SOMETHING FISHY: FISH REMAINS AT THE KLEIN SITE (XBD-362) QUARTZ LAKE, ALASKA

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ABSTRACT

Today, fish are an important part of Alaska subsistence, valued by communities across the region. Coastal fishing practices have long been a focus of both contemporary and past research, but the historic relationship between people and fish in the Interior is less clear. Recent archaeological work has begun to establish the long history of fishing in central Alaska and led to a greater understanding of the role of fish. How central Alaskans selected and processed fish in more recent periods, such as the late Holocene, remains uncertain due in part to collection, preservation, and research bias. This study of late Holocene fish remains from the Klein Site on Quartz Lake adds to our knowledge of fishing during this period. It demonstrates the importance of a variety of non-anadromous fish species and indicates that these fish may have been harvested using mass capture technology such as nets or weirs. Changes in excavation protocol and unique investigations of lakeside archaeological sites expand our understanding of fishing throughout the past. The ecological data embedded in these archaeological sites can also aid researchers in reconstructing past environments so that we may better understand how high-latitude fisheries are changing in the present.

INTRODUCTION

Faunal remains recovered from archaeological sites in the Middle Tanana Valley have provided archaeologists with the opportunity to gain an understanding of subsistence economies in this region of Alaska over the last 14,000 years (Choy et al. 2016; Goebel and Potter 2016; Holmes 2008; Lanoë and Holmes 2016; Potter et al. 2023). However, Doering and colleagues (2020:471) emphasize that sites dating to the mid- to late Holocene period from the Middle Tanana area are relatively under-discussed in anthropological literature compared to earlier periods. Over 40 sites in the Middle Tanana Valley have mid- to late Holocene components, with relevant examples including Swan Point (XBD-156), Pickupsticks (XBD-374), the Bachner Site (XBD-155), the Klein Site (XBD-362), and the Clearview Site (XMH-1303) (ADNR-OHA 2024; Doering 2020; Holmes 2008; Smith 2020). Studying sites dating to these time periods improves our understanding of Alaska hunter-gatherer prey choice and also the identities, agency, and sociality of people living during this period of cultural intensification (Kristensen et al. 2020; Potter 2016; Smith 2020). This is especially true in the context of fish remains. For example, the procurement of fish requires an intensive investment of time and extensive social cooperation, particularly when fishing weirs and nets are employed rather than individualized spearfishing and hook-and-lure strategies (Broughton 1997; Guédon 1974; Smith 2020; Tremayne and Winterhalder 2017). In other words, shifts in subsistence practices and related aspects of procurement techniques can have broader social and cultural implications among groups living during the Holocene in central Alaska.

Previous researchers have examined the fish remains recovered from Swan Point, Broken Mammoth, Upward Sun River, Mead, Cook, Hollembaek, XBD-318, Dixthada, among other sites in the Tanana River Valley in Alaska (Potter et al. 2023; Shinkwin 1975). However, the remains of fish, especially non-anadromous species, specific to Interior Alaska during the late Holocene period are only infrequently considered in previous research. Furthermore, fish remains do not preserve well depending on the depositional environment due to their fragile bone structures and small size (Lyman 1984), and Alaskan archaeologists suggest that traditional grease-rendering practices may lead to the destruction of intact faunal remains (Potter 2007). Screen size can also impact the recovery of fish remains. When ¼" or ⅛" screening is the only method of recovery used during the archaeological excavation, it can lead to biased recovery of larger faunal specimens (Nagaoka 1994; Partlow 2006; Shaffer 1992). Finally, faunal remains were not universally collected, and screens were not always used during excavations in the region (Cook 1977; Holloway et al. 2018). Therefore, fish remains are often missing in reconstructions of subsistence in central Alaska, particularly during later periods (Halffman et al. 2015; Lyman 1994b; Potter et al. 2023).

The Klein Site (XBD-362) on Quartz Lake, Alaska, has yielded hundreds of fish remains from late Holocene components (Fig. 1), adding to our understanding of non-anadromous fishing in central Alaska during more recent periods of the region's history. Here, we describe fish recovered from the late Holocene components of the Klein Site's upper and lower loci during the excavation years 2012–2019. The purpose of the paper is to expand previous knowledge regarding the subsistence economy of Indigenous communities living in the Quartz Lake region of central Alaska between 1200 and 600 years ago. This is accomplished through addressing topics such as seasonality, fishing technologies and strategies, and fish species representation at the Klein Site. The majority of fish bones recovered from the Klein Site are burned or calcined, showing that Dene were processing fish in hearth contexts. The richness of the fish taxa identified in the assemblage, including burbot (*Lota lota*), northern pike (*Esox lucius*), and salmonid species like whitefish (*Coregonus* spp.), reflects the resources the Dene people had access to and preferentially selected for dietary purposes. Nonfish fauna have been recovered from the Klein Site, including large/very large mammals, medium-sized mammals, small/very small mammals, and birds (Gelvin-Reymiller and Reuther 2010; Wetherbee et al. 2022). Additionally, the representation of skeletal elements recovered from archaeological deposits and the fragmentary nature of the assemblage provides an opportunity to interpret preservation biases at the Klein Site.

FISH IN DENE SUBSISTENCE

Several ethnographic accounts and direct interviews show how fishing has been incorporated into Indigenous Alaskans' subsistence economy and culture throughout time. Quartz Lake is on the margins of the traditional territories of the Middle Tanana and Upper Tanana bands (Andrews 1975; Guédon 1974; Pitts 1972). See the language map provided by Krauss and colleagues (2011) for more context on the ancestral lands along the Tanana River. Two bands of particular importance include the Salcha, a band located in east central Alaska near the mouth of the Salcha River, and the Goodpaster band, who resided near the mouth of the Goodpaster River (Andrews 1975; Pitts 1972). Andrews (1975) discusses the importance of both whitefish and anadromous salmon among the Salcha and Goodpaster bands. Mass capture systems such as fish traps aided in extracting salmon in the summer up to Big Delta and near the mouth of Shaw Creek (Pitts 1972). Dip nets were used for whitefish and salmon during the fall months, while pike and grayling were caught using hook-and-line techniques (Andrews 1975; Pitts 1972). Grayling were important in the spring when the ice started to break up in addition to summer and fall months (Andrews 1975:63).

