Lesson IV: Studying the Ocean Biosphere

In the last three lessons, we have learned about the many ways in which the ocean is important to all the life on Earth. We have also learned about the many threats to the continued health of the oceans. One of the roles that scientists must play in society is to provide information to managers so they can make policy decisions to protect a particular resource or environment. The Year of the Ocean program is aimed at insuring that the oceans will continue to thrive. How do we take care of our ocean?

In this unit, we will be introducing the Scientific Method as useful problem solving technique which scientists use to conduct their research. We will also provide examples of the methods and instruments used to collect oceanographic data.

To prepare your class for this lesson, have them think about the ocean first as policy makers. What do they need to do to be good caretakers of the ocean? Next, have them pretend they are scientists who must provide the answers to managers' questions. What data do they need to measure to answer the policy makers questions? How are they going to make these measurements? Some helpful questions might be: What factors influence plant life in the ocean? What about animal life? How can these parameters be measured? What special problems might be encountered in sampling because of the size and depth of the oceans?

What's happening at Year of the Ocean?

The year of the ocean scientists are very busy tracking the drifters that are currently in the water, and continuing to update the web site so that everyone can follow their progression. Keep tuned to the YOTO web site (http://drifters.doe.gov) to follow the tracks and locations of the drifters.

Throughout the course of Year of the Ocean, you will have more and more interaction with the scientists. You will be able to view ocean images, obtain other educational materials, e-mail a scientist with your questions, collect the most up to date data about your drifter, build your own drifter and log on to related sites. Enjoy the materials that are available to you, and good luck following your drifter!

The Scientific Method

Do scientists always find answers to their questions easily? No. Do they always know what the outcome of their experiments will be? No. Each problem or question that a scientist sets out to understand or answer is different. To reach a conclusion about the question or experiment, the scientist must work in an organized manner. In science, this organization takes the form of a series of procedures, sometimes call the **Scientific Methods.** The Scientific Method is simply a problem solving technique which can be adapted to many types of experimental research problems. The following description of the Scientific Method is intended to be complete, even though scientists may not actually perform every step each time they begin a new experiment.

The Scientific Method

Diagram 4.1 shows the order in which the Scientific Method might be used.

1) The process of scientific investigation begins with observations of an unexplained natural phenomenon. For example, swimming at the seashore and observing that the ocean is salty. This leads to the first step in the Scientific Method, which is to *state the problem*.
2) The second step is to *gather information*. Everything that is already known about the problem, all existing data, is gathered. A scientist often gathers the first pieces of information by using her five senses – watching, listening, etc. In our example, you would use your sense of taste to discover that the ocean is salty. Of course, there are many more sophisticated ways to collect data about the precise saltiness of seawater.
3) Step number three is to *form a **hypothesis***. A scientist must now make a prediction, or guess, about what is happening. The hypothesis must always be stated in such a way that it can be tested, that is, proven to be correct or incorrect. As stated in #2, we were discussing the saltiness of the ocean. Our hypothesis might be that the ocean has the same salinity all over the world.

4) Now that we have our hypothesis, *an experiment must be designed and performed using **controlled conditions** to test the hypothesis.* When scientists perform experiments, they are careful to manipulate or change only one condition (the independent variable) at a time. All other conditions (the dependent variables) in the experiment are kept constant**.** Scientists must also run experiments with **controls** to be certain that the observed changes were a result of the independent variable being manipulated. The experiment must be repeated many times to collect an adequate amount of data and to be certain that the same results are obtained. To follow our hypothesis, we would need to measure salinity all over the world, and at many different times.

5) After the controlled experiment is performed, the next step is to *analyze and interpret the collected data.* This is the step where data may be graphed, or computers may be used to look for patterns in the data. In our salinity experiment, we would want to look for statistical differences in our data, to determine if all values were the same.

6) Scientists use their analysis of the data to *draw **conclusions.*** A conclusion is a logical statement based on the observations and data collected during the experiment. A conclusion that might be drawn about the salinity of the ocean might be that differences in salinity do show regional patterns.

7) The scientist now draws on all the collected data and conclusions to answer the initial "How does the conclusion compare with the hypothesis?" Based on the answer to this question, and the *hypothesis is either accepted or rejected*. If salinity varies with region, then our hypothesis is rejected: The ocean does not have the same salinity all over the world.

