Historical Bathymetric Analysis of Tampa Bay

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Introduction

In Florida, approximately 150 to 200 square miles of marshland, tideland, and estuarine water areas have been lost to dredging and landfills. Both new dredging and maintenance dredging exhibit the potential to damage biological resources (seagrass, benthic fauna, etc.), degrade water quality through sediment and contaminate re-suspension (Johnston 1981), and change sediment type and sediment chemistry (Jones et al. 1981). Estuaries are altered commonly by dredging to accommodate vessel traffic (Schoellhamer 1996).

Tampa Bay Estuary has from 1950 to 1980 lost 40% of its seagrass, a consequence of dredging activities, re-suspension of sediment, and nutrient-induced algal growth. Seagrass serves as a protective nursery to fish and shellfish, as food for manatees, and as a stabilizer to bottom sediment (Poor et al. 2001). Modifications of this estuary to facilitate coastal development, including port construction, have resulted in the excavation or filling of 44% of the emergent coastal wetlands (i.e. tidal marshes and mangrove forests)(Lewis 1998). Furthermore dredge and fill activities over the past 100 years have been suggested to have caused a decrease in current velocities, especially in Hillsborough Bay (Goodwin 1984). Tampa Bay also exhibits the lowest rate of sediment input out of all the Gulf Coast estuaries, which is predominately in the form of mud-size sediment (Brooks et al. 1998).

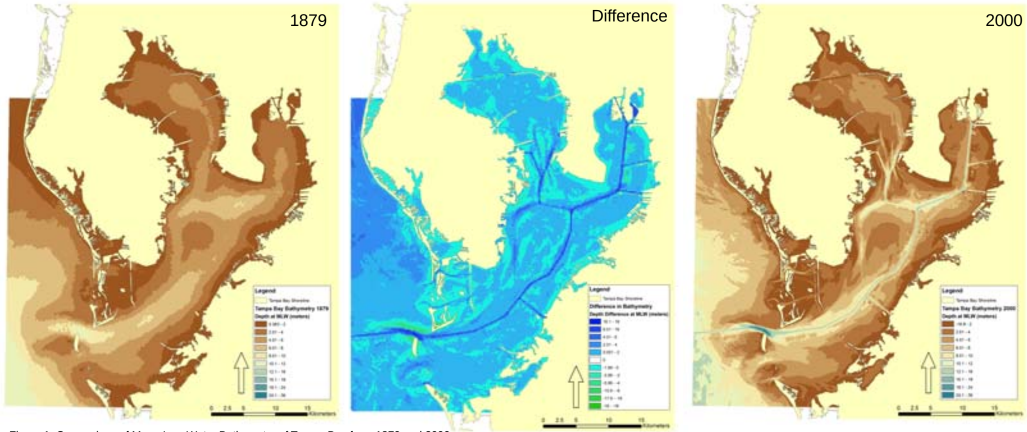

Figure 1: Comparison of Mean Low Water Bathymetry of Tampa Bay from 1879 and 2000.

1879 Bathymetry Data Source: U.S. Department of Interior, U.S. Geological Survey, Gulf of Mexico Integrated Science. Published 2004. **URL: http://dl.cr.usgs.gov/tampa/prod_search_tampa.aspx**

2000 Bathymetry Data Source: U.S. Department of Interior, U.S. Geological Survey, Gulf of Mexico Integrated Science. Published 2001. **URL: http://dl.cr.usgs.gov/tampa/prod_search_tampa.aspx**

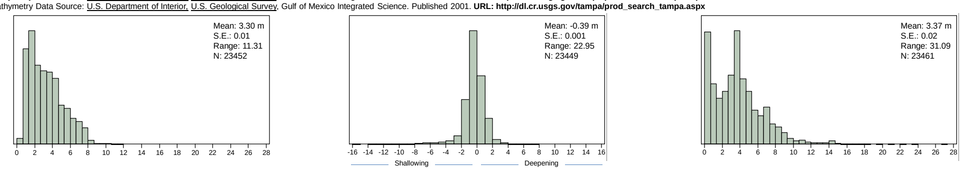

Figure 2. Frequency Distribution of MLW (meters) for 1879 Bathymetry (left), Difference between 2000 and 1879 (middle) and 2000 Bathymetry (right).

