QUANTIFYING STRESS: USING BLOOD BIOMARKERS TO STUDY SHARKS

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Grade Level
High School

Subject Area
Biology

The Virginia Scientists & Educators Alliance (VA SEA) is a project of William & Mary's Batten School & VIMS Office of Outreach and Engagement. The VA SEA project is made possible through funding from VIMS, Virginia Sea Grant, the National Science Foundation, and the MacWhorter Family.

Title: Quantifying Stress: Using Blood Biomarkers to Study Sharks

Focus: This lesson introduces students to real-world marine biology research by modeling how scientists use blood samples from sharks to investigate physiological stress. Students simulate the collection and analysis of shark blood stress biomarkers to explore how environmental conditions in Chesapeake Bay influence animal health.

Grade Level: Biology

Virginia Standards of Learning: This lesson addresses SOL BIO.1 where students will participate in scientific investigation, data collection, and interpretation. BIO.2 where students will focus on chemical and biochemical processes essential for life. BIO.8 which focuses on organismal response to environmental change, and BIO.9 which explores interactions among organisms and their environments.

Learning Objectives: By the end of this lesson, students will be able to:

- Explain what blood stress biomarkers are and why scientists use them to assess animal health.
- Collect and quantify simulated biological data.
- Create and interpret graphs.
- Identify relationships between environmental conditions and physiological stress.

Total length of time required for the lesson: 90 minutes.

Vocabulary:

- **Physiology**: The study of how living organisms and their body systems work.
- **Stress**: A response that happens when an organism is exposed to difficult or harmful conditions in its environment.
- **Biomarker**: A substance found in blood that scientists measure to learn about an organism's health or stress level.
- **Salinity**: The amount of salt dissolved in water.
- **Young-of-Year (YOY):** A fish or shark that is less than 1 year old.
- **Juvenile**: A young organism that is older than 1 year but not an adult.
- **Variable**: Any factor in an experiment that can change, be controlled, or be measured.
- **Environmental Stressor**: A condition in the environment, such as high temperatures, low oxygen levels, or pollution, that makes it harder for an organism to survive.

Background Information:

Sharks are important predators in marine ecosystems and play a key role in keeping ocean food webs balanced. Many shark species use Chesapeake Bay as a nursery habitat, especially when they are young. Nursery areas provide shelter and food, but conditions in estuaries like Chesapeake Bay can change quickly. Water temperature, salinity, oxygen levels, and seasonal conditions vary across the Bay and can affect how sharks grow, behave, and survive.

Some environmental changes cause stress in sharks even when they do not appear injured or sick. Stress is not always visible from the outside, so scientists study what is happening inside the animal's body. One way researchers do this is by collecting small blood samples. Blood carries information about how an animal's body is functioning and responding to its environment. By analyzing these samples, scientists can learn whether sharks are experiencing low stress or high stress in different parts of the Bay.

The research this lesson is based on involves collecting blood samples from sharks caught in different locations within Chesapeake Bay. Each shark experiences different environmental conditions depending on where and when it is caught. By comparing blood samples from sharks living in warmer or cooler waters, higher or lower salinity areas, and different seasons, researchers can identify patterns in stress responses. These patterns help scientists understand which environmental conditions are more challenging for sharks.

This research is important because Chesapeake Bay is changing due to climate change and human activity. Warmer water temperatures, changes in freshwater input, and lower oxygen levels are becoming more common. Young sharks may be especially sensitive to these changes. Understanding how sharks respond to environmental stress helps scientists identify important habitats, predict how shark populations may be affected in the future, and develop better management and conservation strategies.

In this lesson, students model real scientific research by analyzing simulated blood samples from sharks living in different parts of the Bay. By collecting data, graphing results, and identifying trends, students practice the same skills used by marine scientists to study how environmental conditions affect animal health.

Materials & Supplies:

- 25 sandwich bags
- Red beads for each bag
- Multi-colored beads for each bag
- Spoon or scoop per group (5)
- Shark data cards (printed and laminated, see Appendix)
- 25 small plates or petri dishes

Teacher Preparation:

- Gather all materials and supplies.

- Print provided shark identification data cards. Each data card should match one baggie and will include multiple pieces of information such as capture location within Chesapeake Bay, water temperature, salinity, month, sex, and age class (YOY or juvenile). Ensure that each baggie is clearly labeled to match its corresponding data card (for example, Shark 1-25).
- Print Handout for each group of students.
- Set up five student group stations around the classroom. At each station, place the following materials together: five labeled shark blood sample baggies, the matching shark data cards, sampling scoops or spoons, plates, student worksheets, handouts, and calculators.
- Assemble the simulated blood samples using beads. Add ¼ cup of red beads to every baggie to represent blood so total volume looks consistent across sharks. After adding red beads, add colored beads to represent stress biomarkers. Sharks associated with higher water temperatures (July months) must contain more colored biomarker beads (approximately 2 tablespoons) than sharks associated with lower water temperatures (lowest is June, then August). The lowest temperatures should have only 3-4 colored beads, then increase the number of colored beads as the temperature on the cards increases. This pattern should be present across all group sets. For example, a shark captured at approximately 20°C may contain 5 biomarker beads, while a shark captured at approximately 28°C should contain ~30 more biomarker beads. The additional variables on the data cards are intentionally included to require students to think critically and rely on evidence rather than guessing.

Procedure:

Engage/Hook: Begin the lesson by displaying slide (1-2). You may show the “Meet the Scientist” slide and explain that I am a real scientist at the Virginia Instiute of Marine scient that studies sharks. Next, go to slide 3 and show the vocabulary needed for this lesson. This may be given ahead of the lesson so student can study prior to starting the lab. On slide 4, you can explain to students where Chesapeake Bay is, emphasize how large it is, that is an estuarine environment, and important for young fishes. You can segway this slide with explaining that the Bay is very susceptible to climate change and environmental pollution because it is large and there are many major cities and farmland that border the bay. Next slide you can go into more how heatwaves are becoming increasingly more common as well as oxygen-dead zones or areas where there is no oxygen in the water for fish or other aquatic animals to breathe. On slide 6, go through the points. I like to give the simile of goldilocks and the three bears where fish “want” the water just right and not too cold or too hot. As the water gets too hot they can become stressed or die. Go through slide 7 and explain what stress is. This is a good time to relate back to the students and ask how they feel when they are stressed. Are there heart rates increasing, do they get sweaty, maybe get a headache? Things like that are great ways to relate to internal stress and get them thinking for the upcoming slides. On slide 8, ask students, “How can scientists tell if an animal is stressed if it doesn’t look injured or sick?” Allow some students to respond and guide the discussion towards the idea that scientists often must look inside the body to understand how an animal is doing. You can also acknowledge similarities between humans and animals where sometimes people can be internally sick but look fine on the outside. However, humans can speak to others about their internal discomfort whereas animals cannot. The following slides (10-11) will provide images of how blood samples are taken and what a scientist does while out on the boat to process those samples before taking them into the lab. On slide 12, you can explain the importance of replication in science. For higher level students, slide 13 explains what a biomarker is and gives three examples of ones that are commonly used in stress studies. Lastly, on slide 14 I wanted to give an example of the importance of group and teamwork. You can explain that all science is a group effort, and it can take a lot of people to do just one experiment.

Explain that they will now act as marine scientists by analyzing simulated shark blood samples to investigate their stress. Emphasize that scientists rarely know the answer before collecting data, and that their goal today is to use evidence from their data collection to identify patterns.

Introduce the Investigation and Expectations: Divide the class into five groups where they will study 5 sharks per group. If you have less than 25 students, randomyl pass out shark ID cards and associate baggies, you should get the same results. Students will have the Handout with further details about the shark identification cards and how to sample the "blood." Explain that scientists do not rely on just one measurement. Instead, they take multiple samples or replicates and calculate an average to get more accurate results. So, from each baggy, students will take three subsamples (scoops) from each shark's blood (baggie) and then calculate the mean number of stress biomarkers. Clearly explain that students should not pour out or count the beads and make guesses; they must rely on their measurements and data.

Data Collection: Have students record all environmental and biological information from the data cards for each shark. Instruct students to take three level scoops one at a time, replacing the previous scoop back into the baggie before the next scoop. After each scoop, students should count the number of colored biomarker beads and record the number on their worksheet. After collecting the three samples per shark, calculate the mean biomarker count for each individual shark.

Small group Data Exploring and Graphing: Once the data are collected, instruct the students to examine their mean biomarker values and the environmental/biological information for each shark. Have students discuss among their group if they can recognize any patterns based on the data. You could ask guiding questions such as "Which sharks have the highest average biomarker levels" and "What do those sharks have in common"? Have students complete graphs on their worksheets.

Class-Wide Data Compilation, Pattern Analysis, and Discussion: Bring the class back together and show the provided shared data table on the board or projector. You can post this ahead of time to the class's online board and have them fill it out with their data. Ask the group which two-three things from the identification cards that may affect how much stress biomarkers a shark had. Make a line graph for each variable, with the environmental or biological variable on the x-axis and the mean number of biomarkers on the y-axis. For higher level students, they can also do this themselves and practice making graphs digitally. Ask students to describe patterns they notice between biomarker levels and environmental variables. Encourage students to justify their ideas using their data. Students should be able to recognize which variable seems the most likely to influence how many stress biomarkers a shark has; you may guide them in recognizing that the higher temperatures are associated with higher stress levels. You can explain the purpose of the "extra" variables on the data cards by stating that scientists must sort through many different possible explanations to find the most important ones.

