Characterization of the St. Lawrence Estuary's suspended matter size and composition

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Introduction

The St. Lawrence Estuary (SLE) in Quebec, Canada is characterized by two main geological provinces with different mineralogical and chemical signatures[1]. The Canadian Shield on the North Shore and the Appalachian Region on the South Shore.

The SLE is usually divided into two regions : the Upper Estuary featuring the Maximum Turbidity Zone and the Lower Estuary.

The suspended particulate matter (SPM) dynamic in the SLE is strongly influenced by winds, tides, river runoff and the presence of ice in winter. The particle size distribution is an important property of the SPM as it may affect sinking rates, particle re-suspension and the distribution of pollutants.

Little information exists concerning the particle size in the SLE and the SPM's origin.

A few studies have previously been done but didn't cover the complexity of this dynamic estuarine system[2,3,4,5,6].

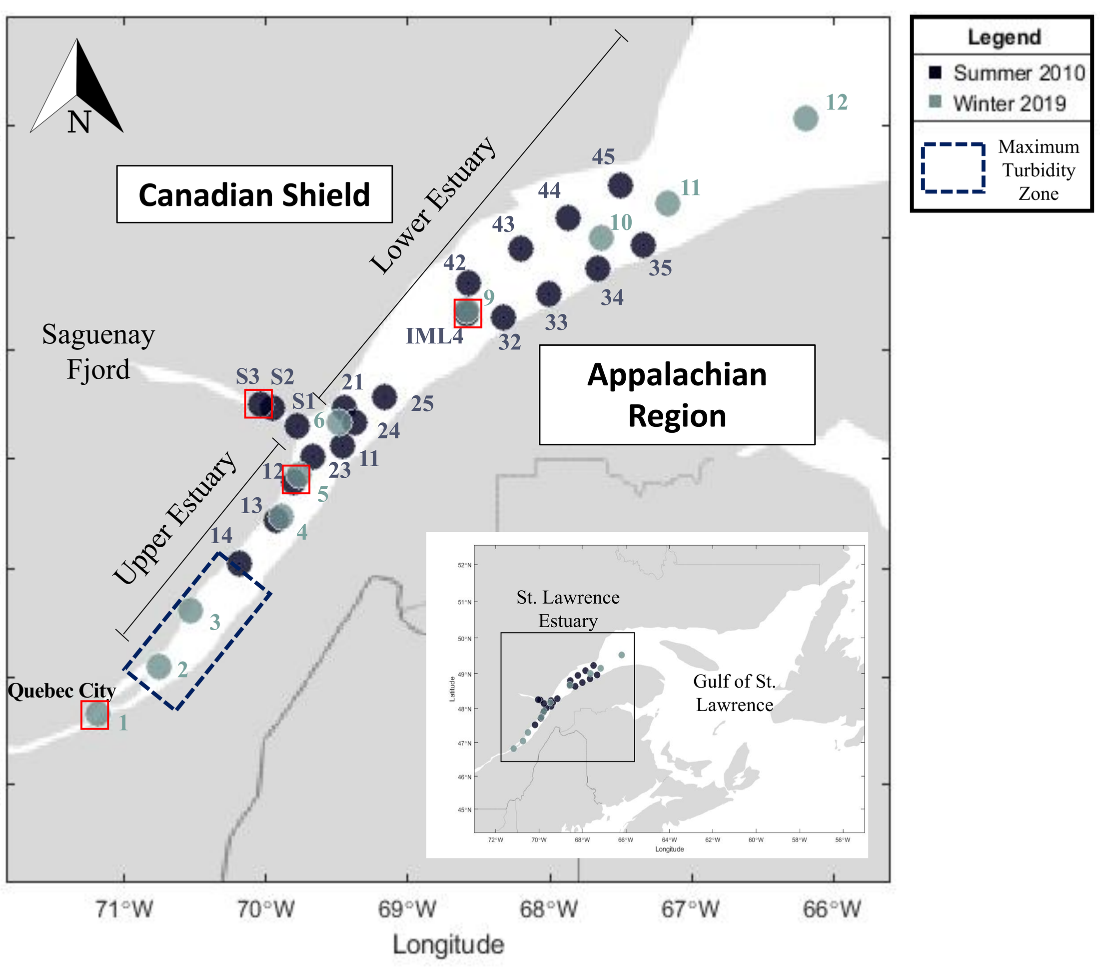


Figure 1 Location of sampled stations in the SLE in summer 2010 and winter 2019. The red squares indicates the location of the stations shown in figure 3.

