PRELIMINARY REVIEW OF L KONG (2017) THESIS CONCERNING CRAWFISH

PART 2 – The 2017 Data Set.

DRAFT EXPERT REPORT

of

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18th February 2019

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Objectives

Kong's (2017) thesis titled "Population characteristics of red swamp crayfish *Procambarus clarkii* from hydrologically impaired locations in the Atchafalaya River Basin" was basically aimed at measuring various environmental and water quality parameters in a section of the Atchafalaya Basin in order to try to determine if there was a relationship between water quality and crawfish production. Temperature, Dissolved Oxygen (DO), pH, Secchi depth (a simple measure of turbidity), and, specific conductance was recorded at all sample locations on every sample date and various parameters were collected from ten red swamp crayfish *Procambarus clarkii* at each site for evaluation. Kong's data was only collected during a portion of the flooding stage of the Atchafalaya River in 2016 and 2017 respectively.

This review assesses Kong's techniques, her assumptions, the quality of her data, interpretations, and conclusions. Where necessary data has been subjected to different plots and other data sets have been incorporated to further interpret the data. Missing from her thesis is any quality control or assessment of the accuracy of her measurements, no calibration data. This is a fundamental of any such study and so does raise the question as to the validity of the measurements. Additionally, Kong (2017) does not have an appendix listing or tabling her data, very important parameters such as GPS coordinates, weather conditions prior to and during sampling, and a table listing of all data sets. This is generally a prerequisite of any academic research effort so that other researchers can utilize the actual data instead of trying to interpret from small scale graphs and maps.

This study reflects data that was only collected during the flood stage of the Atcahafalaya River for each sample site. There was no data collected for the rest of the hydrologic year, so flood vs non-flood comparisons are not possible. As a management tool this thesis thus has very limited application especially as the two floods covered, namely 2016 and 2017, were very different in Missisppi River flooding regime, timing, and scale.

At this point it is important to understand the turbidity (suspended sediment and nutrient) concentrations of flood water of the Mississippi and is major distributary, the Atchafalaya, during the 2016 and 2017 sampling. What is potentially being introduced to the backswamp through the numerous mostly man-made canals, channels, and, pipeline scars connected to the Atchafalaya River? It is also important to note although Kong has no sediment data that 21% of the total sediment load entering the Atchafalaya Basin at its upper end is deposited in the Basin along with 50% of the sand. Roberts etal (1978) revealed that 80% of the sand moves in suspension. As pointed out by the Louisiana Department of Natural Resources (LaDNR) (2019) these sediments do not reach the coast where they are needed. LaDNR further states, "Ongoing rapid and detrimental sedimentation in the Atchafalaya Basin fills swamps and waterways, impairs water quality, and degrades habitats. Conversely, areas of the Louisiana Coast outside the Atchafalaya Basin protection levees area experiencing erosion and subsidence and are in need of sediment sources for restoration projects." This is the sad truth, we are compounding a public safety issue by our incorrect and short-sighted management of the Atchafalaya Basin.

Turbidity and its role in DO abnormalities in the Atchafalaya Basin.

Turbidity the quality of being cloudy, opaque, or thick with suspended matter; "the measurement of turbidity is a key test of water quality."

Human population growth and its associated activities have altered landscapes, hydrologic cycles, and the flux of riverine constituents at accelerating rates over the last several centuries (Galloway and Cowling 2002). Significantly increasing loads of nutrients, particularly nitrogen and phosphorus, have found their way to the coastal ocean, especially during the last half of the 20th century (Figure 1). There are thresholds of nutrient loading above which the nutrient inputs no longer stimulate entirely positive responses from the ecosystem, such as increased fisheries production (Rabalais 2002). Instead changes in land-based sources of nutrients are leading to eutrophication of coastal waters with symptoms of poor water quality, noxious algal blooms, oxygen depletion, and, in some cases, loss of fisheries production (Rabalais et al, 2007). Eutrophication is becoming a major environmental problem in estuarine and coastal waters throughout the world (Nixon 1995), even in inner to mid-continental shelf waters (Rabalais 2005). Estuarine and coastal riverine systems with high water residence time such as the Atchafalaya Basin are susceptible to eutrophication, given adequate light conditions (Cloern 2001). In contrast, coastal ecosystems adjacent to large rivers with swift currents that move materials away from the river mouth that deter the development of stratification are not conducive to the accumulation of biomass or depletion of oxygen, as for example in the Amazon and Orinoco River plumes.

The Mississippi River forms the largest watershed on the North American continent. It discharges on average 580 km^3 of fresh water per year to the northern Gulf of Mexico through two main distributaries: the birdfoot delta southeast of the city of New Orleans, Louisiana, and the Atchafalaya River delta 200 km to the west that carries about one-third of the flow (Meade 1996). The Mississippi River system discharges sediment yields of $210 * 10^6$ Mg/yr., $1.6 * 10^6$ Mg/yr. nitrogen, of which $0.95 * 10^6$ Mg is nitrate and $0.58 * 10^6$ Mg is organic nitrogen, $0.1 * 10^6$ Mg/yr. phosphorus, and $2.1 * 10^6$ Mg/yr. silica (Milliman and Meade 1983, Meade 1996, Goolsby et al. 1999). The Louisiana coastal ecosystem is productive (~300 g Cm^2yr^1; Turner and Allen 1982, Lohrenz et al. 1990) and the location of the second largest zone of coastal hypoxia (defined here as dissolved oxygen <2 mg/L) in the world's oceans (Rabalais et al. 2002).

Figure 1 aptly reveals the uncoupled relationship, before 1975, between the mean annual concentration of nitrate and silicate in the Mississippi River at New Orleans and the coherent changes after 1980 (Rabalais 2007). In other words, mean annual concentration of nitrate and silicate in the Mississippi River at New Orleans were not linked in the pre-heavy use of industrial fertilizer in the Mississippi River's catchment. Once commercial fertilizer use became wide spread the concentrations of these variables became linked, the suspended sediment of the Mississippi River (represented by the silica concentration), and nutrient loading became coupled. Thus, measurements of turbidity then become a good measure of the ever-changing suspended sediment and coupled nutrient loads.

Welch et al (2014) present data related to nutrient loading of the Atchafalaya Basin during the 2011 flood, data that must be considered in evaluating the results presented in Kong's thesis. It is important to note that Welch et al (2014) only sampled main river channels and not any swamp sites. They point out that Nitrate composed about 70% of the total Nitrogen Flux and that there were no substantial losses or gains in the Atchafalaya or Lower Mississippi River channels themselves. But what happens to the nitrogen when it enters the still water of an interior swamp? It has nowhere to go so nitrogen loading of the swamp takes place – a cause of hypoxia.

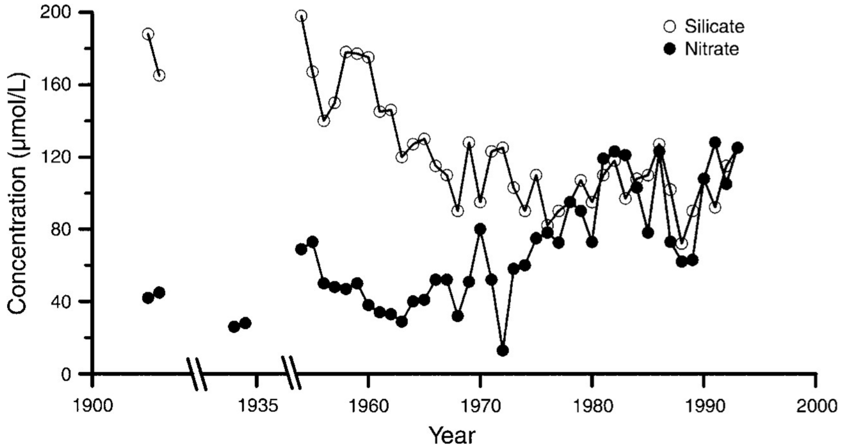

Figure. 1. The mean annual concentration of nitrate and silicate in the Mississippi River at New Orleans. Note the uncoupled relationship between the two variables before 1975 and the coherent changes after 1980 (Rabalais. 2007).

Welch et al (2014) point out that when suspended sediment fluxes increase, agricultural chemicals attached to sediment can be readily transported downstream and may further exacerbate water quality problems in receiving surface-water bodies. So, if you increase the discharge of suspended sediments into interior swamps you are going to exacerbate water quality problems and hence potential lowering of oxygen concentrations and hypoxia. Horowitz (2010) concludes that suspended sediments delivers about 85% of the annual phosphorous flux and 30% of the annual Nitrogen flux to the region.

As streamflow was decreasing in the 2011 flood in the Lower Mississippi River - Atchafalaya River sub basin (Welch etal 2014), orthophosphate composed an increasing percentage of the total phosphorous concentration, probably because of return of waters low in oxygen concentration from stillwater areas such as inundated lands, backwater streams, and floodways. These poorly oxygenated waters promote the release of sediment-bound phosphorous into the more readily available dissolved form. So, the data collected by the Welch etal (2014) during the 2011 flood reveal that Atchafalaya River water entering a swamp had a low oxygen concentration that promoted the release of phosphorous. This is a double whammy – the waters that would have entered the interior swamps would have had low oxygen concentrations, and in addition, this condition would have enhanced the release of a nutrient, phosphorous. So instead of improving water quality, we are enhancing hypoxia! It is incredibly important that before one messes with the natural environment that one understands the consequences. For every action there is a reaction.

<u>Characteristics of 2017 Flood versus the 2016 Flood</u>

Figure 2 represents the daily Basin stage at Butte la Rose recorded for 2016 and 2017. The figure also reveals the rather short time period that Kong sampled her sites in the Basin. Plate 1 depicts the Missisppi Catchment and location of its main distributaries. Suspended sediment loads for each Mississippi/Atchafalaya flood are controlled in part by which Mississippi upstream tributaries are in flood. Reference was made in this phenomenon above when discussing the extreme flood on the Mississippi River of 2011 when the major contributor of streamflow to the lower Mississippi-Atchafalaya River sub basin during April and May was the Ohio River, whose water contained lower concentrations of suspended sediment, pesticides, and nutrients than water from the upper Mississippi River (Welch et al, 2014).

The 2016 flooding on the Missouri and Upper Mississippi Rivers which included extensive snow melt would have contributed very high levels of suspended sediment (Plate 1) during the period of Kong's sampling. By contrast, the 2017 flood peak sampled by Kong in 2017 represented the result of 1:1000-year rainfall in a relatively narrow east-west band from Joplin MO to New Albany IN the lower half of the Mississippi catchment across a portion of the Missisppi and Ohio Rivers (Plates 2 and 3). This was a sudden rainfall induced flood <u>and not fed</u> by the upper reaches of any of the main Missisppi River catchment feeders such as the Missouri River - a very different kind of flood and not a great suspended sediment producer. So, suspended sediment loads reaching the Atcahafalaya Basin were lower than normal for the flood peak on the Atchafalaya River associated with this 1:1000 rainfall event south of St Louis MO, to be discussed below.

What is evident is that for each of Kong's sampling periods is that she did get data during a flood peak, part of the overall Atcahafalaya flood of each year (Figure 3). But what about turbidity on the river while she was sampling – what was the river supplying to her study sites by way of

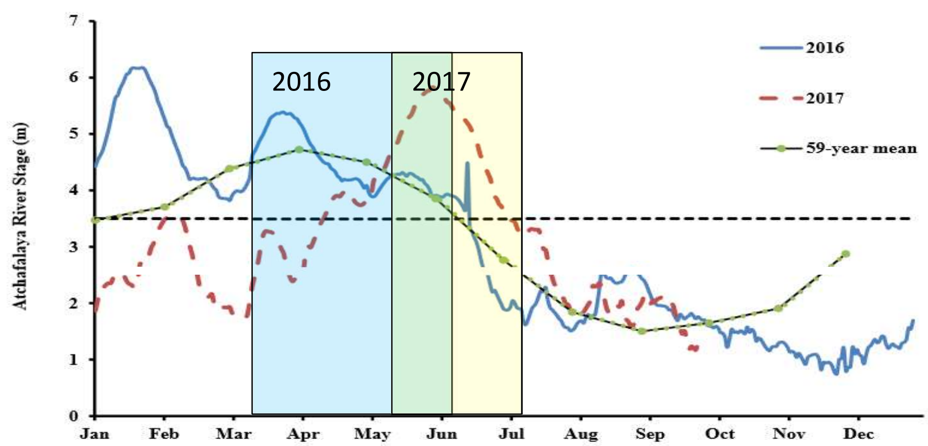

Figure 2. Daily Atchafalaya River stage at Butte La Rose, Louisiana (US Army Corps of Engineers gauge 03120) during the 2016 and 2017 sample years and the 59-year monthly mean. Note the relatively narrow flood band of the 2017 rain induced flood,

Plate 1. Tributaries of the Missisppi River and its catchment.

