Alaska Park Science

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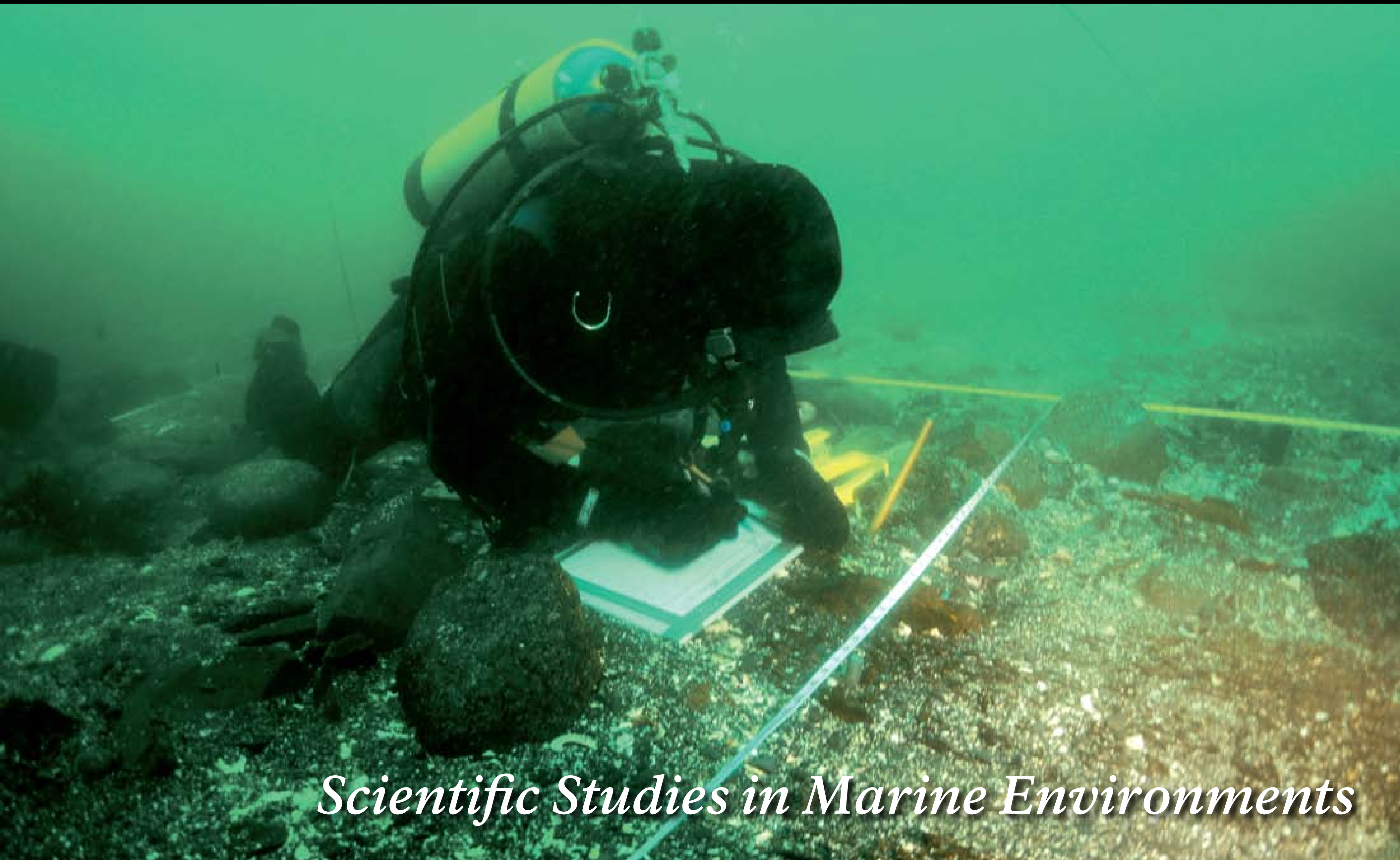

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Cover photo: Scuba diving in Alaska can be a change for divers used to clear tropical seas. Alaska divers typically wear insulated gloves, hoods, and water-tight drysuits to avoid hypothermia from exposure to cold waters. Visibility can also be marginal in some settings, especially at shallow depth and during summer when the abundance of daylight and nutrients combine to produce colorful blooms of phytoplankton (microscopic algae) and zooplankton (minute marine animals). Plankton forms the base of the food chain that supports Alaska's abundant marine fish, seabirds, whales, and other marine wildlife.

NOAA Maritime Heritage Program photograph by Tane Casserley

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Photograph by Caroline Jezierski

Harbor seals on ice.

Article on page 18.

Ocean Park Stewardship in the Alaska Region

Jeff Mow

Peter Armato

(Left) Sea kayakers in Pedersen Lake with seals in the background on an iceberg.
Photograph by Caroline Jezierski

By Jeff Mow and Peter Armato

Since the dawn of time mankind has been fearful and respectful of, and at the same time drawn to, coasts and oceans. These human traits led early explorers out to sea where they mapped ocean boundaries, discovered islands and continental land masses, established trade routes, constructed larger more seaworthy vessels, and refined navigation methods. Throughout this early period of exploration, vast coastal and ocean resources were discovered and exploited. The wealth of resources and perceived enormity of the earth and its oceans led early explorers to believe that coastal and ocean resources were inexhaustible.

Now however, we are armed with the knowledge that our resources are finite and that a delicate balance exists between nature and human activities. There are signs that our oceans are undergoing dramatic change as a result of warming temperatures, the melting of the cryosphere, and ocean acidification. For the first time in a million years, the Arctic Ocean may be ice free during the summer months (http://atoc.colorado.edu/~dcn/reprints/Overpeck_etal_EOS2005.pdf); this could occur as soon as 2030 (National Snow and Ice Data Center). As such, we stand poised to enter a new and challenging era of coastal and ocean exploration, discovery, and stewardship.

In 2006 the National Park Service launched the Ocean Park Stewardship Action Plan, a strategy aimed at reconnecting with and rediscovering our coastal and ocean resources. Our goals include: 1) establishing a seamless network of ocean parks, sanctuaries, refuges and reserves; 2) to discover, map, and protect ocean parks; 3) to engage visitors in ocean park stewardship; and 4) to increase NPS technical capacity for ocean exploration and stewardship.

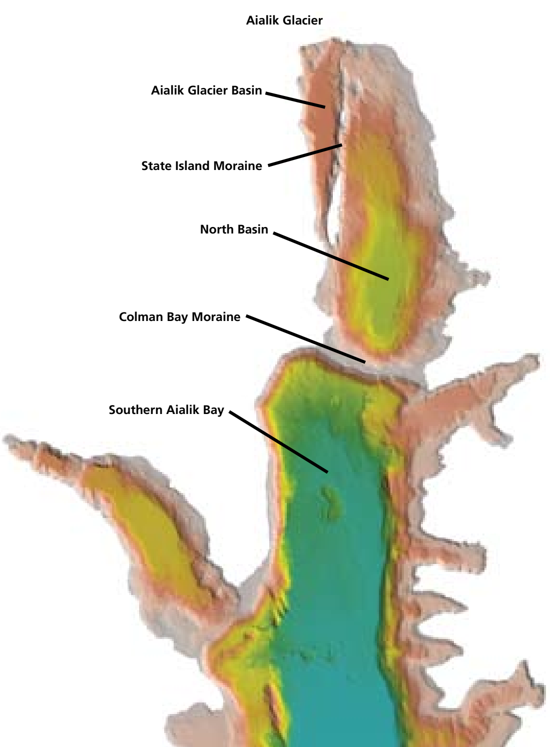
The Alaska Region of the NPS has significant coastal and ocean management responsibilities. We manage approximately 35% of the total land mass, 54% of the marine shoreline and 40% of marine waters held in trust by the National Park Service. As such, accomplishing the goals of the action plan will be a significant undertaking but not insurmountable. Over the next several years, as part of the National Park Service Centennial, the Pacific West and Alaska Regions will give shape to the Pacific Ocean Parks Strategy, which will guide us as we begin our voyage of coastal and ocean re-discovery throughout the Pacific Basin.

The articles that follow not only describe the studies that are monitoring some of the significant changes taking place around us, but also describe some of the new discoveries that are being made in our coastal and ocean park areas.

Marine Ecology and Oceanography in Aialik Bay

Figure 1. (Left) Aerial view of upper Aialik Bay, from Aialik Glacier.
USGS photograph by B. Molnia

Figure 2. Bathymetry of upper Aialik Bay, based on data from Office of Coast Survey and National Geophysical Data Center.



By Anne Hoover-Miller and Alexei Pinchuk

Aialik Bay (*Figure 1*) is a tidewater glacial fjord located in the Kenai Fjords National Park. The rugged deep-water fjord was sculpted by Pleistocene glaciers that, during maximum glacial advance, extended far into the Gulf of Alaska. The precipitous high peaks and steep walls of the mountains flanking the fjord descend into frigid 900 feet (270 m) deep subarctic waters. Located in the upper third of the fjord, a prominent subsurface moraine (sill) stretches from Pedersen Lagoon to the north shore of Colman Bay. A natural dam, the moraine abruptly rises more than 670 ft (200 m) to within 18 ft (5.5 m) of the water's surface. A secondary ragged sill, located farther up fjord, extends from Slate Island through Squab Island (*Figure 2*). Each sill acts as a barrier, interrupting the flow of water from the Gulf of Alaska in its own unique manner, creating distinctive environments within each basin. Each of these environments possesses its own individual physical, chemical, and biological properties that provide a platform for equally unique biota.

Perhaps as recently as 1800, Aialik Glacier rested on the north Colman Bay moraine (*Post 1980*). As Aialik Glacier receded, it exposed a 630 ft (190 m) basin east of Slate and Squab Islands. By about 1900, Aialik Glacier receded to near its present location, leaving a relatively shallow basin west of Squab Island that is currently filling with glacial silt.

As glaciers flow down the mountains, the bedrock they flow over is scoured and ground to fine particles commonly known as glacial flour. Outwash from the glacier is heavily laden with glacial flour that markedly decreases the penetration of light into the water to just a few inches (*Carpenter 1983*). When mixed with salt water, glacial flour may "flocculate" and quickly settle to form a sticky grey silt layer on the floor of the fjord. Lower concentrations of silt may remain suspended in surface waters, eventually becoming so diluted as to tint the water a light blue-green.

Post (*1980*) estimated that in Aialik Bay, glacial sediment on the basin west of Slate Island accumulated at 1 ft (0.3 m) annually; east of Slate Island accumulation rates were slower, about 3.5 inches (9 cm) per year. Approximately 70 taxa of marine invertebrates, including polychaetes (worms), mollusks (e.g., clams), and crustaceans (e.g., shrimps, crabs, amphipods) live in silty benthos of upper Aialik Bay. Near the glacier, where sedimentation rates are highest, 23 taxa were found to reside in the sticky mud (*Carpenter 1983*).

Waters entering the mouth of Aialik Bay are transported by the Alaska Coastal Current (ACC) along the coastline from southeastern Alaska to the eastern Aleutian Islands. The current consists of coastal freshwater runoff mixed with marine waters from the Gulf of Alaska. Conductivity-Temperature-Depth (CTD) profiles have been used to identify seasonal and interannual changes in salinity and temperature by depth throughout water column. CTD measurements taken over the last 35 years in lower Resurrection Bay, a fjord immediately to the east and adjacent to Aialik Bay, have provided an extensive time-series that has profiled changes in the ACC immediately before flowing into Aialik Bay (*Royer 2005*, *Weingartner et al. 2005*). CTD profiles have shown that during the winter,

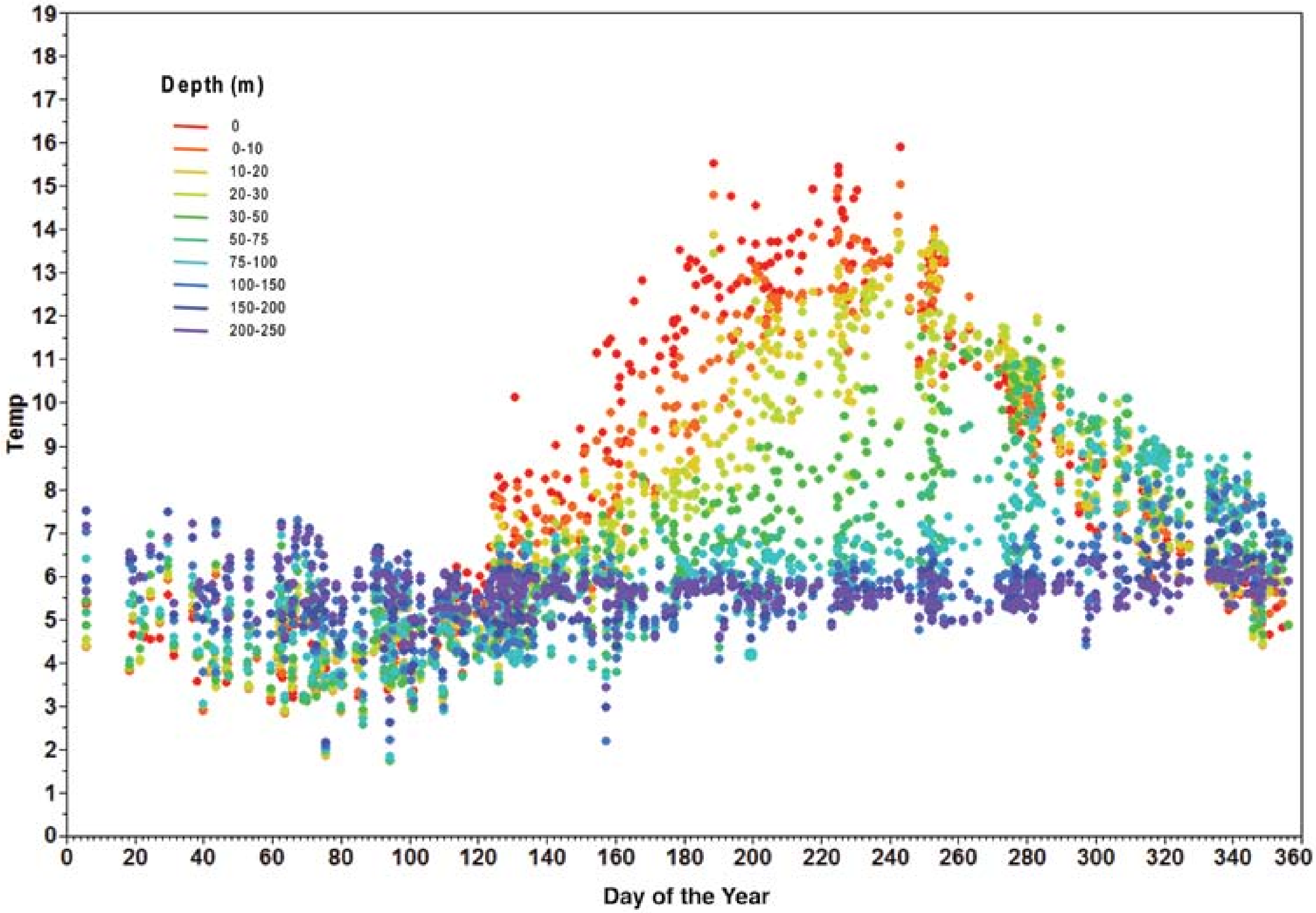


Figure 3. Seasonal changes in temperature by depth, recorded in lower Resurrection Bay at the GAK 1 monitoring station. Based on data from www.ims.uaf.edu/gak1

Figure 4. Location of CTD Sampling Stations in Aialik Bay.

coastal waters are well mixed by storms and show relatively little stratification by depth. Surface waters, exposed to frigid air temperatures, exhibit the lowest temperatures (*Figure 3*). In spring and summer, surface waters freshen and warm from precipitation, melting of snow and glacial ice, and long periods of daylight. Waters stratify across abrupt salinity and temperature gradients, with surface layers of warmer fresher waters forming a productive estuarine surface layer.

Our study investigates seasonal changes in the surface 500 ft (150 m) of the water column of each basin within Aialik Bay. We are interested in better understanding the physical, chemical and biological features associated with tidewater glacial fjords that attracts wildlife such as harbor seals, Kittlitz's murrelets, and foraging black-legged kittiwakes by investigating the following questions: (1) what biological, physical, and chemical characteristics are driven by the presence of tidewater glaciers? (2) What specific attributes sustain species associated with tidewater glaciers? (3) How do those attributes change as glaciers continue to thin and retreat?

Methods

Physical and chemical properties of the water in the top 500 ft (150 m) are measured at eight to 12 stations that extend along the longitudinal axis of Aialik Bay toward Aialik Glacier (*Figure 4*). In 2006, sampling was conducted every two weeks from May 30 - July 31. Sampling included measurements of water conductivity, temperature, chlorophyll-a fluorescence, and dissolved oxygen using a Seabird 19 plus Conductivity-Temperature-Depth (CTD) profiler outfitted with a SB 43 dissolved oxygen sensor and Wet-Labs FLNTURT-220 Flurometer/turbidity sensor. CTD, fluorescence (reflective of chlorophyll-a concentrations from phytoplankton), and dissolved oxygen measurements were averaged every 3.3 ft (1 m) for both downcasts and upcasts, and mathematically extrapolated to profile the sampling trackline.

