Using MODIS Terra Channel 1 (250 m) to Evaluate Water Quality in Tampa Bay and Lake Thonotosassa, Florida

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Background

- Population growth and watershed development have often been associated with increased nutrient concentration in naturally occurring bodies of water (Rast and Thorton 1996; Smith et al. 2003).
- Nutrients found in the urban runoff, are an increasingly important contaminant and eutrophication factor in estuaries and other aquatic ecosystems (FDEP, 2006).

Background (con’t)

- High nutrient concentration: potential to trigger increase of harmful algal blooms (HAB’s).
- Water nutrient concentration not estimated through remote sensing yet
- Possible association with other variables more readily sensed with satellite technology.
- Turbidity: watershed development and potential for HAB’s - closer correlation with satellite reflectance
- Potential to use satellite reflectance to monitor factors that could lead to HAB’s.

Objective

Confirm the correlation between remote sensing reflectance data and *in situ* measurements of turbidity in coastal waters, and further search for potential correlations with other *in situ* indicators of water trophic status, using Tampa Bay as a case study during the time period 2000-2007.

Potential Increase of Freshwater Algal Blooms

- Surface water enrichment - abundance of phytoplanktonic species - some can be toxic.

- Freshwater algal blooms - growing concern for public health in Florida - potential effect (Williams, 2004, as quoted by the report 305 (b) from the FDEP, 2008)

http://www.vdh.state.va.us/epidemiology/DEE/Waterborne/cyanobacteria.htm

Cyanobacteria

- Lower ratios of Total Nitrogen (TN) to Total Phosphorus (TP) could favor abundance of Cyanobacteria

- Some Cyanobacteria can produce toxins that are harmful to humans.

Routes:

- Swallowing water
- Fish consumption
- direct skin contact
- Breathing aerosolized bacterial toxins

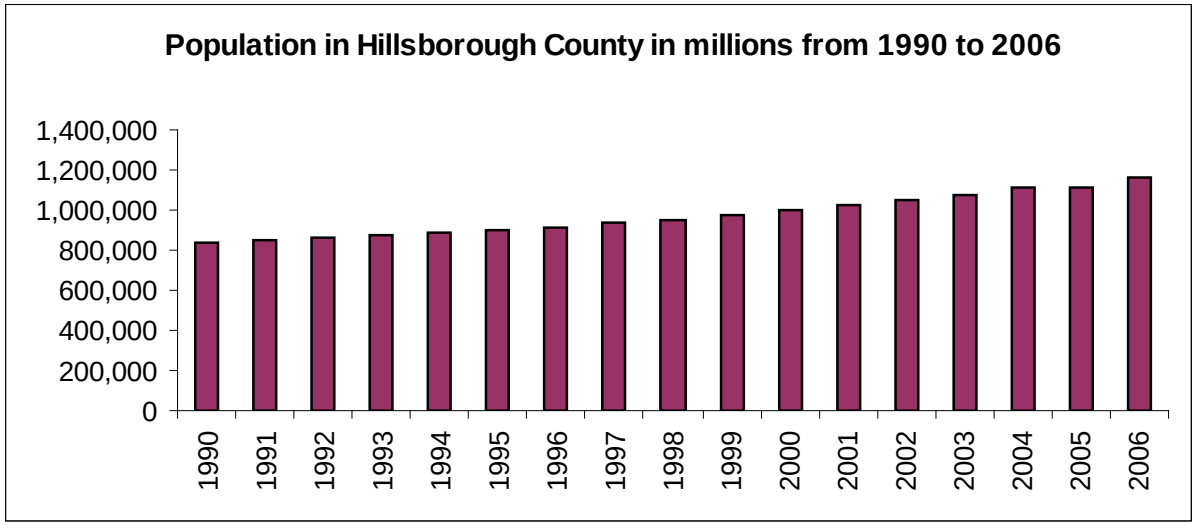
Symptoms:

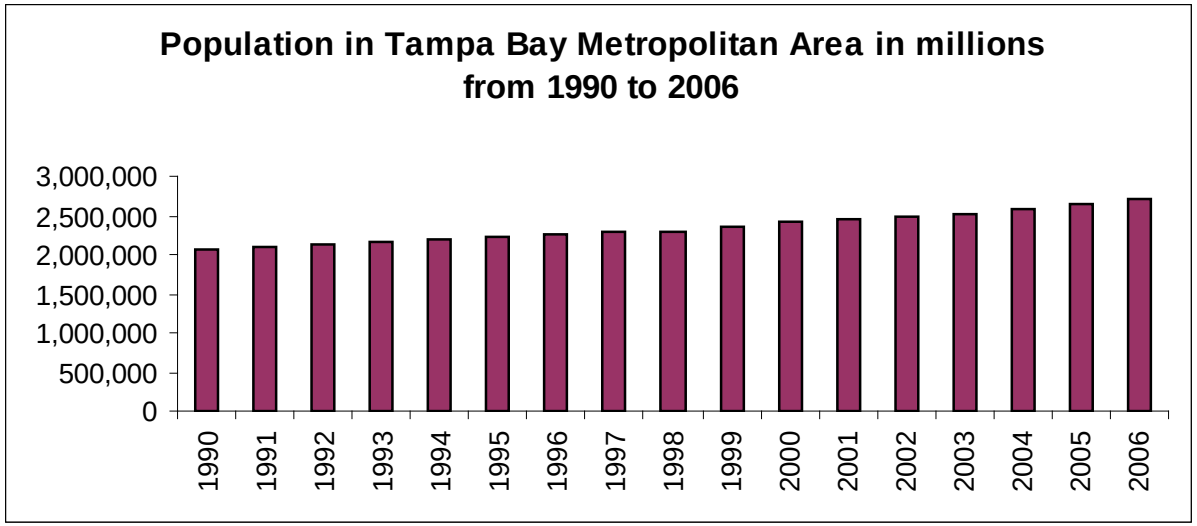
- Stomach pain
- Nausea
- Vomiting
- Diarrhea
- Skin and eye irritation
- Respiratory
- Long-term exposure may result in liver damage.

