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ECOSYSTEM MONITORING LESSON SERIES - SEAMOUNTS

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CURRICULUM CONNECTION:
THIS COULD SERVE AS A CONCLUSION FOR AN ECOSYSTEMS UNIT IN HIGH SCHOOL BIOLOGY, MARINE BIOLOGY, EARTH SCIENCE, OR ENVIRONMENTAL SCIENCE. THIS SEQUENCE ALLOWS STUDENTS TO CONNECT THEIR STUDY OF ECOSYSTEMS WITH THE ENGINEERING CHALLENGE OF DESIGNING A SOLUTION TO THE DIFFICULT PROBLEM OF MONITORING REMOTE, DEEP-SEA ECOSYSTEMS.

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Purpose:
This 4-5 day lesson sequence introduces the concept of ecosystem monitoring, the seamount ecosystem, and oceanographic equipment that E/V *Nautilus* uses to aid scientists in monitoring deep-sea ecosystems. Students will demonstrate their understanding by designing a monitoring protocol for an offshore seamount using E/V *Nautilus* technology.

Curriculum Connection:
This could serve as a conclusion for an ecosystems unit in high school biology, marine biology, earth science, or environmental science class. This sequence allows students to connect their study of ecosystems with the engineering challenge of designing a solution to the difficult problem of monitoring remote, deep-sea ecosystems. If students are comfortable with environmental monitoring or surveying, the first lesson can be skipped.

Standard addressed:
- **NGSS: 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.
- **Science and Engineering Practice**: Constructing Explanations and Designing Solutions

Materials Needed:
- Computers or tablets for student groups to use for research
- Worksheets provided can be printed out for student use or can be used as Google Docs
- Projector or mirroring capabilities to show short videos to class

Provided Student Handouts: *Educator instructions follow.*
A. Warm Up Discussion
B. Introduction to Ecosystem Monitoring
C. Seamount Ecology
D. Oceanographic Research with E/V *Nautilus*
E. Seamount Monitoring Challenge
F. Monitoring Plan Revision Prompts

Background Information
- What are seamounts? (Woods Hole Oceanographic Institution)
  https://www.whoi.edu/main/topic/seamounts
- Seamount biodiversity (NOAA Office of Exploration and Research)
  https://oceanexplorer.noaa.gov/facts/seamounts-biodiv.html
- Studying seamount biodiversity
  http://tos.org/oceanography/assets/docs/23-1_wessel.pdf

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Lesson 1. Intro to Ecosystem Monitoring (~60 minutes)

Learning Objectives:

- Long-term ecosystem monitoring builds rich data sets that show change over time
- Monitoring protocols must be thoughtfully set up to standardize long-term data collection and limit human error

1. Warm-Up Discussion (10-15 min.)

Pass out this warm-up handout to students. This warm-up connects to NGSS: HS-LS2-6 and introduces the idea of ecosystem monitoring. Use these warm-up questions to guide a class or small group discussion centered on the importance of monitoring to ecosystem science and management.

Guide students to notice that monitoring ecosystems can be important to see patterns of change over time and to see the effects of natural or human disturbances (fire, overfishing, climate change, etc.). This is important because it allows scientists to make predictions/build models about ecosystems and it gives policymakers more info about how best to manage the environment.

2. Intertidal Monitoring Videos and Class Discussion (20 min.)

Watch videos 1 & 2 as a class about monitoring the intertidal zone, where the ocean meets land.

Pose the question: *What did you notice about the monitoring efforts of these scientists?*

Use this video and question to continue a discussion about monitoring. Make sure to note:

- The tools scientists used to help them monitor more precisely
- That scientists recorded all of their important information
- Scientists made precise measurements
- Scientists planned or timed when and where they would monitor
- These scientists kept coming back to the same place to take data
- Scientists take samples of the larger ecosystem, can't monitor entire ecosystem

4. Ecosystems Monitoring Quick Challenge (25-30 min)

***This activity can be skipped if short on time*

Break students into groups of two or three. Have students work together to draw out a monitoring plan to track change over time in an intertidal ecosystem using this student handout. Students should fill out the worksheet together to practice creating a specific and detailed monitoring protocol. Prompt students to think about what they have learned from watching the monitoring videos about tools, transects, etc.

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Lesson 2. Introduction to Seamount Ecology (~60 min.)

