

Use of salmon (*Oncorhynchus* spp.) by Brown Bears (*Ursus arctos*) in an Arctic, interior, montane environment

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Sorum, M.S., K. Joly, and M.D. Cameron. 2019. Use of salmon (*Oncorhynchus* spp.) by Brown Bears (*Ursus arctos*) in an Arctic, interior, montane environment. *Canadian Field-Naturalist* 133(2): 151–155. <https://doi.org/10.22621/cfn.v133i2.2114>

Abstract

Salmon (*Oncorhynchus* spp.) is a key dietary item for temperate coastal Brown Bears (*Ursus arctos*) across much of their circumpolar range. Brown Bears living in Arctic, interior, and montane environments without large annual runs of salmon tend to be smaller bodied and occur at much lower densities than coastal populations. We conducted ground and aerial surveys to assess whether Brown Bears fished for salmon above the Arctic Circle, in and around Gates of the Arctic National Park and Preserve. Here, we document the use of salmon by interior Brown Bears in the Arctic mountains of the central Brooks Range of Alaska. We believe our findings could be important for understanding the breadth of the species' diet across major biomes, as well as visitor safety in the park and Brown Bear conservation in the region.

Key words: Alaska; Brown Bear; diet; fishing; mountains; *Oncorhynchus* spp.; salmon; *Ursus arctos*; Brooks Range

Introduction

In temperate environments, Brown Bears (*Ursus arctos*) feed extensively on salmon (*Oncorhynchus* spp.; Hilderbrand *et al.* 1999a; Mowat and Heard 2006). The abundance of salmon in some river systems and their high nutritional value allow Brown Bears in these areas to grow much larger and live at much higher densities than Brown Bear populations without predictable access to seasonal marine resources (Hilderbrand *et al.* 1999a,b; Mowat and Heard 2006). For example, Brown Bears living in interior regions are often much smaller than coastal conspecifics and occur at much lower densities (Hildebrand *et al.* 2018a,b). Substantively lower resource availability is thought to be a major determinant of both body size and population density (Hilderbrand *et al.* 1999a,b; Mowat and Heard 2006). Bears use terrestrial protein sources (Caribou [*Rangifer tarandus*], Arctic Ground Squirrels [*Spermophilus parryii*], and Moose [*Alces americanus*]), as well as plants, nuts, and other foods when access to marine resources, such as salmon, is limited (Welch *et al.* 1997; Rode *et al.* 2001; Gau *et al.* 2002; Mowat and Heard 2006), in areas such as the Arctic, interior, montane environments of the central Brooks Range of Alaska.

Reports from local aircraft pilots of Brown Bears congregating along Arctic rivers during August and September have been received by the National Park

Service (NPS) as early as 2008, although use of salmon by Brown Bears has never been reported in the central Brooks Range or in many other Arctic regions (e.g., MacHutchon and Wellwood 2003; Mowat and Heard 2006). In 2014, the NPS initiated a Brown Bear monitoring project. Global positioning system (GPS) data collected by that project indicated that Brown Bears in the interior mountains of the Brooks Range did indeed spend extended periods along larger river corridors from July through September.

Our goal was to document the timing and location of salmon use by Brown Bears in the central Brooks Range by direct observation. A better understanding of Brown Bear resource use in the region could be useful in determining the breadth of the species' diet across major biomes, as well as locally, for visitor management and Brown Bear conservation.

Methods

We conducted a survey of Brown Bears fishing in and around Gates of the Arctic National Park and Preserve (GANPP; Figure 1). GANPP encompasses an interior Arctic ecosystem characterized by the mountainous terrain of the Brooks Range, extensive spruce (*Picea* spp.) forests and lowland riparian areas on the range's southern flanks, and tundra on its northern side (Wilson *et al.* 2014). The headwaters of three major river systems begin in GANPP:

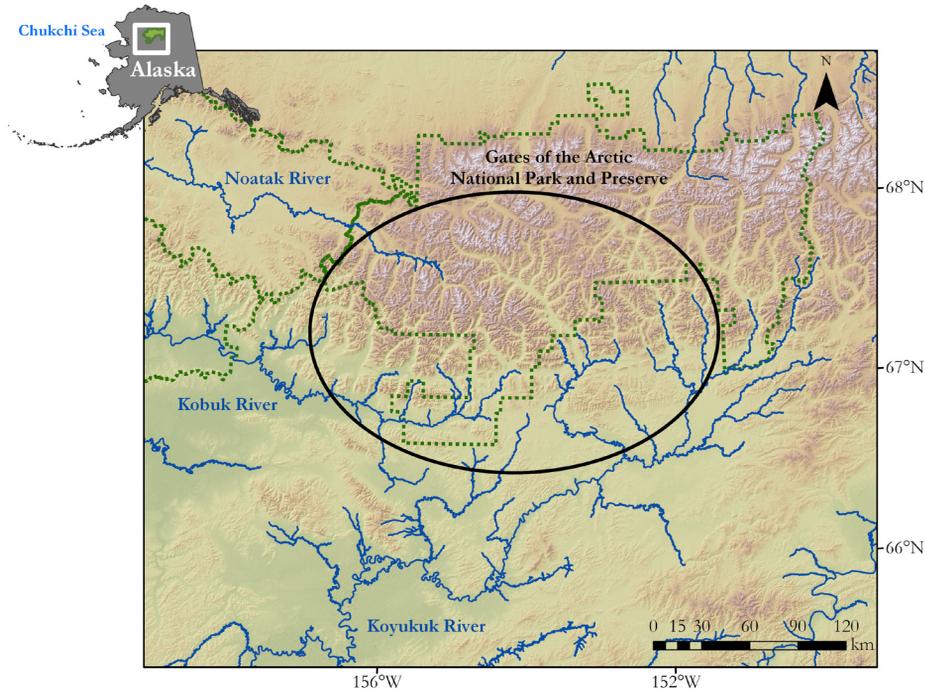


FIGURE 1. Study area (black oval) in the central Brooks Range mountains in Arctic Alaska.

the Kobuk, Koyukuk, and Noatak rivers. The Kobuk River drains west about 550 km (river length) to the Chukchi Sea (part of the Arctic Ocean) with most of the major tributaries arising in the southern Brooks Range. The Koyukuk River, a major tributary of the Yukon River, drains southwest for 1870 river-km from GANPP to the Bering Sea. The Noatak River drains northwest about 660 river-km to the Chukchi Sea, with all of its major tributaries arising in the northern Brooks Range.

Site-specific salmon escapement numbers are not available for our study areas, as these counts usually focus on commercial fisheries in salt water and specific freshwater streams important for sport or subsistence fishing. However, each of GANPP's three main rivers has runs of Chum Salmon (*Oncorhynchus keta*) and Chinook Salmon (*Oncorhynchus tshawytscha*) from mid-July to early September (O'Brien and Berggiler 2005).

We visited one tributary in each of GANPP's three main river systems to document use of salmon by Brown Bears in the region. The specific locations visited were determined from GPS collared bears ($n = 33$) or reports by pilots and were accessible by wheeled or float plane. (For more information about our collaring efforts, which were in accordance with the guidelines of the American Society of Mammalogists [Sikes and Gannon 2011] and approved by United States Geological Survey and

NPS Institutional Animal Care and Use Committees [IACUCs; 2014-1 and 2014A2, respectively], see Hilderbrand *et al.* 2018a.)

In 2016, we surveyed 8 km of the Kobuk River system (Table 1). In 2017, we surveyed 2 km of the Noatak River system and 8 km of the Koyukuk River system (Table 1). Our surveys involved walking along river banks and/or floating down streams in a raft to identify signs of bears fishing (e.g., fish carcass, scat, or observations of bears fishing) and document the presence of salmon species. Along the Noatak River system, we used a vantage point above an area that we suspected bears used for fishing to look for bears using a 20 × 60 spotting scope.

Results

During each stream visit, we observed bears fishing or identified recent signs of fishing activity (i.e., salmon gill plate, mandible, carcass, or bear scat with fish remains in it; Table 1). On the Kobuk River system, 17 August 2016, we found a large pile of fresh gill plates (Figure 2) along a sharp bend in the river where a deep pool had formed. Although we did not observe a bear fishing, we surmised that bears were diving for the salmon carcasses that we observed lying at the bottom of the pool.

On the Koyukuk River system, 2 August 2017, we observed an adult male fishing by "snorkeling" upstream in ~1.5 m of water and another adult male fish-

TABLE 1. Observations of Brown Bears (*Ursus arctos*) using salmon (*Oncorhynchus* spp.) in the central Brooks Range, Alaska, 2016–2017.

