Seasonal Salt Content, in the Neuse River

Web address for GitHub repository

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1 Rationale and Research Questions (Kathlyn)

The maintenance of healthy and functioning water systems is critical not just to human life, but also to the survival of countless other species and their interconnected ecosystems. We are only beginning to understand the impact of human action on water bodies. Conductivity, or the ability of water to pass an electrical current via dissolved salts and other minerals, is a strong indicator of water quality. Changes in conductivity over time suggest a potential pollutant entering the system.

For this study, we chose to analyze how specific conductance can vary depending on the season. In particular, we wanted to address the impact of winterizing the roadways with salt on water quality. Our main research question was: is salting the roads a main driver in changes to water conductivity, or are other minerals a significant factor? Here, we chose to analyze the Neuse River in Kinston, North Carolina over a 46 year period (1976-2022) (???, check on this bc of the NAs). We chose this river due to familiarity with the data and its proximity to an urban center (Kinston pop = 20,398). ADD MORE!

We used the following research questions to guide our work: > 1. How does specific conductance vary seasonally? > 2. Is calcium, magnesium, or sodium the driver of specific conductance? > 3. What is the likely specific conductance in the future (forcasting trends)?

2 Dataset Information (Jack)

Neuse River water quality and discharge data at Kinston, North Carolina. The gage information comes from the United States Geologic Survey (USGS) National Water Information Systems (NWIS) database. USGS gage stations typically collect discharge, and a subset collect water quality data as well. This water quality data may include nutrient concentrations, concentrations of chlorophyll a, specific conductivity, and concentrations of certain ions. Since seasonal salinity trends and their potential sources are the focus of this study, the water quality data being examined includes specific conductivity and concentrations of calcium, magnesium, and sodium in the water column. Specific conductivity will be used as a proxy for salinization, and the relative amounts of each salt ion will be examined in the hopes of identifying a potential source of any seasonal salinity increases, in particular the contribution of road salts to salinization.

To obtain both sets of data, we used the dataRetrieval package to connect directly to the NWIS database and pull water quality and discharge data without needing to download it first. Both sets of data are pulled starting in 1976, and end at the most recent data point in the database in 2022.

Dataset	Info
NeuseWQ	Water quality data collected at USGS gage 02089500
NeuseFlow	Discharge data collected at USGS gage 02089500

3 Exploratory Analysis (Atalie)

The first step we took in our initial exploratory analysis was to wrangle the water quality (WQ) dataset to include only the columns of interest. This included the sampling dates and concentrations for specific conductance, calcium (Ca), sodium (Na), and magnesium (Mg), which were each given separate columns. This dataset contains monthly observations, however, not necessarily sampled on the first of each month. We wrangled the WQ dataset to round the dates to the first of the month to ensure that there are evenly spaced time steps across the years, a necessary condition for time series analyses.

We plotted the specific conductance over time to visualize any gaps in our dataset. We see that the WQ dataset contains many long periods of missing data for specific conductance. Since these missing periods frequently span across many years, we chose to look at WQ data from 2013 through 2021. There are no missing data points from this period of time, and we will therefore not require any interpolation of this dataset.

