Lake Pontchartrain Salinity Stratification

Carol Franze, Louisiana Sea Grant/LSU AgCenter

Overview: In this lesson, students will learn about coastal estuarine habitats, how salinity can vary vertically in a given place and why parts of Lake Pontchartrain aren't fully mixed.

Key words/topics: Lake Pontchartrain, salinity, stratification, saltwater intrusion, animals (fauna), hypoxia, anoxia, hydrology, tidal influence, Mississippi River Gulf Outlet

Activity Supplies:

Glass Container – tall, clear vase. Can substitute large water bottles or tennis ball canisters
Measuring cups
Mixing bowl – easy to pour from into Vase
Tongs
Coffee filter
Salt
Food coloring or Easter egg dye

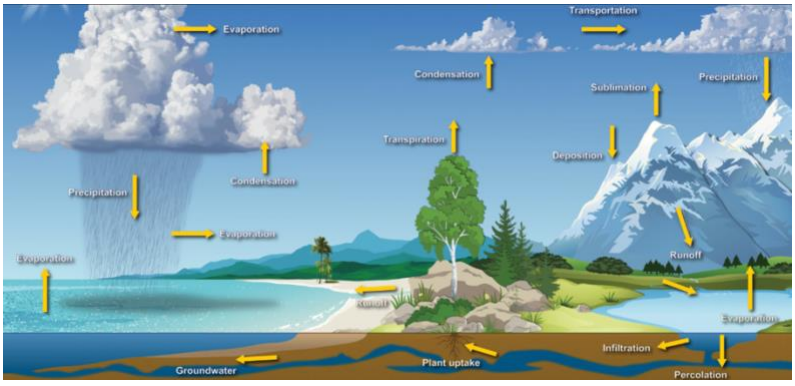
Activity Instructions (can follow along with the video):

(1) Mix ½ cup of salt with 3 cups of water (or other similar ratio). You can heat water to help dissolve the salt, but let the water cool before continuing. Pour this solution into vase.
(2) In a separate container, mix water and dye or food coloring. Any color will do, but darker colors show a better contrast.
(3) Take a coffee filter and place in the vase on the top of the saltwater.
(4) Slowly pour the colored water into the container, making sure not to disrupt the coffee filter. Colored water should be above the filter.
(5) Carefully remove the coffee filter with tongs or your fingers, whichever is easiest.

The saltwater should be on the bottom and the colored water should stay at the top. This demonstrates stratification and will only mix if the container is agitated.

(6) Apply a stirring motion to the surface (mimicking waves). What does this do? *The stirring/wave action will not cause full mixing, however the area where dilution is occurring gets larger.*
(7) Leave the mixture out for a long period of time. What happens? *The colored water layer begins to dilute and mix at where the salt and fresh meet.*

Discussion: Rainwater is freshwater, it has no salt. Ocean water is salty around 33 parts per thousand. Aquatic systems with a salinity between fresh and saltwater are called brackish. Ocean waters are *diluted* with freshwater coming from rivers and streams and urban rainfall runoff (as in the case of New Orleans when rainwater is pumped out to the Lake). Normal *tidal* movement of oceans along shorelines mixes the fresh and



Hydrological Cycle. Source: www.noaa.gov/education

saltwater. Additionally, wind—by direction and strength—helps to mix coastal waters. These different salinities and habitats can be seen all along our coastline. One of Louisiana's largest estuaries is in the Pontchartrain Basin.

Lake Pontchartrain is the large, open water bay in the Pontchartrain *Estuary* located in southeast Louisiana. It connects freshwater rivers and streams along its northern and western shorelines with Gulf of Mexico saltwater through natural passes (Rigolets and Chef) and manmade waterways— the Mississippi River Gulf Outlet (MRGO). A map of the Pontchartrain *watershed* can be found at the following web-link: https://saveourlake.org/apea-drawing/. Using this and Google Maps (See Resource Links) the major rivers and streams, metropolitan areas, major roads and bridges, natural passes and rural areas can be identified.

Water Salinity. Source: P. Summerlin (Wikipedia)

One of the many stressors on Lake Pontchartrain is saltwater intrusion through the Mississippi River Gulf Outlet (https://pubs.usgs.gov/of/2002/of02-206/restoration/lpbf.html). Due to the input of freshwater through rivers, streams and rainfall runoff, the Pontchartrain Estuary is a low salinity basin. The historic average salinity in Lake Pontchartrain is 3.5 ppt, however, recent salinity measurements have been lower due in large part to the closure of the MRGO and recurrent openings of the Bonnet Carré Spillway in the southwestern portion of the lake. Rainfall during late winter and spring during a time when dominant wind and frontal passages are west and northwest, saltwater is pushed out of the basin. In the late spring and summer through most of the fall, the dominant wind and weather patterns are out of the southeast and south, when saltwater is pushed into the basin through open channels (MRGO, Rigolets and Chef Passes).

Since the Estuary is low salinity, the plant communities can be adversely affected by periods of high salinity. Freshwater animals that can't move away from high salinity can also be affected, not only by the stress of high salinity water, but also from oxygen depletion when the water becomes stratified. Salinity stratification occurred in Lake Pontchartrain after the Mississippi River Gulf Outlet was opened in the 1960s and persisted until its closure in 2009.

