DEEP SEA DIVE SIMULATION
ALVIN DIVE LOG, PART 2:

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Key Concept

Research conducted from a deep sea submersible is challenging: space is cramped, the sub gets quite cold, navigation can get tricky, visibility often is low, and all sampling and measuring must be done with remotely operated equipment.

Background

Deep Sea Dive Simulation continues where the lesson *Navigating Deep Sea Vents* leaves off. Students role model continuing a deep sea dive, plotting their course and gathering samples. The simulation is very simple and low tech. It is meant to give students a sense of how very small the sub is, how cramped the scientists are as they work and how busy they are.

Materials

Per dive team of 3 students:

- Masking tape outline of ALVIN on floor (6 foot diameter circle- see illus.)
- Chair (or other porthole structure- see below)
- Shoe box or other container to serve as a collection basket
- Thermometer, attached to sub with string
- Insulated coffee mug, filled with boiling water
- Turkey baster or other water sampler (see ideas listed below)
- Small rocks (3-5 cm in diameter), at least one of which is basalt
- "tube worms" made of straws or rolled paper
- Pillowcase
- Flashlight
- Main Endeavour Vent Field Map from Part 1
- Student pages
- Photographs, video footage or drawings of ALVIN submersible (see below)

The day before the simulation

The day before you conduct this simulation, warn the students that they will be asked to go on an imaginary sub trip the next day. When they walk in the room the next day, the classroom will be dark and the furniture removed to the edges of the room. Each team of three students will be asked to sit inside their own "ALVIN" submersible, marked on the floor in masking tape with a porthole in front.

Show the students images of ALVIN, the submersible used for manned exoeditions to hydrothermal vents. The slide show that comes with the CD-ROM version of this curriculum contains images of ALVIN. You also can get images from National Geographic articles on deep sea exploration. If you can get a copy of the National Geographic video "Dive to the Edge of Creation" about Robert Ballard's expedition to study the vent ecosystem for the first time, you can show your students footage of a dive team functioning inside ALVIN. Many school audio-visual collections include this video.

Explain to the students that ALVIN has been operating since 1964 and is still the premier manned submersible for undersea research. The frame of the sub is made of titanium and the portholes are covered with plexiglass cones nearly a half meter thick. ALVIN is 25 feet long, but much of that length is taken up by ballast and equipment. The crew is contained in a sphere that, once all the computer screens and other equipment are added, has a space only about 2 meters in diameter for the pilot and scientists!

If you wish to add some realism (and levity), post a sign: !PB4UGO! ALVIN crews, in real life, must pay a lot of attention to dive preparation and no small part of this is monitoring what they drink beforehand. There are NO restroom facilities on board the submersible and yet the submersible is underwater for as many as eight hours! So ask your students to decipher the meaning of the sign and follow its directions before they enter class the next day.

<u>Room Preparation</u>

Push your classroom furniture to the walls or use some other room in your school with empty floor space. Outline on the floor in masking tape enough submersibles to accommodate all of your students, with three students per sub. (See illustration.) The masking tape outline of ALVIN should be a circle with a diameter of six feet.

Create a porthole on the outside of the rounded edge of the half-circle. If you have classroom chairs with some kind of opening in the back, you simply can turn a chair backwards in front of each circle. If you wish to be more creative, you could build a front to your subs by cutting portholes in pieces of cardboard. You may even wish to have students create some kind of structure for their sub model. Decide how much labor and time you want to put into the model.

Provide the following equipment for each submersible:

Provide a pair of **tongs** to serve as a manipulator arm. Lab tongs used for picking up hot beakers and flasks work well, as do kitchen tongs.

Provide a **shoe box** or other any other container to serve as a basket to hold the samples the dive crew collects.

Attach a **thermometer** to the sub with string.

Set an **insulated coffee mug** on each chair. You will add hot water to this the day of the simulation to simulate a vent opening. If the mug has a lid and your thermometer can fit through the opening in the lid, cover the mug so the water stays hot for a longer period of time.

