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Annotated Bibliography of Selected Literature on the Piney Point Phosphate Plant

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July 2021

Angelo, M. J., & Glass, J. W. (2021). Integrated Estuary Governance. *William & Mary Environmental Law and Policy Review*, *45*(2), 455. https://scholarship.law.wm.edu/wmelpr/vol45/iss2/5

Estuaries are complex, dynamic ecosystems that play a critical role in supporting crucial economic industries, such as commercial fishing and tourism, and providing the resources necessary to sustain coastal communities. A range of anthropogenic environmental stressors are threatening the health of estuaries throughout the world. Traditional top-down single resource focused environmental regulatory approaches have proved inadequate to protect and restore estuarine systems. In recent years, scientific and legal academics, as well as policymakers, have called for more holistic participatory approaches to addressing environmental challenges. Drawing on the literature on ecosystem management, integrated water resources management, collaborative governance, and adaptive management, we offer a new approach, which we refer to as Integrated Estuary Governance. Our proposal incorporates elements of other approaches that have been demonstrated to be essential in managing natural systems in general and that have particular applicability to estuarine systems.

Barnett, C. (2008). One Last Big Push for Phosphate Mining. *Florida Trend*, *51*(1), 84. https://www.floridatrend.com/article/7700/one-last-big-push-for-phosphate-mining

South-central Florida's landscape will be shaped in large part by a company many residents have never heard of. Mosaic is the only big player left in Florida's phosphate industry, and it controls more than 300,000 acres.

Bioassays of Piney Point Phosphates, Inc. (n.d.). Retrieved May 6, 2021, from http://www.manatee.wateratlas.usf.edu.ezproxy.lib.usf.edu/upload/documents/4082.pdf

Piney Point Phosphates previously operated a phosphate fertilizer manufacturing complex in Manatee County Florida. After Piney Point Phosphates declared bankruptcy, a Receiver was appointed to maintain the phosphogypsum stack system to prevent a release of untreated wastewater. In an effort to close the stack system, the FDEP has authorized discharge of wastewater after RO treatment. In order to expedite the closing of the stack system, alternative treatments of wastewater for discharge to surface waters are being explored at the site. These toxicity tests were used to determine whether effluent treated with a two-stage liming process,

followed by break-point chlorination, then dechlorination would be adequate for discharge. Wastewater treated in this manner is not currently being discharged pending the results of further testing (facility information provided by Jacquelyn Champion, FDEP, Phosphate Management, Tampa).

Burnett, W. C., & Elzerman, A. W. (2001). Nuclide migration and the environmental radiochemistry of Florida phosphogypsum. *Journal of Environmental Radioactivity*, *54*(1), 27–51. https://doi.org/10.1016/S0265-931X(00)00164-8

Phosphogypsum, a waste by-product derived from the wet process production of phosphoric acid, represents one of the most serious problems facing the phosphate industry in Florida today. This by-product gypsum precipitates during the reaction of sulfuric acid with phosphate rock and is stored at a rate of about 40 million tons per year on several stacks in central and northern Florida. The main problem associated with this material concerns the relatively high levels of natural uranium-series radionuclides and other impurities which could have an impact on the environment and prevent its commercial use. We have studied the potential release of radionuclides from phosphogypsum by: (i) analysis of stack fluids, groundwaters, and soils associated with gypsum stacks; and (ii) geochemical modeling. Stack fluids were observed to be very high in dissolved uranium and ^{210}Pb with only moderate concentrations of ^{226}Ra. Underlying soils tend to be enriched in U and ^{210}Pb indicating precipitation when acidic stack fluids enter a buffered environment. Modeling results showed significant increases in radionuclide complexes with sulfate and phosphate, resulting in relatively mobile uncharged or negatively charged solution species within the stacks with likely precipitation of multicomponent solids with increasing pH below the stack. Our evidence thus suggests that, while phosphogypsum stacks do contain significant quantities of dissolved radionuclides, removal mechanisms appear to prevent large-scale migration of radionuclides to the underlying aquifer.

Finucane, J.H., Rinckey, G.R., & Saloman, C.H. (1964, May). Mass Mortality of Marine Animals during the April 1963 Red Tide Outbreak in Tampa Bay, Florida. *A Collection of Data in Reference to Red Tide Outbreaks During 1963.* Retrieved May 6, 2021, from http://www.tampabay.wateratlas.usf.edu.ezproxy.lib.usf.edu/upload/documents/Collection%20of%20Data%20Red%20Tide%20Outbreaks%201963.pdf#page=98

During a red tide outbreak in April 1963 extensive fish kills were observed in Tampa Bay. Ray and Wilson (1957) have shown that a causative organism of mass fish mortalities along the Florida west coast is the dinoflagellate, Gymnodinium breve. Blooms of G. breve were present in

fish killing concentrations for a period of about two weeks from April 3-16 in an area extending from the mouth to approximately 25 miles inside Tampa Bay. No blooms of this organism were detected in upper Hillsborough Bay or Old Tampa Ba. The majority of the dead fish were concentrated in the lower Bay.

