SCIENCE 3D

SHARK WORLD

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 experiments and the field to explore how bodies use energy and oxygen and how it changes with water temperature. They will use these data to predict how sharks might be affected by changes in oxygen levels, which are occurring around the world. They will also use data to investigate what affects shark migrations and use math skills to predict how far sharks might move over different amounts of time. Finally, they will use the evidence to decide whether or not hammerhead sharks follow a blacktip shark migration.

Thousands and thousands of blacktip sharks migrate along the eastern coast of the United States every year. At Palm Beach, Florida, these sharks are found in large schools because there is only a narrow strip of shallow water habitat that the blacktips inhabit before the water gets deep. This makes it possible to count the number of sharks migrating and determine what factors might influence the movements of these sharks. It's also a great place for the team to attach scientific instruments to learn more about the blacktips and their predators!

ACTIVITY I: TEMPERATURE, ACTIVITY, AND ENERGY USE

Every year migrating blacktip sharks swim thousands of kilometers from waters as far north as New York to south Florida, and then back again. That takes a lot of energy and body systems working together!

For the first part of the activity, have students work in groups. They should use the **Mission Reader**, books or resources to answer the questions.

1. **List** and **describe** the steps that occur from a blacktip shark eating a fish to it being turned into energy used for swimming. Include the following terms in your answer: **digestive system, circulatory system, respiratory system, oxygen, mitochondria, cell, cellular respiration, energy, muscular system, and nervous system.**

    A. The shark eats the fish.
    B. The fish is broken into nutrients by the digestive system.
    C. The circulatory system delivers nutrients to the body where they are incorporated into cells.
    D. The gills of the shark, a part of the respiratory system, extracts oxygen from the water.
    E. The circulatory system takes the oxygen to the cells of the body.
    F. Inside the cell's mitochondria, oxygen breaks down chemical bonds in cellular respiration.
    G. Breaking down the bonds releases energy that is used by the muscular system of the tail to contract muscles. The nervous system controls these movements.

It is often important to conduct laboratory studies before doing fieldwork. How do scientists measure the amount of energy that sharks use in the wild? Sometimes they measure the amount of oxygen that animals consume because oxygen is used during cellular respiration to release the energy in chemical bonds stored in the body. In the lab, they can measure how much oxygen sharks remove from a tank while swimming. That's not possible in the wild! It is, however, possible to measure how much sharks move. The more they move, the more oxygen they consume. If we know the relationship between movement (also called "overall dynamic body acceleration" or **ODBA**) and oxygen used, we can measure energy use in the wild. The following page shows some results of an experiment to test this!

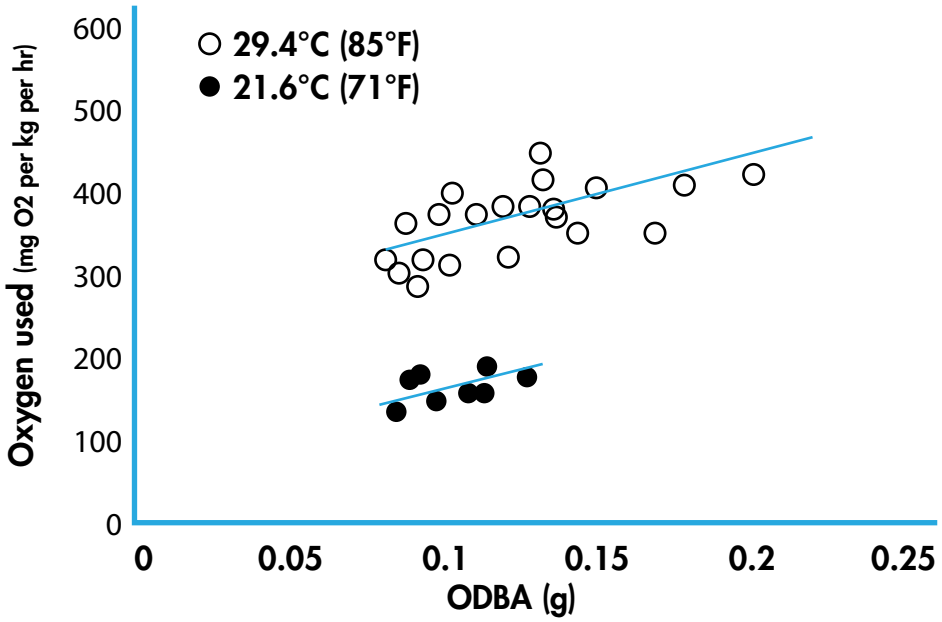


Figure 1. ODBA and oxygen used across two temperatures

2. **Describe** the general relationship between body movement (ODBA) and energy use (oxygen demand). How does this change with water temperature?

