ALGALITA MARINE RESEARCH FOUNDATION

Mapping Plastic Marine Pollution

Lessons for Grades 4-12

http://www.algalita.org/

Contents

Introduction

Since 1999 Algalita Marine Research Foundation (AMRF) has been collecting data on plastic pollution in the North Pacific Subtropical Gyre. Algalita's research team is at the forefront of the investigation into plastic pollution in our oceans. Operating in conjunction with the Oceanographic Research Vessel *Alguita* (ORV *Alguita*), the team has traveled to remote regions of the North Pacific Ocean examining both the scope of plastic contamination and the implications this pollution has on the food chain. The focus of the team's current research includes quantification of plastic debris in the North Pacific Sub-tropical Gyre, as well as studying the biological impact of plastics on marine life and the human food chain. The data gathered by the research team has been compiled into maps to help students visualize the extent of plastic debris in the ocean. Daily observations and photographs taken by the research vessel crew have been geographically linked to provide students a global view into the world of oceanographic research.

This Educator's Guide provides lessons that allow students to explore AMRF's plastic pollution research aboard ORV *Alguita* using free Google Earth software. Lessons are aligned to California Science Content Standards and are accompanied by printable activity sheets.

About .kml Files

The voyages of ORV *Alguita* are stored as .kml files which are compatible with Google Earth and Google Maps. Most lessons require Google Earth software, but modifications can be made if Google Maps is used instead. These files are available for download at:

http://algalita.org/MappingPlasticPollution.htm

About Google Earth

Google provides free Google Earth software that can be downloaded from the website (http://earth.google.com/). An internet connection is required to run the software. The software is very user friendly and most students can intuitively operate the software with minimal assistance.

Caught in the Web: Plastic Pollution in the Pacific Ocean

Grade Level- 4

Concepts

4th Grade Life Sciences

2. All organisms need energy and matter to live and grow. As a basis for understanding this concept

b. Students know producers and consumers (herbivores, carnivores, omnivores, and decomposers) are related in food chains and food webs and may compete with each other for resources in an ecosystem.

4th Grade Investigation and Experimentation

6. b. Measure and estimate the weight, length, or volume of objects.

f. Follow a set of written instructions for a scientific investigation.

EXTENSION ACTIVITY

6 a. Differentiate observation from inference (interpretation) and know scientists' explanations come partly from what they observe and partly from how they interpret their observations.

Vocabulary

- Food Web
- Producer
- Consumer
- Herbivore
- Carnivore
- Omnivore
- Organism

EXTENSION ACTIVITY

- Inference
- Observation

Summary

Using geographically linked observations made by the crew aboard Oceanographic Research Vessel Alguita and exploration on the internet, students determine roles of marine organisms in the ocean food web, and consider how plastic pollution may also enter the food web and affect marine organisms.

Materials

- "Caught in the Web: Plastic Pollution in the Pacific Ocean" activity sheet for each student or group: http://algalita.org/MappingPlasticPollution.htm
- Computers with Google Earth software installed and access to the internet
- Any voyage .kml file: http://algalita.org/MappingPlasticPollution.htm
- Pencil or pen (if activity sheets are printed).

Procedure

1. Discuss oceanographic research and the topic of plastic marine debris with your students. Provide students with some background on the research voyage they will be viewing. Much of this information is contained within the text of the voyage- more detail can be found at http://algalita.org/
2. Students can work individually or in groups. The worksheet provides detailed directions that assume Google Earth is already open and the .kml file of the voyage is already loaded for student use.
3. The amount of text and the vocabulary provided in each vessel communication may be challenging for the fourth grade level. If this is the case, encourage students to use the images provided by the crew to find the organisms they are looking for. Students may need to follow web links or conduct internet searches to find more information about the organisms they choose.
4. Discuss the student's answers to question #3. This is a new area of research and much about the effects of plastic ingestion on organisms is still unknown. Ask students what they can do to prevent plastic from entering the ocean. This is a good opportunity to talk about the distance of your school from the ocean and your connections to the ocean.

Extensions

Observation vs. Inference

The "Caught in the Web: Plastic Pollution in the Pacific Ocean" activity centered on the students recording observations of organisms made by the research vessel crew. In their daily diary, the crew record their observations along with inferences they make from their observations. After an introduction to inferences and observations, have the students fold their papers in half and write "Observations" on one side and "Inferences" on the other. Give the students time to read the daily diary of the crew and make a list of inferences and observations made by the crew. At the end, discuss any difficulties students had in differentiating between the two.

Caught in the Web: Plastic Pollution in the Pacific Ocean

A. In Google Earth, go to the Search Panel under the "Fly to" tab.
B. Type your school's name or address and hit search
C. Click "**Add Placemark**" on the tool bar.
D. **Name** your placemark with the name of your school.
E. Use the Navigation Controls to "zoom out" until you can see the ocean.
F. Use the Ruler tool to **measure the distance** from your school to the ocean.

1) What is the distance from your school to the Ocean?

_____

G. Find the North Pacific Ocean. The small blue sailboats show the voyage of a research vessel carrying scientists studying plastic pollution in the Pacific Ocean.
H. Follow the voyage by clicking on the sailboats to see what the scientists found along the way.

2) Below, record information about 5 organisms the research crew observed during their voyage. You may need to find more information about each organism by following the Web links provided or by doing your own Web search.

