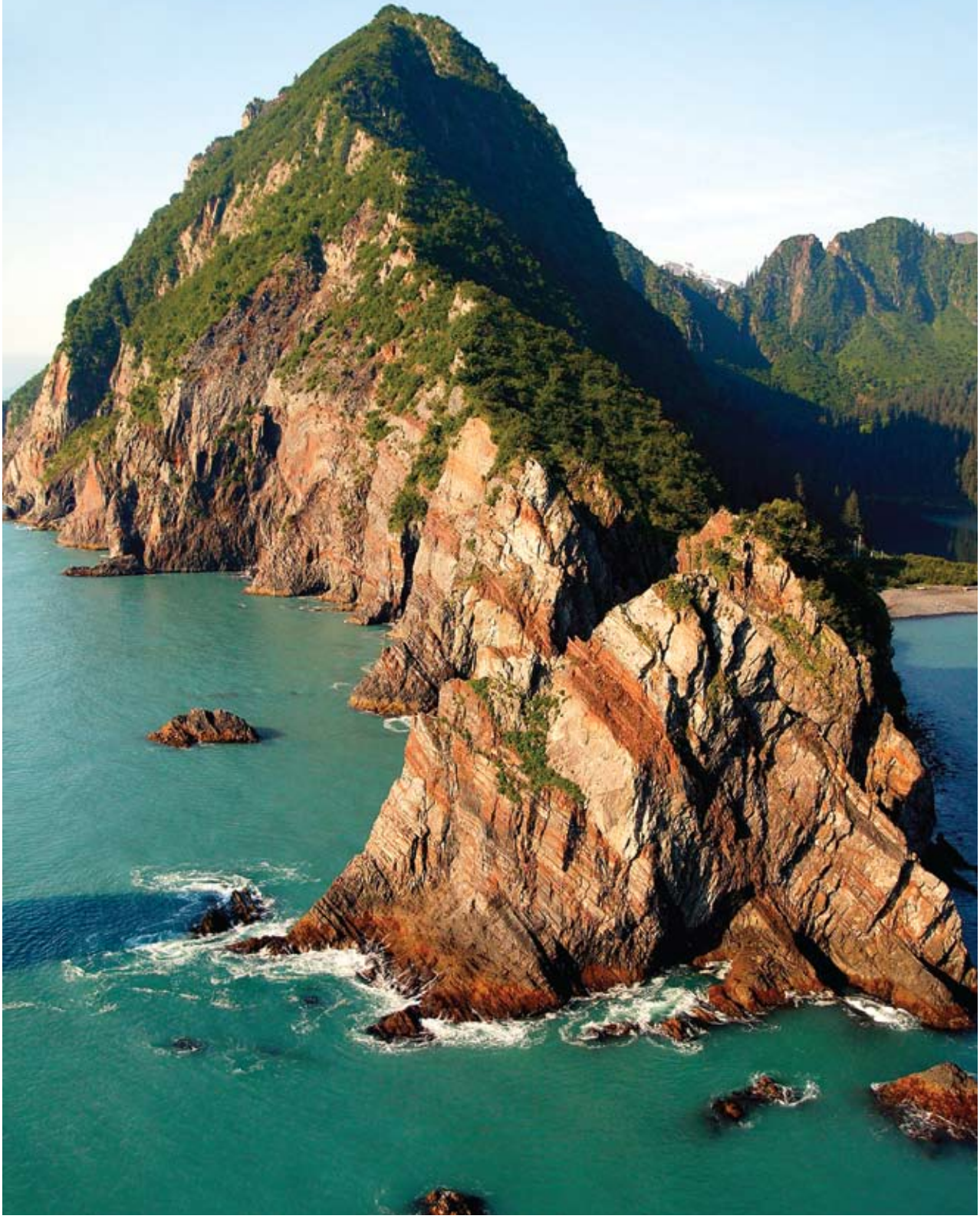
Teachers Resource Manual

National Park Service
U.S. Department of the Interior

Forging Connections: An Education Resource for Kenai Fjords National Park



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Introduction

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Within the National Parks lies all the subject matter necessary for a model elementary and secondary education. From the stories of our country's founding to the history of our Earth's crust, the topics of history, geology, civil rights, conservation, and many more are available in one of the nation's 391 parks. In this edition of the Teacher's Resource Manual, our goal is to tempt teachers to enrich their student's learning with lesson plans and topic discussions of the resources in Kenai Fjords National Park.

The Teachers Resource Manual expands upon Forging Connections, a manual originally written for new interpreters at the park. In this manual, five lesson plans incorporate ideas to help teachers excite students about glaciers, fjords, temperate rainforests, and the scientific method. In addition, eight new sections have been added to the previous manual: Climate Change, Alutiiq History, Harbor Seals, and Dall's Porpoise all address important topics that were not incorporated in the original manual; Temperate Rainforest Ecololgy, Succession in a Glacial Environment, The Harding Icefield, and the Fjord Estuary Ecosystem have been added to help
provide detail about the varied surroundings of the park. Three chapters—Glaciers, Steller Sea Lions, and Geology—have been completely rewritten and expanded upon.

Although sections have been added, re-written and created for a new audience, this manual still aims to help its readers create programs, both for the classroom and the public that will result in enjoyable, relevant, and theme-based interpretation. To further aid teachers and interpreters, there is a thematic index at the back of the manual to show how various topics emphasize specific themes.

This manual is an ongoing effort. This edition expands upon but does not exhaust the topics of Kenai Fjords National Park. We hope that the new format will allow for easy exploration by educators inspired with the myriad of subjects found in the park.

I would like to thank all of the people below for their important contributions to the Teachers Resource Manual.

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Sincerely,

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National Park Service
U.S. Department of the Interior

Kenai Fjords National Park, Alaska

Cultural History

Connected to the Land: The Alutiiq of the Outer Kenai Coast

Kenai Fjords is a place of great change. From the glaciers to the seasons, and from seismic activity to weather and plants or other living things, nothing here stays the same.

The Alutiiq (Sugpiaq) Native people survived here for centuries by following the natural rhythms of Kenai Fjords. They were tuned in to the ongoing changes of this place they called home. Through an acute awareness, they were able to adapt and survive for centuries in a place that later people would dismiss as rugged and inhospitable.

Indeed, some of these extremes would turn out to be their very key to survival. Although Kenai Fjords is not a place where domestication of plants and animals would be widespread, the cycles of nature would lay out an abundant table for its inhabitants. This bounty did not come without great effort, however, and it was available only to those willing to work in concert with others.

Sparsely Settled

Research indicates the Prince William Sound and outer Kenai coast areas in 1800 were not as densely populated as Kodiak Island. Russians and explorers from Britain and Spain estimated a population of 600 people in the early days of contact (Crowell 2006:4). Yet 37 archeological sites have been identified within Kenai Fjords National Park (Crowell 2006:6) and it is estimated there were five villages on the outer Kenai coast at the time of contact (Crowell 2006:6).

Although archeological evidence from Kodiak Island suggests human occupation dating back more than 6,000 years, the Kenai Fjords sites don't offer similar proof. Studies by archeologist Dr. Aron Crowell indicate village occupation in Aialik Bay dating back to 950 (Crowell 2006:2) and human habitation in McCarty Fjord as early as 250 (Crowell & Mann 1998:60). According to Crowell, this absence of older sites on the outer Kenai coast is "the result of the geological factors and almost certainly does not reflect a late date of first occupation" (Crowell & Mann 1998:67).

"Alutiiq" is a contemporary term describing the indigenous people of the area stretching from Chignik Lagoon on the Alaska Peninsula up to the outer Kenai coast and extending to Prince William Sound. It stems from "Aleut," used by Russians encountering coastal Alaskans in the 1740s.

Maybe with better communication, Russians would have realized that folks in this area called themselves "Sugpiaq" or "real people." Sugpiaq included Chugachmiut in Prince William Sound and Lower Cook Inlet, and Koniag on Kodiak Island and the Alaska Peninsula. Unegkurmiut, meaning "people out that way," was a specific reference to people of the outer Kenai coast (DeLaguna 1956:34).

Many factors contribute to the difficulty of pinpointing when the area was first settled. Glaciers and earthquakes have long played a role in Kenai Fjords' history. Advancing glaciers during the Little Ice Age undoubtedly erased archeological evidence. Other sites disappeared in the coastal subsidence following massive earthquakes known to occur in this seismically active region. Shorelines sank two meters in Aialik Bay (Crowell 2006:5) during the 9.2 magnitude earthquake in 1964 and a similar amount in an even greater magnitude quake in 1170 (Crowell & Mann 1998:50).

Adapting to Survive

Mobility was a keystone to the Alutiiq way of life. They used kayaks to do their hunting, fishing, and gathering chores in the marine environment. The larger anyaq boat allowed village residents to pick up and move to different sites throughout the seasons. Nothing was done haphazardly. By the time the salmon runs began in the summer, the villagers had relocated to fish camps at the stream mouths. Reflecting the seasonal nature of a fish camp, these sites were movable as were other short-term camps such as those used for egg collecting and seal hunting (Crowell & Mann 1998:69). The larger sites with multiple house pits occurred in areas of larger resource diversity where people stayed for greater lengths of time due to the expanded availability of food and other resources (Crowell & Mann 1998:155).

Sea travel.

There was a great cooperative effort in the spring through autumn months as people prepared sufficient food stores to get them through the winter when fish were not readily available (Crowell & Mann 1998:153). Storms and snow restricted travel during the winter and more time was spent inside.

During the Little Ice Age (approx. 1100-1800 AD), glaciers in Kenai Fjords extended far beyond their present-day termini. Native people moved from a Harris Bay village site in the early- to mid-1700s when a tidewater glacier got too close, its calving ice stirring the waters and sometimes blocking travel (Crowell & Mann 1998:115). Lives of the Alutiiq in an Aialik Bay settlement were disrupted by two different geologic events: An earthquake in 1170 caused people to leave their homes and the village was subsequently resettled, but a volcanic eruption (circa 1277-1401) caused the people to leave once again (Crowell 2006:6).

People of the outer Kenai coast adapted to all sorts of changes, including the arrival of Russians with their outposts at Alexandrovsky (English Bay and later Nanwalek) in 1786 and Voskresenskii (Seward) in 1793. Unlike other areas where Russian traders took hostages and forced Alaska Natives to hunt for sea otters, it is thought that hunters of the outer Kenai coast received tobacco, beads, and other trade goods for their furs. The people from Aialik Bay did not have problems with food shortages like those indicated by archeological sites of the Koniag on Kodiak Island during this period (Crowell 2006:43).

The establishment of the Russian Orthodox mission in Kenai in 1844 caused some Alutiiq people to leave the outer Kenai coast for Lower Cook Inlet (Cook & Norris 1998:60). The cash economy of fish canneries in Nanwalek in the late 1800s also offered a reliable way to earn a living and more families left the outer coast. Beginning with the 1890 Census, there was no further indication of Alutiiq villages on the outer Kenai coast but many Alutiiq people still used the area for subsistence. Subsistence in this area still continues to this day.

Mary Forgal of Alutiiq-Russian ancestry was married to Frank Lowell who had come to Alaska from Maine and become a trader for the Alaska Commercial Company. It is believed the 1883 volcanic eruption of Mount Augustine in Cook Inlet and ensuing tidal waves were the reasons the Lowell family left Alexandrovsky in 1884 and moved to the head of Resurrection Bay (Brue 2006:7). Two decades later, Mary Lowell would sell her homestead to the man who created the town of Seward and started construction of Alaska Central Railway.

Cleaning fish.

Archeological Digs Help Tell the Story

In 2001, a project designed to link studies in archeology, oral history, and environment began in order to gain a greater understanding of the past and how it relates to the present. People from the communities of Nanwalek, Port Graham, and Seldovia who are descendants of the outer Kenai coast peoples have joined with the National Park Service and the Smithsonian's Arctic Studies Center to conduct a series of archeological digs in Kenai Fjords National Park. Through their oral history and observations, Alutiiq descendants are helping interpret artifacts from these historic sites. Their participation also follows a desire for connection with their history.

Looking at animal bones found in middens, researchers can track how changing temperatures and glacial conditions affected the local food supply and, in turn, how that correlated to human settlement patterns. Scientists believe areas of high resource diversity had more continuous settlement because key resources were available no matter what part of the climate cycle they were in (Crowell 2006:68).

"During cold phases, salmon decline but forage fish such as herring and capelin increase, supporting larger populations of seals, sea lions, and other predators," wrote Dr. Crowell in 2006 when explaining an archeological survey planned for Nuka Bay. These areas with colder waters would attract hunters. Bones found in the middens indicate larger marine mammals during the Little Ice Age.

The subsistence way of life is oftentimes described as being in complete harmony with nature, but some see it simply as another form of economics. Either way you look at it, subsistence doesn't just apply to food; it also entails acquiring materials needed for clothing, shelter, transportation, medicine, and tools (Crowell & Mann 1998:A13). In a cash economy, compensation for labor helps an individual obtain the items necessary for life. In a subsistence economy, an individual's daily tasks are geared to this acquisition of necessities. There are few times when they are "off the clock."

Sifting through the items recovered in the archeological digs, Crowell is able to determine when each particular site was occupied—whether it was prior to Russian contact or shortly after contact. As the Alutiiq people increased their level of trade with the Russians, more copper and iron tools, beads, and china would show up, and less stone tools would be found.

Native Lands within the Park

Descendants of the outer coast Alutiiq people continued to return to the Kenai Fjords in the decades following their move to Lower Cook Inlet. Men would often use their outer coast subsistence camps from October through April, and return to Port Graham and Nanwalek for summer jobs in the fish canneries (Crowell 2006: 66, 68). This subsistence

activity tapered off in the 1930s-40s and was almost non-existent by the time Kenai Fjords National Park was created in 1980.

During the land selection process of the Alaska Native Claims Settlement Act, both Port Graham Corporation and English Bay Native Corporation chose ancestral lands that fell within the boundaries of Kenai Fjords National Park. English Bay Native Corporation eventually sold its 32,000 acres to the park, while Port Graham retains ownership of more than 42,000 acres within park boundaries.

English Bay did retain rights to cultural resources of the lands sold to the National Park Service.

Elders visit a 200 year-old site in the park.

Franklin G. Lowell

Franklin G. Lowell was born around 1848 in West Bath, Maine. His father died before he was five years old and by age 11, Frank was apprenticed to his mother's brother, a ship builder. He grew up among ship builders and sea captains, leaving Maine with an uncle when he was about 15 years old. They sailed around Cape Horn, came through San Francisco, and arrived in Sitka between 1867 and 1868. We know that Frank arrived first in Sitka, Alaska through interviews with Frank's daughter, Eva Lowell Revell Simons. Sitka was also the place where most ships coming up from California entered the new territory. Eva says her father first married an Aleut woman and they had a son. One year later, he moved west to the Kenai Peninsula at English Bay, present day Nanwalek, where he married Mary Forgal Lowell.

Like most sourdoughs, Frank had his hand in many enterprises: taking the census, selling salted salmon, and setting up trading posts. He outfitted Native parties who hunted fur-bearing mammals in return for their supplies and other European goods. With the drop in fur prices, the eruption of Mt. Augustine in 1883, and the economic conditions in the villages along Cook Inlet, Frank and Mary, along with several Native families, moved to the shores of Resurrection Bay. For Frank, it was a short but prosperous period living in the present day area of Seward. Eva tells us Frank had a trading post affiliated with the Alaska Commercial Company, buying fur from Native hunters and selling dried goods. She says the family had several houses in the vicinity, including a cabin beyond Lowell Point, their home on the waterfront, and several other small out-buildings as far inland as Bear Lake.

It is not clear exactly when Frank began working directly for the Alaska Commercial Company, but in 1889 he became the new agent for the Wrangell station on the outer coast of the Alaska Peninsula. As an agent for the Alaska Commercial Company and a private entrepreneur, Frank Lowell employed Alutiiq Natives to hunt sea otters and other fur-bearing mammals (black bear, fox, marten, mink, and river otter) on the outer coast of what is now Kenai Fjords National Park. The story of Frank Lowell's outposts

Resurrection Bay Historical Society photograph

This is the only known photo of Frank (1912). Frank is standing with his coat over his arm beside the captain of one of the Alaska Commercial Company boats.

Franklin G. Lowell and his family are known as the first homesteaders to settle the Seward area in 1883. Many locations throughout the Seward area are named for his family—Lowell Point, Lowell Creek, Mt. Alice and Mt. Eva. During his time in Seward, Lowell operated trading posts in the area that is now Kenai Fjords National Park and employed many Alutiiq Native hunters.

Many people wonder if Frank Lowell is related to James Russell Lowell and the Lowell family of Massachusetts. He is related, but the relationship is distant. In 1639, Percival Lowell and his family immigrated to Newbury, Massachusetts. They had three children: two sons and a daughter. Their daughter died without children but the two sons, John and Richard, sired the future Lowell dynasty. Francis Cabot Lowell, founder of Lowell, Massachusetts, was the seventh generation descendant of John Lowell; James Russell Lowell was his eighth generation descendant (not father and son, but cousins). Frank Lowell was the ninth generation descendant of Richard Lowell. Frank's parents were Eliphalet E. Lowell and Nancy Jane Manson. Frank was born in 1848 and his parents were later married on September 29, 1850. His father died when he was only a few years old, his mother died in 1873.

and stores are integral to the park's cultural history in Aialik Bay. His crews hunted and set up winter camps along the coast between English and Resurrection bays, including Aialik Bay and Nuka Bay.

Eva tells us her father operated a trading post from Resurrection Bay until 1892. Perhaps Frank traveled between the two sites, providing for his family as the fur trade declined after years of over hunting. Frank was the Alaska Commercial Company agent for the Wrangell fur trading station until 1898, a year when no sea otters were taken. The station could not pay expenses and the Alaska Commercial Company halted all credit to Native hunters.

Eva Lowell says her mother, Mary Forgal, refused to leave Resurrection Bay when Frank left the Alaska Commercial Company in the Cook Inlet area. From Alaska Commercial Company records, we know that Frank continued to send supplies to Resurrection Bay, paying for the supplies with fur traded to the company. Frank and Mary's older children ran trap lines, hunted, and fished. In 1903, with her children almost grown, Mary sold her homestead rights to Frank Ballaine, who's brother John was the future founder of Seward.

On August 26, 1895, Frank married Aralena Koshon and they eventually had four children together. Their oldest daughter, Anna, married Benny Benson's father. Benny was the Alutiiq orphan boy who designed the Alaska state flag.

In 1910, census records identify Frank living on Chirikof Island fox farming. The same census records his daughters, Anna and Emma, living in the Herman Orphanage of Kodiak. It is assumed his wife, Aralena Koshon, died in the measles epidemic that swept through Native villages, including Port Wrangell, before the census was taken. Eva visited her father on Chirikof Island in 1912 just after the eruption of the Katmai Volcano. Shortly after her visit, Frank began blue fox farming with John Benson. Frank died at Chignik in 1923. His obituary mentions that three daughters and three sons survived him.

Rockwell Kent

Rockwell Kent was born June 21, 1882, in Tarrytown Heights, New York. Prior to his time spent in Alaska, Kent lived and painted on Monhegan Island off the coast of Maine, and in Newfoundland. There he developed a love for cold, northern climates, fjords, and the isolation of island life.

In 1908, Kent married Kathleen Whiting and began his struggle to support a growing family. He often relied on his skills as an architect, designer, and builder to earn a living. Kent was a socialist, a pacifist, a lover of German culture, and spoke and read German fluently. World War One, with all its anti-German propaganda, depressed him and made him feel extremely alienated from society. In 1914, he and his family were forced to leave Newfoundland because of his pro-German sentiments. At age 36, his marriage was in trouble and he had spent over 10 years trying to earn a living as a professional artist and felt he was failing. His work was known and respected, but he still had to do odd jobs to support his family. He wondered whether he'd ever earn a living as an artist and occasionally thought of moving to Germany, or even committing suicide.

His trip to Alaska was perhaps an attempt to salvage his career and prove his artistic worth. His need for solitude, isolation, and escape from depression also brought him to Alaska. "I crave snow-topped mountains, dreary wastes, and the cruel Northern Sea with its hard horizons at the edge of the world where infinite space begins. Here skies are clearer and deeper and, for the greater wonders they reveal, a thousand times more eloquent of the eternal mystery than those of softer lands."

Kent and his nine-year-old son, also named Rockwell, arrived in Seward aboard the steamer *Admiral Farragut* on Saturday, August 14, 1918. He stayed in Seward at the Sexton Hotel for several days inquiring about a suitable place to settle. He sought a location "that combined the quiet dignity of the primitive forest with the excitement of the ever-changing ocean." He found Fox Island soon after he arrived.

Fox Island NPS photograph by Allison LaDuke

Rockwell Kent is believed to be the first American artist to paint what is now Kenai Fjords National Park. His paintings of the park include several of Bear Glacier and many of the Resurrection Bay and Fox Island area. Kent wrote about his experience living on Fox Island in *Wilderness: A Journal of Quiet Adventure in Alaska* (1920).

When Kent arrived on Fox Island, a 71-year-old Swede and Alaska pioneer named Lars Matt Olson lived there and ran a fox farm and goat ranch in partnership with Thomas W. Hawkins of Brown and Hawkins General Store. Olson had come to Alaska in the 1880s, and gave the Kents use of a dirty goat shed that Kent refurbished using his skills as a carpenter and builder.

Kent returned to New York in March 1919 after spending only seven months in Alaska. He had wanted to stay through the summer of 1919, but his wife wanted him home. He tried unsuccessfully to get her to leave the children with his mother and come to Alaska, and he feared she would leave him if he didn't return.

Even though his time in Alaska was short, it represented the turning point of his professional life. Upon his return to New York, he had a show of his Fox Island sketches. They sold out and his friends urged him to write and illustrate a book using his letters and journal. Kent settled in Vermont with his family, worked on his Alaska paintings, and wrote *Wilderness: A Journal of Quiet Adventure in Alaska*. Its publication in 1920 coincided with a successful show of his paintings. *The New York Times* described it as a "very beautiful and poignant record of one of the most unusual adventures ever chronicled." Critics compared his work to Walt Whitman's *Leaves of Grass* and the writings of Henry David Thoreau.

Kent wrote extensively about the surrounding climate and topography of Fox Island in *Wilderness*. He described Bear Glacier as a place from which, "the winds blow forever fiercely and ice cold." He also wrote about the experience of living in isolation and the meaning of wilderness. "It seems," Kent writes, "that we have…turned out the beaten, crowded way and come to stand face to face with that infinite and unfathomable thing which is wilderness; and here we found OURSELVES—for the wilderness is nothing else." Like so many travelers to Alaska, Rockwell Kent found healing, solace, inspiration, and was forever changed by the beauty of the Alaska landscape.

During the 1920s and 1930s, Kent became one of America's most respected and highly paid graphic artists. He illustrated hundreds of books, including books about his travels to Tierra del Fuego and Greenland.

Fox Island NPS photograph by Allison LaDuke

Kent eventually died on March 13, 1971, in Plattsburgh, New York. He continues to be known as a painter, writer, architect, wood engraver, political activist, laborer, lobster fishermen, union organizer, and lecturer.

Natural History

Land Mammals

Black Bear

Ursus americanus

Basic Facts

Color is not a distinguishing characteristic for the black bear. Phases of the black bear can be cinnamon, black, blonde, and even blue. Black bears differ from brown bears in several ways: they lack the shoulder hump, have a longer snout, and generally have shorter front claws. The weight of the black bear varies from 125 to 500 pounds, depending greatly on environmental conditions such as climate and food availability. In general, the length of a black bear is five feet long and 35-40 inches tall when on all four feet. Black bears have been recorded to reach speeds over 25 miles per hour for a short distance.

They may live to be 25 years in the wild. Man is their only real predator, however, adult male black bears have been known to kill and eat cubs.

© Ron Niebrugge courtesy of NPS

Habitat Range and Local Sightings

The American black bear is the most common bear species native to North America and can be found from Alaska to Mexico and from the Atlantic to the Pacific, including 41 of the 50 U.S. states. In Alaska, black bears occur over most of the state's forested areas and, depending on the season, from sea level to alpine zones. They are not found on the Seward Peninsula, the Yukon-Kuskokwim Delta, or north of the Brooks Range. Black bears are excellent tree climbers and will use trees to escape from danger. Whenever possible, black bears travel to and from food sources along stream corridors dense with shrubbery.

Home ranges are determined by food types, abundance, and availability, and can be as small as one square mile or as great as 100 square miles. In general, females have a home range of two to 10 square miles while males normally have a home range, which is four times larger. The range of every adult bear is composed of an individual territory part of which constitutes its exclusive domain, while the rest it shares with other bears. The home range of a mature male bear will often overlap the home range of several female bears.

The majority of local black bear sightings in the park have been at Exit Glacier due to its accessibility. There have also been numerous sightings throughout the fjords system during the summer season. Boat passengers cruising the fjords can see bears on mountain ledges. As deciduous shrubs and trees leaf out in early summer, bears are more difficult to spot from the tour boats.

Food and Survival Strategies

Black bears are opportunistic feeders with a diet consisting of more than 75 percent vegetable matter. The remaining portion of their diet consists of animal matter such as decaying animal carcasses, fish, small marine animals, and insects. Seasonal availability and geographic location are the biggest factors determining the primary food sources of bears.

During late summer and early fall, black bears start to eat continuously and may gain as much as 30 pounds while preparing for hibernation. Most black bears will hibernate for between four and seven months, depending on the climate of a region. During hibernation, a bear's heart rate will drop from 40-70 beats per minute to 8-12 beats per minute, while metabolism slows down by half and body temperature may reduce slightly (3-9 degrees F). During the entire period of hibernation, black bears do not pass urea or solid fecal waste. Most black bears leave their winter dens in April or May, depending on physiological and climatic conditions. Generally adult males emerge first, while females with newborn cubs are usually the last to leave their dens.

