Argument-Driven Inquiry in BIOLOGY

LAB INVESTIGATIONS for GRADES 9–12

Victor Sampson, Patrick Enderle, Leeanne Gleim,
Jonathon Grooms, Melanie Hester,
Sherry Southerland, and Kristin Wilson

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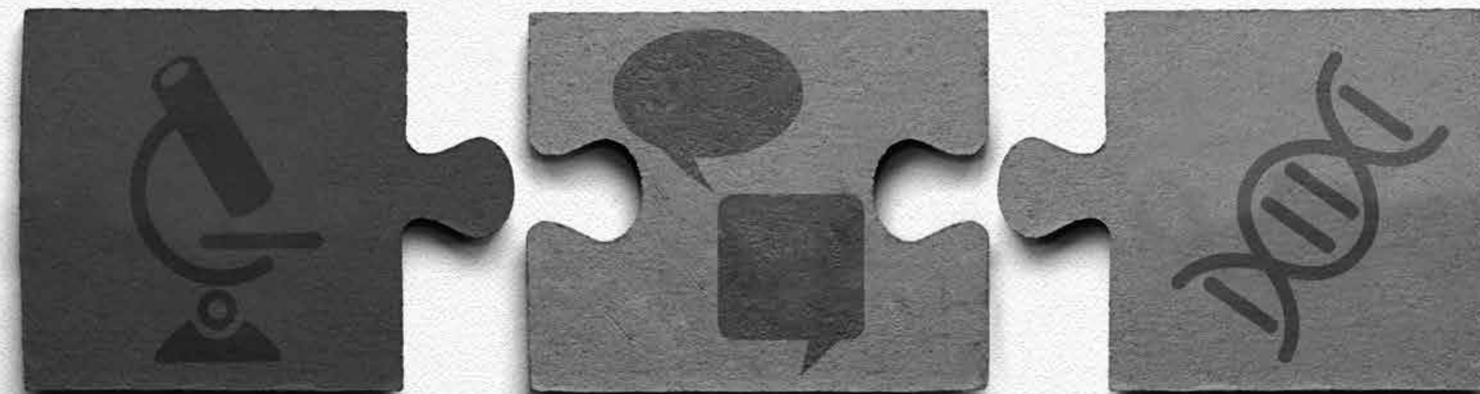

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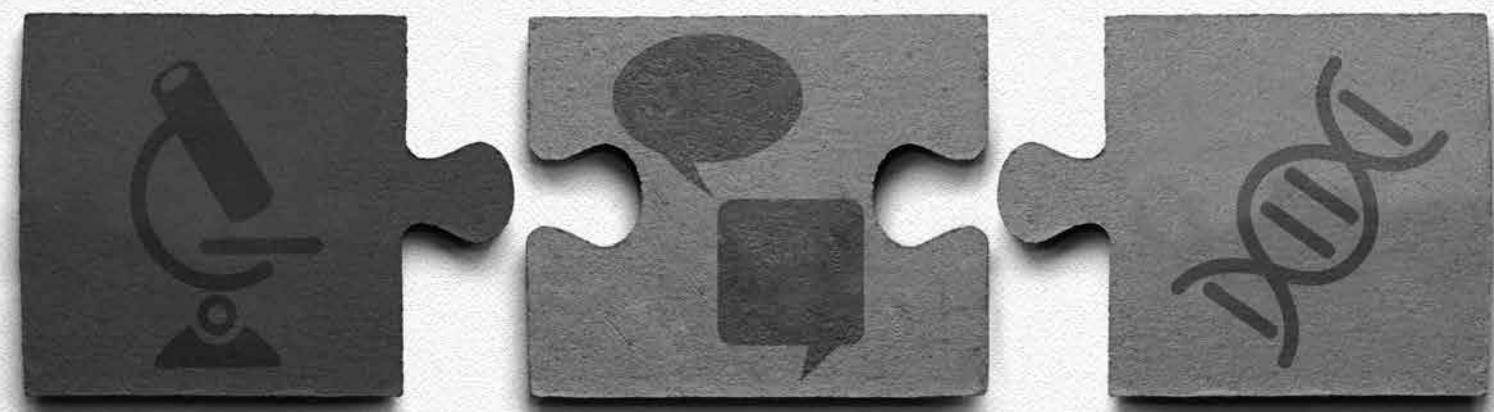

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National Science Teachers Association
Arlington, Virginia

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17 16 15 14 4 3 2 1

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Library of Congress Cataloging-in-Publication Data
Argument-driven inquiry in biology : lab investigations for grades 9-12 / Victor Sampson [and six others].
1 online resource.
Includes bibliographical references.
Description based on print version record and CIP data provided by publisher; resource not viewed.
ISBN 978-1-938946-20-2 -- ISBN 978-1-938946-66-0 (e-book) 1. Biology--Study and teaching (Secondary)--Handbooks, manuals, etc. I. Sampson, Victor, 1974- II. National Science Teachers Association.
QH315
570.71'2--dc23
2014001437

Cataloging-in-Publication Data for the e-book are also available from the Library of Congress.

