SkyTruthing for Students: Deepwater Horizon Teachers Guide

SkyTruthing for Students demonstrates how satellite imagery and ordinary citizens can make a difference protecting the environment. Module 1 takes students through the Deepwater Horizon oil spill disaster of 2010, and allows them to develop their own estimates of how much oil really spilled into the Gulf of Mexico. It shares the story of how SkyTruth, a small conservation group in West Virginia, used satellite imagery to alert the world to the true dimensions of the spill, and it allows students to use the same tools on their own computers to find answers.

Using satellite images from key dates during the spill, Google Earth Pro software, and media stories documenting the progression of the spill, SkyTruthing for Students reveals the roles that citizens, governments and corporations play in documenting and responding to environmental disaster.

Step 1: Learn about the Deepwater Horizon spill

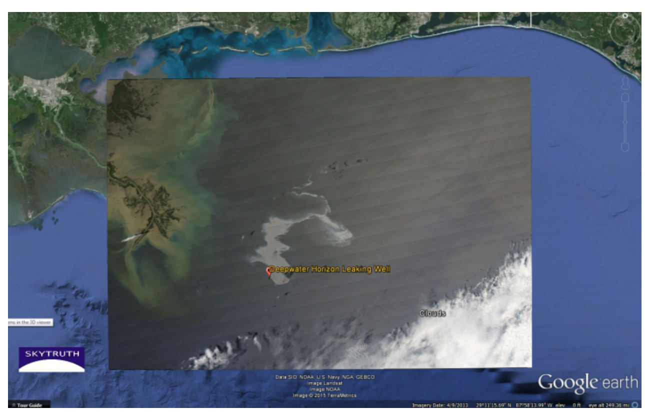
Step 1 provides basic background information to students about the 2010 spill in a compelling narrative that draws them into the subject and provides the context for the exercises and discussion that follows.

To start, go to the SkyTruthing for Students website http://skytruth.org/schools and click on the Deepwater Horizon Oil spill on the left hand column for background information on the spill.

Step 2: Calculate the size of the spill

Note: Although the Deepwater Horizon disaster occurred several years ago, it deeply affected many people in the Gulf region. Some students might want to discuss the impacts on their families or friends.

Step 2 gives students hands-on opportunity to analyze satellite images of the oil spill, determine the size of the spill from those images, and calculate the amount of oil flowing into the Gulf from their estimates. It then allows them to compare their estimates with those of SkyTruth. These exercises require students to analyze satellite images in Google Earth, and apply conversion rates and basic formulas to calculate area, volume, and flow rate.



To complete the exercises, the students will need to use:

- KMZ file that stores the satellite images of the oil spill on 4 separate dates (available on the left hand column of the SkyTruthing for Schools website)
- Google Earth Pro to trace the outline of the spill on the satellite images

- The Guide to using Google Earth Pro and worksheet to calculate the volume of oil spilled and flow rate of leaking oil on each of the dates.

As a first step, go to the SkyTruthing for Students website and download the Guide to Using Google Earth Pro provided in the left-hand column. Following the steps in the guide, have the students use the satellite image provided in the KMZ file for April 25, 2010 to practice using Google Earth by outlining the area of the oil spill on that date.

The satellite images capture only the amount of oil at the surface. The amount of oil beneath the surface remains unknown. The National Oceanic and Atmospheric Administration has developed a simple demonstration to help students understand this concept. You can find it at:

http://response.restoration.noaa.gov/training-and-education/education-students-and-teachers/how-does-oil-act-water.html

Once students have mastered maneuvering in Google Earth Pro, and understand that the images capture only the surface oil and therefore reflect only the minimum amount of oil spilled, they can outline the spill area on the additional dates provided in the KMZ files.

Once they have determined the area on a given date, students can go to the worksheet to work through their calculations of volume and flow rate for each relevant date. The worksheet is available online at the SkyTruthing for Schools website and is attached to this Teacher's Guide as well.

