SCIENCE·3D

SEA TURTLE 360

In this packet, sample student answers are provided in red and notes to teachers are in blue.

In this **Science Mission**, students will use data from Abaco, The Bahamas to develop hypotheses and test their predictions to investigate how nutrients affect plant growth and how the amount and quality of food influence where sea turtles are found. They will also explore the diets of sea turtles in different ecosystems and test predictions on how sea turtles might influence seagrass ecosystems. This mission challenges students to develop hypotheses and test predictions using data.

Note: Students will need different colored utensils to create a stacked bar graph in Activity 2.

Biologist Dr. Beth Whitman is studying the green sea turtles and seagrasses of Abaco, The Bahamas. She wants to know why turtles are found in some areas more than others and if turtles might influence how much seagrass there is in different areas. To answer her questions, she needs to investigate both turtles and seagrass. For example, she needs to know what factors besides turtles might influence the seagrass. For many plants, the amount of nutrients they can get is important for their growth. Light can also be very important. You've seen how Dr. Beth collects her data. Now let's get to work!

ACTIVITY I: WHERE'S THE FOOD?

To understand where turtles might want to spend their time, we need to know about the conditions in their ecosystem. One factor to consider is a turtle's food. Animals need two things from their food – energy and nutrients. How much energy a green sea turtle gets is usually determined by how much total seagrass it can eat. But, how much it gets of different nutrients, like nitrogen and phosphorus, depends on the nutrition levels of the seagrass. In other words, the amount of nitrogen and phosphorus in each bite of seagrass matters!

Plants also need nutrients to grow. Dr. Beth took measurements of the nutrients in the water near and far from blue holes. She sampled three different areas. **Zone 1** was within 200 meters of blue holes. **Zone 2** was further away, between 500 and 1,000 meters from blue holes. **Zone 3** was very far, 5,000 meters or more, from blue holes. She found higher levels of nitrogen and phosphorus in the blue holes. Dr. Beth would like to know if those nutrients end up in seagrasses and whether or not the extra nutrients help the seagrasses grow more.

Another possible factor that would influence the growth of seagrass is the amount of light they get, since they need the energy from the sun for photosynthesis to make sugars. Because of the tides in the area, some water from blue holes may travel hundreds of meters. Dr. Beth found that the most light gets to the bottom in Zone 3, an intermediate amount of light in Zone 2, and the least amount of light near blue holes in Zone 1. However, the water in The Bahamas is quite clear, so there is still a lot of light near blue holes.

1. **Circle** the correct words to complete each hypothesis:

   If nutrients help plants grow, then I think that seagrasses closer to the blue hole will have **more**/**less** nitrogen in their leaves.

   I think that seagrasses closer to blue holes will grow **faster**/**slower**/**at the same rate** compared to seagrasses farther from blue holes.

2. **Calculate** the averages for the data in the table below.

Table 1. Amount of nitrogen in seagrass of Abaco in three study zones

Seagrass Sample Number	Zone 1	Zone 2	Zone 3
1	2	2.5	1.5
2	2.5	1.5	1.75
3	2	1.5	2
4	2.5	2.5	1.25
5	2.5	2	1.5
6	2.5	1.5	1.25
7	2.5	2	1
8	2.5	1.75	1.25
9	2	2	1.5
10	2.5	1.75	1.5
Average	2.35	1.9	1.45

3. **Complete** the table below with predictions based on information in the paragraph on page 2 and the data in Table 1. Using the number 1 for most important and the number 3 for least important, rank the three zones by how fast seagrass should grow if light determines the speed of seagrass growth. Then, rank the three zones by how fast seagrass should grow if the amount of nitrogen (nutrients) determines the speed of seagrass growth.

	Light is most important	Nutrients are most important
Zone 1	3	1
Zone 2	2	2
Zone 3	1	3

4. **Calculate** the averages for the data in Table 2 below.

