HIGH TO LOW:
EXPLORING ESTUARINE GRADIENTS

Cristin Wright
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Grade Level
High School

Subject Area
Biology, Environmental Science, Oceanography

The 2020-21 VA SEA project was made possible through funding from the National Estuarine Research Reserve System Margaret Davidson Fellowship Program which supports graduate students in partnership with research reserves where fieldwork, research, and community engagement come together. VA SEA is currently supported by the Chesapeake Bay National Estuarine Research Reserve, Virginia Sea Grant, and the Virginia Institute of Marine Science Marine Advisory Program.

Title: High to Low: Exploring Estuarine Gradients

Focus: Nutrient, suspended sediment, and phytoplankton levels are measured within an estuary and relationships between them are discussed. Scientists will then plot, both by hand and computer, their results.

Grade Level: High School Biology, Earth Science, and Oceanography

VA Standards of Learning:

Part 1 and 2:

ES.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which:

- Data are organized, communicated through graphical representation, interpreted, and used to make predictions
- Patterns are identified in data and are interpreted and evaluated

ES.8 The student will investigate and understand how freshwater resources are influenced by geologic processes and the activities of humans. Key concepts include:

- identification of sources of fresh water including rivers, springs, and aquifers, with reference to the hydrologic cycle;
- dependence on freshwater resources and the effects of human usage on water quality

ES.10 The student will investigate and understand that oceans are complex, interactive physical, chemical, and biological systems and are subject to long- and short-term variations. Key concepts include

a) physical and chemical changes related to tides, waves, currents, sea level and ice cap variations, upwelling, and salinity variations;
b) importance of environmental and geologic implications;
c) systems interactions;

BIO.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which

- graphing and arithmetic calculations are used as tools in data analysis
- conclusions are formed based on recorded quantitative and qualitative data

BIO.8 The students will investigate and understand dynamic equilibria within populations, communities, and ecosystems. Key concepts include:

- interactions within and among populations including carrying capacities, limiting factors, and growth curves
- nutrient cycling with energy flow through ecosystems
- succession patterns in ecosystems
- the effects of natural events and human activities on ecosystems

A.8 The student, given a data set or practical situation, will analyze a relation to determine whether a direct or inverse variation exists, and represent a direct variation algebraically and graphically and an inverse variation algebraically.

Addition of Part 3 (optional):

PRG.2 The student will create programs that model the relationships among different elements in collections of real-world data.
PRG.4 The student will design and implement a program working individually and in teams using a text-based language.

Learning Objectives:

- Student will analyze collected data from multiple sampling locations and learn about the gradients found in nature
- Students will investigate different biological, chemical, and physical gradients present in estuaries and how they interact with one another.
- Students will collect data and plot line graphs of individual parameters and practice using multiple axis plots.
- (Part 3 - Optional) Students will work with an online programming interface to create digital figures.

Time Required:

This lesson plan should take 60 minutes (without optional Part 3).
This lesson plan should take 120 minutes (with optional Part 3).

Vocabulary

Estuary, head, mouth, gradient, salinity, suspended sediment concentration, nutrient concentration, phytoplankton concentration, terrestrial runoff

Background information

An **estuary** is a coastal body of water where fresh, river water mixes with salty, ocean water. The **head** of the estuary refers to the end of the estuary with freshwater input and the **mouth** of the estuary is the part that is open to the ocean. **Salinity** is the measurement of how much salt is in the water. This is usually measured in parts per thousand (PPT). Throughout the estuary, there is a salinity **gradient.** This means that at the head of the estuary, there is very low salinity and as you travel down the estuary toward the mouth, the salinity increases. There are other gradients that can be found within an estuary. The ones that we will explore during this exercise include suspended sediment concentration, nutrient concentration, and phytoplankton concentration.

Suspended sediment concentration: Suspended sediment refers to the very small pieces of sediment that are suspended within the water column. Some of these particles are large enough to settle to the estuary bottom over time, however some particles are so small, that they are trapped in suspension. Suspended sediment concentration is the measurement of the mass of sediment in a volume of water, usually measured in milligrams per liter. Suspended sediment concentrations tend to be higher in the head of the estuary from **terrestrial runoff**, which is rain water that drains from the land into the river. As the water flows through the estuary, some sediment particles are able to settle out resulting in lower suspended sediment concentrations at the mouth of the estuary. Sediment can also be introduced into the water through erosion from the shoreline or riverbed during times of fast water flow.

Nutrient concentration: Nutrient concentration is the measurement of the nutrients in a volume of water. Nutrients are also introduced into the estuary, in part, from terrestrial runoff. This can be from both agricultural means, in the way of manure and fertilizer, and commercial means, such as industrial wastewater. Nutrients can also enter the estuary from the atmosphere. An example of this is dissolved nitrous oxide from vehicle emissions. There tends to be higher nutrient concentrations (nitrogen and phosphorus) in the head of the estuary where the terrestrial runoff enters the river. These nutrients get used up by primary producers along the estuary, resulting in lower concentrations at the mouth of the estuary.

Phytoplankton concentration: This is the measurement of the number of phytoplankton in a volume of water. In an estuarine system, phytoplankton are the base of many food webs and are critically important in producing dissolved oxygen in the water. As you learned in biology, phytoplankton perform photosynthesis. In order to perform photosynthesis, the phytoplankton need plenty of nutrients and sunlight. In this study, you will learn how suspended sediment and nutrient gradients in an estuary can impact phytoplankton.

Associated Documents:

a. Student Worksheet – Part 1 and 2 (Appendix A.)
b. Student Worksheet – Part 1 and 2: Answer Key (Appendix B.)
c. Student Worksheet – Part 3 (Appendix C., optional)
d. Student Worksheet – Part 3: Answer Key (Appendix D., optional)
    - Includes all coding text needed for Part 3.

Associated Powerpoints:

a. Introduction Powerpoint
b. Sampling Powerpoint (Send to students)

Material and Supplies:

- Instructor computer and projector for Introduction Powerpoint
- Pencil/pen
- Colored pencils
- Ruler
- Student computer for online coding portion (Part 3, optional)

Classroom Prep (Virtual or In-Person Instruction)

- Students will be broken up into groups of 2-3.
- Each group will need at least one computer. If you're only completing Part 1 and 2, one computer for the group will suffice. If choosing to include Part 3, students will all need their own computer.
- Prior to class, the Sampling Powerpoint should be emailed or shared with each student so they can view it in their respective groups.
- The teacher should have the Introduction Powerpoint projected for a short lecture to begin the lesson.

Procedure:

Introduction:

- Show the Introduction Powerpoint. Dialogue for each slide is in the comment section.
  -If you'd like, you can also open the Sampling Powerpoint as a demo.

Part 1 and 2: Data Collection and Data Visualization

- Students will be put into groups of 2-3. Each student will receive the Student Worksheet Part 1 and 2 (Appendix A) to record data.
- The group will open the Sampling Powerpoint on their computer and play the Powerpoint. Slides 2-4 (also included in the Introduction Powerpoint) remind students how to take measurements for suspended sediment concentration, nutrient concentration, and phytoplankton concentration.
- Slide 5 includes a map of the Clark Estuary and the location for each sampling site. Students will click on each site one by one.
- For each site, students will record values for suspended sediment concentration, nutrient concentration, and phytoplankton concentration in the table on the Student Worksheet (Appendix A).
- From the individual site slides, students can return to the map by clicking the "Click to go back to site map" in the upper right corner.
- Once students have recorded data for all eight sites, they will plot the gradients for each of the parameters collected on the Student Worksheet (Appendix A).
- They will then try to plot all three parameters on the multiple axis plot. The instructor will have described how these work in the Introduction Powerpoint.
- After the students have completed the graphs, they will answer questions pertaining to the activity. I will also provide them with a "Mystery Sample" and they will have to determine where they think that sample was taken in the estuary.

Part 3: Coding using R online platform (optional)

- Students will need their individual laptops.
- They will visit https://rdrr.io/snippets/
- The students will walk through how to input their data into the program and create a figure showing the salinity gradient along the estuary. They will then try to make figures for suspended sediment, nutrients, and phytoplankton. If students are struggling with this part, all the code to make all figures is included in Appendix D.
- It is up to the teacher to decide if you want students to copy and paste their digital figures and turn them in, or if the students will just compare them to their hand-drawn figures.

References:

Friedrichs, C. T. (2009). York River Physical Oceanography and Sediment Transport. *Journal of Coastal Research*, *SI*(57), 17–22.

McLusky, D. S., & Elliott, M. (2004). *The Estuarine Ecosystem: Ecology, Threats, and Management* (3rd ed.). Oxford University Press.

National Estuarine Experts Workgroup. (2010, October). *Nutrients in Estuaries*. https://www.epa.gov/sites/production/files/documents/nutrients-in-estuaries-november-2010.pdf

Olausson, E., & Cato, I. (Eds.). (1980). *Chemistry and Biogeochemistry of Estuaries*. John Wiley & Sons.

Reay, W. G. (2009). Water Quality within the York River Estuary. *Journal of Coastal Research*, *SI*(51), 23–39.
U.S. Department of the Interior & U.S. Geological Survey. (2015, June). *Understanding Nutrients in the Chesapeake Bay Watershed and Implication for Management and Restoration - the Eastern Shore* (Circular 1406). https://pubs.usgs.gov/circ/1406/pdf/circ1406.pdf

APPENDIX A

Name: Date:

From High to Low: Understanding Estuarine Gradients

Part 1. Data Collection

1a. Open the Powerpoint provided by your instructor on your laptop. Play the Powerpoint from the beginning. Slides 2-4 are a reminder how to collect data for suspended sediment concentration, nutrient concentration, and phytoplankton concentration.

