Dive Deeper Interactive Program Lesson Plan

Subject (Focus/Topic): Marine Science (Deep-Sea Habitat Restoration)

Grade Level: 6-12

Average Learning Time: 2-3 class periods

Creation Date: Fall 2024

Embark on an expedition as we journey into the depths of the Gulf of Mexico,

on a mission to learn more about communities of deep-sea coral!

Lesson Summary (Overview/Purpose)

Students will explore the restoration of deep Gulf of Mexico coral communities through a visually engaging interactive program. This program is contained in the accompanying downloadable PowerPoint file that has 4 unique sections to learn about the *Deepwater Horizon* oil spill's impacts on benthic habitats, high-tech tools needed for restoration, Gulf coral ecosystems, and how to use observation skills to identify seafloor species. These activities are centered on the science and skills needed to restore the deep-sea Gulf habitats injured by the spill, culminating in an interactive field guide activity. In this final activity, students will take on the role of scientists, exploring the deep sea using live remotely operated vehicle (ROV) footage and identifying a variety of organisms through visual comparisons.

The focus of the activity is deep-sea coral ecosystems, where students will identify corals and various invertebrates and vertebrates that depend on coral for survival. They'll gain insight into this bio-diverse, largely unexplored habitat, where some species are being studied for the first time in history and restored by the Mesophotic & Deep Benthic Communities (MDBC) restoration projects.

Overall Concept (Big Idea/Essential Question)

Corals, as keystone organisms, provide critical habitat not just in tropical shallow waters but also in the deep ocean. The ecosystems structured by corals deep in the Gulf of Mexico were impacted by the largest marine oil spill in U.S. history when the BP *Deepwater Horizon* (*DWH*) oil rig exploded in April 2010 and spilled about 134 million gallons of oil over 87 days. The oil spill also required an unprecedented response effort. Teams worked to collect, disperse, and remove the oil to reduce harm to people and the ecosystem. In addition to the damage done to many coastal and pelagic habitats, animals, plants, and recreation opportunities from Texas to Florida, the spill injured 770 square miles of deep seafloor habitat, leading to the need for a massive restoration effort. How can mapping, seafloor surveys, sampling, and learning more about key seafloor organisms, like deep-sea corals, help restore and protect these fragile ecosystems?

Specific Concepts (Key Concepts)

- Students will understand the relationship between the different seafloor zones of the ocean and the organisms inhabiting them, with a focus on the importance of benthic coral habitats in the mesophotic (twilight) zone and deeper.
- Students will examine the effects of the *DWH* oil spill on deep-sea coral ecosystems in the Gulf of Mexico, identify various species impacted, and learn about the efforts to restore these essential habitats, emphasizing the importance of monitoring and protecting them.
- Students will explore technology used in marine science and career opportunities in the field.

Focus Questions (Specific Questions)

1. What is coral?
2. Where do we find coral colonies?
3. Why are corals important and how do we protect them?
4. What historic event caused damage to some coral habitats in the Gulf and how are experts helping to restore them?

Rationale

- The deep ocean is the largest ecosystem on earth and is very ecologically and economically important. Mapping, observing, and restoring the deep ocean presents many challenges. Understanding and preserving these environments is essential for both ecological functions and human industries that depend on marine resources.
- Opportunities to connect with deep-sea science and technology are limited, but this lesson provides teachers with engaging content and visual aids to help students explore this mysterious world.

Objectives/Learning Goals

- I can compare and contrast different seafloor zones of the ocean and what features support coral growth.
- I can identify key organisms found in deep-water zones of the ocean.
- I can convey what the *Deepwater Horizon* oil spill was and what kind of habitats it impacted.
- I can identify deep-sea tools used to explore and restore ecosystems and how they work.
- I can analyze ROV footage and note the characteristics of deep-sea coral habitats and the species that rely on them.
- I can describe the niche of coral and explain coral's role as a keystone species.
- I can engage in citizen science efforts to identify organisms and monitor coral ecosystems in the Gulf of Mexico.

Background Information

Students should be able to locate the Gulf of Mexico on a map and understand its role in supporting vital industries such as fisheries, tourism, energy production, and shipping. It's essential to connect the region's marine ecosystems to their economic and environmental importance.

