SCIENTISTS IN THE FIELD

Where Science Meets Adventure

DISCUSSION AND ACTIVITY GUIDE

The Great White Shark Scientist

By Sy Montgomery, photographs by Keith Ellenbogen

About the Series

The Great White Shark Scientist is part of the award-winning Scientists in the Field series, which began in 1999. This distinguished and innovative series examines the work of real-life scientists doing actual research. Young readers discover what it is like to be a working scientist, investigate an intriguing research project in action, and gain a wealth of knowledge about fascinating scientific topics. Outstanding writing and stellar photography are features of every book in the series. Reading levels vary, but the books will interest a wide range of readers.

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by Sy Montgomery
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About the Book

Humming a few bars of music from the movie *Jaws* at the beach is likely to have more than a few people quickly leaving the water. Great white sharks are a source of awe, mixed with a ton of irrational fear. Shark scientists like Greg Skomal, however, are actually more frightened of not finding any great whites. Sharks play a crucial role in a healthy ocean ecosystem. This book shows the team tracking, tagging, and studying the great white—an animal less dangerous than our own toilets.

About the Author

While researching some of her many books, Sy Montgomery has been bitten by a vampire bat, hugged by an octopus, and hunted by a tiger, and she has crawled into a pit with 18,000 snakes! She has written more than twenty books for adults and children and has won many honors, including the Orbis Pictus Award, a Robert F. Sibert Medal, the Henry Bergh Award for Nonfiction, and was a National Book Award Finalist in Nonfiction. Besides writing books, she is a popular speaker, and works with many organizations to preserve and protect nature. Montgomery lives on a farm in New Hampshire with her husband.

About the Photographer

Keith Ellenbogen's fascination with the marine world began when he started volunteering at the New England Aquarium as a teen. After receiving his MFA from the Parsons School of Design, Keith was awarded a Fulbright Fellowship to Malaysia, where he solidified his career choice of underwater photography and videography. His commitment to conservation photography has taken him all over the world and he has received many honors and awards for his work. Keith believes in connecting science and the arts to education, and is passionate about marine conservation. When not on assignment, Keith lives in Brooklyn, New York, and is an Assistant Professor in the Photography Department at SUNY/Fashion Institute of Technology.

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Pre-Reading Activity

Have students make a top-ten list of the most dangerous animals on land and sea without doing any research or online searches. Collate the student responses and make a master class list of all animals listed. Discuss the list and elicit responses from students justifying the inclusion of any particular animal. Have a vote to determine the order of perceived danger, with number one being the animal deemed by class vote to be the most dangerous. Save this list for later use.

Have a group discussion about the ways in which we are perceived. Have students share instances in which they were completely misunderstood.

Does your class have a favorite brand of soda or chocolate or pizza or type of apple or cracker? Find something and do a blind taste test in which you have students try the two or more options without knowing which is which. Only you and a small group of students know the identity of each serving. Try to make the servings as exactly the same as possible. Have students taste more than one time. For one of the taste trials, have the same number of bites or drinks, but have only one choice (to see if the students register that it is exactly the same). Does what we say match what we choose? How do our attitudes influence our study of science? It would also be interesting to have one group design a test to prove that their favorite snack is the best and then test it.

Discussion Questions

Look at the picture that begins chapter five on page 42. How do we teach ourselves to become comfortable with creatures that frighten us? How much have our own cultural customs and attitudes toward sharks influenced how we view them and how we react when we see one at a beach?

What benefits to an ecosystem does the great white shark provide? How high of a priority should these sharks be to the beach communities that depend on beach tourism? Is Chatham's marketing of great whites simply putting the best face on a dangerous situation? So many animals are threatened with extinction that no single person can care about all of them. Does the great white shark make your personal list of animals to protect? Which ones do or do not? Why?

Tiger sharks, bull sharks, and even a few mako sharks have posed risks to humans in the ocean. So have eels, jellyfish, corals, and other organisms. To what extent is our preoccupation with the great white influenced by popular culture, the physical size of the great white, and our tendency to mash all 500-plus sharks together into one great white people killer, despite the fact that harm from great whites does not match the evidence? Although the influence of *Jaws* is *not* a factor in discouraging people to visit Chatham, do we still have an irrational fear of great white sharks? The book also says that great whites are vastly misunderstood. What causes some of us to have such a visceral reaction to great whites?

