Effects of Bear Viewers and Photographers on Brown Bears (*Ursus arctos*) at Hallo Bay, Katmai National Park and Preserve, Alaska

by

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A

THESIS

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By

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Abstract

We investigated the effects of bear viewing and photography on brown bears (*Ursus arctos*) that used open habitats at Hallo Bay, Katmai National Park and Preserve (KNPP), Alaska. We also investigated how bear use of the area varied with season, human presence, and time of day. We found that the mean number of bears present varied significantly with season, time of day, and human presence. There were significantly more bears present before the salmon season than during the salmon season; bear numbers increased significantly during the day, and there were significantly more bears when humans were present.

Humans at varying distances least affected activity budgets of sows with spring cubs, but foraging efficiency (bites per minute) of sows with spring cubs was significantly lower with humans <50 m away than with humans absent. Fishing success (chases per catch) of large males and single bears was lower when humans were present, but fishing success of sows with spring and older cubs was higher when humans were present.

We conclude that humans are affecting brown bears that use Hallo Bay and therefore the Katmai NPP Bear Management Plan is being violated as well as the act establishing the National Park Service.

We recommend that managers at KNPP restrict visitor use at Hallo Bay and enforce existing policy.

Introduction

Recreational viewing of wildlife has grown steadily since the late 1970s (Vickerman and Hudson 1991). Many states, including Alaska, promote tourism based on wildlife viewing and photography. The brown bear (*Ursus arctos*) viewing industry along the coast of Katmai National Park and Preserve (KNPP) has been increasing since the late 1980's. Human use of the coast of KNPP is concentrated into a few areas as a result of few high quality bear viewing areas and difficult access along the coast.

KNPP encompasses 1.4 million ha on the Alaska Peninsula and is home to 1,500-2,000 brown bears (Sellers et al. 1999). The coast of KNPP has the highest density of brown bears in the world and is designated as wilderness. While wilderness designation provides protection from human sources of habitat loss, indirect disturbances can also reduce habitat quality (Mattson 1990). Indirect disturbances result when human activities displace animals from preferred habitats or alter behavioral patterns critical for survival and reproduction (Steidl and Anthony 2000). In the case of bears, which hibernate for 5-7 months each winter, small reductions in energy acquired during the active months can impair reproductive success or survival (Rogers 1976, Elowe and Dodge 1989, Hilderbrand et al. 1999a, 1999b).

Numerous studies have indicated that human activities can alter brown bear demography, activity budgets, temporal use, and habitat use in areas of both high human use (Warner 1987, McClellan and Shackleton 1989, Fagen and Fagen 1990, Gunther 1990, Olson and Gilbert 1994, Olson et al. 1997), and low human use (White et al. 1999). When human activity affects activity budgets of brown bears, the effect is usually a decrease in feeding efficiency (Olson and Gilbert 1994, Olson et al. 1997, White et al. 1999).

Although several studies have investigated the effects of human activities on brown bears (Fagen and Fagen 1990, Olson et al 1997, Olson et al 1998, Wilker and Barnes 1998), these studies focused on developed viewing areas in Alaska. In Katmai National Park and Preserve, research into the effects of bear viewing and other human activities on brown bears has been concentrated in the Brooks River area.

Bear viewing along the Katmai coast was initiated after the Exxon Valdez oil spill in 1989. Pilots and boat operators hauling cleaning crews along the Katmai coast realized the potential for bringing tourists to the Katmai coast for bear viewing. The following summer, guides started bringing clients to the Katmai coast. During our study, commercial guides flew their clients to the coast and accompanied the clients inland to view and photograph bears, with no oversight by National Park Service personnel.

The KNPP Bear Management Plan (National Park Service, 1986:1) states that the "…policy of bear management in Katmai is to retain the natural population dynamics of bears, (and) allow their natural patterns of feeding and habitat use to continue unimpeded…" We investigated the effects that these visitors had on the brown bears that used Hallo Bay. We selected Hallo Bay as our study site as it received use by brown bears and tourists throughout the summer season, and the open habitats at Hallo Bay allowed us to view bears and tourists simultaneously.

We used focal sampling (Altmann 1974) to record activity budgets, feeding rates, and fishing success of brown bears with no humans present and with humans present at varying distances from the bears. We used scan sampling (Altmann 1974) to record the number and sex and age classes of bears at Hallo Bay, with and without humans present.

Chapter 1 is a broad investigation of how bear use of the study area varied with human use of the area in regard to total number of bear groups and by each social class of bear. A bear group is defined as a single bear or a family group of bears. Chapter 2 is a much more detailed look at how the activity budgets, grazing efficiency, and fishing success of bears at Hallo Bay varied with humans at different proximities.

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Chapter 1. Effects of season, time, and human activities on brown bear use of Hallo Bay, Katmai NPP, Alaska.

Abstract: We used scan sampling to investigate the effects of human activity, primarily bear viewing and photography, on a population of brown bears (*Ursus arctos*) that used the open habitats at Hallo Bay, Katmai National Park and Preserve (KNPP), Alaska. We recorded 1,505 scan samples during the summers of 1998 – 1999, 1,219 without humans and 286 with humans. Univariate analysis of variance revealed that season, time of day, and human presence significantly affected the mean number of bears that used Hallo Bay. There were significantly more bears present before than during salmon season; bear numbers increased significantly during the day before tapering off very late in the day, and there were significantly more bears when humans were present.

Before the salmon migration, there was a significant increase in mean number of large males through the course of the day. During the salmon migration, the mean number of large males peaked between 0800 –1200 and 2000 – 2359 hours. Sows with spring cubs used the study area very little from 0000 until 0759 hours. After 0800 hours, their use of the area increased and remained near the same level throughout the day. Before the salmon migration, the mean number of sows with older cubs was significantly higher with humans present than absent. The number of single bears increased throughout the day, and there were significantly more single bears before than during the salmon migration.

The policy of bear management in KNPP is to "…retain the natural population dynamics of bears, (and) allow their natural patterns of feeding to continue unimpeded..." The level of human use during 1998-99 may have reached a limit of use within the bounds of Park policy.

1.1 INTRODUCTION

Recreational viewing of wildlife has grown steadily since the late 1970s (Vickerman and Hudson 1991). Many states, including Alaska, promote tourism based on wildlife viewing and photography. The brown bear (*Ursus arctos*) viewing industry along the coast of Katmai National Park and Preserve (KNPP) has been increasing since the late 1980's. Human use of the coast of KNPP is concentrated into a few areas as a result of few high quality bear viewing areas and difficult access along the coast.

One of the highest densities of protected brown bears (*Ursus arctos*) on earth resides in KNPP. The policy of bear management in KNPP is to "…retain the natural population dynamics of bears, (and) allow their natural patterns of feeding to continue unimpeded..." (Katmai Bear Management Plan, National Park Service, 1986:1). While this policy is subject to varying interpretation, it mandates a low tolerance for any human impacts. Meeting the goals of this policy becomes more difficult as human use of KNPP increases.

Human activities can affect wildlife via exploitation, disturbance, habitat modification, and pollution (Knight and Cole 1995). Disturbance is the primary impact within national parks. Several studies have documented changes in use of an area by brown bears in areas of high human use (Warner 1987, Olson et al. 1997, MacHutchon et al. 1998, Olson et al. 1998, Crupi and Gilbert 2002). These studies showed that the number of bears using an area, as well as timing of bear use, changed in response to humans. More specifically, bears shifted their activity patterns from a diurnal to a crepuscular pattern in areas of high human use. Such changes are likely contrary to management for natural and healthy populations of bears, and mitigation of such impacts is likely necessary. Management recommendations generally include limiting the

total number of human visitors, controlling the access and behavior of these visitors, and preventing food conditioning of bears (Aumiller and Matt 1994).

At Hallo Bay, where human use was relatively low, it is unclear what level of human use causes changes in bear use and behavior. Little work has been done in remote areas with few visitors and potentially wary bears. Human use at Hallo Bay was low. It is an area of high bear use due to the concentration of important bear foods, including sedges (*Carex spp*.) and salmon (*Oncorynchus spp*.). Bears along the coast generally preferred these 2 resources (T. Smith, unpublished data). We therefore examined the effects of human presence on bears in foraging areas. We assumed that any change in numbers of bears was a negative impact.

Based on Warner (1987), MacHutchon et al. (1998), and Crupi and Gilbert (2002), we predicted fewer bears would use Hallo Bay when humans were present. We also expected a change in the composition of the bear population using Hallo Bay when humans were present. We predicted that there would be fewer adult male bears and more females with cubs and single bears when humans were present.

In order to investigate these effects, we tested the following null hypotheses:

1. The total number of bears using Hallo Bay would not differ by human presence, by season, or by time of day.

2. Numbers of each class of bears would not differ when humans are present versus absent, by season or by time of day.

Study Area

Hallo Bay is located along the coast of KNPP in south central Alaska (58°26’ N, 154°04’ W), approximately 23 km south of Cape Douglas (Figure 1.1). The Aleutian Range is located a few kilometers to the west and Shelikof Strait separates the Katmai

coast from the Kodiak Island Archipelago. We conducted our study in the open sedge marsh and intertidal habitats with elevations ranging from –3 m to 5 m ASL. The climate was maritime, and temperatures ranged from 0° to 21° C. Mean daily high temperature was 14° C.

The study area at Hallo Bay encompassed about 7 km^2. It included extensive tidal flats, a large creek that drains into Hallo Bay (called Middle Creek for this study) that formed the southern boundary, two tributaries of Middle Creek, sedge meadows, vegetated dunes, and several patches of drier grass habitat. The tidal flats extend up to 1 km into Hallo Bay at the lowest tides. The study area extended up to 1.6 km inland from the shore of Hallo Bay. Black cottonwood (*Populus balsamifera*) and paper birch (*Betula papyrifera*) forest formed the inland boundary of the study area.

Carex ramenskii, C. lingbeyi, Plantago maritima, Triglochin palustre, and *Pucinellia spp.* dominated the sedge meadows. *Elymus mollis, Angelica lucida, Ligustichum scoticum*, and *Epilobium angustifolium* dominated the vegetated dunes and drier grass habitats.

Middle Creek and its tributaries are migratory routes for migrating chum (*Oncorynchus keta*) and silver (*O. kisutch*) salmon. Chum salmon began entering the creek in early July with a peak in early August and silver salmon entered in late July with a peak in late August. Silver salmon continued spawning into September.

1.2 METHODS

We used scan sampling (Altmann 1974) to record the number of bears and humans using Hallo Bay during the summers of 1998-99. We observed bears from a 4-m high observation tower that enabled viewing the entire study area. The observation

tower was located about 700 m north of the mouth of Middle Creek and 15 m inland from the high tide line of Hallo Bay, in the beach grass zone.

We randomly determined which tidal cycle to observe bears each day. Starting at high tide we recorded scans every 30 minutes until the following high tide. Each scan sample began at zero degree azimuth (north) from the observation tower and rotated in a clockwise direction back to zero degrees.

During a scan, we recorded the number of bears and humans that we could see within the study area. We also recorded habitat used, activity, and distance to nearest bear for each bear counted. Additionally, we recorded temperature, wind speed, wind direction, sky cover and precipitation at least every hour. We divided the summer into 2 seasons: before the salmon migration and during the salmon migration. The onset of salmon migration was defined as the time when bears were first observed actively pursuing salmon. Bear use of Hallo Bay varied throughout the day, so we divided the day into 6 4-hour blocks starting at 0000 hours Alaska Daylight Time.

We used all occurrences sampling (Altmann 1974) to record the arrival and departure of humans via air or watercraft. These data were recorded every day and at all hours of the day, and included type of craft, number of people, time of arrival and departure, and what general area of Hallo Bay they visited.

Statistical Analysis

We used Analysis of Variance to determine whether: 1) the total number of bears using the study site at Hallo Bay varied by season, time of day, or human presence, and 2) numbers of each class of bear using the study site at Hallo Bay varied by season, time of day, or human presence. For *post hoc* analyses, we used the Tukey HSD

correction to discern during which time blocks bear group numbers were significantly different from each other.

We compared scans with no humans followed by scans with humans using paired t-tests to determine if the arrival of humans resulted in a significant change in number of bear groups. We then compared scans with humans present that were immediately followed by scans with no humans present and compared these using paired t-tests to see if the mean number of bear groups changed after humans left the study area. We set significance for all analyses at $\alpha < 0.05$.

1.3 RESULTS

We recorded 1,505 scans during 2 field seasons, 1,219 without humans and 286 with humans present. More than 70% of scans with humans present were recorded between 1200 and 1959 hours Alaska Daylight Time (Figure 1.3). Counts ranged from a low of zero bear groups to a high of 39 bear groups totaling 54 bears (8 large males, 4 sows with cubs, 9 sows with older cubs, and 23 single bears). The number of cubs with their mother ranged from 1 – 3 for spring cubs, 1 – 2 for yearlings, 1 – 2 for 2-year olds, and was 2 for 3-year olds.

Tourist Visitation

Tourist visitation to Hallo Bay occurred from late May to early September and most use occurred between 1200 h and 2000 h (Figure 1.3). Weather was the primary determinant of human visitation, with poor weather preventing floatplanes from reaching Hallo Bay. Visitors arrived from Homer and Kodiak, Alaska, primarily by floatplane, although a few visitors arrived by boat. Most short-term visitors (no overnight stay) who arrived by plane remained in Hallo Bay for 1/2 to 2 hours ($\bar{x}$ = 81 minutes, SE = 8.9, range = 5 minutes – 4 hours, n = 81 groups) and spent time watching and photographing

bears. They remained in close proximity to the guide and remained greater than 100 m from bears. Visitors who arrived by boat spent from 1 day to 4 days at Hallo Bay. Unguided visitors to Hallo Bay frequently violated the distances policies of KNPP.

Visitor Use Days (VUDs) at Hallo Bay numbered approximately 320 in 1998 and 400 in 1999 (Figure 1.4). VUDs continued to show an increase from 2000 – 2003 (B. Brock, NPS, Anchorage) (Figure 1.4). The VUD numbers in 2000 – 2003 were probably understated as the Park depends on guides to report their numbers of clients taken to the Park each year, and the guides are charged a fee per customer (B. Brock, NPS, Anchorage). The average size of groups visiting Hallo Bay for short visits was 4.9 (SE = 0.2, n = 53), including the pilot. Overnight visitor groups averaged 1.5 people (SE = 0.22, n = 6). Overnight visitors camped on or adjacent to the study area an average of 23 nights (SE = 6.3, n = 6). Overnight use doubled in 1999 compared to 1998.

Bear Group Numbers

We rejected the first null hypothesis that bear numbers were not affected by time of day. The number of bear groups varied significantly with time of day ($F_{5, 1305} = 34.66$, P = 0.008). The mean numbers of bear groups from 0800 – 1959 h were not significantly different. Mean numbers of bear groups earlier in the day were significantly lower, and mean numbers of bear groups later in the day were significantly higher (Figure 1.5) but bear numbers generally tapered off between 2200 hours and midnight.

Paired Comparisons

We failed to reject the null hypothesis that bear numbers did not differ significantly with human presence. There was no significant difference in number of bear groups between scans when no humans were present and immediately following scans when humans were present (t = -0.23, d.f. = 85, P = 0.816). There was no significant

difference between mean numbers of bear groups between scans when humans were present and immediately following scans after humans departed (t = -.504, d.f. = 82, P = 0.616).

