TEACHERS AND RESEARCHERS EXPLORING AND COLLABORATING

PolarTREC Lesson Resource

Homes Heating Up- A Hermit Crab Investigation

Amy Osborne

Thermal Sensitivity of Embryos and Larvae of Antarctic Marine Ectotherms

PolarTREC Expedition Page
https://www.polartrec.com/expeditions/thermal-sensitivity-of-embryos-and-larvae-of-antarctic-marine-ectotherms

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Janet Warburton and Judy Fahnestock
Education Project Managers
Arctic Research Consortium of the US (ARCUS)
3535 College Rd. Suite 101
Fairbanks, AK 99709
(907) 474-1600
info@polartrec.com
www.polartrec.com

Overview

In this lesson, students will conduct an investigation to discover how the behavior of hermit crabs change as water temperature changes.

Goals

Students will understand and practice the steps of a science investigation through an investigation about hermit crabs' reaction to changing ocean temperature. Students will understand that as ocean temperatures increase some animals will adapt and some will not.

Objectives

- Students will be able to write a hypothesis, and gather, record, and interpret data.
- Students will be able to use data gathered to write a conclusion.
- If using the extension, students will plan and conduct an investigation related to local animals and temperature change.
- Students will be able to identify the challenges like growing too quickly, producing unhealthy larvae, and body temperature increasing to an unhealthy level, which animals in the ocean are facing as ocean temperatures increase.
- Students will understand the role that researchers play in helping understand the impacts the changing ecosystems will have on the animals and plants that call them home.
- Students will understand that Antarctica is a unique environment and the ocean surrounding it is an optimal place for scientists to conduct research.

Product Preparation

Summary of Lesson

This lesson is, ideally, for educators who have access to live ocean invertebrates, like hermit crabs, that can be safely used in a scientific investigation in which the animals are exposed to a range of water temperatures. Marine hermit crabs along the California coast can tolerate a wide temperature range (maximum 27°C/80°F), so are ideal for this lesson. Grainyhand *Pagurus granosimanus* and Blueband *Pagurus samuelis* hermit crabs are the species that were used by the author of this lesson.

In this lesson, students will conduct a teacher-directed investigation focused on the behavior of hermit crabs in different

Resource Details

Date

23 November 2020

Region

Antarctic

Completion Time

Less than a week

Grade

Elementary and Up

Permission

Download, Share, and Remix

Location

Antarctica

Expeditions

Thermal Sensitivity of Embryos and Larvae of Antarctic Marine Ectotherms

Author(s)

Amy Osborne

Related Members

Amy Osborne

Amy Moran

Materials

Materials Needed for each group (You can do this as a whole class or divide students into groups of at least 4 students):**

water temperatures. This lesson is a good follow up or introduction to the “Jumping Into Warming Seas” lesson. Students will briefly learn about the way temperature is affecting marine ectotherms living in Antarctica. They will then conduct their own investigation to discover how temperature impacts the behavior of hermit crabs. Ideally, this is followed by students creating and conducting their own investigation with tide pool creatures or animals or plants in their home community. **This lesson can be done virtually by the educator using the investigation as a demonstration and then having students create their own investigations around their home.**

During the lesson, there will be equal-sized tubs of ice and hot water, ideally with some type of insulation around them so the temperature can be maintained. Atop these tubs are placed containers, also ideally insulated around the edges of the container, holding 1.5 cm of seawater. There is an additional container holding 1.5 cm of seawater at the current seawater temperature. Thermometers are placed in each of the 3 containers holding seawater. Once the containers of seawater have had a chance for the temperature to change by the ice and hot water below it, hermit crabs are then placed in each container. The hermit crabs are given approximately 30 minutes to acclimate to the temperature of the water and then their behavior is observed by students. During the observation, the students note how quickly hermit crabs come out of their shells in different water temperatures.

Prior knowledge of students/lessons to do prior to this activity

- Students should know that the average global temperature is increasing due to global climate change and this increase in temperature also includes an increase in average ocean temperature.
- Students should know that the increase in ocean temperature is affecting living things in the ocean.
- PolarTREC lessons that educators can do prior to this lesson:
  Jumping Into Warming Seas

NatureBridge lessons for NatureBridge educators to do prior to activity

- Greenhouse gas tag: demonstrates the effect that increased gases have on raising the earth’s temperature
- Carbon journey
- Ocean Food Webs
- Jumping Into Warming Seas

Vocabulary

- Tidepools
- Marine Ectotherms
- Endotherms

Hermit crabs (3)-Marine hermit crabs along the California coast can tolerate a wide temperature range (maximum 27°C/80°F) so are ideal for this lesson. The author of this lesson used Grainyhand (*Pagurus granosimanus*) and Bluebanded (*Pagurus samuelis*)hermit crabs. please remember that these are living creatures and should be handled with care and respect.

Stopwatch or other timing device

Seawater

Hot water

Ice

2 containers: one for hot water and one container for ice that are the same size and shape ideally with some sort of insulation around them to keep them hot and cold.

3 Containers for sea water that can fit on top of the cold water and hot water containers. This way the containers of sea water can be indirectly heated and cooled.

3 Thermometers that can be submerged in water

Data recording sheet (in Lesson Materials)

Story of an Antarctic Research Team (in Lesson Materials)

Scientific Investigation Cards-Antarctica style

Topic

Climate Change

Life Science

Tools and Methods

- Climate Change

Science Investigation vocabulary

- Question
- Hypothesis
- Observation
- Data Collection and Analysis
- Conclusion

Organisms and Their Environments

Regulation and Behavior

Climate Change

Background
As the average temperature of the global ocean is rising due to climate change, the ocean ecosystems are and will continue to be impacted. Scientists around the globe are studying the impacts that even small temperature changes might have on life in the ocean.

