**Introduction**

This project aims to estimate excess nitrogen (N\*), which is a measure of the deviation of nitrogen from that predicted by the Redfield ratio, in the North Atlantic, using the Global Ocean Ship-Based Investigations Program (GO-SHIP) dataset and Biogeochemical (BGC) Argo float dataset. The value of N\* provides insight into on-going biological processes, specifically nitrogen fixation and denitrification. Nitrogen fixation causes the N:P ratio to be higher than the ratio predicted by the Redfield ratio, which results in a positive N\*, and denitrification has the opposite effect.[[1]](#footnote-1) Below is the equation for N\*:

**Methodology**

**GO-SHIP Datasets:** The GO-SHIP datasets will be used to create a model that predicts excess nitrate (N\*) from date, position, pressure, temperature, salinity, and oxygen. There are approximately 33 transects in the North Atlantic (see Figure 1).

Map

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**Figure 1:** GO-SHIP transects in the North Atlantic

These data were collected from 2001- 2013 (see Figure 2 and 3). The data shows strong seasonal biases towards the spring, summer, and fall. No data were collected from December through February during this 12-year period.

Chart, histogram

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**Figure 2:** North Atlantic GO-SHIP transects date histogram

Chart, bar chart, histogram

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**Figure 3:** North Atlantic GO-SHIP transects month histogram

Based on the temporal distribution of data, I plan to use the month as the “date” input for my model because this will capture the seasonal variability. As a result, interannual variability and, potentially, multidecadal variability can be modeled.

Below is a sample GO-SHIP transect with corresponding data profiles (see Figure 4 and 5). Data that had a quality control (QC) flag less than 9 were included. The QC flag value ranges from 1 to 9 with 1 being the highest quality data and 9 being the worst. For later analysis, the QC data threshold will be adjusted to create a better model.

Map

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**Figure 4:** Sample GO-SHIP transect.

These data will be used determine a model that can predict N\*. First, I will use a simple linear regression to determine which parameters are best correlated with N\*.

Next, I will use multiple linear regression over the entire North Atlantic basin. If the regression model cannot predict the data well, I will first increase the QC flag threshold to improve the quality of the modelling dataset. Additionally, I will constrain my analysis to a smaller depth range, for example 0-1000 dbar, and use the oxygen saturation state, as opposed to dissolved oxygen concentration because denitrification is inhibited by oxygen.[[2]](#footnote-3) If that does not work, I will create a regression model for the subpolar North Atlantic and the subtropical gyres. The subtropical gyres are a region of high nitrogen fixation, while the subpolar North Atlantic typically are not.[[3]](#footnote-4)

Chart

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**Figure 5:** Sample GO-SHIP data profiles. Temperature is in ºC, salinity is in PSU, oxygen, nitrogen, and phosphate are in µmol/kg.

**BGC Argo Datasets:** Once I have determined an appropriate N\* model, I will apply this model to the BGC Argo floats in the North Atlantic. I plan to use the BGC Argos that are equipped with dissolved oxygen sensors (floats = 226, profiles = 27,583) (see Figure 6 for geographic distribution). These data are collected from September 2003 through June 2020 (see Figure 7), and do not show a seasonal bias like the GO-SHIP data do (see Figure 8). As a result, I hope to determine a monthly average N\* map based on the BGC Argo data in the North Atlantic. The data will be gridded and interpolated over a certain distance. However, depending on the spatial resolution of these data, this method may have to be adjusted.

Map

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**Figure 6:** BGC Argo distribution in the North Atlantic

**Chart, histogram

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**Figure 7:** North AtlanticBGC Argo date histogram

**Chart, bar chart

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**Figure 8:** North Atlantic BGC Argo monthly histogram

*Sample BGC Argo Profiles*

A picture containing diagram

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**Figure 9:** Sample BGC Argo trajectory

Chart, shape

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**Figure 9:** Sample BGC Argo salinity profile

**Chart, histogram

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**Figure 9:** Sample BGC Argo temperature profile

**Results**Chart

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**Figure 9:** Sample BGC Argo oxygen profile

*Preliminary linear regression results*

Preliminary results from this regression, using sklearn.linear\_model.LinearRegression in python are shown below. They reveal that in the North Atlantic salinity is best correlated with N\* over the other parameters.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Lat | Lon | Pres | Temp | Sal | Oxy | Nitrate |
| R2 | 0.0011 | 0.078 | 0.036 | 0.12 | 0.24 | 0.065 | 0.008 |

*Scaled proof that methodology is doable*

I have narrowed the scope of the project to the North Atlantic to make sure these methods are doable. The regression model will initially be applied to a few floats to see if results are consistent with previous estimates of N\* in that region. Additionally, my methods results can be compared to numerical model output.

**References**

Gruber, N and Sarmiento, J (1997). Global patterns of marine nitrogen fixation and denitrification. Global Biogeochemical Cycles 11(2), 235-266.

Wang, W, et al. (2019). Convergent estimates of marine nitrogen fixation. Nature. 566, 205-210.

1. Gruber, N and Sarmiento, J (1997). Global patterns of marine nitrogen fixation and denitrification. Global Biogeochemical Cycles 11(2), 235-266. [↑](#footnote-ref-1)
2. Gruber, N and Sarmiento, J (1997). Global patterns of marine nitrogen fixation and denitrification. Global Biogeochemical Cycles 11(2), 235-266. [↑](#footnote-ref-3)
3. Wang, W, et al. (2019). Convergent estimates of marine nitrogen fixation. Nature. 566, 205-210. [↑](#footnote-ref-4)