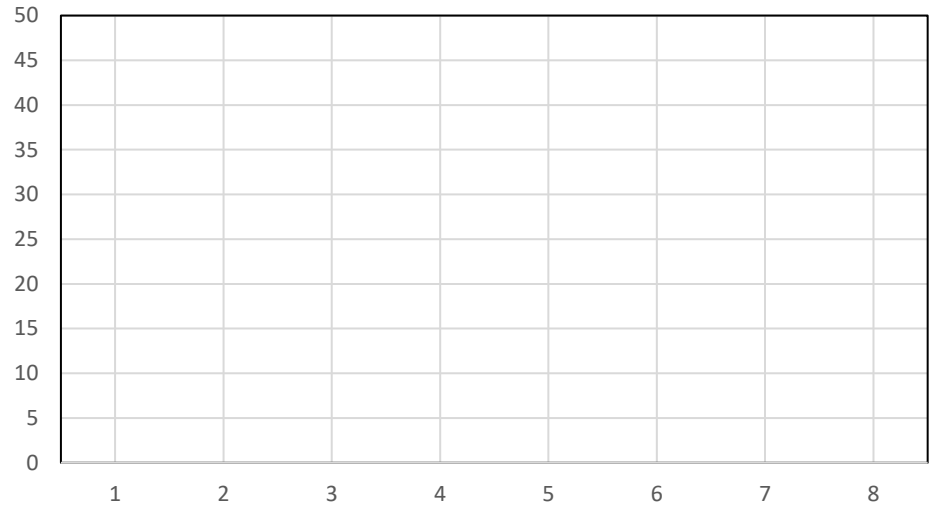
1b. Slide 5 shows the estuary map. Click on each sampling station one-by-one and record data for all parameters in Table 1 below. To return to the map, click "Click to go back to site map" in the upper right corner.

Site Number	Salinity (PPT)	Suspended Sediment Concentration (mg/L)	Nutrient Concentration (mg/L)	Phytoplankton Concentration (cells/L)
1				
2				
3				
4				
5				
6				
7				
8				

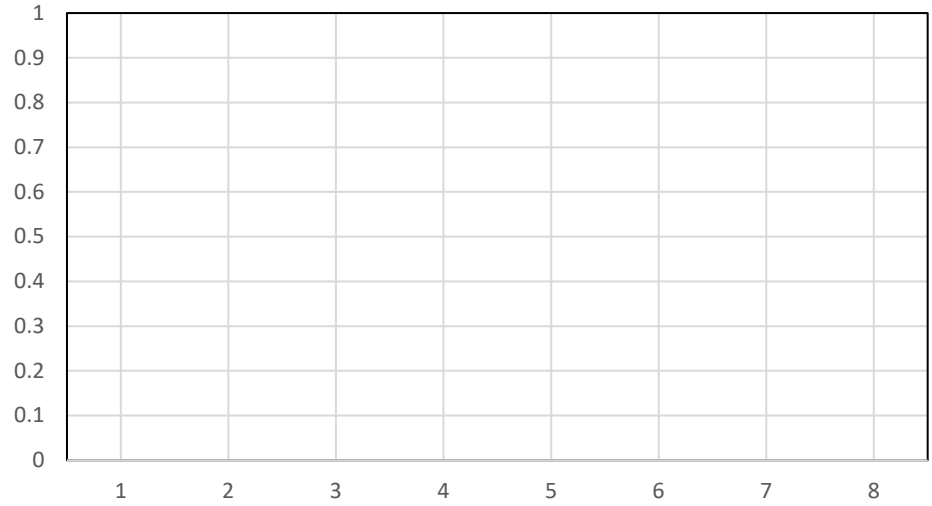
Part 2. Data Visualization

2a. In the spaces provided, draw a line graph for each parameter collected. The site number will be on the x-axis for each figure. Be sure to include axis labels and units.

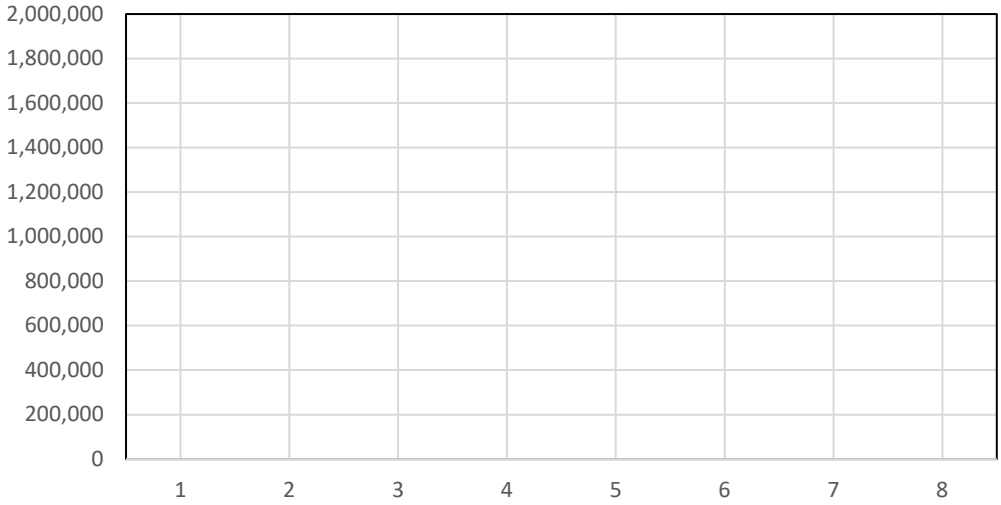
Suspended Sediment Concentration – Plot in blue



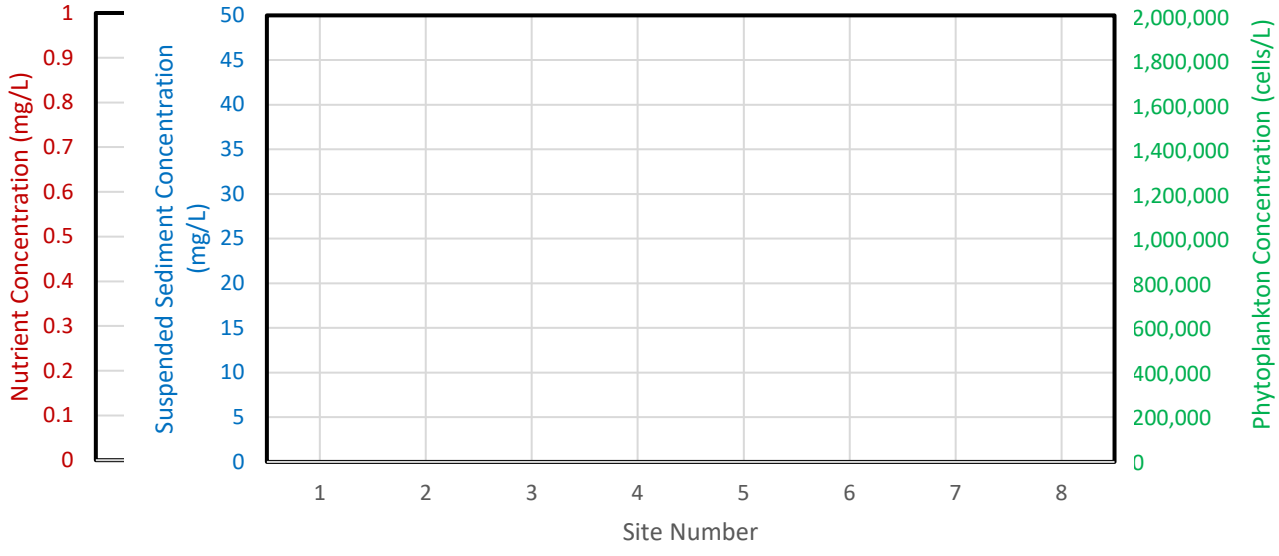
Nutrient Concentration – Plot in red



Phytoplankton Concentration- Plot in green



2b. Now, use a multi y-axis plot below to plot all three parameters (Suspended Sediment Concentration, Nutrient Concentration, and Phytoplankton Concentration) on one plot. A ruler may be helpful in lining up axis.



2c. From earlier, you learned that both suspended sediment concentration and nutrient concentration are higher at the head of the estuary and lower at the mouth of the estuary. Did you observe these patterns in your sampling? What pattern did you observe for phytoplankton concentration?

2d. What happens to each parameter between Site 3 and Site 4?

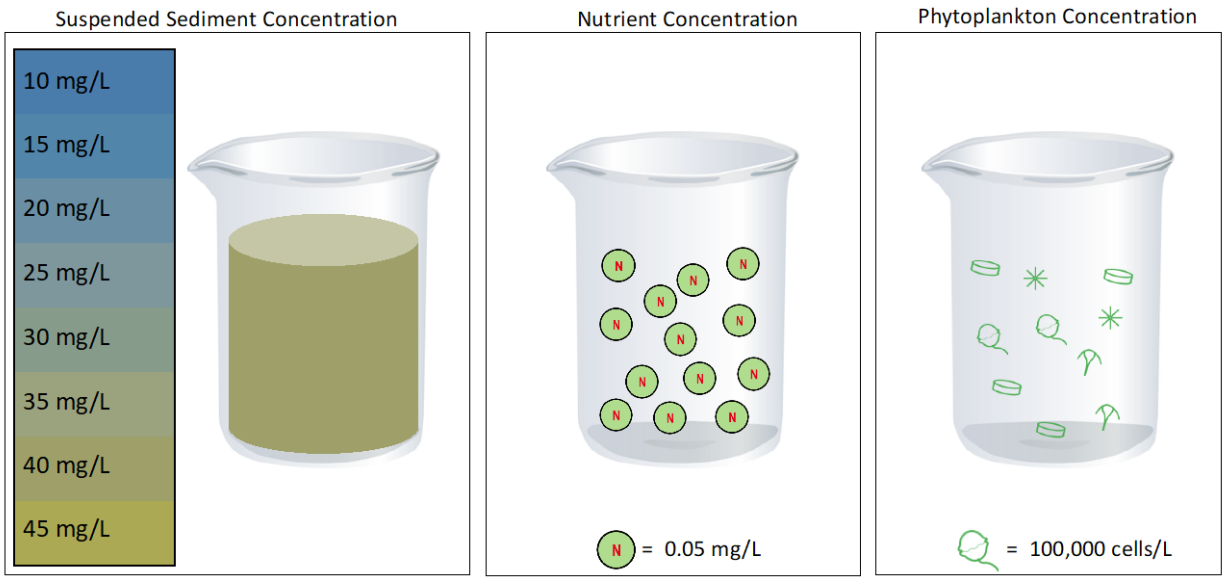
2e. Recall that high suspended sediment concentration impacts the amount of light available in the water column. With this knowledge, why do you think you see low values of phytoplankton where there are very high nutrients?

