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Historical Fisheries Work Conducted in the Arctic Network Parklands:

A Literature Review

Natural Resource Report



ON THE COVER

Seward Peninsula Arctic grayling, *Thymallus arcticus*
Photograph by: F. DeCicco

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A Literature Review

Natural Resource Report

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Preface

The National Park Service's (NPS) primary mission is to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations. Prior to the turn of the 21st century, the Service lacked significant information on the current condition of many of its park resources. This is compounded by the increase of park use by the general public, and the changes that this increased use may have on the resources.

To address this general lack of information about park resources, Congress passed the National Parks Omnibus Management Act in 1998, which mandated the establishment of NPS inventory and monitoring programs to establish baseline and long-term trend information for National Park System resources. This was accomplished through increased funding to the Service-wide Inventory and Monitoring (I&M) Program of the National Park Service. The I&M program is currently coordinating systematic efforts to conduct biological inventories documenting the occurrence, distribution, and relative abundance of vertebrate (mammals, fish, birds, and amphibians) and vascular plant species in the parks.

The basic management goal of the I&M biological inventory program is to provide park managers with comprehensive, scientifically based information about the status of selected biological resources occurring within park boundaries; this information will be used for making management decisions, conducting scientific research, and educating the public. The inventories will also lay the groundwork necessary for park staff to develop effective monitoring programs and management strategies for biological resources in park units.

Introduction

The Arctic Network (ARCN) consists of five Park units in Northwestern Alaska including Bering Land Bridge National Preserve, Cape Krusenstern National Monument, Gates of the Arctic National Park and Preserve, Kobuk Valley National Park, and Noatak National Preserve. The Arctic Network selected fish as an important vital sign to monitor within the Park units during a freshwater scoping workshop (Lawler et al, 2009). Fish were selected for several key reasons. Salmon, charr, grayling, and whitefish species are used by peoples residing in and around the Arctic parklands as a main food source. Fish are a vital link in the food web of many of the other organisms in the park units, and in many lake and stream ecosystems they are the top predators. Fish have also shown a marked susceptibility to global climate change, which is considered a significant threat to arctic ecosystems worldwide (McDonald et al. 1996, Schindler 1998). The scoping process revealed that little information existed on the fish resources in the Arctic Network Parks at this time. The goal of this project was to amass all known fisheries related research, acquire the data, and summarize the results.

The NPS I&M program has a stringent set of guidelines and accomplishments that must occur during the development of the long term monitoring program. One of the preliminary steps required of all park networks involved in this program is the completion of a thorough review of the existing literature. The purpose of this review is to provide baseline data and critical background information on each park to facilitate the selection of key vital signs. The Arctic Network initiated a detailed data mining effort in 2000. This effort was spearheaded by ABR Inc. and the Alaska Natural Heritage Program. This effort uncovered over 5000 documents, the quality of which was relatively unknown. After reviewing this set of literature the Arctic Network staff decided to evaluate the data and compile all data, specifically related to fish, thought to be of high quality.

The data mining efforts demonstrated that research completed to date within the network parklands was patchy in nature. Few publications were available digitally and there had been no effort to compile the data into a single location where they could easily be queried. As such the Arctic Network staff was unable to capitalize on the important work that had been done in the network Parks. To facilitate use of these data all fisheries information was compiled into a single database that would be available for use by all NPS staff.

This report summarizes the fisheries related data the Arctic Network compiled during the data mining effort required by the National Parks Omnibus Management Act¹. This report will be used to help identify data gaps for fisheries research in these parks and help guide the inventory and monitoring of this resource within the Arctic Network Parklands.

¹ Public Law 105–391, Title II, Sections 201–207.

Objectives

The purpose of this work was to identify and evaluate the fisheries research that had been conducted within the Arctic Network Parklands and to summarize data in such a way as to facilitate the identification of critical monitoring needs related to fish. To accomplish this goal we identified four specific objectives:

- Produce an annotated bibliography of fisheries research conducted within the Arctic Network Parklands
- Identify pertinent high-quality data
- Catalog these data into a spatial database
- Summarize existing data by Park unit.

Methods

Description of Study Area

The Arctic Network Parklands are comprised of 5 park units, Bering Land Bridge National Preserve (BELA), Cape Krusenstern National Monument (CAKR), Gates of the Arctic National Park and Preserve (GAAR), Kobuk Valley National Park (KOVA), and Noatak National Preserve (NOAT) (Figure 1). Collectively these units represent approximately 25% of the land area of NPS managed units. GAAR, KOVA, and NOAT are contiguous and encompass a large expanse of mostly mountainous arctic ecosystems at the northern limit of tree line. CAKR lies approximately 20 km to the southwest of NOAT, and due south of that lays BELA. CAKR and BELA border Kotzebue Sound and lie on the Beringian subcontinent --the former land bridge between North America and Asia.

Much of the Arctic Network is designated wilderness or proposed wilderness so access is limited to foot travel, non-motorized boats and fixed wing aircraft. No roadways are found within any of the Arctic Network Parklands, and only limited road access is available to Gates of the Arctic National Park and Preserve and Bering Land Bridge National Preserve.

All of the NPS units within the Arctic Network are relatively recent additions to the National Park System. Portions of Bering Land Bridge National Preserve, Cape Krusenstern National Monument, and Gates of the Arctic National Park and Preserve were initially created by presidential proclamation in 1978. All 5 units were re-designated or created with their present boundaries by the Alaska National Interest Lands Conservation Act² (ANILCA) in 1980. The recent origin of these remote and difficult-to-access units, coupled with limited natural-resource staffing levels, has left the natural resources in these units relatively unstudied.

² Pubic Law 96-487, 94 Stat. 2371 (1980) (codified as amended at 16 U.S.C. 3101-3233 (1994))



Figure 1. Arctic Network Parks with inset of National Parklands in Alaska.

Literature Review

The initial data mining effort for the Arctic Network parklands was conducted between 2000 and 2004 when two research firms, ABR Inc. and the Alaska Natural Heritage Program, were contracted separately to compile bibliographies of all literature relevant to the Arctic Network Parklands. These data were entered into Naturebib (<http://www.nature.nps.gov/nrbib>), the NPS database designed to track park generated literature. These data served as the basis for our literature review. However, as two separate entities had entered data into Naturebib there were an inordinately high number of duplicate references. Furthermore, much of the work contained within Naturebib was not conducted within the boundaries of the Arctic Network Parklands, and, as such, many entries had to be removed. After consolidation, all literature was assigned a primary and secondary category that allowed us to characterize each study and split the literature into useable groups. These data were then transferred to a ProCite[®] database, attributed with the primary and secondary categories, and assigned pertinent keywords that allowed for detailed literature searches by either category or keyword.

Our next step was to categorize papers by quality of studies. To determine quality we distributed the list of fisheries references to biologists and managers from the U.S. Fish & Wildlife Service, U.S. Bureau of Land Management, and the Alaska Department of Fish and Game, all of which had conducted research in this region. These individuals were asked to identify significant works from the lists, and also any relevant studies that were missing. Responses were used to generate the final list of references categorized by quality.

After the sentinel works were identified, copies of each report and associated datasets (when available) were obtained. These data provided information including date, location, species, numbers captured, methods of capture, catch per unit effort, and ancillary data such as water quality and bathymetry. When species and location were

available this information was entered into the NPS managed version of the Alaska Department of Fish and Game's geospatial database, allowing for queries by species, age class, habitat, location and a variety of other attributes.

These datasets were also used to generate lists of species found or expected in the Arctic Network park units. Data about species located adjacent to, but not within, NPS lands were used to generate expected species for the lists. The biologists and managers that assisted with sentinel work identification were contacted to review these lists. This process provided us with expert reviewed species lists, and a better idea of which species to expect within the parks.

A GIS theme was created using ESRI ArcGIS®, containing study site locations and species presence information based on the data acquired from the review. This theme allowed for clear spatial representation of where prior works had been conducted as well as areas of major knowledge gaps. This theme also allowed us to create clear maps of the past fisheries work conducted in each Park unit.

Results

This section displays data regarding fish species and habitat information collected in the Arctic Network Parklands review. Organization of this section is by Park unit, and each unit contains a GIS generated map with study site locations. Study sites have been color coded by habitat on the maps for ease of interpretation: red dots represent lakes; purple dots represent rivers; and green dots represent lagoons. Major rivers and lakes larger than 20 acres in area have been added to provide major landmarks for ease of orientation.

The information provided here represents a suite of data that may serve as important baseline data for long term monitoring. Collecting baseline information is essential particularly in light of predicted climate change that may significantly alter fish populations and distributions. These data may also help to also highlight taxa not traditionally found in these locations. Rough distribution descriptions of fish in each Park unit are described herein to help promote for future study.

Arctic Network Overview

We found remarkably few studies about the distribution and abundance of fish in the Arctic Network Parks. Only 75 sites have been visited in an area that encompasses over 7.7 million hectares. The vast majority (47%) of research was conducted within Gates of the Arctic National Park and Preserve and (24%) the Noatak National Preserve (Figure 2). According to our database a combined total of only 19 sites were studied in BELA, CAKR and KOVA.

