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Katmai National Park and Preserve and Alagnak Wild River

Natural Resource Condition Assessment

Natural Resource Report NPS/SWAN/NRR—2015/1095

ON THE COVER
Grizzly bear near Brooks Camp in Katmai National Park
Photograph by Kevin Stark, Saint Mary's University of Minnesota

Katmai National Park and Preserve and Alagnak Wild River

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Executive Summary

The Natural Resource Condition Assessment (NRCA) Program aims to provide documentation about the current conditions of important park natural resources through a spatially explicit, multi-disciplinary synthesis of existing scientific data and knowledge. Findings from the NRCA will help Katmai National Park & Preserve (KATM) as well as the Alagnak Wild River (ALAG) managers to develop near-term management priorities, engage in watershed or landscape scale partnership and education efforts, conduct park planning, and report program performance (e.g., Department of the Interior's Strategic Plan "land health" goals, Government Performance and Results Act).

The objectives of this assessment are to evaluate and report on current conditions of key park resources, to evaluate critical data and knowledge gaps, and to highlight selected existing stressors and emerging threats to resources or processes. For the purpose of this NRCA, staff from the National Park Service (NPS) and Saint Mary's University of Minnesota – GeoSpatial Services (SMUMN GSS) identified key resources, referred to as "components" in the project. The selected components include natural resources and processes that are currently of the greatest concern to park management at KATM and ALAG. The final project framework contains 11 resource components, each featuring discussions of measures, stressors, and reference conditions.

This study involved reviewing existing literature and, where appropriate, analyzing data for each natural resource component in the framework to provide summaries of current condition and trends in selected resources. When possible, existing data for the established measures of each component were analyzed and compared to designated reference conditions. The discussions for each component, found in Chapter 4 of this report, represent a comprehensive summary of current available data and information for these resources, including unpublished park information and perspectives of park resource managers, and present a current condition designation when appropriate. Each component assessment was reviewed by KATM park resource managers and NPS Southwest Alaska Network (SWAN) staff.

Overall, the condition of the resources in this park is good. However, threats and stressors of high concern may cause resource impact in the near future. Several park-wide threats and stressors influence the condition of priority resources in KATM and ALAG. Those of primary concern include climate change and oil spills. Understanding these threats, and how they relate to the condition of these resources, can help the NPS prioritize management objectives and better focus conservation strategies to maintain the health and integrity of park ecosystems.

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Acronyms and Abbreviations

AAR- Accumulation Area Ratio

ACRC- Alaska Climate Research Center

ADF&G- Alaska Department of Fish and Game

ALAG- Alagnak Wild River

ANIA- Aniakchak National Monument and Preserve

ANILCA- Alaska National Interest Lands Conservation Act

AWC- Anadromous Waters Catalog

CUA- Commercial Use Authorization

ELA- Equilibrium Line Altitude

ENSO- El Niño Southern Oscillation

EPA- Environmental Protection Agency

EVOS- Exxon Valdez Oil Spill Trustee Council

FRMP- Fishery Resource Monitoring Program

FRST- Fishery Resources Status and Trends

GIS- Geographic Information Systems

GLIMS- Global Land Ice Measurements from Space

GMUs- Game Management Units

GSl- Yearly Growing Season Length

GSS- GeoSpatial Services

HUC- Hydrologic Unit Codes

I&M- Inventory & Monitoring

ID- Yearly Ice Days

IRMA - Integrated Resource Management Application

KATM- Katmai National Park and Preserve

KEFJ- Kenai Fjords National Park

Acronyms and Abbreviations (continued)

KTPR- Katmai National Preserve

LACL- Lake Clark National Park and Preserve

NPS- National Park Service

NRCA- Natural Resource Condition Assessment

PRISM- Parameter Regression on Independent Slopes Model

PDO- Pacific Decadal Oscillation

RAWS- Remote Automated Weather Station

RSS- Resource Stewardship Strategy

SWAN- Southwest Alaska Network

SMUMN- Saint Mary's University of Minnesota

USGS- United States Geological Survey

USGS/EROS- United States Geological Survey/Earth Resources Observation and Science

VTTS- Valley of Ten Thousand Smokes

WRCC- Western Regional Climate Center

Chapter 1: NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, hereafter “parks.” NRCAs also report on trends in resource condition (when possible), identify critical data gaps, and characterize a general level of confidence for study findings. The resources and indicators emphasized in a given project depend on the park’s resource setting, status of resource stewardship planning and science in identifying high-priority indicators, and availability of data and expertise to assess current conditions for a variety of potential study resources and indicators.

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement—not replace—traditional issue- and threat-based resource assessments. As distinguishing characteristics, all NRCAs:

- are multi-disciplinary in scope;[1]
- employ hierarchical indicator frameworks;[2]
- identify or develop reference conditions/values for comparison against current conditions;[3]
- emphasize spatial evaluation of conditions and GIS (map) products;[4]
- summarize key findings by park areas; and[5]
- follow national NRCA guidelines and standards for study design and reporting products.

NRCAs Strive to Provide…

Credible condition reporting for a subset of important park natural resources and indicators

Useful condition summaries by broader resource

The breadth of natural resources and number/type of indicators evaluated will vary by park.

[2] Frameworks help guide a multi-disciplinary selection of indicators and subsequent “roll up” and reporting of data for measures ⇨ conditions for indicators ⇨ condition summaries by broader topics and park areas

[3] NRCAs must consider ecologically-based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions. Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-on response (e.g., ecological thresholds or management “triggers”).

[4] As possible and appropriate, NRCAs describe condition gradients or differences across a park for important natural resources and study indicators through a set of GIS coverages and map products.

[5] In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on an area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested.

Although the primary objective of NRCAs is to report on current conditions relative to logical forms of reference conditions and values, NRCAs also report on trends, when appropriate (i.e., when the underlying data and methods support such reporting), as well as influences on resource conditions. These influences may include past activities or conditions that provide a helpful context for understanding current conditions, and/or present-day threats and stressors that are best interpreted at park, watershed, or landscape scales (though NRCAs do not report on condition status for land areas and natural resources beyond park boundaries). Intensive cause-and-effect analyses of threats and stressors, and development of detailed treatment options, are outside the scope of NRCAs.

Due to their modest funding, relatively quick timeframe for completion, and reliance on existing data and information, NRCAs are not intended to be exhaustive. Their methodology typically involves an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in existing data and knowledge bases across the varied study components.

The credibility of NRCA results is derived from the data, methods, and reference values used in the project work, which are designed to be appropriate for the stated purpose of the project, as well as adequately documented. For each study indicator for which current condition or trend is reported, we will identify critical data gaps and describe the level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject-matter experts at critical points during the project timeline is also important. These staff will be asked to assist with the selection of study indicators; recommend data sets, methods, and reference conditions and values; and help provide a multi-disciplinary review of draft study findings and products.

NRCAs can yield new insights about current park resource conditions but, in many cases, their greatest value may be the development of useful documentation regarding known or suspected resource conditions within parks. Reporting products can help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about current park resource conditions to various audiences. A successful NRCA delivers science-based information that is both credible and has practical uses for a variety of park decisionmaking, planning, and partnership activities.

Important NRCA Success Factors

Obtaining good input from park staff and other NPS subject-matter experts at critical points in the project timeline

Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures ⇨ indicators ⇨ broader resource topics and park areas)

Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings

However, it is important to note that NRCAs do not establish management targets for study indicators. That process must occur through park planning and management activities. What an NRCA can do is deliver science-based information that will assist park managers in their ongoing, long-term efforts to describe and quantify a park's desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning[6] and help parks to report on government accountability measures.[7] In addition, although in-depth analysis of the effects of climate change on park natural resources is outside the scope of NRCAs, the condition analyses and data sets developed for NRCAs will be useful for park-level climate-change studies and planning efforts.

NRCA Reporting Products…

Provide a credible, snapshot-in-time evaluation for a subset of important park natural resources and indicators, to help park managers:

Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations

(near-term operational planning and management)

Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values

(longer-term strategic planning)

Communicate succinct messages regarding current resource conditions to

NRCAs also provide a useful complement to rigorous NPS science support programs, such as the NPS Natural Resources Inventory & Monitoring (I&M) Program.[8] For example, NRCAs can provide

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[6]An NRCA can be useful during the development of a park's Resource Stewardship Strategy (RSS) and can also be tailored to act as a post-RSS project.

[7] While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget.

[8] The I&M program consists of 32 networks nationwide that are implementing "Vital Signs" monitoring in order to assess the condition of park ecosystems and develop a stronger scientific basis for stewardship and management of natural resources across the National Park System. "Vital Signs" are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

current condition estimates and help establish reference conditions, or baseline values, for some of a park's Vital Signs monitoring indicators. They can also draw upon non-NPS data to help evaluate current conditions for those same Vital Signs. In some cases, I&M data sets are incorporated into NRCA analyses and reporting products.

Over the next several years, the NPS plans to fund a NRCA project for each of the approximately 270 parks served by the NPS I&M Program. For more information on the NRCA program, visit http://nature.nps.gov/water/nrca/index.cfm

Chapter 2 Introduction and Resource Setting

2.1 Introduction

2.1.1 Enabling Legislation

The area that would become Katmai National Park and Preserve (KATM) first appeared as a place of interest after the volcanic activity of 1912. In the largest eruption of the 20th century, the Novarupta Volcano devastated the area surrounding KATM (Hildreth and Fierstein 2012). Adjacent to Novarupta, Mount Katmai's peak (2,286 m [7,500 ft]) was reduced to a 5.5 km^3 (1.3 mi^3) caldera with a floor elevation of just 994 m (3,260 ft) (Hildreth and Fierstein 2012; Photo 1).

Photo 1. Katmai caldera (NPS photo).

Years of study and interest in KATM resulted in it being designated a national monument on 24 September 1918 by President Woodrow Wilson (NPS 1986). Initially, the establishment of this monument protected 440,299 ha (1,088,000 ac) of KATM including the Novarupta Volcanoe in the newly formed Valley of Ten Thousand Smokes (VTTS). Then, in 1931, President Herbert Hoover extended the boundaries of the monument to also preserve the coastline to the Douglas River and most of the Naknek watershed; this increased the area of KATM to 1,091,678 ha (2,697,590 ac). The extension of the monument was to ensure the protection of "historic and scientific interest" and wildlife, including moose (*Alces alces*) and the large population of brown bears (*Ursus arctos*) (NPS 1986). On 4 August 1942, President Franklin D. Roosevelt added the islands in Shelikof Strait that are adjacent and within 8 km (5 mi) of the park boundary to protect marine mammals that inhabit the islands and prevent poachers from utilizing them as bases (NPS 1986).

President Lyndon B. Johnson increased the size of the monument again on 20 January 1969 to 1,131,963 ha (2,797,137 ac) with the addition of the western end of Naknek Lake. This addition included the shoreline, to ensure the health and ecological preservation of the area (NPS 1986). Finally, the monument increased to its current size of approximately 1.6 million ha (4 million ac) with an addition by President Jimmy Carter of 566,561 ha (1.4 million ac) on 1 December 1978 with the intent to protect habitat used by brown bears and salmon (NPS 1986).

In 1980, The Alaska National Interest Lands Conservation Act (ANILCA) changed the designation of the monument to a national park and added 124,643 ha (308,000 ac) as a national preserve. Sec. 101 states the general purpose of KATM:

> To preserve for the benefit, use, education, and inspiration of present and future generations certain lands and waters in the state of Alaska that contain nationally significant natural scenic, historic, archeological, geological, scientific, wilderness, cultural, recreational and wildlife values. (NPS 1986, p. 5)

> To preserve unrivaled scenic and geological values associated with natural landscapes; to provide for the maintenance of sound populations of, and habitat for, wildlife species of inestimable value to the citizens of Alaska and the Nation, Including those species dependent on vast, relatively undeveloped areas; to preserve in their natural state extensive unaltered arctic tundra, boreal forest, and coastal rainforest ecosystems; to protect and preserve historic and archeological sites, rivers, and lands, and to preserve wilderness resource values and related recreational opportunities including but not limited to hiking, canoeing, fishing, and sport hunting, within large arctic and subarctic wildlands and on free-flowing rivers; and to maintain opportunities for scientific research and undisturbed ecosystems. (NPS 1986, p. 5 and 7)

> "…consistent with management of fish and wildlife in accordance with recognized scientific principles and the purposes for which each conservation system unit is established, designated, or expanded by or pursuant to this act, to provide the opportunity for rural residents engaged in a subsistence way of like to continue to do so." (NPS 1986, p. 7)

ANILCA Section 202(a) continues to define the purposes for the additions to KATM and the preserve:

> "…to protect habitats for, and populations of, fish and wildlife, including, but not limited to, high concentrations of brown/grizzly bears and their denning areas' to maintain unimpaired the water habitat for significant salmon populations; and to protect scenic, geological cultural, and recreational features." (NPS 1986, p. 7)

The Alagnak River begins in KATM. The upper 101.5 km (63 mi) of the river was designated as a Wild River by the passing of Section 601(25) , 603(44), and 605(b) of ANILCA in1980. The Alagnak Wild River (ALAG) is managed by the same policies and with the same general purpose as KATM (NPS 1986). The purpose of Section 605 was to preserve and protect the "free-flowing condition of the river" (NPS 2008, p. 6). The Alagnak River is free from impoundments, inaccessible by road, and is the most popular fly-in fishery in southwest Alaska (NPS 2008).

2.1.2 Geographic Setting

KATM **(**Plate 1**)** is located at the head of the Alaska Peninsula between Shelikof Strait in the Gulf of Alaska and Bristol Bay (Nagorski et al. 2007) and is approximately 1.6 million ha (4 million ac) (NPS 1986, Nagorski et al. 2007). KATM encompasses 795 km (497 mi) of broad coastline, and about 20 off-shore islands (Nagorski et al. 2007). A large portion of the park is located in Lake and Peninsula Borough of Alaska which has a total population of 1,631 people (U.S. Census 2010).The nearest town to KATM is King Salmon, which is 8 km (5 mi) from the park (Nagorski et al. 2007). King Salmon is located in Bristol Bay Borough with a population of 997 (U.S. Census 2010).

Wetlands are important features in KATM, in part because they link terrestrial habitats to aquatic environments. A wide variety of wetland types (marine, estuarine, riverine, paulstrine, and lacustrine) are represented throughout KATM, and cover an area greater than 4,000 km2 (1,500 mi2), approximately 20% of the unit (Nagorski et al. 2007).

KATM also contains over 50 glaciers, approximately 5% of the park's total area (Giffen et al 2007). However, due to the lack of research performed on KATM glaciers, only seven glaciers are named (Giffen et al. 2007). While valley glaciers are the most commonpermanent snow field type, the park also contains small cirque glaciers and numerous small, isolated snowfields. Most KATM glaciers terminate on land with a few terminating in lakes. Three peaks represent the central areas of accumulation. These peaks (all over 2,300 m [7,545.9 ft] above sea level) are also areas of active volcanic activity (Giffen et al. 2007). The eruption of Novarupta in 1912 deposited a layer of volcanic ash over several of the glaciers in the park (Giffen et al. 2007). Most glaciers are retreating, as evidenced by large amounts of moraine cover; however, the retreat of several glaciers appears to be slowed due to the layer of volcanic ash covering them from the 1912 Novarupta volcanic eruption (Nagorski et al. 2007).

Volcanism is a key determinant of the landscape in KATM. The Novarutpa eruption ejected large quantities of ash and pumice which covered 103.6 km^2 (40 mi^2) of an adjacent valley. Some areas were buried by as much as 213 m (700 ft) of ash (NPS 1986). As a result, a large caldera formed after Mount Katmai collapsed. After the eruption, thousands of fumaroles (steam and gas vents) developed as the volcanic deposits cooled, giving the valley its name, Valley of Ten Thousand Smokes (Photo 2). Today, there are no active fumaroles (NPS 1986).

Photo 2. The Valley of Ten Thousand Smokes at sunset (NPS photo).

Soil composition varies across different elevations in KATM. Soils are sparse in high elevations, where coarse rubble deposits or exposed bedrock are common. At mid to low elevations, as well as hilly areas, silty soils and sand volcanic ash cover the stony gravel loam or bedrock. The soils found in valley bottoms and in deep depressions of the foothills are composed of partially decomposed peat and fibrous peat with lenses of volcanic ash, respectively (NPS 1986). The soils in the lowlands of the Naknek drainage are deep, poorly drained loam, which is overylain by peat mats and permafrost (NPS 1986).

KATM often has inclement weather, such as severe winds, and is known to have rapidly changing weather conditions (NPS 1986). During the summer months, average high temperatures reach 17°C (63°F), while the low temperatures average -14°C (7°F) in the winter months (Table 1). KATM experiences moderate precipitation rates with the rainier months occurring from August through October.

Table 1. Monthly temperature and precipitation normals (1955-2005) for KATM / ALAG (Station: 504766, King Salmon WSO AP, Alaska) (WRCC 2011).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Temperature (°C)													
Max	-5.3	-3.8	-0.5	4.9	11.3	15.5	17.5	16.7	12.7	4.8	-1.0	-4.8	5.7
Min	-13.5	-12.6	-9.9	-4.2	1.2	5.4	8.2	8.1	4.2	-3.7	-9.1	-13.5	-3.3
Average Precipitation (cm)													
Total	2.6	1.9	2.3	2.5	3.4	4.3	5.7	7.7	7.6	5.2	3.9	3.2	49.8

The Alagnak River is 127 km (79 mi) long; however, the portion of the river that is designated a wild river is 101.5 km (63 mi) long (NPS 1986; Photo 3). The river originates in Kukaklek Lake which is located in the Aleutian Range of northern Katmai Preserve and drains an area of 3,600 km^2 (2,237 mi^2). This highly braided and twisted river ultimately flows west and empties into Bristol Bay.

Photo 3. Rapids on the Alagnak River (NPS photo).

2.1.3 Visitation Statistics

Most visitors access KATM by the use of floatplanes; however, boats can also be used for access along the coastline. Zodiacs (inflatable boats) are used to bring visitors close to shore for wildlife viewing, and jet boats are used to navigate visitors up shallow streams (NPS 2003a). In 2010, the number of recreational visits totaled 55,172 (NPS 2010). The summer months (June-September) had the most visitors on average (NPS 2010).

Photo 4. Bear viewing platform at Brooks Camp (NPS photo by R. Wood).

Many visitors come to KATM to use the Brooks Camp developed area, which is located at the mouth of the Brooks River (NPS 1986, NPS 2010). Brooks Camp is used by many visitors for overnight stays to fish and observe brown bears (NPS 1986). All visitors must be briefed on bear safety at the visitor center before arriving to Brooks Camp because the camp is located in prime brown bear habitat (NPS 1986, NPS 2010). The Brooks Camp Complex includes a visitor center, viewing platform (Photo 4), campgrounds, trails, and a floating foot-bridge (NPS 1986). This site also allows visitors to plan backcountry trips and to access the VTTS via tour bus.

Hiking in the southwestern corner of the park in the tundra highlands provides visitors with views that overlook Angle and Takayoto Creeks. Guests can also experience scenic views, boating, and wildlife near Grosvenor and Coville Lakes (NPS 1986). During the operating season daily tours of the VTTS are available. River trips and sport fishing are also available at KATM.

Other activities that are available for visitors include canoeing trips on Brooks Lake, Grosvenor Lake and River, Covill Lake, Savonski River, and in the Bay of Islands. Visitors can also float the Nonvianuk and Alagnak Rivers (NPS 1986).

The primary attractions for ALAG visitors are sport and subsistence fishing (NPS 1986). Other popular activities include sport hunting, trapping, rafting, and boat trips on the river and its corridor. Fishermen and hunters visit the park during all times of the year, but most fishing visits occur during the summer (Spang et al. 2006). There are eight lodges located along the river to accommodate fishers, hunters, rafters, and other visitors. The average number of days for overnight stays on the ALAG was seven (Spang et al. 2006).

2.2 Natural Resources

2.2.1 Ecological Units and Watersheds

KATM and ALAG are part of EPA's Pacific Northwest Region 10. This region provides support for Alaska, Idaho, Oregon, Washington, and 271 Native Tribes (EPA 2011). KATM and ALAG are a part of both the Alaska Peninsula Mountain ecoregion and the Bristol Bay-Nushagak Lowlands ecoregion (Plate 2). The Alaska Peninsula Mountains ecoregion includes a portion of the Kodiak Islands and runs down the eastern side of the Aleutian Islands. This region's climate is considered marine, with high annual rates of precipitation (Griffith 2010). The vegetation found throughout includes dwarf shrubs, willow (*Salix* spp.), birch (*Betula* spp.), and alder (*Alnus* spp.). The Aleutian Mountains give this region a large range of elevations (sea level to 2,600 m [8,530 ft]) and include several volcanic mountains (Griffith 2010). The volcanic activity has heavily influenced soil development, as many soils have been formed in "deposits of volcanic ash and cinder" (Griffith 2010, p. 19). Wildlife in the region includes moose, brown bear, caribou, as well as many marine mammals.

The Bristol Bay-Nushagak Lowlands ecoregion (Plate 2) includes lowlands that are found northwest of Iliamna Lake and south down the western side of the Aleutian Islands. A majority of the ALAG is located within this ecoregion. This lowlands region has a marine climate with a slight to moderate rate of annual precipitation (Griffith 2010). A variety of vegetation occurs in this ecoregion, including shrub and wetland communities with species such as crowberry (*Empetrum* spp.), willow, birch, alder, and lichens. Discontinuous permafrost is scattered throughout the region and the soil is well-drained (Griffith 2010). Wildlife associated with Bristol Bay includes brown bear, eagles, osprey (*Pandion haliaetus*) and a variety of waterfowl. Sockeye salmon (*Oncorhynchus nerka*), rainbow trout (*Oncorhynchus mykiss*), and Pacific cod (*Gadus macrocephalus*) are just a few of the fish species likely to be found in the area (NPS 2015).

A large portion of KATM drains into Bristol Bay to the west, including three sub-basins (Level 4 Hydrologic Unit Codes [HUC]): Lake Iliamna, Naknek Lake, and Egegik Bay. These three sub-basins contain 25 different watersheds (Level 5 HUC). Along with the Alagnak, the Naknek River is a large river draining KATM. The eastern portion of KATM drains coastally into the Shelikof Straight portion of the Cook Inlet (Plate 3).

Photo 5. A KATM brown bear with a salmon (NPS photo).

2.2.2 Resource Descriptions

<u>KATM</u>

KATM is home to the largest population of brown bears in North America (Photo 5; NPS 1986). Brown bears in KATM emerge from hibernation by the middle of May and typically feed on sedges, grasses, forbs, carrion, and prey animals. In the large bays near the coast, brown bears feed in salt marshes, and on marine invertebrates. The salmon spawning season (late June to October) influences brown bear distribution in the park and preserve, as they become the brown bears' primary source of food. Berries are also an important food source in KATM during August (NPS 2003a).

Moose have been known to inhabit the Alaska Peninsula since the 1900s. This population of moose became abundant in the 1950s, peaking in the 1960s. The population declined considerably in the 1970s due to low calf recruitment. Despite the decline in the 1970s, moose are still common in KATM and throughout the Alaska Peninsula.

In KATM, there are 180 documented species of birds: 81 landbird species, 64 inland waterfowl species, and 35 seabird species (NPS 2003a). Of the landbirds found in KATM, bald eagles (*Haliaeetus leucocephalus*) are the most surveyed (NPS 2003a). The most abundant coastal birds in KATM include the glaucous-winged gull (*Larus glaucescens*), black-legged kittiwake (*Rissa tridactyla*), black oystercatcher (*Haematopus bachmani*), and harlequin duck (*Histrionicus histrionicus*) (Nagorski et al. 2007).

The rivers in KATM, especially the Alagnak, have a variety of fish. Some important fish species found in KATM river systems include rainbow trout, lake trout (*Salvelinus namaycush*), Dolly Varden (*S. malma*), and especially several species of salmon (e.g., coho [*Oncorhynchus kisutch*], chinook [*O. tshawytscha*], chum [*O. keta*], sockeye [*O. nerka*], and pink [*O. gorbuscha*]) (NPS 1986; Photo 6). KATM provides vital spawning areas for many salmon species. Migration from the sea to spawn in freshwater streams provides essential nutrients to the upstream flow, and ensures the integrity of the park ecosystem (NPS 1986).

Photo 6. Sockeye salmon preparing to spawn near Lake Brooks (NPS photo).

ALAG

The AlagnakWild River has a variety of fish within its waters. The NPS lists 23 species of fish within ALAG, seven of which are listed as "probably present" and 16 species listed as "present" (NPS 2015). The Alagnak River has a significant number of rainbow trout, arctic grayling (*Thymallus thymallus*), and northern pike (*Esox lucius*). The river also offers refuge to all five of the Pacific salmon species found in its waters (NPS 2015).

One hundred twenty three species of birds are listed by the NPS within ALAG (NPS 2015). Seventy four of these species are listed as "present" with remaining forty nine species listed as "probably present" (NPS 2015). The NPS also lists thirty five mammals within ALAG. Only two species (moose, brown bear) are listed as "present" whereas thirty one species are listed as "probably present" and 2 species are listed as "unconfirmed" (NPS 2015). The many animals believed to be utilizing this river area include fox (*Vulpes vulpes*), wolves (*Canis lupus*), and caribou (*Rangifer tarandus*) (NPS 2003a).

ALAG has a variety of vegetation types along the river corridor. The plants present include spruce (*Picea* spp.), willows, salmonberry (*Rubus spectabilis*), blackberry (*Rubus articus*), ferns, wild celery (*Vallisneria americana*), and sourdock (*Rumex crispus*) (NPS 2015).

2.2.3. Resource Issues Overview

There are several events that have altered the resources of KATM. The Exxon Valdez oil spill in the spring of 1989 was one of the most environmentally devastating human-caused events to affect the park (NPS 1990, as cited by Nagorski et al. 2007). The run-aground tanker leaked roughly 10.8 million gallons of crude oil into Prince William Sound, which eventually drifted south through Shelikof Strait (Nagorski et al. 2007). The shoreline of the park in this area received about two to four percent of the total spill volume (NPS 1990, as cited by Nagorski et al. 2007). Many organisms were harmed due to the toxicity of the compounds in the oil (Nagorski et al. 2007). The vegetation in the intertidal region was also damaged, adding to the stress of marine species. Sensitive species impacted in the KATM region include the Steller sea lion (*Eumetopias jubatus*) and harbor seal (*Phoca vitulina*).

Climate change, a stressor on a global scale, has been affecting the parks and surrounding areas. Since 1950, the climate in Alaska has warmed nearly 2°C (3.6 °F), and by 2100, the climate is expected to increase 3°-10°C (5.4°-18°F) (Nagorski et al. 2007). This increase in temperature alters precipitation patterns, snow accumulation, stream flow, and permafrost landscape (Nagorski et al. 2007). Permafrost melt can cause extreme alterations to landscape, which in turn can result in large losses in vegetation. Glaciers in the region have been retreating for years, increasing runoff, erosion, and altering stream flow patterns (Nagorski et al. 2007). The Kittlitz's murrelets (*Brachyramphus brevirostris*) are a sensitive species dependent on glaciated streams and the retreating glaciers appear to be contributing to the decline of this species (Nagorski et al. 2007). Climate change can increase evapotranspiration as well, which may result in a reduction of the wetlands currently covering 4,000 km^2 of the park (Weeks 1999, as cited by Nagorski et al. 2007).

Human use impacts the park's resources in a few ways. Hunting and subsistence fishing have helped the preserve maintain healthy wildlife populations, while intensive sport fishing for rainbow trout has been known to disrupt the natural balance in the KATM river systems. Rainbow trout feed on salmon eggs; when trout harvests are too high, the balance of salmon in the stream is altered (NPS 1986). Salmon, however, are most threatened by the commercial fishing industry. It is important that the salmon stock remain healthy and the necessary passages are maintained, as the fish play a critical role in relation to many other park resources (Nagorski et al. 2007).

Interactions between bears and humans have increased in some commonly visited areas of the park. The Brooks Camp area is located near a major summer and fall brown bear feeding area. The numbers of both bears and humans using the area has increased since the development of the camp.

This increase creates a significant need for management to prevent serious conflicts (NPS 1986). As of 2007, there were 71 individual bears sited at Brooks Camp in July alone, and 49 bears sighted in the fall (Olson, NPS unpublished data, as cited by Hamon et al. 2007).

Several exotic plant and fish species have been found in the park. The Atlantic salmon (*Salmo linnaeus*) was likely introduced accidentally to the area (Nagorski et al. 2007). These salmon are a threat to native fisheries because they could spread disease, compete with native fish, and even become an apex predator (ADF&G 2002, as cited by Nagorski et al. 2007). Northern pike have also been found in KATM water systems; they mainly pose a threat because they prey on the smaller salmon and trout, which can alter species composition (Mann et al. 1998, Bennett et al. 2006; as cited by Nagorski et al. 2007). The exotic plant species found in the interior of the park include bluegrass (*Poa* spp.), pineapple weed (*Matricaria discoidea*), and shepherd's purse (*Capsella bursa-pastoris*) (Densmore et al. 2001, as cited by Nagorski et al. 2007).

Pests and disease are additional possible threats to the interior and coastal regions of KATM. The two known threats reported to be in or near the park are the spruce bark beetle (*Ips typographus*) and chytridiomycosis (Nagorski et al. 2007). The spruce bark beetle is an insect known for high mortality rates in spruce trees across North America. Chytridiomycosis is an infectious waterborne fungus that has contributed to the population decline of native amphibians, including wood frogs; it has not been observed in KATM, but occurs just to the north in Kenai Fjords National Park (KEFJ) (Reeves and Green 2006, as cited by Nagorski et al. 2007).

2.3 Resource Stewardship

2.3.1 Management Directives and Planning Guidance

The main goals for resource management for KATM, found in the general management plan (NPS 1986), are:

- Identify, protect, and perpetuate Katmai's outstanding wildlife, vegetation, water, and volcanic features in their wilderness environment.
- Maintain the park and preserve as an area where the Alaskan brown bears can exist as naturally as possible with minimal adverse effects from humans.
- Preserve the natural spawning conditions for the red salmon, rainbow trout, and other fish native to the park and preserve.
- Manage the natural and physical resources of the park and preserve to ensure the perpetuation of the factors basic to the area's establishment.
- Work cooperatively and interdependently with the Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service in regulating consumptive uses of natural resources in Katmai National Preserve so as to maintain natural population dynamics.

- Encourage and participate in research efforts to ensure adequate information for sound management decisions concerning the park/preserve’s natural, cultural, and physical resources.

- Identify, preserve, and protect the park/preserve's cultural resources, including the remains of early 20th century activities and the sites associated with earlier cultures in a manner consistent with historic preservation laws, NPS policies, and the purpose of the area. Particular attention will be paid to the known locations, such as Fure’s cabin, the village of Old Savonoski, and the Brooks River archeological district.

- Locate and identify known historic and prehistoric sites and structures for possible designation to the National Register of Historic Places and Alaska Heritage Resource Survey.

The goals of the visitor use and interpretation plan inside KATM’s general management plan (NPS 1986) are:

- Foster visitor understanding of and appreciation for the dramatic natural forces responsible for the park’s volcanic features, Alaskan cultural history, and superlative fish and wildlife populations.

- In accordance with the provisions of ANILCA, provide for sport hunting and trapping in the national preserve.

- Provide visitors with adequate means of access to the park, consistent with the wilderness character of the area.

- Interpret the park and preserve through non-sophisticated, highly personal techniques and programs, consistent with KATM visitor use pattern and physical resource values.

- Encourage visitor activities that are appropriate to Katmai’s natural environment, including backpacking, camping, hiking, sight-seeing, fishing, canoeing, and kayaking.

- Through programs, informal talks, and backcountry permits, provide information to visitors to minimize camping impacts on natural areas.

Bear management inside KATM is important since the park holds one of the largest non-hunted brown bear populations (NPS 1983a). The park has created preventive and responsive management objectives to minimize visitor bear confrontations. The goals, as listed in the bear management plan (NPS 1983a), are:

Preventive:

- Provide information and safety programs (e.g., bear biology, bear appreciation, surprise encounters, and food safety) to all visitors, especially backcountry travelers, about bears and their behaviors.

- Extra precautions should be made when KATM employees and visitors use/carry food (e.g., placing food in plastic bags, using overhead caches to hold unused food, hiking with non-odorous foods, emptying garbage from campsite daily, and not feeding bears fish if surprise encounter occurs).
- Observations will be made by the park employees about any visitors coming within 50 m of a bear. When a visitor returns or moves successfully away from a bear, during an encounter, the motivation and bear/human interactions are discussed. If the closeness of a visitor appears to be harassing the bears, a report is later filed.

Responsive:

- Create and follow decision guidelines to adequately protect visitors, the bear population, and keep human/bear interacts at a minimum in the park.

The KATM fire management plan (NPS 1983b) was created to present park managers with adequate guidelines for controlling fire as an ecological process. The fire management goals are:

- Suppress all fires that are not naturally ignited;
- Protect human life, man-made structures, cultural resources, and non NPS lands;
- Maintain habitat that is critical to the survival of sensitive and endangered species; and
- Allow natural processes to occur by permitting wildfires to burn to the full extent.

2.3.2 Status of Supporting Science

The Southwest Alaska Inventory and Monitoring Network (SWAN) identifies key resources network-wide and for each of its parks that can be used to determine the overall health of the parks. These key resources are called Vital Signs. In 2006, the SWAN completed and released a Vital Signs monitoring plan (Bennett et al. 2006). Table 2 shows the network Vital Signs selected for monitoring in KATM and ALAG.

Table 2. SWAN Vital Signs selected for monitoring in KATM and ALAG (Adapted from Bennett et al. 2006). Those in bold are Vital Signs that the SWAN is working independently or jointly with a Network park, federal, state, or private partner to develop and implement monitoring protocols using funding from the Vital Signs or water quality monitoring programs while those in italics are Vital Signs that are monitored independently of SWAN by a Network park, another NPS program, or another federal, state, or private agency.

Category	KATM Vital Signs	ALAG Vital Signs
Air and Climate	**Weather and climate**	**N/A**
Geology and Soils	**Glacier Extent, geomorphic coastal change,** *volcanic and earthquake activity*	*volcanic and earthquake activity*
Water	**Surface hydrology, marine water chemistry, freshwater chemistry**	**Surface hydrology, freshwater chemistry**
Biological integrity	*Invasive/exotic species, insect outbreaks,* **kelp and eelgrass, marine intertidal invertebrates, resident lake fish,** *salmon,* **black oystercatcher, bald eagle, seabirds, river otter (coastal), brown bear, wolf, wolverine,** ***caribou,*** **sea otter,** *harbor sea,* **vegetation composition and structure, sensitive vegetation communities**	*Invasive/exotic species, insect outbreaks,* **resident lake fish,** *salmon,* **bald eagle, brown bear, wolf, wolverine,** ***caribou,*** **vegetation composition and structure, sensitive vegetation communities**
Human use	*Resource harvest for subsistence and sport, visitor use*	*Resource harvest for subsistence and sport, visitor use*
Landscapes (ecosystem pattern and process)	**Landcover/land use, landscape processes**	**Landcover/land use, landscape processes**

2.4 Landcover and Landscape Processes

Existing landcover datasets do not readily lend themselves to assessment due to their variability regarding the definition of landcover classes from one data set to the next. However, some general observations between data set years can be made, as well as statements regarding the importance of how natural processes shape the KATM landscape.

2.4.1 KATM/ALAG Landcover Datasets

Landcover data sets for KATM were created for both 1981 and 2000. The 1981 dataset contains data created by the U.S. Geological Survey Earth Resources Observation and Science (USGS/ EROS) developed from satellite imagery in support of the Bristol Bay Landcover Mapping Project (USGS 1989) (Plate 4). Data are raster format with a 50-meter cell size. A total of 16 landcover types are included (Table 3). The most prevalent landcover type identified was snow/cloud/light barren covering, with 4210.5 km^2 (25.3%) of the total park area.

Table 3. 1981 landcover classes and coverage areas for KATM (USGS 1989).

Landcover Class	Hectares	% Landcover
Snow/Cloud/Light Barren	4,210	25
Closed Shrub Graminoid	240,498	14
Barren	189,785	11
Open Low Shrub Graminoid	181,735	10
Miscellaneous Deciduous (Open Alder, Cottonwood, Birch, Willow)	113,698	6
Deep Clear Water	111,582	6
Open Low shrub/Conifer Woodland Shrub /Tundra	84,605	5
Lichen Shrub Tundra	79,792	4
Conifer Forest	62,621	3
Mixed Forest	51,278	3
Lichen	39,860	2
Mountain Shadow	29,238	1
Shallow/Sedimented Water	21,489	1
Marsh/Very Wet Bog	17,874	1
Wet Bog/Wet Meadow'	16,369	0
Shallow/Sedimented Water - Offshore	1,465	0
Deep Clear Water - Offshore	1,126	0
Total Area	**1,664,070**	---

The 2000 landcover dataset was completed by Geographic Resources Solutions and the Alaska Natural Heritage Program to fulfill the project goals of the KATM Landcover Mapping Project (NPS 2003b). This mapping project was contracted by the NPS Alaska Regional Office and fulfilled a portion of the NPS's Landcover Mapping Program. The 2000 landcover class dataset is represented with a 30-meter cell size and displays 22 landcover classes (NPS 2003b; Plate 5). The most prevalent landcover class was tall alder shrub, covering 3,218.8 km^2 (19.3%) of KATM (Table 4).

Table 4. 2000 landcover classes and coverage areas for KATM (NPS 2003b).

Landcover Class	Hectares	% Landcover
Tall Alder Shrub	357,639,200	19
Barren	313,165,300	16
Dwarf Shrub	192,529,400	10
Water	148,752,600	8
Snow/Glacier	113,415,800	6
Mesic Herbaceous	102,712,300	5
Sparse Vegetation	94,712,400	5
Dwarf Shrub/Mesic Herbaceous	90,130,000	4
Low Willow Shrub	76,711,700	4
Tall Willow Shrub	64,544,100	3
Birch Forest	62,973,100	3
Wet Herbaceous	47,450,800	2
Mixed Low/Dwarf Shrub	43,868,200	2
Open Spruce Forest	42,937,900	2
Mixed Deciduous/Conifer Forest	30,145,900	1
Cottonwood/Poplar Forest	27,985,700	1
Spruce Woodland	23,391,300	1
Dwarf Shrub/Bryophyte	16,729,700	0
No Data	4,391,500	0
Lichen	1,411,500	0
Shadow/Unclassified	1,025,300	0
Closed Spruce Forest	656,000	0
Total Area	**1,857,279,700**	---

2.4.2 Dominant Landscape Processes

Volcanic Activity

During the last 10,000 years, more than 15 volcanic eruptions are believed to have occurred in KATM (Boggs and Klein 2003). These eruptions cause significant disturbance and change to the landscape and vegetation of KATM/ALAG. Debris, lava flows, avalanches, and strong volcanic blasts transform vegetation-rich landcover classes to barren landscapes. The most recent eruption of the Novarupta volcano covered 65 km^2 (25 mi^2) with ash or lava flows (Boggs and Klein 2003).

Glacial Recession

Areas exposed by the retreat of glaciers in KATM provide the opportunity for succession to occur. Barren areas become colonized by alder shrubs, followed by cottonwood and spruce trees intermixed within the shrubs (Jorgenson et al. 2007).

Floral Range Expansion

Elevational range expansion of tall shrubs is apparent when photographs taken of the Lake Grosvenor granite ridge areas in 1919 (showing <50% tall shrub coverage) are compared to more recent photos, which indicate shrub coverage on granite ridges to be over 75% (Jorgenson et al. 2007). Comparisons of photos from long-term monitoring sites, such as the one previously described, show expansion of vegetation into higher elevations of KATM.

Insect Outbreak Effects

Outbreaks of various insect and worm species including beetles, sawflies, bud worms, and defoliators have caused major landscape changes to some regions in Alaska (Wittwer 2005). Wittwer (2005) reported a spruce beetle infestation of 1,174 ha (2,900 ac) in KATM in 2004. Spruce beetle activity was reported to be low in this region, with an estimated one to five trees per acre infested. Spruce beetle numbers were expected to remain the same and, at this level, are not considered a threat to KATM forests (Wittwer 2005). However, Snyder (2006) reported that 2005 spruce beetle range had increased to over 6,880 ha (17,000 ac), causing concern for the forests of the infested areas. Spruce beetle activity in KATM was noted in Iliuk Arm of Naknek Lake, Margol Creek, Ikagluik Creek, and the Savonoski River (Snyder 2006).

Snyder (2006) reported the sunira moth (*Sunira verberata)* defoliated 9,105 ha (22,500 ac) in 2005, and accounted for the heaviest insect activity in KATM around Lake Coville, Lake Grosvenor, the Savonoski River, and the east end of Naknek Lake. Sunira moth activity increased every year from 2003 to 2005, causing intense defoliation, but then declined in 2006 (Snyder 2006). Prolonged defoliation of this magnitude could cause tree mortality in this region of KATM.

Permafrost/Climate Change

Osterkamp (2007a) described a warming trend in Alaskan permafrost over the twentieth century that coincided with observations of higher average temperatures and snow fall totals. Higher snow fall totals, possibly caused by warmer temperatures, insulate the permafrost from below-freezing air temperatures and may be the cause for increased surface and core permafrost temperatures over regions of coastal and inland Alaska. A myriad of other variables can also influence permafrost temperatures including an area’s topography, hydrology, geology, vegetation coverage, and human, animal, or fire disturbance. These variables affect permafrost over various timescales ranging from the effects of a fire, observed in days, to factors that can be tracked over centuries, including climate or geologic changes (Osterkamp 2007b). Therefore, tracking and defining the causes of permafrost temperature changes are extremely difficult (Osterkamp 2007b). Although no data describing surface or core permafrost temperature trends in KATM are available, the region has shown increased temperature and precipitation over the twentieth century (Lindsay 2011).

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Plate 1. Official KATM NPS Park Map with ALAG illustrated (NPS website).

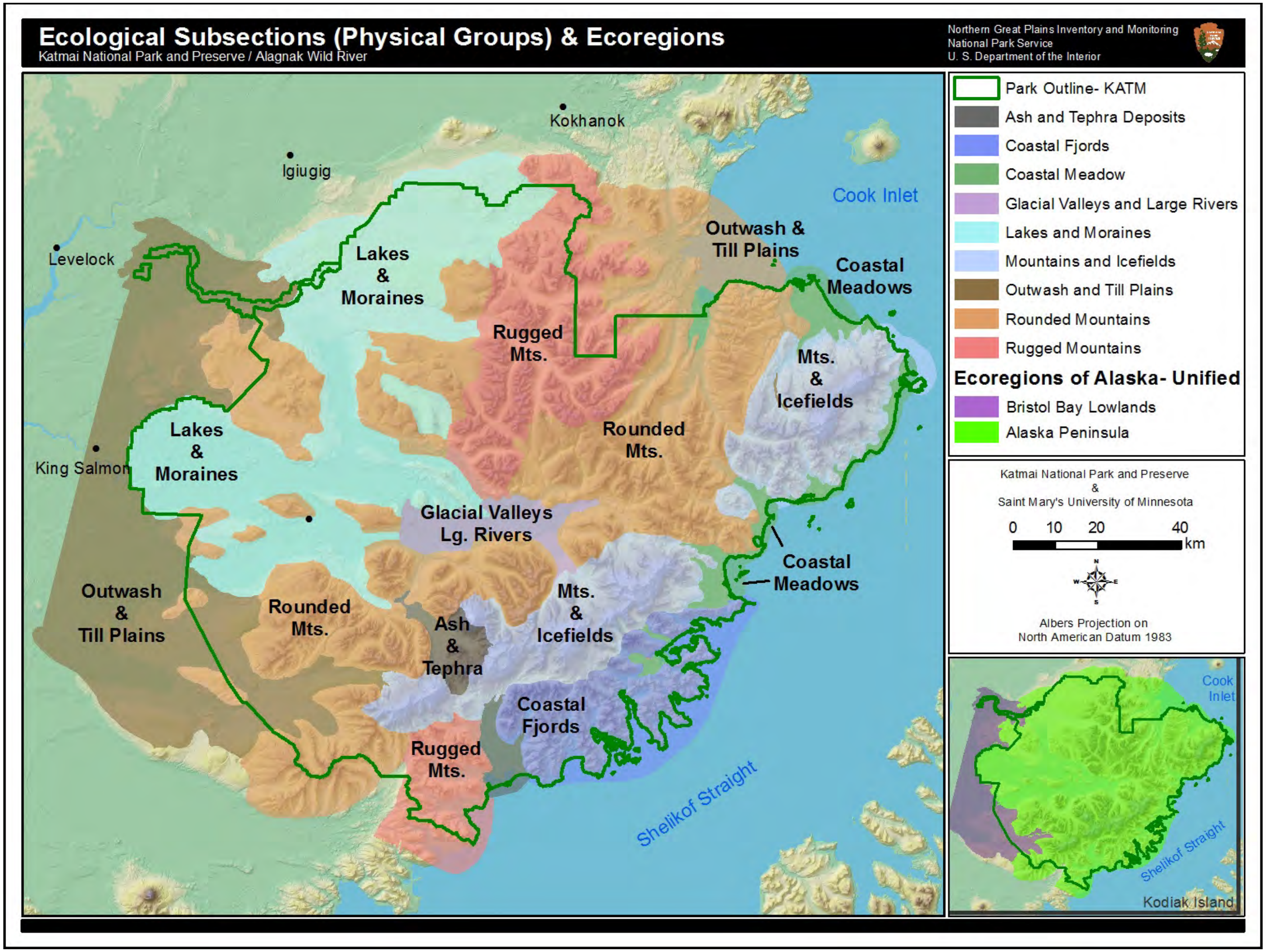

Plate 2. Ecological subsection (physical groups) and Alaska ecoregions in KATM and ALAG.

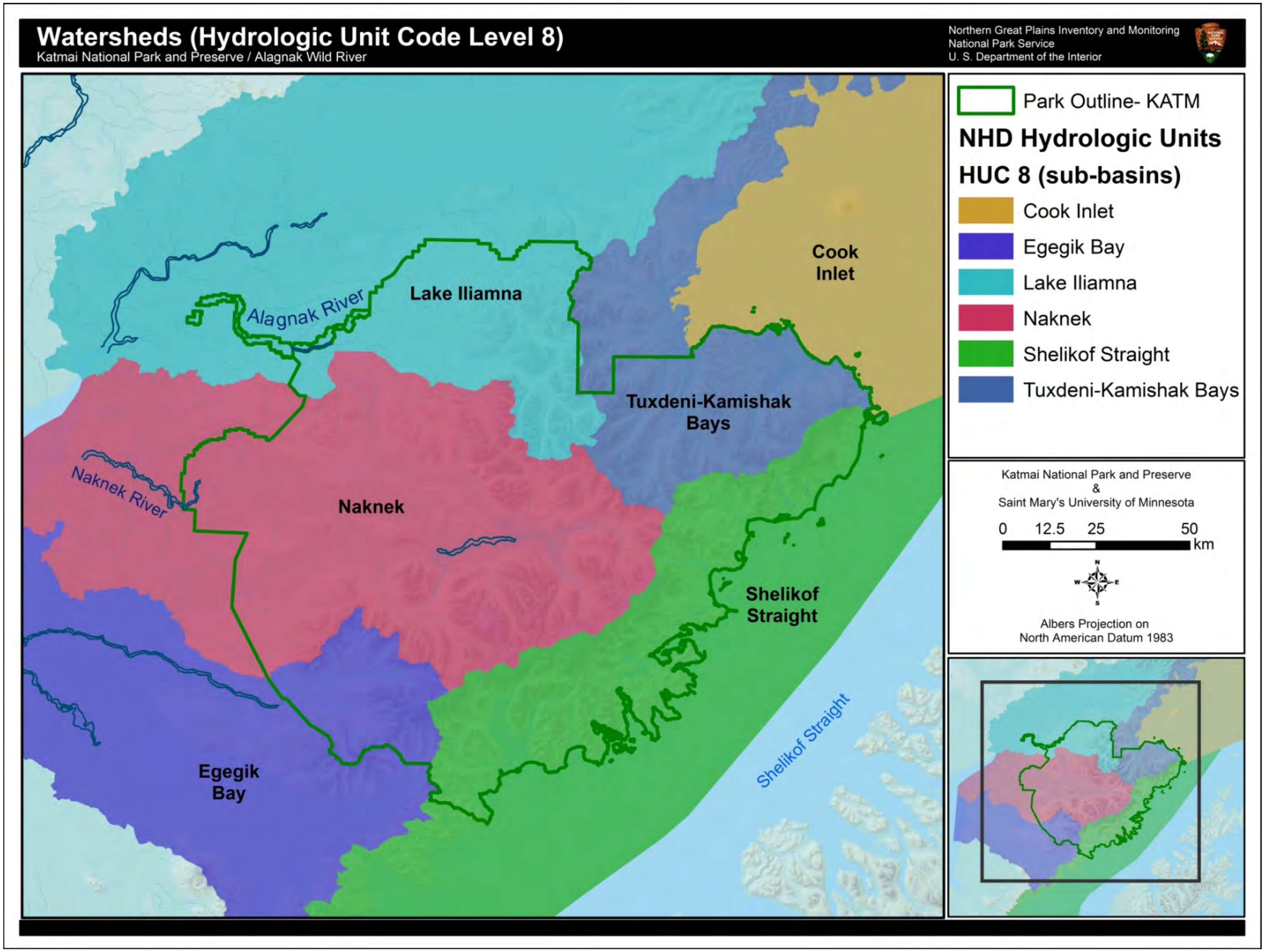

Plate 3. Watersheds and sub-basins of KATM and ALAG.

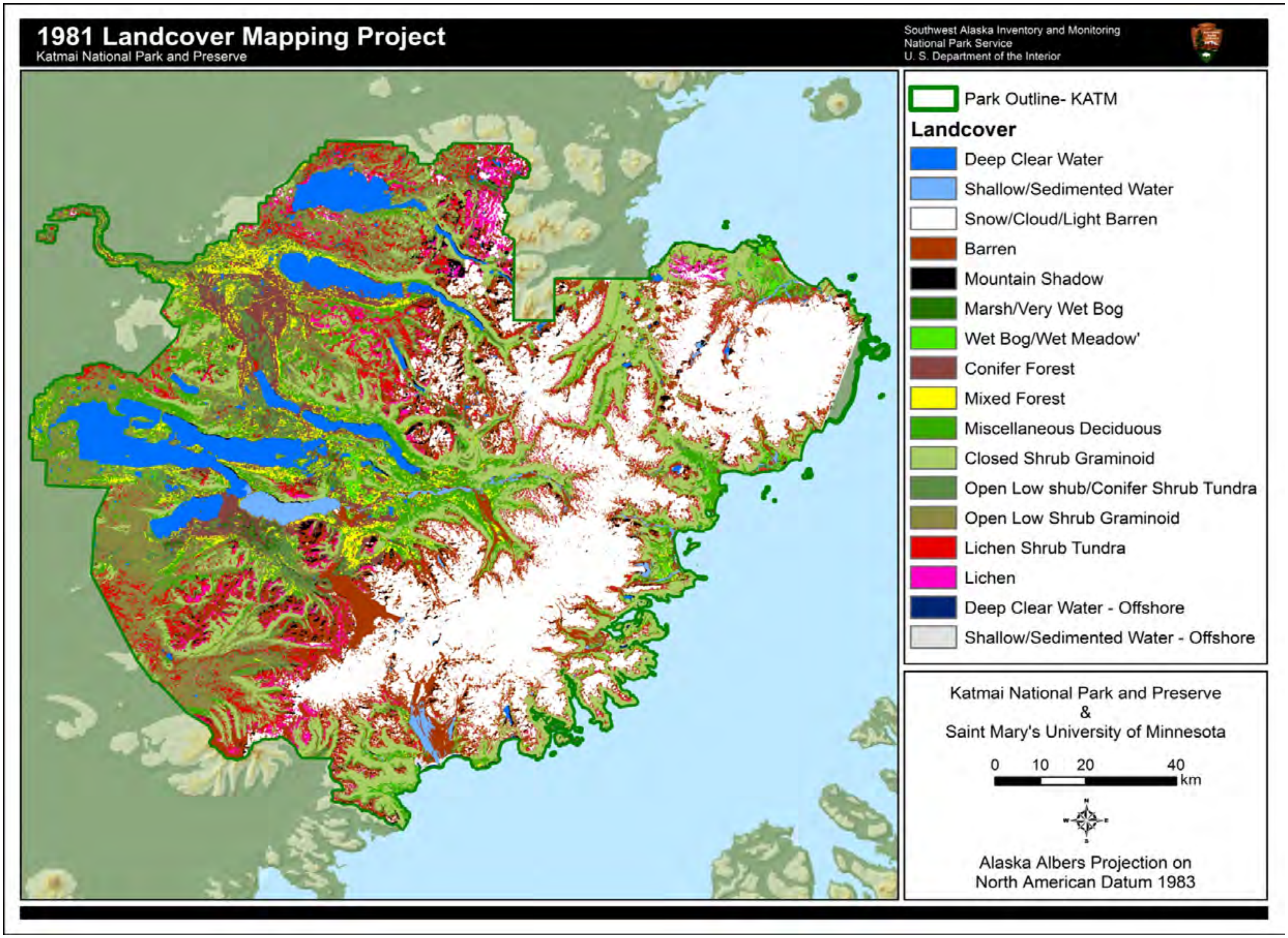

Plate 4. Landcover classes and coverage for KATM and ALAG in 1981. Landcover classes combined from original data for display purposes (USGS 1989).

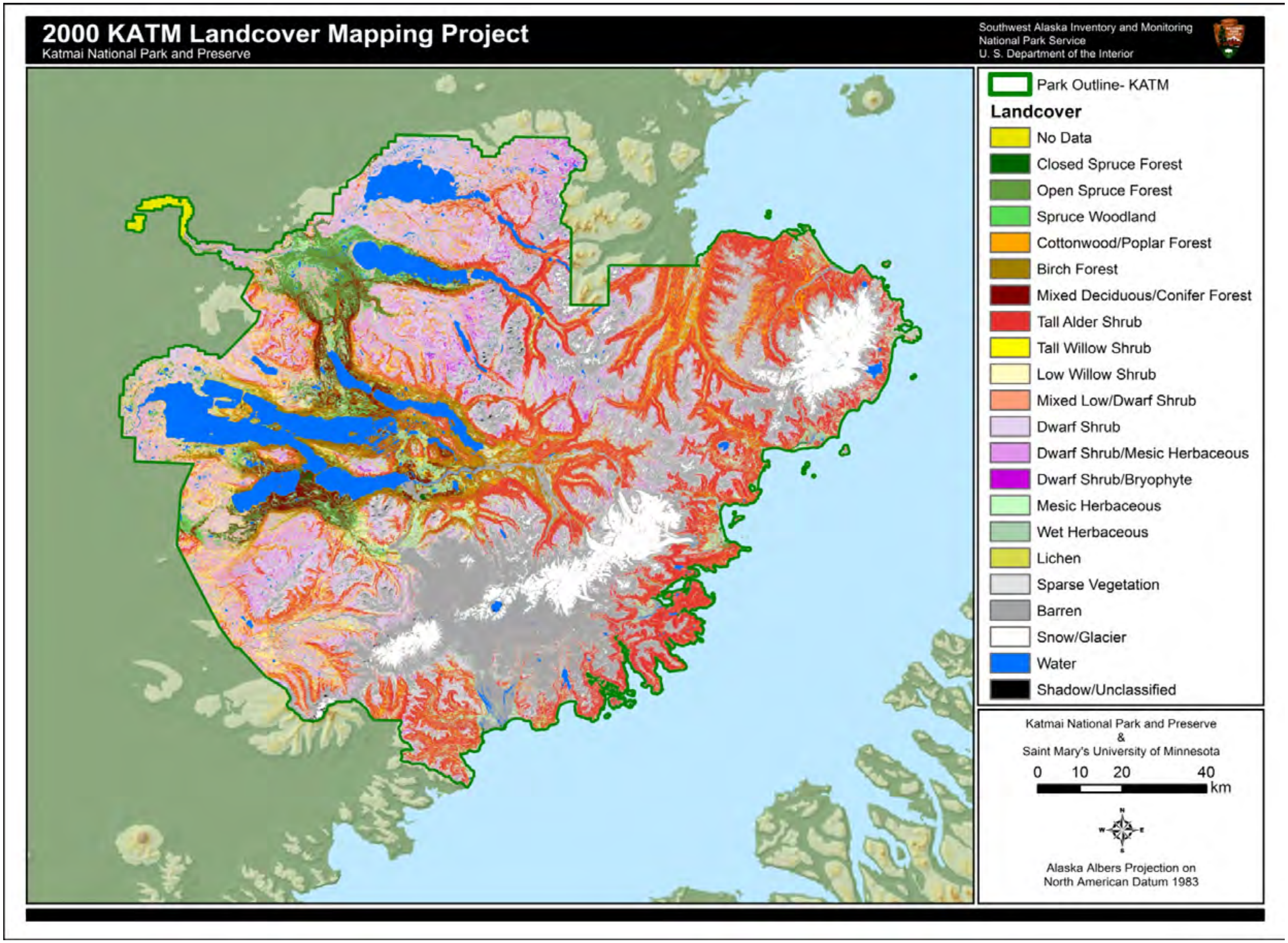

Plate 5. Landcover classes and coverage area for KATM and ALAG in 2000. Landcover classes combined from original data for display purposes (NPS 2003b).

Chapter 3. Study Scoping and Design

This NRCA is a collaborative project between the National Park Service (NPS) and Saint Mary's University of Minnesota Geospatial Services (SMUMN GSS). Project stakeholders include the KATM and ALAG (the parks) resource management team, and SWAN staff. Before embarking on the project, it was necessary to identify the specific roles of the NPS and SMUMN GSS. Preliminary scoping meetings were held, and a task agreement and a scope of work document were created cooperatively between the NPS and SMUMN GSS.

3.1 Preliminary scoping

A preliminary scoping meeting was held during November 2011. At this meeting, SMUMN GSS and NPS staff confirmed that the purpose of the KATM and ALAG NRCA was to evaluate and report on current conditions, critical data and knowledge gaps, and selected existing and emerging resource condition influences of concern to park managers. Certain constraints were placed on this NRCA, including the following:

- Condition assessments are conducted using existing data and information.
- Identification of data needs and gaps is driven by the project framework categories.
- The analysis of natural resource conditions includes a strong geospatial component.
- Resource focus and priorities are primarily driven by the park resource management.

This condition assessment provides a "snapshot-in-time" evaluation of the condition of a select set of park natural resources that were identified and agreed upon by the project team. Project findings will aid KATM and ALAG resource managers in the following objectives:

- Develop near-term management priorities (how to allocate limited staff and funding resources);
- Engage in watershed or landscape scale partnership and education efforts;
- Consider new park planning goals and take steps to further these;
- Report program performance (e.g., Department of Interior Strategic Plan "land health" goals, Government Performance and Results Act [GPRA]).

Specific project expectations and outcomes included the following:

- For key natural resource components, consolidate available data, reports, and spatial information from appropriate sources including: park resource staff, the NPS Integrated Resource Management Application (IRMA) website, Inventory and Monitoring Vital Signs, and available third-party sources. The NRCA report will provide a resource assessment and summary of pertinent data evaluated through this project.

- When appropriate, define a reference condition so that statements of current condition may be developed. The statements will describe the current state of a particular resource with respect to an agreed upon reference point.
- Clearly identify "management critical" data (i.e., those data relevant to the key resources). This will drive the data mining and gap definition process.
- Where applicable, develop GIS products that provide spatial representation of resource data, ecological processes, resource stressors, trends, or other valuable information that can be better interpreted visually.
- Utilize "gray literature" and reports from third party research to the extent practicable.

3.2 Study Design

3.2.1 Indicator Framework, Focal Study Resources and Indicators

Selection of Resources and Measures

As defined by SMUMN GSS in the NRCA process, a "framework" is developed for a park or preserve. This framework is a way of organizing, in a hierarchical fashion, bio-geophysical resource topics considered important in park management efforts. The primary features in the framework are key resource components, measures, stressors, and reference conditions.

"Components" in this process are defined as natural resources (e.g., birds), ecological processes or patterns (e.g., natural fire regime), or specific natural features or values (e.g., geological formations) that are considered important to current park management. Each key resource component has one or more "measures" that best define the current condition of a component being assessed in the NRCA. Measures are defined as those values or characterizations that evaluate and quantify the state of ecological health or integrity of a component. In addition to measures, current condition of components may be influenced by certain "stressors," which are also considered during assessment. A "stressor" is defined as any agent that imposes adverse changes upon a component. These typically refer to anthropogenic factors that adversely affect natural ecosystems, but may also include natural processes or disturbances such as floods, fires, or predation (adapted from GLEI 2010).

During the NRCA scoping process, key resource components were identified by NPS staff and are represented as "components" in the NRCA framework. While this list of components is not a comprehensive list of all the resources in the park, it includes resources and processes that are unique to the park in some way, or are of greatest concern or highest management priority in KATM and ALAG. Several measures for each component, as well as known or potential stressors, were also identified in collaboration with NPS resource staff.

Selection of Reference Conditions

A "reference condition" is a benchmark to which current values of a given component's measures can be compared to determine the condition of that component. A reference condition may be a historical condition (e.g., flood frequency prior to dam construction on a river), an established ecological threshold (e.g., EPA standards for air quality), or a targeted management goal/objective (e.g., a bison herd of at least 200 individuals) (adapted from Stoddard et al. 2006).

Reference conditions in this project were identified during the scoping process using input from NPS resource staff. In some cases, reference conditions represent a historical reference before human activity and disturbance was a major driver of ecological populations and processes, such as "pre-fire suppression.” In other cases, peer-reviewed literature and ecological thresholds helped to define appropriate reference conditions.

Finalizing the Framework

An initial framework was adapted from the organizational framework outlined by the H. John Heinz III Center for Science’s “State of Our Nation’s Ecosystems 2008” (Heinz Center 2008). This initial framework was presented to park resource staff to stimulate meaningful dialogue about key resources that should be assessed. Significant collaboration between SMUMN GSS analysts and NPS staff was needed to focus the scope of the NRCA project and finalize the framework of key resources to be assessed.

The NRCA framework was finalized in May 2012 following acceptance from NPS resource staff. It contains a total of 13 components (Table 5) and was used to drive analysis in this NRCA. Two components (near shore sensitivity index, landcover/landscape processes) were subsequently removed from the list and the concerns around these components were incorporated into chapter 2 of this document. This framework outlines the components (resources), most appropriate measures, known or perceived stressors and threats to the resources, and the reference conditions for each component for comparison to current conditions.

Table 5. KATM and ALAG natural resource condition assessment framework.

KATM and ALAG National Parks
Natural Resource Condition Assessment Framework

	Component	Experts	Data Sources	Measures or Specific Analysis	Stressors	Reference Condition
Biotic Composition						
Ecological Communities						
	Landcover/Landscape Processes (Chapter 2 discussion)	Parker Martin, Amy Miller	Two landcover datasets available in ThemeManager: Landcover - ANIA Group (1981 - ADNR); Landcover ANIA 2008 - early 2000s DU)	Discussion of the dominant landscape processes - successional patterns, fire, insect outbreak effects, permafrost change. References to invasives section for that information.	climate change (precipitation, temp, etc.)	Team agreed that this component does not lend itself to a condition graphic/scoring.
	Invasive and Non-native Species	Whitney Rapp	Regional office datasets - will be provided once updated. Completed in the next few months Feb or March.	Total area of non-natives, Number of non-native species, Invasiveness score, Status of exotic fauna	Vectors of spread, sources	The goal is to prevent future invasions and actively reduce current ones. Identifying which species can be controlled effectively is a priority for the park.
	Land cover/Landscape Processes (Chapter 2 discussion)	Parker Martyn, Amy Miller	Two land cover datasets available in ThemeManager: KATM 1981 Group and KATM 2000	Discussion of the dominant landscape processes - successional patterns, fire, insect outbreak effects, permafrost change. References to invasives section for that information.	Climate change (precipitation, temp, etc.)	Does not lend itself to a condition graphic/scoring.
Mammals						
	Moose	Sherri Anderson	Moose data being compiled by the park over the winter.	Metrics defined in ADF&G moose summary documents: population density, bull:cow ratio	Brown bear predation on neonatal moose, over browsing resulting in poor calf survival	ADF&G defined management goals.
	Bear	Sherri Anderson	Bear data being compiled by the park over the winter	Population Density	human habituation measures (will vary based on different areas in the park)	Park mandate from ANILCA: "high concentrations of brown/grizzly bears and their denning areas". Troy and Sherri will work to define high concentrations as they examine available data and information.
Birds						
	Passerines	Sherri Anderson, Susan Savage (USFWS)	Breeding bird survey data, Alagnak bird survey	Species richness and diversity, Species abundance	not clear what may actually be causing stress on birds overall, most are likely not from in-park issues	Team agreed that this component does not lend itself to a condition graphic/scoring.
Fish						
	Salmon	Troy Hamon	Salmon escapement data provided by Troy. Append Troy's data (escapement related data) using all ADFG individual reports	Escapement, Percent Harvest, Run Timing	Harvest	Runs are effectively regulated by harvest, however salmon run-size by river/watershed varies greatly over time (reference condition is difficult to determine). Maybe reference condition should be based on a larger picture of the Bristol Bay salmon
	Native Fish (non-anadromous)	Troy Hamon	ADFG Mail-in survey, daily guide log, other surveys and literature	**Specific Analysis:** Compile existing data and information from the defined literature sources and provide to the park for future use and updating. Develop a concise summary of the information for Chapter 4 and provide a statement of condition (and graphic) according to conversations with Troy.	Sport fishing (catch and release on Alagnak)	Team agreed that this component does not lend itself to a condition graphic/scoring. Once data are compiled, we might be able to infer condition from trends.

Table 5. KATM and ALAG natural resource condition assessment framework (continued).

	Component	Experts	Data Sources	Measures or Specific Analysis	Stressors	Reference Condition
Environmental Quality						
	Seismic Activity	USGS and AVO - John Paskievitch	Alaska Volcano Observatory Data	**Specific Analysis:** Provide a summary of the recorded seismic history of the park, both background levels of activity and major events.	Consult USGS sources	Team agreed that this component does not lend itself to a condition graphic/scoring
	Climate	Chuck Lindsey	PRISM Data, weather station data	**Specific Analysis:** Comparison of the data from the 4 in-park weather stations to PRISM predictions to determine variation due to topography or location.	Human-induced changes	Team agreed that this component does not lend itself to a condition graphic/scoring
	Human Activity	Michael Shephard, Russ Frith, Timothy Shepherd	CUA database (currently being cleaned), Community harvest surveys, ATV usage survey (Alagnak)	**Specific Analysis:** Use available datasets to provide an overview of visitor use (distribution and primary activity) in the park with close attention to use during hunting seasons, as this is when most conflicts may occur. Identify the areas most prone to user conflict based on findings (spatial and non-spatial). Explain the level of subsistence use in the park based on community survey data (older info) and park staff knowledge (present status).	Human activity can be considered a stressor to valued natural resources	There are some minor corrections that could be completed with the CUA database, then it could be used to create human activity summaries
Physical Characteristics						
	Glaciers	Bruce Giffen, Chuck Lindsey	Glacier extent mapping has already been completed for KATM (Giffen 2007)	Extent, terminus retreat, volumetric estimates (mass balance)	Climate warming	Report the most historic information to describe change
	Water Quality	Claudette Moore	Data sources provided by Claudette Moore	**Specific Analysis:** Examine the available data and information and georeference that data when possible to enable future GIS data display and storage. If enough data exist for individual lakes or rivers, present these data and describe condition accordingly. Provide a brief synopsis of the SWAN temp profile data that are being collected currently.	Diesel fuel spills, other point sources	Team agreed that this component does not lend itself to a condition graphic/scoring

3.2.2 General Approach and Methods

This study involved gathering and reviewing existing literature and data relevant to each of the key resource components included in the framework. No new data were collected for this study; however, where appropriate, existing data were further analyzed to provide summaries of resource condition or to create new spatial representations. After all data and literature relevant to the measures of each component were reviewed and considered, a qualitative statement of overall current condition was created and compared to the reference condition when possible.

Data Mining

The data mining process (acquiring as much relevant data about key resources as possible) began at the initial scoping meeting, at which time KATM and ALAG staff provided data and literature in multiple forms, including: NPS reports and monitoring plans, reports from various state and federal agencies, published and unpublished research documents, databases, tabular data, and charts. GIS data were provided by NPS staff. Additional data and literature were also acquired through online bibliographic literature searches and inquiries on various state and federal government websites. Data and literature acquired throughout the data mining process were inventoried and analyzed for thoroughness, relevancy, and quality regarding the resource components identified at the scoping meeting.

Data Development and Analysis

Data development and analysis was highly specific to each component in the framework and depended largely on the amount of information and data available for the component and recommendations from NPS reviewers and sources of expertise including NPS staff from KATM and ALAG and the SWAN. Specific approaches to data development and analysis can be found within the respective component assessment sections located in Chapter 4 of this report.

Preparation and Review of Component Draft Assessments

The preparation of draft assessments for each component was a highly cooperative process among SMUMN GSS analysts and park staff. Though SMUMN GSS analysts rely heavily on peer-reviewed literature and existing data in conducting the assessment, the expertise of NPS resource staff also plays a significant and invaluable role in providing insights into the appropriate direction for analysis and assessment of each component. This step is especially important when data or literature are limited for a resource component.

The process of developing draft documents for each component began with a detailed phone or conference call with an individual or multiple individuals considered local experts on the resource components under examination. These conversations were a way for analysts to verify the most relevant data and literature sources that should be used and also to formulate ideas about current condition with respect to the NPS staff opinions. Upon completion, draft assessments were forwarded to component experts for initial review and comments.

Development and Review of Final Component Assessments

Following review of the component draft assessments, analysts used the review feedback from resource experts to compile the final component assessments. As a result of this process, and based on the recommendations and insights provided by park resource staff and other experts, the final component assessments represent, the most relevant and current data available for each component and the sentiments of park resource staff and resource experts.

Format of Component Assessment Documents

All resource component assessments are presented in a standard format. The format and structure of these assessments is described below.

Description

This section describes the relevance of the resource component to the park and the context within which it occurs in the park setting. For example, a component may represent a unique feature of the park, it may be a key process or resource in park ecology, or it may be a resource that is of high management priority in the park. Also emphasized are interrelationships that occur among a given component and other resource components included in the broader assessment.

Measures

Resource component measures were defined in the scoping process and refined through dialogue with resource experts. Those measures deemed most appropriate for assessing the current condition of a component are listed in this section, typically as bulleted items.

Reference Conditions/Values

This section explains the reference condition determined for each resource component as it is defined in the framework. Explanation is provided as to why specific reference conditions are appropriate or logical to use. Also included in this section is a discussion of any available data and literature that explain and elaborate on the designated reference conditions. If these conditions or values originated with the NPS experts or SMUMN GSS analysts, an explanation of how they were developed is provided.

Data and Methods

This section includes a discussion of the data sets used to evaluate the component and if or how these data sets were adjusted or processed as a lead-up to analysis. If adjustment or processing of data involved an extensive or highly technical process, these descriptions are included in an appendix for the reader or a GIS metadata file. Also discussed is how the data were evaluated and analyzed to determine current condition (and trend when appropriate).

Current Condition and Trend

This section presents and discusses in-depth key findings regarding the current condition of the resource component and trends (when available). The information is presented primarily with text but is often accompanied by detailed maps or plates that display different analyses, as well as graphs, charts, and/or tables that summarize relevant data or show interesting relationships. All relevant data and information for a component is presented and interpreted in this section.

Threats and Stressor Factors

This section provides a summary of the threats and stressors that may impact the resource and influence to varying degrees the current condition of a resource component. Relevant stressors were described in the scoping process and are outlined in the NRCA framework. However, these are elaborated on in this section to create a summary of threats and stressor based on a combination of available data and literature, and discussions with resource experts and NPS natural resources staff.

Data Needs/Gaps

This section outlines critical data needs or gaps for the resource component. Specifically, what is discussed is how these data needs/gaps, if addressed, would provide further insight in determining the current condition or trend of a given component in future assessments. In some cases, the data needs/gaps are significant enough to make it inappropriate or impossible to determine condition of the resource component. In these cases, stating the data needs/gaps is useful to natural resources staff who wishes to prioritize monitoring or data gathering efforts.

Overall Condition

This section provides a qualitative summary statement of the current condition that was determined for the resource component using the WCS method. Condition is determined after thoughtful review of available literature, data, and any insights from NPS staff and experts, which are presented in the Current Condition and Trend section. The Overall Condition section summarizes the key findings and highlights the key elements used in determining and justifying the level of concern, if any, that analysts attribute to the condition of the resource component. Also included in this section are the graphics used to represent the component condition.

Sources of Expertise

This is a listing of the individuals (including their title and affiliation with offices or programs) who had a primary role in providing expertise, insight, and interpretation to determine current condition (and trend when appropriate) for each resource component.

Literature Cited

This is a list of formal citations for literature or datasets used in the analysis and assessment of condition for the resource component. Note, citations used in appendices and plates referenced in each section (component) of Chapter 4 are listed in that section’s “Literature Cited” section.

3.2.3 Literature Cited

Great Lakes Environmental Indicators Project (GLEI). 2010. Glossary, Stressor. Online (http://glei.nrri.umn.edu/default/glossary.htm). Accessed 9 December 2010.

The H. John Heinz III Center for Science, Economics, and the Environment. 2008. The state of the nation's ecosystems 2008: Measuring the land, waters, and living resources of the United States. Island Press, Washington, D.C.

Stoddard. J. L., D. P. Larsen, C. P. Hawkins, R. K. Johnson, and R. J. Norris. 2006. Setting expectations for the ecological condition of streams: the concept of reference condition. Ecological Applications. 16(4): 1267-1276.

Chapter 4 Natural Resource Conditions

This chapter presents the background, analysis, and condition summaries for the 11 key resource components in the project framework. The following sections discuss the key resources and their measures, stressors, and reference conditions. The summary for each component is arranged around the following sections:

1. Description
2. Measures
3. Reference Condition
4. Data and Methods
5. Current Condition and Trend (including threats and stressor factors, data needs/gaps, and overall condition)
6. Sources of Expertise
7. Literature Cited

The order of components follows the project framework (Table 5):

4.1 Invasive Species and Non-native Species
4.2 Moose
4.3 Bear
4.4 Passerines
4.5 Salmon
4.6 Native Fish
4.7 Seismic Activity
4.8 Climate
4.9 Human Activity
4.10 Glacial Extent
4.11 Water Quality

4.1 Invasive Species and Non-native Species

4.1.1 Description

Invasive species are recognized as one of the major factors contributing to ecosystem change and instability throughout the world (NPS 2009). Non-native species are generally defined as any species that, as a result of some human action, whether intentional or unintentional, has been introduced into an area outside of its natural range (Connealy and Parker 2013). Exotic, alien, introduced and non-indigenous are all synonyms for species that meet this definition (Hiebert and Stubbendieck 1993). The NPS defines non-native, or exotic species, as those species that occur in a given place as a result of direct or indirect, deliberate, or accidental actions by humans (Hiebert and Stubbendieck 1993). Under this definition, species that are native to Alaska, but found outside of their normal range as a result of human action would be considered as non-native by the NPS (Hiebert and Stubbendieck 1993).

Invasive species are defined as any species that can be defined as non-native and that when established can dominate habitats and cause economic loss, environmental damage, or harm to human health (Executive Order 13112 1999). In the past, the impacts of invasive species have been underestimated because their spread can be slow, over years or decades. However, these impacts are a growing concern, both on local and global scales, especially their effect on ecosystems and biodiversity (Anderson et al. 2006). According to Stein et al. (2006) they are the second greatest threat to global biodiversity after habitat loss. The increase in global travel and the resultant breakdown of geographical barriers to plant dispersal is dramatically increasing the rate of accidental or intentional introduction of non-native and invasive species (Marler 2000).

Invasive species threaten ecosystem stability, integrity, and sustainability in a time of fluctuating global climate patterns, increased disturbance (both natural and anthropogenic), and expanding human populations (Von Holle and Simberloff 2005). Species evolve in a unique environment and are adapted to a specific setting. When introduced to a new environment, the factors that normally would deter their spread are limited or not present, creating an opportunity for the invasive species to outcompete their native counterparts for space and resources (Frank and Woods 2011). Over periods of time this can reduce local biodiversity (Connealy and Parker 2013).

Like invasive flora species, invasive fauna also pose a threat to biodiversity. They can spread aggressively and also displace native species (Frank and Woods 2011). They are introduced into an ecosystem through a myriad of different ways, including human transportation, through accidental or intentional release, and wastewater discharge (Fay 2002, Koons et al. 2003).

While most non-native species cause minor effects on natural ecosystems, some can be extremely dangerous. Invasive and non-native species directly affect native plants and ecosystems in a number of ways. They can displace or eradicate native species by monopolizing or controlling limiting resources (Brooks et al. 2004). They threaten and compromise the genetic integrity of the native flora through hybridization (Brooks et al. 2004). This in turn impacts fish and wildlife species and their habitats and food resources (Heutte and Bella 2006, Frank and Woods 2011). The introduction of invasive species also normally results in the loss of services from the affected ecosystems (Kerns and

Guo 2012). This is of particular concern to resource managers, as invasive species can change the structure and function of ecosystems by altering biological, geochemical, and geophysical processes (Ruesink et al. 1995, Anderson et al. 2006). Changes to physical processes may include increased erosion and sedimentation rates, altered nutrient cycling and natural fire regimes and a reduction in light levels (Ruesink et al. 1995, Anderson et al. 2006). These impacts are not limited to terrestrial systems, as invasive species have similar impacts on the native species, community structure and food resources, and the fundamental ecological processes found in freshwater and marine habitats (Molnar et al. 2008).

Alaska is relatively free from non-native plants, due to a number of factors (Densmore et al. 2001). The climate, its relative geographic isolation, and undisturbed ecosystems have historically lessened the threat from invasive infestation (Huxel 1999). They have not, however, provided a complete barrier to non-native plants (Carlson and Shepard 2007). Non-native and invasive species infestations have occurred, but in most cases the populations have been small and had a low percent cover (Nawrocki et al. 2011). However, in the past few decades, an increasing trend can be observed in the introduction of non-native and invasive species in Alaska (McClory and Gotthardt 2008, AKEPIC 2013) and around KATM (Connealy and Parker 2013). This is due mainly to increased human activity in the area although some could be attributed to the increase in available data from recent survey and monitoring programs (Schwörer et al. 2012).

Data being collected by a variety of sources indicate that the invasive species problem is still in its early stages in Alaska, and a proactive approach is necessary if the state wants to maintain its natural resources (Carlson and Shepard 2007). There is the opportunity to develop monitoring and management protocols to detect, track, and eradicate non-native and invasive species when they are first introduced, or during the lag phase before proliferation begins (Densmore et al. 2001, Schwörer et al. 2012).

The Alaska Exotic Plants Information Clearinghouse (AKEPIC) data portal is an interagency database and mapping application created in cooperation with the NPS, U.S. Forest Service, Bureau of Land Management, Department of Natural Resources (DNR), U.S. Fish and Wildlife Service (USFWS), and Alaska Natural Heritage Program (AKNHP) (AKEPIC 2013). This project provides a visual display of the various plant species introductions to Alaska on a spatial and temporal scale. In fact, the database shows that the majority of non-native species have become established in the past 30 years (Carlson and Shepard 2007, AKEPIC 2013). The NPS has established a suite of national and local programs to manage invasive species on park lands, based upon strategies of cooperation and collaboration, inventory and monitoring, prevention, early detection and rapid response, treatment and control, and restoration. At the national level, the NPS has fostered a successful invasive plant management program with the creation of the Exotic Plant Management Teams (EPMT) (NPS 2009). The EPMT teams conduct plant surveys and produce GIS data that represents infested or non-infested areas. This dataset includes all inventory, treatment, and monitoring efforts (NPS 2013b).

KATM has distinct advantages against the introduction and spread of non-native and invasive species. Its remote location limits anthropogenic disturbances and the related advancement of non-native and invasive species and plant material (Connealy and Parker 2013). The boreal climate limits species introduction and spread, as it is intolerable to many non-native plants (Landry and Voznitza 2014). The boreal vegetation found on the Park's forest floor tends to retard non-native plant establishment, thus deterring their expansion throughout the park (Landry and Voznitza 2014). Despite these hindrances, the park is still vulnerable to the establishment and spread of non-native and invasive species (Landry and Voznitza 2014).

Common dandelion (*Taraxacum officinale* ssp. *officinale*), pineapple weed (*Matricaria discoidea*), shepherd's purse (*Capsella bursa-pastoris*), common plantain (*Plantago major*), and annual bluegrass (*Poa annua*) are the most commonly found non-native species in the park (NPS 2013b). Common dandelion and pineapple weed make up nearly half of the total documented occurrences since monitoring began in 1997. The majority of these infestations occur in the Brooks Camp and Lake Camp areas. There are several pernicious species that have been recently introduced into the Alaska National Park system. Regular monitoring and control projects are essential to reduce and eradicate encroaching invasive species in National Park units such as KATM (Landry and Voznitza 2014).

NPS policy, as it relates to managing natural resources, requires managers to implement management practices and programs that maintain, restore, and perpetuate individual native species and normal ecological processes (Hiebert and Stubbendieck 1993). Specific NPS policy on invasive species gives high priority to those species that have substantial impacts on park resources and are relatively easy to manage (Hiebert and Stubbendieck 1993). To date, nearly all national parks have incorporated some type of invasive species management plan into their long-range planning goals and day-to-day operation (NPS 2009). This entails the control and eradication of invasive species that pose a threat to or displace native populations (Ebbert and Byrd 2000, NPS 2006). For those non-native species already present and interfering with natural processes, native species, or natural habitats, appropriate and feasible methods of control and removal are undertaken (NPS 2006).

Non-native fauna are another important area of concern for KATM. There are relatively few invasive mammal introductions to Alaska compared to the lower 48 states and, as many introductions were not well-documented, it is unclear whether some Alaskan species are native or non-native (Bailey 1993). Not all introduced species are considered harmful or unwanted. Nevertheless, some non-native species may directly interfere with native birds through predation or loss of nesting habitat, as well as changes in vegetation caused by overgrazing and trampling. Overpopulation and food web disruption are common concerns related to introduced faunal species. Other species, such as the gypsy moth (*Lymantria dispar*) are highly destructive. They can kill a large variety of native deciduous trees in the area as well as severely altering the environment's natural function (Landry and Voznitza 2014). Because of this, KATM has partnered with statewide efforts to monitor for gypsy moths since 2011 (Landry and Voznitza 2014).

As with terrestrial species, relatively few aquatic invasive species have become established in Alaska as compared to other regions. Despite the low number of introductions to date, Alaska is certainly vulnerable to marine and freshwater species introduction. Once established, these species can be nearly impossible to eliminate (Molnar et al. 2008). Potential introduction pathways include aquaculture (e.g., fish farms), the intentional movement of game or baitfish, the movement of large ships (e.g., cruise ships, fishing vessels) and ballast water from the United States West Coast and Asia, construction equipment, trade of live seafood, and contaminated fishing gear brought to Alaskan waters (Koons et al. 2003, ADF&G 2014). Other pathways include visitors angling equipment or clothing and float planes (W. Rapp, pers. comm. 2014). Interception or elimination of these pathways is likely the best strategy for reducing future invasions (Molnar et al. 2008).

4.1.2 Measures

- Total area of non-natives
- Number of non-native species
- Invasiveness score
- Status of exotic fauna

4.1.3 Reference Conditions/Values

In order to establish a reference condition for KATM, several objectives were considered. One commonly used criterion in identifying reference condition is to return the native habitat to a "natural" condition. This is generally defined as a pre-settlement condition (Marler 2000). For the KATM area this would refer to the period before Russian settlement of the area, which preceded European settlement. This is often appropriate since this is a reference point when species invasions likely began (Marler 2000). For most large parks and wilderness areas, legislation and management policies require the preservation, unimpaired and in perpetuity, of the park's natural resources and wildlife (Hobbs et al. 2010). Along with this notion of protection, preservation, and lack of impairment, the concept of "naturalness" has been added (Hobbs et al. 2010).

Naturalness in this case is defined as the local ecological and environmental conditions persisting over time, in the absence of human intervention (Hobbs et al. 2010). For much of the 20^{th} century, this has been the guiding concept for stewardship of park and wilderness areas and has remained largely unchallenged (Hobbs et al. 2010). For KATM, the assumed "natural" condition would be an absence of non-native species. However, a park completely free of all non-native plant species is likely an unrealistic expectation. Canada's National Park Act uses a concept of "ecological integrity" in place of a "natural condition" (Hobbs et al. 2010).

Ecological integrity is defined as "a condition that is determined to be characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of native species and biological communities, rate of change and supporting processes" (Hobbs et al. 2010). This concept shifts the focus from the past to the future and from cause to effect, allowing resource managers to strive for desired future ecosystems, regardless of whether they were or were not caused by humans (Hobbs et al. 2010). With this as a goal, Parks Canada emphasizes retention of native ecosystem components (Hobbs et al. 2010). Taking this into consideration, the park's goal, and the reference condition for this component, is to prevent future invasions and actively reduce current invasions.

4.1.4 Data and Methods

Across North America, reports of invasive species have increased exponentially in the late 20th century due to increased globalization (Ebbert and Byrd 2000, Carlson and Shepard 2007). It is unknown exactly when invasive species were first introduced into KATM. The park was first inventoried for non-native presence in The Valley of 10,000 Smokes (VTTS) Road and Three Forks Overlook areas by NPS and US Geological Survey (USGS) personnel in 1997 (Densmore et al. 2001). Then in 2000, the Brooks Camp facilities, hiking trails out of Brooks Camp, Lake Camp, the VTTS Road, along the outer coast at Hallo, Swikshak, and Kaguyak Bays, and disturbed areas around Grovsner Lodge, Kulik Lodge and Katmai Lodge were inventoried to complete the KATM survey (Densmore et al. 2001). Small infestations and priority species were manually treated at that time (Landry and Voznitza 2014). Control work continued from 2005 through 2007 at Brooks Camp focusing on common dandelion (Landry and Voznitza 2014). Control work has continued at Brooks Camp and Lake Camp since 2008 (Landry and Voznitza 2014).

The NPS has established exotic plant management teams (EPMT) to monitor and control known infestations and survey new areas (Landry and Voznitza 2014). The Alaska EPMT trains existing park staff, partially funds seasonal park staff, and provides internship support positions in each park (Million and Rapp 2011). In addition to eradicating infestations and completing restoration projects, the EPMT collects field data on invasive plant species occurrences in KATM, in both previously visited and new areas in the park (Landry and Voznitza 2014). In 2010 the EPMT began surveying and controlling non-native and invasive species throughout the growing season (Frank and Woods 2011). The EPMT, park staff, the USGS, participants in Tribal Civilian Corps (TCC), and Southeastern Alaska Guidance Association (SAGA) crews and student interns from Student Conservation Association (SCA) have been involved in the continuing efforts to survey, monitor, and eradicate non-native and invasive species throughout the park on a regular basis since 2005 (Connealy and Parker 2013).

All surveyed areas and treated areas are mapped using GPS equipment, using the Alaska EPMT protocol and standardized data dictionary (Landry and Voznitza 2014). EPMT GIS data and observations from KATM invasive species management reports are compiled following each field season, and are the main source of data for this assessment. This AK-EPMT data is available through the NPS Theme Manager (NPS 2013b). At the time of analysis, the data from the 2013 EPMT inventory was not available. Analysis was performed on the observations ranging from 2000 through 2012 using standard GIS analysis techniques and database queries. Additional data on non-native fauna and freshwater and marine invasive species was downloaded from the "Marine and Great Lakes" on-line database managed by the NPS (NPS 2013a).

4.1.5 Current Condition and Trend

<u>Total area of non-natives</u>

A variety of different invasive and non-native flora species have been introduced into KATM in recent years (Landry and Voznitza 2014). These plants have generally been introduced by visitors and through construction and maintenance activities in the park. Invasive plants usually occur in open, previously disturbed areas. Since forested areas are heavily shaded, this provides protection against most invasive species (Frank and Woods 2011).

Table 6 shows the extent (area) of non-native and invasive species found within the park compared to the area surveyed, 2005-2012 by species. GIS data from the NPS Theme Manager was used for the analysis. Total area surveyed (Figure 1) was calculated using GIS and the polygon features from the AK-EPMT GIS plant survey data for KATM (NPS 2013b). This data was exported to a spreadsheet for further analysis. In the spreadsheet, the total area of infestation was calculated according to the following protocol. For the mapped areas that were greater than 0.5 acres, total area infested was calculated by multiplying the area mapped by the percent cover. For areas less than 0.5 acres, 100% cover was assumed (Landry and Voznitza 2014). Note that there was no survey or control work completed in 2006.

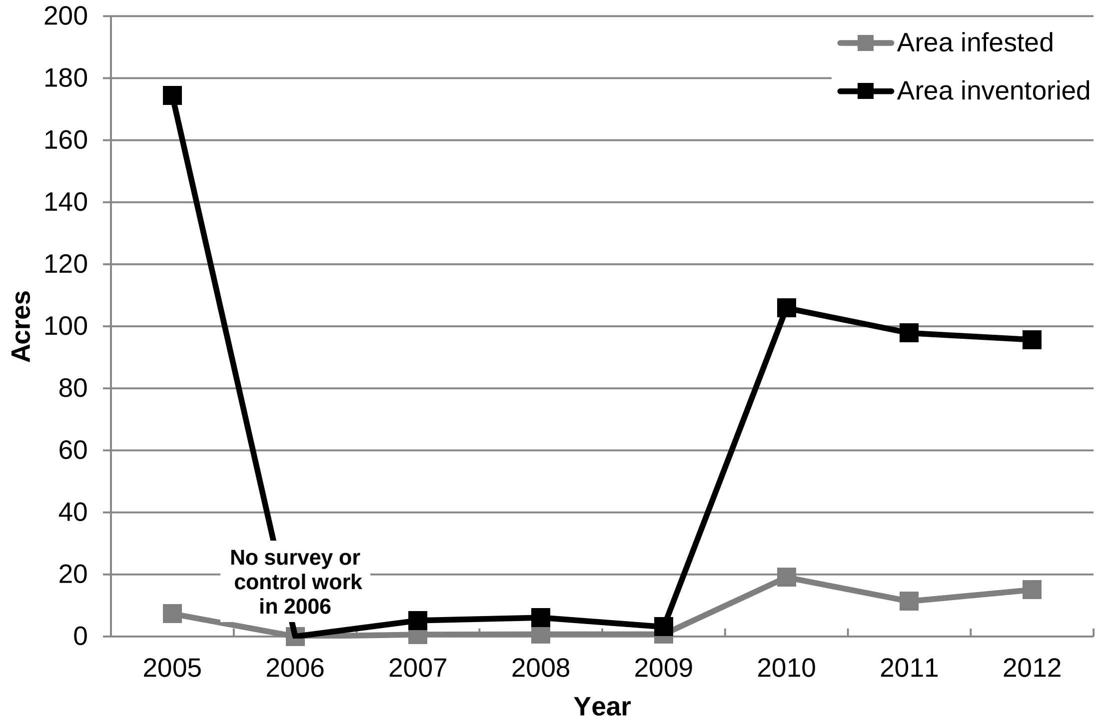

Figure 1. Total area surveyed for KATM and area infested by invasive plants (NPS 2013b). No survey or control work completed in 2006.

Table 6. Summary of invasive plant species for KATM, including area infested and percent of the land cover surveyed in a given year (2005 – 2012) (NPS 2013b)

Common Name	Scientific Name	Aggregate Area Infested (acre)	Percent of Area Surveyed (acre)
pineapple weed	*Matricaria discoidea*	14.29	2.93%
common dandelion	*Taraxacum officinale* ssp. *officinale*	11.27	2.31%
shepherd's purse	*Capsella bursa-pastoris*	6.52	1.34%
annual bluegrass	*Poa annua*	6.35	1.30%
common plantain	*Plantago major*	2.91	0.60%
common sheep sorrel	*Rumex acetosella*	2.56	0.52%
narrowleaf hawksbeard	*Crepis tectorum*	0.34	0.07%
prostrate knotweed	*Polygonum aviculare*	0.25	0.05%
bird vetch	*Vicia cracca*	0.24	0.05%
fall dandelion	*Leontodon autumnalis*	0.15	0.03%
white clover	*Trifolium repens*	0.02	<0.01%
mouse-ear chickweed	*Cerastium fontanum*	<0.01	<0.01%
common red raspberry	*Rubus idaeus*	<0.01	<0.01%
alsike clover	*Trifolium hybridum*	<0.01	<0.01%
red clover	*Trifolium pratense*	<0.01	<0.01%
Total:		44.91	

The remote location of KATM, coupled with the continued efforts of the EPMT, is providing an effective deterrent to the advancement of infestations (Landry and Voznitza 2014). Analysis of the data shows that since monitoring began, the percent of the area infested has remained relatively consistent. Since 2010, when the EPMT began to survey and control throughout the growing season, the infested area has been within ±1 standard deviation of the average infested area, approximately 15%.

This consistency can also be seen in the number of known species. While the total number of invasive species documented remains relatively low, it has increased over the years. Again, since 2010 the number of species documented each year has remained relatively stable. Basically, four species make up the majority of the infested areas found within KATM with Pineapple weed and common dandelion being the most widespread.

Within the park, the majority of the infestations of pineapple weed can be found in and around Brooks Camp facilities and trails and the Lake Camp area. A vast majority of the infestations of common dandelion are found in and around Brooks Camp and its facilities and trails. The Brooks Camp area is also the site of the majority of the shepherd's purse and annual bluegrass infestations. Since Brooks Camp and its facilities are the most heavily disturbed and receive the most human traffic, it is logical that the majority of the infestations would be found there (Densmore et al. 2001, Landry and Voznitza 2014).

Number of non-native species

GPS data on the extent of invasive plant infestations was first collected for KATM in 1997 and completed in 2000 by the USGS. The results showed few infestations, mainly around areas of anthropogenic disturbance and use (Densmore et al. 2001). Thorough surveys, including GPS data, were conducted in 2005 at Lake Camp, Brooks Camp, VTTS Road, and along the outer coast at Hallo, Swikshak, and Kaguyak Bays (Frank and Woods 2011). Surveys were not completed in 2006; however, control work was done at Brooks Camp, focusing on dandelions (Frank and Woods 2011).

Control work continued at Brooks Camp from 2007 through 2009, primarily for a focused interval using a work crew (Frank and Woods 2011). Beginning in 2010, the EPMT had two SCA interns for the entire growing season at Katmai, which allowed more expansive control and inventory work.

In 2010, control was again focused in the Brooks Camp area, along with the VTTS Road, and in the Lake Camp and King Salmon areas (Connealy and Parker 2013). In addition, infestations at Fure's Cabin and Nonvianuk ranger cabin were controlled, and Jojo Lake was added to the survey (Connealy and Parker 2013).

In 2011, locations in Katmai National Preserve at Funnel and Moraine Creeks and Crosswind Lake, on the Outer Coast at Geographic Harbor, Takli and Little Takli Islands, and areas on and around Naknek Lake, including the Bay of Islands, and at Idavain and Margot Creeks were added to the inventory (Connealy and Parker 2013). During the 2011 EPMT season, three new invasive species were found in the park: common mouse-ear chickweed, common chickweed and European forget-me-not (Connealy and Parker 2013).

During 2012, efforts continued in Brooks Camp, VTTS Road, Lake Camp, Fure's Cabin and in King Salmon, and additionally at the landing strips throughout KATM (Landry and Voznitza 2014).

In 2013, the EPMT worked in some of the more commonly disturbed areas of the park including Brooks Camp, VTTS Road, Lake Camp, Fure's Cabin, and in King Salmon (Landry and Voznitza 2014). Surveys were also conducted along the Alagnak Wild River and the Nonvianuk Cabin and River (Landry and Voznitza 2014). The results for the 2013 EPMT were not yet available for inclusion in this analysis.

Table 7 summarizes the invasive species that have been documented in and around KATM. Through the 2012 EPMT survey, a total of 16 species were documented within the park. A total of 35 species have been documented in areas around the park. With the exception of common red raspberry, those species found within the park have also been found in the surrounding area.

The most commonly found invasive plants are common dandelion with 407 instances and pineapple weed with 402 instances. Together they make up just over 40% of all infestations. Shepherd's purse is the next most abundant invasive species making up approximately 14% of all occurrences. Common plantain and annual bluegrass are the other species that have a significant occurrence, each comprising approximately 9% of the total occurrences. The only other species with significant occurrences are common sheep sorrel, fall dandelion, and narrowleaf hawksbeard.

Surveys conducted in 2005 identified eight invasive species present within the park. Short intervals (up to two weeks) of control work dominated the 2007, 2008, and 2009 EPMT seasons (Landry and Voznitza 2014). This is probably the reason for the small numbers of species identified, with two, one, and five species identified respectively. The number of species identified increased to 12 in 2010, most likely due to an increase in area surveyed as well as distributing survey hours throughout the growing season. The number of species documented was steady in both 2011 (11) and 2012 (12).

Analysis of the data shows that the highest number of species documented have been in the Brooks Camp and Lake Camp areas and along the VTTS Road. Plate 6-Plate 10 show the areal extent of the documented sightings of common dandelion, pineapple weed, shepherd's purse, common plantain, and annual bluegrass. Plate 11– Plate 25 show areal extent over time for each non-native species documented in the park.

Table 7. Summary of invasive species found in or near KATM by year of observation (NPS 2013b)

Common Name	Scientific Name	Inside KATM	2005	2007	2008	2009	2010	2011	2012
cultivated chive	*Allium sp.*								(x)
meadow foxtail	*Alopecurus pratensis*								(x)
smooth brome	*Bromus inermis*						(x)		(x)
shepherd's purse	*Capsella bursa-pastoris*	Yes	X			X	X (x)	X (x)	X (x)
Siberian peashrub	*Caragana arborescens*						(x)	(x)	(x)
mouse-ear chickweed	*Cerastium fontanum*	Yes						X (x)	
narrowleaf hawksheard	*Crepis tectorum*	Yes	X	X			X (x)	X (x)	X (x)
split-lip hemp-nettle	*Galeopsis bifida*						(x)		(x)
narrow-leaved hawkweed	*Hieracium umbellatum*							(x)	
foxtail barley	*Hordeum jubatum*						(x)	(x)	
fall dandelion	*Leontodon autumnalis*	Yes					X (x)	X (x)	X (x)
oxeye daisy	*Leucanthemum vulgare*		(x)				(x)	(x)	(x)
yellow toadflax	*Linaria vulgaris*								(x)
birdsfoot trefoil	*Lotus corniculatus*								(x)
pineapple weed	*Matricaria discoidea*	Yes	X (x)				X (x)	X (x)	X (x)
true forget-me-not	*Myosotis scorpioides*							(x)	
common timothy	*Phleum pratense*								(x)
common plantain	*Plantago major*	Yes	X			X	X	X (x)	X
annual bluegrass	*Poa annua*	Yes					X	X (x)	X
European bird cherry	*Prunus padus*								(x)
tall buttercup	*Ranunculus acris*								(x)
creeping buttercup	*Ranunculus repens*								(x)
common red raspberry	*Rubus idaeus*	Yes					X		
common sheep sorrel	*Rumex acetosella*	Yes	X				X (x)	X (x)	X (x)
curly dock	*Rumex crispus*								(x)
crownvetch	*Securigera varia*								(x)
European mountain-ash	*Sorbus aucuparia*						(x)		(x)
common chickweed	*Stellaria media*						(x)	(x)	
common tansy	*Tanacetum vulgare*						(x)	(x)	(x)
common dandelion	*Taraxacum officinale* ssp. *officinale*	Yes	X	X	X	X	X (x)	X (x)	X (x)

Table 7. Summary of invasive species found in or near KATM by year of observation (NPS 2013b) (continued)

Common Name	Scientific Name	Inside KATM	2005	2007	2008	2009	2010	2011	2012
	Trifolium hybridum	Yes					(x)	(x)	X (x)
red clover	*Trifolium pratense*	Yes							X (x)
white clover	*Trifolium repens*	Yes	X				(x)		X (x)
scentless false mayweed	*Tripleurospermum inodorum*						(x)		
bird vetch	*Vicia cracca*	Yes				X	X (x)	X (x)	X
Other		Yes					X (x)	X (x)	

X = species was found within park

(x) was found in areas around the park

X (x) = found within and around the park

Invasiveness score

Identification of species with the greatest potential for establishment and spread was highlighted as a necessary action in a strategic plan for noxious and invasive plant management in Alaska (Carlson and Shepard 2007). Most of the non-native species introduced are not well-adapted to the new environment and do not establish viable populations (Taylor and Hastings 2005). Many of these same species also have rather limited dispersal capabilities, thereby increasing the chance of successful control in small populations. Additionally, introductions usually involve a small number of individuals and smaller populations are much more susceptible to extirpation through human eradications (Taylor and Hastings 2005).

Of those species that can become established, only a small subset proceeds to invade native ecosystems (Taylor and Hastings 2005). These highly invasive plants effectively compete for resources and usually have aggressive reproductive strategies (Schrader and Hennon 2005). For example, certain species may be abundant seed producers or sprout aggressively, while other species produce rhizomes or vegetative pieces that can facilitate spreading (Carlson et al. 2008). Invasive plants frequently create dense-growth thickets and release viable seed that can remain in soils for more than three years. Generally, when there is opportunistic ground disturbance many of these seeds take root, germinate, and push out native plant communities, although many invasive species do not need such disturbances (Schrader and Hennon 2005).

Invasiveness assessment models generally consist of a series of criterion evaluating spatial characteristics, biological characteristics, known or potential impacts on important resources (e.g., biodiversity, water resources, etc.), and ease of control (Carlson et al. 2008). As stated in Carlson et al. (2008) these ranking systems are generally designed to be “robust, transparent, and repeatable in order to aid land managers and the broader public in identifying problematic non-native plants and for prioritizing control efforts.” As with many ranking systems, they are somewhat subjective and may change gradually over time as new or revised information becomes available (Carlson et al.

2008). Ideally these rankings can be used by land managers to help determine treatment priorities, given limited resources.

Scientists have developed an invasiveness ranking protocol and scale specifically for Alaska (Carlson et al. 2008, Nawrocki et al. 2011). It was developed with the goal of informing land managers of the relative dangers of invasive species and to provide a tool to be used in conjunction with site-specific information in order to prioritize control activities (Carlson et al. 2008). For each species reviewed, the protocol uses a climatic screening process and if passed, it is then evaluated in four categories: ecological impacts, biological characteristics and dispersal ability, ecological amplitude and distribution, and feasibility of control (Carlson et al. 2008, Nawrocki et al. 2011). Using a weighted algorithm, it produces scores for each of the categories and an overall "invasiveness rank." This rank is on a scale of zero to 100. The relationship between the invasiveness score and invasiveness rank is shown in Table 8. As of April 2011, a total of 164 invasive species have been ranked according to this methodology (Nawrocki et al. 2011). The overall range of scores, as of April 2011, has Eurasian watermilfoil (*Myriophyllum spicatum*) receiving the highest score of 90 and common pepperweed (*Lepidium densiflorum*) receiving the lowest score of 25 (Nawrocki et al. 2011).

Table 8. Alaska invasiveness ranking (Carlson et al. 2008)

Invasiveness Score	Invasiveness Rank
>80	Extremely Invasive
70-79	Highly Invasive
60-69	Moderately Invasive
50-59	Modestly Invasive
40-49	Weakly Invasive
< 40	Very Weakly Invasive

Individual invasive rankings were obtained from AKEPIC (2013), maintained by the University of Alaska Anchorage, and Carlson et al. (2008). An additional 50 species ranked by Nawrocki et al. in 2011 were added to this listing. One of the species found within the park, common red raspberry, has not yet been rated since it is native to the interior of Alaska. To date, not all species found in Alaska have been assigned a rank in the ranking systems for Alaska (Nawrocki et al. 2011). The lack of invasive score does not necessarily imply a lack of invasiveness, but rather that some species have not yet been evaluated (Nawrocki et al. 2011).

Of the species found to date in KATM (Table 9), only two have an invasive ranking of 60 or greater, bird vetch and smooth brome, indicating a significant threat for invasion. The overall extent of bird vetch is shown in Plate 11. Smooth brome was identified during the 2013 survey season (W. Rapp, pers. comm. 2014). Within the park, the ranked species range from known harmful species, such as bird vetch with a score of 73, to the more benign pineapple weed, with a ranking of 32. The majority of the invasive species found within the park fall in the modestly to moderately invasive category. However, 10 species found around the park, including bird vetch, have invasive rankings of 60 or greater. Siberian peashrub and European bird cherry have scores of 74. It should be noted that presence or absence of certain species in specific years could be due to misidentification by staff and volunteers, overlooking the species, or not revisiting that area of the park (Frank and Woods 2011).

Table 9. Summary of invasiveness ranking for invasive species found in and around KATM (Carlson et al. 2008, Nawrocki et al. 2011).

Common Name	Scientific Name	Invasiveness Rank	In Park?
Siberian peashrub	*Caragana arborescens*	74	
European bird cherry	*Prunus padus*	74	
bird vetch	*Vicia cracca*	73	Yes
yellow toadflax	*Linaria vulgaris*	69	
crownvetch	*Securigera varia*	68	
birdsfoot trefoil	*Lotus corniculatus*	65	
foxtail barley	*Hordeum jubatum*	63	
smooth brome	*Bromus inermis*	62	Yes
oxeye daisy	*Leucanthemum vulgare*	61	
common tansy	*Tanacetum vulgare*	60	
European mountain-ash	*Sorbus aucuparia*	59	
white clover	*Trifolium repens*	59	Yes
common dandelion	*Taraxacum officinale* ssp. *officinale*	58	Yes
alsike clover	*Trifolium hybridum*	57	Yes
narrowleaf hawksbeard	*Crepis tectorum*	56	Yes
true forget-me-not	*Myosotis scorpioides*	54	
common timothy	*Phleum pratense*	54	
tall buttercup	*Ranunculus acris*	54	
creeping buttercup	*Ranunculus repens*	54	
red clover	*Trifolium pratense*	53	Yes
meadow foxtail	*Alopecurus pratensis*	52	
narrow-leaved hawkweed	*Hieracium umbellatum*	51	
common sheep sorrel	*Rumex acetosella*	51	Yes
split-lip hemp-nettle	*Galeopsis bifida*	50	
fall dandelion	*Leontodon autumnalis*	49	Yes
curly dock	*Rumex crispus*	48	
false mayweed	*Tripleurospermum inodorum*	47	
annual bluegrass	*Poa annua*	46	Yes
common plantain	*Plantago major*	44	Yes
common chickweed	*Stellaria media*	42	
shepherd's purse	*Capsella bursa-pastoris*	40	Yes
mouse-ear chickweed	*Cerastium fontanum*	36	Yes
pineapple weed	*Matricaria discoidea*	32	Yes
cultivated chive	*Allium sp.*	NR	
common red raspberry	*Rubus idaeus*	NR	Yes

Status of exotic fauna

Within Alaska, there is growing concern about the invasion of non-native faunal species, especially marine species. Marine species have the same impacts on native species and ecosystems as their terrestrial counterparts (Molnar et al. 2008). Once they become established, they are nearly impossible to eradicate (Molnar et al. 2008).

The NPS has compiled a database of reports of invasive species sightings in National Parks (NPS 2013a). This database compiles reports from sightings documented by the USGS, NPSpecies, Government Performance Results Act (GPRA) reports, NPS Coastal Watershed Assessments (CWA) and The Nature Conservancy (NPS 2013a). It uses a quantitative threat-score index developed by The Nature Conservancy to assess a species' ecological impact, invasive potential, geographic extent, and management difficulty (NPS 2013a). The database is searchable by park unit and contains information on species that have been documented in the park, and also those that are potentially a threat to the park (NPS 2013a). The database shows no document observations of these marine invasive species for KATM, but does list several that have the potential to be a threat to the park in the future. The output of this database for KATM is listed in Table 10.

Table 10. Summary of potential invasive species for KATM (NPS 2013a).

Common Name	Species Name	Threat
Potential Invasive Species		
solitary tunicate	*Ciona intestinalis*	4
zebra mussel	*Dreissena polymorpha*	4
Chinese mitten crab	*Eriocheir sinensis*	4
hydroid	*Garveia franciscana*	4
capitellid worm	*Heteromastus filiformis*	4
brown alga	*Microspongium globosum*	4
softshell clam	*Mya arenaria*	4
Japanese carpetshell	*Ruditapes philippinarum*	4
American shad	*Alosa sapidissima*	3
green crab	*Carcinus maenas*	3
green algae	*Cladophora sericea*	3
boring sponge	*Cliona thoosina*	3
rockweed	*Fucus cottoni*	3
tube dwelling amphipod	*Jassa marmorata*	3
Atlantic salmon	*Salmo salar*	3
single-horn bryozoan	*Schizoporella unicornis*	2
Foraminiferan	*Trochammina hadai*	2
pink hearted hydroid	*Ectopleura crocea*	1
red macroalga	*Polysiphonia brodiei*	1
naval shipworm	*Teredo navalis*	1
Arctic char	*Salvelinus alpinus*	–

The threat classification is similar to the invasive species ranking and assesses the level of impact to native species and native ecosystems. Each species is assigned a score, data permitting, from one to four (NPS 2013a). The categories are defined as;

- 4 - disrupts entire ecosystem processes with wider abiotic influences
- 3 - disrupts multiple species, some wider ecosystem function, and/or keystone species or threatened species
- 2 - disrupts single species with little or no wider ecosystem impact
- 1 - little or no disruption
- (dash) - unknown or not enough information to determine score

Invasive fauna threaten biological diversity in a similar manner as invasive plants (Frank and Woods 2011). Introduced insects can spread aggressively, displace native species and have the potential to cause great economic harm (Frank and Woods 2011). The gypsy moth (*Lymantria dispar asiatica*), in particular poses a significant hardwood deforestation threat to Alaska's forested ecosystems (Frank and Woods 2011). To date, no gypsy moths have been detected in KATM or the surrounding area (Landry and Voznitza 2014). Recreational vehicle traffic is thought to be the primary mode of gypsy moth transport, but potential introductions via shipping ports are of increasing concern (Frank and Woods 2011). A gypsy moth trapping system has been incorporated into EPMT monitoring efforts as part of its overall strategy of early detection and rapid response (Connealy and Parker 2013).

Another notable insect defoliator present in Alaska is the geometrid moth (Frank and Woods 2011). The most destructive insects are the native Bruce spanworm (*Operophtera bruceata*) and the introduced autumnal moth (*Epirrita autumnata*) (Frank and Woods 2011). Both species have been documented in South Central Alaska and are progressing down the Kenai Peninsula (Frank and Woods 2011). An outbreak can involve the defoliation of hundreds of trees and shrubs by caterpillars over numerous years, ending with a crash of the caterpillar population. Caterpillars and defoliation were observed in KATM in 2011 at Brooks Camp and in the Bay of Islands; however, the species and their nativity has not been established (Frank and Woods 2011).

Threats and Stressor Factors

The major threats and stressors to park-wide environmental conditions include climate change, increasing development in the park, and rising park visitation. All of the stressors may have implications on the threat of spread or source of invasive species.

Firstly, climate change can be a major factor in the spread and impact of invasive plant species (Frank and Woods 2011). Climatic models associated with climate change predict milder temperatures and increased precipitation for the park, especially during the winter months (Connealy and Parker 2013). Changing seasonal temperature patterns and precipitation distribution tend to favor invasive species over natives (Brooks et al. 2004). This could lead to simplified ecosystems, stressed native plant species, and a slow northerly shift of native plant communities (Frank and Woods 2011).

Secondly, the occurrence of non-native plants is strongly correlated to anthropogenic disturbances (Nawrocki et al. 2011). Construction equipment, construction fill, and topsoil are often contaminated with invasive plants (Frank and Woods 2011). In Alaska, fill importation accounts for 70% of recorded plant infestations (Nawrocki et al. 2011). Management practices that control the source of fill and topsoil and restricting the use of fertilizer that encourages growth of certain invasive species would promote retention of much of KATM’s rich species diversity (Densmore et al. 2001). Densmore et al. (2001) suggests that quick re-vegetation of disturbed areas would also be beneficial to preserving species richness. Aquatic threats include increases in shipping to local ports, as shipping and cargo vessels have the potential to transport invasive species in their cargo and ballast water. This is becoming an area of increasing concern over the potential introduction of invasive species to Bristol Bay’s maritime shipping ports (Frank and Woods 2011).

Thirdly, since much of the landscape in KATM is undeveloped and affected only by natural successional forces, the wildlife and scenery draw thousands of tourists each year (Connealy and Parker 2013). Rising visitation rates could also potentially spread seed from invasive plants, which can attach to visitors’ clothes and shoes, thereby introducing the organism to other areas unintentionally (Densmore et al. 2001, Koons et al. 2003) Areas of high visitor usage such as the

Brooks Camp, Lake Camp, and campgrounds continue to be areas of high infestation and thus of high priority, especially in the removal and treatment of invasive species (Landry and Voznitza 2014). Trails, paths, and roads act as channels that invasive species frequently follow (Bella 2011). Activities associated with these linear pathways also promote plant invasions through changing habitat conditions, altering microhabitats, and facilitating dispersal (Bella 2011). These areas continue to be high priority sites for the removal and treatment of invasive species (Landry and Voznitza 2014).

The disposal of plant material that accumulates during the EPMT field season has also become a significant issue (Landry and Voznitza 2014). In previous years, several solutions have been attempted to kill viable seeds and plant material that were collected during the field season (Landry and Voznitza 2014). The EPMT has explored burying the material, but assurances could not be made to the prevention of potential spread of any viable material (Landry and Voznitza 2014). Another solution has been burning the plant material in metal drums; however, this has proved problematic as often plant remains at the bottom of the barrels were not completely burned and thus become a potential vector for spreading invasive plants (Landry and Voznitza 2014). Currently all plant material collected is burned in the Brooks Camp incinerator (Landry and Voznitza 2014). While it has been found to be more effective than any other method tried to date, it is not fuel-efficient or sustainable due to the large amount of diesel fuel required to completely incinerate all plant material (Landry and Voznitza 2014).

Data Needs/Gaps

Awareness, communication and information exchange are key to early detection and controlling invasive species (Marler 2000). More information is needed that will allow NPS personnel to predict where an invasive species may be found, or where it might spread (Densmore et al. 2001). The documentation and mapping process being conducted by the EPMT should be continued and expanded to new areas to continue providing information that could be used to develop these prediction scenarios. As part of the effort to reduce current invasions, the identification of non-native and invasive species currently present that can be effectively controlled within the park is another priority. As invasive rankings are developed for new species, this information should be incorporated with the data on the documented occurrences and incorporated into planning projects, the re-vegetation and restoration manual, and EPMT management and control. Continued updates to the restoration and re-vegetation manual as new information and technologies become available should also be completed.

The EPMT recently took part in a research study conducted by the University of Fairbanks (Landry and Voznitza 2014). This study, titled ‘Melibee’s Project’ or Citizen Scientist, is looking at how invasive species are affecting the pollination rates of native wildflowers (Landry and Voznitza 2014).

The study focuses on white sweetclover (*Melilotus alba*), lingonberry (*Vaccinium vitis-idaea*), bog blueberry (*Vaccinium uliginosum*) and bird vetch (*Vicia cracca*). Since white sweetclover is not present in the park, the EPMT chose to focus their observations on bird vetch, lingonberry and bog blueberry (Landry and Voznitza 2014). Data was scheduled to be collected every week, dependent on EPMT control work, and transferred to the project website (http://handsontheland.org/environmental-monitoring/melibee-project/) (Landry and Voznitza 2014). The data collected from this area is highly valuable to the Melibee's project because of King Salmon's unique location in relation to where most other data-sets are collected (Landry and Voznitza 2014). Additionally, the data could prove useful in future management actions.

Overall Condition

Total area of non-natives

Overall, the park is in generally good condition as compared to infestation in the contiguous U.S. and even the more urban areas of Alaska (Landry and Voznitza 2014). Continued monitoring of previously controlled and inventoried sites is critical to extending this trend. Also, as development projects continue, and new ones are designed and built, the EPMT's presence is essential to ensure that these areas are managed and vegetated as needed in order to maintain and improve this condition (Landry and Voznitza 2014).

Number of non-native species

Despite the size of KATM, good progress has been made at controlling invading plant species. Early detection and prevention are keys to providing cost-effective solutions (Marler 2000). Cost and control feasibility increases exponentially each year that a non-native species is left to spread unchecked (Link 2008, NPS 2009). KATM has been fortunate thus far in avoiding major infestations of non-native and invasive species, but eradication programs, as well as EPMT surveys must continue. While the number of invasive species alone does not indicate the level of potential threat (Molnar et al. 2008), when coupled with a scientifically based threat ranking system it can be part of a valuable management tool.

Invasiveness score

Overall, the park is in relatively good condition in terms of highly invasive species, with only one species, bird vetch, occurring in the park. It was first identified in 2009 along the VTTS Road near mile marker 14. The instances of bird vetch have been increasing each year, but are still isolated to the area between mile markers 13 and 14 along VTTS Road and to the 5 mile gravel pit. This species should be a priority for future EPMT investigations to keep it from spreading further. The majority of invasive species that have been documented in the park are in the "modestly invasive" category. With several highly invasive species found in areas around the park, future EPMT should focus on prevention of the spread of these into park areas.

Status of exotic fauna

Relatively little information is available on exotic fauna in and around KATM. Although invasion of non-native fauna seems to be relatively slow based on geographic isolation and increased awareness and education about harmful invasive species, there is still great potential for new introductions (Densmore et al. 2001, McClory and Gotthardt 2008). It is unrealistic to believe that all invasive mammals, birds, aquatic species, and other organisms can be completely eradicated to reflect pre-settlement conditions. It is more realistic to continue to monitor present invasive species and new introductions so an already precarious situation does not become an even bigger problem. It may also be just as important to preserve native species as it is to eradicate non-native invasives. As seen with current trends, Alaska may become even more susceptible to harmful invaders in the future; therefore, the only defense may be increased awareness through monitoring programs such as the EPMTs and continued community involvement.

4.1.6 Sources of Expertise

Whitney Rapp, Research Permitting, Planning, GIS/GPS, IT, Wilderness, & Invasive Species

Carissa Turner, Coastal Area Biologist, Katmai National Park and Preserve

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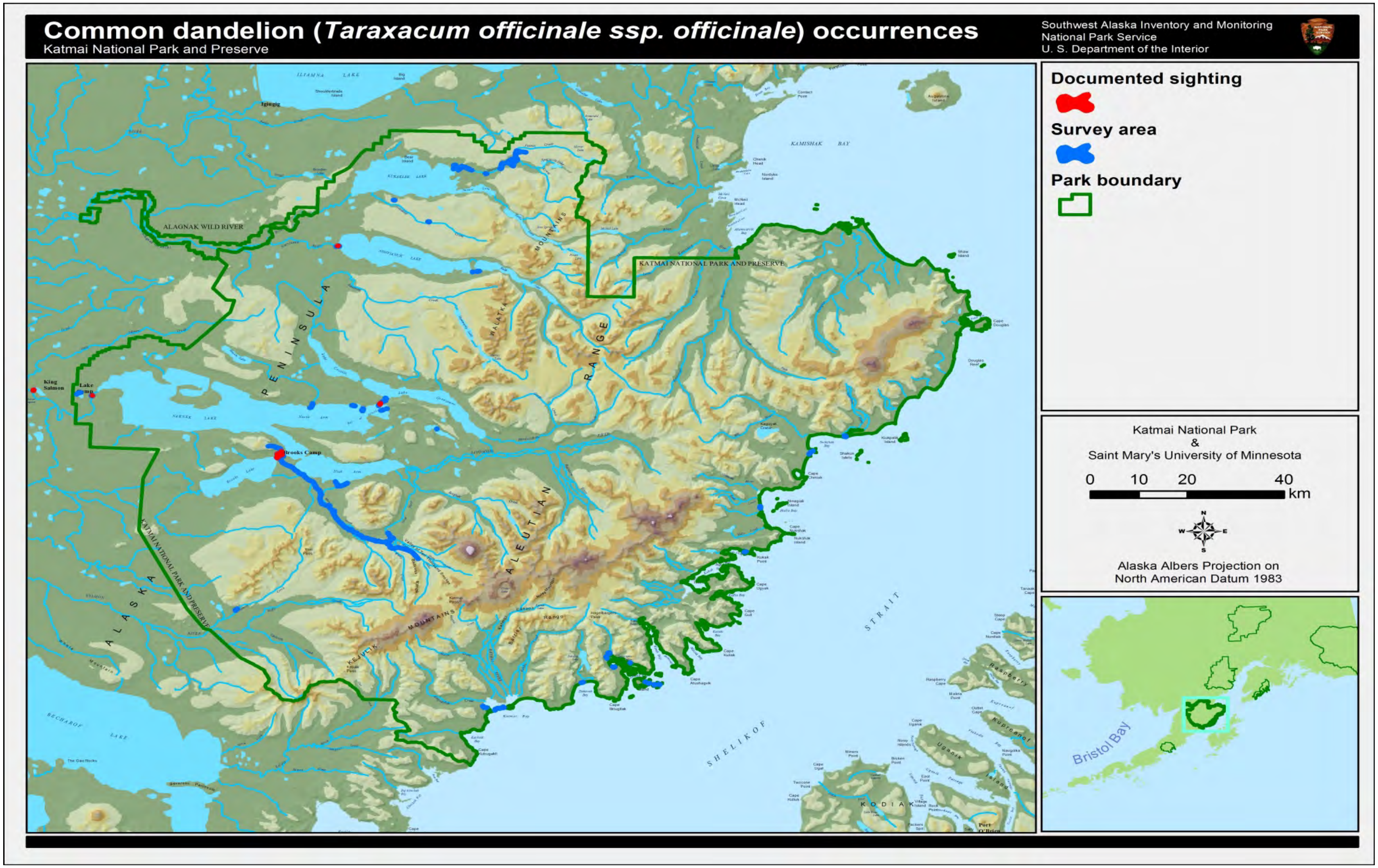

Plate 6. Areal extent of documented common dandelion sightings.

Plate 7. Areal extent of documented pineapple weed sightings.