For 15 million years the continent of Antarctica has been frozen under a thick sheet of ice. Due to the Antarctic Circumpolar Current (ACC), an ocean current that travels around the entire continent of Antarctica, marine animals located in Antarctica have lived in a fairly stable environment for millions of years. The ACC, along with upwelling, which also occurs along the west coast of the United States, means the ocean around Antarctica maintains a steady temperature throughout the year. This makes Antarctica a key location for scientists to research the effects that even small increases in ocean temperature will have on animals that live in the Antarctic marine ecosystem.

In Fall 2019, Dr. Amy Moran and her team of researchers traveled to Antarctica to study the impacts, mainly growth and development, that increasing ocean temperatures will have on marine ectotherms like sea spiders and nudibranchs (aka sea slugs). They found that as ocean temperatures warm some of these animals are growing at a faster rate. Dr. Moran and her team are now studying how this rapid growth rate will affect the development of these animals. See Antarctic Sun article "Larvae La Vida Loca: How Will Warming Oceans Affect Young Invertebrates When They're At Their Most Vulnerable?" by Michael Lucibella for more information. To stay up-to-date on what Dr. Moran and her team are learning about the way warming seas will impact marine ectotherms, visit the website of the research team Invertebrates in the Antarctic: Metabolism, Development, Biomechanics, and Polar Gigantism

As ocean temperatures warm, scientists predict that animals in the ocean will be impacted in a variety of ways. Scientists hypothesize that some animals in the ocean will increase in distribution and/or abundance (e.g. jellyfish, crown-of-thorns starfish, some species of nudibranchs) and some will decrease in distribution and/or abundance (e.g. salmon, sea lions, mussels). These impacts will affect ocean food webs across the globe.

Materials Needed for each group (You can do this as a whole class or divide students into groups of at least 4 students)

- Hermit crabs (3)-please remember that these are living creatures and should be handled with care and respect.
- Stopwatch or other timing-device
- Seawater
- Hot water
- Ice
- 2 containers: one for hot water and one container for ice that are the same size and shape ideally with some sort of insulation around them to keep them hot and cold.
- 3 Containers for seawater that can fit on top of the cold and hot water containers. This way the container of seawater can be indirectly heated and cooled.
- Thermometers that can be submerged in water
- Data recording sheet (see attached)

- Story of an Antarctic Research Team (see attached) and/or
- Scientific Investigation Cards-Antarctica style (see attached)

Procedure

SET UP
Make sure to have the ice, hot water, seawater, and containers ready to go. You can set up the materials with the students or you can have the materials set up ahead of time. (Note hermit crabs will need 15-30 minutes to acclimate to the new water temperature. So, you could set the experiment up with students before doing the Introduction or just before starting the Procedure section)

INTRODUCTION (10 minutes)
Ask students to answer, “How do you think plants and animals in the ocean are being impacted by climate change? Why do you think this is? What can you do to find out more about how plants and animals are being impacted?”

Follow this by choosing one of the following options:

Educator’s choice: “Story of an Antarctic Research Team” from the “Jumping Into Warming Seas” lesson OR “Scientific Investigation Cards-Antarctica style”

OPTION 1: Story of an Antarctic Research Team

A. Ask students to find a comfortable seat and close their eyes. (You can also do this with eyes open and show the pictures as you tell the story.)
B. Tell students that you are going to tell them a short story and they will visualize what they are hearing.
C. Read “Story of an Antarctic Research Team” (see attached resource)
D. Ask students to open their eyes. Share pictures of keywords and concepts from the story: sea ice, Pisten bully, sea ice road with flags, dive hut, divers with dry suits, nudibranch egg case, sea spider with eggs, dive tender, taking salinity and temperature measurements in the water, exploring underwater, nudibranch, sea spider, putting specimens into cooler. (see attached resource)
E. Explain that Dr. Amy Moran and her team in Antarctica are studying the impacts that warming ocean temperatures will have on marine ectotherms like sea spiders and sea slugs (at this point you can show pictures of adult sea spiders and nudibranchs aka sea slugs)
F. Tell students that warming oceans are one of the impacts that climate change is having on the ocean. You can show graphs of warming ocean temperatures (see attached resource).
G. Ask students to write about the following ...”What do you know about the challenges animals in the ocean are facing due to climate change?” “What questions do you have about the challenges marine animals are facing?”.

OPTION 2: Scientific Investigation Cards-Antarctica style

A. Hand out scientific investigation cards
B. Tell students that each card has a step in the scientific process and on the back of each card is an example of each step from the research team in Antarctica.
C. Have students put the cards in order and, as a group, discuss each step.

INVESTIGATION
1. Tell students that marine animals all over the globe are experiencing increasing ocean temperatures and this is impacting their habitats including their ability to find food, shelter, and even to grow and develop. In Antarctica in the fall of 2019, Dr. Amy Moran and her team started

