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Cover: Stemmed arrow and spear points from the Hungry Fox archeological site in Gates of the Arctic National Park and Preserve. Article page 30. National Park Service photograph.

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National Park Service photograph

Natasha Slobodina, an undergraduate student at University of Alaska Anchorage, holds a quartz notched point. Because this material was rarely found, the archeologists working at the site conjecture that it would have been very special to prehistoric people. Although the notched points and scrapers made from the quartz crystal are beautiful, the people living at the site 5000 years ago used them for everyday jobs… another mystery of the past!

Read the article on page 10.

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The Mammal-Eating Killer Whales of Glacier Bay National Park and Preserve: Hunting with the Strong Silent Types

by Volker B. Deecke, Janice M. Straley, Dena R. Matkin and Christine M. Gabriele

Photograph courtesy of Volker Deecke

Prey remains recovered from a killer whale kill for genetic analysis to determine the prey species (harbor seal in this case). Typically we are able to recover only small bits of blubber or tissue—large fragments such as this one are the exception.

(Left) Female transient T086 breaching in Icy Strait during an attack on a Dall's porpoise.

Photograph courtesy of Volker Deecke

Killer whales in Alaskan waters: an introduction

Like two tribes inhabiting the same home range but keeping out of each other's way, two distinct forms, or ecotypes, of killer whales inhabit the coastal waters of the northeastern Pacific. Resident killer whales, one ecotype, live in large stable groups and feed exclusively on fish, predominantly on salmon *(Oncorhynchus spp.)*, while the second ecotype, transient killer whales, feed exclusively on warm-blooded animals. Their primary prey are marine mammals *(Ford et al. 1998, Saulitis et al. 2000)*, although they also take sea birds on occasion. Resident killer whales can be found frequently and predictably in the straits and inlets of southeastern Alaska and Prince William Sound in the summer months because they follow salmon on their annual migration through these coastal waters. By comparison, members of the transient ecotype are stealthy nomads. Presumably because of the lower density of their prey populations and the fact that their prey would quickly cue in on their presence, transients rarely linger for long in the same area. They often cover large distances in a single day, making them difficult to study.

We already know that transient killer whales along the west coast of North America are divided into several distinct populations. The best-studied are the West Coast Transients, a population that ranges from central California to southeastern Alaska. While some of its members use only a sub-section of the geographic range, some individuals have been seen in places as far apart as Glacier Bay and Monterey Bay, even in the same year *(Goley and Straley 1994)*. A second population, the Gulf of Alaska Transients, frequents the open waters of southern Alaska as far west as Kodiak Island and east to Sitka Sound. The third population is a small isolated group of eight individuals, named the AT1 Transients, found in Prince William Sound and the Kenai Fjords. Since the AT1 Transient population no longer contains any reproductive females, it is destined to go extinct *(Matkin et al. 1999)*. Other populations of mammal-eating killer whales are known to exist off the Aleutian Islands and in the Bering Sea, but research in these logistically challenging areas has only begun.

The waters of Glacier Bay National Park and Preserve (Glacier Bay NP&P hereafter) provide important habitat for several species of marine mammals. Several thousand harbor seals congregate near tidal glaciers and on terrestrial haulouts in spring and summer to have their young and to molt *(Matthews and Pendleton 2006)*, and some individual seals forage year-round throughout Glacier Bay. Concentrations of Steller sea lions can be found at haulouts at Point Carolus, and on South Marble Island

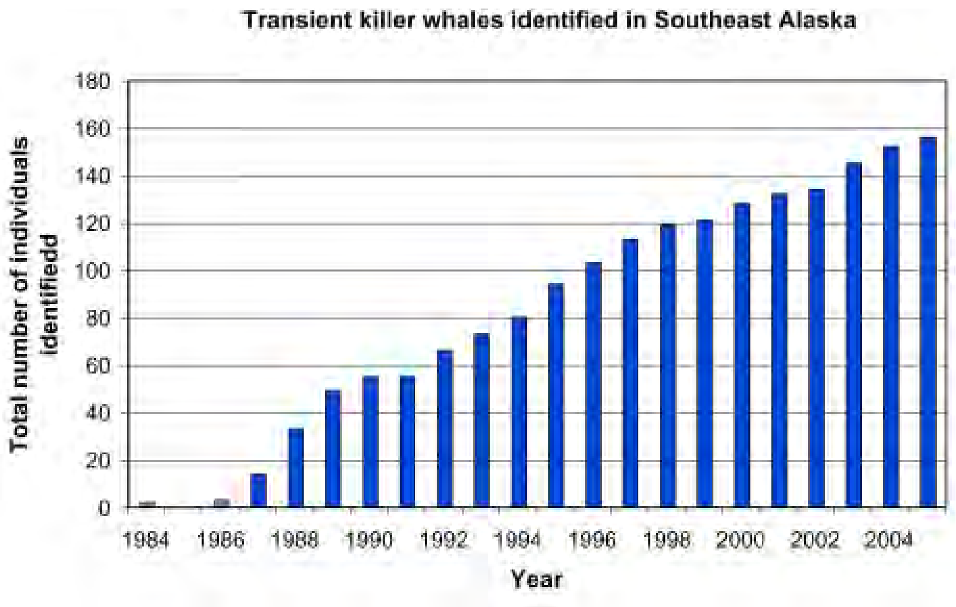

Figure 1. Discovery curve showing the cumulative number of individual transient killer whales identified in and up to a given year in southeastern Alaska. The data suggests that we have not yet identified all members of the West Coast Transients.

where their numbers can exceed 600 individuals. In addition, harbor porpoises are commonly sighted in Glacier Bay, although little is currently known about their abundance. Humpback whales can be seen on a daily basis in the summer and minke whales occasionally feed in the lower Bay.

Glacier Bay NP&P is one of the best places to view and study transient killer whales: the movements of transient killer whales are typically unpredictable, but in Glacier Bay members of the West Coast Transient population can be seen regularly during the summer months. This high frequency of sightings suggests that Glacier Bay provides important habitat for transients. At the same time, these mammal-eating killer whales play an important role in Glacier Bay's ecosystem. As apex predators they are key players in the intricate mechanics of a rich marine food web sustained by nutrient-rich runoff from the glaciers and long summer daylight.

The purpose of our study is to delineate the role of transient killer whales in the ecosystem of Glacier Bay, but also to determine the importance of Glacier Bay (and Glacier Bay NP&P) to the well-being and conservation of the West Coast Transient population. Only by gaining an understanding of the number of individual killer whales using the area, their frequency of occurrence in the park, their movements, diet, and behavior can we expect to address these questions. Our research uses photographic identification of individuals to document which animals are seen in the park. We follow groups of whales using surface observations and acoustic monitoring to document predation events. These techniques help us determine prey preference and the frequency with which predation occurs. Finally, we are conducting acoustic research to document how the animals use their acoustic habitat and how anthropogenic noise may impact their ability to communicate.

The photographic identification of individual killer whales

Photographic identification of individual killer whales is the basis of all research on these uniquely marked animals. Information gained from long term photographic records is used to document births, deaths, associations with other individuals, age at first calving and behavioral parameters. This information is crucial to fully understanding killer whale population dynamics. At Glacier Bay NP&P, photographic records of killer whales date back to 1986. Researchers take black and white photographs of the left side of each whale, recording details of the dorsal fin and saddle patch. Identifiable whales are recorded, catalogued and compared to existing catalogs of whales from the west coast of North America.

One hundred fifty-six transient whales, members of the West Coast population, have been identified in southeastern Alaska *(see Figure 1)*, making transients the more numerous ecotype. In comparison, 122 killer whales of the resident ecotype have been documented. One transient female has been recorded in Glacier Bay every year since 1988. She is sighted most often in Glacier Bay in June and July, in constant company of her three offspring.

Whereas in many parts of their range, transient killer whales typically hunt in small groups of three to five individuals, in Glacier Bay it is not uncommon to see large groups of up to 35 whales *(Matkin et al. 2006)*. Such large groups are made up of members of several matrilines (family groups consisting of one female and her offspring) and groups may travel together for several days before breaking up. The function of such multi-matriline aggregations is currently not fully understood, but they are a rare occurrence in waters outside of Glacier Bay and Icy Strait, and may play an important role in social interactions between members of the West Coast Transient population.

Documenting killer whale predation

Decreases in marine mammal populations in western Alaska have led researchers to speculate that mammal-eating killer whales may have contributed to these declines and may be preventing recovery *(Springer et al. 2003)*. However, data to support this theory are currently scarce. Researchers are just beginning to recognize when predation occurs, and identifying the prey can be difficult because the whales often leave only small bits and pieces behind. In southeastern Alaska, most populations of prey species for transient killer whales (in particular, Steller sea lions, Dall's and harbor porpoises, and harbor seals) are stable or increasing in abundance. Glacier Bay, where harbor seals have declined over 70% during the past decade *(Mathews and Pendleton 2006)*, is a notable exception. Interestingly, during the same time period in Glacier Bay, sea otters have increased from zero in 1992 to about 2,400 individuals in 2004 *(Bodkin et al. 2004, USGS unpublished data)*.

Our methods for observing predation take patience and perseverance. Once initial photo-identification is complete, we follow the killer whales at a slow, constant speed at a distance of 200 yards (183 m) or more while observing the group's behavior. We do not want to disrupt their normal traveling and foraging behavior. If we observe a change in behavior that may indicate predation, noting the exact time and location of the event, we approach to within 100 yards (91 m) and document any signs of a possible kill. For the smaller species that are quickly consumed, it is usually difficult to see an actual kill, but scavenging birds or the sudden onset of vocal behavior often provide cues that a kill has occurred. Larger prey such as Steller sea lions or Dall's porpoise take more time to subdue so that these kills are easier to detect. Once the kill has been completed, we attempt to identify the prey species using visual observation, photographic documentation and the recovery of small prey fragments for genetic analysis. To recover remains, we typically approach close to where the whales dove and gather tiny bits of skin and blubber from the water using a fine-mesh dip net *(see photo page 5)*. We do this quickly because nearby birds are often as keen as we are to recover prey remains.

Since 1986, feeding ecology studies in the Glacier Bay area have determined that West Coast Transients primarily take harbor seals (40%), harbor porpoises (23%), Steller sea lions (16%), seabirds (14%), Dall's porpoises (5%) and minke whales (2%). Transients rarely harass humpback whales or sea otters and have never been seen killing either species *(Matkin et al. 2006)*. Clearly, harbor seals are an important prey species in the waters of Glacier Bay. They may be even more important than our current research suggests because seal kills are difficult to detect, a fact that biases our predation estimates downward. As we become better at detecting predation, we hope to refine these rates to reflect the true importance of harbor seals in the diet of killer whales in Glacier Bay and in southeastern Alaska in general.

The vocal behavior of transient killer whales: Communication with costly calls

Killer whales are acoustic animals that rely primarily on sound for orientation, communication, and location of their prey (using echo-location or by listening for prey sounds). Vision is extremely limited underwater, but sound propagates freely through this medium and presents an effective channel to obtain information about their environment and to transmit information through it. However, acoustic communication is associated with costs, which are far greater for mammal-eating killer whales than for fish-eating whales.

The primary prey of resident killer whales, Pacific salmon, have poor hearing at the frequencies of killer whale communication, so eavesdropping is not a concern. Playback experiments have shown that harbor seals, the primary prey of transient killer whales, respond strongly to transient

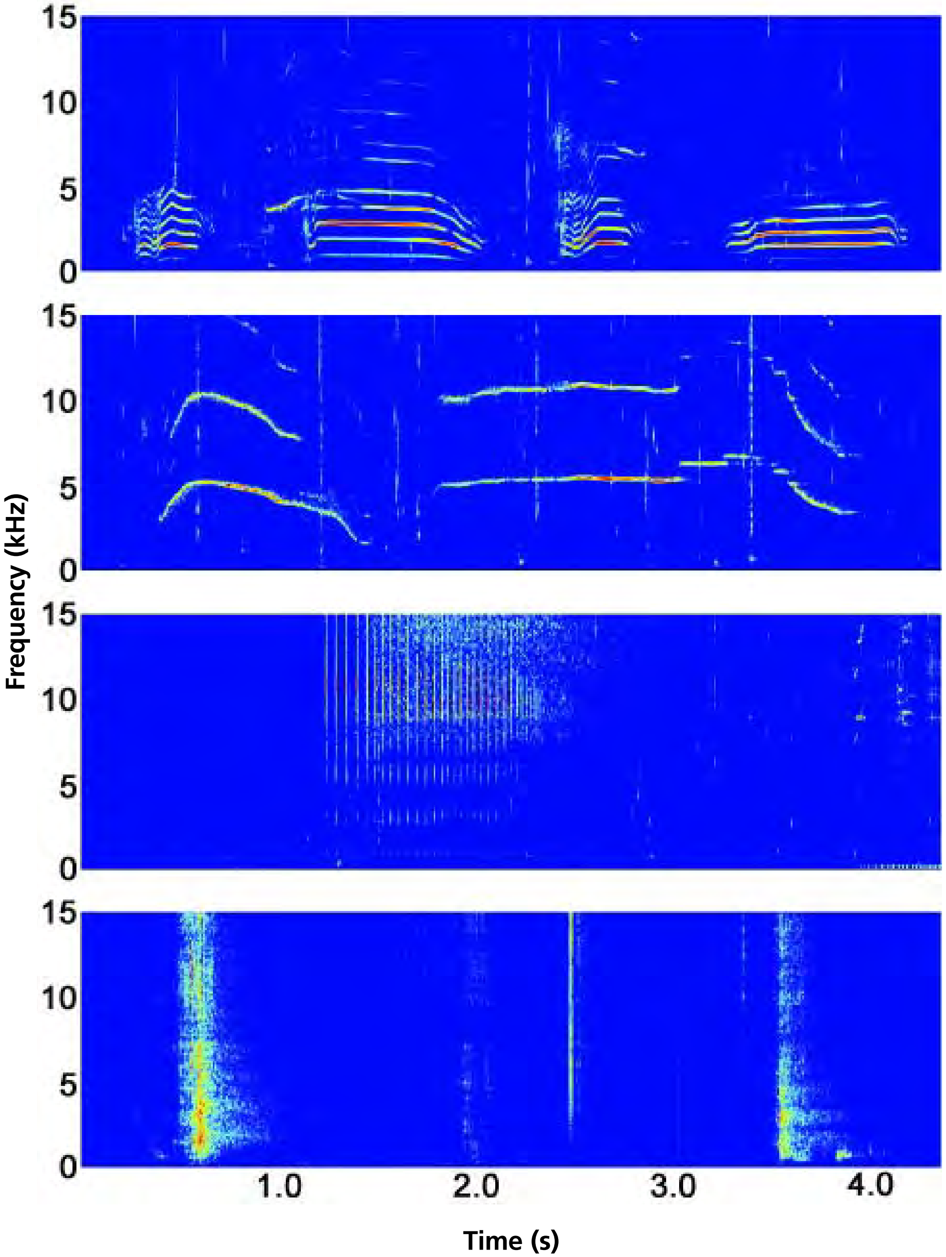

Figure 2. Spectrograms of pulsed calls, whistles, echolocation clicks and prey-handling sounds recorded from transient killer whales.

