**Ocean Acidification Assignment (25 points)**

**PART A (15 points)**

Prepare a brief write up covering the following aspects related to ocean pH.

1. **How does oceanic carbonate buffering maintain the pH of the oceans?**
2. **Using Le Chatlier’s principle explain how the pH would be altered if the CO2 concentration increases in the atmosphere.**
3. **How would a decrease in pH affect marine life and what could be the possible impact on short and long term carbon cycle?**

**PART B (10 points)**

You will use ocean acidification data and plot it using Microsoft Excel. You can access data from the National Oceanic and Atmospheric Administration (NOAA), which supports scientific research regarding changes in our atmosphere and ocean.

**Instructions:**

Access the NOAA Ocean Acidification Data Portal at this link:

<http://www.nodc.noaa.gov/oceanacidification/stewardship/data_portal.html>

From here you will search for ocean acidification data by following the instructions below:

* Make sure the boxes beside “Alkalinity”, “Dissolved inorganic carbon”, “pCO2/fCO2-water”, and “pH” are checked.
* We are going to look at data in the Northern Atlantic Oceans, so type “North Atlantic Ocean” in the box below “Additional Terms” in the lower right.
* Click “SEARCH” in the bottom center of the page.

This search list a number of studies/ocean expeditions that have produced data in the Northern Atlantic Ocean. The data you will be using will have the NCEI Accession 0100064. (**Carbon dioxide, temperature, salinity and other variables collected via time series monitoring from METEOR, POSEIDON and others in the North Atlantic Ocean from 1995-10-02 to 2009-11-25)**

Follow the instructions below to access the data:

* Click “NCEI Metadata” in the appropriate box. Next, click on “HTTPS” link in the Download Data row – this will open a new page with the actual data files.
* Download the file by clicking on “100064.1.1.tar.gz”.
* Find the file and unzip it (double-clicking or right-clicking to select “unzip” should work) to access the folder named “0100064”.
* Open the folder then the “1.1” subfolder, then the “data” subfolder, and finally the “0-data” subfolder.
* You will be working with the “ESTOC\_TS\_Data\_1995-2009.csv” file. Double-click to open.

At this point, you should be looking at a spreadsheet of data in Excel. The names of each column with meaning are listed below:

|  |  |  |
| --- | --- | --- |
| **STATION** |  | Station name as designated by the research team |
| **LATITUDE** |  | Latitude |
| **LONGITUDE** |  | Longitude |
| **DATE** |  | Date presented as decimal to make it easier to plot |
| **SST** | **DEG\_C** | Sea surface temperature in degrees celsius |
| **SSS** |  | Sea surface salinity |
| **ALKALI** | **UMOL/KG** | Alkalinity in micromoles per kilogram of seawater |
| **PH\_TOT** |  | pH total |
| **PH\_TMP** |  | Temperature at which pH was measured |
| **TCARBN** | **UMOL/KG** | Total carbon in micromoles per kilogram of seawater |
| **FCO2** | **UATM** | Fugacity of carbon dioxide in microatmospheres. Describes how much CO2 is dissolved in seawater. |
| **PCO2** | **UATM** | Partial pressure of carbon dioxide in microatmospheres. Describes how much CO2 is dissolved in seawater. |

1. First determine the geographic location in the Northern Atlantic Ocean from which this data come from. Columns 2 and 3 will give you the latitudinal and longitudinal coordinates. Follow the link <https://getlatlong.net> and enter the lat-long coordinates into the Decimal Deg. Latitude and Decimal Deg. Longitude boxes on the right below the map and click “Show Point” so see the location this lat-long represents.

What is the approximate location (Write the coast of the closest continent? For example: southwest coast of Australia)

1. Now you will plot the data in Excel so we can see how ocean conditions have changed in this region from 1995-2009. Return to the ESTOC\_TS\_Data\_1995-2009.csv data file and follow the instructions below and answer the questions.

(Normally missing data is represented by some value like -9999 or -999 etc. There is one anomalous data point in row 145 where *p*CO2 reads as -999. For keeping uniform data length for all variables, you can delete this entire row.)

1. Plot the variation of SST with time. Select the data (numbers only, rows 3-145) in the “DATE” column (column 4) and the corresponding data in the “SST” column (column 5). Click on “Insert”, then “Chart”, then choose “Line with markers”. Format the Y-axis range by double clicking on it.

Do you observe any trend in SST? What is the approximate annual range of SST. In which months do you observe the highest and lowest SST? (Date presented as decimal format. Day of the year can be obtained by multiplying the decimal part of the dates to 365).

1. Now take a look at the variation in pCO2 and pH. You can select Columns, H and L as the Y axis and date as the X axis. Click on “Insert”, then “Chart”, choose “Scatter” or “X-Y Scatter”.

Insert a trendline by right-clicking on an actual data point (any will work) and selecting “Add Trendline…”. Chose “Linear” and click “OK” (note that you can change the color and thickness of the trendline in this same menu.

Label the axes and give the charts appropriate titles “ESTOC Northern Atlantic Seawater pH or pCO2 or SST 1995-2009”.

Sometimes Excel isn’t the best at displaying data in a way that makes it easy to see trends. To improve this, change the x-axis values by double-clicking on the axis (you can also right-click on the axis numbers and select “Format Axis…”. You should not need to do this when you plot pH, but will need to make the minimum “300” and maximum “420” when you plot *p*CO2.

Describe how ocean pH and pCO2 have changed through time. Use your trend line to provide an approximation for how much they have changed.

1. Now examine the relationship between pCO2 and pH. Make a scatter plot with pH on the x axis and pCO2 on the Y axis. Appropriately adjust the Yaxis range and fit a trend line

What can you infer about the relationship between the two quantities. Physically explain your inference.