Step 3: Explore the impact of spill estimates

Step 3 explores the economic and political dynamics and motivations influencing the spill estimates released by BP and the federal government. The narrative describes the chronology of initial figures released by BP and the federal government, and how those figures were challenged by SkyTruth and university scientists. The narrative, combined with news stories from major outlets such as *The New York Times*, *The Washington Post*, and *The Los Angeles Times*, illustrates how citizen analysis of the spill and public awareness helped drive more accurate estimates of the spill. News stories include more indepth discussion about the factors influencing spill estimates, as well as the importance of developing accurate estimates. It provides context for the discussion questions that follow.

Tips for discussion questions:

1. What was the difference between Sky Truth's estimates of the spill and the Coast Guard's announcements of the spill size? Why do you think these were different?

The U.S. Coast Guard and BP initially estimated the spill size of about 1,000 barrels per day. Early on in the spill, SkyTruth estimated that the flow rate was at least 5,000 barrels per day. Soon after that, the Coast Guard revised its estimate up to 5,000 barrels per day. Later, SkyTruth increased its estimate further to 26,500 barrels per day. But the Coast Guard continued to say the spill was 5,000 barrels per day for several weeks, despite evidence challenging that.

Topics to consider in discussing why these figures were different:

- *The Coast Guard and BP were dealing with a major disaster requiring considerations of safety, containment of oil, and development of solutions to stop the spill. Estimating an accurate flow rate might not have been a top priority initially.*

- *BP had strong incentive to minimize public perception and official estimates of the size of the spill for both public relations and economic reasons. They didn't want to look bad to their customers. Perhaps more significantly, under the federal Oil Pollution Act of 1990 (part of the Clean Water Act), BP would have to pay penalties for damages to natural resources based on the amount of oil spilled.*
- *Although the Coast Guard was the primary federal agency in charge of the cleanup, as the polluter with expertise in oil drilling, BP took the technical lead in responding to the spill. The Coast Guard relied heavily on that expertise throughout much of the response, including, possibly, initial estimates of the spill size.*

See for example:

Judges Ruling on Gulf Oil Spill Lowers Ceiling on the Fine BP is Facing. *The New York Times*. January 15, 2015

Scientists offered varied estimates, all high, on size of BP oil leak. *The Washington Post*. June 11, 2010.

2. Why do you think the government began revising its estimates? What role did satellite imagery, SkyTruth, and university scientists play in identifying a more accurate flow rate?

Topics to consider in discussing why the government began revising its estimates:

- *News stories revealed that outside scientists and citizens were challenging their figures, raising questions in the publics' mind and opening up the government to criticism. In a democracy, ultimately the government must respond to the people.*
- *The challenges raised by outside scientists and citizens alerted the government to errors in their estimates.*

See for example: "Estimates Suggest Spill Is Biggest in U.S. History," *The New York Times*. May 28, 2010

Topics to consider in discussing the role of satellite imagery and outside scientists.

- *Satellite imagery allowed those not on the scene of the spill to see for themselves what was happening on the water.*
- *University scientists and nonprofit citizen groups such as SkyTruth are independent of corporations such as BP and the federal government. Therefore, they aren't influenced by the same economic and political pressures faced by BP and the government. Scientists are dedicated to using scientific techniques to discover the truth. SkyTruth is dedicated to informing the public about environmental impacts. Neither would be harmed by estimating high flow rates.*
- *By revealing potential flaws in official estimates, and providing the public with that information, university scientists and SkyTruth gave the federal government incentive to develop more accurate flow estimates.*

3. Why does the amount of oil spilled matter?

This Washington Post article below (and linked to in Step 3 of the lesson) provides a nice summary on the bottom of the first page about why spill estimates matter, namely: (1) understanding the capacity needed for containment and cleanup (2) setting fines that hold BP responsible for the spill and help recover damaged or lost natural resources (3) raising questions about government capability and accountability in the face of an environmental disaster.

Scientists offered varied estimates, all high, on size of BP oil leak. *The Washington Post*. June 11, 2010.

In addition, the federal Flow Rate Technical Group discusses the importance of estimating flow rate in its final report "Review of Flow Rate Estimates for Deepwater Horizon Spill" Published in the Proceedings of the National Academy of Sciences in December 2011.

4. What roles do different entities play in resolving an environmental disaster such as this? What role does government play? What role do businesses play? What role do university scientists play? What role do private citizens and nonprofit organizations play? What role does the media play?