Table 2. Growth rates of seagrass leaves at different distances from blue holes (mm/day)

Site	Zone 1	Zone 2	Zone 3
1	2	0.3	0.4
2	1.25	0.8	0.2
3	1	1.2	0.3
4	2	0.4	0.2
5	1.75	1.4	0.3
6	1.5	0.4	0.3
7	1.5	1.5	0.4
8	1	0.8	0.2
9	1.25	0.5	0.4
10	1.75	0.7	0.3
Average	1.5	0.8	0.3

5. **Draw** a bar graph that shows the differences in leaf growth rate across the three sampling areas. Labels the axes and caption the figure.

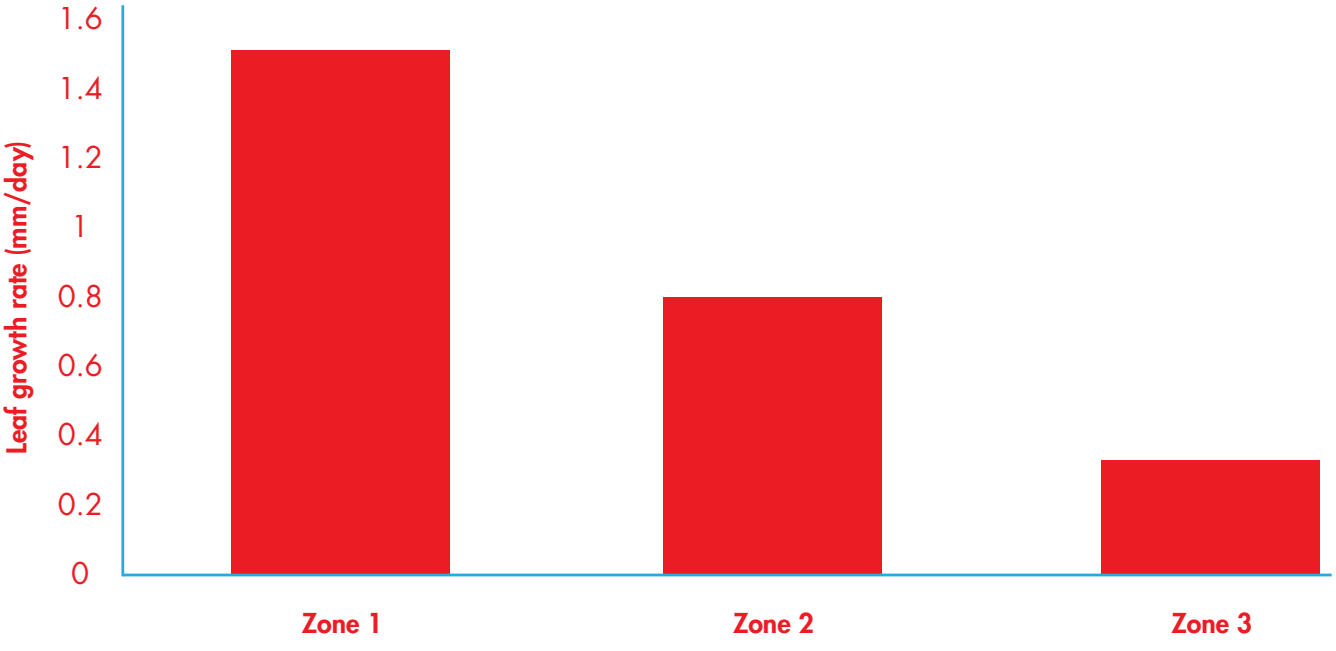

Figure 1. Differences in leaf growth rate at different distances from blue holes

6. Based on your graph and predictions in question 3, **describe** what factor you think is most important for determining how quickly seagrasses grow. Use evidence from the data to support your answer.

I think that nutrients are the most important factor in determining how quickly seagrasses grow. Seagrasses near blue holes, where there are the most nutrients in the water, have the highest nitrogen levels. They also grow the fastest. If light were the most important factor, seagrass near blue holes should not have grown faster because the least light reaches the bottom.

