Advanced Manufacturing & Prototyping Integrated to Unlock Potential

RATIOS AND PROPORTIONAL RELATIONSHIPS

Data Visualization

AQUARIUM FRIEND OR FOE?

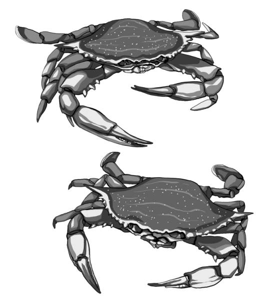
Crab Aquarium Challenge

Fall 2018 7DVM

SECTION 1 – AQUARIUM FRIEND OR FOE

1.1 INTRODUCTION

Aquariums are containers of aquatic animals that live together in ecologically balanced habitats. Scientists often use aquariums to study the behavior of animals. To be fully ecologically balanced, the habitat must allow animals to mate and reproduce and must also contain predators to control the animal population. In this challenge, you will be working as part of a team. Your team has been asked to help scientists select the predators to include in a blue crab display in order to maintain a good ecological balance of crabs and predators.



Blue crabs are an important part of the food web in areas like the Chesapeake Bay and along the coast of Georgia. The scientific name of the blue crab, *callinectes sapidus*, means “a beautiful swimmer that tastes good.”

One scientist who studies the blue crab is Georgia Tech Professor of Biology, Dr. Marc Weissburg. Dr. Weissburg studies how the blue crab responds to odors in water. Watch the video of Dr. Weissburg and see if you can figure out what he is putting in the water for his study.

Watch ***Aquarium Display Challenge*** video #1.

Discuss this question as a class:

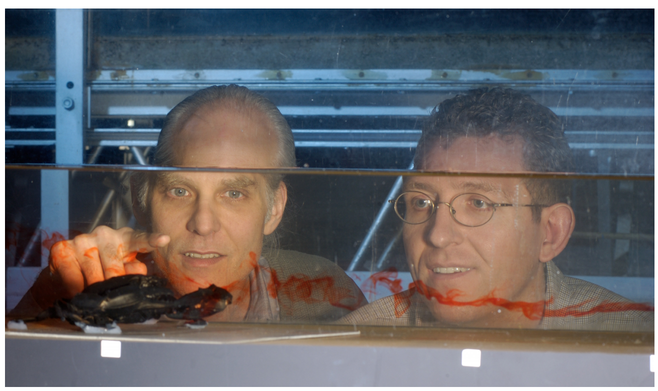
1 What do you think was in the dropper that Dr. Weissburg used?

PLEASE DO NOT WRITE IN THIS BOOK.

1.2 SIMULATION

The liquid in the dropper that Dr. Weissburg used was crab urine. Crab urine has a chemical in it called a pheromone. These pheromones are meant to attract other crabs so they can find each other, mate and reproduce. However, the same chemical pheromone in urine that attracts other crabs for mating can also attract predators looking to eat the crab. When predators are around, it is important the crab not advertise its presence too loudly! In order to create a balanced aquarium habitat, your team will need to understand pheromones and how crabs and predators react to them.

Scientists simplify the natural environment so they can study how animals behave in response to very specific things in the environment. This process is called a **simulation**, or model. In the picture below, Dr. Weissburg is conducting an experiment to see how fast a crab can track the chemical pheromone. He is ***simulating*** or modeling the natural world in a controlled experiment. This is the biological field of Animal Behavior.



KEY TERMS

Simulation: A representation of the real-life situation can test important aspects of a phenomenon under investigation and can be used to generate predictions, explanations, and solutions. However, simulations are limited in what they can represent about the real-life situation.

Before your team can recommend which predators should be put into the blue crab aquarium display to keep it balanced, you will need to collect and analyze data about the blue crab and a few of its predators. In particular, your group will need to collect data from a simulation, analyze data in a table, represent the data in a graph, and analyze the graph to provide reasons for your predator selection.

Because your school does not have the animals or equipment to run experiments like Dr. Weissburg, you will need to use a different type of simulation to understand their behavior. Behavioral scientists frequently use simulations to represent actual events and situations. This allows them to analyze data to understand how animals respond to different environments. Sometimes simulations are done with a computer, other times they use physical items to represent things like animals. In our simulation, we will use physical counters to analyze a simple **food web**.

