The identification of the source(s) and transport mechanisms of phosphorus and nitrogen in the Lower Shuswap, and Salmon Rivers.

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Introduction

Our project focuses on the lower Shuswap and Salmon Rivers, in the reaches just above Shuswap and Mara lake (See Map 1). In 2008 and 2010, respectively, Shuswap Lake and Mara Lake experienced large scale algal blooms. These blooms were due to excess nutrients being present, particularly nitrogen and phosphorous. Phosphorous and nitrogen are considered limiting nutrients in freshwater systems, meaning that algal and plant growth is directly related to the amount available. Therefore, if there is more of these nutrients available than what would occur naturally, there will be more growth than what would occur naturally. Algal blooms have adverse effects on aquatic life, as well as human health and the economy.

Our objective for this research project is to obtain a credible understanding of where the point and diffuse sources of phosphorous and nitrogen are and how the nutrients are being transported into the river. This knowledge will then be applied and used to make management decisions to reduce phosphorus and nitrogen loading into Shuswap and Mara Lakes, and hopefully prevent future blooms.

Research Questions

Our research will be guided by the following questions:

- What are the background levels of phosphorous and nitrogen in the Shuswap and Salmon River?
- Are there excess nutrients that are not from the natural environment?
- Where are these nutrients coming from?
- How are these nutrients being transported into the river?
- What are the land use coefficients for the surrounding area?

Methodology

SITE SELECTION

Sampling currently occurs on the lower Shuswap and Salmon Rivers and their tributaries, as these are the two major rivers that feed directly into the Shuswap and Mara lake system. These two rivers and lake systems were chosen for the their economic and societal importance to the surrounding area. Both systems are very important for recreation and ecological health etc., and algal blooms caused by excess nutrients can lead to large economic and ecological losses.

There are 13 sample sites on the Shuswap River, and 7 on the Salmon River (Map 2-3). There is a sample site on every major tributary on both of the rivers, and then downstream from the tributaries on the main river. The sites range from Mabel Lake to Mara lake on the Shuswap, and from Westwold Aquifer to Shuswap lake on the Salmon River. Sampling above Westwold and Mabel is not necessary, as nitrogen and phosphorous will be at a minimal due to settlement in Mabel lake and filtration through the Westwold Aquifer. Sampling occurs on major tributaries and then again 1 km downstream to allow for mixing to occur. This then allows us to use the difference in concentration of the nutrients to infer whether nutrients are entering the river from the land between sample sites.

SAMPLING FREQUENCY

The frequency of sampling will increase with discharge. During late Fall and the early winter months, frequency will be as low as once every 6 weeks, as the river and its tributaries will only have base flow, and there will not be much runoff due to snow, therefore nutrient concentration is unlikely to change much between visits.

Come freshet, or snowmelt season, sampling with gradually increase to a frequency of every third day. With snowmelt, flow changes frequently due to daily changes in runoff, and therefore nutrient input changes frequently.

Sampling frequency will drop after the peak of freshet, with the average frequency being every 1 to 2 weeks in the summer months.

In months with low frequency sampling, trips will be made to sample after large storm events that create abnormal amounts of runoff.

WATER SAMPLE COLLECTION

Water is collected at the sites in a 500 mL high-density polyethylene bottles, which are immediately put on ice, before they are transferred to a refrigerator for long term storage. All bottles are rinsed with the water at the sample site to prevent dilution or contamination. Samples are collected in flowing water, away from stream banks, upstream of the person sampling, and at a depth of approximately 10 cm below the surface.

PHOSPHOROUS ANALYSIS

All samples are analyzed within 48 hours of collection. The samples are filtered through a 0.45 micron membrane filter, and all phosphorous less than 0.45 microns, which will move through the filter and be left in the sample, is considered dissolved, and all else is considered particulate.

The liquid samples containing the dissolved phosphorous are then analyzed using the Ascorbic Acid Method of Total Dissolved Phosphorous (full method available here). After filtering, the samples are measured out to a volume of 25 mL, and a 0.25 grams of potassium persulfate is added to digest the samples. To speed up digestion of the potassium persulfate, the samples are placed in an autoclave, which uses steam to bring the samples up to a very high temperature. Once the samples go through the autoclave and have cooled, 4 mL of indicator is added. The ascorbic acid within the indicator turns the sample blue, and the intensity of the blue is determined by the amount of phosphorous present (more phosphorous, deeper blue).