7. Previous studies have shown that seagrasses with different genes grow at different rates. However, the seagrasses in the three areas sampled in this study have the same genes. Based on this information and the data in Tables 1 and 2, how do you think genetic and environmental factors influence seagrass growth? Cite evidence to support your claim.

Both genetic and environmental factors influence seagrass growth. The data in the tables show that seagrasses in areas with different nutrients grow at different rates, even when they have the same genetic make-up. But, the previous study shows that genes can affect growth too.

8. Based on what you have learned so far, **predict** where there will be the most seagrass if both nutrients and seagrass growth rates affect the amount of seagrass in an area. **Describe** your reasoning for your prediction.

Accept any reasonable and logical predictions. Many students might predict that there would be the most seagrass near blue holes because that is where there are the most nutrients and the fastest growth rates.

Dr. Beth and the team measured the amount of seagrass found in each area. They did this by seeing how much of the area inside a square meter is covered by seagrass. To take measurements, they drove the boat to a random location within the sampling area. Then they threw the square over their shoulder so they couldn't see where it lands. They assign a "cover score" based on how much of the bottom inside of the square is covered by seagrass. If there is no seagrass, the score is 0. If the entire bottom is covered in seagrass, the score is 5. These data are in Table 3, below.

9. **Calculate** the average scores for each habitat and fill in Table 3 below.

Table 3. Amount of nitrogen in seagrass of Abaco in three study zones

Seagrass Sample Number	Zone 1	Zone 2	Zone 3
1	1	3	2
2	4	3	5
3	3	2	2
4	3	2	5
5	1	2	4
6	2	0	1
7	3	2	4
8	2	4	5
9	2	2	5
10	0	3	5
Average	2.1	2.3	3.8

10. Use the data in Table 3 to **draw** a bar graph of the average cover score of seagrass in each location. Label the axes and caption the figure.

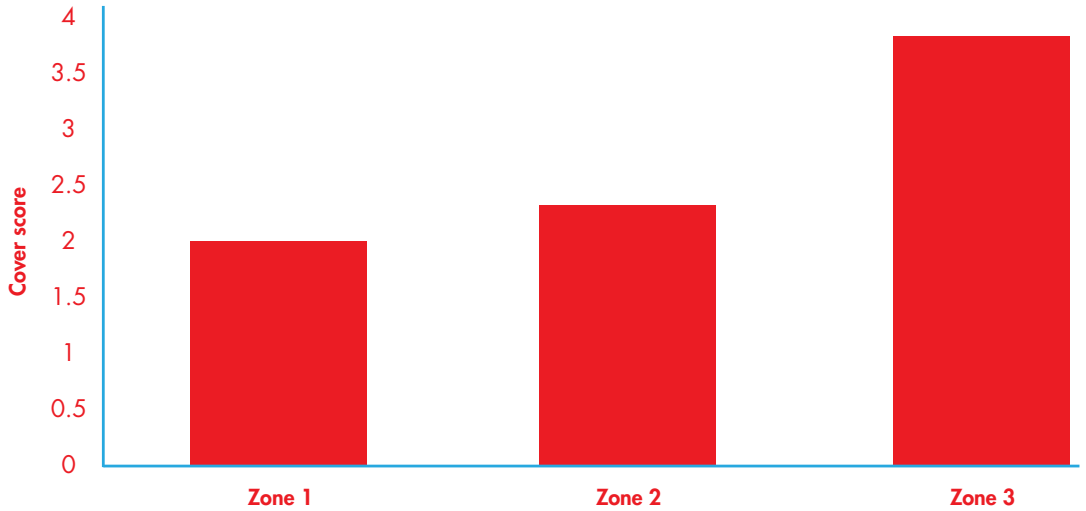

Figure 2. Differences in cover scores at different distances from blue holes

11. Does your figure from question 10 support or reject your hypothesis about the role of nutrients and growth rates in determining how much seagrass is in an area? Provide evidence to support your answer.

