Where did you come from and how did you get here? (and why do I care?)

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Summary

The earthquake off the coast of Japan in March, 2011, and the subsequent tsunami, deposited nearly 5 million tons of debris (known as JTMD) into the ocean. This created a unique opportunity to study the dispersal of floating debris, and the organisms attached to it, by the surface ocean currents.

In Lesson 1 students will construct models of ocean surface currents to explain JTMD dispersal, and then use articles, videos, and satellite images of global air currents and surface ocean currents to adjust and revise their dispersal models. Finally, students will compare and contrast their model to a marine debris dispersal map created by NOAA to make observations about scientific models and determine ways to test their viability.

In a second lesson, students will use the Japanese Ministry of the Environment's predictions of the amount of debris lost in 2011 and the landfill data from Long Beach, WA, collected in 2013, to calculate the amount of debris collected thus far. Students will create a data collection plan that could be implemented to generate more reliable data of JTMD dispersal or the dispersal of debris after a future event.

TAGS: marine debris, ocean currents, global winds, scientific modeling, data collection

Key Concepts

- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4)
- The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. (MS-ESS2-5)
- Global movements of water and its changes in form are propelled by sunlight and gravity. (MS-ESS2-4)
- Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. (MS-ESS3-3)
- NGSS Science Practices

Objectives

- Students will construct models of the surface currents in the Pacific Ocean to explain JTMD dispersal
- Students will critique and revise their models to reflect new understanding about global wind patterns and surface currents
- Students will compare quantities and calculate percentages of debris amounts
- Students will critique the current JTMD data and propose an improved data collection protocol

Teacher Background Information and Additional Resources

NOAA Tsunami Basics

Winds and Climate from Earth Guide

NOAA Ocean Currents

Science Talk Moves

Ambitious Science Teaching

Science Flow Chart

Lesson 1: Where did the debris go?

Engage:

1. Watch National Geographic Japanese Tsunami Video. Share and record student observations on the Tsunami Class Observation Chart (transfer this to larger chart). Consider: What was happening during the Tsunami? What was the water doing? (specifically mention water carrying both natural and manmade items.) Predict: Where did all the debris go after the tsunami? Why do you think that?
2. Introduce the map outline Map 1 Template for constructing the model. Have each student draw a model on their map showing what they think happened to all the tsunami debris. Have them give a reason why and evidence to support their thinking if they have it (it's okay if it's a wild guess at this point).
3. During the engage time the teacher documents student ideas using graphic organizer on a poster paper. Students then work individually to draw their models. While the students are working the teacher selects a few models to be shared that represent groups of thought among the students.
4. Class will meet in a circle for a "Board Meeting" with everyone showing their model. The teacher has each student that she selected share. Students should share: What is the model showing? What evidence is there for those outcomes? Teacher records student thinking without teacher input or guidance. All reasoning and evidence is accepted and charted. (The chart will be added to three different times.) Use speaking and listening rubric for assessment of board meetings.

Explore

5. Read articles (one or both): Misawa Dock Article and/or NPR article about the lone pine tree. Have students use the Tsunami Articles Discussion Student Guide to facilitate their discussions. Tsunami Article Questions Consider: How do these articles support or change your predictions about where the debris went?
6. Explore the Earth: A Visualization of Global Weather Conditions in Air mode. Guide students to observe the wind patterns in the different levels of the atmosphere and consider how these winds might interact with the water and the debris.

Explain

7. Give each student a second map Map 2 Template. Students will draw a second model of where they think the debris went, incorporating any new information from the articles and Earth website.
8. Conduct a "Board Meeting" in the same manner as before, with the teacher pre-selecting students to share what they are thinking and sharing evidence to justify their thinking. Teacher records student thinking on class chart.

Expand

9. Watch NASA - The Ocean: A Driving Force of Weather and Climate (Or use NOAA explanation of global winds and surface currents for a reading option instead.) Have students complete a 3, 2, 1 Reflection during and after the video viewing. 3,2,1, Reflection

10. Explore the Earth interactive website in Water mode. Guide students to observe the wave and current patterns, use the temperature overlays to see how temperature relates to currents, and then go back to the wind patterns to see how the currents relate to the wind.
11. Give each student a third map Map 3 Template to draw their final model incorporating their new knowledge of global wind patterns and uneven heating to explain where the marine debris might have gone.
12. Hold a final "Board Meeting" to share these models and explain and record thinking on class chart.

Evaluate

13. Share the NOAA Prediction of JTMD Distribution and have students compare it to their own. In what ways is NOAA's model similar to their own? In what ways is it different? What might account for those differences? How could we test which aspects of the models were accurate or not?
14. Have students write a reflection using the reflection handout.