Growth in Population

Year	Population in Hillsborough	Population in TBMA
1990	834,054	2,067,959
1991	848,257	2,098,326
1992	860,630	2,125,478
1993	871,750	2,152,357
1994	884,433	2,181,037
1995	897,643	2,212,896
1996	916,064	2,245,224
1997	931,482	2,275,555
1998	945,565	2,305,910
1999	971,079	2,349,879
2000	998,948	2,404,435
2001	1,026,906	2,443,723
2002	1,055,617	2,486,778
2003	1,079,587	2,527,815
2004	1,108,435	2,584,100
2005	1,111,717	2,646,540
2006	1,157,738	2,697,731

Growth in Population





- Hillsborough County, Florida (2004) http://www.hillsboroughcounty.org/managementbudget/communitystatistics/.pdf
- US Bureau of the Census (1990 – 2000) http://www.census.gov/population/www/estimates/metro_general/2006/CBSA-EST2006-01.xls

Possible Factors

- Septic tanks for household sewage treatment were typical in twentieth century development of Florida (Schmidt and Luther, 2002).
- Much of the Tampa Bay watershed is underlain by karst geology (van Beynen et al., 2007)
- Groundwater transport - connection to the cleaner water of the Floridian Aquifer (Cheng and Kindinger, 2004).

Large Scale Sources of Nutrients

- Non-point source pollution: Storm-water accounted for 63 % of total nitrogen loadings to Tampa Bay from 1999-2003.
- A significant portion of the nitrogen entering the bay, about 21 %, comes from atmospheric deposition (air pollution) directly to the bay's surface, either with rainfall or dry deposition.

Factors Attenuating the Problem

- By 1979, nutrient and solids removal had been upgraded to tertiary level treatment
- New pollution controls on bay area power plants and conversion of Tampa Electric's Gannon facility to fueling by natural gas instead of coal.
- Cleaner-burning fuels, improved fuel economy standards
- Expanded mass transit systems
- Increased telecommuting

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28°0'0"N 27°55'12"N 27°50'24"N 27°45'36"N 27°40'48"N 27°36'0"N

Bay Water Monitoring Stations

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TAMPA

SAINT PETERSBURG

Old Tampa Bay

Hillsborough Bay

Tampa Bay

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Hillsborough County, Florida
Water Monitoring Stations
All Bay Stations

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Miles

Legend
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Major Roads
Local Roads

Moderate-resolution Imaging Spectroradiometer (MODIS)

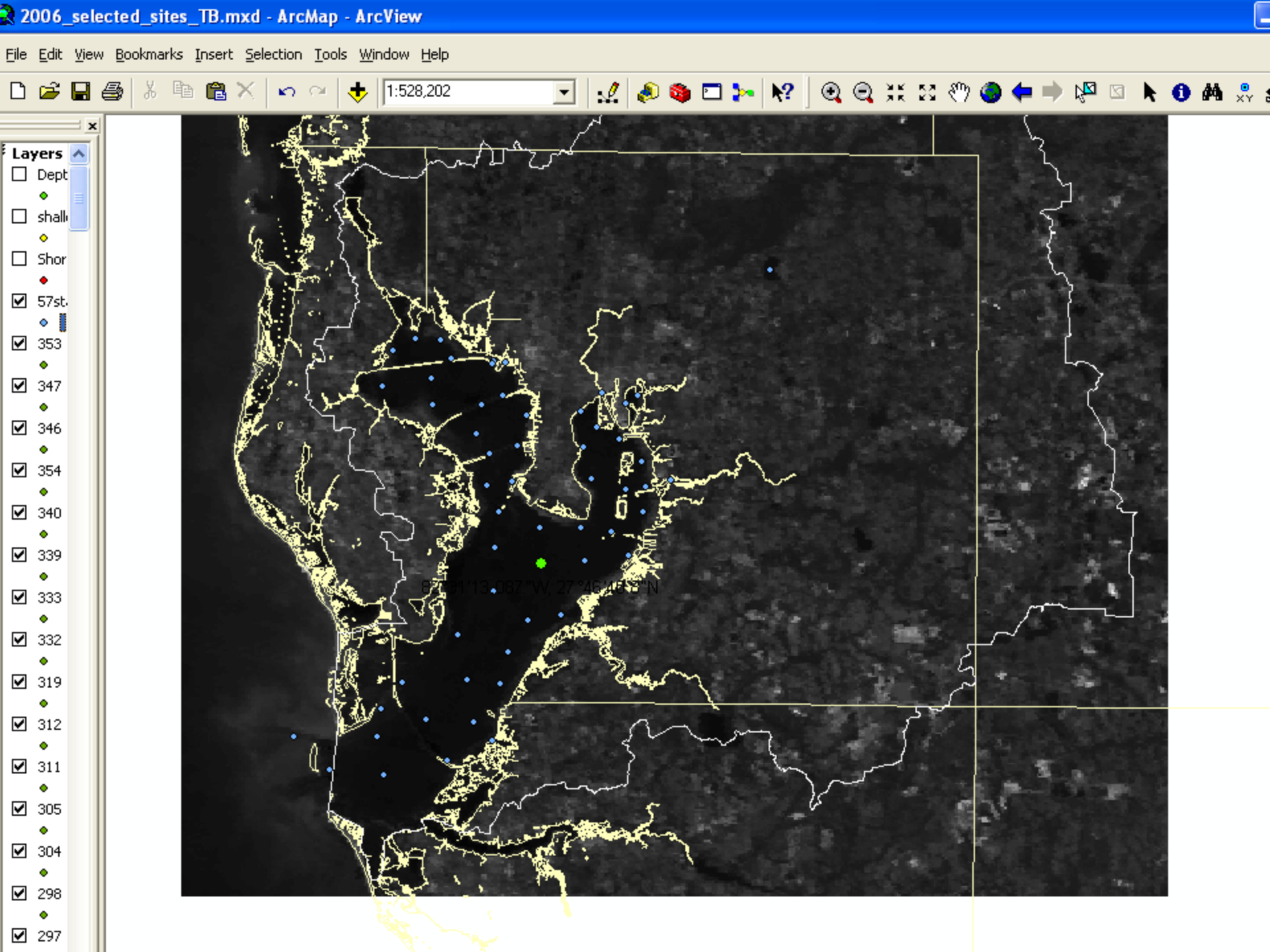
Product Name	**Terra Product**
•Surface Reflectance 8-Day L3 Global 500m	MOD09A1
•Surface Reflectance 8-Day L3 Global 250m	MOD09Q1
•Surface Reflectance Daily L2G Global 1km and 500m	MOD09GA
•Surface Reflectance Daily L2G Global 250m	MOD09GQ
•Surface Reflectance Daily L3 Global 0.05Deg CMG	MOD09CMG