Duan, S., Banger, K., & Toor, G. S. (2021). Evidence of Phosphate Mining and Agriculture Influence on Concentrations, Forms, and Ratios of Nitrogen and Phosphorus in a Florida River. *Water*, *13*(8), 1064. https://doi.org/10.3390/w13081064

Florida has a long history of phosphate-mining, but less is known about how mining affects nutrient exports to coastal waters. Here, we investigated the transport of inorganic and organic forms of nitrogen (N) and phosphorus (P) over 23 sampling events during a wet season (June–September) in primary tributaries and mainstem of Alafia River that drains into the Tampa Bay Estuary. Results showed that a tributary draining the largest phosphate-mining area (South Prong) had less flashy peaks, and nutrients were more evenly exported relative to an adjacent tributary (North Prong), highlighting the effectiveness of the mining reclamation on stream hydrology. Tributaries draining > 10% phosphate-mining area had significantly higher specific conductance (SC), pH, dissolved reactive P (DRP), and total P (TP) than tributaries without phosphate-mining. Further, mean SC, pH, and particulate reactive P were positively correlated with the percent phosphate-mining area. As phosphate-mining occurred in the upper part of the watershed, the SC, pH, DRP, and TP concentrations increased downstream along the mainstem. For example, the upper watershed contributed 91% of TP compared to 59% water discharge to the Alafia River. In contrast to P, the highest concentrations of total N (TN), especially nitrate + nitrite (NO_x–N) occurred in agricultural tributaries, where the mean NO_x–N was positively correlated with the percent agricultural land. Dissolved organic N was dominant in all streamwaters and showed minor variability across sites. As a result of N depletion and P enrichment, the phosphate-mining tributaries had significantly lower molar ratios of TN:TP and NO_x–N:DRP than other tributaries. Bi-weekly monitoring data showed consistent increases in SC and DRP and a decrease in NO_x–N at the South Prong tributary (highest phosphate-mining area) throughout the wet season, and different responses of dissolved inorganic nutrients (negative) and particulate nutrients (positive) to water discharge. We conclude that (1) watersheds with active and reclaimed phosphate-mining and agriculture lands are important sources of streamwater P and N, respectively, and (2) elevated P inputs from the phosphate-mining areas altered the N:P ratios in streamwaters of the Alafia River.

Garcia, J. (2018). Mosaic's Next Chapter. *Florida Trend*, *60*(12), 82. https://www.floridatrend.com/article/24005/mosaics-next-chapter

The successful Streamsong development has provided the phosphate mining company Mosaic with part of the template for its future, but not a whole plan.

Garrett, M., Wolny, J., Truby, E., Heil, C., Kovach, C. (2011). Harmful algal bloom species and phosphate-processing effluent: Field and laboratory studies. *Marine Polluytion Bulletin*, *62*(3), 596-601. https://pubmed.ncbi.nlm.nih.gov/21145070/

In 2002, the Florida Department of Environmental Protection began discharging phosphate-processing effluent into Bishop Harbor, an estuary within Tampa Bay. Because of concerns that the effluent would serve as a nutrient source for blooms of the toxic dinoflagellate Karenia brevis, a field monitoring program was established and laboratory bioassays were conducted. Several harmful algal bloom (HAB) species, including Prorocentrum minimum and Heterosigma akashiwo, were observed in bloom concentrations adjacent to the effluent discharge site. Blooms of diatoms were widespread throughout Bishop Harbor. K. brevis was observed with cell concentrations decreasing with increasing proximity to the effluent discharge site. Bioassays using effluent as a nutrient source for K. brevis resulted in decreased cell yields, increased growth rates, and increased time to log-phase growth. The responses of HAB species within Bishop Harbor and of K. brevis to effluent in bioassays suggested that HAB species differ in their response to phosphate-processing effluent.

Gyp-stack cost fix? (2004). *Florida Trend*, *46*(11), S7.

It's not like you can lock the gate and just walk away. Toxic waste piled 12 stories high and holding a billion gallons of polluted water makes closing down a phosphate plant complicated--and expensive, as state officials are learning.

H. El-Shall, R. Stana, A. El-Midany, & S. Malekzadah. (2004). *IN-SITU MINING OF PHOSPHATE ORES* (NONE, 838807; p. NONE, 838807). https://doi.org/10.2172/838807

Presently the mining of Florida phosphate requires the movement of over a 100-ton of materials (overburden, sand, clay) for every ton of phosphate concentrate recovered. Not only is this energy intensive, but it also causes significant stress on the environment. In 2003, the Department of Energy solicited ideas for innovative mining ideas that could significantly improve the efficiency of mining. An award was made to the University of Florida Engineering Research Center to evaluate the in situ mining of phosphates using an aqueous CO{sub 2} solution. Tests were

carried out in a 15.2 cm (6-inch) diameter column, 1.83 meter (6 feet) long at pressures up to 117.2 kg/cm{sup 2} (40 psi). Results to date demonstrate that initially the MgO is leached from the ore and then the phosphate. While the tests are continuing, so far they have not demonstrated P{sub 2}O{sub 5} concentrations that are economically attractive.

