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Cover: ***Tremella lutescens,*** **a jelly fungi. See story page 18. Photograph courtesy of Gary A. Laursen**

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(Left) Moderate-high severity burn in tussock tundra on the Seward Peninsula with partial re-sprouting of cotton tussock grass. On the horizon, low severity burn reveals quick recovery of tussocks. (Milepost 85 fire; A526)

Figure 1. (Below) Fire mosaic resulting from varied burn severity of the Witch (B242) fire of 1999 in Yukon-Charley Rivers National Preserve.

National Park Service photographs

Space-Based Burn Severity Mapping in Alaska's National Parks

By Brian Sorbel and Jennifer Allen

Introduction

Wildland fire is a powerful force of change across the landscape of Alaska. During the 2004 summer, record high temperatures and low precipitation resulted in the largest fire season in the state's recorded history, with more than six million acres burned. While the extent of the 2004 season was impressive, fires are a yearly summer occurrence. Over the past 50 years, wildland fires have burned nearly two million acres in 14 of the 16 National Park Service units in the state. In their path, fires dramatically alter the vegetation and landscape of the parks. Fire is a natural phenomenon linked to the dynamics of many plant communities and animal populations.

A common misconception of wildland fires is that they affect all burned areas the same. In reality, the effects of fires across the landscape are highly discontinuous and varied. As fires burn under different weather conditions, across changing topography and vegetation types, their behavior and effects also dramatically change. In any given fire, some areas of the landscape are radically changed due to intense scorching or sustained burning, while other areas are completely untouched. This varying burn severity results in a heterogeneous pattern or fire mosaic on the landscape *(Figure 1)*.

Burn severity is a measure of the ecological impacts of the fire, in terms of plant survivorship or mortality, depth of the burn in organic layers, or amount of biomass consumed *(Figures 2-4)*. Information about burn severity helps fire and resource managers understand the effects of wildland fires on the fuels, vegetation, and wildlife.

The NPS Fire Management Program, in conjunction with the U.S. Geological Survey (USGS) EROS Data Center in Sioux Falls, South Dakota, have used remote sensing to map burn severity for all large NPS fires in

National Park Service photographs

Figure 2. Light severity burn on the Jessica (B260) fire of 1999 in Yukon-Charley National Preserve, minimal substrate removal, scorching of some black spruce.

In any given fire, some areas of the landscape are radically changed due to intense scorching or sustained burning, while other areas are completely untouched.

Figure 3. Moderate severity burn on the 1999 Beverly (B248) fire in Yukon-Charley National Preserve, vigorous re-sprouting of fireweed and aspen in the understory.

Alaska since 1999. In addition, fire management staff have installed nearly 300 plots to assess the accuracy of these remotely-sensed maps. This paper describes the methods used to map burn severity and to assess the accuracy of the maps, and discusses the ecological effects and applications of burn severity mapping for NPS fire and resource management.

Satellite Measures of Severity: Landsat Imagery and the Normalized Burn Ratio

On-site mapping of burn severity in Alaska national parks is a challenging endeavor due to the fact that fires may be tens or hundreds of thousands of acres in size and hundreds of miles from airstrips or park facilities. These characteristics favor the use of remotely sensed data for burn severity mapping. The NPS and USGS are using Landsat satellite imagery as a data source for the mapping *(Figure 5)*. Based on methods developed by Key and Benson *(2004, in press)*, GIS burn severity layers are generated by applying the Normalized Burn Ratio (NBR) to pre- and post-fire Landsat imagery. The Normalized Burn Ratio uses data from Landsat bands 4 and 7, the two bandwidths that show the greatest response to burning *(Figure 6)*, to generate an index of burn severity. The ratio is calculated as follows: NBR = (TM Band 4 − TM Band 7) / (TM Band 4 + TM Band 7).

The Normalized Burn Ratio is calculated for both pre- and post-fire Landsat scenes. A final Differenced NBR (dNBR) dataset is derived by subtracting the post-fire ratio from the pre-fire ratio: $dNBR = NBR_{prefire} - NBR_{postfire}$. The dNBR generates a continuous index of burn severity, from unburned to severely burned, with possible values ranging between -2000 and +2000. Generally, a threshold exists between about

-100 and +150 dNBR units that marks an approximate breakpoint between burned and unburned areas. Areas with dNBR values below this threshold are unburned; areas with dNBR values above the threshold are burned. Increasing dNBR values correspond to increased burn severity *(Figure 7)*.

Burn severity data sets have been generated for all large fires on NPS lands in Alaska as part of the NPS-USGS National Burn Severity Mapping Project since 1999. As part of this project, the NPS Alaska Region Fire Management Program notifies the EROS Data Center (EDC) of burns that it would like mapped. The EDC acquires and processes appropriate pre- and post-fire Landsat imagery in order to generate burn severity products including: Geographic Information Systems (GIS) grid format dNBR burn severity data set, satellite-derived final fire perimeter, pre- and post-fire Landsat imagery, and associated metadata. Burn severity data sets have been developed for 27 fires occurring in six different Alaska NPS units between 1999 and 2004 *(Table 1, Figure 9)*. Additional fires on Bureau of Land Management and U.S. Fish and Wildlife Service lands have also been mapped.

Field Measures of Severity: The Composite Burn Index

Composite Burn Index (CBI) plot methods were developed to validate the accuracy and applicability of mapping burn severity with remotely sensed data *(Key and Benson 2004, in press)*. NPS fire management staff have installed 286 Composite Burn Index plots in ten fires occurring in Yukon-Charley Rivers National Preserve, Denali National Park and Preserve, Noatak National Preserve, and near Bering Land Bridge National Preserve.

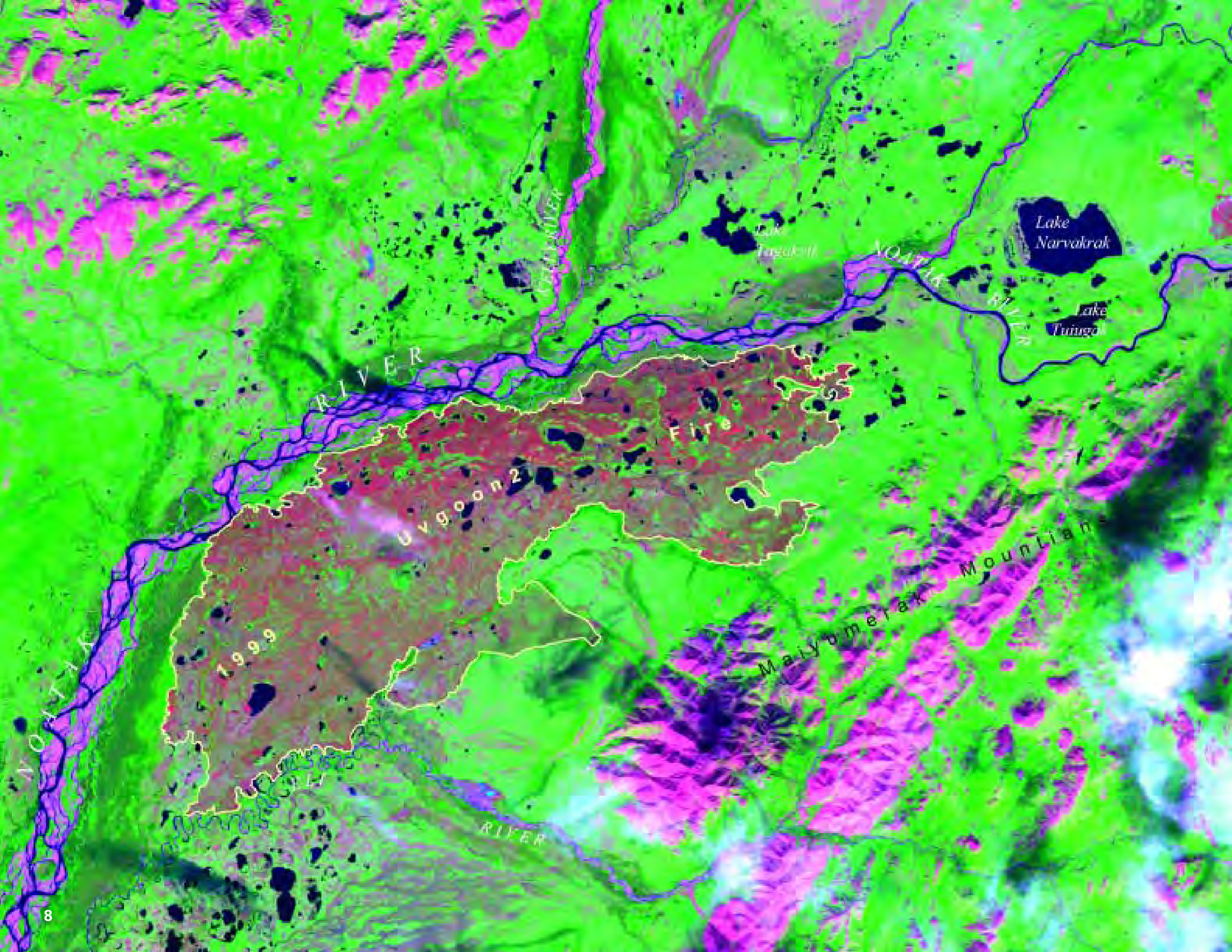
The burn severity of a plot is assessed by scoring the degree of change from the pre-burn to the post-burn state for variables in five vegetation/substrate strata: 1) substrate layer, 2) herbaceous/low shrub and small tree layer, 3) tall shrubs/sapling trees, 4) intermediate trees, and 5) large trees. A score ranging from 0.0 to 3.0 is recorded for each variable, where 0 indicates unburned and 3 indicates the highest burn severity (i.e. the component has either been completely consumed or radically changed by fire). As an example, crews categorize the change caused by fire to the duff layer with possible options being: unchanged (0); light char (1); 50% loss with deep char (2); or consumed (3). In all, up to 22 severity scores are recorded for a variety of variables, such as soil cover/color change, duff and litter consumption, percent of colonizers, percent of altered foliage, percent of canopy mortality, etc. These scores are then averaged to yield CBI ratings for the understory, overstory, and the total plot. The overall CBI plot score is compared with the satellite measure of severity at that location to determine the degree of correlation, and to help determine thresholds for levels of burn severity.

National Park Service photograph

Figure 4. High severity burn on the 2000 Foraker (A274) fire in Denali National Park and Preserve, 100% tree mortality, fire moss growing on exposed mineral soils.

Correlation Between Field and Satellite Measures of Burn Severity

Linear regression analysis was used to assess the relationship between satellite-derived measures of severity as determined by the Differenced Normalized Burn Ratio


Lake Narvakrak
NOATAK RIVER
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Uvgoon2 Fire
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NPS Unit	Year	Fire Name	Fire Number	Fire Size (acres)
Yukon-Charley Rivers National Preserve (YUCH)	1999	Witch	B242	46,956
	1999	Beverly	B248	20,164
	1999	Jessica	B260	48,442
	1999	Pingo	B264	38,174
	2004	Essie Creek	#348	911
	2004	Nation River	#237	66,832
	2004	Edwards Creek	#234	268,520
	2004	Woodchopper Creek	#331	14,905
Noatak National Preserve (NOAT)	1999	Uvgoon 2	B333	88,497
	2002	Cottonwood Bar	A520	13,556
	2002	Uyon Lakes	B001	430
	2003	Okoklik Lake	B342	1,102
	2003	Aklumayuak Creek	B366	289
	2003	Grand Canyon	B444	115
	2004	Uvgoon Creek	#127	11,231
	2004	Poktovik Creek	#174	289
	2004	Sisiak Creek	#213	333
Denali NP and Preserve (DENA)	2000	Foraker	A274	17,956
	2000	Otter Creek	A288	11,576
	2000	Upper Otter Creek	A296	4,726
	2000	Chitsia	A303	9,330
	2001	Herron River	B288	6,238
	2002	Moose Lake	A417	117,920
	2002	John Hansen Lake	A477	25,752
Gates of the Arctic NP and Preserve	2002	Dawn Creek	A480	2,548
Katmai NP and Preserve	2003	West Kamishak Bay	303094	1,285
Kobuk Valley NP	2003	Salmon River	B332	546

Table 1. Fires for which burn severity maps have been generated using Landsat imagery and the differenced Normalized Burn Ratio

Figure 5. (Left) Landsat satellite imagery of the 88,000 acre Uvgoon2 (B333) fire. This fire burned in 1999 in Noatak National Preserve.

NPS Unit	Fire Name	Fire Number	Fire Year	# of CBI Plots	R^2
YUCH	Witch, Jessica	B242, B260	1999	79	0.75
YUCH	Beverly	B248	1999	40	0.46
DENA	Otter Creek, Chitsia	A288, A303	2000	35	0.76
DENA	Foraker	A274	2000	24	0.76
DENA	Herron River	B288	2001	25	0.84
NOAT	Cottonwood Bar	A520	2002	18	0.78
NOAT	Uyon Lakes	B001	2002	18	0.80
Non-NPS Unit (near BELA)	Milepost 85	A526	2002	47	0.82

Table 2. Results of comparison between dNBR and CBI burn severity values. R^2 values range from 0 to 1. Values closer to 1 indicate that remote sensing (dNBR) values correspond favorably to observed burn severity during ground assessment (CBI).