Plankton were sampled at a subset of stations by dropping a pair of 10 in (26 cm) diameter 150 micron mesh CalVet plankton nets, equipped with mechanical flowmeters, to 300 feet (90 m). The nets were then pulled vertically through the water column using an electric pot puller. Plankton samples were preserved in 5% formalin and stained with Rose Bengal. In the lab, samples were identified and counted using split sampling counting methods (e.g., *Coyle and Pinchuk 2005*).

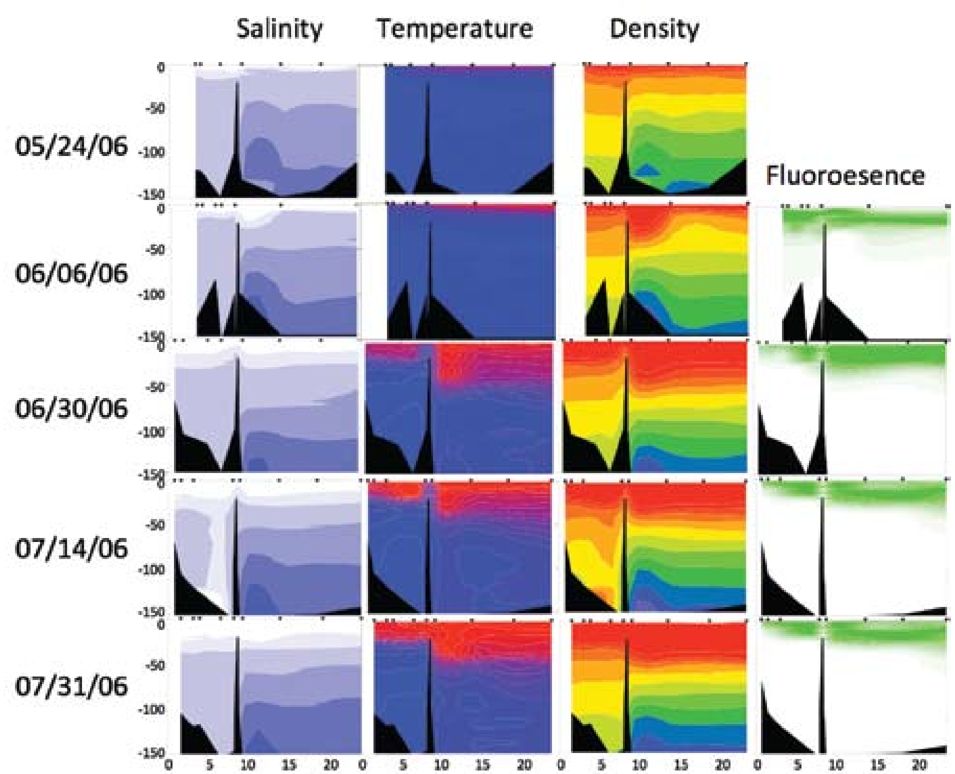
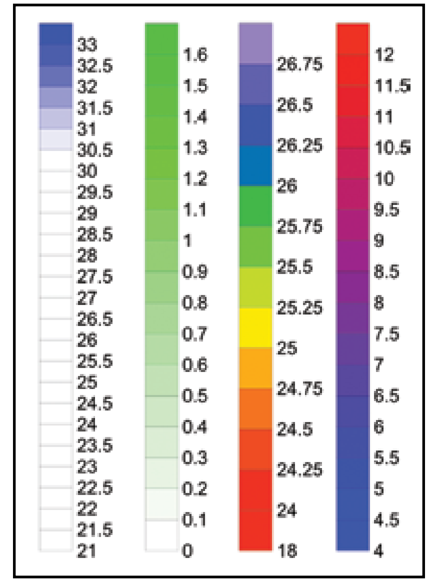


Figure 5. Seasonal changes in salinity, temperature, density and fluorescense by depth, measured from May 24 through July 31, 2006.



Results and Discussion

CTD profiles of Aialik Bay are shown in Figure 5. Below 66 ft (20 m), the bodies of water north and south of the Colman Bay sill differed. The moraine near Coleman Bay, shown in Figure 5 by the black vertical relief reaching nearly to the surface, dramatically impeded the flow of dense, saline, marine waters into the upper bay. The water column north of the sill was distinctly colder, fresher and more uniform than the water column south of the sill, which closely reflected the summer stratification of the Alaska Coastal Current. Surface waters progressively freshened during the summer. South of the sill, surface waters reflected contributions of glacial melt, snowmelt and precipitation from sources east of Aialik Bay; within Aialik Bay, glacial melt, melting ice, and watershed runoff provided additional contributions. Although we saw a progression of increased stratification on both sides of the Colman Bay sill, warmer, fresher waters penetrated to greater depths south of the sill. North of the sill, the warm layer persisted only to about 66 ft (20 m), roughly the depth of water crossing the sill. The shallow moraine near Colman Bay clearly impeded all but surface circulation. During our sampling period, primary productivity, measured by chlorophyll-a fluorescence, was similar on both sides of the moraine and was largely confined to the surface 66-100 ft (20-30 m). Sampling did not include the periods of peak spring or fall plankton blooms, but results indicate that primary productivity persists throughout the summer in both upper and lower Aialik Bay.

During summer months, plankton may be seen swimming in the surface waters. Some species live only a few months, while others live multiple years. Many pass through multiple life stages that provide food for different organisms in the food web. Plankton communities comprise complex food webs, similar to food web structures in terrestrial environments. Like plants, phytoplankton derive their energy from the sun. Zooplankton include grazers (those that eat phytoplankton), carnivores (those that consume grazers and other carnivores), and omnivores (those that eat phytoplankton, grazers, and carnivores). Plankton may be predators and scavengers. As with most marine communities of the North Pacific, zooplankton in Aialik Bay were dominated by several species of copepods —small (0.04-0.08 in/1-2 mm) tear-shaped crustacean with large antennae. Copepods include the primary grazers that transfer energy from phytoplankton to fish, whales, seabirds, and invertebrates, but they also include carnivore and omnivore predators and scavengers.

Vertical plankton tows conducted in Aialik Bay identified differences in the types and distribution of zooplankton within the fjord (*Figures 6 and 7*). Although the tows we conducted were not able to capture all species present, we identified 45 species and taxa groups. Based on numbers counted, two species of copepods, *Pseudocalanus* and *Oithona*, dominated our samples by abundance both north and south of the sill (*Figure 6*). North of the sill, however, the copepods *Oncaea* and *Metridia* were more abundant than they were further south.

The marine environment near tidewater glaciers is challenging for marine organisms. Turbidity from glacial silt reduces penetration of light into the water. The discharge of fresh water causes strong density gradients that, if crossed, are stressful. Habitats near glaciers, however, are more productive than might be expected. Glacial silt has its benefits. Glacial silt may release nutrients and microelements such as iron that help sustain primary productivity. Turbidity and darkness may protect organisms from predators. Rather than migrating to deeper waters during the day to avoid predators, as most plankton do in other locations, zooplankton and shrimp near glaciers tend to remain in mid-waters where they may be better able to forage (*Carpenter 1983*).

Glaciers, however, create serious challenges. Most zooplankton cannot quickly adapt to rapid changes in salinity.

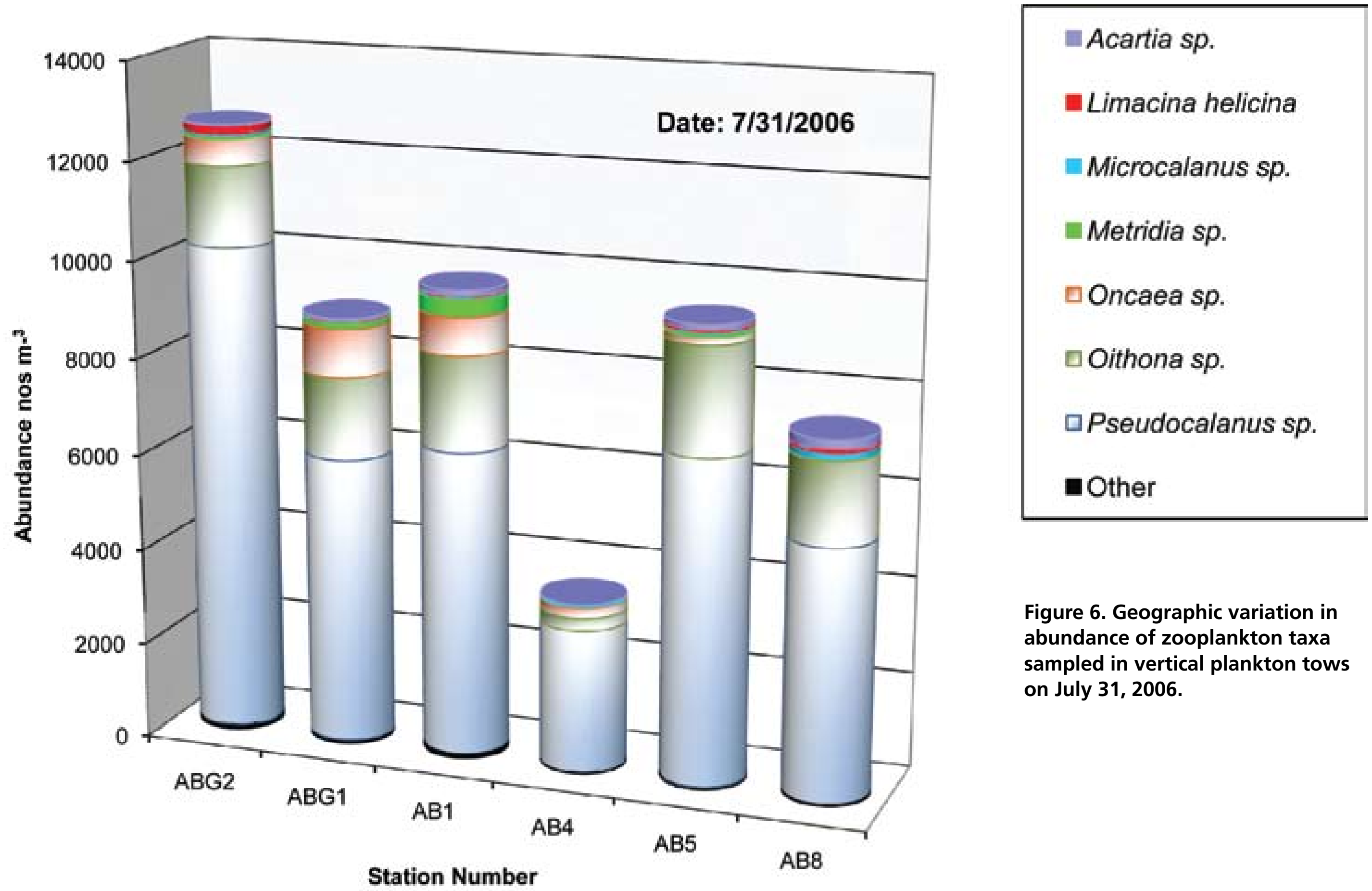


Figure 6. Geographic variation in abundance of zooplankton taxa sampled in vertical plankton tows on July 31, 2006.

Experiments have shown that when exposed to salinities below 9 PSU, copepods die within 15 minutes (*Zajaczkowski and Legezynska 2001*). Practical Salinity Units (PSU) are a measure of salinity based on electrical conductivity. A PSU of about 35 is typical for full-strength seawater. Near the face of the glacier, large quantities of fresh water, released by glacial melt, are ejected in strong outwash currents. Near the Kongsbreen tidal glacier in Svalbard, Zajaczkowski and Legezynska (*2001*) estimated that 15% of the fjords plankton biomass died as a result of osmotic shock from the glacial outwash. With plankton being continuously replenished by circulation of the Alaska Coastal Current, osmotic shock associated with outflow from Aialik Glacier would concentrate dead and impaired plankton in the upper basin near the glacier, providing food for organisms throughout the water column and sea floor. This situation may partially explain why unique assemblages of organisms associate with tidewater glaciers. However, as glaciers recede, the delicate balance of turbidity, chemical, and physical attributes will shift and alter these habitats.

This study will continue to explore seasonal and interannual variability in marine attributes associated with Aialik Glacier. Although little can be done to influence glacial activity, knowledge of how glaciers shape local marine communities will provide insight into ecological changes that may occur with glacial recession. With that knowledge, managers can make informed decisions regarding the need and effectiveness of potential mitigation measures for conserving marine communities impacted by climate change.

Acknowledgements

We are grateful to the Ocean Alaska Science and Learning Center for supporting our investigations of marine ecosystems in Kenai Fjords. We also thank our field and lab assistants who facilitated sample collection and processing, including S. Conlon, M. Terwilliger, A. Graefe, K. Stade, K. Williams, L. Cramer, and D. Miller. In addition, we thank P. Armato for all of his support in facilitating this research and for his thoughtful reviews of drafts of this manuscript. This study was carried out under NMFS General Authorization for Scientific Research Letter of Confirmation No. 881-1673.

Figure 7. Diversity of plankton sampled in Aialik Bay. Sample includes multiple species and lifestages of copepods, shrimp-like euphausiids, spiral-shaped pteropod mollusks, and the bell-shaped hydrozoan jellyfish.

REFERENCES

Armstrong, A.K., E.M MacKevett., Jr., and N.J. Silberling. Carpenter, T.C. 1983.
Pandalid shrimps in a tidewater-glacier fjord, Aialik Bay, Alaska. MSc. Thesis. Institute of Marine Science. University of Alaska, Fairbanks.

Coyle K.O., and A.I. Pinchuk. 2005.
Seasonal cross-shelf distribution of major zooplankton taxa on the northern Gulf of Alaska shelf relative to water mass properties, species depth preferences and vertical migration behavior. Deep-Sea Research II-Topical Studies in Oceanography 52 (1-2):217-245.

Post, A. 1980.
Preliminary bathymetry of Aialik Bay and neoglacial changes of Aialik and Pedersen glaciers, Alaska. USGS Open File Report 80-423.

Royer, T.C. 2005.
Hydrographic responses at a coastal site in the northern Gulf of Alaska to seasonal and interannual forcing. Deep-Sea Research II-Topical Studies in Oceanography 52 (1-2):267-288.

Weingartner, T.J., S.L. Danielson, and T.C. Royer. 2005.
Freshwater variability and predictability in the Alaska Coastal Current. Deep-Sea Research Part II-Topical Studies in Oceanography 52 (1-2):169-191

Zajaczkowski, M.J., and J. Legezynska. 2001.
Estimation of zooplankton mortality caused by an Arctic glacier outflow. Oceanologia 43:341-351.

Remote Monitoring of Pinnipeds in Kenai Fjords National Park

By John M. Maniscalco, Anne Hoover-Miller, and Daniel Zatz

Biologists conducting long-term population and behavioral field research on animals in the wild often encounter difficulties including inclement weather, provisioning for safety and nutrition, and causing unwanted interactions with the subject animals. Recent technological advancements provide us with tags that track animal movements via radio and satellite transmissions, "critter cams" that record the environment animals inhabit, and other sensors that measure physiological changes over time. Enhanced technology expands parameters that can be measured, but often is limited by small numbers of animals that can be captured and tracked, and the need to handle the animals before they are monitored. The technology is also constrained by sensitivities of the sensors and therefore do not measure the breadth of behaviors most animal exhibit. For animals that congregate for extended periods in predictable locations, the latest observational technologies have been enhancing traditional population and behavioral methodologies without the need to be present in the field.

Pinnipeds such as Steller sea lions (*Eumetopias jubatus*) and harbor seals (*Phoca vitulina*) haul out to give birth at well-established sites and often in large groups, as they do in Kenai Fjords National Park. In October 1998, the Alaska SeaLife Center (ASLC) contracted with SeeMore Wildlife Systems, Inc. (SWS) of Homer, Alaska, to install remotely-operated cameras at a Steller sea lion rookery on Chiswell Island, which is also a part of the U.S. Fish and Wildlife Service Alaska Maritime National Wildlife Refuge. Six cameras on the island are functional during the breeding season, providing complete coverage of the entire rookery. Each camera is equipped with 12-18 power optical and digital zoom mounted in weatherproof housings and include remotely-controlled pan, tilt, zoom, windshield wiper/washer functions, and a built-in microphone. Audio and video signals are sent via Cat 5 cable to a central control tower on Chiswell Island, which transmits the images and sound to ASLC via microwave transmission. The cameras and control tower are powered by 12-volt batteries that are kept charged by solar panels and wind generators. At ASLC, audio and video signals are viewed and recorded in real time with television monitors, VCRs, and DVD recorders, while commands for controlling the cameras are sent from custom-made software running on a desktop computer. Digital pictures and video are also taken with a click of the mouse and automatically labeled and stored on a computer hard drive. This technology allows us to observe the sea lions in their natural habitat throughout the year without disturbance and without impairment by the extreme weather conditions that often occur in the Gulf of Alaska.