Most students will answer that their graphs did not support their hypotheses. They thought there would be the most seagrass near the blue holes and the least far from it. This means that nutrients are not likely a contributing factor to the amount of seagrass in an area.

Extend the lesson: In the Mission Reader, students learned about how runoff can lead to algae blooms. These blooms can reduce the visibility of water and the amount of light that gets to the bottom for seagrass. Have students make a poster and/or discuss what they think might happen to seagrass growth rates, cover scores, and turtles if light levels were to drop in the waters of Abaco.

ACTIVITY 2: WHAT DO GREEN TURTLES EAT?

In this case, maybe your hypotheses were not supported! Sometimes we learn even more when our guesses are incorrect! This just means that additional investigations are needed. The amount of producers in an area, or their biomass, can be influenced by how much light they get and how many nutrients are available. But, they can also be influenced by the herbivores that eat them! After all, if all that growth just ends up in the belly of an herbivore it won't be in the habitat.

Green turtles are usually thought of as herbivores. That means they eat only producers, like seagrass and algae. Scientists have attempted to find out if this is the case everywhere. Dr. Beth and the team put cameras out in Abaco to record turtle eating behaviors. Dr. Mike and his colleagues in Western Australia have collected videos from green turtles in a place called Shark Bay. Use the data in Table 4, 5 and 6 to compare and contrast the diets of green turtles in The Bahamas and Western Australia.

1. **Calculate** the average percent of each possible food type in the diets of the turtles represented in the tables below. (Jellyfish and comb jellies are invertebrate animals that drift in the plankton.)

Table 4. Percent of different foods eaten by green turtles wearing cameras in Shark Bay, Western Australia

Turtle #	Seagrass	Algae	Sponges	Jellyfish and comb jellies	Crabs	Fish
1	100	0	0	0	0	0
2	0	0	0	100	0	0
3	0	0	20	80	0	0
4	0	0	10	90	0	0
5	60	20	10	10	0	0
6	100	0	0	0	0	0
7	50	50	0	0	0	0
8	0	0	20	80	0	0
9	10	0	0	90	0	0
10	90	10	0	0	0	0
Average	41	8	6	45	0	0

Table 5. Percent of different foods eaten by green turtles wearing cameras in Abaco, The Bahamas

Turtle #	Seagrass	Algae	Sponges	Jellyfish and comb jellies	Crabs	Fish
1	100	0	0	0	0	0
2	100	0	0	0	0	0
3	100	0	0	0	0	0
4	100	0	0	0	0	0
5	100	0	0	0	0	0
6	100	0	0	0	0	0
7	80	20	0	0	0	0
8	100	0	0	0	0	0
9	100	0	0	0	0	0
10	90	10	0	0	0	0
Average	97	3	0	0	0	0

2. Now **compare** the turtles' diets in the two locations. Use the data in Tables 4 and 5 to complete Table 6.

Table 6. Comparison of average diets of green turtles in Shark Bay, Australia and Abaco, The Bahamas

Green Turtle Diet	Australia	The Bahamas	Expected if turtles ate prey in equal amounts
Seagrass	41	97	16.7
Algae	8	3	16.7
Sponges	6	0	16.7
Jellyfish/Comb jellies	45	0	16.7
Crabs	0	0	16.7
Fish	0	0	16.7

3. Use the data in Table 6 to complete a stacked bar graph to compare the diets of turtles in the two locations. Fill in the legend below the graph and caption the figure.

Note: Some students may need help figuring out how to make the stacked bar graph. They can figure out where each bar should end by adding the percentage of the group they are working on to the total number from all the ones that had been graphed before.

