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Cover: Reconstruction of a duck-billed dinosaur. See story page 5. NPS illustration by Kathy Lepley.

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Right: A carbonized upright fossil tree stump associated with the fossil footprints found in the Chignik Formation of Aniakchak National Monument. See story page 5. Photograph courtesy of Anthony Fiorillo.

Photograph courtesy of Anthony Fiorillo

Figure 1. Coastal exposure of the Chignik Formation in Aniakchak National Monument.

Photograph courtesy of Anthony Fiorillo

Figure 2. Three-toed track attributable to a duck-billed dinosaur.

Left: View of lower Ukak Falls. The rocks in the foreground represent an ancient delta complex within the Naknek Formation.

Photograph courtesy of Anthony Fiorillo

New Frontiers, Old Fossils: Recent Dinosaur Discoveries in Alaska National Parks

by Anthony R. Fiorillo, Russell Kucinski, and Troy R. Hamon

Introduction

Alaska is well known for its rugged geologic beauty and plentiful biological wonders. The National Park Service administers approximately 54 million acres of land in Alaska that includes some of the most fossiliferous rocks in the state. Recognizing that much still needs to be learned about the fossil resources in parks, the Alaska Region of the National Park Service has partnered with the Dallas Museum of Natural History, the University of Alaska Museum of the North, and other institutions to develop a better understanding of paleontology in several Alaska parks.

Initial results suggest that a wealth of basic paleontological information is still to be gathered in Alaska parks *(Fiorillo et al. 2004, Fiorillo and Parrish 2004)*. Arguably, with respect to the public's interest, the most significant finds in the Alaska national parks have been the discovery of dinosaur remains in two parks: Aniakchak National Monument and Preserve and Katmai National Park and Preserve. Here we highlight those discoveries that are requiring scientists to reevaluate their conclusions about dinosaurs in Alaska during the Jurassic and Cretaceous periods.

Aniakchak National Monument and Preserve

Aniakchak National Monument and Preserve, approximately 600,000 acres, is one of the most remote, and thus least visited, parks in the National Park System. The park was established in 1980 because of the volcanic features in the region, the most notable of which is the 6-mile (10 km) wide Aniakchak Caldera, a 2,000 feet (600 m) deep circular feature that is the result of the collapse of a magma chamber. In addition to the prominent volcanic features of the park, there are sedimentary rocks ranging in age from the Late Jurassic Naknek Formation to the Eocene Tolstoi Formation *(Detterman et al. 1981, Wilson et al. 1999)*, representing a period of time from approximately 150–45 million years ago. Of these sedimentary rock units, the Upper Cretaceous Chignik Formation contains the first record of dinosaurs of any kind found in national parks in Alaska.

Alaska contains many geologic terranes that appear to have originated elsewhere and traveled by various movements of tectonic plates to their present locations. Paleomagnetic analysis of the Upper Cretaceous and Lower Tertiary rocks of Aniakchak, however, suggests that the Chignik Formation was formed at approximately its current latitude *(Hillhouse and Coe 1994)*.

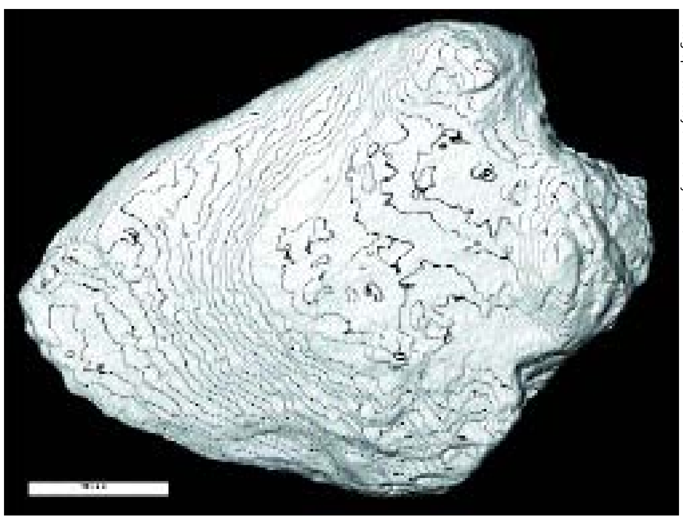
The Chignik Formation was named by Atwood *(1911)* for rocks exposed in the vicinity of Chignik Bay, southwest of what is now Aniakchak National Monument. The rock unit is a cyclic sequence of rocks representing predominately shallow to nearshore marine environments in the lower part and predominately continental environments in the upper part of the section *(Figure 1)*.

The age of the Chignik Formation, based on the occurrence of particular fossil

Photograph courtesy of Anthony Fiorillo

…fossil tracks, along with the more well-known dinosaur discoveries on the Colville River of northern Alaska, document the existence of an extensive high-latitude terrestrial ecosystem capable of supporting large-bodied herbivores.

Such an ecosystem stretched for hundreds of miles over a region roughly composed of present day Alaska and supported non-migrating herds of hadrosaurs.



Photograph courtesy of Anthony Fiorillo

Figure 3a. Above Left: Slab of Chignik Formation containing one footprint and two handprints of a duck-billed dinosaur.

Figure 3b. Left: Contour of a cast of the footprint shown in Figure 3a. Notice the three toes and the elongated heel. The elongated heel is attributed to a sliding motion of the foot during the initial footfall.

Figure 4. Opposite Page: Reconstruction of a duck-billed dinosaur.

marine bivalves, ammonites, and plant fossils, is considered to be late Campanian to early Maastrichtian *(Detterman et al. 1996, Fiorillo and Parrish 2004)* or roughly 77–68 million years old. The age of this sequence is approximately the same age as some of the better known dinosaur locations along the Colville River of northern Alaska *(Fiorillo and Parrish 2004)*.

Cretaceous dinosaurs, reported for the first time from southwestern Alaska in Aniakchak as a set of footprints and handprints *(Figures 2 and 3)*, are attributable to a duck-billed dinosaur called a hadrosaur *(Figure 4) (Fiorillo 2004, Fiorillo and Parrish 2004)*. Fortuitously, these tracks are preserved in association with fossil leaf litter that includes several leaves with feeding trails of herbivorous insects and a standing forest Therefore, several facets of an ancient terrestrial ecosystem are preserved in this one exposure of the Chignik Formation in the monument. The Chignik Formation occurs throughout a large portion of the monument and more survey work will likely yield additional insight into this ancient ecosystem.

Because most of Alaska was near its present latitude or higher during the later Cretaceous period, perhaps the most significant contribution is that the fossil tracks, along with the more well-known dinosaur discoveries on the Colville River of northern Alaska, document the existence of an extensive high-latitude terrestrial ecosystem capable of supporting large-bodied herbivores. Such an ecosystem stretched for hundreds of miles over a region roughly composed of present day Alaska and supported non-migrating herds of hadrosaurs

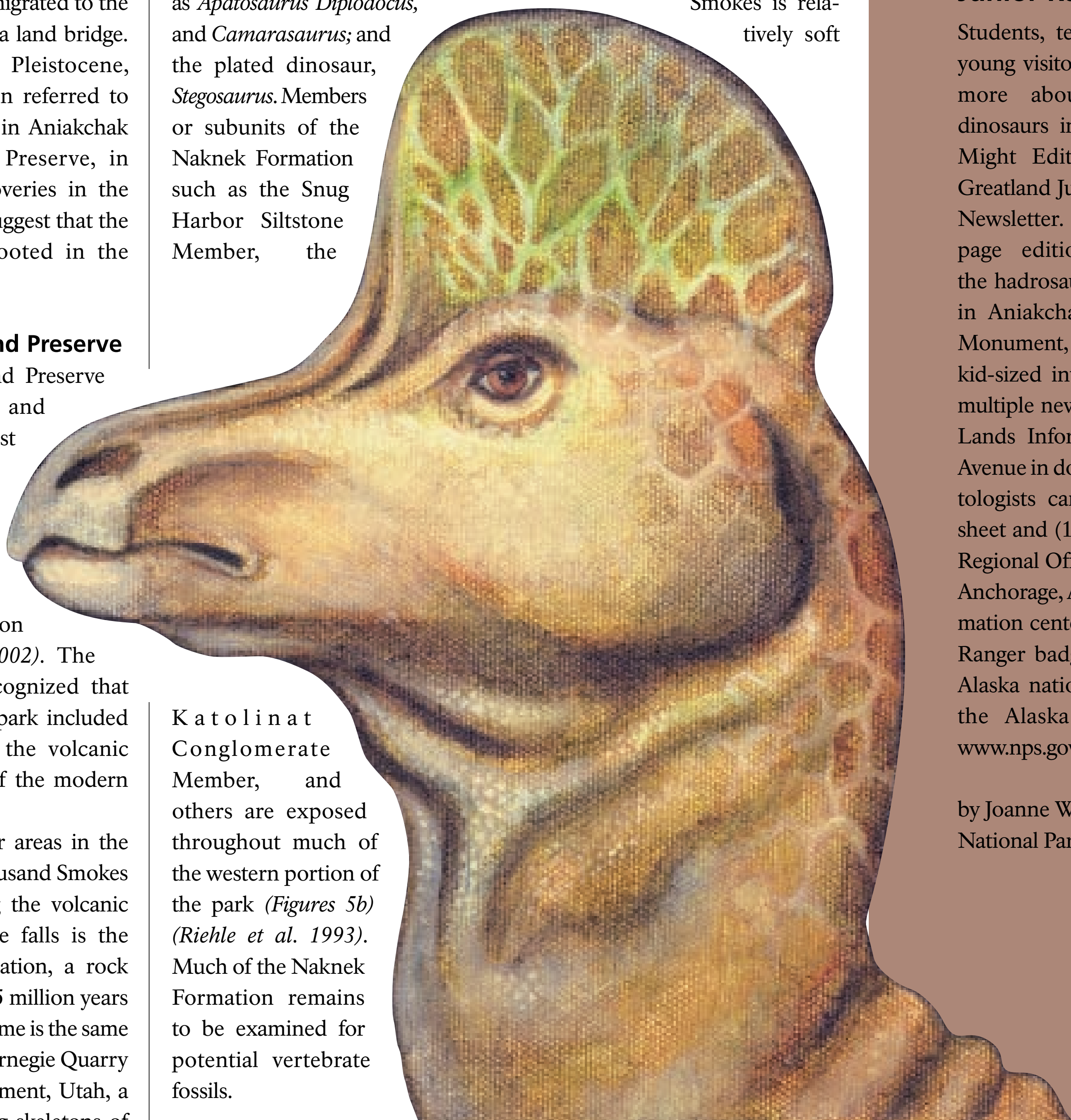
(Fiorillo and Gangloff 2001).

Most of the dinosaur groups in North America during the Cretaceous appear to have originated in Asia and migrated to the American continents across a land bridge. In the much more recent Pleistocene, such a land bridge has been referred to as Beringia. The footprints in Aniakchak National Monument and Preserve, in conjunction with the discoveries in the northern part of the state, suggest that the antiquity of Beringia is rooted in the Cretaceous *(Fiorillo 2004).*

Katmai National Park and Preserve

Katmai National Park and Preserve was established in 1918 and expanded four times, the most recent in 1980. It is one of the oldest national parks in Alaska. The proclamation of this unit as a national monument was based on the enormous 1912 eruption of Novarupta *(Adleman 2002).* The subsequent expansions recognized that important resources of the park included not only those related to the volcanic activity, but also elements of the modern flora and fauna.

One of the more popular areas in the park is the Valley of Ten Thousand Smokes and Ukak Falls. Underlying the volcanic ash and exposed along the falls is the Jurassic-aged Naknek Formation, a rock unit spanning about 155−145 million years ago *(Figure 5a).* This slice of time is the same as that represented by the Carnegie Quarry in Dinosaur National Monument, Utah, a quarry famous for producing skeletons of dinosaurs such as the predator *Allosaurus;* sauropods (a subgroup of the saurischian, or 'lizard-hipped', dinosaurs) such as *Apatosaurus Diplodocus,* and *Camarasaurus;* and the plated dinosaur, *Stegosaurus.* Members or subunits of the Naknek Formation such as the Snug Harbor Siltstone Member, the Katolinat Conglomerate Member, and others are exposed throughout much of the western portion of the park *(Figures 5b) (Riehle et al. 1993).* Much of the Naknek Formation remains to be examined for potential vertebrate fossils.



NPS illustration by Kathy Lepley

Whereas the Naknek Formation underlying the Valley of Ten Thousand Smokes is relatively soft

Dinosaurs Live On in the Greatland Junior Ranger Newsletter!

Students, teachers, and young visitors can learn more about Alaska's dinosaurs in the Dino-Might Edition of the Greatland Junior Ranger Newsletter. This eight-page edition features the hadrosaur discovery in Aniakchak National Monument, including a kid-sized interview with Tony Fiorillo. Single or multiple newsletters are available at Alaska Public Lands Information Center at 605 West Fourth Avenue in downtown Anchorage. Budding paleontologists can complete the newsletter's activity sheet and (1) mail it to Traci Parrish at the Alaska Regional Office, 240 West 5th Avenue, Room 114, Anchorage, AK 99501 or (2) drop it off at the information center to receive a certificate and a Junior Ranger badge. A teacher's unit on dinosaurs in Alaska national parks will soon be available on the Alaska Region curriculum web site at www.nps.gov/akso/ParkWise.

by Joanne Welch, Urban Education Program, National Park Service

Photograph courtesy of Anthony Fiorillo

Figure 5a. View of the Valley of 10,000 Smokes showing the 1912 eruption ash overlying the Jurassic aged Naknek Formation. The gray rocks by the river are the Naknek Formation.