One example of a simple **food web** is the grass, rabbits, and foxes in a meadow or prairie. The grass grows, and the rabbits eat the grass. The foxes, in turn, eat the rabbits. In a food web, we label certain organisms as the eaters and some as the eaten. Therefore, food webs have two types of organisms: **predators** and **prey**.

Watch ***Predator/ Prey*** video #2*.*

KEY TERMS

Food web: feeding relationship within an ecosystem

Predator: an organism that eats other organisms

Prey: an organism that is eaten by another organism

Discuss these questions as a class:

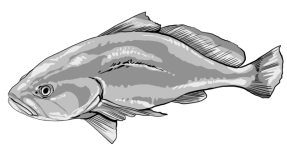
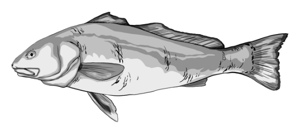
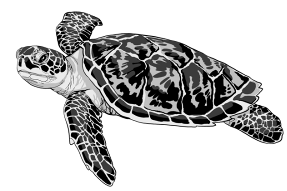
1. What are some other food web examples you can name?
2. Can you identify the predator and the prey in your examples?

1.3 SIMULATING MATING AND PREDATOR EVENTS

Since you cannot have blue crabs, their predators, and water tanks in your classroom to study the crab mating and predator behaviors, we will use a simulation to represent the behaviors. Using the simulation, your class will investigate the effect that different pheromone concentrations have on how many times the crabs mate, compared with how many times they are eaten by predators.

PART 1 of 3 – Understanding the Simulation

Blue crabs have many different predators, and we will be analyzing only three of them. They are the croaker, red drum, and sea turtle as shown below.

Croaker	Red Drum	Sea Turtle
		

You will study what happens when a predator or crab follows the pheromone odor to its source. In our simulation we will use counters to represent the number of times the crabs mate and the number of times different predators manage to eat the crabs instead.

Watch ***Blue Crab/Sea Turtle*** video #3.

PLEASE DO NOT WRITE IN THIS BOOK.

Procedure:

1. Make sure your team has all the necessary materials.
2. Each time a predator eats a crab (called a predator event), your simulation indicates this with a colored counter.
   - Red drum predatory events—**red** counters
   - Croaker predatory events—**green** counters
   - Sea turtle events—**yellow** counters
3. Each person in your group will <u>select a different predator</u> to study. Write the name of each person in your group and their selected predator on the *Mating and Predator Investigation Sheet for Data Trial 1*. Circle the name of your individual predator in the Predator Event Data section.
4. Blue crab mating events are designated by **blue** counters. Each person in your group will record the number of blue crab mating events.
5. Each team will investigate what happens at ONE concentration of pheromone. You will then share data with the rest of the class to complete your data sheet.