Guédon (1974:32–33) describes Tetlin people fishing for whitefish (*Coregonus* spp.), suckers (*Catostomidae*),

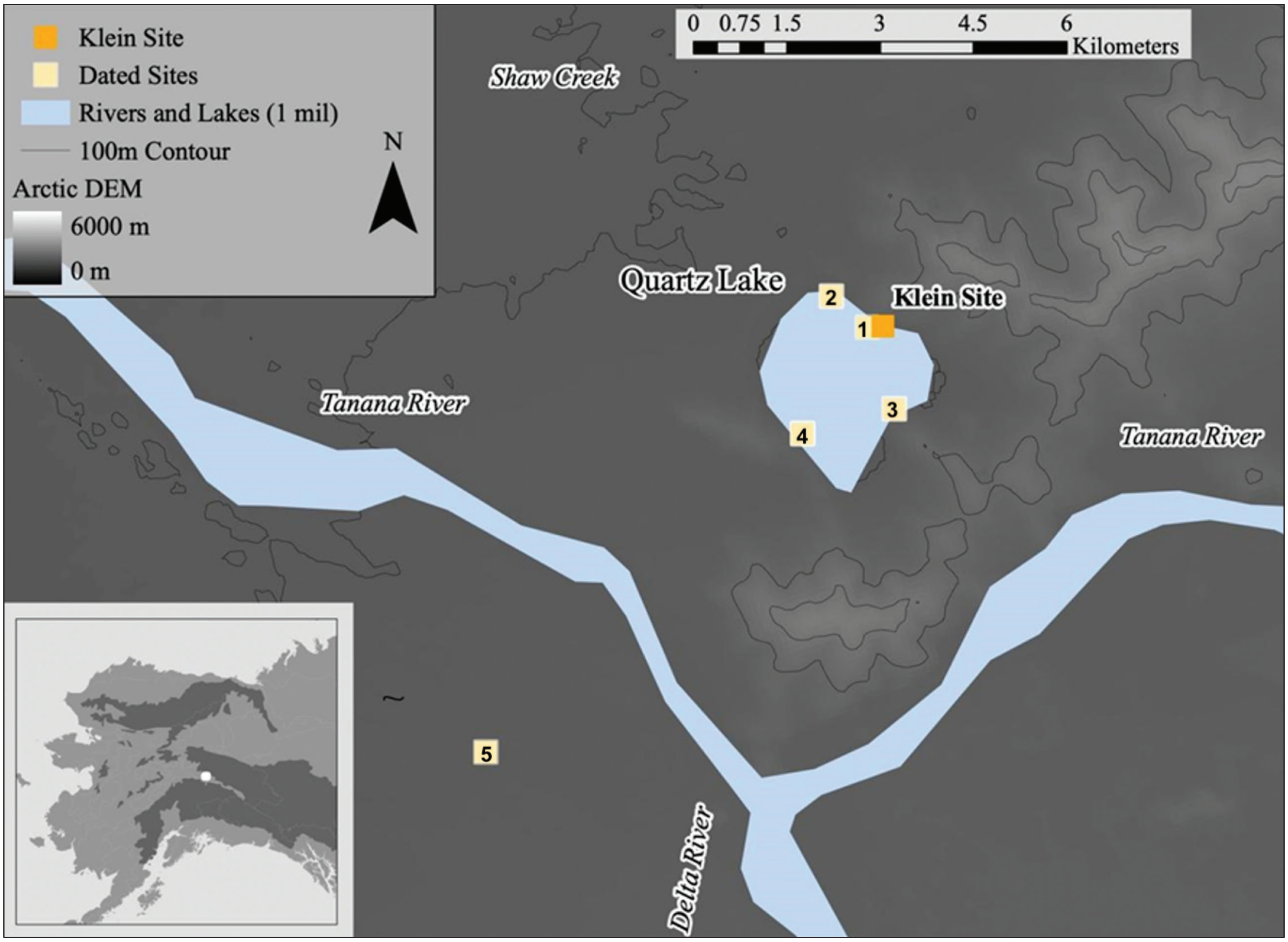

Figure 1. Klein Site, along with several other dated sites, on and adjacent to Quartz Lake, central Alaska. Other dated sites include (1) XBD-00361, (2) XBD-00155, (3) XBD-00444, (4) XBD-00445, and (5) XBD-00072.

grayling (*Thymallus arcticus*), and salmon (*Oncorhynchus* spp.) at strategic fishing spots in the Upper Tanana region. The Tetlin people typically established these fishing spots on a clearwater stream where dip nets and fish traps could be used near a fish weir or at a location where willow branches were intertwined around posts and spread across the water. Northern pike were typically caught with either hooks, small nets, or fish spears in lake outlets clear from mud and ice (Guédon 1974:32–33) and were also taken in the shallows through bow and arrows by people living in the Upper Tanana region (McKennan 1959). However, seasonality played a role in the ability to catch fish, with frozen lakes and rivers preventing any fishing practices from taking place without continuous maintenance of holes in the thick ice (Guédon 1974).

Anadromous salmon are considered to be an important food source for many Indigenous communities across Alaska due to their predictable runs. However, not all Indigenous peoples in central Alaska have access to this food source. For example, Mishler describes:

> One of the most important ethnographic breaks on the Tanana River separates the bands on the Goodpaster River and below, who fished for salmon, from the bands in the valley above the Goodpaster, an area with no salmon; this break coincides with the line between the Lower Tanana and Tanacross languages, a significant linguistic boundary. (Mishler 1986:13)

By the time migrating salmon arrive in the Upper Tanana River, they could be considered inedible to humans based on the quality of meat. Yet, it is important to note that these salmon could still be fed to dogs (Mishler 1986:13), and salmon quality may not have been as great concern at other times in the region's history. We expect that evidence of anadromous salmon above the Goodpaster River (a few miles south of the Klein Site) would be low in numbers in the faunal records compared with areas below the Goodpaster or on the Copper River where this species of fish would have been taken as food for humans. Instead, Indigenous peoples living above the mouth of the Goodpaster River focus their efforts on fishing for whitefish, grayling, and other freshwater fish species like burbot (Mishler 1986). Historically, the Dene communities that had access to salmon in their local environment often stored their salmon harvest by smoking, drying, or storing in an underground cache to allow the flesh to ferment. Fermented salmon was/is considered a delicacy by the Upper Tanana people (Mishler 1986:13).

Freshwater fish can be dried, fermented, or frozen depending on the time of year. For example, the Scottie Creek people would dry-split, freeze, and store whitefish, which would then ferment so they could subsist on it during the winter months (Tyone and Kari 1996). Deboning fish on river/lake ice might help explain why fish remains may not be as common as other taxa in archaeological contexts. Andrews (1975) reports that people associated with the Middle Tanana did not store whitefish, burbot, grayling, and pike but instead consumed them immediately.

Fishing ceases after the rivers and lakes freeze up when moose hunting becomes the primary subsistence pursuit (Andrews 1975; Pitts 1972). This, in combination with the absence of fish snares, harpoons, fish hooks, etc., in the archaeological record, has led anthropologists to recognize the Upper Tanana peoples as a hunting rather than a fishing group (Guédon 1974:32; McKennan 1959). This differs from Mishler's (1986) argument in favor of fish being a major food resource during the winter. A variety of factors may have led these authors to come to differing conclusions, such as the availability of resources in different tributaries branching off the Tanana River. Annual or interannual variation, as well as differences in food preferences between Indigenous communities living in various regions along the Tanana River, could produce cultural differences present in regional ethnographies. Mishler's (1986) ethnographic work and idea of reliance on winter fishing is primarily informed by village locations at Big Delta and the Goodpaster. This compares with Andrews (1975), who conducted ethnographic research on the Salcha River.

