PROJECT GROUP FOUR (4)

BIOGEOCHEMICAL RESPONSES TO SEASONAL AND DECADAL CHANGES IN ATLANTIC OCEAN

PRESENTED BY

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Figure 1: SHOWING world map

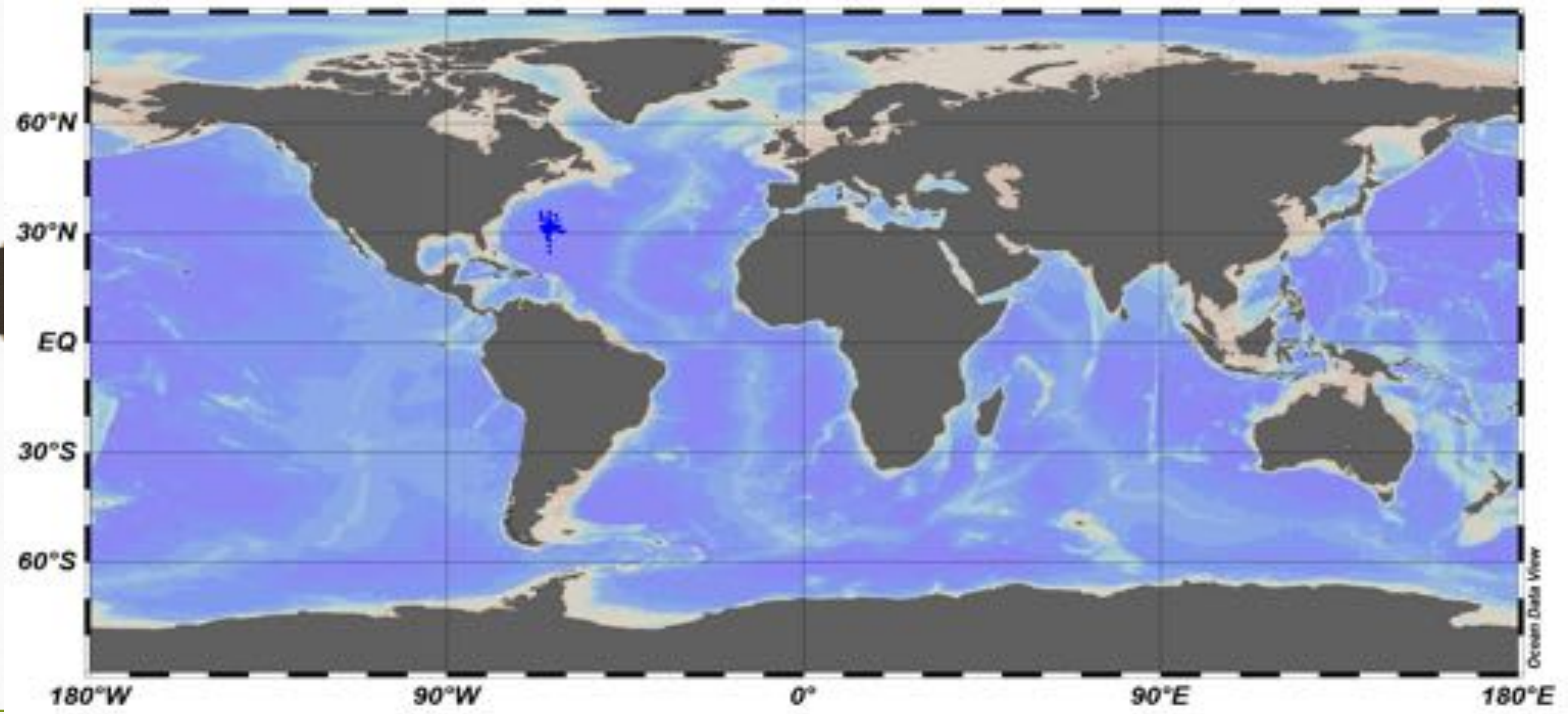
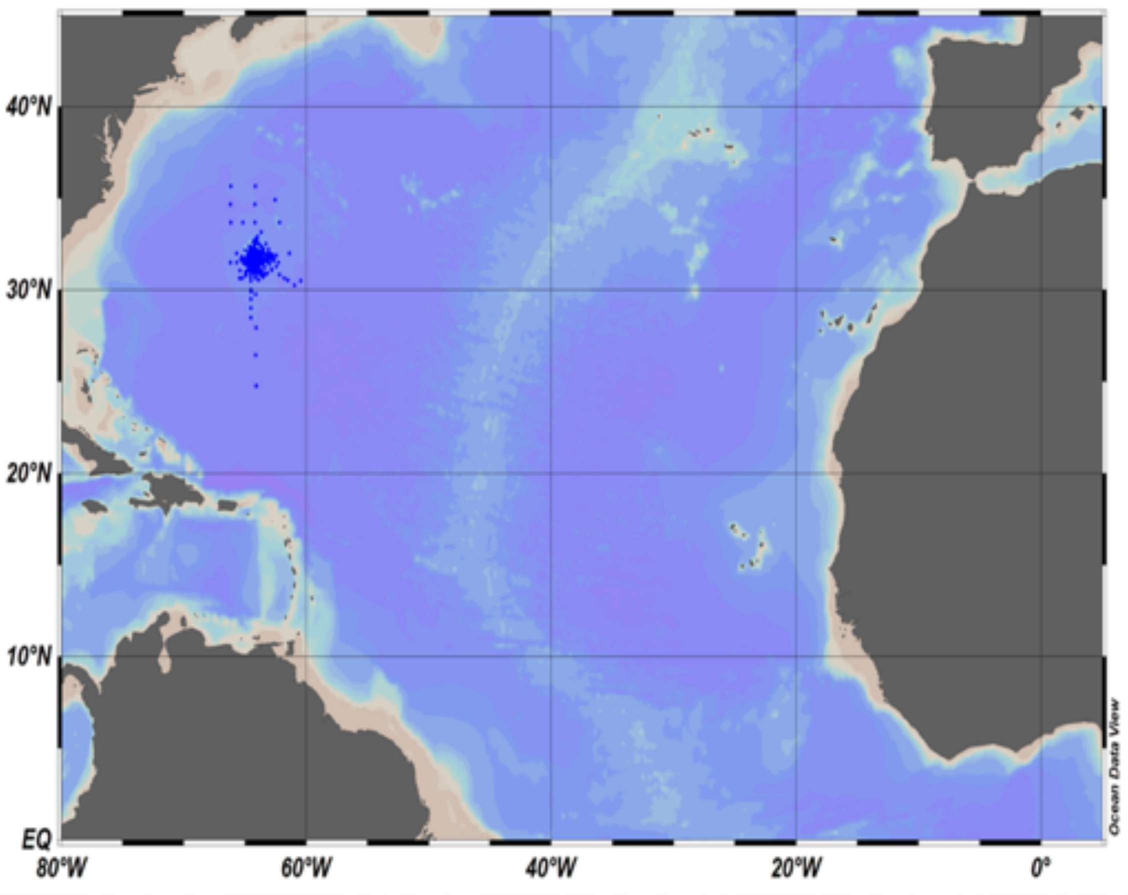
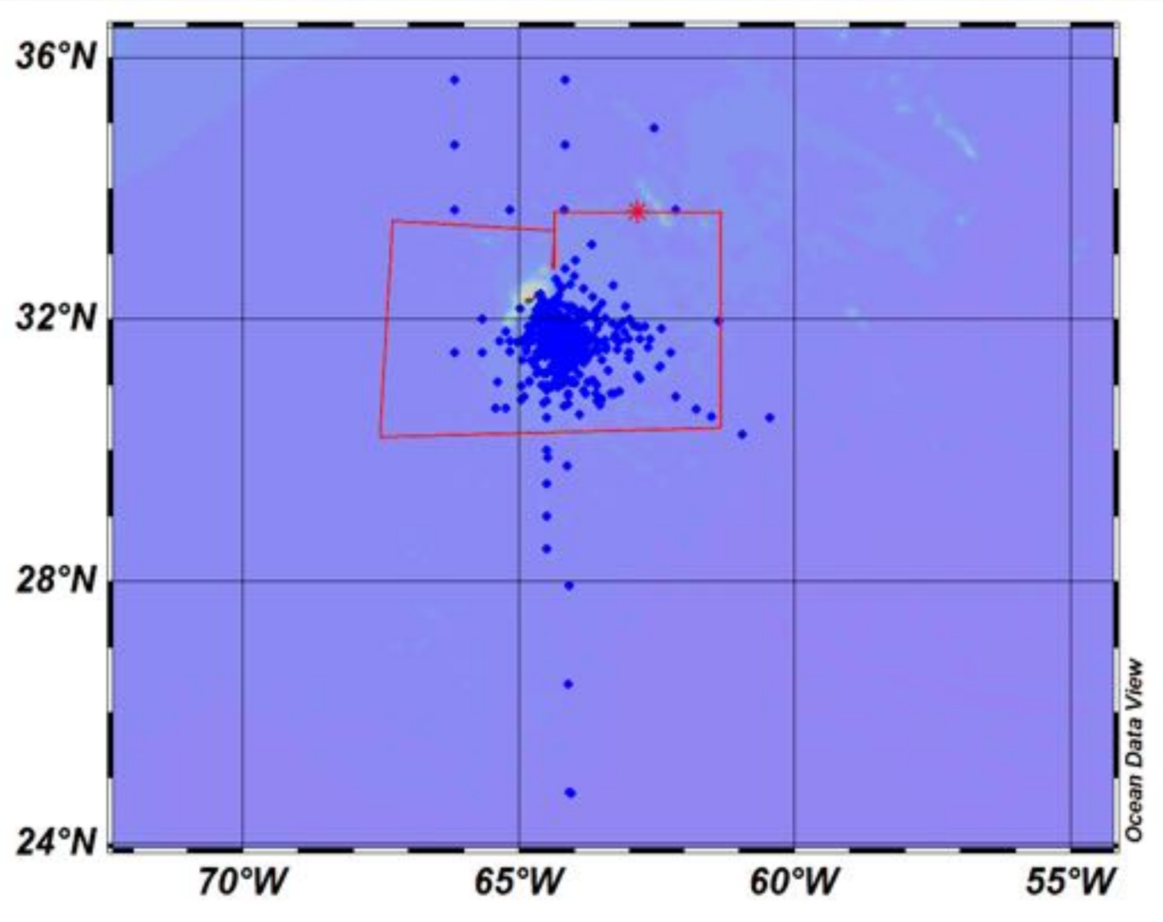