Wrap-Up: Summarize the key takeaway that stress in sharks can be measured internally and is influenced by environmental conditions. Explain that this type of research helps scientists understand how changing environments, like the Chesapeake Bay, affect shark health and survival. Students can either fill out the worksheet questions in class, or it can be taken home for homework.

Assessment: Students will complete a worksheet during their experiments where they will record information and graph the means of the collected data.

References:

- Witeska, Małgorzata, Elżbieta Kondera, Katarzyna Ługowska, and Bartosz Bojarski. "Hematological Methods in Fish – Not Only for Beginners." Aquaculture 547 (January 2022): 737498. https://doi.org/10.1016/j.aquaculture.2021.737498.
- Whitney, Nicholas M., Karissa O. Lear, John J. Morris, Robert E. Hueter, John K. Carlson, and Heather M. Marshall. "Connecting Post-Release Mortality to the Physiological Stress Response of Large Coastal Sharks in a Commercial Longline Fishery." PLOS ONE 16, no. 9 (2021): e0255673. https://doi.org/10.1371/journal.pone.0255673.
- Mohan, John A, Elizabeth R Jones, Jill M Hendon, et al. "Capture Stress and Post-Release Mortality of Blacktip Sharks in Recreational Charter Fisheries of the Gulf of Mexico." Conservation Physiology 8, no. 1 (2020): coaa041. https://doi.org/10.1093/conphys/coaa041.

Handouts/Worksheets:

Student Handout

Quantifying Stress: Using Blood Biomarkers to Study Sharks

Introduction

Sharks live in many different environments throughout Chesapeake Bay. Some parts of the Bay are warmer, saltier, or change more quickly than others. These environmental conditions can cause stress in sharks, even when the sharks do not look injured or unhealthy.

Scientists cannot ask sharks how they feel, so they study what is happening inside the shark's body. One way scientists do this is by analyzing blood samples. Blood can provide information about how an animal is responding to its environment. Higher levels of stress-related substances in blood can indicate that an animal is experiencing more stress.

In this investigation, you will act as a marine scientist. You will analyze simulated shark blood samples using beads to represent blood stress biomarkers. You will collect data, calculate averages, create graphs, and use evidence to determine which environmental factors are most closely related to stress in sharks.

Your Task as a Scientist

You will work in a group to study five sharks. Each shark is represented by a baggie that contains beads simulating a blood sample. Each shark also has an identification card that includes environmental and biological information such as water temperature, salinity, month, sex, and age class.

Scientists do not rely on just one measurement. To improve accuracy, you will take three blood samples (subsamples) from each shark and calculate the mean number of stress biomarkers.

Your goal is to use your data and graphs to identify patterns and determine which environmental factor appears to have the greatest effect on shark stress.

Rules for Sampling

- Do not pour out or count all the beads in the bag.
- Take three level scoops, one at a time.
- After counting each scoop, return the beads to the bag before taking the next scoop.
- Record all data carefully.
- Do not guess conclusions until after you analyze your data.

Student Worksheet

Part A: Shark Identification Information

Record the information from the shark data cards for each shark on the table below. These are common variables that marine scientists record. Do not forget units.

Shark #	Shark ID #	Temperature in °C	Salinity in ppt	Month	Sex	Age Class
#1						
#2						
#3						
#4						
#5						

Part B: Bloody Sampling Data

For each shark, take three subsamples and record the number of stress biomarker beads, then calculate the mean.

Shark #_______
Sample 1: ______
Sample 2: ______
Sample 3: ______
Mean Biomarker Count:______

Shark #________
Sample 1: ______
Sample 2: ______
Sample 3: ______
Mean Biomarker Count: ______

Shark #________
Sample 1: ______
Sample 2: ______
Sample 3: ______
Mean Biomarker Count: ______

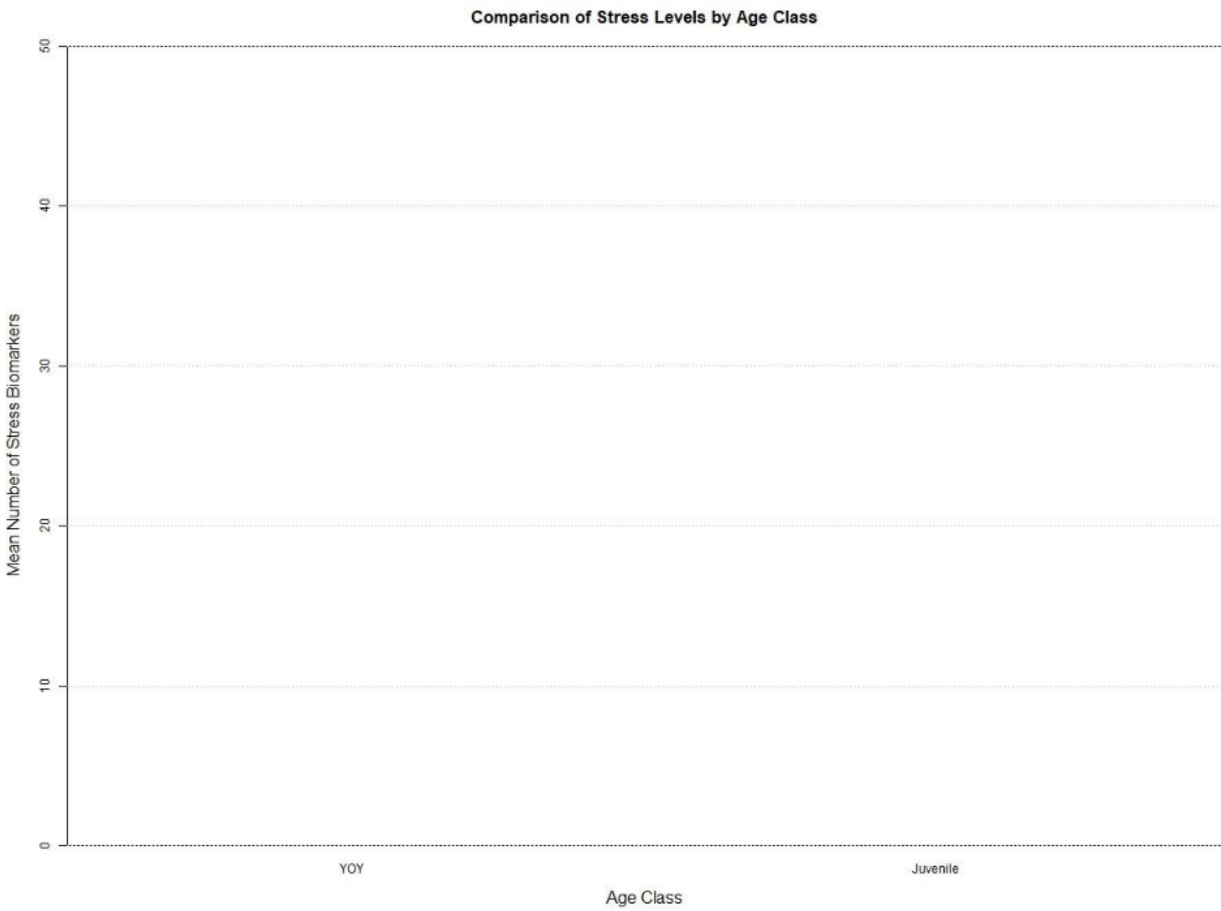
Shark #________
Sample 1: ______
Sample 2: ______
Sample 3: ______
Mean Biomarker Count: ______

Shark #_______
Sample 1: ______
Sample 2: ______
Sample 3: ______
Mean Biomarker Count: ______