researching the growth and development of sea spiders and sea slugs as the ocean temperature changes.
2. Ask students how their behavior changes as their environment changes or their resources change. For example, “How does your behavior change depending on how much food you have? How does your behavior change based on how hot or cold you are? How does your behavior change when your mood changes?” Have students share their ideas.
3. Let students know that today we are going to focus on an animal that lives in the ocean along the coast of the United States both on the east coast and the west coast: the hermit crab. While we don’t have the time or resources to study the way a hermit crab grows and develops under different temperatures, we can conduct an investigation to determine how hermit crabs behave in different water temperatures.
4. Show students hermit crabs. Ask students what they know or think they know about hermit crabs. You can have them record this in a journal or science notebook. You can also have the students draw pictures and make observations of the live hermit crabs.
5. If your students don’t know the steps of a scientific investigation go over the steps. You can use the attached cards for this or whatever method you prefer. If they do know the steps just quickly review them.
6. Tell students we have made our observations and gathered prior knowledge about hermit crabs and how external factors can affect our behavior. We will now move forward with the next steps of our investigation...Question, Hypothesis, Gathering Materials, and conducting the experiment.
7. Show the materials that will be used in the investigation...ice, hot water, containers, thermometers, seawater. Tell students the question is “Will changing water temperatures affect the amount of time it takes for a hermit crab to come out of its shell?” At this point, if your students are skilled at scientific inquiry you could have them design and conduct the experiment themselves. If your students need more direction you can follow the steps below.
8. Hermit crab experiment and data collection- If you haven’t done this yet...Fill one container with hot, even boiling water, fill the other equally sized container with ice. Ideally, wrap these containers in a blanket or put them in a cooler to help insulate them or maintain the temperature. Put 1.5 cm of seawater into each container that will sit atop the ice, hot water, or stand-alone. (Do not directly heat or cool the seawater. This would be dangerous for the animals!)
9. Put one container of seawater on top of the hot water container, one container of seawater on top of the cold water container, and leave one container of seawater on its own.
10. If you have not done so, put a hermit crab in each container of seawater. (You must give the hermit crabs approximately 30 minutes to acclimate to the water temperature before moving on with the rest of the investigation)
11. Put thermometers in each container of seawater.
12. Make sure students have a data collection sheet and a stopwatch or way to time how long it will take the hermit crab to emerge from its shell.
13. Explain to students that once the hermit crabs are acclimated to the water, we will scare them back into their shells and then time how long it takes them to come back out of their shells.
14. Have students write the question: “Will changing water temperatures affect the amount of time it takes a hermit crab to come out of its shell?”
15. Ask students to write a hypothesis including their reasoning behind their hypothesis. For example, I think changing water temperature will affect the amount of time it takes a hermit crab to come out of its shell because….”
16. Once you have given the hermit crabs time to acclimate to the water temperature make sure the person in charge of timing how long it takes the hermit crab to come out of its shell is ready with the timer.
17. Have a student scare the hermit crab so it goes back into its shell (usually picking the crab up and putting it back down is enough so that the hermit crab goes back into its shell). Have students time how long it takes the hermit crab to emerge from its shell again.
18. Record the time on the data collection sheet.
19. Once this has been done with each hermit crab at least 6 times, have students graph the data.
20. Ask students what they notice about the data. What conclusions can they draw from the data?

NatureBridge educators and other educators familiar with science talks - at this point you could move into a science talk. To find out more about conducting science talks use this guide from the Exploratorium Science Talk

Debrief the investigation

- How were your methods? Is there anything we should change and try again?
- Variables: What are the variables in our investigation that we could change and what might the results be? (Use a different type of water; use more extreme temperature differences; use more or fewer hermit crabs; test each hermit crab more than 6 times). For older students discuss the independent and dependent variables.
- For older students ask students how they might revise the experimental design.
- Ask students what questions they still have.

DEBRIEF
Ask students: How do you think plants and animals near your home might be impacted by changing temperature? Can you think of an experiment you could do close to your home related to living things and temperature change? If there is time, students can design their own experiments related to temperature and animal behavior.

ASSESSMENT
1. Have students redesign the current investigation and do it again OR have students design their own investigation focused on the same topic - animals and temperature change.
2. Ask students to answer the following questions:
* How do you think plants and animals in the ocean are being impacted by climate change?
* Why do you think this is?
* What can you do to find out more about how plants and animals are being impacted?
* What questions do you still have about the impact of climate change on plants and animals?
* What questions do you still have about planning and conducting investigations?

Timeline

1-2 hours
Note The hermit crabs will need about 30 minutes to acclimate to the new water temperatures.

Extensions/Adaptations

- This lesson can be adapted for older and younger students based on the level of direction the educator provides. For younger students, this entire investigation can be teacher-directed. Older students can be shown the materials and can design their own investigation including conducting multiple investigations and changing variables.
- Older students can also measure the dissolved oxygen at the different temperatures-this could tie into a lesson about ocean acidification.
- Begin or follow up with PolarTREC lesson "Jumping into Warming Seas".
- Begin with "Hermit Crabs in the Classroom" lesson from the University of Hawaii at Hilo Partnerships for Reform through Investigative Science and Math (PRISM).
- Follow up with California marine life animal cards located in the "Jumping Into Warming Seas" lesson and connect this lesson to the ocean food web. How will food webs be impacted by changes in the abundance and distribution of animals?
- Discuss adaptation. Research animals and plants in your area to find out how their behavior changes when the environment changes.

Extensions related to hermit crabs and temperature change:

- Read about a college biology class's experiment with hermit crabs and behavior change related to changing temperature and salinity from https://biol326.wordpress.com/2017/03/13/climate-change-should-hermit-c…

Extensions related to animal behavior and changes in the environment:

- Start your own phenology project to observe and record sightings of local species and to observe changes in behavior, including migration, blooming, reproduction over time. Here are resources for doing and recording phenology projects, including Citizen Science projects:
  USA Phenology Network
  California Phenology Project
  Budburst
  GLOBE
  iNaturalist programs
- Focus on Migration with PolarTREC educator Katie Gavenus's Arctic Connection-Seasonal Migration Addition

More lessons related to marine animals and changing oceans:

- Ocean Acidification-For NatureBridge educators, this is in the online searchable curriculum.
- For high school students: Piper Bartlett-Browne's PolarTREC lesson "What's on the Bottom?"
- For high school students: Piper Barlett-Browne's PolarTREC lesson "Don't Clam Up"

Transferability

- Anyone who lives near a coast in the United States will have access to hermit crabs. Before collecting them for educational purposes be sure to find out if you need a collecting permit. If you do not live near a coast or if you are unable to collect hermit crabs you can choose a different living thing, including plants, to test the impact of temperature change. It is the author's hope to create a video lesson for this and educators can have students observe the movement of the hermit crabs and temperature of the water via video.
- All educators can connect local phenomena to this lesson.
- All educators can use the resources listed in the Extensions section to do phenology projects with students.