Day #	Distance from land	Name one organism observed that day.	Is the organism a producer or a consumer ? (Circle one)	Is the organism a herbivore, a carnivore or an omnivore? (Circle one)	Was any plastic observed that day? If so, what type?
			Producer/Consumer	Herbivore/Carnivore/Omnivore	
			Producer/Consumer	Herbivore/Carnivore/Omnivore	
			Producer/Consumer	Herbivore/Carnivore/Omnivore	
			Producer/Consumer	Herbivore/Carnivore/Omnivore	
			Producer/Consumer	Herbivore/Carnivore/Omnivore	

3) Many animals (including fish, sea turtles, and birds) mistake plastic for food. What do you think will happen to the consumers you listed above if they accidentally eat plastic?

In the Flow: Plastic Pollution in the Pacific Ocean

Concepts

5th Grade Earth Sciences
3. Water on Earth moves between the oceans and land through the processes of evaporation and condensation. As a basis for understanding this concept:
a. Students know most of Earth's water is present as salt water in the oceans, which cover most of Earth's surface (approximately 70%).
b. Students know when liquid water evaporates, it turns into water vapor in the air and can reappear as a liquid when cooled or as a solid if cooled below the freezing point of water.
c. Students know water vapor in the air moves from one place to another and can form fog or clouds, which are tiny droplets of water or ice, and can fall to Earth as rain, hail, sleet, or snow.

5th Grade Investigation and Experimentation
6. f. Select appropriate tools (e.g., thermometers, meter sticks, balances, and graduated cylinders) and make quantitative observations.
g. Record data by using appropriate graphic representations (including charts, graphs, and labeled diagrams) and make inferences based on those data.

EXTENSION ACTIVITY
3 e. Students know the origin of the water used by their local communities.

Vocabulary

- Evaporation
- Condensation
- Water vapor
- Precipitation
- Watershed

Grade Level- 5

Summary

Using Google Earth students explore Earth's surface to discover the vastness of the planet's oceans, and obtain a global view of the water cycle. Using geographically linked observations made by the crew aboard Oceanographic Research Vessel *Alguita*, students learn about plastic pollution in the Pacific Ocean and how plastic contamination is linked to the water cycle and their daily choices.

Materials

- "In the Flow: Plastic Pollution in the Pacific Ocean" activity sheet for each student or group: http://algalita.org/MappingPlasticPollution.htm
- Computers with Google Earth software installed and access to the internet
- Any voyage .kml file: http://algalita.org/MappingPlasticPollution.htm
- Pencil or pen (if activity sheets are printed).

Procedure

1. Discuss oceanographic research and the topic of plastic marine debris with your students. Provide students with some background on the research voyage they will be viewing. Much of this information is contained within the text of the voyage- more detail can be found at http://algalita.org/
2. Students can work individually or in groups. The worksheet provides detailed directions that assume Google Earth is already open and the .kml file of the voyage is already loaded for the students use.
3. The amount of text and the vocabulary provided under each vessel communication may be challenging for the fifth grade level. If this is the case, encourage students to use the images provided by the crew to find the plastic pollution items they are looking for.
4. Discuss the student's answers to questions 9, 10 and 11. Ask students what local sources of plastic pollution there might be and what they can do to prevent plastic from entering the ocean. This is a good opportunity to discuss the distance of your school from the ocean and your connections to the ocean through the watershed.

Extensions

Tap Water Investigation

Much of the plastic debris polluting the world's oceans comes from single use disposable items such as plastic water bottles. A simple alternative to disposable water bottles is drinking from re-usable bottles; however, many people are concerned about their local water quality. Have your students view the source of their tap water in Google Earth. Finding the source of local tap water can either be a research assignment or the location can be provided to simplify the lesson. Many bottled water companies also use municipal tap water from different locations (check bottle labelling for locations). These locations can also be visited in Google Earth. Local water quality information should be available to lend more information to the investigation.

In the Flow: Plastic Pollution in the Pacific Ocean

A. Use the arrow keys on your computer keyboard to explore Earth.

1) How much of Earth's surface is covered in water? (Circle one)

☐ **none** ☐ **some** ☐ **most** ☐ **all**

B. Place the cursor in the middle of the Earth.
C. Use the arrow key to make the Earth spin and close your eyes.
D. Stop pressing the arrow key; open your eyes.

Record if the cursor is over land or water by putting an X in the box. Repeat 10 times.

Trial	Water	Land
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Total		

Total Water = _____ x 10 = _____%

Total Land = _____ x 10 = _____%

2) How do the results of your experiment compare with the actual % of the Earth's surface that is covered in water? (Circle one)

☐ **Lower** ☐ **Same** ☐ **Higher**

3) From your observations do you think most of this water is salt water or fresh water?

_____

When the ocean is warmed by the sun, liquid water evaporates and becomes water vapor. When the water vapor is cooled some of it turns back into liquid water as clouds or rain. If the air is cold enough, the water will freeze into a solid and fall as snow, sleet, or hail.

F. Using the arrow keys and zoom, search for one location where there is evidence that precipitation has fallen as rain, and another where there is snow.

4) Where did you find evidence that it had rained? Where did you find snow? Describe.

5) What do you think caused the temperature difference between the two locations?

6) For each location, where does the water go after it has fallen or melted?

G. In Google Earth, go to the Search Panel under the "Fly to" tab.
H. Type your school's name or address and hit search 

I. Click "**Add Placemark**"  on the tool bar.
J. **Name** your placemark with the name of your school.

7) How many miles do you think your school is from the ocean? (circle one)

☐ **0-10** ☐ **10-20** ☐ **20-50** ☐ **50-100** ☐ **>100**

K. Use the Navigation Controls to "zoom out" until you can see the ocean.
L. Use the Ruler tool  to **measure the distance** from your school to the ocean.

8) What is the actual distance from your school to the Ocean?

_____

M. Using the navigation controls, follow the path that you think a raindrop would take from your school to the ocean.

9) Do you think the raindrop would find pollution on its path from your school to the ocean? Describe.