Class Numbers

We rejected the null hypothesis that mean numbers of each class did not vary by season, time or human presence. Mean number of large males varied significantly with time of day ($F_{5, 1499}$ = 16.22, P = 0.007), and there was interaction between time of day and season ($F_{2, 1499}$ = 22.07, d.f. = 4, P = 0.005). Overall, mean number of large males was significantly higher from 2000 – 2359 h than the rest of the day (Figure 1.6). Before the salmon migration, the mean number of large males was significantly lower from 0400 – 0759 h and significantly higher from 2000 – 2359 h than the rest of the day (Figure 1.7). During the salmon migration, the mean number of large males was significantly higher from 0800 –1159 and 2000 –2359 hours than from 1200 – 1959 h (Figure 1.7).

The mean number of sows with spring cubs varied significantly with time of day ($F_{1, 1503}$ = 5.32, d.f. = 5, P = 0.029). Sows with spring cubs used the study area very little from 0000 until 0759 hours (Figure 1.8). After 0800 hours, their use of the area increased to >1 group/scan and remained near the same level the rest of the day. Mean number of sows with spring cubs was not significantly different with humans present versus humans absent ($F_{1, 1503}$ = 0.04, P = 0.880).

The mean number of sows with older cubs varied significantly with time of day ($F_{5, 1499}$ = 23.06, P = 0.002), and there was interaction between season and human presence ($F_{2, 1501}$, P = 0.003). The number of sows with older cubs was significantly higher after 0800 h than before 0400 h (Figure 1.9), and there were significantly more

sows with older cubs before the salmon migration when humans were present than when humans were absent (Figure 1.10).

The number of single bears varied significantly with time of day ($F_{5, 1499} = 23.52$, $P < .0001$) and season ($F_{1, 1503} = 28.21$, $P < 0.0001$). The mean number of single bears was significantly lower before 0400 h than after 0800 h, and significantly higher after 2000 h than during the rest of the day (Figure 1.11) and was significantly higher before the salmon migration than during the salmon migration (Figure 1.12). The mean number of single bears did not vary significantly with human presence.

1.4 DISCUSSION

Overall Effects

We initially developed the study protocols to sample from high tide to high tide as we expected bear use of the area to vary according to the tide level. We analyzed bear numbers on the study area according to the tide level and found no significant differences.

We expected bear use of the area to increase during low tide because we expected clamming was a common activity for bears at Hallo Bay and low tide is the only time clams are available to bears. In 1998, we recorded all clamming bears and observed 79 unique clamming bouts in 72 days for an average of 1.1 clamming bout per day. In 1999, we recorded 6 clamming bouts (all in 1 day) in 87 days for an average of 0.07 bouts per day. We defined a clamming bout as 1 bear clamming during 1 tide cycle.

During 1998 – 1999, clamming did not appear to be a very common activity for bears at Hallo Bay, therefore tide level should not have a significant effect on bear use of the study area. At the highest tides, <5% of the inland study area was inundated with

salt water. This also did not have a significant effect on the number of bears that used the study area, although bears did not use the habitat that was inundated.

Total bear numbers at Hallo Bay varied significantly with time of day. We found that human activity had no significant effect on the number of bears that used our study area, the open habitats at Hallo Bay, which is counter to trends at several other areas with high concentrations of bears and humans (Crupi and Gilbert 2002, Olsen et al. 1998, Warner 1987). Bears at these other study areas showed a reduction in use of the area during times of heaviest human use. There are several possible reasons for the bears' lack of response to humans at Hallo Bay.

During our study, Hallo Bay received much less human use than other popular bear viewing areas. Visitors to Hallo Bay averaged fewer than 4 people per day while other areas received visitation rates ranging from 6 people per day at Pack Creek (Warner 1987) to hundreds of visitors per day at Brooks Camp (Olson et al. 1998). Size of visitor groups to Hallo Bay was small for the most part. Groups greater than 8 occurred only once on the study area (see below).

On relatively busy days (high number of visitors); humans were present at Hallo Bay only for a small proportion of the day, leaving the area free of human intrusion for most of the day. Overnight campers were present most of the day but these groups were small (1-2 people). Visitors were present for most of the day at Chilkoot River and Pack Creek (Crupi and Gilbert 2002, Warner 1987), and at Brooks Camp, there are cabins for tourists to remain overnight (Olson et al. 1998).

Although human activities at Hallo Bay are mostly unmanaged, most visitors that were accompanied by guides remained within 50 m of the beach and near the southern boundary of the study area. Overnight visitors and visitors arriving by boat tended to use

more of the area, but in spite of this, most of the inland portion of the study area was undisturbed by human use.

Others have found that bear numbers vary inversely with human use of an area. Crupi and Gilbert (2002) found that on a daily basis, brown bear numbers on the Chilkoot River near Haines, Alaska were inversely related to the numbers of anglers and vehicles. In KNPP, Olson et al. (1998) found that brown bears using a salmon stream with no human activity showed a diurnal activity pattern, while those using a salmon stream with substantial daytime human use showed a bimodal, crepuscular activity pattern. On the other hand, Olsen and Gilbert (1994) found that habituated bears at Brooks Camp continued to use areas during the day when humans were present.

MacHutchon et al. (1998) found that brown bears in coastal British Columbia were primarily diurnal in areas of low human activity. In response to human presence, brown bears appeared to alter their temporal and spatial activity patterns to avoid times and areas of heavy human use.

Warner (1987) compared brown bear numbers and activity patterns between adjacent drainages in southeast Alaska, an area of negligible human use and an area of high human use (Pack Creek). Bears in both areas showed a bimodal activity pattern, but mean bear numbers were higher at Pack Creek than in the control area. Over 80% of the bear observations at Pack Creek were females and less than 1% were males. Warner (1987) attributed the higher bear numbers at Pack Creek to habituation to humans and conditioning to human food.

While it is difficult to say that bears at Hallo Bay have never consumed human foods, it seems reasonable to state that bears using Hallo Bay are not food-conditioned; as we never saw bears attempt to obtain food from humans or their campsites. On the

other hand, these bears probably have habituated to humans, as they generally did not disrupt their current activity when humans approached.

Paired Scans

We found no significant difference in bear numbers when humans were present compared to the previous scan without humans. We also did not find a significant difference in bear group numbers when humans were present compared to the next consecutive scan without humans. This suggests that bears at Hallo Bay did not respond to humans by leaving when humans were present or returning when humans had left.

Individual Classes

Different bear classes respond differently to each other and to the presence of humans. We observed this pattern at Hallo Bay, as there were fewer large males on the study area during the time of day that human use was highest (1200 h – 1959 h) (Figure 1.5). Their use of the area showed a bimodal peak on either side of that period, especially during the salmon migration. This reduction in use by large males may suggest that human use at Hallo Bay is reaching a limit that will result in further impacts to bear use if human use continues to grow.

Gibeau et al. (2002) found that adult males used high quality habitats near areas of human activity but only at night and where hiding cover was adjacent. Elsewhere, adult male brown bears tended to avoid areas and times of human use (Warner 1987, McLellan and Shackleton 1989, Gunther 1990, Mattson 1990, Reinhart and Mattson 1990, Mattson et al. 1992, Olson and Gilbert 1994, Crupi and Gilbert 2002).

It is difficult to say that the reduction in use of the area by large males was due only to the presence of humans as human use at Hallo Bay was inconsistent. While foul weather prevented aircraft from bringing visitors to Hallo Bay on many occasions, there

were also several calm, clear days that visitors did not visit the area. The arrival of humans seemed too unpredictable for large males to have avoided Hallo Bay based solely on human activity patterns, but it is possible that large males have learned to avoid the open habitats at Hallo Bay during times of peak human use. The large males that were present when humans arrived did not leave the study area, suggesting that those individuals have probably habituated to human presence.

MacHutchon et al. (1998) found that brown bears in coastal British Columbia appeared to alter their activity patterns in response to human activity, although this varied between sexes and among age classes. They suggested that lone adult brown bears and family groups tended to avoid areas of human activity both spatially and temporally, while subadults were less affected by humans but tended to avoid areas used by adult bears.

Wielgus and Bunnell (1994, 1995), and Mace and Waller (1997) demonstrated that the presence of large males caused other classes to avoid an area. At McNeil River, Alaska, females with young consistently held their ground against large males while other classes deferred to large males (Egbert and Stokes 1976). We expected the same patterns of use because habitats and topography are similar at these 2 sites. Instead, single bears have the greatest representation on our study area during the peak time used by large males (2000 – 2359 h).

When we compared the number of bears seen in consecutive scans when humans were present to the following scan with no humans, the number of bears remained unchanged. This suggests that the bears that use Hallo Bay may have habituated to humans, at least small groups of humans. There was 1 instance when 2 planes unloaded a total of 13 passengers at once, and, when these people entered the

study area, the nearest bear (~ 50 m away) ran away from the group and into the cottonwood/scrub habitat.

There was evidence that some individual bears may avoid Hallo Bay during the day, when an encounter with humans is more likely. In 2 instances during late evening (nearly dark), researchers leaving the observation tower caused a large male that was over 500 m away to stop moving across the study area and run away into the scrub habitat. However, we often encountered other bears at close range during the dark hours with no reaction from the bears beyond a brief change in their direction of travel. A sow that had previously been radio-collared left the study area whenever humans approached to within 300 – 400 m. She still carried the collar and may have been wary due to her previous experience with humans.

Based on results from other studies, it seems obvious that further increases in human use at Hallo Bay will eventually result in reductions of bear use there, but it is unclear what level of use will cause a significant reduction in bear use. Human use at Hallo Bay has continued to rise significantly (Figure 1.4). Additional studies should be conducted to document bear use and human use of Hallo Bay. Additionally, it is unclear what the effects of overnight camping will be. KNPP policy requires that park managers maintain human use at Hallo Bay to levels that do not affect bear use of the area.

Finally, some effects on bears using Hallo Bay perhaps had already occurred prior to our study. Humans had been visiting Hallo Bay regularly since 1989 and bears that could not tolerate human presence perhaps already had learned to avoid the area. Although we witnessed no short-term effects of human presence other than a reduction in use by large males, this does not mean that there has been no long-term effect.

In support of this, a river approximately 1.6 km north of the study area may have served as a sanctuary for bears that did not want to be exposed to humans. I witnessed 8 – 12 large males fishing in this river several times. I witnessed no other bear classes using this river. I was the only visitor to go to this area during these 2 summers. The closest I ever approached that area of the river the large males used was ~ 1 km and my presence was probably undetected as the beach grass habitat was between the bears and I.

Time of Day Effects

This pattern of use was independent of the pattern of human use. Most visitors arrived at Hallo Bay in the afternoon and early evening. The visitors that camped overnight usually stayed in their tents from 2200 hours until after 0800 hours.

Season Effects

At Hallo Bay during the summers of 1998-99, the number of bears using the study area at any one time decreased once adult salmon started arriving in the streams. There are several possible explanations for this.

First, fishing times are limited. On the study area, bears are limited to fishing the 3 – 4 hours surrounding low tide. Once the tide rises, the tidal flats are inundated with seawater and the inland portion of Middle Creek on the study area also fills with seawater. As a result, shallow areas that permit fishing by bears become too deep and murky for productive fishing. Farther upstream, within the scrub habitat, the influence of tidal water disappears.

Second, even at low tide there are very few good fishing areas once Middle Creek exits the scrub habitat and flows across the study area. The water within Middle Creek is very turbid and fish cannot be seen in the water (pers. obs.). The section of

Middle Creek that crosses the study area has long stretches of deep water and no physical features (e.g. rapids, falls) that force the salmon to expose themselves to predaceous bears. There was only one area (< 50 m long) along the inland stretch of Middle Creek regularly used by bears for fishing.

Once the channel reaches the tidal flats, it becomes braided into several channels, of which salmon use only 1 or 2. These channels were morphologically dynamic between years. In 1998 there was a shallow stretch allowing bears to see the wakes of swimming fish but this characteristic was lacking in 1999.

Third, fishing is likely more productive inland from the study area. Once Middle Creek enters the shrubby habitat inland from the study area, it is less influenced by tidal water and becomes clearer and shallower. We made several investigative forays along this part of the creek and witnessed that salmon are plentiful and easily seen, and the water level is shallow, indicating improved fishing conditions for bears. The trails along the creek created by bears as well as the prevalence of salmon carcasses indicated that bears successfully fish these channels. The pilots who brought clients to Hallo Bay told us that flying over these stretches of the creek allowed them to see several large males, indicating that these may be the higher quality fishing spots.

Dominant male bears typically fish the most productive areas of a stream (Egbert and Stokes 1976). Females may also prefer to fish these same locations but also have to consider the risk of predation on their cubs by other bears (Ben-David et al. 2004). In southeast Alaska, Ben-David et al. (2004) found that females with cubs avoided salmon streams, presumably to avoid predation of their cubs. The habitats in southeast Alaska tend to be very shrubby with limited visibility, which would allow predaceous bears to attack cubs at close distances. The females at Hallo Bay used high quality fishing spots

near large males. These areas were in open habitats where sows could see all bears using the stream channels and could see approaching bears from distances greater than 50 m away, which could reduce the threat of unseen bears attacking and killing their cubs.

1.5 CONCLUSION

It appears that the low levels of human use that occurred during the summers of 1998 – 1999 had little effect on overall bear use of our study area at Hallo Bay. Compared to Brooks Camp, which receives over 10,000 visitors per year (KNPP website), Hallo Bay received very little human use in 1998 – 1999. Although individual bears may have avoided the area during hours that humans were present, human presence did not significantly affect the overall numbers of bears using the area. Based on results from other bear viewing sites with higher human use, an increase of human use of the area or a change in the human use from primarily short visits (averaging 2 hours) to overnight stays may change the temporal and spatial use of the area by bears.

The standard set by the Bear Management Plan for KNPP (National Park Service 1986:1) is to "…retain the natural population dynamics of bears, …(and) allow their natural patterns of feeding and habitat use to continue unimpeded… " It appears that human use at Hallo Bay in 1998-1999 may have been approaching a level of use affecting bear use of the area, as there was some effect on the number of large males that used the area. As human use of Hallo Bay continues to grow, park managers need to monitor this use and develop a management strategy that limits the amount of human use that occurs at Hallo Bay to a level that does not further reduce bear use of the area.