In general, the more sharks move, the more energy they use. At higher temperatures the sharks use more energy no matter how much they move.

3. Do you think that measuring ODBA in the wild is a good way to estimate how much energy sharks are using? Use evidence from the graph to support your answer.

Yes, I do think that this is a good measure. There is a good relationship between oxygen use and OBDA. There is not a lot of difference in values of oxygen use for a particular temperature and level of movement. Some students may argue that it isn't good because it varies with temperature. Such an answer should receive credit, but ask the student to consider if their answer would change if they could also measure water temperature during the trials.

4. Warming water temperatures and large areas with diminished oxygen are two problems that blacktip sharks face in the Gulf of Mexico. Alyssa is working to understand how this will affect blacktip sharks. **Predict** how these two problems could affect sharks. Use evidence from Figure 1 to support your answer.

These problems should have a negative impact on sharks. As water warms, they use more oxygen and need more energy. If an area has warmer water and less oxygen, they may not be able to survive. They likely will not be able to get enough energy in that area either. Sharks will probably have to leave the area or they may die.

ACTIVITY 2: THE MIGRATION

Temperature might be one factor that determines how many sharks come to Florida from waters that are further north. It also may influence how long they stay. Use Figure 2 and Figure 3 to answer the following questions.

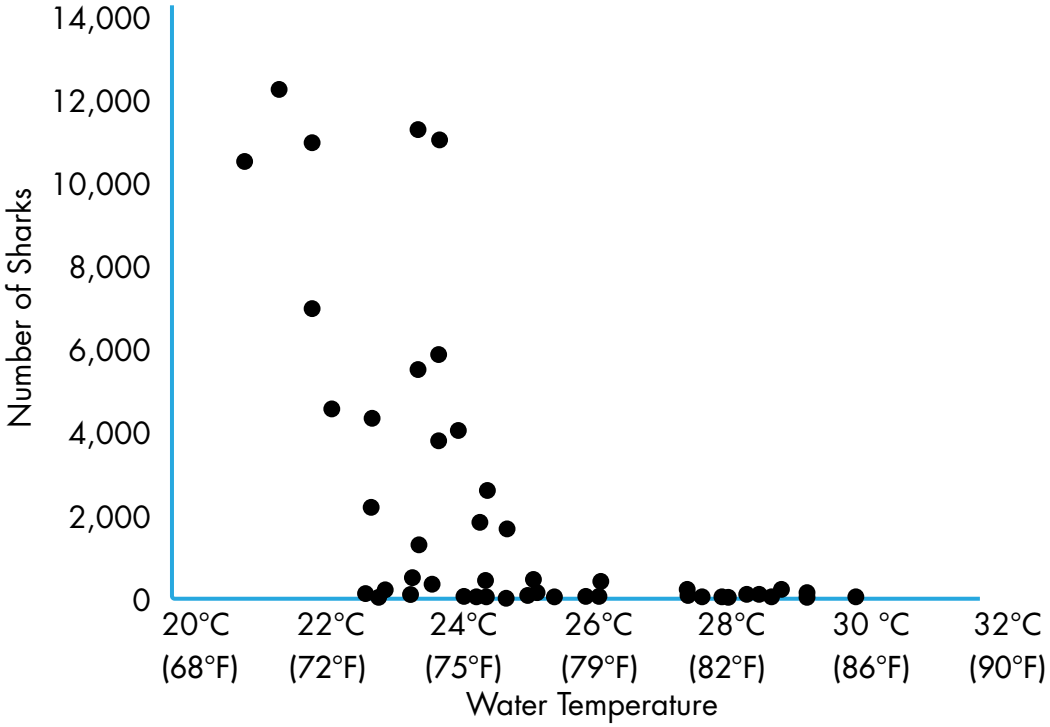


Figure 2. Number of blacktip sharks based on water temperature

