NATIONAL GEOGRAPHIC

RESOURCE LIBRARY
LESSON

Ecosystem Imbalance in the World

Students build on their knowledge of individual impacts on the ocean to see how the whole system can react to threats and changes. They examine ways in which human actions throw marine ecosystems out of balance, explore the concept of how impacts can build, and review their understandings of ecosystem dynamics.

GRADES

9 - 12+

SUBJECTS

Biology, Ecology, Earth Science, Oceanography, Geography, Human Geography, Physical Geography

CONTENTS

ACTIVITY 1: CORAL REEF SUCCESSION | 1 HR

DIRECTIONS

1. Activate students' prior knowledge of ecological succession and types of disturbances. Lead a class discussion or have students use think-pair-share, followed by a class discussion. Ask: *Do ecosystems change over time? What could cause those changes?* Record students' responses on the board. Students may give examples such as volcanic eruptions (Mount St. Helens or Krakatau), wildfires (Yellowstone, western U.S.), nuclear contamination (Chernobyl, Three Mile Island), deforestation (Amazon rainforest), and hurricanes (Katrina, Mitch). They may also mention that ecosystems change gradually as different species flourish and others decline due to a variety of factors.

2.Explore anthropogenic and natural causes of change and ecological succession.
Next, have students draw a two-column chart in their notebooks. Do the same on the board, labeling one column "Anthropogenic Cause for Change" and the other column "Natural Cause for Change." Based on the types of changes they brainstormed, have students classify them as anthropogenic or natural. Explain that one reason for ecosystem change is succession, the progressive change in the species composition of an ecosystem. Ecological succession in terrestrial and marine ecosystems results from both human-caused, or anthropogenic disturbances, and natural disturbances. Often, after a major disturbance, you can observe an ecosystem move through several stages of succession. Discuss the successional stages that occur after one or two of the examples students listed.

3. Build background on shifting baselines and succession in marine ecosystems.
Tell students they will watch a video of the TED talk, "Glimpses of a Pristine Ocean," by Enric Sala. Ask them to pay attention to how Dr. Sala's talk relates to the concept of ecological succession. Show students the first 3 minutes, 30 seconds of the video. After viewing, ask students to summarize what they saw. Elicit from students that the video uses coral reefs with varying degrees of human habitation and impacts to show how the composition of reef species changes over time. Ask students to provide examples of disturbances that occur in marine ecosystems. Add their ideas on the table from Step 2. Elicit examples such as hurricanes, ocean warming, dead zones (anoxia), overfishing, habitat destruction (trawling, coastal development), and pollution (toxic waste, oil spill). Using the example of coral reefs from the video to provide context, ask: *What is a baseline?* Elicit from students that a baseline is a point of reference against which significant change can be measured. Explain that a "shifting baseline" is when our point of reference about what is natural in an ecosystem shifts until we accept its current state as normal, and therefore, lower our standards about its health and sustainability. Ask: *Why is it important to have an accurate baseline for marine ecosystems like coral reefs?* Elicit from students that if we know the baseline for an ecosystem in decline, we can work to restore it to that level. If the baseline has shifted, we may be accepting a degraded system as normal.

4. Divide students into small groups and have them start the worksheet.
Distribute a copy of the Shifting Baselines and Succession worksheet to each student. Divide students into small groups and read aloud the directions. Ask each group to provide at least one example of each item in column 1. Have a whole-class discussion about students' examples. Use the examples generated from Steps 1-3, including the video, to correct any misconceptions students have about each of the items in the list. For example, students may think that a pristine ecosystem is an ecosystem to which humans have no access. Clarify that

the ocean and atmosphere connect humans to all marine ecosystems. Also clarify that sustainability can be defined in different ways, but for this activity they need to think about it in terms of ocean resources and ecology.

5. Have students watch the National Geographic video "Belize Coral Reef."
As students watch the National Geographic video (4 minutes) have them work individually on their worksheets to fill in examples and explanations for as many of the terms as possible. After the video, have groups work together to discuss and refine their examples and explanations. Use the provided answer key to facilitate the discussion. Ask: *Do you think coral reefs can recover from natural disturbances at the same time that anthropogenic disturbances are increasing? Why or why not?*

6. Have students watch Part 2 of the video podcast "Paradise Redefined: Line Islands."
As students watch the Scripps Institution of Oceanography video (7 minutes, 30 seconds), have them work individually on their worksheets to fill in examples and explanations for as many of the terms as possible. After the video, have groups work together to discuss and refine their examples and explanations. Use the provided answer key to facilitate discussion and check for completeness. Ask: *How did the scientists describe the initial stages of coral reef succession? What stages do you think might follow?* Elicit from students that the scientists stated that a hard or rocky substrate free of algae was needed so that the small coral recruits, or polyps, could attach and begin to multiply into a coral colony. The coral colonies would then provide food, space, and shelter for other reef creatures, including herbivores. Then, carnivorous fish and invertebrates would multiply and feed on the herbivores. As biodiversity increased, additional niches would develop. And in the case of the more pristine Line Islands, the reef supported more predators than herbivores and showed signs of stability and resilience.