In general, fisheries studies in the Arctic Network focused on large lakes and rivers. Well over half (64%) of the research was conducted in lake ecosystems, with 29% in rivers, and only 6% in lagoons (Figure 3). This is not particularly surprising as these large

picturesque lakes are relatively easy to access, and are prized for the large lake trout (*Salvelinus namaycush*) they harbor. Due to their limited extent, coastal lagoons (which are confined to BELA and CAKR) were expected to have been poorly studied in terms of numbers of studies.

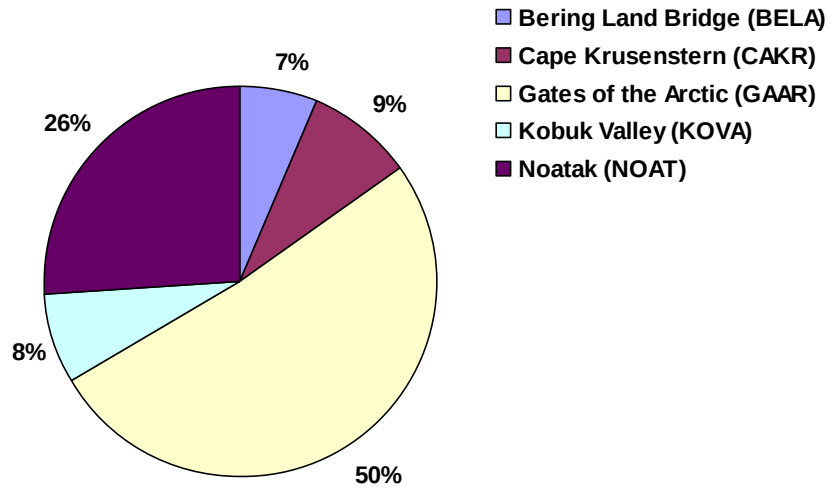


Figure 2. Relative percentage of site visits in each of the Park units in the Arctic Network Parklands.

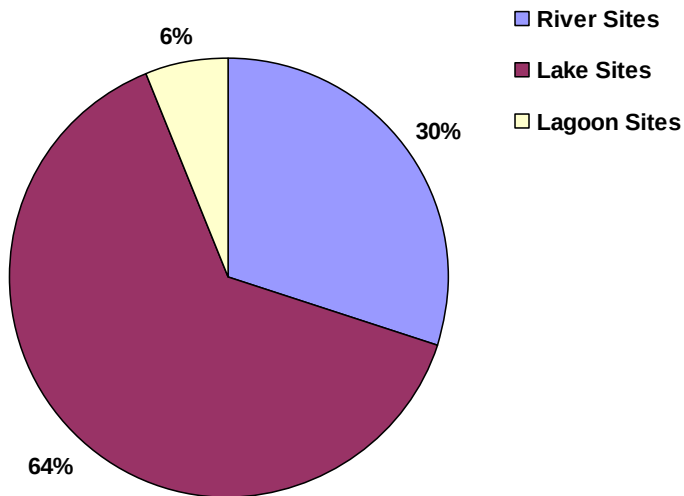


Figure 3. Percentage of sites visited in each of the three key aquatic ecosystems in the Arctic Network Parklands.

Bering Land Bridge National Preserve

Bering Land Bridge National Preserve (BELA) is located on the Seward Peninsula in northwest Alaska. The Preserve encompasses 2.7 million acres of land that protects a small portion of the Bering Land Bridge; a mass of land that connected present day Alaska with eastern Siberia during the Pleistocene. The majority of this land bridge, once thousands of miles wide, now lies beneath the Chukchi and Bering Seas. The Preserve's western boundary is only 42 miles from the Bering Strait and the fishing boundary between the United States and Russia.

Five major physiographic regions occur within the Preserve: the coastal plain, volcanic ash area, uplands, mountains and the lava plateau. The coastal plain is a large flat expanse of land that stretches from Goodhope Bay to the southwestern-most boundaries. This area is a mosaic of thaw lakes and wetlands separated by undulating polygonal ground. Nested within the coastal plain is the volcanic ash area. This circular physiographic region is roughly 40 km across and lies on the Espenberg Peninsula. This region is best known for the four large maar lakes (Plate 2) that occur here. These lakes were formed by ancient volcanic eruptions through permafrost and are up to 100 meters in depth. A small mountain range, the Bendeleben Mountains, borders the southernmost edge of the Preserve. The mountains are largely composed of pre-Cambrian metamorphic rock with large granite intrusions. A large expanse of uplands forms another of the physiographic regions. This area lies between the mountains and the coastal plain and is characterized by the high rolling terrain that is heavily dissected by small steep walled streams. Numerous small thermal vents and drainages occur along Hot Springs Creek, a small creek in the uplands region. Hot Springs Creek is the water source to Serpentine Hot Springs a public bath house that has been utilized by the Alaska natives of the region for many generations. The lava plateau lies within the upland area and abuts the northern edge of the Bendeleben Mountains. This region is composed of a series of five basaltic lava flows. Situated within this region is Imuruk Lake the largest lake within the Preserve. Many other thaw lakes and ponds persist throughout this area.

Due to the complex physiography found in the Preserve there is a high diversity of fish habitat. Extensive surface water is present in the coastal plain despite the small hydrologic budget owing to modest precipitation (25-38 cm/year). Much of the preserve is underlain by relatively shallow continuous permafrost, which restricts drainage. Five major rivers have substantial drainage basins within BELA including the Serpentine, Cowpack, Nugnugaluktuk, Goodhope, and Noxapaga rivers. Headwaters of the Inmachuk, Kugruk, Koyuk, and Kuzitrin rivers also originate here. Serpentine hot springs also adds to the hydrologic budget of the preserve. Rivers and streams vary considerably from low gradient and meandering to high-velocity, several of which terminate in large open coastal lagoons. Other unique riverine habitats include hot spring areas and underground flows through lava tubes. A diversity of lake types is present, with an abundance of small tundra ponds, oxbow lakes, and maar lakes. Several large open lagoon systems line the north-western shoreline of the Preserve.

Summary of Past Work

Despite the complex physiography and the high diversity of aquatic ecosystems here, very little fisheries related work has been conducted within BELA (Table 1, Figure 2). This is likely due, in part, to the remote nature of the Preserve.

Research conducted within the Preserve has largely focused on the maar lakes located in the volcanic ash region. DeCicco and York (1996) briefly investigated these lakes recording the presence of pink salmon (*Oncorhynchus gorbuscha*) in both North and South Devil Mountain lakes, which had occasional access to coastal waters. Other species found in these lakes included Arctic charr (*Salvelinus alpinus*), least cisco (*Coregonus sardinella*), and ninespine stickleback (*Pungitius pungitius*). This investigation provided a range extension for Arctic charr, which are mainly confined relict populations in Alaska. The next closest populations are found in cirque lakes of the Kigluaik Mountains, approximately 160 km to the south.

The only other fisheries investigation obtained in the review was Roeder and Graham's Limnological Investigation (1973). They documented Arctic grayling (*Thymallus arcticus*) (plate 1) and least cisco in Imuruk Lake (Plate 3), a large (71 km²), shallow lake ($Z_{\max} = 4$ m) in the lava plateau. They also documented the presence of Arctic grayling and stickleback in Hot Springs Creek, located upstream of Serpentine Hot Springs.

Table 1. Locations of site investigations, publications, and species found in Bering Land Bridge National Preserve.

Major Drainage	Site Type	Site Name	Publication	Species
Serpentine	Stream	Hot Springs Creek	Roeder & Graham 1979	AG, NSS
Killuk	Lake	South Devil Mountain Lake	DeCicco & York 1996	PS, AC
	Lake	North Devil Mountain Lake	DeCicco & York 1996	PS, LCI, AC
Kougachuk	Lake	North Killeak Lake	DeCicco & York 1996	NSS, LCI
	Lake	South Killeak Lake	DeCicco & York 1996	AC, PS
Kugruk	Lake	Imuruk Lake	Roeder & Graham 1979	AG, LCI

Key to species acronyms – AC: Arctic charr; AG: Arctic grayling; LCI: least cisco; NSS: ninespine stickleback; PS: pink salmon