MODIS

- Surface Reflectance Daily L2G Global 250m
- ID: MOD09GQ
- Channel 1: 0.648 µm (620-670nm)
- Resolution: 250-meter

Atmospheric correction algorithm: Spectral reflectance

- Gaseous and aerosol scattering and absorption
- Adjacency effects caused by variation of land cover
- Bidirectional Reflectance
- Contamination by thin cirrus.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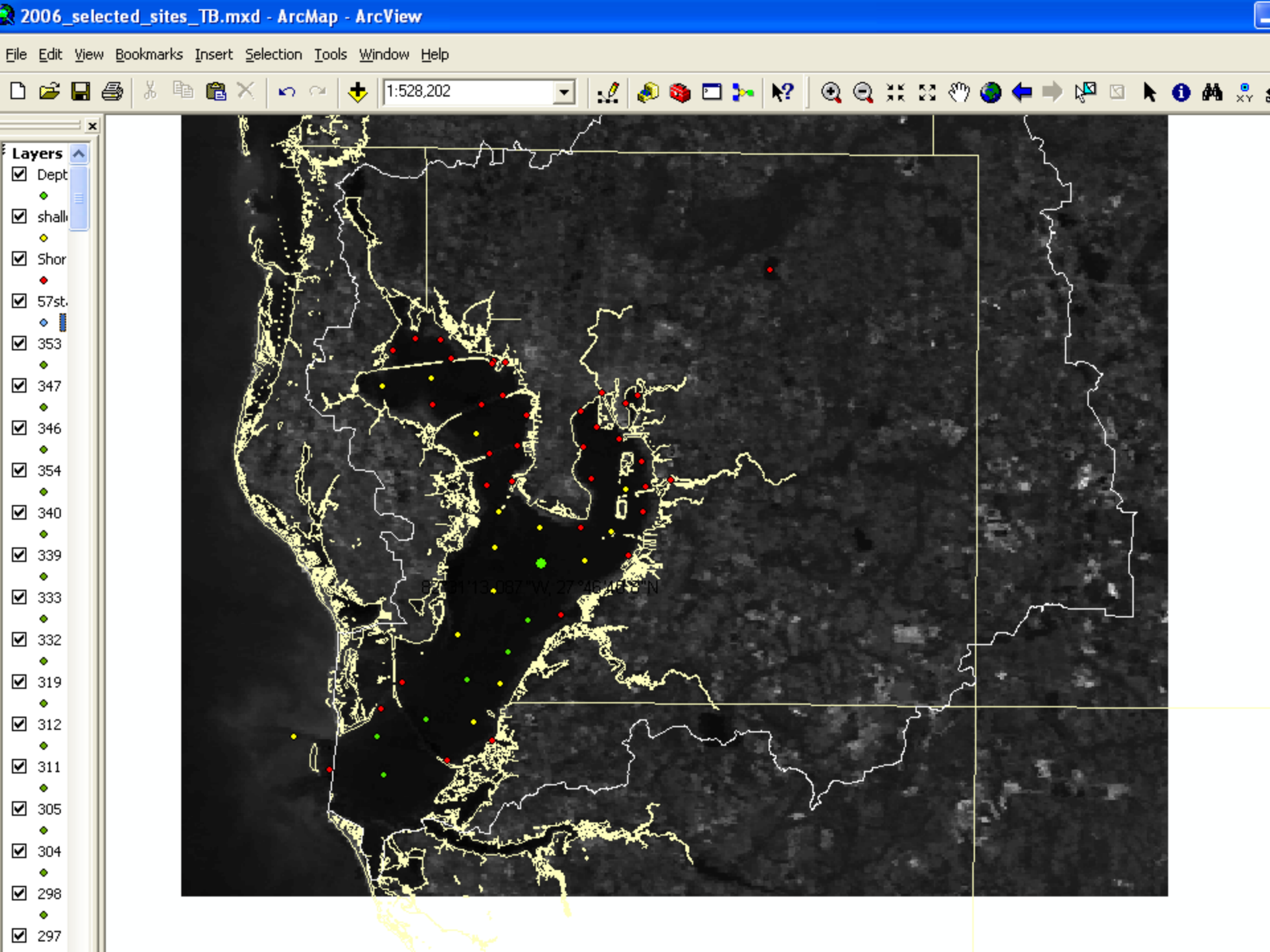
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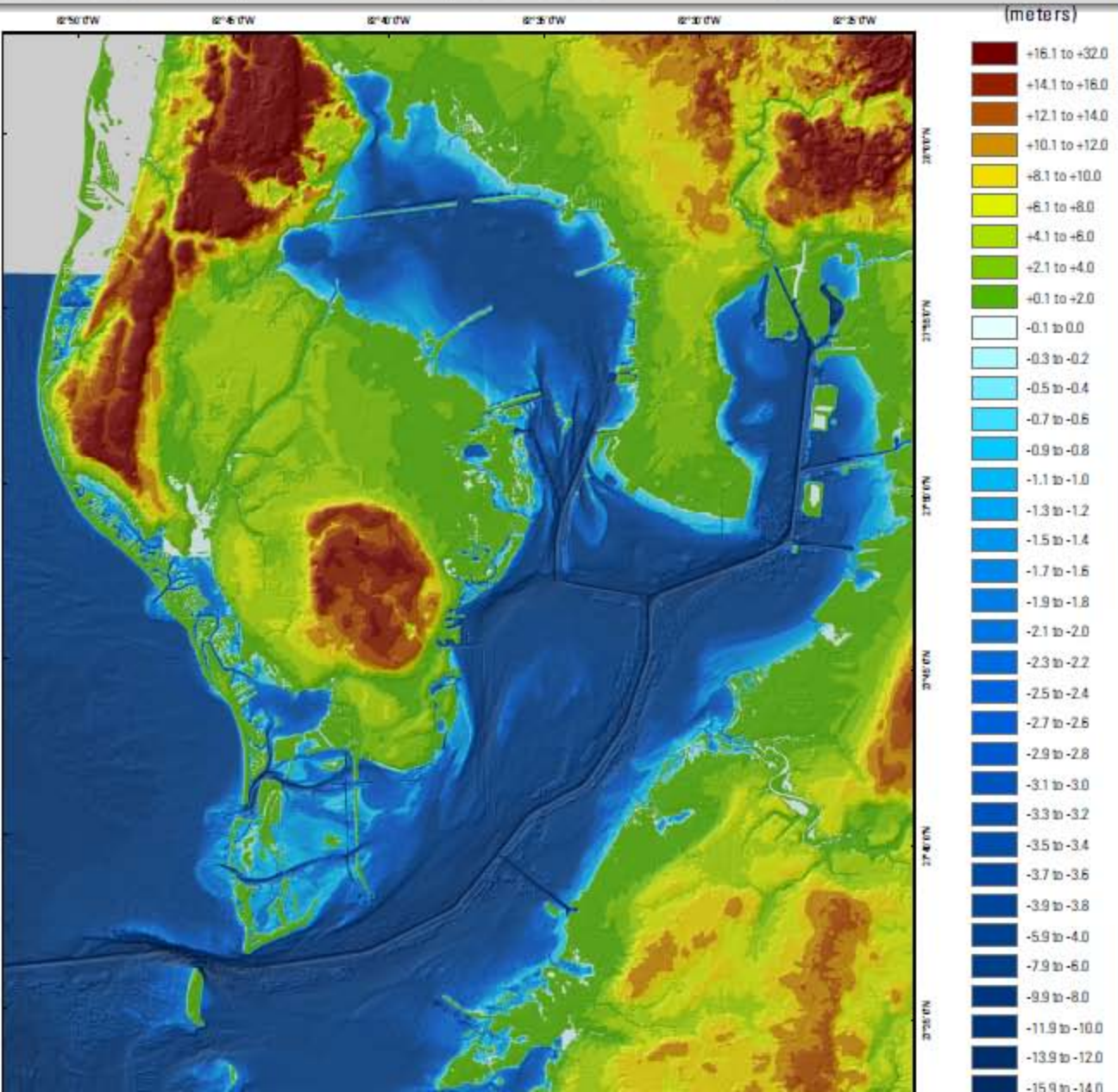
Topobathymetric Data for Tampa Bay, Florida