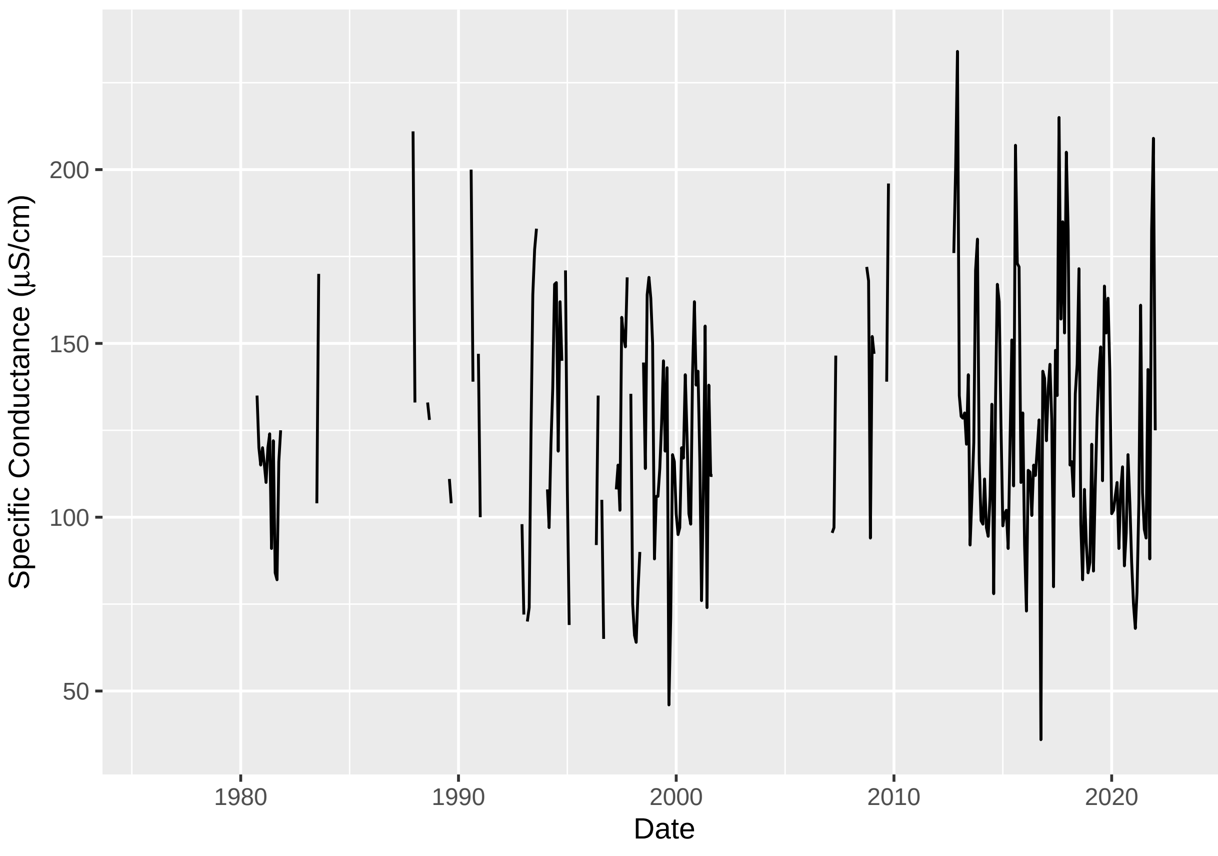

Figure 1: Specific Conductance in the Neuse River

```
##  Date_monthrounded        AvgCa_mg.L      AvgMg_mg.L       AvgNa_mg.L
##  Min.   :2013-01-01   Min.   :2.130   Min.   :0.828   Min.   : 1.560
##  1st Qu.:2015-03-24   1st Qu.:5.520   1st Qu.:2.151   1st Qu.: 7.939
##  Median :2017-06-16   Median :6.223   Median :2.478   Median :10.300
##  Mean   :2017-06-16   Mean   :6.434   Mean   :2.451   Mean   :11.245
```

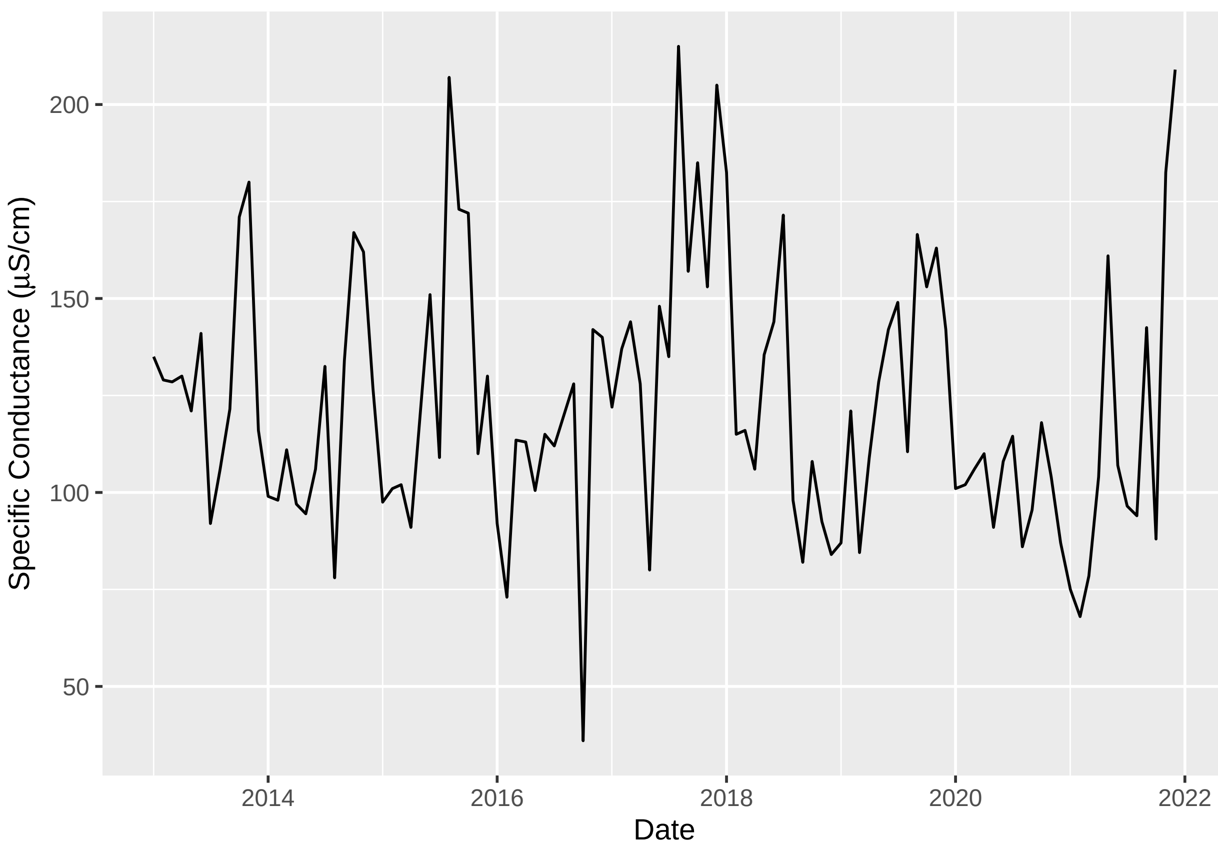

Figure 2: Specific Conductance in the Neuse River from 2013 through 2021.

```
## 3rd Qu.:2019-09-08   3rd Qu.:7.195   3rd Qu.:2.701   3rd Qu.:13.825
## Max.   :2021-12-01   Max.   :9.805   Max.   :3.325   Max.   :26.700
##  AvgSpC_uS.cm
## Min.   : 36.00
## 1st Qu.: 98.75
## Median :115.50
## Mean   :122.73
## 3rd Qu.:142.00
## Max.   :215.00
```