1.6 Figures

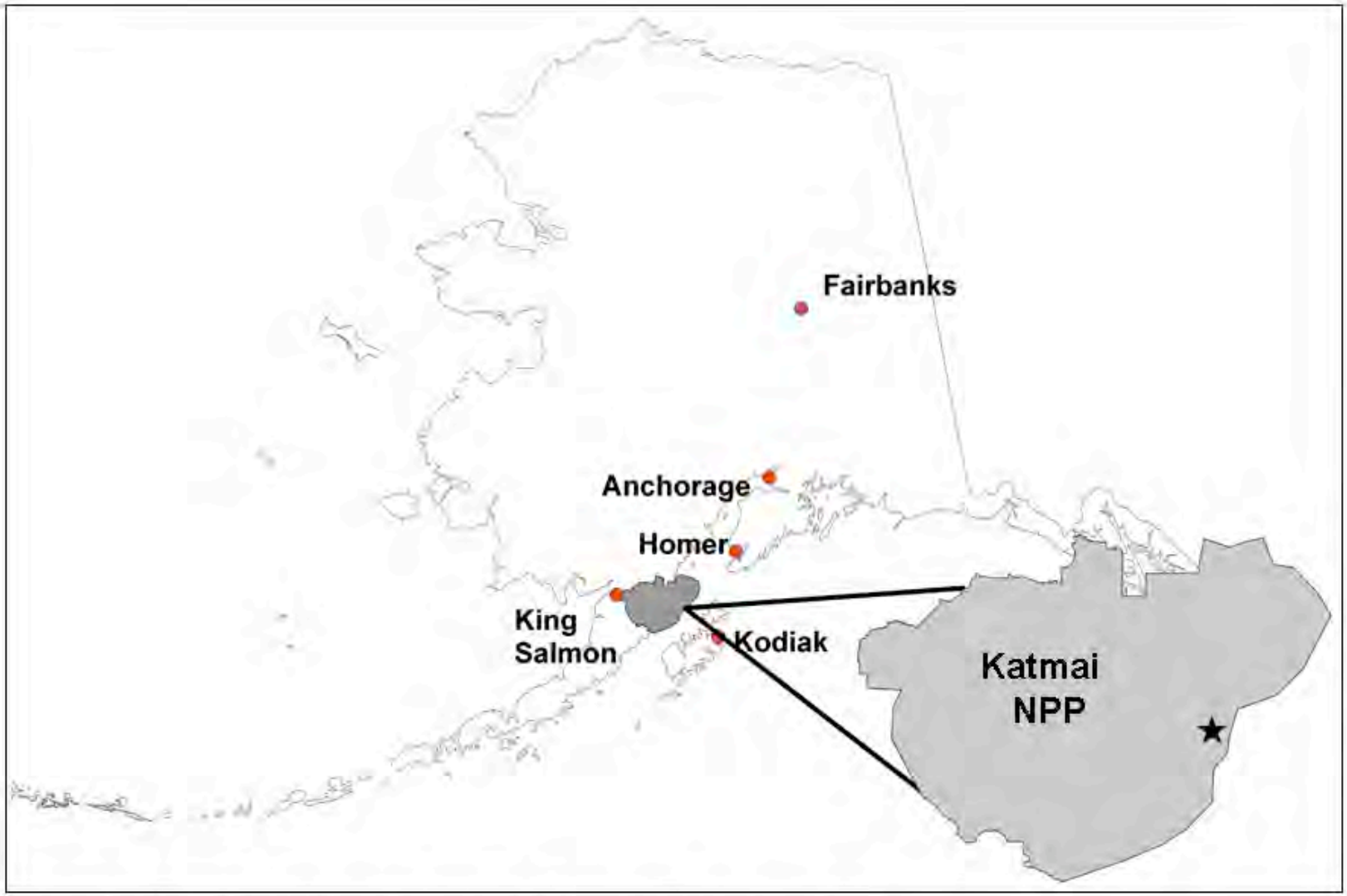

Figure 1.1 Map of Alaska, and location of Katmai NPP and Hallo Bay.

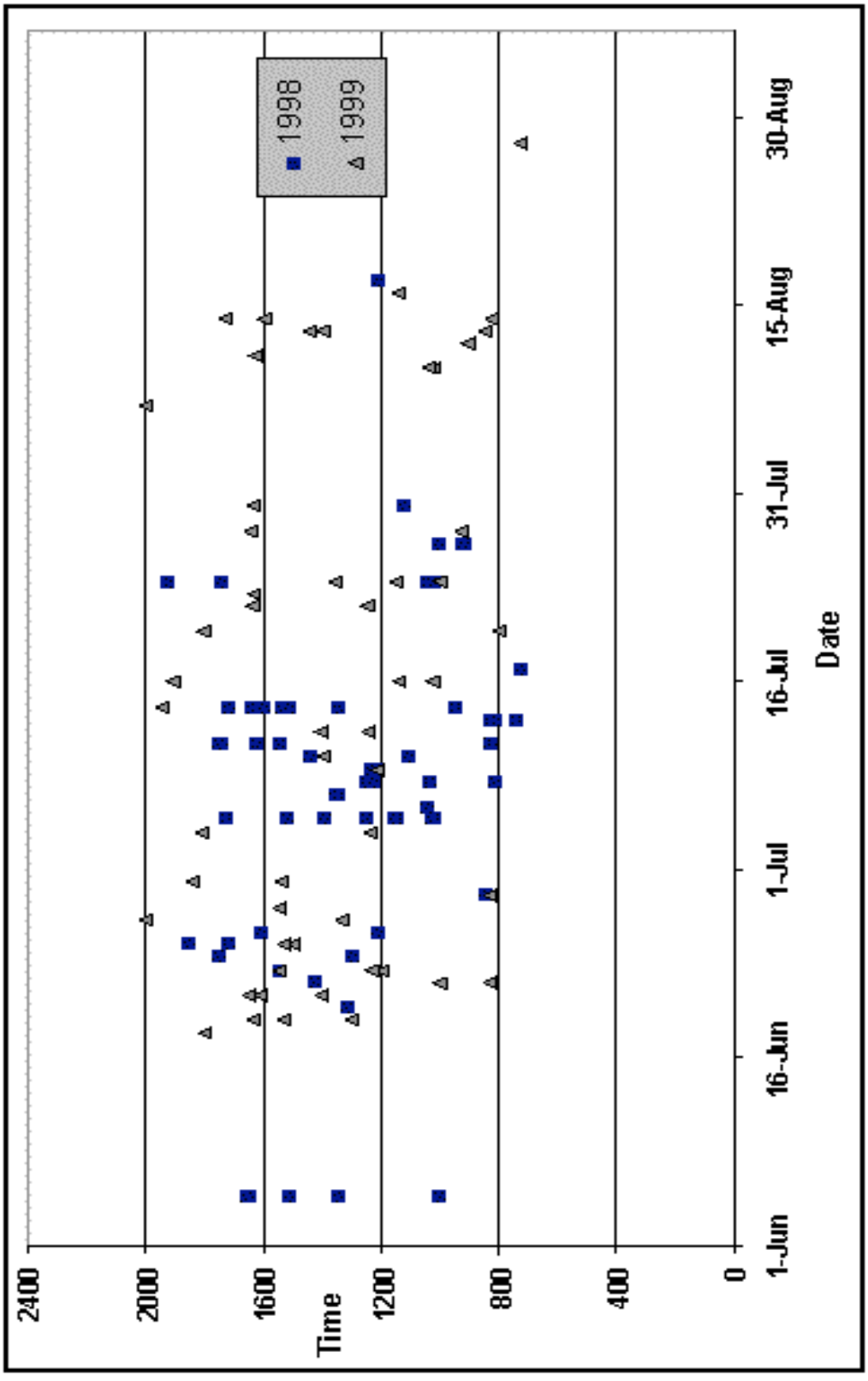

Figure 1.2 Date and Time of Arrival of Visitors to Hallo Bay, Katmai NPP, Alaska, 1998 – 1999.

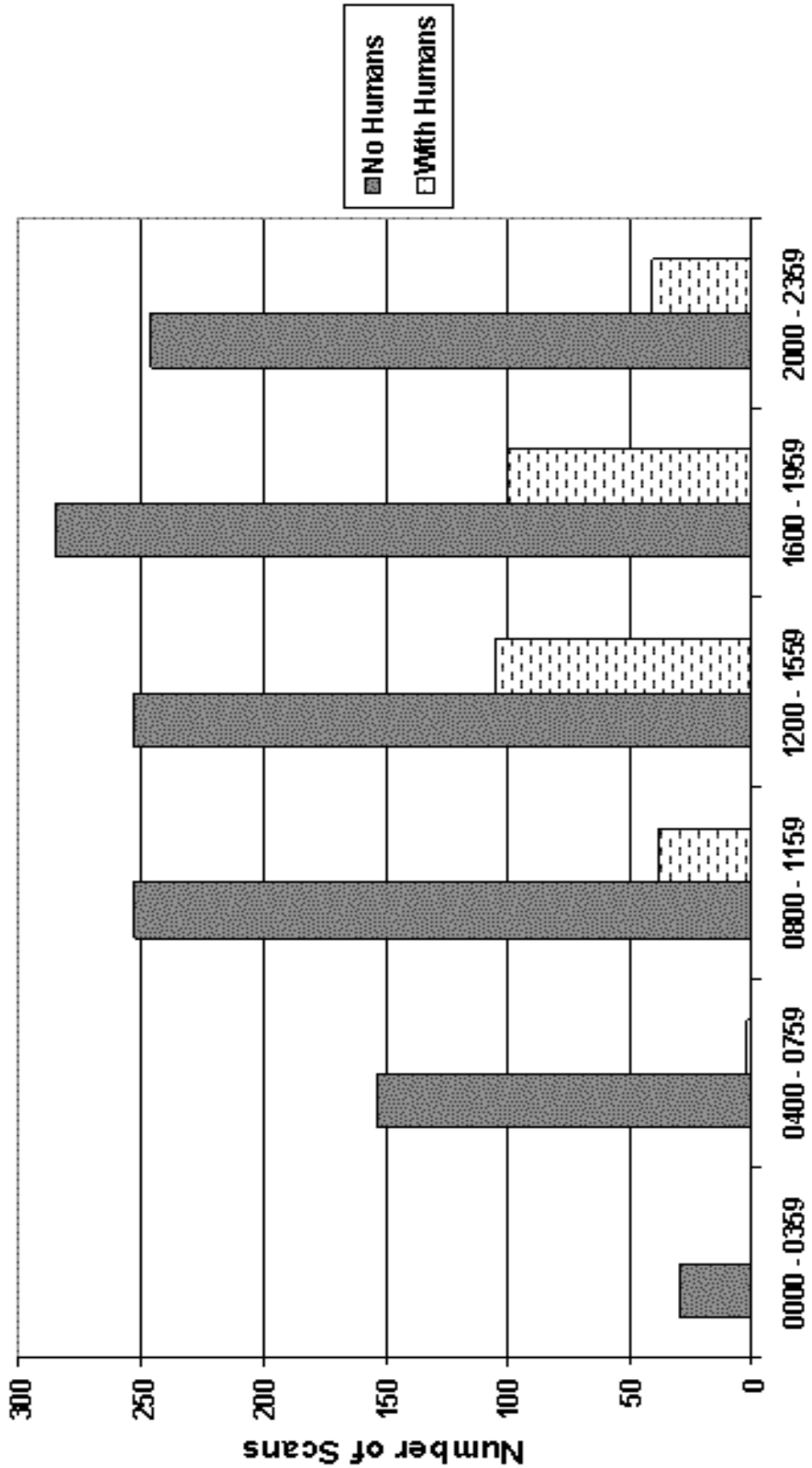

Figure 1.3 Number of Scans categorized by human presence and time of day, Alaska Daylight Time (ADT), Hallo Bay, Katmai NPP, Alaska

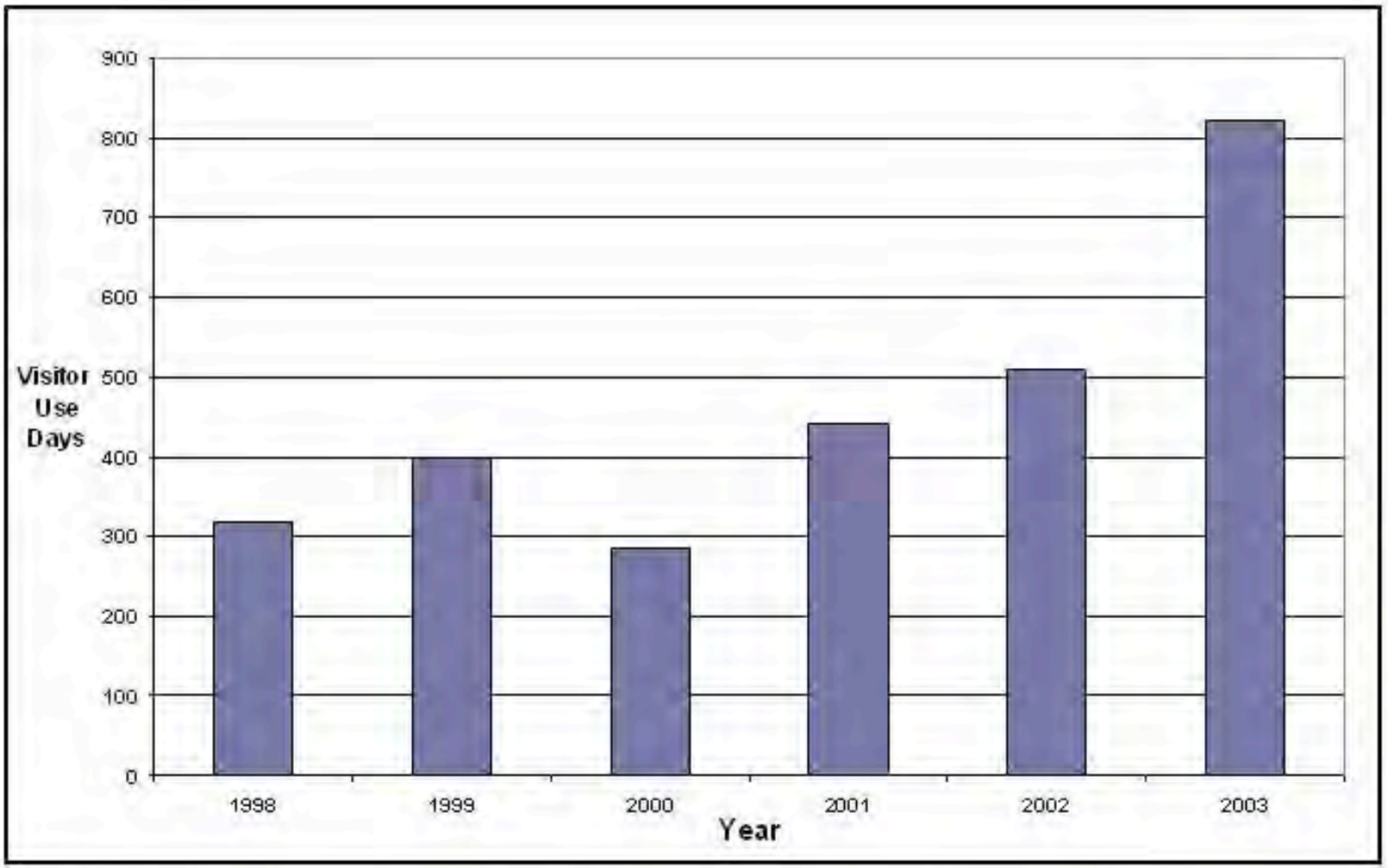

Figure 1.4 Visitor Use Days by year at Hallo Bay, Katmai NPP, Alaska (1998 – 2003). Data from 2000 – 2003 were provided by B. Breck, NPS, pers. comm.