Provide a **turkey baster**, large pipette with a bulb, or a squeezable water bottle so that students may collect a water sample during the simulation. Keep in mind when selecting a tool that the students will be operating the sampling device with tongs.

Place at least one rock, if not a collection of **rocks,** on each chair. The students will be asked to collect rock samples.

Finally, create a tube worm or collection of **tube worms** out of straws and rolled paper and tape them to the side of the chair. The students will be asked to collect some tube worms.

The day of the simulation

Have the lights off in the classroom.

Be ready to boil enough water to fill all the insulated coffee mugs.

As students enter the room, make sure they have heeded the directive "PB4UGO!"

Have each team (i.e., the pilot and two scientists) from the Deep Sea Vent Navigation activity assemble. Give each crew a pillowcase to carry the team's student pages, ruler, writing tools, paper, notebooks and any other tools. Explain that, in real life, each crewmember carries their belongings in a pillowcase to protect the grease seal around the hatch to ALVIN. If any sharp-edged object rubs along the hatch seal, it may not seal properly- a disaster.

Give each team a flashlight.

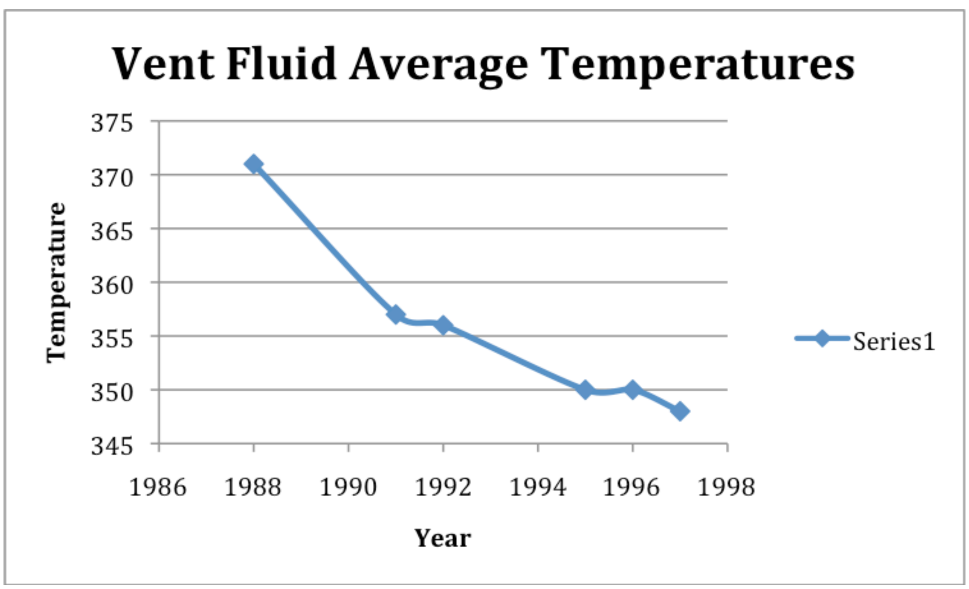
Once each team has its gear assembled in the pillowcase, the students may enter their submersible.

Review the functions of each tool in the submersible and what the coffee mug, rocks and paper tube worms represent. Warn students that they must keep ALL their body parts within the tape circle at all times. They cannot stick their hands or arms beyond the chair to accomplish any of their sampling and measuring tasks; all such work must be done using the tongs from behind the chair.

Add boiling water to each coffee mug and have the students follow the directions in their student pages.