We are also interested in the flow of the Neuse River because this factor may affect salinity. For example, higher discharges may dilute any salinity and drier periods may reflect higher salt content. We started by wrangling the flow dataset to include the parameters of interest, sampling date and discharge.

```
## ActivityStartDate    discharge_cfs        Year          Month
## Min.   :2013-01-01   Min.   :  408   Min.   :2013   Min.   : 1.000
## 1st Qu.:2015-04-02   1st Qu.: 1190   1st Qu.:2015   1st Qu.: 4.000
## Median :2017-07-02   Median : 2410   Median :2017   Median : 7.000
## Mean   :2017-07-02   Mean   : 3556   Mean   :2017   Mean   : 6.522
## 3rd Qu.:2019-10-02   3rd Qu.: 4970   3rd Qu.:2019   3rd Qu.:10.000
## Max.   :2022-01-01   Max.   :37900   Max.   :2022   Max.   :12.000
```

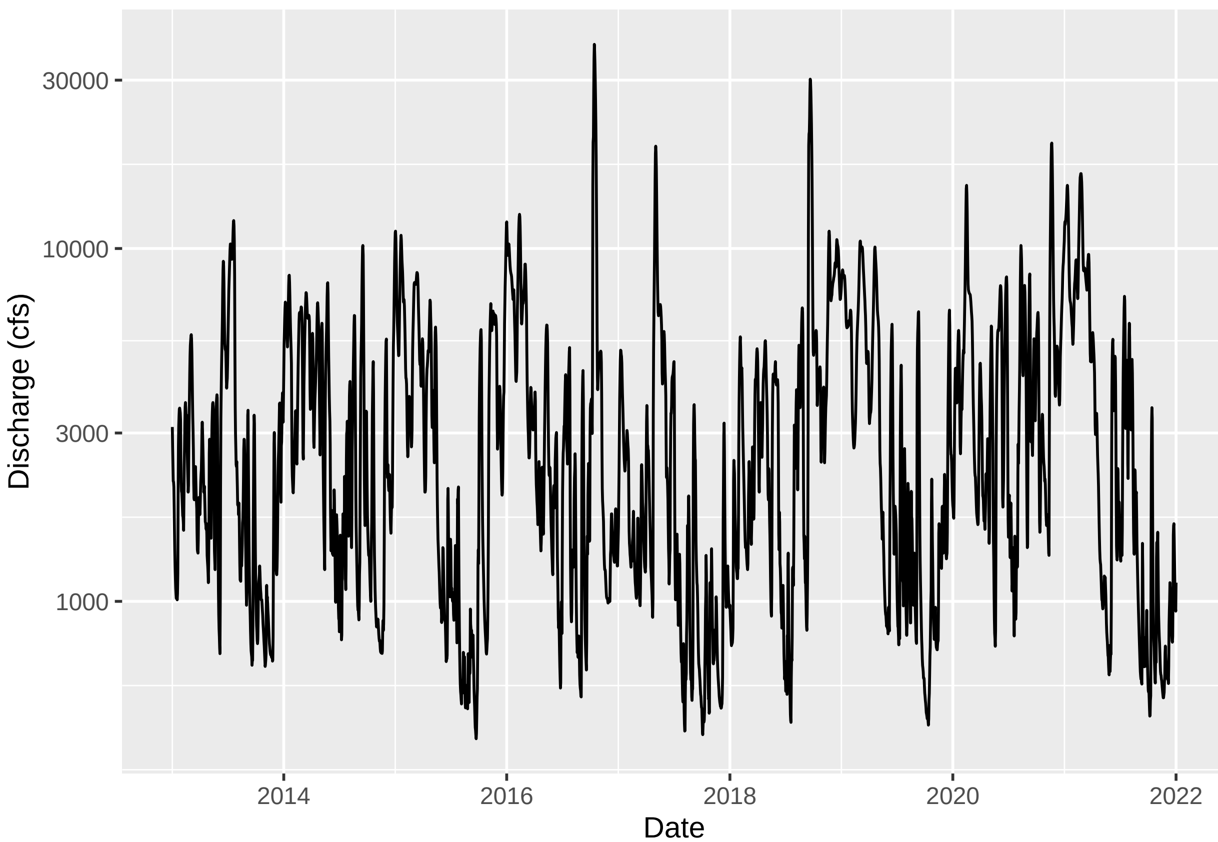

Figure 3: Discharge in the Neuse River from 2013 through 2021.

4 Analysis

4.1 Question 1: How does specific conductance vary seasonally?

After running the the MannKendall test for seasonality, we have determined that for the Nuese river there is no significant in seasonality for conductivity (p = 0.25276). However, we can conclude seasonality in flow data, discharge varies significantly depending on the season (p = 3.368e-07).