6. Have students reflect on what they have learned.
Lead a class discussion about how the terms *shifting baseline, disturbance, succession,* and *sustainability* are all interconnected. Have students use their worksheets to share examples of these ecological principles in coral reef ecosystems. Ask students to brainstorm about how these principles are applicable in other marine or terrestrial ecosystems.

Modification

In Step 1, use a video, animation, or ecosystem diagram to help students visualize the successional stages an ecosystem undergoes after a disturbance.

Modification

In Step 1, you may choose to incorporate the concepts of pioneer species, primary succession, secondary succession, and climax community throughout the discussion.

Informal Assessment

Assess students' worksheets for completeness and accuracy. Check students' understanding by asking them to restate their examples and explanations of the key terms.

Extending the Learning

Have students use Google Earth: Oceans to explore the Ocean Now 2009 Line Islands Expedition Log and reflect upon the current state of the research and how it could impact the establishment and design of coral reef marine protected areas.

OBJECTIVES

Subjects & Disciplines

Biology

- Ecology

Earth Science

- Oceanography

Geography

- Human Geography
- Physical Geography

Learning Objectives

Students will:

- provide marine examples of shifting baselines, ecological succession, sustainability, pristine and disturbed ecosystems, and anthropogenic and natural disturbances
- discuss the relationship among coral reef communities and how anthropogenic disturbances affect reef baselines, ecological succession, sustainability, and pristine versus disturbed conditions

Teaching Approach

- Learning-for-use

Teaching Methods

- Cooperative learning
- Discussions
- Information organization
- Multimedia instruction
- Visual instruction

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information Literacy
  - Learning and Innovation Skills
    - Communication and Collaboration
- Critical Thinking Skills
  - Analyzing
  - Understanding
- Geographic Skills
  - Acquiring Geographic Information
  - Answering Geographic Questions

National Standards, Principles, and Practices

NATIONAL GEOGRAPHY STANDARDS

- **Standard 1:**

How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information

• **Standard 14:**
How human actions modify the physical environment
• **Standard 8:**
The characteristics and spatial distribution of ecosystems and biomes on Earth's surface

NATIONAL SCIENCE EDUCATION STANDARDS

• **(9-12) Standard C-4:**
Interdependence of organisms
• **(9-12) Standard F-3:**
Natural resources
• **(9-12) Standard F-4:**
Environmental quality
• **(9-12) Standard F-5:**
Natural and human-induced hazards
• **(9-12) Standard G-3:**
Historical perspectives

OCEAN LITERACY ESSENTIAL PRINCIPLES AND FUNDAMENTAL CONCEPTS

• **Principle 5d:**
Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (such as symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.
• **Principle 5e:**
The ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on Earth is in the ocean.
• **Principle 5f:**
Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is “patchy”. Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.
• **Principle 6c:**

The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.

- **Principle 6d:**

Much of the world's population lives in coastal areas.

Preparation

BACKGROUND & VOCABULARY

Background Information

A baseline is a reference point upon which ecological change can be measured or compared. Coral reef ecosystems are especially sensitive to the compounded effects of anthropogenic and natural disturbances that can shift their baselines and limit their ability to recover to a more balanced, pristine state. Marine ecologists recognize the importance of studying pristine reef systems and using that data as a baseline for monitoring and managing the succession and sustainability of disturbed coral reef communities and ecosystems.

Prior Knowledge

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Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
anthropogenic disturbance	*noun*	changes to the natural environment caused by human activity.
ecological succession	*noun*	gradual, predictable changes to an ecosystem or habitat.
marine ecosystem	*noun*	community of living and nonliving things in the ocean.

Term	Part of Speech	Definition
shifting baseline	*noun*	slow changes in the standard characteristics of an ecosystem, which cause the standards to be adjusted, such as overfishing leading to a lower "baseline" estimate of the fish population. Also called a sliding baseline.
sustainability	*noun*	use of resources in such a manner that they will never be exhausted.

FUNDER

ORACLE

ACTIVITY 2: COMBINED IMPACTS | 50 MINS

DIRECTIONS

1. Elicit students' prior knowledge.
Remind students of their previous learning about marine ecosystems, food webs, interdependent relationships, and impacts. Ask students to work in pairs to recall as many different types of marine ecosystems as they can. Have them record their answers. Next, ask the student pairs to try to recall examples of natural and/or anthropogenic disturbances that may impact each of the ecosystems on their list. Have them record their answers. Discuss student responses as a class and any questions students may have. Remind them of the interdependent relationships (symbioses, food webs) that exist within and among marine ecosystems.

2. Have students work in groups to predict combined impacts.
Divide students into small groups. Distribute a copy of the blank Four-Column Chart to each group. Ask each group to write the following heads: Ecosystem Type, Impact 1, Impact 2, and Predicted Changes to the Ecosystem. Have each group select one of the ecosystems and its two associated impacts—either natural or anthropogenic—listed below. Encourage students to use what they have already learned to think about the effect of the two impacts separately. Then, have them consider the combined effect of the two impacts and predict what changes might occur within the ecosystem.

