Application of a remote video camera for wildlife study: Implication of Hibernation on Daily Salmon Consumption Rates of Grizzly Bears (*Ursus arctos horribilis*) Located in Brooks Falls, Alaska

Lexynn Kwan[1], Rebecka Lee[2]

December 13, 2020

Abstract: Grizzly bears (*Ursus arctos horribilis*) in Alaska are known to hibernate annually, with length and quality of hibernation being driven by food availability and energy stores. Salmon (*Oncorhynchus* spp.) are a major component of grizzly bears' diet and therefore, the amount of salmon consumed indicates grizzly bear health and fat storage. The rate of salmon consumption by grizzly bears is known to be high from June to August, but there is less focus on consumption in the months leading up to hibernation (October and November). We tested the hypothesis that when grizzly bears near hibernation, an enhanced salmon consumption rate would be observed in an attempt to accumulate final fat stores. We compared the daily salmon consumption rates in the present study to consumption rates from summer months in previous literature. A remote live camera was utilized to observe grizzly bear feeding activity and obtain an approximation of the daily salmon consumption rate. In comparison to the average consumption rate in the summer from previous literature (30 salmon/day), a significantly lower rate was obtained for the pre-hibernation period. Findings from the present study indicate that impending hibernation drastically reduced the Alaskan grizzly bear's daily salmon consumption rate.

1. Introduction

Grizzly bears are well-known hibernators; they are abundant in both the United States and Canada, with common sightings reported in Alaska (North American Bear Center, 2001). The period of hibernation is energetically costly for grizzly bears, beginning anywhere from October to November and ending in the spring. As a result, grizzly bears have been observed to heavily increase their body size and fat stores in the summer months prior to hibernation (Fitz, 2013). Since salmon comprise nearly 50% of the major nutrients in the grizzly bear diet (Hilderbrand et al., 1999), the amount of

[1] Faculty of Science, University of British Columbia, Vancouver, BC (lexynnkwan@gmail.com)
[2] Faculty of Science, University of British Columbia, Vancouver, BC (rebeckalee17@gmail.com)

salmon consumed is indicative of grizzly bear feeding activity, thus affecting their body size and energy storage (Levi et al., 2012).

The amount of salmon consumed also signifies nutrient transfer, since grizzly bears mediate nutrient exchange between marine and terrestrial environments. Specifically, salmon carcass disposal on land increases the amount of nitrogen available within the soil, therefore increasing species richness (Western Wildlife Outreach, n.d.). Since salmon consumption influences the productivity of nearby terrestrial surroundings, grizzly bears are an ideal species to study for an updated model of ecosystemic interactions in a given region.

Although high grizzly bear feeding activity has been commonly associated with high salmon runs in the summer months from June to August (Hilderbrand et al., 1999; McLellan, 2011; Natural Habitat Adventures, n.d.), there is limited literature addressing the pre-hibernation period exclusively, defined in this study as the early winter months of October and November. Thus, this investigation aims to provide information on the pre-hibernation salmon consumption rates. We tested the hypothesis that grizzly bears have increased salmon consumption rates immediately prior to hibernation, in comparison to the summer months. We predicted that grizzly bears would consume more salmon per day in the pre-hibernation period, since these months denote the last days available to accumulate fat stores before they hibernate. This is in concurrence with the U.S. Fish and Wildlife Service (n.d.), who suggest that feeding patterns should become more pronounced in the early winter months near hibernation. Results will yield information on grizzly bear fitness, feeding ecology and population stability.

2. Materials and Methods

2.1 Study Area

Brooks River spans 1.5 km with openings to Naknek Lake and Lake Brooks. It is highly populated with grizzly bears throughout summer, due to the high density of migrating salmon that travel from Bristol Bay every year. A highly frequented area within Brooks River is Brooks Falls, the location of data collection for this study. Brooks Falls acts as a barrier for the salmon who have to leap upstream, serving as a great hunting location for the bears (Katmai National Park and Preserve, 2019).