Measure	P-value
Conductivity	0.25276
Calcium	0.1038
Magnesium	0.29151
Sodium	0.091911
Discharge	3.368e-07

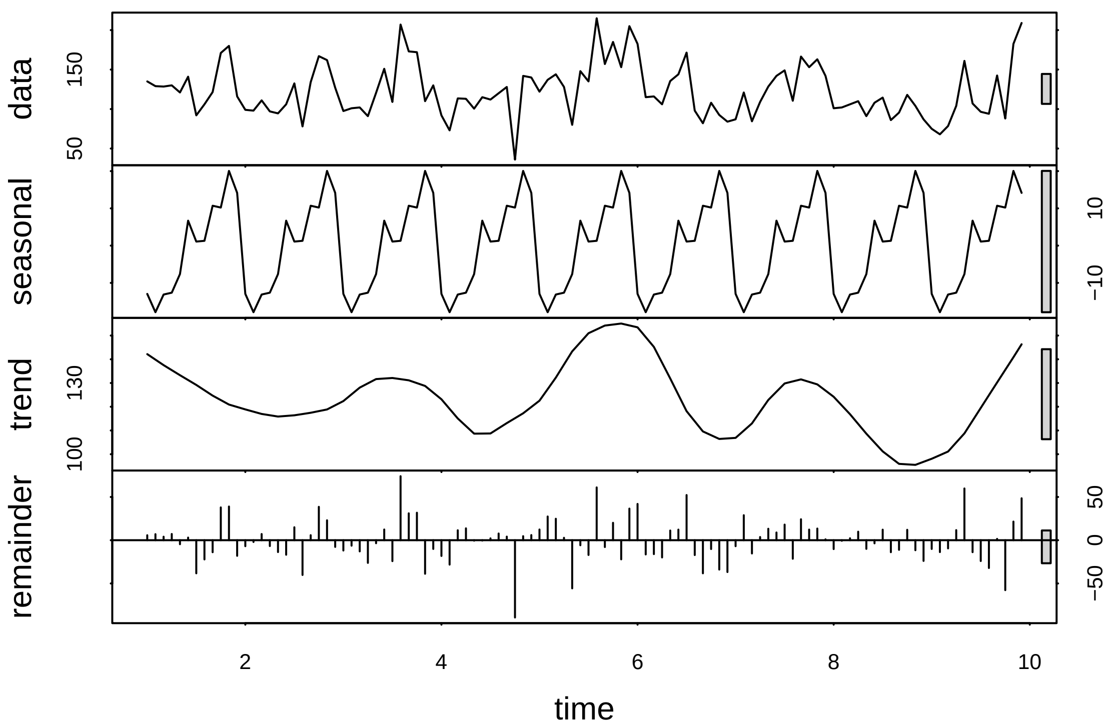

Figure 4: Time Series Decomposition of Conductivity in the Neuse River.

```
## tau = -0.088, 2-sided pvalue =0.25276
```

```
## Score =  -38 , Var(Score) = 1104
## denominator =  432
## tau = -0.088, 2-sided pvalue =0.25276
```

```
## tau = -0.125, 2-sided pvalue =0.1038
```