- **Antarctic**—introduction of invasive species; hunting of top predators such as whales/seals
- **Arctic**—ocean warming; oil and gas development/drilling
- **Coral Reef**—tourism; sediment runoff leading to decreased water clarity

- **Kelp Forest**—ocean warming; trophic imbalances leading to decreased carnivores and increased herbivores
- **Mangrove**—coastal development; hurricanes/tsunamis
- **Open Ocean**—commercial fisheries leading to diminished fish stocks; marine debris
- **Rocky Shore**—human access leading to trampling and collection of organisms; coastal development
- **Salt Marsh and Mudflat**—coastal development leading to water removal and habitat destruction; water pollution due to nutrients, sewage, and wastewater from human activities

3. Have students share and discuss their predictions.
Have each small group trade their written predictions with another group in the class. Ask each group to review and comment on the prediction they are given. Each group should respond to the following prompts on a piece of paper:

- Read the predicted changes of another group. Describe whether you agree or disagree with their prediction and why.
- Write two questions in response to the predicted changes of the other group.

As student groups work, facilitate their discussions and note important points or misconceptions that can later be discussed as a class.

4. Have students create a concept map of ecosystem impacts and effects.
Give each group butcher paper and markers. Using their predicted changes, have each group create a concept map to show the relationship between their ecosystem's combined impacts and the effects of those impacts. Model creating an example concept map using one of the ecosystems not used by the groups, such as sandy shore or deep sea. Write the ecosystem name in the middle and show the two impacts as the primary branches of the ecosystem. The effects of each of the impacts become secondary branches. Students can use arrows and action words to show the cause-and-effect relationships related to the individual impacts and then between the two impacts. Have groups present their concept maps to the whole class and facilitate discussion. Tell students to note similarities and differences in the cause-and-effect relationships of the different ecosystems and their impacts.

5. Have students reflect on what they have learned.
Lead a discussion to summarize student predictions and conclusions. Emphasize the fact that all of the ecosystems are affected by a combination of anthropogenic and natural impacts

that interact in complex ways. Also note that many of the ecosystems are affected by similar impacts. Have students brainstorm actions that are being taken to address some of these impacts. Elicit from students that many citizen groups, research organizations, and governments are working to address these impacts by studying the ecosystems, establishing regulations, educating the public, and establishing marine protected areas. Explain that some conservation actions are comprehensive and occur on large scales, such as the creation of a MPA or network of MPAs. Other conservation actions occur at grassroots levels or by the work of individuals. Examples include fishermen using navigation tools and fixed buoys to avoid groundings and anchor damage; citizen action groups conducting volunteer monitoring projects; community groups participating in beach cleanups; and families selecting biodegradable or alternative products to decrease the addition of nutrients and harmful chemicals to their nearby waterways. Ask students to list ways that they can get involved and help address these impacts in order to restore balance and improve the health of the world ocean.

Informal Assessment

Assess student predictions and concept maps for completeness and accuracy.

Extending the Learning

For homework, have students watch the Northwestern Hawai'ian Islands "Navigating Change: Human Impacts" video. Then lead a discussion about ecosystem balance, combined impacts, management strategies, and efforts to address the negative impacts to Hawaii's marine environment.

OBJECTIVES

Subjects & Disciplines

Biology

- Ecology

Earth Science

- Oceanography

Geography

- Human Geography
- Physical Geography

Learning Objectives

Students will:

- discuss ecological changes to marine ecosystems within the context of combined natural and anthropogenic impacts
- list actions that can be taken to address impacts to marine ecosystems

Teaching Approach

- Learning-for-use

Teaching Methods

- Cooperative learning
- Discussions
- Information organization

Skills Summary

This activity targets the following skills:

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- **(9-12) Standard F-3:**

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- **(9-12) Standard F-5:**

Natural and human-induced hazards

OCEAN LITERACY ESSENTIAL PRINCIPLES AND FUNDAMENTAL CONCEPTS

- **Principle 5f:**

Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is “patchy”. Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.

- **Principle 6d:**

Much of the world’s population lives in coastal areas.

- **Principle 6e:**

Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (such as point source, non-point source, and noise pollution) and physical

modifications (such as changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

• **Principle 6f:**

Coastal regions are susceptible to natural hazards (such as tsunamis, hurricanes, cyclones, sea level change, and storm surges).

• **Principle 6g:**

Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

Preparation

BACKGROUND & VOCABULARY

Background Information

Ecosystems are rarely impacted by a single change. Living systems constantly undergo change due to natural and anthropogenic factors. These changes can combine in ways that lead to ecosystem degradation, ecosystem repair, or succession.

Prior Knowledge

["marine ecosystems", "food webs", "interdependent relationships", "examples of natural and anthropogenic ocean impacts"]

Recommended Prior Activities

- An Imbalance in our Ocean
- Create an Imaginary Marine Ecosystem
- Ecological Relationships
- Human Impacts on Marine Ecosystems
- Marine Ecology Video Scavenger Hunt

Vocabulary

Term	Part of Speech	Definition
ecosystem	*noun*	community and interactions of living and nonliving things in an area.

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