The CTD – Conductivity, Temperature and Depth

School Version

This booklet was made by young volunteers. (Freiwilliges Soziales Jahr in Wissenschaft, Technik und Nachhaltigkeit)

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IOW

The impact of salt

All living creatures are adapted to a certain range of salinity – human beings included. Thus we can only drink water with low salt content. Saltwater leads us to vomiting. Survivors of a shipwreck, who drink saltwater despite the fact, will die of thirst faster than if they had drunken none.
Of course the salinity has a great effect on water organisms. Jelly fish, for instance, would not survive in tap water since it does not contain enough salt. In the Baltic Sea the impact of salinity is shown by the formation of the halocline, the result of a strong vertical salinity gradient. But how is the salinity measured in water?

Experiment 1: It's the mixture

Tools: Beaker, aluminium foil, 3 cables, small lamp with bulb socket, 4 crocodile clips, 4.5V monobloc battery, tea spoon (or spatula)

Chemicals: distilled water, table salt

Method:

- First read the whole method description.
- Fold two stable strips out of aluminium foil.
- Build the following circuit.

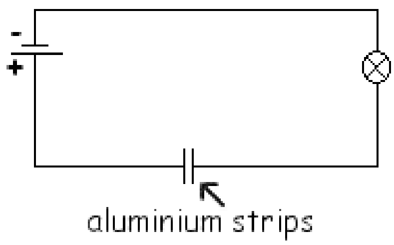

Figure 1: circuit diagramm

- Put both aluminium strips into the dry salt. Make sure they do not touch each other. Note your observation.
- Remove the strips, add one to two tea spoons of salt, stir carefully and attach the strips again. Note your observation.
- Add one to two tea spoons of salt. Note your observation.

Note: *If the lamp does not turn on, try more salt or a different lamp. Since there might be gaseous chlorine or hydrogen produced, only close the circuit for a few minutes.*

The electrical conductivity

The electrical conductivity is a term that can be found in the context of electrical current. It indicates how good a certain matter can conduct electricity. Electrical current is characterized by the fact that electrically charged particles (charge carriers) move along a charge gradient (voltage). For that free charge carriers are necessary.
Salts consist of charged particles, namely ions. In a solid condition these ions are bound in the ion lattice.
Water consists of molecules which do not divide into a positive and a negative part. Thus they are neutral to their environment.
Can you explain your observations in the experiment?

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Unfortunately the conductivity does not only depend on the salinity. What could also have an impact on it?

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Pressure and water depth

Everybody knows this phenomenon: The deeper one dives into the water the bigger is the pressure on the ears. But why?

Experiment 2: Quite some pressure!

Tools: 2 balloons, sealing tape, 4 similar plastic bottles, modelling clay , 2 short flexible tubes (approx. 5cm long), scissors, 2 pegs, 1 small tub, watering can
Chemicals: water

Method:

- First read the whole method description.
- Cut the bottles as you can see in the right-hand illustration.
- Put the four bottles together, so that you have a huge bottle (approx. height about 1m). Seal it with tape.
- Cut a hole into to plastic wall at the top and at the bottom end. It should have about the same diameter as the flexible tube.
- Put one end of the tubes approx. 2cm into the wholes and seal with modelling clay and tape.

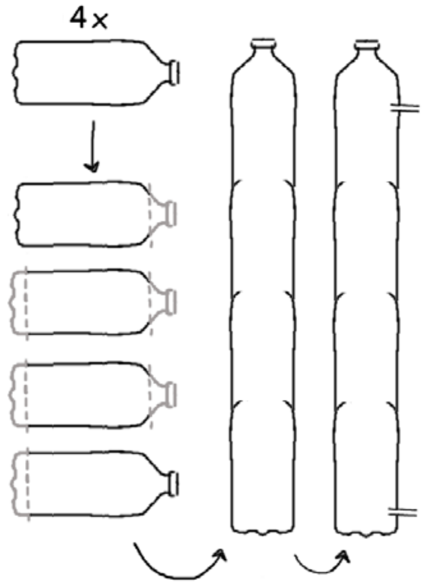

Figure 2: Sketch on how to cut the bottle and where to put the flexible tubes

- Blow some air into the balloons, twist the ends and close them with pegs. Put the opening of the balloons onto the other end of the tubes and seal it with tape.
- Put the bottle in the tub and fill it with a watering can. The water level should be 10cm higher than the top tube.
- First open the top peg, than the bottom.

Questions:

1. What did you observe?
2. What can you conclude from that?

Additional task

The density ρ of water is about 1 000 kg/m^3, the acceleration of free fall g about 10 m/s^2. The water depth is h in m.
The formula for pressure p is:

$$p = \rho \cdot g \cdot h$$

Whereas the pressure is calculated in the measurement unit Pascal (Pa).