Part C: Graphing Data

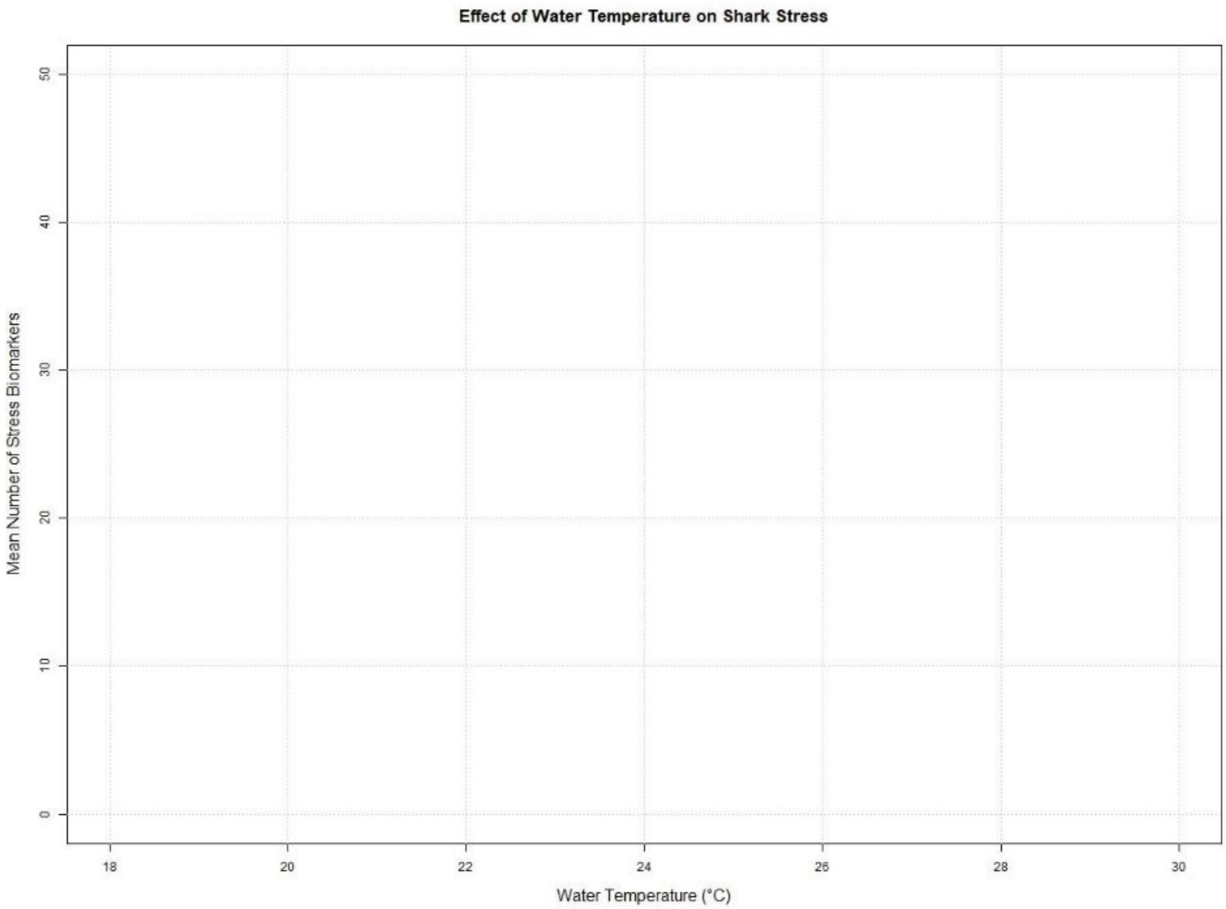
For each graph, first determine what type of graph would best suit the data. Would a bar graph or a line graph be appropriate for the data?

Type of graph: ____



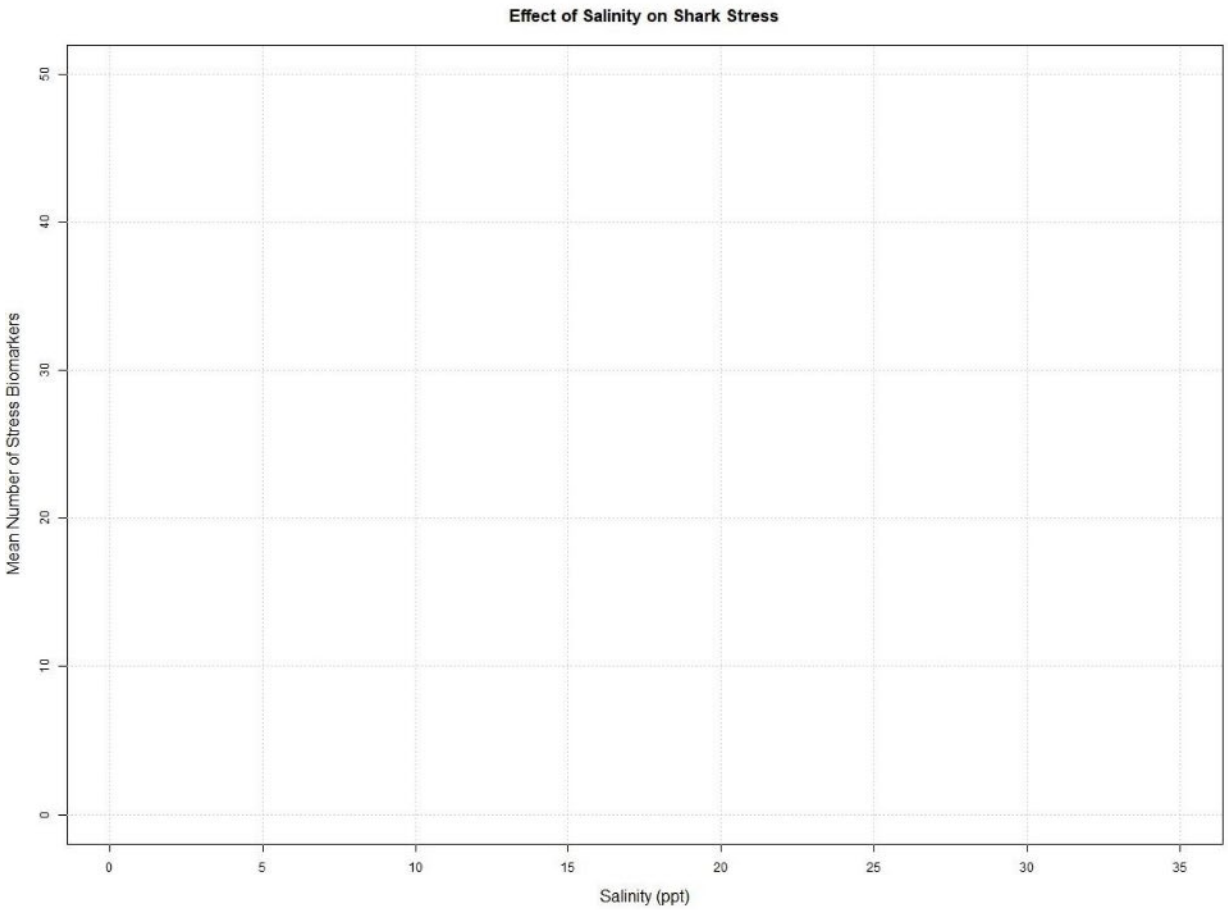
1. Describe what you see.

Type of graph: ___________________________



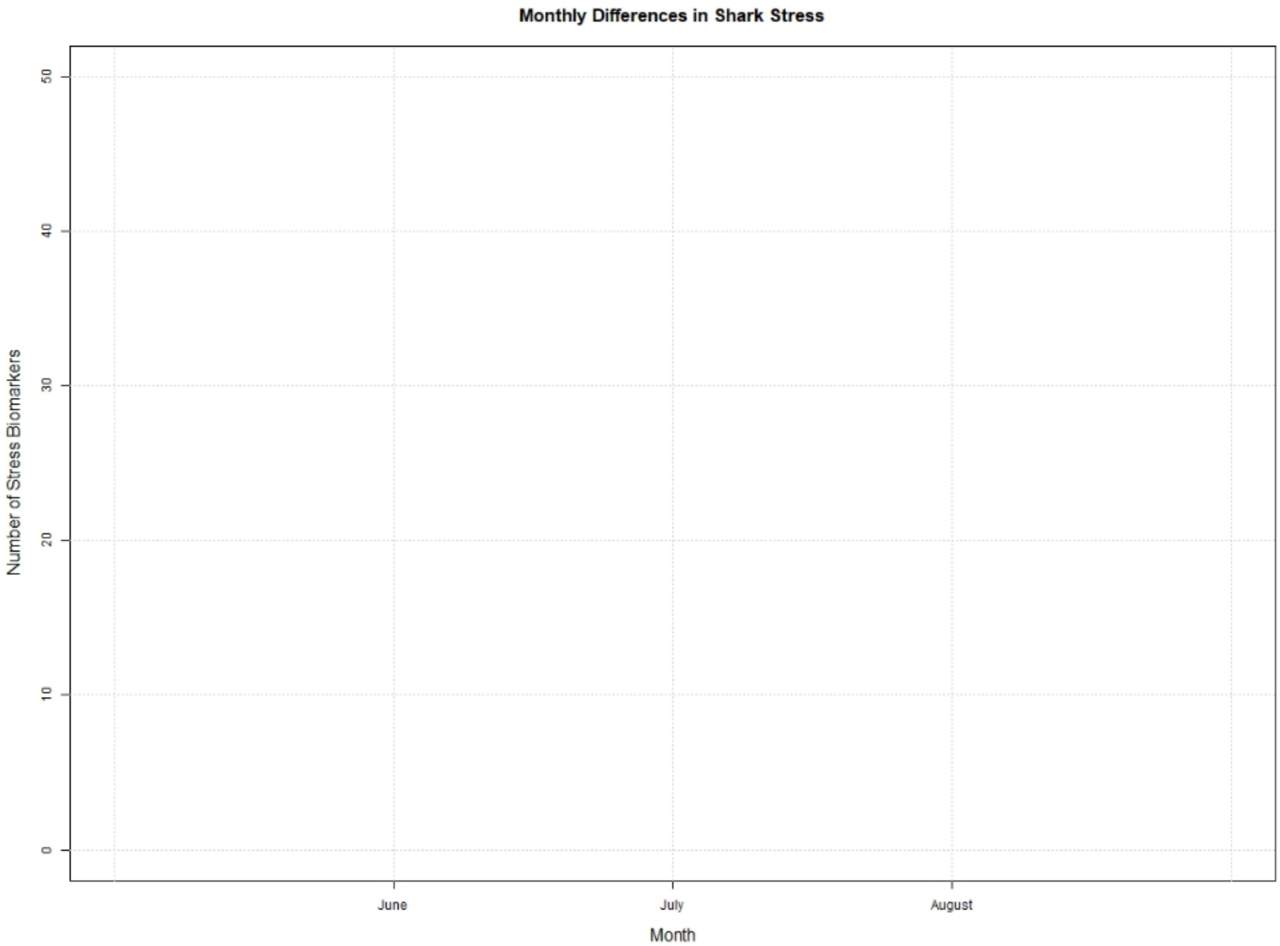
2. Describe what you see.

