Surface Water Quality

2001-2010

Hillsborough County, Florida

ENVIRONMENTAL PROTECTION COMMISSION
HILLSBOROUGH COUNTY

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List of Abbreviations

AWT	Advanced Wastewater Treatment
BMAP	Basin Management Action Plan
BMP	Best Management Practices
BOCC	Board of County Commissioners
BOD	Biological Oxygen Demand
CCMP	Comprehensive Conservation Management Plan
CFS	Cubic Feet per Second
Chl a	Chlorophyll a
COT	City of Tampa
CWA	Clean Water Act (Federal Water Pollution Control Act of 1972)
DO	Dissolved Oxygen
EPCHC	Environmental Protection Commission of Hillsborough County
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FFWC	Florida Fish and Wildlife Conservation Commission
F.S.	Florida Statutes
HB	Hillsborough Bay
HUC	Hydrologic Unit Code
IWR	Impaired Waters Rule
LCI	Lake Condition Index
LTB	Lower Tampa Bay
MDL	Method Detection Limit
MFL	Minimum Flows and Levels
MGD	Million Gallons per Day
MS4	Municipal Separate Storm Sewer System
MTB	Middle Tampa Bay

NNC	Numeric Nutrient Criteria
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
OFW	Outstanding Florida Waters
OTB	Old Tampa Bay
PAR	Photosynthetically Active Radiation
PLE	Pollution Load Estimate
PQL	Practical Quantitation Limit
PR	Palm River
PPM	Parts per million (= mg/L)
PPT	Parts per thousand (‰)
PSU	Practical Salinity Units (= parts per thousand)
SCI	Stream Condition Index
SOP	Standard Operating Procedures
SWFWMD	South West Florida Water Management District
SWIM	Surface Water Improvement Management
SWIMAL	Saltwater Intrusion Minimal Aquifer Levels
TBEP	Tampa Bay Estuary Program
TBW	Tampa Bay Water
TMDL	Total Maximum Daily Loads
TSI	Trophic State Index
USEPA	United States Environmental Protection Agency
WBID	Water Body Identification number
WQI	Water Quality Index
WQS	Water Quality Standards
WWTP	Wastewater Treatment Plant

Chapter 1

INTRODUCTION

History

The Environmental Protection Commission of Hillsborough County (EPCHC) was established in 1967 by the Florida Legislature and charged with maintaining "standards which will insure the purity of all waters and soils consistent with public health and public enjoyment thereof, the propagation and protection of wildlife, birds, game, fish, and other aquatic life" (Chapter 84-446 Laws of Florida). As part of this mandate, the EPCHC established a county-wide surface water quality monitoring (WQM) program in 1972 to provide scientifically sound data to area resource managers. The data collected is transmitted to the Florida Department of Environmental Protection (FDEP) and to the Federal STORET Water Quality System maintained by the U.S. Environmental Protection Agency as well as to the Southwest Florida Water Management District (SWFWMD) and locally to the Tampa Bay Estuary Program and other agencies.

The program started out with 53 fixed sampling stations throughout Tampa Bay. In 1973 sampling in the tributaries and Lake Thonotosassa was added. In 1975, the program began collecting water column profiles to collect hydrographic data at the surface, mid and bottom depths. The monitoring program was expanded in 2000 in response to the construction of several potable water projects including withdraw structures on the Alafia River and Tampa Bypass Canal and a desalination plant at Apollo Beach. This supplemental monitoring, known then as the Hillsborough Independent Monitoring Program (HIMP), included fixed continuous, monitoring stations specialized diurnal studies and monthly hydrographic surveys on the Hillsborough River, Palm River/McKay Bay system, Alafia River, Little Manatee River and in the vicinity of the Apollo Beach desalinization plant. The HIMP ended in 2006, however, fixed continuous monitoring on the Hillsborough and Alafia Rivers and the monthly hydrographic surveys have been incorporated into the monitoring program.

In cooperation with the Hillsborough County Public Works Department, quarterly sampling of minor tributaries was added in 2005 to comply with the Impaired Water Rule, 62-303 F.A.C. The sampling design accommodates the assessment of the County's smaller water bodies for impairment and facilitates the establishment Total Maximum Daily Loads (TMDL) for these systems as needed.

Currently EPCHC maintains 247 monitoring sites; 173 sites are sampled monthly and an additional 74 are sampled on a quarterly basis. The 173 monthly sampling sites include 52 within Tampa Bay and 121 stations in the major rivers, streams and Lake Thonotosassa (Figure 1; Table 1). Of the 173 monthly stations, 120 are sampled for a full suite of water quality parameters including nutrients, chlorophyll, bacteria and turbidity while the remaining 53 stations are hydrographic survey sites (Table 2). The 74 quarterly stations (Figure 2; Table 3) are on smaller streams (“minor tributaries”) and are sampled for the entire range of parameters.

Classification of Surface Waters

The Florida Department of Environmental Protection (FDEP) categorizes surface waters into five classifications based on the primary usage of the water body (Chapter 62-302.400 F.A.C.). The highest classification, Class I, consists of surface waters that are used for potable water supplies. Class II waters are designated for shell fish harvesting and are afforded the second highest level of protection. Most surface waters in the State are Class III waters, commonly referred to as “fishable - swimmable” and are maintained for recreational use, fish consumption and wildlife use. Recently, the State added a sub-class, “Class III –Limited” for artificial water conveyances or waterbodies so physically altered that fishing and swimming are not reasonable uses for these surface waters, e.g. concrete lined drainage ditches. Class IV waters are designated for agricultural water supply and Class V for industrial or navigational uses.

As elsewhere in the State , most water bodies in Hillsborough County fall under the Class III designation, and are subcategorized as marine or freshwater (Figure 3). The Hillsborough River from the City of Tampa’s (COT) reservoir dam at Rowlett Park up stream to Flint Creek and Cow House Creek from the Hillsborough River to its source are classified as Class I waters. Class II waters in Hillsborough County include Old Tampa Bay north of the Howard Frankland Bridge up to and including Mobbly Bay, a portion of Middle Tampa Bay south of Gadsden Point, along the eastern shoreline of Middle Tampa Bay south of Apollo Beach to the Hillsborough-Manatee county line, and the Hillsborough County waters west of the Sunshine Skyway bridge excluding the shipping channel. There are currently no waterbodies within Hillsborough County that fall under the Class IV or Class V designations.

The FDEP further designates certain waterbodies as Outstanding Florida Waters (OFWs). These may include waters within state or national parks, designated aquatic preserves, or lands donated for conservation. Under the OFW designation, the FDEP grants the highest level of protection for water quality. Within Hillsborough County, OFW sites include the Bower Tract on the northeast side of Old Tampa Bay, Egmont Key, the Hillsborough River State Park and the Hillsborough River upstream of Fletcher Avenue to the Withlacoochee River drainage in Pasco County and including Cypress Creek, Thirteen Mile Run and Big Cypress Swamp, Trout Creek up stream to Bruce B. Downs Blvd., Black Water Creek to the Polk County line, and Crystal Springs; the Little Manatee River State Recreation Area and the Little Manatee River from the mouth upstream to S.R. 674; and the Cockroach Bay Aquatic Preserve.

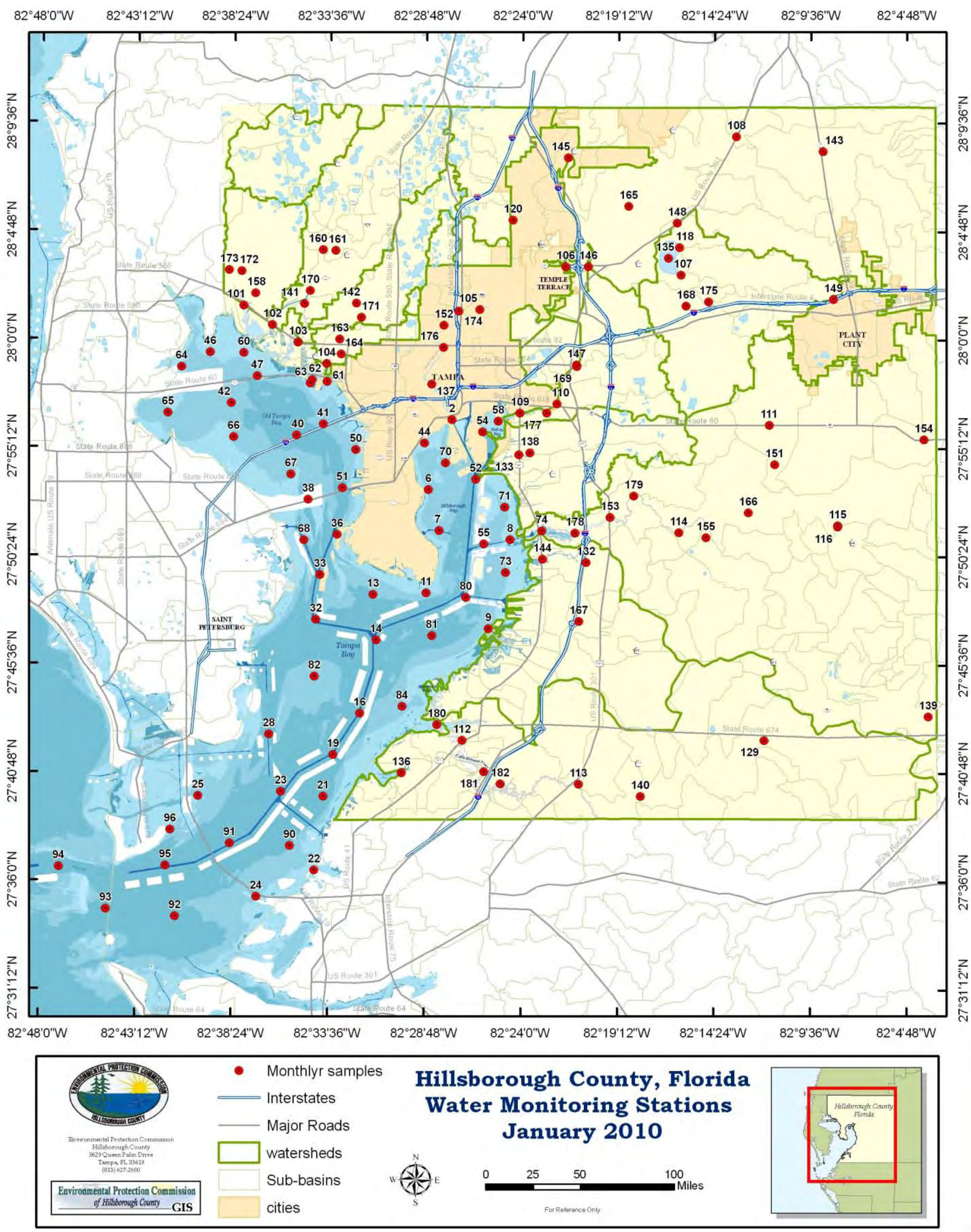


Figure 1 EPCHC monthly surface water quality monitoring stations.

Table 1 EPCHC Monthly Water Monitoring Stations (Excluding Survey Sites).

Station	Latitude	Longitude	Area	Class	Station Description
2	27.941826	-82.458544	Hillsborough River	III (M)	Station is at the N side of the Platt Street Bridge
6	27.889299	-82.477402	Hillsborough Bay	III (M)	Hillsborough Bay E of Ballast Pt. Pier
7	27.858900	-82.468597	Hillsborough Bay	III (M)	Hillsborough Bay
8	27.852400	-82.409302	Hillsborough Bay	III (M)	Hillsborough Bay East
9	27.786501	-82.427200	Middle Tampa Bay	II	Hillsborough Bay Apollo Beach
11	27.812901	-82.478897	Middle Tampa Bay	II	Lower Tampa Bay at Ship Channel Marker
13	27.811800	-82.523201	Middle Tampa Bay	II	Tampa Bay 100 ft. south of Channel F marker
14	27.778000	-82.520302	Middle Tampa Bay	II	Tampa Bay between markers 5F and 67
16	27.723801	-82.533798	Middle Tampa Bay	II	Lower Tampa Bay main channel between 1E and 2
19	27.693399	-82.555901	Middle Tampa Bay	II	Lower Tampa Bay main channel between markers 1D and 2D
21	27.662500	-82.563904	Lower Tampa Bay	II	Lower Tampa Bay 3/4 mile NW of Piney Point
22	27.608101	-82.571198	Lower Tampa Bay	III (M)	Entrance to Bishops Harbor
23	27.666000	-82.599197	Lower Tampa Bay	II	Lower Tampa Bay Port Manatee channel marker 9B
24	27.588400	-82.619301	Lower Tampa Bay	II	Lower Tampa Bay 100 yards north of Sunshine Skyway
25	27.662701	-82.667900	Lower Tampa Bay	II	Lower Tampa Bay east of N causeway bridge span
28	27.708401	-82.609200	Middle Tampa Bay	II	Lower Tampa Bay Marker 6
32	27.793200	-82.570702	Middle Tampa Bay	II	Tampa Bay Marker 5G
33	27.826099	-82.567497	Middle Tampa Bay	II	Tampa Bay Marker 12J
36	27.855801	-82.553299	Old Tampa Bay	III (M)	Old Tampa Bay 100 yards west of Port Tampa Dock
38	27.881800	-82.577499	Old Tampa Bay	II	Old Tampa Bay 100 yards north of west end of Gandy Bridge
40	27.929100	-82.587303	Old Tampa Bay	II	Old Tampa Bay north of center of Howard Franklin Bridge
41	27.937401	-82.565002	Old Tampa Bay	II	Old Tampa Bay north of Tampa end of Howard Franklin Bridge
42	27.952801	-82.641602	Old Tampa Bay	II	Old Tampa Bay south of center of Courtney Campbell CW bridge
44	27.923700	-82.480698	Hillsborough Bay	III (M)	Hillsborough Bay east of Bayshore Blvd.
46	27.990400	-82.659302	Old Tampa Bay	II	Old Tampa Bay southeast of power plant
47	27.972601	-82.620201	Old Tampa Bay	II	Old Tampa Bay north of Courtney Campbell Causeway bridge
50	27.918501	-82.537903	Old Tampa Bay	II	Old Tampa Bay 2 miles southeast of east end of Franklin br.
51	27.890200	-82.548798	Old Tampa Bay	II	Old Tampa Bay 100 ft SE of east end of Gandy Bridge
52	27.896999	-82.438202	Hillsborough Bay	III (M)	Mouth of McKay Bay
54	27.931900	-82.432602	McKay Bay	III (M)	McKay Bay SE of 22nd Street Causeway bridge
55	27.849300	-82.431396	Hillsborough Bay	III (M)	Hillsborough Bay E channel marker 22
58	27.939800	-82.419601	McKay Bay	III (M)	McKay Bay between Palm River and the 22nd St. bridge
60	27.989901	-82.631599	Old Tampa Bay	II	Old Tampa bay 1 mile SW of Cabbagehead Bayou
61	27.968700	-82.562103	Old Tampa Bay	II	Old Tampa Bay 100 yd NE of bridge
62	27.969999	-82.574303	Old Tampa Bay	II	Old Tampa Bay north of municipal beach in channel
63	27.967600	-82.575996	Old Tampa Bay	III (M)	Old Tampa Bay 1/8 mile SW of municipal beach
64	27.979401	-82.683296	Old Tampa Bay	II	Old Tampa Bay Campbell Pkwy
65	27.945601	-82.694298	Old Tampa Bay	II	Old Tampa Bay marker 1 mile S of Campbell Causeway
66	27.927799	-82.639702	Old Tampa Bay	II	Old Tampa Bay 2.7 miles NW of main span Franklin bridge