Speaking to Elders from Nenana and Minto, in the Middle Tanana cultural region farther downriver, Doering has heard accounts at recent fish/culture camps of spears being used to fish for anadromous salmon during the early fall (Charlie, pers. comm. 2022; Lord, pers. comm. 2022). Salmon, and king salmon in particular, are a precious resource that are frequently smoked or dried and stored for winter. Historically, expedient square structures with spruce bark walls were constructed seasonally for this purpose (Charlie, pers. comm. 2022). Fermentation is also known in this area, and whitefish eggs are harvested in late summer and combined with blueberries to make a rich dish for special occasions. Northern pike are actively pursued during the summer in the Minto Flats area, and burbot are frequently harvested in the wintertime. Additionally, freshwater eels were pursued in this area during the summer months (Lord, pers. comm. 2022); however, both eel and anadromous salmon returns have declined significantly in recent years, which has led to many mass capture restrictions and limits to the capture of aquatic resources in general. Such restrictions complicate efforts to maintain traditional fishing practices in the present and future.

Identifying fish species in the archaeological record at the Klein Site and elsewhere can help show how activities at Quartz Lake related to different cultural traditions across the region (Table 1). Ethnographic and traditional knowledge can help to inform archaeological expectations about the seasonality and fishing strategies employed at the Klein Site.

KLEIN SITE BACKGROUND

The Klein Site is located on the northern shore of Quartz Lake, Alaska (Fig. 1). The archaeological materials at this site are encased in loess (aeolian) silt that caps a sand dune situated approximately 100 m away from the lake edge and 5 m above the water level (Doering et al. 2020). Fish resources are easily accessible in the vicinity of the Klein Site (ADFG 2023; Reuther 2013). The lake is currently stocked with several non-native species of trout, with species like pike (*Esox lucius*) eradicated in the 1950s to 1970s during a program undertaken by the State of Alaska to stock easily accessible Interior lakes with more popular sport fish like trout (Dunker et al. 2020). Examples of fish species in rivers and lakes near Quartz Lake include pike, burbot (*Lota lota*), several species of whitefish (*Coregonus* spp.), sheefish (*Stenodus neima*), grayling (*Thymallus arcticus*), and multiple species of anadromous salmon (*Oncorhynchus* spp.). The area is surrounded by a variety of plant species, including birch (*Betula papyrifera*), white spruce (*Picea glauca*), black spruce (*Picea mariana*), quaking aspen (*Populus tremuloides*), soap berry (*Shepherdia canadensis*), wild rose (*Rosa acicularis*), and artemisia *(Artemisia alaskana*) (Doering 2020:135). This ecological habitat sup-

Table 1. Fishing activities related to cultural traditions across the region. Source: Andrews (1975); Charlie, pers. comm. 2022; Guedon (1974); Lord, pers. comm. 2022; Pitts (1972); Potter et al. (2023); and Tyone and Kari (1996).

	Upper Tanana				Middle Tanana			
	Capture Technology	Season of Harvest	Harvesting Location	Storage Type	Capture Technology	Season of Harvest	Harvesting Location	Storage Type
Burbot	Net, fish traps, hook and line	Winter, spring	Upper Tanana, Scottie Creek	Dried, fermented, or frozen	Net, hook and line	Winter, spring	Minto Flats	Consumed immediately
Pike	Hook and line, net, fish traps, bow and arrow, spears	Spring, fall	Upper Tanana River, Mosquito Form stream	Dried, fermented, or frozen	Fish trap, hook and line	Spring, summer, fall	Salcha River, Minto Flats, Goodpaster River	Consumed immediately
Whitefish	Fish trap, net, spears	Spring, summer	Mouth of Nabesna	Dried, fermented, or frozen	Fish trap, net, weir	Spring, summer, fall	Salcha River and Goodpaster River	Consumed immediately
Anad. Salmon	—	—	—	—	Fish traps, spears	Summer and fall	Below the mouth of the Goodpaster River	Smoked or dried, or consumed immediately

ports multiple species of terrestrial fauna that contributed to the Middle Tanana Dene subsistence during the late Holocene, including grouse (*Falcipennis canadensis*), hare (*Lepus americanus*), moose (*Alces alces*), black bear (*Ursus americanus*), and porcupine (*Erethizon dorsatum*) (Doering 2020:135; Smith 2022; Potter 2008; Lanoë et al. 2017).

The Klein Site is a multicomponent site (Fig. 2), with the earliest dated components around 4500 cal BP (Doering et al. 2020; Reuther 2013). The site has two different loci with distinctive late Holocene components and exhibits remarkable organic preservation for Interior Alaska sites from this period (Gelvin-Reymiller and Reuther 2010). Based on radiocarbon chronologies, the Klein upper locus located farther west and higher on the dune dates to 1256 ± 38 BP (AA88629; wood charcoal; δ13C = –23.1‰; Reuther 2013:21), with a calibrated (2σ) age of 1070–1280 cal BP (Bevan and Crema 2021; Doering et al. 2020; Reimer et al. 2020; Reuther 2013). The Klein upper locus feature dates to the same age as the general upper locus region. The Klein lower locus 50 meters to the east has been dated to 560 ± 20 BP (Beta-40143; wood charcoal; δ13C = –24.0‰), with a calibrated (2σ) age of 530–625 years BP (Bevan and Crema 2021; Reimer et al. 2020). Both loci represent brief periods of Indigenous presence on the landscape for only a few days or weeks at a time, based on artifact density and site size (Doering 2020). The intact stratigraphy at the Klein Site consists of horizon humus, loess, and fine-to-medium dunal sands. The late Holocene cultural materials are associated with loess deposits (Unit 3 in the lower locus and Unit 5 in the upper locus) that cap the dunal sands and a very well-expressed forest soil (A/E horizon) that developed by 1280 cal years BP and extends across the site (Fig. 3; see Doering 2020 and Reuther 2013 for more detailed descriptions

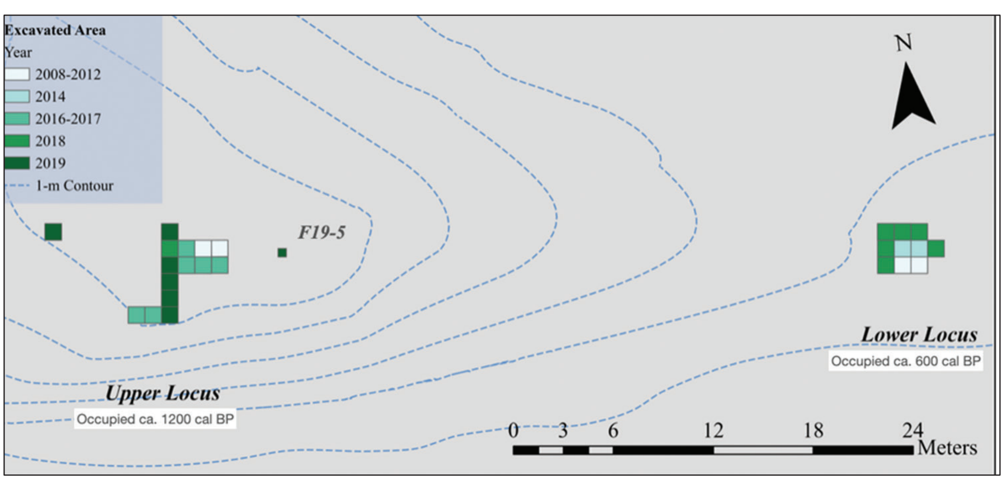

Figure 2. Excavated areas at Klein Site, including feature (F19-5), which is considered separately.

