Research Paper

Brief Study about Water Quality in South Biscayne Bay

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This study is presented to the Customer Support and GIS Manager, who works for the City of Coral Gables, and my point of contact for an internship conducted in the summer of 2023. In this study my objectives are first, to assess the water quality; second, to predict future values; and third, to advise about policies that contribute to keeping water quality in high stands.

I used open-source data collected from the South Florida Water Management District (SFWMD) through the DBHYDRO time series with a total of 650 values in this study. The two specific oceanic sites referenced in these time series are BBCW10, located at latitude 25.472157 and Longitude -80.332112, and BBCW8, located at latitude 25.601242 and longitude -80.305769. Both points belong to the south-central inshore estuary.

The time for each site extends from September 29, 2021, to July 10, 2023. The variables include:

1. Chlorophyll-A: Measured as the daily mean in micrograms per Liter (µg/l).
2. Conductivity: Measured as the daily mean in micro siemens per centimeter (uS/cm).
3. Dissolved oxygen: Measured as the daily mean in milligrams per liter (mg/l).
4. Salinity: Measured as the daily mean in Practical Salinity Units (PSU).
5. Temperature: Measured as the daily mean in degrees Celsius.
6. Turbidity: Measured as the daily mean in nephelometric turbidity units (NTU).

Chlorophyll: The chlorophyll concentration serves as a proxy for gauging the presence of phytoplankton in the water, and this, in turn, significantly influences marine life as it constitutes the primary food source for larger organisms in the sea. High concentrations of chlorophyll in the water are easy to depict with satellite sensors by looking at the color of the ocean, a greener color reflects higher rates of chlorophyll. According to a study conducted by the National Oceanic and Atmospheric Administration between 2016 and 2021, chlorophyll-A levels along the Southeast coast of the U.S. are approximately consistent with the national average. The study revealed no significant trend, but it did identify occasional peaks reaching around 2.0 µg/l. Additionally, the South Florida Water Management District presented a study from December 2012 where the Department of Environmental Resources Management (DERM) established a criterion using the annual geometric means (AGM) by region to assess water quality using the Numeric Nutrient Criteria (NNC), following that example, Miami‐Dade County MS4 Report found out that none of the regions on the Biscayne Bay is compliant with a rule saying that the AGM shall not exceed the criterion (0.4 for the region object of study) more than once in three years[[1]](#footnote-1). Regarding the BBCW8 site, I found 274 values higher than the average of this time series (0.955) and 21 higher than 2.0. On the other hand, on the BBCW10 site, I found 237 values higher than the average of this time series (1.106) and 25 higher than 2.0 but neither have a trend. Therefore, the site is still not compliant with the rule, which is concerning, this indicates the bay is receiving increasing nutrient inputs from inland.

Conductivity: Conductivity is useful as a general measure of water quality; it measures the ability to pass an electrical current. A change in conductivity could indicate that a discharge of some sort of pollutant has entered the water body, human interventions usually tend to increase dissolved solids in the water, thus, increasing conductivity. There is no water quality standard range for conductivity, the intended use is to verify a steady range for such variables but not the same amounts for both sites.

Dissolved Oxygen: Since nearly all life depends on oxygen, its role is critical, and monitoring the amount present in the water will give us a clue about how healthy the ecosystem is. The dissolved oxygen (DO) variable measures the amount of oxygen molecules present in the water, which is also related to other variables, for example, colder water can hold more oxygen, and high levels of salinity are typically associated with lower levels of oxygen. Although, living organisms in Biscayne Bay have different oxygen needs to maintain metabolic functions, Biscayne Bay Water Watch argues that most organisms need at least 5.0 mg/l to grow and reproduce normally. Environments with less than 3.0 dissolved oxygen are called hypoxic, and anoxic when levels drop below 0.05, in which case organisms will die. The goal ultimately when monitoring DO is to prevent events like the “Biscayne Bay fish kill”[[2]](#footnote-2) that occurred in August 2022, which could be related. The sites objects of study present good levels of DO in general, except for the BBCW8, which had levels below 4.0 five times, those low levels were found at the end of July and beginning of August 2022, two months before the fish kill event. The same site has experienced levels below 5.0 twenty-eight 28 times which conflicts with the marine DO criteria for class III marine waters[[3]](#footnote-3).

Salinity: The United States Geological Survey (USGS) concurs with the widely accepted scientific knowledge that the average salinity of the ocean is 35 PPT (where 1 PPT = 1 PSU). They employ the "Venice System" to categorize salinities in water[[4]](#footnote-4). According to this system, middle to lower estuaries fall within the salinity range of 18 to 30 (polyhaline), while marine environments have a salinity range of 30 to 40 (Euhaline). The data collected suggests a general increase in salinity in Biscayne Bay over the past century. Specifically, some values have exceeded 35 PSU, with twelve instances for BBCW8 and twenty-two for BBCW10. Furthermore, there was only one occurrence where the salinity surpassed 40 PSU, and this was observed in BBCW10.