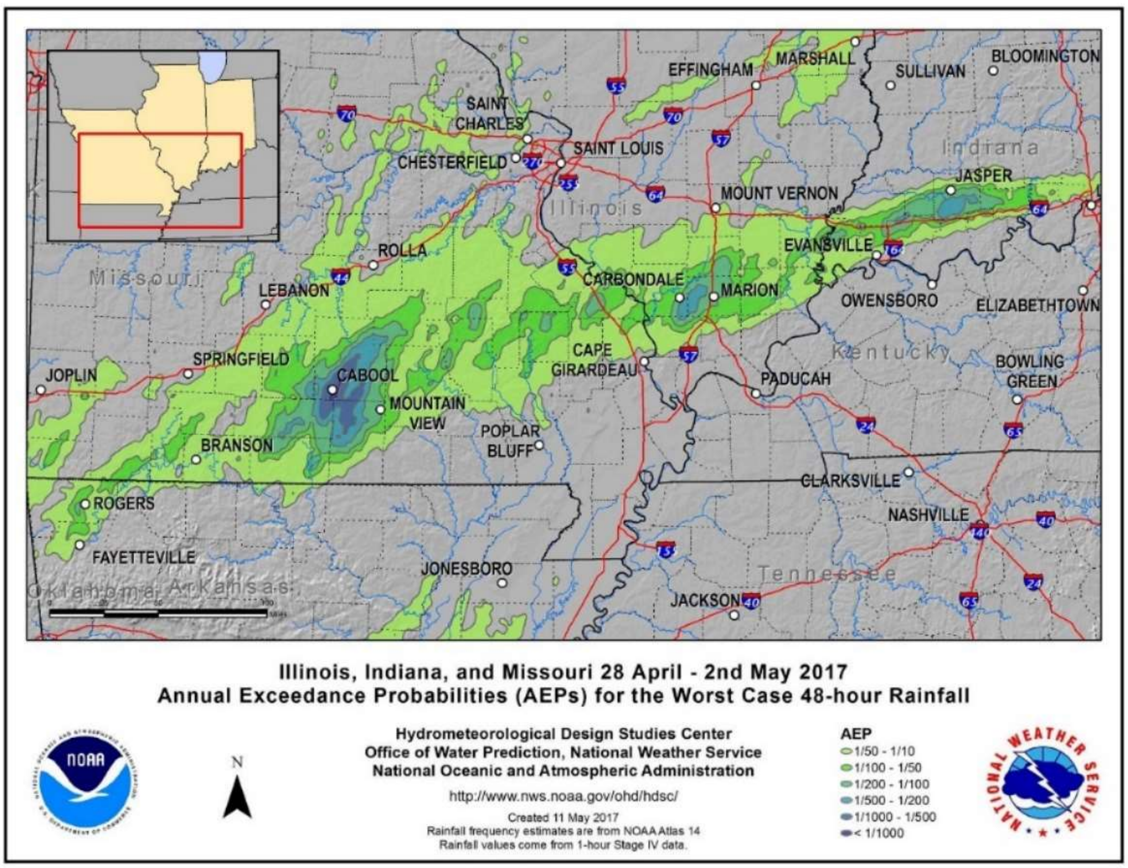

Plate 2. The catastrophic 1:1000-year rainfall event that precipitated a 2017 flood peak event on the Atchafalaya.

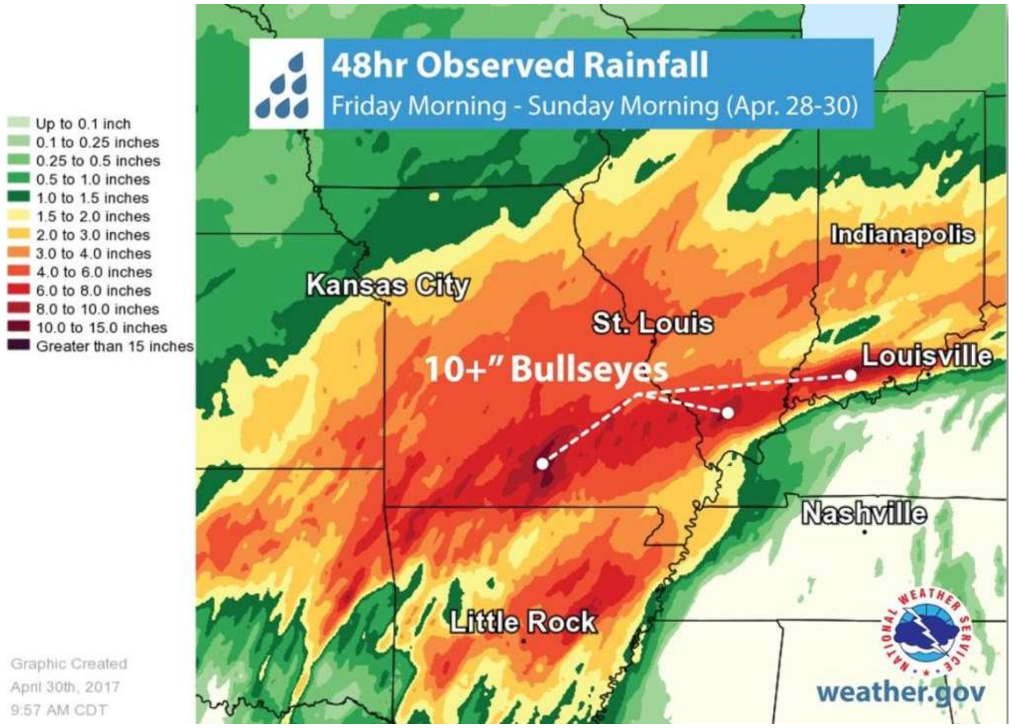

Plate 3. 48 Hour Observed Rainfall during 1:1000- year event.

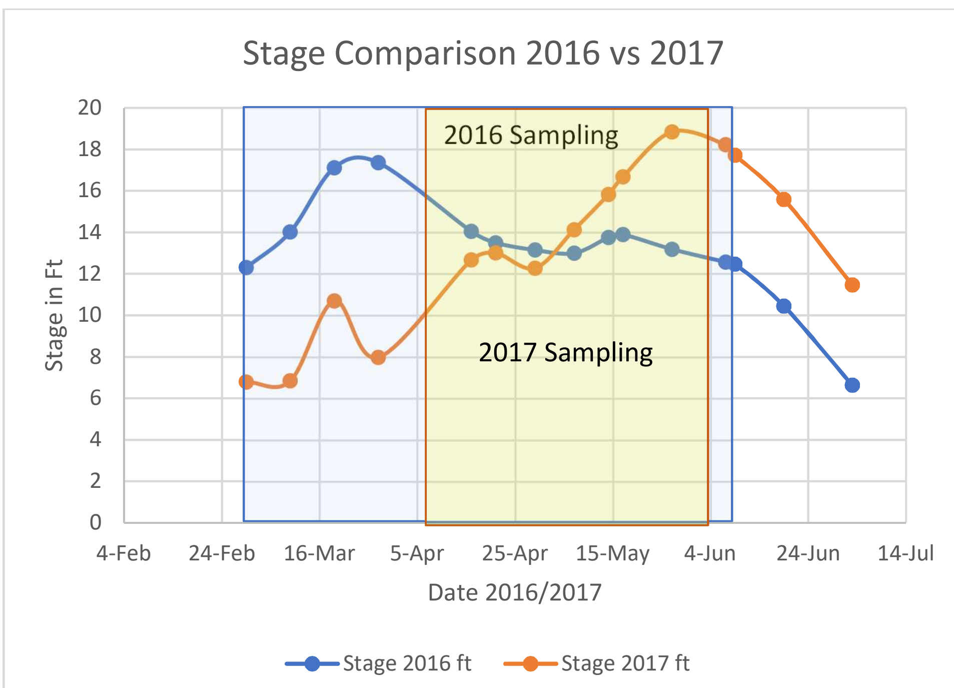

Figure 3. Butte la Rose stage comparison of the 2016 and 2017 flood events respectively sampled by Kong.

nutrients and suspended sediments? Unfortunately, data on turbidity or suspended sediment loads is not recorded at Butte La Rose, but turbidity data is collected (mostly hourly) on the Atchafalaya River at Morgan City (Figures 4a, 4b, and 4c). The higher the turbidity number the greater the concentration of suspend material in the water column. Figure 4a reveals that the turbidity ranged from 86.7 to 114.1 during Kong's 2016 flood sampling.

In contrast during the peak of the 2017 flood (Figure 4b) the turbidity was constantly dropping from 100 to a low of 33.8; reflecting that this river flood pulse was a rainfall induced event (Plates 2 and 3) and the sediment and nutrient load reflected by the turbidity measurements was very low.

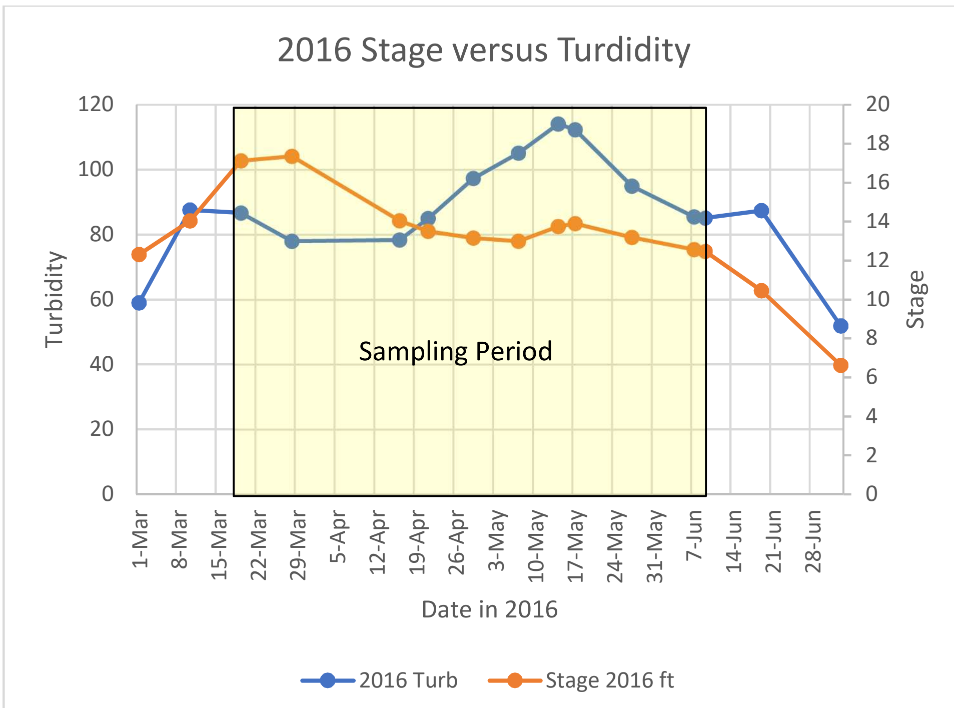

Figure 4a. Stage and turbidity comparison of the 2016 flood peak sampled by Kong (2017)

As previously presented turbidity (suspended sediment) and nutrient levels are coupled. Higher the turbidity the higher the nutrient concentrations being carried by the flood water.

Thus in interpreting Kong (2017) data it is very important to recognize that the 2016 flood water is sourced from the greater Mississippi catchment (Plate 1); as compared to the 2017 flood which reflected a rainfall induced flood pulse with the flood source being the flooding of land and subsequent runoff water from a narrow portion of the lower Mississippi River (Plate 2 and 3). Thus the 2017 flood peak sampled by Kong (2017) was basically a clean water flood with low turbidity (Figure 4b).

Figure 4c contrasts the turbidity as recorded at the Atchafalaya River at Morgan City that covers a six-month period from 1 March to 3 July for each of the 2016 and 2017 floods sampled by Kong (2017). Note that the 2016 flood has fairly constant high turbidity in the 80 plus range while the 2017 flood turbidity period fell rapidly during the sampling period to a low of 33.8.

The latter reflects the rainfall event on the Missisppi as reflected in Plates 2 and 3. The former (2016) reflects a catchment flood, a very distinct difference in turbidity as these data reveal.

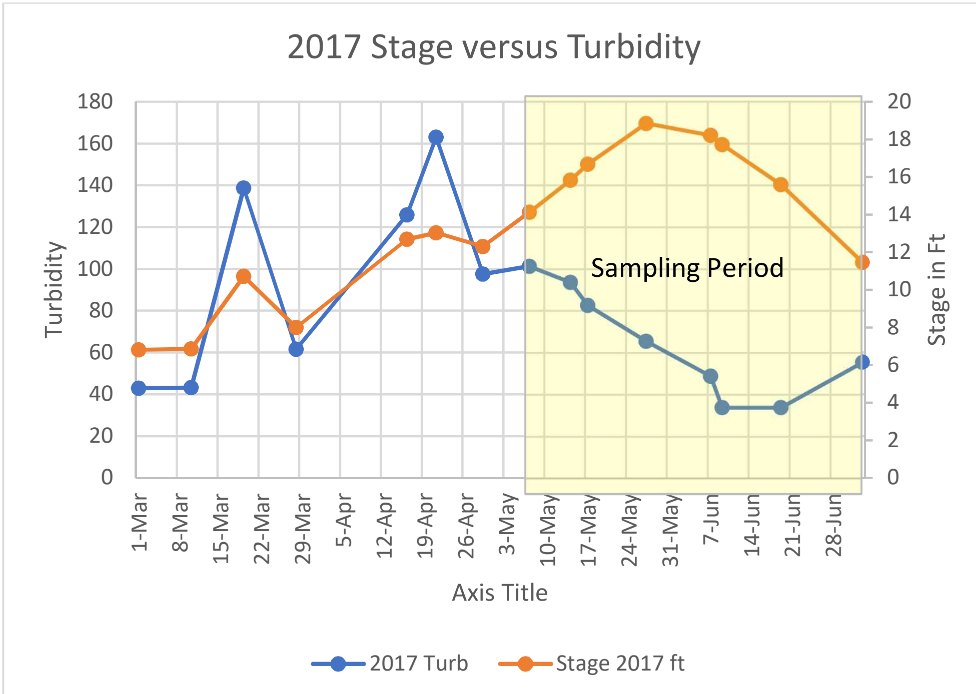

Figure 4b. . Stage and turbidity comparison of the 2017 flood peak sampled by Kong (2017).

