Temperature or Nutrients? Changes in Diatom Abundance and Diatom/Dinoflagellate Ratio during Marine Heat Waves in Tofino Inlet, BC, Canada from 2013 to 2023

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Environmental Science

Introduction

Diatoms are one of the main groups of phytoplankton that form the base of the food web in aquatic systems and make up a large portion of the phytoplankton assemblage in the estuaries and sounds of the Pacific Northwest. Diatoms have a silica-based cell wall and lack flagella, limiting mobility. Due to silica being a significant element of their cell walls, diatoms have a greater silica requirement than dinoflagellates or other phytoplankton groups. As climate change progresses, ocean temperatures rise, and marine heat waves (MHWs) are becoming more frequent. Prior research has found that, in the North-Eastern Pacific Ocean, the relative abundance of diatoms compared to dinoflagellates decreases during these events. **Two main hypotheses proposed to explain this trend are that 1) dinoflagellates are more temperature tolerant, and 2) silicate availability may decrease with increased temperature, and diatoms are more reliant on silicate than dinoflagellates.** For this study, I examined the diatom/dinoflagellate ratio relative to changes in temperature and silicate availability in Tofino Inlet in Clayoquot Sound (Figure 2) on the west coast of Vancouver Island, BC, Canada from 2013-2023, during which time there were multiple marine heat waves. University of Washington Tacoma researchers have been collecting water property data in Clayoquot Sound in the late summer/early fall annually since 2001, and phytoplankton samples since 2006. These data include CTD profiles of temperature, salinity, density, oxygen, fluorescence, transmissivity, and discrete water samples for nutrients and phytoplankton.

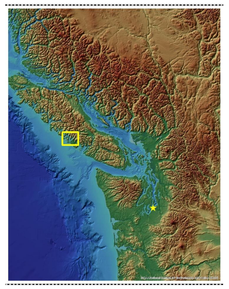

Figure 1. Locator map of Clayoquot Sound in BC, Canada. Clayoquot Sound is outlined in yellow, UWT campus is denoted as a star. Figure courtesy of Tracy Barry.

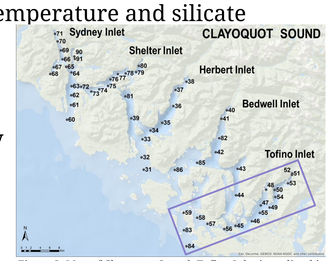

Figure 2. Map of Clayoquot Sound. Tofino Inlet is outlined in purple.

Methods

Field Sampling

- Three phytoplankton samples were collected at select stations: a 10m vertical 20 µm mesh net tow, a surface sample, and a 10m sample. These samples were fixed with 1 mL of 37% Formaldehyde (Formalin).
- Two nutrient samples were taken at each of these stations and other select stations: one surface sample and one bottom sample. These were frozen until they could be sent to UW Seattle's Marine Chemistry Lab for analysis.
- A Conductivity, Temperature, and Depth (CTD) profile was collected using a SeaBird 19 CTD at every station. This instrument collects data on conductivity, temperature, depth, salinity, density, oxygen, fluorescence, and transmissivity as it descends through the water column.

In-Lab Analysis

- Non-net samples were decanted to the 10mL line.
- All samples were counted at 200x on an Olympus BX compound microscope using a 0.1mL Palmer - Maloney slide.
- Organisms were identified to the genus level, and species were possible.

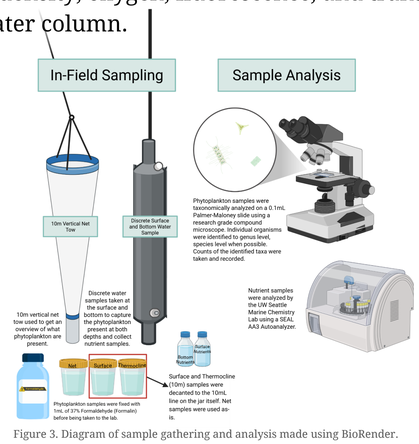

Figure 3. Diagram of sample gathering and analysis made using BioRender.