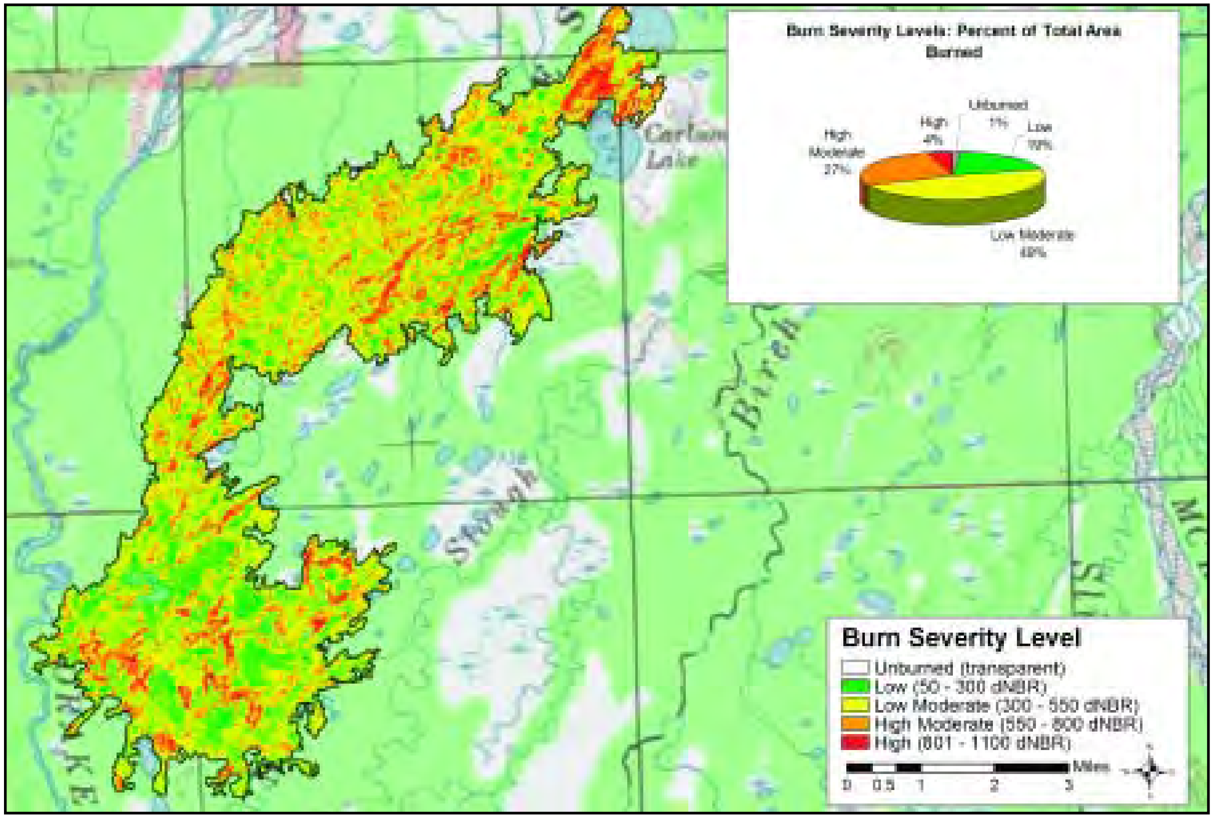
(dNBR) and ground measures of burn severity as determined by the Composite Burn Index (CBI). The relationship between dNBR and CBI values was examined in eight separate instances, as determined by fire location, fire year, and the Landsat scene pairs that were used in the analysis *(Table 2)*.

In order to assess the broad scale application of burn severity mapping, a single analysis of all 286 CBI plots and satellite burn severity values, measured across ten different fires, three parks, and over a span of four years was completed. The linear regression showed a positive correlation between ground and remote sensing measures of burn severity and a good fit with a R^2 value of 0.7024 *(Figure 8)*. These results demonstrate that the dNBR is a suitable measure and predictor of burn severity in Alaska national parks.

Ecological Effects and Applications of Burn Severity

Burn severity mapping captures the heterogeneous nature of fire, and offers a more complete description and quantification of a fire's effect on the landscape. The boreal forest and tundra of Alaska are fire-adapted ecosystems, and they are characterized by a mosaic of different aged landscapes that are maintained by fire. In this system, burn severity strongly influences vegetation patterns and succession after fire. Since many of the plant species are rooted in the organic forest floor mat, the amount of consumption of the organic mat will determine whether vegetation regeneration occurs through seeding or re-sprouting post-fire *(Viereck and Schandelmeier 1980)*.

If fire severity is low to moderate, aboveground portions of plants may be top-killed, but minimal organic mat or duff is burned. Regeneration can occur quickly through re-sprouting from roots and stems for species such as aspen, paper birch, Labrador tea, willow, resin birch, rose, fireweed, tussocks, or northern blue joint grass *(Foote 1983, Viereck and Schandelmeier 1980, Racine et al. 1987) (Figure 3)*. On the other hand, severe burns will consume most of the organic layer and kill most of



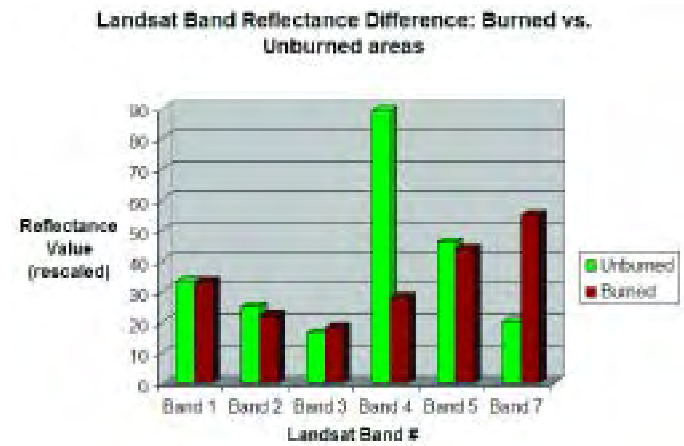


Figure 6. The graph shows different spectral responses or relative brightness values between burned and unburned vegetation in the six Landsat bandwidths. Note how Bands 4 and 7 respond the most, but in opposite ways; yielding information that is distilled in the NBR to focus on fire effects.

Figure 7. (Left) Burn severity map of the 18,000 acre Foraker (A274) fire. This fire burned in Denali National Park and Preserve during 2000.

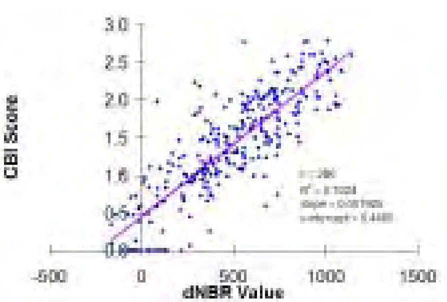


Figure 8. The linear regression model of all 286 CBI plots and satellite burn severity values (dNBR) yielded an R^2 value of 0.7024, indicating strong positive correlation between ground and remote sensing measures.

the underground root structure of shrubs and herbaceous plants, so that reproduction will occur primarily by seed *(Figure 4)*. As a result, severity will influence the plant species composition at a site.

Burn severity and the resulting changes in vegetation can influence wildlife distribution and site utilization. Patchy fires created by varying severity are often used by snowshoe hares and marten *(Paragi et al. 1996)*. Small mammals, such as yellow-cheeked voles often flourish after fires, creating large colonies in the partially burned duff and feeding on the young herbaceous vegetation *(Swanson 1996)*. Moose often take advantage of the newly sprouted willows and deciduous trees after fires. Research has shown that caribou avoid the use of recent burns during the winter due to the decreased amount of lichens, which caribou eat in the winter *(Joly et al. 2002)*. However, researchers have not studied how the mosaic of severity affects moose or caribou habitat and the long-term influence this patchwork will have.

Burn severity maps provide baseline information that can be used for management, monitoring, modeling, and research. Currently, burn severity maps are used to refine and improve final fire perimeters by fire management. Burn severity maps also provide a means to identify unburned islands within fire perimeters, which can be used to determine whether study sites within a fire perimeter have burned and the degree of impact. Severity data will be a key explanatory variable for park staff who monitor vegetation, wildlife, water quality, and permafrost. Resource and fire staff are utilizing burn severity maps to update land-cover vegetation and fuels maps to reflect changes from recent fires. These predictive maps have been used in Yukon-Charley Rivers National Preserve to model changes in bird habitat utilization and will be used to model fire behavior and fire spread for fire management. The severity of fires plays a role in permafrost degradation, nutrient cycling, and water quality parameters *(Dyrness et al. 1986, Yoshikawa et al. 2003)*. Assessing permafrost degradation is a critical component in determining the potential for soil erosion and run-off problems; burn severity maps are used to assess the impact of fire to permafrost. Finally, burn severity mapping provides baseline information that can be used to assess the effects of climate change over time.

Under the USGS-NPS National Burn Severity Mapping Project, burn severity mapping and field validation are occurring in parks throughout the entire NPS system. This partnership has produced burn severity datasets for more than 150 fires occurring in nearly 60 NPS units. All datasets are posted on the USGS-NPS National Burn Severity Mapping Project website: **http://burnseverity.cr.usgs.gov.**

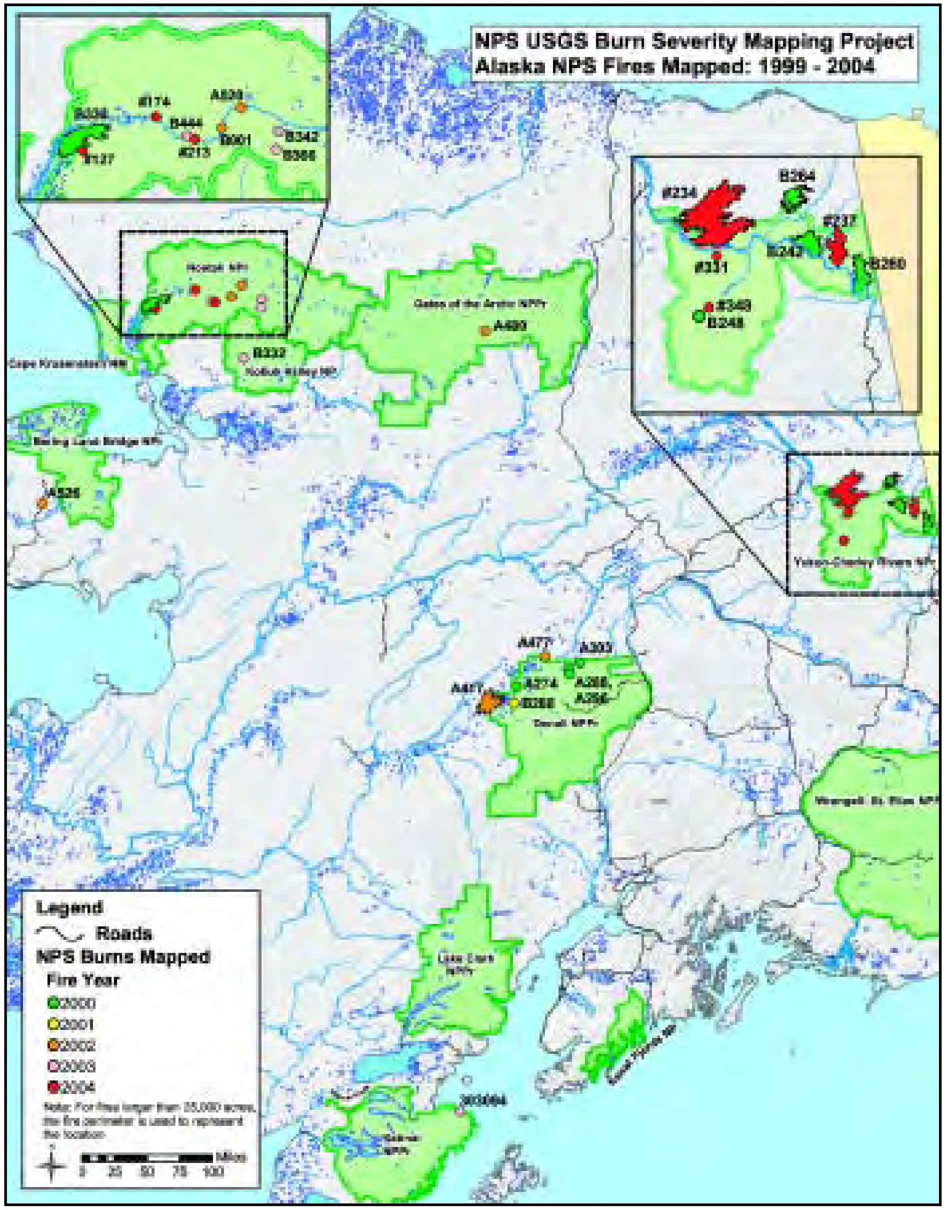


Figure 9. Landsat satellite imagery has been used to generate burn severity maps for 27 fires occurring in six NPS units between 1999 and 2004.

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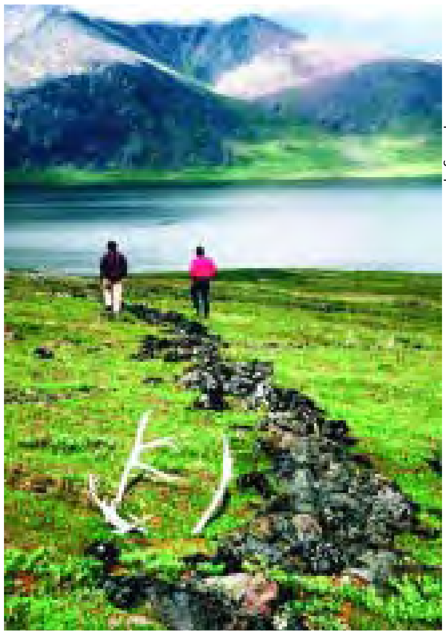
PAKBOATS



National Park Service photograph

Visitors are attracted to Gates of the Arctic for its wilderness character, part of which is evidence of native culture like this caribou surround.

Many visitors choose float trips in Gates of the Arctic National Park and Preserve. This often entails using inflatable or collapsible boats brought in by airplane.

National Park Service photograph

Social Science in Gates of the Arctic National Park and Preserve

By Don Pendergrast

Introduction

In April of 2001, I attended a Wilderness Recreation Estimation Workshop in the National Park Service Regional Office in Anchorage. The workshop, presented by the Aldo Leopold Wilderness Research Institute and U.S. Forest Service, was well attended by representatives of the National Park Service (NPS), U.S. Fish and Wildlife Service, Bureau of Land Management, Alaska Department of Fish and Game, and Alaska State Parks. It did not take long to understand one fundamental truth: no one had more than an educated guess as to what was occurring in Alaska's backcountry. The problem was clear — Alaska is big; backcountry use is often remote and dispersed; and while the visitor numbers are small, the numbers of backcountry managers are considerably smaller. This situation is what makes Alaska parks so unique.

Alaska National Parks are huge, containing intact ecosystems and remote wilderness. Our natural resource specialists study the earth, water, wind, and fire. We have excellent inventory and monitoring programs, which study the flora and fauna. Our cultural resource specialists document ancient and recent histories and relationships with the land.

