

Lesson Plan: What's a Water Column Profile?

Summary

In this activity students explore the relationship between temperature, salinity and density in coastal marine waters. Students access and retrieve water column profile data from the NANOOS and/or the WA Department of Ecology's Marine Water Monitoring database. Using this data, students construct water column profiles and provide plausible explanations for the trends seen.

Key Concepts

- Technology enables scientists to study global and local ocean characteristics over long periods of time.
- Scientists use technology to help them answer questions about the ocean.
- Salinity and temperature affect the density of seawater.

Objectives

- The student will be able to interpret a water column profile to describe water conditions.
- The student will be able to provide plausible explanations to the trends seen in water column profiles.
- The student will be able to describe the relationship between the salinity, temperature and density of water.

Materials

- Computer lab with Internet access or projection screen
- Science journal or similar for each student

Teaching Notes:

- For directions on how to download and construct water column profiles from the NANOOS web portal into excel, please see the tutorial "How to Graph Marine Water Monitoring Data in Excel" at the end of this document.
- This activity can be preceded by the activity on water density, "Introduction to Water Density" which gives students a basic understanding of the relationship between temperature, salinity and density.



Procedure:

- 1) Post an image of a water column profile from data from the [NANOOS Visualization System \(NVS\) Salish Cruise app](#) or the [WA DOE Marine Water Monitoring Data](#) website. Have students write a list of the information they can gather from the graph.
- 2) In a discussion with the entire class, compile a list of information obtained from the profile. Display a map showing where within Washington this profile was taken. Point out any misunderstandings in interpreting the graph.
- 3) In science journals or notebooks, have students speculate on reasons why the graph looks as it does. What factors could affect temperature? What factors could affect salinity? What factors could affect density?
- 4) Divide students into small groups (2-4 per group). Give each group a set of data, or have students select a site from the NVS Salish Cruise app. You may want to choose data from two different locations or data from the same site during two different seasons.
- 5) Have students look at the data and determine the ranges of temperature, salinity, and density for the entire water column for each profile on each day.
- 6) Have students answer questions about the differences they do (or do not) see between the profiles. For example: Which day's average temperature is higher? Which is lower? Do these temperature averages make sense given what season or where each cast was recorded? Look at the salinity profiles. Are there differences in salinity between the two stations, between the two seasons, between the shallow and deep water?
- 7) Have students come together and discuss the differences and similarities that may have found. Encourage students to generate plausible reasons for why they are seeing these trends.



- 8) Have students write two to three paragraphs describing the relationship between temperature, salinity, and depth based on the CTD graphs.

Assessment

- Did student participate in class discussion and demonstrate an understanding of how to interpret water column profiles?
- Did student accurately interpret the data presented in the profiles?
- Did student accurately describe the relationship between salinity, temperature and density?

Resources

- Puget Sound circulation, from “Sound Science: Synthesizing Ecological and Socioeconomic Information About the Puget Sound”, page 23 of document:
<http://www.nwfsc.noaa.gov/publications/documents/Sound%20Science%20.pdf>
- WA Department of Ecology Marine Water Monitoring:
http://www.ecy.wa.gov/programs/eap/mar_wat/mwm_intr.html
- University of Washington Puget Sound Regional Synthesis Model:
<http://www.prism.washington.edu/home>
- Ocean circulation: <http://www.windows.ucar.edu/tour/link=/earth/Water/ocean.html>

Background

CTD

How do scientists “see” the water conditions at depth? One of the most common tools oceanographers use to record measurements on the conditions of the ocean from the surface to the ocean floor is an electronic instrument called the CTD, (c=conductivity, t=temperature, d=depth). CTD instruments are used “in situ” where the instrument is placed in the water it is measuring. As the CTD instrument is lowered through the water (or as it sits still at a given point in the water), measurements of conductivity, temperature and depth are recorded continuously. In general, CTDs can measurement each parameter 24 times per second (24 Hz). This provides a very high resolution description of the water being tested.



CTD instruments measure three important parameters directly - conductivity, temperature and pressure. By measuring conductivity (how easily electric currents pass through the water sample being tested), scientists can get a measurement of that water sample's salinity. This is because electric current passes much more easily through water with a higher salt content. Therefore, if we know the conductivity of the water, we know how much salt is in the water. Salinity is measured in psu (practical salinity units).

A CTD instrument measures temperature, usually via a thermistor, a platinum thermometer, or a combination of these. Pressure is also measured directly by the CTD, and this is how the "D" of CTD is measured. Because depth and pressure are directly related, a pressure measurement can be converted to depth in meters. Conveniently, the pressure in "X" decibars (db) is almost exactly equal to the pressure found at "X" meters of depth. For instance, at about 500 meters below the surface, the pressure is right around 500 db. Pressure measurements on a CTD are obtained using either a strain gauge pressure monitor or a quartz crystal-based digital pressure gauge.

