Conductivity Calibration Lab

All conductivity sensors require calibration. This is because they use a sensor that measures impedance (a measure of the resistivity of a solution caused by the ions in solution) rather than conductivity directly. In our case we are interested in the conductivity of sea water which we will use to derive a salinity value. Calibration is necessary to develop a curve to translate a raw resistivity measurement into conductivity.

We start with known concentrations of salt in parts per thousand (ppt). The resistivity of the known solution is measured with our probe, and along with temperature and pressure measurements, we can derive the conductivity. We will use 5 different known concentrations to create a curve of conductivity vs. raw resistivity (actually a scaled resistivity to put the numbers in a nicer range). The curve will resemble a straight line, but with a little bit of a bow, so we will use Excel to fit a polynomial curve to it to be more exact in our conductivity vs. raw resistivity transfer function. Then we'll use that equation to give us conductivity out in the field.

Excel is used to help us keep track of our calibration.

To start, let's use a table to keep track of the salt concentrations:

First weigh out 110g of Kosher Salt (because it is pure and readily available). Next add water to achieve a given concentration.

For instance, to achieve 40 ppt (0.040 concentration) we need to satisfy the relation in weights (we'll use grams),

$$\frac{salt}{salt + water} = 0.040$$

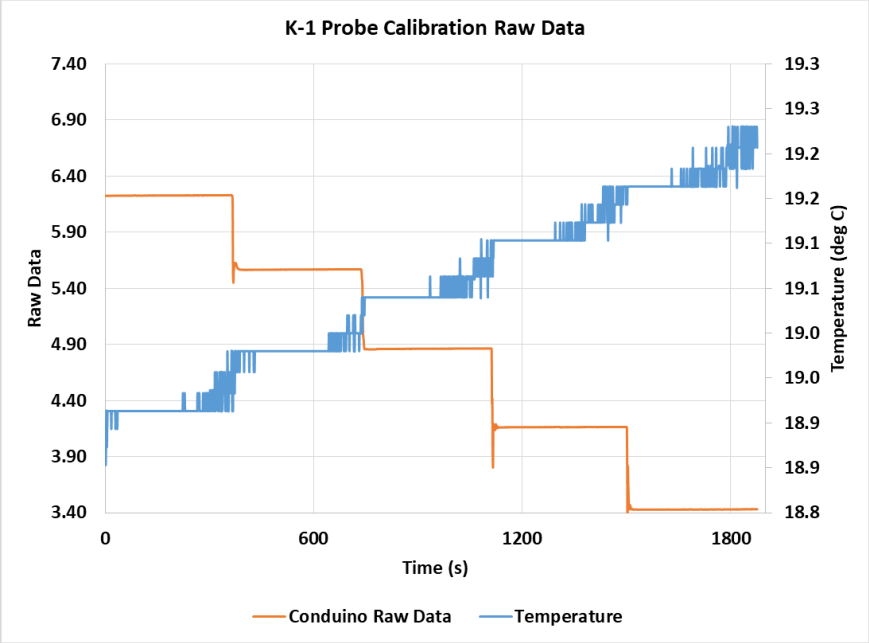
A table is super handy so we can use the actual weights used since it's difficult, and unnecessary to hit the numbers exactly using the scale. Enter the actual weight and let Excel do the concentration calculation.

For this calibration, 110g of salt was used, which resulted in this table:

Concentration	Total Weight	Actual Weight Increment	Target Weight Increment
0.03658	3007	3007	3000
0.03201	3436	429	430
0.02729	4031	595	570
0.02279	4826	795	800
0.01826	6025	1199	1200

Once you've added the water and achieved a first known concentration, use a pump inside the vessel, cover it (with foil for example) and let it circulate a good hour or so to let the salt dissolve and the air bubbles to disappear. Use a low power pump so as not to heat the water, or add air.

Turn on the probe, and make sure you get the green light which indicates the micro-SD card is properly seated. Soak the probe at each concentration, adding incremental water for each soak. For the following calibration data, the probe was soaked for 10 minutes at each concentration.



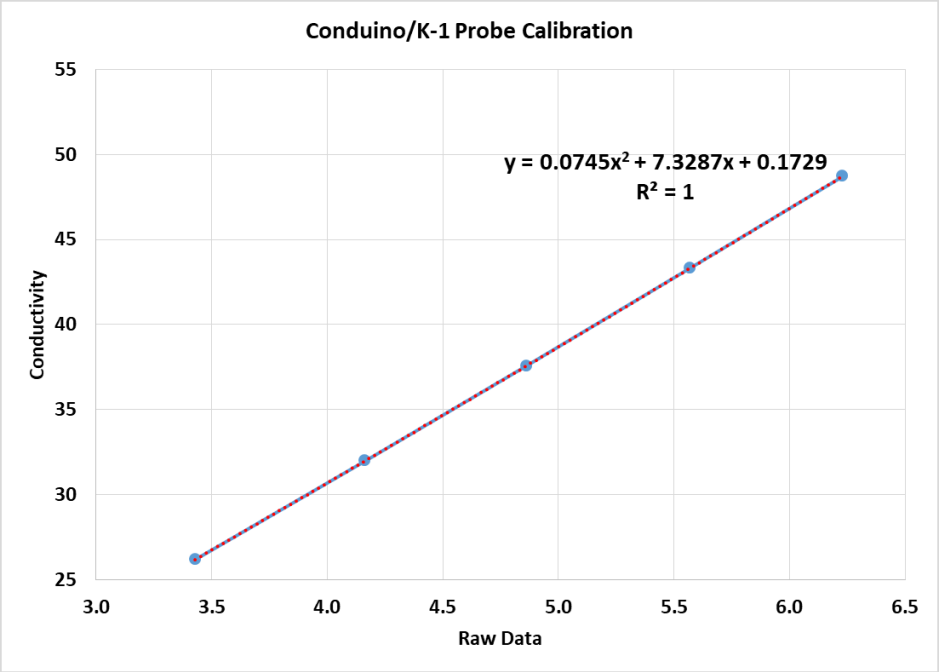
Here, you can see the orange curve stepping down in resistivity after each increment of water is added. The temperature happens to have a slight upward trajectory which is no big deal.

