MODIS satellite project: Progress Report

Objectives:

The goal of this study is to analyze MODIS satellite data from July 2002 until July 2011 for the Bay of Ranobe and ascertain seasonal trends as well as overall trends for this time period. I would also like to assess the relationship between the three datasets: chlorophyll a, sea surface temperature, and reflectance at 547 nm. Another point of interest would be to make regional comparisons within the bay and also among other areas along the coast such as the Tulear bay. Ideally I would like to use the analysis of this data as a supplement to the in situ data collected by ReefDoctor and aid in the assessment of the health of Ranobe.

Methods:

The data used in this study is from the MODIS Aqua satellite. The datasets used are chlorophyll a, sea surface temperature, and reflectance at 547 nm. I am using the reflectance data as a proxy for turbidity. The choice of the bandwidth was made after reading literature concerning the subject and consultation with a former research advisor. The data from the MODIS satellites are made available for free to the scientific community on NASA's website http://oceancolor.gsfc.nasa.gov/. The data can be loaded as raw L0 files with the full bandwidths available which can then be processed in high resolution or it can be loaded already processed to the L2 stage. To process L0 files to the L2 stage instrument/radiometric calibration are applied to obtain geophysical variables at the specified resolution. L2 files are a lot smaller as they do not include all the bandwidths available in the raw data files. Unfortunately I had to use the already processed files because the size of the raw files made it impractical for me to process them within my time constraints. This means that the highest resolution possible from the files was 1 km.

I downloaded daily L2 files from the website for a box delimited by the following coordinates: North: -21.0, South: -24.0, East: 44.0, West: 41.0. I then used the SeaDAS software to process the daily data files and produce monthly averages for the area of interest. The finished products were maps showing the monthly average for the entire area of interest and textfiles of the data values for the bay area (W:43.65, S:-23.25, E:43.42, N:-23). I made averages for the entire bay area, as well as separate averages for the northern half and southern half of the bay. The biggest problem that I encountered while doing this was the deletion of pixels because of automatic flags that SeaDAS applies during processing. I went through the flags and decided to only include those that did not eliminate a large percentage of pixels my area of interest. By doing so, the reliability of the data comes into question because many of the pixels in the bay are in shallow water, which may have significantly skewed the data values.

Progress:

From the monthly averages for each dataset I made single data points that are an average for the entire bay. Figure 1 shows the monthly averages of chlorophyll plotted for the entire time span. Though the range for each month is quite variable, the overall monthly means for chlorophyll decrease as the year progresses. The months that show the most variability are during the summer. Chlorophyll concentration peaks during the summer months around February and March, and also has a local maximum at the end of winter during August. The plot also has local minimums at the months of June and November.

Figure 2 shows the monthly sea surface temperature. The data values move from a high during the summer months of December, January, February, at 30°C to a low during the winter months of July and August at 23/24°C.

The seasonal plot for reflectance (Figure 3) shows the lowest point for turbidity to be in March and April. Reflectance increases slowly until December/January. The range during the summer months of the data for different years is large compared to the other months. There are two local minimums at April and October, and two local maximums at August and January.

After plotting the averages for the bay of each of the months I made averages for the entire year and plotted the time series for each of the data sets. The time series for chlorophyll (Figure 4) shows that average chlorophyll concentration has been decreasing over the time period. The sea surface temperature data (Figure 5) shows that the temperature of the bay has been increasing. The scatter plot for turbidity (Figure 6) does not seem to show a real trend for the time period and fluctuates a lot. When plotting chlorophyll concentration against temperature, the resulting graph (Figure 7) suggests that chlorophyll and temperature are inversely correlated. The plot showing chlorophyll concentration as a function of reflectance (Figure 8) suggests strong positive correlation. This would make sense as an influx of sediments and nutrients into the bay would encourage phytoplankton biomass growth. In both instances further statistical analysis needs to be made in order to determine whether or not the results are statistically significant.

The seasonal trends show a very weak correlation between the different datasets which hints at the complexity of the system. When comparing the seasonal trend of chlorophyll and reflectance it appears that there is an almost inverse relationship. This could be accounted for by the fact that when waters are very turbid not enough light filters for the plankton to photosynthesize as well as when the waters are clear. However, it is strange that the seasonal plots suggest an almost inverse relationship between chlorophyll and turbidity and the yearly time series suggests a correlation between the two. It could also be that the chlorophyll and turbidity seasonal plots are reflecting a delay in the response of the system to an increase in nutrients. Indeed, there are two local minimums in the turbidity plot, April and October, and the two local minimums in the chlorophyll plot are June and November. This could suggest that the decrease in turbidity and nutrients could be one of the causes of the decreased chlorophyll concentration of the following months. It remains to be seen what other possible explanations for the shapes of the plots would be, and whether or not it has anything to do with the reliability of the data.