Reproduction and Young

Black bears reach breeding maturity at about four or five years of age, and breed every two to three years. Females practice delayed implantation in which the fertilized ovum development is arrested for about six months. If the mother has not gained enough fat to sustain herself as well as produce cubs, the embryo will not implant. If the season is a successful one, soon after denning the embryo will begin to develop and the cub will be born after a period of eight weeks. From one to four cubs are born blind and hairless, each weighing eight to 11 ounces. The cubs are weaned between July and September of their first year, but remain with their mother through the first winter after birth.

Human Connections

Today, a major threat to the American black bear is widespread poaching. Asian markets will pay generously for bear gall bladders and paws, considered to have medicinal value in China, Japan, and Korea. The demand for these parts also affects grizzly and polar bears. In Alaska, it is illegal to purchase, sell, or barter any part of a bear.

Bear hunting is popular in Alaska and, with proper management, can occur without causing populations to decline. Bear hunting seasons are held in both spring and fall in some areas, but only in fall in other areas. Cubs and females with offspring may not be killed.

Within Kenai Fjords National Park, we have the responsibility to see to the health and safety of the wildlife while also protecting visitors. Past park research has helped determine how bears respond to issues such as backcountry campsite use, vessels moored near shore, noise levels of people and vessels, and effects of group size. In the end, the balance that the park strives for will hopefully serve the bears as well as the people who wish to see them.

Brown Bear
Ursus arctos

Basic Facts

The most important item to clarify is that a brown bear and a grizzly bear are the same animal, *Ursus arctos*. There is a tendency to refer to the bear that lives in the interior as a 'grizzly' and its coastal inhabitant as a 'brown bear'. The difference is mainly a result of food availability. Coastal bears have greater access to rich supplies of protein obtained through feeding on salmon. Bears in the interior have a diet that lacks this protein so their coat tends to be lighter in color and they tend to be smaller. Brown bears on Kodiak Island are classified as a distinct subspecies, *Ursus arctos middendorffi*, from those on the mainland because they are genetically and physically isolated.

NPS photograph by Jim Pfeiffenberger

In contrast to the black bear, brown bears have a shoulder hump and a "dish-shaped" or concave face. Brown bears are fast for their size, able to attain speeds of 35 miles per hour for a short distance. They have an especially good sense of smell and under the right conditions may be able to detect odors more than a mile away. Their hearing and eyesight are equivalent to that of humans. They may live to 34 years in the wild, though this is rare, generally males live to 22, females 26.

Bears are lean in the spring or early summer when they emerge from hibernation. In contrast, they gain weight rapidly during late summer and fall and are very large just prior to denning. Stores of fat will bring a male's weight to between 500 and 900 pounds, while a weight of 1,400 pounds is not unheard of in the fall. Females weigh about 250 to 600 pounds in the fall. Adult brown bears stand approximately 3.5 feet tall when on all fours, and have a body length of just over seven feet.

Habitat Range and Local Sightings

Brown bears occur throughout Alaska, except on the islands south of Frederick Sound in southeastern Alaska, the islands west of Unimak in the Aleutian Chain, and the islands of the Bering Sea. The population on the Kenai Peninsula is estimated at 250-300 bears.

An animal conducts its normal activities in its home range: gathering food, mating and caring for its young. The size of the home range is extremely dynamic and varies from one geographic region to another, and also from year to year. The size of the home range of an individual brown bear will vary with the concentration of high-energy food sources. The more concentrated the food sources, the smaller the range necessary to maintain the animal. For example, adult male brown bears living in the Brooks Range have an average home range of approximately 521 square miles. Brown bears living in salmon-rich coastal areas, on the other hand, require

only about 10.5 square miles. Brown bears do not normally defend their home ranges from other bears, so it is normal for the home ranges of individual bears to overlap each other.

In Kenai Fjords, brown bears have been seen around Exit Glacier during the spring (May) and fall, even though this is predominantly a black bear habitat. There have also been observations of brown bears in Nuka Bay, around Pederson Glacier, and in Northwestern Fjord.

Food and Survival Strategies

Brown bears are opportunistic feeders, fond of any carrion and often found eating garbage in human dumps. Typically they eat more than 75 percent vegetable matter consisting of berries, flowers, grasses, herbs, and roots. The remaining 25 percent consists of decaying carcasses, fish, insects, elk and moose calves, and a variety of other small mammals. Due to their large size, brown bears require a very high caloric intake of food. In order to achieve this, brown bears will eat 80 to 90 pounds of food per day in the summer and early fall. During this eating binge, in preparation for hibernation, brown bears are able to gain three to six pounds of fat each day. Hibernation lasts from five to eight months in the coldest parts of the brown bear's range. However, in warmer areas, like Kodiak Island, some bears may remain active throughout the winter season.

Reproduction and Young

Female brown bears normally become sexually mature at five or six years of age, their average litter is two cubs and the interval between litters is three to four years. Mating occurs between late May and early July. Females are capable of delayed implantation. If a female does not have enough fat reserves for the winter the embryo will not implant and simply be reabsorbed. Sometime around the denning period, the embryo will attach itself to the uterine wall and after a period of eight weeks (January or February), the cubs will be born while the mother is still in hibernation.

At birth, the cubs are blind and hairless, and very tiny—weighing less than a pound. They are able to move sufficiently to suckle on their mother who remains asleep. Her milk is very rich (over 20 percent fat), allowing the cubs to gain weight quickly in preparation to leave the den in April or May.

Human Connections

Alaska is home to over 98 percent of the United States population of brown bears, and more than 70 percent of the entire North American population. Bear hunting is popular in Alaska and, with proper management, can occur without causing populations to decline. Bear hunting seasons are held in both spring and fall in some areas, but only in fall in other areas. Cubs and females with offspring may not be killed.

In the mid-1980s, Alaska Department of Fish and Game, United States Fish and Wildlife Service, the Forest Service, and National Park Service established an Interagency Brown Bear Study Team (IBBST) to monitor and research brown bears on the Kenai Peninsula in order to assess population and long-term cumulative effects on habitat from continued development. In November 1998, Alaska Department of Fish and Game announced the designation of the Kenai brown bear population as an Alaska Species of Special Concern.

Moose
Alces alces gigas

Basic Facts

The moose is the largest member of the deer family. *Alces alces gigas* is the subspecies of moose found in Alaska. *Gigas* means "giant," and the Alaska moose is the largest of its species. An adult male moose stands six to seven feet tall at the shoulder, is nine feet long from head to rump, and can weigh as much as 1,600 pounds (females can reach 1,300 pounds). Moose have long legs, a huge muscular hump on its back just beyond the head, big ears, and no tail. Its long snout is decorated underneath with a flap of skin called the "dewlap," a structure used to release scent during the rut.

NPS photograph by Jim Pfeiffenberger

As with all members of the deer family, male moose grow antlers each year beginning in April or May. Moose antlers match the rest of the animal in terms of size, reaching up to seven feet across and weighing 70 pounds. During a four-month period of growth, antlers can gain as much as a half a pound a day. In the fall, the soft tissue calcifies and hardens, and the "velvet" which covers the antlers falls off. The antlers are shed sometime between November and January.

Habitat Range and Local Sightings

Worldwide, moose can be found in the northern forests of North America, Russia, and Europe. In Alaska, they are found from the Stikine River in Southeast to the Colville River on the Arctic Slope. The Alaska subspecies is also found in the Yukon Territory as well as northwest British Columbia.

Moose habitat varies with the season. In the summer, moose are found in open vegetated areas. They spend much of their time along streams and lakes where food is abundant. In the winter, moose are more likely to be found in the forest where there is some protection from snowfall. Their territory can be anywhere from a few miles to 60 miles, depending upon the proximity of vegetation and protective areas.

Moose are frequently sighted throughout Alaska, often along highways and roads. In Kenai Fjords National Park, good moose viewing can be found off the Seward Highway near Mile 5 and along Exit Glacier Road. During the summer season, the Exit Glacier area regularly hosts one or two females with calves.

Food and Survival Strategies

Spring and summer provide a nicely mixed diet for moose. In spring, they feed on sedges, horsetail, pondweeds, and grasses. Summer feeding is crucial to winter survival and reproduction for a moose, and during this time they add the new fleshy leaves and tips of willow and cottonwood twigs to their diet. When snows are deep, moose tend to feed on the cambium layer of trees. This habit girdles the trees as the moose must strip the bark off to get to the cambium. Frequently in the black cotton-

wood forest around Exit Glacier one can find trees that have been girdled by moose.

A snowy winter can be a fight for survival even for a healthy moose. Male moose often begin winter with their stored fat running low after a hard rut, while pregnant females struggle to eat enough to support their developing calf and keep themselves going. Deep snow makes both eating and walking difficult as long legs easily sink into snow that is not packed. Consequently, moose often walk along train tracks and highways, causing greater danger from moving vehicles. Wolves, brown bears, and black bears all prey on moose, especially young calves in the spring and summer.

Reproduction and Young

Reproduction is closely linked to nutrition in moose. When food is available and predation is low, a moose population can quickly expand to fill a range. A female moose usually begins to breed between 16 and 28 months and gives birth to twins as often as 90 percent of the time. Triplets occur in about one in 1,000 births. If conditions are poor, however, a moose will wait three or four years before having its first calf and can skip years between calving. The rut occurs in September and early October, as bulls challenge each other by bringing their antlers together and pushing. After a gestation period of almost eight months, calves are born in May or June. They can eat solid food just a few days after birth and are weaned in the fall when females begin breeding.

Human Connections

Moose are the most hunted big game species in Alaska. An average of 7,000 animals are harvested each year, providing more than three million pounds of meat. Their value as a big game species makes moose very important for the Alaska Department of Fish and Game and therefore the animal is well researched.

The local moose population at Exit Glacier has often been referred to as the park's "gardening team." The effects of moose browsing are quite evident along the main paved trail to the glacier. Researchers in the field of moose biology call moose "ecosystem engineers" due to their ability to affect change in their environment.

Mountain Goat
Oreamnos americanus

Basic Facts

In Southcentral Alaska, there are two all-white species of hoofed animals that roam the mountains: Dall sheep and mountain goats. In Kenai Fjords National Park and the surrounding area, only the mountain goat exists. Sheep can be found further inland, where the snow tends to be drier and access to food sources easier. Goats, on the other hand, tend to be stronger and larger and are thus better able to access food in the park, where snow is heavier and wetter.

Mountain goats are not true goats at all, but belong to the antelope family. The hooves of mountain goats consist of two toes that can move independently from each other, allowing for its stunning agility on steep terrain. Mountain goats are very muscular animals with well-developed shoulder muscles to give it great climbing strength and aid in its ability to dig for food in winter. Both male and female mountain goats have black shiny horns that grow about 8-12 inches in length. Horns produce annual growth rings that can age the goat: A two-year-old has one ring, a three-year-old has two, and so on. Their fur is thick and long with coarse hollow guard hair that grows nearly eight inches long to keep them warm in the winter.

NPS photograph by Matt Gray

Habitat Range and Local Sightings

The mountain goat is found among the steep and rugged mountains of northwestern North America from Idaho to Washington, through British Columbia and into Southcentral Alaska. Mountain goat populations are scattered throughout this range and can be found from sea level to elevations over 10,000 feet. In Alaska, mountain goats occur throughout the southeastern Panhandle, and north and west along the coastal mountains to Cook Inlet. Their range extends into the Talkeetna Mountains nearly to Denali National Park.

It is estimated that 3,600 to 4,600 mountain goats occupy the Kenai Peninsula.

Goats are often spotted while climbing the Harding Icefield Trail during the late spring and summer months. Boat tours in Resurrection Bay often see goats between Caines Head and Callisto Head on the west side of the bay. This area has been nicknamed “goat alley” since it is not uncommon to spot nannies right next to the shoreline where they give birth to their kids during the last week of May and first week of June. Later in the season, as the nannies move into the alpine areas, goats are spotted in large groups at high elevations all around the bay.

Food and Survival Strategies

The mountain goat is a very versatile eater, consuming lichens, ferns, grasses, herbs, shrubs, and deciduous or coniferous trees. In the spring and early summer, they follow the flush of nutritious new growth up hill. By summer, goats usually graze on grasses, lichens and low-growing shrubs in high alpine meadows. Goats move to lower elevations in winter where hemlock and lichen become more prevalent in the diet. Toward the end of winter and beginning of spring, goats in the park work their way down to the intertidal zone. After an impoverished winter diet, they increase their salt and mineral intake by feeding on kelp.

Bears, wolves, eagles, and wolverines are all predators of the mountain goats, especially first-year kids. Much of the mountain goat's behavior is a strategy to avoid these animals. Climbing on steep, rocky slopes that other animals can't navigate is their most frequent form of defense. Females travel close behind kids where eagles might try to knock them off their feet. In the end, gravity and avalanches take more mountain goats than any animal seeking prey.

Reproduction and Young

Female mountain goats breed for the first time when they are about two years old. Although males are also sexually mature at this time, the older more dominant billies usually do the breeding. Males begin to get ready to rut in November, when they dig urine pits where they can wallow, soil, and scent their coats. During this time, billies spend little time eating and there is an increase in threats to other males as they begin following nannies at a distance. Only when the nannies are in estrus will the billies approach closely. Mating begins with low body stretches, lip curls, and nuzzling by the males.

Gestation takes about six months. In Kenai Fjords, pregnant females make their way down steep cliffs to the sea to give birth. Nannies find secluded beaches with surrounding territory that only a goat could scale. Nannies give birth to one kid, and rarely to twins, that is ready to ascend the steep cliffs 10 to 14 days after birth. Once the nanny and her kid are back in the mountains, they will group together with other nannies and kids forming bands of 5-20 animals. Billies are never found in these bands and are generally loners outside of the rutting season.

Human Connections

The mountain goat's precipitous habitat has protected it not only from four-footed predators but also from bipedal humans. It wasn't until 1900 that much was known about this cliff-hopping creature. There are early stories of Captain Cook obtaining mountain goat hides, but at that time he assumed they were the pelts of some unknown bear species.

Native Alaskans have used goat fur for blankets and the hide of the animal acted as 'non-skid' treads for the soles of their shoes. Goat horns were softened with steam, and then bent and carved into serving utensils by Alutiiq craftsmen.

Natural History

Marine Mammals

Dall's Porpoise
Phocoenoides dalli

NOAA photograph

Basic Facts

The Dall's porpoise is a member of the family *Phocoenidae* otherwise known as "true" porpoises. Porpoise comes from a Greek word meaning, "pig faced" describing the blunt snout and stocky body form. It is named after W.H. Dall the American zoologist who wrote about and sketched two specimens taken off the coast of Alaska in 1873. The average adult is six feet in length and weighs 300 pounds. Porpoises have small, spade-shaped teeth unlike the cone-shaped teeth of dolphins and other toothed whales. They also have distinctive rigid, protruding growths between each tooth called "gum teeth" which are thought to be used in grasping slippery prey items such as squid. Often reported by visitors as "little orcas," they are black with a bright white region on the belly and flank that extends from mid-body almost to the flukes. The dorsal fin is small and triangular, and often has a gray or white patch starting at the tip and down most of the trailing edge. Considered one of the fastest of the smaller cetaceans, they are known to reach speeds of close to 35 miles per hour, often causing a distinctive "rooster tail" of spray as the dorsal fin hits the surface. Similar to some dolphin species, they often play about ships "porpoising" and riding on the bow waves. The oldest known age is 22 years.

Worldwide population is estimated to be just over one million, while the Alaska stock is estimated at 83,000. Predators include transient orcas and, less frequently, sharks.

Habitat Range and Local Sightings

Their range is from Japan, around the north Pacific Rim, to Baja California. Because they prefer cool water, they are generally pelagic with localized migrations. Exceptions include nearer shore year-round populations in Japan, the Kamchatka Peninsula, Puget Sound, British Columbia, the Aleutians, and Alaska's inside waters, such as the cooler, glacier-fed waters of Kenai Fjords National Park.

	Dall's porpoise are often spotted fishing at the mouth of Resurrection Bay, in front of Bear Glacier, on the crossing to Aialik Bay and within the first part of Aialik Bay. They often come to ride the bow wake of the boats.
Food and Survival Strategies	They commonly feed on animals that live deeper than 590 feet. Their diet includes fish such as herring and anchovies as well squid and crustaceans. They have also been observed in the company of resident orcas feeding on salmon.
Reproduction and Young	The male is sexually mature at five to eight years and the females at three to seven years. Females give birth every three years with a gestation period of 11 to 12 months. At birth, the calf is approximately three feet in length.
Human Connections	Dall's porpoise meat has been used as food, the blubber for an oil source, and the bones ground for fertilizer mainly in Japanese fisheries. In Japan in the 1960s, an estimated 2,500 were caught per year for food with an estimated 10,000 to 20,000 taken as commercial by-catch in salmon gill nets.

Pacific White-Sided Dolphin

Lagenorhynchus obliquidens

NOAA photograph by Beth Hacker

Basic Facts

White-sided dolphins are gregarious, often found in groups of up to several thousand individuals. They seem to enjoy an encounter with a boat and seek out and travel with other species of dolphins, and even baleen whales. Among marine biologists, they are commonly called "lags" (a shortening of their genus). A group of lags can be observed from a great distance as what looks like a boiling of the ocean water. This is caused by their frequent, almost unceasing show of acrobatics. These dolphins swim fast and regularly leave the water in pairs and trios. The Pacific white-sided dolphin is the only dolphin of the eastern Pacific known to turn complete somersaults under natural conditions. Lags are conically shaped, toothed marine mammals with a prominent melon, a short black beak, and a robust body. They have a black back with white side stripes, called "suspenders," stretching from their forehead along their ribs to their anus, and light gray from forehead along the sides. They also have a white belly and a tall two-toned dorsal fin that is curved and resembles a hook. An average adult is seven and a half feet long and weighs 300 pounds.

Habitat Range and Local Sightings

Most reported sightings of these dolphins come from temperate, offshore waters in the north Pacific. They are believed to move close to the Southern California shore in the winter and spring, and then move north and farther out to sea in the summer and fall with excursions inshore following runs of prey. Until recent years they were rarely seen close to shore in our area, but then began appearing more and more. During the 2003 summer season, they were seen often enough that it caused great disappointment when they could not be found. In 2006 and 2007, these sightings again became rare. When spotted, the animals are almost always located at the edge of open water on a line between Barwell Island and No Name Island.

Food and Survival Strategies

Pacific white-sided dolphins feed in large groups on a variety of small schooling fish such as herring, anchovy, capelin, sandlance, hake, and also squid. A pod will often coordinate and circle a school of fish to trap them and then feed extensively.

Lags swim in large groups and will often care for a sick or injured member of their group. Transient orcas are the top predator.

A study in British Columbia correlated the presence of the dolphins with capelin that had also recently come to the area. It is possible that subtle changes in the Kenai Fjords ecosystem are bringing Pacific white-sided dolphins into the area.

Reproduction and Young

Pacific white-sided dolphins may breed and calve in the spring and summer. After a 10- to 12-month gestation period, a three-foot calf is born. A female can reproduce as often as every two years, but most give birth once every three years. This species of dolphin may live to 45 years.

Human Connections

They are still harvested off the coast of Japan, but are at a lower level of commercial harvest than other marine mammals hunted there. Accidental deaths occur when these animals get caught up in fishing nets.

Killer Whale

Orcinus orca

Basic Facts

Killer whales, or orcas, are the largest member of the dolphin family, reaching a length of 23 to 26 feet and weighing four to eight tons. Seeing orcas attack large whales, eighteenth century Basque whalers called the predator "ballena assasina" meaning, "whale killer." Orcas are predatory sea mammals belonging to the suborder Odontoceti or toothed cetacean. Orcas display a prominent dorsal fin easily seen when the animal surfaces. A mature male's dorsal fin is roughly triangular and can extend up to six feet out of the water. Females and sub-adults have smaller, more crescent-shaped dorsal fins. Orcas have a black body and white chin, belly and patch behind the eye. They also have a gray saddle patch behind the dorsal fin. Researchers use black and white photos of the saddle patch and dorsal fin, viewed from the left side, to identify individual whales.

Orcas become sexually mature at 10 to 15 years of age. Upon maturing, the male dorsal fin begins to straighten and grow. The growth spurt distinguishes the male dorsal fin from the female. It takes about five to six years for the fin to reach its full length of up to six feet in height.

© Ron Niebrugge courtesy of NPS

The life expectancy of killer whales is not yet certain. Using mortality rates among known populations, scientists estimate that these whales live 30 to 50 years. Several females among local resident pods in Alaska have reached over 50 years of age. It is believed some individuals, mostly female, may occasionally reach 80 to 90 years of age. Mature orcas are the top predator, while sharks may also prey upon the young. Except for hunting in the past by humans, most death is thought to be due to age, disease, and environmental toxins such as DDT and PCBs. Examination of carcasses indicates tooth wear and gum disease as well as environmental toxins are problems for the orcas in this area.

Habitat Range and Local Sightings

Three kinds of orcas—resident, transient, and offshore—roam the waters around Kenai Fjords National Park. DNA analysis reveals that the three types are genetically distinct populations. Resident and transient populations are most frequently observed. These two types of orcas share the same waters, but their diets differ and they have not been observed associating or interbreeding. Residents eat fish and have a range of at least 800 miles. Transients eat marine mammals and have a range of at least 1,500 miles. Offshore orcas typically live in open ocean areas; during the summer, groups of offshores—or unidentified orcas—turn up in Kenai Fjords. The diet of offshore orcas is not as well known and varies with location and pod (family). Some offshore orcas are known to feed on baleen whales and some pods are believed to possibly feed on sharks.

Food and Survival Strategies

Resident orcas in the Kenai Fjords and Prince William Sound areas eat silver salmon more than any other fish. The resident orcas also eat halibut and occasionally herring.

Transient orcas in this area feed on harbor seals, Dall's porpoise, harbor porpoise, and sea lions. Transients are stealthier than resident orcas because of the nature of their prey. It is for this reason that viewing transients can be challenging. Transients surface briefly in small groups. They seem to dive and travel beneath the water a long distance. They also employ a technique of traveling close to shore, where rocks may camouflage their dorsal fins.

The orca brain is exceptionally large and complex. Particularly well developed, the auditory portion of their brain allows them to transmit and analyze subtle differences in sound. Using echolocation, orcas generate auditory "pictures" so precise that they can pick a silver salmon out of a school of mixed fish. The orca directs its echoes to enhance the acoustic picture; this provides the whale with information about direction, speed, size, shape, and texture of its target.

Reproduction and Young

Orca whales share strong social bonds and a complex social structure. Pods are matriarchal societies composed of multigenerational groups. Both male and female orcas tend to remain with their mother's pod for life. Sub-pods form if the group gets too big. A sub-pod is still associated with the original matriarchal group, but often travels on its own.

Females usually bear their first calf between the ages of 12 and 17. Mating generally occurs in late summer and early fall, although it can occur at any time. After a 13- to 16-month gestation period, most calves are born in the winter or early spring. The long gestation period produces well-developed offspring; a newborn has the ability to swim to the surface for its first breath. Calves are seven to nine feet long at birth, weigh about 400 pounds, and may nurse for a year or longer.

Orcas are not known to mate within their own pod. Instead, several pods come together and males from one pod will join another pod to mate. This gathering of pods is called a "super pod." During the mating period, orcas in the super pod breach, spyhop, lob their tails, and display other social behaviors.

Locally, there is one day during the summer that a super pod is often observed. From 1992 to 1997 on August 1 in Prince William Sound, researchers recorded a super pod aggregation in Montague Strait; however, in 1998 it seemed as if the pod moved to the Kenai Fjords. Since 1998, super pods have been seen on and around August 1 in the Kenai Fjords.

Human Connections

Native arts and legends celebrate the orca. Orca whales hunt and fish for the same foods that some Native peoples use. These people revere the whale and respect its abilities as a predator. Historically, cultures less familiar with the orca feared the powerful predators as vicious killers. No documented case exists of a wild orca killing a human.

The viewing of orcas in aquariums, on TV, and in the movies has changed public sentiment dramatically. Current attitudes toward orcas and other cetaceans show a new public consciousness about the environment and the protection of wildlife.

One group of transient orcas in our area, the "AT1" group, lost 14 of its 22 members after the 1989 Exxon Valdez oil spill. No new calves have been born into this group. As of 2007, the group was down to six individuals. This group of whales is now listed as "depleted" under the Marine Mammal Protection Act. The whales from the AT1 group carry some of the highest levels of industrial contaminants found in any marine mammal. Toxins like DDT and PCBs decrease the effectiveness of the animals' immune system and could be causing reproductive failure in this group.

Minke Whale

Balaenoptera acutorostrata

Basic Facts

Minke was an eighteenth century Norwegian whaler who regularly broke the rules regarding the size of whale he was permitted to hunt. Soon, all the small whales became known as "Minke" whales. In time, the name was formally adopted as the name for this species.

The minke whale is a member of the suborder Mysticete, or mustached whale. The smallest baleen whales in the North Pacific, they average 27 feet and weigh five to nine tons. Their mouth houses 260 to 360 plates of baleen at 12 inches each. They have a narrow, acutely pointed, triangular rostrum. Their highly variable dorsal fin is on the last third of their back. They are a bluish dark gray above with a lighter coloring below. A bright white patch or diagonal band goes across the top of the pectoral fin. They have a low and indistinct blow that starts underwater and continues half a meter out of the water. This makes spotting the blow especially difficult in all but the calmest weather. As they blow, their fin appears simultaneously and flukes are never shown.

NOAA photograph by Pat McGuire

In the Kenai Fjords, we apply the name "Stinky Minke" when referring to this animal. The nickname is due to the difficulty in spotting a minke twice. The minke has a habit of staying down for extended periods and may be on the surface for just a few blows before diving for 20 minutes.

Habitat Range and Local Sightings

Isolated populations of minkes live in the north Pacific, north Atlantic, and the Southern Hemisphere. The International Whaling Commission considers the North Pacific stock to be a "Protection Stock" because of the high uncertainty of the estimated numbers. Minke whales are not listed as endangered, but the population in the north Pacific (between 17,000 and 28,000) is considerably smaller than that of the north Atlantic or Southern Hemisphere.