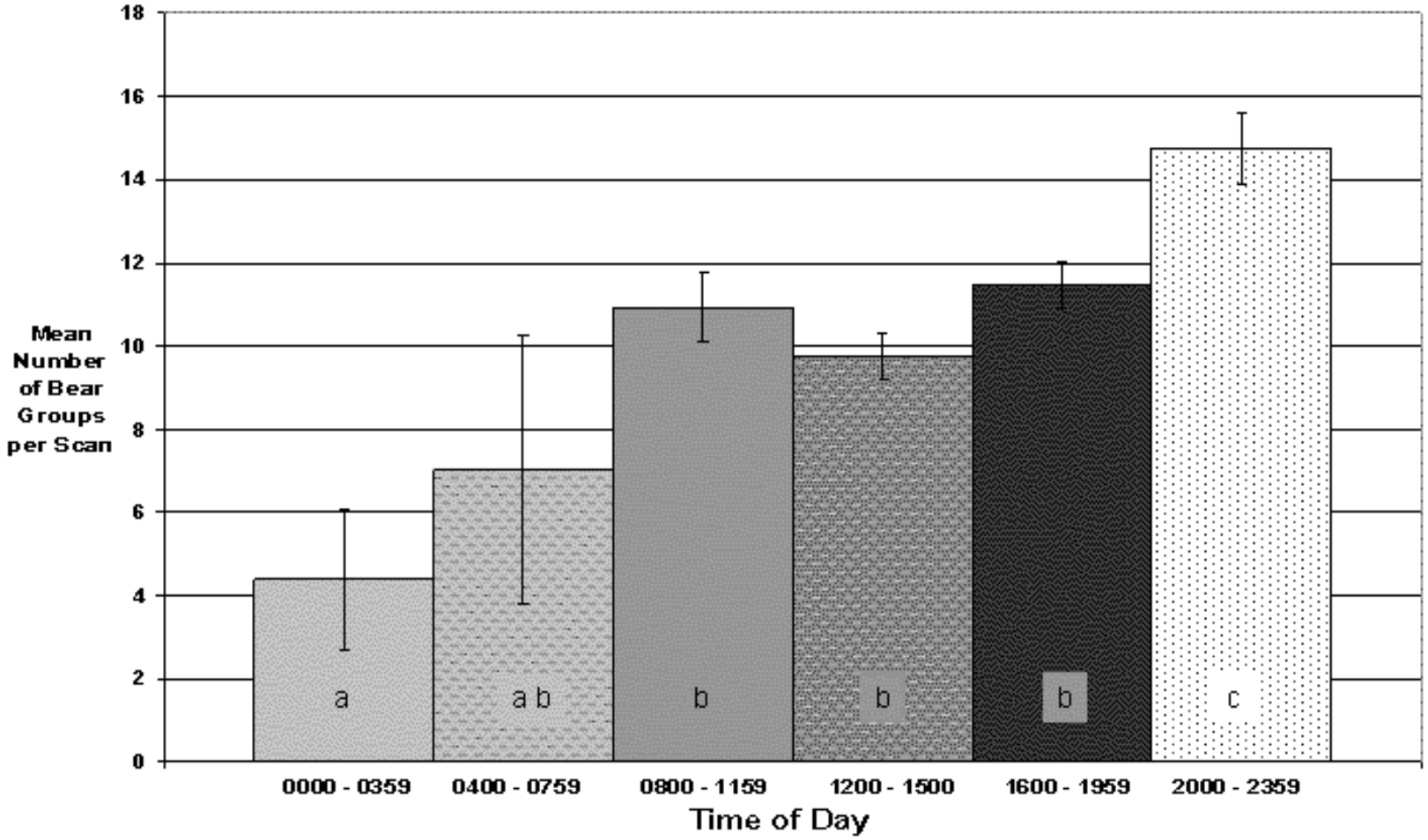

Figure 1.5 Mean number of bear groups by time of day (ADT), 1998 – 1999, Hallo Bay, Katmai NPP, AK. Columns with the same letter are not significantly different. Vertical bars denote 1 standard error.

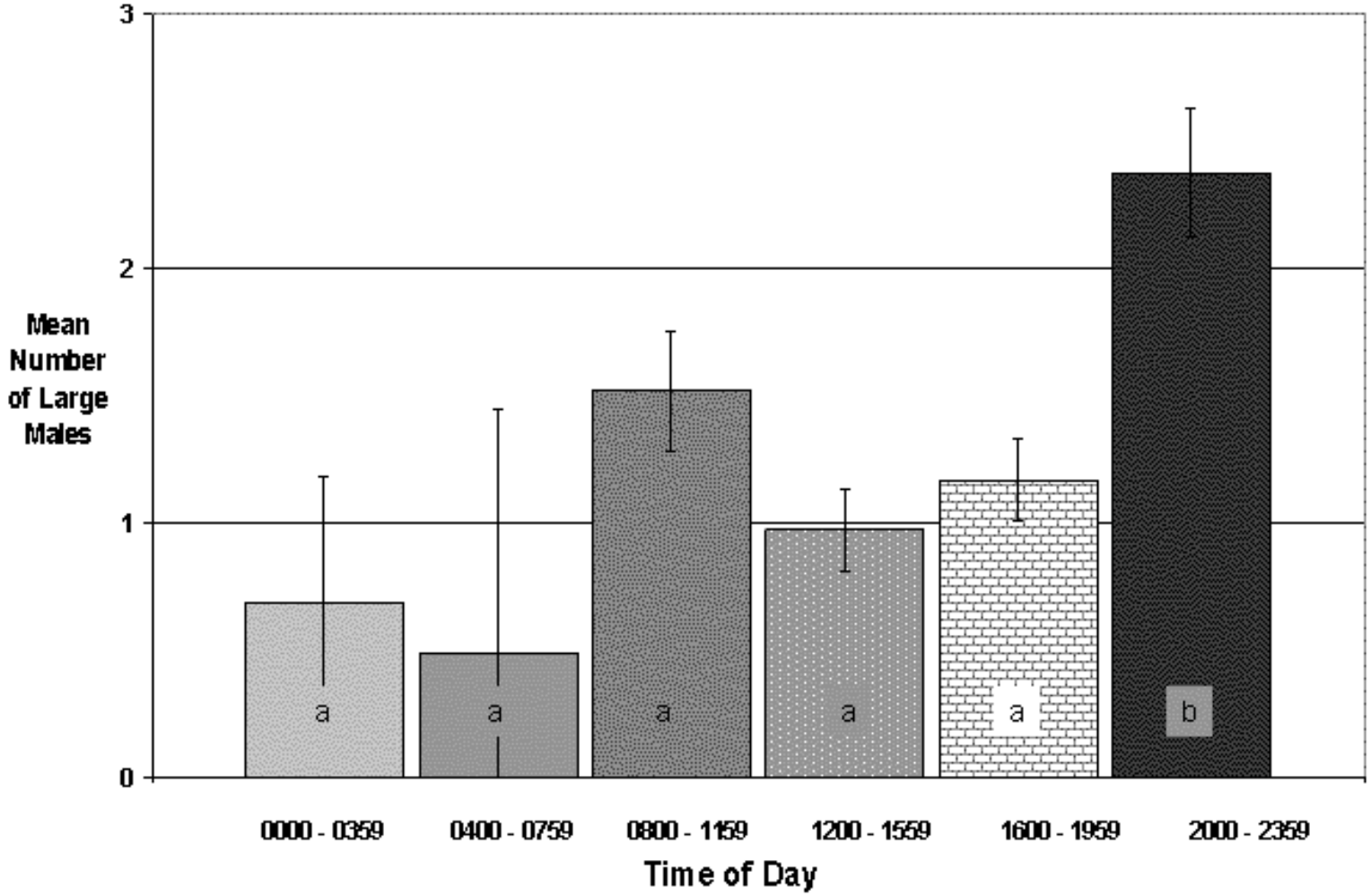

Figure 1.6 Mean number of large males by time of day (ADT), 1998 – 1999, Hallo Bay, Katmai NPP, AK. Columns with the same letter are not significantly different. Vertical bars represent 1 standard error.

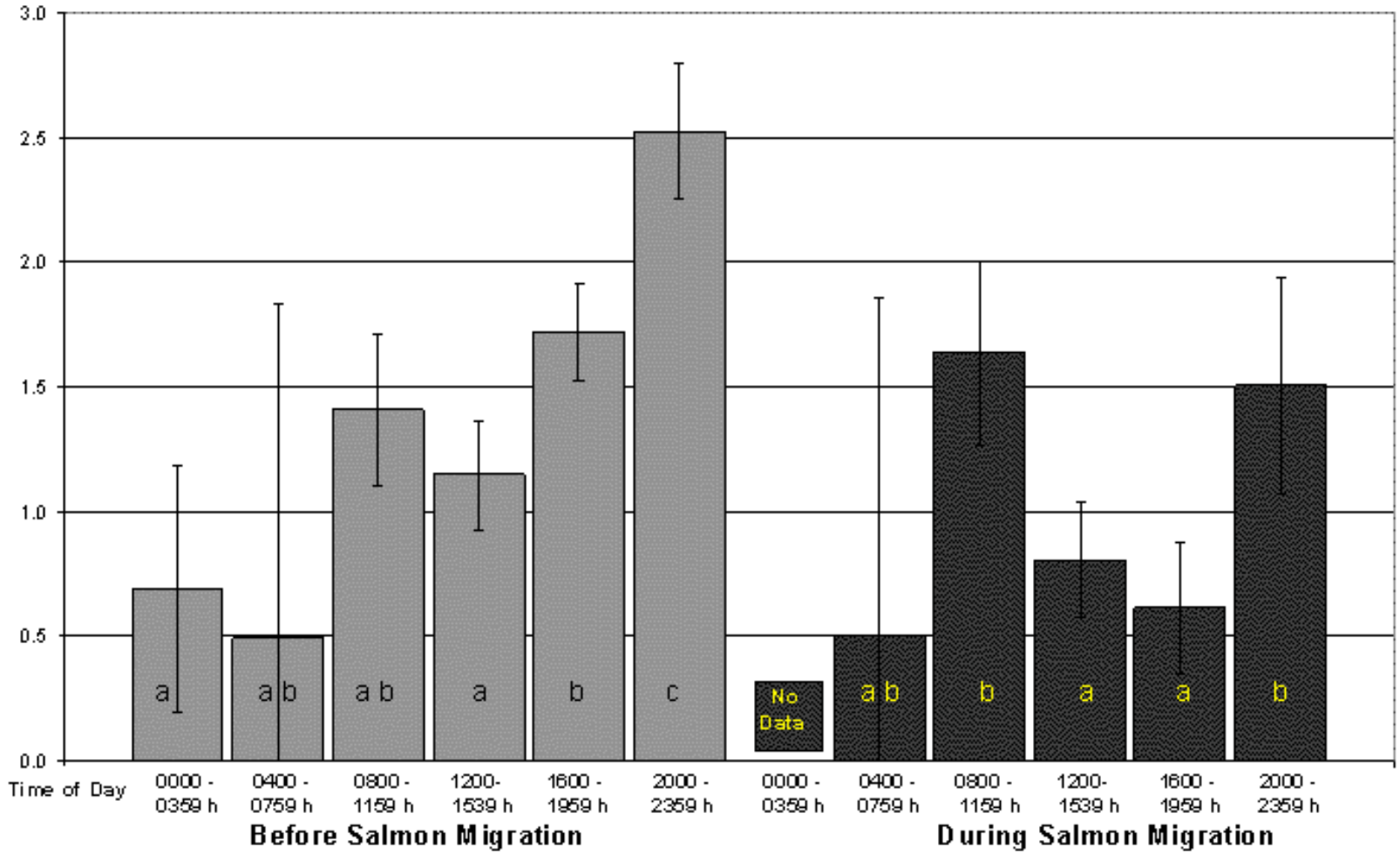

Figure 1.7 Large males by season and time of day (ADT) 1998 – 1999, Hallo Bay,Katmai NPP, AK. Columns with the same letter are not significantly different. Vertical bars represent 1 standard error.

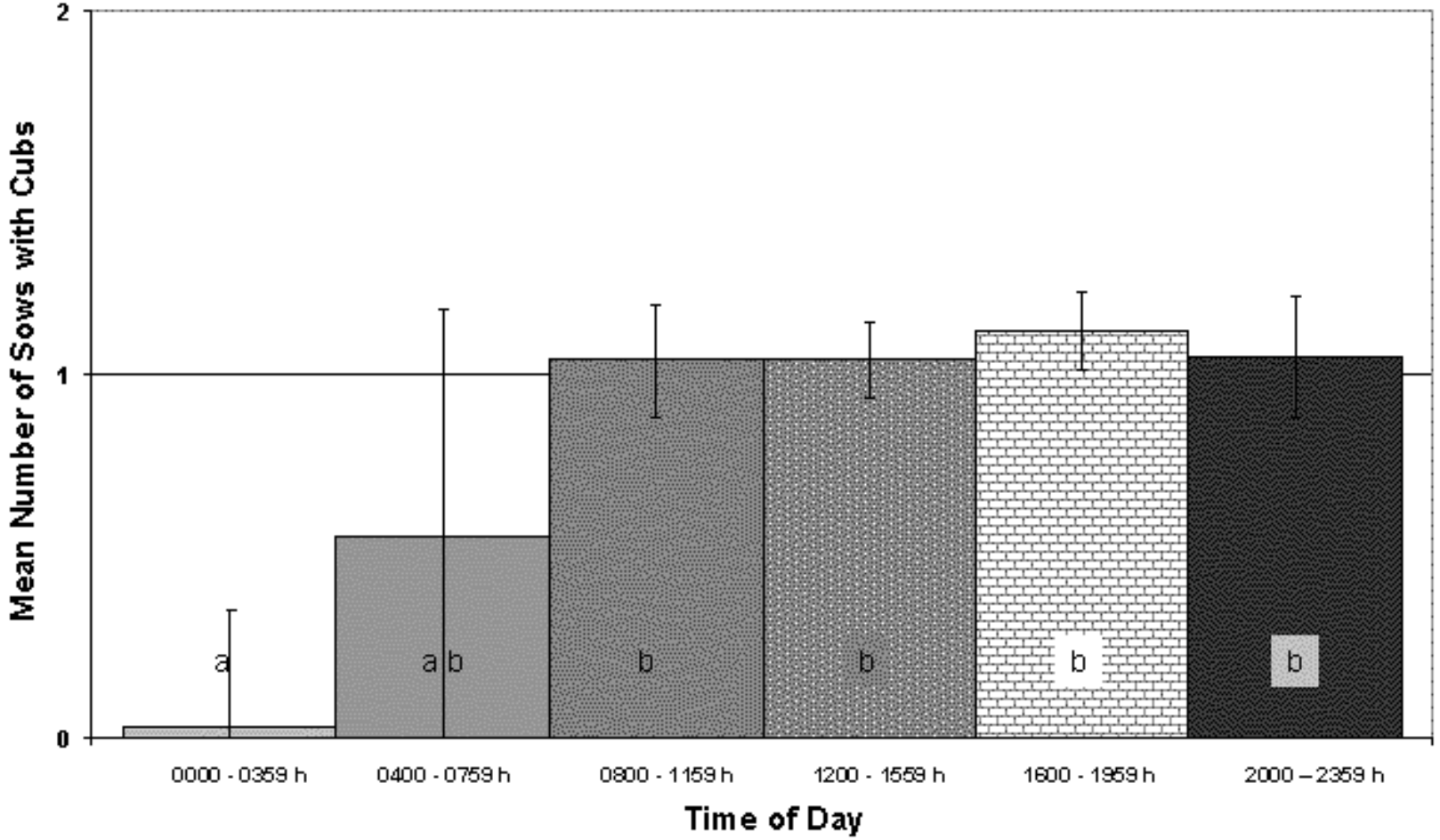

Figure 1.8 Number of sows with spring cubs by time of day (ADT) 1998 – 1999, Hallo Bay, Katmai NPP, AK. Columns with the same letter are not significantly different. Vertical bars represent 1 standard error.