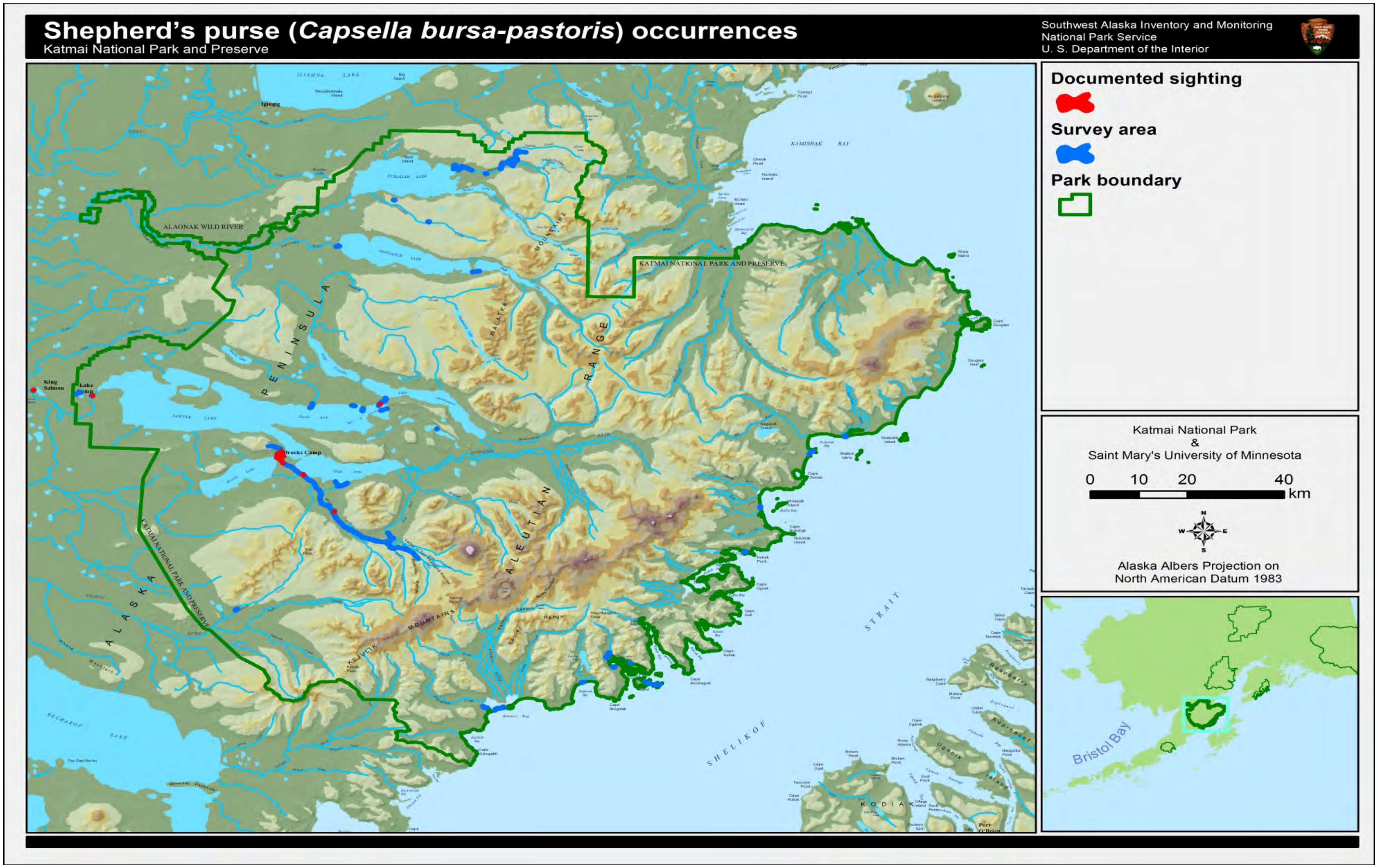

Plate 8. Areal extent of documented shepherd's purse sightings.

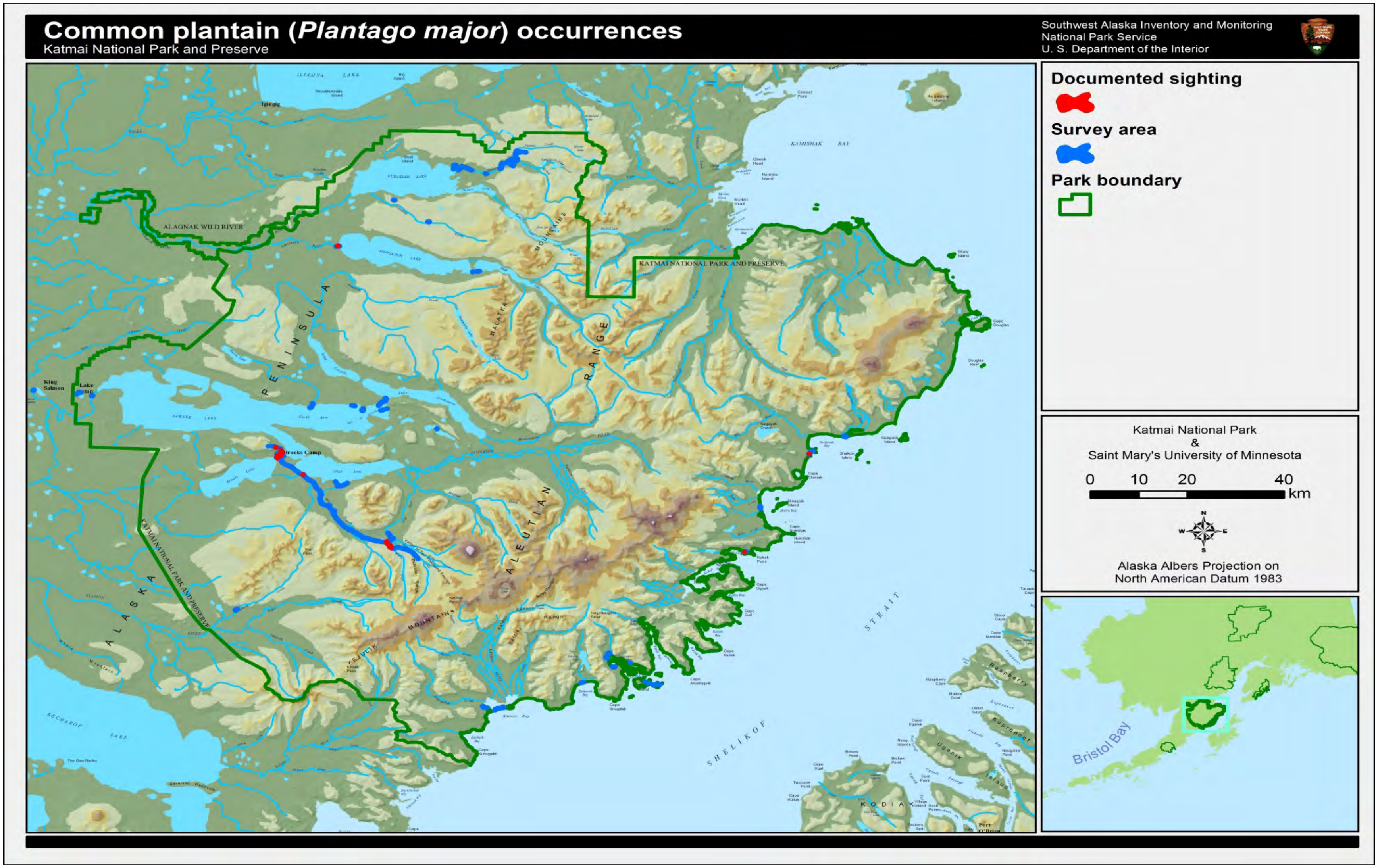

Plate 9. Areal extent of documented common plantain sightings.

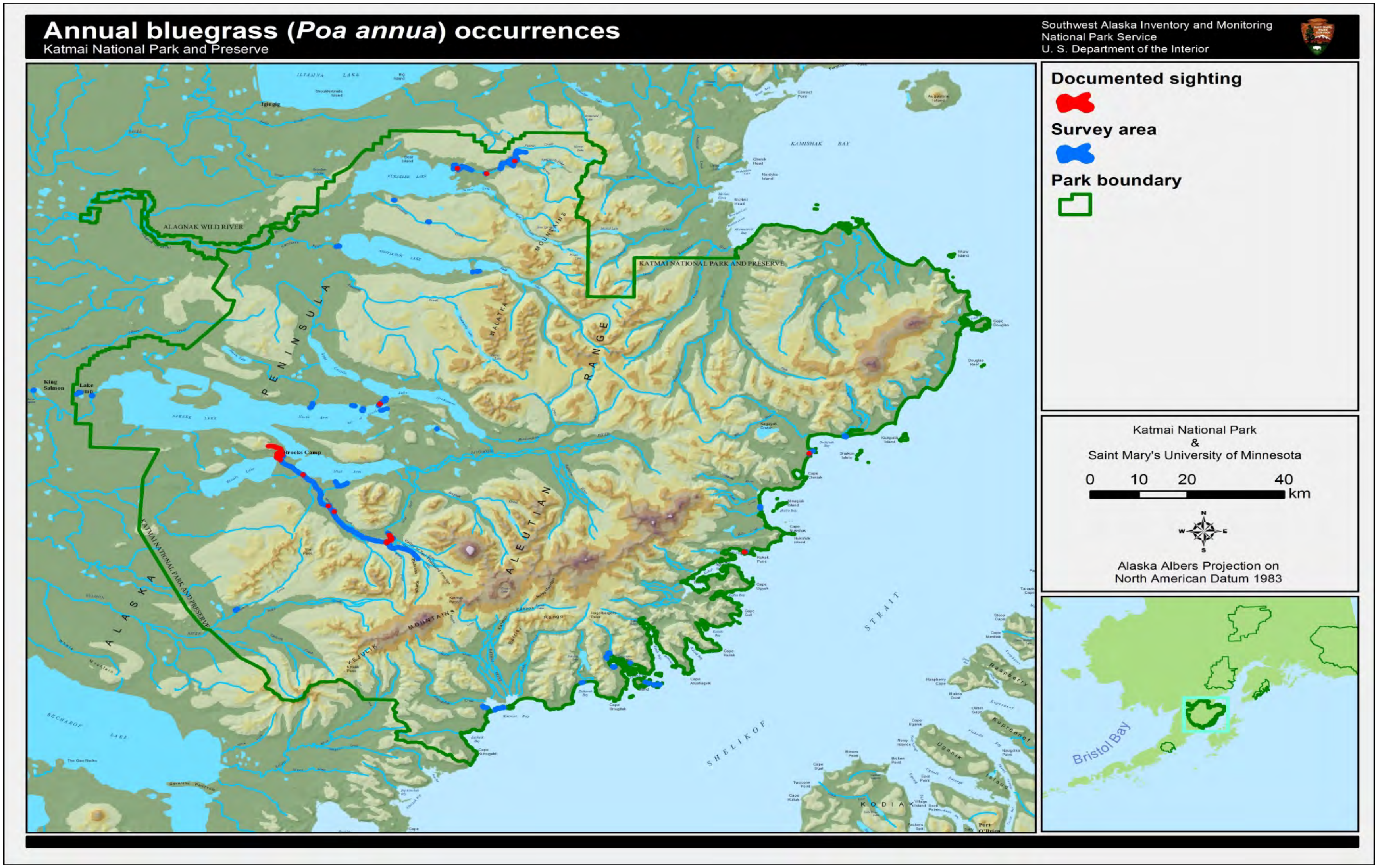

Plate 10. Areal extent of documented annual bluegrass sightings.

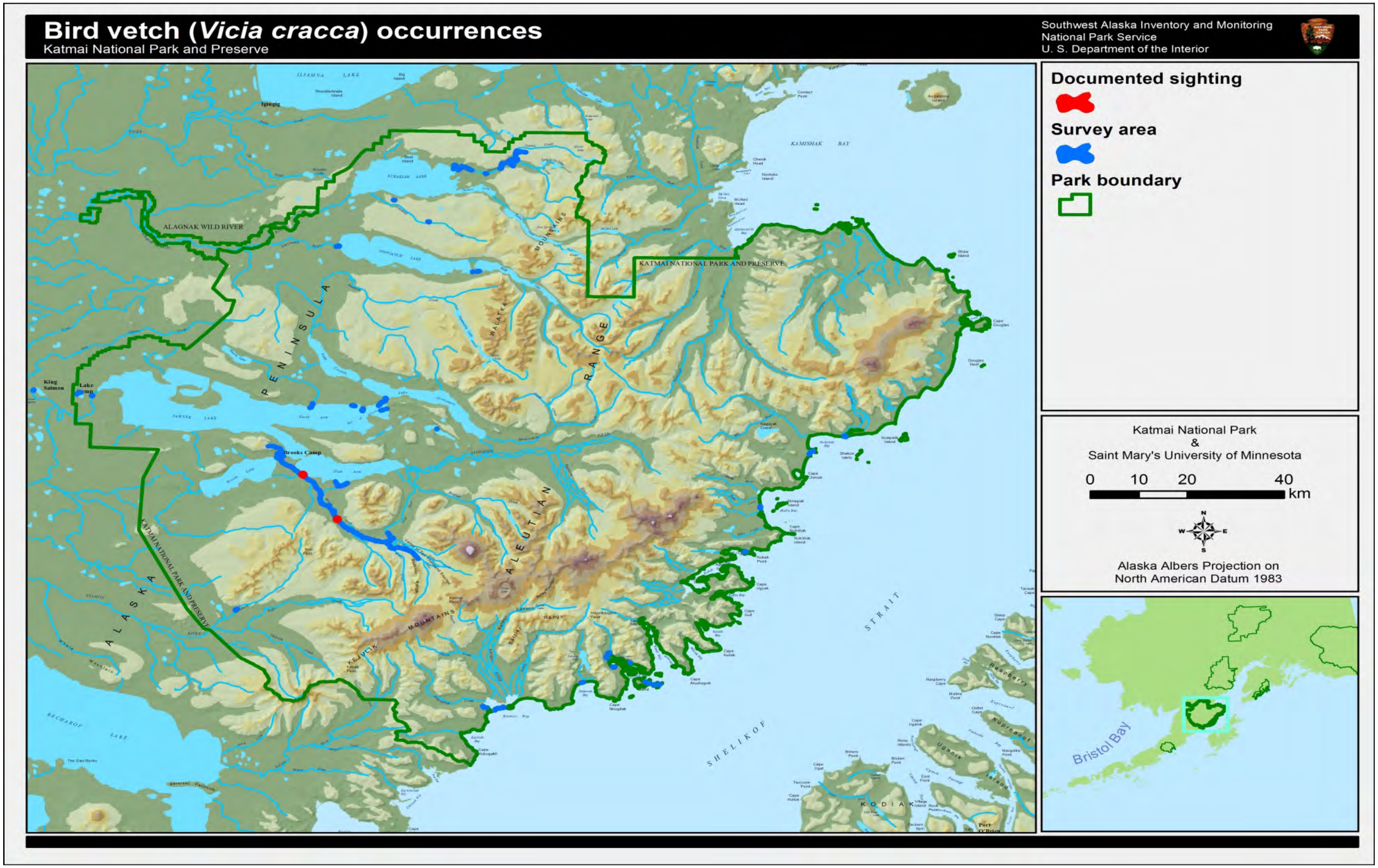

Plate 11. Areal extent of documented bird vetch sightings.

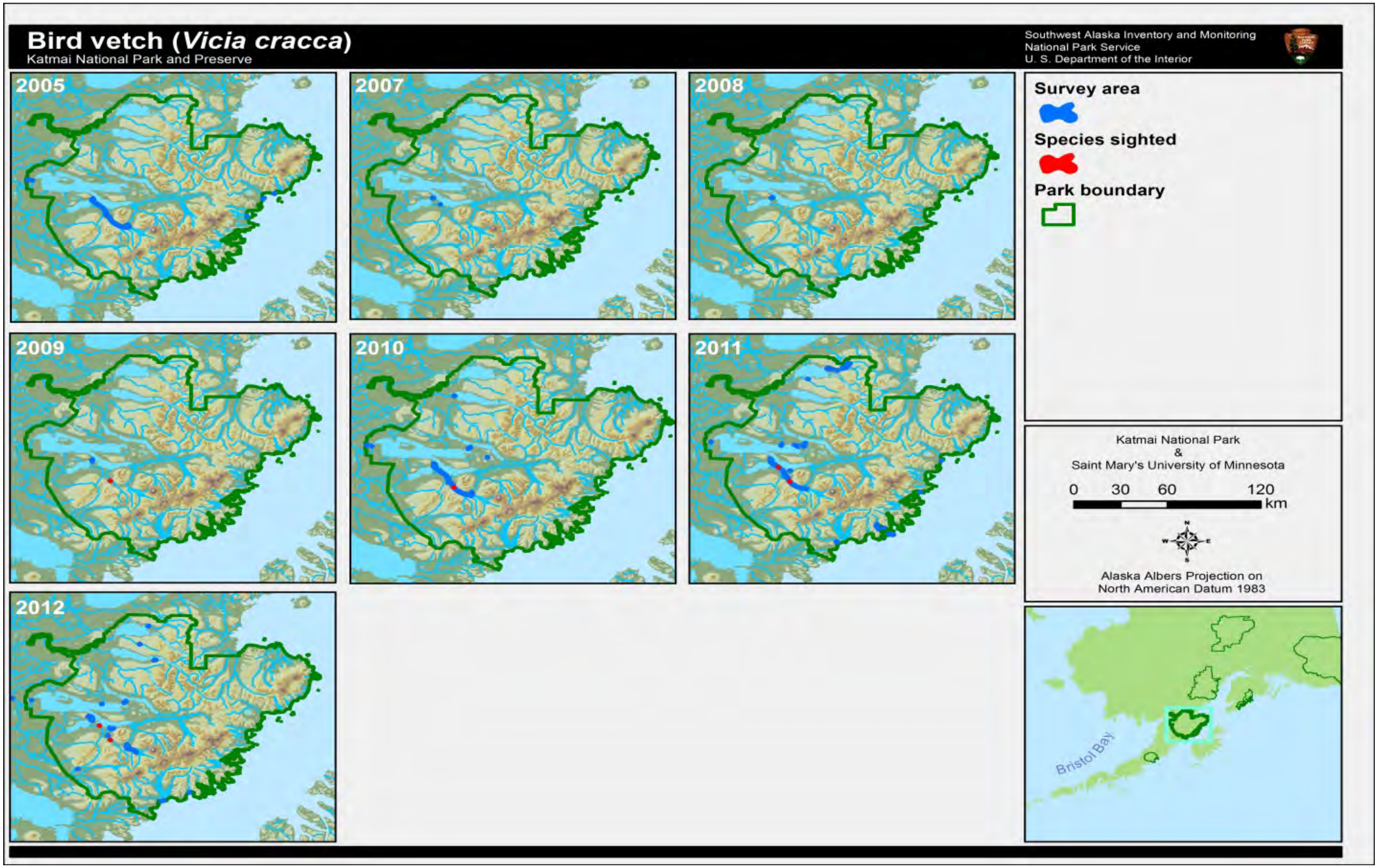

Plate 12. Areal extent of documented bird vetch sightings by year.

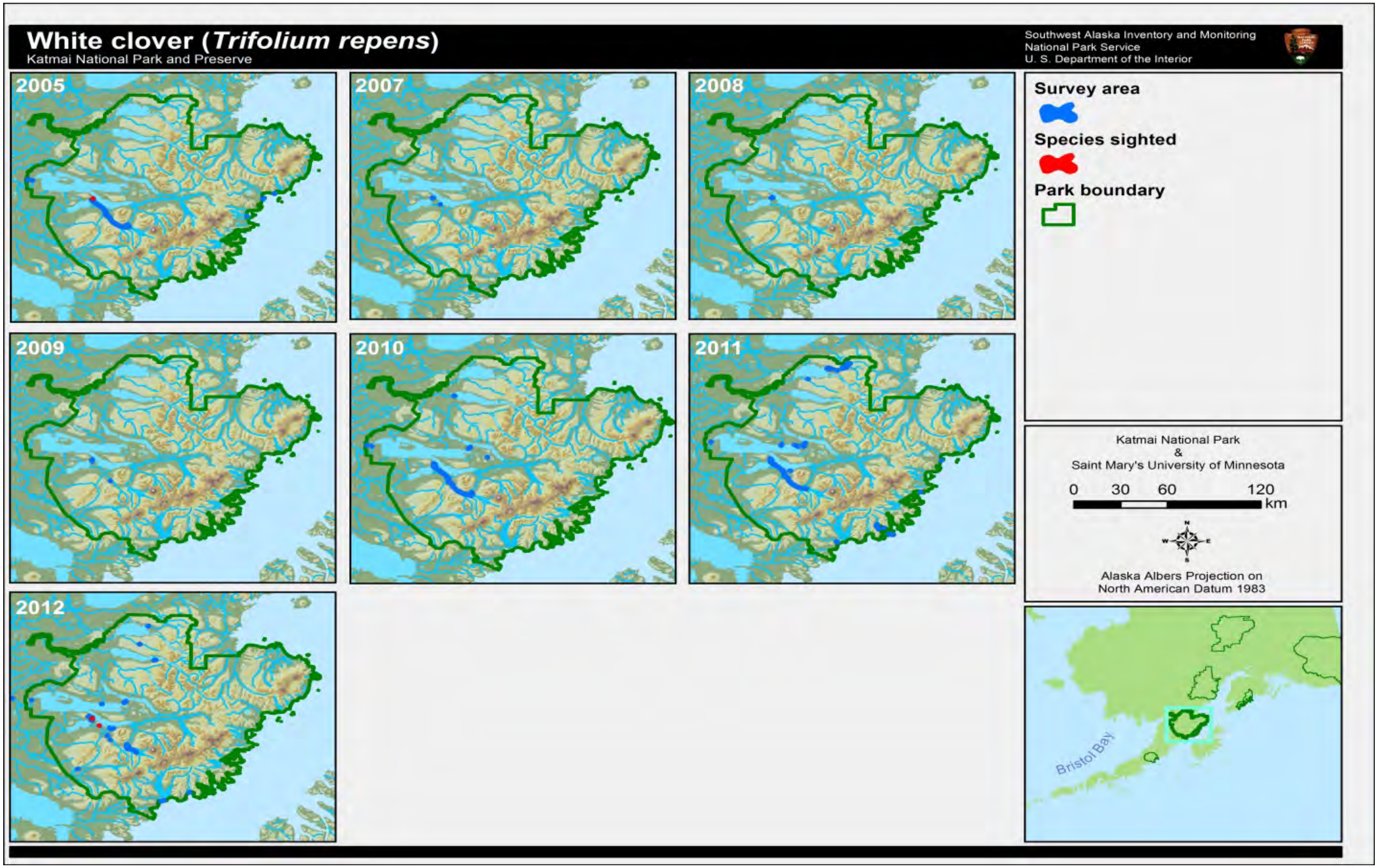

Plate 13. Areal extent of documented white clover sightings by year.

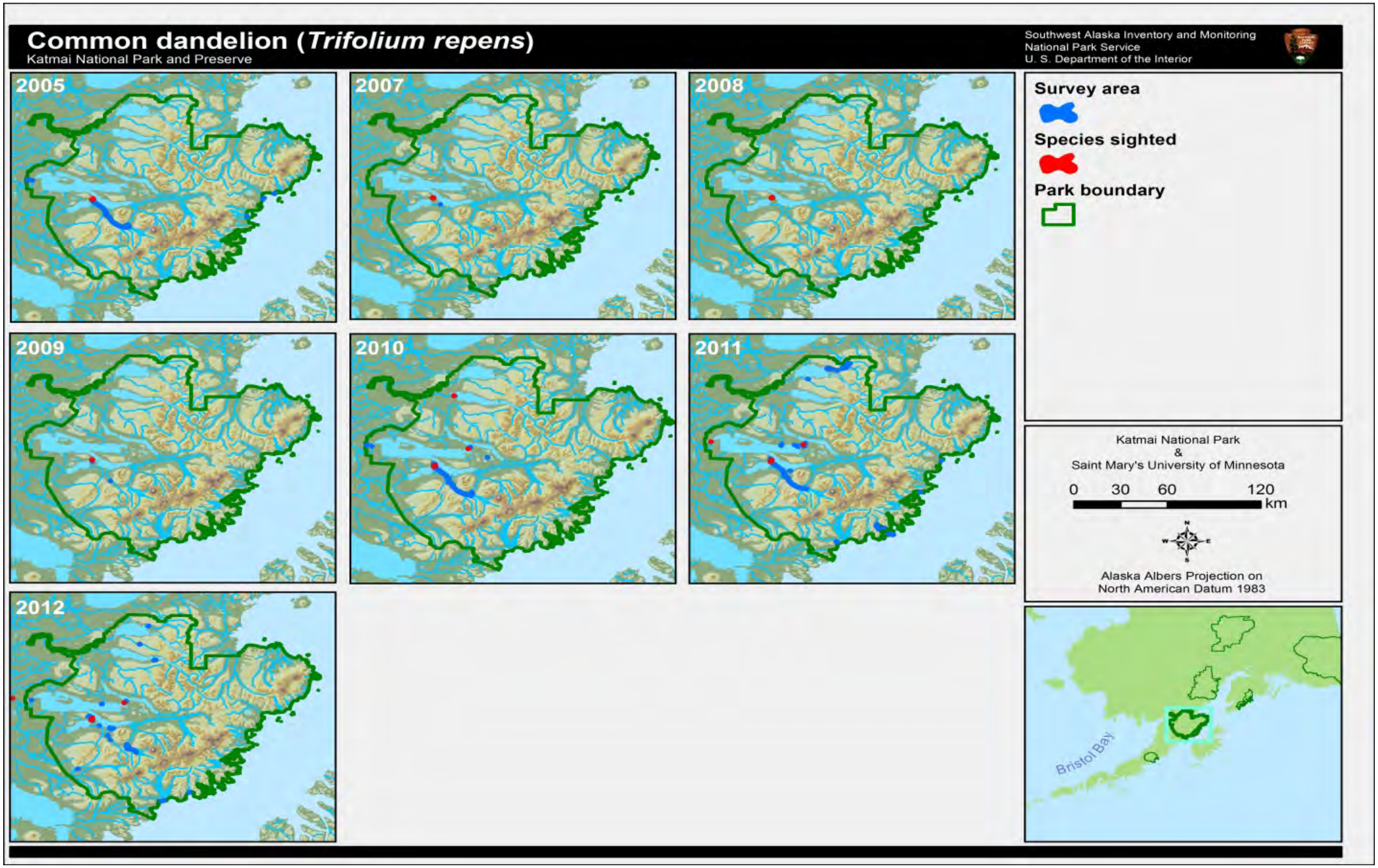

Plate 14. Areal extent of documented common dandelionclover sightings by year.

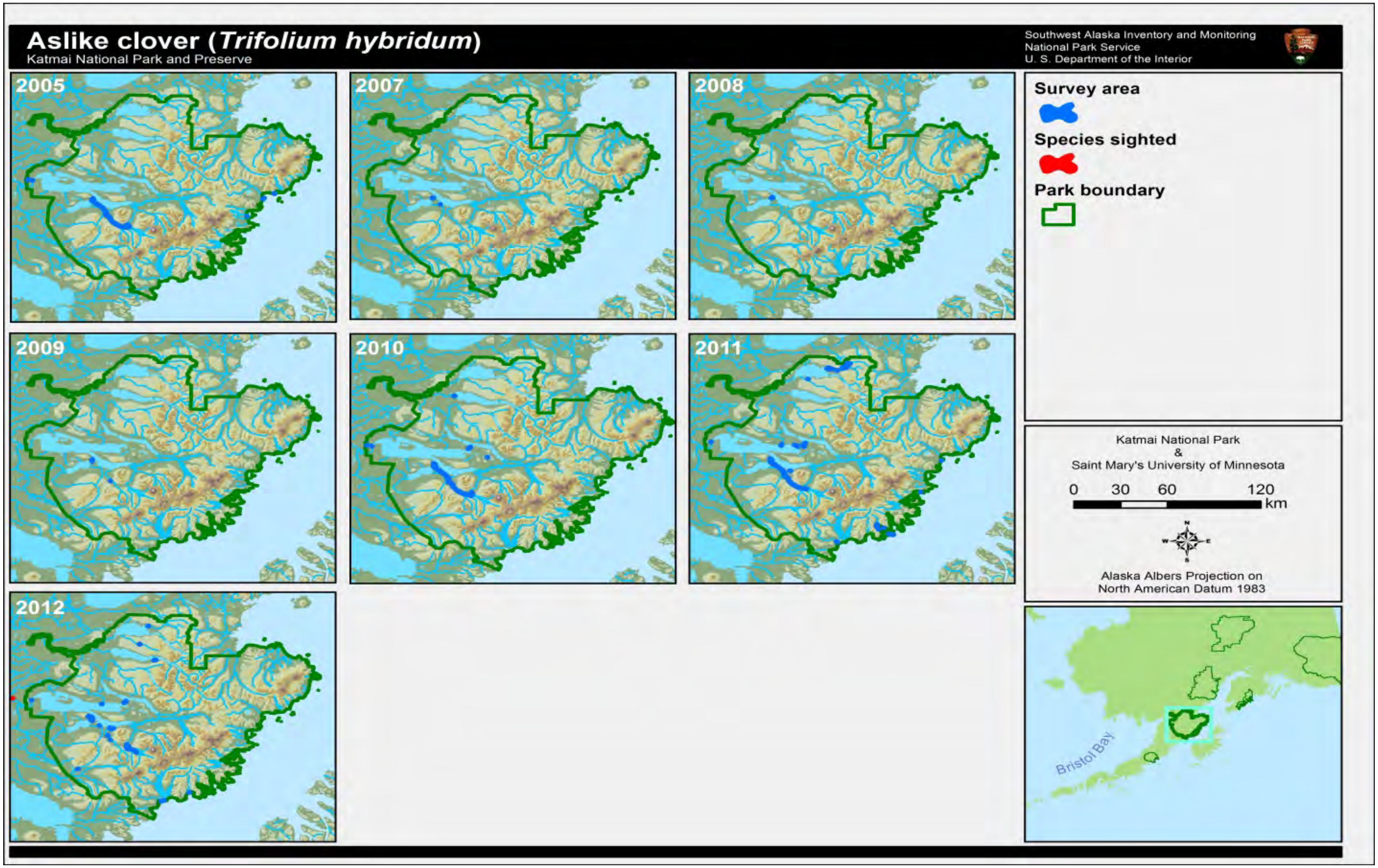

Plate 15. Areal extent of documented aslike clover sightings by year.

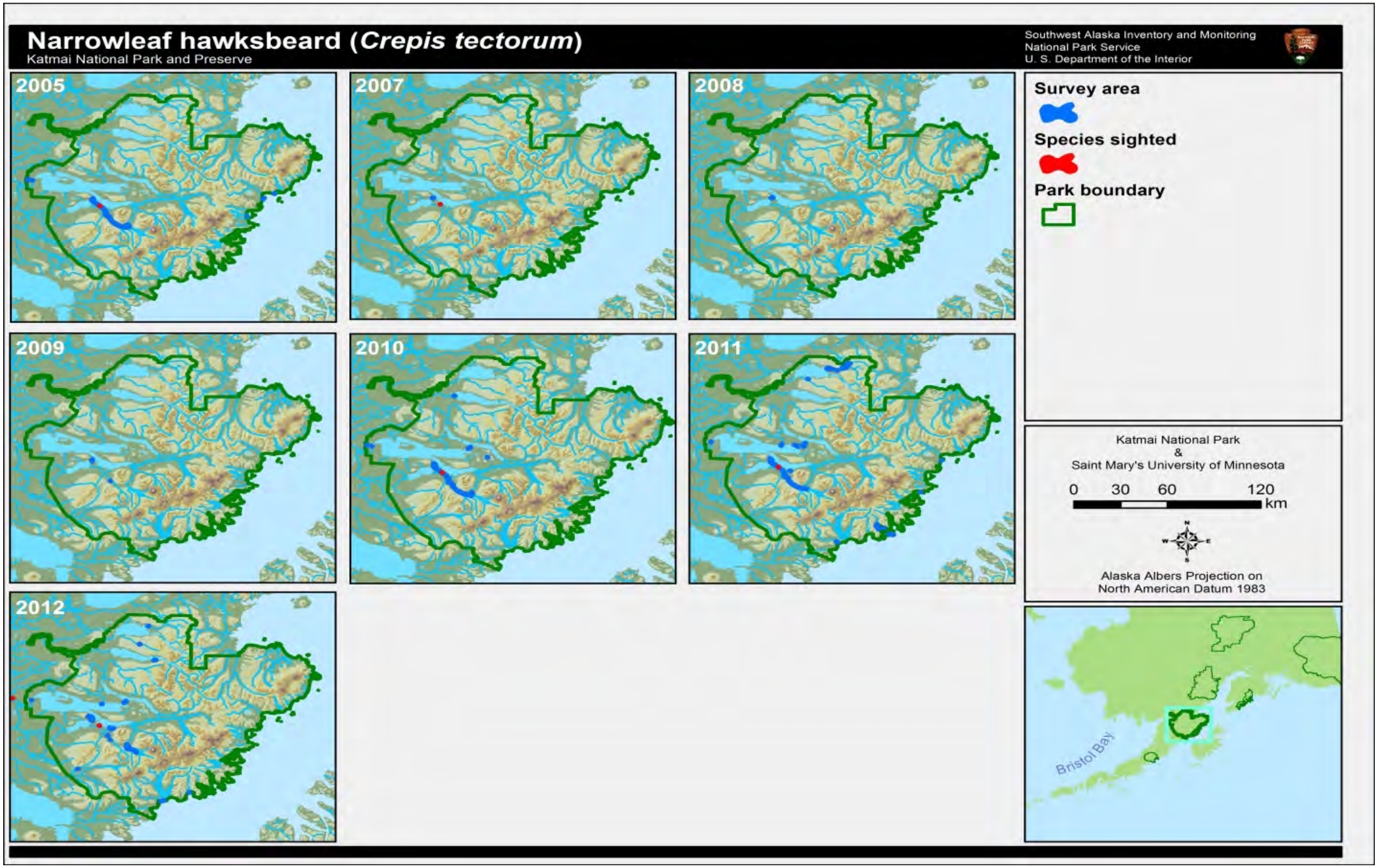

Plate 16. Areal extent of documented narrowleaf hawksbeard sightings by year.

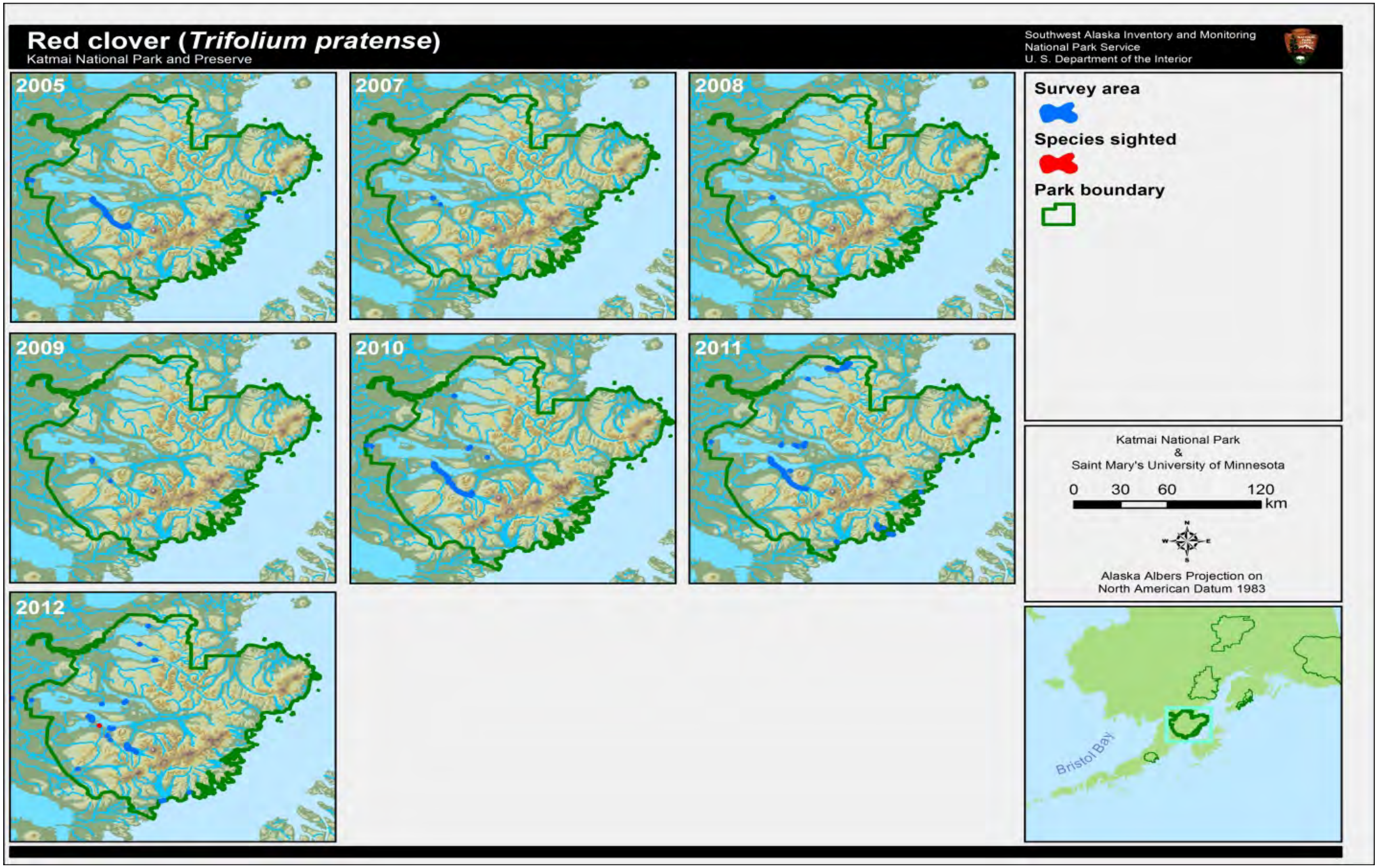

Plate 17. Areal extent of documented common sheep sorrel sightings by year.

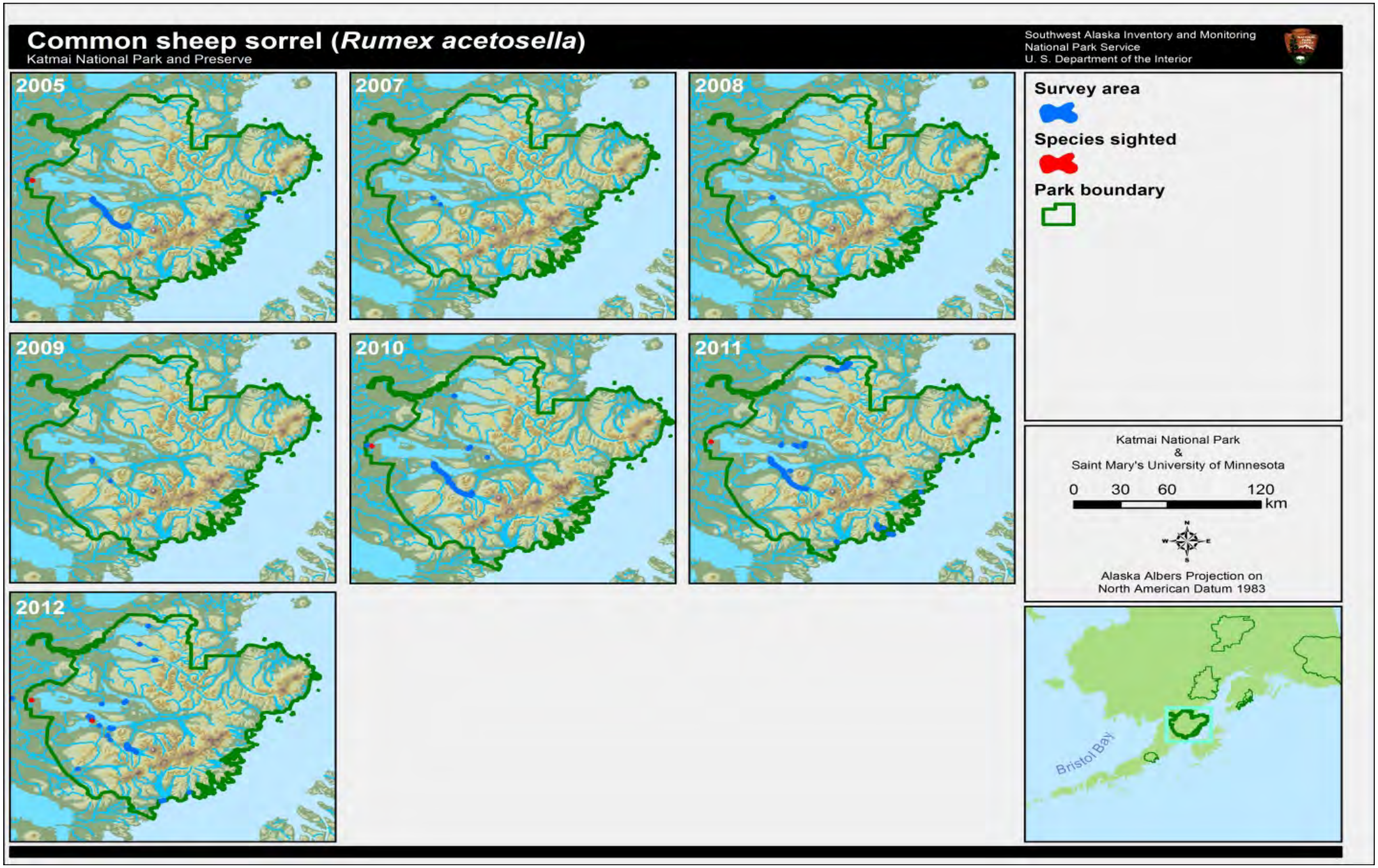

Plate 18. Areal extent of documented common sheep sorrel sightings by year.

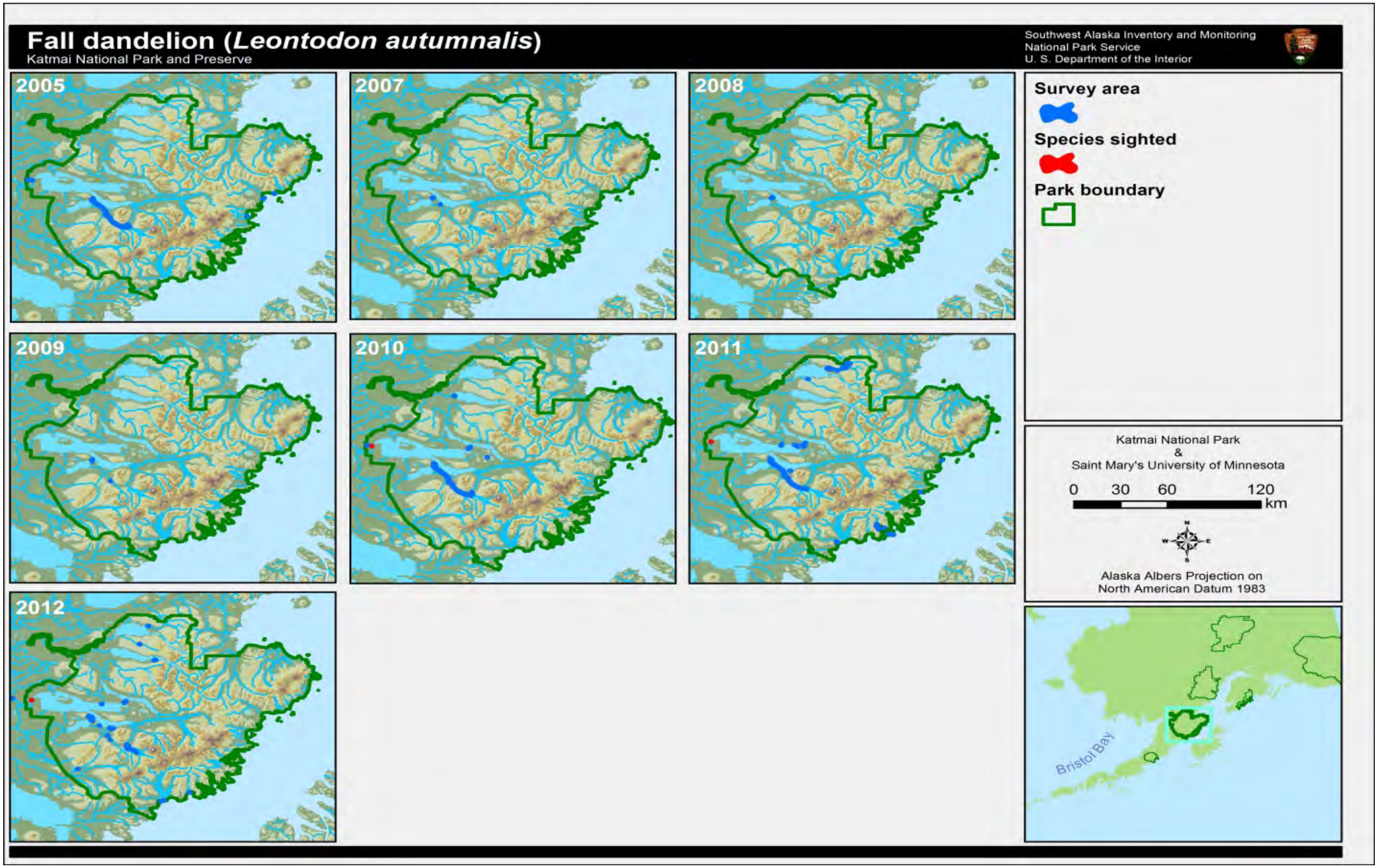

Plate 19. Areal extent of documented fall dandelion sightings by year.

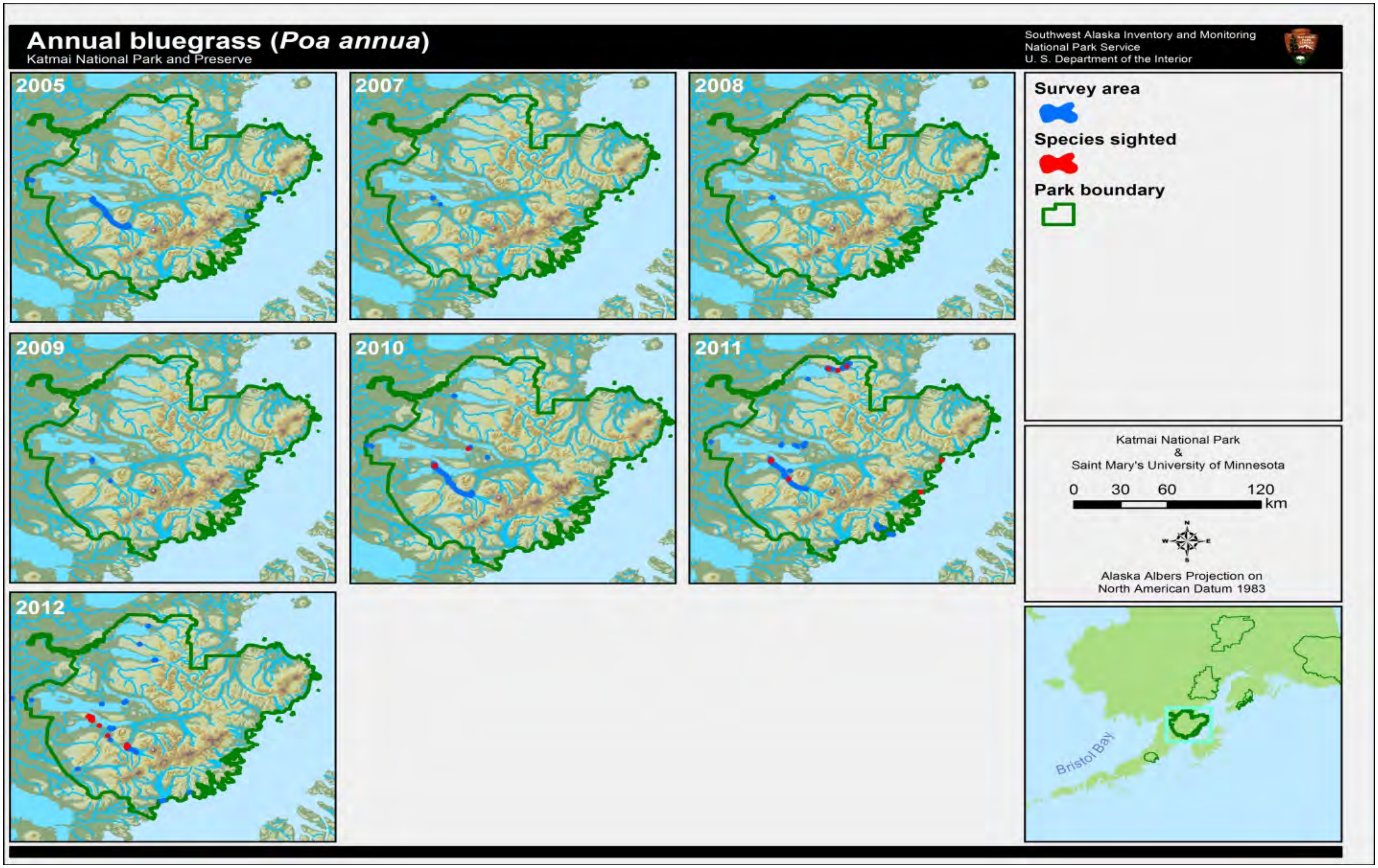

Plate 20. Areal extent of documented annual bluegrass sightings by year.

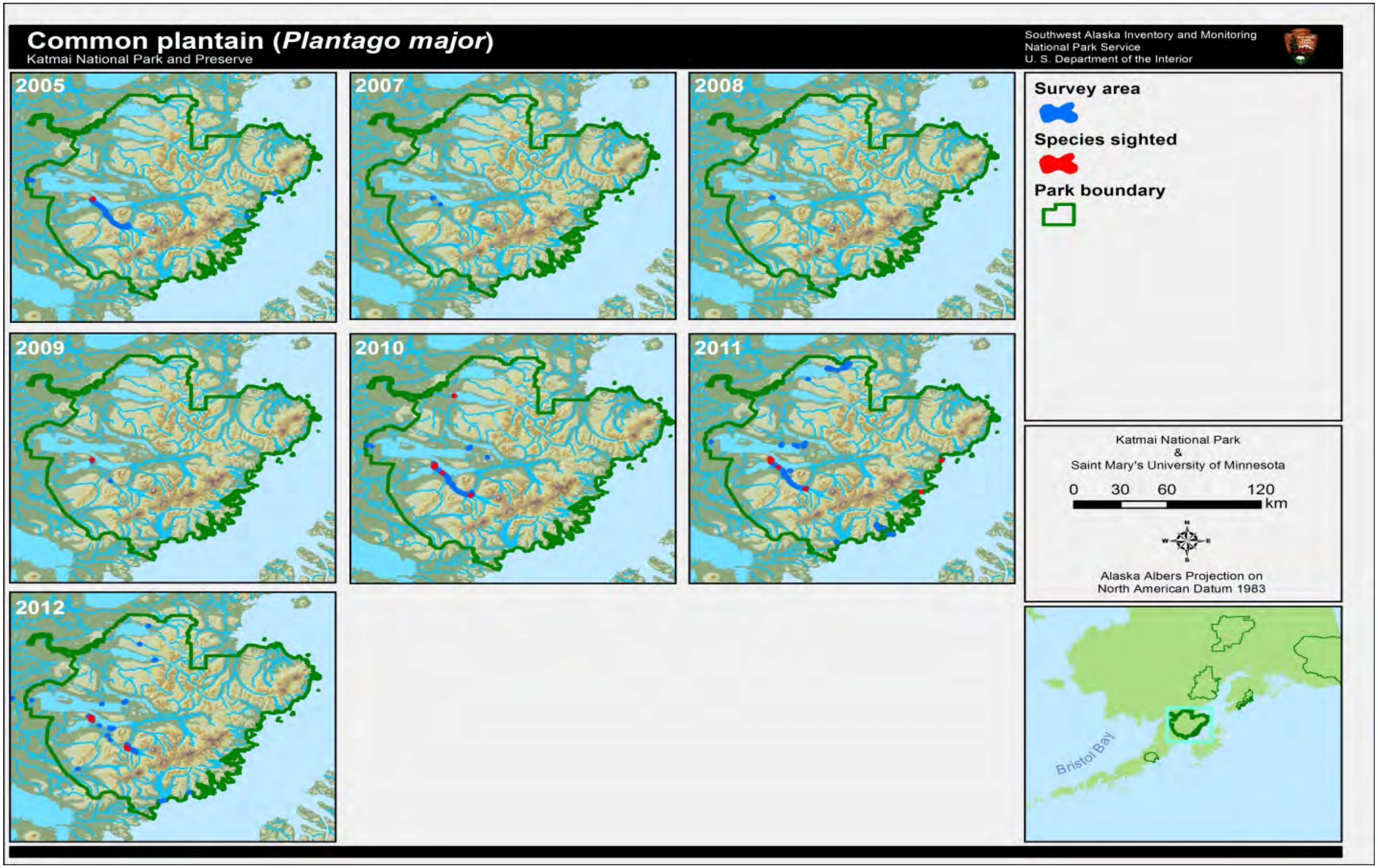

Plate 21. Areal extent of documented common plantain sightings by year.

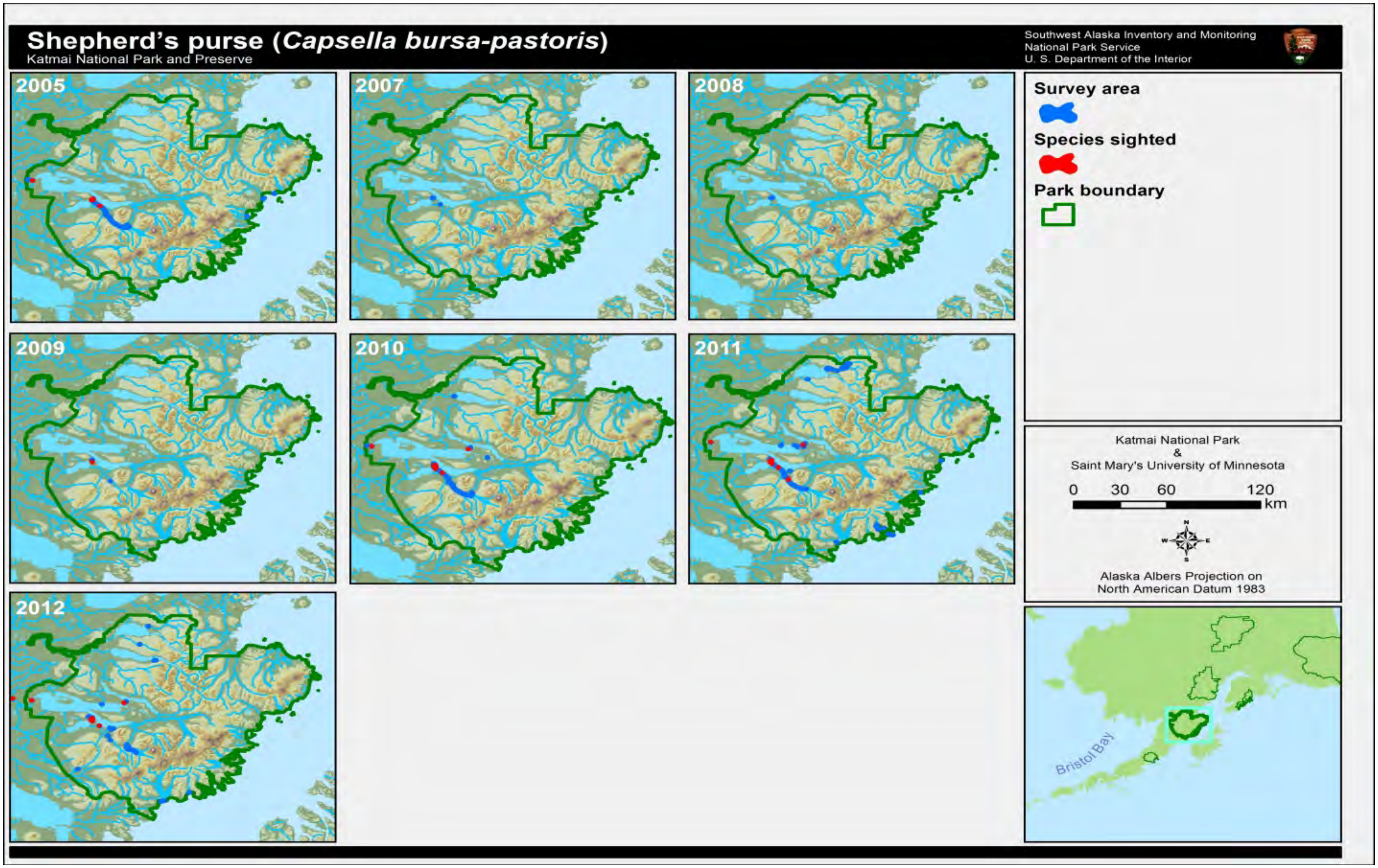

Plate 22. Areal extent of documented shepherd's purse sightings by year.

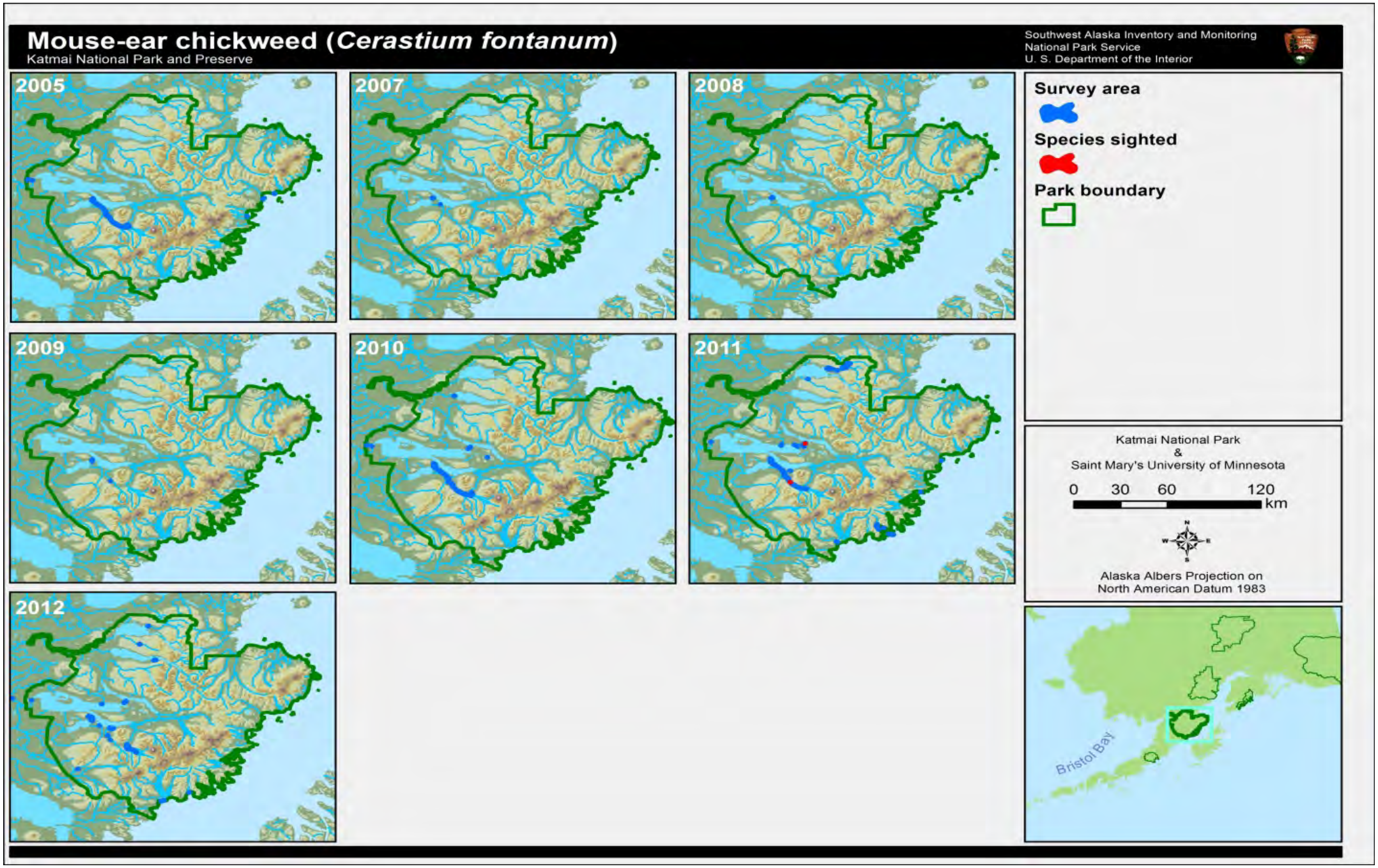

Plate 23. Areal extent of documented mouse-ear chickweed sightings by year.

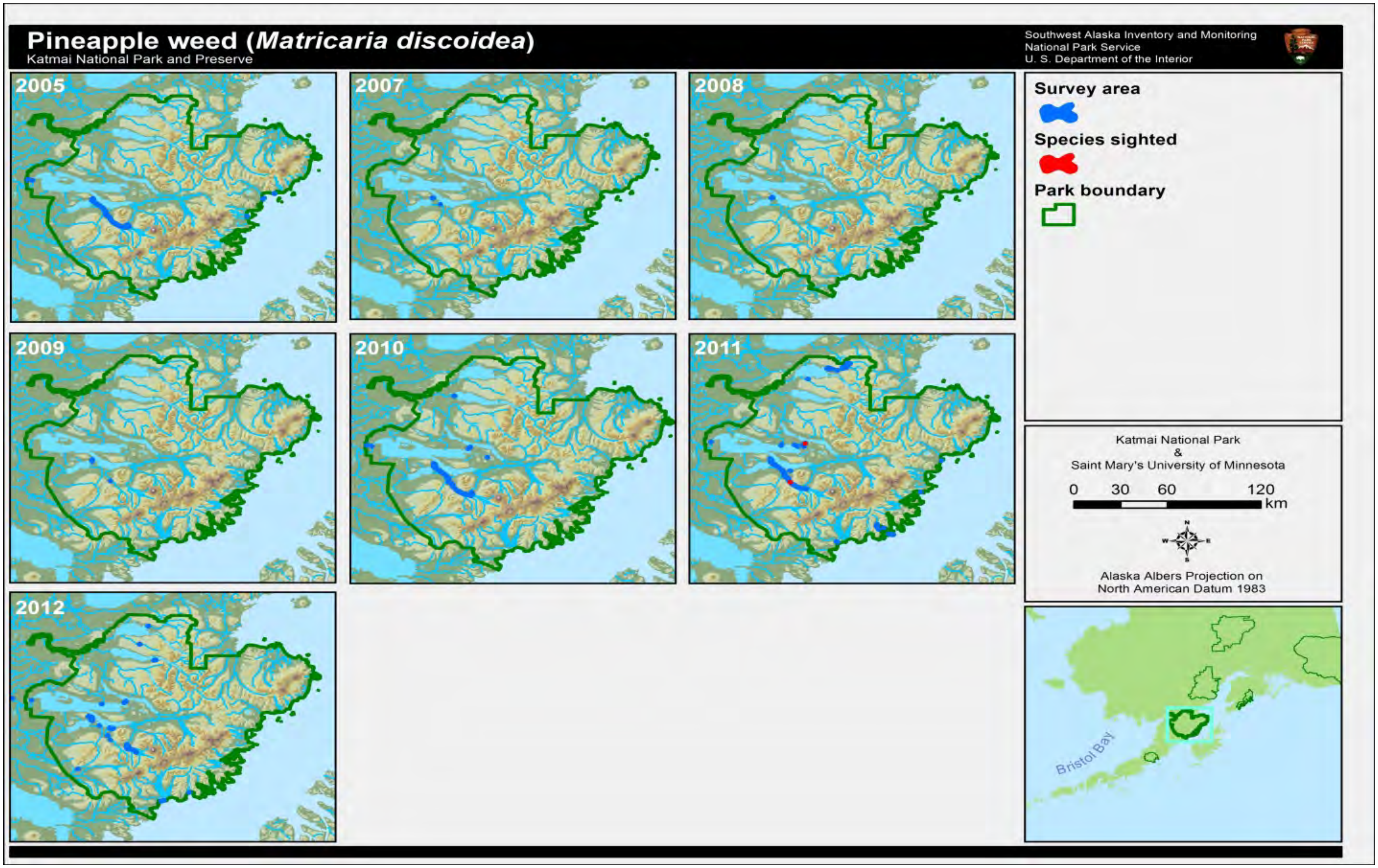

Plate 24. Areal extent of documented pineapple weed sightings by year.

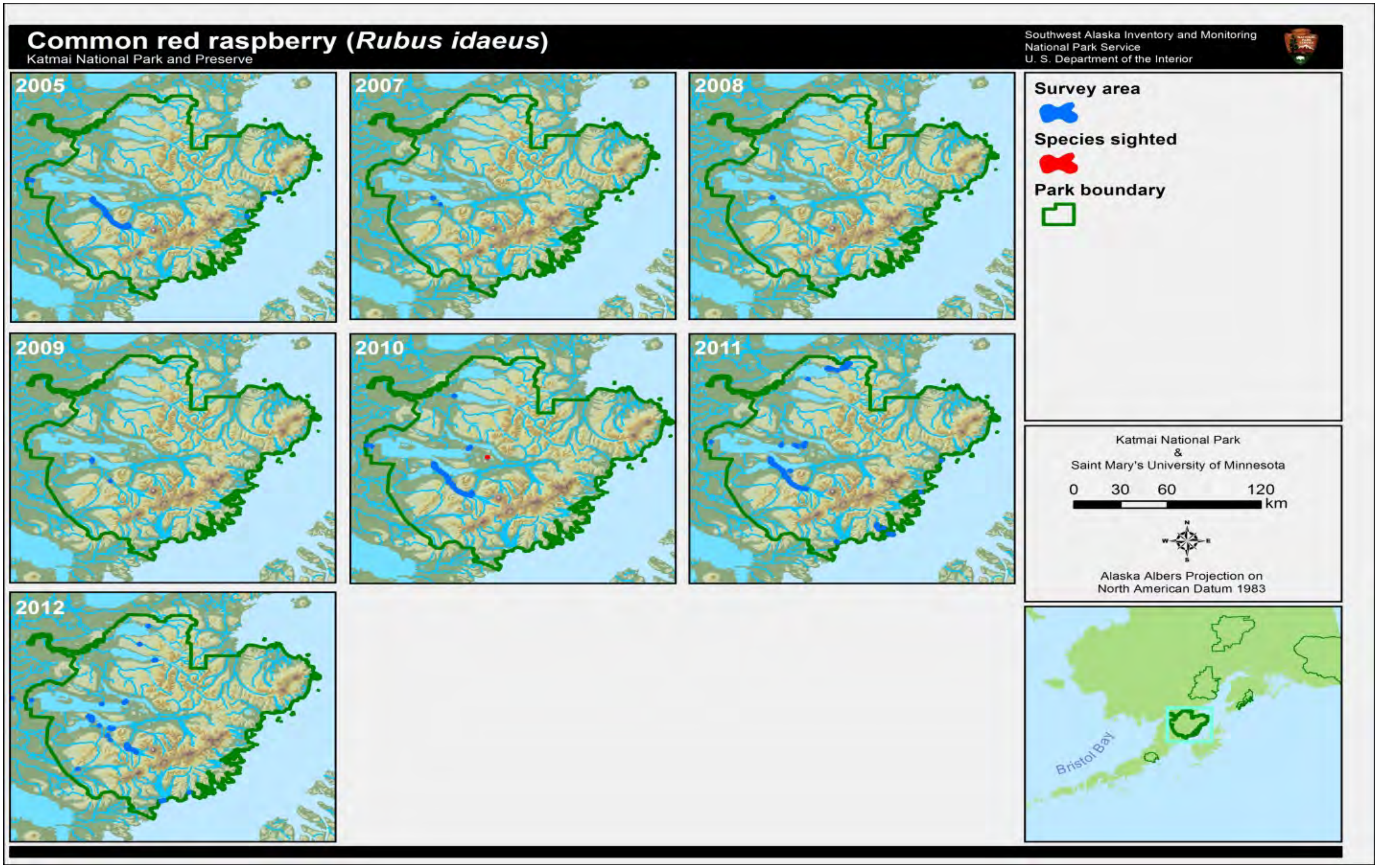

Plate 25. Areal extent of documented common red raspberry sightings by year.

4.2 Moose

4.2.1 Description

Moose (*Alces alces*) (Photo 7) are ubiquitous in the KATM biotic community, present throughout the inland and coastal areas of the park (NPS 2003). They are normally associated with northern forests and subarctic climates typical of southwestern Alaska. Moose are solitary mammals that rarely gather in groups except during the mating season. Females weigh in excess of 363 kg (800 lbs), while males can weigh up to 726 kg (1,600 lbs) and exceed 1.83 m (6 ft) in height (ADF&G 2012). Antlers develop on males within the first year of life and are produced each subsequent summer. Antlers typically develop in three to five months beginning in the spring, and are shed after the mating season. The average moose life span is 16 years, although 25-year-old individuals have been reported (ADF&G 2012).

Photo 7. Bull moose crossing the Brooks River in KATM (NPS photo by Mark Wagner).

Moose are a herbivorous species, feeding primarily on willow (*Salix* spp.), aspen (*Populus* spp.), aquatic vegetation, and a variety of grasses; feeding can result in 1.83 to 2.44 m (6-8 ft) high browse lines in woody vegetation (Rausch et al. 2008). Moose are most often associated with open low or mixed shrub vegetation classifications. Sexual maturity and breeding occur at about 28 months.

Calves are born in the spring, with females typically producing one to two calves per year. During the mating season, sparring between bulls occurs in order to secure mates; injuries are common but rarely serious. Adult moose are generally docile and subdued, although aggressive behavior is occasionally displayed when they become startled, angered, when offspring are threatened or during the mating season.

Natural predators in KATM include wolves (*Canis lupus*) and brown bears (*U. arctos*). Moose populations are protected from hunting within the park portion of KATM, but limited hunting is permitted within Katmai National Preserve (KTPR), which comprises approximately 413,000 acres along the northwestern border of the National Park (Plate 26, 11% of KATM) (NPS 2003). Concession contracts are issued for sport hunting services within KTPR to manage wildlife populations and protect subsistence uses (NPS 2003).

Game management units (GMUs) were established in an attempt to give residents and visitors fair and equal hunting rights throughout the state of Alaska. The Alaska Department of Fish and Game (ADF&G), which monitors these GMUs, tracks parameters such as population density, composition, habitat, and harvest for selected species. ADF&G also establishes moose management objectives for each GMU, which vary between units. Unit 9C encompasses the Alagnak River drainage, Naknek

River drainage, lands drained by the Kvichak River and Kvichak Bay, and all of KATM and KTPR (Plate 26). KATM also contains two small portions of Unit 9A, which include McNeil State Game Refuge and McNeil River State Game Sanctuary (Plate 26).

Historically, moose were an important source of food and hides. Even today, they are essential to many Alaskan industries such as hunting and sightseeing. Moose are a popular attraction in KATM, one of the species visitors most frequently want to see when visiting southwest Alaska (ADF&G 2012).

4.2.2 Measures

- Population size
- Population composition (bull:cow ratio)

4.2.3 Reference Conditions/Values

According to the NPS's enabling legislation, KATM, like all other NPS managed lands, is to manage animal species in a manner consistent with maintaining a natural and healthy population. NPS policies that support the naturally occurring and healthy population are found in sections 4.4.1 and 4.4.3 of the NPS Management Policies (2006) which state that;

> *The NPS will maintain as parts of the natural ecosystem of parks all plants and animals native to park ecosystems…*
>
> *…preserving and restoring the natural abundances, diversities, dynamics, distributions, habitats, and behaviors of native plant and animal populations and the communities and ecosystems in which they occur…*
>
> *…minimizing human impacts on native plants, animals, populations, communities, and ecosystems, and the processes that sustain them.*
>
> *…the Service* (NPS) *does not engage in activities to reduce the numbers of native species for the purposes of increasing the numbers of harvested species (i.e., predator control), nor does the Service permit others to do so on lands managed by the National Park Service*

Management of the moose population in KATM is intended to be implemented through the cooperative efforts of the NPS and the ADF&G . However, when the species in question is a harvested or game species, it should be noted that the NPS management policies may not be congruent with local or state wildlife management policies due to differing management objectives.

Currently, quantitative moose population metrics have not been established by the NPS that would define a set of moose population reference conditions (i.e., ranges of natural variability that embody natural and healthy populations). In lieu of NPS established moose population reference conditions, the following section reports population metrics according to ADF&G defined management goals. While the ADF&G defined management goals are discussed below, it is important to recognize that the NPS goals may differ and that management objectives of the ADF&G do not necessarily represent the management objectives of the NPS.

Two reference conditions were outlined in the ADF&G moose management report for GMU 9 (Butler 2006). Active management of moose does not occur in KATM, however, ADF&G sets population goals for each GMU and those goals represent the reference condition used in this assessment. Firstly, the reference condition for population size is maintenance of existing moose densities in areas with moderate (0.19-0.58 moose/km^2 or 0.5-1.5 moose/mi^2) densities, assuming non-limiting habitat conditions (Butler 2010).

Secondly, the reference condition for the population composition (bull: cow ratio) measure is maintenance of sex ratios of at least 25 bulls:100 cows in medium- to high-density populations (Butler 2010). GMU 9 is typically considered an area with a low to medium density moose population (Butler 2010).

4.2.4 Data and Methods
ADF&G management reports (Butler 2006, 2008, 2010) provided information on defined state management goals. ADF&G conducts annual sex and age composition surveys from November through early December, assuming adequate snow cover, for all GMU 9 subunits (Butler 2010). Harvest rates and other sources of mortality are also reported (ADF&G 2010). ADF&G reports establish moose population and composition objectives, as well as monitor temporal trends in population size and composition.

Moose population and composition data for selected park trend areas were obtained from park staff (NPS 2012). Recent and historical moose surveys from park locales (Alagnak, Aniakchak, Angle/Takayofo, Branch River, Cinder River, Pacific, and the park border) recorded population, density, and composition information. For recent moose surveys, trend areas were surveyed by airplane transects along the trend area boundaries, working inward (Plate 1). Observations and counts were documented and geographic locations recorded using GPS units. This assessment focuses on Angle/Takayofo, Branch River, and the park border locales, due to available data (recent and historical) from which trends could be identified.

4.2.5 Current Condition and Trend

<u>Population Size</u>
In the absence of quantitative moose population metrics from the NPS the following section reports population metrics according to ADF&G defined management goals. While the ADF&G defined management goals are discussed below, it is important to recognize that the NPS goals may differ and that management objectives of the ADF&G do not necessarily represent the management objectives of the NPS.

Butler (2006) and NPS (2003) noted that moose were present but scarce on the Alaskan peninsula prior to 1900 and spread exponentially throughout the southwest in the 1950s and 1960s. Moose populations peaked in the late 1960s (Butler 2010), although Cahalane (1956) noted that Alaska moose were numerous in the area throughout the early 1950s. Comparisons between studies from

1969-1972 and 1982-1983 indicated that there was a 60% decline in moose populations over that period (Sellers 1990, as cited in NPS 2003). These declines were thought to be caused by over-browsing, poor nutrition, and low calf survival (Butler 2010) Moose population densities in Unit 9C are generally considered moderate (0.31-0.35 moose/km^2, 0.8-0.9 moose/mi^2) (Butler 2010).

ADF&G fall sex and age composition surveys indicated slight declines in Unit 9C from 2003 to 2008 (Butler 2006, 2008). However, Butler (2008, 2010) reported that overall Unit 9 moose populations (a much larger area) were relatively stable within the past 30 years. The most recent available survey data indicate that areas of Unit 9C outside of KATM contained approximately 800 moose, a population size considered adequate by the ADF&G (Butler 2010). NPS (2012) reported recent and historical moose densities for several locales within the park (Appendix A). Low densities were reported in the most recent 2010 moose surveys for Angle/Takayofo (0.11 moose/km^2, 0.29 moose/mi^2) and the Branch River (0.10 moose/km^2, 0.26 moose/mi^2), both below the established 0.19-0.58 moose/km^2 (0.5 to 1.5 moose/mi^2) recommended by the ADF&G.

However, these low densities may have been due to a combination of poor survey conditions and absence of moose within the survey area (NPS 2012; S. Anderson, pers. comm., 2012), and therefore may not be indicative of true moose population densities. One of three park border surveys in 2010 indicated low density (09 moose/km^2, 0.24 moose/mi^2.), below 0.19 moose/km^2 (0.5 moose/mi^2). Two other 2010 surveys (0.22, 0.26 moose/km^2, 0.56, 0.68 moose/mi^2) and one 2011 survey (0.29 moose/km^2, 0.75 moose/mi^2) indicated adequate densities for the park border locale. Recently, moose densities have been trending downward within the three reporting areas: Angle/Takayofo (Plate 27), Branch River, and park border (NPS 2012; S. Anderson, pers. comm., 2012).

Population Composition (bull:cow ratio)

In the absence of quantitative moose population metrics from the NPS the following section reports population metrics according to ADF&G defined management goals. While the ADF&G defined management goals are discussed below, it is important to recognize that the NPS goals may differ and that management objectives of the ADF&G do not necessarily represent the management objectives of the NPS. It is noted that in 2008, Young and Bortell reported that in lightly hunted and remote areas of Alaska 60-80 bulls: 100 cows were observed.

Population composition is defined as the ratio of bulls to cows in each management unit. Historically, bull: cow ratios have shown variability across ADF&G Unit 9 (Butler 2010). All composition ratios were above the established ratio of 25 bulls: 100 cows for medium density populations in Unit 9C. Since 2001, bull: cow ratios in Unit 9C have been consistent when compared to years in the late 1990s (Butler 2004, 2006, 2010). Butler (2010) stated that the bull: cow ratio was relatively stable and, as of 2010, above the established management objective of 25 bulls: 100 cows, although ratios were reportedly increasing due to increased recruitment rates (Table 11).

Table 11. Moose population composition in Unit 9C (not including KATM), 1998–2008. Table compiled from several ADF&G reports (Butler 2004, 2006, 2008, 2010).

Year	Males:100 females	Yearling males:100 females	Calves:100 females	Calf %	Adults	Total moose	Moose/hour
1998	*	*	*	*	*	*	*
1999	37	3	9	6	516	550	38
2000	33	2	7	5	290	306	52
2001	30	3	9	7	271	290	42
2002	*	*	*	*	*	*	*
2003[1]	23	3	5	4	91	96	25
2004	*	*	*	*	*	*	*
2005	34	9	19	12	440	504	36
2006	*	*	*	*	*	*	*
2007	40	8	20	13	236	270	34
2008	46	4	13	8	166	181	

* - Not surveyed due to weather factors.

1 – Includes some surveys completed by the U.S. Fish and Wildlife Service.

NPS (2012) reported a 2010 bull: cow ratio of 140:100 at Angle/Takayofo and approximately 64:100 at the Branch River (Appendix A). Estimates at the park boundary indicate population composition was variable in 2010 (42.31, 29.79, and 33.33 bulls to 100 cows) and 2011 surveys (43.75 and 16.30 bulls to 100 cows) (NPS 2012) (Appendix A). Only the most recent 2011 composition ratio was below the 25 bulls: 100 cow ratio recommended by the ADF&G, and may be due to sampling variability or poor weather conditions.

Threats and Stressor Factors

Stressors identified by NPS staff include moose harvest rates and brown bear predation on neonatal moose. Moose are highly desirable as game animals for their meat. Moose harvest in GMU 9 is approximately 154-165/year since 2000, within sustainable limits established by the ADF&G (Butler 2010, ADF&G 2012). From the mid 1960s to early 1970s, relaxed hunting regulations led to slowed population growth and decreased populations in order to rehabilitate willow stands within Unit 9 (Butler 2006, 2008, 2010). The moose population decline in the 1970s was attributed to low calf recruitment rates, liberal hunting regulations, and range damage (Butler 2006, 2008, 2010).

The primary limiting factor of moose populations in Unit 9during the 1970s was identified as brown bear predation on neonatal moose (Butler 2006, 2008, 2010). Predation on calves prevented moose density increases in Unit 9 even after range conditions improved from browsing pressures in the 1950s and 60s (Sellers 1990). Newborn and neonatal moose are exceptionally vulnerable to predators such as bears and wolves, particularly in late winter months when snow hinders a moose's movements. A study by Ballard et al. (1981) found that moose predation by brown bears accounted for 79% of mortalities of collared moose calves.

Butler (2010) stated that while conditions have improved since the 1960s and 1970s, calf recruitment is still low in Unit 9. According to Butler (2010, p. 119), "bear:moose ratios in Unit 9 ranged from >1:1 to 1:10," and in order to achieve significant improvements in calf survival, major reductions in bear densities need to occur, which would likely be opposed by the general public. Extremely low calf:cow ratios reported in the 2000s suggest that recruitment may be a further limiting factor of moose densities. Calf:cow ratios were low in GMU 9 even during years of peak population (Butler 2006).

Butler (2010) suggested that moose harvested within Unit 9 are often not reported by hunters. Closed season hunting and cow moose harvest likely represent a significant unreported percentage of harvest, a major limiting factor of moose density. An estimated 100 unreported moose, many of which are cows, are harvested each year in Unit 9 (Butler 2010). However, Butler (2010) noted that current illegal practices likely do not greatly influence overall moose populations in Unit 9, although illegal harvest of cows may play some role in limiting moose densities (Butler 2006). Illegal harvest would only cease with increased community support and law enforcement efforts, which may not be cost-effective (Butler 2010).

Annual moose harvest rates have declined between 1998 and 2008 (Table **12**). Butler (2006, 2008, 2010) suggested that recent declines in harvest rates are associated with a decrease in hunters rather than changes in the moose population. Hunting success rates have been relatively consistent since 1985 in KTPR and likely the rest of Unit 9C; however, overall hunting numbers in KTPR have shown declines in recent years (S. Anderson, pers. comm., 2012).

Table 12. Annual moose harvest in Unit 9, 1998-2008. An additional 100 moose are estimated as unreported annually. Table compiled from Butler (2006, 2010).

Year	Male	Female	Unknown	Reported Total	Estimated Total
1998	198	2	0	200	300
1999	238	8	7	253	353
2000	176	2	2	180	280
2001	167	8	0	175	275
2002	171	6	2	179	279
2003	177	0	0	177	277
2004	158	3	0	161	261
2005	158	0	2	160	260
2006	124	1	0	125	225
2007	147	0	0	147	247
2008	107	0	0	107	207

<u>Data Needs/Gaps</u>
The 2012 ADF&G moose management report is not yet available. Therefore, the most current available information from older ADF&G reports was utilized for this assessment. Butler (2008, 2010) and Anderson (pers. comm., 2012) noted that inadequate snow cover, aircraft availability, and poor weather conditions often limit moose population composition surveys in Unit 9, which result in infrequent or incomplete surveys. Moose movements also add variability to population estimates and

survey results (Butler 2008, 2010). Butler (2010) noted that sampling variation was introduced into surveys in 2007 and 2008 due to changes in technique. This likely introduced slight variability into the bull:cow ratio estimate.

Moose surveys have not been conducted for the park locales of Alagnak and Pacific within the past 9 years (NPS 2012). Therefore, significant population and composition conclusions were not drawn for these locations. Future surveys for these locales may provide adequate data for comparison and trend analyses. However, S. Anderson (pers. comm., 2012) suggested that in order to have successful aerial surveys, weather and flying conditions need to be very good to excellent. Furthermore, snow depth and snow cover must also be at ideal conditions. Marginal conditions in the past, due to inadequate snow depth and lack of snow cover, likely resulted in underreported moose populations.

Overall Condition

Population size
The measure of population size is not currently a concern to resource managers. Moose populations for Unit 9C have been reportedly stable for the past 30 years, despite slight periodic declines (Butler 2008, 2010). Moose density and composition monitoring in Unit 9C and KATM suggest that density and population objectives are within the established limits, despite annual and seasonal variations.

Population composition (bull:cow ratio)
The measure of population composition (bull:cow ratio) is not currently a concern to resource managers. Moose density and composition monitoring in Unit 9C and KATM suggest that the bull:cow ratio was within desired ranges in recent years (25 bulls:100 cows). Moose compositions in KATM trend areas have remained relatively stable, with slight variations between years.

Summary
The condition of this resource is currently of low concern. Reports indicate that moose populations are stable in KATM and Unit 9C, although may be trending slightly downward based on recent NPS and ADF&G population reports (Butler 2006, 2008, 2010, NPS 2012). Moose population composition (bull:cow ratio) has been consistently above the recommended level of 25 bulls:100 cows established by the ADF&G, again, with slight seasonal and annual variability (Butler 2006, 2008, 2010, NPS 2012).

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Sherri Anderson, KATM Wildlife Biologist

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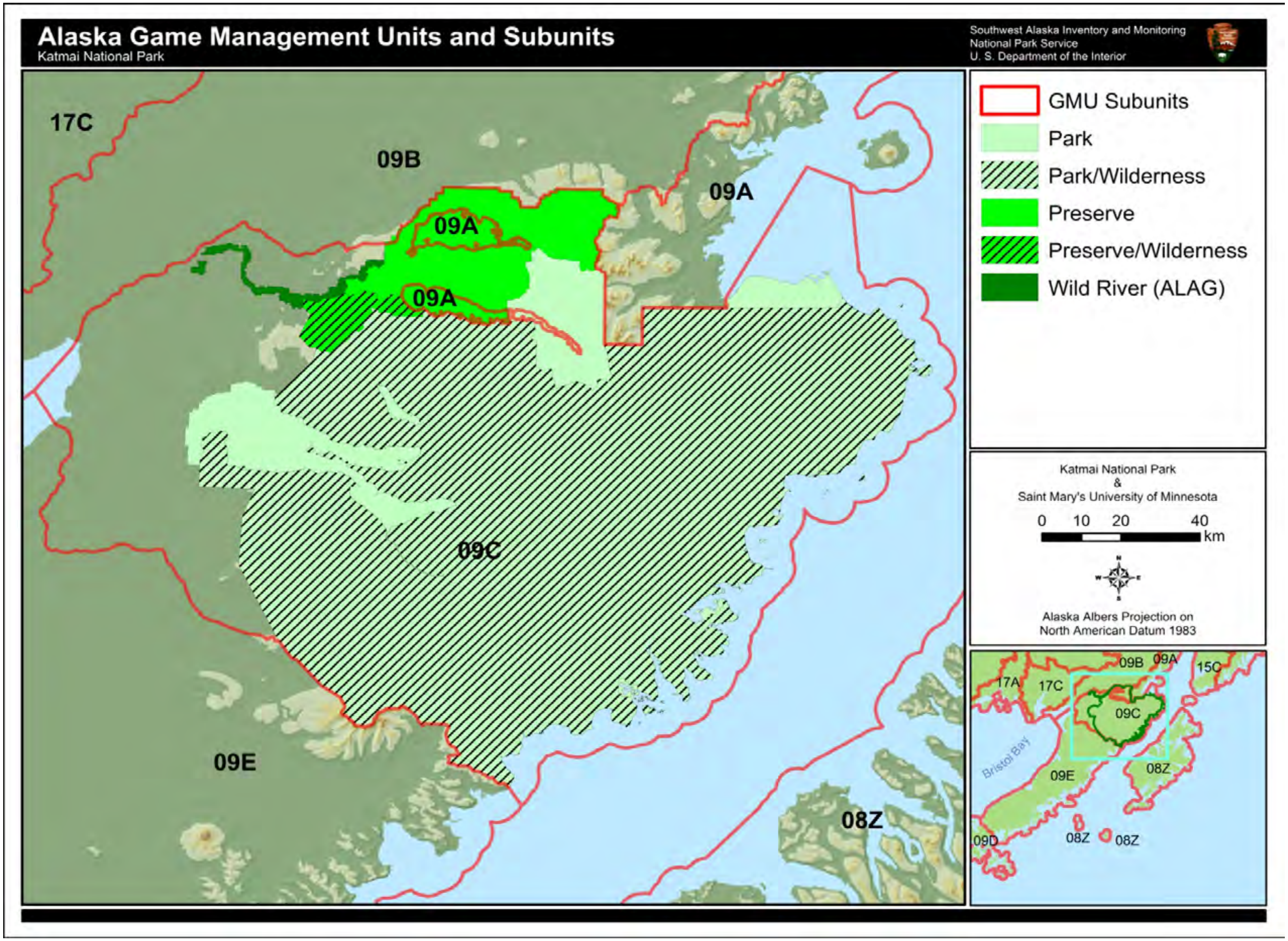

Plate 26. Alaska game management units and subunits. Subunit 9C contains all of KATM and KTPR.

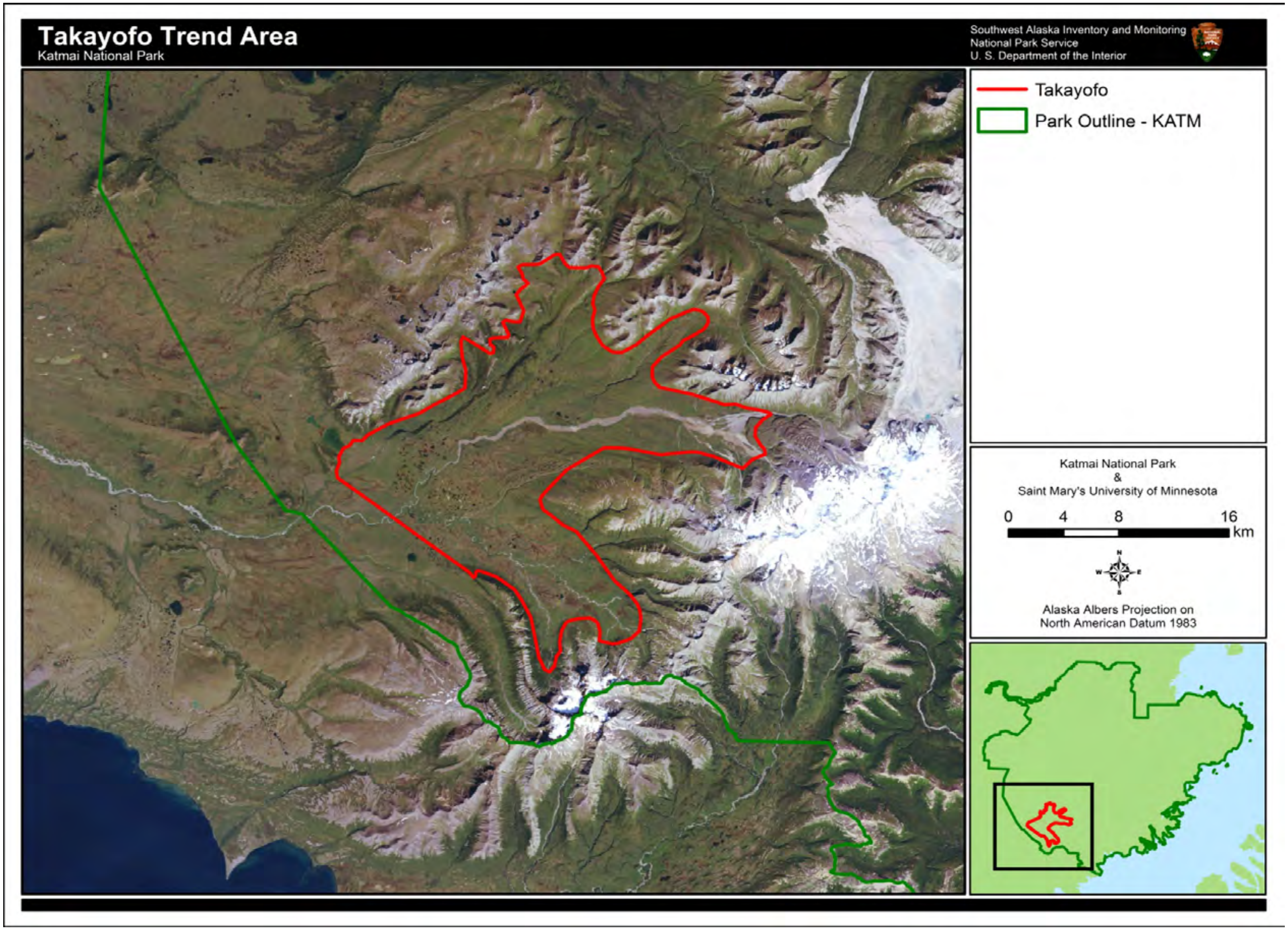

Plate 27. KATM trend area moose survey boundaries.

4.3 Bear

4.3.1 Description

Brown bears (Photo 8) are a prominent mammal species in KATM. Brown bears weigh up to 408 kg (900 lbs) and typically feed on salmon from July through September, with sedge and clams comprising some of their diet in the spring/early summer seasons (Smith and Partridge 2004). Mating generally occurs from May to mid-July, and one to four cubs are typically born in the mid-winter months (Schwartz et al. 2003). Litter intervals for sows are usually three years, and cubs remain with their mother for their first two years (Schwartz et al. 2003).

Photo 8. Brown bears at Brooks Falls, KATM (NPS photo)

KATM is home to the largest protected brown bear population in the world, bringing thousands of visitors each year to witness the brown bears during salmon spawning runs (Loveless et al. in review). Park visitors frequently observe brown bears feeding on sockeye salmon at Brooks Falls, the most popular destination in KATM, during the fall and summer months. Bears are found throughout KATM and the surrounding areas, although larger concentrations are found in the coastal and lake ecosystems. Bear population size within the park, preserve, and surrounding area is known to vary from year to year, as well as season to season; the most recent KATM bear population estimates was approximately 2,200 ± 400 individuals (Olson and Putera 2007, Loveless et al. in review).

Hunting is not permitted within the park portion of KATM; however, in Katmai National Preserve (KTPR) harvest of bears is legal subject to state and federal regulations. No limit has been put on total harvest during the three-week hunting seasons authorized by the State of Alaska (Loveless et al. in review). Alternating hunting seasons were established in the 1980s in order to establish population recovery periods; for example, during odd-numbered years (e.g., 2011) there is a fall bear harvest and during even-numbered years (e.g., 2012) there is a spring bear harvest (Loveless et al. in review). Generally, greater harvest occurs during the fall harvest season than in the spring harvest season (Loveless et al. in review).

4.3.2 Measures

- Population density

4.3.3 Reference Conditions/Values

The reference condition for the KATM bear population is a population above 70% of the pre-1990 counts of a subset of salmon spawning streams: Margot (avg. 59 bears), Contact (avg. 24 bears), Idavain (avg. 20.86 bears), American (avg. 57.43 bears), Savanoski (avg. 83.14 bears), Hardscrabble (avg. 28.71 bears), Nanuktuk (avg. 6 bears), and Moraine/Funnel (avg. 15.5 bears). GLBA staff identified these streams because data are available from pre-1990 and post-1990 bear surveys. The best temporal comparisons can be made with the Nanuktuk and Moraine/Funnel locations because of greater sampling efforts in both pre- and post-1990 survey categories (Appendix B). Park staff also defined the threshold for management concern as 70%; this threshold should represent “high concentrations of brown/grizzly bears” as defined in ANILCA (§202 [2]).

4.3.4 Data and Methods

For this analysis, bear population aerial survey data was obtained from the NPS (2012) ranging from 1984 to 2007. Results were divided into two categories for comparison: pre-1990 and post-1990 counts. Several studies of bear population size and densities exist, dating back to the early 1970s (Appendix B).

Loveless et al. (in review) assessed brown bear populations in the KTPR to determine the effects of increased harvest trends. Spring bear density was determined by summarizing data from aerial line transect surveys from the late 1980s through 2009, which was compared to the minimum bear count in the summer months. Harvest rates were determined based on density estimates and minimum count data.

4.3.5 Current Condition and Trend

Population Density

Based on the Loveless et al. (in review) study, bear population density for KATM was approximately 156 ± 21 per 1,000 km^2 in 2004-2005, one of the highest bear densities recorded. This conclusion was based on 14,400 kilometers of transect surveys flown in Game Management Unit (GMU) 9C, slightly larger than the extent of KATM (Loveless et al. in review). Olson and Putera (2007) estimated the brown bear population of GMU 9C at 124 ± 17 per 1,000 km^2, which corresponded to an estimated population size of 2,255 ± 306 individuals. Bear distributions tend to vary according to salmon runs, which make population monitoring and harvest rate assessments difficult, especially from year to year with fluctuating rates of salmon escapement (Olson and Putera 2007, Loveless et al. in review). Furthermore, bear densities shift between seasons and bear density is only available following large-scale survey efforts (Loveless et al. in review).

According to Nagorski et al. (2007), the Hallo Bay, Kukak Bay, and Chiniak areas contain the highest brown bear densities within KATM, and perhaps the entire world, because of the availability of clams, sedge, and salmon year-round resulting in a rather robust diet. When focusing on the eight selected pre-1990 stream locations (Appendix B), the highest sighting frequencies occurred in Savonoski (85.17 sightings/survey, n=7), Margot (59, n=8), and American (57.43, n=7).

In contrast, in post-1990 studies, Moraine/Funnel (78.25 sightings/survey, n=4) and Nanuktuk (33.6, n=5) recorded the highest sighting frequencies per study. One major caveat when analyzing the survey data is sample size, as the Margot, Idavain, American, Savonoski, and Hardscrabble stream locations showed only one post-1990 study each, with no post-1990 studies noted for Contact. Based on limited data it is difficult to draw significant conclusions. However, an overall average between all eight stream locations in pre and post-1990 surveys exhibited an increase in per study averages (6.70 sightings/survey in pre-1990 studies, n=44, and 8.85 sightings/survey in post-1990 studies, n=14).

When taking into account sample size, Nanuktuk and Moraine/Funnel provide the most useful information regarding population change in bear populations. The average bear observations per study increased at Nanuktuk from six (n=3) in pre-1990 studies to 33.6 (n=5) in post-1990 studies. Likewise, the average bear observations per study at Moraine/Funnel increased from 15.5 (n=2) to 78.25 (n=4). Hamon et al. (2011) provides two hypotheses for this increase; it could be due to either increased population size in KATM or to varying bear distributions because of larger than usual salmon runs in local streams.

Threats and Stressor Factors

Human habituation measures are considered one of the most significant factors affecting KATM bears. Conflicting values regarding the resource often arise between bear viewers, sport fishermen, hunters, and general park users (Olson and Putera 2007, Hamon et al. 2011). Although habituation measures vary by park locale, human and bear interactions have become an increasingly important topic due to increasing visitor use within KATM especially in areas without regularly scheduled NPS presence (Proffitt 2003). Bear viewing, camping, and rafting, all major recreational activities in KATM, have increased in the past 30 years, including a two-fold increase from 1981 to 1991 (Olson et al. 1997). The increased frequencies of these activities coupled with human presence could potentially present an added stress to individual bears. Proffitt (2003) found that encounters between 50 and 100 meters near Moraine and Funnel Creeks influenced bear behavior. In the Brooks Camp Developed Area, platforms for bear viewing, specifically at Brooks Falls, help minimize human effects on bear behavior while still accommodating visitors at that location (Olson et al. 2009).

Human habituation may pose a problem to the well-being and safety of bears and humans alike. Bears' responses to human presence vary. In areas of higher human use in KATM, especially Moraine and Funnel Creeks, bears display habituation to humans (Proffitt 2003, Groth et al. 2007). Food conditioning may be one of the biggest risks to both human and bear well-being in KATM. Groth et al. (2007) noted that anglers at Moraine Creek left bags and food unattended along the creek, which suggested a high potential of bears inadvertently obtaining human food. Groth et al. (2007) also noted inappropriate viewing and fishing practices by visitors within KATM, potentially leading to increased habituation and unnecessary bear/human interactions. Olson et al. (1997) concluded that as human activities began extending later into the fall season, non-habituated adult bears reduced their activity and delayed use of the Brooks River by 17 days.

KTPR is located on the northern edge of KATM where hunting is permitted during the spring and fall bear harvest seasons, currently with no total harvest quota. Harvest rates for alternating years within the preserve from 1987 to 2009 are shown in Table **13**. These calculated harvest rates in are based on the most current KTPR bear population estimates. Hamon et al. (2011) suggested bear population increases within KTPR in recent years, especially during the fall salmon spawning season. Since the calculated rates are based on current population estimates, older historic data from the 1980s and 1990s may not be truly representative of total harvest; it is possibly underestimated (Loveless et al. in review).

Table 13. Bear harvest totals and harvest rates (% of estimated total population) for hunting in KTPR 1987-2009 (Loveless et al. in review).

Year	Total Harvest	Fall Harvest	Fall Harvest Rate (%)[1]	Spring Harvest	Spring Harvest Rate (%)[2]	Bi-annual Harvest Rate (%)	Average Yearly Harvest Rate (%)
1987	12	8	2.9	4	3.1	6.0	3.0
1989	11	4	1.4	7	5.5	6.9	3.5
1991	20	13	4.6	7	5.5	10.1	5.1
1993	16	12	4.3	4	3.1	7.4	3.7
1995	11	5	1.8	6	4.7	6.5	3.3
1997	9	2	0.7	7	5.5	6.2	3.1
1999	17	14	5.0	3	2.4	7.4	3.7
2001	19	12	4.3	7	5.5	9.8	4.9
2003	34	28	10.0	6	4.7	14.7	7.4
2005	35	26	9.3	9	7.1	16.4	8.2
2007	30	23	8.2	7	5.5	13.7	6.9
2009	12	11	3.9	1	0.8	4.7	2.4

1 – Fall harvest rates calculated from number of harvested bears/279 (Current KTPR bear population estimate during fall harvest season).

2 – Spring harvest rates calculated from number of harvested bears/127 (Current KTPR bear population estimate during spring harvest season).

Evidence from the 1960s and 1970s suggests that bears were overharvested throughout southwest Alaska. However, populations have appeared to rebound as the estimate of bears in KTPR was 127 ± 20 individuals in the spring months in 2009 (Loveless et al. in review). According to Olson et al. (2003, p. 8), "although it is not currently known whether human habituation results in increased vulnerability of bears to hunting, even a perceived relationship could result in user conflicts."

Based on a 2007 aerial study of the main drainages within KTPR during the fall spawning season, at least 279 bears occupied the preserve (Loveless et al. in review, (Figure 2). Loveless et al. (in review) also determined bear density in KTPR to be 101 ± 18 bears per 1,000 km^2 (24,704 ac). Fall harvest rates ranged from 8% to 10% within the preserve between 2003 and 2007 and spring harvest rates ranged from 4% to 7% during the same period (Loveless et al. in review). Average yearly harvest rates from 2003 to 2007 ranged from 7% to 8% and although there is no consensus regarding appropriate bear harvest levels, 7% to 10% appears to be the accepted range (Loveless et al. in review). According to Hamon et al. (2011), these increases in harvest correspond with variation in salmon availability and harvest decreases in nearby management areas and changes in population structure suggested moderate harvest pressure in KTPR (Loveless et al. in review). Hamon et al. (2011) suggests that changing population structures could be indicative of moderate harvest pressures, increasing population size, or the level of salmon escapement.

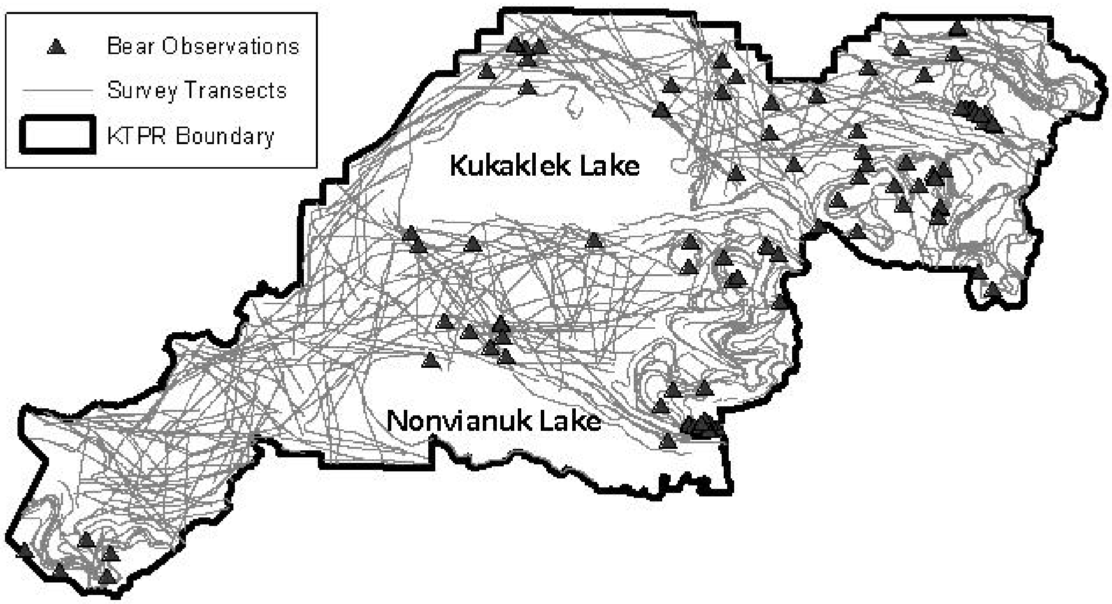

Figure 2. Transects and bear observations from a 2009 KTPR bear population study (Loveless et al. in review).

Data Needs/Gaps

The last population survey in KATM occurred in 2009. However, new population studies will commence in early 2012 (Anderson, pers. comm., 2012). New estimates of bear populations in KTPR would help in better understanding the relationship between increasing family group percentages and the effects of increased harvest rates, especially in fall harvest seasons.

Overall Condition

Population Density

Brown bear populations appear to be thriving in KATM. The most recent population density estimate indicates a bear density of 156 ± 21 per 1,000 km^2 (24,704 ac) across KATM. Future population surveys will expand the knowledge of bear population dynamics in the park. Based on the most recent calculated density, the health of brown bear populations has not shown any signs of impairment or degradation.

Summary

The KATM brown bear resource was considered to be of low concern. Population densities are adequate within the park and KTPR harvest data do not show evidence of overharvest. The trend in condition of this resource is stable based on available population density and ancillary data, such as family composition, from Hamon et al. (2011) and NPS (2012).

4.3.6 Sources of Expertise

Troy Hamon, KATM/ANIA Chief of Resources

Sherri Anderson, KATM/ANIA Wildlife Biologist

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4.4 Passerines

4.4.1 Description

Passerines are birds that belong to the Order Passeriformes, commonly referred to as "perching birds". Bird populations often act as excellent indicators of an ecosystem's health (Morrison 1986, Hutto 1998, NABCI 2009). Birds are typically easy to observe and identify, and bird communities often reflect the abundance and distribution of other organisms with which they co-exist (Blakesley et al. 2010). When SWAN began conducting biological inventories of vertebrates and vascular plants in the network parks in the early 2000s, land birds were identified as one of the top eight priority groups for study (Kedzie-Webb 2001, as cited in Ruthrauff and Tibbits 2009).

Photo 9. Golden-crowned sparrow in ALAG (NPS photo by Kelly Walton).

Together, KATM and ALAG provide a wide range of habitats, from coastal to montane and riparian, that support a variety of passerines. Fifty-six passerine species have been documented in KATM and 46 in the smaller ALAG (NPS 2013). These include several species of conservation concern, such as the golden-crowned sparrow (*Zonotrichia atricapilla*, Photo 9) (BPIF 1999).

4.4.2 Measures

- Species richness and diversity
- Species abundance

4.4.3 Data and Methods

The earliest available observations of bird populations in KATM are from Hine (1919), who studied the region's birds and focused on the area around the mouth of the Katmai River. Several observers recorded bird species during research trips or visits to KATM in the 1960s and 1970s, including Belson (1961), Gibson (1966, 1967a, 1967b, 1970), and Brokaw et al. (1970). In the late summer of 1989, Garber (1989) recorded bird species observed at Brooks Camp and along the road to the Valley of 10,000 Smokes. From 2004-2006, Ruthrauff et al. (2007) conducted a bird inventory in the montane regions of KATM. All sampling occurred during May and June of each year. Survey sites were selected across the park's various ecological subsections through a stratified random sampling design. Surveyors conducted point counts at 468 sites within 29 10-km x 10-km sample plots (Plate 28).

Breeding bird surveys have occurred in KATM, as part of the large-scale North American Breeding Bird Survey (BBS), which began in 1966 and is coordinated by the United States Geological Survey (USGS) and the Canadian Wildlife Service (Robbins et al. 1986). The standard BBS route is approximately 40 km (25 mi) long with survey points at every 0.8 km (0.5 mi). The survey begins ½ hour before sunrise, and at each survey point, the number of birds seen/heard within a 0.4-km (0.25-mi) radius during a 3-minute interval is recorded. Surveys were conducted in KATM (route 03060) from 1993-1997 and in 2000, 2005, and 2012 (USGS 2012; Plate 29).

The first recorded bird observations in ALAG occurred in the summer of 1997 and were documented by Savage (1997). A full bird inventory was conducted in the park during June 2011 (Walton and Gotthardt 2012). Similar to other studies in SWAN parks, this inventory utilized stratified random sampling according to land cover type. During one week of field work, teams conducted point count surveys at 71 points within nine sampling grids spread across various habitat types (Walton and Gotthardt 2012; Plate 30).

4.4.4 Current Condition and Trend

<u>Species Richness and Diversity</u>
According to the NPS Certified Species Lists (NPS 2013), 56 and 46 passerine species are present or probably present within KATM (Table 14) and ALAG (Table 15), respectively. This includes birds that are year-round or seasonal residents as well as species that pass through during migration. In ALAG, Walton and Gotthardt (2012) documented 35 passerines during their 2011 inventory, including the first ever park record of the Arctic warbler (*Phylloscopus borealis*) (Table 15). Previous field observations by Savage (1997) in ALAG recorded just 24 passerine species.

Various early researchers and visitors to the KATM region (1970 or earlier) observed between 12 and 24 passerine species (Table 14). These observations are not directly comparable, as many occurred in different areas of the park. For example, Gibson (1966, 1967a, 1967b) sampled multiple locations while Hine (1919) focused on the area near the mouth of the Katmai River. In a more recent survey of the park's montane regions, Ruthrauff et al. (2007) documented 33 passerine species.

Photo 10. Wilson's warbler (*Wilsonia pusilla*), one of the passerines recorded in nearly every survey or research trip to KATM (NPS photo by Will Elder).

Table 14. Passerines present or probably present within KATM. Abundances are from the NPS Certified Species List (NPS 2013), for those species confirmed present in the park. Species in bold are considered of conservation concern.

Scientific name	Common Name	Abundance	Ruthrauff et al. 2007	BBS 1993-2012	Garber 1989	Brokaw et al. 1970	Gibson 1966-70	Belson 1961	Hine 1919
Eremophila alpestris	horned lark	common	x				x		
Bombycilla garrulus[1,2]	**Bohemian waxwing**								
Certhia americana	brown creeper	uncommon			x	x	x		
Cinclus mexicanus[2]	**American dipper**	uncommon	x			x	x	x	
Corvus caurinus[2]	**northwestern crow**	uncommon					x		
Corvus corax	common raven	common	x	x	x	x	x	x	
Perisoreus canadensis[1]	**gray jay**	common	x	x	x	x	x	x	
Pica hudsonia	black-billed magpie	uncommon	x	x	x	x	x	x	x
Calcarius lapponicus[1]	**lapland longspur**	uncommon	x	x			x		x
Junco hyemalis	dark-eyed junco	common	x	x	x		x	x	
Melospiza lincolnii[1]	**Lincoln's sparrow**	uncommon	x	x					
Melospiza melodia	song sparrow	uncommon		x		x	x		x
Passerculus sandwichensis	savannah sparrow	common	x	x		x	x	x	x
Passerella iliaca	fox sparrow	abundant	x			x	x	x	x
Plectrophenax hyperboreus	Mckay's bunting	occasional							
Plectrophenax nivalis[1]	**snow bunting**	uncommon	x				x		
Spizella arborea	American tree sparrow	common	x	x		x	x	x	
Zonotrichia atricapilla[2]	golden-crowned sparrow	common	x	x		x	x	x	x
Zonotrichia leucophrys	white-crowned sparrow	uncommon	x	x		x	x	x	
Carduelis flammea	common redpoll	common	x	x		x	x	?	x
Carduelis hornemanni[1]	hoary redpoll								
Carduelis pinus	pine siskin								
Leucosticte tephrocotis	gray-crowned rosy-finch	uncommon	x						
Loxia curvirostra	red crossbill	uncommon					x		
Loxia leucoptera[1,2]	white-winged crossbill	uncommon		x			x		
Pinicola enucleator[1]	pine grosbeak	uncommon	x	x			x	?	
Petrochelidon pyrrhonota	cliff swallow								
Riparia riparia	bank swallow	uncommon	x	x		x	x	x	
Tachycineta bicolor	tree swallow	common	x	x		x	x	x	

Table 14. Passerines present or probably present within KATM. Abundances are from the NPS Certified Species List (NPS 2013), for those species confirmed present in the park. Species in bold are considered of conservation concern (continued).

Scientific name	Common Name	Abundance	Ruthrauff et al. 2007	BBS 1993-2012	Garber 1989	Brokaw et al. 1970	Gibson 1966-70	Belson 1961	Hine 1919
Tachycineta thalassina	violet-green swallow	rare		x			x	x	
Euphagus carolinus[1,2]	rusty blackbird	uncommon			x		x		
Lanius excubitor[1,2]	northern shrike	uncommon	x		x		x		
Anthus rubescens*	American pipit	abundant	x			x	x		x
Motacilla tschutschensis	eastern yellow wagtail								
Poecile atricapillus	black-capped chickadee	uncommon	x	x	x	x	x	x	x
Poecile hudsonica[1]	boreal chickadee	uncommon	x	x	x		x		
Dendroica coronata	yellow-rumped warbler	common	x	x			x	x	
Dendroica petechia	yellow warbler	common	x	x			x		x
Dendroica striata[2]	blackpoll warbler	uncommon	x	x		x	x	x	
Seiurus noveboracensis	northern waterthrush	uncommon	x	x		x	x	x	
Vermivora celata	orange-crowned warbler	common	x	x		x	x		
Wilsonia pusilla	Wilson's warbler	abundant	x	x		x	x	x	x
Regulus calendula	ruby-crowned kinglet	rare	x	x			x		
Regulus satrapa	golden-crowned kinglet	uncommon		x			x		
Sitta canadensis	red-breasted nuthatch	uncommon		x			x		
Sturnus vulgaris	European starling								
Phylloscopus borealis	Arctic warbler	rare		x					
Troglodytes troglodytes	winter wren	rare							
Catharus guttatus	hermit thrush	abundant	x	x		x	x		x
Catharus minimus[2]	gray-cheeked thrush	uncommon		x			x		
Catharus ustulatus	Swainson's thrush	uncommon		x			x	x	
Ixoreus naevius[2]	varied thrush	common	x	x	x	x	x	x	
Turdus migratorius	American robin	uncommon	x	x		x	x	x	
Contopus cooperi 1,2	olive-sided flycatcher	uncommon		x			x		
Empidonax alnorum[1]	alder flycatcher	uncommon		x		x	x		
Sayornis saya	Say's phoebe	rare							
		Total species	**33**	**36**	**10**	**24**	**44**	**23**	**12**

1 – North American Landbird Conservation Plan (Rich et al. 2004)

2 – Landbird Conservation Plan for Alaska (Boreal Partners in Flight Working Group 1999)

* formerly known as the water pipit, *Anthus spinoletta*.

Table 15. Passerines present or probably present within ALAG. Abundances are from the NPS Certified Species List (NPS 2013), for those species confirmed present in the park. Species in bold are considered of conservation concern.

Scientific name	Common Name	Abundance	Walton & Gothardt 2012	Savage 1997
Certhia americana	brown creeper			
Cinclus mexicanus	American dipper	rare	x	x
Corvus corax	common raven	uncommon	x	x
Perisoreus canadensis	gray jay	uncommon	x	x
Pica hudsonia	black-billed magpie	uncommon	x	x
Calcarius lapponicus	lapland longspur			
Junco hyemalis	dark-eyed junco	uncommon	x	x
Melospiza lincolnii	Lincoln's sparrow		x	
Melospiza melodia	song sparrow			
Passerculus sandwichensis	savannah sparrow	common	x	x
Passerella iliaca	fox sparrow	uncommon	x	
Plectrophenax hyperboreus	Mckay's bunting			
Plectrophenax nivalis	snow bunting			
Spizella arborea	American tree sparrow	common	x	x
Zonotrichia atricapilla[1]	**golden-crowned sparrow**	uncommon	x	x
Zonotrichia leucophrys	white-crowned sparrow	uncommon	x	x
Carduelis flammea	common redpoll	unknown	x	
Carduelis hornemanni	hoary redpoll		x	
Carduelis pinus	pine siskin		x	
Loxia leucoptera	white-winged crossbill		x	
Pinicola enucleator	pine grosbeak		x	
Riparia riparia	bank swallow	uncommon	x	x
Tachycineta bicolor	tree swallow	uncommon	x	x
Tachycineta thalassina	violet-green swallow			
Euphagus carolinus[1,2]	**rusty blackbird**		x	
Lanius excubitor	northern shrike			
Poecile atricapillus	black-capped chickadee	uncommon	x	x
Poecile hudsonica	boreal chickadee	uncommon	x	x
Dendroica coronata	yellow-rumped warbler	uncommon	x	x
Dendroica petechia	yellow warbler	rare	x	x
Dendroica striata[1,2]	**blackpoll warbler**	uncommon	x	x
Seiurus noveboracensis	northern waterthrush	uncommon	x	x
Vermivora celata	orange-crowned warbler	common	x	x
Wilsonia pusilla	Wilson's warbler	common	x	x
Regulus calendula	ruby-crowned kinglet		x	
Regulus satrapa	golden-crowned kinglet			
Sitta canadensis	red-breasted nuthatch			
Troglodytes troglodytes	winter wren			
Catharus guttatus	hermit thrush	uncommon	x	x
Catharus minimus[1]	**gray-cheeked thrush**	uncommon	x	x
Catharus ustulatus	Swainson's thrush	uncommon	x	x
Ixoreus naevius[1,2]	**varied thrush**	rare	x	
Turdus migratorius	American robin	common	x	x
Contopus cooperi	olive-sided Flycatcher	rare		
Empidonax alnorum	alder flycatcher		x	x
Phylloscopus borealis	Arctic warbler		x	

[1] – Landbird Conservation Plan for Alaska (Boreal Partners in Flight Working Group 1999)

[2] – Audubon Alaska Watchlist (Kirchoff and Padula 2010)

The BBS in KATM has documented between 16 and 28 passerine species during the years it has occurred in the park (Figure 3), with 36 species recorded over all years combined (Table 14, USGS 2012). However, the BBS uses only roadside survey locations and does not sample all the habitat types present in the park. Estimates of park-wide species richness using BBS data would likely be inaccurate, due to the potential bias of using only roadside locations.

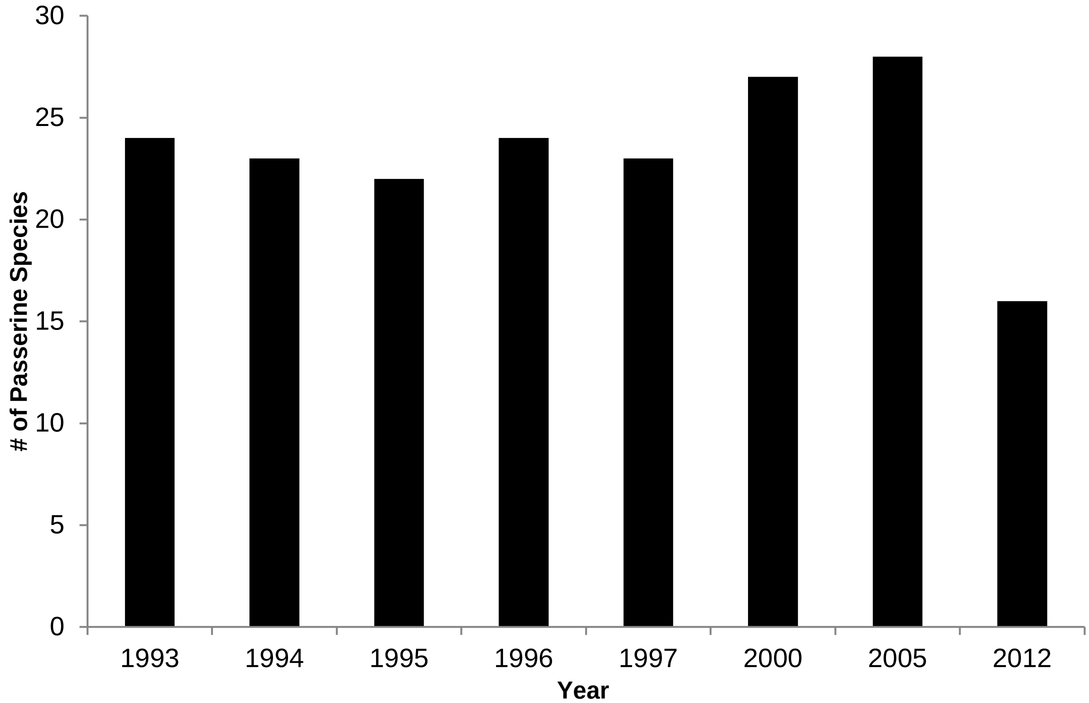

Figure 3. Number of passerine species documented during each KATM BBS (USGS 2012).

Species Abundance

Limited data regarding passerine abundance are available for KATM and ALAG. For ALAG, only Walton and Gotthardt (2012) reported on species abundance. The four most common species during their inventory were Wilson's warbler (*Wilsonia pusilla*), American tree sparrow (*Spizella arborea*), savannah sparrow (*Passerculus sandwichensis*), and white-crowned sparrow (*Zonotrichia leucophrys*). The total number of each passerine species observed and average occurrence (number of individuals/number of points surveyed) in ALAG are presented in Table 16.

Table 16. Number of individuals of each passerine species documented in ALAG, and average occurrence (Walton and Gotthardt 2012). Species with the five highest average occurrences are highlighted in gray.

Species	Individuals	Avg. occurrence	Species	Individuals	Avg. occurrence
alder flycatcher	10	0.141	yellow warbler	3	0.042
gray jay	27	0.380	blackpoll warbler	37	0.521
black-billed magpie	2	0.028	yellow-rumped warbler	43	0.606
common raven	4	0.056	Wilson's warbler	99	1.394
tree swallow	1	0.014	American tree sparrow	76	1.070
black-capped chickadee	4	0.056	savannah sparrow	70	0.986
boreal chickadee	5	0.070	fox sparrow	20	0.282
ruby-crowned kinglet	2	0.028	Lincoln's sparrow	10	0.141
gray-cheeked thrush	6	0.085	white-crowned sparrow	57	0.803
Swainson's thrush	3	0.042	golden-crowned sparrow	16	0.225
hermit thrush	41	0.577	dark-eyed junco	12	0.169
American robin	5	0.070	rusty blackbird	1	0.014
varied thrush	6	0.085	white-winged crossbill	41	0.577
northern waterthrush	46	0.648	pine siskin	1	0.014
orange-crowned warbler	39	0.549	redpoll sp.	14	0.197

For KATM, passerine species abundance has been reported by the BBS and by Ruthrauff et al. (2007). According to BBS data, some of the most abundant species in KATM are the varied thrush (*Ixoreus naevius*), yellow-rumped warbler (*Dendroica coronata*), Swainson's thrush (*Catharus ustulatus*), Wilson's warbler, and white-crowned sparrow (although the final three species were not documented during the most recent BBS in 2012) (Table 17).

Table 17. Abundance of passerine species observed during the KATM BBS (USGS 2012).

Species	1993	1994	1995	1996	1997	2000	2005	2012
olive-sided flycatcher	0	1	0	0	0	0	0	0
alder flycatcher	2	0	0	1	1	1	2	5
gray jay	12	2	6	8	2	18	6	8
black-billed magpie	0	1	0	0	0	0	3	0
common raven	0	0	4	1	2	0	0	1
tree swallow	1	1	2	3	6	1	3	0
violet-green swallow	0	0	0	0	0	0	3	0
bank swallow	0	0	0	4	0	0	0	0
black-capped chickadee	4	0	0	0	2	2	9	0
boreal chickadee	1	4	1	1	0	3	0	3
red-breasted nuthatch	1	0	0	0	0	1	0	0
golden-crowned kinglet	0	0	0	0	0	1	1	0
ruby-crowned kinglet	3	5	4	11	18	5	10	1
Arctic warbler	0	0	0	0	0	0	12	0
gray-cheeked thrush	18	11	12	11	8	13	29	9
Swainson's thrush	57	56	46	47	38	46	94	0
hermit thrush	14	22	22	21	42	19	17	14
American robin	4	3	3	6	12	9	23	16
varied thrush	41	52	50	68	70	63	105	53
lapland longspur	1	0	0	0	0	0	0	0

Table17. Abundance of passerine species observed during the KATM BBS (USGS 2012) (continued).

Species	1993	1994	1995	1996	1997	2000	2005	2012
northern waterthrush	6	9	13	9	3	3	2	0
orange-crowned warbler	22	40	50	53	53	51	23	0
yellow warbler	0	1	2	2	0	1	5	0
blackpoll warbler	4	7	10	11	12	7	17	0
yellow-rumped warbler	18	22	28	40	51	44	89	48
Wilson's warbler	17	31	19	23	24	31	44	0
American tree sparrow	11	12	20	17	21	10	13	9
savannah sparrow	2	1	2	2	3	2	4	1
song sparrow	0	0	0	0	1	0	0	0
Lincoln's sparrow	0	0	0	0	0	1	0	0
white-crowned sparrow	17	17	31	45	30	26	52	0
golden-crowned sparrow	10	9	13	16	12	6	30	2
dark-eyed junco	28	15	27	21	23	18	66	8
pine grosbeak	0	0	0	0	0	1	1	0
white-winged crossbill	0	0	0	0	0	0	47	1
common redpoll	9	21	33	16	21	15	12	8
Total individuals	**303**	**343**	**398**	**437**	**455**	**398**	**722**	**187**

During the Ruthrauff et al. (2007) survey, the most commonly observed species were the golden-crowned sparrow, fox sparrow (*Passerella iliaca*), American pipit (*Anthus rubescens*), and redpoll species (*Carduelis* sp.). The total number of each species observed and average occurrence (number of individuals/number of points surveyed) in KATM are presented in Table 18.