Topics to consider in discussing the role of different entities:

- *The government has a responsibility to ensure that public resources such as water, fish, wildlife, and air are protected. It has a responsibility to ensure that pollution is cleaned up – typically by the polluter under many environmental laws.*
- *Businesses have a responsibility to conduct their operations safely to protect people and the environment. They have a responsibility to follow all laws, including laws that require them to clean up their pollution. They often have technical expertise that the government lacks, and therefore might be required to fulfill many of the technical requirements of clean up.*
- *University scientists and nonprofit citizen groups such as SkyTruth are independent of corporations such as BP and the federal government. Therefore, they aren't influenced by the same economic and political pressures faced by BP and the government. Scientists are dedicated to using scientific techniques to discover the truth. SkyTruth is dedicated to informing the public about environmental impacts. Neither would be harmed by estimating high flow rates.*
- *The media helped independent scientists and citizen groups such as SkyTruth get their message out to the public, and create public pressure for the government to develop more accurate estimates.*

5. How can information like this be used to avoid or minimize oil spills in the future?

Topics to consider for the future:

- *Engineers need to understand just how much oil can gush from a large oil well deep in the Gulf, to develop more effective technologies to prevent or contain future spills.*
- *Environmental scientists need to know how much oil was released into the ecosystem to understand how oil affects water quality and marine life, and determine how to respond to spills to minimize the impact on marine life.*
- *Understanding the vast quantities of oil spilled can serve as a warning. No technology is failsafe all the time. Policymakers and the public need to be aware of the risks of choosing to allow drilling in deep seawater to make decisions about whether and how to drill safely.*

For comprehensive overview of the spill, use of satellite imagery to track its size, capping of the well, and biological and policy implications for the future see: Norse, E.A. and Amos, J. "Impacts, Perceptions and Policy Implications of the Deepwater Horizon Oil and Gas Disaster." *Environmental Law Reporter*. 40 ELR 11058. November 2010.

Science and Math Standards Addressed (grades 9-12)

Standard 1: The Practice of Science

A: Scientific inquiry is a multifaceted activity; The processes of science include the formulation of scientifically investigable questions, construction of investigations into those questions, the collection of appropriate data, the evaluation of the meaning of those data, and the communication of this evaluation.

B: The processes of science frequently do not correspond to the traditional portrayal of "the scientific method."

C: Scientific argumentation is a necessary part of scientific inquiry and plays an important role in the generation and validation of scientific knowledge.

D: Scientific knowledge is based on observation and inference; it is important to recognize that these are very different things. Not only does science require creativity in its methods and processes, but also in its questions and explanations.

> Benchmark - SC.912.N.1.6: Describe how scientific inferences are drawn from scientific observations and provide examples from the content being studied.

> Benchmark - SC.912.N.1.7: Recognize the role of creativity in constructing scientific questions, methods and explanations.

Standard 4: Science and Society

As tomorrow's citizens, students should be able to identify issues about which society could provide input, formulate scientifically investigable questions about those issues, construct investigations of their questions, collect and evaluate data from their investigations, and develop scientific recommendations based upon their findings.

> Benchmark - SC.912.N.4.1: Explain how scientific knowledge and reasoning provide an empirically-based perspective to inform society's decision making.

Standards addressed in Environmental Science and Marine Science courses:

SC.912.E.6.6 Analyze past, present, and potential future consequences to the environment resulting from various energy production technologies.

SC.912.L.17.11 Evaluate the costs and benefits of renewable and nonrenewable resources, such as water, energy, fossil fuels, wildlife, and forests.

SC.912.L.17.13 Discuss the need for adequate monitoring of environmental parameters when making policy decisions.

SC.912.L.17.16 Discuss the large-scale environmental impacts resulting from human activity, including waste spills, oil spills, runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution.

SC.912.N.4.2 Weigh the merits of alternative strategies for solving a specific societal problem by comparing a number of different costs and benefits, such as human, economic, and environmental.

Language Arts Standards

LAFS.1112.RST.1.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

LAFS.1112.RST.1.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

LAFS.1112.RST.3.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

LAFS.1112.WHST.3.9 Draw evidence from informational texts to support analysis, reflection, and research.

