Bayswater Beach

2021 Water Quality & Sediment Sampling Report

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Municipality of Chester

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Bayswater Beach 2021 Water Quality & Sediment Sampling Report

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1.0 Introduction

The following report summarizes the results of water quality and sediment sampling activities conducted at Bayswater Beach Provincial Park in 2021. This work follows a small-scale water quality program that investigated bacteria conditions in Bayswater Pond in 2020, as well as the findings of a report titled *Investigating Concerns of Marine Finfish Aquaculture Impacts at Bayswater Beach Provincial Park, NS*, which summarizes investigations carried out by NS Fisheries and Aquaculture in late 2020.

In 2020, Coastal Action was contracted by the Municipality of Chester to monitor bacteria conditions in Bayswater Pond and the freshwater stream that flows out of the pond across Bayswater Beach. Bacteria samples were collected on four occasions from surface water and beach sand. Bacteria concentrations were found to be very low and no exceedances of Health Canada recreational water quality guidelines were observed. Results can be found in *Water Quality Monitoring Report for Bayswater Pond/Bayswater Beach Provincial Park* (Coastal Action 2020).

In response to concerns regarding the presence of a foul-smelling black substance on Bayswater Beach, a sediment composition study was conducted by the NS Department of Fisheries and Aquaculture in 2020. Isotopic analysis was conducted to investigate possible linkages between the black substance and the open net-pen finfish aquaculture operation located offshore of Bayswater Beach. This sediment composition study determined that C-N isotope signals in the sedimentary organic matter (SOM) on Bayswater Beach did not share a common source with those found in SOM collected from the benthic habitat surrounding the nearby aquaculture operation. The study suggested that the SOM found on Bayswater Beach may be influenced by input from Bayswater Pond and the significant amounts of macrophytic algae that get deposited on the beach. Results from this study can be found in *Investigating Concerns of Marine Finfish Aquaculture Impacts at Bayswater Beach Provincial Park, NS* (NSDFA 2021).

In order to further investigate the conditions influencing this accumulation of organic matter on Bayswater Beach, monitoring activities in 2021 focused on the collection of a benthic sediment core from Bayswater Pond and the continued monitoring of water quality in the pond and stream as it flows across Bayswater Beach. The objectives of this work were:

- To collect a benthic sediment core from Bayswater Pond for paleolimnological and C-N isotope analyses, allowing for the comparison of isotopic signatures between the marine benthic sediment, the black SOM on Bayswater Beach, and the benthic pond sediment.
- To continue water quality investigations in Bayswater Pond through the analysis of *E. coli*, total nitrogen, total phosphorus, and dissolved organic carbon.

2.0 2021 Sampling Results

2.1 Water Quality

Water quality sampling occurred on August 20, 2021, and September 9, 2021, following heavy rainfall events (> 25 mm of rainfall), and on August 24, 2021, during drought conditions (i.e., several days of no precipitation). Sampling occurred at three sites identified as Pond, Culvert, and Beach (Figure 1). Dissolved organic carbon, total phosphorus, total nitrogen, and *E. coli* were analyzed at the Culvert site, whereas only *E. coli* was analyzed at the Pond and Beach sites.

Figure 1. Locations of sediment and water quality sampling sites at Bayswater Beach Provincial Park in 2021.

Total phosphorus ranged from 0.008 mg/L to 0.009 mg/L at the Culvert site (Table 1). Ontario's Ministry of Environment and Climate Change (MOECC) has established two guidelines for phosphorus in water bodies: ≤ 0.02 mg/L for lakes, and ≤ 0.03 mg/L for rivers and streams (Ontario's Ministry of Environment [MOE] 2008). Results at the Culvert site did not exceed either of these phosphorus guidelines and did not display an influence of overland runoff following rainfall.

Total nitrogen ranged from 0.435 mg/L to 0.537 mg/L (Table 1). Dodds and Welch suggest a guideline of 0.9 mg/L for healthy freshwater environments (Dodds and Welch 2000). Results at the Culvert site did not exceed this nitrogen guideline and did not display an influence of overland runoff following rainfall.

Dissolved organic carbon (DOC) ranged from 8.9 mg/L to 13 mg/L (Table 1). Studies show that brown water systems with high DOC concentrations are associated with increased bacteria productivity (British Columbia Environment and Resource Management Department Ministry of Environment, Lands, and Parks 1998).

E. coli concentrations ranged from Not Detected (ND) to 540 CFU/100 mL (Table 2). Health Canada's *E. coli* primary contact guideline for recreational water quality is ≤ 400 CFU/100 mL (Health Canada 2012). One exceedance of this guideline was observed at the Culvert site on August 24, 2021, during drought conditions. Results from the Beach site, located only 10-20 m downstream from the Culvert site displayed a low *E. coli* concentration of 80 CFU/100 mL, suggesting a possible localized source of contamination above the culvert (i.e., beaver activity) or potential sample contamination.