Table 18. Number of individuals of each passerine species documented in KATM, and average occurrence (Ruthrauff et al. 2007). Species with the five highest average occurrences are highlighted in gray.

Species	Individuals	Ave. occurrence	Species	Individuals	Ave. occurrence
northern shrike	1	0.002	yellow warbler	24	0.051
gray jay	4	0.009	yellow-rumped warbler	67	0.143
black-billed magpie	5	0.011	Wilson's warbler	227	0.485
common raven	27	0.058	American tree sparrow	153	0.327
horned lark	40	0.085	savannah sparrow	112	0.239
tree swallow	18	0.038	fox sparrow	269	0.575
black-capped chickadee	4	0.009	Lincoln's sparrow	1	0.002
boreal chickadee	3	0.006	white-crowned sparrow	106	0.226
ruby-crowned kinglet	7	0.015	golden-crowned sparrow	406	0.868
hermit thrush	194	0.415	dark-eyed junco	54	0.115
American robin	136	0.291	Lapland longspur	19	0.041
varied thrush	19	0.041	snow bunting	57	0.122
American pipit	194	0.415	gray-crowned rosy finch	4	0.009
northern waterthrush	2	0.004	pine grosbeak	3	0.006
orange-crowned warbler	138	0.295	redpoll sp.	104	0.222

Threats and Stressor Factors

Due to limited research, it is unclear if any stressors to passerines are present within KATM and ALAG boundaries. However, these species are likely threatened by sources outside the parks, such as mining or the development of off-shore oil and gas exploration. For example, several large developments have been proposed in Bristol Bay west of the parks, which may influence wildlife in the region (Ruthrauff et al. 2007). Climate change is also a threat to birds, particularly those that rely on alpine habitats, as these areas are likely to become drier and experience shifts in vegetation (Ruthrauff et al. 2007). Additionally, many of the passerines that occur in KATM and ALAG are migratory, and face multiple threats during migration and while in their winter habitats.

Data Needs/Gaps

Nearly all of the bird surveys and observations in KATM and ALAG have occurred during the summer months. While this is likely the time when most passerines are present and active in the parks, surveys during other seasons would contribute to a more thorough understanding of the passerine population (Ruthrauff et al. 2007, Walton and Gotthardt 2012). In ALAG, Walton and Gotthardt (2012) recommend utilizing other survey techniques in addition to point counts (e.g., line transects, area searches) and conducting further sampling at high and middle elevations along the upper river reaches. Since both KATM and ALAG support passerines of conservation concern, specific research into those particular species may be beneficial (Ruthrauff et al. 2007).

Overall Condition

It is difficult to assess the overall condition of passerines in KATM and ALAG, due to the limited amount of data that are available. Historical information is primarily from incidental observations as opposed to scientifically designed inventories or surveys. As a result, it is not directly comparable to more recent surveys. However, there is no evidence of any cause for concern among the passerine populations, particularly given the relatively pristine and undisturbed condition of the parks.

4.4.5 Sources of Expertise

Sherri Anderson, KATM/ALAG/ANIA Wildlife Biologist

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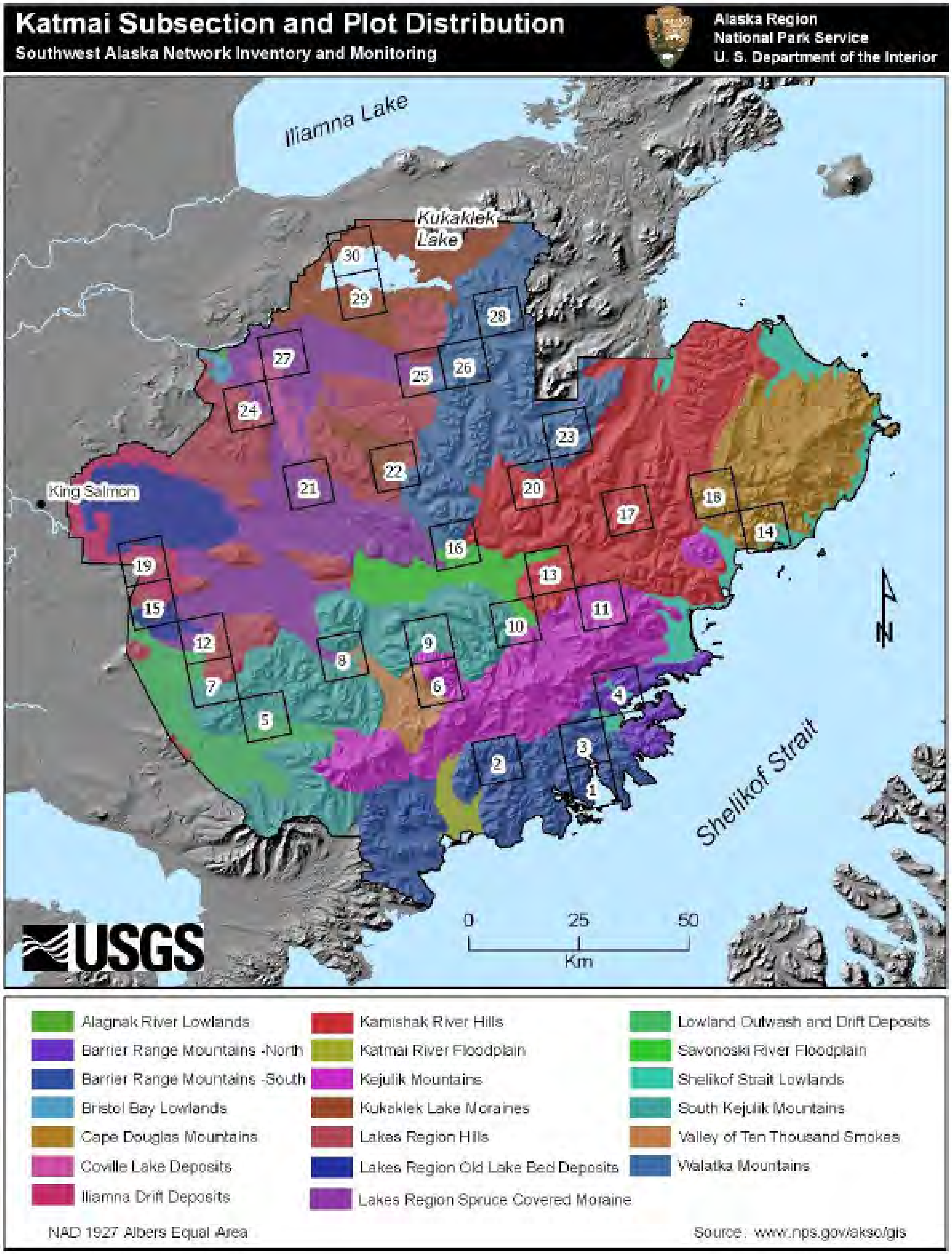

Plate 28. Location of bird sampling plots within KATM in relation to the park's ecological subsections (Ruthrauff et al. 2007).

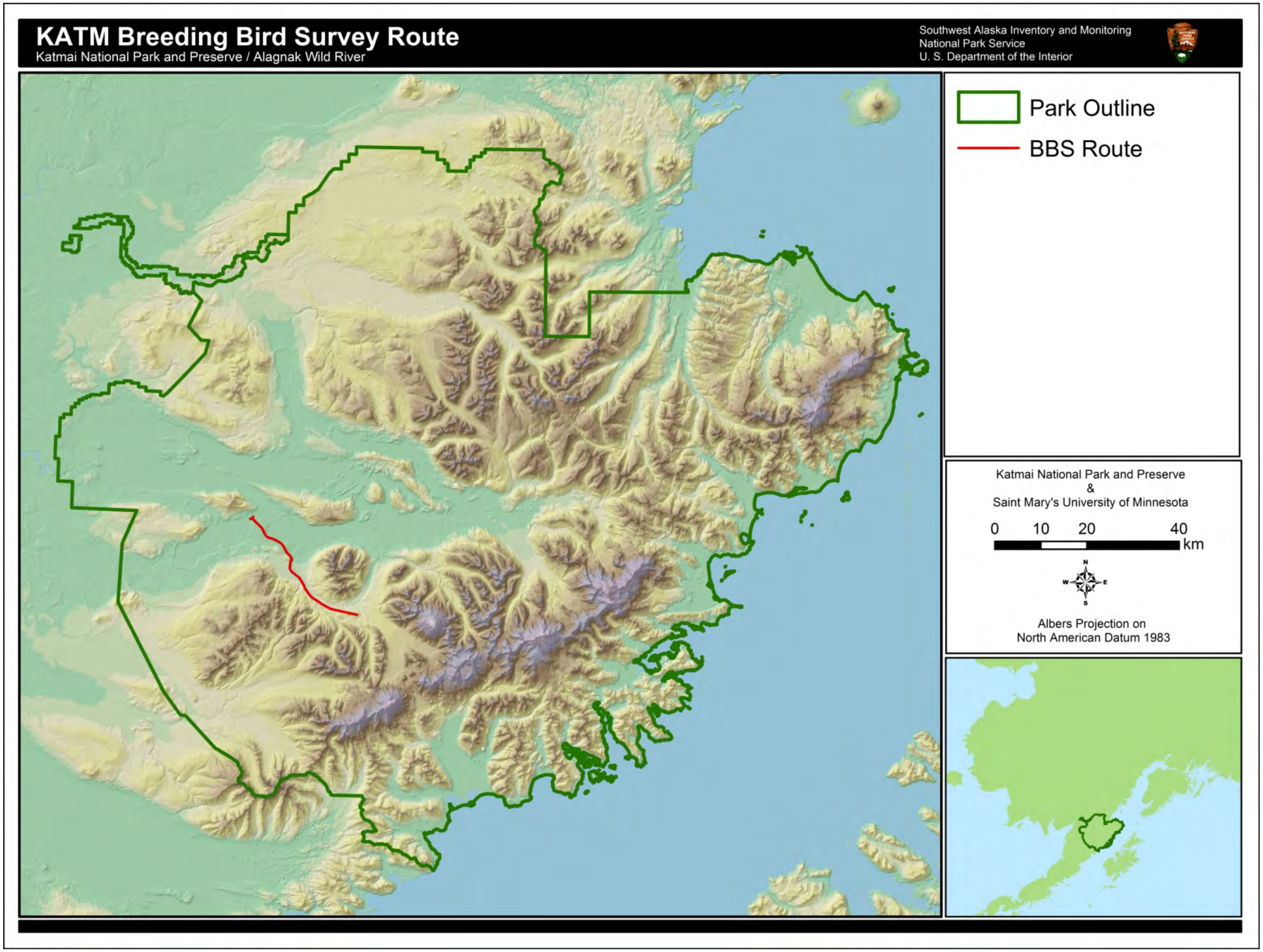

Plate 29. Location of the KATM BBS route within the park

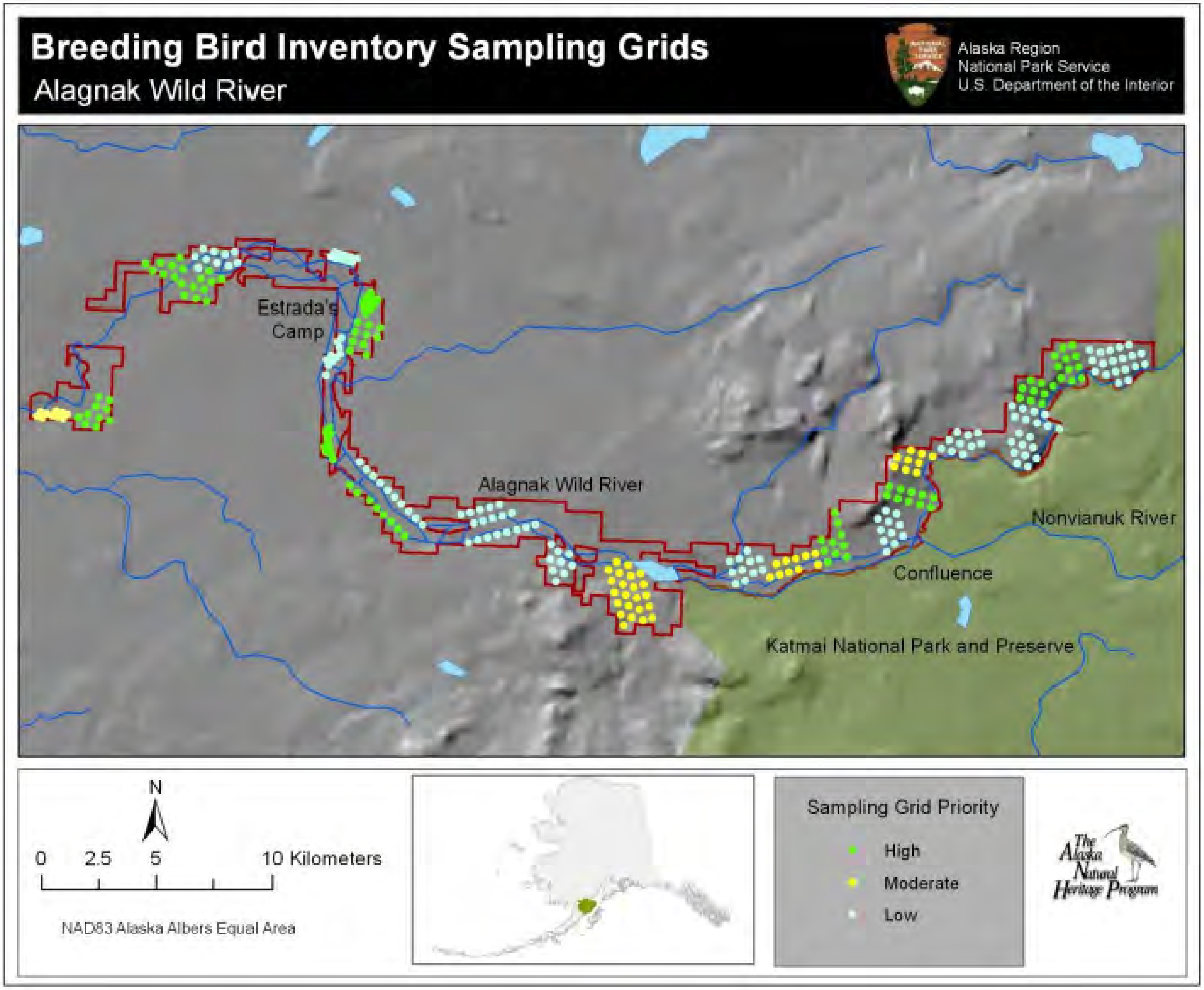

Plate 30. Proposed sampling grids for the ALAG breeding bird inventory, colored by priority (Walton and Gotthardt 2012). Only 9 grids were sampled during the inventory, due to time and travel constraints.

4.5 Salmon

4.5.1 Description

Pacific salmon are semelparous spawning species; they often migrate from their oceanic environments to areas of freshwater to spawn in the late stages of their life cycle, where they remain until they die. Anadromous salmon species use freshwater streams, rivers, and lakes for spawning, rearing, or migration routes during annual runs. Sockeye salmon (*Oncorhynchus nerka*) return to spawning headwaters to deposit their eggs; they make upstream journeys through lakes, streams, and rivers in order to reach natal waters. Salmon are a SWAN Vital Sign, intended to characterize overall health of an ecosystem and serve as an environmental change indicator. The ecological, economic, and social integrity of KATM and the surrounding area is dependent on the maintenance of healthy sockeye salmon spawning runs (NPS 2011).

Other salmon species present in the park include Chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), and pink (*O. gorbuscha*) (NPS 2015). Upon entering the freshwater environment, salmon often undergo dramatic physiological transformations such as a humped back, kype (hook-like jaw), and changes in color. Salmon often return to their original streams, lakes, or rivers, making long upstream journeys across barriers and strong currents.

Photo 11. Sockeye salmon swimming below Margot Creek Falls. NPS photo by Peter Hamel.

Salmon spawning generally coincides with peak visitation at KATM. Visitors are attracted to salmon spawning and high concentrations of brown bears that congregate at locations such as the Brooks Falls to feed on migrating salmon (Photo 11).

Salmon runs begin in June and continue through the end of July to early August, while spawning takes place from early August through October.Salmon are major food sources for bald eagles, brown and black bears, humans, and a variety of other species. They also provide recreational angling for park visitors and the foundation of the commercial and fishery industry in the Bristol Bay area (ADF&G 2012a). Sockeye are typically the most valuable and sought after salmon species, both commercially and recreationally. Commercial harvest of sockeye salmon for the Bristol Bay area was estimated at over 22 million fish in the 2011 season, with all salmon species representing a market value of over $137 million annually (ADF&G 2011, Jones et al. 2012). According to ADF&G (Jones et al. 2012, p. 1), the Bristol Bay area rivers “are home to the largest commercial sockeye salmon fishery in the world” and represent a very important natural resource. The Anadromous Waters

Catalog (AWC) identifies Alaskan waterbodies that are classified as important for the spawning, rearing, or migration of anadromous fishes. Plate 31–Plate 36 display known Pacific salmon streams in the KATM region by species as of 2010.

4.5.2 Measures

- Escapement
- Percent harvest
- Run timing

4.5.3 Reference Conditions/Values

Bristol Bay is divided into five management districts (Naknek-Kvichak, Egegik, Ugashik, Nushagak, and Togiak) which encompass major riverine systems: Naknek, Kvichak, Alagnak, Egegik, Ugashik, Wood, Nushagak, Nuyakuk, Igushik, and Togiak (Jones et al. 2012) (Plate 37)This area contains five major management districts which include all waters (coastal and inland) from Cape Newenham to Cape Menshikof (Jones et al. 2012). Management objectives typically correspond to escapements and harvest rates of major salmon species. However, a reference condition was not established by park staff for the KATM salmon component. Conclusions were drawn from anadromous fish reports, historical data, and temporal trends.

4.5.4 Data and Methods

ADF&G, with assistance from USFWS and NPS, monitor and manage adult salmon throughout Alaska using various methods such as counting towers, weirs, sonar, and aerial surveys (NPS 2011, Jones et al. 2012). Salmon escapement data for the Bristol Bay area were provided by NPS staff (Hamon 2012) and obtained from ADF&G management reports (Weiland 2004, Westing et al. 2005, 2006, Salomone et al. 2007, 2011, Sands et al. 2008, Jones et al. 2009, Morstad et al. 2010, and Jones et al. 2012). Hamon (2012) provided spreadsheets containing historical daily escapement data for each fishing district and river system within Bristol Bay.

ADF&G collects annual harvest data of Pacific salmon species by district (Jones et al. 2012). Historical salmon harvest data were compiled from several ADF&G management reports (Middleton et al. 1965, West 2002, Weiland 2004, Jones et al. 2012) and NPS spreadsheets (Hamon 2012). These data were used to display inshore catch and total harvest rates for the five Bristol Bay districts. Run timing data were also provided by NPS staff, which included mean day of escapement (MDOE) by river system (Hamon 2012). Daily escapement, harvest, and MDOE data were appended from ADF&G reports to NPS spreadsheets.

4.5.5 Current Condition and Trend

<u>Escapement</u>

Estimates of escapement for Pacific salmon species in KATM are undertaken annually by the ADF&G, in collaboration with USFWS and NPS (NPS 2011). Salmon escapement is measured by a variety of methods including weir counts, aerial surveys, counting towers and sonar (NPS 2011).

Escapement information is often necessary for commercial, subsistence, and recreational fisheries management (NPS 2011).

From 1992 to 2011, the maximum sockeye salmon inshore escapement estimate within Bristol Bay was 17.2 million in 2004 (Jones et al. 2012). The minimum escapement estimate was 3.3 million in 1997 (Jones et al. 2012). Sockeye salmon populations, as well as rates of escapement, are often variable from year to year or location to location (Hare and Francis 1994, ADF&G 2011). Figure 4-Figure 6, Figure 10, Figure 13, Figure 16-Figure 19, and Figure 23 show historical inshore sockeye salmon escapement by system to show context. Figure 9, Figure 11, Figure 14, Figure 20, and Figure 24 display sockeye salmon escapement for each district within KATM by system over the past 20 years (1992 to 2011). Figure 27 displays the total escapement for all districts combined from 1992 to 2011.

For the Kvichak, Naknek systems, historical escapement has been highly variable, generally exhibiting periods of higher escapement followed by periods of lower escapement (Figure 4, Figure 5). The Alagnak system escapement has also been historically variable; however, large gaps in data exist (Figure 6). While the Kvichak district saw significant declines in escapement averages over the past 20 years, escapement estimates from the Naknek and Alagnak systems showed moderate increases (Table 19).

Percent catch of total sockeye salmon runs in the Kvichak-Naknek has shown great variability within the past 20 years, reaching a high of approximately 75% in 1996 to a low of approximately 18% in 1997 (Figure 8). The Kvichak system has typically comprised the majority of sockeye salmon escapement within the Kvichak-Naknek district. However, since the early 2000s, ratios have become less extreme, with the Naknek and Alagnak systems accounting for greater percentages of total escapement in 2002 and 2005 (Figure 9). As of 2011, the Kvichak river system accounted for over 50% of the total inshore sockeye salmon escapement in the district (Figure 9).

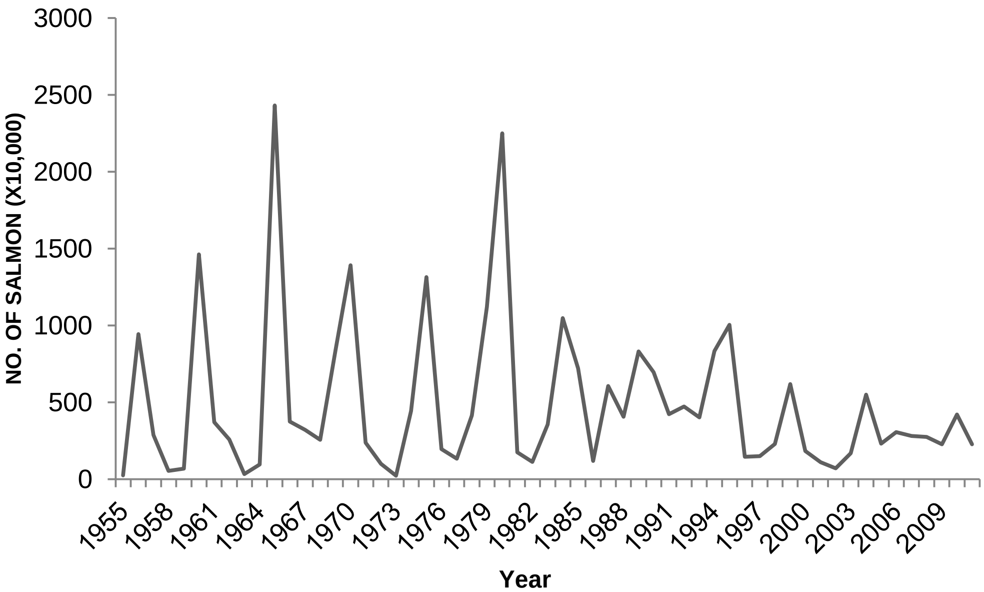

Figure 4. Kvichak system total inshore sockeye salmon escapement, 1955-2011 (Weiland 2004, Westing et al. 2005, 2006, Salomone et al. 2007, 2011, Sands et al. 2008, Jones et al. 2009, Morstad et al. 2010, Jones et al. 2012, and Hamon 2012).

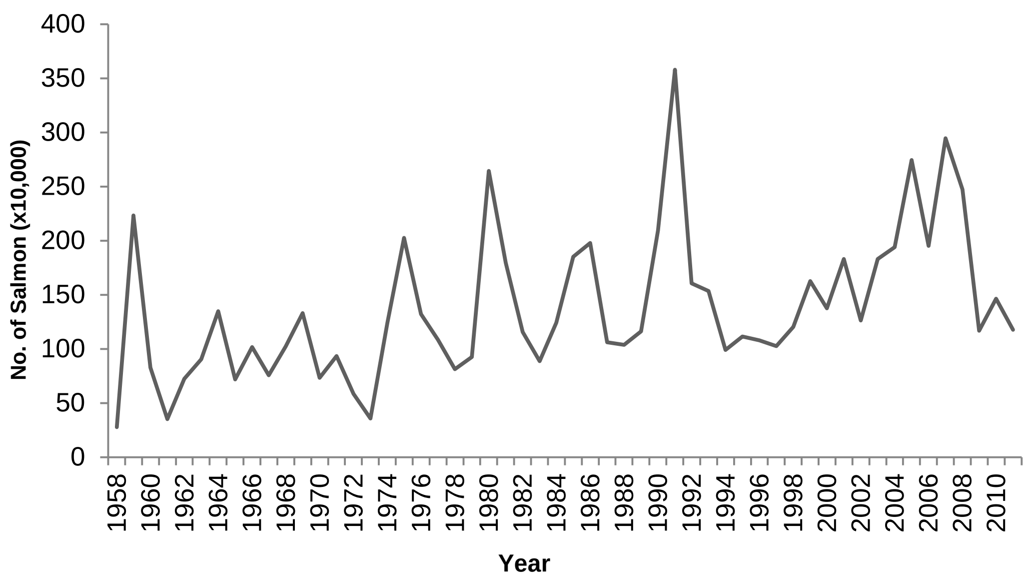

Figure 5. Naknek system total inshore sockeye salmon escapement, 1958-2011 (Weiland 2004, Westing et al. 2005, 2006, Salomone et al. 2007, 2011, Sands et al. 2008, Jones et al. 2009, Morstad et al. 2010, Jones et al. 2012, and Hamon 2012).

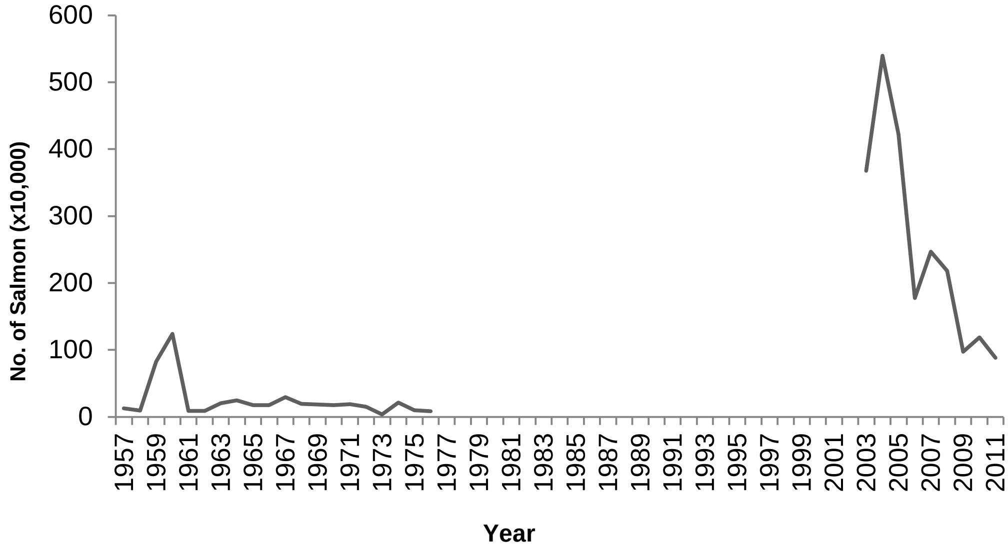

Figure 6. Alagnak system total inshore sockeye salmon escapement, 1957-2011 (Weiland 2004, Westing et al. 2005, 2006, Salomone et al. 2007, 2011, Sands et al. 2008, Jones et al. 2009, Morstad et al. 2010, Jones et al. 2012, and Hamon 2012).

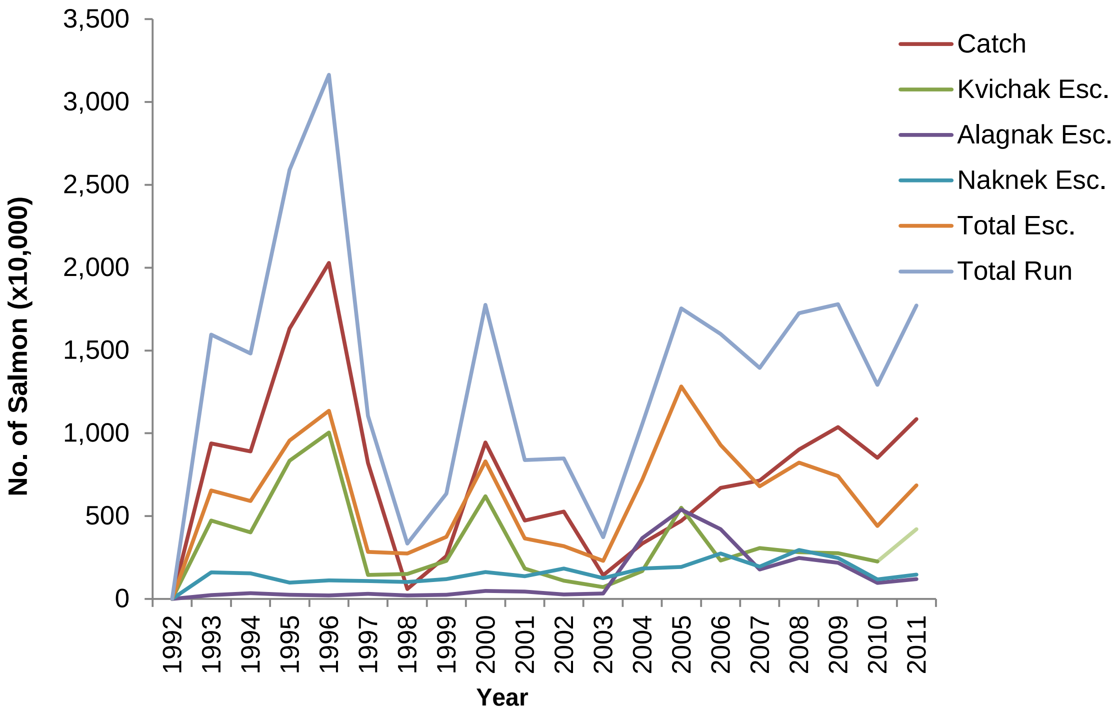

Figure 7. Kvichak-Naknek district total inshore sockeye salmon escapement by system, 1992-2011 (Jones et al. 2012, Hamon 2012).

Table 19. Kvichak-Naknek district average total inshore catch, escapement, and run for sockeye salmon, 1992-2011 (Jones et al. 2012, Hamon 2012).

Period	Catch	Kvichak Esc.	Alagnak Esc.	Naknek Esc.	Total Esc.	Total Run
20-Year Avg.	7,839,430	3,454,175	1,304,927	1,617,109	6,376,211	14,215,641
1992-2001 Avg.	8,576,857	4,149,802	300,789	1,338,140	5,788,731	14,365,588
2002-2011 Avg.	7,102,003	2,758,549	2,309,065	1,896,077	6,963,692	14,065,694

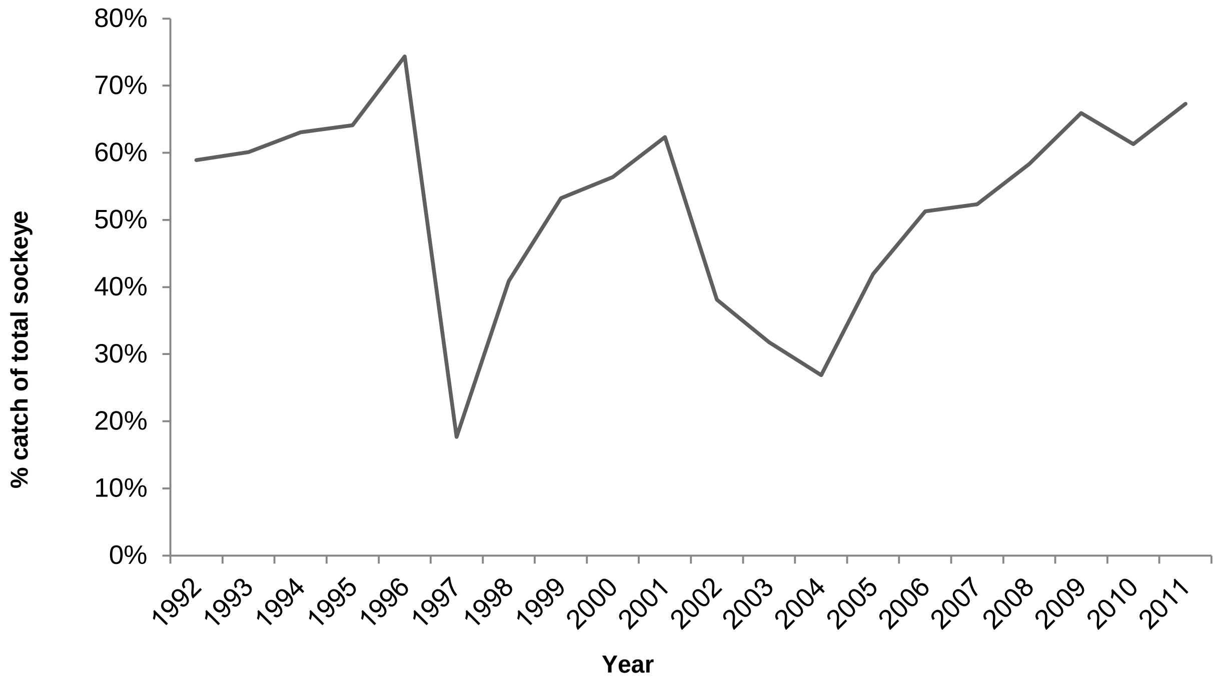

Figure 8. Kvichak-Naknek district percent catch of total sockeye salmon run (Jones et al. 2012, Hamon 2012).

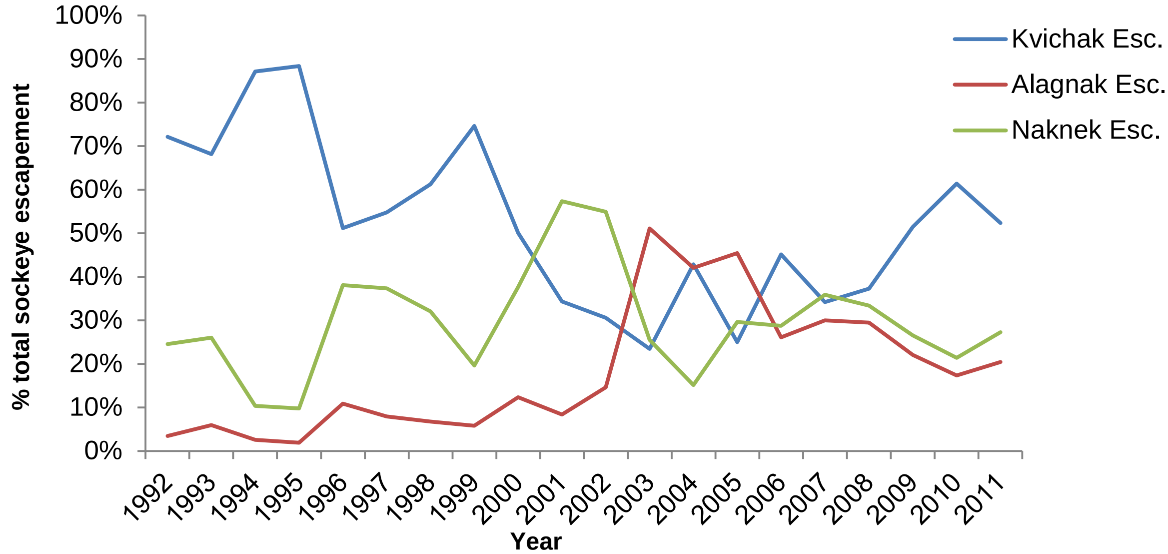

Figure 9. Percentage of total inshore sockeye salmon escapement by Kvichak-Naknek river system, 1992-2011 (Jones et al. 2012, Hamon 2012).

The Egegik district exhibited slight increases in total inshore sockeye salmon escapement since the 1980s (Figure 10), although total escapement typically accounts for only a fraction of the total run (Figure 11). Escapement, catch, and total run of sockeye salmon in the Egegik district have been relatively stable over the past 20 years (Table 20). Harvest in the Egegik has been relatively higher compared to other districts; the percent catch of total run for the district typically accounts for greater than 75% of total runs (Figure 12).

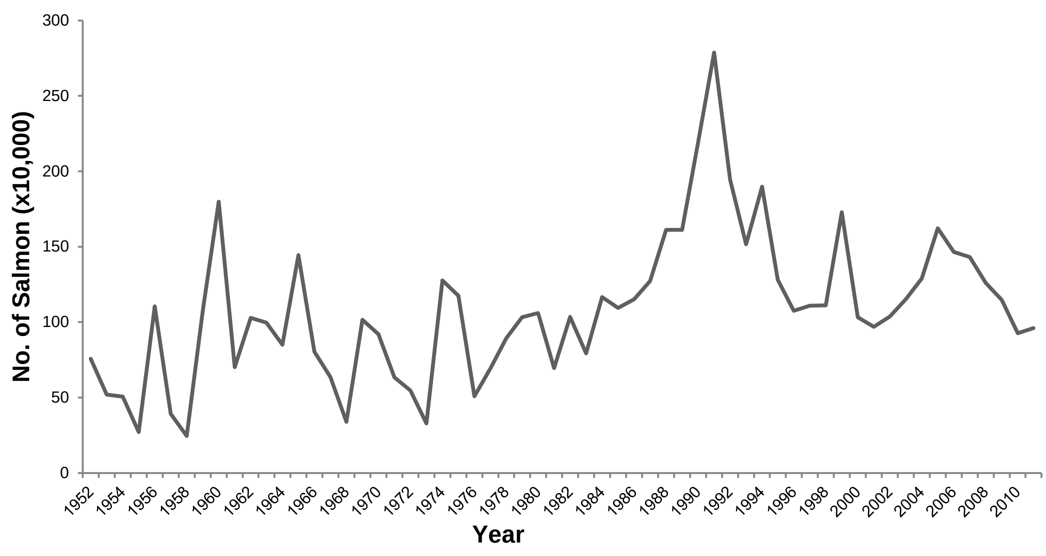

Figure 10. Egegik district total inshore sockeye salmon escapement, 1952-2011 (Weiland 2004, Westing et al. 2005, 2006, Salomone et al. 2007, 2011, Sands et al. 2008, Jones et al. 2009, Morstad et al. 2010, Jones et al. 2012, and Hamon 2012).

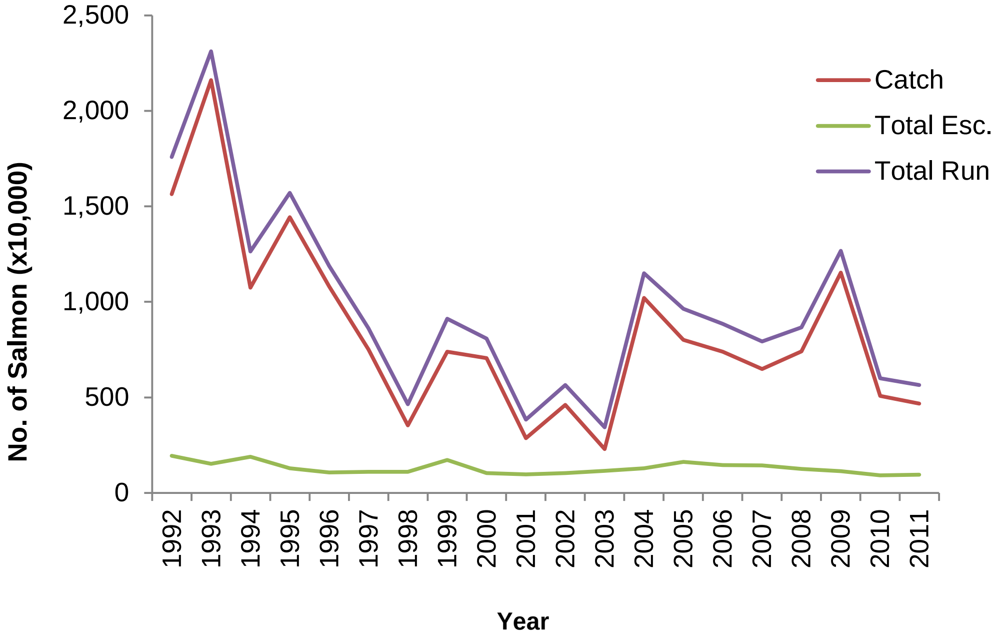

Figure 11. Egegik district total inshore sockeye salmon escapement, 1992-2011 (Jones et al. 2012, Hamon 2012).

Table 20. Egegik district average total inshore catch, escapement, and run for sockeye salmon, 1992-2011 (Jones et al. 2012, Hamon 2012).

Period (Avg)	Catch	Egegik Esc.	Shosky Esc.	King Salmon Esc.	Total Esc.	Total Run
20-Year	8,464,180	1,297,478	6	352	1,297,674	9,761,854
1992-2001	10,159,062	1,365,814	15	313	1,366,006	11,525,067
2002-2011	6,769,298	1,229,143	0	399	1,229,342	7,998,640

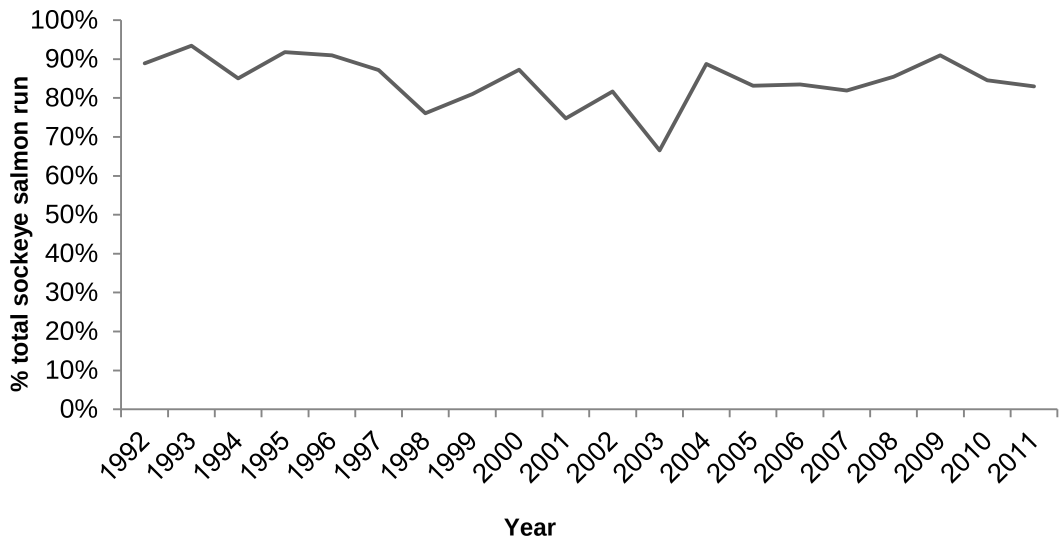

Figure 12. Egegik district percent catch of total sockeye salmon run (%) 1992-2011 (Jones et al. 2012, Hamon 2012).

The Ugashik district also exhibited large historical fluctuations in sockeye salmon escapement, although total escapement increased since the mid-to-late 1970s (Figure 13). The Ugashik district has shown variable harvest and escapement rates over the past 20 years (Figure 14.). Total harvest closely mirrors total run in the Ugashik district and catch has been higher than escapement in all but two years within the past two decades (Figure 14). Escapement, total run, and harvest in the Ugashik district have remained very consistent since 1992 (Table 21). Percent catch of the total sockeye salmon run for the district has ranged from approximately 36% in 2001 to 86% in 1996 (Figure 15).

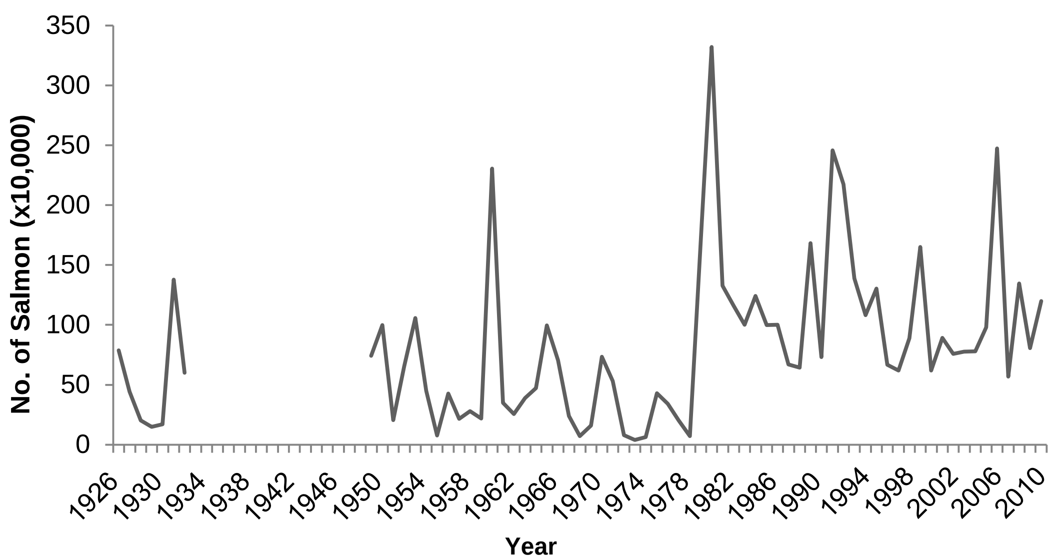

Figure 13. Ugashik district total inshore sockeye salmon escapement, 1926-2011 (Weiland 2004, Westing et al. 2005, 2006, Salomone et al. 2007, 2011, Sands et al. 2008, Jones et al. 2009, Morstad et al. 2010, Jones et al. 2012, and Hamon 2012).

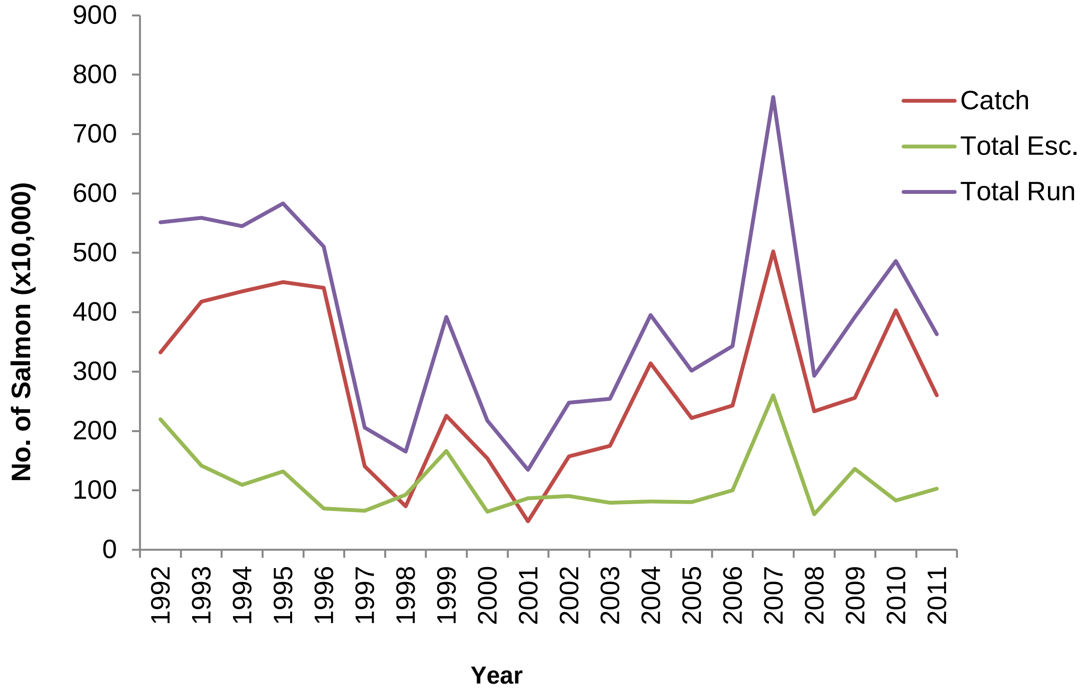

Figure 14. Ugashik district total inshore sockeye salmon escapement, 1992-2011 (Jones et al. 2012, Hamon 2012).

Table 21. Ugashik district average total inshore catch, escapement, and run for sockeye salmon, 1992-2011 (Jones et al. 2012, Hamon 2012).

Period (Avg)	Catch	Ugashik Esc.	King Salmon Esc.	Dog Salmon Esc.	Total Esc.	Total Run
20-Year	2,741,651	1,084,154	11,219	14,598	1,109,970	3,851,621
1992-2001	2,717,943	1,122,980	15,702	7,822	1,146,505	3,864,448
2002-2011	2,765,359	1,045,328	6,735	21,373	1,073,436	3,838,795

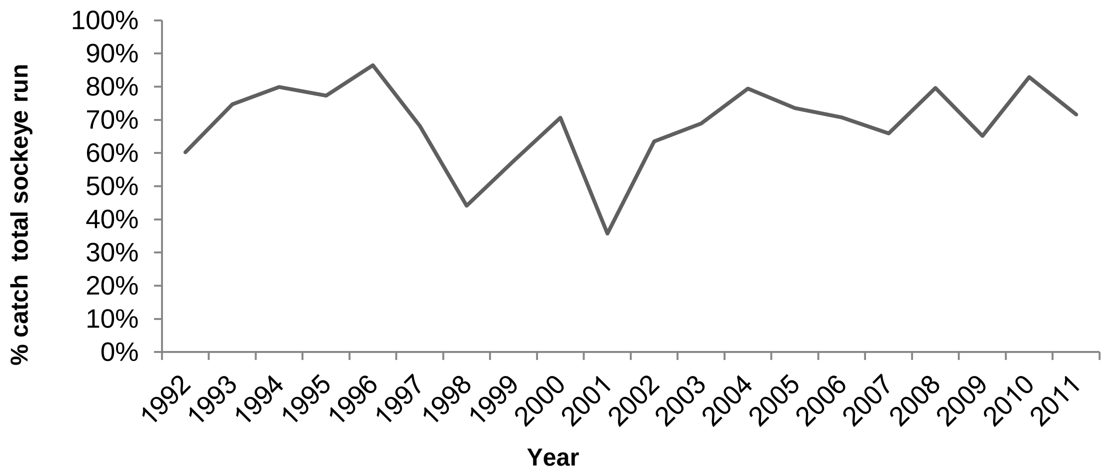

Figure 15. Ugashik district percent catch of total sockeye salmon run, 1992-2011 (Jones et al. 2012, Hamon 2012).

The four major systems in the Nushagak district (Nushagak, Wood, Igushik, and Nuyakuk) have also experienced variable historical escapement rates (Figure 20). The Nushagak and Igushik systems have remained relatively stable with occasional spikes in escapement rates from year to year (Figure 16, Figure 18). The Wood system has generally shown steadily increasing escapement totals from 1956 to 2011 (Figure 17). Despite incomplete datasets for the Nuyakuk system, total escapement has remained stable with a few years experiencing abnormal highs (Figure 19). The Wood district typically contributes the greatest percentage of salmon escapement in the Nushagak district (50-80%), followed by the Nushagak and Igushik systems (6-38%) (Figure 20, Figure 22). The Nuyakuk system contribution is essentially negligible. Total harvest in the Nushagak district has increased by approximately three million fish from 1992-2001 to 2002-2011, following a similar increase in total run (Table 22). Escapement for each system and the district as a whole has remained stable (Table 22).

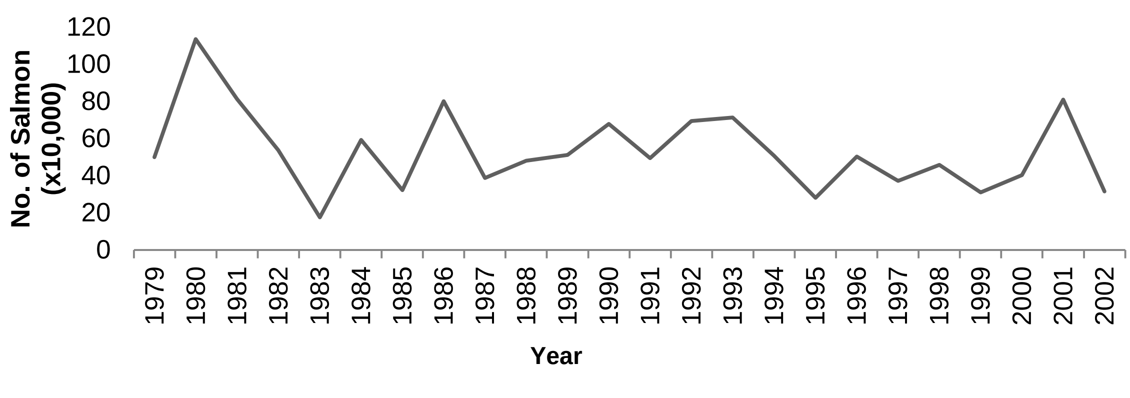

Figure 16. Nushagak system total inshore sockeye salmon escapement, 1979-2002 (Weiland 2004, Westing et al. 2005, 2006, Salomone et al. 2007, 2011, Sands et al. 2008, Jones et al. 2009, Morstad et al. 2010, Jones et al. 2012, Hamon 2012).

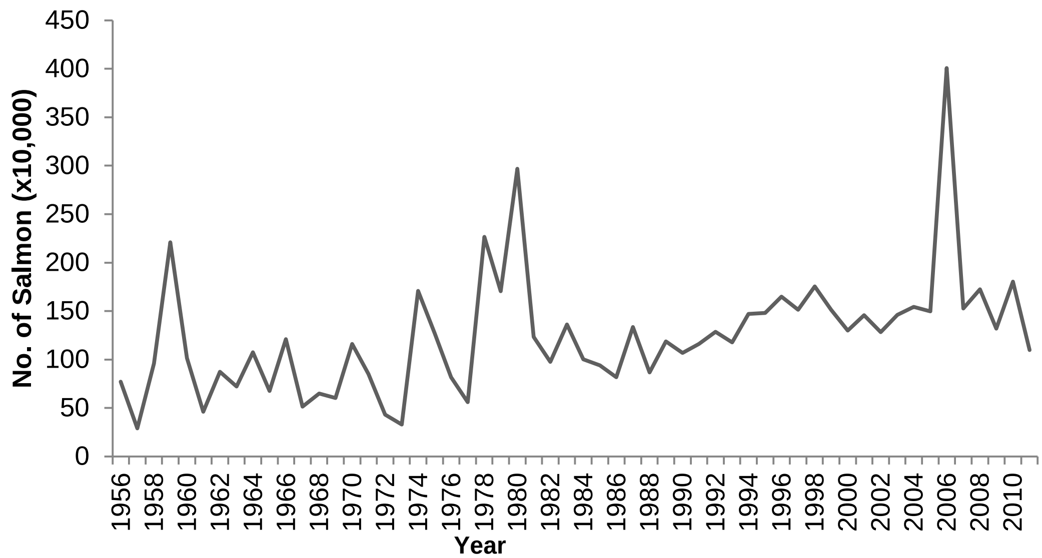

Figure 17. Wood system total inshore sockeye salmon escapement, 1956-2011 (Weiland 2004, Westing et al. 2005, 2006, Salomone et al. 2007, 2011, Sands et al. 2008, Jones et al. 2009, Morstad et al. 2010, Jones et al. 2012, and Hamon 2012).

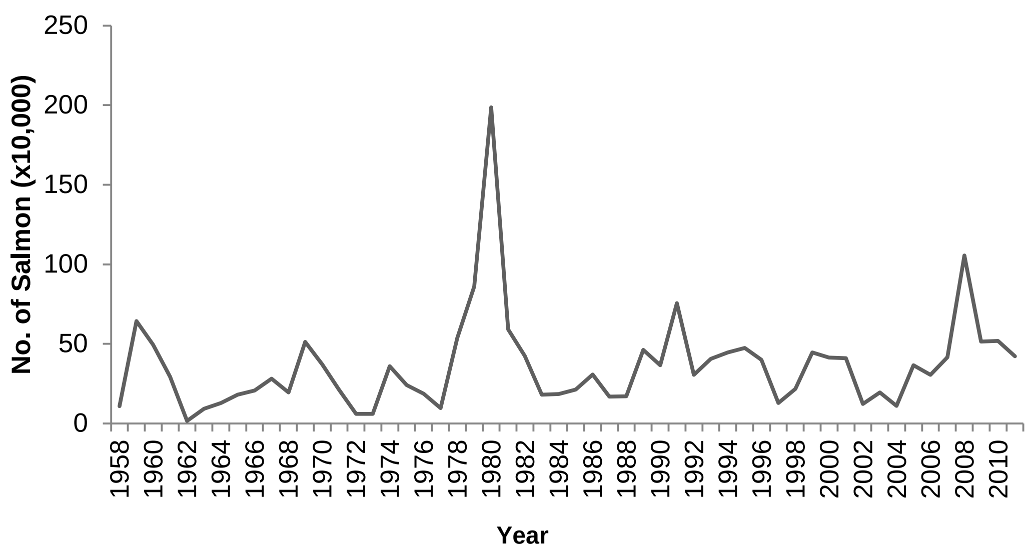

Figure 18. Igushik system total sockeye salmon escapement, 1958-2011 (Weiland 2004, Westing et al. 2005, 2006, Salomone et al. 2007, 2011, Sands et al. 2008, Jones et al. 2009, Morstad et al. 2010, Jones et al. 2012, and Hamon 2012).

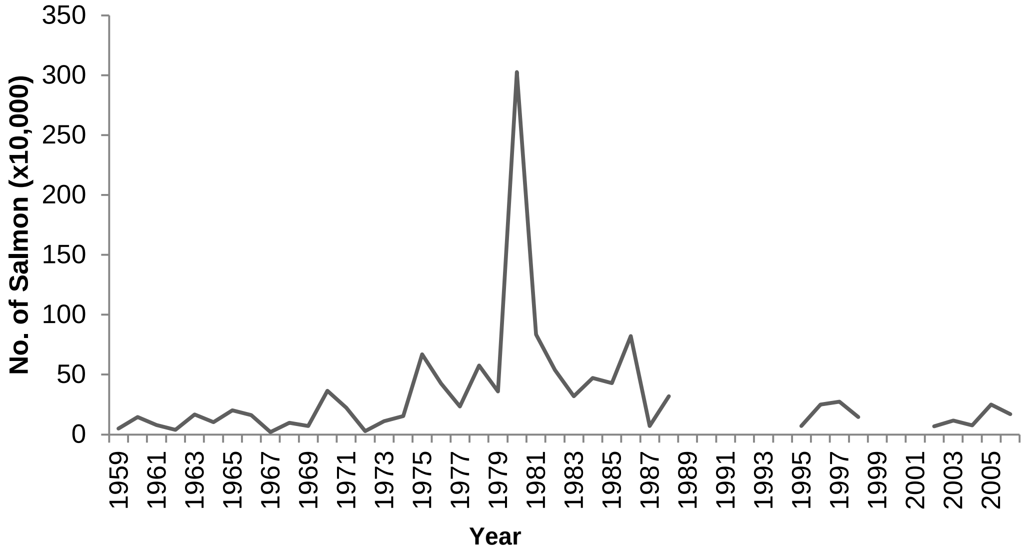

Figure 19. Nuyakuk system total sockeye salmon escapement, 1959-2006 (Weiland 2004, Westing et al. 2005, 2006, Salomone et al. 2007, and Hamon 2012).

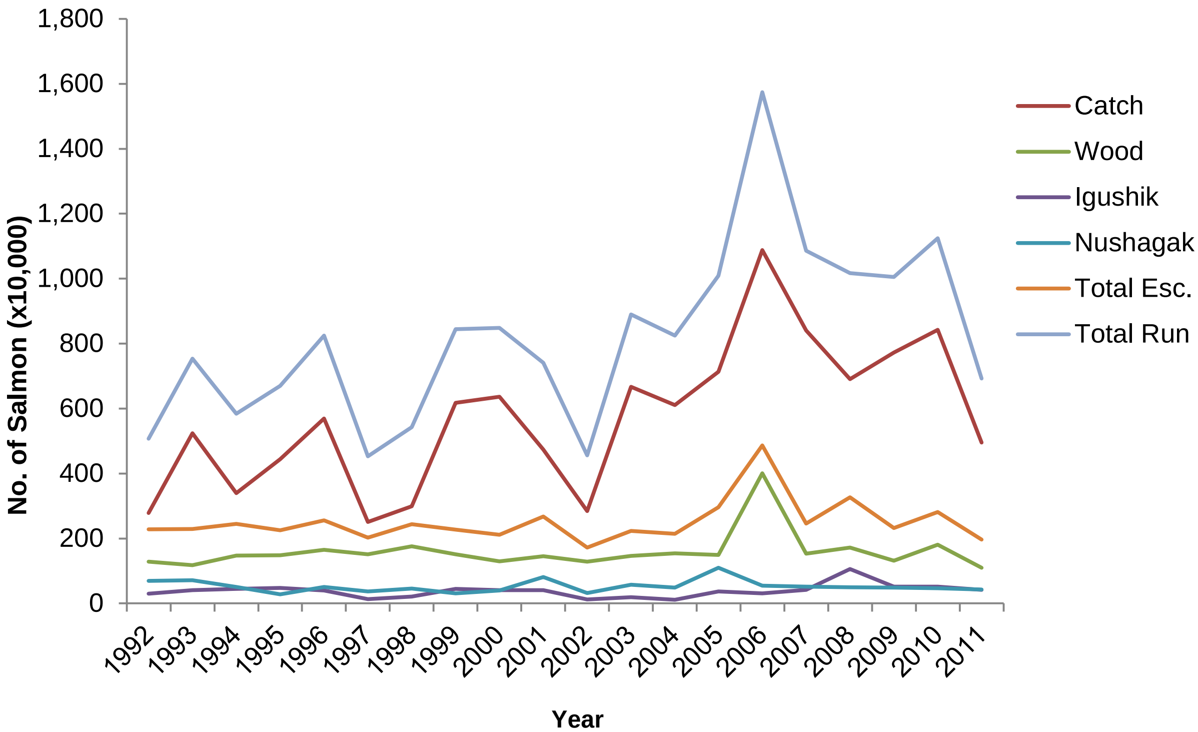

Figure 20. Nushagak district total inshore sockeye salmon escapement by system, 1992-2011 (Jones et al. 2012, Hamon 2012).

Table 22. Nushagak district average total inshore catch, escapement, and run for sockeye salmon, 1992-2011 (Jones et al. 2012, Hamon 2012).

Period (Avg)	Catch	Wood Esc.	Igushik Esc.	Nuyakuk Esc.	Nugashak Esc.	Total Esc.	Total Run
20-Year	5,718,366	1,593,559	383,211	151,575	524,356	2,506,510	8,224,875
1992-2001	4,433,369	1,460,537	364,259	162,021	506,290	2,337,024	6,770,393
2002-2011	7,003,363	1,726,580	402,164	136,951	542,421	2,675,995	9,679,358

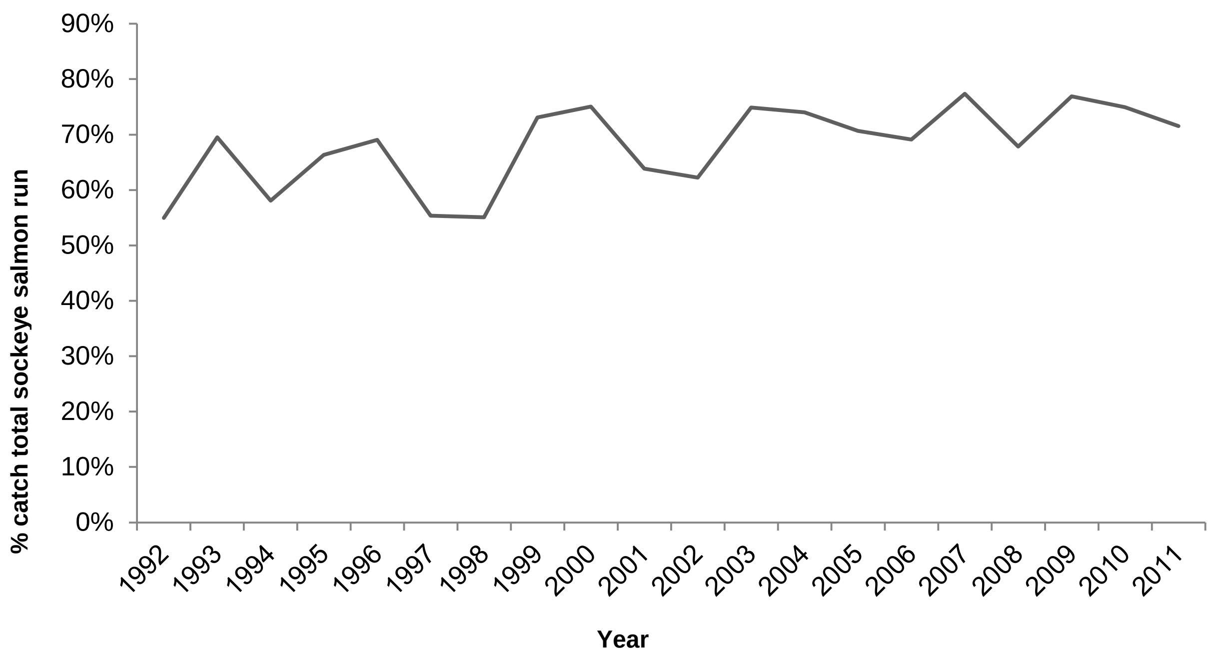

Figure 21. Nushagak district percent catch of total sockeye salmon run, 1992-2011 (Jones et al. 2012, Hamon 2012).

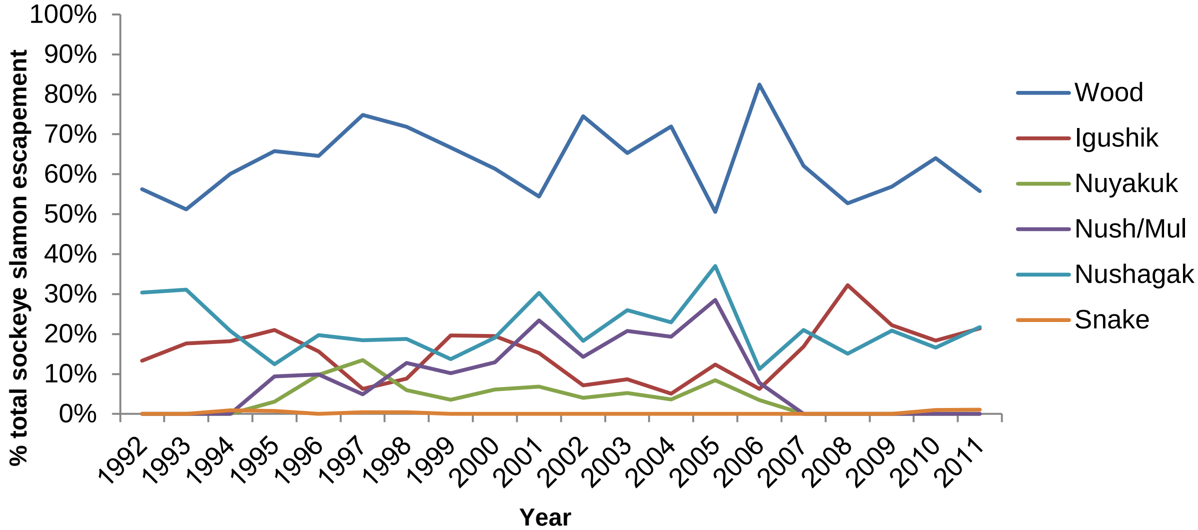

Figure 22. Percentage of total inshore sockeye salmon escapement by Nushagak river system, 1992-2011 (Jones et al. 2012, Hamon 2012).

The Togiak district has shown steadily increasing total escapement since the 1960s (Figure 23). Escapement totals for the Togiak district are relatively low compared to other Bristol Bay districts (Figure 24). Togiak Lake contributes approximately 180,000 to 300,000 salmon annually, whereas the Togiak River system contribution is negligible (Figure 24). Over the past 20 years (1992-2011), total harvest, escapement, and run have remained stable with little variation between years (Table 23, Figure 25). Contributions to total escapement from several Togiak systems have been variable since the early 1990s; however, Togiak Lake has accounted for nearly 100% of escapement in the district since 2006 (Figure 26).

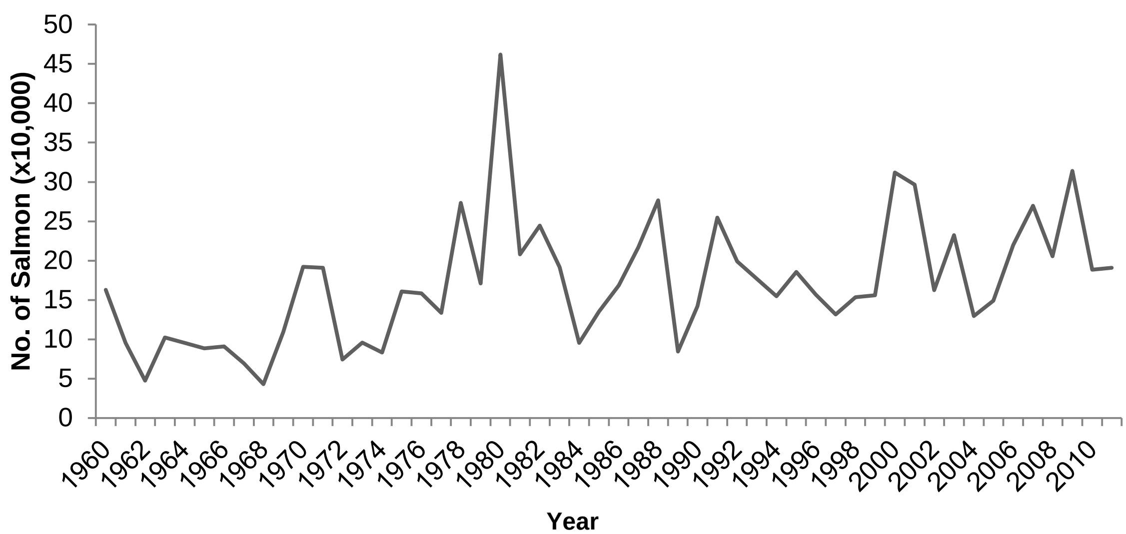

Figure 23. Togiak district total sockeye salmon escapement, 1960-2011 (Weiland 2004, Westing et al. 2005, 2006, Salomone et al. 2007, 2011, Sands et al. 2008, Jones et al. 2009, Morstad et al. 2010, Jones et al. 2012, and Hamon 2012).

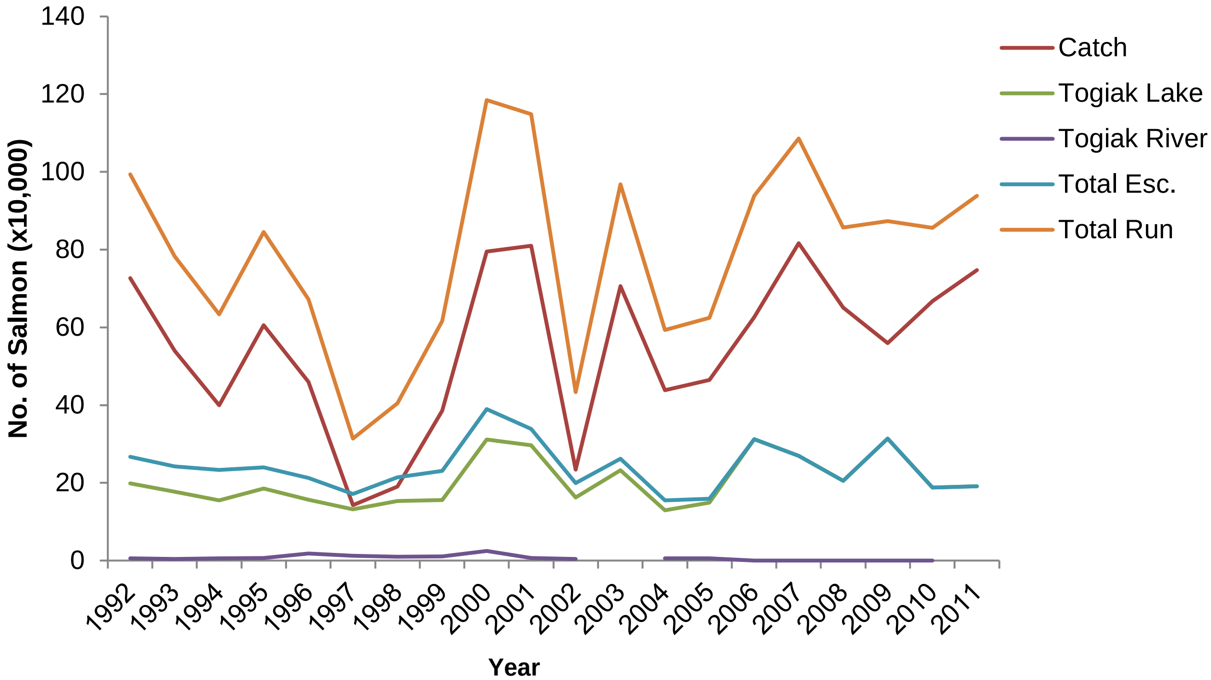

Figure 24. Togiak district total inshore sockeye salmon escapement by system, 1992-2011 (Jones et al. 2012, Hamon 2012).

Table 23. Togiak district average total inshore catch, escapement, and run for sockeye salmon, 1992-2011 (Jones et al. 2012, Hamon 2012).

Period (Avg)	Catch	Togiak Lake Esc.	Togiak River	Tributaries Esc.	Kulukak Esc.	Other Esc.	Total Esc.	Total Run
20-Year	548,408	203,874	9,391	11,086	17,576	17,382	239,897	788,305
1992-2001	505,531	192,347	10,630	13,095	19,441	18,662	254,174	759,705
2002-2011	591,286	215,401	5,260	4,390	8,252	14,183	225,620	816,905

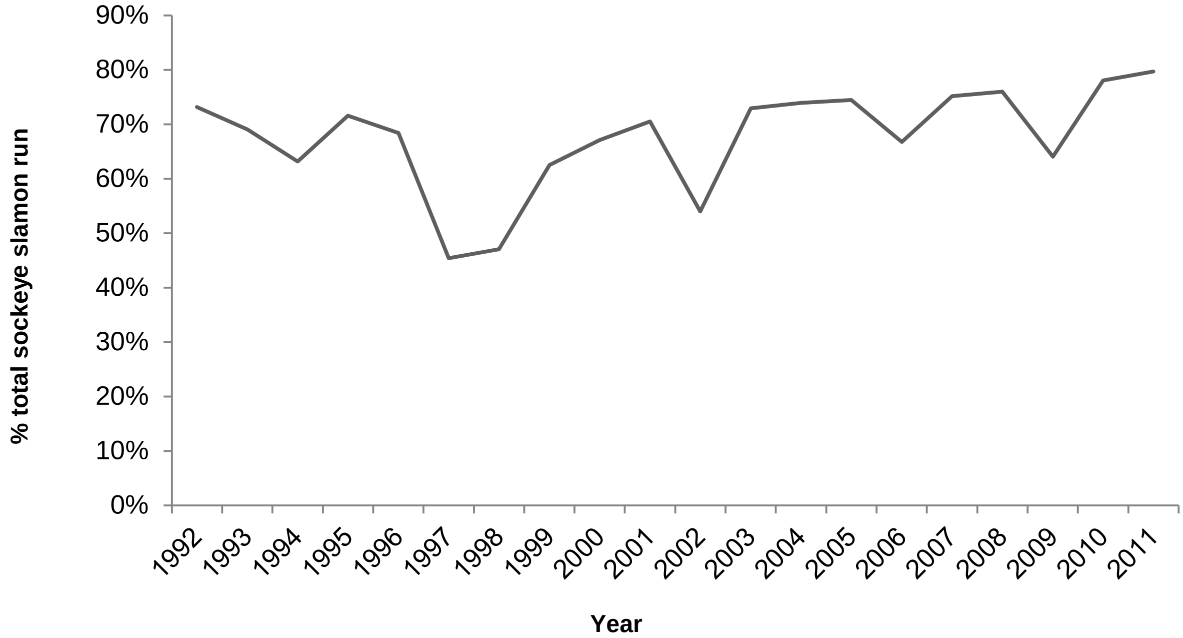

Figure 25. Togiak district percent catch of total sockeye salmon run, 1992-2011 (Jones et al. 2012, Hamon 2012).

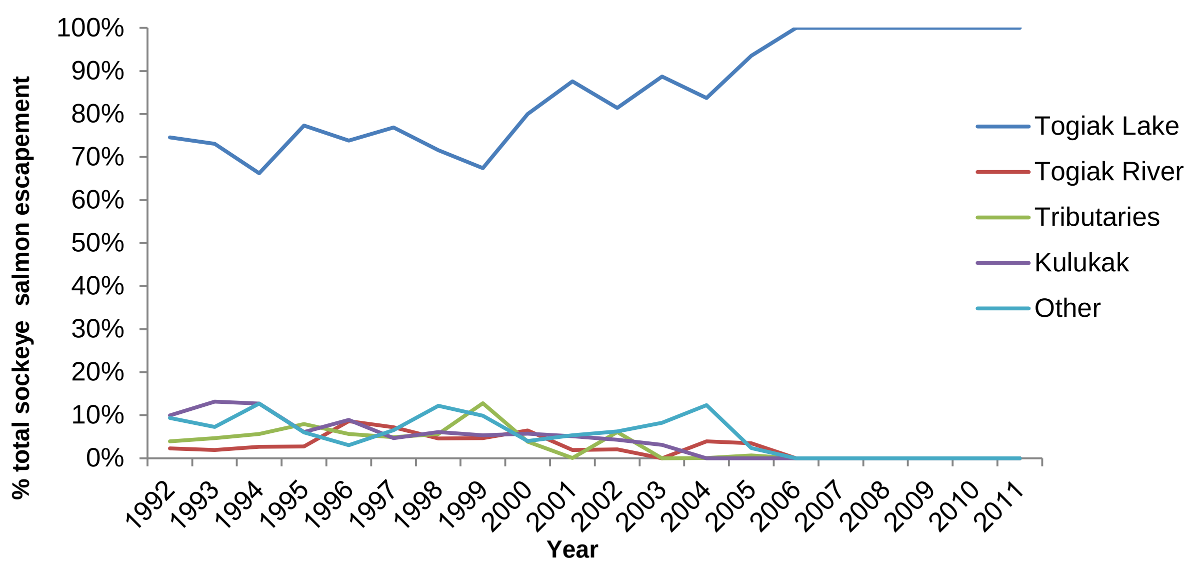

Figure 26. Percentage of total inshore sockeye salmon escapement by Togiak river system, 1992-2011 (Jones et al. 2012, Hamon 2012).

Overall, the Kvichak-Naknek district typically contributes the greatest amount of inshore salmon escapement followed by the Nushagak, Egegik, Ugashik, and Togiak districts, with some variability from year to year (Figure 27, Figure 29). Total sockeye salmon escapement totals within the past 20 years ranged from a low of approximately six million in 2002 to approximately 17 million in 2004 (Figure 27). Total escapement for Bristol Bay increased by approximately one million sockeye salmon on average from 1992-2001 to 2002-2011 (Table 24). Percent catch of total run has ranged from 32% (1996) to 71% (1998) (Figure 28).

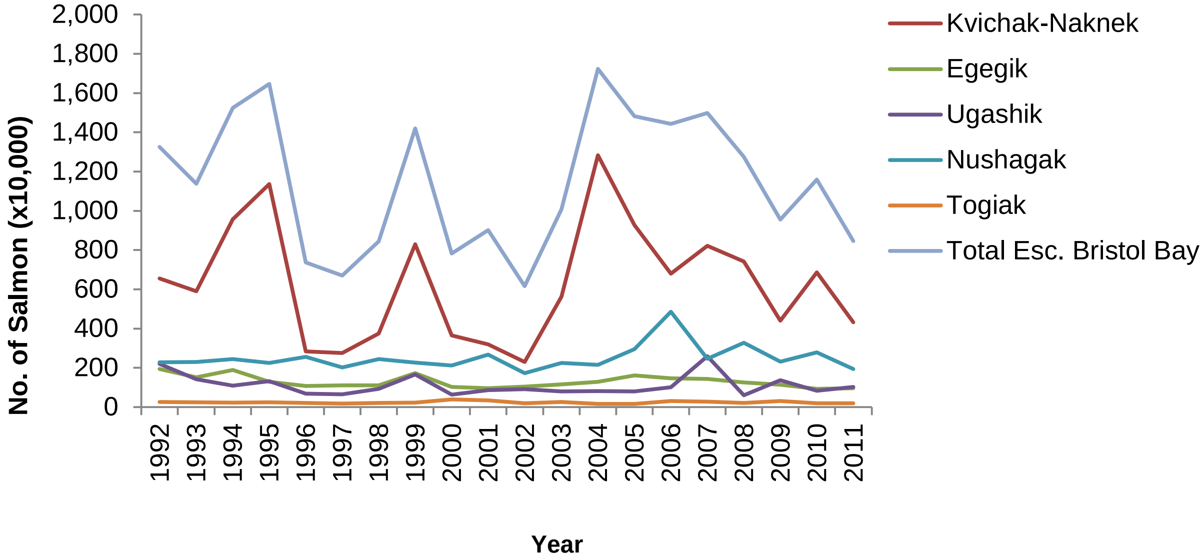

Figure 27. Bristol Bay five-district total inshore sockeye salmon escapement, 1992-2011 (Jones et al. 2012, Hamon 2012).

Table 24. Bristol Bay five-district average yearly inshore escapement for sockeye salmon, 1992-2011 (Jones et al. 2012, Hamon 2012).

Period	Kvichak- Naknek	Egegik	Ugashik	Nushagak	Togiak	Total
20-Year Avg.	6,297,990	1,297,564	1,109,965	2,504,452	239,711	11,498,126
1992-2001 Avg.	5,788,911	1,365,943	1,146,505	2,337,024	254,174	10,989,445
2002-2011 Avg.	6,807,068	1,229,185	1,073,426	2,671,880	225,248	12,006,807

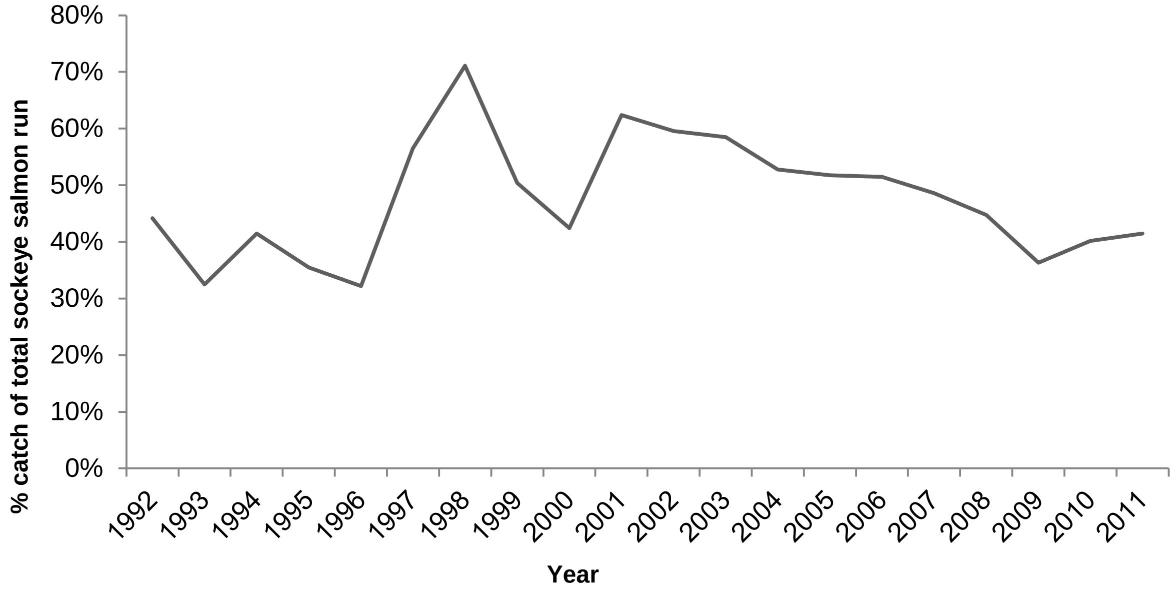

Figure 28. Bristol Bay five-district percent catch of total sockeye salmon run, 1992-2011 (Jones et al. 2012, Hamon 2012).

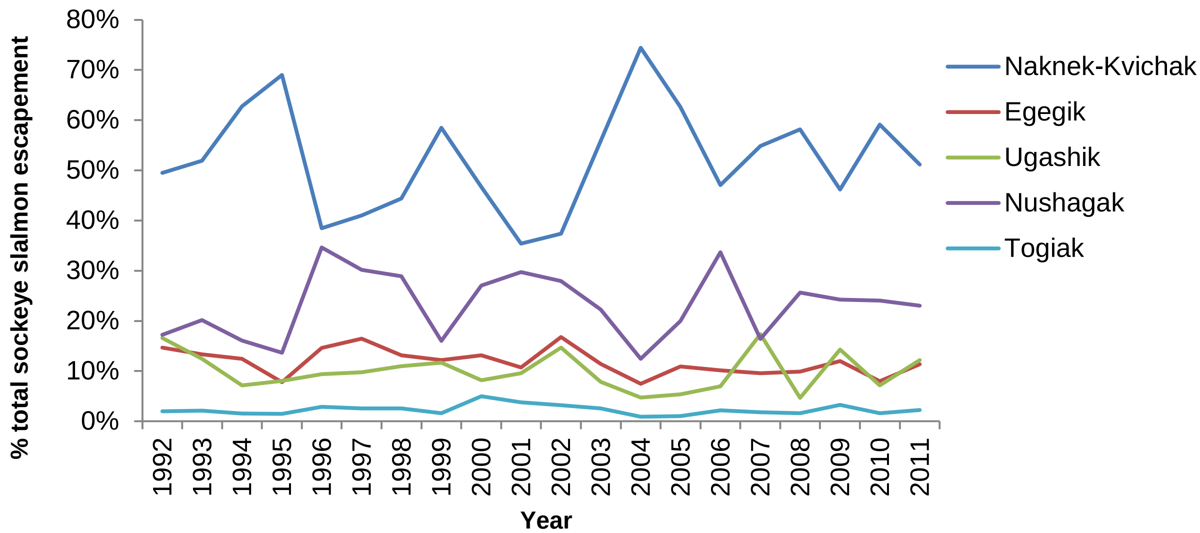

Figure 29. Percentage of total inshore sockeye salmon escapement by Bristol Bay district, 1992-2011 (Jones et al. 2012, Hamon 2012).

Percent Harvest

Salmon harvest includes commercial, recreational, and tribal fishing as a percentage of the total number of individuals present within the system. Commercial harvest of anadromous fishes has steadily increased over the past 60 years, and total harvest rates for all districts have shown significant increases from 1951 to 2011 (Figure 30). Decadal averages of sockeye salmon inshore harvest trended significantly upward from approximately 1980 to present (Table 25). Furthermore, annual harvest rates averaged for all districts from 1956 to 2001 show a steady increase in the percentage of salmon harvested (Figure 31). Average inshore harvest from 1956 to 2011 increased in all five districts.

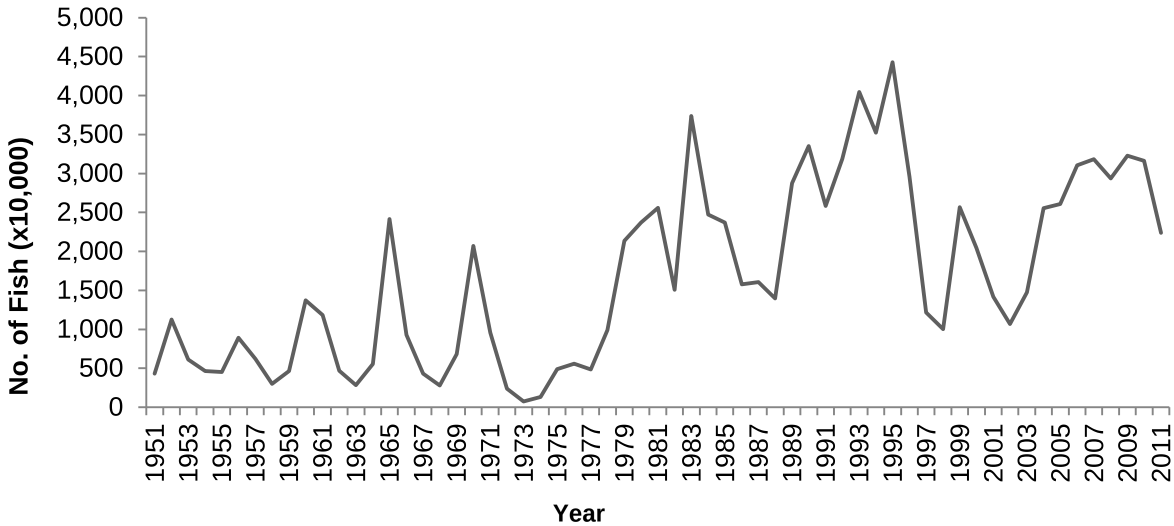

Figure 30. Sockeye salmon inshore harvest for all Bristol Bay districts, 1951-2011 (Middleton et al. 1965, West 2002, Weiland et al. 2004, Jones et al. 2012).

Table 25. Decadal averages of sockeye salmon inshore harvest by district, 1951-2011 (Middleton et al. 1965, West 2002, Weiland 2004, Jones et al. 2012).

Period	Naknek-Kvichak	Egegik	Ugashik	Nushagak	Togiak	Total Harvest	Total Run
Avg. 1951-2011	7,058,588	4,520,545	1,622,008	3,238,559	313,914	16,798,361	29,888,593
Avg. 1951-59	3,734,572	890,146	460,603	834,580	61,658	5,961,006	15,629,022
Avg. 1960-69	5,644,395	1,448,387	382,567	977,832	151,685	8,604,867	21,947,375
Avg. 1970-79	5,338,536	1,148,261	183,034	1,260,421	208,555	8,138,806	19,679,862
Avg. 1980-89	10,057,321	5,448,312	2,841,918	3,679,632	387,728	22,474,785	37,063,149
Avg. 1990-99	10,350,840	10,883,598	3,025,486	4,181,807	355,766	28,861,691	41,232,528
Avg. 2000-09	6,294,195	6,863,248	2,376,390	7,339,673	563,574	23,622,900	34,103,228
Avg. 2010-11	10,054,921	4,911,937	3,351,569	7,823,614	581,995	27,010,231	35,491,860

Run Timing

Sockeye salmon runs historically last from early June until early August, and rarely last until September. Figure 31 shows MDOE per year over time for all Bristol Bay districts, which suggests a possible decrease in MDOE (i.e., salmon runs commence earlier in the year). The Bristol Bay average annual MDOE from 1960-1969 was 192.62, compared to 189.34 from 2000-2009. The MDOE data for Pacific salmon suggest that runs have commenced approximately 3.2 days earlier over the nearly 50-year period from 1950 to 2011. When compared to the MDOE of 191.96 over the entire dataset (1950-2011), the MDOE from 2000-2009 remains approximately 2.6 days earlier. In no cases did the MDOE occur later in the period from 2000-2009 than the average for the entire dataset (1950-2011).

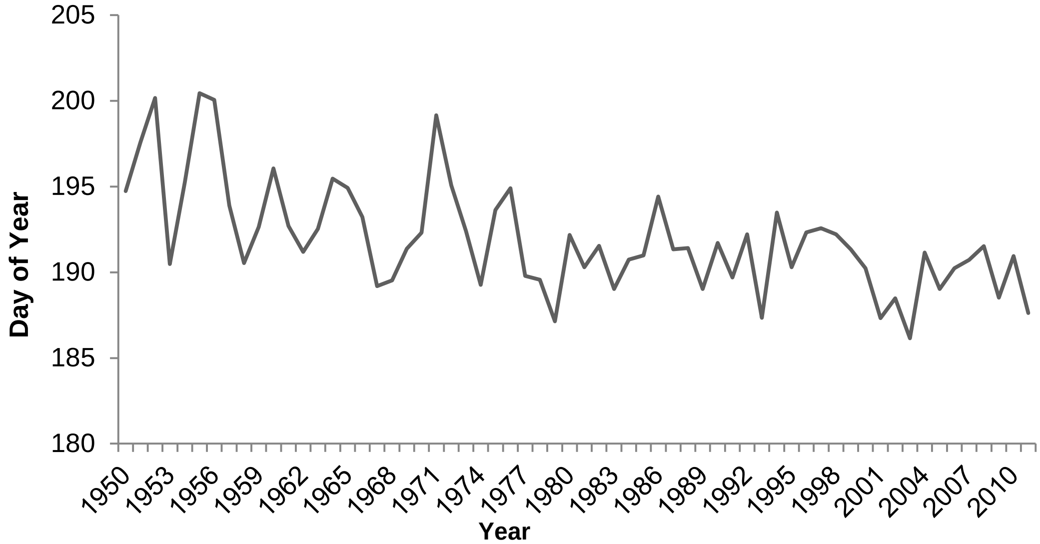

Figure 31. MDOE for all five Bristol Bay districts, 1950-2011 (Hamon 2012).

The MDOE between 1960-69 and 2000-09 varied between districts; however, in almost all cases the MDOE occurred earlier within the year over time. For example, the MDOE of the Kvichak-Naknek district from 2000-09 occurred an average of 1.6 days earlier than from 1960-69 (Table 26).

Table 26. Change in MDOE for Bristol Bay districts and river systems from 1960-1969 to 2000-2009 (Hamon 2012).

District	River	Change
Kvichak-Naknek	Total	-1.63
	Kvichak	-1.816
	Naknek	-1.44
	Alagnak*	1.43
Egegik	Egegik	-6.97
Ugashik	Ugashik	-5.14
Nushagak	Total	-3.69
	Nushagak	N/A
	Wood	-4.13
	Igushik	-0.32
	Nuyakuk**	-6.62
Togiak	Togiak	-0.64
Bristol Bay	Excluding Nuyakuk	-2.92
	Total	-3.28

* Data only available for years 1960-1969 and 2003-2009.

** Data only available for years 1960-1969 and 2000-2006.

Threats and Stressor Factors

Stressors identified by NPS staff include harvest rates and climate change. Climate changes and overharvest of anadromous salmon species stocks can greatly affect fisheries and spawning runs (Finney et al. 2000). Harvest rates directly influence the size of spawning runs and total escapement; therefore, these stocks are often closely monitored (Martell et al. 2008). Throughout Alaska, approximately 31 million salmon were harvested in 2011 (Jones et al. 2012). From 1991-2010 annual commercial catches averaged 25.6 million sockeye salmon, 67,000 Chinook salmon, approximately one million chum salmon, 84,000 Coho salmon, and 253,000 pink salmon (in alternating years) (Jones et al. 2012). Sport and subsistence fishing efforts average 138,000 fish annually and consist of mainly Coho and Chinook (Jones et al. 2012). However, salmon populations are not significantly affected by recreational or subsistence harvests, which comprise a significant economic value yet relatively small segment of overall harvest (Duffield et al. 2007, Jones et al. 2012). The potential exists for fishery collapse, barring regulation, although salmon fisheries in Bristol Bay are closely monitored to ensure sufficient escapement and regulated harvest (Hilborn 2006). According to Martell et al. (2008, p. 409), the Bristol Bay sockeye salmon fisheries "are among the most intensively monitored and managed in the world."

Climate change, warming air and water temperatures, acidification, and fluctuating climate regimes could potentially lead to earlier seasonal salmon spawning runs and increased pre-spawn mortalities (Cooke et al. 2004, Hodgson et al. 2006). Elevated stream temperature (above 13ºC), a potential result of overall climate change, can affect egg and fry incubation in salmon streams (Nagorski et al. 2007). Rising temperatures and changing thermal regimes could lead to elimination of essential salmon habitat along much of the Alaskan coast (Abdul-Aziz et al. 2011). Changes in MDOE could potentially be linked to changes in regional climate regimes; for example, run timing may be altered and occur earlier due to gradual changes in temperature. Williams (1989) noted that altered temperatures at high latitudes could potentially affect production, sediment loading, and habitat composition in lotic systems.

Finney et al. (2000) suggested that significant shifts in decadal population trends were directly related to climate change, based on sediment records and biological indicators from the Bristol Bay area. Finney et al. (2000) also found that collapses in similar fisheries, most notably the Karluk sockeye fishery on Kodiak Island, were partially due to reductions of nutrients deposited by salmon carcasses. They concluded that with higher adult salmon abundance, increases in nutrient loading were seen, which lead to increases in both primary and secondary productivity in the system (Finney et al. 2000).

Data Needs/Gaps

Sizes of salmon runs typically vary greatly between seasons and years (Burgner et al. 1969), so it is often difficult to determine exact escapement or harvest rates. Escapement, harvest, and MDOE are considered estimates, and naturally, inherent variability exists in sampling methodologies. Further analysis examining effects of harvest rates on escapement (and vice versa) may greatly assist in drawing better conclusions about annual escapement and harvest in the Bristol Bay districts.

Inshore harvest data were compiled from various ADF&G reports. Several minor discrepancies exist between reports, possibly due to post-season revisions in harvest data. Therefore, data were compiled from the most recent ADF&G report containing relevant information: 1951-1955 from Middleton et al. (1965), 1956-1982 from West (2002), 1983-1990 from Weiland et al. (2004), and 1991-2011 from Jones et al. (2012). Total run data were also derived from several sources: 1956-1982 from West (2002) and 1991-2011 from Jones et al. (2012).

Because of weather, sampling, and accessibility issues in KATM, some annual studies were not conducted. Greater historical datasets would be valuable in determining long-term temporal trends in MDOE of Bristol Bay salmon. Continued sampling in the Bristol Bay area will be beneficial to future escapement, harvest, and run assessments.

Overall Condition

Escapement

The measure of escapement is not currently a concern to resource managers. Salmon escapement in the five Bristol Bay districts has varied appreciably over the past 60 years. Periodic fluctuations exist in the escapement data, exhibiting natural cycles. Escapement appears to be sustainable within the Bristol Bay districts. However, rates have fallen slightly since 2004 (Figure 27). This may simply be due to natural variation or, in fact, a true overharvest of salmon stocks, pre-spawn mortalities, an increase in in-stream impediments, or a combination of multiple stressors. When viewed within a larger context and with greater, more complete datasets, natural variation may become more apparent. Salmon stocks within Bristol Bay are closely monitored and managed by ADF&G with the goal of “achieving and maintaining sustained production,” likely limiting the risk of severely decreased or overharvested salmon stocks (Clark 2005, p. 1).

Percent Harvest

The measure of percent harvest is currently of low concern to resource managers. Harvest rates of sockeye salmon have steadily increased over the past 60 years throughout Bristol Bay; however, during the same period, total escapement has also increased (Figure 30). Annual harvest for all districts has increased by an average of 25 million salmon since the mid-1950s and over 10 million salmon since the mid-1980s. Harvest rates (% of total run) have steadily increased from approximately 47% in the late 1950s to approximately 61% in the late 1990s. Continued monitoring of harvest rates and total Bristol Bay escapement will be necessary to ensure sustainable salmon stocks.

Run Timing

The MDOE of Pacific salmon in the Bristol Bay districts is approximately 3.2 days earlier on average over the period from 1960 to 2009. Whether this variability is cause for concern is unclear. The MDOE for Bristol Bay salmon has continued to occur earlier in the season over the 40 years of available data. If current trends continue, salmon runs may continue to occur earlier in the season, possibly affecting Pacific salmon spawning, rearing, and the fishery in general.

Summary

The KATM salmon component is currently considered a resource of low concern. Reports and data sources indicate that sockeye salmon escapement is often variable according to natural fluctuations and cycles. Salmon harvest in Bristol Bay districts has increased over the past 60 years, along with escapement. Average harvest rate for all districts has also increased slightly since the 1950s and 1960s. The onset of salmon runs in Bristol Bay has also continued to occur earlier in the year, by an average of approximately three days, since the 1960s.

4.5.6 Sources of Expertise

Troy Hamon, KATM/ANIA Wildlife Biologist

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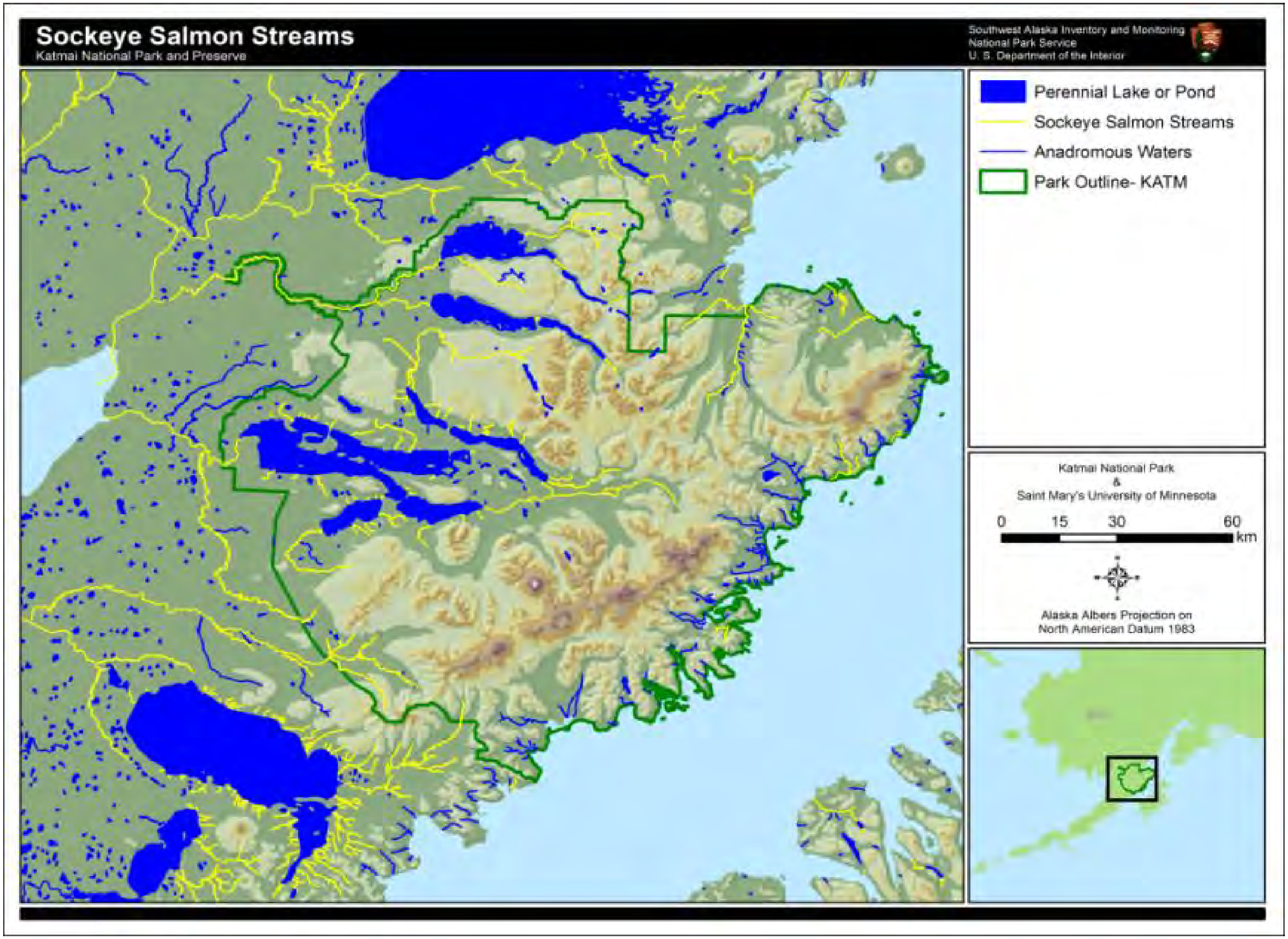

Plate 31. Streams identified by the AWC that support sockeye salmon in the KATM region (ADF&G 2012b).

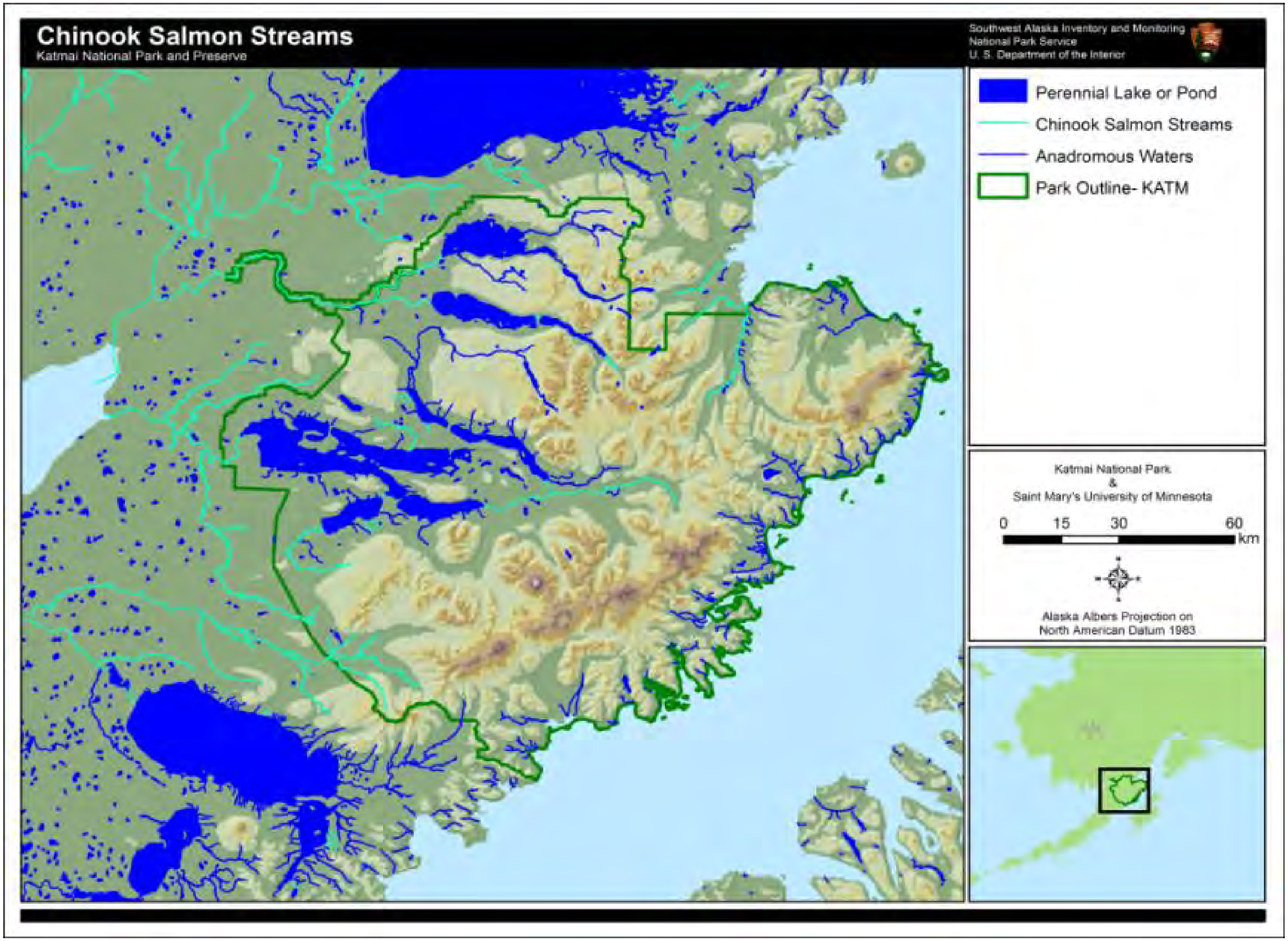

Plate 32. Streams identified by the AWC that support Chinook salmon in the KATM region (ADF&G 2012b).

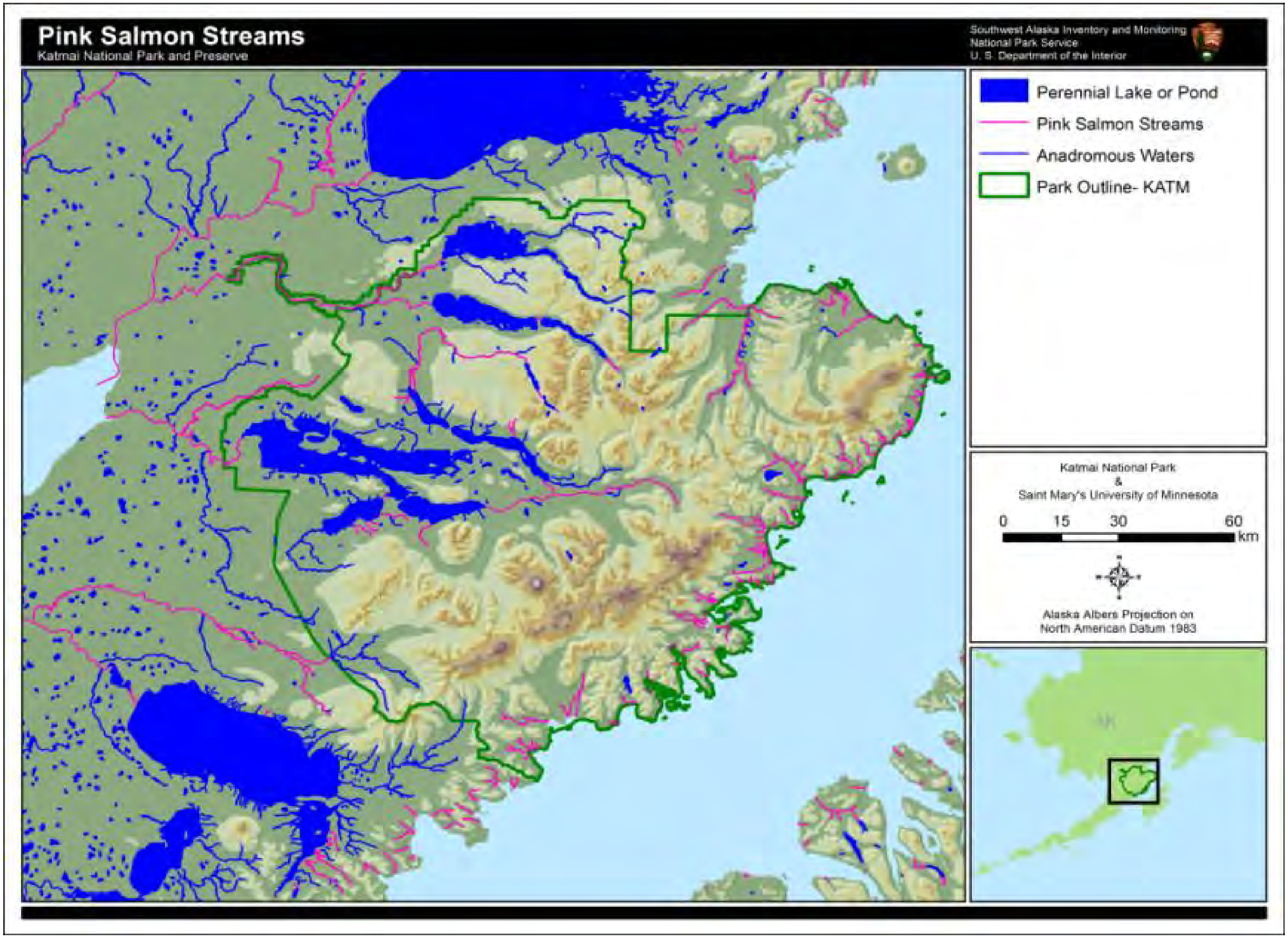

Plate 33. Streams identified by the AWC that support pink salmon in the KATM region (ADF&G 2012b).

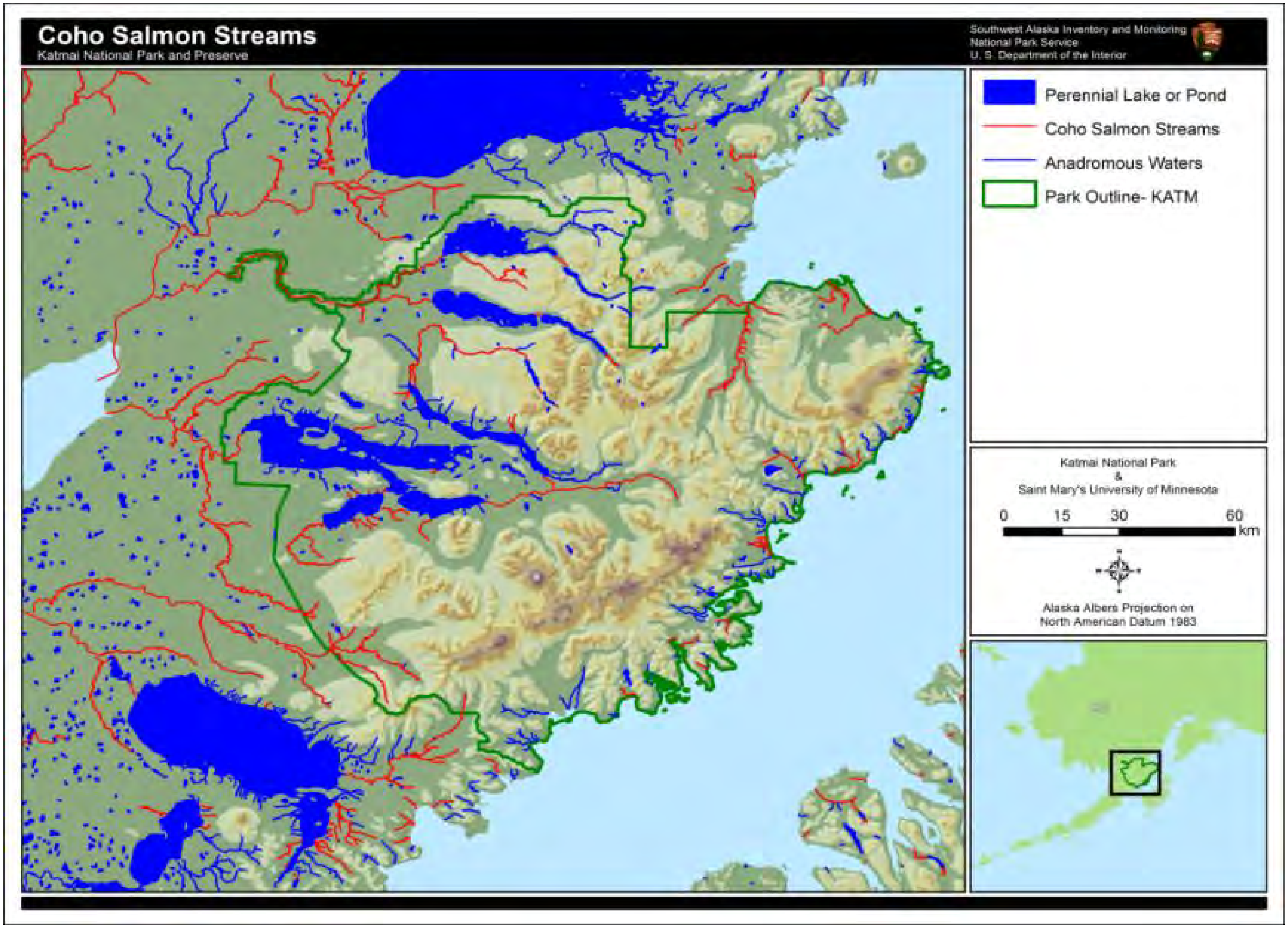

Plate 34. Streams identified by the AWC that support Coho salmon in the KATM region (ADF&G 2012b).

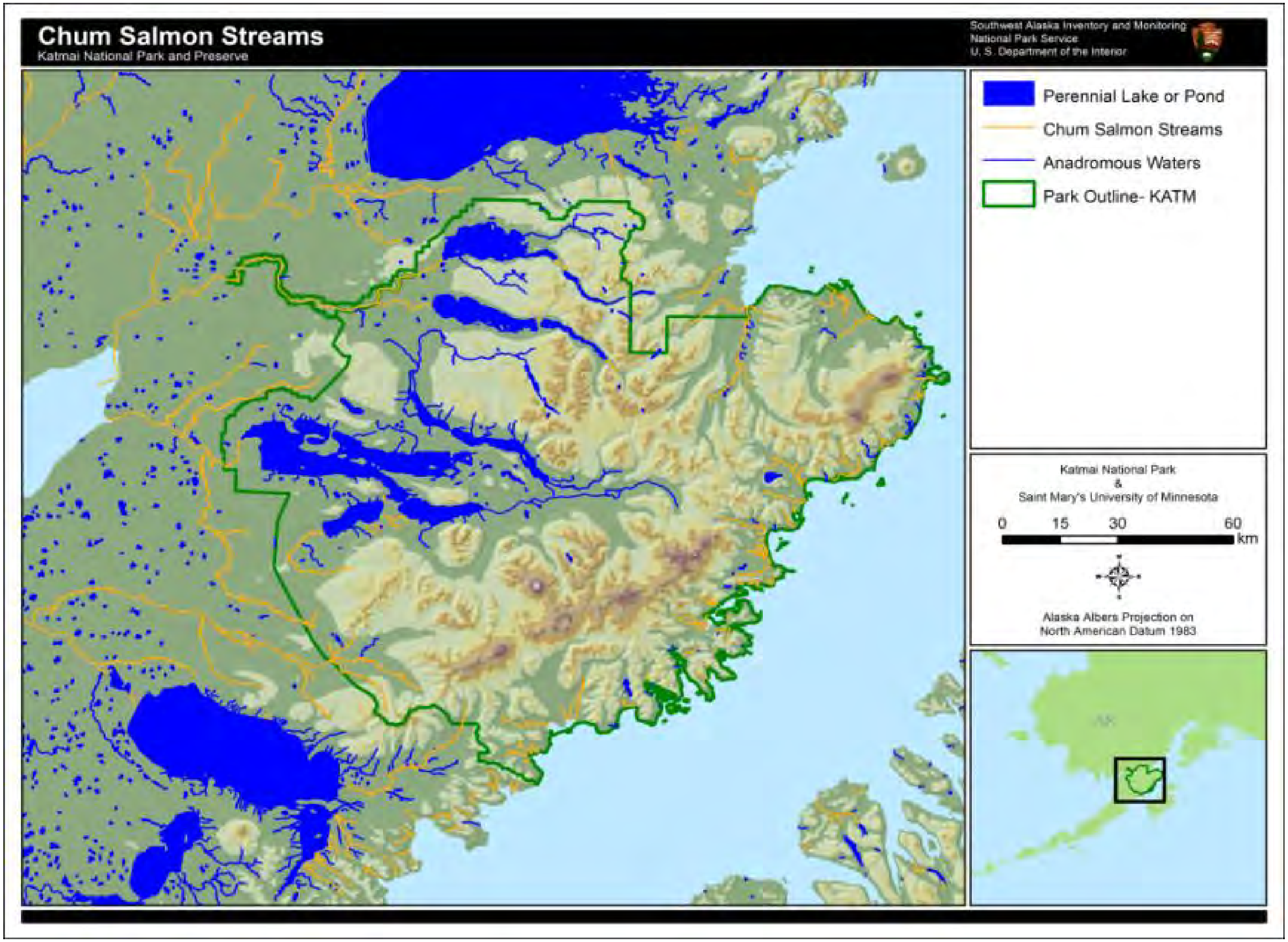

Plate 35. Streams identified by the AWC known that support chum salmon in the KATM region (ADF&G 2012b).

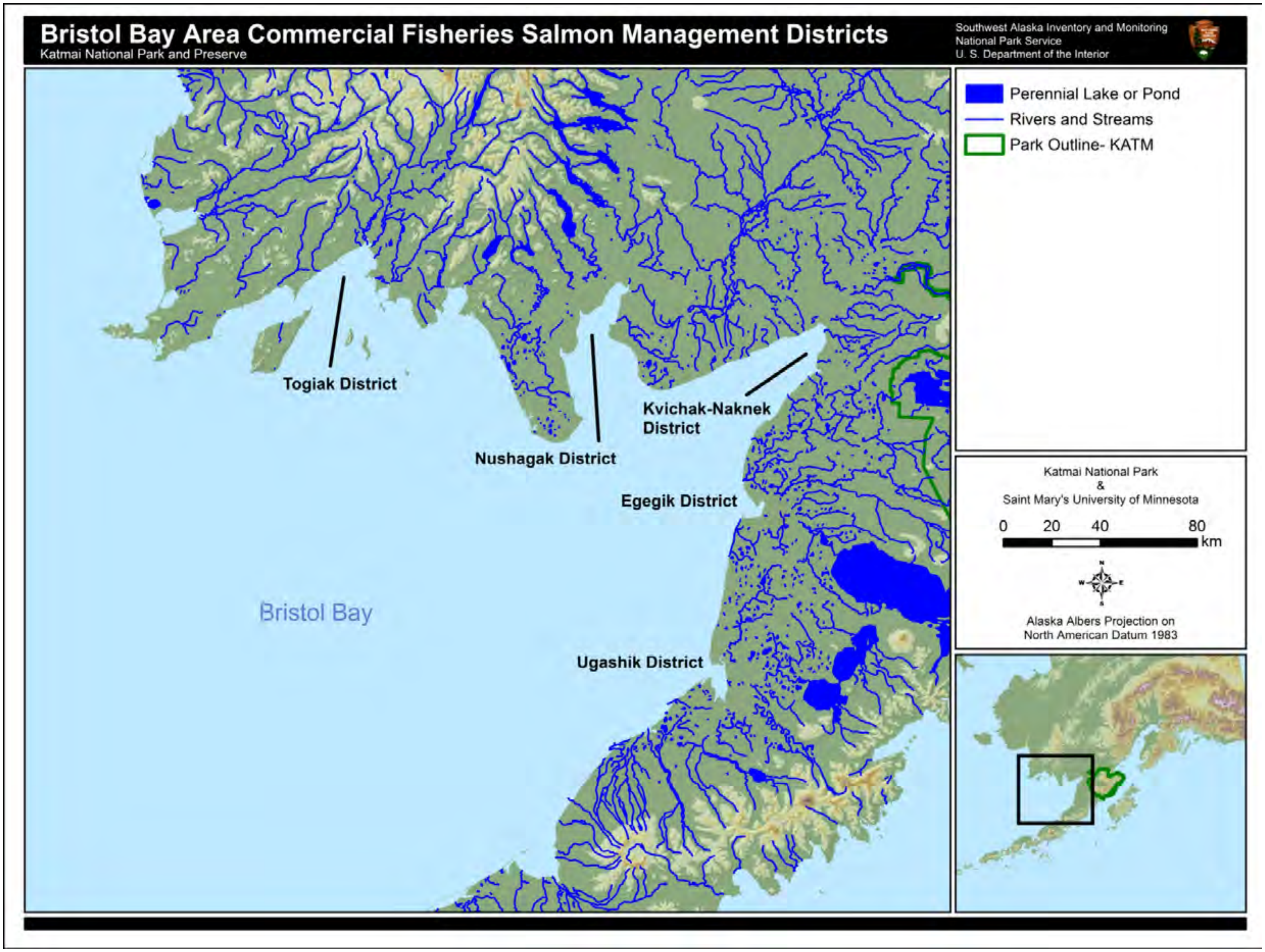

Plate 36. Bristol Bay area commercial fisheries salmon management districts.

4.6 Native Fish

4.6.1 Description

NPS (2012) and Jones et al. (2005) identify 39 native fish species as being present or probably present in (KATM) (Table 27). In ALAG, 23 native fish species are identified as present or probably present (Table 28) (NPS 2012). Resident native fish are easily sampled and can provide insight into the environmental contaminants, changes in the food chain, and ecological health for the water bodies they inhabit.

