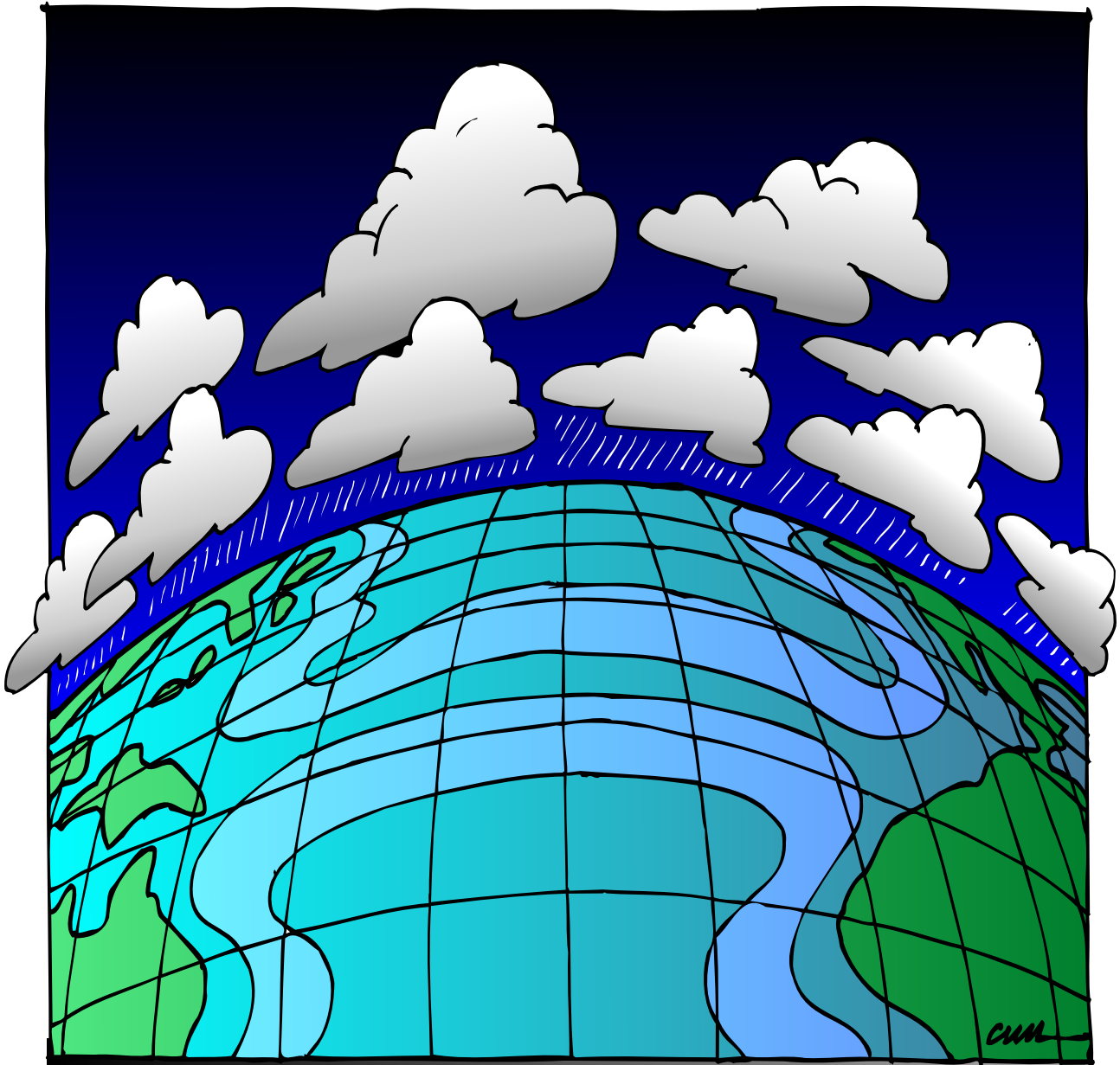


**The Potential
Consequences of
Climate Variability
and Change**

Educational Product	
Educators	Grades 5-8 & 9-12

COASTAL AREAS



What is El Niño?