Objectives

- Measure the **particle size distribution** in the SLE
  -> What is the spatial and vertical distribution
- Define the SPM mineralogical and chemical **composition**
  -> What are the detrital sources

Methods

Sampling

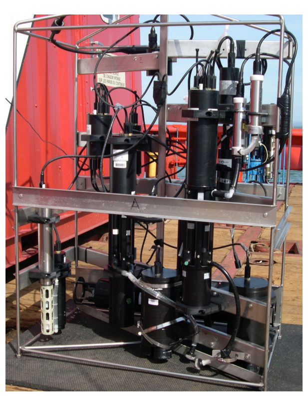
SUMMER 2010

Water samples collected with Niskin bottles :

- Chlorophyll-*a*
- Suspended particulate matter

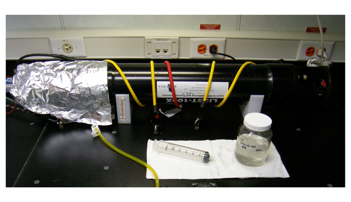
With an **optical profiler** were measured the following properties :

- **Optical** (LISST 100X diffractometer)
  -> particle sizes[7]
- **Biogeochemical** (fluorometer)
  -> chlorophyll fluorescence
- **Physical** (CTD probe)



WINTER 2019

- Particle size (LISST-100X) from water samples at various depths
- Suspended particulate matter and Chlorophyll-*a*



Data processing

Data obtained from **LISST-100X** → classified in 32 size ranges (between 1,25 and 250 µm) → D et V(D)

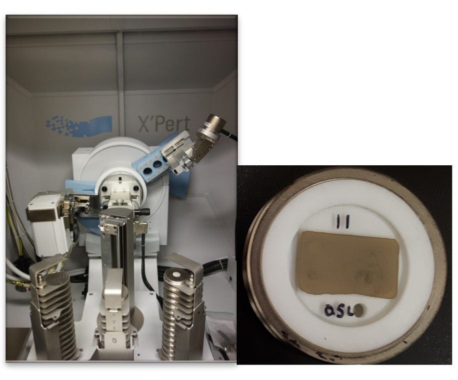
N(D) = 6 V(D) / π D³

N'(D) = N(D) / ΔD

- **D** : Diameter of a volume-equivalent sphere to the median of each size class, µm
- **V(D)** : Volume concentration at size class D, ppm
- **N(D)** : Particle number concentration at size class D, m^{-3}
- **N'(D) :** partcle number density at size class D, m^{-3} μm^{-1}
- **ΔD** : Size class width