Researching sharks requires long hours confined to a boat. Researchers require the assistance of spotter planes and cooperation from the weather. Our view into the water is limited at best. Writing or photographing a book about great whites requires tremendous persistence and patience. Skomal says, *"You want no swell, no surf, good water quality—and sometimes even that's not enough . . . There could be a shark right under us and we wouldn't know it."* (p. 15). Look also at the picture on page 33. Do you have the patience to research sharks? Are you more of a scientist or more of an author? Why?

As the technology for researching great white sharks improves (cameras are getting smaller, more durable; our ability to track animals with GPS/satellite devices is much better; etc.), will our need to spend time on ships in the ocean scouting for great white sharks eventually decrease? How many sharks would need to be tagged before we can rely on our technology more than our physical presence? [Note: the purpose of this question is to determine whether students are able to challenge the basic premise of the question and argue that our physical presence is a given, which may or may not be helped significantly by better technology.]

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On page 55 we read, *"A thousand great white sharks could be sharing the ocean with Cape beach-goers and fishermen—and, so far, rather peacefully! Who would have ever suspected?"* The book shares information on how the city of Chatham uses great white sharks as a promotion to attract visitors. Is this true in other beach towns? Are there areas in which sharks are seen as a threat that must be eradicated?

Great white sharks, with a skeleton made of cartilage, have been swimming the oceans for hundreds of millions of years before the now-extinct T. rex roamed the planet. Speculate on the reasons for its evolutionary success. Speculate on its prospects for the next hundred years and beyond. Will fear and overfishing send the great white into extinction?

Applying and Extending Our Knowledge

Look very carefully at the front-matter charts just after the table of contents. Why did the book team (author, illustrator, editor, art department) decide to include these maps?

- Make predictions for what the various geometrical tan shapes mean.
- There are different shades, different colors, and different concentrations of dots. Make predictions for what these may indicate.
- Fill a container (about the size of a 9 x 13 -inch pan) about half full of water. To this water add food coloring or dust or something to make the water opaque. You do not want students to be able to see the bottom. To this opaque water, add varying amounts of sand, soil, rocks, and other items so that the surface varies significantly in different parts of the pan. Have one area in which an "island" is visible above the water surface. Without removing any water, moving any of the elements under the surface, or otherwise disrupting the pan, make a map of your pan topography. Students may very lightly feel the bottom with their fingertips. After finishing this, carefully siphon off the water and have them map it again
- Define bathymetry and hydrography. Look up the National Oceanic and Atmospheric Administration links defining bathymetry and prepare a chart or online presentation outlining how scientists map oceans and other large bodies of water.
- Have students use a magnifying glass or other tool and figure out how to find the original maps or online versions. If your school has a librarian, this may be a great project for learning how to conduct research. Compare these maps to the class predictions. After answering questions about the shapes and shading, etc., make a similar sort of map for the pan. Include a map key that explains the different shapes, colors, and dots.

Common Core Connections

CCSS.ELA-Literacy.RH.6-8.7 Integrate visual information (e.g., in charts, graphs, photographs, videos, or maps) with other information in print and digital texts.
CCSS.ELA-Literacy.SL.7.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.
CCSS.ELA-Literacy.W.7.7 Conduct short research projects to answer a question, drawing on several sources and generating additional related, focused questions for further research and investigation.
CCSS.ELA-LITERACY.W.6.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
CCSS.ELA-LITERACY.W.6.1(a-d) Write arguments to support claims with clear reasons and relevant evidence.

On page 21, we read that Peter Benchley, the author of *Jaws*, was sickened by the decline in shark numbers. His wife is now president of a shark conservation group, Shark Savers. However, on that same page we read, *"Not everyone is thrilled the sharks are here."*

- Begin the exploration of this book by having each class member write down all the facts and any myths they know about sharks. Add songs or other popular culture shark references. Consolidate the information and keep for reference as students proceed through the book. Make sure to confirm the facts on your list by citing the page numbers that confirm the information or to move the fact over to the myth and folklore section when a "fact" is proven false (include the page numbers here as well).
- In addition to confirming or rejecting facts students have listed, make sure to add important facts that

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were neglected upon creation of the list.