This learning activity was developed to examine the potential impacts of climate variability and change. Each activity is part of an overall series entitled *The Potential Consequences of Climate Variability and Change*, which includes 1–12 teacher resources. Twelve modules (10 printed and 2 online resources) comprise the set and are presented below:

OVERVIEW

- Too Many Blankets (Grades 1–4)
- Global Balance (Grades 5–12)

AGRICULTURE

- El Niño (Grades 5–8)
This activity is provided in an online format only and is available at <http://ois.unomaha.edu/casde/casde/lessons/Nino/teacherp.htm>.
- The Great American Desert? (Grades 9–12)
This activity is provided in an online format only and is available at <http://ois.unomaha.edu/casde/casde/lessons/grass/teacherp.htm>.

COASTAL AREAS

- What Could a Hurricane Do to My Home? (Grades 5–8)
- What Is El Niño? (Grades 5–8,9–12)
- Coral Reefs in Hot Water (Grades 9–12)

FORESTS

- A Sticky Situation (Grades 5–8)
- Planet Watch 2000 (Grades 9–12)

HUMAN HEALTH

- Beyond the Bite: Mosquitoes and Malaria (Grades 5–8,9–12)
- Climate and Disease:A Critical Connection (Grades 9–12)

WATER

- Here, There, Everywhere (Grades 7–8,9–12)

The development of the activities was sponsored by the National Aeronautics and Space Administration and the Environmental Protection Agency, in support of the US Global Change Research Program. The Institute for Global Environmental Strategies implemented the effort. For more information, see <http://www.strategies.org>. For additional resources, please visit <http://teach.earth.com>—Resources for Teaching and Learning about Earth System Science..

Climate Variability & Change

COASTAL AREAS

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ACTIVITY

What Is El Niño?



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What Is El Niño?



This activity explores the potential for climate variability and change to trigger more frequent occurrences of El Niño, and the impacts that could result. Designed to teach through scientific inquiry, the activity seeks to stimulate thought about the long-term impacts of a warmer planet.

GRADE LEVELS

Grades 5–8;9–12

TIME REQUIRED

Three to four 45-minute class periods

OBJECTIVES

Through their participation in the following activity, students will:

- Access information at remote sites using telecommunications;
- Identify impacts by reviewing past El Niño events;
- Make and use scale drawings, maps, and maps symbols to find locations and describe relationships;
- Analyze the data collected and predict what the consequences could be if, as some scientists predict, climate variability and change could create a permanent El Niño.

DISCIPLINES ENCOMPASSED

- Earth System Science
- Environmental Science
- Geography
- Language Arts
- Mathematics
- Meteorology
- Social Studies
- Technology

PREREQUISITE KNOWLEDGE: TEACHER

- El Niño is the periodic disruption of the ocean-atmosphere system in the tropical Pacific that impacts weather worldwide. It is a phenomenon that results from the coupling of the Pacific Ocean and the atmosphere. Sometimes the trade winds over the Pacific Ocean slacken and a wedge of warm water in the western Pacific spreads eastward toward the South American coast, where it traps life-giving colder water deep beneath the ocean's surface. Rains that are usually centered over the far-western Pacific move eastward, causing far-reaching changes in the world's weather.
- Peruvian fishermen first documented the El Niño phenomenon centuries ago when, instead of filling their nets with shimmering anchovies, they found dying fishes washed up on their beaches. Ever since, observations during El Niño years have shown upheavals in the ocean food chain and in weather patterns around the world. El Niño has been blamed for everything from torrential rains in California to plagues in Africa. The El Niño of 1997–1998 even slowed down the Earth's rotation by .7 milliseconds!
- El Niño's have occurred for centuries and even millenia. Mankind was not fully aware of this phenomenon until this century, so there are no quantitative records to compare past events with recent intense El Niño Southern Oscillation (ENSO) events. Thus, while El Niño events are the strongest on record, they are not necessarily the strongest ever. More intense ENSO events may be a natural occurrence in the Earth's system, and not necessarily an effect of global warming. Scientists do not yet have enough information to make this clarification.
- The term Southern Oscillation refers to the oscillating surface pressure between the southeast tropical Pacific and the Australian

Indonesian regions. During an El Niño event, the waters in the eastern Pacific become abnormally warm. The warm waters heat the air above them, causing the barometric pressure to drop in the eastern Pacific and rise in the western Pacific (Australian-Indonesian regions). The change in pressure, causing a reduction in the atmospheric pressure gradient, weakens the low-latitude easterly trade winds.

