Alaska Park Science

National Park Service
U.S. Department of the Interior

Alaska Support Office
Anchorage, Alaska

Connections to Natural and Cultural Resource Studies in Alaska's National Parks

Winter 2002

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Alaska Park Science

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Funded By: The Natural Resources Challenge

Produced By:

ALASKA NATURAL HISTORY ASSOCIATION

Sharing Alaska's Natural and Cultural Heritage

"The act of creating a park is really an act of faith in all of the grand possibilities of the future. It is a contract with the future."
—Dr. Shirley Malcom, National Park Advisory Board

Welcome to our first issue of *Alaska Park Science*. This new semi-annual journal will share what we are learning in Alaska's national parks through the study of their vital cultural and natural resources.

Some of the best places in this country have been chosen as parks. These places are landscapes and historic shrines in which we feel wonder, reverence, respect — and responsibility. We are immensely proud that such places exist and that we are successfully preserving this natural and cultural heritage for future generations. As concepts of American ideas and values evolve, protecting living ideas is gaining prominence nation-wide. The National Park Service not only protects places, but also the ideas they represent.

Sharing these ideas and what we have learned in our resource studies is essential. The National Park Service strives to connect education with research and science, for education can serve as the bridge between knowledge and responsibility. Education tools like *Alaska Park Science* will also serve as the connection between the public who own the resources and those given the responsibility to manage them. The National Park system has been called "America's greatest university without walls." The benefits of almost 400 sites in this "university" system will enrich the educational offerings provided to the public.

National parks are important scientific laboratories, in addition to providing fabulous places for people to visit. Because they are among the places least changed by people, parks provide unique research opportunities. Nationally, this role has been advanced by the National Park Service's Natural Resource Challenge, an effort funded by Congress to expand the scope and quality of science in parks. Alaska has benefited from this initiative and from the many partnerships built around expanding and sharing the knowledge gained in park areas. Research by the US Geological Survey-Alaska Science Center, universities and other agencies is also providing new insights into the world around us.

As part of our "contract with the future," *Alaska Park Science* can connect the public with their national parks and the natural and cultural resources found there. Alaska's national parks serve to teach, inform, inspire and motivate people. In the end, we hope the national parks will inspire and encourage people to make a difference.

Rob Arnberger
Regional Director, Alaska Region
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The Great Eruption of 1912

by Jennifer Adleman
—geologist with the Alaska Volcano Observatory U.S. Geological Survey Alaska Science Center and a graduate student at the University of Alaska, Fairbanks

On the afternoon of June 6, 1912, a volcanic eruption cloud rose 100,000 ft (32 km) into the sky above the Katmai region, 280 miles (450 km) southwest of Anchorage on the Alaska Peninsula *(Fig. 1)*. Explosions were even heard in Cordova, over 370 miles (600 km) away from the Alaska Peninsula. Winds pushed the ash cloud east and within a few hours, ash from a huge volcanic eruption began to fall on Kodiak Island, approximately 100 miles (170 km) southeast of the volcano. Within several hours ash fell on Vancouver, British Columbia and Seattle, Washington. The next day the ash cloud passed over Virginia, and by June 17th it reached the skies above Algeria in Africa *(Fierstein and Hildreth, 2001)*.

While those on board the steamship Dora in the Shelikof Strait, between Kodiak Island and the Alaska Peninsula, watched the towering eruption cloud, pulses of magma from beneath the volcano continued to reach the earth's surface. As the magma depressurized, gases quickly escaped, explosively hurling the molten rock skyward, where it chilled quickly to volcanic ash and pumice. The volume of pumice and ash rushing out of the vent was so great that not all of it became airborne. A flood of pumice spilled out of the choked vent and flowed as a pyroclastic flow—a dense, tumbling mixture of pumice blocks, fine ash, and hot gas—that moved down the former Ukak River valley to form the nearly flat topography seen in the Valley of Ten Thousand Smokes today *(Fig. 2)* *(Fierstein, 1984)*.

During the next three days, life on Kodiak Island was immobilized during the 60-hour eruption. Darkness and suffocating conditions caused by the falling ash and sulfur dioxide gas rendered villagers helpless *(Fig. 3)*. Among Kodiak's 500 inhabitants, sore eyes and respiratory problems were widespread. Water became undrinkable. Radio communications were disrupted and visibility was nil. Roofs in the village collapsed under the weight of more than a foot of ash. Buildings were destroyed as avalanches of ash rushed down from nearby hillsides *(Fierstein and Hildreth, 2001)*.

On June 9th Kodiak villagers saw the first clear, ash-free skies in three days, but their environment had changed fundamentally. Wildlife on Kodiak Island and in the Katmai region was decimated by ash and acid rain from the eruption. Bears and other large animals were blinded by thick ash and many starved to death because large numbers of plants and small animals were smothered in the eruption. Birds blinded and coated by volcanic ash fell to the ground. Even the region's prolific mosquitoes were exterminated. Aquatic organisms in the region perished in the ash-clogged waters. Salmon, in all stages of life, were destroyed by the eruption and its aftereffects. From 1915 to 1919, southwestern Alaska's salmon-fishing industry was devastated *(Fierstein, 1998)*. The biological impact was far worse overall than that of the Exxon Valdez oil spill in 1989 *(Fierstein and Hildreth, 2001)*.

The impact to the land did not cease when the eruption ended. A number of moderate sized lahars—volcanic debris flows consisting of rapidly flowing mixtures of water, mud, and rock debris—resulted from the 1912 eruption. The most publicized lahars occurred a few years after the eruption itself. A landslide, triggered by earthquakes during the 1912 eruption, dammed the Katmai River in Katmai Canyon. The Katmai River remained

Within the broken edifice of a decapitated Mount Katmai is a lake 2 miles (3 km) wide.

tacular member of the monument system." *(Glimpses of Our National Monuments, 1930)*.

Griggs and others believed that the Valley of Ten Thousand Smokes was a modern-day example of how the geyser basins of Yellowstone Park were formed as the region's volcanoes first ceased their activity *(Glimpses of Our National Monuments, 1930)*. This turned out not to be the case. By the 1930s, the valley-filling ash had cooled enough to allow liquid water to pass freely through without it turning to steam *(Fig. 6)*. Today, the Valley of Ten Thousand Smokes is largely smokeless. Warm vapors rise from a few places around the Novarupta vent and along the margins of Baked, Broken, and Falling Mountains as the groundwater percolating through underground fractures turns to steam as it approaches the still-hot rock beneath Novarupta. These few remaining fumaroles tap a deep heat source—molten rock below ground. This is quite different from the "rootless" heat source of the extinct fumaroles, which was actually the cooling of the ash-flow itself *(Fig. 6) (Fierstein, 1984)*.

The origin of the magma expelled in the 1912 eruption has been a topic of great interest. In fact, in 1953 more than forty years after the eruption, Dr. Garniss Curtis of the University of California discovered that the main vent for the great eruption was not Mount Katmai, as previously thought, but a new vent, now plugged by the dome Griggs and his party named Novarupta *(Fig. 7)*. Curtis postulated that so much molten rock was removed from beneath Mount Katmai that Katmai's summit collapsed to form a volcanic depression 2 miles (3 km) wide, called a caldera *(Fig. 4) (Fierstein and Hildreth, 2001)*. Although in the 1950s Dr. Curtis discovered what happened during the 1912 eruption, researchers continue to attempt to understand how and why the magma from underneath Mt. Katmai erupted through the vent at Novarupta.

Volcanic particles suspended in the air, dust and sulfurous aerosols, from the 1912 eruption were detected within days over Wisconsin and Virginia and over California, Europe, and North America within two weeks...

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Figure 3. Drifts of ash in the village of Kodiak, June 1912 by W.J. Erskine

Research, Exploration and Katmai National Park and Preserve

Volcanic particles suspended in the air—dust and sulfurous aerosols—from the 1912 eruption were detected within days over Wisconsin and Virginia and over California, Europe, and North America within two weeks *(Fierstein and Hildreth, 2001)*. Beginning in 1913, before anyone had set foot in the Valley of Ten Thousand Smokes, the transport of the volcanic ash cloud, reported as a dust veil as far east as Greece and Algeria, led to pioneering work on atmospheric turbidity and the effect of aerosols on climate *(Kimball, 1913; Volz, 1975; Fierstein and Hildreth, 2001)*.

Modern scientific study in the Valley of Ten Thousand Smokes began in the 1950s *(Norris, 1996)*, and nearly 30 years later

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Figure 4.
Top: Mount Katmai by R.F. Griggs of the 1915 and 1916 expedition

Middle: Novarupta Steam

Bottom: Present day Katmai Lake

Figure 5. Valley of Ten Thousand Smokes, photo by D. B. Church

Figure 6.
Left: Fossil fumarole along Windy Creek in the Valley of Ten Thousand Smokes.

Right: Ground water moving through welded tuff and into the River Lethe in the Valley of Ten Thousand Smokes.

Katmai National Park and Preserve was designated, encompassing the Valley of Ten Thousand Smokes and surrounding regions. Around that time, part of the ongoing U.S. Geological Survey (USGS) fieldwork culminated in surface and bedrock geologic maps of the region. The University of Alaska, Fairbanks Geophysical Institute (UAFGI), the USGS, and later the Alaska Volcano Observatory (AVO), and others, continue to unravel the mysteries of 1912.

The Katmai Cluster

Scientists now refer to the volcanoes surrounding the Valley of Ten Thousand Smokes as the Katmai Cluster, a 15 mile-long (25 km) line of volcanoes along the Alaska Peninsula *(Fig. 1)*. Recent work in the Katmai area has established an eruptive history for each of these volcanoes by mapping the distribution of erupted materials. Radiometric dating identifies minimum and maximum ages for the different lava flows. Combined with mapping, these radiometric dates help narrow down the timing and frequency of past eruptions. The Katmai Cluster includes (from northeast to southwest) Snowy Mountain, Mount Griggs, Mount Katmai, Trident Volcano, Novarupta volcano, Mount Mageik, Mount Martin, and Alagogshak volcano *(Fig. 8)*. All but Alagogshak have erupted within the last 6,000 years, often explosively, and produced lava flows, domes, and widespread ash deposits. No fewer than 15 eruptive episodes have originated from the Katmai cluster within the last 10,000 years *(Fierstein and Hildreth, 2001)*.

Recent studies of the 1912 eruption have allowed researchers to further investigate the processes and hazards associated with large explosive volcanic eruptions. Recently published estimates of total volcanic material erupted in 1912 at Katmai include 4 cubic miles (17 cubic km) of ash fall and 2.6 cubic miles (11 cubic km) of ash-flow deposit, with 3 cubic miles (13 cubic km) of liquid magma *(Fierstein and Hildreth, 2001)*.

The 1912 eruption of Novarupta was the twentieth century's most voluminous eruption, and one of the five largest in recorded history. Among historical eruptions it is one of the few to have generated a large volume of pumiceous pyroclastic flow that came to rest on land instead of in water. Over the last two decades, detailed studies of the Katmai region's eruptive deposits have contributed to a better understanding of how volcanoes work, including the concurrent production of tremendously high ash plumes and ground hugging ash flows,

Figure 7. Today, the blocky lava dome of Novarupta sits in the ash-and-debris-filled volcanic crater, created by a cataclysmic volcanic eruption in 1912 that rained ash over southern Alaska, western Canada, and the Pacific Northwest (Fierstein, 1998).

The chance of a Novarupta-scale eruption occurring in any given year is small, but such cataclysmic volcanic events are certain to happen again in Alaska. In 1912, Alaska was sparsely populated and there were few airplanes. Now, over six hundred thousand people live in Alaska, and aircraft carrying more than 10,000 passengers and millions of dollars in cargo pass over Alaska's historically active volcanoes each day.

the timing of caldera collapse relative to magma withdrawal, and the distance pumice and ash may travel from the source *(Fierstein and Hildreth, 2001)*.

