UNIVERSITY OF ALBERTA

Department of Biological Sciences
Faculty of Science

CW 312 Biological Sciences Building
Edmonton, Alberta, Canada T6G 2E9

www.biology.ualberta.ca
rolf@ualberta.ca

Tel: 780.492.1257/1870
Fax: 780.492.9457

18 January 2016

To:
Lakewatch, Alberta Lakes Management Society
P.O. Box 4283
Edmonton, Alberta
Canada T6E 4T3

From:
Rolf Vinebrooke
Department of Biological Sciences, University of Alberta
Edmonton, Alberta, Canada T6G 2E9
Tel: 780-492-1870

Re: Littoral Food-Web Survey of Pigeon Lake Summer 2015 – Summary Report, Data & Invoice

Dear Bradley,

Please find attached a report of our findings of the nearshore survey of Pigeon Lake that was conducted this past summer. The lateness of the report is attributable to a delay in the receipt of quality-assured chemical data from the Biogeochemical Analytical Laboratory here at the University of Alberta. Nevertheless, I would greatly appreciate if you could provide the attached report and the raw data file (Excel), along with the appended invoice to the attention of the members of the in-lake remediation subcommittee. As always, I am very willing to answer any questions that might arise from our findings.

Best regards,

Rolf

A Survey of Littoral Food-Web Structure in Pigeon Lake, Alberta Summer 2015

Rolf Vinebrooke

Centennial Centre of Interdisciplinary Science, Department of Biological Science
University of Alberta, Edmonton, Alberta, Canada T6G 2E9
Tel: 780-492-1870/9850

Summary

In collaboration with LakeWatch, I investigated the potential role of food-web structure in the proliferation of cyanobacteria (i.e. blooms) during the ice-free season of 2015 in Pigeon Lake, Alberta. Nearshore (littoral) water chemistry, phytoplankton, zooplankton, and minnow communities were quantitatively sampled at five sites from June to August for a total of 35 collections. Total phosphorus (TP) concentrations increased exponentially over time while the dissolved fraction remained relatively constant at moderately productive (mesotrophic) levels. In contrast, the strong positive correlation between high total chlorophyll concentration and TP suggested that phosphorus uptake by the cyanobacteria from the sediments greatly facilitated the observed mid- to late-summer blooms. Also, detected high abundances of minnows together with sparse abundance of herbivorous zooplankton highlighted the likelihood of predation having severely reduced grazing pressure on the phytoplankton, thereby further stimulating unchecked growth by the cyanobacteria. The hypothesis of weak grazing pressure in Pigeon Lake was supported by evidence from several in vitro experiments in which the impacts of the collected resident zooplankton community on the phytoplankton were undetectable. Therefore, we recommend that a fisheries management strategy be developed with the Province in which efforts are made to suppress the minnow community so as to release herbivorous zooplankton from predation pressure, thereby increasing their grazing impact on the cyanobacteria. Such a strategy could involve enhancement of the piscivorous fish populations (yellow perch), or direct harvesting of the minnows. Similarly, active removal of high P-containing cyanobacterial could further help reduce the contribution of internal chemical and biological recycling of phosphorus to the cyanobacterial blooms. Although elimination of external loading of P is the ultimate solution to lake eutrophication, our findings highlight how removal of P-laden cyanobacteria and minnows could help expedite bioremediation of Pigeon Lake.

We conducted the survey of surface water chemistry, food-web structure, and grazing pressure in Pigeon Lake this past summer from June 3rd to August 18th. The lake was sampled on seven separate occasions. Each of the sampling events involved collections from five sites (Crystal Springs, Grandview, Lakeshore, Johnsonia, and Itaska) located around the lake. Water samples were collected from a distance of 10 m offshore using a 12-L capacity van Dorn bottle. Unfiltered subsamples were stored in virgin high-density polyethylene bottles on ice for analysis of total nutrients while other subsamples were first filtered through a Millipore apparatus fitted with Whatman GF/F filter paper. The filtrate would later be analyzed for total dissolved nutrients while the filter paper was analyzed for total chlorophyll content using high pressure liquid chromatography. Zooplankton collections were performed by pooling three separate 10-m long horizontal hauls of the surface waters, which were conducting using a 30-cm aperture Wisconsin conical net fitted with 64-micron nylon netting. The minnow community was sampled quantitatively by enumerating all individuals that were captured by a 10-m long seine-net sweep of the littoral area.

Total phosphorus (TP) concentrations were initially below 30 μg/L) in June, indicating moderately productive lake conditions (Figure 1). Thereafter, phosphorus concentrations increased over time with total dissolved phosphorus (TDP) typically representing 20 - 30% of the TP pool (i.e. most P was in the form of particulates). Chemical analyses also revealed relatively high concentrations of dissolved organic carbon (7 – 10 mg/L), indicating that most of the TDP was organically bound and not immediately available to phytoplankton.

