Nocturnal Foraging Behaviour of Black Bears, *Ursus americanus*, on Moresby Island, British Columbia

T. E. REIMCHEN

Department of Biology, University of Victoria, Box 3020, Victoria, British Columbia, Canada V8W 3N5; e-mail: reim@uvvm.uvic.ca

Reimchen, T. E. 1998. Nocturnal foraging behaviour of Black Bears, *Ursus americanus*, on Moresby Island, British Columbia. Canadian Field-Naturalist 112(3): 446–450.

Black Bears (*Ursus americanus*) are usually active during daylight but are known to shift to crepuscular and nocturnal activity when daylight activities are disrupted. The principle factors currently thought to promote this shift are the presence of Brown Bears (*U. arctos*) and humans. I examined the extent of diurnal, crepuscular and nocturnal activity of Black Bears in an estuary and stream during salmon spawning migration at Bag Harbour, Haida Gwaii, off coastal British Columbia. A predominance of daylight activity was predicted as there are no Brown Bears on Haida Gwaii and only minimal human disturbance in the remote area. Results show that during daylight, there was low but consistent foraging activity in the stream but no daylight foraging on the estuary even when salmon were abundant. Bears were intolerant of each other during daylight and would rarely forage within visual range of each other. Use of night-viewing goggles show that most foraging on the stream and all foraging on the estuary occurred during darkness with peak activity four to six hours after sunset. Up to six bears foraged simultaneously in the shallows in close proximity to each other with few agonistic interactions. High foraging success during darkness occurred because salmon showed reduced evasive responses to shoreline disturbance compared with daylight. These observations suggest that occasional nocturnal activity by Black Bears on the mainland of western North America might be the result of preferred foraging periods rather than disturbance with diurnally active competitors.

Key Words: Black Bear, *Ursus americanus*, salmon, nocturnal, foraging behaviour, Queen Charlotte Islands, British Columbia.

Black Bears (*Ursus americanus*) are primarily diurnal both in eastern and western North America (Lindzey and Meslow 1977; Larivière et al. 1994; Powell et al. 1997). Vision is presumably important in the behavioural interactions among bears as well as in the search for food, which is highly diverse (Powell et al 1997; Matchutchon et al. *in press*). Black Bears are also active during darkness, for example, where the species overlaps with Brown Bear (*U. arctos*) and where human activities are prevalent during daylight (Olson et al. *in press*). This shift to nocturnal activity occurs in western North America and is interpreted as an ecological restriction to less preferred foraging periods (Machutchon et al. *in press*; Olson et al. *in press*). Yet in a study of Alaskan Black Bear on an estuary with migrating salmon, Frame (1974) found a predominance of crepuscular foraging despite the absence of Brown Bears and absence of human disturbance in the area. This suggests that other factors can facilitate foraging at low light levels.

Haida Gwaii (formerly Queen Charlotte Islands), occurring 80 km off the central coast of British Columbia, have Black Bears but no Brown Bears (Cowan and Guiguet 1956). Molecular phylogenies demonstrate that these Black Bears have high genetic affinity with other coastal subspecies of the Black Bear but are distantly related to interior continental sub-species (Byun et al. 1997). As part of an investigation on trophic associations between Black Bears and salmon on Haida Gwaii, I recorded activity patterns of bears over the salmon spawning period to ascertain the extent of foraging during daylight and darkness. A predominance of daylight activity was predicted based on three lines of evidence, (1) the prevalence of diurnal activity of Black Bears elsewhere in the distribution of the species, (2) the absence of Brown Bears from the archipelago and (3) the low levels of human disturbance in the area.

Study Area

The investigation was carried out at Bag Harbour (52° 22' N, 131° 21' W) in the southern regions of Moresby Island, one of the large islands in the archipelago. From 2000-6000 adult Chum Salmon (*Oncorhynchus keta*) return annually to Bag Harbour from late September to late October. Schools of salmon are most common in shallow waters of the estuary during early October and numbers gradually decline over a three week period as individuals move into the stream. By the last week of October, few individuals remain in the estuary. On capture of a salmon in the stream, bears usually carry the fish into the riparian zone. For 14 days in October 1992 and for 26 days in October 1993, during the major spawning period, I made visual surveys of bear activity on the estuary a minimum of three times during daylight (ca. 0900h,