8) The final step that a scientist completes is *to do something with the results*. This may include publication of the results and conclusions, incorporation into further research, or reporting to the government agency responsible for making and enforcing environmental regulations.

Remember, the scientific method is not a sure way to obtain the answers that scientists are searching for, but it is the process they may follow to set-up their research.

SOLVING A SCIENTIFIC PROBLEM

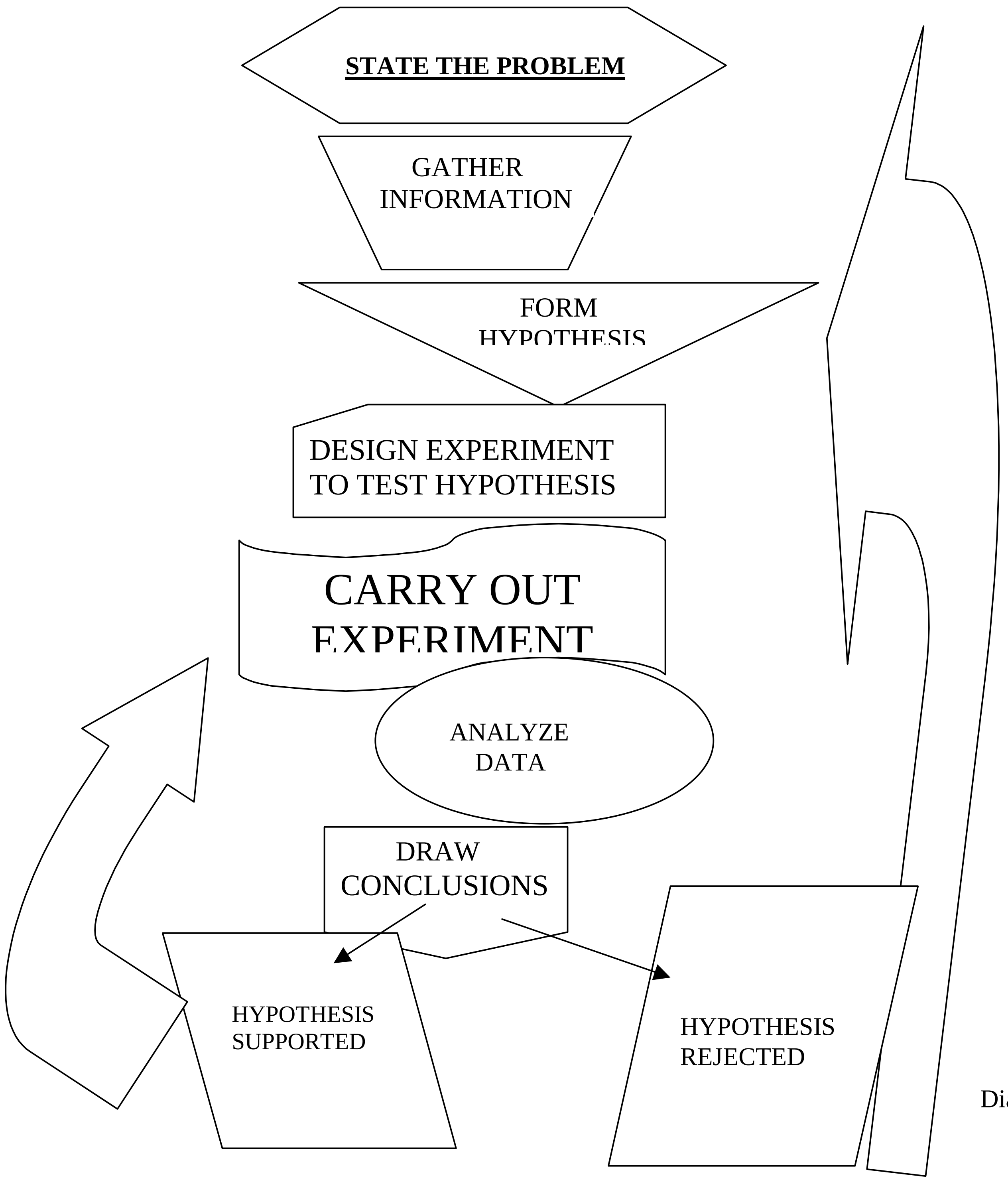
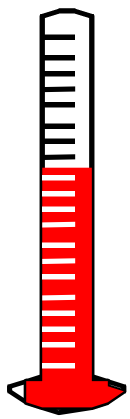


Diagram 4-1
Scientific Method

Instruments and Methods used in Oceanographic Research

The ocean biosphere consists of biotic and abiotic components. In many cases, it is the abiotic, or chemical and physical components, which control what organisms and how many will live in a particular part of the ocean. Some of the important abiotic factors include light, temperature, depth or pressure, salinity, and nutrients. These are called **hydrographic parameters**.



Studying the ocean is more complicated than doing experiments in the laboratory, because the ocean is deep and many regions are far from shore. Scientists have had to develop specialized equipment to collect hydrographic data from ships, aircraft, submarines, and even using satellites.

A CTD is a device used to measure the **Conductivity**, **Temperature** and **Depth** of the water. Conductivity is measured by a thermometer in circuit for the calculation of salinity. Another thermometer is attached to measure the amount of heat in the ocean. Salinity is calculated using the measured temperature of the water, while the conductivity is also measured and correcting for its effect automatically in the electrical circuit. Salinity of the water may also be measured using an inductive salinometer. Depth is measured using an array of pressure sensors and transducers that send information to the deck of the ship. Since the depths that are studied may be great, special thermometers need to be used.

Water/Organism Sampling

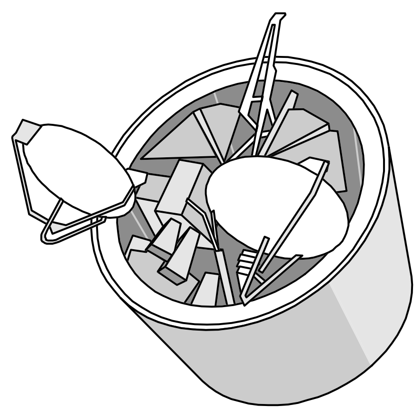
There are many organisms that live in the ocean, and even the smallest of organisms need to be studied. Since the size of plankton varies from about 2µ to 1 m in diameter, the problem of collecting representative samples has plagued scientists for years. One of the early methods for collecting organisms, which is still used, is the **plankton net**. There are many different sizes and types of nets. There are hand-towed nets and other which are so large they must be towed behind a ship. Some of the problems with using nets include clogging, measuring the amount of water flow, and retrieval of the captured organisms. Can you think of others?

Another way to collect organisms is to take a sample of water. **Niskin bottle**s are generally plastic tubes with spring-loaded end-caps. The bottle is attached to a cable and lowered to a predetermined depth in the ocean with the ends open. The bottles are then triggered to close and brought to the surface filled with water from below the surface, sometimes from as deep as 3000m!

Once the organisms are collected there are many means that the organisms are studied. They might be observed through a microscope, or from photographs. They are counted, classified and identified. Measurements such as size, growth rate, or to dependence might be made. Often, organisms are not even collected, but their populations are studied via satellites. Especially, concentration, geographic distribution, seasonal patterns. The physical and biological concepts in the ocean are often so inter-related that the 'big' picture can be traced. For example, the relationships of phytoplankton help scientists to study ocean currents.

Using Satellites to Follow the Ocean "The Big Picture"

As scientists learn more about how the ocean works, they have come to understand the importance of having the "big picture", that is, to have measurements of the same parameter all over the ocean at the same point in time. It is also important to have this type of information every day of the year. This is the type of data collection which is now possible using satellite sensors. A satellite can take measurements over large spaces and time scales and direct the data back to earth. Satellite data of many kinds are now being used to study problems like global productivity, climate change, and marine mammal tracking. We will begin our investigation of **Satellite Oceanography** in our next series of broadcasts.



For more trivia like the following, look at the following web sites:
http://marine.er.usgs.gov and http://www.cmc-ocean.org

Fun Facts 4

- With the temperature, salinity, density and conductivity profiles, a scientist is able to determine which ocean he or she is in without any other data.
- The temperature of almost the entire deep ocean is only a few degrees above freezing, 39° Fahrenheit.
- Only about 5 percent of the ocean bottom has been plotted in detail!
- Far below the surface of the ocean, water greater than 350°C degrees has been found to spew out of cracks in the ocean, called **hydrothermal vents.**
- Using remotely operated vehicles, scientists have found one **black smoker** that is as tall as a fifteen-story building!
- The three-person submersible, Shinkai, has been to a depth of 21,325 feet!