Type of graph: ______________________________________



3. Describe what you see.

Type of graph: ______________________________



4. Describe what you see.

Part D: Data Analysis Questions

1. Which shark had the highest mean biomarker count? What environmental conditions were associated with that shark?

2. Which variable appears to be most strongly related to higher stress levels? Use evidence from your data.

4. Why is it important that scientists take multiple samples and calculate a mean instead of relying on one measurement?

5. Give 3 examples of an environmental variable.

6. Describe what a stressor is and give one example of how a stressor can affect a fish.

Answer Keys:

Part A: Shark Identification Information

Record the information from the shark data cards for each shark on the table below. These are common variables that marine scientists record.

Shark ID #	Temperature	Salinity	Month	Sex	Age Class
1	24.1	18.4	June	Female	YOY
2	23.1	22.7	June	Male	YOY
3	26.8	21.4	June	Female	Juvenile
4	26.8	23.9	July	Female	YOY
5	29.8	19.8	July	Male	Juvenile

Part B: Bloody Sampling Data

For each shark, take three subsamples and record the number of stress biomarker beads, then calculate the mean.

Shark 1

Sample 1: ___12__

Sample 2: ___11___

Sample 3: ___13___

Mean Biomarker Count:

__12.0____

Shark 2

Sample 1: __9____

Sample 2: __10____

Sample 3: __8____

Mean Biomarker Count:

__9.0____

Shark 3

Sample 1: __18____

Sample 2: ___17___

Sample 3: ___19___

Mean Biomarker Count:

__18.0____

Shark 4

Sample 1: __19____

Sample 2: __20____

Sample 3: __18____

Mean Biomarker Count:

__19.0____

Shark 5

Sample 1: __27____

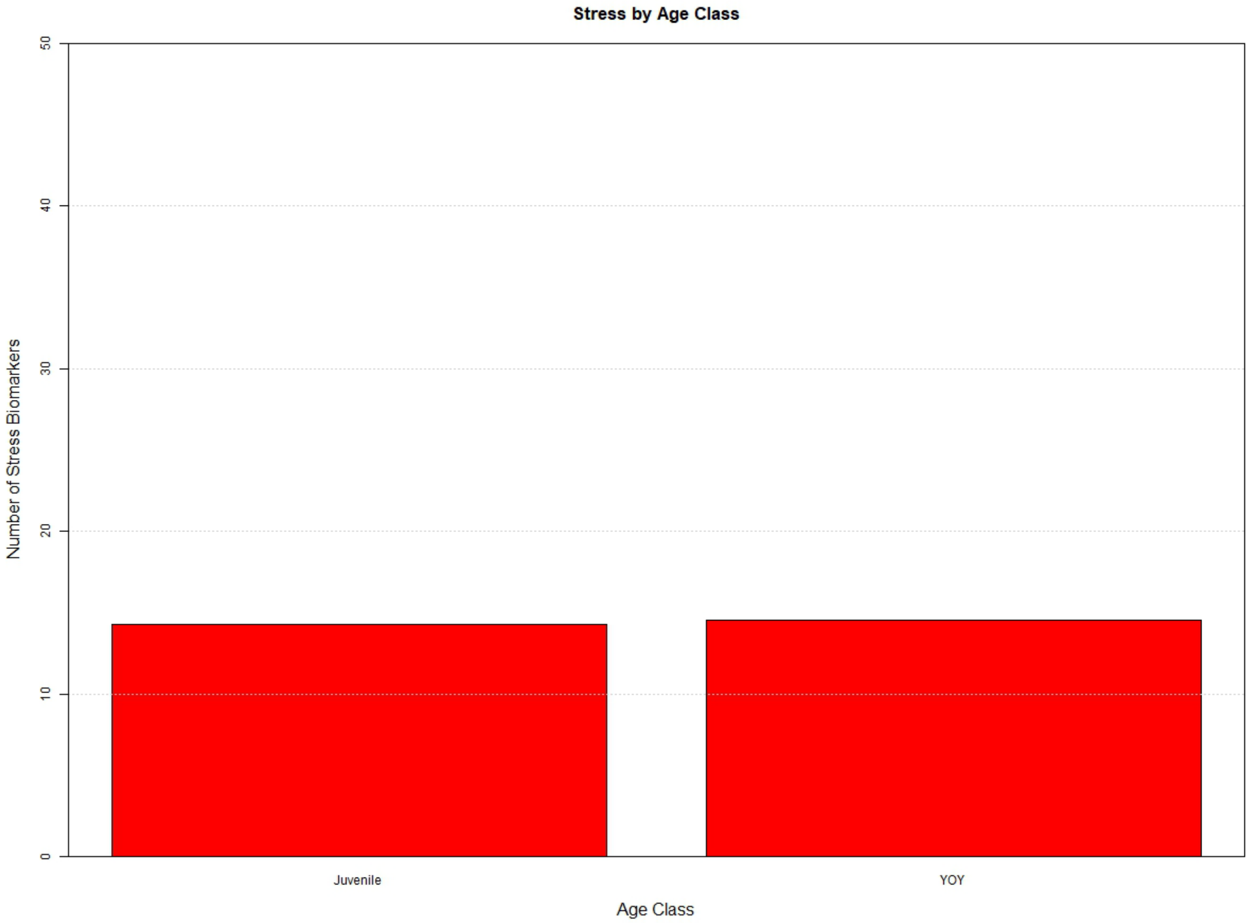
Sample 2: __29____

Sample 3: __28____

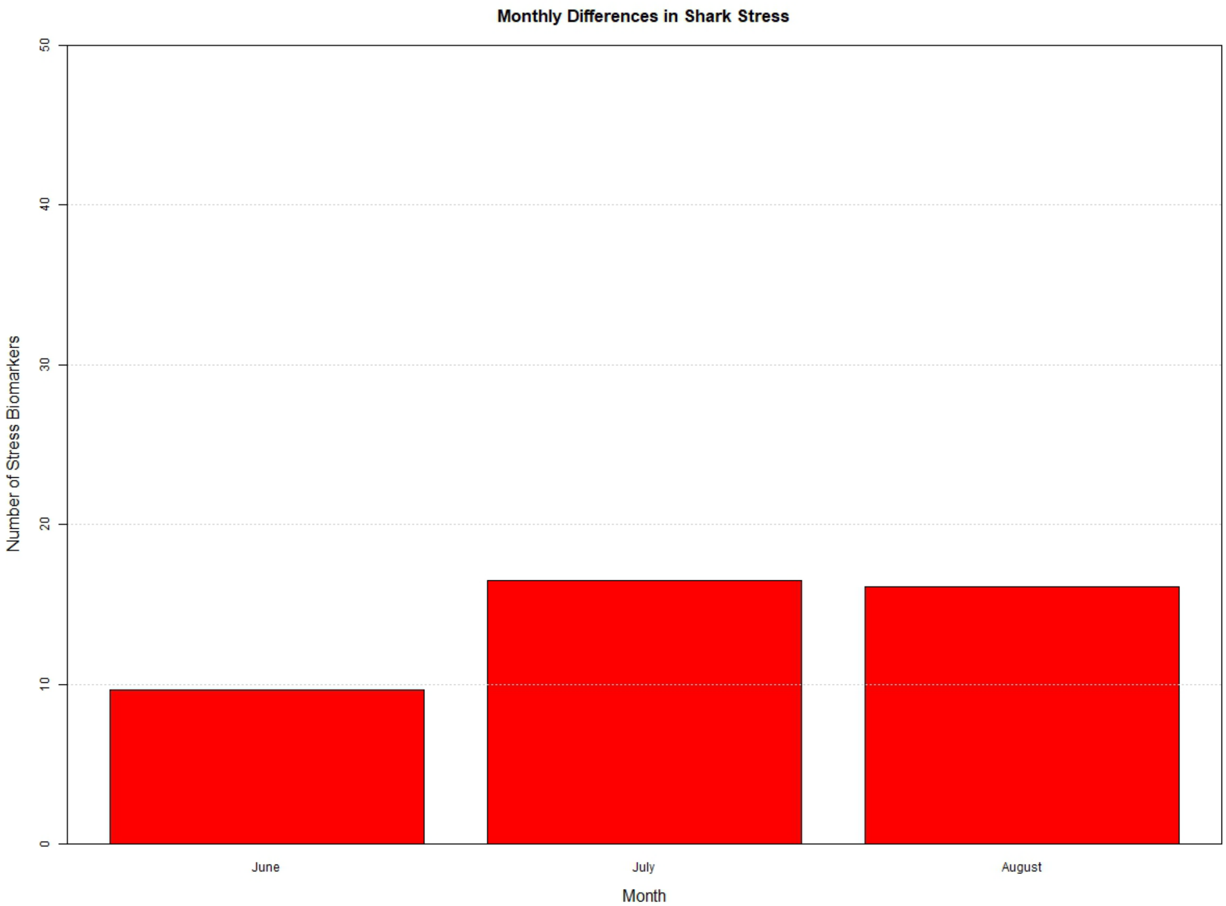
Mean Biomarker Count:

__28.0____

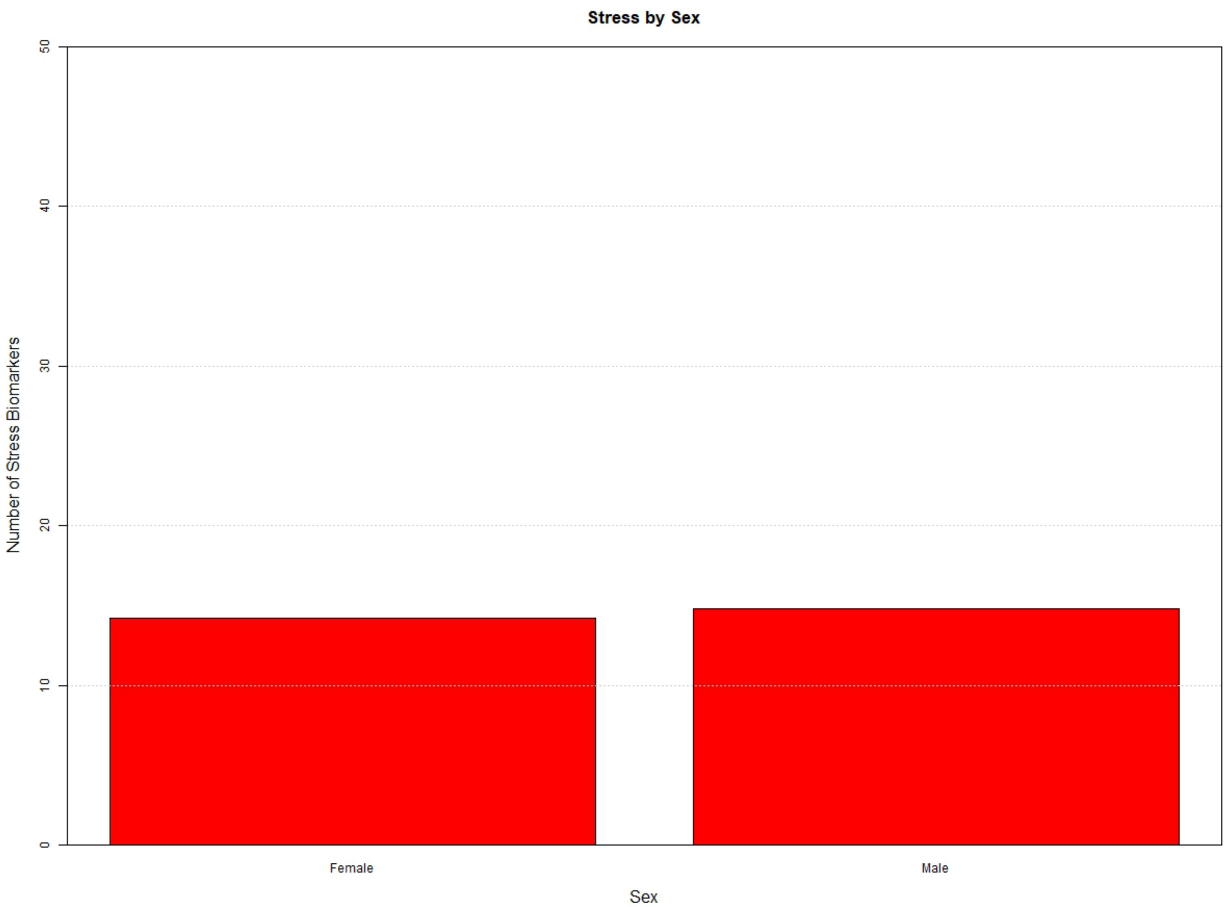
Type of graph: bar graph



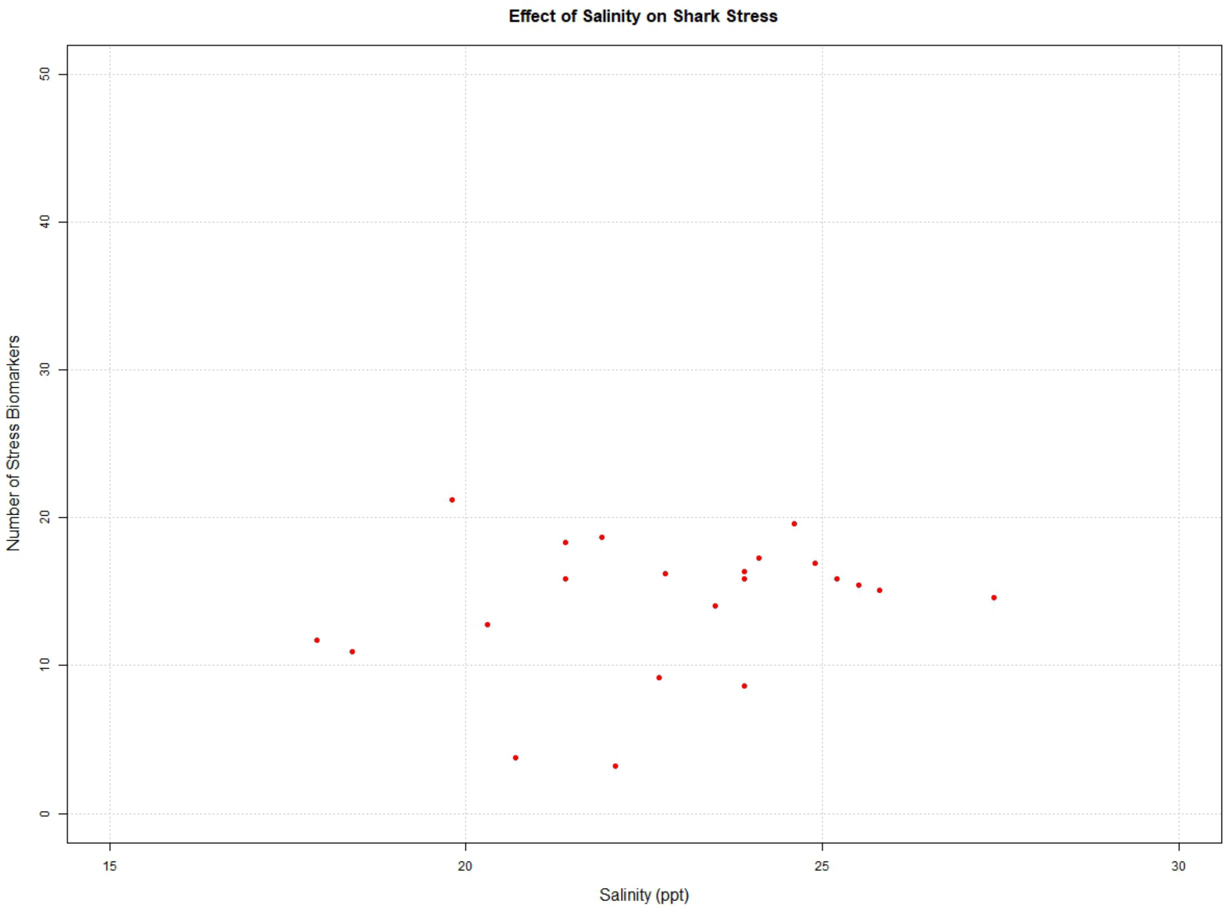
Type of graph: bar graph



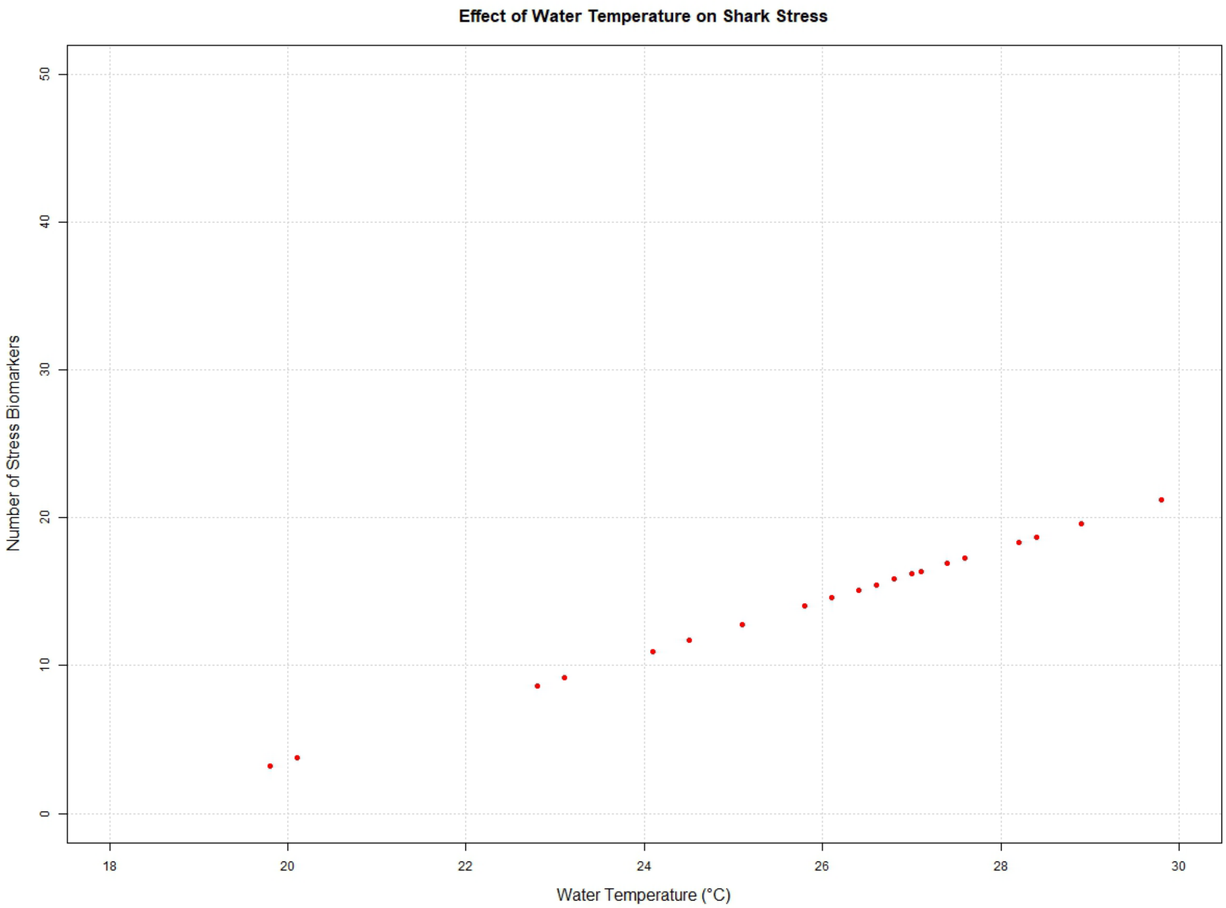
Type of graph: bar graph



Type of graph: scatter plot



Type of graph: scatter plot or line graph



Part D: Data Analysis Questions

1. Which shark had the highest mean biomarker count? What environmental conditions were associated with that shark?

Shark 5 had the highest mean biomarker count (28.0). This shark was caught in July when water temperature was the highest (29.8 °C).

2. Which variable appears to be most strongly related to higher stress levels? Use evidence from your data.

Water temperature appears to be most strongly related to stress levels. Sharks caught in warmer water had higher mean biomarker counts, while sharks in cooler water had lower counts.

4. Why is it important that scientists take multiple samples and calculate a mean instead of relying on one measurement?

Taking multiple samples and calculating a mean makes the results more accurate and reduces the effect of randomness.

4. Give 3 examples of an environmental variable.

Salinity, temperature, and oxygen.

5. Describe what a stressor is and give one example of how a stressor can affect a fish.

A stressor is an external variable like an environmental variable that can take the body out of homeostasis. Heat can make fish breath too fast and waste energy.

Appendices:

Shark #1

Date Caught: June 17, 2025
Location: Upper Chesapeake Bay
Water Temperature (°C): 24.1
Salinity (ppt): 18.4
Dissolved Oxygen (mg/L): 7.4
Sex: Female
Age Class: Young-of-the-Year (YOY)

Shark #2

Date Caught: June 20, 2025
Location: Eastern Chesapeake Bay
Water Temperature (°C): 23.1
Salinity (ppt): 22.7
Dissolved Oxygen (mg/L): 5.6
Sex: Male
Age Class: Young-of-the-Year (YOY)

Shark #3

Date Caught: June 24, 2025 **Location**: Western Lower Chesapeake Bay **Water Temperature (°C):** 26.8 **Salinity (ppt)**: 21.4 **Dissolved Oxygen (mg/L)**: 7.1 **Sex:** Female **Age Class**: Young-of-the-Year (YOY)

Shark #4
Date Caught: July 22, 2025 **Location:** Western Upper Chesapeake Bay **Water Temperature (°C):** 26.8 **Salinity (ppt):** 23.9 **Dissolved Oxygen (mg/L):** 4.9 **Sex**: Female **Age Class**: Juvenile

Shark #5

Date Caught: July 29, 2025 **Location:** Eastern Chesapeake Bay **Water Temperature (°C):** 29.8 **Salinity (ppt):** 19.8 **Dissolved Oxygen (mg/L):** 5.0 **Sex:** Male **Age Class:** Young-of-the-Year (YOY)

Shark #6
Date Caught: June 24, 2025 **Location:** Western Upper Chesapeake Bay **Water Temperature (°C):** 25.1 **Salinity (ppt):** 20.3 **Dissolved Oxygen (mg/L):** 5.7 **Sex:** Female **Age Class:** Young-of-the-Year (YOY)

Shark #7

Date Caught: July 7, 2025 **Location:** Western Upper Chesapeake Bay **Water Temperature (°C):** 22.8 **Salinity (ppt):** 23.9 **Dissolved Oxygen (mg/L):** 4.9 **Sex:** Female **Age Class:** Juvenile

Shark #8
Date Caught: July 28, 2025 **Location:** Central Chesapeake Bay **Water Temperature (°C):** 27.1 **Salinity (ppt):** 23.9 **Dissolved Oxygen (mg/L):** 5.1 **Sex:** Male **Age Class:** Young-of-the-Year (YOY)

Shark #9

Date Caught: July 28, 2025
Location: Central Chesapeake Bay
Water Temperature (°C): 27.1
Salinity (ppt): 23.9
Dissolved Oxygen (mg/L): 5.1
Sex: Female
Age Class: Young-of-the-Year (YOY)

Shark #10

Date Caught: July 29, 2025
Location: Eastern Chesapeake Bay
Water Temperature (°C): 28.2
Salinity (ppt): 21.4
Dissolved Oxygen (mg/L): 5.0