Photograph courtesy of Michael de Roos

Figure 3. Numerous research projects are running in parallel in Glacier Bay NP&P and provide a wealth of information to analyze interactions between species. This photo shows harbor seal PV05GB05 (foreground with radio tag) being attacked by transient killer whale T085A while humpback whale #1795 looks on.

calls *(Deecke et al. 2002)*. Transients probably risk warning their prey every time they call. One of the objectives of our acoustic research is to determine how this high cost has shaped vocal communication of transient killer whales.

The underwater environment can be a noisy place: up near the glaciers, melting bergs of glacier ice release millions of bubbles of air compressed by the weight of the glaciers, creating a loud curtain of white noise called ice fizz. This could mean that in addition to providing hiding spots on or amongst the floes, areas of floating ice near tidal glaciers provide an acoustic refuge for harbor seals, because the noise prevents killer whales from detecting seals acoustically. However, environmental noise can interfere with killer whale hearing throughout their range. Natural sounds include noise generated by waves, rain, or other animals. Increasingly, anthropogenic noise such as that generated by ships may be affecting the whales' ability to maintain contact and communicate with sound. Therefore, another objective of our acoustic research is to determine the effect of anthropogenic noise on the transient killer whales of Glacier Bay.

We are collecting data on the loudness of calls to understand the distance over which killer whales are able to hear each other and to determine the effect of human-generated noise on their communication. We also want to test if vocal communication is associated with specific behavior contexts and whether the animals call preferentially in certain locations within Glacier Bay. We are interested to find out whether transients call more quietly than residents in order to avoid detection by their marine mammal prey. To address these questions, we follow groups of killer whales while towing hydrophones (underwater microphones) to record their vocalizations and to determine the distance of a calling whale to our recording system. Knowing how far a vocalizing whale is away allows us to calculate how loud its call was when the whale made it.

Our results have shown that compared to resident killer whales, transients rarely vocalize and limit their sound communication to a few, narrowly defined behavior contexts. Transient killer whales typically hunt in silence and only vocalize after a successful kill *(Deecke et al. 2005)*, when other prey animals may already have been warned by the ramming and slapping sounds generated during the kill *(see Figure 2)*. In a few instances, we have also recorded vocal behavior that was indicative of social interactions between group members, not after an attack. Our preliminary results on the loudness of calls suggest that vocal behavior after an attack is significantly quieter than the calls of resident killer whales and is probably directed at other members of the hunting group. The differences between the vocal behavior of residents versus transients is probably due to the far more sensitive hearing of marine mammal prey. On occasion, however, we have recorded transient calls that were as loud as or louder than those of residents. This form of vocal behavior probably represents an attempt to establish acoustic contact with other distant groups in the area. Observational information collected in Glacier Bay and elsewhere suggests that these loud calls are audible over 20 miles (32 km).

Transient killer whales in Glacier Bay National Park: A synthesis

Conducting research in Glacier Bay NP&P brings the benefit of working in a location where numerous research projects are running in parallel. Researchers are studying the foraging behavior and population dynamics of harbor seals in Glacier Bay *(e.g., Mathews and Pendleton 2006)* providing us with a new perspective for analyzing the movement patterns and behavior of transient killer whales. Since 2001, the park has maintained a permanent hydrophone at Bartlett Cove to monitor underwater ambient noise levels and the loudness of shipping noise in the lower part of Glacier Bay *(Kipple and Gabriele 2003)*. We can use this information to better assess the effect of noise on killer whale communication. Detailed bathymetry and sound speed profiles are available for much of the bay *(Etherington et al. 2004)* allowing us to model the sound propagation and frequency-dependent attenuation of killer whale calls. This complementary research has provided a rich background of biological and geophysical information that allows us to obtain a far more comprehensive understanding on the behavior of transient killer whales and the role they play in their ecosystem *(see Figure 3)*.

Our findings suggest that the West Coast Transient killer whales play a significant role in Glacier Bay's ecology: they structure the marine mammal community and thereby indirectly affect many other players in this complex marine food web. Just as transients are an important part of Glacier Bay, the park is important to West Coast Transients. Glacier Bay is the largest area of tidewater glaciers in the range of this population and may well be one of only a few areas capable of sustaining large groups of transient killer whales. Because of their high metabolic demand, killer whales can only form large groups in places where food is consistently abundant such as Glacier Bay with its seasonal concentration of harbor seals and other marine mammals. The frequency with which we observe large groups comprised of members of several matrilines suggests that this area is important for maintaining social processes in the West Coast Transient population. The large temporary aggregations of transients may play an important role in mate choice and in enforcing social bonds between members of the population that only encounter each other infrequently. In order to ensure the health of the West Coast Transient population of killer whales, it is therefore our responsibility as researchers, as managers, and as concerned citizens to ensure that the integrity of Glacier Bay's marine ecosystem is maintained for the future.

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National Park Service photograph

Susan Bender and Millie Booth set up an excavation grid at Napaaqtualuit.

(Left) Aminilla Hugo and Deron Smith screen excavated soil to find artifacts they might have missed while digging. Aminilla will find small pieces of stone tools and flakes there amongst the stones.

National Park Service photograph

Archeological Investigations in Anaktuvuk Pass: Nunamiut Students Uncover Their Past

by Julie Esdale and Robert Gal

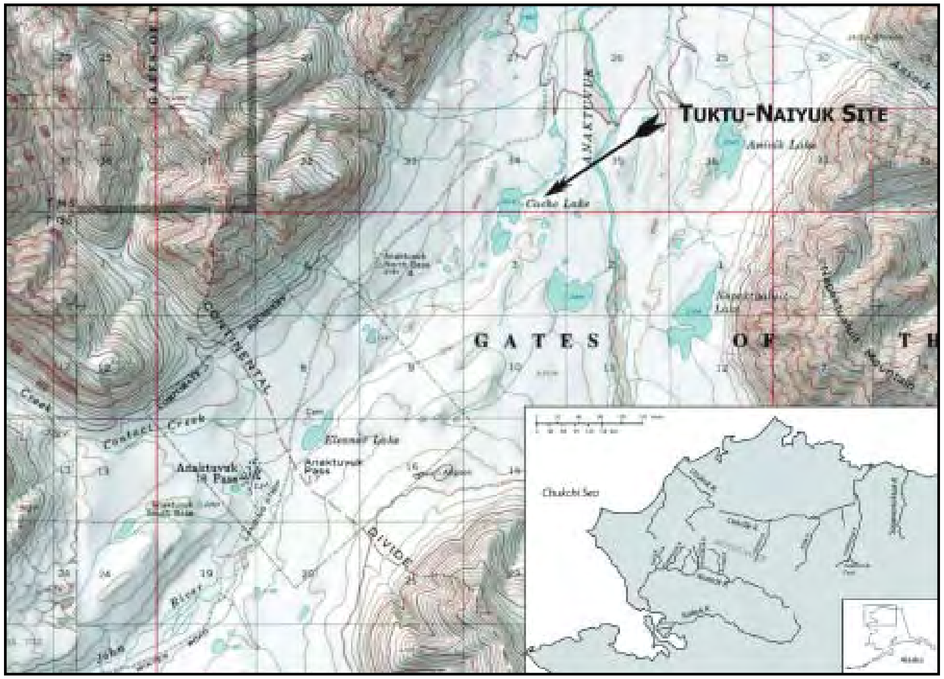
Introduction

Archeological research in northern Alaskan parks is driven largely by resource management concerns: Where do sites occur? What were people doing there? How large are they? How old are they? Is a site common, or rare, and how should it be treated? Is an important site threatened by erosion? By human visitation? To answer these questions and others, archeologists must investigate remote areas in the brief summer season. The logistic support for these investigations are frequently complicated and usually very expensive. Archeologists recognize, however, that local communities should play a role in archeological research and stewardship within their geographic area of patrimony. Since 1985, as prudence and opportunity allowed, NPS archeologists have included students and young adults for varying lengths of time in their field investigations in all five of the northwest Alaskan parks. During the summer of 2004, several agencies (Western Arctic National Parklands, Gates of the Arctic National Park and Preserve, National Park Service-Alaska Regional Office, and Brown University) came together in the village of Anaktuvuk Pass to study the prehistoric archeology at the Tuktu-Naiyuk site. The proximity of the site to the village facilitated the full involvement of local students in the scientific process.

The Tuktu-Naiyuk archeological site, located in the Anaktuvuk River valley four miles north of the village of Anaktuvuk Pass, was originally identified in 1959 by archeologist Jack Campbell with the help of Anaktuvuk Pass residents Thomas Rulland and Robert Paneak *(Campbell 1962a, 1962b)*. The landform was well known by the local Nunamiut people, and was likely used as a campsite by caribou hunters for thousands of years. At Tuktu-Naiyuk, Campbell discovered stone weapon points, some with notches at the base for hafting (notched points) and some without (lanceolate points). He also found flat hand-sized cobbles with notches chipped on two sides to be hafted and used as a hammer (notched pebbles), and stones that had long narrow razorblade-like flakes removed, called microblade cores. In one area of the site, Campbell excavated several ancient fire pits and a stone ring that marked the former location of a skin tent *(Campbell 1961, Shinkwin 1964)*. He was able to gather enough charcoal from this feature, named the "Tuktu House", for a radiocarbon date of 6,500 years ago.

In one area of the site, Campbell excavated several ancient fire pits and a stone ring that marked the former location of a skin tent…He was able to gather enough charcoal from this feature, named the "Tuktu House", for a radiocarbon date of 6,500 years ago.

Because of the artifacts Campbell and



Map of Brooks Range and Anaktuvuk Pass area showing the location of the Tuktu-Naiyuk archaeological site.

his crew discovered and the ancient date on the Tuktu house, the Tuktu-Naiyuk site became an important cornerstone for understanding the cultural chronology of interior northern Alaska. This site is always referenced by archeologists researching and writing about the mid-Holocene (circa 4,000 to 7,000 years ago), even though many questions about Tuktu-Naiyuk have remained unanswered, and in the intervening years, new questions about this time period have emerged. In 1998 NPS Cultural Resource Preservation Program funding was secured for two seasons of work to attempt to integrate the findings from the Tuktu-Naiyuk Site and several other sites from Gates of the Arctic NP&P, from Noatak River sites, and from the Onion Portage Site on the Kobuk River. The first season of work was completed in the Nimiuktuk drainage of the Noatak in the summer of 2000 but the reinvestigation of the Tuktu-Naiyuk Site could not be arranged until 2004.

One set of questions concerned the layout of the Tuktu-Naiyuk Site and its occupational history. Landforms such as the broad Tuktu-Naiyuk terrace were reused repeatedly over time. Small, spatially bounded clusters of archeological material on the terrace can be more confidently attributed to the activities of a single human group than can artifacts diffusely distributed across a landform. One of our goals was to apply precise modern plotting techniques and focus on discrete clusters of artifacts on the terrace to identify the repetitive co-occurrence of forms within the clusters.

Another question was the antiquity of occupations at the site. Although Campbell had dates ranging from 2,500-6,500 years ago, the 6,500 year date is the only one commonly cited by other archeologists. Furthermore, in the 1960s when this work was completed, radiocarbon dating was still in its infancy. Campbell needed a large sample of charcoal to get an age, and so he combined pieces that he found around a wide area. The samples he dated had a greater likelihood of containing charcoal of different ages from different occupations at the site. We can now date just milligrams of charcoal, coming from one twig used in a fire by ancient inhabitants of the site using the AMS technique of radiocarbon dating (accelerator mass spectrometry—a technique that separates carbon isotopes by mass by shooting them through a magnetic field).

The 2004 work at Tuktu-Naiyuk sought to understand the ways this site was used by people in the past and when people had inhabited the site. We also wanted to figure out which stone tools were an important part of the toolkit used by hunter-gatherers in the Brooks Range during what archeologists call the Northern Archaic (roughly 4,000-7,000 years before present) *(Anderson 1968).* The students involved in the project learned about the environmental challenges earlier occupants of the Anaktuvuk valley (possibly even their direct ancestors) had to face, and how their hunting techniques, housing, tools and diet changed over time. We learned from the students too, who had a completely different approach to our investigation. Their contributions gave a richer narrative to the past.

Student Participation

The archeological crew for the 2004 season consisted of National Park Service archeologists from Western Arctic National Parklands and Gates of the Arctic National Park and Preserve, students from University of Alaska at both Fairbanks and Anchorage campuses, Terence Booshu from Point Hope, and several students from the Nunamiut School in Anaktuvuk Pass (Billy Ahgook, Amanilla Hugo, Brandon Rummer, and Diane Sikvayugak). Three students from Noatak Village (Millie Booth, Masaak Penn, and Deron Smith) also spent ten days with us at the site as part of a Shared Beringian Heritage Program archeological mentoring program.

For this project, it was important to use specific modern archeological methods to answer the questions that have arisen since Campbell's excavations in the 1960s.

We can now date just milligrams of charcoal, coming from one twig used in a fire by ancient inhabitants of the site using the AMS technique of radiocarbon dating (accelerator mass spectrometry…)

Students were involved in all aspects of the archeological process. They first learned to identify the characteristics of flaked stone tools in order to discern naturally broken rocks from those broken by humans. They identified previously undiscovered archeological sites on the Tuktu-Naiyuk terrace by systematically examining the ground surface for tiny flakes (the debris left behind when making chipped stone tools) of glassy stones like chert and obsidian. Areas with archeological materials were marked with pin-flags to show the concentration and abundance of flakes, tools, charcoal and other traces of ancient humans. These clusters were precisely plotted with surveying equipment and used to generate maps. The maps were used to target small scale test excavations that aimed to recover a sample of artifacts and material for radiocarbon dating. The location of Campbell's previous excavations were also plotted to put his collections in spatial context. In the future, the maps can be used to monitor changes or impacts to the site condition.