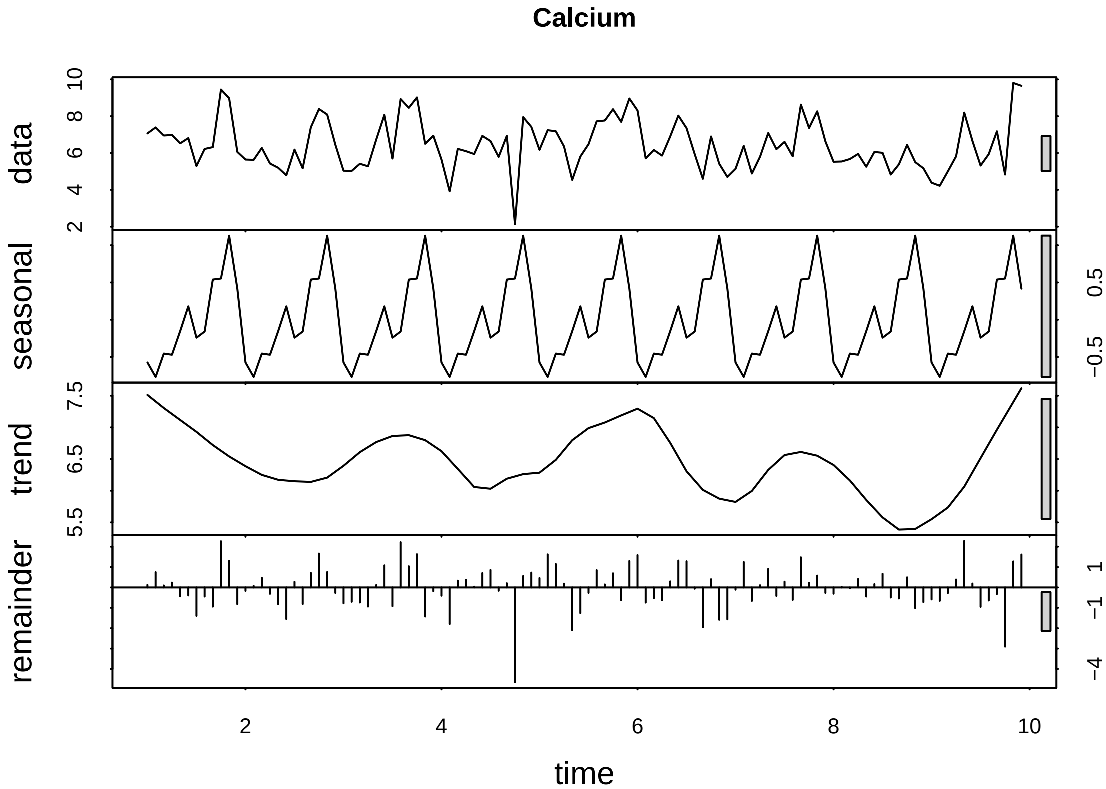

Figure 5: Time Series Decomposition of Calcium in the Neuse River.

```
## Score =  -54 , Var(Score) = 1102
## denominator =  430.993
## tau = -0.125, 2-sided pvalue =0.1038

## tau = -0.0813, 2-sided pvalue =0.29151

## Score =  -35 , Var(Score) = 1101
## denominator =  430.4894
## tau = -0.0813, 2-sided pvalue =0.29151

## tau = -0.13, 2-sided pvalue =0.091911

## Score =  -56 , Var(Score) = 1104
## denominator =  432
## tau = -0.13, 2-sided pvalue =0.091911

## tau = 0.0711, 2-sided pvalue =3.368e-07

## Score =  936 , Var(Score) = 33662
## denominator =  13158.43
## tau = 0.0711, 2-sided pvalue =3.368e-07
```

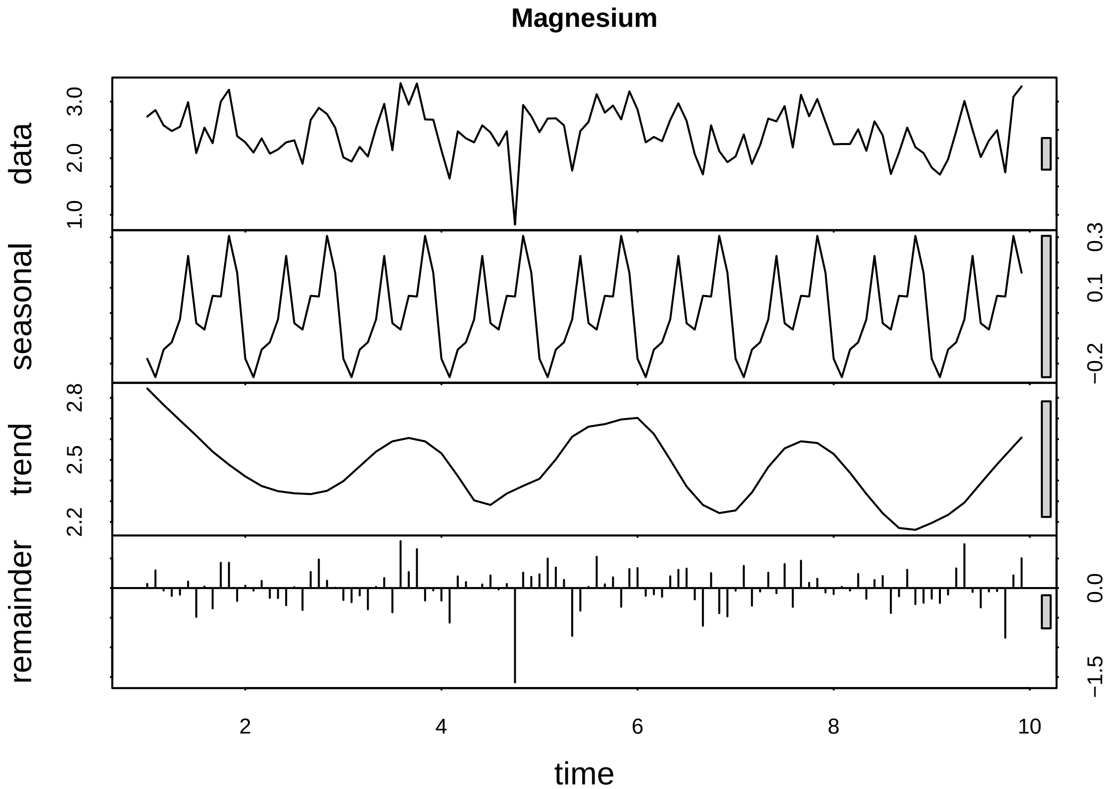

Figure 6: Time Series Decomposition of Magnesium in the Neuse River.