1200h, 1600h). In 1993, I also made visual surveys of the estuary a minimum of four times during darkness (2100h, 2200h, 0100h, 0400 h) using head-mounted full-face night-viewing goggles (Model AN/PVF5, USA, light amplification 110 000×, resolution 270 000 pixels); these provided night-viewing conditions approximately equivalent to mid-day illumination with an overcast sky. During October, sunset (PST) occurs near 1800 h and sunrise occurs near 0700 h; civil twilight extends for 35 minutes both after sunset and before sunrise. Most surveys on the estuary were made from the the field camp which was positioned at the forest edge on a small promontory which projected into the estuary. Bears were usually monitored from distances ranging from 5 m to 100 m. Bear surveys in the stream and riparian habitats were made daily throughout study period in both years. I moved quietly so as to minimize any disturbance and increase likelihood of detecting bear. When bears were encountered, I followed them and recorded their activities (2 m to 25 m distance) until they had moved back into the forest after which I continued upstream until another bear was encountered. I made four complete surveys of the stream each day (ca 0930h, 1100h, 1400h, 1700h). I also made daily searches for the fresh uneaten carcass remnants abandoned by bears in the riparian zone.

Results

Throughout the October study period, there was little bear activity on the estuary during daylight although schools of salmon were common in the estuary from late September to October 20. On three occasions in daylight, I saw solitary adult bears moving across the intertidal flats into the forest but even in these instances, no foraging occurred. Greater than 98% of all bear activity on the estuary occurred during darkness. Solitary adults would begin to arrive on the estuary near twilight. With the onset of darkness, numbers of bears gradually increased reaching a maximum (six adults) near 2200 hours following which, numbers declined to zero by dawn (Figure 1). No family groups were observed. All bears foraged during their presence on the estuary but by the last week of October when all salmon had moved into the stream, no more bears were seen on the estuary.

Bears walked slowly into shallow water and waited motionless usually 3 to 10 m from the shoreline. After a short period (<20 minutes), the bear would leap forward and "belly-flop" into the water occasionally capturing a salmon either by pinning the fish to the substrate with the claws or by seizing the fish in the jaws. Over three weeks, I recorded 31 captures in 129 flops (mean 24% success, range 0-100% among days). Salmon were carried back to shore or into the adjacent forest where they were eaten. If no