Katmai Quakes

Generally, earthquake activity beneath a volcano increases before an eruption because magma and volcanic gas must first force their way up through shallow underground fractures and passageways. When magma and volcanic gases or fluids move, they may cause rocks to break or cracks to vibrate. When rocks break, high-frequency earthquakes are triggered; however, when cracks vibrate either low-frequency earthquakes or a continuous shaking called volcanic tremor is triggered *(Tilling, 1997)*. Fourteen earthquakes of magnitude 6 to 7 rocked the region, and countless smaller shocks occurred before, during and after the 1912 eruption of Novarupta *(Fierstein, 1998)*.

The volcanological significance of earthquakes in Katmai National Park has been debated since the first seismograph was installed in 1963. Katmai seismicity consists almost entirely of earthquakes that can be caused by regional or local tectonic forces. Some of the earthquakes appear to result from rock failure under loading conditions along with local increases in the number of earthquakes associated with hydrothermal fluids. Earthquakes occur along fractures formed near the Mount Trident and Novarupta area during the 1912 eruption. These fractures may now serve as horizontal paths for migrating fluids and/or gases from nearby cooling magma bodies. At Mount Katmai, earthquakes may also occur along the ring-fracture systems created during collapse of the mountains summit in 1912. Circulating hydrothermal fluids and/or seepage from the caldera-filling lake may contribute to the occurrence of these earthquakes *(Moran, in press)*.

Magma(s?) of Katmai

Studies have proposed conflicting models for the magmatic plumbing system that fed the mechanism that triggered the eruption at Novarupta and collapse of Mount Katmai. One model of the eruption requires a single, chemically zoned, magma chamber beneath Mount Katmai *(Hildreth and Fierstein, 2000)*. Another model requires that the large pocket of molten rock that supported the former summit of Mount Katmai was injected with magma from another source and triggered the eruption of 1912 *(Eichelberger, 2000)*. This model requires that the magma under Katmai traveled six miles (10 km) west through an underground channel to explode through the surface at Novarupta *(Eichelberger, 2000)*. An experimental investigation,

Photos © Alaska Volcano Observatory

Figure 8.
Some volcanoes of the Katmai Cluster.

Top: Alagogshak volcano

Middle: Four peaks in the background are Trident Volcano, and the dome in the center is Novarupta.

Right: Mount Griggs

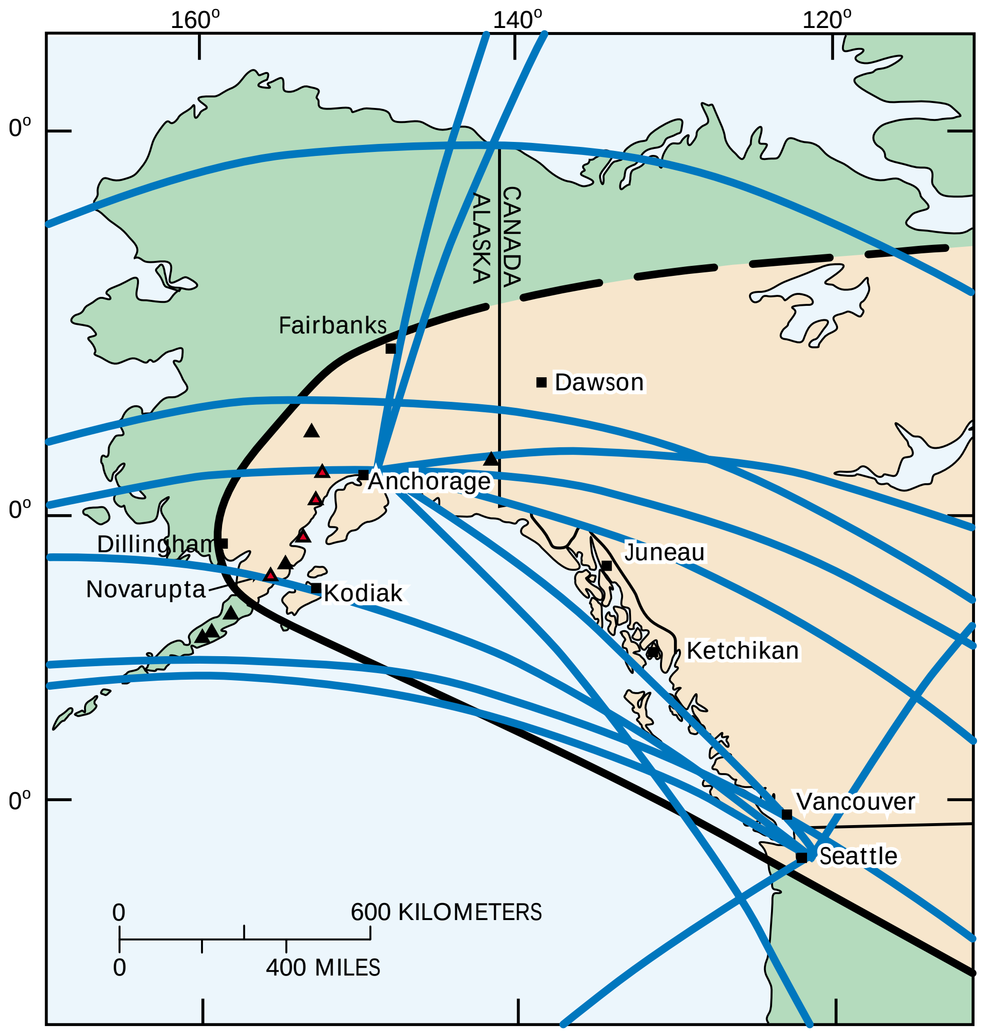

Figure 9. Great-circle and other air-traffic routes (blue lines) between selected cities (Casadevall et. al., 1999) would have been disturbed greatly by the 1912 ashfall from Novarupta. (Fierstein and Hildreth, 2001).

performed in a laboratory, concluded that the Katmai magma in the upper crust prior to eruption must have been 1,470°-1,560° F (800°-850° C) in temperature. The same laboratory studies also suggest that the pre-eruptive storage and crystal growth of the erupted magma was at a shallow depth, or if the magma ascended from greater depth, it did so slowly *(Coombs, 2001)*. Many scientists deviate on almost every aspect of the type of plumbing system and mechanisms that triggered the eruption at Novarupta and the subsequent collapse of Mount Katmai. To complicate matters, Fierstein and Hildreth

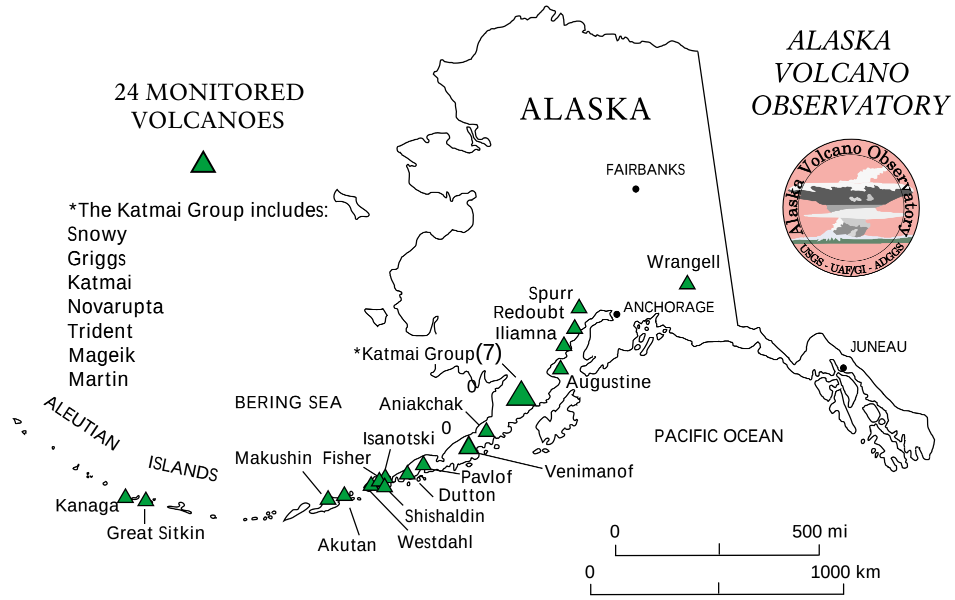

Figure 10. Volcanoes monitored by the Alaska Volcano Observatory as of summer 2002.

(2000) determined that the Katmai summit collapse compensates for only 40% of the magma erupted in 1912. Studies in the Valley of Ten Thousand Smokes continue to look for evidence of the plumbing system and triggering mechanisms at the Valley of Ten Thousand Smokes.

Alaska's Active Volcanoes: Katmai and Beyond

The chance of a Novarupta-scale eruption occurring in any given year is small, but such cataclysmic volcanic events are certain to happen again in Alaska. In 1912, Alaska was sparsely populated and there were few airplanes. Now, over six hundred thousand people live in Alaska, and aircraft carrying more than 10,000 passengers and millions of dollars in cargo pass over Alaska's historically active volcanoes each day. The greatest hazard posed by eruptions of most Alaskan volcanoes today is airborne ash — even minor amounts of ash can cause the engines of jet aircraft to fail during flight *(Fig. 9) (Fierstein, 1998)*.

Today, the heavy ash fall produced by a Novarupta-sized eruption in southern Alaska would bring the state's economy to a standstill, cause health problems, close roads and airports, disrupt utilities, and contaminate water supplies for hundreds of miles. Promptly restoring normal life would depend heavily on community spirit, civic organization, and pre-eruption planning *(Fierstein, 1998)*.

Throughout the western United States an increased focus on volcanic disasters began after the 1980 eruption of Mount St. Helens in Washington State. However, it was the 1986 eruption of Alaska's

Augustine Volcano 180 miles (290 km) southwest of Anchorage that prompted the formation of the Alaska Volcano Observatory and an increase in volcanic monitoring along the Alaska Peninsula, the Aleutian Islands and throughout the North Pacific. The Alaska Volcano Observatory (AVO) is a joint program of the USGS, the Geophysical Institute of the University of Alaska Fairbanks, and the State of Alaska Division of Geological and Geophysical Surveys. AVO uses federal, state, and university resources to monitor and study Alaska's hazardous volcanoes, to predict and record eruptive activity, and to mitigate volcanic hazards to life and property *(Fig. 10)*.

Now, nearly a century since the eruption that formed the Valley of Ten Thousand Smokes, a sizeable amount of monitoring and research instruments have been deployed throughout the state. Today, Katmai's well-established seismic network and benchmark stations are now augmented with satellite imagery, periodic field-based Global Positioning System (GPS) surveys, and gas, geochemical and hydrologic studies. Researchers continue to focus on understanding how volcanoes work, and on monitoring Alaska's active volcanoes and mitigating risks associated with volcanic activity.

More information can be found on the USGS website **www.usgs.gov** or the National Park Service website **www.nps.gov/katm.**

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Digging up Dreams: The Razor Clam Industry in Kukak Bay, Alaska

Photograph courtesy of Alutiiq Museum and Heritage Center

ca 1925—from the collection of Gladys Olsen, Kodiak Island. The cannery gang out for a 4th of July picnic at Swikshak Beach.

Far-left: ca 1925—from the collection of Gladys Olsen, Kodiak Island. Kukak was tucked in the undulating hills that surrounded Kukak Bay. This photograph was taken from the Superintendent's House, which had a panoramic view of both the cannery and the harbor.

Photograph courtesy of Alutiiq Museum and Heritage Center

Left-top: ca 1925—from the collection of Gladys Olsen, Kodiak Island. Three cannery workers find time to play music along Kukak's "cannery row."

Photograph courtesy of Alutiiq Museum and Heritage Center

Left-bottom: ca 1925—from Frieda Nielson's photo album. "First watermelon of the Season!" Frieda Neilson and the superintendent's son enjoy the first taste of fresh melon.

National Park Service photograph

By Katherine Johnson
— historian for Katmai National Park and Preserve, and a PhD candidate in Public History at Washington State University

Seventy-six years ago, a young woman from Homer brought her camera to work. Her name was Frieda Neilson and her photographs reveal an adventurous journey to Kukak Bay, Alaska where she worked as a clam-clipper at a small cannery during the summer of 1925. Now, after years of abandonment, vandalism, and fire, all that remain at Kukak are rubble piles of wood and corrugated metal, skeletal ruins of bunkhouses, and rusted machinery scattered along a rocky shore.

