POLAR TREC
Learning Resources

Details

Completion Time: About a week

Permission: Download, Share, and Remix

Invasive Species Under Ice

Materials

- Computers with Internet Access

Overview

Antarctica is the coldest, driest place on Earth with a fairly limited number of native species which have adapted to these extreme conditions over millions of years. As a result, it's not very likely that a non-native species would survive there . . . right? Actually ever since exploration and exploitation of the Antarctic region began in the 1800's, new species have been showing up, mostly brought in by accident, but some were brought in intentionally. PolarTREC teacher Mike LeBaron worked with the WISSARD (Whillans Ice Stream Subglacial Access Research Drilling) Project, to see how a new, totally unexplored ecosystem, subglacial Lake Whillans, was being drilled into and explored for the very first time. Keeping that sub-glacial ecosystem "clean" while at the same time learning about the possible life forms in it was a major objective of the project. In this lesson students will gain an understanding of the impacts of invasive species and discuss the value of keeping the subglacial lake environment unchanged as a result of human activities.

Objectives

When they complete this lesson, students should be able to:

- describe what an invasive or non-native species is.
- know the traits of non-native species that help them to be successful in new areas.
- list 3 or more typical impacts of non-native species on native species and ecosystems
- identify 3 or more non-native species near where you live and how they have affected the area.
- understand why the WISSARD project was so focused on keeping non-native microbes out of Subglacial Lake Whillans.

Lesson Preparation

This lesson is intended for High School students, but can

be altered or simplified for younger students. This lesson will cover elements of Earth Science, Biology, and ethics. Students will be reviewing multiple sources of data and developing their own understanding from that data. In preparation it will be useful if students have some basic understanding of ecology, invasive species, glacial processes, and evolutionary change in simple organisms (Note – these concepts are not addressed directly by this lesson).
This activity is presented in two parts: Part 1 is focused on understanding the general impact of invasive species. Part 2 will ask students to consider why maintaining subglacial Lake Whillans in an unaltered state is important to both the ecology of that ecosystem and to the scientific objectives of the project.

Procedure

Part 1 – Understanding Invasive Species

This lesson has several specific learning objectives. When you are done with Part 1 you should have a good understanding of what a non-native or invasive species is and how they affect ecosystems. If there are words you don't know, keep track of them so you can share questions with other students in your class. You will also be sharing many of your ideas and what you have learned with your classmates as well.

1. Objective: Be able to describe what an invasive or non-native species is.
a. Working in groups, write down everything you know or believe you know about invasive species. Be specific: describe what they are, list some organisms that you believe are non-native or invasive, and explain how they fit into the ecosystem they occupy. Don't look up anything in a textbook or on the Internet – this is to find out what you know right now.
b. When everyone has completed listing what they know, share your work with one or two other groups. Make sure that everyone shares what they have and that they write down what they agree on and where there are differences.
c. After everyone has shared their information, write your results on the board so you can see what everyone knows.
d. After you've seen the class's ideas, go back and look up information you need using the links below. Take notes on those things that your group didn't agree with and decide why there was a difference in what you originally thought and what the reference links said. Be prepared to discuss these with the class or between groups.
i. http://www.invasivespecies.gov/main_nav/mn_faq.html
ii. http://www.environmentalgovernance.org/research/issues/invasive-species/
e. Did you notice that invasive species can be any living organism? That includes plants, animals, and microbes.

2. Objective: Know the traits of non-native species that help them to be successful in new areas.
a. You've probably learned a little bit about why some (but not all) species that are not native to an area are considered invasive. Use the links below to help build your knowledge of what traits help non-native species be successful when they come into a new ecosystem. Look at several of the links – no one link has all the information.