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PREFACE

The *Next Generation Science Standards* (NGSS Lead States 2013) outline a new set of expectations for what students should know and be able to do in science. The overarching goal of the *NGSS*, as defined by the National Research Council (NRC) in *A Framework for K–12 Science Education* (NRC 2012), is

> to ensure that by the end of 12th grade, *all* students have some appreciation of the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussions on related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside school; and have the skills to enter careers of their choice, including (but not limited to) careers in science, engineering, and technology. (p. 1)

To accomplish this goal, teachers will need to help students become proficient in science by the time they graduate from high school. The NRC suggests that students need to understand four core ideas in the life sciences, be aware of seven crosscutting concepts that span the various disciplines of science, and learn how to participate in eight fundamental scientific practices in order to be considered proficient in science (NRC 2012). The three dimensions of the *Framework,* which form the basis for the *NGSS*, are summarized in Figure 1.

FIGURE 1

The three dimensions of the framework for the *NGSS*

Life Sciences Core Ideas	
From molecules to organisms: Structures and processes Ecosystems: Interactions, energy, and dynamics Heredity: Inheritance and variation of traits Biological evolution: Unity and diversity	
Crosscutting Concepts	**Scientific Practices**
• Patterns • Cause and effect: Mechanism and explanation • Scale, proportion, and quantity • Systems and system models • Energy and matter: Flows, cycles, and conservation • Structure and function • Stability and change	• Asking questions • Developing and using models • Planning and carrying out investigations • Analyzing and interpreting data • Using mathematics and computational thinking • Constructing explanations • Engaging in argument from evidence • Obtaining, evaluating, and communicating information

The NRC also calls for teachers to use new instructional approaches that are designed to foster the development of science proficiency. This book will help teachers accomplish this task by providing a set of 27 lab investigations that were designed using an innovative approach to laboratory instruction called Argument-Driven Inquiry (ADI). The lab investigations are aligned with the content, crosscutting concepts, and scientific practices outlined in the NRC *Framework*. These lab investigations allow students to develop the disciplinary-based literacy skills outlined in the *Common Core State Standards*, for English language arts (NGAC and CCSSO 2010), because the ADI instructional model calls for students to give presentations to their peers; respond to questions; and then write, evaluate, and revise reports as part of each lab. Thus, this book can help teachers make lab instruction more meaningful for students and enable students to learn more inside the school science laboratory.

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ACKNOWLEDGMENTS

The development of this book was supported by the Institute of Education Sciences, U.S. Department of Education, through grant R305A100909 to Florida State University. The opinions expressed are those of the authors and do not represent the views of the institute or the U.S. Department of Education.

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Leeanne Gleim received a BA in elementary education from the University of Southern Indiana and a MS in science education from FSU. While at FSU, she worked as a research assistant for Dr. Sampson. After graduating, she taught biology and honors biology at FSU Schools, where she participated in the development of the Argument-Driven Inquiry (ADI) model. Leeanne was also responsible for writing and piloting many of the lab investigations included in this book.

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INTRODUCTION

The Importance of Helping Students Become Proficient in Science

The new aim of science education in the United States is for all students to become proficient in science by the time they finish high school. *Science proficiency*, as defined by Duschl, Schweingruber, and Shouse (2007), consists of four interrelated aspects. First, it requires individuals to know important scientific explanations about the natural world, to be able to use these explanations to solve problems, and to be able to understand new explanations when they are introduced. Second, it requires individuals to be able to generate and evaluate scientific explanations and scientific arguments. Third, it requires that individuals understand the nature of scientific knowledge and how scientific knowledge develops over time. Finally, and perhaps most important, it requires that individuals be able to participate in scientific practices (such as designing and carrying out investigations, constructing explanations, and arguing from evidence) and communicate in a scientific manner. Science proficiency, in other words, involves more than an understanding of important concepts; it also involves being able to do science.