Answer Key

1. ALVIN location should be plotted on the Endeavor Vent Field Map used in Part 1.
2. The heading straight south would be 180°.
3. The Y coordinate at the edge of the talus slope after heading straight south is 6120 m.
4. The rock sampling station has the coordinates:
   X=4900 m, Y=6120 m, Z=2200 m.
5. The heading to Grotto is about 75°.
6. The students may choose their sampling site, so coordinates will vary.
7. Temperature readings will decline over the sampling period
8. The students' vent fluid temperatures will be far below what one would expect at a real black smoker.
9. It was not possible to model realistic temperatures because we cannot replicate in the classroom the very high pressures that keep the sea water from boiling and allow it to become superheated.
10. The average temperature will be well below 100°C and will vary depending on how much the boiling water has cooled since you poured it in their cups.
11. Student graph should resemble that below with the addition of the average they calculated in step 10.



12. This black smoker seems to be cooling off considerably.
13. Explanations for the cooling trend will vary but could include reduced water flows due to mineral build up, crustal movement, or partial collapse of the vent structure.
14. The coordinates for the tube worm sampling will be the same as those in question #6.

DEEP SEA DIVE SIMULATION

ALVIN Dive Log, Part 2

After a near collision with a black smoker that would have spelled disaster, you and two team members are continuing your dive to the Main Endeavour Hydrothermal Vent Field, near the coast of Oregon, in the Pacific Ocean. This particular vent field was discovered in 1981 and you are part of a long chain of researchers that have worked to uncover the mysteries of the hydrothermal vent field.

The vents are over 2,000 meters below the ocean's surface and surrounded by total darkness.

In spite of the excitement of your near collision, you still have lots of work to accomplish before you can return to the surface.

You know you are on a talus slope. Talus refers to rock rubble made of basalt. You certainly are NOT on the sulfide structure you had hoped to study.

This slope is the western wall of a valley, known as an axial valley, running down the length of the Endeavour Ridge.

You still have a lot of work ahead of you. Time to get back to work.

ALVIN DIVE LOG

DIVE PREPARATION SHEET

Dive # 3194 (continued) Date:

Pilot Name:

Port Observer Name:

Starboard Observer Name:

Your dive plan originally included:

- collecting basaltic rock sample
- recording temperature of a hydrothermal plume from a black smoker on Grotto.
- sampling hydrothermal fluid from a black smoker on Grotto.

1. The bottom currents have decreased since the first part of your dive. ALVIN's position is now:

X= 4900 m Y= 6250 m

Plot this location on your Endeavour Vent Field Map (Map 4) used in part 1.

The scientists have to think about the best way to accomplish all the sampling before the sub runs out of battery power and the pilot runs out of patience.

2. The port scientist has a great idea. She knows that basalt is a rock that formed originally from molten material. She also knows that it is the most common rock on the sea floor and that the talus slope on which you now sit is basically basalt rubble. It would be easy to collect a basalt sample on this slope.

First, the port scientist directs the sub straight south. Give the heading to the pilot:

Heading =

3. You ask the pilot to stop at the edge of the talus slope. After flying straight south from your original position, what is the Y coordinate at the edge of the talus slope?

Y=

Now the sub is in place and the rock sampling can begin.

SAMPLING STATION #1

The pilot is always the busiest crew member on an ALVIN dive what with navigating, "flying" the sub, monitoring oxygen levels in the sub, and doing all the sampling. Have the pilot on your team use the manipulator arm to collect a basalt rock sample and put the sample in ALVIN's basket. The scientists want basalt rock so be sure to collect basalt only and not some other material.

4. The scientist at the starboard port needs to make a careful record of the collection:

Sample Number: 3194-

time of collection:

Coordinates: X:

Y:

Z (depth):

description: (size, color, type of rock):

Navigation

5. While the starboard observer is working on the rock sample, the port scientist has chosen the southern end of the sulfide structure called "Grotto" to find a good black smoker to sample. The coordinates of the smoker chosen are:

X= 4940 m

Y= 6125 m

Tell the pilot the heading and distance needed to travel to reach the black smoker:

Heading:

Distance:

The sub arrives at the base of Grotto and the pilot stabilizes the sub. Now, the task is to take the sub straight up to find the smokers at the top of Grotto.

Look at the map carefully and decide which smoker you will study. The smokers are only located on the orange-colored sulfide structures. Each smoker is marked by a cross on the map. Look carefully, there are not very many on Grotto and some of them are difficult for the sub to reach. So, be sure to choose a smoker which is accessible and which will not put the sub in danger.

6. Give the exact location of the smoker you will sample and study:

(Hint: Use the map key to help identify the smokers and their location.)

X=

Y=

Z= (depth) or Elevation=

SAMPLING STATION #2

Now that you have chosen a smoker, give a few moments to the pilot to position the sub and start taking temperature measurements for you. In the meanwhile, get ready to collect data.

The titanium thermocouple (thermometer) used on ALVIN is quite fragile. It is linked to the hull of the sub so you can read the temperature inside the sub on your computer screen. The pilot has to take the thermocouple out of the basket and bring the tip of it inside the orifice of the black smoker.

This is tricky because the pilot has to keep the sub very stable AND keep the tip of the thermocouple in the hot plume coming out of the smoker orifice for about 20 seconds once the temperature readings have stabilized.

7. Your thermometer is recording more slowly today. You'll have to record the temperature every 20 seconds. The pilot and starboard scientist can help you record the temperature readings every 20 seconds:

Temperature	Time of measurement
T1	tl
T2	t2
T3	t3
T4	t4
T5	t5
T6	t6
T7	t7
T8	t8
T9	t9
T10	T10

8. In what way are these temperature measurements an inadequate simulation of real vent fluid temperatures?

9. Why were we unable to model realistic temperatures?

Time-Series Analysis

Scientists have been collecting data at this area for quite some time. This is called a time-series experiment. You measured the same parameter (hydrothermal fluid temperature) as others measured in 1988, 1991, 1992, 1995,1996 and 1997. Now, you will be able to compare your readings to the data taken during the previous expeditions.

10. First, calculate the average temperature for your expedition and record the average:

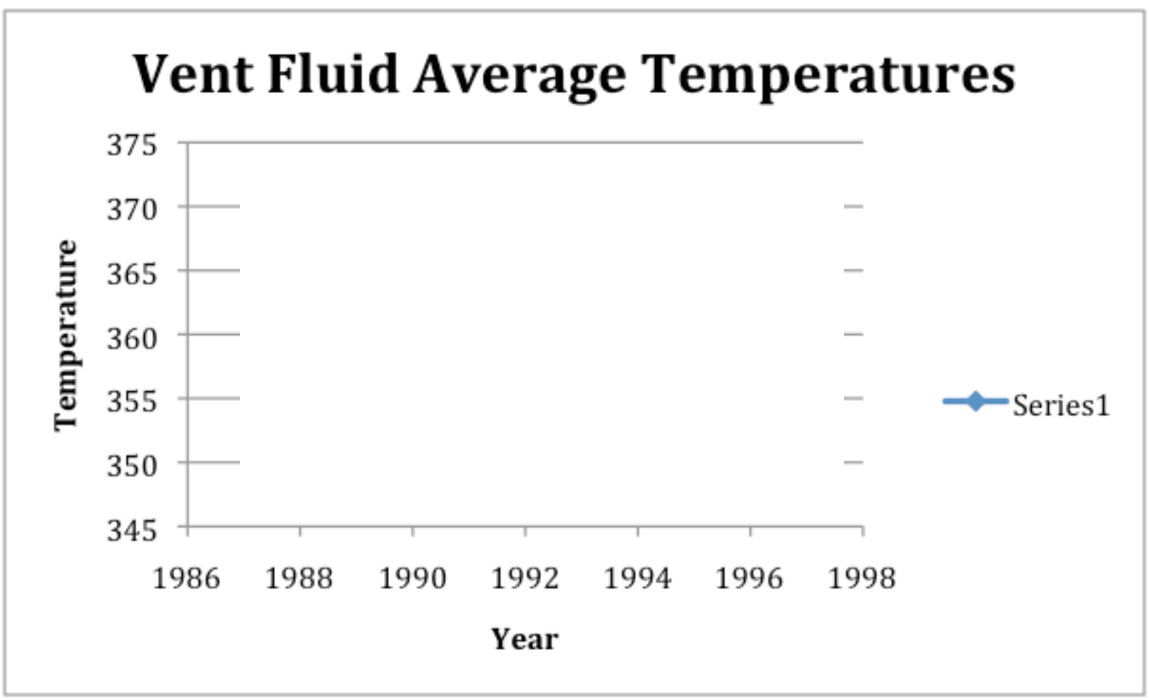
(Hint: Find the average temperature by adding all of the temperature readings and then dividing that total by the number of readings.)

Average Temperature:

Next, add your sampling year and average temperature to the list below:

Year	Temperature
T____	°C
T1997	348°C
T1996	350°C
T1995	350°C
T1992	356°C
T1991	357°C
T1988	371°C

11. Now, you can plot the temperatures and see what kinds of changes have occurred over the years. Plot your data on the graph below.



12. Look at the shape of the curve you've just plotted. What does this graph tell you about the smoker you, and others, have been studying?

13. What do you think is happening to Grotto? Write down the arguments you used to come to that conclusion.

SAMPLING STATION #3

Before the port and starboard scientists get too excited about these new results and start arguing about their possible hypotheses, they better finish sampling. The last sample that needs to be collected is a sample of the fluid itself.

For this collection, the pilot needs to grab the sampling bottle (made of titanium on ALVIN) in the basket, then take it to the orifice of the smoker. Once the sampling bottle spout is inserted in the vent opening, the pilot triggers the sampling device and the bottle fills up with fluid.

This may take a few minutes; the sub has to be very stable and the pilot wants to make sure the spout is correctly inserted in the smoker. Why is the pilot so particular? If the spout moves during the sampling, sea water at 2°C may get into the bottle and the chemical composition of the fluid can change. Then chemists would not be able to accurately compare this year'ssample, which would be a mix of seawater and vent fluid, with the vent fluid samples from previous years. As a result, the scientists would not be able to continue this time-series experiment. No one wants to be the reason a study begun in 1988 can't continue.

So, carefully use the manipulator arm to collect a fluid sample from the black smoker.

Sample number: chem-3194-

Time of fluid sampling:

Oh! This is great! Just a few meters from where you collected hydrothermal fluid and obtained temperature readings from the black smoker, you spot a beautiful clump of healthy tube worms. You realize that the biologists on board ship would love such a sample. Even better, the chemical analysis of the hydrothermal fluid you sampled and your temperature measurements will help them to better understand what kind of environment these worms require. So, go ahead and ask the pilot to sample some tubeworms.

14. Caution the pilot to be as careful as possible in order not to crush them, then collect 'em.

Sample number bio-3194-

Time of sampling:

Location of sample:

X:

Y:

Z: (depth)

Description: (size, color, type of animals, number of animals if possible):

To the Surface

That's the last sample. Time to wrap it up and begin the ascent. Your team settles in and begins to review all that happened. After an hour and a quarter ALVIN breaks the surface of the ocean. You hear the divers securing the lines which will let the R/V Atlantis raise ALVIN back on board. All is in place and up you go. Quite a dive. Now, it's time for a warm shower and something to eat. After that it will be "show and tell" for everyone on board the mother-ship.

Epilogue

Now, you have a sense of why it is so important to have good maps of the sea floor and of the hydrothermal vent fields. Scientists want to understand the evolution of these deep-ocean sulfide deposits. They also want to understand the biology of the vent organisms. To gain these understandings, they have to be able to return to the same area and sample the same smokers year after year. These comparisons show change over time.

When experiments are run very precisely and repeated in the same way, scientists can start developing general models for how hydrothermal fluids circulate inside the oceanic crust. Eventually, the kinds of data that you've just collected may let us accurately predict where sulfide deposits, and their incredible biological communities, are likely to form.