Water Quality Monitoring in Glacial Systems

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Introduction

Glaciers are iconic natural features that define the Alaskan landscape. Much of the surface area over which the Southwest Alaska Network (SWAN) covers has been or is currently influenced by glacial processes. Many of the lake systems monitored by SWAN receive a large portion of their annual inflow from glacial sources, including Lakes Clark and Kontrashibuna. Monitoring major inflowing tributaries to lake systems is a key aspect in studying SWAN's freshwater flow systems. However, since glacial rivers are dynamically different from clear water rivers and present unique logistical challenges, monitoring designs must remain flexible to account for systemic-level differences while still meeting studying objectives. Herein, I discuss SWAN's proposed approach to monitoring surface hydrology and freshwater chemistry vital signs on glacially-influenced lake systems, some of the comparative differences between glacial and non-glacial waters, and the challenges glacial systems present to implementing a long-term monitoring program.

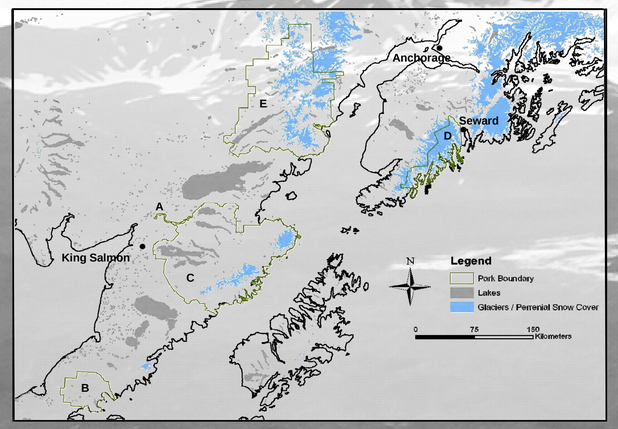


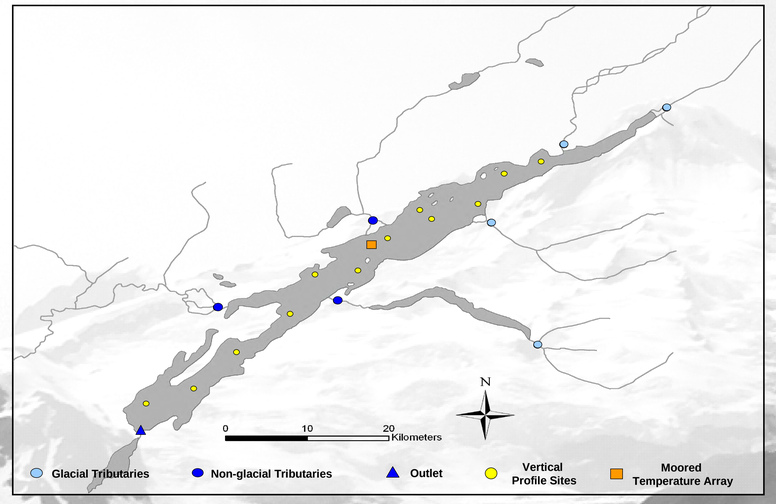
Figure 1. Map of the Southwest Alaska Network showing major lake systems and glacial coverage. National Park units represented by SWAN include Alagnak Wild River (A), Aniakchak National Monument and Preserve (B), Katmai National Park and Preserve (C), Kenai Fjords National Park (D), and Lake Clark National Park and Preserve (E).

Freshwater Flow System Monitoring Strategy

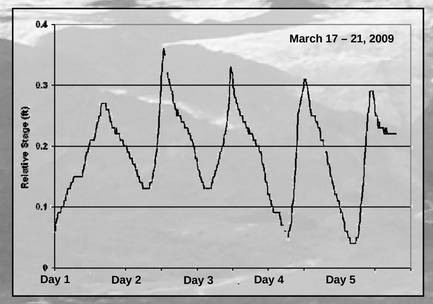
The goal of SWAN freshwater monitoring is to document the natural variability and to monitor for potential influences of large-scale anthropogenic impacts, such as climate change, on large lake systems. We recognize that these lake systems are not isolated basins, but a representation of their integrative components, such as inflowing tributaries, outlets, and contributing lakes. Thus, we use the term freshwater flow systems to more accurately describe these large lakes. The primary objective of SWAN's freshwater flow system monitoring is to describe the current status and trends of water quality and hydrologic conditions.

In order to meet this objective, sampling strategies must account for temporal and spatial scale. Temporally, we will collect water quality and hydrologic data during a mid-summer index period, seasonally during the ice-free season, and continually year-round. Spatially, we will collect data from targeted (e.g., lake outlets and inflowing tributaries) and random, spatially-balanced (e.g., vertical lake profile) sites throughout the lake basin. The variability of glacial and non-glacial tributaries will be assessed through seasonal monitoring of river stage, discharge, physical water quality (e.g., temperature, pH, conductivity), and water chemistry (e.g., nutrients, ions, metals) parameters.