Through subsequent years, remote video studies in Kenai Fjords expanded from the sea lion rookery on Chiswell Island to three nearby sea lion haulouts (resting places with little or no

Figure 1. Sea lions at Chiswell Island.

Photograph by Lauren Washington

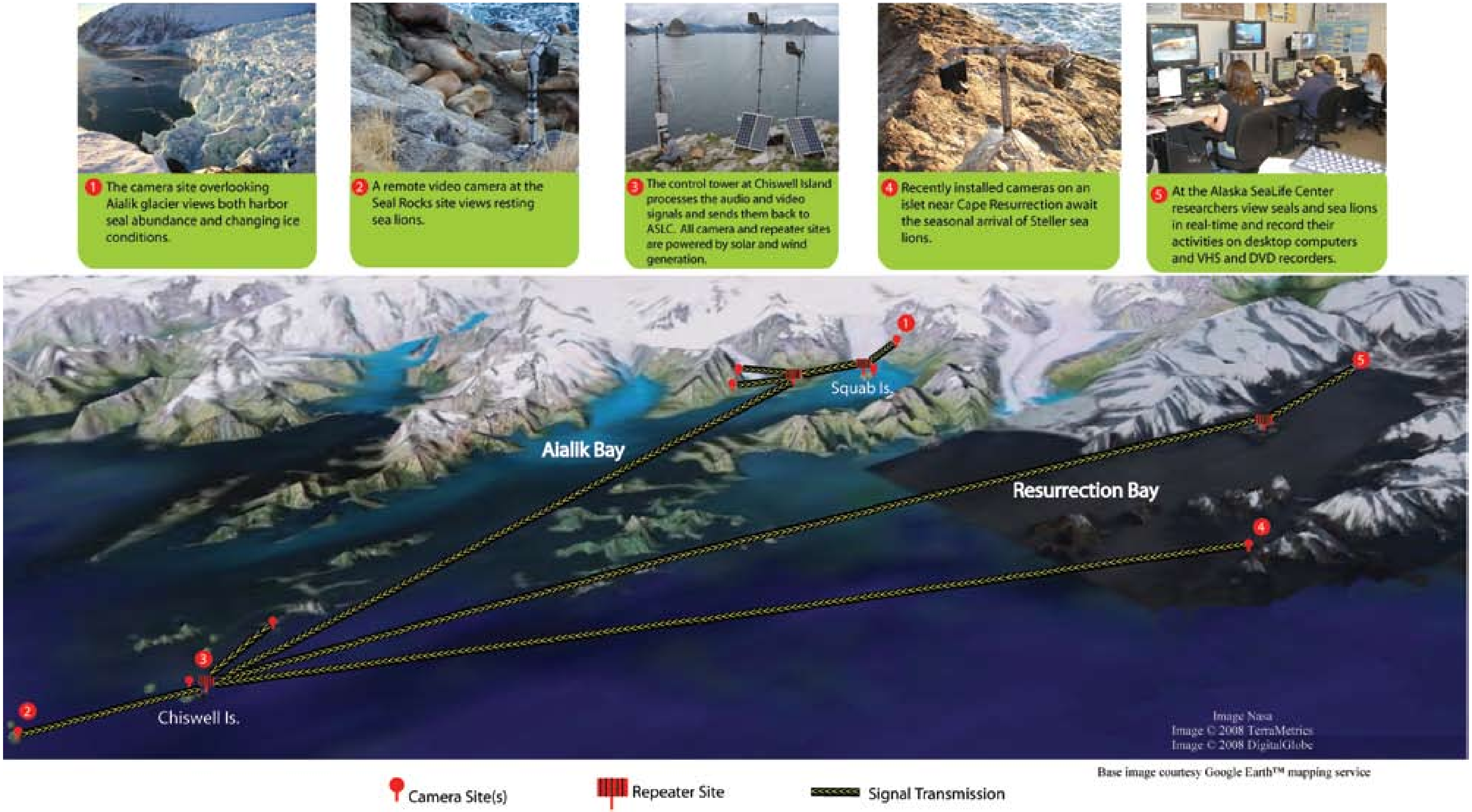


Figure 2. A network of remote signals is transmitted through a hub on Chiswell Island. Audio and video of harbor seals and Steller sea lions are beamed from Chiswell Island through a repeater in Resurrection Bay and back to the Alaska SeaLife Center, where researchers control the cameras and record their observations in real-time from the comfort and convenience of an office setting.

breeding activity) on the outer coast of southcentral Alaska. Remote video studies were further extended to four sites at the head of a neighboring fjord (Aialik Bay) where harbor seals haulout on glacial ice to give birth, molt, and rest. Studying the different habitats where seals and sea lions aggregate provides an unique opportunity to compare and contrast environmental preferences of these divergent pinnipeds.

Long-distance microwave signals need line-of-sight to be transmitted, which introduces another challenge when working in and around the mountainous terrain of southcentral Alaska (*Figure 2*). Therefore, repeater stations at select locations are necessary to send the audio/video signals back to ASLC at the head of Resurrection Bay. We now have in place a complex network of camera and repeater stations throughout a vast section of Kenai Fjords National Park, giving researchers at ASLC the opportunity to conduct detailed wildlife studies without leaving the comfort and convenience of their office. The repeater network allows for monitoring of full-bandwidth, 30 frame-per-second video on a year-round basis without the cost of paying for bandwidth, which is necessary for a satellite-based system.

Additional remote monitoring equipment that has been used with the current infrastructure includes weather stations, a thermal imaging camera, and hydrophones. Wind speed and direction, barometric pressure, and air temperature are received at ASLC from stations on Chiswell Island and Squab Island in Aialik Bay. Several years of weather data have been recorded from each of those locations and continue to be logged on a daily basis helping us to better understand the microclimatic differences between these adjacent habitats. We have also used a remotely-controlled thermal imaging camera on Chiswell Island during the summer of 2005 to assess heat loss in Steller sea lions and to conduct observations at night (*Figure 3*). Hydrophones have been in place at Chiswell Island and in Resurrection Bay to record killer whale (*Orcinus orca*) vocalizations and predation events through various time periods.

Figure 3. Steller sea lions as seen through a remote video, thermal-imaging camera at night.

Published Results and Ongoing Remote Monitoring Studies

The importance of studying Steller sea lions and harbor seals without disturbance is underscored by their status in this part of Alaska as species that are endangered and of special concern, respectively. Both have experienced population declines of around 80% since the early 1980s. Our recent studies in Kenai Fjords and others (*e.g. Eberhardt et al. 2005*) are beginning to see slight but promising increases in pinniped numbers in recent years.

At the Alaska SeaLife Center, we have amassed a virtual mountain of data about local pinniped populations in general and the behavior of individual animals since we began our remote monitoring studies in 1998. Individual Steller sea lions are identified by natural scars or circular patches of fungus that grow in their fur and also by brands or tags applied by researchers. Those that have good, reliable markings and are seen consistently at Chiswell Island or other remotely monitored locations are logged in databases and with digital pictures and video. Databases filled with more than 300,000 records on hundreds of recognizable animals have allowed us to examine a wide-range of behavioral parameters concerning reproductive rates, pup mortality, attendance patterns, extent of maternal care (*Maniscalco et al. 2006*), interseasonal and interannual tenure, pupping site fidelity (*Parker et al. In Press*), unusual behaviors such as care of non-filial young (*Maniscalco et al. 2007a*), and a singular occurrence of live-born twins.

Photograph by Elizabeth Moundalexis

Figure 4. Camera viewing Steller sea lions on Chiswell Island.

The pupping period for Steller sea lions lasts from late May until early July with a peak during the second week in June each year. We have found that reproductive rates among individuals at Chiswell Island are at least 75%, meaning that reproductively mature females will give birth in three out of every four years. However, we have observed that at least four females in particular have given birth every year over seven consecutive years. Others have not been so prolific. These types of data are extremely important in determining the potential of populations to recover from major losses such as the Steller sea lion has seen.

Once pups are born, their mothers stay on shore guarding and nursing them for about 10 days (termed the perinatal period) before they return to a cycle of feeding at sea and nursing their pups on shore (*Maniscalco et al. 2006*). During the perinatal period, pups are vulnerable to being trampled by adult sea lions or more commonly, washed away by heavy surf during occasional summer storms. Researchers typically are unable to

Figure 5. Harbor seal on glacial ice.

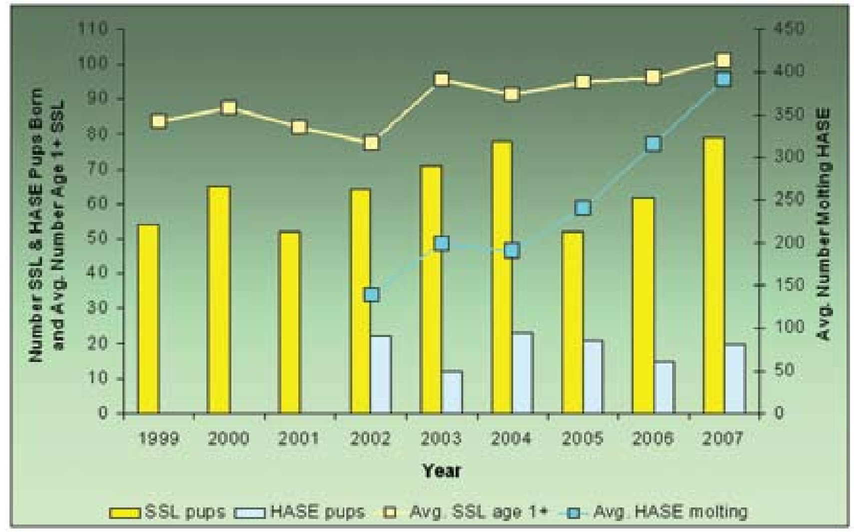


Figure 6. Recent population trends of Steller sea lions (SSL) and harbor seals (HASE) at Chiswell Island and Aialik Bay. The left axis represents the number of pups born and the average number of sea lions older than one; the right axis represents the average number of harbor seals during the molting axis.

conduct field observations during extreme storms in places like the Gulf of Alaska. Observations of this type are not a problem using a remote video monitoring system, and therefore we are able obtain a more accurate picture of important parameters in wildlife population dynamics such as pup mortality (*Figure 4*). Our long-term studies using the remote video system on Chiswell Island indicate that approximately 6% of the pups born are lost to high surf conditions and inattentive mothers, another 8% die from a variety of factors including starvation after maternal abandonment and killer whale predation.

By late summer, we have observed that lactating females spend much greater time foraging at sea compared to earlier in the season (*Maniscalco et al. 2006*), while the pups are spending more time in the water near shore playing and learning to swim. That is the time when killer whales may visit the rookery in search of an easy meal. During 2001, a lone female killer whale preyed upon an estimated 12 pups and returned two years later with another female and a year-old calf that was apparently being trained to prey upon sea lions (*Maniscalco et al. 2007b*).

The number of Steller sea lion pups born at Chiswell Island since 1999 has shown no significant up or downward trend but perhaps a cyclic pattern (*Figure 6*). On the other hand, the numbers of adult and juvenile sea lions using Chiswell Island has increased modestly but significantly during that same time period. These data suggest the possibility of greater survivorship with no overall change in fecundity.

Research on harbor seals using

glacial ice habitats takes advantage of the flexibility of camera control to observe animals in constant motion. Seals that ride on top of ice calved from Aialik Glacier may travel more than five miles during the day. Cameras located on top of Squab Island provide a central location from which to count seals circling the island while cameras above Aialik and Pedersen Glaciers provide insight into glacial activity and the glacial face environments that are too dangerous for humans to explore (*Figure 5*). Since observations began in 2002, numbers of pups born near Aialik Glacier have been similar from year to year, but remain at low levels, about 20% of the numbers counted in 1980. Conversely, numbers of seals counted during the molt, have rapidly increased at a rate of about 20% annually (*Figure 6*). Most of that increase is associated with newly created habitat in Pedersen Lake, expanding through the recession of Pedersen Glacier.

The physical properties of the fjords and adjacent Harding Icefield generate microclimates that influence the weather affecting the animals we observe. The atmosphere over the Harding Icefield often is higher pressure than surrounding regions in the Gulf of Alaska. For that reason, the predominant breezes in the upper fjords reflect the flow of air from the Harding Icefield toward the Gulf of Alaska. During the summer, adiabatic winds created from the heating of land masses, generate southerly "bay breezes" in the afternoons. Weather systems in the Gulf of Alaska affect locations outside the protection of the fjords. Weather stations located on the Harding Ice field (NPS), upper Aialik Bay (ASLC), Pilot Rock in lower Ressurrection Bay (National Weather Service), and on Chiswell Island (ASLC) provide means for contrasting microclimates within fjord systems (*Figure 7*).

Video from Chiswell Island is broadcast on a local television station in Seward, Alaska, and over the internet providing real-time views of Steller sea lions throughout the world. Visit www.alaskasealife.org for the video link; more information can also be found at www.seemorewildlife.com

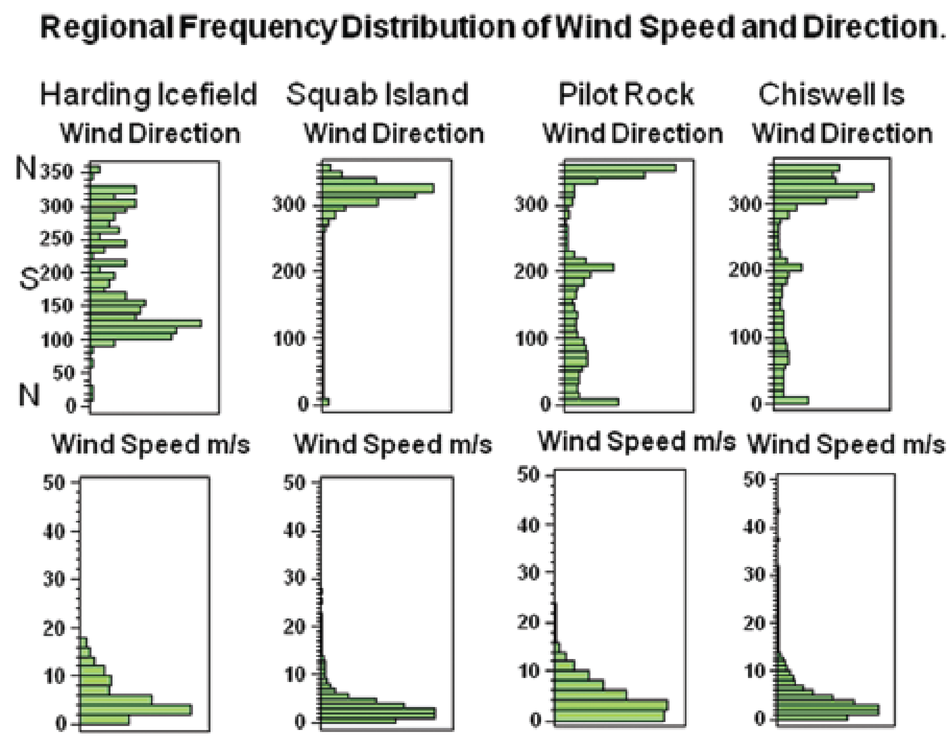


Figure 7. Regional frequency distribution of wind speed and direction in Kenai Fjords National Park.

REFERENCES

Eberhardt, L.L., J.L. Sease, and D.P. DeMaster. 2005.
Projecting the trend of Steller sea lion populations in western Alaska. Marine Mammal Science 21:728-738.

Maniscalco, J.M., P. Parker, and S. Atkinson. 2006.
Interseasonal and interannual measures of maternal care among individual Steller sea lions (Eumetopias jubatus). Journal of Mammalogy 87:304-311.

Maniscalco, J.M., K.R. Harris, S. Atkinson, P. Parker. 2007a.
Alloparenting in Steller sea lions (Eumetopias jubatus): correlations with misdirected care and other observations. Journal of Ethology 25:125-131.

Maniscalco, J.M., C.O. Matkin, D. Maldini, D.G. Calkins, S. Atkinson. 2007b.
Assessing killer whale predation on Steller sea lions from field observations in Kenai Fjords, Alaska. Marine Mammal Science 23:306-321.

Parker, P., J.T. Harvey, J.M. Maniscalco, and S. Atkinson. In Press.
Pupping-site fidelity among individual Steller sea lions (Eumetopias jubatus) at Chiswell Island, Alaska. Canadian Journal of Zoology.

