

LIFE IN THE DEEP SEA

WORKSHEETS AND HANDOUTS

Name _____ Period _____ Date _____

Now that Dr. Widder prepared you as a diver, it is time to investigate the unique properties of life in deep sea. You and your group will have 10 minutes to explore each station. We will rotate clockwise and the stations can be started in any order. Once you arrive, read the information on the station card and answer your questions below.

A necessary skill of an Ocean Scientist is to work collaboratively and build on each other's strengths. Therefore, we encourage you to work with each other to accomplish the goals of the station. Many of these stations are ones you've seen or used; however, note how when they are put into a real world context they stimulate investigative questions and interest into learning more about the deep sea. Bon Voyage!

Station A: The Wonders of Water

Background: *Water has unique properties that make life on Earth possible. We are going to focus on two of these:*

- 1. The Water Molecule: We all talk about water made of hydrogen and oxygen molecules to our students. Here is a way to show the bubbles of gas as the water molecules are being separated.*
- 2. Water Density: Water density increases with increasing salinity. As the density of a liquid increases, its molecules are closer together, which allow objects with less density to float. Liquid water, like most substances, becomes denser as it cools. So, cold saline water is denser than warm fresh water. As water continues to cool however, it expands and becomes ice. Ice is less dense than water, which is why it floats.*

A1 – The Water Molecule

Procedure

1. Hold the points of the pencils against the battery poles and immerse the other ends in the cup of salt water.
2. Observe bubbles rising from each of the pencil points and record the differences.

Analysis

1. What gases are produced by the electrodes?
2. Which electrode, positive or negative, has more bubbles touching it? Why?

A2 – Water Density and Salinity

Procedure

1. Fill the fresh and salt-water cups half-way with water. Try to add equal amounts of water to each glass.
2. Add an egg to each cup and observe.

3. We want to make the egg float. Predict the number of tablespoons your group will need to add before the egg will float.
4. Add salt to the salt-water cup and record the amount added below. It is ok if you add in slow increments to discover the approximate amount of salt needed.
5. Test your progress by placing 1 egg in each cup and observing.
6. Please pour out the salt water into the bucket, and clean up the station area following the activity.
7. Bonus: use the Refractometer to measure the salinity of the water.

Analysis

1. Predict the number of tablespoons it will take to make the egg float? _____ Tsp
2. Amount of salt added to make the egg float. _____ Tsp Salinity? _____
3. Why did the egg float in the salt water but not in the fresh water?
4. Write the relationship between salinity and density. As salinity increases...density...
5. If you were given two water samples, one from the deep ocean and one from the surface, how might you be able to tell them apart?

A-3 Water Density and Temperature

Procedure

1. Place the blue ice cube in the cup of water.
2. Observe where the dye goes. Use the thermometer to measure the temperature of the water in the streams of dye compared to the temperature of the surrounding water.