- Calculate the pressure for:

  h_1 = 1 m p_1 = ________ Pa
  h_2 = 2 m p_2 = ________ Pa
  h_3 = 10 m. p_3 = ________ Pa

- There is another measurement unit for pressure: 1 bar = 100 000 Pa. The most common unit in oceanography is dbar (decibar). Convert the pressures from above into dbar.

  p_1 = ________ Pa = ________ bar = ________ dbar
  p_2 = ________ Pa = ________ bar = ________ dbar
  p_3 = ________ Pa = ________ bar = ________ dbar

- Can you think of a reason why in oceanography pressure is usually stated in dbar?

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- What impact has a change in density on pressure? And what impact has it on the water depth?

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The CTD

The CTD is a probe, which measures **c**onductivity, **t**emperature and pressure, the latter matching water **d**epth. Those probes usually measure continuously, so that researchers can create temperature and salinity profiles. In the central Baltic Sea such a profile, depending on the season, could look like this:

Profile A: ____________

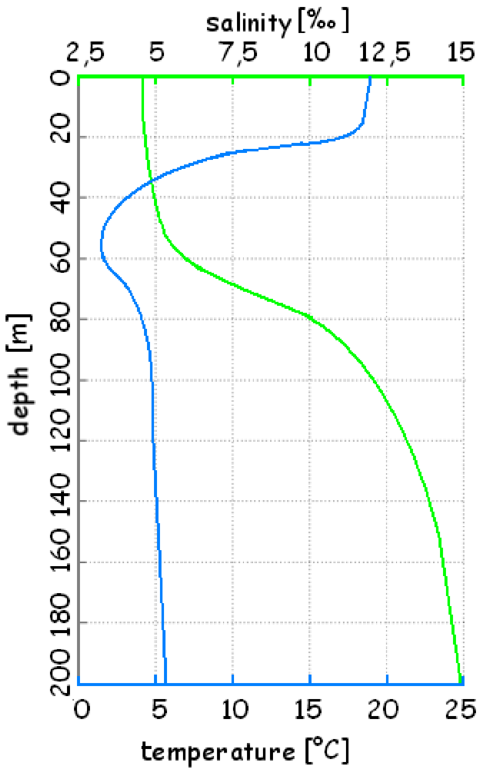

Figure 3: Seasonal presentation of temperature und salinity in the central Baltic Sea[1]

Profile B: ____________

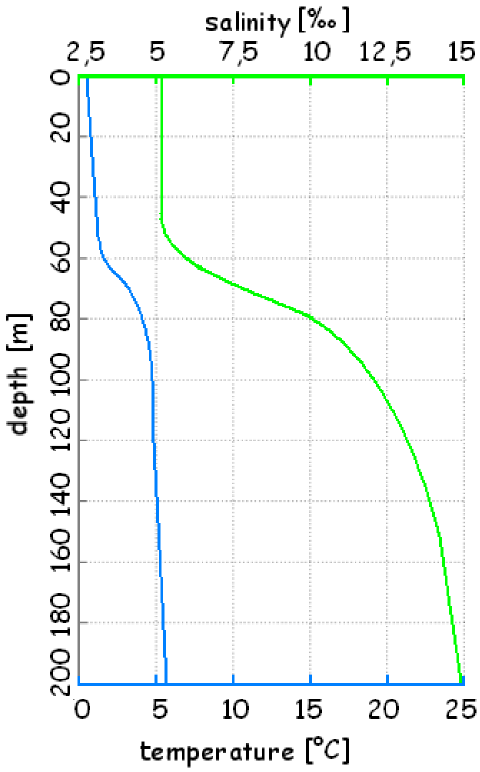

Figure 4: Seasonal presentation of temperature und salinity in the central Baltic Sea [2]

Tasks:

1. These profiles show the summer and winter situation. Can you assign the profiles to the seasons? Give reasons for your decision.
2. Mark the thermocline and the halocline. (These are thin layers in which the temperature (thermo-) or salinity (halo-) respectively changes more rapidly than in the layer above or below).

[1] compare Matthäus (1996) Fig. 32

[2] Loc. cit.

The CTD is used for nearly every measurement in marine research, because it reflects basic hydrographical conditions.
This is the reason why there are many different kinds of CTDs depending on the application area. For example, there are small portable CTD which only have one sensor for each physical quantity.
On board of research vessels (r/v) they usually are measured twice. Often the ship-CTDs have other sensors, too, for example, oxygen sensors. The sensors are combined with a rosette of water samplers, which are tubes that can be closed at a determined point to bring water samples from a certain depth to the surface.
Since they are big and heavy the CTDs set to the water via a winch.