2f. At the mouth of the estuary, there seems to be low amount of phytoplankton, even though the water has a low suspended sediment concentration and there is plenty of light available for photosynthesis. Why do you think this is?

2g. Recall from earlier that sediment and nutrients can both be introduced through terrestrial run off. If there were a large rain storm, would you expect this peak of phytoplankton to move towards the head of the estuary or the mouth of the estuary? Why?

2h. There was a large input of nutrients into the head of the estuary from a wastewater treatment plant creating very high nutrient concentrations. This happened during a time of little rainfall (i.e. very little suspended sediment throughout the estuary). Describe what would you expect the phytoplankton concentration gradient to look like?

2i. A community member brought you a water sample from the estuary to analyze, but cannot remember where they collected it from. Collect data for each parameter and report between which two sites you think the sample came from.



Suspended Sediment Concentration _____

Nutrient Concentration_____

Phytoplankton Concentration _____

This sample was taken between Sites ___ and ____.

Appendix C
Name: Date:

From High to Low: Understanding Estuarine Gradients

Part 3. Coding

In Part 2, you plotted the data you collected by hand. Now, you will plot the data using an online coding program.

3a. Open https://rdrr.io/snippets/ and delete all text in the textbox.

3b. The directions below will show you how to create a plot for salinity using the online program. You will then try to create plots for other parameters.

3c. You are going to create arrays, or a lists of numbers, with the data that you collected. An array looks like this:

[1 2 3 4 5 6 7 8]

3d. In your plots above, the data on the x-axis is the site number. This will be the first array we will create and we will name it "site". Type in the following into the text box:

```
site = c(1, 2, 3, 4, 5, 6, 7, 8)
```

- Name of your data array
- "c" creates the list of numbers into array
- List of numbers in array separated by commas (spaces optional)

3e. Now that you created your list for the site values, we will create a list for the salinity values. (It is important to enter in the salinity values in order of site number, or else your data will not plot properly.) Type in:

```
salinity = c(0.5, 2, 5, 9, 12, 18, 20, 26)
```

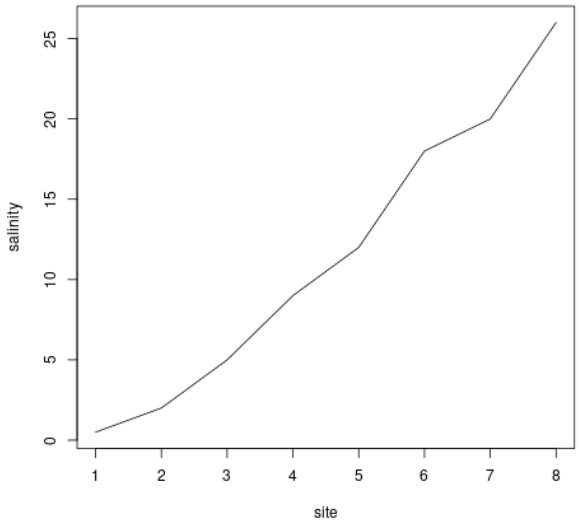
- Name of your data array
- "c" creates the list of numbers into array
- List of numbers in array separated by commas (spaces optional)

3f. Now that we have created both arrays, we are ready to plot the salinity data from all sample sites. Coding is case sensitive, so make sure there are no capitals within your code. Type in:

```
plot(site, salinity, type = 'l')
```

- Command to plot data
- Data you want on the x-axis
- Data you want on the y-axis
- Command to tell the program to plot your data with a line (this is a lower-case L, not a 1)

3g. Once you have typed in all three parts, you can click the green "Run" button! A plot of salinity should pop up on the screen, similar to the one on the right.



3h. Although the figure does include axis labels, there are ways to make your figure more informational, like adding units, a title, or changing the color of the line.

3i. To make your figure better, we are going to add some information to the `plot` line of code. Edit the line to read:

```
plot(site, salinity, type = 'l', col = 'orange', xlab = 'Site Number',
ylab = 'Salinity (PPT)', main = 'Salinity Gradient')
```

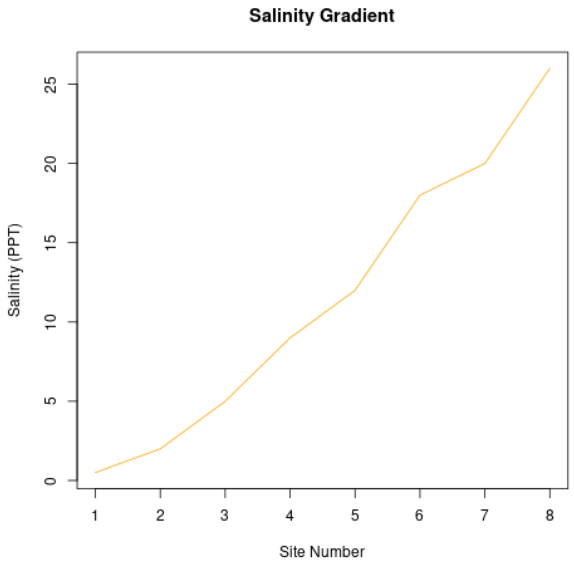
Color of line in single quotes

X-axis label in single quotes

Y-axis label in single quotes

Figure title in single quotes

3j. Now that you have successfully created a figure for the salinity gradient (it should look like the image to the right), you will now make figures for the suspended sediment concentration, nutrient concentration, and phytoplankton concentration in the colors specified in Part 2a.



If you're having errors when you hit the green 'Run' button, be sure to check all spelling and lettering. Another common mistake is forgetting commas between commands within the parenthesis.

If you are struggling with re-creating your plots, you may ask your teacher for the code for each parameter.

APPENDIX B

Name: ANSWER KEY Date:

From High to Low: Understanding Estuarine Gradients

Part 1. Data Collection

1a. Open the Powerpoint provided by your instructor on your laptop. Play the Powerpoint from the beginning. Slides 2-4 are a reminder how to collect data for suspended sediment concentration, nutrient concentration, and phytoplankton concentration.

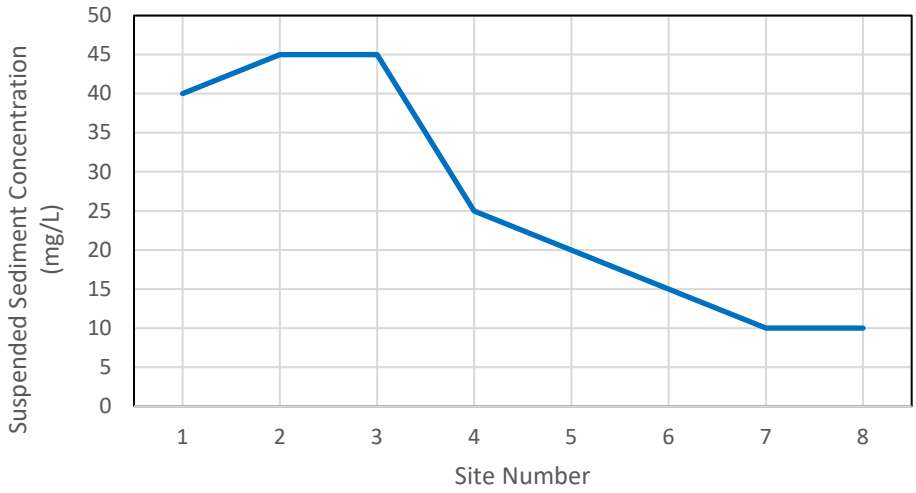
1b. Slide 5 shows the estuary map. Click on each sampling station one-by-one and record data for all parameters in Table 1 below. To return to the map, click "Click to go back to site map" in the upper right corner.