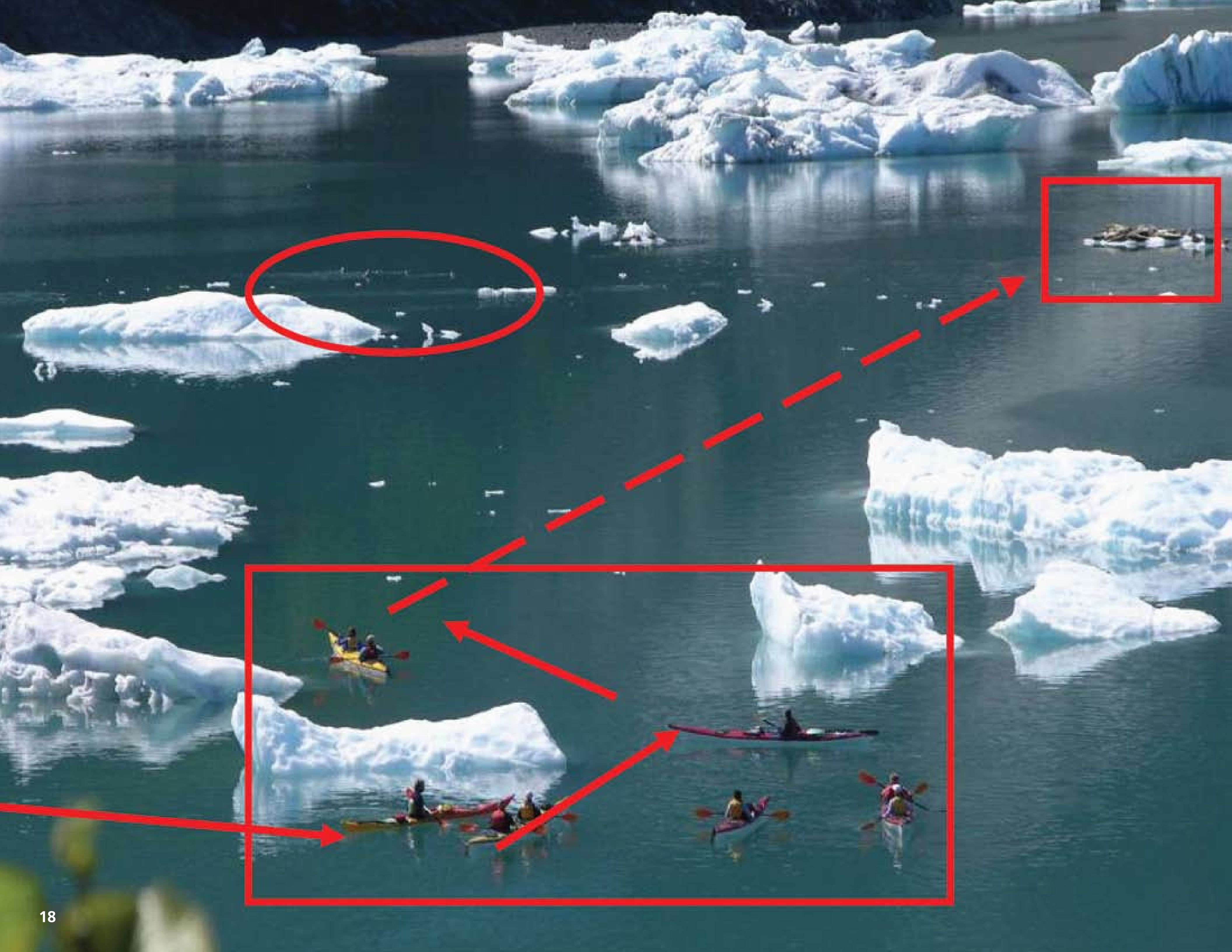


Figure 1. Diagram of a typical kayak interaction. The number and type of kayaks are recorded, and the paddle route (solid arrows) is sketched. The seals being observed are on the iceberg within the red box on the right. Previously disturbed seals are in the water, within the red oval. The dashed line indicates an open field of view between the kayakers and seals on the iceberg.

Integration of Tourism Into the Marine Ecosystem

By Caroline Jezierski, Anne Hoover-Miller, and Brenda Norcross

Marine- and eco-tourism are among the fastest growing industries in Alaska and worldwide. With increased human presence in remote locations, there is growing concern about the potential impact of tourist activities on wildlife and wilderness ecosystems. Kenai Fjords National Park (*Figure 2*) is a coastal park located on the Kenai Peninsula, outside of Seward, Alaska. Visitation to the park increased nearly 300% from the early 1980s to the late 1990s (*Colt et al. 2002*). Sea kayaking is a popular recreational activity in the park; sea kayakers have the ability to paddle close to shore and among floating glacial ice near tidewater glaciers. It is here that they may encounter harbor seals.

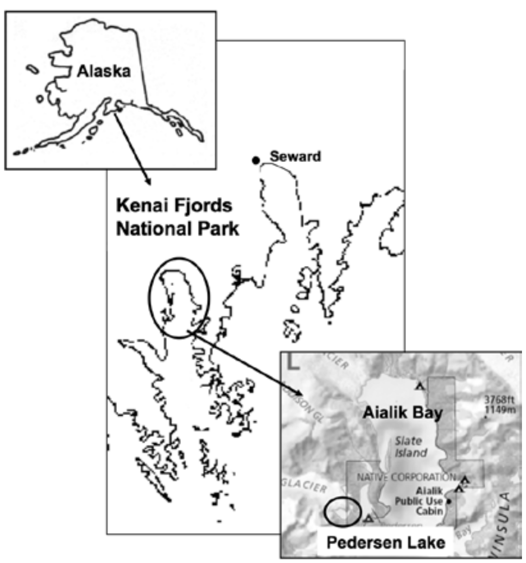


Figure 2. Location of Pedersen Lake in Aialak Bay, Kenai Fjords National Park.

Harbor seals (*Phoca vitulina*) are the most widely distributed pinniped, ranging throughout the coastal areas of the North Atlantic and North Pacific Oceans. On the west coast of North America, harbor seals are found in most nearshore habitats from Baja California to the Bering Sea. Harbor seals in southeastern and southcentral Alaska have the unique opportunity to haul out on ice calved by tidewater glaciers, where they can rest, give birth to their pups, and molt. In summer, the seals undergo an annual molt when they shed and regenerate new hair. During this time, seals bask on the haulout to increase their skin temperature which facilitates hair growth.

Aialik Bay in Kenai Fjords National Park has three tidewater glaciers, Aialik, Holgate and Pedersen Glaciers that produce ice used by harbor seals. Both Aialik and Holgate Glaciers are accessible to large motor vessels and are regularly visited by tour boats. In the past, harbor seals primarily hauled out on the ice in front of Aialik Glacier. Recently, Pedersen Lake's expanding ice habitat created by the recession of Pedersen Glacier, has become the preferred haul out area for harbor seals during the molt.

Ice calved from Pedersen Glacier tends to be larger and persist longer than ice calved from Aialik Glacier. Due to the relatively shallow recessional moraines or gravel bars located throughout the lake, icebergs often are grounded for extended periods of time. In addition, the narrow outlet stream entraps ice within the lake. Because of its relative isolation and persistent glacial ice, Pedersen Lake has become a popular destination for seals and sea kayakers.

Between 1980 and 1989, the number of harbor seals in the Aialik Bay area declined by more than 80% (*Hoover-Miller 1994*), paralleling trends found throughout the Gulf of Alaska (*Pitcher and Calkins 1979, Small et al. 2003*) and Prince William Sound (*Frost et al. 1999*). Although the decline of the harbor seals was likely related to changes affecting marine mammals elsewhere in the Gulf of Alaska, there has been concern about added stress of human disturbance resulting from tourism. In 1979 and 1980, only one to three boats visited upper Aialik Bay daily and most did not venture into the glacial ice, a practice that resulted in few seals abandoning the ice (*Murphy and Hoover 1981*). In 1980, Kenai Fjords National Park was established and visitation increased. Several tour operators are now offering day-tips into the park, in tour boats carrying 12 to more than 100 passengers. Another popular way to explore the fjords is by sea kayak. Water taxis shuttle sea kayaks, paddlers and guides from Seward into the fjords for one or multiple day adventures.

Goals of the study

The overall goals of the project were to assess and reduce the impact of kayaking on harbor seals. Initially, we assessed interactions to determine the extent sea kayakers were disturbing seals and causing them to abandon ice haulouts. Next, we reviewed interactions in order to identify specific kayaker behaviors that caused seals to enter the water. We then proposed paddling techniques to help reduce disturbance and presented them to kayakers through training workshops. Finally, we evaluated whether the paddling recommendations and mitigation trainings were effective at reducing disturbance to harbor seals.

Harbor seal behavior and sea kayaker activity were monitored from mid-July to mid-September, when harbor seals were molting. We collected data from 2004-2006 using a series of remotely operated cameras designed by SeeMore Wildlife Systems Inc. and operated out of the Alaska SeaLife Center in Seward, Alaska (*see Maniscalco et al. in this issue*). Data were also collected while camped along the shores of Pedersen Lake in 2005 and 2006 (*Figure 3*).

Counts and Distribution of Seals

We counted seals daily from about 8am to 5pm. This is when the greatest numbers of harbor seals haul out on glacial ice and the most popular time for kayakers to be in the lake. We divided the lake into six sections based on easily recognizable topographic features. The number of seals for each section of the lake was recorded. We conducted 106 counts of seals during 2005 and 2006 that documented the distribution of up to 340 seals. We observed from zero to 340 seals hauled out on the ice. Eighty-five percent of the seals were counted in the upper portion of Pedersen Lake, while only 15% were in the lower portion of the lake (*Figure 4*). Thus, one of our recommendation was to propose preferred visitation areas. If visitors kayaked or walked along the shore in the lower portion of the lake, they would interact with fewer seals. The majority of the seals in the upper lake could be viewed with binoculars from the lower end of the lake and would be less threatened by the presence of humans.

Seal Behavior

In order to determine whether humans were altering the "normal" behavior of the seals, we observed seals when humans were not in the lake, and when humans were sea kayaking or walking nearby. We used the seal behaviors collected when humans were not in the lake as the "normal" behavior of the seals. To do this, we selected a group of seal(s) hauled out together on one iceberg and recorded their behaviors. When humans were present, the activity of the kayakers and walkers were monitored. Harbor seal behavior was categorized as resting, alert, or abandoning. A behavior was recorded every ten seconds for ten minutes; this series of behaviors made up one behavioral observation. Nearly 2,000 behavioral observations of seals were recorded.

We found that when humans were present, harbor seals rested less and abandoned the ice more than they did when humans were absent. The ramification of increased amount of time spent alert and decreased time hauled out are unknown, but disturbing seals from their haulout may increase energy expenditure and potentially prolong the molt process. The extent to which these factors affect the health and survival of the seals are poorly understood.

Outreach and Education

Four companies in Seward offered guided sea kayak tours in Kenai Fjords National Park during the years of the study. Every year, the guides employed by these companies undergo a period of training. During May 2006 we presented the preliminary results from the 2005 season in which kayakers and walkers were identified as disturbing harbor seals. As a means to mitigate disturbance to harbor seals we provided paddling recommendations. We recommended:

1) Choose the route with the least number of seals hauled out.

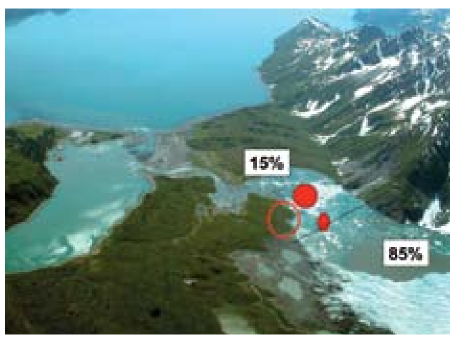
2) Observe the seal behavior. Resting seals are usually lying flat on the ice. If they lift their heads and stare, they are alert.

3) Halt the approach or alter the route so the seals may return to the resting state. If the approach is continued, the seals will abandon the iceberg and enter the water.

Recently disturbed seals are often observed swimming in a group. The seals, once they are in the water, will approach kayakers with apparent curiosity. They will also approach groups of seals still hauled out and flipper-slap an alarm. This

Photograph by Anne Hoover-Miller

Figure 3. Aerial view of Pedersen Glacier on right. The stream, in center of image, connects Pedersen Lake to Pedersen Lagoon, and then to Aialik Bay. Locations of cameras and field observation sites border the lake.



Photograph by Anne Hoover-Miller

Figure 4. Observed distribution of harbor seals hauled out on glacial ice. Red circles are the location of features that mark the division between the upper and lower lake.

Figure 5. Harbor seals as seen through the spotting scope.

behavior frequently causes the seals on ice to enter the water. Once the seals have been disturbed from the ice, they may not haul out again for several hours or days.

To test whether our recommendations were effective, we contrasted the responses of seals to kayakers receiving different levels of training. During the 2006 field season, when a group of kayakers entered the lake, they were classified as a guided or unguided group, a group receiving or not receiving mitigation training, or a group of unknown/mixed training level. The difference in the behavior of the kayakers between guided and unguided groups was apparent. Guided groups stayed together better, minimizing their appearance to one larger group instead of several smaller groups. In addition, the guided groups tended to be quieter and explore the lake with more caution. When a group with a guide who had received training was paddling in the lake, their concern for minimizing their disturbance of seals was apparent. They entered the lake slowly, seeking out the route through the ice with the fewest seals. They observed the behavior of the seals. If they observed seals becoming alert they readjusted their route. Often times, if they observed seals abandoning an iceberg, they paddled to the shore and continued their exploration of the lake from the shore. For the time these groups spent in the lake, the number of seals disturbed was greatly reduced from groups observed in previous years. The results of the educational training were evident. The guides were aware of their potential to disturb seals and actively modified their behaviors to minimize this disturbance.

Observing animals in the wild is exciting and should be considered a privilege. We are the visitors. By educating ourselves about the area we are visiting and the wildlife we may encounter, we can help minimize adverse impacts on the resident wildlife.

Acknowledgements

This project was made possible by support from the Exxon Valdez Oil Spill Trustee Council and the Ocean Alaska Science and Learning Center. We would like to thank our field volunteers Jacob Knight and Sarah Schoen, and Alaska SeaLife Center camera assistants Suzanne Conlon, Kristi Heffron, Morgan Sternberg, and Rebecca Pearce. We would also like to thank the Resource Management Division of Kenai Fjords National Park for their guidance and the local sea kayak outfitters, especially Kayak Adventures Worldwide, for their support throughout the project.

Photograph by Caroline Jezierski

Figure 6. Sea kayaking with Pedersen Glacier in the background.

REFERENCES

Colt, S., S. Martin, J. Mieren, and M. Tomeo. 2002.
Recreation and tourism in south-central Alaska: patterns and prospects. General Technical Report PNW-GTR-551. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Portland, OR.

Frost, K.J., L.F. Lowry, and J.M. Ver Hoef. 1999.
Monitoring the trend of harbor seals in Prince William Sound, Alaska, after the Exxon Valdez oil spill. Marine Mammal Science 15:494-506.

Hoover-Miller, A. 1994.
Harbor seal (Phoca vitulina) biology and management in Alaska. Marine Mammal Commission. Washington, D.C.

Murphy, E.C., and A.A. Hoover. 1981.
Research study of the reactions of wildlife to boating activity along the Kenai Fjords coastline. Final report to the National. Park Service. Anchorage, Alaska.

Pitcher, K.W., and D.G. Calkins. 1979.
Biology of the harbor seal (Phoca vitulina richardsi) in the Gulf of Alaska. Final Report of Outer Continental Shelf Environmental Assessment. U.S. Department of Commerce, National Oceanic and Atmospheric Administration 19(1983):231-310.

Small, R.J., G.W. Pendleton, and K.W. Pitcher. 2003.
Trends in abundance of Alaska Harbor seals, 1983-2001. Marine Mammal Science 19:344-362.

Photograph by Scott Gende

Figure 1. At left, the steamship Queen in front of the Muir glacier, circa 1890. Visitation to Glacier Bay by these ships preceded the establishment of the park by a century. Above, Holland America's Amsterdam enters the park in 2005.