Native fish are sought after by resident and non-resident anglers and provide economic stimulation to the Southwest Alaskan Peninsula. Native fish, including the arctic grayling (Photo 12), rainbow trout, Dolly Varden, and lake trout are commonly targeted by sport fishing anglers.

Photo 12. Arctic grayling from an Alaskan lake (photo by Jacob Zanon 2011, SMUMN GSS).

Table 27. Certified species list of native fish in KATM National Park and Preserve (NPS 2012 and Jones et al. 2005).

Scientific Name	Common Name	Occurrence	Abundance
Clupea harengus pallasii	pacific herring	present in park	abundant
Catostomus catostomus	longnose sucker	present in park	common
Esox lucius	northern pike	present in park	common
Dallia pectoralis	Alaska blackfish	present in park	uncommon
Gadus macrocephalus	Pacific cod	probably present	*
Lota lota	burbot	present in park	uncommon
Gasterosteus aculeatus	threespine stickleback	present in park	abundant
Pungitius pungitius	ninespine stickleback	present in park	abundant
Hypomesus olidus	pond smelt	present in park	common
Hypomesus pretiosus	surf smelt	present in park	unknown
Osmerus mordax	arctic smelt	probably present	*
Thaleichthys pacificus	eulachon	present in park	common
Trichodon trichodon	Pacific sandfish	present in park	unknown
Lethenteron japonicum	Arctic lamprey	present in park	uncommon
Platichthys stellatus	starry flounder	present in park	unknown
Coregonus clupeaformis	humpback whitefish	present in park	common
Coregonus sardinella	least cisco	present in park	common
Oncorhynchus gorbuscha	pink salmon	present in park	abundant
Oncorhynchus keta	chum salmon	present in park	abundant
Oncorhynchus kisutch	coho salmon, silver salmon	present in park	abundant
Oncorhynchus mykiss	rainbow trout, steelhead	present in park	abundant
Oncorhynchus nerka	red salmon, sockeye salmon	present in park	abundant
Oncorhynchus tshawytscha	chinook salmon, king salmon	present in park	common
Prosopium coulterii	pygmy whitefish	present in park	uncommon
Prosopium cylindraceum	round whitefish	present in park	abundant
Salvelinus alpinus	Arctic char	present in park	common
Salvelinus malma	Dolly Varden, Dolly Varden char	present in park	abundant
Salvelinus namaycush	lake trout	present in park	common
Thymallus arcticus	Arctic grayling	present in park	common
Bathyagonus alascanus	gray starsnout	probably present	*
Pallasina barbata	tubenose poacher	present in park	unknown
Cottus aleuticus	coastrange sculpin	present in park	common
Cottus cognatus	slimy sculpin	present in park	abundant
Icelinus borealis	northern sculpin	probably present	*
Leptocottus armatus	Pacific staghorn sculpin	present in park	unknown
Liparis gibbus	variegated snailfish	probably present	*
Alosa sapidissima	American shad	probably present	*
Osmerus mordax	rainbow smelt	probably present	*
Cottus cognatus	slimy sculpin	probably present	*

Table 28. Certified species list of native fish in the Alagnak Wild River Area (NPS 2012).

Scientific Name	Common Name	Occurrence	Abundance
Catostomus catostomus	longnose sucker	probably present	*
Esox lucius	northern pike	probably present	common
Dallia pectoralis	Alaska blackfish	present in park	uncommon
Lota lota	burbot, eelpout	probably present	*
Gasterosteus aculeatus	Alaskan or threespine stickleback	probably present	*
Pungitius pungitius	nine/tenspined stickleback	present in park	common
Hypomesus olidus	pond smelt	probably present	*
Lethenteron japonicum	Arctic lamprey	present in park	uncommon
Coregonus clupeaformis	humpback/lake whitefish	probably present	*
Coregonus sardinella	least cisco	probably present	*
Oncorhynchus gorbuscha	pink salmon	present in park	abundant
Oncorhynchus keta	chum salmon	present in park	abundant
Oncorhynchus kisutch	coho salmon	present in park	abundant
Oncorhynchus mykiss	rainbow trout	present in park	abundant
Oncorhynchus nerka	blueback, kokanee, red salmon, sockeye salmon	present in park	abundant
Oncorhynchus tshawytscha	chinook salmon, king salmon	present in park	common
Prosopium coulterii	pygmy whitefish	probably present	*
Prosopium cylindraceum	round whitefish	present in park	uncommon
Salvelinus malma	Dolly Varden	present in park	common
Salvelinus namaycush	lake trout	present in park	rare
Thymallus arcticus	Arctic grayling	present in park	common
Cottus aleuticus	coastrange sculpin	present in park	uncommon
Cottus cognatus	slimy sculpin	present in park	common

4.6.2 Analysis

Existing data and literature sources for this component were identified, summarized, and presented in this document. The data and methods section of this document identifies the primary data sources and how they were summarized and presented.

4.6.3 Reference Conditions/Values

Reference condition is not available for this component.

4.6.4 Data and Methods

Due to the lack of reference conditions for this component, the primary purpose of this portion of the NRCA is to provide park management with summarized data and information for future use. To fulfill this goal, data and literature identified by park management were compiled and summarized; these data sources include ADF&G statewide mail-in harvest data, ADF&G guide logbook data, and literature provided by SWAN and KATM staff.

ADF&G mail-in sport fishing survey data were acquired via the ADF&G website (ADF&G 2012). These data are segmented into different reporting regions; for KATM and ALAG, regions R and S are of interest (Plate 37). Twelve water bodies from KATM and ALAG are included in the statewide mail-in surveys; American Creek, Brooks Lake, Brooks River, Naknek River A (Naknek River above rapids camp), Naknek River B (Naknek River below rapids camp), and Naknek River are within Area R, and Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are within Area S.

Guide logbook data were acquired from ADF&G fishery data series. These data are presented using reporting regions as well, with areas R and S of interest to KATM and ALAG. In total, 18 water bodies from KATM and ALAG are included in the guide logbook series. The freshwater bodies for Area R include American Creek, Brooks Lake, Brooks River, Naknek River A, Naknek River B, Naknek River, Contact Creek, and Swikshak River. Area S freshwater bodies include Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, Nonvianuk River (into Alagnak), Nonvianuk Lake, Nanuktuk Creek, and Moraine Creek.

Buck (1978) created an annotated bibliography of literature regarding the Naknek River system. Park staff indicated that updating Buck's work to include later publications would provide a useful product for park management to use in the future. The updated bibliography (Appendix **F**) includes both developed annotations and abstracts (when available), according to previous discussions among the core project team.

Current Condition and Trend

ADF&G Mail-in Sport Fishing Survey

Data for Area S (Appendix C) and Area R (Appendix D) were summarized to identify field changes over time for each region (ADF&G 2012, Table 29). Statewide mail-in survey data indicate that, on average, at least 9,000 anglers fish KATM and ALAG water bodies each year, accounting for greater than 28,000 total days fished each year (Table 30). Salmon species are the primary species harvested, according to total number harvested, by the anglers frequenting KATM and ALAG. Coho, sockeye, and king salmon harvest is substantially higher than the non-anadromous native species in the park. Of the non-anadromous species, average yearly smelt harvest is the highest, followed by Dolly Varden and rainbow trout.

Table 29. ADF&G mail-in sport fishing survey: angler counts, days fished, and species-specific harvest for all KATM water bodies included in reporting areas R and S (1996-2010) (ADF&G 2012).

Statewide Survey	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Angler Counts															
Area R	4,586	5,735	5,997	5,299	5,859	6,920	7,463	6,326	4,834	3,412	5,467	5,212	6,399	5,099	5,512
Area S	3,431	3,328	3,010	2,706	2,563	2,363	2,637	2,500	3,437	4,507	4,143	3,983	6,542	4,464	5,280
Total	8,017	9,063	9,007	8,005	8,422	9,283	10,100	8,826	8,271	7,919	9,610	9,195	12,941	9,563	10,792
Days Fished															
Area R	12,719	16,742	14,646	21,158	20,313	21,322	26,779	18,823	23,015	11,325	16,352	16,668	15,857	14,525	15,674
Area S	10,339	12,270	8,865	7,958	9,500	8,576	10,614	0	11,268	13,932	14,874	12,278	14,389	9,995	12,101
Total	23,058	29,012	23,511	29,116	29,813	29,898	37,393	18,823	34,283	25,257	31,226	28,946	30,246	24,520	27,775
King Salmon															
Area R	3,016	4,430	3,443	2,697	2,115	2,656	1,970	2,412	2,742	2,152	2,558	1,431	1,285	2,279	1,266
Area S	931	982	1,561	592	501	508	304	334	1,146	1,008	1,052	1,007	420	199	418
Total	3,947	5,412	5,004	3,289	2,616	3,164	2,274	2,746	3,888	3,160	3,610	2,438	1,705	2,478	1,684
Coho Salmon															
Area R	4754	4,045	2,920	3,694	4,028	4,795	4,743	6,396	7,608	2,875	4,064	4,338	6,034	4,397	5,061
Area S	1,834	763	100	305	480	273	368	531	1,589	756	1,484	493	1,041	755	789
Total	6,588	4,808	3,020	3,999	4,508	5,068	5,111	6,927	9,197	3,631	5,548	4,831	7,075	5152	5,850
Sockeye Salmon															
Area R	1,118	790	1,541	2,079	3,676	3,300	2,379	2,418	2,521	1,243	5,085	4,407	6,725	4,698	4,336
Area S	1,240	2,182	2,519	1,249	1,034	481	600	727	2,121	3,340	3,586	2,101	2,919	2,196	1,614
Total	2,358	2,972	4,060	3,328	4,710	3,781	2,979	3,145	4,642	4,583	8,671	6,508	9,644	6,894	5,950
Pink Salmon															
Area R	89	106	244	53	310	65	68	12	732	77	276	0	685	12	88
Area S	290	22	227	49	175	43	837	24	1,041	77	78	0	278	12	470
Total	379	128	471	102	485	108	905	36	1,773	154	354	0	963	24	558

Table 29. ADF&G mail-in sport fishing survey: angler counts, days fished, and species-specific harvest for all KATM water bodies included in reporting areas R and S (1996-2010) (ADF&G 2012) (continued).

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Chum Salmon															
Area R	55	118	195	104	49	151	211	69	63	54	49	26	26	11	74
Area S	274	305	1104	579	735	343	153	158	241	596	378	110	315	50	803
Total	329	423	1299	683	784	494	364	227	304	650	427	136	341	61	877
Lake Trout															
Area R	194	189	92	0	100	32	160	109	108	96	110	263	69	57	62
Area S	9	10	0	93	54	0	48	0	0	68	23	52	132	0	162
Total	203	199	92	93	154	32	208	109	108	164	133	315	201	57	224
Dolly Varden															
Area R	1046	460	419	346	547	494	216	105	701	198	319	1,086	138	234	847
Area S	270	376	14	68	111	22	7	30	0	13	26	71	33	44	84
Total	1316	836	433	414	658	516	223	135	701	211	345	1,157	171	278	931
Steelhead Trout															
Area R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Area S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rainbow Trout															
Area R	801	405	482	683	484	160	723	171	422	544	240	723	190	237	226
Area S	26	254	35	57	33	166	71	11	163	413	47	122	88	0	0
Total	827	659	517	740	517	326	794	182	585	957	287	845	278	237	226
Arctic Grayling															
Area R	187	362	82	43	73	20	31	76	27	76	80	541	59	35	14
Area S	192	186	228	43	10	0	0	0	33	119	33	65	0	54	115
Total	379	548	310	86	83	20	31	76	60	195	113	606	59	89	129

Table 29. ADF&G mail-in sport fishing survey: angler counts, days fished, and species-specific harvest for all KATM water bodies included in reporting areas R and S (1996-2010) (ADF&G 2012) (continued).

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Whitefish															
Area R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Area S	36	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Total	36	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Northern Pike															
Area R	268	142	235	212	76	66	33	24	13	200	212	25	91	360	171
Area S	212	15	0	9	11	14	0	0	38	113	0	0	0	0	0
Total	480	157	235	221	87	80	33	24	51	313	212	25	91	360	171
Burbot															
Area R	0	1,327	8	0	363	0	0	0	0	74	0	0	0	0	0
Area S	0	39	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	1,366	8	0	363	0	0	0	0	74	0	0	0	0	0
Smelt															
Area R	1,454	4,866	6,519	3,656	2,146	2,940	3,131	8,442	765	2,475	1,606	3,336	3,867	9,354	324
Area S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1,454	4,866	6,519	3,656	2,146	2,940	3,131	8,442	765	2,475	1,606	3,336	3,867	9,354	324
Other															
Area R	0	0	18	81	0	101	0	0	0	0	0	0	0	0	0
Area S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	18	81	0	101	0	0	0	0	0	0	0	0	0

Table 30. ADF&G mail-in sport fishing survey: yearly summary for all KATM water bodies included in reporting areas R and S (1996-2010) (ADF&G 2012).

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean	Min	Max
Angler Counts	8,017	9,063	9,007	8,005	8,422	9,283	10.1k	8,826	8,271	7,919	9,610	9,195	12,941	9,563	10.7k	9,267	7,919	12,941
Days Fished	23.1k	29.0k	23.5k	29.1k	29.8k	29.8k	37.4k	18.8k	34.3k	25.3k	31.2k	28.9k	30.2k	24.5k	27.7k	28.2k	18.8k	37.4k
King Salmon	3,947	5,412	5,004	3,289	2,616	3,164	2,274	2,746	3,888	3,160	3,610	2,438	1,705	2,478	1684	3,161	1,684	5412
Coho Salmon	6,588	4,808	3,020	3,999	4,508	5,068	5,111	6,927	9,197	3,631	5,548	4,831	7,075	5,152	5,850	5,420	3,020	9,197
Sockeye Salmon	2,358	2,972	4,060	3,328	4,710	3,781	2,979	3,145	4,642	4,583	8,671	6,508	9,644	6,894	5,950	4,948	2,358	9,644
Pink Salmon	379	128	471	102	485	108	905	36	1,773	154	354	0	963	24	558	429	0	1,773
Chum Salmon	329	423	1,299	683	784	494	364	227	304	650	427	136	341	61	877	493	61	1,299
Lake Trout	203	199	92	93	154	32	208	109	108	164	133	315	201	57	224	152	32	315
Dolly Varden	1,316	836	433	414	658	516	223	135	701	211	345	1,157	171	278	931	555	135	1,316
Steelhead Trout	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rainbow Trout	827	659	517	740	517	326	794	182	585	957	287	845	278	237	226	531	182	957
Arctic Grayling	379	548	310	86	83	20	31	76	60	195	113	606	59	89	129	185	20	606
Whitefish	36	0	0	0	0	0	0	0	0	0	0	0	0	6	0	2	0	36
Northern Pike	480	157	235	221	87	80	33	24	51	313	212	25	91	360	171	169	24	480
Burbot	0	1,366	8	0	363	0	0	0	0	74	0	0	0	0	0	120	0	1,366
Smelt	1,454	4,866	6,519	3,656	2,146	2,940	3,131	8,442	765	2,475	1,606	3,336	3,867	9,354	3,240	3,658	324	9,354
Other	0	0	18	81	0	101	0	0	0	0	0	0	0	0	0	13	0	101

Guide Logbook Data

Guide logbook data were acquired from ADF&G fishery data series. These data are presented in (Appendix E), detailing angler effort for area R and area S water bodies Data presented in (Appendix E) for area R and area S water bodies show harvest by species and corresponding angler days (ADF&G 2009, 2010, 2011). Total effort for each year across both areas is also presented to identify trend in angler effort (Table 31). Angler effort per year with corresponding species harvest was also summarized (Table 32).

Table 31. Guide logbook total effort for all area R and area S water bodies within KATM and ALAG, 2006-2010. (ADF&G 2009, 2010, 2011).

		Angler Days					
Year	**Trips**	**Resident**	**Non-resident**	**Comped**	**Unknown**	**Crew**	**Total**
2006	6391	443	14784	*	70	539	15836
2007	6365	632	14369	43	94	425	15563
2008	5886	479	13966	35	31	413	14924
2009	5023	472	11543	47	33	293	12388
2010	4090	355	9745	39	47	121	11192

*- Indicates the field was not surveyed during that year.

Table 32. Guide logbook angler effort and species harvested from Area R and S water bodies within KATM and ALAG, 2006-2010 (ADF&G 2009, 2010, 2011).

Year	2006	2007	2008	2009	2010	Mean	Min	Max
Angler Days	14703	15563	15475	12388	11228	13871	11228	15563
King Salmon	1727	1441	1049	812	718	1149	718	1727
Coho Salmon	2604	2494	3754	2686	1522	2612	1522	3,754
Sockeye Salmon	4906	6642	6643	4552	4542	5457	4542	6643
Cutthroat	0	0	0	0	0	0	0	0
Rainbow	364	1116	162	137	2591	874	137	2591
Steelhead	0	0	0	0	0	0	0	0
Lake Trout	*	31	30	65	793	230	30	793
Dolly Varden	41	171	109	94	3596	802	41	3596
Grayling	79	93	27	16	751	193	16	751
Pike	*	4	0	2	70	19	0	70
Sheefish	*	0	0	0	0	0	0	0

*- Indicates the field was not surveyed during that year.

Other Surveys and Literature

Buck (1978) compiled a bibliography which included research and published works about native fish on the Alaskan Peninsula. Buck (1978) was appended for this publication and now includes up to date native fish studies and literature from the Alaskan Peninsula (Appendix **F**). Jones et al. (2005) confirmed the presence of 27 native fish species in KATM and seven for ALAG water bodies. Jones et al (2005) confirmed four target species in ALAG that were previously classified as probably present.

Threats and Stressor Factors

Angling pressure on easily accessed areas of rivers or streams has caused concern for stream trout species in the past. Over the last few years park staff have received reports from anglers regarding deformities of stream trout in the Alagnek River, Brooks River, Naknek River, and Morain creek (T. Hamon, pers. comm., 2013). Mangled or missing jaw structures and missing eyes cause concern for both the health of fish stocks and also the preservation of the wilderness sport fishing experience that a majority of anglers seek when visiting KATM/ALAG (Meka 2003). In 1997-1998 over 30% of rainbow trout sampled from the Alagnak River carried a visible scar or deformity from being previously caught (Meka 2003).Special regulations placed on stream areas with easy access and high angling pressure along with advocating proper fish handling techniques could greatly reduce hooking injuries to released fish (Meka 2003). These regulations include the use of barbless only hooks, single hooks and artificial lures only, coupled with educational programs to promote proper fish handling, hook removal, and release techniques (Meka 2003). Cycles exist regarding the number of fish that carry catch and release injuries from year to year. Stream trout are territorial and will frequent the same sections of stream reaches, as these injured fish die off in heavily fished areas they are replaced by other year classes which are free of catch and release injuries (T. Hamon, pers. comm., 2013). However, pressure on most rivers and streams in KATM and ALAG is minimal. Most water bodies that hold native fish in KATM and ALAG are isolated and experience little anthropogenic disturbance.

Data Needs/Gaps

While the mail-in statewide harvest survey and guide logbook data are important tools used to set regulations and management goals, they do not provide a reference condition for evaluation and assessment. A clear reference condition focused on available data would allow for a statement of condition. In the future, changes in trends of species harvested and angler patterns may indicate the need for additional research and investigation of particular species in the park.

Overall Condition

Averages for angler effort and species harvested were compiled for all KATM and ALAG water bodies included in the ADF&G mail-in sport fishing survey from years 1996-2010. Angler counts were at or above the mean from 2006-2010 with corresponding days fished also above the mean for almost all years from 2006-2010 (excluding 2007). King salmon, Dolly Varden and rainbow trout harvests have been below the mean since 2008 (ADF&G 2010).

Guide logbook angler effort and species harvested data from all KATM and ALAG Area R and S water bodies were summarized from 2006-2010. Data from 2010 shows harvest of lake trout, Dolly Varden, arctic grayling, and rainbow trout all well above the mean for the summarized years (Table 31). In contrast, the angler days, king salmon, and sockeye salmon harvests were all reported below the mean in 2009 and 2010.

4.6.5 Sources of Expertise

Troy Hamon, KATM/ANIA Wildlife Biologist

4.6.6 Literature Cited

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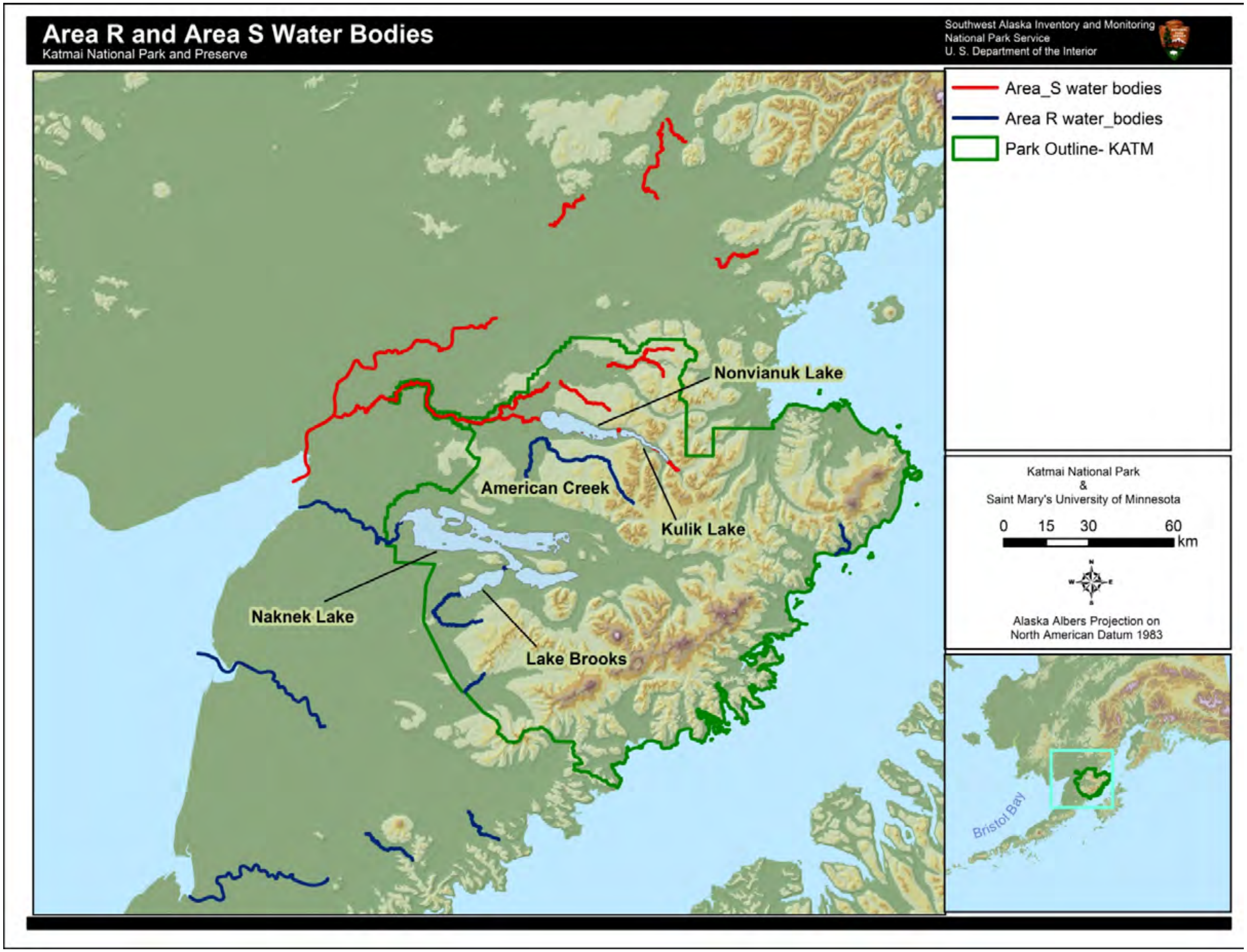

Plate 37. Area R and area S water bodies in and around Katmi National Preserve.

4.7 Seismic Activity

4.7.1 Description

KATM is located in the Aleutian volcanic arc, one of the most volcanic and seismically active regions of the world, due to the northward movement of the Pacific Plate in relation to the North American plate (Page et al. 1991). The Aleutian volcanic arc is geographically described as a curving chain of volcanoes from the far western end of the Aleutian Islands, extending up the southwest Alaskan peninsula, and terminating in south-central Alaska (Simkin and Siebert 1994).

Within KATM, over 50 discrete volcanic vents within 20km (12 mi) of Novarupta (Fierstein 2012) have been identified (Photo 13, Coombs and Bacon 2012). Earthquakes or volcanic eruptions resulting from the interaction between the two plates along the Aleutian volcanic arc are capable of drastically changing the landscape. Major alterations to the flora and fauna of a region can occur over 10 km (6.2 mi) from an epicenter or major eruption (Page et al. 1991). These alterations occur through a variety of mechanisms such as uplift or subsidence, tsunamis, mass movements or mass wasting events (e.g., snow avalanches, and landslides), lava flows, and fallout debris which can cover the landscape with a thick layer of ash (Hoyer 1971, Crowell and Mann 1998, and AVO 2001).

Photo 13. Mount Martin (seen steaming above) is one of the currently active volcanoes in KATM (NPS Photo).

The greatest concentration of seismic activity in KATM occurs within a group of volcanoes known as the Katmai Volcanic Cluster (KVC). The KVC region has historically produced several major seismic and volcanic events with the most significant event, the 1912 Novarupta-Katmai eruption. The Novarupta-Katmai eruption was the largest volcanic eruption to take place in the world during the 20th century and the largest ever recorded in North America (AVO 2001). The KVC includes seven volcanoes, five of which are spaced in a general southwest to northeast pattern along a 12-km ridge (located in the south central portion of KATM) in the following order: Mount Martin, Mount Mageik, Trident Volcano, Mount Katmai, and Snowy Mountain (Plate 38). The other two volcanoes in the KVC are located on the back arc of this ridge line and include Novarupta and Mount Griggs (Plate 38; Dixon and Power 2009).

Over the past two decades, scientists have worked to unravel the volcanic history of KATM and have identified eruptions dating back over one million years. Fierstein (2012) states that "understanding the eruptive history of a volcano provides the best clues as to when, how, and on what scale that volcano may erupt in the future." By analyzing the juxtaposition of lava flows, ash deposits, and other deposits as well as utilizing radiometric dating, estimates can be made regarding the frequency and magnitude of historic volcanic eruptions produced by the volcano in question (Fierstein 2012).

Generally, an increase in seismic activity will accompany a volcanic eruption. A swarm of volcano tectonic (VT) earthquakes, thought to represent brittle failure in the crust, is a common disturbance before an eruption occurs (Umakoshi 2001). In addition to VT earthquakes, deep long-period earthquakes are often observed and are thought to be a record of magma movement under the volcano (Power et al. 2004). A large scale volcanic eruption can cause massive destruction to landscapes, personal property and result in wide-spread casualties. The ability to recognize if the observed seismicity is a precursor to an eruption can provide an opportunity to set plans into action to save human lives through the evacuation of an area in danger.

The Alaska Volcano Observatory (AVO) operates a network with 205 seismograph stations to monitor seismic activity across the Aleutian volcanic arc. AVO inherited 22 seismograph stations in 1988 and added the majority of the existing seismograph stations between 1996 and 2006. (AVO 2013). In 2011, the AVO seismic monitoring network was used to monitor 33 volcanic centers located within the Aleutian volcanic arc (Dixon 2012).

AVO completed a permanent seismic network within KATM in 1998 to monitor the KVC and a second seismic network near Fourpeaked Mountain in 2006 (Dixon and Power 2009). Currently a total of 24 seismograph stations monitor eight volcanoes within KATM (Plate 39; Dixon 2012). The Katmai subnetwork utilizes 20 seismic monitoring stations to monitor the seven volcanoes making up the KVC. The Fourpeaked subnet comprises four seismic monitoring stations to monitor Fourpeaked Mountain (Dixon 2012). These stations are generally placed relatively close to historically active volcanoes, as a majority of the volcanic related seismicity activity in Alaska occurs within 20 km of a volcano. Of the 4,364 earthquakes located by AVO in 2011, 84% were within 20 km of the 33 volcanoes actively monitored by AVO with seismic sensors (Dixon 2012).

4.7.2 Measures

- Summary of recorded seismic history
- Summary of major seismic events

4.7.3 Reference Conditions/Values

Long term trends defining the geologic or seismic background for a region are difficult to achieve, as the factors that produce the frequency and magnitude of events are many and unpredictable. Regional trends could possibly be derived from consistent long-term monitoring of the seismic activity in a region if the seismic networks could capture and record several complete seismic of volcanic cycles but these cycles are often much greater than the time period the AVO seismic network has been operational. Discussion regarding the seismic activity of KATM is limited to the time period in which the KVC seismic monitoring system has been operational. Due to the fact that a consistent number of seismic monitoring stations have only been operational since 1998 for the KVC and 2006 for Fourpeaked Mountain, a complete record of precursor activity has not been determined.

4.7.4 Data and Methods

AVO (2013) monitors and records the daily seismic activity of the 33 volcanoes monitored with seismograph networks by the observatory and is summarized in this report. Information is also presented regarding the seismic station and volcano latitude and longitude locations within KATM, descriptions of each volcano, recorded seismic histories, and recoded volcanic activity.

Dixon (2012) provides a catalog of earthquake hypocenters and a cross reference check of the seismic station and volcano locations within KATM, descriptions of each volcano, recorded seismic histories, and recoded volcanic activity.

Dixon and Power (2009) describes the events and data from the earthquake swarm around Mount Martin in 2006. The importance of understanding and studying earthquake swarms and seismic activity that both result in or fail to produce a volcanic eruption is also discussed.

4.7.5 Current Condition and Trend

Summary of Recorded Seismic History

Within KATM, AVO recognizes 14 volcanoes (Table 33, Plate 38) and maintains 24 seismic monitoring stations (Table 34; Dixon 2012). Dixon (2012) reports that AVO actively monitors eight KATM volcanoes in an effort to record daily seismic activity, predict eruptions, and develop historical seismic activity data in the areas surrounding each volcano. Seismically monitored KATM volcanoes include Mount Martin, Mount Mageik, Trident Volcano, Mount Katmai, Snowy Mountain, Mount Griggs, Novarupta, and Fourpeaked (AVO 2013).

Table 33. Volcanoes located in KATM (AVO 2013).

Name	Latitude (DD)	Longitude (DD)	Elevation (m)	Seismically Monitored	Type
Mount Katmai	58.279	-154.9533	2,047	Yes	Stratovolcano with central caldera
Trident Volcano	58.2343	-155.1026	1,096	Yes	Stratovolcano Cluster
Mount Mageik	58.1946	-155.2544	2,164	Yes	Composite Volcano
Mount Martin	58.1692	-155.3566	1,859	Yes	Stratovolcano And Lava Flow Field
Mount Griggs	58.3572	-155.1037	2,317	Yes	Stratovolcano
Snowy Mountain	58.3336	-154.6859	2,161	Yes	Lava Dome
Novarupta	58.2654	-155.1591	840	Yes	Plinian Pyroclastic Vent With Plug Dome
Alagogshak Volcano	58.15737	-155.39839	1,674	No	Stratocone
Mount Denison	58.4173	-154.451	2,318	No	Stratovolcano
Mount Steller	58.4301	-154.3903	2,271	No	Stratovolcano
Kukak Volcano	58.428	-154.3573	2,040	No	Stratovolcano
Kaguyak Crater	58.6113	-154.0245	900	No	Stratovolcano with caldera
Fourpeaked Mountain	58.7703	-153.6738	2,104	Yes	Stratovolcano
Mount Douglas	58.8596	-153.5351	2,140	No	Stratovolcano

Table 34. Seismic monitoring stations located within KATM (AVO 2013).

Station	Latitude (DD)	Longitude(DD)	Elevation (m)	Seismometer	Open Date
ACH	58.211	-155.326	960	L22	7/25/1996
KJL	58.054	-155.573	792	L4	7/25/1996
KVT	58.382	-155.295	457	L4	8/1/1988
MGLS	58.134	-155.161	472	L4	7/25/1996
ANCK	58.199	-155.494	869	L4	7/25/1996
CAHL	58.0525	-155.302	807	L4	7/25/1996
CNTC	58.2645	-155.884	1,158	L4	7/25/1996
KABR	58.131	-155.969	884	L4	8/12/1998
KAHC	58.649	-155.006	381	L4	10/12/1998
KAHG	58.494	-154.546	1,250	L4	10/12/1998
KAIC	58.485	-155.046	734	L4	10/12/1998
KAPH	58.597	-154.347	907	L22	10/12/1998
KARR	58.498	-154.703	610	L4	10/12/1998
KAWH	58.384	-154.799	777	L4	10/12/1998
KBM	58.275	-155.202	732	L4	7/22/1991
KCE	58.243	-155.183	777	L4	7/22/1991
KCG	58.308	-155.111	762	L22	8/1/1988
KEL	58.44	-155.741	975	L4	8/1/1988
KAKN	58.297	-155.061	1,049	CMG-6TD	8/1/2004
KABU	58.27	-155.282	1,065	CMT-6TD	8/1/2004
CDD	58.93	-153.623	622	S13	8/17/1981
FONW	58.835	-153.918	905	L4	10/19/2006
FOPK	58.758	-153.474	576	L4	9/25/2006
FOSS	58.799	-153.694	1,268	L4	10/10/2006

Since 2006, a total of four periods (all lasting approximately one month) of increased seismic activity have been observed near Mount Martin and Mount Mageik. The earthquake swarm in January 2006 was the largest, totaling 860 earthquakes (Dixon and Power 2009). The other two seismic events were smaller but all four behaved with similar characteristics, consistent with a volcanic earthquake sequence. Earthquakes occurring near a volcano can be caused by a variety of processes with an intrusion of magma the most common cause. Earthquakes occurring away from volcanic centers are attributed to the regional stress.

Trident Volcano has been the source of the most recent volcanic activity within the KVC region. AVO (2013) reports that Trident first erupted in 1953, producing an ash plume reaching 10,000 m (33,000 ft) and large lava flows which created another cone on the flank of Trident (named “New Trident” or “southwest Trident”). Trident continued to have intermittent minor explosive eruptions producing minor ash and gas emissions, lava flows and bombs through 1968 (AVO 2001). These smaller eruptions were observed to send black ash clouds to heights of 6 to 12 km (3.7 to 7.5m) ballistic blocks over 3 km (AVO 2001). Trident Volcano is still active to date through the fumaroles located on its summit (AVO 2013). AVO (2001) estimates that over eight volcanic eruptions, more than likely larger-scaled than the Trident Volcano eruption in 1953, have taken place in the KATM region over the last 10,000 years.

Mount Griggs is currently active with yellow sulfurous fumaroles discharging near its 2,316 m (7,600 ft) peak. Griggs’ volcanic history dates back 290,000 years but was largely built from more recent lava flows between 10,000 and 85,000 years ago. Small lava flows have been a standard occurrence on Mount Griggs, which has not been reported to have produced a large explosive eruption.

Twenty thousand seismic events were recorded by AVO seismographs monitoring the seismic activity around Mount Martin, Mount Mageik, Trident Volcano, Mount Katmai, Snowy Mountain, Mount Griggs, Novarupta, and Stellar Volcano from 1995 to 2012 (Table 35). Seismic events in the KATM region are generally widespread and occur at magnitudes under 2.7. However, a concentration of seismic activity has been observed in both the Katmai cluster and Snowy Mountain regions (Plate 40; NCEDC 2013). The number of earthquakes located in the KATM region is consistent throughout time with deviations attributed to earthquake swarms like the 2006 Mount Martin swarm.

Table 35. Recorded seismic activity by AVO in the KATM region from 1996 to 2012. (Dixon et al. 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012).

Year	Recorded Seismic Events
1995	284
1996	914
1997	922
1998	929
1999	876
2000	466
2001	540
2002	1,581
2003	1,131
2004	976
2005	1,084
2006	2,125
2007	1,375
2008	1,987
2009	1,338
2010	965
2011	1,288
2012	824

Summary of Major Seismic Events

In June 1912, Mount Novarupta produced the largest volcanic eruption recorded in the 20th century (AVO 2001). This eruption resulted in more fallout of ash and debris than all other Alaskan volcanic eruptions combined. AVO (2001) states that a majority of the magma was expelled out of the Mount Novarupta vent; however, most of this magma was amassed under Mount Katmai 10 km away. After the 3-day eruption was complete and Mount Katmai had collapsed, ash reportedly covered the entire landscape of southern Alaska, and gritty fallout accumulated as far as Ketchikan and Puget Sound (a distance of over 1,400 km or 900 miles). The large scale eruption and seismic activity associated with the 1912 event generated scientific interest in the volcanoes of the KVC region and Mount Novarupta in particular (AVO 2001).

Threats and Stressor Factors

Threats and stressors regarding the seismic activity of the KATM region are undefined.

Data Needs/Gaps

Roman (2004) states that VT swarms that are observed but do not result in an eruption are largely not understood. This is mainly caused by the fact that only VT swarms that result in a volcanic eruption are of interest and therefore thoroughly studied. Dixon and Power (2009) stresses the need and importance to study VT swarms that do not result in volcanic eruption. A more thorough understanding of these VT swarms is important for the quick and decisive assessment of future VT swarms and the probability that they may cause a volcanic eruption.

Overall Condition

Within KATM, a total of eight volcanoes are actively monitored (seven of which are in the KVC) utilizing 24 seismic monitoring stations maintained by AVO. These volcanoes include Mount Martin, Mount Mageik, Trident Volcano, Mount Katmai, Snowy Mountain, Mount Griggs, Novarupta, and Stellar Volcano. Seismic events with a magnitude of greater than 0 have numbered over 1,000 per year for these volcanoes since 2002, with a slight decreasing trend in events per year observed from 2006 to 2012.

The volcanoes of the KATM region have displayed a wide array of eruptive scale throughout history. Mount Katmai remains the most likely candidate to produce an explosive eruption of similar magnitude to the 1912 eruption of Novarupta (Fierstein 2012). Mount Mageik is also thought to be capable of such an eruption (Fierstein 2012). However, most of the region's volcanoes are predicted to remain active on a lesser scale with lava flows, small ash plumes and dome building primarily expected to occur/continue from Martin, Griggs, Trident, and Snowy (Fierstein 2012).

4.7.6 Sources of Expertise

James Dixon, Geophysicist, USGS

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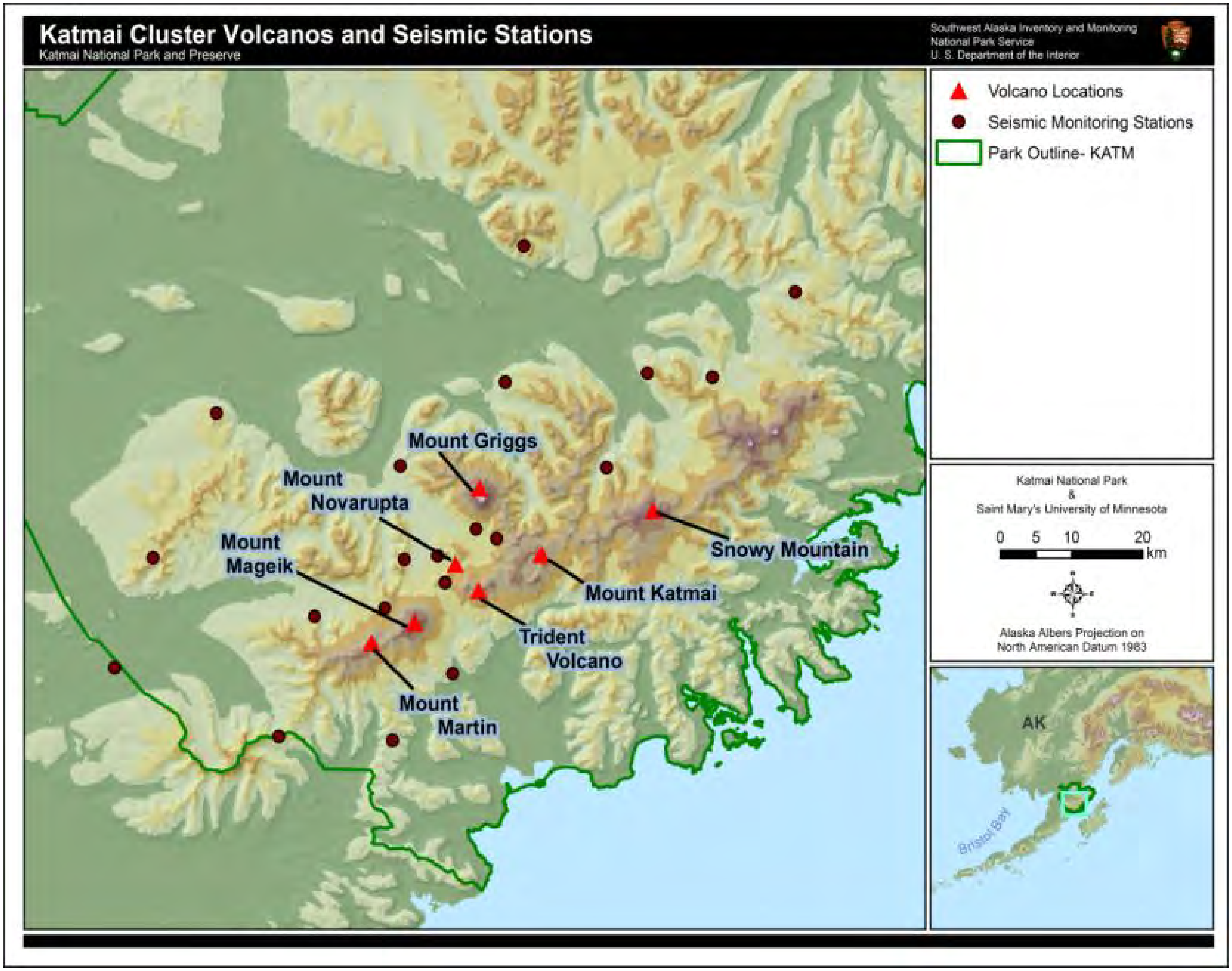

Plate 38 Seismically monitored Katmai Cluster Volcanoes and seismic station locations.

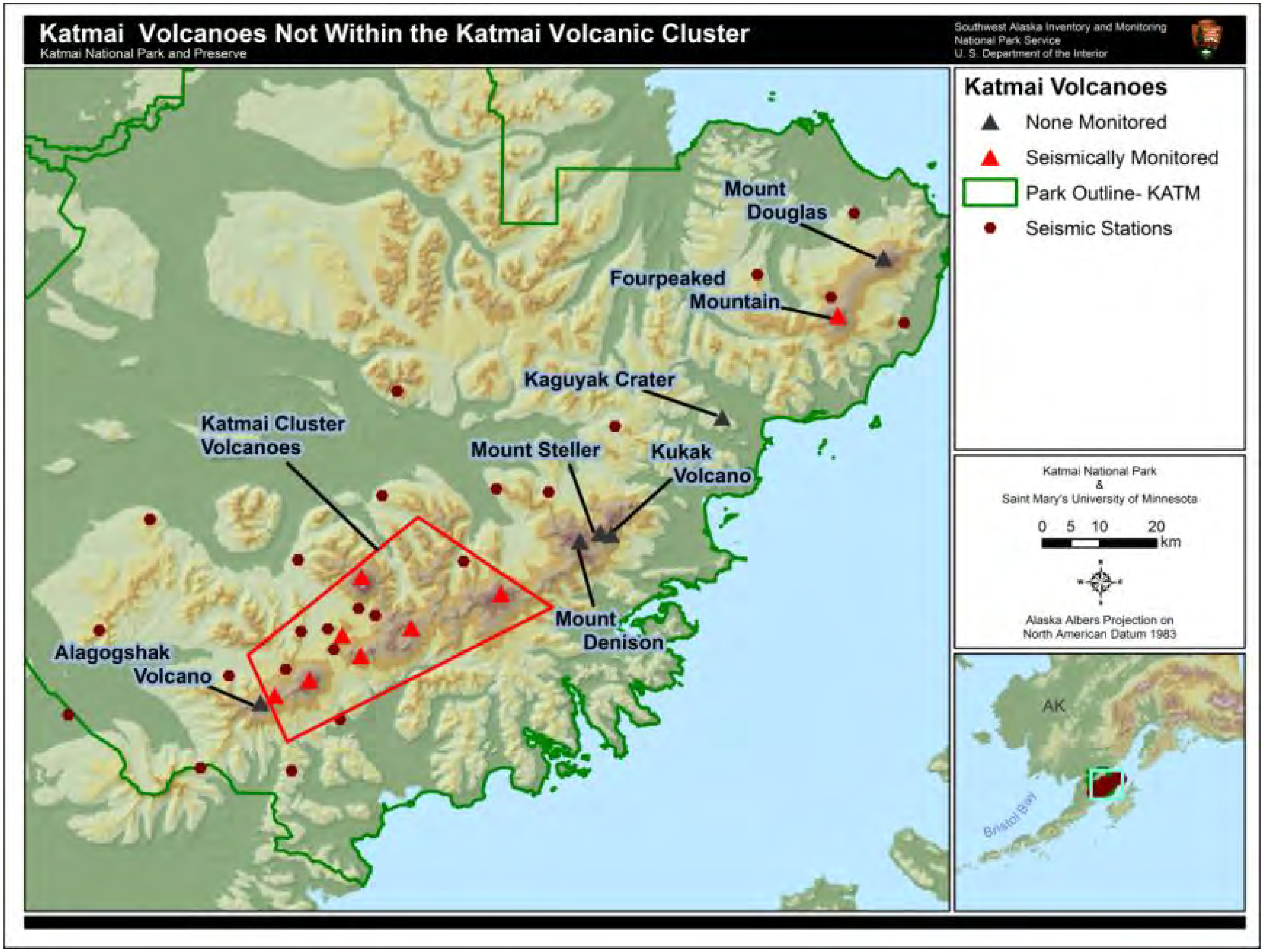

Plate 39 All volcanoes located within KATM. Of the volcanoes not considered part of the Katmai Volcanic Cluster, only Fourpeaked Mountain is actively monitored by AVO.

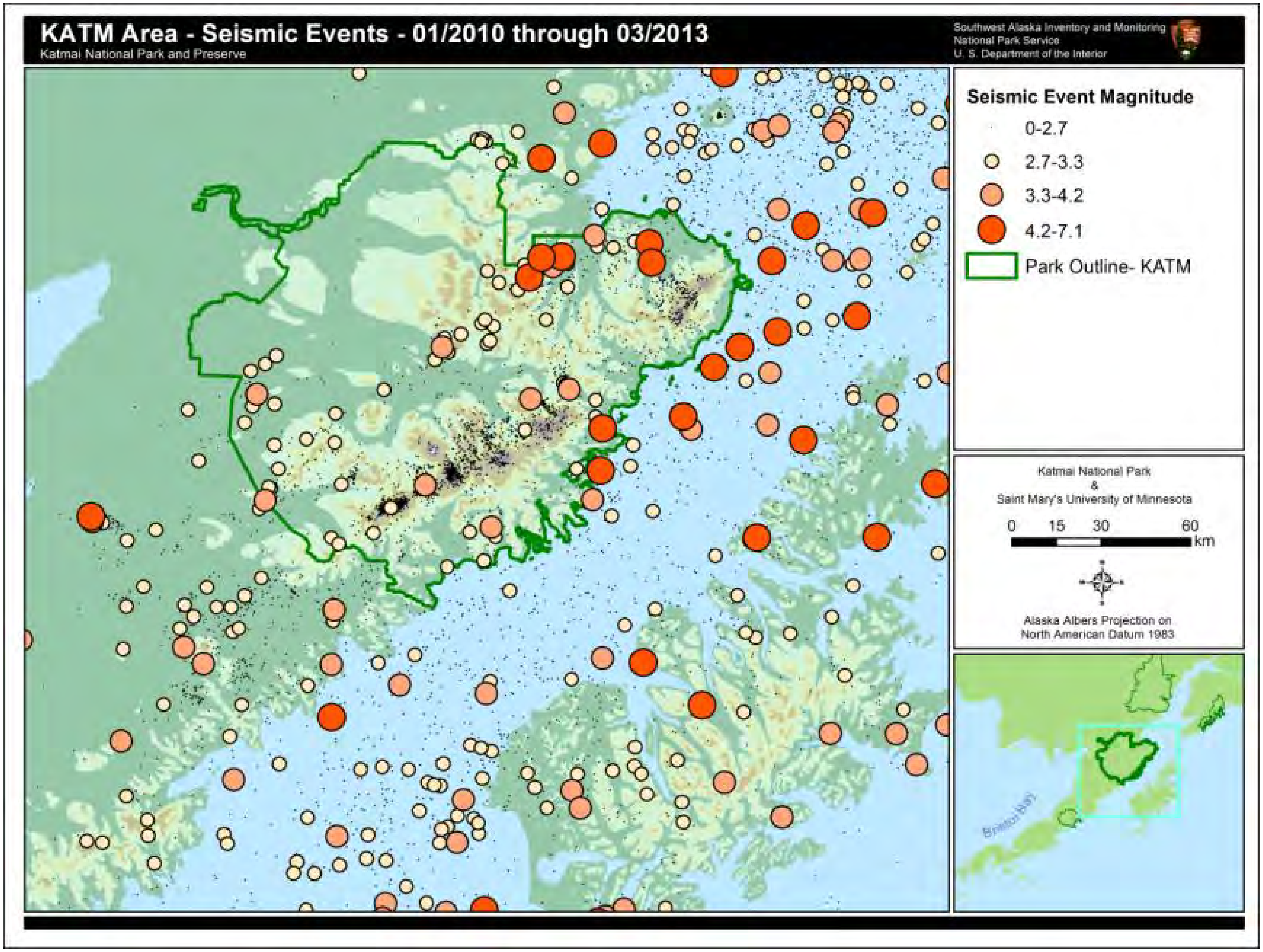

Plate 40 Distribution and magnitudes of recorded seismic events of the KATM region (NCEDC 2013).

4.8 Climate

4.8.1 Description

Climate is widely recognized as one of the most fundamental drivers of ecological condition and ecological change, particularly in Alaska (NPS 2011). As a primary driver of many other ecosystem components (vegetation, wildlife, disturbance regime, etc.), climate also has numerous management consequences and implications. Climate was selected by the SWAN I&M program as a high-priority Vital Sign for southwest Alaska parks (Davey et al. 2007). The climate in KATM and ALAG is described as "transitional between polar (tundra climate) and maritime (maritime subarctic)" (Lindsay 2013, p. 1). Winter temperatures are cold, while summer temperatures are somewhat moderated by nearby open water (e.g., Bering Sea and Gulf of Alaska) (Lindsay 2013).

The climate of KATM and southwest Alaska as a whole is influenced by its high latitude, varying topography, and location near the ocean, as well as atmospheric and oceanic circulation patterns (NPS 2011). Two patterns of particular importance are the Aleutian Low and the Pacific Decadal Oscillation (PDO) (Lindsay 2013). The Aleutian Low is a "semi-permanent low pressure center" in the Gulf of Alaska that influences storm tracks and, therefore, variability in precipitation (Lindsay 2013, p. 2; Bennet et al. 2006). The PDO, which is related to sea surface temperatures in the northern Pacific Ocean, affects atmospheric circulation patterns and alternates between positive and negative phases (Wendler and Shulski 2009). A positive phase is associated with a relatively strong low pressure center over the Aleutian Islands, which moves warmer air into the region, particularly during the winter (Wendler and Shulski 2009). Some of the variation in Alaska's climate over time can be explained by major shifts in the PDO which occurred in 1925 (negative to positive), 1947 (positive to negative), and 1977 (negative to positive) (Mantua et al. 1997). Hartmann and Wendler (2005) found that much of the warming that occurred in Alaska during the last half of the twentieth century was influenced by the PDO shift in 1976-77. Temperatures in southwestern Alaska are also influenced by the El Niño Southern Oscillation (ENSO) (Lindsay 2013).

4.8.2 Data and Methods

Until 2008, no consistent climate data were gathered within KATM boundaries. Conditions in the park were estimated using data from a National Weather Service (NWS) Cooperative Observing Program (COOP) monitoring station at the King Salmon airport, approximately 10 km (6 mi) west of the park (Lindsay 2013; see Plate 41). This station has been in operation since 1955.Other stations with different names at the same location date back to 1948 and 1917, but these data were not consistent in purpose and methods. Lindsay (2013) provides weather information for King Salmon and the greater SWAN region in 2012, comparing it to longer term climate patterns in the area. Lindsay (2013) also discusses the status of climate patterns (e.g., PDO, ENSO) and their potential influence on weather variables.

In 2008 and 2009, four Remote Automated Weather Stations (RAWS) were placed in KATM (Lindsay 2011; Photo 14). These stations are Contact Creek, Coville, Fourpeaked, and Pfaff Mine (Plate 41). Temperature and precipitation data from these stations were obtained through the Western Regional Climate Center website (WRCC 2013). Data were available from October 2008 through February 2013 for all stations, with the exception of Fourpeaked where data collection did not begin until June 2009. However, Lindsay (2013) raises concerns regarding the collection of winter (November-April) precipitation data at RAWS stations. These stations utilize unheated tipping buckets to collect precipitation and are only accurate in measuring liquid precipitation, not snow or snow water equivalent (Lindsay 2013). Sometimes ice or snow that has been stored in the gauge for weeks or even months suddenly melts, resulting in a "delayed" report of precipitation. Buckets can also shake during high winds and cause false precipitation reports. Chuck Lindsay (SWAN Physical Scientist, email communication, 28 March 2013) believes that precipitation readings taken when the temperature is below -0.5°C (31.1°F) or when the wind speed is above 126 km/hr (78 mi/hr) are likely not reliable.

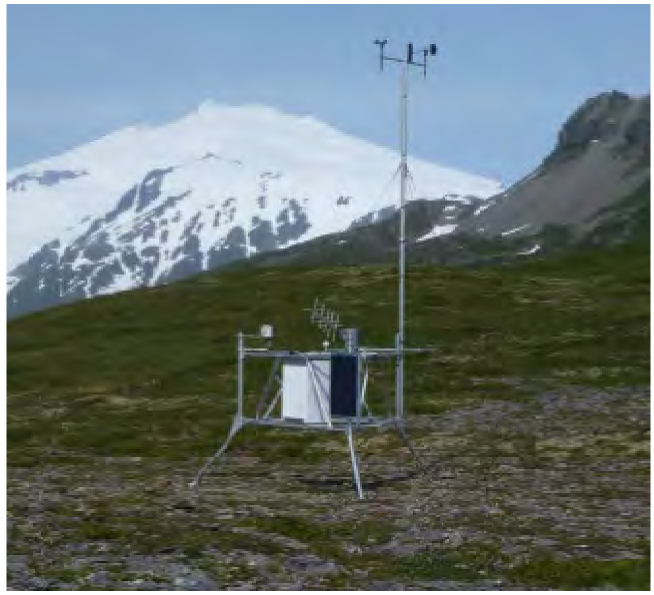

Photo 14. Fourpeaked RAWS monitoring station in KATM (NPS photo by Chuck Lindsay).

The NPS also provided GIS climate data for Alaska from the Parameter Regression on Independent Slopes Model (PRISM). PRISM was developed "to address the extreme spatial and elevation gradients exhibited by the climate of the western U.S." (Davey et al. 2007, p. 20). The model is initialized using climatological normals from stations where actual data are available. It incorporates the "scale-dependent effects of topography" into estimates of climate metrics (i.e., temperature and precipitation) and can be useful in remote areas where little or no climate data has been gathered (Davey et al. 2007, p. 20). The available PRISM data provides temperature and precipitation means for the period 1971-2000.

The NPS also requested evaluation of available weather station data using the RClimDex tool. This tool computes a suite of indices from daily precipitation, maximum temperature, and minimum temperature data with the R Statistical Environment. In total, the tool calculates 27 core indices developed by the Expert Team for Climate Change Detection Monitoring and Indices (ETCCDMI) (Zhang and Yang 2004). Of the 27 indices, the NPS requested reporting of Frost Days, Ice Days, Growing Season Length, Warm Nights, Cool Days, and Annual Total Precipitation. Only one of the weather stations available for the park was analyzed using this toolset: King Salmon Airport - USW00025503. This station includes data for the entire duration of monitoring at the King Salmon Airport (regardless of method or purpose). RClimDex requires various minimum records depending on the index. Other stations had data that were too limited to utilize the RClimDex tools.

4.8.3 Current Condition and Trend

Temperature

The mean annual temperatures in the KATM region from 1971-2000, according to PRISM data, are presented in Table 36 and graphically in Plate 41. It is important to remember that these values are based on modeling rather than actual ground observations. Mean temperatures from 1971-2000 at the four current RAWS station locations ranged from 0.6°C (33°F) at Coville to 2.5°C (36.5°F) at Fourpeaked (PRISM 2010). The lowest mean annual minimum temperature was at Coville (-3.6°C [25.5°F]) and the highest mean annual maximum temperature occurred at Contact Creek (5.8°C [42.4°F]). The greatest range between mean annual minimum and maximum temperatures (8.4°C [47.1°F]) occurred at both the Contact Creek and Coville locations. The lowest range was at Fourpeaked, with a difference of just 6.2°C (11.1° F) (PRISM 2010).

Table 36. Mean annual temperatures (°C) from 1971-2000 for the four current RAWS station locations within KATM, according to PRISM data (PRISM 2010). Overall mean is presented as well as annual mean minimum and maximum temperatures. Note that these values are based on climate modeling and do not represent actual on-the-ground observations.

	Contact Creek	Coville	Fourpeaked	Pfaff Mine	King Salmon Airport
Mean	1.6	0.6	2.5	0.8	1.6
Minimum	-2.6	-3.6	-0.6	-3.3	-2.4
Maximum	5.8	4.8	5.6	4.9	5.6

More recent monthly mean temperature data for each year available, as well as an overall mean, are presented for each of the four RAWS locations in Table 37-Table 40. The final column of each table shows the monthly mean temperatures for each location according to 1971-2000 PRISM data (PRISM 2010). Since data collection began at RAWS stations, the lowest temperature recorded was -40.8°C (-41.4°F) at Pfaff Mine in January 2013. The highest temperature (26.3°C [79.3°F]) occurred at Contact Creek in July 2009. The minimum and maximum temperatures for each RAWS station during the period of record are shown in Table 41.

Table 37. Contact Creek monthly mean temperature (°C) by year and the mean over all years of available RAWS data (WRCC 2013). The final column shows 1971-2000 monthly means according to PRISM data (PRISM 2010). Highlighting indicates months where recent RAWS data means are >1° different from PRISM means (light grey = warmer in RAWS, dark grey = colder in RAWS).

Month	2008	2009	2010	2011	2012	2013	Mean (2008-13)	1971-2000 Mean
Jan.	---	-10.5	-6.2	-3.3	-19.0	-3.1	-8.4	-9.1
Feb.	---	-7.7	-4.2	-6.8	-3.6	-3.9	-5.2	-7.7
Mar.	---	-8.1	-8.2	-4.7	-11.0	---	-8.0	-4.8
Apr.	---	0.1	-1.5	-0.1	0.8	---	-0.2	0.3
May	---	7.0	5.0	6.4	3.3	---	5.4	6.0
June	---	9.3	8.7	8.1	7.3	---	8.4	10.0
July	---	12.7	9.9	9.7	9.7	---	10.5	12.4
Aug.	---	10.6	10.8	10.2	10.8	---	10.6	12.0
Sept.	---	7.5	9.0	8.2	6.8	---	7.9	8.8
Oct.	-1.2	3.8	1.5	2.7	-0.2	---	1.3	1.4
Nov.	-8.0	-7.2	-4	-8.0	-9.9	---	-7.4	-3.7
Dec.	-5.1	-3.1	-14.1	-8.0	-10.1	---	-8.1	-6.7

Table 38. Coville monthly mean temperature (°C) by year and the mean over all years of available RAWS data (WRCC 2013). The final column shows 1971-2000 monthly means according to PRISM data (PRISM 2010). Highlighting indicates months where recent RAWS data means are >1° different from PRISM means (light grey = warmer in RAWS, dark grey = colder in RAWS)

Month	2008	2009	2010	2011	2012	2013	Mean (2008-13)	1971-2000 Mean
Jan.	---	-9.5	-4.0	-3.6	-17.1	-3.9	-7.6	-8.9
Feb.	---	-7.8	-4.7	-8.8	-5.4	-4.3	-6.2	-7.3
Mar.	---	-9.6	-8.3	-5.0	-11.6	---	-8.6	-4.5
Apr.	---	-1.0	-2.7	-1.5	-0.1	---	-1.3	-0.8
May	---	6.3	4.1	5.1	2.1	---	4.4	4.1
June	---	8.9	8.0	6.8	6.9	---	7.7	8.2
July	---	13.0	8.7	8.7	8.9	---	9.8	10.6
Aug.	---	9.8	9.6	9.0	9.6	---	9.5	10.1
Sept.	---	6.9	8.3	6.7	5.3	---	6.8	6.7
Oct.	-2.8	3.2	0.5	1.5	-0.3	---	0.4	0.1
Nov.	-7.9	-8.9	-4.4	-10.3	-6.5	---	-7.6	-4.0
Dec.	-5.6	-1.7	-13.6	-8.0	-10.2	---	-7.8	-7.5

Table 39. Fourpeaked monthly mean temperature (°C) by year and the mean over all years of available RAWS data (WRCC 2013). The final column shows 1971-2000 monthly means according to PRISM data (PRISM 2010). Highlighting indicates months where recent RAWS data means are >1° different from PRISM means (light grey = warmer in RAWS, dark grey = colder in RAWS).

Month	2009	2010	2011	2012	2013	Mean (2009-13)	1971-2000 Mean
Jan.	---	-0.2	-1.8	-8.7	0.8	-2.5	-4.6
Feb.	---	-1.1	-2.7	-1.6	---	-1.8	-4.2
Mar.	---	-3.3	-1.9	---	---	-2.6	-2.0
Apr.	---	0.1	0.8	---	---	0.5	1.0
May	---	4.9	4.3	---	---	4.6	5.5
June	8.3	7.6	6.8	9.4	---	8.0	8.6
July	11.9	9.0	10.5	8.7	---	10.0	10.8
Aug.	11.3	10.8	10.4	10.1	---	10.7	10.8
Sept.	8.0	9.8	7.1	8.5	---	8.4	7.8
Oct.	5.1	3.4	3.8	0.2	---	3.1	2.4
Nov.	-2.1	0.3	-4.7	-0.3	---	-1.7	-2.0
Dec.	-1.2	-3	-3.5	-3.2	---	-2.7	-3.8

Table 40. Pfaff Mine monthly mean temperature (°C) by year and the mean over all years of available RAWS data (WRCC 2013). The final column shows 1971-2000 monthly means according to PRISM data (PRISM 2010). Highlighting indicates months where recent RAWS data means are >1° different from PRISM means (light grey = warmer in RAWS, dark grey = colder in RAWS).

Month	2008	2009	2010	2011	2012	2013	Mean (2008-13)	1971-2000 Mean
Jan.	---	-10.3	-4.3	-4.5	-17.3	-6.3	-8.5	-7.1
Feb.	---	-8.9	-5.6	-9.8	-6.5	-6.6	-7.5	-5.8
Mar.	---	-10.5	-8.3	-5.7	-11.9	---	-9.1	-2.9
Apr.	---	-1.8	-2.8	-2.3	-0.3	---	-1.8	-0.6
May	---	5.6	3.2	3.3	1.6	---	3.4	3.9
June	---	7.8	7.2	6.1	7.4	---	7.1	7.4
July	---	12.2	8.4	8.9	8.1	---	9.4	9.8
Aug.	---	9.4	9.3	8.5	9.2	---	9.1	9.5
Sept.	---	5.9	7.6	5.7	4.4	---	5.9	6.4
Oct.	-3.7	2.1	-0.1	0.6	-0.9	---	-0.4	-0.3
Nov.	-8.2	-8.9	-4.6	-11.0	-8.2	---	-8.2	-3.2
Dec.	-7.0	-4.7	-13.1	-8.9	-10.5	---	-8.8	-7.7

Table 41. Minimum and maximum temperatures (°C) recorded at each of the four RAWS station locations within KATM, along with the month in which they occurred (WRCC 2013).

	Contact Creek	Coville	Fourpeaked	Pfaff Mine
Minimum	-35.9 (Jan 2009)	-32.8 (Jan 2009)	-20.0 (Jan 2012)	-40.8 (Jan 2013)
Maximum	26.3 (July 2009)	26.0 (July 2009)	23.2 (July 2009)	25.6 (July 2009)

A comparison of recent RAWS data from the four stations in KATM to the modeled temperature means from PRISM (1971-2000) shows that monthly means during the RAWS period of record were often more than a degree different than PRISM means (see Table 37-Table 40). At Contact Creek and Pfaff Mine, RAWS means were frequently colder than PRISM means, while RAWS means were occasionally warmer at Fourpeaked. However, it is unclear if this is due to actual change in temperatures over time or simply because of differences in methodology (i.e., RAWS data are actual on-the-ground measurements while PRISM data are based on modeling). The amount of data used in calculating means also has an influence; PRISM means are for a 30-year period while RAWS means in this document are based on approximately 4-5 years of data.

Prior to the establishment of RAWS stations in KATM, climate conditions in the park were estimated based on data from the nearby King Salmon COOP monitoring station. According to the Alaska Climate Research Center (ACRC) (2012a), mean annual temperatures at King Salmon increased nearly 2°C (3.4°F) between 1949 and 2011, while mean winter temperatures rose 4.4°C (about 8°F) during the same period. Six of the last seven years have been colder than climatological normal, including the most recent year (2012). In 2010, the region was warmer and slightly drier in comparison to climatological normals from the previous 30 years, perhaps due to El Niño conditions (Lindsay 2011). Temperatures at weather stations throughout the region were 1.5-2.2°C (2.7-3.9°F) cooler than the 30-year climatological normal during the 2012 hydrologic year (1981-2010) (Lindsay 2013). Cooler conditions in 2012 may be related to a negative phase in the PDO, causing colder sea surface temperatures in the Bering Sea and Gulf of Alaska, as well as a weak La Niña event (part of the ENSO circulation pattern) in early 2012 (JISAO 2013, NWS Climate Prediction Center 2013). Evidence suggests that temperatures in Alaska are typically lower than normal, particularly in the winter, during La Niña events (Papineau 2001). Figure 32 shows the variation in mean daily maximum and minimum temperatures (i.e., difference from the mean for the period 1949-2012) at King Salmon through 2012. From the late 1970s until recently, temperatures were generally warmer than the mean (since 1949) partly due to a shift in the PDO from negative to positive (Lindsay 2013).

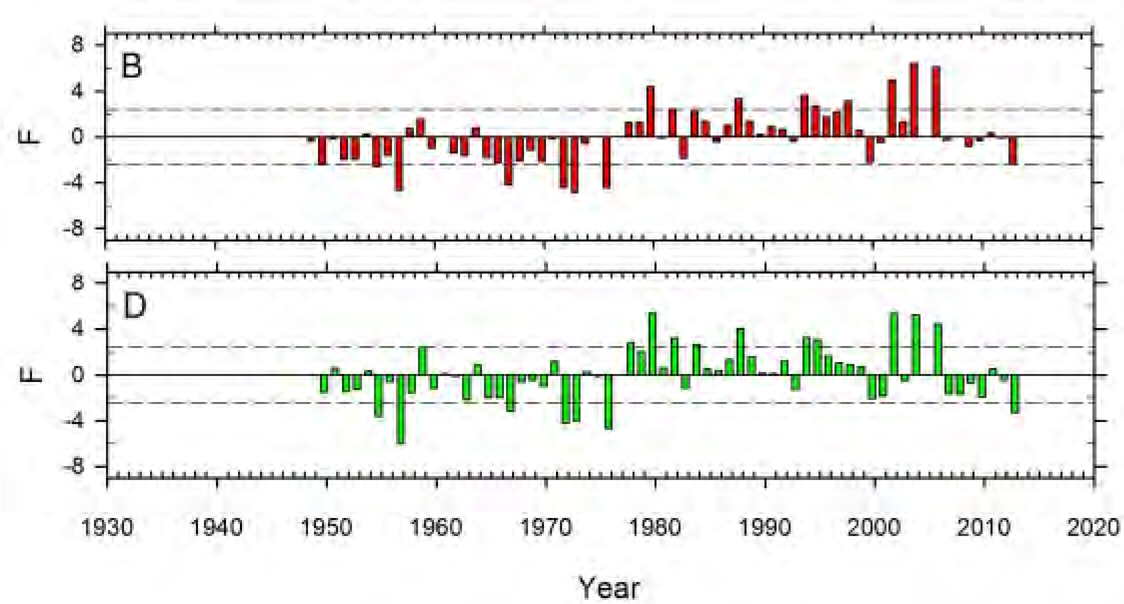

Figure 32. Variation (anomaly) in mean daily maximum (top, in red) and minimum (bottom, in green) temperatures (in °F) from the average over the period of record at the King Salmon COOP station (Lindsay 2013). Dashed lines represent one standard deviation. Note that a variation of 1°F = 0.6°C.

Precipitation

Mean annual precipitation in the KATM region from 1971-2000, according to PRISM data, are presented graphically in Plate 42. Again, it should be noted that these values are based on modeling rather than actual ground observations. The Contact Creek location was generally the driest, averaging just 622 mm (24.5 in) of precipitation annually (PRISM 2010). Fourpeaked was the wettest location with annual mean precipitation of 1,476 mm (58.1 in).

Monthly precipitation data for each year available, as well as an overall mean, are presented for each of the four RAWS locations in Table 42 and Table 45. The final column of each table shows the monthly mean precipitation for each location according to 1971-2000 PRISM data (PRISM 2010). RAWS data suggests that, during the period of record, Pfaff Mine was the driest station, receiving on average just 437.6 mm (17.2) of precipitation annually (WRCC 2013). Fourpeaked was the wettest station by far; in 2012, for example, the location received nearly 3,000 mm (118 in) of precipitation.

Table 42. Contact Creek monthly precipitation (mm) by year and the mean over all years of available RAWS data (WRCC 2013). The final column shows 1971-2000 monthly precipitation according to PRISM data (PRISM 2010).

Month	2008	2009	2010	2011	2012	2013	Mean (2008-13)	1971-2000 Mean
Jan.	---	32.0	7.1	0	6.9	40.1	17.2	43
Feb.	---	17.5	25.9	23.6	26.4	20.8	22.8	22
Mar.	---	16.5	0	10.7	15.8	---	10.8	19
Apr.	---	8.4	15.0	16.0	16.8	---	14.1	20
May	---	32.8	14.5	18.3	27.7	---	23.3	28
June	---	51.5	59.6	48.0	67.6	---	56.7	44
July	---	53.1	116.1	87.4	113.3	---	92.5	64
Aug.	---	58.2	94.8	230.9	120.4	---	126.1	115
Sept.	---	45.9	58.7	111.3	147.6	---	90.9	103
Oct.	65.5	70.1	58.7	99.6	13.5	---	61.5	89
Nov.	14.7	37.1	38.4	48.8	20.6	---	31.9	43
Dec.	22.1	131.8	11.7	43.9	48.8	---	51.7	30
Annual total	**---**	**554.9**	**500.5**	**738.5**	**625.4**	**---**	**604.8**	**622**

Table 43. Coville monthly precipitation (mm) by year and the mean over all years of available RAWS data (WRCC 2013). The final column shows 1971-2000 monthly precipitation according to PRISM data (PRISM 2010).

Month	2008	2009	2010	2011	2012	2013	Mean (2008-13)	1971-2000 Mean
Jan.	---	15.5	0.5	253.5	0	22.9	58.48	43
Feb.	---	16.8	1.8	19.8	15.5	6.6	12.1	26
Mar.	---	24.6	0.5	2.0	4.8	---	7.8	27
Apr.	---	7.6	25.4	37.6	4.6	---	18.8	31
May	---	30.0	29.7	54.6	28.7	---	35.8	49
June	---	80.2	87.9	131.5	60.2	---	90.0	59
July	---	92.9	178.8	88.7	90.9	---	112.8	83
Aug.	---	80.0	224.1	157.5	126.2	---	147.0	133
Sept.	---	69.9	62.0	69.9	131.1	---	83.2	128
Oct.	88.3	107.4	81.5	56.9	10.4	---	68.9	94
Nov.	0	23.4	26.7	34.3	15.0	---	19.9	55
Dec.	10.7	222.3	1.5	40.6	30.7	---	61.2	41
Annual total	**---**	**770.6**	**720.4**	**946.9**	**518.1**	**---**	**739.0**	**767**

Table 44. Fourpeaked monthly precipitation (mm) by year and the mean over all years of available RAWS data (WRCC 2013). The final column shows 1971-2000 monthly precipitation according to PRISM data (PRISM 2010). Annual totals were not calculated for years with missing monthly data.

Month	2009	2010	2011	2012	2013	Mean (2009-13)	1971-2000 Mean
Jan.	---	0	--	47.8	4.3	17.4	159
Feb.	---	2.5	--	411.5	---	207.0	111
Mar.	---	2.8	--	42.2	---	22.5	114
Apr.	---	--	--	278.6	---	---*	106
May	---	--	--	290.8	---	---*	97
June	0	28.4	0	50.8	---	19.8	83
July	1.8	71.2	68.1	454.7	---	149.0	84
Aug.	2.3		363.7	171.2	---	179.1	100
Sept.	1.8	0	584.7	29.0	---	153.9	151
Oct.	11.3	---	288.3	1.5	---	100.4	159
Nov.	0	---	78.0	312.2	---	130.1	151
Dec.	0	---	156.0	895.6	---	350.5	162
Annual total	**---**	**---**	**---**	**2,985.9**	**---**	**---**	**1,476**

* - means were not calculated for months with only one year of available data.

Table 45. Pfaff Mine monthly precipitation (mm) by year and the mean over all years of available RAWS data (WRCC 2013). The final column shows 1971-2000 monthly precipitation according to PRISM data (PRISM 2010). Annual totals were not calculated for years with missing monthly data.

Month	2008	2009	2010	2011	2012	2013 (2008-13)	Mean	1971-2000 Mean
Jan.	---	10.2	28.7	7.1	---	20.3	16.6	94
Feb.	---	3.1	5.1	0.8	---	2.5	2.3	69
Mar.	---	0.5	2.8	1.5	---	---	1.6	62
Apr.	---	1.0	21.8	14.0	---	---	12.3	58
May	---	24.6	6.1	80.5	---	---	37.1	108
June	---	21.8	21.8	44.7	11.4	---	24.9	76
July	---	94.2	73.8	0	111.3	---	69.8	104
Aug.	---	29.5	92.2	0.3	73.7	---	48.9	163
Sept.	---	182.8	31.2	0	284.2	---	124.6	183
Oct.	30.0	131.8	92.4	---	15.5	---	67.4	149
Nov.	0	15.8	6.6	---	4.6	---	6.8	110
Dec.	0.3	83.06	0	---	18.0	---	25.3	85
Annual total	**---**	**598.4**	**382.5**	**---**	**---**	**---**	**437.6**	**1,262**

Substantial differences exist between the monthly precipitation means from recent RAWS data and modeled means from PRISM. As was the case with temperature means, it is unclear if this is due to actual changes in precipitation over time or differences in methodology (i.e., actual measurements vs. modeling). It is also important to note that winter precipitation data (November-April) from RAWS stations is often inaccurate, due to their ability to measure only liquids (Lindsay 2013).

During the 2010 hydrologic year (Oct. 2009 - Sept. 2010), the SWAN region was slightly drier than normal, receiving 75-97% of the typical annual precipitation (Lindsay 2011). In the 2012 hydrologic year (Oct. 2011 - Sept. 2012), the southern part of the SWAN region experienced above average precipitation, with 126-142% of typical annual precipitation (Lindsay 2013). This can be seen in Figure 33, which presents precipitation anomalies at the King Salmon COOP station from the late 1940s through 2012. According to ACRC (2012b), much of southern Alaska experienced record-high snowfall during the winter of 2011-2012. At King Salmon, 2012 was the wettest hydrological year (October-September) during the period of record (Lindsay 2013).

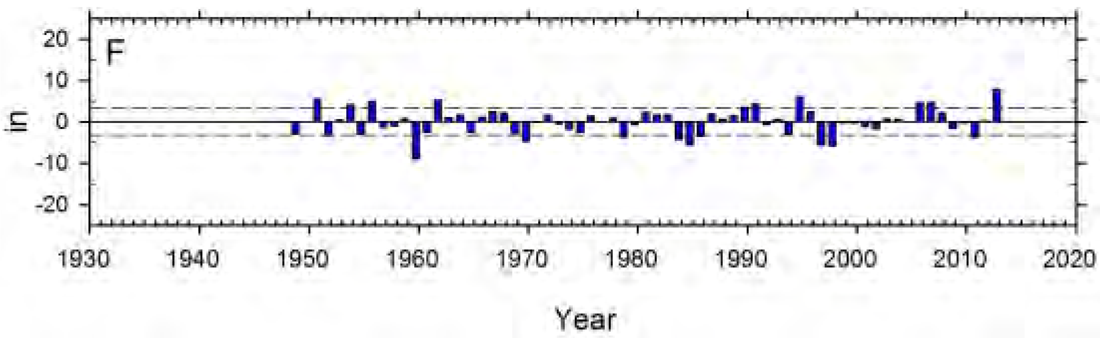

Figure 33. Variation (anomaly) in annual precipitation (in inches) from the average over the period of record at the King Salmon COOP station (Lindsay 2013). Dashed lines represent one standard deviation. Note that 1 inch = 25.4 mm.

RClimDex Indices

Table 46 provides descriptions of each index calculated using RClimDex.

Table 46. Descriptions of RClimDex indices (Zhang and Yang 2004).

Index	Description
Frost Days	Annual count of days when the minimum temperature is less than 0°C.
Ice Days	Annual count of days when the maximum temperature is less than 0°C
Growing Season Length	Annual count of days between the first 6-day period where the temperature is greater than 5°C and the first 6-day period where the temperature is less than 5°C.
Warm Nights	Percentage of days when the minimum temperature is above the 90th percentile.
Cool Days	Percentage of days when the maximum temperature is below the 10th percentile.
Annual Total Precipitation	Annual total precipitation during days when precipitation is greater than 1mm.

King Salmon Station USW00025503

Station USW00025503 at King Salmon Airport includes weather records dating back to 1917. Since 1947, nearly continuous daily records of minimum temperature, maximum temperature, and precipitation are available (Figure 34). Indices were calculated beginning in 1929, when records were consistent in year-long recording of the three parameters. This record is the longest and most complete record in the KATM and ALAG area. Other stations exist within the park, but due to unreliable data duration, the records do not lend themselves to analysis using the RClimDex tool set.

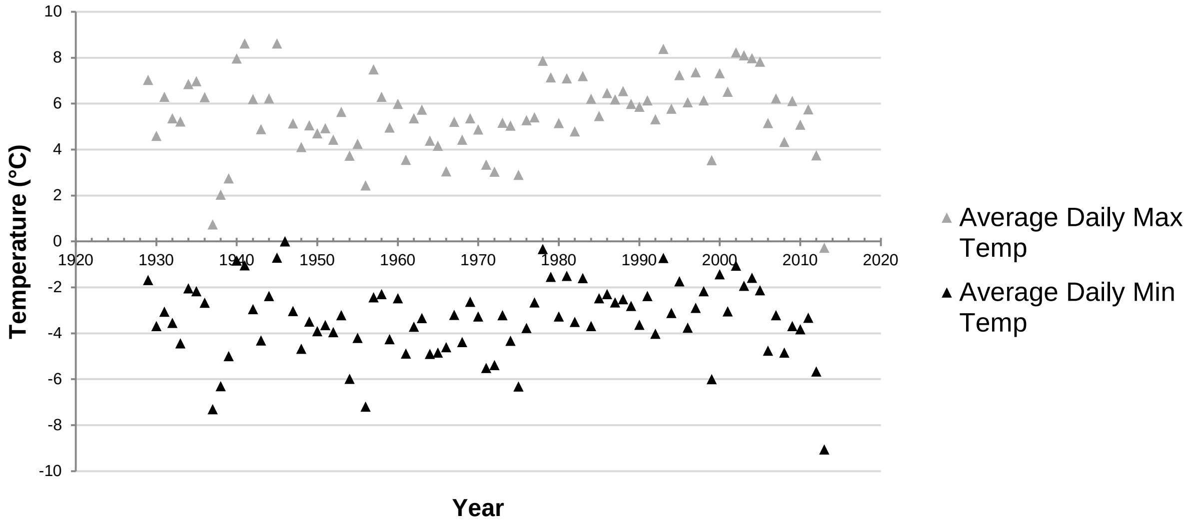

Figure 34. Yearly average minimum and maximum daily temperature at USW00025503, King Salmon Airport.

Yearly Frost Days (FD) at the King Salmon station averaged 188 days (n=72) from 1929 to 2012. FD ranged from 149 days (1978) to 224 days (1956) (Figure 35).

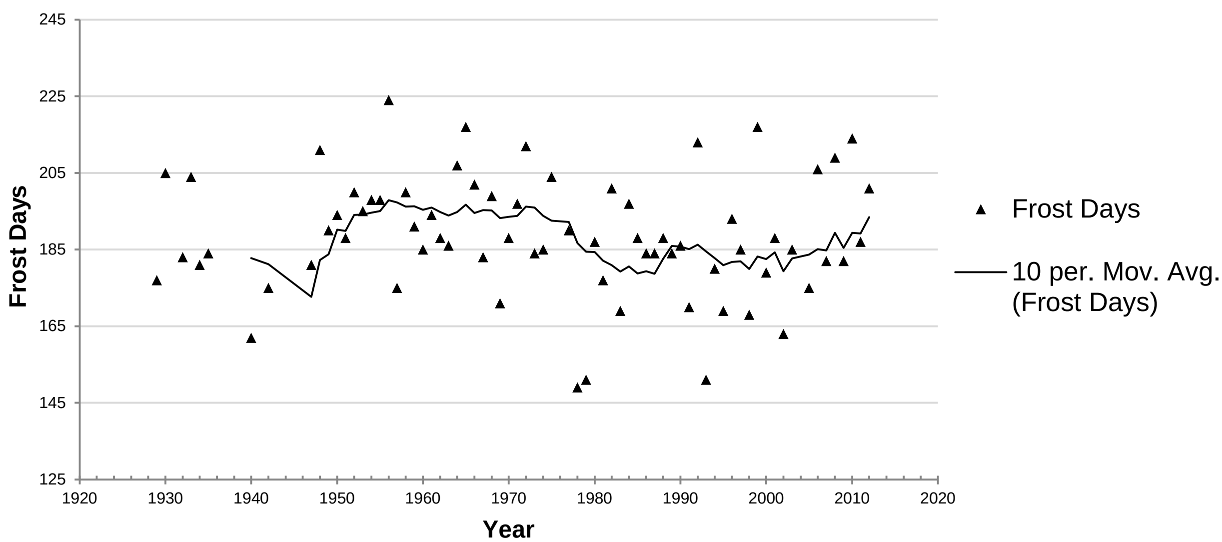

Figure 35. Yearly frost days at USW00025503, King Salmon Airport. Calculated using RClimDex toolset with 10 period moving average.

Yearly Ice Days (ID) at the King Salmon station averaged 85 days (n=71) from 1929 to 2012. ID ranged from 37 days (2000) to 122 days (1999). Between the early 1970s and the mid 1980s, the 10-period moving average decreased from a high of 100 days to a low of 76 days. Since the decrease, the moving average has been in the high 70s to low 80s (Figure 36).

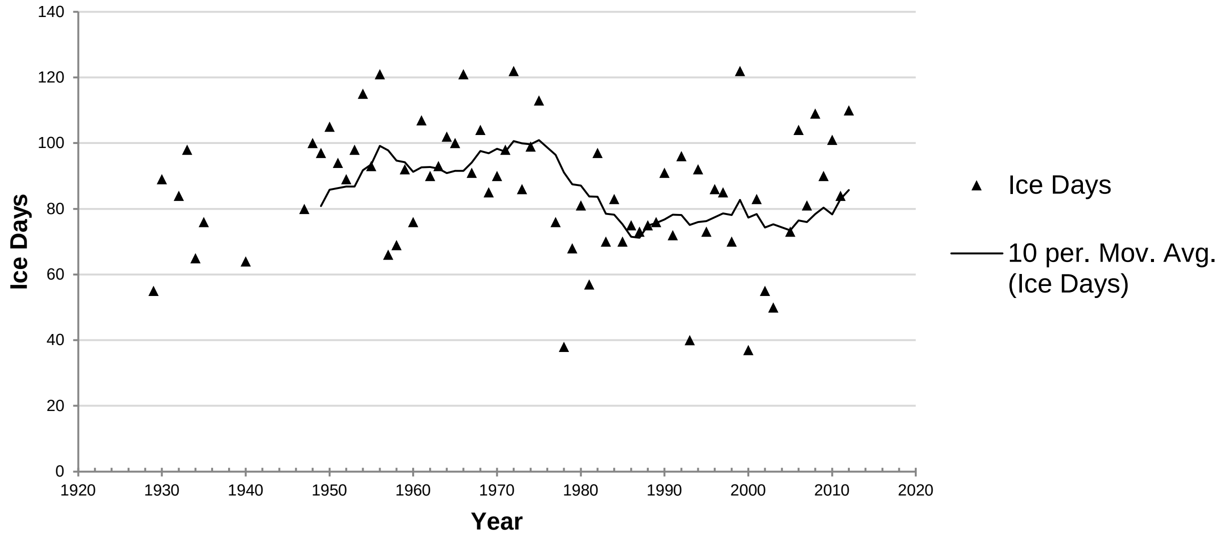

Figure 36. Yearly ice days at USW00025503, King Salmon Airport. Calculated using RClimDex toolset.

Yearly Growing Season Length (GSL) at the King Salmon station averaged 147 days (n=71) from 1929 to 2012. GSL ranged from 120 days (1955) to 178 days (1983). The 10-period moving average has been slightly increasing since 1970 (Figure 37).

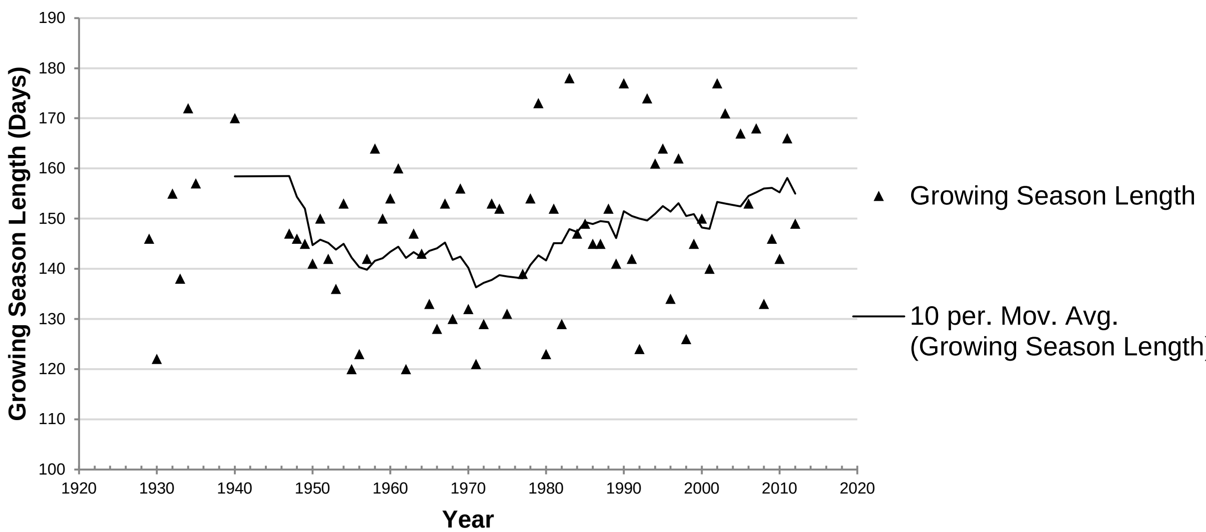

Figure 37. Yearly growing season length at USW00025503, King Salmon Airport. Calculated using RClimDex toolset.

Yearly percent warm nights at the King Salmon station averaged 24% (n=72) from 1929 to 2012. The minimum percentage of warm nights was 3.8% (1964) and the maximum was 65.7% (1979). Similar to the ID index, the percent warm nights changed between the early 1970s and the mid 1980s, with the 10-period moving average increasing from less than 20% to greater than 30% (Figure 38).

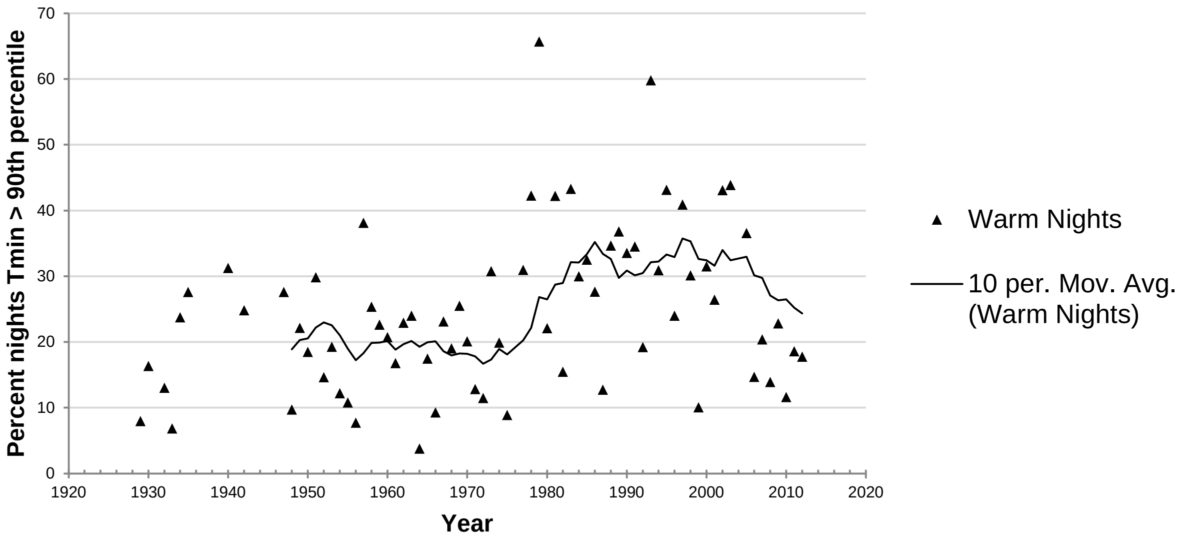

Figure 38. Yearly percent warm nights at USW00025503, King Salmon Airport. Calculated using RClimDex toolset.

Yearly percent cool days at the King Salmon station averaged 26% (n=71) from 1929 to 2012. The minimum percentage of cool days was 1.55% (1940) and the maximum was 62.31% (1966). The 10-period moving average of yearly percent cool days increased until the early 1970s to nearly 40% and then decreased to less than 20% in the 2000s (Figure 39).

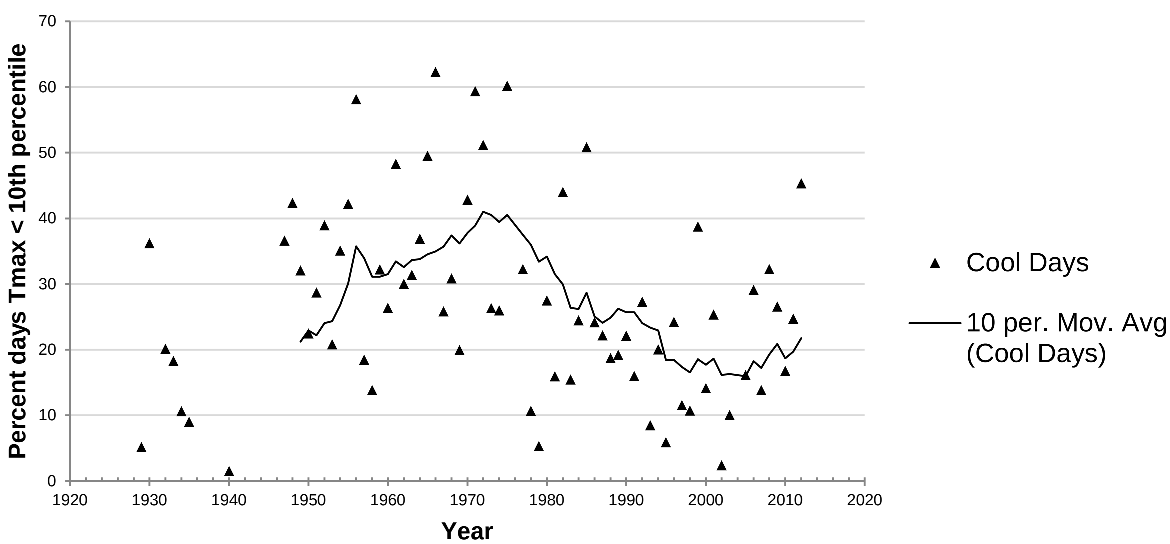

Figure 39. Yearly percent cool days at USW00025503, King Salmon Airport. Calculated using RClimDex toolset.

Yearly total precipitation at the King Salmon station averaged 494 mm (n=70) from 1929 to 2012. Total precipitation ranged from 224 mm (1959) to 799 mm (1935) (Figure 40).

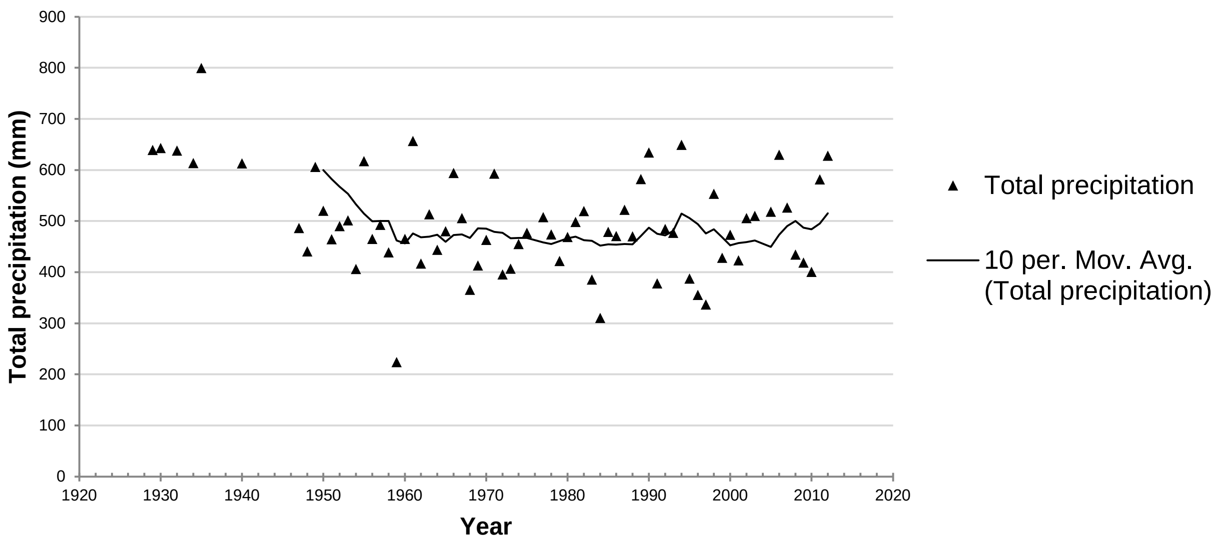

Figure 40. Yearly total precipitation at USW00025503, King Salmon Airport. Calculated using RClimDex toolset.

Threats and Stressor Factors

There is a scientific consensus that human activities, particularly those that produce greenhouse gasses (e.g., fossil fuel burning), have contributed to a general warming trend in global climate (IPCC 2010). Climate models predict that change will be greatest at higher latitudes, like in Alaska (NPS 2011). In the KATM region, temperatures are projected to increase approximately 1°F (about 0.6°C) per decade over the next century (SNAP et al. 2009). Winter temperatures may change more dramatically, increasing by 10°F (about 6°C) by 2080 (SNAP et al. 2009). Precipitation is predicted to increase, yet increased evapotranspiration due to warmer temperatures and a longer growing season will likely lead to an overall drier climate (SNAP et al. 2009). Potential impacts of these changes in southwest Alaska parks include reduced snowpack and a longer growing season, which could affect plant phenology and productivity, wildlife distribution and mating cycles, water availability, and recreational and subsistence activities (e.g., hunting, fishing) (SNAP et al. 2009, NPS 2011).

Data Needs/Gaps

To better understand the climate of the KATM and ALAG area, it will be important to continue gathering data from the four recently established RAWS stations. This information will help identify the range of climate variability within the park and if any changes are occurring over time, perhaps in connection with global climate change. Implementing a more accurate method for measuring wintertime precipitation would also be helpful. Further studies may be needed to explore how changes in climate will impact other park resources (e.g., vegetation and wildlife, water regime, etc.).

Overall Condition

Due to a lack of long-term climate data from within KATM or ALAG boundaries, it is difficult to assess the current condition of climate in the parks. Data from just outside the park (King Salmon) and the greater region suggest that temperatures have been slightly cooler over the last decade in comparison to 30-year normals, perhaps due to a negative phase in the PDO. Annual precipitation has been more variable, but the region was much wetter than average during 2012. However, climate models predict that Alaska will become warmer and drier over the next century, which is a cause for concern regarding the effects on resources in the park.

4.8.4 Sources of Expertise

Chuck Lindsay, SWAN Physical Scientist

4.8.5 Literature Cited

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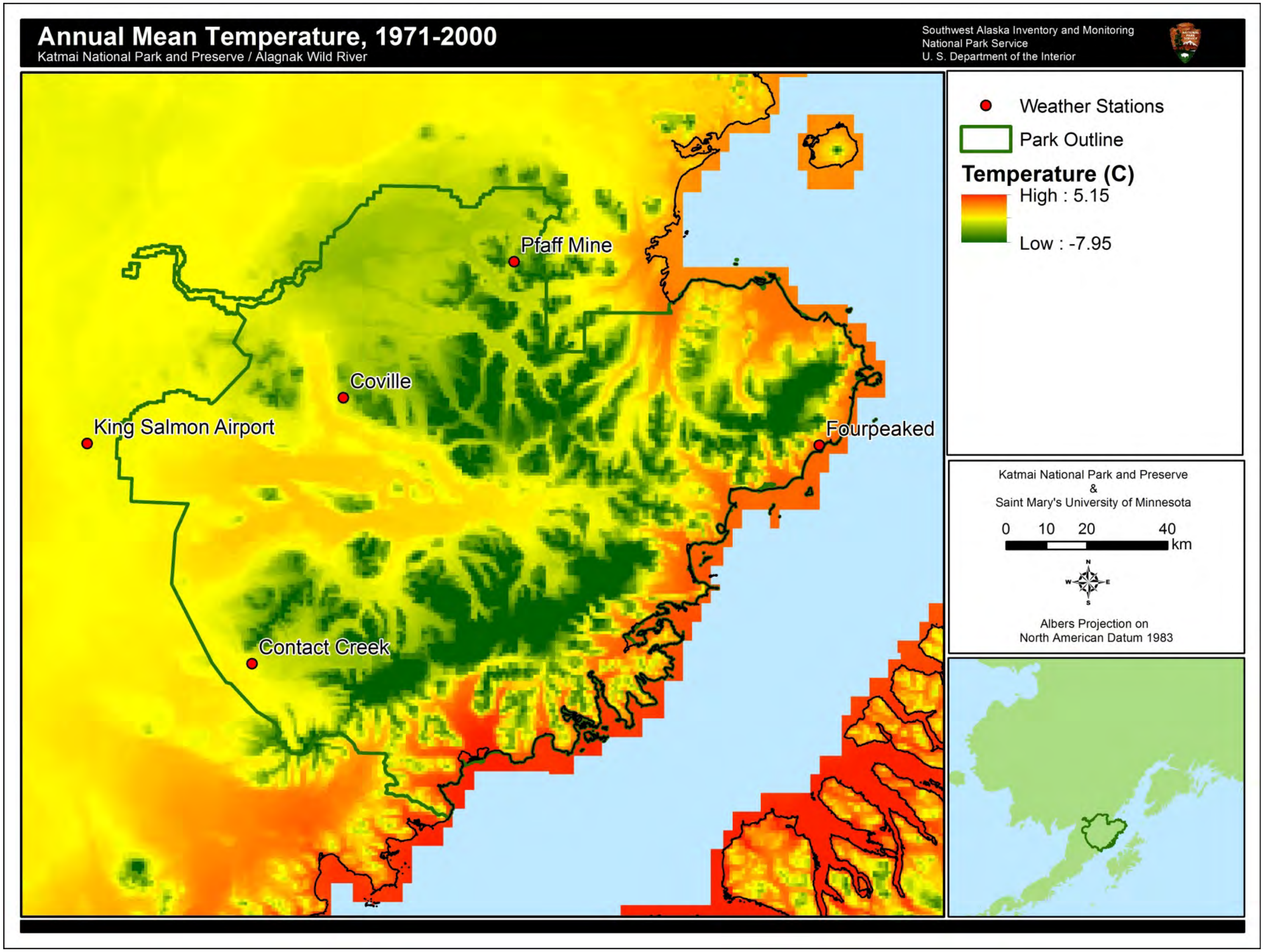

Plate 41. Annual mean temperature in the KATM region, 1971-2000, according to PRISM (2010).

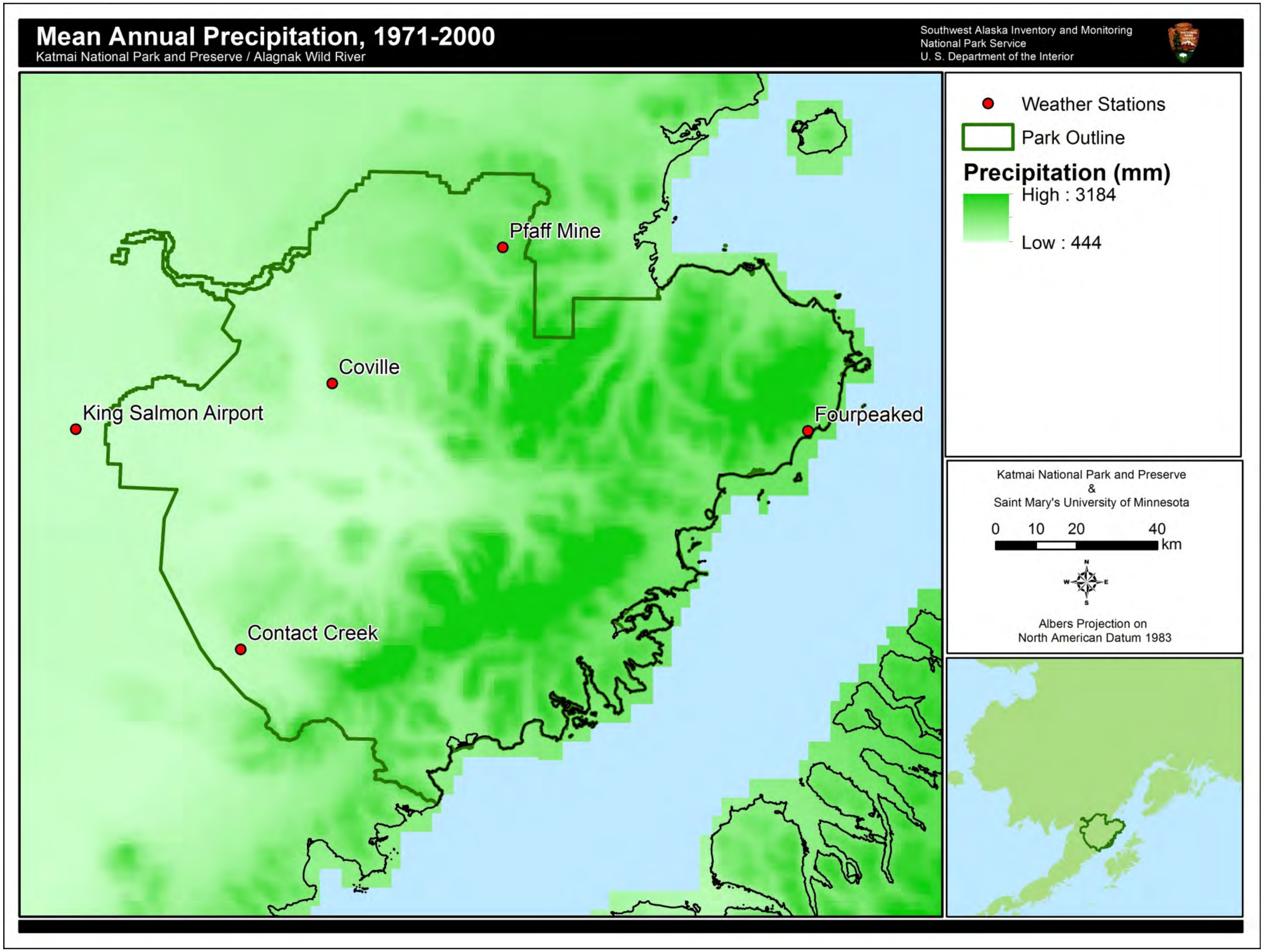

Plate 42. Mean annual precipitation in the KATM region, 1971-2000, according to PRISM (2010).

4.9 Human Activity

4.9.1 Description

Access to KATM and ALAG is limited, as road access to the parks is not available; park visitors generally access the park via a small aircraft or a boat ride that originates in King Salmon, AK. The most common activities for park visitors are sport fishing and bear viewing.

4.9.2 Specific Analysis

For this component, available datasets were used to provide an overview of visitor use in the park. The Commercial Use Authorization (CUA) database (NPS 2012) was the primary source of information for this analysis. In addition, data available online via the NPS IRMA (NPS 2013) provided general summaries of park usage.

Data within the CUA database document the use of park resources by individuals who are guided by a registered and permitted commercial operator within a national park. KATM and ALAG share a CUA data collection system and protocol with ANIA and LACL. Prior to 2006, the CUA database was utilized primarily for fee collection (Fay and Colt 2007). Today, the CUA database includes a multitude of information regarding visitor utilization, duration of stay in the park, and activities.

4.9.3 Reference Conditions/Values

Reference condition does not apply for this topic.

4.9.4 Data and Methods

SWAN provided the CUA database to use for this analysis; this database was delivered at three different times, as updates and modifications to the data occurred. This database holds records of CUA activities within SWAN Parks (KATM, ALAG, ANIA, and LACL), and was originally constructed as a Microsoft Access database but later migrated to SQL Server 2008 R2.

The final version of the database used in this analysis required additional modifications before utilization, including migration of additional data from the original Access database. Once data migration was complete, SQL queries were developed that focused on visitor days within geographic regions of KATM and ALAG; the geographic regions corresponded to visitor use monitoring location developed by SWAN. The server was then linked through ESRI ArcGIS to enable display of data using ArcMAP. Queries and the modified database were delivered back to the SWAN database manager upon completion of the project for future use.

4.9.5 Visitation Summary

Visitation to KATM and ALAG is limited in comparison to most NPS Units. To access KATM, most visitors elect to fly to the town of King Salmon via small aircraft, because road access is unavailable. Once at the park, most visitors view the park via floatplane or boat. Mean visitation from 2003-2012 was 50,884 individuals per year (Table 47, NPS 2013).

Table 47. KATM and ALAG (reported together in source) yearly visitors, 1923-2012 (NPS 2013).

Year	Visitors	Year	Visitors	Year	Visitors
1923	15	1974	11,900	1994	55,728
1924	17	1975	9,700	1995	0
1956	500	1976	10,400	1997	18,802
1957	600	1977	10,000	1998	45,470
1958	700	1978	11,300	1999	51,399
1959	1,100	1979	10,659	2000	71,389
1960	600	1980	11,824	2001	67,038
1961	600	1981	13,115	2002	59,025
1962	300	1982	14,377	2003	51,589
1963	700	1983	11,182	2004	56,787
1964	500	1984	20,074	2005	54,274
1965	800	1985	25,142	2006	68,630
1966	900	1986	41,663	2007	82,634
1967	1,200	1987	38,212	2008	7,970
1968	1,600	1988	45,710	2009	43,035
1969	7,800	1989	40,247	2010	55,172
1970	11,800	1990	40,778	2011	48,939
1971	9,600	1991	41,417	2012	39,818
1972	11,900	1992	46,196		
1973	8,400	1993	53,421		

Total visitor days for CUA activities within KATM decreased since 2005 (Figure 41). In ALAG, total visitor days were stable from 2005-2009. ALAG experienced a peak in visitor days in 2010 (22,134 visitor days), but visitor days dropped dramatically in 2011 and 2012 (5 and 8 visitors, respectively) (Figure 42). Geographically, visitation primarily takes place in the northwestern portion of the park. The southern portion of the park experiences little visitation (Plate 43).

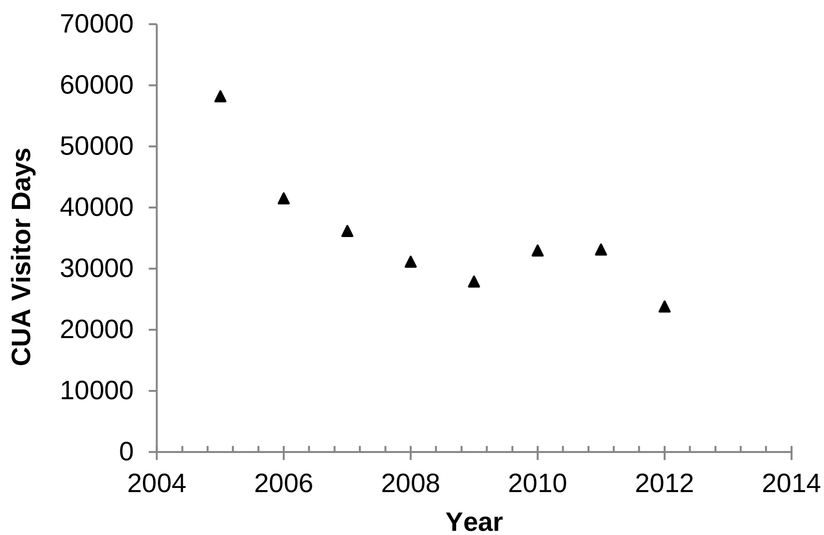

Figure 41. Total visitor days from CUA activities in KATM, 2005-2012 (NPS 2012).

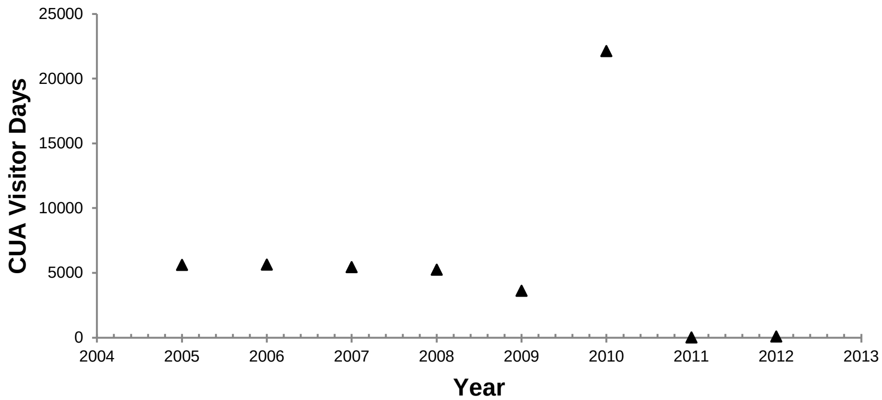

Figure 42. Total visitor days from CUA activities in ALAG, 2005-2012 (NPS 2012).

For CUA activities within KATM, sport fishing, bear viewing, and air taxi were the primary activities (61%, 20%, and 15% of all visitor days within the park from 2005-2012, respectively) (Table 48, NPS 2012). The definition of "air taxi", in this context, means the visitor has been dropped off at the location via an airplane. The "air taxi" visitor's intention (bear viewing, hunting, fishing, etc…), however, is unknown. For the visitor use monitoring locations in KATM, sport fishing was the predominant activity for 33 of the locations, while bear viewing was the predominant activity for 14 (Plate 44, Table 49). Sport fishing was the predominant CUA activity for all visitor use monitoring locations in ALAG, and accounted for 86 percent of the total visitor days within ALAG through CUA operations from 2005-2012 (Table 50,Table 51).

Geographically, the northwest portion of KATM and ALAG are the most visited areas (Plate 43). These areas are relatively easier to access than other locations in the parks, and the primary CUA activity is sport fishing. Along the coast, bear viewing is the primary CUA activity (Plate 44). The southernmost visitor use monitoring locations in KATM experience little CUA activity.

Table 48. Visitor days according to primary activity for CUA operators in KATM, 2005-2012 (NPS 2012).

Primary Activity	Total Visitor Days	Percent Visitor Days
Sport Fishing	175,823	61
Bear Viewing	57,056	20
Air Taxi	44,838	15
Photography	2,202	<1
Not specified	1,985	<1
Backpacking/Camping Overnight	1,520	<1
Kayak Tour	706	<1
Boating Trip	595	<1
Hiking Tours	295	<1
Big Game Transporters	99	<1
Group Camping	84	<1
Charter Boat	26	<1
Incidental Hunt Transporters	12	<1

Table 49. Ranks of CUA activity within each visitor use monitoring location in KATM by total visitor hours, 2005-2012 (NPS 2012).

Location Name	Air Taxi	Backpacking / Camping Overnight	Boating Trip	Bear Viewing	Charter Boat	Group Camping	Hiking Tours	Big Game Transport	Incidental Hunt Transport	Kayak Tour	Photo-graphy	Sport Fishing	Not specified
Above Braids	-	-	-	-	-	-	-	-	-	-	-	1	-
American Creek	2	-	3	4	-	-	-	-	-	5	-	1	6
Battle Lake	-	-	-	-	-	-	-	-	-	-	1	-	-
Battle River	2	-	6	4	-	-	-	3	-	-	5	1	-
Bay of Islands	2	-	-	4	6	-	6	-	-	3	-	5	1
Below Braids	3	-	-	2	-	-	-	-	-	-	-	1	-
Big River	3	-	-	2	-	-	-	-	-	-	-	1	-
Brooks Camp	1	5	10	2	-	8	6	-	-	8	4	3	7
Cape Douglas	-	5	-	2	-	4	3	-	-	-	-	1	6
Contact Creek	2	-	-	3	-	-	-	4	-	-	4	1	-
Dakavak Bay	3	-	-	2	-	-	-	-	-	-	-	1	-
Dakavak Lake	-	-	-	-	-	-	-	-	-	-	-	1	-
Douglas River	-	-	-	1	-	-	-	-	-	-	-	-	-
Fourpeaked Area	-	-	-	1	-	-	-	-	-	-	-	-	-
Funnel Creek	3	-	-	2	-	-	-	-	-	-	-	1	-
Funnel Creek Area	3	5	-	2	-	-	-	-	-	-	4	1	6
Geographic/ Amalik	6	7	-	1	8	-	-	-	-	5	2	3	4
Grosvenor Camp	2	-	-	3	-	-	-	-	-	5	-	1	4
Hallo Bay	5	4	-	1	-	-	-	-	-	-	3	6	2
Hallo Glacier	-	-	-	1	-	-	-	-	-	-	-	-	-
Hammersly Area	2	-	-	-	-	-	-	-	-	-	-	1	-
Headwater Creek	2	-	-	3	-	-	-	-	-	-	-	1	-
Idavain Creek	3	-	-	2	-	-	-	-	-	-	-	1	4
Idavain Lake	-	-	-	-	-	-	-	-	-	-	-	1	-
Kaflia Bay	3	-	-	1	-	-	-	-	-	2	-	-	-

Table 49. Ranks of CUA activity within each visitor use monitoring location in KATM by total visitor hours, 2005-2012 (NPS 2012). (continued)

Location Name	Air Taxi	Backpacking / Camping Overnight	Boating Trip	Bear Viewing	Charter Boat	Group Camping	Hiking Tours	Big Game Transport	Incidental Hunt Transport	Kayak Tour	Photo-graphy	Sport Fishing	Not specified
Kamishak River	2	-	-	-	-	-	-	-	-	-	-	1	-
Kashvik Bay	2	-	-	-	-	-	-	-	-	-	3	1	4
Katmai Bay	1	-	-	1	-	-	-	-	-	-	-	-	-
Kinak Bay	-	-	-	1	-	-	-	-	-	-	2	-	-
Kukak Bay	5	-	-	1	6	-	-	-	-	-	3	2	4
Kukak River	-	-	-	1	-	-	-	-	-	-	-	-	-
Kukaklek Lake	1	-	-	-	-	-	-	2	-	-	-	-	-
Kukaklek Outlet	2	-	3	-	-	-	-	4	-	-	-	1	-
Kulik Lake	-	-	-	-	-	-	-	-	-	-	-	1	-
Kulik River	2	-	-	4	-	-	5	-	-	-	-	1	3
Lake Brooks	1	-	-	-	-	-	-	-	-	-	-	-	-
Lake Camp Area	-	-	-	2	-	-	-	-	-	-	-	1	-
Lake Grosvenor Area	1	-	-	-	-	-	-	-	-	-	-	-	-
Margot Creek	5	-	-	2	-	-	-	-	-	4	6	1	3
Misty Lagoon	-	-	-	1	-	-	-	-	-	-	-	-	-
Moraine Creek	3	-	-	2	-	-	-	-	4	-	-	1	-
Moraine Drainage	3	-	7	2	-	-	-	6	-	-	5	1	4
Morraine Creek	-	-	-	2	-	-	-	-	-	-	-	1	-
Naknek Lake	4	-	-	-	-	-	-	-	-	2	3	1	-
Naknek River	3	2	-	-	-	-	-	4	-	4	6	1	-
Nanuktuk Creek	2	-	-	-	-	-	-	-	-	-	-	1	-
Nonvianuk Lake	2	-	-	-	-	-	-	3	-	-	-	1	-
Nonvianuk Outlet	2	-	3	-	-	-	-	-	-	-	-	1	-
Other:	3	6	-	4	-	-	-	-	-	5	-	1	2
Other: Kinak Bay	-	-	-	1	-	-	-	-	-	-	-	-	-

Table 49. Ranks of CUA activity within each visitor use monitoring location in KATM by total visitor hours, 2005-2012 (NPS 2012) (continued).

Location Name	Air Taxi	Backpacking / Camping Overnight	Boating Trip	Bear Viewing	Charter Boat	Group Camping	Hiking Tours	Big Game Transport	Incidental Hunt Transport	Kayak Tour	Photo-graphy	Sport Fishing	Not specified
Other: Little Ku	-	-	-	-	-	-	-	-	-	-	-	1	-
Other: Mirror Lake	1	-	-	2	-	-	-	-	-	-	-	-	-
Savonoski River	5	-	1	-	-	-	6	-	-	2	-	3	4
Swikshak Bay	-	-	-	1	-	-	-	-	-	-	-	-	-
Swikshak Lagoon	4	-	-	1	-	-	-	-	-	-	-	2	3
Valley of 10000 Smokes	4	1	-	3	-	5	2	-	-	-	7	8	6

Table 50. Visitor days according to primary activity for CUA operators in ALAG, 2005-2012 (NPS 2012).

Primary Activity	Sum	Percent Visitor Days
Sport Fishing	40,925	86
Not Specified	3,703	8
Boating Trip	2,028	4
Air Taxi	810	2
Photography	84	<1
Bear Viewing	77	<1
Kayak Tour	48	<1
Backpacking/Camping	24	<1
Other	8	<1
Big Game Transport	5	<1

Table 51. Ranks of CUA activity within each visitor use monitoring location in ALAG by total visitor hours, 2005-2012 (NPS 2012).

Location Name	Air Taxi	Backpacking/ Camping	Boating Trip	Bear Viewing	Other	Big Game Transport	Kayak Tour	Mountain-eering	Photo-graphy	Sport Fishing	Not Specified
Above Braids	3	4	2	-	-	-	-	-	-	1	-
Below Braids	3	-	2	4	-	-	-	-	-	1	-
In Braids	-	-	2	4	-	-	-	-	3	1	-
Nonvianuk R. Confluence	3	-	2	-	-	4	-	-	-	1	-
Other:	4	-	3	6	7	-	5	-	-	1	2

Primary CUA Activity Summary

As previously noted, air taxi, bear viewing, and sport fishing are the three most prominent CUA activities within KATM, in terms of visitor days spent in the park. Both air taxi and bear viewing CUA activities experience a peak in visitor days during the month of July, whereas sport fishing total visitor days peak in August, with a mean of 8,920 visitor days during that month from 2005-2012 (Figure 43). Sport fishing also accounts for the greatest number of clients brought into the park each year, with peak client counts coming in August as well. Bear viewing and air taxi client counts peak in the month of July (Figure 44).

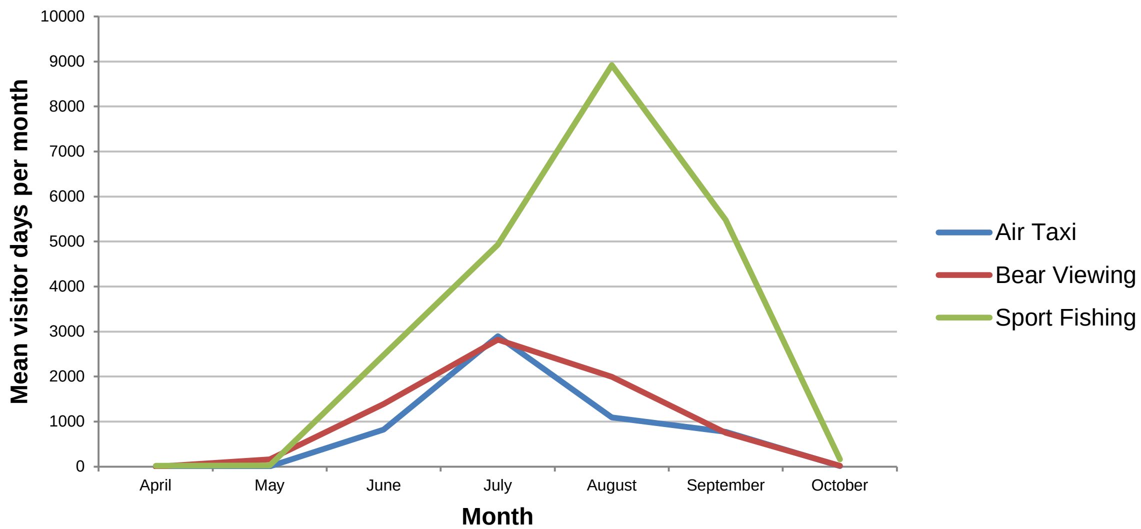

Figure 43. Mean monthly visitor days for the three primary CUA activities in KATM (air taxi, bear viewing, and sport fishing), 2005-2012 (NPS 2012).

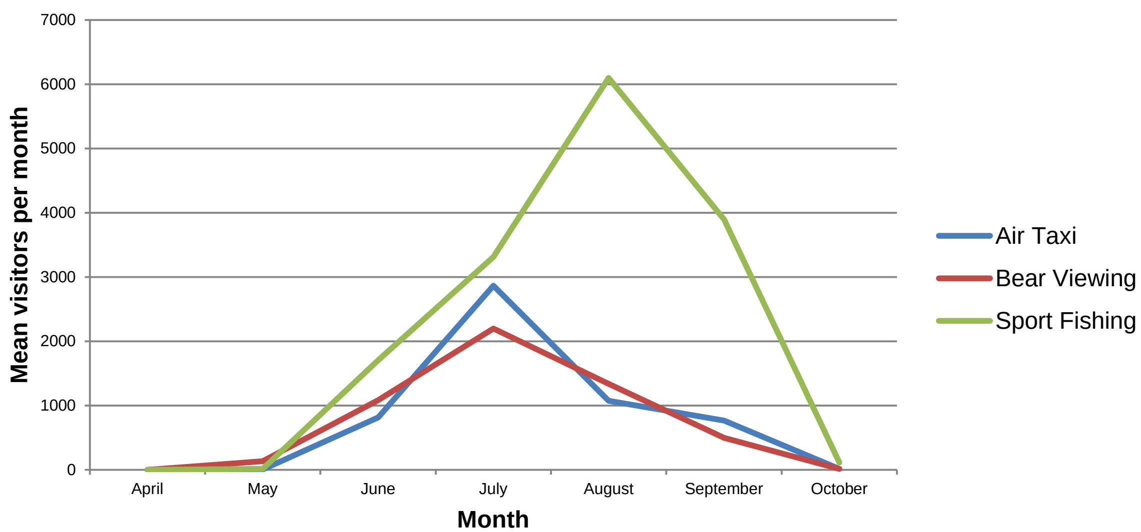

Figure 44. Mean monthly client count for the three primary CUA activities in KATM (air taxi, bear viewing, and sport fishing), 2005-2012 (NPS 2012).