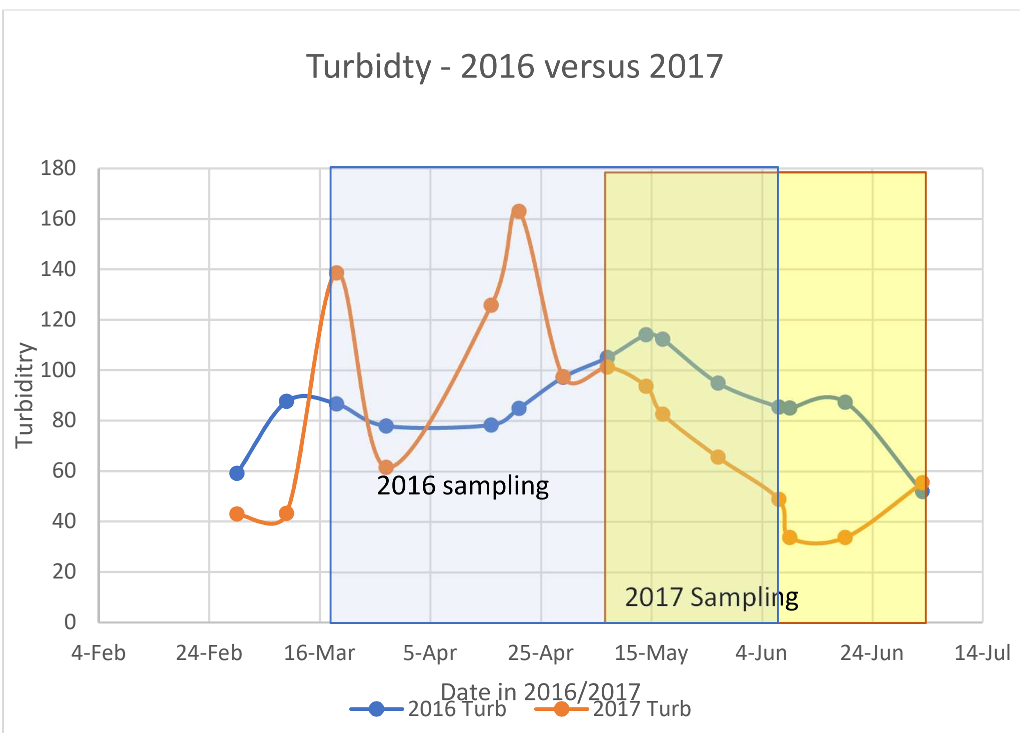

Figure 4c. Turbidity variability during Kong's 2016 and 2017 sampling as collected from the Atchafalaya River at Morgan City.

Kong's Sample Locations

In reviewing this thesis, and as a rule when dealing with relationships such as dissolved oxygen variations at a site, one needs to know the ground elevation of the site in relation to a nearby water level gauge in order to assess whether the sample site is getting flow from adjacent areas especially channels or canals, or is in a near stagnant condition. Inundation depth is also an important factor.

Figure 5 is a Google Image depicting the sample sites where Kong (2017) collected her intensive data for the 2016 and 2017 Atchafalaya River floods. As stated previously Kong does not supply any explanations as to why her sites were chosen other than ease of access, and the environment or elevation. I.e., was it on a levee or was it in an open pond or in a forested swamp? The assumption as she was collecting crawfish implied that there was enough water depth to move by boat. The Nature Conservancy (TNC) have since 26th June 2016 almost continuously also collected water quality data in the same region of the Basin although not at the same locations. Figure 6 depicts the location of TNC data collection sites. Figure 7 is an attempt to superimpose the Kong (2017) data collection locations (Figure 5) on the TNC map (Figure 6). This Part 2 review will focus on the Kong sites that cluster closest to the TNC sites (Blue box in Figure 7).

Determining ground elevations at sites.

Kong (2107) does not supply any data on ground elevations at any of her sites. The measure she uses to determine inundation of her sites is based on an unofficial crawfish season. I quote

"Intensive and extensive sites were sampled twice a month during the crayfish seasons from 19 March to 9 June 2016 and from 7 May to 3 July 2017. There is no official crayfish season set by resource managers in Louisiana, instead, wild crayfish harvest is determined by Atchafalaya River water level. The crayfish season began when the Atchafalaya River level at Butte La Rose, Louisiana (U.S. Army Corps of Engineers gauge 03120, 30°16'57" N, 91°41'17" W) was greater than 3.5 m, which resulted in floodplain inundation at intensive site locations."

So, Kong (2107) seems to be suggesting that the ground elevation, or perhaps the average ground elevation of her sites is 3.5 m or lower as relates to the Butte La Rose gauging station. There is no real or hard data to support her 3.5 m (11.48 ft) assertion. In discussion with commercial crawfishermen in the Basin I am told that they start commercial harvesting once the stage at Butte la Rose has exceeded 7.0 ft for a week. In their experience this overtopping takes about a week to fill the swamp so that they can get boat access. Generally, they need about 18 inches of water to move their boats to their trap sites. Thus, there is no scientific justification for Kong's 3.5 m assertion, none so ever. This is a major flaw of this study. She gives no indication whatsoever of the elevations of her sample sites other than water depths must have exceeded 18 inches for her to have boat access. This lack of data becomes critical as we further discuss Kong (2017) thesis.

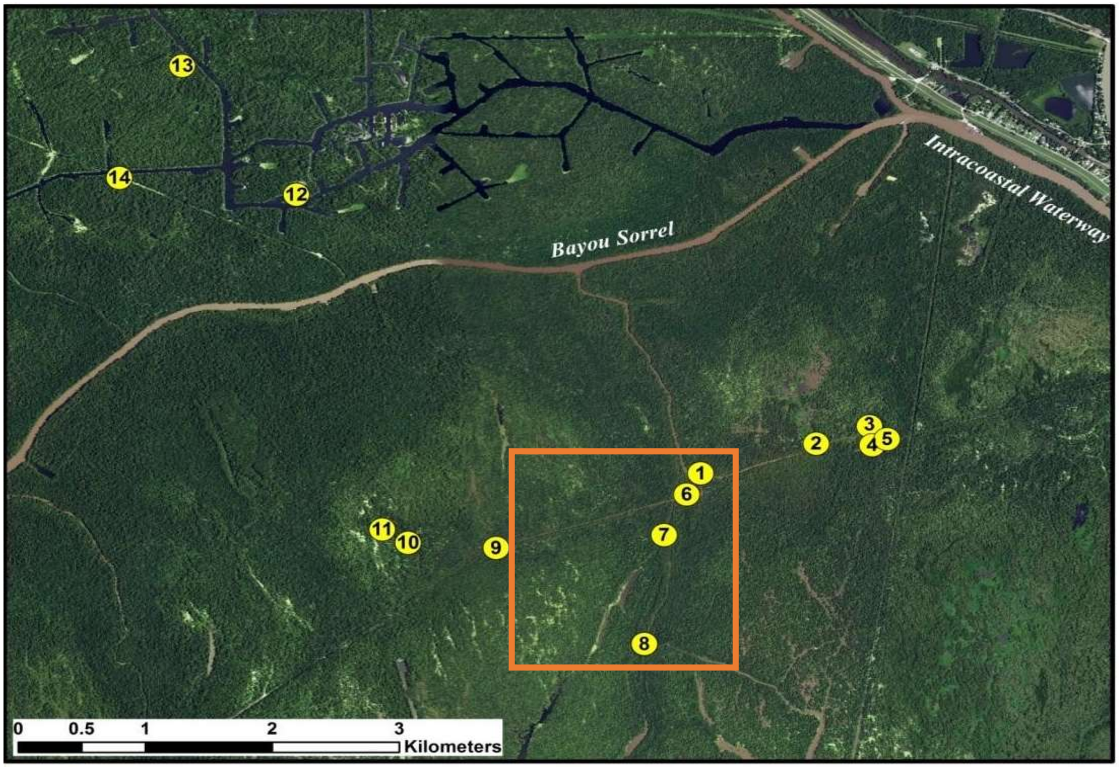

Figure 5. Location of Kong (2017) intensive sample sites. Review sites in orange box.

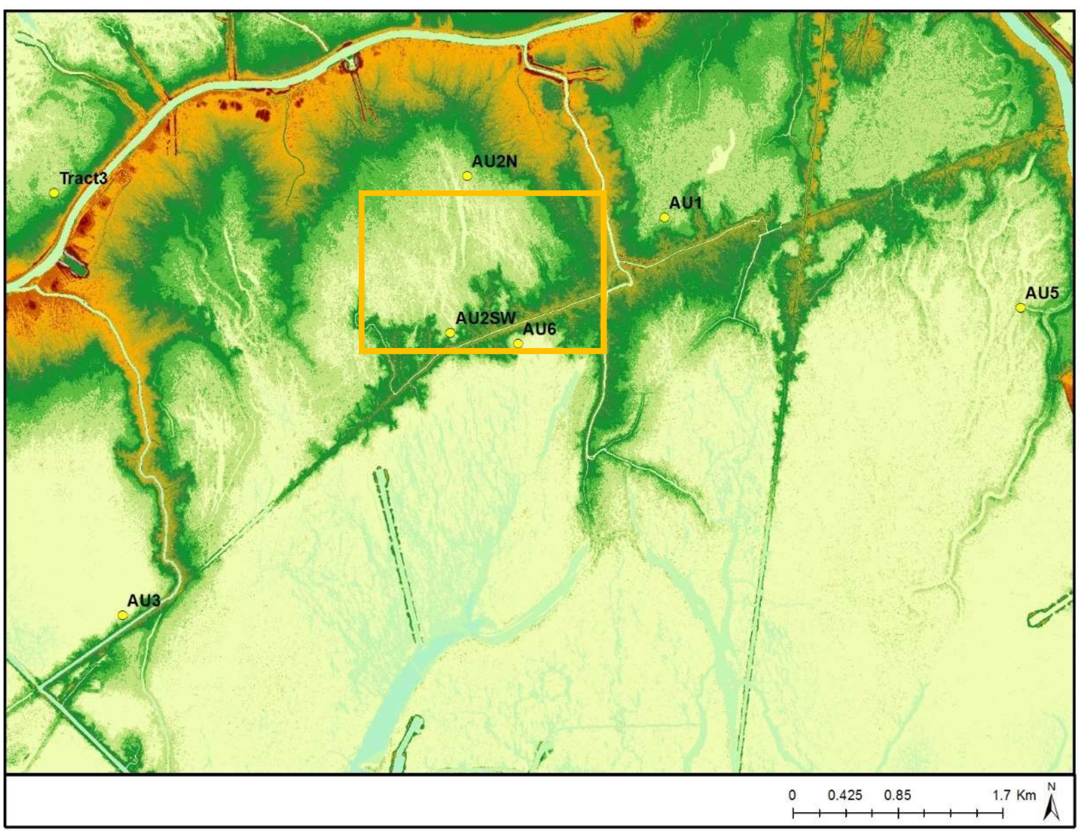

Figure 6. Location of TNC data sites (TNC Personal Comm.) Review sites in orange box.