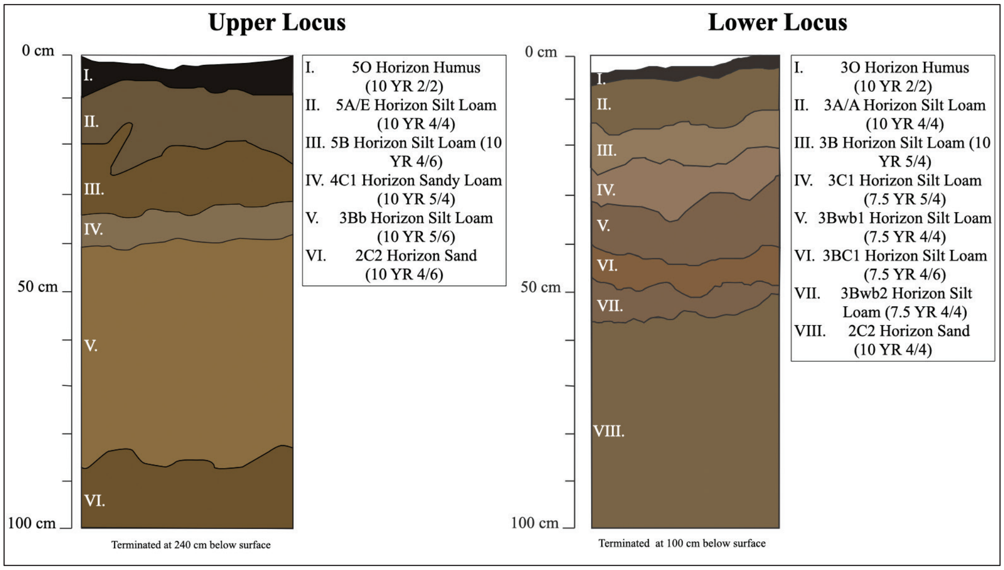

Figure 3. Stratigraphic profiles featuring the upper and lower loci at the Klein Site.

of the Klein Site soils and sedimentary records). The soil pH at the Klein Site is neutral to slightly acidic (8.30 to 6.18; Reuther 2013:544), which lessens the natural impact of differential bone preservation (Nicholson 1996).

Excavations at the Klein Site took place between 2008 and 2019. Gelvin-Reymiller directed initial excavations from 2008 to 2012, Reuther oversaw fieldwork from 2014 to 2017, and Doering and Reuther co-directed fieldwork in 2018 and 2019. Excavations and research at the Klein Site are still ongoing, but two main activity areas and several features have been identified and completely excavated since 2008. Excavations proceeded by 50 cm quad in 1 x 1 m units excavated by trowel in 5 cm arbitrary levels within natural stratigraphic units. Diagnostic material larger than 1 cm was three-point provenienced. All other material was recovered in ⅛" screens except for bulked feature sediments, which were screened through 500 µm sieves in lab.

HYPOTHESES AND EXPECTATIONS

Based on historical and ethnographic accounts, it is expected that burbot, northern pike, whitefish, and/or anadromous salmonids could be represented in the fish assemblage. According to optimal foraging theory (OFT) and the diet breadth model, a prey species should be added to the diet if the resource will maintain or increase the foragers' caloric returns compared with the amount of energy expended while searching for and procuring the resource (Broughton 1997:846–947; Elston and Zeanah 2002; Stephens and Krebs 1986; Tremayne and Winterhalder 2017; Winterhalder 1986). Assuming each of these species are readily available and procured through the same harvesting technique, there are approximately 880 kcal/kg of northern pike meat, 905 kcal/kg of burbot meat, and 1345 kcal/kg of whitefish (Dvoretsky et al. 2023; Jensen et al. 2011; Orban et al. 2006). Based on expectations in the diet breadth model, we hypothesize that the primary species of choice during lake fishing should be whitefish, followed by burbot and northern pike if spear or hook-and-lure technology was the primary fishing technique.

It is important to consider that native fish species have important seasonal correlates that can influence species behavior, availability, and prey rank. Northern pike and whitefish are most active during the summer and early fall, with northern pike feeding on small species of fish and whitefish eating mollusks, bivalves, snails, and other resources from the bottom of the lake. Conversely, burbot are most active when spawning under the ice during winter months (Reynolds 1997). Grayling are particularly easy to catch in the spring once the ice breaks and the fish can swim closer to the surface (Andrews 1975). Based on seasonal availability, we would expect to see summer and early fall fishing for burbot if captured by fish weirs. If spears or bow and arrow were the primary technology used, then pike and whitefish are expected to be prevalent in the archaeological record, particularly during summer and late fall. Additionally, pike are large and were likely plentiful. For example, the Tetlin people preferentially caught pike with fish traps, set nets, and spears after the first frost (late fall) in outlet streams of lakes (Pitts 1972). Burbot could have been used as a late winter/early spring resource to overcome seasonal resource shortages. If so, we anticipate that they would dominate the assemblage if Indigenous peoples lived at Klein during the winter.

We recognize that optimal foraging theory models leave out alternative factors beyond calories that can dictate prey rank. One example includes the work of Manusuri and colleagues (2016), who demonstrate that

25 hydroxyvitamin D is positively associated with the consumption of wild fish among an Indigenous community near Ontario, Canada, with some of the most commonly consumed wild fish including whitefish, pickerel, northern pike, goldeye, burbot, sturgeon, and trout. More specifically, authors mention that 25 hydroxyvitamin D is significantly higher in those individuals who consume these species of wild fish at least once a month (Manusuri et al. 2016). Furthermore, it has been proven that burbot is an excellent source of n-3 fatty acids, vitamin D, vitamin A, and vitamin K (Wong 2008). In addition to their nutritional contributions, there are also cultural factors that can influence the supplementation of fish to the diet. For example, Voinot-Baron (2020) discusses how Yup'ik in Akiak desire the "taste of fish" in the winter and early spring, not just as food but also for their entanglement with symbolism and social values. The examples provided here are just a few ways that rankings of certain fish species within the diet breadth model can fluctuate based on not just caloric return rates but also the provision of vitamins, essential fats, taste preferences, and cultural importance to certain Indigenous communities.

