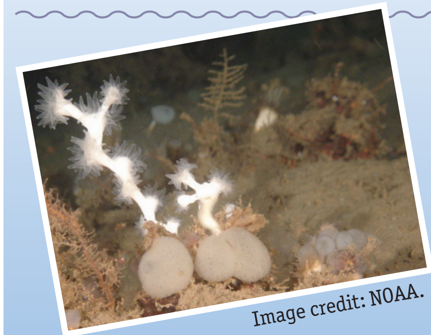
*Lophelia* II 2009:
Deepwater Coral Expedition: Reefs Rigs, and Wrecks

# Your Expedition of Discovery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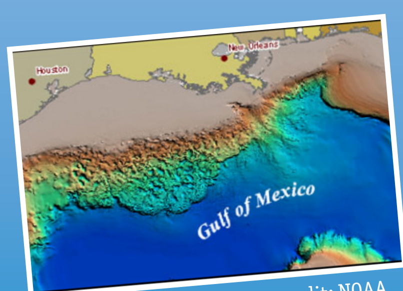

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lesson plan

## Focus
Global Positioning System

## Grade Level
7-8 (Earth Science)

## Focus Question
How can the Global Positioning System be used to describe the location of a specific point on Earth's surface and to navigate to a specific point whose latitude and longitude are known?

## Learning Objectives
- Students will be able to explain how global positioning satellites are used to determine the location of points on Earth's surface.
- Students will identify at least three practical uses for the Global Positioning System (GPS).
- Students will explain how the location of objects may be described by latitude and longitude.
- Given the latitude and longitude of specific locations, students will be able to use GPS technology to find these locations.

## Materials
- Copies of "Global Positioning System Inquiry Guide;" one copy for each student group
- GPS receivers; one for each student group is ideal, but it is possible to complete the activity with fewer units or even just one (see Learning Procedure, Step 1)

## Audio-Visual Materials
None

## Teaching Time
One or two 45-minute class periods, plus time for student inquiry

## Seating Arrangement
Groups of two to four students

## Maximum Number of Students

32

## Key Words

Global Positioning System
GPS
Trilateration
Benchmark
Geocaching

## Background Information

Deepwater coral ecosystems on hard substrates in the Gulf of Mexico are often found in locations where hydrocarbons are seeping through the seafloor. Hydrocarbon seeps may indicate the presence of undiscovered petroleum deposits, and make these locations potential sites for exploratory drilling and possible development of offshore oil wells. Responsibility for managing exploration and development of mineral resources on the Nation's outer continental shelf is a central mission of the U.S. Department of the Interior's Minerals Management Service (MMS). Besides managing the revenues from mineral resources, an integral part of this mission is to protect unique and sensitive environments where these resources are found.

For the past three years, NOAA's Office of Ocean Exploration and Research (OER) has collaborated with MMS on a series of expeditions to locate and explore deep-sea chemosynthetic communities in the Gulf of Mexico. These communities not only indicate the potential presence of hydrocarbons, but are also unique ecosystems whose importance is presently unknown. To protect these ecosystems from negative impacts associated with exploration and extraction of fossil fuels, MMS has developed rules that require the oil and gas industry to avoid any areas where geophysical survey data show that high-density chemosynthetic communities are likely to occur. Similar rules have been adopted to protect archeological sites and historic shipwrecks.

OER-sponsored expeditions in 2006, 2007, and 2008 were focused on discovering seafloor communities near seeping hydrocarbons on hard bottom in the deep Gulf of Mexico; detailed sampling and mapping at selected sites; studying relationships between coral communities on artificial and natural substrates; and gaining a better understanding of processes that control the occurrence and distribution of these communities. The *Lophelia* II 2009: Deepwater Coral Expedition: Reefs, Rigs, and Wrecks will take place aboard the NOAA Ship *Ronald H. Brown*, and is directed toward exploring deepwater natural and artificial hard bottom habitats in the northern Gulf of Mexico with emphasis on coral communities, as well as archeological studies of selected shipwrecks in the same region. Expedition scientists will:

**Images from Page 1 top to bottom:**
*Lophelia pertusa* colony with polyps extended.
http://oceanexplorer.noaa.gov/explorations/08lophelia/logs/sept24/media/green_canyon_lophelia.html