4.2 Question 2: Is calcium, magnesium, or sodium the driver of specific conductance?

##Question 3: <What is the likely specific conductance in the future (forcasting trends)?>

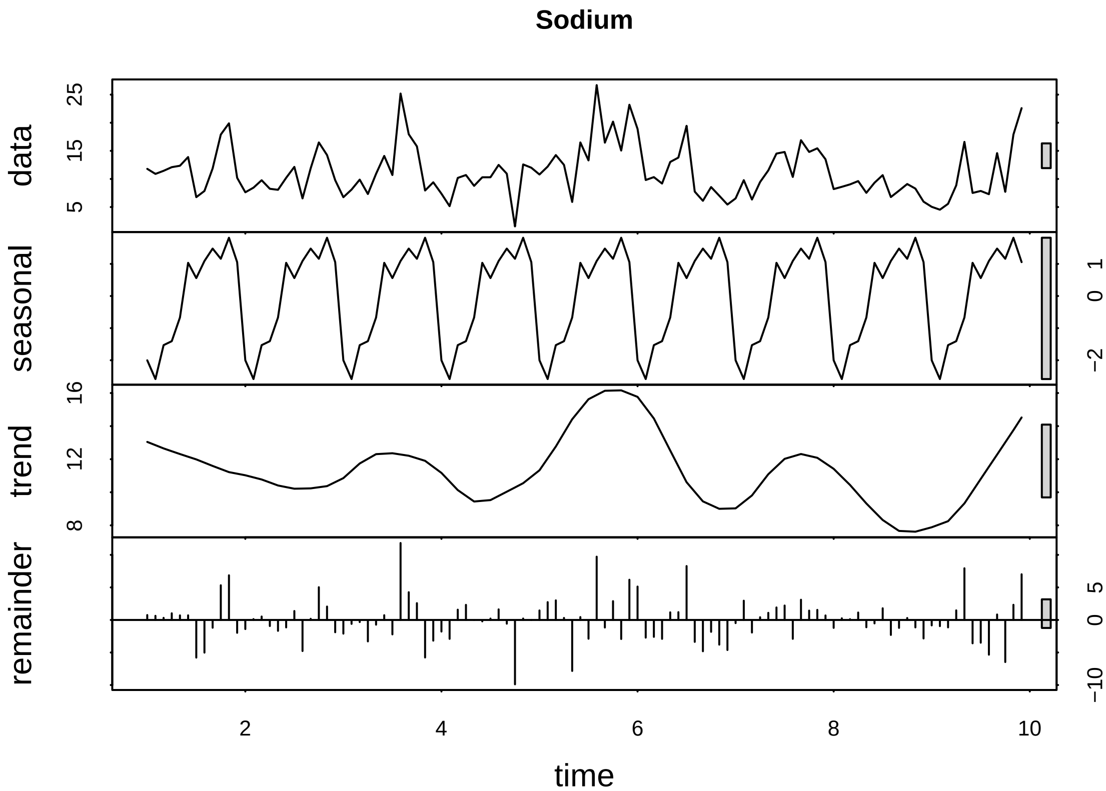

Figure 7: Time Series Decomposition of Sodium in the Neuse River.

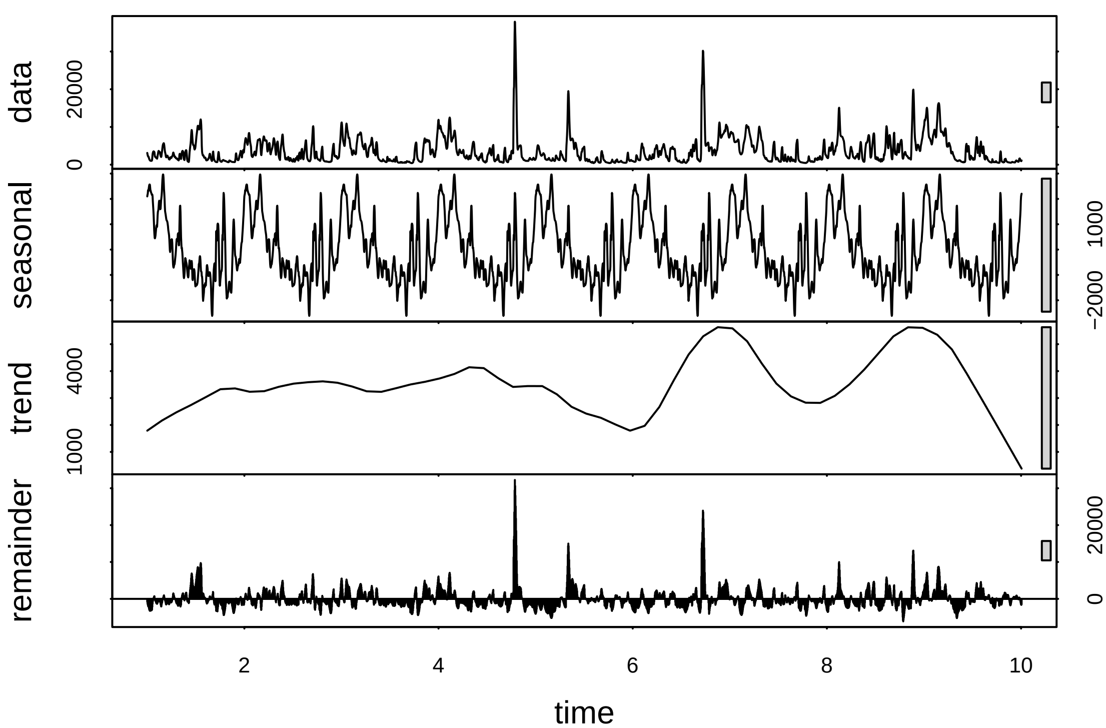

Figure 8: Time Series Decomposition of Discharge in the Neuse River.