Clusters of stone tools potentially represent locations at which people once constructed housing, prepared food, or created and repaired tools. Several clusters of archeological material were chosen for excavation based on the presence of: charcoal (which can be used to date a site); burnt flakes and tools; important artifacts such as stone points or hide scraping tools; or exotic raw materials such as obsidian or quartz crystal. Each student was paired with an archeologist to excavate meter-square test units, and was responsible for recording information about sediment

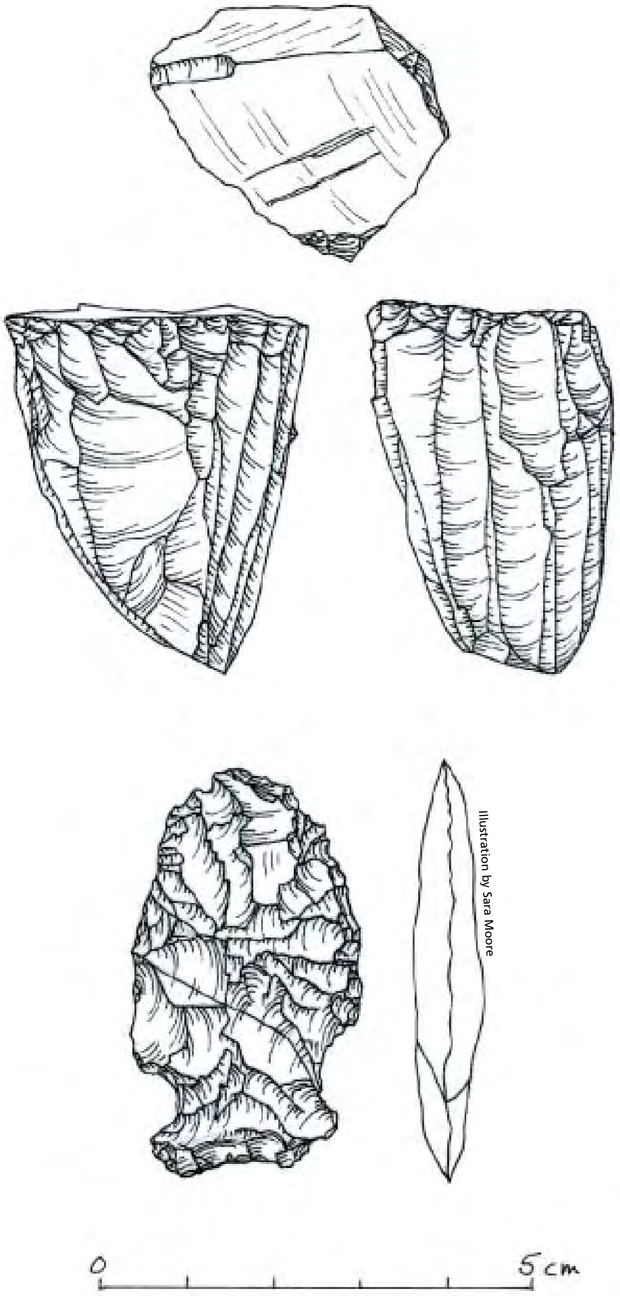


Illustration by Sara Moore

National Park Service photograph

National Park Service photograph

(Top-Right) Before excavations begin, archeologists identify where the largest concentrations of tools, flakes, and burnt material occur. Each artifact found on the surface is marked with a pin flag and then mapped.

(Bottom-Right) Billie Ahgook and Brandon Rummer excavate a unit at the Napaaqtualuit locality at Tuktu-Naiyuk.

(Left) Microblade cores (upper) and notched projectile points (lower) are artifacts commonly found in the Brooks Range dating to the Northern Archaic period.

National Park Service photograph

This 1,900 year-old fireplace, or hearth, was covered with charcoal. A small pit containing several caribou bones was found near the northeast corner of the hearth (top right in photo).

texture, types of stone, any charcoal or other evidence of burning, and most importantly, the three-dimensional location of all flakes and tools (distance north and east of a defined datum point and depth in the unit). These data were carefully recorded so that the site could be reconstructed and analyzed after the field season.

The students also had a good time narrating their experience, what they saw, and aspects of the excavation using videography and drawing. Their perceptions of the environment, cultural finds, and methodologies brought a fresh perspective to the research. For example, place-names are an important part of Nunamiut heritage. The central Brooks Range is dotted with sites named because they were important hunting locations or places where special events occurred. This tradition was honored by the students involved in the project by naming our excavation localities. The Napaaqtualuit excavation area was named by Amanilla and Diane after the mountain looming over the site to the east. The Uyagaluk locality was named by Billy and Brandon for the Nunamiut word for big rock, as there was a large boulder in the middle of the excavation area.

Excavated Areas

Of the 56 new artifact clusters identified on the Tuktu-Naiyuk terrace we focused on three with the best potential to provide information about past life ways during the Northern Archaic period: L-2, Napaaqtualuit, and Uyagaluk.

The first area, L-2, was a ring of stones that likely held down a tent some time in the past. Excavations produced small, thin, stone knives and a fire place. Charcoal in this fireplace was dated using the radiocarbon method. This showed that people erected and warmed up their tent on this spot slightly over 2,100 years ago.

Several different campsites had been made through time in the Napaaqtualuit excavation area. One cluster of stone tools found was made of quartz crystal and located with charcoal and burnt bone. In total, four scrapers, two notched projectile points, and two flake tools were found at the site made from quartz crystal, a stone rarely found in archeological sites in the area. Four radiocarbon dates on the charcoal associated with these points cluster around 5,100 years before present.

Twenty-two yards (20 m) to the south was another ancient campsite. The people who stopped here approximately 4,000 years ago crafted knives and projectile points from obsidian. Obsidian is shiny black volcanic glass, ideal for producing sharp edges. Over a dozen notched points were discovered here, most of them broken in use and discarded. A few meters to the west an interesting hearth (fireplace) was found. It was covered with rocks and thick with charcoal. A small pit of caribou bones was discovered next to the hearth. Charcoal from this feature dated to 1,900 years ago. It appears as if some hunters stopped at the site several thousand years after earlier occupations, warmed up and ate a meal.

At the western edge of the Tuktu-Naiyuk terrace we excavated two localities (D-south and Uyagaluk) that had lanceolate projectile points on the surface. D-south was immediately adjacent to one of Campbell's excavations and we wanted to see if we could find charcoal to date the site (Campbell's date of 5,600 years before present was from here). Excavations uncovered lanceolate weapon points and scraping tools made from black and grey chert. Chert is a common type of stone used for tools in the Brooks Range. This rock is found interbedded with limestone in the mountains to the west of Anaktuvuk Pass, and chert is also found in stream cobbles. When broken, the rock is sharp and strong. In this area, it is often the most common material found at sites *(Giddings 1962, Irving 1951)*. We also found charcoal here, but the age was 3,900 years ago, somewhat younger than Campbell's original determination.

Uyagaluk was another cluster of artifacts, just to the north of D-South. Artifacts found here included notched points, scrapers and lanceolate points. There were also a few possible hearths in this area. Hearths at the Tuktu-Naiyuk site are shallow, and recognized by small pieces of charcoal, burnt bone, and reddened soil. We received a date of 1,750 years ago for charcoal in one of these hearths.

Analysis and Follow-up

After the successful field season, the artifacts, charcoal samples and sediment samples found during excavation went to Fairbanks with one of the authors (Julie Esdale) to be analyzed as part of her doctoral dissertation, but students also had a chance to be involved in the analysis. For a week during October of 2004, during science class at Nunamiut School in Anaktuvuk Pass, high school students learned how stone tools are made, how archeologists analyze artifacts, how they reassemble the spatial data recorded during excavation to reconstruct the site, how radiocarbon dating works, and how findings are reported to the scientific community.

The students watched demonstrations of flint knapping that showed how pieces of obsidian and chert could be broken or flaked to produce tools with sharp edges for cutting, penetrating and scraping animal hides, flesh, and bone. Most of the stone found at an archeology site is not the tools, but the flakes that come off of the tools during flint knapping. Even when tools are absent from the site, these characteristic artifacts can be analyzed for important information about what types of tools were being made and used, and what types of manufacturing techniques were utilized by the ancient hunters *(Kuhn 1994)*. Nunamiut School students carefully considered several attributes on flakes to decide if they had come off of a cutting tool, a scraping tool, a core, or a notched pebble, for example. They also practiced

Site Local	Date	Sample Material	Excavator
L-2 tent ring	2110 ± 40	Wood charcoal	Young
Naiyuk-1	3042 ± 188	Caribou bone	Campbell
Naiyuk-1	3615 ± 217	Bone fragments	Campbell
Naiyuk-2	2576 ± 157	Wood charcoal	Campbell
Naiyuk-2	3292 ± 445	Charred bone	Campbell
Naiyuk-4	5688 ± 183	Bone fragments	Campbell
D-south (Naiyuk-4)	3940 ± 40	Willow charcoal	Esdale
Naiyuk-5	3440 ± 253	Bone fragments	Campbell
Naiyuk-8	3527 ± 191	Bone fragments	Campbell
Tuktu-1	6510 ± 610	Charred bone	Campbell
Napaaq tent ring	60 ± 30	Willow charcoal	Esdale
Uyagaluk	1750 ± 40	Willow charcoal	Esdale
Napaaq quartz point area	5070 ± 40	Alder charcoal	Esdale
Napaaq quartz point area	5109 ± 41	Alder charcoal	Esdale
Napaaq quartz point area	5109 ± 42	Birch charcoal	Esdale
Napaaq quartz point area	5126 ± 42	Birch charcoal	Esdale
Napaaq quartz point area	5255 ± 59	Birch charcoal	Esdale
Napaaq stone hearth	1910 ± 40	Willow charcoal	Esdale
Napaaq stone hearth	1877 ± 57	Willow charcoal	Esdale
Napaaq stone hearth	1940 ± 57	Willow charcoal	Esdale
Napaaq obsidian area	4001 ± 57	Willow charcoal	Esdale
Napaaq obsidian area	4095 ± 59	Willow charcoal	Esdale
Napaaq obsidian area	4980 ± 42	Birch charcoal	Esdale
Napaaq obsidian area	8240 ± 50	Alder charcoal	Esdale

This radiocarbon date table contains all of the existing dates from Tuktu-Naiyuk localities. Campbell's dates are from Gal 1982. Beta Analytic and University of Arizona Radiocarbon Lab produced the dates on charcoal excavated by Esdale and Young in 2004.


National Park Service photograph

Students gather around to show off some of their most interesting finds of the summer (points and scraping tools). From left to right: Diane Sikvayugak, Natasha Slobodina, Aminilla Hugo, Billy Aghook, Terence Booshu, and Brandon Rummer.


Photograph courtesy of Eric Hart

Jeff Rasic (NPS-YUGA) demonstrates to students at the Nunamiut School in Anaktuvuk Pass how stone tools are made. After he finished flint knapping, the students leaned in to take a closer look at the replicated artifacts. The tools on the canvas are all made from obsidian.

The ancient hunter-gatherers primarily used chert as a raw material, but also used obsidian and rare quartz crystal to make notched points and scrapers. People repaired hafted tools, threw out broken and used-up dart points, scraped hides and prepared meals.

drawing different types of artifacts.

Analysis of the spatial data recorded during excavation showed that each separate artifact cluster (i.e. Napaaqtualuit obsidian notched point area, Uyagaluk, L-2) told its own story. Forty-four notched points made from obsidian, chert and quartz crystal were found across the Tuktu-Naiyuk terrace. In one cluster, points were being resharpened and broken points were removed from hafts, while in another cluster notched points were being knapped from large flakes. Furthermore, the points in one cluster dated a thousand years older than the points in another, suggesting that these activities took place several generations apart. In another area of the site, scraping tools were found in abundance (43 were excavated in total at Tuktu-Naiyuk). Instead of repairing projectile points, the emphasis was on hide working.

The class also participated in an experiment designed to explain the principles behind radiocarbon dating organic materials such as charcoal, wood and bone. Finally, our work was summarized in a poster prepared by the students which was made available to view at the Alaska Anthropology Association meetings in 2005 and also displayed at the Nunamiut School. At present, artifacts from the 2004 excavations at Tuktu-Naiyuk are on loan to the NPS by the Arctic Slope Regional Corporation. They will be sent back to Anaktuvuk Pass to be stored and displayed at the Simon Paneak Museum when this facility is able to allocate space and curatorial resources.

Conclusions

The 2004 excavations at Tuktu-Naiyuk answered several questions that had been left unanswered by Jack Campbell's 1960s research. We discovered that people used the site for several thousand years, from over 5,000 years ago to recent times. Ancient hunters used different parts of the Tuktu-Naiyuk terrace at each visit, and the artifacts they left behind recorded specific activities that took place *(Binford 1978)*. The ancient hunter-gatherers primarily used chert as a raw material, but also used obsidian and rare quartz crystal to make notched points and scrapers. People repaired hafted tools, threw out broken and used-up dart points, scraped hides and prepared meals. We can't tell from the flaking debris and charcoal, but we can guess that they also watched for caribou, socialized, told stories, and cared for their children *(Campbell 1998, 2004)*.

The students taking part in this investigation learned how western scientific methods can be used to decipher ages of site occupation and reconstruct campsites or ancient technologies. At the same time the students taught the archeologists how to balance a sterile analytical approach ("locality L-2") with a light hearted, personal approach that was closely tied to the culture of the people we were studying (they gave Inupiaq nicknames to everyone, place names to site localities, and taught us Inupiaq terms for items in excavations and around camp).

Acknowledgements

We would like to thank the Nunamiut School in Anaktuvuk Pass, and especially teachers Just Jensen and Eric Hart for let-

ting us take over several science classes with archeology, thanks also to all the students who participated. We would also like to acknowledge the Naqsragmiut Tribal Council and Arctic Slope Regional Corporation for granting access to the site and allowing for excavations. Funding for this project came from National Park Service grants to Robert Gal, a Shared Beringian Heritage Program grant, Becky Saleeby, and a National Science Foundation grant to Julie Esdale. Thanks goes to Gladys Mekiana and the rest of the Gates of the Arctic operations staff for logistics in Anaktuvuk Pass. We would also like to express our gratitude to Dr. Jack Campbell for coming up to Anaktuvuk Pass and telling us about the work he did at Tuktu-Naiyuk 40 years ago.

Illustration by Georgianna Gordon

A Nunamiut high school student interprets a hunt and kill site at Tuktu-Naiyuk using a modern perspective.

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Lake Ice and Snow Study in Denali National Park and Preserve Promotes Elementary School Science Education

by Martin O. Jeffries, Patty Gallego,
Dorothy DeBlauw, Kim Morris, and
Delena Norris-Tull

Photograph courtesy of Tina Graham

Seen from the trail in spring, Horseshoe Lake is in the foreground and the Nenana River lies just beyond in the middle distance. The ALISON study site has been placed on the west (left) arm of the lake since the study began in winter 2003-04.