In light of this, there is a surprising lack of emphasis on visitor studies, even of the most rudimentary information: the numbers of visitors and recreational use patterns. A notable exception is that the NPS keeps good records for front country use. We know how many people attend the slide show at the visitor center and whether or not they are satisfied with our services and facilities. Unfortunately, we have limited knowledge of our backcountry use, and it is this extensive backcountry that separates Alaska parks from their often smaller counterparts in the rest of the U.S.

Some reasons for this were stated above, but often, the use is so small there are few visible impacts and no apparent crisis. It is possible however that the quality of backcountry experiences cannot be gauged best by physical impacts but instead by social factors. If that is the case, what are those social factors, are they similar to non Alaska parks, and what effects do management actions have upon those factors?

Park management is enhanced by good information and accurate data. In order to adequately manage and maintain high quality backcountry experiences, the NPS needs to identify: 1) basic visitor information — who the visitors are and how many there are; 2) recreational use patterns — where visitors go, how long they stay, and what they do; 3) visitors' motivations and expectations; 4) visitors' experiences and the factors influencing those experiences; and 5) visitor and commercial service providers perceptions of managers and management decisions.

At Gates of the Arctic National Park and Preserve, five studies and one report document the social science work carried out *(Christensen and Watson 2002, Christian 2003, Dear 2001, Glaspell et al. 2002, Vande*

National Park Service photograph

Summer hikers in Gates of the Arctic need to be prepared for all kinds of weather. The Backcountry orientation for visitors goes a long way in promoting visitor safety, keeping expectations realistic, and enhancing wilderness experiences.

National Park Service photograph

Understanding recreational use patterns is critical for park management. Pingo Lake pictured here was once a popular access point for the Noatak River and suffered significant human impacts. Today most of those impacts are not noticeable because it is no longer a primary access point.

Kamp et al. 2000, Watson et al. 2003). This article summarizes these works and synthesizes them into a coherent but general form.

Basic information about visitors

Approximately 70-80% of Gates of the Arctic visitors are male, in their early to middle 40s, and college-educated. Over 90% are caucasian, and more than 75% are not from Alaska. As many as one-third of these visitors did not have a great deal of previous wilderness experience, and over 80% of them were visiting the park for the first time *(Christensen and Watson 2002, Christian 2003, Dear 2001, Watson et al. 2003)*.

Recreational Use Patterns

The park attracts few casual visitors. Typically, the length of stay is over ten nights, 3.5 people is the average group size, and floating is more popular (over 60%) than backpacking. About one-third of the visitors take guided trips. The Noatak River receives the most use, but other popular destinations are the Arrigetch Peaks, the North Fork of the Koyukuk River, the John River, and the Alatna River *(Watson et al. 2003)*. The rates for encountering other visitors are fairly low. The exception is on the Kobuk River during hunting season where the average is 5.8 encounters per trip, which is much higher than the 1.7 per week reported on the Noatak River *(Christensen and Watson 2002, Christian 2003)*.

Visitor motivations and expectations

Visitors chose to travel to Gates of the Arctic for its wildness, wildlife, remoteness, solitude, scenic beauty, lack of human features and signs of modernity, and for the mystique of the Brooks Range and the Arctic *(Christensen and Watson 2002, Christian 2003, Dear 2001)*. These visitors expectations were not met and visitors were disappointed if they saw large groups, saw or heard motorboats or aircraft, and especially if they did not see wildlife or at least signs of wildlife *(Watson et al. 2003)*.

Visitor experiences and factors of influence

Analysis of the visitor responses identified five general dimensions to the "Gates of the Arctic experience": taste of the Gates, freedom from management restrictions, untrammeled wildlife, challenge of access, and risk and uncertainty. The "taste of the Gates" emphasizes identification with management, other visitors, and the uniqueness of arctic wilderness experiences. Aspects of this "taste" included: feeling that managers were doing a good job at protecting wilderness qualities; being concerned with their own impacts and that the visit related to personal values; feeling far from civilization, being "free from the clock"; perhaps being the first visitor to some places; and feeling that the landscape is big.

For 98.5% of the visitors, "taste of the Gates" was a feature of the Gates experience. Ninety-three percent of the visitors viewed "freedom from management restrictions" as an aspect. Almost 95% of the visitors identified wildlife as a component of the experience. "Challenge of access" and "risk and uncertainty" (58.5% and 32.5% respectively) were not as commonly listed as part of the Gates experience.

For each dimension, factors that influ-

Dimension		Influence Factor	Pos or Neg
Taste of Gates (98.5%)	⟵	Management interaction	+
	⟵	Trust in NPS	+
	⟵	Interaction with park employees in backcountry	+
	⟵	Personal use of airplane for access	+
	⟵	Limited availability of trip planning information	+
Freedom from Management Restrictions (93%)	⟵	Management interaction	+
Challenge of Access (58.5%)	⟵	Air flight influences	+
	⟵	Physical development by humans	–
Untrammeled Wildlife (94.5%)	⟵	Wildlife presence	+
	⟵	Physical development by humans	–
	⟵	Personal use of airplane for access	+
	⟵	Changing trip plans at last minute or during trip	+
Risk and Uncertainty (32.5%)	⟵	Management interaction	+
	⟵	Out-group interaction	–

Table 1. Factors influencing experience dimensions for recreational users in Gates of the Arctic National Park and Preserve.

enced them were identified. Factors that have a positive influence on the five dimensions of the Gates experience are fairly easy to understand. For example,"wildlife presence" will have a positive influence on "untrammeled wildlife" because that dimension is characterized by seeing wildlife. Influence factors are presented in Table 1 *(Watson et al. 2003)*.

Influence factors themselves had components. The five components of the "management interaction" influence factor include: receiving a backcountry orientation from a park ranger, registering with the NPS, receiving information about Leave-No-Trace techniques, interaction with park employees in the office or town, and availability of free bear-resistant food storage containers from the NPS *(Watson et al. 2003)*.

Understanding the experience dimensions and the factors that influence them will allow the park to improve management policies to influence the visitors' experiences in a positive manner. Not only do the elements of "management interaction" positively influence visitors' experiences but they may also serve as indicators for other experience dimensions *(Pendergrast 2003, Watson et al. 2003)*.

Visitor Groupings

Depending upon the types of experiences reported, visitors were grouped based on their relationship with the park and wilderness in general. Four visitor groups emerged (Figure 1): low wilderness character (8%); high freedom, low risk and uncertainty (22%); high freedom, high wildlife, low challenge (39%); and high wilderness character (31%). The "high wilderness character" segment agreed positively with all the experience dimensions and stands out as a group of people reporting experiences in line with the purpose and intent of the park *(Watson et al. 2003)*.

Useful information for managers

Visitors and commercial service providers were asked to evaluate the obtrusiveness of ten different management techniques and their level of trust in the NPS. The commercial service providers were asked to "answer the questions based on how you think the listed management techniques would influence your clients' future experiences and conditions at Gates" *(Watson et al. 2003)*.

Visitor evaluation for potential management techniques is clear. Both visitors and operators agreed that mandatory backcountry orientation would have a positive effect on future experiences and conditions

National Park Service photograph

A kayaker contemplates the beauty of Gates of the Arctic.

The effort put into visitor contact is perhaps the single most important management action with regard to protecting wilderness character and providing excellent wilderness recreational opportunities.

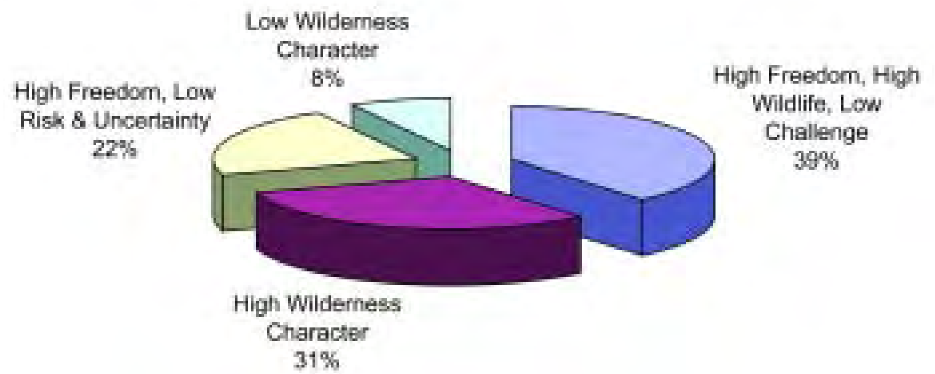


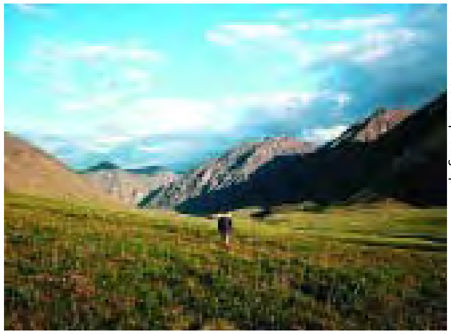
Figure 1. Visitor segments depend upon the types of experiences visitors reported.


National Park Service photograph

Backcountry orientation stresses Leave-No-Trace principles to minimize human impacts. In the arctic these impacts are long lived. This social trail photographed in 2002 at Walker Lake was made in the late 1960s.

at the park. Visitors indicated positive support for registration, use of bear-resistant food containers, group size limitations, advanced reservation limited permit system, restrictions on length of stay in one spot, and alterations to mitigate human impacts. The responses by the commercial service operators generally track those of the visitors, but are shifted toward the more negative portion of the scale. All segments of park visitors trust the NPS. Trust in the NPS is positive but low among commercial service providers *(Watson et al. 2003)*.

The Alaska National Interest Lands Conservation Act of 1980 (ANILCA) created ten new national parks and added 5.9 million acres to existing units. ANILCA provided for customary and traditional subsistence uses by local rural residents on these lands, many of them designated Wilderness. This subsistence activity is a profound difference in ANILCA Wildernesses as compared to other Wilderness-designated areas, where hunting, gathering, and access for subsistence activities are not allowed. It seems to confound managers, researchers, and academics *(Vande Kamp et al. 2001)*. Visitors seldom encounter subsistence activities or evidence, though, most have a positive view of subsistence and would enjoy witnessing subsistence activities and encountering local residents *(Watson et al. 2003, Dear 2001)*. Noise, particularly motorboat noise, was a significant detractor from the Gates of the Arctic experience *(Christensen and Watson 2002, Christian 2003)*.


National Park Service photograph

Remoteness, solitude, and a sense freedom in a large landscape are key elements in the Gates of the Arctic experience.

Conclusions

The effort put into visitor contact is perhaps the single most important management action with regard to protecting wilderness character and providing excellent wilderness recreational opportunities. Through the studies, managers learned that support for limits is not strong, even if visitor use levels increase thereby causing a decrease in the quality of the Kobuk River hunting experience *(Christensen and Watson 2002)*.

The purpose and intent of Gates of the Arctic, as defined by authorizing legislation and management plans, is most closely aligned with the experiences of the "high wilderness character" visitor group which is 31% of all visitors. This segment could thus be seen as an indicator group or keystone group, in the same vein as indicator species or keystone species are noted by ecologists. Learning how to identify this group and understanding their experiences may be critical for managing and maintaining Gates of the Arctic's place on the primitive end of the wilderness spectrum *(Pendergrast 2003, Watson et al. 2003)*.

National Park Service photograph

Visitors chose to travel to Gates of the Arctic for its wildness, wildlife, remoteness, solitude, scenic beauty, lack of human features and signs of modernity, and for the mystique of the Brooks Range and the Arctic.

National Park Service photograph

Above: Spring in the Brooks Range offers plenty of daylight and relatively mild temperatures. It is free from mosquitoes, hiking across tussocks, and crowds. For some it is the perfect season.

Right: The Upper Alatna is typical of the broad glaciated valleys that are the principle routes of travel in Gates of the Arctic.

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figure 1

figure 2

figure 3

figure 4

Wood Inhabiting Fungi in Alaska: Their Diversity, Roles, and Uses

By Gary A. Laursen, Harold H. Burdsall, Jr., and Rodney D. Seppelt

Wood-inhabiting, rotting and/or decomposing fungi from Alaska include representatives from an assortment of fungal groups (cup, jelly, pored, coral, tooth, puffball, gilled, and lichenized fungi) and one fungus-like group (the slime molds). Of the more than 1,500 species recorded for North America, over 250 species of wood-inhabiting fungi have been reported from Alaska. In Alaska, more than 102 genera of gilled, shelf or bracket fungi with pores, jelly fungi, and flat paint-smear-like fungi are known. Most, if not all, of these fungi are known to fruit in Alaska national parks; however, it is important to note, as most of the fungi reported here were collected in national parks, that to collect in any national park necessitates obtaining relevant permits. It is against the law to collect natural objects from national parks without the necessary permits. As with green plant species, some of these fungi are common, some rare, some large and obvious, while others are small and inconspicuous, and some are edible and others poisonous. In this presentation of research on fungi, we make several references to edibility. In so doing, we do not encourage anyone to eat fungi without first consulting a professional.

These fungi are the great recyclers of wood and woody material in the forest ecosystem. They alter the wood structure to produce material with properties that are necessary for inhabitation by other forest biota, both plant and animal and even other fungi. Hence, there is a successional pattern to the work they perform. Some species have been used by indigenous Alaskan peoples for centuries as components of smoking mixtures, curry combs for brushing animals, medicinals, punks to carry fire long distances, and even as leather-like material for clothing.

Amidst dynamic and continually changing cycles of life, death, and decay, significant roles are played by fungi in diseases such as root-rot and heart-rot of trees. They alter organic substrates on the forest floor and recycle nutrients. Fungi are opportunists. They gain access to woody tissues beneath the bark on the bodies of wood-boring beetles. In the process, they leave spores behind in the many galleries produced by the boring insects. Fungi also enter their hosts through woodpecker holes *(Figure 1)* or through bark disruptions caused by moose, bears, porcupines, and rabbits. The invading fungus subsequently spreads out over the substrate as mycelial fans *(Figure 2)*. Entrance may also be gained through wounded and exposed roots, or through wounds created by broken branches, by nibbling rodents, or by heavy winds that can cause excessive movement of tree limbs.