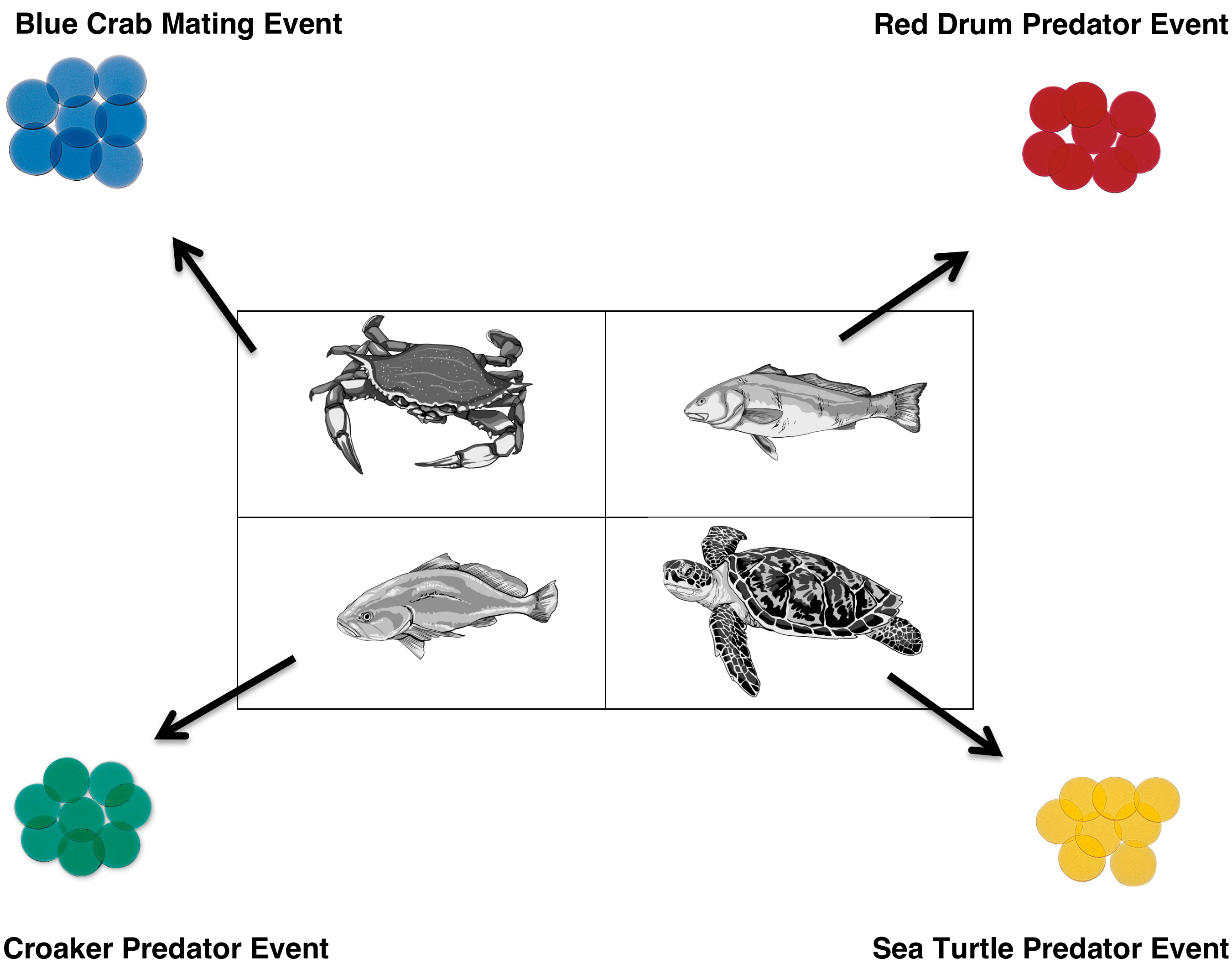
AVAILABLE MATERIALS

- Container with counters inside
- Cardboard tray to put counters on
- *Mating and Predator Sorting Sheet*
- *Mating and Predator Investigation Sheet for Data Trial 1*

Have your teacher come by to verify that your group has each chosen a different predator and recorded the name of that predator on the *Mating and Predator Investigation Sheet for Data Trial 1*.

PART 2 of 3 – Carry Out Your Investigation

Your team's container contains **blue** counters, **green** counters, **red** counters, and **yellow** counters. A blue counter is a blue crab mating event, green counter is a croaker fish predator event, red counter is a red drum fish predator event, and yellow counter is sea turtle predator event. The crab pheromone concentration percent (%) is written on the bottom of the container.



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Procedure, continued:

6. Empty your container into a cardboard tray that has the *Mating and Predator Sorting Sheet* in the bottom of the cardboard tray.
7. Separate the counters into the quadrants for mating and predator events on the *Mating and Predator Sorting Sheet*. Count the number of colored counters in each quadrant.
8. Record the crab number and the number for your predator in the event data table on your *Mating and Predator Investigation Sheet for Data Trial 1*, as shown below.
9. Look on the bottom of your container to see the crab pheromone concentration percent (%). You will record your data on your sheet only for your concentration percent (%).
   - For example, if the bottom of your container shows 40% and your predator is a sea turtle, then you will fill in data only for the 40% values as circled in red below. You will write in the number of crab mating events and your number of sea turtle predator events.

Crab Pheromone Concentration (%)	10	20	30	40	50	60	70	80	90	100
Number of Crab Mating Events										

Circle the name of your Predator: _ **Croaker** **Red Drum** **Sea Turtle**

Crab Pheromone Concentration (%)	10	20	30	40	50	60	70	80	90	100
Number of Predator Events										

10. Fill in the other data values in your data table when the other groups in your class report out their results.

Remember, everyone in the group will record the number of blue crab mating events (**blue** counters), but each person will select and record information for a <u>different</u> predator.

