Factors Affecting Primary Productivity Data Exploration Lab

Developed by Jean R. Anastasia

Part 1: Examining Factors That Affect Primary Productivity

Go to the Factors Affecting Primary Productivity- Invention webpage. When the site loads, you will be viewing graphs showing the chlorophyll concentration and the temperature at a site in the Southern Ocean that lies north of Antarctica, to the west of the southernmost tip of South America in the Pacific Ocean.

Practice interacting with the graphs. You can interact with the data by:

- Moving your mouse over the plotted line, as you do this a dot will appear at that point on the line and the actual data plotted (date and chlorophyll level for example) will be listed at the top right of the graph.
- Zooming in and out of the data to look at different time scales that interest you by changing the width of the highlighted section of the small gray graph in between the large graphs (it loads with all of the data highlighted). Click and drag the small bars at each end of the gray graph to accomplish this.
- Selecting a different part of the time series to explore the data in ways that interest you by moving the highlighted section of the small middle gray graph to the right or left.
- Changing the data that is plotted in the bottom graph by selecting a different parameter under the graphs. You can choose to show the plot of water temperature, light, nutrients, or salinity.

Now be sure the graph is set to show the entire dataset by sliding the bars on the gray graph all the way to the edges. Answer the following questions about the graphs:

1. a) What variable appears on the x-axis (horizontal axis)? time/date

   b) What is the range of that variable on this graph? December 4, 2018- October 25, 2019

2. a) Think about where this data was obtained (you can look at the map at the bottom of the webpage under "Background Information"). From which hemisphere is this data collected (Northern or Southern)?

   Southern

   b) Which months are summer? December, January, February

   c) Which months are winter? June, July, August

3. a) Focus on the top graph. What variable appears on the y-axis (the vertical axis)?

   Chlorophyll (ug/L)

   b) Explain why this variable is used to indicate the amount of primary productivity. (Refer to your lecture notes or textbook if needed):

Primary productivity refers to how active primary producers are such as algae/phytoplankton. Algae have chlorophyll so satellites can measure the amount of chlorophyll that is in the water and use this to know how many primary producers there are and how much primary productivity.

NAME Answer Key L

4. Describe how primary productivity changes over time by describing the pattern that you see in the first graph for the time frame shown.

Primary productivity is low in early December but then increases throughout the month and into January. It reaches its peak in mid January and then begins to decline to low levels by early February and stays at those low levels for the rest of the time.

5. On what specific date does the primary productivity peak? (Remember you can move your mouse over the line to view specific dates shown on the top right of the graph)

January 18, 2019

6. What factors do you think will have the greatest effect on primary productivity? (Refer to the lecture notes and textbook if needed)

Primary producers need light to photosynthesize and nutrients to grow so I think those two factors will have the greatest effect on primary productivity levels,

7. a) Now examine the different parameters that you can select on the bottom graph. Start by leaving "Water Temperature" selected. What is the range of temperatures shown on the graph (be sure to give units too)?

5 - 8 degrees Celsius

b) Convert those temperatures to Fahrenheit by using the formula (__ºC x 9/5) + 32 = __ºF
Give the temperature range of the data on the graph in degrees Fahrenheit:

41 - 46.4 degrees Celsius

c) During which month does the water temperature reach its maximum at this location?

March

d) Does the peak of phytoplankton production correspond to the warmest temperature?