In the past decade, however, the importance of learning how to participate in scientific practices has not been acknowledged in state standards. In addition, many states have attempted to make their science standards "more rigorous" by adding more content to them rather than designing them so they emphasize the core ideas and crosscutting concepts described by the National Research Council (NRC) in *A Framework for K–12 Science Education* (NRC 2012). The increasing number of science standards, along with the pressure to "cover" them that results from the use of high-stakes tests targeting facts and definition, has unfortunately forced teachers "to alter their methods of instruction to conform to the assessment" (Owens 2009, p. 50). Teachers, as a result, tend to focus on content and neglect the practices of science inside the classroom. Teachers also tend to move through the science curriculum quickly to ensure that they cover all the standards before the students are required to take the high-stakes assessment.

The current focus on covering all the standards, however, does not seem to be working. For example, *The Nation's Report Card: Science 2009* (National Center for Education Statistics 2011) indicates that only 21% of all 12th-grade students who took the National Assessment of Educational Progress in science scored at the proficient level. The performance of U.S. students on international assessments is even bleaker, as indicated by their scores on the science portion of the Programme for International Student Assessment (PISA). PISA is an international study that was launched by the Organisation for Economic Co-operation and Development (OECD) in 1997, with the goal of assessing education systems worldwide; more than 70 countries have participated in the study. The test is designed to assess reading, math, and science achievement and is given every three years. The mean score for students in the United States on the science portion of the PISA in 2012 is below the international mean, and there has been no significant change in the U.S. mean score since 2000 (OECD 2012; see Table 1). Students in countries such as China, Korea, Japan, and Finland score significantly higher than student in the United States. These results suggest that U.S. students are not learning what they need to learn to become proficient in science, even though teachers are covering a great deal of material.

TABLE 1

PISA scientific literacy performance for U.S. students

Year	U.S. mean score*	U.S. rank/Number of OECD countries assessed	Top three performers
2000	499	14/27	Korea (552) Japan (550) Finland (538)
2003	491	22/41	Finland (548) Japan (548) Hong Kong-China (539)
2006	489	29/57	Finland (563) Hong Kong-China (542) Canada (534)
2009	499	15/43	Japan (552) Korea (550) Hong Kong-China (541)
2012	497	36/65	Shanghai-China (580) Hong Kong-China (555) Singapore (551)

*The mean score of the PISA is 500 across all years.
Source: OECD 2012

In addition to the poor performance of U.S. students on national and international assessments, empirical research in science education indicates that a curriculum that emphasizes breadth over depth and neglects the practices of science can actually hinder the development of science proficiency (Duschl, Schweingruber, and Shouse 2007; NRC 2005, 2008). As noted in the *Framework* (NRC 2012),

> K–12 science education in the United States fails to [promote the development of science proficiency], in part because it is not organized systematically across multiple years of school, emphasizes discrete facts with a focus on breadth over depth, and does not provide students with engaging opportunities to experience how science is actually done." (p. 1)

The NRC goes on to recommend that science teachers spend more time focusing on key ideas to help students develop a more enduring understanding of biology content. They also call for science teachers to start using instructional strategies that give students more opportunities to learn how to participate in the practices of science. Without this knowledge and these abilities, students will not be able to engage in public discussions about scientific issues related to their everyday lives, to be consumers of scientific information, or to have the skills needed to enter a science or science-related career. We think the school science laboratory is the perfect place to focus on key ideas and engage students in the practices of science and thus to help them develop the knowledge and abilities needed to be proficient in science.

How School Science Laboratories Can Help Foster the Development of Science Proficiency

Laboratory activities look rather similar in most high school classrooms (we define a school science laboratory activity as "an opportunity for students to interact directly with the material world using the tools, data collection techniques, models, and theories of science" [NRC 2005, p. 3]) (Hofstein and Lunetta 2004; NRC 2005). The teacher usually begins a laboratory activity by first introducing his or her students to a concept through a lecture or some other form of direct instruction. The teacher then gives the students a hands-on task to complete. To support students as they complete the task, teachers often provide students with a worksheet that includes a procedure explaining how to collect data, a data table to fill out, and a set of analysis questions. The hope is that the experience gained through completion of the hands-on task and worksheet will illustrate, confirm, or otherwise verify the concept that was introduced to the students at the beginning of the activity. This type of approach, however, is an ineffective way to help students understand the content under investigation, learn how to engage in important scientific practices, improve communication skills, or develop scientific habits of mind (Duschl, Schweingruber, and Shouse 2007; NRC 2005). Most laboratory activities therefore do little to promote the development of science proficiency.