FIGURE 2: SHOWING ATLANTIC OCEAN



- Atlantic Ocean is the 2nd largest
- 106,400,000Km2
- Covers about 20% of the earth surface

CO-ORDINATES OF THE DATA POINTS: BERMUDA ATLANTIC TIME-SERIES STUDY (BATS)



- ~~Longitude: -64.097~~
- Latitude: 31.971
- **Duration:**

The data span through 1988 to 2017

AIM AND OBJECTIVES

- **Aim:**
- To determine the concentration and seasonal variations in biogeochemical parameter in the coastal waters of Atlantic oceans.
- **Specific objectives:**
- To determine variations in temperature, salinity, phosphates, nitrates and nitrites and bacteria abundance in the Atlantic oceans.
- To determine the level of dissolved inorganic nutrients in the selected points.

METHODOLOGY AND DATA ANALYSIS

- Temperature (°C), Dissolved oxygen, Electrical Conductivity, and Salinity CTD_S (PSS-78) was measured using Sea-Bird CTD Instrument.
- Nutrients were determined using Colorimetric Methods.
- Bacterial abundance was counted using DAPI Stain on 0.2µm filter.
- Python and Ocean Data View (ODV) software were used for the statistical data analysis

PARAMETERS OF INTEREST

Parameter	Unit
Temperature	°C
Salinity	PSS
Depth	m
Time	hh mm
Decade	year
Dissolved inorganic carbon CO_2	µmol/kg
TOC	µmol/kg
TN	µmol/kg
PO_4	µmol/kg
NO_3^{2-}	µmol/kg
NO_2^-	µmol/kg
Bacterial enumeration	cells x 10^8/kg

HYPOTHESIS

Evaporation

1. Temp → Salinity

Rapid growth

2. Temp → Bacterial abundance

NULL HYPOTHESIS:

- ✓ There is no correlation between seasonal changes in temperature and salinity at p = 0.05 significant level.
- ✓ There is no correlation between seasonal changes in temperature and bacterial abundance at p = 0.05 significant level.
- ✓ Data were analyzed using Ocean Data View and Python 3.7.0 version tools

Libraries

In [1]:
```
import numpy as np
import pandas as pd
import seaborn as sb
import matplotlib.pyplot as plt
import scipy
from scipy.stats.stats import pearsonr
```