SPM at 10m → analysis of

Mineralogical composition
X-ray diffraction



Chemical compositon
X-ray fluorescence spectrometry analysis

Results

Spatial variability

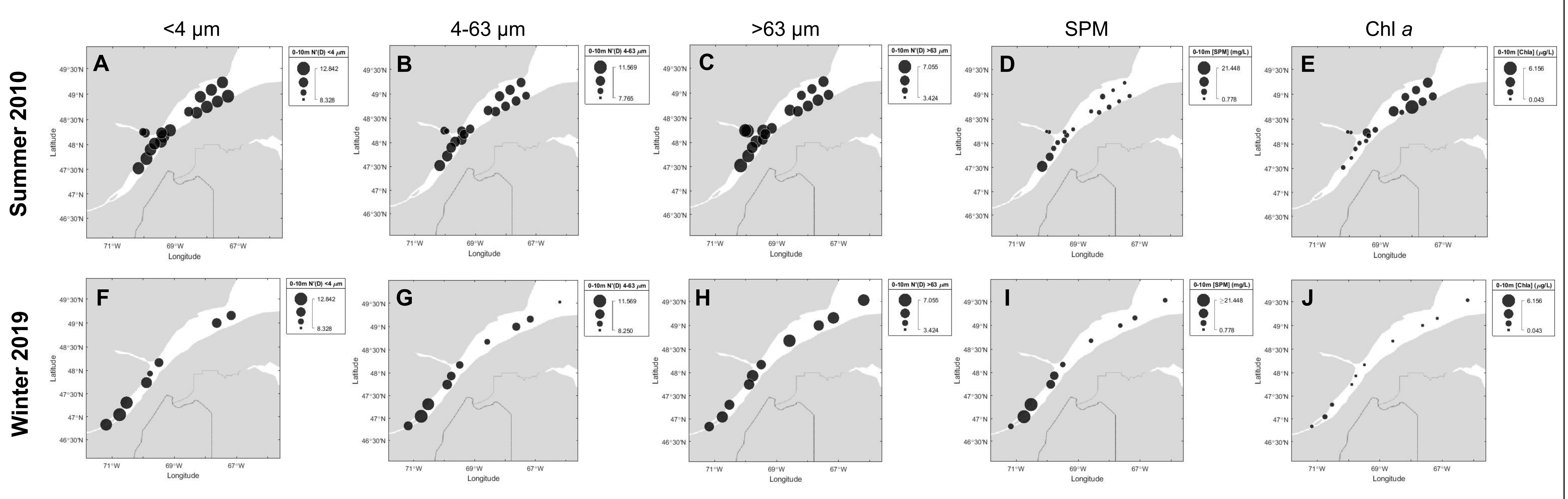


Figure 2. Spatial distribution at the surface (0-10m) of (1) N'(D) (logarithmic scale) for particle size classes (A,F) small (<4 µm), (B,G) medium (4-643µm) et (C,H) large (>63um), (2) concentrations of SPM (D,I) and Chlorophyll-*a* (E,J) in summer 2010 and winter 2019

Near the surface of the water column, there are more small (<4 µm) and medium (4-63 µm) size class particles in summer 2010 than in winter 2019 for a similar location (Fig. 2 A,B,F,G). A higher number of large particles (>63 µm) is present in winter 2019 in the Lower Estuary (LE) (Fig. 2 H). These large size class particles in the LE aren't caused by primary production as there are low chlorophyll-*a* concentrations (< 0.24µg/L) in winter (Fig. 2 J). On the contrary, high Chl-*a* concentrations are present in summer 2010 which is typical of the primary production present in the LE during the sampling period (Fig. 2 E). Also, SPM concentrations being sometimes higher for the same location in winter 2019 than summer 2010 supports a high import of matter by the ice.