PART 3 of 3 – Communicate Your Data

Each group will report the results of its investigation to the whole class, and this will enable you to fill in your event data tables on your *Mating and Predator Investigation Sheet for Data Trial 1.*

Procedure:

1. As each group reports the number of crab mating and predator events that occurred at their concentration of pheromone, record the number of crab mating events in the data table on your *Mating and Predator Investigation Sheet for Data Trial 1*.
2. Record the data for the predator that you chose. You should then have two complete data tables—one for crab and one for a predator.

KEY TERMS

Data trends: noticeable patterns in data over a measure of time

Simple data tables provide a fairly easy way to see **data trends**. Data trends are noticeable patterns in data over a measure of time.

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Discuss these questions as a class:

1. What trends can you see in your data?
2. Do the numbers in the table give you enough information to enable you to make a decision about which predators to include in your aquarium?

1.4 CREATING COORDINATE GRAPHS

Scientists create graphs to better visualize trends and relationships between variables. In this Crab Aquarium Challenge, plotting your data on a graph might make it easier to understand the crab and predator behavior. You can then use that information to make a decision about which animals should be put together to create a balanced habitat.

To create a graph, we will first need to transfer all of our data in the data tables to sets of coordinate pairs (X, Y). After we have all coordinate pairs for our data we will begin to plot our points. You will plot the points for the blue crab as well as your individual predator on *Results Graph for Data Trial 1* on a graph known as a coordinate plane.

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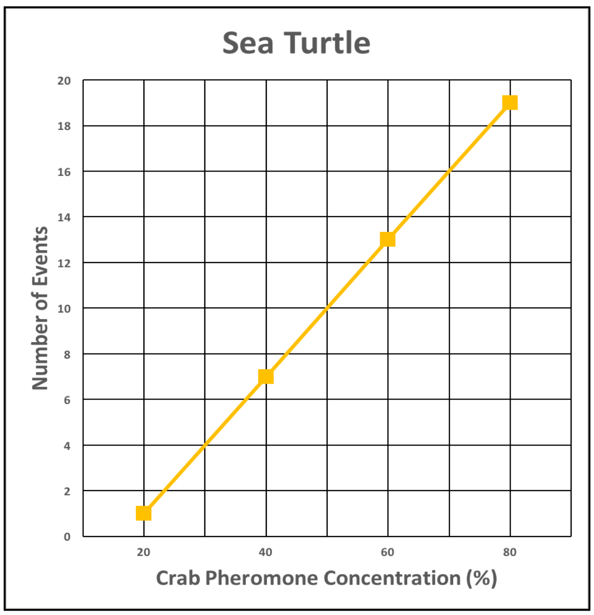
PART 1 of 2 – Add to Your Understanding: Graphing on a Coordinate Plane

Graphs are a visual way to display data and are valuable because they make trends easier to see. A coordinate plane graph is a type of graph that shows the relationship between two variables.

- **Independent Variable** – variable on the horizontal axis that the scientist changes. (Crab Pheromone Concentration Percent)
- **Dependent Variable** – variable on the vertical axis that the scientist observes to see how it responds to the changes. (Number of Events)



All graphs should have the following features:

- Title
- Horizontal axis label and units (if label is a measurement)
- Vertical axis label and units (if label is a measurement)
- Legend (only if more than one set of data is graphed on the same graph)

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Creating Coordinate Pairs

The coordinate pair is a sequence of numbers that can be graphed. The independent variable (X) is first, and the Dependent Variable (Y) is second. They are written as (X , Y)

Example:

Crab Pheromone Concentration (%)	20	40	60	80
Sea Turtle	1	7	13	19

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Discuss this question as a class:

1. What are the four coordinate pairs that can be created from the example above?

PART 2 of 2 – Create Your Coordinate Pairs and Graph the Data

Procedure:

1. On your *Results Graph for Data Trial 1*, create your coordinate pairs for the blue crab and your predator, using the data from your *Mating and Predator Investigation Sheet for Data Trial 1*.
2. Graph the data on the *Results Graph for Data Trial 1*.