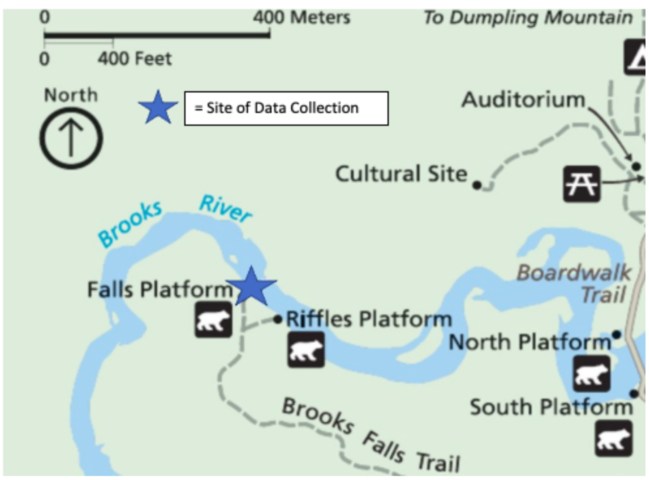

Figure 1: Map showing the study area (Brooks Falls) with noted observational location. Adapted from "Katmai Maps" by National Park Maps, 2020. Retrieved December 11, 2020 from http://npmaps.com/wp-content/uploads/katmai-brooks-camp-map.pdf.

2.2 Experimental Design

We utilized a live camera, produced from Katmai National Park and Explore, to observe grizzly bear feeding activity. The camera was attached at ground level on a major bear highway leading to and from the waterfall. We checked the cameras in hourly intervals at 10:00AM, 1:00PM, and 5:00PM (Alaska Daylight Time) each day. We collected data at these times to (i) have similar amounts of time between each interval, (ii) capture a representative model of feeding activity as grizzly bears are known to feed primarily in the diurnal hours (Munro et al., 2006), (iii) account for the researchers' availability. We began collecting data on October 10th, 2020 and planned to continue until grizzly bears were no longer observed on the live camera. However, due to restrictions on the live footage, data collection ceased on November 4, 2020.

We recorded the date, time of day, number of bears, number of salmon consumed, and qualitative notes for each observation period. The number of bears observed was operationally defined as those in water, whereas bears situated on nearby terrestrial grounds were excluded from the counts. We used our discretion to properly distinguish between individual bears, as the live camera had unstructured image capture that often prevented individual discrimination. Further, the number of salmon consumed was operationally defined as those whose entire capture and consumption occurred within the hourly interval.

2.3 *Approximation of Daily Rates*

For each hour of data collection, we divided the total amount of salmon consumed by the total number of bears observed within that hour, thus indicating the mean amount of salmon consumed per bear in an hour. At the end of each day, we averaged the three hourly consumption rates from the observation intervals, yielding a mean hourly rate for that day. Grizzly bears are estimated to have 21.5 foraging hours daily as they approach hibernation (Parks Canada, n.d.) and it was assumed that the foraging hours were equally productive. As a result, we approximated a daily salmon consumption rate by multiplying the mean hourly consumption rate by 21.5 hours. We then averaged these daily rates to obtain a final mean daily consumption rate, which served as the comparative statistic for this study.

2.4 Statistical Analysis

The approximated mean from the study served as a proxy for the pre-hibernation consumption rate, and we used a 30-salmon per day statistic (Katmai National Park & Preserve Alaska, n.d.) as the reference for the grizzly bear's average consumption rate in the summer months. Since the statistic was obtained from the same location as the present study, it provided relevant insight on the study conditions from June through August. Then, we used a statistical t-test (Graphpad Prism Ver. 8.0) to determine the significance of the difference between the two means from the pre-hibernation period and months of June through August. We used a p-value of 0.05 for comparison when conducting the statistical test.

3. Results

Data was collected from October 10th to November 4th, providing a total of 68 hours for direct observation of grizzly bear feeding activity. The mean daily consumption rate was 15.18 salmon per day, with a corresponding standard deviation of 6.85 salmon per day. The range of daily consumption values extended from 3.83 salmon per day to 31.65 salmon per day, with no outliers identified. A longitudinal representation of the daily salmon consumption rates is provided in Figure 2, with an overall declining trend observed in the latter half of the pre-hibernation period. This decline was accompanied by observations of the bears becoming more passive and idle with their time in the river.