Data Selection and Reduction

```
In [3]:
data_yymmdd = data.loc[data.yymmdd != -999, :]
data_decy = data_yymmdd.loc[data_yymmdd.decy != -999,:]
data_time = data_decy.loc[data_yymmdd.time != -999,:]
data_depth = data_time.loc[data_time.Depth != -999,:]
data_temp = data_depth.loc[data_depth.Temp != -999,:]
data_CTD = data_temp.loc[data_temp.CTD_S != -999,:]
data_Sal1 = data_temp.loc[data_temp.Sal1 != -999,:]
data_all = data_Sal1.loc[data_Sal1.Sigth != -999,:]
data_all1 = data_all.loc[data_all.O21 != -999,:]
data_all2 = data_all1.loc[data_all1.OxFixT != -999,:]
data_all3 = data_all2.loc[data_all2.Anom1 != -999,:]
data_all4 = data_all3.loc[data_all3.CO2 != -999,:]
data_all5 = data_all4.loc[data_all4.Alk != -999,:]
data_all6 = data_all5.loc[data_all5.NO31 != -999,:]
data_all7 = data_all6.loc[data_all6.NO21 != -999,:]
data_all8 = data_all7.loc[data_all7.PO41 != -999,:]
data_all9 = data_all8.loc[data_all8.Si1 != -999,:]
data_all10 = data_all9.loc[data_all9.POC != -999,:]
data_all11 = data_all10.loc[data_all10.PON != -999,:]
data_all12 = data_all11.loc[data_all11.TOC != -999,:]
data_all13 = data_all12.loc[data_all12.TN != -999,:]
data_all14 = data_all13.loc[data_all13.Bact != -999,:]

data_all15 = data_all14.loc[data_all14.TDP != -999,:]
data_all16 = data_all15.loc[data_all15.POP != -999,:]
data_all17 = data_all16.loc[data_all16.SRP != -999,:]

print (data_all15)
```

Data Selection and Reduction Cont'

```
In [17]: final_data = data_all15.loc[:,('Depth','Temp','Sal1','Alk','NO31','NO21','PO41','Bact','TDP')]
         print(final_data)
```

```
            Depth    Temp    Sal1     Alk  NO31   NO21  PO41  Bact  TDP
1020700413  301.3  18.133  36.574  2387.9  3.43  0.010  0.14   1.0  203
1020700414  401.8  17.921  36.546  2385.6  3.97  0.009  0.19   0.9  247
1020801003  398.2  17.791  36.510  2386.5  4.99  0.008  0.20   0.5  248
```

Correlation Matrix

In [21]:
```
data_all18 = final_data.loc[final_data.Depth < 201,:]
corr = data_all18.corr()
corr
```

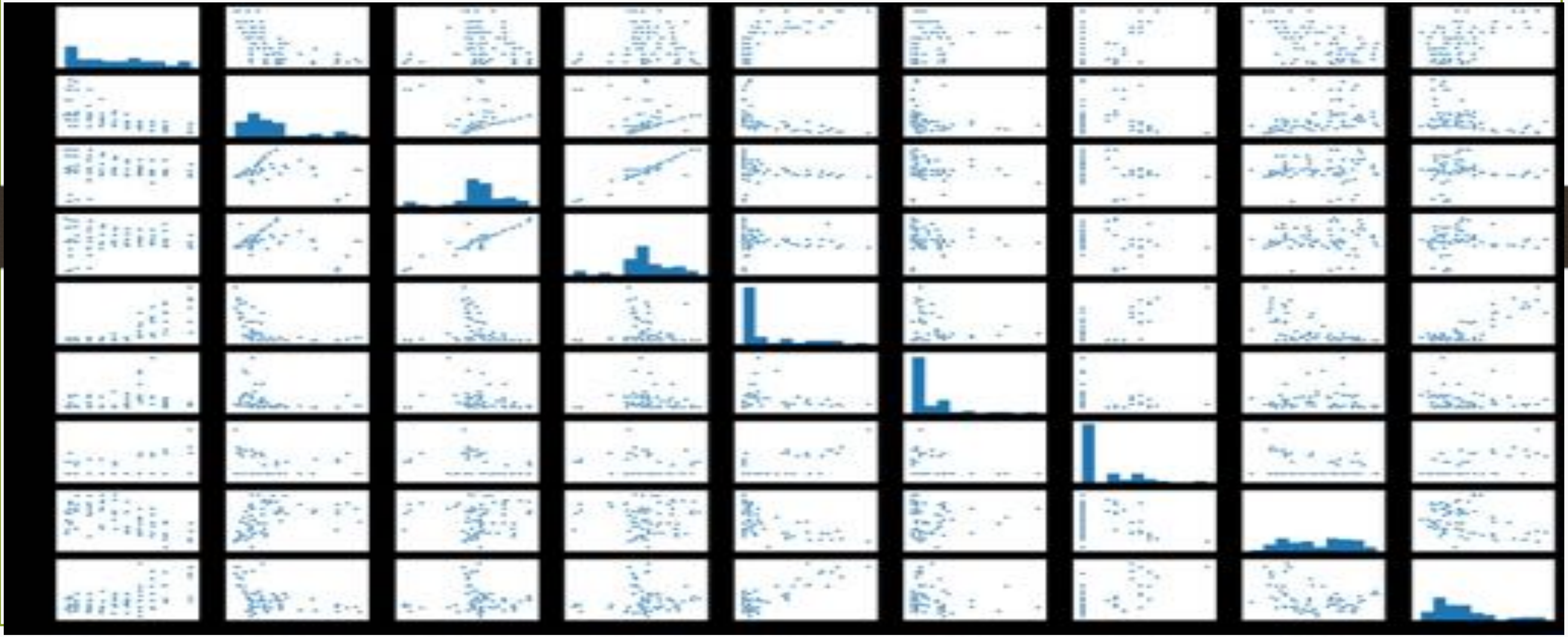
Out[21]:

	Depth	Temp	Salt	Alk	NO31	NO21	PO41	Bact	TDP
Depth	1.000000	-0.652437	-0.061401	0.012246	0.742928	0.250639	0.334225	-0.592564	0.580373
Temp	-0.652437	1.000000	-0.316513	-0.312314	-0.474860	-0.312110	-0.022668	0.410575	-0.405448
Salt	-0.061401	-0.316513	1.000000	0.945417	-0.192274	-0.121042	-0.301168	0.008757	-0.074497
Alk	0.012246	-0.312314	0.945417	1.000000	-0.113296	-0.066036	-0.211415	-0.013356	-0.012968
NO31	0.742928	-0.474860	-0.192274	-0.113296	1.000000	0.024901	0.683175	-0.611802	0.829935
NO21	0.250639	-0.312110	-0.121042	-0.066036	0.024901	1.000000	-0.177357	-0.034716	-0.097591
PO41	0.334225	-0.022668	-0.301168	-0.211415	0.683175	-0.177357	1.000000	-0.298572	0.573776
Bact	-0.592564	0.410575	0.008757	-0.013356	-0.611802	-0.034716	-0.298572	1.000000	-0.368343
TDP	0.580373	-0.405448	-0.074497	-0.012968	0.829935	-0.097591	0.573776	-0.368343	1.000000