I have also made plots for the northern and southern half of the bay. I divided the bay horizontally along the latitude 23.11 S in order to see if there are any regional differences within the bay. The seasonal plot for chlorophyll (Figure 9) shows that the values for the southern part of the bay are more variable than the northern part. However, the overall shape of the graph is not different from the northern one. It appears transposed to lower values. There are no points of overlap between the two halves, except during the summer months which show the greatest range for data point values. The values for reflectance (Figure 10) are also lower in the southern half than in the northern half with the graph shapes showing great similarity and very small overlap between data points. The plot for SST (Figure 11) again shows very little difference between graph shape. Though this plot shows the southern half of the bay as having higher data values than the northern half, the difference doesn't seem very pronounced as there is a lot of overlap between the two datasets. When looking at the plots for the whole time period (Figures 12, 13, 14), it still appears that the paired datasets are transposed as the variations between the shapes of the graphs are very small. The respective positions of the graphs representing the northern and southern half of the bay vis a vis each other are the same as in the seasonal plots. The chlorophyll concentration and reflectance are higher in the northern half of the bay, and sea surface temperature is higher in the southern half of the bay. This consistency between the seasonal and yearly time series makes sense. It remains to be determined if the difference between chlorophyll amount in the two halves of the bay can be correlated with the turbidity and/or the temperature of the water.

Future analysis:

Plans for future analysis would include determining the reliability of the data used and whether or not applying more filter flags would significantly change the data quality. It would be useful to determine if applying more flags would significantly change the data values for monthly averages.

I would also like to compare the MODIS temperature data to other temperature datasets for the southwest coast of Madagascar and see if they correspond or not. One of the datasets that I would like to use for such a comparison would be the temperature data collected by ReefDoctor. Hopefully by doing so I could assess the reliability and accuracy of the temperature datasets which could allow me to extrapolate the accuracy of the other MODIS datasets as well.

If possible, I would like to take a look the daily variability for the different datasets within the bay area and see how significant it is and whether or not it varies on a seasonal basis.

Another direction of interest could be to process the data for other regions near the bay such as Tulear and see if there are any significant differences between the two. Because of the data's low resolution it may make more sense to perform an analysis of a large portion of the southwest Madagascan coast.

Figures:

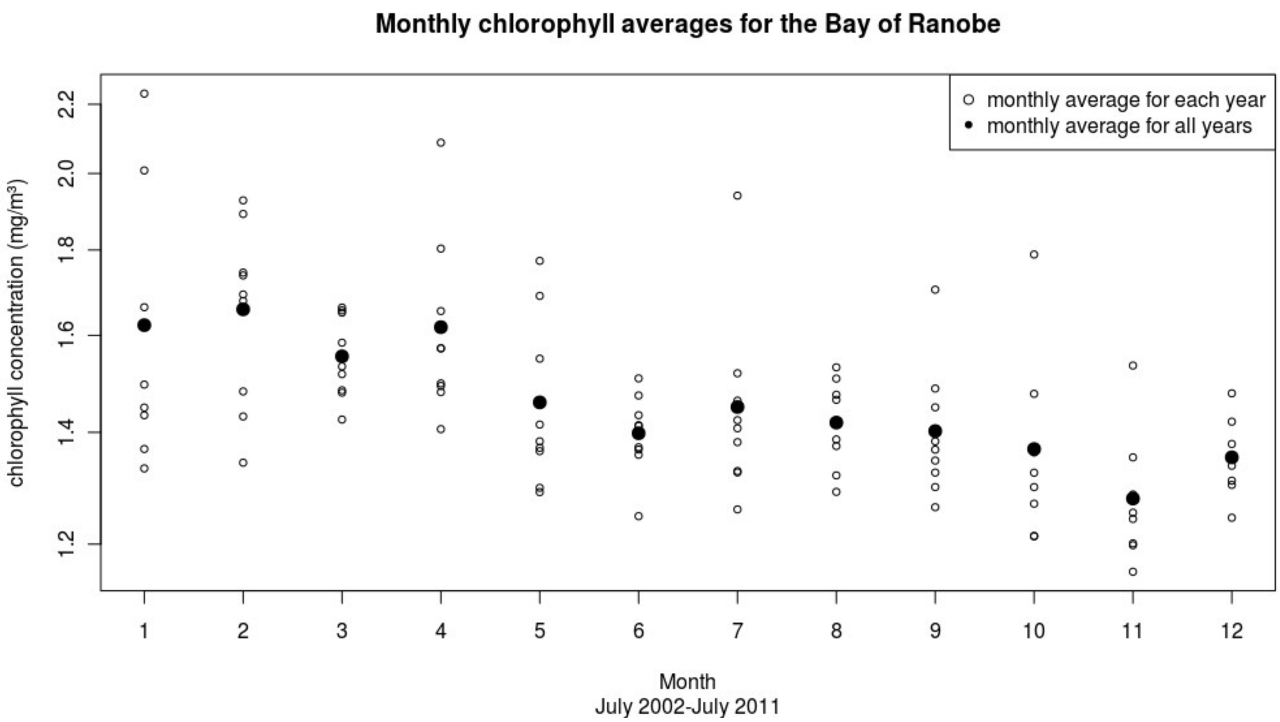


Figure 1

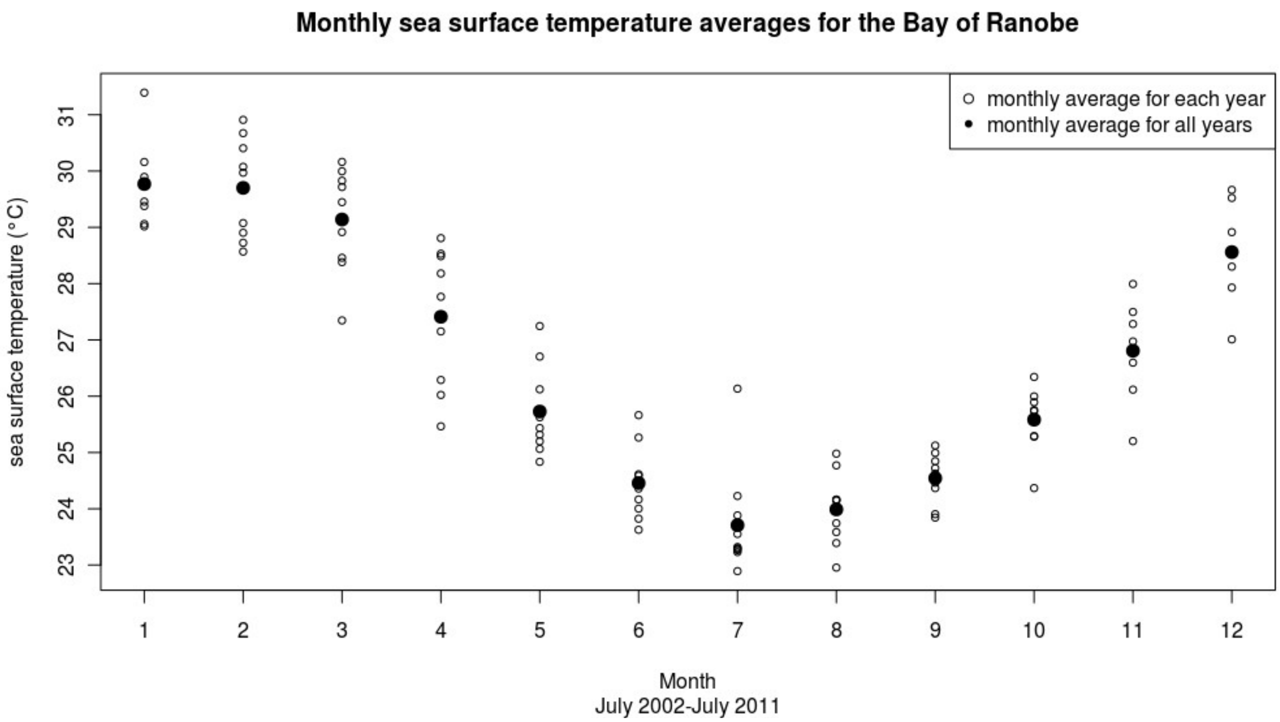
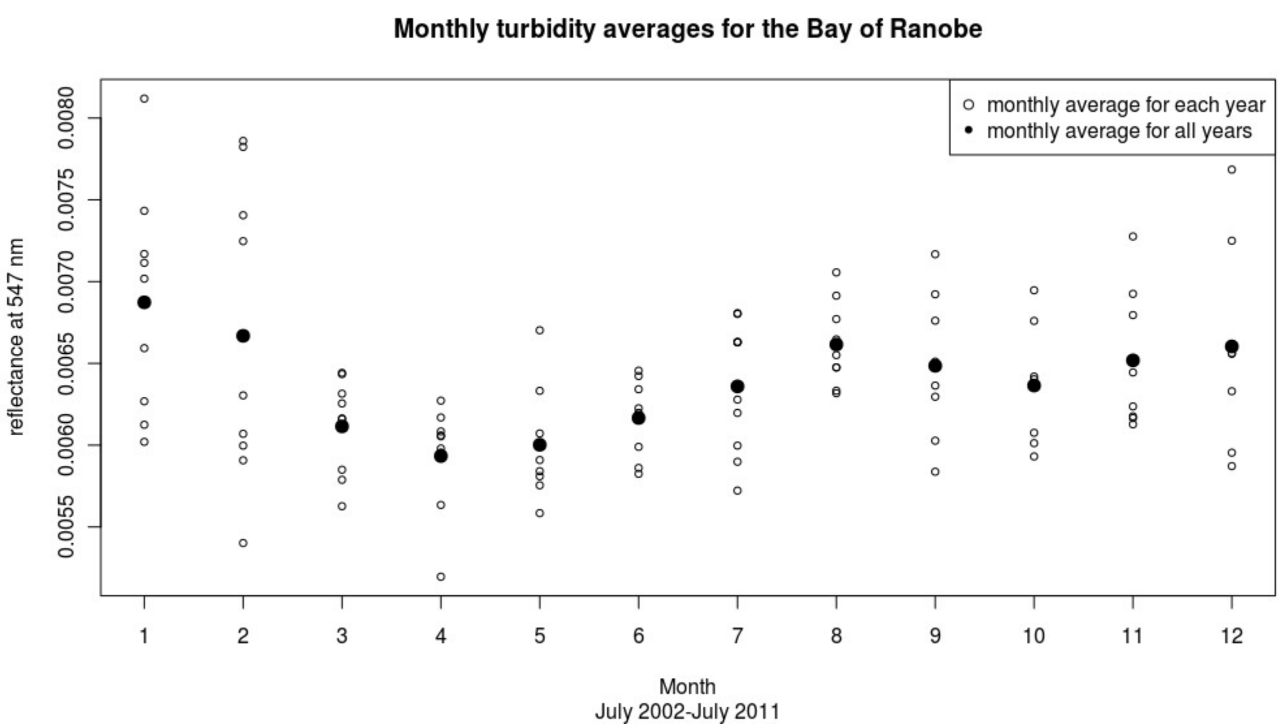