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i. http://www.actionbioscience.org/biodiversity/simberloff.html (look specifically at the heading "Introduced species are not good guests" and analyze the information to find the reasons that invasive species are so successful)
ii. http://www.fs.usda.gov/detail/r8/landmanagement/resourcemanagement/?cid=stelprdb5317039
iii. https://sitn.hms.harvard.edu/sitnflash_wp/2011/12/invasive_species/
iv. http://cisr.ucr.edu/invasive_species_faqs.html
v. http://education.nationalgeographic.com/education/encyclopedia/invasive-species/?ar_a=1
b. Compare what you find or interpret with other students or groups. Create a list of the traits on the board and see if everyone agrees.

3. Objective: Be able to list 3 or more typical impacts of invasive species on the native species and ecosystems.
a. Now the real issue – why do we care about invasive species? Again using the links below, identify the problems that invasive species cause and how they affect native species and ecosystems. Be sure to fully explain what the problems are and why it's a problem. Keep it general – you want to understand the big picture, not the effect of just one or two species.
i. http://www.environmentalgovernance.org/research/issues/invasive-species/
ii. http://www.actionbioscience.org/biodiversity/simberloff.html
iii. http://www.nrdc.org/wildlife/invasivespecies/
iv. http://water.epa.gov/type/oceb/habitat/invasive_species_index.cfm
v. http://www.guardian.co.uk/environment/2010/jan/22/invasive-species-threat
vi. http://www.environment.gov.au/biodiversity/invasive/
vii. http://www.fws.gov/invasives/faq.html (see "why are invasive species a problem?")
b. Share what you've found by listing the major impacts on the board or by discussing it with other students or groups.
By now you should have a good picture of what an invasive species is, why it can be successful, and how it affects ecosystems and economies. What you haven't explored (but you might have read already) is how invasive species move from one area to another and what some of the problem species are.

4. Objective: Be able to identify 3 or more non-native species near where you live and how they have affected the area.
a. Each student or pair of students should select an invasive species and research where it came from, how it got to the area it invaded, and the problems it is causing. Your teacher may assign you a species. The links below give you different ways to find out about invasive species in your area.
i. http://www.invasivespeciesinfo.gov/unitedstates/state.shtml (United States)
ii. http://www.invasivespeciesinfo.gov/resources/listsintl.shtml (International)
iii. http://www.invasive.org/index.cfm (mainly the SE United States)
You may also know of a specific species that you want to investigate. Get your teacher's approval and then make sure that the organism you selected is really an invasive, not just a

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non-native organism.
When everyone has completed their research, think of imaginative ways to share what you've learned. As a class you might make a poster or learning map that shows the species of concern for your area. You might also show how they are affecting the local ecosystems and what native species are being displaced by them.

Part 2 – Keeping Clean!
The WISSARD (Whillans Ice Stream Subglacial Access Research Drilling) Project planning took many years. WISSARD was designed to drill through approximately 2500-3000 feet (800 meters) of ice to get into a shallow lake that lies between the rocks that make up the continent of Antarctica and the ice sheet that covers virtually the entire continent (see the links below for a detailed explanation and diagrams). Subglacial Lake Whillans is one of many lakes that exist under the ice of Antarctica. These lakes have been there for many thousands of years and may contain life forms that can only be found in these dark, cold ecosystems! If living organisms do exist in the lakes beneath the ice, they are probably microbes – very simple organisms that consist of only one cell and are related to organisms such as bacteria or viruses. It's not exactly the type of environment where you might think about invasive organisms, but remember even microbes can be invasive (like West Nile Virus), so a big part of the WISSARD Project was keeping foreign invaders out of these subglacial lakes.

There are many online resources that will help you understand about the WISSARD Project. For this lesson you will use the links below to learn about the project and create a picture in your mind (and on paper) of how the project worked to keep foreign organisms out of the lake. As you read through the online materials, look for answers to these questions:
• How might planning during the 5+ years before the actual drilling have helped to reduce or eliminate possible contamination?
• What was the role of technology in reducing the contamination risk?
• What processes did the people doing the drilling and working at the field site use to control contamination?
• Could contamination still be introduced into the subglacial lake? If so, how?

Read the following articles (they are all short) and take notes that will let you fully answer the questions above. Remember that you may have to interpret and analyze the information in several different articles to come up with a complete understanding to these questions.