Scatter Plot matrix

```
In [23]: sb.pairplot(data_all18)

Out[23]: <seaborn.axisgrid.PairGrid at 0xfc294d3ba8>
```



Correlation and P-value

```
In [24]: mgd = data_all18['Bact']
         hp = data_all18['Temp']
         pearsonr_coefficient, p_value = pearsonr(mgd, hp)
         print (pearsonr_coefficient, p_value)

0.4105747183578767З 0.000208245658480 70393

In [27]: mgd = data_all18['TDP']
         hp = data_all18['NO31']
         pearsonr_coefficient, p_value = pearsonr(mgd, hp)
         print (pearsonr_coefficient, p_value)

0.8299349143984127 1.2735195281922717e-20

In [28]: mgd = data_all18['PO41']
         hp = data_all18['NO31']
         pearsonr_coefficient, p_value = pearsonr(mgd, hp)
         print (pearsonr_coefficient, p_value)

0.6831754499416509 7.634146070908527e-12

In [29]: mgd = data_all18['Temp']
         hp = data_all18['Sal1']
         pearsonr_coefficient, p_value = pearsonr(mgd, hp)
         print (pearsonr_coefficient, p_value)

-0.3165133085363052 0.005040202423028l9
```

FIELD OBSERVATIONS

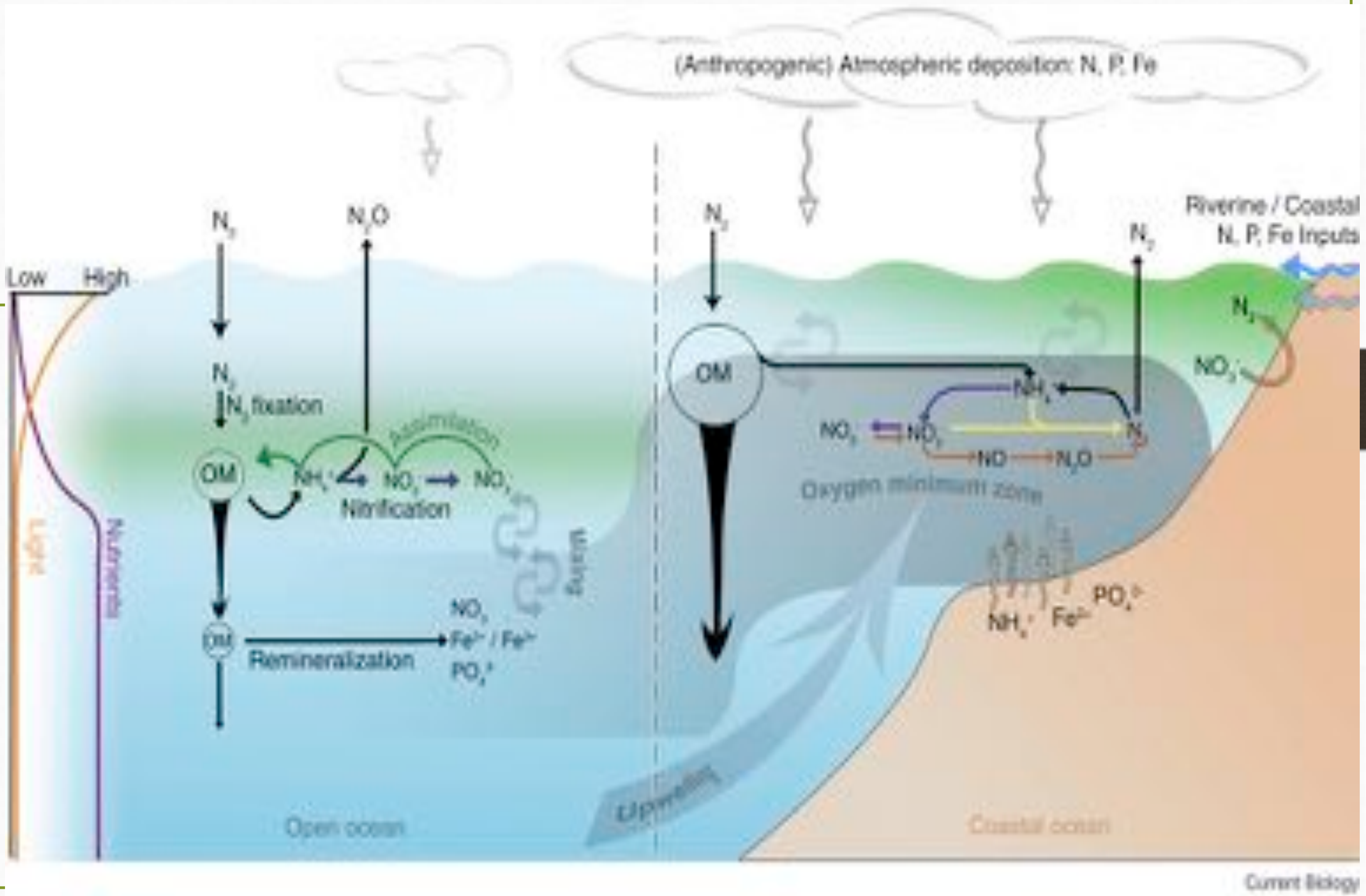
- In this research work our emphasis were on
    1. Total Dissolved Phosphorus (TDP)
    2. Nitrite
    3. Nitrate
    4. Bacterial and production
    5. Salinity
    6. Temperature
- Firstly, we look at nutrient variation along Atlantic Ocean with time using Ocean Data View
- secondly, based on the data gathered in the ocean both in the surface and deep ocean (i.e Between 0 up to 200 m).

FIG 3: SCHEMATIC SHOWING NITROGEN CYCLE PROCESSES

Schematic showing nitrogen cycle processes occurring in the open ocean (left) and the coastal ocean, with an oxygen minimum zone (right).

Depth profiles (far left) show typical distributions of light and nutrients (nitrate and phosphate) in the open ocean that can lead to the formation of a deep chlorophyll a maximum (green shading).

The processes depicted in the open ocean also occur in the coastal ocean; in the presence of an OMZ, denitrification and anammox lead to nitrogen loss.



PRIMARY PRODUCTION RATES

According to the studies carried out by Janet et el., 2012, there is a significant correlation between temperature in open ocean waters and Primary production rates.