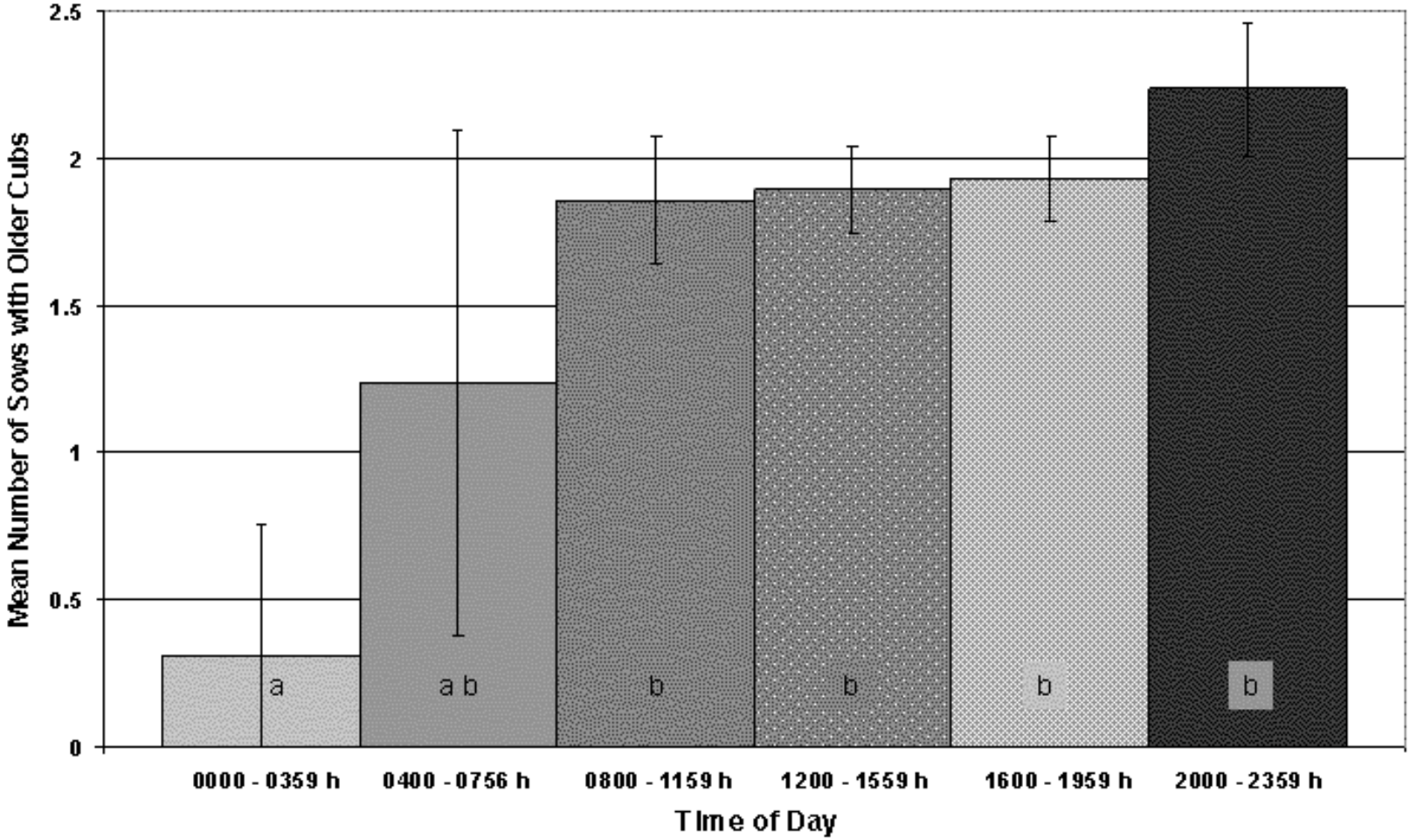

Figure 1.9 Mean number of sows with older cubs by time of day (ADT) 1998 – 1999, Hallo Bay, Katmai NPP, AK. Columns with the same letter are not significantly different. Vertical bars represent 1 standard error.

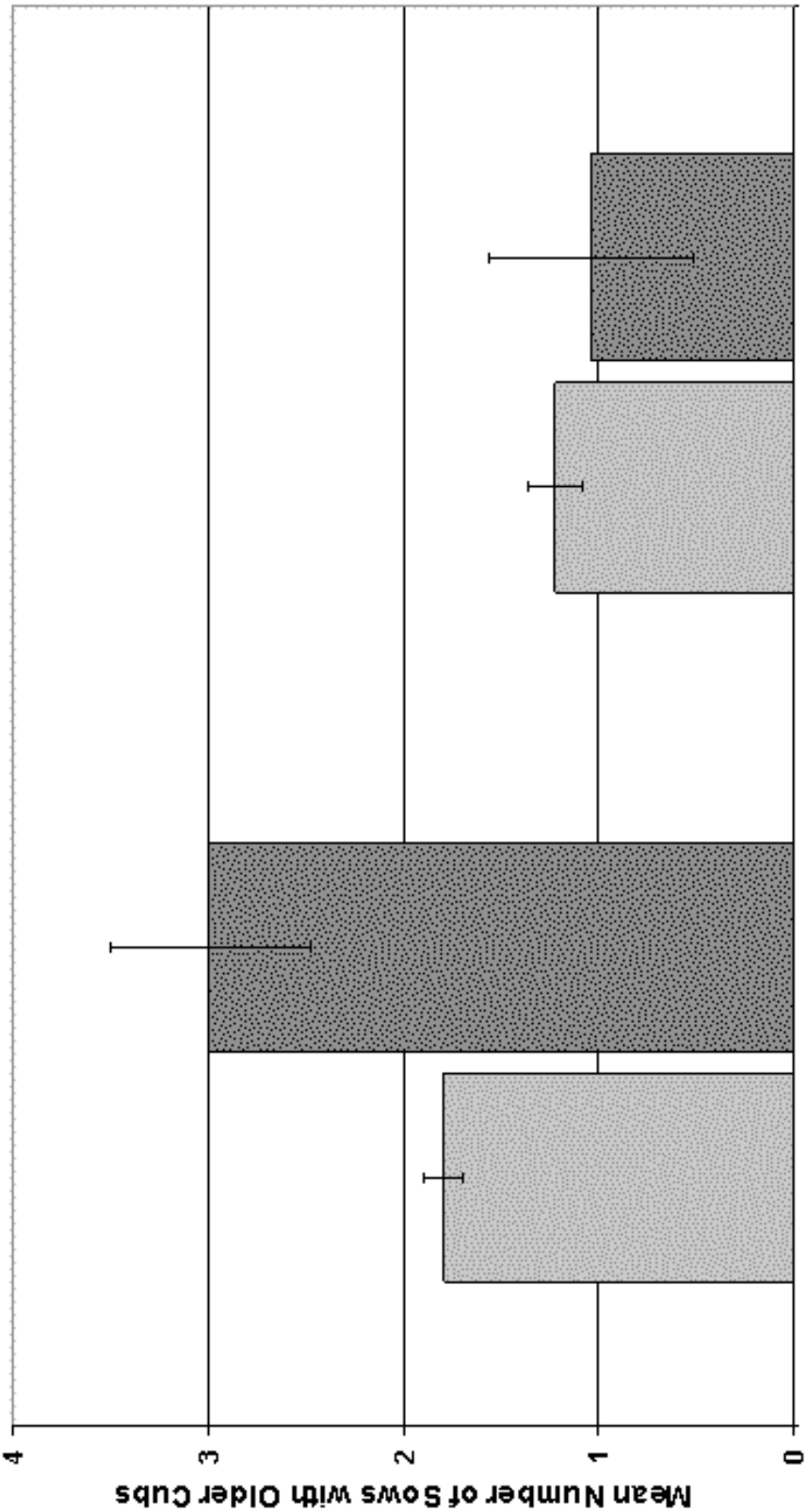

Figure 1.10 Mean number of sows with older cubs by humans and season, 1998 – 1999, Hallo Bay, Katmai NPP, AK. Vertical bars represent 1 standard error.

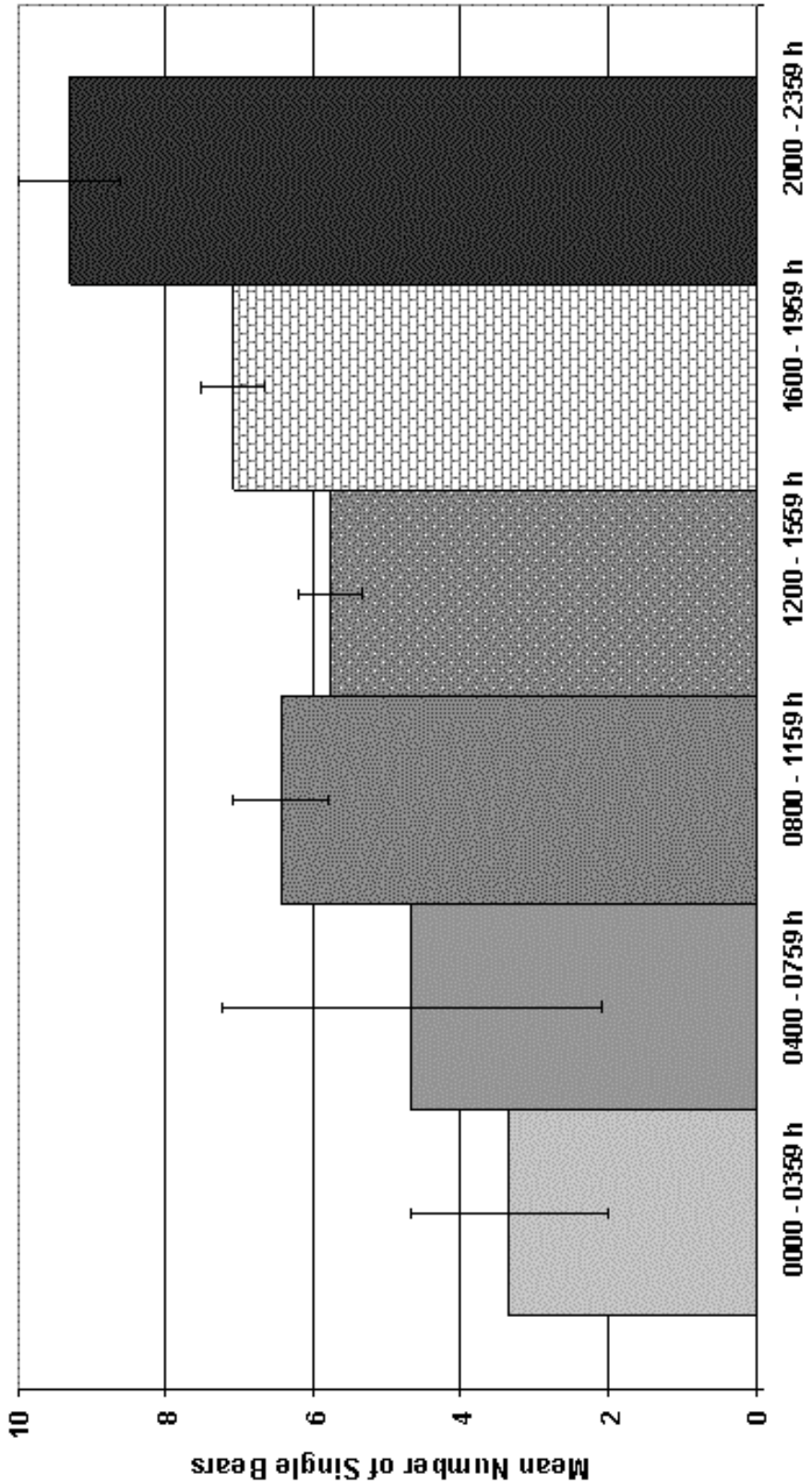

Figure 1.11 Mean number of single bears by time of day (ADT), 1998 – 1999, Hallo Bay, Katmai NPP. Vertical bars represent 1 standard error.

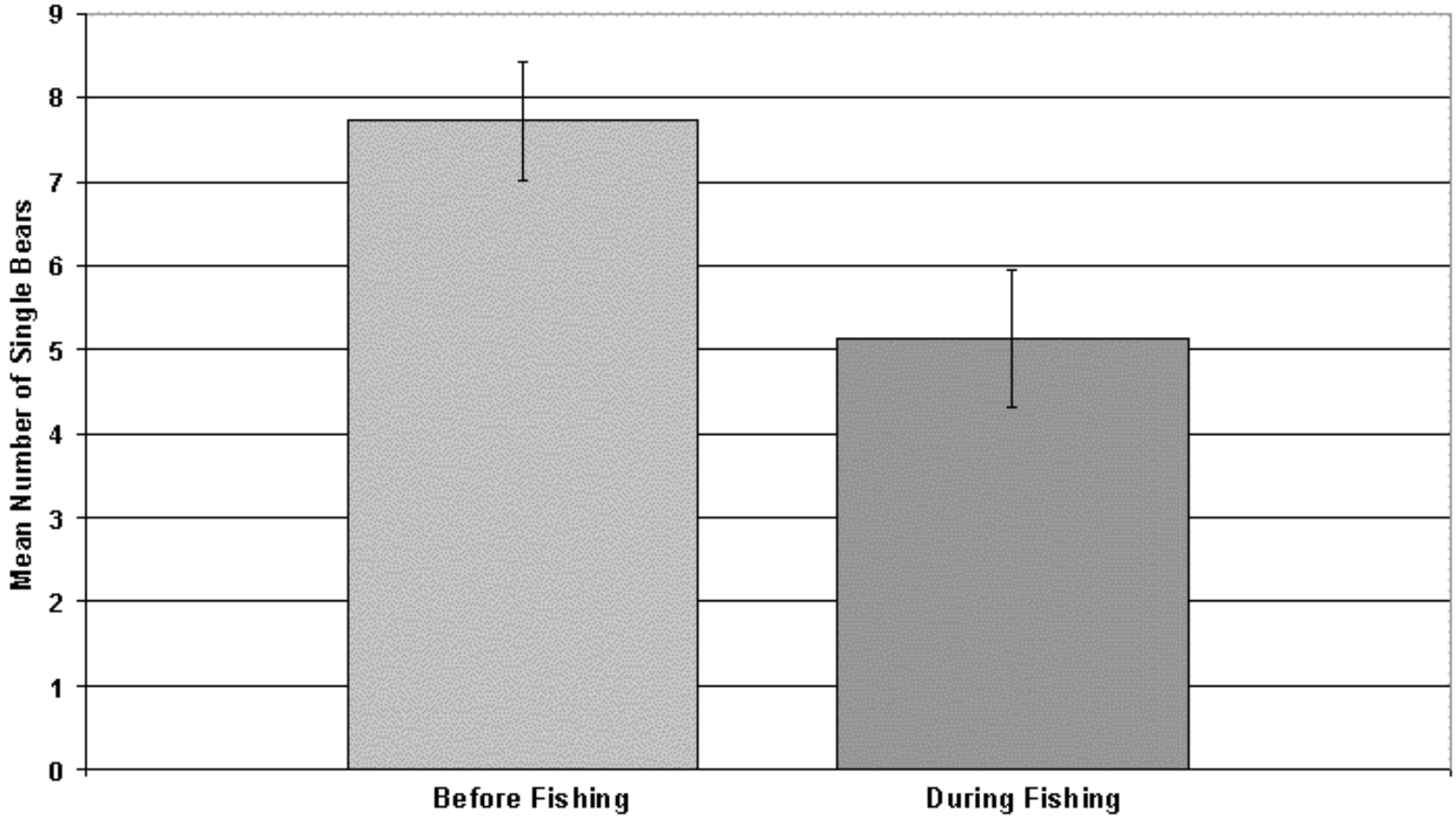

Figure 1.12 Mean number of single bears by season, 1998 – 1999, Hallo Bay, Katmai NPP. Vertical bars represent 1 standard error.

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Chapter 2. Effects of bear viewers and photographers on activity budgets, grazing efficiency, and fishing success of brown bears at Hallo Bay, Katmai NPP, Alaska.