Resources

Resources related to global climate change and the ocean

- NOAA "Assessing the Global Climate in 2019" https://www.ncei.noaa.gov/news/global-climate-201912
- NOAA Global Climate Report: https://www.ncdc.noaa.gov/sotc/global/202001
- NOAA Climate at a Glance (you can choose the month and start/end year to create a time series of surface temperature anomalies): https://www.ncdc.noaa.gov/cag/global/time-series/globe/ocean/1/1/1880-2…

Resources related to hermit crabs

- Biodiversity of the Central Coast-Grainyhand hermit: https://www.centralcoastbiodiversity.org/grainyhand-hermit-bull-pagurus…
- Biodiversity of the Central Coast- Blueband hermit: https://www.centralcoastbiodiversity.org/blueband-hermit-bull-pagurus-s…

- Blueband Hermit Crabs from “Invertebrates of the Salish Sea” https://inverts.wallawalla.edu/Arthropoda/Crustacea/Malacostraca/Eumala…
- Gianella Valere-Rivet, M., Juma, D., & Dunbar, S.G. (2017, March) “Thermal tolerance of the hermit crab Pagurus samuelis subjected to shallow burial events” *Crustacean Research* Retrieved from https://www.researchgate.net/publication/314682121_Thermal_tolerance_of…
- Taylor, Phillip R. (1981, May 25) *Journal of Experimental Marine Biology* “Hermit Crab Fitness: The effect of shell condition and behaviorial adaptations on environmental resistance” *Journal of Experimental Marine Biology* Retrieved from: https://www.sciencedirect.com/science/article/pii/002209818190037X

Assessment

- Students design and conduct their own investigation
- Students answer questions that they answered at the beginning of the lesson
- For English Language Learners or younger students: Students collaboratively create a poster of what is happening during the activity. Everybody has to write, each person has a different color marker. Create a picture of how to do a science investigation. Create a picture of what researchers think might happen to ocean animals due to warming oceans. (Four squares- drawing, words, predictions)

Author/Credits

Amy Osborne, PolarTREC Educator 2019
NatureBridge educator
Truckee, CA
ozontheroad07 [at] gmail.com

Story of an Antarctic Research Team

By Amy Osborne

(underlined sections have visuals that are attached)

Can have students act it out!

You have been transported to the most southern continent on earth...Antarctica. As you look around it is mostly white. There are some snow covered mountains with dark rock peeking out. Then there is the sea that is covered in ice. A flat vast area of white ice where in warmer months you might see ocean.

You are joining Dr. Amy Moran and her team of researchers on an expedition across the sea ice. Dr. Moran and her team are excited to conduct research in Antarctica, especially since the ocean near McMurdo Station, Antarctica is a fairly constant temperature of -1.8°C. It is, also, somewhat isolated from the rest of the world's ocean water due to the Antarctic Circumpolar Current that keeps the water flowing in a clockwise direction around Antarctica.

You get into a red vehicle, called a Pisten Bully, with tracks, like a bulldozer or tank, that move it along the ice and thin layer of snow that covers the sea. As you bump along across the sea ice in the back of the vehicle you stare out the window at the blowing snow and red flags that mark the "road". After 45 minutes you make it to your destination... a blue and yellow one room small building with a hole in the floor known as the dive hut. You help the researchers and divers unload SCUBA tanks and bags filled with dry suits from the back of the vehicle. Dry suits will keep the divers dry when they are in the frigid water. Some of the divers even wear heated vests under their dry suits!

You take everything into the small building and try to stay out of the way as the divers put on their dry suits and all of their SCUBA gear. As they sit around the hole in the floor which leads through the sea ice to the ocean below, the divers talk about what they are collecting that day...marine ectotherms (animals that get their body temperature from their environment...also known as cold-blooded). They are specifically looking for sea spiders, nudibranchs also known as sea slugs, and any egg cases they can find.

Once all of the divers have jumped through the hole to the frigid waters below you and the other dive tender keep an eye on the water in the hole for any signs of bubbles meaning a diver is coming up. You also use your scientific equipment to measure oxygen levels, salinity, and temperature of the water, and heat up lunch for everyone on the small stove that is in the dive hut. When you see bubbles rising in the dive hole you

prepare to grab the divers fins and SCUBA tanks before they climb up the ladder out of the water.

Once the divers are out of the water they begin to pull up what they have collected...sea spiders-eight legged creatures that are brown and yellowish orange, some are about the size of the lid to a peanut butter jar, some males are carrying orange colored eggs- and nudibranchs-sea slugs that are white and look like fancy snails without a shell- and some sea slug egg cases that look like spiraled white string.

The collected animals are put into a large yellow cooler filled with ocean water. You all eat some lunch and the divers change out of their dry suits. The gear, animals, and people are loaded back into the Pisten Bully and you all bump your way back to the snow covered land and the aquarium where the animals will be stored and observed.

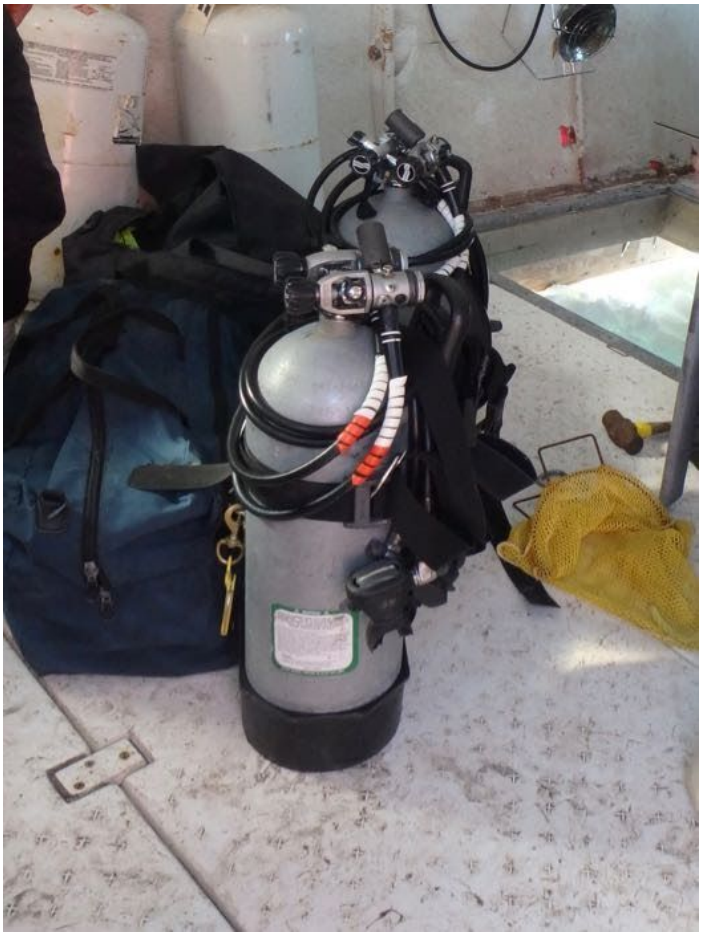
Photos for “Story of An Antarctic Research Team”