Photograph courtesy of Anthony Fiorillo

Figure 5b. Mt. Katolinat, a prominent geographic feature in Katmai National Park, is composed of the Naknek Formation.

and easily worn away, the falls are extant because the river flows over a harder sandstone unit that was an ancient delta. This delta was fed by ancient streams and rivers that carried various types of fossil plant debris *(Figure 6)*. This fossil plant debris can be seen exposed in the rocks along Ukak Falls.

An additional fossil found in the ancient delta was a large bone fragment, which was a cobble in an ancient stream bottom *(Figure 7)*. Analysis of the bone fragment suggests it is from a dinosaur because of its robust nature, but it is so badly worn further identification is unobtainable. Indeed, in many contexts this bone fragment might have been considered insignificant because of the limited information it can offer. However, this fragment is the first occurrence of a Jurassic dinosaur bone in the entire state of Alaska. This insignificant-looking bone fragment shows that detailed attention to the Jurassic rocks of Alaska will likely produce additional insights into the dinosaurs of that time.

Summary

Fossils are the starting point for understanding life in the past. They provide the means for determining long-term patterns of evolution. They also provide the means for examining how ancient organisms may have interacted among themselves within a community. Arguably, the most popular of all fossils are those of dinosaurs.

Two national parks in Alaska have now provided records of dinosaurs. One such find, the Cretaceous dinosaurs of Aniakchak National Monument and Preserve, offer further insight into ancient high latitude ecosystems as well as the antiquity of Beringia. The other dinosaur find, the single Jurassic bone fragment in Katmai National Park and Preserve, shows that the relatively unstudied Jurassic period also has great potential for contributing to our understanding of dinosaurs in North America. Given the abundance of important fossil-bearing rocks in these and other parks, there are likely many more exciting dinosaur discoveries waiting throughout the Alaska Region of the National Park Service.

Photograph courtesy of Anthony Fiorillo

Figure 6. Carbonized plant debris found in the ancient delta complex at Ukak Falls.

Photograph courtesy of Anthony Fiorillo

Figure 7. Fossil bone cobble found in the same delta complex at Ukak Falls.

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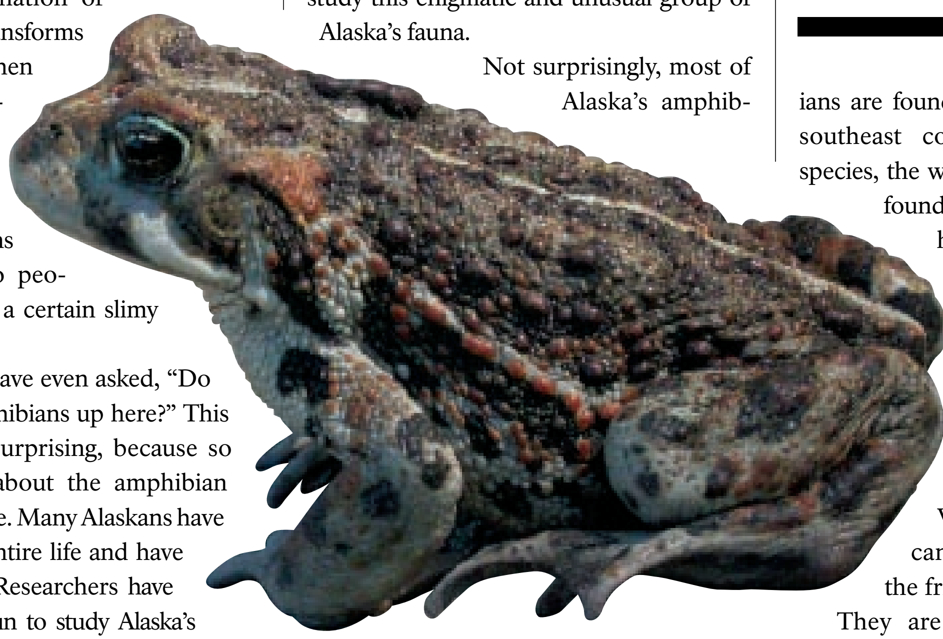
Glacier Toads and Frozen Frogs: Alaska’s Surprising Amphibian Diversity

by **Blain Anderson**

Whenever I mention that I am working on an amphibian study, people’s eyes light up and many smile. Some tell me a story, recalling the first frog they caught in a pond one summer in their youth. Others share their fascination of how a tiny egg transforms into a tadpole, then into a little hopping toad in just a few weeks. Regardless of the reason, amphibians are interesting to people: they all have a certain slimy mystique.

Some people have even asked, “Do we have any amphibians up here?” This question is not surprising, because so little is known about the amphibian species in this state. Many Alaskans have lived here their entire life and have never seen one. Researchers have only recently begun to study Alaska’s frogs, toads, newts, and salamanders. Very little work has been done to date to assess population trends, distribution, and threats *(MacDonald 2003)*. On the bright side, this is changing, as a small but growing group of herpetologists, biologists, geneticists, toxicologists, and naturalists begin to study this enigmatic and unusual group of Alaska’s fauna.



Not surprisingly, most of Alaska’s amphibians are found in the warmer and wetter southeast coastal rainforest, but one species, the wood frog *(Rana sylvatica)*, is found throughout the interior and high above the Arctic Circle in the Brooks Range. This hardy species produces an abundance of glucose, which acts as an antifreeze in its blood and tissues to survive the frigid winters *(Storey and Storey 1992)*. Western toads *(Bufo boreas)*, can tolerate a swim through the frigid saltwater in Glacier Bay. They are regularly found in areas

aOur amphibians live in some very inhospitable habitats. Wood frogs, in particular, are nothing short of amazing. It is astonishing to find frogs above the Arctic Circle…

Left: Earlier this spring, Klondike Gold Rush National Historical Park temporarily fenced off this western toad breeding pond in the Dyea Townsite area that was being used by off-road vehicles.

National Park Service photograph

Right: Western toads *(Bufo boreas),* also known as boreal toads, were found in some very marginal habitats in both the Dyea area and in Glacier Bay. This toad was spotted near Gustavus on a road between the woods and a flooded gravel pit.

National Park Service photograph

National Park Service photograph

As a first step, 250 sets of field-worthy flashcards were printed and distributed to employees and volunteers, to be used as an identification aid. This western toad *(Bufo boreas)* was found by Håken Såtvedt, a helicopter pilot, while working for the I&M Landcover Program in Glacier Bay.

that, until very recently, were covered by glaciers *(Taylor 1983)*. Rough-skinned newts *(Taricha granulosa)* are one of the most toxic creatures on the planet. Ingesting a single individual can kill a full-sized adult human. Individuals of this species have lived 10–20 years, and in their natural habitat travel long distances through the forest to lay their eggs in their natal pond *(Hodge 1976, Stebbins 1995)*.

Amphibians are, indeed, very interesting. But they may be in trouble. Even in Alaska.

Opportunistic Amphibian Inventory

In April 2000, at the Biological Inventory Scoping Meeting held in Anchorage, the National Park Service (NPS) identified amphibians as a taxonomic group to inventory. At that time, few species of amphibians had been confirmed for Alaska's national parks and most were listed as "probably present" by the NPS *(Lenz et al. 2001)*.

Because basic information on species distribution, population status, and habitat requirements was significantly inadequate, staff from the National Parks in southeast Alaska chose to develop an opportunistic inventory to learn about their amphibian species. This project recorded observations reported by field staff and volunteers, and was re-designed to track sightings in all of the national parks in Alaska through the Inventory and Monitoring Program, for the years 2001–03 *(Sharman and Furbish 2000)*.

The first step of this inventory project was to research the amphibian species in Alaska, and to create a set of 'flashcards' to aid species identification in the field. Observation field forms were sent to field staff, researchers, volunteers, and others who might encounter amphibians in the parks. Finally, a tracking database was built to house information on the submitted field forms.

As a direct result of the inventory, five of the six native species of Alaska amphibians were documented in, or near, national parks. By far, the majority of observations came from southeast Alaska: Glacier Bay National Park and Preserve (n = 40) and Klondike Gold Rush National Historical Park (n = 24). In total, 79 observations were recorded by 40 observers *(Anderson 2004)*.

A few sites had more than one individual, and a couple of ponds had hundreds of tadpoles. Observers encountered and documented approximately 1,600 individual amphibians in three years at 65 different sites throughout ten of the 16 national park units in Alaska. The opportunistic inventory project also led to the extension of the known geographic ranges of wood frogs, western toads, rough-skinned newts, and northwestern salamanders *(Ambystoma gracile)*.

The inventory confirmed the presence of wood frogs in Katmai National Park and Preserve, Lake Clark National Park and Preserve, Yukon-Charley Rivers National Preserve, Kobuk Valley National Park, and Gates of the Arctic National Park and Preserve. Interestingly, wood frogs have been documented numerous times in the upper and lower Kobuk River drainage, but have not been found to the north in the Noatak River or its tributaries.

National Park Service photograph

Tiny western toadlets *(Bufo boreas)* emerge from ponds in late July to September and must find food and shelter for the winter.

National Park Service photograph

Another surprising find was a rough-skinned newt *(Taricha granulosa)* off the coast of Sitka on Rockwell Island. Though outside of Sitka National Historical Park, this newt extends the known range of the species and has led to speculation by researchers that this population may have been transplanted, possibly by Alaska Natives.

Columbia spotted frogs (Rana luteiventris) were a surprising addition to this project. Several were located by hikers on the Canadian side of Chilkoot Pass.

National Park Service photograph

Additionally, Columbia spotted frogs *(Rana luteiventris)* were encountered nearby, but not in, Klondike Gold Rush National Historical Park.

Unexpected Sightings

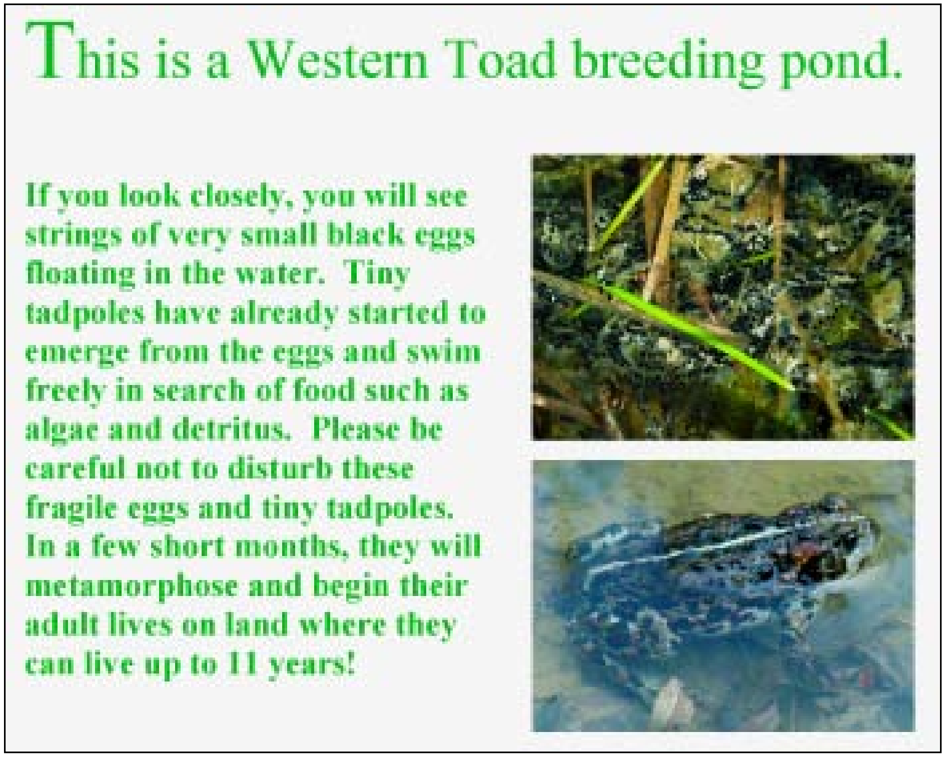
Of note, Glacier Bay's first observation of a northwestern salamander was reported in 2000 on the outer coast in Graves Harbor. This area of the park was probably spared from the last glacial advance and is one of few areas in the park described by researchers as "glacial refugia" *(Manley and Kaufman 2002)*. Northern Chichagof Island, near Pelican, is the nearest known verified location of this species *(MacDonald 2003)*.

Another species, the Columbia spotted frog, was reported from the Canadian side of the Chilkoot Trail, within 5 miles (8 km) of the borders of Klondike Gold Rush National Historical Park.

Western toads were observed in the marine intertidal area of Glacier Bay in several locations throughout the bay. This species was surprisingly abundant in recently de-glaciated areas that have been free of ice for 30–100 years *(American Geographical Society 1966)*. Characteristically, these areas offer little in the way of vegetative cover or other resources for survival. How toads utilize this habitat remains undocumented.

Additionally, a single observation of two wood frogs was submitted from the Tatshenshini River, 12.5 miles (20 km) upstream of Dry Bay, just upriver from Glacier Bay National Park and Preserve.