Hu, C., & Muller-Karger, F. E. (n.d.). *Satellite monitoring of the FDEP Gulf dispersal of the Piney Point Treated Wastewater*. 81. http://www.tampabay.wateratlas.usf.edu/upload/documents/Satellite-Monitoring-of-FDEP-Gulf-Dispersal-of-Piney-Point-wastewater-2004.pdf

Operational and research satellite sensors such as MODIS, SeaWiFS, and AVHRR provide a unique means to monitor the surface ocean. Observations from these satellites were used to monitor the offshore dispersal of treated Piney Point wastewater. The dispersal was conducted during 35 barge trips from 20 July to 30 November 2003 in an offshore region in the Gulf of Mexico. About 248 million gallons of wastewater were discharged over this period. The satellite observations complemented field samples, surface float trajectories, and model results. Satellite data provided real-time and accurate information on the position of the Loop Current, a strong oceanic current that carried materials away from the dispersal region and into an oceanic regime. The satellite data were instrumental to outline the area where the barge would operate prior to the initiation of the dispersal. In addition, the weekly synoptic satellite data analysis helped understand the motion of offshore waters and the way dispersed waters likely moved. Our primary objective was to document surface circulation patterns, changes in surface ocean color that may have implied changes in the concentration of chlorophyll, and help determine possible movement of undiluted discharge toward near-shore environments. We examined areas on the West Florida Shelf (including the downstream area) and near the Florida Keys, and compared observations to spatial and temporal patterns in chlorophyll measured in 2003 with satellite images collected over the previous seven years. This baseline analysis helped understand any possible changes associated with the dispersal of Piney Point wastewater.

Hu, C., Muller-Karger, F. E., & Swarzenski, P. W. (2006). Hurricanes, submarine groundwater discharge, and Florida's red tides. *Geophysical Research Letters*, *33*(11), 2005GL025449. https://doi.org/10.1029/2005GL025449

A *Karenia brevis* Harmful Algal Bloom affected coastal waters shallower than 50 m off west-central Florida from January 2005 through January 2006, showing a sustained anomaly of ~1 mg chlorophyll m^{-3} over an area of up to 67,500 km^2. Red tides occur in the same area (approximately 26–29°N, 82–83°W) almost every year, but the intense 2005 bloom led to a

widespread hypoxic zone (dissolved oxygen <2 mg L^{-1}) that caused mortalities of benthic communities, fish, turtles, birds, and marine mammals. Runoff alone provided insufficient nitrogen to support this bloom. We pose the hypothesis that submarine groundwater discharge (SGD) provides the missing nutrients, and indeed can trigger and support the recurrent red tides off west-central Florida. SGD inputs of dissolved inorganic nitrogen (DIN) in Tampa Bay alone are ~35% of that discharged by all central Florida rivers draining west combined. We propose that the unusual number of hurricanes in 2004 resulted in high runoff, and in higher than normal SGD emerging along the west Florida coast throughout 2005, initiating and fueling the persistent HAB. This mechanism may also explain recurrent red tides in other coastal regions of the Gulf of Mexico.

Jordan, S., & Benson, W. (2013). Governance and the Gulf of Mexico Coast: How Are Current Policies Contributing to Sustainability? *Sustainability*, *5*(11), 4688–4705. https://doi.org/10.3390/su5114688

The quality of life and economies of coastal communities depend, to a great degree, on the ecological integrity of coastal ecosystems. Paradoxically, as more people are drawn to the coasts, these ecosystems and the services they provide are increasingly stressed by development and human use. Employing the coastal Gulf of Mexico as an example, we explore through three case studies how government policies contribute to preventing, mitigating, or exacerbating the degradation of coastal ecosystems. We consider the effectiveness of the current systems, what alternate or additional policy solutions might be needed to ensure the sustainability of the region and its quality of life, and what this example can tell us about the sustainability of coastal systems globally. In our examples, among other aspects, policies that are proactive and networked governance structures are observed to favor sustainable outcomes, in contrast to reactive policies and hierarchical models of governance.

Jr, B. P. (n.d.). *Process engineering: Wastewater treatment plant goes the distance*. Chemical Processing. Retrieved May 6, 2021, from https://www.chemicalprocessing.com/articles/2005/466/

A mobile reverse osmosis (RO) system from USFilter effectively treated water at an abandoned fertilizer plant. This allowed system effluent to be discharged into Tampa Bay without environmental impact.

Jr, B. P., Soule, C., Zamani, S., Timchak, L., Uebelhoer, G., Nagghappan, L., & Helwick, R. (n.d.). *Mobile Wastewater Treatment Helps Remediate Concentrated Acidic Process Water at Fertilizer Plant*. 8. http://www.fwrj.com/TechArticle05/0705%20FWRJ_tech%201.pdf

The benefits recognized from RO treatment compared to the other technologies are: S Timeliness in installation, start-up, and water production. S Modular equipment that enables flexibility to expand or add unit operation(s). S High-quality RO effluent can be discharged and thus reduce the threat of an unplanned or uncontrolled release. S Concentrate that remains results in smaller volume to "double lime" treat for final solution. To date, RO technology has treated more than 350 million gallons of process water, ultimately discharged to Tampa Bay. Site closure activities are scheduled to complete lining of the existing ponds during 2005. Final treatment and disposal of the remaining free and interstitial water will be accomplished using both RO and the lime precipitation circuits. In the end, the Piney Point site will be used to help solve the Tampa Bay area's water supply shortages, as the lined ponds eventually collect rainwater for disposition as a source of supply water. A site that once posed potential disaster for a coastal estuary soon will become a reservoir and water source with the capacity to hold 1.2 billion gallons of fresh water.

