Nitrate & Phosphate Sensor: Analytical Performance Report

This report details Aug/Sept 2023 calibration of the C1000-200 Nitrate & Phosphate Sensor (SN 70105).

1. Benchtop Calibration

The instrument was first calibrated in our laboratory at three fixed temperatures: T = 15 °C, 10 °C, and 5 °C. A series of four combined nutrient standards were measured from high to low concentration. The concentration of each nutrient standard is listed in **Table 1**.

Table 1: Prepared nutrient standards of known nitrate and phosphate concentrations.

Standard Number	Nitrate Concentration (µM)	Phosphate Concentration (µM)
1	50	5
2	25	2.5
3	10	1
4	5	0.5

For clarity, results from benchtop temperature calibration are split between nitrate and phosphate in Sections 1.1. and 1.2. below. For raw data, see Section 4.

1.1. Nitrate Temperature Calibration

Figure 1 shows calibration data from each of the fixed temperature tests for nitrate (NO_3^-) detection. These data are used to determine a relationship between raw sensor measurements and nitrate concentration. Nitrate measurement sensitivity is dependent on temperature, where colder environments/samples produce a lower (raw) sensor signal.

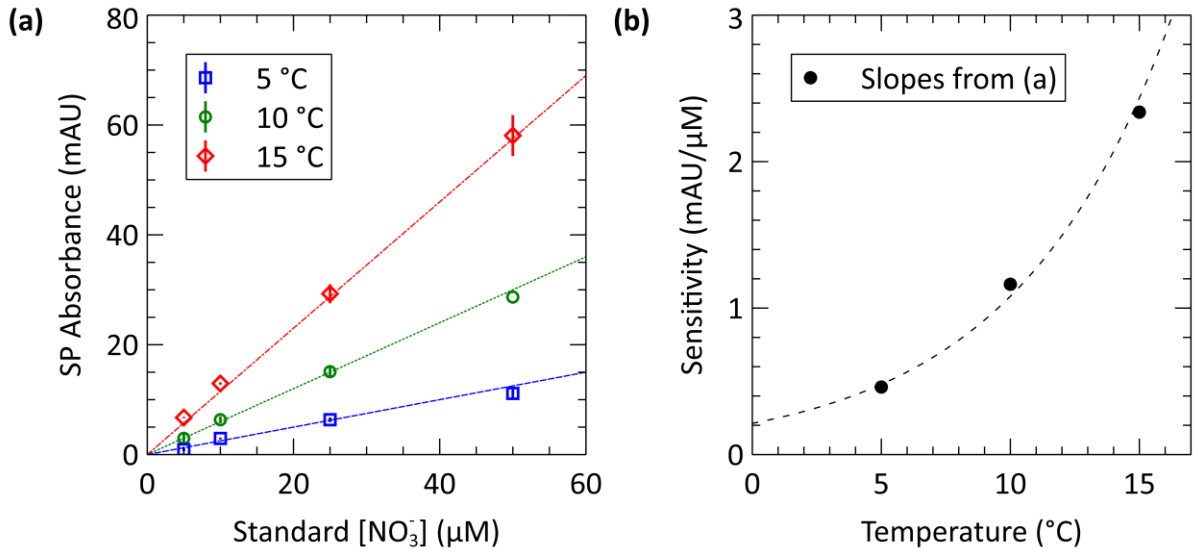

Figure 1: Nitrate calibration using fixed-temperature water bath. **(a)** Short path absorbance measurement vs. concentration of nitrate for each standard. Red, green, and blue datasets represent different fixed test temperatures. Reaction rate increases exponentially with temperature for these tested temperatures. Error bars = 1 standard deviation. **(b)** Extrapolated sensitivity vs. temperature curve from **(a)**. This function (dashed line) is applied to raw measurements to calculate concentration.

1.2. Phosphate Temperature Calibration

Figure 2 shows calibration data for the phosphate (PO_4^{3-}) measurement channel from the same set of fixed temperature testing. These data are used to determine a relationship between raw sensor measurements and phosphate concentration. Phosphate measurement sensitivity is dependent on temperature, where colder environments/samples produce a lower (raw) sensor signal. However, this dependence is less than that of nitrate measurements.

