Hurricane Island
Center for Science and Leadership

Understanding Human Impacts:
Marine Debris

This program description is an example of what Hurricane Island *can deliver to your group. Our educators will work with you to customize lessons to meet your grade level and subject emphasis.*

Overview

This program gives students an opportunity to explore how they can be both scientists and environmental stewards. Hurricane Island's off-the-grid campus is an ideal backdrop for thinking about the impact humans have on the marine environment. This lesson will introduce students to marine debris and help them understand why marine debris poses such a threat to our oceans. This is a good entry point for a larger discussion on sustainability, conservation, and environmental advocacy. Other follow-up discussions could include a lesson in oceanography and ocean movement—tides, currents, and other factors that allow marine debris to be distributed in the marine environment, and how animals use these same strategies for dispersal of their young/larvae. It is also a great introduction to Maine's lobster industry through the inevitable derelict gear that students will collect.

Students will:

- Learn about the major sources of Marine Debris and how long they take to degrade in the marine environment
- Develop questions and hypotheses about Marine Debris in their local environment
- Participate in a ocean cleanup community service project
- Quantify the volume and type of debris washed up on the shore
- Compare their results with other data from previous years or other sites
- Determine the estimated density of trash on their shoreline
- Design a creative art project to communicate the issue of Marine Debris
- Learn more about microplastics and photo-degradation

NGSS connections:

- MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment
- MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems
- HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems
- HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants

CCSS connections:

- CCSS.MATH.CONTENT.6-7.RP. (Ratios and Proportional Relationships) Understand and analyze ratio concepts and use ratio reasoning to solve real-world and mathematical problems
- CCSS.MATH.CONTENT.6-7.EE. (Expressions and Equations) Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.
- CCSS.MATH.CONTENT.HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and origin in graphs and data displays
- CCSS.MATH.CONTENT.HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling
- CCSS.MATH.CONTENT.HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities

Background for Teachers

1. Where does the trash come from?
    a. Land based (80%) and Ocean Based (20%)
    b. Overflowing trashcans, or improper disposal create land-based trash. Land-based trash gets blown into streets, into storm drains, into creeks, makes its way to the ocean
    c. Fisheries and recreational/commercial sources create ocean based trash
    d. Once in the ocean it travels by currents so marine debris that washes up on shores have to be buoyant

2. What is it?
    a. Marine debris is one of the most pervasive, yet potentially solvable, pollution problems plaguing the world's oceans and waterways
    b. It is defined as any man-made object that enters the marine environment due to numerous processes, including careless handling or disposal, intentional or unintentional release of materials or as a result of natural disasters and storms.
    c. Microplastics (less than 5mm but most are less than 1mm) are pervasive throughout the water column and result from:
        i. microbeads/resin pellets from exfoliants and industrial applications being released into the environment
        ii. degradation/fragmenting of plastics by UV radiation and/or thermal or chemical degradation

3. Why is it a problem to the environment?
    a. Entanglement
        i. Animals of all sizes, but especially the great whales and other marine mammals become entangled, which forces them to drag lines, floats and even anchors as they swim. Eventually, if they cannot rid themselves of that man-made drag, they can die of exhaustion.
        ii. Birds, fish and marine mammals can catch synthetic line around their necks. The animals continue to grow while the line neither stretches nor degrades and they slowly die of strangulation or the line rubs them and cuts into their skin, causing open wounds and infection that lead to death.

b. Ingestion
    i. Sea animals misidentify plastic and other marine debris as food and ingest it. This can lead to death through a variety of methods including impaction/blockage, puncture of the digestive tract, and poisoning as the material breaks down in the gut.
c. Ghost Gear
    i. Disconnected fishing pots litter the seafloor and engage in ghost fishing – catching and killing sea creatures for no reason.
    ii. How have we tried to avoid this in the lobster industry? Biodegradable vents—but if they foul up before then they don't always come off.. keep catching the resource
d. Bioaccumulation/Biomagnification
    i. Microplastics absorb persistent organic pollutants (POPs) including things like DDT and PCBs
    ii. Plankton or fish ingest the microplastics, bigger and bigger fish eat those smaller organisms, and then we eat the biggest fish so we end up with the chemicals that the microplastics pick up inside us if not the microplastics themselves.