N. Find the North Pacific Ocean. The small blue sailboats  show the voyage of a research vessel carrying scientists studying plastic trash in the Pacific Ocean.
O. Follow the voyage by clicking on the sailboats to see what the scientists found along the way.

10) What are three different examples of plastic trash that the scientists found in the Pacific Ocean?

1.

2.

3.

Most plastic trash in the ocean comes from litter that gets swept from land into the water when it rains.

11) What could you do to make sure that you don't pollute the ocean with plastic litter? Name three things.

1.

2.

3.

Into the Web: Plastic Pollution in the Pacific Ocean

Concepts

6th Grade Earth Sciences
Focus on Earth Sciences
2. Topography is reshaped by the weathering of rock and soil and by the transportation and deposition of sediment. As a basis for understanding this concept:
a. Students know water running downhill is the dominant process in shaping the landscape, including California's landscape.
b.Students know rivers and streams are dynamic systems that erode, transport sediment, change course, and flood their banks in natural and recurring patterns.
Energy in the Earth System
4. a. Students know the sun is the major source of energy for phenomena on Earth's surface; it powers winds, ocean currents, and the water cycle.
Ecology (Life Sciences)
5. Organisms in ecosystems exchange energy and nutrients among themselves and with the environment. As a basis for understanding this concept:
a. Students know energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis and then from organism to organism through food webs.
b. Students know matter is transferred over time from one organism to others in the food web and between organisms and the physical environment.
6th Grade Investigation and Experimentation
7 b. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

Vocabulary

- Erosion
- Sediment
- Ocean Currents
- Food Web
- Chemical Energy
- Phytoplankton
- Zooplankton

Grade Level - 6

Summary

Using Google Earth, students explore local geography to determine their proximity to the ocean, how water shapes their landscape, and how water transports plastic pollution to the ocean. Using geographically linked observations made by the crew aboard Oceanographic Research Vessel Alguita, students view plastic pollution collected from the Pacific Ocean and learn how that plastic gets incorporated into the marine food web.

Materials

- "Into the Web: Plastic Pollution in the Pacific Ocean" activity sheet for each student or group: http://algalita.org/MappingPlasticPollution.htm
- Computers with Google Earth software installed and access to the internet
- Any Voyage.kml file: http://algalita.org/MappingPlasticPollution.htm
- Pencil or pen (if activity sheets are printed).

Procedure

1. Discuss oceanographic research and the topic of plastic marine debris with your students. Provide students with some background on the research voyage they will be viewing. Much of this information is contained within the text of the voyage - more detail can be found at http://algalita.org/
2. Students can work individually or in groups. The worksheet provides detailed directions that assume Google Earth is already open and the .kml file of the voyage is already loaded for the students use.
3. Question #2 asks the students to investigate how running water shapes topographical features. This will be easier to visually recognize in some regions than others. View your region in Google Earth to ascertain what scale students use to most easily view this phenomenon. Encourage students to try different scales (using the zoom feature) to help them identify these features.
4. For questions 4 and 5 the amount of text and the vocabulary provided under each vessel communication may be challenging at the sixth grade level. If this is the case, encourage students to use the images provided by the crew to find the plastic pollution items and organisms they are looking for.
5. Have students compare the maps they made in question 2. Did they find similar topographical features to those of their classmates? Discuss question 4 - what was the farthest distance from land that a student measured to where the ship's crew observed plastic debris? Discuss the student's answers to questions 3 and 7. What other solutions can the students think of that would address the human made pollutants they listed? This is a good opportunity to discuss the distance of your school from the ocean and your connections to the ocean through the watershed.

Into the Web: Plastic Pollution in the Pacific Ocean

A. In Google Earth, go to the Search Panel under the "Fly to" tab.

B. Type your school's name or address and hit search 

C. Click "**Add Placemark**"  on the tool bar.

D. **Name** your placemark with the name of your school.

E. Use the Navigation Controls to "zoom out" until you can see the ocean.

F. Use the Ruler tool  to **measure the distance** from your school to the ocean.

1) What is the distance from your school to the Ocean?

_____

2) What evidence do you see of how water running downhill has shaped the landscape in your area? Draw a map below that shows the topographical features indicating erosion and deposition of sediment.

3) Along with sediment, what else might be transported to the ocean by water flowing downhill from your area? Make a list.

Natural	Human-made
1.	**1.**
2.	**2.**
3.	**3.**

G. Find the North Pacific Ocean. The small blue sailboats  show the voyage of a research vessel carrying scientists who are studying plastic pollution in the Pacific Ocean.