Results

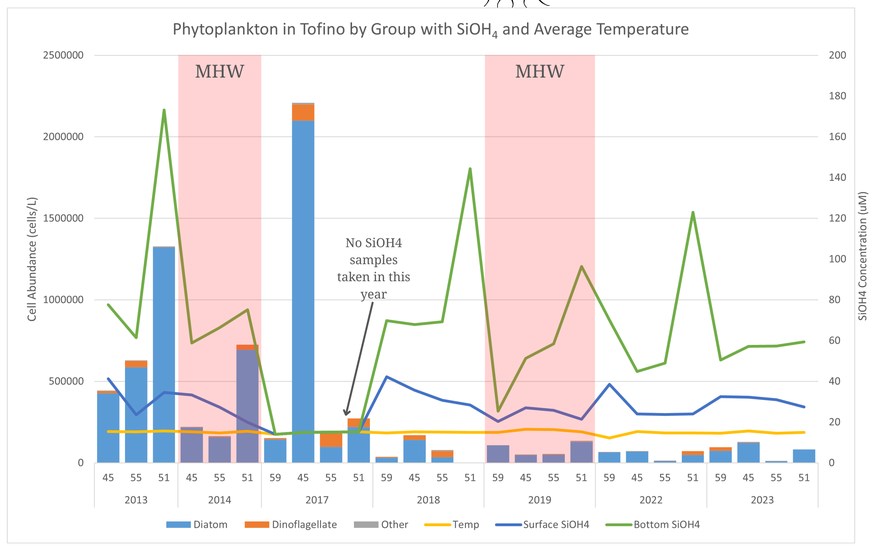

Figure 4. Graph of Phytoplankton Abundance by Group in Tofino Inlet. The Marine Heat Waves are shown in red and can be seen during the years 2014 and 2019. There is a decrease in phytoplankton abundance in 2018. There is no strong temperature or silicate correlation with phytoplankton abundances. Temperature is shown as the average of the first 10m of the water column. Nutrient samples were not taken in 2017, causing an artificial drop in silicate during that year.

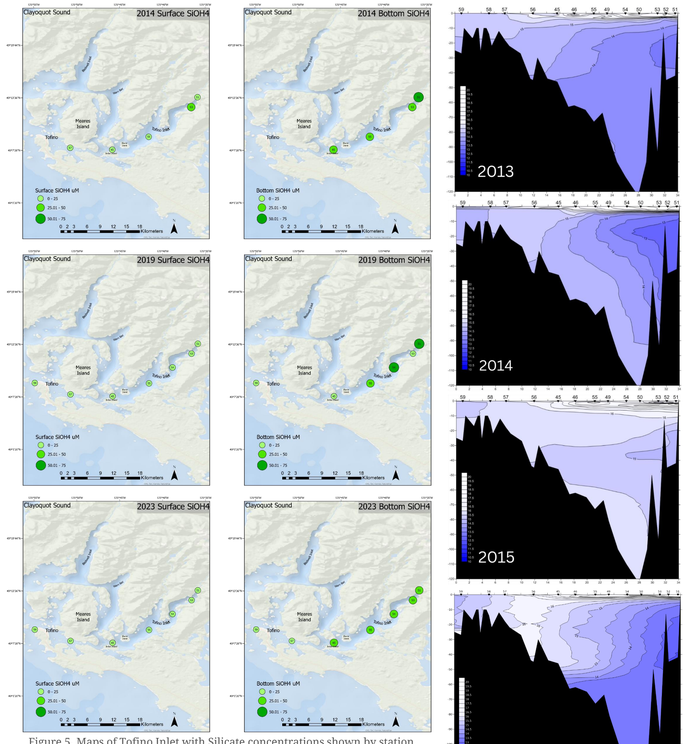

Figure 5. Maps of Tofino Inlet with Silicate concentrations shown by station. Concentrations are in uM. Three years are shown, two MHW years (2014 and 2019), and the most recent year is shown (2023).