Abstract*:* We investigated the effects of human activities, primarily bear viewing and bear photography, on activity budgets of brown bears (*Ursus arctos*) that use Hallo Bay on the coast of Katmai National Park and Preserve (KNPP), Alaska. We divided the bear population into 4 classes (large males, sows with spring cubs, sows with older cubs, single bears) based on expected differences in behavior and response to humans. We recorded 584 focal sessions, 428 without humans and 158 with humans present. Humans at varying distances least affected activity budgets of sows with spring cubs, but foraging efficiency (bites per minute) of sows with spring cubs was significantly lower with humans <50 m away than with humans absent. Fishing success (catches per chase) of large males and single bears was lower when humans were present, but fishing success of sows with spring and older cubs was higher when humans were present. Current KNPP policy requires that humans remain >100 m from sows with cubs and >50 m from other bears. We witnessed several violations of this policy; therefore, an increase in enforcement of those regulations should reduce impacts to bears. Humans have been visiting Hallo Bay for nearly 30 years; therefore, habituation to humans already may have reduced human effects on bear behavior at this location.

2.1 INTRODUCTION

Recreational viewing of wildlife has grown steadily since the late 1970s (Vickerman and Hudson 1991). Many states, including Alaska, promote tourism based on wildlife viewing and photography. Although several studies have investigated the effects of these activities on bears (Fagen and Fagen 1990, Olson et al. 1997, Olson et al. 1998, Wilker and Barnes 1998), these studies focused on developed viewing areas in Alaska.

Katmai National Park and Preserve (KNPP) encompasses 1.4 million ha and is home to 1,500-2,000 brown bears (*Ursus arctos*) on the Alaska Peninsula (Sellers et al. 1999). The coast of KNPP has the highest density of brown bears in the world and is designated as Wilderness. The KNPP Bear Management Plan (National Park Service, 1986:1) states that the "…policy of bear management in Katmai is to retain the natural population dynamics of bears, allow their natural patterns of feeding and habitat use to continue unimpeded…" Olson et al. (1997) investigated the effects of viewing activities on bears at Brooks Camp, in KNPP, a developed and heavily managed bear-viewing site, that receives over 10,000 visitors during the summer months each year. They found that non-habituated adult bears avoided areas of human use, and proposed that this shift in adult use allowed subadults to exploit these abandoned areas.

While wilderness designation provides protection from human sources of habitat loss, indirect disturbances can also reduce habitat quality (Mattson 1990). Indirect disturbances result when human activities displace animals from preferred habitats or alter behavioral patterns critical for survival and reproduction (Steidl and Anthony 2000). In the case of bears, which hibernate for 5-7 months each winter, small reductions in energy acquired during the active months can impair reproductive success or survival (Rogers 1976, Elowe and Dodge 1989, Hilderbrand et al. 1999a, 1999b).

The bear viewing industry along the coast of KNPP has been increasing since the late 1980's. Typically, commercial guides accompany bear viewers with no oversight by National Park Service personnel. Therefore, park managers need to understand the effects of the bear viewing industry on bears along the coast.

The objectives of this study were:

1) To document bear-human interactions at Hallo Bay, KNPP from June through August.

2) To document bear responses to human activity at Hallo Bay, KNPP.

3) To determine the level and type of human use that can occur in pristine areas occupied by large concentrations of foraging brown bears without violating the policy of bear management.

We tested the following null hypotheses:

1) Activity budgets of brown bears do not differ with varying degrees of human proximity.

2) Grazing efficiencies of brown bears do not differ with varying degrees of human proximity.

1) Fishing success of brown bears does not differ with varying degrees of human proximity.

Brown bears top the food chain and only humans pose a real danger to them (McLellan et al. 1999). Habitat quality is the primary determinant of population density and productivity of bears (Rogers 1976, Bunnell and Hamilton 1983, Samson and Huot 1995, Hilderbrand et al. 1999a). Social factors also affect population dynamics: adult and subadult males sometimes injure or kill cubs; adult males intimidate or displace subadult males, and adults out-compete subadults for food (McCullough 1981, Stringham 1983, Aune et al. 1994, Wielgus and Bunnell 1994b, Samson and Huot 2001). The high density of bears at Hallo Bay (Sellers et al. 1999) should cause most bears to be sensitive to the presence of other bears, and exhibit high levels of alert behavior (Egbert and Stokes 1976).

Study Area

Hallo Bay is located along the coast of KNPP in south central Alaska (58°26’ N, 154°04’ W), approximately 23 km south of Cape Douglas (Figure 2.1). The Aleutian Range is a few kilometers to the west and Shelikof Strait separates the Katmai coast

from the Kodiak Island Archipelago. We conducted our study in the open sedge marsh and tidal habitats with elevations ranging from –3 to 5 m ASL. The climate is maritime and temperatures ranged from 0° to 21° C during the summers of 1998-99. Extended periods of rain were common, as were high winds.

The study area at Hallo Bay encompassed about 7 km^2. It included extensive tidal flats, a large tidally influenced creek that drains into Hallo Bay (called Middle Creek for this study) that formed the southern boundary, 2 tributaries of Middle Creek, sedge meadows, vegetated dunes, and several patches of drier grass habitat. The tidal flats extend up to 1 km into Hallo Bay at the lowest tides. The study area extended up to 1.6 km inland from the shore of Hallo Bay before reaching the black cottonwood (*Populus balsamifera*) and paper birch (*Betula papyrifera*) forest that formed the inland boundary of the study area.

Carex ramenskii, C. lingbeyi, Plantago maritima, Triglochin palustre, and *Pucinellia spp.* dominated the sedge meadows. *Elymus mollis, Angelica lucida, Ligustichum scoticum*, and *Epilobium angustifolium* dominated the vegetated dunes and drier grass habitats.

Middle Creek and its tributaries are migratory routes for spawning chum (*Oncorynchus keta*) and silver (*O. kisutch*) salmon. Chum salmon began entering the creek in early July and silver salmon in late July.

We constructed a 4-m high observation tower about 700 m north of the mouth of Middle Creek and 15 m inland from the high tide mark of Hallo Bay, in the beach grass zone. The top 1.5 m of the tower was an enclosed 5.25 m^3 shelter. We located our field camp adjacent to a low ridge that defined the northern boundary of the study area.

2.2 METHODS

We scheduled data collection based on tidal cycles, starting at high tide, continuing through low tide and ending at the subsequent high tide. We randomly determined which of 2 daily tide cycles to observe bears and observed bears for 12-13 hours per day. We divided each tidal cycle into 2 work shifts lasting 6-7 hours.

We observed bears from a 4-m high observation tower that enabled viewing the entire study area. The observation tower was located about 700 m north of the mouth of Middle Creek and 15 m inland from the high tide line of Hallo Bay, in the beach grass zone.

Long daylight allowed us to observe bears around the clock until 10 July. By mid-August, we could not observe bears from 2300 h to 0600 h ADT. We sampled bear behavior from 13 June - 26 August 1998 and 19 June - 31 August 1999.

We divided the study area into 7 habitats: tidal flats, beach/driftwood, beach grass (grass-covered dunes), dry meadow, wet meadow, river, and scrub (black cottonwood/birch/alder). We divided the bear population into 4 classes: large males, single bears, sows with spring cubs, and sows with older cubs. Single bears included independent subadults and females without cubs. We selected these categories based on expected differences in activity budgets and responses to humans and other bears (Egbert and Stokes 1976).

At the start of an observation day, we randomly determined the order of classes to sample. Before each focal session, we scanned the study area and counted the number of bears in that class. Starting at a point due north of the tower, we scanned in a clockwise rotation and determined which bear to observe using a random numbers table.

We used focal sampling (Altmann 1974) to record bear behavior and recorded behaviors using a Hewlett-Packard 200LX palmtop computer loaded with The Observer® software (Noldus Corp.). For each observation, we recorded the habitat the bear was using, distance category to nearest bear and class of the nearest bear, distance category to the nearest human and number of humans in that group. Distance categories were <50 m, 50 – 100 m, 100 – 200 m, 200 – 500 m, and >500 m. We used known distances between landmarks to estimate distances between subjects. We recorded only 29 focal sessions with humans in 1998; therefore, in 1999, technicians approached bears to randomly selected distance classes during randomly selected focal sessions, and we recorded these as focal sessions with humans present. With the increase in visitor use in 1999 over 1998, we used technicians as visitors fewer than 20 times.

We developed an ethogram of 31 behaviors (Appendix Table 1). For statistical analysis, we used only the 5 most prevalent behaviors exhibited by bears in the inland habitats: graze, forage, alert, walk, and resting. These 5 behaviors constituted over 90% of the observed activity for all bears. We defined “graze” as actively cropping plant material, and “forage” as head down, searching for food. “Alert” was head up, scanning. “Walk” was being ambulatory, looking primarily straight ahead (i. e., not searching for food or scanning). “Resting” was lying down, not scanning, feeding, or being social.

We used a 12-40x60 mm variable power spotting scope and 7x35 binoculars to observe bears. Each work shift recorded 4 focal sessions of 30-minutes duration each. Occasionally, we ended a focal session before 30 minutes had elapsed, primarily due to bears disappearing from view. We discarded observations lasting less than 10 minutes.

When humans arrived on the study area, we started a focal session on the bear(s) that the humans approached. We started the focal session once the humans were within 500 m of the observed bear so the >500 m distance to human category was considered as humans absent.

We recorded all air- and watercraft that visited Hallo Bay. We recorded type of craft, times of arrival and departure, and if possible, the number of visitors.

Human Effects on Activity Budgets

We analyzed each class of bears separately. Bear behavior was markedly different in the wet meadow compared to other inland habitats so we kept wet meadow a distinct habitat but pooled observations in other inland habitats. In the wet meadow, independent variables for analysis were season (before or during fishing season) and distance class to humans. In the other habitats, the independent variable was distance class to humans.

KNPP policy states that humans must remain more than 100 m from sows with cubs and 50 m from all other bears. We computed the mean percent of time bears spent in each behavior for the following distances to humans: <50 m for large males and single bears, <100 m for sows with cubs, humans present for all classes, and no humans present for all classes. We defined humans present as humans less than 500 m away and more than the distance required by policy.

We compared the means of behaviors of these distance classes to the mean percent of time without humans present using multivariate Analysis of Variance. We used Tukey HSD for *post hoc* analyses.

Nearly all focal sessions included changes in habitat used, and focal sessions with humans included changes in distance to humans. For analysis, we separated each

focal session into its unique combination of these variables (Appendix Table 2). We considered each unique combination of habitat and distance to humans within a focal session as an observation. We then determined the percentage of time spent in each behavior under these unique combinations, and used that percent for analysis.

Human Effects on Grazing Efficiency

We tested if the grazing efficiency of bears varied with human proximity. We used 3 parameters to test this: bites per minute, bites per step, and bites per alert. We reasoned that bite rate (bites/minute) was a direct measure of feeding efficiency, bites per step was a measure of food dispersion (habitat quality) (Berger et al. 1983), and bites per alert inversely measured the extent that the observed bear was disturbed by human presence.

We randomly selected bears and if no visitors were present, randomly selected what distance to approach the bear. We then recorded a 10-minute focal session. We recorded each bite, step, and alert behavior and distance to humans. We then determined bites per minute, bites per step and bites per alert.

Human Effects on Fishing

We investigated the fishing success of bears with and without humans present, measured as the percentage of successful chases. We could not effectively quantify fish available to bears; therefore, we used the ratio of chases per catch to measure fishing success.

Statistical Analysis

We analyzed the behavioral data with multivariate Analysis of Variance. We then used Tukey HSD to test all pair-wise comparisons between all distance classes from humans. The dependent variables were percent of time spent in graze, forage, alert,

walk, and rest behaviors. For the focal sessions in the wet meadow, the independent variables were season and distance class from humans. For the focal sessions in the other inland habitats, the independent variable was distance class from humans. Significance was set at $\alpha = 0.05$.

The independent variables examined for grazing efficiency were class and distance from humans. We considered each unique combination of distance to humans within a focal session an observation. We analyzed the grazing efficiency data with one-way Analysis of Variance. For fishing efficiency, we compared catch rates when humans were present vs. absent. We used Mann-Whitney U-test to test whether catch success (chases per catch) differed with and without humans present.

2.3 RESULTS

During the summers of 1998 and 1999, we recorded 586 focal sessions, 428 of bears without humans and 158 of bears with humans present. We observed bears without humans present for 210.1 hours and bears with humans present for 78.6 hours during the 2 summers.

For the focal sessions in the wet meadow habitat (n = 302), 244 were without humans and 58 included humans. Focal sessions in the inland habitats (n = 135) included 95 without humans and 40 with humans. For the focal sessions including fishing activity (n = 114), 67 were without humans and 47 were with humans present.

We hoped to identify many individual bears but this proved problematic for several reasons. First was the sheer numbers of bears we observed during 1998 – 1999. Second was the fact that a bear may use the study area and then disappear for days, weeks or months. In spite of some of these problems we feel that we could recognize 5 different large males, 4 sows with spring cubs, 6 sows with older cubs, and 9 individual

bears that used the study area. We discerned large males using scars and other clues (e.g. missing claws). We identified several single bears using pelage color, body morphology, and other traits, and several females with cubs by the number, size, and individual characteristics of the cubs.

During the 2 summers, we observed behavior of a minimum of 8 large males, 6 sows with spring cubs, 7 sows with older cubs and approximately 20 single bears. During the first half of 1999, there was only 1 sow with a spring cub using the study area.

Although these numbers do not give us a large sample size, they still provide us with a reasonable sample size that represents the bears that use Hallo Bay. Sampling only 1 sow with spring cubs during the first half of the 1999 field season could result in that sow having undue influence over the results of that bear class. Tthough we only sampled 1 sow with spring cubs during the first half of 1999, we feel that pooling this data with 1998 data collected from 3 other sows with spring cubs lessens her overall effect on our results.

We recorded 93 focal sessions to assess grazing rates of bears with humans absent and at different distances to humans, 41 with humans and 52 without humans. We were able to determine bite rate for all observations, bites per step for 32 observations with humans and 46 observations without humans, and bites per alert for 39 observations with humans and 51 without humans.

Tourist Visitation

Tourist visitation to Hallo Bay occurred from late May to early September and most use occurred between 0800 h and 2000 h (Figure 2.2). Weather was the primary determinant of human visitation, with poor weather preventing floatplanes from reaching Hallo Bay. Visitors arrived from Homer and Kodiak, Alaska, primarily by floatplane,

although a few visitors arrived by boat. Most short-term visitors (no overnight stay) who arrived by plane remained in Hallo Bay for 1/2 to 1-1/2 hours ($\bar{x}$ = 81 minutes, SE = 8.9, range = 5 minutes – 4 hours, n = 81) and spent time watching and photographing bears. They remained in close proximity to the guide and remained greater than 100 m from bears. Visitors arriving by boat spent from 1 day to 4 days at Hallo Bay. Unguided visitors to Hallo Bay frequently violated the distances policies of KNPP.

Visitor Use Days at Hallo Bay numbered approximately 320 in 1998 and 400 in 1999. The number of visitors per group coming to Hallo Bay for a short visit averaged 4.9 (SE = 0.2, n = 53). Overnight visitor group size averaged 1.5 people (SE = 0.22, n = 6). Overnight visitors camped on or adjacent to the study area from 2 nights to over a month at a time. Overnight use doubled in 1999 compared to 1998.