A graphical representation of the distribution of daily consumption rates, relative to the median, is provided in Figure 3. The data appears to be highly varied within the upper quartile data, with an extensive range observed by the whiskers. A one-sample t-test produced a p-value less than 0.0001, lower than the designated p-value (0.05) for comparison.

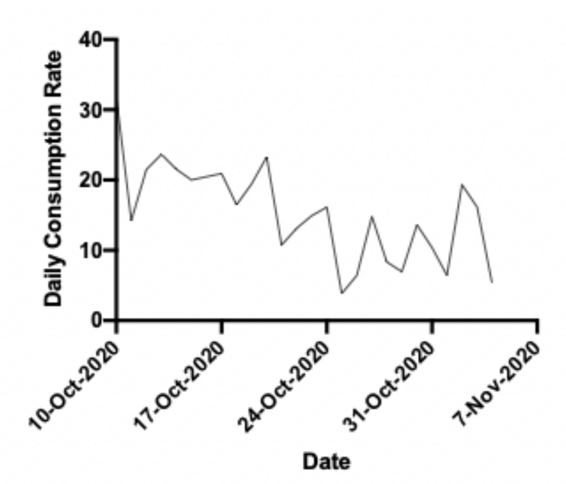

Figure 2: Longitudinal daily amount of salmon consumed by grizzly bears at Brooks Falls in the pre-hibernation period, denoted as October to November, with a mean of 15.18 (+/- 6.85) salmon per day.

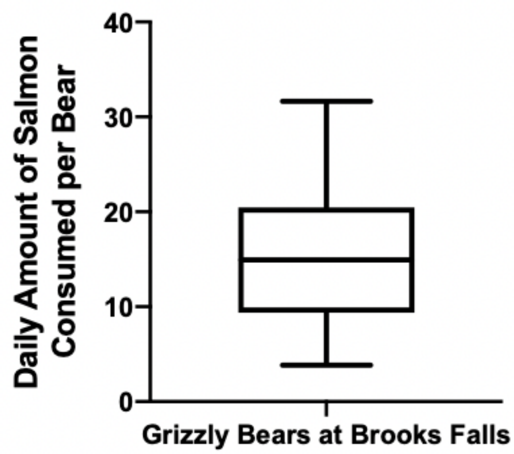

Figure 3: Distribution of daily salmon consumption rates (n=25) at Brooks Falls in the pre-hibernation period with a median of 14.93 salmon per day. Whiskers extended to minimum (3.85 salmon per day) and maximum (31.65 salmon per day) data values.

4. Discussion

4.1 Effect of Impending Hibernation on Salmon Consumption

The mean daily salmon consumption rate in the pre-hibernation period is significantly lower than the comparison statistic for the summer months, implying that the pre-hibernation period influenced the amount of salmon consumed per day by grizzly bears. The lower consumption rate found in the present study contradicts our prediction, as well as previous literature that estimated an enhanced consumption prior to hibernation to accumulate final fat stores (U.S. Fish and Wildlife Service (n.d.).

A potential explanation for this finding is the influence of grizzly bear cubs in observational counts. Numerous observations in the data collection process noted multiple cubs following an adult female. However, Alaskan bears are typically not capable of hunting at full capacity until maturity at 6 years of age (Luque & Stokes, 1974). Thus, the inclusion of cubs in the present study could have underestimated the number of salmon consumed per bear. Another explanation for the reduced consumption rate could be limited salmon availability. Salmon migrations run from May to September, but runs are typically at peak abundance in the study area from June to August (Alaska Department of Fish and Game, n.d.; Alaska Public Lands Information Center, n.d.). The salmon count and abundance throughout the summer months is significantly higher than the pre-hibernation months, which may have contributed to the reduced pre-hibernation consumption rates. This would be in concurrence with Pigeon et al. (2016) whose findings suggested that food availability, rather than timing relative to hibernation, determined pre-hibernation behaviors.

4.2 Implications

A reduced salmon consumption, and thus decreased fat accumulation, has direct implications on grizzly bear fitness, in terms of their health and ability to survive the winter in hibernation (Hilderbrand et al., 1999; Levi et al., 2012). Further, as posed by Van Daele et al. (2012), larger bears require higher nutrient intake and are vulnerable to extinction if their high-nutrient diet sources, such as salmon, become increasingly unavailable. As grizzly bears are already classified as a threatened species (U.S Fish and Wildlife Service, n.d.), the observed reduction in consumption warrants concern for grizzly bear conservation efforts.