The ROV from SeaView Systems, Inc., is prepared for launch.
http://oceanexplorer.noaa.gov/explorations/08lophelia/logs/sept20/media/rov_prep.html

Multibeam bathymetry allows terrain models to be created for large areas of the seafloor.
http://oceanexplorer.noaa.gov/explorations/08lophelia/logs/sept21/media/gomex_multibeam.html

*Lophelia pertusa* create habitat for a number of other species at a site in Green Canyon.
http://oceanexplorer.noaa.gov/explorations/08lophelia/logs/sept24/media/green_canyon_lophelia.html

- Make collections of *Lophelia*, other corals, and associated organisms from deepwater reefs;
- Collect quantitative digital imagery of characterization of deepwater reef sites and communities;
- Conduct archeological/biological investigations on deep water shipwrecks.
- Deploy instruments to measure currents and sedimentation in several sites for a period of approximately one year.

A key requirement for these activities is for scientists to be able to return to specific locations in the Gulf of Mexico, and to be able to accurately describe the geographic positions of deepwater coral reefs and other features discovered by the expedition. A few years ago, this would have been a very difficult requirement to meet; but today, global positioning technology makes this a much easier task.

In this lesson, students will use the Global Positioning System (GPS) to locate specific geographic sites.

## Learning Procedure

1. To prepare for this lesson:
- Review introductory essays for the *Lophelia* II 2009: Deepwater Coral Expedition: Reefs, Rigs, and Wrecks at http://oceanexplorer.noaa.gov/explorations/09lophelia/welcome.html;
- Review procedures and questions on the"Global Positioning System Inquiry Guide," and make copies of the Inquiry Guide for student groups; and
- Determine how many GPS units will be available for student use (many students may have access to suitable units at home; if only a few units are available, these can be shared by having groups complete their assignments on different days).

In most cases, items needed to construct geocaches can be provided by the students. To avoid inappropriate items, each group will be required to have their geocache approved before it is hidden.

2. Briefly introduce the *Lophelia* II 2009: Deepwater Coral Expedition: Reefs, Rigs, and Wrecks and describe deepwater coral communities. You may want to show images from http://oceanexplorer.noaa.gov/gallery/livingocean/livingocean_coral.html. Tell students that while deepwater coral reefs were discovered in the Gulf of Mexico nearly 50 years ago, very little is known about the ecology of these communities or the basic biology of the corals that produce them. Emphasize that a primary purpose of this expedition is to provide information needed to protect these deepwater coral ecosystems from negative impacts associated with exploration and extraction of fossil fuels. Say that one of the most important types of information is the exact location of these ecosystems, so that these sites can be avoided when exploring for fossil fuel resources.

Most students will be familiar with the concept of GPS, but may not fully understand how the system works. The first part of the "Global Positioning System Inquiry Guide" is intended to provide a brief review of GPS, as well as using latitude and longitude to describe a specific location on Earth. You may want to have students complete Part A of the Inquiry Guide and participate in a class discussion of the questions (see Step 6) prior to completing the rest of the inquiry.

3. Give each student group a copy of the "Global Positioning System Inquiry Guide," and remind students that they are to submit their geocache plan for approval BEFORE beginning the field portion of their assignment. If there are not enough GPS receivers for each group to have their own, tell students how the available units will be scheduled among the groups. Be sure each group has at least one student who is familiar with the operation of the GPS receiver that group will be using.

   Now on with the Inquiry!

4. Review students' geocache plans. Be sure their proposed sites are not in dangerous areas and that students have appropriate permission to use the sites. An easy way to avoid these issues is to confine the sites to approved portions of the school grounds, but this makes the geocaching "expeditions" somewhat less adventurous.

5. Provide each student group with the latitude and longitude of a geocache created by one of the other groups. Remind students about schedules (if any) for using the GPS receivers, and when they are to have their "Geocaching Discovery Expeditions" completed.

