KEEPING OUR COASTLINES CLEAN

A U.S. Virgin Islands Marine Debris Curriculum

IMPACTS

Links to the Next Generation Science Standards, Quick Reference Guide

Curricula by Sub-Section		Middle School						High School					Sci & Engineering Practices
		ESS 3-1	ESS 3-2	ESS 3-3	ESS 3-4	ETS 1-1	ETS 1-2	ESS 3-1	ESS 3-3	ESS 3-4	ETS 1-1	ETS 1-2	
Composition & Abundance	Beach Box Exploration			✓									✓
	Investigating Oceanic Garbage Patches			✓					✓				✓
	A Degrading Experience			✓					✓				✓
Sources & Transportation	Watershed Walk	✓		✓				✓					✓
	Sources of Microplastics: Microbeads			✓									✓
Impacts	Entanglement Problems			✓	✓				✓	✓			✓
	Natural Disasters and Marine Debris		✓	✓	✓			✓					✓
Solutions	Linked Beach-Ghut Clean Ups	✓		✓					✓				✓
	Mitigating Microplastics			✓					✓				✓
	Upcycling Plastic Bags					✓	✓				✓	✓	
	Making Connections Through Art			✓					✓				✓

LESSON: Natural Disasters and Marine Debris

This lesson was inspired by Oregon Sea Grant's "Tsunami Debris Species Risk: A Bio Blitz!" lesson (https://oregoncoaststem.oregonstate.edu/sites/oregoncoaststem.oregonstate.edu/files/MD/bioblitz-tsunami-debris-species-lesson-plan.pdf) from the Marine Debris STEAMSS (Science, Technology, Engineering, Art, Math, and Social Studies) curriculum, which was originally sourced from "Aquatic Invasions: A Curriculum for West Coast Aquatic Invasive Species Education" created for Oregon Sea Grant by Jennifer Lam, Tania Siemens, and Sam Chan. It is used with permission from Oregon Sea Grant.

Grade Levels: 5-12

Subject Areas: Marine Biology: Debris Sources, Ecology

NGSS Connections:

- MS-ESS3-2:
  - Natural Hazards - Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.
- MS-ESS3-3:
  - Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
  - ESS3.C: Human Impacts on Earth Systems - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
  - ESS3.C: Human Impacts on Earth Systems - Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
- MS-ESS3-4:
  - ESS3.C: Human Impacts on Earth Systems - Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
- HS-ESS3-1:
  - ESS3.A: Natural Resources - Resource availability has guided the development of human society.
  - ESS3.B: Natural Hazards - Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.
- Appendix F: Science & Engineering Practices

Time: 40-60 min

Description & Objectives: The goal of this lesson is to demonstrate what happens when natural disasters collide with inhabited areas. Students have the ability to interact with scientific models to learn about weather/natural disasters.

Guiding Questions:

- How does marine debris move in marine ecosystems?
- How do natural disasters change how marine debris moves in a system?

Key Ideas & Concepts:

- Natural disasters can create and move large pieces of marine debris.
- Marine debris can help spread invasive species.

Pre-Requisite Skills: Students will need to understand water currents and wind patterns during normal weather. Students will need to be able to make comparisons between data/images presented to them.

Teacher Preparation: This in-class activity works best in pairs or groups depending on the amount of time and resources available.

Materials Needed:

- Internet access needed for hurricane simulator (http://scijinks.jpl.nasa.gov/hurricane-simulation/)
- Fact sheet for Halophila stipulacea

Teacher Instructions:

Introduction & background: As a discussion, brief lecture, or presentation, go over the following points with your class:

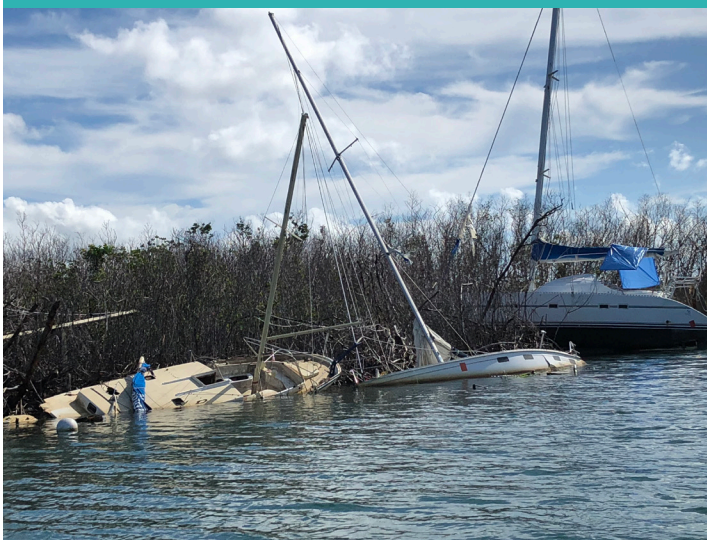
1. Natural disasters & marine debris:
   - In 2017, the U.S. Virgin Islands were devastated by unprecedented back-to-back category 5 hurricanes, Irma and Maria. These natural disasters created a great deal of debris; in fact, Irma and Maria generated as much trash as the U.S. Virgin Islands usually do within an entire year. Hurricane winds and rains distributed much debris across the entire island (images included). Any debris that wasn't collected and properly disposed of, ended up staying in the environment, including the ocean. Hurricanes are one natural disaster that regularly impact the U.S. Virgin Islands.
   - Due to seismic activity, earthquakes and tsunami waves are also disasters that can threaten the

