Environmental Studies of Perdido Bay (2003-2004)

Report for the Law Firm of Levin, Papantonio

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Introduction

Gulf coast estuaries provide critical feeding, spawning and nursery habitats for a rich assemblage of fish, wildlife and plant species (US EPA 2005). For example, Gulf coast estuarine wetlands provide essential habitat for shorebirds and migrating waterfowl, and serve as critical habitats for the young of many economically important finfish and shellfish. In addition, seagrass or submerged aquatic vegetation (SAV) provides shoreline protection and also serves as essential spawning, nursery and feeding habitat for many commercial and recreational species such as brown and pink shrimp, scallops, blue crabs, red drum and spotted sea trout (Heck et al. 1997, 2003).

In fact, Gulf coast estuaries are among the most productive of all natural systems, producing more food per acre than the richest farmlands in the country (US EPA 2005). In addition, estuarine dependant species constitute more than 95% of the commercial fishery harvest from the Gulf of Mexico (US EPA 1999) and many important recreational fishery species depend on estuaries during some part of their life cycle (US EPA 1999).

Estuaries provide receiving waters for wastewater discharges from municipalities and industry, and they also provide abundant opportunities for recreational activities such as swimming, diving and boating (US EPA 1999). The desirability of coastal living has led to an increase in population size in Gulf coastal counties that exceeded 100% between 1960 and 2000 (US EPA 2005). The coasts of both Alabama and northwest Florida have experienced expanded industrial uses of estuaries as well as large increases in population size during the past half century or so, and the rate of population growth has been exceptionally high during the past 25 years.

The Perdido Bay system in the northcentral Gulf of Mexico separates the coastlines of the states of Alabama and Florida. Perdido Bay is a small estuary (only 130km^2, Flemer et al. 1999) with shallow to moderate depths (mean depth 2.2 m, Livingston 2001) and an average salinity of 15 psu (Isphording 2005). Freshwater input into Perdido Bay comes from four main sources: Perdido River, Eleven Mile Creek, Bayou Marcus and Wolf Bay. Prior to the 1940s, Perdido Bay was in a nearly pristine state, with clear waters, white sand bottoms, beds of SAV and abundant finfish and shellfish (Livingston 1998).

Since initial construction in the 1940s, and subsequent expansions of what is now the International Paper Company's (IP) mill in Cantonment, there have been a series of well-documented declines in water quality and environmental conditions in upper Perdido Bay that have been attributed to the discharges of IP and its predecessors, and reported in both the scientific literature and the popular press. For example, in the early 1950s, the Florida Board of Health reported that Eleven Mile Creek, which receives the mill discharges and then empties into upper Perdido Bay, and the upper portion of the Bay near the point where the creek emptied into the Bay were "greatly degraded", and that "...the chemical influence of Eleven Mile Creek can be noted as far south as Lillian Highway Bridge at Highway 98" (Livingston 1998). In 1970, the paper mill was found to be the primary cause of low dissolved oxygen and other adverse conditions such as foam and lignin deposits in Perdido Bay by the US Department of Interior (Pensacola News Journal 7/1/1999). IP's predecessor, the St. Regis Paper Company, installed a new secondary waste treatment system in 1972 in response to new federal pollution control laws (Pensacola News Journal 7/1/1999), and there have been additional upgrades in effluent treatment (Livingston 1998). However, there were continuing citizen's complaints about the effects of pollution from the paper mill. Among the symptoms were low dissolved oxygen in the waters in Eleven Mile creek, with negative effects on animals, along with dark-colored water and foam. Details of the history of these citizen's complaints is contained in the grand jury report on air and water quality in Escambia County that was produced in 1999 and reported on by the Pensacola News Journal.

It is also known that the abundance of submerged aquatic vegetation (SAV) has declined greatly since the construction of the paper mill. This is clearly shown in a 1995 publication by Handley (1995), who reported that the areal coverage of SAV declined from 793 to 534 acres between 1940 and 1987. This is similar to the pattern of SAV loss in other Florida bays influenced by paper mill effluents. For example, in an earlier study, Livingston (Zimmerman and Livingston 1976; Livingston 1998) found that pulp mill effluents from the Fenholloway River were associated with a significant increase in water color (thus lower light levels) and that reduction in light levels and direct contact of pulp mill effluents with SAV had significant adverse impacts on growth and abundance of SAV.

Livingston conducted a long term study within the Perdido Bay system beginning in 1988 (Livingston 1998, 2001) and his work showed important impacts of the mill on Perdido Bay, primarily as a result of excess fertilization of Bay waters by nitrogen and phosphorus that resulted in runaway growth of algae. The superabundant algae were believed to sink to the bottom, where they were broken down by bacteria whose metabolic activities used up all the oxygen in the water and made it unsuitable for fish and shellfish. Livingston found that increasing nutrient discharges from the mill led to large algal plankton blooms from 1994 to 1999 (Livingston 2001), and he suggested that water from Eleven mile Creek had concentration gradients of orthophosphates and ammonia that initiated the alga blooms (Livingston 2001). These blooms appeared to cause a decrease in abundance and species richness in small algae in the bottom sediments as well as a reduction in dissolved oxygen (DO) levels at depth (Livingston 2001). The low DO, in turn, caused major losses of invertebrates and fishes (Livingston 2001). Livingston concluded that continued loading of orthophosphates from 1997 to 1999 caused an almost complete collapse of the small bottom dwelling animals that form the base of the food supply for larger fishes and invertebrates and animal production in the Perdido Bay system.

Flemer et al. (1999) also found that low DO levels in the Perdido Bay system affected the abundance and diversity of bottom dwelling invertebrates.

For example, an index of species diversity, the taxa richness index, was calculated to range from 0.0 – 5.0 for Perdido Bay. This range was much below the values of 5.0 – 30.0 recorded from other Gulf of Mexico estuaries, indicating that the bottom dwelling animals were being environmentally stressed (Flemer et al. 1999).

In summary, Perdido Bay has been negatively impacted by the pulp mill for over half a century and on-going citizens' complaints indicate that the negative impacts continue to this day. The present study was initiated in 2003 and continued in 2004, with the goal of measuring basic water quality parameters that would allow an updated assessment of the condition of Perdido Bay. The focus of this work was on upper Perdido Bay, although samples were also taken from locations in the middle and lower Bay. Based on the data we gathered, along with supporting references, we draw conclusions about the ability of current (2003-2004) water quality conditions to support the abundant plant and animal life characteristic of pre-paper mill conditions in Perdido Bay and other non-polluted estuaries in the northern Gulf of Mexico.

Methods

Water quality was monitored weekly between October 9 and November 11, 2003, and approximately every 10-12 days during the May-November 2004 growing season. Due to inclement local weather and Hurricane Ivan this schedule was modified as needed. Salinity, temperature, dissolved oxygen, turbidity, chlorophyll a concentration, depth, and light transmittance were collected boat side from 29 stations within Perdido Bay. Of these locations, 20 were in the shallow waters along the perimeter of the bay approximately 30-50 m from the shoreline, 5 were located in the deeper waters in the middle of the bay, and 4 were located at the mouths of each important hydrological input to Perdido Bay: the Perdido River, 11-mile Creek, Bayou Marcus, and Wolf Bay. Stations located north of the Highway 98 bridge were spaced approximately 1 mile apart, while south of the bridge, stations were approximately 2 miles apart (Appendix 1).

Salinity, temperature, dissolved oxygen, turbidity, chlorophyll a concentration, and depth were collected using a YSI™ Model 6000 Sonde. The instrument was calibrated prior to each use by technicians at the Dauphin Island Sea Lab. When requested, calibration was confirmed after use in the field to ensure accuracy of apparent outliers. Light transmittance was collected boat side using a Li-Cor™ 4 pi spherical sensor. This sensor measures photosynthetically active radiation (PAR), that is, that part of the light spectrum that can be used by aquatic plants. All samples were collected between late morning and early afternoon. Both the YSI and Li-Cor data were collected approximately 3 cm below the water's surface as well as just off the bottom at the shallow sites (<1 m) along the bay's perimeter and at Bayou Marcus (depth ~1m). For deeper sites (>1 m) in the middle of the bay and at the remaining inputs sites, data were collected at the top, 1 meter, and at the bottom of the water column.

To summarize the large amount of data collected, we produced contour plots using the commercially available Surfer software. This software package uses “kriging”, a method of interpolation which predicts unknown values from data observed at known locations. Estimated values of each measured parameter are then used to produce contour plots that provide readily interpretable images of conditions throughout the study area.

Results

Salinity

During 2003, surface salinity ranged from 9 to 23 psu throughout the Perdido Bay system (Figures 1-5), with the lowest salinity located near Eleven mile Creek and Bayou Marcus. Bottom salinity also ranged from 9 to 23 psu (Figures 6-10), with the lowest salinity again located near Eleven mile Creek and Bayou Marcus.

During 2004, surface salinity ranged from 5 to 24 psu (Figures 11-24) and, as expected, lower salinities were consistently located in the upper part of the bay near Eleven mile Creek and Bayou Marcus. Bottom salinity ranged from 5 to 25 psu (Figures 25-38); however, variance from the expected salinity gradient (lower salinity in the upper bay to higher salinity in the lower bay) can be seen on several dates, including May 17, June 9, July 27 and November 22 (Figures 25, 27, 31 & 38).

Temperature

Surface and bottom temperatures ranged from 21°C to 25.5 °C during 2003, with very little variance occurring on individual sampling days (Figures 39-48). Similar kinds of results were found in 2004, with temperatures ranging from 20.2 °C to 33 °C on both the surface and the bottom (Figures 49-76).

Dissolved Oxygen

In 2003, dissolved oxygen (DO) on both the surface and bottom of Perdido Bay ranged from 72 to108 % saturation with no apparent trend visible on the contour plots (Figures 77-86). However, upon examining the actual data records, instead of the contour plots produced by the Surfer software, it was found that DO at Eleven mile creek was less than 20% saturation on the bottom on four of the five sampling days in 2003 (Appendix 2).

DO on the surface and bottom of Perdido Bay ranged from 6 to 108% saturation in 2004 (Figures 87-114). On the surface, as in 2003, there were no apparent trends in DO levels throughout the bay; however, bottom DO levels were lower in the upper bay (near Eleven mile Creek and Bayou Marcus) on 12 of the 14 sampling days.

Turbidity

Surface turbidity ranged from 2 to 4 NTU in 2003 with the highest levels of turbidity found in the upper portion of the bay near Bayou Marcus and Eleven mile Creek (Figures 115-119). Bottom turbidity levels were much greater and had a much larger range (2-26 NTU) with higher levels of turbidity recorded in the upper portion of the bay, except on October 31 (Figures 120-124).

Turbidity on the surface in 2004 ranged from 3 to 48 NTU in 2004 with the highest levels usually found in the upper portion of the bay near Bayou Marcus and Eleven Mile Creek (Figures 125-138). However, on May 17 turbidity was highest in the lower part of the bay (Figure 125) and on September 2 the turbidity was greatest in the middle part of the bay (Figure 134). On June 9 (Figure 127) and November 12 (Figure 137) turbidity was fairly uniform throughout the bay. Bottom turbidity ranged from 3 NTU to values in excess of 120 NTU during 2004 (Figures 139-152). Again, highest levels of turbidity were normally found in the upper portion of the bay near Bayou Marcus and Eleven Mile Creek; however, on five occasions--July 1, July 27, August 23, September 2 and October 13 (Figures 143,145,147,148, & 149 respectively)-- portions of the middle bay also had high bottom turbidity levels.

Light Transmission (PAR)

Light transmission Bay ranged from 30 to 65 % of incident light on the surface and bottom during 2003 (Figures 153-162). There were no clear trends when looking at the contour plots, but when the actual data were examined, we observed that less than 5% of the incident light was present at the bottom near Eleven mile Creek on all six sampling dates (Appendix 2). Somewhat low levels of incident light were also seen near Perdido River (<10% for all sampling dates), Wolf Bay (< 30% for all six sampling dates) and Bayou Marcus (<30% for all six sampling dates) (Appendix 2).

In 2004, light transmission ranged from 15 to 90% on the surface and 6 to 54% on the bottom (Figures 163-190). Frequently, as in 2004, lower levels of incident light on the surface and bottom were concentrated in the upper Bay.

Chlorophyll a

Chlorophyll a levels, useful as an indicator of algal abundance in the water column, ranged from 0 to 20 µg/L on both the surface and bottom of Perdido Bay (Figures 191-200) in 2003, with consistently higher values in the upper bay near Bayou Marcus and Eleven mile Creek.

Levels of chlorophyll a in 2004 ranged from 4 to 19 µg/L on the surface with no apparent trends in chlorophyll a distribution (Figures 201-214). Bottom chlorophyll a levels ranged from 4 to more than 20 µg/L with 9 of the 14 sampling dates showing high chlorophyll a levels in the upper bay near Eleven Mile Creek and Bayou Marcus (Figures 215-228).

Discussion and Conclusions

Similar to the results found by earlier investigators, including most recently those of Livingston (Livingston 1998, 2001), we found that the upper portion of Perdido Bay experiences: high turbidity levels, which produce unacceptably low light levels for plants like SAV that live below the water's surface; low dissolved oxygen that limits the suitability of Perdido Bay waters as habitat for finfish and shellfish; and regions of high chlorophyll a concentrations that indicate elevated algal populations. Nevertheless, there are also some differences between our results and those of Livingston (1998, 2001) that merit discussion.

One difference is that the chlorophyll a indicator of algal abundance in our study, while elevated in the upper Bay, was usually lower than the values recorded by Livingston during the 1990s, who found many values higher than our contoured maximum of 20 micrograms/liter, and some values over 100 micrograms/liter (Livingston 2001). Thus, Livingston found algal blooms to be a very serious problem for the health of upper Perdido Bay, while at the time of our study, excessive algal abundance did not seem to provide an explanation for the current condition of the Bay. Another difference is Livingston's (1998, 2001) conclusion that the "liquid mud" present in many locations, which supports a very depauperate assemblage of bottom dwelling organisms, is due to a combination of the effects of stratification and the accumulation of dead and decaying algae. Isphording (2005), however, used chemical tracers to determine that the source of the liquid mud is most likely the paper mill effluents, thus implicating the paper mill discharge in the alteration of the sediment characteristics of the bay and, by extension, the animals that dwell in and on these sediments.

A recent "report card" on Gulf of Mexico estuaries (US EPA 2005), which reflects conditions as they existed in 2000, finds that Perdido Bay still suffers from a variety of ecological problems, many of which are consistent with our findings. This EPA report shows that Perdido Bay has poor water quality, including low DO, poor bottom sediment conditions and an unhealthy assemblage of bottom–dwelling invertebrates. Our own results indicate that low light availability and turbid water, along with low DO, make conditions (especially in portions of upper Perdido Bay) unsuitable for healthy SAV beds and the nursery function they provide, or for abundant finfish and shellfish populations.

In summary, the upper portion of Perdido Bay has long been observed to be an area of degraded water quality that supports depauperate populations of submerged aquatic vegetation (SAV) and bottom dwelling animals. The results of our studies in 2003-2004 are in agreement with earlier studies, as well as the report of Isphording (2005). They indicate that unfavorable conditions for SAV and animals living in contact with the bottom sediments continue to exist in the upper Bay, and that they are substantially related to discharges from the IP paper mill.