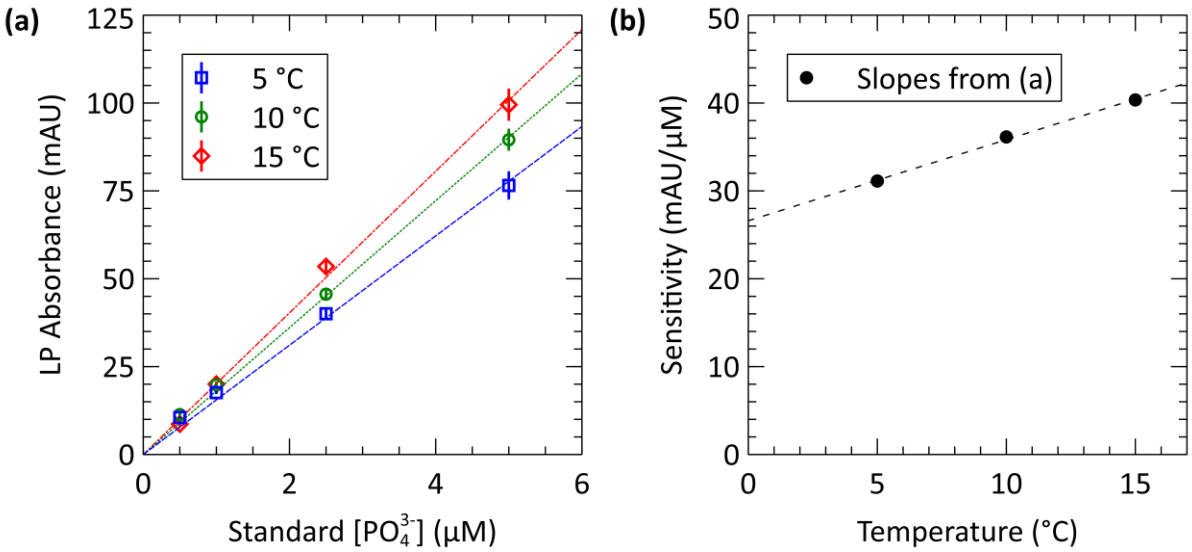

Figure 2: Phosphate calibration results from the same fixed-temperature series of testing. Measurement sensitivity (shown in **(b)**) varies less with temperature compared to nitrate results in **Figure 1(b)**.

1.3. Calibration Parameters

Table 2: Fitting parameters obtained from temperature calibrations (**Figure 1A** and **Figure 2A**). A is measured absorbance when analyzing a standard of concentration C.

Temperature	Nitrate	Phosphate
15	A = 0.0023C	A = 0.0403C
10	A = 0.0012C	A = 0.0361C
5	A = 0.00046C	A = 0.0311C

From Table 2, data are extrapolated for both Nitrate and Phosphate such that:

$S_{NO_3} = 0.000213e^{0.1624T}$; (**Figure 1B**)

$S_{PO_4} = 0.00092T + 0.0266$ (**Figure 2B**).

These fits are used to calculate concentration at any temperature between 0 – 35 °C.

2. Sensor Demo

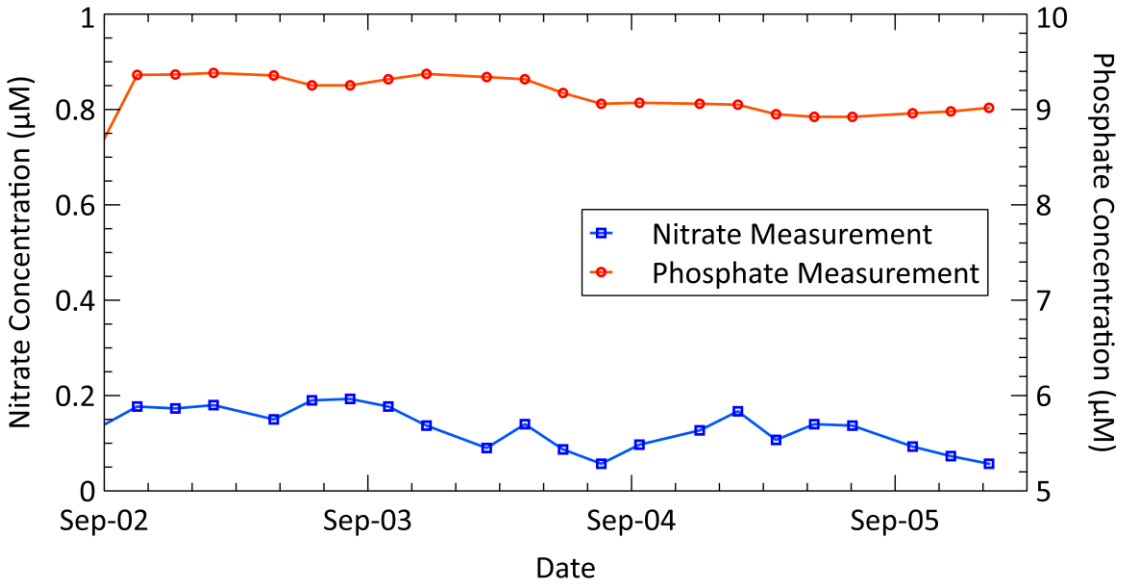

Figure 3: C1000-200 Nitrate & Phosphate Sensor demo in fixed tank. Sample water obtained Sept. 2023 from the COVE (Nova Scotia, Canada). Measurements produced from triplicates using 3-sample averaging.