Each fungus is physiologically specific to its particular decay type and ecologically specific where it impacts standing live and dead wood—in the bole of a tree as a heart-rot, in the sapwood as a sap-rot, or in the roots as a root-rot. Wood decay occurs as two primary processes, white rots and brown rots. The activity of white rot fungi results in a white, punky/spongy rot *(Figure 3)*. These fungi are more numerous than

Fungal Features: Ecology

Figure 1. Woodpecker hole with a fungal porch roof

Figure 2. Invading mycelial fan

Figure 3. White spongy rot

Figure 4. Brown cubical rot

Background: Gilled fungi are common and often poisonous. This *Pholiota squarrosa* should be admired for its beauty, not necessarily its taste.

Photographs courtesy of Gary A. Laursen

those causing brown rots and make up about 80% of all wood-rotting species of fungi. White rot fungi primarily break down the lignin, but also some cellulose. However, brown rot fungi leave a brown, cubical, dry, crumbly decay *(Figure 4)*. Brown rot fungi cause the chemical breakdown of cellulose and hemicellulose substrates leaving behind primarily the brown lignins that "glue" cellulose fibers together. In North America, there are at least 1,500 white rot and 250 brown rot species of fungi. In Alaska, these figures are substantially lower because of the limited number of tree species present.

Wood-rotting fungi are widespread and common in Alaska boreal forests and in alpine and tundra habitats as well *(Volk et al. 1993)*. Listed in Table 1 are 102 genera containing some of the common wood-inhabiting/rotting fungi found in Alaska. The large assemblage of wood-inhabiting/rotting fungi contains representatives found in many Orders and Families. An Order in the club fungi, the *Aphyllophorales,* now split into several Orders, once contained the majority of Alaska's wood-rotting fungal species. Volk et al. *(1994)* have compiled a checklist of more than 254 species of wood-rotting fungi. This listing is far from complete, hence, the enormity of the taxonomic task to be dealt with in Alaska mycology.

Alaska's wood-inhabiting fungi are made up of species that represent many classes. They include slime molds; cup fungi; jelly, resupinate (form fitted to a substrate like a coat of paint), pored polypores (pored fungi), coral, tooth, puffball, and agaric (gilled) fungi; in addition to several Ascolichenes and a few Basidiolichenes (the two main divisions of lichens) in many lichen or lichenized fungal groups. Members of each of these groups demonstrate nature's beauty in their life forms, color, biological roles played, and human uses.

The most primitive class of Alaska wood-inhabiting fungi is the slime molds. These may be seen in the forest after a rain as brightly colored slimy plasmodial 'blobs' on woody substrates. Some of the more common slime mold forms inhabiting

ASCOMYCETES	BASIDIOMYCETES				
Helotiales	***Uredinales***	***Stereales***	***Stereales(cont.)***	***Hericiales***	***Agaricales***
Bisporella	*Chrysomyxa*	*Aleurodiscus*	*Stereum*	*Gloeocystidiellum*	*Clitocybe*
Bryoglossum	*Xenodochus*	*Amphinema*	*Trechispora*	*Hericium*	*Flammulina*
Dasyscyphus		*Athelia*	*Tubulicrinis*	*Lentinellus*	*Hypholoma*
Helotium	***Tremellales***	*Botryobasidium*	*Xenasma*		*Marasmius*
Hyaloscypha	*Bourdotia*	*Ceraceomerulius*		***Gomphales***	*Mycena*
Mollisia	*Ductifera*	*Ceraceomyces*	***Poriales***	*Lentaria*	*Omphalia*
Neolecta	*Exidia*	*Columnocystis*	*Antrodia*	*Macrotyphula*	*Pholiota*
	Heterotextus	*Crustoderma*	*Cerenna*	*Ramaria*	*Pluteus*
Sphaeriales	*Sebacina*	*Cyphella*	*Ceriporia*		*Resupinatus*
Daldinia	*Tremella*	*Cystostereum*	*Coniophora*	***Thelephorales***	*Tricholomopsis*
Hypoxylon		*Cytidia*	*Daedaleopsis*	*Sarcodon*	
	Dacrymycetales	*Dendrothele*	*Fomitopsis*	*Thelephora*	***Boletales***
Pezizales	*Calocera*	*Echinodontium*	*Gloeophyllum*	*Tomentella*	*Hygrophoropsis*
Otidia	*Dacrymyces*	*Hyphoderma*	*Hapalopilus*		
Peziza	*Dacrypinax*	*Hyphodontia*	*Panus*	***Lachnocladiales***	***Lycoperdales***
		Laeticorticium	*Perenniporia*	*Scytinostroma*	*Lycoperdon*
	Auriculariales	*Peniophora*	*Pleurotus*		
	Auricularia	*Phanerochaete*	*Polyporus*	***Cortinariales***	***Nidulariales***
		Phlebia	*Spongipellus*	*Alnicola*	*Nidula*
	Tulasnellales	*Phlebiella*	*Spongiporus*	*Cyphellopsis*	*Nidularia*
	Tulasnella	*Phlebiopsis*	*Trichaptum*	*Crepidotis*	
		Piloderma		*Flamulaster*	
	Cantherellales	*Plicatura*	***Hymenochaetales***	*Gymnopilus*	
	Albatrellus	*Steccherinum*	*Coltricia*		
	Clavulina		*Hymenochaete*		
	Multiclavula		*Phellinus*		

Table 1. Common Wood Inhabiting/Rotting Fungi Genera Found in Alaska

Slime Molds: Plasmodial

Figure 5. *Craterium* yellow plasmodium

Figure 6. *Lycogala epidendrum*

Figure 7. *Stemonitis splendens*

Figure 8. *Trichia varia*

Ascomycetes: Cup fungi

Figure 9. *Bisporella citrina*

Figure 10. *Daldinia concentrica*

Figure 11. *Peziza repanda*

Basidiomycetes: Jelly fungi

Figure 12. *Calocera cornea*

Figure 13. *Dacrymyces palmatus*

Figure 14. *Ductifera* sp.

Figure 15. *Exidia glandulosa*

Figure 16. *Tremella lutescens*

Basidiomycetes: Pored fungi

Figure 17. *Coltricia perennis*

Figure 18. *Cytidia salicina*

Figure 19. *Daedaleopsis confragosa*

Photographs courtesy of Gary A. Laursen


figure 5


figure 6


figure 7


figure 8


figure 9


figure 10


figure 11


figure 12

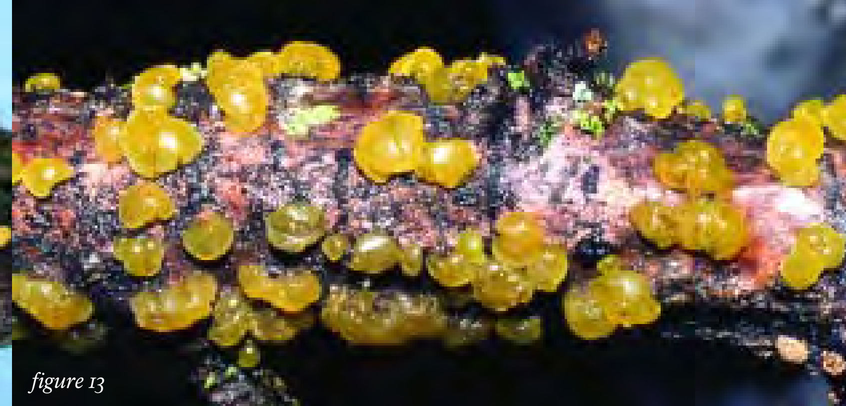
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figure 14


figure 15

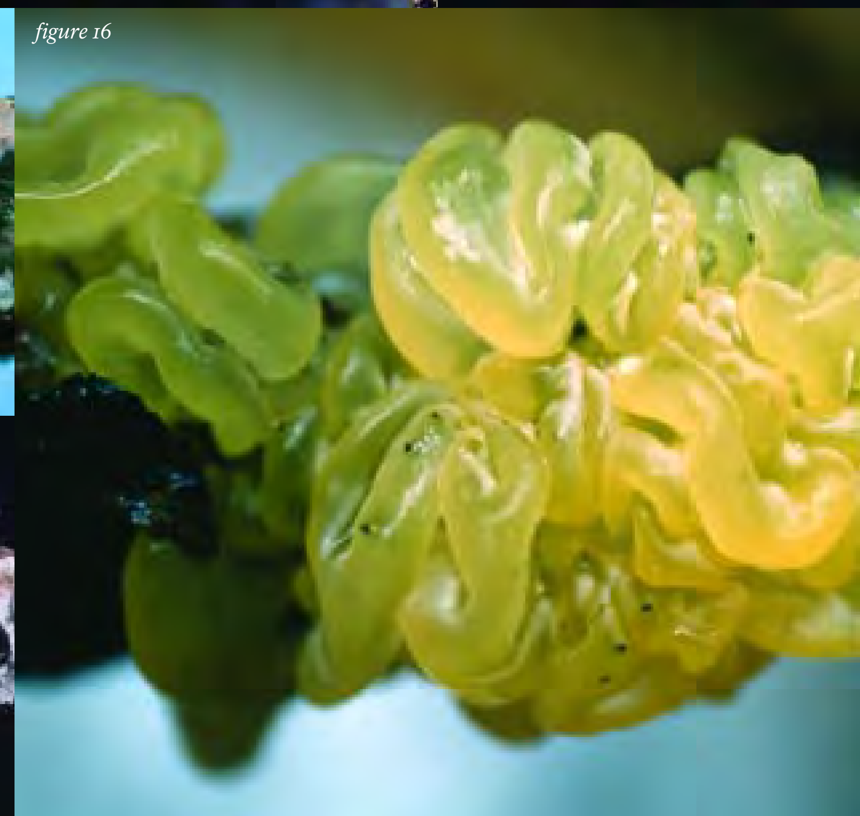
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figure 22


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figure 26


figure 27


figure 28


figure 30


figure 31


figure 32


figure 33


figure 34


figure 35


figure 36


figure 37

Basidiomycetes: Pored fungi (Continued)

Basidiomycetes: Coral fungi

Basidiomycetes: Tooth fungi

Basidiomycetes: Puffball fungi

Photographs courtesy of Gary A. Laursen

northern boreal forests are first seen as white, yellow (Figure 5) and/or as red plasmodia. In the assimilative or 'feeding' stages they engulf bacteria that actually live on the wet and rotting wood. Their plasmodia ultimately mature to form fruit bodies that appear upon 'drying'. Slime molds include *Craterium leucocephalum*, *Lycogala epidendrum* (Figure 6), *Mucilago crustacea*, *Stemonitis splendens* (Figure 7), *Trichia varia* (Figure 8), and *Wilkoumlangiella reticulata*.

The sac or cup fungi (Ascomycetes) are higher up the chain of fungal life forms. They may have dull to bright colors, stalked or sessile cups, 'saddled' stalks, or may have black carbon-like 'fingers', globs, or layers containing small pinhead-like bumps. Examples of cup fungi found in Alaska are: *Bisporella citrina* (Figure 9), *Bryoglossum gracile*, *Daldinia concentrica* (Figure 10), *Neolecta irregularis*, *Peziza repanda* (Figure 11), and *Peziza sylvicola*. All play significant roles, but as with the slime molds, growing on wood debris may not contribute directly to wood decomposition. The fungi may merely find a woody substrate convenient, or they may demonstrate roles not yet fully understood.

Higher up the fungal life form chain are the club fungi (Basidiomycetes), as denoted by their microscopic spore producing club-shaped cells. They include groups such as the jelly fungi, pored fungi, coral fungi, tooth fungi, puffballs, and gilled mushrooms.

The jelly fungi, besides often being brightly colored, feel like the bottom tip of an earlobe when hydrated and fresh. Alaskan examples are *Calocera cornea* (Figure 12), *Dacrymyces palmatus* (Figure 13), *Ductifera* sp. (Figure 14), *Exidia glandulosa* (Figure 15), *Tremella* sp., *Tremella lutescens* (Figure 16) and *Tremella mesenterica*.

The sometimes fleshy, but mostly corky to woody and pored, 'bracket or shelf' fungi show tremendous variation as seen in *Coltricia perennis*, *Cytidia salicina*, *Daedaleopsis confragosa*, *Fomes fomentarius*, *Fomitopsis pinicola*, *Ganoderma applanatum*, *Gloeophyllum sepiarium*, *Laetiporus conifericola*, *Phaeolus schweinitzii*, *Phellinus tremulae*, *Piptoporus betulinus*, *Polyporus* sp., *Polyporus badius*, *Pycnoporus cinnibarinus*, *Tomentella* sp., *Trametes hirsuta*, and *Trichaptum abietinum* (Figures 17-33).

Laetiporus conifericola (Figure 24) is a lemon-flavored edible species and can be found in significant quantities. White and brown heart-rot and sap-rot fungi such as *Fomitopsis pinicola* and *Phellinus pini* contribute greatly toward the ultimate demise of live trees. *Fomes fomentarius* (Figure 20) and *Piptoporus betulinus* (Figure 27) fruit abundantly on standing dead trees and predispose them to being hollowed out by nesting birds and mammals (Figure 1). They also serve a human function. Indigenous peoples collect these two fungi as an additive to pipe tobacco and for their analgesic properties. Still other varieties, such as *Phellinus tremulae* (Figure 26), are first dried, then ashed. The ashes are then mixed with chewing tobacco to decrease tobacco acidity and to enhance the stimulus of nicotine. *Ganoderma applanatum* (Figure 22), the Artist's Conk, is used by artists for etchings. Other *Ganoderma* spp. are said to have medicinal properties and are used by people around the world.

The coral fungi, such as *Clavicorona pyxidata* (Figure 34) and *Ramaria stricta*, also members of the club fungus

THERE ARE POISONOUS (EVEN DEADLY) FUNGI THAT OCCUR ON WOOD. Care should be taken in selecting fungus for the table. It is best to consult a mycologist for accurate identification.