H. Follow the voyage by clicking on the sailboats to see what the scientists found along the way.

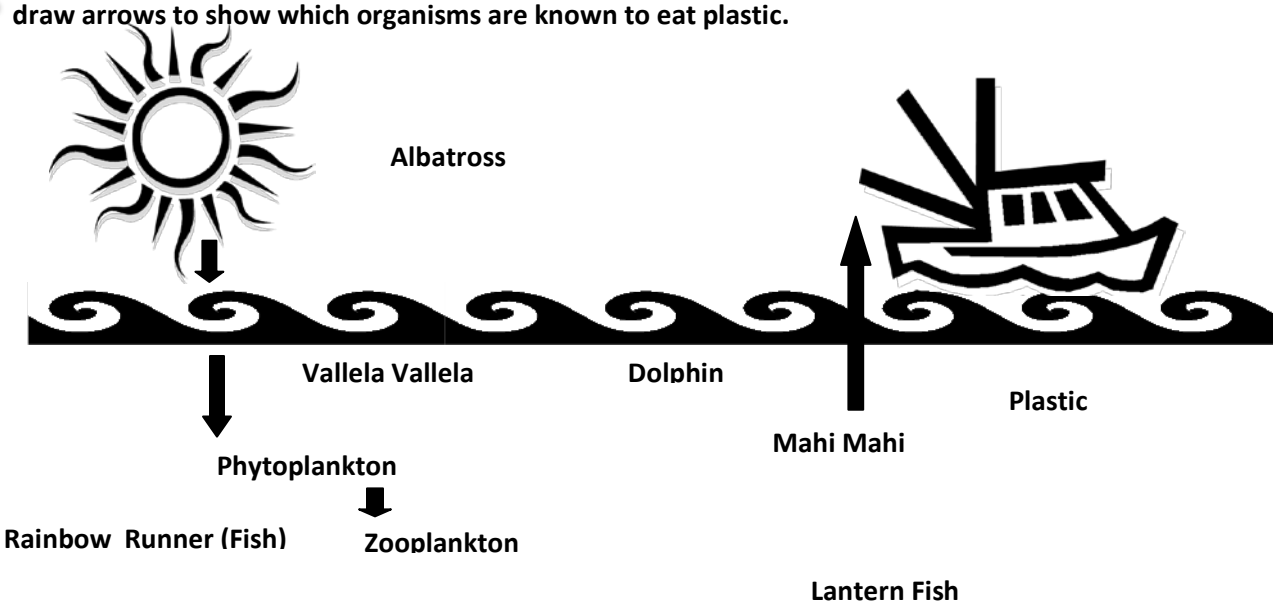
Most plastic debris enters the ocean directly from land, flushed out to sea with rainwater. Powered by energy from the sun, ocean currents are constantly on the move. This means that objects that float continue to travel once they reach the ocean. The plastic debris collected by the scientists aboard ORV Alguita may have already traveled a long way.

4) List 3 pieces of plastic debris the scientists collected and measure the minimum distance that the plastic could have traveled from land.

Plastic (description)	Minimum distance from land
1)	
2)	
3)	

Energy enters the marine ecosystem through sunlight which is transferred by phytoplankton into chemical energy through photosynthesis. This energy is then passed from organism to organism through the food web. Plastic also enters the food web as animals mistake it for food.

5) Using the photographs and information provided by the scientists on the research vessel, draw the organisms below and the food they eat. Draw arrows to show how energy flows through the food web. Also, draw arrows to show which organisms are known to eat plastic.



6) What negative effects might eating plastic have on an organism?

7) What is one thing you could do to make sure that you don't contribute plastic pollution to the ocean food web?

Environmental Changes: Plastic Pollution in the Pacific

Concepts

7th Grade Focus on Life Sciences
Evolution
3. Biological evolution accounts for the diversity of species developed through gradual processes over many generations. As a basis for understanding this concept:
e.Students know that extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient for its survival.

7th Grade Investigation and Experimentation
7. a.Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.
b.Use a variety of print and electronic resources (including the World Wide Web) to collect information and evidence as part of a research project.
d.Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e.g., motion of Earth's plates and cell structure).

Vocabulary

- Marine Organism
- Plastic Debris
- Oceanographic Research Vessel
- Adaptation

Grade Level - 7

Summary

Using geographically linked observations made by the crew aboard Oceanographic Research Vessel Alguita, students learn about plastic pollution in the Pacific Ocean and how plastic contamination is linked to the water cycle and their daily choices. Students record observations of marine organisms and plastic debris, and then develop a spatial diagram showing the distance the observations were made from shore. Using this information and a map generated from the data collected by the research team over a 10 year period, students address how plastic pollution may be changing the marine environment.

Materials

- "Environmental Changes: Plastic Pollution in the Pacific Ocean" activity sheet for each student or group: http://algalita.org/MappingPlasticPollution.htm
- Computers with Google Earth software installed and access to the internet
- Any Voyage.kml file: http://algalita.org/MappingPlasticPollution.htm
- Pencil or pen (if activity sheets are printed).

Procedure

1. Discuss oceanographic research and the topic of plastic marine debris with your students. Provide students with some background on the research voyage they will be viewing. Much of this information is contained within the text of the voyage - more detail can be found at http://algalita.org/
2. Students can work individually or in groups. The worksheet provides detailed directions that assume Google Earth is already open and the .kml file of the voyage is already loaded for the students use.
3. The amount of text and the vocabulary provided under each vessel communication may be challenging for the seventh grade level. If this is the case, encourage students to skim the text and use the images provided by the crew to find the plastic debris and marine organisms they are looking for.
4. Discuss questions 4, 5 and 6. These questions address new areas of research and many of the answers are still unknown. Reading through the observations made by the research crew will give the students an introduction to this field of study and should provide them with ideas to include in their answers. Remind students of the difference between these sorts of inferences and actual observations and tests. Discuss what types of studies the students could design to test their hypothesis. Discuss the observations students made in question 2. What types of plastic debris were observed? Where might it have come from? This is a good opportunity to discuss the distance of your school from the ocean and the student's connections to the ocean through the watershed.

Environmental Changes: Plastic Pollution in the Pacific Ocean

A. In Google Earth, go to the Search Panel under the "Fly to" tab.
B. Type your school's name or address and hit search
C. Click "**Add Placemark**" on the tool bar.
D. **Name** your placemark with the name of your school.
E. Use the Navigation Controls to "zoom out" until you can see the ocean.
F. Use the Ruler tool to **measure the distance** from your school to the ocean.

1) What is the distance from your school to the Ocean?

_____

G. Find the North Pacific Ocean. The small blue sailboats show the voyage of a research vessel carrying scientists studying plastic pollution in the Pacific Ocean.
H. Follow the voyage by clicking on the sailboats to see what the scientists found along the way.