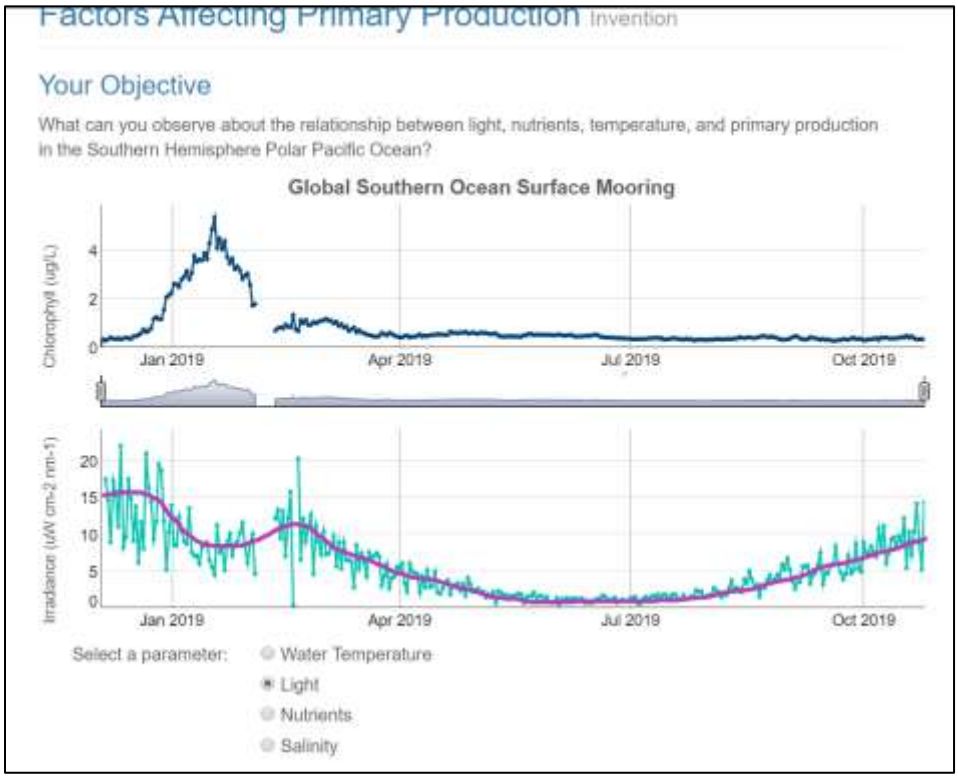
No, phytoplankton peak earlier

e) Now put all of this information together and compare the patterns of primary productivity and temperature. Summarize and explain any relationships that you see:

Phytoplankton peak in January before the temperature is the warmest and they actually decline as temperature is still rising. Temperature doos not seem to affect primary productivity

NAME Answer Key

8. Now select the parameter "Light" on the bottom graph. There is a great deal of variation in light levels as cloud cover and other factors can affect the amount of sunlight on any given day. Focus on large scale trends instead of day to day variations in the graph. For examples, on the picture below I drew a purple line that represents approximate average light levels over longer time periods and smooths out the daily variations.



a) Over which month are light levels the highest in general? December

b) Is primary productivity increasing or decreasing during the month when light levels are highest?

increasing

c) What happens to light levels during the peak of primary productivity? Do they increase or decrease? decrease

d) Remember that phytoplankton are the main primary producers and that high primary productivity (chlorophyll levels) indicates a large amount of phytoplankton in the water. Explain how and why having a large amount of phytoplankton in the water would affect light levels.

When there are high amounts of phytoplankton in the water, they actually make the water less transparent since all of the cells block the light and color the water. Therefore less light can get through the water when there is a high number of phytoplankters in the water. So light levels decrease during a bloom of phytoplankton.

NAME Answer Key

c) Now put all of this information together and compare the patterns of primary productivity and light levels. Summarize and explain any relationships that you see:

Increasing light levels in the summertime lead to increasing primary productivity in the water and a bloom of phytoplankton. Once there is a lot of phytoplankton in the water, they block the light and light levels go down. Light levels decrease after the bloom is over as this part of the world heads into their winter

9. a) Now select the parameter "Nutrients" on the bottom graph. What is the variable plotted on the y-axis (vertical axis)?