SECTION 2 – ANALYZE MATING AND PREDATOR EVENTS

2.1 ANALYZING DATA DIFFERENCES

We will begin by analyzing the difference in the data for the crab mating event data. Your crab mating data table should look like the table below.

Crab Pheromone Concentration (%)	20	30	40	50	60	70	80	90	100
Number of Crab Mating Events	4	6	8	10	12	14	16	18	20

To analyze the difference in the data we will find the difference between the data values for both the independent and dependent variable. We will show we are taking the difference between the values by using the symbol . This symbol will mean we are subtracting the data value on the left from the data value on the right.

Below you will see that we subtracted 30 – 20 for the independent variable

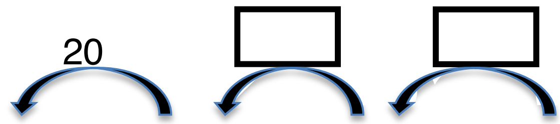
10

Crab Pheromone Concentration (%)	20	30	40	50
Number of Crab Mating Events	4	6	8	10

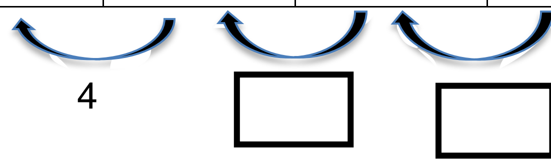
2

Above you will see that we subtracted 6 – 4 for the dependent variable.

What are the data difference analysis values for the example crab mating event table below? Discuss your answers with your group.



Crab Pheromone Concentration (%)	20	40	60	80
Number of Crab Mating Events	4	8	12	16



After you have confirmed the correct data difference analysis values with your group for the crab mating events above, do a data difference analysis for your Crab Mating Event data table and Predator Event data table on your *Mating and Predator Investigation Sheet for Data Trial 1.*

Discuss these questions as a class:

1. Was the data difference the same for all of the predators?
2. Which predator dependent variable had a difference that was **not** consistently the same?
3. How does the inconsistent predator dependent variable impact the graph for that predator? Why?

2.2 ADD TO YOUR UNDERSTANDING: DATA DIFFERENCE, RATE OF CHANGE, LINEAR AND NON-LINEAR RELATIONSHIPS

The analysis of the data shows that the sea turtle had an inconsistent data difference. It begins with a difference of 2 then turns into a difference of 1. Scientists use the data difference analysis to describe graphs. They make a ratio of the data difference of the dependent to the independent variable called **rate of change**.

10 10 10 10 10 10 10 10

Crab Pheromone Concentration (%)	20	30	40	50	60	70	80	90	100
Number of **Sea Turtle** Predator Events	1	3	5	6	7	8	9	10	11

2 2 1 1 1 1 1 1

Inconsistent Data Difference

Initial **Rate of Change:**

$$\frac{\text{Difference of Sea Turtle Predator Events}}{\text{Difference of Crab Pheromone Concentration}} = \frac{2}{10}$$

New **Rate of Change:**

$$\frac{\text{Difference of Sea Turtle Predator Events}}{\text{Difference of Crab Pheromone Concentration}} = \frac{1}{10}$$

When an event shows a rate of change that is constant, it is called a **linear relationship**. If the rate of change is NOT constant, then it is called a **non-linear relationship**.