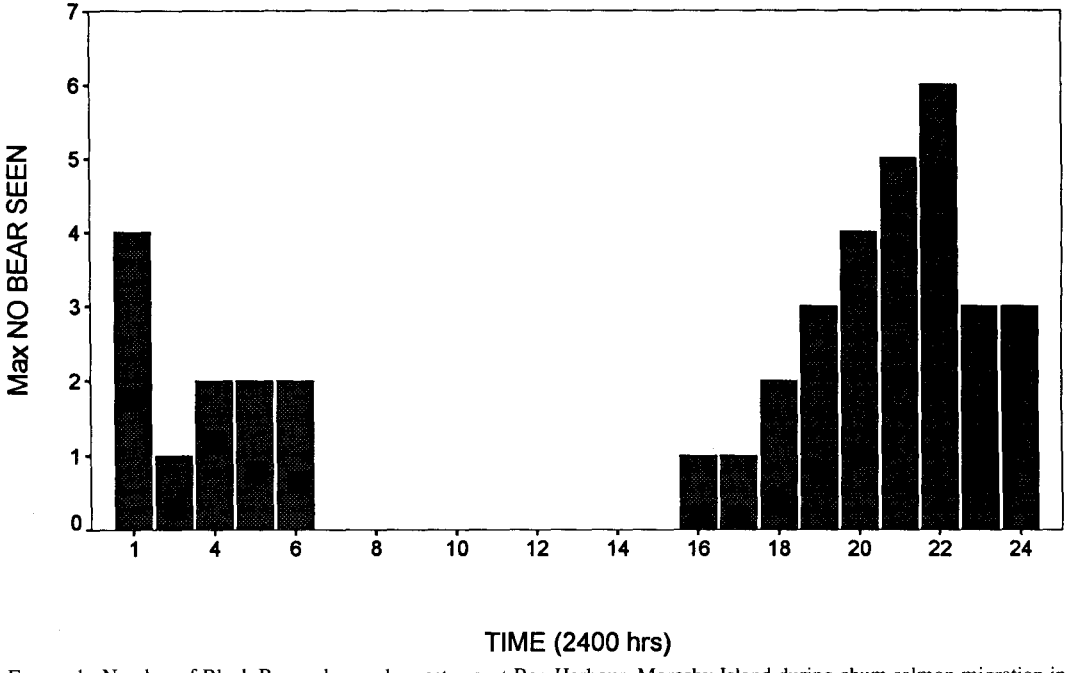

FIGURE 1. Number of Black Bears observed on estuary at Bag Harbour, Moresby Island during chum salmon migration in October, 1993. Data show mean (■) and maximum (histogram) number of bears observed simultaneously during hourly periods. All counts during darkness made with night-viewing goggles.

salmon was captured, the bear repeated the sequence in the same area or moved to another area of the estuary.

Bears distributed themselves throughout a 700 m distance along the shoreline but there was occasional clumping in particular areas where salmon were abundant. On several occasions during darkness, all bears foraged within 50 m along the shore. Despite proximity to each other (ca. 5 m), I saw little evidence for agonistic encounters. In movement along the shoreline, bears usually passed close to each other without conflict. The single aggressive action that I observed during darkness throughout the field season occurred when a bear rushed towards a smaller bear that had just captured a salmon, upon which the latter abandoned its prey, and returned to the tideline to continue foraging.

Within the forested regions of the stream, I made daylight surveys for bear in the riparian zone and in the stream channel. Unlike the pattern on the estuary when bears were rarely seen during daylight, I daily encountered lone adult bears foraging in the stream. Bears searched for salmon under logs and under the overhanging banks. In several pools on the stream where salmon tended to congregate, bears would wade into the pool and seize salmon that swam near the surface and carry these ashore. Spawning activity occurred in shallow water (ca. 10-15 cm) where the salmon were highly visible and partly exposed above the water surface. However, I did not observe bears make any attempts to capture these salmon on the spawning gravels. When the bears walked across the stream, these salmon swam quickly to shelter and were not pursued.

My movement up and down the stream channel was intentionally silent and I typically encountered one or two bears, and on one occasion, four adult bears over the 1 km of spawning gravels. Rarely could I see more than one bear from any single position on the stream as bears were separated from each other by fallen trees as well as by bends in the stream channel. On two occasions that I saw two bears encounter each other on the stream, on first visual contact with the other bear, the smaller of the two ran immediately into the forest beyond the visual range of the larger bear.

I made four surveys of the stream during darkness. While a maximum of one bear occurred on a particular reach (5-10 m) of the stream during daylight throughout the study period, I saw from two to four adult bears foraging in the same reach during darkness. Bears stood in close proximity to each other (<10 m) in the shallow regions where the salmon were spawning. I saw no agonistic encounters among the bears even when salmon were captured. Salmon were eaten on the gravel bars or carried into the forest. Replicated early morning and late afternoon transects for carcass remnants in the riparian zone indicate that bears capture the majority (>80%) of salmon during darkness (Reimchen 1994*).

Discussion

Contrary to the original predictions, the majority of foraging activity by Black Bears during the salmon spawning run at Bag Harbour occurred during darkness rather than daylight. Such extensive nocturnal foraging in North American bears has not been previously described. However, since this is the first investigation using night-viewing goggles to monitor nocturnal activity of bears, it is plausible that nocturnal foraging may be common in western North America where bears overlap with migrating salmon.

Crepuscular foraging activity has been reported previously for both Black Bears and Brown Bears. Frame (1974) observed Black Bears foraging near dawn and dusk (0300 - 0600 h, 1600 - 2200 h) on an Alaskan estuary where salmon were congregating. Frame was not able to make systematic counts during full darkness (2200-0300 h) but there was no indication of any reduction in foraging activity during the onset of darkness. The hourly activity pattern is very similar to that observed at Bag Harbour estuary on Haida Gwaii. Olson et al. (*in press*) found increased crepuscular activity of Alaskan Brown Bears foraging on salmon but suggested that this was in response to reduced human disturbance at dusk and dawn, and reflected a less-preferred foraging period. Daylight foraging occurred in an adjacent stream where no human disturbance occurred. However, the habitat with crepuscular foraging activity was much more open than the forested stream where daylight foraging prevailed, similar to the differences between Bag Harbour estuary and stream.