Steamship photo: Frank LaRoche, Alaska State Library Collection, photo # P130-003

Understanding How Cruise Ships Affect Resources and Visitor Experiences in Glacier Bay National Park and Preserve

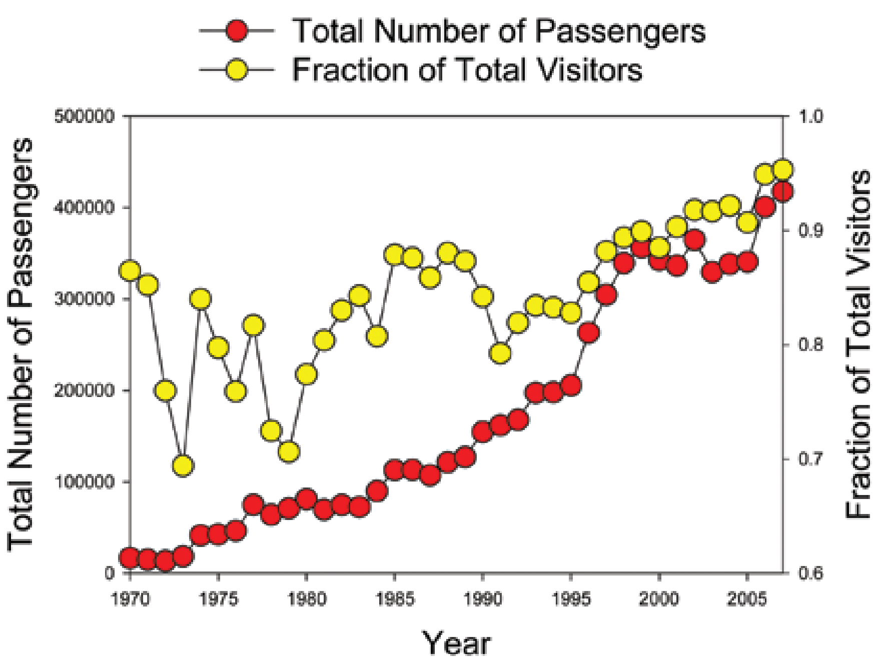
By Scott M. Gende

Visitation by cruise ships to Glacier Bay has a dynamic history, dating back to regular visits by steamships in the early 1880s (*Figure 1*). These "cruises," which may have represented the onset of tourism in Alaska, frequented the area in low but regular numbers until 1899 when an inordinate amount of ice, calved from the surrounding glaciers as a result of an earthquake, restricted visitation to the bay for years afterwards. Ship visitation resumed in the early 1900s and continued at low levels until the 1960s when visitation began to rise, mirroring the growth of the cruise industry worldwide. Cruise ships now provide the primary means of visitor access to the park; in 2007 over 400,000 people—nearly 95% of total park visitation—visited Glacier Bay aboard cruise ships (*Figure 2*).

Cruise ships provide a number of benefits to visitors and park management. The vessels bring a diverse group of visitors to Glacier Bay, including those whose personal travel preferences, physical capabilities, and sheer numbers might otherwise preclude their experiencing the park. Cruise ships also support natural and cultural interpretive programs, with NPS rangers and Hoonah Tlingit cultural interpreters educating a large number of passengers with onboard presentations and commentary (*Figures 3-4*). Since 1996, cruise industry revenue provided to the park through passenger fees has supported these and other programs with an average of over $1.3 million dollars annually. From a visitation standpoint, cruise ships provide an efficient means of maximizing both visitation and interpretive efforts in the park.

Yet, maximizing the numbers and diversity of park visitors through increased cruise ship access could affect park resources and visitor experience in many ways. Cruise ships are essentially floating cities with potential to affect the biological, physical and socio-cultural resources in the park. For example, an oil spill as a result of an accidental grounding by a cruise ship would have the potential to pollute park waters with long lasting effects. Stack emissions (engine exhausts) continually release air pollutants that may harm biota, or interfere with wilderness experiences of other visitors (*Figure 5*). Cruise ships may also directly influence the behavior or survival of wildlife in Glacier Bay. Close encounters between ships and humpbacks whales, an endangered species, are common (*Figure 6*), and a number of fatal collisions have been documented in Alaska, including in Glacier Bay. Disturbance to wildlife, such as harbor seals in Johns Hopkins Inlet, also remains a concern for park management (*Figure 7*).

Considerable uncertainty exists regarding the extent and significance of these impacts, and whether or to what degree they degrade park resources. Although a myriad of potential impacts have been suggested, few have been thoroughly investigated. The Vessel Quotas and Operating Restrictions Final Environmental Impact Statement (FEIS)



Data: Glacier Bay National Park and Preserve

Figure 2. Trends in the number of visitors to Glacier Bay over the past 25 years, and the proportion of those visitors arriving aboard cruise ships.

Photograph by Scott Gende

Figure 3. Cruise ships bring hundreds of thousands of visitors to Glacier Bay every year, providing access to the tidewater glaciers and other resources in the park.

Photograph by Fawn Bauer

Figure 4. An NPS interpretive ranger answers questions from passengers on the front deck of a cruise ship. Cruise ships provide a means for visiting the park for many whose physical capabilities would otherwise limit their access to the park.

of 2003, which outlines conditions and quotas of virtually every vessel type that enters Glacier Bay, reflects this uncertainty. Although the FEIS specifies that the daily maximum number of cruise ships entering the park will remain at two, it provides for a possible 32% increase in seasonal use days for the 'prime' June-August season (92 days), from 139 ship entries to 184 (two ships per day, every day). Any increase would occur at the discretion of the park superintendent, who may change the quota annually as needed to protect park values and purposes [per 36 CFR 13.1160 (b)].

To help better understand how seasonal increases in cruise ship entries may influence park resources, a Science Advisory Board was convened in the summer of 2004 at the request of the superintendent of Glacier Bay. The objectives of this independent panel were to identify what impacts might occur should seasonal entries in ship traffic increase and to recommend studies that could provide insight into the existence or extent of these impacts. The board membership, which is still active, includes ecologists, engineers, biologists, social scientists, and a subsistence coordinator from a number of state and federal agencies.

At meetings throughout 2004 and 2005, the board debated the potential impacts of a seasonal increase in ship traffic and identified information gaps that could be addressed by research or monitoring. These meetings included a day visit aboard Holland America's *Volendam* to view waste reduction and processing, water treatment, and bridge and other ship operations. In September 2005, the board submitted a report to the park superintendent (*Glacier Bay Vessel Management Science Advisory Board 2005*) recommending against immediate increases in seasonal use days, concluding that existing information was insufficient to allow for an informed assessment of the impacts to park resources if increases in cruise traffic were to be allowed. The board recommended specific research and monitoring efforts that could be implemented to address information gaps.

At the superintendent's request, the board also provided suggestions regarding the relative priority and sequencing of studies. Recognizing the difficulty of attributing cruise ship impacts in an inherently variable ecosystem (glacial marine fjord), the board used a number of ranking criteria, including whether a study was economically and logistically feasible, and whether the study could be finished in a timely manner. Perhaps most important, the board assessed whether the study questions were answerable, i.e., sensitive enough to lead to detectable effects given inherent variability in park resources. The board also emphasized that studies focusing on individual species should seek to identify physiological or demographic impacts, as opposed to simply documenting changes in species behavior.

Glacier Bay managers implemented a number of these studies, ranging from biological research and modeling to describing visitor experience. All have been designed to directly inform deci-

Photograph by Bill Eichenlaub

Figure 5. Haze from a cruise ship smokestack hangs in the air while visiting the Margerie Glacier. There is much uncertainty about whether these stack emissions impact the biological resources in the park, including lichen or water quality. Haze may also negatively influence the experience of other visitors in these wilderness areas.

National Park Service photograph by Janet Neilson

Figure 6. A pair of humpback whales surface dangerously close to the bow of a cruise ship in Glacier Bay. Humpback whales are particularly sensitive to cruise ship traffic because ships produce loud underwater noise which may impede the whales' use of acoustic cues for foraging and communication. Ships have also struck and killed humpback whales in the park.

sions that the superintendent will face as park visitation increases. For example, several studies focus on humpback whales because of their endangered species status, recent evidence of ship strikes in Alaska, and their sensitivity to underwater sounds generated by ships. One effort places NPS observers aboard ships to record the frequency of surfacing by whales and other marine mammals at various distances from the ships (*Figure 8*). These data will be used to estimate the likelihood of marine mammals being struck by ships, and to model the population consequences of any potential increase in the occurrence of whale-ship collisions. Modeling efforts are also underway to estimate how whales' exposure to ship-generated underwater noise would vary with changes in the number of ships and their transit speeds. Acoustic data (*Figure 9*) are being used to quantify how the underwater soundscape changes in relation to the daily number ships in Glacier Bay. The park and the board have sought to build these studies upon broad-based support and partnerships, and they have actively engaged the cruise industry as the research and monitoring program develops. Partners and participants of these efforts include Cornell University, Cruise West, Holland America, Marine Acoustics, Inc., Moss Landing Marine Laboratory, the National Marine Mammal Laboratory (NOAA), the Naval Surface Warfare Center, Princess Cruise Lines, and R2 Resource Consultants.

Several other monitoring efforts will provide longer term context for biological trends relative to changes in cruise ship entry numbers. These efforts include the long-term monitoring of the humpback whale population since 1985, renewed harbor seal population studies, and new measurements of marine contaminants in intertidal mussels. Some of the monitoring will be conducted by Glacier Bay scientists (humpback whales, harbor seals) while others are led by scientists from the University of Alaska.

Additionally, the University of Washington has initiated a sociological study to evaluate how cruise ships and other forms of motorized transport influence the quality of visitors' experiences in Glacier Bay. This ongoing study will compare visitor experiences during one- and two-cruise-ship days. Visitors' opinions about cruise ships in Glacier Bay will be measured with a series of interviews and questionnaires targeting different visitor classes such as cruise passengers, charter boat clients,

Photograph by Jamie Womble

Figure 7. Passengers on the bow of a cruise ship observe harbor seals hauled out on the ice flow in Johns Hopkins Inlet. Research elsewhere in Alaska has demonstrated that seals are likely to leave their icebergs and enter the water as a result of encounters with cruise ships, although the physiological 'cost' of the disturbance is unknown. Encounters with harbor seals and other marine mammals are a highlight for visitors and contributes to their experience and perception of Glacier Bay.

Figure 8. An observer stationed at the bow of a cruise ship records encounters with marine mammals in Glacier Bay.

Figure 9. A hydrophone, shown being deployed near the mouth of Glacier Bay, continuously records how underwater ambient noise varies with changes in precipitation, wind, and vessel traffic.

and kayakers.

Finally, in conjunction with the Southeast Alaska Inventory and Monitoring Network, the U.S. Forest Service is spearheading a study to use two types of air samplers to investigate and monitor ambient air quality conditions and sulfur dioxide levels, in accordance with EPA regulations, for areas near the Margerie Glacier where cruise ships congregate and stay for an extended period of time. Passive samplers will yield contaminant concentration data, while through-fall samplers will provide contaminant deposition data. These data will be then compared with a number of other monitoring sites around southeastern Alaska to enable regional comparisons in air quality.

Covering an array of disciplines and approaches, these studies share the common objectives of generating new insights into the presence and extent of impacts and improving the park's ability to manage both the ships and the resources they encounter. Many of these projects are scheduled for completion between 2008 and 2010. To facilitate the communication of results, a meeting is planned for the winter of 2010 to allow researchers to present their findings to the Science Advisory Board and park management. This research program will not eliminate all uncertainty associated with the potential impacts of cruise ships. But these projects—individually targeted and collectively broad—will greatly improve the park's ability to provide a high-quality experience for visitors, while simultaneously protecting the remarkable natural resources that bring them to the park.

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REFERENCES

Glacier Bay Vessel Management Science Advisory Board. 2005. *Final Report.* Available at: http://data2.itc.nps.gov/parks/glba/ppdocuments/Glacier%20Bay%20Science%20Advisory%20Board%20Report%202005.pdf

NOAA Maritime Heritage Program photograph by Tane Casserley

Figure 1. Kodiak Archipelago.

Wir, der Senat der freien Hansestadt Lübeck,

Kodiak

Archiv der Hansestadt Lübeck, courtesy of Evguenia Anichtchenko

Figure 2. Certificate of purchase for the bark *Kad'yak*.

Figure 3. (Left) Wheel hub.

NOAA Maritime Heritage Program photograph by Tane Casserley

Alaska's Submerged History: The Wreck of the Kad'yak

By Jason S. Rogers, Evguenia Anichtchenko, and J. David McMahan

Off Alaska's southcentral coast, a group of islands rises from the ocean. Rugged peaks and remote wilderness, inhabited by America's largest grizzly bears, greet the visitor here in the Kodiak Archipelago (*Figure 1*). Forbidding and aloof as the landscape may seem, it is more hospitable than the surrounding storm-wracked waters of the Gulf of Alaska. To some hardy spirits, however, the sea presented opportunities as well as challenges. The island's native inhabitants, the Alutiiq people, developed sophisticated marine subsistence strategies and were confident masters of the waterways.

Russian explorers were the first Europeans to arrive in Alaska, and for a time they made Kodiak their colonial capitol. The Russians too depended on the sea for their main livelihood, the export of valuable otter and seal fur. In addition to the precious cargo, Russian sailing ships carried passengers and goods between the motherland and the colonies, and knitted Alaska together along a web of sea-lanes.

Traveling by sea was not without risk —even today Alaska's stormy waters are among the most dangerous on earth. Many colonial Russian ships were lost on rocky islands, jagged reefs, or simply swallowed by raging tempests. One such vessel was the *Kad'yak*, a three-masted wooden bark built in Lübeck, Germany, in 1851. A 'bark' (also spelled 'barque') is a sailing vessel with three to five masts, where all masts are square-rigged except the aft-most, which has a fore-and-aft rig. Barks were popular because they could be operated with a smaller crew than full square-rigged ships.

The *Kad'yak* belonged to the Russian-American Company, the enterprise in charge of Russia's colonial possessions in North America. The vessel, commissioned by the company and built in the Lübeck shipyards of Hans Jacob Albrecht Meyer, had a capacity of 238 ¼ *kommerzlasten* (about 477 tons). The ship was approximately 128 feet (40 m) long, 26 feet (8 m) wide, and 19 feet (6 m) deep (*Archiv der Hansestadt Lübeck 1851*). The *Kad'yak* was initially fitted out in Kronstadt, the port of St. Petersburg, and loaded with supplies and provisions for the colonies. On August 7, 1851, the *Kad'yak* left Kronstadt for Alaska.

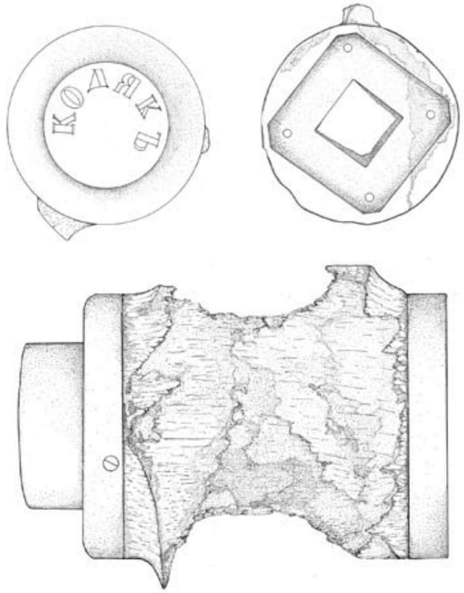
After stops in Copenhagen and Hamburg (*Furuhjelm 1852*), the ship laid on its course around Cape Horn. On May 7, 1852, after a nine-month voyage, the *Kad'yak* dropped anchors at the colonial capitol of Novo-Archangelsk (Sitka). The entire ocean-going fleet in service of the Russian-American Company at that time consisted of 10 vessels. The *Kad'yak* was a major addition (*Figure 2*).

During her eight years in the service of the company, the *Kad'yak* took part in a wide array of company activities. Provisioning, trade and communications remained the main concerns of the company's authorities, and shipping routes reflected these priorities. On average, a ship sailed once a year to collect pelts along the coast of Alaska. The furs were brought to Sitka, then shipped either to the Siberian ports of Russia, or to St. Petersburg. Supplies and people were the main cargo of the company's ships on the return from Russia to Alaska.

Soon after arriving in the colonies, the ship departed for the port of Aian in

NOAA Maritime Heritage Program photograph by Tane Casserley

Figure 4. Diver Steve Sellers measures the location of the hub.



Drawn by M. De Felice, East Carolina University

Figure 5. Drawings of the hub of the ship's wheel.

NOAA Maritime Heritage Program photograph by Tane Casserley

Figure 6. One of the *Kad'yak*'s four cannons.

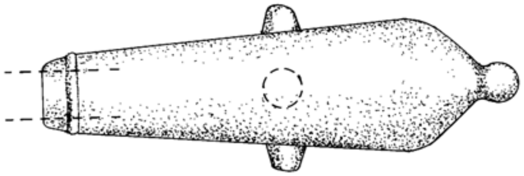


Figure 7. Several of the *Kad'yak's* cannons were located and documented.

Drawn by F. Cantelas, East Carolina University

eastern Siberia to deliver the cargo she carried for this city (*Records of the Russian-American Company 1852*), and to take workers returning to Russia (*Russian-American Company 1853*). Many of the company's employees came to America on term contracts hoping to make capital that would allow them a better life upon their return to their homeland.

In the beginning of 1853, the Chief of the Port at Sitka, Johan Furuhjelm, took the *Kad'yak* on a trading voyage to California and the Sandwich Islands (Hawaii), returning on May 1 (*Russian-American Company 1854*). From June 1853 until the final voyage in 1860, the career of the ship is covered in eight surviving logbooks, which also provide many details about the ship (*Records of the Russian-American Company 1853-59*). The crew of the *Kad'yak* varied from 25 to 30 people and included a captain, two officers, one supercargo, two boatswains, 13 sailors, six to eight hands, usually Native Alaskans, and occasionally some cabin boys. The *Kad'yak* was equipped with two chronometers, compasses, and several rowing boats. Four to six cast iron cannons were carried during some voyages (*Figure 6-7*). When loaded, the vessel drew 14 feet of water, and had an average speed of about four and a half knots.