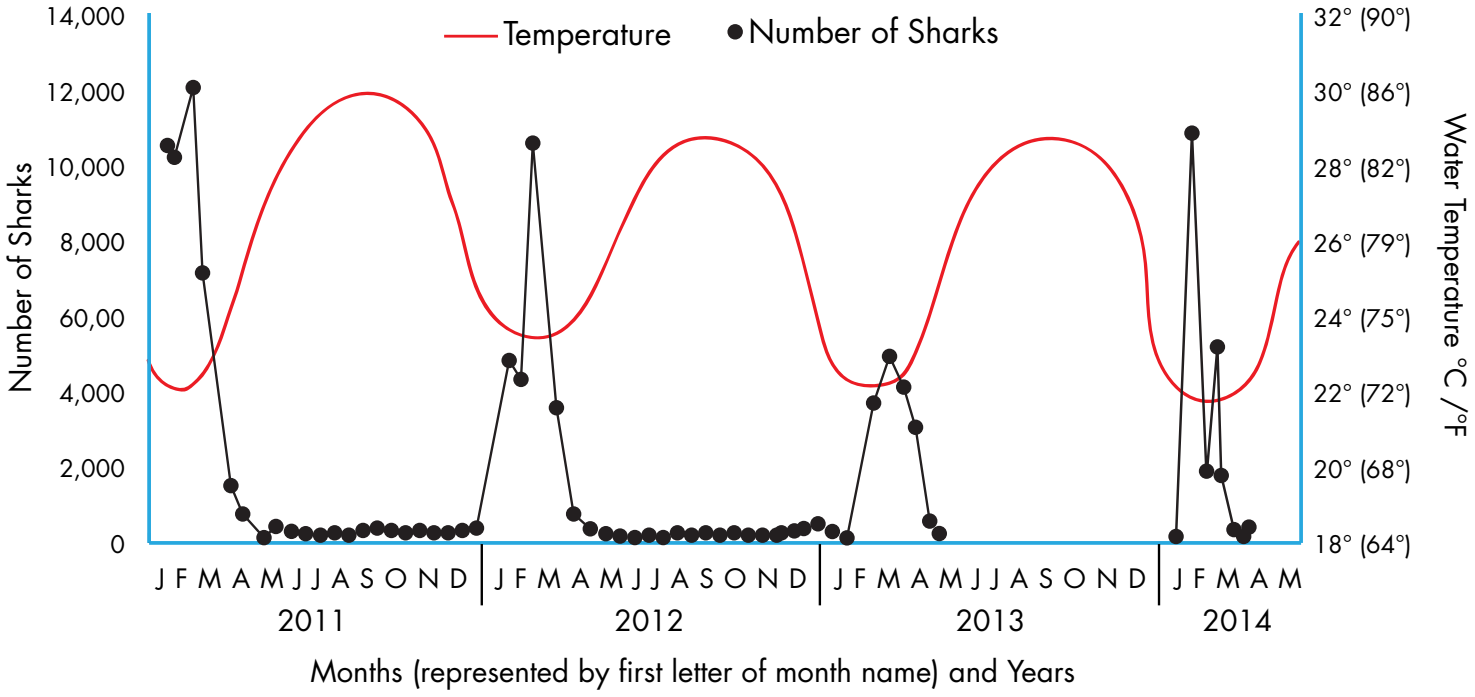


Figure 3. Number of blacktip sharks across water temperature and month from 2011-2014

1. **Describe** the seasonal pattern of blacktip shark presence offshore of Palm Beach, Florida. **Predict** where the sharks are when they are not off Palm Beach.

Sharks are uncommon during most of the year, but they are present in large numbers in February, March, and sometimes in April. I think sharks are probably further north when they are not off Palm Beach. Sharks need more energy when the water is warmer. When waters get very warm, they probably move back north to cooler waters.

2. Do you think that sharks are responding to the water temperatures in Florida, to temperature changes in another location, or to other factors entirely? Use what you have learned from the **Mission Reader**, video, and graphs on the previous page.

Accept any reasonable answers. Students might argue that sharks do respond almost exclusively to the water temperatures in Florida, because there is a strong relationship. A better answer, however, is that they are probably responding to other things as well because there is variation in how many sharks there are at different temperatures. Students might suggest that they respond to temperatures up north by coming south when it gets too cold since sharks are cold-blooded. They might also comment that sharks could be responding to prey or predators. Scientists don't know the answer to this question for sure and it is likely a combination of staying in the right temperature range as well as biological factors (conditions in nursery areas, patterns of prey and predators, mating). In fact, it is thought that the southward migration may be timed to when baitfish are most abundant in more southern waters.