2) Below list 5 marine organisms and 5 pieces of plastic debris the crew observed during the voyage. Using the ruler tool measure the distance the boat was from the nearest shore when these were observed. Write the distance under the corresponding label.

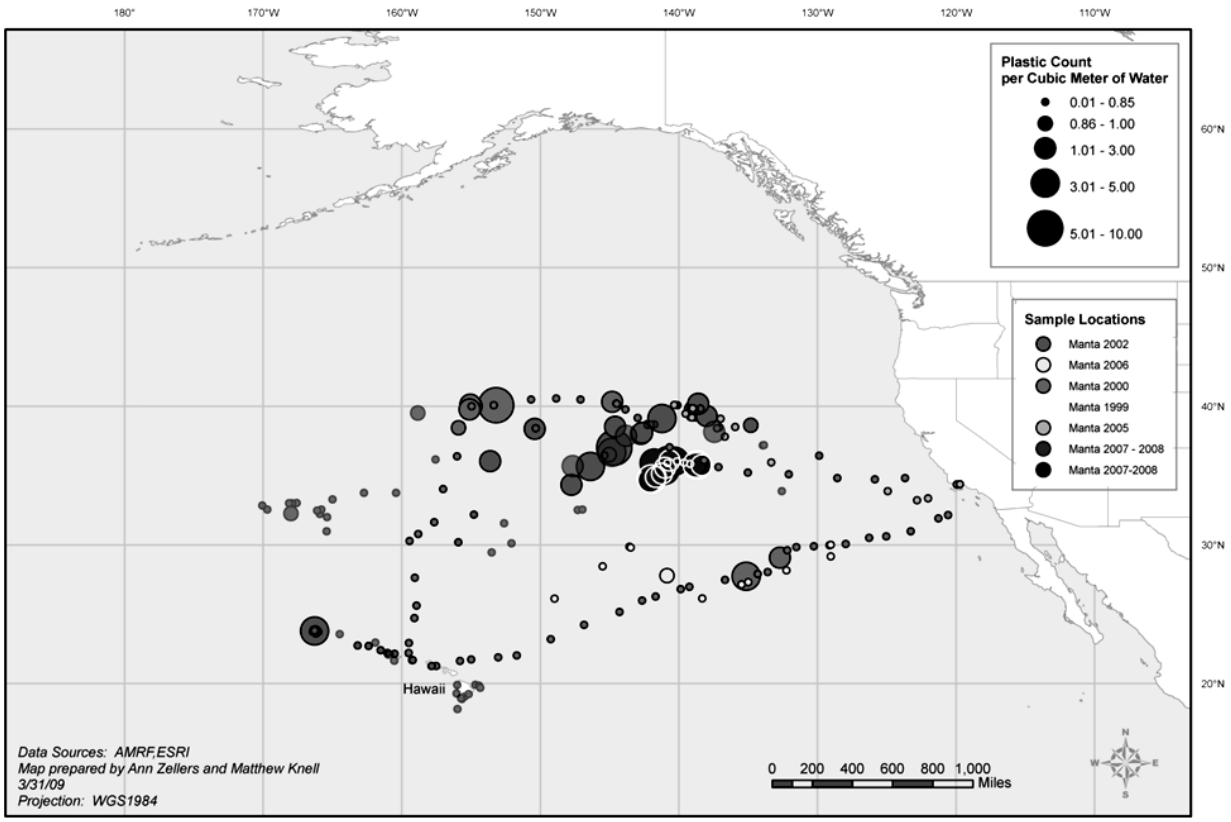
Marine Organisms

1. 2. 3. 4. 5.

|_____|_____|

Plastic Debris

1. 2. 3. 4. 5.



The map above shows the number (count) of plastic particles per cubic meter of water that the ORV Alguita research team has collected during voyages over the past 10 years.

3) Approximately how far from shore are the samples with the most plastic particles? (Use the scale on the map to approximate the distance.)

4) In what ways might plastic debris be changing the marine environment?

5) What effects might these changes have on marine organisms? What organisms do you think will be most impacted?

6) What might happen to species that are unable to adapt to this change in their environment if we continue to allow plastic debris to pollute the ocean?

Trash Travels: Plastic Pollution in the Pacific Ocean

Grade Level - 8

Concepts

8th Grade Focus on Physical Sciences

1.The velocity of an object is the rate of change of its position. As a basis for understanding this concept:

b. Students know that average speed is the total distance traveled divided by the total time elapsed and that the speed of an object along the path traveled can vary.

c. Students know how to solve problems involving distance, time, and average speed.

8th Grade Investigation and Experimentation

f. Apply simple mathematic relationships to determine a missing quantity in a mathematic expression, given the two remaining terms (including speed = distance/time, density = mass/volume, force = pressure × area, volume = area × height).

EXTENSION ACTIVITY

Density and Buoyancy

8. a. Students know density is mass per unit volume.

b. Students know how to calculate the density of substances (regular and irregular solids and liquids) from measurements of mass and volume.

c. Students know the buoyant force on an object in a fluid is an upward force equal to the weight of the fluid the object has displaced.

d. Students know how to predict whether an object will float or sink.

Vocabulary

- Latitude
- Longitude
- Elevation
- Watershed
- Oceanographic Research Vessel

Summary

Using geographically linked observations made by the crew aboard Oceanographic Research Vessel *Alguita*, students learn about plastic pollution in the Pacific Ocean.

Materials

- "Trash Travels: Plastic Pollution in the Pacific Ocean" activity sheet for each student or group: http://algalita.org/MappingPlasticPollution.htm
- Computers with Google Earth software installed and access to the internet
- Voyage 2007.kml file: http://algalita.org/MappingPlasticPollution.htm
- Pencil or pen (if activity sheets are printed).