(Left) Thermal cracks in the ice at the ALISON study site, Nome, March 2004. The photograph covers a patch of ice, roughly 12 x 16 inches (0.3 x 0.4 m).

Photograph courtesy of Martin Jeffries

Since the new Denali National Park and Preserve (DNPP) Visitor Center opened in summer 2005, many thousands of people have seen *Heartbeats of Denali*, a film that introduces visitors to the annual cycle of the park ecosystem. For the freshwater ice scientist, the segment that shows bare, heavily-cracked and wind-polished ice on the Nenana River is particularly interesting. Extending horizontally many tens of meters, the wide, snow-filled, thermal cracks give the ice cover the appearance of crazy paving.

Thermal cracking also occurs under snow cover, on both river ice and lake ice, but the absence of snow amplifies the process and its effects. Without an insulating snow layer, the top of the ice becomes very cold, almost as cold as the air above, while the bottom, resting on water, remains at 32°F (0°C). The large temperature difference causes the ice to bend upwards and crack when it can no longer withstand the curvature *(Metge 1976)*. If this process is repeated often enough, the entire ice cover is reduced to a series of smaller, angular plates defined by a dense network of intersecting cracks; hence the appearance of crazy paving on the frozen Nenana River.

The effectiveness of snow as an insulator is illustrated in Figure 1. It shows data obtained at Horseshoe Lake, 2.2 miles (3.5 km) north of the DNPP Visitor Center. On a cold (-5.7°F, -20.95°C) day in early December 2003, when the ice was 16.5 inches (0.42 m) thick, the average depth of snow on the ice was 6.3 in (0.16 m) *(Figure 1a)*, and the average temperature at the base of the snow was 25.5°F (-3.6°C), a 31.2°F (17.35°C) difference *(Figure 1b)*. The insulating effect of the snow is further illustrated by the almost linear relationship between ice surface temperature and snow depth values *(Figure 1d)*, i.e., the deeper the snow, the higher the temperature on the ice surface at the bottom of the snow.

The data in *Figure 1* were obtained by third, fourth and fifth grade students from Tri-Valley School, Healy, about 8.1 miles (13 km) north of the lake. Since autumn 2003, a total of 60 different students have visited their frozen study site to measure ice thickness, and the depth, density and temperature of the snow on the ice. Because it is a mixed-grade class, some students have been making measurements for as many as three consecutive winters. Integrated into their science and language arts classes, the Horseshoe Lake project has taken students outdoors in winter to study their local ecosystem.

The Tri-Valley School students are participants in ALISON—Alaska Lake Ice and Snow Observatory Network—an exemplary scientific research and science education partnership of K-12 educators and students, and university scientists and educators *(Abbott and Swanson 2006)*. In winter 2005-06, Horseshoe Lake site was one of 22 ALISON sites, 19 of them run by teachers and their students, in four of Alaska's six climate zones—Arctic, Interior, West Coast and Southcentral *(Pearson and Hermans 1998)*.

Photograph courtesy of Martin Jeffries

Wooden stakes and snow depth/temperature probes stand on the ice at Lucille Lake, Wasilla, shortly before sunrise on 14 December 2004. The dark figure standing in the middle distance is co-author Kim Morris.

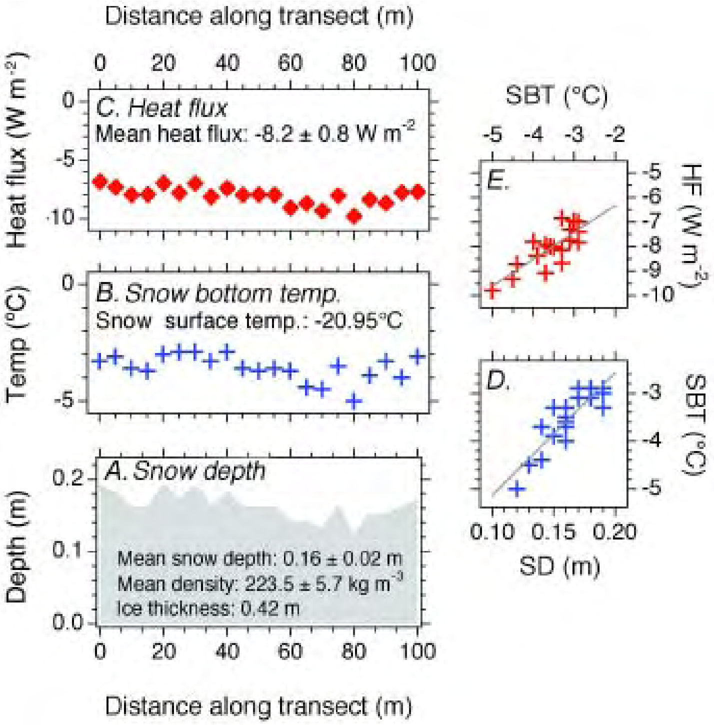

Figure 1. (Left) The graphs on the left side show measurements at 5 m intervals along the transect on the Horseshoe Lake ice, 4 December 2003: (a) snow depth, (b) temperature on the ice surface at the bottom of the snow, and (c) conductive heat flux.

The graphs on the right side show the dependence of (d) snow bottom temperature [SBT] on snow depth [SD], and (e) conductive heat flux [HF] on snow bottom temperature [SBT]. A negative conductive heat flux value indicates that the heat loss is upwards out of the snow to the atmosphere, and the more negative the value the higher the heat flux.

Horseshoe Lake is an oxbow lake *(Figure 2)* that formed when a meander in the Nenana River was cut off from the main channel. Located 1.55 miles (2.5 km) from and 200 ft (60 m) below the trailhead, the lake is a popular hiking destination in summer, but sees much less traffic in winter. Always snowy, occasionally icy due to mid-winter thaws and rain, and steep in places, the winter trail does not deter the intrepid young scientists from Tri-Valley School.

The Horseshoe Lake study site, like most ALISON study sites, consists of an ice thickness gauge and a 330 ft (100 m) long transect marked by 21 wooden stakes spaced 16.5 ft (5 m) apart. The study site is set up in early autumn once the ice is thick enough to support a party composed of Jeffries, Morris and volunteers from the National Park Service (NPS) and the Alaska Natural History Association (ANHA). After setting up the study site, we visit the school to meet the students and engage in a wide-ranging discussion about ALISON measurements, and snow and ice science.

Each time the students visit the site they measure the snow depth and the temperature on the ice surface at the base of the snow at each stake *(Figure 3)*. Using the same probe, they also measure the temperature at the top of the snow at the beginning and end of the transect, and then calculate the average of those two values. Snow samples of known depth are collected with a metal cylinder *(Figure 4)* at three different points along the transect, placed in plastic bags and returned to school to be weighed.

The snow depth and top/bottom temperature data are entered into a computer spreadsheet, which calculates the temperature gradient *(Figure 5)* at each of the 21 stakes. The temperature gradient describes the change in temperature over a change in snow depth. The spreadsheet also calculates the density *(Figure 5)* of the three snow samples from their depth and mass, and the cross-sectional area of the metal sampling cylinder. Finally, the spreadsheet converts the snow density to thermal conductivity *(Sturm et al., 1997)* and multiplies that by the temperature gradient to give the conductive heat flux (flow) *(Figure 5) (Sturm et al. 1998)* at each wooden stake.

Thermal conductivity is simply a measure of how well or how poorly a material conducts heat. For example, the mean density of the snow on 4 December 2003 *(Figure 1)*, 14 lbs/ft^3 (224 kg/m^3), corresponds to a thermal conductivity of 0.00355 BTU/inch hour °F (0.0737 Watts per meter Kelvin). This is very low compared to the ice (2.3 W/m·K) beneath the snow on Horseshoe Lake, or familiar materials in the vicinity of the DNPP Visitor Center; for example, plywood (0.13), asphalt (0.75), glass (1.05) and steel (46.0). Snow, then, with its low thermal conductivity, is a poor conductor of heat. Or, conversely, it is a good insulator. Thus, on 4 December 2003, the snow was acting as a good insulator, protecting the ice from the cold air above; hence the higher temperatures at the bottom than at the top of the snow *(Figure 1b)*.

The amount of heat that was being conducted through the snow cover on 4 December 2003 is shown in *Figure 1c*. The average conductive heat flux along the 330 ft (100 m) transect was -2.6 BTU/ft^2 hour (-8.2 W/m^2), but it varied almost linearly with the depth of snow, i.e., the deeper the snow, the lower the heat flow *(Figure 1e)*. This is because the temperature gradients in the deeper snow are not as high as those in the shallower snow, and lower temperature gradient values multiplied by the thermal conductivity give lower conductive heat flow. The conductive heat flow is important because it is the main source of heat transfer through the ice and snow in the winter, and dominates the surface energy balance. Consequently, the conductive heat flow is a key determinant of the bottom freezing rate and thus the ice thickness.

The Horseshoe Lake ice does not grow thicker by bottom freezing alone. The thickness can also increase by the addition of ice at the top. This is a consequence of the following sequence of events: (1) the mass of accumulating snow pushes the ice surface below the water surface; (2) water percolating upwards to the ice surface through fractures mixes with the snow to form slush; and (3) the slush freezes to form snow ice, sometimes also known as overflow ice. During Winterfest in late February 2005, we observed snow ice layers as much as 9.1 inches (0.23 m) thick, about 41% of the total ice thickness (22 in, 0.56 m).

The ice thickness is measured with a heated-wire gauge. This is nothing more than a simple electrical circuit frozen into the ice. The essential part of the circuit is a resistance wire of known length with a wooden handle at the top end and a metal weight (toggle) at the bottom end in the water below the ice. When a 12-volt battery is connected to the circuit, the resistance wire heats up (an example of Joule heating and Joule's Law in action), melts the ice around it, and the metal toggle can be raised and lowered using the wooden handle. With the toggle pulled up against the bottom of the ice, the length of resistance wire between the wooden handle and the ice surface is measured and subtracted from the total length of wire. The difference between the two lengths is the ice thickness. This ice gauge allows the ice thickness to be measured at the same location on many occasions with minimal disturbance to the ice and snow cover.

The data obtained by the Tri-Valley School students since autumn 2003 at Horseshoe Lake are illustrated in *Figure 6*. The students have visited their study site in a broad range of weather conditions, as illustrated by snow surface temperature values as high as 32°F (0°C) and as low as -5.8°F (-21°C). On one occasion, a student who complained about the cold was told by another student that "A true scientist never gets cold". While no wind speed data are available for the lake, the snow depth and density data tell us that it is a windy location. For example, the fluctuations in snow depth in 2003-4 and 2005-6 are due to wind erosion of the snow cover followed by further precipitation and

Photograph courtesy of Martin Jeffries

Figure 2: Looking south across the west arm of Horseshoe Lake on 14 November 2003. The Alaska Railroad passes along the top of the cliff in the distance.

Photograph courtesy of Dorothy DeBlauw

Figure 3: The snow depth is measured with a special probe. With a digital reader (on top of the probe) connected to a thermistor at the other end of the probe, the temperature on the ice surface at the bottom of the snow cover is measured.

Photograph courtesy of Tina Graham

Figure 4: Obtaining the density of the snow cover begins by taking a snow sample of known volume. For ALISON purposes this is done with a metal cylinder that is pushed through the entire snow thickness to the ice surface.

accumulation. The greatest wind erosion occurs towards the end of the sampling transect (55-100 m, Figure 1) near the cliff *(Figure 2)*.

Snow crystals deposited, or eroded and redeposited, under windy conditions are more tightly packed together and thus more dense than those that accumulate under calm conditions. Consequently, the snow on the Horseshoe Lake ice is invariably more dense than that at the Fairbanks ALISON site, for example, and sometimes as dense as that at the windiest ALISON sites — Barrow, Nome and Wales *(Jeffries and Morris 2006)*. Like all the ALISON sites, the conductive heat flow at Horseshoe Lake is on the same order of magnitude as that through the snow cover on sea ice in the Arctic and Antarctica *(Jeffries and Morris 2006)*. The data obtained at Horseshoe Lake, combined with those from all the other ALISON study sites, have revealed for the first time the magnitude of the conductive heat loss from frozen ponds and lakes, and their importance as winter heat sources.

The ice thickness data are not as complete as the other data sets because the ice thickness gauge has malfunctioned. This is unfortunate from a data collection perspective, but there is an educational silver lining: it demonstrates to the students that in science, as in life in general, things can and do go wrong. The failure of the ice gauges does not, however, reduce the value of the other data. As far as we are aware, the Tri-Valley School students are the first to make systematic snow and ice measurements at Horseshoe Lake. The students are contributing to the knowledge and understanding of the DNPP ecosystem. And the more winters that they visit the lake, the more valuable the data and the students' contribution to DNPP science.

But ALISON is not just about making measurements and obtaining data for scientific research purposes. The scientific research aspects of ALISON go hand in hand with science education. ALISON is a place-based, experiential learning opportunity for teachers and students, who are learning science by doing science. They are being field scientists *(Abbott and Swanson 2006)*, engaging in a fundamental scientific activity, i.e., making measurements. According to Abbott and Swanson *(2006)*, students participating in ALISON "… are learning the science behind the measurements through classroom and fieldwork activities." and "… experiencing scientific inquiry at its best …". Scientific inquiry is at the core of the National Science Education Standards *(NRC 1996)* and the Alaska Science Content and Performance Standards *(AKDEED 2005)*.

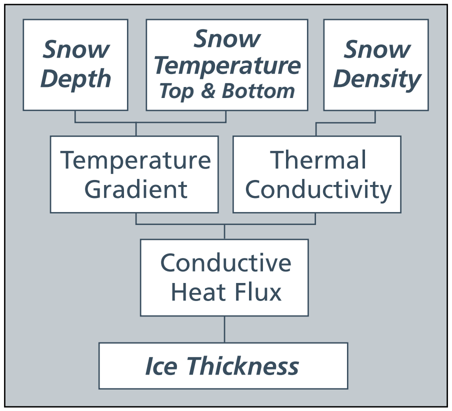

Figure 5: Flow diagram of measurements (italics) and derived data (normal type) obtained at an ALISON study site.

ALISON measurements are simple and easy for a wide age range of students to make and understand *(Abbott and Swanson 2006)*. They are measuring some aspects of abundant materials that are familiar to most, if not all, Alaskan students — snow and ice. Consequently, students understand the relevance of ALISON, are more likely to assume ownership of their study, and students who normally might not take much pride in their work become more involved and excited *(Abbott and Swanson 2006)*.