As grizzly bears are known to deliver salmon-derived nutrients to terrestrial grounds (Helfield & Naiman, 2006), the reduced salmon consumption rate found in the present study indicates a reduction in nutrient transport to nearby terrestrial soils in

Katmai National Park. Thus, these findings may inform ecosystem management services (Levi et al., 2012).

4.3 Limitations

The contradictory findings in this study and wide distribution of data values, seen in Figure 3, could be accounted for by sources of error in this study. One source of error is the use of a potentially non-representative dataset. The daily consumption rates were approximated from three hours of observations per day and hence, grizzly bear activity within the observed hours was assumed to be similar to the non-observed hours. However, in contrast with Munro et al. (2006) who found support for peak feeding rates during diurnal hours, Klinka & Reimchen (2002) produced findings in support of nocturnal hours having pronounced feeding activity and efficiency. Therefore, since data collection was conducted during diurnal hours, the consumption rates may have been an underestimation of the actual number of salmon consumed, considering the findings from Klinka & Reimchen (2002).

Additionally, as seen in Figure 2, the daily consumption rates fluctuated throughout the data collection period. The reliability of these measurements was compromised due to limitations of the live camera. Specifically, the Brooks Falls Live Camera altered its focus randomly, in terms of which bears and areas were captured. Albeit the magnifying ability of the live camera, there were also numerous occurrences where the camera focused on bears that were too far away to accurately observe. In addition, live footage was unavailable when there was insufficient sunlight to charge the solar-powered cameras. This resulted in the early termination of the data collection process on November 4, as footage became inaccessible during study hours. This limited the sample size of the dataset and consequently the statistical power. It is possible that bears were still present and hunting at Brooks Falls following the end of the data collection. Thus, with only one live camera, these restrictions obscured the full observation of the feeding activity occurring within the data collection hours.

5. Conclusion

Investigating the grizzly bear pre-hibernation salmon consumption rate produced a significantly lower value than the 30-salmon per day statistic for the summer months (Katmai National Park & Preserve Alaska, n.d.). The results are inconsistent with the prediction and possible explanations for the observed result include limited salmon availability and confounding effects from the inclusion of bear cubs. The findings of this study suggest implications for grizzly bear health, population stability and ripple effects on terrestrial ecosystem richness.

6. Acknowledgements

This study was conducted through the BIOL 342 laboratory course at the University of British Columbia. We appreciate the opportunity to take this course and would like to thank Celeste Leander, Tessa Blanchard, and Anne Kim for their feedback and direction in producing the manuscript.

Appendix:

Table 1. Relevant statistics obtained from the statistical t-test performed on GraphPad.

Statistic	Value
N	25
P-Value	< 0.0001
Mean Hourly Consumption (SD)	0.73 (0.47)
Mean Daily Consumption (SD)	15.18 (6.85)
Degrees of Freedom (Treatment)	10.82
Degrees of Freedom (Total)	24

Works Cited

Alaska Department of Fish and Game. (n.d.). *Sport fish run timing.* https://www.adfg.alaska.gov/index.cfm?adfg=fishingSportFishingInforuntiming.main

Alaska Public Lands Information Centers. (n.d.). *When do the salmon run?* https://www.alaskacenters.gov/faqs-people-often-ask/when-do-salmon-run#:~:text=The%20salmon%20runs%20start%20in,different%20times%20throughout%20the%20summer

Explore. (n.d.). *Brooks falls brown bears.* https://explore.org/livecams/brown-bears/brown-bear-salmon-cam-brooks-falls

Fitz, M. (2013, November 21). *Bear hibernation.* https://www.nps.gov/katm/blogs/bear-hibernation.htm

Helfield, J. & Naiman, R. (2006). Keystone interactions: salmon and bear in riparian forests of Alaska. *Ecosystems, 9*, 167-180. https://doi.org/10.1007/s10021-004-0063-5

