
N O R T H W E S T
A R C T I C
Cape
Krusenstern
ALASKA
Anchorage
Kivalina
Noatak
Noatak National
Preserve
N
Imik
Lagoon
Kotlik
Lagoon
Cape Krusenstern
National Monument
C h u k c h i S e a
Krusenstern
Lagoon
Tukrok
River
K o t z e b u e
S o u n d
Akulaaq
Lagoon
Sisualik
Lagoon

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.

Even during the summers, prevailing westerly storms created 3 foot (0.9 m) waves within Krusenstern Lagoon, making small boat sampling unsafe

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

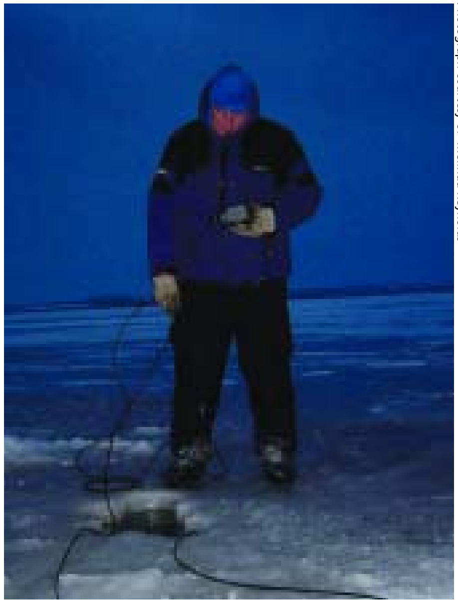
Krusenstern and Sisualik are the two lagoons most utilized for subsistence. While certain species are consistently found in the lagoons (e.g. whitefish in Krusenstern), a complete biological inventory has never been done. We expect to be able to use the biological inventory to determine which processes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



Photograph courtesy of Melinda Reynolds

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

Average Water Temperature / Month / Lagoon

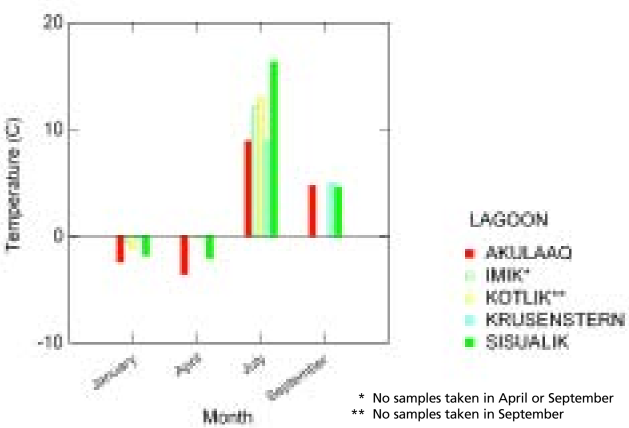


Figure 5. Average water column temperatures for the five lagoons in January, April, July, and September of 2003. Data were collected with a YSI meter and a Hydrolab Minisonde.

Average Salinity / Month / Lagoon

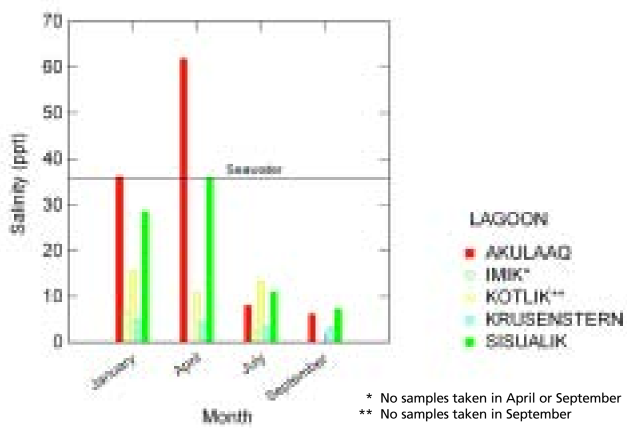


Figure 6. Average salinity for the five lagoons in January, April, July, and September of 2003. Data were collected with a YSI meter and a Hydrolab Minisonde.

Average Dissolved Oxygen / Month / Lagoon

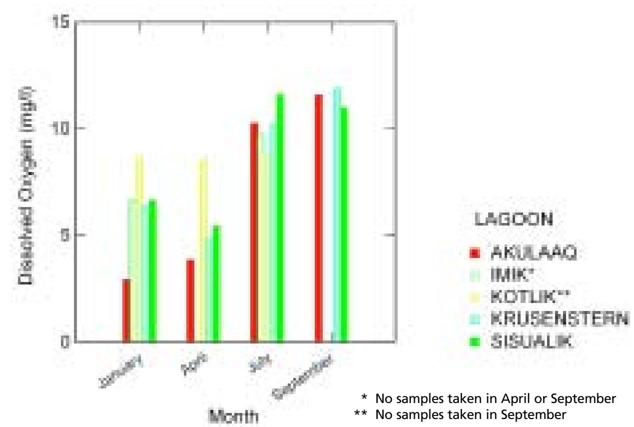


Figure 7. Average dissolved oxygen for the five lagoons in January, April, July, and September of 2003. Data were collected with a YSI meter and a Hydrolab Minisonde.

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.

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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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