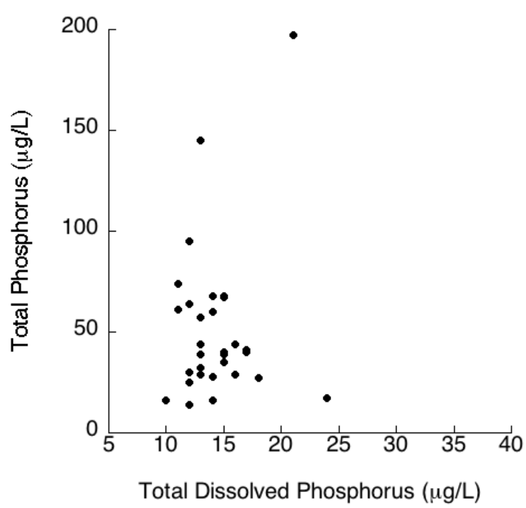

Figure 1. Total phosphorus (TP) as a function of Total Dissolved Phosphorus (TDP) in the littoral zone of Pigeon Lake during summer 2016.

As the proxy for phytoplankton biomass, total chlorophyll concentration similarly increased during the summer, showing a strong positive relationship with TP (Figure 2). As a result, high concentrations of TP in the form of particulates was primarily attributed to increases in the concentration of cyanobacterial cells, which likely derived their high P-content from the sediments. Otherwise, no strong relationship was detected between total chlorophyll and TDP concentrations as the former increased exponentiall during the summer while the latter remained relatively stable. Both the concentration of TP during June and TDP throughout most of the summer indicated that Pigeon Lake should be considered to be of only moderatively productive capacity ("mesotrophic), which highlighted the potential role of an additional factor contributing to the cyanobacterial blooms.

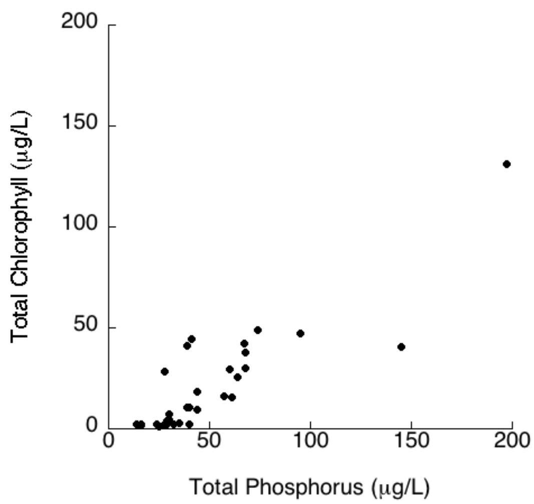

Figure 2. Total chlorophyll concentration (algal biomass) as a function of TP in the littoral zone of Pigeon Lake during summer 2016.

In contrast, total chlorophyll concentration showed a marginally negative exponential relationship with the total biomass of herbivorous zooplankton (Figure 3). The abundance of grazers remained very low despite the progressive increase in their potential food source (phytoplankton) during the summer. Herbivores were only briefly abundant (68 micrograms/L) in early June, and then fell to almost undetectable levels from mid-June to late August. Therefore, the abundance of grazers appeared inadequate to suppress cyanobacterial growth for most of the summer – a correlative finding later confirmed by our series of in vitro grazing experiments showing that herbivory (see Figure 4).

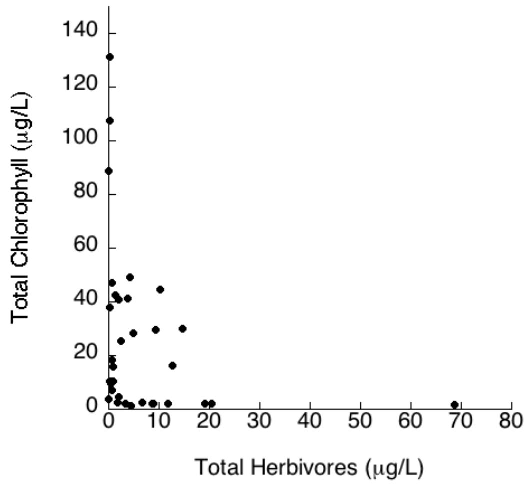

Figure 3. Total chlorophyll concentrationas as a function of the abundance of herbivorous zooplankton in the littoral zone of Pigeon Lake during summer 2016.

Suppression of phytoplankton by zooplankton via grazing pressure was not evident despite amending ambient population densities by a factor of 4 (Figure 4). Reduction in chlorophyll concentrations was marginally detected at 2- and 3-fold ambient densities of zooplankton, but these values were not statistically significant from zero. This finding was attributable to the consistent prevalence of small non-herbivorous cyclopoidal copepods in the zooplankton community throughout the summer of 2015 in Pigeon lake.