6. Lead a discussion of students' answers to questions in Part A of the Inquiry Guide, and their "Geocaching Discovery Expeditions."
   1) The geographic position of a specific location on Earth is typically defined by two horizontal coordinates (latitude and longitude) and elevation (see http://oceanservice.noaa.gov/education/kits/geodesy/lessons/geodesy_meet.pdf (263 kb, 20 pages) for additional discussion about geographic position and coordinate systems).

   2) A location with a latitude of 0° is somewhere on Earth's equator. A location with a longitude of 0° is somewhere on an imaginary line (meridian) that connects the north and south poles and passes through the location of the Greenwich Observatory in England.

   3) The basic concept underlying GPS is the idea that the geographic position of an unknown location can be determined by measuring the distance from that location to three reference points whose locations are known.

4) This method for finding position is known as trilateration.

5) Trilateration is based on finding position using distance between an unknown point and reference points, while triangulation is the method for finding position using angles between an unknown point and two or more reference points.

6) The reference points for GPS are 24 satellites, launched, operated, and maintained by the U.S. Air Force (actually, 24 satellites is the minimum number required so that at least four satellites are always visible from any point on Earth, but there are usually a few more backup satellites in orbit as well).

7) In addition to satellites, the other major components needed for GPS to work are a global network of ground monitoring stations and users who have GPS receivers that can capture signals from the satellites and process information from the signals to calculate position. The locations of ground monitoring stations are precisely determined, and these stations provide data to the satellites about their exact location.

8) In the U.S., GPS is further enhanced by a network of hundreds of stationary, permanently operating GPS receivers known as Continuously Operating GPS Reference Stations (CORS) that continuously receive GPS radio signals and transmit position data to the National Spatial Reference System (NSRS) operated by NOAA's National Geodetic Survey. Using CORS data allows GPS users to determine the accuracy of their coordinates to the centimeter level. (Visit http://www.ngs.noaa.gov/PUBS_LIB/develop_NSRS.html for more information about CORS and NSRS.)

9) A GPS receiver computes the distance to a satellite based on the amount of time required for a radio signal from the satellite to reach the receiver. The satellites and receivers both contain accurate clocks, and periodically they both generate a signal that begins at the same time. When the signal from the satellite is received, however, it appears to begin later than the signal generated by the receiver because of the time required for the signal to travel from the satellite to the receiver. This time delay is proportional to the distance between the satellite and the receiver.

The process is similar to someone clapping their hands in front of a large building: The person hears the echo from their clap after the sound of the clap itself because of the time required for the sound waves to travel to the building and back again. As the distance from the building increases, so does the time delay between the original sound of the clap and the echo. The receiver calculates the time difference between the two signals, and then converts this to a distance measurement. The signal from the satellite also contains information about its position, as well as the time of the signal's transmission as determined from the atomic clock carried aboard GPS satellites. For more information, visit http://www.trimble.com/gps/index.html.

10) Four satellites are typically used by GPS to determine a three-dimensional position of a location on Earth. One reason for this is that three satellites actually establish two possible positions for an object; but since one of these is usually impossible (e.g., a position that is inside the Earth or out in space), the true position can often be worked out from three satellites alone. A fourth satellite, though, eliminates the "untrue" position, and also provides a way to correct for errors in the receiver clock, and thus improves the accuracy of the computed position. If more than four satellite signals are available, the accuracy of the computed position can be improved further. Visit http://oceanservice.noaa.gov/education/kits/geodesy/geo09_gps.html for additional discussion of this concept.

Have students discuss their experiences searching for their assigned geocache, particularly any difficulties they encountered in navigating to a specific geographic location. Since student groups rwill emove the geocaches when (and if) they are found, these geocache locations should not be registered with the official Global GPS Cache Hunt Site.

## The Bridge Connection

http://www.vims.edu/bridge/ – In the "Site Navigation" menu on the left, click on "Ocean Science Topics," then "Human Activities," then "Technology," for links to other resources about Satellites & Remote Sensing. You can also enter "GPS" in the search box for links and activities about navigation and mapping.

## The "Me" Connection

Visit http://cfa-www.harvard.edu/space_geodesy/ATLAS/applications.html for a worksheet that asks students to design a system that incorporates GPS receivers, and encourages students to consider how GPS might be integrated into their daily lives (a component of Project ATLAS (Assisted Transnational Learning using Artificial Satellites), a multidisciplinary, international educational outreach project in which students in the age range of 12–14 years from around the world use satellite and Internet technologies to learn about the world in which they live.