Site Number	Salinity (PPT)	Suspended Sediment Concentration (mg/L)	Nutrient Concentration (mg/L)	Phytoplankton Concentration (cells/L)
1	0.5	40	0.8	500,000
2	2	45	0.75	600,000
3	5	45	0.75	800,000
4	9	25	0.4	1,700,000
5	12	20	0.2	1,100,000
6	18	15	0.15	800,000
7	20	10	0.1	700,000
8	26	10	0.05	500,000

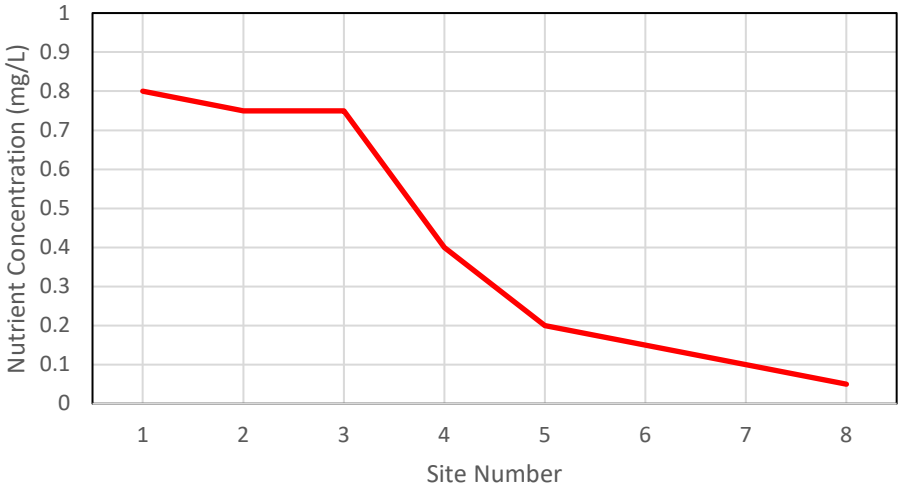
Part 2. Data Visualization

2a. In the spaces provided, draw a line graph for each parameter collected. The site number will be on the x-axis for each figure. Be sure to include axis labels and units.

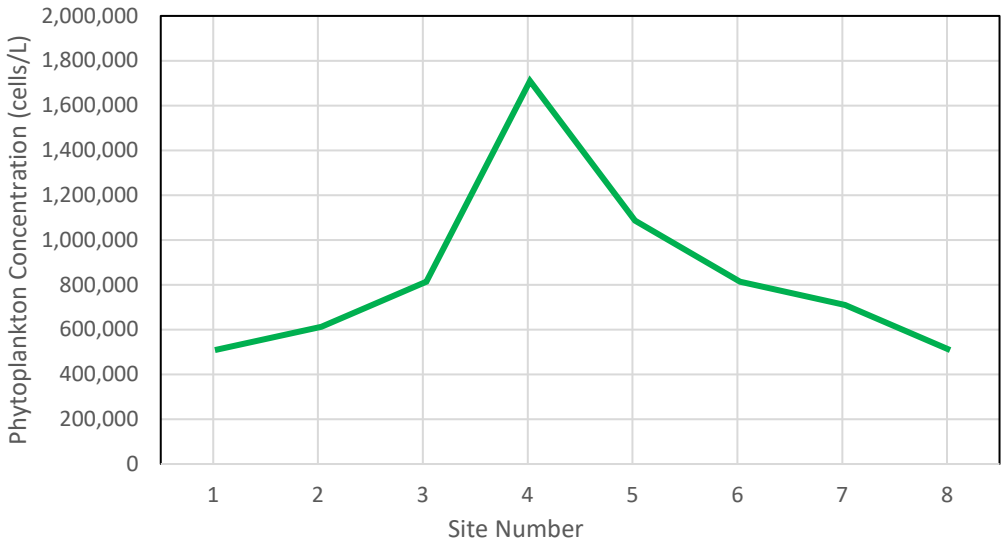
Suspended Sediment Concentration – Plot in blue



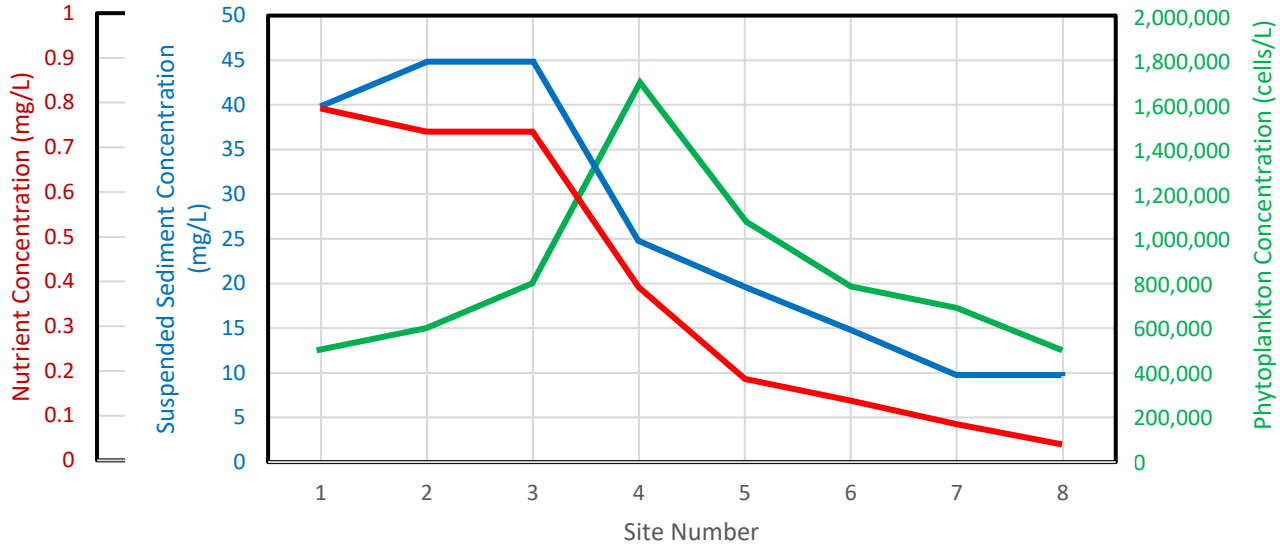
Nutrient Concentration – Plot in red



Phytoplankton Concentration- Plot in green



2b. Now, use a multi y-axis plot below to plot all three parameters (Suspended Sediment Concentration, Nutrient Concentration, and Phytoplankton Concentration) on one plot. A ruler may be helpful in lining up axis.



2c. From earlier, you learned that both suspended sediment concentration and nutrient concentration are higher at the head of the estuary and lower at the mouth of the estuary. Did you observe these patterns in your sampling? What pattern did you observe for phytoplankton concentration?

Yes, these patterns were observed in the Clark Estuary. Phytoplankton concentration was low at the head of the estuary, increased to a maximum in the middle estuary, and then decreased to a low at the mouth of the estuary.

2d. What happens to each parameter between Site 3 and Site 4?

There was a large decrease in both suspended sediment concentration and nutrient concentration, and a large increase in phytoplankton concentration.

2e. Recall that high suspended sediment concentration impacts the amount of light available in the water column. With this knowledge, why do you think you see low values of phytoplankton where there are very high nutrients?

There are low values of phytoplankton at the head of the estuary because of the high suspended sediment concentrations. When suspended sediment concentrations are so high, it prevents sufficient sunlight to enter the water, so phytoplankton cannot efficiently photosynthesize.

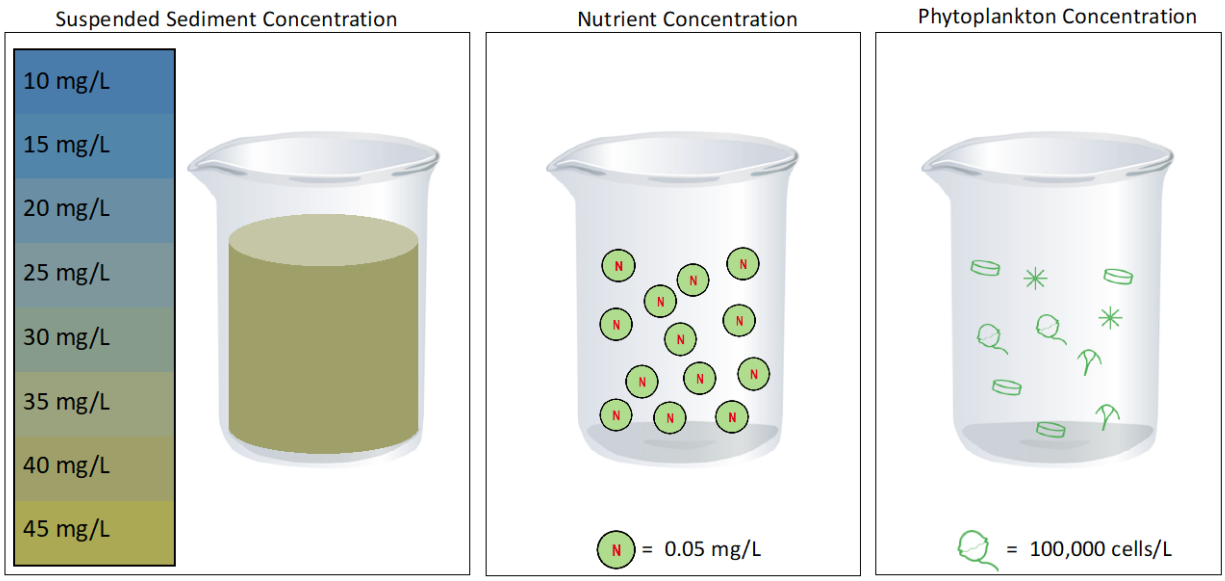
2f. At the mouth of the estuary, there seems to be low amount of phytoplankton, even though the water has a low suspended sediment concentration and there is plenty of light available for photosynthesis. Why do you think this is?

There are low values of phytoplankton at the mouth of the estuary because of the low nutrient concentrations. Although suspended sediment concentrations are low and there is sufficient sunlight for photosynthesis, nutrients have been used up throughout the estuary. The low values of nutrients at the mouth cannot support high phytoplankton concentrations.

2g. There was a large input of nutrients into the head of the estuary from a wastewater treatment plant creating very high nutrient concentrations. This happened during a time of little rainfall (i.e. very little suspended sediment throughout the estuary). Describe what would you expect the phytoplankton concentration gradient to look like?

If suspended sediment concentrations were low, I would expect there to be high phytoplankton concentrations in areas where there are high nutrient concentrations. Therefore, there would be high phytoplankton concentration at the head of the estuary and low concentrations at the mouth of the estuary.