Effects of Human Activities

Wet Meadow

We rejected the null hypothesis that activity budgets of brown bears do not differ with humans at different distances ($\alpha = 0.05$). Each class showed some significant change in its activity budget.

Large males. – Large males showed only 1 significant effect due to human presence. Before fishing season, foraging was 125% higher with humans present than when humans were absent ($F_{2, 156} = 3.554$, $P = 0.023$). Although not statistically significant, large males spent 150% more time walking when humans were <50 m away than when humans were absent.

Sows with spring cubs. – Sows with spring cubs showed only 1 significant effect due to human presence. Before fishing season, sows with spring cubs grazed 25% less with humans present than when humans were absent ($F_{2, 125} = 3.456$, $P = 0.029$).

Sows with older cubs. – Sows with older cubs showed only 1 significant effect due to human presence. During fishing season, the percent of time spent walking was six-fold higher when humans were present than when humans were absent, from 8% to 51% ($F_{2, 74}$ = 12.688, P < 0.000). Although not statistically significant, time spent grazing was 43% lower when humans were present, and 62% higher when humans were <100 m away, compared to when humans were absent.

Single Bears. – Before fishing season, single bears spent 87% more time alert when humans were <50 m away than when humans were absent ($F_{2, 224}$ = 5.995, P = 0.010). Before fishing season, resting was 240% higher when humans were present than when humans were absent ($F_{2, 224}$ = 4.573, P = 0.010).

Inland Habitats

Large males. — Large males spent significantly more time walking with humans <50 m away than when humans were absent ($F_{2, 59}$ = 4.973; P = 0.007).

Sows with spring cubs. — Activities of sows with spring cubs did not vary significantly with humans at different distances. Although not statistically significant, sows with spring cubs spent 46% less time grazing when humans were present, and 67% less time grazing when humans were <100 m away, than when humans were absent.

Sows with older cubs. — Activities of sows with older cubs did not vary significantly with humans at different distances. Although not statistically significant, sows with older cubs grazed 33% less, foraged 145% more, and were alert 48% less when humans were <100 m away, compared to when humans were absent.

Single Bears. — Single bears foraged significantly more when humans were present than when humans were absent ($F_{2, 112}$ = 3.09; P = 0.046). Although not statistically significant, the amount of time that single bears rested decreased to zero when humans

were present, and was 220% higher when humans were <50 m away, compared to when humans were absent.

Human Presence and Grazing Rate

We tested if humans affected the grazing efficiency of bears in the wet meadow habitat, measured as bites per minute, bites per step, and bites per alert. We rejected the null hypothesis that grazing efficiency for sows with spring cubs did not change with proximity to humans (α = 0.05). Sows with spring cubs took 45% fewer bites per minute when humans were less than 50 m away vs. absent ($F_{1, 17}$ =3.862; n = 3, 16; P = 0.042) (Figure 2.3). The other classes did not show a significant change in bites per minute, nor were there any significant differences for bites per step or bites per alert for any class.

Human Presence and Fishing Success

We tested if humans affected fishing success of bears at Hallo Bay. Fishing success was defined as chases per fish caught. We failed to reject the null hypothesis that fishing success did not change with respect to proximity to humans (α = 0.05). We did not find a statistically significant change in the fishing success of any classes in association with human proximity, although large males and single bears showed a large decrease in fishing success with humans present vs. absent and sows with spring cubs showed a large increase in fishing success with humans present (Figure 2.4).

2.4 DISCUSSION

Numerous studies have indicated that human activities can alter the demography, activity budgets, habitat use, and timing of habitat use of brown bears both in areas of high human use (McClellan and Shackleton 1989, Fagen and Fagen 1990, Gunther 1990, Olson and Gilbert 1994, Olson et al. 1997), and low human use (White et al. 1999). When human activity affects activity budgets of brown bears, the effect is

usually a decrease in feeding efficiency, at least of more dominant, displaced classes (Olson and Gilbert 1994, Olson et al. 1997, White et al. 1999).

Wilker and Barnes (1998) found that high and moderate responses to humans occurred more frequently with unstructured bear viewing. In this case, unstructured bear viewing is defined as no limit on the number of visitors, no viewing schedule, overnight camping allowed, and cabin rentals at the viewing site. Conversely, structured bear viewing is defined as limited number of viewers, scheduled viewing times, viewing from a raised platform, and no overnight use at the viewing site (Aumiller and Matt 1994). Knight and Cole (1995) and Aumiller and Matt (1994) believed that structured bear viewing was less disruptive because the patterns of human activity were consistent and predictable.

Jope (1985) reported that negative encounters occurred more frequently in areas of low human use than areas of high human use, apparently because of habituation to humans in high-use areas. Jope (1985) also found that bears reacted to humans within 150 m, and usually did not react to humans >150 m.

McClellan and Shackleton (1989) reported that brown bears in the Flathead drainage of British Columbia responded more strongly to human encounters in open habitats than in cover and responded more strongly when humans were on foot than when they were in vehicles or aircraft.

McClellan and Shackleton (1989) and Jope (1985) measured only obvious movements (e.g., running away) of the bears with respect to humans and would have failed to discern changes in activity budgets. We rarely saw bears run away when humans were present, including researchers traveling to and from the observation tower.

In light of the results of Wilker and Barnes (1998), Aumiller and Matt (1994), McClellan and Shackleton (1989), and Jope (1985), human visitation should have an impact on brown bears that use open habitats at Hallo Bay. Hallo Bay is an undeveloped and unmanaged bear-viewing site. Human visitation to the study area at Hallo Bay was relatively low in 1998 and 1999, with fewer than 300 visitor-use days each summer. However, the schedule of visiting humans was unpredictable, as aircraft could only reach Hallo Bay in good weather, yet good weather did not guarantee the arrival of visitors. The infrequent arrival of tour boats with visitors was less weather-dependent, and, once in Hallo Bay, the visitors could be shuttled ashore in most weather conditions.

Previous studies were not detailed enough to detect subtle changes in a bear's behavior. While we witnessed only 5 instances where bears abandoned the area they were using when humans appeared, we detected several effects associated with human proximity to bears. If we had investigated the effects of human activities on a scale similar to these other studies, we would have failed to detect any real effect of human activities at Hallo Bay.

Effect of Humans on Bear Activity Budgets

There is no doubt that humans had significant effects on the activity budgets of all classes of bears at Hallo Bay. In the wet meadow, all significant changes occurred when humans were merely present, and in the case of single bears, when humans were less than 50 m away. In the other inland habitats, some of the significant effects occurred with humans at closer distances (<50 m, <100 m); this may be a result of reduced visibility in these habitats. For example, the vegetation canopy in the grass dunes was over 1.3 m high, and therefore could have interfered with the bears' ability to detect humans until humans were relatively close.

Small sample sizes, especially at the closer distances from bears, probably reduced our ability to detect significant effects. In spite of this limitation, we feel that our study showed that effects on bear activity budgets have already occurred at Hallo Bay.

Human Effect on Grazing Efficiency

Sows with spring cubs showed a significant reduction in bites per minute when humans were within 50 m. Bites per minute showed a downward trend beginning when humans were present. Sows with spring cubs also showed a decrease in bites per step and bites per alert when comparing humans <50 m to humans absent.

The fact that sows with spring cubs decreased their intake rate so significantly with humans <50 m could have serious consequences for these bears. Sows with nursing cubs have higher metabolic costs than other classes due to lactation (Robbins 1993, Farley and Robbins 1995). Body condition influences age of first reproduction, litter size, and interval between breeding (Rogers 1976, Bunnell and Tait 1981, Elowe and Dodge 1989, Samson and Huot 1995). Diet also affects milk composition (Jenness 1985).

Also, before fishing season, few food sources for bears other than vegetation are available. Bears are typically at their lowest weight at this time of year and sows with cubs that are nursing have to rely almost solely on vegetation to meet their energy demands. Reducing their caloric intake from vegetation during this time could have a more adverse effect on their energy balance than later when salmon are available.

Human Effects on Fishing

Spawning salmon are an important food resource for coastal populations of brown bears. While animal protein ingested in the spring and early summer helps bears to recover from the drain of hibernation, the mass gained at this time of year is primarily

muscle tissue (Hilderbrand et al. 1999b). Salmon that spawn in late summer and fall provide the energy needed for bears to accumulate and store enough fat to allow them to hibernate 5-7 months of the year (Farley and Robbins 1995, Hilderbrand et al. 1999a, 1999b).

Females give birth to young during hibernation and need sufficient reserves to support nursing while hibernating (Rogers 1976, Elowe and Dodge 1989, Samson and Huot 1995). Coastal brown bears typically gain these reserves from eating salmon and storing the reserves as fat. Also, salmon are necessary for males to attain their large size (Welch et al. 1997, Rode et al. 2001). Any activity that reduces the ability of bears to catch salmon could have serious deleterious effects on the individual and the population (Hilderbrand et al. 1999a).

The presence of humans negatively affected fishing success of large males. On the individual level, this could have serious repercussions for the ability of these bears to attain the body mass required for survival during hibernation (Watts and Jonkel 1988). Although Gibeau et al. (2002) found that large males used high quality habitats in proximity to human activity; our results suggest that even though they continued to use these habitats, their ability to use these habitats efficiently may have been reduced.

On the population level, a reduction or absence of large males using the open habitats at Hallo Bay could have negative consequences for the survival of cubs. Wielgus and Bunnell (1994a) and LeCount (1987) attributed reduced cub survival in their study areas to predation by young males, resulting from hunting mortality of older males. The removal of large males through hunting allowed subadult males to use areas previously occupied by large males. Although large males do cannibalize cubs, an influx of cannibalistic subadults may result in an increase in cub mortality (Wielgus and Bunnell

1994a, LeCount 1987). Hunting does not occur at Hallo Bay, but large males may eventually abandon fishing sites exposed to human disturbance for less disturbed fishing sites elsewhere. The result could be the same as removal of large males by hunting: an influx of subadult males that may prey more heavily on cubs.

Unlike other bear viewing locations where bears have access to salmon for large portions of the day, the bears at Hallo Bay have access to ripe (pre-spawning) salmon for only 6-7 hours per day (~3 hours per low tide, twice a day). The short duration of daily fishing opportunity compounds the potential impact to bears fishing in Middle Creek. Even a short-term disturbance can affect a large portion of the available fishing opportunity.

Overnight visitors currently have the greatest access to bears throughout a fishing session as these tourists can remain at Hallo Bay during low tide. Floatplanes generally arrive at Hallo Bay shortly before high tide and leave shortly after high tide. This guarantees low water will not trap the planes and their clients are not required to walk across mucky tide flats. Negative impacts to bears could be severe with high numbers of overnight visitors, as the bears have very limited options for otherwise obtaining ripe salmon at Hallo Bay. Ripe salmon are higher in lipid content than spawned salmon and therefore are more nutritious for bears (Reimchen 2000, Gende et al. 2001).

At the levels of visitor use in 1998-99 at Hallo Bay, humans were rarely present when bears were fishing. Over 90% of the fishing focal sessions with humans present involved research technicians making approaches to fishing bears. However, if overnight use continues to increase at Hallo Bay, more visitors will be able to observe fishing bears, thereby increasing the probability of human impacts.

2.5 CONCLUSION

The KNPP Bear Management Plan (National Park Service, 1986:1) states, “The policy of bear management in Katmai is to retain the natural population dynamics … (and) …allow their natural patterns of feeding and habitat use to continue unimpeded…” The activity budgets of bears using Hallo Bay changed with humans at different distances when compared to no humans present.

KNPP policy dictates that visitors should remain at least 100 m from sows with cubs and at least 50 m from other bears. This rule is to prevent disturbances to bears and to reduce the potential for injury to humans. We recorded several instances where tourists approached to within 50 m of sows with cubs. Enforcing the policy will reduce the impacts to the grazing efficiency of sows with spring cubs.

This policy was not effective in eliminating impacts caused by humans as limited law enforcement presence allowed visitors to move as they desired at Hallo Bay. During the summers of 1998-99, park law enforcement personnel were present in Hallo Bay for only a few weeks each summer. Stationing law enforcement personnel at Hallo Bay for all or most of the summer would reduce impacts of visitors to bears.

While it is important for bears to feed on high quality foods throughout the summer, the ability to catch and eat salmon is critical for coastal brown bear populations to remain productive (Hilderbrand et al. 1999a). The presence of humans reduced the ability of large males and single bears to catch fish. This can be weighed against the increased fishing success of females with young of all ages when humans were present and the possible implications on breeding biology of these bears. This is beneficial to females and the population as nutritional status of females strongly influences

reproductive rates, and growth and survival of cubs. However, KNPP policy states that no changes to behavior should occur, and this is violated.

Human activities at Hallo Bay were affecting the activity budgets of bears that used the area. It is possible that these activities were negatively affecting the productivity of sows with cubs. Since most significant effects occurred when humans were merely present, enforcing the existing policy will reduce only some of the effects. If human use of the area continues to rise, especially overnight camping, the managers of KNPP will need to consider limiting human activities at Hallo Bay and setting some areas as off-limits to humans.

If future visitor-use trends result in crowds of humans at the fishing spots used by bears, the result could be a drastic change in the fishing success of bears. At the level of visitor use in 1998-99, the impacts, although potentially great, are infrequent. Overnight visitors have the most exposure to fishing bears, and therefore could have a greater negative effect on the bears that use Hallo Bay. The Park should make it a priority to protect bears engaged in fishing from human harassment during low tide.

Although eliminating human use of Hallo Bay is an option for staying within the bounds of the Bear Management Plan, this measure appears extreme, especially in the context of the contributions of bear viewing areas to the public's understanding and acceptance of bears. If human activity at Hallo Bay continues to increase, then park managers should consider a management system similar to other bear viewing sites such as McNeil River State Wildlife Management Area (Aumiller and Matt 1994).