As the Katmai wilderness continues to reclaim the last historical remnant of the commercial razor clam industry, efforts to preserve this part of Alaska's past are currently underway by historians and archeologists working for Katmai National Park and Preserve. These photographs not only provide a unique perspective of daily life at a razor clam cannery, but they contribute to a larger cultural resource project designed to preserve and interpret the history of this obscure Alaskan industry.

Bringing the Kukak Cannery back to life is this extraordinary collection of photographs that expose a cross-cultural, multi-aged industrial society where both men and women worked, ate, and recreated together. Still, glaringly absent from the collection are photographs of Kukak's canning process. Lack of light probably limited the photographer's ability to shoot inside the buildings. But through the eye of her camera lens, this young clam-clipper shows us life beyond the dark canning lines.

Through her collection of photographs, Frieda Neilson takes us along as she journeys to Kukak on the steamship *Redondo*. She invites us on her explorations of Kukak's vast hillsides and we attend her swimming parties in the surrounding bay. We relish with her the rare delight of fresh watermelon and anxiously await the fall arrival of the Alaska steamship coming to transport both product and people south. Contrary to belief that early cannery life was gloomy, oppressive, and inhospitable, these photos depict a liberated, varied, and even fun social life at a cannery. Employees played card games, made music, and even took comfort in pets. And behind these daily activities, unobtrusively stood a one year-old Kulak Cannery — looking as fresh and hopeful as its young photographer.

The Kukak Bay cannery was located on the eastside of the Alaska Peninsula, directly across from Kodiak Island. The deep harbor carved by Pleistocene glaciers cradled the cannery from the gale force winds and provided fishing vessels a safe port along the volatile Shelikof coastline. On a rare day, the surrounding landscape offered our young photographer a panoramic view of the fiery Aleutian Mountain Range, but on more typical days, Pacific storms brought long episodes of fog and rain to the cannery (*U.S. Government 1924)*.

In 1923, industry insiders heralded Kukak as "the best equipped and most efficient clam cannery on the Pacific Coast" *(Oliphant 1924)*. Despite its notoriety, Kukak was just one of many Alaskan canneries that canned razor clams from 1916 to 1964. The clamming industry itself began on the Oregon Coast by early twentieth century entrepreneurs. These early canners played a vital role in the development of a U.S. clam industry by pioneering the canning technology used to pack minced clams. Because clams are extremely perishable, this innovative canning method permitted the sale of minced razor clams to markets located beyond local regions *(Sunday Oregonian, 1916)*. By 1914, clam

National Park Service photograph

ca 1925—from Frieda Nielson's photo album. "Cookie Jim," the cannery cook and a cannery worker pose for the camera in front of the cannery building, which protruded out over the deep waters of Kukak Bay on Kukak's main pier.

Photograph courtesy of Alutiiq Museum and Heritage Center

ca 1925—from the collection of Mary Olsen, Kodiak Island. A tender delivers a boatload of live razor clams to the cannery from Swikshak Beach located 20 miles south of Kukak Bay

canners moved to Grays Harbor, Washington, and eventually, reached the rich clam beds near Cordova, Alaska in 1916. Success of these clam canners inspired a brief rush of young dreamers to northern shores, each hoping to uncover his fortune buried in the Alaskan mud. One of those dreamers was Elmer E. Hemrich, whose expectations alone marked Kukak, as indeed, significant.

The Hemrich family's fame came not from canning clams, but rather, from brewing beer. Both Hemrich's father and uncle owned breweries from Seattle to Aberdeen; his uncle was, in fact, the president of Seattle Brewing and Malting Company, the company that made one of Seattle's first nationally recognized products — Rainier Beer. In 1916, the family's brewing enterprises came to a halt when Washington State adopted Prohibition, four years before national voters passed the Volstead Act. Seeking financial alternatives, Hemrich looked to the flourishing razor clam industry in his hometown of Aberdeen. In 1915, Hemrich and his father had incorporated the Surf Packing Company and in 1916 Elmer Hemrich traveled north to prospect Alaska's razor clam beaches *(Fribrock, 1999)*.

Hemrich began his journey in Chignik, Alaska, a small fishing village on the eastside of the Alaska Peninsula. While hugging the shoreline of Shelikof Strait, Hemrich "discovered" probably the most prolific razor clam beach in Alaska, known today as Swikshak Beach. On arrival in Anchorage, Hemrich convinced a trapper named George Palmer to invest in Surf Packing, and together they built a small

National Park Service photograph

…the era of great social crusades resonated in the social and work experience at Kukak and certainly debunked the stereotype that canneries were sparse, oppressive, and harsh working environments.

ca 1925—from Frieda Nielson's photo album. "Two Lovers" was all Frieda Neilson wrote to describe the last photograph in her Kukak photo album.

clam cannery on Polly Creek. Due to little success, Palmer sold his interests to the near monopolistic salmon packers. Still determined to realize the potential of Alaska's razor clam beaches, in 1923 Hemrich incorporated a new company, Hemrich Packing, and with capital from East Coast investors, built the Kukak Cannery, twenty miles south of Swikshak Beach *(Fribrock, 1999)*.

In 1925, the same year the Kodiak photographer captured Kukak in time, Hemrich brought on highly respected superintendent, Frank McConnaghy to run the Kukak clam operation. Both Hemrich and McConnaghy were from Aberdeen, where the Populist Movement enjoyed the greatest support of any other third party in Pacific Northwest history *(Schwantes, 1989)*. Populists advocated an assortment of social and economic reforms, which in some respects were transplanted in Kukak Bay.

Perhaps neither McConnaghy nor Hemrich consciously administered a progressive and populist managerial style, but the era of great social crusades resonated in the social and work experience at Kukak and certainly debunked the stereotype that canneries were sparse, oppressive, and harsh working environments. Instead, Kukak's management provided quite the opposite situation. Today Frank McConnaghy is still considered a pillar of Kodiak for contributing to the community, everything from personal loans to church donations *(Pestrikoff, 2001)*. Kukak even served as one of the first radio broadcasting stations in Alaska: in 1923, Elmer's brother became KNT's licensee and transferred the station from Aberdeen to Kukak Bay. The station transmitted only 100 feet and supposedly played concert music for one hour per day. Although KNT only lasted one year, it illustrates Hemrich's attempt to improve, perhaps even enrich, the daily experience of his employees *(Broadcasting Station Directory)*.

Hemrich never realized the success from clams as his family did from beer. For nearly a decade, the clam canner fought competitive East Coast markets, labor strikes, and poor clam seasons, even rumors that President Harding died from eating Alaskan shellfish. Hemrich exhaustively solicited potential investors and ultimately leased Kukak to other clam packing companies. In 1936, Kukak was crippled by fire during its most promising season *(Seward Gateway, 1934)*. Although a new company rebuilt Kukak, the cannery never achieved its operational potential. When Congress repealed Prohibition in 1933, Hemrich battled for three more years, and then surrendered in 1936 when the once optimistic clam canner deserted Kukak and returned to the beer brewing business in Aberdeen *(Alaska Sportsman, 1948)*. 1949 was the final year Kukak processed clams, although Swikshak remained an important clamming beach through the 1960s.

Briefly after Hemrich left, the clam business surged upward along with the booming Dungeness crab fishery. Crab fishermen paid Swikshak diggers a high price for razor clams and used the succulent shellfish for bait *(Nickerson, 1975)*. Despite the good bait prices, the market conditions for minced clams declined, forcing a series of consolidations among clam canners. By the 1960s only the industrial giant, the Alaska Packers Association, could compete in the minced clam market. The fatal blow to the industry occurred in 1964 when the Good Friday Earthquake destroyed Kodiak clam canneries and dropped clam beds in Cordova *(Pacific Fisherman, 1965)*.


Photograph courtesy of Alutiiq Museum and Heritage Center

In 1931, the Kukak Bay Cannery was absorbed into the federal management system when a presidential proclamation expanded the boundaries of what was then Katmai National Monument *(Clemens and Norris, 1999)*. Recent decades have worn down the Kukak Cannery to a dilapidated state, but the site's contributing resources, coupled with historical research and photographs, yield significant information pertaining to the Alaskan clam industry and its meaning to Katmai National Park and Preserve. Since Kukak was a major clam canning facility, the site provides historians a better context in which to understand this obscure industry and the people who pioneered its development on the Pacific Coast.

The National Historic Preservation Act (NHPA) mandates that the National Park Service evaluate historic properties found on federal land. The law states "the spirit and direction of the Nation are founded upon and reflected in its historical heritage." Indeed, the Kukak Cannery maintains integrity of location, association and feeling and is significant as a site. Echoing NHPA is clam digger Ralf Peiltsch, who told a NPS researcher, "Until the last chunk of cannery machinery sinks into the earth, it (Kukak) still means something to someone." *(Peiltsch, 2001)* The Kukak Cannery and the men and women who were involved it its construction and operation contributed significantly to the development of the commercial clamming industry in Alaska. The site evokes a sense of the forward-minded attitudes in which, despite a hostile and remote environment, a modern and complex facility was built. But perhaps more importantly, for Hemrich or our young photographer, Frieda Neilson, Kukak was a place that embodied the Alaskan Dream.

More information can be found on the National Park Service website **www.nps.gov/katm.**

Note: Frieda Neilson's photographs are housed in the Lake Clark-Katmai National Parks collections in Anchorage, Alaska.

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Surprising Humpback Whale Songs in Glacier Bay National Park

National Park Service photograph

Humpback whales migrate from Alaska to Hawaii for their winter mating and calving season. Humpback whale song is typically associated with the mating season, but research at Glacier Bay has revealed that whales frequently sing in Alaska in the fall.

Left: In the past decade, there has been growing concern about disturbance and other effects of man-made noise on marine mammals. Aerial behaviors like this head-slap are used as a social signal among whales, but can also indicate disturbance.

National Park Service photograph

by C. M. Gabriele
— wildlife biologist for Glacier Bay National Park

and A. S. Frankel
— works for Marine Acoustics Incorporated

Exciting research in Glacier Bay National Park is leading researchers to reevaluate previous concepts about humpback whale singing. Prior to the present research, humpback whales were thought to sing rarely in their summer feeding areas, and songs were predominantly associated with the winter mating season. With the installation of an underwater acoustic monitoring system in May 2000, researchers have found that humpback whales sing frequently in Alaskan waters, in late summer and early fall. The acoustic monitoring system, intended primarily to record ambient noise and vessel traffic, has provided many hours of humpback and killer whale vocalizations relevant to a variety of research interests. By describing Alaska whale songs and comparing them with recordings made in Hawaii, advances will hopefully be made in current knowledge about the functions of the songs and the humpback whale mating system.

Natural History of Humpback Whales

Humpback whales *(Megaptera novaeangliae)* are migratory baleen whales that spend summers in high latitude feeding grounds and in the winter migrate to tropical mating and calving grounds. For southeastern Alaska humpbacks, the winter migration entails a 2,500-mile swim to the Hawaiian Islands, the largest of three main wintering areas in the North Pacific. The other wintering areas in the North Pacific are near the Baja Peninsula in Mexico and near Japan and the Philippines. The greatest numbers of humpbacks occur in Hawaiian waters from January to April each year, although some whales can be found as early as November and as late as June. In the mid-twentieth century, biologists employed by commercial whalers examined thousands of carcasses, discovering that humpbacks do not feed in their winter grounds, and that both male and female reproductive organs are inactive in the summer *(Chittleborough 1955, 1958, Nishiwaki 1959).*

Why Whales Sing in the Mating Season

Humpback whale song is among the longest and most complex vocalizations made by any animal. Essentially, a song is a series of sounds made in a predictable order. In the case of humpback whales, the song is typically about 15 minutes long, punctuated when the whale surfaces to breathe. It is thought to be a mating-related display because it primarily occurs during the winter and is performed only by males. All males in a breeding ground sing essentially the same song, but singers make improvisations that others adopt, resulting in progressive change in the song. Despite much research in the years since songs were first scientifically described *(Payne and McVay 1971),* the functions of the songs remain unclear. Male humpbacks may sing as a sexual advertisement to females, for male-male coordination, or as maintenance of space between competing males.