The intensity of the blue is measured on a Milton Roy 401 spectrometer at 540 nm. The spectrometer shines a light through the sample, which is held in a 5cm long cuvette, and determines how much light is absorbed. The amount absorbed is directly related to amount of phosphorous within the sample. A calibration curve is prepared each time the spectrometer is turned on by measuring the absorbance of samples with known amounts of phosphorous in them. The absorbance of these samples are plotted against the known concentrations, forming a linear relationship, then the formula for this line is used to determine the concentration within the field samples.

NITROGEN ANALYSIS

At this time, we are only measuring nitrogen in the form of nitrate. Nitrate concentrations are determined in a similar way to phosphorous, using colorimetric methods. Water is filtered through 0.7 micron filters to remove organic matter and particulate nitrogen. The Nitrate via manual vanadium (III) reduction is then used to determine the amount of nitrate present (full method here). This method measures nitrate and any nitrite, since nitrite is likely to be negligible in our samples it does not need to be separated out.

10 mL of filtered sample is measured out, and vanadium chloride mixture and Greiss reagent is added to allow for color formation. In this case, if nitrate is present, a pink color will form, with deeper pink meaning more nitrate is present. Color formation takes 6-10 hours, and is stable for 48 hours. We typically prepare our samples the day before and then run them the following day.

For absorbance of nitrate, we use a Vernier spectrometer at 540 nm, and the sample is held within a cuvette with a 1 cm path length. The same procedure is done to determine concentration from absorbance, using standards with known concentrations and plotting them against their absorbance, and getting an equation to determine the samples concentrations from it.

DISCHARGE DATA

With the phosphorous and nitrogen analysis we determine concentrations in terms of mg/l, but we want to know the total loading of these nutrients, which is given in units of mass per time (for example; kilograms per day). For this, we need to know discharge, or the volume of water flow through in a given time. The Shuswap and Salmon Rivers are already monitored, but their tributaries are not. Because we do not have the resources to continually monitor the discharge data, we are using a method called a rating curve. Rating curves use the depth of the water body at a point, paired with incremental discharge data (measured by hand) to determine the discharge at any water height.

On all tributaries, we installed staff gauges, which is essentially a meter stick used to measure the height of the water at a certain point in time. In addition to the staff gauges, all 7 of the tributaries on the Shuswap have pressure transducers installed, which measure the height of the water at 15 minute intervals.

Currently, every two weeks we are also measuring the real time discharge using a Swoffer 3000 meter. This method works by splitting the stream in to several equal width sections, depending on width of the channel. Within these sections we measure the depth and velocity using the Swoffer. We then determine the area of the subsection by multiplying the depth by the width. The area is then multiplied by the velocity to get the discharge within that sub-section. The total discharge is then determined by the summing all the subsections (see diagram).

On the same days we measure discharge, we also read the staff gauges, and pull pressure measurements from the transducers. The discharge data is then plotted against the pressure data and staff gauge measurement. Using these we can create a rating, then interpolate the discharge at all heights and pressures.

Discharge will be measured at all points in the year, from the highest discharge to lowest discharge. The data will then be used to determine the loading of nutrients, by the following equation: concentration of nutrient (mg/L)*1000*Discharge(m^3/sec)*86400= loading (mg/day)

LINEAR INTERPOLATION OF DATA

Because we cannot sample every day, we must interpolate the data for the dates we do not sample. To do this, we interpolate the data linearly between two sampling days using the following equation: $y = y_1 + (x - x_1)\frac{y_2 - y_1}{x_2 - x_1}$

Where: y= interpolated value

y_1= concentration of nutrients on sample date 1 (known)

x= any date between two sampling dates (concentration unknown)

x_1= sample date 1 (concentration known)

y_2= concentration on sample date 2 (known)

x_2= sample date 2 (concentration known)

Literature Review

Background of the surrounding area, past studies, and surveys performed by the Fraser Basin Council and Shuswap Watershed Council are being extensively reviewed, as well as methods for the measurement of nitrate and phosphorous. Relevant links can be found here.