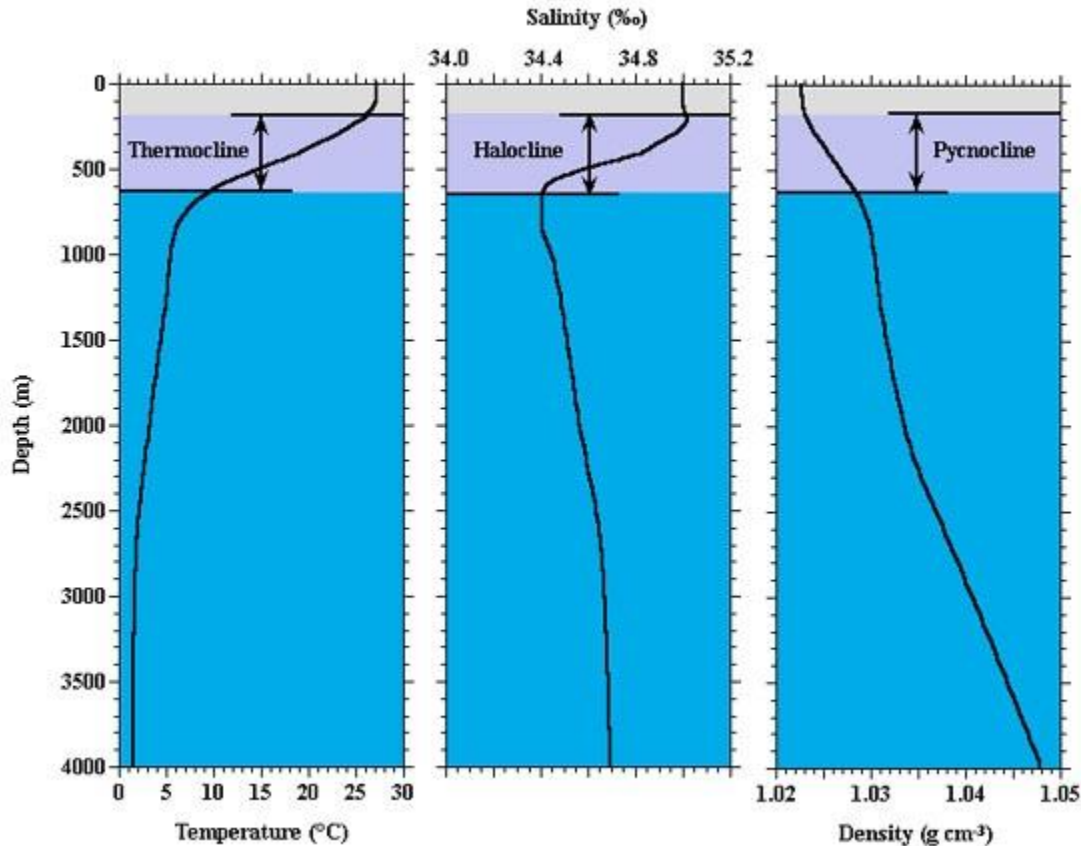
Analysis

1. What is the temperature of the water? _____ of the melted blue water? _____
2. Where did the blue dye go as the ice melted?
3. How does the action of the blue water explain how currents could be formed?

Conclusions

The zone in which temperature changes rapidly with depth is called a **thermocline**, the zone in which salinity changes rapidly with depth is called a **halocline** and the zone in which density changes rapidly with depth is called a **pycnocline**. These “clines” (from the Greek word meaning “to lean” like an incline) have a profound influence on where different animals live in the ocean.

1. Which of the previous experiments demonstrates how these clines can be formed? Explain.
2. Look at the graphs of a thermocline, halocline and pycnocline below. What is life like in the deep sea (below 1000 or 1500 m) in terms of temperature, salinity and density?



3. How do you think these different properties might influence where different animals live?

Station B: Animal Adaptations to Life in the Deep Sea – Using bioluminescence to survive

Background: Many animals spend most of their lives in near darkness and use bioluminescence to help them do all the things they need to do to survive: find food, attract mates and avoid being eaten. In fact most of the animals living in the open ocean – out away from shore – are bioluminescent.

Advantages of bioluminescence vary. Many fish, squid and shrimp use their bioluminescence for camouflage with a trick called **counterillumination**. Dim blue light filters down through the depths in the midwater or mesopelagic zone (200-1000 m). At these depths predators can locate prey by searching for the silhouettes of the animals swimming above them. To camouflage themselves, organisms have **photophores** (light organs) located on their bellies or ventral sides of their bodies. These photophores are used to produce light that matches the color and intensity of light coming from above.

This makes the animal almost invisible to the predators below them. Animals can even adjust the light from their belly lights to match the light fluctuations from above.

Procedure

There are 8 deep-sea specimens for you to observe at this station. Investigate and explore the adaptations these organisms have to survive life in the deep sea. Then choose four of the organisms to focus on and answer the following questions.