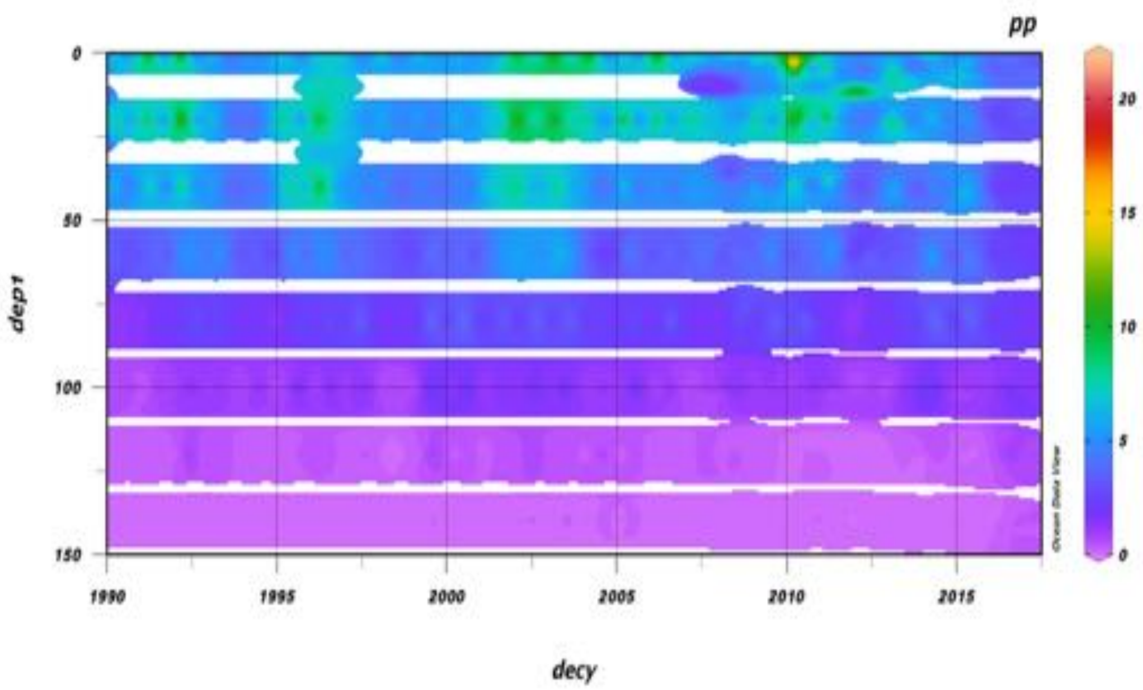


Fig 4A: Plot of primary production from 1990 – 2017 over a depth transec

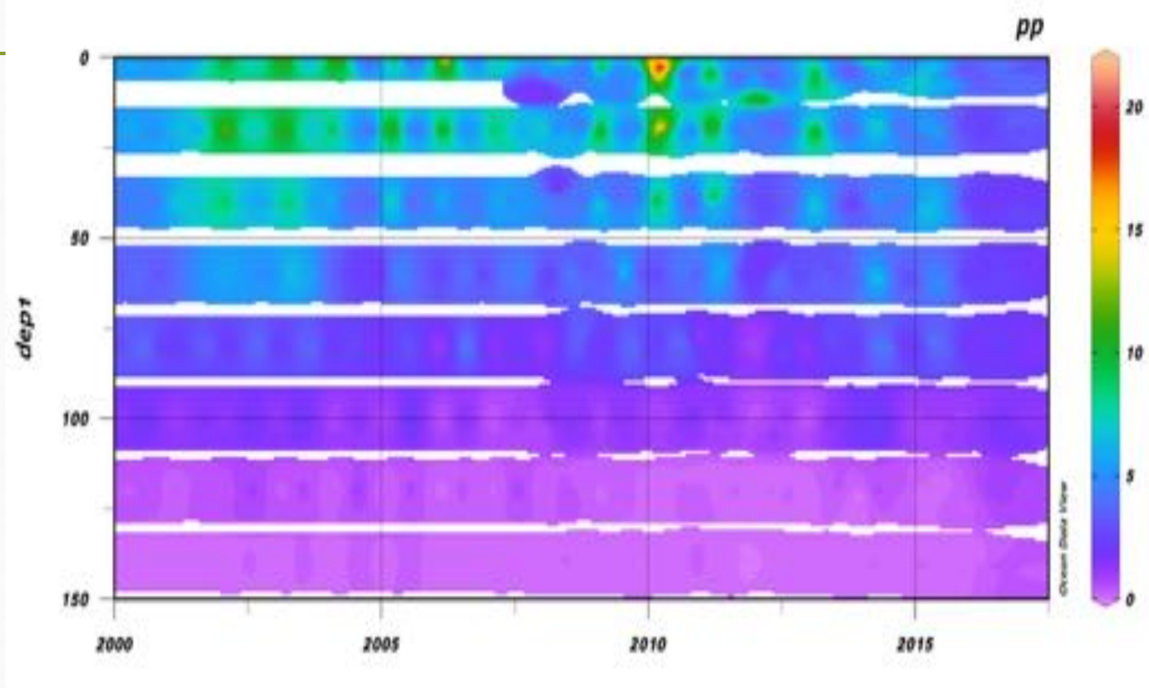


Figure 4B: Plot of primary production from 2000 – 2017 over a depth transect

PRINCIPAL FACTORS REGULATING BACTERIAL GROWTH AND ABUNDANCES

- The principal factors regulating bacterial growth and abundances are temperature, substrate supply, predation and mortality due to viruses (Li & Dickie 1987, White et al. 1991, Fuhrman 1992 and Kirchman et al. 1995)
- Surprisingly, the qualitative and quantitative relationships among these factors are poorly understood as show in this second plot of bacteria.
- In low to middle latitudes, bacterial activities are normally at a minimum when water temperatures are low (Findlay et al. 1991, Shiah & Ducklow 1995 etc.