By D. Tyler[3], D.G. Zawada[1], A. Nayegandhi[2], J.C. Brock[1], M.P. Crane[1], K.K. Yates[1], and K.E.L. Smith[1]

USGS
science for a changing world

USGS Web site: http://gisdata.usgs.gov/website/topobathy/.



(meters)

+16.1 to +32.0
+14.1 to +16.0
+12.1 to +14.0
+10.1 to +12.0
+8.1 to +10.0
+6.1 to +8.0
+4.1 to +6.0
+2.1 to +4.0
+0.1 to +2.0
-0.1 to 0.0
-0.3 to -0.2
-0.5 to -0.4
-0.7 to -0.6
-0.9 to -0.8
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-9.9 to -8.0
-11.9 to -10.0
-13.9 to -12.0
-15.9 to -14.0

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[1]U.S. Geological Survey.
[2]SAIC, contracted to U.S. Geological Survey.
[3]ETI, contracted to U.S. Geological Survey.

Open-File Report 2007-1051 (revised)

Scale 1:80,000

1 0 1 2 3 4 5 Kilometers

1 0 1 2 3 4 5 Miles

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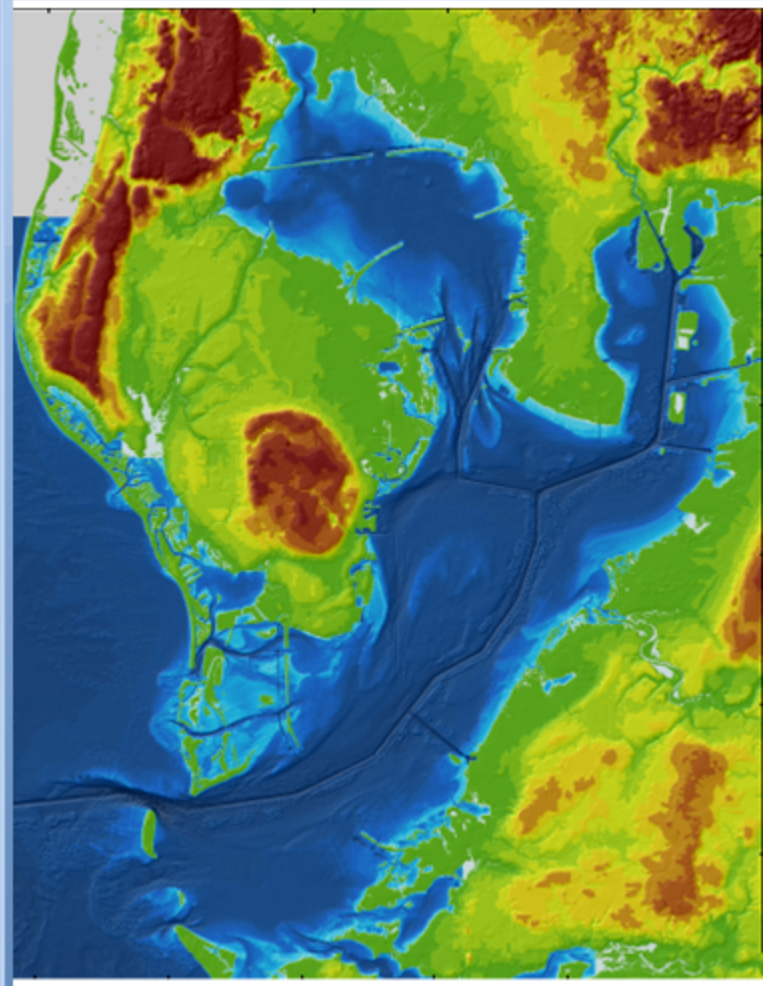

