Sharp reduction in nutrient concentrations in deep British Columbian strait linked to marine heatwave

Hayley V. Dosser[1], Stephanie Waterman[1], Jennifer Jackson[2], Brian Hunt[1,2]

1- University of British Columbia, Vancouver, 2- Hakai Institute, Victoria & Heriot Bay

1. Key Points

A marine heatwave known as The Blob and a subsequent El Niño impinged on the British Columbian coast from 2014 to 2016. From 2015 onwards, **anomalously low levels of nutrients** were recorded in Johnstone Strait, a 400m deep channel north of Vancouver Island. Low levels have persisted through 2018.

2. Study Area and Data

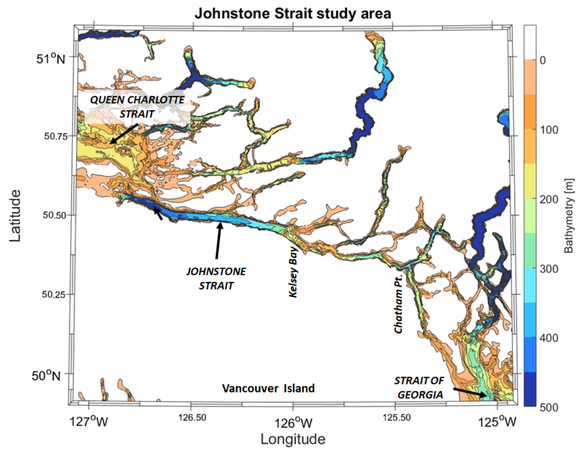


Figure 1: Bathymetric map for Johnstone Strait and nearby regions. This study focuses on data from the deeper western end of Johnstone Strait, from the sill with Queen Charlotte Strait to Kelsey Bay.

Nutrient Data Sources	Number of samples in the study area	Available years used in the analysis	Contact / public data access
Hakai Institute	Pre-2015: none 2015-2018: 188	2015 to 2018	www.hakai.org
Department of Fisheries and Oceans Canada	Pre-2015: 55 2015-2018: 2	1977-78, 2001-03, 2014, 2017	www.waterproperties.ca

3. Nutrient Concentration Decline

The 2015-2018 mean concentrations of all three nutrients **declined by roughly two standard deviations** from their 1975-2014 mean values.

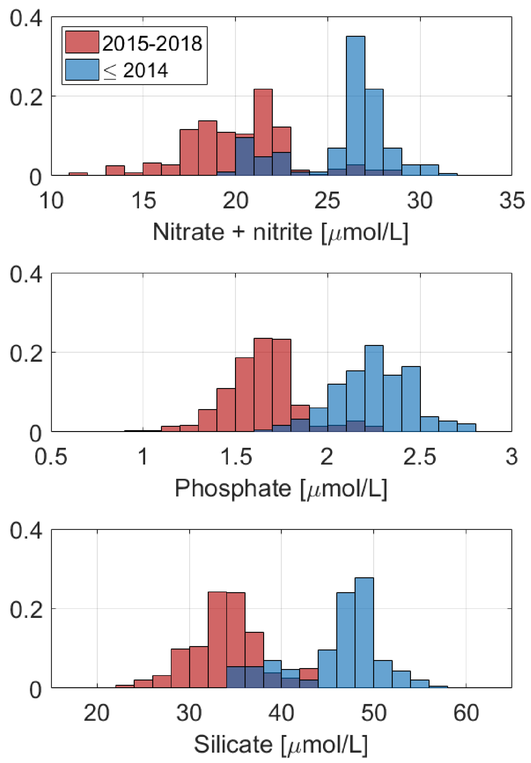


Figure 2: Probability distributions for nitrate+nitrite, phosphate, and silicate nutrient concentrations from before 2015 (in blue) and from 2015-2018 (in red). Dark purple indicates overlap between the distributions.

4. Sampling Bias and Inter-agency Comparison

To confirm the decline in nutrient concentrations during 2015-2018 is a real signal, we must first rule out other causes:

- Seasonal bias due to differences in the months sampled.
- Discrepancies between Hakai and DFO data collection and processing.

Since 2015, most nutrient samples in Johnstone Strait have been collected by the Hakai Institute during the spring and summer.

Seasonal bias:
We compare data from before 2015 with data from 2015-2018 using only samples from the months common to both periods: April, May, September, and November.

Inter-agency comparison:
Bottle samples were independently collected by scientists from both DFO and Hakai.

We have one **point of comparison** in July 2017, which shows good agreement for all 3 nutrients, validating the result.

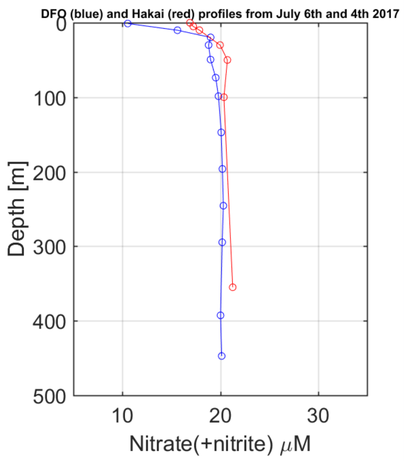


Figure 3: Vertical profiles of nitrate concentration collected by DFO (in blue) on July 6th, 2017 and by Hakai (in red) on July 4th, 2017 at nearby sampling stations.