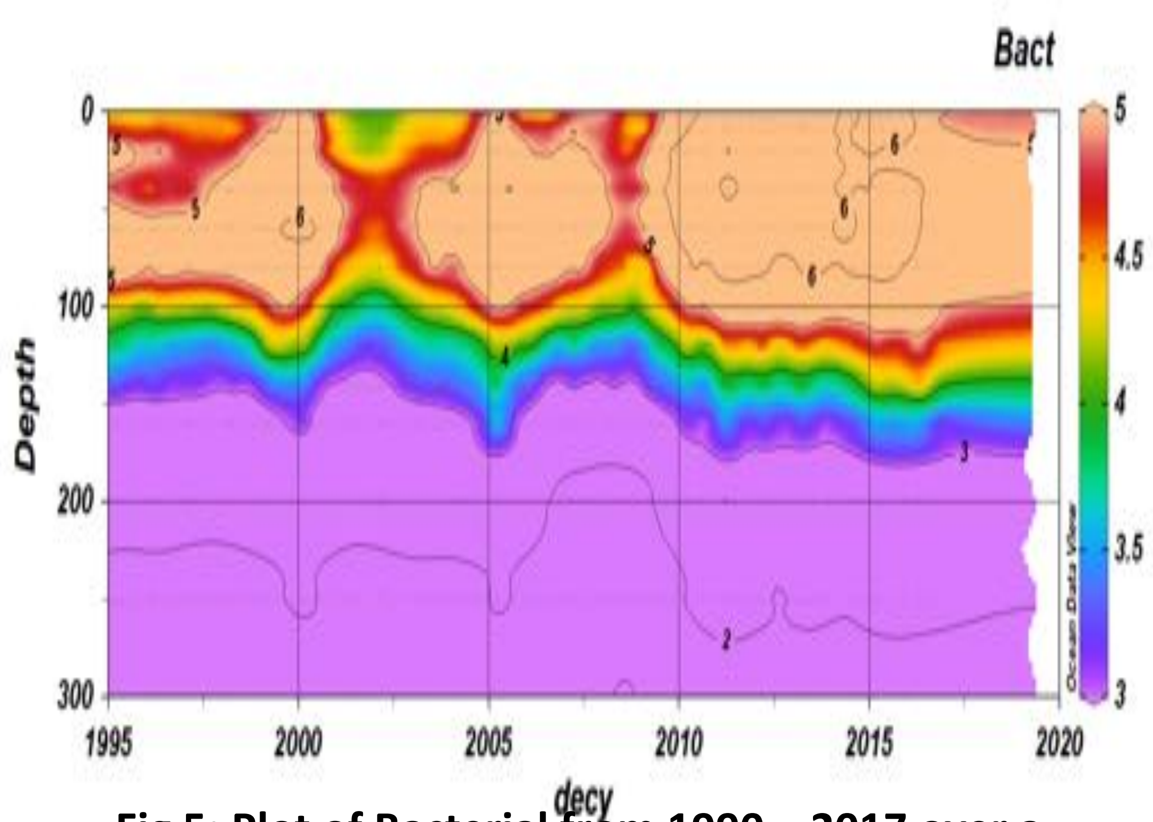


Fig 5: Plot of Bacterial from 1990 – 2017 over a depth transect

TEMPERATURE AND SALINITY

The salinity of the ocean is a function of several factors; one major factor is Temperature.