A sea covered in ice known as sea ice near McMurdo Station, Antarctica. Photo by Amy Osborne, courtesy of ARCUS

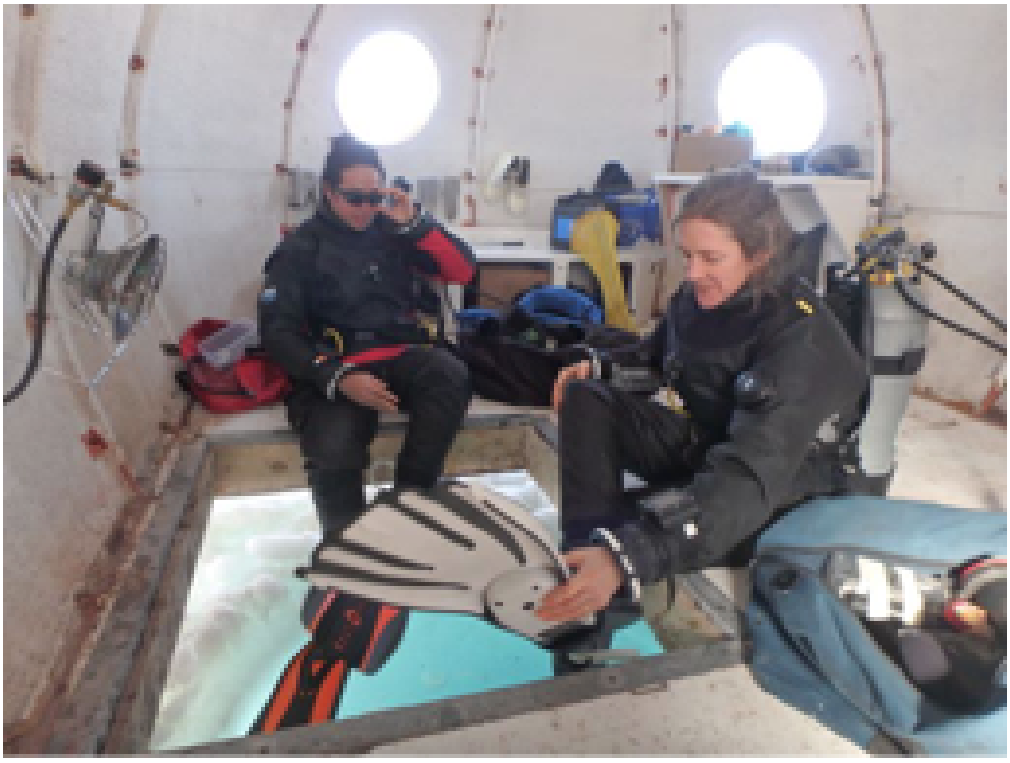
Pisten Bully on the sea ice near McMurdo Station, Antarctica. Photo by Amy Osborne courtesy of ARCUS

Driving along a sea ice “road” in Antarctica. Photo by Amy Osborne, courtesy of ARCUS

PolarTREC educator, Amy Osborne, enters a dive hut which has been placed on the sea ice near McMurdo Station, Antarctica. Photo by Denise Hardoy courtesy of ARCUS



SCUBA tanks that divers use to help them breathe when going underwater. Photo by Amy Osborne, Courtesy of ARCUS

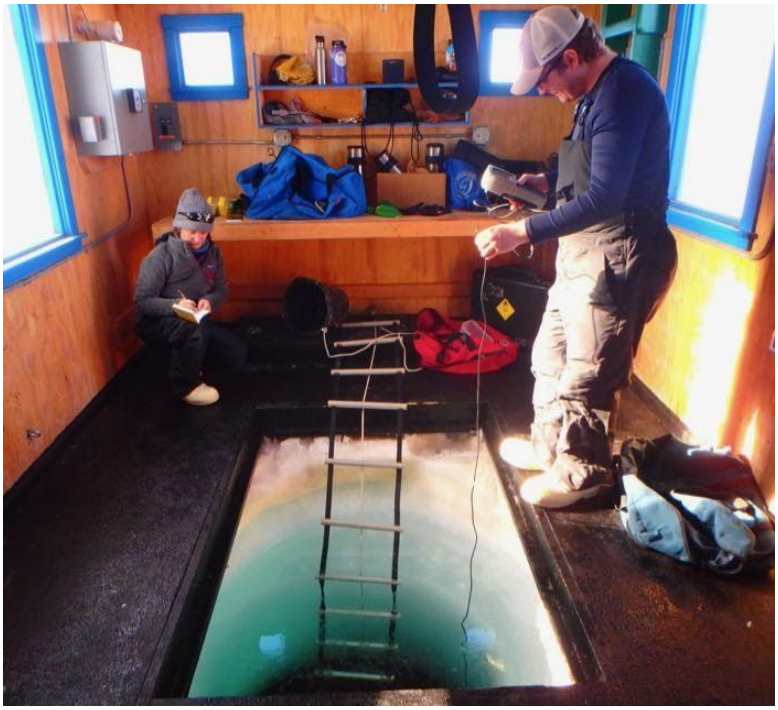


Dressed in dry suits, science divers and researchers Dr. Amy Moran and Aaron Toh prepare to dive through a hole in the ice into the frigid waters below. Photo by Amy Osborne courtesy of ARCUS