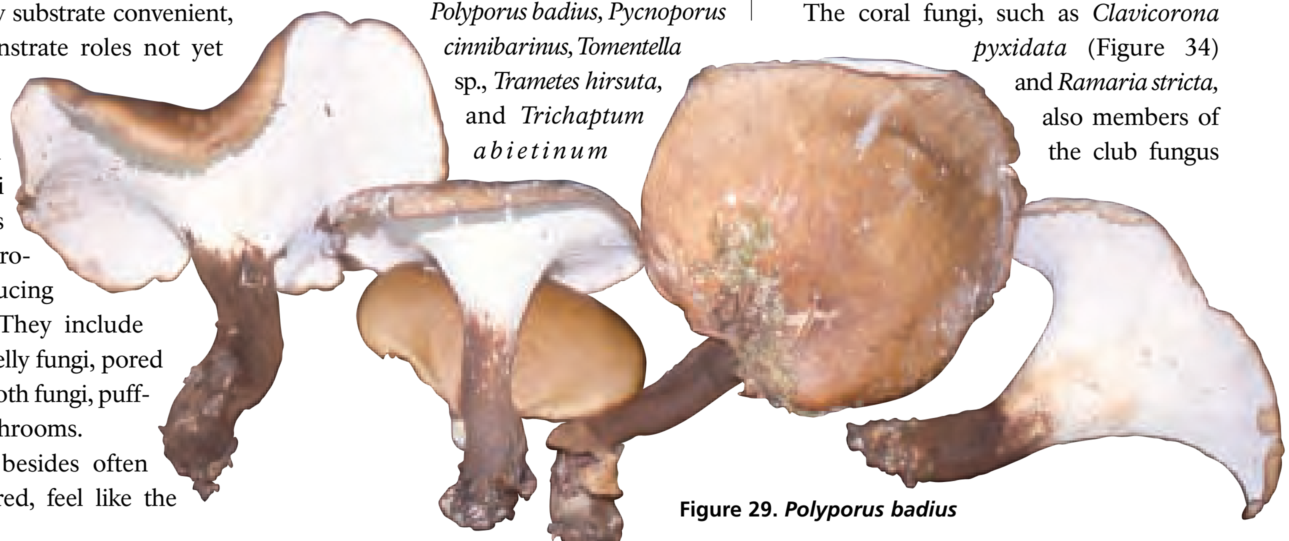

Figure 29. ***Polyporus badius***

Collecting of natural objects from National Park Service areas is restricted by law and regulations. Always check with local managers before collecting plants or other objects from park or monument areas. Regulations may vary between areas.

group, often look just like the corals found in tropical waters. Several are poisonous, that is, gastro-intestinally upsetting or simply not palatable. Others are edible, but not deliciously so. This group in Alaska is best left to the squirrels!

The perennial heart-rot tooth fungus *Echinodontium tinctorum* (Figure 35) that grows on western hemlock was used by indigenous peoples for its red ochre color. First dried and then ground to a powder, the internal tissue of the conk was used for making red ochre paint. *Hericium racemosum* (Figure 36), an annual tooth fungus, is a delicious edible.

Even the puffball fungi, such as *Lycoperdon molle* and *L. pyriforme* (Figure 37), are edible if you get to them before they begin turning color (from pure white to an olive green inside) and you beat the bugs or other parasitizing fungi.

Many wood-inhabiting gilled (lamellate or agaric fungi) mushrooms are NOT considered to be edible. In fact, *Galerina autumnalis* (Figure 38) is DEADLY POISONOUS and extreme care must be taken not to confuse this with other less- or non-poisonous species. Other species in different wood-inhabiting genera are actually edible. Particularly notable as edibles are *Armillaria gallica* (Figure 39), a virulent root-rotting fungus, *Flammulina fennae* (Figure 40), *F. velutipes* (Figure 41) and *Pluteus cervinus* (Figure 42). Others may cause significant gastrointestinal upset if eaten. Species of *Alnicola*, *Crepidotus mollis* (Figure 43), *Flammulaster muricata* (Figure 44), *Hygrophoropsis aurantiaca* (Figure 45), *Lentinellus cochleatus* (Figure 46), *Panus crinitis* (Figure 47), *Pholiota elongatipes* (Figure 48), *P. squarrosa* (Figure 49), *P. squarroso-adiposa* (Figure 50), *Pleurotus dryinus* (Figure 51), *Tricholomopsis platyphylla* (Figure 52), and *Xeromphalina cauticinalis* (Figure 53) are best photographed and left on the log!

The Ascolichenes and Basidiolichenes are abundant on all types of wood in various stages of decomposition. Lichens are symbiotic associations between fungi (mycobionts) and algae (photobionts). The fungal partners may "decompose" woody substrates to which they attach in part, but to our knowledge this has never been documented. Wood associated ascolichen and basidiolichen species are represented by *Ichmadophila ericetorum* (Figure 54) and *Lichenomphalia hudsoniana* (Figure 55).

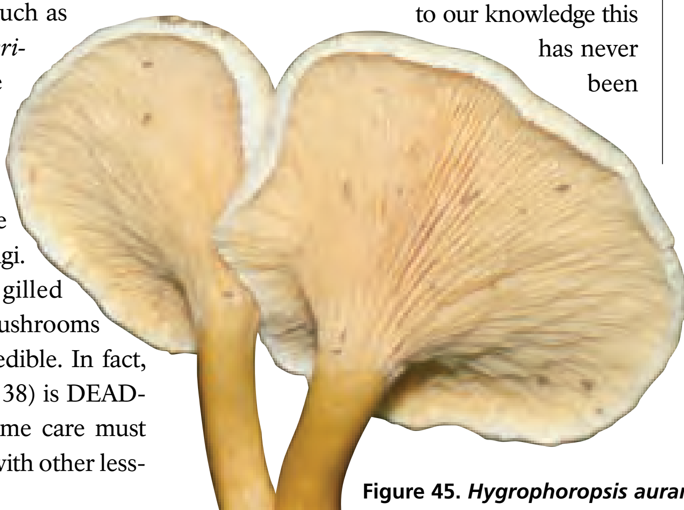

Figure 45. *Hygrophoropsis aurantiaca*

Significance

Several of the wood-inhabiting fungi are edible forest products not requiring the destruction of the forest. Many fungi occur annually and are thus considered sustainable and renewable resources that can supplement the tables of connoisseurs. While most wood-inhabiting fungi are not desirable for food either because of size (the thin crusts) or texture (tough or woody), most are not poisonous. However, THERE ARE POISONOUS (EVEN DEADLY) FUNGI THAT OCCUR ON WOOD. Care should be taken in selecting any fungus for the table. It is best to consult a mycologist for accurate identification.

Acknowledgments

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Basidiomycetes: Gilled fungi

Figure 38. *Galerina autumnalis*

Figure 39. *Armillaria gallica*

Figure 40. *Flammulina fennae*

Figure 41. *Flammulina velutipes*

Figure 42. *Pluteus cervinus*

Figure 43. *Crepidotus mollis*

Figure 44. *Flammulaster muricata*

Figure 45. *Hygrophoropsis aurantiaca* (Photo page 24)

Figure 46. *Lentinellus cochleatus*

Figure 47. *Panus crinitis*

Figure 48. *Pholiota elongatipes*

Figure 49. *Pholiota squarrosa*

Figure 50. *Pholiota squarroso-adiposa*

Figure 51. *Pleurotus dryinus*

Figure 52. *Tricholomopsis platyphylla*

Figure 53. *Xeromphalina cauticinalis*

Asco- & Basidiolichens: The Lichenized fungi

Figure 54. *Ichmadophila ericetorum*

Figure 55. *Lichenomphalia hudsoniana*

Photographs courtesy of Gary A. Laursen


figure 38


figure 39


figure 40


figure 41


figure 42


figure 43


figure 44


figure 46


figure 47


figure 48


figure 49


figure 50


figure 51


figure 52

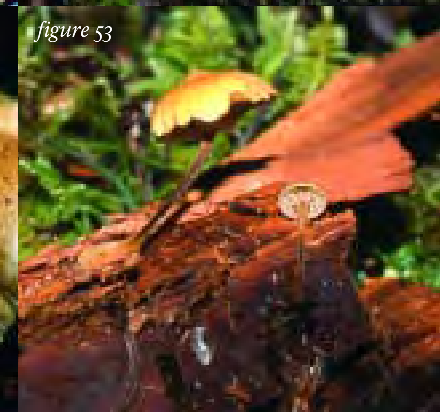
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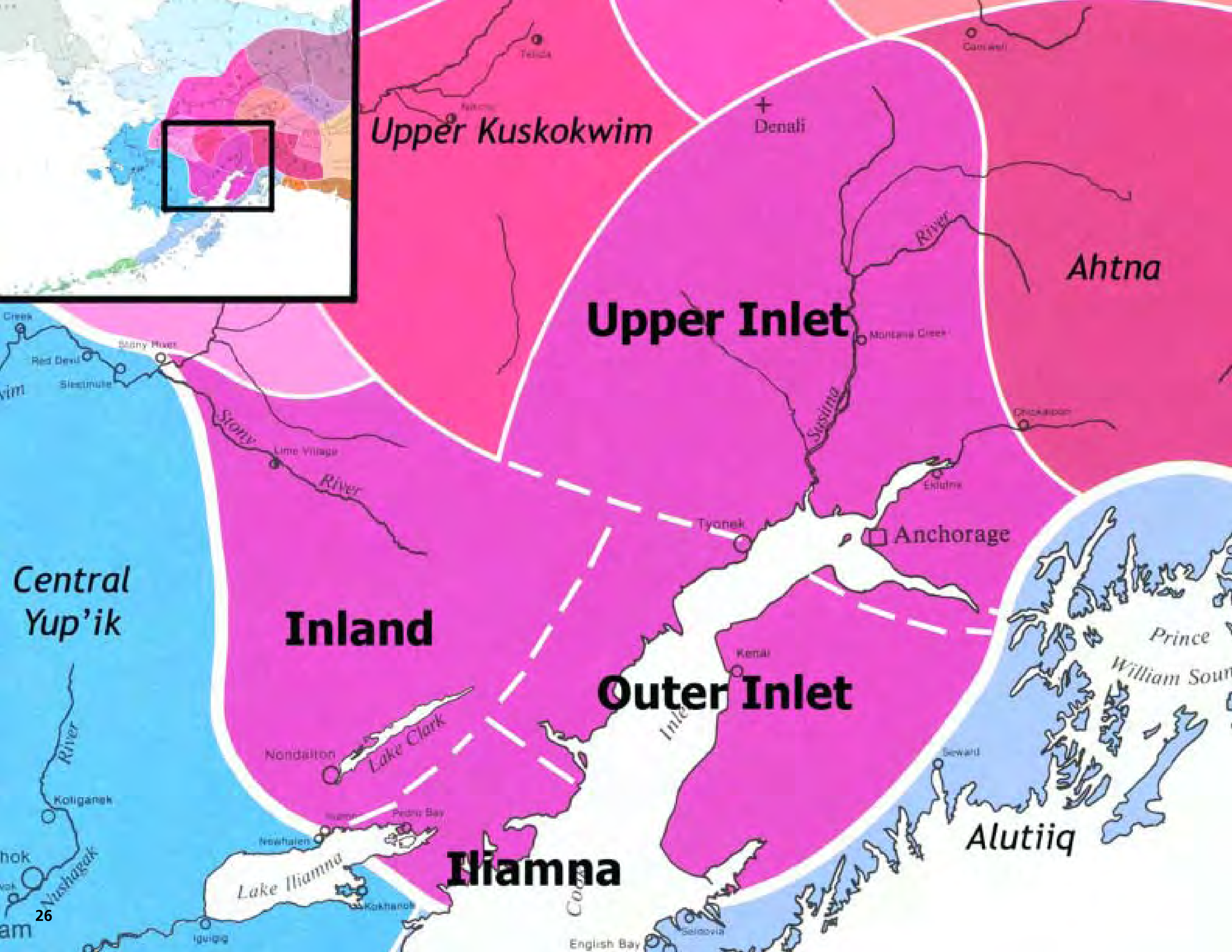
figure 54


figure 55


Upper Kuskokwim
Denali
Ahtna
Upper Inlet
Susitna
River
Stony
River
Lime Village
Tyonek
Anchorage
Eklutna
Central
Yup'ik
Inland
Outer Inlet
Kenai
Prince
William Soun
Lake Clark
Nondalton
Inlet
Seward
Alutiiq
Koliganek
River
Nushagak
Pedro Bay
Newhalen
Lake Iliamna
Iliamna
Kokhanok
Igiugig
English Bay
Seldovia
Stony River
Red Devil
Sleetmute
Montana Creek
Chickaloon

Speaking Across Generations: Dena'ina Language Revitalization in Southcentral Alaska

"Languages are more than just practical systems of communication. Each is also a creation of beauty, through the collective and creative spirit of countless generations of our ancestors, with spiritual and emotional values unique to the identity of each society" (Krauss 1995).

Photograph courtesy of Alan Boraas

People gather on the Kenai beach at the Dena'ina Festival in June 2004 to witness the pulling in of the set-net. The Festival was part of a three-week Dena'ina Language Institute.

Left: Language map showing four Dena'ina language dialect areas (developed by Michael Krauss 1992).

By Karen K. Gaul and Gary Holton

Pulling in a set-net generally takes only a few people. But on the Kenai beach in June 2004, a group of several dozen Dena'ina Athabascans from various communities all around the Cook Inlet region gathered to witness the pulling in of the net. They were gathered together for a second annual Dena'ina Festival. The celebration included a potlatch, traditional set-net fishing, and song and dance performances. The festival, hosted by the Kenaitze Indian Tribe, was one of the high points during the Dena'ina Language Institute. The institute was supported by a U.S. Department of Education Title VII grant, and was co-sponsored by the Alaska Native Language Center, Kenai Peninsula College, and the Interior Athabaskan Tribal College. Students and teachers met every day for the first three weeks of June for an intensive period of study and future planning.

Fading Voices

Dena'ina is one of the many endangered languages of Alaska. It belongs to the Athabascan language family, which is comprised of some forty languages spread across parts of Alaska, Canada, the U.S. Pacific Northwest, California, and the U.S. Southwest *(Krauss and Golla 1981)*. Dena'ina speakers have historically lived in the areas around the region of Cook Inlet, but differences in pronunciation and vocabulary have developed into various dialects correlated with particular regions *(see map) (Kari 1975, Kari and Kari 1982)*. What is now Lake Clark National Park and Preserve, encompassing over four million acres, lies at the heart of Inland Dena'ina, one of four dialect areas. Upper Inlet Dena'ina stretches as far north as Denali, and the Outer Inlet dialect skips across the Inlet to include the west coast and the east coast, stretching across most of the Kenai Peninsula. The Dena'ina spoken in the region of Pedro Bay and Old Iliamna comprises a fourth dialect *(Kari and Kari 1982, Russell Kari 1987)*.

