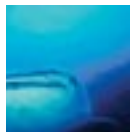


## Shark detectives



Oceans are often considered mysterious, fascinating places filled with unique and scary animals. One of the most misunderstood and therefore scariest animals is the shark, yet the whale shark, the world's largest fish, is considered harmless to humans. This student-directed activity involves research, deductive reasoning, and students' own curiosity to solve a mystery involving whale sharks. During the course of solving the case students learn about the whale shark's place in the food chain, the cyclic effect of El Niño on ocean water temperatures, and the hypothetical effect El Niño has on this food chain. Other areas that are addressed include world geography and upwelling.

In order for students to have the information they need to solve the mystery, they should be introduced to some basic terms. Have students look up the definitions for the words listed on their activity sheets. They can also use some of the listed references to find out more in-depth information.

- *El Niño* is a weather cycle that warms up ocean waters by several degrees. This warm water pools up in certain areas of the globe and can prevent upwelling.
- *Upwelling* is the process where cold, nutrient-rich water surfaces near the coast along different continents. Upwelling provides nutrients to many animals, including plankton.
- *Plankton* are microscopic organisms that drift on ocean currents. These plants and animals are the basis of many oceanic food chains.
- *Filter feeders* are animals that either filter or suck in volumes of water to take in microscopic types of food, such as plankton.

Using the whale shark as the animal under investigation, students assume the role of detectives. The detectives are responsible for trying to discover what is happening to the whale shark population and why so many of them are dying. (Explain to students that this is a fictitious scenario created for the activity and that the whale sharks are not really dying.) You will need to give students their activity sheets, which has information on the whale shark, a description of the case, a map, and their clues. Basic information is on their activity sheets; student can find additional information online, in books, and so on.

### The setup

Divide students into teams or detective agencies with each agency having two to three students (maximum of five students). It is important when you create the agencies that you try to achieve a good mix of personalities. Have students name their agencies and place each agency's name on the board, leaving room for their final conclusion. Give each agency their clues and maps.

As students start on the case, they should be encouraged to use their resources and to view each team member's ideas as possible answers. Students can use libraries or the internet (using the resources listed) or find their own sources for their research.

Once students start the activity, there are a variety of ways to assess them. They can be measured on how well they work as a team and their ability to logically present and support their conclusion, and once the activity is done they can be graded on their answers to the discussion questions. Teachers will need to decide how to weight the various assessment areas.

### Standards

This activity was designed with the National Science Education Standards in mind. The standards that are met include A (Earth and Space Science), C (Life Science), E (Science in Personal and Social Perspectives), and G (Science as Inquiry).

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## Solve the case!

**Your agency's name:** \_\_\_\_\_

### Materials

- All 14 clues
- Map
- Copy of the answer sheet (one per agency)

### Time needed

Two class periods (one period for research and one period for students to use clues and map to come up with their hypothesis)

### The case

Whale sharks have been mysteriously washing up on beaches (use the map and clues to find out where), and fewer sharks are being seen in the wild. Scientists are very concerned because they cannot seem to find any reason for the problem. Your job is to take the clues the scientists have gathered and see if your agency can figure out a possible reason.

### The victim

Whale sharks are not only the world's largest shark, they are also the world's largest fish. They can reach a maximum length of 20 meters and have been estimated to reach 60 years in age. Their color is often referred to as grayish or bluish with creamy white spots located between pale horizontal and vertical stripes. They do not reach maturity until they are over 9 meters in length. They prefer warmer waters and are often found in areas of high productivity because they feed on a variety of planktonic animals. They are able to suck in their food, which allows them to collect more plankton than just filtering. Whale sharks are frequently seen at the surface of the ocean, usually vertically or near vertical, because that is where large groups of plankton are found. Whale sharks are livebearers and can have as many as 300 pups at each birth. These sharks are considered harmless to humans and are listed as vulnerable

with the International Union for Conservation of Nature and Natural Resources (Knickle and Martins).

### Directions

1. Decide on a name for your detective agency and ask your teacher to list it on the board.
2. Define the terms below. This will help with solving the case.
3. Read over the provided clues and look at the map. Decide which clues seem to be the most helpful to your agency and discard any clues that seem to be misleading. On the clues your agency discards write the reason for discarding them. (e.g., Clue: The shark was found in the air. Reason: Sharks don't live in the air so this clue doesn't make sense.)
4. Use the remaining clues and the map to come up with a hypothesis (possible explanation) for why the whale sharks are dying. Write your conclusion on your answer sheet.
5. Present your agency's hypothesis to the class and the reasoning behind it.
6. Discuss the clues that were discarded and see if everyone had similar reasons for getting rid of them.

**FIGURE 1** World Map



## Solve the case!

### Clues

Clue 1: Sharks 1 and 6 had skin lesions on their entire bodies. Each lesion was filled with pus. This suggests some type of infection.

Clue 2: The weight of all sharks that have been found has been below the average weight for whale sharks.

Clue 3: Fish populations off the coast of Ecuador have drastically declined in numbers over the past season.

Clue 4: Average water temperatures of the ocean have been warmer than normal, especially along the coast of South America.

Clue 5: Iron and other mineral levels are normal.

Clue 6: Hunting rates for sharks have not risen—hunting has been stable with no large spikes.

Clue 7: There have been no major pollution events such as oil spills—water qualities are relatively normal.