1. Where are the bioluminescent organs located on the organism and how does the production of light in these specific areas benefit the organism?
2. What other adaptations enable this organism to reside in the deeper depths of the ocean? Dentition, Color, Body shape, Eyes.
3. *If you have time, sketch the organism and color in the photophores with highlighter.*

Analysis

1. Organism 1 _____

- a. Bioluminescent light
- b. Other Adaptations

2. Organism 2 _____

- a. Bioluminescent light
- b. Other Adaptations

3. Organism 3 _____

- a. Bioluminescent light
- b. Other Adaptations

4. Organism 4 _____

- a. Bioluminescent light
- b. Other Adaptations

Conclusions

1. Name 3 ways animals use bioluminescence to survive.
2. Why do you think the majority of bioluminescence in the ocean is blue in color?

Station C: Changes with Depth – Pressure

Background: *The weight of the Earth's atmosphere at the surface of the ocean is equal to 1 atmosphere, 1 bar, or 14.7 pounds per square inch (psi). You are exposed to that amount of pressure every day. Water is much denser than air, and if you dive into the ocean you will experience an increase in pressure as you dive deeper. The deeper you go in the ocean, the greater the amount of water you have pressing in on you. The greatest impact is on animals with gas-filled spaces in their bodies – such as ear canals and fish swim bladders.*

C1 – Water Pressure Demonstration Tube

Procedure

1. Using the beaker or pitcher, fill the cylinder with water to approximately 1 cm from the top.
2. Using three hands, remove the blue corks from the demonstration cylinder at the same time.
3. Observe the spouts of water.
4. Repeat if necessary.