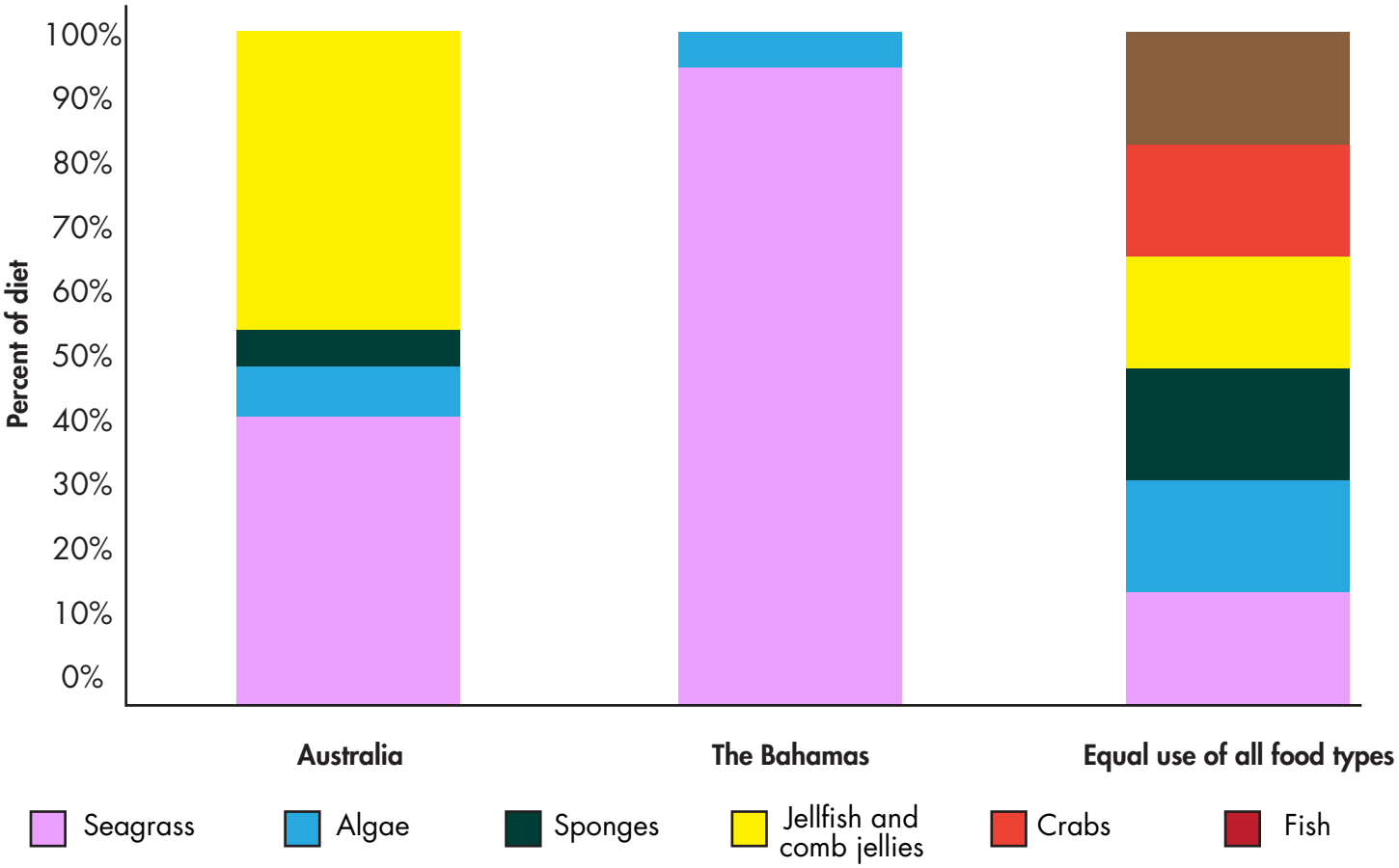

Figure 3. Comparison of diets [food/prey] of green turtles in Australia and The Bahamas

4. **Compose** a paragraph that compares and contrasts the diets of green turtles in both locations.

Complete answers should include that green turtles eat seagrass and algae in both areas, and some individuals only ate producers. In Shark Bay, some turtles ate animals like sponges and jellyfish. Some individuals only ate these animals.

5. **Describe** why it was important that the science teams collected data from many different turtles. Use evidence in Tables 4 and 5.