Hilderbrand, G., Schwartz, C., Robbins, C., Jacoby, M., Hanley, T., Arthur, S. & Servheen, C. (1999). The importance of meat, particularly salmon, to body size, population productivity, and conservation of North American brown bears. *Canadian Journal of Zoology, 77*(1), 132-138. https://doi.org/10.1139/z98-195

Katmai National Park & Preserve Alaska. (2019). *Bears of brooks river 2019: a guide to their identification, lives, and habits.* National Park Service, U.S. Department of the Interior. https://www.nps.gov/katm/learn/photosmultimedia/ebooks.htm

Katmai National Park & Preserve Alaska. (n.d.) *Brown bear frequently asked questions*. National Park Service, U.S. Department of the Interior. .https://www.nps.gov/katm/learn/photosmultimedia/brown-bear-frequently-asked-questions.htm#9

Klinka, D. & Reimchen, T. (2002). Nocturnal and diurnal foraging behavior of brown bears (*Ursus arctos*) on a salmon stream in coastal British Columbia. *Canadaian Journal of Zoology, 80*(8), 1317-1322. https://doi.org/10.1139/z02-123

Levi, T., Darimont, C., MacDuffee, M & Mangel, M. (2012). Using grizzly bears to assess harvest-ecosystem tradeoffs in salmon fisheries. *Public Library of Science: Biology, 10*(4), Article e1001303. https://doi.org/10.1371/journal.pbio.1001303

Luque, M. & Stokes, A. (1974). Fishing behavior of Alaska brown bear. *Bears: Their Biology and Management, 3*, 71-78. https://doi.org/10.2307/3872756

McLellan, B. (2011. Implications of a high-energy and low-protein diet on the body composition, fitness, and competitive abilities of black (*Ursus americanus*) and grizzly (*Ursus arctos*) bears. *Canadian Journal of Zoology 89*(6), 546-558. https://doi.org/10.1139/z11-026

Munro, R., Nielsen, S., Price, M., Stenhouse, G. & Boyce, M. (2006). Seasonal and diel patterns of grizzly bear diet and activity in west-central Alberta. *Journal of Mammalogy, 87*(6), 1112-1121. https://doi.org/10.1644/05-MAMM-A-410R3.1

Natural Habitat Adventures. (n.d.). *The Ebbs and Flows of a Grizzly Bear Season.*https://www.nathab.com/alaska-northern-adventures/about-grizzly-bear-season/#:~:text=In%20late%20summer%2C%20bears%20on,from%20the%20sea%20to%20spawn

North American Bear Center. (2001). *Brown/grizzly bear facts.* https://bear.org/brown-grizzly-bear-facts/

Oke, K., Cunningham, C., Westley, P., Baskett, M., Carlson, S., Clark, J., Hendry, A., Karatayev, V., Kendall, N., Kibele, J., Kindsvater, H., Kobayashi, K., Lewis, B., Munch, S., Reynolds, J., Vick, G. & Palkovacs, E. (2020). Recent declines in salmon body size impact ecosystems and fisheries. *Nature Communications, 11,* Article 4155. https://doi.org/10.1038/s41467-020-17726-z

Parks Canada. (n.d.). *Grizzly bears*. https://www.pc.gc.ca/en/pn-np/mtn/ours-bears/generaux-basics/grizzli-grizzly

Pigeon, K., Stenhouse, G. & Cote, Steve. (2016). Drivers of hibernation: linking food and weather to denning behavior of grizzly bears. *Behavioral Ecology and Sociobiology, 70*(10), 1745-1754. https://doi.org/10.1007/s00265-016-2180-5

U.S. Fish & Wildlife Service. (n.d.). *Grizzly bear*. https://www.fws.gov/mountain-prairie/es/grizzlyBearHistoryHabitatDiet.php

Van Daele, M. B., Robbins, C., Semmens, B., Ward, E., Van Daele, L. & Leacock, W. (2013). Salmon consumption by Kodiak brown bears (*Ursus arctos middendorffi*) with ecosystem management implications. *Canadian Journal of Zoology, 91*(3), 164-174. https://doi.org/10.1139/cjz-2012-0221

Western Wildlife Outreach. (n.d.). *Grizzly biology & behavior. http://westernwildlife.org/grizzly-bear-outreach-project/biology-behavior*