Nudibranch egg case. Photo by Amy Osborne, courtesy of ARCUS

Sea spider (*Ammothea*) with egg cases. Photo by Amy Osborne courtesy of ARCUS Crary Lab, McMurdo Station, Antarctica (2019)

Dive tender and PhD student Graham Lobert helps diver and PhD student Aaron Toh, dressed in a dry suit, with his collecting device and flashlight. Photo by Amy Osborne, courtesy of ARCUS



PolarTREC educator Amy Osborne and PhD student Graham Lobert take salinity, oxygen, and temperature measurements of the ocean. Inside a dive hut on the sea ice in Antarctica. Photo by Anne Todgham, courtesy of ARCUS

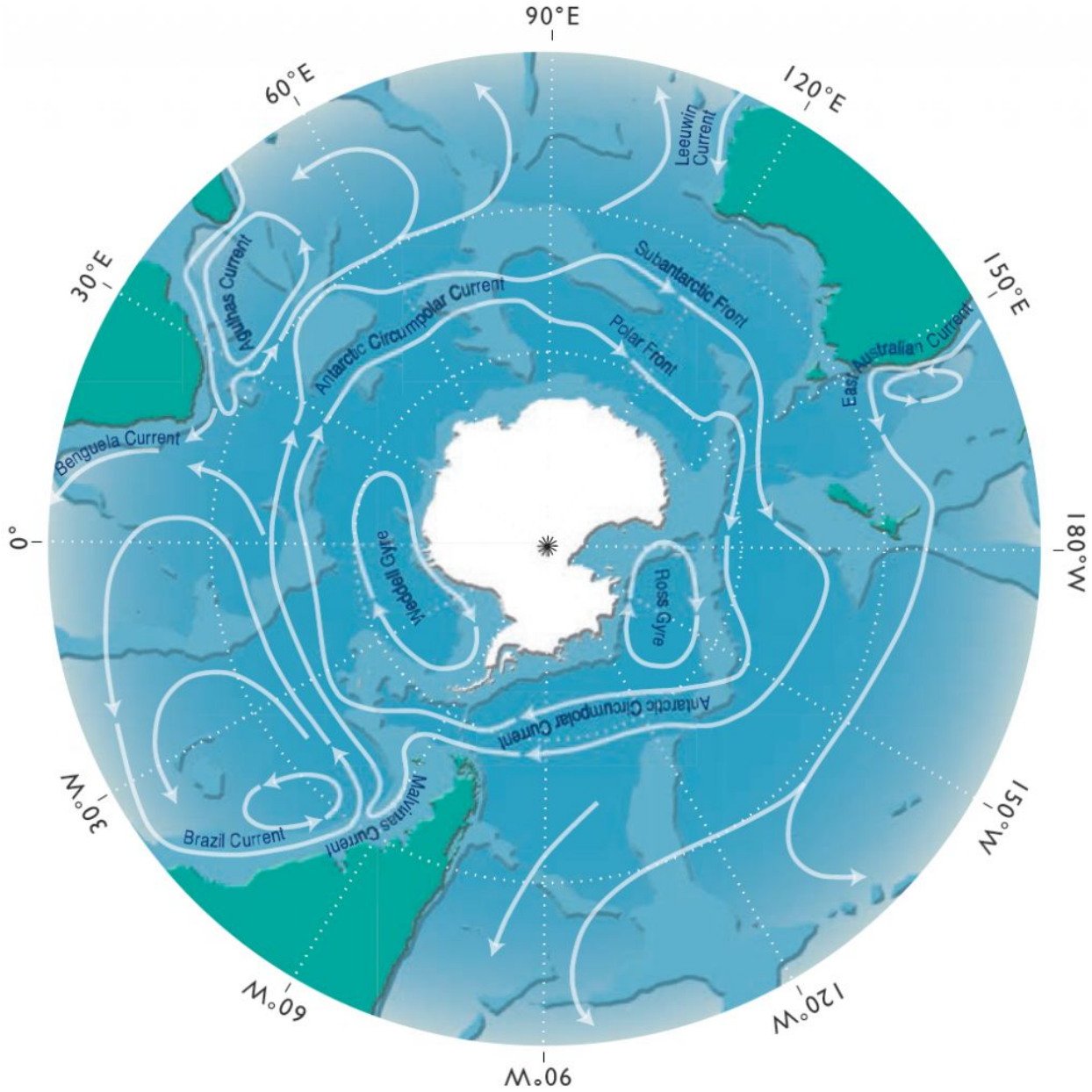
Researcher Dr. Amy Moran and Graham Lobert put sea spiders into a cooler of sea water to transport them back to the lab. Photo by Amy Osborne courtesy of ARCUS

PhD students Graham Lobert and Aaron Toh look at nudibranch eggs under a microscope and record what they are seeing. Crary Lab, McMurdo Station, Antarctica, Photo by Amy Osborne courtesy of ARCUS

Underwater in Antarctica, researcher and diver Dr. Amy Moran searches for and collects sea spiders, nudibranchs, and their eggs. Photo by Tim Dwyer, courtesy of ARCUS

Adult nudibranch (*Tritonia challengeria*) Photo by Amy Osborne, Courtesy of ARCUS

Adult sea spider (*Ammothea*) Photo courtesy of ARCUS by Amy Osborne, Crary Lab, McMurdo Station, Antarctica (2019)



"The major ocean currents south of 20°S are shown by the arrows. The largest current in the world, the Antarctic Circumpolar Current, circles from west to east around Antarctica. This current creates a fairly isolated marine ecosystem in the ocean around Antarctica. As a result, warm subtropical waters are kept away from the continent and the ocean temperature in the Southern Ocean is fairly constant. Around McMurdo Station the ocean temperature stays constant at around -1.8°C" (Diagram courtesy of Academic Press / de Vos Design) (Photo: Academic Press / de Vos Design)

Name:	**HERMIT CRAB INQUIRY DATA COLLECTION SHEET**						Date:
Trial	Temperature-WARM container	Time for hermit crab to emerge in WARM container	Temperature-neutral	Time for hermit crab to emerge in neutral container	Temperature -COLD side	Time for hermit crabe to emerge in COLD container	Notes
1							
2							
3							
4							
5							
6							
Average Temp/Average time for hermit crab to emerge							

SCIENTIFIC INVESTIGATION-ANTARCTICA STYLE

All photos by Amy Osborne, unless otherwise noted, (PolarTREC 2019) courtesy of ARCUS.