Procedure

1. Discuss oceanographic research and the topic of plastic marine debris with your students. Provide students with some background on the research voyage they will be viewing. Much of this information is contained within the text of the voyage - more detail can be found at http://algalita.org/
2. Students can work individually or in groups. The worksheet provides detailed directions that assume Google Earth is already open and the .kml file of the 2007 voyage is already loaded for the students use.
3. Discuss question 7. What distance and time did the students calculate? Did their calculations vary, and why? What further information did they feel was important to include in the calculation (7d). Discuss question 9. This is a relatively new topic of research and little is known about the effects of plastic on marine organisms. Why might this be an important research topic? Discuss the distance of your school from the ocean, your student's connections to the ocean through the watershed, and what they can do to prevent plastic from entering the ocean.

Extensions

Not All Plastic Floats: Density and Buoyancy

All of the plastic pollution collected by the ORV Alguita research crew was floating on or near the ocean's surface, but not all plastic floats. Many types of plastic sink directly to the bottom of the ocean, or remain suspended in the water column. The amount of plastic visible on the ocean's surface varies with sea state and barometric pressure. Have students create a list of plastic items described by the ship's crew. Then ask the students to discern which plastic items might sink if changes were made to the plastic object (e.g. the bottle cap was removed, or the air was let out of the balloon.) Have students develop a hypothesis, and collect the items to test the hypothesis using a tub of water. Measure mass and volume to calculate the density of each item to further illustrate their observations of buoyancy. What does this tell us about the quantity of plastic pollution in the ocean relative to the observations of the research crew?

Trash Travels: Plastic Pollution in the Pacific Ocean

A. In Google Earth, go to the Search Panel under the "Fly to" tab.
B. Type your school's name or address and hit search 
C. Click "**Add Placemark**"  on the tool bar.
D. **Name** your placemark with the name of your school.

1) What is the latitude and longitude of your school? (Record below)

Latitude_____

Longitude_____

E. Use the Navigation Controls to "zoom out" until you can see the ocean.
F. Use the Ruler tool  to **measure the distance** from your school to the ocean.

2) What is the distance from your school to the Ocean?

_____

G. Using zoom functions and the navigation controls, begin to follow the path that you think a raindrop would take through the watershed from your school to the ocean.

3) a. What is the force acting on the water that causes the water to continue moving after reaching the ground?

b. How can this knowledge help you predict where the water will travel?

c. Latitude and longitude alone do not provide enough information to help you predict the route your rain drop will take- what third measurement of location do you need? (Hint: Activate this function now by checking the box next to “terrain” under the “Layers” tab- the third measurement will appear at the bottom of the screen with latitude and longitude. Do this before continuing.)

H. Imagine the largest storm of the year and where that water would flow. Use the measurement you activated in question 3 to continue following the path that rainwater would most likely take through the watershed from your school to the ocean.

4) a. Given what you have observed along the route of your watershed, do you think that a bucketful of the water sampled just before it entered the ocean would be clean enough to drink? If not, what types of pollutants would you expect to find in the water?

b. What types of pollutants would you predict that you might find in storm water run off that you could observe with your eyes? Where do these go?

Plastic debris is one type of pollution entering the Pacific Ocean through our watersheds. Oceanographic Research Vessel *Alguita* sailed from the Port of Long Beach on a research voyage to Hawaii studying plastic pollution in the Pacific Ocean

I. Scroll out until you can view the Pacific Ocean.
J. Take a moment to follow the voyage by clicking on the sailboat icons 
K. Use the navigation control to "zoom in" until Day 2 and Day 3 of the voyage fill the screen.
L. Measure  the distance between the location of the research vessel on each of these days. (The position of the sailboat icons in Google Earth are the positions that the research vessel was at on noon that day.)

5) a. How far did the research vessel travel in 24 hours?

_____

b. What was the average speed that the research vessel was traveling at? (Remember average speed = total distance traveled divided by the total time elapsed.)

_____

The speed you calculated above was the average speed, but the research vessel's speed may have varied during this time.

M. Click on the sailboat icon for "Day 2" to read the captain's comments about the day. You will notice that the vessel actually stopped for some time to do research.

6) a. What species of marine mammal did the crew observe while the boat stopped?

b. Can that species of marine mammal move faster than the average speed you calculated for the research vessel? (Use an internet browser to visit the following site to gather the information you need to answer this question; http://www.acsonline.org/factpack/finwhl.htm) Circle one. YES / NO

☐ ☐

N. Use the ruler tool to measure the distance from the “Day 4” icon to the shore.
O. Click on the sailboat icon for **“**Day 4.”

7) a. What plastic pollution does the crew describe collecting on Day 4?

b. How far was the research vessel from shore on Day 4?_____

c. Assuming the plastic was moving at the average speed of the California Current (1 km per hr or 0.6 mph) what is the minimum amount of time that it would have taken the plastic to travel from the nearest shore to the point where it was collected?

d. What other information and variables would you need to take into account to make this calculation more accurate?

8) What other types of plastic pollution did the research crew find during their voyage?

9) Do you think the type of pollution that these researchers are studying has an effect on marine organisms living in the Pacific Ocean? If so, what effect?

10) What could you do, as an individual, to help keep plastic debris out of the Pacific Ocean?