2h. A community member brought you a water sample from the estuary to analyze, but cannot remember where they collected it from. Collect data for each parameter and report between which two sites you think the sample came from.



Suspended Sediment Concentration __40 mg/L___

Nutrient Concentration___0.65 mg/L___

Phytoplankton Concentration ___1,000,000 cells/L___

This sample was taken between Sites _3_ and _4_.

Appendix D

Name: Answer Key Date:

From High to Low: Understanding Estuarine Gradients

Part 3. Coding

In Part 2, you plotted the data you collected by hand. Now, you will plot the data using an online coding program.

3a. Open https://rdrr.io/snippets/ and delete all text in the textbox.

3b. The directions below will show you how to create a plot for salinity using the online program. You will then try to create plots for other parameters.

3c. You are going to create arrays, or a lists of numbers, with the data that you collected. An array looks like this:

[1 2 3 4 5 6 7 8]

3d. In your plots above, the data on the x-axis is the site number. This will be the first array we will create and we will name it "site". Type in the following into the text box:

```
site = c(1, 2, 3, 4, 5, 6, 7, 8)
```

- Name of your data array
- "c" creates the list of numbers into array
- List of numbers in array separated by commas (spaces optional)

3e. Now that you created your list for the site values, we will create a list for the salinity values. (It is important to enter in the salinity values in order of site number, or else your data will not plot properly.) Type in:

```
salinity = c(0.5, 2, 5, 9, 12, 18, 20, 26)
```

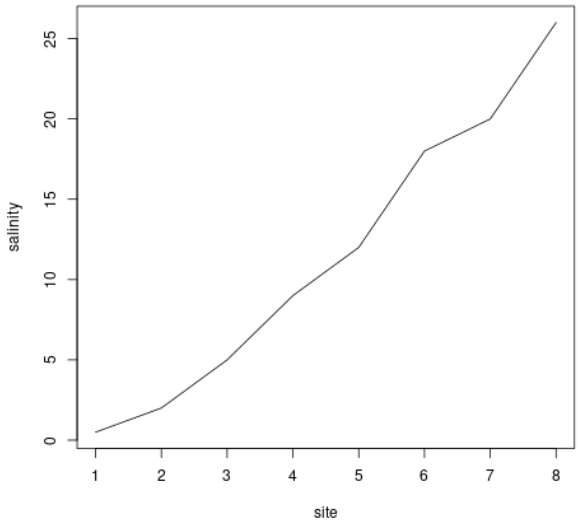
- Name of your data array
- "c" creates the list of numbers into array
- List of numbers in array separated by commas (spaces optional)

3f. Now that we have created both arrays, we are ready to plot the salinity data from all sample sites. Coding is case sensitive, so make sure there are no capitals within your code. Type in:

```
plot(site, salinity, type = 'l')
```

- Command to plot data
- Data you want on the x-axis
- Data you want on the y-axis
- Command to tell the program to plot your data with a line (this is a lower-case L, not a 1)

3g. Once you have typed in all three parts, you can click the green "Run" button! A plot of salinity should pop up on the screen, similar to the one on the right.



3h. Although the figure does include axis labels, there are ways to make your figure more informational, like adding units, a title, or changing the color of the line.

3i. To make your figure better, we are going to add some information to the `plot` line of code. Edit the line to read:

```
plot(site, salinity, type = 'l', col = 'orange', xlab = 'Site Number',
ylab = 'Salinity (PPT)', main = 'Salinity Gradient')
```

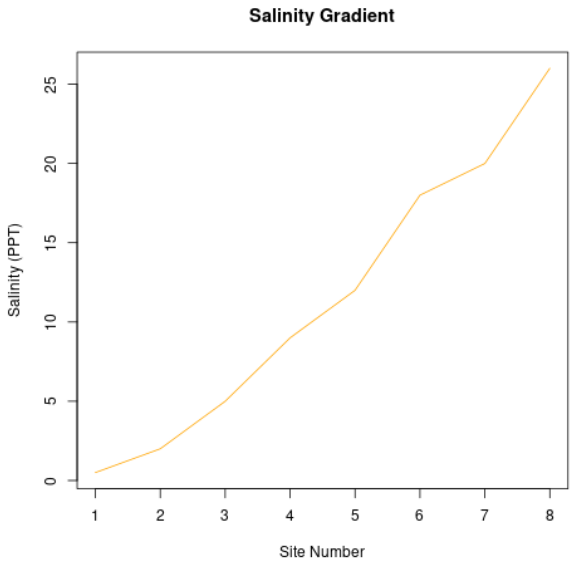
Color of line in single quotes

X-axis label in single quotes

Y-axis label in single quotes

Figure title in single quotes

3j. Now that you have successfully created a figure for the salinity gradient (it should look like the image to the right), you will now make figures for the suspended sediment concentration, nutrient concentration, and phytoplankton concentration in the colors specified in Part 2a.



If you're having errors when you hit the green 'Run' button, be sure to check all spelling and lettering. Another common mistake is forgetting commas between commands within the parenthesis.

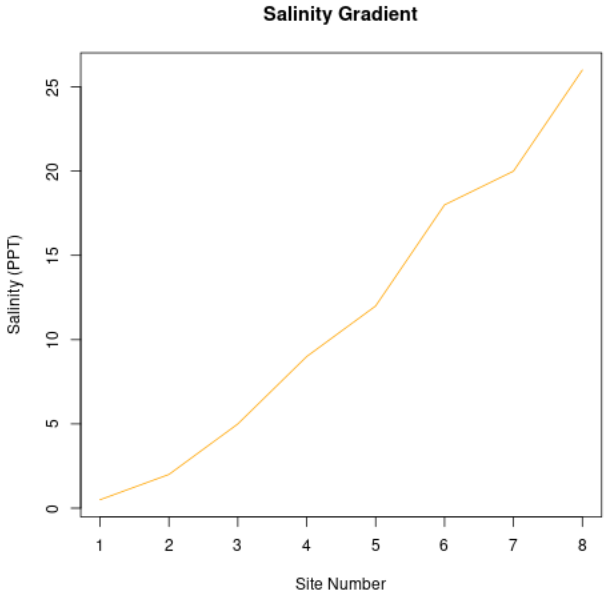
If you are struggling with re-creating your plots, you may ask your teacher for the code for each parameter.

All code and figures are listed below:

- Have students type in the code manually if you supply them with the final code. There are sometimes errors with the quotation marks when code is copy and pasted into the program.

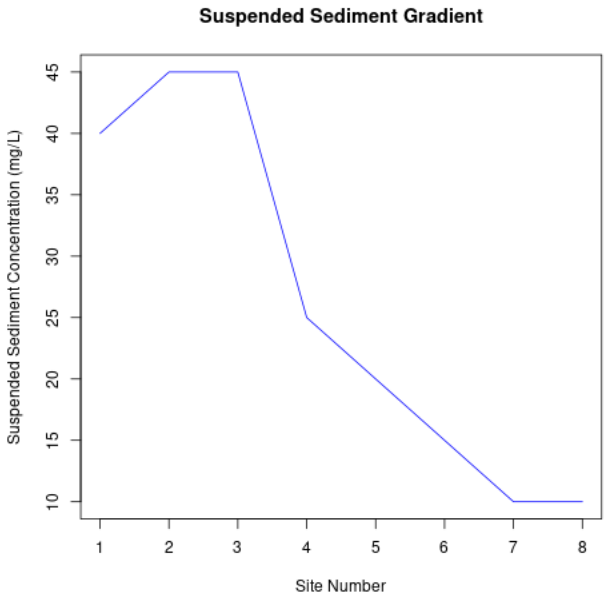
Salinity:

```
site=c(1, 2, 3, 4, 5, 6, 7, 8)
salinity = c(0.5, 2, 5, 9, 12, 18, 20, 26)
plot(site, salinity, type = 'l', col = 'orange', xlab = 'Site Number',
ylab = 'Salinity (PPT)', main = 'Salinity Gradient')
```



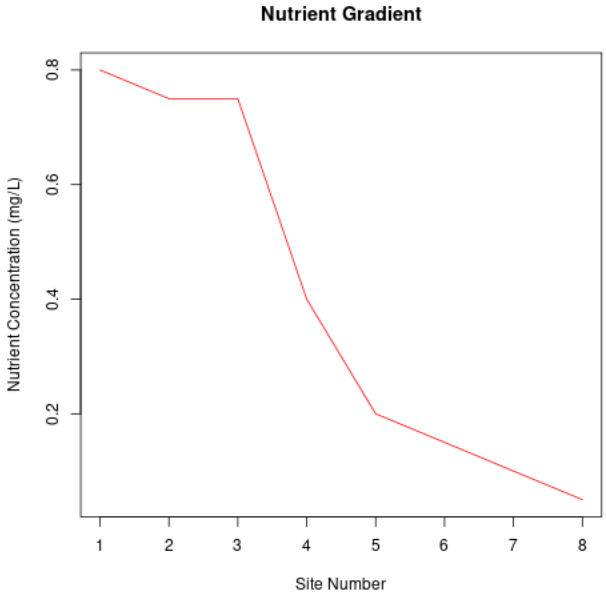
Suspended Sediment Concentration:

```
site=c(1, 2, 3, 4, 5, 6, 7, 8)
ssc = c(40,45,45,25,20,15,10,10)
plot(site, ssc, type = 'l', col = 'blue', xlab = 'Site Number', ylab =
'Suspended Sediment Concentration (mg/L)', main = 'Suspended Sediment
Gradient')
```



