Ocean Layering: Density, Salinity, Temperature, and Circulation

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Activity: Stirring and mixing

Goal:

Students will make their own model of the ocean and how water can be stirred around and mixed together. Students are introduced to what a horizontal or vertical slice through the ocean might look like.

Instructor Prep:

- Make or obtain different colors of clay or dough. Each group of students should have two different colors. Clay or dough can be used, a soft dough will just be easier to mix.
- Dough can be easily made, there are several recipes available online. Flour, water, salt, and cream of tartar works well.
- Find plastic knives, one for each group, or something else they can cut the dough in half with.

Figure 1. Example section through the dough. The yellow and blue areas have been stirred. The greener areas have been mixed.

Implementation:

- The same dough can be reused for multiple classes. Start with the primary colors: period 1 mixes red+yellow, yellow+blue, and blue+red. Period 2 then mixes orange+green, green+purple, and purple+orange. If the dough looks too similar after a few periods, mix in some more food coloring.
- Put the students in groups, 4-5 students per group works well.
- Tell the students they are going to make their own model of the ocean. They will be given two different colors of clay and each person in the group will get to try and mix them together. The different colors are different types of water. They could be fresh water and salty water, warm water and cold water, water with an oil spill and water without, water with sewage outflow in it and water without, water with a lot of tiny plants in it and water with almost no plants in it, etc.
- Pass out the clay so that each group has two different colors.
- Go over the directions. The first person will start mixing when I say “START” and pass it to the next person when I say “PASS”. Everyone will stop when I say “STOP”. What does “PASS” mean? Pass it to the next person in your group.
- Let each student mix the dough for about 10-15 seconds for dough or longer for clay. The goal is to end up with colors that are not completely mixed as in the figure above.
- Have each group form their dough into a ball. Cut the ball in half.

- Discuss what the slice through the dough looks like. What do you see? It's swirled and stirred and mixed and twisted. How many colors can you see? Probably three, there are areas where the colors did not mix at all (blue+yellow) as well as areas where they did (green). How well did the two colors mix? Can you put a number on it? In the figure above, it did not mix completely because there are areas that are still yellow and blue. It did mix some because there are areas that are green. How much is green? Maybe 40%. This is just a very rough number to get the students thinking about quantifying what happened.
- At the end of each period, have the students fully mix the two colors into one so they can be used for the next period.

Conclude:
- Bring the discussion back to the ocean. The ocean is so big that oceanographers cannot look at all of it at once. One way to figure out what is going on is to take a slice through the middle, just like the slices through the dough. The different patterns that are visible in the dough tell you what happened to the dough, and the different patterns in the ocean will tell you what happened to the ocean. The slices can be in the horizontal, such as the temperature at the surface observed from satellites, or in the vertical that shows temperature from the surface to the bottom.

Possible Extensions:
- Use a straw to take a core through the clay. This is like taking a sediment core through the earth and looking at the different layers of sediment, or like taking a single profile of ocean temperature or salinity, or sending a weather balloon through the atmosphere. Scientists would like to know everything in three dimensions, but practically they cannot.
- Do you get a different picture if you cut the clay in a different direction or different place? The answer will depend on how the students mixed the clay. Most likely they will see similar swirling patterns no matter where they slice. But a group could just concentrate on mixing half of the clay very well so that there was one area that was well mixed and one area that was not mixed at all. Slices through these regions will be different. In the ocean, a vertical slice is very different from a horizontal slice.
- Try and separate the two colors: how much of each color can you completely separate, how much cannot be separated? This is one way to estimate how well the dough is mixed. If you can separate 40% of it back into its original colors (blue or yellow), and 60% of it is green, then the dough is 60% mixed.
- Try and find the most efficient way to mix two things: squish, twist, fold, press, punch, throw on floor, etc. This should lead to some good experimentation, and will require more dough or food coloring for multiple experiments. The most efficient way will be to stretch the layers out so there is a lot of surface area between the two colors. Kneading does this pretty well, push to stretch the dough out, fold it over, then give it a quarter turn and repeat.