Tampa Bay Integrated Science Pilot Study
A 2001-2002 drought-induced imprint on estuarine processes?

INTRODUCTION

Coastal bays and estuaries are well known for their intrinsic recreational and economic value, yet these ecosystems are also among our most troubled natural environments (Cloern, 2001). Urban development, agriculture and shipping are just a few examples that can cause a wide range of deleterious change in the coastal zone. These human-induced alterations, however, occur simultaneously to cycles of natural variability (i.e., climate change). To effectively manage coastal ecosystems one needs to be able to distinguish between man-made and natural causes of change. The U.S. Geological Survey in 2001 initiated a broad program of scientific study in Tampa Bay (Fig. 1) to address this theme (Robbins and Yates, 2001). The Tampa Bay Estuary Project is based on a holistic integration of the fields of geology, biology, hydrology and geochemistry to examine natural and human-induced change. This report presents some initial geochemical and hydrological observations made during a prolonged period of drought in Tampa Bay.

PRELIMINARY OBSERVATIONS

Historic river discharge

The Tampa Bay watershed experienced severe drought conditions in 2000-2001. Long-term flow records (1933-1992) of the Alafia River at Lithia indicate a significant decreasing trend (Fig. 2) in annual mean flows (Stoker et al., 1996) and annual peak flows (Hammett, in press). Annual mean flows in the Alafia River, Hillsborough River, and Sweetwater Creek for the 2000 water year were the lowest on record. Such reduced riverine inflow resulted in observed elevated salinities throughout large portions of the bay. These trends can be attributed in part to climatic variability, as well as other factors such as drier antecedent conditions, decreased ground water inflow and sea level fluctuations.

Exchange processes at the sediment/water interface

Interstitial waters (i.e., pore waters) can provide a powerful forensic tool to interpret post-depositional change in sediments (McKee et al., 1996). Pore water profiles from four sites in Tampa Bay indicate upward diffusion from sediments into the water column for many nutrients such as phosphorus and ammonia. In contrast, selected metal profiles show a flux into the seabed (Fig. 3). Such divergent pore water profiles influence the availability of these constituents for biologically mediated uptake. A suite of geochemical tracers suggests that exchange across the sediment/water interface at the four sampling sites is limited to recycled seawater facilitated by tidal forcing, rather than submarine groundwater discharge. Results from a geophysical survey indicate an abrupt change in stratigraphic units, with the deeper layer having either lower porosity or less saline pore waters. The current drought regime suggests that the former explanation is more plausible, and the geophysical resistivity anomalies typically corroborate observed geochemical results.

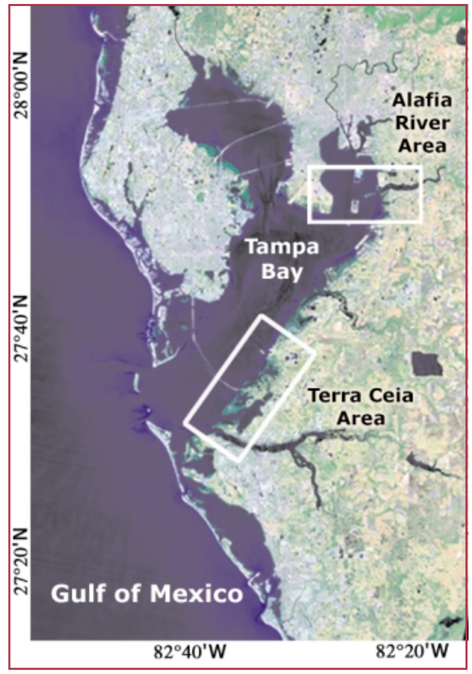

Figure 1. Satellite image of Tampa Bay indicating demonstration study sites near the Alafia River and Terra Ceia area. Colors are near natural; healthy plants are green, agricultural fields are pink or beige.

Estuarine processes at the Alafia River/ocean mixing zone

Estuaries are biogeochemical reactors where a complex suite of reactions and processes transforms riverine constituents (i.e., contaminants) as they are transported out to sea (Swarzenski et al., 1995). An important effect of these processes is the removal of many particle reactive constituents (Fig. 4) from the dissolved phase onto particles (scavenging), where their fate is bound closely to that of the particle. This implies that when a particle settles onto the seabed and becomes buried, the attached chemical is no longer bioavailable in the water column. Not all scavenging reactions are irreversible, so that additional processes such as early diagenesis or bioturbation can re-introduce some contaminants to the water column via pore water advection/diffusion. Estuarine

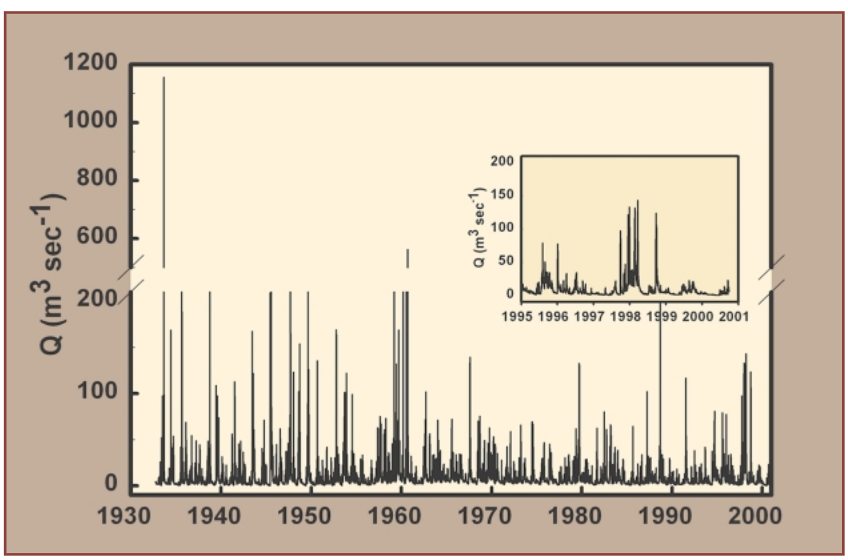

Figure 2. Historic Alafia River daily mean discharge at Lithia, Florida.

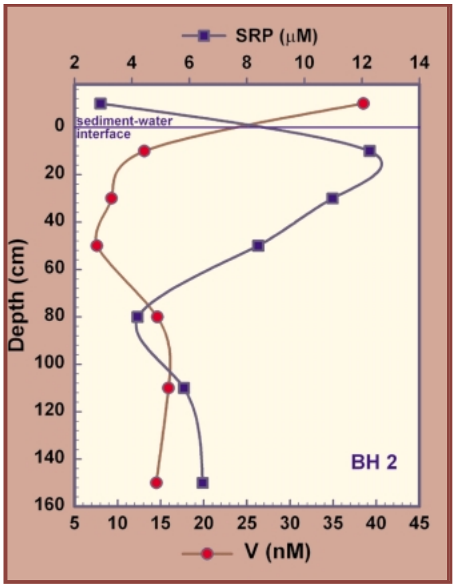

Figure 3. Pore water profiles of dissolved vanadium (nM) and soluble reactive phosphorus-SRP (µM).

processes did not occur in the bay water column during the sampling period, but instead occurred in the Alafia River. How these findings compare to non-drought conditions needs to be evaluated with regard to ecosystem health and sustainability.

Bioturbation

Exchange at the sediment/water interface can be greatly influenced by biologically facilitated mixing, i.e., bioturbation. In Tampa Bay, the population of ghost shrimp (thalassinidean) was most dense (mean = ~31 m^{-2}) closest to the Alafia River mouth. Biomass and apparent bioturbation rates by this benthic organism appeared to exceed those of clams and worms.

SUMMARY

- Rainfall and streamflow into Tampa Bay were at record lows in 2000 and 2001;
- Salinities were elevated bay-wide, and approached marine values;
- Exchange at the sediment/water interface was principally recycled seawater (bay water);
- Active bioturbation by ghost shrimp can facilitate the transport of sediment and solutes.

LINKS TO OTHER TAMPA BAY RESEARCH

These investigations are directly coupled to: 1) geologic framework studies , which provide a more robust interpretation of the underlying stratigraphy, 2) wetland studies , that allow us to examine, for example, the hydrologic control on wetland structure, and 3) paleo-eutrophication studies that can place our modern interpretations into an historic context. We need to continue to develop a better understanding of external/internal influences on the observed responses, to be able to critically evaluate long-term trends in ecosystem health.

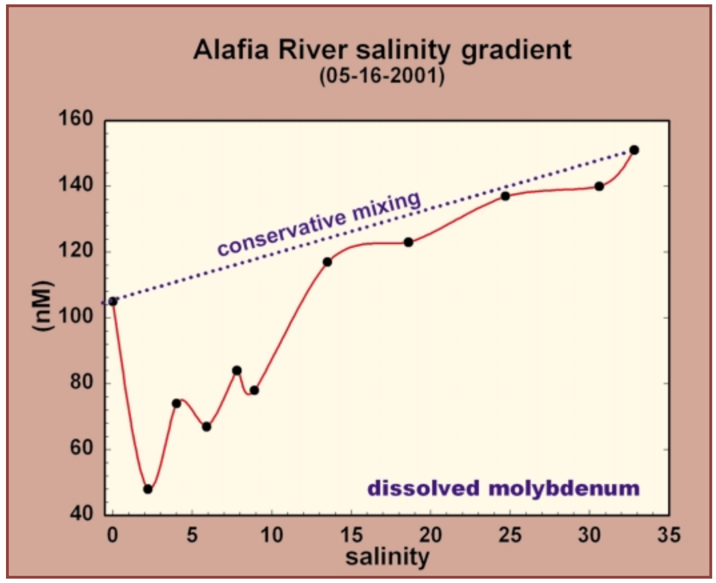

Figure 4. Dissolved molybdenum versus salinity in the Alafia River/Tampa Bay mixing zone.

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