3. More Information, Authorship & Contact

Testing, analysis, and documentation was performed by Edward Luy of Dartmouth Ocean Technologies Inc. (DOT); for technical inquiries, contact Eddy.Luy@DartmouthOcean.com or AfterSales@DartmouthOcean.com.

For more information on the Nitrate & Phosphate Sensor, review our most recent publication *Two chemistries on a single lab-on-chip: Nitrate and orthophosphate sensing underwater with inlaid microfluidics*; URL: https://www.frontiersin.org/articles/10.3389/fsens.2022.1080020/full

4. Appendix: Raw Data

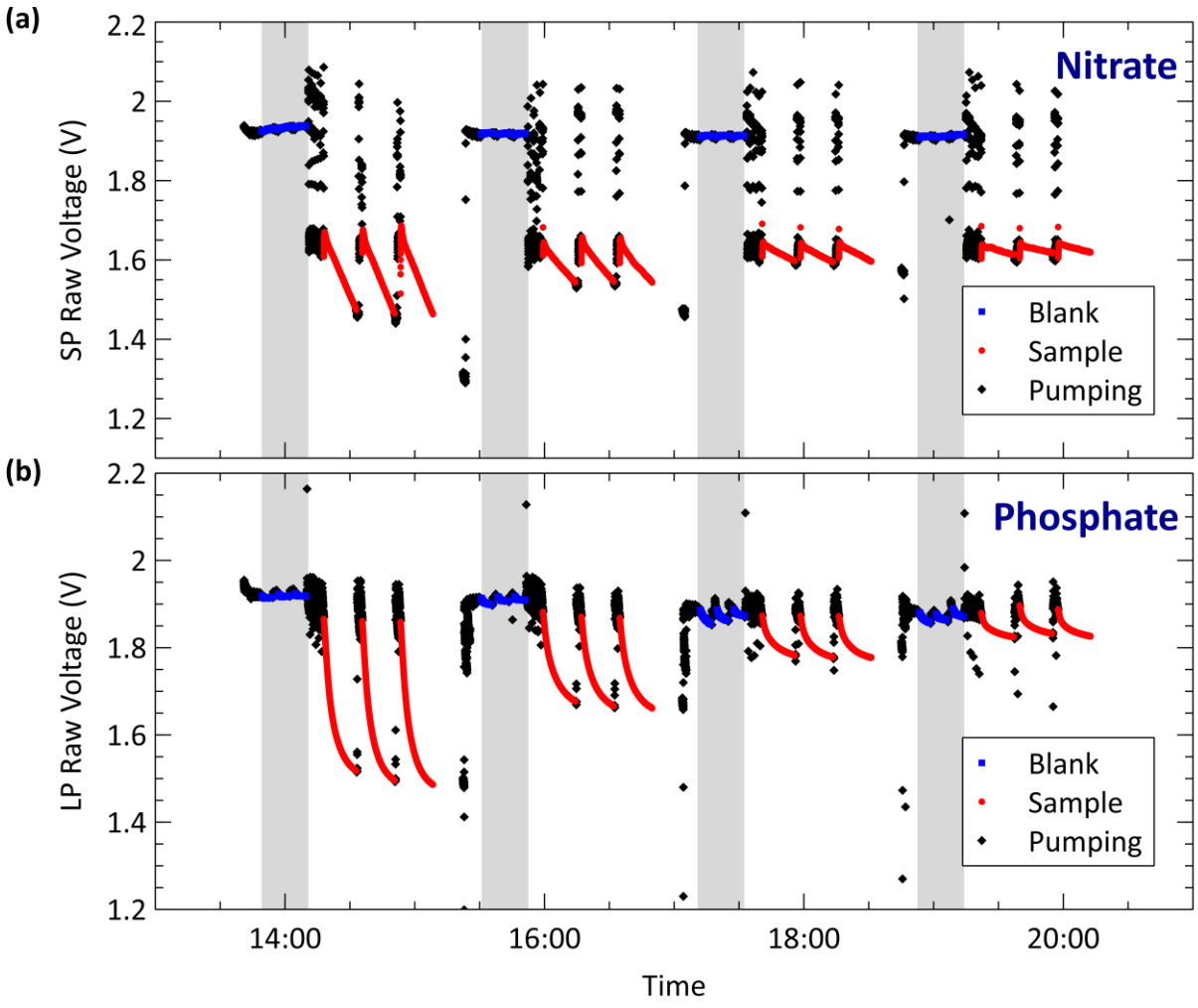

Figure 4: NP Sensor raw measurements during 15 °C test. Grey regions are blank measurements. Blanks and samples are measured in triplicate and averaged. **(a)** Short path photodiode voltage measurements – used to detect nitrate. **(b)** Long path photodiode voltage measurements – used to detect phosphate.