Historical Data

Before sampling for this project began, we were given access to the Ministry of the Environment's phosphorous and nitrogen data for the Shuswap and Salmon from 2011 to 2013. As an exercise, we interpolated the data between sampling dates, and did some basic statistical analyses. This data will be used as a comparison tool and will also be used to create land use coefficients, along with our own data. If preliminary results from this data set would like to be viewed, please contact Megan Ludwig (information below).

Constraints/Problems

The only current issue we are facing, is lack of knowledge to what type of agricultural practices are actually happening on these rivers and where. We are working with the Ministry of Agriculture on determining if this information is available, and how concise and accurate it is.

One foreseeable constraint is land access. In our second year of sampling, we will determine where to sample based on the previous year's samples, meaning if there is a stretch of river with particularly high nutrient loading, we will want more samples from that area to confirm our findings. The Shuswap River is easily accessed by boat and we will have no access issues, but since the Salmon is smaller, we likely will. The Salmon has much less water and fewer public access roads than the Shuswap, and we will likely be contacting land owners next spring in hopes of alleviating this issue.

Looking Forward

Our research has just begun on these rivers, and we have many more months of monitoring, as well as a few other objectives, listed below.

PIEZOMETERS

Piezometers are small amounts of tubing used to measure ground water depth, as well as sample ground water. They are driven into the ground and covered in a mesh casing to keep fine silts out, but allow water in. We have built 30 piezometers so far from polyethylene tubing and will be working to install them over the next month.

The piezometers will be installed just above high water mark, and will be used to measure and sample subsurface runoff from the surrounding land. Their locations will be determined using a stratified random approach, meaning we will divide all the land parcels along the rivers into strata based on their land uses, and randomly select parcels within each strata. This approach will allow us to have thorough sampling, without being bias.

MASS BALANCE

After gathering water samples and data for the next year, we will work to answer the research questions mentioned above using a mass balance approach. A mass balance assumes that all inputs must equal the outputs. Using this approach, if the natural inputs are not equal to the total outputs in terms of nutrients, it can be assumed that nutrients are coming in from some other source. These sources will likely include agriculture, industry etc.

LAND USE COEFFICIENTS

Using the mass balance approach and our data, we will be working to determine land use coefficients for the surrounding areas. These coefficients apply a number to each type of land use which can then be used to estimate nutrient loading into the river, without direct measurement. These coefficients can be used for entire watersheds to make management decisions.

LITERATURE REVIEW

Currently, the past reports prepared by the Fraser Basin Council and the Shuswap Watershed Council related to water quality and overall health of the lower Shuswap have been reviewed to gain a better understanding of the area. We have also reviewed papers related to colorimetric determination of phosphorous and nitrogen, as well as literature relating to land use coefficients. All these subjects and more will be reviewed more thoroughly throughout the project.

THESIS DEFENSE

One of the biggest objectives of this project for myself, is to gain enough knowledge and understanding of the nutrient loading within these systems to write a thesis. I then hope to publish my findings in a peer reviewed journal, as well as defend my thesis and receive a master's degree by summer of 2018.

Summary

In the time between May 2016 and August 2016, the early stages of monitoring as well as installation of equipment has been completed. In this time, we have collected close to 200 samples from 20 different sites on the lower Shuswap and Salmon Rivers. The samples have been tested for phosphorous and nitrate levels using colorimetric determination methods. Discharge data has also been gathered at these sites, and staff gauges and pressure transducers have been installed. Review of pertinent literature has begun, as well as analysis of past nutrient data provided by the Ministry of the Environment.

Contact

If there are any questions pertaining to the project, feel free to contact me;