Station	Latitude	Longitude	Area	Class	Station Description
67	27.900200	-82.592003	Old Tampa Bay	II	Old Tampa Bay between Howard Frankland and Gandy bridges
68	27.851900	-82.580803	Old Tampa Bay	II	Old Tampa Bay channel marker 16
70	27.908899	-82.463203	Hillsborough Bay	III (M)	Hillsborough Bay 300 yards S of SW tip of Davis Islands
71	27.876499	-82.413803	Hillsborough Bay	III (M)	Hillsborough Bay 3000 yards S of Port Sutton silos
73	27.828100	-82.413101	Hillsborough Bay	III (M)	Hillsborough Bay 3/4 mile NE of Cut A range marker
74	27.858999	-82.383003	Alafia River	III (M)	Under the E side of US Hwy 41 (SR 45)
80	27.809601	-82.445999	Hillsborough Bay	III (M)	Lower Hillsborough Bay C Channel junction
81	27.781300	-82.474098	Middle Tampa Bay	II	Middle Tampa Bay 1 mile N of Simmons Park
82	27.751101	-82.571800	Middle Tampa Bay	II	Middle Tampa Bay at J range marker south cut
84	27.729000	-82.498703	Middle Tampa Bay	II	Middle Tampa Bay 1 mile W of Bahia Beach
90	27.625999	-82.591499	Lower Tampa Bay	II	Lower Tampa Bay 1.25 mi south of Mullet Key
91	27.627899	-82.641502	Lower Tampa Bay	II	Lower Tampa Bay ship channel buoy R4A
92	27.573700	-82.686798	Lower Tampa Bay	II	Lower Tampa Bay SW Skyway buoy R70
93	27.578899	-82.744102	Lower Tampa Bay	III (M)	Lower Tampa Bay SW Channel bell buoy 5
94	27.610001	-82.783203	Lower Tampa Bay	III (M)	Egmont channel Tampa Bay buoy R10
95	27.611200	-82.694702	Lower Tampa Bay	II	Mullet Key Channel Tampa Bay buoy R14
96	27.637800	-82.691002	Lower Tampa Bay	II	Lower Tampa Bay 1 mile north of Mullet Key Ship Channel
101	28.024799	-82.631599	Old Tampa Bay Tributary	III (M)	Double Branch Creek at SR 580 bridge
102	28.010599	-82.607803	Old Tampa Bay Tributary	III (M)	Channel A at SR 580 bridge
103	27.997601	-82.586304	Old Tampa Bay Tributary	III (M)	Rocky Creek at SR580 bridge
104	27.982100	-82.562302	Old Tampa Bay Tributary	III (M)	Sweetwater Creek at Memorial Highway bridge
105	28.022200	-82.434998	Hillsborough River	III (M)	Station is on the W side of the Rowlett Park Drive bridge w/ blue water pipes
106	28.054001	-82.363800	Hillsborough River	III (F)	Hillsborough River at SR 582 bridge
107	28.048100	-82.267601	Lake Thonotosassa Tributary	III (F)	Baker Creek at Thonotosassa-Plant City Road
108	28.150200	-82.221703	Hillsborough River	III (F)	Hillsborough River at US 301 bridge
109	27.945999	-82.401604	Palm River	III (M)	W side of US 41 bridge
110	27.952600	-82.370796	Palm River	III (M)	N side of SR 60 bridge
111	27.937401	-82.194099	Alafia River Tributary	III (F)	Turkey Creek at SR 60 bridge
112	27.704300	-82.448700	Little Manatee River	III (M)	Station is at US 41 bridge
113	27.671900	-82.352097	Little Manatee River	III (F)	Little Manatee River at US 301 bridge
114	27.857800	-82.268997	Alafia River	III (F)	Alafia River at Bell Shoals Road
115	27.863100	-82.137001	Alafia River	III (F)	N Prong Alafia River upstream of confluence w/ S Prong
116	27.862301	-82.137100	Alafia River	III (F)	S Prong of Alafia River upstream of confluence w/ N Prong
118	28.068300	-82.268898	Lake Thonotosassa	III (F)	Lake Thonotosassa at mouth of Flint Creek
120	28.088301	-82.407700	Hillsborough River Tributary	III (F)	Cypress Creek at SR 581
129	27.704599	-82.197899	Little Manatee River	III (F)	Little Manatee River at SR 674
132	27.835699	-82.346199	Hillsborough Bay Tributary	III (F)	Bullfrog Creek at Symmes Road
133	27.915001	-82.402199	Hillsborough Bay Tributary	III (M)	Delaney Creek at US 41
135	28.060400	-82.278297	Lake Thonotosassa	III (F)	Lake Thonotosassa center
136	27.680000	-82.499199	Cockroach Bay	III (M)	Cockroach Bay at HCC Study Center
137	27.966999	-82.475098	Hillsborough River	III (M)	Station is at the S side of the Columbus Avenue bridge
138	27.916500	-82.392998	Hillsborough Bay Tributary	III (F)	Delaney Creek at 36th Ave. & 54th Street
139	27.722000	-82.061600	Alafia River	III (F)	Alafia River South Prong at Bethlehem Road
140	27.663000	-82.300598	Little Manatee River	III (F)	Little Manatee River at CR 579

Station	Latitude	Longitude	Area	Class	Station Description
141	28.026100	-82.581200	Old Tampa Bay Tributary	III (M)	Rocky Creek at Waters Avenue
142	28.026699	-82.538002	Old Tampa Bay Tributary	III (F)	Sweetwater Creek at Anderson Road upstream side
143	28.139299	-82.149597	Hillsborough River Tributary	III (F)	Blackwater Creek at SR 39 under RR bridge
144	27.838100	-82.382202	Hillsborough Bay Tributary	III (M)	Bullfrog Creek at US 41
145	28.134501	-82.361702	Hillsborough River Tributary	III (F)	Trout Creek at SR581 east side of northbound span
146	28.054100	-82.345001	Tampa Bypass Canal	III (F)	Tampa Bypass Canal at south side of Fowler Ave. Bridge
147	27.981501	-82.354500	Tampa Bypass Canal	III (F)	Tampa Bypass Canal at north side of MLK Blvd.
148	28.086399	-82.271004	Hillsborough River Tributary	III (F)	Flint Creek at US 301 bridge east side
149	28.030199	-82.140800	Lake Thonotosassa Tributary	III (F)	Mill Creek at north side of I-4
151	27.908300	-82.189598	Alafia River Tributary	III (F)	Turkey Creek at Durant Road
152	28.010500	-82.464996	Hillsborough River	III (M)	Station is at the S side of the Sligh Avenue Bridge
153	27.869101	-82.326401	Alafia River	III (M)	Under E side of US 301 bridge.
154	27.926701	-82.065201	Alafia River Tributary	III (F)	English Creek at SR 60
155	27.854179	-82.246468	Alafia River Tributary	III (F)	Fishhawk Creek at Fishhawk Blvd.
158	28.033910	-82.621730	Old Tampa Bay Tributary	III (F)	Double Branch Creek at Countryway Blvd.
160	28.065940	-82.565750	Old Tampa Bay Tributary	III (F)	Rocky Creek at Gunn Hwy
161	28.065650	-82.555240	Old Tampa Bay Tributary	III (F)	Brushy Creek at Gunn Hwy
163	28.000100	-82.551790	Old Tampa Bay Tributary	III (F)	Lower Sweetwater Creek at Golden Dr.
164	27.989070	-82.550280	Old Tampa Bay Tributary	III (F)	TIA Drain at George Rd.
165	28.098690	-82.311310	Hillsborough River	III (F)	Hillsborough River at Morris Bridge Rd.
166	27.872660	-82.211260	Alafia River	III (F)	Alafia River at Lithia-Pinecrest Rd.
167	27.792210	-82.352170	Hillsborough Bay Tributary	III (F)	Bullfrog Creek at Big Bend Rd.
168	28.025217	-82.263483	Lake Thonotosassa Tributary	III (F)	Baker Creek at Muck Pond Rd. W of Pemberton Creek Dr.
169	27.980450	-82.354367	Tampa Bypass Canal Tributary	III (F)	Sable Creek behind DEP at 3804 Coconut Palm Dr.
170	28.035933	-82.576300	Old Tampa Bay Tributary	III (F)	Channel A just below Rocky Creek confluence
171	28.016367	-82.533633	Old Tampa Bay Tributary	III (F)	Channel G at Anderson Rd.
172	28.050110	-82.633530	Old Tampa Bay Tributary	III (F)	Twin Branch Acres Road
173	28.051150	-82.644040	Old Tampa Bay Tributary	III (F)	Tampa Bay Downs
174	28.021030	-82.452750	Hillsborough River Tributary	III (M)	Sulphur Springs Run @ Sulphur Springs Park
175	28.028258	-82.244611	Lake Thonotosassa Tributary	III (F)	Baker Creek at McIntosh Rd.
176	27.994180	-82.465380	Hillsborough River	III (M)	Station is at the southernmost brown apartment build just S of Hillsborough Ave bridge
177	27.945900	-82.379083	Palm River	III (M)	Station is at bend in the river
178	27.857517	-82.355350	Alafia River	III (M)	Station is next to " Dixie's Dockside Waterfront pub." W side of island.
179	27.884933	-82.306650	Alafia River	III (M)	Upstream of Buckhorn Springs
180	27.715667	-82.469883	Little Manatee River	III (M)	Station is just past the "Y" in river to the N side
181	27.681033	-82.430517	Little Manatee River	III (M)	Station is near historical CM station
182	27.672217	-82.417000	Little Manatee River	III (M)	Station is near a small cove on the S side of river

Table 2 Monthly survey stations

Station	Latitude	Longitude	Area	River Kilometer	Class
1301	27.855200	-82.392783	Alafia River	1	III (M)
1303	27.857750	-82.375700	Alafia River	3	III (M)
1304	27.858050	-82.365650	Alafia River	4	III (M)
1306	27.858517	-82.345217	Alafia River	6	III (M)
1307	27.863383	-82.336367	Alafia River	7	III (M)
1309	27.867333	-82.320867	Alafia River	9	III (M)
1310	27.866367	-82.312833	Alafia River	10	III (M)
1311	27.871850	-82.309683	Alafia River	11	III (M)
1312	27.879000	-82.312650	Alafia River	12	III (M)
1314	27.878200	-82.297450	Alafia River	14	III (M)
1315	27.876750	-82.292433	Alafia River	15	III (M)
1502	27.952650	-82.465350	Hillsborough River	2	III (M)
1503	27.959355	-82.464380	Hillsborough River	3	III (M)
1505	27.971370	-82.481270	Hillsborough River	5	III (M)
1506	27.978970	-82.476950	Hillsborough River	6	III (M)
1507	27.986250	-82.470930	Hillsborough River	7	III (M)
1509	27.997730	-82.470900	Hillsborough River	9	III (M)
1510	28.004550	-82.470100	Hillsborough River	10	III (M)
1512	28.018080	-82.464700	Hillsborough River	12	III (M)
1514	28.017920	-82.447420	Hillsborough River	14	III (M)
1515	28.014450	-82.440930	Hillsborough River	15	III (M)
1601	27.718050	-82.480050	Little Manatee River	1	III (M)
1603	27.711383	-82.460950	Little Manatee River	3	III (M)
1604	27.711150	-82.453983	Little Manatee River	4	III (M)
1606	27.696833	-82.457550	Little Manatee River	6	III (M)
1607	27.690850	-82.452183	Little Manatee River	7	III (M)
1608	27.688683	-82.441400	Little Manatee River	8	III (M)
1610	27.676217	-82.434800	Little Manatee River	10	III (M)
1611	27.668550	-82.438950	Little Manatee River	11	III (M)
1612	27.666717	-82.431400	Little Manatee River	12	III (M)
1614	27.669350	-82.411650	Little Manatee River	14	III (M)
1615	27.664533	-82.408400	Little Manatee River	15	III (M)
1616	27.666617	-82.405567	Little Manatee River	16	III (M)
1701	27.936150	-82.425517	McKay Bay/Palm River	1	III (M)
1703	27.944167	-82.407250	Palm River	3	III (M)
1705	27.947700	-82.390617	Palm River	5	III (M)
1409	27.788167	-82.427867	Big Bend	N/A	III (M)
14410	27.777867	-82.406300	Big Bend	N/A	III (M)
14415	27.779600	-82.412217	Big Bend	N/A	III (M)
14418	27.781400	-82.416833	Big Bend	N/A	III (M)
14420	27.782617	-82.421500	Big Bend	N/A	III (M)
14421	27.784033	-82.418983	Big Bend	N/A	III (M)
14424	27.788683	-82.415383	Big Bend	N/A	III (M)
14426	27.792150	-82.411083	Big Bend	N/A	III (M)
14427	27.793000	-82.413817	Big Bend	N/A	III (M)
14429	27.793067	-82.413967	Big Bend	N/A	III (M)
14431	27.797750	-82.411950	Big Bend	N/A	III (M)
14432	27.793800	-82.420150	Big Bend	N/A	III (M)
14434	27.776400	-82.438733	Big Bend	N/A	III (M)
14435	27.772583	-82.430967	Big Bend	N/A	III (M)
14437	27.778950	-82.423200	Big Bend	N/A	III (M)
14438	27.772467	-82.423100	Big Bend	N/A	III (M)
14439	27.800150	-82.425400	Big Bend	N/A	III (M)