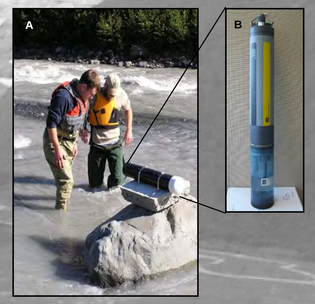
Due to the logistical challenges and expense of repeated access to many sites, SWAN will use automated data loggers as a primary means of data collection. Such technology allows for frequent, repeat measurements, an important consideration in glacial systems that experience daily fluctuations due to melting, without the need for continual staff presence at a site.



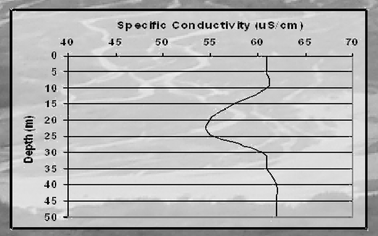
Sampling schematic of Lake Clark flow system displaying index (yellow symbols), seasonal (blue symbols), and continuous (orange symbol) monitoring sites. By monitoring input points (i.e., tributaries) we can assess the influences of glacial systems, and impacts to those systems, on large lake environments.



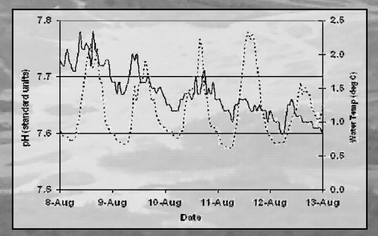
Sample hydrograph of a glacial river (20-Mile River near Anchorage, AK; data provided by USGS Water Resources Division). Note diel pulsing of river stage due to daily melting of snow and ice. A strategy of SWAN's freshwater flow system monitoring is to continuously monitoring water quality parameters in glacial rivers to capture the variability generated by the daily pulsing of flows (see picture to the right).



SWAN staff deploying a water quality instrument in Exit Creek, Kenai Fjords National Park (A). Multiparameter instrument used to continuously record water temp, pH, dissolved oxygen, specific conductivity, and turbidity (B).



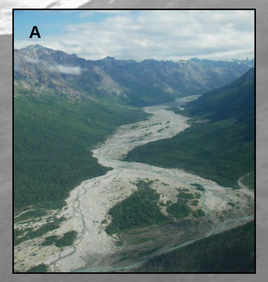
Specific conductivity profile collected in the upper basin of Lake Clark near Tlikakila River confluence on August 20, 2008. The lens of less conductive water between 10 m and 30 m is a result of cold, less conductive glacial water entering the lake and sinking below warmer surface waters.

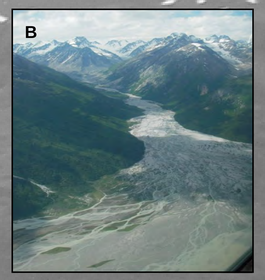


Water temperature (dashed line) and pH (solid line) data for Exit Creek within Kenai Fjords National Park collected between August 8 and August 13, 2008. The diel pulsing of water quality parameters illustrates the importance of continuous over synoptic monitoring when characterizing conditions in glacial systems.

Comparative differences between glacial (denoted with an *) and non-glacial rivers for discharge and selected water quality parameters within the Lake Clark flow system. Data collected from 1999 to 2001, reported in Brabets 2002.

Tributary	Discharge	Specific Conductance	pH	Water Temperature	Dissolved Oxygen	Suspended Sediment
	(ft^3/sec)	(µS/cm)		(°C)	(mg/L)	(mg/L)
Chokotonk River*	258 - 2,190	28 - 74	7.0 - 8.2	0 - 10.0	11.3 - 14.3	9 - 211
Tlikakila River*	25 - 12,000	31 - 117	7.2 - 8.1	0 - 9.4	11.0 - 14.0	5 - 710
Currant Creek*	279 - 2,760	36 - 74	6.9 - 7.6	1.7 - 7.5	11.1 - 14.9	3 - 282
Kijik River	432 - 3,000	70 - 88	7.0 - 7.8	3.5 - 12.5	9.4 - 13.7	2 - 123
Tanalian River	179 - 5,920	44 - 54	7.0 - 7.8	5.5 - 13.5	10.1 - 13.8	1 - 5
Lake Clark Outlet	8,530 - 23,800	55 - 62	7.0 - 7.9	4.5 - 11.5	10.3 - 14.1	1 - 5





Glacial river valleys in the Necons (A) and Neacola River (B,C) watersheds within Lake Clark National Park and Preserve. Such glacial rivers are characterized by braided, continuously shifting channels with extensive hyporheic flows. These features present challenges in establishing gaging sites to monitor river hydrology as stage discharge rating curves must be re-calculated with each major shift in the channels cross sectional profile.

Glacial river deltas for the Tlikakila River / Lake Clark (A) and Neacola River / Kenibuna Lake (B) areas within Lake Clark National Park and Preserve. Aside from the navigational challenges presented by such environments, the continued suspension and flushing of glacial silt by currents and wind result in a constantly shifting turbidity plume that greatly affects light transparency and lake productivity.

Citations

Brabets, T.P. 2002. Water quality of the Tlikakila River and five major tributaries to Lake Clark, Lake Clark National Park and Preserve, Alaska, 1999-2001. U.S. Geological Survey Water Resources Investigations Report 02-4127. pp. 29.

U.S.G.S. Water Resources Division. http://waterdata.usgs.gov/ak/nwis/rt. Accessed March 23, 2009.