- Read a selection from *The Three Little Hawaiian Pigs* and *The Magic Shark* by Donivee Laird. Watch video clip from *Jaws.* Create a Venn diagram showing the differences between real sharks and fiction/Hollywood, as well as the similarities. Discuss the kernel of truth the author or director uses to exaggerate the fear factor.
- Peter Benchley wrote *White Shark* about twenty years after he wrote *Jaws.* Read both books and compare the depictions of the great white shark in each book to the science in this book and other current nonfiction books about great white sharks.
- Visit the Chatham Chamber of Commerce website. What does Chatham put on its home page? Is it easy to find information about great white sharks here? Design an ad campaign to accentuate the benefits of the great white shark for the Chatham Chamber and its guidebook. [Note: At the time of this writing, the Chatham Chamber does not mention great whites. It does bury the name of the Chatham Shark Center in its guidebook, but does *not* list its phone number.] If possible, make a sixty-second promotional video that can be shared electronically and shown at your school extolling the benefits of great white sharks.
- Have one group of students do a satirical video exposé (see Jon Scieszka's *True Story of the Three Little Pigs* for inspiration) outlining the slander and libel in fiction and media directed toward the great white shark. Have another group present the rebuttal (or the point of view of another group in favor of removing great whites).

Common Core Connections

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CCSS.ELA-Literacy.SL.7.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.
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Studying great white sharks obviously requires scientists to be in the ocean. The ocean, however, does not do anything to accommodate the scientists. We read on page 3, *"'Chatham Inlet is a pretty dangerous area on a normal day,' Greg tells us. 'And this isn't a normal day!' Until just an hour ago, the National Weather Service had a small craft advisory in place. To even attempt to find great whites, the weather has to be good enough so that both the spotter plane and the boat can go out. Wind, rain, and fog will scuttle an outing. Waves make the job harder: they crinkle the water's surface and stir up sand from the bottom. 'You can be right over a shark and not see it,' Greg says. And when a shark is spotted, waves make it difficult to keep the animal in view—and exceptionally difficult to film it."*

- Prepare a poster or online presentation explaining what the National Weather Service is and the type of reports they typically issue for the Cape Cod area during July. Make sure to explain what a "small craft advisory" means and other advisories or warnings.
- Why do the great white shark scientists need a spotter plane? Pretend the government is looking to cut costs and has decided that spotter planes are too expensive. You and two teammates are going to have three minutes each to argue for continuing to fund spotter planes. Plan your presentation and then present it. Make sure it explains what a spotter plane is and how it works with the boat. Have Congress (classmates) vote. To add interest to this presentation, include a bunch of options in which funding the spotter plane requires giving up some class or school benefit.
- Always there is at least one person who does not understand or respect the power of the weather or the power of the ocean or both. This person is arguing for taking the boat and the plane out to look for great whites despite the small craft advisory. Unbelievably, he convinces the skipper and crew to head out! Create a series of skits showing the range of possibilities. Then present a report showing the most likely scenarios. Communicate with scientists at the National Weather Service soliciting the percentages and odds of a few scenarios from least likely to most likely. This is another opportunity to work with your school or local librarian.
- One of the essential problems to solve in researching great white sharks is how to find them! Brain-

storm with your students what kinds of organisms the class could observe in an outdoor area, such as a field or empty lot or wilderness area (whichever matches your school environment). Make predictions for what animals should be there. Make a list of ways you could prove that these animals are present in the environment even if you do not see them.

Common Core Connections

CCSS.ELA-Literacy.SL.7.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.
CCSS.ELA-Literacy.SL.7.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.

Pages 10 and 11 define sharks with a labeled drawing of a great white shark. In this section, we learn that Earth hosts about five hundred species of sharks.