Additional sensors and instruments can be mounted on the CTD frame. Common sensors include a pH meter, dissolved oxygen sensors, transmissometers – which measure light transmission, and fluorometers, which measures the amount of chlorophyll in the water. Chlorophyll measurements can give researchers an indication of how many phytoplankton are in the water.

The CTD is usually mounted within a frame, which also holds several bottles for collecting seawater and a mechanism (called a rosette or carousel) that allows researchers to control when individual bottles are closed. This enables researchers to collect water samples at specific depths. Chemical and biological analyses of the water samples occur on the ship, or water samples are preserved and stored for later analysis at a shore-based laboratory.

A common sampling technique using a CTD is the vertical CTD cast. Scientists select a location of interest. The ship travels to that location and stays as close to the same spot as possible as the CTD is lowered through the water column to within a few meters of the bottom, then raised back up to the ship. The ship can then move to a different location and repeat the sampling process. CTD data collected through vertical casts can be graphed against depth. These graphs are called water column profiles. Water column profiles can give scientists a good picture of the conditions of the entire water column from surface to depth at each sampling spot.





CTD instrument in frame without bottles



CTD, bottles within rosette

Marine Water Monitoring

The Washington Department of Ecology

http://www.ecy.wa.gov/programs/eap/mar_wat/mwm_intr.html) conducts regular marine water monitoring of Puget Sound, Willapa Bay and Grays Harbor. About 40 stations (specific locations on the water) are monitored on a monthly basis. Other stations are monitored on a rotating schedule or during targeted research projects. An interesting aspect of this monthly sampling is that it is conducted via a float plane instead of a boat. The float plane has been specifically modified with a special trap door to be able to do the water sampling. As the float plane lands at each station, a WA DOE technician onboard the plane lowers the CTD into the water through the special trap door, collects the water column profile data and some water samples, and then brings the CTD back onboard the plane. The pilot flies the plane to the next station and the technician repeats the sampling,





Kenmore Air float plane used for water monitoring



CTD being lowered through trap door of float plane into the water

University of Washington Research Cruises

The University of Washington conducts periodic oceanography cruises in Puget Sound, roughly every 6 months. Volunteer students help scientists to measure well-resolved sections of CTD data and other biochemical properties down the axis of the Main Basin, Whidbey Basin and Hood Canal. Much of the CTD and bottle data collected on these cruises is available at the [NANOOS Visualization System \(NVS\) Salish Cruise app](#).

Oceanic Remote Chemical Analyzer (ORCA) Project

The [Oceanic Remote Chemical Analyzer \(ORCA\)](#) is an autonomous moored profiling system providing real-time data streams of water and atmospheric conditions. It consists of a profiling underwater CTD with a variety of chemical and optical sensors, and a surface mounted weather station, solar power system, winch, and custom computer and software package equipped with WIFI/cellular communication. Since its deployment in 2000, the ORCA system has provided a near-continual stream of high-resolution water quality data from locations in the Puget Sound, Washington State. There are currently 6 mooring systems deployed, spread throughout Puget Sound and Hood Canal.



Salinity, Temperature and Density

The density of ocean water varies significantly from place to place. Temperature and salinity are two variables that greatly influence the density of seawater. As seawater warms, it expands, making the warmer seawater less dense than cooler seawater. The dissolved salts within seawater make it more dense than freshwater, and the saltier the water, or the higher its salinity, the more dense the water.

Water masses of differing densities tend to form layers – become stratified - within the water column. Different densities act as barriers to water mixing, which becomes very important to ocean and estuarine water circulation. Water stratification due to water layers of high and low salinity (called a halocline) can be seen in water column profiles of salinity vs depth as an area of the line graph where the slope is relatively flat. Layers of cold and warm water are called a thermocline, and this too can be seen in a water column profile of temperature. Pycnoclines are layers of water of different densities. These can either mimic the salinity or temperature profiles depending on whether density differences in water column are salinity driven or temperature driven.

Water stratification plays a vital role in ocean circulation. While the circulation of surface waters of the ocean are driven mostly by winds, the circulation of the deep ocean water is driven by density differences. Circulation in the depths of the ocean is referred to as thermohaline (thermo for temperature, haline for salt) circulation. The deep ocean is layered with the most dense (that is the coldest) water on bottom and the lightest water on top. Water tends to move horizontally throughout the deep ocean, moving along lines of equal density. Vertical circulation is limited because it is easier for water to move along lines of constant density than across them.

In estuaries, where fresh water from rivers meet up with salt water from the ocean, water circulation will tend to have fresh river water floating above the saltier water from the ocean, until mixed by wind and currents. The layering of the water masses can affect the distribution of organisms and sediments in the estuary.