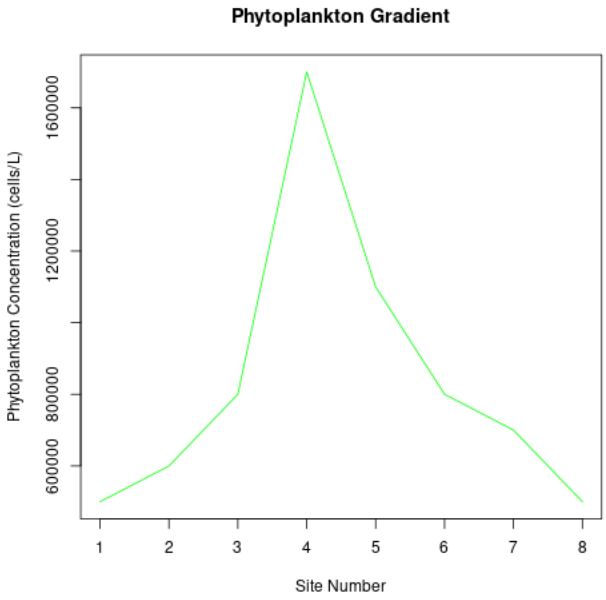
Nutrient Concentration:

```
site=c(1, 2, 3, 4, 5, 6, 7, 8)
nutrients = c(0.8, 0.75, 0.75, 0.4, 0.2, 0.15, 0.1, 0.05)
plot(site, nutrients, type = 'l', col = 'red', xlab = 'Site Number',
ylab = 'Nutrient Concentration (mg/L)', main = 'Nutrient Gradient')
```

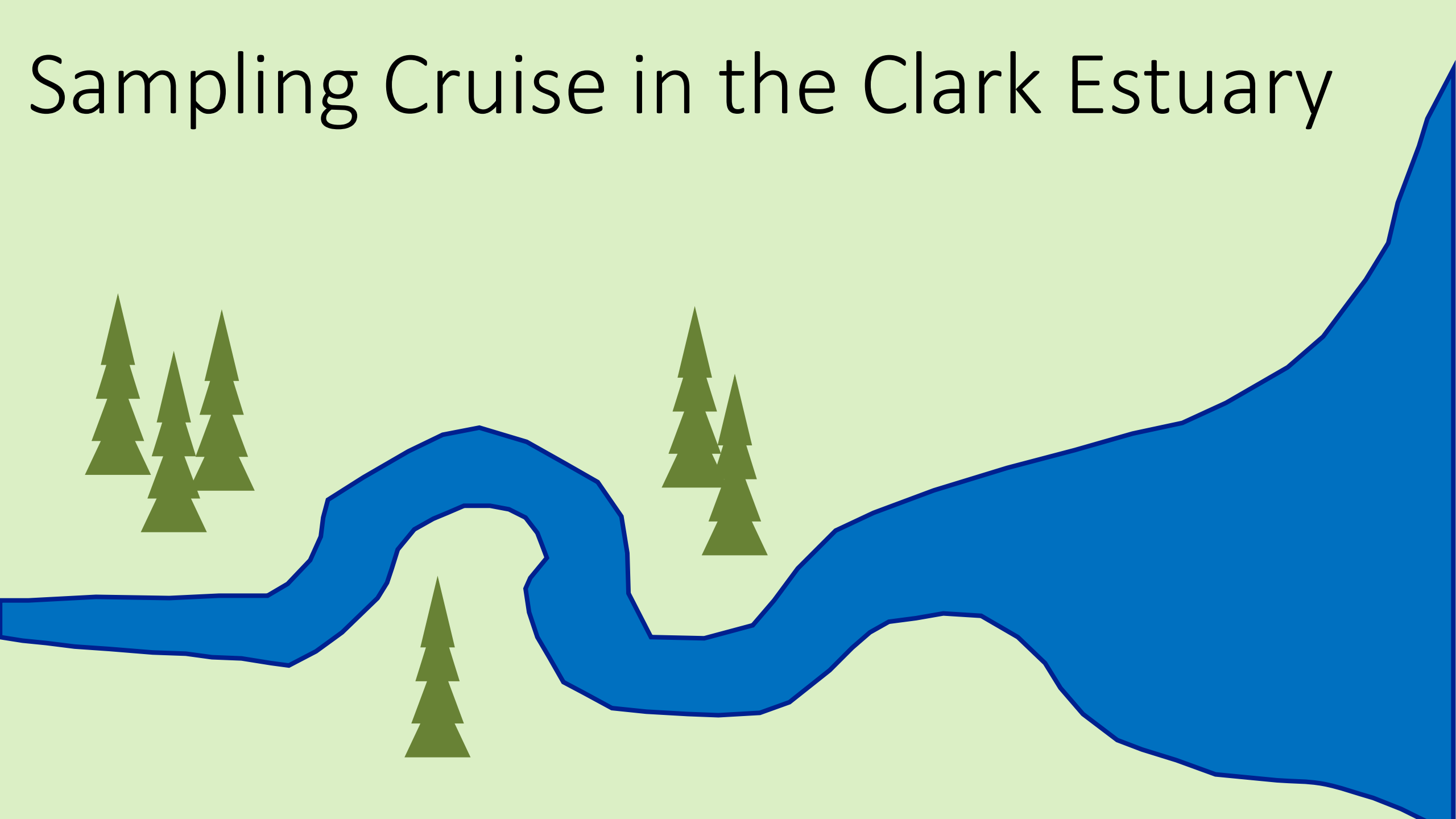


Phytoplankton Concentration:

```
site=c(1, 2, 3, 4, 5, 6, 7, 8)
phyto = c(500000, 600000, 800000, 1700000, 1100000, 800000, 700000,
500000)
plot(site, phyto, type = 'l', col = 'green', xlab = 'Site Number',
ylab = 'Phytoplankton Concentration (cells/L)', main = 'Phytoplankton
Gradient')
```

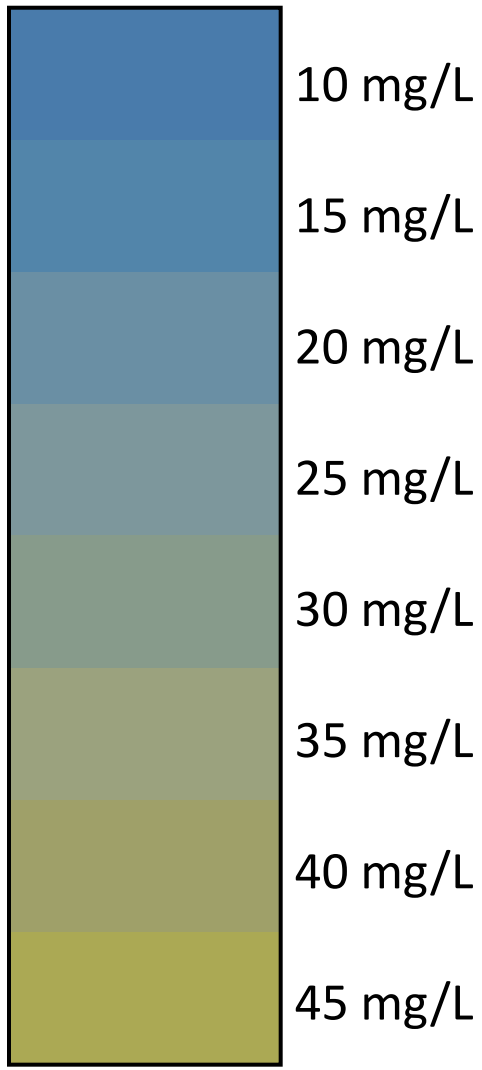


Sampling Cruise in the Clark Estuary



At each sample site, there will be three beakers to collect data from. Each water sample will be 1L.

- For suspended sediment concentrations, you will match the color of the water in the beaker to the color bar on the left. This will tell you how much sediment is in the water.



For example, this water sample has 20 mg/L of suspended sediment.

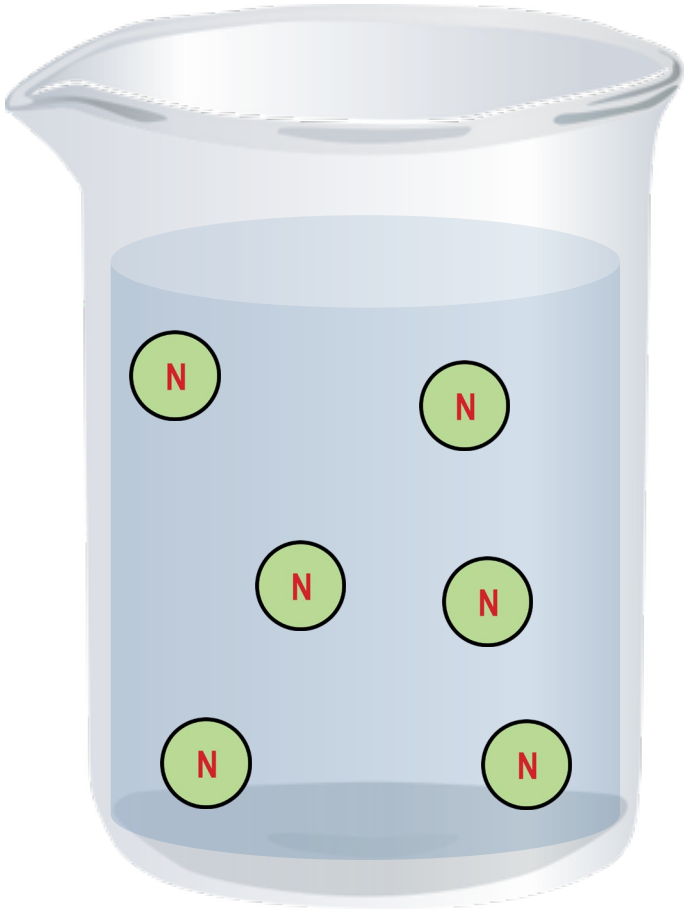
At each sample site, there will be three beakers to collect data from. Each water sample will be 1L.