Article set 1 – WISSARD Explained (http://www.wissard.org/science-and-operations) GBASE (http://www.wissard.org/wissard-science/science-projects/gbase), Stewardship (http://www.wissard.org/stewardship), and Clean Access Technology (http://www.wissard.org/stewardship/clean-access-technology-and-procedures) – this set explains and shows pictures of the project and its objectives.
Article 2 – WISSARD Work Site (http://www.polartrec.com/expeditions/antarctic-sub-glacial-lake-and-stream-studies/journals/2012-11-07). This gives you an introduction to WISSARD and our work site. It has part of the information you need to answer the puzzle.

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Article 3 – Moving Day (http://www.polartrec.com/expeditions/antarctic-sub-glacial-lake-and-stream-studies/journals/2012-11-28). This article includes more information on the equipment at setup.
Article 4 – Status Update (http://www.polartrec.com/expeditions/antarctic-sub-glacial-lake-and-stream-studies/journals/2012-12-01). More general information.
Article 5 – Last Visit (http://www.polartrec.com/expeditions/antarctic-sub-glacial-lake-and-stream-studies/journals/2012-12-12). Updates on the equipment and work site
And finally, if you want to watch part of a podcast that explains the project, see Antarctica Day (http://www.polartrec.com/resources/event/antarctica-day-2012-michael-lebaron-and-the-wissard-expedition-mcmurdo-station) and listen starting at approximately 34 minutes into the podcast.
Take a look at the many other journal articles and the blogs in PolarTREC.com and WISSARD.org for additional information or just to learn about life in Antarctica.

Extension

1. The Scientific Method and Scientific Argument – Students tend to view science as a set of rules or known facts that they are responsible for learning. They rarely understand the nature of science and how scientific data become scientific knowledge. All too often they view the scientific method as a set of well-defined steps that do not change from one type of work to another. They also don't comprehend that scientists argue all the time, not because one person wants to "win", but because discourse and argumentation are how we question what we think we know and ultimately learn and expand our knowledge. This last part is more nearly the real scientific method. The Summer 2013 issue of The Science Teacher (NSTA.org) has a number of good articles and guidelines for helping students understand scientific argument and its place in the Scientific Method (see resources). Based on the information provided in the various resources for the WISSARD Project, students could:
a. Develop a graphic organizer or flow chart of the different information and how it was used to plan the project and develop the technology that was used in the project. This could be done in teams with some level of debate on how such a plan could be developed.
b. Make further use and development of the Socratic Seminar form of discussion as they consider the value of keeping non-native species out of remote environments like Antarctica.
c. Review other projects and journal entries at www.polartrec.com and engage students in a compare and contrast type literature review to let them see the different approaches to scientific research, the time frames in which planning and field work are done, and the outcomes of the work.

2. Popular Press - Follow up on the articles that were published in popular press about the WISSARD Project or include these in the student reading. See the listings of publications and resources at:
a. http://www.polartrec.com/expeditions/antarctic-sub-glacial-lake-and-stream-studies/related
b. http://www.wissard.org/publications

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3. Antarctic Invasives – Look at what organisms have made the jump from more northern latitudes onto the Antarctic continent, how they got there, and what if anything, is being done to control them.
a. NPR – Antarctica Visitors Unwittingly Bring Invasive Species (http://www.npr.org/2012/03/06/148072123/visitors-unwittingly-bring-invasive-species-to-antarctica)
b. National Geographic - Alien Species Invading Antarctica via Tourists, Scientists (http://news.nationalgeographic.com/news/2012/03/120305-antarctica-invasive-species-environment-science-tourists/)
c. National Geographic - Antarctica Braces for Influx of Invasive Species (http://newswatch.nationalgeographic.com/2013/01/07/antarctica-braces-for-influx-of-invasive-species/)
d. NSF Antarctic Sun Article (http://antarcticsun.usap.gov/science/contentHandler.cfm?id=2771)
e. Many other articles are available using a query such as "Antarctic Invasive Species".