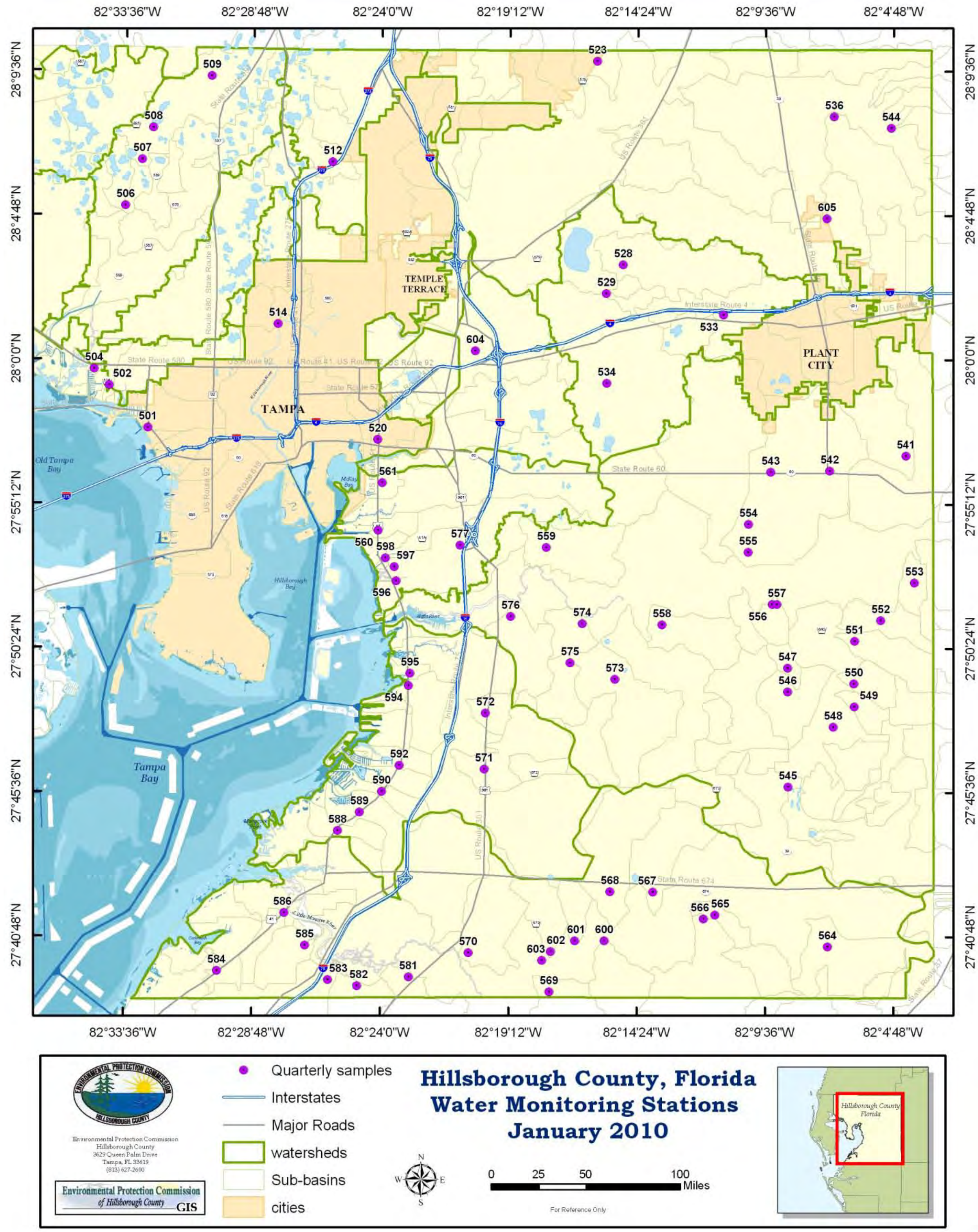


Figure 2 EPCHC quarterly water quality monitoring stations.

Table 3. Quarterly minor tributary stations.

Station	Latitude	Longitude	Area	Class	Station Description
501	27.962070	-82.545820	Old Tampa Bay Tributary	III (M)	Fish Creek - SR 60 (N bound) SW of TIA before CCCauseway
502	27.985560	-82.570180	Old Tampa Bay Tributary	III (M)	Memorial Highway NW of Town N Country Blvd.
504	27.994600	-82.579480	Old Tampa Bay Tributary	III (M)	Memorial Highway SE of Hillsborough Ave.
505	28.083910	-82.572720	Old Tampa Bay Tributary	III (F)	Berkford Ave. N of Gunn HWY S of Antilla
506	28.085280	-82.560300	Old Tampa Bay Tributary	III (F)	Rocky Creek at Turtle Creek Blvd. W of Pelican Point W off Bellamy
507	28.110783	-82.549883	Old Tampa Bay Tributary	III (F)	Orange Blossom Creek at Tobacco Rd. S of Turtle Ridge Dr.
508	28.128330	-82.543200	Old Tampa Bay Tributary	III (F)	Lake Carlton Outlet at VanDyke Rd. W of Old Tobacco Rd. E of Carlton Ave.
509	28.157066	-82.506500	Old Tampa Bay Tributary	III (F)	Lutz-Lake Fern Rd. W of Cypress Green E of Heritage Harbor
511	28.133610	-82.430440	Hillsborough River Tributary	III (F)	Lake Hanna Outlet at Livingston Ave. N of Wain Ranch Ln. S of Max Smith Rd.
512	28.109410	-82.430790	Hillsborough River Tributary	III (F)	Thirteen Mile Run at Livingston Ave. N of I-275 & S of Vandervort
513	28.058430	-82.461330	Hillsborough River Tributary	III (F)	Curiosity Creek at 122nd Ave. W of Florida & E of Ola
514	28.019750	-82.464700	Hillsborough River Tributary	III (F)	Twin Lake Outlet at N Rivershore Dr - W of Sitka
520	27.955750	-82.402080	Palm River Tributary	III (F)	Utica Creek at US 41, S of Acline Street
523	28.165500	-82.265233	Hillsborough River Tributary	III (F)	New River at Morris Bridge Road E of Cross Creek Blvd (N)
528	28.052717	-82.249017	Hillsborough River Tributary	III (F)	Campbell Branch at McIntosh Rd. N of Campbell Branch Rd.
529	28.036883	-82.259450	Lake Thonotosassa Tributary	III (F)	Pemberton Creek at Pemberton Creek Dr. in Pemberton Creek Estates off Muck Pond Rd.
533	28.025017	-82.186033	Lake Thonotosassa Tributary	III (F)	Spartsman Branch Beauchamp Rd E of n Forbes Rd
534	27.986940	-82.259000	Lake Thonotosassa Tributary	III (F)	Baker Creek at HWY 574 W of Valrico Rd.& McIntosh
536	28.135083	-82.116867	Hillsborough River Tributary	III (F)	Itchepackesassa Creek in Cone Ranch
541	27.946810	-82.072130	Alafia River Tributary	III (F)	Howell Creek at Nesmith Rd.
542	27.938610	-82.119680	Alafia River Tributary	III (F)	Mustang Ranch Creek behind "Mustang Ranch" NE corner of SR 60 & SR 39
543	27.937820	-82.156520	Alafia River Tributary	III (F)	Little Alafia N of SR 60 W of Cable Rd & E of Wallace Rd
544	28.128620	-82.081130	Hillsborough River Tributary	III (F)	Polk Creek at Mr. Tew's Ranch
545	27.763350	-82.145580	Alafia River Tributary	III (F)	Hurrah Creek at HWY 39 N of Balm -Picnic Rd./Thatcher Rd./ 672
546	27.816160	-82.145890	Alafia River Tributary	III (F)	Chito Branch at HWY 39 N of Jameson Rd.
547	27.829270	-82.145790	Alafia River Tributary	III (F)	Moccasin Creek at HWY 39 N of Moccasin Hollow Rd.
548	27.796483	-82.117367	Alafia River	III (F)	S Prong Alafia River at Jameson Rd.
549	27.807883	-82.104250	Alafia River Tributary	III (F)	Halls Branch at Walter Hunter Rd. N of Virgil Hall Rd. & S of Evers Rd.
550	27.820533	-82.104367	Alafia River Tributary	III (F)	Owens Branch at Walter Hunter Rd. N of Evers Rd. & S of Crumley Rd.
551	27.844067	-82.104050	Alafia River Tributary	III (F)	Mizelle Creek at Walter Hunter Rd. S of 640/Edison Rd.
552	27.855583	-82.087833	Alafia River Tributary	III (F)	West Branch at Keysville Rd. N of Lithia Pinecrest
553	27.876417	-82.066633	Alafia River Tributary	III (F)	Sloman Branch at Nichols Rd. E of Pritcher Rd.
554	27.908967	-82.170467	Alafia River Tributary	III (F)	Medard Discharge at Turkey Creek Rd. N of cemetery
555	27.893460	-82.170510	Alafia River Tributary	III (F)	Turkey Creek Rd S of RR tracks
556	27.864467	-82.155467	Alafia River Tributary	III (F)	McDonald Branch at Thompson Rd. E of Brantley 1/2 mile W of CR 39 .5+ miles
557	27.864640	-82.152690	Alafia River Tributary	III (F)	McCollough Branch at Thompson Rd. E of Bryant Rd.
558	27.853183	-82.224233	Alafia River Tributary	III (F)	Little Fishhawk Creek at Fishhawk Blvd Between Lithia Pinecrest and station #155
559	27.896033	-82.296600	Alafia River Tributary	III (F)	Buckhorn Creek at Creekbridge Rd.
560	27.905217	-82.401633	Hillsborough Bay Tributary	III (M)	Port Sutton Ditch at US 41 N of Madison

Station	Latitude	Longitude	Area	Class	Station Description
561	27.931633	-82.399217	McKay Bay Tributary	III (F)	51st S N of 20th Avenue
564	27.674690	-82.120780	Little Manatee River Tributary	III (F)	Aldermans Creek at Taylor Gill Rd. S of SR 674
565	27.692220	-82.191100	Little Manatee River Tributary	III (F)	Prairie Branch Creek at Grange Hall Loop - E (N-S)
566	27.690067	-82.198200	Little Manatee River Tributary	III (F)	Grange Hall Loop (E-W)
567	27.705000	-82.229683	Little Manatee River Tributary	III (F)	Pierce Branch at SR 674
568	27.705083	-82.256400	Little Manatee River Tributary	III (F)	Carlton Branch at SR 674
569	27.649500	-82.294317	Little Manatee River Tributary	III (F)	South Fork Little Manatee River at CR 579
570	27.671133	-82.344683	Little Manatee River Tributary	III (F)	Dug Creek at Saffold Rd E of US 301
571	27.773067	-82.335033	Hillsborough Bay Tributary	III (F)	Little Bullfrog Creek at US 301 S of Big Bend Rd.
572	27.803983	-82.334367	Hillsborough Bay Tributary	III (F)	US 301 N of Cowley Rd.
573	27.822950	-82.253550	Alafia River Tributary	III (F)	Bell Creek at Rhodine Rd.
574	27.853633	-82.274033	Alafia River Tributary	III (F)	Bell Creek at Boyette Rd. W of Bell Shoals
575	27.832033	-82.281733	Alafia River Tributary	III (F)	Pelleham Branch at Donneymoor Dr.
576	27.857567	-82.318867	Alafia River Tributary	III (F)	Rice Creek at Balm Riverview Dr.
577	27.897117	-82.350433	Hillsborough Bay Tributary	III (F)	Progress Blvd. just W of I-75
581	27.657567	-82.381950	Little Manatee River Tributary	III (F)	Lightfoot Rd. W of Sundance Trail
582	27.652683	-82.414083	Little Manatee River Tributary	III (F)	Timberlee Rd. S of Surrey Trail
583	27.656033	-82.432283	Little Manatee River Tributary	III (F)	Curiosity Creek at Lightfoot Rd. E of I-75
584	27.660950	-82.501533	Cockroach Bay Tributary	III (F)	Cockroach Creek at US 41
585	27.675050	-82.446683	Little Manatee River Tributary	III (F)	Wildcat Creek S at Stephens Rd.
586	27.693033	-82.459717	Little Manatee River Tributary	III (M)	Heritage Park Creek at Heritage Park off US 41 S of the LMR
588	27.738783	-82.426350	Middle Tampa Bay Tributary	III (M)	Wolf Branch at US 41 N of NW 19th Ave
589	27.748983	-82.412900	Middle Tampa Bay Tributary	III (M)	US 41 N of 12th St. NE
590	27.760567	-82.399167	Middle Tampa Bay Tributary	III (M)	Miller Mac Rd Ditch at US 41 N of Di Mere Packing
592	27.774900	-82.388100	Middle Tampa Bay Tributary	III (M)	Newman Branch at US 41 N of Elsberry Rd.
594	27.819233	-82.382517	Hillsborough Bay Tributary	III (M)	Kitchen Creek at US 41
595	27.826100	-82.381683	Hillsborough Bay Tributary	III (M)	Dug Creek at US 41
596	27.877350	-82.390383	Hillsborough Bay Tributary	III (M)	Archie Creek at Old Bayshore Blvd./CR 41A
597	27.885133	-82.391683	Hillsborough Bay Tributary	III (M)	N Archie Creek at Old Bayshore Blvd./CR 41A
598	27.890067	-82.397183	Hillsborough Bay Tributary	III (M)	Creek Canal at Old Bayshore Blvd./CR 41A
600	27.677850	-82.259950	Little Manatee River Tributary	III (F)	Carlton Branch at ULMR County Preserve
601	27.677883	-82.278483	Little Manatee River Tributary	III (F)	Gully Branch at ULMR County Preserve
602	27.671950	-82.293433	Little Manatee River Tributary	III (F)	Branch at ULMR County Preserve
603	27.666900	-82.299000	Little Manatee River Tributary	III (F)	S Branch at ULMR County Preserve
605	28.078200	-82.121900	Hillsborough River Tributary	III (F)	East canal at Knights-Griffin Rd