The cargo and the number of the passengers varied depending on the destination. On the inter-colony voyages (June 19-September 28, 1853 and July 20-September 25, 1854), the ship followed the route Sitka - Unalaska - St. Michael Redoubt - Unalaska - Sitka and carried timber, food supplies and up to 15 passengers. The company's officials on business trips, workers going to their service destinations, seminary students anxious to be reunited with their families during the school break, a Lutheran pastor visiting believers in remote Alaska outposts, and traveling Native Americans all ventured the North Pacific and Bering Sea aboard the *Kad'yak*.

Starting in 1853 the *Kad'yak's* main destination was San Francisco, where the Russian-American Company purchased most of its food supplies, and where a new commercial opportunity arose in 1852: the sale of ice. The ice was used for food refrigeration and other needs of the ever-increasing gold rush population. Before 1852, ice for San Francisco was carried around Cape Horn from New England. Despite the fact that more than half of the ice melted during the journey, the trade was still profitable. A joint venture with a San Francisco banker was formed to exploit this new commercial opportunity.

At first ice was collected from Swan Lake near Sitka, but the mild winter and rains of southeastern Alaska often interfered with company commercial planning, and Kodiak became an alternative place for ice supply. Here ice was harvested from Icehouse Lake on Woody (Lesnoi) Island (*Keithahn 1945*).

Leaving Kodiak on March 30, 1860, bound for San Francisco with a full cargo of ice, the *Kad'yak* ran aground on a previously unknown pinnacle of rock. The crew of 25 abandoned ship, and fortunately no lives were lost in the

Figure 8. Alaska State Archeologist Dave McMahan surfaces from a dive on the *Kad'yak* wreck site.

Figure 9. Archeologist Tane Casserley prepares to dive on the *Kad'yak* wreck site.

Figure 10. Archeologist Evguenia Anichtchenko ascending from the *Kad'yak* wreck site.

accident. Captain Illarion Archimandritov, a skipper with two decades of service to the company, stayed aboard until the last moment. Even when the ship laid on its side he remained close by, looking for ways to save as much as possible from the ship (*Russian-American Company 1861*). The vessel was kept afloat for several days by her load of ice, and drifted towards Spruce Island, just north of Kodiak. Here in Icon Bay she finally settled to the bottom, where she lay undisturbed for over 140 years (*Figures 8-10*).

Over time, the wreck faded from memory. Only a few obscure historical references remained to tantalize researchers. Alaskan archeologist Michael Yarborough became interested in the ship in the 1980s, and collected information about her wrecking. Several

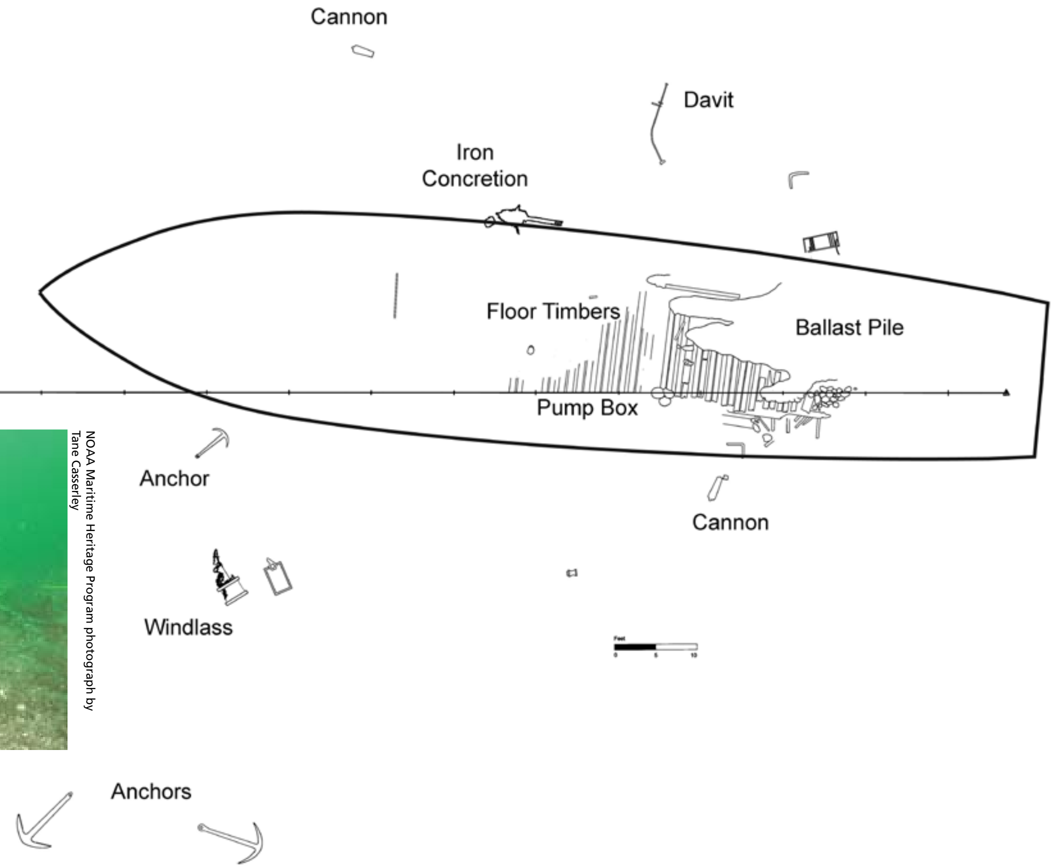


Figure 11: Map of the *Kad'yak*'s remains, with an outline showing the approximate shape of the vessel.

Map by J. Rogers and F. Cantelas, East Carolina University

NOAA Maritime Heritage Program photograph by Tane Casserley

Figure 12: Author J. Rogers mapping the site.

early attempts to locate the vessel were unsuccessful. Through Yarborough, Dr. Bradley Stevens of the National Oceanic and Atmospheric Administration (NOAA) Fisheries Research Center in Kodiak learned of the *Kad'yak*'s story. Stevens took up the hunt, and by deciphering early Russian maps and survey reports he came up with a promising search area.

In the summer of 2003, a group of divers and researchers finally located the *Kad'yak*'s remains, 80 feet below the surface of Icon Bay. Plans were made to explore the site and document surviving parts of the wreck. In the interim, East Carolina University graduate student Evguenia Anichtchenko combed libraries and archives in Washington D.C., St. Petersburg, Lübeck and elsewhere, searching for written evidence pertaining to the vessel. Among historical sources, Anichtchenko uncovered important documents such as the *Kad'yak*'s surviving logbooks and the certificate of purchase.

A three-week site investigation took place in the summer of 2004, funded by grants from the NOAA and the National Science Foundation, and supported by the Kodiak Historical Society, the Baranov Museum, the Alutiiq Museum and the State of Alaska Office of History and Archaeology. The team of underwater archeologists, historians, and volunteers documented the remaining hull structure, recorded significant objects, and mapped the entire site (*Figure 11*). Large items such as cannons and anchors were measured and documented on-site (*Figure 6*). A number of small diagnostic artifacts were recovered for conservation and eventual public display. One of these artifacts, the hub of the ship's wheel, is inscribed with the vessel's name and thus proves the identity of the wrecked ship (*Figure 3-5*). The artifacts remaining on the site, including remnants of the vessel, are owned by the State of Alaska and protected by state law against unauthorized disturbance.

The *Kad'yak* was a hard-working vessel plying difficult waters; her wreck site contains a wealth of information and evidence pertaining to shipboard life from the period. Careful examination and interpretation of these material remains can fill in many details about life and culture in the Russian colonies, and paint a richer picture of Alaska history (*Anichtchenko 2005*). The distribution of artifacts and structure throughout the site also make it possible for archeologists to recreate the final sinking and site formation processes.

The results of the *Kad'yak* investigation revealed two main areas of remains spread in a linear pattern across the seabed (*Figures 11-12*). Anchors and capstan remnants indicate the bow, the ballast pile and midships hull show where the ship's deepest portion settled, while rudder and steering gear remains denote the stern. The team was thus able to determine the wreck's orientation, and concluded that the vessel initially grounded on a high reef. As wind, waves, and current pushed the ship into deeper water between rocky outcrops, the stern broke away and came to rest some distance from the rest of the vessel (*Cantelas et al. 2005*).

A further important result of the project was positive knowledge that a historic shipwreck can survive in the harsh conditions of Alaska's unforgiving maritime environment. Despite storms, tsunamis, and ice, the remains of ancient ships await researchers in the cold depths of the northern oceans. Future underwater discoveries will play an important role in understanding Alaska's history and heritage.

The story of the *Kad'yak* reminds us that throughout history, seaside Alaska communities have been heavily dependent on maritime transport and marine resources for essential aspects of livelihood. As Alaska has more coastline than the rest of the United States combined, it is no surprise that even today a large percentage of the state's population lives near the ocean. The *Kad'yak* shipwreck site is significant as a physical remnant of Alaska history, and as a symbolic reminder of the importance of maritime culture for this region.

Photograph by Tim Runyan, East Carolina University

Figure 13. Tane Casserley and Steve Sellers with the wrecked vessel's bilge pump tube.

REFERENCES

Anichtchenko, Evguenia. 2005.
Ships of the Russian-American Company, 1799-1867. MA thesis. East Carolina University. Greenville, N.C.

Archiv der Hansestadt Lübeck. 1851.
Altes Senatsarchiv Iterna Lastadie. MS. 4/13, N 16. Lübeck, Germany.

Cantelas, Frank, Timothy Runyan, Evguenia Anichtchenko, and Jason Rogers. 2005.
Exploring the Russian-American Company Shipwreck Kad'yak. Report prepared for NOAA Office of Ocean Exploration and National Science Foundation. Greenville, N.C.

Furuhjelm, Johan Hampus. 1852.
Report of the Chief Manager of the Russian-American Company, Johan Hampus Furuhjelm, to the St. Petersburg office, May 12. Records of the Russian-American Company, Correspondence of Governors General, Communications Sent, January 1-December 31, 1852. Volume 33. Microfilm roll 58. United States National Archives. Washington, DC.

Keithhahn, Edward. 1945.
Alaska Ice, Inc. Pacific Northwest Quarterly 36(2).

Records of the Russian-American Company. 1852.
Correspondence of Governors General, Communications Sent, January 1-December 31, 1852. Volume 33. Microfilm roll 58. National Archives. Washington, DC.

Records of the Russian-American Company. 1853-1859.
Logs of the bark Kodiak. Microfilm M11, Roll 75. United States National Archives. Washington, DC.

Russian-American Company. 1853.
Otchet Rossisko-Amerikanskoi kompanii, Glavnago Pravleniia za 1852 god (Annual Report of the Russian-American Company, Head Office, for the year 1852). St. Petersburg, Russia.

Russian-American Company. 1854.
Otchet Rossisko-Amerikanskoi kompanii, Glavnago Pravleniia za 1853 god (Annual Report of the Russian-American Company, Head Office, for the year 1853). St. Petersburg, Russia.

Russian-American Company. 1861.
Otchet Rossisko-Amerikanskoi kompanii, Glavnago Pravleniia za 1860 god (Annual Report of the Russian-American Company, Head Office, for the year 1860). St. Petersburg, Russia.

Figure 1. House depressions in a settlement on Mink Island, abandoned near the beginning of the Little Ice Age, are in the foreground.

National Park Service photograph by Jeanne Schaaf

Mink Island, Katmai National Park and Preserve, Pacific Coast of the Alaska Peninsula

By Jeanne M. Schaaf

National Park Service photograph by Jeanne Schaaf

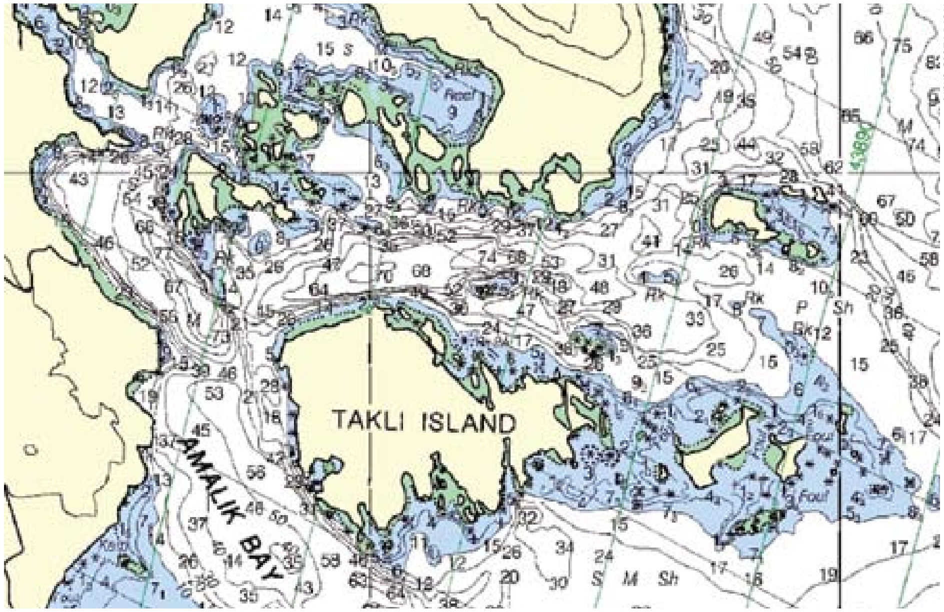
Figure 2. Nora Foster identified over 12,300 shells from the lower midden alone. She compares the intertidal resources near the site with the richest she has seen in Alaska.

The Mink Island site is located on a small, unnamed island along the Pacific coast of the Alaska Peninsula, across Shelikof Strait from the Kodiak Archipelago. The site is important regionally for its excellent preservation of several nested occupation floors and associated shell and bone deposits dating between 5500-2100 BC and AD 0-1500 (*Figure 1*). The recently excavated site provides a high-resolution and long-term snapshot of human adaptation to a volatile environment, from the time the earliest known maritime-based people settled along this coast to site abandonment in the Little Ice Age. In addition, the well-preserved vertebrate and invertebrate assemblages and site stratigraphy are unparalleled records of the area's environmental and natural history over the past 7,000 years (*Figure 2*).

The discoveries at the Mink Island site led to the designation of the Amalik Bay Archeological District National Historic Landmark, which includes the Takli Island Archeological District, long recognized as significant based on early research conducted by the University of Oregon.

The Takli Island group may have been a single large island when the first marine-focused hunter-gatherers camped there around 5500 BC (*Figure 3*). Sea levels continued to rise and stabilized at present levels after a high stand around 4,000 years ago, at which time the site was apparently abandoned for the next 2,000 years. Tsunamis generated by earthquakes and volcanic eruptions, high waves and winds from winter storms, and changes in relative sea level over the millennia have erased most of the early archeological record along the coast. The Mink Island site is a rare occurrence, and though much diminished in size, it retains a remarkable integrity in the remaining deposits (*Figure 4*). The data from Mink Island confirm a close cultural connection with Kodiak Island after 5500 BC until 1000 BC or the beginning of the Kachemak tradition on Kodiak Island (not present at Mink Island). Connections to earlier Paleo-Arctic sites on the Alaska Peninsula and in the Aleutian Islands are also indicated. The use of non-local basalt for the early large blades found on Kodiak Island suggests an Alaska Peninsula origin for these earliest people.

The first people to leave a trace on Mink Island arrived during a time when summers were warmer and drier than today with mean July temperatures perhaps 4.5° F (2.5° C) warmer (called the Hypsithermal interval). The island vegetation would have been similar to now, with low willow and birch shrubs, grass, lichens and a multitude of flowering plants, allowing an unobstructed 360° view which included the Kodiak island group 40 miles (25 km) to the east. Although alder pollen is abundant by 5000 BC in local peat deposits, it is still a rare occurrence in the vegetation on Mink Island. Within the view and soundscape was an



NOAA 2003 chart

Figure 3. Glacial ice retreated from the coast by 16,000 years ago. The Takli Island group may have been a single large island when the first marine-focused hunter-gatherers camped there around 5500 BC. Mink Island is indicated by the arrow. The blue shading shows water depth from 1-10 fathoms—and suggests a rough size of the former island.

National Park Service photograph by Mike Hilton

Figure 4. The Mink Island site is a rare occurrence in this volatile environment, and though much diminished in size, it retains a remarkable integrity in the remaining deposits.

important resource—a Steller sea lion rookery—located three miles (1.8 km) south. While no faunal material was recovered for this time period, the bones of immature sea lions appear throughout the succeeding occupation levels and likely sustained these earliest people as well. They constructed a house or shelter by excavating a basin about 16 inches (40 cm) deep and covering its floor with powdered red ochre.