Table 1. Water quality analysis from three sampling events at the Culvert site in Bayswater Pond in 2021.

	Date	Dissolved Organic Carbon	Total Phosphorus	Total Nitrogen
		(mg/L)	(mg/L)	(mg/L)
Culvert	20-Aug-21	8.9	0.008	0.435
	24-Aug-21	13	0.009	0.490
	09-Sept-21	10	0.009	0.537

Table 2. E. coli analyses from three sampling events at the Culvert, Pond, and Beach sample sites at Bayswater Beach Provincial Park in 2021.

	Date	Culvert	Pond	Beach
E. coli (CFU/100 mL)	20-Aug-21	ND	ND	50
	24-Aug-21	540	20	80
	09-Sept-21	20	100	90

2.2 Bayswater Pond Sediment Core

A sediment core was collected on September 14th, 2021 from the center of Bayswater Pond using a gravity corer (Figure 1). The core was cut into 18 1-cm sections, which were then individually sealed in plastic bags and delivered to Dr. Ian Spooner at Acadia University for a paleolimnological analysis of several elements (Figure 2). Following this analysis, the samples were shipped to the University of New Brunswick for analysis of %C, %N, and stable isotopes of carbon and nitrogen (Figure 3). These data can be used to create a geochemical 'signature' to characterize the benthic sediment from Bayswater Pond and compare this signature to those found in the NS Fisheries and Aquaculture study on Bayswater Beach and the marine benthic sediment offshore. This analysis also provides insight into the sources and anthropogenic activities that have influenced the chemistry of Bayswater Pond.

2.2.1. Geochemical Analyses

The paleolimnological analysis and interpretation were provided by Dr. Ian Spooner at Acadia University. Overall, the timeline represented in the sediment core from Bayswater Pond is difficult to interpret.

The observed increase in lead (Pb) at 5 cm depth may indicate an increase in atmospheric deposition of combustible lead, which would correlate to approximately the year 1920. However, increases in titanium (Ti), rubidium (Rb), chromium (Cr) and other metals may be the result of geological processes associated with landscape disruption, possibly related to the construction of Route 329 and increased traffic (Dunnington et al. 2018).

Iron (Fe) and manganese (Mn) data suggest a trend toward reducing (redox) conditions (Mackereth 1966). Decreasing levels of sulphur (S) and strontium (Sr) suggest that marine influence on sedimentation in the pond has reduced over time, possibly associated with Route 329 creating a barrier between the beach and pond.

Collectively, the paleolimnological analyses of metals in the benthic sediment of Bayswater Pond provide a unique signature of the local conditions in the pond for comparison to nearby sources and ecosystems.