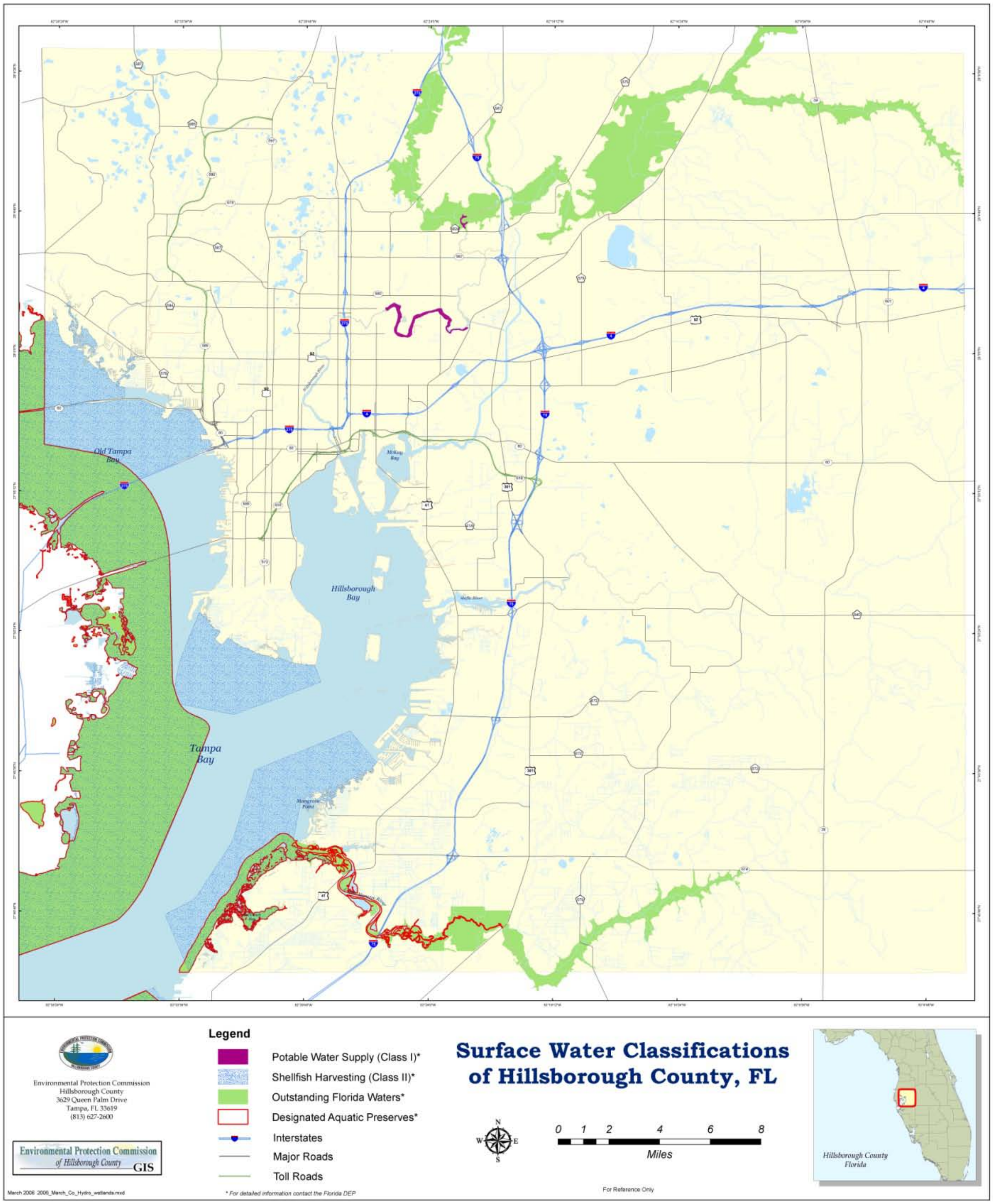
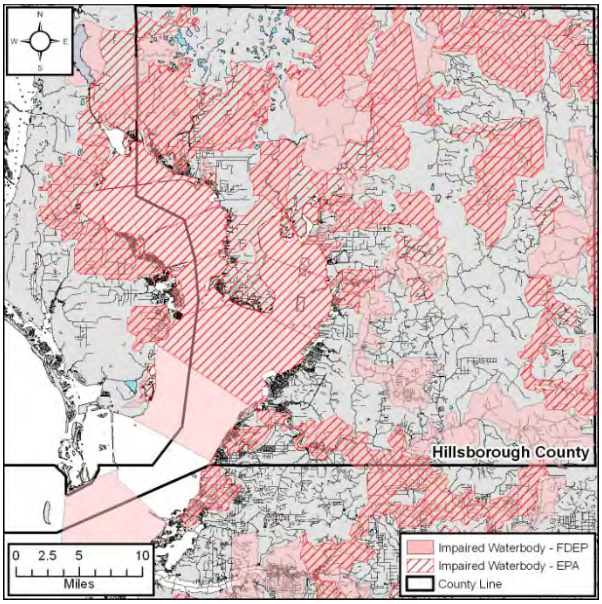


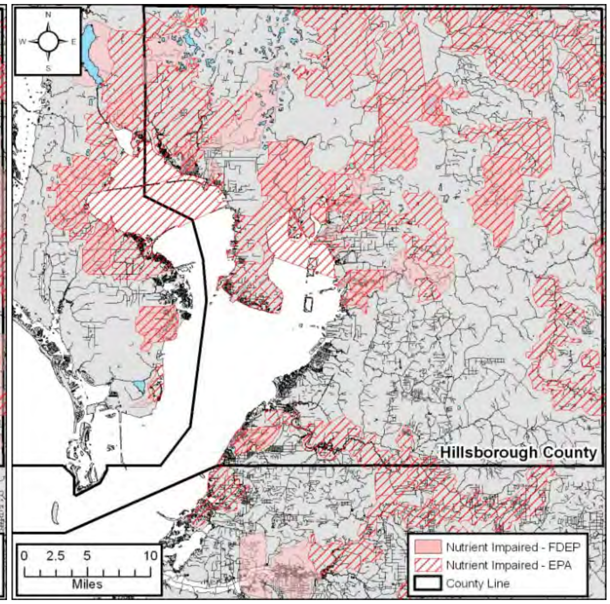
Figure 3. Surface water classifications for Tampa Bay and Hillsborough County waters.

Impaired Waters and Total Maximum Daily Loads

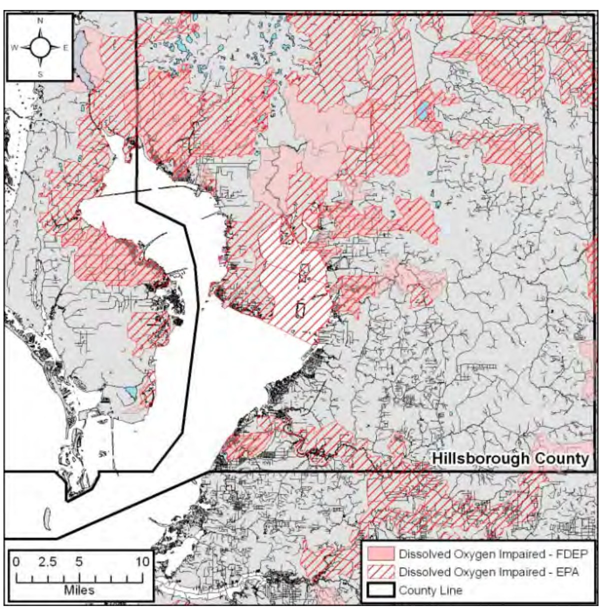
Under section 303(d) of the federal Clean Water Act (CWA), the state of Florida is required to develop a list of all waterbodies which do not meet set water quality standards for given parameters. This is referred to as the Impaired Waters List and the criteria for identifying impaired waters are outlined in Chapter 62-303 of the F.A.C. Water bodies and their surrounding drainage basins are identified by a numbering system referred to as the Water Body Identification (WBID). In order to mediate impaired waters, the state is required to calculate the Total Maximum Daily Load (TMDL) for the water quality parameter which is causing the impairment. The TMDL is defined as the amount of a pollutant a water body can assimilate and still maintain water quality standards (F.S. 403.067). The TMDLs which have been established so far for Tampa Bay, the Alafia River and Hillsborough River Basins are found in 62-304 of the F.A.C. Once the TMDLs are established for an impaired waterbody, a Basin Management Action Plan (BMAP) is developed to address the impairment and work towards improving the water quality within the affected water body. Tables 4 and 5 list the waterbodies within Hillsborough County which are currently listed as impaired waters and the parameters for which they are impaired. Figure 4A shows the location of impaired waters and their surrounding watersheds within the Tampa Bay watershed and Hillsborough County. Water quality parameters which are most commonly responsible for impairments include nutrients which is manifested as high Chlorophyll a (Chl. a) levels or measured as the Trophic State Index for lakes (Figure 4B), dissolved oxygen (Figure 4C), fecal coliform bacteria, high bacteria levels in shellfish or along public beaches (Figure 4D), and heavy metals such as lead (Pb) and mercury (Hg). The specific water quality criteria for these individual parameters will be addressed in subsequent chapters. As of October 2009, a BMAP addressing the fecal coliform impairments for the Hillsborough River and its tributaries has been adopted and nutrient TMDLs for Tampa Bay tributaries are currently under development.



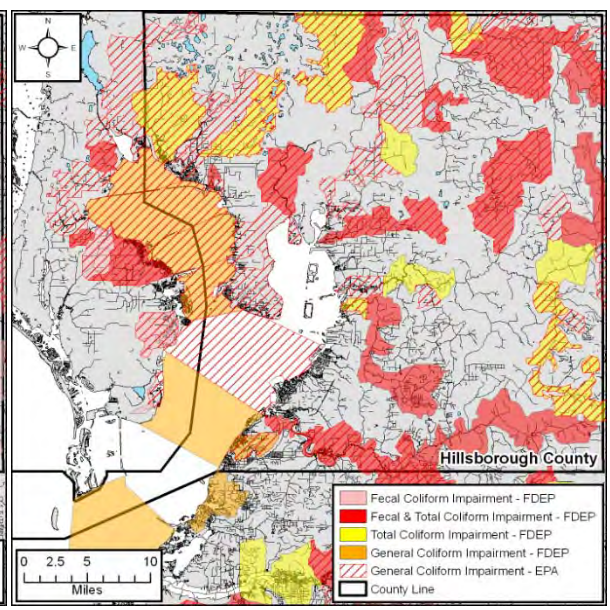
A). All impaired waters



B). Nutrients/Chlorophyll a



C). Dissolved Oxygen



D). Fecal and Total Coliform Bacteria

Figure 4. Impaired waters within Tampa Bay and Hillsborough County: A. All impaired waterbodies; B. Nutrient (chlorophyll a) impairments; C. Dissolved oxygen impairments; D. Fecal/coliform bacteria impairments.

Table 4 Hillsborough County Impaired Waters: Tampa Bay and Coastal Tributaries.

Drainage	WBID	Waterbody	Class	Impairments
Hillsborough Bay	1558D	Hillsborough Bay (Lower)	III (M)	Nutrients (Chl a)
Hillsborough Bay	1558E	Hillsborough Bay (Upper)	III (M)	DO
Hillsborough Bay	1558EB	Davis Island Beach	III (M)	Bacteria (beach advisory)
Hillsborough Bay Tributary	1576	Mango Drain	III (F)	DO
Hillsborough Bay Tributary	1579	Bellows Lake Outlet	III (F)	DO; Fecal Coliform; Nutrients (Chl a)
Hillsborough Bay Tributary	1579A	Bellows Lake	III (F)	Nutrients (TSI)
Hillsborough Bay Tributary	1605	Delaney Creek (FW)	III (F)	DO; Fecal Coliform; Nutrients (Chl a); Pb
Hillsborough Bay Tributary	1605D	Delaney Creek (Tidal)	III (M)	DO; Fecal Coliform; Nutrients (Chl a); Pb
Hillsborough Bay Tributary	1666	Bullfrog Creek (FW)	III (F)	Fecal Coliform
Hillsborough Bay Tributary	1666A	Bullfrog Creek (Tidal)	III (M)	DO; Fecal Coliform; Nutrients (Chl a)
Hillsborough Bay Tributary	1688	Little Bullfrog Creek	III (F)	DO; Fecal Coliform
Hillsborough Bay Tributary	1536A	Palm River (FW)	III (F)	DO; Nutrients (Chl a)
Hillsborough Bay Tributary	1536C	Tampa Bypass Canal	III (F)	DO; Nutrients (Chl a)
Hillsborough Bay Tributary	1536E	Palm River (Est)	III (M)	DO; Nutrients (Chl a)
Hillsborough Bay Tributary	1536F	Six Mile Creek	III (F)	DO; Nutrients (Chl a)
Hillsborough Bay Tributary	1584A	Ybor City Drain	III (M)	DO; Fecal Coliform
Hillsborough Bay Tributary	1584B	McKay Bay	III (M)	DO; Nutrients (Chl a)
Hillsborough Bay Tributary	1584C	East Bay	III (M)	DO
Lower Tampa Bay	1558A	Tampa Bay (Lower)	II	Bacteria (in shellfish)
Lower/Middle Tampa Bay	1558BZ	Tampa Bay Lower North	II	Bacteria (in shellfish)
Middle Tampa Bay	1558B	Tampa Bay (Middle)	II	Bacteria (in shellfish)
Middle Tampa Bay	1558C	Tampa Bay (Upper)	II	Fecal Coliform
Middle Tampa Bay	1558CC	Bahia Beach	III (M)	Bacteria (beach advisory)
Middle Tampa Bay Tributary	1693	Big Bend Bayou	III (M)	DO
Middle Tampa Bay Tributary	1778	Cockroach Bay	III (M)	DO; Nutrients (Chl a); Bacteria (in shellfish)
Old Tampa Bay	1558F	Old Tampa Bay (Lower)	II	Fecal Coliform; Bacteria (in shellfish)