Note to teachers:

- Print these two sided
- These can be used to introduce science investigations using research conducted in Antarctica in Fall 2019 and 2021 as an example!
- They can also be used to help students develop their own investigations.

OBSERVATION

All photos by Amy Osborne, unless otherwise noted, (PolarTREC 2019) courtesy of ARCUS.

In Antarctica the ocean is a frigid -1.8°C (29°F) and often has ice on top of it called sea ice. There is a variety of wondrous life underwater.

It is cold and windy on the sea ice in Antarctica.

Sea Spider, sea stars on the Antarctic ocean floor.(Photo by Tim Dwyer)

What are you observing about the topic you are researching?

All photos by Amy Osborne, unless otherwise noted, (PolarTREC 2019) courtesy of ARCUS.

Prior Knowledge

All photos by Amy Osborne, unless otherwise noted, (PolarTREC 2019) courtesy of ARCUS.

Antarctic ocean researcher Dr. Amy Moran knows that sea spiders and nudibranchs live in the cold waters of Antarctica.

Nudibranch

Dr. Moran

Sea Spider

She knows these animals are cold-blooded (ectotherms), meaning their bodies cannot control their temperature.

Dr. Moran also knows that these animals have survived in constant cold temperatures for millions of years. They are sensitive to small changes in water temperature.

Dr. Moran knows that, due to global climate change, the temperature of the ocean water is getting warmer.

What do you know or think you know about the topic you are researching?

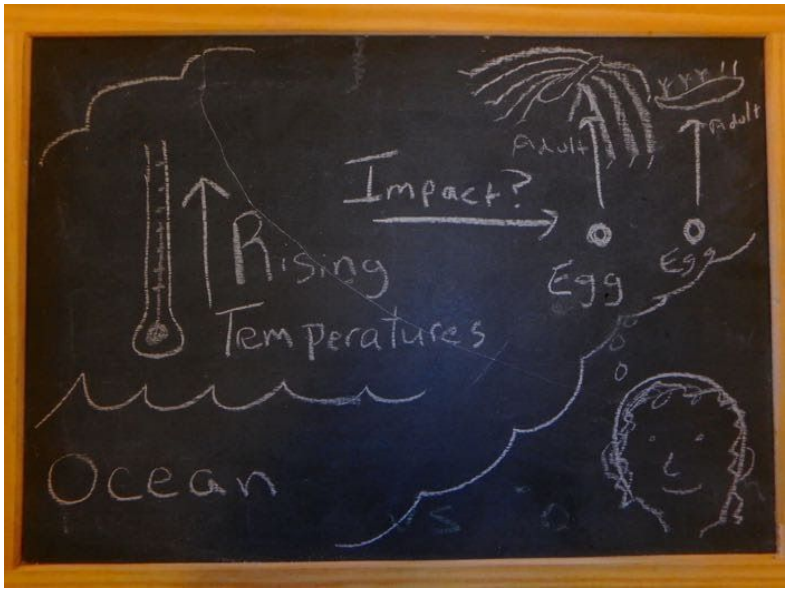
All photos by Amy Osborne, unless otherwise noted, (PolarTREC 2019) courtesy of ARCUS.

Asking Questions

All photos by Amy Osborne, unless otherwise noted, (PolarTREC 2019) courtesy of ARCUS.

Dr. Moran wondered:

Will changing ocean temperatures affect the growth and development of marine ectotherms?



What questions do you have about the topic you want to research?

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Choosing a Question

All photos by Amy Osborne, unless otherwise noted, (PolarTREC 2019) courtesy of ARCUS.

Dr. Moran received a grant from the National Science Foundation to spend two summer seasons in Antarctica running tests to find the answers to her question.

Antarctica is here!

Look at the questions you asked and choose one to investigate.

To choose your question, ask yourself...

- **Is it testable-can it be answered by experimenting?**
- **Is it specific?**
- **Do you have the time to test it?**
- **Do you have the resources to test it?**

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HYPOTHESIS

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Dr. Moran and her team have worked with sea spiders before and know, from other researchers, that marine invertebrate growth can be affected by warming ocean temperatures.

They hypothesize that the growth of the animals they are studying will speed up under warmer water conditions. They also hypothesize that this sped up growth will affect the way the animals develop.

Nudibranch Eggs (Photo by A. Toh)

Faster and different

Adult Nudibranch

Now that you have chosen your question to investigate, use what you know and have observed to write your hypothesis.

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PLANNING THE INVESTIGATION

All photos by Amy Osborne, unless otherwise noted, (PolarTREC 2019) courtesy of ARCUS.

The steps the Antarctica research team took to do their research:

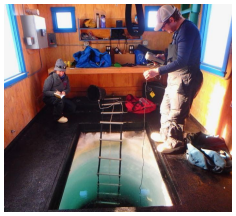
1. **Collect sea spiders, nudibranchs, and their eggs from the ocean around Antarctica**

Sea Spider with eggs

Dr. Moran diving in Antarctica
(Photo by Tim Dwyer)

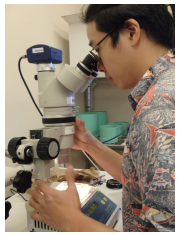
Nudibranch egg case

2. **Measure and record the temperature of the water and amount of oxygen in the water.**



PolarTREC educator Amy Osborne and PhD researcher Graham Lobert measure and record oxygen, salinity, and temperature of the water under the sea ice in Antarctica. (Photo by Anne Todgham)

3. **Observe eggs and larvae exposed to different temperatures and record observations.**



Aaron Toh observes eggs under a microscope

4. **Analyze the data.**

PhD researcher Aaron Toh compiles and analyzes the data so far.

What steps will you take to conduct your investigation?

