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| **TEACHER: Mr. Singh** | **SCHOOL: Nanuet Senior High School** |
| **DATE:** 4/8/26(Trip is scheduled for this date) | **SUBJECT:** AP Environmental Science |
| **GRADE LEVEL:** 11/12th | **Classes:** APES |
| **Standard: AP Environmental Science CED**<br>Unit 9: Global Change<br>• 9.3 Impacts of Global Climate Change<br>• 9.6 Sea Level Rise<br>• 9.8 Human Adaptation Strategies<br>Unit 1: The Living World - Ecosystems<br>• Energy flow and trophic structure<br>• Biodiversity and ecosystem stability<br>**NGSS**<br>HS-ESS3-1: Construct an explanation based on evidence for how natural hazards influence human activity.<br>HS-ETS1-3: Evaluate solutions to complex real-world problems based on prioritized criteria and trade-offs. | **Field Trip Site**: The Maritime Aquarium, Norwalk, CT<br>1 class period (Pre-trip preparation)<br>60-minute resilience program<br>60-90 minutes aquarium exploration<br>15 minute 4D film<br>1 class period (Post-trip synthesis and modeling) |

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| **Instructional Objective: Students will:** |
| Construct explanations for how sea level rise and storm surge increase coastal hazard risk. |
| Evaluate coastal mitigation strategies using evidence from simulation activities. |
| Propose and justify a resilience plan under economic constraints. |
| Analyze the ecological roles of marine organisms within their ecosystems. |
| Develop a systems diagram that shows how climate change affects coastal ecosystems and how communities respond. |
| **Motivation:** |
| In class, we spend a lot of time analyzing data, looking at models, and discussing climate change and ecosystem dynamics. While that foundation is important, students gain a deeper understanding when they can see these systems in action. This field trip gives students the opportunity to move beyond lectures and apply what they have learned in a real-world setting. |

During the resilience program, students will model storm surge and test mitigation strategies instead of simply reading about them. They will have to make decisions under budget constraints, just like real communities do. Exploring the aquarium exhibits allows students to observe marine organisms firsthand and connect concepts like trophic levels, biodiversity, and adaptations to living systems. Seeing these organisms up close helps make ecological relationships more concrete and meaningful. By combining climate modeling, engineering decision-making, and direct observation of marine life, this experience reinforces APES content in a way that feels relevant and authentic. Learning outside the classroom encourages curiosity, engagement, and systems thinking. By combining climate modeling, engineering decision-making, and direct observation of marine life, this experience reinforces APES content in a way that feels relevant and authentic.

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| **Delivery of Instruction** |
| **Pre-Trip Preparation** |
| Review of Climate Change and Coastal Hazards<br>Students review key concepts including sea level rise, storm surge, coastal erosion, and human vulnerability. Discussion focuses on how climate change increases risk to coastal communities. |
| Introduction to Coastal Resilience<br>Students examine examples of structural and non-structural mitigation strategies such as seawalls, dune restoration, wetlands, and zoning regulations. Emphasis is placed on trade-offs and economic constraints. |
| Guided Discussion and Map Analysis<br>Students analyze maps showing coastal population density and projected sea level rise. Students discuss which communities are most vulnerable and why. |
| Field Trip Expectations<br>Students are introduced to the structure of the aquarium program and informed that they will be required to collect observations, evaluate strategies, and justify decisions using evidence. |

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| **Field Trip** |
| **Aquarium Program: Resilience by Design**<br>• Storm Simulation Modeling<br>Students participate in a hands-on simulation modeling coastal storm conditions. They observe how storm surge impacts different coastal features.<br>• Mitigation Strategy Testing<br>Students test various coastal protection strategies and evaluate their effectiveness.<br>• Budget-Constrained Decision-Making<br>Students work collaboratively to develop a resilience plan while operating under economic limitations. Students must justify their chosen solutions. |

| Field Trip |
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| **Aquarium Exploration Component**<br><br>• Independent Exhibit Investigation<br>Students explore aquarium exhibits in small groups, observing marine organisms across multiple habitats.<br><br>• Ecological Role Analysis<br>Students identify organisms, determine trophic levels, and analyze adaptations and ecological roles within marine ecosystems.<br><br>• Biodiversity and Stability Discussion<br>Students consider how biodiversity contributes to ecosystem resilience and how human impacts affect marine systems. |
| **4D Film**<br><br>• Environmental Film<br>Students view a 4D educational film selected by the aquarium closer to the trip date. |

| Post-Trip Instruction |
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| • Systems Modeling Activity<br>Students construct a systems diagram linking climate drivers, physical impacts, ecological consequences, and human adaptation strategies.<br><br>• Evidence-Based Justification<br>Students write a brief explanation using evidence from the resilience simulation and aquarium observations to justify mitigation strategies. |

| Closure |
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| Whole-Class Discussion<br>Students discuss how economic constraints influence environmental decision-making and how biodiversity and ecosystem health relate to climate resilience. |

| Extended Practice |
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| Students will complete an AP-style free-response question addressing the climate resilience, mitigation strategies, economic trade-offs, and marine biodiversity concepts explored during the field trip. |