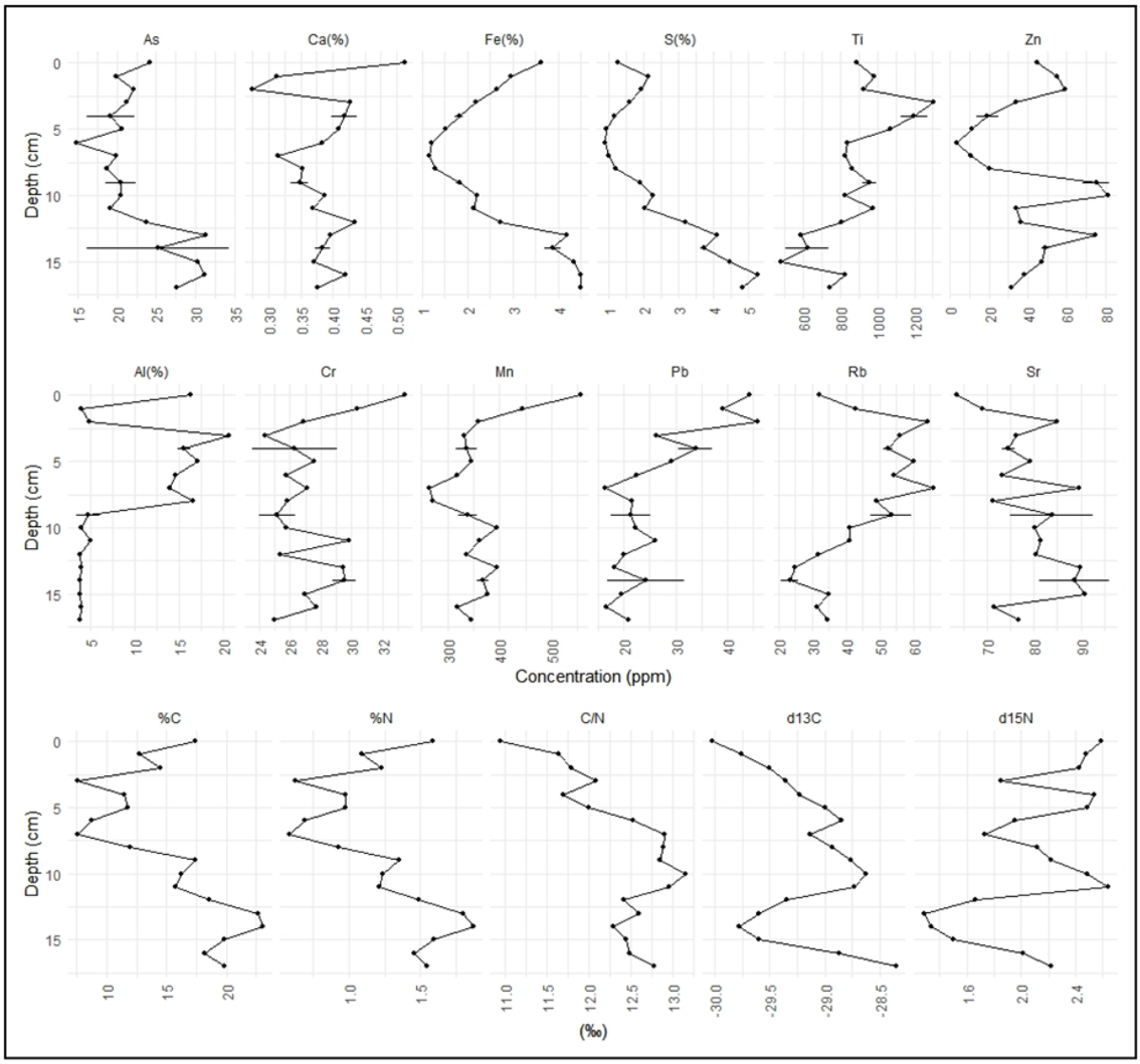

Figure 2. Geochemical analyses of benthic sediment collected from Bayswater Pond on September 14, 2021, provided by Dr. Ian Spooner, Acadia University.

2.2.2. Isotope Analyses

Following the paleolimnological metals analyses at Acadia University, the Bayswater Pond sediment core was sent to the SINLAB at the University of New Brunswick for analysis of %C, %N, and stable isotopes of both carbon and nitrogen (Figure 3). Interpretation of this isotopic analysis was provided by Dr. Ian Spooner at Acadia University.

The carbon, nitrogen and C/N isotopes data represent a unique chemical signature for sediment in Bayswater Pond. There is a significant dissimilarity between $\delta^{13}C$ and $\delta^{15}N$ values in the Bayswater Pond sediment to those observed in the Bayswater Beach and benthic marine samples collected in 2020 (NSDFA 2021).

Declining C/N values likely indicate the development of more autochthonous productivity (i.e., in-situ photosynthesis of plants and algae within the pond ecosystem). This factor may have contributed to the apparent increase in reducing conditions and may be associated with transportation development, pond outlet restriction, and perhaps inputs to the pond from anthropogenic activity within the watershed.

The C/N ratios remain between 10 and 20, indicating that both autochthonous and allochthonous productivity were likely contributing to the organic sediment load in Bayswater Pond (Meyers and Lallier-Vergés 1999; Meyers and Teranes 2001; Talbot 2001). The decreasing $\delta^{13}C$ is in contrast to increasing %C and $\delta^{15}N$. These relationships are complex, especially in a transitional freshwater-marine environment like Baywater Pond, which also likely has been subject to significant chemical and physical anthropogenic influence. Talbot and Lærdal (2000) and Filippi and Talbot (2005) proposed that falling $\delta^{13}C$ (and relatively high $\delta^{15}N$ and C/N) is recorded in freshwater sediments during water level rise, thus the data from Bayswater Pond may be, in part, related to outlet manipulation and consequent impacts on the water level.

In summary, the bulk geochemical data retrieved from Baywater Pond sediment indicates that this material is unique with respect to other organic material gathered locally and that it has likely been significantly influenced by anthropogenic activity.