Extend the lesson: Have students design studies to test their ideas about what sharks are responding to when they migrate.

ACTIVITY 3: MAKING TRACKS

We now know when the blacktip sharks are in the waters off of Palm Beach, Florida and that they migrate north when the water warms. Do the hammerhead sharks follow the blacktip sharks all year? Maybe they just take advantage of the opportunity when the blacktips are around. Let's use some data from hammerhead and blacktip sharks to answer this and other questions. Scientists have put special tags that use satellites on the sharks to determine their location. Use the data that comes from these tags and from the shark-cams in addition to what you've learned about blacktip migrations to answer the following questions.

The velocity that the sharks swim can help us. When measured over long periods of time, their velocity will help us calculate how far sharks might swim in a particular amount of time. For example, scientists can predict how long it would take for a shark to swim directly from North Carolina to Florida.

1. Use the data in Table 1 below to complete the table. For distance traveled per day and average distance traveled per day, round your answer to the nearest kilometer. Round all other values to the nearest tenth. To calculate averages, use the values in each column.

Table 1. Swimming distances, time, and velocity of blacktip sharks

Blacktip Shark #	Distance (km)	Time between positions (hrs)	Average velocity (km/hr)	Distance (km) traveled per day (24 hrs)
Blacktip 1	48	24	2.0	48
Blacktip 2	75	50	1.5	36
Blacktip 3	36	20	1.8	43
Blacktip 4	190	100	1.9	46
Blacktip 5	340	200	1.7	41
AVERAGE	137.8	78.8	1.8 Note: If students divide the average distance by average time between positions they will get 1.7.	43 Note: If students got 1.7 in Average velocity, then they would arrive at a value of 41 km per day.

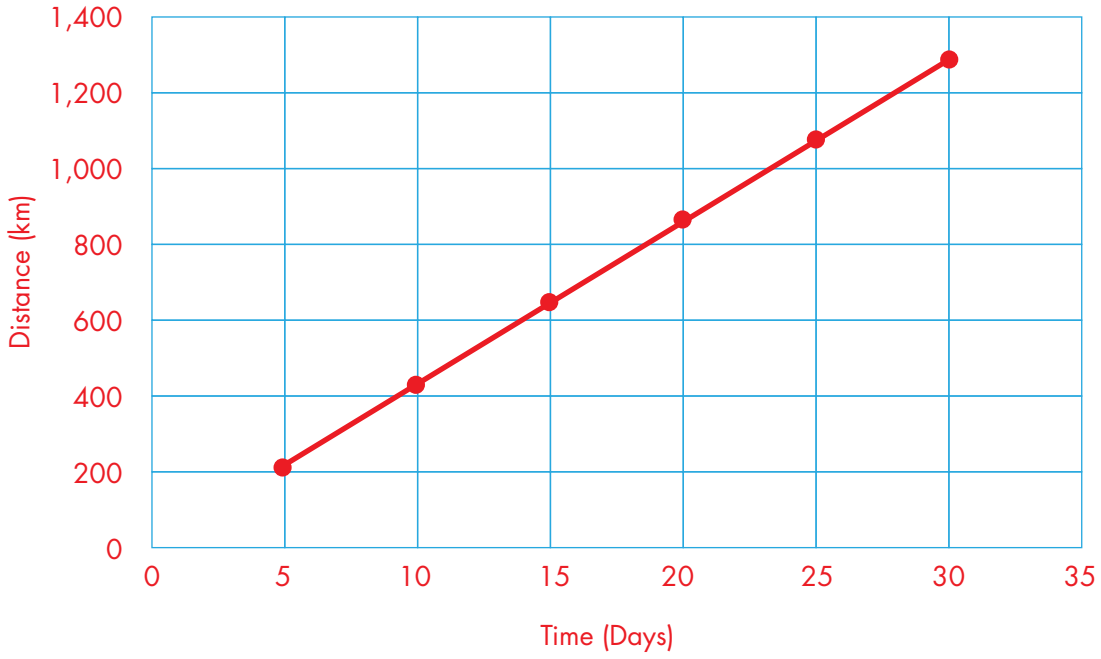
2. Based on your calculation of average distance traveled per day in Table 1, calculate the potential distances blacktip sharks might swim over the time periods in Table 2 below.