Based on the sex ratio of calves *(Glockner 1983)*, we assume that there is nearly a 1 to 1 ratio of adult males to females in the population. Male-male competition is a key feature of the humpback whale mating system because most females give birth every other year, causing the ratio of available males to females to be at least 2 to 1. Many researchers believe that song may be a form of acoustic competition, analogous to the vigorous and sometimes injurious physical competition among males for females. Although scientists do not fully understand song function, its importance in humpback whale social life is clear, given that an individual male will sing for hours, and a chorus of whale song can be heard all day and night during the winter in Hawaii.

Processing and Recording Alaska Songs

The humpback whale songs reported here were recorded during acoustic monitoring to characterize ambient noise in Glacier Bay National Park, a steep-walled glacial fjord system in southeastern Alaska. The seafloor in the area is the remnant of a glacial moraine, which is flat and sporadically rocky at a depth of 40-60 meters. Glacier Bay and the surrounding area is inhabited by 50 to 100 humpback whales between June and August, and a much smaller number of whales from September through May *(Gabriele et al. 1999)*. Since 1985, approximately 355 different humpbacks have been individually identified in the area, including at least 36 known adult males. Although the Park has a long-term population monitoring program that focuses on individually identified whales, we monitored songs remotely. Therefore, no opportunities to determine the identity of individual singers existed nor if different song episodes were made by the same whale.

Satellite photograph of Glacier Bay, showing the location of the hydrophone. Population monitoring shows that Glacier Bay hosts 40-60 humpback whales in the summer, and smaller numbers in the fall.

Alaska Recordings: We listened to and made digital recordings of underwater sound using an anchored hydrophone and computerized monitoring system near the mouth of Glacier Bay. A submerged cable, five miles long, connects the hydrophone to a custom built computer and Digital Audio Tape (DAT) recorder at Park Headquarters. Using this system we recorded humpback whale vocalizations directly onto the computer hard disk (80 kHz sampling rate) or onto the DAT recorder (48 kHz sampling rate). All of the recordings were archived onto compact disks for future use and analysis.

From May 20, 2000 - March 8, 2001 and July 13, 2001 - June 20, 2002, the acoustic monitoring system was automated to make 30-second ambient noise recordings on a set schedule. Longer recordings of whale songs could only be made if a person was present to detect the song and make a recording. The monitoring was variable during the summer months since staff were in the field several days per week. From September through mid-January, monitoring occurred approximately 30-40 hours per week. No acoustic monitoring was possible between March and late June 2001, due to equipment problems. However, monitoring between March and mid-June 2002 detected no whale song as the animals moved into the area, suggesting the same was probably true in 2001.

Comparison to Hawaii Recordings: We chose the highest quality Alaska recordings to compare with songs recorded of whales in the Hawaiian islands in winter 2000 and 2001, and measured their degree of similarity on a variety of acoustic parameters. We extracted individual song units (notes) from the digitized recordings using customized detectors written in Matlab computer software. We used the computer program Acoustat *(Fristrup and Watkins 1993)* to quantitatively make 97 measurements of each unit's frequency, temporal and contour characteristics.

Description of Song Recordings

We discovered that humpback whales frequently sing while they are in the Glacier Bay area from August through November *(Table 1);* however we heard no songs earlier than August, despite the presence of whales. After November, no songs were heard in the Park, probably due to the absence of whales. Humpbacks do sing after November in other areas, resulting in the songs heard during migration by investigators monitoring vocalizations in the open ocean *(Clapham and Mattila 1990, Abileah et al. 1996, Norris et al. 1999, Watkins*

The songs recorded in the Park were solos, not the multiple-whale chorus that is typical in wintering grounds. Non-song whale vocalizations in the background were rarely heard, although feeding whales can be quite vocal.

et al. 2000, Charif et al. 2001). Acoustic monitoring continued through mid-January in both 2001 and 2002, but no additional whale songs were heard. During the spring of 2002, as whales began to migrate back in the area, no songs were heard.

The songs recorded in the Park were solos, not the multiple-whale chorus that is typical in wintering grounds. Non-song whale vocalizations in the background were rarely heard, although feeding whales can be quite vocal. Song sessions were sometimes preceded by or ended with episodes of unstructured vocalizations. Song sessions were considerably shorter than reported in the Hawaii wintering grounds, where whales often sing continuously for hours. The longest song session observed during this study was 4.5 hours, on November 8, 2000, but most sessions were much shorter *(Table 1)*. The sessions were quite variable in length and were significantly longer in 2000 than in 2001. Based on the apparent loudness and quality of the recordings, singers recorded in 2001 also tended to be farther away from the hydrophone than singers in 2000. The apparent decrease in singing in 2001 and the whales increased distance from the hydrophone were probably due to lack of whales in the area, which is known based on population monitoring during the summer and fall *(Doherty and Gabriele 2001)*.

Differences from Previous Studies

Prior to this study, humpback whale songs had rarely been recorded in Alaska waters. In southeastern Alaska, Baker et al. (1985) reported hearing singing from a group of whales in late December 1979 and early January 1980. McSweeney et al. (1989) detected only two occurrences of humpback whale song in five summers of effort (August 25, 1979 and September 3, 1981), and concluded that whale song in southeastern Alaska was a rare occurrence. Two factors may account for the difference from our results. First, although the dates of their acoustic monitoring were not specified, we suspect that these investigators did not monitor in September and October. Secondly, our study used a remote hydrophone, which allowed us a much greater flexibility with regard to weather, sea conditions and daylight than would be feasible with vessel-based monitoring.

The humpback whale songs we recorded in Glacier Bay occurred earlier and were more prevalent than songs previously documented in any feeding area. Humpback whales sang quite commonly in late summer and fall in Glacier Bay, corroborating findings from Stellwagen Bank, a feeding area off Cape Cod in the North Atlantic, where whale songs were recorded in November and May *(Mattila et al. 1987)*. However, it is unclear why whale song in southeastern Alaska began in late August while those in Stellwagen Bank were not observed until November, since humpbacks are present in both areas throughout that time period. Details of acoustic monitoring effort in the Stellwagen Bank study may reveal the source of this difference.

National Park Service photograph

Installing the hydrophone, mounted on its customized aluminum anchor, near the mouth of Glacier Bay. The hydrophone anchor sits on the sea floor at 30 meters deep and is connected by a five-mile cable to a listening station at Park headquarters.

Singing in Feeding Grounds

It appears that (presumably male) humpbacks sing sporadically in between feeding bouts in the autumn. Since there were no visual observations of the singers recorded, very little can be said about their behavior or the presence, proximity, or identity of other whales in the vicinity. In mid-summer, humpback whale song

Year	# Days Song Observed	# Hours Song Observed	Date of First Song	Date of Last Song	Mean session length in minutes (std dev)	Maximum session length in minutes
2000	18	21.9	29 August	16 November	73.1 (62.7)	270
2001	11	2.8	23 August	9 November	15.7 (13.1)	48

Table 1. Statistics on song occurrences in Glacier Bay 2000 and 2001

National Park Service photograph

appears to be rare or non-existent although other vocalizations are heard. Although the monitoring effort was less in the summer, this does not account for the lack of songs in May through late August.

With a sufficient acoustic monitoring effort we believe that song recordings could be made in any area where humpback whales congregate in the autumn. The increase in song in late summer and fall may correspond with the beginning of seasonal hormonal activity in male humpbacks prior to the migration to winter grounds. Studies of the reproductive tracts of male humpbacks revealed that testis weights in the wintering areas are much greater than in the feeding areas *(Chittleborough 1955, Nishiwaki 1959)*. Behavioral indications of increased male hormonal activity in the autumn are probably often subtle. Overt observations, however, have included singing and aggressive behavior between whales in Sitka Sound *(J. Straley pers. comm.)* and a known mature male apparently pursuing a known mature female in Glacier Bay *(J. Doherty pers. comm.)*.

The prevalence of humpback whale song in Alaska may indicate that the full range of mating behavior can occur in the autumn and winter in northern waters. Some humpback whales of mixed ages and sexes have been observed wintering in southeastern Alaska *(Straley 1999)*. We do not know whether autumn whale songs or other behaviors directly result in reproductive success. The occurrence of humpback whale singing and other behavior typical of the mating season may indicate that even when males and females forgo migration, they may not be sacrificing the opportunity to mate. Even in light of new discoveries, it seems likely that humpback whale song will retain its mysteries for years to come.

Implications for Human Impacts on Whale Habitat

In the past several years, there has been growing concern about the effects of man-made noise on marine mammals *(National Research Council 1994, 2000)*. The underwater acoustic monitoring program that made these discoveries possible originated from concerns that vessel-generated noise could harm endangered humpback whales in Glacier Bay. These whales could be considered ‘auditory specialists’, because acute hearing appears essential to their ability to navigate, socialize, detect predators, find food and find mates. The whales rely on sounds, which can travel for miles, since vision is limited by underwater visibility. This visibility may be several body lengths or less, especially in the plankton-rich feeding habitats.

Man-made noises added to typical ocean noise can make it more difficult for whales to hear vocalizations, may interfere with listening for predators or prey, and may cause changes in vocal behavior. Studies have shown increases in humpback whale song tempo and length in the presence of vessel noise and other man-made sources *(Norris 1995, Miller et al. 2000)*. Now that it is known humpbacks sing in Glacier Bay, we must consider the potential effects of vessel noise on singers and listeners. Most readers have probably not considered underwater noise pollution as an important form of habitat degradation for marine species. As natural soundscape issues gain attention in National Parks across the country, we hope that attention to preservation of natural sound environments in underwater habitats will result as well.

To hear recordings of humpback whale sounds recorded during this study, visit the Park’s website at:
http://www.nps.gov/glba/learn/preserve/projects/acoustics/index.htm.

ACKNOWLEDGEMENTS

The Glacier Bay National Park underwater acoustic monitoring program is conducted in cooperation with the U.S. Navy Naval Surface Warfare Center (NWSC) in Bremerton, Washington. We gratefully acknowledge the expertise of Blair Kipple (NSWC) and Russ Dukek (Mantech Inc.) for system design and for their creativity and patience during those bleak times when cable repair seemed impossible. Numerous staff at Glacier Bay National Park, NSWC and Mantech helped with the installation and maintenance of the system, proving that it takes a village to maintain a hydrophone. Hawaii humpback whale songs were made available by the generosity of Claudia Merrill, of Dolphin Discoveries in Kona, Hawaii. We thank Jess Grunblatt, (NPS Alaska Support Office) for making the satellite image of Glacier Bay available.

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National Park Service photograph

Figure 2: Archeological survey crew members traveling by jet boat on the Mulchatna River in May 2002.
Left to right: Matt O'Leary of the BIA-ANCSA office, George Alexie of the Nondalton Tribal Council, and Alan Boraas of Kenai Peninsula College.

Photo courtesy of Dave Mcmahan

Figure 3: Bill Trefon, Sr., president of the Nondalton Tribal Council, holds a mid-nineteenth century Russian copper tea kettle at a Dena'ina Mulchatna village in May 2000.

Left: Figure 5: Red and Gladys Vail with their daughter-in-law, Marie Andrews at the Vail camp in 1933-1934 on the Mulchatna River. This cabin has collapsed and was documented by the survey crew.

Photo courtesy of Mr. and Mrs. William Andrews

Little Known Mulchatna Villages Emerging After 120 Years of Solitude

by John Branson

— historian for Lake Clark National Park and Preserve, Port Alsworth, Alaska

During the past two years a multi-agency archeology crew has conducted the first archeological survey on the middle part of the Mulchatna River in southwestern Alaska *(Fig. 1)*. Led by a state archeologist, Dave McMahan, and National Park Service historian John Branson, the crew has located the outlines of 17 Dena'ina Athapaskan house sites in the Mulchatna River valley. Most of the Dena'ina houses were large, multifamily, semi-subterranean dwellings with one to five rooms, which are now heavily vegetated and difficult to discern. In addition to McMahan and Branson, the crew included representatives from Nondalton Tribal Council (Bill Trefon, Sr. and George Alexie), and Bureau of Indian Affairs ANCSA Office (Matt O'Leary) *(Figs. 2, 3)*. Participating agencies and organizations included the Lake and Peninsula Borough, Nondalton Tribal Council, the Kijik Corporation, and the National Park Service, with local logistical support donated by Northern Wilderness Adventures, Inc.