The Tri-Valley School students have certainly enjoyed making lake ice and snow measurements. They have given them a reason to learn, for example, some International System units, the modern metric system of measurement, and now they know the difference between the Celsius and Fahrenheit units of temperature. By visiting Horseshoe Lake as part of the study of a local ecosystem, the students have learned to observe, reason and predict. They have addressed questions such as "why does it rain rather than snow?", "how cold does the weather have to be for snow to fall?", "what types of plants and animals survive beneath the snow through the winter?", "which animals need snow for survival?", and "does lake ice differ from river ice?". The students have learned that science is fun and that it continues through the winter no matter what the weather.

The Tri-Valley School students are the youngest participants in ALISON. They have demonstrated that elementary school students are capable of doing good science in their own backyard that contributes, in this case, to a larger goal of increasing the knowledge and understanding of the variation of lake ice and snow characteristics and processes around the huge state that is Alaska. It is our hope that the Tri-Valley School students will be able to continue visiting Horseshoe Lake through at least spring 2009, and thus, along with ALISON students elsewhere in Alaska, be able to say that they were scientists during the International Polar Year of 2007-2009.

Acknowledgements

We thank Martha Tomeo (formerly of NPS) for encouraging discussions about having an ALISON site at Horseshoe Lake, David Tomeo (ANHA), and Phil Brease, Kristen Friesen, Pam Sousanes and Larissa Yocum (all NPS) for their assistance setting up the study site in the autumn, helping with class field trips during the winter, and retrieving equipment in the spring. ALISON has been supported

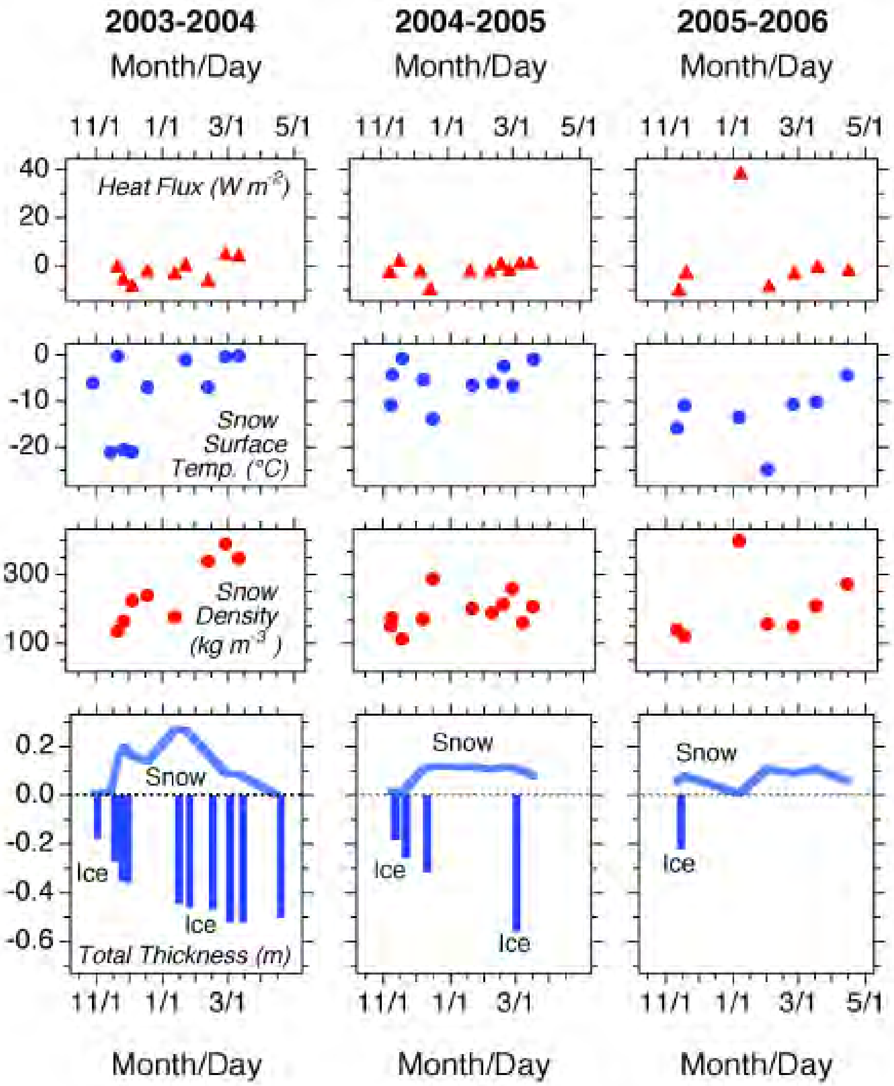

Figure 6: Average conductive heat flux through the snow (top/first row), average temperature at the snow surface (second row), average snow density (third row), and average snow depth and ice thickness (bottom row) at Horseshoe Lake during winters 2002-03 (left), 2004-05 (middle) and 2005-06 (right).

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WEB LINKS

ALISON: http://www.gi.alaska.edu/alison

International Polar Year:

- **International Programme Office: http://www.ipy.org**
- **U.S. Government: http://www.us-ipy.gov**
- **University of Alaska Fairbanks: http://www.uaf.edu/ipy**

Changes in the Abundance and Distribution of Trumpeter Swans in Denali National Park and Preserve, Alaska

by Carol McIntyre

U.S. Fish and Wildlife Service photograph

Figure 1. Trumpeter swans are the largest species of waterfowl in North America. The nestling swans, called cygnets, grow quickly during the summer on a rich diet of aquatic insects and plants.

(Left) Migrating trumpeter swans are common sights in Alaska's coastal wetlands around spring thaw and before fall freeze up.

Photograph courtesy of Robert A. Winfree

The Alaska National Interest Lands Conservation Act (ANILCA) of 1980 was landmark legislation. Along with creating many new federal conservation units in Alaska, it also added substantial acreage to existing national parks including Mt. McKinley National Park. With the passage of ANILCA, Mt. McKinley National Park became Denali National Park and Preserve and expanded in size from approximately two to six million acres. Included in the ANILCA additions were the rich boreal forest wetlands of the upper Kuskokwim River and the Minchumina Basin region. This mosaic of wetlands is one of the most productive ecosystems in Denali and the summer home to thousands of ducks, grebes, loons, swans, shorebirds, gulls, terns, and songbirds. The elegant trumpeter swan *(Cygnus buccinator)* is the largest, and perhaps most conspicuous, bird species in the area in summer. Hundreds of pairs of trumpeter swans, along with many non-breeding subadults, live in this region each summer.

Trumpeter swans were not always so numerous in this region, or across their North American Range. Early fur trade and European settlement of North America greatly reduced the numbers and distribution of trumpeter swans *(Mitchell 1994)*. In 1935, only 69 trumpeter swans were known to exist in the wild *(Mitchell 1994)*, but breeding populations in Alaska were not described until 1954 *(Monson 1956)*. Although the abundance of trumpeter swans has increased substantially since the early 1960s, the population has not returned to its original size or distribution across North America *(Mitchell 1994)*.

Natural History

Two species of swans occur in Alaska, the trumpeter swan and the tundra swan *(Cygnus columbianus)*. Trumpeter swans mostly summer in the south coastal and interior boreal forest and taiga habitats, while tundra swans summer mainly on the western and northern coastal tundra *(Conant et al. 2000)*. While both species occur in Denali, tundra swans generally migrate through the area in spring and autumn migration, and only the trumpeter swan nests in Denali.

The tundra swan has a goose-like, higher pitched call than the distinctive trumpet-like "oh-OH" call of the trumpeter swan. On closer inspection, there is a notable difference in the head and bill profile of each species. The tundra swan's bill is slightly dish-shaped or concave and is smaller in proportion to its smoothly rounded head. In contrast, the bill of the trumpeter appears heavy and somewhat wedge-shaped in proportion to its large angular head.

Trumpeter swans are one the largest species of waterfowl in the world, measuring at nearly 5 feet in length (1.5 m) with a wingspan of almost 7 feet (2 m). Males average about 28 pounds (12.7 kg) and


Photograph courtesy of Robert A. Winfree

The feathers on the head, neck, and lower body of trumpeter swans are often stained from feeding in iron-rich marshes. American wigeons, seen in front of this swan, often feed on the plant materials that are stirred up by the feeding activities of trumpeter swans.

females average about 22 pounds (10 kg).

Trumpeter swans in Alaska belong to the Pacific Coast Population. Traveling in flocks, trumpeter swans leave their wintering areas from mid- to late February and start their northward migrations. Trumpeter swans gather on ice-free lakes in central British Columbia and southern Yukon on their way north. One of the most important staging areas along the spring migration route is Marsh Lake, Yukon, where thousands of trumpeter swans, as well as tundra swan and many other waterfowl, stop to feed at Tagish Narrows and M'Clintock Bay.

Flocks of swans migrating across the deep blue spring skies of Denali are always a welcome sight. Trumpeter swans arrive on their Alaska breeding grounds from mid-April through early May, often when most lakes are still frozen. The nesting season for trumpeter swans, from nest building to the start of autumn migration, is one of the longest for birds in North America, and swans begin courtship and nest building activities immediately upon their return to Alaska.

Trumpeter swans generally build their nests in emergent vegetation away from shorelines *(Hansen et al. 1971)*, and they often renovate and reuse nests for many years. Although they are usually tolerant of other waterfowl nesting nearby, they can be quite aggressive towards mammals and float planes *(Hansen et al. 1971)*. The female lays from one to nine large eggs (length 4.33-4.92 in, 110-125 mm; width 2.75-3.19 in, 70-81 mm; and mass 9.91-14.46 oz, 281-410 grams) *(Mitchell 1994)*. The tiny cygnets hatch 32 to 37 days after egg-laying and mass at hatch range from 6.10-9.70 oz (173-275 g) *(Mitchell 1994)*. Cygnets grow rapidly over the summer, reaching masses ranging from 9.30-16.00 lb (4,222-7,264 g) when they are 90 days old *(Mitchell 1994)*.

The cygnets remain close to their parents during the summer and their parents lead them to feeding areas and protect them from predators *(Mitchell 1994; Figure 1)*. Nesting swans tend to be more successful at raising cygnets in areas with abundant invertebrate populations and/or macrophytes (aquatic plants) *(Mitchell 1994)*. Cygnets feed heavily on invertebrates in their first two weeks of life, but switch to vegetation primarily during the remainder of the summer. In contrast to their summer diet of submerged, floating, and emergent vegetation, trumpeter swans feed on pasture grasses, grains, and tuberous crops on their winter ranges *(Mitchell 1994)*.

The increase in the population size of trumpeter swans is often hailed as a success story, yet many questions remain about the future of trumpeter swans. Will populations of trumpeter swans continue to increase and will their distribution continue to expand across interior Alaska? How will global climate change affect nesting habitat and food supplies of trumpeter swans in Alaska?

Trumpeter swans are long-lived (32.5 years in captivity; 24 years in the wild) and often return to the same nesting areas for many years *(Mitchell 1994)*. Trumpeter swans do not usually obtain a mate until they are two to four years old. Once they obtain a mate, they may stay paired for many years.

Abundance of Trumpeter Swans in Alaska and Denali

The Migratory Bird Management Division of the U.S. Fish and Wildlife Service (FWS) is responsible for monitoring populations of trumpeter swans and other waterfowl species in Alaska. FWS biologists conducted the first statewide trumpeter swan census in Alaska in 1968 as part of an assessment of this species, which was listed as threatened under the Endangered Species Act of 1966 *(Conant et al. 1993)*. To determine the abundance of trumpeter swans in the remote and vast areas of Alaska, the FWS developed aerial survey methodologies that could be duplicated by competent observers to collect comparative data over time *(Hansen et al. 1971)*. This foresight paid off, as the same survey methodologies have been used by the FWS for conducting the statewide trumpeter swan census in Alaska ever since.

The 1968 FWS trumpeter swan census was a great success; the FWS biologists counted 2,848 trumpeter swans in the survey area, including 43 adults in the Denali region. The discovery of such a large number of trumpeter swans led to removing the trumpeter swan from the threatened species list *(Conant et al. 1993)*. Further, the 1968 census provided a solid baseline for measuring extension of range, population growth, and population dynamics of trumpeter swans in Alaska *(Hansen et al. 1971)*.

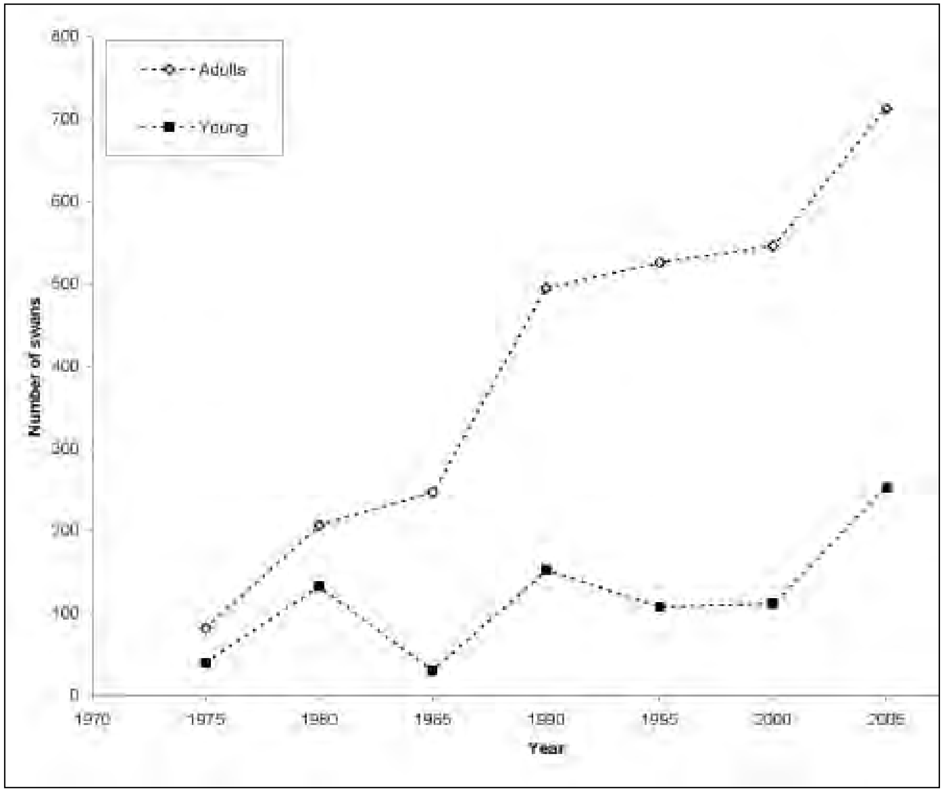

Figure 2. The abundance of trumpeter swans in the northwest region of Denali substantially increased between 1968 and 2005. Data are from U.S. Fish and Wildlife Service statewide trumpeter swan surveys.