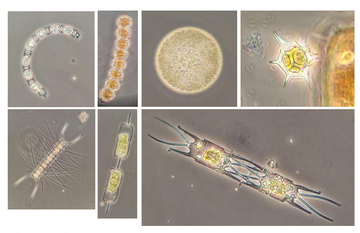

Figure 6. Photos of frequently observed phytoplankton, taken during the course of the study. Top Row: Left to Right – *Eucampia zodiacus, Alexandrium catenella, Coscinodiscus spp., Dictyocha speculum.* Bottom Row: Left to Right – *Chaetoceros spp., Ditylum brightwellii, Odontella longicruris.*

Figure 7. Surfer sections of Tofino inlet, showcasing the temperature range of Tofino Inlet in select years, a pre-MHW year (2013), two MHW years (2014 and 2019), a directly post-MHW year (2015), and the most recent year (2023).

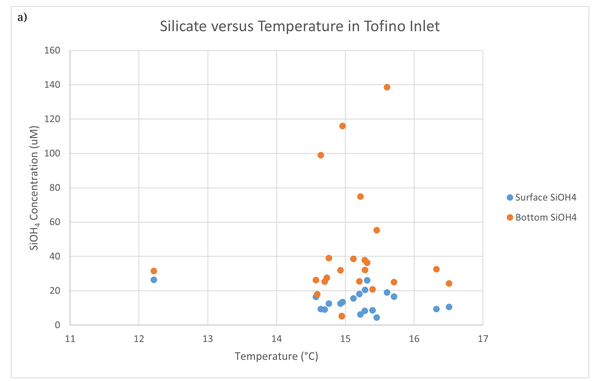

Figure 8. Silicate Graphs. a) Silicate versus temperature, a scatter plot showing the silicate concentration at the varying temperatures. All years are present; silicate is grouped by bottom and surface. The temperature here is the average of the first 10m of the water column. b) Surface silicate concentrations by station. A box and whisker plot that shows the range of silicate levels at each station in Tofino throughout the entire timespan that sampling has been performed (2003 – 2023, minus 2017, 2020, and 2021 because no samples were collected). c) Bottom silicate concentrations by station. This is the same as 8b, but for the bottom silicate concentrations.

Conclusion & Future Work

- No readily visible trends or patterns can be seen between diatom abundance and temperature or silicate.
- There is an overall decrease in phytoplankton abundance in 2018 (Figure 4).
- Regardless of year, diatoms remain the most prevalent group in Tofino Inlet in early September, though the exact ratio can vary year to year as well as station to station (Figure 4).
- The range of silicate concentrations in Tofino Inlet is relatively small, with some exceptions (Figure 8).
- A spatial pattern is present with surface silicate concentrations being highest at the mouth of the inlet and lowest at the head of the inlet. This pattern is reversed in the bottom silicate (Figures 4, 8b, and 8c). We hypothesize that this is due to phytoplankton in the surface layer uptaking silicate before sinking to deeper depths. Toward the head of the inlet, these phytoplankton become trapped behind the sill, leading to elevated silicate concentrations at the bottom. In contrast, increased flushing at the mouth of the inlet mixes deep and surface water together over the sill, replenishing surface silicate levels.
- During the MHW of 2014, the ocean temperature in Clayoquot Sound increased. In Tofino Inlet, this temperature has not returned to its 2013 pre-MHW values as of 2023 (Figure 7). Another MHW occurred in 2019.
- As marine heat waves are expected to increase in frequency, size, and duration (NOAA, 2024), continued monitoring is needed in Clayoquot Sound to see how/if the phytoplankton react to these future events.

Acknowledgements

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References QR Code