USGS science for a changing world

Topobathymetric Data for Tampa Bay, Florida

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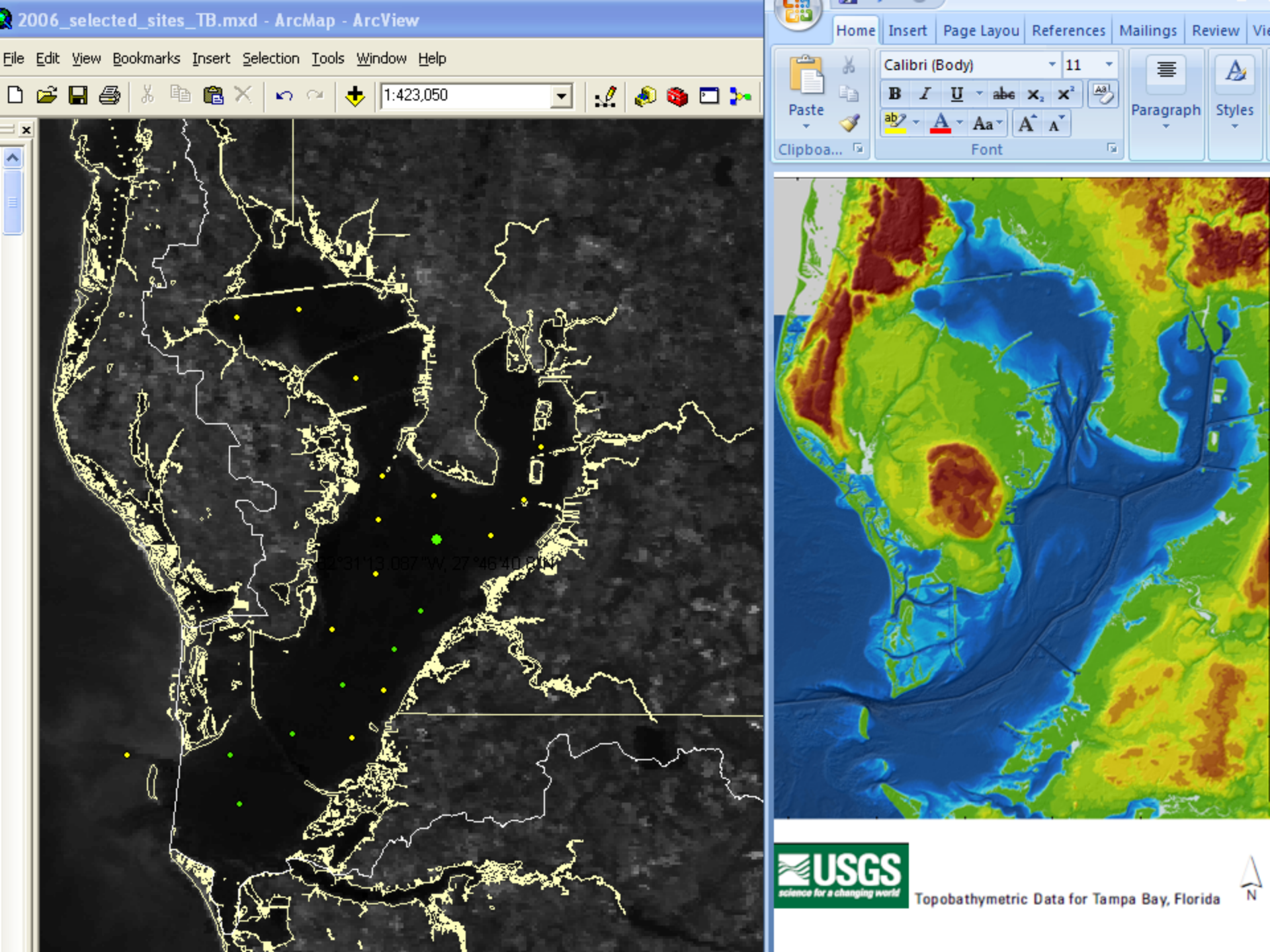
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