SECTION 1

Nutrients and oxygen

A lake re-emerges: Analysis of contaminants in the *Semá:th X̱ó:tsa* (Sumas Lake) region following the BC floods of 2021
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RAINCOAST CONSERVATION FOUNDATION

NUTRIENTS AND OXYGEN

Capsule

Nitrogen and phosphorus concentrations were 43 and 19 times higher, respectively, in surface waters of the former *Semá:th X̱ó:tsa* (Sumas Lake) compared to our upstream reference site. This corresponded to dissolved oxygen levels in Sumas waterways that were 52% lower than our upstream reference site. This implicates fertilizers, manure, wastewater effluent and/or leaking septic fields in degrading the fundamental properties of fish habitat in Sumas waterways.

Introduction

The catastrophic floods of late 2021 in British Columbia and Washington State overwhelmed urban, agricultural and industrial infrastructure in the *Semá:th X̱ó:tsa* (Sumas Lake) area, raising concerns about the impacts of contaminant discharges into fish habitat. The absence of pre-flood baseline data and ongoing monitoring of freshwater quality in the area highlighted the urgent need for water sampling and analysis to assess the level of risk to fish and the environment.

Freshwater habitats that are fish-bearing require good water quality, starting with suitable dissolved oxygen (DO), temperature, hardness, conductivity, and neutral acidity (pH). Other important factors to consider are the concentrations of nutrients such as nitrogen and phosphorus. While all of these water properties in moderation are features of healthy aquatic ecosystems, they can become harmful through human activities.

Dissolved oxygen ensures that fish and other organisms inhabiting aquatic environments get the oxygen they need. The measurement of DO provides a direct indication of an aquatic ecosystems' ability to support fish life. Hardness, measured as calcium carbonate, indicates the dissolved content of the minerals calcium and magnesium in water. Hardness can affect the chemistry of water and the interactions of other chemicals. Temperature affects water chemistry, the amount of oxygen it holds, and the health of fish. Conductivity is the ability of water to conduct an electrical current, and can indicate the amount of dissolved substances, chemicals, and minerals in the water (1). pH provides an indication of how acidic or basic (alkaline) the water is, which can also have a significant effect on fish health.

Excess nutrients are associated with degraded fish habitat and eutrophication. In moderation, nitrogen

and phosphorus are essential for plant growth. Too much of these nutrients can lead to excessive plant and algae growth and cause declines in dissolved oxygen levels in water as the plants decay (2).

Runoff from human activities such as agriculture, leaking septic systems, or discharges from sewage treatment plants can release nutrients into fish habitat. Both nitrogen and phosphorus can enter waterways from agricultural lands (3,4).

Reduced levels of dissolved oxygen can impact the growth and development of salmon at all life stages and can negatively affect the swimming performance of migrating adults and other cold water fish (5,6).

Methods

We collected 27 surface water samples from 11 sites in the Sumas Lake area of the Fraser Valley (British Columbia; 10 on December 15, 2021, 9 on December 23, 2021, 6 on January 27, 2022 and 2 on February 2, 2022) as well as 4 groundwater samples on February 2, 2022. Two of these samples from Abbotsford groundwater sources will be evaluated separately. Details for sampling sites are listed in the Executive Summary. Temperature, pH, conductivity, and dissolved oxygen were measured at each site using a YSI meter.

Collected water samples were stored in the field at 4°C in suitable containers supplied by partnering laboratories, and delivered the same day to Caro Analytical Services in Richmond, BC (CARO Analytical Services - Water, Soil, Air, Plant, Food Testing) for analysis. They used their in-house SM2340 B (2017) method for measuring hardness, the TKN; NO2+NO3 by colour protocol for measuring total nitrogen; and the Colorimetry in water method for measuring total phosphorus. Data are presented as milligrams per litre (mg/L).