Nitrate (uMol/L)

Aside from nitrogen (nitrate is one form of nitrogen), what other nutrients do primary producers need (refer to the lecture notes or text if needed):

phosphorous, potassium, iron, silica

b) Over which months or season are nutrient levels the highest in general? Fall, Sept & Oct

c) Do nutrient levels increase or decrease during the peak in primary productivity? decrease

Explain why. Primary productivity is high when there are a large amount of primary producers in the water and these producers need nutrients to grow. As the phytoplankton grow during the peak in primary productivity, they use up the nutrients and nutrient level decrease.

e) Now put all of this information together and compare the patterns of primary productivity and nutrient levels. Summarize and explain any relationships that you see:

Nutrient levels are naturally high in high latitudes (polar regions) because there is no thermocline and no layering of the water column so nutrients can easily mix up from the bottom. When the primary productivity peaks in January, the growth of all that phytoplankton causes a decrease in nutrient levels. Once the bloom of phytoplankton is over (primary productivity decreases), nutrient levels increase again.

10. Synthesize your overall observations by explaining which factors lead to the pattern of primary productivity shown:

Light and Nutrient levels are the main factors. Nutrient levels are naturally high in high latitudes (polar regions) because there is no thermocline and no layering of the water column so nutrients can easily mix up from the bottom. Light levels are low in high latitudes throughout the winter (June, July and August) but increase through the fall and peak in December. This increase in light triggers the growth of phytoplankton and causes primary productivity to increase and peak in January. The peak of primary productivity means there are a lot phytoplankton in the water and this blocks the light and light levels decrease. The growth of phytoplankton during the peak in primary productivity also uses up the nutrients in the water so nutrient levels decrease. The depletion of nutrients along with the decreasing light levels as summer ends, causes the phytoplankton growth to slow and ends the peak in primary productivity.

NAME Answer Key

Part 2: Predicting Factors That Affect Primary Productivity

Go to the Factors Affecting Primary Productivity- Application webpage. When the site loads, at the top of the page where it says Variable 1 – Light, you will be viewing graphs showing the chlorophyll concentration and the light levels at a site in the Southern Ocean that lies north of Antarctica, to the west of the southernmost tip of South America in the Pacific Ocean.

Answer the following questions about the graphs:

1. a) What range of dates are shown on the x-axis (give months and years)?

   December 14, 2015- October 25, 2019

   b) How does that compare to the graphs in Part 1 of this lab (refer to Question 1b from Part 1)?

   This is a much longer time scale, Part 1 only sho

2. The top graph shows the pattern of primary productivity for a three-and-a-half-year period, but the bottom graph only shows the light availability for the last several months of that time frame. Based on what you learned about light level patterns and their relationship to patterns of primary productivity in Part 1 of this lab, you are to predict what the light levels would be for the missing part of the graph (from December 2015- December 2018). On the bottom graph, use your mouse to draw your prediction for what the rest of the light level (Irradiance) dataset should look like. After you have made your estimate, click the "Check Prediction" box to see the actual observed data. Take a screen shot of the graph with your drawn prediction shown and paste it into a word file that has your name at the top.

3. Scroll down the page to "Variable 2- Nutrients". Once again, the top graph shows the pattern of primary productivity for a three-and-a-half-year period, but the bottom graph only shows the nutrient levels for the last several months of that time frame. Based on what you learned about nutrient level patterns and their relationship to patterns of primary productivity in Part 1 of this lab, you are to predict what the nutrient levels would be for the missing part of the graph (from December 2015- December 2018). On the bottom graph, use your mouse to draw your prediction for what the rest of the Nitrate dataset should look like. After you have made your estimate, click the "Check Prediction" box to see the actual observed data. Take a screen shot of the graph with your drawn prediction shown and paste it into the same Word file that you pasted your light level prediction graph in. Save the file and submit it with this completed worksheet.

Unfortunately, due to an instrument issue, we do not have a complete record of nitrate data for this location. However, based on what you can see from the relationship between chlorophyll and nitrate for the periods where we do have data, explain your reasoning for your prediction?

Nutrients should be generally high in this part of the world due to the ease of vertical mixing of nutrients since there is no thermocline and no layering of the ocean here. Each peak in primary productivity that happens in January will result in a decrease in nutrient levels as the growth of phytoplankton uses up the nutrients in the water. Nutrient levels will increase again after the end of each peak in primary productivity