

## Beaufort Gyre Exploration Project: Dispatch 24: The How and Why of the CTD

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The most common three-letter abbreviation in oceanography is CTD.

C = conductivity

T = temperature

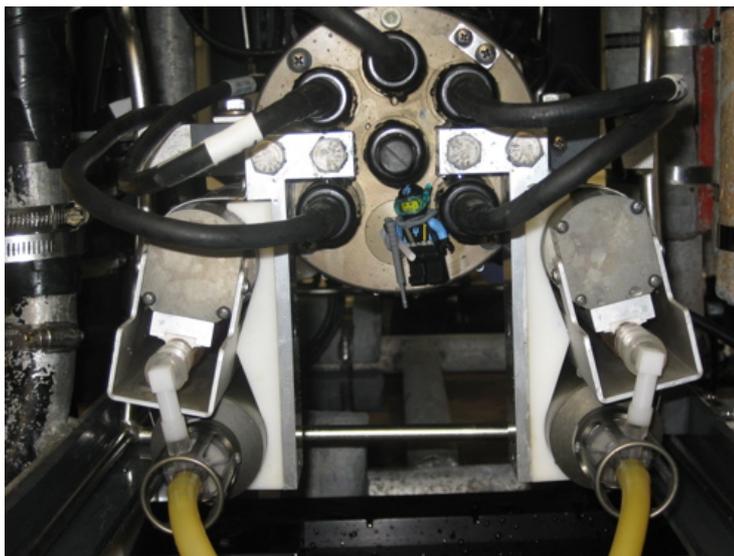
D = depth

Measuring these parameters of ocean water establishes the layers of the ocean water sandwich. In order to understand the questions being asked out here, you must first understand how the sandwich layers are determined.

Temperature is measured with a thermometer. In the Arctic, the temperature of ocean water does not change very much, ranging from -1C to 5C, depending on location and time of year.



Eli's right-most cilium is draped over the temperature sensor.

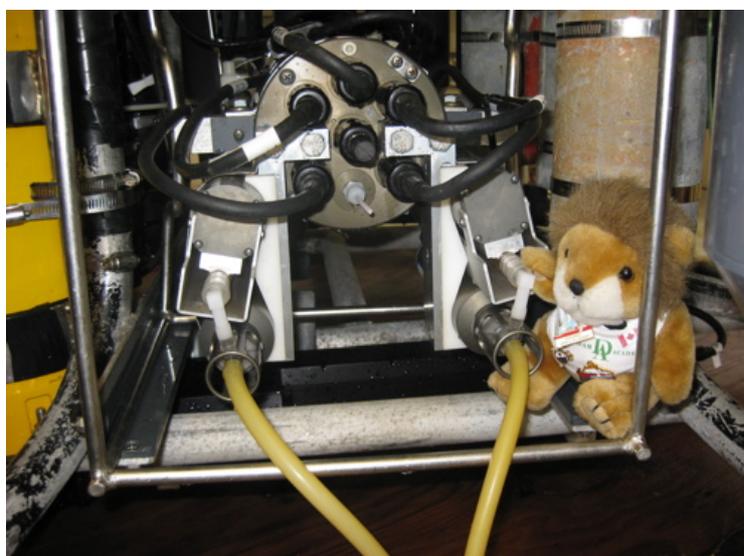


Diver Man is hanging on the pressure sensor of the CTD.

Depth is calculated by measuring hydrostatic pressure. See Dispatch # 20, August 5 2008 for an explanation of hydrostatic pressure (and its effect on Styrofoam cups). Hydrostatic pressure increases in a very predictable way as depth increases and the pressure sensor has been very finely calibrated to correspond to a specific depth.

Conductivity is used to determine the salinity by measuring how much electricity can be conducted in a particular sample of ocean water. Ocean water is, on average, 35 parts per thousand (ppt) salt, primarily NaCl (sodium chloride, table salt). Na<sup>+</sup>Cl<sup>-</sup> is an ion, meaning that it can accept electrons. Electricity is the flow of electrons so the more salt in the water, the greater electric current it can conduct. As with pressure and depth, conductivity and salinity are very finely calibrated. (FYI: the units of conductivity are mho= 1/ohm)

A typical CTD profile looks like this.



Cavaleo has his paw on the conductivity cell of the CTD.

A partial CTD profile. Depth in meters is on the vertical axis. Across the top is salinity and across the bottom is temperature. The Niskin bottle sample number is on the inside left.

Courtesy of Sarah Zimmermann

This partial scan shows how temperature and salinity change with water depth. As the depth increases (moving down on the vertical axis), temperature (in red) increases, until a maximum is reached at a depth of 400 meters. Then temperature slowly decreases as depth increases.

Salinity, shown in blue, increases rapidly with depth, until about 400 meters deep, where it increases only very slowly to about 35 PSU (practical salinity units; 35PSU = 35 ppt). Note that the differences being measured here are very small 0.1 degrees C and 0.01 ppt.

The "ocean water sandwich" layers can be defined by temperature and salinity. For example, the sample from Niskin bottle #14 from about 330 to 400 meters depth contains the warmest water. But wait --isn't warm water less dense than cold water. Why isn't this water up near the surface? Yes, warm water is less dense but this water also has relatively high salinity (note values of blue trace in this sample), which makes this water more dense than the colder water above.

This profile nicely illustrates that, in the Arctic, salinity is a primary determiner of water density, of the layers in our ocean water sandwich. Certain types of water have certain salinity and temperature signatures and as the layers are identified, so is their source. In this way, specific types of water can be followed as it moves around in the Beaufort Sea.

It seems a bit strange to calculate salinity by measuring conductivity! Here is a simple test you can do at home to test whether sea water conducts electricity. All equipment here can be found around the house or purchased at a local hardware store.

Experiment to try at home: Sea Water Switch

*Purpose of experiment:* The purpose of this experiment is to determine whether sea-water conducts electricity.

Schematic of a Sea Water Switch.

*Materials:*

- 1 battery (C cell works well)
- about 50 cm of coated copper wire
- 1 switch
- 1 light bulb
- 1 bowl
- 2 liters de-ionized water (available at the grocery store).

*Procedure:*

1. Make sea water. Pour 1 liter of the de-ionized water into a clean container and add 35 grams of table salt. Stir until dissolved. Label bottle "sea water."
2. Set up your circuit as shown in the schematic, but \*do not\* include the bowl of water.
3. Close your switch. The light bulb should light up. If it does not, recheck your connections and test your battery.

Question: what kind of control is this test?

4. Cut your wire in the circuit as shown in the schematic. Be sure to remove the plastic coating to expose some of the copper on each wire end. Place each wire into the bowl. The wires must not touch (why not?).
5. Pour de-ionized water in the bowl. Close the switch. Does the light bulb light up? Why or why not?
6. Replace the de-ionized water with your sea water. Close the switch. Does the light bulb light up? Why or why not?

*Questions:*

1. What is the Independent Variable (the component changed)?
2. What is the Dependent Variable (the measurement of the change)?
3. Write a Hypothesis for this experiment, using if...then construction.
4. Write a Results paragraph, describing in detail what happened.
5. Write a sentence summarizing your conclusions from this experiment.
6. Suggest some QFS, Questions for Further Study. Make predictions about what might happen in these studies. Explain your predictions.
7. Have fun and if you complete any part of this experiment, please send me your results!

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