An Examination of Data Gaps and Estimate of the Water Budget for Eyak Lake, Alaska

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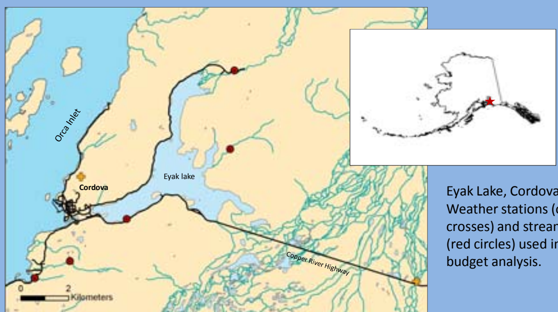
Introduction and Location

Eyak Lake is a valuable natural ecosystem adjacent to the vast Copper River Delta in south-central Alaska. The lake is habitat for salmon and resident fish, including coho, pink, and sockeye salmon, cutthroat trout, Dolly Varden, stickleback, eulachon, and sculpin. The fishing town of Cordova is situated on the shore, and much of the town's float plane traffic uses the lake, while Eyak River supports both sport and subsistence fisheries. The lake and river are used recreationally by residents all year, and many homes are situated within their floodplains. Because of the lake's diverse wildlife, scenic beauty, and economic value, in 1981 Eyak Lake was recommended for designation as an "Area Meriting Special Attention" by the Alaska Coastal Policy Council; this designation was approved in 1986.

Eyak Lake has undergone many changes since the founding of Cordova in the late 1800s. Odiak Slough, which probably served as a secondary drainage (after Eyak River) during times of high water, was filled in during the early part of the 20th century. Road building and commercial and residential development has occurred along two sides of the lake, increasing sediment run-off and disrupting fish access to streams as a result of poor culvert installation. A weir at the mouth of the lake was constructed after the 1964 Good Friday earthquake to stabilize the water level, and while salmon and other species of fish still access the lake, it is unclear how the weir has impacted the natural functioning lake and its future as fish and wildlife habitat.

An understanding of the habitat and physical processes occurring in the Eyak Lake watershed are necessary to guide restoration and preservation work, particularly in regards to the maintenance of fish habitat, the transportation and dilution of pollutants, and flood control. Little hydrologic data has been collected in the basin, and in this context we attempt to model a surface water budget for the lake by using hydrology models and available flow, weather, and spatial data.



Eyak Lake, Cordova. Weather stations (orange crosses) and stream gages (red circles) used in water budget analysis.

Methods

Water Budget

A water budget model was used in an attempt to better understand the hydrology of Eyak Lake, in hopes of quantifying the components of the budget and understanding the timing and magnitude of surface and inferring groundwater flows. The water budget consists of the continuity equation

$$Q_{Lake\_out} = Q_{tributaries} + P \pm S \pm GW - E \pm Error$$

Eyak Lake tributary monthly mean flows (*$Q_{tributaries}$*)

The Eyak Lake tributary monthly mean flows are modeled using two methods, an inverse distance weighted method (IDW) and statistical equations developed by the US Forest Service (R10 FLOWMOD); both methods are compared to the few local stream flow records available.

IDW – Inverse Distance Weighted

Q is the modeled discharge of interest (monthly);
n is the rank of the gage in order of closest to farthest away;
Q_n is the discharge from the nth closest gage;
A is the basin area of the modeled point;
A_n is the basin area of the gage n
D_n is the distance from the gage n to the modeled point;
p is the power coefficient to change the weighting of the distances, I used a value of 1

$$Q = \left[\frac{\sum_{n=1}^{i} Q_n \frac{A}{A_n} \frac{1}{D_n}^{p}}{\sum_{n=1}^{i} \frac{1}{D_n}^{p}} \right]$$

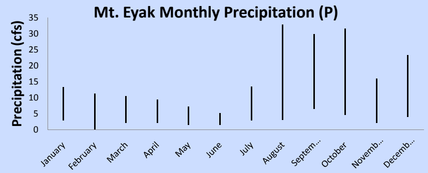
R10 FLOWMOD

Equations are from Cordova Region Table IX-6, p. IX-27, and Appendix VI (Orsborn and Strom, 1991).

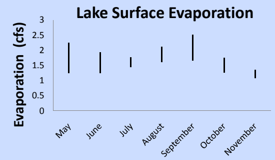
Mean Monthly Ratios to Qaa	
October	1.37
November	0.68
December	0.35
January	0.3
February	0.25
March	0.18
April	0.21
May	0.79
June	1.75
July	2.11
August	2.02
September	1.92

$$Q_{aa} = 8.0 * (A * H^{0.5})^{1.30}$$

Estimated values of monthly incidental precipitation on the lake, as the product of Mt. Eyak monthly precipitation and lake area.