Potential Use Conflict – Hunted Park Areas

KATM/ALAG staff requested an analysis of areas where hunting could conflict with other visitor use activities in the park. Hunting is permitted in the Preserve portion of KATM; the Preserve intersects 13 different visitor use monitoring locations utilized in the CUA database (Plate 45). Big game hunting seasons begin in August, with moose and bear being the two species most hunted (see the Moose [Chapter 4.2] and Bear [Chapter 4.3] chapters for information regarding harvest of these species).

During the primary hunting seasons (August-October; no CUA activity recorded from 2005-2012 during December or January), sport fishing and bear viewing were the primary CUA activities within visitor use monitoring areas that allowed hunting. Rates of all CUA activities are higher in August than in September and October, with the exception of big game transport (Table 52).

Table 52. August, September, and October CUA activity within hunted SWAN Visitor Use Monitoring Areas, 2005-2012 (NPS 2012).

	August		September		October	
Activity	**Visitor Days**	**Total Visitors**	**Visitor Days**	**Total Visitors**	**Visitor Days**	**Total Visitors**
Air Taxi	703	672	319	269	10	10
Backpacking/Camping Overnight	5	5	-	-	-	-
Boating Trip	545	145	32	32	-	-
Bear Viewing	2,789	2,256	363	336	-	-
Big Game Transport	-	-	60	44	-	-
Photography	135	54	24	24	-	-
Sport Fishing	41,313	33,630	23,048	19,750	592	592
Not Specified	38	38	45	18	-	-

The Moraine Drainage visitor use monitoring area is the most visited of all monitoring areas from August-September, 2005-2012 (Table 53). The Moraine Drainage is also the most diverse monitoring area regarding activity type, with visitors participating in seven different types of activities during hunting seasons. The Braids monitoring locations in ALAG (Above Braids, Below Braids, In Braids) are popular sport fishing areas, with many multi-day fishing trips operating within those areas. Overall, bear viewing and sport fishing appear to offer the largest potential for user conflict during hunting seasons, especially in the Braids area of ALAG and Moraine Drainage in KATM.

Table 53. August CUA activities within hunted SWAN Visitor Use Monitoring Areas, 2005-2012 (NPS 2012).

Location Name	Activity	Visitor Days	Total Visitors
Above Braids	Air Taxi	25	22
	Boating Trip	105	15
	Sport Fishing	1,086	538
Battle River	Air Taxi	20	20
	Sport Fishing	4,200	3,957
Below Braids	Air Taxi	106	106
	Boating Trip	105	15
	Sport Fishing	7,446	2,291
Funnel Creek Area	Air Taxi	58	58
	Backpacking/Camping Overnight	5	5
	Bear Viewing	710	616
	Photography	34	34
	Sport Fishing	3,017	3,017
In Braids	Boating Trip	105	15
	Bear Viewing	17	17
	Photography	84	12
	Sport Fishing	276	51
Kukaklek Lake	Air Taxi	6	6
Kukaklek Outlet	Air Taxi	25	25
	Boating Trip	70	70
	Sport Fishing	3,635	3,599
Moraine Drainage	Air Taxi	195	179
	Boating Trip	10	10
	Bear Viewing	2,062	1,623
	Photography	17	8
	Sport Fishing	15,436	14,533
	Not Specified	38	38
Nanuktuk Creek	Air Taxi	4	4
	Sport Fishing	4,411	4,275
Nonvianuk Lake	Air Taxi	4	4
	Sport Fishing	72	72
Nonvianuk Outlet	Air Taxi	176	165
	Boating Trip	45	5
	Sport Fishing	1,357	1,240
Nonvianuk R. Confluence	Air Taxi	84	83
	Boating Trip	105	15
	Sport Fishing	377	57

Table 54. September CUA activities within hunted SWAN Visitor Use Monitoring Areas, 2005-2012 (NPS 2012).

Location Name	Activity	Visitor Days	Total Visitors
Above Braids	Air Taxi	24	9
	Sport Fishing	255	120
Battle River	Air Taxi	47	37
	Bear Viewing	21	21
	Big Game Transport	31	31
	Photography	17	17
	Sport Fishing	4,976	4,806
Below Braids	Air Taxi	90	90
	Sport Fishing	3,551	629
Funnel Creek Area	Air Taxi	35	11
	Bear Viewing	12	12
	Sport Fishing	1,461	1,461
Kukaklek Outlet	Air Taxi	18	20
	Boating Trip	32	32
	Big Game Transport	8	4
	Sport Fishing	2,586	2,586
Moraine Drainage	Air Taxi	29	26
	Bear Viewing	330	303
	Big Game Transport	16	4
	Photography	7	7
	Sport Fishing	6,489	6,428
	Not Specified	45	18
Nanuktuk Creek	Sport Fishing	2,167	2,167
Nonvianuk Lake	Air Taxi	14	14
	Sport Fishing	49	49
Nonvianuk Outlet	Air Taxi	44	44
	Sport Fishing	1,497	1,497
Nonvianuk R. Confluence	Air Taxi	18	18
	Big Game Transport	5	5
	Sport Fishing	17	7

Table 55. October CUA activities within hunted SWAN Visitor Use Monitoring Areas, 2005-2012 (NPS 2012).

Location Name	Activity	Visitor Days	Total Visitors
Battle River	Sport Fishing	146	146
Below Braids	Sport Fishing	12	12
Kukaklek Outlet	Air Taxi	7	7
	Sport Fishing	154	154
Moraine Drainage	Air Taxi	3	3
	Sport Fishing	6	6
Nonvianuk Lake	Sport Fishing	9	9
Nonvianuk Outlet	Sport Fishing	265	265

Threats and Stressor Factors

Threats and stressors do not apply to this component.

Data Needs/Gaps

In order to allow for future comparison, yearly updates of the CUA database are important for maintaining the integrity and quality of the database.

Summary

Geographically, the remoteness of KATM and ALAG make visitation expensive and time consuming. Hence, these parks are two of the least visited NPS Units. Visitors that do visit KATM and ALAG often choose to experience bear viewing or sport fishing as a primary activity and air taxi is a primary mode of transport for many visitors. Brooks Camp and the coast are popular locations for bear viewing, and the northwest portion of the park experiences relatively large sport fishing pressure when compared to other park monitoring locations. The southern portion of KATM experiences little visitation, due to the difficulty of travel.

4.9.6 Sources of Expertise

Russ Frith, SWAN Data Manager Assistant

Tim Shepherd, SWAN Data Manager

Michael Shephard, SWAN Program Manager

4.9.7 Literature Cited

Fay, G., and S. Colt. 2007. Southwest Alaska Network Long-Term Visitor Use Monitoring Protocol Development Final Report. Southwest Alaska Network. National Park Service. Anchorage, AK.

National Park Service (NPS) 2012. SWAN Commercial Use Authorization Database. Delivered by Tim Shepherd, SWAN Data Manager.

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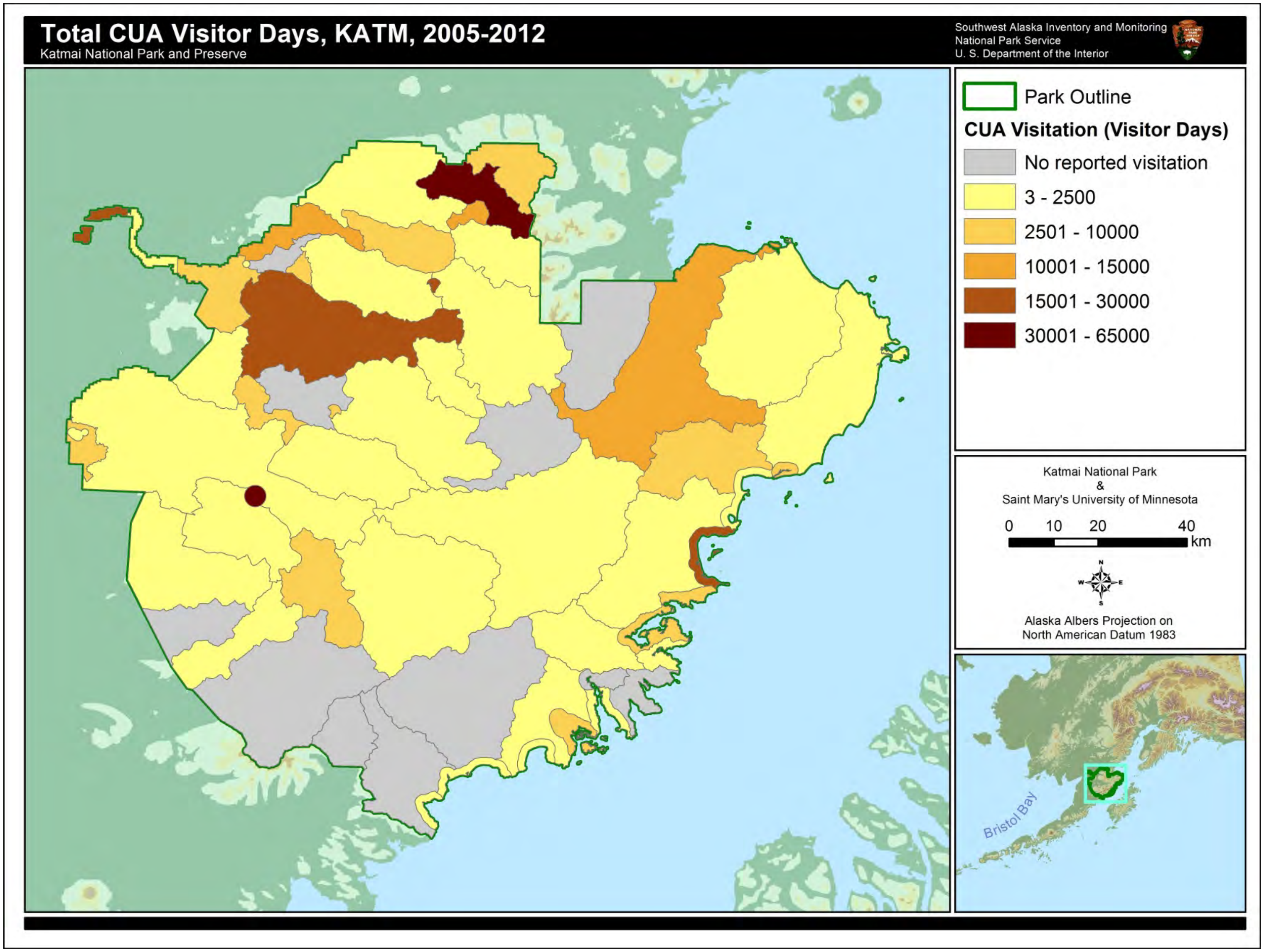

Plate 43. Total CUA visitor days by visitor use monitoring location, 2005-2012, KATM (NPS 2012).

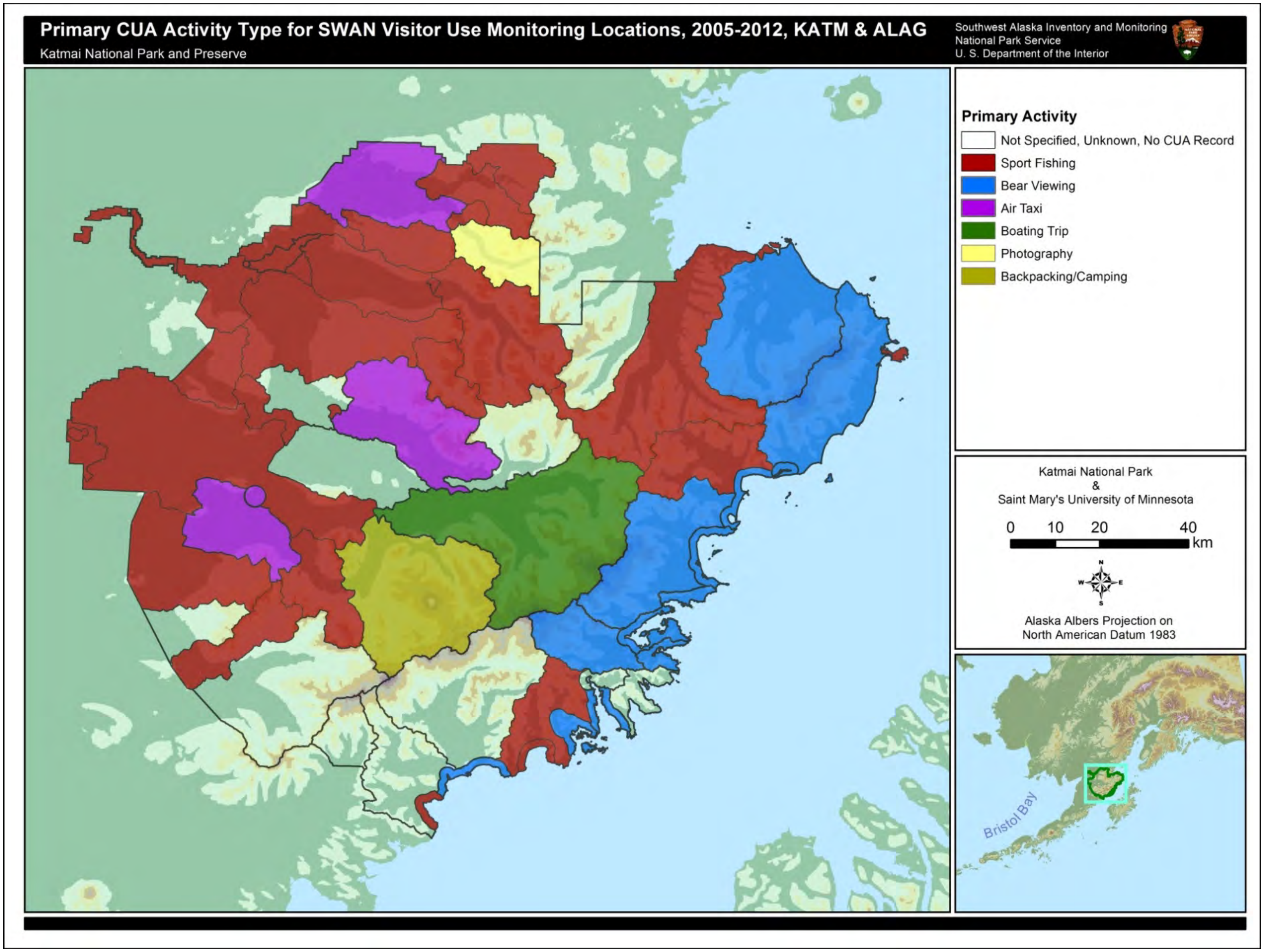

Plate 44. Primary CUA Activity Type for SWAN Visitor Use Monitoring Locations, 2005-2012, KATM (NPS 2012).

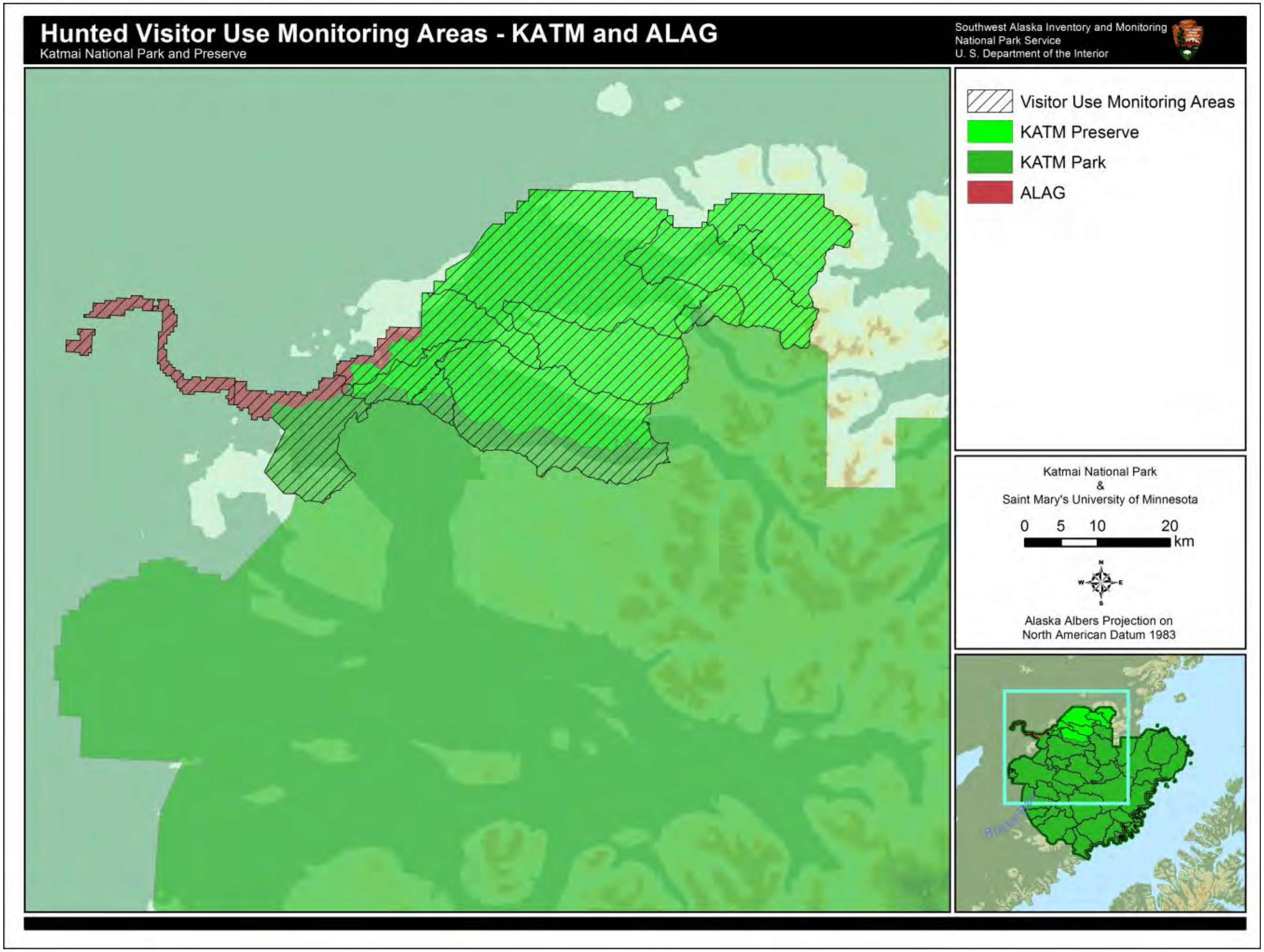

Plate 45. Hunted SWAN visitor use monitoring areas, KATM and ALAG.

4.10 Glacial Extent

4.10.1 Description

Glaciers are large persistent bodies of ice that flow under the influence of gravity (Photo 15; Marshak 2005). The formation of a glacier requires three conditions: abundant snowfall, cool summer temperatures, and the gravitational flow of ice (NPS 2010). Aerial photography datasets from the early 1980s indicates that glaciers and permanent snow fields covered about 6% of the 16,591 km^2 (6,406 mi^2) of KATM (Giffen and Lindsay 2011). In 2009, 264 glaciers originate, are completely enclosed, or are partly within KATM (Table 57, Arendt et al. 2012); these glaciers cover 908.4 km^2 (350.7 mi^2) of the KATM landscape (Arendt et al. 2012). Glaciers are an important part of the KATM ecosystem. As glaciers recede, vegetation colonizes and in some cases, salmon populations colonize associated streams and lakes. Streams and wetlands are fed by the hydrologic inputs provided by glaciers. Primary glaciation areas include the Mount Douglas area, Kukak Volcano to Mount Katmai area, and the Mount Martin and Mount Mageik area (Plate 46). Several glaciers of the Mount Martin and Mount Mageik area are uniquely covered with a thick layer of volcanic ash. Volcanic ash was deposited in this glacierized area when Mount Novarupta erupted in1912. Frequent and persistent winds continue to redistribute volcanic ash across the landscape (Giffen and Lindsay 2011). Glaciers in KATM mainly terminate on land, although two glaciers terminate into large lakes (Giffen et al 2007).

Photo 15. Ash-covered glacier on the slopes of Mount Katmai (NPS Photo).

Glaciation begins with the accumulation of fresh, loosely packed snow containing 90% air, due to the space created by its hexagonal crystals (Marshak 2005). As new layers of snow accumulate on top of the old snow, pressure increases from the weight, squeezing out air pockets and, over time, transforming the snow into a packed granular material called firn, which contains only 25% air (Marshak 2005). As melting occurs, water recrystallizes in the spaces between grains until the firn is transformed into a solid mass of glacial ice containing only 20% air (Marshak 2005).

Glacier mass balance studies determine the difference between the annual accumulation and ablation (all processes that remove mass, i.e., sublimation, melting, and calving) of a glacier during a mass balance year (Veins 1995, NPS 2010, Cogley et al. 2011). A mass balance year is 12 months long, beginning during the accumulation season and lasting until the end of the ablation season (Cogley et al. 2011). A mass balance year is dependent upon elevation and some glacial areas in southwest Alaska can experience ablation until late November and accumulation into late August, for simplicity a mass balance year is often tied into the water year (Chuck Lindsay pers. com., 2012). If the rate of accumulation is higher than that of ablation, the glacier will, thicken, advance or both. However, if the rate of ablation is higher than that of the accumulation, the glacier will retreat (Marshak 2005). The accumulation zone is the area on a glacier where more mass is gained than lost, whereas the area where more mass is lost than gained is known as the ablation zone (Figure 45, Cogley et al. 2011). The accumulation area ratio (AAR) represents the ratio of the accumulation zone to the area of the glacier at the end of a mass balance year (Cogley et al. 2011). Mass balance studies can provide information on the stability of glaciers, runoff predictions, and a measurement of climatic variation and trends (Muirhead 1978).

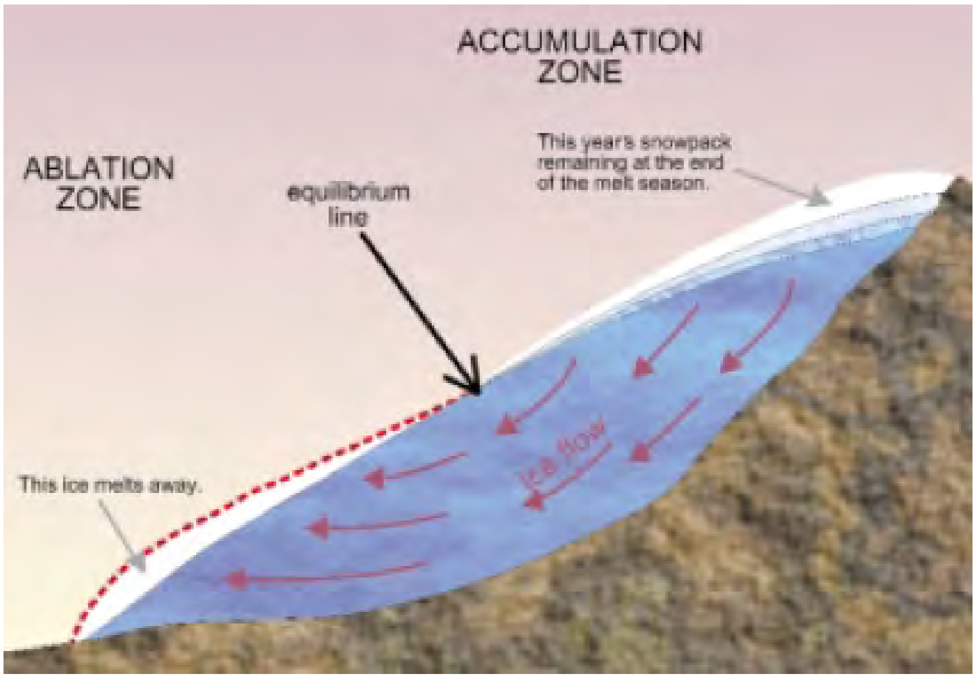

Figure 45. Illustration of a glacier showing the accumulation zone, ablation zone, and equilibrium line (Valentine et al. 2004).

Glacier firn lines define the boundary between the melting ablation zone and the snow-covered accumulation zone. Late summer is the end of the ablation season, and during this time, the late summer firn line reaches its highest elevation, called the annual firn line. The annual firn line is closely related to the equilibrium line, which separates the accumulation zone from the ablation zone (Figure 45, Muirhead 1978). The equilibrium line altitude (ELA) is the spatially averaged altitude of the equilibrium line at the end of a mass balance year (Cogley et al. 2011). The position of the firn line varies depending on the season. During winter, snow covers the entire glacier. As spring thaw occurs, the firn line moves up the glacier. The amount of accumulation and the ablation rate together determine how far the firn line will move up the glacier before the cycle repeats (Muirhead 1978).

To uphold the park's enabling legislation, the Southwest Alaska Network (SWAN) Inventory and Monitoring (I&M) Program has identified "glacial extent" as a Vital Sign in KATM. Utilizing Landsat satellite imagery to monitor glaciers on a park-wide scale, the objective of this Vital Sign is to map the glacial extent boundary on a repeating decadal scale and thus identify areas where glacial cover is stable, growing, or shrinking, and estimate rates of change (Bennett et al. 2006). Glacial processes are complex. The measures identified in this assessment represent some of the metrics used to understand the overall condition of glaciers in KATM.

4.10.2 Measures

- Area
- Rate of terminus retreat
- Mass balance (surface elevation)
- Late summer season firn line
- Glacial lake outburst floods

4.10.3 Reference Conditions/Values

Landsat data (1974, 1986/87, 2000), aerial photography, historic photographs and maps acquired by scientists during early investigations of the park's glaciers provide a baseline for the condition of glaciers in KATM (Giffen et al. 2007).

4.10.4 Data and Methods

Giffen et al. (2007) mapped and compared the extent of ice fields and glaciers in KATM by creating GIS polygons from Landsat imagery collected in 1974, 1986/87, and 2000. Where available, higher resolution satellite imagery and aerial photography were used to assist in the interpretation of the Landsat data. The goal of this publication was to identify the previously undocumented behavior of KATM decrease (Giffen et al. 2007).

Arendt et al. (2012) provides glacial extent data based on the interpolation of topographic maps from the 1950's and satellite imagery from the late 2000's.

4.10.5 Current Condition and Trend

<u>Area</u>

Giffen et al. (2007) reported a heavy moraine cover on KATM glaciers. Some glaciers with debris covered termini are advancing, however, heavy moraine cover is most often associated with glaciers that are in recession (Arendt et al. 2012, Giffen et al. 2007). Using Landsat data, image processing software, and GIS, it was determined that glacier cover in KATM decreased by 76 km^2 (29 mi^2 or 7.7 %) between 1986 and 2000 (Table 56).

Table 56. Glacial extent and change in glacial cover for glaciers located in KATM between 1986 and 2000. Data collected using landsat images and measured in km^2. Table compiled from Giffen et al. (2007).

Glacial ice measured in km^2	1986/87	2000	1986/87-2000 change in glacial cover	% change
Mount Douglas area	347.74	330.18	-17.57	-5.10
Mount Katmai, Snowy Mountain, Kukak Volcano area	563.46	509.85	-53.6	-9.50
Mount Mageik Mount Martin	74.32	69.72	-4.6	-6.20
Glacier ice within park boundary	985.52	909.75	-75.77	-7.70

*The data above reflect the removal of areas represented by nunataks or other areas barren of glacier ice but inside of the mapped boundary of glacier extent.

Satellite based glacier boundary mapping efforts by Arendt et el. (2012) indicate that glaciers covered 6.4% of the total land area in KATM during the mid-1950s (derived from 1:63360 scale USGS quadrangle maps). In the 1950s to 2009 timeframe, glaciated area had reduced by 15% covering 5.4% or 908.4 km^2 (351.7 mi^2) of KATM in 2009.

Table 57. Summary statistics for glaciers in KATM. Table compiled from Arendt et al. (2012).

Time period	Number of glaciers	Total glacier area (km^2)	Estimated volume (km^3)*
Map date (1956)	258	1066	714
Modern (2009)	264	908.7	587
Absolute change	6	-155	-127
Percent change	2	-15	18

*volumes and volume changes are preliminary and subject to change. They are derived from area/volume scaling (Bahr et al. 1997) using coefficient/exponent values of 0.2055/1.375 from Radic and Hock (2010).

Rate of Terminus Movement

Glaciers within KATM have been showing terminus movement since the 1950s (Table 58). Giffen et al. (2007) reported noticeably faster terminus movement of interior glaciers compared to coastal glaciers from 1987 to 2000. Glacial movement within KATM between 1951 and 1986 was similar for coastal and interior glaciers (Giffen et al. 2007). From 1986 to 2000, the rate of terminus movment for all glaciers measured slowed from rates identified between 1951 and 1987 (Giffen 2007).

Table 58. Glacial terminus movement in KATM. Table compiled from Giffen et al. (2007).

Glacier ID	Change (m) 1951-	Mean annual rate of change (m/yr)	Change (m) 1951-2000	Mean annual rate of change (m/yr)	Change (m) 1986/87-	Mean annual rate of change (m/yr)
A (Spotted Glacier)*	-1186	-33	-1452	-30	-266	-20
B*	-760	-21	-871	-18	-11	-9
C*	-869	-24	-832	-17	37	3
D*	-452	-13	-728	-15	-276	-21
E#	-383	-11	-511	-10	-128	-10
F (Fourpeaked Glacier)#	-3432	-95	-3595	-73	-163	-13
G (Hook Glacier)*	-633	-18	-1212	-25	-579	-45
H*	-332	-18	-1062	-22	-430	-33
I*	-189	-5	-671	-14	-482	-37
J#	101	3	-47	-1	-148	-11
K#	88	2	69	1	-19	-1
L#	108	3	-19	0	-127	-10
M#	-541	-15	-615	-13	-74	-6
N#	-1105	-31	-1357	-28	-252	-19
O#	-1182	-33	-1298	-26	-116	-9
P (Hallo Glacier)#	-916	-25	-766	-16	150	12
Q#	-68	-2	-166	-3	-98	-8
R#	-432	-12	-735	-15	-303	-23
S (Knife Creek Glacier)*	176	5	95	2	-81	-6
T (Serpents Tongue Glacier)*	-1276	-35	-1276	-26	0	0
Average rate of terminus change	-679.2	-18.9	-852.5	-17.4	-173.3	-13.3
North and west flowing (Interior)*	-646.778	-18.0	-889.889	-18.2	-243.111	-18.7
South and east flowing (Coastal)#	-705.636	-19.6	-821.818	-16.8	-116.182	-8.9

* Indicates north and west flowing interior glaciers

# Indicates south and east flowing coastal glaciers.

Mass Balance (Surface Elevation)

Currently no data are available regarding the mass balance of glaciers in KATM.

Late Summer Season Firn Line

Currently no data are available regarding late season firn line for KATM.

Glacial Lake Outburst Floods

A glacial lake outburst flood has never been reported in KATM.

Threats and Stressor Factors

Climate Change

Climate is one of the most important factors influencing ecosystems. In Alaska, climate is constantly fluctuating on multiple temporal scales, including several natural cycles. One climate fluctuation of particular importance in Alaska is the Pacific Decadal Oscillation (PDO) (Lindsay 2011). Mantua et al. (1997) formally identified this pattern of climate variability in a study relating climate oscillation to salmon production. The PDO, which is related to sea surface temperatures in the northern Pacific Ocean, affects atmospheric circulation patterns and alternates between positive and negative phases (Wendler and Shulski 2009). A positive phase is associated with a relatively strong low pressure center over the Aleutian Islands, which moves warmer air into the state, particularly during the winter (Wendler and Shulski 2009). Some of the variation in Alaska's climate over time can be explained by major shifts in the PDO which occurred in 1925 (negative to positive), 1947 (positive to negative), and 1977 (negative to positive) (Mantua et al. 1997). Hartmann and Wendler (2005) found that much of the warming that occurred in Alaska during the last half of the twentieth century was likely due to the PDO shift in 1976-77.

Over the time period of 1949 to 2008 an increase of summer and winter temperatures was reported from two different long-term climate stations located in SWAN park regions (Lindsay 2011). The mean annual temperature over this time period has increased by 3.8°F in King Salmon, Alaska and 4.0°F in Homer, Alaska (Lindsay 2011). SWAN park region average annual temperatures are estimated to increase by about 0.9-1.1˚ F per decade (SNAP 2008).

Data Needs/Gaps

Giffen et al. (2007) identified glacial extent and determined that terminus retreat was occurring in KATM. Further study of glacial extent and terminus retreat will be done every 10 years in an effort to develop trends for the region (Giffen and Lindsay 2011). (Pers.Com. Chuck Lindsay) suggests that volume change data for KATM glaciers is the most obtainable and important data need. Currently no data exist for glaciers in KATM regarding mass balance, late summer season firn line, or glacial lake outburst flood events.

Overall Condition

Area

Giffen et al. (2007) observed that most glaciers in KATM from 1951-2000 showed steady retreat but some ash covered glaciers changed very little or showed no change. A reduction of 76 km^2 (29 mi^2) or 7.7% of the total glacial area was observed from 1987-2000 analyses (Giffen et al. 2007). In separate but complimentary glacier mapping efforts, Arendt et al. (2012) also reports a decrease in glacial area in KATM of 155km^2 (60 mi^2) from 1956 to 2009. Glacier mapping is scheduled to be repeated every 10 years in KATM to monitor the glacial extent of the region (Giffen and Lindsay 2011).

Rate of Terminus Retreat

Combined data for terminus glacial retreat between 1951 and 2000 show that coastal glaciers and interior glaciers had similar recession rates over that time: 17 m/year and 18 m/year, respectively. However, observations from 1987-2000 identified that coastal glaciers were receding at 9 m/year and interior glaciers at 19 m/year (Giffen et al. 2007). Arendt et al. (2012) adds that some glaciers still heavily covered in ash from the eruption of Mount Novarupta are advancing.

Mass Balance (surface elevation)

Mass balance studies focus on documenting change in a glacier's volume (mass) over time by analyzing volume, area, and elevation change. Glacial mass balance studies provide information that can indicate changes in regional climates. No studies have been conducted to identify the mass balance of glaciers in KATM.

Late Summer Season Firn Line

Measuring the average elevation of the late season firn line of a region over time can also provide insight into climate trends. An increase or decrease in the elevation of late season firn line over many years or decades can indicate changes in the regional and local climate. No studies have been conducted to collect late season firn line data in KATM.

Glacial Lake Outburst Floods

A glacial lake is created when a glacier dams melt water in, on, beneath, or behind glacial ice. The failure of the glacial dam releases this melt water, creating an outburst flood. Outburst floods cause an increase in water discharge over a few days, but can last up to two weeks (NPS 2008). The occurrence of an outburst flood can cause hazardous boating conditions, an increase in iceberg calving, standing waves, strong currents, and redistribution of sediments and debris (NPS 2008). Glacial lake outburst floods have not been reported at KATM.

Summary

Summer and winter average temperatures have been increasing in the KATM region for over 50 years. Higher average yearly temperatures have caused many of the glaciers in KATM to retreat. Average yearly temperatures are predicted to continue increasing in the SWAN parks region which would translate to continued retreat of the glaciers in KATM.

4.10.6 Sources of Expertise

Bruce Giffen, Alaska Regional Office Geologist, National Park Service.

Chuck Lindsay, Physical Science Technician, National Park Service.

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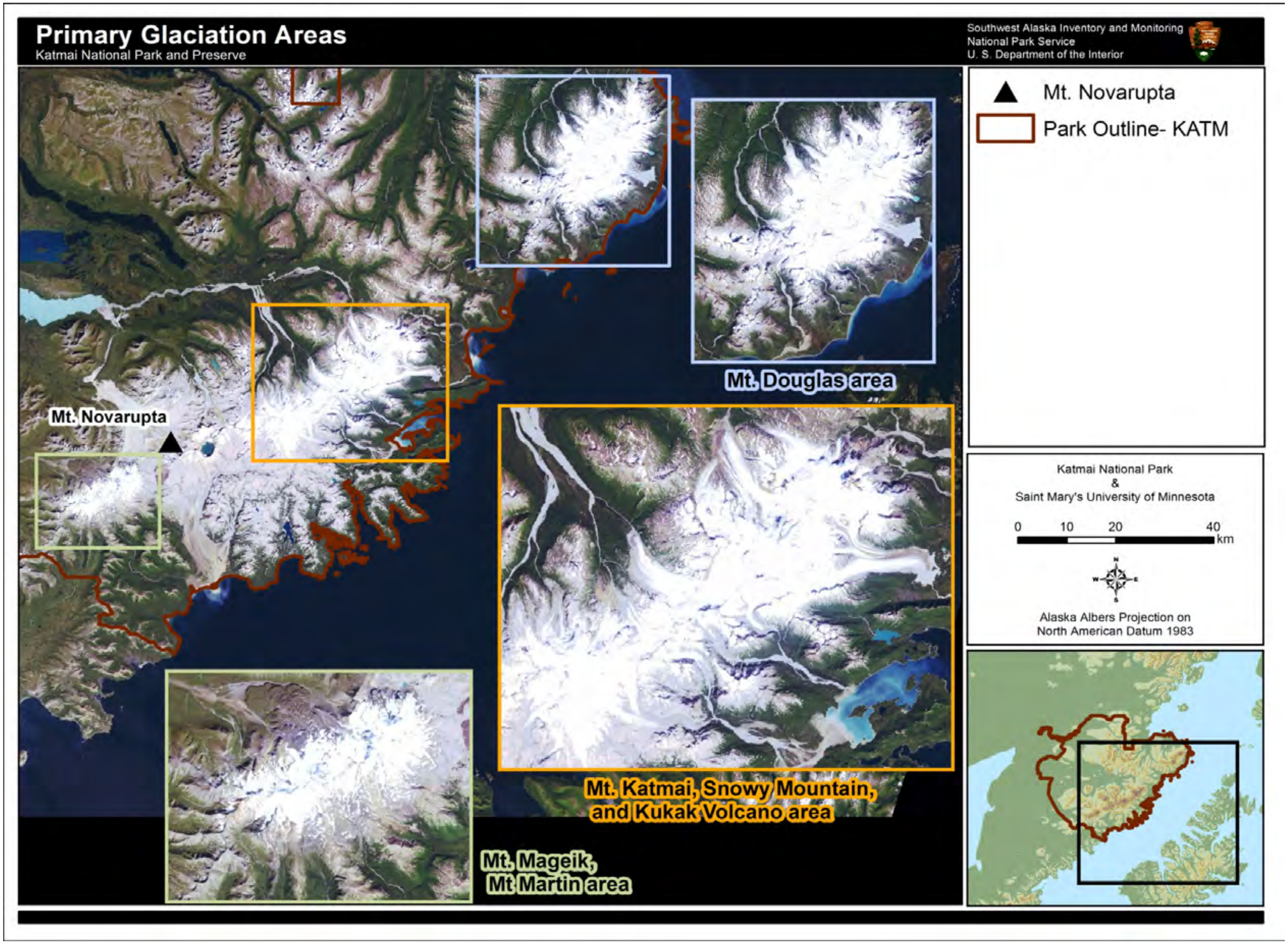

Plate 46. Primary glaciation areas in Katmai National Park and Preserve.

4.11 Water Quality

4.11.1 Description

Aquatic systems within SWAN NPS units are remote and pristine, providing researchers with an opportunity to examine the effects of man-made disturbances, namely climate change and atmospheric pollutants, on intact systems. Currently, water quality data for SWAN NPS units such as KATM and ALAG are minimal, but a monitoring plan for KATM exists. Specifically, SWAN intends to examine lake water quality parameters (Photo 16), both physical and chemical, along with data regarding other Vital Signs (e.g., surface hydrology, lake ice phenology, and glacial extent) to develop a more complete understanding of watershed dynamics (NPS 2012).

Photo 16. Water quality data collection in an Alaskan water body. (Photo from NPS).

Prior to analysis of this component, SWAN aquatic ecologist Claudette Moore (pers. comm. 2012) suggested that gathering existing data sources and producing data tables for future use was the most useful exercise for the NRCA. Through data and literature searches, past water quality reports for KATM and ALAG were collected and data were input into tables according to guidance from NPS contacts. Within this component section, a summary of data sources and tables are provided for the reader. Because recently collected data are minimal, an assessment of condition is not provided for this component.

4.11.2 Data and Methods

Tables referenced in the following data and methods description paragraphs are presented at the end of this document. Curran (2003) provided historical water quality data collected in fulfillment of the Water Quality Monitoring and Assessment Partnership Program initiated by the U.S. Geological Survey (USGS). A baseline measurement of water quality constituents was collected from the Alagnak River Basin including field determinations of temperature, pH, dissolved oxygen (DO), specific conductance (SpC), alkalinity, and bicarbonate. Lab determinations were also performed on inorganic constituents, major ions, nutrients, organic carbon, trace elements, and suspended sediments. The study also included bank erosion and boat wake monitoring in an effort to assess the effects and frequency of jet boat travel on the Alagnak River. The report focused on the hydrology and geomorphology of the Alagnak Basin and how human impacts have affected the region. The Alagnak River drains a large watershed totaling 3,600 km^2 in southwestern Alaska. The data were collected during studies conducted between 1999 and 2001, mainly focused below the confluence of the Alagnak River and the Nonianuk River. However, some sampling efforts occurred at the outlets of Kukaklek and Nonvianuk Lakes. Kukaklek Lake occupies 174 km^2 and Nonvianuk Lake comprises 132 km^2; the Alagnak River originates from these two lakes (Figure 46).

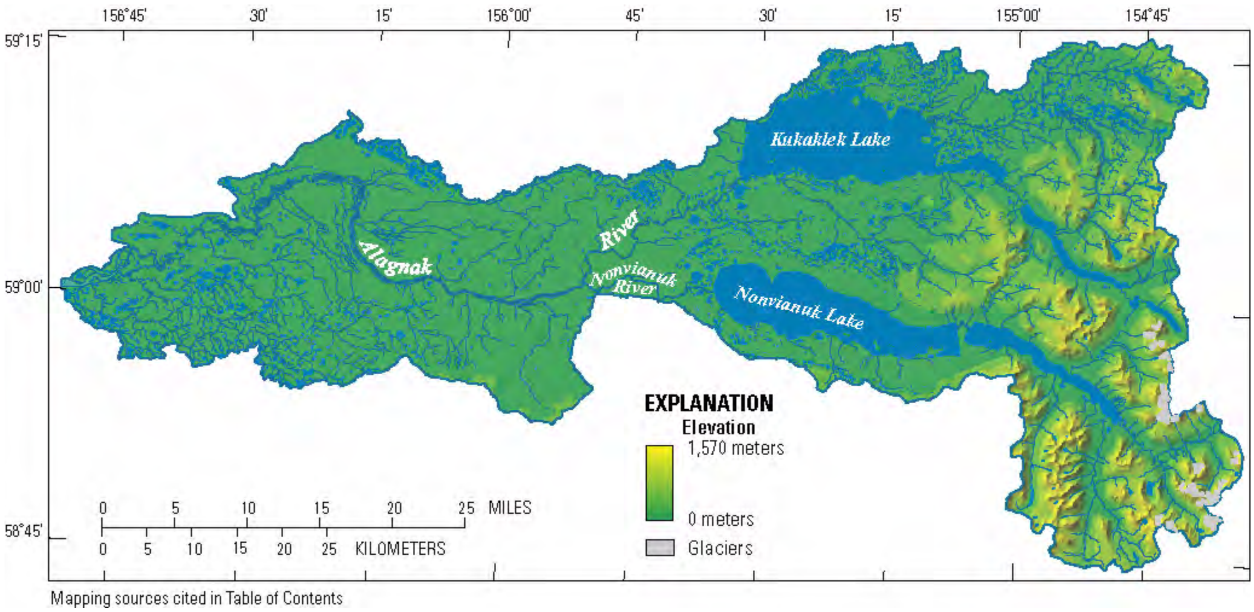

Figure 46. Topography of the Alagnak River Basin (from digital elevation model). Figure from Curran (2003).

LaPerriere (1996) provides water quality data for KATM water bodies from 1990-1992. These data include lake and stream ion balances, metals sampling, and light, as well as characteristics associated with light parameters (Table 59-Table 72).

Kim et al. (1969) conducted a ground water quality summary for regions across Alaska. A summary table was compiled that includes the regions sampled, locations of sampling sites in latitude and longitude, date, and sampling results for six different parameters (Table 73). Information regarding the accuracy of measurements and units for data from Kim et al. (1969) are not available.

Keith et al. (1992) conducted a geochemistry study of the waters in the Valley of Ten Thousand Smokes Region. During the eruption of Mount Novarupta in 1912, the region was covered by ash fallout and an ash flow sheet filled the valley northwest of Katmai Pass. Water quality sampling plans were established to monitor the waters flowing above and below the ash deposits to determine the effect on water quality parameters above and below the ash deposition areas. Samples determined that the level of major constituents (e.g. Cl, Na, Mg) was found to be higher in water below the ash flow sheet compared to samples taken above the ash sheet. Data collected and presented in Keith et al. (1992) regarding the areas sampled, dates, and chemical data were compiled from the original report (Table 74).

Gunther (1992) performed a chemical survey of 12 remote lakes of the Alagnak and Naknek River systems. A compiled table presents 13 parameters that were sampled from the 12 lakes in the Alagnak and Naknek Drainages. Preparation of the bottles used to collect water samples was conducted in a special room designed for trace metal analysis. Samples for all parameters except pH were collected in these bottles and taken back to the lab for analysis: pH readings were measured in the field. Water samples were taken from the approximate middle of each sampled lake at a depth of 0.5m (Table 75).

LaPerriere and Edmundson (2000) surveyed seven large lakes in the Naknek River drainage and four in the Alagnak River drainage within Katmai National Park and Preserve, Alaska, once a summer during the period 1990–92 to determine baseline limnological conditions. All 11 study lakes are within KATM and were accessed by float plane and sampled in the first two weeks of August. The three-year averages of six different parameters were compiled (Table 76).

LaPerriere and Jones (2002) conducted a limnological survey of the nutrient and plankton levels in 11 lakes located in KATM (Table 77). Lakes were sampled for five parameters by float plane from a location near the center from 1990 to 1993. Nutrient samples were taken three times at each location at a depth of 2 m. To determine the vertical distribution of phytoplankton, triplicate samples were taken at depths of 1 m, the Secchi depth, and twice the Secchi depth. Triplicate vertical hauls with a 20-pm mesh zooplankton net (0.235 x 1 m) were made from just above the bottom of each lake.

LaPerriere (1992) performed a synoptic survey of lakes and rivers in KATM during early August 1990. Samples were taken from a float plane at the deepest spot that the weather conditions allowed. Field values were recorded for dissolved oxygen, specific conductance, pH, temperature, light penetration, and Secchi readings. Algal samples were taken to be analyzed for chlorophyll as an estimate of biomass at 1 m, the Secchi depth, and twice the Secchi depth. Zooplankton was sampled in triplicate by vertically hauling the net to the surface just above the lake bottom. All other water samples including trace metal analyses were taken in triplicate from a depth of 2m. In all, 31 different metals were sampled for in eight lakes and streams across KATM (Table 78). Ten other KATM lakes were also sampled for eight water quality parameters (Table 78).

Burgner et al. (1969) performed a limnological study of several salmon nursery lakes on the Alaskan peninsula in an effort to explain why lakes are producing salmon at different rates. Eutrophic zones of sockeye salmon nursery lakes were sampled from May 1961 to November 1962. Data from 20 water bodies detailing 19 water chemistry parameters were compiled (Table 79)

Dahlberg (1972) conducted limnological tests in the lake basins of Naknek and Brooks Lake in 1972. These data, contained temperature readings at various depths and Secchi disk readings, along with 13 other lakes sampled for 12 different element concentrations were compiled (Table 80-Table 82).

Frenzel and Dorava (1999) conducted physical, biological, and chemical water quality analyses on the Kamishak River in northwestern KATM (Table 83). The river was sampled over a 305 meter reach about 12.87 km upstream from its mouth at Cook Inlet. These data were collected in July 1998 and are likely not representative of the typical conditions as the river rose an estimated 2.5 meters during the sampling visit.

Goldman (1960) sampled the primary productivity and limiting factors in three lakes of the Alaskan Peninsula: Brooks Lake, Naknek Lake, and Becharof Lake (Table 84-Table 88).

Gunther (1986) performed surface water quality analyses on 19 separate lakes or streams from 1984 to 1986 (Table 89). A total of 17 parameters were sampled for during this study which was focused on the Battle Lake drainage in KATM but covered other lakes and streams in KATM as well.

Johnson and Berg (1999) performed water quality analyses on water bodies in KATM for the parameters of hardness, total alkalinity and baseline hydrocarbons (Table 91 and Table 91).

Threats and Stressor Factors

Nagorski et al. (2007) notes that oil spills, pollutants transferred through the atmosphere and biological processes, and climate change have negatively affected KATM water quality in the past and are likely to continue to in the future. Natural water quality degradations caused by geothermal springs in KATM have caused the parameters of pH, chloride, sulfate, arsenic, cadmium, temperature and selenium to be reported outside the allowed state and federal water quality standards (Nagorski 2007).

Data Needs and Gaps

Water quality data do not exist for most drainages in KATM. The available data includes gaps of several years, and is inconsistent with regards to the time of year the sampling was conducted. Previous sampling locations have not been revisited again or often enough to develop trends and conclusions. Jones et al. (2005) reports that flow and water quality characteristics in many SWAN park water bodies including KATM are completely unknown, making ecological evaluations of these water bodies difficult.

Overall Condition

Condition is unknown at this time due to lack of reference condition and limited data.

4.11.3 Sources of Expertise

Claudette Moore, SWAN Ecologist

Table 59. Lake ion balances, 1990, Katmai National Park and Preserve (LaPerriere 1996).

	HCO_3 (mg/L)	HCO_3 (meq/L)	Cl (mg/L)	Cl (meq/L)	SO_4 (mg/L)	SO_4 (meq/L)	Total Anions (meq/L)	Ca (mg/L)
Battle	2.9	0.05	4.3	0.12	15	0.31	0.48	3.83
Brooks	35.3	0.58	9.1	0.26	0	0	0.83	8.11
Coville	33.3	0.55	4.4	0.12	0	0	0.67	7.16
Grosvenor	30.5	0.5	4.9	0.14	0	0	0.64	7.34
Idavain	25.6	0.42	8.3	0.23	1.6	0.03	0.69	5.47
Kukaklek	8.8	0.14	6.3	0.18	2.3	0.05	0.37	3.48
Kulik	7.7	0.13	8.1	0.23	7.3	0.15	0.51	4.24
Murray	10.7	0.18	8.8	0.25	0	0	0.42	3.81
Naknek	37.6	0.62	12.8	0.36	27	0.56	1.54	17.3
Nonvianuk	12.2	0.2	8.9	0.25	1.3	0.03	0.48	4.58

Table 59. Lake ion balances, 1990, Katmai National Park and Preserve (LaPerriere 1996). (continued)

	Ca (meq/L)	Mg (mg/L)	Mg (meq/L)	K (mg/L)	K (meq/L)	Na (mg/L)	Na (meq/L)	Total Cations	Ion_Sum (meq/L)
Battle	0.19	0.75	0.062	<.05	<.01	1.8	0.1	0.33	0.81
Brooks	0.41	2.09	0.17	<.05	<.01	3.89	0.17	0.76	1.59
Coville	0.36	1.62	0.13	<.05	<.01	3.21	0.14	0.63	1.3
Grosvenor	0.37	1.39	0.11	<.05	<.01	2.88	0.13	0.61	1.25
Idavain	0.27	1.4	0.11	<.05	<.01	2.87	0.12	0.51	1.2
Kukaklek	0.17	0.78	0.06	<.05	<.01	2.23	0.1	0.33	0.7
Kulik	0.21	0.45	0.04	<.05	<.01	1.4	0.06	0.31	0.82
Murray	0.19	0.38	0.03	<.05	<.01	1.4	0.06	0.28	0.7
Naknek	0.87	2.51	0.21	<.05	<.01	6.83	0.3	1.37	2.91
Nonvianuk	0.23	0.608	0.05	<.05	<.01	1.7	0.07	0.35	0.83

Table 60. Lake ion balances, 1991, Katmai National Park and Preserve (LaPerriere 1996).

	HCO_3 (mg/L)	HCO_3 (meq/L	Cl (mg/L)	Cl (meq/L)	SO_4 (mg/L)	SO_4 (meq/L)	Total Anions (meq/L)	Ca (mg/L)
Battle	2.4	0.04	4.6	0.13	18	0.38	0.54	3.7
Brooks	34.9	0.57	9.8	0.28	0	0	0.85	73.8
Coville	28.5	0.47	3.7	0.1	0	0	0.57	6.16
Grosvenor	29	0.48	10.5	0.3	0	0	0.77	6.8
Hammersley	11.8	0.19	9.6	0.27	0	0	0.46	3.6
Kukaklek	9.4	0.15	8.9	0.25	0	0	0.4	3.3
Kulik	8.4	0.14	2.9	0.08	8	0.17	0.39	4.2
Murray	9.5	0.16	2.6	0.07	0	0	0.23	3.5
Naknek	37.8	0.62	14.7	0.41	30	0.63	1.66	16.4
Nonvianuk	12	0.2	3	0.08	2	0.04	0.32	4.48

Table 60. Lake ion balances, 1991, Katmai National Park and Preserve (LaPerriere 1996). (continued)

	Ca (meq/L)	Mg (mg/L)	Mg (meq/L)	K (mg/L)	K (meq/L)	Na (mg/L)	Na (meq/L)	Total Cations	Ion_Sum (meq/L)
Battle	0.19	0.77	0.06	0.3	0.01	1.67	0.1	0.33	0.87
Brooks	0.39	2.05	0.17	0.87	0.02	3.61	0.16	0.74	1.59
Coville	0.31	1.39	0.11	0.37	0.01	2.81	0.12	0.55	1.12
Grosvenor	0.34	1.3	0.11	0.4	0.01	2.71	0.12	0.57	1.34
Hammersley	0.18	0.43	0.03	0.2	0.01	1.3	0.06	0.28	0.74
Kukaklek	0.17	0.75	0.06	0.4	0.01	2.03	0.09	0.33	0.73
Kulik	0.21	0.46	0.04	0.37	0.01	1.27	0.06	0.31	0.7
Murray	0.18	0.36	0.03	0.2	0.01	1.23	0.05	0.26	0.49
Naknek	0.82	2.45	0.2	0.84	0.02	6.45	0.28	1.32	2.98
Nonvianuk	0.22	0.61	0.05	0.3	0.01	1.6	0.07	0.35	0.67

Table 61. Lake ion balances, 1991(LaPerriere 1996).

	HCO_3 (mg/L)	HCO_3 (meq/L	Cl (mg/L)	Cl (meq/L)	SO_4 (mg/L)	SO_4 (meq/L)	Total Anions (meq/L)	Ca (mg/L)
Battle	2	0.03	1	0.03	15	0.31	0.37	3.91
Brooks	34.9	0.57	2.4	0.07	0	0	0.64	7.97
Coville	29.3	0.48	0.9	0.03	0	0	0.51	6.86
Grosvenor	29.9	0.49	0.9	0.03	0	0	0.52	7.28
Hammersley	11.1	0.18	0.4	0.01	0	0	0.19	3.58
Kukaklek	8.4	0.14	1.5	0.04	0	0	0.18	3.45
Kulik	7.7	0.13	0	0	0	0	0.13	4.3
Murray	10.4	0.17	0.5	0.01	0	0	0.18	3.74
Naknek	35.4	0.58	4.5	0.13	29	0.61	1.32	17.2
Nonvianuk	11.5	0.19	0.7	0.02	0	0	0.21	4.57

Table 61. Lake ion balances, 1991 (LaPerriere 1996). (continued)

	Ca (meq/L)	Mg (mg/L)	Mg (meq/L)	K (mg/L)	K (meq/L)	Na (mg/L)	Na (meq/L)	Total Cations	Ion_Sum (meq/L)
Battle	0.2	0.79	0.06	0.3	0.01	<1	<.03	0.36	0.73
Brooks	0.4	2.02	0.17	0.87	0.02	<1	<.03	0.73	1.37
Coville	0.34	1.52	0.12	0.37	0.01	<1	<.03	0.59	1.1
Grosvenor	0.36	1.4	0.11	0.4	0.01	<1	<.03	0.6	1.12
Hammersley	0.18	0.4	0.03	0.2	0.01	<1	<.03	0.27	0.46
Kukaklek	0.17	0.76	0.06	0.4	0.01	<1	<.03	0.33	0.51
Kulik	0.22	0.43	0.03	0.37	0.01	<1	<.03	0.31	0.44
Murray	0.19	0.36	0.03	0.2	0.01	<1	<.03	0.28	0.46
Naknek	0.86	2.45	0.2	0.84	0.02	<1	<.03	1.35	2.67
Nonvianuk	0.23	0.58	0.05	0.3	0.01	<1	<.03	0.35	0.56

Table 62. Lake ion balances, 3-year averages, Katmai National Park and Preserve, 1990-1992 (LaPerriere 1996).

	Sampled (y/n)			HCO_3 (mg/L)	HCO_3 (meq/L)	Cl (mg/L)	Cl (meq/L)	SO_4 (mg/L)	SO_4 (meq/L)	Total Anions (meq/L)	Ca (mg/L)	Ca (meq/L)
	1990	1991	1992									
Battle	y	y	y	2.43	0.04	3.3	0.09	16	0.33	0.46	3.81	0.19
Brooks	y	y	y	35	0.57	7.1	0.2	0	0	0.77	7.96	0.4
Coville	y	y	y	30.4	0.5	3	0.08	0	0	0.58	6.7	0.33
Grosvenor	y	y	y	29.8	0.48	5.4	0.15	0	0	0.64	7.1	0.35
Hammersley	n	y	y	11.4	0.19	5	0.14	0	0	0.33	3.6	0.18
Idavain	y	n	n	25.6	0.42	8.3	0.23	1.6	0.03	0.69	5.47	0.27
Kukaklek	y	y	y	8.87	0.14	5.6	0.16	0.77	0.02	0.32	3.4	0.17
Kulik	y	y	y	7.93	0.13	3.7	0.1	5.1	0.11	0.34	4.2	0.21
Murray	y	y	y	10.2	0.17	3.8	0.11	0	0	0.28	3.7	0.18
Naknek	y	y	y	36.9	0.6	18.8	0.53	28.7	0.59	1.72	17	0.85
Nonvianuk	y	y	y	11.9	0.2	4.2	0.12	1.1	0.02	0.34	4.5	0.22

Table 62. Lake ion balances, 3-year averages, Katmai National Park and Preserve, 1990-1992 (LaPerriere 1996). (continued)

	Mg (mg/L)	Mg (meq/L)	K (mg/L)	K (meq/L)	Na (mg/L)	Na (meq/L)	Total Cations	Ion_Sum (meq/L)
Battle	0.77	0.06	<.5	<.01	1.72	0.07	0.32	0.78
Brooks	2.05	0.17	<.5	<.01	3.73	0.16	0.73	1.5
Coville	1.5	0.12	<.5	<.01	3	0.13	0.58	1.16
Grosvenor	1.36	0.11	<.5	<.01	2.83	0.12	0.58	1.22
Hammersley	0.4	0.03	<.5	<.01	1.3	0.06	0.27	6
Idavain	1.4	0.11	<.5	<.01	2.87	0.12	0.5	1.19
Kukaklek	0.76	0.06	<.5	<.01	2.15	0.09	0.32	0.64
Kulik	1.44	0.04	<.5	<.01	1.32	0.06	0.31	0.65
Murray	0.37	0.03	<.5	<.01	1.31	0.06	0.27	0.55
Naknek	2.47	0.2	<.5	<.01	6.61	0.29	1.34	3.06
Nonvianuk	0.6	0.05	<.5	<.01	1.63	0.07	0.34	0.68

Table 63. Metals sampling in KATM lakes, 1990 (LaPerriere 1996).

Lake	Test #	Ag	Al	As	B	Ba	Be	Bi
Battle Lake	1	<0.01	0.41	<0.04	<0.03	0.0038	<0.0006	<0.04
Battle Lake	2	<0.01	0.04	<0.04	<0.03	0.0038	<0.0006	<0.04
Battle Lake	3	<0.01	<0.03	<0.04	<0.03	0.0035	<0.0006	<0.04
Brooks Lake	1	<0.02	<0.04	<0.05	<0.04	0.0019	<0.0007	<0.05
Brooks Lake	2	<0.03	<0.05	<0.06	<0.05	0.0021	<0.0008	<0.06
Brooks Lake	3	<0.04	<0.06	<0.07	<0.06	0.0022	<0.0009	<0.07
Coville Lake	1	<0.01	<0.03	<0.04	<0.03	0.0016	<0.0006	<0.04
Coville Lake	2	<0.01	<0.03	<0.04	<0.03	0.001	<0.0006	<0.04
Coville Lake	3	<0.01	<0.03	<0.04	<0.03	0.001	<0.0006	<0.04
Grosvenor Lake	1	<0.01	<0.03	<0.04	<0.03	0.0018	<0.0006	<0.04
Grosvenor Lake	2	<0.01	<0.03	<0.04	<0.03	0.0023	<0.0006	<0.04
Grosvenor Lake	3	<0.01	<0.03	<0.04	<0.03	0.0016	<0.0006	<0.04
Idavain Lake	1	<0.01	<0.03	<0.04	<0.03	0.0016	<0.0006	<0.04
Idavain Lake	2	<0.01	<0.03	<0.04	<0.03	0.0017	<0.0006	<0.04
Idavain Lake	3	<0.01	<0.03	<0.04	<0.03	0.001	<0.0006	<0.04
Kukaklek Lake	1	<0.01	<0.03	<0.04	<0.03	0.001	<0.0006	<0.04
Kukaklek Lake	2	<0.01	<0.03	<0.04	<0.03	0.001	<0.0006	<0.04
Kukaklek Lake	3	<0.01	<0.03	<0.04	<0.03	0.0009	<0.0006	<0.04
Kulik Lake	1	<0.01	<0.03	<0.04	<0.03	0.0032	<0.0006	<0.04
Kulik Lake	2	<0.01	<0.03	<0.04	<0.03	0.003	<0.0006	<0.04
Kulik Lake	3	<0.01	<0.03	<0.04	<0.03	0.0031	<0.0006	<0.04
Murray Lake	1	<0.01	<0.03	<0.04	<0.03	0.0027	<0.0006	<0.04
Murray Lake	2	<0.01	<0.03	<0.04	<0.03	0.0031	<0.0005	<0.04
Murray Lake	3	<0.01	<0.03	<0.04	<0.03	0.0032	<0.0006	<0.04
Naknek Lake	1	<0.01	0.26	<.04	0.04	0.0038	<0.0006	<0.04
Naknek Lake	2	<0.01	0.05	<.05	0.05	0.0042	<0.0005	<0.04
Naknek Lake	3	<0.01	<.03	<.04	0.04	0.0041	<0.0006	<0.04
Nonvianuk Lake	1	<0.02	<.03	<.04	<.03	0.0024	<.0006	<0.04
Nonvianuk Lake	2	<0.03	<.03	<.04	<.03	0.0025	<.0006	<0.04
Nonvianuk Lake	3	<0.04	<.03	<.04	<.03	0.0026	<.0006	<0.04

Table 63. Metals sampling in KATM lakes, 1990 (LaPerriere 1996). (continued)

Lake	Cd	Co	Cr	Cu	Fe	K	Li	Mg
Battle Lake	<0.003	<0.01	<0.01	<0.003	0.036	<.5	<.002	0.766
Battle Lake	<0.003	<0.01	<0.01	<0.003	<0.01	<.5	<.002	0.745
Battle Lake	<0.003	<0.01	<0.01	<0.003	<0.01	<.5	<.002	0.751
Brooks Lake	<0.003	<0.01	<0.01	<0.003	0.02	0.7	<.002	2.07
Brooks Lake	<0.003	<0.01	<0.01	<0.003	0.092	0.7	<.002	2.17
Brooks Lake	<0.003	<0.01	<0.01	<0.003	0.035	<.5	<.002	2.04
Coville Lake	<0.003	<0.01	<0.01	<0.003	0.23	<.5	<.002	1.68
Coville Lake	<0.003	<0.01	<0.01	<0.003	0.63	<.5	<.002	1.59
Coville Lake	<0.003	<0.01	<0.01	<0.003	0.07	<.5	<.002	1.59
Grosvenor Lake	<0.003	<0.01	<0.01	<0.003	0.093	<.5	<.002	1.45
Grosvenor Lake	<0.003	<0.01	<0.01	<0.003	0.13	0.7	<.002	1.38
Grosvenor Lake	<0.003	<0.01	<0.01	<0.003	0.01	<.5	<.002	1.33
Idavain Lake	<0.003	<0.01	<0.01	<0.003	0.032	<.5	<.002	1.38
Idavain Lake	<0.003	<0.01	<0.01	<0.003	0.03	<.5	<.002	1.39
Idavain Lake	<0.003	<0.01	<0.01	<0.003	0.035	<.5	<.002	1.42
Kukaklek Lake	<0.003	<0.01	<0.01	<0.003	<.01	<.5	<.002	0.786
Kukaklek Lake	<0.003	<0.01	<0.01	<0.003	<.01	<.5	<.002	0.798
Kukaklek Lake	<0.003	<0.01	<0.01	<0.003	<.01	<.5	<.002	0.756
Kulik Lake	<0.003	<0.01	<0.01	<0.003	<.01	<.5	<.002	0.44
Kulik Lake	<0.003	<0.01	<0.01	<0.003	0.02	<.5	<.002	0.447
Kulik Lake	<0.003	<0.01	<0.01	<0.003	0.061	<.5	<.002	0.452
Murray Lake	<0.003	<0.01	<0.01	<0.003	0.056	<.4	<.002	0.382
Murray Lake	<0.004	<0.01	<0.01	<0.003	0.089	<.4	<.002	0.383
Murray Lake	<0.004	<0.01	<0.01	<0.003	0.077	<.4	<.002	0.386
Naknek Lake	<0.003	<0.01	<0.01	<0.003	0.14	0.5	0.012	2.53
Naknek Lake	<0.004	<0.01	<0.01	<0.003	0.02	<.4	0.011	2.51
Naknek Lake	<0.003	<0.01	<0.01	<0.003	0.01	<.5	0.012	2.48
Nonvianuk Lake	<0.003	<0.01	<0.01	<0.003	0.059	<.5	<.002	0.612
Nonvianuk Lake	<0.003	<0.01	<0.01	<0.003	<.01	<.6	<.002	0.582
Nonvianuk Lake	<0.003	<0.01	<0.01	<0.003	0.076	<.5	<.002	0.63

Table 63. Metals sampling in KATM lakes, 1990 (LaPerriere 1996). (continued)

Lake	Mn	Mo	Na	Ni	P	Pb	Sb	Se
Battle Lake	0.023	<0.005	1.8	<0.01	<0.2	<0.04	<0.04	<0.08
Battle Lake	0.022	<0.005	1.7	<0.01	<0.2	<0.04	<0.04	<0.08
Battle Lake	0.023	<0.005	1.8	<0.01	<0.2	<0.04	<0.04	<0.08
Brooks Lake	<.002	<0.005	3.8	<0.01	<0.2	<0.04	<0.04	<0.08
Brooks Lake	<.002	<0.005	4.06	<0.01	<0.2	<0.04	<0.04	<0.08
Brooks Lake	<.002	<0.005	3.82	<0.01	<0.2	<0.04	<0.04	<0.08
Coville Lake	0.0077	<0.005	3.29	<0.01	<0.2	<0.04	<0.04	<0.08
Coville Lake	0.0084	<0.005	3.16	<0.01	<0.2	<0.04	<0.04	<0.08
Coville Lake	0.007	<0.005	3.17	<0.01	<0.2	<0.04	<0.04	<0.08
Grosvenor Lake	<.002	<0.005	3.04	<0.01	<0.2	<0.04	<0.04	<0.08
Grosvenor Lake	<.002	<0.005	2.9	<0.01	<0.2	<0.04	<0.04	<0.08
Grosvenor Lake	<.002	<0.005	2.7	<0.01	<0.2	<0.04	<0.04	<0.08
Idavain Lake	0.0092	<0.005	2.91	<0.01	<0.2	<0.04	<0.04	<0.08
Idavain Lake	0.009	<0.005	2.86	<0.01	<0.2	<0.04	<0.04	<0.08
Idavain Lake	0.0086	<0.005	2.84	<0.01	<0.2	<0.04	<0.04	<0.08
Kukaklek Lake	<.002	<0.005	2.23	<0.01	<0.2	<0.04	<0.04	<0.08
Kukaklek Lake	0.003	<0.005	2.25	<0.01	<0.2	<0.04	<0.04	<0.08
Kukaklek Lake	<.002	<0.005	2.2	<0.01	<0.2	<0.04	<0.04	<0.08
Kulik Lake	<.002	<0.005	1.3	<0.01	<0.2	<0.04	<0.04	<0.08
Kulik Lake	<.002	<0.005	1.4	<0.01	<0.2	<0.04	<0.04	<0.08
Kulik Lake	<.002	<0.005	1.4	<0.01	<0.2	<0.04	<0.04	<0.08
Murray Lake	<.002	<0.005	1.5	<0.01	<0.2	<0.04	<0.04	<0.08
Murray Lake	<.002	<0.006	1.3	<0.02	<0.1	<0.04	<0.04	<0.07
Murray Lake	<.002	<0.006	1.3	<0.02	<0.1	<0.04	<0.04	<0.07
Naknek Lake	<.002	<0.005	6.81	<0.01	<0.2	<0.04	<0.04	<0.08
Naknek Lake	<.002	<0.006	6.68	<0.02	<0.1	<0.04	<0.04	<0.07
Naknek Lake	<.002	<0.005	6.99	<0.01	<0.2	<0.04	<0.04	<0.08
Nonvianuk Lake	<.002	<0.005	1.7	<0.01	<0.2	<0.04	<0.04	<0.08
Nonvianuk Lake	<.002	<0.005	1.6	<0.01	<0.2	<0.04	<0.04	<0.08
Nonvianuk Lake	<.002	<0.005	1.7	<0.01	<0.2	<0.04	<0.04	<0.08

Table 63. Metals sampling in KATM lakes, 1990 (LaPerriere 1996). (continued)

Lake	Si	Sn	Sr	Ti	Tl	V	Zn
Battle Lake	2.38	<.05	0.016	<.003	<0.08	<0.004	0.011
Battle Lake	2.34	<.05	0.015	<.003	<0.08	<0.004	<0.003
Battle Lake	2.27	<.05	0.016	<.003	<0.08	<0.004	<0.003
Brooks Lake	4.58	<.05	0.028	<.003	<0.08	<0.004	<0.003
Brooks Lake	4.8	<.05	0.029	<.003	<0.08	<0.004	<0.003
Brooks Lake	4.62	<.05	0.028	<.003	<0.08	<0.004	<0.003
Coville Lake	4.35	<.05	0.027	<.003	<0.08	<0.004	<0.003
Coville Lake	4.17	<.05	0.026	<.003	<0.08	<0.004	<0.003
Coville Lake	4.23	<.05	0.026	<.003	<0.08	<0.004	<0.003
Grosvenor Lake	3.72	<.05	0.025	<.003	<0.08	<0.004	<0.003
Grosvenor Lake	3.61	<.05	0.025	<.003	<0.08	<0.004	<0.003
Grosvenor Lake	3.36	<.05	0.023	<.003	<0.08	<0.004	<0.003
Idavain Lake	3.36	<.05	0.024	<.003	<0.08	<0.004	<0.003
Idavain Lake	3.4	<.05	0.024	<.003	<0.08	<0.004	<0.003
Idavain Lake	3.33	<.05	0.024	<.003	<0.08	<0.004	<0.003
Kukaklek Lake	1.39	<.05	0.013	<.003	<0.08	<0.004	<0.003
Kukaklek Lake	1.41	<.05	0.013	<.003	<0.08	<0.004	<0.003
Kukaklek Lake	1.32	<.05	0.013	<.003	<0.08	<0.004	<0.003
Kulik Lake	2.22	<.05	0.016	<.003	<0.08	<0.004	<0.003
Kulik Lake	2.29	<.05	0.016	<.003	<0.08	<0.004	<0.003
Kulik Lake	2.36	<.05	0.016	<.003	<0.08	<0.004	<0.003
Murray Lake	2.62	<.05	0.012	<.003	<0.08	<0.004	0.0097
Murray Lake	2.45	<.04	0.012	<.002	<0.06	<0.003	0.029
Murray Lake	2.52	<.04	0.012	<.002	<0.06	<0.003	0.04
Naknek Lake	3.89	<.05	0.048	<.003	<0.08	<0.004	0.007
Naknek Lake	3.73	<.04	0.048	<.002	<0.06	<0.003	0.032
Naknek Lake	3.88	<.05	0.049	<.003	<0.08	<0.004	<0.003
Nonvianuk Lake	1.69	<.05	0.016	<.003	<0.08	<0.004	<0.003
Nonvianuk Lake	1.61	<.05	0.016	<.003	<0.08	<0.004	<0.003
Nonvianuk Lake	1.93	<.05	0.016	0.006	<0.08	<0.004	<0.003

Table 64. Metals sampling in KATM lakes, 1991 (LaPerriere 1996).

Lake	Depth	Test	Ag	Al	As	B	Ba	Be	Bi
Battle Lake	1m	1	<0.01	0.04	<0.04	<0.02	0.0034	<0.0005	<0.04
Battle Lake	1m	2	<0.01	0.06	<0.04	<0.02	0.0034	<0.0005	<0.04
Battle Lake	1m	3	<0.01	0.06	<0.04	<0.02	0.0035	<0.0005	<0.04
Battle Lake	2m	1	<0.01	0.03	<0.04	<0.02	0.0034	<0.0005	<0.04
Battle Lake	2m	2	<0.01	0.03	<0.04	<0.02	0.0036	<0.0005	<0.04
Battle Lake	2m	3	<0.01	0.061	<0.04	<0.02	0.0034	<0.0005	<0.04
Battle Lake	3m	1	<0.01	0.03	<0.04	<0.02	0.0035	<0.0005	<0.04
Battle Lake	3m	2	<0.01	0.03	<0.04	<0.02	0.0036	<0.0005	<0.04
Battle Lake	3m	3	<0.01	0.06	<0.04	<0.02	0.0034	<0.0005	<0.04
Battle Lake	4m	1	<0.01	0.04	<0.04	<0.02	0.0037	<0.0005	<0.04
Battle Lake	4m	2	<0.01	0.04	<0.04	<0.02	0.0034	<0.0005	<0.04
Battle Lake	4m	3	<0.01	0.03	<0.04	<0.02	0.0034	<0.0005	<0.04
Battle Lake	5m	1	<0.01	0.03	<0.04	<0.02	0.0033	<0.0005	<0.04
Battle Lake	5m	2	<0.01	0.04	<0.04	<0.02	0.0036	<0.0005	<0.04
Battle Lake	5m	3	<0.01	0.1	<0.04	<0.02	0.0036	<0.0005	<0.04
Battle Lake	10m	1	<0.01	0.04	<0.04	<0.02	0.0035	<0.0005	<0.04
Battle Lake	10m	2	<0.01	0.068	<0.04	<0.02	0.0035	<0.0005	<0.04
Battle Lake	10m	3	<0.01	0.071	<0.04	<0.02	0.0037	<0.0005	<0.04
Battle Lake	20m	1	<0.01	0.06	<0.04	<0.02	0.0037	<0.0005	<0.04
Battle Lake	20m	2	<0.01	0.064	<0.04	<0.02	0.0033	<0.0005	<0.04
Battle Lake	20m	3	<0.01	0.067	<0.04	<0.02	0.0034	<0.0005	<0.04
Battle Lake	30m	1	<0.01	0.04	<0.04	<0.02	0.0035	<0.0005	<0.04
Battle Lake	30m	2	<0.01	0.03	<0.04	<0.02	0.0034	<0.0005	<0.04
Battle Lake	30m	3	<0.01	0.05	<0.04	<0.02	0.0035	<0.0005	<0.04
Battle Lake	40m	1	<0.01	0.03	<0.04	<0.02	0.0034	<0.0005	<0.04
Battle Lake	40m	2	<0.01	0.02	<0.04	<0.02	0.0034	<0.0005	<0.04
Battle Lake	40m	3	<0.01	0.03	<0.04	<0.02	0.0036	<0.0005	<0.04
Battle Lake	50m	1	<0.01	<0.02	<0.04	<0.02	0.0037	<0.0005	<0.04
Battle Lake	50m	2	<0.01	<0.02	<0.04	<0.02	0.0035	<0.0005	<0.04
Battle Lake	50m	3	<0.01	<0.02	<0.04	<0.02	0.0027	<0.0005	<0.04
Battle Lake	N/A	1	<0.01	0.093	<0.04	<0.02	0.0037	<0.0005	<0.04
Battle Lake	N/A	2	<0.01	0.11	<0.04	<0.02	0.0037	<0.0005	<0.04
Battle Lake	N/A	3	<0.01	0.11	<0.04	<0.02	0.0036	<0.0005	<0.04
Brooks Lake	N/A	1	<0.01	<0.02	<0.04	<0.02	0.0023	<0.0005	<0.04
Brooks Lake	N/A	2	<0.01	<0.02	<0.04	<0.02	0.0021	<0.0005	<0.04
Brooks Lake	N/A	3	<0.01	<0.02	<0.04	<0.02	0.0022	<0.0005	<0.04
Coville	N/A	1	<0.01	<0.02	<0.04	<0.02	0.0016	<0.0005	<0.04
Coville	N/A	2	<0.01	<0.02	<0.04	<0.02	0.0017	<0.0005	<0.04
Coville	N/A	3	<0.01	<0.02	<0.04	<0.02	0.0017	<0.0005	<0.04
Grosvenor	N/A	1	<0.01	<0.02	<0.04	<0.02	0.0018	<0.0005	<0.04

Table 64. Metals sampling in KATM lakes, 1991 (LaPerriere 1996). (continued)

Lake	Depth	Test	Ag	AL	As	B	Ba	Be	Bi
Grosvenor	-	2	<0.01	<0.02	<0.04	<0.02	0.0017	<0.0005	<0.04
Grosvenor	-	3	<0.01	<0.02	<0.04	<0.02	0.0018	<0.0005	<0.04
Hammersly	-	1	<0.01	<0.02	<0.04	<0.02	0.0028	<0.0005	<0.04
Hammersly	-	2	<0.01	<0.02	<0.04	<0.02	0.0028	<0.0005	<0.04
Hammersly	-	3	<0.01	<0.02	<0.04	<0.02	0.0029	<0.0005	<0.04
Kulik	-	1	<0.01	<0.02	<0.04	<0.02	0.0032	<0.0005	<0.04
Kulik	-	2	<0.01	<0.02	<0.04	<0.02	0.0031	<0.0005	<0.04
Kulik	-	3	<0.01	<0.02	<0.04	<0.02	0.0034	<0.0005	<0.04
Kukaklek	-	1	<0.01	<0.02	<0.04	<0.02	0.001	<0.0005	<0.04
Kukaklek	-	2	<0.01	<0.02	<0.04	<0.02	0.001	<0.0005	<0.04
Kukaklek	-	3	<0.01	<0.02	<0.04	<0.02	0.001	<0.0005	<0.04
Murray	-	1	<0.01	<0.02	<0.04	<0.02	0.003	<0.0005	<0.04
Murray	-	2	<0.01	0.03	<0.04	<0.02	0.003	<0.0005	<0.04
Murray	-	3	<0.01	<0.02	<0.04	<0.02	0.003	<0.0005	<0.04
Naknek	-	1	<0.01	0.05	<0.04	0.05	0.0042	<0.0005	<0.04
Naknek	-	2	<0.01	0.05	<0.04	0.04	0.0043	<0.0005	<0.04
Naknek	-	3	<0.01	0.04	<0.04	0.05	0.004	<0.0005	<0.04
Nonvianuk	-	1	<0.01	<0.02	<0.04	<0.02	0.0029	<0.0005	<0.04
Nonvianuk	-	2	<0.01	<0.02	<0.04	<0.02	0.0029	<0.0005	<0.04
Nonvianuk	-	3	<0.01	<0.02	<0.04	<0.02	0.0027	<0.0005	<0.04

Table 64. Metals sampling in KATM lakes, 1991 (LaPerriere 1996). (continued)

Lake	Depth	Test	Ca	Cd	Co	Cr	Cu	Fe	K
Battle Lake	1m	1	3.6	<0.002	<0.01	<0.01	<0.002	0.009	<.2
Battle Lake	1m	2	3.6	<0.002	<0.01	<0.01	<0.002	0.01	0.4
Battle Lake	1m	3	3.7	<0.002	<0.01	<0.01	<0.002	0.017	0.3
Battle Lake	2m	1	3.6	<0.002	<0.01	<0.01	<0.002	0.01	<.2
Battle Lake	2m	2	3.7	<0.002	<0.01	<0.01	<0.002	0.01	0.58
Battle Lake	2m	3	3.7	<0.002	<0.01	<0.01	<0.002	0.018	0.3
Battle Lake	3m	1	3.7	<0.002	<0.01	<0.01	<0.002	0.034	0.2
Battle Lake	3m	2	3.7	<0.002	<0.01	<0.01	<0.002	0.015	0.3
Battle Lake	3m	3	3.6	<0.002	<0.01	<0.01	<0.002	0.023	0.3
Battle Lake	4m	1	3.7	<0.002	<0.01	<0.01	<0.002	0.016	0.3
Battle Lake	4m	2	3.7	<0.002	<0.01	<0.01	<0.002	0.02	0.3
Battle Lake	4m	3	3.6	<0.002	<0.01	<0.01	<0.002	0.015	<.2
Battle Lake	5m	1	3.6	<0.002	<0.01	<0.01	<0.002	0.016	<.2
Battle Lake	5m	2	3.7	<0.002	<0.01	<0.01	<0.002	0.015	0.4
Battle Lake	5m	3	3.54	<0.003	<0.01	<0.01	<0.002	0.03	<.3
Battle Lake	10m	1	3.7	<0.002	<0.01	<0.01	0.004	0.018	<.2
Battle Lake	10m	2	3.7	<0.002	<0.01	<0.01	<0.002	0.017	0.64
Battle Lake	10m	3	3.7	<0.002	<0.01	<0.01	<0.002	0.01	0.4
Battle Lake	20m	1	3.7	<0.002	<0.01	<0.01	<0.002	0.019	<.2
Battle Lake	20m	2	3.52	<0.002	<0.01	<0.01	<0.002	0.02	0.4
Battle Lake	20m	3	3.5	<0.002	<0.01	<0.01	<0.002	0.016	<.2
Battle Lake	30m	1	3.6	<0.002	<0.01	<0.01	0.003	0.024	0.3
Battle Lake	30m	2	3.5	<0.002	<0.01	<0.01	<0.002	0.019	<.2
Battle Lake	30m	3	3.5	<0.002	<0.01	<0.01	<0.002	0.021	0.3
Battle Lake	40m	1	3.7	<0.002	<0.01	<0.01	<0.002	0.01	0.2
Battle Lake	40m	2	3.6	<0.002	<0.01	<0.01	<0.002	0.04	<.2
Battle Lake	40m	3	3.9	<0.002	<0.01	<0.01	0.004	0.022	0.3
Battle Lake	50m	1	3.8	<0.002	<0.01	<0.01	0.004	0.009	0.2
Battle Lake	50m	2	3.9	<0.002	<0.01	<0.01	<0.002	0.015	0.2
Battle Lake	50m	3	2.9	<0.002	<0.01	<0.01	<0.002	0.01	<.2
Battle Lake	-	1	3.7	<0.002	<0.01	<0.01	<0.002	0.02	0.2
Battle Lake	-	2	3.7	<0.002	<0.01	<0.01	<0.002	0.02	0.3
Battle Lake	-	3	3.7	<0.002	<0.01	<0.01	<0.002	0.02	0.3
Brooks Lake	-	1	8	<0.002	<0.01	<0.01	<0.002	0.018	0.92
Brooks Lake	-	2	7.6	<0.002	<0.01	<0.01	<0.002	0.017	0.97
Brooks Lake	-	3	7.8	<0.002	<0.01	<0.01	<0.002	0.016	0.73
Coville	-	1	6.2	<0.002	<0.01	<0.01	<0.002	0.1	0.2
Coville	-	2	6.2	<0.002	<0.01	<0.01	0.003	0.11	0.51
Coville	-	3	6.07	<.003	<0.01	<0.01	<0.002	0.1	0.4

Table 64. Metals sampling in KATM lakes, 1991 (LaPerriere 1996). (continued)

Lake	Depth	Test	Ca	Cd	Co	Cr	Cu	Fe	K
Grosvenor	-	1	6.8	<0.002	<0.01	<0.01	<0.002	0.038	0.4
Grosvenor	-	2	6.7	<0.002	<0.01	<0.01	<0.002	0.041	0.4
Grosvenor	-	3	6.8	<0.002	<0.01	<0.01	<0.002	0.04	0.4
Hammersly	-	1	3.6	<0.002	<0.01	<0.01	<0.002	0.01	0.3
Hammersly	-	2	3.5	<0.002	<0.01	<0.01	<0.002	0.01	<.2
Hammersly	-	3	3.6	<0.002	<0.01	<0.01	<0.002	0.01	<.2
Kulik	-	1	4.2	<0.002	<0.01	<0.01	<0.002	0.02	0.3
Kulik	-	2	4.1	<0.002	<0.01	<0.01	<0.002	0.021	0.3
Kulik	-	3	4.3	<0.002	<0.01	<0.01	<0.002	0.02	0.52
Kukaklek	-	1	3.3	<0.002	<0.01	<0.01	<0.002	0.01	0.4
Kukaklek	-	2	3.2	<0.002	<0.01	<0.01	<0.002	0.01	0.4
Kukaklek	-	3	3.3	<0.002	<0.01	<0.01	<0.002	0.01	0.3
Murray	-	1	3.6	<0.002	<0.01	<0.01	<0.002	0.047	0.3
Murray	-	2	3.5	<0.002	<0.01	<0.01	<0.002	0.051	0.2
Murray	-	3	3.5	<0.002	<0.01	<0.01	<0.002	0.043	0.2
Naknek	-	1	17	<0.002	<0.01	<0.01	<0.002	0.043	1.2
Naknek	-	2	16.3	<0.003	<0.01	<0.01	<0.002	0.069	0.8
Naknek	-	3	16	<0.002	<0.01	<0.01	<0.002	0.045	0.52
Nonvianuk	-	1	4.6	<0.002	<0.01	<0.01	<0.002	0.01	0.46
Nonvianuk	-	2	4.43	<0.002	<0.01	<0.01	<0.002	<.005	<.3
Nonvianuk	-	3	4.4	<0.002	<0.01	<0.01	<0.002	0.008	0.3

Table 64. Metals sampling in KATM lakes, 1991 (LaPerriere 1996). (continued)

Lake	Depth	Test	W	Li	Mg	Mn	Mo	Na	Ni
Battle Lake	1m	1	<.01	<.002	0.732	0.022	<0.005	1.6	<0.01
Battle Lake	1m	2	<.01	<.002	0.739	0.023	<0.005	1.6	<0.01
Battle Lake	1m	3	<.01	<.002	0.742	0.023	<0.005	1.6	<0.01
Battle Lake	2m	1	<.01	<.002	0.728	0.022	<0.005	1.6	<0.01
Battle Lake	2m	2	<.01	<.002	0.752	0.024	<0.005	1.7	<0.01
Battle Lake	2m	3	<.01	<.002	0.751	0.024	<0.005	1.7	<0.01
Battle Lake	3m	1	<.01	<.002	0.741	0.024	<0.005	1.6	<0.01
Battle Lake	3m	2	<.01	<.002	0.744	0.024	<0.005	1.7	<0.01
Battle Lake	3m	3	<.01	<.002	0.741	0.024	<0.005	1.6	<0.01
Battle Lake	4m	1	<.01	<.002	0.745	0.025	<0.005	1.7	<0.01
Battle Lake	4m	2	<.01	<.002	0.751	0.025	<0.005	1.7	<0.01
Battle Lake	4m	3	<.01	<.002	0.74	0.024	<0.005	1.7	<0.01
Battle Lake	5m	1	<.01	<.002	0.733	0.023	<0.005	1.7	<0.01
Battle Lake	5m	2	<.01	<.002	0.743	0.025	<0.005	1.7	<0.01
Battle Lake	5m	3	<.02	<.002	0.705	0.021	<0.005	1.6	<0.01
Battle Lake	10m	1	<.01	<.002	0.743	0.024	<0.005	1.7	<0.01
Battle Lake	10m	2	<.01	<.002	0.746	0.024	<0.005	1.6	<0.01
Battle Lake	10m	3	<.01	<.002	0.749	0.024	<0.005	1.6	<0.01
Battle Lake	20m	1	<.01	<.002	0.758	0.025	<0.005	1.7	<0.01
Battle Lake	20m	2	<.02	<.002	0.698	0.021	<0.005	1.6	<0.01
Battle Lake	20m	3	<.01	<.002	0.717	0.024	<0.005	1.6	<0.01
Battle Lake	30m	1	<.01	<.002	0.725	0.025	<0.005	1.7	<0.01
Battle Lake	30m	2	<.01	<.002	0.705	0.025	<0.005	1.6	<0.01
Battle Lake	30m	3	<.01	<.002	0.699	0.023	<0.005	1.6	<0.01
Battle Lake	40m	1	<.01	<.002	0.74	0.026	<0.005	1.7	<0.01
Battle Lake	40m	2	<.01	<.002	0.715	0.025	<0.005	1.6	<0.01
Battle Lake	40m	3	<.01	<.002	0.762	0.028	0.006	1.7	<0.01
Battle Lake	50m	1	<.01	<.002	0.764	0.029	<0.005	1.7	<0.01
Battle Lake	50m	2	<.01	<.002	0.767	0.029	<0.005	1.7	<0.01
Battle Lake	50m	3	<.01	<.002	0.585	0.021	<0.005	1.3	<0.01
Battle Lake	-	1	<.01	<.002	0.769	0.025	<0.005	1.7	<0.01
Battle Lake	-	2	<.01	<.002	0.764	0.025	<0.005	1.6	<0.01
Battle Lake	-	3	<.01	<.002	0.771	0.025	<0.005	1.7	<0.01
Brooks Lake	-	1	<.01	<.002	2.1	<0.002	<0.005	3.73	<0.01
Brooks Lake	-	2	<.01	<.002	1.99	<0.002	<0.005	3.47	<0.01
Brooks Lake	-	3	<.01	<.002	2.05	<0.002	<0.005	3.64	<0.01
Coville	-	1	<.01	<.002	1.4	0.004	<0.005	2.83	<0.01
Coville	-	2	<.01	<.002	1.4	0.004	<0.005	2.8	<0.01
Coville	-	3	<.02	<.002	1.37	0.005	<0.005	2.8	<0.01
Grosvenor	-	1	<.01	<.002	1.3	0.003	<0.005	2.72	<0.01

Table 64. Metals sampling in KATM lakes, 1991 (LaPerriere 1996). (continued)

Lake	Depth	Test	W	Li	Mg	Mn	Mo	Na	Ni
Grosvenor	-	2	<.01	<.002	1.3	0.003	<0.005	2.69	<0.01
Grosvenor	-	3	<.01	<.002	1.3	0.003	<0.005	2.73	<0.01
Hammersly	-	1	<.01	<.002	0.429	<0.002	<0.005	1.3	<0.01
Hammersly	-	2	<.01	<.002	0.425	<0.002	<0.005	1.3	<0.01
Hammersly	-	3	<.01	<.002	0.423	<0.002	<0.005	1.3	<0.01
Kulik	-	1	<.01	<.002	0.456	0.002	<0.005	1.3	<0.01
Kulik	-	2	<.01	<.002	0.447	0.002	<0.005	1.2	<0.01
Kulik	-	3	<.01	<.002	0.463	0.002	<0.005	1.3	<0.01
Kukaklek	-	1	<.01	<.002	0.769	0.002	<0.005	2.06	<0.01
Kukaklek	-	2	<.01	<.002	0.74	0.003	<0.005	2	<0.01
Kukaklek	-	3	<.01	<.002	0.754	0.002	<0.005	2.04	<0.01
Murray	-	1	<.01	<.002	0.371	0.002	<0.005	1.3	<0.01
Murray	-	2	<.01	<.002	0.361	0.002	<0.005	1.2	<0.01
Murray	-	3	<.01	<.002	0.361	0.003	<0.005	1.2	<0.01
Naknek	-	1	<.01	0.01	2.53	0.003	<0.005	6.58	<0.01
Naknek	-	2	<.02	0.011	2.38	<0.002	<0.005	6.38	<0.01
Naknek	-	3	<.01	0.011	2.44	<0.002	<0.005	6.39	<0.01
Nonvianuk	-	1	<.01	<0.002	0.626	<0.002	<0.005	1.6	<0.01
Nonvianuk	-	2	<.02	<0.002	0.588	<0.002	<0.005	1.6	<0.01
Nonvianuk	-	3	<.01	<0.002	0.608	<0.002	<0.005	1.6	<0.01

Table 64. Metals sampling in KATM lakes, 1991 (LaPerriere 1996). (continued)

Lake	Depth	Num	P	Pb	Sb	Se	Si	Sn	Sr
Battle Lake	1m	1	<.09	<0.04	<0.04	<.04	2.12	<.04	0.014
Battle Lake	1m	2	<.09	<0.04	<0.04	<.04	2.13	<.04	0.014
Battle Lake	1m	3	<.09	<0.04	<0.04	<.04	2.15	<.04	0.015
Battle Lake	2m	1	<.09	<0.04	<0.04	<.04	2.1	<.04	0.015
Battle Lake	2m	2	<.09	<0.04	<0.04	<.04	2.16	<.04	0.015
Battle Lake	2m	3	<.09	<0.04	<0.04	<.04	2.17	<.04	0.015
Battle Lake	3m	1	<.09	<0.04	<0.04	<.04	2.14	<.04	0.015
Battle Lake	3m	2	<.09	<0.04	<0.04	<.04	2.16	<.04	0.015
Battle Lake	3m	3	<.09	<0.04	<0.04	<.04	2.13	<.04	0.015
Battle Lake	4m	1	<.09	<0.04	<0.04	<.04	2.14	<.04	0.015
Battle Lake	4m	2	<.09	<0.04	<0.04	<.04	2.16	<.04	0.015
Battle Lake	4m	3	<.09	<0.04	<0.04	<.04	2.14	<.04	0.015
Battle Lake	5m	1	<.09	<0.04	<0.04	<.04	2.11	<.04	0.015
Battle Lake	5m	2	<.09	<0.04	<0.04	<.04	2.19	<.04	0.015
Battle Lake	5m	3	<.09	<0.04	<0.04	<0.04	2.33	<.04	0.015
Battle Lake	10m	1	<.09	<0.04	<0.04	<0.04	2.14	<.04	0.015
Battle Lake	10m	2	<.09	<0.04	<0.04	<0.04	2.16	<.04	0.015
Battle Lake	10m	3	<.09	<0.04	<0.04	<0.04	2.16	<.04	0.015
Battle Lake	20m	1	<.09	<0.04	<0.04	<0.04	2.18	<.04	0.016
Battle Lake	20m	2	<.09	<0.04	<0.04	<0.04	2.07	<.04	0.015
Battle Lake	20m	3	<.09	<0.04	<0.04	<0.04	2.06	<.04	0.014
Battle Lake	30m	1	<.09	<0.04	<0.04	<0.04	2.15	<.04	0.015
Battle Lake	30m	2	<.09	<0.04	<0.04	<0.04	2.06	<.04	0.015
Battle Lake	30m	3	<.09	<0.04	<0.04	<0.04	2.06	<.04	0.014
Battle Lake	40m	1	<.09	<0.04	<0.04	<0.04	2.15	<.04	0.015
Battle Lake	40m	2	<.09	<0.04	<0.04	<0.04	2.1	<.04	0.014
Battle Lake	40m	3	<.09	<0.04	<0.04	<0.04	2.21	<.04	0.015
Battle Lake	50m	1	<.09	<0.04	<0.04	<0.04	2.18	<.04	0.015
Battle Lake	50m	2	<.09	<0.04	<0.04	<0.04	2.2	<.04	0.016
Battle Lake	50m	3	<.09	<0.04	<0.04	<0.04	1.69	<.04	0.012
Battle Lake	-	1	<.09	<0.04	<0.04	<0.04	2.21	<.04	0.016
Battle Lake	-	2	<.09	<0.04	<0.04	<0.04	2.18	<.04	0.015
Battle Lake	-	3	<.09	<0.04	<0.04	<0.04	2.26	<.04	0.015
Brooks Lake	-	1	<.09	<0.04	<0.04	<0.04	4.19	<.04	0.028
Brooks Lake	-	2	<.09	<0.04	<0.04	<0.04	3.94	<.04	0.026
Brooks Lake	-	3	<.09	<0.04	<0.04	<0.04	4.06	<.04	0.027
Coville	-	1	<.09	<0.04	<0.04	<0.04	3.83	<.04	0.024
Coville	-	2	<.09	<0.04	<0.04	<0.04	3.82	<.04	0.023
Coville	-	3	<.09	<0.04	<0.04	<0.04	3.88	<.04	0.023
Grosvenor	-	1	<.09	<0.04	<0.04	<0.04	3.33	<.04	0.023

Table 64. Metals sampling in KATM lakes, 1991 (LaPerriere 1996). (continued)

Lake	Depth	Num	P	Pb	Sb	Se	Si	Sn	Sr
Grosvenor	-	2	<.09	<0.04	<0.04	<0.04	3.29	<.04	0.023
Grosvenor	-	3	<.09	<0.04	<0.04	<0.04	3.33	<.04	0.023
Hammersly	-	1	<.09	<0.04	<0.04	<0.04	2.32	<.04	0.012
Hammersly	-	2	<.09	<0.04	<0.04	<0.04	2.26	<.04	0.012
Hammersly	-	3	<.09	<0.04	<0.04	<0.04	2.27	<.04	0.012
Kulik	-	1	<.09	<0.04	<0.04	<0.04	2.16	<.04	0.015
Kulik	-	2	<.09	<0.04	<0.04	<0.04	2.12	<.04	0.014
Kulik	-	3	<.09	<0.04	<0.04	<0.04	2.2	<.04	0.015
Kukaklek	-	1	<.09	<0.04	<0.04	<0.04	1.32	<.04	0.012
Kukaklek	-	2	<.09	<0.04	<0.04	<0.04	1.27	<.04	0.012
Kukaklek	-	3	<.09	<0.04	<0.04	<0.04	1.29	<.04	0.012
Murray	-	1	<.09	<0.04	<0.04	<0.04	2.38	<.04	0.012
Murray	-	2	<.09	<0.04	<0.04	<0.04	2.37	<.04	0.011
Murray	-	3	<.09	<0.04	<0.04	<0.04	2.3	<.04	0.011
Naknek	-	1	<.09	<0.04	<0.04	<0.04	3.67	<.04	0.047
Naknek	-	2	<.09	<0.04	<0.04	<0.04	3.53	<.04	0.046
Naknek	-	3	<.09	<0.04	<0.04	<0.04	3.5	<.04	0.046
Nonvianuk	-	1	<.09	<0.04	<0.04	<0.04	1.6	<.04	0.016
Nonvianuk	-	2	<.09	<0.04	<0.04	<0.04	1.52	<.04	0.016
Nonvianuk	-	3	<.09	<0.04	<0.04	<0.04	1.54	<.04	0.016

Table 64. Metals sampling in KATM lakes, 1991 (LaPerriere 1996). (continued)

Lake	Sample	Test	Ti	Tl	V	Zn
Battle Lake	1m	1	<.002	<.04	<.003	0.0082
Battle Lake	1m	2	<.002	<.04	<.003	<.002
Battle Lake	1m	3	<.002	<.04	<.003	<.002
Battle Lake	2m	1	<.002	<.04	<.003	<.002
Battle Lake	2m	2	<.002	<.04	<.003	<.002
Battle Lake	2m	3	<.002	<.04	<.003	<.002
Battle Lake	3m	1	<.002	<.04	<.003	<.002
Battle Lake	3m	2	<.002	<.04	<.003	<.002
Battle Lake	3m	3	<.002	<.04	<.003	0.005
Battle Lake	4m	1	<.002	<.04	<.003	
Battle Lake	4m	2	<.002	<.04	<.003	
Battle Lake	4m	3	<.002	<.04	<.003	<.002
Battle Lake	5m	1	<.002	<.04	<.003	<.002
Battle Lake	5m	2	<.002	<.04	<.003	0.005
Battle Lake	5m	3	0.003	<.08	<.003	<.002
Battle Lake	10m	1	<.002	<.04	<.003	<.002
Battle Lake	10m	2	<.002	<.04	<.003	<.002
Battle Lake	10m	3	<.002	<.04	<.003	<.002
Battle Lake	20m	1	<.002	<.04	<.003	0.002
Battle Lake	20m	2	<.002	<.08	<.003	<.003
Battle Lake	20m	3	<.002	<.04	<.003	<.002
Battle Lake	30m	1	<.002	<.04	<.003	<.002
Battle Lake	30m	2	<.002	<.04	<.003	<.002
Battle Lake	30m	3	0.006	<.04	<.003	<.002
Battle Lake	40m	1	<.002	<.04	<.003	0.002
Battle Lake	40m	2	<.002	<.04	<.003	0.002
Battle Lake	40m	3	<.002	<.04	<.003	0.005
Battle Lake	50m	1	<.002	<.04	<.003	<.04
Battle Lake	50m	2	<.002	<.04	<.003	<.003
Battle Lake	50m	3	<.002	<.04	<.003	0.003
Battle Lake	-	1	<.002	<.04	<.003	<.002
Battle Lake	-	2	<.002	<.04	<.003	<.002
Battle Lake	-	3	<.002	<.04	<.003	<.002
Brooks Lake	-	1	<.002	<.04	<.003	<.002
Brooks Lake	-	2	<.002	<.04	<.003	<.002
Brooks Lake	-	3	<.002	<.04	<.003	<.002
Coville	-	1	<.002	<.04	<.003	0.002
Coville	-	2	<.002	<.04	<.003	<.002

Table 64. Metals sampling in KATM lakes, 1991 (LaPerriere 1996). (continued)

Lake	Sample	Test	Ti	Tl	V	Zn
Coville	-	3	<.002	<.08	<.003	0.0096
Grosvenor	-	1	<.002	<.04	<.003	<.002
Grosvenor	-	2	<.002	<.04	<.003	<.002
Grosvenor	-	3	<.002	<.04	<.003	0.0075
Hammersly	-	1	<.002	<.04	<.003	<.002
Hammersly	-	2	<.002	<.04	<.003	<.002
Hammersly	-	3	<.002	<.04	<.003	<.002
Kulik	-	1	<.002	<.04	<.003	0.002
Kulik	-	2	<.002	<.04	<.003	<.002
Kulik	-	3	<.002	<.04	<.003	<.002
Kukaklek	-	1	<.002	<.04	<.003	<.002
Kukaklek	-	2	<.002	<.04	<.003	<.002
Kukaklek	-	3	<.002	<.04	<.003	<.002
Murray	-	1	<.002	<.04	<.003	<.002
Murray	-	2	<.002	<.04	<.003	<.002
Murray	-	3	<.002	<.04	<.003	<.002
Naknek	-	1	<.002	<.04	<.003	<.002
Naknek	-	2	<.002	<.08	<.003	<.002
Naknek	-	3	<.002	<.04	<.003	<.002
Nonvianuk	-	1	<.002	<.04	<.003	<.002
Nonvianuk	-	2	<.002	<.08	<.003	<.002
Nonvianuk	-	3	<.002	<.04	<.003	<.002

Table 65. Metals sampling in KATM lakes, 1992 (LaPerriere 1996).

Lake	Test	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd
Battle Lake	1	<.008	0.18	<.01	<0.02	0.0042	<.0002	<0.04	3.99	<.007
Battle Lake	2	<.008	0.16	<.01	<0.02	0.0025	<.0002	<0.04	3.87	<.007
Battle Lake	3	<.008	0.19	<.01	<0.02	0.0029	<.0002	<0.04	3.86	<.007
Brooks Lake	1	<.008	<.05	<.01	<0.02	0.0019	<.0002	<0.04	7.97	<.007
Brooks Lake	2	<.008	0.1	<.01	<0.02	0.0021	<.0002	<0.04	8.04	<.007
Brooks Lake	3	<.008	<.05	<.01	<0.02	0.0025	<.0002	<0.04	7.91	<.007
Coville Lake	1	<.008	0.11	<.01	<0.02	0.002	<.0002	<0.04	6.89	<.007
Coville Lake	2	<.008	0.08	<.01	<0.02	0.001	<.0002	<0.04	6.87	<.007
Coville Lake	3	<.008	<.05	<.01	<0.02	0.001	<.0002	<0.04	6.81	<.007
Grosvenor	1	<.008	<.05	<.01	<0.02	0.0015	<.0002	<0.04	7.26	<.007
Grosvenor	2	<.008	<.05	<.01	<0.02	0.0017	<.0002	<0.04	7.3	<.007
Grosvenor	3	<.008	<.05	<.01	<0.02	0.001	<.0002	<0.04	7.28	<.007
Hammersly Lake	1	<.008	<.05	<.01	<0.02	0.0023	<.0002	<0.04	3.57	<.007
Hammersly Lake	2	<.008	<.05	<.01	<0.02	0.0023	<.0002	<0.04	3.57	<.007
Hammersly Lake	3	<.008	<.05	<.01	<0.02	0.0022	<.0002	<0.04	3.61	<.007
Kukaklek Lake	1	<.008	<.05	<.01	<0.02	<.0004	<.0002	<0.04	3.56	<.007
Kukaklek Lake	2	<.008	<.05	<.01	<0.02	<.0004	<.0002	0.04	3.43	<.007
Kukaklek Lake	3	<.008	<.05	<.01	<0.02	<.0004	<.0002	<0.04	3.37	<.007
Kulik Lake	1	<.008	<.05	<.01	<0.02	0.0025	<.0002	<0.04	4.33	<.007
Kulik Lake	2	<.008	<.05	<.01	<0.02	0.0023	<.0002	<0.04	4.2	<.007
Kulik Lake	3	<.008	<.05	<.01	<0.02	0.0028	<.0002	<0.04	4.37	<.007
Murray Lake	1	<.008	<.05	<.01	<0.02	0.0023	<.0002	<0.04	3.75	<.007
Murray Lake	2	<.008	<.05	<.01	<0.02	0.0022	<.0002	<0.04	3.71	<.007
Murray Lake	3	<.008	<.05	<.01	<0.02	0.0021	<.0002	<.05	3.75	<.007
Naknek Lake	1	<.008	0.1	<.01	0.05	0.0046	0.0002	<0.04	17.2	<.007
Naknek Lake	2	<.008	0.07	<.01	0.05	0.0042	<.0002	<0.04	17.2	<.007
Naknek Lake	3	<.008	<.05	<.01	0.05	0.0039	<.0002	<0.04	17.2	<.007
Nonvianuk Lake	1	<.008	<.05	<.01	<0.02	0.0022	<.0002	0.05	4.64	<.007
Nonvianuk Lake	2	<.008	<.05	<.01	<0.02	0.0018	<.0002	<0.04	4.52	<.007
Nonvianuk Lake	3	<.008	<.05	<.01	<0.02	0.0023	<.0002	<0.04	4.56	<.007

Table 65 Metals sampling in KATM lakes, 1992 (LaPerriere 1996). (continued)

Lake	Test	Co	Cr	Cu	Fe	K	W	Li	Mg
Battle Lake	1	<0.01	<.04	<.007	0.036	<1	<.03	<.004	0.806
Battle Lake	2	<0.01	<.04	<.007	0.022	<1	<.03	<.004	0.784
Battle Lake	3	<0.01	<.04	<.007	0.022	<1	<.03	<.004	0.785
Brooks Lake	1	<0.01	<.04	<.007	0.019	<1	0.03	<.004	2.02
Brooks Lake	2	<0.01	<.04	<.007	0.023	<1	<.03	<.004	2.05
Brooks Lake	3	<0.01	<.04	<.007	0.02	<1	<.03	<.004	2
Coville Lake	1	<0.01	<.04	<.007	0.099	<1	<.03	<.004	1.53
Coville Lake	2	<0.01	<.04	<.007	0.081	<1	0.04	<.004	1.52
Coville Lake	3	<0.01	<.04	<.007	0.057	<1	<.03	<.004	1.5
Grosvenor	1	<0.01	<.04	<.007	0.024	<1	<.03	<.004	1.4
Grosvenor	2	<0.01	<.04	<.007	0.026	<1	<.03	<.004	1.41
Grosvenor	3	<0.01	<.04	<.007	0.02	<1	<.03	<.004	1.4
Hammersly Lake	1	<0.01	<.04	<.007	<.006	<1	<.03	<.004	0.4
Hammersly Lake	2	<0.01	<.04	<.007	<.006	<1	<.03	<.004	0.398
Hammersly Lake	3	<0.01	<.04	<.007	<.006	<1	<.03	<.004	0.404
Kukaklek Lake	1	<0.01	<.04	<.007	<.006	<1	0.07	<.004	0.773
Kukaklek Lake	2	<0.01	<.04	<.007	<.006	<1	<.03	<.004	0.757
Kukaklek Lake	3	<0.01	<.04	<.007	0.006	<1	<.03	<.004	0.743
Kulik Lake	1	<0.01	<.04	<.007	<.006	<1	<.03	<.004	0.432
Kulik Lake	2	<0.01	<.04	<.007	<.006	<1	<.03	<.004	0.424
Kulik Lake	3	<0.01	<.04	<.007	<.006	<1	<.03	<.004	0.443
Murray Lake	1	<0.01	<.04	<.007	0.006	<1	<.03	<.004	0.358
Murray Lake	2	<0.01	<.04	<.007	<.006	<1	<.03	<.004	0.356
Murray Lake	3	<0.01	<.04	<.007	0.02	<1	<.03	<.004	0.356
Naknek Lake	1	<0.01	<.04	<.007	0.043	<1	<.03	0.008	2.45
Naknek Lake	2	<0.01	<.04	<.007	0.024	<1	<.03	0.004	2.46
Naknek Lake	3	<0.01	<.04	<.007	0.025	<1	<.03	0.007	2.45
Nonvianuk Lake	1	<0.01	<.04	<.007	<.006	<1	0.03	<.004	0.587
Nonvianuk Lake	2	<0.01	<.04	<.007	<.006	<1	<.03	<.004	0.571
Nonvianuk Lake	3	<0.01	<.04	<.007	<.006	<1	<.03	<.004	0.577

Table 65. Metals sampling in KATM lakes, 1992 (LaPerriere 1996). (continued)

Lake	Test	Ni	P	Pb	Sb	Se	Si	Sn	Sr	Mn
Battle Lake	1	<.03	<.1	<.06	<.09	<.1	2.3	<.06	0.016	0.025
Battle Lake	2	<.03	<.1	<.06	<.09	<.1	2.2	<.06	0.015	0.025
Battle Lake	3	<.03	<.1	<.06	<.09	<.1	2.2	<.06	0.015	0.025
Brooks Lake	1	<.03	<.1	<.06	<.09	<.1	3.8	<.06	0.027	0.001
Brooks Lake	2	<.03	<.1	<.06	<.09	<.1	3.7	<.06	0.027	<.001
Brooks Lake	3	<.03	<.1	<.06	<.09	<.1	3.7	<.06	0.027	<.001
Coville Lake	1	<.03	<.1	<.07	<.09	<.1	3.4	<.06	0.025	0.0058
Coville Lake	2	<.03	<.1	0.09	<.09	<.1	3.4	<.06	0.025	0.0049
Coville Lake	3	<.03	<.1	0.07	<.09	<.1	3.7	<.06	0.024	0.0056
Grosvenor	1	<.03	<.1	<.06	<.09	<.1	3.3	<.06	0.024	0.002
Grosvenor	2	<.03	<.1	0.08	<.09	<.1	3.4	<.06	0.025	0.002
Grosvenor	3	<.03	<.1	0.07	<.09	<.1	3.3	<.06	0.024	0.002
Hammersly Lake	1	<.03	<.1	<.06	<.09	<.1	2.1	<.06	0.011	<.001
Hammersly Lake	2	<.03	<.1	<.06	<.09	<.1	2.2	<.06	0.012	<.001
Hammersly Lake	3	<.03	<.1	<.06	<.09	<.1	2.1	<.06	0.012	<.001
Kukaklek Lake	1	<.03	<.1	0.07	<.09	<.1	1.4	<.06	0.013	0.001
Kukaklek Lake	2	<.03	<.1	<.06	<.09	<.1	1.2	<.06	0.012	0.001
Kukaklek Lake	3	<.03	<.1	<.06	<.09	<.1	1.3	<.06	0.012	<.001
Kulik Lake	1	<.03	<.1	<.06	<.09	<.1	2	<.06	0.015	0.002
Kulik Lake	2	<.03	<.1	<.06	<.09	<.1	2	<.06	0.014	<.001
Kulik Lake	3	<.03	<.1	<.06	<.09	<.1	2.1	<.06	0.015	0.002
Murray Lake	1	<.03	<.1	<.06	<.09	<.1	2.2	<.06	0.012	0.002
Murray Lake	2	<.03	<.1	<.06	<.09	<.1	2.2	<.06	0.011	0.0031
Murray Lake	3	<.03	<.1	<.06	<.09	<.1	2.2	<.06	0.012	0.002
Naknek Lake	1	<.03	<.1	<.06	<.09	<.1	3.4	<.06	0.0471	0.002
Naknek Lake	2	<.03	<.1	<.06	<.09	<.1	3.7	<.06	0.0474	<.001
Naknek Lake	3	<.03	<.1	<.06	<.09	<.1	3.5	<.06	0.047	<.001
Nonvianuk Lake	1	<.03	<.1	<.06	<.09	<.1	1.4	<.06	0.016	0.002
Nonvianuk Lake	2	<.03	<.1	<.06	<.09	<.1	1.4	<.06	0.015	0.002
Nonvianuk Lake	3	<.03	<.1	<.06	<.09	<.1	1.4	<.06	0.016	0.001

Table 65. Metals sampling in KATM lakes, 1992 (LaPerriere 1996). (continued)

Lake	Test	Ti	Tl	V	Zn
Battle Lake	1	<.003	<.2	<.006	<.005
Battle Lake	2	<.003	<.2	<.006	<.005
Battle Lake	3	<.003	<.2	<.006	<.005
Brooks Lake	1	<.003	<.2	<.006	<.005
Brooks Lake	2	<.003	<.2	<.006	<.005
Brooks Lake	3	<.003	<.2	<.006	<.005
Coville Lake	1	<.003	<.2	<.006	<.005
Coville Lake	2	<.003	<.2	<.006	<.005
Coville Lake	3	<.003	<.2	<.006	<.005
Grosvenor	1	<.003	<.2	<.006	0.006
Grosvenor	2	<.003	<.2	<.006	0.006
Grosvenor	3	<.003	<.2	<.006	0.009
Hammersly Lake	1	<.003	<.2	<.006	<.005
Hammersly Lake	2	<.003	<.2	<.006	<.005
Hammersly Lake	3	<.003	<.2	<.006	<.005
Kukaklek Lake	1	<.003	<.2	<.006	<.005
Kukaklek Lake	2	<.003	<.2	<.006	<.005
Kukaklek Lake	3	<.003	<.2	<.006	<.005
Kulik Lake	1	<.003	<.2	<.006	<.005
Kulik Lake	2	<.003	<.2	<.006	<.005
Kulik Lake	3	<.003	<.2	<.006	<.005
Murray Lake	1	<.003	<.2	<.006	<.005
Murray Lake	2	<.003	<.2	<.006	<.005
Murray Lake	3	<.003	<.2	<.006	<.005
Naknek Lake	1	<.003	<.2	<.006	<.005
Naknek Lake	2	<.003	<.2	<.006	<.005
Naknek Lake	3	<.003	<.2	<.006	<.005
Nonvianuk Lake	1	<.003	<.2	<.006	<.005
Nonvianuk Lake	2	<.003	<.2	<.006	<.005
Nonvianuk Lake	3	<.003	<.2	<.006	<.005

Table 66. Ion balances in KATM streams, 1990 (LaPerriere 1996).

	HCO_3 (mg/L)	HCO_3 (meq/L	Cl (mg/L)	Cl (meq/L)	SO_4 (mg/L)	SO_4 (meq/L)	Total Anions (meq/L)	Ca (mg/L)	Ca (meq/L)
American Creek	35.4	0.58	6.8	0.19	2.5	0.05	0.82	7.93	0.4
Battle 1	0	0	9.4	0.26	18.3	0.38	0.65	6.57	0.33
Battle 2	0	0	7.4	0.21	6	0.13	0.33	2	0.1
Battle 3	0	0	7.6	0.21	3.7	0.08	0.29	2.1	0.11
Battle 4	5.5	0.09	7.5	0.21	4.7	0.1	0.4	1.85	0.09
Battle 5	0.6	0.01	8	0.23	17.7	0.37	0.6	10.95	0.55
Battle River	5.4	0.09	8.2	0.23	6.7	0.14	0.46	4.04	0.2
Brooks 2	64.1	1.05	7.4	0.21	8.3	0.17	1.43	24.3	1.22
Brooks 3	30.4	0.5	9.7	0.27	22	0.46	1.23	9.72	0.49
Brooks 4	34.2	0.56	4.7	0.13	12.3	0.26	0.95	8.7	0.44
Brooks 5	45.1	0.74	4.1	0.12	6.3	0.13	0.99	19.3	0.97
Brooks 6	37.6	0.62	5.2	0.15	1	0.02	0.78	12.5	0.63
Brooks 7	70.3	1.15	8	0.23	4.7	0.1	1.48	19.7	0.99
Brooks River	27	0.44	5.8	0.16	6	0.13	0.73	8.1	4
Margot Creek	32.3	0.53	5.6	0.16	13	0.27	0.96	14.2	0.71
Nonvianuk River	12.9	0.21	5.8	0.16	3.7	0.08	0.45	4.6	0.23
Savonoski River	31.7	0.52	7.7	0.22	25	0.52	1.26	21	1.05
Ukak River	50.5	0.83	26.8	0.75	70	1.46	3.04	32.6	1.63

Table 66. Ion balances in KATM streams, 1990 (LaPerriere 1996). (continued)

	Mg (mg/L)	Mg (meq/L)	K (mg/L)	K (meq/L)	Na (mg/L)	Na (meq/L)	Total Cations	Ion_Sum (meq/L)
American Creek	1.76	0.144	<.5	0	3.28	0.14	0.68	1.5
Battle 1	2.57	0.211	0	0	2.24	0.1	0.64	1.29
Battle 2	0.348	0.029	0	0	1.5	0.07	0.19	0.52
Battle 3	0.262	0.021	<.5	0	1.4	0.1	0.19	0.48
Battle 4	0.19	0.016	<.4	0	0.96	0.04	0.15	0.55
Battle 5	1.8	0.15	0	0	2.2	0.1	0.79	1.39
Battle River	0.753	0.062	<.4	0	1.74	0.08	0.34	0.8
Brooks 2	3.77	0.309	1.1	0.03	6.23	0.3	1.82	3.25
Brooks 3	1.81	0.15	<.5	0	3.48	0.15	0.79	2.02
Brooks 4	2.65	0.22	0.9	0.02	3.95	0.17	0.85	1.8
Brooks 5	3.3	0.27	0	0	5.29	0.23	1.47	2.46
Brooks 6	2.89	0.24	0	0	4.17	0.18	1.04	1.82
Brooks 7	2.7	0.22	<.4	0	4.75	0.21	1.41	2.89
Brooks River	2.06	0.169	0.7	0.02	3.79	0.2	0.76	1.49
Margot Creek	2.02	0.17	<.5	0	3.35	0.15	1.02	1.98
Nonvianuk River	0.651	0.053	<.4	0	1.7	0.07	0.36	0.81
Savonoski River	4.92	0.4	1.2	0.03	4.34	0.2	1.67	2.93
Ukak River	8	0.66	2.2	0.06	24.3	1.06	3.4	6.44

Table 67. Ion balances in KATM streams, 1991 (LaPerriere 1996).

	HCO_3 (mg/L)	HCO_3 (meq/L	Cl (mg/L)	Cl (meq/L)	SO_4 (mg/L)	SO_4 (meq/L)	Total Anions	Ca (mg/L)	Ca (meq/L)	Mg (mg/L)	Mg (meq/L)	K (mg/L)
West Creek	45.8	0.75	0	0	0	0	0.75	11	0.55	2.63	0.216	0.5
Up-a-tree Creek	57	0.93	5.4	0.15	16	0.33	1.42	16.4	0.82	2.73	0.22	0.95
Hidden Creek	51.7	0.85	734	0.21	0	0	1.06	12.2	0.6	2.57	0.21	1.1
One-shot Creek	38.9	0.64	9.6	0.27	0	0	0.91	9.6	0.48	1.79	0.15	0.82
Headwater Creek	35.6	0.58	4	0.11	0	0	0.7	7.8	0.39	2.44	0.2	0.82

Table 67. Ion balances in KATM streams, 1991 (LaPerriere 1996). (continued)

	K (meq/L)	Na (mg/L)	Na (meq/L)	Total Cations	Ion Sum (meq/L)
West Creek	0.01	3.92	0.17	0.95	1.7
Up-a-tree Creek	0.02	4.51	0.2	1.26	2.68
Hidden Creek	0.03	4.1	0.18	1.03	2.09
One-shot Creek	0.02	3.37	0.1	0.79	1.7
Headwater Creek	0.02	4.02	0.17	0.79	1.49

Table 68. Ion balances in KATM streams, 1992 (LaPerriere 1996).

	HCO3 (mg/L)	HCO3 (meq/L	Cl (mg/L)	Cl (meq/L)	SO_4 (mg/L)	SO_4 (meq/L)	Total Anions
West Creek	58.1	0.95	3	0.1	0.3	0.03	1.04
Up-a-Tree Creek	67.5	1.11	2.2	0.06	15	0.31	1.48
Hidden Creek	42.7	0.7	2.7	0.08	0	0	0.78
One Shot Creek	35.3	0.58	1.8	0.05	0	0	0.63
Headwater Creek	42.6	0.7	2.3	0.06	0	0	0.76
Cat	37.7	0.62	2	0.06	19.3	0.4	1.08

Table 69. Metals sampling in KATM streams, 1990 (LaPerriere 1996).