Lewis, M. A., & Russell, M. J. (2015). Contaminant profiles for surface water, sediment, flora and fauna associated with the mangrove fringe along middle and lower eastern Tampa Bay. *Marine Pollution Bulletin*, *95*(1), 273–282. https://doi.org/10.1016/j.marpolbul.2015.04.001

Contaminant concentrations are reported for surface water**,** sediment**,** flora and fauna collected during 2010–2011 from the mangrove fringe along eastern Tampa Bay, Florida. Concentrations of trace metals, chlorinated pesticides, atrazine, total polycyclic aromatic hydrocarbons, and polychlorinated biphenyls were species-, chemical- and location specific.

Contaminants in sediments did not exceed proposed individual sediment quality guidelines. Most sediment quality assessment quotients were less than one indicating the likelihood of no inhibitory effect based on chemical measurements alone. Faunal species typically contained more contaminants than plant species; seagrass usually contained more chemicals than mangroves. Bioconcentration factors for marine angiosperms were usually less than 10 and ranged between 1 and 31. Mercury concentrations (ppm) in blue crabs and fish did not exceed the U.S. Environmental Protection Agency fish tissue criterion of 0.3 and the U.S. Food and Drug Administration action level of 1.0. In contrast, total mercury concentrations in faunal species often exceeded guideline values for wildlife consumers of aquatic biota.

Longman, P. (1992). Strip Miners in the Garden of Eden. *Florida Trend*, *34*(10). link.gale.com/apps/doc/A11877458/ITOF?u=tamp44898&sid=ITOF&xid=ef116fa1
Global competition? No problem. The biggest threat to Florida's phosphate companies is at home: fighting their image as environmental pillagers.

Lopez, J., Bloom, J., Curran, R., & Compton, G. (2021, April 3). Imminent Failure of Phosphogypsum Stack in Tampa Bay Exposes Phosphate Industry Risks. *Center for Biological Diversity*. https://biologicaldiversity.org/w/news/press-releases/imminent-failure-of-phosphogypsum-stack-in-tampa-bay-exposes-phosphate-industry-risks-2021-04-03/
Catastrophic wastewater release highlights need for federal action.

Lopez, J. (2021, April 12). *Piney Point- Letter to Congress* [Request for Congressional Hearing]. https://www.biologicaldiversity.org/campaigns/phosphate_mining/pdfs/2021_04_12_Piney_Point_letter_Congress.pdf
We request (1) a congressional hearing to investigate the regulatory framework of the phosphate industry and the failure to evaluate and minimize the unreasonable risk or ensure protection of human health and the environment through adequate regulation of phosphogypsum and process wastewater; and (2) identify areas where Congress can provide additional resources to help EPA quickly and comprehensively address this problem.

Luther, M. E., Meyers, S. D., & Gilbert, S. A. (2008). A Coastal Ocean Prediction System for Tampa Bay, Florida. *Journal of Ocean Technology*, *3*(3), 25–32. https://eds.b.ebscohost.com/eds/detail/detail?vid=2&sid=6c93676c-a07e-41ec-bae6-bfaf329bd337%40sessionmgr103&bdata=JnNpdGU9ZWRzLWxpdmU%3d#AN=RN239301690&db=edsbl

The USF College of Marine Science has developed a Coastal Ocean Prediction System for Tampa Bay based on an integrated observing system and circulation model as a sub-regional component of the US Integrated Ocean Observing System. The model system ingests real-time observations of the physical forcing functions for Tampa Bay to produce three-dimensional fields of circulation, temperature, salinity, and water level. The hydrodynamic model, based on the ECOM-3D code, is fully operational in either a nowcast-forecast mode or a hindcast mode and is described on our web site (http://ompl.marine.usf.edu/TBmodel). Water level, temperature, salinity, surface heat and moisture fluxes, and winds come from the Tampa Bay Physical

Oceanographic Real-Time System (TB-PORTS; http://ompl.marine.usf.edu/ports/ or http://tidesandcurrents.noaa.gov/tbports/tbports. shtml?port=tb) augmented with observations from the USF Coastal Ocean Monitoring and Prediction System (COMPS; http://comps.marine.usf.edu/). Daily river discharge is obtained from the USGS National Water Information System. Precipitation is derived from several gauges operated by the Southwest Florida Water Management District, USGS, and NOAA. The raw observational data undergoes an automated QA/QC procedure before being input into the model. A water quality module has been developed that produces fields of chlorophyll, nutrients, and dissolved oxygen from time-varying estimates of nutrient and fresh water loading. A wave module provides directional wave spectra and bottom stresses based on the SWAN code. The integrated observing and modeling system provides a decision support tool that is used to enhance security, safety, and efficiency of maritime transportation, to guide search and rescue efforts, and to evaluate the bay ecosystem response to environmental stressors. Such stressors include severe storms, seasonal and interannual changes in fresh water input, as well as human impacts, such as hazardous material spills, river withdrawals, nutrient loading, changing land use patterns, and alterations in bay bathymetry. In addition to its routine use by the Tampa Bay Pilots and the US Coast Guard, the Coastal Ocean Prediction System has been used to support management decisions in several environmental issues affecting the bay. For example, the model has been used to investigate the effects of concentrate discharge from a seawater desalination facility recently built on Tampa Bay for the regional water supply authority; to simulate the trajectory of wastewater discharges and hazardous material spills for the Florida Department of Environmental Protection; to predict trajectories of raw sewage spills into the bay for the Pinellas County Health Department; to investigate transport and fate of human pathogens in the bay, and to evaluate changes in salinity and estuarine residence time due to natural variability and to anthropogenic alterations in fresh water input and bathymetry of the bay for the Southwest Florida Water Management District.