- For nutrient concentration, you will count the number of nutrient icons in each beaker. Each icon represents 0.05 mg of nutrients. Find the nutrient concentration in mg/L.

N = 0.05 mg/L

N N = 0.1 mg/L

N N N = 0.15 mg/L



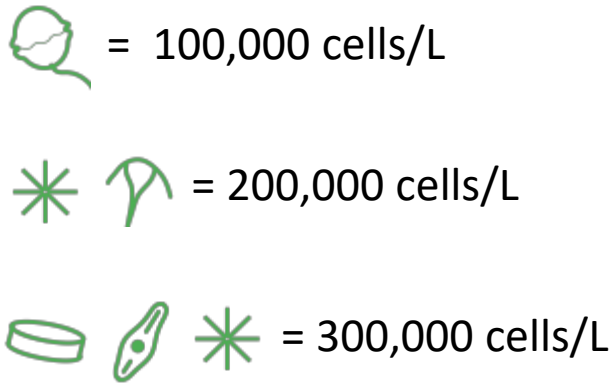
0.05 mg/L * 6 = 0.3 mg/L

N * 6 = 0.3 mg/L

For example, this water sample's nutrient concentration is 0.3 mg/L.

At each sample site, there will be three beakers to collect data from. Each water sample will be 1L.

- For phytoplankton concentration, you will count the number of phytoplankton icons in each beaker. Each icon (no matter the shape) represents 100,000 phytoplankton cells. Find the cell concentration in cells/L



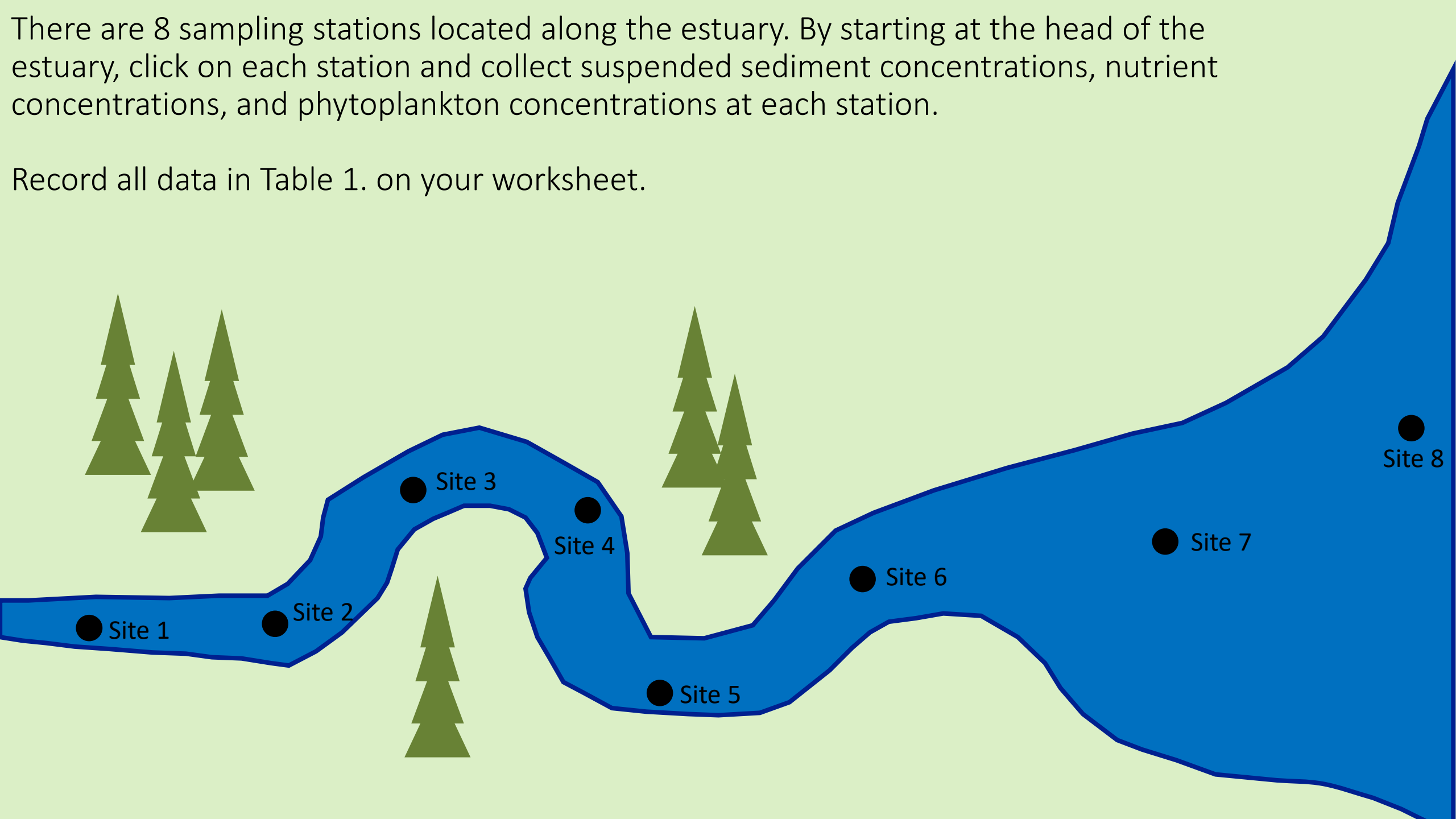
100,000 cells/L * 7 = 700,000 cells/L

* 7 = 700,000 cells/L

For example, this water sample has 700,000 cells/L of phytoplankton.

There are 8 sampling stations located along the estuary. By starting at the head of the estuary, click on each station and collect suspended sediment concentrations, nutrient concentrations, and phytoplankton concentrations at each station.

Record all data in Table 1. on your worksheet.