In another notable find for southeastern parks, an NPS volunteer came across a single rough-skinned newt on tiny Rockwell Island in Sitka Sound. Interestingly, no species record exists from the nearby Baranof Island *(Whitman 2004)*. Rockwell Island is not previously known to have this species and lies one kilometer from Sitka National Historical Park. Researchers have speculated that this population of newts, and those of nearby islands, may have been transplanted, perhaps long ago, by Alaska Native peoples. The Tlingit, Haida, and other peoples of the Pacific Northwest have many amphibians in their legends, and one group, the frog house of the Raven moiety, uses frog symbology for its cultural traditions and identity *(Post 2004)*.



Sign, explaining the temporary closure of a breeding pond.

As a part of this inventory project, 58 specimens were identified in the holdings of the University of Alaska Museum of the North, which had been collected in national parks in Alaska. This holding is a small but significant collection and could be a resource for further research into genetics, phenology, biodiversity, and other studies *(Arctos Database 2003)*.

Are Western Toads Declining?

Probably the most important tangential information discovered during this project were the comments and observations received from the public. Long-term residents reported a significant decline from the 1970s to today in the once abundant western toad populations in the Gustavus and Skagway areas. These reports suggest that something in the local areas may be causing the decline.

One plausible theory is that localized drying of wetlands is affecting toad numbers. Post-glacial rebound, which happens after the weight of the glaciers is removed from the landscape, may be exacerbating this situation *(Sharman 2002)*. Much of the land surrounding Glacier Bay is rebounding upward approximately 0.8 inches (2 cm) per year *(Larsen et al. 2003)*. The land sheds water as it rises, thus reducing available aquatic habitat.

Basic inventories like this one provide valuable baseline information for longer term ecological monitoring. This project was a useful first step toward understanding the poorly known distribution of amphibians in Alaska's national parks. More research on Alaska's amphibians, including long-term monitoring, may be warranted since this group of animals may serve as possible indicators of our parks' ecological health. Only through additional study can we better understand the roles of amphibians in the ecosystem, their spatial distribution, habitat requirements, population trends, and the possible causes of these trends.

Yes — Alaska does have amphibians

The answer to the question "Are there any amphibians in Alaska?" is a resounding Yes! We do have amphibians in the state, and, in fact, we have six native species. This is certainly a small number compared to the tropics, or even British Columbia, but Alaska can honestly claim amphibian biodiversity.

Our amphibians live in some very inhospitable habitats. Wood frogs, in particular, are nothing short of amazing. It is astonishing to find frogs above the Arctic Circle in a place where, in the summer, temperatures may be as hot as 90°F (32°C) and the winter temperature can drop to -70°F (-57°C). Also remarkable are western toads, glacial pioneers, living and swimming in the newly exposed landscapes of Glacier Bay.

Unfortunately, at least three non-native species new to the state have been recently introduced to lakes and ponds near Juneau, Pelican, Ketchikan, and Palmer. Often these releases are unwanted pets. These releases, though well-meaning, can spread diseases and the newcomers can often out-compete native species for food and shelter. Non-native species may also become a pest in short order, as has happened elsewhere *(MacDonald 2003)*. Fortunately, no introduced species have been found in Alaska's national parks to date.

Recently, researchers from across the state met in Juneau at the first Conference on Amphibians of Alaska. Although many topics were discussed, it became clear to the participants that the state is beginning to see many of the same unexplained declines and problems that have been documented in amphibian populations worldwide. Many commented that there is much to do before we can understand how these threats are affecting our amphibians.

At this conference, Richard Carstensen of Discovery Southeast suggested that the reason people can relate to amphibians might be because they are one of the few animals that we can actually catch. Who can resist holding a frog? Especially in the proximity of a squealing youngster, if only to prove there's nothing to fear.

Yes, frogs are interesting, mysterious, and fun. In Alaska, though, we are just beginning to get acquainted with ours.

…the reason people can relate to amphibians might be because they are one of the few animals that we can actually catch.

Acknowledgments

The author wishes to thank Sara Wesser, National Park Service, Inventory and Monitoring Program; Deborah Rudis, U.S. Fish and Wildlife Service; Nancy Deschu; and Monique Anderson for timely review and helpful comments on this article. Funding for this project came from the Inventory and Monitoring Program, Southeast Alaska Network, Chiska Derr – Network Coordinator, Lewis Sharman – former Network Lead.

More information on Alaska's interesting amphibians, and the final report for this project, can be found at http://www.nature.nps.gov/im/units/AKRO/Amphibians/ak_amphibs.htm.

Wood frogs (Rana sylvatica) were found near large lakes and rivers at several parks. The abundance of sightings near lakes and rivers may be due to thermal "lake effects" that keep the areas warm longer than surrounding areas, or because the areas are more accessible to potential observers.

National Park Service photograph

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Near Left: Nick Tanape of Nanwalek has many roles in his community — master qayaq builder, cultural messenger, hunter, fisherman, and father to name a few. He is an invaluable role model for the Suqpiat people.

Photograph courtesy of Ronald T. Stanek

Far Left: The village of Nanwalek in 1898

Albatross Collection, National Archives

Suqpiat of the Lower Kenai Peninsula Coast

by Ronald T. Stanek

Nanwalek and Port Graham are two small mostly Alaska Native communities of 165 people and 255 people respectively, located at the southwestern tip of the Kenai Peninsula at the mouth of the Cook Inlet. In 1995, the National Park Service contracted with the Alaska Department of Fish and Game, Division of Subsistence to provide an ethnographic overview and assessment for Port Graham and Nanwalek *(Stanek 1998)*. The focus of this project was the Native cultural history of the outer Kenai Peninsula. Current residents of these two communities have ancestors who lived in former communities along the outer Kenai Peninsula coast, and they continue using the bordering waters and lands in Kenai Fjords National Park. The ethnographic overview and a subsequent Minerals Management Service contract report *(Stanek 2000)* provide first-hand accounts of people who lived along the outer Kenai Peninsula coast in the late 1800s and early 1900s and give detailed descriptions of traditional and contemporary life.

Research Methods

The primary objective of the project was to record the knowledge of many living residents who had ancestral ties to areas in the park. Information on the ancestral background of Nanwalek and Port Graham residents was best gained by asking people about their family histories. This was done through oral interviews and recordings. Oral histories of deceased individuals were also a source of information, through audiotapes that were available from family members and archives. Although some published documents provided descriptions of community histories, very few gave detailed backgrounds of individual families.

Other sources of information included written accounts and journals of early explorers and workers in Russian and American trade companies, and early Russian Orthodox Church records. Archives and libraries contained historical documents and photographs related to the area. Scientific reports and government documents provided valuable statistical information for the study.

Unegkurmiut of the Kenai Peninsula Coast

Sufficient differences occurred between languages of the Alutiiq living on Kodiak Island and the Alaska Peninsula (Koniag Alutiiq) and the Alutiiq of the Kenai Peninsula and Prince William Sound (Chugach Alutiiq) for linguists to identify two distinct dialects. Ethnographers in the 1930s documented at least eight social groupings of Chugach Alutiiq Natives that occupied Prince William Sound at the time of contact with Russian traders. A ninth group, known as the Unegkurmiut, lived along the outer coast of the lower Kenai Peninsula *(Figure 1)*.

Orthographic variations occurred between the Alutiiq of Nanwalek and Port Graham and other Chugach Alutiiq in Prince William Sound communities. Although Sugcestun speakers from the latter two areas understand each other, there are recognizable differences in many words. Exactly how this variation resulted is not clear; however, tracing the ancestry of families in Nanwalek and Port Graham has provided some understanding.

The first European contact with the Unegkurmiut occurred sometime in the late 1780s by Russian fur traders. The accounts of Captain James Cook's travel to the area in 1786 include reference to lower Cook Inlet Natives, as do the journals of Captains Billings and Saryschev in 1790 during their expedition to the northwest coast. The naturalist, Carl Merck, described the Native inhabitants encountered as he sailed into lower Cook Inlet. Later in 1794, Captain George Vancouver's expedition sailed just outside Port Dick and also described Natives they encountered.

Describing past Unegkurmiut life is a work in progress pursued by anthropologists, archeologists, and Native descendants. Information from archeological studies along the outer coast coupled with traditional knowledge and cultural practices found in Nanwalek and Port Graham today, provide a basis for describing much of Unegkurmiut way of life in the contact and proto-contact period.

Nanwalek elders born in the early 1900s used many of the same technologies

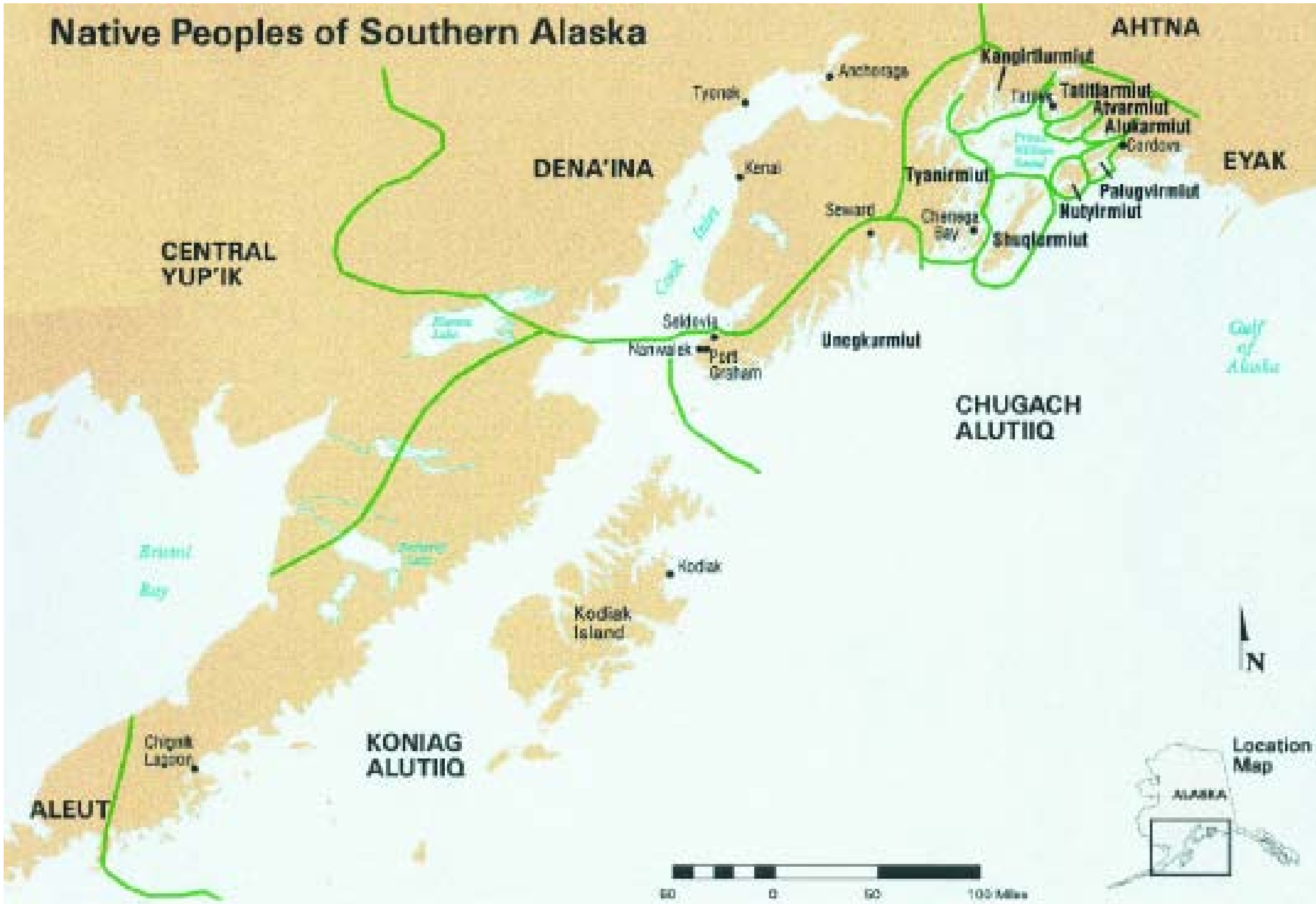


Figure 1. Map showing the locations of the Chugach Alutiiq and the Koniag Alutiiq in southcentral Alaska.

of their parents and grandparents. Spears, traps, weirs *(Figure 2),* hooks, watercraft, and techniques of resource harvest and preservation of earlier times were described and recorded. Some elders continued use of traditional spears, hooks, and weirs into the 1950s, at which time laws prohibited their usage. Western technologies for fishing were introduced and made the legal means of harvest. But one Nanwalek elder continued to use a certain type of spear *(Figure 3)* for catching salmon and preferred that method to the rod and reel or hook and line in the 1940s and 1950s. Preservation of foods through drying, smoking, fermentation, and storage in bladders of seal oil are well known in village life today.

In the 1830s, a trading post and Russian Orthodox chapel were established at Yalik village. Church records provided lists of people who were christened and other activities of the clergy. In 1880, Yalik village had a population of 32 people. Owing to the devout following of the Native people in the Russian Orthodox Church, and the difficulty of servicing such a distant and inaccessible locale by clergy headquartered in Kenai, Yalik residents were requested to move to Alexandrovsk (later named English Bay and then Nanwalek).