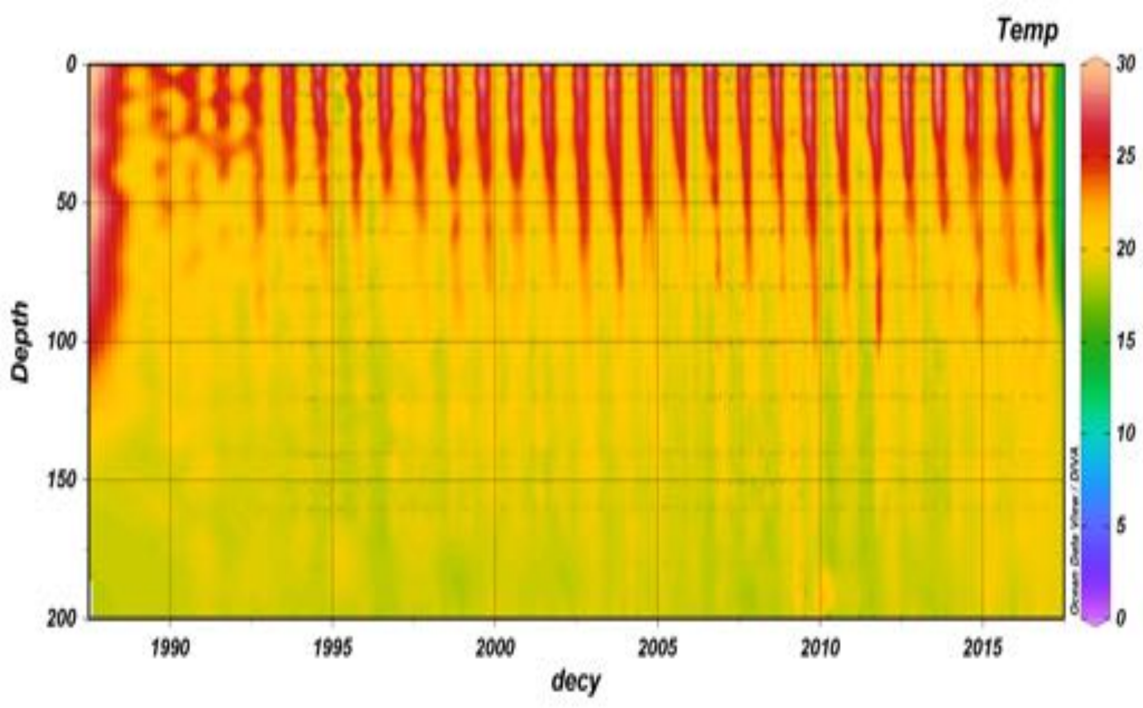


Fig 6: Plot of Temp from 1990 – 2017 over a depth transect

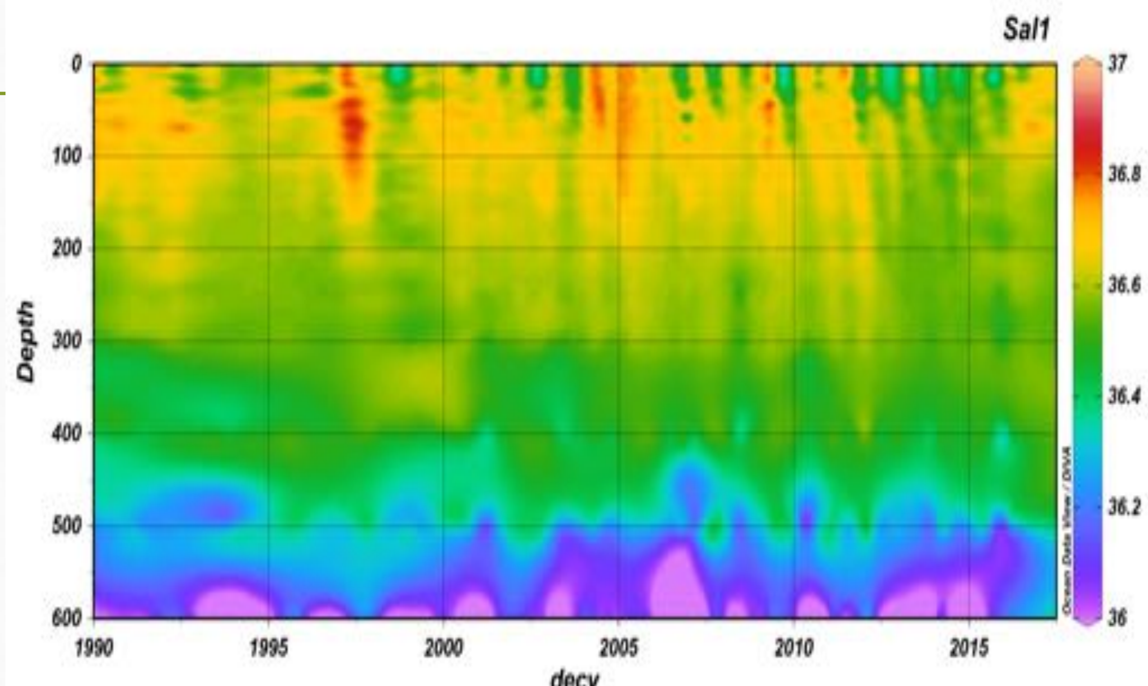


Fig 7: Plot of Salinity from 1990 – 2017 over a depth transect

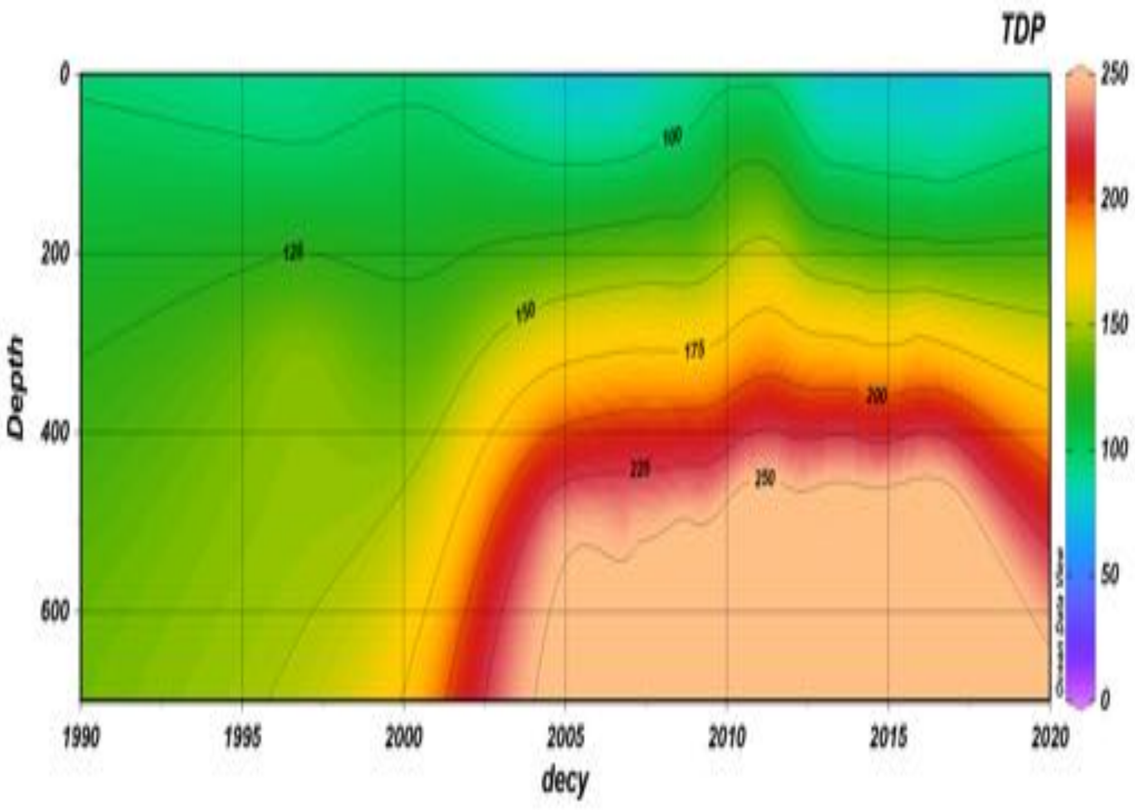


Fig 8: Plot of TDP from 1990 – 2017 over a depth transect

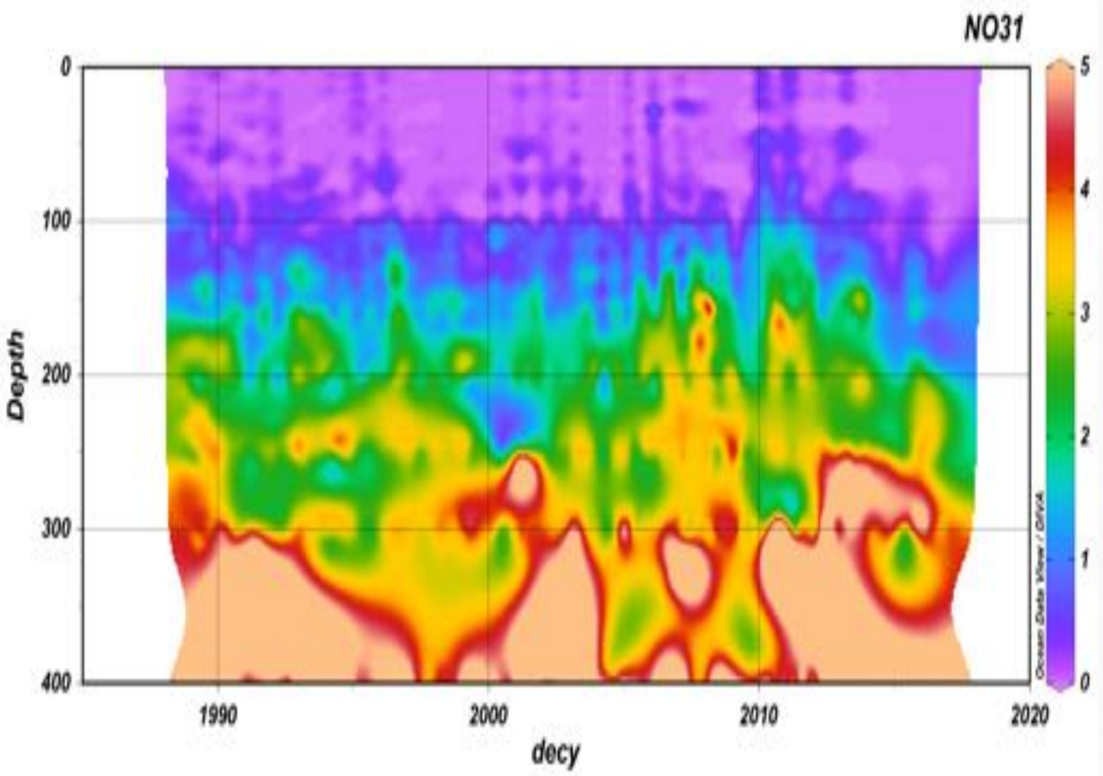


Fig 9: Plot of Nitrate from 1990 – 2017 over a depth transect