Martin, D. F., Dooris, P. M., & Sumpter, D. (2001). Environmental Impacts of Phosphogypsum Vs. Borrow Pits in Roadfill Construction. *Journal of Environmental Science and Health, Part A*, *36*(10), 1975–1982. https://doi.org/10.1081/ESE-100107441

A comparison was performed of the environmental impacts of using phosphogypsum versus conventional fill materials (e.g., from borrow pits) for road construction. The study compared a hypothetical roadway with an actual roadway in Florida; the two facilities differed only in that phosphogypsum was employed as fill material instead of conventional materials. The effect of the two construction approaches on the plant and animal communities was considered, as was the

impact on the surface and ground water. A summary was made of the comparative impacts, and a comparison matrix was constructed using integral numbers to depict impacts ranging from – 5 (most impact) to 0 (none) to + 5, showing most benefit of the part of the project on a given resource. Values were subjective, based upon investigators' experience. Four categories (plant and animal communities, water quality, water resources, and air quality) were considered. The cumulative total was +12 for phosphogypsum and – 6 for conventional fill material.

McGowan, K. T., & Martin, J. B. (2007). Chemical composition of mangrove-generated brines in Bishop Harbor, Florida: Interactions with submarine groundwater discharge. *Marine Chemistry*, *104*(1), 58–68. https://doi.org/10.1016/j.marchem.2006.12.006Locations and compositions of submarine ground water discharge (SGD), which constitutes sources to coastal zones of low salinity water, terrestrial contaminants, and solutes with concentrations elevated by diagenetic reactions, may be altered in tropical settings where widespread mangrove forests increase salinity of shallow pore waters through evapotranspiration. The red mangrove (Rhizophora mangle) is ubiquitous in Bishop Harbor on the west coast of Florida, where sampling at four sites shows salinities of pore waters increase to three times the average marine values at depths up to 160 cm below the sediment–water interface in and around the mangroves. The increase in salinity is greatest in open areas within the mangrove forests, while seaward of the forest, the salinity remains near the values of the surface water. Major element concentrations (Cl−, SO42−, Na+, K+, Mg2+, and Ca2+) increase with salinity, but the depth profiles of major element/Cl− ratios vary across the area. The two sites located closest to the mainland have the greatest increase in salinity and are the only sites with major element/Cl− ratios that vary with depth in the sediment, reflecting in situ diagenesis. In contrast, the sites located farthest from the mainland have constant major element/Cl− ratios with depth but with values less than seawater ratios. Low ratios suggest that a non-marine source of water, possibly meteoric, mixes with pore water at these sites before salinity increases through evapotranspiration. If the water is meteoric, the seepage face is located farther from the coast than regions without mangrove forests. The steep salinity gradients indicate that the water bypasses the seepage face by transportation through the mangroves.

Miller, R. L., & Sutcliffe Jr., H. (1982). *Water-quality and hydrogeologic data for three phosphate industry waste-disposal sites in central Florida, 1979-80* (USGS Numbered Series No. 81–84; Water-Resources Investigations Report). U.S. Geological Survey. http://pubs.er.usgs.gov/publication/wri8184

This report is a compilation of geologic, hydrologic, and water-quality data and information on test holes collected in the vicinity of gypsum stack complexes at two phosphate chemical plants and one phosphatic clayey waste disposal pond at a phosphate mine and beneficiation plant in central Florida. The data were collected from September 1979 to October 1980 at thee AMAX Phosphate, Inc., chemical plant, Piney Point; the USS AgriChemicals chemical plant, Bartow; and the International Minerals and Chemical Corporation Clear Springs mine, Bartow. Approximately 5,400 field and laboratory water-quality determinations on water samples were collected from about 78 test holes and 31 surface-water, rainfall, and other sampling sites at phosphate industry beneficiation and chemical plant waste-disposal operations. Maps show locations of sampling sites. (USGS)

Miller, R., & Sutcliffe, H. (2021). Effects of Three Phosphate Industrial Sites on Ground-Water Quality in Central Florida, 1979 to 1980. *Water-Resources Investigations Report 83-4256*. https://doi.org/10.3133/wri834256

Geologic, hydrologic, and water quality data and information on test holes collected in the vicinity of gypsum stack complexes at two phosphate chemical plants and one phosphatic clayey waste disposal pond at a phosphate mine and beneficiation plant in central Florida are presented. The data were collected from September 1979 to October 1980 at the AMAX Phosphate, Inc. chemical plant, Piney Point; the USS Agri-Chemicals chemical plant, Bartow; and the International Minerals and Chemical Corporation Clear Springs mine, Bartow. Approximately 5,400 field and laboratory water quality determinations on water samples collected from about 100 test holes and 28 surface-water , 5 rainfall, and other sampling sites at phosphate industry beneficiation and chemical plant waste disposal operations are tabulated. Maps are included to show sampling sites.

Mosaic Company. (2021). The Mosaic Company SWOT Analysis. *Marketline.Com*, 1–7.