Caribbean region. Though the U.S. Virgin Islands have not experienced a major tsunami since 1867, anywhere there is an earthquake nearby or underwater, there is a potential for a tsunami. Tsunamis can be generated by other activities that add large amounts of energy to the ocean, including landslides that could be triggered by hurricanes, flooding, or earthquakes. Tsunamis move away from the origin point and carry with them marine species and marine debris. The farther away the origin point from land, the more variety of species and marine debris there will be when the wave does meet a land mass.
    - ***Teacher Note:*** *For more information about tsunamis, please visit: https://www.tsunami.noaa.gov/*

2. Invasive marine species:
    - Invasive species are organisms that have physical traits that enable them to reproduce quickly and when they are introduced from elsewhere, overtake native species and out compete them for resources. Once established, it is very hard to remove them.
    - In the U.S. Virgin Islands, there is an invasive species of seagrass (Halophila stipulacea) that is easily spread by human activity (e.g., boating). Optional: you can share the fact sheet included at the end of this lesson.
        - ***Teacher Note:*** *For more information about invasive species, please visit: https://oceanservice.noaa.gov/facts/invasive.html*
3. Connecting the dots - natural disasters and invasive marine species:
    - Compared to nearshore areas, the open ocean is less productive. If nearshore species are swept out to sea by a natural disaster, those species are less likely to survive for long periods. However, sometimes the nearshore species can hitch a ride on human-made debris rafts. Natural disasters can move marine debris rafts that may transport invasive species to new locations.
        - The invasive seagrass in the U.S. Virgin Islands, Halophila stipulacea, could get caught on marine debris that gets moved around during natural disasters.
    - Understanding how ocean and wind currents move in relation to natural disasters can allow scientists to predict where marine debris rafts will arrive at new areas after a natural disaster. In addition to weather data, scientists can use the size of the marine debris raft to create a mathematical model to predict the location and time the marine debris raft will encounter near shore areas.
        - **Guiding questions:** Ask the students if they think debris moves in specific patterns or if it moves randomly. NOTE: If you have already completed the Lesson: Investigating Oceanic Garbage Patches, you can have students think back to how gyres work.

A fishing net and other marine debris items washed ashore following Hurricane Maria in the East End Marine Park, a marine protected area on St. Croix, in November 2017 (Photo credit: Kristin Wilson Grimes).

Derelict vessels resulting from Hurricanes Irma and Maria in the St. Thomas East End Reserves, a marine protected area and NOAA priority watershed on the east end of St. Thomas (Photo credits: Kristin Wilson Grimes).



- If you haven't completed the lesson "Investigating Oceanic Garbage Patches", you can introduce the idea of marine debris movement now. Use videos to introduce:
  - The idea of how water flows around the globe (Ocean Heroes: What is a Gyre? by One World One Ocean, https://www.youtube.com/watch?v=h6i16CrI8ss)
  - How microplastics and some macroplastics move through the oceans (TRASH TALK by NOAA https://marinedebris.noaa.gov/videos/trash-talk-what-great-pacific-garbage-patch-0)
- After watching any of the videos, review (or teach) how water moves around the globe (earth movement and wind patterns contribute to the way water flows, and hurricane formation).

In-class activity & assignment:
Have the students complete the SciJinks hurricane simulation, available here: http://scijinks.jpl.nasa.gov/hurricane-simulation/. Have students run the simulation for each season and answer the following questions (worksheet included at the end of this lesson): As the high pressure system moves closer to the islands: (1) How do wind patterns around the U.S. Virgin Islands change? (2) How does the temperature change (look in the low pressure system cloud to find the temperature)? Think about how marine debris moves in the Caribbean Sea and the Atlantic Ocean: (1) How do you think the changing wind patterns affect where marine debris goes? (2) If a hurricane were to move across the U.S. Virgin Islands, where might debris end up? Think about what you know about invasive species. If there is a lot of marine debris in the ocean, is it possible for an invasive seagrass to get moved from one area to another during a hurricane?