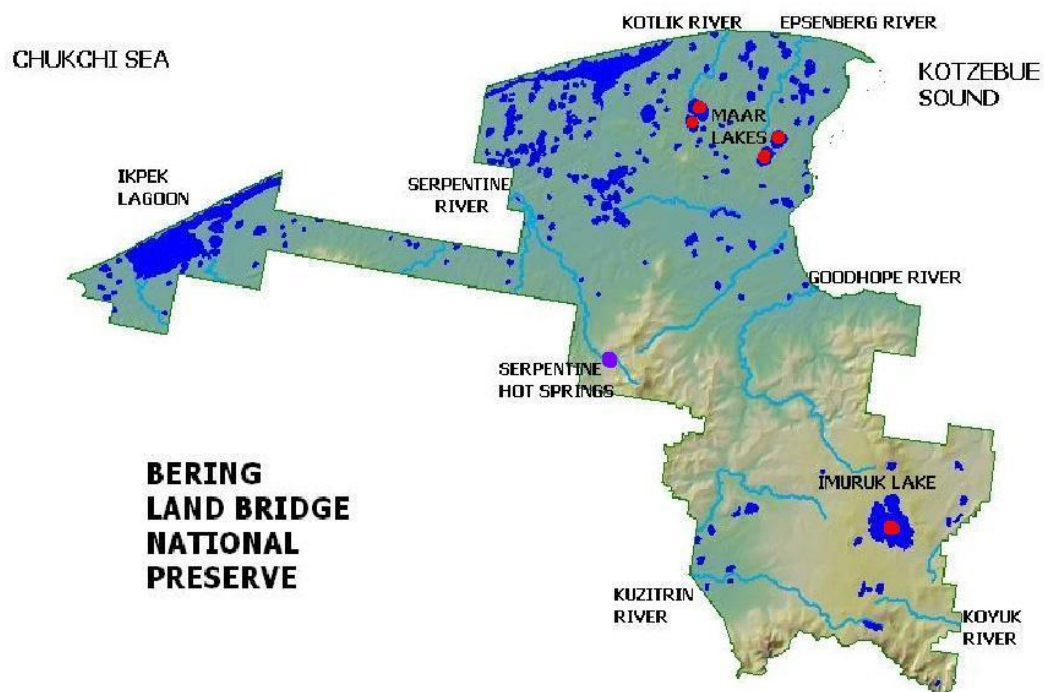


Figure 4. Bering Land Bridge National Preserve and locations of fisheries work (dots correspond to locations in Table 1; red dots represent lakes, purple dots represent rivers, green dots represent lagoons).

Current Projects and Future Recommendations

No current fisheries projects are being conducted within the Bering Land Bridge National Preserve. The network is monitoring a large suite of lakes within the preserve and is intending to monitor fish in the deep fish bearing lakes in the future.

Further study and classification of the freshwater and lagoon resources within BELA is needed. While there has been considerable work on freshwater and marine/coastal fish in the region by the Alaska Department of Fish and Game and others, little of that work has occurred within Preserve boundaries. A large-scale, multi-part investigation of lakes, rivers, and coastal lagoons would provide insight for monitoring the fisheries resource in the Preserve. Interviews with local resource users may also provide useful information about species distributions.



Plate 1. Seward Peninsula Arctic grayling; note localized dark coloration. (Photo by F. DeCicco)



Plate 2. North (left side) and South Devil Mountain maar lakes in Bering Land Bridge National Monument. (Photo by A. Larsen)



Plate 3. Imuruk Lake in Bering Land Bridge National Monument.

(Photo by A. Larsen)

Cape Krusenstern National Monument

Cape Krusenstern National Monument (CAKR) is located in northwestern Alaska approximately 65 km north of Kotzebue. The Monument encompasses 650 thousand acres of land comprised of a mosaic of low rolling limestone hills, a wide coastal plain dotted with thousands of small thaw lakes and several large coastal lagoons. The Preserve is bordered to the west by the Chuckchi Sea and to the south by Kotzebue Sound resulting in a strong polar maritime climate. A series of 114 beach ridges have formed over the past 5,000 years recording the changing shorelines of the Chukchi Sea. Thousands of archeological sites are found within the monument preserving human activities of the region for the past 9,000 years.

Three ecoregions occur within the Monument including Kotzebue Sound Lowlands, Brooks Foothills and Kobuk Ridges and Valleys. The Kotzebue Sound Lowlands occur along the southernmost boundary of the Monument. This ecoregion is characterized by low topographic relief. Thousands of small lakes and ponds prevail in thaw depressions and between ancient beach ridges. The Igichuk and Mulgrave Hills run the length of the monument and are part of the Brooks Foothills ecoregion. These low rolling limestone hills are part of the Western Brooks Foothills. The Noatak Lowlands run along the easternmost edge of the monument and represent the westernmost extension of the Kobuk Ridges and Valleys ecoregion.

The monument is characterized by a number of streams that flow from the uplands and empty into the Chukchi Sea or adjacent coastal lagoons. During the ice-free season, some of these streams and associated lagoons provide important habitat for anadromous and freshwater fish populations, birds, and terrestrial animals. Most of the streams in CAKR are clear water streams, exhibiting low levels of suspended solids, turbidity, and nutrients. At the Red Dog Mine site outside of the monument, waters have naturally high concentrations of cadmium, lead, and zinc. These high concentrations are due to the large metal ore deposits found in the region. Ground water information for within the monument is currently sparse.

Nine large coastal lagoons distributed along the western edge of the monument provide important habitat for fish. A number of short river systems flowing mainly from east to west drain into the lagoons, providing habitat for anadromous and resident fish species. The lagoons display a high degree of variation in connection to the Chukchi Sea; several of the lagoons are opened to sea water intrusion daily, while others only infrequently during severe storm events. Some lagoons are infused with large quantities of salt water at high tide, as the tides retreat the percentage of salt water drops and fresh riverine waters inputs lower salinity. Access between some of the lagoons and the marine environment is occasionally closed due to alongshore sediment transport. The high degree of temporal and spatial variation in salinity results in a highly variable and potentially stressful environment for fish.

Table 2. Locations of site investigations, publications, and species found in Cape Krusenstern National Monument.

Major Drainage	Site Type	Site Name	Publication	Species
Omikviorok	Omikviorok River		Houghton & Hilgert 1983, DeCicco 1985	DV, PS, CS, BCI, AG, HWF, NSS
	Lagoon	Ipiavik Lagoon	DeCicco 1985	DV, AG
Situkuyok	River	Situkuyok	Young 1974	HWF, RWF, AG, NP, LNS
Kiligmak	Lagoon	Kotlik Lagoon	Reynolds 2009 (unpublished data)	PH, HWF, ACI, DV, BSC, FHS, NSS
	Stream	Kilikmak Creek	Young 1974	ABF
Tuliluk	Lagoon	Krusenstern Lagoon	Reynolds 2009 (unpublished data)	BC, BWF, HWF, LC, TSS, RSM, SHF, AG
Akulaq	Lagoon	Akulaaq Lagoon	Reynolds 2009 (unpublished data)	BCI, BWF, HWF, LC, ABF, FHS
Sisualik	Lagoon	Sisualik Lagoon	Reynolds 2009 (unpublished data)	PH, BC, HWF, LC, SFC, TSS, YFS, FHS CS, SFL, AFL

Key to species acronyms – ABF: Alaska blackfish; ACI: Arctic cisco; AFL: arrowtooth flounder; AG: Arctic grayling; BCI: Bering cisco; BWF: broad whitefish; BSC: belligerent sculpin; FHS:

fourhorn sculpin; CS: chum salmon; DV: Dolly Varden charr; HWF: humpback whitefish; LCI: least cisco, LNS: longnose sucker; NP: northern pike; NSS: ninespine stickleback; PH: Pacific herring; PS: pink salmon; RWF: round whitefish; RSM: rainbow smelt; SFC: saffron cod; SHF: sheefish; SFL: starry flounder; TSS: threespine stickleback; YFS: yellowfin sole

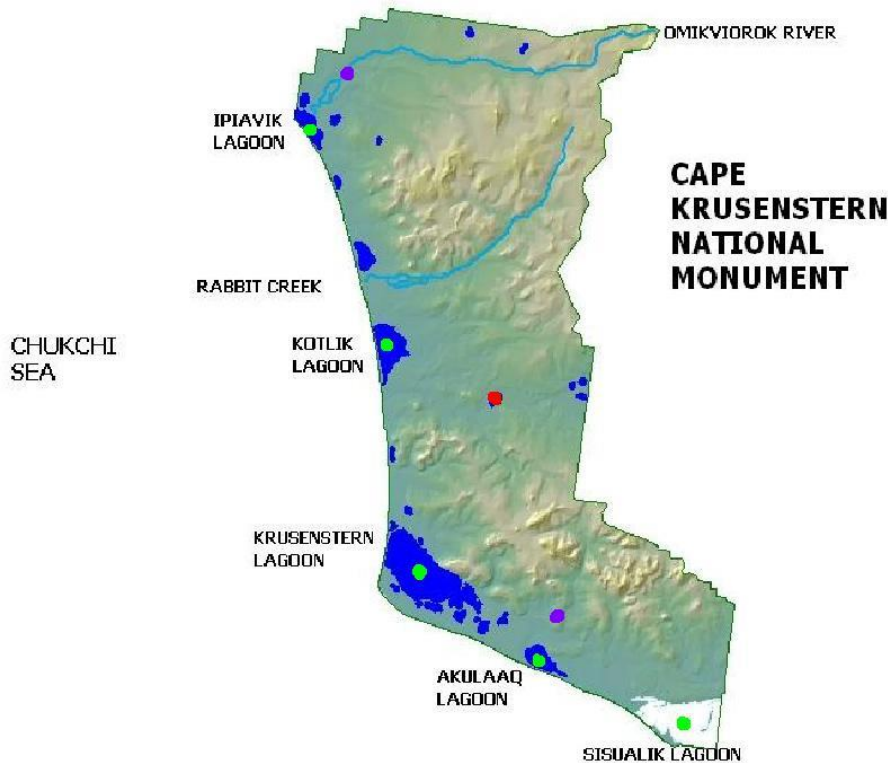


Figure 5. Cape Krusenstern National Monument and locations of investigation sites (dots correspond to locations in Table 2 ; red dots represent lakes, purple dots represent rivers, green dots represent lagoons).