Because the house was partially eroded and only partially excavated, no other architectural details have been documented except for two low perpendicular berms of unknown function on the house floor. In an ochre-stained pit below the house floor, a finely made boat-shaped lamp was found resting on two large basalt blades and mussel shell (*Figure 5*). Charcoal from the bottom of this basalt lamp yielded the oldest date for the site, predating the radiocarbon dates on the house floor by over 200 years. It and a similar lamp found on a house floor at the Zaimka Mound site on Kodiak Island are believed to be the oldest reported lamps in North America. The discrepancy between the dates from the sub-floor pit containing the lamp and the house floor may indicate separate occupations, or it may be due to the use of old driftwood, as the only material available for radiocarbon dating from the bottom of the lamp was unidentified softwood. Driftwood could have been "banked" on the island for quite a long time prior to settlement.

Although no evidence was found in the artifact assemblage, these people undoubtedly used watercraft for travel, fishing and for hunting a variety of sea mammals abundant in the area, such as porpoise, seal, sea otter and sea lion. Artifacts recovered from the house are dominated by large basalt blades, similar to those found at two earlier sites, one on the Alaska Peninsula (Ugashik Narrows, 8000 BC) and the other in the Aleutian Islands (Anangula, 9000 BC). A few microblades, a broken bifacial point, a grooved ground stone artifact, and some simple flake tools encrusted with ochre and organic residue comprise the small artifact collection from this occupation.

The site stratigraphy records evidence of a turbulent period immediately following the earliest occupation of the site and coincident with the end of the warm period or Hypsithermal interval. The next major occupation closely followed a volcanic eruption which deposited a 4-inch (10-cm) thick blanket of white ash on the site around 4600 BC (*Figure 6*). The site was reoccupied within years of the ashfall by sea lion hunters using ochre-stained, stemmed chipped points, large basalt blades, whale bone clam digging tools and expedient objects made from temporarily abundant pumice (such as grooved net floats). A contemporary occupation at the Tanginak Spring site in the Kodiak Archipelago similarly occurs just above

Figure 5. In an ochre-stained pit below the earliest house floor, a finely made boat-shaped lamp was found resting on two large basalt blades and mussel shell.

Figure 6. Immature sea lion scapula and tools from an occupation on the white ash or tephra from a volcanic eruption, 4600 BC.

the white ash, indicating that the volcanic event had widespread but not disastrous effects on local populations.

Around 4000 BC, corresponding with a short-term warm spike, people may have over-wintered on the island in a substantial house, and did so for many seasons based on the thick, laminated floor sediments. This is a rare example of a mid-Holocene and coastal winter house in Alaska. The builders utilized driftwood logs to support the structure, based on the size of the post holes, and heated it with a large pebble-filled hearth. Stone lamps, pecked from rounded cobbles and microblades are present in the assemblage, while large blades are lacking. A brief cold period (with a 4.5° F/2.5° C drop in mean summer temperature) followed this winter occupation and is possibly reflected by light use of the site until a small, temporary shelter was occupied around 3400 BC. This was a shallow oval depression, with a pole-supported hide cover that was, along with the floor, stained with red ochre (*Figure 7*). By this time, the use of ground slate tools is established, although evidence for the use of ground slate occurs in the preceding occupation. The floor, sealed by a volcanic ash, is exceptionally well-preserved, with discreet activity areas such as concentrated ochre grinding and stockpiling, chipped stone tool manufacture and bone needle production. The 36-inch (90-cm) thick deposit above this floor contains cultural material throughout, including distinct occupation surfaces, yet the dates from 22 excavation levels range from 3400 BC to 2100 BC in no particular order, indicating continuous site use during a period of rapid deposition.

Cultural activity abruptly ceased at the site by 2100 BC, a cooler period, and a 40-inch (1-m) thick sand dune formed on the site. This is consistent with a hiatus in the archeological record elsewhere in the region. By AD 0 the site was reoccupied, and the site occupants began accumulating an extensive shell and bone midden on top of the earlier deposits that eventually became 10 feet (3 m) thick over the next 1,500 years (*Figure 8*). As did the earlier site occupants, people continued harvesting a wide variety of intertidal resources, as well as adding whales to the list of sea mammals procured. Several human burials associated with this period of site occupation were removed from the site in the 1960s. In 1997 eroding burials were excavated, consisting of two extended sub-adults, with three small children placed between them on planks hewn from driftwood. An older female was buried in a flexed position in a pit placed immediately above the previous burial. Radiocarbon dates corrected for the marine carbon reservoir effect, place the interment of the family around AD 1450, contemporaneous with the last occupation of the site, a late prehistoric village

National Park Service photograph by Jeanne Schaaf

Figure 7. Red ochre-stained shelter occupied around 3400 BC.

of five houses, abandoned at the onset of the Little Ice Age.

Amalik Bay is spectacularly rich in marine resources with migratory waterfowl and terrestrial resources immediately available as well. The fauna identified from the Mink Island site show that despite severe periodic perturbations in the environment, people kept coming back throughout the known prehistory of the region.

Invertebrate fauna collected from the site number in the thousands and with 28 species identified, including large butter clams, mussel, whelks, snails, cockle, chiton, limpet, sea urchin and razor clam, among others. Vertebrate faunal elements recovered number over 250,000 and consist primarily of sea mammals (whale, harbor and Dall's porpoise, Steller sea lion, walrus, bearded seal, northern fur seal, harbor seal, ribbon seal, spotted seal, ringed seal and sea otter). Terrestrial mammals present in the collection are few and represent bear, caribou, dog or wolf, unidentified medium and small mammals and microtines (*Figure 9*). Fish identified include salmon, halibut, cod and rockfish.

Excavations were completed at the Mink Island site in 2000 and in 2006, a revetment of gabion baskets filled with local cobbles was placed to protect the remaining portion of the site (*Figure 10*). The site is visited annually to closely monitor the site's condition (*Figure 11*).

National Park Service photograph by Jeanne Schaaf

Figure 8. Around 0 AD, site occupants began accumulating an extensive shell and bone midden on top of the earlier deposits that eventually became over 10 feet thick over the next 1,500 years. Mike Hilton is shown here preparing a sediment peel from this shell midden.

National Park Service photograph by Jeanne Schaaf

Figure 9. Small-scale remains were recovered by water-screening through a fine mesh screen in the field by Barbara Bundy and by flotation of bulk samples in the lab. Recovery of micro-blades, fine bone needle fragments, micro debitage and even rare diatoms was accomplished by this painstaking effort.

National Park Service photograph by Jeanne Schaaf

Figure 11. Former Katmai Wilderness District Ranger, Missy Epping, stands on a shell midden at Mink Island, undergoing erosion from both active beaches.

National Park Service photograph by Roy Wood

Figure 10. A revetment now protects the oldest portion of the site from wave erosion.

Analyses of the extensive collections are underway, and the material can be viewed in the Katmai collections housed at the National Park Service, Anchorage Office.

Note:

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Round Island or Qayassiq "Place to go in a Kayak" Walrus Islands State Game Sanctuary & National Natural Landmark, Bristol Bay, Alaska

By Jeanne M. Schaaf

The Round Island archeological site is significant as the oldest dated coastal site, by over 3,000 years, in Alaska north of the Alaska Peninsula. The site has clear evidence of island-based walrus hunting about 5,700 years ago (3790 BC) and again 3,600 years ago (1630 BC). Over 100 mapped prehistoric surface depressions on Round Island represent semi-subterranean houses, cold storage pits and other activity areas from settlements affiliated with the Norton and Thule cultural traditions spanning the last 2,500 years before contact in the late eighteenth century (*Figure 1*). Excellent bone preservation in the site's major occupations provides an important opportunity to better understand the prehistoric subsistence economies and their environments as well as the natural history of important marine species from mid-Holocene times.

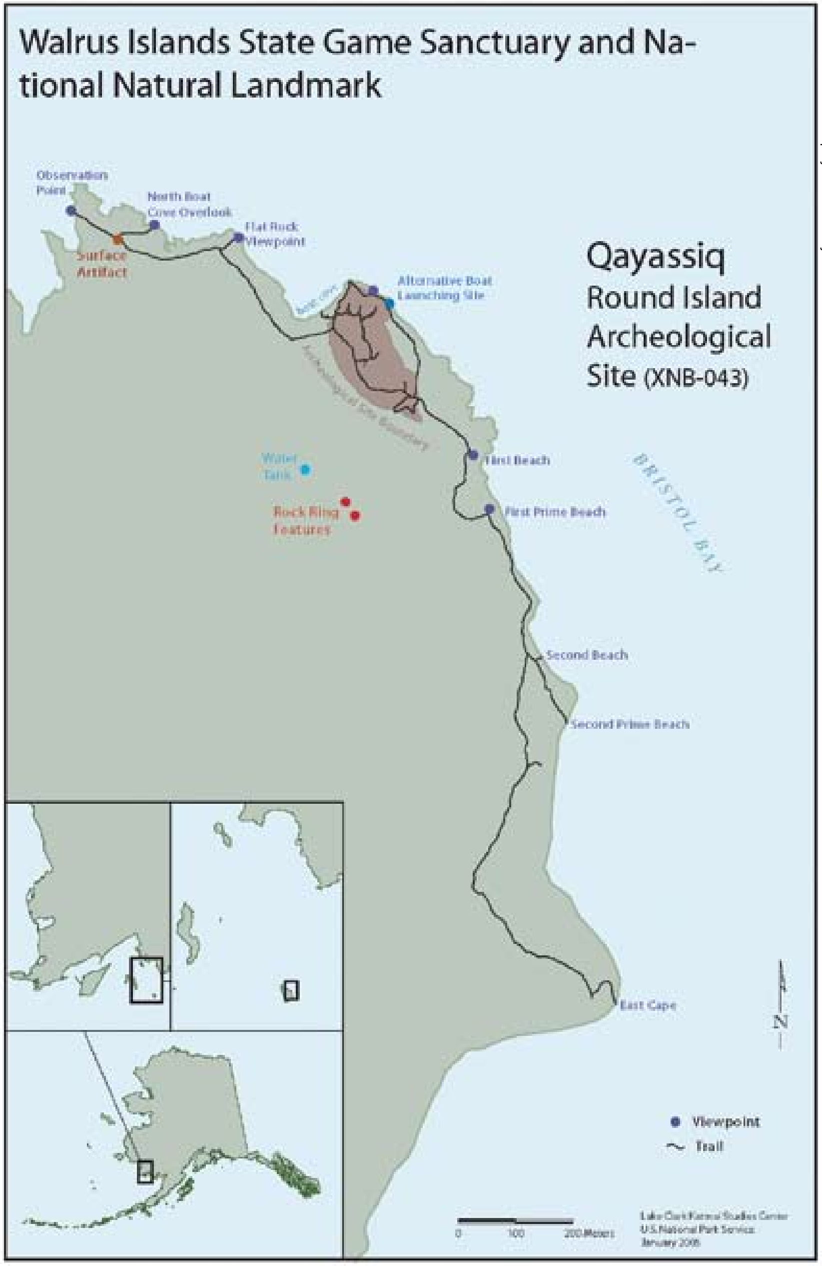
Round Island, known as *Qayassiq* ("place to go in a kayak") by local Yup'iq speakers, is one of seven islands protected in the Walrus Islands State Game Sanctuary, located in northern Bristol Bay, Alaska (*Figures 2 and 3*). The sanctuary was established in 1960 primarily to protect what was then the last remaining terrestrial haulout for Pacific walrus (*Odobenus rosmarus divergens*) in North America (*Figure 4*). The sanctuary attained National Natural Landmark status in 1968, adding nationwide recognition to the importance of this area for its concentration of Pacific walrus, with Round Island in particular serving as a summer haulout for male walrus.

Round Island is the southeastern-most island in the sanctuary, located 63 miles southwest of Dillingham and 35 miles south/southeast of the villages of Togiak and Twin Hills in Togiak Bay. Sheer-walled, granodiorite cliffs rising to an elevation of 1,400 feet (420 m) encircle the island, except for a low bench along the northeastern shore, where the site and the only boat landings are located (*Figure 5*). Only 1.3 square miles (3.4 sq. km) in area, Round Island is seasonally home for as many as 14,000 walrus, hundreds of Steller sea lions and 250,000 nesting seabirds (*Figure 6*). Grey, humpback, minke and orca whales pass by, sometimes feeding offshore in the spring on their migration north. This area is one of Bristol Bay's principal spawning areas of herring and yellowfin sole, and all five species of Pacific salmon are found here. The vegetation is a mosaic of wet and dry tundra, meadow and herb communities, and the site area is a bluejoint grass meadow.

While the entire area that is now Bristol Bay was under glacial ice during the maximum extent of Pleistocene glaciations, ice during the last glacial maximum 20,000 years ago was confined in this region to the Ahklun Mountains north of the Walrus Islands and to the Alaska Peninsula (*Figure 7*). The Walrus Islands were high ground, overlooking part of the vast southern Bering Land Bridge plain, exposed when sea level was 300 feet (90 m) lower than it is today. As the plain flooded and the land rebounded from the

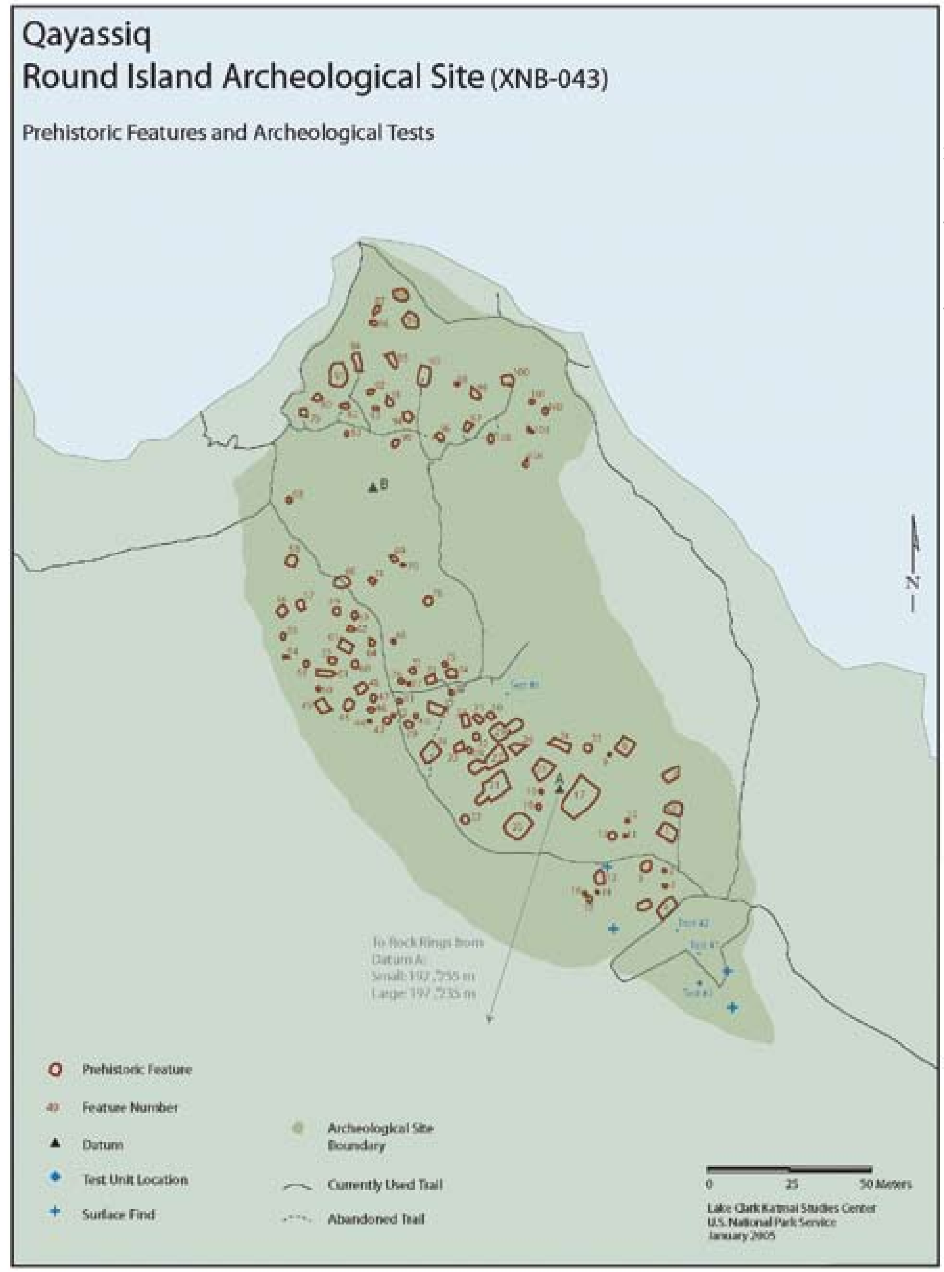
Figure 1. Surface depressions from semi-subterranean houses, storage pits, and other activities can be seen on Round Island.

National Park Service photograph by Jeanne Schaaf



National Park Service map by Barbara Bundy

Figure 2. Location of the Walrus Islands State Game Sanctuary, Qayassiq or Round Island and site XNB-043.