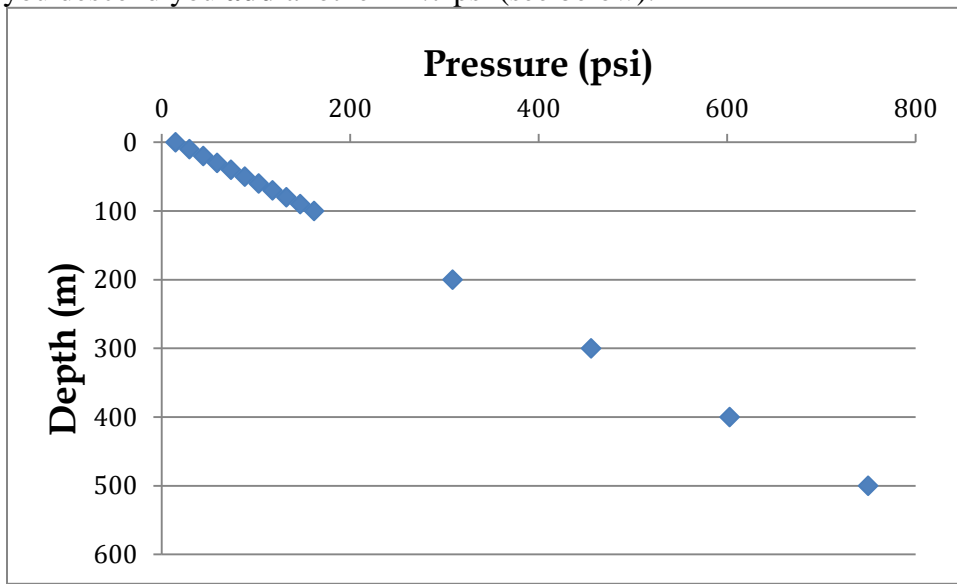
Analysis

1. What is the relationship between the distance of the holes from the top of the cylinder and the stream length:

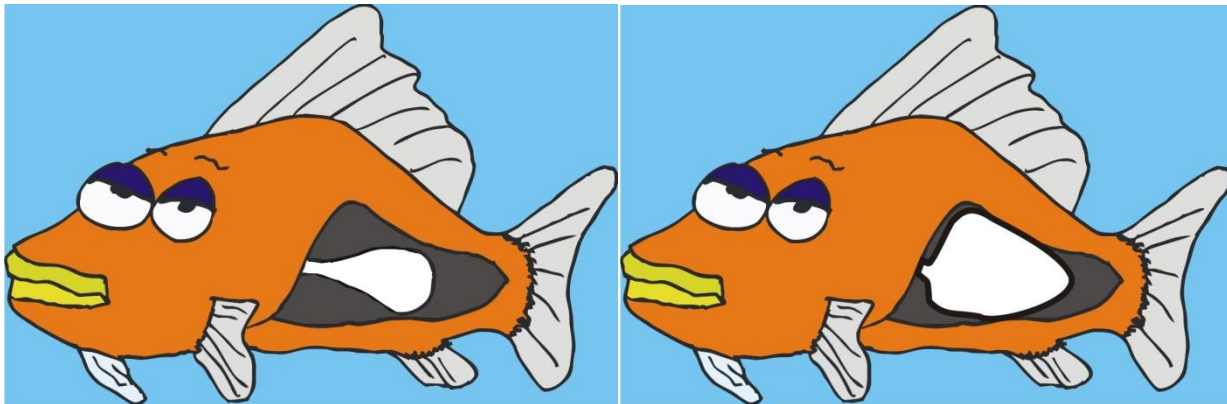
Conclusions –

Water is heavy, much heavier than air. The weight of the Earth's atmosphere at the surface of the ocean is equal to 1 atmosphere or 14.7 pounds per square inch (psi). If you dive into the ocean you feel the pressure build up very quickly because water is so heavy compared to air. At just 10 m the pressure doubles to 2 atmospheres or 29.4 psi. If you dive deeper the pressure **increases**. For every 10 m that

you descend you **add** another 14.7 psi (see below).



1. Use the graph above to determine how much pressure a fish would feel that is living at 500 m?



A

B

E. Widder

2. Note the differences in the size of the swim bladder in these two fish, A and B. They are the same species and size of fish, however fish B has a noticeable increase of gasses in the swim bladder. Which fish would be swimming higher in the water column?

Station D: Changes with Depth – What is Light?

Emitted light results from changes that occur in atoms when they absorb energy. Different types of light are distinguished by their different sources of energy. The two main forms of light are **incandescence** or hot light and **luminescence** or cold light.

In **incandescence** the energy to produce the light comes from heat so these sources generate both heat and light. Examples include the sun, a candle flame and an incandescent light bulb.

In **luminescence** the energy to produce the light is produced by some means other than heating. Four examples of luminescence are:

- **Fluorescence** – The energy comes from light. Wavelengths of light are absorbed and the substance immediately re-emits the light at a lower intensity. The re-emitted light stops when you remove the light source. “Black Light” posters are fluorescent.
- **Phosphorescence** – The energy comes from light. Wavelengths of light are absorbed and the substance slowly re-emits the light at a lower intensity. The re-emitted light does not stop when you remove the light source. It may continue re-emitting light for a long time. Glow-In-The-Dark paint and toys are phosphorescent.
- **Chemiluminescence** – The energy comes from a chemical reaction and is generated by the release of energy created from the chemicals combining.
- **Bioluminescence** – The energy comes from a chemical reaction and is a form of chemiluminescence created by living organisms. Fireflies and lantern fish bioluminesce.

Procedure/Analysis

D-1 Incandescence and Luminescence

Read the background information and then look at the real world examples of light. Dr. Widder may also provide insight as well.

Record the following observations:

	Incandescence	Fluorescence	Phosphorescence	Chemiluminescence	Bioluminescence
Hot or Cold?					
Energy Source					
Colors?					

D-2 Fluorescence and Phosphorescence

1. Use the UV flashlight to shine on the fluorescent material (Fluorescent highlighter and clay). Turn the light off.
Did the fluorescent material emit light after the flashlight was turned off?
2. Use the UV flashlight to shine on the phosphorescent material (Phosphorescent putty in petri dishes). Turn the light off.
Did the phosphorescent material emit light after the flashlight was turned off?
3. Now try the flashlight with the red light.
Record the difference in luminescence emitted using the red light and UV light.