The Mulchatna River is a 160 mile-long river that begins at Turquoise Lake, with its upper portion designated a Wild and Scenic River. It is the major tributary of the Nushagak River, which drains into Bristol Bay near Dillingham. The Mulchatna country has long been rich in fish and game and in the days before Russian contact those abundant resources sustained the Dena'ina on its upper reaches and Yup'ik Eskimos on its lower stretches. Russian explorers probably visited by the 1790s but documentation of their activities is sparse. Certainly during the Russian era, the Mulchatna Dena'ina had access to Russian trade goods. By 1850 Russian Orthodox priests were in the area, and by the late 1880s, prospectors had arrived in the Mulchatna country *(Fig. 4)*. Today, the Mulchatna River draws thousands of people each year: subsistence fishermen, hunters, and trappers on the lower river; sport hunters, fishermen, and floaters on the upper and middle parts.

It is known that the villages on the Mulchatna were abandoned by the late 1880s after a scarlet fever epidemic decimated much of the local Dena'ina population. Earlier epidemics during the Russian era had probably already thinned the local population from an estimated 400 in 1800 to 180 in 1880 (Petroff claimed 180 people lived in the "Mulchatna villages" in 1880). By the end of the decade, permanent settlements probably ceased to be occupied except on trapping and hunting trips. Most of the people who survived the scarlet fever epidemic relocated to historic Kijik village on Lake Clark.

The survivors were urged to move to Kijik by the Russian Orthodox priest from Nushagak in order to attend the newly built Holy Cross Church. In addition, the trading posts at present-day Iliamna were much more accessible from Kijik than from the more remote Mulchatna. The growing commercial salmon industry on Bristol Bay offered employment opportunities for the Kijik people; however, the commercial fishery was a double-edged sword. Commercial salmon traps near the mouth of the Nushagak reduced escapement to the Mulchatna River spawning grounds, thus diminishing the primary food source of the Dena'ina and making their subsis-

Photo courtesy of Dave Mcmahan

Figure 1: Landsat map of the Lake Clark-Iliamna region of southwestern Alaska. The portion of the Mulchatna River being surveyed for archaeological resources is shown.

Photo courtesy of Marie Millett

Figure 4: Dena'ina men acted as guides and packers for early twentieth century prospectors in the Mulchatna River valley. In this 1908-1909 photograph from Bonanza Creek, miners (the Milletts) and Dena'ina men are shown together. Standing from left to right are O.B. Millett, Gerasim Balluta, Hugh Millett, Marka Karshekoff, Trefon Balluta, and Yacko Evan. Sitting are Theresa Millett and two unidentified mining engineers.

tence lifeways more tenuous. In short, as the 19th century closed and the 20th century dawned, the Mulchatna villages were too isolated and resource poor to sustain large populations.

The Mulchatna River, from where the Mosquito River enters up to its head at Turquoise Lake, is the ancestral homeland for many people from Nondalton, a Dena'ina Athapaskan village of about 250 people located near the outlet of Lake Clark. Many of those living in Nondalton trace their families to Kijik, and to the villages along the Mulchatna *(Fig. 5)*. The Mulchatna has always had special significance to the people of Nondalton. In fact, a priority to protect cultural sites from inappropriate development has partially guided land selections made by the Lake and Peninsula Borough along the Mulchatna.

Oral histories compiled from Nondalton elders describe at least three historic Dena'ina villages near confluences of major tributaries of the Mulchatna River. During the survey, archeologists located the rectangular outlines of Dena'ina houses near some of the reported sites. In addition, they found several others whose existence was beyond living memory. McMahan believes some of the sites might be one or more of Petroff's 19th century "Mulchatna villages", while others may be as much as several hundred years old.

Another part of the project is to locate and document early 20th century prospector-trapper cabins and camps in the study area. Interviews and historic photographs are being collected from some of those who once lived on the Mulchatna. During the 1920s through the 1940s a number of Dillingham based trappers built cabins and trapped animals along the survey area. In fact, two trappers in the 1940s located ruins of three large multi-family houses. At the time, they thought Russians had built the houses, which is why they called the area "Russian Slough". Many older people in Dillingham still use the term to describe that channel of the Mulchatna River; however, no one in Nondalton had knowledge about a Dena'ina village along the Mulchatna called "Russian Slough". When the archeology crew located the same three houses, they recognized the classic Dena'ina multifamily style. "Russian Slough" should more properly be called "Dena'ina Slough" *(Fig. 6)*.

The late archeologist, James VanStone, from the Field Museum of Natural History in Chicago conducted the first surveys on the lower Mulchatna River in the 1960s. This last spring Choggiung Ltd., the Native village corporation of Dillingham, used a grant from the National Park Service to survey the lower Mulchatna and Nushagak rivers for archeological resources. In the late 1970s the National Park Service conducted a brief archeological survey near the source of the Mulchatna River at Turquoise Lake. But it was not until May 2000, when the present joint effort began, that any intensive archeological survey was undertaken on the resource-rich middle portions of the river. In short, the middle Mulchatna River was terra incognita for archeologists until May 2000. After two years of archeological fieldwork a glimpse into the cultural history of the Mulchatna River is beginning to emerge.

In 2001 McMahan was back on the

Mulchatna to extract charcoal for radiocarbon dating from the hearths of a few Dena'ina house sites. Through radiocarbon dating and careful excavation of test pits, the crew hopes to date Athapaskan occupancy on the river. Based on similar work already done at the Kijik National Historic Landmark by the National Park Service, it is known that Dena'ina people have been living in southwestern Alaska for at least the past 800 years.

If the survey continues, McMahan and his colleagues will be able to shed light on the length and extent of Dena'ina history on the Mulchatna River. That history will also certainly involve contact with their downstream Yup'ik neighbors and with prospectors in the late 19th century.

More information can be found on the National Park Service website **www.nps.gov/lacl.**

Figure 6: Archeologist Dave McMahan writes notes in a Dena'ina house depression at "Russian Slough" in May 2001.

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Courtesy of Anchorage Museum of History and Art, McC 1935-1 A

Exit Glacier in 1948, photo taken by Steve McCutcheon.

Left: Over 100,000 visitors hiked to Exit Glacier this past summer.

National Park Service photograph

The Retreat of Exit Glacier

by Susan Huse
— biologist for the Alaska Support Office, National Park Service

As thousands of visitors hike up the Exit Glacier valley this summer, they will benefit from work completed in 2001 by Joel Cusick, a mapping specialist for the National Park Service. His work has recreated the history of Exit Glacier's movement over the last 200 years, using techniques such as aerial photography and tree coring to identify and date the extent of the glacier. His findings will help further biological research and park planning, and it will help visitors gain insight into the magnitude and the time scale of glacier movements. Scientists studying plant and soil growth in a glacial environment gain a chronology of the valley's exposure, which helps determine when plants began to reestablish and the soil chemistry began its progression from glacial till to forest soil.

Kenai Fjords National Park

Kenai Fjords National Park lies along the Kenai Peninsula coast in southcentral Alaska, just southwest of Prince William Sound. The park landscape is a dramatic juxtaposition of land and water, shaped by the advance and retreat of glaciers. The park is capped by the largest icefield entirely contained within the United States, Harding Icefield, a 300 square mile expanse covering a mountain range under ice several thousand feet thick.

Exit Glacier is one of 38 glaciers that flow out from the Harding Icefield. During the early nineteenth century, the glacier almost reached the Resurrection River, approximately 1.25 miles (2 km) below its present location. In the last 200 years, the glacier retreated exposing the valley below. The exposed valley is a natural laboratory where we can see the processes of life reclaiming a barren landscape: moss, lichen and fireweed colonize the bare rock; followed by grasses, shrubs, alders, and cottonwood; and finally, a spruce-hemlock forest grows where 200 years ago only ice and rock existed. Exit Glacier is accessible by road and thousands of park visitors have an opportunity to experience the glacier firsthand.

Understanding Glaciers

To map the history of a glacier's movements, one must first understand how glaciers work. Alpine glaciers, like Exit Glacier, form when more snow falls on mountain peaks during the year than melts during the summer. As the snow pack builds up and thickens, its weight compresses the snow beneath and turns it to ice. As more and more snow and ice accumulate, the glacier grows. The weight of the ice high in the mountains begins to push the ice below, down the mountain, and it actually flows very slowly down through the valley. The movement of the glacier scrapes the ground beneath, scouring the valley floor, and carrying along the dislodged rocks and debris. Rock avalanches from the peaks and the valley surrounding the glacier add more debris. With time the growing glacier becomes a jumbled mix of rock and ice.

Even as the snow falls in the colder alpine environment at the top of the glacier, the accumulation zone, the ice is continually melting in the warmer regions at the bottom of the glacier, the ablation zone. When the accumulation at the top pushes the ice down through the valley faster than the ice melts at the bottom, the front edge of the glacier advances. When the ice at the bottom melts faster than the ice is pushed downhill, the glacier recedes.

During a recession, the ice and rock continue to flow downhill to the toe of the

National Park Service photograph

Roadside sign showing the extent of Exit Glacier in 1899.

glacier. As the ice melts, rock deposits are left on the ground in front of the leading edge of the glacier, glacial till. In this way a continuous layer of till is left across the newly exposed valley floor. There are also periods when the ice at the front melts at essentially the same rate as the ice flows down. This is called a period of stagnation, and the front edge of the glacier stays in one place, neither receding nor advancing. The rock and debris, however, continue to be pushed downward to the leading edge of the glacier where it is deposited as the ice melts away. If a period of stagnation lasts for several years, the till will build up higher and higher at the stationary leading edge, creating a long mound of rock at the front of the glacier. When the glacier begins to recede again, this moraine is left behind outlining the leading edge of the glacier. If a glacier advances after a period of stagnation, it will plow away the newly formed moraine. The moraine that marks a glacier's maximum advance is called the terminal moraine. The series of moraines that are left behind as the glacier goes through periods of recession and stagnation are called linear moraines. These linear moraines show a series of glacier outlines during the recession period.

Mapping Glaciers Over Time

In particular, how can a researcher reconstruct the retreat of a glacier as it melts back? Joel Cusick, a mapping specialist at the National Park Service's office in Anchorage, undertook the task of recreating Exit Glacier's retreat as one part of his University of Alaska-Anchorage Master's thesis. To identify and map the changes, Cusick had to use several techniques to piece together the history of Exit Glacier.

Using Aerial Photographs

The easiest way to map a glacier's changes is to look at historic aerial photographs. The edge of the ice can be traced on the photograph and dated to when the photograph was taken. Cusick compiled photographs from collections around the state, including federal and state agencies, libraries and museums, the University of Alaska, the City of Seward, and Aeromap US Inc. The series of photos almost covered a 50-year span: 1950, 1961, 1973, 1974, 1978, 1984, 1985, 1993, 1996, 1997, and 1998. Unfortunately, although nearby Seward was incorporated in 1903, the Exit Glacier area had little commercial value and photos found prior to 1950 were oblique. Oblique photos are not taken looking directly downward, and so they could not be used effectively in the computer.

Cusick was able to use some photographs, which he scanned so they could be used in a digital format. To use the photographs together, Cusick needed to georeference them, or specify exact real-world coordinates in the photographs. This then enabled computer mapping software known as GIS (Geographic Information Systems) to overlay each photograph exactly on top of the others, correcting for scale, direction and center point. In order to georeference the photographs, Cusick identified control points that were clear landmarks both in the photographs and on the ground. He determined the real-world coordinates of each control point with a Pathfinder Pro XR GPS receiver and fed these data into the GIS. Once the photographs were scanned and georeferenced, reconstructing the leading edge of the glacier during the past 50 years was a straightforward process: trace the edge of the glacier as it appears in the photograph for each date.

Using Biological Evidence

But what about the glacier prior to 1950? Without aerial photographs researchers had neither identified how far down the valley the glacier extended, nor the shape of the leading edge. Using the series of linear moraines left by the receding glacier, they could determine the shape of the glacier at a particular point in time, corresponding to periods of stagnation. To determine the age of the moraines and reconstruct the history of the glacier, researchers relied on analyzing natural processes that take place in the wake of the glacier.