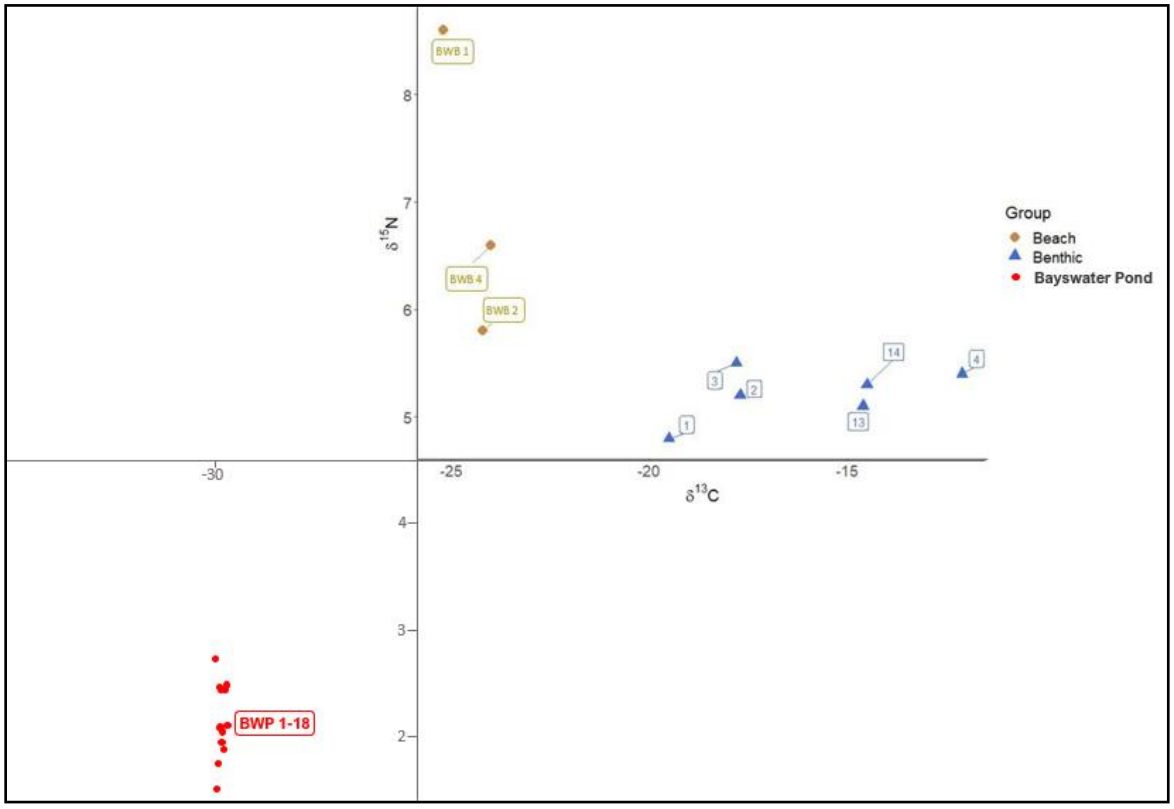

Figure 3. A comparison of stable isotope chemistry of Bayswater Pond sediment samples (BWP 1-18 from an 18 cm long gravity core) to samples of organic matter collected at Bayswater Beach (Beach) and in the offshore environment (Benthic). This diagram is modified from Figure 9 in a report by the Nova Scotia Department of Fisheries and Aquaculture, April 28, 2021, entitled "Investigating Concerns of Marine Finfish Aquaculture Impacts at Bayswater Beach Provincial Park, NS".

3.0 Discussion & Recommendations

Baywater Beach Provincial Park did not experience any closures of the marine swimming area in 2021. The monitoring activities reported here observed one exceedance of Health Canada's *E. coli* primary contact guideline on August 24, 2021, during drought conditions (i.e., several days of no precipitation) at the Culvert sample site; however, bacteria conditions on the same day in the stream on Bayswater Beach did not exceed guidelines.

Low concentrations of total phosphorus, total nitrogen, and dissolved organic carbon suggest that the pond is not rich in nutrients and is likely not a highly productive aquatic environment.

Analyses of the sediment core indicate that the sediment found in Bayswater Pond is distinct from the beach and marine benthic sediments investigated by NSDFA (2021). The pond has likely been impacted by anthropogenic activities related to land clearing, the development of Route 329, and manipulation of the pond's outlet.

Completion of this analysis means that there are now three distinct isotopic 'fingerprints' that have been investigated in the local area: Bayswater Pond, the marine benthic sediment near aquaculture operations offshore, and a sediment organic layer at 50-cm depth on Bayswater Beach.

It is recommended that a sample of the foul-smelling black substance be collected from Bayswater Beach when it appears on the surface of the sand, which seems to occur during the warm summer months. Once collected, this sample would undergo a paleolimnological and C/N isotope analysis to be compared to the three distinct isotopic signatures already established in the local area.

Should MOC be interested in financially supporting this initiative, Coastal Action can facilitate the collection of this sample by coordinating with local residents. Sample analysis would then be coordinated with Dr. Ian Spooner at Acadia University and the University of New Brunswick.

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