## Connections to Other Subjects

Physical Science, Mathematics

## Assessment

Written reports and class discussions provide opportunities for assessment.

## Extensions

1. Have students visit http://oceanexplorer.noaa.gov/explorations/09lophelia/welcome.html to find out more about the *Lophelia* II 2009: Deepwater Coral Expedition: Reefs, Rigs, and Wrecks.

2. Have students find out about "Travel Bugs" (see http://www.geocaching.com/track).

## Multimedia Discovery Missions

http://oceanexplorer.noaa.gov/edu/learning/welcome.html
Click on the links to Lessons 3, 5, and 6 for interactive multimedia presentations and Learning Activities on Deep-Sea Corals, Chemosynthesis and Hydrothermal Vent Life, and Deep-Sea Benthos.

## Other Relevant Lesson Plans from NOAA's Ocean Exploration Program

**Forests of the Deep Ocean**
(PDF, 300 kb) (from the *Lophelia* II 2008 Expedition)
http://oceanexplorer.noaa.gov/explorations/08lophelia/background/edu/media/forests.pdf

Focus: Morphology and ecological function in habitat-forming deep-sea corals (Life Science)

In this activity, students will be able to describe at least three ways in which habitat-forming deep-sea corals benefit other species in deep-sea ecosystems, explain at least three ways in which the physical form of habitat-forming deep-sea corals contributes to their ecological function, and explain how habitat-forming deep-sea corals and their associated ecosystems may be important to humans. Students will also be able to describe and discuss conservation issues related to habitat-forming deep-sea corals.

**I, Robot, Can Do That!**
(9 pages, 357k) (from the 2005 Lost City Expedition)
http://oceanexplorer.noaa.gov/explorations/05lostcity/background/edu/media/lostcity05_i_robot.pdf

Focus: Underwater Robotic Vehicles for Scientific Exploration (Physical Science/Life Science)

In this activity, students will be able to describe and contrast at least three types of underwater robots used for scientific explorations, discuss the advantages and disadvantages of using underwater robots in scientific explorations, and identify robotic vehicles best suited to carry out certain tasks.

**Sonar Simulation**
(PDF, 308kb) (from the Bonaire 2008: Exploring Coral Reef Sustainability with New Technologies Expedition)
http://oceanexplorer.noaa.gov/explorations/08bonaire/background/edu/media/sonarsim.pdf

Focus: Side-scan sonar (Earth Science/Physical Science)

In this activity, students will describe side-scan sonar, compare and contrast side-scan sonar with other methods used to search for underwater objects, and make inferences about the topography of an unknown and invisible landscape based on systematic discontinuous measurements of surface relief.

**Mapping the Aegean Seafloor**
(8 pages, 288 kb) (from the 2006 Phaedra Expedition)
http://oceanexplorer.noaa.gov/explorations/06greece/background/edu/media/seafloor_mapping.pdf

Focus: Bathymetric mapping of deep-sea habitats

In this activity, students will be able to create a two-dimensional topographic map given bathymetric survey data, create a three-dimensional model of landforms from a two-dimensional topographic map, and interpret two- and three-dimensional topographic maps

**Monsters of the Deep**
(6 pages, 464k) (from the Expedition to the Deep Slope 2007)
http://oceanexplorer.noaa.gov/explorations/07mexico/background/edu/media/monsters.pdf

Focus: Predator-prey relationships between cold-seep communities and the surrounding deep-sea environment (Life Science)

In this activity, students will be able to describe major features of cold seep communities, and list at least five organisms typical of these communities; and will be able to infer probable trophic relationships among organisms typical of cold-seep communities and the surrounding deep-sea environment. Students will also be able to describe the process of chemosynthesis in general terms, contrast chemosynthesis and photosynthesis, and describe at least five deep-sea predator organisms.