Values in blue in the table are if students calculated average velocity and average distance traveled per day based on the average distance (137.8 km) and average time between positions (78.8 hrs).

Table 2. Potential swimming distances of blacktip sharks over time

Days	Potential Distance Traveled (km)
5	215 (205)
10	430 (410)
15	645 (615)
20	860 (820)
25	1,075 (1,025)
30	1,290 (1,230)

3. Use the data in Table 2 above to create a graph to show the distance sharks could travel over time. Provide a title for your graph and label your axes.



Distances blacktip sharks may travel over time.

4. **Describe** how the slope of the line would change if you were to plot the distance sharks could swim over time if your estimate of velocity was based on:

Note: Students may struggle with this question and it could serve as a good classroom discussion. Alternatively, have students plot lines on their graph above for these two sharks and discuss why the lines have more gradual or steeper slopes.

A. Blacktip shark 1 in Table 1

The slope would be steeper because the shark is moving faster than the average velocity. It was swimming at an average of 2 km/hr instead of the overall average of 1.7 km/hr.

B. Blacktip shark 2 in Table 1

The slope would be more gradual because the shark is moving slower than the average velocity. It was swimming at an average of 1.5 km/hr instead of the overall average of 1.7 km/hr.

Extend the lesson: Have students think about the ways that determining average speed and calculating how far something can move over different time periods might be useful in their lives.

Shark-cam revealed some interesting behavior of a great hammerhead shark in the early morning hours. The data for how deep and fast the shark was swimming are shown in Figure 4. The data on swimming speed and depth were recorded by the computer every second.

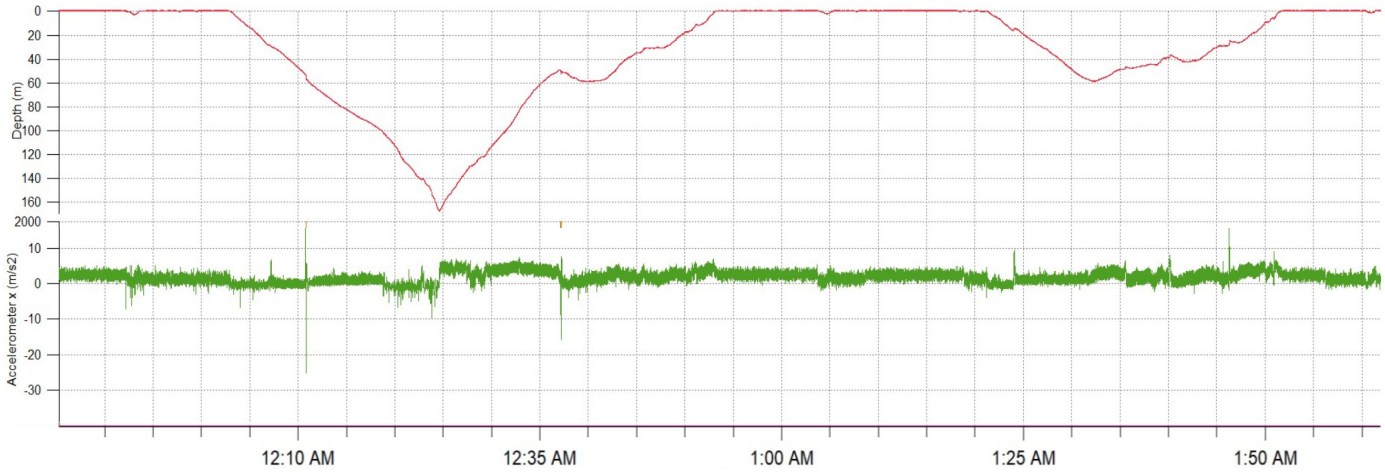


Figure 4. Swimming depth and velocity of a great hammerhead shark measured by Shark-cam

5. **Describe** the swimming depth and speed of the great hammerhead shark based on the data in Figure 1. **Predict** what the shark might have been doing when its behavior changed.

The shark swam near the surface for a while before it swam down to more than 160 m deep. It didn't stay at the bottom for a long time before it swam back to the surface. It stayed at the surface for about a half hour before making another trip down to 60 m. The shark made several very fast swims, over 10 m/sec at around 12:10 a.m. when it was swimming down and at 1:45 a.m. during its second dive.

Accept any reasonable behavior predictions. For example, the shark might have been looking for food or chasing food. It might have been interacting with other sharks.