Before starting the lesson, teachers should review basic concepts related to marine ecosystems and habitats, such as the structure of food webs, trophic levels, the types of species found in different ocean zones, and characteristics of the Gulf of Mexico's marine environment. It is important to note that some of the work mentioned in the Dive Deeper program occurs in the Flower Garden Banks National Marine Sanctuary (FGBNMS) and that NOAA and the National Marine Sanctuary Foundation support a network of underwater protected areas to conserve vital natural resources. Exploring the FGBNMS website, linked above, will help provide background information on protected areas in the Gulf and the unique geology that supports coral habitats there. This foundational knowledge will help students better understand the significance of deep-sea coral ecosystems, how they come to be, and their role in supporting both local biodiversity and essential industries.

Deep-Sea Corals

- Deep-sea corals are less well-studied compared to shallow-water corals.
- These corals rely more on organic matter that sinks from above for nutrition, due to the absence of sunlight for photosynthesis from symbiotic algae.
- The conditions in deep water, such as colder temperatures and reduced light, contribute to slower growth rates, which can make recovery from disturbances like oil spills more difficult.

Common Misconceptions/Preconceptions

Students may primarily associate coral ecosystems with shallow, tropical waters dominated by hard corals. However, they might not realize the diverse soft coral ecosystems that thrive in the deep waters of the Gulf of Mexico, where conditions differ significantly from shallow reefs.

Teaching Materials

- Computer for projection by teachers, or student computers for individual or group work
- Dive Deeper Online interactive program downloaded to device(s) being used
- Art supplies to if you choose to make species cards and food chains as a post-lesson activity

Technical Requirements

- Access to a smartboard or projector
- Computer with internet access

Teacher Preparation

Teachers should review the available resources to decide which to incorporate as pre-lesson and post-lesson activities for the Dive Deeper interactive program. The Dive Deeper program (5.6 GB) can be downloaded directly onto student laptops from the National Marine Sanctuary Foundation MDBC web page where this lesson plan was downloaded. If student computers are not available, teachers can present the activity on a smartboard or a projector, guiding the class through the field guide activities and encouraging student participation in navigating the interactive elements.

Keywords

- Ecosystem
- Hard and soft coral
- Coral polyp
- Phytoplankton and zooplankton
- Invertebrates and vertebrates
- Benthic
- Mesophotic benthic zone
- Deep benthic zone
- Habitat restoration
- ROV surveys
- Trophic level
- Niche
- Keystone Species

Lesson Procedure

To allow for adequate time for student engagement with this program, two class periods are recommended, with the first focusing on an introduction to these topics using the “Oil Spill, Ecosystems, and Tools” tabs and the second focusing on the “ROV Survey” tab activity and follow-up discussions. Optional student assessment ideas are included below as follow-up activities for the Dive Deeper program in additional class periods.

1. As an introduction to these habitats and restoration, begin with the Deep Gulf Coral Restoration overview video in the “Oil Spill” Tab in the Dive Deeper Interactive Program or watch directly from YouTube here.
2. Have students access the Dive Deeper Activity PowerPoint program by downloading the file and clicking on the “Slide Show” icon from the beginning to launch presentation mode. Instructions and background information are clearly organized within the activity. Have students use the mouse, touchpad, or touchscreen on their computers to click on tabs and icons throughout. Allow a minimum 30 minutes for students to engage with the program.
    a. If student computers are not available, download the program to the instructor's computer and run in Slide Show mode while projecting onto the classroom screen or smartboard. Use the connected computer’s mouse, touchpad, or touchscreen to click on tabs and icons throughout.
3. There are 4 main sections to the program and although they can be done in any order it is recommended that students engage with the material using the tabs to the right as background for the main activity to the left.

    a. Click “Oil Spill” first to review the issue. (10 minutes)
    b. Click on “Ecosystems” next to learn about the habitats and locations connected to the oil spill restoration work. (2-5 minutes)
    c. Click the “Restoration Tools” as the third section - this section is interactive. (10-15 minutes)
    d. Lastly, have students click and complete the “ROV Survey” activity. Allow 20-30 minutes for this culminating segment. There are 4 “survey sites” with 4 “ROV surveys” in each. If short on time, students can be grouped and assigned a site to complete.
4. Encourage students to take notes on the species they observe during the activity. As a follow-up project, they can create species cards based on their observations.
5. Conclude with a post-activity discussion on threats to marine ecosystems, restoration efforts, and the following focus questions:
    a. What is coral?
    b. Where do we find coral?
    c. Why are corals important, and how can we protect them?
    d. What historic event caused damage to some coral habitats in the Gulf and how are experts helping to restore them?
6. Introduce students to Citizen Science Projects. After they gain experience using the Dive Deeper “ROV Survey” activity, direct them to the Click-A-Coral site where they can help verify coral species from more real ROV footage in the Gulf, contributing to training artificial intelligence to automatically identify different species.