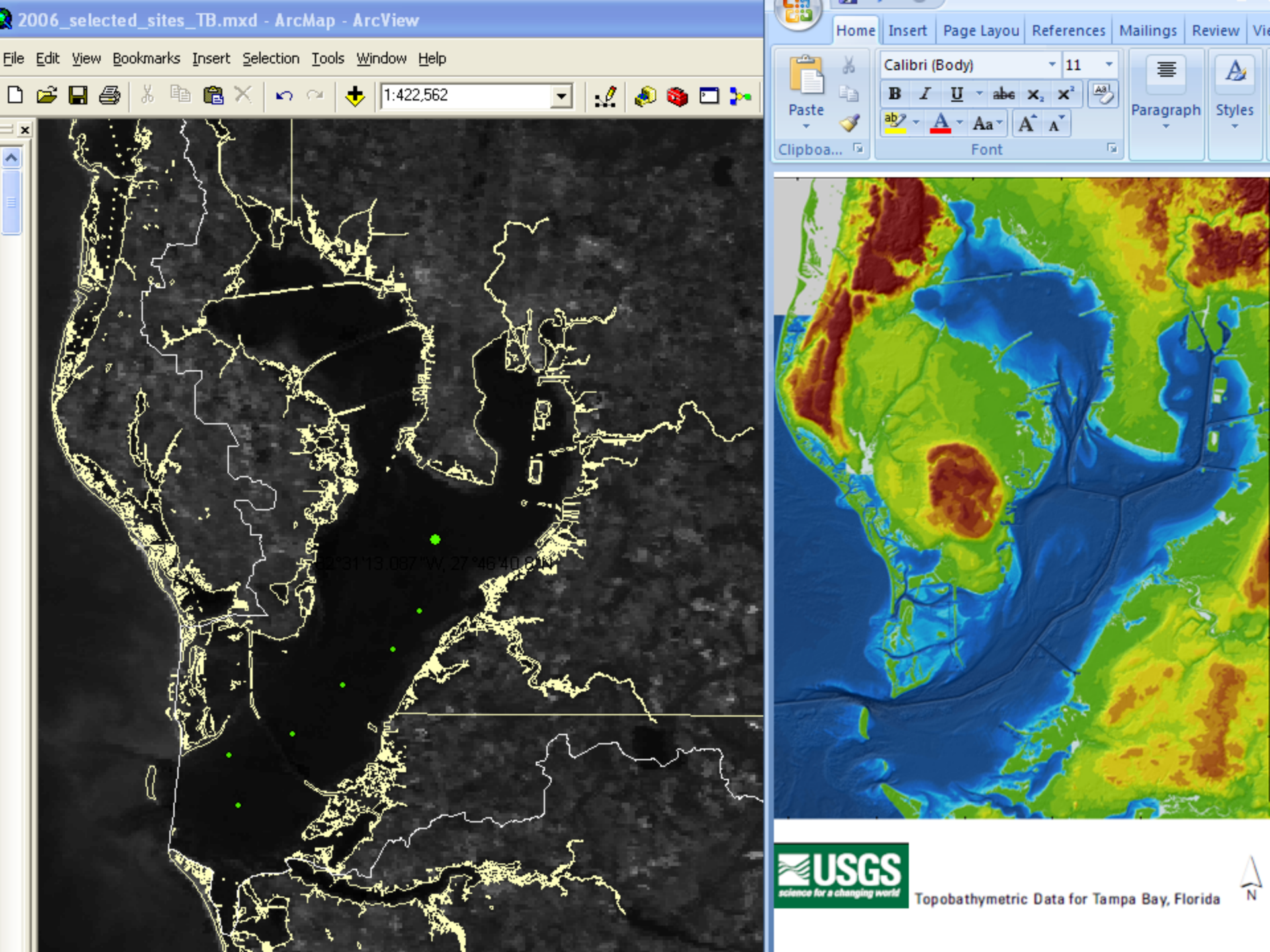
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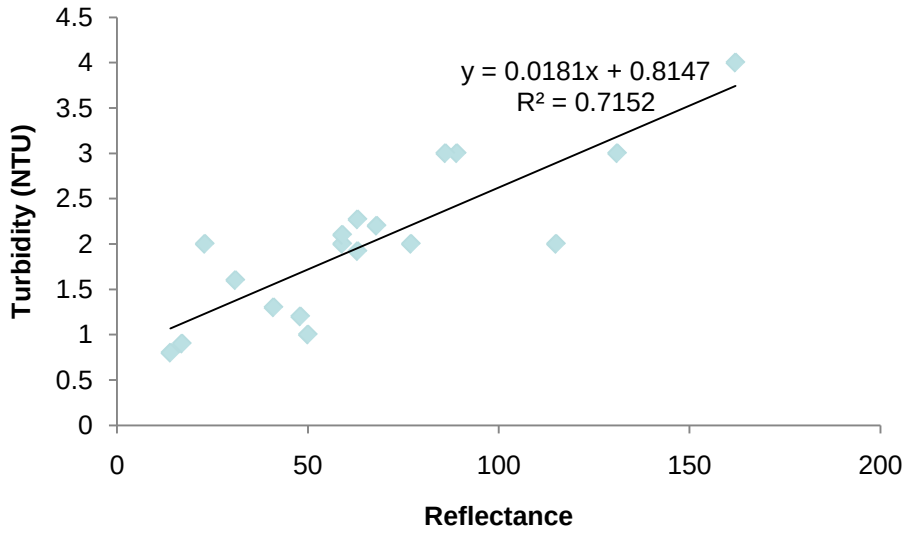
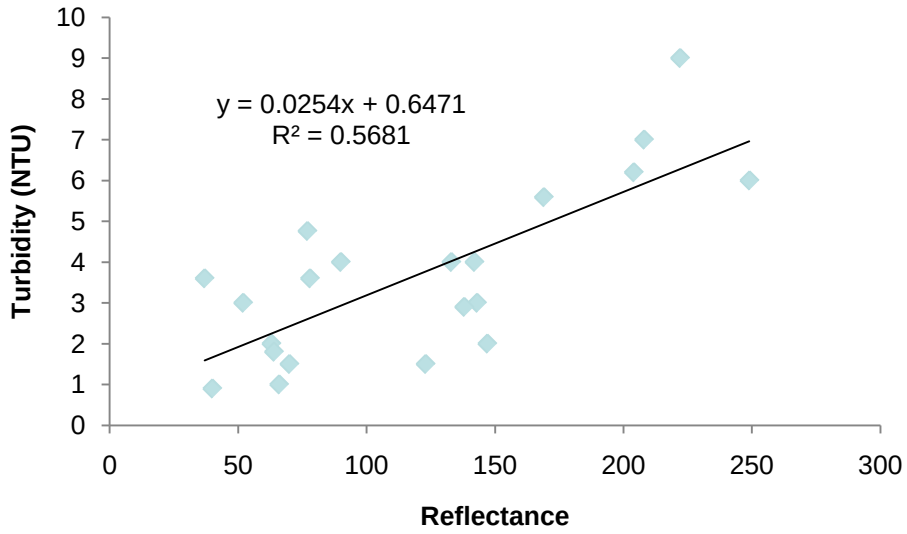
Coefficient of Determination: *In situ* & Reflectance