6. When the positions of hammerhead sharks are measured several days apart (like the blacktip sharks in Table 1), their average speed is usually around 2.5 km/hr. **Compare** and **contrast** this speed to those measured by Shark-cam in Figure 4. What do you think causes these differences?

This question is well suited for a class discussion. Have students think about how fast they move at different times of their days. Have them consider when they are in the car, in class, eating lunch, or playing sports. Then have them think about how their estimates would change if they only measured their position at bedtime every night or where they were several days apart.

For a lot of the time, the swimming speed of the great hammerhead in Figure 4 is similar to this average speed. But, there are times when the shark with Shark-cam swam much faster. This shark may have been chasing prey or interacting with other sharks. When you measure speed by seeing how far a shark travels over a long period of time, you don't measure the fast swims.

Use Figure 5 to answer the following questions.

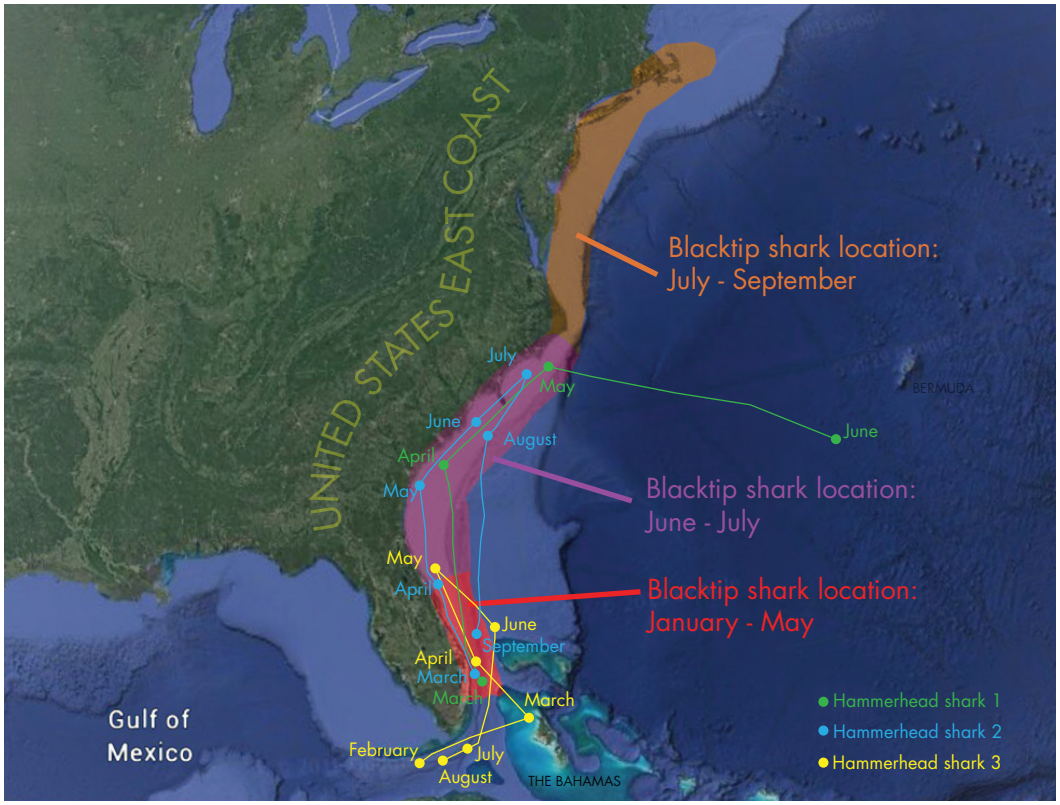


Figure 5. Movements of three tagged hammerhead sharks in relation to the blacktip shark migration

7. Based on the tracks of hammerhead sharks and the blacktip shark migration in Figure 5, do you think that hammerheads are following the blacktips all year? Use evidence from the data to support your answer.

Complete answers will suggest that the hammerheads do not follow the blacktip sharks. Hammerheads were in the same area when blacktip sharks were in Florida. However, when blacktip sharks moved north, the hammerheads were in places that the blacktip sharks were not.

8. Do you think that enough hammerhead sharks have been tracked to figure out why they move in the ways that were observed? Why or why not?

I do not think that enough sharks have been tracked to make any conclusions on reasons for their movement. Every shark did something different, so it is hard to know why they behaved the ways they did.