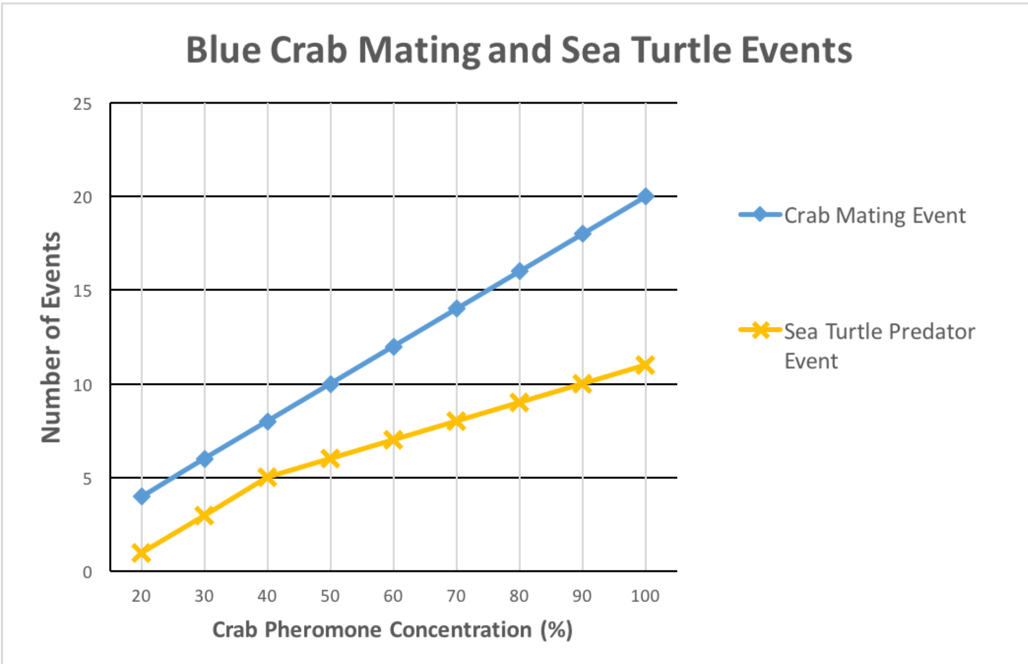
KEY WORDS

Rate of change: ratio of the data difference of the dependent to the independent variable

Linear relationship: constant rate of change

Non-linear relationship: rate of change that is not constant

The graph for the crab mating and sea turtle predator events are shown below. In the graph, you can easily see, or visualize, the difference between linear and non-linear data.



Discuss this question as a class:

1. Looking at the graphs of all the predators, which ones are linear, and which are non-linear?

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2.3 RATE OF CHANGE

Look at the croaker data difference below. Is the difference consistently the same? The ratio of the dependent variable difference to the independent variable data difference is also known as the **rate of change**.

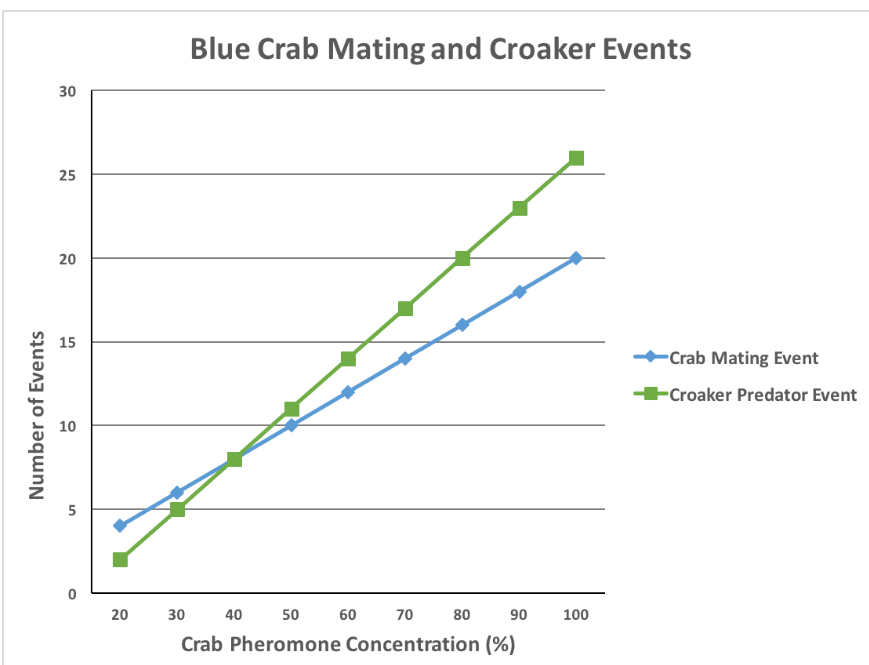
$$\textbf{Rate of Change} = \frac{\text{Dependent Variable Data Difference}}{\text{Independent Variable Data Difference}} = \frac{3}{10}$$

10 10 10 10 10 10 10 10

Crab Pheromone Concentration (%)	20	30	40	50	60	70	80	90	100
Number of **Croaker** Predator Events	2	5	8	11	14	17	20	23	26

3 3 3 3 3 3 3 3

Because of this consistent data difference, the graph of the croaker predator data is **linear**. The graph of the blue crab data and the croaker predator is shown below. Notice that both are **linear**.