Resources
• Computers with Internet Access
• PolarTREC WISSARD Project Journal - http://www.polartrec.com/expeditions/antarctic-subglacial-lake-and-stream-studies. This journal follows the day-to-day activities of PolarTREC teacher Mike LeBaron during the WISSARD project in November/December of 2012. Explore the PolarTREC web site – there are many journals written by other teachers on projects in both the Arctic and Antarctic which may interest students and provide additional insight into the unique features of these areas. Specific links are provided in the procedure for this lesson.
• WISSARD Web Site - http://www.wissard.org/. For ongoing updates on the project and science news, check this site. It gets regular updates. Check the blogs and multimedia. Specific links are provided in the procedure for this lesson.

Assessment
Teachers may want to asses student work in the data gathering stages of this lesson and then see how they can integrate their findings with those of their classmates through an open discussion. For an overall understanding of what students take away from this lesson, a student lead discussion or Socratic seminar is an excellent tool. Students should be able to identify and discuss the reasons why keeping the subglacial lake environment unchanged is critical to the long term study of this and other similar systems. Their reasoning should be supported by the research they did on invasive species. In a Socratic seminar, each student has a chance to interact in an open forum and is free to express their own opinion and support it with the data they researched or learned about from their fellow students. Ultimately this gives all students the chance to reflect on what they learned. The teacher's role is to keep the discussion on track, ask open-ended "starter" questions if needed, and simply observe. The students direct the overall discussion through their comments and the statements they make to one-another.

Some links to help get a Socratic Seminar discussion started are:
• Guidelines for Socratic Seminars: http://nwabr.org/sites/default/files/SocSem.pdf

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• Chowning, Jeanne Ting, Socratic Seminars in Science Class, The Science Teacher, Vol. 76, No. 7, October, 2009 (available to NSTA members at their web site, NSTA.Org)
Teachers, here are some possible ways to start the discussion if needed. Remember that rather than asking for student opinions, the goal is to encourage well-justified reasoning based on evidence in the text they read or research they have done. Some ideas for discussion questions include:
• How have invasive species affected our region?
• How might the future scientific research of Lake Whillans be affected by the release of non-native microbes?
• How could non-native microbes affect the native populations in Lake Whillans?
• Is there a moral justification for keeping non-native organisms out of Lake Whillans?
• Should scientific research be conducted at all on such remote and potentially delicate environments as those at Lake Whillans?
• What is the societal/scientific value of research at Lake Whillans?

Notes to Teachers
The WISSARD Project has been over 5 years in the planning and design stage. This is an important (sidelight) element to help students understand – that often the planning for a scientific activity takes much longer than the actual time spent "doing the science". The field setup and equipment testing period at McMurdo Station was about 2 months. After the testing period, the equipment was "traversed" (hauled on sleds by large tractors) 600 miles over the ice to the actual field site over Lake Whillans. Once the equipment was at the field site, the actual drilling and sampling was less than 3 weeks. The samples obtained from Lake Whillans will be used by many different members of the science team for years to come.
The project also relied on many new technologies for the drilling and sample collection. The complexity of the project, the number of people involved, and the logistics of making it all work in the severe environment of Antarctica are difficult for most people to comprehend.
This is an "objective based" lesson. Keep the students focused on the objectives. Here's a quick look at what the main findings for each of the objectives should focus on and discover.
• Be able to describe what an invasive species is.
Any species (plant, animal, or microbial) which does not normally occur in a given ecosystem is considered non-native. If that organism has a negative or detrimental impact on the ecosystem, it is an invasive.
• Know the traits of invasive species that help them to be successful in new areas.
Generally non-native species are successful because they are new to the ecosystem and may not have any natural predators to limit or control their numbers; they may reproduce more often or produce more offspring than similar native species do so they can increase their numbers quickly; they may make better use of or be more efficient at using local resources such as food, habitat. They may also utilize resources on a different time frame (earlier or later than native species) and therefore reduce the available resources for the natives.
• Be able to list 3 or more typical impacts of invasive species on the native species and ecosystems.

