

Teaching Notes for new version of Planet Earth Salinity Lesson
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This was modified from a classic data-using lab with step-by-step instructions. This version is intended to have the student doing more self-guided exploration, more making of inference and hypothesis, and less following of detailed instructions. It presumes a 21st century student who is a digital native, and somewhat accustomed to figuring out how to use apps by trying things and seeing what happens.

Learning Goals:

- * All students will experience the process of exploring a professional caliber geoscience data set using a professional caliber data visualization tool.
- * Some students will greatly enjoy the data exploration process and be motivated to do further such explorations, thus increasing their likelihood of moving towards a career in science or geoscience.
- * Students will experience the geoscience habit of mind of reasoning from multiple working hypotheses, and using observational evidence to distinguish among the working hypotheses.
- * Students will strengthen their ability to support a claim by reasoning from observational evidence.
- * Students will strengthen their ability to generate a hypothesis that is compatible with observational data and with theoretical constraints (the known behavior of materials of different density)
- * Students will experience the process of using the behavior of a model to provide insight that they use in their interpretation of a data set.
- * Students will begin to realize that scientific doesn't just answer questions; it generates new questions. And they will strengthen their ability to ask questions of a type that can be answered through data.
- * Students will know that a tongue of salty water exits from the Mediterranean Sea via the Straits of Gibraltar and travels westward out into the Atlantic Ocean in mid-water depths.
- * Students will understand that the tongue of salty water sinks as it leaves the Mediterranean because the high salt content makes it more dense than the surface Atlantic water.
- * More broadly, students will understand that the water in the ocean depths moves around, and that these motions are driven by differences in density.
- * A few students might reason out that the tongue of salty settles out in the middle of the water column rather than traveling along the Atlantic seafloor because it is warmer than the Atlantic water.

Procedure:

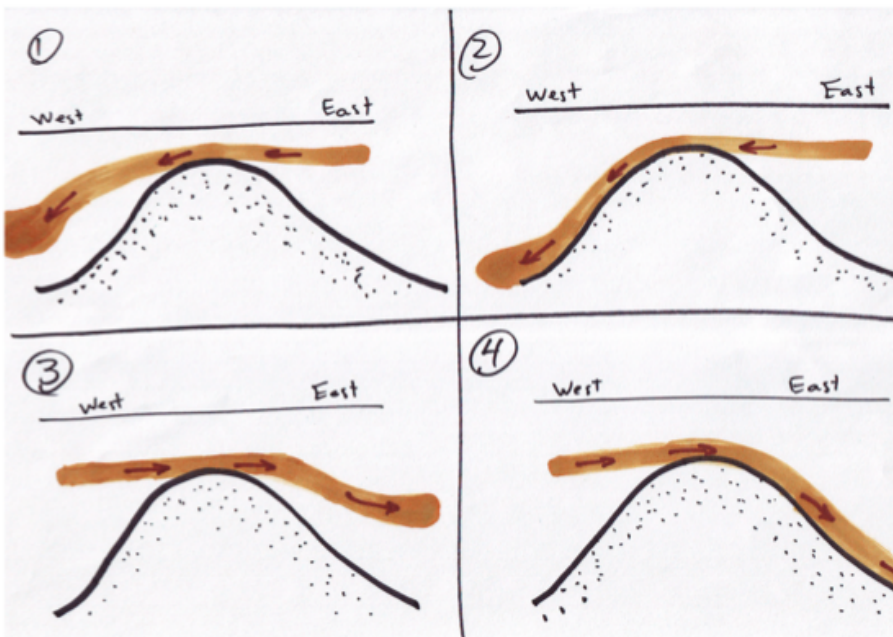
Begin with a demonstration of the behavior of waters of different density. As students watch, prepare a saturated saltwater solution and dye it red with food coloring. Put room temperature tap water in a clear container (a beer glass works especially well), and dye it light blue with food coloring. Carefully pour the salt solution down the side of the glass

(that's why the slant-walled beer glass is good). It will slide under the fresh water and form a two layer, two color system. It is also possible to have students do this themselves, but there is a bit of a knack to getting the two layers to develop, and I'd rather have the students spend more of their time in data exploration.