As one means of interpreting the risk of nutrient-related effects in fish habitat at our sample locations, we compared our results to the most protective Environmental Quality Guidelines (EQGs) for fish and fish habitat available in a Canadian provincial or federal jurisdiction. Jurisdictions with relevant EQGs in Canada included British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Canada (federal) and the Canadian Council of Ministers of the Environment (CCME). While these Environmental Quality Guidelines don't fully explain contaminant risks to fish, they do provide a basic benchmark to gauge the health of fish habitat.

We refer to the most protective EQG in Canada herein as the 'pan-Canadian Environmental Quality Guideline to protect fish and fish habitat' or the 'pan-Canadian EQG'.

We report here on nutrient concentrations in 25 surface and 2 ground water samples following the British Columbia floods of late 2021, and evaluate results against our pan-Canadian EQG to protect fish and fish habitat.

Results

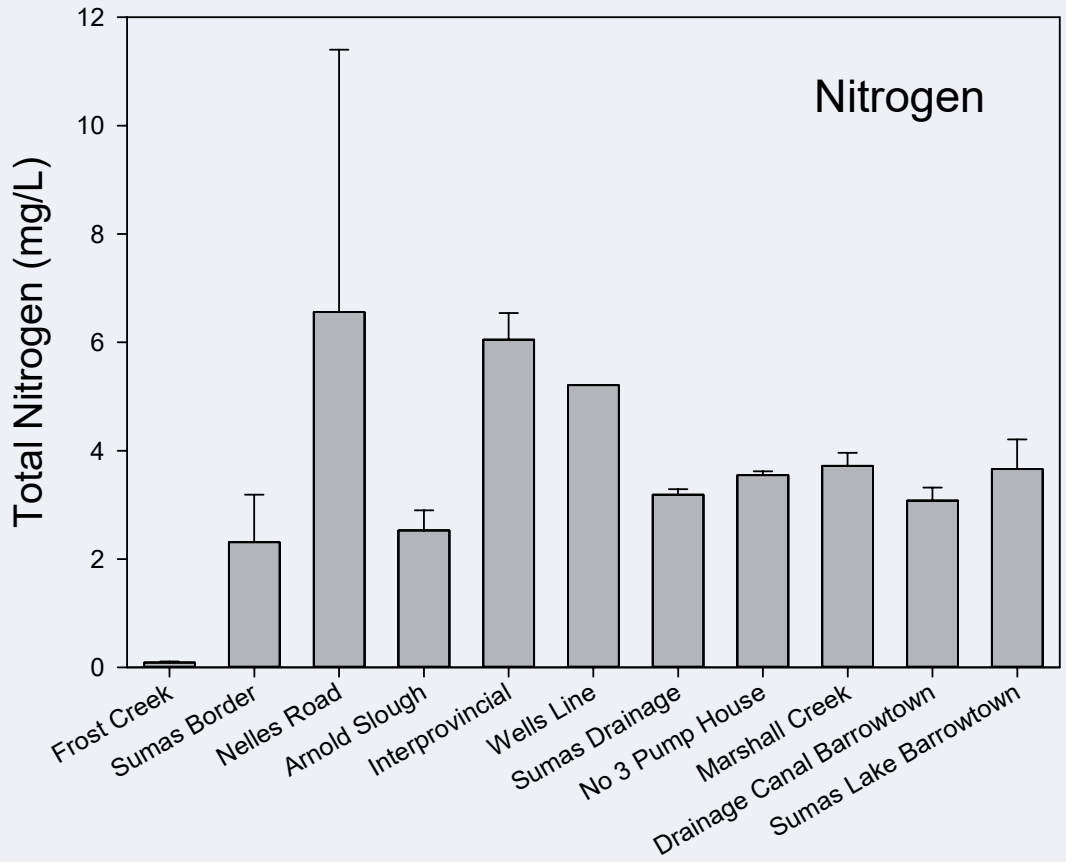
Surface water

- Average temperature ranged between 2.7 and 6.6 °C across all surface water sites and sampling dates, in line with seasonal expectations.
- Average conductivity ranged between 119.5 to 194.5 -uS/cm across surface water sites and sampling dates.
- Average pH ranged from 6.7 to 7.4, in the guideline range of 6.5 to 9.0 across surface water sites and sampling dates.
- Average hardness ranged from 40.0 to 158.0 mg/L across surface water sites and sampling dates.
- Average total nitrogen (includes nitrate, nitrite and ammonia) ranged between 0.09 and 5.56 mg/L across surface water sites and sampling dates.