		In situ		R^2 (Reflectance & *in situ*)			
Site №	n	**Turbidity (NTU)**	Depth (m)	**Turbidity**	TN	TP	TN/TP
14	18	**2.02**	7.12	**0.71**	0.28	0.05	0.26
16	21	**2.90**	7.45	**0.56**	0.02	0.01	0.01
19	23	**2.98**	7.64	**0.51**	0.07	0.008	0.08
23	19	**2.61**	8.92	**0.19**	0.003	0.16	0.04
91	16	**2.64**	9.15	**0.50**	0.05	0.01	0.02
92	21	**3.37**	5.7	**0.04**	8.66×10^{-5}	0.07	0.005
95	17	**3.54**	8.44	**0.005**	4.51×10^{-7}	0.06	0.0007

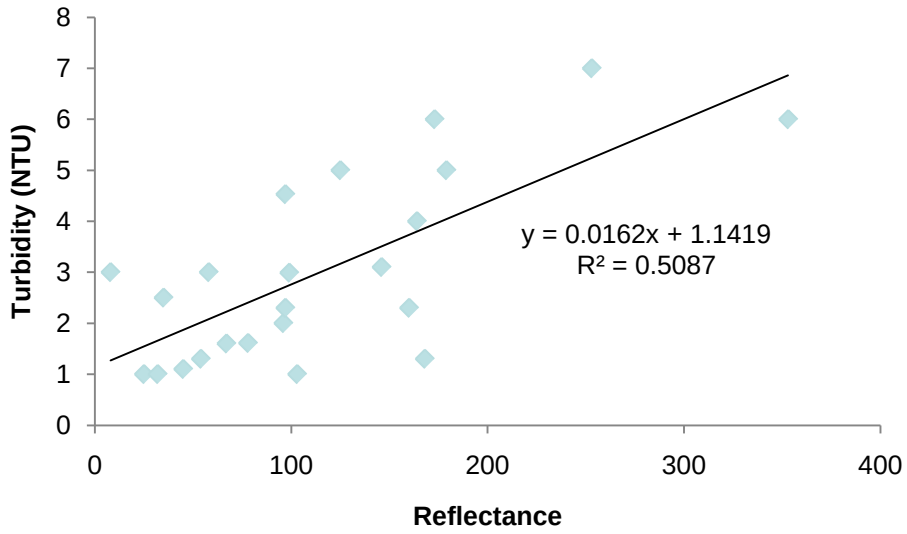
Turbidity & Reflectance: Station 14



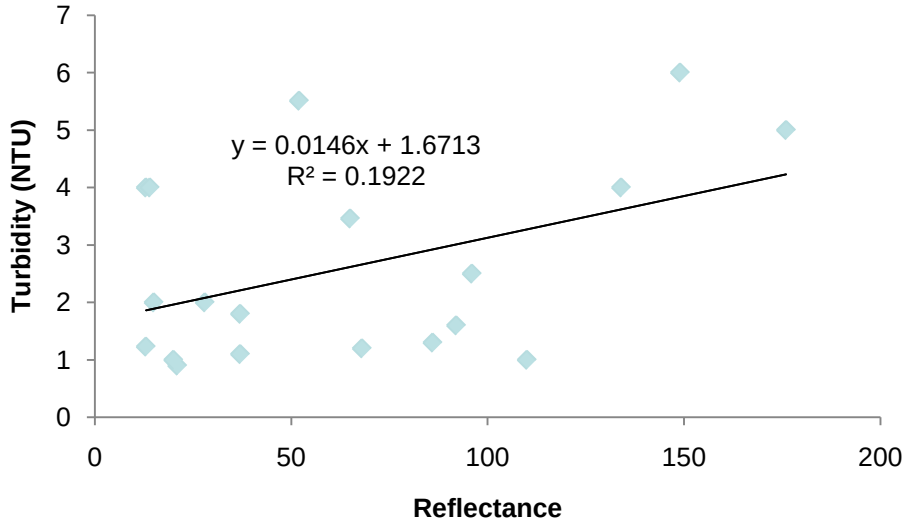
Turbidity & Reflectance: Station 16



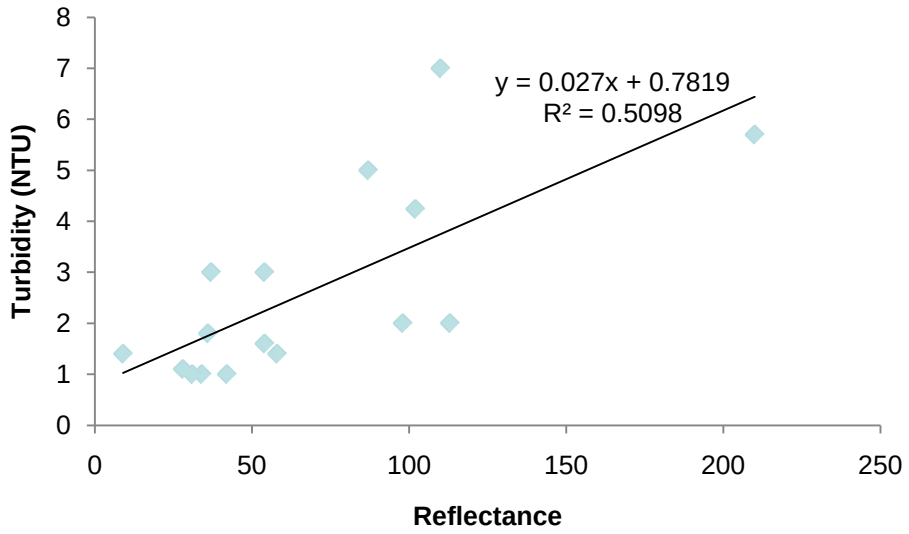
Turbidity & Reflectance: Station 19



Turbidity & Reflectance: Station 23



Turbidity & Reflectance: Station 91



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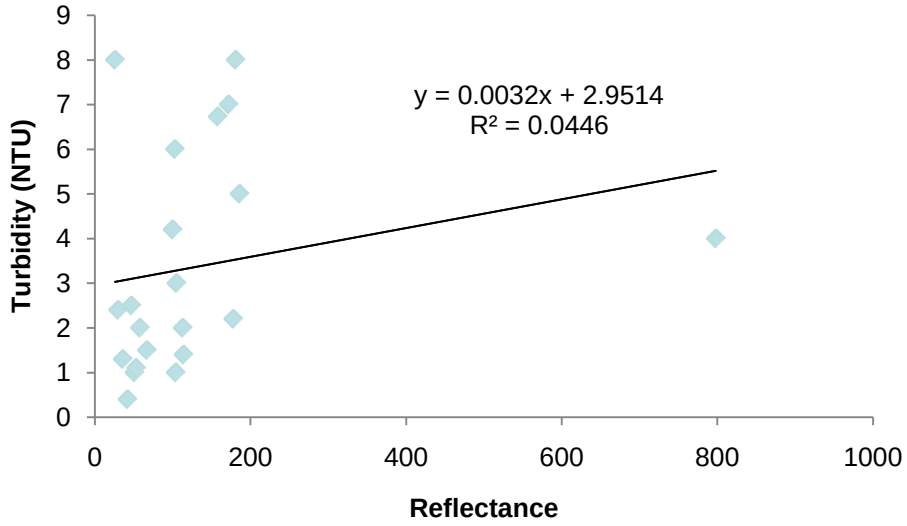
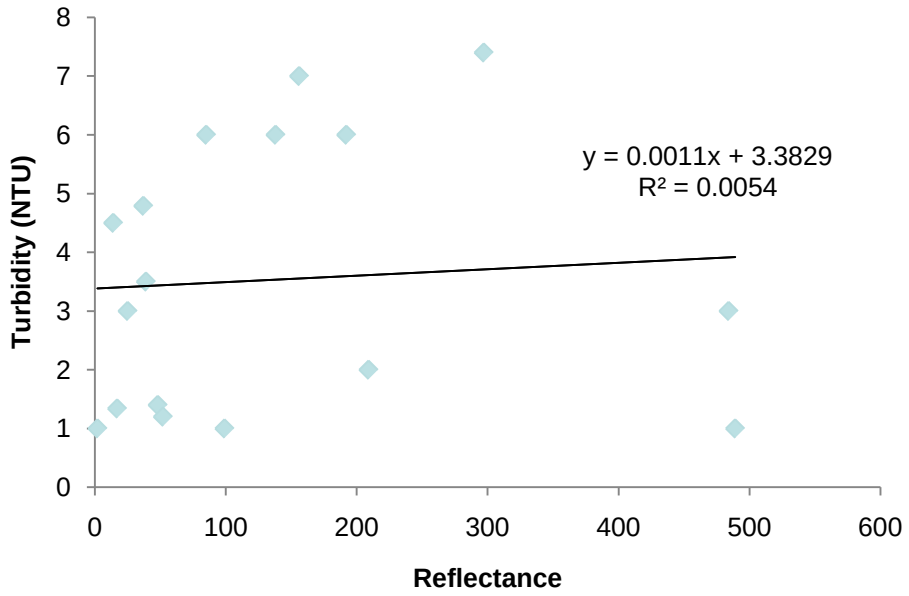
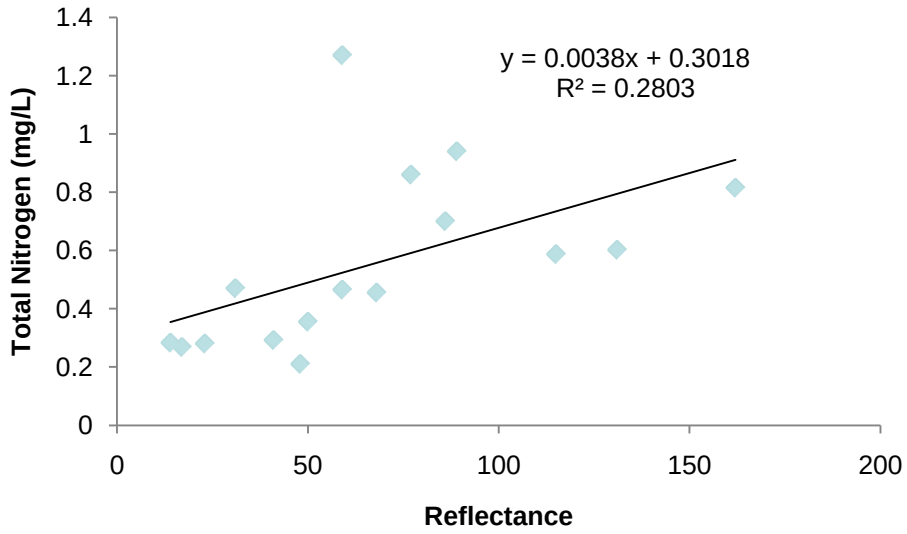