The Oceans Are Downhill from Everywhere: Changes Caused by Humans in the North Pacific Gyre Ecosystem

Concepts

Biology/Life Sciences - Grades Nine Through Twelve

Ecology 6. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:

a. Students know bio diversity is the sum total of different kinds of organisms and is affected by alterations of habitats

b. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size

c. Students know how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death.

d. Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration

Vocabulary

- anthropogenic
- watershed
- respiration
- photosynthesis
- ecosystem

Grade Level 9-12

Summary

Using Google Earth and geographically linked observations made by the crew aboard the Ocean Research Vessel Alguita, students will look at anthropogenic ocean ecosystem changes due to plastic marine debris and nutrients that enter the ocean from watersheds.

Materials

• Activity Sheet for each student: "The Oceans Are Downhill from Everywhere: Changes Caused by Humans in the North Pacific Gyre Ecosystem" (Ecosystem Instability HS Bio v.2.docx)

• Computers with Google Earth and PowerPoint software installed and access to the internet

• Files
- "Dead Zone" spreads across Gulf of Mexico Image
- GyreAnimation.pps
- North Pacific Currents Map.kmz
- Voyage 2009.kml
- Voyage2007.kml
- AMRF_GIS_DATA_Sites.kmz

• Pencil or pen (if activity sheet is printed).

Procedure

1. Discuss or let students view "Mapping Plastic Pollution" found at: http://algalita.org/Maps_Home.html. Pay particular attention to "Sampling in the North Pacific Gyre: Background". This could be done the day before along with "Synthetic Sea" explained in Extension #1.
2. Students complete the worksheet using their computers.

Extension

1. Watch the Synthetic Sea shortened (7+ minutes) free version at: http://www.algalita.org/pelagic_plastic_mov.html
2. Describe some of the current research findings related to marine plastic debris.
3. What future research needs to be done to get data related to the problem of plastic marine debris?

The Oceans Are Downhill from Everywhere: Changes Caused by Humans in the North Pacific Gyre Ecosystem

A. Using Google Earth, go to the Search Panel under the "Fly to" tab.

B. Type your place of learning or school's address and hit search. 

C. Click "Add Placemark"  on the tool bar.

D. Name your placemark with the name of your school.

1) What is the latitude and longitude of your school? (Record below)

Latitude_____

Longitude_____

E. Use the Navigation Control to "zoom out" until you can see the ocean.

F. Use the Ruler  tool to measure the distance from your school to the ocean.

2) What is the distance from your school to the ocean?

_____

G. Use the direction ring around the Navigation Controls to rotate your view of the world until the ocean coast nearest to your school is at the top of the screen.

H. Use the Navigation Control tilt down function to move your viewing angle to a horizontal view of the earth.

I. Using zoom functions and the navigation controls, follow the path that you think a raindrop would take through the watershed from your school to the ocean.

Let's Look at Nutrients

Nutrients in the form of nitrates move downhill like plastics from the land into the ocean and can promote "blooms" of tremendous amounts of phytoplankton in the water. Common sources of nitrate contamination include fertilizers, animal wastes, septic tanks, municipal sewage treatment systems, and decaying plant debris. When the sun is shining, phytoplankton produce oxygen through the process of photosynthesis. They also use the process of respiration which requires oxygen. At night phytoplankton cannot photosynthesize, but their respiration still requires oxygen. This may deplete the water of oxygen for other marine life if there is an extensive bloom.
Phytoplankton are an important food for zooplankton. However in excessive amounts, the phytoplankton can produce red tides, reduce needed oxygen for marine life, and produce toxins.

3) In the Global Earth satellite view, find and describe one potential source that could be contributing nitrogen compounds to the surface water from your school as it flows to the ocean.

See " Dead Zone' spreads across Gulf of Mexico" which is available at
http://oceancolor.gsfc.nasa.gov/cgi/image_archive.cgi?c=CHLOROPHYLL
Drag the scroll bar slightly more than 1/3 of the way down to find the image. Read the text below the image.

4) What causes the phytoplankton bloom and low levels of oxygen off the coast of Texas according to most studies?

Let's Look at Plastic Marine Debris

5) What types of plastic debris would you predict that you might find in storm water that flows to the ocean from your school or home?

Plastic marine debris has negatively affected the ocean. Plastic nets that are lost from fishing vessels are called Ghost Nets and they can entangle marine animals. Plastic ingested by marine life can cause death by blocking the digestive system. Toxins in the plastic or absorbed onto the plastic from the water can affect life. Many research expeditions were started in 1999 by the Algalita Marine Research Foundation. In 2007 the Oceanographic Research Vessel *Alguita* sailed from the Port of Long Beach on a research voyage to Hawaii studying plastic pollution in the Pacific Ocean and a daily blog was recorded. You can download the blog.

J. Open an internet browser and visit the link:
http://www.algalita.org/MappingPlasticPollution.htm
Go to the table near the bottom of the page and click to download:
FallVoyage2007.kml, Voyage2009.kml, North Pacific Currents.kmz, AMRF_GIS_DATA_Sites.kmz, and Gyre Animation.pps

K. Open all of the .kmz and the .kml files in Google Earth. In the Places section, check only the < **ORVAlguitaGyreVoyage2007.kml** > file box to make it active. Move to the Pacific Ocean near the coast of California and zoom in just enough to see some sailboats with the days numbered. Take a moment to follow the voyage by clicking on the sailboat icons. Each icon contains the blog for the day and images taken by the crew.

6) Plastic marine debris impacts life in the ocean. Review the observations made by the crew on the research vessel and describe how plastic debris might impact the survival of one species that was observed during the voyage.

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7) Non native species that invade an ecosystem may cause problems. The spread of the Zebra Mussel is one example. Zebra Mussels cause problems by clogging pipes that transport water. How might plastic debris contribute to the spread of non-native species across the world's oceans? (Look at the photograph on Day 8)

L. In the Places section, check the < NorthPacificMapForGyre.kmz > file box to make it active.

Notice that the major currents in the North Pacific Ocean rotate in a clockwise direction and form the North Pacific Gyre. The North Pacific Eastern "Garbage Patch" is found inside of this gyre northeast of the Hawaiian Islands. A large amount of plastic debris accumulates in this location from the shores of the countries bordering the North Pacific Ocean.