	Test	Ag	Al	As	B	Ba	Be	Bi
American Creek	1	<.01	0.13	<.04	<.03	0.0034	<.0006	<.04
American Creek	2	<.01	0.22	<.05	<.03	0.0041	<.0005	<.04
Battle River	1	<.01	0.09	<.05	<.03	0.0039	<.0005	<.04
Battle River	2	<.01	0.07	<.05	<.03	0.0036	<.0005	<.04
Battle #1	1	<.01	3.85	<.05	<.03	0.0094	0.0006	<.04
Battle #1	2	<.01	3.82	<.05	<.03	0.011	<.0005	<.04
Battle #2	1	<.01	0.2	<.05	<.03	0.005	<.0005	<.04
Battle #2	2	<.01	0.2	<.05	<.03	0.0045	<.0005	<.04
Battle #3	1	<.01	0.16	<.04	<.03	0.0039	<.0006	<.04
Battle #3	2	<.01	0.03	<.05	<.03	0.0041	<.0005	<.04
Battle #4	1	<.01	0.04	<.05	<.03	0.0009	<.0005	<.04
Battle #4	2	<.01	0.05	<.05	<.03	0.001	<.0005	<.04
Battle #5	1	<.01	0.16	<.05	<.03	0.0048	<.0005	<.04
Battle #5	2	<.01	0.15	<.05	<.03	0.0074	<.0005	<.04
Brooks River	1	<.01	0.16	<.04	<.03	0.0021	<.0006	<.04
Brooks River	2	<.01	<.03	<.04	<.03	0.0021	<.0006	<.04
Brooks #2	1	<.01	0.06	<.05	<.03	0.0049	<.0005	<.04
Brooks #2	2	<.01	0.05	<.05	<.03	0.0049	<.0005	<.04
Brooks #3	1	<.01	<.03	<.04	<.03	0.044	<.0006	<.04
Brooks #3	2	<.01	0.06	<.05	<.03	0.0049	<.0005	<.04
Brooks #4	1	<.01	0.2	<.05	<.03	0.0043	<.0005	<.04
Brooks #4	2	<.01	0.19	<.05	<.03	0.0044	<.0005	<.04
Brooks #5	1	<.01	0.11	<.05	<.03	0.0053	<.0005	<.04
Brooks #5	2	<.01	<.03	<.04	<.03	0.0051	<.0006	<.04
Brooks #6	1	<.01	0.03	<.04	<.03	0.005	<.0006	<.04
Brooks #6	2	<.01	0.06	<.05	<.03	0.005	<.0005	<.04
Brooks #7	1	<.01	0.05	<.05	<.03	0.0083	<.0005	<.04
Brooks #7	2	<.01	<.03	<.04	<.03	0.008	<.0006	<.04
Margot Creek	1	<0.01	0.14	<.04	<0.03	0.0023	<.0006	<.04
Margot Creek	2	<0.01	0.13	<.04	<0.03	0.0024	<.0006	<.04
Nonvianuk River	1	<0.01	<.03	<.04	<0.03	0.0031	<.0006	<.04
Nonvianuk River	2	<0.01	0.11	<.05	<0.03	0.0037	<.0005	<.04
Savonoski River	1	<0.01	6.95	<.05	<.03	0.039	<.0005	<.04
Savonoski River	2	<0.01	7.93	<.04	<.03	0.046	<.0006	<.04
Ukak River	1	<0.01	6.27	<.05	0.17	0.029	<.0005	<.04

Table 69. Metals sampling in KATM streams, 1990 (LaPerriere 1996). (continued)

	Test	Ca	Cd	Co	Cr	Cu	Fe	K
American Creek	1	7.76	<.003	<.01	<.01	<.003	0.4	<.5
American Creek	2	8.09	<.004	<.01	<.01	<.003	0.46	<.4
Battle River	1	4	<.004	<.01	<.01	<.003	0.03	<.4
Battle River	2	4.08	<.004	<.01	<.01	<.003	0.083	<.4
Battle #1	1	6.45	<.004	<.01	<.01	<.003	0.22	<.4
Battle #1	2	6.69	<.004	<.01	<.01	<.003	0.21	0.6
Battle #2	1	2	<.004	<.01	<.01	<.003	0.16	0.4
Battle #2	2	2	<.004	<.01	<.01	<.003	0.18	<.4
Battle #3	1	2.1	<.003	<.01	<.01	<.003	0.12	<.5
Battle #3	2	2.1	<.003	<.01	<.01	<.003	0.14	<.4
Battle #4	1	1.9	<.004	<.01	<.01	0.003	0.049	<.4
Battle #4	2	1.8	<.004	<.01	<.01	<.003	<.01	<.4
Battle #5	1	10.6	<.004	<.01	<.01	<.003	0.02	<.4
Battle #5	2	11.3	<.004	<.01	<.01	<.003	0.035	0.6
Brooks River	1	7.89	<.003	<.01	<.01	<.003	0.065	0.8
Brooks River	2	8.24	<.003	<.01	<.01	<.003	0.084	0.6
Brooks #2	1	23.6	<.004	<.01	<.01	<.003	0.28	1.3
Brooks #2	2	24.9	<.004	<.01	<.01	<.003	0.28	0.9
Brooks #3	1	93.46	<.003	<.01	<.01	<.003	0.28	<.5
Brooks #3	2	9.98	<.004	<.01	<.01	<.003	0.29	0.5
Brooks #4	1	8.71	<.004	<.01	<.01	<.003	0.57	0.8
Brooks #4	2	8.68	<.004	<.01	<.01	<.003	0.56	1
Brooks #5	1	19.8	<.004	<.01	<.01	<.003	0.85	0.8
Brooks #5	2	18.8	<.003	<.01	<.01	<.003	0.92	<.5
Brooks #6	1	12.4	<.003	<.01	<.01	<.003	0.65	<.5
Brooks #6	2	12.6	<.004	<.01	<.01	<.003	0.62	0.5
Brooks #7	1	20.1	<.004	<.01	<.01	<.003	0.98	<.4
Brooks #7	2	19.3	<.003	<.01	<.01	<.003	0.96	<.5
Margot Creek	1	14.3	<.003	<.01	<.01	<.003	0.28	<.5
Margot Creek	2	14	<.003	<.01	<.01	<.003	0.28	<.5
Nonvianuk River	1	4.59	<.003	<.01	<.01	<.003	0.14	<.5
Nonvianuk River	2	4.6	<.004	<.01	<.01	<.003	0.086	<.4
Savonoski River	1	21.3	<.003	<.01	<.01	0.007	8.39	1.3
Savonoski River	2	20.7	<.004	<.01	<.01	0.012	9.32	1
Ukak River	1	32	<.004	<.01	<.01	0.0093	6.25	2

Table 69. Metals sampling in KATM streams, 1990 (LaPerriere 1996). (continued)

	Test Number	Li	Mg	Mn	Mo	Na	Ni	P
American Creek	1	<.002	1.72	0.026	<.005	3.27	<.01	<.2
American Creek	2	<.002	1.8	0.028	<.006	3.28	<.02	<.1
Battle River	1	<.002	0.753	0.021	<.006	1.76	<.02	<.1
Battle River	2	<.002	0.753	0.021	<.006	1.71	<.02	<.1
Battle #1	1	<.002	2.51	0.083	<.006	2.27	<.02	<.1
Battle #1	2	<.002	2.62	0.085	<.006	2.2	<.02	<.1
Battle #2	1	<.002	0.356	0.019	<.006	1.58	<.02	<.1
Battle #2	2	<.002	0.34	0.017	<.006	1.42	<.02	<.1
Battle #3	1	<.002	0.259	0.004	<.005	1.4	<.01	<.2
Battle #3	2	<.002	0.264	0.004	<.006	1.4	<.02	<.1
Battle #4	1	<.002	0.191	<.002	<.006	0.93	<.02	<.1
Battle #4	2	<.002	0.188	<.002	<.006	0.98	<.02	<.1
Battle #5	1	<.002	1.76	0.017	<.006	2.2	<.02	<.1
Battle #5	2	<.002	1.84	0.015	<.006	2.19	<.02	<.1
Brooks River	1	<.002	2.01	0.005	<.005	3.64	<.01	<.2
Brooks River	2	<.002	2.1	0.003	<.005	3.94	<.01	<.2
Brooks #2	1	<.002	3.67	0.019	<.006	6.04	<.02	<.1
Brooks #2	2	<.002	3.87	0.02	<.006	6.41	<.02	<.1
Brooks #3	1	<.002	1.76	0.018	<.005	3.53	<.01	<.2
Brooks #3	2	<.002	1.85	0.019	<.006	3.43	<.02	<.1
Brooks #4	1	<.002	2.66	0.04	<.006	3.99	<.02	<.1
Brooks #4	2	<.002	2.63	0.047	<.006	3.9	<.02	<.1
Brooks #5	1	<.002	3.36	0.067	<.006	5.22	<.02	<.1
Brooks #5	2	<.002	3.2	0.063	<.005	5.35	<.01	<.2
Brooks #6	1	<.002	2.86	0.041	<.005	4.18	<.01	<.2
Brooks #6	2	<.002	2.91	0.04	<.006	4.15	<.02	<.1
Brooks #7	1	<.002	2.74	0.059	<.006	4.63	<.02	<.1
Brooks #7	2	<.002	2.66	0.057	<.005	4.86	<.01	<.2
Margot Creek	1	<.002	2.03	0.012	<.005	3.34	<.01	<.2
Margot Creek	2	<.002	2	0.013	<.005	3.35	<.01	<.2
Nonvianuk River	1	<.002	0.648	0.0084	<.005	1.7	<.01	<.2
Nonvianuk River	2	<.002	0.653	0.011	<.006	1.6	<.02	<.1
Savonoski River	1	0.007	4.86	0.15	<.006	4.13	<.02	0.2
Savonoski River	2	0.0085	4.97	0.15	<.005	4.55	<.01	0.2
Ukak River	1	0.067	7.8	0.11	<.006	24.2	<.02	0.3

Table 69. Metals sampling in KATM streams, 1990 (LaPerriere 1996). (continued)

	Test Number	Pb	Sb	Se	Si	Sn	Sr	Ti
American Creek	1	<.04	<.04	<.08	5.5	<.05	0.029	0.0097
American Creek	2	<.04	<.04	<.07	6.07	<.04	0.03	0.011
Battle River	1	<.04	<.04	<.07	2.21	<.04	0.015	<.002
Battle River	2	<.04	<.04	<.07	2.21	<.04	0.015	<.002
Battle #1	1	<.04	<.04	<.07	5.45	<.04	0.031	<.002
Battle #1	2	<.04	<.04	<.07	5.55	<.04	0.031	<.002
Battle #2	1	<.04	<.04	<.07	2.65	<.04	0.0087	<.002
Battle #2	2	<.04	<.04	<.07	2.37	<.04	0.0082	<.002
Battle #3	1	<.04	<.04	<.07	1.41	<.05	0.0073	<.003
Battle #3	2	<.04	<.04	<.07	1.4	<.04	0.0069	<.002
Battle #4	1	<.04	<.04	<.07	2.14	<.04	0.0062	<.002
Battle #4	2	<.04	<.04	<.07	2.19	<.04	0.0056	<.002
Battle #5	1	<.04	<.04	<.07	3.94	<.04	0.043	<.002
Battle #5	2	<.04	<.04	<.07	3.98	<.04	0.044	<.002
Brooks River	1	<.04	<.04	<.07	4.45	<.05	0.028	<.003
Brooks River	2	<.04	<.04	<.07	4.69	<.05	0.03	<.003
Brooks #2	1	<.04	<.04	<.07	9.09	<.04	0.0656	0.003
Brooks #2	2	<.04	<.04	<.07	9.27	<.04	0.0684	<.002
Brooks #3	1	<.04	<.04	<.08	8.11	<.05	0.037	<.003
Brooks #3	2	<.04	<.04	<.07	8.11	<.04	0.036	0.004
Brooks #4	1	<.04	<.04	<.07	8.84	<.04	0.033	0.01
Brooks #4	2	<.04	<.04	<.07	8.78	<.04	0.032	0.0091
Brooks #5	1	<.04	<.04	<.07	8.19	<.04	0.0762	0.004
Brooks #5	2	<.04	<.04	<.08	7.98	<.05	0.0776	0.003
Brooks #6	1	<.04	<.04	<.08	5.17	<.05	0.0562	0.003
Brooks #6	2	<.04	<.04	<.07	5.26	<.04	0.0556	<.002
Brooks #7	1	<.04	<.04	<.07	6.3	<.04	0.0896	<.002
Brooks #7	2	<.04	<.04	<.08	6.36	<.05	0.0921	<.003
Margot Creek	1	<.04	<.04	<.08	6.28	<.05	0.038	0.012
Margot Creek	2	<.04	<.04	<.08	6.29	<.05	0.038	0.01
Nonvianuk River	1	<.04	<.04	<.08	1.71	<.05	0.016	<.003
Nonvianuk River	2	<.04	<.04	<.07	1.81	<.04	0.016	0.003
Savonoski River	1	<.04	<.04	<.07	14.2	<.04	0.0748	0.254
Savonoski River	2	<.04	<.04	<.08	16.3	<.05	0.0793	0.365
Ukak River	1	<.04	<.04	<.07	15.3	<.04	0.0939	0.224

Table 69. Metals sampling in KATM streams, 1990 (LaPerriere 1996). (continued)

	Test Number	Tl	V	Zn
American Creek	1	<.08	<.004	<.003
American Creek	2	<.06	<.003	0.0056
Battle River	1	<.06	<.003	0.055
Battle River	2	<.06	<.003	0.014
Battle #1	1	<.06	<.003	0.014
Battle #1	2	<.06	<.003	0.025
Battle #2	1	<.06	<.003	0.007
Battle #2	2	<.06	<.003	0.056
Battle #3	1	<.08	<.004	<.003
Battle #3	2	<.06	<.003	0.02
Battle #4	1	<.06	<.003	0.029
Battle #4	2	<.06	<.003	0.015
Battle #5	1	<.06	<.003	0.004
Battle #5	2	<.06	<.003	0.021
Brooks River	1	<.08	<.004	<.003
Brooks River	2	<.08	<.004	<.003
Brooks #2	1	<.06	<.003	0.005
Brooks #2	2	<.06	<.003	0.016
Brooks #3	1	<.08	<.004	0.016
Brooks #3	2	<.06	<.003	0.027
Brooks #4	1	<.06	<.003	0.007
Brooks #4	2	<.06	<.003	0.015
Brooks #5	1	<.06	<.003	0.005
Brooks #5	2	<.08	<.004	<.003
Brooks #6	1	<.08	<.004	0.05
Brooks #6	2	<.06	<.003	0.06
Brooks #7	1	<.06	<.003	0.019
Brooks #7	2	<.08	<.004	0.012
Margot Creek	1	<.08	<.004	<0.003
Margot Creek	2	<.08	<.004	<0.003
Nonvianuk River	1	<.08	<.004	<0.003
Nonvianuk River	2	<.06	<.003	0.006
Savonoski River	1	<.06	0.015	0.045
Savonoski River	2	<.08	0.02	0.02
Ukak River	1	<.06	0.012	0.017

Table 70. Stream metals sampling at Brooks Lake inlet streams, 1991 (LaPerriere 1996).

	Test	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu
Up-a-tree Creek	1	<.01	0.96	<.04	0.02	0.0093	<0	<.04	17	<.002	<.01	<.01	<.002
Up-a-tree Creek	2	<.01	0.92	<.04	0.02	0.0086	<0	<.04	16	<.002	<.01	<.01	0.002
Up-a-tree Creek	3	<.01	1.2	<.04	<.02	0.0099	<0	<.04	16.2	<.003	<.01	<.01	0.002
Headwater Creek	1	<.01	0.31	<.04	<.02	0.0049	<0	<.04	7.7	<.002	<.01	<.01	<.002
Headwater Creek	2	<.01	0.47	<.04	<.02	0.0061	<0	<.04	8	<.002	<.01	<.01	0.004
Headwater Creek	3	<.01	0.36	<.04	<.02	0.0055	<0	<.04	7.6	<.002	<.01	<.01	<.002
West Creek	1	<.01	<.02	<.04	<.02	0.0036	<0	<.04	11	<.002	<.01	<.01	<.002
West Creek	2	<.01	<.02	<.04	<.02	0.0037	<0	<.04	11	<.002	<.01	<.01	<.002
West Creek	3	<.01	<.02	<.04	<.02	0.0036	<0	<.04	11	<.002	<.01	<.01	<.002
Hidden Creek	1	<.01	0.12	<.04	<.02	0.0035	<0	<.04	12	<.002	<.01	<.01	0.003
Hidden Creek	2	<.01	0.12	<.04	<.02	0.0036	<0	<.04	12.4	<.003	<.01	<.01	<.002
Hidden Creek	3	<.01	0.13	<.04	<.02	0.0033	<0	<.04	12.1	N/A	<.01	<.01	<.002
One Shot Creek	1	<.01	0.57	<.04	<.02	0.0075	<0	<.04	9.73	<.003	<.01	<.01	<.002
One Shot Creek	2	<.01	0.55	<.04	<.02	0.0076	<0	<.04	9.27	<.003	<.01	<.01	<.002
One Shot Creek	3	<.01	0.59	<.04	<.02	0.0075	0.0005	<.04	9.78	<.003	<.01	<.01	<.002

Table 70. Stream metals sampling at Brooks Lake inlet streams, 1991 (LaPerriere 1996). (continued)

	Test	Fe	K	W	Li	Mg	Mn	Mo	Na	Ni	P	Pb	Sb
Up-a-tree Creek	1	1.66	0.84	<.01	<.002	2.8	0.058	<.005	4.61	<.01	0.1	<.04	<.04
Up-a-tree Creek	2	1.55	0.9	<.01	<.002	2.67	0.051	<.005	4.38	<.01	0.1	<.04	<.04
Up-a-tree Creek	3	1.92	1.1	<.02	0.002	2.72	0.055	<.005	4.55	<.01	0.1	<.04	<.04
Headwater Creek	1	0.716	0.68	<.01	<.002	2.41	0.036	<.005	4.04	<.01	<.09	<.04	<.04
Headwater Creek	2	0.906	0.96	<.01	<.002	2.51	0.041	<.005	4.06	<.01	0.09	<.04	<.04
Headwater Creek	3	0.76	0.82	<.01	<.002	2.36	0.036	<.005	3.97	<.01	<.09	<.04	<.04
West Creek	1	0.31	0.5	<.01	<.002	2.62	0.025	<.005	3.93	<.01	<.09	<.04	<.04
West Creek	2	0.31	0.59	<.01	<.002	2.66	0.023	<.005	3.96	<.01	<.09	<.04	<.04
West Creek	3	0.31	0.4	<.01	<.002	2.61	0.023	<.005	3.88	<.01	<.09	<.04	<.04
Hidden Creek	1	0.43	1.2	<.01	<.002	2.6	0.02	<.005	4.02	<.01	<.09	<.04	<.04
Hidden Creek	2	0.42	1.1	<.02	<.002	2.58	0.019	<.005	4.18	<.01	<.09	<.04	<.04
Hidden Creek	3	0.44	1.1	<.02	<.002	2.53	0.018	<.005	4.09	<.01	<.09	<.04	<.04
One Shot Creek	1	0.811	0.88	<.02	<.002	1.81	0.028	<.005	3.44	<.01	<.09	<.04	<.04
One Shot Creek	2	0.803	0.7	<.02	<.002	1.73	0.029	<.005	3.27	<.01	<.09	<.04	<.04
One Shot Creek	3	0.816	0.89	<.02	<.002	1.82	0.029	<.005	3.41	<.01	<.09	<.04	<.04

Table 70. Stream metals sampling at Brooks Lake inlet streams, 1991 (LaPerriere 1996). (continued)

	Test Number	Se	Si	Sn	Sr	Ti	Tl	V	Zn
Up-a-tree Creek	1	<.04	8.77	<.04	0.0496	0.063	<.04	0.004	0.0059
Up-a-tree Creek	2	<.04	8.42	<.04	0.048	0.057	<.04	0.005	<.002
Up-a-tree Creek	3	<.04	9.03	<.04	0.0497	0.08	<.08	0.005	<.002
Headwater Creek	1	<.04	8.33	<.04	0.029	0.019	<.04	<.003	<.002
Headwater Creek	2	<.04	8.88	<.04	0.03	0.031	<.04	<.003	0.003
Headwater Creek	3	<.04	8.41	<.04	0.029	0.021	<.04	<.003	0.002
West Creek	1	<.04	5.06	<.04	0.05	<.002	<.04	<.003	<.002
West Creek	2	<.04	5.15	<.04	0.0502	<.002	<.04	<.003	<.002
West Creek	3	<.04	5	<.04	0.049	<.002	<.04	<.003	<.002
Hidden Creek	1	<.04	8.39	<.04	0.032	0.0075	<.04	<.003	<.002
Hidden Creek	2	<.04	8.44	<.04	0.033	0.0073	<.08	<.003	<.002
Hidden Creek	3	<.05	8.43	<.04	0.032	0.0075	<.08	<.003	<.002
One Shot Creek	1	<.05	8.09	<.04	0.037	0.033	<.08	<.003	0.003
One Shot Creek	2	<.05	7.61	<.04	0.035	0.03	<.08	<.003	<.002
One Shot Creek	3	<.05	7.87	<.04	0.037	0.033	<.08	<.003	0.003

Table 71. Stream metals sampling at Brooks Lake inlet streams, 1991 (LaPerriere 1996).

	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu
Kulik #8	<.008	0.22	<.1	<.02	0.0075	<.0002	<.04	69.1	<.007	<.01	<.04	0.01

	Fe	K	W	Li	Mg	Mh	Mo	Na	Ni	P	Pb	Sb
Kulik #8	0.1	<1.1	<.03	<.004	6.15	0.032	<.01	4.7	<.03	<.1	0.07	<.09

	Se	Si	Sn	Sr	Ti	Tl	V	Zn
Kulik #8	<.1	5.52	<.06	0.242	0.003	<.2	<.006	0.005

Table 72. Light and associated characteristics, 1990-1992 (LaPerriere 1996).

Test	1990 K_d(Par)	1991 K_d(Par)	1992 K_d(Par)	1990 Secchi Depth	1991 Secchi Depth	1992 Secchi Depth	1990 Depth of 1% Light
Units	(m^{-1})	(m^{-1})	(m^{-1})	(m)	(m)	(m)	(m)
Battle	0.081	0.057	0.073	18	18	16	56
Brooks	0.164	0.25	0.183	9.8	9.6	9.6	28
Coville	0.274	0.26	0.349	6	4.9	6.2	17
Grosvenor	0.179	0.2	0.219	12	7.8	11	26
Hammersly	-	0.188	0.128		12	16	-
Idavain	0.411	-	-	4.4	-	-	11
Kukaklek	0.178	0.103	0.151	16	11	12	26
Kulik	0.148	0.146	0.135	12	8.3	11	31
Murray	0.108	0.183	0.177	16	10	14	43
Naknek	0.156	0.288	0.186	6.5	3.2	6.2	29
Nonvianuk	0.128	0.144	0.202	14	9	11	36

Table 72. Light and associated characteristics, 1990-1992 (LaPerriere 1996). (continued)

Test	1991 Depth of 1% Light	1992 Depth of 1% Light	1990 Phytoplankton	1992 Phytoplankton	1990 Apparent Color
Units	(m)	(m)	(mg/m^{3}chl.*a*)	(mg/m^{3}chl.*a*)	(Pt-Co Units)
Battle	81	63	0.16	0.09	3
Brooks	18	25	0.37	0.57	5
Coville	18	13	0.56	1.75	17
Grosvenor	23	21	0.45	0.59	0
Hammersly	24	36	-	0.55	-
Idavain	-	-	1.02	-	0
Kukaklek	45	30	0.28	0.97	10
Kulik	32	34	0.34	0.58	0
Murray	25	26	0.23	0.46	0
Naknek	16	25	0.5	0.88	13
Nonvianuk	32	23	0.3	0.68	0

Table 72. Light and associated characteristics 1990-1992 (LaPerriere 1996). (continued)

Test	**1991 Apparent Color**	**1992 Apparent Color**	**1990 Turbity**	**1991 Turbidity**	**1992 Turbidity**
Units	(Pt-Co Units)	(Pt-Co Units)	(NTU)	(NTU)	(NTU)
Battle	≤1	0	0.4	0.4	1.9
Brooks	0	7	0.51	0.4	2.3
Coville	0	4	0.83	1	1.7
Grosvenor	0	6	0.62	0.6	1.4
Hammersly	0	3	-	0.4	2.7
Idavain			0.77	-	-
Kukaklek	0	≤1	0.44	0.5	1.1
Kulik	0	≤1	0.46	0.5	1.7
Murray	0	11	0.29	0.5	1.2
Naknek	≤10	33	0.81	1.3	1.8
Nonvianuk	0	5	0.61	0.4	1.5

Table 73. Various water quality data measurements from Kim et al. (1969).

Location	Lat	Long	Mo	Year	Iron	Chlor.	TDS	Hard.	Alk.	Col
King Salmon	58.41	156.4	4	65	0.06	13	234	19	161	25
King Salmon	58.41	156.39	4	65	0.15	4	114	50	49	10
King Salmon	58.41	156.39	4	65	0.34	6	121	55	54	10
King Salmon	58.41	159.39	11	65	0.22	2	200	10	63	10
King Salmon	58.41	156.39	8	66	0.46	5	113	52	57	5
King Salmon	58.41	156.39	9	66	0.5	4	106	5	50	5
King Salmon	58.41	159.39	9	66	0.32	1	153	8	107	5
King Salmon	58.41	156.4	8	67	0.04	4	96	24	28	0
King Salmon	58.41	159.39	9	67	0.3	n/a	62	14	11	30
King Salmon	58.41	156.4	10	67	0.24	10	218	19	152	5
King Salmon	58.41	156.39	10	67	0.5	6	110	50	54	10
King Salmon	58.41	156.39	10	67	0.25	11	126	60	65	5
Kotlik	63.02	163.33	4	63	0.02	12040	21200	3010	1170	N/A
Koyuk	64.56	161.09	N/A	N/A	0.02	1620	3112	849	262	5
Koyuk	64.56	161.09	N/A	N/A	0.08	2901	761	366	297	5
Kwethluk	69.49	161.26	4	58	10	17	390	210	n/a	90
Kwethluk	69.49	161.26	8	58	10	8	250	185	n/a	80
Kwethluk	69.49	161.26	9	58	7	8	140	195	n/a	80
Kwethluk	69.49	161.26	1	59	4	11	570	91	n/a	n/a
Kwethluk	69.49	161.26	1	60	7	17	340	203	n/a	80
Kwethluk	69.49	161.26	2	68	0.03	4	301	167	239	15
Kwethluk	69.49	161.26	8	66	1	1	248	227	242	15
McKinley Park	63.43	148.55	2	61	0.1	113	330	297	n/a	5
McKinley Park	63.43	148.55	5	61	0.05	3	500	320	n/a	5
McKinley Park	63.43	148.55	7	61	0.05	1	341	271	n/a	5
McKinley Park	63.43	148.55	10	61	0.1	1	349	262	n/a	5
Manley HS	65	150.38	7	61	0.05	65	260	63	n/a	5

Table 73. Various water quality data measurements from Kim et al. (1969). (continued)

Location	Lat	Long	Mo	Year	Iron	Chlor.	TDS	Hard.	Alk.	Col
Manley H S	65	150.38	11	61	0.05	64	254	44	n/a	10
Manokotak	58.58	159.03	1	67	0.02	3	39	19	15	0
Matanuska Val.	61.37	149.1	10	48	0.09	3	166	130	132	n/a
Matanuska Val.	61.37	149.6	10	48	0.05	3	292	219	141	n/a
Matanuska Val.	61.32	149.3	10	48	0.11	5	273	228	unk	n/a
Matanuska Val.	61.33	149.9	8	49	0.02	8	159	140	131	n/a
Matanuska Val.	61.35	149.21	8	49	0.02	65	538	530	378	n/a
Matanuska Val.	61.35	149.7	8	49	0.02	74	852	490	304	n/a
Matanuska Val.	61.36	149.6	8	49	0.06	42	388	269	218	n/a
Matanuska Val.	61.38	149.3	8	49	0.02	8	143	104	75	
Indian Mt.	65.59	153.41	5	61	0.03	2	139	114	118	0
Indian Mt.	65.59	153.41	3	62	0.03	2	142	118	119	5
Indian Mt.	65.59	153.41	3	62	0.03	2	121	102	106	10
Indian Mt.	65.59	153.41	3	62	0.02	1	129	110	112	5
Indian Mt.	65.59	153.41	11	64	0.11	2	135	118	118	5
Indian Mt.	65.59	153.41	11	67	0.2	3	132	107	110	5
Indian Mt.	65.59	153.41	9	67	0.06	4	152	128	135	0
Juneau	58.21	135.35	9	65	0.42	2	79	118	12	0
Juneau	58.23	134.34	9	65	0.6	1	136	98	103	5
Juneau	58.23	134.33	9	65	2.31	3	119	84	83	5
Juneau	58.21	134.35	9	65	0.04	1	94	92	76	5
Kaltag	64.2	158.43	6	67	0.48	5	135	61	98	5
Kasiglook	60.52	162.32	Unk.	Unk.	7.7	0	158	110	123	60
King Salmon	58.41	156.4	Unk.	Unk.	0.02	44	242	101	129	5
King Salmon	58.4	156.27	Unk.	Unk.	0.04	3	83	21	29	0
King Salmon	58.41	156.4	Unk.	Unk.	1.6	1	188	19	124	0
King Salmon	58.41	156.4	9	59	0.39	19	221	65	148	10
King Salmon	58.41	156.4	9	59	1.9	7	120	58	46	5
King Salmon	58.41	156.4	9	59	0.06	4	75	53	59	0

Table 73. Various water quality data measurements from Kim et al. (1969). (continued)

Location	Lat	Long	Mo	Year	Iron	Chlor.	TDS	Hard.	Alk.	Col.
King Salmon	58.41	156.4	9	59	0.01	16	241	19	156	20
King Salmon	58.41	156.39	9	59	0.18	7	109	46	40	0
King Salmon	58.41	156.39	9	59	0.04	16	216	13	164	60
King Salmon	58.41	156.39	9	59	0.15	12	248	24	159	5
King Salmon	58.41	156.4	3	62	0.1	4	96	32	35	5
King Salmon	58.41	156.4	6	62	3.42	5	126	10	124	16
King Salmon	58.41	156.4	7	62	0.1	14	225	16	157	10
King Salmon	58.41	156.39	7	62	0.25	6	130	48	78	0
King Salmon	58.41	156.39	7	62	0.2	5	107	48	55	0
King Salmon	58.41	156.4	7	62	0.15	5	81	27	29	0
King Salmon	58.41	156.4	7	62	0.15	5	83	21	30	0
King Salmon	58.41	156.39	3	63	0.21	4	106	50	54	5
King Salmon	58.41	156.39	5	63	0.31	5	163	12	126	20
King Salmon	58.41	156.4	7	64	0.11	14	226	25	150	20
King Salmon	58.41	156.4	10	64	0.07	15	214	20	145	20
King Salmon	58.41	156.4	10	64	0.11	13	216	Unk	151	30
King Salmon	58.41	156.39	10	64	0.19	5	106	49	32	5
King Salmon	58.41	156.4	4	65	0.02	13	240	26	170	20

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992).

Area	Map No.	Field Number	Date	Temp	pH	pH	SiO_2	Ca	Mg
Units				°C	Field	Lab	mg/L	mg/L	mg/L
Upper Knife Creek Tributaries	24	KJ-89-21	26-Aug-89	2.9	5.3	4.06	51	23.6	5.22
Upper Knife Creek Tributaries	25	KJ-82-04	26-Jul-82	5	5.4	4.18	10.6	16.6	1.87
Upper Knife Creek Tributaries	26	KJ-89-18	26-Aug-89	4.5	5.9	4.42	40.9	14.7	3.23
Upper Knife Creek Tributaries	27	KJ-89-19	26-Aug-89	2.6	4.2	3.98	28.6	34	2.58
Upper Knife Creek Tributaries	28a	86KAT198	1-Aug-86	3	5.2	3.92	13.3	22.7	2.9
Upper Knife Creek Tributaries	28b	KJ-89-20	26-Aug-89	3.7	5.3	4.45	38.5	21.1	2.6
Upper Knife Creek Tributaries	29	KJ-89-17	26-Aug-89	0.7	5.9	3.87	51.2	20.7	6.62
Upper Knife Creek Tributaries	S3	84KAT124	6-Aug-84	10	5.7	6.27	25.7	24.1	2.15
Lower Knife Creek	3a	KJ-82-09	12-Aug-82	11	5.9	7.09	28.4	56.4	11.6
Lower Knife Creek	3b	KJ-89-01	19-Aug-89	7.8	5.3	5.68	86.6	42	14.6
Lower Knife Creek	3c	90KAT266	3-Jun-90	9.2	5.4	5.49	25.1	37.9	8.47
Lower Knife Creek	4	86KAT207	6-Aug-86	6	5.5	6.78	24	44.1	9.65
Upper River Lethe	15	86KAT203	5-Aug-86	2.5	5.3	6.49	9.8	4.4	0.94
Upper River Lethe	16	KJ-89-12	24-Aug-89	4.7	5.6	4.82	42.9	2.1	1.04
Upper River Lethe	17	KJ-82-08	4-Aug-82	7	5.7	6.49	52.4	10.1	1.83

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992). (continued)

Area	Map no.	Field number	Date	Li	K	Li	$HC0_3$	$S0_4$	Cl	F	B[a]	Cond.
Units:				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mS
Upper Knife Creek Tributaries	24	KJ-89-21	26-Aug-89	6.3	0.99	0.007	0	87	3.1	0.79	<0.05	205
Upper Knife Creek Tributaries	25	KJ-82-04	26-Jul-82	2.9	0.5	<0.01	5	32	1.5	0.46	0.25	264
Upper Knife Creek Tributaries	26	KJ-89-18	26-Aug-89	4.9	0.68	0.005	5.8	46	1.9	0.51	<0.05	121
Upper Knife Creek Tributaries	27	KJ-89-19	26-Aug-89	6.8	0.38	0.007	0	106	1.9	1.83	<0.05	292
Upper Knife Creek Tributaries	28a	86KAT198	1-Aug-86	3.8	0.34	0.01	0	62	3.4	0.22	0.05	246
Upper Knife Creek Tributaries	28b	KJ-89-20	26-Aug-89	6.5	0.64	0.011	9.1	79	3	3.15	<0.05	188
Upper Knife Creek Tributaries	29	KJ-89-17	26-Aug-89	10.9	1.26	0.007	a	111	5.1	0.32	<0.05	268
Upper Knife Creek Tributaries	S3	84KAT124	6-Aug-84	8.1	0.5	<0.01	25	58	5	1.8	0.15	224
Lower Knife Creek	3a	KJ-82-09	12-Aug-82	42.5	2.37	0.08	55	140	57	1.6	0.3	565
Lower Knife Creek	3b	KJ-89-01	19-Aug-89	39.6	2.4	0.068	26.4	100	33.3	1.33	0.21	440
Lower Knife Creek	3c	90KAT266	3-Jun-90	29.3	1.76	0.076	58.8	113	38	1.5	0.15	474
Lower Knife Creek	4	86KAT207	6-Aug-86	31	1.1	0.07	37	104	40.8	1.35	0.2	483
Upper River Lethe	15	86KAT203	5-Aug-86	1.5	0.15	0.007	13.8	14	1.2	0.07	0.25	44.1
Upper River Lethe	16	KJ-89-12	24-Aug-89	4.2	0.97	0.003	10.3	11	1.2	0.11	<0.05	30.4
Upper River Lethe	17	KJ-82-08	4-Aug-82	4	1.27	<0.01	26	13	4	0.75	0.1	53.8

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992). (continued)

Area	Map no.	Field number	Date	δD[a]	$\delta^{18}O$[a]	Fe	Mn	As	Sr	Ba	Rb	Cs
				o/oo[b]	o/oo[b]	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Upper Knife Creek Tributaries	24	KJ-89-21	26-Aug-89	-114	-15	38.4	0.43	-	0.13	0.02	-	-
Upper Knife Creek Tributaries	25	KJ-82-04	26-Jul-82	-117	-15.9	-	0.12	-	-	-	0.03	0.03
Upper Knife Creek Tributaries	26	KJ-89-18	26-Aug-89	-	-	26.4	0.3	-	<.05	<.05	-	-
Upper Knife Creek Tributaries	27	KJ-89-19	26-Aug-89	-114	-14.8	1.4	0.39	-	0.09	<.05	-	-
Upper Knife Creek Tributaries	28a	86KAT198	1-Aug-86	-	-	-	-	-	-	-	-	-
Upper Knife Creek Tributaries	28b	KJ-89-20	26-Aug-89	-108	-14.3	10.2	0.19	-	0.05	<.05	-	-
Upper Knife Creek Tributaries	29	KJ-89-17	26-Aug-89	-	-	39	0.4	-	<.05	<.05	-	-
Upper Knife Creek Tributaries	S3	84KAT124	6-Aug-84	-	-	-	-	-	-	-	-	-
Lower Knife Creek	3a	KJ-82-09	12-Aug-82	-	-	-	0.13	-	0.14	-	0.05	0.34
Lower Knife Creek	3b	KJ-89-01	19-Aug-89	-	-	38.7	0.39	-	0.24	0.06	-	-
Lower Knife Creek	3c	90KAT266	3-Jun-90	-115	-15.4	-	-	-	-	-	-	-
Lower Knife Creek	4	86KAT207	6-Aug-86	-	-	-	-	-	-	-	-	-
Upper River Lethe	15	86KAT203	5-Aug-86	-	-	-	-	-	-	-	-	-
Upper River Lethe	16	KJ-89-12	24-Aug-89	-	-	9.7	0.09	-	<.05	<.05	-	-
Upper River Lethe	17	KJ-82-08	4-Aug-82	-	-	-	0.09	-	0.05	-	0.04	0.08

[a] δDand $\delta^{18}O$ are reported relative to Standard Mean ocean water (SMOW).

[b] o/oo parts per thousand

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992). (continued)

Area	Map no.	Field number	Date	δ13C[a]	δ18O(SO4)[b]	Spring	Quartz	Na-K	Na-K-Ca	Na-K-Ca	K-Mg
				o/oo	o/oo		Cond.	B=4/3	Mg cor.		
Upper Knife Creek Tributaries	24	KJ-89-21	26-Aug-89	-	-4.7	-	-	-	-	-	-
Upper Knife Creek Tributaries	25	KJ-82-04	26-Jul-82	-	-	-	-	-	-	-	-
Upper Knife Creek Tributaries	26	KJ-89-18	26-Aug-89	-	-	-	-	-	-	-	-
Upper Knife Creek Tributaries	27	KJ-89-19	26-Aug-89	-	-	-	-	-	-	-	-
Upper Knife Creek Tributaries	28a	86KAT198	1-Aug-86	-	-	-	-	-	-	-	-
Upper Knife Creek Tributaries	28b	KJ-89-20	26-Aug-89	-	-7.4	-	-	-	-	-	-
Upper Knife Creek Tributaries	29	KJ-89-17	26-Aug-89	-	-	-	-	-	-	-	-
Upper Knife Creek Tributaries	S3	84KAT124	6-Aug-84	-	-	-	-	-	-	-	-
Lower Knife Creek	3a	KJ-82-09	12-Aug-	-	-	-	-	-	-	-	-
Lower Knife Creek	3b	KJ-89-01	19-Aug-	-	-	-	-	-	-	-	-
Lower Knife Creek	3c	90KAT26	3-Jun-	-	-	-	-	-	-	-	-
Lower Knife Creek	4	86KAT20	6-Aug-	-	-	-	-	-	-	-	-
Upper River Lethe	15	86KAT20	5-Aug-	-	-	-	-	-	-	-	-
Upper River Lethe	16	KJ-89-12	24-Aug-	-	-	-	-	-	-	-	-
Upper River Lethe	17	KJ-82-08	4-Aug-	-	-	-	-	-	-	-	-

[a]δ13C values reported relative to the Chicago Peedee belemnite (PDB).

[b]δ18O values reported relative to SMOW; analyzed by C. Janik, USGS.

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992). (continued)

Area	Map no.	Field number	Date	Te mp	f pH	l pH	SiO:z	Ca	Mg	Li	K	Li
				C			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Upper River Lethe	18	KJ-89-14	24-Aug-89	4.1	5.4	4.72	37.1	5	0.86	4	0.95	0.002
Upper River Lethe	19	KJ-89-13	24-Aug-89	5.1	5.3	4.28	36.3	10	1.45	3.4	0.76	0.002
Lower River Lethe	5a	KJ-82-12	13-Aug-82	13	6	7.46	27.6	25.1	8.54	35.2	2.51	0.125
Lower River Lethe	5b	86KAT139	20-Jul-86	10	5.7	7.3	26.5	28.6	9.2	34.4	1.8	0.11
Lower River Lethe	5c	KJ-89-05	20-Aug-89	8.4	5.5	5.9	42.5	11.5	4.47	27.1	1.81	0.069
Lower River Lethe	5d	90KAT270	5-Jun-90	112	5.6	5.98	28.4	20.3	7.1	26.3	2.02	0.113
Windy Creek	6	KJ-89-06	20-Aug-89	14.2	-	5.45	15	17.5	1.62	4.3	0.57	0.002
Windy Creek	7	86KAT140	20-Jul-86	14	5.7	6.99	10.1	14.1	2.2	3.1	0.22	0.005
Ukak River	1	84KAT121	6-Aug-84	15	6.2	6.94	53.1	35.6	9.48	31.1	2.46	0.08
Ukak River	2a	KJ-82-10	12-Aug-82	13	5.9	7.35	26.7	37.9	9.03	35.9	2.11	0.102
Ukak River	2b	86KAT135	19-Jul-86	14	5.9	7.05	23.6	39.9	9.1	6.2	1.3	0.08
Ukak River	2c	KJ-89-02	19-Aug-89	8.4	-	5.51	67.9	25.9	9.17	33.4	2.08	0.066
Ukak River	2d	90KAT265	3-Jun-90	9.3	5.8	5.29	22.2	26.6	6.09	22.4	1.47	0.068
River Lethe Springs (mid-valley	S4	90KAT264	2-Jun-90	8.8	5.5	6.32	26.4	17.5	6.33	24.9	1.65	0.086
River Lethe Springs (mid-valley	S5(1)	90KAT281	8-Jun-90	5.3	5.7	5.6	20.4	8.5	1.75	11.1	0.67	0.036
River Lethe Springs (mid-valley	S5(2)	90KAT282	8-Jun-90	4.9	5.5	5.5	20.2	8.7	1.64	10.3	0.63	0.036
Cold Springs above ash flow	S1a	KJ-82-01	19-Jul-82	5	5.6	7.4	19.4	16	2.98	5.3	0.5	<.01
Cold Springs above ash flow	S1b	86KAT136	19-Jul-86	9	5.7	7.06	19.1	18.3	3.4	4.9	0.17	0.01
Cold Springs above ash flow	S1c	KJ-89-03	19-Aug-89	4.8	-	5.39	19.2	17.3	1.89	5.2	0.52	0.004
Cold Springs above ash flow	S2a	KJ-82-13	14-Aug-82	5	5.6	7.37	20.3	16.3	3.12	4.1	0.74	0.01

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992). (continued)

Area	Map no.	Field number	Date	$HC0_3$	$S0_4$	Cl	F	B[a]	con do	δD[b]	$\delta^{18}O$[b]	Fe
				mg/L	mg	mg/	mg/	mg/L	mS	o/oo	o/oo	mg/L
Upper River Lethe	18	KJ-89-14	24-Aug-89	12.2	10	1.5	0.12	<0.05	30.1	-	-	4.7
Upper River Lethe	19	KJ-89-13	24-Aug-89	0	40	1.2	0.11	<0.05	33.6	-	-	16.9
Lower River Lethe	5a	KJ-82-12	13-Aug-82	82	60	40	1.65	0.4	380	-	-	-
Lower River Lethe	5b	86KAT139	20-Jul-86	67.5	71	26.7	1.2	0.4	358	-	-	-
Lower River Lethe	5c	KJ-89-05	20-Aug-89	46	26	17.1	2.33	0.06	241			6.8
Lower River Lethe	5d	90KAT270	5-Jun-90	74.1	63	26.4	2.29	<0.10	367	-105	-14.1	-
Windy Creek	6	KJ-89-06	20-Aug-89	42.5	23	2.1	0.21	<0.05	125	-	-	1.3
Windy Creek	7	86KAT140	20-Jul-86	24.9	21	1.5	0.06	<0.1	102	-	-	-
Ukak River	1	84KAT121	6-Aug-84	58	62	47	1.4	0.25	378	-	-	-
Ukak River	2a	KJ-82-10	12-Aug-82	27	90	46	1.55	0.6	507	-	-	-
Ukak River	2b	86KAT135	19-Jul-86	18.2	83	31.8	0.75	0.47	393	-	-	-
Ukak River	2c	KJ-89-02	19-Aug-89	38	101	24.9	1.4	0.13	341	-	-	21
Ukak River	2d	90KAT265	3-Jun-90	56.8	73	26.4	1.63	<0.10	358	-110	-14.9	-
River Lethe Springs (mid-valley)	S4	90KAT264	2-Jun-90	57.6	46	20.9	2.41	<0.10	315	-102	-13.9	-
River Lethe Springs (mid-valley)	S5(1)	90KAT281	8-Jun-90	21.9	25	8.8	2.31	1	154	-104	-14.2	-
River Lethe Springs (mid-valley)	S5(2)	90KAT282	8-Jun-90	28	24	8.1	2.21	0.33	150	-105	-14.3	-
Cold Springs above ash flow	S1a	KJ-82-01	19-Jul-82	66	21	2.1	0.14	0.15	140	-109	-15	-
Cold Springs above ash flow	S1b	86KAT136	19-Jul-86	46	18	2.4	0.05	<.05	128	-	-	-
Cold Springs above ash flow	S1c	KJ-89-03	19-Aug-89	44.7	17	2.8	0.28	<.05	126	-109	-13.8	0.11
Cold Springs above ash flow	S2a	KJ-82-13	14-Aug-82	63	11	2.4	0.02	0.15	120	-	-	-

aMethod for B changed in 1989 from spectrophotometric carmin method to DC plasma which changed error from ±D.05 to ±D.OI.

bδD and δ18O are reported relative to Standard Mean Ocean Water (SMOW).

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992). (continued)

Area	Map no.	Field number	Date	Mn	As	Sr	Ba	Rb	Cs	$\delta^{18}O(SO_4)^b$
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	o/oo
Upper River Lethe	18	KJ-89-14	24-Aug-89	0.07	<.05	<.05	-	-	-	-
Upper River Lethe	19	KJ-89-13	24-Aug-89	0.1	-	<.05	<.05	-	-	-
Lower River Lethe	5a	KJ-82-12	13-Aug-82	0.03	-	0.07	-	0.05	0.09	-
Lower River Lethe	5b	86KAT139	20-Jul-86	-	-	-	-	-	-	-
Lower River Lethe	5c	KJ-89-05	20-Aug-89	0.09	-	0.14	0.1	-	-	-
Lower River Lethe	5d	90KAT270	5-Jun-90	-	-	-	-	-	-	-
Windy Creek	6	KJ-89-06	20-Aug-89	0.03	-	0.11	0.04	-	-	-
Windy Creek	7	86KAT140	20-Jul-86	-	-	-	-	-	-	-
Ukak River	1	84KAT121	6-Aug-84	-	-	-	-	-	-	-
Ukak River	2a	KJ-82-10	12-Aug-82	0.07	-	0.1	-	0.05	0.05	-
Ukak River	2b	86KAT135	19-Jul-86	-	-	-	-	-	-	-
Ukak River	2c	KJ-89-02	19-Aug-89	0.13	-	0.17	0.03	-	-	-
Ukak River	2d	90KAT265	3-Jun-90	-	-	-	-	-	-	-
River Lethe Springs (mid-valley)	S4	90KAT264	2-Jun-90	-	-	-	-	-	-	-
River Lethe Springs (mid-valley)	S5(1)	90KAT281	8-Jun-90	-	-	-	-	-	-	-
River Lethe Springs (mid-valley)	S5(2)	90KAT282	8-Jun-90	-	-	-	-	-	-	-
Cold Springs above ash flow	S1a	KJ-82-01	19-Jul-82	-	-	0.03	1.53	0.02	-	-
Cold Springs above ash flow	S1b	86KAT136	19-Jul-86	-	-	-	-	-	-	-
Cold Springs above ash flow	S1c	KJ-89-03	19-Aug-89	<.01	-	0.04	<.05	-	-	-
Cold Springs above ash flow	S2a	KJ-82-13	14-Aug-82	0.01	-	0.02	-	0.03	0.08	-

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992). (continued)

Area	Map no.	Field number	Date	Spring	Quartz	Chalced	Na-K	Na-K-Ca	Na-K-Ca	K-Mg	Mg-Li
Upper River Lethe	18	KJ-89-14	24-Aug-89	-	-	-	-	-	-	-	-
Upper River Lethe	19	KJ-89-13	24-Aug-89	-	-	-	-	-	-	-	-
Lower River Lethe	5a	KJ-82-12	13-Aug-82	-	-	-	-	-	-	-	-
Lower River Lethe	5b	86KAT139	20-Jul-86	-	-	-	-	-	-	-	-
Lower River Lethe	5c	KJ-89-05	20-Aug-89	-	-	-	-	-	-	-	-
Lower River Lethe	5d	90KAT270	5-Jun-90	-	-	-	-	-	-	-	-
Windy Creek	6	KJ-89-06	20-Aug-89	-	-	-	-	-	-	-	-
Windy Creek	7	86KAT140	20-Jul-86	-	-	-	-	-	-	-	-
Ukak River	1	84KAT121	6-Aug-84	-	-	-	-	-	-	-	-
Ukak River	2a	KJ-82-10	12-Aug-82	-	-	-	-	-	-	-	-
Ukak River	2b	86KAT135	19-Jul-86	-	-	-	-	-	-	-	-
Ukak River	2c	KJ-89-02	19-Aug-89	-	-	-	-	-	-	-	-
Ukak River	2d	90KAT265	3-Jun-90	-	-	-	-	-	-	-	-
River Lethe Springs (mid-valley)	S4	90KAT264	2-Jun-90	8.8	74	43	184	34	no change	35	44
River Lethe Springs (mid-valley)	S5(1)	90KAT281	8-Jun-90	5.3	64	32	177	18		30	40
River Lethe Springs (mid-valley)	S5(2)	90KAT282	8-Jun-90	4.9	64	32	178	15		30	40
Cold Springs above ash flow	S1a	KJ-82-01	19-Jul-82	-	-	-	-	-	-	-	-
Cold Springs above ash flow	S1b	86KAT136	19-Jul-86	-	-	-	-	-	-	-	-
Cold Springs above ash flow	S1c	KJ-89-03	19-Aug-89	-	-	-	-	-	-	-	-
Cold Springs above ash flow	S2a	KJ-82-13	14-Aug-82	-	-	-	-	-	-	-	-

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992). (continued)

	Map no.	Field number	Date	Temp	f pH	l pH	SiO_2	Ca	Mg	Li	K	Li
				C			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Cold Springs above ash flow	S2b	86KAT141	20-Jul-86	7	5.9	6.81	19.1	14.8	3.5	4.4	0.24	0;008
Cold Springs above ash flow	S2c	KJ-89-07	20-Aug-89	5	5.39	18.5	18.6	1.88	4.8	-	0.45	0.005
Cold Springs above ash flow	S6	90KAT279	6-Jun-90	3.9	5.3	5.73	10.2	36.4	2.73	4.1	0.54	0.005
Streams above ash flow sheet	8	KJ-89-04	20-Aug-89	12	-	5.54	14.7	12.2	2.15	6.1	0.53	0.001
Streams above ash flow sheet	9a	KJ-82-11	13-Aug-82	12.5	5.7	7.22	20.2	11.2	2.1	4.1	0.66	<0.01
Streams above ash flow sheet	9b	KJ-89-23	28-Aug-89	11	-	5.32	20.4	9.2	1.52	4.3	0.48	0.001
Streams above ash flow sheet	10	KJ-89-22	28-Aug-89	8.5	6.8	5.43	19	33.2	2.65	15.1	0.58	0.005
Streams above ash flow sheet	11	KJ-89-08	21-Aug-89	13.1	-	5.41	29.5	27.3	2.36	7	0.62	0.005
Streams above ash flow sheet	12	84KAT123	6-Aug-84	14	5.9	7.01	19.8	26	2.85	3.8	0.85	<0.01
Streams above ash flow sheet	13	KJ-89-15	25-Aug-89	9.9	5.7	5.09	38.1	11.8	2.59	8.3	2.05	0.005
Streams above ash flow sheet	14	KJ-89-16	25-Aug-89	6.9	5.5	4.42	97	19.7	8.15	17.5	2.52	0.007
Precipitation	20	89KAT261	31-Aug-89	4	-	4.66	2.6	0.2	0.1	1.1	0.09	<0.001
Precipitation	21	86KAT172	28-Jul-86	14	5.2	5.44	2	0.36	0.05	0.2	<0.1	0.007
Precipitation	22	89KAT260	31-Aug-89	4	-	4.81	14.1	0.63	0.07	1.7	0.07	<0.001
Precipitation	23	KJ-82-03	25-Jul-82	15	5.5	5.66	0.3	0.15	0.01	1.5	<0.01	<0.01
Mid-valley thermal springs	T1(1)	87KAT220	24-Jul-87	15	5.7	6.73	55.5	89.5	17.9	73.3	2.96	0.16

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992). (continued)

Area	Map no.	Field number	Date	$HC0_3$	$S0_4$	Cl	F	B[a]	Cond	δD[b]	$\delta^{18}O$[b]	Fe
				mg/L	mg/L	mg/L	mg/L	mg/L	mS	o/oo	o/oo	mg/L
Cold Springs above ash flow	S2b	86KAT141	20-Jul-86	48.4	21	3	0.03	0.48	121	-	-	-
Cold Springs above ash flow	S2c	KJ-89-07	20-Aug-89	46.1	16	2.3	0.12	<.05	119	-109	-13.8	0.02
Cold Springs above ash flow	S6	90KAT279	6-Jun-90	47.1	83	3.6	0.19	<0.10	277	-111	-14.8	-
Streams above ash flow sheet	8	KJ-89-04	20-Aug-89	51.9	18	2.6	0.37	<0.05	136	-	-	0.6
Streams above ash flow sheet	9a	KJ-82-11	13-Aug-82	71	5	1.4	0.75	0.3	100.7	-110	-14.5	1.6
Streams above ash flow sheet	9b	KJ-89-23	28-Aug-89	46.5	5	2.3	0.17	<.05	83.6	-111	-14.4	2.4
Streams above ash flow sheet	10	KJ-89-22	28-Aug-89	62	72	2.4	0.24	0.2	259	-106	-13.8	0.7
Streams above ash flow sheet	11	KJ-89-08	21-Aug-89	49	35	2.2	0.22	<0.05	161	-	-	4.9
Streams above ash flow sheet	12	84KAT123	6-Aug-84	58	25	2	0.19	<.1	177	-	-	-
Streams above ash flow sheet	13	KJ-89-15	25-Aug-89	17.4	28	12	0.11	<.05	130	-117	-15.6	1.2
Streams above ash flow sheet	14	KJ-89-16	25-Aug-89	5.8	79	9.1	0.17	<.05	196	-	-	42.4
Precipitation	20	89KAT261	31-Aug-89	8.9	5	0.9	<0.1	<.05	4.5	-93	-11.8	-
Precipitation	21	86KAT172	28-Jul-86	11	2	0.4	0.25	0.05	9.2			-
Precipitation	22	89KAT260	31-Aug-89	10	1	1.1	<0.1	<.05	8.5	-101	-13.2	-
Precipitation	23	KJ-82-03	25-Jul-82	11	<.2	0.3	0.29	0.15	7.6			-
Mid-valley thermal springs	T1(1)	87KAT220	24-Jul-87	105	330	69.6	3	0.7	-	-109		

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992). (continued)

Area	Map no.	Field number	Date	Mn	As	Sr	Ba	Rb	Cs	$\delta^{13}C$[a]	$\delta^{18}O(SO4)$[b]
	-	-	-	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	o/oo	o/oo
Cold Springs above ash flow	S2b	86KAT141	20-Jul-86	-	-	-	-	-	-	-	-
Cold Springs above ash flow	S2c	KJ-89-07	20-Aug-89	0.01	-	0.09	0.06	-	-	-	-
Cold Springs above ash flow	S6	90KAT279	6-Jun-90	-	-	-	-	-	-	-	-
Streams above ash flow sheet	8	KJ-89-04	20-Aug-89	0.01	-	0.16	0.03	-	-	-	-
Streams above ash flow sheet	9a	KJ-82-11	13-Aug-82	0.07	-	0.02	-	0.03	0.08	-	-
Streams above ash flow sheet	9b	KJ-89-23	28-Aug-89	0.09	-	0.02	<.05	-	-	-	-
Streams above ash flow sheet	10	KJ-89-22	28-Aug-89	0.03	-	0.03	0.02	-	-	-	-
Streams above ash flow sheet	11	KJ-89-08	21-Aug-89	0.08	-	0.17	0.1	-	-	-	-
Streams above ash flow sheet	12	84KAT123	6-Aug-84	-	-	-	-	-	-	-	-
Streams above ash flow sheet	13	KJ-89-15	25-Aug-89	0.01	-	<.05	<.05	-	-	-	-
Streams above ash flow sheet	14	KJ-89-16	25-Aug-89	0.59	-	0.09	<.05	-	-	-	-
Precipitation	20	89KAT261	31-Aug-89	-	-	<.05	<.05	-	-	-	-
Precipitation	21	86KAT172	28-Jul-86	-	-	-	-	-	-	-	-
Precipitation	22	89KAT260	31-Aug-89	-	-	<.05	<.05	-	-	-	-
Precipitation	23	KJ-82-03	25-Jul-82	-	-	-	-	-	-	-	-
Mid-valley thermal springs	T1(1)	87KAT220	24-Jul-87	-	-	-	-	-	-	-	-

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992). (continued)

Area	Map no.	Field number	Date	Spring	Quartz	Chalced	Na-K	Na-K-Ca	Na-K-Ca	K-Mg	Mg-Li
Cold Springs above ash flow	S2b	86KAT141	20-Jul-86	-	-	-	-	-	-	-	-
Cold Springs above ash flow	S2c	KJ-89-07	20-Aug-89	-	-	-	-	-	-	-	-
Cold Springs above ash flow	S6	90KAT279	6-Jun-90	-	-	-	-	-	-	-	-
Streams above ash flow sheet	8	KJ-89-04	20-Aug-89	-	-	-	-	-	-	-	-
Streams above ash flow sheet	9a	KJ-82-11	13-Aug-82	-	-	-	-	-	-	-	-
Streams above ash flow sheet	9b	KJ-89-23	28-Aug-89	-	-	-	-	-	-	-	-
Streams above ash flow sheet	10	KJ-89-22	28-Aug-89	-	-	-	-	-	-	-	-
Streams above ash flow sheet	11	KJ-89-08	21-Aug-89	-	-	-	-	-	-	-	-
Streams above ash flow sheet	12	84KAT123	6-Aug-84	-	-	-	-	-	-	-	-
Streams above ash flow sheet	13	KJ-89-15	25-Aug-89	-	-	-	-	-	-	-	-
Streams above ash flow sheet	14	KJ-89-16	25-Aug-89	-	-	-	-	-	-	-	-
Precipitation	20	89KAT261	31-Aug-89	-	-	-	-	-	-	-	-
Precipitation	21	86KAT172	28-Jul-86	-	-	-	-	-	-	-	-
Precipitation	22	89KAT260	31-Aug-89	-	-	-	-	-	-	-	-
Precipitation	23	KJ-82-03	25-Jul-82	-	-	-	-	-	-	-	-
Mid-valley thermal springs	T1(1)	87KAT220	24-Jul-87	15	107	77	150	30	no change	36	46

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992). (continued)

Area	Map no.	Field Number	Date	Temp	f pH	l pH	SiO_2	Ca	Mg	Li	K
	-	-	-	C			mg/L	mg/L	mg/L	mg/L	mg/L
Mid-valley thermal springs	T1(2)	87KAT221	24-Jul-87	17	5.7	7.01	58.6	94	19.9	83	4.21
Mid-valley thermal springs	T1(3)	KJ-89-09	23-Aug-89	17.8	5.7	6.49	38.3	90.8	16	78.1	3.63
Mid-valley thermal springs	T1(1)	KJ-89-10	23-Aug-89	17.8	5.9	5.89	38	89.9	15.8	80.6	3.63
Mid-valley thermal springs	T1(4)	KJ-89-11	23-Aug-89	17.6	5.7	6.32	37.3	89.8	15.8	78.4	3.41
Mid-valley thermal springs	T1(5)	90KAT268	4-Jun-90	29.2	5.9	6.23	52.5	95.3	21.3	98.3	6.57
Mid-valley thermal springs	T1(4)	90KAT269	4-Jun-90	21.2	5.5	6.15	40.6	86	18	71.9	4.03
Mid-valley thermal springs	T1(5)	91KAT300	15-Mar-91	27	5.3	5.59	36.5	98.5	29.3	98.2	6.53
Mid-valley thermal springs	T1(4)	91KAT301	15-Mar-91	24	5.3	5.59	35.7	97.7	26.2	72.9	5.19
Thermal springs south side of Katmai Pass	T2	KJ-82-07	3-Aug-82	15	5.7	8.05	67.5	33.5	31.1	98.9	7.92
Thermal springs south side of Katmai Pass	T2	84KAT126	9-Aug-84	15	6	6.84	42.9	44	30	121	8.91
Hot springs north side of Mageik Creek	T3(1)	KJ-82-05	3-Aug-82	40	6.8	7.9	105	136	59.3	231	29
Hot springs north side of Mageik Creek	T3(2)	KJ-82-06	3-Aug-82	42	6.8	7.59	111	116	65.1	252	29
Hot springs north side of Mageik Creek	T3(3)	84KAT131	9-Aug-84	40	6.5	7.53	105	157	69.7	218	25
Katmai caldera lake	M2	-	7-Jul-75	5.5	3	2.05	120	300	51	760	90
Katmai caldera lake	M5	-	7-Jul-75	5.5	3	1.94	140	300	62	590	110

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992). (continued)

Area	Map no.	Field number	Date	Li	HCO_3	SO_4	Cl	F	B[a]	Cond.	δD[b]	$\delta^{18}O$[b]
	-	-	-	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mS	o/oo	o/oo
Mid-valley thermal springs	T1(2)	87KAT221	24-Jul-87	0.2	127	390	73.6	2.9	0.8	-	-108	-14.7
Mid-valley thermal springs	T1(3)	KJ-89-09	23-Aug-89	0.204	135	276	71	2.93	0.67	934	-112	-14.5
Mid-valley thermal springs	T1(1)	KJ-89-10	23-Aug-89	0.204	132	279	68.4	2.84	0.46	917	-111	-14.5
Mid-valley thermal springs	T1(4)	KJ-89-11	23-Aug-89	0.188	127	280	67.6	2.42	0.4	906	-111	-14.6
Mid-valley thermal springs	T1(5)	90KAT268	4-Jun-90	0.355	204	225	89.7	2.76	1.04	1124	-108	-14.4
Mid-valley thermal springs	T1(4)	90KAT269	4-Jun-90	0.213	144	186	70.4	2.76	0.4	924	-110	-14.7
Mid-valley thermal springs	T1(5)	91KAT300	15-Mar-91	0.321	178	310	79	2.91	0.86	1036	-112	-14.6
Mid-valley thermal springs	T1(4)	91KAT301	15-Mar-91	0.247	144	300	71.2	2.64	0.99	945	-111	-14.6
Thermal springs south side of Katmai Pass	T2	KJ-82-07	3-Aug-82	0.038	190	93	145	0.1	1.65	-	-99	-13.5
Thermal springs south side of Katmai Pass	T2	84KAT126	9-Aug-84	0.03	452	54	113	0.1	3.4	926	-	-
Hot springs north side of Mageik Creek	T3(1)	KJ-82-05	3-Aug-82	0.58	337	410	262	2.89	2.8	2080	-97	-13.1
Hot springs north side of Mageik Creek	T3(2)	KJ-82-06	3-Aug-82	0.64	377	330	279	2.77	4.2	2280	-96	-13
Hot springs north side of Mageik Creek	T3(3)	84KAT131	9-Aug-84	0.5	569	480	251	2.5	5.5	2040	-96	-13
Katmai caldera lake	M2	-	7-Jul-75	0.92	-	1250	1350	0.9	12	6580	-	-
Katmai caldera lake	M5	-	7-Jul-75	1.2	-	1200	1750	1.1	14	7580	-	-

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992). (continued)

Area	Map no.	Field number	Date	Fe	Mn	As	Sr	Ba	Rb	Cs	δ13C[a]	δ18O(SO4)[b]
				mg/	mg/L	mg/	mg/	mg/	mg/	mg/	o/oo	o/oo
Mid-valley thermal springs	T1(2)	87KAT221	24-Jul-87	-	-	-	-	-	-	-	-	-
Mid-valley thermal springs	T1(3)	KJ-89-09	23-Aug-89	<.01	<.01	0.34	0.33	0.03	0.07	0.06	-12.9	-3.4
Mid-valley thermal springs	T1(1)	KJ-89-10	23-Aug-89	<.01	<.01	0.23	0.3	0.03	0.06	0.06	-14.7	-3.2
Mid-valley thermal springs	T1(4)	KJ-89-11	23-Aug-89	<.01	<.01	0.52	0.23	<.05	0.06	0.05	-13	-
Mid-valley thermal springs	T1(5)	90KAT268	4-Jun-90	0.05	0.004	-	-	-	0.04	0.02	-	-
Mid-valley thermal springs	T1(4)	90KAT269	4-Jun-90	0.04	0.007	-	-	-	0.02	0.02	-	-
Mid-valley thermal springs	T1(5)	91KAT300	15-Mar-91	0.07		-	0.27	0.01	0.06	0.05	-	-
Mid-valley thermal springs	T1(4)	91KAT301	15-Mar-91	0.14		-	0.25	0.01	0.07	0.06	-	-
Thermal springs south side of Katmai Pass	T2	KJ-82-07	3-Aug-82	20.1	1.16	-	0.4	-	0.09	0.05	-	-
Thermal springs south side of Katmai Pass	T2	84KAT126	9-Aug-84	0.04	0.33	0.86	0.29	-	<.01	0.04	-	-
Hot springs north side of Mageik Creek	T3(1)	KJ-82-05	3-Aug-82	1.2	0.02	0.66	0.5	-	0.49	0.52	-	-
Hot springs north side of Mageik Creek	T3(2)	KJ-82-06	3-Aug-82	1.2	0.03	0.61	0.57	-	0.46	0.9	-	-
Hot springs north side of Mageik Creek	T3(3)	84KAT131	9-Aug-84	<.1	<.1	1.34	0.5	-	0.29	0.19	-	-
Katmai caldera lake	M2	-	7-Jul-75	-	-	-	-	-	-	-	-	-
Katmai caldera lake	M5	-	7-Jul-75	-	-	-	-	-	-	-	-	-

Table 74. Data for water samples from the Valley of Ten Thousand Smokes region (Keith et al. 1992). (continued)

Area	Map no.	Field number	Date	Spring	Quartz	Chalced.	Na-K	Na-K-Ca	Na-K-Ca	K-Mg	Mg-Li
					Cond.	Cond.	B=4/3	Mg cor.			
Mid-valley thermal springs	T1(2)	87KAT221	24-Jul-87	17	109	80	165	39	no change	42	50
Mid-valley thermal springs	T1(3)	KJ-89-09	23-Aug-89	17.8	90	59	159	36	no change	41	52
Mid-valley thermal springs	T1(1)	KJ-89-10	23-Aug-89	17.8	89	59	157	36	no change	41	52
Mid-valley thermal springs	T1(4)	KJ-89-11	23-Aug-89	17.6	89	58	155	34	no change	40	51
Mid-valley thermal springs	T1(5)	90KAT268	4-Jun-90	29.2	104	74	185	53	no change	50	61
Mid-valley thermal springs	T1(4)	90KAT269	4-Jun-90	21.2	92	62	172	39	no change	42	52
Mid-valley thermal springs	T1(5)	91KAT300	15-Mar-91	27	88	57	184	52	no change	47	55
Mid-valley thermal springs	T1(4)	91KAT301	15-Mar-91	24	87	56	189	43	no change	43	51
Thermal springs south side of Katmai Pass	T2	KJ-82-07	3-Aug-82	15	116	88	199	80	no change	50	15
Thermal springs south side of Katmai Pass	T2	84KAT126	9-Aug-84	15	95	64	192	80	no change	53	11
Hot springs north side of Mageik Creek	T3(1)	KJ-82-05	3-Aug-82	40	140	114	237	181	33	71	61
Hot springs north side of Mageik Creek	T3(2)	KJ-82-06	3-Aug-82	42	143	117	230	180	23	71	62
Hot springs north side of Mageik Creek	T3(3)	84KAT131	9-Aug-84	40	140	114	229	174	31	66	56
Katmai caldera lake	M2	-	7-Jul-75	-	-	-		-	-	-	-
Katmai caldera lake	M5	-	7-Jul-75	-	-	-	-	-	-	-	-

Table 75. Chemistry of twelve lakes of the Alaska Peninsula (Gunther 1992).

Area	Date Sampled	pH	Alkalinity	Cl	NO_3	SO_4	Ca	Mg	K	Na	Al	Cu	Zn	Cb
Alagnak Drainage														
Battle	26 Jun. 1986	6.6	52	47	8	166	128	63	6	61	9	6.5	0.6	0.98
Iron Springs	4 Aug. 1986	3.6		41	<2	1516	270	242	10	87	742	<1	317	1.02
Nonvianuk	20 Jun. 1986	7	203	31	2.6	120	232	57	9	71	0.8	<1		1.04
Pirate	4 Sept. 1986	6.7	86				85	28						
Kukaklek	4 Sept. 1986	7	149				152	63						
Kulik	20 Aug. 1984	7.2	155		17	227	174	47	9			<1	0.5	
Naknek Drainage														
Coville	2 Aug. 1986	7.6	502	49	<.05	41	267	140	12	140	2	<1	0.7	0.95
Hammersly	20 Aug. 1984	7.1	204				164	45	7			<1	0.5	
Idavain	20 Jun. 1986	7.5	417	56	<.05	17	242	116	14	129	<.4	<1	<.1	1.02
Murray	20 Aug. 1984	7.1	186				175	43	9			<1	0.5	
Pecker	10 Aug. 1986	7	107	97	<.05	25	39	60	15	123	3.3	<1	1	1.05
Tony Malones	23 Aug. 1984	9.3	797											

Table 76. Values are a three year average from samples taken between 1990 and 1992 (LaPerriere and Edmundson 2000).

Lake	Kd (PAR) (m^{-1})*	Secchi depth (m)	Phytoplankton (μg^{-1} chl)	Apparent color (Pt-Co units)	Turbidity (NTU)	Depth of 1% light (m)
Battle	0.07	17	0.13	1.3	0.83	67
Brooks	0.199	9.7	0.47	4	1.1	24
Coville	0.294	5.7	1.16	7	1.2	16
Grosvenor	0.199	10	0.52	2	0.87	23
Hammersly	0.158	14	0.55	1.5	1.6	30
Idavain	0.411	4.4	1.02	0	0.77	11
Kukaklek	0.144	13	0.63	4	0.68	34
Kulik	0.143	10	0.46	0.3	0.89	32
Murray	0.156	12	0.34	3.7	0.66	31
Naknek	0.21	5.3	0.69	19	1.3	23
Nonvianuk	0.158	12	0.49	1.7	0.84	30

Table 77. Lake mean total phosphorus (TP), total nitrogen (TN), TN:TP values, total chlorophyll and zooplankton as ash-free dry weight (µg/L) for Katmai lakes, 1990-1993. Number of summer mean values used to calculate the lake mean are given in parentheses. Data from Lakes Hammersly and Idavain are included but were not part of this analysis. Missing data indicated by a dash.

Lake	Total P	Total N	TN:TP	Total chlorophyll	Zooplankton
	µg/L	µg/L	-	µg/L	µg/L
Battle	2 (4)	222 (3)	99	0.1 (3)	0.9 (3)
Brooks	5	92 (3)	18	0.5 (3)	25 (3)
Coville	10	146 (3)	15	1.3 (3)	25 (3)
Grosvenor	4	223 (3)	52	0.7 (3)	18 (3)
Kukaklek	4	118 (2)	30	0.6 (2)	28 (3)
Kulik	4	377 (3)	94	0.7 (3)	4 (3)
Murray	4	148 (2)	33	0.4 (2)	11 (3)
Naknek	5	164 (2)	33	0.7 (2)	15 (3)
Novianuk	4	206 (3)	46	0.6 (3)	50 (2)
Hammersly	4	185 (2)	46	0.6 (1)	9.5 (2)
Idavain	22	-	-	1 (1)	144 (1)

Table 78. Trace metal analysis of KATM water bodies (LaPerriere 1992).

Water body	Test #	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co
Battle Lake	1	<0.01	0.41	<0.04	<0.03	0.0038	<0.0006	<0.04	3.89	<0.003	<0.01
Battle Lake	2	<0.01	0.04	<0.04	<0.03	0.0038	<0.0006	<0.04	3.78	<0.003	<0.01
Battle Lake	3	<0.01	<0.03	<0.04	<0.03	0.0035	<0.0006	<0.04	3.81	<0.003	<0.01
Coville Lake	1	<0.01	<0.03	<0.04	<0.03	0.0016	<0.0006	<0.04	7.45	<0.003	<0.01
Coville Lake	2	<0.01	<0.03	<0.04	<0.03	0.001	<0.0006	<0.04	7.02	<0.003	<0.01
Coville Lake	3	<0.01	<0.03	<0.04	<0.03	0.001	<0.0006	<0.04	7	<0.003	<0.01
Idavain Lake	1	<0.01	<0.03	<0.04	<0.03	0.0016	<0.0006	<0.04	5.39	<0.003	<0.01
Idavain Lake	2	<0.01	<0.03	<0.04	<0.03	0.0017	<0.0006	<0.04	5.43	<0.003	<0.01
Idavain Lake	3	<0.01	<0.03	<0.04	<0.03	0.001	<0.0006	<0.04	5.6	<0.003	<0.01
Kulik Lake	1	<0.01	<0.03	<0.04	<0.03	0.0032	<0.0006	<0.04	4.19	<0.003	<0.01
Kulik Lake	2	<0.01	<0.03	<0.04	<0.03	0.003	<0.0006	<0.04	4.23	<0.003	<0.01
Kulik Lake	3	<0.01	<0.03	<0.04	<0.03	0.0031	<0.0006	<0.04	4.3	<0.003	<0.01
Naknek Lake	1	<0.01	0.26	<.04	0.04	0.0038	<0.0006	<0.04	17.5	<0.003	<0.01
Naknek Lake	2	<0.01	0.05	<.05	0.05	0.0042	<0.0005	<0.04	17.3	<0.004	<0.01
Naknek Lake	3	<0.01	<.03	<.04	0.04	0.0041	<0.0006	<0.04	17	<0.003	<0.01
American Creek	1	<0.01	0.13	<.04	<.03	0.0034	<.0006	<0.04	7.76	<0.003	<0.01
American Creek	2	<0.01	0.22	<.05	<.03	0.0041	<.0005	<0.04	8.09	<0.003	<0.01
Margot Creek	1	<0.01	0.14	<0.04	<0.03	0.0023	<0.0006	<0.04	14.3	<0.003	<0.01
Margot Creek	2	<0.01	0.13	<0.04	<0.03	0.0024	<0.0006	<0.04	1.4	<0.003	<0.01
Savonoski River	1	<0.01	6.95	<.05	<.03	0.039	<.0005	<0.04	21.3	<0.003	<0.01
Savonoski River	2	<0.01	7.93	<0.04	<0.03	0.046	<0.0006	<0.04	20.7	<0.004	<0.01

Table 78. Trace metal analysis of KATM water bodies (LaPerriere 1992). (continued)

Water body	Test#	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni
Battle Lake	1	<0.01	<0.003	0.036	<.5	<.002	0.766	0.023	<0.005	1.8	<0.01
Battle Lake	2	<0.01	<0.003	0.036	<.5	<.002	0.766	0.023	<0.005	1.8	<0.01
Battle Lake	3	<0.01	<0.003	<0.01	<.5	<.002	0.745	0.022	<0.005	1.7	<0.01
Coville Lake	1	<0.01	<0.003	<0.01	<.5	<.002	0.751	0.023	<0.005	1.8	<0.01
Coville Lake	2	<0.01	<0.003	0.23	<.5	<.002	1.68	0.0077	<0.005	3.29	<0.01
Coville Lake	3	<0.01	<0.003	0.63	<.5	<.002	1.59	0.0084	<0.005	3.16	<0.01
Idavain Lake	1	<0.01	<0.003	0.07	<.5	<.002	1.59	0.007	<0.005	3.17	<0.01
Idavain Lake	2	<0.01	<0.003	0.032	<.5	<.002	1.38	0.0092	<0.005	2.91	<0.01
Idavain Lake	3	<0.01	<0.003	0.03	<.5	<.002	1.39	0.009	<0.005	2.86	<0.01
Kulik Lake	1	<0.01	<0.003	0.035	<.5	<.002	1.42	0.0086	<0.005	2.84	<0.01
Kulik Lake	2	<0.01	<0.003	<.01	<.5	<.002	0.44	<.002	<0.005	1.3	<0.01
Kulik Lake	3	<0.01	<0.003	0.02	<.5	<.002	0.447	<.002	<0.005	1.4	<0.01
Naknek Lake	1	<0.01	<0.003	0.061	<.5	<.002	0.452	<.002	<0.005	1.4	<0.01
Naknek Lake	2	<0.01	<0.003	0.14	0.5	0.012	2.53	<.002	<0.005	6.81	<0.01
Naknek Lake	3	<0.01	<0.003	0.02	<.4	0.011	2.51	<.002	<0.006	6.68	<0.02
American Creek	1	<0.01	<0.003	0.01	<.5	0.012	2.48	<.002	<0.005	6.99	<0.01
American Creek	2	<0.01	<0.003	0.4	<.5	<.002	1.72	0.026	<0.005	3.27	<0.01
Margot Creek	1	<0.01	<0.003	0.46	<.4	<.002	1.8	0.028	<0.006	3.28	<0.02
Margot Creek	2	<0.01	<0.003	0.28	<.5	<.002	2.03	0.012	<0.005	3.34	<0.01
Savonoski River	1	<0.01	<0.003	0.28	<.5	<.002	2	0.013	<0.005	3.35	<0.01
Savonoski River	2	<0.01	0.007	8.39	1.3	0.007	4.86	0.15	<0.006	4.13	<0.02

Table 78. Trace metal analysis of KATM water bodies (LaPerriere 1992). (continued)

Water body	Test #	P	Pb	Sb	Se	Si	Sn	Sr	Ti	Tl	V	Zn
Battle Lake	1	<0.2	<0.04	<0.04	<0.08	2.38	<.05	0.016	<.003	<0.08	<0.004	0.011
Battle Lake	2	<0.2	<0.04	<0.04	<0.08	2.34	<.05	0.015	<.003	<0.08	<0.004	<0.003
Battle Lake	3	<0.2	<0.04	<0.04	<0.08	2.27	<.05	0.016	<.003	<0.08	<0.004	<0.003
Coville Lake	1	<0.2	<0.04	<0.04	<0.08	4.35	<.05	0.027	<.003	<0.08	<0.004	<0.003
Coville Lake	2	<0.2	<0.04	<0.04	<0.08	4.17	<.05	0.026	<.003	<0.08	<0.004	<0.003
Coville Lake	3	<0.2	<0.04	<0.04	<0.08	4.23	<.05	0.026	<.003	<0.08	<0.004	<0.003
Idavain Lake	1	<0.2	<0.04	<0.04	<0.08	3.36	<.05	0.024	<.003	<0.08	<0.004	<0.003
Idavain Lake	2	<0.2	<0.04	<0.04	<0.08	3.4	<.05	0.024	<.003	<0.08	<0.004	<0.003
Idavain Lake	3	<0.2	<0.04	<0.04	<0.08	3.33	<.05	0.024	<.003	<0.08	<0.004	<0.003
Kulik Lake	1	<0.2	<0.04	<0.04	<0.08	2.22	<.05	0.016	<.003	<0.08	<0.004	<0.003
Kulik Lake	2	<0.2	<0.04	<0.04	<0.08	2.29	<.05	0.016	<.003	<0.08	<0.004	<0.003
Kulik Lake	3	<0.2	<0.04	<0.04	<0.08	2.36	<.05	0.016	<.003	<0.08	<0.004	<0.003
Naknek Lake	1	<0.2	<0.04	<0.04	<0.08	3.89	<.05	0.048	<.003	<0.08	<0.004	0.007
Naknek Lake	2	<0.1	<0.04	<0.04	<0.07	3.73	<.04	0.048	<.002	<0.06	<0.003	0.032
Naknek Lake	3	<0.2	<0.04	<0.04	<0.08	3.88	<.05	0.049	<.003	<0.08	<0.004	<0.003
American Creek	1	<0.2	<0.04	<0.04	<0.08	5.5	<.05	0.029	0.0097	<0.08	<0.004	<0.003
American Creek	2	<0.1	<0.04	<0.04	<0.07	6.07	<.04	0.03	0.011	<0.06	<0.003	<0.005
Margot Creek	1	<0.2	<0.04	<0.04	<0.08	6.28	<.05	0.038	0.012	<0.08	<0.004	<0.003
Margot Creek	2	<0.2	<0.04	<0.04	<0.08	6.29	<.05	0.038	0.01	<0.08	<0.004	<0.003
Savonoski River	1	0.2	<0.04	<0.04	<0.07	14.2	<.04	0.0748	0.254	<0.06	0.015	0.045
Savonoski River	2	0.2	<0.04	<0.04	<0.08	16.3	<.05	0.0793	0.365	<0.08	0.02	0.02

Table 78. Trace metal analysis of KATM water bodies (LaPerriere 1992). (continued)

Water body	Ortho	Total P	Alkalinity	Chi	Secchi	Kd	Trans	1% depth	Color	Turbidity
	(mg/L	µg/L	(mg/L	(mg/m3)	(m)	(m -1)	(%/m)	(m)	(CPU)	(NTU)
Batttle	<.01	1.9	2.4	0.12	18.3	0.089	92	56	3	0.4
Brooks	<.01	5.7	28.9	0.28	9.8	0.164	85	28	5	0.51
Coville	<.01	13	27.3	0.42	6	0.274	76	17	17	0.83
Grosvenor	0.003	<3	25	3.4	11.5	0.177	84	26	0	0.62
Idavain	<.01	22	21	0.77	4.4	0.379	67	11	0	0.77
Kukaklek	<.01	<3	7.2	0.26	16.3	1.18	83	26	10	0.44
Kulik	<.01	<3	6.3	0.21	11.8	0.145	87	30	0	0.46
Murray	<.01	17	8.8	0.17	15.5	0.121	89	38	0	0.29
Naknek	<.01	<3	30.8	0.38	6.5	0.156	86	30	13	0.81
Nonvainuk	<.01	<3	10	0.23	13.8	0.129	88	35	0	0.61

Table 79. Chemical analyses from sockeye salmon nursery lakes in KATM (Burgner et al. 1969).

Water Body	Month	Total Dissolved Solids	pH	Alkalinity	Sodium	Potassium	Magnesium	Nitrate	Silica
Amanda Lake	Aug	21.5	7.3	10.84	0.55	<.20	0.75	0.075	4.3
Ualik Lake	Aug	17.5	7.13	10.5	0.8	0.35	0.7	0.02	2.1
Lake Nunavaugaluk	Aug	18	7.16	10.42	0.55	<.3	0.65	0.12	2.1
Lake Aleknagik	June-Oct.	30.5	7.15	12.51	0.63	0.35	0.95	0.111	2.6
Lake Nerka	June-Oct.	20.7	7.14	11.99	0.45	0.37	0.87	0.167	2.2
Lake Beverley	June-Oct.	24	7.21	11.9	0.8	<.33	0.8	0.16	2.8
Lake Kulik	June-Oct.	25.3	7.11	12.46	0.68	0.33	0.68	0.173	3
Lake Togiak	June-Oct.	35	7.29	18.69	0.75	0.5	1.33	0.16	3.3
Tikchik Lake	Aug	42	7.34	22.45	0.55	<.7	2.12	0.09	5.4
Nuyakuk Lake	Aug	36.5	7.3	22.99	0.4	trace	1.55	0.11	6.4
Lake Chauekuktuli	Aug	50	7.29	29.46	0.4	trace	2.6	0.135	6.4
Iliamna Lake	June-Oct.	26.3	7.26	13.96	0.83	0.6	0.83	0.058	4.5
Lake Clark	June-Oct.	32	7.28	19.59	0.8	1.28	1.03	0.113	8.6
Kukaklek Lake	July-Aug.	23	7	8.88	4.02	1.23	1.15	0.018	1.1
Nonvianuk Lake	July-Aug.	32.5	7.21	10.54	3.25	0.9	1.12	0.017	4.1
Coville Lake	June-Oct.	51.6	7.13	25.28	3.18	0.46	1.21	<.014	9
Grosvenor Lake	June-Oct.	53.5	7.24	25.42	2.98	0.47	1.89	<.014	7.7
Naknek Lake	June-May	139.5	7.35	28.54	10.4	1.16	4.16	0.087	9.3
Brooks Lake	June-May	74.8	7.31	26.78	4.3	0.95	2.18	0.012	10.5
Lower Ugashik	Aug	22.4	7.23	14.57	7.13	0.8	1.28	0.019	1.4

Table 79. Limnology of lakes in KATM (Burgner et al. 1969). (continued)

Water Body	Month	Iron	Manganese	Calcium	Boron	Copper	Strontium	Aluminum
Amanda Lake	Aug	0.01	0.002	5.1	0.007	0.0003	0.06	0.005
Ualik Lake	Aug	0.011	0.001	3.95	0.011	0.0004	0.08	0.003
Lake Nunavaugaluk	Aug	0.01	0.001	4.9	0.007	0.003	0.07	0.003
Lake Aleknagik	June-Oct.	0.006	0.001	4.95	0.008	0.0003	0.07	0.004
Lake Nerka	June-Oct.	0.011	0.001	4.68	0.015	0.0003	0.06	0.005
Lake Beverley	June-Oct.	0.008	0.001	4.23	0.012	0.0003	0.07	0.005
Lake Kulik	June-Oct.	0.009	0.001	4.65	0.005	0.0003	0.08	0.004
Lake Togiak	June-Oct.	0.006	0.001	7.23	0.013	0.0002	0.1	0.004
Tikchik Lake	Aug	0.01	0.001	7.7	0.01	0.0004	0.09	0.005
Nuyakuk Lake	Aug	0.007	trace	8.4	0.017	0.0004	0.1	0.005
Lake Chauekuktuli	Aug	0.005	trace	11	0.009	0.0004	0.1	0.003
Iliamna Lake	June-Oct.	0.011	<.003	5.11	0.022	0.0004	0.06	0.01
Lake Clark	June-Oct.	0.026	0.001	6.75	0.03	0.0006	0.09	0.017
Kukaklek Lake	July-Aug.	N/A	N/A	3.29		N/A	N/A	N/A
Nonvianuk Lake	July-Aug.	0.04	0.01	5.33	0.003	N/A	N/A	N/A
Coville Lake	June-Oct.	0.052	0.01	7.79	0.003	N/A	N/A	N/A
Grosvenor Lake	June-Oct.	0.04	0.01	6.9	0.003	N/A	N/A	N/A
Naknek Lake	June-May	0.04	0.01	18.16	0.008	N/A	N/A	N/A
Brooks Lake	June-May	0.041	0.01	8.88	0.004	N/A	N/A	N/A
Lower Ugashik	Aug	N/A	N/A	4.81	N/A	N/A	N/A	N/A

Table 79. Limnology of lakes in KATM (Burgner et al. 1969). (continued)

Water Body	Month	Molybdenum	Mean C Fixation	Mean Chlorophyll (Mg/L)	Mean Secchi Reading
Amanda Lake	Aug	0.0015	N/A	0.7	8.5
Ualik Lake	Aug	0.0014	2.5	0.8	9.7
Lake Nunavaugaluk	Aug	<.0001	1.4	0.6	13
Lake Aleknagik	June-Oct.	0.0004	2	1.3	8.7
Lake Nerka	June-Oct.	0.0013	1.7	0.9	12.6
Lake Beverley	June-Oct.	0.0004	1.7	1	12
Lake Kulik	June-Oct.	0.0015	1.6	0.8	11.5
Lake Togiak	June-Oct.	0.0006	1.9	1.4	10.4
Tikchik Lake	Aug	trace	1.6	0.6	10.7
Nuyakuk Lake	Aug	<.0001	N/A	0.2	10
Lake Chauekuktuli	Aug	0.0003	1	0.5	15.3
Iliamna Lake	June-Oct.	0.0015	1.5	0.8	9.8
Lake Clark	June-Oct.	0.0028	1.6	1.1	3.8
Kukaklek Lake	July-Aug.	N/A	1.1	0.6	10.2
Nonvianuk Lake	July-Aug.	N/A	1.2	0.5	13.2
Coville Lake	June-Oct.	N/A	5.9	1	5.4
Grosvenor Lake	June-Oct.	N/A	2.9	0.7	8.4
Naknek Lake	June-May	N/A	3.4	0.9	4.4
Brooks Lake	June-May	N/A	1.7	0.5	10.8
Lower Ugashik	Aug	N/A	1.2	0.8	8.5

Table 80. Chemical analyses from sockeye salmon nursery lakes of Southwestern Alaska. Element concentrations are in parts per million (Dahlberg 1972).

Water Body	Sr	Na	K	Mg	Fe	Mn	Ca	Cu	Al	Ti	Co	Ni
Lake Clark	0.05	1.3	1	0.9	0.22	0.005	6.8	0.003	0.4	0.1	0.004	0.006
Lake Iliamna	0.04	1.4	7	0.7	0.03	1	4.7	0.003	<.1	<.1	0.006	0.004
Lake Nerka	0.03	1	0.2	0.6	0.12	0.002	4.1	0.002	0.1	<.1	0.005	0.005
Lake Aleknagik	0.04	1.2	0.2	0.7	0.04	0.002	4.3	0.002	0.4	0.2	0.003	0.005
Coville Lake	0.03	2.5	0.6	1.2	0.24	0.006	5.3	0.002	0.2	<.1	0.002	0.005
Grosvenor Lake	0.03	2.5	0.6	1.2	0.11	0.003	5.9	0.004	0.1	0.1	0.002	0.003
North Arm	0.06	8	1.2	2.7	0.05	0.002	18.2	0.003	0.4	<.1	0.007	0.005
Iliuk Arm	0.06	7.6	1.2	2.7	0.037	0.011	18	0.006	0.7	0.2	0.011	0.008
West End	0.06	7.8	1.2	2.6	0.04	0.001	18.1	0.002	0.3	<.1	0.006	0.004
Brooks Lake	0.04	3.4	1.9	1.9	0.03	0.002	7.2	0.003	0.1	0.3	0.007	0.002
Becharof	0.04	4.7	1.2	1.2	0.02	0.002	5.6	0.003	0.1	0.1	0.007	0.003
Upper Ugashik Lake	0.02	6.9	1.1	1.1	0.05	0.003	3.1	0.003	<.1	<.1	0.006	0.003
Lower Ugashik Lake	0.02	6	1	1	0.03	0.002	2.9	0.003	0.1	0.1	0.009	0.005

Table 81. Secchi readings (m) in four basins of the Naknek River System during the summer of 1972 (Dahlberg 1972).

Date	North Arm	South Bay	Iliuk Arm	Brooks Lake
16-Jul	7.2	3.5	0.8	9.5
3-Aug	8	4.2	0.7	12.5
8-Sep	7.6	3	0.5	10.5

Table 82. Temperature readings (Celsius) in four basins of the Naknek River system during the summer of 1972 (Dahlberg 1972).

Depth (m)	North Arm 3-Jul	North Arm 3-Aug	North Arm 8-Sep	South Bay 3-Jul	South Bay 3-Aug	South Bay 8-Sep	Iliuk Arm 3-Jul	Iliuk Arm 3-Aug	Iliuk Arm 8-Sep	Brooks Lake 3-Jul	Brooks Lake 3-Aug	Brooks Lake 8-Sep
0	14.3	11.1	10.7	8.3	10.8	10.3	6.9	9.6	8.8	9	11.8	11.1
5	6.8	10.6	10.2	7.4	9.8	10.3	5.8	9.4	8.8	7.8	11.3	10.9
10	6.5	10.5	10	7	8.7	10.3	5.7	9	8.8	6.9	11	10.8
20	4.9	8.5	8.8	5.8	6.9	9.9	5.4	8.8	8.3	6.3	7.4	10.8
30	4.3	7.1	7.1	5.2	6.4	9	5.2	7.1	7.4	5.5	6.3	7.6
40	4.1	6.4	6.6	5.1	5.9	7.6	5.1	6	7	4.9	5.9	6.4
50	4.1	5.7	6.5	5.1	5.6	7.3	5.1	5.3	6.8	4.9	5.7	6.4

Table 83. Chemical and physical water quality properties of the Kamishak River (Frenzel and Dorava 1999).

Water Temp. (°C)	Specific cond. (µS/cm)	Dissolved oxygen concentration (mg/L)	pH -	Phosphorus (P) total as P	Orthoposphate (PO_4) dissolved as P	Phosphorus (P) dissolved as
6.7	68	12.2	7.4	0.357	0.012	<.010

Table 83. Chemical and physical water quality properties of the Kamishak River (Frenzel and Dorava 1999). (continued)

Nitrite+nitrate (NO_2+NO_3) dissolved as N	Ammonia (NH_3) dissolved as N	Ammonia+organic nitrogen (NH_3+OrgN) total as N	Ammonia+organic nitrogen (NH_3+OrgN) dissolved as N
0.088	0.027	0.24	<0.10

Table 84. Rates of primary productivity in mg C/m^3/day for the first 5 m of four Brook Lake stations (Goldman 1960).

Date	Station 1	Station 2	Station 3	Station 4
Sample Depth	5 meters	35 meters	65 meters	35 meters
18 Jun- 3 Jul	4.59	4.85	5.55	3.89
8 Jul-23 Jul	2.91	2.59	3.98	3.4
28 Jul to 12 Aug	2.82	3.68	3.59	4.82
17 Aug- 2 Sept	2.52	2.7	3.31	5.55
Mean	3.21	3.45	4.11	4.42
Standard error	0.05	0.05	0.12	0.19
No. of measurements	96	96	96	24

Table 85. Rates of primary productivity in mg C/m^3/day for the first 20 m of three Brook Lake stations (Goldman 1960).

Date	Station 2	Station 3	Station 4
Sample Depth	35 meters	65 meters	35 meters
18 Jun- 3 Jul	6.01	6.08	5.92
8 Jul-23 Jul	2.45	4.8	4.4
28 Jul to 12 Aug	3.24	3.82	9.86
17 Aug- 2 Sept	2.42	2.8	4.19
Mean	3.53	4.38	6.09
Standard error	0.07	0.12	0.14
No. of measurements	144	144	39

Table 86. Rates of primary productivity in mg C/m^3/day for the first 35 m of three Brook Lake stations (Goldman 1960).

Date	Station 2	Station 3	Station 4
Sample Depth	35 meters	65 meters	35 meters
18 Jun- 3 Jul	4.45	4.85	
8 Jul-23 Jul	2.19	4.05	
28 Jul to 12 Aug	2.84	4.22	8.18
17 Aug- 2 Sept	1.79	2.24	
Mean	2.82	3.84	8.18
Standard error	0.05	0.07	0.21
No. of measurements	176	176	12

Table 87. Rates of photosynthetic carbon fixation in three lakes of the Alaskan Peninsula in 1957 (Goldman 1960).

Date	Naknek mg $C/m^3/Day$	Naknek mg $C/m^2/Day$	Date	Brooks mg $C/m^3/Day$	Brooks mg $C/m^2/Day$	Date	Becharof
20-Jun	10.23	163.66	18-Jun	3.8	170.9		
6-Jul	14.05	244.8	3-Jul	4.87	219.14		
20-Jul	10.79	172.61	23-Jul	4.19	188.73		
4-Aug	8.71	139.43	2-Aug	3.1	139.45	23-Aug	0.63
19-Aug	10.42	166.64	22-Aug	1.96	88.07		
5-Sep	10.69	171.12	2-Sep	3.19	143.64		
Mean	10.81	173.04		3.52	158.32		0.63

Table 88. Water quality in three Alaska Lakes, 1957, values in ppm (Goldman 1960).

Lakes	Brooks	Brooks	Brooks	Brooks	Naknek	Naknek	Becharof
Stations	1	2	3	4	A	B	
Phosphorus	0.0065	0.007	0.0073		0.0087	0.0095	0.0083
Nitrite	0.0015	0.0012	0.0019	0.0038	0.0083	0.005	0.003
Silicon	10.45	10.58	10.77	11.95	10.9	11.6	1.04
Total Hardness $CaCO_3$	36.13	35.17	35.48		69.5	71	24.9
Bound CO_2 as $CaCO_3$	31.79	31.48	32	31.54	35.3	35.1	18

Table 89. Surface water chemistry in various KATM lakes and streams collected during the summers of 1984 and 1986. Collections in the Battle Lake drainage were done in the summer of 1986, n = the number of samples, charge balance is calculated as cations divided by anions (Gunther 1986).

KATM Lake or Stream(n)	Chloride	Nitrate	Sulfate	pH	H+	Alkalinity	Ca	Mg
Brooks (1)	N/A	<.1	96.4	7.6	0.03	602	N/A	N/A
Kulik(1)	N/A	16.5	227.4	7.2	0.06	155	N/A	47.4
Murry(1)	N/A	N/A	N/A	7.1	0.08	186	N/A	42.6
Hammersly(1)	N/A	N/A	N/A	7.1	0.08	204	N/A	45
Malone's(1)	N/A	N/A	N/A	9.3	0	797	N/A	N/A
Nonvianuk (3)	30.81	2.59	119.67	7.03	0.1	203	175.6	56.7
Idavain (2)	56.14	0.59	16.55	7.48	0.03	417	242	116.35
Coville(2)	48.57	<.05	40.65	7.55	0.03	502	247	139.75
Pecker(2)	97.36	<.05	24.7	6.95	0.11	106.5	39.3	59.3
Kukaklek (3)	N/A	N/A	N/A	6.95	0.11	149	N/A	N/A
Battle (1)	46.75	5.86	103.6	6.55	2.82E-01	58	94.8	38.7
Tributary 1 (4)	37.95	1.7	1034.5	4.16	69.94	N/A	193.63	156.28
Tributary 2 (2)	35.6	1.64	59.2	6.13	0.76	35.5	45.85	17.73
Tributary 3 (2)	48.84	4.58	34.45	6.65	0.22	80.5	76.6	17.2
Tributary 4 (1)	22.72	0.87	14.2	6.65	2.24E-01	90	52.7	13.94
Tributary 5 (2)	39.31	1.05	546.7	7.05	0.09	175	442.5	163
Iron Springs (1)	41.63	<2	1510.2	3.65	2.24E-02		488.8	238
Iron Springs (2)	41.25	1	1514.8	3.68	211.7	N/A	236	241
Mine (2)	30.25	1.97	69.45	7.18	7.00E-02	177.5	134	59.3
Pirate (2)				6.7		86	84.9	27.6

Table 89. Surface water chemistry in various KATM lakes and streams collected during the summers of 1984 and 1986. Collections in the Battle Lake drainage were done in the summer of 1986, n = the number of samples, charge balance is calculated as cations divided by anions (Gunther 1986). (continued)

KATM Lake or Stream(n)	K	Na	Fe	Al	Charge Balance	Cu	Pb	Zn	Mn
Brooks (1)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Kulik(1)	8.8	N/A	N/A	N/A	N/A	<1	<.2	0.5	1.5
Murry(1)	8.8	N/A	N/A	N/A	N/A	<1	<.2	0.5	1.9
Hammersly(1)	7.4	N/A	N/A	N/A	N/A	<1	<.2	0.5	1
Malone's(1)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nonvianuk (3)	8.7	70.8	N/A	0.43	0.88	N/A	N/A	N/A	N/A
Idavain (2)	13.67	129.04	<1	0.41	1.03	<1	N/A	<1	N/A
Coville(2)	12.24	139.94		2.05	0.92	<1	N/A	0.66	N/A
Pecker(2)	14.72	122.57	2.22	3.31	1.05	<1	N/A	0.94	N/A
Kukaklek (3)	N/A	N/A	<1	1.16	N/A	N/A	N/A	N/A	N/A
Battle Lake Drainage									
Battle (1)	5.12	60.58	1.04	8.28	0.97	<1	N/A	N/A	N/A
Tributary 1 (4)	8.01	85.25	13.45	646	1.16	3.75	N/A	250.1	N/A
Tributary 2 (2)	4.66	50.18	1.52	21.41	1.08	<1	N/A	0	N/A
Tributary 3 (2)	5.09	58.4	1.19	2.67	0.96	<1	N/A	1	N/A
Tributary 4 (1)	4.56	46.09	<1	1.08	0.93	<1	N/A	2	N/A
Tributary 5 (2)	4.87	86.96	<1	10.75	0.98	<1	N/A	2	N/A
Iron Springs Lake (1)	9.52	85.17	38.8	1062	1.27	6.44	N/A	246	N/A
Iron Springs Lake (2)	9.83	87.37	48.39	1078.5	1.25	6.6	N/A	215	N/A
Mine Creek (2)	3.16	70.53	<1	7.75	1	<1	N/A	0.7	N/A

Table 90. Hardness and total alkalinity from six sampling sites in Katmai National Park and Preserve, Alaska. Total hardness (calcium + magnesium) was measured during 1997 (Johnson and Berg 1999).

Site	Hardness $CaCO_3$ (mg/L)	Total Alkalinity (mg/L)
Brooks Lake	30.4	28.9
Naknek Lake	52.9	27.7
Lake Camp	53.4	30.6
Alagnak Wild River	1.64	22.4
Grosvenor Lake Lodge	2.39	28.3
Kulik River Lodge	1.3	13

Table 91. Water samples tested for aromatic hydrocarbons from three areas within Katmai National Park and Preserve (12-13 August 1997). Samples were collected upstream, downstream and at the suspected source of contamination. Sample results are in parts per billion (ug/L). All values were below minimum detection levels (Johnson and Berg 1999).

	Lake Camp LCW-1	**Lake Camp LCW-2**	**Lake Camp LCW-3**	**Brooks Lake BLW-1**	**Brooks Lake BLW-2**	**Brooks Lake BLW-3**	**Naknek Lake NLW-1**	**Naknek Lake NLW-2**	**Naknek Lake NLW-3**
	Upstream	Downstream	Source	Upstream	Downstream	Source	Upstream	Downstream	Source
Benzene	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
Chlorobenzene	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
1,2 Dichlorobenzene	<.50	<.50	<.50	<.50	<.50	<.50	<.50	<.50	<.50
1,3 Dichlorobenzene	<.50	<.50	<.50	<.50	<.50	<.50	<.50	<.50	<.50
1,4 Dichlorobenzene	<.50	<.50	<.50	<.50	<.50	<.50	<.50	<.50	<.50
Ethylbenzene	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
Toluene	<.30	<.30	<.30	<.30	<.30	<.30	<.30	<.30	<.30
p,m -Xylenes	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
o-Xylenes	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
Total Xylenes	<.40	<.40	<.40	<.40	<.40	<.40	<.40	<.40	<.40

4.11.4 Literature Cited

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Chapter 5 Discussion

Chapter 5 provides an opportunity to summarize assessment findings and discuss the overarching themes or common threads that have emerged for the featured components. The data gaps and needs identified for each component are summarized and the role these play in the designation of current condition is discussed. Also addressed is how condition analysis relates to the overall natural resource management issues of the park.

5.1 Component Data Gaps

The identification of key data and information gaps is an important objective of NRCAs. Data gaps or needs are those pieces of information that are currently unavailable, but would help to inform the status or overall condition of a key resource component in the park or would allow the park to develop a more thorough understanding of the topic in order to inform possible management decisions. Data gaps exist for most resource components assessed in this NRCA. Table 92 provides a detailed list of the data gaps identified in this assessment by component. Each data gap or need is discussed in further detail in the individual component assessments (Chapter 4).

Table 92. Identified data gaps or needs for the featured components.

Component	Data Gaps/Needs
Invasive Species and Non-native Species	➢Increase awareness, communication and information exchange surrounding invasive and non-native species ➢Continue and expand documentation and mapping of current invasive and non-native species ➢Develop invasive rankings and incorporate into planning projects and doccuments ➢Continued updates to the restoration and re-vegetation manual a priority
Moose	➢Current population and sex survey information available only from 9 year old survey data. Data variability likely introduced due to differing collection techniques ➢Population and sex survey data absent from Alagnak and Pacific areas
Bear	➢No current population survey (most recent is 2009)
Passerines	➢Bird observation and surveys predominately occur during summer ➢Introduce sampling at high and middle eleveations as well as introducing other survey techniques to augment point count ➢Conduct additional surveys during seasons other than summer
Salmon	➢Further analysis on salmon harvest rates on escapement ➢Continued sampling/surveys to build historical datasets
Native Fish	➢Lack of data to assign a clear reference condition

Table 93. Identified data gaps or needs for the featured components. (continued)

Component	Data Gaps/Needs
Seismic Activity	➢Need to study VT swarms that do not result in volcanic eruption
Climate	➢Continue data gathering from RAWS stations ➢Implement a more accurate method for measureing wintertime precipitation
Human Activities	➢To allow for future comparison, yearly updates of the CUA database are important for maintaining the integrity and quality of the database.
Glacial Extent	➢Further study of glacial extent and terminus retreat ➢Volume change analysis needed
Water Quality	➢Water quality data do not exist for most drainages in KATM ➢Existing data collection methods/times are inconsistent

Many of the park's data needs involve the challenge of determining ways to effectively sample and monitor biological phenomena in order to increase statistical confidence and to ensure long-term monitoring techniques are possible. To increase statistical confidence, sampling techniques of existing survey efforts could be strengthened and improved, or in some cases, designing entirely different approaches in terms of long-term data collection. Some statistical confidence will increase by simply consistently repeating the existing surveys to increase the total number of samples (e.g., years), as some sampling methods have only been repeated for a few consecutive years.

The sampling and monitoring efforts in KATM are complicated given the remote location of the park, as well as potentially extreme environmental conditions. Techniques for large animal surveys (aerial) often require ideal weather during the survey as well as for optimal sighting conditions. Moose surveys are frequently impacted by a lack of snow cover, inadequate snow depth and less than optimal flying conditions. Weather and sampling conditions also impact other population surveys in KATM including passerines, salmon, and bear. A consistent but opportunistic and flexible approach to population surveys is necessary to gather data and improve analyses.

5.2 Park-wide Component Observations

5.2.1 Biotic Composition

<u>Ecological Communities</u>

Invasive and Non-native Species

Historically, Alaska has been relatively free from non-native plants due to its geographic isolation and undisturbed ecosystems (Densmore et al. 2001). However, in the past few decades an increasing trend has been observed with the introduction of non-native and invasive species in the state (McClory and Gotthardt 2008, AKEPIC 2013). Invasive species problems in Alaska appear to be in their early stages and a proactive approach is necessary if natural resources are to be retained (Carlson and Shepard 2007).

KATM has distinct advantages against the introduction and spread of non-native and invasive species. The park's remote location limits anthropogenic disturbances and the related advancement of non-native and invasive species. The boreal climate and boreal vegetation are deterrents to non-native species; nonetheless several non-native species are currently present in the park. Since 2010, when the EPMT began surveying and controlling non-natives and invasives in KATM, the percent of area infested has remained relatively constant at around 15%. Four main species, pineapple weed, common dandelion, shepherd's purse and bluegrass comprise the majority of infestations.

Mammals

Moose

Moose are common within KATM. Originally scarce on the Alaskan peninsula (prior to 1900), moose populations grew exponentially until they peaked in the late 1960s (Butler 2010). Natural predators of moose within KATM include wolves and brown bears. Limited hunting is also allowed with KTPR.While current survey trends in KATM indicate declining populations, overall, populations are considered to have been stable for the past 30 years (Butler 2008, 2010). Consistent moose population/sex surveys would aid in obtaining a more complete picture of the moose in KATM.

Bear

KATM is home to the largest protected brown bear population in the world (Loveless et al. *in review*). Brown bears are found throughout KATM at population densities of approximately 156 (± 21)/1,000 km^2. Abundant salmon runs and limited anthropogenic presence have encouraged this concentration.

While anthropogenic influence is low in KATM, studies have shown human activity to affect bear activity (non-habituated bears) delaying their use of certain portions of a stream by as much as 17 days (Olsen et al 1997). Managing the human influence along current and consistent population/sex surveys will be important for maintaining the bear's presence and in gaining an accurate insight into managing the bears.

Birds

Passerines

Bird populations can be an important indicator species as they often reflect an ecoystem's health (Morrison 1986, Hutto 1998, NABCI 2009).Fifty-six species of passerines have been identified in KATM, and 46 species have been documented in ALAG (NPS 2013). Nearly all of the bird surveys and observations have been during the summer months at KATM. While this is the most likely time for passerines to be present and active, surveys during other seasons would be beneficial in understanding the passerine population. Other survey methods as well as specific research on the several species of concern in KATM would be beneficial.

Fish

Salmon

Abundant salmon runs are vital to KATM and occur throughout the streams in the park. Sockeye salmon are integral to the ecological, economic and social integrity of KATM and the surrounding area (NPS 2011b). Four other species of salmon are present and include; Chinook, chum, coho, and pink. Peak salmon runs occur from July to August and draw large numbers of visitors to the park as well brown bear.

While salmon escapement and harvest are closely monitored, the significant variability in salmon runs makes it difficult to determine exact escapement or harvest rates. Further analysis examining effects of harvest rates on escapement (and vice versa) may allow for better conclusions and improved assessments.

Native Fish (non-anadromous)
NPS (2012) identified 39 native fish species as being present or probably present in KATM, and 23 species in ALAG. Statewide mail-in surveys indicate that, on average, 9,000 fishermen visit the water bodies in KATM and ALAG (ADF&G 2012).

Angling pressure on easily accessed areas of rivers or streams has caused concern for stream trout species in the past. From 1997-1998, over 30% of rainbow trout sampled from the Alagnak River carried a visible scar or deformity from being previously caught (Meka 2003). However, pressure on most rivers and streams in KATM and ALAG is minimal. Most water bodies that hold native fish in KATM and ALAG are isolated and experience little anthropogenic disturbance.

5.2.2 Environmental Quality

Seismic Activity
Located in the Aleutian volcanic arc, KATM has experienced considerable seismic and volcanic activity throughout its history. More than 50 discrete volcanic vents are located within 20 km (12 mi) of Novarupta (Fierstein 2012). Volcanism has drastically impacted the landscape in KATM with major landscape impacts occurring more than 10 km (6.2 mi) from an epicenter of a major eruption (Page et al. 1991). Impacts to KATM include; uplift, subsidence, tsunamis, mass movements, mass wasting, lava flow, and debris wich can cover the landscape with a thick layer of ash.

Within KATM, the AVO recognizes 14 volcanoes and maintains 24 seismic monitoring stations (Dixon 2012). The AVO actively monitors eight KATM volcanoes in an effort to record daily seismic activity, predict eruptions, and develop historical seismic activity data in the areas surrounding each volcano (Dixon 2012). Seismically monitored KATM volcanoes include Mount Martin, Mount Mageik, Trident Volcano, Mount Katmai, Snowy Mountain, Mount Griggs, Novarupta, and Fourpeaked (AVO 2013). Seismic events with a magnitude of greater than 0 have numbered over 1,000 per year for these volcanoes since 2002, with a slight decreasing trend in events per year observed from 2006 to 2012.

Climate
As a primary driver of many other ecosystem components (vegetation, wildlife, disturbance regime, etc.), climate has numerous management consequences and implications. Climate was selected by the SWAN I&M program as a high-priority Vital Sign for southwest Alaska parks (Davey et al. 2007).

The KATM and ALAG climate is described as "transitional between polar (tundra climate) and maritime (maritime subarctic)" (Lindsay 2013, p. 1). Winter temperatures are cold, while summer temperatures are somewhat moderated by nearby open water (e.g., Bering Sea and Gulf of Alaska) (Lindsay 2013).

There is a scientific consensus that human activities, particularly those that produce greenhouse gasses (e.g., fossil fuel burning), have contributed to a general warming trend in global climate (IPCC 2010). Climate models predict that change will be greatest at higher latitudes, indicating that Alaska is at high risk (NPS 2011a). In the KATM region, temperatures are projected to increase approximately 1°F (about 0.6°C) per decade over the next century (SNAP et al. 2009). Potential impacts of these changes in southwest Alaska parks include reduced snowpack and a longer growing season, which could affect plant phenology and productivity, wildlife distribution and mating cycles, water availability, and recreational and subsistence activities (e.g., hunting, fishing) (SNAP et al. 2009, NPS 2011a).

Human Activities

Access to KATM and ALAG is limited, as road access to the parks is not available; park visitors generally access the park via a small aircraft or a boat ride that originates in King Salmon, AK. The most common activities for park visitors are sport fishing and bear viewing. Brooks Camp and the coast are popular locations for bear viewing, and the northwest portion of the park experiences relatively large sport fishing pressure whereas the southern portion of KATM experiences little visitation, due to the difficulty of travel.To allow for future comparison, yearly updates of the CUA database are important for maintaining the integrity and quality of the database.

5.2.3 Physical Characteristics

Glaciers

Aerial photography datasets from the early 1980s indicate that glaciers and permanent snow fields covered about 6% of the 16,591 km^2 (6,406 mi^2) of KATM (Giffen and Lindsay 2011). Glacial extent has been identified as a Vital Sign in KATM and the monitoring of the extent is critical to upholding the park's mission. The mapping of the glacial extent boundary on a repeating decadal scale will help to identify areas where glacial cover is stable, growing, or shrinking, and estimate rates of change (Bennett et al. 2006).

Giffen et al. (2014) observed that most glaciers in KATM from 1951-2000 showed steady retreat, but some ash covered glaciers changed very little or showed no change. A reduction of 76 km^2 (29 mi^2), or 7.7% of the total glacial area, was observed from 1987-2000 analyses (Giffen et al. 2014). Summer and winter average temperatures have been increasing in the KATM region for over 50 years. Higher average yearly temperatures have caused many of the glaciers in KATM to retreat, and average yearly temperatures are predicted to continue increasing in the SWAN parks region which would translate to continued retreat of the glaciers in KATM.

Water Quality

Aquatic systems within SWAN are remote and pristine, providing researchers with an opportunity to examine the effects of man-made disturbances such as climate change and atmospheric pollutants on intact systems. Currently, water quality data for SWAN NPS units such as KATM and ALAG are minimal, but a monitoring plan for KATM exists.

Nagorski (2007) notes that oil spills, pollutants transferred through the atmosphere and biological processes, and climate change have negatively affected KATM water quality in the past and are likely to continue to in the future. Natural water quality degradation caused by geothermal springs in KATM have caused pH, chloride, sulfate, arsenic, cadmium, temperature, and selenium to be reported outside the allowed state and federal water quality standards (Nagorski 2007).

5.2.4 Park-wide Threats and Stressors

Anthropogenic impacts from climate change to tourism potentially impact KATM and ALAG and their resources. Arguably the most relevant, long-term threat to KATM and ALAG is climate change. Alaska already experiences cyclical shifts in weather and climate because of the PDO. Depending on the phase of the PDO, warmer or cooler air pushes into the northern latitudes for extended periods of time, causing shifts in temperature and precipitation regimes.

If a global warming trend persists, glacial melt and shifts in climate regimes would change the dynamic of KATM and ALAG. From 1950-2005, the recession of glaciers resulted in exposure of new shoreline, streams, and revegetation of once-covered bare ground. Places in higher latitudes, such as KATM and ALAG, are anticipated to experience greater rates of change and higher variability.

For biological resources analyzed in this assessment many concerns also stem from climate change (warming). Salmon may experience decreased survival of eggs and fry, slowed growth, premature smolting, and shifts in onsets of runs (Alderice and Velsen 1978), Other potential impacts of a warmer climate include reduced snowpack and a longer growing season, which could affect plant phenology and productivity, wildlife distribution and mating cycles, water availability, and recreational and subsistence activities (e.g., hunting, fishing) (SNAP et al. 2009, NPS 2011a).

Human use in KATM/ALAG is also considered a stressor; hunting has had both positive and negative impacts on the park’s resources. Hunting and subsistence fishing have been a management tools used to control wildlife populations. Salmon, bear, moose harvest occurs in the preserve. Sport fishing has been known to disrupt the natural balance in the KATM river systems because rainbow trout feed on salmon eggs. If sport fishermen start taking too many trout, then the balance of salmon in the stream may be thrown off (NPS 1986).Salmon, however, are most threatened by the commercial fishing industry.

Interactions between bear and humans have increased in some commonly visited areas of the park. The Brooks Camp area is located near a major brown bear feeding area during the summer and fall, and numbers of both bears and humans using the area has increased since the development of the camp. This increase creates a significant need for management to prevent serious conflicts (NPS 1986).

Another threat to resources in KATM and ALAG are human caused disasters such as oil spills. The Exxon Valdez oil spill in spring of 1989 was one of the most environmentally devastating (human-caused) events to affect the park (NPS 1990, as cited by Nagorski et al. 2007). The shoreline of the park in this area received about two to four percent of the spill (NPS 1990, as cited by Nagorski et al. 2007). Many organisms were harmed due to the toxicity of the compounds in the oil (Nagorski et al. 2007). The vegetation in the intertidal region was damaged, adding to the stress of some marine species.

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Appendix A. Recent and historical moose survey data for park locales within KATM. Blank cells indicate unreported information. Table modified from NPS (2012).

Year	Survey Date	Total Bull	Total Cow	Total Calf	Unknown	Total	Survey Min.	Sq. Miles	Moose/ Hour	Min/sq. Mile	Bulls:100 Cows	Moose/ sq. Mile
Alagnak												
1991	12/16/1991 12/18/1991	30	77	10	0	117	117	225.00	60.00	0.52	38.96	0.52
Aniakchak												
1999	12/14/1999	39	65	2	0	106	240	230.00	26.50	1.04	60.00	0.46

Appendix A. Recent and historical moose survey data for park locales within KATM. Blank cells indicate unreported information. Table modified from NPS (2012). (continued)

Survey Date		Total Bull	Total Cow	Total Calf	Unknown	Total	Survey Min.	Sq. Miles	Moose/ Hour	Min/sq. Mile	Bulls:100 Cows	Moose/ sq. Mile
Angle/Takayofo												
1969	11/30/1969	102	109	39	1	251	194		77.63		93.58	
1971	10/24/1971	113	132	15	0	260	96		162.50		85.61	
1972	11/12/1972	143	181	26	0	350	156		134.62		79.01	
1973	12/10/1973	49	114	15	0	178	174		61.38		42.98	
1974	11/18/1974	82	237	43	0	362	144		150.83		34.60	
1975	11/12/1975	48	106	25	0	179	228		47.11		45.28	
1975	12/5/1975	96	202	41	0	339	162		125.56		47.52	
1976	11/4/1976	91	157	34	0	282	180		94.00		57.96	
1977	11/16/1977	120	197	40	0	357	126		170.00		60.91	
1978	12/3/1978	51	91	11	0	153	108		85.00		56.04	
1980	11/29/1980	48	121	29	1	199	138		86.52		39.67	
1981	11/23/1981 12/4/1981	55	116	33	0	204	234		52.31		47.41	
1982	11/18/1982	63	139	12	0	214	180		71.33		45.32	
1983	10/27/1983	103	185	21	0	309	168		110.36		55.68	
1992	12/8/1992	111	134	21	0	266	174	225	225	0.77	82.84	1.18
1993	11/23/1993	95	99	18	4	216	115	169	112.70	0.68	95.96	1.28
1994	?	37	53	12	1	103	213	225	29.01	0.95	69.81	0.46
1999	12/1/1999	21	39	6	0	66	240	143	16.50	1.68	53.85	0.46
2000	11/30/2000 - 12/1/2000	67	88	22	10	187	180	225	62.33	0.80	76.14	0.83
2001	11/7/2001 - 11/8/2001	33	65	21	0	119	205	143	34.83	1.43	50.77	0.83
2004	12/7/2004	37	41	5	0	83	145	143	34.34	1.01	90.24	0.58
2005	11/21/2005	48	69	7	0	124	202	143	36.83	1.41	69.57	0.87
2010	11/26/2010	21	15	6	0	42	239	147	10.54	1.63	140.00	0.29

Appendix A. Recent and historical moose survey data for park locales within KATM. Blank cells indicate unreported information. Table modified from NPS (2012). (continued)

Survey Date		Total Bull	Total Cow	Total Calf	Unknown	Total	Survey Min.	Sq. Miles	Moose/ Hour	Min/sq. Mile	Bulls:100 Cows	Moose/ sq. Mile
Branch River												
1978	12/14/1978	19	47	11	21	98	90		65.33		40.43	
1980	11/30/1980	17	47	8	0	72	78		55.38		36.17	
1981	11/21/81 11/23/81	51	126	23	0	200	170	211.9	70.59	0.80	40.48	0.94
1982	12/1/1982	75	184	37	0	296	180	211.9	98.67	0.85	40.76	1.40
1983	11/22/1983	40	104	38	0	182	220	211.9	49.64	1.04	38.46	0.86
1984	?	50	92	31	0	173	145	211.9	71.59	0.68	54.35	0.82
1986	?	29	122	31	0	182	165	211.9	66.18	0.78	23.77	0.86
1987	?	77	212	35	0	324	245	211.9	79.35	1.16	36.32	1.53
1988	?	45	130	48	0	223	235	211.9	56.94	1.11	34.62	1.05
1989	?	109	337	45	0	491	280	211.9	105.21	1.32	32.34	2.32
1992	?	66	196	44	0	306	370	211.9	49.62	1.75	33.67	1.44
1994	11/21/1994 1123/94	40	99	36	8	183	241	255	45.56	0.95	40.40	0.72
1995	12/14/1995	42	108	19	0	169	144		70.42		38.89	
1996	12/4/96 12/5/96	33	117	21	0	171	297	212	34.55	1.40	28.21	0.81
2005	11/22/05 11/23/05	49	134	22	0	205	355	285	34.65	1.25	36.57	0.72
2010	11/17/10 11/18/10	36	56	0	0	92	453	360.18	12.19	1.26	64.29	0.26

Appendix A. Recent and historical moose survey data for park locales within KATM. Blank cells indicate unreported information. Table modified from NPS (2012). (continued)

Survey Date		Total Bull	Total Cow	Total Calf	Unknown	Total	Survey Min.	Sq. Miles	Moose/ Hour	Min/sq. Mile	Bulls:100 Cows	Moose/ sq. Mile
Park Border												
1981	11/22/1981	16	69	10	0	95	120	100	47.50	1.20	23.19	0.95
1982	11/30/1982	26	84	8	0	118	105	152.6	67.43	0.69	30.95	0.77
1983	10/22/1983	30	91	18	0	139	120	152.6	69.50	0.79	32.97	0.91
1984	11/7/1984	39	140	17	0	196	180	215	65.33	0.84	27.86	0.91
1985	12/6/1985	24	117	12	0	153	205	152.6	44.78	1.34	20.51	1.00
1986	12/1/1986	22	104	20	0	146	125	152.6	70.08	0.82	21.15	0.96
1987	11/18/1997	17	84	12	0	113	135	152.6	50.22	0.88	20.24	0.74
1988	11/11/1988	30	95	30	0	155	120	152.6	77.50	0.79	31.58	1.02
1989	11/19/1989	44	110	19	0	173	190	152.6	54.63	1.25	40.00	1.13
1990	12/11/1990	35	112	26	0	173	180	152.6	57.67	1.18	31.25	1.13
1992	11/14/1992	53	138	39	0	230	245	152.6	56.33	1.61	38.41	1.51
1993	11/24/93 11/26/93	34	102	27	0	163	141	153	69.36	0.92	33.33	1.07
1994	11/8/1994	67	125	19	0	211	148	152.6	85.54	0.97	53.60	1.38
1995	12/6/1995	34	135	42	0	211	230	185	55.04	1.24	25.19	1.14
1996	12/6/1996	41	131	40	0	212	260	185	48.92	1.41	31.30	1.15
2010	11/30/2010	11	26	12	0	49	302	204.8	9.74	1.47	42.31	0.24
2010	12/8/10 12/9/10	28	94	37	0	159	440	282.08	21.68	1.56	29.79	0.56
2010	11/25/2010	22	66	16	3	107	210	157	30.57	1.34	33.33	0.68
2011	12/5/2011	7	16	3	3	29	212		8.21		43.75	
2011	11/28/2011	15	92	8	0	115	180	153.00	38.33	1.18	16.30	0.75

Appendix A. Recent and historical moose survey data for park locales within KATM. Blank cells indicate unreported information. Table modified from NPS (2012). (continued)

Survey Date		Total Bull	Total Cow	Total Calf	Unknown	Total	Survey Min.	Sq. Miles	Moose/ Hour	Min/sq. Mile	Bulls:100 Cows	Moose/ sq. Mile
Cinder River												**Cinder River**
1983	11/1/1983	20	41	10	0	71	120	148	35.50	0.81	48.78	1983
1986	11/26/2986	26	39	4	0	69	120	115	34.50	1.04	66.67	1986
1987	12/10/1987 12/11/1987	40	59	11	0	110	120	148	55.00	0.81	67.80	1987
1988	11/27/1988	23	34	18	0	75	120	148	37.50	0.81	67.65	1988
1993	12/13/1993	37	65	8	0	110	180	148	36.67	1.22	56.92	1993
1998	11/24/1998	35	53	9	0	97	120	148	48.50	0.81	66.04	1998
Pacific												**Pacific**
1983	11/19/1983	26	52	10	0	88	60	225	88.00	0.27	50.00	1983
1987	12/10/1987	28	41	5	0	74	180	225	24.67	0.80	68.29	1987
1994	12/1/1994	22	52	14	0	88	180	225	29.33	0.80	42.31	1994
1998	11/23/1998	50	52	9	5	116	120	225	58.00	0.53	96.15	1998

Appendix B. Stream bear survey data in KATM from 1974 to 2007, showing stream location, number of individual bear observations, and pre- and post-1990 average survey counts (NPS 2012).