Although many people moved to Nanwalek, other locations along the southern tip of the peninsula also became their new homes. A number of current residents were born at Windy Bay, Port Chatham, and Koyuktolik Bay. Slowly the populations in all of the lower peninsula diminished, and by the 1950s, the last community to be abandoned was Port Chatham. Everyone moved to either Nanwalek or Port Graham.

This study found that 19 locations *(Table 1)* between Resurrection Bay and Port Graham Bay, are named with Sugcestun placenames and/or contain notable archeological evidence of pre-contact and early historic occupation. Two primary settlement locations, Aialik and Yaliq Bays, were occupied by Nanwalek and Port Graham residents who were alive in the 1970s and 1980s. First-hand accounts were recorded in oral histories, and were passed on in oral traditions and later recorded by grandchildren. These testimonials indicate that nearly every bay, island, and beach had habitations such as barabaras, semi-subterranean houses, and were used for some aspect of survival. The shorelines of Nuka Passage and Nuka Bay also had temporary campsites occupied by Nanwalek residents, and in the 1930s, Euro-American settlers living on Nuka Island found Native masks stored in nearby caves. Coincidentally, a description of a masking ceremony was provided in an oral history of a Nanwalek resident when he was a small boy accompanying his father during a winter trapping trip to Nuka Bay in the very early 1900s.

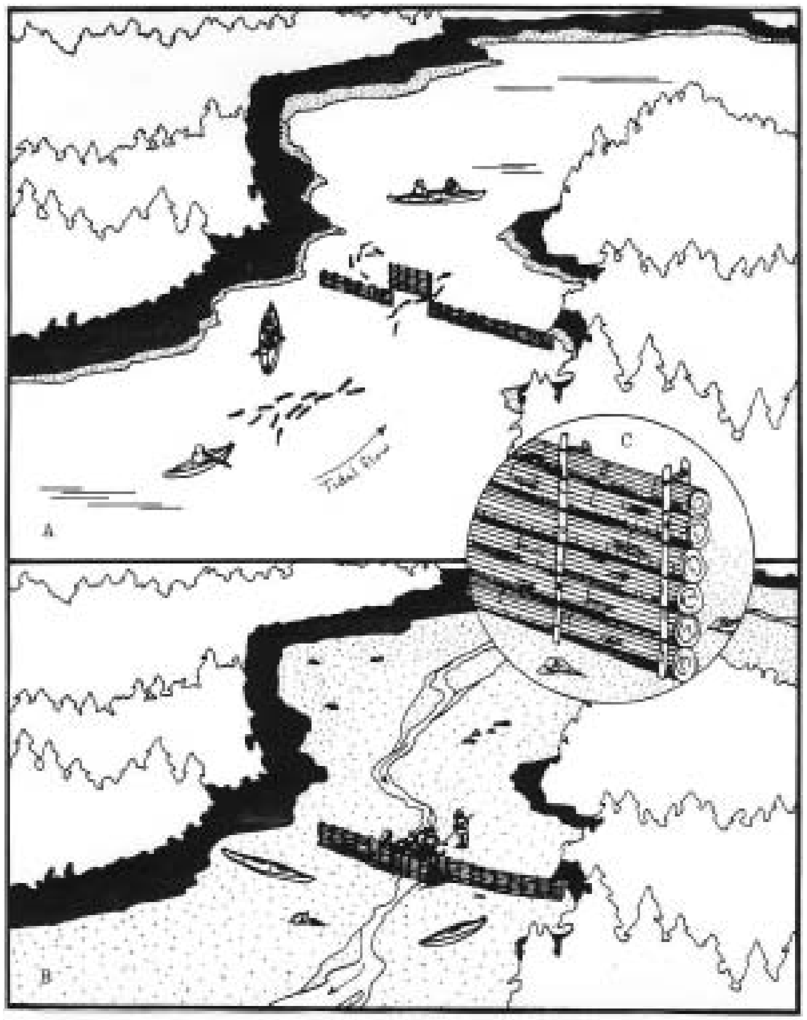
Study results showed that most Nanwalek and Port Graham residents traced their ancestry to the Alutiiq or Suqpiat who lived in a number of the aforementioned settlements and camps along the outer coast. Contact with Russian fur traders and Aleut hunters who accompanied them in the late 1700s and Euro-American and Asian immigrants in the 1800s, resulted in intermarriages and families of mixed ancestries. Family surnames were indicative of many different family ancestries, and those in the two communities included a high incidence of Russian origin. Some names were traced to Prince William Sound communities, while others were from Kodiak, the Chigniks, Kenai, and Seldovia. Interestingly, some surnames that appeared in church records were no longer present. A few names were of recently immigrated people who married into the community.

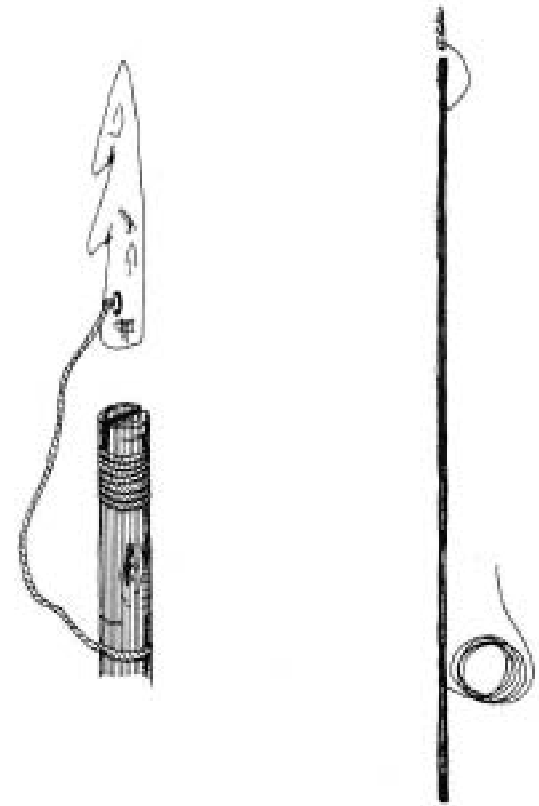
Throughout the 1800s, diseases such as influenza virus, and measles took a devastating toll on the Native populace throughout Alaska. The fur trade drastically altered traditional Native life by focusing the Native economies around cash and their populations around trade centers. Fur value drastically declined in the late 1880s, while the pursuit of gold brought many Euro-American immigrants, and the commercial fishing industry took hold at the turn of the century. Prince William Sound Suqpiat were affected by the decline in fur values as the Nuchek trading post closed, and by increased competition for subsistence resources and conflict among regional groups. Many families left the sound and moved to the outer Kenai Peninsula. There, they integrated with the Unegkurmiut and eventually moved on to Nanwalek and Port Graham.

Contemporary Life in Port Graham and Nanwalek

Suqpiaq is still the predominant cultural background ascribed by Nanwalek and Port Graham residents; however, some refer to themselves as Aleut. Several languages may be spoken in contemporary households. English is the primary language taught in schools, while Sugcestun is spoken in many homes and taught in school classes and an immersion program in Nanwalek. Russian is also understood by many elder residents and is often heard in Russian Orthodox Church ceremonies, and many Russian words are embedded in the Sugcestun lexicon.

Today, an outsider visiting these villages might not expect residents had ties to Prince William Sound, the outer Kenai Peninsula, and Russia that go back for hundreds or perhaps a thousand years. But salmon hanging in drying racks or curing in smokehouses is telling as to the origins of these people. Most people would simply tell you that this is the way they have been taught. If you have dinner at someone's home you might be served





Left: Figure 2. A fish weir in the English Bay River, early 1900s. Drawn by Cynthia Pappas as described by the late Joe Tanape.

Right: Figure 3. Diagram of a fish spear used by one resident at least until the 1940s and 1950s. Drawn by Cynthia Pappas as described by the late Sergius Moonin.

Settlement/Community	Pre-1880	1880	1890	1900	1910	1920	1929	1939	1950	1960	1970	1980	1990
Kangiak (Day Harbor)	*	De Laguna notes there were villages in Day Harbor and a group called the Kanirmiut or “Bay People”											
Qutalleq (Resur. Bay)	*	A village mentioned by one of Birket-Smith’s (1953) informants.											
Kani’lik (Two Bays)	*	De Laguna notes this may be Two Arm Bay. Birket-Smith (p.116) indicates Kangilik as near Seward.											
Aialik (Aialik Bay - several sites)	*	Archeological sites (Schaaf 1988); Oral tradition (McMullen 1997) describe occupation. Residents moved to Nanwalek and Koyuktolik Bay in mid 1800s.											
(Two Arm Bay)	*	Archeological site and found in oral history.											
(McArthur Pass)	*	Extensive archeological evidence, Schaaf and Johnson (1990), indicates resident population in last 1,000 years.											
Nuka Bay (Ualeq in De Laguna)	*	A number of village and camp sites on west side of Nuka Is. (Crowell 1993).											
Yaaliq (Yalik Bay)	NDA	32	Billings 1790 expedition met the Yalermiut. Moved to Nanwalek and other Cook Inlet communities in the 1880s.										
Kangiliq (Port Dick)	*	West arm of Port Dick (Leer et al.). Vancouver’s expedition encountered a large number of Natives in kayaks. Same name of village near Seward.											
Tagaluq (Rocky Bay)	*	Oral history of Port Graham and Nanwalek residents and Leer et al. 1980.											
Kaniagaluq (Picnic Harbor)	*	Oral history of Port Graham and Nanwalek residents.											
Nunalleq (Windy Bay village)	*	Oral history of Port Graham and Nanwalek residents and Leer et al. 1980.											
Ashivak (Cape Douglas)	NDA	46	85	Aband.	---	---	---	---	---	---	---	---	---
Tamarwik	*	A small village and travel stop at Anderson Beach on the mainland north of Perl Island. A sockeye stream and good harbor seal area.											
Arrulaa’ik	*	Clam Cove Village located at Port Chatham - inhabited at the time of Vancouver’s expedition in 1794.											
To’qakvik (Chrome Village)	*	Based on De Laguna’s informants, this was the village at the site of Portlock.											
Portlock (Port Chatham)	---	---	---	Established in 1915		47	NDA	---	---	---	---	---	---
Qugyugtuliq (Dogfish Bay)	*	De Laguna and oral history of Port Graham and Nanwalek residents. Abandoned in the 1930s.											
Nanwalek (English Bay)	20	88	107	NDA	NDA	NDA	107	48	75	78	58	124	158
To’qakvik or Coal Village	100	Established in the 1850s, moved to Nanwalek in the 1860s.					---	---	---	---	---	---	
Paluwik (Port Graham)	*	---	---	---	Established in 1912		NDA	93	92	139	107	161	166
Seldovia (Ostrovski)	NDA	74	99	144	173	258	379	410	460	460	437	473	459

Sources: Rollins 1978; De Laguna 1956; Meganack 1982; Tanape 1983; Birket-Smith 1953; Schaaf 1988; Schaaf and Johnson 1990; Crowell 1993; Leer et al. 1980

* Permanent or seasonal settlements in pre-1880s. Documented by archeological and or oral history information.

NDA Site was occupied but no population estimates available.

Table 1. Settlements and historic population estimates for the lower Cook Inlet and outer Kenai Peninsula coast.

rice, potatoes, salmon, hamburger, seal meat, and vegetable salad. They might say a prayer and face religious icons in one corner of the room. On further inquiry, they tell you their parents are of Aleut and Russian ancestry, and these practices were passed down through generations.

Homes are heated by oil, wood, or electricity. Motorized boats, trucks, and airplanes are common means of transportation. Traditional knowledge and experience provided by elders helps everyone survive in an economy that is dependant on cash, but where cash does not always adequately provide for everyone's needs, and may only average between $6,000 and $8,000 per person annually. Wild food consumption ranks the highest among communities in southcentral Alaska, averaging more than 325 pounds per person per year. Salmon make up half or more of the total annual wild resources harvested, while halibut and other saltwater fish are about one-third the harvest. Shellfish, moose, goat, black bear, and birds make up the remainder.

Combining the traditional knowledge of their ancestors with modern technology and education has afforded Unegkurmiut descendants a unique way of life. Residents still travel the coastline in search of wild resources for food and income. Elders have taught them to respect the land and waters, as well as fellow man. Unfortunately, events of the twentieth century brought dramatic changes to a well-adapted society. Western educators forced children to lose much of their language, which meticulously described and defined how to live in the environment. Oil spills poisoned the foods that fed generations. But by learning new skills and remembering the wisdom of their elders, residents have not only learned to survive, but improved their natural and manmade environments. Today the connection with the outer Kenai Peninsula and Kenai Fjords National Park is still very much intact. Although the area is a national park, Nanwalek and Port Graham Corporation members hold title and retain subsistence rights on select lands in the park. But those are not the most significant ties; clearly the knowledge and stories of ancestors, the names of old villages, bays, and islands are the true threads that tie the two.

Note:

This article on the Suqpiat or Alutiiq cultural ties with Kenai Fjords National Park draws upon information compiled over many years of work with residents of Nanwalek and Port Graham. Several other reports contain more detailed descriptions of historical and contemporary subsistence lifeways in these two communities *(Stanek 1985, 1998, 2000)*, while an in-depth description of the park is contained in Cook and Norris *(1998)*.