**Appendix A:** Pre-Lab

Understanding Sea Level Rise

NASA Sea Level Change Portal
https://sealevel.nasa.gov

NASA Global Mean Sea Level
https://sealevel.nasa.gov/understanding-sea-level/key-indicators/global-mean-sea-level/

Explore the graphs and explanations.

Answer in complete sentences:

1. What are the two primary causes of global sea level rise?
2. Describe the trend in global mean sea level over the past century.
3. Why does thermal expansion occur as ocean temperatures increase?
4. How does NASA measure global sea level?

Storm Surge & Coastal Vulnerability

Research the mechanism of storm surge using the NASA site above or other reputable sources.

Respond:

1. Explain how wind and air pressure contribute to storm surge formation.
2. Why does storm surge cause more damage when sea level is already elevated?
3. Identify two physical features that make a coastline more vulnerable (e.g., low elevation, lack of vegetation, steep slope, etc.).
4. Identify two human factors that increase vulnerability (e.g., dense development, aging infrastructure).

Coastal Flood Mapping

Visit:

NOAA Sea Level Rise Viewer
https://coast.noaa.gov/slr/

Select a coastal state or region.

Answer:

1. Which location did you examine?
2. Compare projected flooding under a lower sea level rise scenario and a higher scenario.
3. What types of land use (residential, commercial, wetlands, roads) are most affected?
4. Based on what you observed, explain why even small increases in sea level can change flood frequency.

Reflection

In 5-6 complete sentences, explain:

Why is understanding coastal vulnerability important before attempting to design solutions?

**Appendix B:** Aquarium Lab(My best guess)

Materials Provided

- Sediment tray ("Beach in a Box")
- Sand substrate
- Adjustable water level system
- Wave/storm simulation tool
- Model infrastructure pieces
- Model protection structures
- Budget allocation sheet
- Resource constraint cards

Scenario

A coastal town has experienced increased flooding over the past decade. Sea level has risen approximately 15 cm, and storms are becoming more intense.

You have been given a $150 million adaptation budget.

However, long-term maintenance costs must also be considered.

Section 1 - Baseline Shoreline Model (Trial 1)

Construct your shoreline using the sediment tray.

Record:

Beach Slope: Steep / Moderate / Gentle
Distance from Shoreline to Infrastructure: __________
Elevation of Infrastructure: __________

Storm Conditions:
Water Level Increase: __________
Wave Intensity: __________

Measure:

Maximum Inland Flooding Distance: __________
Erosion Severity: Low / Moderate / Severe
Infrastructure Damage: None / Partial / Severe

Describe sediment transport patterns.

Section 2 - Adaptation Strategy Options

You must select from the following strategies.

| Strategy | Initial Cost | Annual Maintenance |
|---|---|---|
| Concrete Seawall | $70M | High |
| Offshore Breakwater | $60M | Moderate |
| Dune Restoration | $40M | Low |
| Living Shoreline (Vegetation + Marsh) | $35M | Low |
| Elevate Infrastructure | $50M | Low |
| Managed Retreat (Relocate Structures) | $30M | Minimal |

Budget Limit: $150M

You may combine strategies but cannot exceed the budget.

Section 3 - Resource Constraint Cards

Each group receives one constraint:

- High tourism economy
- Endangered coastal species habitat
- Limited long-term maintenance funding
- Dense residential development

Your strategy must consider this constraint.

Section 4 - Design Plan

List selected strategies:

1. ____________________
2. ____________________
3. ____________________

Total Initial Cost: __________
Projected Maintenance Burden: Low / Moderate / High

Section 5 - Justification

In 6-8 sentences:

- Explain why you selected these strategies.
- Identify at least one trade-off.
- Explain how your constraint influenced your decision.
- Discuss whether your plan prioritizes short-term or long-term resilience.