Year	Margot No.	Contact No.	Idavain No.	American No.	Savonoski No.	Hardscrabble No.	Nanuktuk No.	Moraine/Funnel No.
1974	54		6	14	150			
1975	120		20	35	138	64		
1976[1]	143		64	128		23		
1976[2]					163	36		
1977[1]	52		16	97	71[2]			
1980	72	38	38	75	47	15	0	21
1984	8				13	28		
1985	5	28	2	22	0	28	15	10
1986	18	6	0	31		7	3	
1992	2		0	6	3	1	8	17
1993							50	
2005							16	47
2006							27	72
2007							67	177
Avg. pre-1990	59	24	20.86	57.43	83.14	28.71	6	15.5
n	8	3	7	7	7	7	3	2
Avg. post-1990	2		0	6	3	1	33.6	78.25
n	1		1	1	1	1	5	4

1 – Summer

2 – Fall

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation.

Angler Counts	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Other Shoreline	28	75	*	*	*	94	10	33	17	19	36	*	*	*	*
Other Boat	69	45	*	144	108	15	179	78	146	72	35	75	129	*	22
Saltwater Total	69	90	*	144	107	97	189	111	162	90	53	74	129	*	22
FRESHWATER															
Kvichak River	1,718	1,880	1,668	1,927	1,939	5,547	3,643	4,568	2,146	1,936	1,899	1,973	2,335	1,904	1,763
Newhalen River Drainage	1,788	1,556	1,555	1,620	1,278	*	*	*	698	718	930	679	516	648	520
Battle River	*	*		*	*	*	*	*	*	*	*	*	539	276	489
Alagnak (Branch) River Drainage	2,727	2,563	2,355	1,836	1,764	2,363	2,637	2,500	2,078	3,129	2,634	2,685	2,527	1,591	1,536
Copper River (tributary of Iliamna Lake)	749	1,020	994	1,351	942	*	*	*	599	478	782	860	741	792	661
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	317	416
Lower Talarik Creek	470	358	339	501	594	*	*	*	384	347	*	*	0	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	799	441	480
Kulik River	332	405	655	435	386	*	*	*	796	691	869	586	1,183	997	1,105
Moraine Creek	372	360	*	435	413	*	*	*	563	687	640	712	1,494	842	1,254
Tazimina River	*	*	*	248	*	*	*	*	*	*	*	*	*	*	*
Other Streams	1,739	1,196	1,852	1,272	910	313	202	426	251	372	439	292	*	*	*
Iliamna Lake and Tributaries	868	583	710	606	581	*	*	*	617	981	1,655	1,348	983	823	1,120
Unspecified Streams/Lakes	*	*	*	*	*	*	*	*	*	*	*	*	211	180	170

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation (continued).

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Lake Clark Drainage	728	855	905	793	581	1,275	726	589	1,017	642	709	753	761	656	886
Gibraltar Lake	*	*	*	*	202	*	*	*	*	*	*	*	418	425	409
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	313	296	*
Other Lakes	511	834	860	846	660	131	136	111	217	37	18	55	*	*	*
Freshwater Total	8,051	8,076	8061	7,131	6,894	5,748	4,783	5,284	6,000	6,061	6,761	6,518	7,327	6,325	6,411
Grand Total	8,051	8,106	*	7,193	6,907	5,817	4,878	5,284	6,079	6,097	6,761	6,556	7,394	*	6,411
KATM Total	3,431	3,328	3,010	2,706	2563	2,363	2,637	2,500	3,437	4,507	4,143	3,983	6,542	4,464	5,280

*- Indicates the field was not surveyed during that year.

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

Days Fished	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Other Shoreline	43	262	*	*		167	10	33	17	19	0	*	*	*	*
Other Boat	270	263	*	166	236	90	439	91	213	98	0	267	244	*	22
Saltwater Total	313	525	*	166	236	257	449	124	230	117	0	267	244	*	22
FRESHWATER															
Kvichak River	4,484	3,947	3,339	5,095	7,365	16,059	12,461	11,586	5,790	5,463	7,022	5,557	5,849	6015	6,061
Newhalen River Drainage	3,037	3,773	3,506	5,178	3,063	*	*	*	1,842	1,273	2,169	1,643	1,470	1,370	968
Battle River	*	*	*	*	*	*	*	*	*	*	*	*	592	304	614
Alagnak (Branch) River Drainage	8,121	11,062	7,715	6,411	7,589	8,576	10,614	0	9,028	11,228	11,747	8,881	8,652	5541	6459
Copper River (tributary of Iliamna Lake)	1,558	2,782	2,191	3,359	2,194	*	*	*	1,349	1,082	1,868	2,513	1,520	1,959	1,756
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	545	615
Lower Talarik Creek	601	408	544	603	1,034	*	*	*	438	427	*	*	354	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	1,058	587	480
Kulik River	1,644	512	1,150	726	743	*	*	*	1,253	1,022	2,103	1,711	1,898	1,761	1,584
Moraine Creek	574	696	*	821	1,168	*	*	*	987	1,682	1,024	1,686	2,189	1,257	2,349
Tazimina River	*	*	*	589	*	*	*	*	*	*	*	*	*	*	*
Other Streams	2,980	2,647	4,410	2,651	2,815	662	791	951	714	843	1,060	7,235	*	*	*
Iliamna Lake and Tributaries	1,117	1,017	1,310	2,153	1,666	*	*	*	1,398	2,034	3,942	2,618	1,795	1,134	1,833
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	594	228	470
Lake Clark Drainage	1,003	3,132	1,462	2,331	1,429	4,328	1,985	1,472	2,886	1,244	1,103	1,377	2,008	1,725	1,964
Gibraltar Lake	*	*	*	*	630	*	*	*	*	*	*	*	501	533	485
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	751	789	*
Other Lakes	1,146	1,729	2,415	5,176	1,449	131	262	114	363	37	29	196	*	*	*
Freshwater Total	26,265	31,705	28,042	35,093	31,145	29,756	26,113	24,079	26,048	26,335	32,067	33,417	29,231	23,748	25,681
KATM Total	10,339	12,270	8,865	7,958	9,500	8,576	10,614	0	11,268	13,932	14,874	12,278	14,389	9,995	12,101

*- Indicates the field was not surveyed during that year.

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

King Salmon	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Other Shoreline	0	0	*	*	*	23	0	0	0	0	0	*	*	*	*
Other Boat	0	20	*	37	0	0	68	0	80	0	0	0	84	*	0
Saltwater Total	0	20	*	37	0	23	68	0	80	0	0	0	84	*	0
FRESHWATER															
Kvichak River	107	47	239	0	167	61	49	183	27	217	80	68	344	91	0
Newhalen River Drainage	0	0	0	0	0	*	*	*	13	0	0	0	78	0	0
Battle River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Alagnak (Branch) River Drainage	931	982	1,531	592	501	508	304	334	1,146	1,008	1,052	1,007	394	199	405
Copper River (tributary of Iliamna Lake)	43	0	17	22	20	*	*	*	27	0	0	0	26	0	0
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0
Lower Talarik Creek	0	0	0	0	0	*	*	*	0	0	*	*	0	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	26	0	13
Kulik River	0	0	30	0	0	*	*	*	0	0	0	0	0	0	0
Moraine Creek	0	0	*	0	0	*	*	*	0	0	0	0	0	0	0
Tazimina River	*	*	*	25		*	*	*	*	*	*	*	*	*	*
Other Streams	21	24	13	0	0	0	0	60	0	61	0	0	*	*	*
Iliamna Lake and Tributaries	0	0	224	0	0	*	*	*	0	154	0	0	13	0	0
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	65	10	0
Lake Clark Drainage	0	0	0	0	0	0	0	0	0	0	0	0	42	0	0
Gibraltar Lake	*	*	*	*	0	*	*	*	*	*	*	*	0	0	0
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	*
Other Lakes	43	39	0	0	0	0	0	0	0	0	0	0	*	*	*
Freshwater Total	1,145	1,092	2,054	639	688	569	353	577	1,213	1,440	1,132	1,075	988	300	418
Grand Total	1,145	1,112	*	676	688	592	421	577	1,293	1,440	1,132	1,075	1,072	*	418
KATM Total	931	982	1,561	592	501	508	304	334	1,146	1,008	1,052	1,007	420	199	418

*- Indicates the field was not surveyed during that year.

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

Coho Salmon	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Other Shoreline	0	0	*	*	*	0	0	0	39	44	27	*	*	*	*
Other Boat	0	0	*	0	21	19	43	12	261	0	0	0	57	*	0
Saltwater Total	0	0	*	0	21	19	43	12	300	44	27	0	57	*	0
FRESHWATER															
Kvichak River	346	535	97	146	262	1,314	628	749	594	1,186	700	588	1,070	839	1,031
Newhalen River Drainage	20	406	77	178	74	*	*	*	366	0	0	58	54	0	32
Battle River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Alagnak (Branch) River Drainage	1,834	763	100	305	480	273	368	531	1,550	756	1,466	493	1,022	696	764
Copper River (tributary of Iliamna Lake)	0	22	61	177	0	*	*	*	0	0	0	138	48	105	16
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0
Lower Talarik Creek	0	30	0	23	0	*	*	*	0	0	*	*	19	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	19	29	0
Kulik River	0	0	0	0	0	*	*	*	39	0	18	0	0	30	25
Moraine Creek	0	0	*	0	0	*	*	*	0	0	0	0	0	0	0
Tazimina River	*	*	*	0		*	*	*	*	*	*	*	*	*	*
Other Streams	49	89	0	220	157	183	12	138	142	88	0	10	*	*	*
Iliamna Lake and Tributaries	0	100	61	0	126	*	*	*	26	58	62	29	114	222	129
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	67	0	55
Lake Clark Drainage	0	110	17	0	0	46	259	0	65	0	0	0	77	0	0
Gibraltar Lake	*	*	*	*	0	*	*	*	*	*	*	*	0	0	34
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	*
Other Lakes	0	22	0	0	21	0	0	0	0	0	0	0	*	*	*
Freshwater Total	2,249	2,077	413	1,049	1,120	1,816	1,267	1,418	2,782	2,088	2,246	1,316	2,490	1,921	2,086
Grand Total	2,249	2,077	*	1,049	1,141	1,835	1,310	1,430	3,082	2,132	2,273	1,316	2,547	*	2,086
KATM Total	1,834	763	100	305	480	273	368	531	1,589	756	1,484	493	1,041	755	789

*- Indicates the field was not surveyed during that year.

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

Sockeye Salmon	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
SALTWATER															
Other Shoreline	0	138	*	*	*	0	0	0	0	0	0	*	*	*	*
Other Boat	0	120	*	0	0	0	0	0	0	0	0	0	0	*	0
Saltwater Total	0	258	*	0	0	0	0	0	0	0	0	0	0	*	0
FRESHWATER															
Kvichak River	1,604	1,404	2,910	3,516	3,554	4,017	2,147	2,754	1,350	1,852	927	873	0	2,711	2,628
Newhalen River Drainage	3,513	4,348	6,838	6,356	3,414	*	*	*	2,741	1,528	2,085	1,886	1,039	2,662	753
Battle River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Alagnak (Branch) River Drainage	1,240	2,182	2,519	1,249	1,034	481	600	727	2,121	3,340	3,346	2,101	2,849	2,070	1,553
Copper River (tributary of Iliamna Lake)	325	293	850	825	668	*	*	*	73	97	158	225	195	201	229
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0
Lower Talarik Creek	46	0	237	108	0	*	*	*	0	0	*	*	0	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	70	66	51
Kulik River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Moraine Creek	0	0	*	0	0	*	*	*	0	0	240	0	0	60	10
Tazimina River	*	*	*	132	*	*	*	*	*	*	*	*	*	*	*
Other Streams	220	630	863	559	84	12	34	0	0	0	261	475	*	*	*
Iliamna Lake and Tributaries	319	725	1,059	846	611	*	*	*	708	579	1,106	713	1,271	657	1,800
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	130	110	0
Lake Clark Drainage	51	443	159	161	148	473	34	314	147	236	122	0	225	103	51
Gibraltar Lake	*	*	*	*	0	*	*	*	*	*	*	*	126	56	0
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	664	884	*
Other Lakes	0	32	203	257	0	0	0	0	79	0	0	0	*	*	*
Freshwater Total	7,318	10,057	15,638	14,009	9,513	4,983	2,815	3,795	7,219	7,632	8,245	6,273	9,346	9,580	7,075
Grand Total	7,318	10,315	*	14,009	9,513	4,983	2,815	3,795	7,219	7,632	8,245	6,273	9,346	*	7,075
KATM Total	1240	2,182	2,519	1,249	1,034	481	600	727	2,121	3,340	3,586	2,101	2,919	2,196	1,614

*- Indicates the field was not surveyed during that year.

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

Pink Salmon	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Other Shoreline	0	0	*	*	*	0	0	0	0	0	0	*	*	*	*
Other Boat	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
Saltwater Total	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
FRESHWATER															
Kvichak River	0	0	0	0	10	276	215	175	0	246	0	91	0	0	0
Newhalen River Drainage	0	9	279	0	0	*	*	*	0	58	0	0	18	0	0
Battle River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Alagnak (Branch) River Drainage	290	22	227	49	175	43	837	24	1,041	77	78	0	278	12	396
Copper River (tributary)	145	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0
Lower Talarik Creek	0	0	0	0	21	*	*	*	0	0	*	*	0	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	74
Kulik River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Moraine Creek	0	0	*	0	0	*	*	*	0	0	0	0	0	0	0
Tazimina River	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*
Other Streams	83	9	0	0	62	0	0	0	0	0	0	0	*	*	*
Iliamna Lake and Tributaries	104	0	0	0	0	*	*	*	0	0	0	131	0	0	0
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Lake Clark Drainage	21	0	0	0	0	11	18	0	0	0	0	76	0	0	0
Gibraltar Lake	*	*	*	*	0	*	*	*	*	*	*	*	0	0	0
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	*
Other Lakes	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*
Freshwater Total	643	40	506	49	268	330	1,070	199	1,041	381	78	298	296	12	470
Grand Total	643	40	*	49	268	330	1,070	199	1,041	381	78	298	296	*	470
KATM Total	290	22	227	49	175	43	837	24	1,041	77	78	0	278	12	470

*- Indicates the field was not surveyed during that year.

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

Chum Salmon	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
SALTWATER															
Other Shoreline	0	0	*	*	*	0	0	0	0	0	0	*	*	*	*
Other Boat	0	0	*	0	0	0	19	42	0	0	0	0	0	*	0
Saltwater Total	0	0	*	0	0	0	19	42	0	0	0	0	0	*	0
FRESHWATER															
Kvichak River	44	0	42	78	113	0	248	351	33	542	0	15	0	0	95
Newhalen River Drainage	0	0	0	0	0	*	*	*	33	0	0	0	0	0	0
Battle River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Alagnak (Branch) River Drainage	274	305	1,104	579	735	343	153	158	241	596	378	110	278	50	771
Copper River (tributary of Iliamna Lake)	0	0	58	0	0	*	*	*	0	0	0	0	0	0	0
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0
Lower Talarik Creek	33	0	0	0	0	*	*		0	0	*	*	0	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	37	0	32
Kulik River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Moraine Creek	0	0	*	0	0	*	*	*	0	0	0	0	0	0	0
Tazimina River	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*
Other Streams	0	0	0	0	0	0	0	*	0	0	0	0	*	*	*
Iliamna Lake and Tributaries	0	0	0	31	52	*	*	*	0	0	0	32	0	0	0
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Lake Clark Drainage	0	0	0	16	0	75	0	139	0	0	0	0	0	0	0
Gibraltar Lake	*	*	*	*	0	*	*	*	*	*	*	*	0	0	0
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	*
Other Lakes	22	0	0	0	0	0	0	*	0	0	0	0	*	*	*
Freshwater Total	373	305	1204	704	900	418	401	648	307	1,138	378	157	315	50	898
Grand Total	373	305	*	704	900	418	420	648	307	1,138	378	157	315	*	898
KATM Total	274	305	1104	579	735	343	153	158	241	596	378	110	315	50	803

*- Indicates the field was not surveyed during that year.

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

Lake Trout	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Other Shoreline	0	0	*	*	*	0	0	0	0	0	0	*	*	*	*
Other Boat	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
Saltwater Total	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
FRESHWATER															
Kvichak River	53	0	0	0	0	103	102	0	151	0	0	0	0	19	27
Newhalen River Drainage	0	114	41	0	37	*	*	*	16	0	10	26	115	0	17
Battle River	*	*	*	*	0	*	*	*	*	*	*	*	0	0	0
Alagnak (Branch) River Drainage (ALAG)	9	10	0	79	54	0	48	0	0	68	23	52	65	0	137
Copper River (tributary of Iliamna Lake)	0	0	0	0	0	*	*	*	0	0	0	0	0	0	12
Funnel Creek (Katm)	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0
Lower Talarik Creek	0	0	0	0	0	*	*	*	0	0	*	*	0	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	67	0	25
Kulik River	0	0	0	14	0	*	*	*	0	0	0	0	0	0	0
Moraine Creek	0	0	*	0	0	*	*	*	0	0	0	0	0	0	0
Tazimina River	*	*	*	0		*	*	*	*	*	*	*	*	*	*
Other Streams	0	0	0	0	0	0	0	0	15	72	0	0	*	*	*
Iliamna Lake and Tributaries	19	30	18	0	0	*	*	*	49	0	17	0	267	0	0
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	0	0	42
Lake Clark Drainage	134	101	81	427	99	266	190	533	558	290	66	111	112	392	336
Gibraltar Lake	*	*	*	*	0	*	*	*	*	*	*	*	0	0	0
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	*
Other Lakes	175	83	79	239	132	0	0	0	0	0	0	0	*	*	*
Freshwater Total	390	338	219	759	322	369	340	533	789	430	116	189	626	411	596
Grand Total	390	338	*	759	322	369	340	533	789	430	116	189	626	*	596
KATM Total	9	10	0	93	54	0	48	0	0	68	23	52	132	0	162

*- Indicates the field was not surveyed during that year.

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

Dolly Varden	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
SALTWATER															
Other Shoreline	0	32	*	*	*	0	0	0	0	0	0	*	*	*	*
Other Boat	0	27	*	0	0	0	15	0	0	0	0	0	0	*	0
Saltwater Total	0	59	*	0	0	0	15	0	0	0	0	0	0	*	0
FRESHWATER															
Kvichak River	389	46	8	33	42	622	120	60	40	0	53	18	0	42	15
Newhalen River Drainage	170	491	107	177	42	*	*	*	0	37	37	69	137	22	70
Battle River	*	*	*	*	0	*	*	*	*	*	*	*	0	0	0
Alagnak (Branch) River Drainage	270	376	14	68	111	22	7	30	0	13	26	71	0	22	84
Copper River (tributary of Iliamna Lake)	0	0	0	0	0	*	*	*	30	0	0	0	30	0	0
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0
Lower Talarik Creek	0	0	0	0	28	*	*	*	0	0	*	*	0	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Kulik River	0	0	0	0	0	*	*	*	0	0	0	0	0	22	0
Moraine Creek	0	0	*	0	0	*	*	*	0	0	0	0	33	0	0
Tazimina River	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*
Other Streams	24	81	0	46	12	33	0	0	30	0	0	0	*	*	*
Iliamna Lake and Tributaries	24	264	0	46	154	*	*	*	205	212	83	201	131	0	0
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	0	0	14
Lake Clark Drainage	49	675	67	11	20	88	53	180	53	0	0	0	0	0	29
Gibraltar Lake	*	*	*	*	0	*	*	*	*	*	*	*	0	0	0
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	*
Other Lakes	98	129	263	78	254	0	0	0	0	0	0	0	*	*	*
Freshwater Total	1,024	2,062	459	459	663	765	180	270	358	262	199	359	331	108	596
Grand Total	1,024	2,121	*	459	663	765	195	270	358	262	199	359	331	*	596
KATM Total	270	376	14	68	111	22	7	30	0	13	26	71	33	44	84

*- Indicates the field was not surveyed during that year.

Appendix C. ADF&G mail-in sport fishing survey results for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

Steelhead Trout	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
SALTWATER															
Other Shoreline	0	0	*	*	*	0	0	0	0	0	0	*	*	*	*
Other Boat	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
Saltwater Total	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
FRESHWATER															
Kvichak River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Newhalen River Drainage	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Battle River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Alagnak (Branch) River Drainage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper River (tributary of Iliamna Lake)	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	0	*
Lower Talarik Creek	0	0	0	0	0	*	*	*	0	0	*	*	0	*	0
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Kulik River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Moraine Creek	0	0	*	0	0	*	*	*	0	0	0	0	0	0	0
Tazimina River	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*
Other Streams	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*
Iliamna Lake and Tributaries	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Lake Clark Drainage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gibraltar Lake	*	*	*	*	0	*	*	*	*	*	*	*	0	0	0
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Other Lakes	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*
Freshwater Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
KATM Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*- Indicates the field was not surveyed during that year.

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

Rainbow Trout	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Other Shoreline	0	0	*	*	*	0	0	0	0	0	0	*	*	*	*
Other Boat	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
Saltwater Total	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
FRESHWATER															
Kvichak River	58	27	25	135	506	526	225	551	131	0	0	457	136	38	60
Newhalen River Drainage	82	254	377	724	101	*	*	*	89	77	72	10	272	0	87
Battle River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Alagnak (Branch) River Drainage	26	254	35	57	33	166	71	11	27	0	47	20	66	0	0
Copper River (tributary of Iliamna Lake)	0	0	0	49	56	*	*	*	14	0	0	0	0	0	0
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0
Lower Talarik Creek	0	0	0	0	0	*	*	*	0	0	*	*	0	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Kulik River	0	0	0	0	0	*	*	*	136	199	0	102	22	0	0
Moraine Creek	0	0	*	0	0	*	*	*	0	214	0	0	0	0	0
Tazimina River	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*
Other Streams	423	191	17	0	61	0	32	0	0	0	158	0	*	*	*
Iliamna Lake and Tributaries	21	48	35	98	183	*	*	*	62	221	0	197	351	0	57
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Lake Clark Drainage	0	120	0	12	11	0	8	21	27	0	0	0	0	0	0
Gibraltar Lake	*	*	*	*	0	*	*	*	*	*	*	*	27	10	0
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	15	0	*
Other Lakes	0	231	313	70	11	0	0	11	35	0	0	0	*	*	*
Freshwater Total	610	1,125	802	1,145	962	692	336	594	521	711	277	786	889	48	204
Grand Total	610	1,125	*	1,145	962	692	336	594	521	711	277	786	889	*	204
KATM Total	26	254	35	57	33	166	71	11	163	413	47	122	88	0	0

*- Indicates the field was not surveyed during that year.

Appendix C. ADF&G mail-in sport fishing survey results for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

Arctic Grayling	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
SALTWATER															
Other Shoreline	0	0	*	*	*	0	0	0	0	0	0	*	*	*	*
Other Boat	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
Saltwater Total	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
FRESHWATER															
Kvichak River	98	222	71	118	216	877	294	662	78	48	137	220	464	130	295
Newhalen River Drainage	328	874	506	135	65	*	32	*	405	64	96	15	107	17	65
Battle River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Alagnak (Branch) River Drainage	192	186	228	32	0	0	0	0	33	119	33	65	0	0	0
Copper River (tributary of Iliamna Lake)	0	0	0	0	10	*	*	*	0	0	0	0	0	0	23
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0
Lower Talarik Creek	25	0	0	0	16	*	*	*	0	0	*	*	0	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	0	20	0
Kulik River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Moraine Creek	0	0	*	11	10	*	*	*	0	0	0	0	0	34	115
Tazimina River	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*
Other Streams	422	126	79	43	135	13	74	0	34	0	0	70	*	*	*
Iliamna Lake and Tributaries	57	0	10	0	50	*	*	*	16	0	76	0	67	0	46
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	0	20	0
Lake Clark Drainage	289	1273	296	207	206	619	51	187	198	110	58	82	180	241	205
Gibraltar Lake	*	*	*	*	0	*	*	*	*	*	*	*	0	0	0
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	*
Other Lakes	165	313	536	215	78	0	0	0	0	0	0	0	*	*	*
Freshwater Total	1,576	2,994	1726	761	786	1,509	451	849	764	341	400	452	818	462	749
Grand Total	1,576	2,994	*	761	786	1,509	451	849	764	341	400	452	818	*	749
KATM Total	192	186	228	43	10	0	0	0	33	119	33	65	0	54	115

*- Indicates the field was not surveyed during that year.

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

Whitefish	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
SALTWATER															
Other Shoreline	0	0	*	*	*	0	0	0	0	0	0	*	*	*	*
Other Boat	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
Saltwater Total	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
FRESHWATER															
Kvichak River	320	0	0	0	0	737	8	91	45	0	0	0	0	0	0
Newhalen River Drainage	18	14	0	68	0	*	*	*	0	0	0	0	0	0	81
Battle River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Alagnak (Branch) River Drainage	36	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Copper River (tributary of Iliamna Lake)	0	0	0	0	14	*	*	*	0	0	0	0	0	0	0
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0
Lower Talarik Creek	0	0	0	0	0	*	*	*	0	0	*	*	0	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Kulik River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Moraine Creek	0	0	*	0	0	*	*	*	0	0	0	0	0	0	0
Tazimina River	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*
Other Streams	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*
Iliamna Lake and Tributaries	0	0	0	0	0	*	*	*	60	0	0	0	0	0	0
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Lake Clark Drainage	18	676	83	0	77	90	0	30	0	26	0	0	0	0	0
Gibraltar Lake	*	*	*	*	0	*	*	*	*	*	*	*	0	0	0
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	*
Other Lakes	0	0	450	0	0	0	0	0	30	0	0	0	*	*	*
Freshwater Total	392	690	533	68	91	827	8	121	135	26	0	0	0	6	81
Grand Total	392	690	*	68	91	827	8	121	135	26	0	0	0	*	81
KATM Total	36	0	0	0	0	0	0	0	0	0	0	0	0	6	0

*- Indicates the field was not surveyed during that year.

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

Northern Pike	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
SALTWATER															
Other Shoreline	0	0	*	*	*	0	0	0	0	0	0	*	*	*	*
Other Boat	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
Saltwater Total	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
FRESHWATER															
Kvichak River	74	21	41	81	79	240	48	551	166	53	0	10	34	13	10
Newhalen River Drainage	108	34	25	19	0	*	*	*	0	0	114	0	0	0	15
Battle River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Alagnak (Branch) River Drainage	212	15	0	9	0	14	0	0	38	95	0	0	0	0	0
Copper River (tributary of Iliamna Lake)	0	0	18	16	0	*	*	*	0	0	0	0	0	0	0
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0
Lower Talarik Creek	0	0	0	0	0	*	*	*	0	0	*	*	0	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Kulik River	0	0	0	0	11	*	*	*	0	0	0	0	0	0	0
Moraine Creek	0	0	*	0	0	*	*	*	0	18	0	0	0	0	0
Tazimina River	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*
Other Streams	0	0	0	115	0	26	0	0	0	0	0	0	*	*	*
Iliamna Lake and Tributaries	62	0	0	0	10	*	*	*	73	72	102	0	289	0	20
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Lake Clark Drainage	137	63	189	19	41	185	7	24	274	29	0	21	137	100	103
Gibraltar Lake	*	*	*	*	0	*	*	*	*	*	*	*	0	0	0
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	*
Other Lakes	24	15	38	385	57	14	9	0	13	90	0	0	*	*	*
Freshwater Total	617	148	311	644	198	479	64	575	564	357	216	31	460	113	148
Grand Total	617	148	*	644	198	0	64	575	564	357	216	31	460	*	148
KATM Total	212	15	0	9	11	14	0	0	38	113	0	0	0	0	0

*- Indicates the field was not surveyed during that year**.**

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

Burbot	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
SALTWATER															
Other Shoreline	0	0	*	*	*	0	0	0	0	0	0	*	*	*	*
Other Boat	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
Saltwater Total	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
FRESHWATER															
Kvichak River	41	0	0	0	0	0	4	0	101	0	0	0	0	0	0
Newhalen River Drainage	0	129	0	0	0	*	*	*	0	0	0	0	0	0	0
Battle River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Alagnak (Branch) River Drainage	0	39	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper River (tributary of Iliamna Lake)	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0
Lower Talarik Creek	0	0	0	0	0	*	*	*	0	0	*	*	0	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Kulik River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Moraine Creek	0	0	*	0	0	*	*	*	0	0	0	0	0	0	0
Tazimina River	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*
Other Streams	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*
Iliamna Lake and Tributaries	0	0	0	0	0	*	*	*	0	10	0	0	0	0	0
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Lake Clark Drainage	16	180	92	0	0	29	0	32	0	74	0	0	0	0	133
Gibraltar Lake	*	*	*	*	0	*	*	*	*	*	*	*	0	0	0
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	*
Other Lakes	81	0	120	77	0	0	0	0	0	0	0	0	*	*	*
Freshwater Total	138	348	212	77	0	29	4	32	101	84	0	0	0	0	133
Grand Total	138	348	*	77	0	29	4	32	101	84	0	0	0	*	133
KATM Total	0	39	0	0	0	0	0	0	0	0	0	0	0	0	0

*- Indicates the field was not surveyed during that year.

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

Smelt	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
SALTWATER															
Other Shoreline	0	0	*	*	*	0	0	0	0	0	0	*	*	*	*
Other Boat	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
Saltwater Total	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
FRESHWATER															
Kvichak River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Newhalen River Drainage	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Battle River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Alagnak (Branch) River Drainage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper River (tributary of Iliamna Lake)	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0
Lower Talarik Creek	0	0	0	0	0	*	*	*	0	0	*	*	0	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Kulik River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Moraine Creek	0	0	*	0	0	*	*	*	0	0	0	0	0	0	0
Tazimina River	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*
Other Streams	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*
Iliamna Lake and Tributaries	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Lake Clark Drainage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gibraltar Lake	*	*	*	*	0	*	*	*	*	*	*	*	0	0	0
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	*
Other Lakes	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*
Freshwater Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	0	0	*	0	0	0	0	0	0	0	0	0	0	*	0
KATM Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*- Indicates the field was not surveyed during that year**.**

Appendix C. ADF&G mail-in sport fishing survey for area S, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, Battle River, Alagnak River Drainage, Funnel Creek, Kulaklek River, Kulik River, and Moraine Creek are included in calculation. (continued)

Other	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
SALTWATER															
Other Shoreline	0	0	*	*	*	0	0	0	0	0	0	*	*	*	*
Other Boat	0	0	*	0	0	0	0	0	49	12	0	0	0	*	0
Saltwater Total	0	0	*	0	0	0	0	0	49	12	0	0	0	*	0
FRESHWATER															
Kvichak River	0	0	0	0	0	233	0	0	0	0	0	0	0	0	0
Newhalen River Drainage	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Battle River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Alagnak (Branch) River Drainage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper River (tributary of Iliamna Lake)	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Funnel Creek	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0
Lower Talarik Creek	0	0	0	0	0	*	*	*	0	0	*	*	0	*	*
Kukaklek River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0
Kulik River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Moraine Creek	0	0	*	0	0	*	*	*	0	0	0	0	0	0	0
Tazimina River	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*
Other Streams	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*
Iliamna Lake and Tributaries	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Unspecified Streams and Lakes	*	*	*	*	*	*	*	*	*	*	*	*	0	0	18
Lake Clark Drainage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	102
Gibraltar Lake	*	*	*	*	0	*	*	*	*	*	*	*	0	0	0
Iliamna River	*	*	*	*	*	*	*	*	*	*	*	*	0	0	*
Other Lakes	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*
Freshwater Total	0	0	0	0	0	233	0	0	0	0	0	0	0	0	120
Grand Total	0	0	*	0	0	233	0	0	49	12	0	0	0	*	120
KATM Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*- Indicates the field was not surveyed during that year**.**

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation.

Angler Counts	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Unalaska Island - Boat	337	315	*	*	*	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	194	*	*	*	*	*	*	*	*	322	*
Unalaska Bay - Boat	509	647	935	1,193	823	605	1,346	768	813	775	752	1,154	452	607	455
Other Boat	1,080	935	8,92	876	885	660	659	692	666	938	788	1,200	1,154	520	1,074
Other Shoreline	564	465	507	386	644	447	794	557	600	293	385	487	389	498	288
Saltwater Total	2,037	2,093	2,119	2,164	1,926	1,448	2,416	1,810	1,759	1,893	1,716	2,630	1,824	1,839	1,703

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Angler Counts (continued)	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
FRESHWATER															
Cold Bay Area (including Russel Creek)	325	325	364	382	428	226	305	406	347	402		431	385	666	485
Naknek River above Rapids Camp	1,450	1,331	1,567	1,784	1,822	*	*	*	1,446	1,295	1,843	1,318	1,713	1,586	1,711
Naknek River below Rapids Camp	2,261	2,749	2,983	2,819	2,666	*	*	*	1,968	1,790	1,809	1,667	1,749	1,586	2,045
Brooks River	1,364	1,705	1,746	881	1,436	*	*	*	866	1,064	1,524	1,524	1,804	1,370	1,468
American Creek	399	450	472	575	471	*	*	*	558	558	923	714	1,278	725	962
Unalaska Bay Streams	*	*	343	425	334	313	303	*	384	*	*	*	*	*	*
Sapsuk River (Nelson River)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	204
Other Alaska Peninsula/Aleutian Streams	*	*	*	*	*	*	*	906	686	874	1,193	536	1,300	1,103	970
Other Alaska Peninsula / Aleutian Lakes	*	*	*	*	*	*	*	*	*	167	335	381	365	366	337
Other Streams	1,365	1,748	956	1,062	1,283	897	638	380	550	276	481	184		86	262
Ugashik System	717	788	648	791	741	696	650	538	379	464	348	427	379	497	518
Egegik River and Becharof System	384	480	514	470	569	507	772	774	566	669	724	641	330	415	699
Naknek Lake - Bay of Islands	275	431	304	353	511	*	*	*	*	*	*	*	*	*	*
Naknek Lake	287	400	149	246	226	*	*	*	375	*	575	551	586	475	532
Naknek River and Tributaries	*	*	*	*	*	6,424	7,160	6,326	683	*	636	756	982	943	505
Brooks Lake	*	*	*	*	215	183	*	*	*	*	*	*	*	*	*
Other Lakes	477	325	299	333	267	*	141	250	268	109	18	37	351	*	*
Other Systems	54	45	*	155	215	*	*	*	*	*	*	*	*	*	*
Freshwater Total	6,354	7,321	7,415	40,301	7,155	6,430	6,363	6,265	6,261	5,890	7,042	6,337	7,340	6,397	6,698
Grand Total	7,862	8,928	8,973	51,291	8,316	7,421	8,220	7,630	7,436	7,205	8,250	8,076	8,428	7,417	7,747
KATM Total	4,586	5,735	5,997	5,299	5,859	6,920	7,463	6,326	4,834	3,412	5467	5,212	6,399	5,099	5,512

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Days Fished	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Unalaska Island - Boat	1,625	1,224	*	*	*	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	1,091	*	*	*	*	*	*	*	*	1,667	*
Unalaska Bay - Boat	775	1,159	3,290	4,425	2,366	1,808	3,819	2,147	9,877	3,085	2,535	5,246	2,778	2,291	991
Other Boat	2,465	4,254	2,286	4,332	3,714	2,177	1,443	1,665	2,633	3,807	2,479	3,438	3,713	1,121	3,189
Other Shoreline	2,227	2,370	1,628	2,233	3,363	1,714	4,074	2,124	2,159	1,822	2,187	3,260	1,243	2,225	1,117
Saltwater Total	7,092	9,007	7,204	10,990	10,534	5,699	9,336	5,936	14,669	8,714	7,201	11,944	7,734	7,303	5,297

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Day Fished	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
FRESHWATER															
Cold Bay Area (including Russel	1,241	1,106	1,959	2,515	3,400	1,067	1,650	2,182	1,783	2,114	*	3,168	2,331	4,588	3,128
Naknek River above Rapids Camp	4,926	3,961	5,077	7,509	10,057	*	*	*	6,022	4,540	5,729	7,391	5,732	5,950	6,657
Naknek River below Rapids Camp	7,045	9,712	8,902	13,680	12,354	*	*	*	10,934	6,362	6,568	5,630	6,214	6,224	8,448
Brooks River	3,784	3,971	2,916	1,418	3,227	*	*	*	3,317	1,945	3,887	3,882	3,951	2,513	3,469
American Creek	543	1,085	811	1,081	1,033	*	*	*	863	681	2,248	1,234	2,183	1,112	2,034
Unalaska Bay Streams	*	*	1,140	3,809	1,786	1,146	2,378	*	3,258	*	*	*	*	*	*
Sapsuk River (Nelson River)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	642
Other Alaska Peninsula/Aleutian	*	*	*	*	*	*	*	2,834	2,265	2,836	4,687	2,254	5,033	3,773	3,300
Other Alaska Peninsula / Aleutian	*	*	*	*	*	*	*	*	*	723	817	537	753	3,949	913
Other Streams	4,165	2,513	2,926	4,230	4,574	3,802	2,061	711	2,180	1,315	1,320	593	*	*	466
Ugashik System	2,195	853	1,442	2,008	2,403	2,961	2,118	1,317	1,017	882	443	1,393	598	868	1,390
Egegik River and Becharof System	610	666	1,008	1,868	1,256	1,009	1,395	1,656	1,427	2,120	1,748	1,290	662	1,086	1,465
Naknek Lake - Bay of Islands	518	469	463	788	1,005	*	*	*	*	*	*	*	*	*	*
Naknek Lake	829	1,505	414	382	406	*	*	*	977	540	1,018	1,199	1,011	2,329	816
Naknek River and Tributaries	*	*	*	*	*	20,176	24,401	18,823	3,666	1,797	2,631	4,723	2,498	2,347	907
Brooks Lake	*	*	*	*	502	*	*	*	*	*	*	*	*	*	*
Other Lakes	859	427	486	777	1,346	954	270	912	464	313	57	36	1,038	*	*
Other Systems	54	5,251	*	236	1,627	75	*	*	*	*	*	*	*	*	*
Freshwater Total	27,124	31,519	27,544	40,301	44,976	31,190	34,282	28,435	3,8173	2,6168	31,153	36,241	32,004	3,5016	33,635
Grand Total	34,216	40,526	34,748	51,291	55,510	36,889	43,618	34,371	5,2842	34,882	38,354	48,185	39,738	42,319	38,932
KATM Total	12,719	16,742	14,646	21,158	20,313	21,322	26,779	18,823	2,3015	11,325	16,352	16,668	15,857	14,525	15,674

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

King Salmon	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Unalaska Island - Boat	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	0	*	*	*	*	*	*	*	*	0	*
Unalaska Bay - Boat	0	0	0	0	101	0	0	26	150	199	27	47	0	0	17
Other Boat	149	229	213	77	101	170	93	23	57	136	0	219	63	26	271
Other Shoreline	0	49	0	0	50	33	0	36	27	0	0	16	0	10	0
Saltwater Total	149	278	213	77	252	203	93	85	234	335	27	282	63	36	288
FRESHWATER															
Cold Bay Area (including Russel Creek)	54	22	0	23	0	84	150	0	0	123	*	68	42	10	0
Naknek River above Rapids Camp	571	625	441	138	278	*	*	*	199	528	294	298	42	599	84
Naknek River below Rapids Camp	2,413	3,606	3,002	2,559	1,827	*	*	*	2,543	1,394	2,203	857	914	1,543	1,094
Brooks River	0	12	0	0	0	*	*	*	0	0	0	0	0	0	0
American Creek	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Unalaska Bay Streams	*	*	90	0	0	0	0	*	0	*	*	*	*	*	*
Other Alaska Peninsula/Aleutian Streams	*	*	*	*	*	*	*	524	468	503	513	290	653	480	649
Other Alaska Peninsula / Aleutian Lakes	*	*	*	*	*	*	*	*	*	0	76	0	39	0	26
Other Streams	565	651	417	242	507	976	186	0	93	62	48	68	*	0	61
Ugashik System	21	128	45	142	53	23	37	12	46	0	79	0	26	21	0
Egegik River and Becharof System	86	43	156	22	0	86	72	72	391	40	381	0	13	0	26
Naknek Lake - Bay of Islands	32	0	0	0	0	*	*	*	*	*	*	*	*	*	*
Naknek Lake	0	187	0	0	10	*	*	*	0	12	0	0	0	0	39
Naknek River and Tributaries	*	*	*	*	*	2,656	1,970	2,412		218	61	276	329	137	49
Brooks Lake	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*
Other Lakes	0	0	0	0	0		20	0	27	0	0	0	*	*	*
Other Systems	0	0	*	0	0	0	*	*	*	*	*	*	13	*	*
Freshwater Total	3,742	5,274	4,151	3,126	2,675	3,825	2,435	3,020	4,029	2,880	3,655	2,256	2,071	2,790	2,041
Grand Total	3,891	5,552	4,364	3,203	2,927	4,028	2,528	3,105	4,263	3,215	3,682	2,538	2,134	2,826	2,329
KATM Total	3,016	4,430	3,443	2,697	2,115	2,656	1,970	2,412	2,742	2,152	2,558	1,431	1,285	2,279	1,266

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Coho Salmon	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Unalaska Island - Boat	142	0	*	*	*	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	42	*	*	*	*	*	*	*	*	175	*
Unalaska Bay - Boat	0	92	111	100	143	117	434	191	618	205	113	356	0	101	277
Other Boat	771	555	1,113	207	199	252	81	702	373	423	233	548	142	417	510
Other Shoreline	312	90	213	469	444	603	830	444	1,035	173	348	555	183	317	235
Saltwater Total	1225	737	1,437	776	828	972	1,345	1,337	2,026	801	694	1,459	325	1,010	1,022
FRESHWATER															
Cold Bay Area (including Russel Creek)	788	884	342	1,387	808	1,430	521	1,290	887	*	*	917	1,773	2,421	1,948
Naknek River above Rapids Camp	1,449	721	825	1,597	1,214	*	*	*	1,661	849	1,430	1,202	2,020	1,625	1,207
Naknek River below Rapids Camp	3,305	3,158	1,722	2,075	2,335	*	*	*	4,784	1,223	2,129	2,577	2,805	2,369	3,289
Brooks River	0	156	305	22	41	*	*	*	275	0	49	53	118	72	57
American Creek	0	0	0	0	0	*	*	*	0	44	0	19	86	0	0
Unalaska Bay Streams	*	*	321	492	417	341	511	*	*	*	*	*	*	*	*
Other Alaska Peninsula/Aleutian Streams	*	*	*	*	*	*	*	732	882	857	1,727	570	2,854	1,560	751
Other Alaska Peninsula / Aleutian Lakes	*	*	*	*	*	*	*	*	*	24	455	13	14	2,276	288
Other Streams	2,180	1,135	449	1,455	358	678	385	348	1,001	769		566	*	113	311
Ugashik System	491	631	223	830	513	690	856	529	408	921	393	336	74	233	251
Egegik River and Becharof System	375	370	117	44	341	272	1,057	607	379	1,535	1,642	1,028	770	656	921
Naknek Lake - Bay of Islands	0	10	5	0	0	*	*	*	*	*	*	*	*	*	*
Naknek Lake	0	0	63	0	0	*	*	*	0	117	0	48	0	0	34
Naknek River and Tributaries	*	*	*	*	*	4,795	4,743	6,396	888	642	456	439	1,005	331	474
Brooks Lake	*	*	*	*	438	*	*	*	*	*	*	*	*	*	*
Other Lakes	58	244	99	0	0	0	0	951	0	88	0	0	*	*	*
Other Systems	9	0	*	0		*	*	*	*	*	*	*	289	*	*
Freshwater Total	8,655	7,309	4,471	7,902	6,465	8,206	8,073	10,853	11,639	8,363	8,583	8,486	11,808	11,656	9,895
Grand Total	9,880	8,046	5,908	8,678	7,293	9,178	9,418	12,190	13,665	9,164	9,277	9,945	12,133	12,666	10,917
KATM Total	4,754	4,045	2,920	3,694	4,028	4,795	4,743	6,396	7,608	2,875	4,064	4,338	6,034	4397	5,061

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Sockeye Salmon	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Unalaska Island - Boat	33	0	*	*	*	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	31	*	*	*	*	*	*	*	*	0	*
Unalaska Bay- Boat	46	0	0	151	21	39	390	422	356	78	12	65	0	0	112
Other Boat	450	661	1,012	546	861	174	98	170	501	800	0	683	326	0	1,171
Other Shoreline	200	131	61	378	655	477	575	554	116	199	243	678	103	604	238
Saltwater Total	729	792	1,073	1,075	1,568	690	1,063	1,146	973	1,077	255	1,426	429	604	1,521
FRESHWATER															
Cold Bay Area (including Russel Creek)	260	210	38	49	233	106	154	0	790	84	*	230	0	1,351	358
Naknek River above Rapids Camp	265	79	595	1,257	1,265	*	*	*	828	342	1,164	2,368	3,596	3,019	1,118
Naknek River below Rapids Camp	297	146	192	626	1,352	*	*	*	471	611	3,352	1,812	1,933	848	2,907
Brooks River	433	434	490	85	506	*	*	*	996	133	415	61	353	238	311
American Creek	63	0	0	0	0	*	*	*	0	12	0	0	0	56	0
Unalaska Bay Streams	*	*	194	97	70	86	289	*	109	*	*	*	*	*	*
Other Alaska Peninsula/Aleutian Streams	*	*	*	*	*	*	*	411	45	46	130	733	1,221	1,547	791
Other Alaska Peninsula / Aleutian Lakes	*	*	*	*	*	*	*	*	*	267	244	0	156	413	80
Other Streams	395	393	96	269	479	1,129	269	102	23	109	94	150	*	0	236
Ugashik System	556	843	1,077	22	901	331	768	105	452	0	0	210	0	34	151
Egegik River and Becharof System	25	273	44	452	187	157	0	186	163	0	77	425	0	32	47
Naknek Lake - Bay of Islands	0	53	228	0	214	*	*	*	*	*	*	*	*	*	*
Naknek Lake	60	78	36	111	159	*	*	*	226	11	73	128	364	50	0
Naknek River and Tributaries	*	*	*	*	*	3,300	2,379	2,418	0	134	81	38	479	487	0
Brooks Lake	*	*	*	*	180	*	*	*	*	*	*	*	*	*	*
Other Systems	50	0	*	*	497	*	*	*	*	*	*	*	65	*	*
Other Lakes	113	83	0	189	180	280	5	0	248		0	0	*	*	*
Freshwater Total	2,517	2,592	2,990	3,157	6,149	5,389	3,864	3,285	4,351	1,794	5,630	6,431	8,167	8,075	5,999
Grand Total	3,246	3,384	4,063	4,232	7,717	6,079	4,927	4,431	5,324	2,871	5,885	7,857	8,596	8,679	7,520
KATM Total	1,118	790	1,541	2,079	3,676	3,300	2,379	2,418	2,521	1,243	5,085	4,407	6,725	4,698	4,336

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Pink Salmon	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
SALTWATER															
Unalaska Island - Boat	0	18	*	*	*	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	51	*	*	*	*	*	*	*	*	*	*
Unalaska Bay - Boat	118	28	15	1477	92	0	408	243	1,047	623	295	211	131	337	0
Other Boat	30	238	103	121	256	81	37	19	1,367	225	127	362	112	23	11
Other Shoreline	647	642	576	469	789	151	309	76	184	167	299	1,185	49	346	168
Saltwater Total	795	926	694	2,067	1,188	232	754	338	2,598	1,015	721	1,758	292	706	179
FRESHWATER															
Cold Bay Area (including Russel Creek)	98	0	142	0	553	0	0	121	30	12		84	82	634	278
Naknek River above Rapids Camp	69	0	179	53	108	*	*	*	15	0	120	0	65	0	25
Naknek River below Rapids Camp	20	0	65	0	202	*	*	*	684	77	156	0	61	12	63
Brooks River	0	9	0	0	0	*	*	*	0	0	0	0	0	0	0
American Creek	0	0	0	0	0	*	*	*	0	0	0	0	18	0	0
Unalaska Bay Streams	*	*	451	308	246	169	82	*	195	*	*	*	*	*	*
Other Alaska Peninsula/Aleutian Streams	*	*	*	*	*	*	*	73	0	15	329	214	262	164	910
Other Alaska Peninsula / Aleutian Lakes	*	*	*	*	*	*	*	*	*	31	0	0	0	1234	0
Other Streams	148	256	27	253	0	21	68	52	200	257	22	0		0	0
Ugashik System	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Egegik River and Becharof System	145	22	0	0	0	23	7	24	0	0	0	0	0	0	0
Naknek Lake - Bay of Islands	0	43	0	0	0	*	*	*	*	*	*	*	*	*	*
Naknek Lake	0	54	0	0	0	*	*	*	0	0	0	0	0	0	0
Naknek River and Tributaries	*	*	*	*	*	65	68	12	33	0	0	0	541	0	0
Brooks Lake	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*
Other Systems	0	257	*	*	112	*	*	*	*	*	*	*	45	*	*
Other Lakes	79	0	128	0	0	20	0	0	0	0	0	0	*	*	*
Freshwater Total	559	641	992	614	1,221	319	225	282	1,157	392	627	1,740	1,074	2,044	1,276
Grand Total	1,354	1,567	1,686	2,681	2,409	551	979	620	3,755	1,407	1,348	3,498	1,366	2,750	1,455
KATM Total	89	106	244	53	310	65	68	12	732	77	276	0	685	12	88

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Chum Salmon	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
SALTWATER															
Unalaska Island - Boat	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*
Unalaska Bay - Boat	0	0	0	0	0	0	44	25	225	0	31	126	0	0	0
Other Boat	0	0	17	188	22	93	0	0	0	64	0	66	13	0	161
Other Shoreline	0	18	0	0	52	65	63	28	330	0	0	0	31	11	0
Saltwater Total	0	18	17	188	74	158	107	53	555	64	31	192	44	11	161
FRESHWATER															
Cold Bay Area (including Russel Creek)	100	0	25	0	73	0	0	126	0	0	*	0	31	632	170
Naknek River above Rapids Camp	0	6	9	14	12	*	*	*	0	0	16	26	11	11	12
Naknek River below Rapids Camp	55	112	186	90	37	*	*	*	47	54	33	0	15	0	62
Brooks River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
American Creek	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Unalaska Bay Streams	*	*	13	0	38	0	0		210	*	*	*	*	*	*
Other Alaska Peninsula/Aleutian Streams	*	*	*	*	*	*	*	125	0	0	78	15	31	48	0
Other Alaska Peninsula / Aleutian Lakes	*	*	*	*	*	*	*	*	*	0	0	30	0	839	0
Other Streams	199	0	0	58	38	16	102	0	16	0	0	0		0	0
Ugashik System	33	29	0	0	0	0	0	14	0	0	0	0	0	0	0
Egegik River and Becharof System	0	0	0	0	0	0	0	0	0	108	0	0	0	0	12
Naknek Lake - Bay of Islands	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*
Naknek Lake	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Naknek River and Tributaries	*	*	*	*	*	151	211	69	16	0	0	0	0	0	0
Brooks Lake	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*
Other Systems	0	0	*	0	0	0	*	*	*	*	*	*	*	*	*
Other Lakes	0	0	0	78	0	8	0	0	0	0	0	0	0	*	*
Freshwater Total	387	147	233	240	198	175	313	334	289	162	127	71	88	1530	256
Grand Total	387	165	250	428	272	333	420	387	844	226	158	263	132	1541	417
KATM Total	55	118	195	104	49	151	211	69	63	54	49	26	26	11	74

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Lake Trout	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Unalaska Island - Boat	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*
Unalaska Bay - Boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Shoreline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saltwater Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRESHWATER															
Cold Bay Area (including Russel Creek)	0	0	0	0	0	0	0	0	453	0	*	0	0	0	0
Naknek River above Rapids Camp	118	30	12	0	27	*	*	*	33	0	12	0	0	0	0
Naknek River below Rapids Camp	9	0	0	0	0	*	*	*	30	0	63	0	0	0	0
Brooks River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
American Creek	0	0	12	0	0	*	*	*	0	0	0	9	0	0	0
Unalaska Bay Streams	*	*	0	0	0	0	0	*	0	*	*	*	*	*	*
Other Alaska Peninsula/Aleutian Streams	*	*	*	*	*	*	*	0	0	0	0	0	0	10	0
Other Alaska Peninsula / Aleutian Lakes	*	*	*	*	*	*	*	*	*	0	56	0	65	28	75
Other Streams	0	0	0	333	0	9	0	155	81	0	0	0		0	0
Ugashik System	214	149	31	45	64	17	0	119	0	0	0	0	0	0	0
Egegik River and Becharof System	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naknek Lake - Bay of Islands	67	148	28	0	64	*	*	*	*	*	*	*	*	*	*
Naknek Lake	0	11	40	0	0	*	*	*	15	80	12	0	69	47	62
Naknek River and Tributaries	*	*	*	*	*	32	160	109	30	16	23	254	0	10	0
Brooks Lake	*	*	*	*	9	*	*	*	*	*	*	*	*	*	*
Other Systems	0	0	*	*	18	*	*	*	*	*	*	*	67	*	*
Other Lakes	50	106	42	35	0	0	0	0	163	0	0	0	*	*	*
Freshwater Total	458	444	165	413	182	58	160	383	775	96	166	263	201	95	137
Grand Total	458	444	165	413	182	58	160	383	775	96	166	263	201	95	137
KATM Total	194	189	92	0	100	32	160	109	108	96	110	263	69	57	62

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Dolly Varden	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Unalaska Island - Boat	0	81	*	*	*	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	59	*	*	*	*	*	*	*	*	45	*
Unalaska Bay - Boat	37	0	68	100	192	22	60	269	479	118	38	298	153	105	0
Other Boat	305	122	300	64	7	11	74	27	0	292	219	60	225	0	9
Other Shoreline	281	1,336	688	221	563	119	407	256	580	159	267	298	46	485	80
Saltwater Total	623	1,539	1,056	385	821	152	541	552	1059	569	524	656	424	635	89
FRESHWATER															
Cold Bay Area (including Russel Creek)	681	108	404	44	721	679	308	349	15	27	*	134	123	1,305	774
Naknek River above Rapids Camp	705	54	135	247	174	*	*	*	88	81	153	0	45	0	171
Naknek River below Rapids Camp	171	207	141	88	353	*	*	*	57	0	26	71	48	66	73
Brooks River	0	0	0	0	10	*	*	*	0	0	0	0	0	0	195
American Creek	170	138	76	0	10	*	*	*	316	81	28	215	0	152	304
Unalaska Bay Streams	*	*	300	540	268	173	543	67	655	*	*	*	*	*	*
Other Alaska Peninsula/Aleutian Streams	*	*	*	*	*	*	*	182	109	26	558	138	1,191	645	118
Other Alaska Peninsula / Aleutian Lakes	*	*	*	*	*	*	*	*	*	824	47	9	15	501	60
Other Streams	501	707	53	467	328	351	93	40	97	200	81	30		34	0
Ugashik System	122	251	105	228	338	98	150	359	148	27	14	29	0	0	15
Egegik River and Becharof System	219	260	0	78	149	162	63		136	12	111	38	117	0	152
Naknek Lake - Bay of Islands	0	27	59	0	0	*	*	*	*	*	*	*	*	*	*
Naknek Lake	0	34	8	11	0	*	*	*	13	24	84	26	45	16	104
Naknek River and Tributaries	*	*	*	*	*	494	216	105	227	12	28	774	0	0	0
Brooks Lake	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*
Other Systems	341	208	*	11	319	*	*	*	*	*	*	*	44	*	*
Other Lakes	182	78	83	114	0	776	0	0	27	24	28	0	*	*	*
Freshwater Total	3,092	2,072	1,364	1,828	2,670	2,787	1,373	1,102	1,888	1,338	1,158	1,638	1,628	2,719	1,966
Grand Total	3,715	3,611	2,420	2,213	3,491	2,939	1,914	1,654	2,947	1,907	1,682	2,294	2,052	3,354	2,055
KATM Total	1,046	460	419	346	547	494	216	105	701	198	319	1,086	138	234	847

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Steelhead Trout	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Unalaska Island - Boat	0	0	*	*	0	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	0	0	0	0		*	*	*	*	0	*
Unalaska Bay - Boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Shoreline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saltwater Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRESHWATER															
Cold Bay Area (including Russel Creek)	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0
Naknek River above Rapids Camp	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Naknek River below Rapids Camp	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Brooks River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
American Creek	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Unalaska Bay Streams	*	*	0	0	0	0	0	*	0	*	*	*	*	*	*
Other Alaska Peninsula/Aleutian Streams	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0
Other Alaska Peninsula / Aleutian Lakes	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0
Other Streams	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0
Ugashik System	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Egegik River and Becharof System	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naknek Lake - Bay of Islands	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*
Naknek Lake	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Naknek River and Tributaries	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0
Brooks Lake	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*
Other Systems	0	0	*	0	0	*	*	*	*	*	*	*	0	*	*
Other Lakes	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*
Freshwater Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KATM Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*- Indicates the field was not surveyed during that year

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Rainbow Trout	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Unalaska Island - Boat	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	*	*	*	*	*	*	*	*	*	0	*
Unalaska Bay - Boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Shoreline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saltwater Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRESHWATER															
Cold Bay Area (including Russel Creek)	0	0	0	0	0	0	0	0	0	0		0	0	0	0
Naknek River above Rapids Camp	295	163	255	343	256	*	*	*	141	143	104	0	108	0	215
Naknek River below Rapids Camp	308	83	133	0	182	*	*	*	37	32	70	0	67	43	11
Brooks River	0	0	0	0	24	*	*	*	0	358	22	152	0	0	0
American Creek	119	0	0	280	0	*	*	*	136	0	0	264	0	177	0
Unalaska Bay Streams	*	*	0	0	0	0	0	*	0	*	*	*	*	*	*
Other Alaska Peninsula/Aleutian Streams	*	*	*	*	*	*	*	0	0	21	0	0	0	0	0
Other Alaska Peninsula / Aleutian Lakes	*	*	*	*	*	*	*	*	*	110	0	114	10	17	0
Other Streams	208	12	55	0	12	0	0	0	0	0	0	0		0	0
Ugashik System	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0
Egegik River and Becharof System	11	63	0	0	0	67	0	0	27	20	11	0	0	0	0
Naknek Lake - Bay of Islands	66	77	52	23	22	*	*	*	*	*	*	*	*	*	*
Naknek Lake	13	82	42	37	0	*	*		14	11	22	0	15	0	0
Naknek River and Tributaries	*	*	*	*	*	160	723	171	94	0	22	307	0	17	0
Brooks Lake	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*
Other Systems	0	0	*	0	0	*	*	*	*	*	*	*	0	*	*
Other Lakes	0	0	0	0	0	*	*	0	0	0	0	0	*	*	*
Freshwater Total	1,020	480	537	683	496	246	723	171	449	695	251	837	200	254	226
Grand Total	1,020	480	537	683	496	246	723	171	449	695	251	837	200	254	226
KATM Total	801	405	482	683	484	160	723	171	422	544	240	723	190	237	226

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Arctic Grayling	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Unalaska Island - Boat	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*
Unalaska Bay - Boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Shoreline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saltwater Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRESHWATER															
Cold Bay Area (including Russel Creek)	0	0	0	0	0	0	0	0	0	0		0	0	0	0
Naknek River above Rapids Camp	141	51	38	22	6	*	*	*	0	43	6	10	0	0	0
Naknek River below Rapids Camp	29	311	0	21	67	*	*	*	16	33	74	0	33	0	14
Brooks River	0	0	10	0	0	*	*	*	0	0	0	0	26	0	0
American Creek	17	0	17	0	0	*	*	*	0	0	0	0	0	0	0
Unalaska Bay Streams	*	*	0	0	0	0	0	*	0	*	*	*	*	*	*
Other Alaska Peninsula/Aleutian Streams	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0
Other Alaska Peninsula / Aleutian Lakes	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0
Other Streams	90	41	151	127	0	22	0	0	0	0	0	0	*	0	0
Ugashik System	0	50	0	0	0	0	55	0	0	0	0	0	0	0	0
Egegik River and Becharof System	24	27	0	0	0	0	27	35	65	0	17	0	14	0	0
Naknek Lake - Bay of Islands	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*
Naknek Lake	0	0	17	0	0	*	*	*	0	0	0	15	0	0	0
Naknek River and Tributaries	*	*	*	*	*	20	31	76	11	0	0	516	0	35	0
Brooks Lake	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*
Other Systems	0	0	*	0	0	0	*	*	*	*	*	*	0	*	*
Other Lakes	0	50	0	21	0	0	0	28	0	*	0	0	*	*	*
Freshwater Total	301	530	233	191	73	42	113	139	92	76	97	541	73	35	14
Grand Total	301	530	233	191	73	42	113	139	92	76	97	541	73	35	14
KATM Total	187	362	82	43	73	20	31	76	27	76	80	541	59	35	14

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Northern Pike	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
SALTWATER															
Unalaska Island - Boat	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	0	*	*	*	*	*	*	*	*	0	*
Unalaska Bay - Boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Shoreline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saltwater Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRESHWATER															
Cold Bay Area (including Russel Creek)	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0
Naknek River above Rapids Camp	108	0	32	39	0	*	*	*	0	0	87	0	25	0	10
Naknek River below Rapids Camp	0	0	13	107	0	*	*	*	0	129	0	0	0	107	0
Brooks River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	146
American Creek	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Unalaska Bay Streams	*	*	0	0	0	56	0	*	0	*	*	*	*	*	*
Other Alaska Peninsula/Aleutian Streams	*	*	*	*	*	*	*	0	0	0	0	0	0	8	0
Other Alaska Peninsula / Aleutian Lakes	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0
Other Streams	0	15	0	0	261	0	0	0	0	0	0	0		0	0
Ugashik System	430	103	0	19	0	0	0	0	0	0	74	0	0	0	0
Egegik River and Becharof System	0	31	0	0	0	0	0	0	0	0	10	0	0	0	0
Naknek Lake - Bay of Islands	120	127	177	19	0	*	*	*	*	*	*	*	*	*	*
Naknek Lake	40	15	13	47	76	*	*	*	13	71	0	25	58	211	15
Naknek River and Tributaries	*	*	*	*	*	66	33	24	0	0	125	0	8	42	0
Brooks Lake	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*
Other Systems	0	0	*	0	0	39	*	*	*	*	*	*	*	0	*
Other Lakes	26	0	0	0	0	0	0	0	0	0	0	0	*	*	*
Freshwater Total	724	291	235	231	337	161	33	24	43	200	296	0	91	368	171
Grand Total	724	291	235	231	337	161	33	24	43	200	296	25	91	368	171
KATM Total	268	142	235	212	76	66	33	24	13	200	212	25	91	360	171

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Burbot	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Unalaska Island - Boat	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	0	*	*	*	*	*	*	*	*	0	*
Unalaska Bay - Boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Shoreline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saltwater Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRESHWATER															
Cold Bay Area (including Russel Creek)	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0
Naknek River above Rapids Camp	0	1,327	8	0	0	*	*	*	0	74	0	0	0	0	0
Naknek River below Rapids Camp	0	0	0	0	363	*	*	*	0	0	0	0	0	0	0
Brooks River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
American Creek	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Unalaska Bay Streams	*	*	0	0	0	0	0	*	0	*	*	*	*	*	*
Other Alaska Peninsula/Aleutian Streams	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0
Other Alaska Peninsula / Aleutian Lakes	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0
Other Streams	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0
Ugashik System	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Egegik River and Becharof System	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naknek Lake - Bay of Islands	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*
Naknek Lake	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Naknek River and Tributaries	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0
Brooks Lake	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*
Other Systems	0	0	*	0	0	0	*	*	*	*	*	*	*	*	*
Other Lakes	0	1,327	0	0	0	*	0	0	0	0	0	0	*	*	*
Freshwater Total	0	1,327	8	0	363	0	0	0	0	74	0	0	0	0	0
Grand Total	0	1,327	8	0	363	0	0	0	0	74	0	0	0	0	0
KATM Total	0	1,327	8	0	363	0	0	0	0	74	0	0	0	0	0

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Smelt	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Unalaska Island - Boat	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	0	*	*	*	*	*	*	*	*	0	*
Unalaska Bay - Boat	0	81	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Boat	22	0	0	0	0	0	96	304	77	13	47	0	629	0	0
Other Shoreline	0	0	0	0	681	0	0	0	0	0	0	0	0	0	0
Saltwater Total	22	81	0	0	681	0	96	304	77	13	47	0	629	0	0
FRESHWATER															
Cold Bay Area (including Russel Creek)	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0
Naknek River above Rapids Camp	727	0	3,523	2,708	0	*	*	*	0	990	0	0	1,258	0	324
Naknek River below Rapids Camp	727	4,866	2,996	948	2,146	*	*	*	765	1,485	1,023	856	2,609	9,354	0
Brooks River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
American Creek	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Unalaska Bay Streams	*	*	0	0	0	0	0	*	0	*	*	*	*	*	*
Other Alaska Peninsula/Aleutian Streams	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0
Other Alaska Peninsula / Aleutian Lakes	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0
Other Streams	0	0	0	0	0	0	0	0	0	0	0	0		0	0
Ugashik System	0	0	0	2,889	2,044	0	0	0	0	0	0	0	0	0	0
Egegik River and Becharof System	0	270	0	0	0	0	0	0	0	0	0	0	0	0	0
Naknek Lake - Bay of Islands	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*
Naknek Lake	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Naknek River and Tributaries	*	*	*	*	*	2,940	3,131	8,442	0	0	583	2,480	0	0	0
Brooks Lake	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*
Other Systems	0	0	*	0	0	0	*	*	*	*	*	*	0	*	*
Other Lakes	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*
Freshwater Total	1,454	5,136	0	6,545	4,190	2,940	3,131	8,442	765	2,475	1,606	3,336	3,867	9,354	324
Grand Total	1,476	5,217	3,238	6,545	4,871	2,940	3,131	8,746	842	2,488	1,653	3,336	4,496	9,354	324
KATM Total	1,454	4,866	6,519	3,656	2,146	2,940	3,131	8,442	765	2,475	1,606	3,336	3,867	9,354	324

*- Indicates the field was not surveyed during that year.

Appendix D. ADF&G mail-in sport fishing survey for area R, angler counts, days fished, and species catch, 1996-2010 (ADF&G 2012). For KATM Total field, American Creek, Brooks Lake, Brooks River, Naknek RiverB, Naknek RiverA, Naknek River are included in calculation. (continued)

Other Fish	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SALTWATER															
Unalaska Island - Boat	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*
Cold Bay Area-Boat	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*
Unalaska Bay - Boat	0	0	26	186	11	0	24	56	1,629	0	0	344	0	0	0
Other Boat	92	50	0	99	0	13	0	19	0	476	17	312	0	0	31
Other Shoreline	141	99	264	0	254	0	0	0	0	0	0	0	0	0	31
Saltwater Total	233	149	290	285	265	13	24	75	1629	476	17	656	0	216	62
FRESHWATER															
Cold Bay Area (including Russel Creek)	0	0	46	0	0	0	0	0	0	0	*	0	0	0	0
Naknek River above Rapids Camp	0	0	18	81	0	*	*	*	0	0	0	0	0	0	0
Naknek River below Rapids Camp	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Brooks River	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
American Creek	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0
Unalaska Bay Streams	*	*	0	0	0	0	0	*	0	*	*	*	*	*	*
Other Alaska Peninsula/Aleutian Streams	*	*	*	*	*	*	*	0	0	0	0	0	0	259	0
Other Alaska Peninsula/Aleutian Lakes	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0
Other Streams	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0
Ugashik System	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Egegik River and Becharof System	0	0	0	0	0	5,168	0	0	0	0	0	0	0	0	0
Naknek Lake Bay of Islands	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*
Naknek Lake	0	0	0	0	0	101	*	*	0	0	0	0	0	0	0
Naknek River and Tributaries	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0
Brooks Lake	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*
Other Systems	0	0	*	0	0	0	*	*	*	*	*	*	0	*	*
Other Lakes	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*
Freshwater Total	0	0	64	81	265	5,269	0	0	0	0	0	0	0	259	0
Grand Total	233	149	354	366	265	5,282	24	75	1,629	476	17	656	0	475	62
KATM Total	0	0	18	81	0	101	0	0	0	0	0	0	0	0	0

*- Indicates the field was not surveyed during that year**.**

Appendix E. ADF&G Guide logbook data for area R and S angler effort, 2006-2010 (ADF&G 2009, 2010, 2011). For total field, resident, nonresident, unknown and crew are included in calculation.

			Angler Days					
Angler Effort 2006	**Trips**	**Businesses**	**Guides**	**Resident**	**Non-resident**	**Unknown**	**Crew**	**Total**
Area R Water bodies								
Naknek River and Tributaries	560	27	62	103	1,310	4	126	1,543
Brooks River	346	20	75	29	793	5	21	848
Brooks Lake	28	10	15	2	73	2	0	77
American Creek	460	20	62	59	11,80	4	15	1,258
Naknek River above rapids camp	478	14	38	38	1,072	12	83	1,205
Naknek River below rapids camp	299	12	31	33	653	3	67	756
Area S Water bodies								
Alagnak (Branch) River	2,202	26	120	49	4,939	9	96	5,093
Kulik River	419	12	59	37	1,094	2	1	1,134
Little Kulik (into Nanuktuk Cr.)	26	6	12	0	59	0	0	59
Nanuktuk Creek	103	13	33	8	231	0	0	239
Nonvianuk Lake	30	10	15	7	58	0	0	65
Nonvianuk River (into Alagnak)	208	14	50	7	554	0	69	630
Moraine Creek	645	22	107	30	1,522	23	56	1,631
Funnel Creek	52	10	18	3	109	0	0	112
Battle River	108	10	27	2	274	1	4	281
Kulaklek River	427	14	55	36	863	5	1	905
Totals	6,391	240	779	443	14,784	70	539	15,836

Appendix E. ADF&G Guide logbook data for area R and S angler effort, 2006-2010 (ADF&G 2009, 2010, 2011). (continued)

Angler Effort 2007	Trips	Businesses	Guides	Angler Days: Resident	Non-resident	Comped	Unknown	Crew	Total
Area R Water bodies									
Naknek River and Tributaries	699	21	54	217	1,594	3	8	74	1,896
Brooks River	328	24	78	43	784	1	3	25	856
Brooks Lake	33	6	9	3	94	0	0	0	97
American Creek	460	19	65	51	1,091	2	27	13	1,184
Naknek River above rapids camp	548	14	35	83	1,213	0	8	121	1,425
Naknek River below rapids camp	270	12	27	34	573	0	6	47	660
Area S Water bodies									
Alagnak (Branch) River	2,157	24	102	55	4,641	1	26	35	4,758
Kulik River	387	19	56	36	1,011	7	1	0	1,055
Little Kulik (into Nanuktuk Cr.)	41	7	16	0	83	0	0	0	83
Nanuktuk Creek	100	10	28	3	198	0	2	0	203
Nonvianuk Lake	26	6	6	4	99	1	1	6	111
Nonvianuk River (into Alagnak)	135	15	40	14	342	0	4	13	373
Moraine Creek	653	24	104	36	1,504	22	1	52	1,615
Funnel Creek	21	5	14	1	50	0	0	0	51
Battle River	129	10	33	8	342	0	0	31	381
Kulaklek River	378	14	58	44	750	6	7	8	815
Totals	6,365	*	*	632	14,369	43	94	425	15,563

*- Indicates the field was not surveyed during that year.

Appendix E. ADF&G Guide logbook data for area R and S angler effort, 2006-2010 (ADF&G 2009, 2010, 2011). For total field, resident, nonresident, unknown and crew are included in calculation. (continued)

				Angler Days					
Angler Effort 2008	**Trips**	**Businesses**	**Guides**	**Resident**	**Non-resident**	**Comped**	**Unknown**	**Crew**	**Total**
Area R Water bodies									
Naknek River and Tributaries	684	22	66	165	1,590	11	6	109	1,881
Brooks River	317	20	73	34	783	7	4	5	833
Brooks Lake	317	20	73	34	783	7	4	5	833
American Creek	595	19	71	60	1,512	1	0	1	1,574
Naknek River above rapids camp	639	18	49	43	1,562	3	6	92	1,706
Naknek River below rapids camp	276	14	33	39	604	0	1	42	686
Area S Water bodies									
Alagnak (Branch) River	1,813	22	106	26	4,083	4	6	54	4,173
Kulik River	19	5	10	0	64	0	0	0	64
Little Kulik (into Nanuktuk Cr.)	61	8	18	2	139	0	0	0	141
Nanuktuk Creek	126	9	36	3	299	0	0	0	302
Nonvianuk Lake	18	7	9	0	64	0	0	15	79
Nonvianuk River (into Alagnak)	142	17	45	18	363	0	0	18	399
Moraine Creek	468	23	93	6	1,206	0	0	25	1,237
Funnel Creek	43	6	11	0	103	0	0	0	103
Battle River	114	11	26	2	309	2	4	47	364
Kulaklek River	254	11	51	47	502	0	0	0	549
Totals	5,886	*	*	479	13,966	35	31	413	14,924

*- Indicates the field was not surveyed during that year.

Appendix E. ADF&G Guide logbook data for area R and S angler effort, 2006-2010 (ADF&G 2009, 2010, 2011). For total field, resident, nonresident, unknown and crew are included in calculation. (continued)

Angler Effort 2009	Trips	Businesses	Guides	Angler Days: Resident	Non-resident	Comped	Unknown	Crew	Total
Area R Water bodies									
Naknek River and Tributaries	565	22	58	120	1,370	15	17	22	1,544
Brooks River	253	22	76	23	632	3	1	5	664
Brooks Lake	28	7	11	4	57	1	0	0	62
American Creek	488	14	45	62	1,140	0	3	7	1,212
Naknek River above rapids camp	308	10	33	36	673	11	1	80	801
Naknek River below rapids camp	574	13	43	57	1,433	12	3	73	1,578
Area S Water bodies									
Alagnak (Branch) River	1,418	23	87	54	2,992	2	3	45	3,096
Kulik River	416	13	54	63	1,006	0	2	0	1,071
Little Kulik (into Nanuktuk Cr.)	17	8	10	0	43	0	0	0	43
Nanuktuk Creek	46	10	19	2	93	0	0	0	95
Nonvianuk Lake	14	4	5	2	21	0	0	13	36
Nonvianuk River (into Alagnak)	83	9	16	3	190	0	0	20	213
Moraine Creek	510	21	85	12	1,162	2	0	10	1,186
Funnel Creek	54	6	14	7	124	1	0	0	132
Battle River	137	11	37	4	369	0	0	18	391
Kulaklek River	112	12	30	23	238	0	3	0	264
Totals	5,023	*	*	472	11,543	47	33	293	12,388

*- Indicates the field was not surveyed during that year.

Appendix E. ADF&G Guide logbook data for area R and S angler effort, 2006-2010 (ADF&G 2009, 2010, 2011). For total field, resident, nonresident, unknown and crew are included in calculation. (continued)

				Angler Days					
Angler Effort 2010	**Trips**	**Businesses**	**Guides**	**Resident**	**Non-resident**	**Comped**	**Unknown**	**Crew**	**Total**
Area R Water bodies									
Naknek River and Tributaries	486	21	64	99	1,245	4	6	8	1,362
Brooks River	282	21	74	20	726	1	4	0	751
Brooks Lake	14	7	10	0	35	0	0	0	35
American Creek	460	21	52	38	1,168	22	5	40	1,237
Naknek River above rapids camp	113	6	23	1	421	0	4	3	1,350
Naknek River below rapids camp	183	8	20	29	412	0	5	2	448
Contact Creek	48	11	22	9	109	4	1	0	123
Swikshak River	18	4	8	0	65	0	0	0	65
Area S Water bodies									
Alagnak (Branch) River	1,337	19	84	44	2,778	6	18	22	2,868
Kulik River	406	13	43	65	1,016	1	2	0	1,084
Little Kulik (into Nanuktuk Cr.)	18	7	11	0	47	0	0	0	47
Nanuktuk Creek	59	10	22	2	135	1	1	0	139
Nonvianuk Lake	20	4	8	5	39	0	0	0	44
Nonvianuk River (into Alagnak)	63	7	15	6	136	0	1	4	147
Moraine Creek	370	19	65	22	860	0	0	2	884
Funnel Creek	39	9	21	2	103	0	0	0	105
Battle River	76	10	21	10	227	0	0	40	277
Kulaklek River	98	8	22	3	223	0	0	0	226
Totals	4,090	*	*	355	9,745	39	47	121	11,192

*- Indicates the field was not surveyed during that year.

Appendix E. ADF&G Guide logbook data for area R and S angler effort, 2006-2010 (ADF&G 2009, 2010, 2011). For total field, resident, nonresident, unknown and crew are included in calculation. (continued)

Effort and Harvest 2006	Angler Days	King Salmon	Coho Salmon	Sockeye Salmon	Cutthroat	Rainbow	Steelhead	Dolly Varden	Grayling
Area R Water bodies									
Naknek River and Tributaries	1,543	496	828	288	0	29	0	9	0
Brooks River	848	0	0	0	0	36	0	0	0
Brooks Lake	77	2	0	4	0	5	0	0	0
American Creek	1,258	0	0	0	0	16	0	25	0
Naknek River above rapids camp	1,205	110	745	965	0	13	0	0	0
Naknek River below rapids camp	756	435	208	160	0	1	0	0	0
Area S Water bodies									
Alagnak (Branch) River	5,093	684	815	3,347	0	160	0	6	75
Kulik River	1,134	0	1	0	0	0	0	0	0
Little Kulik (into Nanuktuk Cr.)	59	0	0	0	0	0	0	0	0
Nanuktuk Creek	239	0	0	0	0	0	0	0	0
Nonvianuk Lake	65	0	0	0	0	6	0	0	0
Nonvianuk River (into Alagnak)	630	0	1	13	0	20	0	0	0
Moraine Creek	1,631	0	0	0	0	61	0	1	4
Funnel Creek	112	0	0	0	0	1	0	0	0
Battle River	281	0	0	0	0	0	0	0	0
Kulaklek River	905	0	6	129	0	17	0	0	0
Area R and S total	14,703	1,727	2,604	4,906	0	365	0	41	79

*- Indicates the field was not surveyed during that year.

Appendix E. ADF&G guide logbook data for area R and S, harvest by species (number of fish), and effort, 2006-2010 (ADF&G 2009, 2010, 2011). (continued)

Effort and Harvest 2007	Angler Days	King Salmon	Coho Salmon	Sockeye Salmon	Cutthroat	Rainbow	Steelhead	Lake Trout	Dolly Varden	Grayling	Pike	Sheefish
Area R Water bodies												
Naknek River and Tributaries	1,896	575	892	836	0	44	0	0	30	6	4	0
Brooks River	856	5	0	15	0	22	0	0	0	0	0	0
Brooks Lake	97	0	0	6	0	27	0	0	0	0	0	0
American Creek	1,184	0	0	22	0	123	0	0	119	0	0	0
Naknek River above rapids camp	1,425	80	806	1,491	0	8	0	0	4	1	0	0
Naknek River below rapids camp	660	241	193	270	0	0	0	0	0	0	0	0
Area S Water bodies												
Alagnak (Branch) River	4,758	540	601	3,903	0	322	0	5	9	68	0	0
Kulik River	1,055	0	0	0	0	0	0	0	0	0	0	0
Little Kulik (into Nanuktuk Cr.)	83	0	0	0	0	5	0	0	0	0	0	0
Nanuktuk Creek	203	0	0	0	0	30	0	0	3	0	0	0
Nonvianuk Lake	111	0	0	3	0	161	0	22	0	0	0	0
Nonvianuk River (into Alagnak)	373	0	2	25	0	197	0	4	0	9	0	0
Moraine Creek	1615	0	0	6	0	120	0	0	0	9	0	0
Funnel Creek	51	0	0	0	0	0	0	0	0	0	0	0
Battle River	381	0	0	0	0	0	0	0	0	0	0	0
Kulaklek River	815	0	0	65	0	57	0	0	6	0	0	0
Area R and S total	15,563	1441	2,494	6,642	0	1,116	0	31	171	93	4	0

*- Indicates the field was not surveyed during that year.

Appendix E. ADF&G guide logbook data for area R and S, harvest by species (number of fish), and effort, 2006-2010 (ADF&G 2009, 2010, 2011). (continued)

Effort and Harvest 2008	Angler Days	King Salmon	Coho Salmon	Sockeye Salmon	Cutthroat	Rainbow	Steelhead	Lake Trout	Dolly Varden	Grayling	Pike	Sheefish
Area R Water bodies												
Naknek River and Tributaries	1,881	361	1,136	586	0	1	0	0	0	0	0	0
Brooks River	833	0	1	10	0	0	0	0	0	0	0	0
Brooks Lake	*	*	*	*	*	*	*	*	*	*	*	*
American Creek	,574	0	9	0	0	31	0	3	66	0	0	0
Naknek River above rapids camp	1,706	82	1,523	1,720	0	11	0	0	15	0	0	0
Naknek River below rapids camp	686	298	422	209	0	0	0	0	3	1	0	0
Area S Water bodies												
Alagnak (Branch) River	4,173	308	663	3,787	0	13	0	5	25	22	0	0
Kulik River	1,448	0	0	0	0	50	0	0	0	0	0	0
Little Kulik (into Nanuktuk Cr.)	141	0	0	0	0	0	0	0	0	0	0	0
Nanuktuk Creek	302	0	0	0	0	0	0	0	0	0	0	0
Nonvianuk Lake	79	0	0	19	0	1	0	4	0	0	0	0
Nonvianuk River (into Alagnak)	399	0	0	32	0	4	0	17	0	0	0	0
Moraine Creek	1,237	0	0	4	0	27	0	0	0	4	0	0
Funnel Creek	103	0	0	0	0	3	0	0	0	0	0	0
Battle River	364	0	0	0	0	17	0	0	0	0	0	0
Kulaklek River	549	0	0	276	0	4	0	1	0	0	0	0
Area R and S total	15,475	1,049	3,754	6,643	0	162	0	30	109	27	0	0

*- Indicates the field was not surveyed during that year.

Appendix E. ADF&G guide logbook data for area R and S, harvest by species (number of fish), and effort, 2006-2010 (ADF&G 2009, 2010, 2011). (continued)

Effort and Harvest 2009	**Angler Days**	**King Salmon**	**Coho Salmon**	**Sockeye Salmon**	**Cutthroat**	**Rainbow**	**Steelhead**	**Lake Trout**	**Dolly Varden**	**Grayling**	**Pike**	**Sheefish**
Area R Water bodies												
Naknek River and Tributaries	1,544	261	993	297	0	8	0	0	33	9	0	0
Brooks River	664	0	3	8	0	0	0	0	0	0	0	0
Brooks Lake	62	0	0	0	0	0	0	0	0	0	0	0
American Creek	1,212	0	0	0	0	26	0	1	58	0	0	0
Naknek River above rapids camp	1,578	34	807	1,600	0	23	0	0	1	0	0	0
Naknek River below rapids camp	801	365	325	81	0	0	0	0	0	0	2	0
Area S Water bodies												
Alagnak (Branch) River	3,096	150	558	2,494	0	7	0	2	1	7	0	0
Kulik River	1,071	0	0	0	0	63	0	24	0	0	0	0
Little Kulik (into Nanuktuk Cr.)	43	0	0	0	0	0	0	0	0	0	0	0
Nanuktuk Creek	95	0	0	4	0	1	0	0	0	0	0	0
Nonvianuk Lake	36	0	0	0	0	0	0	1	0	0	0	0
Nonvianuk River (into Alagnak)	213	2	0	7	0	4	0	37	1	0	0	0
Moraine Creek	1,186	0	0	4	0	0	0	0	0	0	0	0
Funnel Creek	132	0	0	0	0	0	0	0	0	0	0	0
Battle River	391	0	0	0	0	0	0	0	0	0	0	0
Kulaklek River	264	0	0	57	0	5	0	0	0	0	0	0
Area R and S total	12,388	812	2,686	4,552	0	137	0	65	94	16	2	0

Appendix E. ADF&G guide logbook data for area R and S, harvest by species (number of fish), and effort, 2006-2010 (ADF&G 2009, 2010, 2011). (continued)

Effort and Harvest 2010	**Angler Days**	**King Salmon**	**Coho Salmon**	**Sockeye Salmon**	**Cutthroat**	**Rainbow**	**Steelhead**	**Lake Trout**	**Dolly Varden**	**Grayling**	**Pike**	**Sheefish**
Area R Water bodies												
Naknek River and Tributaries	1,362	270	173	223	0	2,539	0	752	3,503	719	70	0
Brooks River	751	1	0	8	0	5	0	0	0	0	0	0
Brooks Lake	35	0	0	0	0	0	0	0	0	0	0	0
American Creek	1,273	0	0	0	0	1	0	1	48	0	0	0
Naknek River above rapids camp	1,350	46	358	1,603	0	9	0	0	2	1	0	0
Naknek River below rapids camp	448	155	213	120	0	0	0	0	0	0	0	0
Contact Creek	123	0	0	0	0	1	0	0	36	7	0	0
Swikshak River	65	0	169	0	0	0	0	0	0	0	0	0
Area S Water bodies												
Alagnak (Branch) River	2,868	246	609	2,522	0	14	0	31	7	24	0	0
Kulik River	1,084	0	0	0	0	2	0	4	0	0	0	0
Little Kulik (into Nanuktuk Cr.)	47	0	0	16	0	0	0	0	0	0	0	0
Nanuktuk Creek	139	0	0	0	0	9	0	0	0	0	0	0
Nonvianuk Lake	44	0	0	0	0	0	0	1	0	0	0	0
Nonvianuk River (into Alagnak)	147	0	0	6	0	2	0	4	0	0	0	0
Moraine Creek	884	0	0	0	0	9	0	0	0	0	0	0
Funnel Creek	105	0	0	0	0	0	0	0	0	0	0	0
Battle River	277	0	0	0	0	0	0	0	0	0	0	0
Kulaklek River	226	0	0	44	0	0	0	0	0	0	0	0
Area R and S total	11,228	718	1,522	4,542	0	2,591	0	793	3,596	751	70	0

Appendix F. Alaska Peninsula Native Fish Bibliography

Summary
This is an updated version of the bibliography provided in:

Buck, E.U. 1978. Bibliography, synthesis, and modeling of Naknek River aquatic system information. National Park Service. U.S. Department of the Interior, Seattle, Washington.

Citations marked with an * are the original works from Buck (1978); all un-marked citations were appended into Buck (1978) to update the Alaskan Peninsula native fish bibliography. Abstracts or introductions were inserted form the original documents text when available. Documents lacking an abstract or appropriate introduction were annotated.

Adams, F. J. 1993. The effects of global warming on the distribution of steelhead trout (*Oncorhynchus mykiss*) populations on the Alaska Peninsula, Alaska. 1992 progress report. U.S. Fish and Wildlife Service, King Salmon, Alaska.

Abstract from report: An investigation to determine the distribution, age and size structure, and sex composition of steelhead trout (*Oncorhynchus mykiss*) populations of the Alaska Peninsula, Alaska was conducted during summer and fall 1992. Water temperatures of selected drainages on the Peninsula were also collected. The study was an expansion of a long term investigation initiated in 1991 as part of the global climate change component of the Fishery Resource Monitoring Program (FRMP). The FRMP is designed to assess possible effects of climatic warming on fishery resources. The presence of steelhead trout on the Alaska Peninsula is not documented north of the Chignik River system. It is hypothesized that steelhead trout will extend their range northward and their growth rate will change as a result of increased water temperatures from long term environmental global warming. Study objectives were to: (1) document the presence of steelhead trout in drainages of the Alaska Peninsula and monitor long term changes in their distribution; (2) describe length, weight, and age structure and sex composition of steelhead trout populations in drainages where they exist; (3) monitor long term changes in air and water temperatures and correlate these changes with growth and distribution of steelhead trout on the Alaska Peninsula. During 1992, six drainages were sampled: Meshik River, King Salmon River- Mother Goose Lake, Chignik River, Sandy River, Sapsuk River, and Russell Creek. King Salmon-Mother Goose Lake drainage was added to the sampled rivers in 1992 after reviewing the 1991 sampling design. Approximately 6,000 fish representing 14 species were captured in all the drainages combined. Twenty three juvenile and six adult steelhead trout were captured in the Sandy drainage. One juvenile and five adult steelhead trout were captured in Russell Creek drainage. No steelhead were caught in the other four rivers. Juvenile steelhead trout lengths ranged from 49-158 mm, weights from 1-49 g, and ages from 0-2 years. Adult steelhead trout lengths ranged from 328-680 mm, weights from 350-3,800 g, and ages from 2.2-2.4. The youngest first time spawner was age 2.1, while most fish spawned for the first time at age 2.2. Three adults were repeat spawners and appeared to have spawned annually. Thermographs were recovered from the Chignik River, Sapsuk River, and Russell Creek drainages in 1992. Minimum temperatures ranged from -0.2 to -0.4 °C. Maximum temperatures ranged from 12.8 to 15.8 °C. Thermographs placed in the Meshik River and Sandy River drainages could not be found and were presumed lost during spring ice break-up. A thermograph was placed in the King Salmon Mother Goose Lake drainage for the first time in 1992.

Keywords: steelhead trout, global warming, water temperature, Alaska Peninsula.

Adams, F. J., B. Mahoney, and S. Lanigan. 1993. Fishery survey of lakes and streams on Izembek and Alaska Peninsula National Wildlife Refuges, 1985 and 1986. Alaska Fisheries Technical Report Number 20. U.S. Fish and Wildlife Service, King Salmon, Alaska.

Abstract from report: During May through September, 1985 and 1986, nine lakes and eight streams on the Izembek National Wildlife Refuge and on the Pavlof Unit of the Alaska Peninsula National Wildlife Refuge (Refuges) were surveyed. The purpose of the survey was to characterize the fish populations and describe the physical and chemical features of the lakes and streams because limited information was previously available. Gill nets, minnow traps, electrofisher, dip nets, carcass recovery, and angling were used to sample the fish populations. Standard hydrological, limnological, and water quality methods were used to sample physical and chemical characteristics. Anadromous and resident fish were captured including: Arctic char (*Salvelinus alpinus*); Dolly Varden (*S. malma*); chum salmon (*Oncorhynchus keta*); coho salmon (*O. kisutch*); pink salmon (*O. gorbuscha*); sockeye salmon (*O. nerka*); coastrange sculpin (*Cottus aleuticus*); fourhorn sculpin (*Myoxocephalus quadricornis*); threespine stickleback (*Gasterosteus aculeatus*); ninespine stickleback (*Pungitius pungitius*); starry flounder (*Platichthys stellatus*); and Arctic lamprey (*Lampetra japonica*). The occurrence of these species generally reflects the geographic range reported in the literature. However, the presence of fourhorn sculpin and ninespine stickleback within the study area represents a southern range extension for each of these species. Length, weight, and age characteristics of chum, coho, and sockeye salmon, and Arctic char from the Refuges generally exhibit similar characteristics to other Alaska populations. The typical ages of adult pink salmon and Dolly Varden differed from other Alaska populations. Age 0.1 pink salmon were captured in Swan Lake, which was not a typical age for returning adults of this species. The oldest Dolly Varden captured in this study was age 6 years, which is considerably younger than the maximum age reported for other Alaskan populations. Open lakes exhibited greater species diversity than closed lakes. Tundra streams exhibited greater species diversity than upland streams. Mean lengths and weights of juvenile coho salmon and Dolly Varden sampled in the lakes were greater than from the streams. Mean lengths at age of juvenile coho salmon captured in the tundra streams were greater than those captured in the upland streams. Shoreline development was similar for open and closed lakes, but the closed lakes were significantly deeper. Conductivity and pH were greater for the open lakes. Discharge was greater in the upland streams, although the tundra streams exhibited greater conductivity, alkalinity, and pH. Bathymetry indicated that the lakes were glacially formed kettle lakes.

Keywords: Arctic char, Dolly Varden, chum salmon, coho salmon, pink salmon, sockeye salmon, Izembek National Wildlife Refuge, Alaska Peninsula National Wildlife Refuge, lakes, streams, Alaska.

Adams, F. J. 1996. Status of rainbow trout in the Kanektok River, Togiak National Wildlife Refuge, Alaska, 1993-94. Alaska Fisheries Technical Report Number 39. U.S. Fish and Wildlife Service, King Salmon, Alaska.

Abstract from report: The Kanektok River supports one of the largest sport fisheries for rainbow trout (*Oncorhynchus mykiss*) in southwest Alaska. To monitor stock status, rainbow trout within the wilderness area of Togiak National Wildlife Refuge between river km 28 and 60 were sampled during June-September 1993. Eight hundred twenty-seven rainbow trout≥ 200 mm were captured by hook and line. Fork lengths ranged from 213-581 mm and ages from scales were 3-10 years. Due to the low number of recaptures, an abundance estimate could not be generated. Comparisons of results from 1993 and 1985-87 indicated that only the length distributions from 1985 and 1986 were not significantly different. The major concern from these comparisons was the absence of large (> 600 mm) fish in 1993. Comparisons of age frequencies among the years indicated that only 1993 was significantly different from the other years, and age at full recruitment to the sampling gear was one year younger in 1993. To determine seasonal movements, rainbow trout were radio-tagged during August-September 1993 and relocated from aircraft from October 1993-August 1994. Fifteen flights relocated 2-23 of 26 radio-tagged fish with most fish moving less than 10 km throughout the year. The limited movement indicates that this reach of the river provides important habitat for rainbow trout in all seasons. Fork lengths of 35 incidentally captured Arctic grayling (*Thymallus arcticus*) and 181 Dolly Varden (*Salvelinus malma*) ranged from 267-443mm and 216-629mm, respectively. Scale ages of Arctic grayling ranged from 3-7 years. Otolith ages of a subsample of Dolly Varden ranged from 4-10 years. The absence of large rainbow trout and the younger age at full recruitment in 1993 indicate that the size and age structures may be changing. Although subsistence and sport harvest appear to be low, and these apparent changes may be attributed to sampling bias, aging error, or natural variation, hooking and handling mortality over several years may have affected the population. It is recommended that monitoring of the population and fishing pressure continue, and the effects of hooking and handling mortality be determined. To satisfy the Refuge objective of conserving fish and wildlife populations in their natural diversity, public use on this portion of the river should not be increased. Arctic grayling and Dolly Varden populations should continue to be monitored as part of the rainbow trout studies.

Keywords: rainbow trout, Arctic grayling, Dolly Varden, Kanektok River, Togiak National Wildlife Refuge, movement, Alaska

Adams, F. J. 1999. Status of rainbow trout in tributaries of the upper King Salmon River, Becharof National Wildlife Refuge, Alaska, 1990-92. Fisheries Technical Report Number 53. U.S. Fish and Wildlife Service, King Salmon, Alaska.

Abstract from report: The King Salmon River is a glacially turbid stream with several clear water tributaries that support rainbow trout *Oncorhynchus mykiss*. During the late 1980's, sport fishing effort appeared to increase on Gertrude Creek, one of the more easily accessible tributaries in the drainage. To monitor stock status of rainbow trout, Gertrude Creek and four other tributaries of the upper river were sampled using hook and line during May-September 1990-1991 and May-June 1992. One thousand two-hundred rainbow trout≥200 mm were captured with fork lengths ranging from 200-652 mm and ages from scales ranging from 3-11 years. To estimate abundance, fish > 300 mm were marked with anchor tags, but a valid estimate could not be generated due to the low number of fish recaptured in each tributary. To determine seasonal movements, rainbow trout were implanted with radio transmitters and relocated from aircraft during October 1991-October 1992. Most fish overwintered in four areas in the river, and entered only one tributary to spawn. Information from radio tagged and anchor tagged fish during summer and fall indicated that two geographic groups existed within the study area: one group predominately used the upper three tributaries while the second group used the two lower tributaries. Although most fish remained within one tributary during summer-fall, several fish moved among tributaries between and within the sampling years. Rainbow trout in the King Salmon River were characterized by a sex composition, maturity, and spawning frequency typical of rainbow trout in southwest Alaska. Based on movements, maturity, size and age of fish captured during spring, Whale Mountain Creek appeared to be the primary spawning stream. A creel survey conducted at Gertrude Creek in summer 1991 indicated that the fishery was small, it was strictly a catch and release sport fishery, and anglers targeted rainbow trout. Likewise, the winter subsistence fishery in the lower river was small, but targeted all species and was harvest oriented. Three hundred ninety-seven Arctic grayling and 178 Dolly Varden were incidentally captured in Gertrude Creek during 1990-92. Fork lengths and ages ranged from 230-460 mm and 3-9 years for Arctic grayling. Fork lengths for Dolly Varden ranged from 220-627 mm; ages were not estimated. Dates of first capture suggested that Dolly Varden were anadromous. The study indicated that the rainbow trout population in the upper King Salmon River was stable over the sampling years. With the limited amount of fishing effort and small harvest, there were no immediate threats to the population. To maintain the health of the population, conservative management is imperative and requires that the population and fishing pressure be monitored periodically. Arctic grayling and Dolly Varden populations should also be monitored as part of the rainbow trout studies.

Keywords: rainbow trout, Arctic grayling, Dolly Varden, abundance estimate, movement, creel, survey, maturity, otoliths, King Salmon, River Bechar of National Wildlife Refuge Alaska

*Alaska Dept. of Fish and Game, Div. of Commercial Fisheries. 1960-1977. Bristol Bay annual management reports. Anchorage.

The reports include statistics on subsistence fishing in the Naknek River system (sometimes combined with the Kvichak). The period through 1973 is also covered by Middleton et al 1973.

Keywords: subsistence fishing, Naknek River, gill nets, sockeye salmon, Chinook salmon, chum salmon, pink salmon, coho salmon, Arctic char, whitefish, pike, suckers.

*Alaska Dept. of Fish and Game, Div. of Commercial Fisheries. 1975. Catalog of waters important for spawning and migration of anadromous fishes. Region 2 and 4. (Rev. ed. Juneau.) 195 pp.

A catalogue of designated anadromous fish streams giving detailed locations by township, range, and section, and latitude and longitude.

Keywords: anadromous fish, American Creek, Big Creek, Brooks River, Coville Lake, Coville River, Eskimo Creek, Grosvenor Lake, Grosvenor River, Hammersly Lake, King Salmon Creek, Murray Lake, Naknek Lake, Naknek River, Pauls Creek, Savonoski River.

*Alaska Dept. of Fish and Game, Div. of Commercial Fisheries . 1977. Naknek River sockeye salmon smolt investigations. Operational plans. 4 pp. The smolt studies project was begun in 956 by the U.S. Fish and Wildlife Service and transferred to the Alaska Dept. of Fish and Game in 1966.

Plans for 1977 are to determine if sonar censusing is applicable for outmigrating smolt and to identify problems in changing from the fyke net counting method now in use. Measurements will begin in mid-May and end in early July, thus catching the peak smolt outmigration.

Keywords: Naknek River, sockeye salmon, juvenile fish, smolt, census, fish migration, fyke nets, growth rates, age, mortality, fish populations, sonar.

Alaska Dept. of Fish and Game. 1983. Naknek lake rainbow trout research proposal.

Proposal from report: The Bristol Bay region of Western Alaska is known worldwide for its quality recreational fishing. Within Bristol Bay the Naknek River drainage supports one of the worlds finest rainbow trout populations. These fish are individually large in size, collectively are thought to comprise one of the largest populations in Bristol Bay, and are available to the sport angler in outstanding esthetic surroundings. The rainbow trout inhabiting the Naknek River system are considered unique and of great value by both state and federal agencies administering fisheries within the area.

Keywords: Naknek Lake, Naknek River, rainbow trout, Brooks River, Bay of Islands, creel census.

Alaska Dept. of Fish and Game. 1988. Southwest Alaska rainbow management plan. Division of Sport Fish.

Introduction from report: The southwestern sport fish management area includes all waters and drainages flowing into Bristol Bay north of Cape Menshikof, Kuskokwim Bay and includes the Kuskokwim River and its tributaries from Aniak River downstream to Kuskokwim (Figure 1). Within this 54,700 square mile area is some of the most productive salmon, rainbow trout, Arctic grayling, Arctic char, and Dolly Varden waters in the world. Wild rainbow trout stocks of the area are world famous and are the cornerstone to a multimillion dollar sport fishing industry. Over 100 commercial guides and outfitters operate in southwest Alaska offering services that

range from outfitted but unguided float trips, to luxurious wilderness lodge accommodations complete with daily fly-out fishing. Current prices for these services range from $1,500 to $4,000 per fishermen per week. In addition to lodges and outfitters, nearly 50 air taxis regularly fishermen throughout the area. Total economic value of the recreational fishery in Southwest Alaska is estimated at over 50 million per year. Anglers travel from many parts of the country and the world to enjoy the unique opportunity of for wild rainbow trout in the undeveloped, scenic landscape of southwestern Alaska. Sport fishery harvest and effort estimates for the years 1977 to 1987 are summarized from the Alaska Statewide Harvest Survey (Table 1). Currently, over 65,000 man-days of angling effort are expended annually in southwestern Alaska. Annual angling effort (all species) has nearly doubled since 1980 and estimated rainbow trout sport harvests have risen proportionally from 3,000-4,000 fish annually in the late 1970s to a recent average of 7,400 (1983-1987).

Keywords: rainbow trout, Naknek Lake, Naknek River, Brooks River.

Alaska Dept. of Fish and Game. 1990. Southwest Alaska rainbow management plan. Division of Sport Fish.

Introduction from report: The southwestern sport fish management area includes all waters and drainages flowing into Bristol Bay north of Cape Menshikof, Kuskokwim Bay and includes the Kuskokwim River and its tributaries from Aniak River downstream to Kuskokwim (Figure 1). Within this 54,700 square mile area is some of the most productive salmon, rainbow trout, Arctic grayling, Arctic char, and Dolly Varden waters in the world. Wild rainbow trout stocks of the area are world famous and are the cornerstone to a multimillion dollar sport fishing industry. Over 100 commercial guides and outfitters operate in southwest Alaska offering services that range from outfitted but unguided float trips, to luxurious wilderness lodge accommodations complete with daily fly-out fishing. Current prices for these services range from $1,500 to $4,000 per fishermen per week. In addition to lodges and outfitters, nearly 50 air taxis regularly fishermen throughout the area. Total economic value of the recreational fishery in Southwest Alaska is estimated at over 50 million per year. Anglers travel from many parts of the country and the world to enjoy the unique opportunity of for wild rainbow trout in the undeveloped, scenic landscape of southwestern Alaska. Sport fishery harvest and effort estimates for the years 1977 to 1987 are summarized from the Alaska Statewide Harvest Survey (Table 1). Currently, over 100,000 man-days of angling effort are expended annually in southwestern Alaska. Annual angling effort (all species) has nearly tripled since 1980 and estimated rainbow trout sport harvests have risen proportionally from 3,000-4,000 fish annually in the late 1970s to a recent average of 5,200 (1986-1990).

Keywords: rainbow trout, Naknek Lake, Naknek River, Brooks River, recreational fishery.

*Alexander, C. P. 1920. The crane-flies (Tipulidae, Diptera). Ohio Journal of Science. 20:193-203.

Several new species are described and range extensions are recorded for the Naknek drainage.

Keywords: aquatic insects, diptera.

*Allin, R. W. 1959. Reconnaissance of Bristol Bay sport fishery. Unpublished. U.S. Fish and Wildlife Service. Federal Aid in Fish Restoration. 8(5):1-44.

Naknek River sport fishing is discussed, including: operation of fishing camps (military and private), standard fishing patterns and sport fish availability. Extensive creel census data for 1956 to1958, with time and size of catch, are presented.

Keywords: Naknek River, Naknek Lake, Rapids Camp, Lake Camp, Base Dock, Brooks Lake, Brooks River, Brooks Camp, Coville Lake, rainbow trout, grayling, Dolly Varden char, Chinook salmon, coho salmon, sockeye salmon, lake trout, growth rates, creel census, fish harvest, sport fishing, regulation ,fish migration, Grosvenor Lake, Hammersly Lake, Murray Lake.

*Andrews, R. E. 1961. Creel census and population sampling of the sport fishes in the Cook Inlet and Bristol Bay drainages. Pages 115-151in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau.Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska, Project F-5-R-2, Job 2-C. Annual Progress Report, 1960-1961. Vol. 2.

Species caught, fishing locations, and a general description of ten fishing camps (three military, seven private) are given. Detailed data for the Naknek River (from military creel census forms) and averages (1956 through 1960) for fish length and weight, number of fishermen and hours fished are presented. Pictures of the private camps at Grosvenor Lake and Brooks Lake and an aerial photo of Brooks River Falls are included.

Keywords: Naknek River, Naknek Lake, sockeye salmon, coho salmon, Chinook salmon, Dolly Varden char, Arctic char, rainbow trout, grayling, northern pike, lake trout, fish harvest, creel census, fishing regulation, sport fish, sport fishing, fly fishing, Brooks Lake, Brooks River, Naknek River, Grosvenor Lake, Coville Lake, American Creek, Brooks Camp, Grosvenor Camp, Fish Camp, Rapids Camp, Lake Camp, waterfalls.

*Andrews, R. E. 1966. Inventory and cataloging of the sport fish and sport fish waters in the Bristol Bay and lower Kuskokwim drainages. Pages 171-182 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-5-R-7, Job 12-A. Annual Progress Report, 1965-1966. Vol. 7.

A table of species for various parts of the Naknek River drainage, and Chinook salmon escapement on Big Creek is included in this report.

Keywords: Naknek River, King Salmon Creek, Big Creek, Brooks River, Idavain Lake, Naknek Lake, Coville-Grosvenor Narrows, American River, rainbow trout, grayling, Chinook salmon, coho salmon, pink salmon, sockeye' salmon, Dolly Varden char, lake trout, fish migration, spawning, census.

Author Unknown. 1983. Summary of field crew activities during the 1983 herring sac-roe season Big

River District, Chignik Finfish Management Area, Alaska.

A summary of the 1983 herring season including testaments to the total catch, weather conditions, crew travel, and methods of herring fishing.

Keywords: poor weather, herring, Amber Bay, Bristol Bay Aniakchak Bay.

Author Unknown. 1986. Fish species and water quality of battle lake tributaries.

Objective from report: The objective of this project is to document the fish species present in the tributaries and outlet streams of Battle Lake. Very little is known of the fisheries in the areas that were added to Katmai National Monument in 1978. Five major streams enter Battle Lake. In one of the stream drainages is a lode mining claim which the claimants may soon propose to reopen. This project will provide information on fish species and other aquatic resources that will be used in assessing potential environmental impacts of a mining operation. It also represents a first step in developing a database on aquatic systems in the park and preserve.

Keywords: Battle Lake, geology, hydrology, limnology, water quality, surface water flow

*Atkinson, C. E., J. R. Rose, and T. O. Duncan. 1967. Pacific salmon in the United States. Pages 43-223 in Salmon of the north Pacific Ocean-PartIV. Spawning populations of north Pacific Salmon. International North Pacific Fisheries Commission. Bulletin 23.

Report includes spawning ground maps for chum, coho, pink and sockeye salmon, and weir and tower counts. The statistics given show that the Naknek is second only to the Kvichak River in sockeye salmon production for the Bristol Bay fisheries.

Keywords: Naknek River, chum salmon, coho salmon, sockeye salmon ,pink salmon, spawning, fish migration, fish populations.

*Biesinger K. 1967. Micronutrients as possible factors limiting primary productivity in certain Alaskan lakes. Ph.D. Thesis. University of Michigan, Ann Arbor. 114 pp.

A study was conducted on the effects of trace elements on primary productivity of plankton from four lakes of the Naknek system. The relative productivity of these lakes was also measured.

Keywords: Coville Lake, Grosvenor Lake, Naknek Lake, Brooks Lake, lake morphometry, water chemistry, vitamins, vitamin B, nannoplankton, depth, trace elements, phytoplankton, vanadium, Jithium, manganese, molybdenum, sodium, cobalt, zinc, boror, copper, primary productivity, nutrients.

*Bilello, M.A., and R.E. Bates. 1971. Ice thickness observations, North American Arctic and subarctic. 1966-67, 1967-68. U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, Hanover, NH. Special Report 43, Part V. III pp.

Chronological record for two years cataloging progression of ice freeze up and breakup at King Salmon for the Naknek River.

Keywords: navigation, Naknek River, ice, ice cover, ice breakup.

*Bill, D. L. 1975. 1974 Naknek River sockeye salmon smolt studies. Pages14-23 in P. Krasnowski, ed. 1974 Bristol Bay sockeye sa1mon smolt studies. Alaska Dept. of Fish and Game. Technical Data Report 20.

Sampling was conducted between May 21 and June 27, 1974, with a total outmigration estimate for 1974 of 819,369. Forty-eight percent of the catch was between June 2 and 4. Daily and hourly catch and average length and weight by age groups are given.

Keywords: sockeye salmon, Naknek River, smolt, juvenile fish, fish migration, age, growth rates, water temperature, fyke nets, fish populations, census.

*Biwer, D. A. 1972. 1970 Naknek River sockeye salmon smolt studies. Pages24-31 in P.A. Russell, ed. 1970 Bristol Bay sockeye salmon smolt studies. Alaska Dept. of Fish and Game. Technical Data Report 4.

Reports on sampling conducted between May 28 and June 16, 1970.Statistics include daily and hourly outmigration catches, and sample lengths, weights, and ages.

Keywords: sockeye salmon, Naknek River, smolt, juvenile fish, fish migration, age, growth rates, water temperature, fyke nets, fish populations, census.

*Boles, H. 1952. Relation of weir plankton samples to conditions on Brooks Lake. Report prepared for course at Univ. of Washington.

(Unable to obtain referenced in Merrell 1957b).

*Branson, B.A., and W.A. Heard. 1959. Snails from upper peninsula of Alaska with feeding habits of Brooks Lake fishes. Nautilus. 73(1):14-16.

Gastropods form a significant portion of the diet of some fish in Brooks Lake. Habitat and species of snails and slugs captured in the lake are noted and detailed analyses of the stomach contents of various fish species are given.

Keywords: gastropods, snails, char, Naknek River, Brooks Lake, aquatic habitats, food habits, food abundance, Dolly Varden char, lake trout, whitefish, Alaska blackfish, sticklebacks, sockeye salmon, smolt, predation, aquatic plants.

Brookover, T. E. 1989. Creel and escapement statistics for the Alagnak River during 1988. Division of Sport Fish, Fishery data series No. 89. Alaska Department of Fish and Game, Juneau, Alaska.

Abstract from report: A roving creel survey was conducted on a 19.2 kilometer (11.5 mile) section of the lower Alagnak River from 24 June through 4 August 1988. An estimated 13,287 angler hours of sport fishing effort were expended on the lower river. This effort resulted in a catch (fish kept and fish released) of 2,954 chinook salmon, 1393 pink salmon, 538 chum salmon 79 coho salmon, and 121 rainbow trout. Of this catch, an estimated 1243 chinook salmon, 49 coho salmon, 178 chum salmon, 162 pink salmon, and 18 rainbow trout were harvested (kept). The spawning escapement of chinook salmon into the Alagnak drainage during 1988 was estimated to be 7,900 fish. Age 1.3 chinook salmon were the most abundant age group in both the sport harvest (53%) and spawning escapement (61%).

Keywords: Chinook salmon, pink salmon, coho salmon, chum salmon, rainbow trout, survey, sport harvest, sport catch, sport effort, escapment, age composition, Alagnak River, Bristol Bay.

*Burgner. R. L. 1964. Factors influencing production cf sockeye salmon (*Oncorhynchus nerka*) in lakes of southwestern Alaska. Verhandlungen Internationale Vereinigung fur Theoretische und Angewandte Limnologie. 15:504-513.

Discusses factors in general and some lake chains specifically. Includes a table showing area, average red salmon escapement between 1955 and 1961, and the number of spawners per square kilometer of water surface for Naknek Lake.

Keywords: sockeye salmon, Naknek Lake, fish populations, acreage.

*Burgner, R. L. et al. 1969. Biological studies and estimates of optimum escapements of sockeye salmon in the major river systems in southwestern Alaska. Fishery Bulletin. 67(2):405-459.

The report of an intensive research program conducted in 1961 and 1962 on the Naknek and other nearby drainages by the Auke Bay Laboratory and the Fisheries Research Institute (University of Washington).

Keywords: Brooks Lake, Brooks River, Coville Lake, Coville River, Grosvenor Lake, Grosvenor River, American Creek, Hard scrabble Creek, Naknek Lake, Iliuk Arm, North Arm, South Bay, sockeye salmon, smelts, sticklebacks, whitefish, size, depth, volume, lake morphometry, shores, elevation, Savonoski River, Ukak River, water chemistry, dissolved oxygen, dissolved solids, alkalinity, sodium, potassium, magnesium, nitrates, silica, iron, manganese, calcium, boron, nutrients, water temperature, thermocline, thermal stratification, .primary productivity, phytoplankton, chlorophyll, secchi disks, standing crops, fish populations, fish migration, light penetration, spawning, census, weirs, fyke nets, tagging, fish behavior, fry, juvenile fish, smolt, reproduction, predation, competition, Arctic char, lake trout, northern pike, coho salmon, Dolly Varden char, gulls, age, growth rates, hydrogen ion concentration.

*Cahalane, V. H. 1954. A biological survey of Katmai National Monument. Pages 75-109 in R.S. Luntey, ed. U.S. National Park Service.Interim report on Katmai Project, Katmai National Monument, Alaska.

The survey includes a listing of several species of fish reported or observed within the Monument.

Keywords: lampreys, whitefish, grayling, rainbow trout, DollyVarden char, suckers, northern pike, sticklebacks, Grosvenor Lake, Brooks River, Coville Lake, Alagogshuk Creek, Savonoski village.

*Cahalane, V. H. 1959. A biological survey of Katmai National Monument. Smithsonian Institute. Smithsonian Miscellaneous Collections. 138(5):1- 264.

A discussion and data on the bear-salmon interactions: in the Naknek River drainage. Includes some data and a discussion of the effect of otter and beaver on fish.

Keywords: Savonoski River, Rainbow River, Naknek Lake, Naknek River, Iliuk Arm, Ukak River, Brooks River, Brooks Lake, Margot Creek, Grosvenor Lake, Hardscrabble Creek, American Creek, Idavain Lake, Coville Lake, sport fishing, rainbow trout, sockeye salmon, Dolly Varden char, subsistence fishing, spawning, fish migration, beavers, food habits, aquatic habitats, predation, silting, dams, carnivores.

*Coe, D. L. 1966. Katmai National Monument. National Parks Magazine. 40(June): 4-9.

A general discussion of fishery resources, particularly sport fishing: and a picture showing the extensive braiding and ash deposits in the lower Ukak River Valley (where it flows into Iliak Arm of Naknek Lake).

Keywords: Naknek Lake, Iliuk Arm, Brooks Lake, Ukak River, depth, sport fishing, rainbow trout, lake trout, Dolly Varden char, grayling, whitefish, northern pike, sockeye salmon, fish migration, Brooks River, Naknek River.

Chalfant, P., V. Mizner, and K. L. Jope. 1984. Nonvianuk creel census Katmai National Park and Preserve. National Park Service, King Salmon, Alaska.

Summary from report: The number of people fishing at Nonvianuk, amount of time spent fishing, numbers of fish caught, and numbers kept were recorded during 18 4-hour periods from June 11 to September 15, 1984. Regression analysis was used to evaluate the relationship of the number of rainbow trout caught with variables such as date, time of day, and number of people fishing. This relationship was used to derive an estimate of 986 rainbow trout caught, of which approximately 67 (6.25%) were kept, at Nonvianuk during this period. This constituted a catch rate of approximately 0.5 rainbow trout per hour of fishing or 1.1 rainbow trout per fisherman. Continued monitoring is needed in future years to detect any changes that occur in the number of rainbow trout caught per unit effort, in the release rate, or in the distribution of the catch over the season. This monitoring is necessary to ensure the preservation of a high-quality fishery at Nonvianuk.

Keywords: Regression analysis, rainbow trout, Katmai National Park and Preserve, creel census.

*Dahlberg, M. L. 1972a. Studies of sockeye salmon in the Naknek River system, 1972. Pages 1-94 in U.S. National Marine Fisheries Service Auke Bay Biological Laboratory. Manuscript Report 108.

A detailed study of sockeye salmon escapement to American Creek based on weir enumeration at the Coville Narrows. The gravel incubator fry enhancement project on the northwest, arm of Naknek Lake is discussed, and a table showing elemental analyses of surface waters of the area is included.

Keywords: sockeye salmon, smelts, sticklebacks, juvenile fish, age, growth rates, fish migration, census, weirs, spawning, fish populations, Miss 42 Creek, Coville Narrows, American Creek, Coville Lake, Hardscrabble Creek, Grosvenor River, Grosvenor Lake, Brooks Lake, Brooks River, fecundity, fyke nets, nets, carrying capacity, Naknek Lake, Northwest Basin, North Arm, Iliuk Arm, aquiculture, gravels, water temperature, secchi disks, light penetration, water chemistry, strontium, sodium, potassium, magnesium, iron, manganese, calcium, copper, aluminum, titanium, cobalt, and nickel.

*Dahlberg, M. L. 1972b. Naknek system red salmon studies. Plan of operation. April 1972 - March 31, 1973. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Intradepartmental memo. pp. 1-8.

This plan includes the incubation of 1.5 million eggs at the Northwest Basin of Naknek Lake and a study of the movement of juvenile sockeye salmon from their spawning beds to nursery lakes.

Keywords: sockeye salmon, juvenile fish, fish migration, fish populations, spawning, weirs, fyke nets, nets, Coville Lake, American Creek, Grosvenor Lake, Brooks Lake, Naknek Lake, Northwest Basin, water chemistry, light penetration, secchi disks.

*Dahlberg, M. L. 1972c. Limnetic sampling of juvenile sockeye salmon. Pages 9-30 in Naknek system red salmon studies. Plan of operation. April 1, 1972 - March 31, 1973. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Intradepartmental memo.

This report describes various methods used for enumerating adult sockeye salmon in the Naknek drainage, and calls for a tow net assessment of the lake resident fish of the area. The development of adequate towing gear and sampling schedules are also discussed.

Keywords: sockeye salmon, Naknek River, Naknek Lake, American Creek, Brooks River, juvenile fish, smolt, fish migration, weirs, fyke nets, nets, census.

*Dahlberg, M. L. 1973a. Bristol Bay red salmon studies in freshwater. Plan of operation. July 1, 1973 - June 30, 1974. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Intradepartmental memo. pp. 1-8.

The plan calls for assessment of juvenile sockeye salmon and associated lake resident fish in the Naknek River system along with physical and chemical water quality measurements. The gravel incubation hatchery on the Northwest Arm of Naknek Lake is scheduled to begin operation in August, 1973.

Keywords: Naknek Lake, Northwest Basin, sockeye salmon, juvenile fish, nets, water chemistry, sticklebacks, water temperature.

*Dahlberg, M.L. 1973b. Limnetic sampling of juvenile sockeye salmon. Pages 9-11 in Bristol Bay red salmon studies in freshwater. Plan of operation. July 1, 1973 - June 30, 1974. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Intradepartmental memo.

Sampling procedures (similar to those of the previous year, Dahlberg, 1972c) for the assessment of lake resident fish are outlined.

Keywords: sockeye salmon, Naknek River, Naknek Lake, juvenile fish, nets

*Dahlberg, M. L. 1973c. Processing of lacustrine fish samples. Pages 1218 in Bristol Bay red salmon studies in freshwater. Plan of operation. July 1, 1973 - June 30, 1974. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Intradepartmental memo.

Measurement procedures (the same as those used in the previous year) for sockeye salmon and other lake resident fishes are outlined.

Keywords: sockeye salmon, juvenile fish, length, weight, age.

*Dahlberg, M. L. 1975. Carrying capacity of nursery lakes for sockeye salmon. Field operations report for 1973. U.S. National Marine Fisheries Service. Auke Bay Biological Laboratory. Manuscript Report 121. 5 pp.

Report includes spawning ground counts for important tributaries of, and water temperature profiles (and seasonal changes) of various basins within, the Naknek River system. Also collected were data on 14 chemical elements, water transparency and phytoplantkton (chlorophyll a).

Keywords: sockeye salmon, juvenile fish, smolt, Naknek Lake, North west Basin, aquiculture, water temperature, phytoplankton, chlorophyll, water quality, calcium, magnesium, strontium, sodium, potassium, aluminum, titanium, iron, manganese, cobalt, nickel, copper, zinc, mercury, spawning, census, South Bay, Brooks Lake, Coville Lake, Grosvenor Lake, North Arm, secchi disks, thermal stratification, light penetration.

*Dahlberg, M. L. 1976a. Carrying capacity of lakes for sockeye salmon. Plan of operation. July 1, 1976 - September 30, 1977. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Intradepartmental memo. 5pp.

The plan calls for studies of large-scale stocking of eyed eggs in streams of the Naknek system, including Bay of Islands Creek in the North Arm of Naknek Lake and Brooks Lake tributaries. It also proposes measurement of primary and secondary production in the lakes and hydroacoustic surveys to determine distribution and abundance of fish in the North Arm.

Keywords: Naknek River, Naknek Lake, Bay of Islands Creek, Brooks Lake, North Arm, sockeye salmon, juvenile fish, census, water chemistry, light penetration, water temperature, chlorophyll, length, nets, zooplankton, phytoplankton, primary productivity, secondary productivity, fecundity, aquiculture, spawning.

*Dahlberg, M. L. 1976b. Carrying capacity of nursery lakes for sockeye salmon. Field operations report for 1974. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Manuscript Report 132. 18 pp.

Temperature profiles, water transparency data, and zooplankton measurements for several of the lakes are reported. Sockeye salmon spawning escapements on August 1 are recorded from aerial survey counts.

Keywords: water temperature, secchi disks, zooplankton, copepods, rotifers, Daphnia, sockeye salmon, light penetration, North Arm, Iliuk Arm, Northwest Basin, South Bay, Grosvenor Lake, Coville Lake, Brooks Lake, Idavain Lake, American Creek, Hardscrabble Creek, Grosvenor River, Margot Creek, Headwaters Creek, Brooks River, Hidden Creek, One Shot Creek, Up A Tree Creek, Naknek River, spawning, census, fish migration.

*Dahlberg, M. L., and Y. Sheng. 1977. Carrying capacity of nursery lakes for sockeye salmon. Field operation report for 1976. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Manuscript Report 141. 12 pp.

Temperature profiles, water transparency, and zooplankton measurements for several of the lakes are reported. A detailed summary of proposed research is outlined, but the program was cancelled and dismantled in July, 1976.

Keywords: water temperature, secchi disks, Naknek Lake, Books Lake, Coville Lake, Grosvenor Lake, zooplankton, copepods, rotifers, light penetration, Daphnia.

*Dahlberg, M. L., and G. J. Thomason. 1976. Carrying capacity of nursery lakes for sockeye salmon. Field operations report for 1975. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Manuscript Report 135. 23 pp.

Aquiculture experiments were conducted at the King Salmon incubation facility using fertilized eggs collected from Miss 42 Creek and water directly from the Naknek River. Water quality measurements for this river water, as well as temperature profiles, secchi disk readings and chlorophyll a measurements for some of the basins are recorded. A table of zooplankton catch taken throughout the summer is included.

Keywords: sockeye salmon, aquiculture, chlorophyll, primary productivity, depth, secchi disks, light penetration, water temperature, Northwest Basin, North Arm, Grosvenor Lake, Coville

Lake, Brooks Lake, alkalinity, hydrogen ion concentration, dissolved oxygen, dissolved solids, zooplankton, Daphnia, rotifers, copepods.