Sex: Male
Age Class: Young-of-the-Year (YOY)

Shark #11

Date Caught: July 29, 2025 **Location:** Eastern Chesapeake Bay **Water Temperature (°C):** 28.2 **Salinity (ppt):** 21.4 **Dissolved Oxygen (mg/L):** 5.0 **Sex:** Female **Age Class:** Young-of-the-Year (YOY)

Shark #12
Date Caught: August 17, 2025 **Location:** Lower Chesapeake Bay **Water Temperature (°C):** 26.6 **Salinity (ppt):** 25.5 **Dissolved Oxygen (mg/L):** 6.3 **Sex:** Female **Age Class:** Juvenile

Shark #13

Date Caught: August 17, 2025
Location: Lower Chesapeake Bay
Water Temperature (°C): 26.8
Salinity (ppt): 25.2
Dissolved Oxygen (mg/L): 6.5
Sex: Male
Age Class: Young-of-the-Year (YOY)

Shark #14

Date Caught: August 24, 2025
Location: Eastern Chesapeake Bay
Water Temperature (°C): 26.1
Salinity (ppt): 27.4
Dissolved Oxygen (mg/L): 5.6
Sex: Male
Age Class: Young-of-the-Year (YOY)

Shark #15

Date Caught: August 24, 2025 **Location:** Western Lower Chesapeake Bay **Water Temperature (°C):** 27.4 **Salinity (ppt):** 24.9 **Dissolved Oxygen (mg/L):** 5.2 **Sex:** Female **Age Class:** Young-of-the-Year (YOY)

Shark #16
Date Caught: June 18, 2025 **Location:** Upper Chesapeake Bay **Water Temperature (°C):** 24.5 **Salinity (ppt):** 17.9 **Dissolved Oxygen (mg/L):** 7.2 **Sex:** Male **Age Class:** Young-of-the-Year (YOY)

Shark #17

Date Caught: June 21, 2025 **Location:** Eastern Chesapeake Bay **Water Temperature (°C):** 19.8 **Salinity (ppt):** 22.1 **Dissolved Oxygen (mg/L):** 5.8 **Sex:** Female **Age Class:** Young-of-the-Year (YOY)

Shark #18
Date Caught: June 25, 2025 **Location:** Western Upper Chesapeake Bay **Water Temperature (°C):** 20.1 **Salinity (ppt):** 20.7 **Dissolved Oxygen (mg/L):** 6.1 **Sex:** Male **Age Class:** Young-of-the-Year (YOY)

Shark #19

Date Caught: July 5, 2025
Location: Central Chesapeake Bay
Water Temperature (°C): 27.0
Salinity (ppt): 22.8
Dissolved Oxygen (mg/L): 5.4
Sex: Female
Age Class: Juvenile

Shark #20

Date Caught: July 12, 2025
Location: Western Lower Chesapeake Bay
Water Temperature (°C): 27.6
Salinity (ppt): 24.1
Dissolved Oxygen (mg/L): 5.1
Sex: Male
Age Class: Young-of-the-Year (YOY)

Shark #21

Date Caught: July 20, 2025
Location: Western Upper Chesapeake Bay
Water Temperature (°C): 25.8
Salinity (ppt): 23.5
Dissolved Oxygen (mg/L): 4.8
Sex: Female
Age Class: Young-of-the-Year (YOY)

Shark #22

Date Caught: July 27, 2025
Location: Eastern Chesapeake Bay
Water Temperature (°C): 28.4
Salinity (ppt): 21.9
Dissolved Oxygen (mg/L): 5.0
Sex: Male
Age Class: Young-of-the-Year (YOY)

Shark #23

Date Caught: August 2, 2025
Location: Central Chesapeake Bay
Water Temperature (°C): 28.9
Salinity (ppt): 24.6
Dissolved Oxygen (mg/L): 4.7
Sex: Female
Age Class: Young-of-the-Year (YOY)

Shark #24
Date Caught: August 10, 2025 **Location:** Lower Chesapeake Bay **Water Temperature (°C):** 26.4 **Salinity (ppt):** 25.8 **Dissolved Oxygen (mg/L):** 6.0 **Sex:** Male **Age Class:** Juvenile

Shark #25
Date Caught: August 10, 2025 **Location:** Lower Chesapeake Bay **Water Temperature (°C):** 26.4 **Salinity (ppt):** 25.8 **Dissolved Oxygen (mg/L):** 6.0 **Sex:** Male **Age Class:** Young-of-the-Year (YOY)

Student Handout

Quantifying Stress: Using Blood Biomarkers to Study Sharks

Introduction

Sharks live in many different environments throughout Chesapeake Bay. Some parts of the Bay are warmer, saltier, or change more quickly than others. These environmental conditions can cause stress in sharks, even when the sharks do not look injured or unhealthy.

