SMS-303: Integrative marine sciences III.

Lab 5, Mixing.

Stations and activities:

I. Convective mixing, heat:
You have two tanks. In one you have a heating element on the bottom, in one you have a heating element near the surface.
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 (if they are not plugged already) 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.

The heating elements simulate sun heating from the ocean (top) and subsurface source of heat (heater at bottom of tank). When heating from the top water column stratifies while heating from the bottom reduces stratification, entraining surrounding waters and creating a convection cell.

II. Convective mixing, ice:

You have a tank in which you will put ice (or there may be ice already).
Q: How will the ice affect the circulation if you put it all in one place?

Use dye to trace water as it interacts with the ice.

Q: Observe the circulation and speculate where in the oceans does such a circulation takes place.

Convection under ice entrains surrounding waters into depth similar to circulation patterns in Polar Regions as well as in Maine lakes. In the oceans, salt rejection from recently formed ice provides additional contrast between water under the ice and surrounding waters.

III. 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?

Kelvin-Helmholtz bellows (internal waves) form at the interface of two immiscible fluids (fluids that cannot mix) due to an instability that arises from the shear (one fluids flows to the left the other to the right). Similar waves in the ocean break and mix fluid from below the density interface with fluid from above, as at the base of the oceanic mixed layer (or top of bottom boundary layers).

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 sawdust to check your answers as you start the fluid rotating and then stop it and to determine how fast the fluid is rotating as function of distance from the boundary.

Shear arising from movement of the boundary of the container causes large shear which generate an instability (similar to K-H above) that mixes fluid with different momentum propagating momentum across the fluid towards the center of the tank. Stopping the rotation generate strong shear with the momentum now propagating from the fluid into its sink at the tank wall. In that manner friction is much enhanced and momentum propagate much faster than one would predict based on molecular viscosity.

V. Wind mixing:

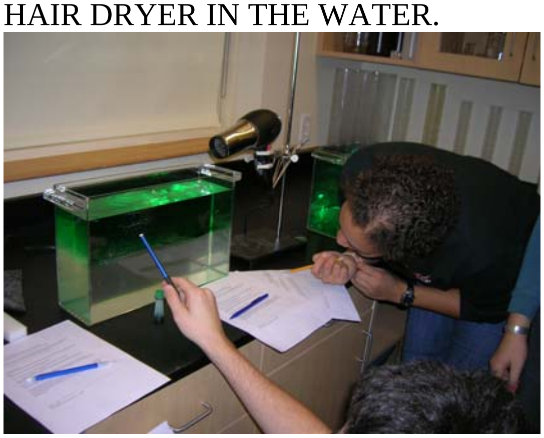
You have two tanks filled with water and a hair dryer. One tank is stratified the other is not.

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.



Despite strong 'wind' fluid from the upper layer does not mix much with lower layer fluid due to the density contrast between them (while mixing well within the upper layer). When no density contrast is present mixing occurs throughout the tank.

VI. Breaking internal waves.

You have a tank with fresh water on top of blue salty water. Slowly move up and down once paddle to generate an internal wave packet. 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?

An internal wave propagating along the interface breaks on a beach causing mixing between the fluids across the interface.