The fate of Dena'ina is not unique. Many of Alaska's indigenous languages are severely endangered. They have been helped along the path to oblivion for many years by both official and unofficial policy. Beginning in the 1880s, official U.S. educational policy forbade all use of Alaska Native languages in schools *(Alton 1998)*. The removal of children to residential schools furthered the process of severing transmission of Native languages from parent to child.

Today, children no longer grow up speaking Dena'ina, and there are few fully fluent speakers of Dena'ina remaining. Some elders learned Dena'ina as a first language, but most of them were taught English in grade schools at a very young age and, in many cases, were forbidden to speak their native language.

Nearly 20 years ago, anthropologist Linda Ellanna predicted that Dena'ina was moribund *(Ellanna 1986)*. Such a prediction is fairly ominous *(see also Krauss 1980)*. Whether Dena'ina can be revitalized into a widely and actively spoken language remains to be seen. A growing number of people in southcentral Alaska are hoping to turn the tide.

Language as a Cultural Resource

Cultural resource managers in the National Park Service work to record and preserve archeological sites, historic structures, cultural landscapes and ethnographic resources. But one of the most significant ethnographic resources for the Dena'ina and other Native groups is not a site, structure, or object, it is their language, with all of its subtle and complex meanings. Language cannot be found or recovered in the landscape, it is stored in people's memories.

Just a generation or two ago, there were no audio or written recordings of Dena'ina. Like other languages and cultural traditions for the vast majority of human experience on earth, it was orally shared. The National Park Service, among many other organizations and individuals, has played a key role in supporting a series of research projects that have focused on the gathering and recording of interviews in the Dena'ina language and on Dena'ina culture, for language and culture are inextricably tied.

Currently, Lake Clark National Park is conducting an ethnographic overview and assessment for the western Cook Inlet region surrounding and including the park. One element of the broader project is to inventory and catalog all existing audio recordings in Dena'ina into one database. This includes recordings held in NPS archives as well as at the Alaska Native Language Center, the Bureau of Indian Affairs, in individual collections, and elsewhere. These recordings represent the contributions of numerous Dena'ina such as Andrew Balluta, Albert Wassilie, Harry Balluta, Ruth Koktalash, and many others who dedicated their time and energy to the preservation of Dena'ina language and culture. So far, James Kari, Professor Emeritus at the University of Alaska Fairbanks, has inventoried around 350 different recordings. This work is an important step in assessing what we have in Dena'ina, and contributes to the further use of the recordings in revitalization programs and research.

In another element of the ethnographic project, Ron Stanek and Davin Holen of the Alaska Department of Fish and Game, and Karen Gaul with the NPS are compiling existing data and conducting new interviews with Dena'ina residents of the Lake Clark area. In doing so, they piece together a more detailed understanding of kinship, travel patterns, subsistence practices, and overall cultural occupancy and land use in the Lake Clark region.

This project builds on others that have been done in the area. A quarter of a century ago, Linda Ellanna and Andrew Balluta conducted research in the Nondalton area for *Nuvendaltin Quht'ana, The People of Nondalton (Ellanna and Balluta, 1992)*. Supported by the National Park Service, this ethnographic research provided important accounts of social organization, land use, and belief systems. In the late

Photograph courtesy of Mrs. Ray Schaleben

Residents of Old Nondalton with school teacher Hannah Breece (far left) on July 4th, 1911. Breece was a teacher in Iliamna, and traveled to Old Nondalton to teach in the summer. In classrooms such as Breece's, English was taught and Native languages forbidden.

National Park Service photograph by Karen Gaul

Dena'ina language revitalization remains an achievable goal. Revitalization can take many forms, but in all cases it requires a strong commitment from within the community.

Left: Pete Bobby, an elder of Lime Village, is a Dena'ina speaker and assists in teaching the language to interested learners.

1990s, Project Jukebox, a joint project between the park and the UAF Rasmuson Library, compiled interviews of elders, photos, and maps into an interactive CD-ROM. Viewers can listen to elders speak on various topics, hear descriptions of photos, and be guided through trails on a map. Elders also offer Dena'ina words for various places and objects. These interviews contribute to both cultural and linguistic preservation.

The Lake Clark cultural resources management program also periodically supports the work of linguist Kari in gathering vocabulary for dictionaries and related educational materials *(Kari 1994)*. In interviews with Nickoli Kolyaha, for example, Kari was told some of the beautifully descriptive names of the Lake Clark and Old Iliamna areas such as "the fish swim up climbing" *(Diqak'ghileha)*, "Upon it we paint ourselves" *(Veq'Nuhuch'nashchigi)*, and "the one in the timbered valley" *(Taq'Nust'in) (Kolyaha 1999)*. Kari, along with James Fall, have tracked down hundreds of Dena'ina place names throughout the region, building maps, and tying the names to stories, families, and their seasonal use patterns, which has been gathered and published in *Shem Pete's Alaska (Kari and Fall 2003)*.

Research by Priscilla Russell, often in conjunction with Dr. Kari, has contributed to publications in plant lore, bird traditions, resource use, and village economy in some of the more interior inland areas *(Russell Kari 1983, 1985, 1987; Russell 2003)*. Peter Kalifornsky, a Dena'ina elder and recorder of Dena'ina culture and history, worked with Alan Boraas, Jim Kari, and Priscilla Russell to produce a collection of writings called *A Dena'ina Legacy: K'tl'egh'I Sukdu (Kalifornsky 1991)*. Kalifornsky, who lived

National Park Service photograph

Michelle Ravenmoon of Lake Iliamna and Chad Chickalusion of Tyonek, making birch bark baskets during a language lesson.

on both sides of Cook Inlet over the course of his life, writes this about education of the young: "They should be aware of the old people and retain all of their language work. They should learn without writing … Study the words, the remaining words. And all the different songs. And the place names that they made long ago. And they should compare all the living things, how living things grow" *(Kalifornsky 1991)*.

The recordings of oral narratives in Dena'ina by all of these Dena'ina elders and researchers capture the most valuable linguistic resource of all: spoken Dena'ina, with all of its idioms, rhythms, playfulness, and beauty. The tapes can be used for instructional materials in emerging Dena'ina language programs. They can become tutorials for Dena'ina language in use. In addition, the details contained in the studies of traditional use of plants, birds, fish, and other animals offer a cultural and environmental context for students of the language.

First Steps

Several years ago, Pauline Hobson of Nondalton and other members of the Dena'ina community began raising the question of whether they might more actively work on Dena'ina revitalization. They approached the Alaska Native Language Center, and their efforts to preserve their language have been multiplying ever since.

Much of the initial work of language revitalization involves bringing speakers and learners together. This may seem an obvious and perhaps redundant task, but it is not. Learning a language takes an uncommon level of commitment, as well as good supporting materials. Because the Dena'ina language area spans a large territory, which includes both urban and remote areas, connecting people across this vast and geographically diverse region is particularly challenging.

National Park Service photograph by Karen Gaul

Sondra Stuart, Mary Hobson (an elder from Nondalton) and Raina Thiele at the Dena'ina Language Institute at Kenai Peninsula College, June 2004.

In May 2003 the Kenaitze Indian Tribe hosted the first Dena'ina Festival. This event drew speakers from across all the Dena'ina dialect areas to discuss the prospects for language revitalization. More than 100 people attended. The festival was followed by a three-week Dena'ina language course held at Kenai Peninsula College and sponsored by the University of Alaska Fairbanks. Dena'ina speakers were encouraged by the presence of interested and dedicated students, many of whom had long been eager to learn, but lacked a teacher who shared their enthusiasm. Over the following year, people traveled periodically to additional workshops to teach and learn from one another, as part of a U.S. Department of Education project. The number of Dena'ina learners at the 2004 summer institute grew from ten the previous year to 40.

Elders serve as language mentors for learners, even across some distances. Gladys Evanoff, a mentor, says that the process is going well for her. "[This work] is making [the language] come back for me. I kind of forgot, since I've been away from my Grandma for so long. I can understand everything, but learning to speak is more difficult. It's helping me to come back to where I started" (personal communication).

Occasional meetings throughout the year provide crucial contact between all those involved in language revitalization efforts. Some people also have continued to hold regular meetings by audio-conference. The Alaska Native Heritage Center is offering classes in Dena'ina. Additionally, those interested in learning Dena'ina can also subscribe to a Dena'ina "word-of-the-day" email list, or Jan Gu Dena'ina Qena.

New Initiatives

Complementing all of these efforts is a project at the University of Alaska Fairbanks that will create digital access to Dena'ina materials housed at the Alaska Native Language Center. The center maintains a comprehensive collection of nearly everything written in or about the Dena'ina language. This collection includes some of the first written materials, such as William Anderson's *(1784)* Dena'ina wordlist, collected on the 1778 Cook expedition; field notes from linguists who have worked with the language over the past 50 years; and more recent curriculum materials. In addition, the collection includes more than 200 audio recordings of stories, songs, and linguistic material.

The Dena'ina Archiving, Training, and Access (DATA) project will help to make all of these materials discoverable and accessible. The result will be a searchable archive of texts and recordings which can serve as an additional resource for those wishing to learn more about Dena'ina language and culture. Annual workshops will train community members in the use of the archive so that it can continue to expand as a dynamic resource well after the project is completed.

Additionally, in the previous year, the Alaska Native Heritage Center received a three-year grant from the Department of Education for Dena'aina Qenaga Qunuhdulzex ("the Dena'ina Language is coming back") and the Kenaitze Indian Tribe received significant funding from the Administration for Native Americans through the Department of Health and Human Services. Each of these programs will produce curricular materials for teaching Dena'ina language, and will archive existing Dena'ina materials.

Significance

In the midst of the Dena'ina Festival in June 2004, the group of Dena'ina from around Cook Inlet received word of the passing away of James "Diamond Jim" Wilson of Nondalton, an important elder who had contributed greatly to the teaching of Dena'ina language and culture. The news of his loss was particularly devastating and poignant at the festival and institute as younger generations struggled, day by day, syllable by syllable, to learn and teach Dena'ina. With the loss of each elder is the loss of all the knowledge of the language and culture he or she holds in memory.

When a language disappears, a way of viewing and thinking about the world goes with it. Poetry, puns, lullabies, and endearments are gone forever. The collective history, culture, and values of the Dena'ina people are embedded in the sounds, words, and grammatical structures of the Dena'ina language. English may function equally well as a system of communication, but it lacks the long-standing connection with the Dena'ina people.

Dena'ina language revitalization remains an achievable goal. Revitalization can take many forms, but in all cases it requires a strong commitment from within the community. And community efforts, like that among contemporary Dena'ina in southcentral Alaska may just be what it takes to bring back an almost lost language. Through ongoing collaborative efforts, institutions such as the National Park Service, the Alaska Native Language Center, and others can support this effort by providing access to research, documentation, and recordings of Dena'ina language. Communities can come to see archives as their own language reservoir, holding resources that can help to build and develop language and culture in creative and dynamic ways that will be sustainable in a rapidly changing world.

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Photograph courtesy of Maria Williams

Figure 1. Wales Kingikmiut Dancers.

To Dance is to Be: Heritage Preservation in the 21st Century

By Maria Williams

Alaska Native cultural practices continue to be a central force in virtually all villages throughout Alaska. In order to maintain cultural knowledge and ensure its survival, Alaska Native people need to learn the best methods of recording and archiving music, dance, and oral history. In 2003 and 2004, two Inupiaq communities, Wales and King Island *(see map on page 2)*, took leading roles in two major heritage preservation projects. Their experiences provide useful models for other communities that plan on embarking on their own heritage preservation endeavors. Both projects were funded in part by the Shared Beringian Heritage Program of the National Park Service, Alaska Region, which was established in 1991. The program focuses on research in the Bering Straits area, including support for exchanges between the United States and Russia. Alaska Native people have been dealing with outside pressures since the early eighteenth century, beginning with the Russian colonial presence and continuing when Alaska became an U.S. territory. Along with the expansion of Europeans and Americans into Alaska were accompanying hardships for the indigenous people: epidemic diseases, strong Christian missionary activities, and western educational policies such as English language-only rules. These resulted in decimated populations throughout the entire territory of Alaska, a decline in indigenous languages *(see article by Gaul, this issue)*,

At the festival, dancers of all ages were brought together. From left to right: Ernie Franksen of Tikigaq Traditional Dancers of Point Hope; members of the Wales Kingikmiut Dancers; a young dancer of the Tikigaq Traditional Dancers of Point Hope; and Autumn Ridely of the Anchorage Kingikmiut Dancers.

and in many cases the abolishment of traditional religion and associated music and dance repertoires.

Native people are deeply spiritual people; historically, they had a rich ceremonial life that was profoundly expressed through music and dance — core means by which people communicate their identities and beliefs. With the introduction of Christianity, traditional cultures, including aspects such as music and dance, were not viewed favorably by the missionaries. Sadly, most of the missionaries did not tolerate masked dancing and other forms of religious expressions. Dance, language, and ceremonial practices either had to be practiced in secret, or were lost.

In the 1960s, during the Native Solidarity Movement *(Williams 1997)*, as Alaska Native people became more politically active their re-identification with their cultures, languages, music and dance became a banner of their newfound political and social strength. One of the major outcomes of that movement has been a renaissance in traditional music and dance practices, resulting in multiple dance festivals and younger people becoming actively involved in their village dance groups.

The King Island IRA Council and the Native Village of Wales undertook documentation projects that focused on music and dance, which they view as a vital part of their cultural patrimony. Both projects were supported by the Shared Beringian Heritage Program in 2003 and 2004. These provide exceptional examples of how Alaska Native communities are using recording technology to document their cultural knowledge so that it will not be lost.

The Fifth Annual Kingikmiut Dance Festival

In 1999, the Native village of Wales resolved to sponsor an annual dance festival in June of each year. The concept for their festival was based on a historical practice in which multiple villages come together for trade and exchange. Previous to 1999, Wales had not hosted a dance festival in decades.

In June 2004 the village celebrated its Fifth Annual Kingikmiut Dance Festival *(Figure 1)*. Kingikmiut is the Inupiaq word for the village; it was named Wales after Captain Cook's voyage in 1778. For the 2004 festival, Wales IRA Council members Luther Komonaseak and Wenton Weyapuk, Jr. were inspired to re-establish ties with their Siberian neighbors. Wales is only 54 miles from Siberia and in the past, until the Cold War began in 1948, exchange between the Inupiaq peoples of Alaska and eastern Russia was very common. The gatherings that accompanied such exchanges always included song and dance. The Fifth Annual Kingikmiut Dance Festival featured a large Russian dance group *(Figure 2)*, as well as

Photographs courtesy of Gregory Gusse

Photograph courtesy of Gregory Gusse

Figure 2. Special guests at the 5th Annual Kingikmiut Dance Festival included a Russian dance group. This is a dance that originates in the Chukchi area.

the Tikigaq Traditional Dancers of Point Hope *(Figure 3)*, and dance groups from Brevig Mission and other villages on the Seward Peninsula.