One way to address this problem is to change the focus of laboratory instruction. A change in focus will require teachers to place more emphasis on "how we know" (i.e., how new knowledge is generated and validated) in addition to "what we know" about life on Earth (i.e., the theories, laws, and unifying concepts). Science teachers will also need to focus more on the abilities and habits of mind that students need to have in order to construct and support scientific knowledge claims through argument and to evaluate the claims or arguments made by others (NRC 2012). As explained in the *Framework* (NRC 2012), argumentation (i.e., the process of proposing, supporting, and evaluating claims) is essential practice in science:

> Scientists and engineers use evidence-based argumentation to make the case for their ideas, whether involving new theories or designs, novel ways of collecting data, or interpretations of evidence. They and their peers then attempt to identify weaknesses and limitations in the argument, with the ultimate goal of refining and improving the explanation or design (p. 46).

The NRC therefore calls for argumentation to play a more central role in the teaching and learning of science.

In addition to changing the focus of instruction, teachers will need to change the nature of laboratory instruction to promote and support the development of science proficiency. To change the nature of instruction, teachers need to make laboratory activities more authentic by giving students an opportunity to engage in scientific practices instead of giving them a worksheet with a procedure to follow and a data table to fill out. These activities, however, also need to be educative for students in order to help student develop the knowledge and abilities associated with science proficiency; students need to receive feedback about how to improve and teachers need to help students learn from their mistakes.

The argument-driven inquiry (ADI) instructional model (Sampson and Gleim 2009; Sampson, Grooms, and Walker 2009, 2011) was designed as a way to make lab activities more authentic and educative for students and thus help teachers promote and support the development of science proficiency inside the classroom. This instructional model reflects research about how people learn science (NRC 1999) and is also based on what is known about how to engage students in argumentation and other important scientific practices (Berland and Reiser 2009; Erduran and Jimenez-Aleixandre 2008; McNeill and Krajcik 2008; Osborne, Erduran, and Simon 2004; Sampson and Clark 2008).

Organization of This Book

The remainder of this book is divided into two parts. Part I begins with two text chapters describing the ADI instructional model and the development and components of the ADI lab investigations. Part II contains the lab investigations, including notes for the teacher, student handouts, additional information for students, and checkout questions. Four appendixes contain standards alignment matrices, timeline and proposal options for the investigations, and a form for assessing the investigation reports.

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Lab 12. Explanations for Animal Behavior: Why Do Great White Sharks Travel Over Long Distances?

Teacher Notes

Purpose

The purpose of this lab is to *introduce* students to many of the theories and concepts used by biologists to study and explain the behavior of animals. This lab also gives students an opportunity to design and carry out an investigation with the goal of developing an explanation for the long-range movement of great white sharks, using an online database available at the OCEARCH website. This database, called Global Shark Tracker, allows students to see the location of several great white sharks and to track their long-range movement over time. Students will also learn about the different methods used by scientists to answer research questions and how scientific knowledge can change over time.

The Content

Behavior is how an animal responds to sensory input. Behavior has both *proximate* and *ultimate* causes. Proximate mechanisms include the hormonal, nervous, and environmental stimuli that elicit a particular behavior pattern. Ultimate causes are the reasons why the behavior pattern evolved over time. Genes and the environment influence the behavior of animals. An *innate behavior* is one that occurs in all individuals of a population, regardless of individual differences in experience, whereas a *learned behavior* is one that develops only within specific individuals and stems from experience. Behavioral ecologists tend to examine behaviors such as foraging, courtship rituals, and migration through the lens of natural selection. Therefore, many of the explanations for animal behavior posed by scientists are based on the assumption that animals behave in a way that increases their fitness (or reproductive success).

Social behavior refers to the interactions that take place between two or more animals, usually of the same species. Social behaviors that are competitive in nature, such as the establishment of a dominance hierarchy or a territory, enable one animal to gain an advantage in obtaining access to limited resources (such as food or a mate). Social behaviors that are more cooperative in nature, such as pack hunting, enable animals to expend less energy to obtain the resources needed to survive. Finally, specific reproductive behaviors, such as courtship rituals or migration to a breeding ground, tend to increase the likelihood of finding a mate or to maximize the quantity of partners or the quality of a single partner. Most behaviors that animals engage in are explained by looking for ways that a behavior increases the likelihood that the animal will survive, find a mate, and produce offspring. A similar approach can be used to explain the long-range movements of the great white shark.

Timeline

The instructional time needed to implement this lab investigation is 180–250 minutes. Appendix 2 (p. 391) provides options for implementing this lab investigation over several class periods. Option E or G (250 minutes) should be used if students are unfamiliar with scientific writing because either of these options provides extra instructional time for scaffolding the writing process. You can scaffold the writing process by modeling, providing examples, and providing hints as students write each section of the report. Option F or H (180 minutes) should be used if students are familiar with scientific writing and have the skills needed to write an investigation report on their own. In options F and H, students complete stage 6 (writing the investigation report) and stage 8 (revising the investigation report) as homework.