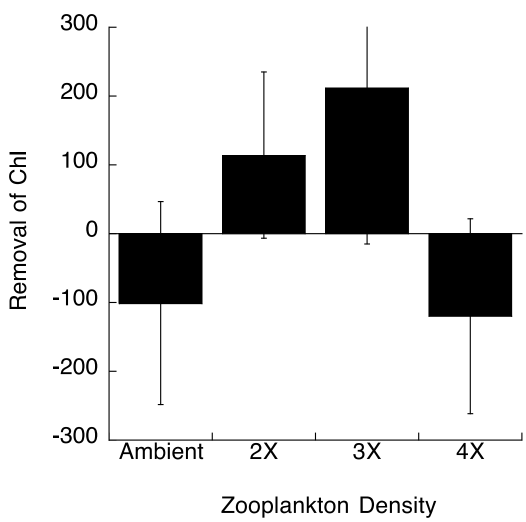

Figure 4. Impact of zooplankton on phytoplankton chlorophyll across a gradient of ambient zooplankton densities collected from Pigeon Lake during summer 2016.

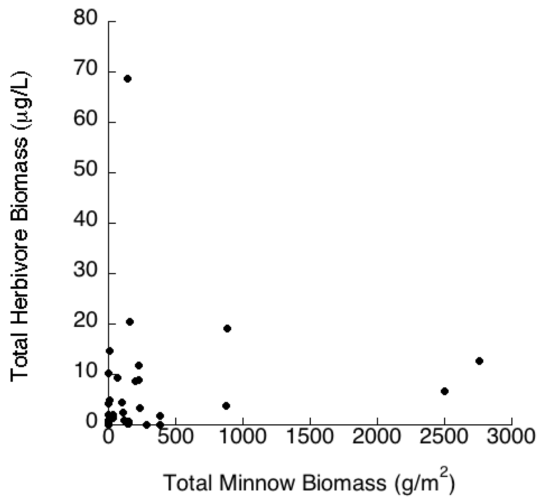

Figure 5. Total herbivorous zooplankton biomass as a function of total minnow biomass in the littoral zone of Pigeon Lake during summer 2016.

Similarly, herbivore biomass showed a marginally negative exponential relationship with total minnow biomass (Figure 5). Here, minnow abundance was highly cyclical across both sampling sites and sampling dates, peaking in both mid-June and mid-July at substantially high levels of ~2.5 kg/m^2. The highly variable nature of the minnow population and the expected lag time required for their predation to suppress herbivore densities are likely reasons for the lack of a stronger negative relationship. Nevertheless, the almost complete absence of visually conspicuous large herbivores relative to the higher abundance of smaller microscopic omnivores attests to strong predatory pressure suppressing these consumers of algae. Further, the relative inedibility of the predominantly cyanobacterial phytoplankton also likely contributed to the weak grazing impact by the zooplankton. The recorded complete absence of zooplankton species capable of consuming cyanobacteria (e.g., bosminids) also helped explained the weak grazing pressure.

These findings suggest that the proliferation of cyanobacteria in Pigeon Lake during summer 2015 was the consequence of the combined effects of two ecological processes. Biogeochemical translocation of P from the sediments into the watercolumn in the form of cyanobacterial cells plus release from grazing pressure because of minnows suppressing herbivorous zooplankton appear to be contributing factors of the cyanobacterial blooms. As a result, it is recommended that reduction of internal loading of P (i.e. harvesting of P-rich cyanobacterial blooms) together with adaptive fisheries management (i.e direct or indirect culling of minnows via enhancement of their predator populations, namely yellow perch) be implemented to mute cyanobacterial outbreaks and improve water quality in the lake.

To:
LakeWatch, Alberta Lakes Management Society
P.O. Box 4283
Edmonton, Alberta
Canada T6E 4T3

From:
Rolf Vinebrooke
Department of Biological Sciences, University of Alberta
Edmonton, Alberta, Canada T6G 2E9
Tel: 780-492-1870

Re: Littoral Food-Web Survey of Pigeon Lake Summer 2015 – Invoice

The following is the breakdown of the total cost of the littoral survey and sample analyses performed by our lab in collaboration with LakeWatch:

1. Two undergraduate research assistants (@ $2000/month from June –August)…..$12,000
2. Transportation (7 round trips)………..…………………………………………$1500
3. Field sampling equipment (seine net, plankton nets, water filtration unit)…………..$500
4. Chemical reagents & sample containers……………………………………………...$500
5. Chlorophyll and water chemistry analyses………………………………………….$2000
6. University of Alberta – 20% ICR for External clients……………………………...$3300

Balance Due $19,800