**One Tough Worm**
(8 pages, 476k) (from the Expedition to the Deep Slope 2007)
http://oceanexplorer.noaa.gov/explorations/07mexico/background/edu/media/worm.pdf

Focus: Physiological adaptations to toxic and hypoxic environments (Life Science)

In this activity, students will be able to explain the process of chemosynthesis, explain the relevance of chemosynthesis to biological communities in the vicinity of cold seeps, and describe three physiological adaptations that enhance an organism's ability to extract oxygen from its environment. Students will also be able to describe the problems posed by hydrogen sulfide for aerobic organisms, and explain three strategies for dealing with these problems.

**Let's Go to the Video Tape!**
(11 pages; 327kb PDF) (from the Cayman Islands Twilight Zone 2007 Expedition)
http://oceanexplorer.noaa.gov/explorations/07twilightzone/background/edu/media/videotape.pdf

Focus: Characteristics of biological communities on deepwater coral habitats (Life Science)

Students will recognize and identify some of the fauna groups found in deep-sea coral communities, infer possible reasons for observed distribution of groups of animals in deep-sea coral communities, and discuss the meaning of "biological diversity." Students will compare and contrast the concepts of "variety" and "relative abundance" as they relate to biological diversity, and given abundance and distribution data of species, will be able to calculate an appropriate numeric indicator that describes the biological diversity of a community.

**Treasures in Jeopardy**
(8 pages; 278kb PDF) (from the Cayman Islands Twilight Zone 2007 Expedition)
http://oceanexplorer.noaa.gov/explorations/07twilightzone/background/edu/media/treasures.pdf

Focus: Conservation of deep-sea coral communities (Life Science)

Students will compare and contrast deep-sea coral communities with their shallow-water counterparts and explain at least three benefits associated with deep-sea coral communities. Students will also describe human activities that threaten deep-sea coral communities and describe actions that should be taken to protect resources of deep-sea coral communities.

**Come on Down!**
(6 pages, 464k) (from the 2002 Galapagos Rift Expedition)
http://oceanexplorer.noaa.gov/explorations/02galapagos/background/education/media/gal_gr7_8_l1.pdf

Focus: Ocean Exploration

In this activity, students will research the development and use of research vessels/vehicles used for deep ocean exploration; students will calculate the density of objects by determining the mass and volume; students will construct a device that exhibits neutral buoyancy.

**Life is Weird**
(8 pages, 268k) (from the 2006 Expedition to the Deep Slope)
http://oceanexplorer.noaa.gov/explorations/06mexico/background/edu/GOM%2006%20Weird.pdf

Focus: Biological organisms in cold seep communities (Life Science)

In this activity, students will be able to describe major features of cold seep communities, and list at least five organisms typical of these communities. Students will also be able to infer probable trophic relationships among organisms typical of cold-seep communities and the surrounding deep-sea environment, describe the process of chemosynthesis in general terms, and contrast chemosynthesis and photosynthesis.

## Other Resources

*The Web links below are provided for informational purposes only. Links outside of Ocean Explorer have been checked at the time of this page's publication, but the linking sites may become outdated or non-operational over time.*

http://oceanexplorer.noaa.gov – Web site for NOAA's Ocean Exploration Program

http://celebrating200years.noaa.gov/edufun/book/welcome.html#book – A free printable book for home and school use introduced in 2004 to celebrate the 200th anniversary of NOAA; nearly 200 pages of lessons focusing on the exploration, understanding, and protection of Earth as a whole system

http://oceanservice.noaa.gov/education/kits/geodesy – "Geodesy Discovery Kit" from NOAA's National Ocean Service

http://oceanservice.noaa.gov/topics/navops/positioning – NOAA's National Ocean Service webpage on the Global Positioning System http://www.pbs.org/wgbh/nova/longitude/gps.html – "GPS: The New Navigation," a shockwave game that explains how the Global Positioning System (GPS) works

http://www.pbs.org/wgbh/nova/shackletonexped/navigate/find.html – "Find Your Longitude Shockwave Learning Activity;" another shockwave game from PBS

http://www.nasm.si.edu/exhibitions/gps/ — A visual introduction to GPS from the Smithsonian Institution's National Air and Space Museum

http://sciencespot.net/Pages/classgpslsn.html – GIS & GPS Resources & Lesson Plan Links from The Science Spot

http://www.trimble.com/gps/index.html – GPS tutorial from Trimble Navigation, Ltd.