Scientists cannot ask sharks how they feel, so they study what is happening inside the shark's body. One-way scientists do this is by analyzing blood samples. Blood can provide information about how an animal is responding to its environment. Higher levels of stress-related substances in blood can indicate that an animal is experiencing more stress.

In this investigation, you will act as a marine scientist. You will analyze simulated shark blood samples using beads to represent blood stress biomarkers. You will collect data, calculate averages, create graphs, and use evidence to determine which environmental factors are most closely related to stress in sharks.

Your Task as a Scientist

You will work in a group to study five sharks. Each shark is represented by a baggie that contains beads simulating a blood sample. Each shark also has an identification card that includes environmental and biological information such as water temperature, salinity, month, sex, and age class.

Scientists do not rely on just one measurement. To improve accuracy, you will take three replicate blood samples (subsamples) from each shark and calculate the mean number of stress biomarkers.

Your goal is to use your data and graphs to identify patterns and determine which environmental factors appear to have the greatest effect on shark stress.

Rules for Sampling

- Do not pour out or count all the beads in the bag.
- Take three level scoops, one at a time.
- After counting each scoop, return the beads to the bag before taking the next scoop.
- Record all data carefully.
- Do not guess conclusions until after you analyze your data.

Student Worksheet

Name:________________________

Part A: Shark Identification Information

Record the information from the shark data cards for each shark on the table below. These are common variables that marine scientists record. Do not forget units.

Shark #	Shark ID #	Temperature in °C	Salinity in ppt	Month	Sex	Age Class
#1						
#2						
#3						
#4						
#5						

Part B: Bloody Sampling Data

For each shark, take three subsamples and record the number of stress biomarker beads, then calculate the mean.

Shark #_______

Sample 1: ______
Sample 2: ______
Sample 3: ______
Mean Biomarker Count:
______

Shark #________

Sample 1: ______
Sample 2: ______
Sample 3: ______

Mean Biomarker Count:
______

Shark #________

Sample 1: ______
Sample 2: ______
Sample 3: ______
Mean Biomarker Count:
______

Shark #________

Sample 1: ______
Sample 2: ______
Sample 3: ______
Mean Biomarker Count:
______

Shark #_______

Student Worksheet

Name:__________________________

Sample 1: ______

Sample 2: ______

Sample 3: ______

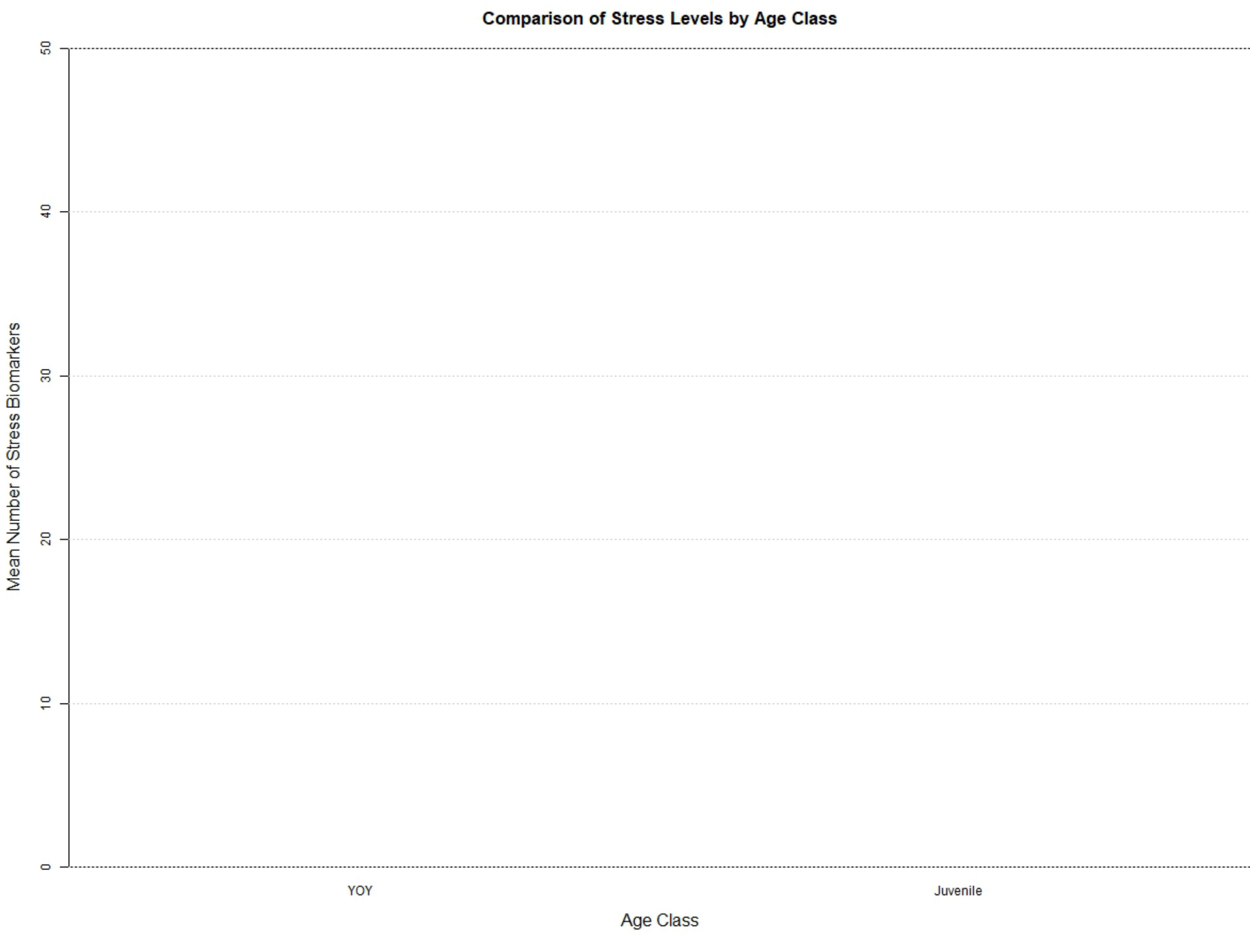
Mean Biomarker Count:

______

Part C: Graphing Data

For each graph, first determine what type of graph would best suit the data. Would a bar graph or a line graph be appropriate for the data?