Since the **rate of change** is linear for the croaker, it is consistent no matter which set of coordinate data pairs we use. If the data is linear, then we can find the **rate of change** for any two coordinate pairs and they will be the same.

Let's look at finding the **rate of change** for the coordinate pairs highlighted in red below.

10 10 10 10 10 10 10 10

Crab Pheromone Concentration (%)	20	**30**	40	50	60	70	**80**	90	100
Number of **Croaker** Predator Events	2	**5**	8	11	14	17	**20**	23	26

3 3 3 3 3 3 3 3

To find the Rate of Change for the coordinate pairs **(30, 5)** and **(80, 20)** we subtract to find their data differences:

$$\textbf{Rate of Change} = \frac{\text{Dependent Variable Data Difference}}{\text{Independent Variable Data Difference}} = \frac{20-5}{80-30} = \frac{15}{50} = \frac{3}{10}$$

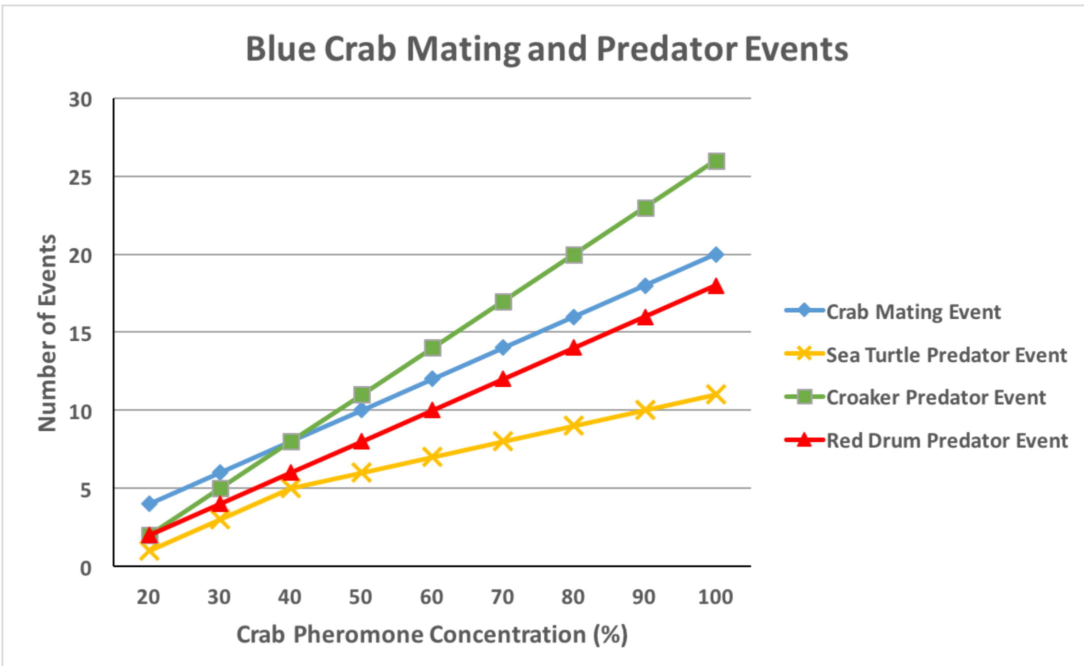
Discuss these questions as a class:

1. Can you find the rate of change for the coordinate pairs (40, 8) and (60, 14)?
2. Can you find the rate of change for the coordinate pairs (20, 2) and (90, 23)?
3. What should we expect the rate of change to be of any two coordinate pairs of the croaker predator event data? Why?

2.4 INTERPRETING THE DATA AND THE GRAPH

Scientists analyze data and graphs to understand trends and relationships between variables. Graphs can give a visual understanding of the trends and relationships between variables. This visualization of the data makes the data easier to understand and communicate.

When we put all of our predators on one graph, it creates the graph below. This is the same graph that you made with your teacher.



Discuss these questions as a class:

1. Are the rates of change of all the predators the same?
2. How does the Rate of Change of each of the predator events compare to the crab mating events?
3. Based on the graph which predator(s) would your group use to balance this aquarium ecosystem? Why?
4. Which predator would be the worst to balance this aquarium ecosystem? Why?