http://www.unavco.org/edu_outreach/resources.html – Web site for UNAVCO, a consortium of research institutions whose mission is to promote Earth science by advancing high-precision techniques for measuring and understanding crustal deformation, with links to educational activities using GPS and GPS tutorials

## National Science Education Standards

**Content Standard A: Science As Inquiry**
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

**Content Standard C: Life Science**
- Structure and function in living systems
- Populations and ecosystems
- Diversity and adaptations of organisms

**Content Standard E: Science and Technology**
- Abilities of technological design
- Understandings about science and technology

**Content Standard F: Science in Personal and Social Perspectives**
- Populations, resources, and environments
- Science and technology in society

## Ocean Literacy Essential Principles and Fundamental Concepts

**Essential Principle 5.**
**The ocean supports a great diversity of life and ecosystems.**
*Fundamental Concept c.* Some major groups are found exclusively in

the ocean. The diversity of major groups of organisms is much greater in the ocean than on land.

*Fundamental Concept d.* Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (such as symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.

*Fundamental Concept f.* Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is "patchy". Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.

*Fundamental Concept g.* There are deep ocean ecosystems that are independent of energy from sunlight and photosynthetic organisms. Hydrothermal vents, submarine hot springs, and methane cold seeps rely only on chemical energy and chemosynthetic organisms to support life.

**Essential Principle 6.**
**The ocean and humans are inextricably interconnected.**

*Fundamental Concept b.* From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.

*Fundamental Concept e.* Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (such as point source, non-point source, and noise pollution) and physical modifications (such as changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

*Fundamental Concept g.* Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

**Essential Principle 7.**
**The ocean is largely unexplored.**

*Fundamental Concept a.* The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.

*Fundamental Concept b.* Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.

*Fundamental Concept c.* Over the last 40 years, use of ocean resources has increased significantly, therefore the future sustainability of ocean resources depends on our understanding of those resources and their potential and limitations.

*Fundamental Concept d.* New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

*Fundamental Concept f.* Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking.

## Send Us Your Feedback

We value your feedback on this lesson.
Please send your comments to:
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## For More Information

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## Your Expedition

# Global Positioning System Inquiry Guide

All ocean exploration expeditions need reliable methods for locating specific points on Earth's surface. Historically, this was a tall order for a ship in the middle of a featureless ocean and hundreds of miles from visible landmarks. Today, the Global Positioning System makes it relatively easy to keep track of exactly where a ship is on Earth's surface, and to return to exactly the same location, time after time. In this inquiry, you will use GPS technology in a kind of "treasure hunt" called geocaching (pronounced "GEE - oh -cashing").

### Part A. Research

The following guidance questions will help ensure that you have a good understanding of how GPS works.

1. What three numbers are typically used to define the geographic position of a specific location on Earth?

______________________________

______________________________

______________________________

2. A location with a latitude of 0° is where? A location with a longitude of 0° is where?

______________________________

______________________________

3. The basic concept underlying GPS is the idea that the geographic position of an unknown location can be determined by measuring the ________________ from that location to three reference points whose location is known.

4. This method for finding position is known as ________________

5. How is this method different from "triangulation?"

______________________________

______________________________

6. What are the reference points for GPS?

______________________________

______________________________

7. What other major components are needed for GPS to work?

______________________________

______________________________

## Your Expedition

# Global Positioning System Inquiry Guide - continued

8. In the U.S., GPS is further enhanced by a network of hundreds of stationary, permanently operating GPS receivers known as ________________ that continuously receive GPS radio signals and transmit position data to the National Spatial Reference System (NSRS) operated by NOAA's National Geodetic Survey.

9. A GPS receiver computes the distance to a satellites based on

_______________________________________________

10. How many reference points are typically used by GPS to determine a three-dimensional position of a location on Earth?

_______________________________________________

_______________________________________________

## Part B. Create a Geocache

Geocaches are hidden containers, usually concealed outdoors, that are the objects of a sort of high-tech treasure hunting game played throughout the world by people equipped with GPS devices. The basic idea is to locate geocaches and then share your experiences online. There are more than 800,000 active geocaches around the world, and a dedicated Web site (http://www.geocaching.com) to assist geocaching enthusiasts. For this inquiry, you will create a geocache for another student group to find, and test your own GPS skills by searching for a geocache created by one of the other groups.