Hunting and fishing do not operate on their own diet breadth models but rather work in conjunction. Therefore, it is important to recognize that in addition to the representation of fish and birds, various sized mammals are represented in the Klein Site faunal assemblage. In terms of encounter rates, fish are considered to be evenly spaced and predictable, with an exception being fish on the Upper Tanana, which are clumped and predictable (Martin 1983). Small mammals, moose, sheep, and bear are also considered to be evenly spaced and predictable, which differs from the clumped and unpredictable nature of caribou (Martin 1983:624). The combination of fish abundance and specialized technology such as nets and weirs would have significantly reduced harvesting costs and thus made this resource desirable.

Some of the terrestrial fauna present in the Klein assemblage may be considered high ranked according to the traditional diet breadth model, particularly those faunal remains identified as being large mammals. Moose and bears are some examples of large mammals that are common in the Quartz Lake region and may have supported the subsistence of people living at the Klein Site during the Holocene. However, low-level taxonomic identification of the faunal elements recovered from this site is not possible at this time due to the fragmentary nature of the assemblage. Future research implementing zooarchaeology by mass spectrometry (ZooMS) or stable isotope analysis may be able to more firmly establish contributions to diet. Regardless, fish are an important contribution to diet in the ethnographic period (Andrews 1975; Choy et al. 2016; Guédon 1974), and the Klein Site's late Holocene assemblage should reflect this.

Specialized mass capture technology is an optimal way to maximize encounter rates (Smith 2020; Stiner and Munro 2002). While whitefish are high in calories compared to other local fish, overall return rates for all fish species are relatively low if spearing, hook, and lure fishing methods are pursued because they are individualized and less efficient (Smith 2020). The innovation of mass capture technologies, such as nets or weirs, could have made fish a more attractive and important resource to past central Alaskans. Spear or hook-and-lure fishing is effective when fish are active, but mass capture technologies can harvest fish regardless of activity level.

Determining skeletal element representation at the Klein Site will not only aid in interpreting taphonomic biases, but also understanding preferential deposition of certain elements as a product of harvesting technologies. If only certain portions of the skeleton such as vertebrae, ribs, spines/rays, or crania are represented then this would indicate lake processing and would be more consistent with the more individualized spearing or hook-and-lure fishing techniques. Alternatively, representation of elements from the entire skeleton of the fish could indicate transportation of the whole fish. The fish could have been carried or transported in baskets back to the campsite. The location of fish processing would also impact which skeletal elements are brought back to the Klein Site. We expect to observe the presence of both cranial and postcranial remains if butchery took place directly at the Klein Site. In this case, head and fin elements would be removed at the consumption site itself rather than at the fishing locale to facilitate transportation (Russ 2009). An exception includes instances where fish heads would have been fermented and consumed by the individuals at the Klein Site. While these connections are somewhat uncertain, they are supported by information about fish processing from the ethnographic record (above) and can be combined with other lines of inference to suggest fishing technologies. Analyzing the fish remains from the upper locus, lower locus, and the upper locus feature (F19-5) will help determine whether fish species, skeletal element representation, and fishing methods are consistent across all of the late Holocene components of the Klein Site or if certain components differ from one another.

METHODS

During the 2008–2019 seasons, excavation methods remained relatively consistent. Recording of provenience information including the site name, northing, easting, and elevation allows for determining the spatial distribution of fish remains across both the upper and lower loci. Exact northing and easting information is not available for some of the artifact bags associated with the Klein lower locus 2014 excavations. This project focuses on traditional zooarchaeological analysis of the complete late Holocene fish assemblages—upper and lower loci. Analysis involved recording the number of specimens present (NSP), names of skeletal elements identified, directionality (left or right side), whether the bones represent fragments or complete skeletal elements, overall element size, and degree of burning (Lyman 1994a; Stiner et al. 1995). The Klein Site collections are housed at the University of Alaska Museum of the North. The fish remains from the 2008–2011 excavations are encompassed within a single accession (UA2012-177), while subsequent collections were given accession numbers by each year of excavation (UA2014-057, UA2016-060, UA2017-066, UA2018-061, and UA2019-154). The fish remains recovered from the 2019 excavation season were analyzed by Holly McKinney, and the fish elements excavated between 2008 and 2018 were identified by McKenna Litynski.

All fish remains are identified down to the lowest taxonomic level possible. Spines, rays, and the majority of brachial parts are assigned to the general class Actinopterygii but still contribute to the analysis of the fish assemblage by NSP. Fish specimens available for comparison in the University of Wyoming Archaeological Repository (UWAR) skeletal reference collection include northern pike, rainbow trout (*Oncorhynchus mykiss*), brook trout (*Salvelinus fontinalis*), channel catfish (*Ictalurus punctatus*), white sucker (*Catostomus commersoni*), bluegill (*Lepomis macrochirus*), common sucker (*Catostomus commersonii*), yellow perch (*Perca flavescens*), brown trout (*Salmo trutta*), cutthroat trout (*Oncorhynchus clarkia*), and longnose sucker (*Catostomus catostomus*). Additional comparative specimens that McKinney had access to include burbot and whitefish. All of the comparative specimens listed were used in analyzing the fish remains from the 2012–2019 excavations at the Klein Site. Supplementary materials aided in making low-level taxonomic identifications (Cannon 1987). These methods were applied to all fish remains recovered and are considered by upper locus, lower locus, and the upper locus feature.

Several metrics were recorded, including the maximum centrum width and maximum length in vertebral elements, as well as measuring length, maximum width, and maximum thickness in nonvertebral elements (Colley 1990). Complete vertebrae are characterized by elements that have a complete centrum and a portion of the vertebral spine intact. Nonvertebral specimens were identified as being "complete" if the element was 100% intact. Any skeletal elements that did not fit these criteria were marked as being "fragmentary." This metric information was recorded based on their potential significance for future studies and is provided in the supplemental materials. However, 97% of the fish assemblage at the Klein Site is fragmented (Supplemental Table 1). In considering the vertebrae specimens, 13% represented in the Klein Site fish assemblage are complete. Therefore, the fish assemblage is far too fragmentary to complete a robust species size/dietary contribution based on metric attributes. We understand that NSP, fragmentary counts, and bone weights do not always directly reflect human subsistence and food choice (Colley 1990; Peres 2009). However, recognizing the fragmentary condition of the elements, we chose to focus on measuring bone weight in grams while taking into consideration the effects of burning and taphonomic impacts as an attempt to estimate differences in the fish contribution at the various Klein Site loci. When used in combination with NSP information, fish bone weight can more accurately measure the relative importance of certain taxa in an assemblage than if NSP or weight were considered independently (Colley 1990; Peres 2009).