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MATERIALS and TOOLS (1)

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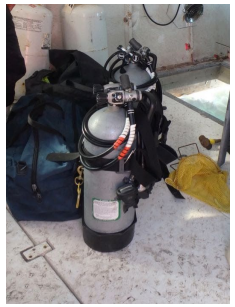
To conduct her experiments Dr. Moran needed to collect animals from the ocean and then study them in the lab.

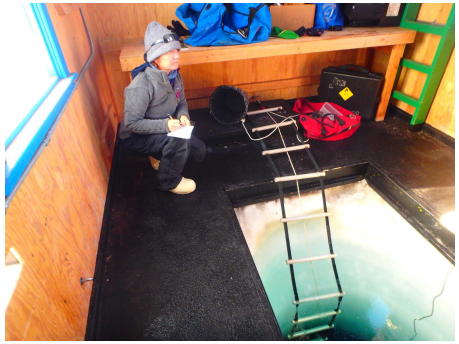
She needed more researchers to help her do her experiments and more divers to help her collect the animals she needed.

Science divers prepare to dive through a hole into the icy ocean below.

To collect under water the dive team needed: a Pisten Bully to help travel on the sea ice, a collecting container with a flashlight, SCUBA gear, a hole in the ice with a dive hut over it to stay warm.



The team needed people to make sure the divers stayed safe (aka dive tenders) and collect more data.



PolarTREC educator Amy Osborne (Photo by Anne Todgham) and PhD student Graham Lobert dive tended and collected data while the divers were in the water.

What human resources and tools will you need to conduct your research?

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MATERIALS and TOOLS (2)

All photos by Amy Osborne, unless otherwise noted, (PolarTREC 2019) courtesy of ARCUS.

Once the research team brought the animals back to the lab they needed tools to make observations and identify animals.

ID charts for nudibranch and sea spider growth

Welled trays to look at eggs under a microscope

Nudibranch egg case under a microscope

To learn how animals grow at different temperatures, they needed a way to keep the eggs they were studying at specific temperatures.

PhD student Graham Lobert observes embryos in a thermal block. A tool designed by the research team that creates a temperature gradient in water.

PhD student Aaron Toh looks in an incubator set at a very cold temperature

Are there any additional tools you will need to conduct your research?

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EXPERIMENTING and RECORDING RESULTS and OBSERVATIONS

All photos by Amy Osborne, unless otherwise noted, (PolarTREC 2019) courtesy of ARCUS.

Dr. Moran and her team looked at and recorded the way the embryos and larvae of sea spiders and sea slugs changed over time under different water temperatures.

PhD students and researchers Aaron Toh and Graham Lobert observe and record the growth of sea spiders and nudibranchs under different water temperatures.

How will you record your data?

Begin experimenting!

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ANALYZING DATA

All photos by Amy Osborne, unless otherwise noted, (PolarTREC 2019) courtesy of ARCUS.

Dr. Moran along with her research team of Aaron Toh and Graham Lobert used a computer to help them compile their data and look at in a way that they could better understand the data they gathered.

Aaron Toh uses a computer to compile and analyze data.

Look at the data you collected.

How can you present the information in a way that you can easily understand it, like using a graph?

What do you notice about the data you collected?

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CONCLUSION

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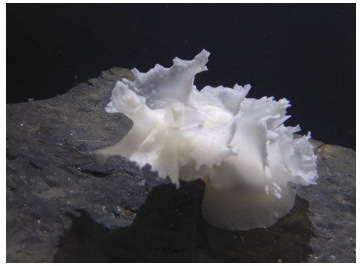
What are they finding out?

The research team is learning that as ocean temperatures increase the sea spiders and nudibranchs develop more quickly.

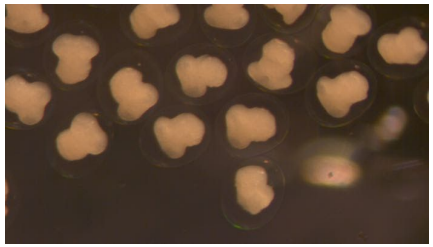


Faster

Faster

Ocean Temperature

Sea Spider Eggs (Photo by A Toh)



Veliger stage of Nudibranch (Photo by A Toh)

Larvae of these invertebrates are really sensitive to warmer temperatures! They develop a lot faster when the water is a little warmer than usual.

What can you conclude from the data you gathered?

MORE EXPERIMENTING AND MORE QUESTIONS

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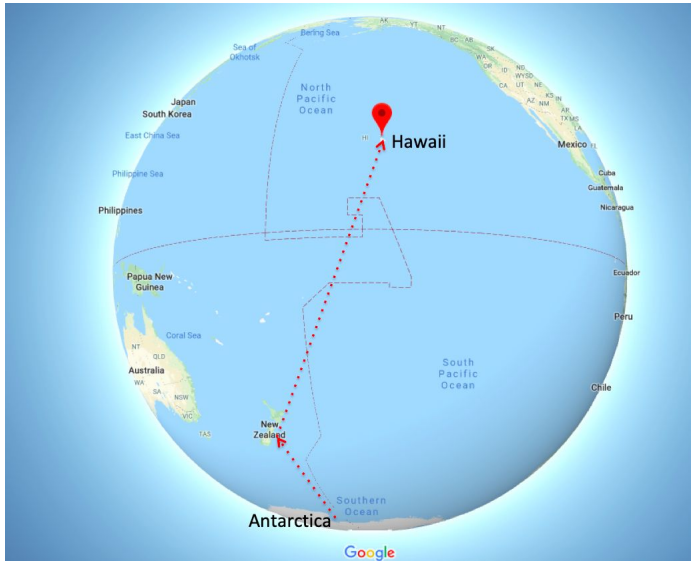
Now What?

The Antarctic research team is running some long-term experiments throughout 2019-2022.

They will be in Antarctica for two seasons doing their research.



They will take some of their specimens back to Hawaii and run more tests in the lab there.

What questions do you still have about your investigation?

How might you change parts of it and re-run your experiments?

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