SECTION 3 – AQUARIUM HABITAT #2

3.1 NEW AQUARIUM

Dr. Weissburg has now built a new aquarium that has different amounts of water in it and a different pump that circulates the water. He is wondering whether this might change the results of the experiment. To test this, he sent new containers to us with simulated data collected from his lab. Your job is to analyze, interpret, and draw conclusions from this new data.

PART 1 of 2 – Carry out the Data Trial 2 Investigation

Remember that your team's container has **blue** counters, **green** counters, **red** counters, and **yellow** counters. Each person in the group should select a different predator than in data trial 1.

Procedure:

1. Make sure your team has all the necessary materials. This time, you will use the *Mating and Predator Investigation Sheet for Data Trial 2*.
2. Each person in the group will select a different predator to study. Write the name of each person in your group and their selected predator on the *Mating and Predator Investigation Sheet for Data Trial 2*. Circle the name of your individual predator in the Predator Event Data section.
3. Each team will investigate what happens at ONE concentration of pheromone. You will then share data with the rest of the class to complete your data sheet.
4. Empty your container into a cardboard tray that has the *Mating and Predator Sorting Sheet* in the bottom of the cardboard tray.
5. Separate the counter into the quadrants for mating and predator events on the *Mating and Predator Sorting Sheet*. Count the number of colored counters in each quadrant.
6. Record the crab number and the number for your predator in the event data table on your *Mating and Predator Investigation Sheet for Data Trial 2.*
7. Look on the bottom of your container to see the crab pheromone concentration percent (%). You will record your data on your sheet only for your concentration percent (%).

PART 2 of 2 – Communicate Your Data

Each group will report the results of its investigation to the whole class, and this will enable you to fill in your event data tables on your *Mating and Predator Investigation Sheet for Data Trial 2.*

Procedure:

1. Each group should report the number of crab mating and predator events that occurred at their concentration of pheromone.
2. Record the number of crab mating events for each pheromone concentration in the data table on their *Mating and Predator Investigation Sheet for Data Trial 2*.
3. Record the data for all predators in this aquarium. You should then have two complete data tables—one for crab, and one for a predator.
4. On your *Results Graph for Data Trial 2*, create your coordinate pairs for the blue crab and all predators, using the data from your *Mating and Predator Investigation Sheet for Data Trial 2.*
5. Graph the data on the *Results Graph for Data Trial 2*.

3.2 ANALYZING MATING AND PREDATOR EVENTS

Similar to Habitat #1, we will analyze the data difference for the crab mating events and the predator events. Based on the graphs, what should we expect to happen to the **rate of change**? Why?

PART 1 of 3 – Analyzing Data Difference

Analyze the data difference for the crab mating event data and your predator data on the *Mating and Predator Investigation Sheet for Data Trial 2.*

PART 2 of 3 – Analyzing Rate of Change from Habitat #2

Find the **rate of change** for Habitat #2. Remember that to find the **rate of change**, you should divide the dependent variable data difference by the independent variable data difference.

$$\textbf{Rate of Change} = \frac{\text{Dependent Variable Data difference}}{\text{Independent Variable Data difference}}$$

Calculate the **rate of change** for your crab and predator event data for Habitat #2. Share your data with your group, and record the data at the bottom of *Mating and Predator Investigation Sheet 2 for Data Trial 2.*

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Discuss these questions as a class:

1. Did the rate of change of any of the predators change from the first data trial?
2. How does the rate of change of each of the predator events compare to the crab mating events for the second trial?

PLEASE DO NOT WRITE IN THIS BOOK.

SECTION 4 – ANSWER THE CHALLENGE

4.1 INTERPRETING AND COMMUNICATING THE DATA

Graphs are meant to communicate information and help you to make decisions. Think about what your graphs mean.

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Discuss these questions as a class:

1. What will happen to the population of crabs if the crabs are eaten more quickly than they are able to reproduce?
2. Predators that are most attracted to the crab pheromone will find and eat the crabs the quickest. Which predators do you think are most attracted to the crab pheromone?

Using the information that you learned from Dr. Weissburg's simulation, write a *Recommendation Letter* recommending which predators you would put in the blue crab tank. Use evidence from the simulation to support your decisions.

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