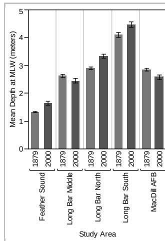

Figure 5: 1879 and 2000 Mean Depths at MLW (meters) in Each Study Area

Table 2: Wilcoxon Statistics

Study Site	Z Score	Prob>|Z|
Feather Sound	-0.95	0.34*
MacDill AFB	-3.60	<0.05
Long Bar North	3.73	<0.05
Long Bar Middle	-5.84	<0.05
Long Bar South	3.21	<0.05

* Denotes no statistical significance.

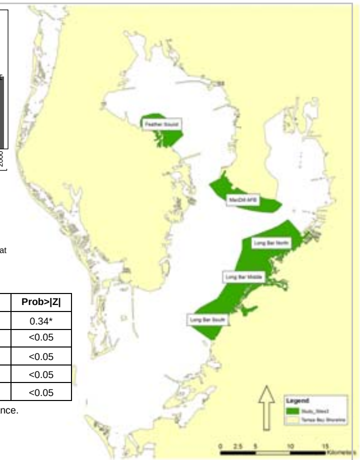

Figure 6: Tampa Bay Study Areas

Table 3: Mean Depth at MLW (meters) for Special Areas in Tampa Bay (Mean ± S.E.)

	Feather Sound	MacDill AFB	Long Bar North	Long Bar Middle	Long Bar South
1879	1.33 ± 0.02	2.86 ± 0.05	2.90 ± 0.05	2.63 ± 0.06	4.10 ± 0.08
2000	1.23 ± 0.04	2.65 ± 0.08	3.28 ± 0.07	2.69 ± 0.09	4.50 ± 0.01
Difference	0.09 ± 0.03	0.21 ± 0.05	-0.33 ± 0.03	-0.08 ± 0.04	-0.38 ± 0.05

The only area in which there was no significant difference among years of depths at MLW was the feather sound site. Other sites were determined to be significantly deeper except the MacDill AFB site which was significantly shallower.

Study Area

The Tampa Bay ecosystem includes 967 km² of primarily unvegetated or sparsely vegetated estuarine waters with an average depth of 3.5 m, 72 km² of emergent coastal wetlands, and a 5700 km² watershed. Approximately 10% of the 967 km² of open water area (101 km²) has shallow (<2 m) shelves vegetated with sea grasses (Lewis et al. 1998).

The Tampa Bay estuaries' physical structure, such as historical circulation and transport processes, has been considerably modified within the past century, mainly due to dredging of ship channels, construction of major causeways, and usage of the estuarine sediments as shoreline landfills (Santschi et al. 2001).

Methods

- 1879 Bathymetry
  - Performed kriging interpolation from point data using ArcGIS Geo-statisical Analysis (ESRI 2009).
- 2000 Bathymetry
  - Converted Vertical Datum from NAVD 88 to Mean Low Water (MLW) using VDatum Software (NOAA 2009).
- Difference Analysis
  - Performed analysis with ArcGIS Spatial Analysis (ESRI 2009).
  - ArcGIS Spatial Analysis zonal statistics (ESRI 2009) were performed for Management Areas of Tampa Bay (Figure 4).
- Statistical Analysis
  - The non-parametric Wilcoxon 2-Sample Test, Normal Approximation was used to determine statistical significance of changes in depth between years within study areas.

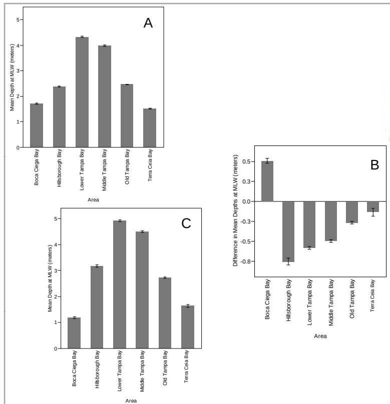

Figure 3: Mean Depth at MLW (meters) for Bay Management Areas in 1879 (A), 2000 (C), Difference in Mean MLW (meters) shown in (B).