Clue 8: Autopsy for Shark 3: This shark was found in Australia and shows signs of attack.

Clue 9: Fewer whale sharks have been sighted feeding in ocean waters.

Clue 10: Juvenile sharks have appeared stunted in development and growth. They are also showing signs of illness.

Clue 11: This is an El Niño year.

Clue 12: Whale sharks are found from the equator to +/- 30–40 degrees latitude.

Clue 13: Whale sharks have washed up on the coast of Ecuador, the western coast of Mexico, the coasts of Brazil and Venezuela, off the coasts of Africa and Madagascar, and off the coast of Australia.

Clue 14: The shark was found in the air.

### Student answer sheet

Agency's name: \_\_\_\_\_  
\_\_\_\_\_

#### Define these terms:

Plankton \_\_\_\_\_

Filter feeder \_\_\_\_\_

Productivity \_\_\_\_\_

Upwelling \_\_\_\_\_

El Niño \_\_\_\_\_

Discarded clues with reasons \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Hypothesis with reason \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

#### Follow-up questions

- 1a. What would happen to the whale shark population if excess nutrients were added to the oceanic system?
- b. What would happen to the population (long-term consequence) if only the adult whale sharks were dying?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

2. What would happen to other shark populations if the plankton population increased or decreased?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

3. How would your agency test your hypothesis regarding the cause of the whale shark problem? \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

#### Assessment

You will be graded on your teamwork, ability to logically present and support your hypothesis, and your answers to the follow-up questions.

**Teacher answer sheet**

In this activity, there is a hypothetical connection between the El Niño cycle, plankton, and the whale shark populations. Because El Niño warms up surface temperatures and decreases the amount of upwelling that occurs, there is less plankton available (whale sharks' main food source) and the sharks are starving.

Plankton, which is the basis of all marine food chains, consists of two main groups. Phytoplankton (plant plankton) and zooplankton (animal plankton) are found throughout the ocean, but most concentrations are near the surface because phytoplankton undergoes photosynthesis and therefore needs the Sun. Zooplankton eats phytoplankton, fish eat the plankton, and other animals eat the fish, and so on. However, some of the largest animals, such as blue whales and whale sharks, eat plankton as well. Because plankton needs the Sun and other nutrients such as nitrogen, large aggregations of plankton are frequently found in specific areas of the oceans. Nutrients from the land increase the amount of plankton found along coastlines, and areas with upwelling also have increased amounts of plankton due to the cold, nutrient-rich water that comes from the ocean's depths.

In the ocean, when organic matter dies, it sinks and decomposes. When that happens, nutrients that plants need, such as nitrates and phosphates, dissolve and are relatively inaccessible to the plants. Upwelling brings these nutrients to the surface and makes them available to plankton. Upwelling occurs when winds push warm surface water away from the shore allowing the colder water underneath to surface, bringing up its nutrients. Major areas of upwelling include the west coast of North and South America, and southern and northern Africa. These areas are associated with strong currents, such as the California, Peru, Benguela, and Canary currents (Canright 1998).

However, in years when El Niño is occurring, upwelling is negatively affected. In normal years, trade winds push the warm surface waters into the western Pacific, which allows upwelling to occur. During El Niño years, these trade winds relax, resulting in higher sea temperatures and less upwelling. Without upwelling to bring the nutrients to the surface for plants to use, fewer phytoplankton are producing, which leads to a decrease in primary productivity (NOAA/TAO Project). This reduction in productivity will affect all organisms, but animals that are dependent on large amounts of plankton, such as whale sharks, could hypothetically see enough of a decrease in food availability to show symptoms of starvation.

Some of the clues are unhelpful or can lead to incorrect conclusions. This is done on purpose because in science not all data that are collected will be useful. Number 8 is an unhelpful clue due to the fact that a shark attack on one shark would not

lead to a population problem. Number 1 is misleading because it could direct students towards illness or infection. Other clues have neither a positive or negative effect, they simply offer more information, such as numbers 5, 9, and 12.

**Follow-up questions**

- Excess nutrients: When excess nutrients are available, phytoplankton would be able to increase their output, which could lead to a bloom of plankton. Blooms can provide more food for other animals.
  - Only the adults are affected: If only the adults are dying, it means that all the mature individuals in the population are being removed. A decrease in the number of reproductively-able individuals will reduce the number of pups that are born in the future, which could lead to a decrease in whale shark populations for the near future.
- Other shark populations could also show an effect if plankton is increased or decreased. Plankton is the basis of the food chain, so if plankton increases there will be more food available for primary and secondary consumers. Having more food available can increase health and could increase the reproduction rate, and so on. A decrease in plankton could have the opposite effect.
- This answer will be dependent on the agency, but you would want to see if they started with their hypothesis, their experiment makes sense, and that they had used what they had learned in their design.

**Resources**

- El Niño educational websites—[www.elnino.noaa.gov/edu.html](http://www.elnino.noaa.gov/edu.html)  
 Make your own El Niño activity (teaches about El Niño and upwelling)—<http://sealevel.jpl.nasa.gov/education/make-your-own-el-nino.html>  
 National Geographic's *The Sharks*—available from [www.amazon.com](http://www.amazon.com)  
 Florida Museum of Natural History—[www.flmnh.ufl.edu/fish/Gallery/Descript/Whaleshark/whaleshark.html](http://www.flmnh.ufl.edu/fish/Gallery/Descript/Whaleshark/whaleshark.html)

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