Summary of Past Work

Relatively few studies have been completed in CAKR. However, the small amount of research that has been conducted provides a good overview of the fish community composition that is present. This is particularly true in the coastal lagoons found on the western shoreline of the Monument.

DeCicco (1985) and Reynolds (2009, unpublished data) investigated five of the nine lagoons in the monument. They both noted the presence of anadromous Dolly Varden charr (*Salvelinus malma*) as juveniles preparing to head to sea, and adults returning to the rivers to spawn or overwinter. The lagoons provide high quality habitat for multiple marine taxa including members of the sculpin (*Cottidae*), cod (*Gadidae*), herring (*Clupeidae*) and flounder (*Pleuronectidae*) families (Table 2). The authors also discussed the presence of several diadromous fish taxa that move freely between fresh and salt water, including members of the whitefish (*Coregoninae*) and salmon

(*Salmoninae*) families, as well as threespine sticklebacks. These ecosystems support a high diversity of fish because they are nutrient-rich and highly-productive environments (plate 4), due in part to the extensive mixing of marine and fresh waters. The lagoons are also an important source of fish for subsistence users in the surrounding area.

Houghton and Hilgert (1983) and DeCicco (1985) collected Dolly Varden charr, Arctic grayling, Bering cisco (*Coregonus laurettae*), pink salmon, chum salmon (*Oncorhynchus keta*), humpback whitefish (*Coregonus clupeaformis*), and ninespine stickleback, in the Omikviorok river system in the north end of the Monument. DeCicco also noted that this system provided spawning locations for pink and chum salmon, and Dolly Varden charr. Young (1974) collected humpback whitefish, Arctic grayling, northern pike (*Esox lucius*), and longnose suckers (*Catostomus catostomus*) from the Seetakuyuk River system in the southeast corner of the Monument, and Young collected only Alaska blackfish (*Dallia pectoralis*) from Kilikmak Creek Lake in the middle of the Monument.

Extensive fish surveys have been conducted by the Alaska Department of Fish and Game on both the Willuk and Kivalina Rivers, which lie just north of the National Monument. These surveys monitor water quality conditions, as the rivers are both in close proximity to Red Dog Mine, a large open-pit lead-zinc mine. The surveys also provide important information on strength of the Dolly Varden char runs, which make up a large portion of the local subsistence-users' diets.

Current Projects and Future Recommendations

Current fisheries research in the Monument is limited to a graduate research project investigating food web structure, physicochemical conditions, and species richness of fish and invertebrates, by Melinda Reynolds.

Work by DeCicco and Reynolds has provided essential baseline data for long-term monitoring of fish in the coastal lagoons of Cape Krusenstern. Continued monitoring of these ecosystems is important for understanding these dynamic ecosystems that provide an important subsistence resource to the native people of the region. Large-scale mining activities in the region and the spread of contaminants via wind or ground water threaten the food value of fisheries resources; careful monitoring of contaminant loads in these fish is advised. We also recommend increased effort in sampling small streams and isolated ecosystems in the Monument to better understand the distribution of resident fish.



Plate 4. Tidal interface between Akulaaq Lagoon (bottom) and Kotzebue Sound (top).
Photo)

(NPS

Gates of the Arctic National Park and Preserve

Gates of the Arctic National Park and Preserve (GAAR) encompasses 8.4 million acres in the Central Brooks Range. The park and preserve contain two National Natural Landmarks: Arrigetch Peaks (37,400 acres) and Walker Lake (181,120 acres); and six federally designated Wild and Scenic Rivers: the Alatna River; the John River; the Kobuk River; the Noatak River; the North Fork of the Koyukuk River; and the Tinayguk River.

Tributaries of four major river systems originate in Gates of the Arctic and drain into three terminal basins. To the north the Nigu, Killik, Chandler, Anaktuvuk, and Itkillik rivers flow into the Colville River which terminates in the Arctic Ocean. The Noatak River and the Kobuk River flow westward, both from headwaters in the western side of the Park, into Kotzebue Sound and the Chukchi Sea. The Reed River, a tributary to the Kobuk, originates as glacial runoff from the flanks of Mount Igikpak, one of the few remaining ice caps in the region. The John, Alatna, and North Fork of the Koyukuk rivers drain southwest to the Yukon River, which terminates into the Bering Sea.

Habitat types available for fish range from small glacial or spring-fed headwater streams to large meandering rivers and from small tundra ponds to a handful of large glacially formed oligotrophic lakes. A major factor limiting fish distribution may be the ability to re-access locations following glaciation in the recent geologic past (Hamilton et. al 1986). Species must also be tolerant to the harsh conditions present in this environment as small stream and rivers often freeze down to the gravel in mid-winter (Reynolds 1997).

There are at least three “warm” springs located within the Park and Preserve, with numerous groundwater upwelling areas. These springs provide essential over-wintering habitat for many species that do not migrate back to large main-stem river areas. The upwelling areas are also heavily used by salmonids as spawning areas (Yoshihara 1973)

as they provide a constant flow of oxygenated water necessary for survival of eggs. Many of the spring areas remain open when air temperatures are as low as -35°C and colder.

Table 3. Locations of site investigations, publications, and species found in Gates of the Arctic National Park and Preserve.

Major Drainage	Site Type	Site Name	Publication	Species
Arctic	Stream	Graylime Creek	Kogl 1971, Winslow 1969	DV
	Stream	Ikagiak Creek	Kogl 1971	AG, LT, RWF, SSC, DV
	River	Killik river	Kogl 1971	AG, SSC
Itkillik	Lake	Itkillik Lake	Furniss 1974	LT, AG, RWF, SSC
Chandler	Lake	Amiloyak Lake	Bendock and Burr 1985, 1986; Troyer 1994	LT, AC, AG, RWF, SSC
	Lake	Fish Lake	Heckart 1964	LT, AC, AG, RWF
	Lake	Chandler Lake	Roguski and Spetz 1968, Furniss 1974, Bendock 1979, Troyer and Johnson 1994	LT, AC, AG, RWF, SSC
	Lake	Little Chandler Lake	Troyer & Johnson 1994	LT, AC
Killik	Lake	Tulilik Lake	Bendock 1979	AG, BB, RWF, SSC
	Lake	Lake Kaniksarak	Bendock 1979	AG
Kurupa	Lake	Headwater Lake	Bendock 1979	No Fish Present
	Lake	Outwash Creek Lake	Bendock 1979	No Fish Present
	Lake	Kurupa Lake	Bendock 1979	LT, AC, RWF
Koyukuk	Stream	Ekokpuk Creek	Winslow 1969	AGC
	Lake	Agiak Lake	Bendock 1979	AC, LT, AG
	Lake	Takahula Lake	Roguski & Spetz 1968	NP, AG
	Lake	Tobuk Lake	Roguski & Spetz 1968	NP
Kobuk	River	Kobuk River	Alt 1972	SHF
	Lake	Selby-Narvak Lakes	Roguski & Spetz 1968	LT, AG, NP
	Lake	Nutuvukti Lake	Roguski & Spetz 1968	NP

Table 3. Locations of site investigations, publications, and species found in Gates of the Arctic National Park and Preserve (Continued).

Major Drainage	Site Type	Site Name	Publication	Species
Kobuk cont.	Lake	Walker Lake	Roguski & Spetz 1968, Adams 1990, Johnson & Troyer 1994	LT, AC, LCI, RWF, AG, NP, BB, SSC
Noatak	Stream	Anorat Creek	Bowden et al. 2005 (unpublished report)	SSC
	Stream	Oyukak Creek	Bowden et al. 2005 (unpublished report)	SSC
	Stream	Kugrak Springs	Bowden et al. 2005 (unpublished report)	SSC, DV
	Stream	Komakak Creek	Bowden et al. 2005 (unpublished report)	SSC
	Stream	Nushralutak Creek	Bowden et al. 2005 (unpublished report)	SSC, DV
	Lake	Lake #1	Bowden et al. 2005 (unpublished report)	AG, SSC
	Lake	Lake #2	Bowden et al. 2005 (unpublished report)	AG, RWF
	Lake	Lake Omelaktavik	Alt 1978, Bowden et al. 2005	NP
	Lake	Lake #6	Bowden et al. 2005 (unpublished report)	NP
	Lake	Lake #9	Bowden et al. 2005 (unpublished report)	AG
	Lake	Isiak Lake	Alt 1978	LT, RWF, NP, LCI
	Lake	Matcharak Lake	Bowden et al. 2005 (unpublished report)	LT, RWF, LCI, NSS
	Lake	Kavachurak Creek Lake	Alt 1978	AG, RWF
	Lake	Lake Kipmik	Bowden et al. 2005 (unpublished report)	LT, RWF, SSC

Key to species acronyms – AG: Arctic grayling; AGC: Angayukaksurak charr; BB: burbot; LT: lake trout; LCI: least cisco; NP: northern pike; NSS: ninespine stickleback; RWF: round whitefish; SHF: sheefish; SSC: slimy sculpin