Profiles

Some hints for interpreting water column profiles:

- To read the CTD profiles, note that depth is along the vertical (or y) axis, with the water surface, 0 m, toward the top of the page and the deepest depth toward the bottom of the page. The parameter given (temperature, salinity or density) is plotted along the x-axis with a scale at the top of the figure.
- Well-mixed layers of water will have similar density, (and salinity and temperature) readings over some range of depth. These portions of the graphed line will look vertical on the plot. In Puget Sound, surface waters may be well-mixed due to wind and tides, deeper waters due to mixing over sills (shallow, narrow places over which the tidal currents flow strongly).
- Salinity plot: The near-surface profile (top 5 meters) often shows a freshwater layer from rivers flowing into Puget Sound and/or rainfall. Alternately, there could be a large mixed layer showing the depth over which wind and waves mix the freshwater with ocean water from the Straits of Juan de Fuca (perhaps 5-15 m thick). At mid-water depths, salinity signals often show mixing over the sills at Admiralty Inlet or Tacoma Narrows. Deep water salinity is determined by a combination of ocean salinity, how much freshwater is coming into the Sound, and mixing experienced from mechanical forces such as wind and tidal currents over sills. The general circulation of an estuary is fresher water flowing out to sea over saltier water flowing in from the ocean at depth, thus giving the deeper water more ocean-like salinity (and temperature).
- Temperature plot: This typically depends on the season. In general the deep water temperature is stable throughout the year, varying by only 1-2 degrees C. The surface temperature varies much more (7-8 degrees C) based on the season. Surface temperature is more tied to sun, air temperature, and temperature of fresh water coming into the Sound, sun, air temperature, In early winter it is common to see a plot where temperature is coldest at surface, warmer at 30-50 m and than colder again at the bottom, but not as cold as at the surface. In this case, you are seeing a temperature bulge from last summer's surface water, which has mixed down. As in the salinity plot, if you do see a true mixed layer you can discuss how the sills at Admiralty Inlet force deep marine waters up into shallower depths which then mix with the surface water.
- Density plots: Density is a function of temperature AND salinity AND pressure. Pressure increases uniformly with depth so we don't plot it or discuss it as it is a straight diagonal line with depth.) Denser water



is pulled by gravity towards the bottom. Colder water is more dense than warmer water, and saltier water is more dense than fresher water. Both salinity and temperature affect density of water, but in estuaries (like Puget Sound) density usually mimics the salinity curve because salinity is a more powerful control on density than temperature.

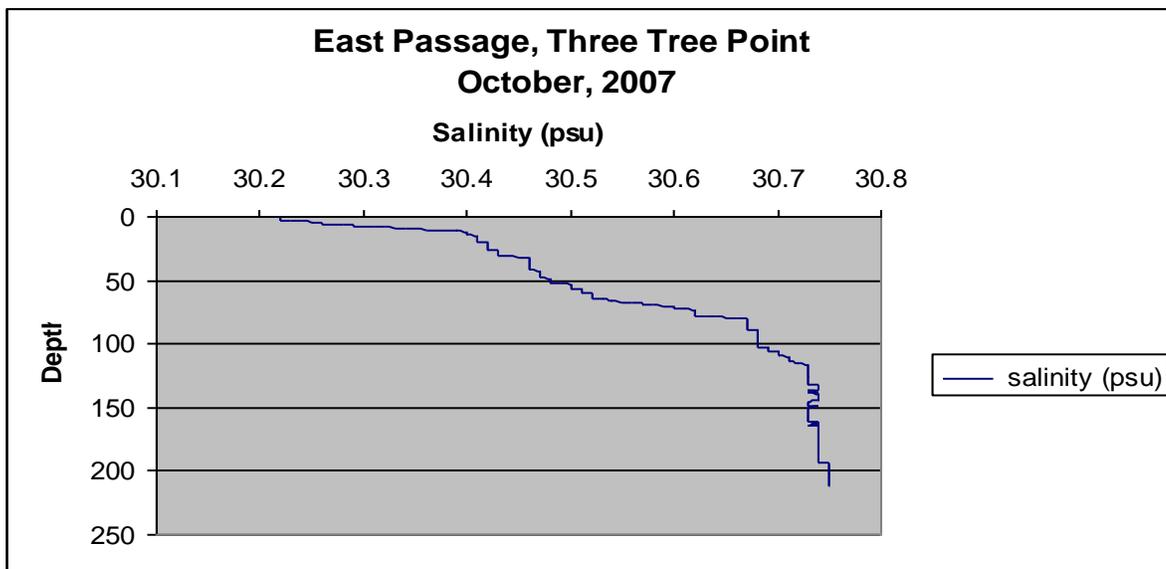
Three Tree Point, October, 2007

The three water column profiles pictured below were measured by the WA DOE marine water monitoring program at Three Tree Point in central Puget Sound in October, 2007.

Review these profiles and make a list of the information you can gather from the graphs.