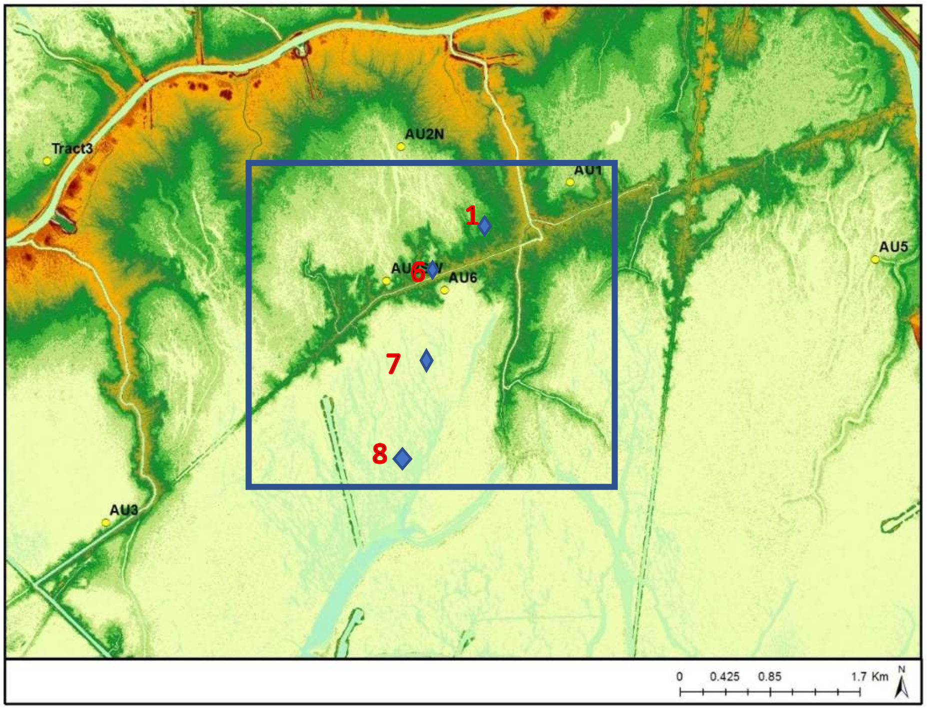

Figure 7. Four of Kong's 2016 sampling sites, namely sites 1, 6, 7, and 8, that are in the same region of the Basin as data collected by TNC at sites AU1, AU6, and AU2SW in 2017 and 2018. Note this is a LiDAR image and the richer the color the higher the elevations. Thus, all the TNC sites and Kong's 1, 6, and 7 are on the edges of levees even if they are subaqueous, at higher elevations that the interior backswamp in this portion of the Basin. Kong's site 8 is more of a backswamp location.

Figure 8 from Kong (2017) presents Butte La Rose daily water level stage data for 2016 and 2017 with her assumed 3.5 m 'line.' TNC however, do supply data from which it is possible to get a representation of the ground elevation at their sites. Figure 9 is their representation of the daily mean water stage for 2017 at Butte La Rose and Figure 10 represents mean daily water levels at their 7 monitoring sites for the same time period. TNC verbal communication via email 01/28/2019 informed that the water levels presented in Figure 10 are as follows; "The depth sensor on the Sonde (instrument) is about 15 cm off of the sediment surface, so these data … would be the water levels above the sensor, which is 15 cm above the soil surface." Thus, if one knows the river stage and one knows the water depth at each sample site; by simple subtraction and then subtracting the instruments height above ground of 15 cm, one can get the elevation of each site as it relates to the datum used for the Butte La Rose gauging station. TNC (2017) state that Sonde water level data track the stage at Butte La Rose.

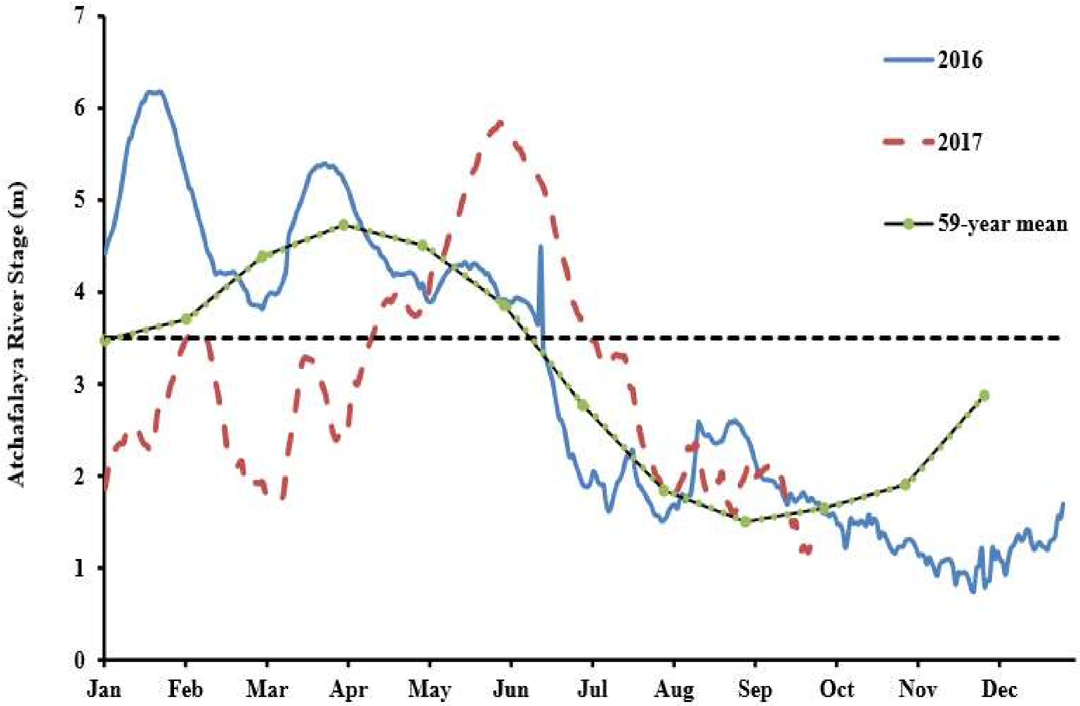

Figure 8. Daily Atchafalaya River stage at Butte La Rose, Louisiana (US Army Corps of Engineers gauge 03120) during the 2016 and 2017 sample years and the 59-year monthly mean. Note the relatively narrow flood band of the 2017 rain induced flood. Also shown is the Kong 3.5 m line.

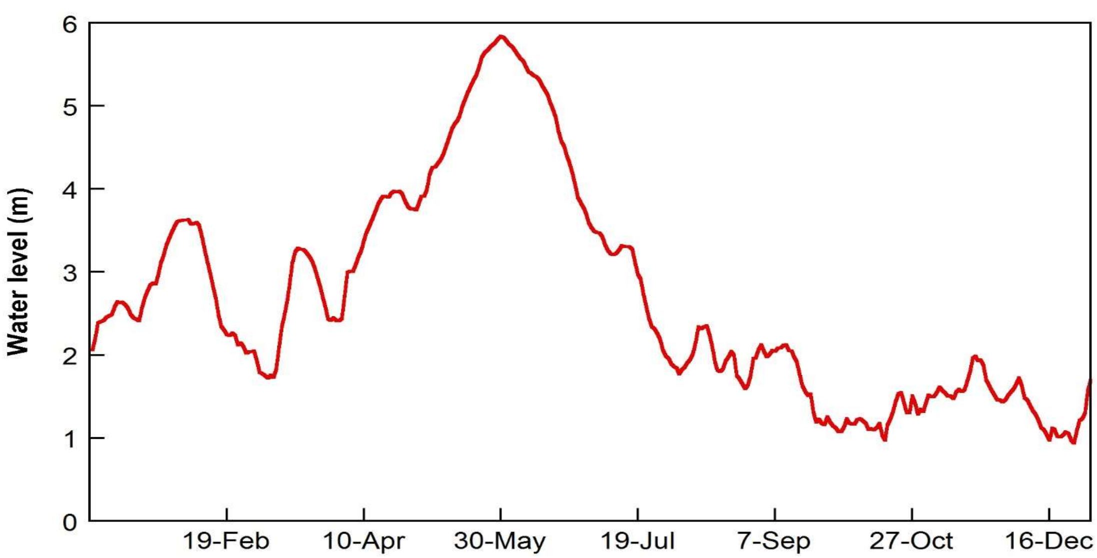

Figure 9. Daily mean water levels at Butte La Rose during 2017. Preliminary data from USGS gage 07381515 Atchafalaya River at Butte La Rose, LA (TNC 2017).

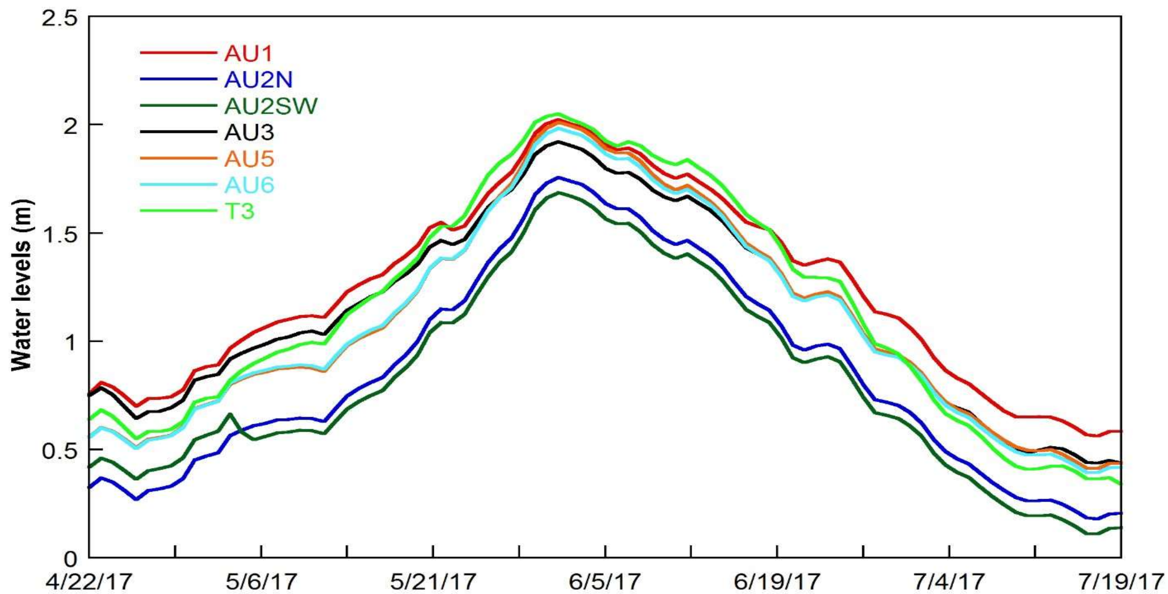

Figure 10. Daily mean water levels during the 2017 flood pulse at the seven TNC (2017) monitoring sites.

Doing the subtraction for the TNC sites AU1, AU6, and AU2SW gives a ground elevation for each sampling data sites and then calculating the average gives a ground elevation as relates to the Butte La Rose gauge datum of 2.47 meters (8.1 ft), which is 1.0 meter (3.28 ft) lower than the 3.5m unscientific assumption made by Kong (2017).

So, we have the water levels during the sampling period based on the Butte La Rose gauge and we have a determination of the ground elevations. So now we can assess the water quality data against these known parameters; we can tell if the sites were receiving flood water at the time each was sampled.

Kong's Results

Figure 11 is a stage curve from Kong with the relevant elevations and the 7 May to 3 July 2017 study period outlined. The only data that Kong (2017) presents for actual measurements over time at each of her sample sites is dissolved oxygen; all others she presents as means calculated for data collected at all 14 sites on the days sampled. This averaging in another flaw and includes two outlier clusters (Table 1). However, the DO data is useful (Figure 11). There are three very important features of Kong's DO plot as reveled in Figure 12. Firstly sites 3, 4, and 5 that form a cluster in the eastern edge of her study area reveal that throughout the study period they did not experience hypoxia, the DO concentrations did not drop below the 2.0 mg/l level. We can ask why but given the lack of GPS data and not knowing exact elevations and the proximity to a channel intersection suggests these three sites were not in a swamp or pond location, rather adjacent to a channel or a crossing of two channels. Sites 12, 13, and 14 are distinctly separate from the rest of the sample sites being North of Bayou Sorrel (Figure 5). These sites appear to

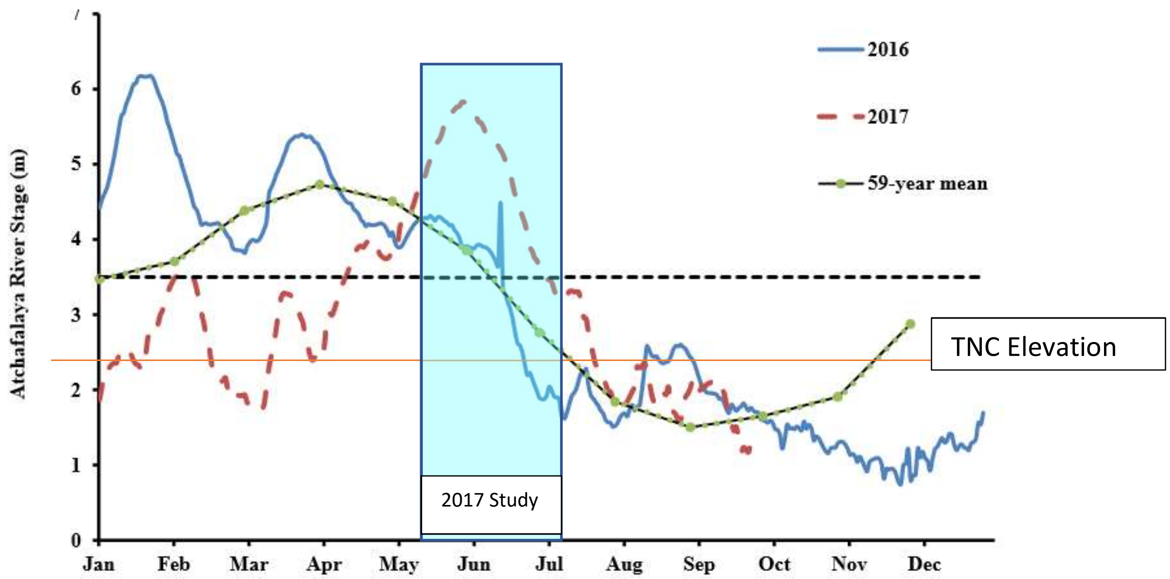

Figure 11. Daily Atchafalaya River stage at Butte La Rose, Louisiana (US Army Corps of Engineers gauge 03120) during the 2016 and 2017 sample years and the 59-year monthly mean. Also shown is the Kong 3.5 m line and TNC elevation of 2.47 m. Modified from Kong (2017).

have experienced hypoxia the whole study period (Table 1). One of Kong's objectives was to determine if hypoxia was the result of a lack of flushing which seems to be interwoven into the thesis, then these outlier cluster data are a misfit and must be ignored. For the same reason, when these data are utilized to determine average or mean conditions for a sample date, they will skew the data away from the actual hypoxic condition at each site. Another major flaw of Kong's data presentation and conclusions is that in Figure 12 she assumes that every occasion that a sample falls in the hypoxic zone (Brown circles) means that the sample location became hydrologically disconnected. This will be shown not to be true.