Drainage	WBID	Waterbody	Class	Impairments
Old Tampa Bay	1558FB	Picnic Island South	III (M)	Bacteria (beach advisory)
Old Tampa Bay	1558G	Old Tampa Bay (Gandy to Howard Frankland)	II	Bacteria (in shellfish)
Old Tampa Bay	1558H	Old Tampa Bay (Howard Frankland to Courtney Campbell)	II	Fecal Coliform; Bacteria (in shellfish)
Old Tampa Bay	1558HB	Ben T. Davis Beach (North)	III (M)	Bacteria (beach advisory)
Old Tampa Bay	1558HC	Ben T. Davis Beach (South)	III (M)	Bacteria (beach advisory)
Old Tampa Bay	1558HE	Cypress Point Park (South)	III (M)	Bacteria (beach advisory)
Old Tampa Bay	1558I	Old Tampa Bay north of Courtney Campbell)	II	Bacteria (in shellfish)
Old Tampa Bay Tributary	1474	Brooker Creek*	III (F)	Fecal Coliform
Old Tampa Bay Tributary	1498	Brushy Creek	III (F)	DO; Fecal Coliform
Old Tampa Bay Tributary	1507	Rocky Creek	III (F)	DO; Fecal Coliform; Nutrients (Chl a)
Old Tampa Bay Tributary	1507A	Channel A	III (M)	DO; Nutrients (Chl a)
Old Tampa Bay Tributary	1563	Lower Rocky Creek	II	DO; Fecal Coliform; Nutrients (Chl a)
Old Tampa Bay Tributary	1513	Double Branch Creek	III (M)	DO; Fecal Coliform
Old Tampa Bay Tributary	1516	Sweetwater Creek	III (F)	DO; Fecal Coliform; Nutrients (Chl a)
Old Tampa Bay Tributary	1570	Sweetwater Creek	III (F)	Fecal Coliform
Old Tampa Bay Tributary	1570A	Sweetwater Creek (Tidal)	III (M)	DO; Fecal Coliform; Nutrients (Chl a)
Old Tampa Bay Tributary	1530	Moccasin Creek (Tidal)*	III (M)	DO; Fecal Coliform
Old Tampa Bay Tributary	1463M	Little Lake Wilson	III (F)	Fecal Coliform; Nutrients (TSI)
Old Tampa Bay Tributary	1473W	Lake Juanita	III (F)	Nutrients (TSI)
Old Tampa Bay Tributary	1473X	Mound Lake	III (F)	Nutrients (TSI)
Old Tampa Bay Tributary	1473Y	Calm Lake	III (F)	Nutrients (TSI)
Old Tampa Bay Tributary	1474V	Crescent Lake	III (F)	Nutrients (TSI)
Old Tampa Bay Tributary	1474W	Lake Dead Lady	III (F)	Nutrients (TSI)
Old Tampa Bay Tributary	1493E	Buck Lake	III (F)	Nutrients (TSI)
Old Tampa Bay Tributary	1496A	Sunset Lake	III (F)	Nutrients (TSI)

* Water body falls within Hillsborough and Pinellas Counties.

Table 5 Hillsborough County Impaired Waters: Alafia, Hillsborough and Little Manatee River basins.

Drainage	WBID	Waterbody	Class	Impairments
Alafia River	1583	Poley Creek*	III (F)	Fecal Coliform
Alafia River	1592C	Mustang Ranch Creek	III (F)	DO; Fecal Coliform; Nutrients (Chl a)
Alafia River	1610	Mined Area*	III (F)	Nutrients (Chl a)
Alafia River	1621A	Alafia River (above Hillsborough Bay)	III (F)	Fecal Coliform
Alafia River	1621E	Alafia River (North Prong)*	III (F)	Nutrients (Chl a); Un-ionized Ammonia
Alafia River	1621F	Lithia Springs	III (F)	DO
Alafia River	1621G	Alafia River (above Hillsborough Bay)	III (M)	Hg (fish consumption advisory)
Alafia River	1635	Buckhorn Spring	III (F)	Fecal Coliform
Alafia River	1653	Alafia River (South Prong)	III (F)	DO
Alafia River	1673	Hooker's Prairie	III (F)	DO; Nutrients (Chl a)
Hillsborough River	1402	Cypress Creek	III (F)	DO; Fecal Coliform; Nutrients (Chl a)
Hillsborough River	1440E	Cypress Creek North**	III (F)	DO; Nutrients (Chl a)
Hillsborough River	1442	New River**	III (F)	DO; Nutrients (Chl a)
Hillsborough River	1443A	Hillsborough River**	III (F)	Nutrients (Chl a)
Hillsborough River	1443B	Hillsborough River	I	DO
Hillsborough River	1443E	Hillsborough River Reservoir	I	Nutrients (TSI)
Hillsborough River	1451G	King Lake	III (F)	Nutrients (TSI)
Hillsborough River	1451W	Saxon Lake**	III (F)	Nutrients (TSI)
Hillsborough River	1455	Trout Creek	III (F)	DO; Nutrients (Chl a)
Hillsborough River	1462A	Crystal Springs**	III (F)	DO
Hillsborough River	1469	Big Ditch	III (F)	DO; Nutrients (Chl a)
Hillsborough River	1483	Channelized Stream*	III (F)	DO; Nutrients (Chl a)
Hillsborough River	1489	Two Hole Branch*	III (F)	Nutrients (Chl a)
Hillsborough River	1495A	Itchepackasassa Creek*	III (F)	Fecal Coliform
Hillsborough River	1495B	Itchepackasassa Creek*	III (F)	DO; Nutrients (Chl a)
Hillsborough River	1518	East Canal	III (F)	DO; Nutrients (Chl a)

Drainage	WBID	Waterbody	Class	Impairments
Hillsborough River	1522A	Flint Creek	III (F)	DO
Hillsborough River	1522B	Lake Thonotosassa	III (F)	DO; Nutrients (TSI)
Hillsborough River	1537	Lake Wire*	III (F)	Nutrients (TSI); Pb
Hillsborough River	1542A	Mill Creek	III (F)	DO; Nutrients (Chl a)
Hillsborough River	1543A	Lake Hunter Outlet*	III (F)	DO
Hillsborough River	1547	Seffner Canal	III (F)	DO
Hillsborough River	1561	Sparkman Branch	III (F)	Nutrients (Chl a)
Little Manatee River	1742A	Little Manatee River (East of I-75)	III (F)	Hg (fish consumption advisory)
Little Manatee River	1742B	Little Manatee River (North Fork)	III (F)	Hg (fish consumption advisory)
Little Manatee River	1742C	Little Manatee River (Tidal)	III (M)	DO; Nutrients (Chl a); Hg (fish consumption advisory)
Little Manatee River	1760	Mill Bayou	III (M)	Nutrients (Chl a)
Little Manatee River	1768	Alderman Creek	III (F)	Nutrients (Chl a)
Little Manatee River	1779	Hayes Bayou	III (M)	Nutrients (Chl a); Hg (fish consumption advisory)
Little Manatee River	1784	Bolster Bayou	III (M)	Hg (fish consumption advisory)
Little Manatee River	1790	Little Manatee River (South Fork)***	III (F)	Hg (fish consumption advisory)
Little Manatee River	1792	Unnamed Drainage Ditch***	III (F)	DO; Fecal Coliform; Nutrients (Chl a)
Little Manatee River	1800	Long Branch***	III (F)	Fecal Coliform

Drainage basins encompass Hillsborough and adjacent counties: * Polk County; ** Pasco County; ***Manatee County

Freshwater Inflows, Water Resources and Minimum Flows and Levels

Population growth and the resulting increase in demand for drinking water has led to greater demands on ground and surface water resources in Hillsborough County. Over pumping of groundwater at area well fields has resulted in drops in lake levels, the drying up of wetlands, salt water intrusion into the Floridian aquifer, land subsidence and the formation of sinkholes. Increasing reliance on surface water withdrawals as a potable water sources has led to concerns about the effects of reduced freshwater inflows on the ecology of the downstream estuary. To address this, the Southwest Florida Water Management District has been directed to establish minimum flows and levels (MFLs) for various waterbodies within the Tampa Bay drainage basin (Chapter 40D-8 F.A.C .). The minimum flow is defined as " the flow for a surface watercourse at which further withdrawals would be significantly harmful to the water resources or ecology of the area and which may provide for the protection of non-consumptive uses (e.g., recreational, aesthetic, and navigation) (Chapter 40D-8.021(8) F.A.C.). Within Hillsborough County, minimum flows have been established or proposed for several rivers and springs including the lower and upper portions of the Hillsborough River, Sulfur Springs, Tampa By-Pass Canal, and the freshwater and estuarine portions of the Alafia River. Data provided to SWFWMD by the EPCHC monitoring program was instrumental in developing these MFLs.

Additionally, minimum water levels have been established for wetlands and most larger lakes within Hillsborough County and the SWFWMD has set a Saltwater Intrusion Minimal Aquifer Level (SWIMAL) for the Floridian Aquifer north of State Road 60 in Hillsborough County in response to well field pumping (Chapter 40D-8 F.A.C .).

Chapter 2

PHYSICAL PARAMETERS

Introduction

Physical parameters such as depth, temperature, salinity, pH and dissolved oxygen are important in regulating chemical and biological processes in the water column. These parameters are measured in the field using a Hydrolab® Quanta® multiparameter sonde. This instrument contains an array of probes which can be lowered through the water column and take measurements at various depths. For the purposes of the EPCHC monitoring program, measurements are taken at the surface, middle and bottom depths at each station. The Hydrolab® Quanta® has an electronic surface display unit as well as an internal memory for electronically storing the measurements. Data are recorded both electronically and on field sheets as a backup record. Electronically stored data is directly exported to a computer database upon returning from the field.

Depth

Tampa Bay is naturally a shallow system with an average depth of around 4 meters (approx. 12 feet). Dredged areas for shipping channels and port facilities however may exceed 12 meters (approx. 40 feet) in depth. In general, the bay is shallower in the northern segments of Old Tampa Bay and Hillsborough Bay (with the exception of the Port of Tampa and the shipping channels) and deeper towards Lower Tampa Bay and the Gulf of Mexico. Depth plays an important role in conjunction with other physical variables, such as water clarity, in determining light penetration which further affects the distribution of seagrasses. For example, seagrass distribution in Tampa Bay is typically confined to shallower areas (< 2 meters) due to limited light available for photosynthesis (Photosynthetically Active Radiation or PAR) below this depth. Light is attenuated with depth due to interactions between light particles (photons) and water molecules, with shorter wavelengths of the light spectrum (i.e. red and yellow light) being filtered out at shallower depths while longer wavelengths (blue and violet light) penetrating to deeper depths. Suspended matter (turbidity) in the water column further limits light penetration through adsorption and scattering of photons. Depth can also influence dissolved oxygen levels. Artificially created deep basins in Tampa Bay are often characterized by low dissolved oxygen (hypoxia) due to poor water circulation. Another factor directly related to depth is pressure, which can influence geochemical processes. Due to the density and weight of the overlying water column, pressure increases with depth with an increase of 1 atmosphere of pressure for every 10 meters of depth – so for example, bottom pressure at our deepest station of 15 meters would be 2.5 times greater than at the surface.

The depth at the EPCHC water monitoring stations in Tampa Bay ranged from 0.4 meters (1.3 feet) to 15.2 meters (49.8 feet) with a median depth of 3.8 meters (12.5 feet). Station depths were variable over time due to the tidal stage at the time of sampling. The shallowest sites were in Hillsborough Bay (station 44) and Old Tampa Bay (stations 62 and 64). The deepest sampling station (station 16) was located in Middle Tampa Bay near the shipping channel. The monthly tributary stations were shallower relative to the bay stations with a median depth of 1.2 meters (3.9 feet). Depths ranged from 0 to 11.4 meters (37.4 feet), with the deepest station located near the mouth of the Alafia River in the ship turning basin by the Mosaic fertilizer plant (station 1301).

Temperature

Temperature is also an important factor influencing the physical and chemical properties of water, the solubility of solids and gases, and regulating metabolism in plants and animals. The water temperature is closely tied to the air temperature and fluctuates seasonally. The discharge of thermal effluent (cooling water) from power plants also can cause localized high water temperatures. Water density is inversely related to temperature, with warmer waters being less dense and rising to the surface, while bottom water temperatures tend to be colder (Figure 5, Table 6). This in turn influences the circulation patterns of the water column. The boundary between the warmer and cooler water masses is referred to as the thermocline. Large temperature differences between surface and bottom waters can result in stratification of the water column restricting the mixing of surface and bottom waters below the thermocline. This can ultimately lead to low dissolved oxygen at depth causing die-offs of fish and invertebrate communities. The solubility of solids and gases are also influenced by water temperatures. Solids are more soluble with increasing water temperatures while conversely, gases are less soluble. Higher water temperatures thus result in reduced levels of dissolved oxygen which can result in hypoxic or anoxic conditions during the summer months. This has commonly resulted in summer time fish kills. Extended periods of cold water temperatures during the winter months can also be detrimental to fish and large mammals such as manatees.

During 2001-2010, air temperatures at the time of sampling ranged from 4.5°C to 35.5°C (40.1 to 95.9°F) with coldest temperatures occurring in January and warmest in June and July (Table 6). Surface water temperatures at the EPCHC water monitoring stations ranged from 8.5°C to 35.2°C (47.3 – 95.4°F) with a median of 24.9°C (76.8°F). Mid-depth and bottom water temperatures were slightly colder with bottom temperatures being around 0.2°C (0.36°F) colder than surface temperatures on average. The coldest water temperatures for all strata were recorded in January 2010 during a prolonged cold weather front. During this time the Tampa Bay area experienced 10 days where night time air temperatures dropped below freezing. This weather extreme resulted in large fish kills in Tampa Bay and throughout Florida as well as a large number of manatee and sea turtle deaths. The highest recorded surface temperature was recorded in July 2002 at Station 9 in Middle Tampa Bay near Apollo Beach. This station typically had high surface temperatures due to the direct influence of the thermal discharge from Tampa Electric's Big Bend power plant. Water temperatures followed a similar pattern from year to year, with lowest temperatures in January and highest temperatures typically occurring in August and were similar among bay segments (Figure 6).