5. Nutrients and Upwelling

Nutrients in Johnstone Strait are replenished each spring by upwelling of dense, cold, saline water arriving through Queen Charlotte Sound.

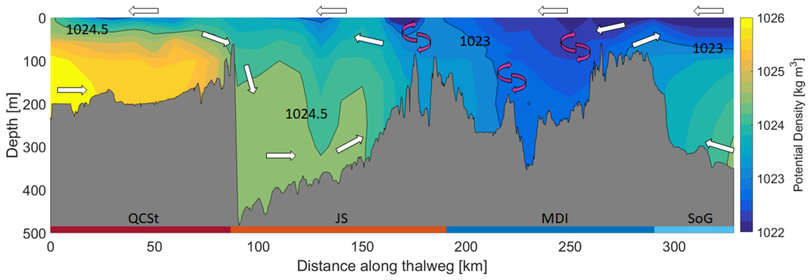


Figure 4: Lateral density transect along the thalweg (bathymetry in grey) from Queen Charlotte Strait (QCSt), through western Johnstone Strait (JS), eastern JS and the Discovery Islands (MDI), and into the Strait of Georgia (SoG). White arrows show likely circulation and pink arrows indicate tidal mixing.

Hypothesis:
Anomalously warm, low-density water from The Blob and El Niño:

- **depress deep isopycnals** on the continental shelf
- **limit or delay** the inflow of nutrient-rich upwelled water passing over the sill from Queen Charlotte Strait into Johnstone Strait
- reduce volume of **nutrient-rich** water entering Johnstone Strait

El Niño is known to cause weak coastal upwelling along the British Columbian coast, with anomalously shallow, warm, and fresh upwelled source water.

6. The Blob and El Niño in Johnstone Strait

Comparing properties in Johnstone Strait during the spring upwelling period shows anomalously **warm, fresh, and low-density** water during The Blob and El Niño years.

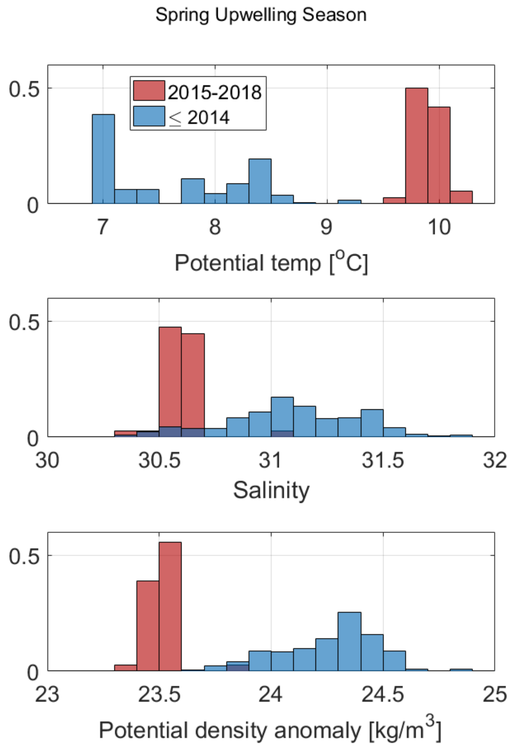
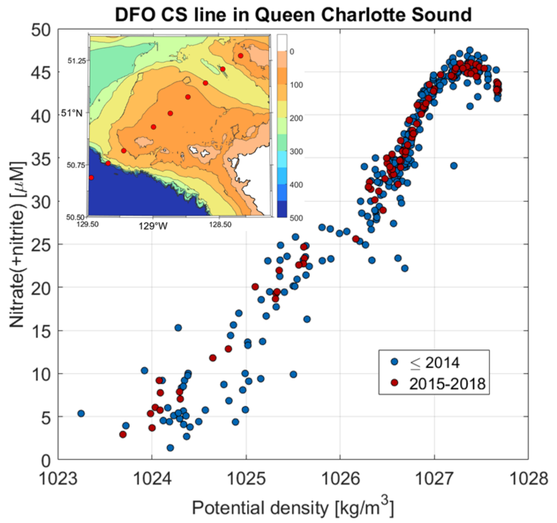


Figure 5: Probability distributions using data from April and May for potential temperature, salinity, and potential density anomalies from before 2015 (in blue) and from 2015-2018 (in red). Dark purple indicates overlap between the distributions.

7. Upwelled water on the continental shelf

Queen Charlotte Sound is the main upwelling path to Johnstone Strait.



Upwelled water on the shelf **does not** show a decline in nutrients during 2015-2018. Nutrient concentration increases with density, suggesting a reduction in dense, upwelled water passing over the sill from QCSt into JS.

Figure 6: Nitrate vs. density along a sampling line in Queen Charlotte Sound, with pre-2015 samples in blue and 2015-2018 in red. Inset shows bathymetric map.

8. Summary

During The Blob and El Niño years, and continuing into 2018, Johnstone Strait experienced an inflow of anomalously warm, fresh, low-density water during **spring upwelling**. Nutrient concentrations were anomalously low from 2015-2018; we hypothesize this is due to less upwelled water making it over the sill into the Strait as **dense, nutrient-rich waters** are pushed deeper in the water column.

hayley.dosser@hakai.org

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