SMS-303: Integrative marine sciences III.

Lab 3, Mixing.

I. Convective mixing:
You have three tanks. In one you have a heating element on the bottom, in one you have a heating element near the surface and in the third you will put ice.
Before you do anything answer the following:
Q: Which do you expect to cause the most mixing through entrainment of adjacent waters?

Plug both heating element, put ice in the third tank and use food coloring to trace the waters.

Q: Observe the circulation and speculate where in the oceans does such a circulation takes place. Discuss at least one oceanic setup for which each tank is an analogue for.

Students (Kayla, Michelle and Erin) fascinated by convection above a submerged heating element (left) and below ice (right). Convection causes the fluid to rise or sink entraining with it surrounding fluid. A surface heating element does not cause convection except around it.

II. Kelvin-Helmholz billows:
In a long skinny cylinder you have water overlaid by mineral baby oil. You are about to lift one side (the right one) and observe what happens at the interface between two fluids flowing in opposite directions (why do will they flow in opposite direction?).
Q: What do you think will happen at the interface between the two fluids?
Lift the right side 10-20cm above the table and observe the interface.
Q: Why don't the two fluids mix?

Erin, Michelle and Kayla observe the formation of KH billows in a tube. Elevating one side of the tube slowly does not cause waves to form on the interface between the two fluids, however raising it rapidly does. These waves grow and eventually break.

III. Mixing of dyed water:
Fill a small rectangular tank with water from the tap. Put a divider between both sides of the tank and put 4 drops of green food coloring in one side and 4 drops of yellow food coloring at the other side. Mix each side and wait until the fluid is at rest.
Q: What will happen when you raise the barrier between the two sides?
Raise slowly the barrier and observe what happens. Write carefully the time when you opened the barrier on the tank and come periodically to observe the evolution of the fluid.

Jen and Brianne add dye to the two compartments. If all is at rest prior to the experiment, both halves of the tank will maintain their color throughout the lab with little mixing occurring at the center of the tank. This showcase how slow mixing is in the absence of stirring.

IV. Diffusion of momentum:
You have a round vessels full of water on a rotating table.
Q: How will the fluid react when you start/stop the rotating tank?

Use dye to check your answers as you start the fluid rotating and then stop it. Use pieces of paper to determine how fast the fluid is rotating.

Kayla, Erin and Michelle observe how momentum propagates into and out of the boundary of a rotating tank as it is spinned down or up. Dye near the boundary exhibits how stirring and mixing is accelerated in zones of high shear.

V. Wind mixing:

You have two tanks filled with water and a hair dryer. One tank is stratified the other is not.

Before you start discuss the following questions:

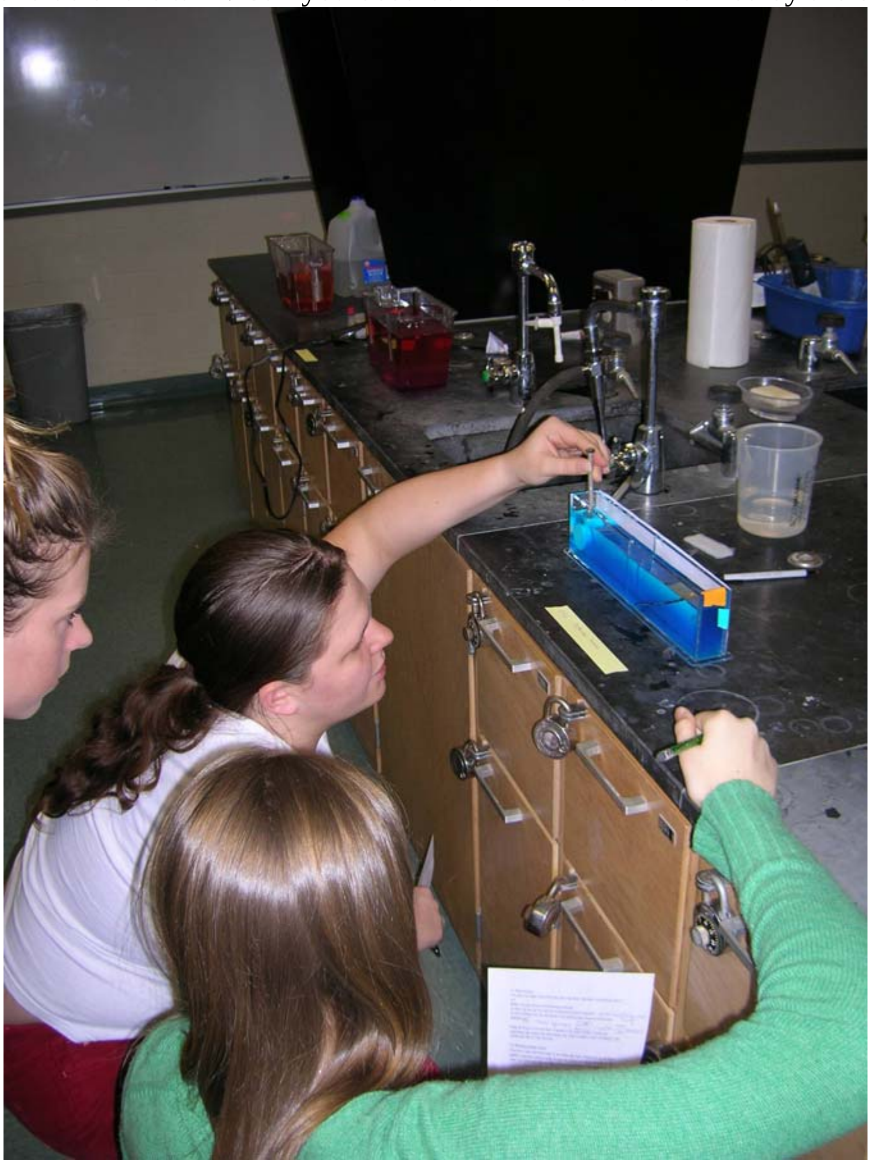
Q: How can you use the food dye to determine which is stratified?

Q: How different will the mixing be in the stratified tank compared with the non-stratified one?

Keep the dryer on low and direct it parallel to the water's surface. Perform the experiment and explain the observations. BE VERY CAREFUL NOT TO INSERT THE HAIR DRYER IN THE WATER.

Rachel, Rebecca and Paul (left) and Jen (right) study how stratification inhibit winds penetration. In a non stratified tank wind stress easily mixes the fluid top to bottom causing overturning of the fluid. In a stratified tank the layer below the pycnocline is isolated from direct wind effects. The wind excites internal waves at the pycnocline that do cause motion within the lower layer, however the fluid below the pycnocline exhibit little mixing compared to the fluid above.

VI. Breaking internal waves.
You have a tank with fresh water on top of blue salty water. Slowly move up and down a paddle to generate internal waves. See how they interact with the sloped surface on the other side of the tank. Can you observe the mixed fluid formed by the breaking waves?



Brianne excites internal waves that propagate along the tank and break on a sloping boundary. Such a mixing mechanism has been found to be significant in the ocean.

In class demo: cabeling

Emmanuel demonstrates cabeling. Fresh water overlays salt water. When mixing occurs the density of the combined fluid is denser than the average density of the fluid before mixing. This results in a change of volume of the fluid that can be observed using a long narrow tube extending upward from the vessel.

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