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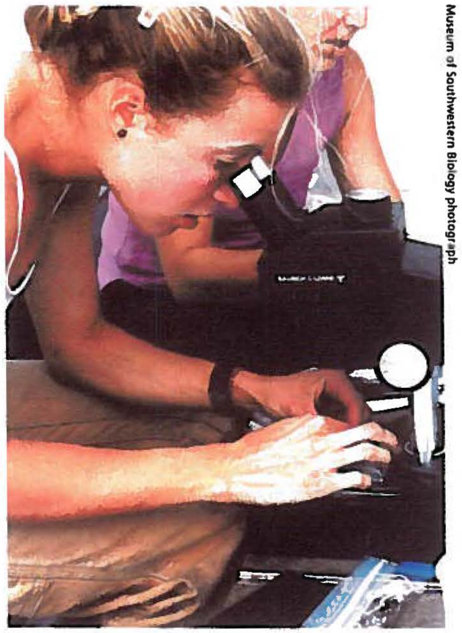

Museum of Southwestern Biology photograph

Figure 1. Doctoral student Natalie Dawson of the University of New Mexico uses a microscope to examine a diminutive shrew in our field laboratory.

Kurt Galbreath, a doctoral student at Cornell University, checks his sampling locality along the shores of Lake Clark.

Museum of Southwestern Biology photograph

Mammal Diversity: Inventories of Alaska National Parks Stimulate New Perspectives

by Joseph Cook, Natalie Dawson, Stephen MacDonald, and Amy Runck

Environmental conditions on earth have never been static, but an impressive series of indicators are now demonstrating that humans may be exacerbating rapid shifts in ecosystems on a global scale. Scientific investigations are focusing on the implications of environmental change in Alaska and elsewhere in the Arctic because, globally, high latitudes are particularly sensitive to these shifts. National park lands have become focal points of studies aimed at assessing changing environments because they are thought to reflect pristine areas that have been relatively unaltered by direct human influence.

Unfortunately, climate warming and related habitat shifts, increased pollutants on land and in the air, emerging diseases and pathogens, introduction of non-native species, and loss of biotic diversity now are likely impacting even our most pristine parks and preserves. To identify and track these and future perturbations, we need solid and extensive baseline information on environmental conditions, both past and present, in our national parks and preserves. Without rigorous documentation of the current status of organisms in these public lands, it will be impossible to predict how a future of unknown environmental change will affect the wildlife in these areas where so many people gather to appreciate, experience, and learn from the natural world.

One key element to understanding current conditions throughout the national parks is to catalog biotic diversity. Globally, losses of native organisms or additions of exotics have severely impacted our biosphere, so that changes in biotic composition are likely to have strong effects on the functioning of the world's ecosystems. The current global extinction rate is 100– to 1,000-fold greater than pre-human levels, and loss of local diversity can strongly affect ecosystem processes at both local and global scales *(Lawton and May 1995, Pimm et al. 1995)*.

In Alaska, we are failing to adequately document and study these rapid changes in biodiversity, leaving us unable to assess causes and understand the often-complex dynamics. Without such information, we cannot develop functional policies that minimize negative biological and societal impacts. Climate warming is predicted to have amplified impacts in high-latitude ecosystems and is expected to influence the distribution of mammals and other organisms, including parasites, pathogens, and associated diseases. A baseline for wildlife and the pathogens that might impact wildlife (and human) health is vitally important so that we can rapidly track these emerging threats in the North.

Assessing change begins with modern inventory studies and long-term monitoring programs that can be used to develop rigorous databases. Ideally, these databases would be based on permanently archived museum specimens that have been collected regularly over many years and that contain representatives from all environmental gradients throughout a given region. The biological inventory program of the National Park Service (NPS) has begun to accomplish this task, but future work must continue if we hope to adequately represent all the distinctive biomes throughout

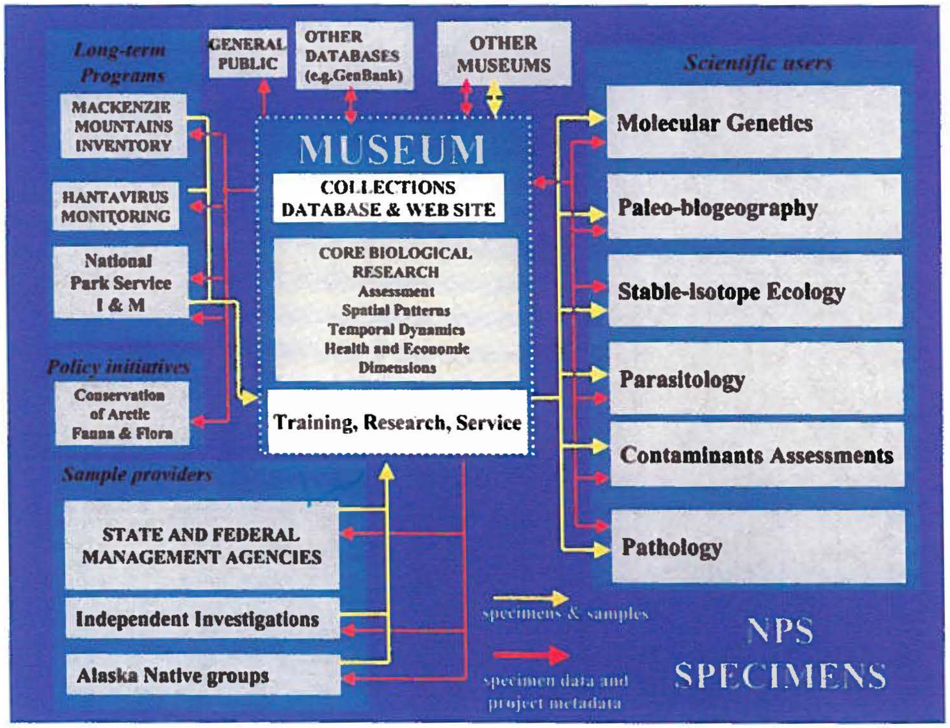


Figure 2. Schematic that demonstrates the many connections among the many providers, projects, and users of specimens that will arise from NPS inventory efforts.

Alaska and if we hope to effectively address temporal change. This inventory has brought together scientists, teachers, and students from around Alaska and the world to participate in establishing baseline information on mammals in arctic regions. These inventory materials and databases have been, and will continue to be, used in diverse scientific studies.

One of the important lessons learned from the 1989 *Exxon Valdez* disaster in Prince William Sound was that baseline inventory data, so critical to interpretation of the impacts of catastrophic events, were unavailable for that incredibly productive ecosystem. In short, it was difficult in many cases to assess the damage of the oil spill. Regular sampling and preservation of select museum specimens will prove invaluable as we attempt to monitor temporal change in the biotic diversity of Alaska national parks.

Field Inventories Provide Material for Diverse Studies

During the past four years, the Beringian Co-evolution Project (BCP), an international effort sponsored by the National Science Foundation, has teamed with the NPS Alaska Region Inventory and Monitoring Program to inventory the mammals and associated parasites in 11 of Alaska's national parks, monuments, and preserves. Our focus was on little known small mammals: shrews, bats, rodents, pika, hares, and weasels.

In some ways, these field studies of small mammals have not changed substantially over the past 100 years. We still camp at remote and beautiful sites to sample small mammals and spend long hours trying to learn about their habits and habitats. The methods used to investigate mammals, however, have evolved considerably. Our camps are now portable laboratories *(Figure 1)*. They allow us to create a variety of special preparations that are sent to specialists worldwide for analysis. We now haul liquid nitrogen tanks to ultrafreeze tissue samples, microscopes to sample and prepare tiny parasites, numerous vials to sort and preserve all the material, Global Positioning System (GPS) units to precisely georeference samples, and solar powered electric fences to keep the bears at bay.

Materials collected in these recent efforts represent geographically extensive and site intensive collections of unprecedented depth and scope. Each mammal we collect is assigned a unique field identifier, and all tissues, parasites, and other subsamples are linked to the original specimen. Thus all samples can be associated with a specific animal, GPS locality, and date of collection *(Figure 2)*. All mammals sampled are preserved as scientific specimens (vouchers), usually as cleaned skeletons or whole bodied in alcohol. Survey crews preserve tissues (heart, liver, kidney, spleen, and lung), and embryos in liquid nitrogen. These samples are deposited in cryogenic archives, such as the Alaska Frozen Tissue Collection at the University of Alaska Museum of the North. Searchable databases at the University of Alaska Museum of the North provide ready access to these collections (http://arctos.database.museum/SpecimenSearch.cfm).

Modern Collections Help Establish Baseline Environmental Conditions

Museum specimens provide a critical historical baseline for assessment of change caused by natural or human perturbations. Each carefully prepared specimen documents environmental conditions at a particular locality on a specific date. We cannot go back in time and recollect a particular specimen at a particular location. As they represent historical populations, the value of these specimens increases through time, particularly as the diversity of many localities is degraded. We have lost the opportunity to document environmental change in many areas because no baseline inventory was ever conducted.

One of the benefits of museum specimens is the ability to track diseases through time. For example, the discovery of deadly Hantavirus in the Southwestern U.S. was largely based on archived tissue samples associated with museum specimens at the Museum of Southwestern Biology. Because of inventories and museum collections, we now know that this "new" disease has existed for a long time, that it is widespread in western North America, and that closely related strains are found throughout the New World. Hantavirus is likely in Alaska, although we have yet to thoroughly survey for its existence.

In addition to vouchering each mammal captured, researchers process, preserve, and archive the many fleas, ticks, mites, tapeworms, roundworms, and other parasites that make a mammal's body their home. Viruses are screened at several labs. These materials are dispersed to international experts and to major collections such as Louisiana State University, Indiana State University, Georgia Southern University, Harvard School of Public Health, and University of Wyoming. Species lists and preliminary assessments of host associations and biogeographic distribution are in progress for respective components of the parasite fauna. Assessments of parasite diversity (e.g., numerical diversity, abundance, species richness, and overall geographic distribution) will soon be followed by extensive DNA analyses.

An Expanded View of the Mammals of Alaska

Alaska is home to slightly over 100 species of mammals, of which nearly half fit into the small mammal category. Among these, 32 species have been documented in national parks through voucher specimens as a direct result of this inventory *(Table 1)*.

The NPS/BCP inventory has produced a number of new and exciting insights into Alaska's mammals, including the tiny shrew, *Sorex yukonicus,* one of the newest mammals described for North America. While reviewing museum collections at the University of Alaska in 1993, one of our Russian colleagues, Dr. Nikolai Dokuchaev, recognized a new shrew species from collections made in the 1980s. This shrew is among the smallest mammals in the world, weighing less than a nickel. Since Dr. Dokuchaev's discovery *(Dokuchaev 1997)*, our inventories have documented that this "rare" species is actually widespread throughout Alaska, with a total of 37 specimens now known to science *(Figure 3)*. The tiny shrew probably occurs in neighboring Yukon Territory, but has not yet been documented in Canada.

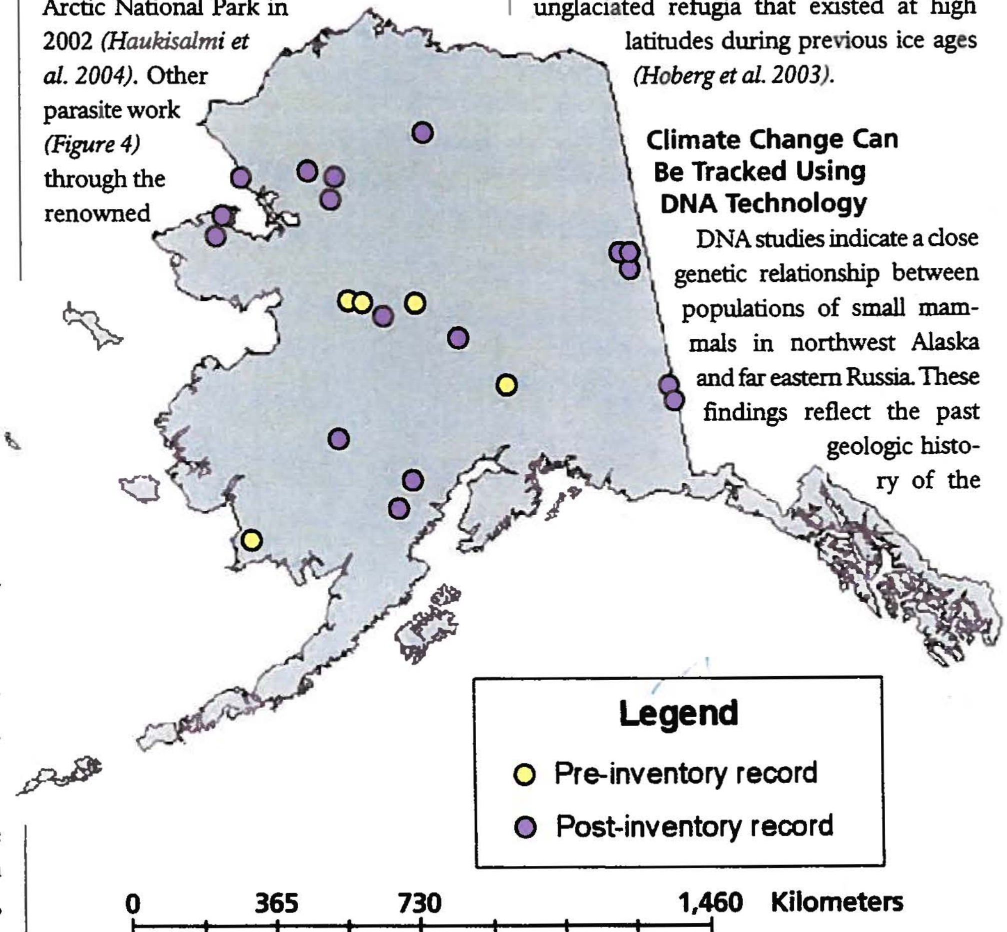
Our work also significantly extends and clarifies the range of the singing vole, *Microtus miurus,* a vocal (as its common name implies), semi-colonial species of the mountains in Alaska and adjacent Canada. The vole had been previously recorded in Denali National Park and Preserve (DENA). The discovery of this highly social rodent at the southwest end of the Alaska Range in Lake Clark National Park and Preserve and in the Nutzotin Mountains in northern Wrangell-St. Elias National Park and Preserve extends the range over 185 miles (300 km) to the southwest and 125 miles (200 km) to the east of DENA. In addition, the inventory provided an opportunity to re-examine several preserved specimens listed as *Microtus miurus* from the Yukon-Tanana Highlands in and near Yukon-Charley Rivers National Preserve that are housed in the collections of the U.S. National Museum (Smithsonian Institution), Washington, D.C., and the Slater Museum, University of Puget Sound. All proved to be misidentified originally and are now identified as tundra voles, *Microtus oeconomus*. Because these specimens had been archived, we were able to make a significant correction to our understanding of the distribution of the singing vole.

