Coral reefs ride out the storm

Educator guide

PAPER DETAILS

Original title: Hurricane Allen's impact on Jamaican coral reefs

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Authors: Nancy Knowlton, J.D. Woodley *et al.*

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LEARNING STANDARDS ALIGNMENT

Learning Performance: Students will analyze data on Jamaican coral reefs from before and after an ecological disturbance and consider it as a model for ecosystem dynamics, the relationships between organisms and Earth processes, and the complexity of systems formed by these patterns of interactions.

The following tables provide an overview of the learning standards covered by this article, including the A Framework for K-12 Science Education (Framework), Common Core State Standards English Language Arts-Literacy (CCSS ELA), Common Core State Standards Statistics and Probability (CCSS HSS), AP Science Practices, and Vision and Change for Undergraduate Education. Where applicable, activities and information will be marked with specific standards to which they are linked.

A Framework for K-12 Science Education		
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models (SEP2) Develop and use a model based on evidence to illustrate the relationships between systems and their components in the natural and designed worlds. **Analyzing and Interpreting Data (SEP4)** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-ESS2-2)	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. **ESS2.E Biogeology** The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it.	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Systems and System Models (Systems)** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Common Core State Standards English Language Arts-Literacy		
Key Ideas and Details	Craft and Structure	Integration of Knowledge and Ideas
RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **RST.9-10.2** Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **RST.11-12.2** Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.	**RST.9-10.4** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. **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, energy). **RST.9-10.6** Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address. **RST.11-12.4** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics. **RST.11-12.5** Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas. **RST.11-12.6** Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.	**RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. **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. **RST.11-12.8** Evaluate the hypotheses, data, analyses, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

AP Science Standards	
AP Science Practices	AP Biology Content Standards
Science Practice 1 (SP1) The student can use representations and models to analyze situations or solve problems qualitatively and quantitatively, and re-express key elements of natural phenomena across multiple representations in the domain. **Science Practice 5 (SP5)** The student can perform data analysis to identify patterns or relationships and evaluate the evidence provided by data sets in relation to a particular scientific question.	**Essential knowledge 4.A.5: Communities are composed of populations of organisms that interact in complex ways. (EK4.A.5)** The structure of a community is measured and described in terms of species composition and species diversity. **Essential knowledge 4.B.4: Distribution of local and global ecosystems changes over time (EK4.B.4)** Geological and meteorological events impact ecosystem distribution. **Essential knowledge 4.C.4: The diversity of species within an ecosystem may influence the stability of the ecosystem. (EK4.C.4)** Natural and artificial ecosystems with fewer component parts and with little diversity among the parts are often less resilient to changes in the environment.

Connections to the Nature of Science	
Vision and Change for Undergraduate Biology Education Core Competencies and Disciplinary Practices	A Framework for K-12 Science Education Understandings About the Nature of Science
Ability to tap into the interdisciplinary nature of science Apply concepts and knowledge across traditional boundaries	**Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-PS4-3)

ARTICLE OVERVIEW

Article summary (recommended for educator use only)

This article examines the effects of hurricanes on coral reef communities. The researchers compared ecological survey data from before and after Hurricane Allen and tracked mortality in affected areas for a period after the storm. Prior to this study, there had been no research that concretely described the impacts of a tropical cyclone on a reef. This study was the first to employ a comparative analysis of extensive data from before the storm with data from during and after the storm. The researchers were able to identify various characteristics of corals and storms that modulate the tropical cyclone's impact.

Importance of this research

This was the first study to use a comparative analysis of conditions both before and after a storm. Because of this, researchers were able to draw more concrete conclusions about a storm's impact based on empirical evidence. Important in its time, this historical paper has become relevant again due to the effects of climate change on the pattern and severity of extreme weather events. The conclusions from this study further our understanding of how ecological communities are affected by these disturbances and inform future research.

Experimental methods

- Comparative analysis of ecological survey data from before and after disturbance (Hurricane Allen)
- Tracking of individual organisms to monitor survival and recovery
- Statistical hypothesis testing

Conclusions

- The size and shape of corals impacts how they are damaged by storms and their chances of recovering from this damage.
- The frequency and intensity of hurricanes is likely a significant contributor to the differences between coral reefs on the northern and southern coasts of Jamaica.
- Physical disturbances are important forces for shaping ecological communities.

ACTIVITIES FOR INTERACTIVE ENGAGEMENT

Learning Performance: Students will analyze data on Jamaican coral reefs from before and after an ecological disturbance and consider it as a model for ecosystem dynamics, the relationships between organisms and Earth processes, and the complexity of systems formed by these patterns of interactions.

Writing an abstract Students write a new abstract for the article at a grade-appropriate reading level.	**RST.9-10.2** **RST.11-12.2**
Locating this study in the larger field Students use the annotated list of references to explain how this research builds on the published work of at least one other independent group of scientists. Students will evaluate whether data from this research supports or contradicts previous conclusions, and reflect on the statement that scientific knowledge is a "community effort."	**RST.9-10.8** **RST.11-12.8**
Science in the news Students explore news stories in the Related Resources tab and evaluate the stories for tone, accuracy, missing information, etc. They may then write their own news stories on the article.	**RST.9-10.5** **RST.11-12.5** **RST.9-10.6** **RST.11-12.6** **RST.9-10.8** **RST.11-12.8**
Results and conclusions Students diagram each of the experiments presented in the study (divided up by figure, if appropriate). They then consider the results depicted in each figure, and how these results support the conclusions of the study.	**SEP2** **SP1** **PS2.A**
The next steps Students design a follow-on experiment to this study that either addresses flaws or unanswered questions in the research at hand, or builds on it to explore a new question. As this is a historical study, students may also consider the body of research which followed, and how the study informs current research.	**SEP6** **SP6**

DISCUSSION QUESTIONS

1. How does the structure and form of coral reef organisms make them more or less likely to be damaged in storms? Are these characteristics unique to coral, or are there other types of organisms that could be affected similarly?	**SEP2** **SEP4** **LS2.C** **EK4.C.4** **SP1** **SP5**
2. Some coral forms are more easily damaged than others. What are some advantages that these more “fragile" forms might have over more “sturdy" forms in other circumstances?	**LS2.C** **EK4.C.4**
3. What effect does an organism’s surroundings have on the type and severity of damage it sustains? How does this, in turn, affect other organisms?	**SEP2** **Patterns** **Systems** **EK4.A.5** **SP1**
4. Based on what you've learned and your observations from Figures 3C and 3D, which coral do you think is *Acropora palmata* and which is *Montastrea annularis*? How does the damage differ from what you would expect after having read about Hurricane Allen’s impact?	**SEP2** **ESS2.E** **SP1**
5. What other ecosystems sometimes undergo serious disturbances? How do these disturbances change each community’s sustainability and makeup?	**SEP2** **LS2.C** **EK4.A.5** **EK4.B.4** **EK4.C.4** **SP1**