Materials and Preparation

The materials needed to implement this investigation are listed in Table 12.1. The OCEARCH Global Shark Tracker database, available at *http://sharks-ocearch.verite.com.*, is free to use and can be run online using an internet browser. There is also a companion app for the website that can be used on mobile devices. The app can be downloaded for free from the Apple App store or Google Play. You should access the website or download the mobile app and learn how it works before beginning the lab investigation. In addition, it is important to check if students can access and use the website from a school computer because some schools have set up firewalls and other restrictions on web browsing.

TABLE 12.1

Materials list

Item	Quantity
Computer with internet access	1 per group
Student handout	1 per student
Investigation proposal C (optional)	1 per group
Whiteboard, 2' × 3'*	1 per group
Peer-review guide and instructor scoring rubric	1 per student

* As an alternative, students can use computer and presentation software such as Microsoft PowerPoint or Apple Keynote to create their arguments.

Topics for the Explicit and Reflective Discussion

Concepts That Can Be Used to Justify the Evidence

To provide an adequate justification of their evidence, students must explain why they included the evidence in their arguments and make the assumptions underlying their analysis and interpretation of the data explicit. In this investigation, students can use the following concepts to help justify their evidence:

- Animals often engage in specific types of behaviors (e.g., foraging, migration, establishment and defense of a territory, courtship displays) because these behaviors tend to increase reproductive success (or fitness).
- Animal behavior results from both genetic and environmental factors. Some behaviors, as a result, are inherited and fixed, whereas others are learned though experience.

We recommend that you review these concepts during the explicit and reflective discussion to help students make this connection.

How to Design Better Investigations

It is important for students to reflect on the strengths and weaknesses of the investigation they designed during the explicit and reflective discussion. Students should therefore be encouraged to discuss ways to eliminate potential flaws, measurement errors, or sources of bias in their investigations. To help students be more reflective about the design of their investigation, you can ask the following questions:

- What were some of the strengths of your investigation? What made it scientific?
- What were some of the weaknesses of your investigation? What made it less scientific?
- If you were to do this investigation again, what would you do to address the weaknesses in your investigation? What could you do to make it more scientific?

Crosscutting Concepts

This investigation is well aligned with three crosscutting concepts found in *A Framework for K–12 Science Education,* and you should review these concepts during the explicit and reflective discussion.

- *Patterns:* Patterns are often used to guide the organization and classification of life on Earth. In addition, a major objective in biology is to identify the underlying cause of observed patterns, such as the long-term movements of the great white shark.
- *Cause and Effect: Mechanism and Explanation:* One of the main objectives of science is to identify and then test potential causal relationships.
- *Scale, Proportion, and Quantity:* It is critical for scientists to recognize what is relevant or important at different sizes, times, or energy scales. It is also important for scientists to think proportionally about the phenomenon they are studying and not just in absolute values. For example, in this investigation it is important (and useful) to think in proportions rather than in absolute numbers.

The Nature of Science and the Nature of Scientific Inquiry

It is important for students to understand that *scientists use different methods to answer different types of questions*. Examples of methods include experiments, systematic observations of a phenomenon, literature reviews, and analysis of existing data sets; the choice of method depends on the objectives of the research. There is no universal step-by-step scientific method that all scientists follow; rather, different scientific disciplines (e.g., biology vs. physics) and fields within a discipline (e.g., ecology vs. molecular biology) use different types of methods, use different core theories, and rely on different standards to develop scientific knowledge. For example, in this investigation the students use an existing database rather than collecting data in the field. It is also important for students to understand that *scientific knowledge can change over time.* A person can have confidence in the validity of scientific knowledge but must also accept that scientific knowledge may be abandoned or modified in light of new evidence or because existing evidence has been reconceptualized by scientists. There are many examples in the history of science of both evolutionary changes (i.e., the slow or gradual refinement of ideas) and revolutionary changes (i.e., the rapid abandonment of a well-established idea) in scientific knowledge. Biologists, for example, long worked under the assumption that great white sharks are coastal territorial predators that rarely interact with other members of the species. However, as scientists learned more about the long-range movements of the great white shark, they abandoned these views. Great white sharks are now considered to be migratory predators that spend a great deal of time in the open ocean. This is but one example of how scientific knowledge is tentative and often revised to better account for natural phenomena.

You should review and provide examples of these two important concepts of the nature of science (NOS) and the nature of scientific inquiry (NOSI) during the explicit and reflective discussion.