River system	Observation	Dates	Notes
Kobuk	Salmon gill plates	17 August 2016	Fresh pile of plates found adjacent to a deep pool formed at bend in river
	Fresh bear tracks	1–4, 17, 29 August 2016 9–10 September 2016	Single bears and family groups
Koyukuk	1 bear*	29 August 2016	Adult fishing near Chum Salmon
	1 bear*	4 August 2016	Adult fishing near Chum Salmon
	1 male bear	2 August 2017	Large male snorkeling upstream in 1.5 m of water
	1 male bear	2 August 2017	Large male fishing along a shallow side stream
	1 male bear	21 August 2017	Large male fishing along a shallow portion of river
Noatak	Salmon gill plates	22 August 2017	Fresh pile of plates found along bank of river
	3 bears	28 July 2017	A Brown Bear family group fishing at the confluence
	11 bears	29 August 2017	8 independent bears and 1 sow with 2 2-year-old cubs fishing along 2 km of river
	1 male bear	30 August 2017	Male bear fishing along a shallow side stream

*Aerial survey; all other observations were made during ground-based surveys.

ing along a shallow (<0.5 m) portion of the stream.

On 29 August 2017, we spent 4 h observing bears fishing from a vantage point above the Noatak River. We observed 11 bears (eight independent adults and one female with two 2-year-old cubs) using ~2 km of stream. Each adult was observed catching at least one salmon. Most bears either walked upstream along the bank or in the stream to locate and catch spawning Chum Salmon (Figure 3). All bears fished along a

small (<250 m) section of stream and were often close to other bears.

We also documented the presence and spawning activity of Chum Salmon at each stream.

Discussion

Our surveys substantiate earlier reports that interior, montane Brown Bears in the Arctic fish for salmon. Although the Brown Bears we studied lived about 400 km inland (or 550–1800 river-km from the coast), Chum Salmon were present and used by Brown Bears. Our findings build on past research that evaluated broad diet patterns of Brown Bears across North America (Mowat and Heard 2006). Even though salmon occur in streams throughout the Brooks Range, Mowat and Heard (2006) reported no use of salmon by Brown Bears in the central Brooks Range. Our observations of Brown Bears fishing for salmon across multiple river systems throughout the central Brooks Range provide evidence that salmon are not only used by bears here, but are likely an important seasonal food resource in the region.

Many interior populations of Brown Bears rely solely on terrestrial food resources, such as green vegetation, berries, and ungulates to satisfy their nutritional requirements (Gau *et al.* 2002; MacHutchon and Wellwood 2003; Mowat and Heard 2006). However, if available, some interior bear populations consume salmon (Belant *et al.* 2006). In the Arctic interior, food is even more limited for bears, as the growing season is short and ungulate densities are quite low and sparsely distributed over vast areas (Gasaway *et al.* 1992). Thus, where salmon resources are available, they likely play an important dietary role for bears living in the Arctic interior and may alter their distribution, body size, and population density (Hilderbrand *et al.* 1999a; Deacy *et al.* 2016, 2019).



FIGURE 2. Salmon remains (jaws and gill plates) found along a tributary of the Koyukuk River, Alaska, 22 August 2017. Piles such as these were common along well-worn game trails at the river edge. Photo: Matthew Cameron, National Park Service.



FIGURE 3. A Brown Bear (*Ursus arctos*) successfully acquiring a salmon (*Oncorhynchus* spp.) from a tributary of the Noatak River, central Brooks Range Alaska, 30 August 2017. Photo: Mathew Sorum, National Park Service.

Consumption of salmon by Brown Bears provides a direct avenue for nutrient and energy transfers from marine to lotic to terrestrial systems (Hilderbrand *et al.* 1999c). Inputs of marine-derived nutrients into a terrestrial system creates cascading effects across trophic levels via increased productivity (Mathewson *et al.* 2003; Winder *et al.* 2005), and the effects are likely compounded in a nutrient-limited system, such as GANPP. Ultimately, this relationship creates biological hotspots with higher productivity, species diversity, and richness (Naiman *et al.* 2002). Identification of these areas is important for conservation and preservation of these important ecological systems. For example, areas of congregating Brown Bears in this low-density system may warrant additional hunting and/or visitation restrictions in the future to avoid overhunting and/or disturbance during the critical period of hyperphagia.

Identification and further elucidation of the relation between salmon and bears in interior ecosystems will improve the understanding and management of population dynamics of both predators and their prey. Future research should consider estimating the composition of salmon in the diet of Brown Bears and the influence of salmon on seasonal distribution and habitat selection patterns of bears.

Acknowledgements

Funding for this work was provided by the United States National Park Service. We thank pilots E. Sieh, S. Sample, and C. Cebulski for reporting their observations of Brown Bears that helped lead to this study. Dave Gustine and Grant Hilderbrand were instrumental in Brown Bear collaring efforts. We thank Lavern Beier, Mark Melham, Jared Hughey, and Ken Hill for field assistance. We also thank Thomas Jung, Dwayne Lepitzki, William Leacock, and an anonymous reviewer for providing recommendations, which improved this manuscript.

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Received 24 August 2018

Accepted 30 May 2019