The Mosaic Company (Mosaic or 'the company'), a Delaware corporation, is one of the leading producer and marketer of concentrated phosphate and potash crop nutrients and animal feed ingredients. The company operates in the Americas, Asia Pacific and other regions of the world. It is headquartered in Plymouth, Minnesota, and employed about 9,100 employees as of December 31, 2014

Opyrchal, A. M., & Wang, K.-L. (1981). *Economic Significance of the Florida Phosphate Industry: An Input-output (I-O) Analysis*. U.S. Department of the Interior, Bureau of Mines.

https://play.google.com/store/books/details?id=rnMVVYP-sK0C&rdid=book-rnMVVYP-sK0C&rdot=1

This Bureau of Mines study assesses the economic significance of the Florida phosphate industry to selected counties in Florida, the State of Florida, and the Nation; it also includes a brief survey of the industry's international impact. Based on forecasts of Florida phosphate production in 1981, and using constant 1977 dollars, estimates are given for 1981 for regional and national output, the value of this output, income, and employment created by the phosphate industry in Florida. Federal, State, and county tax revenues generated by the State's phosphate industry are also estimated for 1981. The concentrated impact f the phosphate industry on certain areas of Florida and on the State's regional industries is examined using economic base analysis complimented by an industrial complex approach. The industry's impact at the State and national levels is examined through input-output analysis. In addition, an attempt to forecast for 1990 the effects of constraints on phosphate rock mining as a result of economic conditions and other factors is included as an appendix to the report. Also discussed is the phosphate industry's importance to the U.S. balance of trade: U.S. agricultural production, including forward linkages; the U.S. sulfur industry; and the phosphate industry's importance to the production of fluorine and uranium by-products from fertilizer manufacturing.

Perpich, Jr. B. *Process Engineering: Wastewater Treatment Plant Goes the Distance.* Chemical Processing. Retrieved May 19, 2021. https://www.chemicalprocessing.com/articles/2005/466/

A mobile reverse osmosis (RO) system from USFilter effectively treated water at an abandoned fertilizer plant. This allowed system effluent to be discharged into Tampa Bay without environmental impact.

Pittman, C. (2017). Time Bombs: Florida's mountains of toxic phosphate waste pose explosive future danger. *Sarasota Magazine*, *39*(9), 126. https://www.thefreelibrary.com/TIME+BOMBS%3A+Florida%27s+mountains+of+toxic+phosphate+waste+pose...-a0509893599

The largest fertilizer manufacturing plant in the world sits about six miles southwest of the Polk County hamlet of Mulberry, with its entrance in walking distance of the Hillsborough County line. About 800 employees work there, turning phosphate rock into nearly 5 million tons of fertilizer and animal food ingredients every year.

Powers, M. B. (2021). Closed Leaking Fla. Phosphate Site Cost Estimated at $200M. *Engineering News-Record*, *286*(9), 14.

The article report that Florida Gov. Ron DeSantis redirected $15.4 million to treat high phosphorous and nitrogen levels in reservoir water, and the legislature is expected to provide an initial $100 million, with more by year-end, to finance closure, estimated at $200 million.

Rains, M. C., Landry, S., Rains, K. C., Seidel, V., & Crisman, T. L. (2013). Using Net Wetland Loss, Current Wetland Condition, and Planned Future Watershed Condition for Wetland Conservation Planning and Prioritization, Tampa Bay Watershed, Florida. *Wetlands*, *33*(5), 949–963. https://doi.org/10.1007/s13157-013-0455-4

The Tampa Bay Watershed is emblematic of moderately sized coastal watersheds in the US, particularly along the Gulf Coast: one-third of the wetlands were lost between the 1950s and 2007; numerous wetland remain, though many have been impacted; most of the remaining wetlands are hydrologically connected to downstream wetlands and waterbodies; there are future constraints to wetland conservation; and the spatial complexity of these factors make it difficult to coordinate watershed-scale wetland conservation planning. Therefore, the Tampa Bay Watershed can serve as a model system for studying ways to coordinate watershed-scale wetland conservation planning efforts. The development of a technical framework to support coordinated, watershed-scale wetland conservation planning requires that spatially explicit information be obtained, analyzed, and organized so customizable queries can be run by stakeholder agencies. The approach described herein does so by using readily available data to create a geodatabase organized into a set of screening layers that can be intersected hierarchically to identify areas where wetland preservation and restoration might be best used to accomplish overarching goals. The information and tools described herein were developed in conjunction with stakeholder input and are in the process of being integrated into a watershed master plan for freshwater wetland conservation.

Sandhu, D., Singh, A., Duranceau, S. J., Nam, B. H., Mayo, T., & Wang, D. (2018). Fate and transport of radioactive gypsum stack water entering the Floridan aquifer due to a sinkhole collapse. *Scientific Reports*, *8*(1), 11439. https://doi.org/10.1038/s41598-018-29541-0

Groundwater aquifers are an essential source of drinking water, and must be protected against contamination. Phosphogypsum stacks originating from the processing of phosphate rock contain small amounts of radionuclides, such as 226Ra. In September 2016, a sinkhole located beneath a phosphogypsum stack collapsed under central Florida's carbonate karst terrain, where the aquifer

is mostly confined, raising concern over water quality in the regions nearby. Monitoring and modeling the transport of the contaminated plume is vital to ensure drinking water criteria are met and to improve decision making regarding treatment. To achieve this, a geochemical modeling using PHREEQC software was employed to investigate the trajectory of the plume based on hydraulic and hydrologic conditions. Adsorption was simulated as a removal mechanism that could further reduce the intensity of the plume. The aquifer's response to the release of contaminated water from the collapsed stack was quantified by simulating a number of scenarios, including variable radionuclide leakage quantities. Results suggest that it may take between 11-17 years and between 5.2 to 8.3 km from the sinkhole leak to reduce radionuclide concentrations to previous levels. Coupling the adsorption effect by minerals in Floridan aquifer (e.g. ferrihydrite, carbonate) can reduce radionuclide migration time to 9-16 years and distances between 4.3 to 7.8 km from the sinkhole leak. It can also reduce the distance needed to lower radionuclide concentrations, though not significantly. Additionally, due to the complexities of soil chemistry, the importance of groundwater remediation is emphasized.