8) Plastic debris and chemical pollutants from your watershed might flow far enough from land to get into a major current of the North Pacific Gyre.
a. What is the name of the first encountered major current?

b. What direction does this major current move?

Changes in an ecosystem can result from changes in climate, changes in population size, human activity, and introduction of nonnative species.

9) Based on what you have experienced with this lesson, how has human activity changed the ocean ecosystem in the North Pacific Ocean?

The Algalita Marine Research Foundation (AMRF) has been measuring the marine plastic density in the North Pacific Gyre since 1999. Activate these four files in Google Earth:

North Pacific Current Map.kmz , AMRF GIS Data Sites.kmz, Voyage 2007.kml., and Voyage 2009.kml.

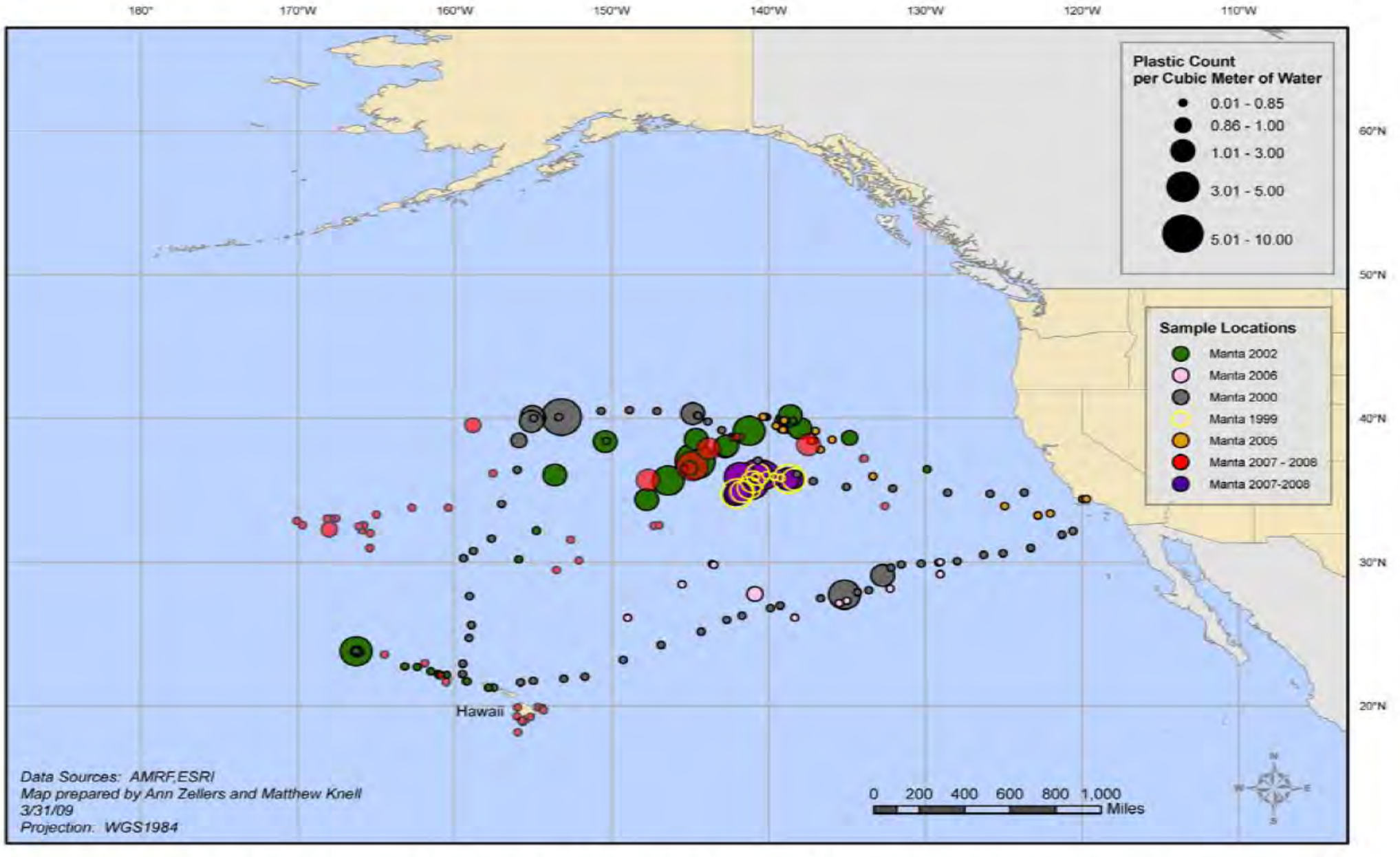
M. Highlight the Pacific Current Map and use the slider at the bottom of the Places section to highlight how the data collection sites of the Algalita Marine Research Foundation fall into the North Pacific Gyre.

10) If you were in charge of choosing two areas that have not been explored for marine plastic debris within the North Pacific Gyre that are east of the international time zone, what are the latitudes and longitudes of the approximate centers of these areas? Latitude and longitude appear at the bottom of the screen as you move the cursor.

Area #1 Latitude _____ Longitude _____

Area #2 Latitude _____ Longitude _____

11) Watch the animation of trash traveling to the "Garbage Patch" in the PowerPoint animation named GyreAnimation.pps. What ideas do you have to take action against the problem of marine plastic debris?



Count Densities of Plastic Debris from Ocean Surface Samples North Pacific Gyre 1999 - 2008