Type of graph: ____

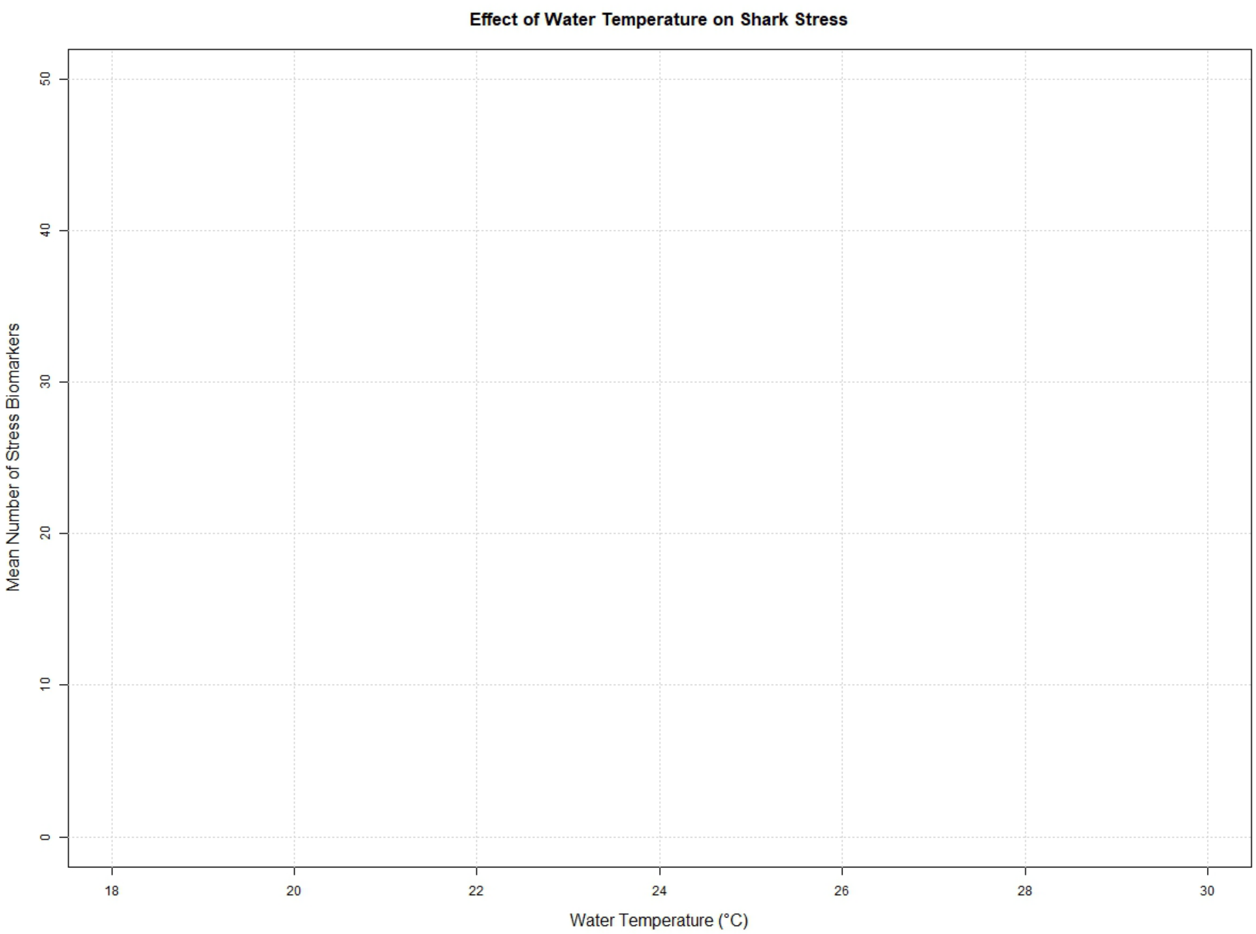


1. Describe what you see.

Student Worksheet

Name:________________________

Type of graph:____________________

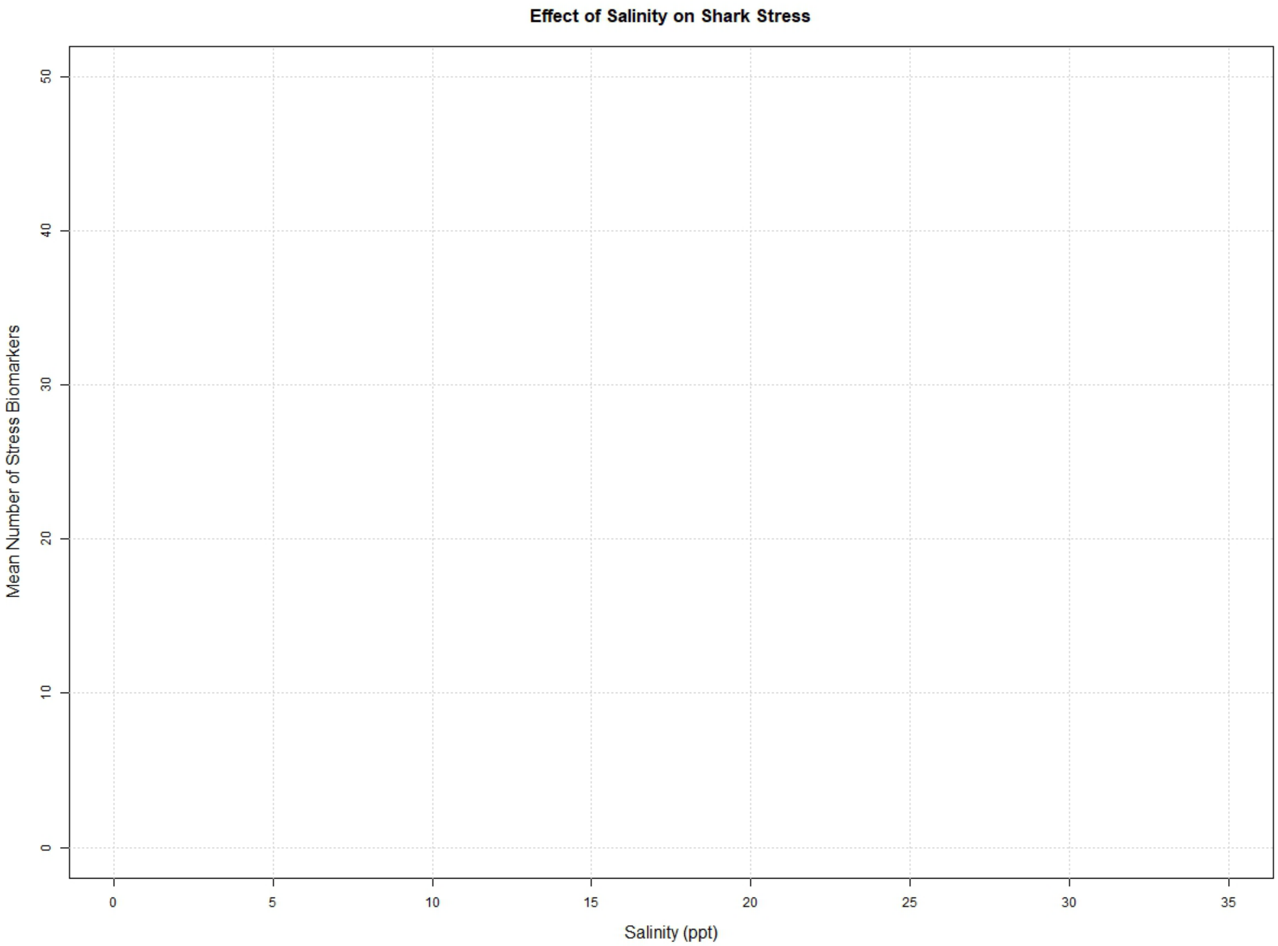


2. Describe what you see.

Student Worksheet

Name:________________________

Type of graph: _________________________

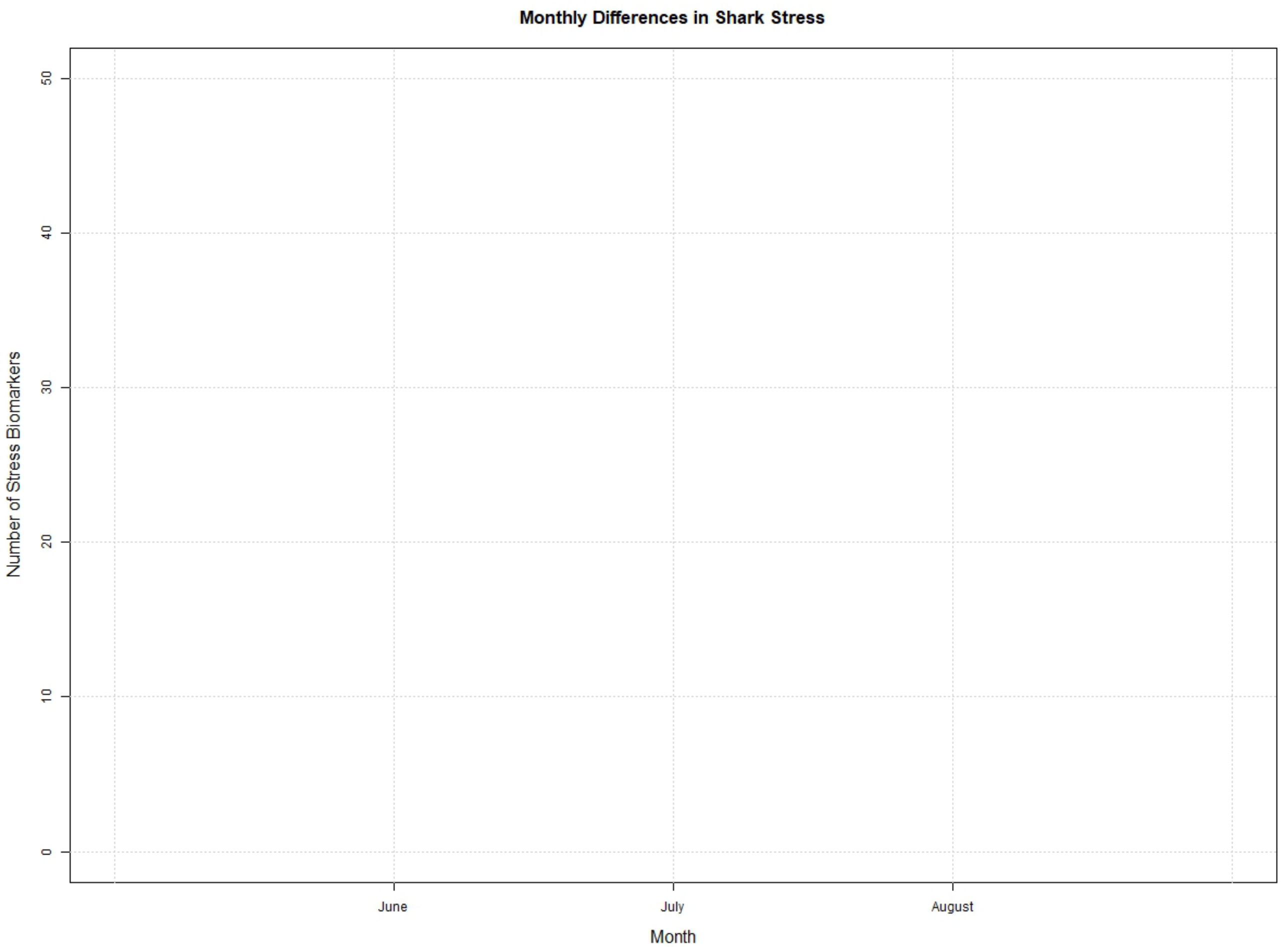


3. Describe what you see.

Student Worksheet

Name:_________________________

Type of graph: _____________________________



4. Describe what you see.

Student Worksheet

Name:________________________

Part D: Data Analysis Questions

1. Which shark had the highest mean biomarker count? What environmental conditions were associated with that shark?

2. Which variable appears to be most strongly related to higher stress levels? Use evidence from your data.

4. Why is it important that scientists take multiple samples and calculate a mean instead of relying on one measurement?

5. Give 3 examples of an environmental variable.

6. Describe what a stressor is and give one example of how a stressor can affect a fish.