Schrandt, M. N., MacDonald, T. C., Sherwood, E. T., & Beck, M. W. (2021). A multimetric nekton index for monitoring, managing and communicating ecosystem health status in an urbanized Gulf of Mexico estuary. *Ecological Indicators*, *123*, 107310. https://doi.org/10.1016/j.ecolind.2020.107310

Biological assessments have been used for decades to determine ecological conditions in aquatic environments, yet they have not been extensively applied in estuaries that serve as transition zones between freshwater and marine environments. We present the development and validation of a nekton (fish and selected macroinvertebrate) index for annual monitoring of ecosystem health in Tampa Bay, Florida. We relied on long-term fisheries independent monitoring data of the early recruit and juvenile life history stages of nekton in Florida's inshore waters. A set of metrics that included measures of abundance, species diversity, trophic structure, and taxa of commercial or recreational importance were explored, and a subset was selected via statistical models. Reference conditions specific to each season and management section of the bay were established from the long-term dataset. The final Tampa Bay Nekton Index included five metrics: the total number of taxa, the number of benthic taxa, the number of recreational/commercial fishery taxa, the number of feeding guilds, and the Shannon-Weiner diversity index. Nekton index scores were calculated for each sample and averaged by bay management section and year and then a "stoplight" color-coding system, based on quantiles, was used to group index scores for communication and management. In general, Tampa Bay's nekton community appears to be

resistant to large-scale changes in functional structure. The index was sensitive to a prolonged red tide event but eventually returned to preperturbation levels, indicating nekton community resilience. This index will be incorporated into monitoring and managing strategies of the local estuary program. Because this index was developed specifically for Tampa Bay and relies on bay-specific reference conditions, the index cannot be directly applied to other systems, but the methodology is transferrable so similar indices could be developed for other ecosystems with long-term monitoring data. Furthermore, using regional data, the index could be expanded/developed to assess health status *among* estuaries to inform decisions on prioritization of limited resources.

Sheehan, L., Sherwood, E. T., Moyer, R. P., Radabaugh, K. R., & Simpson, S. (2019). Blue Carbon: An Additional Driver for Restoring and Preserving Ecological Services of Coastal Wetlands in Tampa Bay (Florida, USA). *Wetlands*, *39*(6), 1317–1328. https://doi.org/10.1007/s13157-019-01137-y

Coastal habitats, including mangroves, salt marsh, and seagrass meadows, provide numerous ecosystem services, including improved water quality, shoreline stabilization, and essential fish habitat. Over the past few decades, the quantification of greenhouse gas fluxes in wetlands has improved, leading to the recognition of these habitats as long-term carbon sinks. Quantifying this "blue carbon" as an ecosystem service provides added value for wetland protection and restoration and serves as a useful management tool when implementing plans for sustained ecosystem health and productivity. Tampa Bay (Florida, USA), a highly urbanized estuary, provides an interesting case study to assess the role of blue carbon in supporting management and informing restoration decisions. This review provides results from the Tampa Bay Blue Carbon Assessment, which quantified existing carbon stocks and identified the future carbon sequestration trajectories of coastal habitats with respect to climate change and sea-level rise. Examples are provided of how these data can be used to prioritize restoration efforts, support and enhance management decisions, and potentially attract new partners to support wetland restoration projects that offer additional climate change mitigation and adaptation benefits. This added valuation can help drive investment towards additional wetland restoration activities to help meet management targets in estuaries worldwide.

Tenneson, M. (2009). Phosphorus Fields. *Discover*, *30*(11), 55–59. https://eds.b.ebscohost.com/eds/detail/detail?vid=9&sid=50522050-904d-460b-a62c-c89a937f2ab2%40sessionmgr102&bdata=JnNpdGU9ZWRzLWxpdmU%3d#AN=RN260208613&db=edsbl

The article presents an in-depth examination of how phosphorus (P) and nitrogen (N) fertilizers, which drive agriculture, are poisoning the Earth. Topics include an overview of gypstacks, which are a result of phosphorus mining, the environmental and ecological impacts of P and N demand, such as hypoxia, and the environmental damages caused by agricultural runoff. The challenges of gypsum waste disposal from phosphate mining are also discussed.

The Fourth Tampa Bay Area Scientific Information Symposium BASIS 4. (n.d.). 303. https://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1133&context=basgp_report

These Proceedings contain presentations given at the fourth Tampa Bay Area Scientific Information Symposium held October 27–30, 2003 in St. Petersburg, Florida. Since its inception in 1987, the BASIS conference series has provided a forum for sharing state-of-the-art research on Tampa Bay. The theme of BASIS-4, Linking Science and Management, is organized around the major elements of the Tampa Bay Estuary Program's Comprehensive Conservation and Management Plan: Water and Sediment Quality; Habitat Protection and Restoration; Fish and Wildlife Protection; Dredging and Dredged Material Management; Spill Prevention and Response; Watershed Management; and Invasive Species. More than 200 scientists, resource managers and students from the Tampa Bay area participated in the four-day symposium, which included 60 oral presentations and more than 80 posters.

