Agricultural Research & Technology
Open Access Journal
ISSN: 2471-6774

Juniper PUBLISHERS key to the Researchers

Opinion
Volume 13 Issue 1 - January 2018
DOI: 10.19080/ARTOAJ.2018.13.555873

Agri Res & Tech: Open Access J

RxHYPOXIA Idea for the Gulf Mexico "Dead Zone"

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Submission: December 16, 2017; **Published:** January 08, 2018

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Opinion

The cartoon shows the horizon in the distance, a spinning wind machine in the seawater, surface waves on the Gulf of Mexico and underneath a vertical slice through the shallow water column showing undersea water currents moving from left-to-right above the seabed. The illustration depicts the overall oxygen (O2) chemodynamics produced by the action of the wind machine and water mixer fixed onto the sea bottom. In combination, the coupling drives the transport of highly oxygenated sea surface water downward to aerate the bottom waters with low to zero oxygen content. Large turbine blades draw power from the atmospheric wind, rotate a drive-shaft fitted with propeller blades attached and mix a single targeted water layer positioned deep in the water underneath the surface waves. The layer is approximately one meter in thickness or less. Once mixed the layer retains its vertical position as it moves in a horizontal direction away from the mixer.

The stratification of the Gulf seawater is not depicted in the cartoon however, it is a necessary concept to understand with respect to the targeted layer and occurs as follows. All marine water is stratified vertically in layers of various density. Low salt content, warm freshwater from the rivers entering the sea has a low density. This high buoyancy water appears on the surface of the ocean where the wind waves often seen. The very salty and much cooler water underneath has a high density, lacking buoyancy it resides at depth in the water column. It is a large body of and water and extends to these a floor where currents are slow. On the shelf many well defined layers will form between sea surface and sea floor. This curious result is a vertically stacked system of water volumes with relatively thin vertical layers (~1 to 10m thickness) and extremely large horizontal surface area (~1,000 km2).The layer targeted for mixing is one within the stack. Another curious feature of stratification is that the system of layers remixes extremely slowly. It takes centuries and more for the layers in a basin to remix. However, natural mixing does occur within each individual layer. All stratified layers are not created equal, they have various thickness and mixing rates (aka diffusion coefficients). Now back to the cartoon contents and oxygen.

The rotating propeller blades destroy any water density stratification and mix the oxygen within to uniform value throughout control volume reach. Typically, the vertical reach distance is centimeters to a meter and a function of the power, rotation speed and diameter of the propeller. After mixing the layer moves horizontally to the right and off-stage with the water current, so to speak. The layer now possesses a high degree of sustained turbulence imparted by the action of the propeller. Its ability to transport oxygen vertically downward towards the sea floor is now significantly enhanced. In other words, the once "choke point" oxygen transport-resistant layer has been replaced by one that rapidly moves the oxygen within downward to the next layer. This mixing of a single layer increases the efficiency of oxygen movement (aka flux) along its entire pathway distance from the sea surface to the sea bed. Such is the mandate of the well-known resistance-in-series (RIS) law of diffusive chemical transport theory. A corollary of the theory demands that all the oxygen concentrations throughout the water column, from sea surface to sea bed, must increase appropriately to accommodate the presence of the mixed layer. This means the water oxygen concentration near or on-bottom must increase and be enjoyed by the wildlife living there. A theoretical calculation follows to provide details.

Using year 2015 measured oxygen data obtained at sample station C1.hex offshore Louisiana in four meters water, an example calculation with the constant flux model (CFM) is presented, and shown making a theoretical prediction of expected improved O2 concentration that may be achieved by mixing a single layer. The CFM identified layer #3 from the surface spanning the depth 1.4 to 1.7 meters as the significant "choke point" in restricting O2 transport. Sea surface concentration is 6.6gr O2/m3 but, the measured values at depth were much lower, at depth 2.8m. and deeper they were 0.0. Clearly a hypoxic condition existed at this sample station. The CFM derived diffusion coefficient for the layer was estimated to be 0.44m2/day and the layer was contributing 24% of the total transport resistance. Assuming propeller mixing is 97% efficient in destroying the resistance, the RIS model projects O2 concentration 1.6g/m3 at 2.4m and 1.1g/m3 on the sea floor. Clearly, if the modeling approach is correct significant improvement in oxygen conditions can be achieved by mixing key layer. Now back to the cartoon (Figure 1).

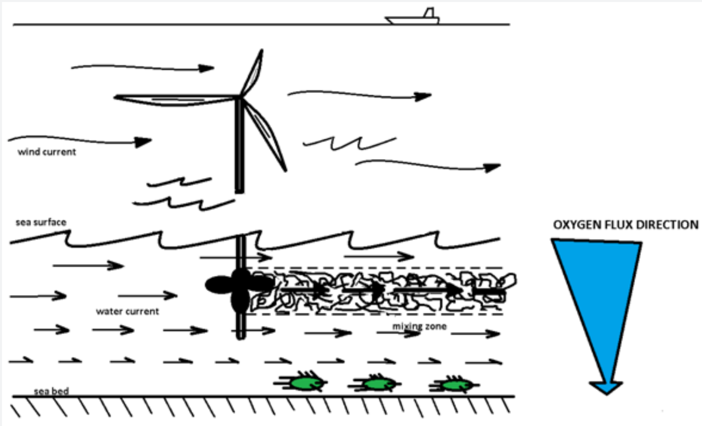

Figure 1

As it moves to the right the layer also expands in size by lateral isopycnal diffusion which transports oxygen as well. Dypycnal eddy diffusion also occurs but at a very slow rate, the layer does not easily mix or expand in the vertical direction with layers above or below. A magical birds-eye view downward from above and into the stacked water layers would see the size of this layer expanding in the lateral dimension, much as does the bow-wave wake created by a boat moving on the surface. If such RxHYPOXIA is executed properly normal summertime dead zone water conditions will not occur; fish and other bottom residing life forms are maintained and allowed to grow and flourish year-round, a natural and the preferred outcome. This new idea for RxHYPOXIA is a bit radical for it involves destroying a single, thin, horizontal stratified water layer at a specific depth. The oversized arrow to the right of the cartoon entitled "oxygen flux direction" depicts the movement from atmosphere to seabed and highlights the now open pathway for movement through the water column. On the sea floor a school of fish is shown thriving on the refreshed bottom water conditions

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How to cite this article: Louis J T. RxHYPOXIA Idea for the Gulf Mexico "Dead Zone". Agri Res & Tech: Open Access J. 2018; 13(1): 555873. DOI: 10.19080/ARTOAJ.2018.13.555873

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