*Dewey, R. E. 1971. Naknek system red salmon studies. Plan of operation. April 1, 1971 - March 31; 1972. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Intradepartmental memo. 15pp.

Included in the plans are collection of phytoplankton in Brooks and Naknek Lakes, determination of the reasons for juvenile salmon density variations in different nursery areas, studies of cestode (Triaenophorus crassus) infestation of juvenile salmon, construction of a weir at the Coville River outlet, and initial development of an incubator in the Northwest Basin of Naknek Lake.

Keywords: sockeye salmon, juvenile fish, spawning, fish migration, smolt. Brooks River, Naknek River, Naknek Lake, Brooks Lake, American Creek, Coville Lake, Grosvenor Lake, fish populations, mortality, weirs, fyke net$, age, length, weight, phytoplankton, dissolved oxygen, carbon dioxide, ammonia, aquiculture, Northwest Basin, animal parasites, fecundity, census, water temperature.

*Dewey, R. E. 1972. Gravel incubator studies. Pages 31-45 in M.L. Dahlberg. Naknek system red salmon studies. Plan of operation. April 1, 1972 - March 31, 1973. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Intradepartmental memo.

This report includes a detailed description of the experimental incubation system proposed for Miss 42 Creek. The relationships between spawning and nursery areas for the Naknek River drainage, the use of spawning channels, and the taking of spawners in Miss 42 Creek are also discussed.

Keywords: sockeye salmon, juvenile fish, Naknek River, Naknek Lake, North Arm, Northwest Arm, aquiculture, spawning, mortality, Miss 42 Creek.

*Dewey, R. E. 1974. Red salmon aquiculture studies. Anadromous fishes investigations. Progress report July 1 - December 31. 1973. 17 pp.

(Unable to obtain - referenced in Dahlberg, 1975.)

*Dewey, R. E., S. Tsunoda, and W. L. Hartman. 1971. Naknek system red salmon investigations, 1966-67. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Manuscript Report 1-71. 44pp.

A detailed report of the statistics collected at the Brooks River weir in 1966 and 1967, including actual counts; and length, sex, and age determinations of samples taken daily. Tables show total egg deposition calculated for the previous 11 years for Brooks Lake and its tributaries, and for the previous 8 years for Hidden Creek. Spawning ground surveys for Hidden Creek, One Shot Creek, Up A Tree Creek, Headwaters Creek, West Creek and lake spawners are presented. The failure of an attempt to use artificial odors to lure spawning fish into previously barren streams;

and the results of long term studies on the embryonic development of the three wave spawning sockeye are described. Routine weather data, incident solar radiation and water temperatures were taken during the field season.

Keywords: Naknek River, Naknek Lake, Brooks River, Brooks Lake, sockeye salmon, juvenile fish, smolt, spawning, fish migration, fish populations, census, weirs, coho salmon, pink salmon, Chinook salmon, rainbow trout, length, age, Hidden Creek, fecundity, Headwaters Creek, One Shot Creek, Up A Tree Creek, West Creek, Ten Shot Creek, embryonic growth stage, water temperature, weather, climatology, American Creek.

*Dotson, P. A. 1963. Creel census of the sport fishes in the Bristol Bay drainage. Pages 315-326 in Alaska Dept. of Fish and Game, Div. of Sport Fisheries, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska, Project F-5-R-4, Job 8-D-2. Annual Progress Report, 1962-1963. Vol. 4.

Data was collected using voluntary creel census at the military camps along the Naknek River. Tables portray harvest and effort data as well as length and number of the various species caught.

Keywords: Naknek River, Naknek Lake, King Salmon Creek, Pike Lake, Big Creek, rainbow trout, Chinook salmon, grayling, Dolly Varden char, coho salmon, lake trout, pink salmon, northern pike, whitefish, sockeye salmon, chum salmon, sport fishing, fish harvest, creel census.

*Dumond, D.E. 1964. Archeological survey in Katmai National Monument, Alaska, 1963. University of Oregon, Eugene. 46 pp.

This project was an attempt to use archaeological research to study fluctuations in prehistoric salmon migrations. The report contains nothing that would help such study.

Keywords: sockeye salmon, archaeology, Brooks River.

*Dunway, D. O. 1990. Creel and escapement statistics for the Alagnak River, Alaska during 1989. Fishery Data Series No. 90-9. Division of Sport Fish, Alaska Department of Fish and Game, Anchorage, Alaska.

Abstract from report: A roving creel survey was conducted on a 19.2 kilometer (11.5 mile) section of the lower Alagnak River from 28 June through 6 August 1989. An estimated 19,723 angler-hours of sport fishing effort were expended on the lower river. This effort resulted in a catch (fish kept plus fish released) of 3,726 chinook salmon *Oncorhynchus tshawytscha,* 0 pink salmon *Oncorhynchus gorbuscha,* 473 churn salmon *Oncorhynchus keta,* 55 coho salmon *Oncorhynchus kisutch,* and 158 rainbow trout *Oncorhynchus mykiss.* Of this catch, an estimated 1,333 chinook salmon, 55 coho salmon, 14 churn salmon, and 14 rainbow trout were harvested (kept). The spawning escapement of chinook salmon into the Alagnak drainage during 1989 was estimated to be 5,400 fish. Age 1.4 chinook salmon was the most abundant age group in the sport harvest (58 percent).

Keywords: Chinook salmon, *Oncorhynchus tshawytscha,* pink salmon, *Oncorhynchus gorbuscha,* coho salmon, *Oncorhynchus kisutch,* chum salmon, *Oncorhynchus keta,* rainbow trout, *Oncorhynchus mykiss*, creel survey, sport harvest, sport catch, sport effort, escapement, age composition, Alagnak River, Bristol Bay.

*Dye, J., M. et al. 2002. Stock assessment of northern pike in LakeAleknagik, 1998-1999, Fishery Data Series No. 02-14. Alaska Department of Fish and Game, Anchorage Alaska.

In 1998 and 1999, we performed a capture-recapture experiment to determine abundance of northern pike *Esox lucius* in Lake Aleknagik, located in Southwest Alaska. Radiotelemetry was used to determine that the northern pike population in the lake was closed from July 1998 through July 1999, and thus that abundance and length composition of northern pike in the lake could be reliably estimated by the experiment. Estimated abundance was 11,580 (SE-800) northern pike, 300 mm fork length in 1998. However, abundance was probably slightly more because northern pike were not recaptured in one of the sampling locations. The mean length of northern pike was 485 mm (SE = 0.05; n = 1,249) in 1998, which was similar to the 1999 mean length of 489 mm (SE =0.08; n =1,102).

Keywords: northern pike, *Esox lucius*, Lake Aleknagik, length composition, population abundance, radiotelemetry.

Eaton, D. M. and F. J. Adams. 1995. The effects of global warming on the distribution of steelhead trout populations on the Alaska Peninsula. Fisheries Technical Report Number 33. U.S. Fish and Wildlife Service, King Salmon, Alaska.

An investigation to determine the distribution and population characteristics of steelhead trout *Oncorhynchus mykiss* on the Alaska Peninsula, Alaska, was conducted during 1991-1994. It is hypothesized that steelhead trout will extend their range northward and their growth rate will change as a result of increased water temperatures from long term environmental global warming. The study was the first phase of a long-term investigation initiated in 1991 as part of the global climate change component of the Fishery Resources Status and Trends (FRST). The FRST is designed to assess possible effects of climatic warming on fishery resources. The six drainages studied were: Meshik River, King Salmon River-Mother Goose Lake, Chignik River, Sandy River, Sapsuk River, and Russell Creek. The Meshik and King Salmon rivers are north of the documented distribution of steelhead on the Alaska Peninsula; the other sites fall within the known range of steelhead trout. Twenty-one adults and 389 juvenile steelhead trout were captured in Russell Creek from 1991-1994. The abundance of juvenile steelhead trout in Second Creek, a tributary to Russell Creek, was estimated at 3,807 ± 1,779 in 1994. Two adult steelhead trout, 40 adult non-anadromous rainbow trout, and 43 juvenile trout were captured in Sandy River from 1992-1993. No steelhead trout were caught in the other four rivers. A total of 753 stream km was surveyed by helicopter in the six study drainages during 1993. One steelhead trout was observed in Russell Creek and 18 redds were observed in Sandy River.

Thermographs were placed in all study drainages and 12-35 continuous months of bi-hourly temperatures were recorded. Minimum temperatures ranged from -0.3 to -2.0 °C. Maximum temperatures ranged from 10.0 to 17.0 °C. Total accumulation of daily temperature units varied from 1,460 in King Salmon River-Mother Goose drainage to 2,067 in Sandy River for a 12 month period common to all drainages.

As expected, steelhead trout were not located in the two northern most drainages. However, no steelhead trout were located in two of the four southern most drainages in which steelhead trout have been previously reported. Alaska Peninsula steelhead populations appear to be small with restricted distributions. Locating these populations is labor and time intensive and overlooking a population is possible. After trying various sampling techniques, methods that maximize the area sampled, such as underwater direct observation and aerial surveys using a helicopter, can be used to document changes in steelhead trout abundance and distribution. The long-term benefit of the sampling program and integration of distribution, abundance, growth, and temperature data will not be realized until additional sampling is conducted in the future.

Keywords: steelhead trout global warming water temperature Alaska Peninsula Alaska

*Eicher, G. J. 1951. Effect of tagging on the subsequent behavior and condition of red salmon. U.S. Fish and Wildlife Service. Special Scientific Report-Fisheries 64. 4 pp.

No noticeable difference in upstream migration or in spawning behavior between tagged and untagged sockeye salmon, as observed in this experiment conducted in Rideen Creek.

Keywords: Ridden Creek, sockeye salmon, spawning, fish migration, fish behavior.

*Eicher, G. J. 1956. Differential productivity of Bristol Bay red salmon spawning grounds. Pages 69-72 in Science in Alaska. Proceedings of the 4th Alaska Science Conference, Juneau, 1953. Alaska Div., American Association for the Advancement of Science.

Three types of spawning areas are identified in the Naknek River drainage: beach areas, runoff streams, and streams connecting lakes. The latter is probably the most productive.

Keywords: Naknek River, sockeye salmon, spawning, productivity.

*Eicher, G. J. 1963. Factors influencing the return of red salmon to the Naknek. Kvichak and other fisheries of Bristol Bay, Alaska. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Manuscript Report 2. 92 pp.

The results of numerous studies of the Naknek and Bristol Bay area are discussed. From this overview a relationship is found between escapement, numbers, and age at outmigration, and water temperatures. Tables included show the 1921 through 1953 escapement estimates for the Naknek River system and the ocean water temperatures for summer months.

Keywords: Naknek River, Naknek Lake, Brooks River, Brooks Lake, Grosvenor Lake, Coville Lake, Savanoski River, sockeye salmon, fish migration, fish populations, spawning, census,

smolt, juvenile fish, weirs, age, growth rates, water temperature, tagging, mortality, environmental effects.

*Eicher, G. J. 1964. Differential productivity of Bristol Bay spawning grounds. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Manuscript Report 16. 9 pp.

An analysis comparing the utilization and important of the three types of sockeye salmon spawning grounds in the Naknek River system.

Keywords: sockeye salmon, Naknek River, spawning, productivity.

*Eicher, G. J. 1967. History of the Bristol Bay investigation 1938-1956. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Manuscript Report 6-67. 13 pp.

This report is a year by year account of activities in the Bristol Bay area by U.S. Bureau of Commercial Fisheries biologists.

Keywords: Naknek River, Naknek Lake, Brooks River, Brooks Lake, Hidden Creek, Coville Lake, Grosvenor Lake, sockeye salmon, weirs, spawning, fish migration, smolt, fish ladders, waterfalls, fish barriers.

*Eicher, G. J. 1971. The effects of laddering a falls in a salmon stream. U. S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Manuscript Report 84. 5 pp.

The observed effect on the weir counts of a fish ladder built around the Brooks River falls in 1950 is discussed. Counts for 1940 through 1955 and pictures of both the falls and the ladder are included.

Keywords: Brooks River, Kidawik Creek, sockeye salmon, chum salmon, Chinook salmon, pink salmon, coho salmon, rainbow trout, fish migration, spawning, fish barriers, census, weirs, fish ladders, waterfalls, age, growth rates, discharge (water).

Eicher, G. J., and G. A. Rounsefell. 1957. Effects of lake fertilization by volcanic activity on abundance of salmon. Limnology and Oceanography. 2:70-76.

The Naknek drainage was the only sockeye salmon producer that received significant ash from the 1912 Mt. Katmai eruption. Evidence from various sources indicate that nutrients from such ash have a positive effect on salmon productivity. Limited data comparing the Naknek to other Bristol Bay drainages and supporting this theory are included.

Keywords: sockeye salmon, Savonoski River, Naknek Lake, Brooks Lake, soil chemical properties, fertility, volcanoes, productivity, water chemistry, plankton, Iliuk Arm, juvenile fish, hardness (water), silica, nitrites, carbon dioxide.

*Ellis, R. J. 1963. The abundance and distribution of juvenile red salmon and associated species in lakes of the Naknek River system and Karluk Lake. U.S. Bureau of Commercial Fisheries, Auke

Bay Biological Laboratory. Manuscript Report 63-2. 80 pp.

This report is a summary of the first year's (1961) study of the distribution, abundance, and growth of juvenile red salmon in the lakes of the Naknek River system and Karluk Lake. 1960 and 1961 escapements of sockeye salmon and water temperatures from various locations are included.

Keywords: Naknek Lake, Naknek River, South Bay, Iliuk Arm, Brooks Lake, Brooks River, Coville Lake, Coville River, Grosvenor Lake, Grosvenor River, sockeye salmon, fyke nets, nets, juvenile fish, fry, smolt, age, growth rates, fish populations, fish migration, standing crops, smelts, sticklebacks, whitefish, American Creek, spawning, water temperature, euphotic zone.

*Ellis, R. J. 1974. Distribution, abundance, and growth of juvenile sockeye salmon, *Oncorhynchus nerka*, and essociated species in the Naknek River system, 1961-64. U.S. National Marine Fisheries Service. Special Scientific Report-Fisheries 678. 53 pp.

A report on studies to determine utilization by sockeye salmon of the eight interconnected, but distinct basins of the Naknek River system. Bathymetry, morphometry, and water chemistry data for the various basins are summarized; and the distribution of spawners from 1959 through 1963 with a correlation between their numbers and smolt production is presented. Tow nets were used to determine the patterns of interlake migration by presmolt sockeye salmon. A detailed chart presents catches and location of catches of various species of fish, and some discussion and data on predation by other species is included. The summary of this report suggests that the variability of aquatic habitats within the Naknek drainage gives great stability to the system's capacity for producing sockeye salmon.

Keywords: sockeye salmon, Naknek River, Naknek Lake, American Creek, Coville Lake, Coville River, Grosvenor Lake, Hardscrabble Creek, Grosvenor River, Savonoski River, Iliuk Arm, South Bay, Brooks River, Brooks Lake, Headwater Creek, North Arm, Bay of Islands Creek, Northwest Basin, West End, juvenile fish, smolt, fish migration, fish populations, census, zooplankton, age, length, waterfalls, bathymetry, lake morphometry, productivity, water chemistry, hydrogen ion concentration, alkalinity, spawning, nets, fyke nets, weirs, smelts, sticklebacks, coho salmon, whitefish, lampreys, cisco, burbot, Arctic char, Dolly Varden char, northern pike, lake trout, aquatic plants, growth rates, fecundity, Margot Creek, predation, gulls, ducks, rainbow trout.

*Ellis, R. J., and W. L. Hartman. 1967. Catalog of the streams of the Naknek River system, Bristol Bay, Alaska. U.S. Bureau of Commercial Fisheries, Auke Bay Biological Laboratory. Manuscript Report.

(Unable to obtain - referenced in Wallace, 1969)

*Ellis, R. J., and W. McNeil. 1975. Possible management procedures for maximum production of sockeye salmon in the Naknek River system, Katmai National Monument, Alaska. Unpublished.

Paper for presentation at the American Institute of Biological Sciences meeting, Corvallis, or. 7 pp.

The development of salmon within the Naknek River system is discussed, including calculations showing underutilization of the peripheral basins and suggestions for enhanced recruitment to them.

Keywords: sockeye salmon, Naknek Lake, North Arm, Northwest Arm, Brooks Lake, juvenile fish, spawning, fish migration, Creek, Brooks River, Headwaters Creek, Bay of Islands Creek, Coville Lake, nets, fecundity, mortality, waterfalls, aquiculture.

*Ellis, R. J. and W. J. McNeil. In press. Possible management procedures for maximum production of sockeye salmon in the Naknek River system, Katmai National Monument, Alaska. NOAA Technical Report NMFS SSRF. 19pp.

Basic Productivity of the Naknek River drainage is evaluated along with this system's capacity to produce sockeye salmon naturally. Factors limiting sockeye salmon production are discussed and management procedures for increasing productivity are proposed.

Keywords: sockeye salmon, aquiculture, spawning, productivity, juvenile fish, fish migration, sticklebacks, whitefish, smelts, Brooks Lake, North Arm, Northwest Basin, age, Naknek Lake, Coville Lake, Grosvenor Lake, Iliuk Arm, South Bay, West End, smolts, predation, nets, fecundity, mortality.

Faustini, M. A. 1996. Status of rainbow trout in the Goodnews River, Togiak National Wildlife Refuge, Alaska, 1993-1994. Alaska Fisheries Technical Report Number 36, U.S. Fish and Wildlife Service, King Salmon, Alaska.

Abstract from report: To monitor stock status, the rainbow trout population of the Goodnews River was sampled from June 1993 through August 1994. A total of 570 rainbow trout was captured using hook and line gear. Lengths ranged from 226-625 mm, and ages from scales ranged from 2-9 years. The length and age frequency distributions of rainbow trout from the North Fork were significantly different from that of the Middle Fork. Fifteen flights relocated 18 of 21 radio tagged rainbow trout between October 18, 1993 and August 18, 1994. Most fish moved less than 10 km throughout the year. The limited annual migration of rainbow trout shows that all waters where rainbow trout occur in the Goodnews Drainage should be considered important for spawning and overwintering. Length and age frequency distributions were compared to data collected in 1988-1989. In 1993- 1994, on both the Middle Fork drainage and the North Fork, fewer large rainbow trout were caught, and on the North Fork, a smaller maximum size was recorded. The age distributions of fish from the Middle Fork were significantly different from each other, while those from the North Fork were not different. While the changes may be attributed to natural variation, these populations warrant continued monitoring. We recommend that long term monitoring continue and that the incidence and effects of hooking mortality on rainbow trout within the drainage be determined. Arctic grayling

and *Salvelinus* spp. populations should continue to be monitored as part of the rainbow trout studies. To fulfill the Refuge objective to conserve fish and wildlife populations and habitats in their natural diversity, it is further recommended that public use be controlled at near present levels.

Keywords: rainbow trout, Arctic grayling, Arctic char, Dolly Varden, Goodnews River, radio tracking, Togiak National Wildlife Refuge Alaska

*Goldman, C. R. 1958. Primary productivity and limiting factors in three lakes of the Alaska Peninsula. Ph.D. Thesis. University of Michigan, Ann Arbor. 96 pp.

This thesis is duplicated in Goldman, 1960.

Keywords: Naknek Lake, Brooks Lake, Headwaters Creek, Ukak River, Iliuk Arm, Savonoski River, phytoplankton, diatoms, zooplankton, primary productivity, nutrients, water chemistry, nutrient requirements, lake morphometry, light penetration, volcanoes, photosynthesis, euphotic zone, magnesium, phosphorus, nitrates, turbidity, cultures, lake sediments, hot springs, calcium, sodium, potassium, hardness (water).

*Goldman, C. R. 1960. Primary productivity and limiting factors in three lakes of the Alaska Peninsula. Ecological Monographs. 30(2):207-230.

Primary productivity and nutrient chemistry measurements 8, and studies are reported and compared for Brooks and Naknek Lakes.

Keywords: Naknek Lake, Brooks Lake, Headwaters Creek, Ukak River, Iliuk Arm, Savonoski River, phytoplankton, diatoms, zooplankton, primary productivity, nutrients, water chemistry, nutrient requirements, lake morphometry, light penetration, volcanoes, photosynthesis, euphotic zone, magnesium, phosphorus, nitrates, turbidity, cultures, lake sediments, hot springs, calcium, sodium, potassium, hardness (water).

*Goldman, C. R. 1964. Primary productivity and micronutrient limiting factors in some North American and New Zealand lakes. Verhandlugen Internationale Vereinigung fur Theoretische and Angewandte Limnologie. 15:365-374.

Results of carbon-14 bioassays on Brooks and Naknek Lakes using nutrients (nitrate, sulfate, magnesium), vitamins (BI2, thiamine, biotin) and some trace elements are discussed.

Keywords: Brooks Lake, Naknek Lake, vitamins, nutrient requirements, nutrients, deficient elements, productivity.

*Goldman, C. R. and T. R. Merrell. 1957. Salmon survival investigations, Red salmon studies at

Brooks Lake. U.S. Fish and Wildlife Service. 4 pp.

A plan of research for primary productivity measurements in Brooks and Naknek Lakes is presented. Additional studies on possible limiting effects of nutrients are proposed.

Keywords: primary productivity, Naknek Lake, Brooks Lake, Nutrient requirements, vitamins, magnesium, potassium, calcium, phytoplankton.

*Greenbank, J. 1967. Sport fish survey, Katmai National Monument, Alaska. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Manuscript Report 35. 30 pp.

This report of a 1954 survey done in the Naknek drainage includes species caught, observations on parasites and stomach contents and locations of the catches. Aquatic vegetation and beaver activity for some locations is noted. The U.S. Bureau of Fisheries predator fish destruction program conducted from 1920 through 1925 and the predator fish bounty system continued into the late 20s are also described.

Keywords: sockeye salmon, sport fishing, Naknek Lake, Naknek River, Brooks Lake, Coville Lake, Grosvenor Lake, water chemistry, whitefish, cisco, rainbow trout, Dolly Varden char, northern pike, grayling, lake trout, suckers, lampreys, Pike Lake, Idavain Lake, Muriel Lake, Jojo Lake, Ukak River, Zero Creek, One Shot Creek, beavers, impoundments, coho salmon, pink salmon, chum salmon, Arctic char, aquatic plants, sticklebacks, sculpins, snails, burbot, Pacific cod, food habits, predation, animal parasites, creel census, algae, age, growth rates, length, weight, subsistence fishing, fish harvest, regulation, commercial fishing.

*Gwartney, L. A. 1975. Inventory and cataloging of the sport fish and sport fish waters of the Bristol Bay area. Pages 103-120 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska, Project F-9- 7, Study G-1. Annual Performance Report, 1974-1975. Vol. 16.

Chinook salmon, *Oncorhynchus tshawytscha*, catches by commercial, subsistence, and sport fishermen are presented for 1969-1974 for the Naknek River. Chinook salmon escapement estimates are presented for the Naknek and Branch river systems. Harvests of other sport fish are included.

Keywords: Naknek River, Chinook salmon, rainbow trout, sockeye salmon, grayling, census, creel census, sport fishing, commercial fishing, subsistence fishing, fish migration, spawning.

*Gwartney, L. A. 1976. Inventory and cataloging of the sport fish and sport fish waters of the Bristol Bay areas. Pages 87-105 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-9- 8. Study G-1. Annual Performance Report, 1975-1976. Vol. 17.

Data obtained from voluntary creel census implemented at Brooks Camp in 1975 are recorded. Sockeye salmon escapement estimates based on aerial surveys and rainbow trout spawning surveys are also included.

Keywords: Naknek River, Pauls Creek, Big Creek, King Salmon Creek, Brooks River, American River, rainbow trout, Chinook salmon, sockeye salmon, grayling, creel census, census, Brooks Camp, sport fishing, fish harvest, Smelt Creek, growth rates, spawning, fish migration.

*Gwartney, L. A., and R. Russell. 1977. Inventory and cataloging of sport fish in sport fish waters of the Bristol Bay area. Pages 95-118 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-9-9, Study G-1. Annual Performance Report, 1976-1977. Vol. 18.

This report of the second year of voluntary creel census at Brooks Camp tabulates sport fish harvest of Chinook salmon for 1967-76, Chinook escapement for 1970-76, and rainbow trout spawning survey counts for 1972-1976. A comparison of Brooks River creel census figures for 1954 with 1975 and 1976 shows a shift from heavy dependence on rainbow trout in 1954 to recent large catches of sockeye salmon and grayling. Subsistence fishery statistics are included.

Keywords: Brooks Camp, Brooks River, Naknek River, Chinook salmon, Smelt Creek, Big Creek, rainbow trout, creel census, sport fishing, census, Arctic grayling, Dolly Varden char, sockeye salmon, lake trout, pike, coho salmon, spawning, fish migration, fish populations, Pauls Creek, King Salmon Creek, subsistence fishing, commercial fishing.

Gwartney, L. A. 1981.Inventory and cataloging of sport fish and sport fish waters of the Bristol Bay area. Annual performance report. Alaska Department of Fish and Game, Sport Fish Division.

Abstract from report: Since the mid 1950's, the rainbow trout, Salmo gairdneri Richardson, of the Naknek River system in Bristol Bay have received more fishing pressure than those of any other system in the area. Within the past 5 years, however, research studying the effect of angling pressure and condition of the stocks has been very limited. A comprehensive study was initiated in 1981 to define population parameters, fish movements and sport angling effort in the Naknek River drainage. This study continued in 1982. During April and Hay 1982, an estimate of 2,000 spawning Naknek River rainbow trout was made and, of these, 119 were tagged. Sizes of fish and subsequent recoveries are presented and discussed. A creel census was also initiated to estimate the numbers of rainbow trout caught and kept in the Naknek River at Lake Camp. In addition to catch data, fish retained were measured, weighed and scales taken for age analysis. Results of these studies are summarized and discussed. Estimates of rainbow trout spawners in index streams of the Bristol Bay area were conducted and presented, as are chinook salmon, *Oncorhynchus tshawytscha* (Walbaum), escapement estimates of the Naknek drainage. Hean lengths and weights of Arctic grayling, *Thymallus arcticus* captured at Ugashik Lake Outlet between 1978 and 1982 are presented.

Keywords: Rainbow trout, Arctic grayling, Chinook salmon, Naknek River, Brooks Camp Iliamna Lake, Tagging and Escapement.

Gwartney, L. A. 1983. Naknek drainage rainbow trout study. 1983 interim report. Alaska Department of Fish and Game , King Salmon, Alaska.

Background from report: The Bristol Bay area includes all waters draining into Bristol Bay from Cape Newenham to Port Heiden (Figure 1). The area contains some of the best recreational fishing within the State. Although effort is locally heavy on coho salmon, chinook salmon, Arctic grayling and Dolly Varden char, the rainbow trout of Bristol Bay have always demanded the attention of the Division of Sport Fish more than any other single species. Concerns by all individuals involved with rainbow trout have influenced the Board of Fisheries and the Federal government before statehood to adopt very restrictive angling.methods and fishing seasons to insure the continual survival of these wild trout populations. With anticipated increases in fishing effort, it is imperative that the managing agencies continue to update and expand their knowledge of this species. To provide statistically sound estimates of catch and effort and to continue to learn about migrations, areas of concentration, and spawning behavior the Alaska Department of Fish and Game funded by the National Park Service has initiated a two year drainage wide study. Rainbow trout were studied extensively between 1971 and 1976 at Lower Talarik Creek, located on the north shore of Lake Iliamna, and a comprehensive report was completed in 1977 (Russell, 1977). Since this study was completed, rainbow trout spawning surveys and sporadic creel census studies have been conducted on selected streams in the Iliamna area. Within the Bristol Bay area however, the Naknek drainage has received more recreational angling effort than any other river system. Major areas of angler concentrations include Naknek River and Brooks River with smaller amounts of effort throughout the system.

Keywords: Bristol Bay, rainbow trout, Talarik Creek, Naknek drainage, Lake Iliamna, Brooks River, Naknek River.

Gwartney, L. A. 1984. American and Idavain Creek rainbow surveys. Alaska Department of Fish and Game, Sport Fish Division, King Salmon, Alaska.

Report includes fishing survey data from Idavain Creek and American Creek, data on the distribution, abundance, size and age was collected during fish samples. Scales were taken and fish were tagged during the pilot study of these water bodies.

Keywords: American Creek, Idavain Creek, rainbow trout, dolly varden, jet boat.

Gwartney, L. A. 1984. Bristol Bay sport fish status report.

Introduction from report: The Bristol Bay Sport Fish Area encompasses all waters flowing into Bristol Bay from Cape Newenham to Port Heiden. Within the area, some of the world's best rainbow trout, grayling, salmon, and char fishing await the angler's lure. Along with these populations of exceptional sport fish, there remains a constant challenge to maintain or enhance their numbers through the regulatory process) to keep the area open to the maximum number of anglers, and to continually inform and educate the angling public. Research programs are designed to help answer questions about sport fish population, harvest, and size parameters of

important species within the area. Results hopefully lead to meaningful, logical, and enforceable regulations.

Keywords: Bristol Bay, rainbow trout, status report, Brooks Lake.

Gwartney, L. A. 1984. Naknek drainage rainbow trout study. 1984 interim report. Alaska Department of Fish and Game, King Salmon, Alaska.

Background from report: The Bristol Bay area includes all waters draining into Bristol Bay from Cape Newenham to Port Heiden (Figure 1). The area contains some of the best recreational fishing within the State. Although effort is locally heavy on coho salmon, chinook salmon, Arctic grayling and Dolly Varden, the rainbow trout of Bristol Bay have always received more attention than any other single species. Individuals concerned about rainbow trout management have influenced the Alaska Board of Fisheries and the Federal government to adopt very restrictive angling methods and fishing seasons to ensure the continual survival of these wild trout populations. With anticipated increases in fishing effort, it is imperative that the managing agencies continue to update and expand their knowledge of this species. To provide statistically sound estimates of catch and effort and to continue to learn about migrations, areas of concentration and spawning behavior, the Alaska Department of Fish and Game, funded by the National Park Service, initiated a study in the Naknek River drainage, which will be completed in 1985. Rainbow trout were studied extensively between 1971 and 1976 at Lower Talarik Creek, located on the north shore of Lake Iliamna (Figure 1), and a comprehensive report was completed in 1977 (Russell, 1977). Since this study was completed,· rainbow trout spawning surveys and sporadic creel census studies have been conducted on selected streams in the Iliamna area. Within the Bristol Bay area, however, the Naknek drainage has received more recreational angling effort than any other river system. Major areas of angler concentration include Naknek River, Bay of Is lands and Brooks River, with minimal effort occurring throughout the remainder of the system (Figure 2). Greenbank (1954) provides an excellent description of all major water bodies in the drainage. The first significant recreational utilization of the Naknek River stocks originated in the mid-1950's when two military recreational camps were established on the Naknek River. The camps were named Lake and Rapids Camp (Figure 3) and provided military personnel access to some of the world's finest fishing. Between 1956 and 1974 these two camps operated annually, fishing primarily for rainbow trout in the early years, and for rainbow trout, chinook and sockeye salmon in the" later years. During these years, a voluntary creel census operated at each camp, provided the only estimates on numbers of fish retained and size of fish caught. While these data lacked statistical analyses, they do provide a minimal number of fish harvested. Catches ranged from 644 rainbows in 1966 to 2,621 in 1957 (Appendix 1). From 1956 through 1962 the average length of rainbow trout caught at the military recreation camps fluctuated from 14.6 to 19.6 inches (Paddock, 1964). In 1974, the two camps were permanently closed resulting in a reduction of effort during subsequent years on all species.

Keywords: Bristol Bay, rainbow trout, Talarik Creek, Naknek drainage, Lake Iliamna, Brooks River, Naknek River.

Gwartney, L. A. 1984. Naknek drainage rainbow trout study radio tagging. 1984 interim report. Alaska Department of Fish and Game, King Salmon, Alaska.

Background from report: Movements of rainbow trout in the Naknek system have always been of prime interest to both anglers and biologists. Tagging, primarily with Floy tags, has been done throughout the system since 1966. Recoveries have provided managing agencies with some knowledge of rainbow trout movements, however, due to the low recovery rate particularly in areas which receive little angling pressure, many unanswered questions remain. To better define movements and population structures of rainbow trout in the Naknek system, tagging utilizing radio telemetry equipment was initiated. The United States Fish and Wildlife Service provided all receiving equipment, antennas and expertise associated with the project. The Alaska Department of Fish and Game purchased and implanted the transmitters, conducted aerial tracking of radio tagged trout, and provided periodic updates of rainbow trout movements.

Keywords: radio telemetry, transmitters, rainbow trout, Naknek system, aerial tracking.

Gwartney, L. A. 1984. Radio transmitters in Naknek rainbow. Sport Fish Division. Alaska Department of Fish and Game, King Salmon, Alaska.

Report describes that transmitters were placed in 24 rainbow trout in the Naknek River near the mouth of Naknek Lake. Movements of the trout were tracked from the air and data about rainbow movements in the system recorded.

Keywords: radio telemetry, transmitters, rainbow trout, Naknek system, aerial tracking.

Gwartney, L. A. 1985. Naknek drainage rainbow trout study in the Katmi National Park and Preserve. Sport Fish Division. Alaska Department of Fish and Game, King Salmon, Alaska.

Abstract from report: Within Alaska, the Naknek drainage in Bristol Bay offers anglers some of the world's best opportunities to catch wild rainbow trout. While the trout populations appear stable, concern by the managing agencies and angling public resulted in this study to better understand life history of the involved stock. Several creel censuses were conducted to determine numbers of trout caught and kept in the Naknek River, Brooks River and Bay of Islands portion of Naknek Lake in 1983 and 1984. Census data are presented and compared to previous estimates since 1977. Length frequencies from trout retained by anglers on the Naknek River between 1981 and 1984 are presented. Between 1981 and 1985, over 2,800 trout were tagged throughout the drainage utilizing Floy tags. Over 300 recoveries were made. Movements and areas of trout concentrations are presented. In conjunction with tagging, length frequencies of captured trout are presented for Naknek River, Brooks River, American Creek and Idavain Creek. Length-weight comparisons were made for Naknek River rainbows during 1981, 1982 and 1983. Spawning surveys were accomplished in all major tributaries. Numbers of trout observed by stream are presented and discussed. Sufficient scales were collected from the Naknek River, Brooks River, American and Idavain Creeks to develop age-length relationships for each stream. Statistical comparisons between streams are made and presented.

Keywords: Brooks River, American Creek, Idavain Creek, Naknek River, Bristol Bay, rainbow trout.

Gwartney, L. A. 1985. Draft rainbow trout management plan for Bristol Bay and southwest Alaska. Sport Fish Division. Alaska Department of Fish and Game, King Salmon, Alaska.

Background from report: The Bristol Bay/Southwest Alaska area includes all Bristol Bay drainages north of the Egegik/King Salmon rivers, the Togiak Bay drainages, the Kuskokwim Bay drainages and those lower Kuskokwim River tributaries from the Kwethluk River upstream to the Aniak River (Figure 1). Sport fishery harvest and effort estimates for the years 1977 to 1984 are summarized from the Alaska Statewide Harvest Survey (Table 1). Approximately 60,000 man-days of angling effort are expended annually in the Bristol Bay/Southwest Alaska area. This annual angling effort (all species) has doubled since 1979 and rainbow trout harvest has risen proportionally from 3,000-4,000 fish annually in the late 1970' s to a recent average of nearly 9,000 [1982 to 1984]. Rainbow trout harvest rate, the number of trout kept per angler per day of fishing in Bristol Bay/Southwest Alaska area, has remained surprisingly consistent over this period, 1977 to 1984. On the average, anglers have retained about one rainbow trout for every seven days spent sport fishing in this area (range approximately 5 to 9 days per trout). This equates to an average of 0.15 rainbow trout harvested per man-day of fishing effort. Note that this is not a reflection of catch rate or fish abundance but only the numbers and rate at which trout are retained during fishing.

Keywords: rainbow trout, abundance, Bristol Bay, Southwest Alaska, Togiak Bay, Kuskokwim Bay drainages.

Hamon, T. R. 1999. Katmai documented fish species.

Report presents a list of the documented fish species of Katmai National Park.

Keywords: Katmai National Park, documented fish species.

Hamon, T. R. et al. 2000. Selection on morphology of spawning wild sockeye salmon by a gill net fishery. Transitions of the American Fisheries Society 129: 1300-1315, 2000.

Abstract found in report: Human activities can cause artificial selection in wild animals. To examine the effects of gill-net selectivity on locally differentiated populations of sockeye salmon *Oncorhynchus nerka* in Bristol Bay, Alaska, we completed a three-part study: (1) We showed differentiation in the body form of mature sockeye salmon spawning in beach and stream habitats that were separated by less than 300 m. (2) Because gill-net selection acts directly on the girth of immature sockeye salmon, we correlated girth at capture with the morphological characters distinguishing locally differentiated populations on the spawning grounds. By tagging individual fish and measuring them both when immature and when mature, we found morphology at maturity to be highly correlated with girth during immaturity. (3) Using selection regimes from the fishery catch and escapement data for 1994, we examined the effects of gill-net selectivity on populations of mature adults. We showed that although populations of mixed ocean age-classes

may be subject to disruptive selection, single age-class populations are more likely to experience directional selection. The effect of this selection depends on cumulative selection pressures, which probably include natural and sexual selection on this trait. Even so, gill-net selection can be a strong selective force, resulting in significant additional selection on body size and shape within populations.

Keywords: Human activities, sockeye salmon, gill-net, selection, escapement, Bristol Bay

*Harry, G.Y. et al. 1964. Summary report of studies on the optimum escapement of sockeye salmon in southwestern Alaska, 1961-62. U.S. Bureau of Commercial Fisheries, Auke Bay Biological Laboratory. Manuscript Report 64-2. 119 pp.

A summary of two years of intensive research on major southwest Alaskan sockeye salmon river systems (including Naknek), this report analyzes historical and current run data numerically and biologically. Morphometric, freezing, and water chemical characteristics of various lakes and basins within the system are presented, and estimates of total potential spawning area and the number of redd sites are calculated. Comparisons with other Bristol Bay drainages and optimum or target escapement levels are discussed.

Keywords: Naknek River, Naknek Lake, Brooks River, Brooks Lake, Grosvenor River, Grosvenor Lake, Coville Lake, American Creek, sockeye salmon, juvenile fish, smolt, Iliuk Arm, fish migration, fish populations, spawning, predation, mortality, age, length, growth rates, water chemistry, productivity, primary productivity, lake morphometry, hydrogen ion concentration, depth, area, volume, density, sticklebacks, smelts, whitefish, coho salmon, lake trout, northern pike, Dolly Varden char, Arctic char, nets, dissolved solids, alkalinity, sodium, potassium, magnesium, nitrate, silica, iron,- manganese, calcium, boron, phytoplankton, secchi disks, photosynthesis, thermal stratification, light penetration, ice cover, thermocline.

*Hartman, W. L. 1959a. Red salmon spawning behavior. Pages 48-49 in Science in Alaska. Proceedings of the 9th Alaska Science Conference, Fairbanks, 1958. Alaska Div., American Association for the Advancement of Science. (Abstr.)

Observations of sex ratios, redd building, defense of redd territory and 2.ctual spawning are recorded for the Brooks River in 1957.

Keywords: fish behavior, Brooks River, sockeye salmon, spawning.

*Hartman, W. L. 1959b. Salmon survival investigations. Red salmon studies at Brooks Lake. Field operations report, 1958. U.S. Bureau of Commercial Fisheries, Brooks Lake Laboratory. Manuscript Report. 160 pp.

Ecological studies on the freshwater phases of the life history of sockeye salmon and studies on related limnology and climatology were made at Brooks Lake, Alaska, in 1956. Data are presented and interpreted on adult sockeye salmon spawning distribution and behavior, age, sex. length, fecundity, and bear predation; on juvenile sockeye salmon ages·, food, growth, migration from the lake, relative abundance, and distribution in the lake; and salmon behavior and abundance.

Keywords: sockeye salmon, fish migration, spawning, fish populations, weirs, census, fish behavior, chum salmon, Chinook salmon, coho salmon, pink salmon, age, growth rates, length, fecundity, One Shot Creek, Hidden Creek, Up A Tree Creek, Headwaters Creek, mortality, predation, juvenile fish, smolt, fyke nets, food habits, rainbow trout, Dolly Varden char, lake trout, whitefish, sculpins, Alaska, blackfish, sticklebacks, weight, zooplankton, phytoplankton, productivity, primary productivity, animal parasites, water temperatures, phosphorus, nitrogen, silica, nitrites, turbidity, dissolved oxygen, hardness (water), alkalinity, aquatic plants, Naknek Lake, gulls, bathymetry, light penetration, secchi disks, hydrogen ion concentration.

*Hartman, W. L. 1960. Red salmon studies, field operations report, 1959. U.S. Bureau of Commercial Fisheries, Brooks Lake Laboratory. Manuscript Report. 88 pp.

(Unable to obtain--referenced in Hoopes, 1962a)

*Hartman, W. L. 1971. Alaska's fishery resources--The sockeye salmon. U.S. Dept. of Commerce. Fishery Leaflet 636. 8 pp.

A general discussion of sockeye salmon life cycle and harvests which includes a photograph of the Brooks Lake weir.

Keywords: Brooks Lake, fish barriers, fish migration, sockeye salmon, weirs, Brooks River.

*Hartman, W. L., and R. L. Burgner. 1972. Limnology and fish ecology of sockeye salmon nursery lakes of the world. Journal of the Fisheries Research Board of Canada. 29(6):699-715.

Physical, chemical and morphometric characteristics of the lakes, as well as competing fish species, are summarized and included in this discussion which specifically includes Naknek, Brooks, and Coville Lakes.

Keywords: Naknek Lake, Brooks Lake, Coville Lake, sockeye salmon, lake morphometry, water chemistry, juvenile fish, fish migration, fish populations, prey fish, fish behavior, competition, sticklebacks, whitefish, zooplankton, sculpins, Dolly Varden char, Arctic char, rainbow trout.

*Hartman, W. L., and C. Y. Conkle. 1960. Fecundity of red salmon at Brooks and Karluk Lakes, Alaska. Fishery Bulletin. 61(180):53-60.

Egg counts from the ovaries of a sample taken from Brooks Lake over a two year period averaged slightly under 4,000 eggs per female sockeye salmon.

Keywords: sockeye salmon, Brooks Lake, fecundity.

*Hartman, W. L., and R. F. Raleigh. 1962a. Tributary homing of sockeye salmon at Brooks and Karluk Lakes, Alaska. American Zoologist. 2(3):414 (Abstr.)

Experimental studies were conducted showing that sockeye salmon showed an extremely strong preference for particular spawning areas and could not be persuaded to spawn in alternative locations.

Keywords: Brooks Lake, sockeye salmon, fish migration, fish behavior, spawning.

*Hartman, W. L and R. F. Raleigh 1962b. Tributary homing of sockeye salmon at Brooks and Karluk Lakes, Alaska. Journal of the Fisheries Research Board of Canada. 21(3):485-504.

The experimental studies of sockeye salmon preference for particular spawning areas conducted in Brooks Lake and its tributaries are reported in detail.

Keywords: sockeye salmon, Brooks Lake, Brooks River, West Creek, Headwaters Creek, Hidden Creek, One Shot Creek, Up A Tree Creek, fish migration, spawning, fish behavior, weirs, tagging, fish populations, fish genetics.

*Hartman, W. L., W. R. Heard, and R. Dewey. 1964. Sockeye salmon studies at Brooks Lake biological field station, 1963. U.S. Bureau of Commercial Fisheries, Auke Bay Biological Laboratory. Manuscript Report 64-7. 36 pp.

Weir counts for spawning sockeye salmon and estimates of out migrating fry are given for Brooks Lake and its tributaries for the 1963 season. The findings of a 10 year study of the interactions between threespine stickleback and sockeye fry, and the apparent effects of various chemical and physical factors on productivity and egg development are also discussed.

Keywords: Brooks Lake, Brooks River, Naknek Lake, sockeye salmon, fish migration, fish populations, spawning, juvenile fish, smolt, weirs, nets, coho salmon, pink salmon, Chinook salmon, chum salmon, age, length, rainbow trout, growth rates, fecundity, mortality, Up A Tree Creek, One Shot Creek, Hidden Creek, Headwaters Creek, West Creek, fish behavior, productivity, sticklebacks, competition, water chemistry, water temperature, zooplankton, trace elements, phytoplankton.

*Hartman, W. L., W. R. Heard, and R. Dewey 1966. Sockeye salmon studies at Brooks Lake biological field station, 1964-65. U.S. Bureau of Commercial Fisheries, Auke Bay Biological Laboratory. Manuscript Report 2-66. 46 pp.

Weir counts for the 1964 and 1965 seasons, sockeye spawning found surveys for Brooks River, a table listing fish observed in the Brooks River, and a map showing known spawning areas for the various species are included. Studies of embryological development, and limnological comparisons to other sockeye salmon drainages are discussed.

Keywords: Brooks Lake, Brooks River, Naknek Lake, sockeye salmon, fish migration, fish populations, juvenile fish, smolt, spawning, coho salmon, Chinook salmon, weirs, gill nets, nets, length, growth rates, age, rainbow trout, fecundity, mortality, Hidden Creek, West Creek, fish behavior, One Shot Creek, Up A Tree Creek, Headwaters Creek, Bluff Cove, lampreys, cisco,

whitefish, lake trout, Dolly Varden char, Arctic char, grayling, Alaska blackfish, suckers, sticklebacks, sculpins, water temperature, water chemistry, primary productivity, trace elements, phytoplankton, dissolved solids.

*Hartman, W. L., W. R. Heard, and B. Drucker. 1967. Migratory behavior of sockeye salmon fry and smolts. Journal of the Fisheries Research Board of Canada. 24(10):2069-2099.

Studies of sockeye salmon smolt and their migratory behavior, including underwater observations are reported. Light, water temperature, wind and currents were all found to affect smolt behavior.

Keywords: sockeye salmon, juvenile fish, fry, fish migration, fish behavior, lake trout, spawning, One Shot Creek, Hidden Creek, Brooks Lake, Brooks River, Naknek Lake, Naknek River, Coville Lake, water temperature, light intensity, depth, predation, Grosvenor Lake, ice cover, smolt.

*Hartman, W. L., W. R. Heard, and C. W. Strickland. 1961. Red salmon studies, field operations report, 1960. U.S. Bureau of Commercial Fisheries, Brooks Lake Laboratory. Manuscript Report. 54 pp.

(Unable to obtain--referenced in Hoopes 1962a)

*Hartman, W. L., W. R. Heard, and C.W. Strickland 1962. Red salmon studies at Brooks Lake biological field station, 1961. U.S. Bureau of Commercial Fisheries, Auke Bay Biological Laboratory. Manuscript Report 62-6. 53 pp.

Weir statistics for the 1961 season are reported. Survival of eggs and fry in stream gravels was investigated through the winter and the behavior of and predation upon spawning salmon in Hidden Creek was studied. The occurrence and distribution of fish species in the Naknek Lake system is presented in an extensive table.

Keywords: Brooks Lake, Brooks River, sockeye salmon, spawning, fish populations, fish migration, juvenile fish, smolt, weirs, length, age, growth rates, census, fecundity, mortality, West Creek, Hidden Creek, Up A Tree Creek, One Shot Creek, nets, chum salmon, Chinook salmon, pink salmon, coho salmon, rainbow trout, fish behavior, benthic fauna, smelts, predation, aquatic plants, char a , whitefish, sticklebacks, sculpins, Alaska blackfish, productivity, Naknek River, Naknek Lake, Coville Lake, Grosvenor Lake.

*Hartman, W. L., T. R. Merrell, and R. Painter. 1964. Mass spawning behavior of sockeye salmon in Brooks River, Alaska. Copeia. 1964 (2): 362-368.

A detailed description of spawning behavior of sockeye salmon in the Brooks River, including discussions of timing, redd size and density, redd guarding activity, and the pattern of spawning waves.

Keywords: Brooks River, sockeye salmon, spawning, fish behavior, fish migration.

*Hartman, W. L., C. W. Strickland, and D. T. Hoopes. 1962. Survival and behavior of sockeye salmon fry migrating into Brooks Lake, Alaska. Transactions of the American Fisheries Society. 92(2):133-139.

This paper describes the behavior of sockeye salmon fry during their migration from stream spawning gravels to lake nursery areas. Certain features of the migratory behavior are discussed in terms of survival values.

Keywords: sockeye salmon, Brooks Lake, Naknek Lake, Hidden Creek, fish migration, juvenile fish, fry, fish behavior, fyke nets, light intensity, predation, Dolly Varden char, rainbow trout, coho salmon, sculpins, food habits.

*Hartman, W. L. et al. 1963. Red salmon studies at Brooks Lake biological field station, 1962. U.S. Bureau of Commercial Fisheries, Auke Bay Biological Laboratory. Manuscript Report 63-6. 36 pp.

Details are presented concerning the operations of the Brooks River weir and the count of sockeye salmon and other species passing through it. Smolt out-migration sampling by trapping in the Brooks River and experimental research of homing orientation are described. Limnological, primary productivity, and lake resident fish data and a table showing principal zooplankters in the Naknek River system are also included.

Keywords: Brooks Lake, Brooks River, sockeye salmon, juvenile fish, smolt, spawning, fish migration, census, coho salmon, pink salmon, Chinook salmon, chum salmon, rainbow trout, weirs, nets, age, growth rates, length, mortality, fecundity, Hidden Creek, One Shot Creek, Up A Tree Creek, West Creek, Headwaters Creek, Naknek Lake, Coville River, Coville Lake, Grosvenor Lake, Naknek River, whitefish, sculpins, Alaska blackfish, sticklebacks, primary productivity, zooplankton, phytoplankton, copepods, rotifers, water temperature, Daphnia.

*Heard, W. R. 1962. The use and selectivity of small-meshed gill nets at Brooks Lake, Alaska. Transactions of the American Fisheries Society. 91(3):263-268.

Details B.re reported of catches of small mesh gill nets used to sample lake-dwelling juvenile sockeye salmon and associated small fishes in Brooks Lake.

Keywords: gill nets, Brooks Lake, sticklebacks, whitefish, Alaska blackfish, sculpins, sockeye salmon, coho salmon, rainbow trout, lake trout, Dolly Varden char, aquatic plants, Arctic char, growth rates, juvenile fish.

*Heard, W. R. 1964. Phototactic behavior of emerging sockeye salmon fry •. Animal Behavior. 12(2-3):382-388.

The emergence of sockeye salmon fry from streambed gravels was observed during periods of natural daylight and darkness as well as observations made using artificial illumination to eliminate darkness.

Keywords: sockeye salmon, Brooks River, juvenile fish, fry, light intensity, light penetration, fish n:.igration, spawning, fish behavior.

*Heard, W. R. 1965. Limnetic cottid larvae and their utilization as food by juvenile sockeye salmon. Transactions of the American Fisheries Society. 94,191-193.

Yearling sockeye salmon were captured with cottid larvae in their stomachs during July of 1959 and 1963, and predation on the larvae appears to be significant for a short period of time. *Cottus aleuticus* and *C. cognatus* are found in Brooks Lake and the surrounding streams. Habitat features, and sizes and times of larvae tow catches are discussed.

Keywords: Brooks Lake, sockeye salmon, sculpins, juvenile fish, fish food organisms, fish diets, plankton nets , predation, aquatic habitats.

*Heard, W. R. 1966. Observations on lampreys in the Naknek River system of out west Alaska. Copeia. 1966(22):332-339.

Lamprey captured in the Naknek system are described. Their behavior and their apparent effect on the various fish populations are discussed.

Keywords: lampreys, sockeye salmon, rainbow trout, whitefish, sticklebacks, Naknek River, Naknek Lake, Coville Lake, Grosvenor Lake, Brooks Lake, Brooks River, fish migration, spawning, growth rates, life cycles, fish behavior, fyke nets, weirs, parasitism, anadromous fish, juvenile fish, predation, food habits, Grosvenor River, ammocetes, sculpins, life history studies.

*Heard, W. R., and W. L. Hartman. 1966. Pygmy whitefish Prosopium coulteri, in the Naknek River system of southwest Alaska. Fishery Bulletin. 65:555-579.

This report examines in detail the pygmy whitefish, found throughout the Naknek River system. The studies were conducted in the South Bay of Naknek Lake and in Brooks Lake, and include size, age, and growth determinations, diets (based on stomach analyses), fecundity calculations, and depth ranges. Differences found between the two study populations are discussed.

Keywords: whitefish, Naknek Lake, Brooks Lake, Brooks River, South .Bay, Iliuk Arm, sockeye salmon, Grosvenor Lake, Coville Lake, Hammersley Lake, aquatic plants, predation, fish behavior, spawning, length, growth rates, age, sculpins, sticklebacks, cisco, competition, food habits, insects, zooplankton, midges, stoneflies, copepods, clams, nematodes, fecundity, sexual maturity, ice cover, Daphnia.

*Heard, W. R., R. L. Wallace, and W. L. Hartman. 1969. Distributions of fishes in fresh water of Katmai National Monument, Alaska, and their zoogeographical implications. U.S. Fish and Wildlife Service. Special Scientific Report-Fisheries 590. 20 pp.

Twenty-four species of fish are known within the Naknek drainage and each is discussed in fine detail. The present distribution of fish is discussed in terms of the area's geography, its postglacial evolution, and the pattern of fish movement following glaciation.

Keywords: lampreys, whitefish, cisco, pink salmon, chum salmon, coho salmon, sockeye salmon, Chinook salmon, rainbow trout, Arctic char, Dolly Varden char, lake trout, grayling, smelts, Alaska blackfish, northern pike, suckers, burbot, sticklebacks, sculpins, Naknek River, Naknek Lake, Brooks Lake, Pike Lake, West Creek, Headwaters Creek, Hidden Creek, One Shot Creek, Up A Tree Creek, Brooks River, Margot Creek, Bay of Islands Creek, Idavain Lake, Ukak River, Kagluik Creek, Muriel Lake, Savonoski River, Rainbow River, Grosvenor River, Jojo Lake, Hardscrabble Creek, Grosvenor Lake, Coville River, Coville Lake, American Creek, Hammersly Lake, Murray Lake, freshwater fish, anadromous fish, fish barriers, fish establishment, turbidity, aquatic plants, weirs, spawning, fish migration, juvenile fish, fry, aquatic habitats, glaciation, ice cover, waterfalls, Pacific cod, flounder.

Hillborn et al. 2003. Biocomplexity and fisheries sustainability. University of Washington, Seattle, Washington.

Description from report: A classic example of a sustainable fishery is that targeting sockeye salmon in Bristol Bay, Alaska, where record catches have occurred during the last 20 years. The stock complex is an amalgamation of several hundred discrete spawning populations. Structured within lake systems, individual populations display diverse life history characteristics and local adaptations to the variation in spawning and rearing habitats. This biocomplexity has enabled the aggregate of populations to sustain its productivity despite major changes in climatic conditions affecting the freshwater and marine environments during the last century. Different geographic and life history components that were minor producers during one climatic regime have dominated during others, emphasizing that the Biocomplexity of fish stocks is critical for maintaining their resilience to environmental change.

Keywords: Biocomplexity, Bristol Bay, sockeye salmon, life history, and environmental change

*Hoopes, D. T. 1962a. Ecological distribution of spawning sockeye salmon in three lateral streams, Brooks Lake, Alaska. Ph.D. Thesis. Iowa State University, Ames. 235 pp.

The results of a three year study of the distribution of spawning sockeye salmon on three tributaries of Brooks Lake (Hidden, One Shot and Up A Tree Creeks). This study considers possible ecological factors to explain the patterns observed. Factors include such things as stream gradients, gravel size, stream length and width, available refuge sites, etc.

Keywords: Brooks River, Brooks Lake, Hidden Creek, Up A Tree Creek, One Shot Creek, Headwaters Creek, sockeye salmon, fish migration, fish populations, spawning, fish behavior, gradients (stream), gravels, census, weirs, ice cover, predation, mortality, beavers, fish barriers, sculpins, sticklebacks, carnivores.

*Hoopes, D. T. 1962b. Distribution of spawning sockeye salmon in small lateral streams.

Unpublished. Paper for presentation at the 13th Alaskan Science Conference, Juneau.

(Unable to obtain.)

*Hoopes, D. T. 1972. Selection of spawning sites by sockeye salmon in small streams. Fishery Bulletin. 70(2):447-458.

This study to identify the factors that influence selection of spawning sites by sockeye salmon found that the composition of the stream bottom was more important than gradient, water depth, velocity or cover availability.

Keywords: sockeye salmon, Brooks Lake, Up A Tree Creek, Hidden Creek, One Shot Creek, fish migration, spawning, fish populations, fish behavior, weirs, census, depth, gradients (streams), bottom sediments, velocity, gravels, predation.

Horton, G. E. 1994. Effects of jet-driven and propeller-driven boat turbulence on salmonid reproduction. Alaska Cooperative Fish and Wildlife Research Unit. University of Alaska Fairbanks, Fairbanks, Alaska.

Introduction from report: Effort by freshwater anglers has more than doubled in southwestern Alaska during the last decade. Resource managers expect this increase to continue. As angling pressure increases, boat operators venture further into headwater streams to avoid crowding in the main channels. Jet-driven jon boats are the preferred vehicle for angling and other purposes (e.g., hunting and transport) because of their speed, maneuverability, and, especially, shallow draft. Shallow headwaters are also preferred by Pacific salmon (genus *Oncorhynchus*) and rainbow trout (*O. mykiss*) as sites of egg deposition (i.e., redds) for reproduction. Controversy continues over the effects of jet boats on salmonid reproduction because objective information from scientific studies is quite limited. A New Zealand study, published in 1975, used pressure measurements under a passing jet boat to simulate pressure effects on fertilized eggs (embryos) of chinook salmon (*O. tshawytscha*) in the laboratory. Because embryo mortality rates were as high as 40 percent, the investigators concluded that jet boats could kill significant portions of embryos in small, shallow streambeds. These findings have been questioned because the effects were the result of laboratory simulations, not field trials. Results of an unpublished (1988) study in a Missouri Ozark stream indicated that both jet-driven and propeller-driven jon boats caused significant substrate disturbance at water depths of 18-26 mm, but had no effect at 44 mm; jet boats had the lesser effect at 36 mm.

Keywords: Jet-driven, salmonid, propeller-driven, fertilized eggs, rainbow trout, Pacific salmon.

Irving, D. B. and M. A. Faustini. 1994. Status of rainbow trout in the Goodnews River, Togiak National Wildlife Refuge, Alaska, 1988 and 1989. U.S. Fish and Wildlife Service, King Salmon, Alaska.

Abstract from report: The population characteristics of rainbow trout (*Oncorhynchus mykiss*) in the Goodnews River on the Togiak National Wildlife Refuge (Refuge) were studied from June through September, 1988 and 1989. The study objectives were to: (1) describe length, weight, age, and sex composition of rainbow trout; (2) estimate the annual survival rate of each year class of rainbow trout vulnerable to the sport fishery; (3) estimate seasonal sport fishing catch rates of rainbow trout; (4) evaluate scale versus otolith ageing methods; (5) compare rainbow trout population characteristics with other southwest Alaska stocks; and (6) describe length and weight data of Dolly Varden and Arctic Char (*Salvelinus* sp.) and Arctic grayling (*Thymallus arcticus*). Three hundred and eighty-seven rainbow trout were captured using hook and line, minnow traps, and electrofishing. Lengths ranged from 27-686 mm and weights from 1-2,550 g. Otolith ages ranged from 0-11 years and scale ages ranged from 0-8 years. The female to male sex ratio was 1:2.04. Comparisons between scale and otolith aged rainbow trout revealed that scale ages underestimated the otolith age by 1-3 years for fish 3 years and older. The Goodnews fish populations were compared to those of the Kanektok River. More large rainbow trout were caught in the Goodnews River than in the Kanektok River. Goodnews River rainbow trout also exhibited larger length at age than fish from the Kanektok River. However, creel survey data revealed that catch rates of rainbow trout from the Goodnews River were one-third that of the Kanektok River. Based on catch data, the population probably does not have the capacity to support large increases in fishing pressure without suffering a decrease in the size composition. One hundred and seventy-five *Salvelinus sp.* and 130 Arctic grayling were also sampled. *Salvelinus* sp. lengths and weights ranged from 278-629 mm and 225-2,825 g, and Arctic grayling ranged from 275-510 mm and 250- 1,550 g, respectively. These species were found to be slightly larger than other Arctic grayling and *Salvelinus* sp. populations in southwestern Alaska. We recommend continued monitoring of the sport fishery through the Refuge's Special Use Permits and public use surveys; that the resident fish populations be sampled again in five years to note any changes in size composition; and that a conservative approach be practiced in management of the Goodnews River rainbow trout population.

Keywords: rainbow trout, Arctic grayling, Arctic char, Dolly Varden, Goodnews River, Togiak National Wildlife Refuge, Alaska

*Idyll, C. P. 1968. The incredible salmon. National Geographic Society Magazine. 134(August):195-219.

A picture of a sockeye ascending the falls is included in this article of spawning salmon observations in the Brooks River in the summer of 1966.

Keywords: sockeye salmon, Brooks River, spawning, fish migration, fish behavior, predation, waterfalls.

*Jaenicke, H. W. 1965. Naknek smolt study report, 1956-65. U.S. Fish and Wildlife Service. Unpublished.

(Unable to obtain--referenced in Van Valin, 1969a)

Jaenicke, M. J. 1997. Survey of the rainbow trout sport fishery on the upper Alagnak River, Alaska, during June 1997. Fishery Data Series No. 98-27, Anchorage. Alaska Department of Fish and Game, Dillingham, Alaska.

Abstract form report: The Alaska Department of Fish and Game-Division of Sport Fish and the National Park Service-Katmai National Park and Preserve conducted a cooperative project to monitor the rainbow trout fishery in the upper Alagnak River. A creel census during 8-30 June 1997 documented that 159 angler-days (792.5 hours) of effort occurred at the upper Alagnak River, and that 935 rainbow trout *Oncorhynchus mykiss* were caught and released. Overall CPUE was 1.18 fish per hour. No sport fishing effort via trolling for lake trout *Salvelinus namaycush* at the outlet of Kukaklek Lake occurred during the June 1997 creel census period. The typical angler on the upper Alagnak River was guided, nonresident, and fished from shore. Continued monitoring of the fishery and changes to the sampling design are recommended to ensure that the rainbow trout population remains healthy in the Alagnak River.

Keywords: Rainbow trout, *Oncorhynchus mykiss,* lake trout, *Salvelinus namaycush,* creel census, angler demographics, biological composition, Alagnak River, Kukaklek Lake, Southwest Alaska.

Jaenicke, M. J. 1998. Survey of the rainbow trout sport fishery on the Nonvianuk and Alagnak rivers, 1996. Fishery Data Series No. 98-13, Anchorage. Alaska Department of Fish and Game, Dillingham, Alaska.

Abstract from report: The Alaska Department of Fish and Game-Division of Sport Fish and National Park Service-Katmai National Park and Preserve conducted a cooperative project to evaluate the current status of the rainbow trout stocks in the Alagnak and Nonvianuk rivers. A creel census indicated that total sport fishing effort at the headwaters of the Nonvianuk River during 8 June to 30 June 1996 was 755 angler hours, with 1,529 rainbow trout caught and released. Most anglers were guided (59%), not an Alaskan resident (58%), used air charter to access the area (80%), fished from shore (91%), and fished with fly gear (91%). Fifty-seven rainbow trout were Floy tagged during the creel census. Length and age data were collected from 620 rainbow trout from the Nonvianuk River ($n = 297$) and Alagnak River ($n = 323$) during June through September 1996. The length distribution of rainbow trout differed significantly ($p < 0.001$) between the outlet of Nonvianuk Lake and the lower 11 miles of the Nonvianuk River, while the length distribution was not significantly different ($p = 0.38$) between three zones on the upper Alagnak River. Based on age composition information from other systems in southwest Alaska, the rainbow trout stock in the Nonvianuk River and Alagnak River appears to have a smaller proportion of age-6 and age-7 year old fish than would be expected in a healthy stock. An emergency order issued in 1996 created a catch-and-release rainbow trout fishery on the Alagnak and Nonvianuk rivers. Preliminary indications from a more intensive research project started in April 1997 on the rainbow trout stock in the Alagnak River drainage by the U.S. Geological Survey-Biological Research Division indicate that the stock status may not be lacking in larger, older fish as suggested from results from this 1996 project.

Keywords: Rainbow trout, *Oncorhynchus mykiss*, creel census, angler demographics, biological composition, Nonvianuk River, Alagnak River, Southwest Alaska.

Jones, T. M. and T. R. Hamon. 2005. Baseline Inventory of Freshwater Fishes of the Southwest Alaska Inventory and Monitoring Network: Alagnak Wild River, Aniakchak National Monument and Preserve, Katmai National Park and Preserve, Kenai Fjords National Park, and Lake Clark National Park and Preserve. National Park Service, Anchorage, AK.

Abstract from report: The National Park Service (NPS) Inventory and Monit oring (I&M) Program has undertaken a nationwide inventory of natural resources. As part of this effort, freshwater fish inventories were conducted within Southwest Alaska Network (SWAN) for the Alagnak Wild River (ALAG), Aniakchak National Monument and Preserve (ANIA), Katmai National Park and Preserve (KATM), and Kenai Fjords National Park (KEFJ). A previous fisheries inventory of Lake Clark National Park and Preserve (LACL) matching the scope of current I&M program objectives was conducted by the Alaska Department of Fish and Game (ADF&G) in 1980 (Russell et al. 1980). Thirty three species of freshwater fish were identified as potentially occurring within the entire SWAN network (AKNHP 2000). The SWAN freshwater fish inventory project documented 28 of the 33 freshwater species (84.8% of all freshwater species) predicted to occur within park boundaries (AKNHP 2000). For individual SWAN parks, this inventory verified 66.7% of expected species within ALAG (16 of 24), 56.3% within ANIA (9 of 16), 96.0% within KATM (24 of 25), 81.3% (13 of 16) within KEFJ, and 96.2% (25 of 26) within LACL.

Keywords: Reports, inventory, fishes, freshwater, aquatic, Alaska blackfish, *Dallia pectoralis*, Arctic char, *Salvelinus aplinus*, Arctic grayling, *Thymallus arcticus*, Arctic lamprey, *Lampetra camtschatica*, burbot, *Lota lota*, chinook salmon, *Oncorhynchus tshawytscha*, chum salmon, dog salmon , *Oncorhynchus keta*, coastrange sculpin, *Cottus aleuticus,* coho salmon, *Oncorhynchus kisutch*, Dolly Varden, *Salvelinus malma*, Eulachon, *Thaleichthys pacificus*, humpback whitefish, *Coregonus pidschian*, lake trout, *Salvelinus namaycush*, least cisco, *Coregonus sardinella*, longnose sucker, *Catostomus catostomus*, ninespine stickleback, *Pungitius pungitius*, northern pike, *Esox lucius*, Pacific staghorn sculpin, *leptocottus armatus*, pink salmon, *Oncorhynchus gorbuscha*, pond smelt, *Hypomesus olidus*, pygmy whitefish, *Prosopium coulteri*, rainbow trout, *Oncorhynchus mykiss*, round whitefish, *Prosopium cylindraceum*, slimy sculpin, *Cottus, cognatus*, sockeye salmon, kokanee, *Oncorhynchus nerka*, threespine stickleback, *Gasterosteus aculeatus*. Aialik Bay, Alaska, Aniakchak National Monument and Preserve, Aniakchak River, Alagnak Wild River, Idavain Lake, Katmai National Park and Preserve, Kenai Fjords National Park, Kukaklek Lake, Lake Clark National Park and Preserve, Margot Valley, Meshik Lake, Mulchatna River, Naknek River Lakes, Nonvianuk Lake, Nuka Bay, Resurrection Bay, Southwest Alaska Network, Stony River, Surprise Lake.

Jope, K. L. 1985. Nonvianuk creel census Katmi National Park and Preserve.

Report presents creel census data taken from a protocol over a 96 day period. Report presents the species surveyed with detail to rainbow trout catch effort and angler numbers though the season.

Keywords: rainbow trout, lake trout, grayling, king salmon, creel census, Nonvianuk, Katmai Park.

Jope, K. L. 1987. Brooks falls fish ladder Katmai National Park and Preserve.

A fish ladder was constructed at the waterfall on Brooks River in Katmai National Monument (Katmai National Park and Preserve) by the Bureau of Commercial Fisheries during 1949-50. It was constructed because Bureau biologists perceived a need to assist salmon in passing the 6- to 8-foot-high waterfall, particularly during periods of low water. The river bank at the upper end of the fish ladder is eroding, and action must be taken to stem this erosion before severe irreversible pact occurs. The National Park Service (NPS) proposes to dewater the fish ladder, remove it within a 5 year study period, and then restore the ladder site to near its original contour and condition. This assessment evaluates that proposal, summarizes available information, and discusses the legal consistency of various alternatives to ladder removal. The NPS has determined that the ladder is incompatible with the legal requirements of national park management and with the purposes for which Katmai was established. The NPS has no legal authority to repair, restore, or reopen the fish ladder. In fact, such an action, if taken, would be contrary to congressionally mandated park management objectives (Alaska National Interest Lands Conservation Act of 1980 (ANILCA) and senate Report 96-413, page 171). The Alaska Department of Fish and Game (ADF&G) has expressed concern that closure of the ladder would result in future declines in productivity of aquatic habitats in the Brooks River drainage. ADF&G is of the opinion that closure of the ladder is incompatible with state statutes.

Keywords: Brooks falls, fish ladder, Katmi National Park and Preserve, ladder removal, declines, aquatic habitats.

*Idyll, C. P. 1966a. Timing, age, condition, and abundance of red salmon smolt from the Naknek River system, Alaska, 1956-65. U.S. Bureau of Commercial Fisheries, Auke Bay Biological Laboratory. Manuscript Report. 40 pp.

(Unable to obtain--referenced in Siedelman, 1972)

*Idyll, C. P. 1966b. The use of fluorescent pigment in the marking of sockeye salmon smolts. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Manuscript Report 4-66. 5 pp.

This study used age, two smolts captured approximately 24 miles upstream from the mouth of the Naknek River.

Keywords: Naknek River, sockeye salmon, marking techniques, age, length, mortality, feeding rates.

*Lindsey, C. C. 1964. Problems in zoogeography of the lake trout, Salvelinus namaycush. Journal of the Fisheries Research Board of Canada. 21:997-994.

The occurrence of lake trout in several lakes of the Naknek River drainage and the cohabitation with sea-run lampreys is discussed.

Keywords: lake trout, lampreys, Naknek Lake, Brooks Lake, Grosvenor Lake, Coville Lake, Hammersly Lake, fish populations.

Mahoney, B. 1986. Battle Lake Drainage, Fishery Investigation Katmai National Park. U.S. Fish and Wildlife Service, King Salomn, Alaska.

A fishery inventory and habitat evaluation of major tributaries and the outlet stream was conducted on 28 July 1986 during a trip to Battle Lake, a 906.5 hectare lake located in Katmai National Park. The primary objectives were: 1) to document fish species composition and distribution in five major Battle Lake tributaries and; 2) to measure discharge of the five major tributaries and the lake outlet stream. A backpack electroshocker was used to collect fish. No fish species were captured in the tributaries to Battle Lake and eight coast range sculpins (Qottus aleuticus) were collected in the outlet stream. stream habitats were observed and described. Participating in data collection were: David Morris, Superintendent, Katmai National Park; Andrav Gunther, Research Associate, University of California, Berkeley; Barbara Mahoney, Fishery Biologist and Gary Sonnevil, Project Leader, King Salmon Fishery Assistance Office.

Keywords: Battle Lake, electro fishing, Katmai National Park,

*McAfee, W. S. 1960. Redds of the red salmon, *Oncorhynchus nerka*, in three streams of the Alaska Peninsula. M.S. Thesis. University of Michigan, Ann Arbor. 39 pp.

Measurements of redd size, water velocity, water depth, gravel compaction and egg distribution are given for red salmon spawning sites in the Brooks Lake drainages of the Naknek system. Redds were excavated and the depth, distribution, and number of eggs found are reported.

Keywords: sockeye salmon, rainbow trout, Dolly Varden char, sculpins, Brooks Lake, Brooks River, Headwaters Creek, Up A Tree Creek, Hidden Creek, spawning, fish behavior, velocity, bottom sediments, gravels, fecundity, mortality, predation.

*McCart, P. J. 1970. Evidence for the existence of sibling species of pygmy whitefish (Prosopium coulteri) in three Alaskan lakes. Pages 81-98 in C.C. Lindsey and C.S. Woods, eds. Biology of coregonid fishes. University of Manitoba Press.

External characteristics and measurements of two morphological forms of pygmy whitefish found within the Naknek River drainage are reported and discussed. It is postulated that the two forms survived glaciation in different refugia and their current distributions overlap in the Naknek system.

Keywords: whitefish, Brooks Lake, Naknek Lake, Grosvenor Lake, varieties, fish taxonomy.

*McCurdy, M. L. 1972. 1971 Naknek River sockeye salmon smolt studies. Pages 29-34 in P.A.

Russell and M.L. McCurdy, eds. 1971 Bristol Bay sockeye salmon smolt studies. Alaska Dept. of Fish and Game. Technical Data Report 2.

Estimated total numbers, age distribution, average weights and lengths, peak period and the water temperature during the 1971 sockeye salmon outmigration are reported.

Keywords: Naknek River, sockeye salmon, juvenile fish, smolt, fish migration, fyke nets, census, fish populations, age, weight, length, water temperature.

*McCurdy, M. L. 1974a. 1972 Naknek River sockeye salmon smolt studies. Pages 38-48 in K.P. Parker, ed. 1972 Bristol Bay sockeye salmon smolt studies. Alaska Dept. of Fish and Game. Technical Data Report 13.

Estimated total numbers, age distribution, length and weight data, peak periods, water temperatures and hourly and daily catch distribution for the 1972 sockeye salmon outmigration are reported.

Keywords: Naknek River, sockeye salmon, juvenile fish, smolt. Fish migration, census, fyke nets, water temperature, age, length, weight, fish populations

*McCurdy, M. L. 1974b. 1973 Naknek River sockeye salmon smolt studies. Pages 23-32 in K.P. Parker, ed. 1973 Bristol Bay sockeye salmon smolt studies. Alaska Dept. of Fish and Game. Technical Data Report 14.

Total numbers, age distribution, length and weight data, water temperatures, and distribution of outmigration by days and hours for the 1973 sockeye salmon outmigration (the lowest migration recorded) are reported.

Keywords: Naknek River, sockeye salmon, juvenile fish, smolt, fish migration, census, fish populations, fyke nets, water temperature age, length, weight.

*McHenry, E. T., and A. Paddock. 1968. Creel census of the sport fishes of the Bristol Bay drainage. Pages 223-240 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-5-R-9, Job 12-D. Annual Progress Report. Vol. 9.

Catches and species of the Lake and Rapids Camps on the Naknek River are reported based on the voluntary creel census reports. Detailed figures from military sources and characteristics of the fisheries at the several locations are discussed. Visitor restrictions in Katmai National Monument are included.

Keywords: rainbow trout, Chinook salmon, sockeye salmon, coho salmon, northern pike, lake trout, Dolly Varden char, grayling, Naknek River, Smelt Creek, Lake Camp, Rapids Camp, Base Dock, sport fishing, creel census, fish harvest, fish migration, pink salmon.

*McPhail, J. D. 1961. A systematic study of the Salvelinus alpinus complex in North America.

Journal of the Fisheries Research Board of Canada. 18(5):793-816.Morphological characteristics of a 1958 collection of char from

Brooks Lake and its tributaries are reported.

Keywords: Brooks Lake, Dolly Varden char, Arctic char, fish populations, fish taxonomy.

*Malick, J. G., S. L. Schroder, and O. A. Mathisen. 1971. Observations on the ecology of the estuary of Naknek River, Bristol Bay, Alaska. Fisheries

Research Institute, University of Washington, Seattle. Studies were conducted primarily on the lower river, near the canneries around the village of Naknek. Observations include water temperature, dissolved oxygen, salinity, turbidity, studies of bottom fauna, and fish species.

Keywords: Naknek River, tides, bottom sediments, sockeye salmon, dissolved oxygen, salinity, water temperature, turbidity, secchi disks, light penetration, sediment load, zooplankton, smelts, flounders, sticklebacks, lampreys, herring, waste disposal, water pollution, periphyton, benthic fauna.

*Mattson, C. R. 1962. Chum salmon resources of Alaska from Bristol Bay to Point Hope. U.S. Fish and Wildlife Service. Special Scientific Report-Fisheries 425. 22 pp.

The chum salmon run in the Naknek River is compared with other drainages along the west coast of Alaska. Most chum salmon spawn in Big Creek, with few reaching weirs or counting towers in the Upper Naknek River.

Keywords: chum salmon, Naknek River, Big Creek, King Salmon Creek, Smelt Creek, Pauls Creek, fish migration, weirs, spawning.

Meka, J. M. et al. 1999. Alagnak Watershed Rainbow Trout Seasonal Movement. Alaska Biological Resources Division, Anchorage, Alaska.

Abstract from report: Adult rainbow trout were radio-tagged in two locations in the Alagnak River drainage in 1997 and 1998 and radio-tracked until March 1999. The telemetry data indicate the two different sample groups exhibited independent movements with little geographic overlap. However, some tagged fish from each sample group migrated downstream to the same general area during the spawning season. Rainbow trout within each sample group may have evolved the observed seasonal movement patterns to optimize food availability during the summer and thermal refugia in the winter.

Keywords: Alagnak River drainage, rainbow trout, radio-tagged fish, seasonal movement.

Meka, J. M. et al. 2000. Alagnak Watershed Rainbow Trout Seasonal Movement. Alaska Biological Resources Division, Anchorage, Alaska.

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Keywords: Alagnak River drainage, rainbow trout, radio-tagged fish, seasonal movement.

Meka, J. M. 2000. Current rainbow trout research on the ALAG River Biological Resources Division, Anchorage, Alaska.

The report outlines current and previous rainbow trout research that has been done on the Alagnak river drainage. A request for anglers to turn in tagged fish to further the research is also made and management considerations and genetic analysis work is presented.

Keywords: Alagnak River drainage, rainbow trout, radio-tagged fish, seasonal movement genetic analysis.

Meka, J. M. 2003. Evaluating the hooking injury and immediate physiological response of wild rainbow trout to capture by catch and release angling. Thesis. University of Alaska Fairbanks, Fairbanks, Alaska.

Abstract from report: Rainbow trout from the Alagnak River watershed, Alaska, were captured by angling to determine the types of terminal gear contributing to hooking injury and the physiological response to angling based on concerns over high incidences of hooking injuries and the physiological impact of multiple recaptures on individual fish. Landing and hook removal times were recorded for a portion of fish captured, and plasma cortisol, glucose, ions (sodium, chloride, potassium), and lactate were evaluated in fish following capture to document physiological changes in relation to capture duration. The majority of new injuries resulted when fish were captured using barbed J hooks, and barbed J hooks took longer to remove than barbless hooks. Fish were hooked internally more frequently when captured with J hooks compared to circle hooks, but similar overall hooking injury rates were observed for both hook types. Novice anglers injured proportionally more fish than experienced anglers, and experienced anglers took longer to land fish than novice anglers. Plasma cortisol and lactate increased significantly with increasing landing and handling times. Fish captured at cooler water temperatures had significantly lower cortisol and lactate concentrations than fish caught at warmer temperatures indicating that water temperature influenced the magnitude of the physiological response.

Keywords: rainbow trout, J hooks, circle hooks, physiological response, Alagnak River.

*Merrell, T. R., Jr. 1957a. Salmon survival investigations. U.S. Fish and Wildlife Service. 6 pp.

A coherent research plan for the year is outlined focusing on three elements: adult sockeye salmon, juvenile sockeye salmon, and climatological, hydrological, and ecological factors. Studies concentrate on Brooks Lake and its tributaries and Brooks River.

Keywords: sockeye salmon, Brooks Lake, juvenile fish, project, planning, research priorities.

*Merrell, T. R., Jr. 1957b. Evaluation of Brooks Lake Research Station. U.S. Bureau of Commercial Fisheries. 53 pp.

A historical summary of research results from 1940 to 1956 for the Brooks Lake Station. A chronological review of research is provided. Data summarized include weir counts; tagging studies; age, length, and weight measurements; and sex determinations. Marking studies of juvenile sockeye provided little useable data. Collection of climatological data is summarized. Water temperature records for all stations are reviewed. In most instances data are not presented but, rather, existing data are characterized. Water chemistry data are summarized for total hardness, alkalinity, silicon, soluble phosphorus, nitrite nitrogen, ferric iron, dissolved oxygen and pH. A compilation of plankton sampling is provided.

Keywords: history, Brooks Lake, Brooks River, fish migration, census, fish ladders, weirs, sockeye salmon, Chinook salmon, pink salmon, chum salmon, coho salmon, rainbow trout, spawning, tagging, juvenile fish, age, length, weight, water levels, Naknek Lake, One Shot Creek, water temperature, research equipment, alkalinity, hardness (water), silicon, phosphorus, nitrites, iron, dissolved oxygen, hydrogen ion concentration, plankton.

*Merrell, T. R., Jr. 1958a. Progress report on the Brooks Lake Research Station. Page 89 in A.W. Johnson, ed. Science in Alaska. Proceedings of the 8th Alaska Science Conference, Anchorage, 1957. Alaska Div., American Association for the Advancement of Science. (Abstr.)

This abstract gives a brief discussion of the Brooks Lake station and its early development from 1940 to program reorganization and expansion in 1957.

Keywords: Brooks Lake, sockeye salmon. research facilities, research priorities.

*Merrell, T. R., Jr. 1958b. Salmon Survival Investigations. Red salmon studies, Brooks Lake. field operations report, 1957. U.S. Bureau of Commercial Fisheries, Brooks Lake laboratory. Manuscript Report. 165 pp.

Ecological studies on the fresh-water phases of the life history of sockeye salmon and studies en related limnology and climatology were made at Brooks Lake, Alaska, in 1957. Data are presented and interpreted on adult sockeye salmon spawning distribution and behavior, age, sex, length, fecundity, and bear predation; on juvenile sockeye salmon ages, food, growth, migration from the lake, relative abundance, and distribution in the lake; and on climatological and limnological factors that may influence sockeye salmon behavior and abundance.

Keywords: alkalinity, bathymetry, light penetration, hydrogen ion concentration, nitrites, turbidity, dissolved oxygen, hardness (water), weirs, sockeye salmon, chum salmon, Chinook salmon, coho salmon, pink salmon, rainbow trout, fish migration, Brooks River, fecundity, tagging, length, spawning, census, predation, fish behavior, juvenile fish, age, gill nets, zooplankton, copepods, Daphnia, parasitism, scuba diving phytoplankton, diatoms, growth rates, food habits, primary productivity, water temperatures, phosphorus, silica.

*Merrell, T. R., Jr. 1958c. Brooks Lake winter field trip, February 12-20, 1958. U.S. Bureau of Commercial Fisheries. 7 pp.

Ice conditions throughout the drainage are noted with observations of open water occurrence. Fyke netting provided catches of pygmy whitefish at the Brooks Lake outlet. Gill netting was generally unproductive. Brooks Lake was quite acidic with a pH of 6.2. Water temperatures were approximately 1.0°C at the surface increasing to about 3.5°C at the bottom in deeper waters. Survival of sockeye salmon spawning was evaluated by checking gravels in Brooks River. Large numbers of planaria were observed in association with eggs and fry. Basic considerations for winter research are mentioned including best modes of transportation during winter.

Keywords: benthic fauna, fish, sockeye salmon, fry, ice cover, iced lakes, water levels, Brooks Lake, Naknek River, Naknek Lake, Iliuk Arm, Brooks River, whitefish, fyke nets, fish migration, winter, snow cover, gill nets, sculpins, sticklebacks, Alaska blackfish, rainbow trout, water temperature, light penetration, hydrogen ion concentration, fish eggs.

*Merrell, T. R., Jr. 1964. Ecological studies of sockeye salmon and related limnological and climatological investigations, Brooks Lake, Alaska, 1957. U.S. Fish and Wildlife Service. SI.ecial Scientific Report-Fisheries 456. 66 pp.

Ecological studies on the fresh-water phases of the life history of sockeye salmon and studies on related limnology and climatology were made at Brooks Lake, Alaska, in 1957. Data are presented and interpreted on adult sockeye salmon spawning distribution and behavior, age, sex, length, fecundity, and bear predation; on juvenile sockeye salmon ages, food, growth, migration from the lake, relative abundance, and distribution in the lake; and en climatological and limnological factors that may influence sockeye salmon behavior and abundance.

Keywords: sockeye salmon, fish migration, spawning, fish populations, weirs, census, fish behavior, chum salmon, Chinook salmon, coho salmon, pink salmon, age, growth rates, length, fecundity, One Shot Creek, Hidden Creek, Up A Tree Creek, Headwaters Creek, mortality, predation, juvenile fish, smolt, fyke nets, food habits, rainbow trout, Dolly Varden char, lake trout, whitefish, sculpins, Alaska blackfish, sticklebacks, weight, zooplankton, phytoplankton, productivity, primary productivity, animal parasites, water temperatures, phosphorous, nitrogen, silica, nitrites, turbidity, dissolved oxygen, hardness (water), alkalinity, aquatic plants, Naknek Lake, gulls, bathymetry, light penetration, secchi disks, hydrogen ion concentration.

*Middleton, K. R. et al. 1974. Naknek-Kvichak District subsistence fishery. Pages 4-9 and 19-22 in

T.R. Schroeder, ed. Subsistence fishing in Bristol Bay, 1963-1973. Alaska Dept. of Fish and Game. Bristol Bay Data Report 47.

Subsistence permits were first used in 1963 in the Naknek River system and for the following 11 years an average of 70 were issued each year. A table summarizes by year subsistence catches in the Naknek River.

Keywords: Naknek River, sockeye salmon, Chinook salmon, chum salmon, pink salmon, coho salmon, subsistence fishing, regulation, gill nets.

Miller, J. L. 2003. Freshwater Fish Inventory of the Alagnak Watershed, Alagnak Wild River, Southwest Alaska Inventory and Monitoring Network. Alaska Inventory and Monitoring Program, National Park Service, King Salmon, Alaska.

Abstract from report: A freshwater fish inventory was conducted from March through August, 2002 in the Alagnak Watershed. The objectives of the inventory were (1) to document species that were expected yet undocumented and (2) to provide initial descriptions of the distributions, abundance, and biologic characteristics of these species. Minnow traps, minnow seines, beach seines, snorkel gear, hand nets, fyke nets, tow nets, gill nets, hook-and-line, and a gastric lavage were used to sample fish. River, lake, pond, and stream habitats were sampled. Nine of 14 expected but undocumented species were captured or observed: Alaska blackfish (*Dallia pectoralis*), Arctic lamprey *(Lampetra japonica*), burbot (*Lota lota*), coastrange sculpin (*Cottus aleuticus*), ninespine stickleback (*Pungitius pungitius*), northern pike (*Esox lucius*), round whitefish (*Prosopium cylindraceum*), slimy sculpin (*Cottus cognatus)*, and threespine stickleback (*Gasterosteus aculeatus*). The fish community of the Alagnak Watershed appears to have fewer species (lower species richness) than the adjacent Naknek and Kvichak systems.

Keywords: Alagnak Wild River, Alaska blackfish, Arctic lamprey, burbot, coastrange sculpin, humpback whitefish, inventory, Katmai National Park and Preserve, least cisco, longnose sucker, ninespine stickleback, northern pike, pond smelt, pygmy whitefish, round whitefish, slimy sculpin, and threespine stickleback.

Minard, E. R. 1987. Naknek River Drainage rainbow trout spawning ground survey. Sport Fish Division, Dillignham, Alaska.

Abstract from report: Rainbow trout spawning ground surveys were conducted from fixed wing (Piper Supercub) aircraft on 30 streams in the Naknek drainage. In total 35 surveys were flown and abundance of spawning rainbow trout estimated. Raw counts were expanded to account for missed river sections and variable counting conditions for Brooks and Naknek Rivers estimated spawning abundance was 270 and 366 rainbow trout, respectively. For streams where a continuum of data exists, it appears that rainbow trout spawning abundance in 1987 was low compared to long-term averages.

Keywords: rainbow trout, spawning, aircraft, Brooks River, Naknek River.

Minard, E. R. and T. E. Brookover. 1988. Effort and catch statistics for the sport fishery in the Naknek River. Fishery Data Series No. 49. Alaska Department of Fish and Game, Division of Sport Fish, Juneau, Alaska.

Abstract from report: An estimated 70,373 angler-hours of effort were expended by recreational anglers fishing the Naknek River from 1 June through 30 October 1987. Anglers caught (landed) and harvested (kept) an estimated 14,250 and 11,419 Chinook salmon *Oncorhynchus tshawytscha*, 2,292 and 2,187 coho salmon *Oncorhynchus kisutch*, and 7,657 and 1,169 rainbow trout *Salmo gairdneri*. Age 1.4 Chinook salmon (53 percent) and age 5 rainbow trout (40 percent) dominated the harvest. Anglers using bait out-fished those using artificial lures nearly 2 to 1 when fishing for Chinook salmon in the lower river. The spawning escapement of Chinook salmon, as determined by aerial survey counts of live fish expanded for missed areas, was estimated to be 6,500 fish. The age composition of the escapement closely approximated that of the sport harvest.

Keywords: Chinook salmon, *Oncorhynchus tshawytscha*, sockeye salmon, *Oncorhynchus nerka*, coho salmon, *Oncorhynchus kisutch*, and rainbow trout, *Salmo gairdneri*, sport harvest, sport effort, creel survey, escapement, Naknek River.

National park Service. 1983. Fishery management plan Katmai National Park and Preserve.

Introduction form report: Fishing has traditionally been an activity of major importance to people living in the Katmai region. Prior to the 1912 eruption of Novarupta, Natives in year-round villages and seasonal fishing camps took advantage of the great runs of salmon in the Naknek and Kvichak River drainages and along the coast of Shelikof Strait. Human use of the fishery resource has continued to the present. Commercial salmon fishing is the mainstay of the Bristol Bay economy. Local residents use the fishery resources for subsistence, and high-quality sport-fishing attracts visitors to the area. Sport-fishing is permitted throughout Katmai National Park and Preserve, and subsistence use of the fishery is permitted in Katmai National Preserve. It is the policy of the National Park Service to manage sport fishing so that mortality of native fish species is compensated by natural reproduction. In Katmai, fishing is generally regulated according to restrictions established by the State (Appendix 1). If necessary, however, the National Park Service has authority to establish regulations that are more stringent. Fishing may be more tightly restricted in some waters, for example, (1) when fish mortality exceeds compensation by natural reproduction, (2) to preserve or restore the full spectrum of native species, (3) to protect rare plant or animal species on adjacent lands, (4) to protect spawning habitat, or (5) to maintain natural distributions and densities of wildlife species that use fish for food

Keywords: Katmi National Park and Preserve, National Park Service, rainbow trout, chum salmon, pink salmon, sockeye salmon.

National Park Service. 1986. Fishing regulations Katmai National Park and Preserve. Environmental Assessment.

Issue statement from report: Visitation in Katmai has been rapidly rising over the last decade. Most day-users and a portion of overnight visitors spend time fishing during their visit to the park and preserve. Informal observations, as well as the Statewide Harvest Survey, indicate that the harvest of fish in Katmai has risen significantly in recent years. Impact on bears has been observed in some areas, and facilities that were built to reduce impact are being overtaxed. The purpose of this assessment is to summarize available information and to evaluate the biological effects of alternatives for addressing the issue.

Keywords: Policies, Organic Act, NPS management, Katmai National Park and Preserve, wildlife, fish, human use.

*Nelson, M. L. 1970. Subsistence fishing in Bristol Bay, 1963-1969. Alaska. Dept. of Fish and Game. Bristol Bay Data Report 19. 29 pp.

(Unable to obtain update in Middleton, et al. 1974.)

*Paddock, A. D. 1964a. Inventory and cataloging of sport fish and sport fish waters in the Bristol Bay and lower Kuskokwim drainages. Pages 63-94 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-S-R-S, Job 4-A. Annual Progress Report, 1963- 1964. Vol. S.

A general description is given of the sport fisheries of the Naknek River and several of its tributaries. King Salmon Creek is judged one of the major Chinook salmon spawning areas in the drainage. A special fishery in Idavain Lake for highly colored Dolly Varden char, known locally as "golden trout" is mentioned.

Keywords: Naknek River, King Salmon Creek, Big Creek, Naknek Lake, Idavain Lake, American River, Grosvenor Lake, Coville Lake, Brooks River, rainbow trout, Chinook salmon, Dolly Varden char, lake trout, Arctic char, northern pike, coho salmon, grayling, chum salmon, lake trout, sport fishing, fish harvest, spawning, census, creel census, fish populations.

*Paddock, A. D. 1964b. Creel, census of the sport fisheries in the Bristol Bay drainage. Pages 95-108 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-S-R-S, Job 4-D. Annual Progress Report, 1963-1964. Vol. 5.

Tables summarize creel census reports from the military camps en the Naknek River and show that the harvests of rainbow trout are decreasing, sockeye salmon are increasing, and Chinook salmon are remaining fairly constant.

Keywords: Naknek River, Lake Camp, Base Dock, Rapids Camp, King Salmon Creek, rainbow trout, sockeye salmon, Chinook salmon, grayling, lake trout, Dolly Varden char, coho salmon, chum salmon, northern pike, whitefish, sport fishing, fish harvest, creel census, fish migration, spawning, fish populations.

*Paddock, A. D. 1965a. Inventory and cataloging of the sport fish and sport fish waters in the Bristol Bay and the lower Kuskokwim drainages. Pages 231-247 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-S-R-6, Job 12-A. Annual Progress Report, 1964-1965. Vol. 6.

The catches for 1964 of Chinook salmon and rainbow trout showed declines. Size comparisons of rainbow trout or grayling from different tributaries within the system are made. Data on catch composition 8,nd mean size of sport fish species from King Salmon River for 1962 to 1964, and the results of a 1964 sport fish survey (other than Chinook salmon) on King Salmon Creek and Big Creek are given.

Keywords: Chinook salmon, rainbow trout, grayling, Dolly Varden char, Arctic char, Naknek River, Naknek Lake, King Salmon Creek, Big Creek, Bay of Islands, Brooks River, sport fishing, fish harvest, fish migration, spawning, census, fish populations, growth rates, productivity.

*Paddock, A. D. 1965b. Creel census of the sport fishes in the Bristol Bay drainage. Pages 263-272 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-5-R-6, Job l2-D. Annual Progress Report, 1964-1965. Vol. 6.

The sport fish harvest data presented, based on creel census reports from the military camps, show an increasing harvest of sockeye salmon, a particularly large run and harvest of pink salmon and a small ice fishing harvest of rainbow trout. The number of civilian boats counted, however, indicate a considerable portion of the harvest is not covered in this survey.

Keywords: Naknek River, Lake Camp, Rapids Camp, Base Dock, Brooks River, rainbow trout, grayling, Chinook salmon, sockeye salmon, pink salmon, coho salmon, lake trout, northern pike, Dolly Varden char, sport fishing, fish harvest, creel census, fish migration, ice fishing.

*Paddock, A. D. 1968. Inventory and cataloging of the report fish and sport fish waters in the Bristol Bay and lower Kuskokwim drainages. Pages 205-222 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-5-R-9, Job l2-A. Annual Progress Report, 1967-1968. Vol. 9.

Estimates of the sport and subsistence harvest and the escapement of Chinook salmon during 1967 are presented. Information on the timing, size, and age composition of the sport fishery for coho salmon and a brief discussion of the growth rates of rainbow trout are also included.

Keywords: Brooks River, Big Creek, King Salmon Creek, Naknek River, Chinook salmon, rainbow trout, coho salmon, commercial fishing, sport fishing, subsistence fishing, fish harvest, census, fish migration, spawning, growth rates.

*Paddock, A. D. 1968. 1969a. Inventory and cataloging of the sport fish and sport fish waters of the Bristol Bay and lower Kuskokwim drainages. Pages 247-264 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska.

Project F-9-1, Job 12-A. Annual Progress Report, 1968- 1969. Vol. 10.

Extremely high escapement counts, increased sport catch and estimates of subsistence harvests are reported for Chinook salmon. Rainbow trout fishing from mid February to mid April, and the recovery of two previously tagged rainbows are described. Information based on aerial surveys is presented on coho salmon spawning in King Salmon Creek.

Keywords: Naknek River, Naknek Lake, King Salmon Creek, Big Creek, Bay of Islands, Brooks River, rainbow trout, coho salmon, Chinook salmon, sport fishing, fish harvest, census, subsistence fishing, fish migration, fish populations, weirs, ice fishing, spawning.

*Paddock, A. D. 1969b. Creel census of the sport fisheries in the Bristol Bay drainage. Pages 265-274 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-9-l, Job 11-D. Annual Progress Report, 1968-1969. Vol. 10.

A new form of creel census was conducted at the military camps and an estimated catch higher than previous years is attributed to this improved counting method. The spring fishery for rainbow trout from mid February to April is reported, and a developing fishery for Dolly Varden char is briefly described.

Keywords: Bay of Islands, Brooks River, King Salmon Creek, Naknek River, Naknek Lake, Rapids Camp, Lake Camp, Base Dock, coho salmon, burbot, pink salmon, grayling, Arctic char, lake trout, rainbow trout, Chinook salmon, Dolly Varden char, sport fishing, fish harvest, creel census.

*Paddock, A. D. 1970. Creel census of the sport fisheries in the Bristol Bay drainage. Pages 233-240 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-9-2, Job 12-D. Annual Progress Report, 1969-1970. Vol. 11.

Various problems with the creel census reports are discussed. Estimates of total Chinook salmon catch, results of a direct census of the rainbow trout summer sport fishery, and the increasing Dolly Varden char fishery are also reported.

Keywords: King Salmon Creek, Base Dock, Rapids Camp, Lake Camp, Naknek River, Naknek Lake, Chinook salmon, rainbow trout, Dolly Varden char, sockeye salmon, pink salmon, sport fishing, fish harvest, creel census, fish migration, fish populations.

*Paddock, A. D., and M. M. Whitehead. 1970. Inventory and cataloging of the Export fish and sport fish waters of the Bristol Bay and lower Kuskikwim drainages. Pages 213-227 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-9-2, Job l2-A. Annual Progress Report, 1969-1970. Vol 11.

Sport and subsistence catches, as well as escapement of Chinook salmon are estimated. A tagging program for rainbow trout was continued end a discussion of recoveries is included.

Keywords: Chinook salmon, rainbow trout, Naknek River, Naknek Lake, Lake Camp, Rapids Camp, Snag Point, Production Point, Tower Point, subsistence fishing, census, commercial fishing, fish migration, fish populations, spawning.

*Pella, J. J., and H. W. Jaenicke. In press. Some observations on the biology and variations of populations of sockeye salmon of the Naknek and Ugashik systems of Bristol Bay, Alaska, 1956-1969. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory.

(Unable to obtain - referenced in Ellis and McNeil [in press])

*Phillips, C. E. 1972. Report of field operations, Coville Lake, 1972. Pages 94-114 in U.S. National Marine Fisheries Service. Auke Bay Biological Laboratory. Manuscript Report 108.

Construction and operation of the Coville Narrows weir is discussed. A table presenting counts through the weir and results of sampling for sex, length, and age is included. Fry outmigration was sampled with fyke nets and the catches of both smolt and other fish are reported. Tables also present water temperatures.

Keywords: Coville Narrows, Coville Lake, Grosvenor Lake, American Creek, weirs, fyke nets, length, age, fecundity, fish migration, smolt, juvenile fish, fish populations, Hardscrabble Creek, lampreys, sticklebacks, smelts, sculpins, suckers, whitefish, water temperatures.

*Redick, R. R. 1967a. Inventory and cataloging of the sport fish and sport fish waters in the Bristol Bay and lower Kuskokwim drainages. Pages 189-204 in A1aska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-5-R-8, Job 12-A. Annual Progress Report, 1966-1967. Vol. 8.

The commercial fishery on Chinook and coho salmon in the Naknek-Kvichak district and the subsistence fishery on Chinook salmon in the Naknek River are discussed. Studies of the migration and spawning habits of rainbow trout in the Naknek River are described in detail. Tributaries to Naknek Lake and Naknek River were surveyed and results are listed.

Keywords: Naknek River, Naknek Lake, Big Creed, King Salmon Creek, Pauls Creed, Smelt Creek, Gunbarrel Creek, Grosvenor Lake, American River, Coville Lake, Eskimo Creek, Pike Lake, rainbow trout Dolly Varden char, lake trout, Arctic char, Chinook salmon, grayling, coho salmon, northern pike, sport fishing, commercial fishing, fish harvest, census, growth rates, fish migration, spawning, subsistence fishing, juvenile fish, weirs, Brooks River, productivity, Lake Camp, Bay of Islands.

*Redick, R.R. 1967b. Creel census of the sport fishes of the Bristol Bay drainage. Pages 205-216 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-5-R-8, Job 12-D. Annual Progress Report, 1966-

1967. Vol. 8.

Creel census reports from the military recreation camps on the Naknek River are summarized and the percentage of various species making up this catch are compared to prior years.

Keywords: Naknek River, Naknek Lake, King Salmon Creek, Lake Camp, Rapids Camp, Base Dock, Dolly Varden char, grayling, rainbow trout, sockeye salmon, Chinook salmon, coho salmon, sport fishing, fish harvest, creel census, northern pike, lake trout, fish migration, growth rates, pink salmon.

*Robertson, A. D. 1967. Naknek River red salmon smolt study, 1966. Pages 34-40 in D.M. Steward, ed. 1966 Bristol Bay red salmon smolt studies, a summary of data collected from red salmon (*Oncorhynchus nerka*) smolt programs in the Kvichak, Wood, and Naknek Rivers. Alaska Dept. of Fish and Game. Informational Leaflet 102.

This report on the results of the 1966 studies includes peak hours and days, catches, and ages of the samples taken. A table is included which tabulates escapement and smolt outmigrants by age group for the years 1956 to 1966. Water temperatures and river discharge are also included.

Keywords: sockeye salmon, Naknek River, Census, fyke nets, water temperature, discharge (water), fish migration, smolt, age, growth rates, fish populations.

*Siedelman, D. L. 1971a. Inventory and cataloging of the sport fish and sport fish waters of the Bristol 3ay and lower Kuskokwim drainages. Pages 95-116 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport fish Investigations of Alaska. Project F-9-3, Job G-l-E. Annual Progress Report, 1970-1971.Vol. 12.

A low subsistence harvest for 1970 is reported and the commercial fishery for Chinook salmon is discussed. Escapement estimates of Chinook salmon are reported for King Salmon Creek, Big Creek, and Naknek River, based on float and aerial observations. Rainbow trout were sampled and tagged in the Bay of Islands area of Naknek Lake.

Keywords: Bay of Islands, Naknek Lake, Naknek River, Big Creek, King Salmon Creek, Chinook salmon, rainbow trout, subsistence fishing, commercial fishing, sport fishing, census, fish migration, spawning, fish populations, ice cover, sticklebacks, food habits.

Russell, R. 1980. Brooks River rainbow trout spawning survey.

The report outlines the study objectives and methods for the sampling of spawing rainbow trout in the Brooks River both above and below the falls. The survey was conducted in one day with the number of confirmed spawning rainbow trout being noted.

Keywords: rainbow trout, Brooks River, Brooks Falls, spawning peak

Schwanke, C. J. 2002. Abundance and movement of the rainbow trout spawning stock in the upper Naknek River. Thesis. University of Wyoming, Laramie Wyoming.

Abstract from report: Native rainbow trout *Oncorhynchus mykiss* in the Naknek River of Southwest Alaska attain large sizes and support a popular recreational fishery. I studied the dynamics of the spawning stock during 2000 and 2001. Three methods of capturing spawning fish were assessed; the length structures and sex ratios of spawning fish were described; mark-recapture estimates of the number of spawning fish were conducted; and movements of fish following spawning were determined. I found that drifting gill nets and beach seines were efficient sampling gears, but hook and line was inefficient and biased toward immature fish. Median fork lengths of spawning fish were 640 mm for females and 697 mm for males with fish up to 860 mm in the samples. There were about 3,000 spawning fish in the Naknek River during each year of the study. Eighty percent of radio-tagged fish moved from the river upstream into Naknek Lake following spawning and most of these fish returned to the river in the fall. This information can be used in future monitoring of the spawning stock and assessment of the effectiveness of sport fishing regulations.

Keywords: native rainbow trout, Naknek River, Naknek Lake, spawning, gill nets, beach seines, fork-length, Relative stock density, cumulative length frequency distributions, transmitters.

*Siedelman, D. L. 1971b. Creel census of the sport fisheries in the Bristol Bay drainage. Pages 31-52 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F9-3, Job G-IV-C. Annual progress Report, 1970-1971. Vol. 12.

Creel census reports from military camps are summarized in several tables, including a length frequency diagram and age determinations of the sport-caught Chinook salmon. The rainbow trout and sockeye salmon fishery following the Chinook salmon run was monitored and statistics are reported.

Keywords: sockeye salmon, coho salmon, Chinook salmon, Dolly Varden char, rainbow trout, Base Dock, Rapids Camp, Lake Camp, Naknek River, Naknek Lake, creel census, sport fishing, fish harvest, fish migration, fish populations, growth rates.

*Siedelman, D. L. 1971b 1972. 1969 Naknek River sockeye salmon smolt studies. Pages 46- 61 in M. L. McCurdy, ed. 1969 Bristol Bay Sockeye salmon smolt studies. Alaska Dept. of Fish and Game. Technical Data Report 3. Peak outmigration periods, age, weight, and length (If outmigrating smolts are reported using the same index procedures as in past years.

Keywords: Naknek River, sockeye salmon, juvenile fish, smolt, fish migration, age, growth rates, census, water temperature, fish populations, mortality.

*Siedelman, D. L 1973. Creel census of the sport fisheries in the Bristol Bay drainage. Pages 48-58 in Alaska Dept of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish investigations of Alaska. Project F9-5, Job G-IV-C. Annual Progress Report, 1972-1973. Vol. 14.

A voluntary creel census program was utilized to estimate the Naknek River Chinook salmon sport catch during 1972. In addition, sport fish catches by species are tabulated and discussed for each facility.

Keywords: Naknek River, Base Dock, Rapids Camp, Lake Camp, FAA Dock, Arctic Grayling, rainbow trout, Chinook salmon, sockeye salmon, pink salmon, sport fishing, fish harvest, creel census.

*Siedelman, D.L. 1974. sport fish waters Dept. of Fish and Fish Restoration. F9-6, Job G-I-E.Inventory and cataloging of the sport fish and of the Bristol Bay area. Pages 93-119 in Alaska Game, Div. of Sport Fish, Juneau. Federal Aid in Sport Fish Investigations of Alaska. Project Annual Progress Report, 1973-1974. Vol. 15.

The subsistence and commercial harvests of Chinook salmon are summarized and escapements are estimated by aerial surveillance. Aerial and food surveys were also conducted to determine the numbers of spawning rainbow trout in the Naknek and Brooks Rivers.

Keywords: Brooks River, Naknek River, Pauls Creek, King Salmon Creek, Big Creek, Chinook salmon, rainbow trout, census, spawning, fish populations, subsistence fishing, commercial fishing, fish migration, waterfalls.

*Siedelman, D.L., and P. B. Cunningham. 1972a. Inventory and cataloging of the sport fish and sport fish waters of the Bristol Bay area. Pages 67-84 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-9-4, Job G-I-E. Annual Progress Report, 1971-1972. Vol. 13.

Subsistence and commercial harvest of Chinook salmon, and the sex ratios, ages, lengths and weights from a commercial catch sample are reported. Aerial spawning surveys of rainbow trout were conducted in May in the Naknek River, and later in the summer for Chinook spawning estimates in Paul's Creek, Big Creek and the Naknek River.

Keywords: Naknek River, Pauls Creek, King Salmon Creek, Big Creek, Chinook salmon, rainbow trout, subsistence fishing, commercial fishing, sport fishing, census, fish populations, fish migration, spawning, growth rates.

*Siedelman, D.L., and P.B. Cunningham 1972b. Creel census of the sport fisheries in the Bristol Bay drainage. Pages 183-198 in Alaska Dept. of Fish and Game, Div. Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-9-4, Job G-IV-C. Annual Progress Report, 1971-1972. Vol. 13.

Extensive data is represented from sport fishing surveys and the military creel census, including biological data for both Chinook salmon and rainbow trout. Census figures also cover the catch of Arctic grayling and sockeye salmon.

Keywords: King Salmon Creek, Naknek River, Naknek Lake, Base Dock, Rapids Camp, Lake Camp, creel census, sport fishing, fish harvest, rainbow trout, Chinook salmon, coho salmon, Dolly Varden char, sockeye salmon, grayling, growth rates, spawning, fish migration, fish populations.

*Seidelman, D. L., and P. B. Cunningham. 1973. Inventory and cataloging of the sport fish and sport fish waters of the Bristol Bay area. Pages 35-51 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau, Federal Aid in Fish Restoration. Sport Fish Investigations for Alaska. Project F-9-5, Job G-I-E. Annual Progress Report, 1972-1973, Vol. 14.

Subsistence and commercial Chinook salmon harvest are briefly summarized. Aerial surveys of Chinook salmon escapement were conducted for the Naknek River and several tributaries. The rainbow trout spawning population was aerially estimated in late May and early June.

Keywords: Naknek River, Big Creek King Salmon Creek, Pauls Creek, Chinook salmon, rainbow trout subsistence fishing, commercial fishing, spawning, fish populations, fish migration, census.

*Stefanich, F. A. 1962. Creel census of the sport fishes in the Bristol Bay drainage. Pages 207-220 in Alaska Dept. of Fish and Game, Div. of Sport Fish, Juneau. Federal Aid in Fish Restoration. Sport Fish Investigations of Alaska. Project F-5-R-3, Job 10-D-2. Annual Progress Report, 1961-1962. Vol. 3.

The port harvest at the three military camps along the Naknek River is summarized. The catch was predominately rainbow trout and Chinook salmon with (other species reported. Sizes and lengths for fish take, number of anglers, and hours fished are included.

Keywords: Naknek River, Naknek Lake, rainbow trout, lake trout, grayling, sockeye salmon, Dolly Varden char, Chinook salmon, chum salmon, northern pike, coho salmon, sport fishing, fish harvest, creel census.

*Straty, R. R. 1960. Methods of enumerating salmon in Alaska. Transactions of the North American Wildlife Conference. 25:286-297.

A discussion of smolt sampling with fyke nets and a comparison between tower and weir counts of migrating sockeye salmon on the Naknek River in 1957.

Keywords: Naknek River, fish migration, sockeye salmon, smolt, weirs, fish populations, census fyke nets.

* Straty, R. R. 1962. Collection of salmon eamples for racial studies, 1961. U.S. Bureau of Commercial Fisheries, Auke Bay Biological Laboratory. Manuscript Report 63-9. 44 pp. Smolt, b100k samples and some scale samples were collected for this study.

Keywords: Naknek River, sockeye salmon, King Salmon Creek, fish' physiology, juvenile fish, fish migration.

*Straty, R.R. 1963a. The extent of spawning population segregation in the red salmon (*Oncorhynchus nerka*) runs of the Naknek River system, Alaska. M.S. Thesis. University of Hawaii, Honolulu. 68 pp.

This study was designed to determine the extent to which different spawning stocks of sockeye salmon are segregated by time during the run to the Naknek River system. Segregation by age in the run and on the spawning grounds was also studied.

Keywords: sockeye salmon, fish migration, fish populations, spawning, Naknek River, Brooks Lake, Iliuk Arm, Coville Lake, Grosvenor Lake, American Creek, Hardscrabble Creek, Brooks River, Savonoski River, age, length, Bay of Island Creek, Margot Creek.

*Straty, R. R. 1963b. The extent of spawning population segregation in the red salmon (*Oncorhynchus nerka*) runs of the Naknek River system, Alaska. U.S. Bureau of Commercial Fisheries, Auke Bay Biological Laboratory. Manuscript Report 63-9. 44 pp.

This manuscript appears to be a duplication of material contained in Straty (1963a), with a small amount of additional data and several new photographs.

Keywords: sockeye salmon, fish migration, fish populations, spawning, Naknek River, Brooks Lake, Iliuk Arm, Coville Lake, Grosvenor Lake, American Creek, Hardscrabble Creek, Brooks River, Savonoski River, age, length, Bay of Island Creek, Margot Creek.

*Straty, R. R. 1966. Time of migration and age group structure of sockeye salmon (*Oncorhynchus nerka*) spawning populations in the Naknek River system, Alaska. Fishery Bulletin. 65(2):461-488.

This publication is a duplication of Straty (1963a, and 1963b).

Keywords: sockeye salmon, fish migration, fish populations, spawning, Naknek River, Brooks Lake, Iliuk Arm, Coville Lake, Grosvenor Lake, American Creek, Hardscrabble Creek, Brooks River, Savonoski River, age, length, Bay of Island Creek, Margot Creek.

*Straty, R. R 1974. Migratory pattern of adult sockeye salmon (*Oncorhynchus nerka*) in Bristol Bay as related to the distribution of their home river waters. U.S. National Marine Fisheries Service, Anke Bay Biological Laboratory. Manuscript Report 109. 118 pp.

Tidal observations at King Salmon are reported. Observations of tagged adult sockeye are recorded from the Naknek River drainage.

Keywords: Naknek River, sockeye salmon, tides, water levels, fish migration.

*Straty, R. R., and H. W. Jaenicke. 1971. Studies of the estuarine and early marine life of sockeye salmon in Bristol Bay, 1965-67. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Manuscript Report 83. 137 pp.

Peak periods of smolt outmigration, stomach contents, and age and size comparisons with smolt from the Kvichak and Wood Rivers, are reported. Smolt marking with microwave tabs is described. Salinity data are recorded for the Naknek River at high tide from off the mouth to 11 miles upstream.

Keywords: Naknek River, sockeye salmon, salinity, water levels, tides, juvenile fish, smolt, food habits, aquatic insects, growth .rates.

*U.S. Dept. of Commerce. 1964. United States Coast Pilot 9. Pacific and Arctic Coasts. Alaska, Cape Spencer to Beaufort Sea. Coast and Geodetic Survey. 7th ed. 329 pp.

Averages of extreme dates for ice breakup and free up are presented for the Naknek River.

Keywords: ice, ice cover, ice breakup, Naknek River.

*U.S. Dept. of the Interior. 1961. A preliminary stream catalog of the Naknek River system--red salmon investigations. U.S. Bureau of Commercial Fisheries, Auke Bay Biological Laboratory. Manuscript Report. 1 vol.

(Unable to obtain - referenced in Wallace, 1969)

*U.S. Dept. of the Interior, Alaska Planning Group. 1974. Proposed Katmai National Park, Alaska. Final Environmental Statement. 652 pp.

Reviews fishing (subsistence. sport and commercial) in the area and discusses impacts of the proposed park designation. A detailed description of American Creel is included with estimates of spawning areas, gravel quality and numbers of salmon encountered in various surveys from 1939 to the present.

Keywords: Smelt Creek, King Salmon Creek, Big Creek, Naknek River, Naknek Lake, American Creek, Brooks Camp, Brooks River, Coville Lake, Headland Creek, pink .salmon, sockeye salmon, rainbow trout, Dolly Varden char, sculpins, whitefish, commercial fishing, subsistence fishing, sport fishing, fish harvest, ice fishing, spawning, fish migration, fish ladders, weirs, gravels, census, fish populations, waterfalls.

*U.S. Geological Survey. 1976. Water resources data for Alaska. Water year 1976. Water-Data report AK-76-l. 401 pp.

Summary of daily measurements of discharge for Eskimo Creek at King Salmon. Extreme records and some drainage information is presented.

Keywords: Discharge (water), peak discharge, discharge measurement, Eskimo Creek, drainage area, low flow, stream gages.

*U.S. National Park Service. 1974 Proposed wilderness, Katmai National Monument, Alaska. Final Environmental Statement. 204 pp.

(Unable to obtain)

*Trautman, M. B. 1961. Observations of spawning behavior and predation on sockeye salmon at Hidden Creek, Katmai National Monument, Alaska, July and August 1961. U.S. Bureau of Commercial Fisheries. 19 pp.

Hidden Creek was surveyed daily for distribution of salmon along this tributary. Observations of fish behavior and predation by bears and otters is noted. Contradicting previous opinions, both bears and otters are believed to prefer gravid females and selectively prey upon these. Experimental transfer of a small number of salmon between spawning locations provided little information. Detailed behavior notes are provided. Predation loss of salmon in Hidden Creek was calculated as 81.8% for 1961 a year of low salmon escapement.

Keywords: sockeye salmon, Brooks Lake, Hidden Creek, fish behavior, fish migration, spawning, predation, census, otters, Headwaters Creek.

*Tsunoda, S. 1967. Movements of spawning sockeye salmon in Hidden Creek, Brooks Lake, Alaska. M.S. Thesis. Oregon State University, Corvallis. 52 pp.

Studies were conducted during August 1963 on the behavior and movements of approximately 2500 sockeye salmon which entered Hidden Creek to spawn. The objectives were to describe the movements within an entire small stream to 'determine factors related to and the significance of these movements to species.

Keywords: sockeye salmon, Brooks Lake, Hidden Creek, spawning, fish behavior, weirs, census, fish migration, age, mortality, predation, water levels, water temperature, length, carnivores.

*U.S. Army Corps of Engineers. 1954. Harbors and rivers in Alaska survey report. Interim report No.5. Alaska District, Anchorage. 140 pp.

Engineering and hydrological design considerations are discussed for power generation produced by diverting Grosvenor and Coville Lake runoff into the Bay of Islands in Naknek Lake. A proposal to enhance the navigability of the Naknek River upstream to King Salmon is outlined.

Keywords: Grosvenor Lake, hydroelectric power, Brooks Lake, Coville Lake, water levels, average runoff, drainage area, Naknek Lake, power head, Naknek River, depth, width, tides, navigation.

U.S. Geological Society.1999. Alagnak rainbow trout investigations. Alaska Biological Science Center, Anchorage, Alaska.

Reports on the population structure, abundance, migration, life history, and population health of the prized rainbow trout fishery in the Alagnak River.

Keywords: Alagnak River, rainbow trout, life history, abundance.

*Van Valin, G. R. 1969a. Naknek River red salmon smolt study, 1967. Pages 33-43 in D.M. Steward. ed. 1967 Bristol Bay red salmon smelt studies. Alaska Dept. of Fish and Game. Informational Leaflet 134.

Dates and estimated totals of smelt outmigration on the Naknek River are given in this report of the 12th consecutive year of smolt studies. Age, weight and length data from a sample are presented in a chart with similar data from the previous years. This data shows the 1967 smelt to be the largest on record.

Keywords: Naknek Lake, Naknek River, sockeye salmon, smolt, juvenile fish, fish migration, fish populations, fyke nets, census, fish populations, water temperature, age, growth rates.

*Van Valin, G. R. 1969b. Naknek River sockeye salmon smolt study, 1968. Pages 62-77 in M.L. McCurdy, ed. 1968 Bristol Bay sockeye salmon smelt studies. Alaska Dept. of Fish and Game. Informational Leaflet 138.

Sampling procedures are described in detail in this report giving dates and totals of smelt outmigration en the Naknek River. Size data, and the apparent effects of water temperature and prior years escapement levels are also discussed.

Keywords: sockeye salmon, smelt, Naknek River, census, fyke nets, Naknek Lake, juvenile fish, fish migration, growth rates, water temperature, fish populations.

*Wagner, J. L. and W. L. Hartman. Progressive Fish Culturist. 1960. An underwater camera case. 22: 188-191.

A photograph of a male sockeye salmon on a redd is included in this article describing the construction of underwater photographic equipment for the Brooks Lake salmon research laboratory.

Keywords: photography, sockeye salmon, Brooks Lake, Brooks River, spawning, fish behavior.

Wall, C. L. and T. R. Hamon. 2000. Fish inventory of Up A Tree Creek, Brooks Lake drainage, Bristol Bay, Alaska. Resource management technical report KATM-NR-00-01. National Park Service, King Salmon, Alaska.

Abstract from report: Up A Tree Creek is a low-gradient stream draining into Brooks Lake within Katmai National Park. There is considerable beaver activity upstream and increasing species diversity downstream. The aquatic community includes ninespine stickleback, rainbow trout, Dolly Varden char, coast range sculpin, and three species of salmon. Hydrocarbon contamination affects salmon reproduction. The fuel storage facility along the Valley of 10,000 Smokes road is situated within 300 m of Up A Tree Creek. Despite that proximity, it lies in a different watershed with surface flow that does not intersect the creek. The direction of groundwater flow in the area is not known. If the present schedule for removal of fuel is interrupted and the containment area shows signs of fatigue, studies of groundwater movement might be beneficial.

Keywords: Katmai National Park, Up A Tree Creek, low-gradient stream, rainbow trout, Dolly Varden, hydrocarbon contamination, species list.

*Wallace, R. L. 1963a. Preliminary report, smolt trapping at Grosvenor and Coville Lake, Naknek River system, Bristol Bay, Alaska. Pages 62-69 in R.J. Ellis.

The abundance and distribution of juvenile red salmon and associated species in lakes of the Naknek River system and Karluk Lake. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Manuscript Report 63-2. Weights, measurements and descriptions of smolt captured during outmigration, and descriptions of Coville and Grosvenor Rivers are included in this report.

Keywords: Coville Lake, Coville River, Grosvenor Lake, Grosvenor River, Naknek River, Savonoski River, Iliuk Arm, sockeye salmon, smolt, juvenile fish, fish migration, census, fish populations, fyke nets, age, growth rates.

*Wallace, R. L. 1963b. Summary of field notes, fry movement from Lake Coville to Grosvenor Lake. Pages 70-80 in R.J. Ellis. The abundance and distribution of juvenile red salmon and associated species in lakes of the Naknek River system and Karluk Lake. U.S. National Marine Fisheries Service, Auke Bay Biological Laboratory. Manuscript Report 63-2.

Observations of small fish predators and school movements are described. Species captured with beach seines are listed and water temperatures during outmigration are recorded.

Keywords: Coville Lake, Grosvenor Lake, Coville River, sockeye salmon, fyke nets, sticklebacks, smelts, fish migration, smolt, juvenile fish, predation, lake trout, Dolly Varden char, gulls, water temperature, growth rates, fish behavior, whitefish.

*Wallace, R. L. 1969. Some aspects of the comparative ecology of fishes associated with juvenile sockeye salmon, *Oncorhynchus nerka* (Walbaum), in the lakes of the Naknek River system, Alaska. Ph.D . Thesis. Oregon State University, Corvallis. 145 pp.

Four species of fish: pond smelt, least cisco, threespine stickleback and ninespine stickleback, are discussed in detail. Also included are chemical and physical information on the lakes, distribution of species by location and water depth, and the food habits by species and ages.

Keywords: sockeye salmon, smelts, cisco, stickleback, juvenile fish, competition, predation, food habits, West End, South Bay, Iliuk Arm, Grosvenor Lake, Coville Lake, water chemistry, zooplankton, nets, North Arm, age, growth rates, length, fecundity, distribution, ,

Weiss et al. 1990. Anadromous fish habitat assessment Exxon Valdes oil spill Kodiak oil spill zone. Alaska Department of Fish and Game. Habitat Division, Kodiak Oil Spill Office, Kodiak, Alaska.

Alaska Peninsula information from report introduction: The Alaska Peninsula and islands comprising the Kodiak Archipelago (Shuyak, Afognak, and Kodiak) were categorized geographically to simplify data recording. A total of 69 streams were compiled, 19 for the Alaska Peninsula and 50 for the Kodiak islands. Criteria for selecting streams to be surveyed on the Alaska Peninsula concerned: (1) moderate to heavy oil impact occurring in or near any stream; (2) geographic representation of oiled streams; and, (3) relative importance of each affected anadromous fish stream to the commercial fishery.

Keywords: Alaska Peninsula, oil impact, Exxon Valdes oil spill, fish habitat assessment

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