Walters, S., Lowerre-Barbieri, S., Bickford, J., Tustison, J., & Landsberg, J. (2013). Effects of Karenia brevis red tide on the spatial distribution of spawning aggregations of sand seatrout Cynoscion arenarius in Tampa Bay, Florida. *Marine Ecology Progress Series*, *479*, 191–202. https://doi.org/10.3354/meps10219

A passive acoustic survey using a random stratified design detected spawning aggregations of sand seatrout Cynoscion arenarius over 2 sequential spawning seasons (2004 and 2005) in Tampa Bay, Florida. In 2005, an intense Karenia brevis red tide at ichthyotoxic concentrations entered Tampa Bay 3 mo after the spawning season began. The bloom persisted through the end of the spawning season and was temporally associated with significant changes in the spatial distribution of spawning aggregations. Red tide was most prevalent and concentrated within the lower portion of Tampa Bay and extended to a lesser degree into the middle bay, but remained

absent from the upper bay. While the percentage of sand seatrout aggregations in the middle bay zone did not significantly change from 2004 to 2005, aggregations in the non-impacted area of the upper bay increased, and the red tide-exposed lower bay experienced a significant and pronounced decline. These significant bay-wide changes in the sand seatrout spawning population coincided with the red tide event, most notably the considerable decline in the lower bay, but the broad spatial distribution of the aggregations in concert with certain reproductive and life history characteristics may buffer the population from long-term effects. Typically, it is difficult to assess the effect of disturbances on marine fish populations due to complexities in measuring the extent of the perturbation and the magnitude of the loss to the population. Our spatially explicit sampling design further enabled us to demonstrate the widespread effects of red tide on fisheries and provides an important tool for assessing the extent of loss to a spawning fish population.

Wang, K.-L., Klein, B. W., & Powell, A. F. (1975). *Economic Significance of the Florida Phosphate Industry*. U.S. Bureau of Mines https://books-google-com.ezproxy.lib.usf.edu/books?hl=en&lr=&id=Kj2HjBESWOgC&oi=fnd&pg=PA1&dq=Economic+Significance+of+the+Florida+Phosphate+Industry&ots=rEgPIXS4WN&sig=cVqhrDT5O9YYi1hmiZkHihwGyGo#v=onepage&q=Economic%20Significance%20of%20the%20Florida%20Phosphate%20Industry&f=false

This Bureau of Mines study illustrates the economic significance of the Florida phosphate industry to the State and to the Nation. Environmental considerations related to phosphate industry activity are discussed briefly. Based on forecasts of Florida phosphate production in 1975, and using 1972 dollars, regional and national output value, income, and employment created by the phosphate industry were estimated for 1975. State and Federal government tax revenue generated by the phosphate instruct, are also measured. Further, the concentrated impact of the phosphate industry on certain Florida areas and on regional industries is examined. Finally, the phosphate industry's importance to the U.S. balance of payments, U.S. agricultural production, and the Frasch sulfur industry is considered, in addition to byproduct fluorine, and potential byproduct uranium from fertilizer manufacturing.

Water-quality and hydrogeologic data for three phosphate industry waste-disposal sites in central Florida, 1979-80. (1982). https://doi.org/10.3133/wri8184

This report is a compilation of geologic, hydrologic, and water-quality data and information on test holes collected in the vicinity of gypsum stack complexes at two phosphate chemical plants and one phosphatic clayey waste disposal pond at a phosphate mine and beneficiation plant in

central Florida. The data were collected from September 1979 to October 1980 at thee AMAX Phosphate, Inc., chemical plant, Piney Point; the USS AgriChemicals chemical plant, Bartow; and the International Minerals and Chemical Corporation Clear Springs mine, Bartow. Approximately 5,400 field and laboratory water-quality determinations on water samples were collected from about 78 test holes and 31 surface-water, rainfall, and other sampling sites at phosphate industry beneficiation and chemical plant waste-disposal operations. Maps show locations of sampling sites. (USGS)

Xian, G., Crane, M., & Su, J. (2007). An analysis of urban development and its environmental impact on the Tampa Bay watershed. *Journal of Environmental Management*, *85*(4), 965–976. https://doi.org/10.1016/j.jenvman.2006.11.012

Urbanization has transformed natural landscapes into anthropogenic impervious surfaces. Urban land use has become a major driving force for land cover and land use change in the Tampa Bay watershed of west-central Florida. This study investigates urban land use change and its impact on the watershed. The spatial and temporal changes, as well as the development density of urban land use are determined by analyzing the impervious surface distribution using Landsat satellite imagery. Population distribution and density are extracted from the 2000 census data. Non-point source pollution parameters used for measuring water quality are analyzed for the sub-drainage basins of Hillsborough County. The relationships between 2002 urban land use, population distribution and their environmental influences are explored using regression analysis against various non-point source pollutant loadings in these sub-drainage basins. The results suggest that strong associations existed between most pollutant loadings and the extent of impervious surface within each sub-drainage basin in 2002. Population density also exhibits apparent correlations with loading rates of several pollutants. Spatial variations of selected non-point source pollutant loadings are also assessed.