Annual average surface temperatures at the EPCHC monitoring sites going back to 1975 show a general increasing trend over time. However, there is wide variability among years and several extremely cold years during the late 1970s – early 1980s (Figure 7). The lowest water temperature was 6°C (42.8°F) in January 1977 at Station 95 in Lower Tampa Bay, and low water temperatures were recorded throughout Tampa Bay during January – February 1977. This was one of the coldest winters on record for the Tampa Bay area and is remembered as the year it snowed in Tampa (January 19, 1977; Kameel Stanley "Half-incher of '77 snarled bay area" St. Petersburg Times January 19, 2009 http://www.tampabay.com/news/weather/article968623.ece ; accessed 21 April 2011). The highest recorded water temperature was 35.3 °C (95.5°F) at Station 8 in Hillsborough Bay (mouth of the Alafia River) in September 1997. Surface temperatures exceeding 35°C were also recorded in August 2009 at Station 52 in Hillsborough Bay and in July 2002 at Station 9 in Middle Tampa Bay near Apollo Beach.

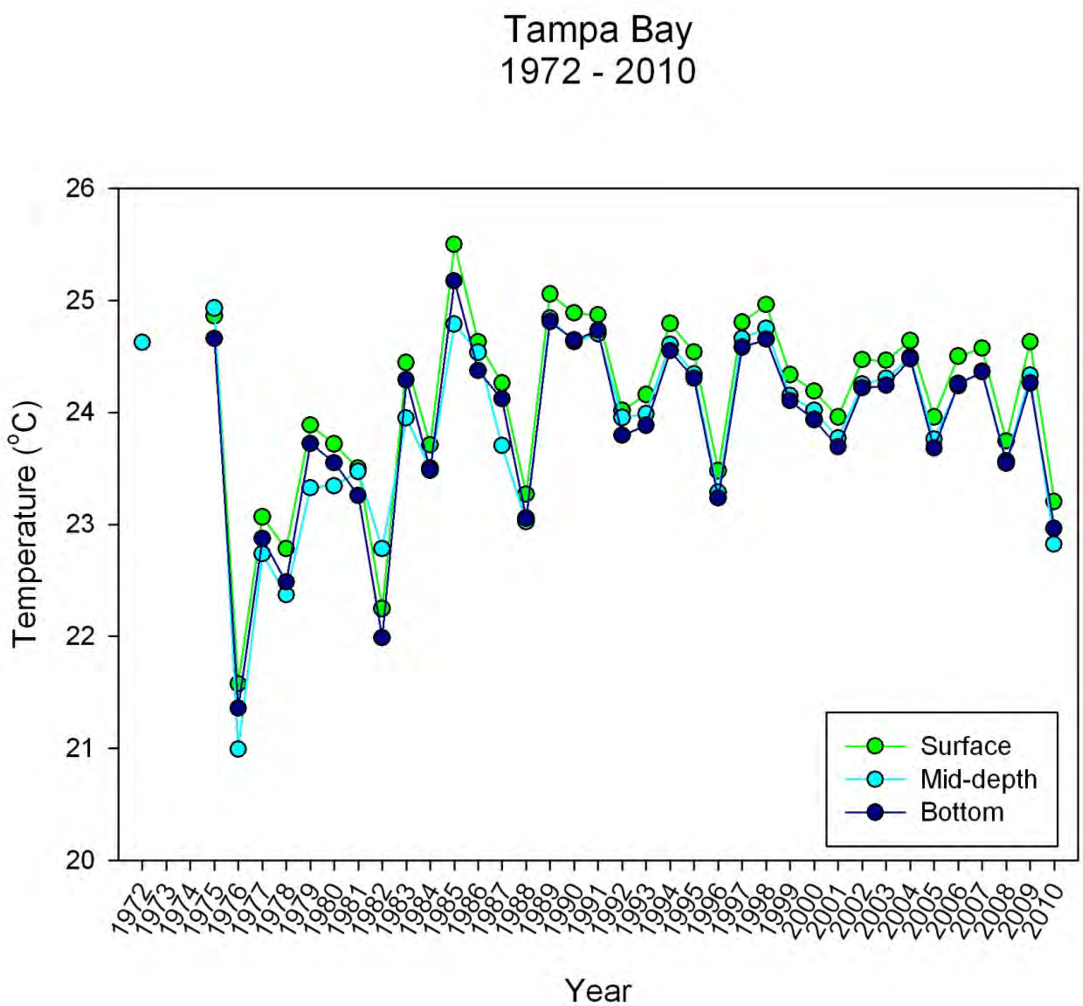


Figure 5. Annual average water temperature by depth stratum.

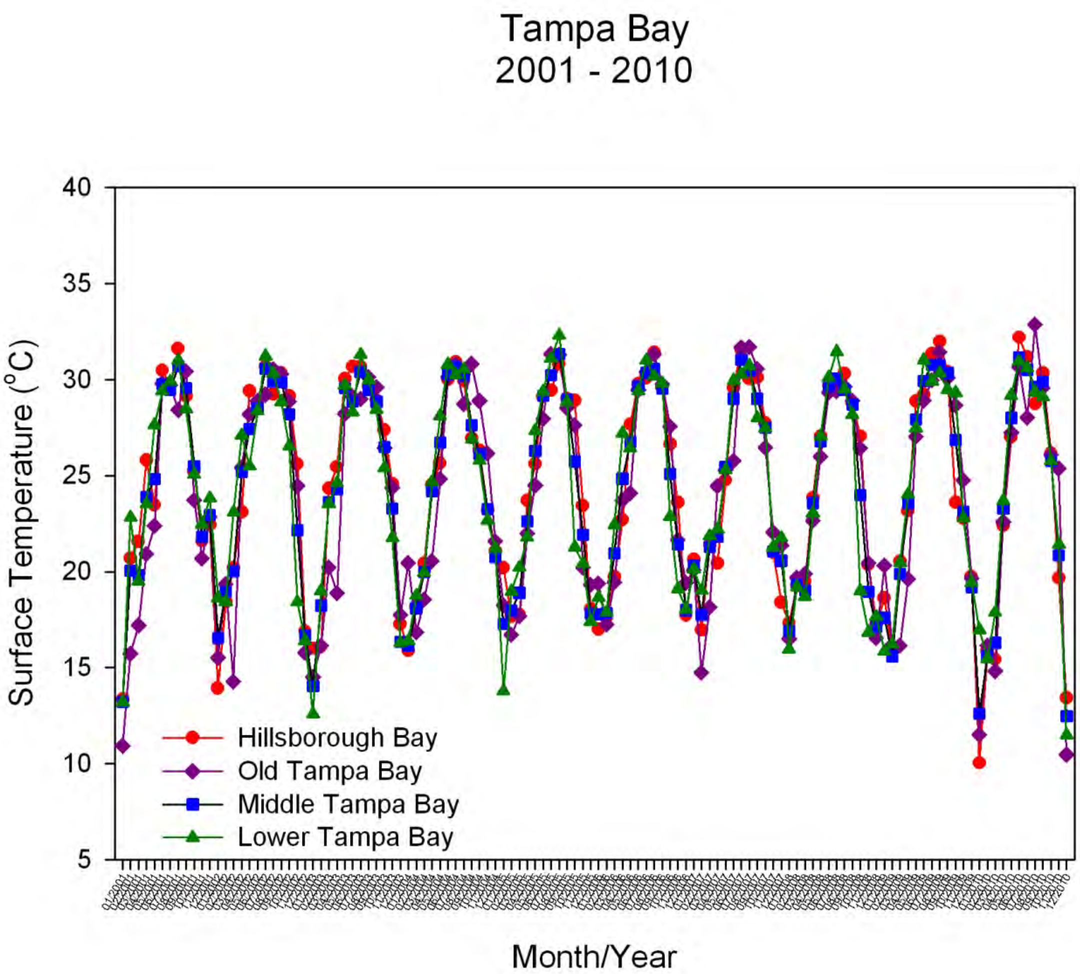


Figure 6. Monthly average surface water temperatures January 2001 – December 2010

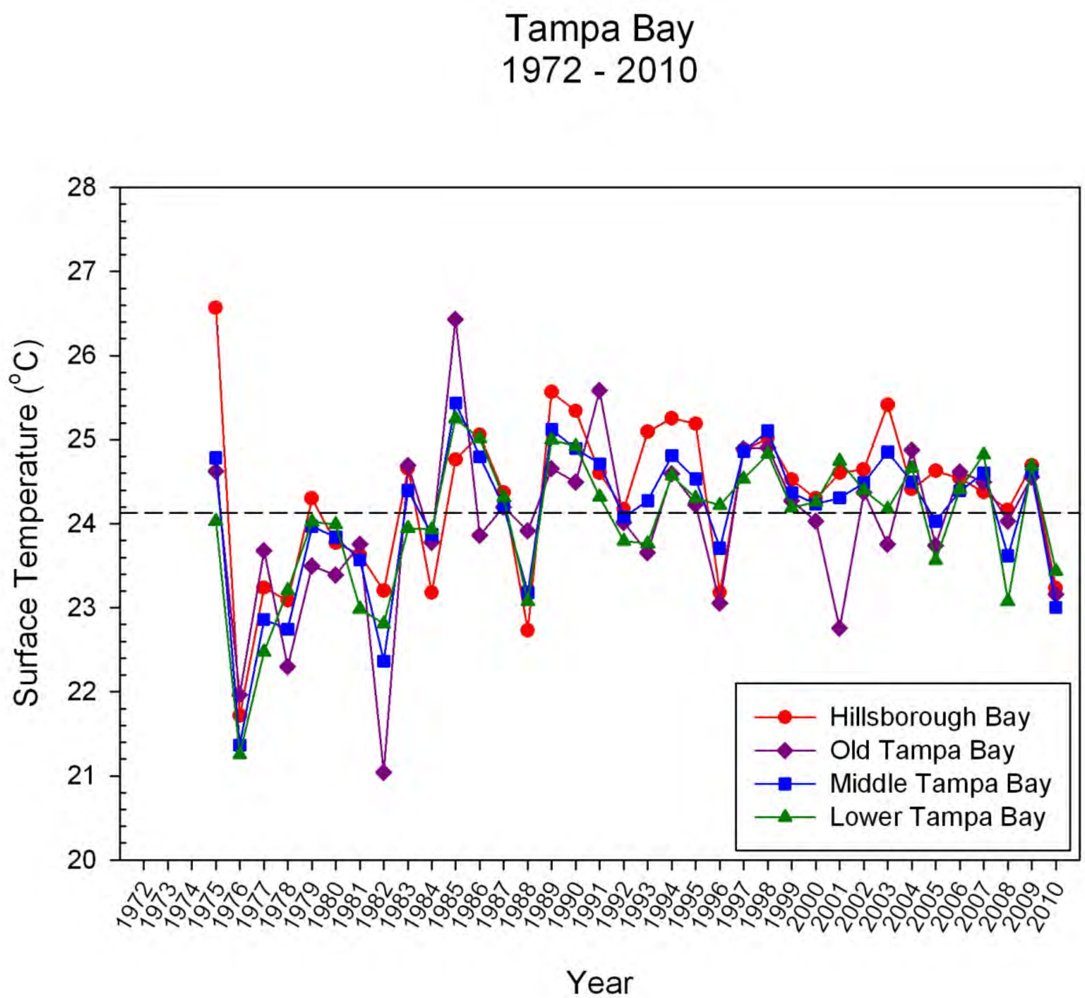


Figure 7. Tampa Bay annual average surface water temperature 1972 – 2010. Dashed line = overall bay-wide average.

Table 6. Tampa Bay 1972 - 2010 annual median, minimum and maximum physical parameter values.