Site 1.

Figure 13a is a plot of Butte La Rose stage and Atchafalaya/Morgan City turbidity for the duration of the 2017 sampling. What is very apparent as pointed out previously is that as the stage is rising the turbidity is falling representing low turbidity and hence nutrient levels due the rainfall induced flood peak during Kong (2017) sampling. The replot of the Kong data for Site 1 (Figure 13b) reveals that for the full study period the site was flooded with at least 4.0 feet of water using a ground elevation determined for this site based on the TNC (2017) data. Maximum flooding was at 10 feet above ground! It was being flushed by Atchafalaya River flood waters. So, there was a hydrologic connection to a channel somewhere. As this was a low turbidity rain water induced flood the lack of nutrients is reflected in that the DO concentration rises from being hypoxic early May 2017 to 5 mg/l at the peak of the flood, but then drops back to hypoxic once this "clear" water flush has past (Figure 13b and c). This is strong proof that Atchafalaya River turbidity is directly coupled with DO concentration. Kong (2017) states categorically without any justification that there was no hydrologic connection 5/7/2017 and 7/3/2017. Figure 13b reveals otherwise! This is another major flaw of this thesis. The question at this site then becomes; what is driving the oxygen concentrations as the flood progresses?

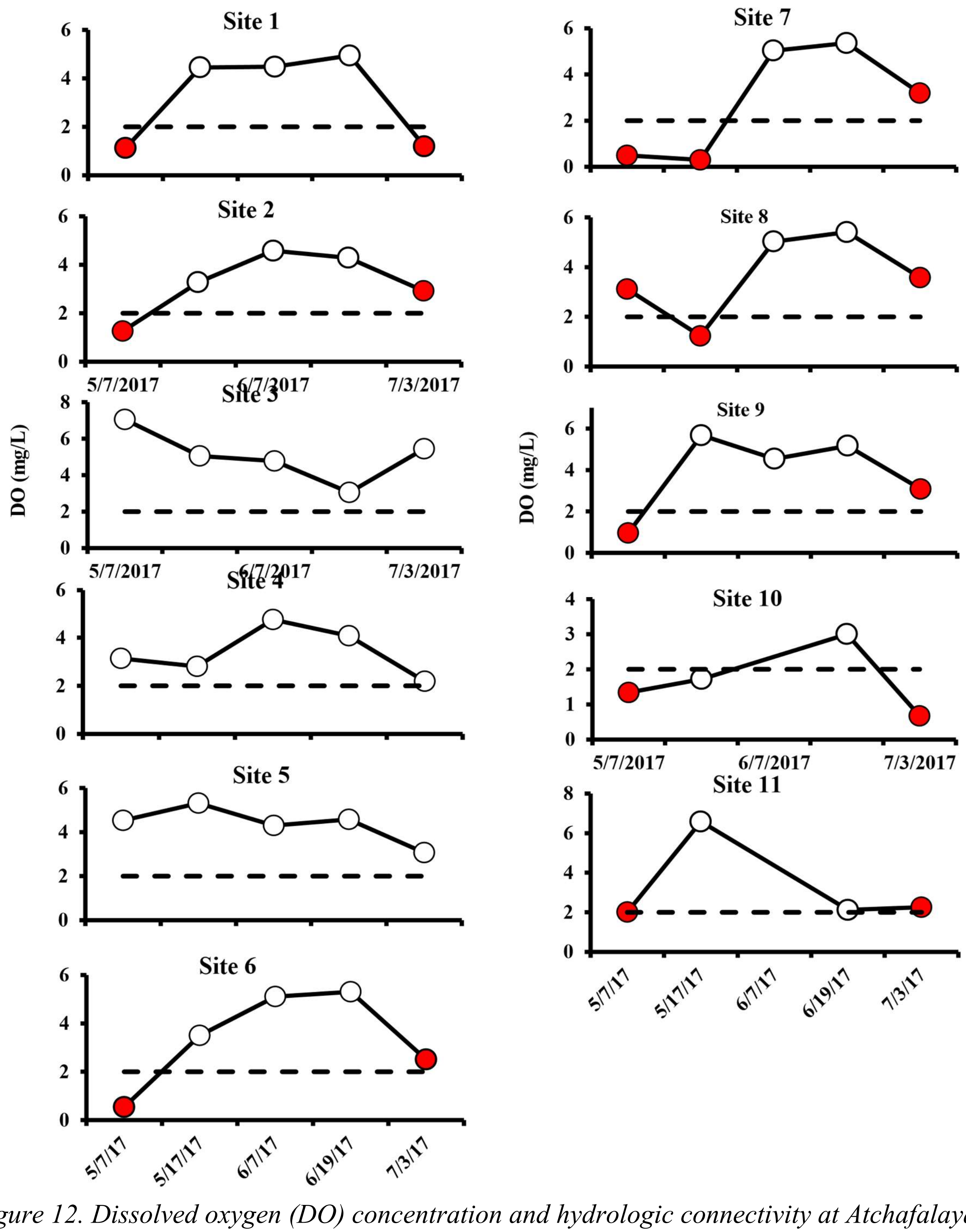

Figure 12. Dissolved oxygen (DO) concentration and hydrologic connectivity at Atchafalaya Basin sample locations during the 2017 sample season (Kong 2017). The red dots indicate when Kong assumes the site is hydrologically disconnected from flood water input. The dashed horizontal line on the graphs indicates hypoxic level (DO < 2 mg/L).

Table 1. Mean (±SE) physicochemical parameters at intensive sample ($n = 14$) locations in the Atchafalaya Basin Preserve and adjacent state land from 19 March to 9 June 2016 ($n = 7$ sample dates) and 7 May to 3 July 2017 ($n = 5$ sample dates). Velocity and pH were only recorded in 2017.

	DO (mg/ L)		Temperature (°C)		Specific Conductance (mS/cm)		Secchi (cm)		pH	Velocity (cm/s)
Site	2016	2017	2016	2017	2016	2017	2016	2017	2017	2017
1	4.29 ± 1.16	3.24 ± 0.85	20.85 ± 1.29	23.60 ± 1.70	0.438 ± 0.089	0.423 ± 0.078	17.7 ± 0.6	30.6 ± 4.8	7.32 ± 0.08	0.009 ± 0.006
2	3.07 ± 1.03	3.27 ± 0.59	21.27 ± 1.23	23.83 ± 1.57	0.318 ± 0.061	0.361 ± 0.021	28.5 ± 5.4	41.2 ± 6.01	7.15 ± 0.09	0.054 ± 0.042
3	5.95 ± 0.43	5.07 ± 0.64	21.14 ± 1.20	24.40 ± 1.58	0.252 ± 0.030	0.341 ± 0.017	19.6 ± 2.8	39.4 ± 5.9	7.30 ± 0.05	0.051 ± 0.024
4	4.91 ± 0.68	3.40 ± 0.46	21.22 ± 1.22	24.45 ± 1.40	0.250 ± 0.025	0.347 ± 0.015	28.9 ± 4.0	51.6 ± 7.4	7.11 ± 0.06	0.183 ± 0.040
5	5.63 ± 0.39	4.36 ± 0.36	21.14 ± 1.25	24.37 ± 1.41	0.251 ± 0.029	0.347 ± 0.020	23.2 ± 2.6	47.2 ± 3.5	7.14 ± 0.03	0.301 ± 0.042
6	3.55 ± 1.11	3.39 ± 0.88	21.13 ± 1.24	24.16 ± 1.57	0.205 ± 0.017	0.275 ± 0.036	24.0 ± 2.7	29.4 ± 6.1	7.15 ± 0.10	0.035 ± 0.021
7	4.42 ± 0.81	2.88 ± 1.08	21.39 ± 1.20	24.61 ± 1.41	0.261 ± 0.022	0.372 ± 0.019	21.6 ± 3.5	36.0 ± 6.6	7.14 ± 0.11	0.030 ± 0.022
8	4.68 ± 0.75	3.67 ± 0.75	21.53 ± 1.30	24.48 ± 1.52	0.266 ± 0.028	0.367 ± 0.012	19.7 ± 2.8	35.4 ± 6.6	7.20 ± 0.08	0.051 ± 0.038
9	4.09 ± 0.92	3.89 ± 0.85	22.09 ± 1.21	24.41 ± 1.62	0.257 ± 0.023	0.337 ± 0.017	26.4 ± 4.5	46.4 ± 7.9	7.21 ± 0.08	0.026 ± 0.020
10	2.75 ± 0.96	1.68 ± 0.49	22.25 ± 1.40	24.19 ± 1.83	0.273 ± 0.030	0.371 ± 0.021	29.7 ± 4.3	51.0 ± 5.5	6.91 ± 0.08	0.005 ± 0.003
11	3.40 ± 0.94	3.24 ± 1.11	21.83 ± 1.29	25.16 ± 1.85	0.261 ± 0.029	0.361 ± 0.026	17.6 ± 2.3	32.8 ± 5.0	7.10 ± 0.09	0.006 ± 0.002
12	1.59 ± 0.33	0.53 ± 0.24	21.53 ± 1.04	23.97 ± 1.17	0.236 ± 0.012	0.325 ± 0.009	96.8 ± 11.6	91.8 ± 14.7	6.80 ± 0.03	0.016 ± 0.010
13	1.57 ± 0.38	0.58 ± 0.17	21.42 ± 1.01	24.13 ± 1.29	0.233 ± 0.015	0.324 ± 0.006	95.1 ± 19.3	121.8 ± 8.6	6.75 ± 0.06	0.021 ± 0.008
14	1.64 ± 0.41	0.63 ± 0.48	21.52 ± 1.06	23.71 ± 1.18	0.232 ± 0.012	0.318 ± 0.004	103.4 ± 16.7	111.0 ± 9.1	6.79 ± 0.07	0.021 ± 0.006

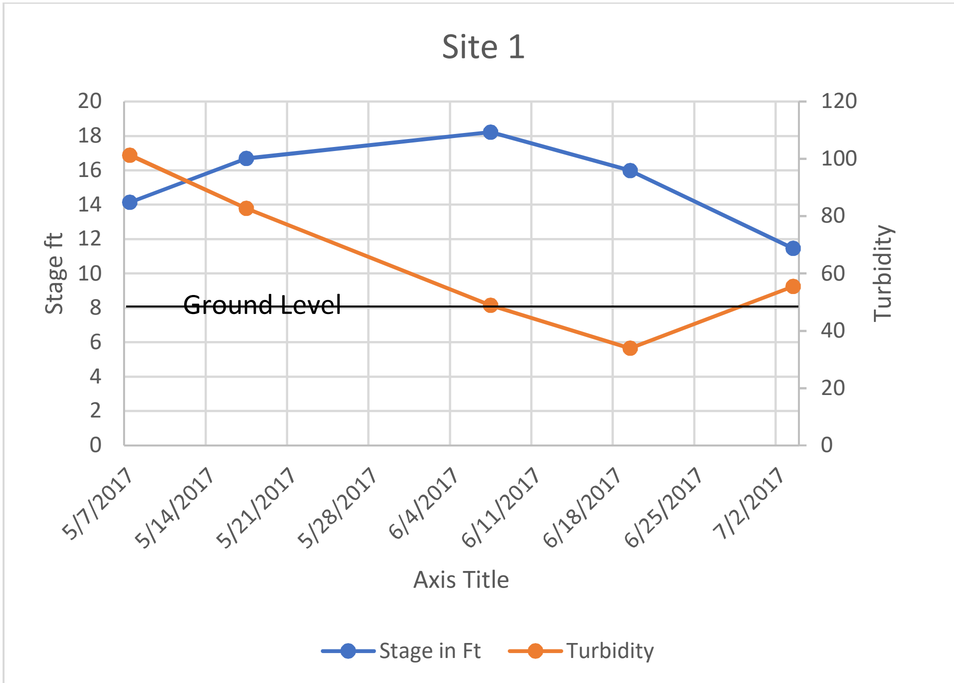

Figure 13a. Stage in feet at Butte La Rose and Morgan City Turbidity for duration of 2017 study.