- Normally, trade winds blow across the Pacific Ocean from east to west. These same winds push water away from the western coast of South America, allowing cold, nutrient-rich water to rise to the surface to nourish plankton, fishes, seabirds, sea lions, and other marine life of the coastal region. The trade winds pile up warm water in the western Pacific north of Australia, keeping surface water temperatures and sea level in the western Pacific higher than elsewhere.
- During an El Niño, the trade winds weaken, or even reverse direction. This permits the water piled up in the western Pacific to spread eastward as an enormous wave of water—a few inches high and a thousand miles wide. If it reaches the South American coast, we know it as El Niño.
- The impacts of El Niño on coastal areas have included the devastation of coastal fisheries off Peru, dying sea lions off California, mud slides in California, and a phenomenon called coral bleaching that weakens or kills living coral reefs.
- Scientists note that the worst El Niño on record, in 1997–98, could be a preview of our weather to come.
- El Niño events disrupt weather patterns worldwide.
- Climate variability and change may disrupt weather patterns worldwide.
- Changes due to El Niño and climate variability and change may have positive and negative effects on people and the environment.
- During the past 20 years, more and more people have moved to the coast. Now 44 million people live along the East Coast of the United States from Maine to Texas with more people moving closer to the coast all the time.
- Climate Change is the change in climate over a time period which ranges from decades to centuries. The term refers to both natural and human-induced changes. The term “climate variability” refers to shorter term (years to decades) fluctuations in climate such as those caused by El Niño/Southern Oscillation.
- The United Nations Framework Convention on Climate Change defines climate change as: “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.” In other words, the FCCC uses the term Climate Change to mean only those changes, which are brought about by human activities.
- Many factors, both natural and of human origin, determine the climate of the Earth.
- A number of minor gases in the atmosphere, although relatively transparent to sunlight, absorb most of the infrared heat energy emitted by the Earth towards space. This phenomenon has been called the “greenhouse effect” and the absorbing gases that cause it “greenhouse gases.” Important greenhouse gases include: water vapor, carbon dioxide, methane, nitrous oxide, ozone, and halocarbons.
- An analysis of temperature records shows that the Earth has warmed an average of 0.5° C over the past 100 years. The warming is real and significant though its intensity has varied from decade to decade, from region to region and from season to season. However, it is important to understand that although temperature records do go back 100 years, global sampling was relatively poor until the mid-20th century. This provides at least some uncertainty about the older temperature records. During the past

50 years, global temperature sampling has significantly improved, especially with the use of satellites beginning about 40 years ago. But, during this period, there has also been an exponential growth of the human population. The massive urban growth that accompanies this population growth, causing urban heat islands, causes scientists to question the accuracy of these temperature observations (most of which are made in or close to cities). These factors complicate scientific interpretation of the records as to whether the observed global warming of 0.5° C (0.9° F) is real or a result of observational bias.

- Further evidence of past climate conditions can be found in ice cores, sediment cores, and tree rings.

PREREQUISITE KNOWLEDGE: STUDENTS

Students must have the following skills and knowledge to complete this activity:

- Ability to read and interpret maps and data tables.
- Ability to make and use timelines.
- Ability to employ graphs, tables, and maps in making arguments and drawing conclusions.
- Ability to use Internet browsers to do research for problem-solving.
- Ability to work collaboratively in groups.