In Alaska, we find minkes traveling through bays and shallow coastal waters in the summer months. In the park, Pilot Rock seems to be the most likely place to spot a minke. Minkes move to subtropical areas in the winter, although their migrations do not always follow strict seasonal patterns.

Food and Survival Strategies

Minke whales in the North Pacific feed mostly on krill and sandlance. Southern populations of minkes have a more varied diet including many more fish and squid.

Reproduction and Young

Female minke whales ovulate twice a year, in February and August. The gestation period for these animals is 10 to 11 months. A newborn calf weighs about 1,000 pounds and is about 10 feet in length. They stay close to their mother, suckling for four to five months. Young minkes become sexually mature at age six for males and seven for females. Minke whales live an average of 50 years. Transient orca whales may prey on young minke whales.

Human Connection

The International Whaling Commission banned the hunting of all whales in 1986. However, no one is bound by the ban because the commission rules let members reject its rulings. In 2004, Norway planned to harvest 640 whales and is the only country today that still hunts whale for profit. The Institute of Cetacean Research is a nonprofit Japanese research organization that studies the interaction of marine mammals and fish populations. In part, the organization is funded by the sales of minke whale meat harvested for research purposes.

Humpback Whale
Megaptera novaengliae

NOAA photograph by Janice Waite

Basic Facts

The humpback whale is a member of the Balaenopteridae family of baleen whales. Whales in this group feed by straining prey through baleen plates lining the roof of their mouths. Male humpbacks reach an average of 46 feet and 25 tons, females an average of 49 feet and 35 tons. The humpback has a distinctive body shape and unusually long pectoral fins (flippers), which are nearly one-third of their total body length. The dorsal fin shape varies, but is often a small triangular nubbin with a step or hump most noticeable when the whale arches its back to dive and from which it derives its common name. They are often white or partially white in color and the underside of the fluke (tail) often has white markings unique to each whale.

Humpback whales are listed as an endangered species with a worldwide population estimated in 2007 at 30,000 to 40,000 whales. The North Pacific population seen in Alaska is estimated at around 6,000 whales.

Habitat Range and Local Sightings

Humpbacks travel between winter breeding grounds and summer feeding grounds. The animals that spend their summer in Kenai Fjords National Park winter in Hawaii and Mexico, and may travel as far as the Chukchi Sea. Locally, we find humpback whales throughout Resurrection Bay and the waters surrounding Kenai Fjords National Park. Several spots near the Chiswell Islands also attract feeding humpbacks.

Food and Survival Strategies

Humpback whales spend from mid-April until November feeding around Kenai Fjords National Park. Each day a humpback eats approximately a ton of food. When feeding, 12 to 36 ventral throat grooves allow a humpback whale's mouth to swell to enormous proportions. A humpback can hold 500 gallons of seawater laden with prey in its mouth. Using its tongue, the animal pushes the water out through up to 400 two-foot long baleen plates hanging down from each side of its upper jaw. The prey catches on the baleen and is swallowed. Euphausiids (krill), copepods, and small schooling fish, such as white capelin and herring, make up much of a humpback's diet.

Reproduction and Young

Humpbacks breed and give birth during the winter months in Hawaii and Mexico. Gestation lasts about 11 months, and every one to three years a single calf is born. Twinning happens occasionally, but often only one animal will survive. At birth, a calf is 16 feet long and weighs two tons. Humpback calves stay with their mothers and nurse heavily, building a fat layer, before making their first migration north to Alaska's cold waters. Young calves, as well as older whales, must watch out for transient orcas, their biggest predator.

Male humpback whales sing songs in their winter breeding grounds. The songs contain two to eight "themes" always sung in sequence. A whale can sing for 20 minutes or as much as seven hours. Singing may be used to show a whale's dominance among males competing for a female. Male humpbacks interested in mating with a female become her "escort." They follow behind and below a female cow and calf, waiting until the female is receptive. A male sometimes instigates a skirmish using its barnacle encrusted chin and the front edge of its pectoral fins as weapons against a rival. Older males often show scarring along their backs from these interactions.

Human Connections

The extensive migration of the humpback whale underscores how rich an environment the Kenai Fjords ecosystem is: Swimming nearly 3,000 miles, the humpback comes all the way to Alaska to feed. Here, it finds water with enough nutrients and oxygen to support the volume of food necessary for its sustenance. During the summer months, it is able to add the three to four inches of blubber necessary to see it through the winter.

Historically, humpbacks were hunted for their oil, meat, and baleen. Humpbacks proved an easy target for hunters because they tend to feed close to land. By the time a ban on international whaling was drawn up in 1964, the population of humpback whales was as low as 1,000 animals.

A comprehensive study known as the Structure of Populations, Levels of Abundance and Status of Humpback Whales, or SPLASH, initiated in December 2003, hopes to further refine our knowledge of North Pacific humpback populations. SPLASH research took place in Russia, Mexico, Alaska, and the Philippines. The research goal is to understand population structure and assess status trends and human impacts to the humpback population.

Fin Whale
Balaenoptera physalus

NOAA photograph by Janice Waite

Basic Facts

The fin whale is a member of the Mysticete (mustached) suborder of whales. The second largest whale on the planet, fin whales reach 70 to 80 feet in length and weigh 40 to 80 tons. Fin whales have a distinctive V-shaped pattern of coloration around their head called a "chevron." Although the overall visible color of the animal is dark gray, the right side of the head, upper lip, lower lip, and a portion of the baleen are white. They sometimes have dark ear and eye stripes in a pattern that is called a "blaze." The dorsal fin of the whale is also distinct. Researchers classify dorsal fins into one of six different shapes and this, along with scaring, chevron and blaze patterns, is what they use to identify individuals. A fin whale's flukes are broad and triangular, and its head is pointed. Called the "greyhound of the sea," the sleek, muscular fin whale swims at speeds up to 20 miles per hour. Upon surfacing, the fin whale lets go a blow 18 to 20 feet high. From a distance it might be mistaken for a humpback whale, but the length between the blow and the dorsal fin is much greater for the fin whale. The fin whale rarely shows its flukes when diving.

Habitat Range and Local Sightings

Fin whales are found in all the world's oceans, but tend to stay in deep water. Fjords provide the right environment for spotting fin whales. In Kenai Fjords, we tend to see fin whales just two or three times a season, usually quite early (May) and again much later in the season (August). The area between the end of the Resurrection Peninsula and Cheval Island and on over towards Agnes Cove is the best place in the park to spot a fin whale.

Food and Survival Strategies	The fin whale is a filter feeder with 500 to 900, three-foot-long baleen plates hanging from the roof of its mouth and 64 ventral throat grooves allowing for expansion of the mouth. The plates and throat grooves enable the whale to take in huge quantities of water laden with prey and then strain out the food. Eastern north Pacific fin whales spend the summer months feeding in the waters of	Alaska. They eat euphasiids (krill), copepods, and small schooling fish like herring and capelin. Fin whales have no tight social organization but sometimes travel in groups of 2-10, employing a circling technique to corral a school of fish before gulping a large mouth full of water filled with food.
Reproduction and Young	Fin whales found in Alaska during the summer spend their winters off of Mexico, where they breed and give birth. Gestation lasts a full year, and females give birth only once every two years. A calf weighs about four tons and is 22 feet long at birth. Young whales nurse for six to seven months and leave their mothers soon after this time.	Sexual maturity is reached by age six for males and seven for females. It is quite possible that fin whales live to be 100 years of age. Transient orca whales may prey on young fin whales. There have been several incidents recorded of young fin whales stranding but exact cause of death in these cases is unknown.
Human Connections	When the blue whale population became depleted from hunting, attention turned toward the fin whale. The fin whale was faster than most whaling boats in the early days but as technology improved, the whalers could keep up. Between 1950 and	1960, about 30,000 fin whales were taken each year. In 1972, the Marine Mammal Protection Act kept fin whales in U.S. waters safe, but it wasn't until 1986 that fin whales were protected worldwide.

Harbor Seal

Phoca vitulina

Basic Facts

The harbor seal is a member of the family Phocidae or "true earless or hair seals." Only a wrinkling or opening in the skin denotes external ears. The first sighting in the water is usually of the round head. The fore flippers are small and placed far forward with five long, clawed digits. The longer hind flippers are used for locomotion under water but cannot be turned forward as with sea lions. Harbor seals wriggle and hunch to travel on land. Because this is laborious, they will roll or slide whenever possible. The average adult found in Alaska waters is just over five feet in length and weighs about 190 pounds. Harbor seals in Atlantic waters are significantly smaller than those in Alaska or the Western Pacific, averaging five feet long and 185 pounds.

NOAA photograph by John Bortinak

Harbor seals have various haul-outs in Kenai Fjords National Park both on boulders near shore at high tide and on ice flows in front of tidewater glaciers. They are seen more often out of the water during pupping season in June and later during their fall molt, August through September. Their color varies from silver white to almost black with contrasting colored spots, rings, or blotches. In our local waters the "light" phase is more common. Pups are generally born with spotted silver coats but occasionally show a longer, softer white or gray coat (lanugo) that sheds usually within 10 days.

Harbor seals are known to have lived to over 30 years of age. The average for females in the wild is around 25-30 years. Males are usually shorter lived, partly due to the stress of fighting during the breeding season.

Transient orcas and large sharks, including the salmon and sixgill, feed on harbor seals, especially pups. Diseases such as distemper, influenza, heartworm, and bacterial infections, as well as gut nematodes, take their toll on the population. In 1999, the worldwide population was estimated at around half a million. During the 1980s, numbers declined 63-85 percent in Alaska. Locally, the seals in Aialik Bay near Aialik Glacier have decreased from more than 1,600 to about 200 seals. This decline coincides with a widespread decline of sea lions, marine birds, and other marine species throughout the Gulf of Alaska. Recently, harbor seal numbers are climbing again. In the park, the numbers are at about 50 percent of the original population of the 1980s.

Habitat Range and Local Sightings

Pacific harbor seals are found in the temperate and subarctic coastal waters extending from Mexico to the Bering Sea to Hokkaido, Japan. In general, the harbor seal is non-migratory, making limited movements due to foraging and breeding. One exception is young seals that have been known to disperse up to 150 miles.

Around Kenai Fjords they inhabit rocky shores, beaches, and ice. Thumb Cove and Humpy Cove on the east side of Resurrection Bay offer occasional sightings of harbor seals, generally in the water. There are haul-out areas on the northwest sides of both Hive Island and Rugged Island. Even better viewing is experienced in either Porcupine Cove or Spire Cove on the west side south of Bear Glacier. Further out in Aialik Bay, Aialik Glacier gives the most consistent viewing of harbor seals as they use the ice in front of the glacier as haul-out, pupping, and fishing platforms.

Food and Survival Strategies

Pacific harbor seals are opportunistic, eating a variety of schooling fish, bottom fish, crustaceans, and squid. They consume up to eight percent of their body weight in food per day. The ice flows from the tidewater glaciers and sharp drop-offs from rocky shores of the surrounding fjords offer access to various prey items and refuge from predation by marine predators. Low profile on the water makes them less visible to terrestrial predators.

Reproduction and Young

Pacific harbor seals are sexually mature at three to five years of age. In Alaska, they breed in July through August. After a 10-month gestation period, females give birth in June to a single pup. Three to four weeks later, after the pup is weaned, mating takes place.

Harbor seal pups weigh about 25 pounds at birth and are ready to enter the water almost immediately. Pups gain about one-and-a-half pounds a day on the rich milk and usually weigh 55 to 66 pounds when weaned. Females recognize and find their own pup both on land and in the water by vocalizations unique to that pair. A few weeks before weaning, the pup often rides on its mother's back as she dives and swims. After the pup is weaned, the mother promptly abandons it.

Although individuals come together at haul-out and breeding sites, harbor seals are generally solitary by nature with no social cohesion other than the mother-pup bond during lactation. When groups of seals are together, there is usually agonistic behavior such as biting, head butting, flipper waving, and snorting.

Human Connections

Alaska Natives are allowed a subsistence harvest of approximately 2,700 per year for meat, blubber, and hide. Harbor seals are an indicator species and are known to carry accumulated pollutants in blubber.

Steller Sea Lion

Eumetopias jubatus

NPS photograph by Jim Pfeiffenberger

Basic Facts

Steller sea lions are the largest members of the Otariid, or "eared seal," family. Female sea lions average seven feet in length and about 600 pounds. Male sea lions, slightly longer at nine feet, weigh more than twice as much as females at an average of 1,500 pounds with "beach masters" reaching up to 2,400 pounds. The otariids in Alaska include three animals: fur seals, California sea lions and Steller sea lions. The eared seals differ from the phocids, or "earless" seals, by having visible external ear flaps and long hind flippers that can be turned under, making travel on land easy.

The Steller sea lion is called "*seevitchie*" by the Aleuts and "*sivuch*" by the Russians, each translating to "seawolf." The name that the animal now bears comes from George Wilhelm Steller, a naturalist aboard the 1741 Vitus Bering expeditions. Steller thought the creature resembled a lion because the male's large neck and shoulder region look similar to the mane of a lion.

Steller sea lions are light tan to reddish brown in color. Males are visibly larger and appear lighter in color than females. Juveniles are chocolate brown in color and appear in early June. Pups stay dark for their first four to six months and then molt to a lighter color.

Top predators include transient orcas and salmon sharks. The camera placed on Chiswell Island tracks the details of predation. During the summer of 2003, live video footage was recorded showing an older transient female orca teaching a younger female and her calf how to feed at the rookery. One method of teaching was to bat puffins into the air with their tails, possibly practicing what it would be like to toss sea lions. A researcher reported on three separate occasions finding the lungs and esophagus of a sea lion in the water, reminiscent of mouse remains that a cat leaves behind.

Habitat Range and Local Sightings

Steller sea lions live in an arc around the north Pacific from central California to Japan. The animals seen in our area of Alaska are from the western stock. Steller sea lions do not migrate, but individuals disperse widely outside of breeding season. Throughout the year in the Seward area, groups of young males cruise the shoreline from the small boat harbor to Lowell Point and back again. It is not unusual to see them in the harbor swimming around the piers and fish-cleaning stations looking for snacks.

Sea lions have numerous haul-outs in the Kenai Fjords. Following the east side of Resurrection Bay, at the north end of Emerald Cove, several large rock islands serve as sea lion haul-outs. From early in the spring season until late July, sea lions use these rocks to dry off and warm up. In August, the sea lions move out to the tip of the cape and become less dependably visible. The entrance to Mary's Bay on Rugged Island and the south side of Hive Island will sometimes yield sea lions on the rocks below the cliffs.

When traveling into Kenai Fjords National Park, the south side of No Name Island (including the separate rocks on both the southwest and southeast ends) often gives the first view of Steller sea lions. Rounding Cape Aialik, look for sea lions hauled out on the rocks that make up the cape. In the Chiswells many of the islands are haul-outs. The sloping rock at the southwest arm of Cecil's Place is a favorite haul-out as well as the back of the arm that faces the Grotto on Natoa Island. Chiswell Island is the only sea lion rookery in our local area.

Food and Survival Strategies

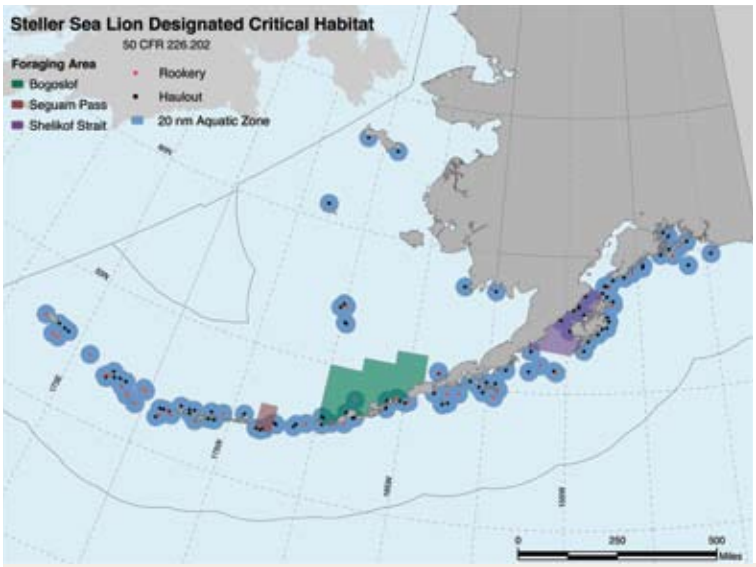
Steller sea lions are opportunistic marine carnivores. Their most important prey species include: pollock, Atka mackerel, pacific herring, capelin, pacific sandlance, pacific cod, and salmon. Haul-outs and rookeries are mostly located on remote and rocky coasts and islands with easy access to the open sea. Steller sea lions often feed at night, but hunt schooling prey by day in large groups. It is believed that group feeding may help in controlling the movement of schooling fish and prey.

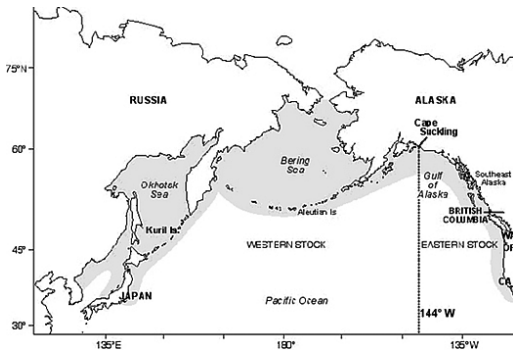
In the years 1976 and 1977, there was a warming period in the Gulf of Alaska waters. This warming lessened the availability of some of the sea lion's prey, specifically oily fish like sandlance, white capelin, and herring. Sea lions now rely on pollock as a main dietary source. This diet switch may be a contributing factor in the decline of the sea lion as pollock lacks the oil critical to the maintenance of sea lion blubber.

Reproduction and Young

Female Steller sea lions are sexually mature at four to six years of age. Bulls become mature at three to eight years, but cannot defend territory until they are nine or 10 years old. In early May, adult male sea lions haul out on established rookeries to claim their area. A returning bull will attempt to reclaim a spot he has held in past years. Eventually, he will be too old (between 13 to 15 years) to compete and will spend his retirement at a haul-out or possibly hold down some less desirable territory at the rookery edge. The competition for territory consists of aggressive displays: roaring, hissing, and chest-to-chest confrontations with open mouths that sometimes end in severe injury. The victor stays out of the water for as long as a month before any females visit him. Male sea lions fast during this time.

In late May or early June, female sea lions arrive at the rookery. Their main objective is to find a good beach on which to give birth. The male with the best birthing territory ends up with the most females. Just 10 to 14 days after giving birth, the female is ready to mate. After fertilization occurs, the embryo develops for a few weeks and then stops. After three to four months, in September or early October, the embryo implants in the uterine wall and resumes growing. This delayed implantation allows the pups to be born at an optimal time. Total gestation time is 11 and one half months.





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The Steller Sea Lion Decline

In the 1960s, there were between 250,000 and 300,000 Steller sea lions worldwide. The Gulf of Alaska and Aleutian Islands historically contained the largest percentage of this population. In 1977, this area contained 74 percent of the global population, but by 1989 it dropped to 56 percent. In 1990, the Steller sea lion was listed as threatened throughout its range. Later studies of mitochondrial DNA from Steller sea lions suggest that there are at least two stocks, an eastern stock (California through Southeast Alaska) and a western stock (Prince William Sound and areas west). The decline was happening solely to the western stock and in 1997, the listing of the western stock was reclassified as endangered.

To adequately protect the species, scientists needed to understand the reason for the decline. Two main theories were initially put forth. In 1976 and 1977, a warming trend in the Gulf of Alaska and the Bering Sea caused changes in the structure of fish populations for these areas. Small oily fish were greatly reduced and larger but less nutritionally useful fish took their place. The diet of Steller sea lions changed from capelin, herring, eulachon, and sandlance to pollock, cod, and hake. The change would be as if a human diet switched from steak and eggs to popcorn. There was also concern that perhaps fishermen were competing with Steller sea lions for the resources that were available. Regulations to protect the sea lions included: a three-mile buffer zone to restrict boats from approaching rookeries and disturbing sea lions, a 10-mile "no trawl" zone around the Ugamak Island rookeries, and a 20-mile "no trawl" zone around six rookeries during the winter roe pollock fishery. These regulations allowed sea lions more available pollock at a time when it would be most nutritionally important for them, when female sea lions are pregnant and when the pollock was rich with roe.

Since the early 1980s when the decline became known, much research has focused on Steller sea lions. Studies conducted in Kenai Fjords National Park through the Alaska SeaLife Center have examined food availability, environmental change, disease, predation, and pollution. The work of Don Calkins, chief Steller sea lion scientist at the Alaska SeaLife Center, and his colleagues points toward nutritional stress as one of the causes of decline. In essence, reduced prey availability is causing a nutritional problem that decreases the fitness of young animals.

Since 2000, survey data indicates that the decline has slowed or stopped. The western stock has increased approximately 5.5 percent between 2000-2002. These trends continued between 2002-2004. These are the first reported population increases since the 1970s. The most recent published data for the 2006 Steller sea lion stock assessment reports a population estimated at 39,500.

Pups, usually one per female and weighing 35 to 50 pounds, are born mid-May to mid-July. For five to 13 days the mother stays with the pup; she then leaves the pup alone while she goes out to forage. At 10 to 14 days the pups form groups of their own—sleeping and playing together while the mothers forage. Pups are able to crawl and swim soon after birth but do not enter the water for about four to six weeks. The mother and pup find each other through scent and vocalizations. Pups will sometimes approach other females, but females will not accept pups that are not their own. A pup will continue nursing from the mother even after it starts foraging on its own. Some pups nurse until the mother's next birth and some until they are three years old.

Female Steller sea lions can live for 30 years. The males don't fair as well, likely due to the competition for territory; bulls live to be 15 to 18 years old.

Human Connections

Alutiiq and Aleut hunters have harvested sea lions for hundreds of years. The skin was used to cover kayaks made of spruce or hemlock wood; the meat was eaten, the intestines made into waterproof garments; the fat provided oil for lamps and was also used as waterproofing. Today, Native Alaskans may still legally harvest sea lions for subsistence purposes.

Sea Otter
Enhydra lutris

© Photograph by Fabrice Simon

Basic Facts

Sea otters are the largest members of the weasel family, and are related to skunks, wolverines, weasels, badgers, martens, and minks. Sea otters average four to five feet long and weigh 80 pounds, but they can be as much as six feet and 100 pounds. The sea otter lacks the blubber, and consequently size, that all other warm-blooded sea animals need to stay warm. In place of blubber, sea otters have a dense coat of luxuriously soft fur. Made up of a dark brown underfur with sparse guard hairs of lighter brown or silver color, the sea otter's coat consists of 600,000 to 1,000,000 hairs per square inch and must be kept immaculately clean to keep the animal warm. A sea otter's head fur turns grayish-white, almost silvery, with age, giving rise to the nickname "old man of the sea."

Coyotes and bald eagles are both known to prey on sea otters, especially pups. Otherwise, humans have proved to be the most threatening predator throughout history. There have been reports of transient orcas feeding on sea otters in the Aleutian Islands. This may be due to the drastic decline of sea lion and seal populations, the normal food for these transients. So far, this hasn't been a problem in Resurrection Bay or the Kenai Fjords.

Habitat Range and Local Sightings

In Alaska, they range from Southeast Alaska, through Prince William Sound, the Kenai Fjords, and the Aleutian Islands. Other populations are found in the western north Pacific off the Kuril Islands and in California from Point Ano Nuevo south to San Nicolas Island.

Local sea otters are accustomed to boats, so there is excellent viewing in the small boat harbor with one or two otters often frequenting the entrance area between the jetties. We also see rafts of three to five otters between the harbor and just north of Caines Head. Occasionally we view otters further out in the park, but they often dive before boats get close.

Food and Survival Strategies

Sea otters favor shallow coastal water, especially kelp beds, and feed in the intertidal zone. Though they can dive to depths of 250 feet and more, they usually dive between five and 60 feet in search of food. Their diet includes clams, mussels, crabs, and sea urchins. Otter teeth are well designed for a diet of shellfish because the lower front teeth act as a scoop for cleaning out shells, while flat, sturdy molars crush the shells of most prey species. A tough shell presents no problem for a sea otter and they will use rocks as tools to open up a difficult shell.

Sea otters spend much of their life eating. In captivity, they consume 25 percent of their body weight every day. Food is the fuel that runs the sea otter's high-speed metabolism, a metabolism essential for warmth. The metabolic needs of the sea otter help it play an important role in the ecosystem. The sea otter is known as a "keystone species," one that indicates overall health of the ecosystem it lives in. This is due to the otter's selective consumption of sea urchins. Sea otters prefer older, larger sea urchins, a significant choice because sea urchins are heavy grazers. Large populations of sea urchins left unchecked will create an "urchin barren" synonymous with an "intertidal desert." By eating large amounts of sea urchins, the sea otter keeps the intertidal zone healthy and diverse.

Reproduction and Young

Mating usually takes place in September and October, although we note couples in Resurrection Bay going through mating rituals throughout the summer, especially in July and August. Look for pinwheeling pairs with the male biting the female's nose. Single pups, about 10 inches long and weighing about five pounds, are usually born in late spring or early summer, but can be born any time of year. Newborn pups require constant attention because they can't swim, feed themselves, or clean their own fur. Look for females lying on their backs with their pups resting on top of them.

Resurrection Bay is not as favored for pupping as Prince William Sound. Females like small, protected coves with good kelp beds to help keep pups safe. Sea otters have been known to occupy Emerald Cove in the spring and summer seasons. A pregnant female frequented the exposed rocks of the cove in 2002, a rare sight, as sea otters almost never come to land.

Human Connections

Native Alaskans are permitted to harvest sea otters for subsistence and making traditional handicrafts. Historically, sea otters were nearly hunted to extinction, first by the Russians who forced the Aleut and Alutiiq people to hunt and later by the Americans after the Alaska purchase. It is estimated that there were between 100,000 and 150,000 sea otters in and around Alaska waters at the time of the Russian arrival in 1741. By 1900, nearly half a million sea otters had been killed, and the world population was estimated between 1,000 and 2,000. In 1911, sea otters were protected by international treaty, but several years later they were thought to have become extinct. Today, about 168,000 sea otters live off the coast of Alaska and Russia, with another 2,400 along the central California coast.