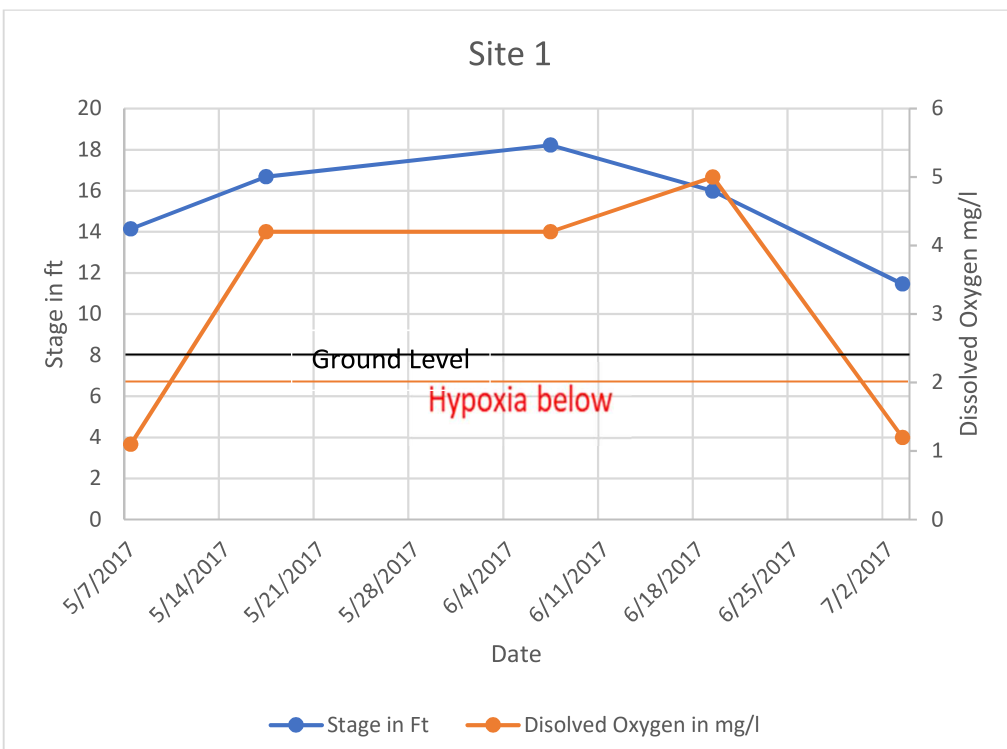

Figure 13b. Stage at Butte La Rose in feet and Dissolved Oxygen collected by Kong (2017).See Figure 12 by comparison.

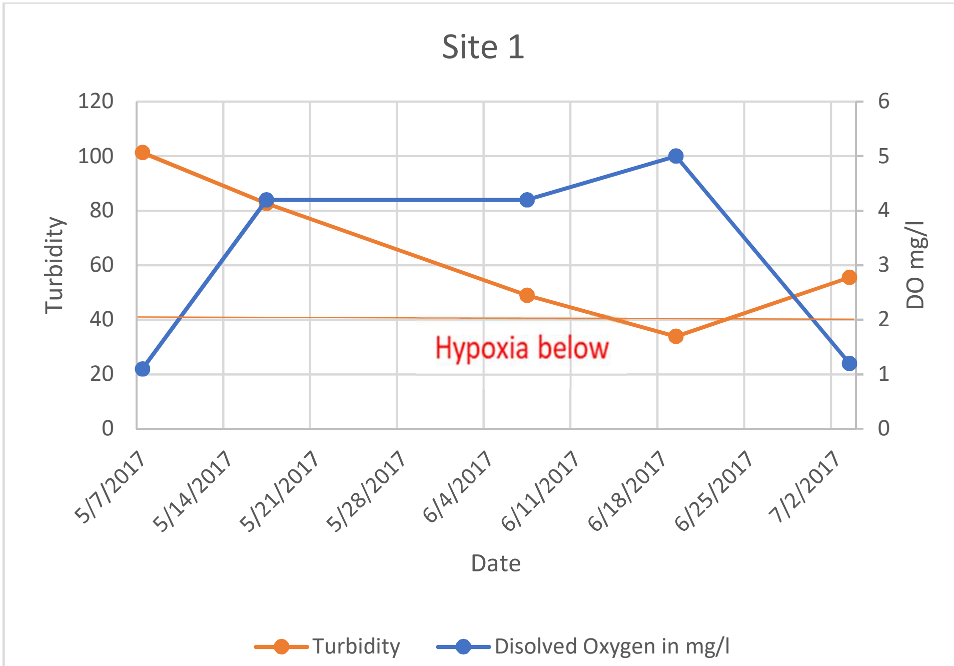

Figure 13c. Plot of Dissolved Oxygen from Kong (2017) and Turbidity from Morgan City over the time data was collected for Site 1 in 2017.

<u>*Site 6.*</u>

Figure 14a is a plot of Butte La Rose stage and Atchafalaya/Morgan City turbidity for the duration of the 2017 sampling. What is very apparent as pointed out previously is that as the stage is rising the turbidity is falling representing low turbidity and hence nutrient levels due the rainfall induced flood peak during Kong (2017) sampling. The replot of the Kong data for Site 1 (Figure 14b) reveals that for the full study period the site was flooded with at least 3.0 feet of water using a ground elevation determined for this site based on the TNC (2017) data. Maximum flooding was at 10 feet above ground! It was being flushed by Atchafalaya River flood waters. So, there was a hydrologic connection to a channel somewhere. As this was a low turbidity rain water induced flood the lack of nutrients is reflected in that the DO concentration rises from being hypoxic early May 2017 to 5.3 mg/l at the peak of the flood, but then drops back to almost hypoxic once this “clear” water flush has past (Figure 14b and c). This is strong proof that Atchafalaya River turbidity is directly coupled with DO concentration. Kong (2017) states categorically without any justification that there was no hydrologic connection 5/7/2017 and 7/3/2017. Figure 14b reveals otherwise! This is another major flaw of this thesis. The question at this site then becomes; what is driving the oxygen concentrations as the flood progresses?

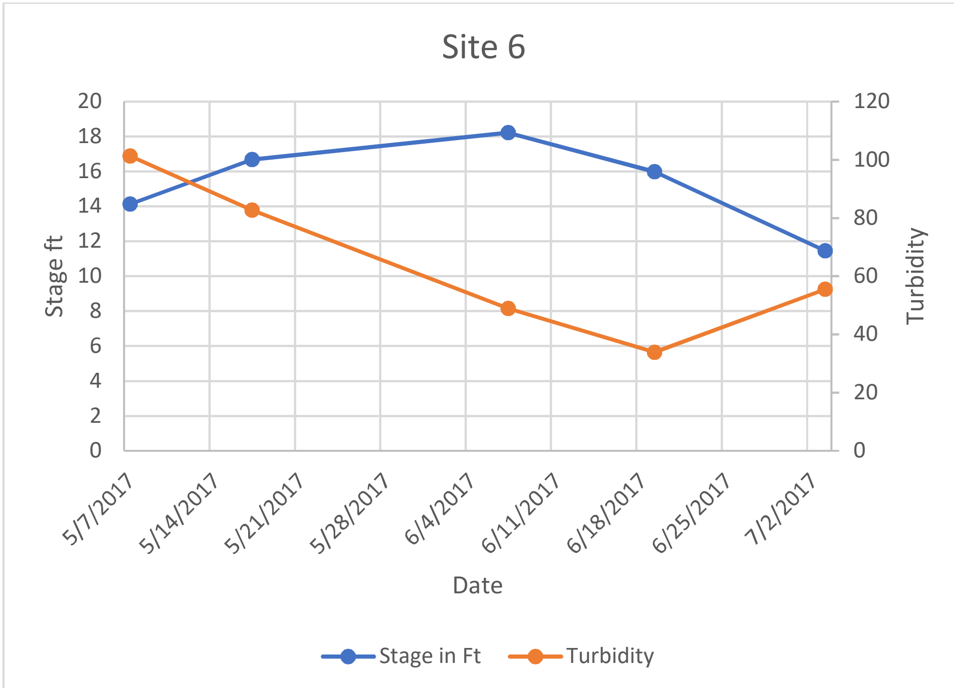

Figure 14a. Stage in feet at Butte La Rose and Morgan City Turbidity for duration of 2017 study

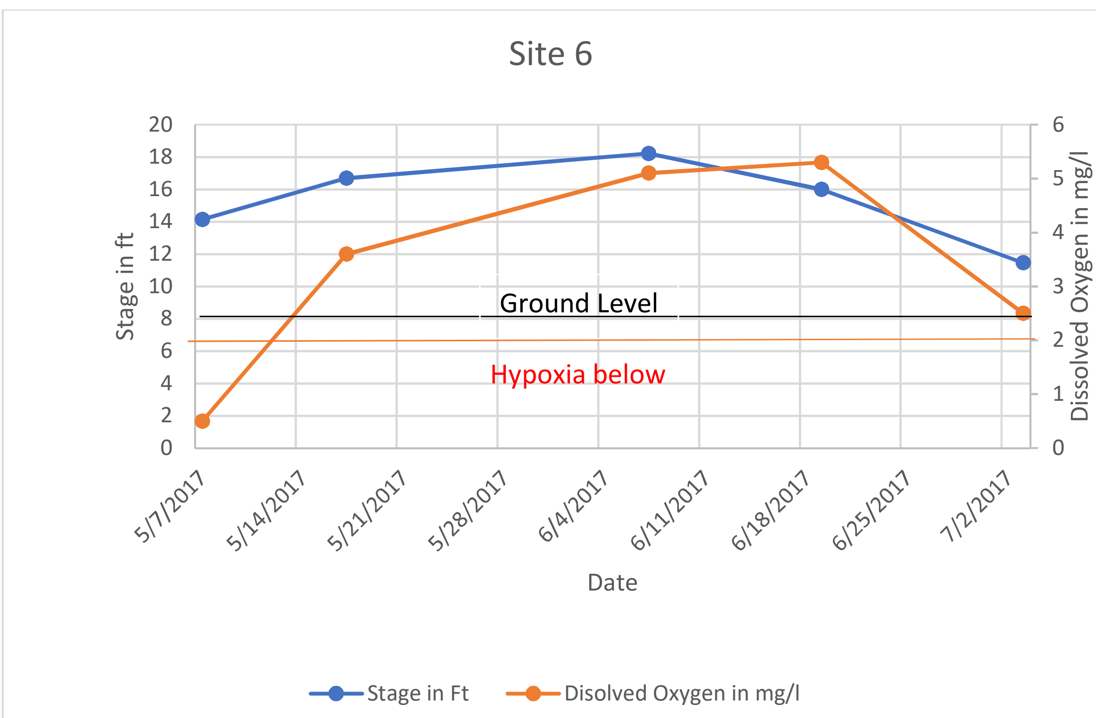

Figure 14b. Stage at Butte La Rose in feet and Dissolved Oxygen collected by Kong (2017).

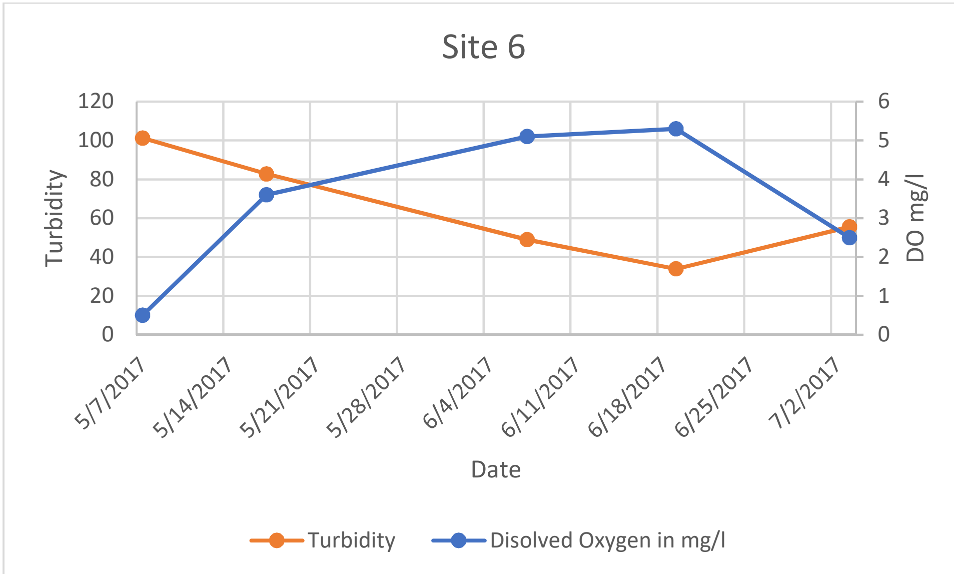

Figure 14c. Plot of Dissolved Oxygen from Kong (2017) and Turbidity from Morgan City over the time data was collected for Site 1 in 2017.

Site 7.