Hints for Implementing the Lab

- Learn how to use the online database before the lab begins. It is important for you to know how to use the database so you can help students when they get stuck or confused.
- A group of three students per computer tends to work well.
- Allow the students to play with the database as part of the tool talk before they begin to design their investigation or fill out an investigation proposal. This gives students a chance to see what they can and cannot do with the database.
- Be sure that students record actual values (e.g., number of individuals in a location or time in each location), rather than just attempting to hand draw what they see on the computer screen.
- Encourage the students to take "screen shots" of the migration patterns they observe using the database and then use the images in their reports.

LAB 12

Topic Connections

Table 12.2 provides an overview of the scientific practices, crosscutting concepts, disciplinary core ideas, and support ideas at the heart of this lab investigation. In addition, it lists NOS and NOSI concepts for the explicit and reflective discussion. Finally, it lists literacy and mathematics skills (*CCSS ELA* and *CCSS Mathematics*) that are addressed during the investigation.

TABLE 12.2

Lab 12 alignment with standards

Scientific practices	• Asking questions • Planning and carrying out investigations • Analyzing and interpreting data • Using mathematics and computational thinking • Constructing explanations • Engaging in argument from evidence • Obtaining, evaluating, and communicating information
Crosscutting concepts	• Patterns • Cause and effect: Mechanism and explanation • Scale, proportion, and quantity
Core idea	• LS2: Ecosystems: Interactions, energy, and dynamics
Supporting ideas	• Animal behavior • Foraging • Territories • Mating • Migration
NOS and NOSI concepts	• Methods used in scientific investigations • Science as a body of knowledge
Literacy connections *(CCSS ELA)*	• *Reading*: Key ideas and details, craft and structure, integration of knowledge and ideas • *Writing*: Text types and purposes, production and distribution of writing, research to build and present knowledge, range of writing • *Speaking and listening*: Comprehension and collaboration, presentation of knowledge and ideas
Mathematics connection *(CCSS Mathematics)*	• Reason quantitatively and use units to solve problems

Lab 12. Explanations for Animal Behavior: Why Do Great White Sharks Travel Over Long Distances?

Lab Handout

Introduction

Shark populations worldwide are declining in areas where they were once common. As a result, the International Union for Conservation of Nature (IUCN), has classified many species of shark as threatened with extinction. One species of shark that is currently on the IUCN "Vulnerable" list is the great white shark (*Carcharodon carcharias*). The great white shark is found in coastal surface waters of all the major oceans. It can grow up to 6 m (20 ft.) in length and weigh nearly 2,268 kg (5,000 lb). The great white shark reaches sexual maturity at around 15 years of age and can live for over 30 years. Great white sharks are apex predators (see the figure to the right). An apex predator is an animal that, as an adult, has no natural predators in its ecosystem and resides at the top of the food chain. These sharks prey on marine mammals, fish, and seabirds.

A great white shark

Great white shark conservation has become a global priority in recent years. However, our limited understanding of their behavior has hindered the development of effective conservation strategies for this species. For example, little is known about where and when great white sharks mate, where they give birth, and where they spend their time as juveniles. We also know that some great white sharks travel long distances, such as from Baja California to Hawaii or from South Africa to Australia, but we do not know why they make these journeys. There are, however, a number of potential explanations that have been suggested by scientists. For example, great white sharks might travel long distances because they need to do one or more of the following:

- Find and establish a territory (an area that they defend that contains a mating site and sufficient food resources for them and their young) once they reach sexual maturity or after losing a territory to other great white sharks.
- Migrate between a foraging site and a mating site on an annual or seasonal basis.

- Forage for food—slowly traveling over long distances allows the sharks to find, capture, and consume new sources of food along the way without expending a great deal of energy.
- Find a foraging site with other sharks in it and cooperate with them to capture prey and minimize the amount of energy required to capture and consume food.
- Follow their prey as the prey migrates on an annual or seasonal basis.
- Move between several different foraging areas because they quickly deplete their food source in a given area and must move onto new foraging areas to survive.

All of these potential explanations are plausible because they can help a great white shark survive longer or reproduce more. It is difficult, however, to determine which of these potential explanations is the most valid or acceptable because we know so little about the life history and long-range movements of the great white shark. Most research on this species has been carried out at specific aggregation sites (such as the one near Dyer Island in South Africa). Although this type of research has enabled scientists to learn a lot about the feeding behaviors and short-range movements of the great white shark, we know very little about how they act in other places. A group called OCEARCH (*www.ocearch.org*), however, is trying to facilitate more research on their life history and long-range movements so people can develop better conservation strategies to help protect the great white shark.