Additional Activities for Grades 9-12:

- Have your students do some additional research on Halophila stipulacea.
  - Ask them to research how the species lives and how it moves from place to place. Then, go back to the simulation and determine where Halophila stipulacea would move to if it were attached to large marine debris items after hurricanes in each season: spring, summer, fall, winter.
- Incorporate a field trip to a meteorological or coastal data station. A great resource is Ocean and Coastal Observing Virgin Islands (OCOVI; http://www.ocovi.org), a St. Thomas-based organization that supports the Caribbean Coastal Ocean Observing System (CARICOOS; https://www.caricoos.org).
- Analyze local marine debris data before and after major local hurricanes (e.g., Hurricanes Hugo, Marilyn, Irma, and Maria). Data are hosted on the Virgin Islands Marine Advisory Service (VIMAS) website (https://www.uvi.edu/community/virgin-islands-marine-advisory-service/st-thomas/coast-weeks.aspx). Pre- and post-data for Irma and Maria can be gained by contacting VIMAS (Mr. Howard Forbes, Jr.: howard.forbes@uvi.edu).
- Have your students research how hurricanes and tsunamis are created, grow, and dissipate. Then, have your students make a hypothesis about the types of marine debris generated by hurricanes versus tsunamis, make predictions on how the mode of transportation might impact what types of marine debris end up where, and how that might make a difference for the types of invasive species that get around on marine debris during those events.
- The topic of natural disasters offers rich opportunities for the discussion of how scientists, government, non-profit organizations, and residents work together to respond, recover, and rebuild.
  - **Guided questions:** Who is responsible for natural disaster response and debris removal? Is it the federal or territorial governments' responsibility or someone else? How did local organizations and residents contribute to response efforts after Irma and Maria? Information can be found in the U.S. Virgin Islands Hurricane Recovery and Resilience Task Force report (https://www.usvihurricanetaskforce.org) and through the St. Thomas Recovery Team (https://strtvi.org).

Teacher Notes:

- As a result of the 2017 hurricanes, talking with some students about natural disasters may unleash many emotions. Educators can review resources produced by the American Psychological Association (APA) related specifically to the mental health impacts of natural disasters. Local psychological resources, some of whom are available to do guest lectures, include Insight Psychological Services, LLC (https://www.insightvi.com), Beautiful Dreamers (https://www.beautifuldreamers.org), and the St. Thomas Recovery Team (https://strtvi.org). Suggested APA links include https://www.apa.org/topics/disasters/ and https://www.apa.org/helpcenter/recovering-disasters.aspx.
- For more information about the impacts of natural disasters on marine debris production, please see Spotlight: Marine Debris and Natural Disasters, Removal of Abandoned and Derelict Vessels following Hurricanes Irma and Maria in the U.S. Virgin Islands

Natural Disasters and Marine Debris Worksheet

You will be completing a simulation about hurricanes. Please record your data as you use the simulation and answer the following questions. Here is the link for the simulation: http://scijinks.jpl.nasa.gov/hurricane-simulation/.

1. Record wind and temperature patterns for hurricanes from each season:

Season	Temperature	Wind Movement
Spring		
Summer		
Winter		
Fall		

2. How do wind patterns around the U.S. Virgin Islands change as the high pressure system (the hurricane) moves closer to the islands? _____

3. How does the temperature change (look in the low pressure system cloud to find the temperature) as the high pressure system (the hurricane) moves closer to the islands?

For the next few questions, think about how marine debris moves in the Caribbean Sea and the Atlantic Ocean.

4. How do you think the changing wind patterns affect where marine debris ends up after a hurricane? _____

5. If a hurricane were to move across the U.S. Virgin Islands, where might the debris end up?

Think about what you know about the invasive species Halophila stipulacea and its impacts on marine life in the U.S. Virgin Islands.

6. If there is a lot of marine debris in the ocean, is it possible for the invasive seagrass to get moved from one area to another during a hurricane?

7. What is one way that we can help stop the spread of Halophila stipulacea?

Natural Disasters and Marine Debris Worksheet Grades 9-12

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1. Record wind and temperature patterns for hurricanes from each season:

Season	Temperature	Wind Movement
Spring		
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6. If there is a lot of marine debris in the ocean, is it possible for the invasive seagrass to get moved from one area to another during a hurricane?

7. What is one way that we can help stop the spread of Halophila stipulacea?

8. Do some additional research on Halophila stipulacea. Research how the species lives and how it moves from place to place. Then go back to the simulation and determine where Halophila stipulacea would move to if it were attached to large marine debris after hurricanes in each season:
   a. Spring:
   b. Summer:
   c. Fall:
   d. Winter:

For the next few questions, think about how marine debris moves in the Caribbean Sea and the Atlantic Ocean.