GATES OF THE ARCTIC NATIONAL PARK AND PRESERVE

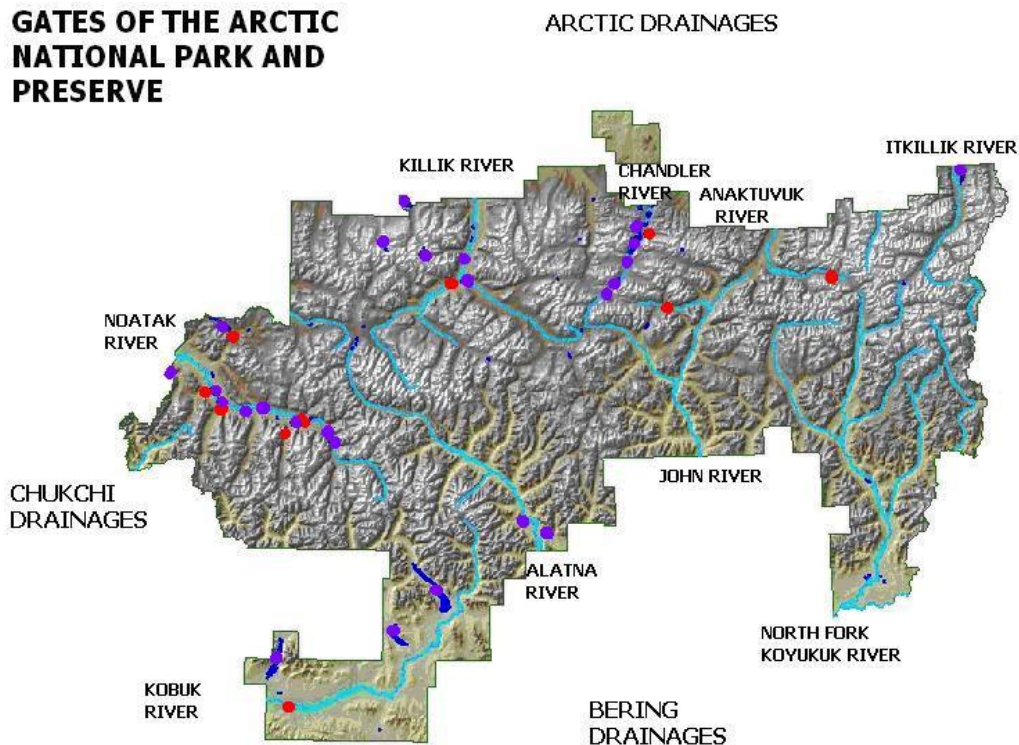


Figure 6. Locations of sites investigated in Gates of the Arctic NP&P (dots correspond to site locations in Table 3 ; red dots represent lakes, purple dots represent rivers, green dots represent lagoons).

Summary of Past Work

Beaufort Sea Drainages: North Sloping drainages in Gates of the Arctic drain into the Beaufort Sea. The data we compiled shows that fisheries research conducted in these drainages has been limited to lakes and the headwater tributaries flowing into the Colville River. Studies of lake fish communities in other regions along the North Slope suggest fish species richness increases with lake size and depth and is inversely related to slope of inflows and outflows connected to fish-bearing water bodies (Hershey et al. 1999). Data collected in this review of North Sloping drainages of GAAR indicates that lake size is not a factor determining fish species diversity. Unfortunately, the majority of these studies focused on snapshots of fish presence/absence data and often did not record multiple visits to confirm this data. Bendock (1979) surveyed headwater lakes in the Kurupa River and Outwash Creek drainages and speculated that fish absence was due to high stream gradients that did not permit passage. Further studies on presence/ absence must be conducted to determine whether or not fish presence is related to lake size and or slope of outflow streams. Stream sites investigated in the Arctic drainages were typically small braided systems with large gravel substrate. Graylime (a.k.a. Grayling)

creek, in the headwaters of the Anaktuvuk River, contained rearing juvenile Dolly Varden (Winslow 1969, Kogl 1971). Ikagiak creek, which drains into Chandler Lake, has populations of Arctic grayling, lake trout, round whitefish (*Prosopium cylindraceum*), slimy sculpin (*Cottus cognatus*), and rearing (unidentified) charr (Kogl 1971). The Killik River was also sampled by Kogl (1971), and was found to contain Arctic grayling and slimy sculpin. The main Colville River, outside of the park boundaries, is listed by the Alaska Department of Fish and Game anadromous catalog (Johnson and Daigneault 2008) to contain populations of chum and pink salmon, Dolly Varden charr, and several (undifferentiated) whitefish species. The species in this system that have not yet been located in Gates of the Arctic are likely candidates to be found there in the future.

Chukchi Sea Drainages: This system consists of the waters of the Noatak drainage, which originates in the western edge of Gates of the Arctic at the base of Arrigetch Peaks, and the Kobuk River drainage, which drains the southwestern portion of the Park and also has headwaters near Arrigetch Peaks. Both of these large river systems ultimately flow into Kotzebue Sound and the Chukchi Sea, and provide heavily used travel routes for the region. Several large survey projects have occurred in the upper Noatak drainage with an emphasis on lakes. During the summer of 1973, Young (1974) examined a number of large lakes, mostly in the Noatak Preserve, to collect data for the expansion of Park Service lands. In the summer of 1977, Alt (1978) also sampled a large number of lakes, with emphasis on the headwater region. In the summer of 2005, Luecke (Bowden et al., 2005) surveyed fish in lakes previously sampled by Alt and Young. Fish were present in almost all lakes sampled in the region, with Arctic grayling, lake trout and round whitefish being the most common species. Also present were northern pike, Dolly Varden charr, least cisco, slimy sculpin and ninespine stickleback. In the lakes that have been sampled multiple times, only one lake, Lake Matcharak, showed a difference in species composition, with least cisco not being found on the latest survey. This may be due to an incomplete survey or a total loss of this species from the lake. Huryn (Bowden et al., 2005) selectively surveyed fish in 20 streams in the upper Noatak drainage with minnow traps and kick-nets. Slimy sculpin were found in Anorat Creek, Oyukak Creek, Kugrak River, Komakak Creek, and Nushralutak Creek. Juvenile Dolly Varden charr also were found in Kugrak and Nushralutak creeks. Arctic grayling were not located during this survey but are likely present in this area.

The Kobuk drainage begins at Walker Lake, a large headwater lake and National Natural Landmark (plate 6), and is joined by tributaries from several other large lakes (Nutuvukti and Selby-Narvak Lakes) before leaving the Park. As part of a larger survey of lakes on the south slope of the central Brooks Range, Roguski and Spetz (1968) visited several of the large lakes (Nutuvukti, Selby-Narvak, and Walker) in the upper Kobuk River drainage, recording surface area, depth, and species compositions. In Walker Lake they found lake trout, Arctic charr, and slimy sculpin. Nutuvukti Lake contained northern pike and humpback whitefish, while Selby-Narvak also contained northern pike, as well as Arctic grayling and lake trout. Adams (1990) and Johnson and Troyer (1994) investigated Walker Lake for more in-depth looks at the population characteristics of lake trout and their interactions with Arctic charr. They describe habitat use, age ranges, condition factors, as well as noting that the lake trout population did not appear to be experiencing heavy exploitation at that time.

While conducting surveys on the taxonomy and ecology of sheefish (*Stenodus leucichthys*), Alt (1969, 1972) recorded a thorough list of species present in the main stem Kobuk River mainly inside and outside of the Kobuk Valley National Monument (Table 4). During this time period, Alt helped collect sheefish in an attempt by the Alaska Department of Fish and Game to create a hatchery stock; a plan that was ultimately given up due to mortality issues at the hatcheries. Taube and Wuttig (1998) and Stuby and Taube (1998), as well as others, have sampled this sheefish population to gain further information on the topics of abundance, composition, and mortality effects of sport fishing, within and outside of the Park boundaries.

Bering Sea Drainages: These drainages flow from the south slope of the central Brooks Mountain Range into the Koyukuk River, and then into the Yukon River. Within GAAR, this includes the Alatna River, the Hammond River, the John River, the North Fork of the Koyukuk River, and the Tinayguk River, as well as most of their tributary streams. The literature review showed that a paucity of fisheries work had previously been conducted in these drainages inside of Park boundaries. In 1968, Roguski & Spetz investigated Takahula and Tobuk Lakes, both of which are in the Alatna River drainage. They found northern pike in both lakes, with Arctic grayling also present in Takahula Lake. One lake site, Agiak Lake (plate 5), and one river site, Ekokpuk Creek, have been examined in the John River drainage. Bendock & Burr (1985) noted that Agiak Lake contained Arctic charr, lake trout, and Arctic grayling. Ekokpuk Creek contained, what Winslow (1969) described as a dwarf morph of *Salvelinus*, referred to by the local residents as Angayukaksurak (old man fish), which was later described by Morrow (1973) as a distinct species, *Salvelinus anaktuvukensis*, differentiated from Dolly Varden charr by meristics and life-history characters.

Current Projects and Future Recommendations

The National Park Service and the University of Alaska Fairbanks are currently supporting a graduate student to determine if species designation for the Angayukaksurak charr (*Salvelinus anaktuvukensis*) found near Anaktuvuk Pass is warranted. Gates of the Arctic and the Arctic Network are currently conducting aerial surveys of open-water habitats during winter months in Gates of the Arctic. These open-water habitats are important for spawning salmon and resident fish; therefore, the inventory and monitoring program is considering a long-term effort aimed at monitoring fish presence in these habitats. The Arctic Network is also scheduled to conduct a park-wide fisheries inventory in GAAR.