One of the best methods for aging a moraine is by aging the lichens growing on

Once the photographs were scanned and georeferenced, reconstructing the leading edge of the glacier during the past 50 years was a straightforward process: trace the edge of the glacier as it appears in the photograph for each date.

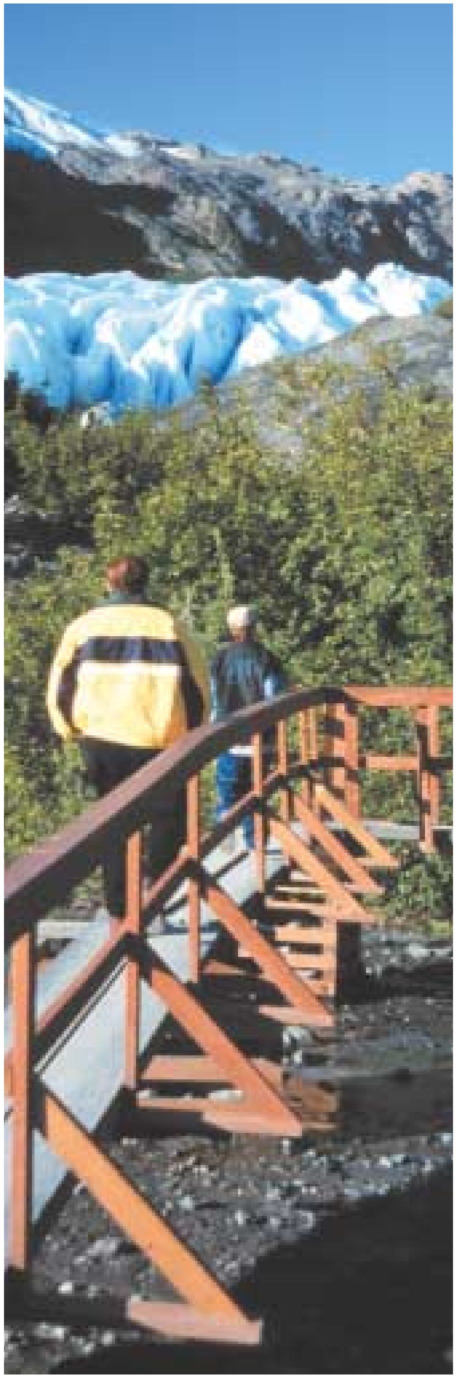
the rocks. When the glacier first recedes creating the moraine, it is barren. Lichen spores soon settle on the rocks and begin to grow, growing at a constant rate determined by the local climate. To calculate that rate, researchers compare lichen from nearby surfaces they can date. For instance, gravestones are completely clean when they are placed in a cemetery and inscribed on each gravestone is the date it was put there. Or slag piles from the railroad construction in Portage, north of Seward, might be used for determining lichen growth rates. Portage is too far away, however; its climate is less maritime and not adequately representative of the Exit Glacier area. In the end, no useful sources for lichen growth rates were found, since the glacier is in a relatively underdeveloped area. Cusick had to find another method.

Dendrochronology - using tree rings to reconstruct history

A very common biological technique, known as dendrochronology, assigns dates to environmental events in the past by counting tree rings. As a tree grows, its

Right: The hike from the parking lot to Exit Glacier is approximately a half mile long.

Far Right: Exit Glacier is one of 38 glaciers that flow out from the Harding Icefield.



National Park Service photograph

Courtesy of Page Spencer, National Park Service

trunk continually grows outward. In spring and early summer the trees grows a soft light-colored wood with larger cells. As growth slows in late summer and fall, the tree cells are much smaller and darker. It is this difference between the early and later growth rates that creates the characteristic ring pattern within the trunk. By counting the number of rings, researchers can determine the number of years of growth, i.e., a tree's age.

Using the oldest tree, if you subtract its age from the year it was sampled, and then subtract the number of years it took for a tree to establish on the moraine, you have the year the moraine was created by the glacier. Sounds easy, until you get started. To date the moraine using trees, a researcher must first decide how long after a glacier retreats from a moraine does it take for a particular species to start growing there. Does it grow the next day, the next year, the next decade? If the moraine is very old, will the first trees have died already, or is there a species that will live for a hundred years?

Several species of trees and shrubs grow in the Exit Glacier Forelands. Alder establish very quickly on disturbed areas and are typically the first trees to colonize the moraines; however, they do not live long enough to date older moraines. Birch trees are not common enough to use consistently. Therefore, researchers eliminated alder and birch as useful markers. Black cottonwood trees *(Populus balsamifera ssp. trichocarpa)* are prevalent along the moraines, and live long enough to date many of the pre-1950s moraines. Unfortunately the rings of cottonwood can be indistinct, because the wood cells do not vary greatly from spring to fall. Cottonwood centers can also be rotten, losing the earlier rings. Cusick relied on averaging multiple counts for the best estimate of age. Sitka spruce *(Picea sitchensis)* takes much longer to grow on the moraines, but it can live a long time and has distinct rings. Therefore, it was used extensively for dating the older moraines.

When determining the age of a tree, the most accurate method is to simply cut down the tree right at ground level and count the rings on the stump. If you count rings that are above ground level, the tree may have grown a few years before the rings appear at the height you cut. The Exit Glacier Forelands, however, are within a national park where trees are protected. Cusick could not cut down the trees. Instead he used tree cores, drilling out a narrow tube of the trunk and counting the rings on the core.

Cusick visited each moraine and selected trees on the top, distal (farthest from the glacier) and proximal (closest to the glacier) sides. The tree with the widest trunk may not be the oldest, since harsher conditions, such as cold glacier breezes or a rocky substrate, can affect a tree's growth. Its trunk may seem narrower than younger trees that started under more favorable conditions. So, Cusick used a combination of trunk size and trunk appearance to select older trees for coring.

The next step was to determine the number of years it takes for specific species to begin growing on a moraine — this is known as the ecesis interval. This interval depends upon the tree species and upon the local climate conditions. Cottonwoods colonize much sooner than spruce, and therefore have a shorter ecesis interval. Previous research showed a wide range of intervals for spruce, 5 to 60 years. Crossen (1997) calculated an ecesis interval of 5 years for cottonwood and 25 years for spruce for Portage, Alaska. To determine whether Crossen's research would be applicable to Exit Glacier, Cusick compared his cores to moraines that were dated from the photographs. One of the photographs showed a moraine being formed in 1950, and the oldest cottonwood on this moraine dated to 1956, according to the core. Since the moraine was still being

When determining the age of a tree, the most accurate method is to simply cut down the tree right at ground level and count the rings on the stump. If you count rings that are above ground level, the tree may have grown a few years before the rings appear at the height you cut. The Exit Glacier Forelands, however, are within a national park where trees are protected. Cusick could not cut down the trees.

formed in 1950, Cusick calculated a 5-year lag, corresponding exactly with Crossen. Cusick then sampled spruce on several moraines to calculate an ecesis interval for spruce. With just a small number of trees, he calculated an average interval of 26 years for spruce. Crossen's estimate was similar, but based on a larger sample size, so Cusick used Crossen's estimate of a 25-year ecesis interval for spruce.

The Reconstructed Exit Glacier History

With the moraines mapped and the ecesis intervals determined, Cusick could now visit each moraine, sample the oldest trees and determine the age of each moraine. Using the moraine dates, Cusick could reconstruct the history of Exit Glacier and its dramatic retreat up the valley.

The Little Ice Age (LIA) was a time of global cooling from approximately 1350 to 1870 AD. During this time glaciers expanded in the northern regions, moving down the mountains and scouring the vegetation that had been in the valleys below. Park Service personnel recently discovered evidence of a buried forest dating back to at least 1170 AD high in the Forelands near the current glacier's edge. Exit Glacier advanced from the Harding Icefield during the Little Ice Age, burying this existing forest and advancing to a maximum marked by the terminal moraine dated to 1815.

With the warming trend of the 1800s, Exit Glacier began to retreat from its 1815 maximum. Very slowly, the glacier retreated 230 feet (70 m) from 1815 to 1889, averaging about 3.1 ft/year (1 m/yr) *(see Table 1)*. The glacier then retreated much more rapidly between 1889-1899, interspersed with periods of stagnation, which are marked by linear moraines (1889, 1891, 1894 and 1899). During this time, the glacier retreated 1680 ft (512 m), about 168 ft/yr (51 m/yr).

The next fifteen years was a period of a slow but steady retreat, as the glacier retreated only 42 ft/yr (13 m/yr). In the years between 1914 and 1917, Exit Glacier experienced its most rapid retreat. In just 3 years, the glacier retreated 908 ft (277 m) or almost a foot per day. From 1917 to 1973, Exit Glacier continued to retreat with periods of slow to moderate retreat. There were five periods of retreat, with the ice melting fastest between 1961 and 1968 (115 ft/yr or 35 m/yr).

During the retreat of Exit Glacier from its Little Ice Age maximum in 1815 until recent times, the glacier has left a series of more than 11 moraines and retreated more than 1.25 miles (2 km). The glacier had an average retreat of roughly 6/10 of a mile each century or one kilometer each century.

Date (Year A.D.)	Distance of Retreat ft (m)	Retreat Rate ft/yr (m/yr)
1815 – 1889	230 (70)	3 (1)
1889 – 1891	299 (91)	151 (46)
1891 – 1894	446 (136)	147 (45)
1894 – 1899	935 (285)	187 (57)
1899 – 1914	630 (192)	43 (13)
1914 – 1917	909 (277)	302 (92)
1917 – 1926	974 (297)	108 (33)
1926 – 1950	469 (143)	23 (7)
1950 – 1961	692 (211)	62 (19)
1961 – 1968	794 (242)	115 (35)
1968 – 1973	171 (52)	33 (10)
Total Retreat		
1815-1999	6549 (1996)	43 (13)

Table 1: Exit Glacier Retreat Distances and rates through Time

Discussion

By identifying the chronology of the Exit Glacier retreat, Cusick has furthered both research and education at Kenai Fjords National Park. Knowing the dates when the valley floor was exposed, researchers have the opportunity to study the processes of vegetative and soil succession. A variety of questions can be explored: How does a rocky, barren expanse slowly become a forested valley? How do soils develop and plants colonize the area? How do insects, birds and mammals move in and an ecosystem evolve?

Visitors to the park can imagine the power of glacial forces by seeing firsthand the effects of the glacier. As visitors proceed up the valley towards the glacier, they are also taking a trip through time. Interpretative signs show when the glacier retreated past points along the way. Similar to hikers in the Grand Canyon, visitors can take a walk through history and experience geologic time in a way no text can ever provide.

More information can be found on the National Park Service website **www.nps.gov/kefj.**

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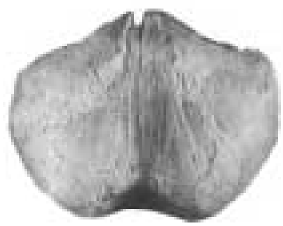
National Park Service photographs

Fossilized for Eternity

Recently, Denali National Park and Preserve confirmed something that many have known for a long time: there are some fossils at Denali and at least one of those fossils is named after a park geologist.

In July of 1996, Phil Brease, park geologist, and Pam Sousanes, park physical science technician, accompanied paleontologist Robert B. Blodgett from Oregon State University on a site investigation at Shellabarger Pass. During four rainy days, they chipped an exposed section of limestone to examine and collect marine fossils that were up to 400 million years old. Numerous species of bivalves, gastropods, trilobites and brachiopods were uncovered in the effort, including a few specimens that may never have been identified before.



Myriospirifer breasei **lived in shallow platform ocean environments.**

National Park Service photograph

In a recent article in the *Journal of the Czech Geological Society* (Volume 46, Number 3-4, Frýda, Blodgett and Megl, 2001), Dr. Blodgett describes a new species of Brachiopod (a clam type mollusc) that came from the Shellabarger effort, and which he has named the *Myriospirifer breasei.* As Blodgett states in the article, "For Phil F. Brease, U.S. National Park Service geologist at Denali National Park, Alaska, who ably assisted one of us (Blodgett) during late July 1996 in the collection of the species."

The genus *Myriospirifer* lived in shallow platform ocean environments in Late Devonian time (391-400 million years ago) around Gondwana and Baltica. *M. breasei* is thought to be of Siberian origin, and arrived in Alaska on a rifted section of that continent. In any case, *M. breasei* is the first newly discovered species, plant or animal, living or dead that occurs inside the park.

Two Parks Recognized as Globally Important Bird Areas

Using scientific information and the recommendations of experts, the American Bird Conservancy's Important Bird Area Program aims to identify and protect a network of key sites in the United States to further national and global bird conservation. Criteria for selection include the role of each area in the ongoing effort to conserve wild birds and their habitats. The American Bird Conservancy has recognized 100 areas in the United States as globally Important Bird Areas including seven areas in Alaska. These include Denali National Park and Preserve, Bering Land Bridge National Preserve, and five U.S. Fish and Wildlife National Refuges: Alaska Maritime, Arctic, Izembek, Yukon Delta, and Yukon Flats. These Alaska areas share the list with 93 other areas across the United States including Big Bend National Park (Texas) and Everglades National Park (Florida).

The Important Bird Area (IBA) concept has led to the recognition and protection of some 3,500 sites throughout the world. Since 1995, the IBA Program has concentrated on identifying and documenting the top sites throughout the United States — those of significance not just on a national but on a global level. Some of these sites are important in conjunction with other sites; they exist as part of a chain along a migratory pathway. Other sites are independent, and a few support species found nowhere else on earth.

The goal of the Important Bird Areas Program is not only recognizing sites, but also mobilizing the resources needed to protect them and the bird populations they support. Recognition is an important first step, since it raises the awareness of the public and of the managing agencies about a site's exceptional value. Moreover, with more than 71 million Americans interested in birds, the public is a powerful constituency for bird conservation.

For more information on the America Bird Conservancy's Important Bird Area Program, visit their web site **http://www.abcbirds.org/ iba/ aboutiba.html.**

Alaska Students Gather to Manage Alaska's Oceans for the Future

As much of the National Park Service focuses on partnerships and education, coastal parks across the nation continue to find creative ways to encourage future stewards of the world's oceans. Kenai Fjords National Park, based in Seward, Alaska, in partnership with state and federal agencies, Alaska schools, and private organizations, co-sponsored an event that blends partnerships, education, and marine protection in new, meaningful, and active ways. The first Alaska Student Ocean Conference was held April 9-10, 2002, at the Alaska SeaLife Center, a nonprofit research aquarium and National Park partner in Seward. The conference will be an annual event.

Nine teachers, each with a group of five middle and/or high school students, were selected to receive funding and support to attend. The groups came from urban centers like Fairbanks, Juneau, Anchorage, and Palmer, and also represented rural Alaska from the villages of Healy, Tok, and Yakutat. Together, students, teachers, and professionals began an exploration of coastal and ocean issues, with dynamic field trips including coastal hikes, boat trips, and computerized marine boating simulations. Meshing academic theory with on-the-ground realities, it was a time for questions, discoveries, and more questions.

As students began to synthesize a vision for the future of Alaska's coast and oceans, they were treated to a discussion with Dr. Sylvia Earle, a world-renowned figure in the exploration and preservation of our planet's marine resources. Dr. Earle currently leads the National Oceanic and Atmospheric Administration's (NOAA) Sustainable Seas Expeditions program, which involves extensive study of our national marine sanctuaries. Keeping her global perspective in mind, students were able to further refine a vision for the future of Alaska's marine resources and draft recommendations on how Alaska might achieve their goals. Throughout the process, students also explored careers in science and natural resource management. The final outcome? Students presented their recommendations to a panel of Alaska environmental policy-makers.

The Alaska Student Ocean Conference's primary sponsors included: the Coastal America Partnership, National Geographic Society, National Park Service, Alaska SeaLife Center, Alaska State Coastal Management Program, and NOAA-National Marine Fisheries Service and Sustainable Seas Expeditions. Other partners who provided staff and expertise included: U.S. Fish and Wildlife Service, U.S. Air Force, Alaska Vocational Technical Center, Army Corps of Engineers, Kenai Peninsula Borough, Qutekcak Shellfish Hatchery, Alaska Marine Conservation Council, Kenai Fjords Tours, Seward Charter Boat Association, The Ocean Conservancy, Alaska Oceans Network, Qutekcak Native Tribe, Alaska State Parks, and U.S. Coast Guard.

This list of partners may seem overwhelming. However, each one provided a vital perspective, helping the students to understand not only the complexity of ocean and coastal management across Alaska, but also the complexity of these issues faced by all in the future.

The Sustainable Seas Expedition (SSE), the Coastal America Partnership, and its Coastal Ecosystem Learning Centers have partnered to reach out to students and teachers from coastal communities around the U.S. to host Student Ocean Conferences. The National Geographic Society, NOAA, and the Richard and Rhonda Goldman Fund established the SSE in 1998. Coastal America is a partnership of federal agencies, including the Department of the Interior and the National Park Service, established in 1992 to protect, preserve and restore our coastal watersheds.

For more information please visit the Alaska Student Ocean Conference website **(www.gov.state.ak.us/dgc).** If you want to find out about co-sponsoring a Student Ocean Conference in your area, visit the Coastal America website describing Student Ocean Conferences **(www.coastalamerica.gov/ text/soc.html).** You can also contact Lisa Matlock, Education Coordinator for the Ocean Alaska Science & Learning Center partnership between Kenai Fjords National Park and the Alaska SeaLife Center, at (907) 224-2148 or lisa_matlock@nps.gov.

New Learning Centers

At Kenai Fjords National Park, design of a new learning center is under way. Annual visitation at Kenai Fjords in the past 10 years has increased from 60,000 to more than 290,000. The present visitor center in Seward is inadequate for both visitors and staff. A multi-agency facility incorporating the needs of the NPS, Forest Service, and other partners will be built on an 11-acre site near the Alaska SeaLife Center, a popular visitor destination and partner with the park.

Denali National Park and Preserve has joined with eight other Alaska national parks to create a world-class center for education and research. The center will provide facilities to support field science and research in Denali NP&P and other northern parks. The staff will develop programs, exhibits, and publications to showcase science and its role in preserving these parklands. Field seminars, lecture series, teacher training, Elderhostel programs and distance learning opportunities highlight some of the programs planned.

Air Time for Peregrine Falcon Chicks

Two one-week-old peregrine falcon chicks in Yukon-Charley Rivers National Preserve in Northeast Alaska were on the air, long before they were in the air.

Although there are 47 peregrine nesting sites in the preserve and nearby areas, the once-endangered falcons are only recently recovering from decimation due to chemicals such as DDT, which prevented successful breeding. As part of an active preservation and education program, each summer a few active peregrine aeries are selected as sites for small remote cameras that transmit a video signal to the National Park Service visitor center in Eagle. Last summer, visitors and residents watched the amazing growth of chicks from birth to first flight. This year, the aerie on Eagle Bluff, just downstream of the historic Yukon River town, will gain a worldwide audience.

National Park Service photograph

There are 47 peregrine nesting areas in Yukon-Charley Rivers National Preserve.

This past spring filming began for an electronic field trip that will air in early December. The National Park Service, with the U.S. Department of Education, the Satellite Educational Resources Commission and One Planet Education, are the prime sponsors of the peregrine program.

Two middle school students from Eagle, Amanda Westphall and Garf Hall, participated with the researchers and the production crew. Both students took an interest in the project last summer, and actively worked with the park on the project in the weeks leading up to the filming. The crew filmed the birds' habitat, watched adult birds flying and bringing food back to the nest and spent time discussing the recovery of the species with biologists.

"Journeys to Living Laboratories" is a six-part series of electronic field trips to locations where endangered species are being studied and protected. The project will compare habitat, recovery, survival and ecosystems of six endangered and threatened species worldwide. In addition to cable and broadcast television programs, the efforts will produce on-line classroom lessons and activities and a DVD for use in classrooms. Other segments will explore the wolves and bears of Yellowstone National Park, the piping plovers of Assateague Island National Seashore in Maryland and the wild dogs and black rhinos of Mkomazi Game Reserve in Tanzania.

Hubbard Glacier Closing Russell Fiord

Hubbard Glacier in Wrangell-St.Elias National Park and Preserve, near Yakutat, continued its advance and for a short time blocked the entrance to Russell Fiord from Disenchantment Bay. Earlier this summer, the Glacier closed off the channel, creating a 39-mile (63 km) long, ice-dammed lake. The dam eventually broke open later in the summer.

For a few tense weeks before the dam broke, water had continued to flow into the fiord from the glacier, causing the water level to rise a half foot per day. The Forest Service convened a multidisiplinary team of specialists to implement monitoring strategies and reactivate monitoring sites in the impacted area.

The last time Hubbard Glacier closed the entrance to Russell Fiord was in May 1986. News media from around the

National Park Service photograph

National Park Service photograph

The last time Hubbard Glacier closed the entrance to Russell Fiord was in May 1986.

world converged on Yakutat, and covered this significant glaciological event. Between May 29 and October 7, runoff from a 695 square miles (1,800 square km) area raised the water level in Russell Lake to 83 feet (25 m) above sea level. The rising water inundated alluvial fans, outwash plains in front of several tributary glaciers and part of the densely forested fringes of the former Russell Fiord. Because of ice calving, the dam narrowed and began to break about midnight on October 7, 1986. Within 24 hours the water level had reached the former high-tide level of Russell Fiord.

In the future, should a stable ice dam form and the lake level rise to an elevation of 131 feet (40 m), Russell Fiord could drain southward into the Situk River drainage, altering a world-class fishery and inundating national forest and private land. The Situk River is a world-renowned steelhead and salmon stream and the most productive stream for its size in Alaska. It is a primary subsistence and commercial stream and has a popular sport fishery with many lodges to support visitation.

Because of the cultural, environmental and economic consequences of Russell Lake draining into the Situk River, citizens and officials of the community of Yakutat, as well as representatives of several state and federal agencies, are showing interest and concern about the behavior of Hubbard Glacier. The Forest Service is taking the lead in the dissemination of information about this significant event; the U.S. Geological Survey (USGS) is providing research and technical expertise; and an interagency team of Forest Service, National Park Service, and USGS representatives is providing ongoing monitoring. Current information and photographs of Hubbard Glacier can be found on the Tongass National Forest's website **www.fs.fed.us/r10/tongass** and the USGS website **www.usgs.gov.**

The results of the data collection benefit the Pacific walrus population and subsistence hunters in both countries, who strive to understand this important resource while co-managing the shared walrus population.

4th Chukotka Walrus Harvest Monitoring Workshop

For the fourth year, U.S. residents met with Russian residents at a workshop conducted in Nome from July 8-12, to discuss the walrus harvest on both sides of the Bering Sea. The National Park Service is funding Kawerak Inc., a regional non-profit corporation for a "Chukotka Walrus Harvest Monitoring Project." The project

National Park Service photograph

The data collected on the harvest is important in documenting and understanding the trends of the Pacific walrus population.

includes an annual workshop that the Eskimo Walrus Commission (EWC) has hosted for three consecutive years in Nome.

The purpose of the workshop and project is to document the subsistence harvest of walrus in eight hunting villages in Chukotka, Russia. Walrus hunters in the villages of Enurimo, Inchoun, Uelen, Lorina, Yanrakynnot, Novo-Chaplino, Sireniki and Enmelen provide data and biological samples to researchers. The efforts in Russia correspond to similar efforts in the U.S. in which walrus hunters in the villages of Gambell, Savoonga, Diomede, Wales and Shishmaref provide information and biological samples to walrus harvest monitors.

The data collected on the harvest is important in documenting and understanding the trends of the Pacific walrus population. The results of the data collection benefit the Pacific walrus population and subsistence hunters in both countries, who strive to understand this important resource while co-managing the shared walrus population.

Alaska's National Parks Contain Many Unsolved Mysteries

The mission of the National Park Service is to protect the diverse species of plants and animals found in national parks, including species such as lanternfish and shrews. Given the number of extinctions in the last century, it is easy to see the importance of species diversity and the protection of rare species.