1. Planning—Three things are essential to create a geocache:
   - An appropriate container;
   - An appropriate location in which to hide the container;
   - Something to put into the container; and
   - A GPS receiver so you can accurately record the exact location in which your geocache is hidden.

   Typical geocache containers include water bottles, screw-top plastic storage jars, watertight boxes used on boats to protect cameras and cell phones, and ammunition boxes. It's usually a good idea to put the contents of the cache inside a zip-top plastic bag, just in case the container leaks. It's a good idea to label the container with the word "Geocache" and the name of your school, just in case someone finds it who is not part of your class.

   The most important features of a suitable geocache site are that you have permission to use the site for your geocache, and that the site is not located in a dangerous area.

## Your Expedition

# Global Positioning System Inquiry Guide – continued

What you put inside your geocache is up to you (within obvious limits). Most caches include a logbook and pencil so that finders can record their presence. This doesn't make much sense for this inquiry, however, since found geocaches will be brought back to your class. Other typical items are a welcome note, small toys, such as action figures, games, playing cards, etc.

Be sure you understand how to use the GPS receiver before you head out to hide your geocache.

2. Approval—Write a brief description of your geocache, including type of container, what the cache will contain, and where it will be hidden. Be sure that you have permission to use the proposed site. Submit the plan to your teacher for approval.

3. Assembly—Put your geocache together according to your approved plan.

4. Into the Field!—Take your geocache to the location approved by your teacher, and hide it. Take careful notes about the specific location and use your GPS receiver to find the latitude and longitude of the site. Be sure you understand which units your GPS receiver uses to display latitude and longitude. Three unit systems are commonly used:
   - Decimal degrees (such as 117.32457 degrees);
   - Degrees and decimal minutes (such as 117 degrees, 19.4742 minutes); or
   - Degrees, minutes, and decimal seconds (such as 117 degrees, 19 minutes, 28.452 seconds)

   Note that degrees, minutes, and seconds may be represented by the symbols °, ', and " respectively.

   If your GPS receiver uses decimal degrees, record latitude and longitude to five decimal places (which represents a distance of about 4 ft at the equator).

   If your GPS receiver uses degrees and decimal minutes, record latitude and longitude to three decimal places (which represents a distance of about 6 ft at the equator).

   If your GPS receiver uses degrees, minutes and decimal seconds, record latitude and longitude to two decimal places (which represents a distance of about 1 ft at the equator). Remember that even though your receiver may display a lot of decimal places, the true accuracy may be less than the number of decimal places might suggest.

   Write the latitude and longitude of your geocache on an index card, along with any clues you think will help to find the geocache. Remember that the idea

## Your Expedition

# Global Positioning System Inquiry Guide – continued

is to hide the geocache well enough so someone isn't likely to discover it by accident, but not so well that it can't be found at all!

### Part C. Join a Geocaching Discovery Expedition

Your teacher will give you an index card from another student group that contains the latitude and longitude of a geocache they created, and may also contain some other clues to help you find it. Obtain any last minute instructions from your teacher, double-check that you know how to use your GPS receiver, then launch your expedition to find the geocache!

Tip: It is usually very useful to make a simple sketch map to help keep you oriented as you search. When you start out, take a minute to find your latitude and longitude using your GPS receiver, then make a mark near the center of a piece of paper and write your latitude and longitude near the mark. This is your starting point. Now draw a vertical arrow to show the direction of north. Rotate the paper so that the arrow points toward north. Now compare your starting location with the latitude and longitude of the geocache you are trying to discover. Assuming you are in North America, if the latitude of the geocache is greater than the latitude of your starting location, you need to go farther north. If the latitude of the geocache is less than the latitude of your starting location, you need to go farther south. Similarly, If the longitude of the geocache is greater than the longitude of your starting location, you need to go farther west, and if the longitude of the geocache is less than the longitude of your starting location, you need to go farther east. You can repeat this process whenever you are uncertain about which way to go.

Keep track of how long it takes you to discover your assigned geocache. When you have found it, bring it back to class for further discussion.