4. How big of a problem is it?
    a. Concentration of trash in the N. Atlantic Gyre is 25,000 pieces per km^2
    b. The Marine Environmental Research Institute (MERI) in Blue Hill, ME has been collecting water samples and has yet to collect a sample that does not contain microplastic pieces

5. What can you do?
    a. Consumer power
        i. Don't use face wash with microbeads
        ii. Avoid single-use products, or ensure that they are recycled if possible
    b. Host your own beach cleanup
    c. Make sure that your land trash is properly disposed of
    d. Help raise awareness—share this with friends, etc.

Program Activities:

1. Marine Debris Timeline—30 minutes. Students guess how long it takes different items (glass bottle, wool, apple core, aluminum can, etc.) to degrade in the marine environment. Students are presented with items and with cards listing different dates and try to put them in the right order.
2. Developing Questions and Hypotheses – 30 min. Students develop their own questions about marine debris along their coastline and design hypotheses to test using data they will collect during a coastline cleanup.
3. Coastline Cleanup—2 hrs. Students participate in environmental stewardship by cleaning up a portion of their coastline, while collecting data on the type, location, amount, etc. of debris they find to address their hypotheses
4. Using Data to Address Hypotheses – 1 hour. Students compile their data as a class and use the class data to investigate their own hypotheses. Students will create graphs that are appropriate to their data

Example Extensions

5. Quantifying the Amount of Trash on Their Coastline—20 minutes. Students take a closer look at the data they collected, or existing data from other beach cleanups, to calculate an estimate of how much trash there is along the coast of their entire island, town, or State. This helps put the "problem" in perspective.
6. Using Art to Communicate the Marine Debris Problem—10 minutes for artist slideshow, 1-2 days to implement the art project. Students first take a look at a slideshow of other artists and how they have used their art to advocate for the marine environment. Students then use the trash they have collected for an art installation project that focuses on using their materials/location to communicate a message.
7. A Closer Look at Microplastics—1 hour. This program lets students take a look at sources of microplastics (face wash exfoliation beads), and then students go out and take their own ocean samples and process them to see if there are microplastics.
8. Understanding Currents – 1 hour. In this activity, students discover the forces that drive ocean currents, including temperature, salinity and wind. They relate their findings to the distribution of marine debris on a global scale and make predictions about areas that will have high pollution densities.
9. Understanding Buoyancy – 1 hour. Students will explore density and buoyancy as it relates to currents, organism adaptations, and ocean going vessels. They will learn about the shipping trade and how ballast water affects the marine environment.

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Sample Activity: Marine Debris Timeline

Before the lesson:

1. Gather materials necessary for the timeline and make timeline cards that correspond to each item
2. Split class into groups of no more than 5 participants
3. Make sure you have answer key timeline with the full sequence ready to deliver to kids at the end of the lesson

Time needed: 40 min - Allow 10-15 min for pre-discussion, 10 min for groups to work on putting their own timeline together, add an additional 5 min if groups will then compare and come up with a common time line, and 10 min for post discussion.

Pre-discussion:

1. Give some background to Marine Debris – can be taken from the Teacher Background sheet or any additional resources (linked at the end of this file).
2. Explain directions to students
    a. Challenge to try to figure out how long it takes different items to degrade in the marine environment
    b. All have boxes with date cards and items
    c. Create your own timeline, matching one card up with each item (10 min)
    d. Suggested modifications:
        i. You can have groups check with you up to 3 times during that period to see how many items they have out of order
        ii. Students can each take a single item and they can try to arrange themselves in a row without knowing the "numbers" on the timeline, then they can be given numbers and see if they want to rearrange themselves again before learning the "correct" timeline
        iii. Create a competition – group with the most items correct wins (bragging rights or an actual prize)

During the activity:

1. Circulate through the classroom – giving feedback as it relates to how you want to run the activity (see modifications above)
2. At the end of 10 min, announce the correct timeline for items, allowing students to make comments as time allows

Post discussion:

1. What was the most surprising item on your timeline?
2. How do you think we could estimate some of these degradation times?
    a. Ex. Modern plastic wasn't invented until 1908, how can we say that it could take more than 450 years to degrade?
    b. What kind of scientific experiment could you conduct to make estimates like this? Students can research this on their own or read/listen to this short article:http://www.slate.com/articles/news_and_politics/explainer/2007/06/will_my_plastic_bag_still_be_here_in_2507.html
3. A lot of the debris found on the Maine coast comes from the lobster industry. Using data from the Department of Marine Resources, calculate…. [ex. have students calculate: how many buoys are lost each year if each lobsterman loses 2, 5, 10, etc. buoys; percent of lobster tags issued to each zone and whether some zones produce more debris than others in total, per square mile, etc.)
    a. http://www.maine.gov/dmr/rm/lobster/licensesandtags.htm
    b. http://www.pressherald.com/2012/12/02/maine-voices-a-million-lost-lobster-traps-wash-debris-ashore_2012-12-02/
4. Glass is the item that takes the longest to degrade but it isn't necessarily the most damaging.
    a. On one hand: Base ingredient is silica, where else do we find this material in the natural marine environment? (Plankton shells, coral spicules, snail shells)
    b. On the other: There is an environmental cost to producing these materials in the first place. Where do we get glass from? What are the costs of shipping it compared to other items based on its weight?
5. What are some things you can do to help with this problem?
    a. Cut back on the amount of overall trash you produce
    b. Opt for reusable instead of single use products
    c. Recycle as much of your trash as you can (how many of the items in the timeline could be recycled?)
    d. Join local efforts to pick up trash
    e. Keep streets, sidewalks, parking lots, and storm drains free of trash
6. What are others doing?
    a. Vinalhaven transfer station takes all marine debris for free – also will stockpile washed up buoys so fishermen can come back and claim their lost gear
    b. Rozalia Project, 5 Gyres Project, NOAA, Fishing for Energy, etc. are all organizations focused on reducing marine debris.

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Sample Activity: Developing Hypotheses

Before the lesson:

1. Have students complete the Marine Debris Timeline activity OR have a general discussion with them about Marine Debris
2. Photocopy student worksheets
3. Determine types of data it would be easy for your students to collect while out in the field
4. Develop potential hypotheses that would be easily investigated to help direct students if they have trouble coming up with their own

Time needed: 30 min – 10 min to introduce activity, 15 min for groups to work on their own, 5 min for groups to confer and refine hypotheses

Pre-discussion:

1. Give marine debris background OR have students complete the Marine Debris timeline activity first.
2. We are going to be conducting our own marine debris cleanup. What are some things that you already know about marine debris? (Students should provide information about examples of debris, how long it takes them to degrade, how much debris there is, etc.)
3. Now I want you to think of some questions you could ask about marine debris in our area. For example, our timeline was concerned with 'how long does it take for each type of marine debris to degrade?'. We want to think of other questions we could answer, just by going out and looking on our own coastline. Can anyone think of another question? (If necessary, prompt with a question such as "What do you expect to find when you go out?" to help generate topics for questions).
    a. Possible questions:
        i. Where does the debris on our coast come from?
        ii. How much debris is there on our coast?
        iii. What types of debris show up on our coast?
        iv. Where does most of the debris collect on the coast?
4. Single out one of the questions that a student came up with and write it up on the board (Ex. "Where does the debris on our coast come from?")
5. So lets look at this question and see what we can do with it. What do you mean by "where it comes from"?

   a. Lead students in a discussion of the question and try to make it more specific (land vs ocean based trash?, type of manufacturing?, household vs industry?, etc.)
   b. End question example: "How much marine debris on our coast comes from the land vs the ocean?"
   c. ***NOTE: Asking Statistical Questions is a more advanced version of this exercise and is a separate lesson with similar flow
6. Now lets make a hypothesis, does anyone know why a hypothesis is different than just asking a question?
   a. Hypothesis includes what you predict the result will be and why
   b. Lead students through making at least two different hypotheses from their own question
      i. The marine debris on our coast will be mostly ocean based because we have a lot of commercial fisheries
      ii. The marine debris on our coast will be mostly ocean based because it will take longer for land based debris to make it into the ocean
      iii. The marine debris on our coast will be mostly land based because we generate more trash on land where we live than on the ocean.
      iv. Etc.
7. Now how could we test this?
   a. Have students suggest types of information they would need, what data they would need to collect, how do they classify their data, etc.
   b. For our example – collect all marine debris, sort it into categories, count how much is in each category (Are we measuring weight? Number of pieces?)
8. Now what would we expect our data to look like if our hypothesis <u>was supported</u>? What would we expect our data to look like if our hypothesis <u>was not supported</u>?
   a. Use the terms "supported" or "not supported". We can't say that they are "correct/right" or "incorrect/wrong" because whatever they come up with as an answer is just one snapshot at one time with one way of collecting data.
   b. For our example, students could come up with a pie chart to see which type had a greater percentage, or a bar graph to see which bar is bigger.
   c. This is a good opportunity to remind students/teach students about good graphing mechanics (labeling, scale, legends, etc.)
9. Now you are going to try this on your own in groups of 2 or 3. [Hand out worksheet] You need to come up with at least two more questions you have about marine debris on our coastline and use the same process to develop hypotheses for