A top priority of GAAR and the Inventory and Monitoring program should be to conduct surveys of fish contaminants, especially from ecosystems where subsistence users rely on fish as a food source. A statistically valid study of fish presence and absence conducted during water quality and habitat surveys in the parks six National Wild and Scenic Rivers and other areas of exceptional value should also be conducted. Areas of exceptional value would include water bodies where relevant baseline data from past studies exists and those water bodies are designated as exceptional by the park superintendent, park staff or national/international authorities. Results from these surveys will be used to inform and guide the direction of Inventory and Monitoring efforts within the park.



Plate 5. Amiloyak and Agiak Lakes at the continental divide in Gates of the Arctic National Park and Preserve. The Amiloyak drainage flows north into the Arctic Ocean and the Agiak drainage flows south into the Koyukuk River, Yukon River, and then Bering Sea. (NPS Photo).



Plate 6. Walker Lake, a popular sport fish location in Gates of the Arctic National Park and Preserve. (NPS Photo)

Kobuk Valley National Park

Kobuk Valley National Park (KOVA) encompasses 1.7 million acres of land and a 98 km stretch of the Kobuk River. The park is bounded to the north by the Baird Mountains and to the south by the foothills of the Waring Mountains. The park provides protection for several important geographic features, including the central portion of the Kobuk River (plate 7), the Great Kobuk Sand Dunes, and the Little Kobuk and Hunt River dunes. Sand created by the grinding action of ancient glaciers was carried to the Kobuk Valley by both wind and water to create these dunes.

Two major ecoregions are represented in the Park: the Brooks Range and Kobuk Ridges and Valleys. The northern half of the Park is predominated by the Baird Mountains, a major set of mountains within the Brooks Range. The heavily incised mountains are nearly completely vegetated with boreal forest at low elevations and arctic tundra above treeline. Bedrock consists of folded metamorphosed sediments that are exposed near the base of the mountains. The southern half of the Park is predominated by the Kobuk River floodplain and adjacent lowlands. Thousands of small thaw ponds, oxbows and wetlands form a mosaic across this relatively flat terrain. The foothills of the Waring Mountains form the southernmost boundary of the Park and form a barrier between the Kobuk River lowlands and the Selawik River lowlands.

The Kobuk River drains 31,028 km² and has an estimated annual average flow of 438 m³ per second. The river is 558 km long and 0.30 to 0.45 km wide in its lower and middle reaches. It is clear, except at the highest water stage, and has a generally sandy or gravelly bottom. The river is 50 m above sea level at the eastern boundary of Kobuk Valley National Park. Meander scrolls, oxbow bends, and sloughs are abundant along the river's course. The floodplain of the Kobuk River varies from 1.6 to 12.8 km wide. The Kobuk is considered an important migratory route for fish in western Alaska.

The major tributaries of the Kobuk River within the park boundary are the Kallarichuk, Salmon, Tutuksuk, Kaliguricheark, Hunt, and Akillik Rivers. All have their headwaters in the Baird Mountains, and are entirely undeveloped. The Salmon River is designated a National Wild and Scenic River.

Numerous small lakes and ponds lie in the Kobuk watershed, particularly in the lowlands along the river. Some ponds and lakes formed as detached oxbows of the meandering river, while others are thaw ponds, formed where permafrost has melted and caused depressions. Some small lakes of indeterminate origin lie on the north slopes of the Waring Mountains, and some true cirque lakes are found in the Baird Mountains.

Table 4. Locations of site investigations, publications, and species found in Kobuk Valley National Park.

Major Drainage	Site Type	Site Name	Publication	Species
Kobuk	River	Akillik River	Melchior 1976	AG
	River	Salmon River	Melchior 1976	AG, CHS, DV
	River	Kobuk River	Alt 1969, Melchior 1976, Stuby & Taube 1998, Taube & Wuttig 1998	AG, CHS, PS, LT, DV, BWF, LCI, ACI, RWF, SHF, RSM, LNS, NP, ABF, BB, SSC
	River	Kallarichuk River	Melchior 1976	AG
	River	Elaroniluk Creek	Melchior 1976	NP

Key to species acronyms – ABF: Alaska blackfish; ACI: Arctic cisco; AG: Arctic grayling; BB: burbot; BWF: broad whitefish; CHS: chum salmon; DV: Dolly Varden charr; LCI: least cisco; LNS: longnose sucker; LT: lake trout; NP: northern pike; PS: pink salmon; RSM: rainbow smelt; RWF: round whitefish; SHF: sheefish; SSC: slimy sculpin

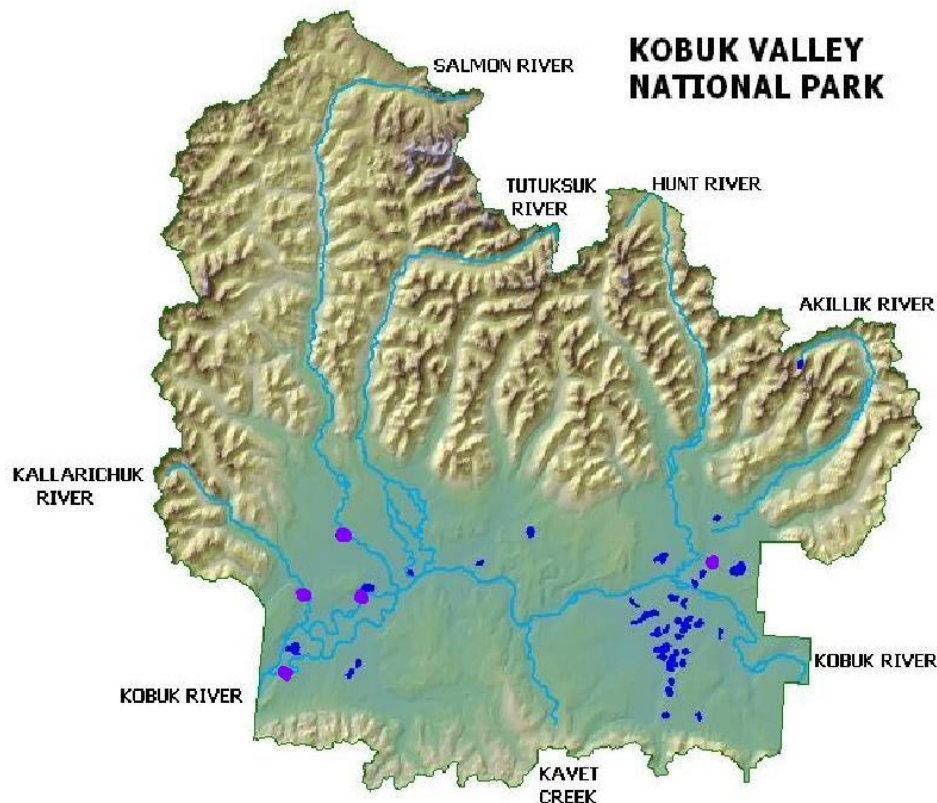


Figure 7. Locations of sites visited in Kobuk Valley National Park (dots correspond to site locations in Table 4 ; red dots represent lakes, purple dots represent rivers, green dots represent lagoons).

Summary of Past Work

Prior to the inception of the Park multiple studies were conducted to determine what species occur in the Kobuk River drainage. Alt (1969) gives a thorough list of species for the main stem Kobuk River (both inside and outside of Park boundaries). Herbert Melchior conducted a preliminary natural resource survey of this area in 1976, prior to its inception as a National Park. He visited five sites in the Park and collected Arctic Grayling in 4 of the 5 locations. He also collected chum salmon, Dolly Varden charr (originally determined as Arctic charr), and northern pike. He observed pink salmon, king salmon, coho salmon, sockeye salmon, sheefish (plate 8), and other whitefish species, in commercial and subsistence harvests downstream of the park. He suggests that as these species have been found just outside of the park boundaries they most likely also reside within them. DeCicco (1985) also suggests that the rivers in this park are important spawning locations for Dolly Varden charr based on communication with subsistence users in this area.

The Kobuk River supports a world-class sheefish fishery; all Alaska sport-fish size records for this species have been set here. A number of researchers, including Alt (1969, 1972, and 1980) and Taube & Wuttig (1998), have investigated various aspects of the sheefish population in the main stem of the Kobuk River. Research topics range from abundance to life-history characters. Alt's investigations also describe aspects of the least cisco population that resides in the Kobuk River. These fish are an important local subsistence source, and are increasingly becoming an important source of sport-fish investment in the region.

Current Projects and Future Recommendations

There are currently no fisheries projects occurring in Kobuk Valley National Park. The Arctic Network I&M staff are scheduled to conduct a fisheries inventory here as a part of the Arctic Network inventory and monitoring process.

The Kobuk Valley may make a good location for studying the effects of a lake-drying trend that has been recorded from other areas of northwestern Alaska. There are numerous low-lying small lakes present that would make for a unique study area relatively free of other outside influences. This could tie together nicely with a study of the wetland areas in the valley that may be threatened with global climate change if permafrost levels begin to decrease. These low-lying wetland and lake habitats have not yet been thoroughly investigated, but may play a large role in the recruitment ability of the Kobuk River's large fish stocks.