The Shared Beringian Heritage Program sponsored the Siberian exchange and provided funds for the village of Wales to hire a professional videographer and recording engineer to document the festival. This is one of the few examples in which an Alaska Native village controlled and in essence owned the documentation of such an event. The organizers produced 18 DVDs of the complete three-day festival in addition to a 28-minute documentary film. The Native Village of Wales will archive the materials, use the documentary for educational purposes, and market it to generate income that could support the documentation of the next festival. The video, entitled *Nilgaq: 5th Annual Kingikmiut Dance Festival June 25-27, 2004,* was completed in October of 2004. It features highlights of the dance festival in addition to interviews with many of the dance groups and captures the heart of why the annual dance festival has become so important.

Kingikmiut, or Wales, was once known as the dance capital of the Seward Peninsula. Captain Henry Trollope visited Wales in 1853-54 and wrote… *the place is sort of a capital in these parts and has four dancing houses, which is a very expressive manner of estimating the extent and population for a place (Ray 1975).* Because of its strategic location, Kingikmiut flourished. Before the 1900 and 1917 epidemics, it consisted of two related villages and consolidated into one village once the populations had been decimated by disease. After these terrible epidemics, Christian missionary policies along with western educators' English-only policies, forced music, dance, and other expressions of traditional Native culture to go underground.

Repression of Native culture by western educators and missionaries was common all over Alaska and is a major reason why many Alaska Native languages are threatened today. In the first part of the twentieth century, traditional dance and music became associated with the old ways and were looked down upon. After the 1960s, a strong revitalization movement arose. Today there is a renaissance in traditional music and dance practices. In Wales and other Seward Peninsula communities, the younger people, who make up a large percentage of the population, have a great thirst for learning to sing and dance their traditional songs. There is even a group in Anchorage called the Anchorage Kingikmiut Dancers, which was formed by Wales people and their descendants now living in Anchorage. Wales descendants Gregory Nothstine and Roy Roberts learned songs from their elders and reconstituted their cultural patrimony. One of the outstanding features of the Kingikmiut Dance Festival is that it features so many young dance groups *(Figure 4)*. The Kingikmiut Dance Group of Wales, the Anchorage Kingikmiut Dancers, the Brevig Mission Dancers, and the Shishmaref Dance Group are all made up mainly of junior high and high school students. Young composers like Roy Roberts are beginning to write new songs, and it is

Photograph courtesy of Gregory Gusse

Figure 3. The Tikigaq Traditional Dance Group of Point Hope, Alaska are joined by two dancers from the Wales Kingikmiut Dancers at the 5th Annual Kingikmiut Dance Festival in June 2004.

Photograph courtesy of Maria Williams

Figure 4. Young Drummers with the Wales Kingikmiut Dance Group.

exciting to see their vitality and energy at these festivals.

The Kingikmiut Dance Festival is a symbol of survival. It is a beautiful illustration of the strength that is found in indigenous peoples. The festival encourages them to express who they are as their ancestors have done for thousands of years: To dance is to be.

King Island Heritage Preservation Project

Another heritage preservation project, partially funded by the Shared Beringian Heritage Program, was undertaken by the King Island IRA Council. Like the Wales project it also focuses on music and dance.

The King Island people have undertaken a monumental task: to document their entire music and dance repertoire. In the years since they moved from their home on King Island to Nome and elsewhere in the 1960s, the former residents of the village have maintained a large repertoire of songs and dances, including masked dances and ceremonials, such as the Wolf Dance and Polar Bear songs. King Island elder Ted Mayac, Sr., along with Gabriel Muktoyuk, Chief of King Island, worked with the author for two years to record their music and dance repertoires along with information on cultural context *(Figure 5)*. In addition to the songs and dances, the documentation includes interviews with King Island elders Catherine Kasgnoc, Edward Muktoyuk, Helen Pushruk, and Leo Kunnuk. Some of the interviews were with people from Little Diomede and Russia. Historically, King Island people traded, married, and sometimes went to war with people in these Bering Straits communities *(Figure 6)*. Music and dance were often traded or gifted among all these indigenous groups. King Island is a small island off the coast of the Seward Peninsula. In the early twentieth century, it was isolated for months at a time by the winter ice pack, thus shielding the community from some of the epidemic diseases that swept most other Alaska Native villages. Their first missionary, arriving in the 1920s, was a Jesuit Priest named Father LaFortune. He believed in bilingual education and allowed traditional dancing to continue. Because the King Island people were able to continue to openly speak their language and celebrate their songs and dances, their repertoire remained quite large. After the forced relocation of the village to the mainland in the 1960s, the effects of being removed from their protective homeland became apparent. The younger generations began losing some of the traditional knowledge, especially in the areas of language and winter hunting skills *(Kasgnoc 2000)*.

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Photograph courtesy of Maria Williams

Figure 5. Ted Mayac, Sr. and Gabriel Muktoyuk in Nome, Alaska in June 2004 during one of the recording sessions.

Photograph courtesy of Maria Williams

Figure 6. View from Wales, of Little Diomede with Siberia to the right.

King Island culture bearers such as Paul Tiulana—who noted that with the passing of each elder a large amount of history, songs, dances, and other important cultural knowledge were being lost—began recording cultural and historic information about King Island in the 1980s and 1990s in order to conserve their knowledge *(Tiulana 1987)*. In 2000, Ted Mayac, Sr. and Sylvester Ayek continued this work in a sound repatriation project involving the recordings of Father Bernard Hubbard. In 1936 Father Hubbard came to King Island with recording engineer Ed Levin. Although there to deliver and install a large statue of Jesus Christ on top of King Island, they also filmed 27 hours of footage and taped over seven hours of sound recordings. The film footage had been repatriated to the King Islanders in the early 1990s, but the sound recordings remained elusive. The author, working with the Smithsonian National Studies Human Film Archive, received funding from the Ford Foundation and the

Photographs courtesy of Gregory Gusse

The Kingikmiut Dance Festival is a symbol of survival. It is a beautiful illustration of the strength found in Alaska Native culture.

Alaska Humanities Forum to obtain copies of the sound recordings and organize a gathering in Nome in 2000. Elders listened to the recordings and were able to identify the songs, composers, and speakers. This inspired Ted Mayac, Sr. to begin planning a larger project to record the surviving repertoire of the King Islanders so that no more songs nor dances would be lost *(Figure 7)*.

The final outcome will be a large collection of compact disk and video recordings that will be indexed and archived in Nome at the King Island IRA Council offices. This project will insure that King Island music, dance, and other cultural knowledge will be maintained for the younger generations, who will be able to learn their songs along with the associated history and cultural contextual significance of their repertoire.

The Significance of Historic Preservation Projects

For all indigenous people, music and dance are unique expressions of who they are. Their songs include origin stories, famous events in the village history, encounters in their daily subsistence lifestyles, and social commentary. Each village has its own unique style, and as generations pass, the repertoires have been shrinking. With the advent of desktop computers and digital cameras, documentation and recording can now be done by semi-professionals. The huge costs of filmmaking have been significantly reduced. With younger people's familiarity and ease with computer technology, these processes can now be undertaken by community members, even high school students.

Local control of information is important. The two examples cited in this article are significant because the village councils managed these projects and will maintain the archival information. These two projects are based on a different model from the usual scenario of an anthropologist who comes to a village, learns some basic information, and then returns to an urban or university setting where s/he develops theories based on what was collected. Indigenous people have not always received copies of the material, recordings, or articles, produced in such research, thus diminishing anthropologists' reputations in Native communities.

These two projects did work with a qualified academic person – myself, an ethnomusicologist. However, my role was to facilitate the projects, find the funding, provide professional expertise, and basically stay out of the way. The indigenous scholars in these two projects led the discussions and interviews, guided the videography, and were clear about what the final outcomes would be. Indigenous scholars such as Wenton Weyapuk, Jr. of Wales and Ted Mayac, Sr. of King Island, who are knowledgeable and fluent in their own languages as well as English, created a rewarding research environment because they translated for outsiders and Natives who did not speak Inupiaq. They were able to explain the meaning of song texts, or tell of the importance of certain genres. They also had knowledge of their own village's history and the ties with other Bering Straits communities on both the American and the Russian side.

Photograph courtesy of Maria Williams

Figure 7. Earl Mayac and Ted Mayac, Sr. reviewing notes for the King Island Heritage Project, March 2004.

Alaska is home to a diverse and large indigenous population and each village has its own unique style of dance and music. The repertoire is reflective of a place in its geographic environment and spiritual place. This "insider" information is understood by members of a village community but often remains hidden to an "outsider" who is not a member of the culture. Pairing knowledgeable elders and indigenous scholars with academic researchers establishes a more effective context for research,

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one that puts the control in the hands of the Native villages. Cultural knowledge needs to be maintained at the village level. These two projects have been successful because of the researchers' sensitivity and the National Park Service's awareness that this new way to conduct research could have a positive outcome for all involved.

One of the rewards of the two projects described above was learning about the importance of music and dance repertoires in the history of both communities. For example, the King Island people feel that their Polar Bear songs, especially composed for successful hunters who killed a polar bear, are their most sacred repertoire. I learned that the polar bear is a highly respected and almost revered being for King Island people. There are special terms for polar bears, and when one is hunted the whole village gathers. The special event includes newly composed songs that tell the story of the hunt, the hunter, and the bear. As part of his obligations, the hunter must host a large gathering and feed everybody. Because these songs are historical time-markers for the King Island people, retaining them is vitally important.

As indigenous communities across Alaska find ways to maintain their unique identities and histories, documenting their culture practices is important. How they are documented by audio or video recording, what type of information is recorded, and who will have access must be acknowledged and defined. Hopefully these two projects will provide useful models for future endeavors. This was a remarkable experience with which to be associated and an honor to work and learn from our Native elders and culture bearers.

To learn more about the Shared Beringian Heritage Program and these two projects visit **http://www.nps.gov/akso/beringia.**

The Road to Ethnomusicology

Maria Williams (Tlingit) was born and raised in Anchorage, Alaska. Growing up there, she was exposed to many different kinds of music, partially because Anchorage is home to many different Alaska Native music and dance groups. She studied music in public school and played in the orchestra as well. Williams earned a Bachelor of Arts degree in Music from Dominican College of San Rafael and also played with Anchorage Symphony Orchestra for a few seasons.

Williams decided to study ethnomusicology when she learned about the program at University of California - Los Angeles (UCLA). She received an M.A. and Ph.D in Music, specializing in Ethnomusicology from UCLA and loved it. "I feel that ethnomusicology is very interdisciplinary and combines anthropology, music, and culture studies as a way to understand how music is placed within different societies," Williams said.

Currently, Williams teaches ethnomusicology courses at the University of New Mexico. These include Native American Music, Alaska Native Music and Culture, and Indigenous World Music. She feels that, "ethnomusicology opens a window to understanding other cultures, and music is such a wonderful vehicle to learning about other people."

Williams, an Alaska Native, said the best preparation for this career was already having an understanding of the indigenous world. "Of course, my academic background in western classical art music also helped because it is a rigorous pedagogy," added Williams. Ethnomusicology is looking at or trying to understand music within its cultural context. It is not limited to non-western music.

Maria Williams

Ethnomusicology is a wonderful area because there are many beautiful music traditions in the world. "We live in a rich human soundscape and we should celebrate our diversity as human beings. If anyone is interested in pursuing ethnomusicology I would recommend that they get well-trained in one or more music traditions—even western classical art music offers a great background," said Williams. Having a good understanding of one music tradition or method does make it easier to study or learn about another, she added.

Photographs courtesy of Gregory Gusse


NORTHWEST ARCTIC
Kivalina
Cape Krusenstern
ALASKA
Anchorage
Noatak
Noatak National Preserve
Imik Lagoon
Kotlik Lagoon
Cape Krusenstern National Monument
Chukchi Sea
Krusenstern Lagoon
Kotzebue Sound
Akulaaq Lagoon
Sisualik Lagoon
N

Cape Krusenstern National Monument: Year-Round Sampling to Characterize Water Quality, Species Richness, and Food Web Structure in Five Coastal Lagoons

By Melinda Reynolds, Terry Reynolds, Charlie Lean, and Lisa Clough

Photograph courtesy of Terry Reynolds

Figure 2. Cyrus Harris eating the eggs out of a freshly caught whitefish. A delicacy eaten as a quick energy snack.

Figure 1. (Left) Lagoon locations within Cape Krusenstern National Monument.

Monitoring changes in the resources of an ecosystem is a way to determine the health of that ecosystem, but prior to monitoring, baseline data must be collected. For the previous two years, researchers have been working to establish baseline data for the lagoons in Cape Krusenstern National Monument (CAKR), one of the four park units of Western Arctic National Parklands (WEAR). The monument is located about 16 miles (25 km) northwest of Kotzebue, Alaska *(Figure 1)*. It contains five coastal lagoons (Akulaaq, Imik, Kotlik, Krusenstern, and Sisualik) that are likely to be essential fish nurseries, over-wintering habitats, major feeding locations along coastal bird migration routes, and are currently important resources for subsistence fishing and hunting.

One of the primary reasons the monument was established was to preserve and protect the continuing relationship between people, the land, and its resources *(Figure 2)*. During freeze-up in the fall many people "catch their winter's supply of whitefish at the outlets of the lagoons near Cape Krusenstern" *(Georgette and Loon 1993)*. These whitefish are caught with nets or by digging trenches near the outlet of the Tukrok River *(Figure 3a-b)*. Krusenstern Lagoon along with the sloughs and river are "…the major source of frozen winter whitefish for the residents of Kotzebue and Sisualik" *(Uhl and Uhl 1977)*.

In this tradition-rich past, sustainable harvesting of foods from the lagoons was well balanced by the remoteness of the area and self management of the resources. Today, improved access to boats and other transportation has increased the use of the area by non-traditional families. This is causing concern about the sustainability of the resources among both resource managers and local families. Establishing baseline data is not only important as a means to gain park-specific information, but is also essential for fostering synergistic management of lagoon resources that have traditionally been a major part of local subsistence practices.