Vertical PSD

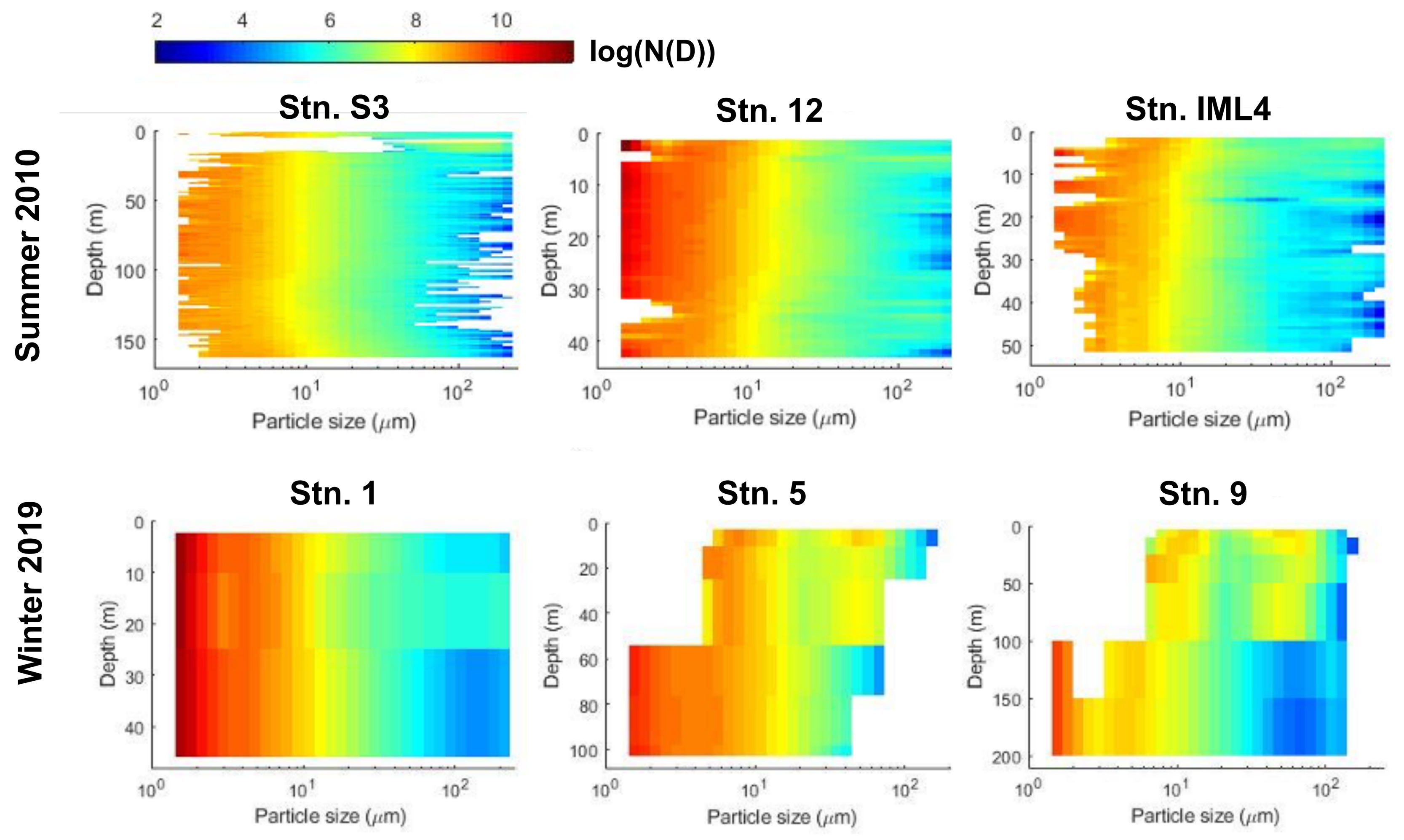


Figure 3. Vertical distribution of particle number concentration (logarithmic scale) in summer 2010 and winter 2019. Note the different vertical scales.

Although being in different regions of the SLE, the stations show a similar vertical profile with dominance of small size particles (Fig. 3).

In winter 2019, a higher number of particles at large size classes are present near the surface.

Station S3, representing the Saguenay shows a lower number of small size particles than the other stations.

Station 1, near Quebec City, shows the highest number of small particles compared to the other summer and winter stations.

Stations 12 and 5 (Upper Estuary) are similar except for larger size particles present in higher numbers down to depths of 54m in winter.

Stations IML4 and 9 (Lower Estuary) differ from the UE due to a lower number of small particles. In winter, more large particles are present between 0 and 100m.

There is a predominance of seasonal over spatial variations.

