EEB 325 Water Movement Lab
Fall 2017 Due 7 November 2017

Water Movement Lab

This exercise uses ordinary fish aquaria to illustrate the hydrodynamics of water in lakes as it is subject to heating, cooling, and the action of wind. Specifically, we will examine how light, ice, and wind interact to control thermal distributions in lakes during a complete annual cycle (i.e., from winter ice cover to summer stratification to autumn turnover). We also will examine the effects of wind energy on water currents.

Materials:
Aquarium with depth marked in 1cm increments
Thermometer
Lamps with 200w bulbs (suspended above water)
Styrofoam
Food dye
Fan/hair dryer
Stopwatch
Strainer
Lab notebook

Procedure:

1) Add ice to your aquarium and mix until the lake is uniformly 4°C. Allow the system to come to rest with a thin layer of ice floating on the surface.
2) Apply a moderate wind (**1st wind**) with fan to the surface of the water by blowing from one side and then the other. After a minute or two, record the temperature at depth intervals, every 0.5 cm from surface to 4cm, and then every cm afterwards. Is the temperature uniform? What season is this temperature profile associated with?
3) Remove all of the ice with a strainer, save the ice in a bucket or bin. If the water level changes, record N/A for measurements until the lake level. Apply moderate to strong wind (**2nd wind**) for a few minutes. Record temperatures as before. Is the temperature uniform? What is this type of temperature profile called?
4) Fix you lamp above the lake's surface (safely!). The closer your lamp is to the water surface, the faster the water will heat up. Turn them on and allow entire surface of the water to heat up to 25°C. You can use the time you wait to start thinking about the problem set questions.
5) When surface temp reaches 25°C (with lamp still on), scatter 6-9 drops of food coloring evenly over the surface of the water. Record temps at each depth interval. Record depth of the homogenous colored layer.
6) While dye is in upper third of water column, apply more wind **gently** (**3rd wind**), blowing from one side and then the other. After a few minutes, the upper portion of the water column should be well mixed. At this point, turn off the light and stop the fan to allow the currents to slacken.

7) Hold the fan 2-3 feet from the tank and at a **low angle**. Turn the fan on again (**4th wind**). Blow gently from one side approximately 5-10 seconds do that the surface water builds up on one side. You should see a tilt of the thermocline of about 10-15 degrees. You are creating an internal seiche, an oscillation of the thermocline. Turn off the fan and time the period of oscillation using a stopwatch. A period is the amount of time required to complete the up and down motion. Take the average of three measurements.
8) Allow the system to come to rest. Carefully add a layer of ice to the surface with minimal disturbance of water. Observe the descending convection cells sinking through the thermocline region. When the thermocline is at mid-depth, carefully remove the ice.
9) Apply a **strong** (**5th wind**) to turn the lake over. When mixing is complete, record temperatures.
10) Clean tanks and turn over to dry.

Procedure adapted from West Virginia University Limnology Lab Manual 2010

Water Movement Problem Set/Guiding questions:

1) Plots of Temperature vs. Depth: Graph your 4 data sets, Wind 1, Wind 2, *just* prior to Wind 3, and Wind 5.
    a. Describe the thermal patterns you see and what causes them. Describe the seasonal aspects of the changes you are seeing.
    b. What is the ecological significance of thermal stratification in Summer? Fall turnover?
2) Plots of Density vs. Depth: Use the attached table of water density as a function of temperature, plot water density as a function of depth for **D1** and **D2** on the same graph.
    a. Use inference to determine the conditions necessary for a river influent to flow on top versus into the hypolimnion.
3) Period of internal seiche:
    a. What was the period of the internal sieche you created?
    b. Define seiche in your own words, and what is its limnological significance?
4) How does using a model lake in a lab help us to understand the hydrodynamics of dimictic lake? What are the limitations of this approach?
5) Calculate the theoretical period of the internal seiche you created (show your work). The period is the time required for the oscillation to complete one up-and-down cycle. The period (T) of a unimodal, internal seiches in a rectangular basin of uniform depth, when the two layers have thicknesses of Z_e and Z_h (e=epilimnion, h=hypolimnion) and mean densities of the epilimnion (D_e) and hypolimnion (D_h) is given by:

$$T = \frac{2L}{\sqrt{\dfrac{g(D_h - D_e)}{\dfrac{D_h}{Z_h} + \dfrac{D_e}{Z_e}}}}$$

    where L= length of the basin in the direction of the wind (fetch) and g= acceleration of gravity (980 cm/s^2)

    Use the density info from your aquarium to estimate the theoretical period of an internal seiche. Our aquaria are 30 cm long and 21 cm deep. Define all your terms. Compare your theoretical calculation to your observed (average) period. Why might they differ?