Plate 7. Main stem of the Kobuk River.

(Photo by F. DeCicco)



Plate 8: Sheefish (*Stenodus leucichthys*) from the Kobuk River.

(Photo by F. DeCicco)

Noatak National Preserve

The Noatak National Preserve (NOAT) encompasses 6.5 million acres of land and, in combination with sections of Gates of the Arctic National Park and Preserve, the entire Noatak River drainage including all headwaters. The Noatak River is the second largest river in Alaska wholly contained within the Arctic. The river traverses the western Brooks Range and forms a large distributary as the river terminates in Kotzebue Sound. The Noatak River and its surrounding watershed (3,035,200 ha) is an internationally recognized UNESCO (United Nations Educational, Scientific, and Cultural Organization) Biosphere Reserve due to its status as one of North America's largest mountain-ringed river basins with an intact ecosystem. The Noatak River is classified as a National Wild and Scenic River.

The Noatak watershed is a complex mosaic of 10 major subsections: Kobuk-Noatak Coastal Plain, Noatak Lowlands, Noatak Basin, Baird Northern Mountains, Baird Southern Mountains, Endicott Mountains, Kiana Hills, DeLong Mountains, Schwatka Mountains North and the Schwatka Mountains South. These subsections include a diverse assortment of physiographic features including floodplains, coastal plain, delta, glaciated valleys and uplands, both rounded and rugged mountains as well as hills. This diverse physiography results in an equally diverse aquatic landscape.

The Noatak watershed is host to a multitude of lakes and streams ranging from small seasonal streams and ponds to large lakes and rivers. Feniak Lake, the largest waterbody within the Preserve, is an oligotrophic lake surrounded by glacial moraines. Countless thaw ponds occur throughout the Preserve. Other ponds and lakes formed as detached oxbows of the meandering river or developed as part of the extensive flat delta at the mouth of the Noatak persist throughout the area.

The main stem Noatak River and its many tributaries provide habitat and migration routes for many species, from resident Arctic grayling to anadromous Pacific salmon. These waterways also allow colonization of the many diverse lakes within this Preserve that range from small wetland nurseries to large lakes.

Table 5. Locations of site investigations, publications, and species found in the Noatak National Preserve.

Major Drainage	Site Type	Site name	Publication	Species
Aniuk	Lake	Camp 4 - Lake 1	Young 1974	LT, RWF, AG
	Lake	Kikitaliorak Lake	Alt 1978	LT, LCI, RWF, AG
	Lake	Kiingyak Lake	Alt 1978	LT, RWF, AG
Cutler	Stream	Cutler River	Young 1974	AG, DV, NSS, SSC
	Lake	Kaluich Creek Lake	Alt 1978, Young 1974	AG, DV

Table 5. Locations of site investigations, publications, and species found in the Noatak National Preserve (Continued).

	Lake	Camp 7 - Lake 2	Young 1974	CHS
Makpik	Stream	Feniak Lake	Alt 1978, Young 1974	RWF, AG, LT, SSC
Anisak	Lake	Desperation Lake	Alt 1978	LT, RWF, AG
	River	Eli River	DeCicco 1983	AG, DV, SSC, CHS
Kelly	River	Kelly River	DeCicco 1983	AG, DV, SSC, RWF, CHS, PS
	Lake	Kelly River Lake	Alt 1978	RWF, AG
Kugururok	River	Kugururok River	DeCicco 1983, Cappiello 1995, Foy 1996	AG, DV, SSC, RWF, CHS, PS, SKS, CNS, HWF, LNS, NP, BB
Nimiuktuk	River	Nimiuktuk River	DeCicco 1983	AG, DV, SSC, RWF, CHS, PS,
	Lake	Aniralik Lake	Alt 1978	RWF, AG
Noatak	Lake	Lake Tulugak	Young 1974	LCI, NP
	Lake	Lake Narvakrak	Young 1974	ABF
	Lake	Lake Kangilipak	Alt 1978	LCI, RWF, NP
	Lake	Aliktongnak Lake	Webb 1980	NP, LNS, BWF, HWF
	Lake	Lake #3 Unnamed	Webb 1980	NP, HWF, BWF, AG, LCI
	Lake	Lake #4 Unnamed	Webb 1980	BWF, NP

Key to species acronyms – ABF: Alaska blackfish; ACI: Arctic cisco; AG: Arctic grayling; BB: burbot; BWF: broad whitefish; CHS: chum salmon; CNS: Chinook salmon; DV: Dolly Varden charr; HWF: humpback whitefish; LCI: least cisco; LNS: longnose sucker; LT: lake trout; NP: northern pike; PS: pink salmon; RSM: rainbow smelt; RWF: round whitefish; SHF: sheefish; SKS: sockeye salmon; SSC: slimy sculpin

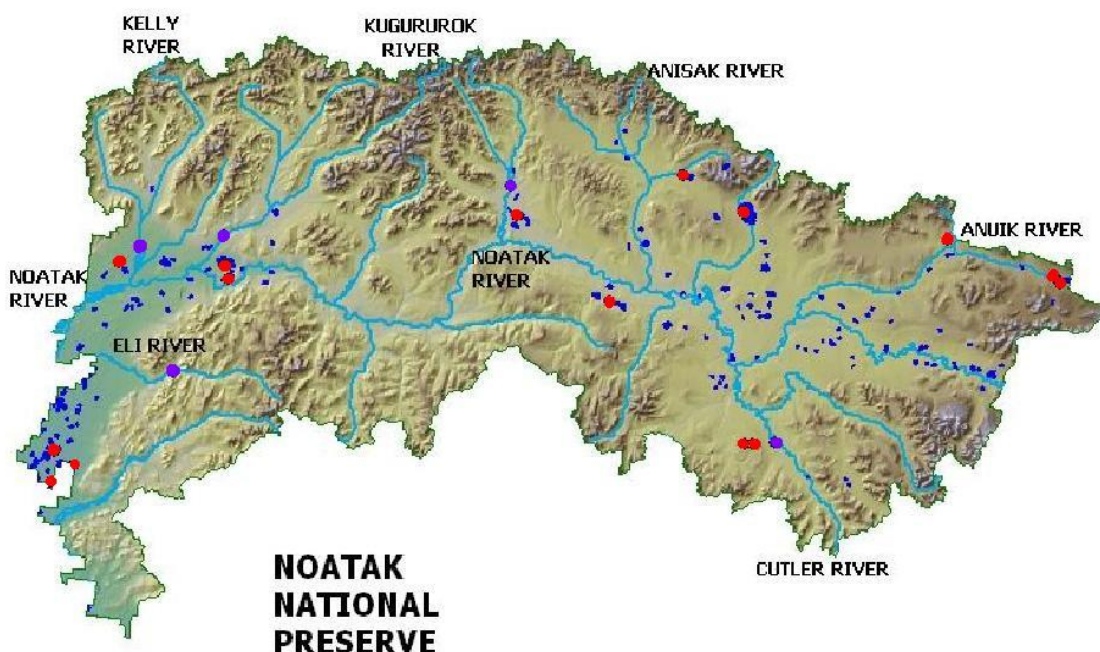


Figure 8. Locations of sites visited in the Noatak National Preserve (dots correspond sites located in Table 5 ; red dots represent lakes, purple dots represent rivers, green dots represent lagoons).

Summary of Past Work

The majority of sites in the Noatak Preserve sampled for fish were lakes. Studies by Young (1974), Alt (1978), and Webb (1980), looked at lake systems throughout the basin, mainly visiting larger lakes accessible to float planes. Species richness was typically low, rarely exceeding four fish species (Table 5). Composition varied by lake type; shallow lakes contained fish that prefer warmer conditions such as northern pike and deeper lakes contained cool-water fishes such as lake trout. A cursory review of these works shows that species composition also appears to vary temporally, as some lakes are used only seasonally as spawning areas for migratory species.

River systems, on the other hand, appear to become more species diverse as they approach the Chukchi Sea based on data available. This may be due in part to the Pacific salmon runs that spawn in the lower section of the river; these fish provide a large nutrient influx that can support a higher primary production and consequently higher density and diversity of fish (Wipfli et al. 1998). Capiello (1995) and Foy (1996), investigated characters of Dolly Varden runs within the Kugururok River, including timing of and duration of migrations. Both of these studies provided distinctly larger species list for this river than others nearby (12 species in Kugururok compared to six

species in both the Kelly and Nimiuktuk Rivers, which are downstream and upstream of it respectively). This suggests that many of these systems may have higher fish species diversity than previously thought, yet require more thorough surveys to document the seasonal variation in composition.

Studies prior to 1980 have listed Arctic charr within lake and river systems in the Noatak Drainage; however these observations have not been corroborated by recent collections. Recent modifications to taxonomy have identified these fish to be Dolly Varden charr (Armstrong and Morrow 1980). The current belief is that only Dolly Varden charr reside within this drainage (Fred DeCicco, pers. com.).