Site 1

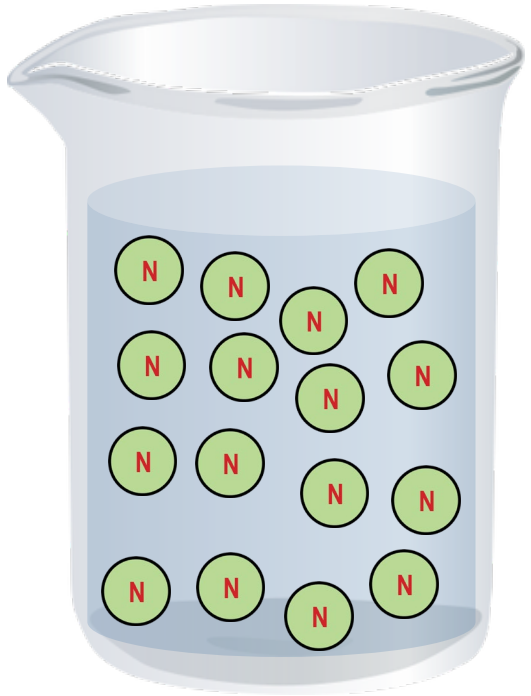
Salinity = 0.5 PPT

Click to go back to site map

Suspended Sediment Concentration

10 mg/L
15 mg/L
20 mg/L
25 mg/L
30 mg/L
35 mg/L
40 mg/L
45 mg/L

Nutrient Concentration



N = 0.05 mg/L

Phytoplankton Concentration

= 100,000 cells/L

Site 2

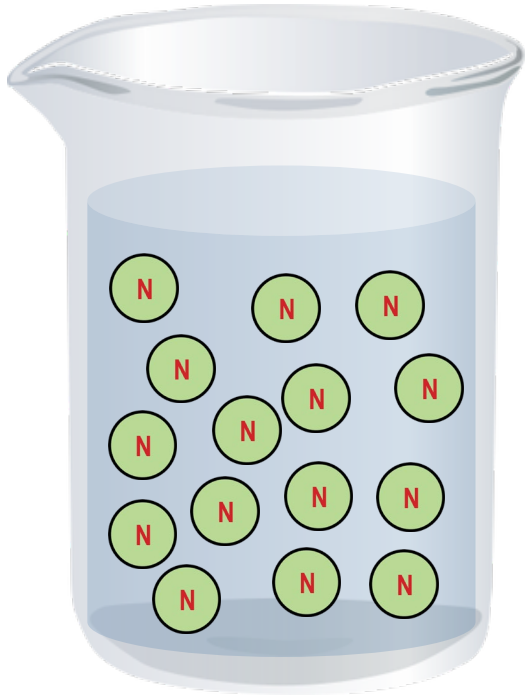
Salinity = 2 PPT

Click to go back to site map

Suspended Sediment Concentration

10 mg/L
15 mg/L
20 mg/L
25 mg/L
30 mg/L
35 mg/L
40 mg/L
45 mg/L

Nutrient Concentration



N = 0.05 mg/L

Phytoplankton Concentration

= 100,000 cells/L

Site 3

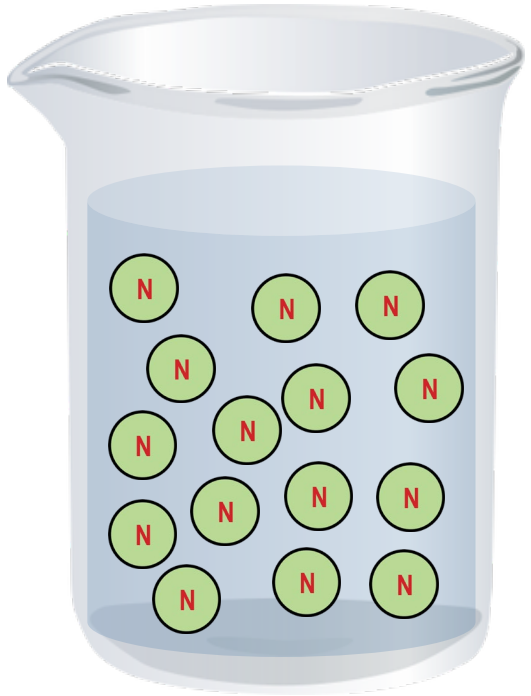
Salinity = 5 PPT

Click to go back to site map

Suspended Sediment Concentration

10 mg/L
15 mg/L
20 mg/L
25 mg/L
30 mg/L
35 mg/L
40 mg/L
45 mg/L

Nutrient Concentration



N = 0.05 mg/L

Phytoplankton Concentration

= 100,000 cells/L

Site 4

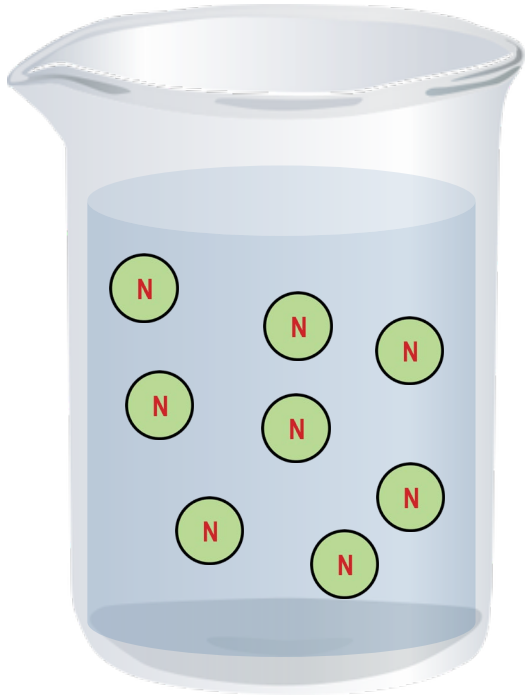
Salinity = 9 PPT

Click to go back to site map

Suspended Sediment Concentration

10 mg/L
15 mg/L
20 mg/L
25 mg/L
30 mg/L
35 mg/L
40 mg/L
45 mg/L

Nutrient Concentration



N = 0.05 mg/L

Phytoplankton Concentration

= 100,000 cells/L

Site 5

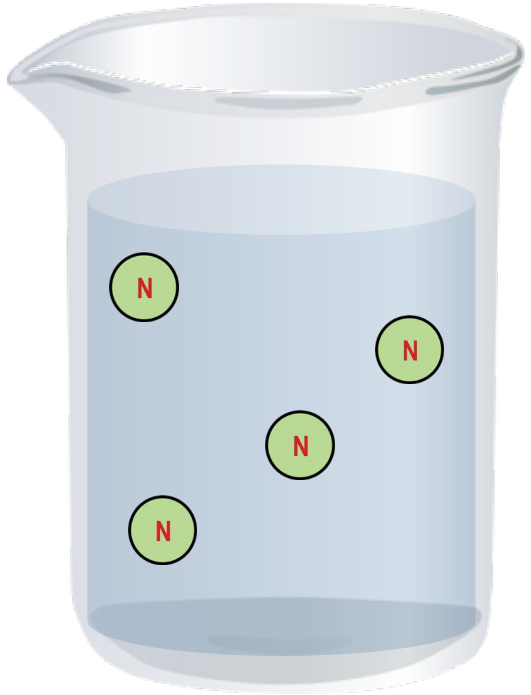
Salinity = 12 PPT

Click to go back to site map

Suspended Sediment Concentration

10 mg/L
15 mg/L
20 mg/L
25 mg/L
30 mg/L
35 mg/L
40 mg/L
45 mg/L

Nutrient Concentration



N = 0.05 mg/L

Phytoplankton Concentration

= 100,000 cells/L

Site 6

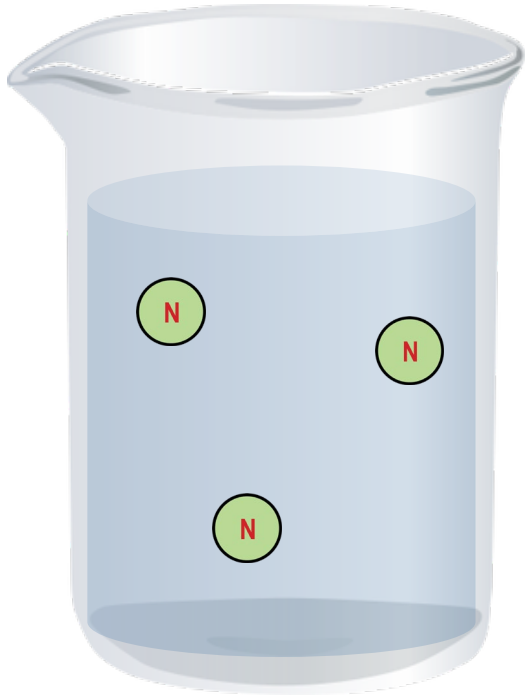
Salinity = 18 PPT

Click to go back to site map

Suspended Sediment Concentration

10 mg/L
15 mg/L
20 mg/L
25 mg/L
30 mg/L
35 mg/L
40 mg/L
45 mg/L

Nutrient Concentration



N = 0.05 mg/L

Phytoplankton Concentration

= 100,000 cells/L

Site 7

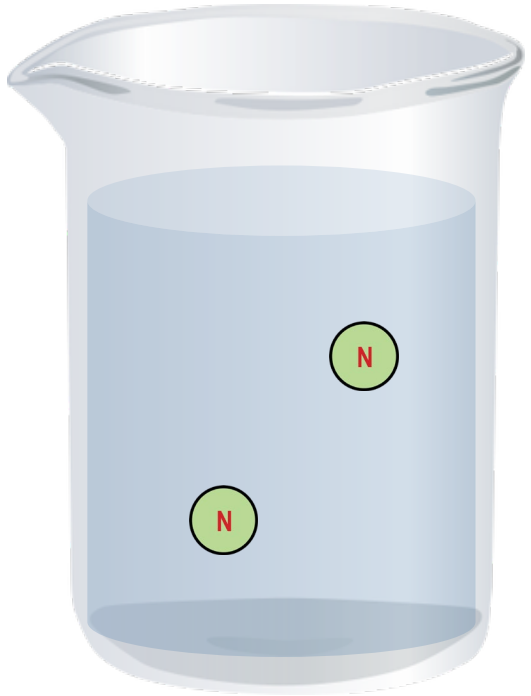
Salinity = 20 PPT

Click to go back to site map

Suspended Sediment Concentration

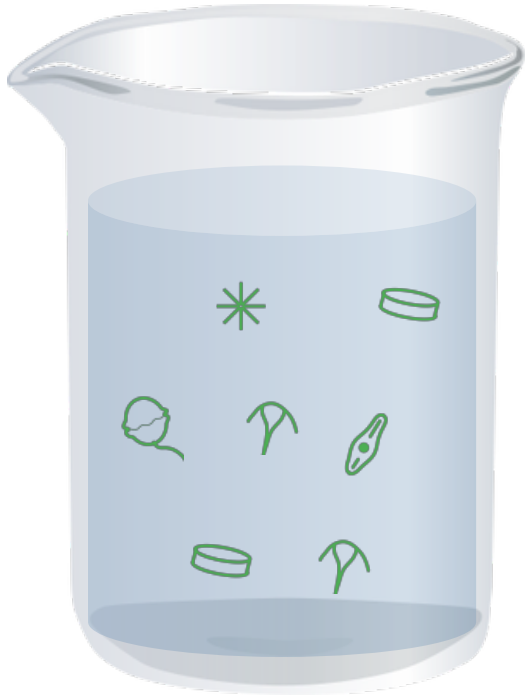
10 mg/L
15 mg/L
20 mg/L
25 mg/L
30 mg/L
35 mg/L
40 mg/L
45 mg/L

Nutrient Concentration



N = 0.05 mg/L

Phytoplankton Concentration



= 100,000 cells/L

Site 8

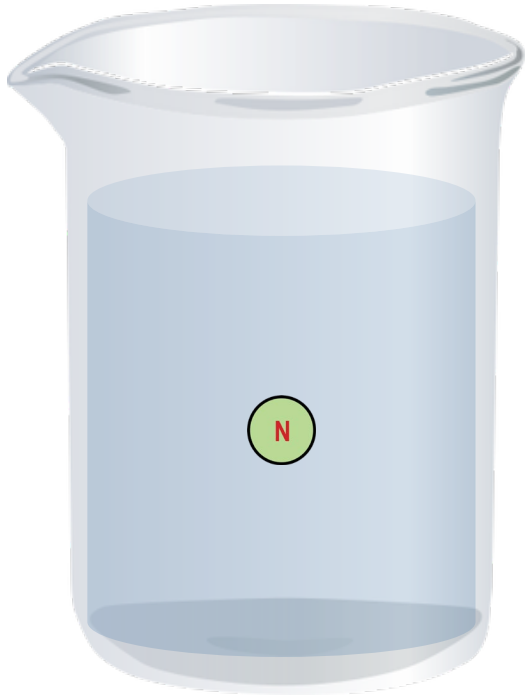
Salinity = 26 PPT

Click to go back to site map

Suspended Sediment Concentration

10 mg/L
15 mg/L
20 mg/L
25 mg/L
30 mg/L
35 mg/L
40 mg/L
45 mg/L

Nutrient Concentration



N = 0.05 mg/L

Phytoplankton Concentration

= 100,000 cells/L