New Parasites Discovered that Reflect Distinctive Geologic History

Our Finnish colleagues already have found and described a new parasitic worm species from our studies in Gates of the Arctic National Park in 2002 *(Haukisalmi et al. 2004)*. Other parasite work *(Figure 4)* through the renowned National Parasite Laboratory in Beltsville, Maryland, has also uncovered a phenomenal number of new species. These new forms provide a strong signal that their mammalian hosts likely are relicts of unglaciated refugia that existed at high latitudes during previous ice ages *(Hoberg et al. 2003)*.

Climate Change Can Be Tracked Using DNA Technology

DNA studies indicate a close genetic relationship between populations of small mammals in northwest Alaska and far eastern Russia. These findings reflect the past geologic history of the



Distribution of tiny shrew
Sorex yukonicus

Figure 3. Thanks to the BCP/NPS inventory, we now know that the new shrew species for North America, *Sorex yukonicus,* has a much wider range than originally suspected.

Key to Abbreviations: N=National P=Park Pr=Preserve M=Monument	Central Alaska Network			Southwest Alaska Network*		Arctic Alaska Network				
	Denali NPPr	Yukon-Charley Rivers NPr	Wrangell-St. Elias NPPr	Kenai Fjords NP	Lake Clark NPPr	Bering Land Bridge NPr	Cape Krusenstern NM	Gates of the Arctic NPPr	Kobuk Valley NP	Noatak NPr
Shrews										
cinereus shrew	●	●	●	●	●	●	●	●	●	●
pygmy shrew	●	●	●		●		●	●	●	
montane shrew	●	●	●	●	●	●	●	●	●	●
water shrew	●		●							
tundra shrew	●	●	●		●	●	●	●	●	●
barren ground shrew						●	●	●	●	●
tiny shrew	●	●	●		●	●	●	●	●	
Bats										
little brown bat			●		●					
Carnivores										
American marten	●	●	●		●			●		
ermine	●	●			●			●		●
least weasel	●					●		●		●
Rodents										
Alaska marmot								●		
hoary marmot	●	●	●							
arctic ground squirrel	●	●	●		●	●	●	●	●	●
northern flying squirrel	●									
red squirrel	●	●	●		●			●	●	
American beaver	●	●						●		
meadow jumping mouse	●				●					
northern red-backed vole	●	●	●	●	●	●	●	●	●	●
collared lemming						●	●	●	●	●
brown lemming	●	●	●			●	●	●	●	●
long-tailed vole		●	●							
singing vole	●		●		●	●	●	●	●	●
tundra vole	●	●	●	●	●	●	●	●	●	●
meadow vole	●	●	●		●			●		
taiga vole	●	●						●	●	
muskrat	●	●			●	●	●	●		●
northern bog lemming	●	●	●		●			●		
NA porcupine	●	●	●					●	●	●
Lagomorphs										
collard pika	●	●	●		●					
snowshoe hare	●		●		●			●		●
Alaskan hare						●				

* *The inventory of Katmai Park & Preserve will be completed by autumn 2004*

Table 1. Preliminary checklist of vouchered small mammal species from selected Alaska park lands. Other mammal species are present or probably present within parks shown here, but have not been substantiated with a voucher specimen.

region when these areas were connected by the Bering Land Bridge, up to about 10,000 years ago. Similarly, the parasites we have examined are closely related across this region. Such discoveries provide a much more powerful and predictive framework for understanding wildlife relationships across larger landscapes.

DNA analyses also can reveal when species have recently colonized a new area. Kurt Galbreath provided evidence for the recent invasion of Alaska by the tundra vole *(Galbreath and Cook 2004)*. Other technologies, such as stable isotope analyses, have tremendous promise for providing insight into changing environmental conditions, but specimens must be preserved and available for such investigations.

Vouchers in the Future

The voucher specimen-based inventory of National Park Service lands in Alaska establishes a framework for tracking change in northern environments. Already, a diverse set of publications (more than 50 peer-reviewed papers) based on BCP/NPS collections has set the stage for more comprehensive assessments of high latitude environments (http://www.msb.unm.edu/mammals/Cook/CurrentProjects/0051.html).

The new museum collections will continue to provide material for a large number of scientific investigations well into the future. Accessible collections are among the finest resources available to environmental scientists and educators today as specimens provide insight into the many tough questions facing society and its relationship to the natural world. Without a rigorous doc-

Museum of Southwestern Biology photograph

Figure 4. Kayce Bell, an undergraduate student at Idaho State University, explores the guts of a small vole in search of parasite specimens.

umentation of the resources we have available in our national parks, it is impossible to predict how these national treasures may change in the future. Dramatic environmental change on several levels has made future conditions in these northern ecosystems unpredictable. Knowledge is the key to facing the future with the certainty and clarity that will be necessary to deal with environmental change.

Acknowledgments

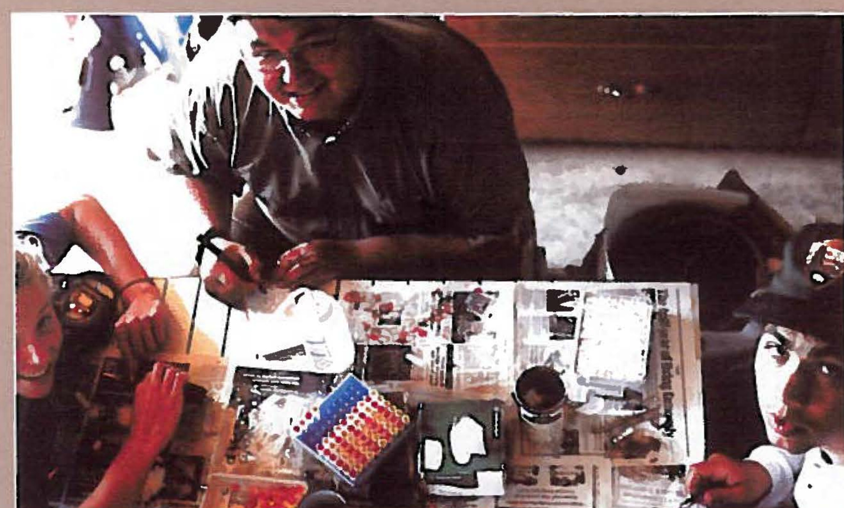
A project of this kind involved the hard work and diverse talents of many individuals and institutions. The enthusiastic support of many dedicated employees of the National Park Service is recognized. Special thanks to our field crews, our foreign collaborators, and the staff of the University of Alaska Museum of the North, especially Brandy Jacobsen, Gordon Jarrell, and Dusty McDonald. Dr. Jarrell, in particular, has worked tirelessly to establish web accessible databases for the University of Alaska Museum of the North.

Inventories Jumpstart Future Scientists

In addition to stimulating new discoveries in mammal diversity, the project sought to inspire future biologists and scientists. Four high school students (two Native Americans), ten undergraduate college students (three Native Americans), 13 graduate students, and four postdoctoral associates (two Russians, one Canadian) participated in the inventory fieldwork from 2001–2004. The Native American students came from Noorvik (Inupiat) and Dillingham (Yup'ik) in Alaska, and from Idaho (Shoshone).

Students and collaborators learned modern methods for field inventory in parasitology and mammalogy. Seasoned biologists provided field training to students at all levels. Museum and laboratory training continued at the University of Alaska Museum of the North, Museum of Southwestern Biology-Albuquerque, and U.S. National Parasite Collection-USDA in Maryland once the field season had ended. At these sites, students explored the role of museums in natural resource management.

We also helped design and execute small mammal field projects with high school teacher, Mike Sellers, and his students at Noorvik, Alaska. These students won competitions in the Alaska Native High School Science Symposium in 1999, and then, attended the National Conference in Minneapolis, where their project placed second in 2000. Two of these students were members of our field crews in northwestern and central Alaska.



Museum of Southwestern Biology photograph

Natalie Dawson, Tim Dyasuk, and Tazhay Jones at Amalik Bay in Katmai National Park and Preserve. Tim is an undergraduate student from Dillingham, Alaska.

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To what extent does the number of visitors who are present currently affect the quality of visitor experiences at Exit Glacier?

National Park Service photograph

Figure 1: Exit Glacier developed area.

Figure 2: Left: A typical sequence of photos used to estimate the number of visitors on the Overlook Loop Trail during the quasi-experimental study of direct reactions to use levels.

National Park Service photographs

Managing Exit Glacier's Popularity: Social Science Looks at Visitor Experiences

by Mark E. Vande Kamp, Darryll R. Johnson, Robert E. Manning

Introduction

The developed area at the base of Exit Glacier provides visitors with the rare opportunity to easily approach a glacier on foot. Visitors can park less than a mile from the glacier terminus and walk to the face of a towering mass of ice *(Figure 1)*. When the ice melts into safe configurations, visitors hiking the Overlook Loop Trail can even touch the glacier at selected locations. The Exit Glacier developed area (hereafter, Exit Glacier) is the only area of Kenai Fjords National Park that is accessible by road and is a popular tourist destination, with 132,695 visits in 2003 *(National Park Service 2004)*. The developed area also serves as the trailhead for the Harding Icefield Trail that leads visitors upward through sensitive alpine habitat. Visitation to Exit Glacier grew quickly in the early 1990s *(National Park Service 2004)*, and in 2001 the road to the area was paved, creating the potential for even greater visitation. A 1995 Development Concept Plan for the area *(National Park Service 1995)* strongly recommended that studies of visitation be completed to help managers prevent unacceptable impacts due to increased visitation.

When we began talking with Kenai Fjords managers about conducting studies of visitors at Exit Glacier, they had already decided to use the Visitor

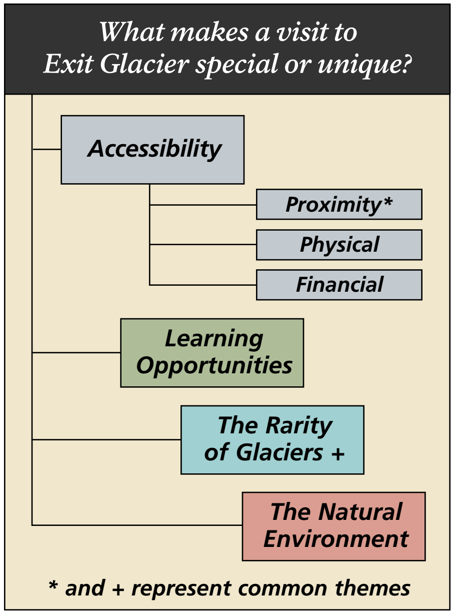

Figure 3. Conceptual map of responses to one of the primary questions in the qualitative interview study of visitors to the Exit Glacier developed area.

Experience and Resource Protection (VERP) framework (National Park Service 1997) to plan for and manage possible negative impacts of recreational use. As they began to apply the VERP framework, the planning team identified a wide range of information about visitors and their experiences needed to apply VERP effectively. Some of those needs are described by questions such as:

- What do visitors see as the "Exit Glacier experience"?
- Do some groups of visitors have characteristics or engage in activities that make them more sensitive to the presence of other visitors?
- To what extent (if any) does the number of visitors who are present currently affect the quality of visitor experiences at Exit Glacier?
- At what point might the number of visitors who are present unacceptably degrade the quality of visitor experiences at Exit Glacier?

In order to address this range of questions, we designed a research program that included a variety of studies using a number of research methods. In this article we briefly describe several studies that used different research methods, the reasons why each method was chosen, and some highlights of the information we collected. We will also discuss several findings of the research that illustrate how the diverse information was integrated to help managers of Exit Glacier plan policies to effectively manage visitation.

Research Methods and Questions

Of the questions given high priority by managers, the four listed above are given as examples, because each of them was addressed by a different research method. The four research methods were: 1) qualitative interviews, 2) a mail survey, 3) a quasi-experimental survey of reactions to experiences, and 4) an experimental survey of reactions to photographs.