KEY TERMS AND CONCEPTS

The following terms and concepts will be presented in the following text and activities:

Climate change
Climate variability
El Niño
Trade winds
Thermocline
Food chain
Ecosystems
Greenhouse effect
Greenhouse gases

SUGGESTED READING/RESOURCES

■ **WEB PAGES**

El Niño Web Sites

NASA El Niño Primer

<http://nsipp.gsfc.nasa.gov/enso/index.html>

NOAA El Niño Page

<http://www.elnino.noaa.gov>

<http://www.pmel.noaa.gov/toga-tao/el-nino/home.html>

El Niño/Southern Oscillation Education Resources

<http://www.cdc.noaa.gov/ENSO/enso.education.html>

Earth System Science Online:ESS ISSUES

<http://www.usra.edu/esse/essonline/>

El Niño Theme Page

<http://www.pmel.noaa.gov/toga-tao/el-nino/nino-home-low.html>

El Niño

http://observe.ivv.nasa.gov/nasa/earth/el_nino/elnino.html

Visualizations of El Niño

Gulf of Maine Aquarium

<http://octopus.gma.org>

Click on SPACE AVAILABLE, WEATHER, DETECTING EL NIÑO.

NASA

<http://nsipp.gsfc.nasa.gov/enso/nino/>

Climate Variability and Change: Background Information

US Global Change Research Information Office

<http://www.gcrio.org/index.html>

Earthview

<http://earthview.sdsu.edu/>

Global Climate Change

<http://www.climatechange.gc.ca/>

Earth System Science Online

<http://www.usra.edu/esse/essonline/>

ACTIVITY

What Is El Niño?

This activity will answer the question: What could be the impact of increasing El Niño events on coastal areas?

MATERIALS

- Computers with Internet access
- Pencils
- Adding machine tape
- Scissors
- Meter stick
- Activity sheets
- Colored pencils

PROCEDURE

Step 1

Ask students what they know about El Niño. Have them explain what they think the term means and what they have heard in the news about it. List answers on a chalkboard or overhead projector.

Step 2

Have the students explore the EL NIÑO PAGE FOR STUDENTS Internet site:
http://www.coe.usouthal.edu/oar/html/el_nino.html.

They should read the introduction and then work through the GET INFO section, answering Questions 1–9 on the *Student Activity Sheet 1: El Niño*.

Step 3

Using the answers they obtained from the tutorial, discuss with students what happens in an El Niño year and a non-El Niño year in the tropical Pacific Ocean. List answers on the chalkboard or overhead projector, comparing it to the list from Step 1.

Step 4

Using the information from the EL NIÑO PAGE FOR STUDENTS, have students make a timeline from 1950 to the present and highlight the El

Niño years to see if there is any trend toward increasing frequency.

- a. Divide students into groups of 3 or 4. Assign each student a role; Director (makes sure necessary steps are completed), Runner (responsible for obtaining and returning all supplies), Secretary (records all information and answers), and Accountant (makes all necessary calculations and measurements).
- b. Get supplies (adding machine tape, meter stick, scissors, *Student Activity Sheets 2–4*, and colored pencils).
- c. Have each group measure 1 meter of adding machine tape.
- d. The groups should then determine how to divide the length of the paper evenly (1 meter/number of years) and plot data.
- e. Answer Questions 10 and 11 on *Student Activity Sheet 1: El Niño* as a group.

Step 5

Working in the same groups, students investigate the El Niño web sites listed in the Suggested Reading/Resources section listed on p. 4. They are to put together a list of impacts on coastal areas due to El Niño. Have students record the information on the *Student Activity Sheet 2: El Niño Research*. Students may also use a search engine such as Alta Vista or Lycos to find more information, or you may have them visit the library.

Step 6

As groups, students illustrate *Student Activity Sheet 3: World Map*, showing where different El Niño impacts have occurred. Students should create a color-coded key (using the colored pencils) for each type of event, such as a fish with a circle and line through it to indicate fish kills. For ideas for creating map symbols, refer students to EARTH WEEK: A DIARY OF THE PLANET, reported in many newspapers, or to Discovery Channel Online's Earth Alert, www.discovery.com/news/earthalert/earthalert.html.

Step 7

Groups then investigate the climate change web sites listed in the Suggested Reading/ Resources section listed on p. 4. They are to put together a list of causes and effects of climate variability and change. Have students record the information on the ***Student Activity Sheet 4: Climate Variability and Change Research***. Students may also use a search engine such as Alta Vista or Lycos to find more information, or you may have them visit the library.