Brown Bears in Alaska also fished during darkness but it was assumed that these were scavenging for dead salmon as visual cues for capturing live salmon would be lacking (Olson et al. *in press*). Machutchon et al. (*in press*) compared Black Bear daily foraging activity in three disjunct regions of western Canada. On the coastal mainland, where Brown Bears are found, Black Bear activity shifted primarily to darkness while on Vancouver Island, where Brown Bears are absent, Black Bears were mainly active during daylight. Machutchon et al. (*in press*) concluded that the shift to nocturnal activity of Black Bears on the mainland was in response to Brown Bears, and represented a less-preferred foraging period as capture of salmon would have been more difficult during darkness. However, the bear study on Vancouver Island was not on a salmon river so the comparisons with the mainland are not ecologically equivalent. Brown Bears were equally active during daylight and dark-

*See Documents Cited section.

ness in the salmon season but nocturnal activity was attributed to increased human activity during daylight (Machutchon et al. *in press*).

Increased crepuscular and nocturnal activity of Black Bears on Haida Gwaii can not be due to the Brown Bear as there are no Brown Bears in the archipelago. Furthermore, there are only low levels of human disturbance at this site, particularly during autumn rains when salmon spawning migration occurs, so this is not a likely cause for nocturnal foraging. One cannot exclude the potential competitive effects of indigenous peoples of Haida Gwaii who have inhabited the region for at least 8000 years. However, there has been no permanent use of these estuaries for 80 years (Dalzell 1973). If daylight is a preferred period for foraging, then Black Bears could have been expected to exploit this after 80 years of non-disturbance.

The assumption that darkness equates to lowered foraging success in bears may be reasonable but this is not supported by field evidence. Rather, results from Bag Harbour indicate that crepuscular and nocturnal activities of Black Bears have direct benefits for foraging. In Bag Harbour estuary and stream habitats, bears were visually intolerant to each other during daylight and they spaced themselves outside of the visual field of each other. When two bears came into visual contact with each other, there was immediate evasive responses by one of the individuals. Even in regions of the stream with high salmon density, there was rarely more than a single bear visible during daylight from any single position on the stream. However, during darkness on the same regions of the stream and on the estuary, adult bears frequently foraged very close to each other with only low intensity agonistic responses. The absence of visual cues during darkness appeared to be a major factor in this elevated density of foraging bears.

One additional benefit of nocturnal foraging could be capture efficiency of salmon. Schools of salmon often swam within a few metres of shoreline in the estuary. When I approached during daylight, these schools moved quickly into deeper water and would have been difficult for a wading predator to capture. Yet during darkness, these schools were much less responsive to shoreline intrusion. With night-viewing goggles, I observed salmon moving slowly past bears which were standing motionless in the water (Reimchen 1994*). I was also able to walk slowly into these fish schools without causing serious evasive responses. Capture success of bears appeared to be directly related to number of salmon of the estuary, reaching 100% when fish were abundant in shallow water. Abundance of salmon in the shallow waters was itself associated with activity of Harbour Seal (*Phoca vitulina*) as presence of this predator tended to lead to increased schooling along the shoreline where the seals were unable to swim (Reimchen 1994*). I did not monitor bear activity on streams during darkness for sufficient periods to ascertain capture efficiency but the overnight accumulation of fresh carcasses in the riparian zone during my early morning surveys and the low accumulation during daylight showed that a large proportion of salmon capture from the stream occurred during darkness.

The specific foraging behaviour of Black Bears during darkness at Bag Harbour was similar to that described for Brown Bears during daylight at McNeill River, Alaska in which the most common fishing technique (during daylight) was the "standing-plunging-forepaws-mouth" sequence (Luque and Stokes 1976). I was unable to determine what stimulus bears used before lunging for salmon during darkness, but it could have been tactile stimuli when salmon swam past the legs of the bears. Another common technique used by Brown Bears in Alaska was the "standing-mouth" sequence in which bears stood motionless, and seized the salmon which were close to the surface. This was also used by Black Bears during daylight in Bag Harbour stream where schools of salmon occurred in small (4 m wide) pools and where fish were restricted in their escape. I did not observe this foraging method on the estuary, probably due to the increased evasive opportunities of salmon.