Qualitative Interviews

Qualitative interviews are conducted verbally by trained interviewers and generally use open-ended questions that encourage respondents to discuss opinions or experiences that may be complex *(Tashakkori and Teddlie 1998)*. The method is qualitative because it describes the range of opinions or experiences present in a population. In contrast, quantitative methods provide specific estimates of the number of visitors with particular opinions or experiences.

Qualitative interviews were chosen to address the question, *"What do visitors see as the 'Exit Glacier experience'?"* because the question was difficult to answer by asking visitors anything other than open-ended questions. We could have constructed closed-ended questions for use in a mail survey or other quantitative study, but existing information was insufficient to support confidence in their results. It was possible that visitors might have complex and unique experiences that we did not anticipate or understand. To be effective, closed-ended questions, such as those asking respondents to circle answers from a list, should include all the common responses, and ideally, the less common responses as well. If they do not, they are likely to limit or bias responses.

Kristin Anderson, a researcher trained in qualitative interviewing, asked 89 groups of Exit Glacier visitors several probing questions. After transcribing and analyzing the interviews, she found that responses fell into four broad categories. *Figure 3* shows the categories as well as some more specific themes (see *Vande Kamp et al. 2003* for more a detailed report). The most common response revolved around the theme of proximity. Participants were delighted to be able to get so close to the glacier. One woman said, *"I think that probably the uniqueness is that you can get right up there at the glacier and actually touch the ice. I mean that is so fabulous. Being able to look in a cave, or you know look up and see the fissures and the blue ice, you are so close, that's what probably makes it special."*

Another common type of response indicated that the glacier itself, as a rare natural feature, was the defining characteristic of visitors' experience. As one participant said, *"It's not every day you see a hundred feet of ice."*

The results of the qualitative interviews were relatively unsurprising. The most commonly described characteristics of the Exit Glacier experience concern the glacier and the ability of visitors to closely approach it. The only category of responses not directly associated with the glacial ice concerned the larger context of the natural environment preserved in the area. After hearing of such results, critics might wonder if it was necessary to conduct a study that resulted in obvious conclusions. Many things seem obvious in retrospect, but without systematic research, managers could not be certain whether some visitor groups entered the area for complex or unique experiences that were not anticipated.

Mail Survey

Among other purposes, the mail survey addressed the question, *"Do some groups of visitors have characteristics or engage in activities that make them more sensitive to the presence of other visitors?"* The primary advantage of a mail survey is the ability to send a relatively large number of questions to visitors for completion at their leisure. Minimizing intrusion on visitors' recreation is important, and mail surveys also tend to reduce refusals to participate.

High response rates increase the validity of the survey by making the results more likely to reflect the views of all visitors. A second advantage is that the short contact procedure allows survey workers to approach and obtain the cooperation of a larger sample of visitors in a given period of time. Our mail survey distributed two different versions of the study questionnaire and obtained responses from 458 and 455 respondents. Approximately 75 percent of respondents who gave contact information returned completed questionnaires. A wide range of questions about visitors, their activities, and their experiences at Exit Glacier provided a basis for assessing visitors' similarity.

A statistical technique called cluster analysis was used to identify groups of visitors who held similar motivations for visiting Exit Glacier. A technical description of the analysis and the details of results can be found in the project report *(Swanson et al. 2003)*. The cluster analysis and related statistical tests were intended to detect visitor groups who were particularly sensitive to other visitors; but the results consistently showed a high degree of overlap in the motivations of the different groups of visitors, the activities in which they engaged, and the levels of crowding they reported. For example, the crowding ratings for every group identified by the cluster analysis fell between the two lowest numbers on the crowding scale (the lowest number was labeled "not at all crowded"). In general, Exit Glacier visitors showed considerably more similarities than differences in the experiences they desired and the impact of other visitors on those experiences.

Quasi-experimental Survey of Reactions to Experiences

A quasi-experiment is a research design in which observations are made across a range of conditions that are not randomly assigned *(Campbell and Stanley 1963)*. For example, the respondents in our survey on the Overlook Loop Trail encountered different numbers of visitors; but rather than manipulating those numbers and randomly assigning respondents to different conditions, we simply recorded the level of visitation they encountered.

We selected a quasi-experiment to address the question, *"To what extent (if any) does the number of visitors who are present currently affect the quality of visitor experiences at Exit Glacier?"* primarily because it was not feasible to manipulate visitation levels on the Overlook Loop Trail. At the same time, it was critical that managers examine the relationship between use levels and visitor experiences in this area of Exit Glacier, if the VERP process was to establish an effective balance between visitation and its impact on visitor experience. The study focused on the Overlook Loop Trail because it is the area in which visitors can approach close to the glacial ice. Visitors also approach the glacier from the outwash plain, but only when that area is not blocked by Exit Creek.

Respondents to the survey were approached by a survey worker stationed at the end of the trail section that most closely paralleled the glacial ice. Visitors who had just walked near the ice were asked to make a series of judgments about the number of other visitors they encountered. During the surveys, another survey worker photographed the Overlook Loop Trail on a set interval. The number of visitors that respondents encountered was estimated based on the number of visitors who were visible in the photographs taken during their hikes *(Figure 2)*.

Analyses of the quasi-experiment supported three conclusions: small numbers of visitors (average of 7.5, maximum 26) were generally seen in the photographs of the Overlook Loop Trail; few respondents felt

National Park Service photograph

Figure 4. Photo of the type used in the experimental survey of reactions to simulated use levels. Each photo used the same background, and the number of visitors in the picture was manipulated digitally.

National Park Service photograph

Figure 5. The opportunity to closely approach a glacier is a focal point of visitors' experiences at the Exit Glacier developed area.

current visitor density was high enough to detract from their experience; and the relationships between the observed (photographed) visitation levels and survey responses were weak and inconsistent. The low visitor densities and small number of respondents reporting negative impacts undoubtedly limited the statistical power of the analyses testing their relationships.

In general, the evidence that current conditions did not detract significantly from visitor experiences should encourage managers. However, the analyses should not be interpreted as evidence that visitor density will have no impact on future visitor experiences at all possible use levels.

Experimental Survey of Reactions to Photographs

The survey of reactions to a range of simulated use levels used a repeated-measures experimental design *(Campbell and Stanley 1963)*. Respondents made a series of different evaluative judgments about six photographs. The experimental manipulation was contained in the photos—each showed the same view of the Overlook Loop Trail, except that the number of visitors who were present ranged from zero to 50 *(Figure 4)*. This type of "image-capture survey" has been used in a wide variety of settings *(Manning et al. 1996, Manning et al. 1999, Manning et al. 2002)*, but it was particularly well suited to Exit Glacier because it allowed us to collect judgments about higher levels of visitor use than are currently seen.

In general, the photos showing 20 to 40 visitors on the Overlook Loop Trail were the point at which more than half the respondents rated the levels of visitor use negatively. In one of the most interesting judgments, about a quarter of respondents said that the photo with 30 visitors showed the use level that should prompt the NPS to restrict visitation. However, another quarter of respondents said that the NPS should not restrict visitation at all.

The research literature has not established that respondents' reactions to the photos correspond to their reactions if they were to actually experience the pictured conditions. Therefore, the experimental and quasi-experimental surveys were designed to test the level of correspondence by asking respondents to make the same series of judgments. However, the overlap in the range of visitor density depicted in the photographs and the range of actual conditions turned out to be minimal. The photographs taken in the quasi-experimental study showed that approximately three-quarters of the respondents experienced conditions in which fewer than ten visitors were visible, and 99% experienced visitor densities lower than those shown in the third ICS photograph (20 visible visitors). Thus, the statistical power of the comparison between the studies was too weak to support firm conclusions about the correspondence between the results. Regardless, there is currently no other practical method to gather data concerning visitors' evaluations of visitor density levels outside the current range at Exit Glacier.

Integrating Data Across Studies to Support Conclusions

In addition to providing a range of data suited to addressing a wide variety of questions, the results of diverse studies can also be combined in at least two useful ways. First, results from different studies that address the same question serve as a form of triangulation that increases confidence in the validity of their shared conclusion. Second, the results of studies addressing slightly different questions can be combined to support conclusions that neither study could address independently.

Triangulation can be seen in the results of the interviews and the mail surveys. One conclusion of the qualitative study was that many visitors felt that the ability to closely approach the glacier was a unique aspect of their experience. Several results from the mail survey also emphasize the importance of approaching the ice. For example, when choosing from a list of 15 activities, more than three-quarters of respondents reported that "Viewing Exit Glacier" or "Walking Up To and/or Touching Exit Glacier" were most important to the quality of their experience. Together, these and other results of the two research studies emphasize that approaching Exit Glacier is a critical aspect of visitor experiences.

The number of visitors on the Overlook Loop Trail is important to the VERP process because it is a potential indicator that might be monitored to protect visitor experiences. The experimental survey and the quasi-experimental survey both address questions about the relationship between use levels and experience quality on the Overlook Loop Trail. However, their differences allow them to provide data that are unique in their implications for the VERP process. For example, the results of the quasi-experimental survey showed that few respondents felt current visitor density was high enough to detract from their experience. This finding suggests that managers could allow use levels to rise and still protect the experiences desired by current visitors, but it does not suggest the point at which most current visitors would feel that use levels would detract from their experiences. In contrast, the results of the experimental survey reflect visitors' judgments of high levels of use that might occur in the future. By asking respondents to make judgments about a range of photographs that included use levels much higher than current levels, the study provided data that can help managers make a more informed decision about the maximum use levels they should allow on the Overlook Loop Trail before taking action.

Conclusion

The multi-method research program undertaken at Exit Glacier was not without drawbacks. The researchers designing the studies were required to have diverse skills and to collaborate effectively. Implementing the studies was complex, and field workers sometimes had difficulty understanding and carrying out the many different tasks they were assigned. And although it was cheaper to conduct the studies concurrently than to spread them out over several field seasons, it cost more to conduct the multi-method research program than it would have to conduct only one or two of the highest priority studies. Despite these drawbacks the research program provided a wealth of information useful in planning for the future management of Exit Glacier. Only a few small portions of that information have been described in this article, but we hope that they illustrate how the breadth of the multi-method research program provided park managers with an integrated set of information about visitor experiences and use levels. Such information can help managers develop policies to assure that the quality of visitors' experiences is not degraded by the level of use they encounter in the Exit Glacier developed area.

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Aniakchak Sockeye Salmon Investigations

by Troy R. Hamon, Scott A. Pavey,
Joe L. Miller, and Jennifer L. Nielsen

Introduction

Aniakchak National Monument and Preserve provides unusual and dramatic landscapes shaped by numerous volcanic eruptions, a massive flood, enormous landslides, and ongoing geological change. The focal point of the monument is Aniakchak Caldera, a restless volcano that embodies the instability of the Alaska Peninsula. This geological instability creates a dynamic and challenging environment for the biological occupants of Aniakchak and unparalleled opportunities for scientists to measure the adaptability of organisms and ecosystems to change.

The sockeye salmon *(Oncorhynchus nerka)* is one member of the Aniakchak ecosystem that has managed to adapt to geologic upheaval and is now thriving in the park. Aside from just surviving in the harsh environment, these salmon are also noteworthy for providing essential marine-derived nutrients to plants and animals and as a source of food for historic and present day people in the region.

With this backdrop, researchers from the National Park Service (NPS), U.S. Geological Survey (USGS), and University of Alaska Anchorage have begun to study how the volcanic landscape of Aniakchak has contributed to the local adaptations and relatedness of its different sockeye inhabitants. More specifically, the goal of the research is to measure the evolution of shape and genetic similarity of sockeye populations across a diverse range of habitats that reflect the violent history of the monument—Surprise Lake, located in the semi-dormant Aniakchak Caldera; Aniakchak River, a high gradient river flowing through the denuded route of a massive ancient flood; and Albert Johnson Creek, a sinuous, low-gradient creek draining into the Aniakchak River. By understanding the role of extreme habitat variation in shaping the ecology and evolution of sockeye, this project will help NPS managers identify the role of geological events in creating species diversity and promote management actions that protect ecosystem functions and resource users.