Figure 2



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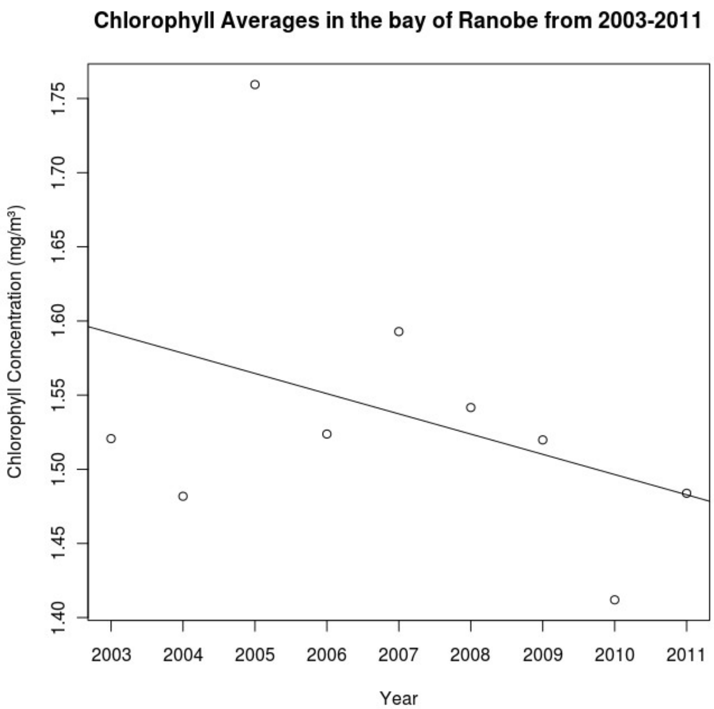

