Applicable standards

Next Generation Science Standards (NGSS)

High School Life Science

Element of the curriculum	Lessons 1	2	3	4	5	6
Matter and Energy in Organisms and Ecosystems						
HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.	✓	✓				✓ ✓
Interdependent Relationships in Ecosystems						
HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.			✓	✓		✓
HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.			✓	✓		✓
HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.		✓	✓	✓	✓	✓
HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.		✓				

High School Earth and Space Sciences

Element of the curriculum	Lessons 1	2	3	4	5	6
Earth's Systems						
HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.		✓				✓
HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.	✓					
HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.		✓				✓
Weather and Climate						
HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.		✓		✓		✓

Applicable standards

Next Generation Science Standards (NGSS)

High School Earth and Space Sciences (continued)

Element of the curriculum	Lessons 1	2	3	4	5	6
Human Sustainability						
HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.			✓			✓
HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.				✓		
HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.					✓	
HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.		✓		✓		✓

High School Engineering Design

Element of the curriculum	Lessons 1	2	3	4	5	6
HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	✓	✓				✓
Science and Engineering Practices						
Asking questions	✓	✓	✓	✓		
Developing and using models	✓	✓		✓		
Planning and carrying out investigations	✓					
Analyzing and interpreting data	✓	✓		✓		
Using mathematics		✓		✓		
Constructing explanations	✓	✓		✓	✓	✓
Engaging in argument from evidence		✓	✓	✓	✓	✓
Obtaining, evaluating and communicating information		✓	✓	✓	✓	✓

SCHEME OF WORK

Lesson 1: What is ocean acidification?

Overview

An introduction to the issue of ocean acidification, this lesson uses a combination of video, theory and practical demonstrations to develop students' understanding of the 'other carbon problem'.

Learning outcomes

- Recall that the release of CO_2 by burning fossil fuels increases the level of atmospheric CO_2
- Understand the process of ocean acidification and that the oceans act as a 'carbon sink' for atmospheric CO_2
- Investigate the impact of increased levels of atmospheric CO_2 on ocean chemistry

Resources

Slideshow 1:
Ocean acidification process

Student Sheet 1a:
Ocean acidification in a cup

Student Sheet 1b:
Do you like your oceans still or sparkling?

Student Sheet 1c:
Reflect and connect

Subject Update:
Learn more: Ocean acidification process

Lesson 2: Data analysis: Chemistry

Overview

One of the most used data sets to show the trend in ocean acidification over the past 20 years is from the Hawaii Ocean Time-series. Students will use real data from a series of research 'cruises' to analyse the information and identify trends. There are options to use ICT to examine the data set, as well as using print outs of graphs and data tables.

Learning outcomes

- Present data using appropriate methods and carry out and represent mathematical analysis
- Interpret data, including identifying patterns and trends and use data to make inferences and draw conclusions
- Evaluate data critically, showing awareness of potential sources of random variations and systematic errors

Resources

Slideshow 2:
Using Excel to create graphs

Student Sheet 2a:
Ocean acidification data and question sheet

Student Sheet 2b:
Ocean pH graph

Student Sheet 2c:
Ocean carbon dioxide graph

Student Sheet 2d:
Ocean acidification graph and question sheet

Student Sheet 2e:
Ocean acidification Excel and question sheet

Data Set:
Ocean acidification spreadsheet (students)

Data Set:
Ocean acidification spreadsheet (teachers)

Subject Update:
Learn more: Hawaii Ocean Time-series

Lesson 3: Research in action

Overview

The Arctic Ocean is known as a 'sentinel system'. This is because ocean acidification is happening more rapidly in these cold waters. Students will learn about the research that is currently being undertaken in this remote region.

Learning outcomes

- Learn how scientists work in extreme environments and develop knowledge of science careers
- Link the survey techniques used by students to the environmental and biological survey techniques used by the Catlin Arctic Survey scientists
- Understand how to investigate the relationship between the health of organisms within an ecosystem and environmental factors such as pH

Resources

Student Sheet 3a:
Scientist tweet sheet

Student Sheet 3b:
Blog post

Student Sheet 3c:
Storyboard template

Student Sheet 3e:
Ocean acidification Excel and question sheet

Diagram:
Sea surface temperature

Diagram:
Changing sea surface pH

Video:
Channel 4 News reports from the Arctic

Gallery:
Ice Base science

Gallery:
Water sampling

Gallery:
Trawling for copepods

Gallery:
Making an ice hole

Lesson 4: Data analysis: biology

Overview

The Catlin Arctic Survey scientists wanted to see what impact increased ocean acidification might have on a type of zooplankton, copepods. To do this, they trawled for copepods through a hole in the ice and placed them in experimental batches. These experimental batches were exposed to different levels of pH simulating both current and predicted scenarios. After seven days, the batches were examined to see how many of the copepods had survived in each scenario and analyse the impact that future acidification might have on zooplankton, the foundation of the Arctic food web.

Learning outcomes

- Present data using appropriate methods and carry out and represent mathematical analysis
- Interpret data, including identifying patterns and trends and use data to make inferences and draw conclusions
- Evaluate data critically, showing awareness of potential sources of random variations and systemic errors

Resources

Slideshow 4:
Using Excel for calculations

Student Sheet 4a:
Copepod survival adult data sheet

Student Sheet 4b:
Copepod survival Nauplii data sheet

Student Sheet 4c:
Copepod survival data

Student Sheet 4d:
Copepod survival Excel and question sheet

Data Set:
Copepod survival data spreadsheet (students)

Data Set:
Copepod survival data spreadsheet (teachers)

Lesson 5: From ice to paper

Overview

Scientists work to increase our understanding, so it is important for the Catlin Ice Base research team to share their findings with a wider audience. They did this in three ways. First, they wrote a scientific paper, recording their research, data and analysis. Second, the university published a press release to share the findings more widely outside the science community. They also collaborated with Encounter Edu to make this educational resource. This lesson examines the process and difficulties of sharing science with different audiences.

Learning outcomes

- Understand that scientists need to share their findings
- Know about and evaluate the different ways of sharing scientific research
- Compare the style and language of scientific papers with press releases

Resources

Slideshow 5:
Sharing research

Student Sheet 5a:
Published paper summary

Student Sheet 5b:
Press release

Lesson 6: Conference in a classroom

Overview

Scientists often share their results at conferences. They do this in a number of ways, one of which is by presenting a poster. At conferences, researchers will stand next to their posters displaying their research and answer questions relating to their work. In this lesson, students will turn the classroom into a mini-conference venue and display their research into ocean acidification.

Learning outcomes

- Understand how field research teams communicate results
- Be able to explain the main issue and science of ocean acidification
- Discuss research topics with peers

Resources

Student Sheet 6a:
Research poster template

Subject Update:
Learn more: Ocean acidification process