Considering hearth-centered areas exist at both the Klein upper and lower loci, it is essential to consider the level of burning to which the fish remains were subjected within the hearth contexts. Differences in burning patterns across the Klein Site fish assemblage may provide insight into Dene cooking or cleaning practices. However, it is important to recognize the taphonomic complexity surrounding fish bones and burning levels in archaeological contexts. An example includes Nurminen's (2015) work demonstrating that there is differential survivorship of fish remains when exposed to an open fire, with the bones of larger species surviving better than the bones associated with smaller fish. Additionally, smaller bones in general are more likely to be destroyed than larger elements (Nurminen 2015), which can impact interpretation of skeletal element signatures in the archaeological record at the Klein Site. Nonetheless, there is a high survivorship pattern for vertebrae after having been exposed to burning (Nurminen 2015), which allows for an accurate representation of fish species associated with Klein subsistence practices. Fish elements are assigned a category of burning on a scale of 0 to 6 based on macroscopic appearance and color as described by Stiner and colleagues (1995:226), with 0 referring to bone that exhibits no characteristics of burning and 6 indicating bone that is completely white and therefore fully calcined.

To understand the variability in fish remains across the Klein Site, we conducted three different chi-squared tests to determine if there are statistically significant differences between skeletal element representation (crania, spines/rays/ribs/gills), burning scales (0–6), and species representation (northern pike, burbot, and whitefish) across the lower locus, upper locus, and upper locus feature at the Klein Site. The upper locus feature was separated specifically because it contained a large number of specimens that were treated differently in a distinct location from the rest of the activity at the upper locus.

RESULTS

UPPER LOCUS

In considering the upper locus feature separately, the NSP of fish remains recovered from the upper locus of the Klein Site totals 321. Of the elements analyzed, 305 (95%) are fragmentary and 16 (5%) are complete. The majority of complete bones are vertebrae. The complete fish assemblage associated with the upper locus weighs 5.21 g. The assemblage is dominated by three primary species: northern pike, burbot, and whitefish (Fig. 4). A total of 47 northern pike, 42 burbot, and 3 whitefish skeletal elements are represented in the Klein upper locus faunal remains, along with 229 unknown Actinopterygii. The skeletal element representation of fish remains recovered from the upper locus reflects both cranial and postcranial elements but is dominated by vertebrae (Supplemental Table 1; Fig. 5). Based on the burning index for the fish remains recovered from the upper locus, a high number of bones (191 or ~60%) fall under the burning category of 2, meaning more than half are carbonized (Fig. 6).

UPPER LOCUS FEATURE

The fish assemblage recovered from the cooking feature associated with the Klein upper locus totals to 1719 NSP.

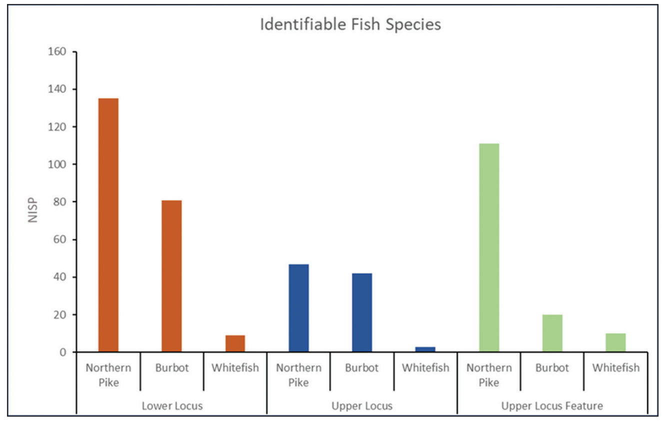

Figure 4. Number of identifiable fish species present (NISP) from each of the site components. Unknown Actipoterigyii remains are not included in this graph.

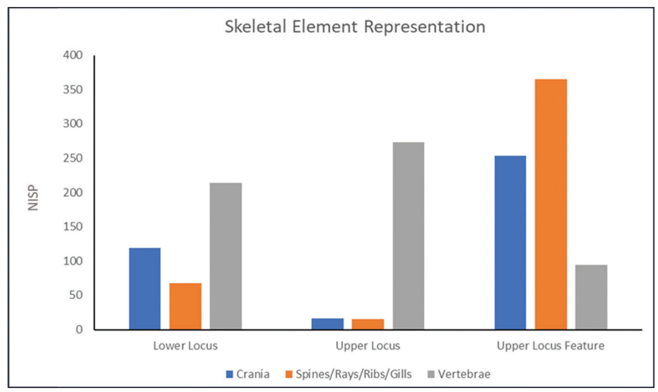

Figure 5. Number of identifiable fish species present (NISP) of identifiable skeletal elements from each of the site components. Unidentifiable skeletal elements are not included in this graph.

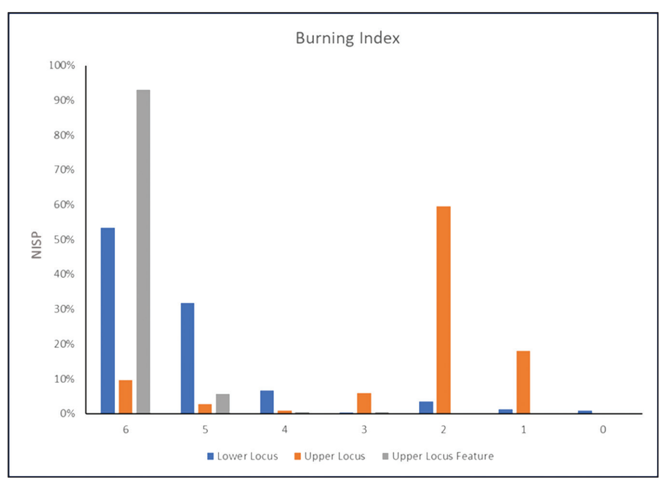

Figure 6. Percentage of burned skeletal elements from each of the site components on a scale of 0 to 6, with a burning index of 6 indicating full calcination, 3 reflecting full carbonization, and 0 indicating no burning.

Almost all the fish remains from the cooking feature are fragmented, with only 10 complete vertebral elements evident. This is likely due to the fragile remains being exposed to high temperatures and is supported by the fact that over 90% (1600) of these fish remains are fully calcined and are therefore assigned a burning index of 6. The remainder of the bones recovered from the Klein upper locus feature are assessed as burning conditions of 5 (99 remains), 4 (10 remains), and 3 (10 remains). No fish skeletal elements associated with this feature assemblage exhibit characteristics of a burning index less than 3 (Fig. 6).