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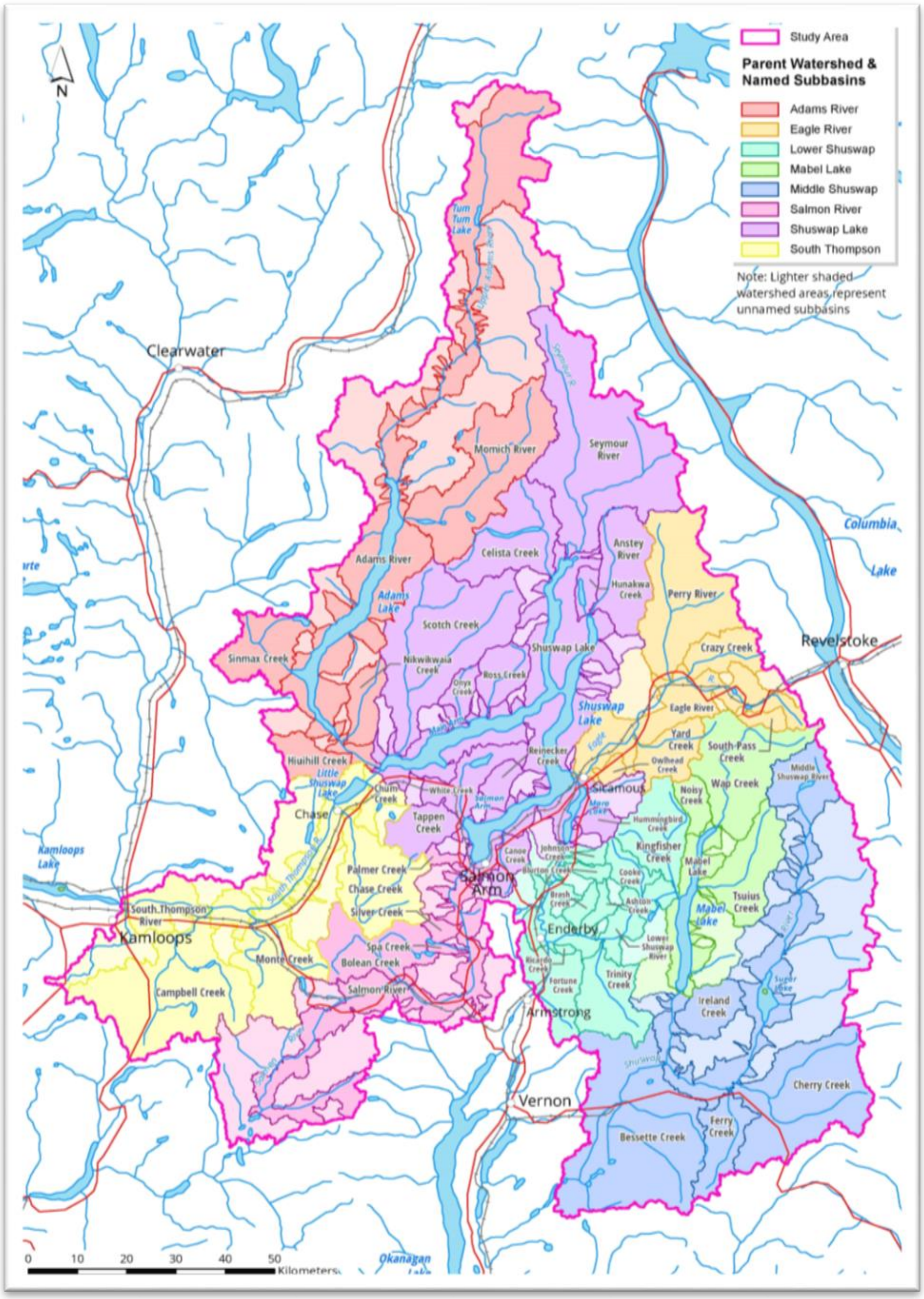
Appendix

MAP 1: WATERSHED BOUNDARY/STUDY AREA



Map 1: Watershed Map
Our study area focuses on the Lower Shuswap Watershed (blue-green) and Salmon River Watershed (pink)
Source: Shuswap Watershed Council