at least one of them. Work in your groups but each of you should write your own answers on your worksheet (this can be done in lab notebooks with prompts).

During the activity:

1. Circulate through the groups offering suggestions and pointing out areas that might cause trouble (e.g., a hypothesis that isn't testable given what you have the capacity to measure).
2. Students should turn in worksheets for teacher feedback (***NOTE: Peer Critique of Hypotheses is a more advanced version of this exercise and is a separate lesson)

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Sample Activity: Coastal Cleanup

Before the lesson:

1. Split students into groups of 3-5
2. Gather materials for each group
    a. Data collection: Clipboard, Rozalia Project datasheet (or the one that they developed), several pencils
    b. Trash collection: Each group needs 2 heavy duty contractor bags (extra strength trash bags), a pocket knife to cut pieces of rope**, work gloves
    c. Instructor should bring first aid kit into the field with them
    d. ***NOTE: If students are too young to carry their own knife or there are other safety concerns, the instructor should bring a knife and be called over when it is needed – this greatly increases amount of movement by instructor so extra chaperones with knives would make this scenario much smoother.
3. ***NOTE: If students have completed the Questions and Hypotheses section of this unit they should have already discussed what they expect to find and developed their own data sheets prior to going in the field. Using the Rozalia data sheet will likely cover most of the questions they ask. Post-cleanup discussion can then be centered around their own questions and sharing with the group.

Time needed: allow for at least 2 hours for this activity—half hour of transit time, 1 hour of cleanup, half hour to tally up what was found, get a total count of pieces of trash, and talk about what we found.

Pre-discussion:

1. What do you expect to find when you go out?
2. Where do you think most of the trash you find comes from?
3. Take time to look over your datasheet. The items are separated out by different major categories: "food waste items, personal waste, fishing debris, industrial debris, and other debris pieces."
4. When you look at the back of your datasheet be sure to look at the small ruler on the bottom. You will likely find pieces or plastic or foam that you can't identify or that doesn't fit in one of the categories. If this is the case be sure to measure it, and put it in the correct size category for "other debris pieces"
5. Please be careful when you are cleaning up trash—if you find a piece of broken glass, or something that looks dangerous, please find one of the leaders to help

you take care of it properly. Also, some of the rope or line that you find along the coast my have almost invisible, but sharp monofilament line that may cut up your hands if you grab it wrong. Be careful!

6. We are going to spread out along our coastline, and your goal is to collect as much marine debris as you can in the allotted time! In your groups make sure you have someone who is designated as the data keeper who is just tallying the trash that is being collected. Depending on how much debris we find you may need more than one tally person per group.

In the field:

1. Make sure that groups know their boundaries for scouting out trash. Make sure that they stay within eyesight of instructors.
2. Try to get the groups to rotate roles so everyone has a chance to tally what they collect as well as look for trash
3. It is helpful to sit with data collectors at first to make sure they are familiar with the datasheets

Post discussion:

1. Have groups sit down and write in totals for each row, and then a grand total for each page, and a final total. Have each group check their numbers by another group member.
2. Based on just what your group found, make a guess and write it down on a small slip of paper about the total number of pieces of trash you think we collected today. (You can give a prize or bragging rights to the winner)
3. Go-around: What type of debris did you find the most of?
4. What was the weirdest or most surprising thing you found?
5. How do you think your numbers compare to other cleanups on our coastline? On other nearby islands/coasts?
    a. Show data of past cleanup events in your area or surrounding areas
6. Where do you think most of this marine debris is coming from?
7. How does this change your attitude about what you do with your trash? What do you think you could do to help improve the quality of the marine environment?