Learning Objectives:

- Learn the geologic setting, abiotic and biotic factors that makeup seamount ecosystems
- Identify difficulties of monitoring in seamount ecosystems

1. Warm-Up Question (10 min.)

Use this warm-up question to prompt discussion, reviewing the last lesson and introducing the difficulties of monitoring deep-sea ecosystems:

Think back to our last lesson. How would your protocol have to change if your ecosystem was in complete darkness? Be specific.

2. Seamount Research (30 min.)

Students will learn about seamount ecology independently or in small groups using the information and links provided on their student handout. If students do not have the ability to use computers/iPads to do research, you can look at the pictures and video provided on a TV or projector as a class while students fill out their handout.

3. Class Discussion (15 min.)

Have students contribute to a class list on whiteboard or butcher paper of what they learned about these ecosystems and why they would be hard to study. If students do not touch on the following, make sure to bring the following things into the discussion:

- Seamounts have changes in depth (as seen on the map picture included in the article) that can create different conditions for organisms along the slope of the seamount
- Some seamounts are deep below the surface which makes them dark and hard to access. Deep sea environments also have high pressure.
- Some areas might have cold water while other areas might have warm waters from nearby hotspots in the Earth's crust
- Lots of different currents can be present that bring important nutrients
- Hard to study because humans cannot physically visit most of these ecosystems. They are also cold, dark with a lot of currents

4. Get students into project groups (5 min.)

Use the remaining time in your lesson to put students into groups of three or four. These are the groups that students will work for the two final lessons so choose groups which can work well independently.

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Lesson 3. Monitoring Design Planning (~60 min.)

Learning Objectives:

- Identify important oceanographic tools that can be used to monitor deep-sea ecosystems
- Design an appropriate monitoring protocol to show change over time of an ecosystem

1. Warm-Up Question (5 min.)

Use these warm-up question to prompt discussion of why seamount ecosystems are hard to study and what creative ideas students might have to study them:

In the last lesson, you learned about seamount ecosystems and what would make them difficult to study or monitor. What tools or ideas can you think of that would help scientists to be able to study seamounts?

2. Technology Research (20 min.)

Put students back into their project groups, chosen at the end of the last lesson. Using the links provided on the student handout, students will learn about different technologies aboard E/V *Nautilus* that help scientists access these deep-sea ecosystems. Students will work in their project groups and split up the research fairly. To keep track of what they are learning, students should fill out the research phase handout.

3. Design Phase (35 min.)

Have students move on to the design seamount monitoring protocol handout. This handout explains what students are tasked to do and gives them a template for their protocol. Students should work together along with the information they have gathered about monitoring protocols, seamount ecosystems, and available oceanographic technology. Students will continue their work on this design in the following lesson. During this phase, you as the teacher should walk around and check-in with student groups, asking leading questions to help students see where they could improve their protocols.

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Lesson 4. Revising Seamount Monitoring Protocol (~60 min-120 min/1-2 class periods)

Learning Objectives:

- Design an appropriate monitoring protocol to show change over time of an ecosystem

1. Warm Up (5-10 min.)

Have students meet up in their groups and brainstorm two questions or challenges they are having with their current protocol strategy. Make sure ALL students in the group understand these questions or challenges.

2. Revise Design (40 min.)

Give students the revisions handout that prompts students with questions to find major holes or errors in their monitoring protocol. Students should use this to guide the revisions and finalization of their protocol. Make sure students know this is the last time they will have to work on their monitoring design. Students should turn in their monitoring proposal to you by the end of class. You can even have some sort of competition for the best monitoring protocol.

3. Wrap-up Discussion (10-15 min.)

Once students have turned in their work, bring the class together to discuss challenges students had and how they problem solved to meet these challenges. You can then explain how scientists from Canada's Department of Fisheries and Oceans established a monitoring protocol for offshore seamounts using this 3.5 minute video (there is also a copy of this video in the google folder). This video is of Dr. Cherisse Du Preez explaining the photo mosaic method of monitoring her team created. You can watch this short video and ask students to name specific steps these scientists took to create a long-term monitoring protocol. Possible answers:

- Taking photos year after year to see changes in habitat and biodiversity
- Creating a transect line to find the subsequent study sites
- Creating a 10x10 meter grid for photos so there is a larger "target" to find when coming back in future years
- Creatively using bucket lids and reflective tape so a camera or ROV could find these markers