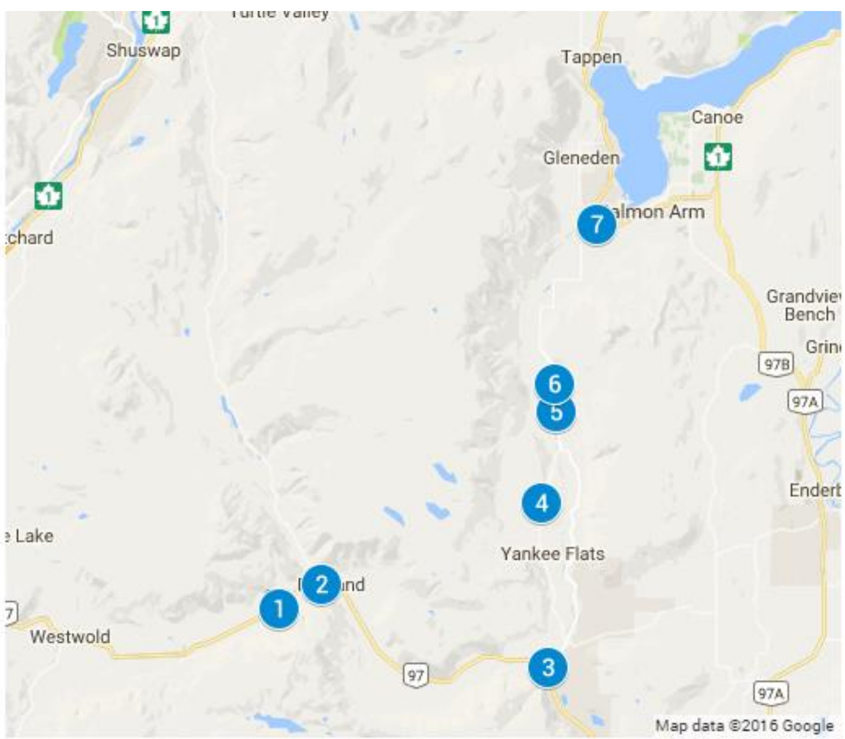
MAP 2-3: SAMPLING SITES

Shuswap River Sample Sites

1. Rivermouth Marina
2. Kingfisher Creek
3. Shuswap Canoe Put In
4. Cooke Creek
5. Falls Creek
6. Hidden Creek
7. Shuswap at Ashton Crk Bridge
8. Ashton Creek
9. Brash Creek
10. Fortune Creek
11. Enderby Boat Launch
12. Grindrod
13. Mara Lake Bridge

Salmon Sample Sites

1. Upstream Falkland
2. Bolean Creek
3. Glenemma
4. Spa Creek
5. Silver Creek
6. Downstream Silver Crk
7. HWY 1 Bridge



COLORMETRIC DETERMINATION OF PHOSPHOROUS

Acrobat Document

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COLORMETRIC DETERMNATION OF NITROGEN

Adobe Acrobat Document

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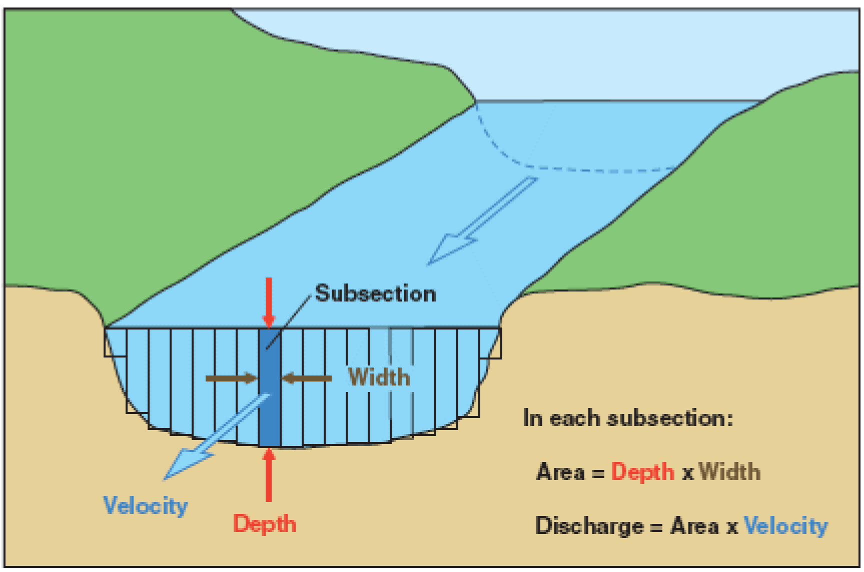
Procedure provided by Karen Perry, PhD, University of British Colombia, Okanagan

MEASURING DISCHARGE DIAGRAM



Current-meter discharge measurements are made by determining the discharge in each subsection of a channel cross section and summing the subsection discharges to obtain a total discharge.

Source: United States Geological Survey (http://water.usgs.gov/edu/streamflow2.html)

RELEVENT LITERATURE

Water quality reports for the region, prepared by the Fraser Basin Council: http://www.fraserbasin.bc.ca/water_quality_resources.html

Example on how to determine and use land use coefficients for nutrients:

Adobe Acrobat Document

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