FWS personnel have conducted a statewide trumpeter swan census every five years since 1975 across all trumpeter swan nesting habitat in Alaska. The number of trumpeter swans detected on the five-year census is striking, with an increase from 4,170 swans in 1975 to 23,692 swans in 2005 *(FWS, unpublished data)* and far exceeded the expectations of the FWS biologists that developed and implemented this program *(Hansen et al. 1971)*. While the numbers of swans has stabilized in some regions of Alaska, numbers continue to increase in interior Alaska as swans use previously unoccupied habitat *(Conant et al. 2000)*.

The numbers of trumpeter swans in Denali has increased along with the statewide population *(Figure 2)*. Over the last 30 years, trumpeter swans have dispersed across the vast wetlands in the northwest and are starting to use higher elevation ponds and lakes *(Figure 3)*.

The standardized FWS census data are an invaluable resource for biologists and land managers to document changes in the distribution and abundance of trumpeter swans across their range in many national parks and refuges. Ongoing research at the University of Alaska Fairbanks by Josh Schmidt and Mark Lindberg is yielding exciting results about the factors influencing the trends in population abundance of trumpeter swans in Alaska. This research, funded partially by the Alaska Department of Fish and Game, includes a detailed analysis of the long-term FWS trumpeter swan census data including: 1) estimating the spatial and temporal rates of population change and swan production rates; 2) describing the variation in size, elevation and latitude of water bodies used by breeding swans; 3) projecting maximum sustainable breeding populations for Alaska, and 5) providing recommendations for future swan surveys *(Schmidt and Lindberg 2005)*.

The Future of Trumpeter Swans in Alaska and Denali

While all three populations of North American trumpeter swan populations are increasing *(Caithamer 2001)*, biologists are still concerned about the future of this species. Trumpeter swans remain on the National Audubon Society and Audubon Alaska watchlists because they are vulnerable to disturbance and habitat alteration, and they are susceptible to lead poisoning.

Trumpeter swans from Alaska winter mainly in southeastern coastal Alaska, coastal and interior British Columbia, and western Washington *(Mitchell 1994)*, and biologists are concerned about conditions of their winter grounds *(King 1984)*. For instance, trumpeter swans wintering in northwestern Washington and southwestern British Columbia began dying off in large numbers from lead poisoning in December 1999, and the die-off continued through the winter of 2005-2006. The Trumpeter Swan Society called this the largest swan die-off from lead poisoning anywhere in North America. Although lead shot was banned for waterfowl hunting in Washington in 1986 and in Canada in 1999, decades of accumulated lead shot remains in trumpeter swan wintering habitat in the region (www.trumpeterswansociety.org). The swans inadvertently ingest spent shotgun pellets while feeding in areas where the pellets have accumulated and one or two ingested lead pellets can kill a swan. The Washington Department of Fish and Wildlife, the U.S. Fish and Wildlife Service, and the Canadian Wildlife Service are currently conducting research to identify areas of lead-shot contamination and develop a clean-up plan.

Although lead shot was banned for waterfowl hunting in Washington in 1986 and in Canada in 1999, decades of accumulated lead shot remains in trumpeter swan wintering habitat in the region.

On a local level, long-time NPS personnel are concerned that increased low-level aircraft traffic associated with flight seeing is displacing some nesting swans on the southside of the Alaska Range, particularly in the upper reaches of the Tokositna River *(Roger Robinson, NPS, personal communication)*. The FWS census data suggest that more trumpeter swans occurred in the upper reaches of the Tokositna River from 1975 to 1985 than from 1995 to 2005 *(Figure 4)*. Although other factors may be influencing the distribution of swans in this area, these observations suggest that more research is necessary to determine the response of trumpeter swans to low-flying aircraft in this and other areas in Denali and to develop mitigation measures.

The increase in the population size of trumpeter swans is often hailed as a success

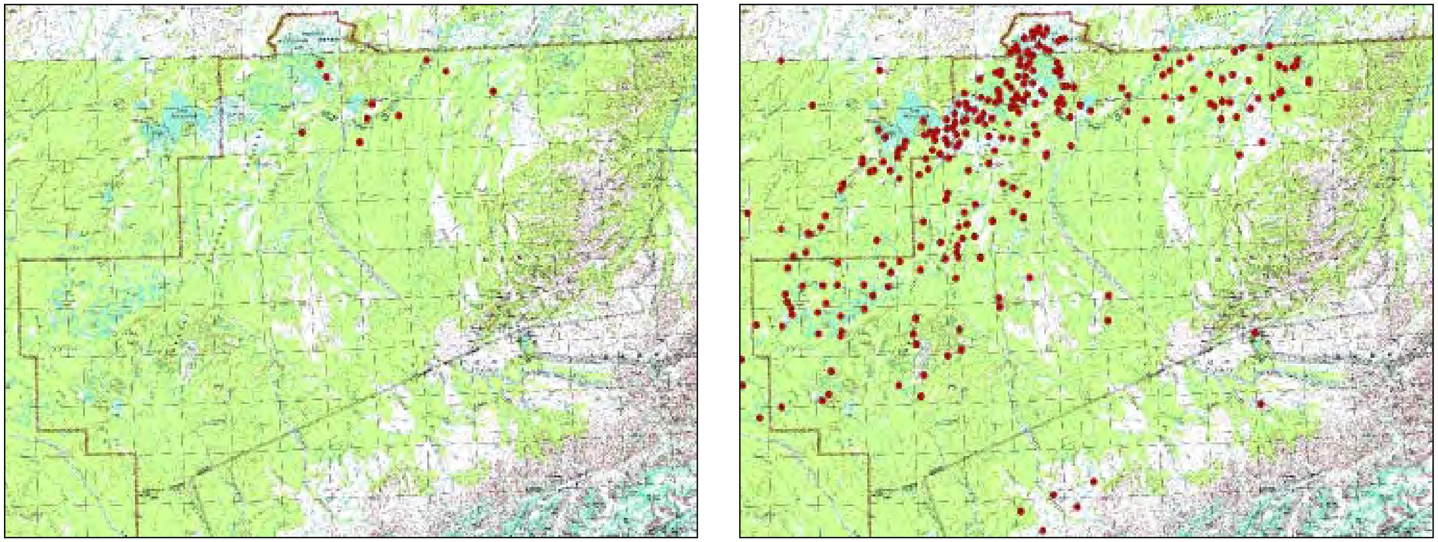

Figure 3. Distribution of trumpeter swans in the boreal forest wetlands in the northwest region of Denali in 1968 (left) and 2005 (right). Note trumpeter swans using higher elevation water bodies in 2005.

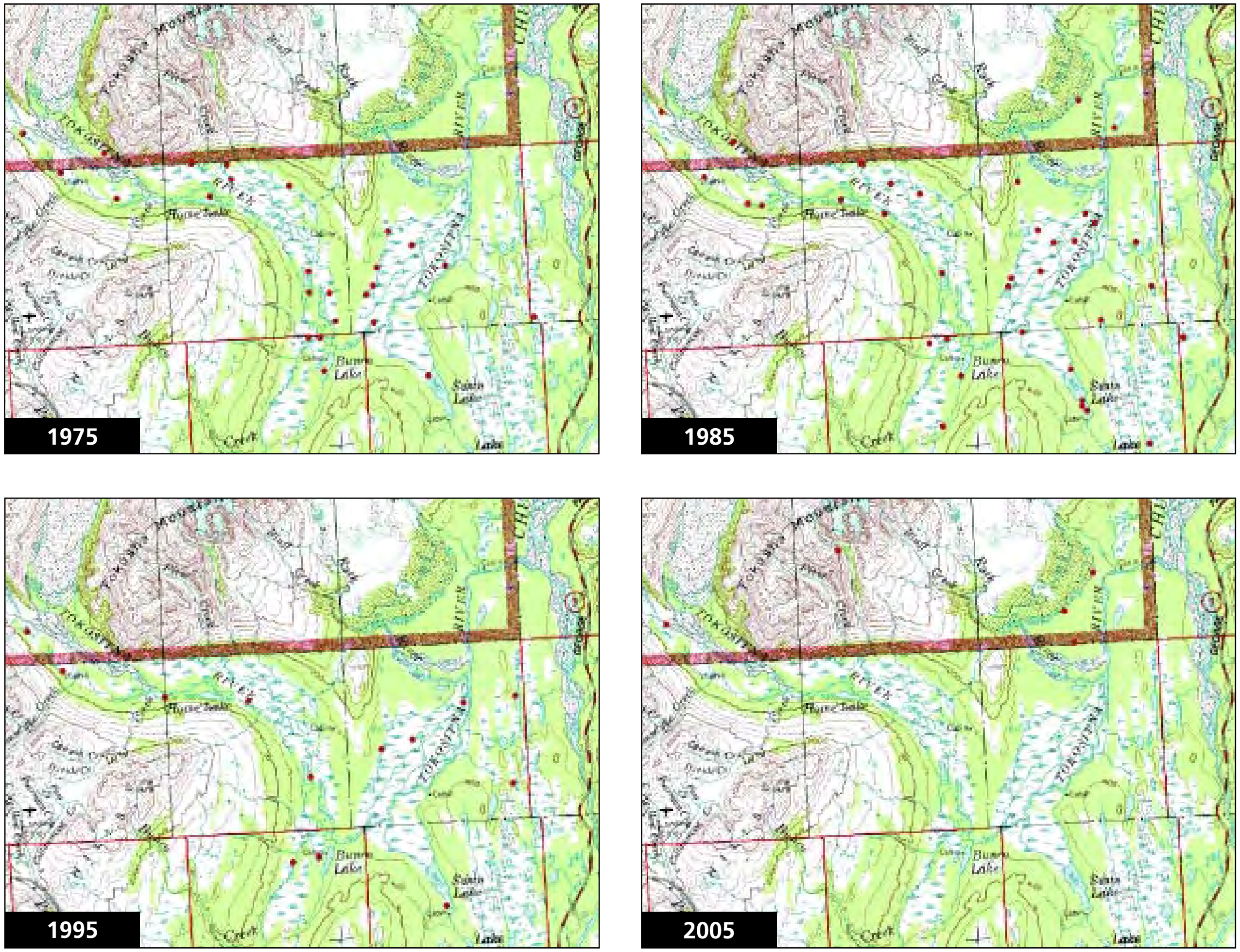

Figure 4. Spatial and temporal changes of trumpeter swan distribution in the upper Tokositna River, Denali National Park and Preserve, Alaska, 1975 to 2005.

story, yet many questions remain about the future of trumpeter swans. Will populations of trumpeter swans continue to increase and will their distribution continue to expand across interior Alaska? How will global climate change affect nesting habitat and food supplies of trumpeter swans in Alaska? And, how will changes on the winter range and along migration routes affect trumpeter swans in Alaska? The many changes on the wintering grounds and the potential changes that could occur along migration corridors and on summer grounds due to many factors including habitat alteration and global climate change certainly are all reasons that we need to remain vigilant about the management and conservation of this species.

To learn more about trumpeter swans in Denali visit: **http://www.nps.gov/dena/home/resources/Wildlife/birdweb/index/birdwatchTS.htm**

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Excavations at the Hungry Fox Archeological Site, Gates of the Arctic National Park and Preserve


National Park Service photograph

Figure 1. The excellent preservation conditions at the site are exemplified by this piece of split root cordage, and other delicate organic items such as wood shavings.

(Opposite page, clockwise from left)

Numerous ground slate tools such as this ulu were recovered from the site and are good archeological evidence for an Iñupiaq cultural affiliation.

View of the Hungry Fox site excavations in 2004.

Nearly a ton of fire cracked rock was excavated from Hungry Fox in 2004. These rocks were heated and used in cooking.

National Park Service photographs

by Jeff Rasic

Gates of the Arctic National Park, spanning the central portion of the Brooks Range in northern Alaska, is filled with remote river valleys that are hundreds of miles from the nearest city or highway, and where it is easy to imagine yourself as the first person to explore a side valley or climb a peak un-named on any map. Floating down one of these rivers in the early 1980s, a commercial river guide spotted a scatter of thousands of bleached animal bones strewn down a steep river bank. Even from a distance the patch of white would have seemed obvious and out-of-place to someone with a good eye, and it would have called for a closer look to anyone with an ounce of curiosity. The guide had both, and what he found were the remains of an important archeological site that would later be named Hungry Fox. What was to explain the presence of this apparently intensive occupation in this now uninhabited valley? How old was the site? Who lived here? What were they doing? When he reported the find to National Park Service (NPS) staff it began a two-decade effort to learn from the site, and to watch over it in the face of sporadic but relentless river erosion *(Spearman 1992, Devinney 2000, Sweeney 2000)*.

In 2004, NPS archeologists closed the last chapter on the site when they excavated its last remaining portion in response to a shift in the river's course that had begun rapidly eroding the bluff. The information that was rescued answered a number of questions that had been raised about the site over the years and yielded detailed information about fifteenth century Inupiat life in this portion of northern interior Alaska.

History of Investigation and Significance of the Hungry Fox Site

One of the things that made the Hungry Fox site interesting is the excellent preservation of organic materials like bone, antler, and even some wood. At most archeological sites in the region, bone and other organic materials have long ago decayed, and only stone tools and debris from their manufacture remain. While informative, the stone component of a site may compose less than 1% of all the artifacts and refuse that were once discarded, and as a result they provide only a limited picture of past activities. At Hungry Fox fragile bird and fish bones appeared as if they were from the previous summer rather than a previous century; an early visit to the site discovered a wood fishing float made of soft poplar wood; and later excavations uncovered split root cordage *(Figure 1)* and delicate, curved wood shavings left from making tool handles or a maybe a bow. Preservation like this stood to reveal a variety of insights about prehistoric diet, the seasons during which people made their residence, and the techniques they used to manufacture tools, process animals, and prepare food.

Another intriguing question raised at Hungry Fox concerned the cultural affiliation of its occupants. During a visit to the site in 1992, NPS Ranger Jon Peterson

(Clockwise from top left)

Figure 2. Example of a ceramic cooking pot fragment.

Figure 3. Close up of the cultural layer at Hungry Fox showing the dense layer of animal bone, charcoal, wood fragments, fire cracked rock and stone tool debris.

Figure 4. The bulk of material excavated from Hungry Fox consisted of animal bones, the food remains of the site's occupants.

Figure 5. Large stone slabs with roughly sharpened edges were tools used to smash bones to extract marrow and bone grease.