Integrating Standards for Mathematical Practice (MP):

- MAFS.K12.MP.1.1 Make sense of problems and persevere in solving them.
- MAFS.K12.MP.2.1 Reason abstractly and quantitatively.
- MAFS.K12.MP.3.1 Construct viable arguments and critique the reasoning of others..
- MAFS.K12.MP.5.1 Use appropriate tools strategically.
- MAFS.K12.MP.6.1 Attend to precision.
- MAFS.K12.MP.7.1 Look for and make use of structure.
- MAFS.K12.MP.8.1 Look for and express regularity in repeated reasoning.

Name: ______________________________ **Date:** ________________

Oil Spill Flow Rate Calculations Worksheet

Directions: Find out how SkyTruth calculated the minimum flow rate of the oil spill on a given day by following these steps:

1. Use Google Earth Pro to measure the area (A) of the oil slick that can be seen from space.
2. Calculate the minimum volume of the slick, in cubic meters (m^3), assuming a depth of 1 micron, or μ.
3. Convert the volume of oil in cubic meters to volume in barrels (V_{bbl}).
4. Calculate the flow rate by dividing the number of barrels of oil leaked by the number of days the well head was leaking.

Step 1) Using the steps outlined in the Guide to Using Google Earth Pro, draw a polygon around the oil spill and find the area, A, in square kilometers (km^2) from Google Earth. Record your measurements in the Area column of the Oil Spill Area and Estimated Volume Chart below.

Step 2) Calculate the minimum volume of the spill, in cubic meters, or m^3. Working through the conversions shows that the volume of 1 km^2 at 1 μ = 1 m^3. Therefore, the area you determined in km^2 equals the volume in m^3.

If you want to understand how that calculation works, see the Appendix below.

Regardless, record your values for the Area (km^2) and Estimated Volume (m^3) in the Oil Spill Area and Estimated Volume Chart below.

OIL SPILL AREA AND ESTIMATED VOLUME CHART

date	Area (km^2)	Estimated Volume (m^3)
April 25, 2010		
April 27, 2010		
April 29, 2010		
May 1, 2010		

Step 3) Convert the oil slick volume in cubic meters to slick volume in barrels. To do this, multiply slick volume in cubic meters by the number of liters in a cubic meter (1,000), and then convert that to barrels.

To calculate the number of liters of oil on each day, multiply the number of cubic meters you got in the Estimated Volume above, by 1000. Record your numbers in the “slick volume (L)” column of the Flow Rate Chart.

$$1\ m^3 = 10 \times 10 \times 10\ L = 1{,}000\ L$$

Then convert liters to barrels. Barrels are much larger than liters. Each liter is 0.00628981077 of a barrel. To find the number of barrels on each day, multiply the amount in the “slick volume (L)” column by 0.00628981077. This is the estimated number of barrels seen from space on the surface of the ocean that day. Record your numbers in the “slick volume (bbl)” of the Flow Rate Chart.

Step 4) Calculate the flow rate/per day. The flow rate equals the total number of barrels estimated for that day divided by the number of days the well head had been leaking. (The oil rig exploded on April 20, 2010.)

$$\text{Flow rate} = \text{total } V_{bbl} \text{ of oil leaked/ number of days leaking}$$

FLOW RATE CHART

date	slick volume (L)	slick volume (bbl)	# of days leaking	flow rate (bbl/# days)
April 25, 2010				
April 27, 2010				
April 29, 2010				
May 1, 2010				

APPENDIX: Why does 1 km^2 of liquid that is 1 μ deep equal 1 m^3 in volume?

To calculate the volume of liquid you multiply the area by the depth.

In this case, because we are using kilometers and microns, there is a convenient trick to finding volume. Here's how it works:

$$1\ km^2 = 1{,}000{,}000\ m^2 \quad \text{OR} \quad 1 \times 10^6\ m^2$$

$$1\ \mu = \frac{1}{1{,}000{,}000}\ m \quad \text{OR} \quad 1 \times 10^{-6}\ m$$

When kilometers and microns are both converted to meters, you can see that when you multiply them together, they equal 1.

$$1{,}000{,}000\ m^2 \times \frac{1}{1{,}000{,}000}\ m = 1\ m^3$$

Therefore, the minimum volume on one square kilometer of oil in cubic meters is 1 m^3.