The 1989 Exxon Valdez oil spill killed at least 1,000 sea otters, and mortality rates continued to rise through 1993 as a result of the spill. The population of Prince William Sound sea otters is listed as recovering, but evidence of the oil spill continues today.

Natural History

FWS photograph by Art Sowls

Birds

Steller's Jay
Cyanocitta stelleri

Basic Facts

All jays are members of the Corvidae family, sharing loud calls, a bold nature, and scavenging habits with crows and ravens. Corvidae are considered to be one of the most intelligent and adaptable bird families worldwide. The wings of jays are short and rounded, allowing them more maneuverability through dense trees, and a long, rounded tail acts like a rudder to improve maneuverability as well. Their flight pattern is often a few flaps followed by a glide as they lose altitude. Jays must beat their wings repeatedly to climb back up again.

USFS photograph by Dave Herr

Sometimes mistakenly called the blue jay, the Steller's jay is a much darker blue with black around the head. The Steller's jay has a dark crest on its head that it can puff up or fold back, and just above the eyes are streaks of blue in the surrounding black feathers. These stylish "eyebrows" are one way to tell an Alaska Steller's jay from those of the western interior states where the markings are white. There is no distinction between male and female plumage.

The northern goshawk is the Steller's most common predator, however owls and domestic cats can also prey upon them. In response to an attack, a group of birds will "mob" the culprit in an attempt to make the predator leave.

Habitat Range and Local Sightings

The Steller's jay has the largest range of any jay and can be found to the west of and in the Rocky Mountains, as far north as Southcentral Alaska, and as far south as Nicaragua. In Alaska, they are a year-round resident and can be seen regularly at local birdfeeders.

Steller's jays live in conifer forests and pine-oak forests where food is available most of the year. Locally, we find more Steller's jays toward the town of Seward than out by Exit Glacier where the forest is made up mostly of deciduous trees. There is a thick population in the town of Seward, where the jays probably benefit from many feeders as well as the evergreen trees.

Food and Survival Strategies

Steller's jays usually feed on nuts, acorns, seeds, insects, berries, eggs, and young chicks. They will also scavenge fat (suet) and meat off animal carcasses. They will often hide excess food in the soil, under branches, or in cracks in trees to eat later when food is scarce. In the winter, as much as 95 percent of its diet comes from this stored food.

Steller's jays might be considered the alarm system for surrounding communities. Their call is a cheeky, repetitive "shack, shack, shack" and is often recognized as a

warning call by other birds and mammals in the area. As with many of the Corvidae family, jays are excellent mimics. Scientists have studied jays repeating the call of the red-tailed hawk to scare away predators.

Reproduction and Young

During courtship, the male feeds the female and jumps around her, often changing direction in one jump. All courtship behavior is evident in the spring before nest building begins. Steller's jays build a nest made up mostly of conifer twigs, on a horizontal branch or in a crotch of the tree 12 feet off the ground. Both male and females vigorously defend their nesting site once it is constructed.

Females lay three to four eggs that have green spots. The eggs hatch in about 16 days, and the birds fledge in about three weeks. Both male and female birds care for the chicks. Young jays stay with their parents over winter and flock up with other families. Those living in the mountains will move to lower elevations in the winter if they cannot find enough food during storms.

Human Connections

Another discovery of the German naturalist Georg Wilhelm Steller, the Steller's jay was described and named in the year 1741.

Black-Billed Magpie
Pica hudsonia

Basic Facts

The term magpie comes from the name Meg, short for Margaret, and the word pie, a French word that imitates the call of the bird. Magpies are related to jays and crows. Easily identified by their markings, the head, neck, and back of the magpie are black with a green iridescence showing on the wings and tail. They have white bellies, shoulders, and white wing patches visible during flight. The young share the same color patterns as adults, but possess a much shorter tail. Magpies range from 17 to 22 inches in length, half of which is made up by their long distinctive tails.

FWS photograph by Dave Menke

Magpies have predators but do not seem too vulnerable to attacks. Adults often attack small creatures such as squirrels and crows that threaten eggs and nestlings. The nest is a bit of a fortress and well guarded while the female is laying and incubating eggs. Fledglings face the most danger since raptors prey on the young when they first learn to fly.

Habitat Range and Local Sightings

Magpies favor shrub thickets, open woodlands, and forest edges. In Alaska, they like to inhabit coastal saltwater beach areas, but are widespread throughout the southern part of the state.

Exit Glacier hosts numerous families of magpies. They seem to have a fondness for the parking lot and if you watch for a while, you will learn why. Oftentimes, one can witness a magpie perched on a car bumper nibbling at the smorgasbord of bugs accumulated at the front of the car after a long drive.

Food and Survival Strategies

Magpies are omnivorous with a liking for meat. In truth, they will eat almost anything: They probe the soil for earthworms and insects; they catch flying insects on the wing; they rob other bird's nests of eggs and young; and they eat road-killed animals. When things get scarce, they feed on old berries or seeds that have been left on plants. Magpies cache food in small pits dug into the soil. In this way, they prepare for harsh winter times ahead. They travel and nest in groups, known as colonies. The colonies help to provide safety in numbers, but with the numbers comes an ever-present competition for available resources.

Reproduction and Young

Magpies usually begin nesting in late March or early April. Selecting tall trees or bushes, the nest appears as a dome-shaped weaving of sticks. An entrance to either side usually marks the finished structure. Inside sits a cup, lined with grass and mud for the eggs. Both male and female magpies participate equally in the nest building activities. Magpies lay six to nine small eggs each season. The eggs are small, with a greenish and grey coloring, marked with brown spots. Eggs take about 16 days to hatch. Females alone incubate the eggs, but males provide food for their mates during this time. Once the eggs hatch, males do more of the feeding of the nestlings and fledglings while the females stay in the nest. Males also defend the nest site from predators, more often than females. Magpies stay with their offspring for the first six months of their life, longer than most bird species.

Human Connections

A century ago, magpies were known to kill barnyard fowl and so a bounty was placed on them in many states. In Idaho alone, over 150,000 magpies were poisoned or otherwise destroyed in response to the bounty. Today, those who rant about magpies usually charge them with the death of songbirds. They are known to eat other birds' eggs and chicks, but more typically magpies act as scavengers. Magpies are quite helpful cleaning up carrion, eating insects, and catching rodents. In places where ticks exist, magpies can be seen grooming ungulates that don't seem to mind their presence.

Peale's Peregrine Falcon

Falco peregrinus pealei

Basic Facts

There are three subspecies of peregrine falcon: Peale's, Arctic (also called 'tundra'), and American. Only the Peale's occurs in the Seward area. The scientific name *Falco peregrinus* means "falcon wanderer." The peregrine falcon's distinctive dark head and mustache give it a hooded appearance. Adults have a blue-grey back, and pale undersides with dark barring. The Peale's is the largest and darkest plumed of the peregrines.

The bird's most obvious characteristic in the field is its speed. Called "nature's finest flying machine," peregrine falcons have been clocked traveling 220 miles per hour. Peregrine falcons weigh one-and-a-half pounds, and are approximately 16 inches long with a wingspan of about 41 inches.

© Photograph by Craig Lovell

Habitat Range and Local Sightings

The Peale's peregrine falcon resides on the coast from Washington to Alaska. Although the Arctic and American subspecies migrate 8,500 miles south into Argentina and Chile, most of the Peale's stay in Alaska. When food gets scarce, irruptive migration may occur. This type of migration is a response to food availability. Many captive-bred reintroductions around North America are Peale's, therefore this subspecies range extends across North America.

On the bay tour, look for peregrine falcons at Emerald Cove, and the south sides of the Resurrection Peninsula and Barwell Island. Peregrines can also sometimes be found in the Cheval Narrows, on the east side of Matushka, and in the Beehive Islands.

Food and Survival Strategies

Peregrine falcons specialize in aerial capture of birds. Flying high above their prey, falcons go into a stoop or dive reaching speeds of up to 200 miles per hour. The falcon hits its prey with talons and beak forward, killing on impact. If the bird is not killed, the falcon will finish it off with a bite to the neck using a special notch in the bill that all falcons have.

Peregrine falcons are a top-level predator in our coastal ecosystem. Eagles may harass them at their nesting areas but their biggest threat comes from man. Organochlorides and other toxic pollutants create hazards for the birds. Weakening eggshells and decreasing productivity are common effects of pollutants. DDT has been banned in the U.S., but some falcons migrate to places in South America where the toxin is still used.

Reproduction and Young

Peregrine falcons nest on rock ledges on high steep cliffs, often under an overhang. Instead of using a nest, they lay their eggs in a "scrape," or a protected rocky depression. Once established, the same pair of peregrine falcons will reuse a given nest site year after year.

Peregrine falcons lay one clutch of three to four eggs each year. The female incubates the eggs while the male defends the nest and hunts for food. Eggs hatch after 30-32 days. The female parent stays with the young while the male keeps them fed. Baby falcons, called "eyasses," are completely helpless but grow to 10 times their birth size in three weeks. The young fledge 35 to 40 days after hatching, although the parents may continue to feed them for another few weeks. In the wild, peregrine falcons live about 15 years.

Human Connections

The sport of falconry, or hunting with trained falcons, has roots as far back as 2200 BC when the birds were used to hunt by the Heian dynasty in China. In 384 BC, Aristotle made reference to the sport in Europe. In medieval Europe, falconry was very popular and your station in life determined what bird you could use for hunting: A king could use a gyrfalcon, an Earl a peregrine, a yeoman a goshawk, and a priest a sparrow hawk. Current federal regulations allow the capture of wild peregrine falcon chicks in several western states, including Alaska. Permitted individuals raise and breed the birds.

In 1970, the American and Arctic subspecies were listed as endangered. The population in 1974 hit a low of 324 nesting pairs. Populations had plummeted 90 percent in 40 years. Recovery efforts involved local, state and federal agencies, as well as private organizations. Recovery east of the Rockies had great success with falcons being released in major cities such as New York, Boston, and Chicago. These falcons nest on skyscrapers and feed on pigeons. By 1998, there were an estimated 5,000 nesting pairs in the United States. In 1999, President Clinton removed the bird from the endangered species list; however, it remains protected by the Migratory Bird Act.

Bald Eagle
Haliaeetus leucocephalus

Basic Facts

Unique to North America, the bald eagle's scientific name means "white-headed sea eagle." The bald eagle is not actually bald. The term "bald" comes from the word "piebald," meaning markings that are two colors, usually black and white. Eagles are classified as raptors, or birds of prey. The bald eagle belongs to the Falconiformes order, birds that hunt primarily during the day. Since 1782, the bald eagle has been our national bird, symbolizing wilderness, power, and freedom.

FWS photograph by Dave Menke

Males measure about three feet from head to tail, weigh seven to 10 pounds, and have a wingspan of about six-and-a-half feet. Females are slightly larger and may reach 14 pounds with a wingspan of about eight feet. Juvenile bald eagles look quite different from their parents. Juveniles are mottled brown in color with some white, but there is no distinctly white head or tail for the first four years of life. Visitors often think they are seeing golden eagles when they spot a juvenile next to a mature bald eagle, although golden eagles are smaller.

Habitat Range and Local Sightings

Bald eagles nest from Alaska to Newfoundland, and south from Baja California to the gulf coast of Florida. Bald eagles are not found outside of North America.

In Alaska, bald eagles engage in nesting during the spring and summer. During this time, the nesting pair stays close to its territory and doesn't interact with other eagles. In the winter months, eagles may migrate and gather in groups to feed on an abundant food source, such as a late run of salmon. It is during these gatherings that young eagles may meet potential mates. Bald eagles mate for life.

Generally, bald eagles return to the same nesting territory year after year. The size of nesting territories varies in accordance with the availability of food resources. Both male and female eagles help build the nest, which is usually constructed high in a tree with a good view of the surrounding area. Frequently, bald eagles have two or three nests within the same nesting territory, rotating between nests from year to year. Eagles construct the largest nests in North America.

Food and Survival Strategies

Bald eagles feed on fish, birds, and mammals. They are both hunters and scavengers, preferring to steal food from other animals or to eat dead animals. In the park, a very small sample of nests revealed that bald eagles eat a variety of fish (pollock and rock fish), birds (gulls, puffins, and ducks), and mammals (marmot). During salmon runs, eagles feast on dying and dead salmon. Winter limits fishing

and hunting opportunities, so eagles often depend on their skills as scavengers to survive.

Like all soaring birds, bald eagles have a hollow skeleton, relatively wide wings, and primary feathers allowing for good flight control. Relying on flight for survival, bald eagles must spend a large part of their day preening their feathers. Eagles have excellent vision and can spot prey over a half-mile away. Bald eagles make use of warm air currents and air forced upward by wind blowing against a mountainside. Without these air currents and winds, bald eagles can appear awkward and clumsy in flight. Perching on a tree or rock is an energy saving method of hunting. Eagles swoop or drop down quickly on prey with sharp talons extended, striking and killing fish and other animals. This classic hunting maneuver is called stooping. Bald eagles use their huge, hooked beak to tear prey into bite-size morsels. Bald eagles communicate through calls and visual displays. Eagles make several distinct sounds, ranging from a harsh cry to a low snickering call. To compete for food with other eagles, they engage in mock attacks, raising their wings and talons.

Reproduction and Young

In Kenai Fjords, the female bald eagle lays one to four eggs between the first of April and the middle of May. Both parents take turns incubating the eggs for a period of about 34 days. During this time, the eggs face the greatest danger. Research in Kenai Fjords National Park has demonstrated that high precipitation in April and May is correlated with reproductive failure. The newly hatched eaglets must be protected from the cold, wind, and rain for at least a month by one of their parents.

Feeding the eaglets is a full-time job. After ten weeks, the young bald eagles may weigh 11 pounds and are ready to fledge. Four to five years later, they are fully grown and ready to mate. In the wild, bald eagles may live for 30 years or longer. While mature bald eagles have few natural enemies, newly hatched eaglets are vulnerable to predators such as owls, seagulls, and crows.

Human Connections

Native folktales and stories generally portray the bald eagle as powerful, intelligent, and helpful. Some native cultures revered the eagle. In contrast, early European settlers, who observed bald eagles eating dead livestock, wrongfully concluded that the birds preyed on farm animals. In the 1800s many counties offered bounties on eagles. One of Alaska's early settlers, Josephine Sather, claims to have killed more than 200 bald eagles in defense of her fox farm. Alaska offered a bounty on bald eagles until 1953.

By the 1960s, as the result of shooting, loss of habitat, and the use of pesticides, the number of successfully nesting bald eagles in the U. S. (excluding Alaska) was reduced to fewer than 450 pairs. In 1972, the use of DDT was banned in the United States and in 1973, the Endangered Species Act was passed. These factors, along with public education, were instrumental in reviving bald eagle populations in the Lower 48. The U.S. Fish and Wildlife Service has proposed that the bald eagle be removed from the endangered species list—a success story for wildlife conservation.

In spite of Alaska's bounty on eagles, the Alaska population was never endangered.

Marbled Murrelet
Brachyramphus marmoratus

Basic Facts

The marbled murrelets belong to the Alcid or Auk family that includes puffins, murres, guillemots, auklets, and dovekie. Designed with an aquatic life in mind, Auks are seabirds that come ashore only to nest. They are typically short and squat with stubby wings suited for flying underwater.

The marbled murrelet can be confused with the kittlitz's murrelet, but the distinction between the two is evident as the bird takes flight: Watch the tail retrices during take off, the marbled murrelet's retrices will change quickly from white to brown, while those of the kittlitz's remain white. The marbled murrelet is less than 10 inches long and weighs just seven to nine ounces.

In Kenai Fjords, we encounter the marbled murrelet mostly during the breeding season. At this time, it is brown with irregular white bars and mottled back

and wings. The neck and undersides are a yellowy-white. It has a short, thin bill often carried pointing up at an angle. Winter plumage is a starker white belly and throat with black or brown covering the back, wings and the head down to and including the eye.

Habitat Range and Local Sightings

The marbled murrelet is found along a north Pacific arc from Kamchatka, Russia through the Aleutian Islands to Central California. In the summer, it occurs in protected bays and coves near old-growth forests. In the winter, it is found offshore.

In waters near the park, concentrations of feeding murrelets can be seen at the north end of Eldorado Narrows, Tonsina Beach, Thumb Cove, Humpy Cove, in protected coves on the east side of the Aialik Peninsula, and in the Cheval Narrows. At least one local birder has reported hearing murrelets in the forest at Old Mill subdivision, Mile 8 of the Seward Highway. The local nesting season can be determined by watching murrelets on the water. In May they are plentiful, and their shrill cry can be heard from boats leaving the harbor. Suddenly in June, they seem to all but disappear. Then sometime in July, the birds return to the coves and can be spotted regularly again.

Food and Survival Strategies

Marbled murrelets eat small fish, primarily herring, capelin, and sandlance in our area. They dive for food using their wings to propel them underwater. While no definitive study has determined their diving range, a similar species, the cassin's auklet, dives to 150 feet. Murrelets typically conduct short dives of 30 seconds. They can

swallow fish under water and sometimes drive small schools of fish to the surface, feeding on them in a series of shallow dives. Upon surfacing after a series of dives, the birds will flap vigorously, fluffing their plumage and restoring insulation. Their feathers are unusually thick and dense to keep out the cold.

Reproduction and Young

Unlike most Alcids, the marbled murrelet does not nest in colonies but in the canopy of old-growth spruce forests, sometimes traveling as far as 40 miles inland. Active nests are difficult to confirm because the birds are well camouflaged in the forest, and they have a habit of traveling at night. Nests are typically located 60-80 feet up the tree, but have also been found on the open tundra in the far north part of the bird's range: One was found 1,900 feet up a scree slope on Chichagof Island in Southeast Alaska.

Pairs lay a single egg in late May. The male and female take turns incubating the egg for about a month. After hatching, adults carry meals from the sea to the nest. Under cover of darkness and at speeds up to 100 miles per hour, the birds elude owls, eagles, and falcons. They must also avoid leading nest robbers such as jays, ravens, and crows to their nest. The young fledge in late June and early July. At this time, they have the black and white plumage of winter adults. The molt of the hatch year and following year undergo distinct patterns, allowing researchers to age the young birds and determine productivity.

Human Connections

Populations of murrelets in California, Oregon, Washington, and British Columbia have experienced a massive decline. These populations are listed as threatened under the Endangered Species Act. The biggest threats to murrelet populations come from human activity such as logging, gill net by catch, and oil spills.

The Exxon Valdez oil spill killed between 8,000 and 12,000 marbled murrelets in Prince William Sound. This figure represents about 5-10 percent of the population in the effected area.

Tufted Puffin and Horned Puffin

Fratercula cirrhata and *Fratercula corniculata*

Basic Facts

Puffins belong to the Alcid family, a group of diving birds that swim underwater using their wings for propulsion and their feet for steering. Two species of puffins nest in Kenai Fjords National Park, the horned and the tufted.

The puffins we see from the tour boats are ready for the breeding season. The horned puffin has pure white feathers around the face, large flashy beak plates and the characteristic fleshy black horn above the eye. The tufted puffin also has white facial feathers and colorful beak plates, but the addition of two tufts of yellow feathers atop its head distinguishes this species. Both puffins stand 15 inches tall, the tufted puffin is heavier at 1.7 pounds than the horned puffin at 1.4 pounds. The weight difference seems slim, but for a bird that must beat its wings 400 times a minute to stay aloft, it is very big.

Tufted puffins arrive in the rookery islands about mid-May. Horned puffins usually follow one week later. Both types of puffins begin their breeding season by gathering in large groups on the water. Puffins mate for life, and it is thought that these gatherings may reunite mated pairs.

FWS photograph by Art Sowls

Habitat Range and Local Sightings

Tufted puffins range from Big Sur California in the eastern north Pacific to Hokkaido Japan in the western north Pacific and northward through the Aleutian Islands. Horned puffins live in breeding colonies as far south as Queen Charlotte Island in British Columbia, and their range extends eastward to eastern Siberia and the Sea of Okhotsk and north to coasts in the Chukchi Sea, including Point Barrow. Puffins do not migrate over long distances, but make their home on the open waters over the continental shelf when their nesting time ends. This habit is referred to as nomadic.

Locally, the cliffs at the base of Beehive Islands I and II in the Chiswell Islands have the heaviest concentration of nesting puffins—both tufted and horned. Abuzz with puffin activity, Beehive Islands I and II are named for the constant flurry of puffins surrounding them.

We also find horned puffins at Caines Head, where a small group (10-20) nests around a little cove at the south end of the headland. On the east side of the bay, horned puffin nests appear at the base of the Resurrection Peninsula, just south of the Fox Island spit. Emerald Cove is one of the busiest horned puffin nesting areas. Tufted puffins show up just past Cheval Island.

Food and Survival Strategies

The puffin diet consists mostly of white capelin (74 percent for tufted and 61 percent for horned). Sandlance and other small fish make up the rest of the horned puffin's diet. The tufted puffin eats euphasiids (small, shrimp-like crustaceans) small squid, and sandlance (listed in order of frequency) in addition to white capelin.

Both bald eagles and peregrine falcons prey on puffins. To protect themselves from airborne attack, puffins form distinct flight patterns between nesting areas and feeding areas. They fly in large groups and in patterns that roughly resemble a wheel, making it hard for a bird of prey to find and attack an individual.

Reproduction and Young

Puffins come to land only for nesting purposes. The puffin's return to their offshore islands indicates year-to-year fluctuation of productivity cycles in the near shore waters. A breeding pair of puffins puts its energy into just one egg. This strategy aims for a very high success rate, one that must consider annual changes in food availability. In studies conducted by the U.S. Fish and Wildlife Service, the overall success rate (successful fledging of chick) for tufted puffins was 65 percent and for horned puffins 60 percent.

Tufted puffins dig burrows three to six feet deep in the tops of islands and headlands, while horned puffins use rock crevices for their nesting sites. Both birds may employ grass and feathers for nesting material or may just use the substrate at hand for their egg laying.

Both adults brood the egg. Upon hatching, parents provide the young chick with a steady diet of fish. Although classic photos show puffins with lots of fish in their mouths, the nutritional value of the fish decreases with size. Adults carry fewer fish at a time and make more trips, in order to feed older nestlings approximately 14 fish per day. When the puffin chicks fledge, they leave the nest at night in order to avoid predators. They flutter down to the water's edge alone and head for the open sea. They won't return to land again for two to three years, when they become breeding adults at the rookery.

Human Connections

The Inuit people of Alaska used puffin skins to make feather-lined parkas. Beak plates were collected and strung together to form rattles used by shaman in rituals. Both the Aleuts and the Inuits sewed beak plates for decoration on the outside of their garments.

Common Murre and Thick-Billed Murre

Uria aalge and *Uria lomvia*

Basic Facts

The murre is the largest member of the Alcid family, web-footed diving birds with short legs and wings that includes auks, murres, and puffins. Visitors often mistake murres for loons. Their shape and coloring is similar, but a loon is much bigger. The murre's stance and coloring closely resembles a penguin: Their feet sit far back on their body giving them a distinct upright posture. Two species of murre reside in the park: the common and the thick-billed. We see the common murre most frequently, usually at close range along the edge of nesting sites on rocky cliffs.

The common murre is dark brown, appearing black, on its head, back, and wings. They have white undersides and a thin white stripe on the back edge of their folded wing. A faint brown streaking appears on their flanks. Their sharp, slender bill is often pointed upwards. The common murre weighs just over two pounds and is 17.5 inches long with a wingspan up to 26 inches.

USFWS photograph

The thick-billed murre is more robust than the common, with a heavier head and neck. The most identifiable field mark is a white stripe extending down its cheeks from the bill. The back of the thick-billed murre appears blacker than that of the common and there is little or no brown streaking on the flanks. The thick-billed murre weighs just over two pounds and is 18 inches long with a wingspan of 28 inches.

Habitat Range and Local Sightings

The murre's range is circumpolar from 36 to 75 degrees north. In the Pacific Ocean, murres breed from Northern California to the Bering Sea. The bird is especially abundant in the Gulf of Alaska. Murres spend their winters at sea over the continental shelf and just south of the pack ice in the Bering Sea. Common and thick-billed murres nest together throughout their range. The thick-billed murre predominates from the Aleutians northward.

The murre is seen in greater numbers on the bay tour than on an all day tour. The south side of Cape Resurrection has birds nesting on many ledges and in caves. Barwell Island is the most populated murre nesting site in our area. In the early season, look for "great rivers of murres" flowing out beyond Barwell across the ocean surface. In May and June, one can often see "wheeling" of murres above Barwell. Wheeling is a defensive flight pattern practiced by the birds to keep them safe from bald eagles and peregrine falcons.

On the all day tour, murres are found in small numbers on the water from Caines Head south. They have numerous small nesting colonies throughout the Chiswell Islands. Thick-billed murres are rare in our area.

Food and Survival Strategies

Murres are mid-water feeders. The deepest diving of all alcids, they can reach depths of 600 feet and swallow their prey under water. In Alaska, the common murre feeds at the trophic level of some marine mammals consuming such things as pollock, sculpin, flounder, and capelin.

Gulls have been known to prey on murre chicks. The dense colonial nesting habit of the murres helps to protect their young from terrestrial and aerial predation.

Reproduction and Young

Murres nest in dense colonies on sheer cliff ledges, standing side by side and often touching each other. This dense nesting habit protects murres and their chicks from gulls, ravens, eagles and other predators. Murres use no nesting material.

Murres begin breeding at five to six years of age and lay a single pyramidal egg. Designed for life on a ledge, the pear-shaped egg does not roll when jostled but spins around the smaller end. Egg color varies from greenish to pinkish, with patterns of mottling making each egg distinct. This is important with such close, undefined nesting quarters. Males and females take shifts of 14-17 hours incubating their egg over a 33-day period. Upon hatching, both parents feed the chick for about 20 to 25 days, after which the female flies off. The male parent stays on to care for the chick. When the chick fledges, its male parent leaves with it, spending up to two months with the chick.