Year	Depth (meters)		Air Temp (°C)		Surface Temp (°C)		Middle Temp (°C)		Bottom Temp (°C)		Surface DO (mg/L)		Middle DO (mg/L)		Bottom DO (mg/L)		Surface pH		Middle pH		Bottom pH		Surface Salinity (psu)		Middle Salinity (psu)		Bottom Salinity (psu)	
1972	4.0		26.0		.		26.0		.		.		7.1		.		.		8.1		.		.		26.9		.	
	0.6	17.7	9.0	34.4	.	.	13.0	33.0	.	.	.	.	1.1	13.8	.	.	.	.	6.5	8.6	.	.	.	.	17.9	39.9	.	.
1973	.		.		.		.		.		.		.		.		.		.		.		.		.		.	
	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1974	4.0		25.0		.		.		.		.		7.4		.		.		8.1		.		.		23.9		.	
	0.6	14.3	5.0	33.0	.	.	.	.	.	.	.	.	0.8	11.4	.	.	.	.	7.1	8.7	.	.	.	.	4.4	35.2	.	.
1975	4.0		28.0		26.0		26.0		26.0		7.2		6.8		6.5		8.3		8.3		8.3		.		25.5		.	
	0.6	11.0	8.0	35.0	12.0	32.0	12.0	32.0	12.0	31.0	3.7	16.5	0.3	14.8	0.0	14.5	6.3	9.3	4.4	9.3	5.9	9.2	.	.	6.8	34.9	.	.
1976	3.7		24.0		23.0		23.0		23.0		7.7		7.5		6.9		8.4		8.3		8.3		25.5		24.8		25.5	
	0.3	12.2	9.0	36.0	10.0	29.5	10.0	29.5	10.0	29.0	3.8	18.0	2.0	15.0	0.5	11.0	7.1	9.9	7.0	9.9	7.3	9.7	5.7	39.4	5.9	37.2	11.9	37.2
1977	3.4		25.0		25.0		25.0		25.0		7.4		7.0		6.7		8.3		8.4		8.3		30.5		29.8		31.2	
	0.3	15.2	9.0	39.0	6.0	32.0	6.0	32.0	6.0	31.5	4.6	17.6	0.6	15.8	0.3	13.0	6.9	9.2	5.8	9.2	6.9	9.3	13.9	38.7	17.2	38.7	14.5	39.5
1978	3.7		27.0		23.5		23.0		23.0		7.5		7.2		6.8		8.5		8.5		8.4		25.5		25.3		26.2	
	0.3	15.2	5.0	38.0	11.0	34.0	11.0	34.0	11.0	31.5	3.1	18.8	0.1	13.2	0.1	11.0	6.6	9.3	6.6	9.3	6.3	9.8	15.8	36.4	11.4	36.4	16.5	37.2
1979	3.7		27.0		25.5		25.0		25.5		7.5		7.2		6.7		8.6		8.5		8.6		25.5		25.5		26.2	
	0.3	13.4	7.0	35.0	10.5	32.0	9.5	31.5	11.0	30.5	1.7	15.2	0.9	14.8	0.1	12.4	7.1	9.0	5.3	9.0	7.5	9.0	0.4	38.0	3.9	38.0	13.3	38.0
1980	3.7		26.0		24.0		23.5		24.0		7.2		6.9		6.6		8.4		8.4		8.4		26.3		25.5		26.3	
	0.3	12.2	9.0	34.0	12.5	33.0	12.0	31.5	12.5	31.0	3.7	18.9	1.8	13.6	0.3	13.0	6.0	9.7	6.0	9.9	6.1	9.6	13.2	40.3	13.2	40.3	15.2	40.3
1981	4.0		27.0		24.5		24.5		24.0		7.6		7.2		6.9		8.4		8.4		8.4		28.4		27.9		29.1	
	0.6	12.2	4.0	35.0	9.3	32.5	8.5	32.5	9.0	31.5	4.2	18.2	0.1	17.8	0.1	18.0	5.5	9.6	5.4	9.2	5.5	9.2	11.9	40.3	13.9	38.7	20.0	38.7
1982	3.7		26.0		22.0		22.5		21.5		8.1		7.6		7.4		8.1		8.4		8.0		27.7		26.3		28.4	
	0.4	13.1	10.0	37.0	12.5	33.5	12.0	31.0	7.1	30.5	2.4	19.0	0.1	18.1	0.1	17.8	7.3	9.5	7.0	9.4	7.4	9.4	14.6	37.2	13.1	37.2	15.2	38.0
1983	3.7		25.0		25.3		24.5		25.3		6.9		6.6		6.0		7.8		7.9		7.8		22.7		22.0		23.4	
	0.6	13.9	8.0	34.0	12.5	32.8	7.8	32.4	12.6	32.4	2.2	12.6	0.2	11.0	0.1	11.0	6.7	9.8	6.2	9.9	3.8	9.8	3.3	36.5	4.7	36.5	8.1	36.5
1984	3.7		25.0		26.0		26.0		25.9		6.8		6.7		6.3		8.0		8.0		8.0		24.9		23.7		25.6	
	0.8	14.3	8.0	33.0	12.7	31.7	10.5	31.7	12.7	31.2	2.8	11.0	1.7	9.6	0.1	10.1	6.7	8.7	6.0	8.7	5.5	8.7	12.4	35.9	13.1	36.4	18.6	36.4
1985	3.7		26.0		27.2		25.8		26.7		6.3		6.2		5.6		8.0		8.0		8.0		29.0		28.3		29.2	
	0.6	11.0	8.0	34.0	13.3	33.4	13.3	32.8	13.4	32.0	3.7	16.5	1.3	10.7	0.1	9.6	7.0	8.8	6.2	8.7	6.1	8.8	9.0	38.2	7.5	39.2	19.7	37.2

Year	Depth (meters)		Air Temp (°C)		Surface Temp (°C)		Middle Temp (°C)		Bottom Temp (°C)		Surface DO (mg/L)		Middle DO (mg/L)		Bottom DO (mg/L)		Surface pH		Middle pH		Bottom pH		Surface Salinity (psu)		Middle Salinity (psu)		Bottom Salinity (psu)	
1986	3.7		26.0		24.8		25.1		24.5		6.6		6.2		5.9		7.9		7.9		7.9		26.6		25.9		26.9	
	0.6	12.2	10.0	36.0	13.5	32.9	14.6	31.8	14.6	31.8	2.3	10.7	0.7	9.3	0.2	8.8	7.4	10.2	7.2	11.0	7.3	10.7	15.8	34.7	10.7	35.1	18.3	35.0
1987	4.0		25.0		24.1		22.5		24.6		6.7		6.5		6.1		8.0		8.0		8.0		25.6		24.4		26.3	
	0.8	12.8	9.0	33.0	13.8	32.9	13.8	32.6	13.8	32.6	3.3	11.2	2.9	11.1	0.2	10.2	7.5	8.4	7.4	9.0	7.1	8.4	4.9	37.0	4.1	37.6	11.8	37.9
1988	3.7		25.0		24.3		23.8		24.0		6.6		6.4		6.1		7.9		8.0		7.9		26.8		26.6		27.5	
	0.6	13.1	9.0	33.0	11.8	31.8	11.7	31.2	11.8	31.0	3.6	13.7	1.5	12.2	0.1	8.7	6.7	8.4	6.9	8.5	6.2	8.3	0.4	41.6	2.5	41.9	9.1	42.0
1989	4.0		26.0		25.6		25.2		25.6		6.3		6.1		5.8		7.7		7.7		7.7		27.8		27.8		28.2	
	0.6	12.2	9.0	32.0	13.8	33.8	13.0	32.8	12.9	32.3	3.4	10.8	0.3	11.4	0.1	9.3	7.2	8.3	7.2	8.5	7.0	8.2	12.3	40.2	18.0	40.2	18.9	40.2
1990	4.0		26.0		27.3		26.5		27.2		6.8		6.7		6.4		7.9		7.9		7.8		28.6		28.6		28.9	
	0.6	11.7	7.0	34.0	14.0	32.7	13.8	32.9	13.8	32.6	3.8	11.4	1.0	10.5	0.1	9.6	7.5	8.2	7.3	8.6	7.5	8.2	13.4	36.2	18.6	36.4	23.6	36.5
1991	3.8		26.0		25.5		25.2		25.4		6.9		6.6		6.4		7.9		7.9		7.9		29.0		29.1		29.4	
	0.9	13.4	9.0	37.0	15.0	32.4	15.0	32.3	14.9	32.0	3.8	16.2	0.5	12.1	0.1	10.4	7.2	8.7	6.6	8.3	7.1	8.2	6.1	36.4	5.3	36.4	14.1	36.4
1992	3.5		26.0		23.8		23.9		23.9		7.0		6.7		6.5		7.8		7.9		7.8		27.6		27.6		27.8	
	0.9	12.2	9.0	34.0	13.6	34.3	13.6	34.1	14.0	32.0	2.2	11.5	0.8	9.9	0.1	8.6	7.5	8.4	7.5	8.4	7.3	8.2	14.3	34.9	15.9	35.0	19.1	34.9
1993	3.7		25.0		24.4		24.2		23.6		7.0		6.7		6.4		7.9		7.9		7.9		26.4		26.6		26.8	
	0.8	12.2	12.0	36.0	13.4	33.2	13.4	32.0	13.4	31.7	3.3	12.2	1.1	9.8	0.1	9.4	7.6	8.3	7.5	8.2	7.3	8.2	16.5	36.3	20.1	36.2	21.2	37.6
1994	3.7		26.5		25.8		25.5		25.6		6.9		6.6		6.3		8.0		8.0		7.9		27.4		27.5		27.7	
	0.8	11.6	8.5	33.5	13.1	32.3	13.1	31.8	13.1	31.2	1.9	11.4	0.9	10.6	0.1	9.3	7.3	8.4	7.3	8.3	7.1	8.3	9.0	34.9	11.7	38.5	13.2	35.0
1995	3.8		26.0		25.3		25.2		25.3		7.0		6.7		6.4		8.0		8.0		7.9		23.6		23.9		24.3	
	0.9	14.0	10.5	35.0	12.2	33.7	14.2	33.9	14.0	35.1	3.7	14.0	0.3	13.4	0.1	12.8	7.0	8.7	7.1	8.6	7.1	8.6	8.3	35.1	11.7	35.2	12.7	39.9
1996	3.8		25.5		24.2		24.1		24.0		6.9		6.7		6.5		8.0		8.0		8.0		24.3		24.6		24.9	
	0.8	11.3	7.5	33.0	11.7	31.5	11.8	31.5	11.6	31.4	2.8	11.5	0.9	11.1	0.1	10.3	7.3	8.4	7.3	8.4	7.3	8.3	4.0	34.9	11.7	35.1	17.5	35.1
1997	3.7		25.0		24.9		24.6		24.4		6.7		6.5		6.3		8.0		8.0		8.0		27.6		27.7		28.0	
	0.8	11.3	12.5	32.0	14.7	35.3	14.7	32.3	14.8	31.5	2.0	13.4	0.4	8.7	0.1	8.8	7.3	8.7	7.4	8.4	7.3	8.2	6.8	35.3	16.0	35.4	17.0	35.5
1998	4.0		26.0		24.5		24.4		24.4		6.8		6.4		6.1		7.9		7.9		7.9		20.0		20.9		21.3	
	0.9	12.5	10.5	34.0	15.0	33.5	14.7	32.4	6.8	32.4	2.7	11.9	0.7	12.1	0.1	10.5	7.1	8.5	7.3	8.5	7.0	8.3	2.9	33.6	5.7	33.7	8.9	34.0
1999	4.0		25.5		25.3		24.9		24.8		6.6		6.5		6.3		8.0		8.0		8.0		26.6		26.8		27.0	
	0.9	11.7	4.5	33.5	11.5	34.8	11.5	32.0	11.5	32.0	2.9	10.8	0.8	9.0	0.4	8.9	7.5	8.6	7.4	8.7	7.3	8.7	16.4	34.7	18.8	34.9	19.8	35.1
2000	4.0		27.0		24.3		24.2		24.1		6.5		6.3		6.2		7.9		7.9		7.9		30.2		30.4		30.4	
	0.9	11.6	10.0	35.0	13.3	33.7	13.3	31.6	13.3	31.2	4.1	9.3	0.5	8.9	0.1	8.9	7.0	8.5	7.5	8.5	7.5	8.4	23.1	36.1	23.2	36.2	23.5	36.2

Year	Depth (meters)		Air Temp (°C)		Surface Temp (°C)		Middle Temp (°C)		Bottom Temp (°C)		Surface DO (mg/L)		Middle DO (mg/L)		Bottom DO (mg/L)		Surface pH		Middle pH		Bottom pH		Surface Salinity (psu)		Middle Salinity (psu)		Bottom Salinity (psu)	
2001	3.9		24.5		23.5		23.5		23.5		6.5		6.2		6.1		8.0		8.0		8.0		31.0		31.1		31.2	
	0.6	11.6	6.5	35.0	9.5	34.4	9.4	33.4	9.2	31.9	3.2	11.4	0.0	10.0	0.0	9.3	7.3	8.7	7.6	8.6	7.4	8.5	2.3	35.7	15.8	35.8	20.8	49.5
2002	4.0		26.0		26.2		26.0		26.1		6.4		6.1		5.9		8.0		8.0		7.9		28.5		28.6		28.8	
	0.6	11.9	4.5	32.5	10.7	35.2	10.7	31.7	10.5	31.3	3.4	15.2	1.6	10.6	0.0	10.5	7.5	8.8	7.5	8.4	6.8	8.4	7.6	36.0	18.0	36.1	20.4	36.1
2003	4.2		26.0		25.5		25.2		25.2		6.7		6.4		6.1		8.2		8.1		8.1		21.5		21.9		22.1	
	1.0	11.6	7.0	32.0	12.3	33.5	12.2	32.7	12.2	32.0	3.4	11.9	0.5	10.4	0.1	9.8	7.7	8.8	7.5	8.7	7.0	8.6	7.8	34.1	9.9	34.2	10.1	34.5
2004	3.9		26.0		25.3		25.3		25.4		6.6		6.3		6.0		8.1		8.1		8.1		24.4		24.6		24.9	
	0.7	11.9	10.0	34.0	14.2	33.8	14.5	32.1	14.6	32.1	3.5	10.9	0.3	9.4	0.1	10.1	6.8	8.9	6.8	8.8	6.7	8.7	0.3	35.8	1.6	35.9	5.9	36.0
2005	3.7		25.0		23.4		23.3		23.1		6.9		6.7		6.4		8.1		8.1		8.1		25.0		25.2		25.5	
	0.6	14.2	9.5	35.5	11.8	33.6	12.3	33.1	12.2	33.0	3.0	11.4	1.5	17.4	0.2	12.2	7.5	8.8	7.6	8.5	7.3	8.4	11.4	34.5	11.4	34.4	15.3	34.6
2006	3.7		26.0		24.1		23.7		23.8		6.4		6.3		6.2		8.1		8.1		8.1		27.6		27.6		28.0	
	0.4	12.3	11.0	35.3	16.3	33.7	16.3	32.2	16.3	31.7	2.2	9.7	0.8	8.8	0.1	8.9	7.8	8.5	7.7	8.5	7.6	8.5	14.5	37.9	13.3	37.9	17.4	37.9
2007	3.7		26.1		24.8		24.5		24.6		6.3		6.2		6.1		8.0		8.0		8.0		29.4		29.4		29.7	
	0.6	12.7	10.5	34.0	11.1	32.9	11.2	32.5	11.1	32.4	3.1	10.9	1.3	10.7	0.2	10.9	5.7	8.7	5.5	8.7	6.1	8.9	15.5	37.0	18.9	37.0	22.4	37.0
2008	3.8		25.8		23.7		23.5		23.6		6.5		6.4		6.3		8.1		8.1		8.1		30.3		30.2		30.5	
	0.4	13.4	9.7	35.5	14.9	32.8	14.6	32.4	13.9	32.2	2.7	10.2	0.1	10.1	0.1	9.1	7.5	8.8	7.3	8.7	7.0	8.8	17.4	36.6	21.2	36.6	22.6	36.5
2009	3.7		27.5		24.9		24.8		24.8		6.4		6.2		6.1		8.1		8.0		8.0		30.2		30.2		30.5	
	0.4	15.2	11.1	35.4	14.7	35.0	14.3	32.4	14.1	31.8	0.9	12.1	0.1	10.7	0.2	10.8	7.2	9.0	7.3	8.9	7.3	8.8	11.2	49.7	12.3	48.1	19.4	48.7
2010	3.7		27.0		25.5		25.3		25.4		6.4		6.4		6.4		8.1		8.1		8.1		25.5		25.7		25.9	
	0.5	12.0	6.1	35.5	8.5	34.0	8.2	33.3	8.4	32.9	2.0	9.4	0.4	9.7	0.2	10.5	7.7	8.9	7.5	8.9	6.9	8.8	11.9	34.7	14.1	34.7	15.4	34.8

Salinity and Conductivity

Salinity and conductivity are related physical parameters that measure the concentration of dissolved ions (salts) in water. These parameters are important in regulating chemical reactions in the water column as well as influencing the physical properties of water such as density. Biologically, the concentration of ions in the surrounding water is important in the transport and regulation of water and nutrients across cell membranes (osmosis) by organisms. Many estuarine species of fish and invertebrates depend on low salinity and freshwater habitats during some stages of their life cycles, so maintaining a salinity gradient from fresh to salt water is important for their survival. Habitats with low salinities ranging from 0.5 to <5 parts per thousand, defined as "oligohaline" are especially important for juvenile fish and restoring these areas has been a high priority for the TBEP's Comprehensive Conservation Management Plan (CCMP).