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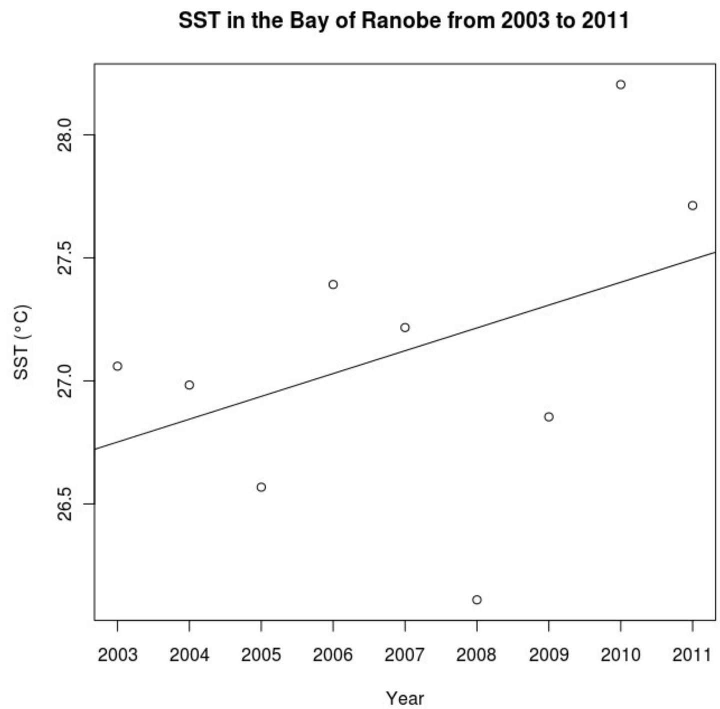


Figure 5

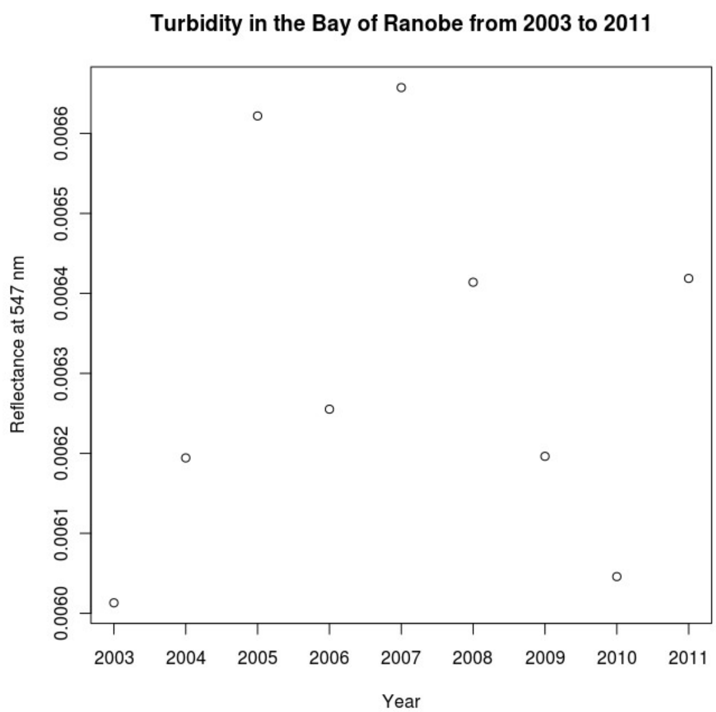
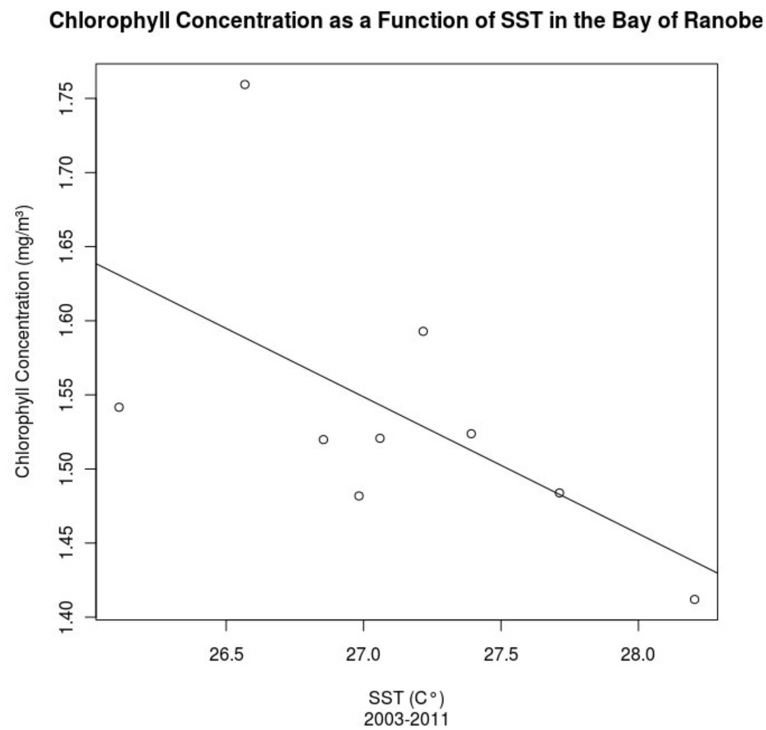