Human Connections

Murres act as an indicator species for researchers. They nest in such large numbers that a change in food availability results in rafts of dead murres washing ashore. Recent research shows that, feeding toward the top of the food chain, murres accumulate toxins in the way of many local marine mammals. Murre eggshells gathered on remote islands in the Bering Sea contained elevated levels of persistent organic pollutants.

Alaska Natives collect murre eggs for food. In the 1990s, an average household on St. Lawrence Island consumed 60-104 murre eggs each year.

Murres were heavily impacted by the Exxon Valdez oil spill. The population in the spill area declined about 40 percent, however the birds appear to have recovered to pre-spill levels.

National Park Service
U.S. Department of the Interior

Kenai Fjords National Park, Alaska

Park Science

© Ron Niebrugge courtesy of NPS

Geology

The stark beauty of a land shrouded in ice, bordering the ocean, and teeming with wildlife covers a plot taking place underneath it all. Beneath the splendor, larger forces are at work. The movement of tectonic plates and the delivery and formation of various rock types prescribe where birds nest, where Steller sea lions breed, and where glaciers flow. The varying rock of the fjords underwrites the spectacle seen above—in one place eroding into graceful arches, in another withstanding the ocean's constant blows.

Crustal Collision

Plate tectonics theory describes how the Earth is put together, and how it changes over time. The center of the Earth is a tremendously hot core of iron and nickel. Surrounding this is a hot mantle of liquid rock. On the outer edge of the Earth, where it is at last cool enough for the magma to harden into solid rock, the material forms a crust. Convection currents are at work within the Earth. Boiling magma rises from the mantle, cooling near the crust and sinking back again to be re-warmed. This movement disrupts the crust, breaking it into pieces and moving them around.

Continental plates are pieces of crust visible as the continents of the Earth. Oceanic plates are heavier pieces of crust, sinking lower into the mantle and are covered by oceans. The plates collide at their edges, causing earthquakes. The collision of plates also builds mountains.

Mysteries of Movement

The rocks that make up Kenai Fjords National Park have sometimes been carried great distances. Some rock was once coral reef close to the equator: It was carried along as the Pacific plate rotated counter-clockwise, traveling north, transforming en route to stone. In the far western end of the park, a mixture of chert and basalt scraped from the ocean floor is jumbled with spectacular white blocks of limestone that carries fossils matching those found in China and Afghanistan. These segments of rock moved from their original home are called terranes. The entire coastline of Alaska is made of a mixture of terranes and local igneous material.

NPS photograph by Paul Ollig

Take a walk in Exit Glacier Valley and you are surrounded by evidence of geologic change. The mountains around you formed at the bottom of the sea. Layers of dark-colored mud, sand, and gravel eroded from an ancient shore and were deposited by underwater landslides into the sea. These sediments transformed slowly, under heat and pressure into sandstone, mudstone, and unsorted rock assemblages called conglomerate. Here, in Kenai Fjords National Park, these sediments were uplifted as mountains when the North Pacific Oceanic plate and the North American continental plate collided.

Light-colored granodiorite is common along much of the park's coast and formed when a piece of the Pacific plate subducted underneath the North American plate. During the subduction, some rock melted into magma, which intruded and cooled to form plutons inside the local bedrock. In many areas, the softer sedimentary rocks that once surrounded the granodiorite plutons have eroded, leaving the harder rock standing as sea stacks and capes.

In the park, as the North Pacific oceanic plate subducts beneath us, it is now dragging the edge of the continent down with it. The Kenai Mountains are very gradually sinking below the sea. Evidence for this is found in the lovely half-moon coves of Aialik Bay. In the heyday of the Ice Age, which began about 1.8 million years ago, ice built up in the curve of every peak, gouging out cirques; high valleys that nourished glaciers. A warming climate raised sea level 10,000 years ago and snow falling at lower elevations melted in the summers, no longer transforming to glacial ice. The cirques are now drowned in ocean water and the peaks that edged above Pleistocene ice are now islands surrounded by sea.

Capes and Cliffs

Many visitors to Kenai Fjords National Park take a boat trip out of Resurrection Bay to see the wildlife, glaciers, and scenery. On the east side of the bay, Cape Resurrection presents a massive, sheer cliff to the pounding of the waves. The bubbled texture of the cliff, ideal for nesting birds like black-legged kittiwakes and horned puffins, is igneous: lava that bubbled up underneath the water and cooled quickly, forming pillow basalt.

On the opposite side of the bay, the shore is eroded into spires, cliffs, and coves. Exposed areas reveal buckled layers of ancient sediment. Mud, transformed by heat and pressure, becomes shale, a fine-grained, dark-colored stone with many thin layers; more time, more pressure, and the shale hardens to slate. If there is sand mixed with the original mud, it may become greywacke instead. These softer layers crumble into the sea more rapidly than basalt. Arches and spires form from the erosive action of waves.

As you round the corner to the west, moving out of Resurrection Bay, Cape Aialik juts into the tumultuous water. Here is granodiorite, part of a massive pluton that extends down the shore, cropping up again at the entrance to Northwestern Fjord. Granite is lighter-colored than the ocean sediment rocks. It is more resistant to weathering, more resistant to the action of glaciers upon its surface. Where glaciers have carved the bedrock into impossibly steep cliffs, the slate crumbles once the ice melts away; but the granodiorite stands, the sheer surface draped with waterfalls.

Cliffs and islands of greywacke, like Nuka Island, have virtually no seabirds nesting on them as their softer surface is too easily eroded to make a safe home. Granitic islands, on the other hand, are packed with birds. The Chiswell Islands, pinnacles of granodiorite stretching up from the sea floor, are home to tens of thousands of puffins, murres, and auklets. Birds seem to have an affinity for granite—one of many ways that bedrock influences the life found on its surface. Sea lions, too, congregate on smooth granitic slabs washed by ocean swells to mate, give birth, and rest.

Seams So Real

The bedrock of Kenai Fjords National Park has been carried north by the action of the tectonic plates. It has been heated and pressed into a new form. It has also been broken. The fractures in the rock filled swiftly with jets of superheated water from deep in the Earth. The water carries dissolved minerals such as iron, silica, arsenic, gold. These precipitate out, forming white and brown streaks across the darker bedrock.

As park glaciers retreat, more bedrock is exposed. Signs of past events are visible in the white seams of quartz shooting through the dark greywacke and in layers of upended slate silently pointing to the slow, inexorable compression of plates. Ice has left its scouring marks across every surface. Yet these signs of the past are quickly engulfed by a wave of verdant life racing across the landscape, filling every conceivable niche, and rushing forth to hide the larger forces at work.

Sediment layers. © Ron Niebrugge courtesy of NPS

Quartz seams. NPS photograph by Paul Ollig

Glaciers

Kenai Fjords National Park is a land dominated by glaciers, massive rivers of ice that flow out from the Harding Icefield. Today nearly 56 percent of the park is covered by ice, but all of this land was once buried beneath the ice and still bears its influence. The dramatic coastal fjords and valleys of the park reveal a long history of glaciation.

© Ron Niebrugge courtesy of NPS

Bear Glacier's crevasses and moraines.

The Making of a Glacier

The formation of a glacier requires three conditions: abundant snowfall, cool summers, and the gravitational flow of ice. All of these conditions are met in Kenai Fjords. Moist air moving off the Gulf of Alaska in the winter drops, on average, 60 feet of snowfall on the Harding Icefield every year. These prevailing weather systems from the Gulf also ensure cool (and wet) summers in which much of the winter snow does not melt. As the snow accumulates, the weight of overlying layers causes the snowflakes to degrade and compact. This process, called firnification, is the first step in the transition from airy snow into dense glacial ice. A first year snowfall is approximately 80 percent air. As the snow degrades and compacts, it passes through stages defined by air content: firn is 50 percent air, névé is 20-30 percent air, and eventually glacial ice is less than 20 percent air. In Kenai Fjords, the entire process takes about 4-10 years.

Slip Sliding Away

Dense and heavy glacier ice begins to flow downhill. Extremely thick glaciers, which form in areas of especially high snowfall, tend to flow faster than thinner glaciers, as their greater mass is more affected by gravity. Similarly, glaciers with steeper gradients flow faster than glaciers spread across gentler slopes.

There are three main types of glacial movement: basal slippage, pressure melting, and plastic deformation. Basal slippage occurs when the ice slides or slips over the underlying bedrock. This process is facilitated by meltwater flowing at the base of the glacier which reduces friction between the ice and the bedrock. In temperate regions where there is high melting, such as Kenai Fjords, basal slippage can account for up to 90 percent of overall movement. Because meltwater plays such an important role in basal slippage, glaciers flow faster in summer than winter. From the Edge of Glacier Trail at Exit Glacier, you can hear the meltwater rushing beneath the ice and eventually gushing out across the outwash plain.

When the underlying bedrock is particularly rough or a large obstacle such as a ridge or boulder is present, pressure melting begins. As the weight of the glacier bears down on the obstacle, the ice on the uphill side is subject to increasing pressure, which causes the ice to melt. The meltwater then flows around the obstacle and refreezes on the downhill side, facilitating the movement of the glacier downhill.

Plastic deformation occurs when the ice itself flows as a viscous solid. As the ice responds to gravity, layers within the ice slide over one another along layers

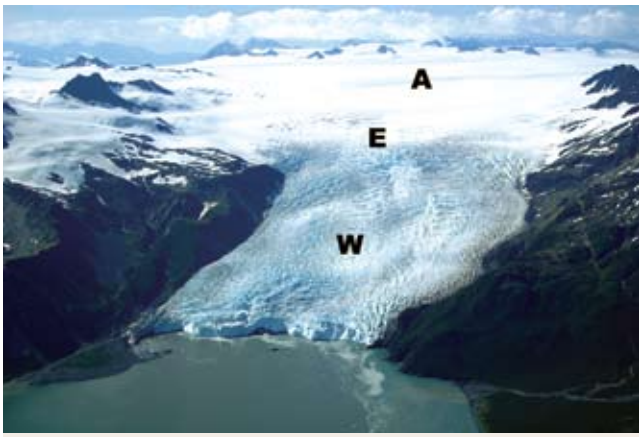
or planes of weakness in the ice. This is referred to as plastic deformation because bonds between ice crystals are stretched or altered, rather than broken. Thicker glaciers are more likely to move by plastic deformation than thinner glaciers, as this type of movement is in response to weight and pressure from overlying ice.

All that the Glacier Leaves Behind

The erosional and depositional features created by the ice are an important part of the glacial process in the park. Like flowing water, flowing ice has a tremendous ability to reshape the landscape. As the ice erodes the terrain, it creates new landscapes and yields a tremendous amount of sediment and debris.

Where glaciers flow downhill, the tremendous weight of the ice pushing down on the underlying bedrock causes a great deal of erosion. Over time, glaciers can wear away even the strongest rocks, leaving behind a variety of features. The most prevalent erosional feature in Kenai Fjords is the steep-sided, flat-bottomed U-shaped valley. This classic shape is evident on the drive to Exit Glacier.

Glacial erosion is also visible on a very small scale throughout the park. The rocks along the Edge of Glacier Trail at Exit Glacier bear the minute marks of a passing glacier known as striations. Striations are usually small scratches or gouges left by the passage of ice, or gravel frozen in the ice, over the bedrock. Striations tell glaciologists the direction of past glacial movement.



NPS photograph

Glacier Zones

Glaciers are divided into two zones: an accumulation zone (A), where new snow adds to the mass of the glacier; and a wastage or ablation zone (W), where seasonal snow and glacier ice melt. These zones are separated by an equilibrium line (E) that indicates the point at which accumulation is balanced out by ablation. On advancing glaciers the equilibrium line is at lower elevations, indicating that the accumulation zone is larger than the ablation zone.

At Exit Glacier, the equilibrium line is currently located above the glacier in the icefield, indicating that Exit Glacier has no accumulation zone. All of the snow that falls on Exit Glacier each winter melts completely during the summer.

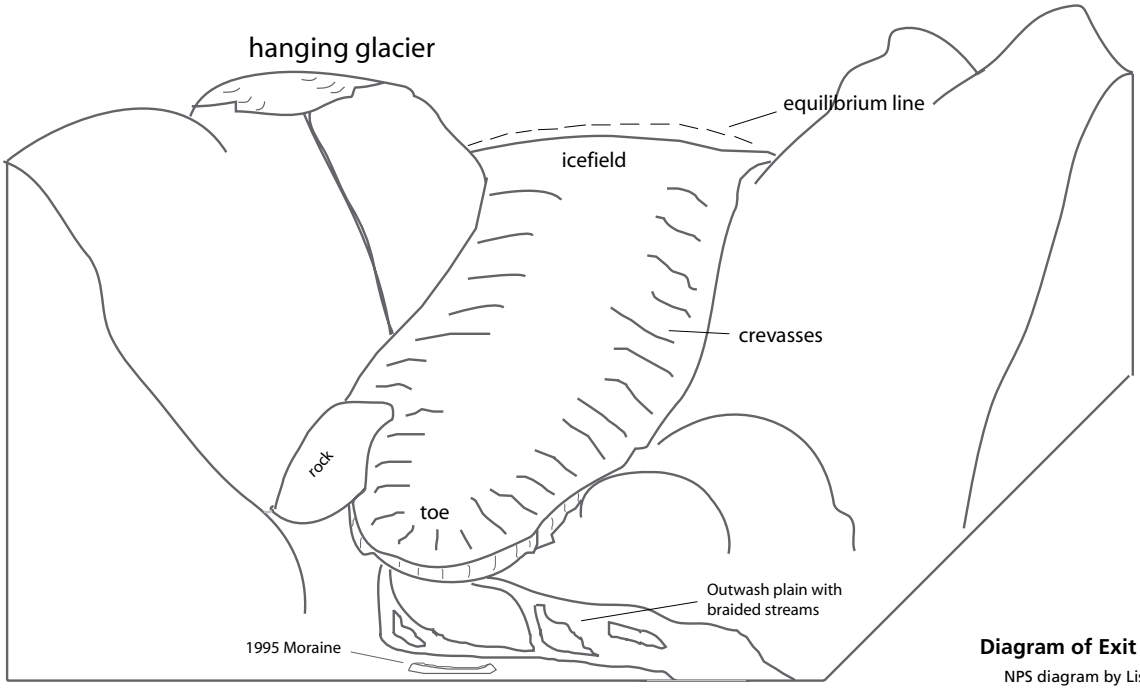


Diagram of Exit Glacier.
NPS diagram by Lisa Gordon

Glacier Features

Glaciers have many distinct features within the ice that result from the downhill movement of the ice.

Crevasses are deep, narrow fissures that form where the ice is under extra tension as when it flows over bedrock obstacles. Crevasses may be as long as the terrain dictates, but have a depth of about 30 meters or less.

Seracs form when multiple crevasses intersect, leaving behind large blocks or towers of ice.

Icebergs are large blocks of glacier ice that have broken off or "calved" from the terminus of the glacier into the ocean.

Ogives are black and white bands that form on a glacier after it falls over steep terraine. Black bands form in summer from sediment and depositional debris and white bands in the winter from snow. Beneath the icefall, the glacier begins to flow again. The center of the glacier moves faster than its edges creating the chevron shape of an ogive.

NPS photograph

The erosional power of glaciers creates sediment and debris, which is carried downhill by the glacial ice and meltwater and deposited into a variety of landforms. As ice melts at the toe of the glacier, the debris is deposited at the edge of the ice. Large piles of debris accumulate into distinct ridges, called moraines. Several types of moraines form, classified according to location. As a glacier advances, it tends to create only small moraines. The ice redistributes any material that accumulates. However, receding glaciers often leave behind a series of recessional moraines or "footprints" of the former extent of the ice. At Exit Glacier, recessional moraines are dated to show the recession of the glacier over time. Along the sides of a glacier, lateral moraines form where debris accumulates. Where two glaciers flow together, their lateral moraines merge, forming a medial moraine, which is carried downhill atop the merging glacier. Bear Glacier, the largest glacier in Kenai Fjords National Park, has two distinct medial moraines.

The water melting from a glacier plays a very important role in the formation of depositional features at terrestrial glaciers. The majority of sediment eroded by the glacier is carried by the melt streams. The grey color of glacial rivers is a result of a large amount of very fine rock particles, known as glacial flour. At Exit Glacier, the rushing meltwater streams redistribute the sediment deposited in recessional moraines across the outwash plain. The sediment loads carried by the streams create braided stream channels. As the amount of meltwater issuing from a glacier changes, the fluctuating volume of flow determines how much sediment can be carried. When water volume is high, more sediment and larger rocks and boulders move with the flow of the river. As water volume decreases, larger rocks are deposited along the streambed, often blocking or altering the stream channel. Thus, many channels form across a wide, rocky riverbed.

A Story in the Landscape

From tiny striations only millimeters wide to stunning fjords thousands of feet deep, the land of Kenai Fjords National Park tells a story of ice that has taken thousands of years to write. Today the national park exists to preserve the story written in the landscape and to protect the coming chapters. Here in Kenai Fjords, we will be watching as the glaciers of the Harding Icefield respond to a changing climate and the slow processes of time.

Park staff carrying radio transmitter device to track Exit Glacier.

Pederson Glacier.

Enjoying the blue ice.

The Harding Icefield

The Harding Icefield and its outflowing glaciers cover 700 square miles of Alaska's Kenai Mountains in glacier ice. Created more than 23,000 years ago during the Pleistocene Epoch, the Harding Icefield was a small piece of the vast ice sheet that covered much of Southcentral Alaska (*Figure 1*). Indeed, at the time, ice blanketed one third of the Earth's surface.

Naming the Ice

Icefield, ice cap, ice sheet—the terms can be confusing. Ice sheets are huge and continental in scope. Antarctica and Greenland are the only present-day ice sheets. Ice caps are dome-shaped and cover the terrain they rest on. Icefields vary in size and connect a series of glaciers. Bedrock can show through the ice of an icefield. The Harding Icefield is thousands of feet thick, but it does not completely bury the underlying mountains. Nunatak, meaning "lonely peak" is the term for such mountaintops surrounded in ice.

Over 30 glaciers of different size and type flow outward from the Harding Icefield. Some of these glaciers are tidewater (Aialik Glacier) or terminate in lakes (Skilak Glacier), and some end on land (Exit Glacier). Icefields are sensitive to climate change, growing and melting in response to changes in temperature and snowfall. Icefields also exert their own influence on local and global climate, changing pressure systems and wind directions, serving to keep adjacent land and water cold.

Climate Change Past and Present

Scientists studying glacial geology and past climates recognize that the last two and a half million years of Earth's history fluctuated periodically between cold and warm conditions. Studies of glacial deposits on land indicate at least four major periods of glaciation. Evidence from deep-sea cores suggests that a dozen major glaciations may have occurred during the Pleistocene Epoch. Most scientists accept the Milankovitch theory (see climate change section of this manual) of orbital forcing—that cyclical changes in the Earth's orbit around the sun are a principal cause of the ice age and long-term changes in the Earth's climate. Recent scientific studies are documenting

Alaska glaciers account for less than one percent of the Earth's area currently covered by ice, but a recent study suggests this ice is melting quickly. Airborne laser altimetry used to measure changes in volume and area of 67 glaciers in Alaska (including 14 glaciers from the Harding Icefield) estimates about 40 cubic miles of ice may be melting annually. This study further calculated that during the last decade, Alaska's melting glaciers contributed eight percent of the observed annual rise in global sea level.

significant short-term changes in Alaska glaciers and the Harding Icefield.

A National Park Service (NPS) study using aerial photographs and satellite imagery measured a three percent reduction in the surface area of the Harding Icefield over a period of 16 years. The NPS plans to repeat this study every ten years to monitor further changes.

In 2004, the NPS installed an automated weather station at 4,200 feet on a nunatak in the northeastern part of the Harding Icefield (*Figure 2*). The weather station records and transmits weather observations (temperature, wind speed and direction, relative humidity, precipitation, snow depth, and solar radiation) hourly. Current weather observations and summary reports can be viewed at the Western Region Climate Center's website: http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?akAHAR

During the first three full years of operation, the lowest observed temperature was -21 degrees F, the highest observed temperature was 68 degrees F, and the maximum observed sustained wind gust was 117 miles per hour.

The Lure of the Icefield

Access to the Harding Icefield is exceptional in comparison to other large icefields. A steep, four-mile trail leads from the ranger station at Exit Glacier up to the edge of the icefield, affording visitors with a spectacular view and skilled mountaineers with ready access to the ice.

Before the early 1920s, local residents paid little attention to the huge icefield in the mountain range behind the town. Alutiiq and Dena'ina Natives were no doubt familiar with the ice and had accessed it, but there is no record of any attempted crossing until 1936. Yule Kilcher, a 27-year-old Swiss immigrant, had heard of the icefield and seen its edge from the steamer that had dropped him off in Seward. Needing to get to Homer and unwilling to wait for another steamer, Kilcher decided to cross the Harding. He headed up Lowell Creek but returned within a week, having learned a crossing like this would be more of an expedition than a hike.

The first known crossing of the icefield occurred in 1940 when two Alaskans, Eugene "Coho" Smith and Don Rising, crossed from Bear Glacier to Tustumena Lake. In the mid-1960s, two parties attempted but failed to make the crossing. In 1968, a mountaineering party departed Homer on horseback, travelled up Chernof Glacier on foot and skis, and completed the first ascent of Truuli Peak, the highest point on the Kenai Peninsula. Part of this group, including Yule Kilcher, continued across the Harding Icefield and skied down Exit Glacier. The trip took eight days. Notable recent explorations include a 14-hour solo crossing of the icefield from Skilak Glacier to Chernof Glacier and a kite-skiing expedition from Exit Glacier to Grewingk Glacier.

Ice as Far as the Eye Can See

In 1980, the founding legislation for Kenai Fjords National Park included a segment to protect and preserve the Harding Icefield and its out-flowing glaciers. Today, during the warmth of the mid-summer season, many people climb the Harding Icefield Trail to see the ice firsthand. At the top, the view is unlike any other: Mountain peaks enshrouded with ice stretch off into the distance and many must be tempted to come back someday, like Kilcher, and go further.

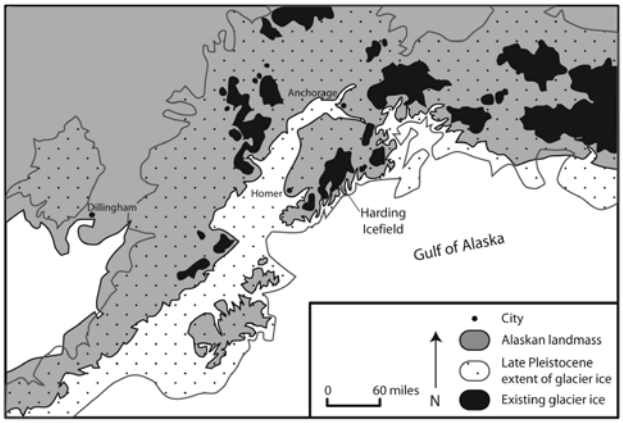


Figure 1: Extent of ice in Southcentral Alaska.

USGS photograph by Bruce Molnia

Figure 2: Nunatak on which the weather station is located.

Succession in a Glacial Landscape

Any time a great disturbance such as a flood, a volcanic eruption, or a glacier impacts the land and its plant communities, there follows a very orderly process of reclamation called plant succession. The best place in the park to witness this process in action is the Exit Glacier valley. When it was advancing, the glacier marched over this landscape and eradicated the forest that once grew here. Its present day retreat enables the rebuilding process which over time turns rocks to soil and gravel plains to forest.

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Arrivals and Departures

When a glacier advances it is like a bulldozer, scraping away everything in its path. Forests are overwhelmed and broken up in the relentless forward march. A glacier in retreat leaves behind little but rock, silt, and a series of streams. However, in a remarkably short time, plants begin to reclaim the open ground. First, the spores of lichens and mosses waft into niches in the rock, spreading slowly and clinging to tiny fragments of soil. Next, seeds of fireweed and dryas, which resemble dandelion seeds, drift on the wind and take root in gravel. Shrubs move in next, their seeds traveling mostly by wind and occasionally by animal. These include willow (*Salix* sp.), which survives in the wetter spots best and has its seeds borne in a cottony mass; and alder, its tiny seeds winged like a maple's.

Of all the initial pioneer plants arriving in the process of plant succession, perhaps the most important is the alder. In Kenai Fjords National Park, it is shrubby, Sitka alder (*Alnus crispa*). Alder has mastered a method of fertilizer production capable of providing food from a soil that is mostly rock. The alder forms a symbiotic relationship with bacteria found in the soil. This specialized bacteria, called *Frankia* ssp, inoculates the alder and makes a small nodule on its roots. Within its diminutive space, the bacteria take in gaseous nitrogen and convert it into nitrates, the building blocks needed for plant growth.

Alder's partnership with bacteria benefits the entire forest. Alder is deciduous, dropping its leaves in winter. These leaves form the basis for rich new soil that stimulates the growth of the very plants that will one day replace the alder—cottonwood trees (*Populus balsamifera*). Cottonwoods are fast-growing, deciduous trees capable of surviving in difficult situations. Bury the base of most trees and they smother, but not cottonwood. Cut it down and it sprouts again. Let a river tear it loose, and it sprouts from its own driftwood.

Alder, a pioneer plant. NPS photograph by Lisa Gordon

Unlike the fluffy seeds of the cottonwood, Sitka spruce seeds are tiny and winged, and only travel about a mile from the parent tree. A glacier in retreat often leaves the nearest source of spruce far down the valley. Eventually, spruce seedlings spring up beneath the faster-traveling cottonwoods and reach for the light. The spruce overwhelms the cottonwoods with shade. They take advantage of the nitrogen-rich soil manufactured by the alder that came first. Within 150-200 years, there is little sign of the deciduous trees left and spruce becomes dominant.