Step 8

Each group will discuss possible impacts a permanent El Niño-like climate might have on the world, and then answer questions on ***Student Activity Sheet 5: World Impacts***. They should use the information gained from their previous research.

CONCLUSION

- Ask the students for their interpretation of El Niño.
- Discuss with students the affects El Niño has had on coastal communities, including environment, wildlife, and humans.
- Ask students to predict the effect a permanent El Niño-like climate might have on coastal communities around the world.

EXTENSIONS

1. Complete Internet activity from Step 2.
2. Select activities from the following Internet sites:
<http://globe.fsl.noaa.gov/fsl/html/templ.cgi?activities&lang=en&nav=1>
<http://www.coe.usouthal.edu/oar/html/enrich.elnino.html>
El Niño Teachers Guide
http://observe.ivv.nasa.gov/nasa/education/teach_guide/el_nino.html
3. Have students research La Niña to compare and contrast it to El Niño.

Student Activity Sheet 1: EL NIÑO

Names _____

Answer the following questions in complete sentences, using your own words:

1. Explain what El Niño is.



2. What effect does El Niño have on the United States?



3. What effect does El Niño have on the western Pacific?



4. How are sea temperatures and weather conditions during an El Niño different from non-El Niño conditions?



5. What effects are there on Pacific Sea life and productivity during El Niño?



6. Draw what the patterns on El Niño look like in the Pacific Ocean.



7. Give the weather effects El Niño has on the state where you live during:



a) September to November.

b) November to December.

c) February to April.

8. What difference in the average temperature does El Niño cause in your state during:



a) September to November?

b) November to December?

c) February to April?

9. What difference in average rainfall does El Niño cause in your state during:



a) September to November?

b) November to December?

c) February to April?

10. What decade has had the most El Niño events since 1950?



11. Is the number of El Niño events increasing or decreasing in recent years?



Student Activity Sheet 2: EL NIÑO RESEARCH

Names

On this page number and list the Internet site addresses with a one-paragraph summary of the data obtained from the sites. Data should include impacts on coastal areas due to El Niño. Be sure the data is *in your own words*. Use additional pages if necessary.



Student Activity Sheet 3: WORLD MAP

Names _____

Illustrate the world map showing where different El Niño impacts have occurred. Create a color-coded key for each type of event.



Student Activity Sheet 4: CLIMATE VARIABILITY & CHANGE RESEARCH

Names

On this page number and list the Internet site addresses with a one-paragraph summary of the data obtained from the sites. Data should include causes and effects of climate variability and change. Be sure the data ***is in your own words***. Use additional pages if necessary.



Student Activity Sheet 5: WORLD IMPACTS

Names _____

Answer the following questions in complete sentences, using your own words. Use the information you have gained from your research.

1. Do you think El Niño events are becoming more or less severe? Why?



2. What do you think would happen to your state if El Niño events occurred more frequently? Give at least four impacts, explaining each.



3. What do you think would happen to the coastal areas of the United States if El Niño events occurred more often? Give at least four impacts, explaining each.



4. What effects does climate variability and change have on Earth Systems?



5. What effects does climate variability and change have on coastal communities?



6. When comparing El Niño events and climate variability and change, a big difference is the time over which they occur. Which is a long-term change and which is a short-term change? How did you come to this conclusion?



7. Some people believe that due to climate variability and change, a permanent El Niño will occur. What effects do you think this would have on coastal communities around the world?



8. Do you think some coastal areas and marine life would benefit or be negatively impacted? Why? How?



Appendix A

Bibliography

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January, 1999. P. 98–106.

The Globe Program.
<http://globe.fsl.noaa.gov>.

TOPEX/POSEIDON exhibit text. 1998.
A cooperative effort of the New England
Aquarium, the Gulf of Maine Aquarium, and
Massachusetts Institute of Technology, with
funding provided by the Jet Propulsion
Laboratory.