Figure 6



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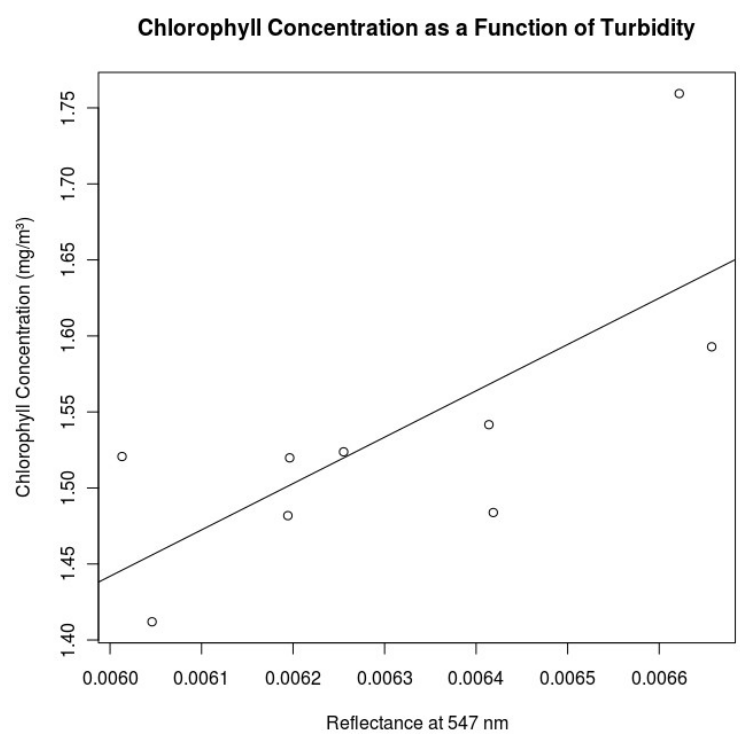