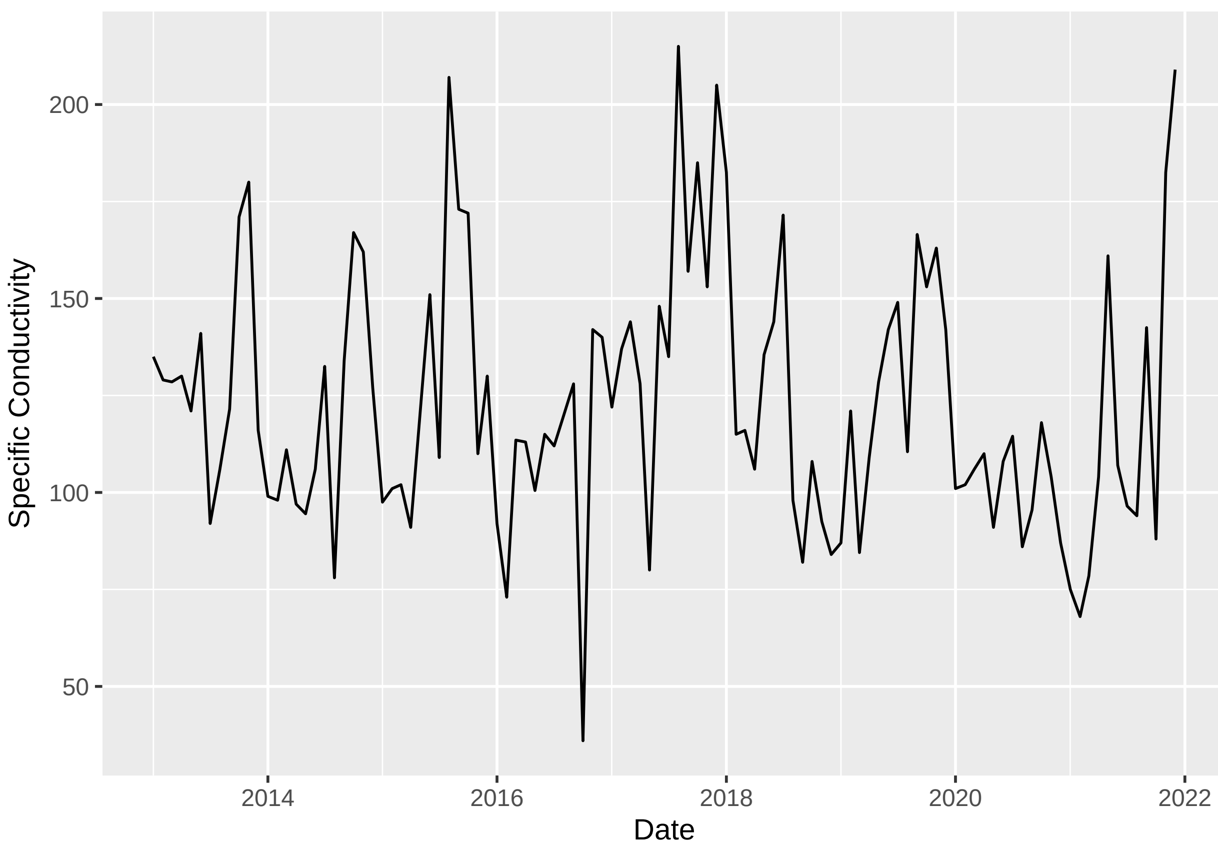

Figure 9: Conductivity in the Neuse River from 2013 through 2021.