- Average total phosphorus ranged from 0.02 to 0.85 mg/L across surface water sites and sampling dates.
- Average dissolved oxygen ranged from 3.6 mg/L to 13.8 mg/L across surface water sites and sampling dates.
- Nitrogen concentrations were 43 times higher in our 10 Sumas surface water sites compared to our upstream reference site (Frost Creek).
- Phosphorus concentrations were 20 times higher in our 10 Sumas surface water sites compared to our upstream reference site (Frost Creek).
- Average dissolved oxygen concentrations decreased by 52% in our 10 Sumas Lake surface water sites compared to our upstream reference site (Frost Creek).
- Average concentrations of nitrogen and phosphorus increased by 184% and 140%, respectively, between December 15th, 2021 and January 27th, 2022 across all surface water sites.
- No change in average dissolved oxygen concentrations were observed over the duration of this study.

Groundwater

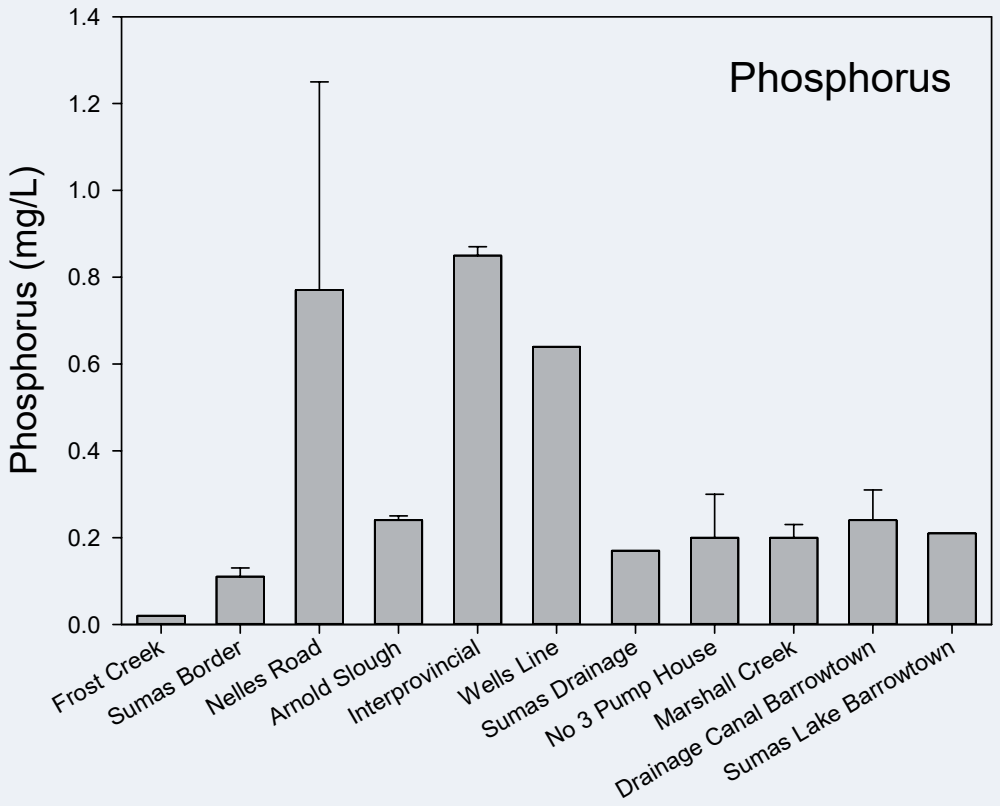
- Temperature ranged from 10.4 to 10.8 °C in groundwater water sites.
- Conductivity ranged from 203.2 to 374.8 -uS/cm in groundwater water sites.
- pH ranged from 6.56 to 6.84; all sites were in the guideline range of 6.5 to 9.0 across groundwater sites.
- Hardness ranged from 127.0 to 208.0 mg/L across groundwater sites.
- Total nitrogen (includes nitrate, nitrite and ammonia) ranged between 10.1 and 16.6 mg/L across groundwater sites.
- Total phosphorus ranged from 0.01 to 5.03 mg/L across groundwater sites.
- Dissolved oxygen ranged from 1.15 mg/L to 4.36 mg/L across groundwater sites.