<http://www.coe.usouthal.edu/oar/index.html>

<http://www.ec.gc.ca/climate/whatis/index.html>

<http://www.climatechange.gc.ca/>

<http://www.gcrio.org/cgi-bin/showcase?>

<http://www.nacc.usgcrp.gov/>

http://ess.geology.ufl.edu:80/usra_esse/el_nino.html

Appendix B

Assessment Rubric & Answer Keys

Student Activity Sheets 1–5

Assessment Rubric

SKILL	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Demonstrates ability to access relevant information at appropriate Internet sites.	Able to access relevant information from appropriate Internet sites.	Accesses some relevant information from appropriate Internet sites.	Accesses very little relevant information at a few appropriate Internet sites.	Is not able to access relevant information at appropriate Internet sites.
Collects and summarizes data.	Able to collect a lot of data that is well summarized.	Able to collect some data with good summarization.	Able to collect some data with poor summarization.	Not able to collect and summarize data.
Represents findings clearly on map/graph or model.	Findings are clearly represented.	Findings are represented somewhat clearly.	Findings are not represented clearly.	Not able to represent findings.
Provides logical answers to questions.	All answers are logical.	Provides many answers, most are logical.	Provides few or illogical answers.	Not able to provide answers
Participates in class discussions/presentations.	Always participates.	Participates frequently.	Rarely participates.	Does not participate.
Infers links between El Niño events and climate variability and change.	Able to infer many links.	Able to infer some links.	Able to infer links with guidance.	Not able to infer any links.

ANSWER KEYS Student Activity Sheets 1–5

Student Activity Sheet 1**EL NIÑO**

Students' answers should be in their own words and in complete sentences.

1. El Niño is a natural, somewhat irregular oscillation in the ocean-atmosphere system in the tropical Pacific having important consequences for weather around the globe. These oscillations begin with warmer than normal ocean temperatures across the central and eastern tropical Pacific Ocean. The warmer ocean temperatures cause convection cloudiness to migrate from Australian-Indonesian regions eastward, toward the central tropical Pacific Ocean. These conditions weaken the easterly trade winds, causing an El Niño event.
2. Among the consequences are increased rainfall across the southern tier of the U.S., which causes destructive flooding.
3. El Niño causes drought in the western Pacific and is sometimes associated with devastating brush fires in Australia.
4. In non-El Niño conditions, the trade winds blow towards the west across the tropical Pacific. These winds pile up warm surface water in the west Pacific, so that the sea surface is about 1/2 m higher in Indonesia than at Ecuador. The sea surface temperature is about 8 degrees C higher in the west, with cool temperatures off South America, due to an upwelling of cold water from deeper levels. Rainfall is found in rising air over the warmest water, and the east Pacific is relatively dry. During El Niño, the trade winds relax in the central and western Pacific leading to a depression of the thermocline in the eastern Pacific, and an elevation of the thermocline in the west. The weakening of easterly trade winds during El Niño also occurs. Rainfall follows the warm water eastward, with associated flooding in Peru and drought in Indonesia and Australia. The eastward displacement of atmospheric heat overlaying the warmest water results in large changes in the global atmospheric circulation, which in turn force changes in weather in regions far removed from the tropical Pacific.
5. In normal, non-El Niño conditions, the sea surface temperature is about 8 degrees C higher in the west, with cool temperatures off South America, due to an upwelling of cold water from deeper levels. This cold water is nutrient-rich, supporting high levels of primary productivity, diverse marine ecosystems, and major fisheries. During El Niño, an isotherm drop can reduce the efficiency of upwelling to cool the surface and cut off the supply of nutrient rich thermocline water to the euphotic zone. The result was a rise in sea surface temperature and a drastic decline in primary productivity, the latter of which adversely affected higher trophic levels of the food chain, including commercial fisheries in this region.
6. Diagrams should match those on the Internet site.
7. Answers depend on location. Use the following site to acquire information for your area:
<http://www.pmel.noaa.gov/toga-tao/el-nino/impacts.html#part2>
http://www.nnic.noaa.gov/products/analysis_monitoring/ensostuff/
8. Same as #7.
9. Same as #7.
10. The decade that has had the most El Niño events since 1950 is the 1990s.
11. The number of El Niño events is increasing in recent years.

Student Activity Sheet 2

EL NIÑO RESEARCH

Each will have to be reviewed for:

1. Accurate summarization of data;
2. Summaries that contain all relevant data; and
3. The use of many different sites.

Student Activity Sheet 3

EL NIÑO MAP

Illustrations should be accurate, easy to interpret, and color coded.