Lead a discussion of what just happened. Get out onto the table (and onto the blackboard) the idea the two fluids have different densities, and that saltier water is less dense than fresher water, and that the higher density fluid flowed underneath the lower density fluid.

Then introduce the data viewer. As you demonstrate on the computer projector, step quickly through the main controls on the data viewer, as they annotate the diagram on the front page of the student handout.

Explain that they are going to try to figure out what is going on with the flow of water through the Straits of Gibraltar. Sketch four possibilities on the blackboard, which you could refer to as "alternate working hypotheses." Sketches would be something like this:



The format of the revised exercise, in which students' data exploration is scaffolded by providing simple sketches of possible interpretations, was inspired by Mayer, R. E., Mautone, P., & Prothero, W. (2002). Pictorial aids for learning by doing in a multimedia geology simulation game. *Journal of Educational Psychology*, 94(1), 171-185.

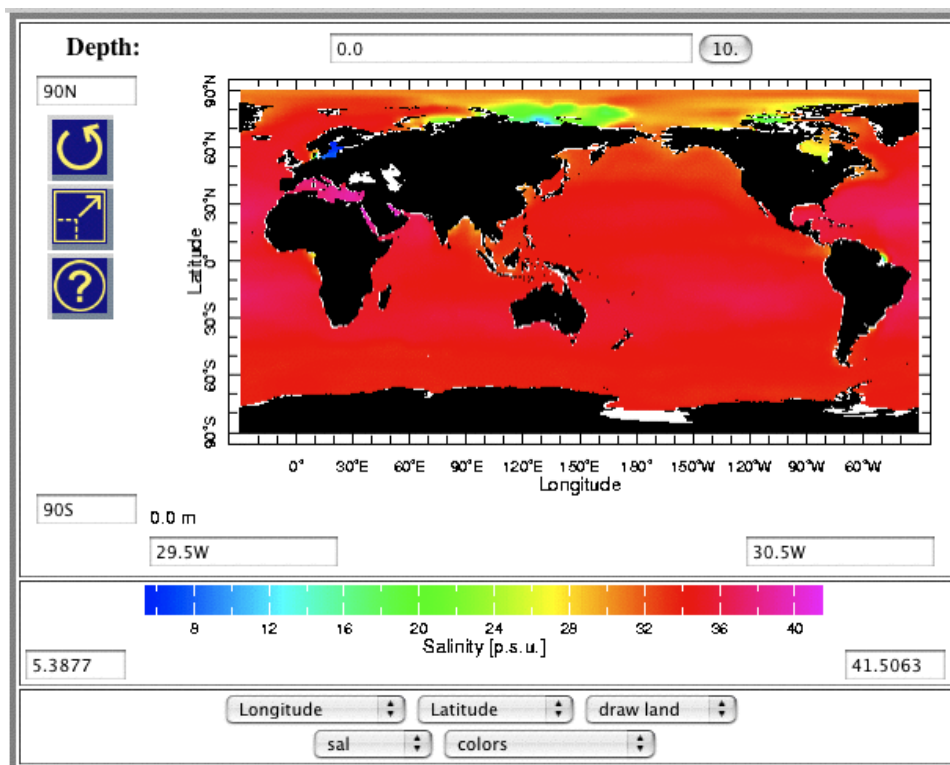
The following two pages are the student handout.

Using the Data Viewer

To Get Started:

- Go to: <http://eesc.columbia.edu/courses/ees/data/>
Look around at the treasure trove of available data.
- Select "Oceanographic Data"
- Select "Annual: Levitus Salinity"
- Click anywhere on the map to pull up the controls.

Controls:



1. Use the Data Viewer to gather evidence in support of one of the three spatial hypotheses for the behavior of seawater in the vicinity of the Straits of Gibraltar, sketched on the board by your teacher. Sketch your evidence below.

2. Write a hypothesis explaining what Earth process or processes might have caused the water to behave as you have sketched above. Take into account your observations from the demo at the start of the class.

3. Write a question that you would like to explore through use of the Data Viewer. The question can be a direct outgrowth of the exploration you have just completed, or not.