Figure 1.1: Total nitrogen concentrations in surface waters



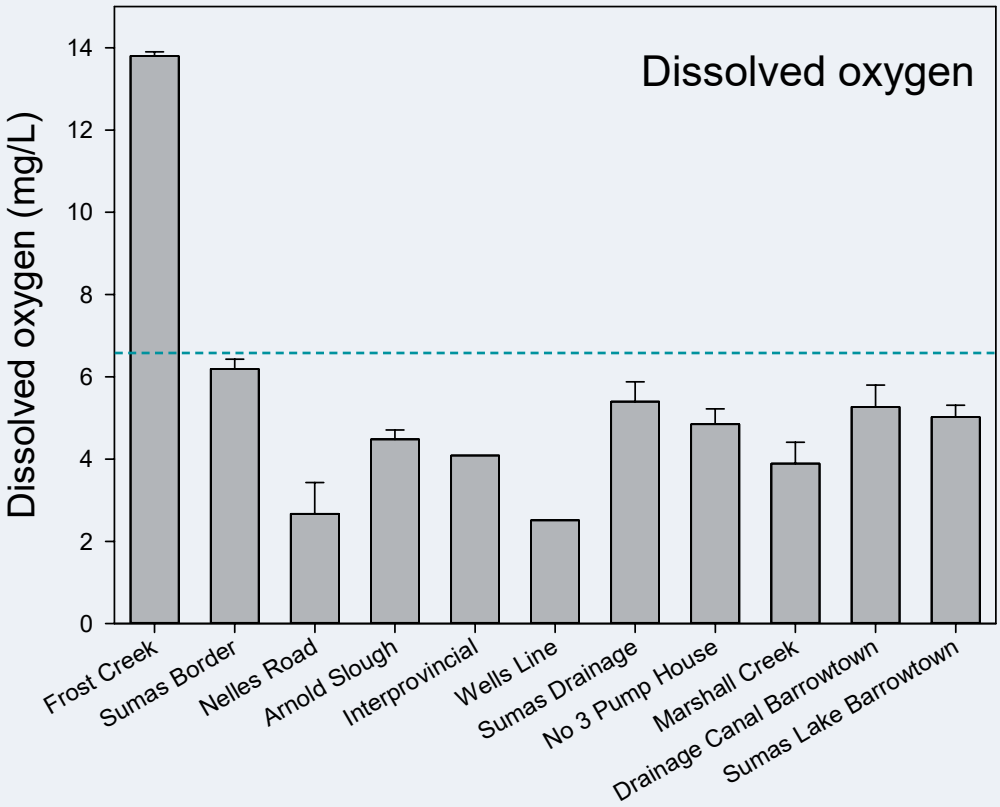
The average concentrations of total nitrogen was relatively high in the agriculturally-influenced Sumas Lake sites compared to our reference site upstream (Frost Creek). The sites followed the downstream flow of water from our reference site above Cultus Lake (Frost Creek), through the Sumas Lake area, and being discharged into the Fraser River through the Barrowtown Pump Stations.

Figure 1.2: Phosphorus concentrations in surface waters



Average concentrations of phosphorus were relatively high at agriculturally-influenced Sumas Lake sites compared to our reference location upstream (Frost Creek). The sites followed the downstream flow of water from our reference site above Cultus Lake (Frost Creek), through the Sumas Lake area, and being discharged into the Fraser River through the Barrowtown Pump Stations.

Figure 1.3: Dissolved oxygen in surface waters



Average concentration of dissolved oxygen (mg/L) declined at sites in Sumas Lake waterways, indicating degraded fish habitat. The sites followed the downstream flow of water from our reference site above Cultus Lake (Frost Creek), through the Sumas Lake area, and being discharged into the Fraser River through the Barrowtown Pump Stations. The dotted line denotes the Environmental Quality Guideline for Dissolved Oxygen established by the CCME.

Conclusions

While temperature, hardness, pH, and conductivity are important parameters for water quality, we focus here on the implications of excessive nutrient levels on dissolved oxygen in fish habitat.

» Nitrate, phosphorus and dissolved oxygen have Environmental Quality Guidelines listed by a Canadian jurisdiction. The most conservative pan-Canadian guideline for nitrate is BC Environmental Quality Guidelines. For phosphorus, the most conservative guideline is CCME. The most conservative guideline for dissolved oxygen is from CCME (6.5 mg/L) for cold water biota in adult life stages. The guideline for cold water biota in early life stages is 9.5 mg/L. There is no freshwater aquatic guideline for total nitrogen.

» While phosphorus does not have a guideline for aquatic organisms in running surface water, 7 surface water sites that we deemed to be 'stagnant' and one groundwater site exceeded the CCME guideline of 0.01 mg/L for freshwater lakes. These include: Sumas Border, Nelles Road, Arnold Slough, Interprovincial, Wells Line, Marshall Creek, No. 3 Pump House, and Groundwater 457.

» Four surface water sites had average DO levels below our pan-Canadian guideline of 6.5 mg/L, with the lowest DO at Wells Line at 3.5 mg/L.

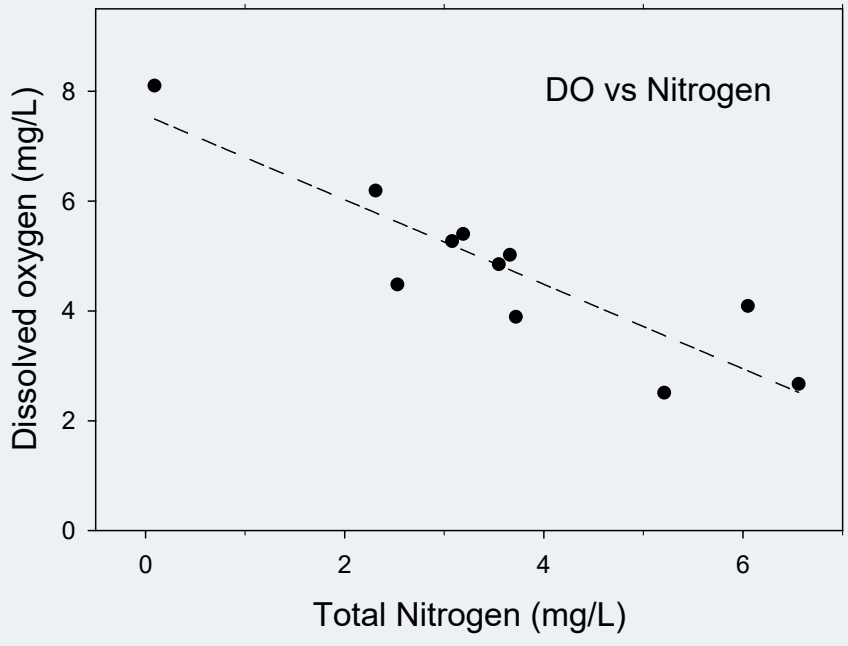
» Nitrogen and phosphorus concentrations were 43 and 20 times higher, respectively, in our 10 Sumas surface water sites compared to our upstream reference site (Frost Creek).