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Objectives

The overall objective of this project is to compare different lagoon systems over an annual cycle. We know the lagoons vary in their exchange with the waters of Kotzebue Sound. Sisualik is open to the Kotzebue Sound year round, Akulaaq, Imik, and Kotlik are intermittently open to either the Kotzebue Sound (Akulaaq) or the Chukchi Sea (Imik and Kotlik), and Krusenstern lagoon is closed to Kotzebue Sound. These classifications are based on traditional knowledge and informal observations made

Photograph courtesy of Melinda Reynolds

Figure 3a. Sam Williams digs a fish harvesting trench at the closed mouth of the Tukrok River in September 2003. Trenches are dug where the river naturally opens to the Kotzebue Sound in the springtime as a result of ice break-up.

by the local community and NPS personnel. Also of note is the observation that even if water exchange is limited, strong westerly storms can push seawater into all the lagoons. We want to understand the impacts of the different water exchange types on: 1) water quality parameters (dissolved oxygen, salinity, depth, temperature, and chlorophyll); 2) species richness (the number of species in a habitat); and 3) food web structure throughout the course of the year.

Sampling took place four times each year: January, April, July, and September for two years. Within each annual cycle we had two ice-covered and two open water sampling periods. The logistics of sampling were quite challenging, with winter collections straining our technological limits. Sub-zero days with gusty winds brought wind-chills near -30°F (-34°C) where equipment was difficult to operate. Even during the summers, prevailing westerly storms created 3 foot (0.9 m) waves within Krusenstern Lagoon, making small boat sampling unsafe (not to mention the logistics of getting a larger river boat into a lagoon that is closed off from the surrounding estuary). Accessing Imik and Kotlik lagoons proved to be quite challenging via float plane and snowmobile so they were sampled on an opportunistic basis. We focused our attention on Akulaaq, Krusenstern, and Sisualik.

We made sure to visit different locations within each lagoon, and the number of sites varied with the size of the lagoon. Our sampling scheme was similar to the one followed in the Blaylock and Houghton (1983) lagoon study. The sampling locations were placed in four general areas: (a) near creek/river inlets and outlets, (b) in the center of the lagoon, (c) along the shoreline-side of the lagoon, and (d) near any known anomalies (e.g., springs).

Objective 1: To determine water quality parameters

At each sampling station, dissolved oxygen, water temperature, depth, and salinity were measured *(Figure 4)*. Water samples were collected and filtered so that chlorophyll-a content could be determined. During the ice-covered sampling periods, 3.3 x 3.3 feet (1 x 1 m) holes were augered a day prior to sample collection to minimize disturbance of the water column from drilling.

A preliminary analysis of the data collected in 2003 shows that all five lagoons have super-cooled water in January *(Figure 5)*. These below-zero water temperatures can be explained by the inverse relationship between salinity and water temperature. That is, the higher the salinity, the lower the freezing point. Akulaaq has the lowest water temperature and the highest salinity, and Krusenstern has the highest water temperature and the lowest salinity *(Figure 6)*. This salinity-temperature relationship may keep the lagoons from freezing to the bottom and ultimately provide an environment in which salt tolerant species can over-winter.

Akulaaq Lagoon appears to have the most unstable environment. It has the greatest range in salinity and dissolved oxygen levels throughout the year *(Figure 7)*. Krusenstern Lagoon appears to have the most stable environment. Salinity levels were fairly constant year-round and dissolved oxygen never fell to a species-limiting level.

A preliminary look at the chlorophyll-a data for January 2003 shows that Akulaaq, Krusenstern, and Sisualik all have measurable chlorophyll, despite the fact that the sun never fully comes above the horizon at this time of year. The April 2003 data show

Photograph courtesy of Cyrus Harris

Figure 3b. Joanne Sheldon stands near the trench she and Cyrus Harris dug at the closed mouth of the Tukrok River in October 2004. Whitefish follow the current created by the trench and get trapped at the end of the trench making for easy catch. A north wind and low tide are the ideal conditions for catching lots of fish.

marked increases in chlorophyll concentration, indicating that the spring bloom in the lagoons takes place well prior to the period of ice melt. We are in the process of investigating the relationship between chlorophyll concentration and ice thickness and snow cover during the spring period.

Objective 2: To determine species richness

Krusenstern and Sisualik are the two lagoons most utilized for subsistence. While certain species are consistently found in the lagoons (e.g. whitefish in Krusenstern), a complete biological inventory has never been done. We expect to be able to use the biological inventory to determine which processes are important to the major subsistence fisheries.

At each sampling station, we collected phytoplankton and zooplankton (microscopic, free-floating algae and animals, respectively), and benthic (bottom) samples. Epibenthic (species living on the bottom) and pelagic (species swimming in the water column) species were collected with nets and/or traps placed in various locations in each lagoon *(Figure 8a and 8b)*. Phytoplankton and zooplankton samples were preserved and will be analyzed at a later date. A partial list of benthic, epibenthic, and pelagic species currently identified can be seen in Table 1. This list includes only those macro species collected during 2003. Data for 2004 are still being compiled. Krusenstern and Sisualik have the greatest species richness and Akulaaq has the lowest number of species. The data imply that lagoons that are closed (Krusenstern) and open (Sisualik) to the Kotzebue Sound have the greatest species richness and lagoons that are intermittently open (Akulaaq, Imik, and Kotlik) have the lowest species richness.

Objective 3: To determine food web structure

To our knowledge, no one has assembled a food web for the lagoons of Cape Krusenstern National Monument. Knowing more about food habits of species in these lagoons will allow for better management and/or monitoring of the utilized species.

We are using stable isotope analysis along with gut content analysis to determine food web structure. Carbon isotope ratios will give insight as to the source of carbon in the lagoons and nitrogen isotope ratios will help determine trophic levels

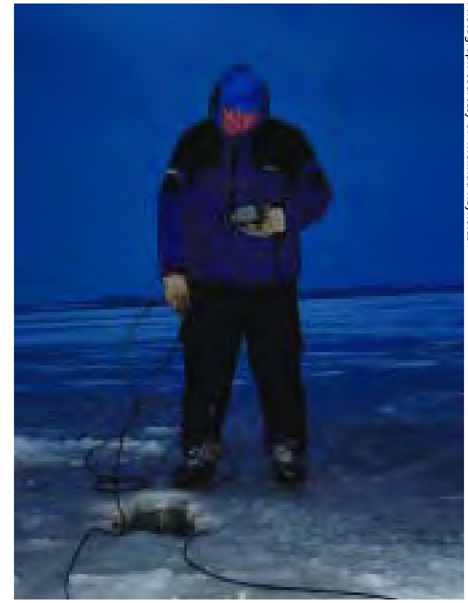

Figure 4. Charlie Lean using a YSI meter to collect water quality data in Krusenstern Lagoon in January 2003.

Photograph courtesy of Melinda Reynolds

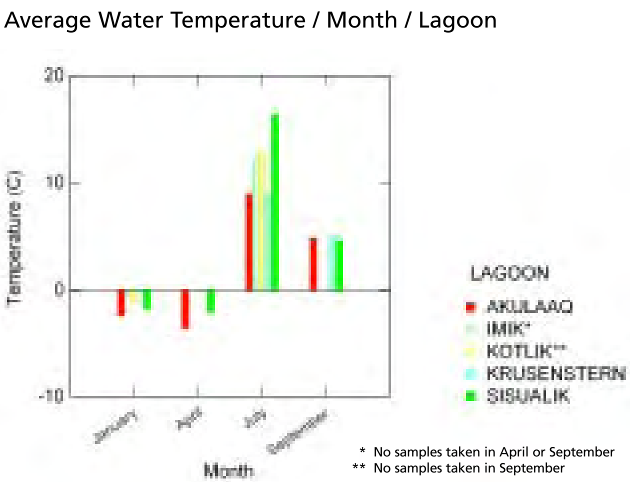

Figure 5. Average water column temperatures for the five lagoons in January, April, July, and September of 2003. Data were collected with a YSI meter and a Hydrolab Minisonde.

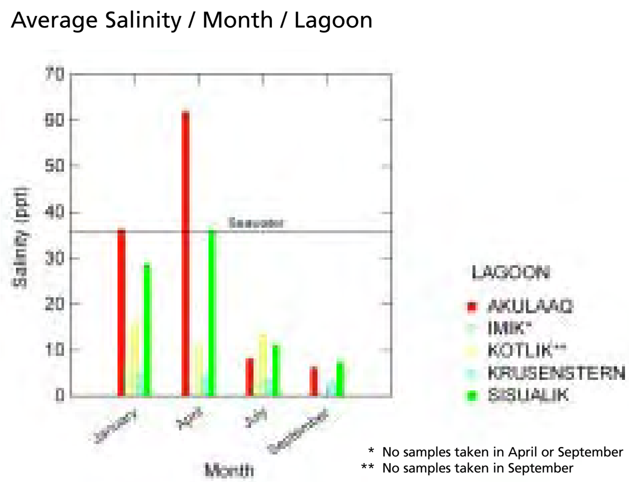

Figure 6. Average salinity for the five lagoons in January, April, July, and September of 2003. Data were collected with a YSI meter and a Hydrolab Minisonde.

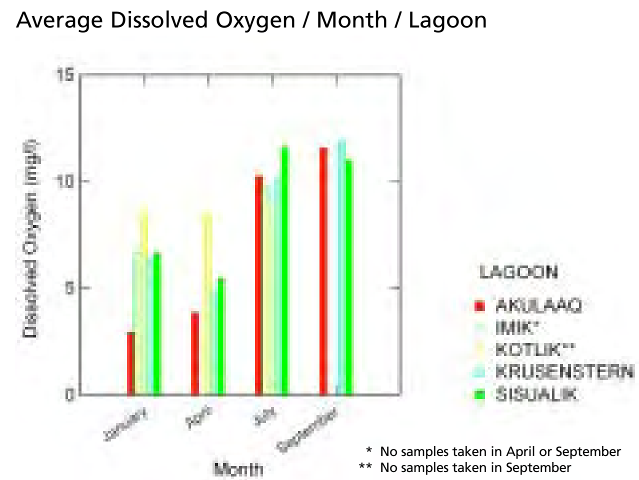

Figure 7. Average dissolved oxygen for the five lagoons in January, April, July, and September of 2003. Data were collected with a YSI meter and a Hydrolab Minisonde.

AKULAAQ		IMIK		KOTLIK		KRUSENSTERN		SISUALIK	
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**	**Scientific Name**	**Common Name**	**Scientific Name**	**Common Name**	**Scientific Name**	**Common Name**
Crangon sp.	Shrimp	*Macoma sp.*	Clam	*Clupea pallasii*	Pacific Herring	*Coregonus laurettae*	Bering Cisco	*Clupea pallasii*	Pacific Herring
Dallia pectoralis	Alaska Blackfish		Chironomid	*Coregonus pidschian*	Humpback Whitefish	*Coregonus pidschian*	Humpback Whitefish	*Coregonus laurettae*	Bering Cisco
Lepidopsetta sp.	Sole		Isopod	*Coregonus sp.*	Cisco	*Coregonus sardinella*	Least Cisco	*Coregonus pidschian*	Humpback Whitefish
Macoma sp.	Clam			*Macoma sp.*	Clam	*Gasterosteus aculeatus*	Threespine Stickleback	*Coregonus sardinella*	Least Cisco
Myoxocephalus quadricornis	Fourhorn Sculpin			*Myoxocephalus quadricornis*	Fourhorn Sculpin	*Macoma sp.*	Clam	*Crangon sp.*	Shrimp
	Isopod			*Mytilus sp.*	Mussel	*Platichthys stellatus*	Starry Flounder	*Eleginus gracilis*	Saffron Cod
	Polychaete			*Salvelinus malma*	Dolly Varden	*Pungitius pungitius*	Ninespine Stickleback	*Gasterosteus aculeatus*	Threespine Stickleback
				Juvenile Salvelinus sp.	Trout	*Stenodus leucichthys*	Sheefish	*Limanda aspera*	Yellowfin Sole
						Thymallus arcticus	Arctic Grayling	*Macoma sp.*	Clam
							Smelt	*Myoxocephalus quadricornis*	Four Horn Sculpin
							Amphipods	*Oncorhynchus keta*	Chum Salmon
							Chironomid	*Platichthys stellatus*	Starry Flounder
							Mysid shrimp	*Pungitius pungitius*	Ninespine Stickleback
							Polychaetes	*Stenodus leucichthys*	Sheefish
									Smelt
									Amphipods
									Chironomid
									Mysid shrimp
									Polychaete

Table 1. Benthic, epibenthic, and pelagic species collected during the four sampling periods in 2003. Species were collected with a ponar grab, nets, and/or traps.

(Michener and Schell 1994). Basically, the carbon isotope ratios will tell us what the various species are eating and the nitrogen isotope ratios will tell us how energy is being transferred within the system (i.e. producer, herbivore, carnivore, etc.). Sampling involved collecting small pieces of muscle tissue from each of the different species caught in the various nets and/or traps. Whole organisms were submitted for analysis if they were too small for muscle tissue sampling. Isotope samples are currently being analyzed.

Conclusion

This research is providing baseline information on many of the basic components necessary for subsequent monitoring of an ecosystem. Comparing the various lagoon systems, monitoring water quality and species richness, and understanding food web structure will provide valuable tools in understanding arctic lagoon systems. Based on the preliminary data presented here, Krusenstern and Sisualik lagoons provide stable environments in which many different species can thrive, while Akulaaq Lagoon is an unstable and often harsh environment that only few species can inhabit. Analysis of the 2004 data will provide inter-annual comparison of these lagoon systems. Now that the baseline data has been collected, these important, locally utilized resources can be monitored for changes throughout time.

Acknowledgments

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Photograph courtesy of Melinda Reynolds

Figure 8a. Terry Reynolds and Charlie Lean deploying a beach seine in Krusenstern Lagoon in September 2003.

Figure 8b. (Right) Vickie McMillan preparing to set minnow traps in Akulaaq Lagoon in January 2003.

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Photograph courtesy of Terry Reynolds

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Photograph courtesy of Gregory Gusse

Colette Topkok of the Anchorage Kingikmiut Dancers performs in the yearly festival held in Wales.