In summary, data collected from daylight and nocturnal surveys of estuary and stream at Bag Harbour indicates that most foraging on salmon by Black Bears occur during nocturnal periods. Furthermore, various aspects of bear behaviour differ between daylight and darkness including foraging positions, individual distances among bears and levels of agonistic interactions. Neither human nor Brown Bear activities, the main factors contributing to nocturnal foraging on the mainland, are important at Bag Harbour and cannot account for elevated nocturnal activity. Rather, nocturnal activity appears to be a preferred period for foraging, particularly in estuaries where salmon are not spatially restricted. The rapid evasive responses of salmon during daylight to shoreline disturbance and their relative lack of response during darkness, suggest an immediate advantage to nocturnal foraging. Low levels of agonistic responses among the bears during darkness relative to daylight will accentuate the capacity of lower ranking bears to use the high quality habitats during darkness. These trends are consistent with optimal foraging predictions and may have broader geographical relevance because salmon is a major nutrient source for coastal bear populations from Washington, Oregon, British Columbia and Alaska (Gilbert and Lanner 1992; Willson and Halupka 1995). Further nocturnal investigations with night-viewing devices in other geographical areas, and on other ursid species, could be informative for inter-

preting the behavioural ecology of bears during salmon spawning migration.

Acknowledgments

I am grateful to B. Gilbert for discussion and to C. French and D. Seguin for field assistance. The field research was funded by Canadian Parks Service while analyses and manuscript preparation were supported with a Natural Sciences and Engineering Research Council of Canada operating grant.

Documents Cited (marked * in text)

Reimchen, T. E. 1994. Further studies of predator and scavenger use of chum salmon in stream and estuarine habitats at Bag Harbour, Gwaii Haanas. Canadian Parks Service, Technical Report, Queen Charlotte City, British Columbia.

Literature Cited

Byun, S. A., B. F. Koop, and **T. E. Reimchen.** 1997. North American Black Bear mtDNA phylogeography: implications for morphology and the Haida Gwaii glacial refugium controversy. Evolution 51: 1647–1653.

Cowan, I. Mc.T., and **C. J. Guiguet.** 1956. The mammals of British Columbia. British Columbia Provincial Museum Handbook Number 11.

Dalzell, K. E. 1973. The Queen Charlotte Islands: places and names. Cove Press, Prince Rupert, British Columbia.

Frame, G. W. 1974. Black Bear predation on salmon at Olsen Creek, Alaska. Zeitschrift fuer Tierpsychologie 35: 23–38.

Gilbert, B. K. and **R. M. Lanner.** 1995. Energy, diet selection and restoration of Brown Bear populations. Proceedings of the 9th International Conference on Bear Research and Management 9: 231–240. [Paters: French Ministry of the Environment and Natural History Museum of Grenoble.]

Lariviere, S., J. Huot, and **C. Samson.** 1994. Daily activity patterns of female Black Bears in a northern mixed-forest environment. Journal of Mammalogy 75: 613–620.

Lindzey, F. G., and **E. C. Meslow.** 1977. Home range and habitat use by Black Bears in southwestern Washington. Journal of Wildlife Management 41: 413–425.

Luque, M. H., and **A. W. Stokes.** 1976. Fishing behaviour of Alaskan Brown Bear. International Conference Bear Research and Management 3: 71–78.

Machutchon, A. G., S. Himmer, H. Davis, and **M. Gallagher.** *in press.* Temporal and spatial activity patterns among coastal bear populations. International Conference Bear Research and Management 10: Fairbanks, Alaska.

Olson, T. L., R. C. Squibb, and **B. K. Gilbert.** *in press.* Brown Bear diurnal activity and human use: a comparison of two salmon streams. International Conference Bear Research and Management 10: Fairbanks, Alaska.

Powell, R. A., J. W. Zimmerman, and **D. E. Seaman.** 1997. Ecology and behaviour of North American Black Bears: Home ranges, habitat and social organization. Chapman and Hall, Wildlife Ecology and Behaviour Series, London.

Willson, M. F., and **K. C. Halukpa.** 1995. Anadromous fish as keystone species in vertebrate communities. Conservation Biology 9: 489–497.

Received 6 August 1997
Accepted 5 January 1998