There was a lot of variation among individuals in Australia. Only sampling one turtle may have given an inaccurate reflection of turtle diets.

6. Are green turtles in The Bahamas herbivores? Use evidence to support your answer.

Yes, they only ate producers.

7. Are green turtles in Shark Bay, Australia herbivores? Use evidence to support your answer.

No, herbivores eat producers and in Australia, turtles are eating a lot of animals.

8. Is the ultimate source of energy and matter the same for green turtles in The Bahamas and Australia? Use evidence to support your answer.

Yes, it is the same. The ultimate source of energy is the sun. Even green turtles in Australia that eat animals ultimately get energy from the sun that has passed through producers. The source of the matter is also the same. The matter comes from the carbon dioxide and nutrients that enter producers and then are passed through the food web. Some students may say the source of matter is different because the diets are different. This answer should be accepted but be sure to talk to students about where the matter that entered those animals came from, so they understand the flow of energy and the cycle of matter.

9. **Predict** why there are differences in what green turtles eat in the two locations.

Accept all reasonable answers that involve a testable idea. Students might say that they think there are different amounts of the different prey food types in each area. They may suggest that genetic differences are the reason.

10. **Describe** how you would test your hypothesis from your answer above.

Accept all reasonable answers that test their hypotheses. They might suggest surveying the ecosystem to see what food is available to turtles or testing different prey to see if they have different amounts of energy or nutrients.

ACTIVITY 3: WHERE ARE TURTLES FOUND AND COULD THEY AFFECT SEAGRASSES?

Now we know what turtles in Abaco eat. Let's continue our investigation to determine if turtles influence how much seagrass is in an area. A lot of turtles would be needed to keep the amount of seagrass low. To investigate this possibility, we need to measure the density of turtles, or the number in a given area. Dr. Beth measures the number of turtles per square kilometer by flying drones over each study area. This method allows her to see all the way through the water to the bottom to observe all of the turtles. Once Dr. Beth completes her flights, she and the team watch the videos and count the number of turtles that were recorded on each drone flight. Then, she divides the number of turtles counted by the area (square kilometers) the drone flew over. These calculations let her compare the density of turtles in different areas even if she flies over areas of different sizes.

1. **Predict** in which Zone (1, 2 or 3) you think turtle densities will be highest. **Explain** why you made this prediction using the data you already analyzed.

Students may think that turtle density will be highest *near* blue holes (Zones 1 and 2) where the seagrass grows fastest and is more nutritious since sea turtles of Abaco eat mostly seagrass. They may also argue that there must be the greatest density near blue holes because so much seagrass seems to be disappearing. Alternatively, students may argue there should be the most turtles in Zone 3, which has the most seagrass. Either of these, or any other well-reasoned and testable hypothesis is acceptable.

2. **Draw** a bar graph of what you predict turtle densities will be in the three sample areas.