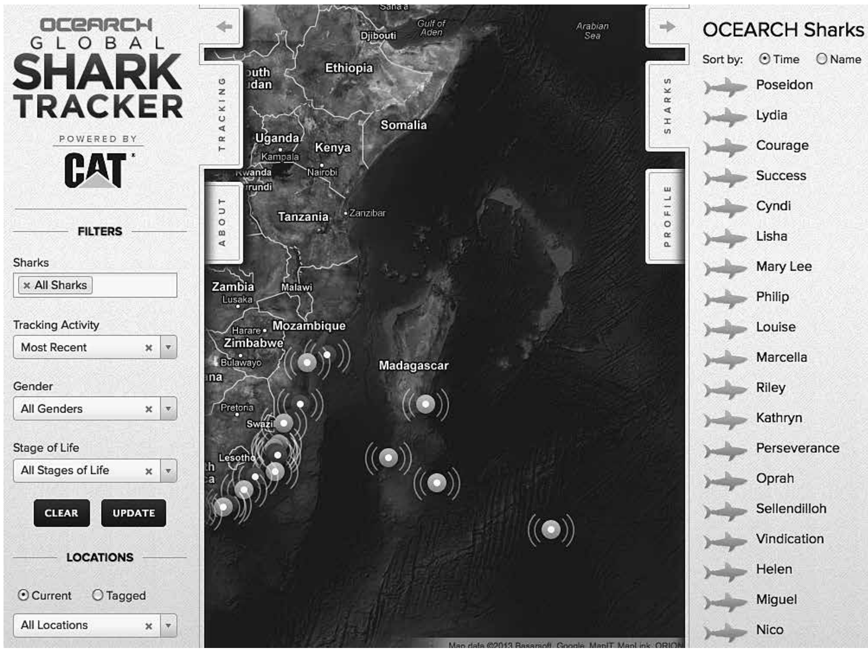
This group of researchers has been catching and tagging great white sharks to document where they go over time. To tag and track a great white shark, OCEARCH places a SPOT tag on the shark's dorsal fin. These tags emit a signal that is picked up by global positioning satellites. Unfortunately, the signal can only be detected when the shark's dorsal fin breaks the surface of the water and a satellite is directly overhead. Researchers at OCEARCH call these signals "pings." The time span between pings can vary a great deal (from once an hour to once in a three-week period) because of individual shark behavior and the orbit of a satellite.

OCEARCH has created the Global Shark Tracker database (*www.ocearch.org*) and a companion app for mobile devices (visit the Apple App Store or Google Play to download the free app) to share the real-time data they collect (see the figure on the opposite page). This database allows users to see the current location of all the sharks that the OCEARCH researchers have tagged. It also allows users to track the movement of each shark over time. Users can also search for sharks by name, sex (male or female), and stage of life (mature or immature).

Your Task

Use the OCEARCH Global Shark Tracker database to identify patterns in the long-range movements of the great white shark, and then develop an explanation for those patterns.

A screen shot of Global Shark Tracker from the OCEARCH website



The guiding question of this investigation is, **Why do great white sharks travel over long distances?**

Materials

You will use an online database called Global Shark Tracker to conduct your investigation. You can access the database by going to the following website: *www.ocearch.org*.

Safety Precautions

1. Use caution when working with electrical equipment. Keep away from water sources in that they can cause shorts, fires, and shock hazards. Use only GFI-protected circuits.
2. Wash hands with soap and water after completing this lab.
3. Follow all normal lab safety rules.

Getting Started

Your first step in this investigation is to learn more about what is already known about the great white shark. To do this, check the following websites:

- Animal Diversity Web (*http://animaldiversity.ummz.umich.edu/accounts/Carcharodon_carcharias*)
- MarineBio (*http://marinebio.org/species.asp?id=38*)
- The Smithsonian National Museum of Natural History Ocean Portal (*http://ocean.si.edu/great-white-shark*)

You can then use the OCEARCH Global Shark Tracker database to identify patterns in the long-range movement of great white sharks. To accomplish this task, it is important for you to determine what type of data you will need to collect and how you will analyze it.

To determine *what type of data you will need to collect,* think about the following questions:

- What data will you need to determine if there are patterns in the long-range movements of great white sharks?
- What data will you need to determine if there are sex-related, age-related, or geographic region–related differences in the long-range movements of great white sharks?

To determine *how you will analyze your data,* think about the following questions:

- How can you identify a pattern in the ways great white sharks move over long distances?
- How can you determine if there are patterns in the way great white sharks move over long distances based on sex, age, or geographic region?
- What type of table or graph could you create to help make sense of your data?