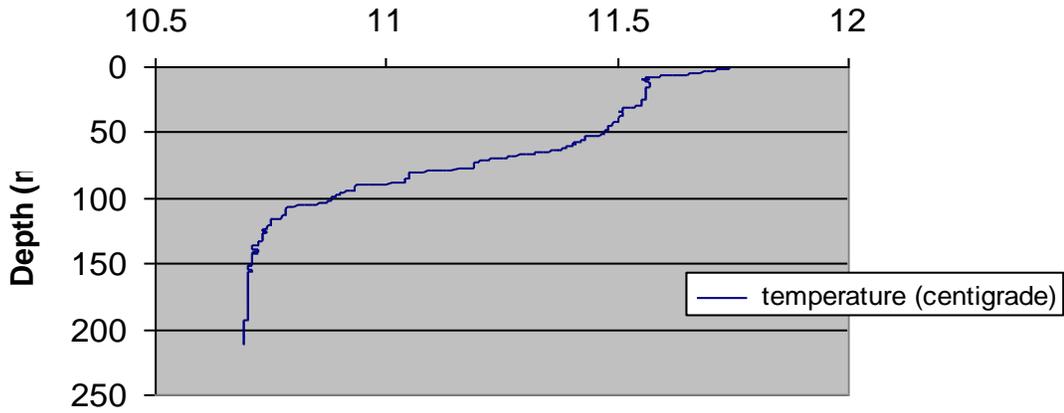
Scientists familiar with reading water column profiles determined the following interesting features:

- From surface (0 m) to 10 m in depth: there is a sharp freshwater signal in the salinity plot. Temperature plot shows warmer water, this warmer water is likely due to the warmer temperature of the atmosphere warming the surface water.
- From 10 m down to 50 m: This layer of water is somewhat mixed, as seen by the steepness of the line at this depth, but it is still a somewhat stratified layer of estuarine water.
- 50-100 m: This layer of water shows strong stratification, it is a transition layer from estuarine surface water to deep water. The main thermocline, halocline and pycnocline are at ~120m
- 100 m-200 + m: This is a stable layer of well-mixed deep, colder, and saltier water



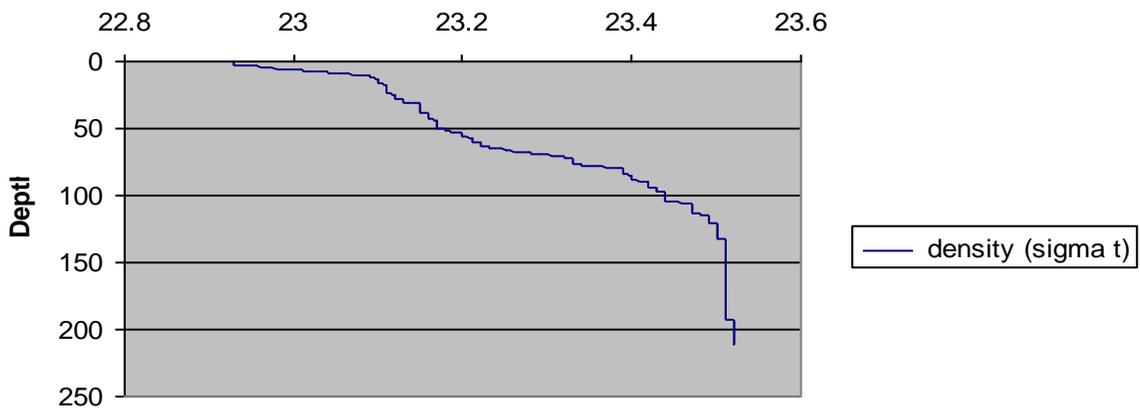
East Passage, Three Tree Point
October, 2007

Temperature (centigrade)



East Passage, Three Tree Point
October, 2007

Density



Introduction to Water Density

Summary

In this activity students explore the relationship between temperature, salinity and density. Students design their own investigations with warm, cold, salty and fresh water to determine how each property affects water density.

Subject Area: earth science, physical science

Grade Level: 6-12

Key Concepts

- Salinity and temperature affect the density of water.
- Water masses of different densities tend not to mix.

Objectives

- The student will be able to demonstrate that cold, saltier water is more dense than fresh, warmer water.
- The student will be able to explain what happens when cold, saltier water and warm fresh water are combined.

Materials:

Materials for class demonstration:

- Large clear container
- Water
- a can of Diet Coke (or some other diet soft drink)
- a can of Coke (or other kind of non-diet soft drink)

Materials for student groups:

- Several clear straws
- Food coloring
- Colored Pencils
- Beakers or small test tubes for water
- Four water solutions of different densities, numbered for identification; supply enough for each group of students to test all four:
 - Warm (steaming but not boiling) fresh water
 - Room temperature fresh water
 - Room temperature salty water, 20-35 ppt
 - Ice water saturated with salt

Procedure:



Demonstration:

Fill a large, clear container with water. Ask students which can of soda they think will float and why. Immerse both cans in the water and ask students to explain what happens. (The can of Coke should sink due to its higher density from the sugar it contains.)