Next, create a table by translating the known salinity and temperature to conductivity using a calculator at salinometry.com: http://salinometry.com/stp-conductivity-calculator/

For the calculator, enter the known salinity in PPT, enter temperature in degrees C, and pressure in dBar (deci-bar). Our pressure sensor reports in mbar (millibar), so divide that number by 100 (since 1000mBar=10dBar).

Known Salinity (PPT)	temp	Conduino Raw Data	Conductivity (salinometry.com)
18.26	**19.20**	**3.43**	26.187
22.79	**19.13**	**4.16**	31.981
27.29	**19.06**	**4.86**	37.580
32.01	**18.99**	**5.57**	43.303
36.58	**18.93**	**6.229**	48.717

From this table the transfer function is plotted



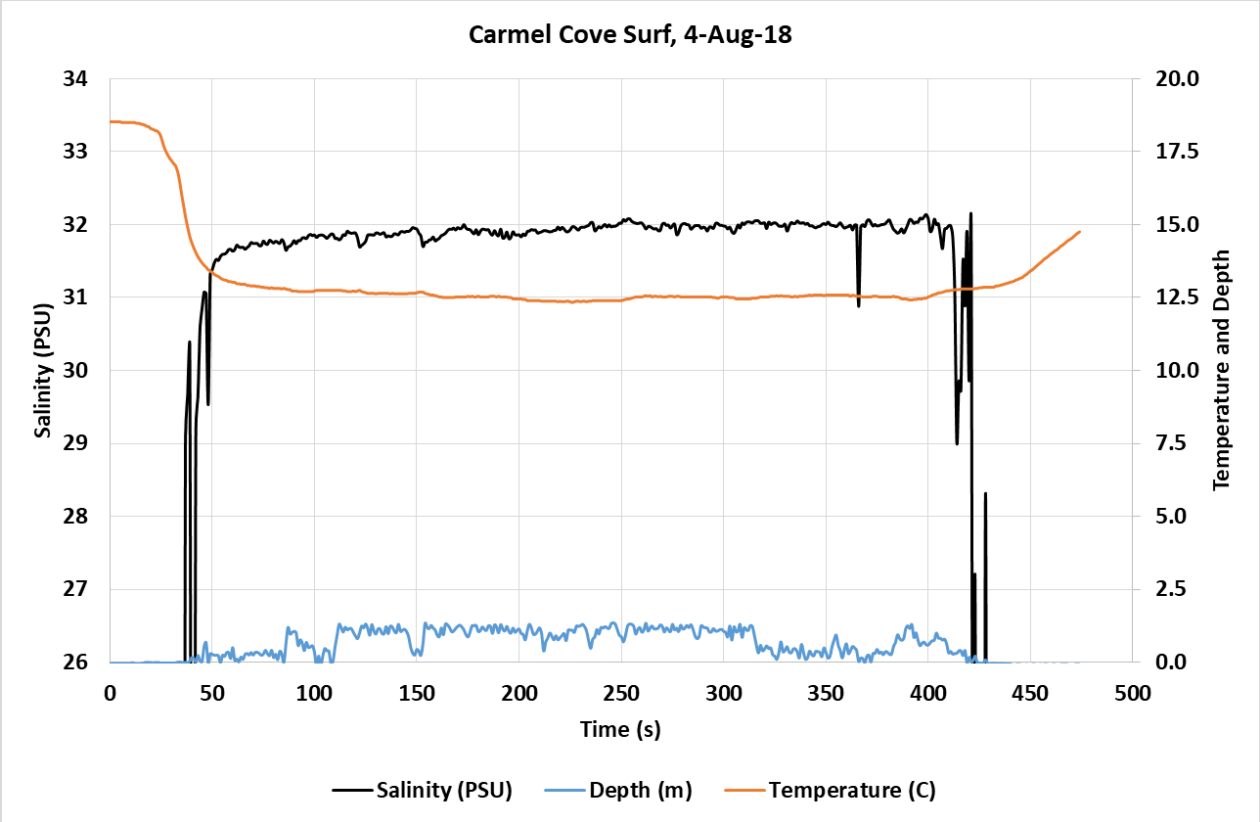
Here, the "Trendline" feature in Excel is used. You can choose from many options including linear, exponential, power, polynomial, etc. Choose polynomial and you get a great fit. Excel displays R^2, the coefficient of determination, typically used in statistical analysis where you're trying to get a curve to represent a cluster of data. When $R^2=1$, it's as good as it gets.

The equation,

$$y = 0.0745x^2 + 7.3287x + 0.1729$$

can now be embedded into the Arduino program resident in the probe electronics to report the conductivity value directly.

After taking the now calibrated probe for a spin in the Carmel surf, and then calculating salinity using the Excel conversion template, we get the following response:



No surprises here, it's salty and cold!

8/26/18