The complete fish assemblage at the upper locus weighs 12.65 g. This is likely a result of how fragmentary the fish assemblage associated with the feature is and how calcination reduces bone weight. Due to the fragmentary nature of the assemblage, the majority of remains (1578) recovered from the feature are unknown Actinopterygii. Those fish bones that are identifiable down to lower taxonomic levels are consistent with the findings from the Klein upper and lower loci, including 111 northern pike, 20 burbot, and 10 whitefish remains (Fig. 4). Comparatively, the skeletal element representation associated with the upper locus feature is quite different from the upper and lower loci (Supplemental Table 1; Fig. 5). The feature is dominated by spines, rays, gills, and ribs followed by cranial fragments with very few vertebrae represented in this assemblage.

LOWER LOCUS ASSEMBLAGE

The lower locus fish assemblage consists of NSP of 566. Of these remains 507 (90%) are fragmentary and 59 (10%) elements are complete. Like the upper locus, the majority of complete remains in the lower locus are vertebrae. The assemblage associated with the lower locus consists of 135 northern pike elements, 81 burbot elements, and 9 whitefish elements in addition to 341 unknown Actinopterygii elements (Fig. 4). The total weight of the fish assemblage associated with the Klein lower locus amounts to 14.68 g. Additionally, the representation of burning at the lower locus is significantly different from the upper locus (Fig. 6), with the exception of the feature, considering over half of the fish remains (302 or ~53%) are highly calcined and therefore assigned a burning index of 6. A total of 180 (~31%) fish remains fall under the burning index of 5.

SIMILARITIES AND DIFFERENCES IN FISH USE

When considering the upper locus feature and the remainder of the upper locus assemblage together, there is a high reliance on fish in this portion of the site. This finding is strongly driven by the high weight and NSP values associated with the upper locus feature. However, the lower locus assemblage is heavier when considering the upper locus feature and upper locus separately. The burning index and increased NSP at the lower locus further support the concept of fish being prevalent despite the increased likelihood of weight loss with higher burning intensity (Gallo et al. 2021). Additionally, there is a higher percentage of complete bones within the lower locus compared with the upper locus and upper locus feature. Within the upper locus feature and the lower locus, pike appear to dominate the assemblage relative to the representation of whitefish and burbot. Similar to the upper locus, the fish assemblage recovered from the lower locus is dominated by vertebrae but also reflects some crania and spine/ray/gill/rib remains (Supplemental Table 1; Fig. 5). However, the upper locus feature is unique in that it is dominated by spines, rays, gills, and ribs and contains much fewer vertebrae compared to the rest of the upper locus assemblage.

When considering the lower locus and the combined upper locus and upper locus feature data (Table 2), chi-squared tests demonstrate that there is not a significant difference between species representation (X_2 = 4.305, *df* = 2, *p* = 0.1162), but there is a significant difference between skeletal element representation (X_2 = 55.454, *df* = 2, *p* = <0.0001) and burning level (X_2 = 442.08, *df* = 6, *p* = <0.0001). These differences can be attributed to a significantly lower number of spines/rays/ribs/gills associated with the lower locus and a higher proportion of calcined elements associated with the upper locus combined with the upper locus feature. Although these sample sizes of fish bone may seem like a relatively small sample, particularly for the lower locus, it still provides pertinent information about species richness that can be used to consider fishing practices.

In comparing the upper locus assemblage to the faunal remains associated with the upper locus feature (Table 2), there is a significant difference between the represented species (X_2 = 28.435, *df* = 2, *p* = <0.0001), skeletal elements (X_2 = 542.05, *df* = 2, *p* = <0.0001), and burning level (X_2 = 876.07, *df* = 6, *p* = <0.0001). These results are driven by a higher proportion of burbot, less vertebrae in the upper lo-

Table 2. Sample sizes used in conducting chi-squared tests that examined differences/similarities in species, skeletal element representation, and burning levels.

Species Representation				
	Upper Locus and Upper Locus Feature	Lower Locus	Upper Locus	Upper Locus Feature
Burbot	62	77	42	20
Northern pike	158	131	47	111
Whitefish	13	9	3	10
Skeletal Element Representation				
	Upper Locus and Upper Locus Feature	Lower Locus	Upper Locus	Upper Locus Feature
Burbot	269	115	16	253
Northern pike	380	72	15	365
Whitefish	367	214	273	94
Burning Level				
	Upper Locus and Upper Locus Feature	Lower Locus	Upper Locus	Upper Locus Feature
Burning 6	1631	301	31	1600
Burning 5	118	181	19	19
Burning 4	13	38	3	3
Burning 3	29	2	19	19
Burning 2	191	20	191	191
Burning 1	0	7	0	58
Burning 0	29	17	19	0

cus feature relative to the upper locus assemblage, and significantly more calcined bones associated with the upper locus feature compared to the upper locus remains. While these differences between the upper locus and the feature may be a product of taphonomic bias and fragmentation, the findings are still relevant in interpreting spatial differences regarding the contribution of fish to subsistence at the Klein Site.

DISCUSSION

The results of our analysis of fish remains from the Klein Site suggest several trends in fish procurement and processing. Dene ancestors may have practiced specialized fishing techniques, including the possible use of mass capture technology such as nets or weirs based on the representation of all three fish taxa and the presence of both cranial and postcranial remains. While all three fish species are represented in the assemblage, the NSP values for northern pike are higher compared with burbot and whitefish. This is noteworthy considering it refutes the initial hypothesis that whitefish should have been the primary species of choice during lake fishing, followed by burbot and northern pike, if spear or hook-and-lure technology was the primary fishing technique. This is consistent with the notion that specialized technology results in the increased pursuit of lower-ranked species (Doering 2020; Doering et al. 2020; Smith 2011). It is also worth considering that the spatial distributions of bone weight imply differences in the relative proportion of fish represented at the Klein Site loci, with the majority of fish cooked and prepared at the lower locus followed by the upper locus feature area. This compares to lower burning intensities and a lower assemblage weight at the upper locus (when considering the feature separately).

A limitation of this research includes the inability to calculate minimum number of individuals due to the fragmentary nature of the fish assemblage. We recognize that hundreds of fish bones do not necessarily amount to that many fish, making interpretations of subsistence choice more ambiguous at the Klein Site. This being said, ongoing traditional zooarchaeological analyses examining the prevalence of aquatic faunal remains relative to the representation of nonfish taxa at the Klein Site imply that freshwater fish are a major supplement to diet at both the upper and lower locus (Doering et al. n.d.; Wetherbee et al. 2022). This concept is supported by the importance of fish to Indigenous peoples represented in both the ethnographic record and archaeological contexts associated with the Holocene period in Alaska (McKechnie and Moss 2016; Miszaniec et al. 2023; Moss et al. 2016; Potter et al. 2023; Smith 2011).