- 1) With the entire class, fill a jar with clear, room temperature tap water. Using a straw (or eye dropper) partially filled with one of the colored solutions, place the tip of the straw halfway into the tap water. Ask students if they think the solution will float or sink, and why. Release the water from the straw into the beaker and discuss what happens.
- 2) Direct students to use the straws, food coloring, and samples to design and carry out a series of experiments to show how water masses of different densities interact. Give them time to plan their procedures.
- 3) Have students practice getting the liquid into a straw using a finger over the end of the straw. If necessary, suggest students to use only two liquids at a time (to limit the variables for each test); encourage students to experiment to see which color liquid will stack on another liquid.
- 4) Students can record results by coloring in outlines of the straws on a piece of paper to match the stack or by making diagrams of their own.
- 5) Ask students to summarize their experiments and share their findings with the rest of the class. How did they decide which liquid was more dense in each experiment? Were there any discrepancies? Can students stack all four liquids in the straw?
- 6) Ask students to explain how water density plays a role in coastal environments. Discuss with students how these results relate to estuaries, polar oceans, and equatorial ocean regions. Where and when are water masses not stratified? In what ways would density affect how pollution is dispersed in the water? How would seasonal changes affect water density? What kind of adaptations would animals living in an estuary need in order to live there? Is it possible that warm, salty water could be denser than cold fresh water? Why or why not?

Assessment

- Performance: Did students work together to design and conduct useful experiments to determine relationship between temperature, salinity and density?
- Product: Can students accurately explain the relationship between water density, salinity and temperature?

Background:



The density of water is affected by two factors: temperature and the amount of dissolved material (in this case, salt). The relationship between these factors is important in determining the environment of an estuary, where fresh and salt water meet and mix.

While in liquid form, water molecules move around each other randomly. Hydrogen bonds continually form and break between different molecules depending on the energy available. Decreasing water temperatures indicate a decreasing availability of energy. This decrease in energy means the water molecules, moving around each other less, are closer together. Colder water is therefore, more dense than warmer water. Conversely warmer water expands, making the water less dense than cooler water.

Note: This pattern holds true until temperatures are cold enough where there is not enough energy available to break hydrogen bonds once they formed, and water reaches its greatest density (4 C for freshwater, colder for salt water). As the temperature continues to decrease, the formation of hydrogen bonds forces water molecules to line up in crystalline formation. This becomes visible to us when the temperature reaches 0 degrees Celsius and ice forms. This rigid, crystalline structure forces the water molecules to take up more room than when they were moving randomly in their liquid form, meaning that water at this temperature is actually less dense – which is why ice floats.)

Salt water is more dense than fresh water because it contains salt and other dissolved minerals. The temperature and amount of salt dissolved in a water mass affects the way it will behave when it comes into contact with other, different water masses. The higher the salinity of a water mass, the greater its density. Conversely, the more fresh a water mass, the lower its density. When two water masses of differing salinity (and therefore, different densities) meet, the fresher, less dense water tends to float above the saltier, denser water. In estuaries, where fresh water from rivers meet up with salt water from the ocean, water circulation will tend to have fresh river water floating above the saltier water from the ocean, until mixed by wind and currents. The layering of the water masses can affect the distribution of organisms and sediments in the estuary.



Downloading and Graphing Water Column Profile Data from PRISM Cruises and the Washington Department of Ecology Marine Water Monitoring Program for Excel

DOE Marine Water Monitoring Dataset

Downloading data into Excel:

1. Go to the NANOOS homepage, www.nanoos.org
2. Choose "Products" from the menu bar along the left side of the homepage.
3. Scroll down the list of products and choose "Marine Water Monitoring"
4. You can also reach the site through the NANOOS Visualization System http://nvs.nanoos.org/Explorer?action=oiw:mobile_platform:WADOE_Floatplane:details and selecting "Marine Flight Float Plane Monitoring" in top left of pop up window.
5. You can also reach the site directly at: <http://www.ecy.wa.gov/apps/eap/marinewq/mwdataset.asp?staID=126>
6. You will be taken to the marine water monitoring data page of the Washington State Department of Ecology website. This site allows you to download data from its Marine Water Monitoring Program. Take a few moments to become familiar with the page.
7. There are two "station group" options: Puget Sound or coastal estuaries. Selecting the circle next to "coastal estuaries" will change the map to show the monitoring sites for the coastal estuaries - Willapa Bay and Grays Harbor. Selecting the circle next to "Puget Sound" will bring up the map to see monitoring sites for Puget Sound.
8. Choose a monitoring site: Either use the pull-down menu under "Selected station" OR select a location on the map. (Notice that diamonds signify core stations monitored monthly, squares are sites monitored on a rotating basis.)
9. Select a year and month. The data for the selected month will appear in the table below. In our example we will graph data from station EAP001: East Passage – SW of Three Tree Point for Oct., 2007.