2.6 Figures

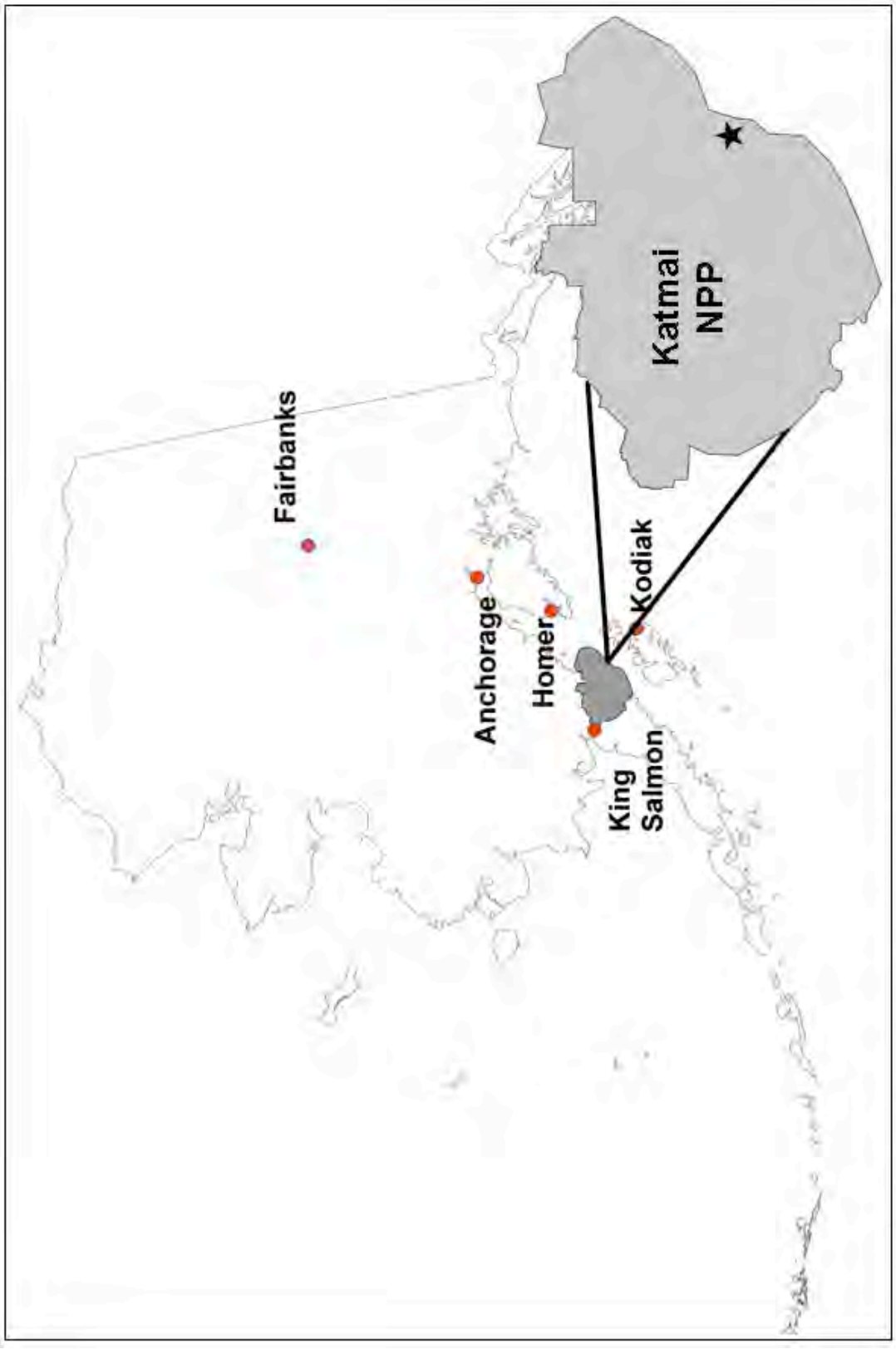

Figure 2.1 Map of Alaska, and location of Katmai NPP and Hallo Bay.

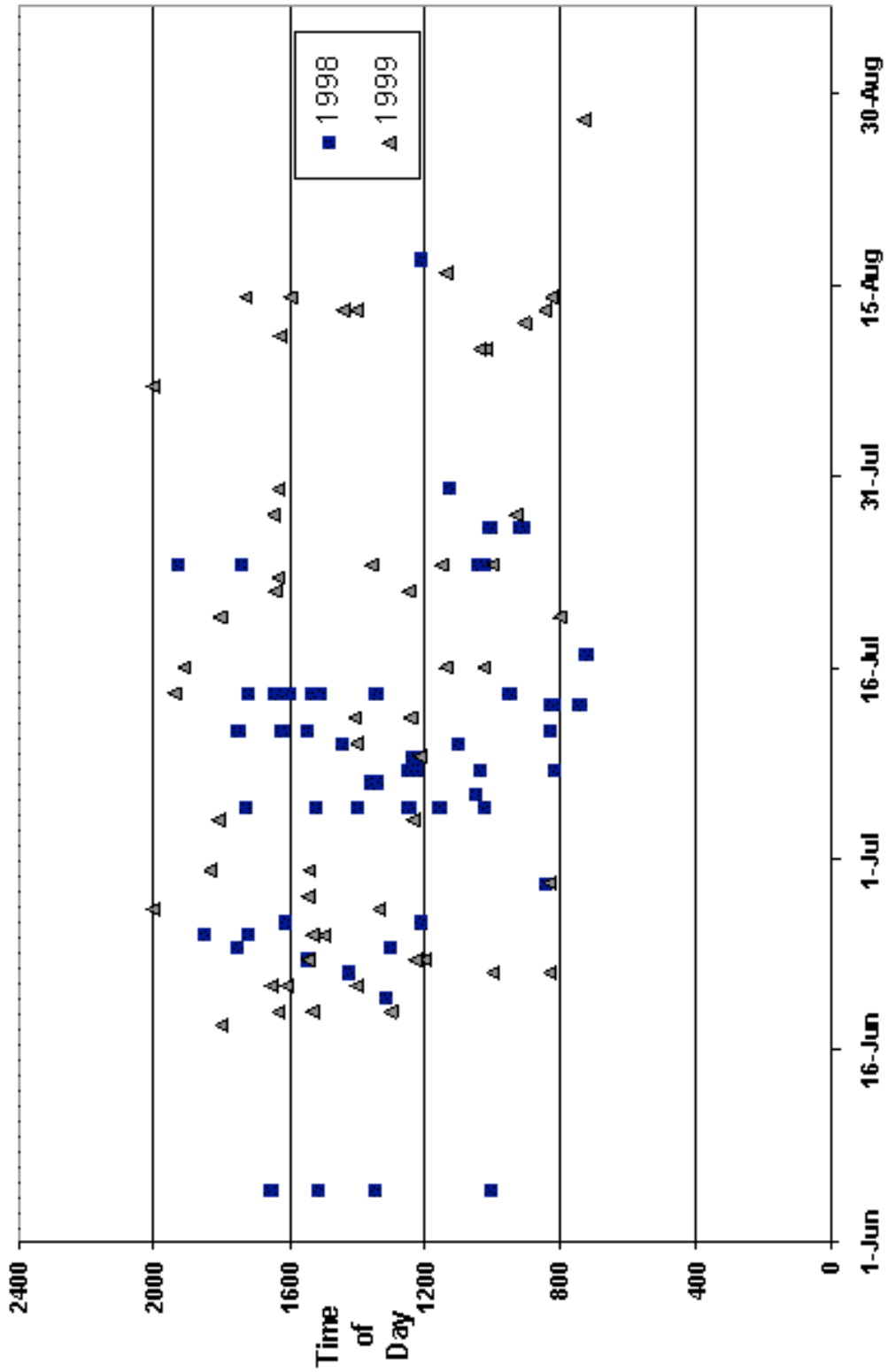

Figure 2.2 Date and Time of Arrival (ADT) of Visitors to Hallo Bay, Katmai NPP, Alaska, 1998 – 1999.

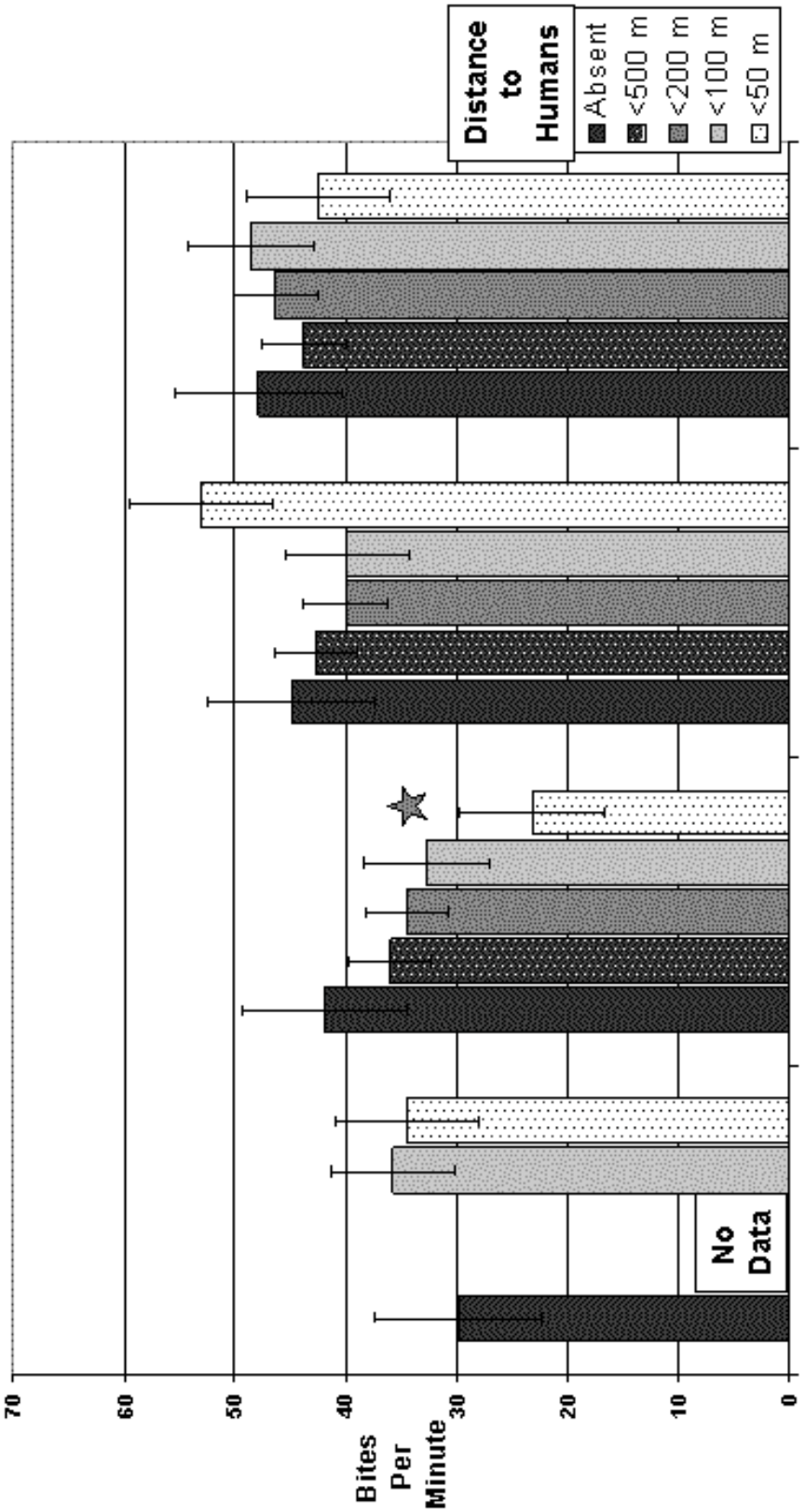

Figure 2.3 Effects of distance to humans on bite rates for all bear classes, Hallo Bay, Katmai NPP, Alaska, 1998 – 1999. ★ = $p < 0.05$.

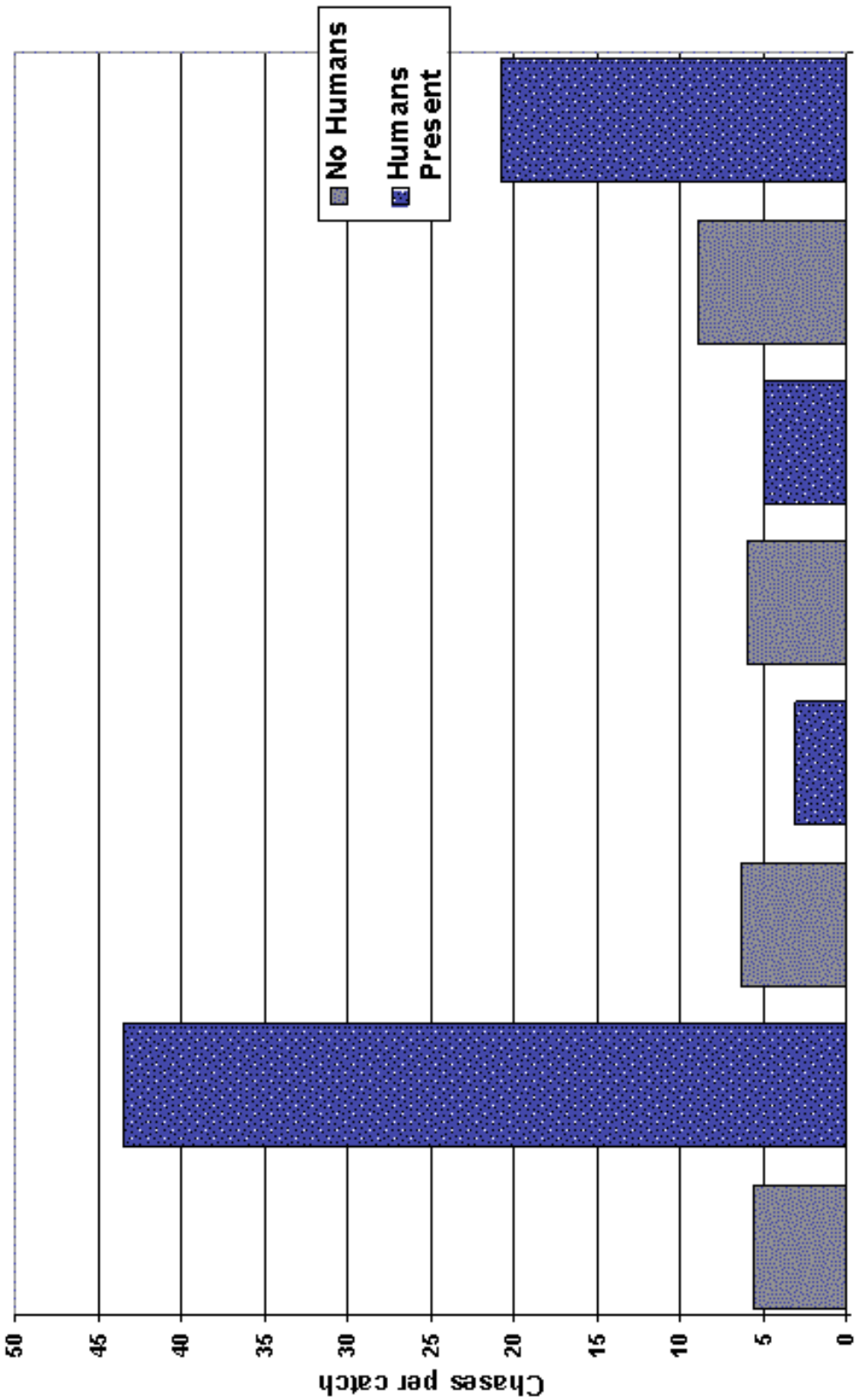

Figure 2.4 Mean fishing success rates of all bear classes, 1998 – 1999, Hallo Bay, Katmai NPP, Alaska. Success rate is defined as number of chases per catch.

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2.8 CONCLUSION

We found that the activity budgets of brown bears that used our study site at Hallo Bay varied significantly with humans present, and to a lesser extent, with humans at closer proximities. Although these effects may not have had significant biological effects on the bears, these effects do not meet the standards of the KNPP Bear Management Plan. Of greater concern is the significant reduction of the grazing efficiency of sows with spring cubs when humans were <50 m away. Humans this close to sows with cubs is a violation of Park policy and should be corrected with consistent law enforcement presence at Hallo Bay.

Additionally, human activity at Hallo Bay also appeared to affect the use of the study area by large male bears. The pattern of use of the study area by large males exhibited a bimodal pattern with peak use by large males before and after the times of highest human use. Some of these effects should be weighed against the opportunity of the public to gain a greater appreciation of brown bears through photographs and visitation to Hallo Bay.

2.9 RECOMMENDATIONS

With the growing number of visitors to Hallo Bay, we recommend that Park managers begin managing human use at Hallo Bay. We recommend that Park managers develop a system to limit the number of day users and overnight users allowed at Hallo Bay. We also recommend establishing a camping area away from the open sedge meadows. We also feel that overnight users should be kept a minimum distance from fishing bears. Further research may determine a critical distance that humans should remain away from fishing bears. Finally, we recommend that Park

Rangers remain at Hallo Bay throughout the bear viewing months to ensure compliance with Park Service policies and rules.