Figure 5: CTD of r/v Elisabeth Mann Borgese with rosette of water samplers

1.) pressure sensor from below
2.) conductivity sensor from below
3.) temperature sensor from below
4.) serial data output for PC
5.) No. 4 with sealing
6.) control lamp
7.) magnet switch
8.) lifting body
9.) sensors
10.) cage for protection
11.) rope

Figure 6: labelled portable CTD

CTDs are also used for long-term monitoring. In May 2013 on a monitoring expedition this profile was measured at 55° 15' north und 15° 59' east (see map):

Figure 8: western Baltic Sea with station TF0213

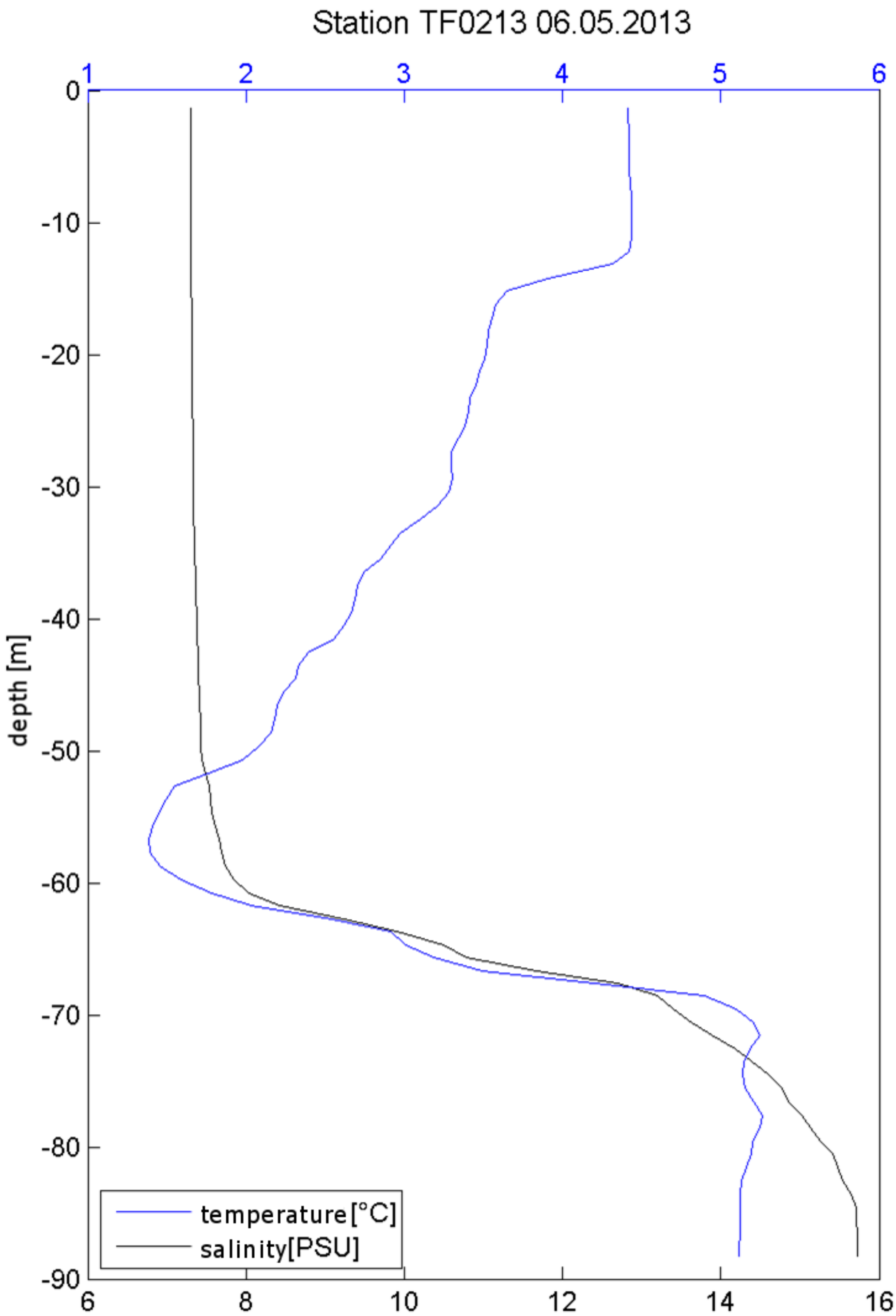

Figure 7: profile of station TF0213 at the 6th of May 2013

Notes: