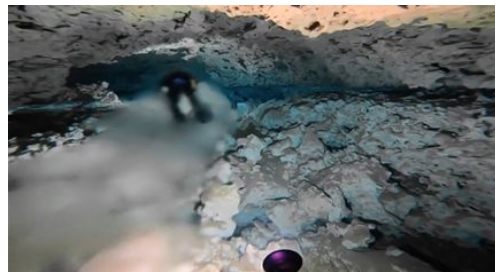
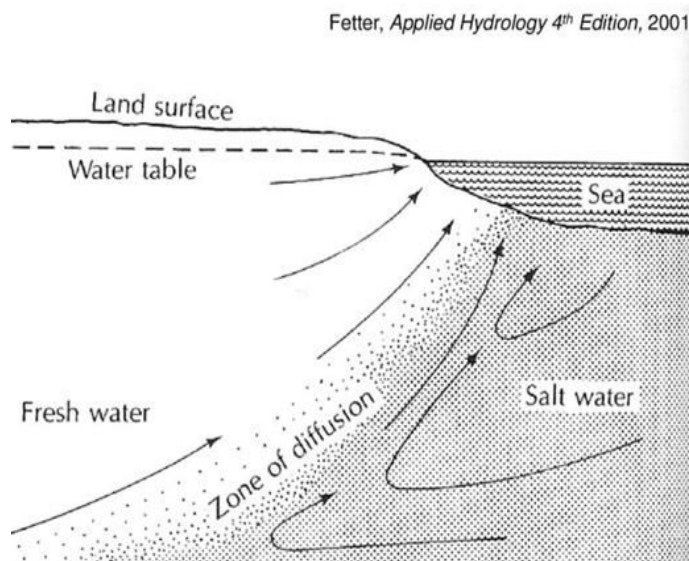


Under the Jungle - Geo Karst challenge - Sunday Aug 9

Flow in the saline water ?

DOES THE SALT WATER IN THE CAVES FLOW? Last week, I recovered a flow meter for Dr. Beddows in a deep salt water passage in Maya Blue. Why put a flow meter in stagnant salt water? One of Dr. Beddows big research questions is how does salt water move, which directions and how fast? And - is the flow below the halocline different then the deeper saline flow in the all salt-water passages? She is working to refine the classic general textbook cartoon showing deep (100+ m) inflow and then outflow of saline water dragged along below the halocline since it does not fit with her data.



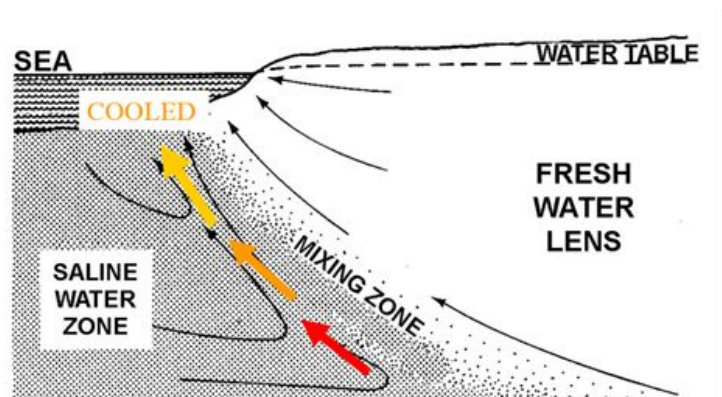
The classic textbook diagram is a generalization - and it basically says that the salt water under the halocline flows unidirectionally towards the coast, and there is mixing along the way. Coastal discharge is a mixture = brackish. There has to be a deep (ie ~ 100 m maybe) inflow of marine water.

Part of the drive to this saline circulation is the mixing along the halocline, and part is also the geothermal heating in the middle of the peninsula that makes the deep saline water less dense.

If this is true - then the saline water in the middle of the peninsula should be WARMER since it is closer to the deep geothermal source, and the shallow saline water gets COLDER as you get closer to the coast.

Circulacion de las aguas salinas

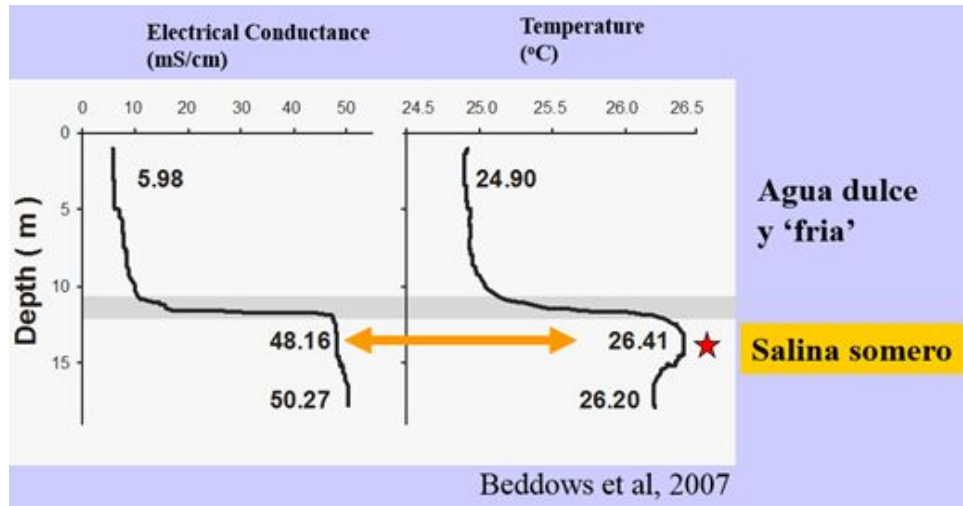
Senal geotermico se puede usar como trazador natural.



Gradiene geotermico es mayor en el Centro de la plataforma

(Cooper, 1964)

If we go around and collect a large number of profiles from caves across the halocline and into the saline water - we find an interesting thing.... Which is that the SHALLOW SALINE WATER which is 1-5 m below the halocline has one temperature, then you hit a mini-halocline and then go into the DEEPER SALINE WATER.



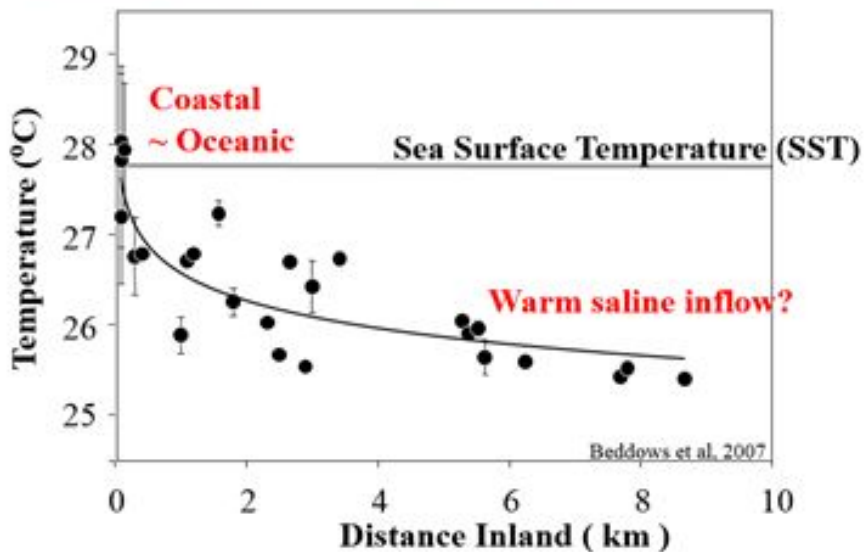
From the collection of profiles - you then take the temperature from 1-5 m below the halocline - and plot them up by distance from the coast.... You *should* find that the hottest SHALLOW SALINE WATER is inland, and the coldest at the coast - since the warm geothermal water cool down little by little as they flow away from the heat source.

WHOA - We have the opposite of the simple textbook pattern

Shallow saline water is warmest at the coast - and colder inland.

And very importantly - the temperature of the shallow saline at the coast MATCHES the sea surface temperature of the Caribbean coastal ocean.

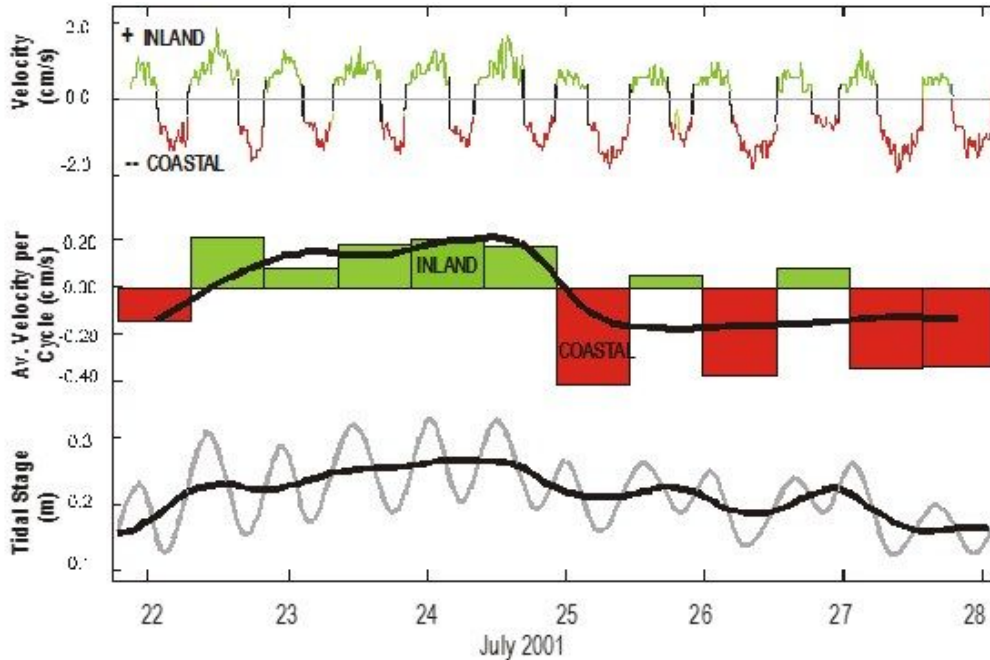
Mas caliente cerca de la costa – indicando flujos del mar al interior



Is it possible that the shallow Caribbean water is at least sometimes flowing INLAND under the halocline?

The answer is YES indeed - which is totally not consistent with the general text book presentation. Several of you have said that you have experienced that - in River Run, or Aerialito.

If you put a flow meter in the SHALLOW saline water - you can also see that the flow switches direction from going INLAND - and then going COASTWARD - all based on the tides and sea level.



The second part of this figure shows in the big green and red block the SUM of the flow over tidal cycles. You can see that the system is switching from NET INFLOW July 23-25, 2001. And then with sea level dropping a bit (lower part - follow the black line "average" value) you can see that the net flow goes to alternative OUT and IN for 4 cycles.... Then with sea level being low enough it goes to the final two blocks being net COASTAL OUTFLOW.

The SHALLOW saline water is dynamically responsive to tides and sea level. And that is NOT consistent with the simple textbook. Not uncommon - that some areas and sites don't match the textbook exactly. You will also notice that there are no caves in that simple diagram. :-)

HOW FAST IS THE SHALLOW SALINE WATER FLOWING?

The shallow saline water velocity can be ~2 cm/s at peak Which is 1.7 km/day. That is impressive.

It is only at those peak velocities though some of the time. If you add up all the + and -s over time, you get saline flow at 100's of m/day in some sites. Still VERY impressive.

Here is one kicker though - it is not uncommon for the fresh water to continue flowing to the coast all while the shallow saline is flowing inland. The velocity across the halocline can therefore be super high sometimes - with fresh water flowing out at cm/s and saline water flowing in a cm/s. Gives a super sharp and super flowy halocline..... Like in River Run, or Xunan Ha.

HOW COMMON IS IT FOR THE SHALLOW SALINE TO BE FLOWING BY TIDES?

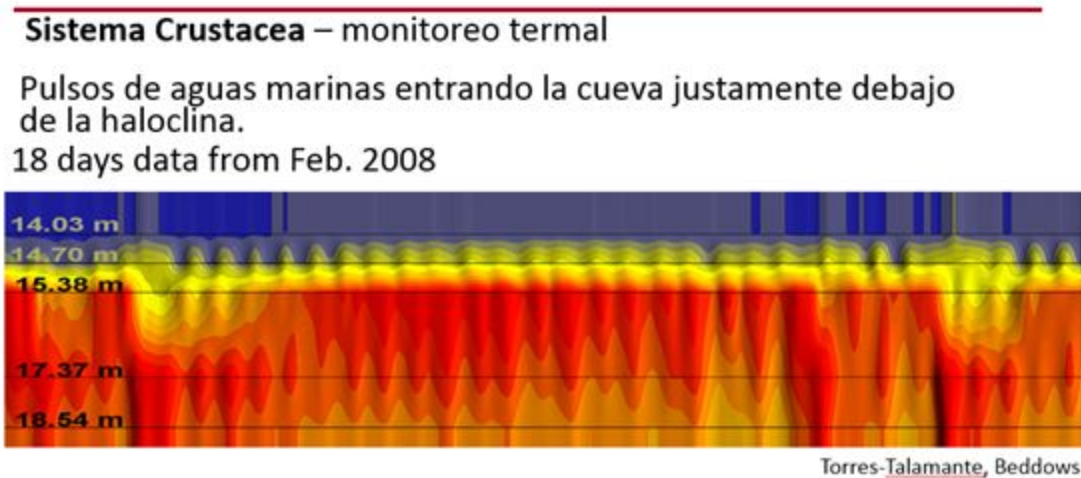
Pretty common.

The temperature plotted against distance from the coast over nearly 10 km transect says this is a regional phenomenon - and either the active saline circulation gets that far inland, or the water cools down enough that we don't see the temperature difference much anymore at ~8-10 km inland.

Not all the fresh water passages are flowing and not all the saline water is flowing. However - when the shallow saline water is flowing I am finding this tidal influence is pretty common - including along the whole coastline.

E.g. Sistema Crustacea in Puerto Morelos

Using the temperature as a nice tracer of the new warm Caribbean water - you can also see the pulses of marine water coming into the systems using temperature strings. The data in the diagram below is from a set of thermometers hung in the cave. The blue is the colder fresh water, the yellow the halocline, and the red are the pulses of warm toasty marine water coming into the cave. This site is ~1 km from the coast.

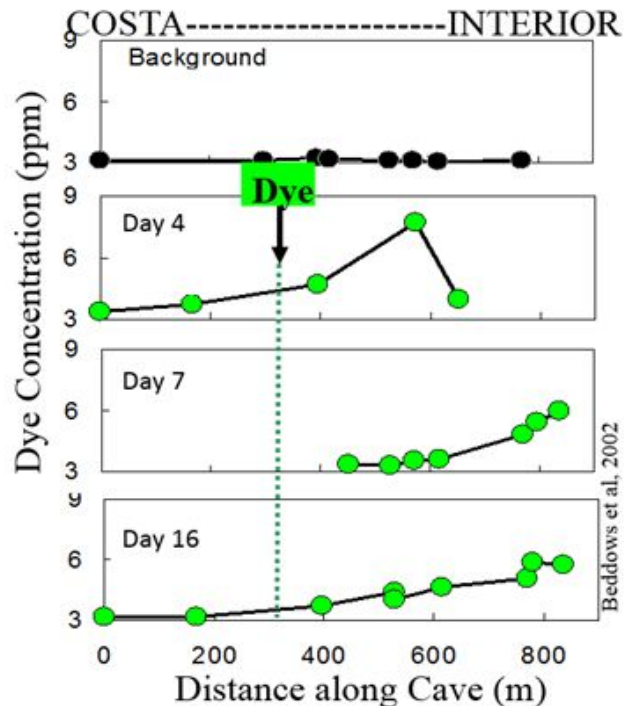


The actual beginning of the story involved a wild goose chase....

The very beginning of this story was that for my PhD I wanted to measure how effective the fresh water was at ENTRAINING the shallow saline water. I released some dye in River Run and it NEVER came out in the samples even though we were sampling 24 hours through the night for 3 days. We lost it.

We ended up diving to find the dye - and there it was way the *%#@& at the end of the cave - which based on the model was IMPOSSIBLE. That was when I put the flow meter in (data from July 2001) and we also did more dye tracing.

Dye was released ~300 m inland of Cenote Ponderosa (which hers is at distance 0 m) and water samples were collected along the flow path in the days that followed. You can see that by Day 4 - most f the dye had moved INLAND of where it was released, although some did work its way toward the cenote. Overall though during this test - the dye moved inland.



Where does the sewage go?

The use of disposal wells assumes that the saline water is flowing to the coast, and away from water supplied. It is also taken that at “normal” groundwater flow rates of meters/year.... That it will take a very long time before the waste water reaches the coast and it will all be nice and cleanly filtered by the aquifer along the way.

Helium balloons rise up - correct?

Similarly - the disposal water from showers and toilets is mostly fresh, and so it will be light/low density and rise up to the halocline....

Once it hits the halocline - it is going to flow with this tidal shallow saline water.

When sea level is low - it is going to flow toward the coast - as expected.

When sea level is high - it is going to flow inland..... A slight problem since there is mixing with the fresh water along the way and it is heading to the water supply well.... Oops.

And there is not much filtering along the way in caves, and even the holes in the rocks.

Since the net flow rates are ~100's of m a day, then disposal water can show up in caves in days/weeks/months..... And not decades and centuries even if the source point is some km's distance away.

FLUJOS DE AGUA SALINA POR EPOCA OCEANOGRAFICO