These can compete with or displace the native species. They can be more effective as predators against native species. They may have defenses such as toxins that no native species have a resistance to. They may reproduce more rapidly or in greater numbers than similar native species.

• Be able to identify 3 or more invasive species in your area and their impacts to the local ecosystem.

Will vary by area.

• Understand why the WISSARD project was so focused on keeping non-native microbes out of Subglacial Lake Whillans. If you listened to the Live Event recording, you heard Dr. Ross Powell explain some of the technology and the purpose of it. He also elaborated on why clean access drilling is so important to the project. Remember that the focus of the planning was to limit the introduction of new microbial species. This planning relied on keeping the equipment bacteriologically clean and limiting physical contact with humans and surface equipment. To keep everything clean required disinfecting all equipment with UV light or chemical decontaminants like hydrogen peroxide that would kill microbes but have a limited impact on the subglacial system.

• Be able to explain why keeping the subglacial lake environment "clean" is critical to the long term study of this and other similar systems.

a) Fundamentally, to understand how this subglacial environment works and the microbial life forms in it, you simply need to make sure that the microbes you detect in your samples can only have originated in the subglacial environment and not have been introduced through human actions.

b) Since the types and complexity of microbes in the subglacial lake is not known, you also want to limit the possibility of exposing the native microbe population to an outside population of microbes that could interact with it and result in changes or mutations in the native population's DNA.

c) Finally, because you may want to sample and explore this environment over time or at different but connected physical locations, you again want to make sure that you do not introduce new populations that over time could induce change over a broader area.

d) Any introduced microbes could potentially be a threat to the native microbes. Consider that the ecosystem of the subglacial lakes has been isolated for hundreds of thousands of years and is unlikely to have any resistance to an introduced microbe "invader". They could also cause mutations of the native organisms and the introduction of new DNA into the native organisms. Any of these items would change the environment and make identification or isolation of the original strains of microbes more difficult or impossible.

The Socratic Seminar

I hope that you will try the Socratic Seminar if you have not done one before. They can be a truly remarkable experience for both you and your students. They are student centered and let students experience learning through discussion. They can also be a train wreck if the students have not done the background work or simply cannot accept the responsibility of leading themselves through the learning process. As a teacher, your biggest challenge will be to remain distant and intervene only if the discussion drifts off focus or needs new inputs

to revitalize it. Your job is to listen and observe. Students may have a hard time with this, but both AP/Honors and regular classes will almost always rise to the challenge and find real enjoyment in the discussion time.

Credits

This lesson was developed by PolarTREC teacher Mike LeBaron based on his experiences as a member of the WISSARD team and the objectives of the WISSARD Project. (mlebaron@iss.k12.nc.us). Special thanks to Dr. Ross Powell, Northern Illinois University, Department of Geology and Environmental Sciences, DeKalb, Illinois and Susan Kelly, WISSARD Outreach Coordinator, Montana State University, Bozeman, Montana.

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National Science Education Standards (NSES)

Content Standards, Grades 9-12

Content Standard A: Science As Inquiry:
a. Abilities necessary to do scientific inquiry
b. Understandings about scientific inquiry

Content Standard D: Earth ad Space Science:
c. Origin and evolution of the earth system

Content Standard E: Science and Technology:
a. Abilities of technological design
b. Understandings about science and technology

Content Standard G: History and Nature of Science:
b. Nature of scientific knowledge

Common Core Science Standards
• RST.9-10.1. Cite specific textual evidence to support analysis of science texts, attending to the precise details of explanations or descriptions.
• RST.9-10.5. Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force).
• RST.11-12.8. Evaluate the hypotheses, data, analysis, and conclusions in a science text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
• RST.9-10.9. Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Next Generation Science Standards
• HS.Interdependent Relationships in Ecosystems
• HS.Earth's Systems
• HS.Matter and Energy in Organisms and Ecosystems
North Carolina Earth Science Essential Standards
• EEn.2.7 – Explain how human activities affect the biosphere
• EEn.2.8 – Human behaviors and sustainability