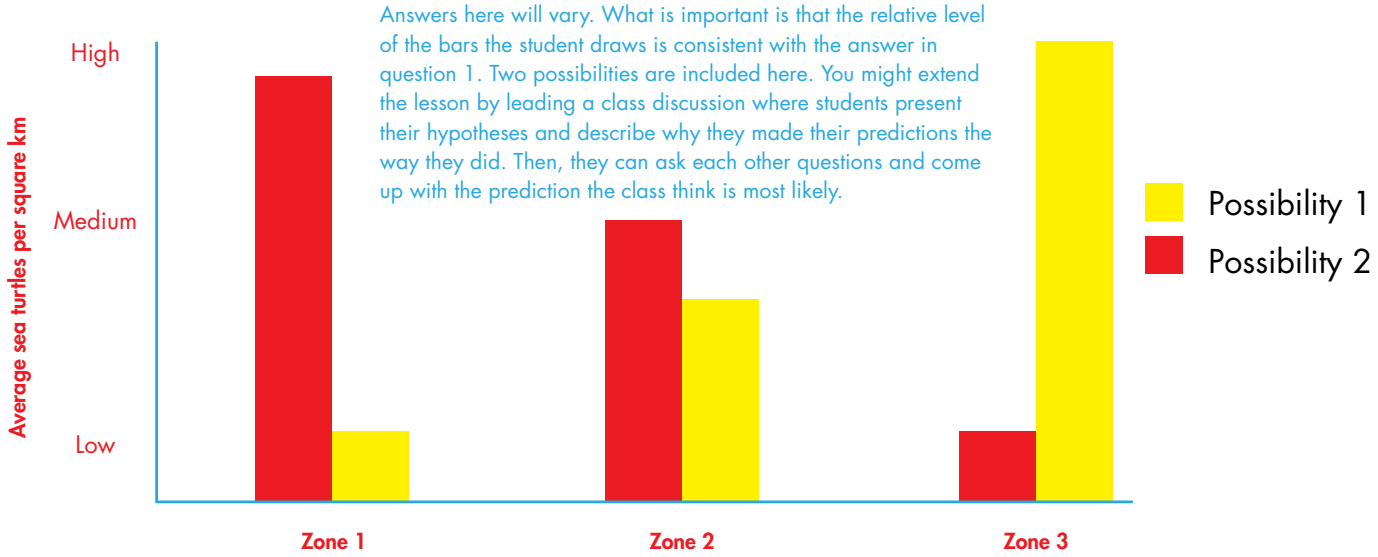

Figure 4. My prediction of turtle densities in different areas of Abaco

Table 7 summarizes the data Dr. Beth collected using drones.

3. **Complete** Table 7 by calculating the average densities of turtles.

Table 7. Turtle densities in three study sites off of Abaco, The Bahamas

Flight Number	Zone 1 (Turtles per km^2)	Zone 2 (Turtles per km^2)	Zone 3 (Turtles per km^2)
1	150	125	5
2	75	50	25
3	100	75	0
4	125	125	5
5	50	100	5
6	25	50	0
7	100	75	25
8	125	25	10
9	150	0	5
10	125	25	10
11	150	50	10
12	150	125	0
13	225	75	10
14	100	25	5
15	50	100	0
16	150	50	15
17	75	75	0
18	25	50	5
19	150	20	5
20	100	50	0
Average	110	63.5	7

Ask students to look at the table and make an argument for why the drone needed to be flown many times in each habitat. They should understand that there are differences in data within each sample area. More flights means more accurate data.

4. **Draw** a bar graph of the average density of turtles in each study site. Label the axes and caption the figure.