Sitka spruce seedlings prefer sunny locations. In the dark understory of a coniferous forest, it is hemlock seedlings that do best. Given another century or so, hemlocks may become the dominant tree in other areas. In Kenai Fjords, the mixture of spruce and hemlock may be more balanced.

Reading the Clues

Alder and cottonwood currently dominate Exit Glacier valley. This is one of the ways in which glacial activity can be dated. As the ice melts away, the land is recolonized. Succession is fairly predictable—from mosses and lichens, dryas and fireweed, to alder and willow, then cottonwood, and finally spruce and hemlock. Anyone who is familiar with its pattern can trace out a rough idea of where the ice was and how long ago. If ice advances again, or in places where landslides, windstorms, fires, or human activity have reset the clock, the plants of early succession can be found at work.

The former height of Exit Glacier can be measured by the vegetation. Clumps of spruce and hemlock trees cling to the sides of the valley, while cottonwood trees remain lower. Where cottonwoods grow there was more recently ice. When the glacier last advanced, it wasn't high enough to wipe out the spruce and hemlock groves on the slopes above. They survived to reveal the extent of the ice just a few hundred years earlier.

Resilient but Fragile

Given such a short amount of time to work, and starting with nothing but gravel and stone, it's amazing that there is any soil on the ground at all. The thin layer of soil is easily damaged, even by footsteps. Winter storms can wash it away. The plants of the rainforest don't need deep taproots; instead, they have shallow roots that spread out, clinging to what little soil exists, clutching the bedrock beneath. This broad web of roots, each holding onto the other, connects the trees in a rainforest. This helps the forest withstand windstorms. When a storm does topple a tree, it will often snap the trunk while the roots still hold the base of the tree in place. At Exit Glacier, visitors can observe the thin, dense mat of roots and soil where the river pouring out of the glacier tears into the bank, undercutting the vegetation.

In a place where nutrients are at a premium, everything that dies is instantly taken apart and recycled to support life. Fallen trees become nurse logs, the next generation of trees sprouting on the decaying wood. Dead trees hold water, allowing seedlings to make it through dry spells safely. Fungi convert tough, hard lignin into digestible nutrients. Some kinds of plants, like the blue-berried skunk currant (*Ribes glandulosum*), are seldom found on the ground, doing best on top of old logs and stumps.

The Bigger Picture

Climbing up the slopes, the trees face increasingly shorter seasons and heavier snows, and are replaced by lush meadows of wildflowers. This mosaic benefits wildlife: Black bears take shelter in dense clumps of alder, climbing up to subalpine meadows to consume nutritious summer foods, and entering mature spruce forests in the fall to eat blueberries.

Even out in the midst of the Harding Icefield, there are plants beginning to colonize the nunataks as ice melts and more rock is exposed. Seeds make their way to these rock islands surrounded by ice. They hang on in a land where they are likely covered in snow all but two to three months of the year.

Exit Glacier, like many glaciers in Kenai Fjords National Park, is undergoing rapid recession now. Seedlings of alder, cottonwood, and dwarf fireweed quickly colonize the seemingly barren landscape, exposed by melting ice. A visit to the glacier is just one snapshot in time. Next year, 50 years from now, a century ahead in time, succession will create a different place, still linked to the past by the patterns that shape its changing landscape. Patterns we are still learning to recognize.

NPS photograph by Paul Ollig

The forest begins near Exit Glacier.

A walk up to Exit Glacier shows increasingly younger vegetation, culminating in bare rock beside the blue walls of ice. Look carefully, not far from the ice the first colonizers are taking hold. Dwarf fireweed, alder, willow, mosses, and lichens are beginning the process of transforming the debris and bedrock into a garden of life.

Temperate Rainforest Ecology

To many, the word rainforest brings to mind lush vegetation and an abundance of reptiles and amphibians. This rainforest of dream vacations is the "tropical rainforest." In a tropical rainforest, there is not much change in daylight hours from winter to summer and seasons are measured by weather patterns, not by temperature. Tropical rainforests are found between the tropics of Cancer and Capricorn.

Temperate rainforests have rain and trees in common with their tropical namesakes but little else. To be considered a rainforest an area must receive 80 inches of rainfall or more each year. In the temperate regions of our planet, this amount of rain falls consistently on the eastern edge of the Pacific Ocean.

The Trees for the Forest

In Kenai Fjords, the primary tree of the rainforest is the Sitka spruce (*Picea sitchensis*). Sitka spruce trees have very sharp needles and bark that sheds in rounded, puzzle-piece-like flakes. This resilient tree lives along the coast from northern California to western Alaska. It grows straight and fast, its wood in the southern part of its range is highly valued for its straight grain and strength. It is the hardest of the soft woods.

In the forests of Kenai Fjords National Park, Sitka spruce is abundant, but held to elevations usually lower than 1,000 feet. Above this level, snow does not melt quickly enough to allow the trees a sufficiently long growing season. Even below 1,000 feet, many of the trees crack along their trunks from early frosts. Mixed with the spruces are mountain hemlock trees. Mountain hemlock (*Tsuga Mertensiana*) ranges higher up the slopes, and is tolerant of short seasons and heavy snowfall.

Traveling by boat along the shoreline of Kenai Fjords National Park, the difference between spruce and hemlock can be seen as a difference in color: Spruce trees are grayish or bluish in tone; hemlocks have a brighter, yellow-green cast.

© Photograph by Fabrice Simon

Kenai Fjords National Park boasts the northernmost boundary of the temperate rainforest ecosystem. The forest extends south along the coast of North America as far as northern California. Two factors combine throughout this range to produce perfect conditions for the rainforest ecosystem: high coastal mountains and ocean lying just to the west.

The location of the ocean is significant. As moisture from the ocean rises to form clouds, the prevailing winds whisk the clouds toward the mountains of Southcentral Alaska. In the Kenai Fjords, the mountains literally trap the clouds producing our somewhat soggy climate. The park receives 80-150 inches of precipitation annually; easily triple the wet clime of Seattle, Washington. Due to the damp conditions, temperate rainforests experience few fires.

The ocean also moderates the temperature of coastal regions along the eastern north Pacific, keeping them a few degrees warmer than lands out of its weather reach. Kenai Fjords National Park is dominated by conifers, but unlike rainforests to the south there is persistent snow at sea level during the winter season.

Layer Upon Layer

A temperate rainforest consists of three layers: the canopy (trees above 15 feet tall), the understory (shrubs 10-13 feet tall), and the forest floor. In Kenai Fjords, the canopy is comprised of Sitka spruce and mountain hemlock. In an old-growth forest, a forest that has not experienced disturbance in over 175 years, the canopy layer can be diverse enough to contain microclimates. Microclimates create niches, which create species diversity. The marbled murrelet is one species found in Kenai Fjords National Park that needs old-growth spruce, preferably with lots of moss for building its secretive nesting sites. Within the forest, light availability and temperatures decline and humidity increases as you work your way down through the layers.

The understory is usually comprised of thorny devil's club (*Oplopanax horridum*), blueberry bushes (*Vaccinium* sp.), or a blueberry relative called rusty Menziesia (*Menziesia ferruginea*). Waist-high lady fern (*Athyrium filix-femina*), deadly baneberry (*Actaea rubra*), and cucumber-flavored twisted stalk (*Streptopus amplexifolius*) also thrive in the cool, moist shade.

The forest floor is a fairly dark place but what it lacks in light, it makes up for in nutrient availability. Still, few plants are able to grow here. Mosses and lichens survive without much sun and the tiny leaved Lingonberry (*Vaccinium vitis-idaea*) thrives threaded amidst the moss. Mosses and lichens have also developed the ability to live without soil, as epiphytes on tree trunks and branches, this "second home" offers better access to sunlight and the ability to absorb moisture from the air.

In this tightly cycled ecosystem, the forest floor is constantly being supplied with nutrients in the form of litterfall. Litterfall is the material that works its way down from the plants above. Twigs, cones, leaves, and bits of lichen fall to the ground and are recycled into a soil layer that is thin but rich. Layers of the canopy control the throughfall, another name for the moisture that reaches the forest floor.

The Ties That Bind

Many symbiotic relationships exist within the temperate rainforest. One of the least visible, but most extensive, is the mutualistic relationship of mychorhizzal fungi with many of the forest plants including the Sitka spruce tree. These fungi have a network of root-like mycelia delving into decaying trees and rotting leaves, working loose trapped nutrients. They penetrate into the roots of living trees, in turn, exchanging their gathered nutrients for the sugars made in the canopy far above. Fungi, bacteria, and insects act as the decomposers and recyclers of the forest, breaking down and redistributing the litterfall from the trees above.

In temperate rainforests, downed trees act as "nurse logs" to seedlings. Seeds that land on a nurse log have an advantage from the supply of nutrients, water, and soil found in the decaying wood. This commensal relationship benefits the seedlings that will become the replacement primary producers of the downed tree.

Plants and animals can have symbiotic relationships. The small, red squirrel derives the bulk of its diet from the seeds of Sitka spruce. They nest in and under their favorite trees—usually older ones that produce many cones. They store cones in burrows and do not always remember where they put them, which spreads the seeds. Their digging aerates the soil around the roots, and their waste becomes compost, returning nutrients from squirrel to tree. Both tree and squirrel benefit in this mutualistic relationship.

One does not often associate fish with forests, but salmon are another contributor to the ecosystem. As salmon travel up freshwater streams to spawn and die, their carcasses bring essential nutrients. Forest consumers such as bear, marten, eagles, and river otter feed on the salmon and carry their nutrients back into the forest.

The northern limit of the coastal temperate rainforest is a dynamic linking of oceanic, atmospheric, and physiographic conditions, which combine to produce a tightly knit biotic community. Sunlight is rationed through layers of conifers. The understory thickens in relation to the canopy overhead. On the forest floor, all manner of creatures carry on the business of recycling any cone or branch that drops to the ground. The rainforest thrives using a thin soil layer on steep slopes often enshrouded with clouds and fog, a faultless example of nature's excellence.

Fjord Estuary Ecosystem

The fjord estuary ecosystem is one of the richest assemblages of life on earth, but not one of the most well known. Found only in six locations around the planet (Chile, Norway, New Zealand, Alaska, Greenland, and Antarctica), fjord estuaries require just the right combination of events for their construction.

About 27-32,000 years ago, this precise mixture began in Alaska during the Wisconsin glacial period. Snow piling up for years and years, compressing into ice underneath its own weight, spread across the Kenai Peninsula as the Cordilleran ice sheet. Here in the Kenai Fjords, ice covered the mountains and carved the valleys. The ice etched out a landscape of U-shaped valleys with jagged ridges, known as arêtes, in between. Many of these valleys extended 600-1000 feet below what would become sea level once the warming progressed. Once filled with seawater, these long deep arms of the sea are called fjords; other glacially carved valleys were elevated on mountainsides and appear today as what we call "hanging valleys."

About 10,000 years ago as the ice began to melt, the valleys filled with seawater. Some of the lower glacial features drowned and became beautiful half moon bays. Now, even as they melt, glaciers continue to move downhill under the force of gravity, eroding the bedrock beneath them. The meeting of this fresh water with the ocean creates an estuary. When the contribution of fresh water is from glaciers, a fjord estuary ecosystem is the result. Glacial run-off colors the saltwater grey with the rock flour it carries. In the park, this sediment accumulates as much as a foot a year at the bottom of the 600- to 1000-foot deep bays. The fresh meltwater provides calcium, iron, magnesium, potassium, and trace elements to the ecosystem.

Essential Parts of the Whole

All ecosystems consist of biotic (living) and abiotic (non-living) elements. The non-living elements drive the richness of the living elements in Kenai Fjords National Park. Beginning with the spring season, long days of sunlight, fresh water influx, cold, oxygen-rich seawater, and local nutrient availability conspire with tides, strong winds, and currents to assemble a new crop of biotic elements in the ecosystem. Each spring

McCarthy Glacier. USGS photograph by Bruce Molnia

Keystone Species

In most ecosystems there is a "keystone species," one that has a role linking the whole ecosystem. The sea otter holds that role for the fjord estuary ecosystems of Alaska. Feeding on a variety of shellfish but always keeping the sea urchin population in check. Sea urchins have been known to create "urchin barrens" eliminating giant stands of kelp if there is not a local predator to keep their numbers down. The sea otter inadvertently keeps the macro-algae community healthy by being a voracious predator of sea urchins. This affords many other creatures a place to hide from large prey. If the sea otter population is healthy then one can conclude that the ecosystem it lives in is healthy.

is a little bit different based on the timing of the abiotic elements. However, each year the fjords can count on a great spring bloom in the phytoplankton community sometime between early April and early June.

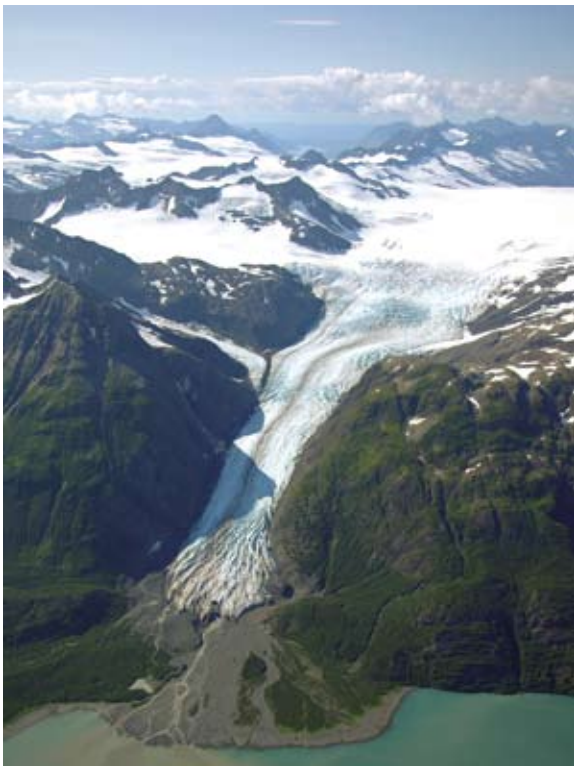
Phytoplankton is "plant plankton," the primary producer and the key ingredient of the complex fjord food web. Primary producers all use the sun's energy to convert carbon dioxide and nutrients into carbohydrates supporting the growth of the creatures that feed on them. In Kenai Fjords National Park, the presence of phytoplankton is evidenced by the deep green color of the water. The phytoplankton is the food source for many of the zooplankton, or "animal plankton." An abundance of phytoplankton gives rise to an abundance of zooplankton. Some zooplankton and invertebrates are grazers feeding strictly on phytoplankton or algae. The presence of great numbers of phyto and zooplankton bring the larger consumers to the fjords to feed. Consumers eat other animals and in some food webs are referred to as predators or carnivores. They come in all shapes and sizes from the zooplankton to creatures like the humpback whale that travel 2,700 miles from their winter breeding grounds to take advantage of the rich waters of this ecosystem.

Some of these consumers come in such great numbers that scientists call them "indicator species." The common murre is one example of an indicator species. It is a diving seabird feeding on small oily fish like sandlance and capelin. Its local colonies can easily be 10,000 strong in Kenai Fjords. If a shortage or delay of their prey fish occurs, scientists are easily alerted by a sudden die-off in the population.

With all of this feeding going on there is also a lot of waste and decay. Detritivores, like crab, are the garbage men of the ocean, feeding on the waste and decay of other creatures and recycling the system nutrients.

The Perfect Mixture

From the primary producers to the garbage men of the sea, the fjord estuary ecosystem is a varied and rich network. The complex web of life flourishes here because of the unique physical setting created where the glacial streams meet the sea. Understanding the links between the abiotic and biotic elements found in the fjords helps us appreciate this unique ecosystem and understand our own role to play as visitor and steward.



Dinglstadt Glacier. USGS photograph by Bruce Molnia

Pederson Glacier. USGS photograph by Bruce Molnia

Climate Change

Kenai Fjords National Park has always been a place to examine change. The park is referenced as a "window to past ice ages" and "a place where the ice age still lingers." Visitors have come to the park to be reminded of the Earth's most recent glaciation, the Wisconsin glacial period, when the Cordilleran ice sheet rested thousands of feet thick atop the Kenai Peninsula. In recent years, Kenai Fjords, along with many of Alaska's national parks, has also become a place to examine the future of climate change for our nation and our planet.

McCarthy Glacier, 2004 USGS photograph by Bruce Molnia

McCarthy Glacier, 1909 USGS photograph

The World's Icy Crystal Ball

Alaska and arctic regions are responding to climate change faster and with observable outcomes not yet occurring as dramatically outside of this area.

Data from the Seward weather station shows a 1.2 degrees Celsius increase in Seward temperatures over the last 59 years. During this same time period, Exit Glacier, one of Alaska's most visited land-based glaciers, has gone from being the main attraction of the valley's outwash plain to becoming a river of ice missing in action. The view across the plain from the park's main trail now shows bedrock, glacial till and several recessional moraines, but no ice. From a different vantage point, further away from the glacier, one can still find the toe of the glacier resting precariously between two rock outcroppings that tower above the level of glacial ice. In this new version of rock, paper, scissors, sun heats rock and rock melts ice.

The Edge of the Glacier Trail, originally built in 1989 to view the side of Exit Glacier, has had to be reworked twice in recent years to keep up with melting ice. In 2000, the trail was expanded and visitors could safely view ice along the trail. The trail is still there, but the glacier has again melted in from its edges so significantly that in 2005, a 540-foot extension off the trail was created to get visitors close to the ice once again.

Throughout the park, other glaciers are responding in a similar manner. Studies conducted in the mid-1990s and early 2000 (Echelmeyer) measured changes in ice volume of 13 glaciers in the park. Out of 13, 10 were losing volume. A new study completed in October 2006 (Molnia) reports that of the three that were gaining in volume, two are now reported to be shrinking, and data is lacking on the third.

Changing Climate, Changing Responsibilities

As we witness changes in glaciers and changes in temperature in the park, we are also seeing changes in populations of various animal species. Several species appear to be in decline.

Marbled and Kittlitz's murrelets have declined between 60-83 percent since the mid-1970s. Harbor seals are another species in the park that has seen a transformation in population numbers over the last 25 years. With the 1980s as a starting point, a drop of about 80-85 percent was seen from 1995-2002. However, recently the harbor seal numbers seem to be climbing again and researcher Anne Hoover-Miller says their numbers are at about 50 percent of the original population of the 1980s.

Both within the park and in surrounding parts of the Kenai Peninsula, insect populations are expanding.

NPS photographs

Exit Glacier aerial photos, 1993, 2004, 2005, and 2006.

Warming or Natural Cycles?

Serbian astronomer Milutin Milankovitch clearly outlined the cause of past natural cycles of warming and cooling periods. Four factors having to do with the tilt of the Earth's axis, the shape of the Earth's orbit, solar forcing and precession, what season the Earth is closest to the sun in a given year, combine to create approximately 100,000-year cycles. The bottom line of the graph shows that during each 100,000 year period, which is also called a 'glacial age' (Pielou 1991) there are between 60 and 90,000 years of glaciations or cold times and 10 to 40,000 years of interglacial or relatively warm times. Given Milankovitch cycles our planet should be heading into cooler times right now, but it isn't.

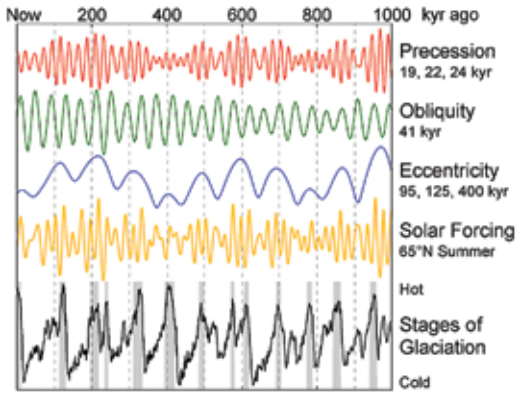


Chart: Milankovitch

The spruce bark beetle infestations that have plagued areas north of the park are not infesting Kenai Fjords because of the heavy amount of rainfall present here. However, leaf miners seem to be more and more present in the cottonwood and alder trees found near Exit Glacier.

Many separate studies suggest that climate change is altering our ecosystem in a multitude of ways. Scientists believe there is no single cause of species decline, but climate seems to be a variable that triggers decline in prey abundance and availability and in disease presence.

One Park's Answer

Changing climate will continue to melt glaciers, change predator-prey interaction, and perhaps introduce new species to what were once cooler lands. National parks are created to preserve and protect a resource but if the resource moves due to climate change, the purpose of the park must be adaptable. In Kenai Fjords National Park, the policy is to be proactive. Through education and interpretation, we inform visitors about the local effects of climate change. The park has taken a stand to try to reduce its own contribution to climate change by recycling, purchasing cars that conserve fuel, traveling less, and in the past, using a fuel cell to power its Exit Glacier Nature Center. In addition, the park purchases renewable energy credits to offset all of its electrical, diesel, gasoline, air travel, car travel, heating oil, and propane needs. Stewardship is a message that parks have always promoted, and stewardship will be the message that enables a more stable climate future.

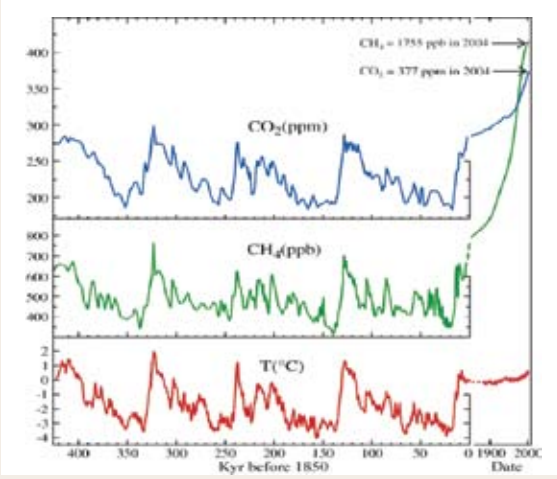
Greenhouse Gasses

Carbon dioxide and temperature tend to rise and fall in unison. We know that our way of life—burning fossil fuels—contributes to carbon dioxide levels in the atmosphere, and is raising the planet's temperature.

Carbon dioxide is one of several gases (methane, nitrous oxide, and chlorofluorocarbons are some others) that contribute to the "greenhouse effect," essentially warming the planet by trapping solar radiation within our atmosphere. Scientific data shows a rise in carbon dioxide, which correlates directly to the industrial age and the rise in the use of fossil fuels.

"In the last 17 years, carbon dioxide levels have risen faster than in any 1,000 year period over the last 800,000 years."

ERIC WOLFF, SCIENTIST WITH THE BRITISH ANTARCTIC SURVEY, BBC NEWS, SEPTEMBER 4, 2006.



Graph courtesy of James Hansen

National Park Service
U.S. Department of the Interior

Kenai Fjords National Park, Alaska

Lesson Plans

Lesson Plan

National Park Service
U.S. Department of the Interior

Kenai Fjords National Park, Alaska

Glacial Detectives

OVERVIEW: Students will learn basic glacial concepts in preparation for a trip to Exit Glacier or deeper exploration of the site online.

OBJECTIVE: Students will learn about glacial features by examining real photographs from Kenai Fjords National Park. In small groups, students will study photos and learn how glaciers move, how they affect the lands around them, and what clues they leave when they have been in an area.

BACKGROUND: Teachers need to read the Glaciers and Harding Icefield sections of this manual. Together as a class, read chapters 3, 4 and 5 of *Frozen in Motion*.

VOCABULARY: Braided Stream, Calving, Cirque Glacier, Crevasse, Fjord, Glacial Advance, Glacial Recession, Glacier, Iceberg, Icefield, Moraine, Morphology, Outwash Plain, Serac, Striation, Tidewater Glacier, Valley Glacier.

PROCEDURE: Set up 7 stations and place pictures from each of the above groups at each station. Divide the class into 7 "Investigative Teams." Tell them they will be working as a group to unravel clues about glaciers.

Give each team a Glacial Detective Form and let them know they will have about 5 minutes at each station. Their job is to look at the pictures and try to answer the questions for each station in as much detail as they can.

Keep time and let groups know when they should move on to the next station.

GRADE LEVEL: 3-5

SUBJECT: Glaciers

KEYWORDS: Glacial Advance, Moraine, Outwash Plain, Striations

DURATION: 45-60 minutes

GROUP SIZE: 7 groups

SETTING: Classroom

NATIONAL STANDARDS: Science D 1, F 4, G 1

MATERIALS

You will need to go online and print out the photographs and worksheet found in this lesson plan. To enlarge photos and manipulate spacing on worksheet go to http://www.nps.gov/kefj/forteachers/index.htm

Print and laminate (only include station numbers on student copies):

- **Station 1** - Exit Glacier 1950 and 2007
- **Station 2** - Outwash Plain and Braided Streams
- **Station 3** - Striations and Moraines
- **Station 4** - Crevasses and Seracs
- **Station 5** - Holgate Glacier Calving
- **Station 6** - The Harding Icefield and aerial view of fjords
- **Station 7** - Two pictures of park rangers: one with an audience in front of a glacier; one banding a bird or taking a hair sample from an animal.

Print enough copies of the Glacial Detectives form for each student group.

ASSESSMENT: At the end of 30 minutes gather the groups together and discuss each of the stations. Students should be able to grasp these concepts in the group discussion:

- ✔ **How are glaciers formed?**
- ✔ **Do glaciers move? If so, what causes them to move?**
- ✔ **What are some signs of movement you may have seen in the photographs?**
- ✔ **Do glaciers affect the land around them? In what ways?**
- ✔ **Does the land or do people affect glaciers? In what ways?**
- ✔ **Are there different kinds of glaciers? Can you say what makes them different?**
- ✔ **Why do we have a national park with glaciers in it?**
- ✔ **Do you think there are any history lessons in Kenai Fjords National Park?**

PARK CONNECTIONS: To help students understand the concept of national parks spend some discussion time on station 7 and the bonus question.

The four reasons we have national parks are:

1. **Conservation**—Parks help preserve the animals and the ecosystem that supports them.
2. **Education**—So that anyone can visit parks and learn more about the geology, biology, and cultural history that are a part of the park.
3. **Enjoyment**—So people can come and just appreciate the beauty and wonders.
4. **Inspiration**—Hopefully, once you've seen a national park you'll leave feeling different, perhaps wanting to draw or paint or write. Inspiration is the feeling that drives many artists to create.

EXTENSIONS: For older groups, spend some time talking about the Harding Icefield.

What is an icefield?
How does it form?
When did this one form?
What conditions make Seward a place where icefields and glaciers can exist?

Plan a field trip to Kenai Fjords National Park. Visit the "For Teachers" page at http://www.nps.gov/kefj/ to reserve a date.

BONUS

Ask learners to decide what makes Kenai Fjords National Park so special?

The answer to the bonus question is the United States was the first nation to recognize the value of setting lands aside so future generations could enjoy undisturbed, the wildness, beauty and history preserved in each site.

It is also empowering to remind students that these lands belong to them.

TIPS

For younger groups, you might develop Hint Cards for each station. Have them attempt to complete the station without a hint card but allow them to check the hint if they need to.

HINTS:

Station 1 - Is Exit Glacier growing or shrinking?

Station 2 - Do you see any plants? What do you mostly see in this picture?

Station 3 - Look at the rocks in the first picture; are there marks on these rocks? In the second picture look at the piles of rocks; how did they get here?

Station 4 - The mountain that this glacier comes down is not smooth.

Station 5 - Seawater is warmer than glacial ice.

Station 6 - Picture one feeds all of the glaciers in the park, picture two is a little like the footprint of a glacier.

Station 7 - The rangers are helping a bird; the ranger is teaching students.

ADDITIONAL RESOURCES

Alaska's Glaciers: *Frozen in Motion* by Katherine Hocker, Alaska Geographic, Anchorage, 2005.

www.nps.gov/kefj/forteachers/index.htm

STATION 1

Exit Glacier in 1950 Historical Society

Exit Glacier in 2007 USGS photograph by Bruce Molnia

STATION 2

An aerial image of Exit Glacier and the immediate surroundings. NPS photograph

Exit Glacier and its surroundings. NPS photograph

STATION 3

USGS photograph by Bruce Molnia

This boulder has been altered by the passage of glacial ice.

NPS photograph by Doug Capra

Exit Glacier and surrounding area.

STATION 4

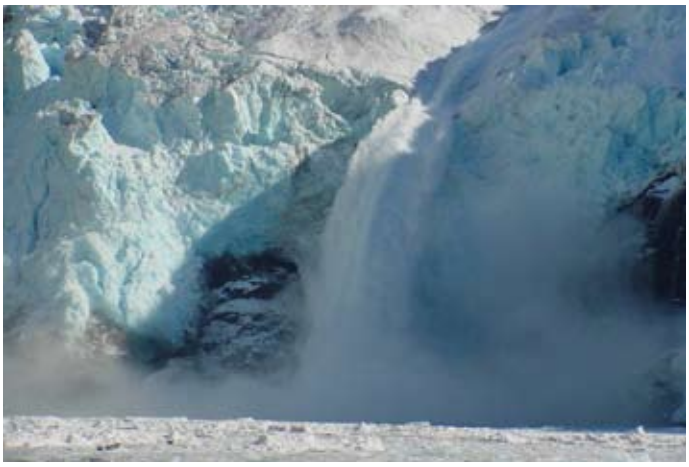
© Ron Niebrugge courtesy of NPS

This photo shows the face and upper edge of Exit Glacier.

NPS photograph by Lisa Gordon

This photo shows the surface of Aialik Glacier.

STATION 5



Holgate Glacier.

NPS photograph by CJ Rea

STATION 6

The Harding Icefield. NPS photograph by Jim Pheiffenberger

USGS photograph by Bruce Molnia

The coastline of Kenai Fjords National Park.

STATION 7

A park ranger working at Exit Glacier. NPS photograph by Doug Capra

A park ranger working in the field. NPS photograph

GLACIAL DETECTIVES WORKSHEET

Name: _____

STATION 1

These two pictures were taken at Exit Glacier 57 years apart.
What do they tell you about how Exit Glacier is changing?

STATION 2

These two pictures were taken of the land in front of Exit Glacier.
How is this area different from other wild and unpopulated places you know of?

Describe the area:

STATION 3

These two photographs show clues that glaciers were once here.
What are the clues?

How were the clues formed?

STATION 4

These two pictures show features found on a glacier.
Describe what you see and if you know the names of these features write them down.

Can you guess how they may have been created?

STATION 5

This is a picture of Holgate Glacier. Holgate is a glacier that ends in the water. What is happening in this picture?

Can you guess why we don't see this occurring in the pictures of Exit Glacier?

STATION 6

These pictures are of large features found in Kenai Fjords National Park.
Describe what you see in the pictures. If you can, name the features.

Can you guess how these features were formed?

STATION 7

These are pictures of park rangers at work. What are the rangers in these pictures doing?

Can you list 2-3 reasons why we have park rangers and national parks?

Bonus Question: What was the first country to come up with the idea of setting aside national lands to create parks?

Lesson Plan

National Park Service
U.S. Department of the Interior

Kenai Fjords National Park, Alaska

Those Fabulous Fjords

OVERVIEW: Students will become fluent in the vocabulary and physical geography of fjords. They will understand where fjords occur and why.

OBJECTIVE: Students will use maps and photographs to learn where the fjords of the world are located and to reach conclusions about fjord formation and other glacial processes.

BACKGROUND: Read the Fjord Estuary Ecosystem section of this manual.

VOCABULARY: Arête, Bay, Calving, Erosion, Estuary, Fjord, Glacier, Hanging Valley, Horn, Ice Age, Salinity, Sediment, U-Shaped Valley, V-Shaped Valley

Grade Level: 6-8

Subject: Fjord biology, geology and geography, glacial processes

Keywords: Fjord, glacier, estuary, ice age, sediment

Duration: 6 sessions of 45-60 minutes

Group Size: Whole class and 8 groups

Setting: Classroom

National Standards: Science A 1, C 4, F 2-4; Geography 1-4, 7,8, 17

MATERIALS

Students will need Internet access.

The following maps are available for loan to teachers who are conducting this lesson (contact the education specialist at Kenai Fjords National Park 907-224-7500). If you would like to obtain your own maps, all of the ones listed are available through the Internet (see the Additional Resources section for places to locate maps).

- Map of Kenai Fjords National Park
- Map of Glacier Bay National Park
- Map of Scandinavia
- Map of Antarctica
- Map of New Zealand Coast
- Map of Chile Coast
- Map of Greenland Coast
- Map of the World

Photographs from the chapter on Fjords may be printed using the online version of this manual http://www.nps.gov/kefj/forteachers/index.htm. Should you have any difficulty contact the park education specialist.

Picture List for the Lesson Plan:

- Picture of a glacier at the head of a fjord.
- Picture of a fjord with no glacier.
- Picture of Aialik Bay from above, showing sediment outflow.
- Picture of waterfalls associated with glacial ice melt, flowing into saltwater
- Aerial picture of Kenai Fjords showing multiple fingers of the sea.
- Picture of a bay and a fjord showing extent, depth, width, and height of each.
- Picture of a hanging valley
- Picture of a V-shaped valley

Day 1

CLASSROOM ACTIVITY: Begin with an icebreaker activity by creating a KWL chart. Have a large piece of paper to write on and document what the students know (K), what they want to know (W), and when they've finished the lesson, what they've learned (L). To help participation ask these questions:

What is a Fjord?
Does anyone know where there is one?
What do you find there?
Can people live there? Animals? What else?

Many other questions can be asked to inspire discussion. Fill in the K and W parts of the chart and let the students know that when they are done with this unit you will all fill in the L part.

When the K and W sections are completed, read as a class, the Fjord Estuary Ecosystems section of this manual. If there is time left in class have students begin defining the vocabulary words, working in small groups to facilitate discussion. Assign unfinished vocabulary as homework.

HOMEWORK ASSIGNMENT: Find definitions for the vocabulary words in this lesson plan.

Day 2

CLASSROOM ACTIVITY: As a class, go through the vocabulary list and have students volunteer their answers.

HOMEWORK ASSIGNMENT: Using your vocabulary sheet and what you now know about fjords, write a story that takes place in a fjord. Be as creative as you like but be sure to use every vocabulary word in the story.

(Note: Let the students know they will have several days to complete this homework assignment. Ideally, if the lesson plan begins on a Monday and you assign this homework on a Tuesday, they would have until the following Monday to complete the assignment.)

Day 3

Begin the class session by breaking students up into small groups. Use the number of maps (6-8 maps, one group per map) to determine the number of groups.

Ask the groups to look at their maps for a few minutes and find the fjords on each of the maps. Have students look for the word 'fjord,' and after they get a feel for what a fjord is see if they can point them out from map to map.

Pass out the Finding Fjords Worksheet and have students complete the map portion of the assignment in class. Give the groups about 5 minutes with each map and then have all the groups move at once to the next map table.

After the groups have completed the map section of the worksheet bring the group together and go through the questions. Have groups share their answers and discuss any topics that are unclear.

This discussion should focus on the location of fjords (found in northern and southern hemispheres, found in coastal regions, found in mountainous regions, not found near equator), the features of fjords (long narrow inlets, often have islands associated with them, deep water compared to nearby bays) the climate in fjord locations can also be brought up (areas of heavy precipitation, areas that don't have extremely hot summers.)

Day 4

During the next class period have the same groups spend their time examining the available photographs (the pictures are found in the Teachers Manual and can be downloaded from http://www.nps.gov/kefj/forteachers/index.htm. Give the student groups about 5-8 minutes with each photograph. Ask them to use what they've learned about fjords so far to answer questions about the pictures.

Day 5

Spend the following day reviewing the photograph section of the worksheet. Remind students that their fjord stories are due on the next classroom day. If there is still time at the end of this day, allow them time to work on the stories.

Day 6

Collect the fjord story assignment. Review the KWL chart and determine what students have learned. Ask for volunteers to read their story to the class.

FINDING FJORDS WORKSHEET

Examine the maps in the classroom and answer the following questions.

Map Questions:

1) In what parts of the world are fjords located?

2) Is there any part of the world where fjords are not found?

3) Look at the physical features found on the maps. What water or land features are always part of the fjords?

4) By looking at the maps, can you come up with a more exact definition of a fjord?

Photograph Questions:

1) Describe what you see in the picture and how this may have affected the surrounding landscape.

2) Is this a fjord? Why or why not?

3) What is odd about the water in this picture? How do you think this happened?

4) Describe what is happening in this picture. How might this affect the land? The water?

5) What is this a picture of? Can you describe how this area was formed?

6) Describe how fjords (picture #6A) and bays (picture #6B) are different. Are there any ways in which they are similar?

7) What would you call this? (Hint: look at the vocabulary words) How was it formed? When was it formed? What letter is it shaped like?

8) Describe the difference in shape and surroundings from Picture #7.

ASSESSMENT: Review student's answers on their Finding Fjords Worksheet to create assessment. Students should have ample time to complete the work both in class with their groups and to correct the work at home between classes. Look for these points to be made:

Map Questions:

- Fjords are found in both hemispheres but tend to be near the poles.
- Fjords are not found near the equator.
- Oceans and mountains are always associated with fjords, long fingers of the sea reaching into the land. Sometimes there are still glaciers in fjords.
- A fjord is a place where there once was a glacier, when the glacier melted the sea took its place.

Photograph Questions:

- There is a glacier at the edge of the ocean. The rock around it is steep. The glacier may have had an affect on the rock. There are not many plants in the picture near the glacier.
- This could be a fjord but the glacier is gone.
- The water is oddly colored, looks like the regular ocean water on one side but its very grey/brown on the other. A river brought the dirty water into the bay.
- Waterfalls are running down a mountain side from a glacier. The water could erode the rock. The water from the ice is fresh water and it's flowing into the ocean water, which is salty.
- It's a picture of a fjord. The areas of water were once valleys carved out by glaciers. Now the glaciers are gone.
- A fjord has to be carved by a glacier. For this reason, it is deeper than a bay that is not a fjord. But a fjord can be called a bay, and a bay can't be called a fjord unless a glacier created it. Bays and fjords are similar because they are both surrounded by land on 3 sides.
- This is a 'hanging valley' carved by ice when the surrounding ice was this far up the mountain. It is also a U-shaped valley
- This is a V-shaped valley or river valley.

Grade vocabulary homework and the fjord story homework.

PARK CONNECTIONS: At the end of this activity after students have handed in their worksheets, ask the class if they can imagine why a national park might have been created here. Pass around the map of Kenai Fjords National Park to help with ideas. Try to generate some of these reasons:

- There aren't many fjords in the world and in the Kenai Fjords National Park we have great examples of them.
- Kenai Fjords National Park can teach us a lot about the past. The fjords were created by the glaciers expanding during the Ice Age.
- Kenai Fjords National Park has an icefield which is the largest icefield found completely within the U.S. boundary.
- Fjords are unique environments and home to many species of animals. By protecting Kenai Fjords National Park we protect the homes of these animals.
- Natural places provide us with laboratories to study the process of nature. Kenai Fjords National park is one of these great laboratories.

USGS photograph by Bruce Molnia

Picture 1: McCarty Glacier at the head of McCarty Fjord.

Picture 2: Thumb Cove. USGS photograph by Bruce Molnia

USGS photograph by Bruce Molnia

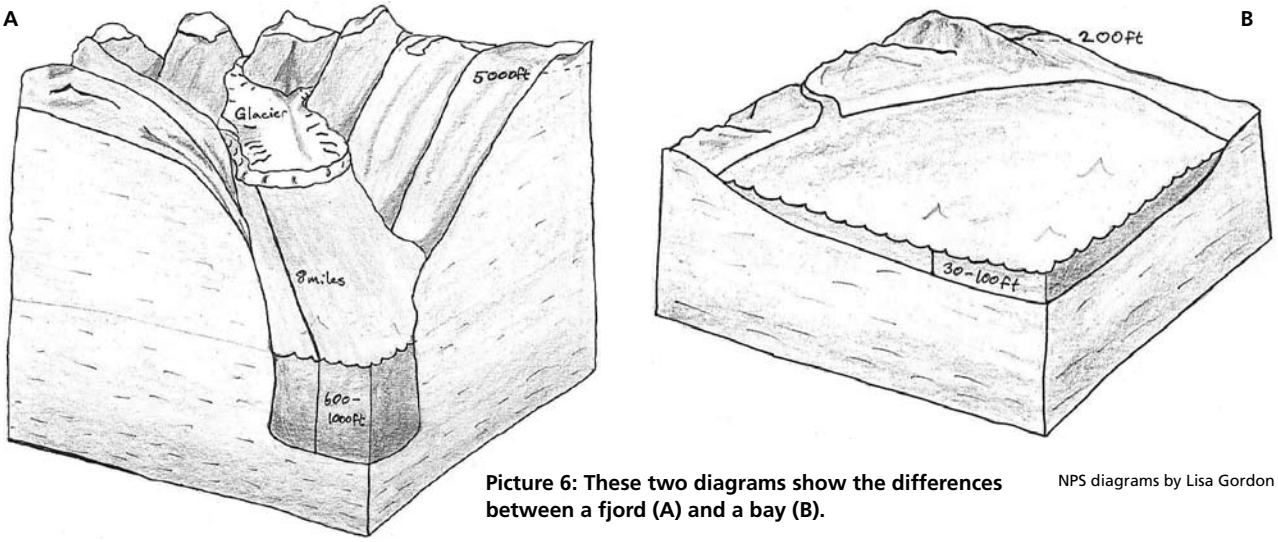
Picture 3: Aialik Glacier from above showing water discolored from sediment.

NPS photograph by CJ Rea

Picture 4: Melting glacial ice creates many waterfalls.

NPS photograph

Picture 5: This aerial image shows the Kenai Fjords coastline.



Picture 6: These two diagrams show the differences between a fjord (A) and a bay (B).

NPS diagrams by Lisa Gordon

Picture 7: Hanging valleys show where a glacier in the mountains abutted a larger glacier. As all of the ice melted, the larger glaciers became the fjords.

NPS photograph by CJ Rea

Picture 8: A river carved this V-shaped valley behind the town of Seward.

NPS photograph by CJ Rea

Lesson Plan

National Park Service
U.S. Department of the Interior

Kenai Fjords National Park, Alaska

The Scientific Method

OVERVIEW: Students will conduct a basic soil science experiment and re-familiarize themselves with the scientific method.

OBJECTIVE: Students will observe the effects of soil on seed germination and growth. Students will determine the nutrient and pH values of the soils they used for their seeds.

BACKGROUND: This lesson is ideal as a precursor to the lesson on Succession and Nutrient Cycling in a Temperate Rainforest Ecosystem. It will prepare students for a more extensive encounter with experimental design.

VOCABULARY: Lichens, Litterfall, Nitrogen Fixing, Nutrient cycling, Photosynthesis, Precipitation, Soil pH, Substrate, Succession, Temperate Rainforest, Throughfall.

PROCEDURE: About 2 weeks prior to starting this lesson, prepare 5 bean seeds in 5 cups of good potting soil. Label these plants with the date they were planted. Keep track of appropriate watering schedule to keep the plants healthy. Decide on amount and frequency of watering for students so that this is not a variable.

Review the Scientific Method on Day 1 and for the next 3 weeks allow students 5 minutes each day to observe the growth of their bean and collect data. The second and third 60-minute classroom session will take place approximately 3 weeks after the first and after the bean seeds have grown.

Grade Level: 10-12

Subject: Scientific Procedure

Keywords: Conclusion, Hypothesis, Scientific Method, Observations, Variables

Duration: 3 sessions of 60 minutes, plus 5 minutes each school day to observe.

Group Size: groups of 3-5

Setting: Classroom

National Standards: Science A 1, A 2

MATERIALS

Bound journal for experiments and observations

Clear plastic cup with 2 holes in the bottom—1 for each student

Slightly wider cup (or cottage cheese container) to act as a saucer

1-5 previously planted bean seeds in plastic cups, also with two holes in the bottom

Small plastic sandwich bag of soil that a student collects and brings from home

Soil test kits (a set of 10 for each nitrogen, potassium, phosphorus, and pH) can be ordered from Carolina Biological Supply. See Additional Resources at the end of this lesson.

Day 1

CLASSROOM DISCUSSION: Begin Day 1 by reviewing the scientific method with the students. (See additional resources at the end of this lesson for topics of discussion.) Let them know that they will be conducting several scientific investigations over the course of the next 3-4 weeks. Instruct students to fill a sandwich bag full of soil from their home and bring it in to school. Any soil is fine and a variety of soils will make for the best experiment. At this time, you should soak enough beans for each student over night.

Days 2-22

Divide the class into 6 groups of 3-5 students each. Ask them to examine their soil and their bean seed and make observations about each. Students will each plant 1 bean seed in their soil and make a hypothesis, such as "My bean will grow 5 inches tall in 12 days." Have the students title their experiment. Have the students state their hypothesis. This experiment will be taking place as the class is preparing for the next 2 activities. Allow students a few minutes each day to collect data and make observations on their seed's growth.

Day 23

Prepare a large graph with each student's name for this day (the X-axis will have student names; the Y-axis height of bean plant in inches). Within three weeks (judge by the growth of the seeds) students will begin to conclude this experiment. They should have a series of daily observations and a growth chart that shows their hypothesis as well as their actual results. Allow students to meet in their groups and discuss results for about 20 minutes before bringing the whole class together. Students should complete the following Classroom Activity during this time and chart their bean's growth on the class graph.

Have students each report and mark on a permanent classroom graph the height their bean seed attained and note any odd characteristics (such as "yellow leaves, brown stem, leaves shriveled") by their name at the bottom of the graph. Have a classroom discussion about the results. Include the activity questions in the classroom discussion.

CLASSROOM ACTIVITY: Drawing Conclusions
Each student should complete these questions while meeting in groups.

1) Why did some of the bean seed grow so fast?
2) What may have kept some from germinating?
3) What was the variable?
4) How does soil affect the growth of plants?
5) What properties need to be present in the soil for good plant growth?
6) Can you make a guess about the soil from the yard where the seed grew the best?
7) What do you think may have happened if we used a fireweed seed instead of a bean seed?

HOMEWORK: Have students write a conclusion for their experiments in their journal.

Day 24

CLASSROOM ACTIVITY: If it does not come up in the classroom conversation, introduce a discussion of nitrogen, phosphorus and potassium. You could direct students by asking if they've ever used a fertilizer or by having them check the label of a fertilizer their parents have used.

Bring up the topic of pH and its affects on plants. Ask students to consider what grows in their yards beneath evergreen trees.

Give each student a soil testing kit and have them test and chart the results of nitrogen, phosphorus, potassium, and pH for their soil. Have them discuss which factors may have limited or helped their bean seeds to grow. Compare the results with others in their groups and then with the whole class.

HOMEWORK: Write up a hypothesis, methods, data, observations, and conclusion for the fertilizer and pH portion of the lab. Have student groups compare their results and create one graph for their notebook that represents the group's results. Ask students to write a conclusion for the entire experiment based on group results, individual results and classroom discussion.

ASSESSMENT: Look for all aspects of the lab to be written up in the journal. There should be a hypothesis, charted data, observations, and a conclusion for both parts of the experiment. There should be an understanding of variables within the lab and there should be some comparisons made between the student's work and that of his group.

PARK CONNECTIONS: If your class lives near a glacier, you might suggest that the soils they brought from home are like the soils in Kenai Fjords National Park—lots of rock, not much nourishment or water. Ask how long it takes after glacial till is formed for plants to grow? How would you be able to determine this? How would this quality of soil affect a park manager's decision to build a trail? How does it affect the growth of plants in an area where the glacier has been?

EXTENSION: It is likely that no student's bean seeds will grow as well as the teacher's since the teacher is using potting soil. Raise this as a question: Why didn't your seeds do as well? See if anyone can come up with an answer about the origin of the soil. In some areas the soil will be glacial till, largely rock and recently broken down rock. This type of soil does not hold water or nutrients well. Clay soils present another problem by binding nutrients so tightly to the soil molecules and not allowing for drainage. What do the folks who make potting soil need to be sure they are working towards for a good soil?

ADDITIONAL RESOURCES: Good Sources for reviewing the scientific method.

http://scifiles.larc.nasa.gov/text/educators/tools/pbl/scientific_method.html
http://scifiles.larc.nasa.gov/text/educators/tools/pbl/scientific_method.html
http://quest.nasa.gov/projects/flies/sciMethod.html

Carolina Biological Supply sells Rapitest 66-5404 kits that will run 10 soil samples each for nitrogen, phosphorus, potassium, and pH.
http://www.carolina.com/product/rapitest+soil+test+kit.do?keyword=rapitest+66-5404&sortby=bestMatches

NATIONAL
PARK
SERVICE

Lesson Plan

National Park Service
U.S. Department of the Interior

Kenai Fjords National Park, Alaska

Temperate Rainforest Ecology

OVERVIEW: Students will review the concept of ecosystems and thoroughly examine the members of their local ecosystem. By concentrating on a specific relationship within the rainforest ecosystem, students will better understand the entire community.

OBJECTIVE: Students will be aware of the important connections between living and non-living parts of the ecosystem. They will understand how seemingly distant events (glacial melt, ocean temperature, industrial development) can impact the local forest.

BACKGROUND: Read the Succession and Temperate Rainforest Ecology sections of this manual.

VOCABULARY: Canopy, Commensal, Conifer, Decomposer, Epiphyte, Fog Drip, Forest Floor, Lichen, Litterfall, Mutualistic, Nurse Log, Nutrient Cycling, Parasitic, Predatory, Understory.

PROCEDURE: One to three days ahead of the classroom activity have students read the sections on Succession and Temperate Rainforest Ecology in this manual and find two online resources that discuss temperate rainforests. Provide them with the vocabulary words to define and help bolster their reading.

GRADE LEVEL: 10-12

SUBJECT: Relationships in the Temperate Rainforest Ecosystem

KEYWORDS: Commensalism, Mutualism, Nutrient Cycling, Parasitism, Predation

DURATION: 2-3/60-minute class periods

GROUP SIZE: Individuals

SETTING: Classroom and at home

NATIONAL STANDARDS: Science C 4, 5, 6, F 5, 6

MATERIALS

Teacher's Resource Manual
Internet Access

Day 1

During the classroom activity, allow students to keep their vocabulary list and any resources they've printed with them for use during classroom discussion.

Ask a student to explain the difference between a forest and a rainforest. Follow this with asking a student to explain the difference between a tropical and a temperate rainforest.

Ask if any students can explain what differences there might be between a temperate rainforest in Alaska and in Washington (snow down to sea level, tree species, seasonality).

Review the vocabulary words as a class.

Day 2

CLASSROOM DISCUSSION: Begin with a refresher introduction on the definition of an ecosystem: All of the biotic (living) and abiotic (non-living) elements and how they interact together in a given area (the person doing the research defines the area).

Ask the class to think about the reading they've done and begin to name the biotic and abiotic components of the temperate rainforest. Have one student write the components on the board in a random order with space between words as other students come up with additional components. Try to encourage the class to come up with 15-20 items. Examples: trees, lichen, soil, rivers, bears, insects, salmon, fungus, rotting wood, blueberries, humans, sun, rocks, moss, moose, birds, nutrients.

When enough components are posted, ask if someone can draw a line from one component to another and define the relationship between the two by writing it on the line. Have 2-3 students do an example each. Explain that we are creating a "Web of Connectivity."

HOMEWORK: Hand out the activity sheet that explains the Rainforest Web of Connectivity activity.

Day 3

CLASSROOM DISCUSSION: Have students discuss the connections they made on the Rainforest Web of Connectivity homework assignment. Try to encourage lots of classroom participation so different ways of viewing the ecosystem are talked through.

Hand out the second activity "Advocating for the Rainforest." Ask students to let you know what pair they will be doing their poster about such that multiple aspects of the temperate rainforest community are represented.