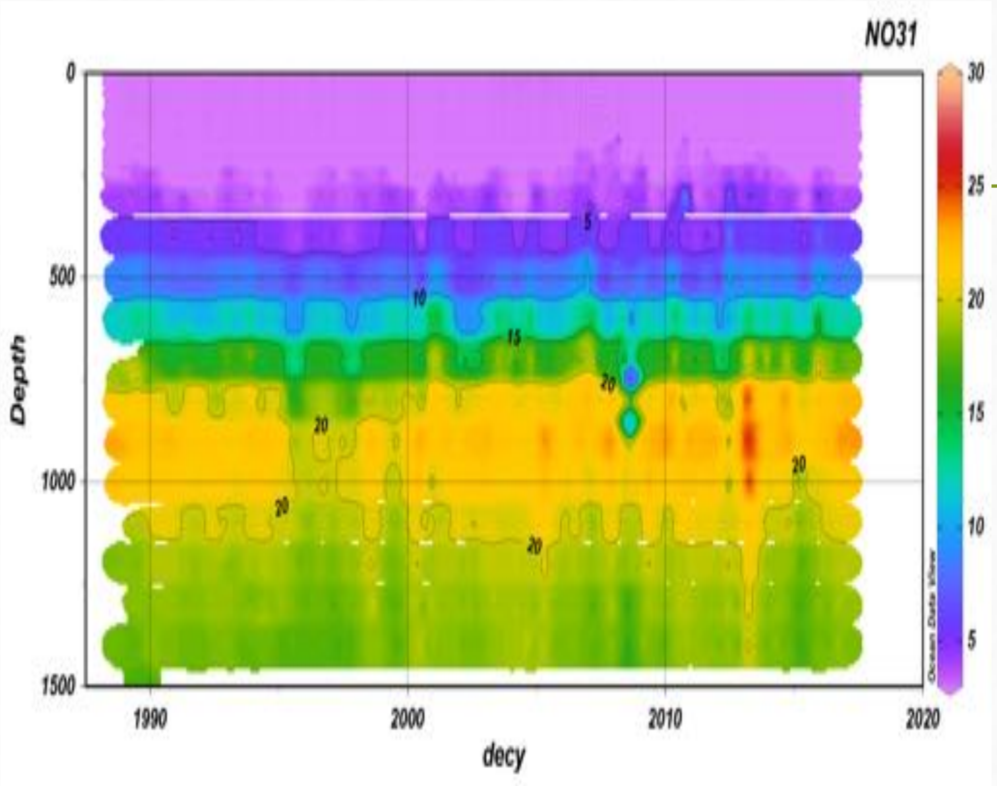


Fig 10: Plot of Nitrite from 1990 – 2017 over a depth transect

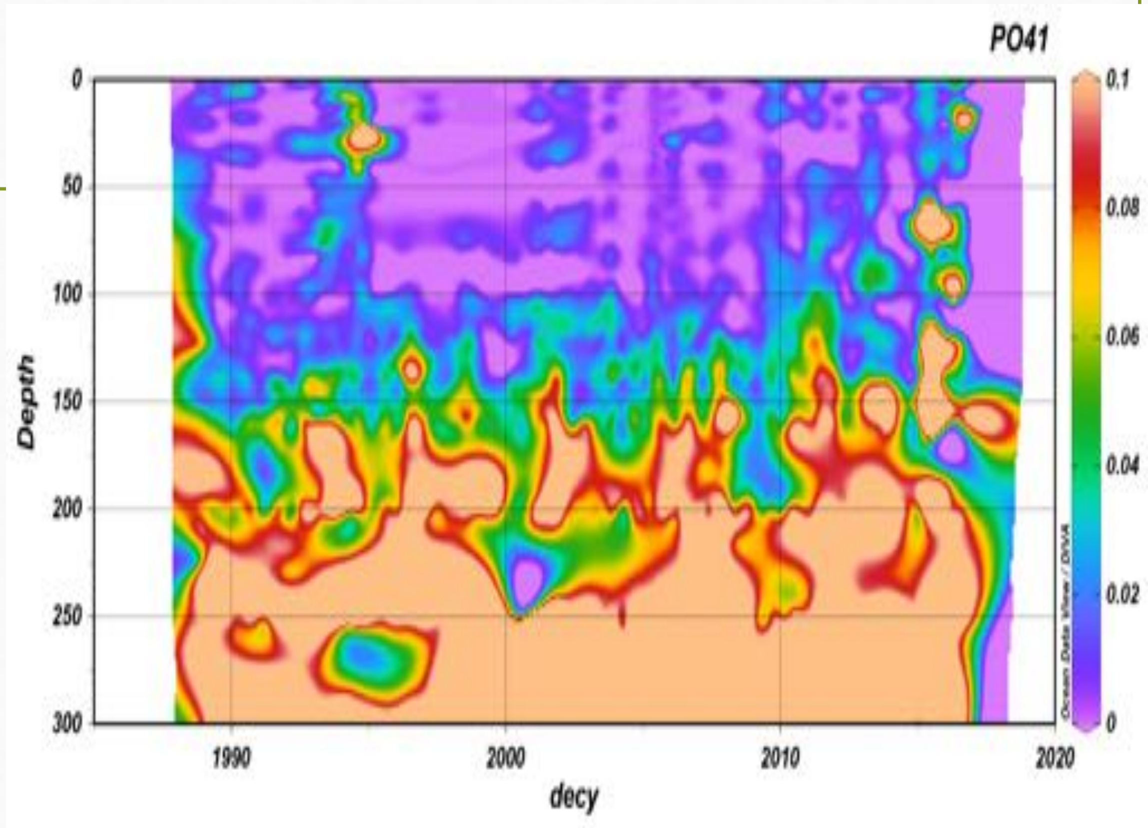


Fig 10: Plot of Nitrite from 1990 – 2017 over a depth transect

CONCLUSION AND RECOMMENDATIONS

There is significant correlation between temperature and bacterial production rates.

Temperature increases with time which confirms effect of global warming in the ocean.

THANK YOU FOR LISTENING