» There was a 52% decrease in average dissolved oxygen concentrations in our Sumas Lake surface water field sites compared to our reference site at Frost Creek.

» We detected an 84% increase in the average concentration of nitrogen, and a 40% increase in average phosphorus concentrations between December 15, 2021 and January 27, 2022 in all surface water sites.

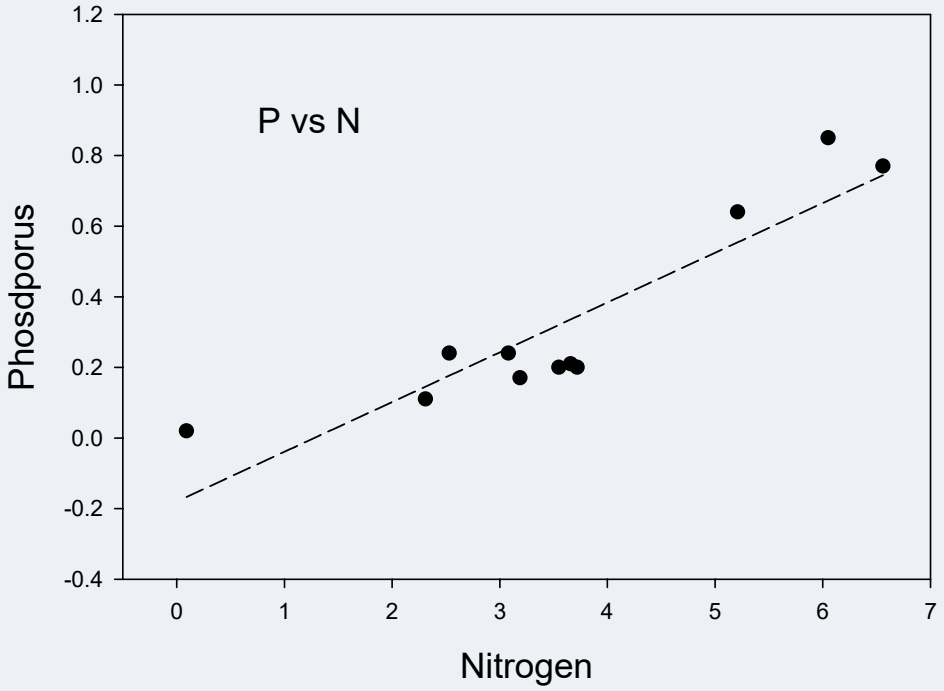
» We suggest analyzing nitrate and nitrite separately to be able to compare these to their guidelines; chloride concentrations are required to determine nitrite guidelines.

Figure 1.4: Dissolved oxygen declines with increasing nitrogen



Dissolved oxygen in surface waters of the Sumas Lake area declined with increasing Nitrogen levels (r2-0.65; p=0.003), indicating eutrophication of fish habitat.

Figure 1.5: Phosphorus and nitrogen are correlated



Phosphorus and nitrogen levels in surface waters of Sumas Lake waterways were strongly correlated (r2=.83; p=0.0001), suggesting that agricultural fertilizers and livestock manure are contributing to the degradation of fish habitat.

The dissolved oxygen levels in the former Sumas Lake area were below the concentrations needed to support healthy fish, indicating degradation of fish habitat. The strong correlation between nitrogen and phosphorus appears to reinforce the connection to agricultural practices, through fertilizer application, soil tillage, manure, wastewater treatment plant effluent and/or leaking domestic (septic) wastewater.

The strong negative correlation between dissolved oxygen and total nitrogen suggests a link between agricultural sources of nutrients and the loss of function of this fish habitat. Our findings suggest that the floods of 2021 may have flushed these nutrients into fish habitat, but pre-flood nutrient concentrations may already have been elevated. Future water quality monitoring would help identify the source of these nutrients, inform potential flood and/or seasonal-related pollution pulses in surface water, and provide a basis for solutions in the Sumas Lake region.

References

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