Lesson 2: Tracking the debris

Engage

1. Ask students: Why should we care about where the debris went? Collect and record ideas.
2. Watch John Chapman Misawa 1 Interview about Asian species crossing the Pacific on the Misawa dock.
3. Add any new thinking to the list after watching the video.

Explore

4. Give students the Japanese estimates of the amount of debris that washed into the ocean found on the JTMD Estimation Worksheet.
5. Using the worksheet,have students calculate percentages of debris so they can make statements about how much debris was floating, how much sunk, and what types of debris this might be.

Explain

6. Have students make a prediction about what type of debris and what amount of debris they would expect to find on along the North American West Coast citing their models of debris dispersal, the amounts and types of debris predicted by the Japanese government and their own personal experiences as evidence.
7. Share and compare predictions and claims.

Expand

8. Introduce the Long Beach Marine Disposal Site data. Give students time to look at the data. Encourage them to focus on small pieces that they can make sense of (dates, measurements, labels).
9. As a group, share and document observations about the data (how is it organized (or not), what units, what length of time, what length of beach, what's missing, etc.)
10. Have students find the total estimated amount of JTMD found at Long Beach and calculate what percentage of the overall drifting JTMD that has been found.
11. Discuss the question: Does this data give scientists a fair picture of what kinds of debris and how much debris from the Tsunami is arriving on our coast? What is it missing or what could be added to it?

Evaluate

12. Show the current Marine Debris collection instructions “Tsunami Debris Watch” posted at the beach and the SOLVEOregon’s Marine Debris Collection Protocol. Discuss the advantages and limitations of the current system.
13. Students work in groups to create a new Japanese Tsunami Marine Debris collection protocol with the goal to get more meaningful data about how much debris, what type, and where it is being found.
14. Groups present their protocol proposals to classmates (and other interested community members to make work more relevant).

Extensions

- Share the Original “windage” model for predicting JTMD dispersal. Using this as an inquiry question, have students design ways to test the windage model. (Do more buoyant materials move faster than lower sitting items?)
- The Japanese prediction data is in 1,000 metric tons. To emphasize math and give students a better concept of how much debris this is, a possible activity would be to convert the amounts to metric tonnes, then to kilograms, then to pounds.
- Another extension possibility might be to have students research the length of the entire North American West Coast and extrapolate the amount of debris that could be collected if this 11km stretch of beach were an average. The actual distribution would, of course, be uneven.

Assessment

1. **Performance**
    - “Board Report” discussion participation
    - Reading discussion participation
    - Marine debris collection protocol proposal presentation

2. **Products -**
    - Refined model of Pacific Ocean surface currents to explain possible paths of JTMD
    - “Riding the North Pacific Currents” Explanation
    - JTMD percentage calculations worksheet
    - Marine debris collection protocol proposal

3. **Assessment rubrics**
   Speaking and Listening Rubric

JTMD Collection Protocol Rubric

	1 Needs Support	2 Developing	3 Proficient	4 Exceeding
sorting system	Lacks a system to sort the collected debris or system may be too vague “blue things / yellow things”	Has a system to sort debris but lacks any type of justification for choices made.	Has a system to sort debris and a logical justification for the chosen categories.	Proficient plus
schedule: time, personnel, and locations.	Lacks a schedule to collect the debris or it may be too vague.	Has a schedule but lacks any type justification for choices made.	Has a schedule to collect the debris that covers time, personnel, and locations along with a logical justification.	Proficient plus
reporting	Lacks a way to report data collected or it may be too vague.	Has a way to report the data but lacks any type of justification for choices made.	Has a way to report collected data in an organized way and a logical justification.	Proficient plus

Model of Currents Rubric

	1 Needs Support	2 Developing	3 Proficient	4 Exceeding
Show how wind has an effect on ocean currents.	Lacks information on wind.	Displays wind info but is unclear or incorrect.	Displays wind information in a way that is clear and correct.	Proficient plus
Show how the earth's uneven temperatures affect on ocean currents.	Lacks information on temperature.	Displays temperature info but is unclear or incorrect.	Displays temperature info in a way that is clear and correct.	Proficient plus

Show how the earth's rotation affect on ocean currents.	Lacks information on rotation.	Displays rotation info but is unclear or incorrect.	Displays rotation info in a way that is clear and correct.	Proficient plus
Show how the oceans currents affect marine debris.	Lacks any information on marine debris	Displays marine debris but does not connect it to the temperature, rotation, or wind.	Displays Marine debris and shows how it is connected to temperature, rotation, and wind.	Proficient plus
Key	Lacks a key	Has a key but it is incomplete, vague, or not utilized.	Key is well defined and helps to make the information clear to a viewer.	Proficient plus