Optional Extensions/Student Assessments

Formative Assessments:

1. **ROV Footage Observation Journal**
   During the “ROV Survey” activity, students can maintain an observation journal where they note the species they identify and any interesting features about the seafloor habitat. This journal will help track individual engagement and understanding throughout the activity.
2. **Class Discussion & Checkpoints**
   After each section of the interactive program (“Oil Spill, Ecosystems, Tools, ROV Survey”), include a brief class discussion or quick "exit ticket" question to gauge understanding. For example, "Name one way oil spills impact deep-sea coral ecosystems" or "What tools are used to map the ocean floor?"

Summative Assessments:

1. **Species Identification Cards (Post-Activity)**
   As a follow-up, students can create species cards based on the organisms they identified during the ROV surveys. You can assess these based on accuracy, completeness, and the connections students make to coral ecosystems. Each card should include:
    - A visual representation (drawing or digital image)
    - Scientific name and common name
    - Habitat description and fun fact
    - A short explanation of the organism's relationship to other species in the area and its role in the ecosystem such as trophic levels
2. **Student Presentation**
   Students can give a short presentation on a species or a specific aspect of deep-sea coral restoration. This allows for assessment of both content comprehension and presentation skills.

3. **Final Reflection Essay**
   Have students write a brief essay answering the essential question: "How can mapping, seafloor surveys, and learning about key seafloor organisms help guide restoration efforts in ecosystems like deep-sea coral habitats?" This could assess their grasp of the lesson's overall goals and key concepts.
4. **Citizen Science Participation Report**
   After engaging with the Click-A-Coral citizen science project, students could submit a reflection on their experience, describing what they learned about coral identification and how their contributions might help real-world restoration efforts.

Rubric Components:

- **Scientific Accuracy**: Correct identification and description of species, tools, and zones.
- **Critical Thinking**: Ability to connect species to broader ecosystem roles and restoration efforts.
- **Engagement**: Participation in the interactive field guide and the citizen science activity.

Standards:

Next Generation Science Standards (NGSS)
https://www.nextgenscience.org/

- **MS-LS2 Ecosystems: Interactions, Energy, and Dynamics**
  - MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
  - MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
  - MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations
- **MS-ESS3 Earth and Human Activity**
  - *MS-ESS3-3:* Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- **HS-LS2 Ecosystems: Interactions, Energy, and Dynamics**
  - *HS-LS2-6:* Evaluate 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 Biological Evolution: Unity and Diversity**
  - HS-LS4-1: Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
  - HS-LS4-6: Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

- **HS-ESS3: Earth and Human Activity**
  - HS-ESS3-3: Create a computational simulation to illustrate the relationships among the 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 computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Ocean Literacy Principles Addressed
http://www.coexploration.org/oceanliteracy/documents/OceanLitChart.pdf

- Principal 2: The ocean and life in the ocean shape the features of Earth
- Principal 5: The ocean supports a great diversity of life and ecosystems

Additional Resources

Mesophotic and Deep Benthic Communities Restoration Projects

Gulf Spill Restoration

NOAA Restoration Center

National Marine Sanctuaries

National Marine Sanctuary Foundation

Click-A-Coral Community Science Site

Deepwater Horizon Oil Spill Information

News Article: Fourteen years after BP oil spill, Galveston scientists are striving to save the Gulf's deep-sea coral. The Texas Tribune, 9/27/24

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This lesson plan was developed by Roy Arezzo, NOAA Teacher at Sea Alumni Association Fellow, with support from the staff of the Mesophotic and Deep Benthic Communities restoration projects. Learn more about NOAA's Teacher At Sea program here.