Why has a rare species of shrew appeared at Yukon-Charley Rivers National Preserve and Wrangell-St. Elias National Park and Preserve? Why are the normally nocturnal lanternfish at Glacier Bay National Park making daytime appearances?

Thanks to a new natural resources inventory program in Alaska's national parks, we may soon have answers to some of these puzzling questions. As scientists and citizens around the country debate issues of resource management, global warming and appropriate recreational use in national parks, this inventory program focuses on collecting baseline data about resources in national parks. The information can then be useful in guiding and making scientifically sound decisions.

For instance, at Glacier Bay National Park and Preserve, marine biologists have observed rarely documented behaviors in lanternfish. Lanternfish are named for their one-time use as fuel in lanterns. They are an important part of the food chain, since they are a rich food source for many marine mammals, birds and larger fish. Until recently, scientists thought these fish were nocturnal, spending the daytime in deep waters and coming to the surface at night to feed. Recent fieldwork found lanternfish at the surface in great numbers during the day, but only in active glacial fjords. It is suspected that the water melting from glaciers is cloudy enough to hide the lanternfish from predators during the day (Mike Litzow, U.S. Geological Survey, Alaska Science Center), changing our knowledge about lanternfish behaviour.

In the parks of Northwest Alaska, Cape Krusenstern National Monument, Bering Land Bridge National Preserve and Noatak National Preserve, 16 plants considered rare or critically imperiled have been found that were previously undocumented in these parks. One of these, *Potentilla fragiformis,* a handsome flower with five petals, was known only in Russia and has never before been documented in North America.

At Yukon-Charley Rivers and Wrangell-St. Elias, both in eastern Alaska, researchers from the University of Alaska found 10 shrews from the species that is aptly named "tiny shrew." Before the inventory at these parks began, specimens had only been found in Central and

National Park Service photographs

Southcentral Alaska. Through the new program, we are greatly expanding our under-standing of this species' range and habitat requirements.

The mission of the National Park Service is to protect the diverse species of plants and animals found in national parks, including species such as lanternfish and shrews. Given the number of extinctions in the last century, it is easy to see the importance of species diversity and the protection of rare species.

Congress has funded the Inventory and Monitoring Program as a part of a Natural Resource Challenge to improve science and stewardship in national parks. The National Park Service is collaborating with scientists and researchers from universities and other agencies. The inventory program will serve as a baseline for long-term monitoring of plants, animals and environmental conditions like air and water quality. It will help park managers and researchers better understand arctic and sub-arctic ecosystems, information essential to unlocking the mysteries of global warming, ecosystem dynamics and natural variation.

Weather at the Top of North America

Climbers from the Japanese Alpine Club installed an improved weather station at 19,200 feet on Mt. McKinley last June. It sends real-time weather data to scientists at University of Alaska Fairbanks, and daily updates are posted on the web (www.denali.gi.alaska.edu). The new wind gauge replaces one that was routinely destroyed because it could not withstand gusts exceeding 200 mph. The resulting data from the new weather station will be of great scientific interest and could also be an additional forecasting tool for climbers. It was originally placed for that purpose after Japanese adventurer Naomi Uemura's tragic disappearance in 1984, just after he became the first person to reach the summit alone in winter.

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Amphibian Flashcards

The Inventory & Monitoring Program (I&M) just received 250 copies of Amphibians of Alaska. This seven-page set of waterproof flashcards was developed and designed to aid in the identification of amphibians found in our National Parks. This educational product shows the five most commonly occurring species of frogs, toads, salamanders and newts in Alaska. The Inventory & Monitoring Program will be sending copies to parks for distribution to field crews, volunteer groups, schools and visiting scientists.

These flashcards are a part of a region-wide Opportunistic Survey of Amphibians. A field form and Geographic Information System (GIS) database product have also been created to keep track of viable observations by trained staff and volunteers. This is an exciting new learning resource that scientists, interpreters, seasonal field crews, local community members and others can use.

Effects of Low-Level Military Flights on Calving Caribou

At an estimated 40,000 strong, the Fortymile Caribou Herd is one of the most prominent caribou herds of Interior Alaska. Although 40,000 animals is a substantial number of caribou, this estimate is well below the historical high of more than 500,000 caribou of the 1920s. In addition to fewer animals, the Fortymile Caribou Herd currently occupies only a fraction of its historical range. In recent years, the herd has been in the news due to the Alaska Department of Fish and Game's efforts to increase herd production and growth in an attempt return the herd to its historical numbers and distribution. The National Park Service has an interest in this herd not only for its intrinsic value but also as an important component of the Yukon-Charley Rivers National Preserve ecology. The U.S. Air Force. too, has a great interest in the herd as the entire herd distribution is overlaid by airspace designated as a Military Operations Area. As such, the U.S. Air Force conducts substantial aircraft training over land areas that are critical to the well-being of the herd.

Previous studies on other herds of caribou have shown relatively mild behavioral responses of caribou to military jet flights, but no studies have been conducted during the sensitive calving period. In May 2002, a new research project was initiated through a cooperative effort of the Alaska Department of Fish and Game, the National Park Service, and the U.S. Air Force. A team of biologists and forward ground controllers took to the field in areas just east and south of the Preserve. Behavior of cow caribou and cows with calves was observed before, during and immediately following low-level military jet overflights. Movements of radio-collared caribou and survival of newborn calves in relation to overflight history were also recorded. Field efforts for this study coincided with the calving period and ran from mid-May through early June. Researchers are in the process of sorting and organizing the large amount of data collected during this short field season.

National Park Service photograph

Hollow caribou hair traps substantial air for excellent insulation against the cold.

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Adult bulls can accumulate fat deposits — mostly on their back and rump — that weigh 60 pounds or more in early fall.

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National Park Service photograph

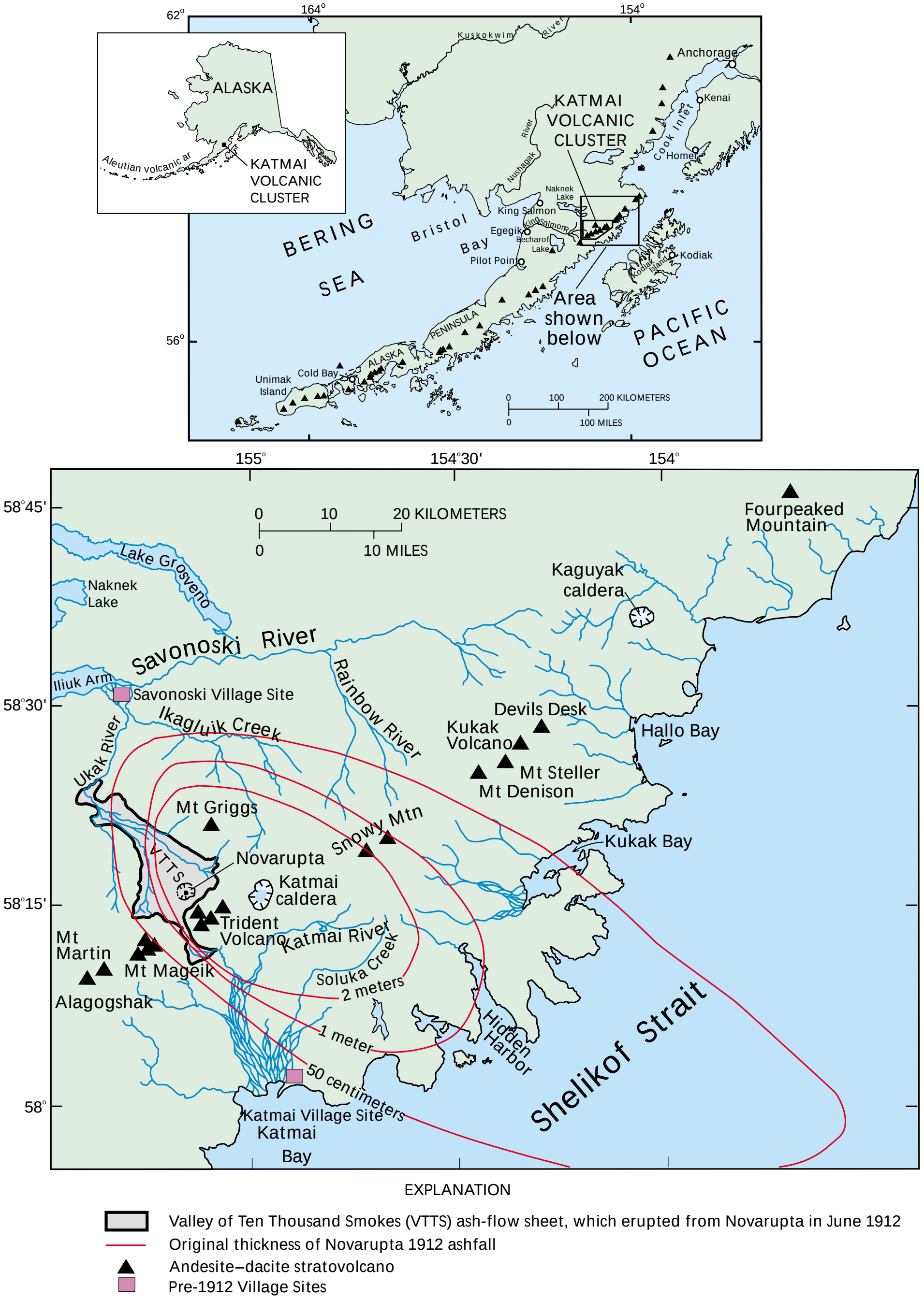

Figure 1. Regional geographic setting of the Katmai volcanic cluster with respect to other young volcanoes of the Aleutian arc. (modified from Fierstein and Hildreth, 2001)

dammed for three years until a very heavy snowmelt in 1915; the dam was breached and an enormous flood broke out into Katmai Canyon. Prior to his exploration of the Valley of Ten Thousand Smokes, botanist Dr. Robert F. Griggs landed on the shore of Katmai Bay in 1915—nearly 19 miles (30 km) downstream from Katmai Canyon. There he "found the countryside ravaged by a great flood whose waters were just subsiding." *(Griggs, 1922)*. Although Griggs called it a 'flood', a great volume of debris was also transported during this event. The tidal-flat area, 6 miles (10 km) wide, was choked with pumice and ash, turning upriver stretches of land into quicksand and destroying Katmai village (already abandoned in 1912). Trees were snapped off near ground level for several miles by the violent impact of the water, a fan of huge boulders was deposited at the mouth of the canyon, and the water volume was so great that it flooded the valley to a depth of approximately 10 feet (3 m) *(J. Fierstein, personal communication, 2002)*.

Katmai National Monument and the Discovery of a New Volcano

In 1916, the National Geographic Society funded an expedition to Katmai led by botanist Dr. Robert F. Griggs. This was the first group of scientific explorers to visit the Katmai region. Mount Katmai was believed to be the source of the material erupted over those three days in June 1912. Within the broken edifice of a decapitated Mount Katmai, Griggs and his party saw a lake 2 miles (3 km) wide of robin's egg blue water and a small dacite lava dome they named Horseshoe Island *(Griggs, 1922)*.

Figure 2. The Valley of Ten Thousand Smokes at sunset, mountains in back are, left to right, Jule Peak and Griggs (formerly known as Knife Peak).

This island is now submerged beneath 820 feet (250 m) of lake water (Fig. 4) *(Fierstein and Hildreth, 2001)*. Only six miles (10 km) south of Mount Katmai, the party discovered another newly formed volcanic dome, a crumb cake of gray rock about 1,200 feet in diameter and 150 feet high, which they named Novarupta (Latin for new vent) *(Fig. 4) (Rozell, 2001)*. West of these two volcanic features lay voluminous flows of volcanic ash that filled the valley to as much as 650 feet (200 m) deep. Griggs named this area the "Valley of Ten Thousand Smokes" for the numerous jets of steam ascending from the hot volcanic material covering the valley floor *(Fig. 5) (Fierstein and Hildreth, 2001)*.

In 1918 Griggs' descriptions of these spectacular features helped persuade President Woodrow Wilson to designate Katmai National Monument, to preserve the dramatic landscape for future generations to experience and for scientific study *(Guffanti, 2001)*. In the 1930s Katmai National Monument was described as, "not only the largest, but also the most spec-

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