National Park Service map produced by Barbara Bundy

Figure 3. A site area of 5.7 acres (2.3 hectares) was defined, containing 105 surface depressions thought to be prehistoric features. The feature outlines are sometimes irregularly angular because they are drawn from the GPS data and are dependent on the point recorded.

weight of the ice, areas of high ground became increasingly smaller islands, reaching their present configuration by 2,000 years ago when sea level was within three feet (1 m) of today's level. The Walrus Islands were still part of the mainland 8,000 years ago when sea level was about 50 feet (15 m) below present, but by 6,000 years ago it rose to within 30 feet (9 m) of present sea level, and Round Island became separated from the other islands and the mainland (12 miles/19 km distant at its nearest point). It was around this time that people first camped on the island and hunted walrus with spear-mounted, chipped stone points.

Two radiocarbon dates, 3680 BC and 3790 BC, and some artifacts from the earliest occupation identified on Round Island indicate that this occupation is contemporaneous with the Northern Archaic tradition (*Figure 8*). On the north side of Cape Newenham, 70 miles (110 km) west of Round Island, the earliest coastal sites are recorded in Security Cove and are assigned to the Northern Archaic tradition based only on artifact types (*Ackerman 1998*). These sites are thought to represent seasonal excursions to the coast by inland-based caribou hunters using spear-mounted and usually side-notched points. Inland Northern Archaic sites are recorded near the mouth of Goodnews River, in the Ahklun Mountains and at Kagati Lake where the hunters constructed stone cairn drive lines to channel caribou into a small lake around 2200 BC.

Following the Northern Archaic people, the Arctic Small Tool culture is represented in this region by a few scattered mainland sites. It is securely identified and dated at only one site, located 100 miles (160 km) northeast in the Wood River chain of lakes draining into Nushagak Bay. Bureau of Indian Affairs archeologists excavated small shelters with slab-lined hearths at the site dating between 1600 BC and 1500 BC and found small, finely chipped end blades and scrapers, characteristic of Arctic Small Tool assemblages. This culture practiced a mixed subsistence economy, seasonally balancing terrestrial (caribou and fish) and marine (seal) resource use. On Round Island, there is evidence of a localized but substantial occupation occurring 2,100 years after the earliest hunters camped there. Radiocarbon dated to 1630 BC, the occupation is contemporaneous with Arctic Small Tool sites on the mainland and shares some elements in stone tool technology (*Figure 9*). Both the earliest and this component at Round Island were identified in limited test excavations in a very small area of the overall 5.7-acre site. The limited number of artifacts recovered from these occupations at this time does not allow certain identification of cultural affiliation.

Prior to the recent archeological discoveries on Round Island, the earliest recorded coastal sites in northwestern Bristol Bay were dated to the Norton tradition, beginning about 500 BC. With about a 600-year gap between dated Arctic Small Tool sites, villages of the related Norton tradition are found along the coast of western Alaska and up major river drainages. Robert Shaw documented five sites dated from 500 BC to AD 1300 on Summit Island, located within the Walrus Island Sanctuary, just off the mainland coast and about 19 miles (30 km) north of Round Island (*Shaw 1998*). Summit Island was occupied intermittently beginning 2,500 years ago, during a time when large village sites affiliated with the Norton tradition became widespread in this area. Shaw proposed that this was the result of a population increase and innovations in net fishing and possibly food storage technologies. Several other Norton sites have been studied in this region, in Chagvan Bay just northeast of Security Cove, on nearby Hagemeister Island, in the Wood River/Tikchik Lakes drainage and on the northern Alaska Peninsula.

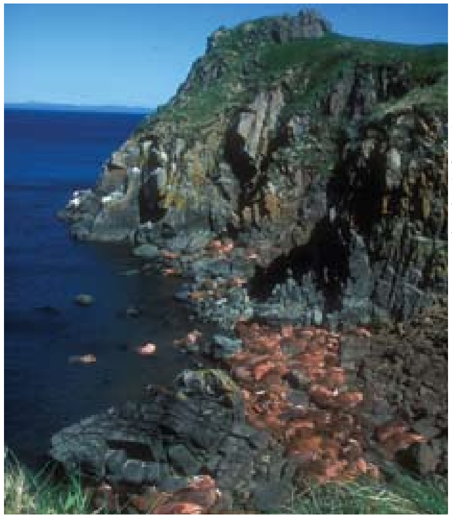
The Norton tradition in this region spans about 1,500 years and traits include thin, well-made ceramics, with fiber or sand temper and often decorated with linear or check stamping, square or rectangular houses, notched stone net sinkers, stone lamps, small bifacially flaked side and end blades, and some use of ground slate (*Figure 10*). The Norton culture on Round Island is represented by several of these artifact types, diagnostic chipped stone points and many well-defined single-roomed square houses lacking apparent entries. These houses, associated with cache pits for food storage, occur in at least two distinct clusters that may represent temporally distinct settlements. Two radiocarbon dates from the Norton culture occupations on Round Island are 10 BC and AD 50 and it follows the preceding occupation by about 1,600 years.

National Park Service photograph by Judy Alderson

Figure 4. Sanctuary personnel and volunteers observe and document wildlife daily on Round Island.

NPS photograph by Judy Alderson

Figure 5. View of Round Island.



National Park Service photograph by Judy Alderson

Figure 6. Round Island is seasonally home to as many as 14,000 walrus, the highest number counted in a single day in 1977.

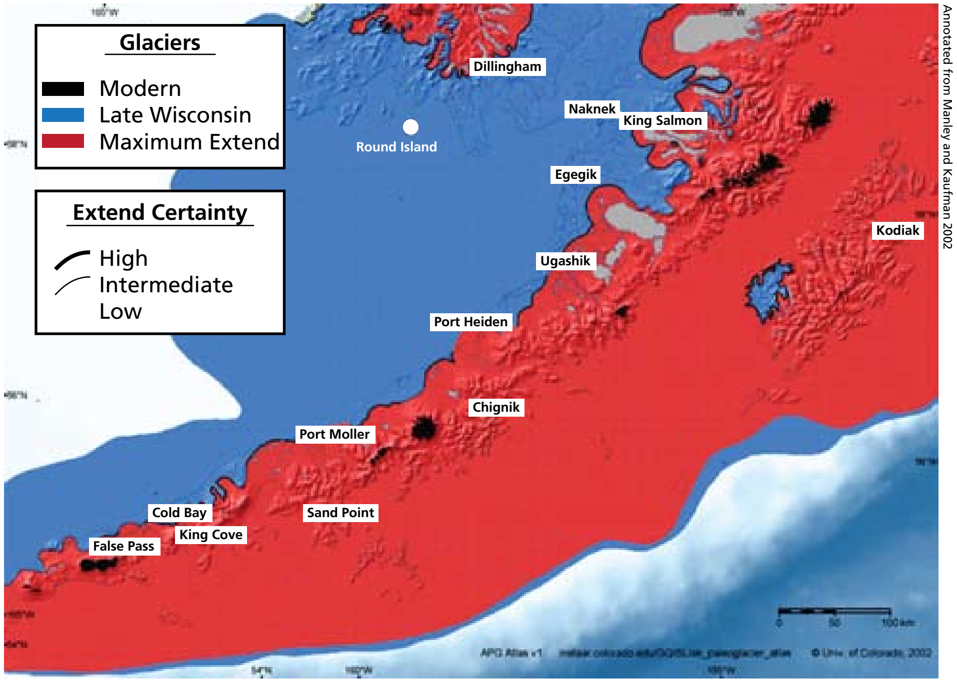


Figure 7. Maximum extent of glacial ice in the Pleistocene (blue) and during the late Wisconsin glaciation (red).

Figure 8. Walrus skull with broken spear point. Tip of arrow scale is the location of the wood charcoal sample, with calibrated range of 3730-3590 BC.

Sometime after 1000 AD, the Norton culture was replaced or absorbed by a northern maritime-based culture, the Thule tradition, directly ancestral to the Yu'pik-speaking people inhabiting the area, including the Tuyuryarmiut of Togiak Bay, at the time of contact. The Thule occupation on Round Island occupies the center and the highest land within the site area at 132 feet (40 m) above sea level. It has large deep house depressions, at least three with storm sheds or entry rooms and a very large rectangular depression measuring 24 by 40 feet (7 x 12 m), that is probably a men's community house or *qasgik* (*Figure 11*). The Thule village has several cache depressions and some sod borrow areas are apparent.

The late prehistory and history of this immediate area is best told in the report of the 1960 excavations at Old Togiak on the mainland by Makoto Kowta (*1963*). Kowta's analysis of the occupations and artifacts dated by typology from 1000 AD to 1700 AD showed a mixed economy with emphasis on both land and sea hunting and fishing, with shellfish collecting becoming increasingly important through time. Antler armor slats found in the upper levels of the site indicate increasing levels of technological sophistication and warfare. A decrease through time in seal remains at Old Togiak may have resulted from over-hunting or environmental change. This may have forced residents to diversify and abandon winter settlements in the summer months for fishing and hunting inland. This is the subsistence pattern practiced by the Tuyuryarmiut at the time of contact (see also *VanStone 1967*).

Round Island was named by Captain James Cook when he sailed across Bristol Bay, briefly stopping at Cape Newenham in 1778. Togiak Bay was bypassed by most early exploration, until 1819 when the Russian Fort Alexandrovsk was established at Nushagak. But even as late as 1890 and despite commercial activities in the Bay, the isolation of the Tuyuryarmiut is evident in travelers' descriptions of them. The transition for Togiak residents from sea mammal hunting with skin boats and hand-held harpoons to guns, wooden boats and outboard motors occurred during the 1930s and 1940s. Round Island was a primary walrus-hunting site before and after the transition, until it was closed to hunting in 1960. Limited walrus hunting by Togiak residents was resumed in 1995 (*Fall et al. 1991*).

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More information about the National Natural Landmarks program and about other Natural Landmarks in Alaska is available at: http://www.nature.nps.gov/nnl/Registry/USA_Map/States/Alaska/alaska.cfm

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National Park Service photograph by Judy Alderson

Figure 11. A measuring tape is strung along one side of a depression that is probably a men's community house or *qasgik* and is central to a Thule tradition settlement at Round Island sometime after 1000 years ago.

National Park Service scan by Barbara Bundy

Figure 9. A small, finely worked side blade recovered from Round Island and dated to about 3,300 years ago suggests an Arctic Small Tool tradition occupation.

National Park Service scan by Barbara Bundy

Figure 10: A notched stone net weight is evidence of the emphasis on net fishing during the Norton tradition.

National Park Service photograph by Jeanne Schaaf

Figure 12. Bristol Bay Native Association interns Paul Askoak and Chasity Anelon assist sanctuary managers launch a boat from the boat cove.

REFERENCES

Ackerman, Robert E. 1998.
Early Maritime Traditions in the Bering, Chukchi, and East Siberia Seas. Arctic Anthropology 35(1):247-262.

Fall, James A., Molly Chythlook, Janet Schichnes, and Rick Sinnott. 1991.
Walrus Hunting at Togiak, Bristol Bay, Southwest Alaska. Technical Paper No. 212. Alaska Department of Fish and Game, Division of Subsistence. Juneau, Alaska.

Kowta, Makoto. 1963.
Old Togiak in Prehistory. Ph.D. Dissertation. University of California, Los Angeles.

Shaw, Robert D. 1998.
An Archeology of the Central Yupik: A Regional Overview for the Yukon-Kuskokwim Delta, Northern Bristol Bay, and Nunivak Island. Arctic Anthropology 35(1):234-246.

VanStone, James W. 1967.
Eskimos of the Nushagak River: An Ethnographic History. University of Washington Press. Seattle.

Figure 1. Brown bear sampling softshell clams in front of Katmai Wilderness Lodge.

Figure 2. Rain-washed remains of a sea otter scat providing strong evidence that the otter was probably foraging on deeply buried gaper clams and did not suffer from insufficient roughage.

Study Documents Important Interactions Between Clams and Charismatic Predators in SWAN Parks

By Dennis C. Lees

Bivalves constitute a critical source of nutrition for major "charismatic" predators such as bears, sea otters, many species of sea (diving) ducks and shorebirds, and a variety of invertebrates at some time during a year. For example, nursing female bears along the coast achieve more digestible energy from foraging on razor and softshell clams than on vegetation.

Clams, a dominant sedentary life form in soft beaches habitats, have a wide range of physiological tolerances, and are among the longest living animals, some species living more than 20 years. With such longevity and lack of mobility, they are good indicators of long-term conditions.

For these reasons, the National Park Service has implemented a long-term monitoring program in the Southwest Alaska Network (SWAN) to assess not only the "charismatic" species, but also the resources that support them. To assist in their planning, we examined soft sediments on beaches in three SWAN parks to provide baseline data on infaunal assemblages, especially clams and mussels. The surveys were conducted in Kenai Fjords National Park (Kenai Fjords), Lake Clark National Park and Preserve (Lake Clark), and Katmai National Park and Preserve (Katmai). Beaches were examined using sampling techniques and visual assessments often employed on soft beaches to reveal species composition and abundance. Although the techniques provided quantitative information on clams as small as a few millimeters, the focus was on larger clams used for prey by the predators. In addition, the surveys provided considerable visual observations of ongoing or recent predation.

The survey found that soft beach habitats differed greatly within and among the parks. Habitats in Katmai range from compact sandy mud supporting softshell clams to clean fine sand supporting razor clams but include a few gravel/sand/silt beaches with littleneck clams. Gravel/sand/silt sediments with littleneck and butter clams dominate beaches in Kenai Fjords, whereas sand beaches with razor clams or mud beaches with softshell clams dominate in Lake Clark. Generally, beaches in Kenai Fjords appear to be geologically younger than those in Katmai or Lake Clark.

A guide to the clams was produced during this program to provide assistance to visitors and NPS staff in these parks in identifying, understanding, and enjoying bivalves found in intertidal sediments (*Guide to Intertidal Bivalves in Southwest Alaska National Parks*). The guide includes brief descriptions of 29 species found during the surveys as well as comments on clam ecology, typical habitats and feeding types, and their distribution among the parks. It also includes drawings and photographs to depict the appearance of the clams and, where possible, indicators revealing their presence in the field (e.g., "shows" or scat).

REFERENCES

Lees, D.C. 2006.
Guide to intertidal bivalves in southwest Alaska national parks. National Park Service. Anchorage, Alaska. NPS/AKRSWAN/NRTR-2006/02. The guide can be accessed at the following web address: http://www.nature.nps.gov/im/units/swan/Libraries/Reports/LeesD_2006_SWAN_GuideIntertidalBivalves_630223_small.pdf

Alaska Park Science Receives Prestigious International Awards

By Robert Winfree

The *Alaska Park Science* journal has won the Award of Distinguished Technical Communication and been voted Best of Show among publications in the Society for Technical Communication's (STC) 2008 International Competition. *Alaska Park Science* qualified for entry in the International Competition when it won a Distinguished award in the STC Puget Sound Chapter's 2007-2008 competition. The judges for each competition reviewed three issues produced during 2006 and 2007 (Volume 5, No. 1 and 2; and Volume 6, No. 1). *Alaska Park Science* was first judged against other scholarly and professional journals, and then across all award-winning entries in 18 categories of technical publications (books, magazines, reports, articles, etc.).

According to information provided by the STC, an entry winning the Award of Distinguished Technical Communication meets or exceeds high standards in all areas and applies the principles of technical communication in a superior way, particularly in how it anticipates and fulfills the needs of its audience. In announcing their choice of *Alaska Park Science* for Best of Show, the judges shared the following remarks:

This publication is a great example of creativity and professionalism in technical communication. It is well designed and beautifully produced, and offers interesting content that will appeal to a variety of readers. We all felt that the Alaska Park Science Journal *presents an impressive set of articles on a theme of topics in each issue. There is an outstanding focus on educationally supportive references and images that add value to each article. This peer-reviewed journal demonstrates a respect for consistent editing. It synthesizes the different styles of many authors to create a seamless, comprehensive piece. Overall, the* Alaska Park Science Journal *is a beautiful publication suitable for a wide audience. Every textual and graphic element of this publication complements another; nothing seems to be out of place or without a purpose.*

The STC is the world's largest individual membership organization dedicated to advancing the arts and sciences of technical communication. Its 14,000 members include technical writers and editors, content developers, illustrators, designers, academics, web designers and developers, and translators in over 130 chapters and 21 countries worldwide. More information about the STC is available at: http://www.stc.org/

Alaska Park Science is distributed twice a year to science teachers, university and community libraries throughout Alaska, and to other science professionals working in Alaska's national parks. Printed copies are also available through the bookstore outlets of the NPS cooperating association in Alaska, Alaska Geographic. Information about publishing in *Alaska Park Science* and printable files of articles from back issues are available at: http://www.nps.gov/akso/AKParkScience/index.htm

Alaska Park Science

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Photograph by Judy Alderson

STC BEST OF SHOW

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