National Park Service photographs

Table 1. Animal Species Identified at Hungry Fox

Caribou	*Rangifer tarandus*
Sheep	*Ovis dalli*
Moose	*Alces alces*
Wolf or dog	*Canis* sp.
Willow ptarmigan	*Lagopus lagopus*
Raven	*Corvus corax*
Grayling	*Thymallus arcticus*
Arctic ground squirrel	*Spermophilus parryii*
Meadow vole	*Microtus pennsylvanicus*
Duck	*Anas* sp.

found a small, flaked-stone arrow point that archeologists refer to as the Kavik type *(Campbell 1968, Wilson 1978)*. Although the site was solidly within recent and centuries-old Nunamiut Eskimo territory, Kavik points were usually associated with Athapaskan archeological sites, known from areas much further to the east and south. Some researchers linked Kavik points to a specific Gwich'in Athapaskan group, the Di'haii *(Burch and Mishler 1995)*. The find was not entirely surprising since both Nunamiut and Gwich'in Athapaskan oral history recounted stories of a now-vanished Gwich'in tribe that had lived in the mountains of the central Brooks Range until a few centuries ago *(Burch and Mishler 1995, Hall 1969, Raboff 2001)*. The relationship between the Iñupiaq speaking Nunamiut, or Mountain Eskimo, and the Di'haii Gwich'in appears to have been complex, sometimes involving trade and cooperative hunting, other times a rotation of land use that maintained a healthy distance, and not infrequently, open hostility in the form of raiding and warfare. The find of a Kavik point at Hungry Fox hinted that the site might represent a Di'haii Gwich'in village from this dynamic era, or as some suggested, a Nunamiut encampment with evidence for trade or some other, less harmonious interaction with Gwich'in people. Whatever the explanation, few Kavik sites were known anywhere, and fewer still had been found this far west. So the site, if it was in fact Kavik, stood to provide information about this mysterious people *(Burch and Mishler 1995)*.

Careful not to remove the Kavik point from its position and risk losing its association with other artifacts or samples, Peterson photographed and sketched the point then left it in place so that it could be recorded precisely by an archeologist. Later that same summer, Grant Spearman, an archeologist and Nunamiut specialist from the Simon Paneak Museum in Anaktuvuk Pass, returned to the site for this purpose, but was unable to find the point. (It has never been relocated, presumably lost to the river or the pocket of a kayaker.) Spearman did, however, record important details about the site deposits *(1992)*, confirming the abundance of well preserved organic artifacts, and for the first time noting fragments of handmade clay pots *(Figure 2)*, and ground slate tools such as ulus. Such artifacts are commonly found in Iñupiaq sites from the last several hundred years, and their occurrence raised doubts about the simple explanation of Hungry Fox as a prehistoric Gwich'in or Kavik site. Spearman also collected a sample of charcoal that through radiocarbon dating established the age of the site at about 500 years ago, putting it solidly prior to European contact *(Table 2)*.

Archeologists and park rangers continued to make periodic site visits through the 1990s during the course of other projects in the area. The site remained stable, but enigmatic. The scattered nature of the eroded artifacts made it difficult to tell if the deposit accumulated over a long time from many episodes of use, or from fewer more intense occupations. Other pockets of artifacts were found along the bluff within a few hundred feet of the main concentration, and it was uncertain whether these artifacts represented portions of one large settlement or were from separate, unrelated occupations of the bluff. Researchers collected some artifacts and samples over the years, but these were small and dictated by whether they were in immediate danger of being lost to erosion, rather than their usefulness in studying some aspect of prehistoric life.

In 2000 a brief but systematic field effort defined the boundaries of the site by excavating a series of small test holes, and also set a permanent marker to measure the rate of erosion *(Sweeney 2000)*. The testing showed that the site did not extend much further inland, and that very little of the site deposits remained. Shortly afterwards, a gravel bar that shielded the Hungry Fox bluff from active river erosion shifted, and the current began to cut into base of the bluff and cause blocks of the intact site deposits to tumble into the river.

Excavations in 2004

A concentrated effort to rescue remaining information from Hungry Fox was conducted in July 2004. A team of Gates of the Arctic archeologists with the help of three volunteers spent two weeks working at the site. In all, 42 square meters were excavated, even though some of the excavating involved sweeping up slumped and out-of-context artifacts heaped at the base of the bluff. Despite this, a substantial portion of intact deposits were excavated in a controlled manner and yielded a large volume of samples and artifacts.

Once a broad exposure of the site was visible, it was clear that the artifacts occurred in a single, very dense layer that

Table 2. Radiocarbon Dates from the Hungry Fox Site

Lab Number	Measured C14 Age (BP)	Calibrated Calendar Age (AD)*	Comments
CAMS-114502	460±35	1423-1450	Worked (grooved and split) caribou antler collected in 2004
CAMS-114503	455±40	1419-1458	Worked (grooved, split and whittled) moose metatarsal collected in 2004
Beta-59590	530±80	1311-1445	Charcoal sample collected in 1992
Beta-59589	360±80	1453-1633	Charcoal sample collected in 1992
Beta-85825	420±60	1427-1618	Unidentified bone collected in 1992 or 1993

*IntCal 2004 calibration curve.

consisted almost entirely of refuse (e.g., bone, charcoal, heat fractured rock, stone tool debris) and lacked intervening lenses of naturally deposited sand *(Figure 3)*. This indicates that the site was never abandoned for long, if at all, and the deposit accumulated rather quickly, perhaps over the course of a few years. Excavations failed to uncover any remains of houses, fire hearths or storage pits. This fact, combined with the extremely dense accumulation of refuse, indicates that the site deposits are a midden, or trash dump. Middens typically occur at the periphery of a settlement and contain the detritus from occasional cleaning of house floors, and the bothersome debris from common areas. With such a small portion of the site preserved one can only guess at the size of the settlement, but the thick midden suggests it was at least of modest size, perhaps with housing for a few families.

Food Processing, Cooking and Diet

The bulk of material excavated from Hungry Fox consisted of animal bones, the food remains of the site's occupants *(Figure 4)*. Analysis of this large volume of material is ongoing, but an estimated 300,000 individual specimens were collected. Table 1 shows a fairly broad range of animals were used at Hungry Fox, including caribou, sheep, moose (a single specimen), fish (grayling and others), waterfowl (one or more duck species), birds (ptarmigan and raven), and small game (ground squirrel). Caribou bones are predominant and were presumably the mainstay of the diet.

The numerous bones in the midden might give the impression that game was plentiful, but animals were nonetheless used intensively. Many of the site's caribou bones have been purposely broken to obtain nutrient-rich marrow. We found several large stone slabs with sharpened edges *(Figure 5)*, and a handful of hammer stones, tools used to smash bones for this purpose. In addition, a large proportion of the bones were found as tiny, angular fragments that result from people pulverizing and then boiling them to obtain grease, a vital part of a diet based on lean, wild game. We also excavated nearly a ton (884 kg, 8000 pieces) of fire-charred and fragmented rock that was part of this process. These stones were heated in fires then placed directly in pots of liquid where they released heat for boiling.

The site contained a number of cooking pot fragments, which were thick, fairly soft, and lack decoration. They are not poorly made, but rather minimalist and utilitarian. Small feather imprints remain preserved in the fired clay and show that small, downy feathers were used for temper. Occasionally a potter's fingerprint is also frozen in time on the surface of a sherd.

Hungry Fox also contained a large number of ground slate ulus and ulu fragments. These tools were knives used by women primarily to slice meat and fish. They are one of the best indicators at Hungry Fox for the cultural affiliation of the site's occupants, since ulus and other ground slate tools are a hallmark of Iñupiaq Eskimo sites, yet are absent from Kavik sites.

Hunting

The animal bones at the site clearly indicate that hunting was an important activity conducted by people based at Hungry Fox, but there are surprisingly few tools directly indicative of hunting in the midden. Hunting tools that were found, however, include stone projectile points *(Figure 6)*, and antler arrow points *(Figure 7)*. Both are of a style typical of late prehistoric and historic period Iñupiaq sites and compare well with artifacts recovered from Iñupiaq sites on the Kobuk River, the vicinity of Barrow and across northern Alaska *(Ford 1959, Giddings 1952, Hall 1971, Murdoch 1892)*. We also recovered two examples of blunt antler arrowheads used to hunt birds and small game.

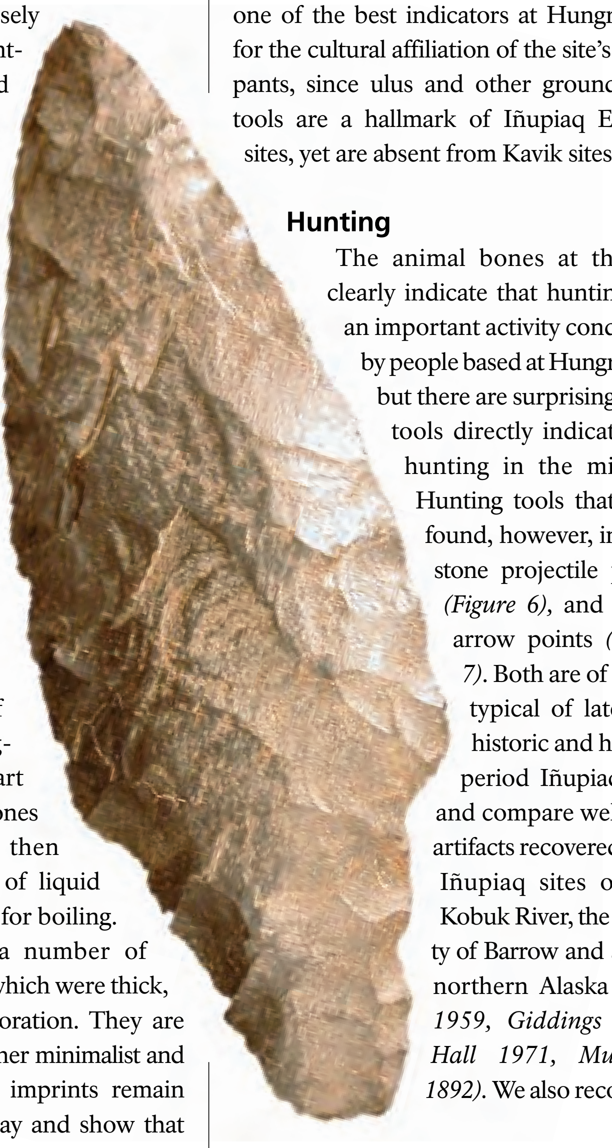

Figure 6. A stemmed arrow point made of chert, one of several excavated from the site. Length is 1.8 in (4.5 cm).

National Park Service photograph

Tool and Clothing Manufacture

A detailed study of the stone tool assemblage was completed for the artifacts excavated in 2004, which included 1,310 pieces of flaking debris, 69 flaked stone cores and tools, and 608 ground slate and jade tools. The analysis showed that people procured small nodules of a glassy stone called chert from nearby stream gravels, which was shaped to produce simple flake knives as well as nicely crafted arrow points. The analysis also indicates that people were very conservative with their use of chert raw materials, which is curious to see in the Brooks Range where there are abundant sources of high quality stone raw materials. Evidence for this stingy use of chert is seen in the use of a technique called bipolar reduction, in which small chert pebbles were placed on a stone anvil and smashed with a stone hammer. The technique allowed even the smallest pieces of stone to be used to make usable flakes for cutting and scraping tasks. This conservative use of chert may indicate that occupation of the site spanned the winter months, during which access to stream pebbles would have been limited by frozen ground and snow cover.

Eleven fragments of ground jade tools were found in the site and these were likely detached from adzes. Jade (or jadeite) comes from sources on the upper Kobuk River and is a typical element of late prehistoric Iñupiaq technology. Adzes made of this tough stone were used for woodworking. They were laborious to produce and probably highly valued tools, so it is no surprise that only small fragments broken from bit ends are found in the Hungry Fox midden.

Ornamental and Other Items

Some of the more intriguing finds were a few bone and amber beads *(Figure 8)*, and a single teardrop-shaped slate pendant with a drilled hole *(Figure 12)*. Used as charms or amulets or to decorate clothing and tools, these small items were probably lost on house floors and inadvertently discarded during cleaning. The presence of amber suggests wide trade networks or wide ranging travels since the known sources of amber are confined to the Arctic coast near Barrow and places on the Kobuk River some 75-100 miles to the west.

A number of carved, incised or otherwise shaped pieces of bone and antler were collected *(Figure 9)*. Many of these consist of items that were either broken before they were completed, or broken in use but are too small to determine an exact function.

Summary

So far our studies have shown that a fairly substantial Iñupiaq settlement once existed in a place that today seems remote and unpopulated. Recently all that remained of the settlement was the trailing edge of its trash dump, but even that provided some rich information. Given the midden's contents the settlement probably once consisted of a few or maybe several houses, and was occupied for a considerable portion of the year. People ranged from the camp to pursue caribou, they climbed the nearby hills to track sheep, and fished in the

Figure 7. Antler arrow point fragments. The length of the artifact on the far left is 2.0 in (5.2 cm).

National Park Service photograph

National Park Service photograph

Figure 8. A drilled bone bead from Hungry Fox. A few amber beads were also found.

National Park Service photograph

Figure 9. A number of carved, incised or otherwise shaped pieces of bone and antler were collected. This is a piece of grooved or incised bone with an unknown function.

National Park Service photograph

National Park Service photograph

Figure 11. Auger tests were used to determine the extent of the archeological deposits inland from the bluff edge.

(Left) Figure 10. View of the Hungry Fox site showing eroded artifacts at the base of the bluff and intact deposits held precariously together in blocks near the top of the bluff.

streams and lakes. They trapped ground squirrels and harvested waterfowl. Back in camp a intense effort was made to derive sustenance from these animals—meat was partitioned, parts likely shared between families, and bones were processed to capture every ounce of fat.

The idea that the Hungry Fox site represents a Di'haii Gwich'in or Kavik occupation can now be placed in a midden itself. Evidence points clearly to a single, relatively brief period of Iñupiaq Eskimo occupation. The original report of a Kavik point remains neither confirmed or disproved, but no other Kavik points or artifacts were found in subsequent studies. A possible explanation for the original Kavik point report is that the point was instead a damaged or repaired Iñupiaq stemmed point, which could appear similar to a stemmed Kavik point. Typical Iñupiaq traits at Hungry Fox include ground slate and jade tools, specific forms of antler and stone arrow points, pottery, and amber beads.

Large scale archeological excavations, particularly by land management agencies like the NPS, are rare since they consume a non-renewable resource. However, careful, judicious use of this tool has important benefits. Even if the Hungry Fox site had not been threatened, limited sampling of the site could just as well have been justified. William Lipe *(1996)*, a noted scholar on the topic of cultural resource management, makes a good point when he says that excavating only threatened sites "has the unintended effect of trivializing archeological research and its contributions." It suggests that the meandering of a river or the widening of a road are better justifications for archeological work than is learning about the past, sharing this knowledge with the public, or inspiring students. Excavation is one of the smallest threats to archeological sites and when done right, the benefits are clear. Some modest benefits have already accrued from work at Hungry Fox, and ongoing studies and analyses will hopefully continue this pattern.