Figure 8

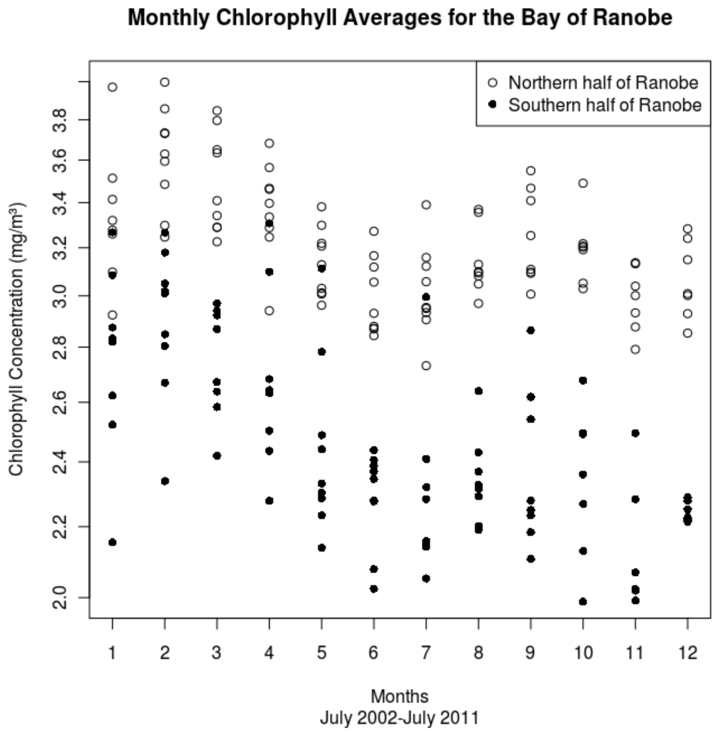


Figure 9

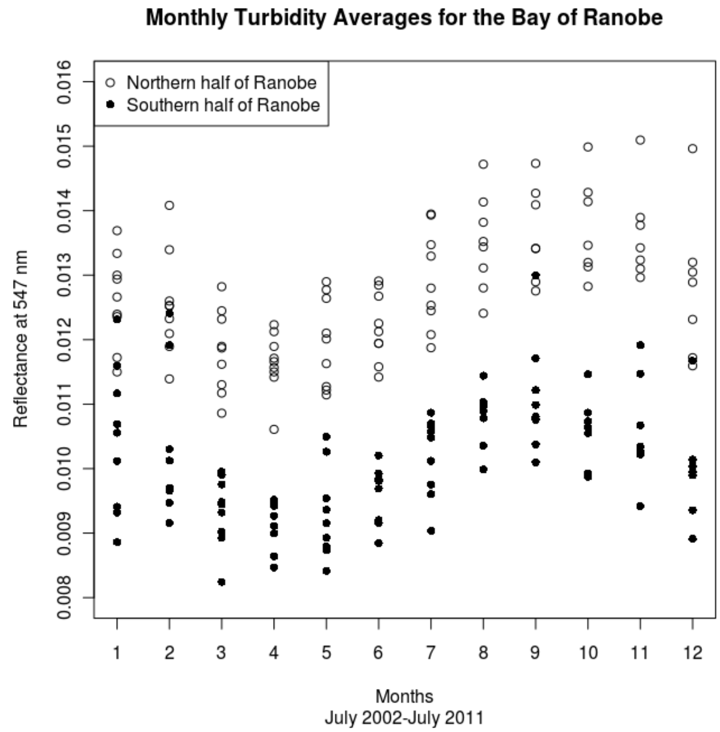
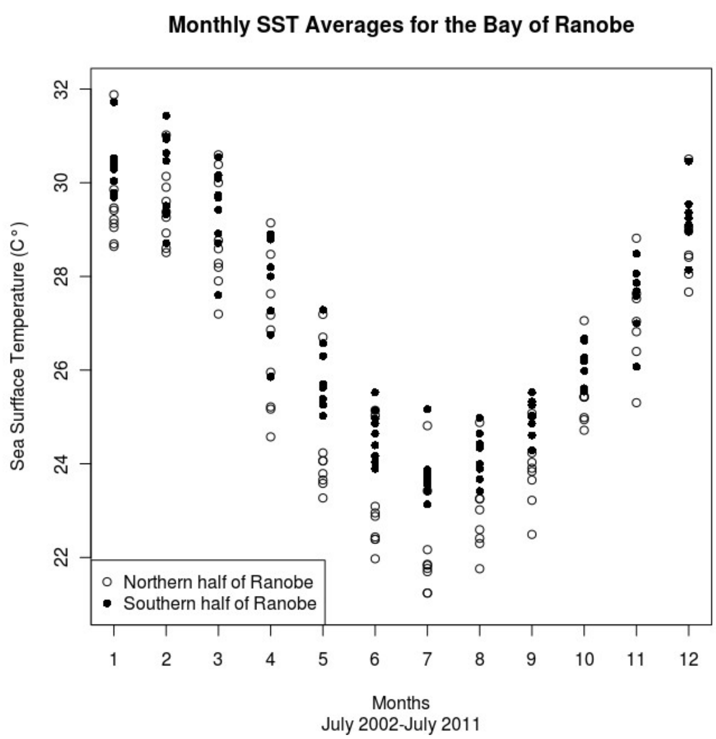