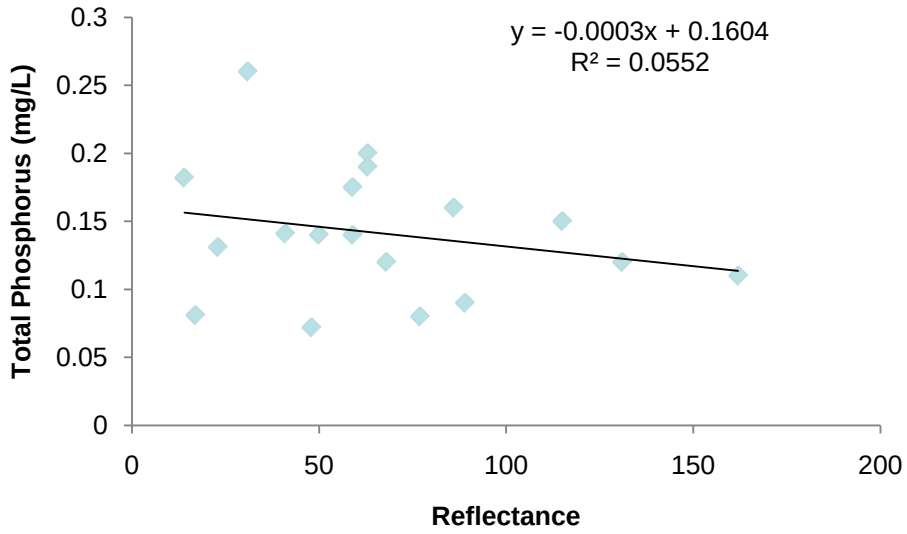
Turbidity & Reflectance: Station 95



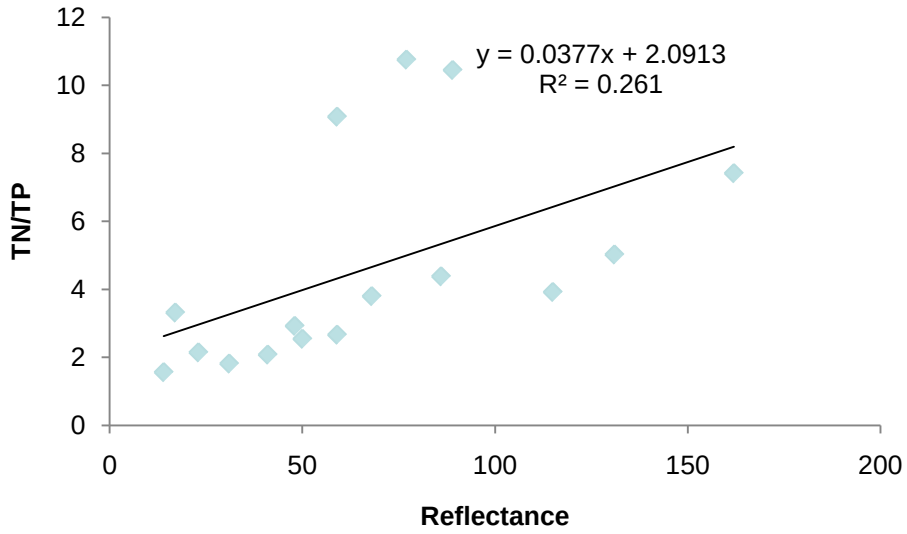
Total Nitrogen & Reflectance: Station 14



Total Phosphorus & Reflectance: Station 14



Ratio TN:TP & Reflectance: Station 14



Questions

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References

- Carlston, P. R., L. A. Yarbro, et al. (2003). "Effect of el El Niño on demographic, morphological, and chemical parameters in Turtle-grass *(Thalassia testudium): an unexpected test of inidicators."* *Environmental Monitoring and Assessment* ***81: 393 – 408.***

- Florida Department of Environmental Protection (FDEP) (2006). Integrated water quality assessment for Florida. 305 (b) report: Tallahassee, FL, Florida Department of Environmental Protection.

- Florida Department of Environmental Protection (FDEP) (2008). Integrated water quality assessment for Florida. 305 (b) report: Tallahassee, FL, Florida Department of Environmental Protection.

- Lipp, E. K., R. Kurz, et al. (2001). "The effects of seasonal variability and weatheron microbial fecal pollution and pathogens in a subtropical estuary." Estuaries **24(2): 266 - 276.**

- Rast, W. and J. Thorton (1996). "Trends in eutrophication research and control." Hydro. Proc. **10: 295-313.**

- Smith, S. V., D. P. Swaney, et al. (2003). "Humans, hydrology, and the distribution of inorganic nutrient loading to the ocean " Bioscience **53(3): 235-245.**