9. How do you think the tsunami wave affects where marine debris ends up?

10. If a tsunami were to move north, across the U.S. Virgin Islands, where would the debris end up?

11. If it moved south?

12. If it moved east?

13. If it moved west?

14. Think about what you know about the invasive species Halophila stipulacea. If there is a lot of marine debris in the ocean, is it possible for the invasive seagrass to get moved from one area to another during a tsunami?

When Seagrass INVADES

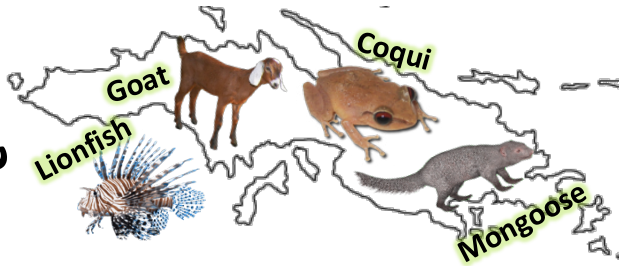
Why are seagrass beds important?

- ***They're a home*** – They provide shelter to baby fish, snails, sea cucumbers, and crabs.
- ***They're part of the food web*** – They provide hunting grounds for other marine animals.
- ***They're on your dinner plate*** – Seagrasses support commercially-important seafood, like snapper, conch, and crabs.
- ***They're something turtles love*** – Turtles eat seagrass, tourists love turtles and our economy loves tourists!
- ***They store carbon*** – Seagrasses remove carbon dioxide from the atmosphere, helping to mitigate climate change.

What is an invasive?

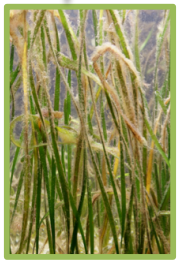
Invasive species are plants or animals that aren't native to the ecosystem, which can cause harm.

Other St. Thomas Invaders



What kinds of seagrass beds can you find in the USVI?

Native



Shoal Grass
Halodule wrightii
1-13 inches long
thin, flat blades

Turtle Grass
Thalassia testudinum
4-30 inches long
wide, flat blades

Manatee Grass
Syringodium filiforme
4-12 inches long
round, thin blades

Invasive

Halophila stipulacea
1-6 inches long
short, paddle shaped blades

What can you do to help slow the spread of *Halophila*?

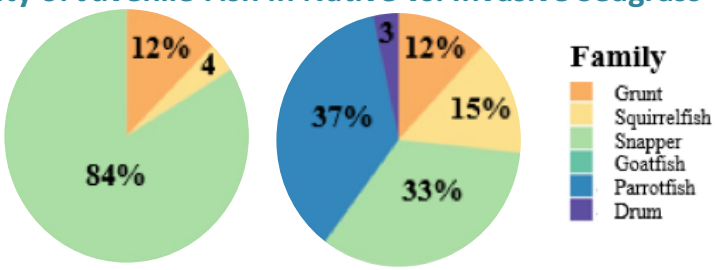
- Help us to increase awareness of this invasive species and the threats it poses!
- Use caution when boating to decrease its spread:
  - Use moorings and avoid anchoring, whenever possible
  - Turn off engines in shallow areas to decrease kicking up the seagrass

What's so bad about *Halophila*?

Since its introduction to St Thomas in 2012, its presence has caused some problems:

- It outcompetes the native seagrasses and grows onto sand beds that stingrays and other species rely on for habitat
- It decreases the fitness of sea urchins that eat it
- It changes the food web (see below)

Diversity of Juvenile Fish in Native vs. Invasive Seagrass



Halophila stipulacea (Invasive)

Syringodium filiforme (Native)

A healthier seagrass ecosystem contains more fish families.

Center For Marine and Environmental Studies

VIRGIN ISLANDS EPSCoR

References: Ocean Portal (2015). Smithsonian Institute. Retrieved from http://ocean.si.edu/seagrass-and-seagrass-beds Willette, D. A., & Ambrose, R. F. (2009). The Distribution and Expansion of the Invasive Seagrass *Halophila stipulacea* in Dominica, We Indies, with a Preliminary Report from St. Lucia. *Aquatic Botany*, *91*(3), 137–142. http://doi.org/10.1016/j.aquabot.2009.04.001 Seagrass images: Hs: F.T. Short, Hw: H.Hillewaert Tt: D. McShaffer Sf: M. Davis, seagrass circle photho: Robert Zalog. Invasive photos: goat: longviewfarms.org, mongoose: zt2downloadlibrary.wikia.com, lionfish: ww2.biol.sc.edu, coqui:themumble.wikia.com , STT map:www.maphill.com. megaphone: www.clipartbest.com. All other Symbols courtesy of the Integration and Application Network