If you find any interesting facts, or have any questions that you would like to share with the staff at Project Oceanography, please feel free to send them to us at askocean@marine.usf.edu or call us toll-free at 1-888-51-ocean. Visit our web page for more exciting information http://www/marine.usf.edu/pjocean/

Activity IV-1. The Scientific Method

Divide the students into teams of two or three. Propose an overall question to them about studying the ocean. (For example, A group of 6 scientists would like to know why whales migrate and where they go. The animals travel together in pods, so how do they communicate with one another?) Using the information that they have just learned about the Scientific Method, have the students design an experiment to find make a conclusion about the proposed question.

Activity IV-2. The Scientific Method at Work

In Activity 1, the students completed their approach to designing an experiment that would support the hypothesis proposed to them. Have the students identify the obstacles of studying this question. Furthermore, have them research and identify what instruments would be necessary (and could be used) to do so.

Activity IV-3 Visit the YOTO web site

If the students have not already visited the YOTO web site, have them do so. If you do not have access to the internet, the following page contains data that the students may use for 'tracking' a drifter. Using the scientific method, and the data available, have the students track a drifter for several days using the locations given in latitude and longitude. Maps may be copied from the packet, downloaded from the web page, or a poster-size may be obtained through an e-mail or phone request to the YOTO office. At the time of this writing, the e-mail address and phone number was not available, but you may visit the site at: http://drifters.doe.gov. These maps are designed with longitude and latitude to follow a drifter through its voyage. What other information are the drifters collecting in addition to ocean currents? What other applications can we use drifters for? What questions do you think the scientists used to determine where the drifters were deployed? What questions do you think the scientists are going to answer using the data collected?

Note: you may want to follow your drifter for several weeks, as you can use the information to determine the velocity and current speeds of a drifter in the show to be aired on October 30, 1998; Satellite Oceanography III: Measuring Currents from Space.

Activity IV-4. Instruments and Organism Study

Using the information learned in Year of the Ocean II: From Microbes to Mammals, and the information discussed in this packet about the different instruments used to study the ocean, discuss each effect on organisms, and how we measure each. Listed are several instruments that can be used for the study of organisms and the ocean. The instruments range from being very simple and only having the ability to measure one parameter, while the other has the ability to measure many, can be left in the ocean for a very long time, and might not need scientists to be on-site to take the measurements. Have the students research the instruments used, and possible other ways to take the same measurement.

EFFECT	METHODS USED
Depth/pressure	From Soundings to pingers
Temperature	From thermometers to thermistors
Salinity	From weighing sea salt to conductivity

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STUDENT INFORMATION LESSON IV
History of ocean study and early instrumentation

Oceanographic studies really got a jump start in the 1870's, when the HMS *Challenger* left England and sailed the world's oceans. Captain Maury, a United States Naval Officer, threw out weighted lines with knots tied in them to take bottom soundings to measure the depths of the Atlantic, Pacific, Indian, and Arctic Oceans. Today's oceanographers and scientists have overcome many of the challenges offered by the ocean that Capt. Maury faced on the *Challenger*. Today's instruments are much more sophisticated, and can gather much more data.

Do scientists always find answers to their questions easily? No. Do they always know what the outcome of their experiments will be? No. Each problem or question that a scientist sets out to understand or find the answer to is different. To reach a conclusion about the question or experiment, the scientist must work in an organized manner. In science, this organization takes the form of a series of procedures or **Scientific Methods.** The series of methods include: state the problem, gather information, form a **hypothesis**, design an experiment following a series of steps using **controlled conditions** to test the hypothesis manipulate or change only one condition (the independent variable) and keep all other conditions in the experiment the same**,** run experiments with **controls,** collect an adequate amount of data, analyze and interpret the collected data, and draw **conclusions.** The scientist now draws on all the collected data and conclusions to answer the question. The biggest question that a scientist asks is, "Does the conclusion compare with the hypothesis?, and was it supported by the experiment?". The conclusion is compared to the initial hypothesis, and then the *hypothesis is either accepted or rejected*. The final step that a scientist completes is *to do something with the data.* This may include publication of the results and conclusion, or incorporation into further research.

The scientific method is not a sure way to obtain the answers that scientists are searching for, but it is the process that they follow to set-up their research.

Fun Facts IV

- Did you know that with the temperature, salinity, density and conductivity profiles, a scientist would be able to determine which ocean they were in without any other data?!

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