Student Activity Sheet 4

CLIMATE VARIABILITY & CHANGE RESEARCH

Each will have to be reviewed for:

1. Accurate summarization of data;
2. Summaries that contain all relevant data; and
3. The use of many different sites.

Student Activity Sheet 5

WORLD IMPACTS

Students' answers should be in their own words and in complete sentences.

1. El Niño events are becoming more intense because conditions suggest that the strength of 1997 El Niño event could equal or surpass that in 1982–1983, making it the strongest El Niño this century.
2. Answers depend on data obtained in Questions 7–9 on *Student Activity Sheet 1: El Niño*.
3. Some answers may be found at: http://www.nnic.noaa.gov/products/analysis_monitoring/ensostuff/ and may include, but are not limited to:
 - The abnormally warm ocean waters off the west coast could result in the appearance of unusual marine species.
 - Another impact can be reduced tropical storm and hurricane activity across the eastern seaboard and Gulf Coast of the United States.
 - Abnormally wet weather could effect California during the winter due to an increase in winter storm activity.
 - The Southeastern United States may expect an overall pattern of wetter than normal conditions during October–March, with cooler than normal temperatures across the Gulf Coast States.

- The Southwestern United States may see wintertime rainfall at lower elevations and increased snowfall at higher elevations. The chances of wintertime drought are significantly reduced across the region.
 - Rains that are usually centered over the far-western Pacific move eastward, causing far-reaching changes in the world's weather.
4. Answers could include, but should not be limited to:
- The long-term trend is one of net global warming. Corresponding with this warming, alpine glaciers have been retreating, sea levels have risen, and climatic zones are shifting.
 - Physical and biological processes.
 - Droughts, floods, ice storms, or wind events.
 - Long-term shifts in average climate conditions and/or a change in the frequency of extreme climate events.
 - Direct and indirect impact on lands, oceans, and resources.
 - Natural resources, water resources, and the associated socio-economic systems.
5. Some possible effects could be severe coastal storms, storm surge issues, large tsunamis, flooding, sea level rise, changes to the fresh water supply, coastal subsidence, susceptibility of the coastal shrubland, forest and other coastal ecosystems, hypoxia, water toxification, effects on coastal fisheries. These effects could in turn cause major impacts to the region's health, ecosystems, recreation, and infrastructure.
6. El Niño is a short-term change, while climate variability and change is a long-term change. This is determined by the information gained from research conducted in Steps 5 and 7 of the activity.
- 7.–8. Answers differ with each student's opinion. They should be logical with supporting data.

Appendix C

National Education Standards

This activity responds to the following National Education Standards:

STANDARDS FOR THE ENGLISH LANGUAGE ARTS

Standard 3: Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and of other texts, their word identification strategies, and their understanding of textual features (e.g., sound-letter correspondence, sentence structure, context, graphics).

Standard 4: Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

Standard 5: Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.

Standard 6: Students apply knowledge of language structure, language conventions (e.g., spelling and punctuation), media techniques, figurative language and genre to create, critique, and discuss different print and non-print texts.

Standard 7: Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.

Standard 8: Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

Standard 12: Students use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

National Council of Teachers of English and International Reading Association. 1996. Standards for the English Language Arts p.24–46. Urbana, Illinois and Newark, Delaware: National Council of Teachers of English and International Reading Association.

NATIONAL GEOGRAPHY STANDARDS GEOGRAPHY FOR LIFE

GEOGRAPHY STANDARDS: 5–8

Geography Standard 1: *The World in Spatial Terms.* How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.

Geography Standard 7: *Physical Systems.* The physical processes that shape the patterns of the Earth's surface.

Geography Standard 8: *Physical Systems.* The characteristic and spatial distribution of ecosystems on the Earth's surface.

Geography Standard 15: *Environment and Society.* How physical systems affect human systems.

American Geographical Society, Association of American Geographers, National Council for Geographic Education, and National Geographic Society. 1994. Geography for Life National Geography Standards p. 143–182. Washington, DC: National Geographic Research and Exploration.