Figure 10



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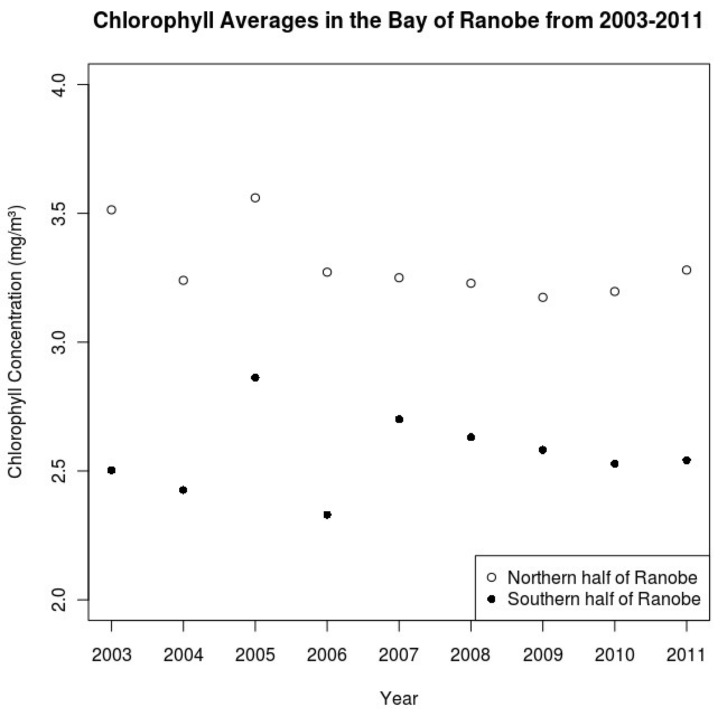

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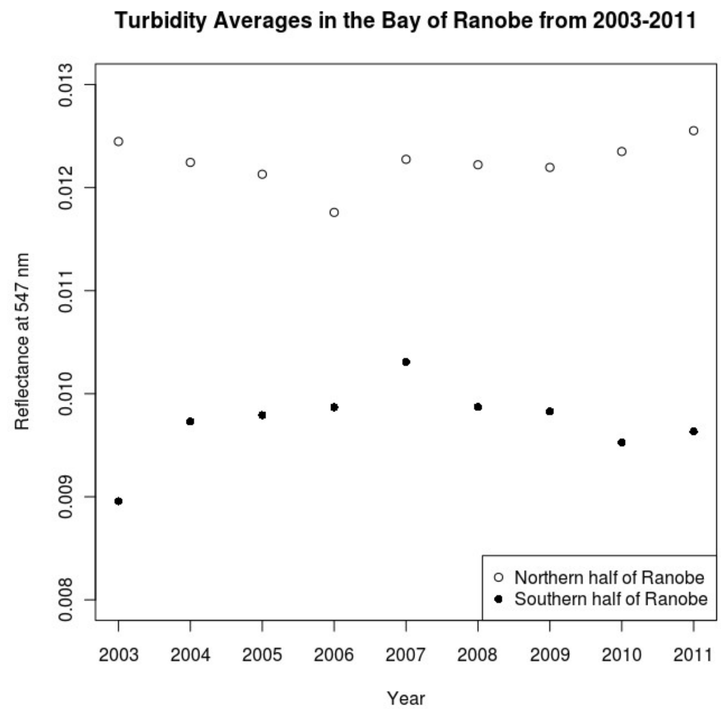

Figure 13

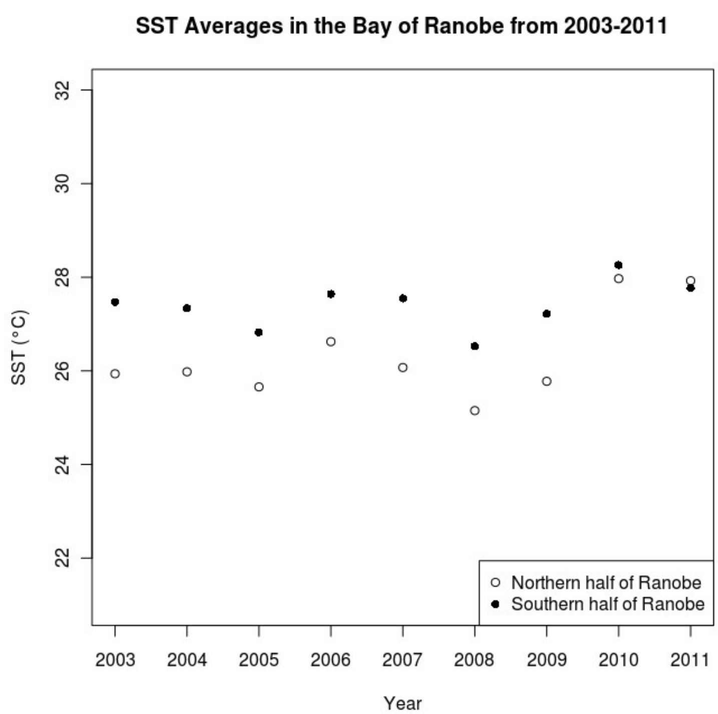

Figure 14