Additional Resources

The following section contains articles and resources that may be helpful in furthering your understanding of the Marine Debris topic:

1. Plastics Breakdown infographic. Ocean Conservancy. 2012. <http://www.oneworldoneocean.com/blog/entry/plastics-breakdown-an-infographic>
2. "Will My Plastic Bag still be here in 2057?" Slate article by Juliet Lapidos. 2007. <http://www.slate.com/articles/news_and_politics/explainer/2007/06/will_my_plastic_bag_still_be_here_in_2507.html>
3. Marine Litter—trash that kills. EPA. <http://www.epa.gov/owow/oceans/debris/toolkit/files/trash_that_kills508.pdf>
4. The Prevalence and Environmental Impact of Single Use Plastic Products. Tarique Zaman. CWRU.edu <http://www.cwru.edu/med/epidbio/mphp439/Single_Use_Plastics.pdf>
5. Rozalia Project Manifesto for a Clean Ocean. Rachael Miller. 2012. Expedition CLEAN. <http://rozaliaproject.blogspot.com/2013/11/rozalia-project-manifesto-for-clean.html>
6. Fishing for Energy. 2014. <http://marinedebris.noaa.gov/sites/default/files/FFE__Fact%20Sheet_2014_revised.pdf>
7. Plastic Marine Debris, An in-depth look. NOAA Alaska. <http://dec.alaska.gov/eh/marine-debris/docs/Gen_Plastic-detailed_hi_9-20-11.pdf>
8. In a Nutshell: microplastics and fisheries. Ana Markic and Simon Nicol. <http://www.spc.int/DigitalLibrary/Doc/FAME/InfoBull/FishNews/144/FishNews144_27_Markic.pdf>
9. Know What's In Your Face Wash: Why Illinois Banned Microbeads. Alexandra Sifferlin, June 24, 2014, Time Magazine <http://time.com/2917462/why-illinois-banned-microbeads/>
10. The present and future of microplastic pollution in the marine environment. Juliana Ivar do Sul and Monica Costa. 2014. Environmental Pollution.

Other online resources:

1. NOAA's Marine Debris Blog: https://marinedebrisblog.wordpress.com/

2. Ocean Conservancy International Coastal Cleanup: http://www.oceanconservancy.org/our-work/international-coastal-cleanup/
3. Arthur, C., J. Baker and H. Bamford (eds). 2009. Proceedings of the International Research Workshop on the Occurrence, Effects and Fate of Microplastic Marine Debris. Sept 9-11, 2008. NOAA Technical Memorandum NOS-OR&R-30. http://marinedebris.noaa.gov/sites/default/files/Microplastics.pdf
4. Marine Environmental Research Institute (MERI) microplastics research. http://www.meriresearch.org/RESEARCH/MicroplasticsResearch/tabid/351/Default.aspx

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Marine Debris Brainstorming Worksheet

Today we are going to ask the question: "What would you like to know about marine debris on your coastline?"

Turn to someone beside you and in pairs (no more than three people) discuss what aspects of marine debris on your coastline interest you. Come up with several questions as a group and write one of them up on the board. Continue with questions 2 and 3 while you wait for others to be finished.

1. What we wonder about marine debris on our coastline is….
   List as many questions as you can come up with

2. A hypothesis we can form from our question is…..
   Write a statement about what you think is going on (your claim) and why you think it is happening (your reasoning). Limit this to only one or two of your questions that are most interesting to you.
   "We think we'd find …… because……"; "We think…. will happen because ….."

3. A way we can test this is…..

   Explain how you could test your hypothesis. What data would you need to collect? If the hypothesis appears to be untestable based on information you have available to you (e.g., "There will be more debris on Hurricane Island because they are too lazy to clean it up regularly") then work on another one of your questions/hypotheses.

4. We'll know that we have <u>supported</u> our hypothesis if…..

   Sketch two scenarios below: one showing data that would support your hypothesis if you found it and one showing data that would not support your hypothesis. Remember to LABLE YOUR AXES *so we can tell what the data in your graphs represents.*