GEOGRAPHY STANDARDS: 9–12

Geography Standard 1: *The World in Spatial Terms.* How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.

Geography Standard 7: *Physical Systems.* The physical processes that shape the patterns of the Earth's surface.

Geography Standard 8: Physical Systems.

The characteristic and spatial distribution of ecosystems on the Earth's surface.

Geography Standard 15: Environment and Society. How physical systems affect human systems.

Geography Standard 18: The Uses of Geography. How to apply geography to interpret the present and plan for the future.

American Geographical Society, Association of American Geographers, National Council for Geographic Education, and National Geographic Society. 1994. Geography for Life National Geography Standards p. 183–222. Washington, DC: National Geographic Research and Exploration.

CURRICULUM AND EVALUATION STANDARDS FOR SCHOOL MATHEMATICS

CURRICULUM STANDARDS: 5–8

Standard 1: Mathematics as problem solving.

Standard 2: Mathematics as communication.

Standard 3: Mathematics as reasoning.

Standard 4: Mathematical connections.

National Council of Teachers of Mathematics. 1989. Curriculum and Evaluation Standards for School Mathematics p. 63–119. Reston, VA: The National Council of Teachers of Mathematics, Inc.

CURRICULUM STANDARDS: 9–12

Standard 1: Mathematics as problem solving.

Standard 3: Mathematics as reasoning.

Standard 4: Mathematical connections.

National Council of Teachers of Mathematics. 1989. Curriculum and Evaluation Standards for School Mathematics p. 121–186. Reston, VA: The National Council of Teachers of Mathematics, Inc.

NATIONAL SCIENCE EDUCATION STANDARDS

CONTENT STANDARD: K–12

Unifying Concepts and Processes

Standard: As a result of activities in grades K–12, all students should develop understanding and abilities aligned with the following concepts and processes:

- Systems, orders, and organization
- Evidence, models, and explanation
- Consistency, change, and measure

National Research Council. 1996. National Science Education Standards p. 115–119. Washington, DC: National Academy Press.

CONTENT STANDARDS: 5–8

Science as Inquiry

Content Standard A: As a result of activities in grades 5–8, all students should develop:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Earth and Space Science

Content Standard D: As a result of activities in grades 5–8, all students should develop understanding of:

- Structures of the earth system

Science and Technology

Content Standard E: As a result of activities in grades 5–8, all students should develop:

- Abilities of technological design
- Understandings about science and technology

Science in Personal and Social Perspective

Content Standard F: As a result of activities in grades 5–8, all students should develop understanding of:

- Natural hazards
- Risks and benefits
- Science and technology in society

National Research Council. 1996. National Science Education Standards p. 143–171. Washington, DC: National Academy Press.

CONTENT STANDARDS: 9–12**Science as Inquiry**

Content Standard A: As a result of activities in grades 9–12, all students should develop:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Life Science

Content Standard C: As a result of activities in grades 9–12, all students should develop understanding of:

- Interdependence of organisms
- Matter, energy, and organization in living systems
- Behavior of organisms

Earth and Space Science

Content Standard D: As a result of activities in grades 9–12, all students should develop understanding of:

- Energy in the earth system

Science and Technology

Content Standard E: As a result of activities in grades 9–12, all students should develop:

- Abilities of technological design
- Understandings about science and technology

Science in Personal and Social Perspective

Content Standard F: As a result of activities in grades 9–12, all students should develop understanding of:

- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global changes

National Research Council. 1996. National Science Education Standards p. 173–207. Washington, DC: National Academy Press.

CURRICULUM STANDARDS FOR SOCIAL STUDIES

Strand 3: People, Places, & Environments. Social Studies programs should include experiences that provide for the study of people, places, and environments.

Strand 8: Science, Technology, & Society. Social Studies programs should include experiences that provide for the study of relationships among science, technology, and society.

Strand 9: Global Connections. Social Studies programs should include experiences that provide for the study of global connections and interdependence.

National Council for the Social Studies. 1994. Expectations of Excellence Curriculum Standards for the Social Studies p. 21–30. Washington, DC: National Council for the Social Studies.

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