STRATIFICATION LAB DATA SHEET

Depth (cm)	Temp After Wind 1	D1 g/cm^3 (from Wind 1)	Temp After Wind 2	Temp Before Wind 3	D2 g/cm^3 (from Wind 3)	Temp After Wind 5
0						
0.5						
1						
1.5						
2						
2.5						
3						
3.5						
4						
5						
6						
7						
8						
9						
10						
13						
17						
21						

TABLE 7. *Density of water as a function of temperature from 0° C. to 35° C. at a pressure of 1 atm.*

°C.	0.0	0.1	0.2	0.3	0.4
0	0.9998679	0.9998746	0.9998811	0.9998874	0.9998935
1	0.9999267	0.9999315	0.9999363	0.9999408	0.9999452
2	0.9999679	0.9999711	0.9999741	0.9999769	0.9999796
3	0.9999922	0.9999937	0.9999951	0.9999962	0.9999973
4	1.0000000	0.9999999	0.9999996	0.9999992	0.9999986
5	0.9999919	0.9999902	0.9999883	0.9999864	0.9999842
6	0.9999681	0.9999649	0.9999616	0.9999581	0.9999544
7	0.9999295	0.9999248	0.9999200	0.9999150	0.9999099
8	0.9998762	0.9998701	0.9998638	0.9998574	0.9998509
9	0.9998088	0.9998013	0.9997936	0.9997859	0.9997780
10	0.9997277	0.9997189	0.9997099	0.9997008	0.9996915
11	0.9996328	0.9996225	0.9996121	0.9996017	0.9995911
12	0.9995247	0.9995132	0.9995016	0.9994898	0.9994780
13	0.9994040	0.9993913	0.9993784	0.9993655	0.9993524
14	0.9992712	0.9992572	0.9992432	0.9992290	0.9992147
15	0.9991265	0.9991113	0.9990961	0.9990808	0.9990653
16	0.9989701	0.9989538	0.9989374	0.9989209	0.9989043
17	0.9988022	0.9987848	0.9987673	0.9987497	0.9987319
18	0.9986232	0.9986046	0.9985861	0.9985673	0.9985485
19	0.9984331	0.9984136	0.9983938	0.9983740	0.9983541
20	0.9982323	0.9982117	0.9981909	0.9981701	0.9981490
21	0.9980210	0.9979993	0.9979775	0.9979556	0.9979335
22	0.9977993	0.9977765	0.9977537	0.9977308	0.9977077
23	0.9975674	0.9975437	0.9975198	0.9974959	0.9974718
24	0.9973256	0.9973009	0.9972760	0.9972511	0.9972261
25	0.9970739	0.9970482	0.9970225	0.9969966	0.9969706
26	0.9968128	0.9967861	0.9967594	0.9967326	0.9967057
27	0.9965421	0.9965146	0.9964869	0.9964591	0.9964313
28	0.9962623	0.9962338	0.9962052	0.9961766	0.9961478
29	0.9959735	0.9959440	0.9959146	0.9958850	0.9958554
30	0.9956756	0.9956454	0.9956151	0.9955846	0.9955541
31	0.9953692	0.9953380	0.9953068	0.9952755	0.9952442
32	0.9950542	0.9950222	0.9949901	0.9949580	0.9949258
33	0.9947308	0.9946980	0.9946651	0.9946321	0.9945991
34	0.9943991	0.9943655	0.9943319	0.9942981	0.9942643
35	0.9940594	0.9940251	0.9939906	0.9939560	0.9939214