- Create a Venn diagram that shows the range of differences among all the different types of sharks.
- Have students create a field guide featuring ten or more sharks that demonstrate this range. Pattern the descriptions after, say, Peterson Field Guide descriptions of animals from your part of the world.
- Do another guide but look for ten species of sharks that are most like the great white shark.
- Obviously, a great white shark, like any organism, has habitat requirements. Map places in which great whites commonly occur. What does each place offer the shark in terms of food, water temperatures, physical features of the coastline, protection, nursery sites, etc.? What regional variations, if any, are found in different great white territories?
- We read that when great white shark numbers decreased, one area saw an increase in cownose rays. This resulted in the decimation of the scallop population and a decrease in water quality. Have students create charts showing how the food chain works when it has a healthy great white shark population and when great white numbers decrease.
- Make a list of all the predators in your neighborhood (don't forget insects, reptiles, and other less obvious predators). For each predator, explore the value this predator adds to your region. How are predators in your neighborhood similar to and different from the great white shark in its role as a top predator in the ocean? Make a graph or a diagram or other visual explanation of the similarities and differences.
- Create a field guide showing several of the more common organisms that share the habitat with great whites.
- The labeled diagram of the great white has several interesting components that are only briefly explained. Assign groups of students to present more detailed descriptions of each. For example, how does the lateral line on the great white shark (or any fish) sense water currents? How do the ampullae of Lorenzini work? Encourage students to make models or create movies to explain these terms.
- In the "Pattern" label from page 11, we read that great whites have distinctive patterns of dark and light that are "as individual as fingerprints." Have students use black and white construction paper to create models of sharks showing how scientists use these patterns for identification purposes.
- Sharks also have very distinctive teeth. Research the teeth of the great white and, say, tiger sharks, whale sharks, mako sharks, bull sharks, and cookiecutter sharks. Prepare a poster or online report showing the teeth and making a hypothesis for how the shape of the teeth predicts the type of food that makes up the bulk of its diet.
- Take close-up photographs of just the back of the head of each student. Make sure to identify each head with a letter or number code. Make sure to have an answer key for whom the head belongs. Make a slide show (or print out pictures) of all of the heads. Make sure the slide show is in a random order. Hand students a class list. Go through the photos and have the students assign the code letter or number for each head to one of the students in the class. Ideally, when the slide show is through, each student should have the entire class matched. Go through the slides again, but this time, do the activity as a whole class or in groups. Then show the head that belongs to the student. Compare the results for doing the activity alone and in groups. Is

this easier or harder with humans than with shark patterns?
- Do this activity again, but insert heads that do not belong to anyone in the class.
- Do a variation of this activity but use footprints (barefoot).

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Longitude and latitude are the guides that allow scientists to report precisely where in the ocean sharks are located. The tracking devices on sharks also report GPS coordinates that allow scientists to discover ranges and patterns of behavior of great whites.

- Find the longitude and latitude of your school to the nearest degree.
- Using Google Maps, zoom in to the location of your school. Print out maps for students and have them insert and label a grid showing precise locations where students found trash.
- If your classroom has a document camera, use this tool to share several of the students' maps. Discuss the different ways students numbered or labeled their grids.
- Share the exact GPS location (which can be found online through a longitude-latitude search: www.findlatitudeandlongitude.com). Discuss why it is important to have a standard reference. Discuss why a simpler numbering system might be easier for tracking trash at school.

Common Core Connections

CCSS.ELA-Literacy.RH.6-8.7 Integrate visual information (e.g., in charts, graphs, photographs, videos, or maps) with other information in print and digital texts.
CCSS.ELA-Literacy.SL.7.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.
CCSS.ELA-Literacy.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
CCSS.ELA-Literacy.W.7.7 Conduct short research projects to answer a question, drawing on several sources and generating additional related, focused questions for further research and investigation.

Like wind, currents are not something that students can easily see. Like a tree branch that moves, the effects of wind are visible. So, too, can we understand currents by objects that are moved by them. Currents are influenced by many factors, including wind, water density, and seismic activity (among others).

- Using a tray of water, a cork, and a fan, observe what happens to the cork when a fan is placed in various locations (north, south, east, and west). Observe and record what the cork does each time the fan is moved. Time how long it takes the cork to move across the pan. Repeat again with heavier or lighter corks. Repeat again with other floating objects.
- Replace the water above with salt water and repeat.
- With either fresh water or salt water, repeat the activity above, but this time tap on the bottom of the pan in the center lightly at first and then gradually tap harder. Change the location of where you tap and repeat. Observe and record what the cork does each time the tapping increases in intensity. Try this without the fan blowing.
- Place items like bricks or rocks in the pan and repeat the activities above. Place a solid wall of bricks halfway across the pan and repeat. Ask students what ocean animals would have to do to stay alive if we assume that the cork is a food source.
- Students should notice that it is possible to predict what the cork will do fairly accurately if we know the direction the wind is blowing, how soft or hard

the tapping is, where the tapping is located, where the objects are located, etc. Have students write an explanation of how currents affect shark behavior and our ability to find and track them. If time allows, have the students present their findings orally.