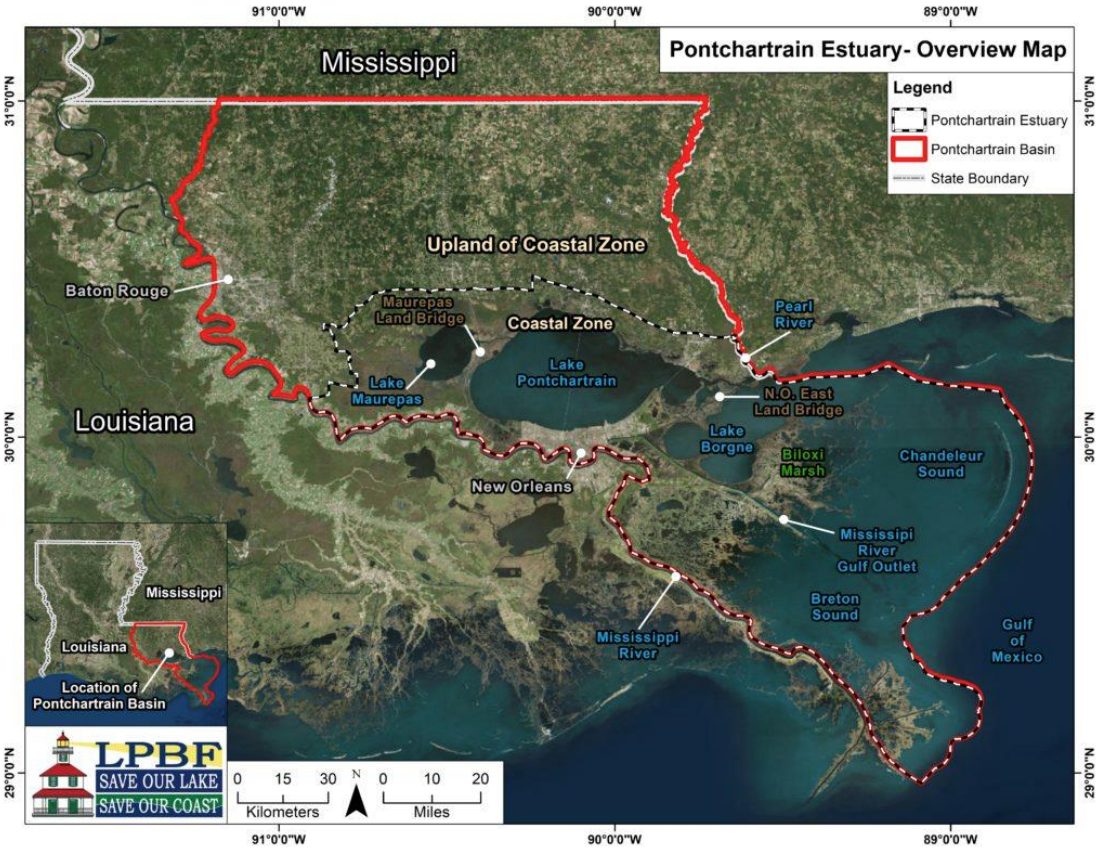
How does salt stratification develop?
In Lake Pontchartrain, high salinity water from the Gulf of Mexico moves into the lake through the Inner Harbor Navigation Canal (IHNC). The IHNC connects the Intracoastal Waterway and the MRGO to the Lake. These waterways are deep to accommodate large sea going vessels. Since the average depth of Lake Pontchartrain is 3 m (about 15 ft.) and because saltwater is denser than freshwater, during summer months the Gulf of Mexico water is forced as a wedge up into the basin. As it spreads out under the fresh water in the deeper areas of the Lake the barrier between the dense saltwater and lighter freshwater doesn't mix. Eventually oxygen is used up in the dense, salt layer and the animals there become stressed and die. This area—referred to as the dead zone—sets up during the early summer and persists until winter when north-northwesterly frontal passages become frequent and strong. Water level in the Lake is lower as wind pushes water out through the passes and the IHNC and reduces the high salinity and the wedge under the freshwater.

Why does the oxygen get depleted in the salt layer?
All animals need oxygen. The oxygen we breathe is a by-product of photosynthesis from plants, algae and other phytoplankton. Oxygen doesn't easily penetrate the surface of water, unless there are waves or

surface disruption. Light penetration into water is the typical limiting factor for oxygen production. As sunlight hits water it is significantly scattered and only some of the sunlight penetrates the surface and will continue to be reduced the deeper the light travels through the water column. The area light penetrates is the photic zone, where plants make oxygen. During the night oxygen production diminishes or stops altogether. Think of a snow globe with water in it. It is closed and no additional water can be put in and none can get out. If the animals are breathing 24 hours a day, the oxygen can get used up, a low oxygen environment would be called hypoxic; no oxygen would be anoxic. There are some animals that can live in these low oxygen situations, but most will be stressed and die if it remained low or depleted. Mobile animals can move away from the hypoxic or anoxic waters.

The salt stratified water can remain for 4 to 5 months and the extent of the affected water bottoms has reached over 100 sq. mi. The *Rangia* clam is an animal that could not move out of the affected area, resulting in significant losses in Lake Pontchartrain. *Rangia* clams serve as a keystone species that indicates the health of the water bottoms. Since the closure of the MRGO, *Rangia* clam numbers have increased, indicating salt stratification and high salinity water in Lake Pontchartrain has been reduced and is no longer an issue affecting water quality.

Questions to Check Understanding



1. On the map provided please identify and mark the following features:
    a. Draw a circle around Lake Pontchartrain
    b. Within the lake, draw a plus sign where the salinity is higher
    c. Within the lake, draw a negative sign where the salinity is lower.
    d. Put a star next to the Mississippi River Gulf Outlet

2. What is salinity and how does it form?

3. It's late summer. Which direction is the wind coming from and how is it affecting salinity in Lake Pontchartrain?

4. What would likely happen to the *Rangia* clam population if the Mississippi River Gulf Outlet were to be reopened? Why?