4. After you removed the light source from the putty, which light produced the larger amount of luminescence in the putty? Explain.

D-3 Chemiluminescence – Light Sticks

Observe the two light sticks: one is in hot water and one in cold water.

1. After an hour at these different temperatures- If you allow each light stick to come back to room temperature, do you think they will emit the same amount of light or will one be brighter than another?
2. If the latter, which one will be brighter and why?

D-4 Bioluminescence

Gently stimulate the dinoflagellates, once.

1. What color is the light emitted and approximately how long did it last?
2. Predict why this light may be beneficial for the dinoflagellate?

Station E: Changes with Depth – Light in the Ocean

Background: Visible light can be **emitted**, **scattered** (*reflected*) and **absorbed** and these properties play key roles in how light is transferred through ocean depths. The amount of sunlight in oceanic waters decreases with depth, and the color changes as the wavelengths of light become scattered and absorbed. Most of the visible light is absorbed in the top 10 meters of the surface with very little visible light penetrating below 150 meters depth. Wavelengths of light change are absorbed and scattered with depth as well. The longer wavelengths like red light are absorbed first where as the shorter wavelengths penetrate deeper.

The absence or presence of light defines where organisms live in the water column. Visible wavelengths of light from the sun allow photosynthesis to occur in plants inhabiting the surface layers of the ocean. Below these surface layers (between 100-1000 m) is a dimly lit area that does not support photosynthesis but animals live there. Sunlight is absent below 1000m.

E-1 Light Bottles

1. Turn out lights and shine the flashlight into the top of each bottle. If the flashlight is water-proof, push the light against the surface of the water.
2. Record how the light looks as it shines through each bottle. Pay attention to the colors of light you see and the relative depths where they dissipate.

Bottle Number	Treatment	Observations with White Light	Observations with Blue Light stick	Observations with Red Light stick
1	Water only			
2	Water + Coffee creamer			
3	Water + Blue dye			
4	Water + Coffee creamer + Blue Dye			

1. Activate blue and red light sticks
2. Lower the blue light stick into each bottle, one after the other
3. Observe and record the light you see in each bottle above
4. Lower the red light stick into each bottle, one after the other
5. Observe and record the light you see in each bottle above.

Analysis

1. Did the light decrease in intensity or retain the same intensity as it passed through the water? Explain.

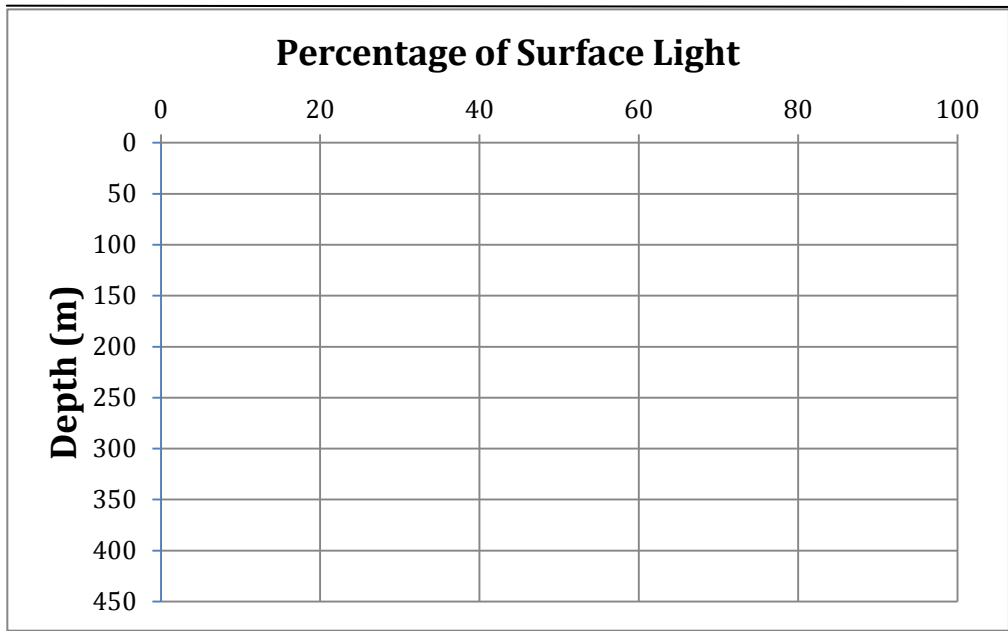
In clear ocean water, visible light **decreases** approximately 10-fold for every 75 m that you descend. This means that at 75 m the light is 10% as bright as it was at the surface; and at just twice that depth, 150 m, it is another 10-fold dimmer, or 1% of surface light. Below this depth there is insufficient light for photosynthesis, but there is still plenty of light for seeing. This is because eyes are useful over an astonishing range of intensities. It is believed that the very sensitive eyes of some deep-sea fish can still detect sunlight at 1000 m.