Common Core Connections

CCSS.ELA-Literacy.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
CCSS.ELA-Literacy.SL.7.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.

Greg Skomal knew that he wanted to be a shark biologist from the time he was in the eighth grade. We also know that shark biologists spend a lot of time riding in choppy waves, dealing with sunburn, coping with the vastness of the ocean, and studying an animal that is capable of biting you in half with one snap of its powerful jaws filled with razor-sharp teeth. We haven't even mentioned the difficulties of fitting the puzzle pieces of information together, which anyone who has ever done a large jigsaw puzzle knows can be frustrating.

- Are you capable of doing shark research? If you found yourself in a science-related career, what type of work would you be doing? Write the most likely science-related job description for your hypothetical science job twenty years from now.
- Get several 60-piece or 100-piece puzzles and take one piece out of each puzzle. Mix them up. Do not show the puzzle boxes just yet. Have students look at the one puzzle piece and draw a picture of the completed puzzle and write a description of the puzzle.
- Next show the puzzle covers and have students predict which piece belongs with which puzzle. For both this activity and the one above, keep adding pieces (without trying to find connecting pieces yet).
- Since much of science involves many puzzles on top of each other, mix all the pieces together and have students build the puzzles (maybe allowing a ten-minute puzzle break each day until finished).

Common Core Connections

CCSS.ELA-LITERACY.W.6.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
CCSS.ELA-LITERACY.W.6.1(a-d) Write arguments to support claims with clear reasons and relevant evidence.
CCSS.ELA-Literacy.RH.6-8.7 Integrate visual information (e.g., in charts, graphs, photographs, videos, or maps) with other information in print and digital texts.

Other Websites to Explore

Great White Sharks from *National Geographic,* MarineBio, and the Smithsonian

animals.nationalgeographic.com/animals/fish/great-white-shark/

marinebio.org/species.asp?id=38

ocean.si.edu/great-white-shark

Discovery Center shark site with many links to sharks, including this one showing how a shark's jaws work: sharkopedia.discovery.com/shark-topics/feeding-hunting-diet/#how-a-sharks-jaws-work

California Academy of Science article on great white sharks by John McCosker: www.calacademy.org/scientists/advice-concerning-sharks

Social behavior of great whites from Natural History: www.naturalhistorymag.com/picks-from-the-past/191391/sociable-killers

Current shark article from *Science Daily* (source for daily science news): www.sciencedaily.com/releases/2016/02/160226133806.htm?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+sciencedaily%2Fplants_animals%2Fsea_life+%28Sea+Life+News+--+ScienceDaily%29

For students who may wish to pursue shark research: yyy.rsmas.miami.edu/groups/fmg/research/sfssp.html

Southwest Marine Fisheries information on shark habitats: swfsc.noaa.gov/textblock.aspx?Division=FRD&ParentMenuId=87&id=917

Shark Savers, Wendy Benchley, wife of the late Peter Benchley (of *Jaws* fame) has served on the board of this group: www.sharksavers.org/en/home/

An interview with Wendy Benchley about Jaws and the evolution of her interest in sharks and the ocean: suvudu.com/2011/08/shark-week-at-suvudu-the-legacy-of-jaws-an-interview-with-wendy-w-benchley.html

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Chatham Chamber of Commerce site and guidebook link:
www.chathaminfo.com
online.flipbuilder.com/jhgd/eulj/#p=1

Further Reading

Ellis, Richard, and McCosker, John. *Great White Shark.* Stanford University Press, 1995.

Civard-Racinais, Alexandrine, and Fontenoy, Maud. *Great White Shark: Myth and Reality.* Firefly Books, 2012.

Skomal, Greg. *The Shark Handbook: The Essential Guide for Understanding the Sharks of the World.* Cider Mill Press, 2008.

Compagno, Dando, and Fowler. *Sharks of the World (Princeton Field Guide).* Princeton University Press, 2005.

Teacher Guide by Ed Spicer