Department of Ecology Marine Water Monitoring

Ecology home > Environmental Assessment Program > marine water quality monitoring

Long-term marine water quality data

[notes on data availability and qualifiers](#)

station group: Puget Sound coastal estuaries

selected station: EAP001 - East Passage - SW of Three Tree Point

station information:

type	latitude	longitude	max. depth	county	wrta	*map detail
core	47.4167	-122.3800	212.5 meters	King	09	TopoZone.com

selected year: 08 07 06 05 04 03 02 01 00 99 98 97 96 95 94 93 92 91 90 89 88

Data for **gray-shaded** years are available on request: [data request form](#)
 Data for **pink-shaded** years are provisional and have not yet been finalized.

selected month: Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Oct

Note: discrete sample data are not available for this station/year/month combination

detailed-profile data for EAP001, October 25, 2007 *provisional*

depth (meters)	temp-ature (celsius)	salinity (psu)	density (sigma t)	chloro-phytl raw (ug/l)	dissolved oxygen (mg/l)		light trans- mission (%)
					raw	corrected	
0.5	11.74	30.22	22.93	0.6	6.0	63.3.0	
1.0	11.74	30.22	22.93	0.6	6.0	66.8.0	
1.5	11.72	30.22	22.93	0.6	6.0	78.0.0	
2.0	11.72	30.22	22.93	0.6	6.0	90.0.0	
2.5	11.71	30.22	22.93	0.7	6.8	91.7.0	
3.0	11.70	30.23	22.95	0.7	6.8	92.3.0	
3.5	11.69	30.24	22.95	0.8	6.8	92.8.0	
4.0	11.68	30.25	22.96	0.7	6.8	92.8.0	
4.5	11.66	30.25	22.97	0.7	6.8	92.8.0	
5.0	11.66	30.26	22.97	0.8	6.7	93.2.0	

KEY: station type: core 26, rotating 47

10. To download the data into Excel, scroll down and select “CSV” (CSV stands for comma separated variable, data in this form is easily imported into excel) and “month” (this downloads data for only one month), select “Get File”.
11. File will download into excel. A pop-up window may appear asking whether to open or save file, select “Open” and “OK”.
12. You have now successfully downloaded data into excel. The next step is to graph this data.

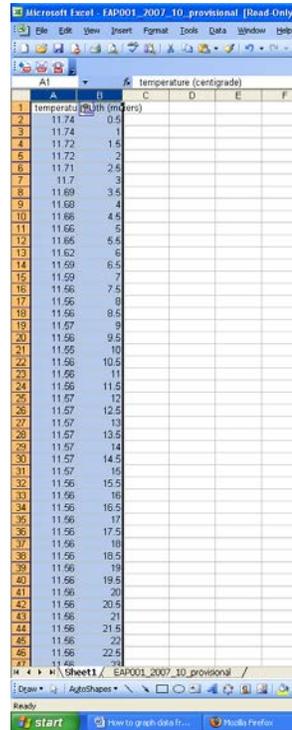
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
station	date	time	depth (m)	salinity (p)	temperatu	density (s	chlorophy	dissolved	dissolved	light trans	pH							
EAP001	10/25/2007		0.5	30.22	11.74	22.93	0.6	6.9		63.3	7.9							
EAP001	10/25/2007		1	30.22	11.74	22.93	0.6	6.9		56.8	7.9							
EAP001	10/25/2007		1.5	30.22	11.72	22.93	0.6	6.9		78.9	7.9							
EAP001	10/25/2007		2	30.22	11.72	22.93	0.6	6.9		90.4	7.9							
EAP001	10/25/2007		2.5	30.22	11.71	22.93	0.7	6.8		91.7	7.9							
EAP001	10/25/2007		3	30.23	11.7	22.95	0.7	6.8		92.1	7.9							
EAP001	10/25/2007		3.5	30.24	11.69	22.95	0.8	6.8		92.8	7.9							
EAP001	10/25/2007		4	30.25	11.68	22.96	0.7	6.8		92.8	7.9							
EAP001	10/25/2007		4.5	30.25	11.66	22.97	0.7	6.8		92.9	7.9							
EAP001	10/25/2007		5	30.26	11.66	22.97	0.8	6.7		93.2	7.9							
EAP001	10/25/2007		5.5	30.26	11.65	22.98	0.8	6.7		93.2	7.9							
EAP001	10/25/2007		6	30.28	11.62	23	0.8	6.7		93.3	7.9							
EAP001	10/25/2007		6.5	30.29	11.59	23.01	0.8	6.6		93.3	7.9							
EAP001	10/25/2007		7	30.29	11.59	23.01	0.8	6.6		93.4	7.9							
EAP001	10/25/2007		7.5	30.31	11.56	23.03	0.9	6.6		93.5	7.9							
EAP001	10/25/2007		8	30.32	11.56	23.04	0.9	6.5		93.7	7.9							
EAP001	10/25/2007		8.5	30.33	11.56	23.04	0.8	6.5		93.7	7.9							
EAP001	10/25/2007		9	30.34	11.57	23.05	0.8	6.5		93.8	7.9							
EAP001	10/25/2007		9.5	30.35	11.56	23.06	0.7	6.4		93.9	7.9							
EAP001	10/25/2007		10	30.36	11.55	23.07	0.7	6.4		94	7.9							
EAP001	10/25/2007		10.5	30.39	11.56	23.09	0.6	6.3		94.2	7.9							
EAP001	10/25/2007		11	30.39	11.56	23.09	0.6	6.2		94.3	7.9							
EAP001	10/25/2007		11.5	30.39	11.56	23.09	0.5	6.2		94.3	7.9							
EAP001	10/25/2007		12	30.4	11.57	23.09	0.5	6.1		94.3	7.9							
EAP001	10/25/2007		12.5	30.4	11.57	23.1	0.4	6.1		94.3	7.9							
EAP001	10/25/2007		13	30.4	11.57	23.1	0.4	6.1		94.3	7.9							
EAP001	10/25/2007		13.5	30.4	11.57	23.1	0.4	6		94.3	7.9							
EAP001	10/25/2007		14	30.4	11.57	23.1	0.4	6		94.2	7.9							
EAP001	10/25/2007		14.5	30.4	11.57	23.1	0.4	6		94.2	7.9							
EAP001	10/25/2007		15	30.41	11.57	23.1	0.5	6		94.2	7.9							
EAP001	10/25/2007		15.5	30.41	11.56	23.1	0.4	5.9		94.2	7.9							
EAP001	10/25/2007		16	30.41	11.56	23.1	0.4	5.9		94.2	7.9							
EAP001	10/25/2007		16.5	30.41	11.56	23.1	0.4	5.9		94.1	7.9							
EAP001	10/25/2007		17	30.41	11.56	23.11	0.4	5.9		94.1	7.9							
EAP001	10/25/2007		17.5	30.41	11.56	23.11	0.4	5.9		94.1	7.9							
EAP001	10/25/2007		18	30.41	11.56	23.11	0.4	5.9		94	7.9							
EAP001	10/25/2007		18.5	30.41	11.56	23.11	0.4	5.9		94.2	7.9							
EAP001	10/25/2007		19	30.41	11.56	23.11	0.4	5.9		94.2	7.9							
EAP001	10/25/2007		19.5	30.41	11.56	23.11	0.4	5.9		94.2	7.9							
EAP001	10/25/2007		20	30.42	11.56	23.11	0.4	5.9		94.2	7.9							
EAP001	10/25/2007		20.5	30.42	11.56	23.11	0.3	5.9		94.1	7.9							
EAP001	10/25/2007		21	30.42	11.56	23.11	0.3	5.9		94.1	7.9							
EAP001	10/25/2007		21.5	30.42	11.56	23.11	0.4	5.8		94.2	7.9							
EAP001	10/25/2007		22	30.42	11.56	23.11	0.4	5.8		94.2	7.9							
EAP001	10/25/2007		22.5	30.42	11.56	23.11	0.4	5.8		94.1	7.9							
EAP001	10/25/2007		23	30.42	11.56	23.11	0.4	5.8		94.1	7.9							

Graphing Data in Excel

Note: These directions provide step-by-step instructions for creating graphs in Excel 2003. Procedures for newer versions of Excel will be similar, but menu items may be located in different places.

1. Open a new worksheet: select “Insert” then select “worksheet”.
2. Return to your downloaded data worksheet (select appropriate tab on bottom left of worksheets). We will make a temperature vs. depth graph, the temperature will be along the x-axis and the depth will be along the y-axis. You will need the temperature and the depth data in adjacent columns.
 - a. Return to your downloaded data worksheet. Copy the temperature column by placing your cursor over the letter at the top of column F, then click and copy the column (CTRL+C).
 - b. Move to your new spreadsheet, select column A and paste the data (CTRL+V)
 - c. Return to your downloaded data worksheet. Copy the depth column by placing your cursor over the letter at the top of column D, then click and copy the column (CTRL+C).
 - d. Move to your new spreadsheet, select column B and paste the data (CTRL+V)
3. You should now have your x axis data – temperature in column A and your y axis data – depth in column B. You are ready to make a graph!
 - a. Select both columns A (temperature) and B (depth) by placing

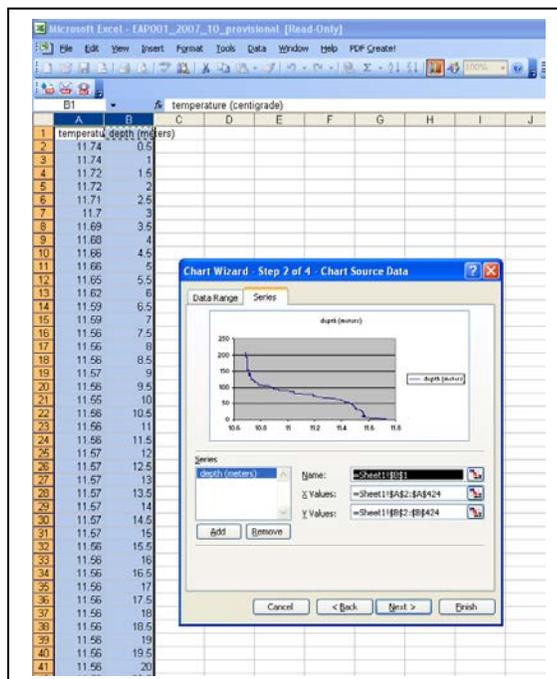
cursor over the letter at the top of column A, holding down the mouse and moving it over to the letter at the top of column B.