To calculate the 10% decrease in light with each 75 m of increasing depth you simply **multiply** the light by 0.1, which is the same as 10%

Depth (m)	Percentage of surface light
0	100
75	10
150	1

225	0.1
300	0.01
375	0.001
450	0.0001

2. Plot these data on the graph below:



E-2 – Challenges of the Deep

Procedure: View the video clip from: Challenges of the Deep – Survival at Extreme Depths.

Analysis

1. List the colors from the color chart attached to the ROV, in the order they disappeared during the decent.

Conclusions

1. What factors affected the light transmission in the bottles?
2. Why is the red wavelength of light absorbed quickly in the water, and blue light penetrates further?
3. From the video footage – At what depth was only blue light visible?

4. Figure 2 below is a graph that shows light penetration in the open ocean vs. coastal waters. What are 2 factors that would affect light penetration in both the coastal waters and open ocean?

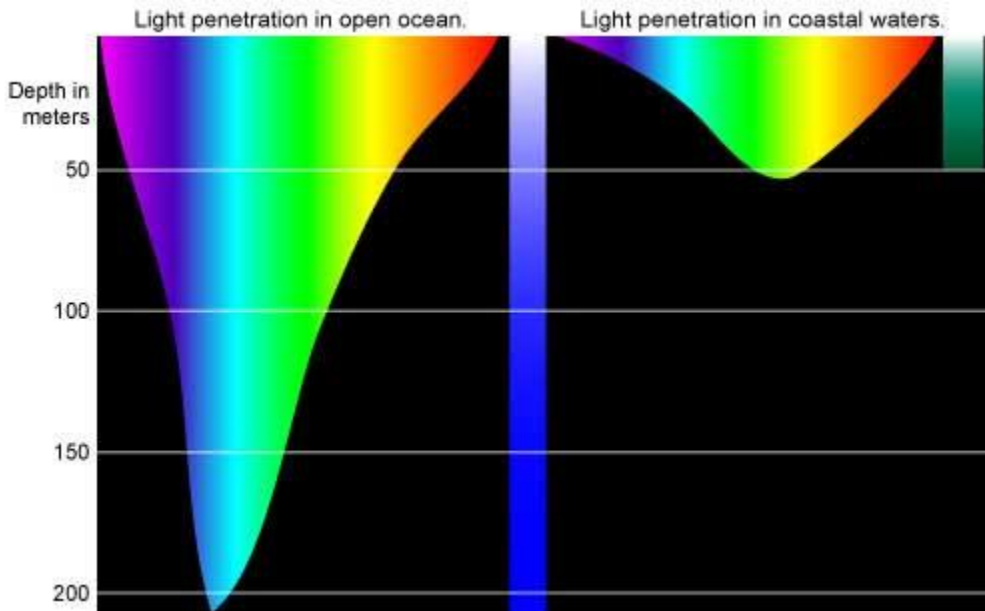


Figure 2. Light attenuation in open ocean vs. coastal waters. NOAA