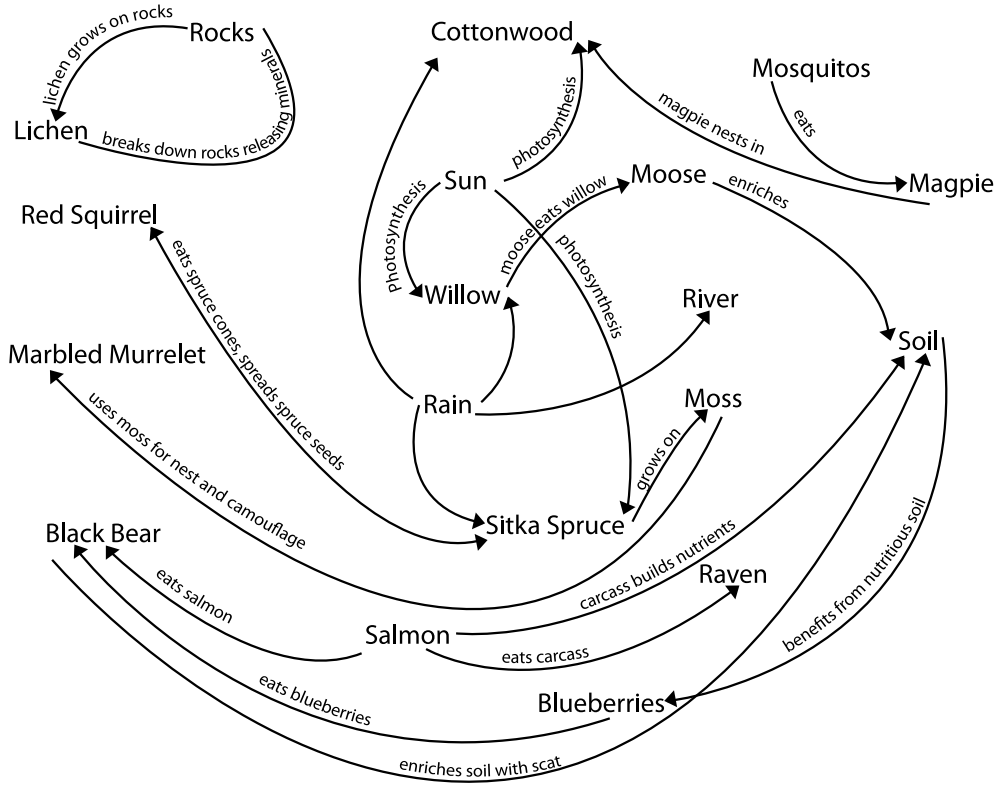
ASSESSMENT: The 2 homework assignments should provide for assessment of students. Check that these points are made in the student's work:

- ✔ The web of relationships should have no less than 15-20 elements in it.
- ✔ Student should be able to describe 10 or more relationships within these elements.
- ✔ Student should be able to clearly define the relationship between the elements chosen.
- ✔ A student with a grasp of the basic material will have no problem creating a poster to promote this relationship.

ADDITIONAL RESOURCES:

http://www.inforain.org/
http://www.nationalgeographic.com/xpeditions/lessons/08/g68/venn.html
http://ocid.nacse.org/lichenland/
http://curriculum.calstatela.edu/courses/builders/lessons/less/biomes/rainforest/temp_rain/temprain.html
Ancient Forests of the Pacific Northwest by Elliot A. Norse, Island Press, 1989

The Temperate Rainforest Web of Connectivity



RAINFOREST WEB OF CONNECTIVITY

Activity 1

On a blank sheet of paper, recreate the biotic and abiotic elements of the temperate rainforest ecosystem. Leave room between the elements you include so that you can detail the relationships between elements. When you have thought of all of the elements you can (elements not listed in today's discussion are fine to add) begin to draw arrows showing how one element affects another. For example, you might have 'moss' and 'marbled murrelet.' On the arrow going from moss to murrelet write: "The moss makes a camouflaged nesting spot for the murrelet."

Once you have completed your 'Rainforest Web of Connectivity' pick one relationship pair to spend time detailing. Be sure to answer these questions:

1.) Describe the two parts of the temperate rainforest ecosystem that you've chosen. Explain in detail the relationship between these two and their contribution to the ecosystem as a whole.

2.) How can this relationship be affected by living things outside of the relationship?

3.) Can humans impact this relationship? If humans are part of your pair, how might they alter their behavior to change their impacts?

4.) How might climate impact this relationship?

5.) Is there one member of the relationship that benefits more? Explain. Equally? Explain.

6.) If these two elements are both biotic, are they mutualistic, commensal, parasitic or predatory? Explain.

ADVOCATING FOR THE RAINFOREST

Activity II

Create a poster advocating for the pair you have chosen. The poster's audience can be humans or the ecosystem in general, or at any individual part of the ecosystem, or at influences completely outside the temperate rainforest ecosystem. Define the poster's audience on the back.

Lesson Plan

National Park Service
U.S. Department of the Interior

Kenai Fjords National Park, Alaska

Succession and Nutrient Cycling in a Temperate Rainforest Ecosystem

OVERVIEW: Students will examine succession in two forest ecosystems: a recently de-glaciated area and an established temperate rainforest. (Note: This lesson can be adapted to succession in any forest ecosystem.)

OBJECTIVE: Students will examine the differences in throughfall, litterfall, and soil condition in the two forests sites. Students will learn to design an experiment to investigate a well thought out hypothesis. Students will gain an understanding of nutrient cycling in a forest. Students will understand how outside influences, natural or human-made, can interfere with this cycle.

BACKGROUND: Read sections on Succession and Temperate Rainforest Ecology in this manual.

VOCABULARY: Lichens, Litterfall, Nitrogen Fixing, Nutrient cycling, Photosynthesis, Precipitation, Soil pH, Substrate, Succession, Temperate Rainforest, Throughfall.

PROCEDURE: The 4 classroom sessions combine 2 field days and 2 classroom discussions with an on-going sampling program of once a week for 2-3 months. Homework includes reading the Succession and Temperate Rainforest Ecology sections of this manual (1), Experimental Design (2), and Dealing with Data (3). Students will need 7 days and some class time to complete Experimental Design. Following completion of each assignment, a classroom discussion will follow.

GRADE LEVEL: 10-12

SUBJECT: Succession

KEYWORDS: Litterfall, Nutrient Cycling, Succession, Temperate Rainforest, Throughfall

DURATION: 4 sessions of 60 minutes (initial set up and design); sampling once a week for 2-3 months.

GROUP SIZE: 6 groups

SETTING: Classroom and fieldwork

NATIONAL STANDARDS: Science A 1,2, C 4, E 1, 2, F 2, 5, G 2

MATERIALS

Journals for each student

8-12 1x1 sq. meter Litterfall catchers (Need 4- 1"x 2" x 3' boards per catcher and 1 3'2"x3'2" piece of fine mesh screen per catcher)

6 Throughfall catchers (Need 8-12, 2 liter bottles and 8 -12, 2' pieces of rebar or strong wood stake, duct tape, clear plastic cup and volume cylinder for measuring.)

6 Soil test kits (a set of 10 for each nitrogen, potassium, phosphorus, and pH) can be ordered from Carolina Biological Supply.

Day 1

OPTIONAL FIELD DAY 1: If time and transportation allow, the best scenario is to take the students to the two forest sites where they will eventually do their experiment and just let them spend time observing the ecosystem. Ask them to write the date and location and observations for the sites in their journals. Encourage observations of the plants, animals, and soil at each site and comparisons of the two sites. This part of the procedure can be skipped but it will diminish the student's input.

HOMEWORK ASSIGNMENT 1: Have students read Succession and the Temperate Rainforest Ecology of this manual. Ask them to take notes as they read and to be prepared to discuss local forest ecosystems the next day in class. Have them research vocabulary words: Canopy, Lichen, Litterfall, Nutrient Cycling, Nitrogen Fixation, pH, Substrate, Succession, and Throughfall.

Day 2

CLASSROOM DISCUSSION:

1) What are the requirements for a forest to grow? (sunlight, water, soil, seeds, nutrients)
2) Which of these might be less available in an area where a glacier has recently been? (soil, seeds, and water retention ability)
3) How do soil and seeds get to an area? (litterfall, animal transport, wind, rain)
4) What hypothesis could we propose comparing a more recently deglaciated area with one that has undergone years of succession?

Try to have students come up with a hypothesis which can be tested using one of the methods below. Use the following sheet as a homework assignment, allowing students a week to prepare the class experimental design.

A. Hypothesis: There is less soil in a more recently deglaciated area. There are less nutrients in a recently deglaciated area.

Test—Test soil nutrients with soil test kit.

B. Hypothesis: Soil composition and nutrient availability are better in an established forest due to long-term contribution from the forest canopy.

Test—Measure litterfall in both ecosystems.

C. Hypothesis: Less rain hits the ground, hence less soil run-off
occurs in an established forest.

Test—Measure throughfall in both ecosystems.

HOMEWORK ASSIGNMENT 2: Experimental Design

From our classroom discussion, we came up with 3 hypotheses we would like to test in our forest ecosystems. Read the hypotheses stated below. With the scientific method in mind, write out methods for testing each of these 3 hypotheses. Be very exacting in your descriptions as we will use student designs for these experiments.

Spend time determining the best testing scenario for each hypothesis. Consider how data will be collected, what will be measured and quantified. Is there any qualitative data to be gathered? Write out your experimental design or methods for each hypothesis with an explanation of why you would do it this way.

Talk with each other to expand on ideas, but do your own write up. Consider carefully where and why you might disagree with another student's design.

1) The soil in a recently deglaciated area will not be as healthy as the soil in the established ecosystem.

Consider: How do we define a healthy soil?
How do we test soil health?
Where should we test the forest's soil?
How often does this test need to be repeated?
How do we prevent bias in this experiment?

2) The forest canopy is a major contributor to the soil of its ecosystem. Therefore, the litterfall is likely more diverse and more plentiful in the established ecosystem.

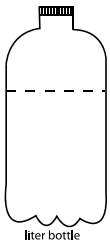
Consider: How can we measure litterfall? Weight? Volume? Type?
Should we sort litterfall to further define it?
Where should we test litterfall?
What outside influences may affect our results?
How often should the data be gathered?
How do we prevent bias in this experiment?

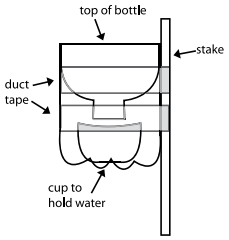
3) With a more developed canopy, less rain hits the ground (throughfall), hence less soil run-off occurs in an established forest.

Consider: How do we measure throughfall?
Where do we measure throughfall?
How often should the data be gathered?
What local and/or outside influences may affect our results?
How do we prevent bias in this experiment?

Throughfall Catcher

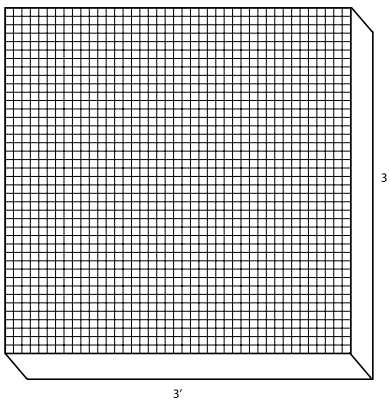
Cut the top off of a 2 liter bottle and remove the lid





Tape bottom of bottle to stake.
Place a small cup in bottle.
Place top of bottle upside down to act as a funnel
When measuring, pour contents of cup into graduated cylinder.

Litterfall Catcher



Nail four 2" x 4"x 3' boa
together to form a 3' x
(1meter) square.
Staple gun fine mesh s
the bottom.

HOMEWORK ASSESSMENT:
Give students a week to research and complete this assignment with some time available on school computers and in group discussion.

When grading this homework, look for students who suggest more than one replica of the same data. (e.g. two groups examine litterfall in the young and two groups examine litterfall in the old forest). Also, look for a student who realizes that litterfall may vary from forest edge to forest middle and includes those variations. Look for students who see that collection of data over a period of months is of value (e.g. collect rainfall samples on Monday and Friday each week for 2 months). Look for an example that talks of weighing the litterfall. Also, look for a design that talks of sorting and weighing separately—seeds, lichens, sticks, leaves, etc. In this way, the biggest contributor to litterfall for an ecosystem can be determined.

Checklist for Assessment:

- ✔ Did the student do a design for each of the 3 hypotheses?
- ✔ Was the design well thought out?
- ✔ Were variables considered?
- ✔ Were multiple trials or data replicates considered?
- ✔ Was bias considered?

Day 3

CLASSROOM ACTIVITY: Field Work Initial Set up
This activity will vary depending on the distance to the field site, experimental design chosen, and data collection method chosen. Ideally, the whole class could walk to both sites at least once a week. Teams could collect litterfall, throughfall, and soil data on one site at each location each week and present data back in the classroom.

Initial site selection will take time. The site must be chosen (remember to remove bias from site selection) and equipment set up. You will need 6 teams to collect data for the 3 experiments (soil nutrients and pH, litterfall, and throughfall) with two replicas at both forest sites:

Sites 1 and 2: Successional Forest Edge Sites
Sites 3 and 4: Successional Forest Mid Sites
Sites 5 and 6: Successional Forest Deep Sites
Sites 7 and 8: Temperate Forest Edge Sites
Sites 9 and 10: Temperate Forest Mid Sites
Sites 11 and 12: Temperate Forest Deep Sites

If only one pair or small group of students can visit the site each week, eliminating the mid-forest sites would cut down on the work. Data collection could also be reduced to once every two weeks. In the scenario above, one group of students would test for each variable at sites 1 and 7.

Before field work gets started be sure the exact number of data collection dates, stations, and analysis is known by all students. Help the class to establish a clear, concise way of organizing data in their notebooks. One example follows, but this will vary depending on your design.

EXAMPLE:

9/23/10	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Soil pH						
Soil N						
Soil P						
Soil K						

9/23/09	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Throughfall cc's						
Litterfall - Leaves g						
Litterfall - Seeds g						
Litterfall - Twigs g						
Litterfall - Lichen g						
Litterfall - Other g						
Litterfall - Other g						

Make necessary adjustments to the data collection as needed, but aim for at least one collection of data every other week to be shared with the class. Students should have access to all data collected so that they can keep track of the information in their journals and participate in interpreting the entire project's results.

Continue sampling the sites for 2-3 months. Each time students visit the sites, they should be gathering data as well as listing observations (such as weather, animal disturbance to equipment etc.) about the site. All data should be posted after each site visit on classroom charts or graphs so that each student has access to every team's results.

HOMEWORK ASSIGNMENT 3: Dealing with Data or Now What Do We Know?

Complete this worksheet within your journal.

1) Review the data charts in your journal. Based on trends you see in the data, decide how best to graph your results. Complete graphs for each site and each part of the experiment (soil, litterfall, throughfall). If any data is left out, explain your reason. To be certain graphs can be interpreted by anyone, remember to title the graph and clearly label the axis and scale. Graphing of various sites can be combined so long as labeling is clear.

2) Did you notice any irregularities in the data? If so, do you know how these occurred? If there is not a known explanation can you make an educated guess?

3) Write a conclusion for each experiment. Be thorough and explain how your hypothesis was proven or disproved. As a part of your conclusion be sure that you answer the following questions:

- ✔ Where does the soil show the best quality for plant growth needs?
- ✔ What soil had the poorest nutrient quality?
- ✔ Where is the greatest amount of litterfall? The least?
- ✔ Where is throughfall the highest? lowest?
- ✔ At which site did plant growth appear to be thickest? Did this correlate to any of the things you were testing for?
- ✔ What can you say about the relationship between the 3 things you were testing for? In other words, do you think the amount of throughfall correlates to the amount of litterfall or to the quality of the soil?

4) Now that you have completed this experiment, what would you do to change it if you were to re-run it in the future?

5) Has this experiment generated any new questions about the two ecosystems being examined?

6) Now think on a larger scale and write down how human influences or natural phenomena might manipulate each of the ecosystems you studied.

ASSESSMENT: The student's ability to make sense of these questions in their journal will thoroughly evaluate the thought put into this project. Pay close attention to:

Graphed results—can you read and understand them? Are they organized well?

Observations of possible data errors—if there were discrepancies, what did the student do?

The answers to Question 3 contain the real conclusions where all items can be compared. It should be weighted heavily.

The final 3 questions assess the student's ability to take knowledge from this project and apply it to other projects and to their understanding of the workings of the world.

Day 4

CLASSROOM DISCUSSION ON EXPERIMENTAL DESIGN (this will occur 7-9 days after Homework Assignment 2 is given): If possible, use the experimental design of the students in the actual field work; ideally drawing from the work of three students (one each for throughfall, litterfall and nutrient availability).

Prior to beginning field work, discuss the chosen designs with the class and see if anyone can discover any flaws in the design. If you see a flaw but can get data even with this flaw, leave it as a learning tool for students later on.

Discuss bias with the students and look at ways bias might influence the designs chosen. Be certain to mention site selection bias and determine a way to eliminate it. A hoola hoop toss over the shoulder is a good unbiased way to chose a site within a given area.

After bias has been covered, determine methodology for each part of the experiment. Remind students that hypothesis, methods, data, observations, and conclusion will all be important in their journal write-ups of their field work.

PARK CONNECTIONS: Add a seventh question to the list above: If you were a resource management professional in a national park tasked with allowing the public to observe the resources but also with conservation of those same resources, how would you allow for viewing of these two ecosystems? What if you were tasked with adding a trail to your park, which ecosystem do you think could better withstand visitation and why?

ADDITIONAL RESOURCES:

http://www.inforain.org/
http://www.nationalgeographic.com/xpeditions/lessons/08/g68/venn.html
http://ocid.nacse.org/lichenland/
http://curriculum.calstatela.edu/courses/builders/lessons/less/biomes/rainforest/temp_rain/temprain.html
Ancient Forests of the Pacific Northwest by Elliot A. Norse, Island Press, 1989

Carolina Biological Supply sells Rapitest 66-5404 kits that will run 10 soil samples each for nitrogen, phosphorus, potassium, and pH.
http://www.carolina.com/product/rapitest+soil+test+kit.do?keyword=rapitest+66-5404&sortby=bestMatches

National Park Service
U.S. Department of the Interior

Kenai Fjords National Park, Alaska

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National Park Service
U.S. Department of the Interior

Kenai Fjords National Park, Alaska

Thematic Index

Thematic Index

"The chief aim of interpretation is not instruction, but provocation." – FREEMAN TILDEN

Meaningful Interpretation

The purpose of this section is to provide teachers and interpreters ideas to create meaningful connections to the resources of Kenai Fjords National Park. The goal in interpreting the rich cultural and natural history of the park is to facilitate connections with the audience that ultimately results in resource stewardship. The idea is that if people care about a place, they are more apt to care for it.

Meaningful lessons and programs can be achieved by providing opportunities for the audience to form their own intellectual and emotional connections to the meanings and significance inherent in the resource through the cohesive development of a relevant idea.

Creating Opportunities

Knowledge of the resource and knowledge of the audience in combination with appropriate, effective techniques provide interpretive opportunities that are relevant, enjoyable, and meaningful.

Intellectual opportunities seem to provoke or inspire: Awareness, comprehension, discovery, enlightenment, insight, reasoning, mindfulness, perceptiveness, recognition, revelation, understanding.

Emotional connections seem to provoke, evoke or inspire: Admiration, anger, aversion, awe, compassion, concern, curiosity, delight, despair, disgust, empathy, fear, grief, happiness, joy, nostalgia, pride, relief, respect, reverence, sorrow, surprise, sympathy, tranquility, wonder.

Effective techniques include: Stories, quotes, explanations, analogies, examples, illustrations, discussions, demonstrations, music, drama, props, role-playing, comparisons, participation, questioning, guided imagery, activities, statistics, sensory involvement.

Themes

An interpretive product must develop an idea or ideas cohesively to be relevant, provocative, and meaningful throughout its delivery. An idea provides a platform for the audience to consider, react to, build upon, appropriate, and transform.

Themes for programs and lessons should tie into the larger significance statements and interpretive themes of the park. A successful theme:

- Expresses meaning – what the audience should care about
- Links a tangible resource to its intangible meanings
- Is more powerful and more broadly relevant to the audience when a tangible resource is linked to a universal concept
- Organizes an interpretive product
- Is appropriate for the audience

Below are examples of using the tangible resources and facts from the manual to connect to their intangible meanings. The "opportunities for connection" statements may help to develop theme statements, relevant ideas, and opportunities for the audience to form their own intellectual and emotional connections with the resource.

Cultural History

Resource: **Alutiiq people**
Meanings: culture, loss, resourcefulness, tradition, archeology, subsistence, interdependence
Opportunities for connection: The tradition and culture of the Alutiiq people are entwined with the sea.

Resource: **Franklin Lowell**
Meanings: resourcefulness, challenge, family, adventure
Opportunities for Connection: Frank Lowell's life tells a story of the resourcefulness and challenges of early Alaska territory adventurers.

Resource: **Rockwell Kent**
Meanings: inspiration, wilderness, solace, healing
Opportunities for Connection: Rockwell Kent is a story of a despondent artist who comes to Alaska for healing, solace, and creative energy. How many people today come here for the same reasons?

Note: Wilderness is filled with wonderful quotes that can be used to enhance a variety of themes.

"The still, deep cup of the wilderness is potent with wisdom."
"It seems that we have both together by chance turned out of the beaten, crowded way and come to stand face to face with that infinite and unfathomable thing which is the wilderness; and here we have found OURSELVES – for the wilderness is nothing else."
"Alaska is a fairyland in the magic beauty of its mountains and waters. The virgin freshness of this wilderness and its utter isolation are a constant source of inspiration."

Natural History

Land Mammals

Resource: **Bears – Brown & Black**
Meanings: adaptation, hibernation, backcountry safety, values, responsibility, native culture, predator/prey relationships, ecosystem, myths
Opportunities for Connection: Bears are the perfection of nature's design; The ability to identify a brown vs. black bear and the knowledge of their evolution with the land will help you in traveling safely in bear country.

Resource: **Moose**
Meanings: evolution, succession processes, ecosystem role
Opportunities for Connection: Moose are the gardeners of Exit Glacier.

Resource: **Mountain Goat**
Meanings: adaptation, survival, grace, danger
Opportunities for Connection: The harsh and rugged landscape of Kenai Fjords National Park is the perfect home for mountain goats; Mountain goats are uniquely designed for steep and rugged terrain.

Marine Mammals

Resource: **Dolphins & Porpoises—Pacific White-Sided Dolphin, Dall's Porpoise, Orca**
Meanings: ecosystem indicators, survival, predator/prey, awe, wonder
Opportunities for Connection: An orca's survival depends on its specialization in feeding.

Resource: Whales— Fin, Humpback, Minke

Meanings: endangered species, migration, ocean abundance, controversy, over-harvesting, values—hunting vs. viewing, importance of fjords, ecosystem role/web of life, mystery, conservation, communication, social system

Opportunities for Connection: The beautiful adaptation of a whale gives us hope and anticipation for the future; The sighting of a whale satisfies a longing and fascination with the sea; In the depths of the ocean lie the secrets to a mysterious world awaiting our discovery.

Resource: Other Marine Mammals—Steller Sea Lion, Harbor Seal, Sea Otter

Meanings: adaptation, survival, research, loss, decline, relationships, ecosystem complexity, agency management, protection, success, ecological indicators

Opportunities for Connection: Marine mammals graciously share our world while we dictate their survival; The legends of the sea depict our longing for connection to it; A disruption in the food chain can endanger or threaten a species, even you.

Land and Seabirds

Resource: Land Birds: Steller's Jay & Black-Billed Magpie

Meanings: perseverance, survival, role in succession, curiosity, intelligence, wilderness, behavior, niches

Opportunities for Connection: Birds have inspired and helped humans in many ways.

Resource: Raptors: Bald Eagle & Peale's Peregrine Falcon

Meanings: conservation, success, symbolism, ecosystem health, awe, history

Opportunities for Connection: The bald eagle and peregrine falcons' recovery is a story of successful wildlife conservation.

Resource: Marine Birds: Puffins & Murrelets

Meanings: daptation, survival, habitat, interconnections

Opportunities for Connection: Alcids soar toward the heights of the ocean floor in their inverted sky; Marine birds are masterfully adapted to survive in water, on land and in the air; The marbled murrelet lives a very codependent lifestyle. It needs both the old growth spruce forest and the ocean to survive; Marbled murrelets ties the ocean and terrestrial ecosystems together.

Park Science

Resource: Geology

Meanings: power, change, sanctuary, dynamism, destruction, rebirth

Opportunities for Connection: The dynamic geology of Kenai Fjords National Park creates a sanctuary for marine and terrestrial life; Geologic forces continue to shape the park, creating a home for a diversity of life.

Resource: Glaciers

Meanings: power, change, dynamic nature, geologic time

Opportunities for Connection: Glaciers are a testament to the power of a snowflake; Glaciers are timeless sculptors creating masterpieces for us to enjoy; Deceptive flowing with tranquility, glaciers really are icy bulldozers, gutting trenches and building ridges; As the sculptors of rolling hills and valley, glaciers have been the sculptors of civilizations.

Resource: **Harding Icefield**
Meanings: adventures, survival, harsh landscapes
Opportunities for Connection: Many people are drawn to the ice, facinated by this beautiful foreign land.

Resource: **Succession in a Glacial Landscape**
Meanings: change, wonder, life, colonization, productivity
Opportunities for Connection: As glaciers recede, forests are reborn.

Resource: **Temperate Rainforest Ecosystem**
Meanings: diversity, habitat, nutrient cycling, interconnections
Opportunities for Connection: Coastal temperate rainforests are among the most biologically productive ecosystems on earth.

Resource: **Fjord Estuary Ecosystem**
Meanings: dependency, dynamism, abundance of life, home, productivity
Opportunities for Connection: The fjord estuary ecosystem is home for an abundance of life.

Resource: **Climate Change**
Meanings: change, impacts, responsibility, stewardship
Opportunities for Connection: Kenai Fjords National Park is a living laboratory for learning—a window to studying our natural world.

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Forging Connections: An Education Resource for Kenai Fjords National Park