Section 6 - Retest (Trial 2)

Repeat storm simulation under identical conditions.

Record:

Flood Distance: __________
Change from Trial 1: __________
Percent Reduction in Flooding: __________
Erosion Severity Change: __________

Did your system fail or become overtopped?

Long-Term Climate Projection

Assume sea level rises an additional 0.5 meters by 2100.

Would your design remain effective?

Explain:

• Which components would fail first?
• Which are adaptive?
• Would maintenance costs increase?

Section 8 - Ecosystem & Community Connection

During exhibit exploration:

1. Identify one coastal ecosystem that naturally reduces storm damage.
2. Identify one species dependent on that ecosystem.
3. Explain how your design impacts biodiversity.

Write a 6-8 sentence systems explanation connecting:

Coastal ecosystem health → Reduced storm damage → Economic stability

**Appendix C**: Aquarium Exploration

Coastal Ecosystem Identification

Identify 10 species from coastal or estuarine ecosystems displayed in the aquarium.

You must include at least:

- 3 invertebrates
- 3 fish
- 2 primary producers (algae, marsh grass, etc.)
- 2 higher trophic level organisms

For each species, record:

| Species Name | Habitat | Ecological Role | Vulnerability to Sea Level Rise or Storms |
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Ecosystem Services & Natural Protection

Choose two coastal ecosystems represented in the aquarium (examples: salt marsh, estuary, rocky shore, barrier island).

For each ecosystem:

1. Describe how it reduces storm damage.
2. Explain how it reduces erosion.
3. Identify one human activity that threatens this ecosystem.
4. Explain how loss of this ecosystem would increase community vulnerability.

Biodiversity & Infrastructure Connection

Respond in a structured paragraph (8-10 sentences):

How does biodiversity contribute to coastal resilience?

Your response must include:

- At least two species examples
- One ecosystem service
- One connection to economic stability
- One link to your engineering design decisions from Appendix B

Part IV - Local Application

Connect this investigation to your own region.

1. Identify one ecosystem near your local coastline that provides storm protection.
2. Explain whether hard engineering or nature-based solutions would be more appropriate locally and why.
3. Explain how climate change may alter species distribution in that ecosystem.

**Appendix D:** AP-Style FRQ

A coastal town has experienced increasing flooding over the past several decades. Officials are evaluating adaptation strategies to reduce long-term damage.

Questions (a) and (b) refer to Stimulus 1 below.

Stimulus 1: Global Mean Sea Level Change

Table 1. Change in Global Mean Sea Level Relative to 1900

| Year | Sea Level Change (cm) |
|---|---|
| 1950 | 2 cm |
| 1980 | 6 cm |
| 2000 | 10 cm |
| 2020 | 15 cm |

(a) Describe the overall trend in global mean sea level shown in Table 1.

(b) Identify one physical cause of the sea level rise shown in Table 1.

Questions (c) through (g) refer to Stimulus 2 below.

Stimulus 2: Shoreline Model Results from Field Investigation

During the aquarium modeling activity, students measured flooding distance under different protection scenarios.

Table 2. Flooding Distance During Storm Simulation

| Trial | Protection Strategy | Flooding Distance (cm) |
|---|---|---|
| 1 | No Protection | 18 cm |
| 2 | Concrete Seawall | 10 cm |
| 3 | Dune + Vegetation | 6 cm |

(c) Calculate the percent reduction in flooding when a concrete seawall was installed compared to no protection. Show your work.

(d) Calculate the percent reduction in flooding when dunes and vegetation were installed compared to no protection. Show your work.

(e) Based on Table 2, identify which strategy was most effective at reducing flooding.

(f) Describe one environmental disadvantage of using a concrete seawall.

(g) Explain how dune restoration or vegetation buffers reduce coastal erosion.

Questions (h) through (j) refer to Stimulus 3 below.

Stimulus 3: Adaptation Budget Constraints

The town has a $150 million adaptation budget.

Table 3. Strategy Costs

| Strategy | Initial Cost | Maintenance Cost |
|---|---|---|
| Concrete Seawall | $70M | High |
| Offshore Breakwater | $60M | Moderate |
| Dune Restoration | $40M | Low |
| Living Shoreline | $35M | Low |

(h) Identify two strategies from Table 3 that could be implemented together without exceeding the $150 million budget.

(i) Explain one economic trade-off the town must consider when choosing between a seawall and dune restoration.

(j) Justify which strategy type (hard engineering or nature-based) would provide greater long-term resilience under continued sea level rise.