Acknowledgements

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National Park Service photograph

Figure 12. A drilled and ground slate artifact, perhaps a pendant. Length is 1.9 in (4.7 cm).

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Going for the Gold in Kantishna

by Ann Kain and Phil Brease

In 1903, very little was known about the Mount McKinley region when Judge James Wickersham made the first attempt to climb Mount McKinley. Although unsuccessful in reaching the summit of Mount McKinley, Wickersham played a pivotal role in the mining history of the area. He found a little gold in Chitsia Creek in the northern Kantishna Hills and staked four claims. Alaska, having experienced both major and minor gold rushes for the previous twenty years, was primed and the news of Wickersham's discovery spread. By 1904 numerous prospectors were picking and panning the creeks draining the Kantishna Hills.

The Kantishna stampede was the result of relatively simultaneous gold discoveries by Joe Dalton on Eureka Creek and Joe Quigley on Glacier Creek. News of these discoveries in June of 1905 brought thousands of prospectors into the area. Towns such as Diamond, Glacier City, and Roosevelt were quickly established as supply points along the northern river routes used by the stampeders to reach the gold fields of the Kantishna Hills. In very short order, most of the creeks in the Kantishna Hills were staked from beginning to end *(Capps 1918)*.

By the fall of 1905, Eureka, on Moose Creek at the mouth of Eureka Creek, became the hub of the district. Numerous stores in Eureka supplied the local miners, and a restaurant which commanded $4.50 a day for board alone was a successful enterprise *(Prindle 1907)*. In addition to the commercial establishments, a few cabins and about 20 tents were located in Eureka *(Sheldon 1930)*. In December 1905 a post office was established, officially changing the name of the community to Kantishna *(Dickerson 1989, Orth 1967)*. A permanent land recording office was established in 1909, with Bill Lloyd, a local miner, serving as the first commissioner of Kantishna. In 1919-20, C. Herbert Wilson became Kantishna's commissioner, constructing the Kantishna roadhouse as a residence for his family *(Brown 1991)*. Over the years, the building became a focal point of the community, serving as the post office, the commissioner's office, and a place for travelers and others to spend the night. The historic Kantishna Roadhouse still stands on its original site.

Placer gold (gold washed from creek gravels) was found in many of the creeks throughout the district, but before long all those who rushed into Kantishna realized that the only areas which were showing a profit were the placer gold claims on Eureka and Glacier Creeks, most of which were held by Dalton and Quigley. As fast as it grew, Kantishna's population diminished during the spring of 1906. Kantishna survived the population decrease because those who remained in the area, Joe Dalton and Joe and Fannie Quigley, continued to turn a profit. They stayed for most of the rest of their lives. Glacier City also survived for several more years, owing to its location as a transportation point and lumber resources. However, the other communities soon faded from existence.

During the early years of placer gold mining in Kantishna, annual gold production fluctuated between $20,000 and $30,000 from several creeks, including Moose, Eureka, Glacier, Caribou, Glen,


NPS Photograph, Denali National Park and Preserve Museum Collection

Large scale placer mining on Moose Creek near the townsite of Kantishna, 1983

(Left) Townsite of Kantishna and hydraulic placer mining on Moose Creek, 1922

U.S. Geological Survey, P.S. Smith Collection #1404


National Park Service, Denali National Park and Preserve

Banjo Mill, 1987

and Friday Creeks *(Brooks and Martin 1921)*. Placer miners, with pick and shovel, used the open-cut method, groundsluicing the upper gravel layer, then shoveling the lower layer, down to bedrock, into sluice boxes. Using automatic dams, the miners collected a large amount of water, which when released, enabled them to groundsluice a large area in a short amount of time. The remoteness of the region, as well as the relatively narrow drainages of the gold bearing creeks, dictated the use of simple mining methods. Supplies and equipment had to be barged on the rivers from Fairbanks or Nenana and then hauled overland using sleds or wagons. Transportation difficulties and lack of space to operate large equipment in the narrow creek drainages prohibited the use of hydraulic and mechanized mining methods and restricted mining to shallow deposits.

Placer gold was primary to the mining activity, but was not the only mineral found in quantity. Gold lodes, mineral found in veins in bedrock, were not plentiful in the district, but other mineral lode mines were discovered as a result of the quest for gold lodes. The Quigleys were responsible for much of the exploration and development of both gold and other ore deposits, including galena and stibnite, which contain lead and antimony. Lode mining of these ores, as well as silver, zinc, and copper occurred throughout the district. Profitable quantities of antimony, used in hardening lead (mainly for munitions and as an alloy for other metals), were found on Stampede, Slate and Caribou Creeks, while lead-silver deposits were located on the ridge between Eureka and Friday Creeks.

Although Quigley was the dominant mining figure in Kantishna, several others played a significant role in the district. Miners William Taylor, Pete Anderson, Charles McGonagall, and Tom Lloyd are probably better known for the 1910 Sourdough Expedition, the first successful ascent of Mount McKinley's north peak, than they are for mining. However, these men lived and mined in the Kantishna District for the better part of their lives.

Transportation of equipment into Kantishna and shipments of ore out of the district played a crucial role in the success or failure of mining ventures. Over and over again transportation expenses had a major impact on the district. During the first years of mining, access to the district was from the north traveling the Yukon River to the Tanana River to the Kantishna River. At the community of Roosevelt on the Kantishna River a rather crude overland corduroy road, constructed using logs as a base with dirt over the top, extended to the southeast for approximately thirty miles to Glacier City and into the Kantishna Mining District. Naturally, the rivers were only navigable in summer at which time the road was a virtual quagmire. Consequently, equipment and ore had to be shipped over the road in the winter requiring the stockpiling of goods in the fall at Roosevelt, waiting for the road to freeze.

In 1917 Congress created Mount McKinley National Park encompassing an area to the south and east of the mining district. By the early 1920s, the Alaska Railroad (ARR) was completed from Seward to Fairbanks skirting the eastern boundary of the park. A winter sled road from Kobe to the east at the Nenana River on the railroad provided an alternate route for shipping, but did not solve the transportation problems for the district; this road, too, became a swamp during the summer months.

By the early 1920s gold production was on the decline. Even so, large scale hydraulic placer mines were beginning to operate in some areas, where drainage width allowed. Two companies set up hydraulic operations on the wider drainages of Moose, Caribou, and Glacier Creeks. The Kantishna Hydraulic Company constructed a twelve thousand foot long ditch system, including dams and piping, to bring water from Wonder Lake to Moose Creek, just above Eureka Creek. Along the banks of Moose Creek in the Eureka/Kantishna settlement five hydraulic giants were used to strip the gravel and run it through the sluice boxes *(Bundtzen 1978)*. Although the Kantishna Hydraulic Company developed a rather extensive operation on Moose Creek, the amount of gold recovered was not nearly as much as anticipated. The mining enterprise was soon scaled back, but it did continue for a few years.

Mount McKinley Gold Placer Company, Incorporated, began setting up hydraulic operations on Caribou Creek in 1920. As with the Kantishna Hydraulic Company on Moose Creek, an extensive ditch and flume system was associated with this mining venture. In 1922 the mine was in full operation, but the high investment in equipment, wages, and transportation soon took its toll. The amount of gold recovered was not nearly enough to offset the high costs, and the operation was suspended in 1923. The Mount McKinley Gold Placer Co. also held claims on Glacier Creek but there is no evidence that any work occurred on this creek during that time period *(Buzzell 1989)*.

In the mid-1920s the mining activity in Kantishna was in serious decline. In 1925 only thirteen miners were successfully producing gold *(Bundtzen 1978)*. Dalton, the Quigleys, and a few others remained, despite the decline.

Mining in the Kantishna area continued to decline until the mid-1930s. Two events occurred that helped bring about an increase in production of both gold and the various ores from the lode mines. In 1934 President Roosevelt raised the price of gold to $35.00 an ounce, making gold mining much more profitable. In 1938 the Alaska Road Commission (ARC) finally completed the road from the ARR at McKinley Park Station to the Kantishna Mining District, greatly diminishing the transportation problems and making Kantishna accessible year round. Mining in Kantishna began to change once again as it moved into a boom period. Several mills were constructed to process the ores from lode mines, and placer mining moved into a new phase with the introduction of new equipment. As a result, over the next few years, the Kantishna District produced more gold, both lode and placer, than at any earlier time *(Buzzell 1989)*.

Federal Order L-208 directed the closure of gold mining operations as a non-essential wartime industry. All the larger placer and lode operations in Kantishna closed, with only a few small operators continuing to work during the war years.

In the 1930s the Carrington Company of Fairbanks, also known as Caribou Mines, leased claims on Caribou Creek from William Taylor and began placer mining using a dry-land dredge which had a trommel screen, sand elevator, belt stackers, and recovery tables. A dragline fed the gold-bearing gravel into the dredge *(Bundtzen 1978)*. The Carrington Mines operated three seasons on Caribou Creek, from 1939-41, and became the most productive placer-gold mining operation in the history of the Kantishna District. U.S. Geological Survey geologist Edward Cobb wrote in 1973 that the total gold production on Caribou Creek in 1940 was 4,000 ounces, most of which came from the Carrington Mines *(Cobb 1973)*.

By the late 1930s and early 1940s the mining industry in the Kantishna Hills was prospering. The Banjo Mill of the Red Top Mining Company was milling and shipping tons of gold ore, and the Carrington Company was mining a large section of Caribou Creek with the drag-line system. At a time when gold mining in the McKinley region was thriving, World War II shut down the industry as a whole. Federal Order L-208 directed the closure of gold mining operations as a non-essential wartime industry. All the larger placer and lode operations in Kantishna closed, with only a few small operators continuing to work during the war years.

The end of the war brought renewed interest in mining, but at much lower levels than before the war. The Carrington mine on Caribou Creek reopened in 1946 and continued as the largest gold producing operation until 1948, when they leased the equipment to the Glacier Creek Mining Company for use on Glacier Creek. However, in 1949 both Carrington and the Glacier Creek Mining Company closed down; the gold on both creeks had been depleted.

For the first 40 years of mining (1905-45) in the McKinley region, mining methods changed very little. However, after World War II, the bulldozer became a very important piece of mining equipment, not only in Kantishna, but industry-wide. Some of the small one- or two-man placer operations, Johnny Busia on Moose Creek for instance, continued using the simple pick and shovel techniques and the hydraulic equipment; but the bigger operations turned to the bulldozer-hydraulic combination, increasing efficiency and productivity.

Throughout the 1950s and 1960s and into the 1970s, placer mining continued in the heart of Kantishna, but there were no major strikes. Most of the claims were worked with heavy equipment such as bulldozers and front end loaders.

With the passage of Alaska National Interest Lands Conservation Act (ANILCA) in 1980, Kantishna became part of Denali National Park and Preserve. There were over 400 patented and unpatented mining claims in the ANILCA additions. While not all of these claims were actively mined, there was still substantial mining activity occurring. Section 202(3) of ANILCA directed the Alaska Land Use Council, in cooperation with the Secretary of the Interior, to conduct a study to evaluate the resources of the Kantishna Hills and Dunkle Mine areas. Information compiled for this study was to include mineral potential, estimated cost of acquiring the mining properties, and the environmental impacts of mineral development. ANILCA permitted mining to continue during the study period, subject to regulation.

In 1985, the Park Service was directed to do a Environmental Impact Study of mining. The final report, issued in 1990, recommended that the NPS acquire all patented and valid unpatented mining claims in the park. This, of course, would be a long drawn-out process involving validity exams, land appraisals, and more lawsuits filed by miners. Today this process still is not complete, but the vast majority of the claims are now Park Service property.

Denali National Park and Preserve Museum Collection, DENA 16-1.6

Joe Quigley, Johnny Busia, and Fannie Quigley observe hydraulic placer mining on Moose Creek, 1922

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National Park Service photographs

2006 Alaska Park Science Symposium

Park Science in Central Alaska: Crossing Boundaries in a Changing Environment

The 2006 Alaska Park Science Symposium was held at Denali National Park and Preserve, September 12-14, 2006. This 3-day symposium was the second in what is planned to be a biennial series of scientific conferences that are place-based, in that the symposia focus on specific national parks in Alaska, drawing scientists from many disciplines who conduct science in these areas. The focus of the 2006 symposium was on Denali, Wrangell-St. Elias, and Yukon-Charley Rivers, and the adjacent lands and waters of central Alaska and western Yukon.

Approximately 300 people were in attendance, including 200 scientists, managers, and agency staff, and 100 students and local community members. The symposium organizers made concerted efforts to bring together diverse audiences, and to provide opportunities for dialog among scientists, resource managers, decision makers, educators, students, local residents, the Alaska Native community, and the First Nation/Yukon community.

2006 ALASKA PARK
SCIENCE
Symposium

During all three days of the symposium, leading biological, physical, cultural, and social scientists shared their research through presentations or posters. Distance learning technologies were utilized to broadcast live to the Murie Science and Learning Center and to other locations. Cultural program elements facilitated recognition of subsistence lifestyles and traditional ecological knowledge. Symposium opportunities included viewing new documentary films about the focus parks and meeting authors of new books. Workshops, special planning groups, training sessions, and field trips were offered immediately before and after the symposium.

Summary papers from the symposium will be peer reviewed and published. The next symposium will be held in 2008.

2006 Alaska Region Science Strategy

The National Park Service-Alaska Region recently released a multi-disciplinary science strategy designed to meet the intention of the 1998 National Parks Omnibus Management Act for implementing proactive scientific investigations. It is intended to support planning for resource management challenges over the next 10 to 50 years. The strategy identifies major challenges we face in Alaska, in terms of science, information needs and organizational structure.

The strategy's overarching vision and desired end is to support an adaptive management approach to identify the sustainable balance between preservation and park use. The way to achieve the vision is shaped by three strategy objectives:

1) increase the amount and quality of scientific research in parks,
2) enhance interdisciplinary data integration, and
3) expand the use of science in decision-making.

The third section of the strategy, the implementation plan, offers suggestions to align existing NPS assets to achieve these goals. The plan provides guidance that is not contingent upon new funding sources, but rather focuses on existing sources.

The strategy was developed cooperatively with the US Environmental Protection Agency and with support from the National Park Foundation. A copy of the Science Strategy can be found at: **www.nps.gov/alaska/strategy.pdf**

Alaska Park Science

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http://www.nps.gov/akso/AKParkScience/index.htm

Photograph courtesy of Robert A. Winfree