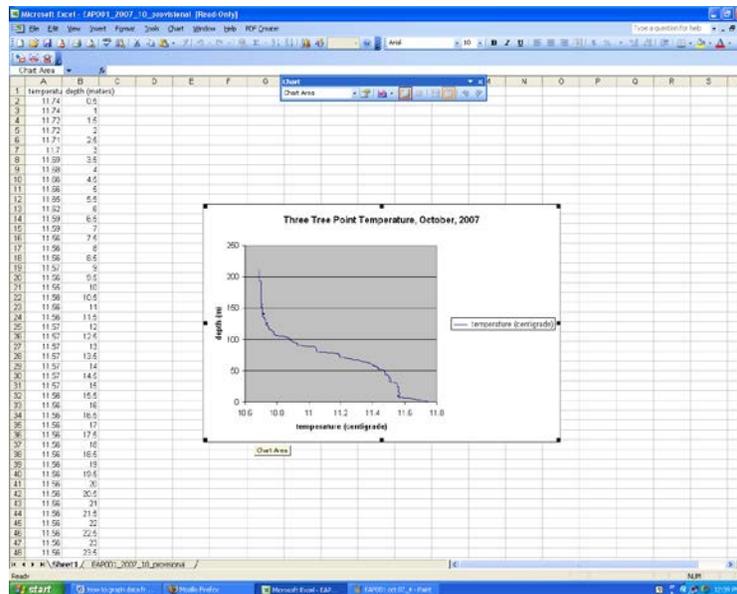
Both columns should be highlighted.



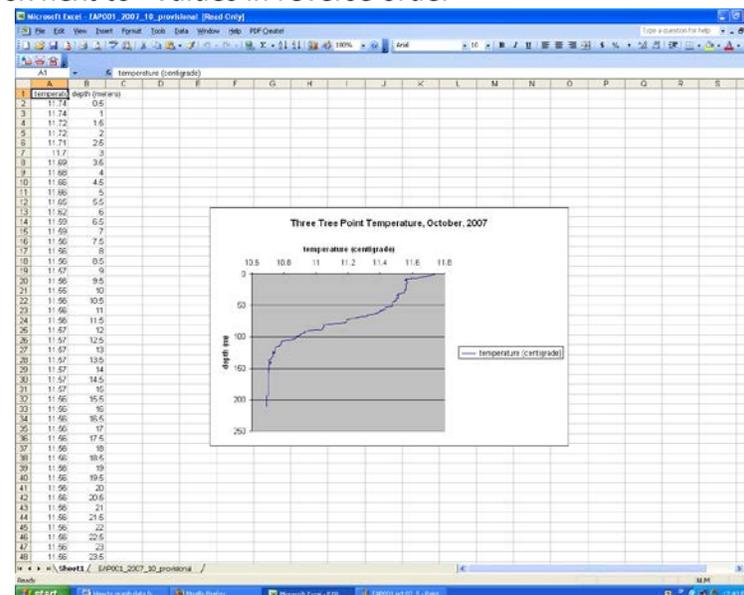
- Click on the “chart wizard” icon in the menu bar of Excel.
- Under the “Standard Types” tab select “XY scatter”.
- For chart sub-types select “scatter with data points connected by lines without markers”.
- Select “Next”
- Select the “Series” tab.
- Highlight the text within the Name box



- h. Move cursor up to cell A1 and select cell A1 (this will change the label for the line from “depth” to “temperature”).)
- i. Select “Next”
- j. You can now give your chart a title, for example: Three Tree Point Temperature, October, 2007. You can also give labels for the X and Y axis.
- k. Select “Next”
- l. Select “as object in”
- m. Select “Finish”



4. To reverse the order of your depth data, so that 0 m depth will be at the top of the Y axis scale and the deepest depth will be at the bottom of the scale:
 - a. double click along the y axis, a “format axis” window will appear.
 - b. Select the tab: “Scale”
 - c. Check the box next to “Values in reverse order”



- d. Select “OK”.

5. You can also change the appearance of the x-axis or y-axis from the format axis window. For example, if you want a line to appear every 10 m instead of every 20 m, double click along the y axis; from the “format Axis” window select the “Scale” tab. Change the Major unit value from “20” to “10”. If you would like to change the data range of the x-axis, double click along the x axis. From the “Format Axis” window select “Scale” tab. Change the values in the Minimum and Maximum boxes to the data range you would prefer.
6. You can edit your graph title and axis titles by clicking on the text in the graph. Double clicking on the titles will allow you to change font and color of the text.
7. Once you have edited the graph and it looks the way you would like it to, you can copy and paste the entire graph into a word document, powerpoint presentation or other program by clicking on the outer edge of the graph and then hitting copy. You can then paste it into the document of your choice.
8. To make a water column profile of a variable other than temperature repeat the Graphing Data in Excel procedure except in step #2 instead of choosing column F from your downloaded data, choose the column of the variable you would like to graph. For example, if you would like to graph salinity, you would select column E from your downloaded data to copy into the new worksheet.