History

Aniakchak Caldera was formed 3,500 years ago by a tremendous volcanic eruption on the Alaska Peninsula *(Figure 1)*. More than 12 cubic miles (50 km^3) of material were extruded *(Miller and Smith 1987, Riehle et al. 1987, Begét et al. 1992)* causing massive landslides, debris flows, ash deposits, and a tsunami in Bristol Bay. Following this eruption, the caldera filled with water, forming a large lake similar to Crater Lake in Oregon *(McGimsey et al. 1994)*. Between 3,400 and 500 years ago, the caldera wall ruptured and the lake (now known as Surprise Lake) drained, causing a catastrophic flood that scoured the valley below *(Figure 2)*, depositing car-sized boulders in the floodplain

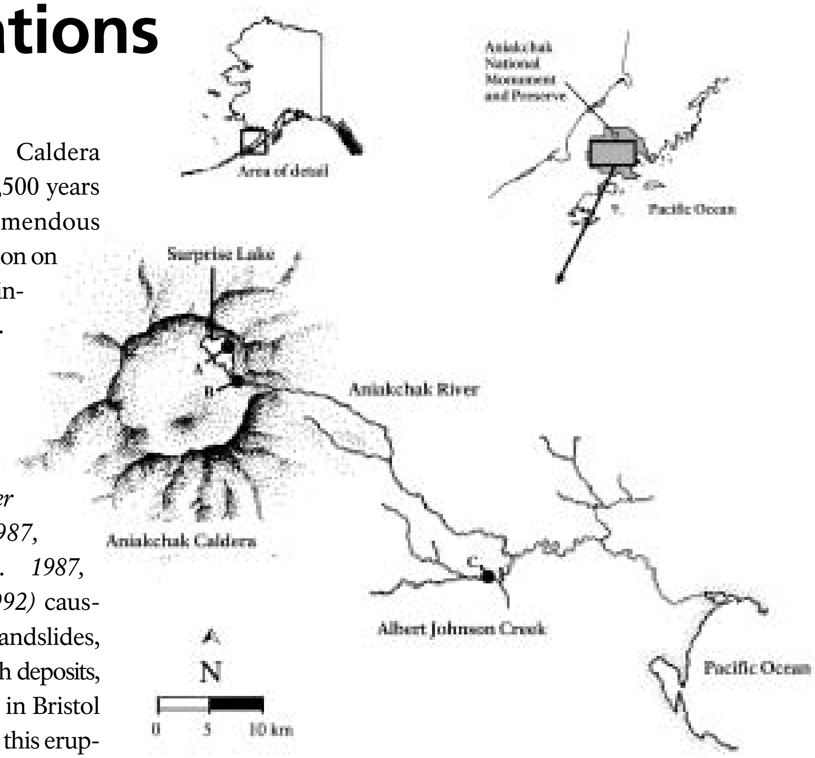

Figure 1. Map showing location of Aniakchak National Monument and Preserve on the Alaska Peninsula. Letters A, B, and C correspond to sockeye salmon spawning areas in Surprise Lake, Aniakchak River outlet, and Albert Johnson Creek, respectively.

Opposite Page: Surprise Lake surrounded by the Aniakchak Caldera.

National Park Service photograph

National Park Service photograph

Figure 2. Aniakchak River flowing out of the caldera at "The Gates." When the ancient caldera ruptured, a massive flood ensued creating the present day Aniakchak River and a new migratory corridor for fish colonizing Surprise Lake.

In 1931, Aniakchak erupted again, covering the caldera with ash and debris, wiping out plants in the caldera and decimating aquatic life in Surprise Lake

(Waythomas et al. 1996). Where the caldera wall ruptured, a drainage was formed connecting Surprise Lake with the Gulf of Alaska *(Waythomas et al. 1996)*. This drainage, now known as the Aniakchak River, provided new habitat for fish species and a colonization route to Surprise Lake.

In 1931, Aniakchak erupted again, covering the caldera with ash and debris, wiping out plants in the caldera and decimating aquatic life in Surprise Lake *(Jaggar 1932)*. This event occurred only nine years after the caldera was first described in 1922 *(Smith 1925, Hubbard 1931)*, providing rare photo-documentation of a completely natural ecosystem before and after a major eruption. Continuing volcanism and unique geologic landforms have contributed to Aniakchak's designations as a National Natural Landmark *(Bureau of Land Management 1970)*, National Monument and Preserve, and Wild River *(U.S. Public Law 96-487, 1980)*.

Photograph © Troy Hamon

Figure 3. An iron spring flowing into the western end of Surprise Lake. The western and southern beaches of Surprise Lake have numerous springs but are unfit for sockeye salmon spawners because of anoxic conditions.

Colonization by Salmonids

The life history of sockeye salmon is highly variable among individual locations, but some general rules apply. After emerging from eggs buried in gravel, juvenile sockeye salmon typically rear in large freshwater lakes for one or two years before going to sea. Some populations do not use lakes but instead rely on river habitat for juvenile rearing. After rearing in freshwater, sockeye migrate to the sea as smolts. All sockeye spend one to three years at sea attaining most of their adult mass by feeding on rich marine food resources. As adults they return to their natal freshwater to spawn and restart the cycle.

Sockeye are anadromous, spawning in freshwater after migrating from the sea. This means that freshwater spawning habitat is essential for perpetuating their life history. The availability of new freshwater habitat following volcanism, glaciation, or other geological events provides opportunities for fish to colonize new areas and become locally adapted to their habitat. Colonizing a new habitat also provides a mechanism for creating new populations that are physically and genetically divergent from ancestral populations—key steps in the creation of species diversity and the process of evolution.

After the catastrophic Aniakchak flood, the connection between Surprise Lake and the ocean provided new freshwater habitat for anadromous species. Sockeye salmon and Dolly Varden *(Salvelinus malma)* subsequently colonized the lake and river, establishing spawning populations *(Mahoney and Sonnevil 1991)*. The natural history of the populations of sockeye salmon in Aniakchak Caldera is unique in two aspects: 1) they are some of the most recently established natural populations known in southwest Alaska, and perhaps the most recent, and 2) they either persisted through the 1931 eruption, or they recolonized quickly following the eruption.

Most other lake systems in southwest Alaska have had viable habitat for around 10,000 years while Surprise Lake has only been accessible for about 1,800 years. The eruption of 1931 likely wiped out most of the salmon run for a couple of years. Fish returning later may have found the environment suitable once again, or the present populations may be less than 70 years old. Because sockeye salmon generally have a five year life cycle, the current population in Surprise Lake has had between 14 and 400 generations to become adapted to local habitats.

Measuring Adaptation and Genetic Similarity

Management decisions that protect both the resource and resource users require a detailed understanding of focus species. Measurements of local adaptation (physical characteristics such as body size or shape) and genetic similarity/divergence are critical for establishing the presence or absence of multiple populations and, subsequently, defining the scale at which management actions are applied. If two groups of fish are clearly distinct both in physical and genetic characteristics, they may require independent management consideration.

In this context, the NPS and USGS began a multi-year study to determine how

National Park Service photograph

Figure 4. Representative sockeye salmon beach spawners from Surprise Lake. The fish on the left is a female (held by NPS employee Chistina Olson), and the right, a male (held by NPS employee Bill Hobbins).

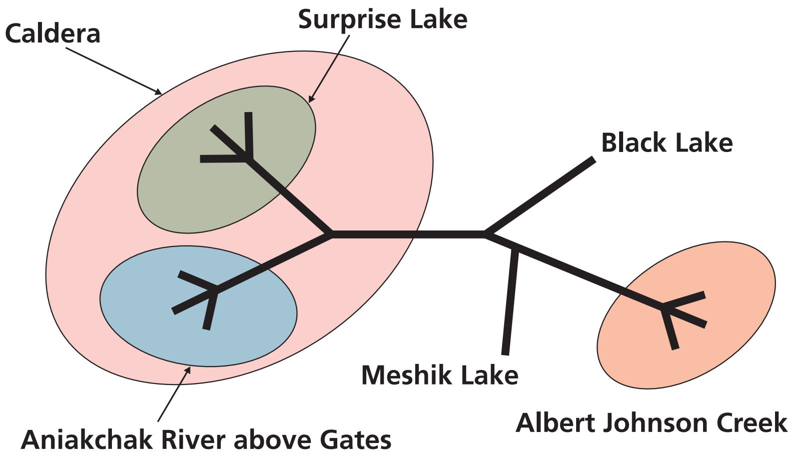

Figure 5. Diagrammatic representation of genetic similarity among Surprise Lake, Aniakchak River, and Albert Johnson Creek sockeye salmon. It appears that each group of salmon is genetically different from the others; however, fish from the caldera (Surprise Lake and Aniakchak River) are more similar to one another than either is to fish from Albert Johnson Creek. Black and Meshik Lakes represent two nearby sockeye populations outside of the Aniakchak River drainage.

USGS Alaska Science Center photograph

Biologists sampling sockeye spawners with a seine in the outlet of the Aniakchak River.

sockeye have adapted to the landscape of Aniakchak and to investigate genetic similarity among fish in certain habitat types. The study had four main objectives. First, the entire Aniakchak River drainage was to be searched to identify and catalogue spawning populations of sockeye salmon. Second, physical characteristics of habitat in use by sockeye were to be compared with characteristics of habitat not used by sockeye. Third, physical size and shape of sockeye were to be compared among populations. Finally, genetic analyses were to be used to examine the similarity and potential divergence among populations.

Extensive surveys both on the ground and by air confirmed the existence of populations in Albert Johnson Creek, in Aniakchak River within the caldera, and in Surprise Lake. There were no sockeye populations in the rest of the mainstem of Aniakchak River, nor in any of the other tributaries. In the caldera, there were populations of sockeye spawning along the lake beaches where water feeds into the lake from the caldera wall, but none along the opposite side of the lake where water drains in from the main interior of the caldera. Most of the groundwater entering from that side is high in heavy metals and has no dissolved oxygen *(Figure 3)*, consistent with the known vulnerabilities of incubating sockeye eggs; however, more than eight lake beach populations were identified. The aggregate number of spawners in any year is probably less than 50,000 or as low as 5,000, which is relatively small. The neighboring Chignik River system (Chignik and Black Lakes) usually has returns in excess of two million fish. As long as sockeye remain abundant in the Chignik lakes and commercial harvest effort remains focused on Chignik Bay, the small run of Surprise Lake and Aniakchak River sockeye salmon is unlikely to suffer adverse fishing impacts.

Comparisons of body depth revealed patterns of divergence among the different spawning populations. Overall, sockeye from Albert Johnson Creek and Surprise Lake *(Figure 4)* were deep bodied while those from the Aniakchak River were relatively shallow. The shapes of the caldera spawners fit patterns observed elsewhere in southwest Alaska, however the stream spawners from Albert Johnson Creek were surprisingly deep-bodied. In other sockeye populations, where different habitat

…Albert Johnson Creek fish, inhabiting a stream, are particularly deep-bodied, does not fit the pattern. It is not yet clear whether there is an alternative explanation due to the different life history or migration difficulty experienced by these fish, or if the present explanation for body depth variation needs closer scrutiny.

types are interconnected, body depth tends to be smallest in streams and greatest in lakes then rivers. It is not yet clear whether the differences in body shape are explained by adaptation to spawning habitat or responses to other factors such as migratory difficulty or life history variation. Nevertheless, we found that differences were consistent over several years, indicating a stable and real pattern of divergence in body shape.

Genetic sampling also confirms these differences. All three populations are genetically differentiated, suggesting reproductive isolation among the groups *(Figure 5)*. Even the nearby Surprise Lake and Aniakchak River spawning populations in the caldera appear to differ from each other. These results suggest that even with the relatively short time frame since colonization of the caldera, substantial differences in body depth and genetic markers have developed. The genetic analyses also suggest that caldera lake and river populations, as a group, are distinct from Albert Johnson Creek.

With additional data, these findings will help us understand the origins of colonizing sockeye salmon populations in the park. Additional work on both a small and a large scale will help us to determine how these results integrate with sockeye throughout their range, and may have implications for conservation and restoration of endangered populations. At present, the populations at Aniakchak, though relatively small, appear to be very healthy and represent adaptations to a unique region.

USGS Alaska Science Center photograph

Transporting field gear down the Aniakchak River from Surprise Lake. Field work in Aniakchak can be difficult because of weather, remoteness, and challenging river conditions.

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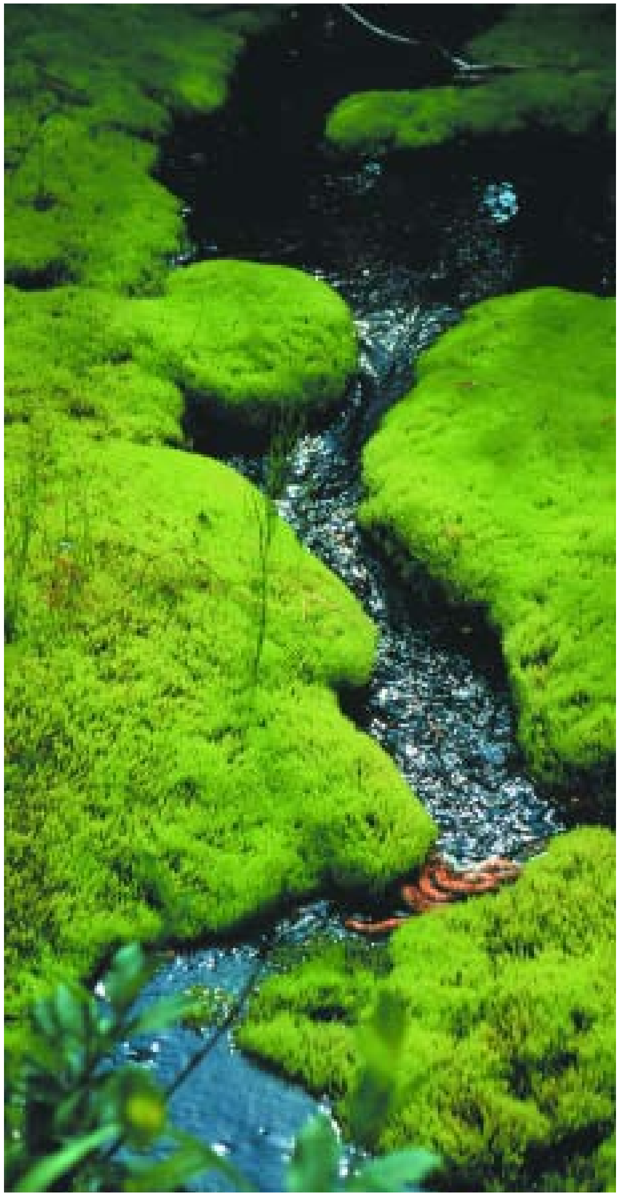

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