Temperature: According to the USGS, temperature plays a role of great influence on biological activities, chemistry, and other types of water measurements like conductivity, dissolved oxygen, or salinity. If the temperature goes too far above or below a certain range, living creatures would not be able to survive. Miami-Dade County code has set a maximum limit of 90 degrees Fahrenheit (about 32 Celsius) to water temperature[[5]](#footnote-5), but some of the readings obtained have higher values: thirty-six and twenty-eight for BBCW8 and BBCW10, respectively. These high values are concerning, but follow a trend in general rising temperatures and the climate change phenomenon, which can put greater strains on water environments such as the Biscayne Bay estuary.

Turbidity: Turbidity serves as a proxy variable to determine the suspended solids ocean water contains, the ocean takes a great amount of nutrients, metals, and pollutants from inland practices, most of them human but regular environmental activities like precipitation also affect this variable. When water is clearer its turbidity is low, in the opposite case, particles present in the water block light and make the water look darker. The Miami-Dade County code sets up a maximum desirable of 29 NTU and I have found that none of the values exceed such measurement, moreover, they rarely exceeded 25 units (only three times for both sites combined).

Gaps in data:

The data have some gaps that I filled up using the average between the range missing, the specific gaps are as follows:

1. Salinity: for BBCW8 -> 08-dec-2022 and 27-May-21, 2023 - Jun 5,2023. missing data from BBCW10 -> from 31-aug-21 to 28-Sep-21
2. Conductivity: BBCW8->Missing value 8-Dec-22.
3. Dissolved oxygen: BBCW8-> Missing value 8-Dec-22.
4. Chlorophyll A: BBCW8-> missing values from 12-Jan-23 to 25-Jan-23 BBCW10 -> missing values from 8-Oct-22 to 25-oct-22 and 21-Jan-23 to 25-Jan-23.

I operated the Google Collaboratory platform along with the Python programming language to conduct thorough data analysis, seeking a model capable of forecasting future values for these specific variables. Initially, I uploaded the corresponding Excel files for each variable, subsequently merging them into a consolidated Pandas data frame, while discarding irrelevant data points. Subsequently, my analysis proceeded with several steps.

In the first step, I extracted descriptive statistics for the variables, visualizing their distributions, identifying outliers, and uncovering potential correlations. The second step involved evaluating the alignment of present values against established thresholds set by local authorities and biological standards, highlighting instances where deviations occurred.

For the third step, my focus was on developing a predictive model capable of offering insights into the future behavior of these variables. In this endeavor, I experimented with seven distinct models; however, none of them exhibited a satisfactory level of accuracy, all falling short of a threshold of 75%.

This study encountered several significant challenges. Foremost among these was the struggle to locate an up-to-date database containing a sufficient volume of data suitable for training predictive models and identifying temporal patterns. The second obstacle emerged from the limited timeframe available for producing results, given the intricate and novel nature of the underlying problem. The third challenge pertained to the selection of explanatory variables (x) and the target variable (y), with time eventually being chosen as the latter. This decision was motivated by the intention to predict specific temporal patterns. However, even with this choice, I had to incorporate a dummy variable and trim the data to enhance the precision of the predictive models.

Unfortunately, the predictive models encountered a setback due to the absence of a two-year data span within the time series. This deficiency prevented the models from effectively comparing the July-September timeframe, resulting in diminished accuracy levels.

While this academic endeavor provided valuable insights into the intricacies of water quality and the application of Python for constructing rudimentary predictive models, the actual models generated do not exhibit a sufficient level of accuracy for prospective practical utilization.

From a biological point of view, the bibliography explored suggested that human inputs into the Bay are more than the Bay can tolerate, and a degraded environment is an outcome of mixing fertilizers on the landscapes nearby exacerbated by rainy seasons. The most important human inputs to minimize are nitrogen, chemicals, paints, and oils that come from industries and homes.

1. https://casetext.com/regulation/florida-administrative-code/department-62-department-of-environmental-protection/division-62-departmental/chapter-62-302-surface-water-quality-standards/section-62-302532-estuary-specific-numeric-interpretations-of-the-narrative-nutrient-criterion [↑](#footnote-ref-1)
2. https://blogs.ifas.ufl.edu/miamidadeco/2022/10/21/october-2022-biscayne-bay-fish-kill/ [↑](#footnote-ref-2)
3. https://floridadep.gov/sites/default/files/tsd-do-criteria-aquatic-life.pdf [↑](#footnote-ref-3)
4. https://pubs.usgs.gov/fs/2004/3108/report.pdf [↑](#footnote-ref-4)
5. <https://floridadep.gov/sites/default/files/13_Miami-Dade_County_Code.pdf> [↑](#footnote-ref-5)