The presence of certain fish species in both Klein Site loci supports the hypothesis that mass capture technology, such as nets or weirs, was used. In both components, species that are active in the summer, such as northern pike and whitefish, were found with burbot, a species typically active in the winter and spring (Andrews 1975). The spatial dimensions of the Klein Site and artifact assemblage at both loci suggest that they were short-term camps, likely only used for a few days or weeks rather than months or years. Thus, the most parsimonious, though subject to debate, explanation for the presence of fish that are active in different seasons would be a mass capture strategy rather than lures, which are most effective when fish are active. Based on the high prevalence of northern pike across all of the site loci, it is likely that the Klein Site was inhabited during the summer or fall, and burbot were bycatch. This may also explain the lower overall number of burbot despite their higher caloric returns.

Without direct evidence of nets or fishing architecture, it is difficult to firmly establish the use of mass capture technology at Klein. However, this tentative conclusion is further supported by the skeletal elements represented at each locus. While skeletal element representation is dominated by postcranial elements, both loci featured cranial (upper locus = 5%, upper locus feature = 36%, lower locus = 30%) and postcranial (upper locus = 95%, upper locus feature = 64%, lower locus = 70%) fish remains despite the potential for differential preservation in favor of postcranial remains. This implies that the fish were brought to the site whole for butchering. Individually caught fish, such as those caught with a spear or hook and line, are frequently butchered at the fishing location in the ethnographic record (Tyone and Kari 1996). Carrying more than three large, slippery fish is relatively difficult without some kind of container. Fish caught in a net might be transported back to a processing site or camp whole in the net, resulting in the deposition of both cranial and postcranial remains represented at the Klein Site's lower and upper loci. While no "smoking net" is present, the material signature is suggestive of mass capture technology.

The use of nets or other specialized mass capture technology is consistent with broader cultural trends that archaeologists have identified within the late Holocene (Doering 2020; Potter 2008, 2016). Many lines of evidence at varying scales from these studies, from artifacts and faunal remains to site locations, indicate fish and fishing were part of a broader transition from generalized to specialized subsistence strategies. Mass capture technology very well could have been part of this trend, and is ubiquitous today and in the recent past. Additional research is needed to confirm if mass capture was indeed part of this trend. Ultimately, the hundreds of fish remains recovered from both loci at the Klein Site show that freshwater fish were an important resource for Dene at Quartz Lake.

In the upper and lower loci, almost all fish remains recovered showed signs of heat alteration. This was particularly noticeable for fish remains recovered from the feature at the upper locus where nearly all elements were fully calcined. It is also notable that the ratio of postcranial to cranial remains was different between the feature and fish remains recovered at other parts of the upper locus. This suggests that crania and spines, ribs, and rays were processed separately from other postcranial portions of fish. Another explanation for this difference includes activity areas, such as remains coming from a cooking feature compared with a midden or house/tent floor, which can have an impact on the variation between the assemblages. It is possible that fish were split into portions for different types of preparation such as drying, smoking, boiling, and/or fermenting. While density-mediated destruction could have impacted skeletal remains, the basic sediment conditions and evidence of both cranial and postcranial elements implies preservation bias minimally impacted the fish assemblage at the Klein Site relative to other archaeological sites associated with taphonomic conditions that do not favor the preservation of small fish remains.

Due to the extensive cultural processing and various taphonomic processes, most of the identified elements were fragmented. It is notable that the upper locus feature had the highest fragmentation rate, and this is likely because this feature was collected as a bulk sample and later processed in the lab. This suggests that additional fragmentary remains may have fallen through the ⅛" screen used on other excavated materials. While it is not possible to bulk entire excavation areas, taking feature samples can be an important way of recovering fragile and fragmented remains from small taxa. This also reinforces the need to use ⅛" or smaller screen to recover a faunal assemblage that is representative of subsistence activities (Nagaoka 1994; Partlow 2006; Shaffer 1992; Stewart and Wigen 2003).

A notable amount of fire-altered quartz and schist fragments were recovered at both loci. It is not clear if these pieces of rock were altered in the process of stone boiling or other cultural activities such as banya or steam baths, but it is possible that they were employed in rendering fish grease. Quartz Lake was traditionally associated with these rocks, as indicated by the traditional name *Ttheech'el Menn'* or "cracked rock lake" (Smith and Kari 2023). Almost all the analyzed remains were burned, suggesting that if they were boiled during the cooking process, they were later discarded into a fire.

CONCLUSION

The analysis of fish remains from the late Holocene components of the Klein Site's upper and lower loci suggest that Dene may have used specialized mass capture technology such as nets or weirs to harvest a wide variety of fish species. There is variation in skeletal element representation across the different site loci, but nearly all were directly exposed to heat and burned. These results show that freshwater fish were an important resource to the residents of Quartz Lake for over a thousand years, and they suggest that further investigations of freshwater sites could reveal more details about the importance of fish throughout central Alaska's history.

The results of the analysis reported here show the importance of directing our attention to late Holocene assemblages and freshwater fishing in central Alaska. The Klein Site provides valuable information about diet breadth and subsistence economy and potential clues to technologies used in procuring foods in the last thousand years of Alaska history. Archaeologists have investigated relatively few sites from this time and ecological zone. Ethnographic records indicate lakes and rivers were very important places throughout Alaska history. Investigating more of these locations, where intact deposits exist, can help refine ecological and cultural histories of the region.

Understanding the recent past in the sub-Arctic is key to contextualizing the significant ecological changes that residents of central Alaska have experienced. By investigating lacustrine and riverine settings, archaeologists can contribute to a broader understanding of ecological history by tracing human–animal interactions throughout the past and applying what we learn to our present. Bridging ethnographic accounts with archaeological data from diverse periods allows us to connect the dots between the past and the present.

ACKNOWLEDGEMENTS

The Klein Site and Quartz Lake are located on the traditional Tanana Dena homelands. We are grateful to the living descendants from Nenana, Chena, and Healy Lake for continued support of this research. The authors thank the excavators of the Klein Site and everyone involved in the recovery of the fish remains from the bulk sediment samples in the lab. The 2014, 2016, and 2017 excavations were supported by the Geist Fund from the University of Alaska Museum of the North and co-led with Reuther by Scott Shirar and Sam Coffman for the UAF Alaska Summer Research Academy. Excavations in 2019 were conducted with support of National Science Foundation Award #1830705 and the Wenner-Gren Foundation for Anthropological Research Grant #9754. Fish identifications by McKinney were supported by National Science Foundation Award #1521501. We especially thank the support of the Gelvin-Reymiller family in pursuing the work begun by Carol Gelvin-Reymiller, who passed away in April 2013. We also recognize the enduring support of Dr. David R. Klein, who passed away in November 2020 and was the impetus of many years of archaeological research at Quartz Lake. This manuscript benefited from comments provided by the editors and anonymous reviewers and copyediting assistance of Miriam McGovern.

SUPPLEMENTARY MATERIALS

Supplementary Table 1: Excel spreadsheet featuring a complete list of fish remains analyzed as part of this paper: https://docs.google.com/spreadsheets/d/16WhRfgNKyM3f3g-tizLksEiIlcU7Wi1A/edit?usp=sharing&ouid=102163952115222138362&rtpof=true&sd=true

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