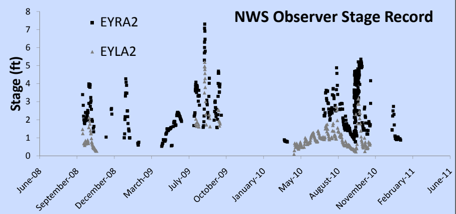
Lake surface evaporation calculated from an Atmospheric Conductance Approach (Dingman, 1994). The evaporation rate values are distributed over the entire lake area resulting in a volumetric rate. Months that the lake is typically covered in ice are not shown.



Groundwater *(GW)* and Lake Storage *(S)*

To our knowledge little is known about the Eyak Lake and groundwater exchange; however, areas where major tributaries flow into the lake are also likely sources of groundwater inflow. To calculate lake storage, inflow and outflow from the lake plus the lake level and capacity would be needed, as we could not quantify the groundwater exchange to the lake. Regretfully these components were not available.

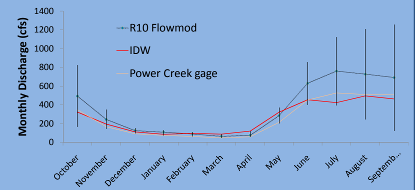
Observer stage data for two of the three sites on the Eyak River. We looked into the existence of cross-section data that related to these stage records in hope of calculating a rough hydrograph using Manning's Equation but no cross-section data were found.



Results

Although the entire water budget could not be calculated due to lack of data, we found the results for the two tributary hydrology models interesting.

Five Gages	IDW % Error		
	Middle Arm Gage	Nicolet Creek Gage	Power Creek Gage
October	0.12%	-0.38%	-7.15%
November	-0.19%	-0.67%	16.95%
December	0.49%	-0.98%	20.70%
January	0.56%	-0.95%	15.83%
February	-0.42%	-0.65%	51.16%
March	0.02%	-0.25%	82.13%
April	-0.26%	-0.72%	101.21%
May	-0.24%	0.89%	50.05%
June	-0.15%	5.34%	0.74%
July	0.07%	2.93%	-19.76%
August	-0.32%	1.74%	-2.86%
September	-0.13%	0.51%	-8.50%



Four Gages	IDW % Error		
	Middle Arm Gage	Nicolet Creek Gage	Power Creek Gage
October	10.54%	-24.33%	-13.80%
November	-15.93%	-42.58%	32.70%
December	41.78%	-62.13%	39.94%
January	47.92%	-60.28%	30.55%
February	-35.72%	-41.09%	98.71%
March	1.61%	-15.59%	158.48%
April	-22.07%	-45.93%	195.29%
May	-20.19%	56.27%	96.57%
June	-12.80%	338.30%	1.43%
July	6.18%	185.79%	-38.13%
August	-27.22%	110.33%	-5.51%
September	-10.73%	32.38%	-16.40%

The R10 FLOWMOD equations performed within the model's expected error bounds. We assume that incorporation of more watershed characteristics (lakes, glaciers, % forested, etc) may address some of the variability, but conducting a regression of basin characteristics to monthly mean stream flow was not within the scope of this study nor were there enough long term gages to adequately perform this examination.

IDW has a lower percent error for the gages that have short records and smaller basins. Inherently the IDW will have a smaller error at gage locations due to the incorporation of the gage data itself; when the IDW was conducted for the gage locations without including the gage at the modeled location the error increased dramatically.

Conclusions

We realized through this process that hydrologic data for Eyak Lake, River, and tributaries was limited. Although one goal of this study was to close a water budget for Eyak Lake, this was not possible due to lack of data. However, our examination of the available data allowed us to make an assessment of data needs. First, there is a basic lack of flow information coming into and out of Eyak Lake. Second, lake level monitoring and a complete bathymetry data set would assist in understanding of the timing of lake storage and the groundwater component of the budget. If a reasonable record of lake outflow and the lake storage existed we could make some inferences as to whether there is a large amount of in- or outflow as groundwater.

The results from this project identify data gaps, help prioritize issues, and will guide data collection and restoration efforts. This project points out the importance of stream flow models, and the need for a stream flow gage on the Eyak River near the outflow of Eyak Lake. The water budget information will be useful in guiding a sediment budget for the lake, and to assess human impacts on sediment input. Most significantly, knowledge of the lake hydrology and specifically the outflow hydrograph will be necessary to the effective design of the outflow weir when the current one is replaced.

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