Once you have identified patterns in the ways great white sharks move over long distances, you will then need to develop an explanation for those patterns. You can develop one of your own or see if one of the explanations outlined in the "Introduction" section of this investigation is consistent with the patterns you identified. These explanations stem from what scientists know about the behavior of other animals and reflect some of the theories that scientists currently use to explain animal behavior.

Investigation Proposal Required? ☐ Yes ☐ No

Connections to Crosscutting Concepts and to the Nature of Science and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

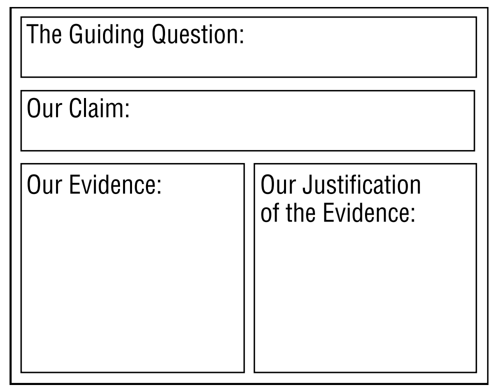
- the importance of identifying patterns,
- the importance of identifying the underlying cause for observations,

- the importance of examining proportional relationships,
- how scientific knowledge can change over time, and
- how the methods used by scientists depend on what is being studied and the research question.

Argumentation Session

Once your group has finished collecting and analyzing your data, prepare a whiteboard that you can use to share your initial argument. Your whiteboard should include all the information shown in the figure to the right.

Argument presentation on a whiteboard



To share your argument with others, we will be using a round-robin format. This means that one member of your group will stay at your lab station to share your group's argument while the other members of your group go to the other lab stations one at a time to listen to and critique the arguments developed by your classmates.

The goal of the argumentation session is not to convince others that your argument is the best one; rather, the goal is to identify errors or instances of faulty reasoning in the arguments so these mistakes can be fixed. You will therefore need to evaluate the content of the claim, the quality of the evidence used to support the claim, and the strength of the justification of the evidence included in each argument that you see. In order to critique an argument, you will need more information than what is included on the whiteboard. You might, therefore, need to ask the presenter one or more follow-up questions, such as:

- Why did you decide to focus on those data?
- What did you do to analyze your data? Why did you decide to do it that way? Did you check your calculations?
- Is that the only way to interpret the results of your analysis? How do you know that your interpretation of your analysis is appropriate?
- Why did your group decide to present your evidence in that manner?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those alternative ideas?
- How confident are you that your claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your original argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question!

Report

Once you have completed your research, you will need to prepare an investigation report that consists of three sections that provide answers to the following questions:

1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

Your report should answer these questions in two pages or less. This report must be typed, and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!

Lab 12. Explanations for Animal Behavior: Why Do Great White Sharks Travel Over Long Distances?

Checkout Questions

Nowhere in the world is there a movement of animals as spectacular as the wildebeest migration that occurs from July to October each year in Africa. Over 2 million wildebeest travel from Serengeti National Park in Tanzania to the greener pastures of Maasai Mara National Reserve in Kenya. The wildebeest expend a lot of energy to migrate because of the great distance they travel. The wildebeest also have to cross the Mara River in Maasai Mara, where crocodiles will prey on them. In addition, the wildebeest will be hunted, stalked, and run down by the large carnivores found in the Maasai Mara. Many wildebeest, as a result, do not survive the migration.

1. Given the fact that wildebeest must expend a lot of energy and may even die during a migration, why would wildebeest engage in this type of behavior?

2. There is a single, universal, step-by-step scientific method that all scientists follow regardless of the type of question that they are trying to answer.

   a. I agree with this statement.
   b. I disagree with this statement.

   Explain your answer, using examples from your investigation about animal behavior.

3. Scientific knowledge may be abandoned or modified in light of new evidence or because of the reconceptualization of prior evidence and knowledge.

   a. I agree with this statement.
   b. I disagree with this statement.

   Explain your answer, using information from your investigation about animal behavior.

4. Scientists often attempt to identify patterns in nature. Explain why the identification of patterns is useful in science, using an example from your investigation about animal behavior.

5. Scientists often attempt to identify the underlying cause for the observations they make. Explain why the identification of underlying causes is so important in science, using an example from your investigation about animal behavior.

6. Scientists often need to look for proportional relationships. Explain what a proportional relationship is and why these relationships are important, using an example from your investigation about animal behavior.

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*Page numbers printed in **boldface** type refer to figures or tables.*

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PB349X1
ISBN: 978-1-938946-20-2

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