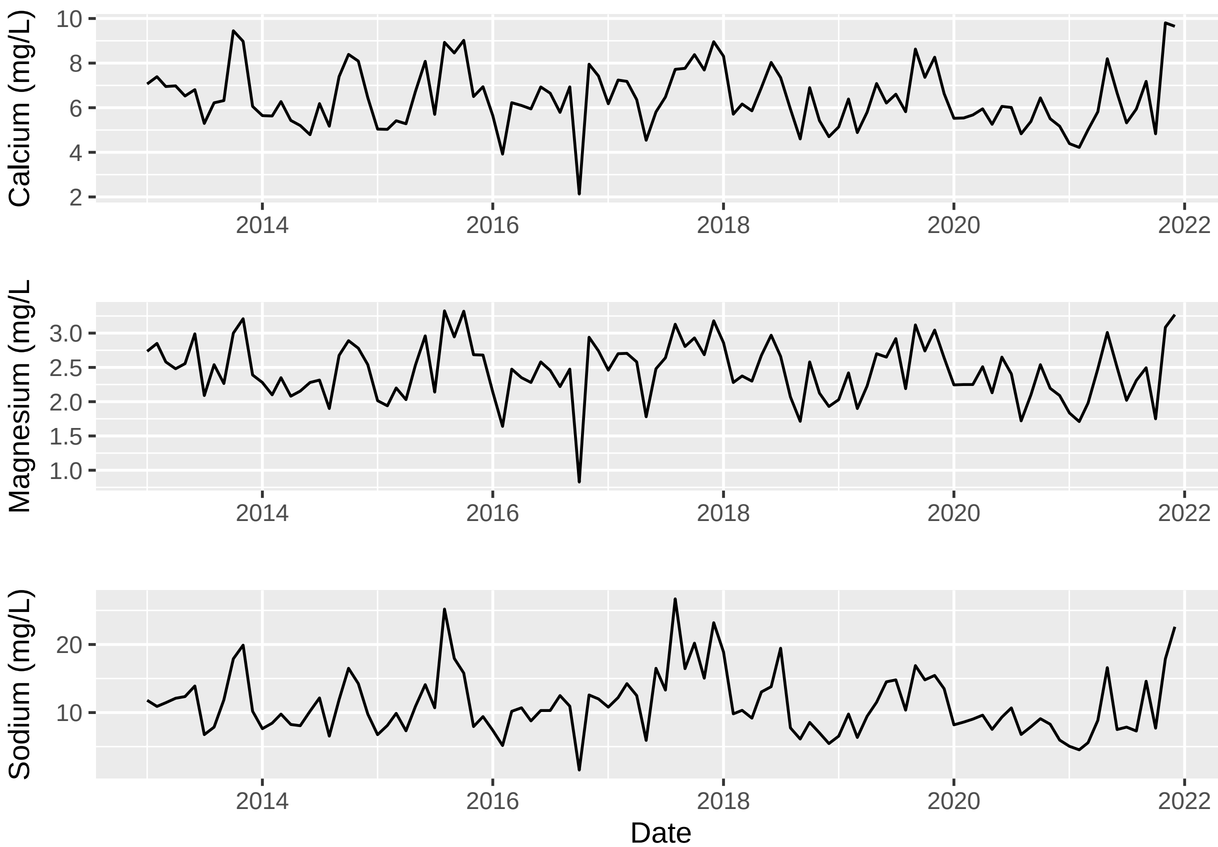

Figure 10: Calcium, Magnesium, and Sodium in the Neuse River from 2013 through 2021

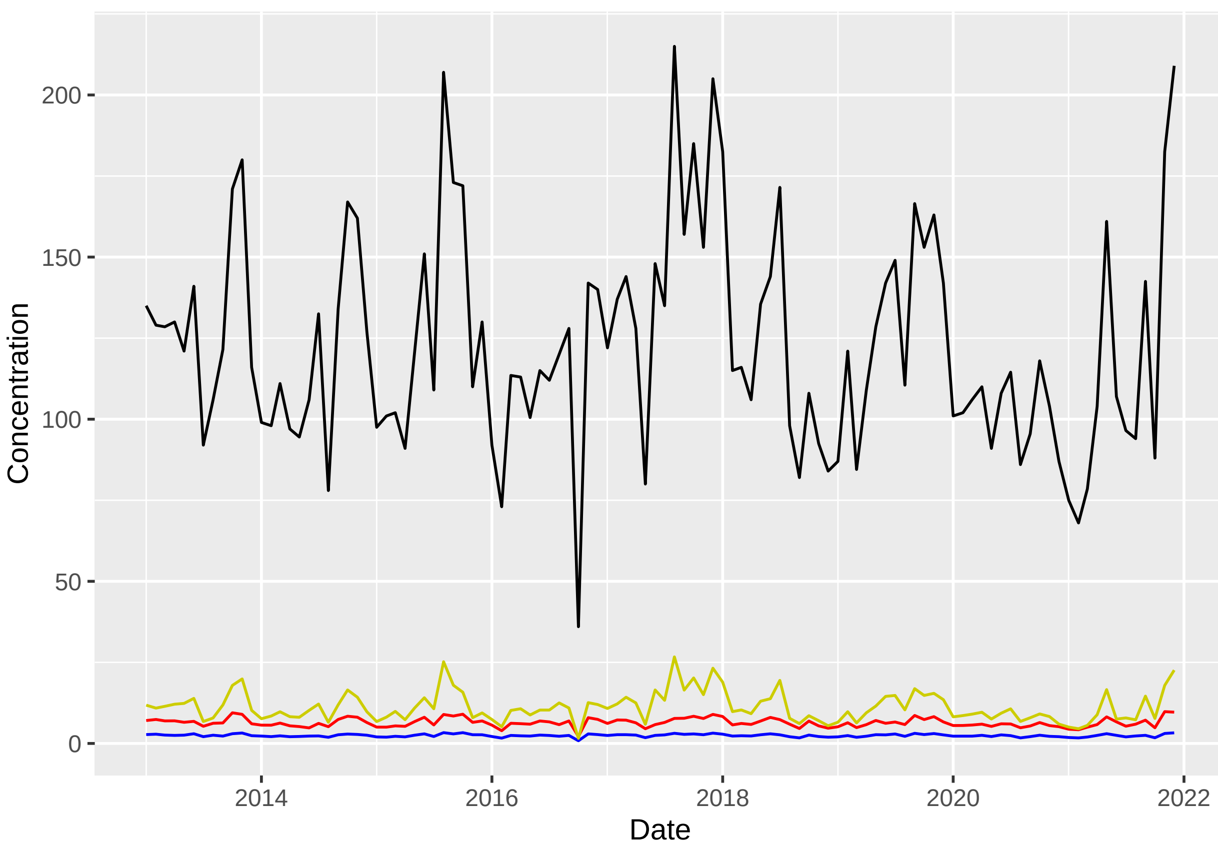

Figure 11: Specific Conductivity and salts in the Neuse River from 2013 through 2021

5 Summary and Conclusions

6 References

<add references here if relevant, otherwise delete this section>