season. However, over the 3 fall sample periods only 2.2 hours of use by the 5 nonhabituated families was observed in Zone 3, where these accumulations of salmon were also available. This was in contrast to 113.5 hours of activity by the 5 habituated families.

In 1990 nonhabituated family group activity continued to be concentrated in Zone 5, despite relatively high day use by anglers. On several occasions Bear #38 was observed fishing in this zone while anglers were present. In those cases the anglers were often at the opposite end of the zone. However, the other nonhabituated family was never observed on the river with people present, similar to 2 other nonhabituated family groups seen in 1988. Also, activity by nonhabituated families increased substantially in both Zones 4 and 5 during October, when groups of anglers stopped using the river. Continued use of the river by some nonhabituated family groups despite increased human activity in 1990 may reflect the high energetic demands of supporting dependent young (Gittleman and Oftedal 1987, Oftedal and Gittleman 1989).

Nonhabituated females with young have been involved in most reported charges at Brooks River since 1987 (Olson et al. 1990: $n = 4/4$, R.C. Squibb, NPS, unpubl. data 1989-91: $n = 18/19$). Olson et al. (1990) reported that in >60% of high-intensity encounters, several of which were charges, the encounter resulted in the bear leaving the immediate area. The probability of such encounters appears highest late in the season due the high level of activity by nonhabituated females with young (Olson et al. 1990), and there is therefore greater potential for displacement of bear families from the river at that time. The effects of such displacements are unknown; however, Troyer (1980b:16) emphasized the significance of Brooks River to bears during the fall, as "the Savonoski River, some 20+ miles from Brooks, is the only other close stream that harbors salmon in late fall."

Habituated Family Groups.—Habituated family groups appeared to distribute their use primarily in relationship to salmon availability. Activity by these bears was concentrated in Zones 3 and 4 where fish were most abundant, based on capture rates. As salmon carcasses accumulated in Zones 3 and 4 in October, these families showed even less use of Zone 5. Use of Zone 3 by these females not only provided access to a zone with high fish capture rates, but

probably also allowed for less interaction with adult males, most of whom concentrated use in Zones 4 and 5.

Human activity appeared greatest in proximity to Brooks Camp, and use of Zone 3 by habituated females resulted in more constant exposure of their young to people. The degree to which the dependent offspring of habituated females are exposed to people could be important to consider if they retain that degree of habituation when independent. Between 1989 and 1991 at Brooks River most property damage and encounters in which a bear obtained food or fish from a person involved habituated subadults, habituated adult females, or dependent young of habituated females (R.C. Squibb, NPS, unpubl. data).

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