Figure 15a is a plot of Butte La Rose stage and Atchafalaya/Morgan City turbidity for the duration of the 2017 sampling. What is very apparent as pointed out previously is that as the stage is rising the turbidity is falling representing low turbidity and hence nutrient levels due to the rainfall induced flood peak during Kong (2017) sampling. The replot of the Kong data for Site 7 (Figure 15b) reveals that for the full study period the site was flooded with at least 3.0 feet of water using a ground elevation of 8.1 ft as determined for this site based on the TNC (2017) data. Maximum flooding was at least 10 feet above ground! It was being flushed by Atchafalaya River flood waters. So, there was a hydrologic connection to a channel somewhere. As this was a low turbidity rain water induced flood the lack of nutrients is reflected in that the DO concentration rises from being hypoxic early May 2017 to 5.4 mg/l at the peak of the flood, but then drops back to 3.3 mg/l once this “clear” water flush has past (Figure 15c). This is strong proof that Atchafalaya River turbidity is directly coupled with DO concentration (Figure 15c). Kong (2017) states categorically without any justification that there was no hydrologic connection during May and again early July (Figure 12). This is another major flaw of this thesis. The question at this site then becomes; what is driving the oxygen concentrations as the flood progresses?

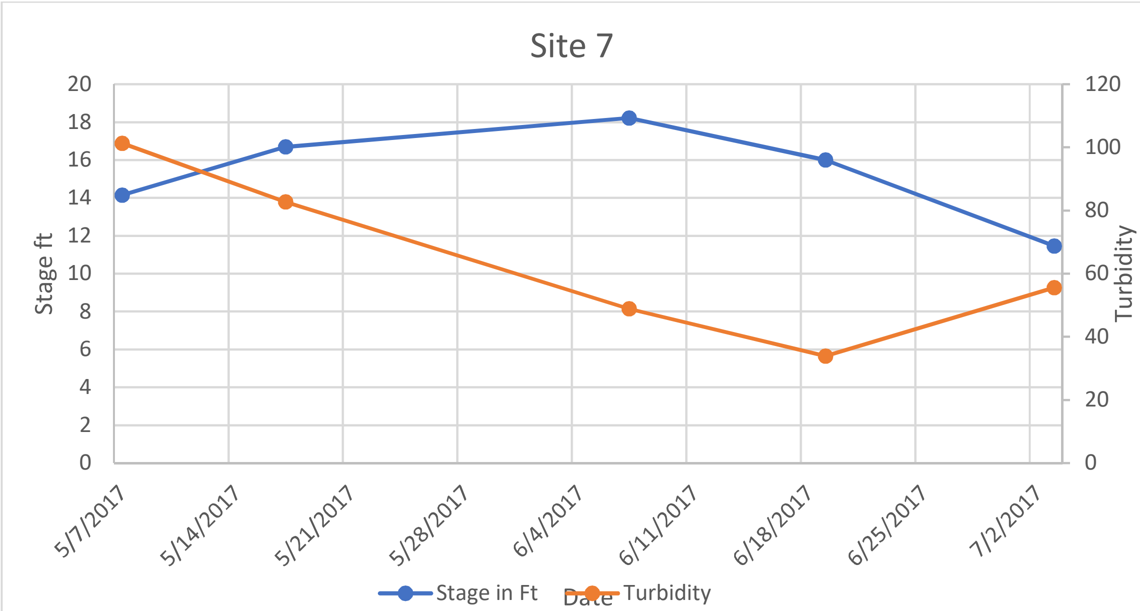

Figure 15a. Stage in feet at Butte La Rose and Morgan City Turbidity for duration of 2017 study.

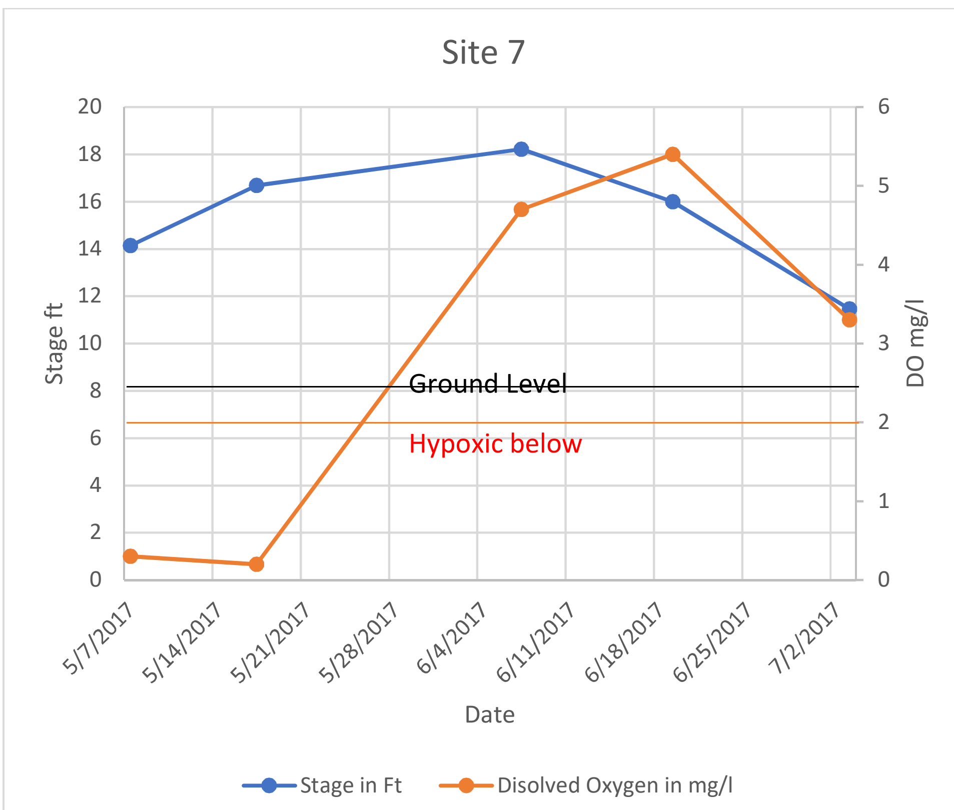

Figure 15b. Stage at Butte La Rose in feet and Dissolved Oxygen collected by Kong (2017).

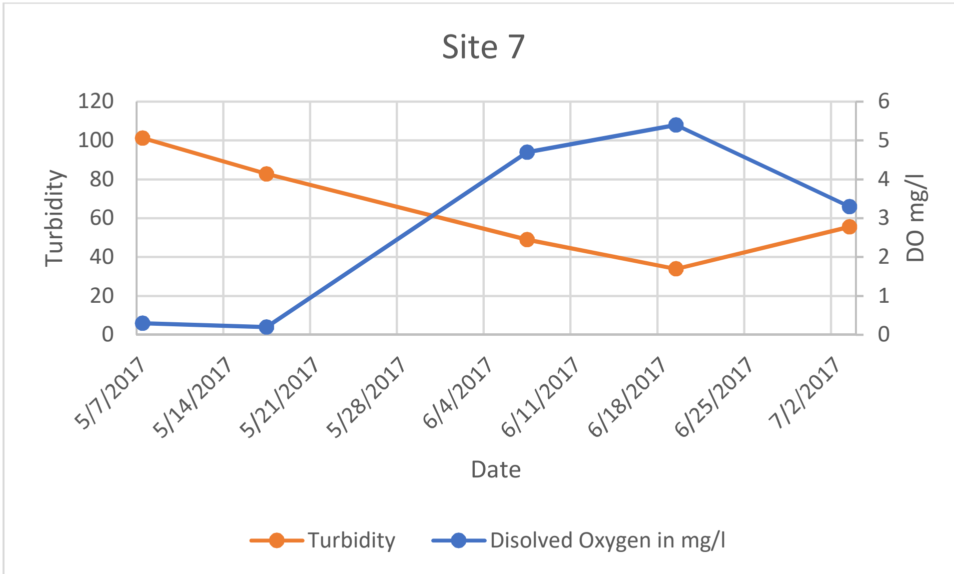

Figure 15c. Plot of Dissolved Oxygen from Kong (2017) and Turbidity from Morgan City over the time data was collected for Site 1 in 2017.

Site 8.

Figure 16a is a plot of Butte La Rose stage and Atchafalaya/Morgan City turbidity for the duration of the 2017 sampling. What is very apparent as pointed out previously is that as the stage is rising the turbidity is falling representing low turbidity and hence nutrient levels due the rainfall induced flood peak during Kong (2017) sampling. The replot of the Kong data for Site 1 (Figure 16b) reveals that for the full study period the site was flooded with at least 3.0 feet of water using a ground elevation of 8.1 ft determined for this site based on the TNC (2017) data. Maximum flooding was 10 feet above ground! It was being flushed by Atchafalaya River flood waters. So, there was a hydrologic connection to a channel somewhere for the duration of Kong(2017) sampling. As this was a low turbidity rain water-induced flood the lack of nutrients is reflected in that the DO concentration rises from being hypoxic mid May 2017, to 5.5 mg/l at the peak of the flood but then drops back to 3.7 mg/l once this "clear" water flush has past (Figures 16b and c). This is strong proof that Atchafalaya River turbidity is directly coupled with DO concentration. Kong (2017) states categorically without any justification that there was no hydrologic connection in May 2017 and again at the end of her study. Figure 16b reveals otherwise; there was never less than 3 ft of flow over ground! This is another major flaw of this thesis. The question at this site then becomes; what is driving the oxygen concentrations as the flood progresses?

Note that Kong's Sites 2, 6, 9, 10, and 11, also could have been included in this discussion. They would basically have mirrored the above sites.

Kong's Turbidity Data

Kong (2017) used Secchi Disc readings as a measure of turbidity (Table 1). Such is an opaque disk, typically white, used to gauge the transparency of water by measuring the depth (*Secchi depth*) at which the disk ceases to be visible from the surface. If used correctly by the same

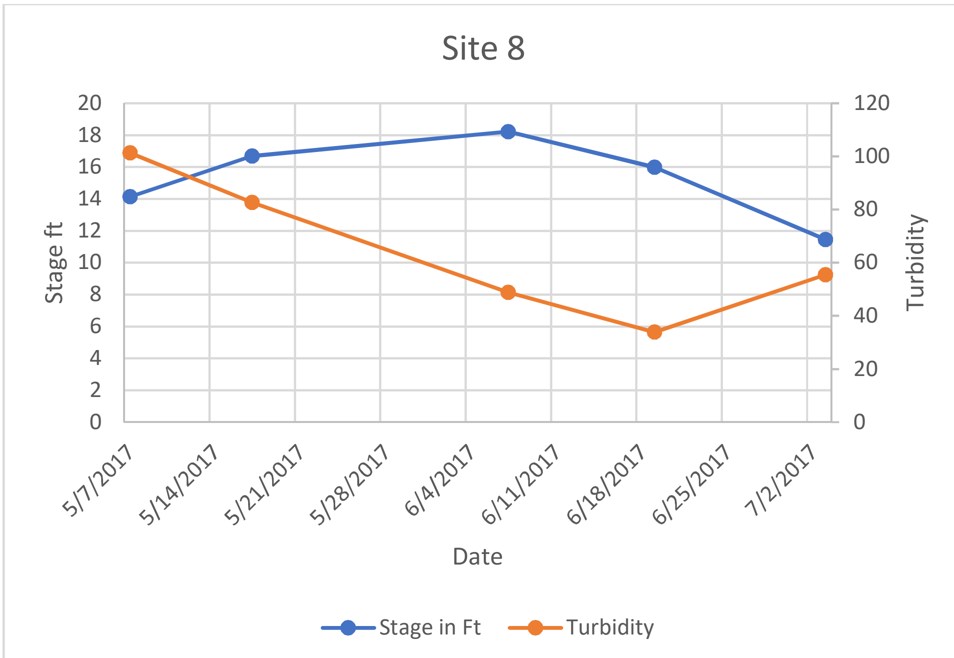

Figure 16a. Stage in feet at Butte La Rose and Morgan City Turbidity for duration of 2017 study.

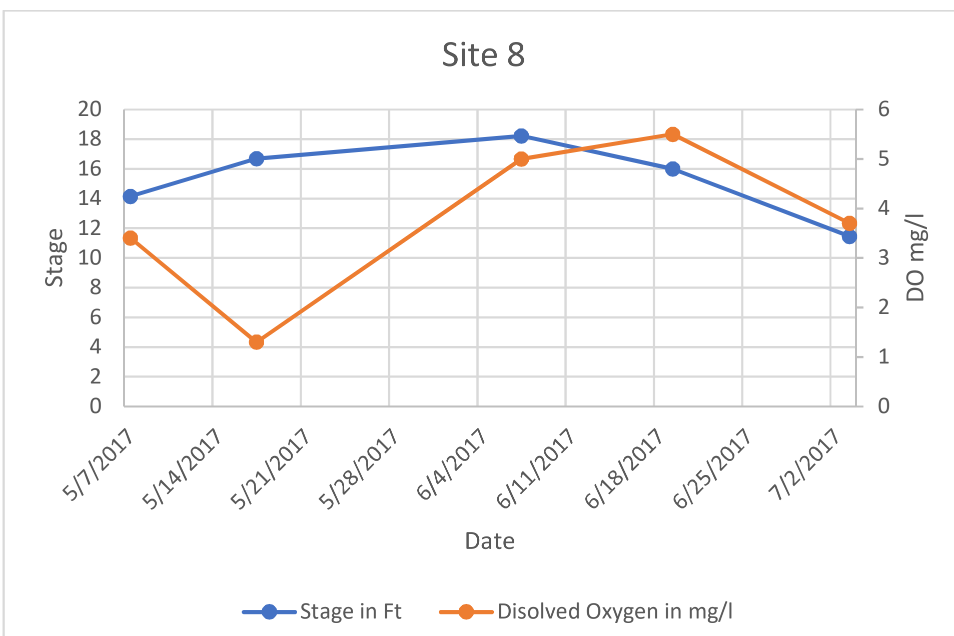

Figure 16b. Stage at Butte La Rose in feet and Dissolved Oxygen collected by Kong (2017).