Composition of surface SPM

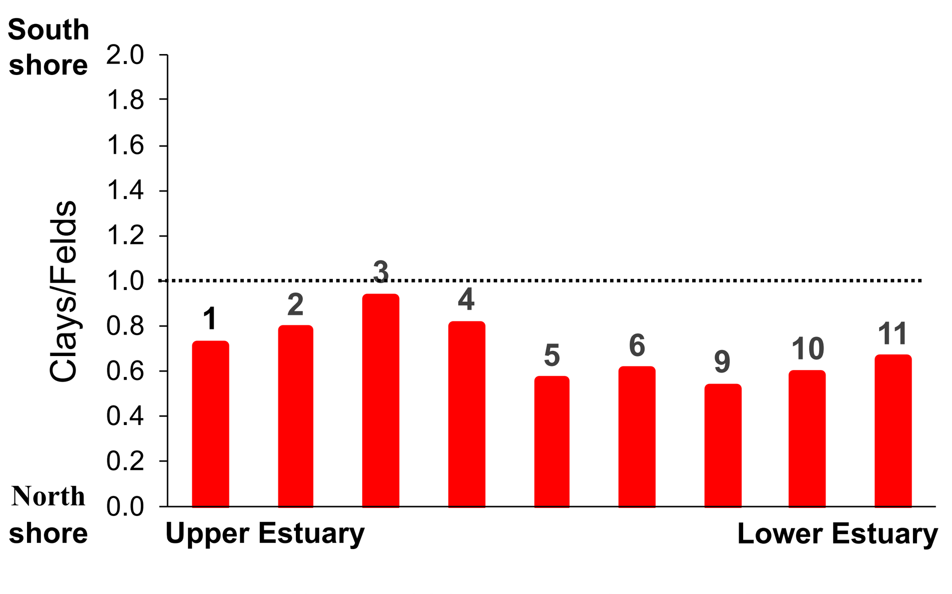


Figure 4. Clays/Total feldspars ratio for various SPM samples taken at 10m along the estuary
N. B. : Location of sample in Fig. 1

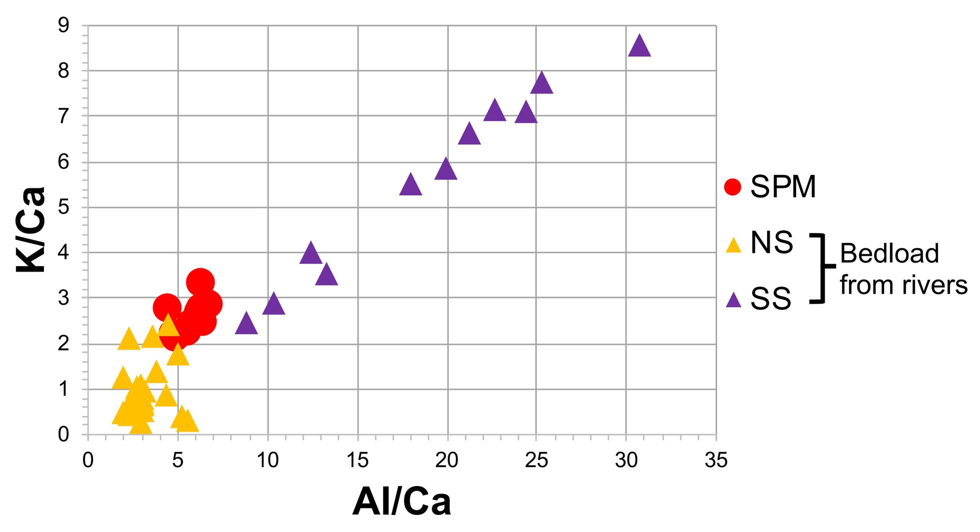


Figure 5. K/Ca vs Al/Ca distribution for surface (10m) SPM samples and sediment samples from the North Shore (NS) and the South Shore (SS)

Fig. 4 shows a relatively similar mineralogical composition between all the stations along the estuary.

The lower Clays/Total feldspars ratio and thus, higher proportion of feldspars are similar to the bedload composition of North Shore rivers. The Canadian Shield is the major source of the SPM in winter, confirming previous results from surface sediment analysis[1].

This is validated by the chemical composition of the SPM that is closer to sediments from the North Shore than the South Shore (Fig. 5).

Conclusions

- + small and medium size class particles in summer than winter
- + large size class in winter in the Lower Estuary → inorganic and may come from ice transport
- Large size classes + present near the surface in winter
- + vertical variability between seasons than spatially
- SPM composition indicates the Canadian Shield as the main source of particles in the SLE

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