Current Projects and Future Recommendations

The Arctic Network initiated a fish inventory in the Preserve in 2006 (Ayers and Larsen, unpublished data). A total of twenty-six locations were surveyed in the Preserve, consisting of seventeen lake and nine river sites. Sites were located in the vicinity of Feniak Lake or in the lower Noatak near the confluence of the Noatak and Kelly Rivers. Sixteen of the twenty-four species thought to occur in the Preserve, as listed in NPSpecies, were observed during the survey. All listings found in NPSpecies for the Preserve are based on reviews of the literature, with no supporting documentation in the form of personal observations or voucher specimens. As such, the number of fish species in the Preserve may be lower than that listed in NPSpecies. Continued fish-inventory efforts will help provide a voucher-based tracking system for fishes.

Future recommendations include a survey of the southeastern portion of the Preserve, as well as a directed effort to capture migrating species during known periods of migration. Voucher specimens were taken for five species during the initial inventory; a continued voucher collection would ensure the best data available for species presence.



Plate 9. Mature male Dolly Varden (*Salvelinus malma*)

(Photo by F. DeCicco)

Discussion

We observed three major patterns during this literature review: 1) research in the Arctic Network Parklands has focused on rare and unique aquatic ecosystems within the parks; 2) the vast majority of studies have been short synoptic studies designed to assess species richness; and 3) little high-quality data were found.

In general, very little fisheries related research has occurred within Arctic Network Parks despite the diverse array of aquatic ecosystems that it contains. The Arctic Network comprises approximately 25% of National Park lands, and yet fewer than 100 sites have been sampled for fish. As noted in the park discussions, most of the sites were high-profile sites such as Walker Lake, Devil Mountain Lakes, the Kobuk River and the coastal lagoons in Cape Krusenstern. Sites that were visited frequently tended to be ecosystems that were renowned for sport fishing such as the Kobuk River or Walker Lake. This pattern of fish research is not too surprising given access to these parks is limited and costly. This pattern, however, focuses on the rare and unique aquatic features and overlooks common ecosystems and features that are not obvious to the casual observer. As a result the scope of inference is very limited.

The vast majority of studies completed in the Arctic Network Parklands have been short presence/absence studies that did not provide data on seasonal habitat use, migration, life history, or demography. Data currently available simply provided basic information regarding species distribution. The few intensive studies that have been conducted showed higher species richness and more complex life histories than was expected. Two graduate studies on the Kugururok River, that elapsed multi-month periods, provided species lists that were more than two times the size of those given for any of the other rivers in the region. These studies were able to capture seasonal variation in community composition that other shorter studies were not capable of detecting. Studies of this type provide essential information regarding demography and life histories of the fish species found in the Arctic Network Parklands. This information will be valuable to the Inventory and Monitoring Program. Although there are relatively few studies for the region, there are several sites that have had multiple visits over the years, which may provide baseline data that could prove useful in detecting long term trends.

Access issues and harsh weather conditions have had dramatic affects on the number and type of research that has taken place in the Arctic Network Parklands. Overcoming these obstacles will be a major challenge to developing an effective long-term monitoring program. Garnering experiences from past research to identify data gaps will be helpful in developing an effective program.

Appendix A

Freshwater & Anadromous Fish Species

Acronym	Common Name	Scientific Name	BELA	CAKR	GAAR	KOVA	NOAT
ABF	Alaska Blackfish	<i>Dalia pectoralis</i>	X*	XY	X	XY	XY
AC	Arctic Charr	<i>Salvelinus alpinus</i>	XY*	X	XY	X*	X
** It should be noted that many past reports of riverine Arctic charr are now accepted as Dolly Varden charr**							
ACI	Arctic Cisco	<i>Coregonus autumnalis</i>	X	X			
AG	Arctic Grayling	<i>Thymallus arcticus</i>	XY*	XY	XY*	XY	X
AGC	Angayukaksurak charr	<i>Salvelinus anaktuvukensis</i>			XY		
AL	Arctic Lamprey	<i>Lampetra japonica</i>	X	X		X	X
BCI	Bering Cisco	<i>Coregonus laurettae</i>	X	XY		X	X
BWF	Broad Whitefish	<i>Coregonus nasus</i>	X	XY	X	XY*	XY
BB	Burbot	<i>Lota lota</i>	X	X	XY	XY	XY
CNS	Chinook Salmon	<i>Oncorhynchus tshawytscha</i>	X	X		X	XY
CHS	Chum Salmon	<i>Oncorhynchus keta</i>	X	XY*	X	XY	XY
COS	Coho Salmon	<i>Oncorhynchus kisutch</i>	X	X			X
DV	Dolly Varden	<i>Salvelinus malma</i>	X*	XY	XY	XY	XY
HWF	Humpback Whitefish	<i>Coregonus clupeaformis</i>	X	XY	XY	X*	XY
LT	Lake Trout	<i>Salvelinus namaycush</i>			XY	XY*	XY
LCI	Least Cisco	<i>Coregonus sardinella</i>	XY*	XY	XY	XY*	XY
LNS	Longnose Sucker	<i>Catostomus catostomus</i>	X	XY	X	XY	XY
NSS	Nine-Spine Stickleback	<i>Pungitius pungitius</i>	XY	XY	XY	X	XY
NP	Northern Pike	<i>Esox lucius</i>	X*	XY	XY	XY*	XY
PS	Pink Salmon	<i>Oncorhynchus gorbuscha</i>	XY	XY		XY	XY
PSM	Pond Smelt	<i>Hypomesus olidus</i>	X*	X		X	
RSM	Rainbow Smelt	<i>Osmerus mordax</i>	X	XY		XY	X
RWF	Round Whitefish	<i>Prosopium cylindraceum</i>	X	XY	XY*	XY*	XY
SHF	Sheefish (Inconnu)	<i>Stenodus leucichthys</i>	X	Y	XY	XY*	X
SSC	Slimy Sculpin	<i>Cottus cognatus</i>	X*	X	XY*	X	XY
SKS	Sockeye Salmon	<i>Oncorhynchus nerka</i>					XY
TSS	Three-Spine Stickleback	<i>Gasterosteus aculeatus</i>		XY			

X = Listed as present in Park by NPSpecies

Y = Listed in Park by Literature Review

* = Voucher specimens were collected in the Park unit.

Appendix B:

Marine Fish Species

Acronym	Common Name	Scientific Name	BELA	CAKR	NOAT
	Alaska plaice	<i>Pleuronectes quadritub</i>	X	X	
	Arctic alligatorfish	<i>Aspidophoroides olriki</i>	X	X	
	Arctic Cod	<i>Boreogadus saida</i>	X	X	
	Arctic Flounder	<i>Liopsetta glacialis</i>		Y	
	Arctic sculpin	<i>Myoxocephalus scorpioides</i>	X	X	
	Arctic Shanny	<i>Stichaeus punctatus</i>	X	X	
	Arctic Staghorn sculpin	<i>Gymnocanthus tricuspis</i>	X*	X*	
AFL	Arrowtooth flounder	<i>Atheresthes stomias</i>	X	X	
BSC	Belligerent sculpin	<i>Megalocottus platycephalus</i>	X	XY	
	Bering Flounder	<i>Hippoglossoides robustus</i>	X	X	
	Brightbelly sculpin	<i>Microcottus sellaris</i>	X	X	
	Capelin	<i>Mallotus villosus</i>	X	X	
	Coastrange Sculpin	<i>Cottus aleuticus</i>	X	X	
	Eyeshade sculpin	<i>Nautichthys pribilovius</i>	X	X	
	Fish Doctor	<i>Gymnelis viridis</i>	X	X	
FHS	Fourhorn Sculpin	<i>Myoxocephalus quadricornis</i>	X*	XY	X
	Fourline snakeblenny	<i>Eumesogrammus praecisus</i>	X	X	
	Leister sculpin	<i>Enophrys lucasi</i>	X	X	
	Marbled eelpout	<i>Lycodes raridens</i>	X	X	
PH	Pacific herring	<i>Clupea harengus sp</i>	X	XY	
	Pacific Sand Lance	<i>Ammodytes hexapterus</i>	X	X	
	Plain sculpin	<i>Myoxocephalus jaok</i>	X	X	
	Ribbed Sculpin	<i>Triglops pingeli</i>	X	X	
	Rough hookear sculpin	<i>Artediellus scaber</i>	X	X	
SFC	Saffron Cod	<i>Eleginus gracilis</i>	X	XY	
	Shorthorn sculpin	<i>Myoxocephalus scorpius</i>	X	X	
	Slender eelblenny	<i>Lumpenus fabricci</i>	X	X	
	Snake prickleback	<i>Lumpenus sagitta</i>	X	X	
	Spatulate sculpin	<i>Icelus spatula</i>	X	X	
SFL	Starry flounder	<i>Platichthys stellatus</i>	X	XY	
	Stout eelblenny	<i>Lumpenus medius</i>	X	X	
	Wattled eelpout	<i>Lycodes palearis</i>	X	X	
	Whitespotted greenling	<i>Hexagrammos stelleri</i>	X	X	
YFS	Yellowfin sole	<i>Limanda aspera</i>	X	XY	

X = Listed as present in Park by NPSpecies

Y = Listed in Park by Literature Review

* = Voucher specimens were collected in the Park unit.

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