Figure 4: Tampa Bay Bodies of Water, Management units.

Table 1: Mean Depths at MLW (meters) for Management Areas of Tampa Bay (Mean ± S.E.)

	Hillsborough Bay	Terra Ciea Bay	Lower Tampa Bay	Old Tampa Bay	Boca Ciega Bay	Middle Tampa Bay
1879	2.391±0.003	1.519±0.002	4.327±0.003	2.465±0.002	1.717±0.003	3.983±0.002
2000	3.155±0.007	1.654±0.008	4.914±0.006	2.734±0.004	1.207±0.005	4.49±0.005
Difference	-0.759±0.005	-0.133±0.007	-0.586±0.002	-0.271±0.002	0.513±0.004	-0.504±0.002

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Conclusions/Implications

Tampa Bay's benthic landscape has been altered drastically through dredging operations aimed at channelization of the bay for large maritime operations, as evident in the 2000 bathymetry (Figure 1). A major shipping channel has been dredged from the mouth to the upper reaches of Lower Tampa Bay, where it splits into two branches, one entering Old Tampa Bay and the other going into Hillsborough Bay (Galperin et al. 1991). In addition , depths of estuaries vary for multiple reasons including inputs of terrestrial and marine sediments, autochthonous biogenic production, natural and anthropogenic changes to inflows, tidal characteristics, bottom profiles, and sea level rise.

A comparison of historical (1879) and modern (2000) depth data registered to mean low water (MLW) allows an assessment of depth changes for the entire bay, bay management areas, and areas of special interest (Feather Sound, Southern Interbay Peninsula (labeled MacDill AFB), and a system of offshore bars along the southeast bay shore (labeled Long Bar)). It was determined using non-parametric statistics that the only area of special interest that was not different between the two surveys was Feather Sound, which was the smallest study area. Feather Sound is located in Old Tampa Bay on the central eastern shore of the Pinellas peninsula. As such, the Sound could have been sheltered from strong circulation forces within Old Tampa Bay, which would result in a low degree of sediment transport and deposition. MacDill AFB was determined to be significantly shallower, which could be caused by sediment fluxes from Old Tampa Bay and Hillsborough Bay. The AFB area may also serve as a point of accumulation due to altered bay circulation. The other special interest sites were determined to be significantly deeper between the two surveys, which could have been caused by dredging, management activities, and altered bay circulation from earlier dredging activities which could cause altered sediment fluxes.

Our data are at two different spatial scales: 2000 bathymetry is extremely fine resolution (more spatially sensitive) and 1879 bathymetry is more coarse resolution (less spatially sensitive). Using the best available data at the time the general trend in the data is that, overall, there have been changes to the estuaries' bottom, with more shallowing at the Boca Ciega Bay and the MacDill AFB special study site. Boca Ciega Bay is composed mainly of sand and grass flats with a few tidal channels. In addition Boca Ciega Bay has been dredged and filled extensively, resulting in a large decrease in estuarine habitat. More than 75% of this area is less than 2 m in depth (Brooks et al. 1998). Furthermore, Boca Ciega Bay is guarded by barrier islands, which have been documented to be sediment sinks (Penland et al. 1988).

Estuarine depth is the product of coastal sediment budgets that involve terrestrial, marine, and autochthonous sources and sinks. Previous accounts of estuarine depth changes usually have been related to anthropogenic changes to sediment dynamics. The mean depth of Tampa bay has increased by more than 5% in the past century (Goodwin 1984), which is consistent with our findings. Whether the depth of Tampa Bay will change as a result of climate change is an open but important question. Changes in the depth characteristics of Tampa Bay could affect water quality, the dispersion, abundance, or productivity of seagrasses, and possible benthic communities including intertidal oysters.

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