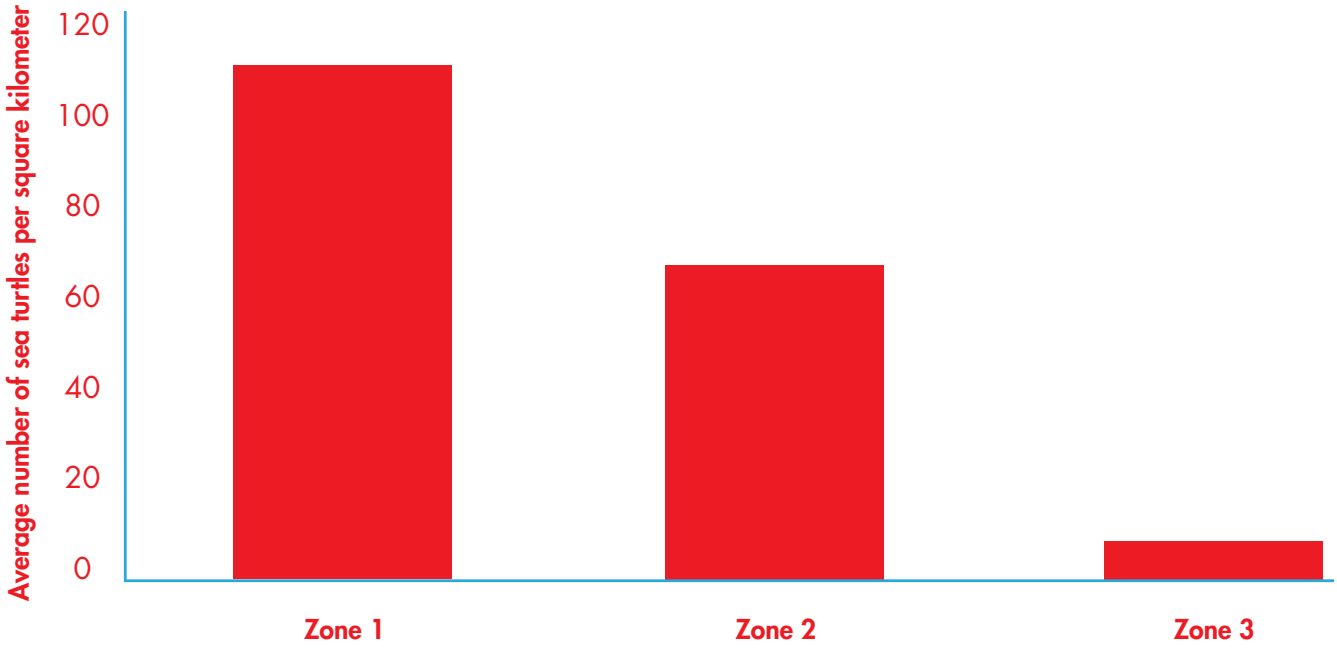

Figure 5. Densities of turtles in three study sites of Abaco

5. Was your hypothesis about where turtles should be found supported? **Support** your answer by comparing the figure you drew for question 4 and your prediction from questions 1 and 2.

Answers should be consistent with their prediction and the results. Many students will probably say that their hypothesis was rejected because they thought turtles would be where there was the most seagrass (Zone 3), and this was where there were the least turtles. Others will say that their prediction was supported because there were more turtles where the seagrass had more nutrients and was growing faster.

6. Based on your work so far, do you think that the amount of seagrass in each location is influenced by turtles. **Compose** a paragraph to support your conclusion.

The data support the idea that turtles influence the amount of seagrass in an area. We found out that green turtles eat seagrass. Even though seagrass has more nutrients and grows faster near blue holes, there are fewer seagrasses there. But, there are more turtles in these areas. They may be eating so much seagrass, which could be reducing the amount of seagrass in that area.

One way to test whether herbivores influence the plants in an area is to build cages, called exclosures, that keep herbivores away from the plants. This allows the plants to grow without being eaten. Dr. Beth put five exclosures out in each of the study locations. She also selected five locations without exclocures where she would measure seagrass. She measured the seagrass at the beginning of the experiment and again after several months. Then, she calculated how much more the seagrass grew where it was protected from turtles compared to how much the seagrass grew where turtles could feed on it.

7. **Identify** the control and the experimental treatments in the study described in the paragraph above.

The control is measuring the seagrass where turtles can feed in the areas without exclosures.

The experiment is area with exclosures.

Dr. Beth discovered that the seagrass did not change in the areas where turtles could feed. This was the same in Zone 1 (less than 200 meters from blue holes), Zone 2 (between 500 and 1,000 meters from blue holes) and Zone 3 (more than 5,000 meters from blue holes). But, inside the exclosures there were differences. More than 5,000 meters from blue holes, the seagrass in the exclosure did not change during the experiment. In contrast, between 500 and 1,000 meters from blue holes the seagrass grew more in exclosures than in areas where where turtles could feed (the control). Close to blue holes, the seagrass in the exclosures grew to fill the entire exclosure! Its cover score would be a 5.

8. Based on the summary of the experiment results in the paragraph above, do you think the data support the hypothesis that turtles affect how much seagrass is in an area? **Cite** evidence to support your answer.

Yes, I think the data support this hypothesis. In areas where there are not many turtles, the seagrass doesn't grow more in exclosures. But, near blue holes where there are lots of turtles, protecting the seagrass helps it cover much more area.