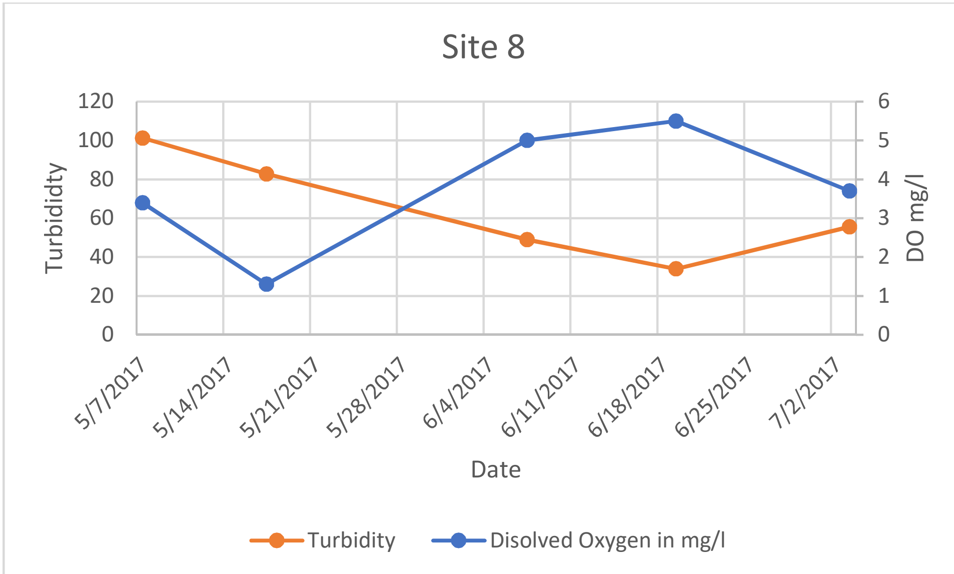

Figure 16c. Plot of Dissolved Oxygen from Kong (2017) and Turbidity from Morgan City over the time data was collected for Site 1 in 2017.

viewer on all occasions it allows a relative assessment of turbidity as well as being able to give comparisons from one area to another or a time series of change over a given measurement cycle. The lower the number the more turbid the water. In non-turbid swamp stillwater and pond environments Secchi disc reading of a 100 cm are common, In the very turbid suspended sediment laden conditions Secchi disc readings can be as low as 10 cm.

Unfortunately, Kong (2017) only presents means (with standard deviations) for each of her 14 sites utilizing all the readings collected during her 4 months study in 2016 (Table 1). However, the means for the sites under consideration, namely 1, 6, 7, and 8, range from 30.6 – 36.0 cm. By contrast the 2016 data ranged from 17.7 to 24.0 cm being far more turbid than the 2016 sampling at the same sites, reflecting the 1:1000-year Mississippi rain induced flood peak versus a Mississippi catchment induced flood. The other cluster mentioned previously, north of Bayou Sorrel, have Secchi disc readings ranging from 91.8 to 111.0 cm. This latter cluster of samples were taken in what is an impoundment because of spoil piles from oil and gas activities and pipelines that effectively seal off this area from freshwater inputs, other than the annual rainfall. However, during major floods, this still water location will get some input of suspended sediments and associated nutrient loading. Not surprisingly, these still water areas are hypoxic, compounded in parts that there is an abandoned brine disposal site (and maybe some drilling mud) within the impoundment.

It is thus very easy to explain the impacts of allowing suspended sediment laden Mississippi catchment (the norm) flood waters to enter swamp and pond environments; these waters bring in vast amounts of nutrients associated with suspended sediments that result in a rapid lowering of oxygen concentrations from background levels and lead to hypoxia. Kong's data bears this out very clearly and raises questions about the viability of using channel cuts to flush back swamp environments to improve water quality. This 2016 data set does not support this hypothesis as advocated by groups such as TNC.

Table 2 Mean (±SE) *Procambarus clarkii* and *P. zonangulus* carapace length (CL), catch per unit effort (CPUE), and totals of both species collected during the crayfish season from 7 May to 3 July 2017 at intensive sample locations. Horizontal lines indicate the absence of *P. zonangulus*.

	P.clarkii		*P. zonangulus*		Total	
Site	CL	CPUE	CL	CPUE	CL	CPUE
1	42.9 ± 0.2	12.3 ± 8.8	43.7 ± 0.7	1.4 ± 0.6	43.0 ± 0.2	13.1 ± 9.0
2	43.6 ± 0.3	6.4 ± 2.6	46.0 ± 1.0	0.9 ± 0.4	43.7 ± 0.3	6.4 ± 2.7
3	44.1 ± 0.4	3.1 ± 0.8	42.6 ± 1.3	0.8 ± 0.2	44.0 ± 0.4	3.5 ± 0.7
4	42.4 ± 0.4	2.4 ± 0.7	43.0 ± 0.6	1.3 ± 0.3	42.6 ± 0.4	2.8 ± 0.7
5	42.7 ± 0.9	0.6 ± 0.3	45.1 ± 2.1	0.4 ± 0.2	43.5 ± 0.9	0.8 ± 0.5
6	43.1 ± 0.2	6.5 ± 3.5	44.8 ± 0.8	1.5 ± 0.6	43.3 ± 0.2	7.4 ± 3.9
7	43.7 ± 0.6	1.9 ± 0.8	44.1 ± 1.1	0.7 ± 0.3	43.8 ± 0.5	2.2 ± 1.0
8	44.2 ± 0.6	2.0 ± 1.0	47.5 ± 1.2	0.5 ± 0.3	44.6 ± 0.6	2.3 ± 1.2
9	41.9 ± 0.3	7.4 ± 1.7	45.2 ± 2.3	1.6 ± 0.7	42.1 ± 0.3	7.6 ± 1.8
10	43.0 ± 0.2	11.7 ± 2.0	42.6 ± 1.0	1.5 ± 0.5	43.0 ± 0.2	12.0 ± 2.0
11	44.6 ± 0.2	17.8 ± 3.5	44.3 ± 1.4	1.0 ± 1.0	44.5 ± 0.2	18.1 ± 3.6
12	42.5 ± 0.5	0.4 ± 0.2	—	—	42.5 ± 0.5	0.4 ± 0.2
13	45.0 ± 1.1	0.4 ± 0.1	—	—	45.0 ± 1.1	0.4 ± 0.1
14	40.2 ± 2.1	0.2 ± 0.1	—	—	40.2 ± 2.1	0.2 ± 0.1

One important management consequence of flooding back swamps with suspended sediment laden water that Kong (2017) did not consider is the infilling and eventual loss of these unique forested wetlands.

Crawfish Assessment

Kong (2017) sampled the *Procambarus clarkii* species of crawfish biweekly at her 14 fixed sites during the 2016 and 2017 crayfish seasons. Sex, reproductive form (males only), and standard carapace length were recorded for all captured individuals and catch per unit effort (CPUE) was determined as the number of crawfish per trap. Table 2 presents data on the mean and standard deviation of the carapace length (CL) and the catch per unit effort (CPUE). The data are graphed in Figure 17.

These data reveal that crawfish size across the study area, irrespective of each's DO footprint, are the same. It is obviously an age-related characteristic rather than one determined by environment. However, her CPUE reveal that in some hypoxic areas the abundance of crawfish is lower. There are some yet unexplained spikes in her data. Unfortunately, she does not supply actual data collected on each sample date, which would allow a time-series review. Kong (2017) does use a lot of statistical 'tests' to try to draw some conclusions as to what her data are indicting but given the fatal flaw of her 3.5 m assumption and at times indicating that there was no connectivity when the data show there was, places all this statistical assessment in question and the validity of her conclusions.

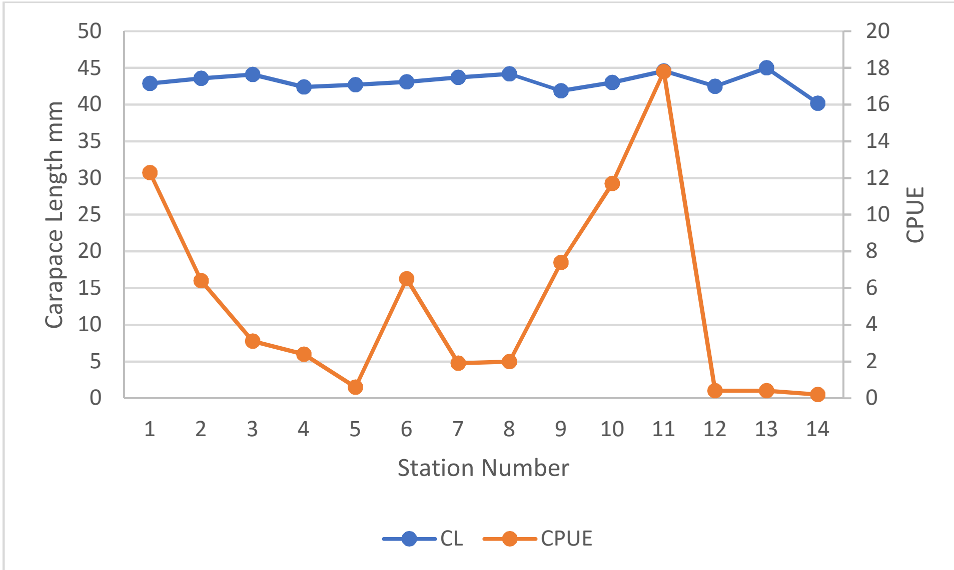

Figure 17. Graph of mean carapace length (CL) and mean catch per unit effort across Kong's study region for the duration of her 2017 study.

Conclusions

Although missing some of the specific data that Kong (2017) collected (i.e., individual sites did not list all data collected on each date, rather seasonal or location means were presented) the data still allow an assessment of the 2017 flood and its consequences in the Atchafalaya Basin. Specific conclusions are as follows:-

1. The 2016 Missisppi catchment flood originated on the Missouri (largest tributary) and Missisppi Rivers and as such the Atcahafalaya River would have had significant suspended sediment loads, as compared if the major flood had been from the Ohio River. Thus, floodwaters that would have overflowed river levees and utilized man-made channels and pipeline conduits would carry suspended sediment into Kong's study sites. By contrast the 2017 flood peak sampled by Kong was due to a 1:1000-year induced rainfall event in the mid portion of the Missisppi River, not a catchment flood. As such the sampled 2017 flood peak had a very low suspended sediment load and hence turbidity and hence nutrients (Figure 4c).
2. Kong had an apparent major flaw in her study related to a 3.5 m ground elevation estimation. Utilizing data from the TNC allowed the determination of a very representative ground elevation at the various study sites. This becomes critical when reviewing the dissolved oxygen data presented by Kong (2017).
3. The sample sites chosen for this evaluation were done so to try to compare her data with that being collected by TNC (Kong sites, 1, 6, 7, and 8). At all these sites Kong assumes that when low oxygen or anoxic conditions are present, it meant that hydrologic connections to the flooding River and Bayou Sorrel were disconnected; in other words, there was no 'fresh' flow entering her sites. This is a major flaw in this study. At all times

that these sites had at least 3.0 feet of flow over ground. Oxygen concentrations peaked as the flood peaked, totally opposite of the catchment flood of 2016! Additionally, low DO is not a lack of hydrologic connection as Kong surmised.

4. In comparing Kong (2017) 2016 flood data with her 2017 data it is readily apparent that the impacts of suspended sediment and nutrient loading associated with the Atchafalaya floodwaters explains the lowering of oxygen levels. Fortunately, she does supply some Secchi disc turbidity data that support the conclusion that dropping dissolved oxygen concentrations and resultant hypoxia are a consequence of nutrient load associated with suspended sediment inputs.
5. Kong's data reveal that crawfish size across the study area, irrespective of each's DO footprint, are the same. However, her CPUE reveal that in some hypoxic areas the abundance of crawfish is lower. There are some unexplained spikes in her data. Her statistical study is invalid given some of her assumptions.

AS CONCERNS THE MANAGEMENT OF THE BASIN, THIS 1:1000 YEAR RAIN INDUCED 2017 FLOOD DATA AS WELL AS THE 2016 CATCHMENT FLOOD DATA AS PRESENTED IN KONG'S 2017 THESIS DOES NOT SUPPORT OPENING OR CUTTING CUTS IN CHANNEL BANKS AND TRYING TO FLUSH SWAMPS WITH SUSPENDED SEDIMENT LADEN FLOOD WATERS TO IMPROVE WATER QUALITY AND REDUCE HYPOXIC EVENTS. RATHER THESE ACTIONS LEAD TO HYPOXIA.