Conductivity is the measure of how well an electrical current is transmitted (i.e. conducted) through water. This is directly proportional to the concentration of dissolved ions in the water – the higher the concentration the stronger the conductance of the electric current. Conductivity is the reciprocal of electrical resistance (measured in ohms) – the commonly used unit for conductivity is mhos – which is simply "ohms" spelled backwards. In water quality measurements, conductivity is usually expressed as micromhos (µmhos). The same probe is used for measuring both conductivity and salinity. The probe measures the conductance of an electrical current between two electrodes to measure the conductivity of the water and the instrument converts this reading into salinity. The measurements are also corrected for temperature and pressure, which also influences conductivity. The measurement of conductivity is recorded more often for freshwater sites, where the concentration of dissolved ions is low and salinity is effectively zero. The conductance is lowest further upstream at the tributary sites and increases downstream where there is tidal mixing of fresh and estuarine waters. Since density also increases with higher concentrations of dissolved ions, the conductivity usually increases with depth. The input of weathered rocks and soil from terrestrial runoff as well as inflows of ground water from natural springs can also increase conductivity in freshwaters.

Salinity is measured in estuarine and marine waters where the concentrations of dissolved ions are higher. As the name suggests, salinity refers to the amount of "salt" dissolved in the water and is expressed in parts per thousand (‰ or ppt) which is equivalent to grams per kilogram (or liter). More recently, the "practical salinity unit" (psu) has been more commonly used as the standard unit for salinity when measurements are calculated from conductivity. One psu is equivalent to 1‰, so the terms are interchangeable and typically salinities are presented simply as a number without the units shown. The major constituent of the dissolved salts is sodium chloride (NaCl = "table salt") which forms sodium (Na^+) and chloride (Cl^-) ions when dissolved. Other common ions in seawater include magnesium (Mg^{2+}), Calcium (Ca^{2+}), potassium (K^+), sulfate (SO_4^{2-}), and bicarbonate (HCO_3^-) – among many others. Salinity in Tampa Bay is largely influenced by precipitation, with lower salinities observed during the wet season months and in years of above average rainfall and higher salinities during the dry season months and during drought years. There is generally an increase in salinity towards the lower part of Tampa Bay where there is a greater influence from tidal exchange with the Gulf of Mexico and fewer tributaries bringing in fresh water. Since the density of water increases with salinity, salinities are typically higher in the bottom water than at the surface (Figure 8). This can be especially evident in the tributaries where surface waters can be fresh while mid-depth and bottom waters can have relatively high salinities forming a distinct “salinity wedge”. This often occurs near the mouth of the tributary when river flows are high and there is an incoming tide.

During the 2001-2010 time period the median salinities at the surface, mid-depth and bottom were 27.5, 27.7 and 28.0 respectively. The lowest annual salinities occurred in 2003 and the highest in 2001 (Table 6; Figures 9 and 10.). The minimum salinities recorded at the Tampa Bay monitoring stations for all depth strata occurred in September 2004, which was the same month Hurricane Frances hit the Tampa Bay area. This was particularly evident in Hillsborough Bay, where the average surface salinity dropped to near 5 psu (Figure 9). The lowest surface and mid-depth salinities (0.3 and 1.6 respectively) were at Station 58 in McKay Bay, the lowest bottom salinity (5.9) was at Station 8 in Hillsborough Bay near the Alafia River. These were also the lowest salinities on record going back to 1972.The highest salinity (37.9 at all depths) occurred in March 2006 at Station 93 in Lower Tampa Bay near Egmont Key. The highest bottom salinities on record were 42 in June 1988 at stations 92 and 93 in Lower Tampa Bay. [Note: salinities >48 were recorded on two occasions in the database (See Table 6); July 2009 at Station 94 and July 2001 at Station 68. These records are considered to be erroneous and were excluded from the analysis]. Overall salinities in Tampa Bay tend to fall within the polyhaline range (18 – 30) in the upper and middle segments and euhaline range (>30) in Lower Tampa Bay (Figures 9 and 10).

The monthly tributary stations had surface salinities ranging from 0 to 41.65 during the 2001-2010 reporting period with a median value of 8. Freshwater sites, (defined as salinity <0.5) had conductivity measurements ranging from 0 to <1076 µmhos. The lowest surface conductivity measurements were recorded at stations 107 (Baker’s Creek) in June 2004 and at station 138 (Delany Creek) in April 2003. Bottom salinities at the tributary stations ranged from 0 – 48 (median = 17.8) with the highest reading at station 102 (Channel “A” at S.R. 580 bridge) in December 2008, although this value is questionable. Bottom conductivities at the freshwater sites(<0.5 psu) ranged from 55 – 1049 µmhos. The minimum bottom conductivity reading was measured at minor tributary station 573 on Bell Creek in June 2005; the 1049 µmhos was recorded at station 101 on Double Branch Creek in January 2007.

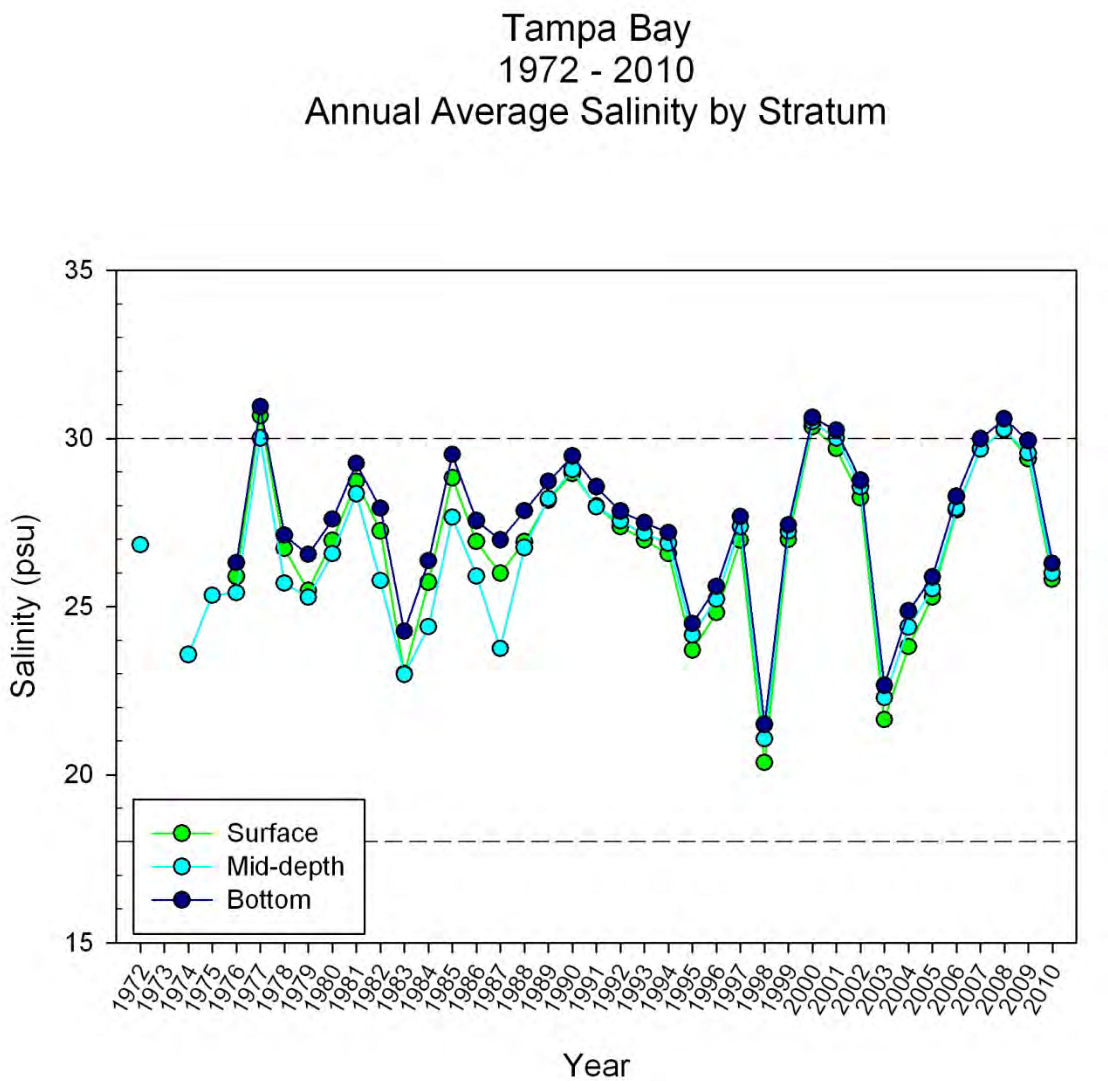


Figure 8. Annual average bay-wide salinity for surface, mid-depth and bottom. Dashed lines represent lower salinity cutoffs for euhaline (30 psu) and polyhaline (18 psu) salinity zones.

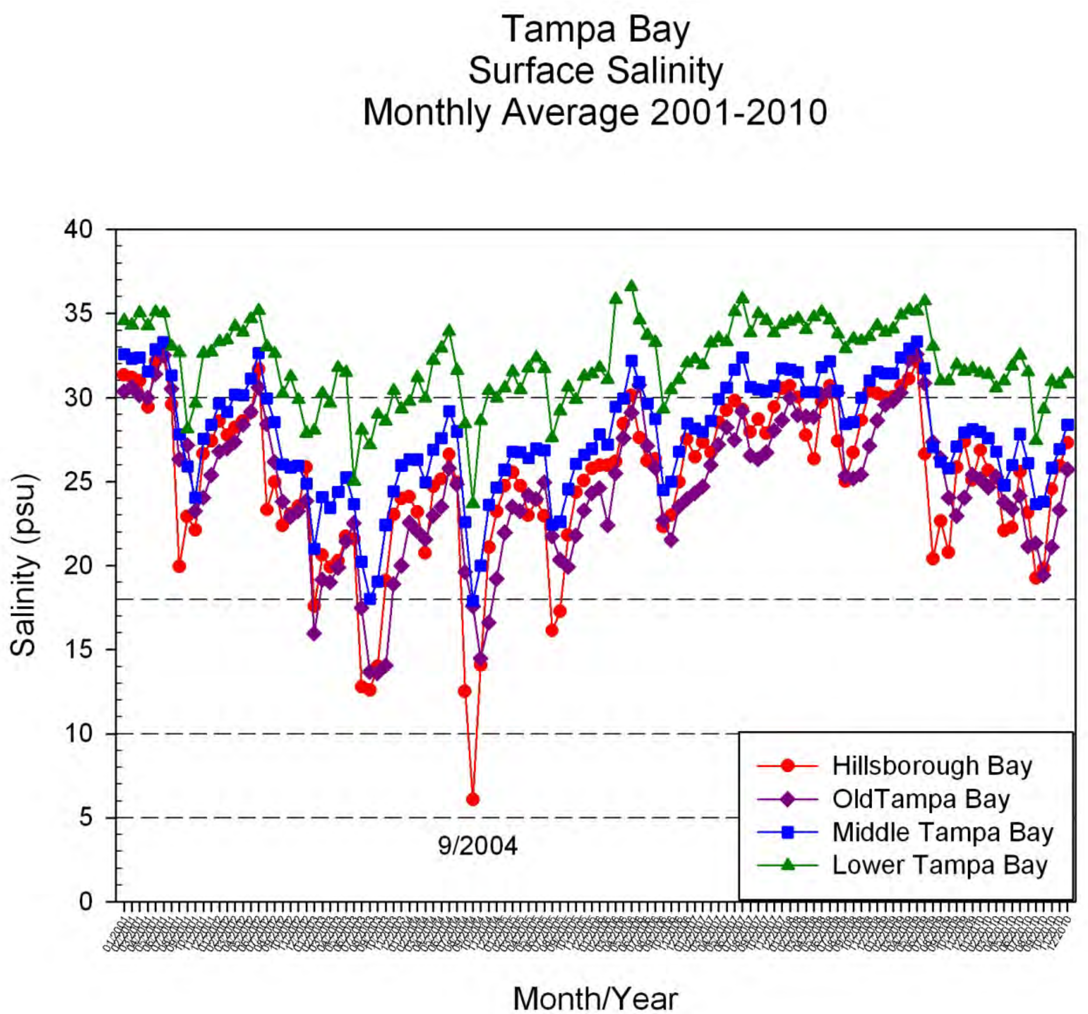


Figure 9. Average monthly salinity by bay segment 2001-2010. Dashed lines indicate salinity zone cutoffs: Oligohaline (< 5 psu); Low Mesohaline (5-10 psu); High Mesohaline (10-18 psu); Polyhaline (18-30 psu) and Euhaline (>30 psu).

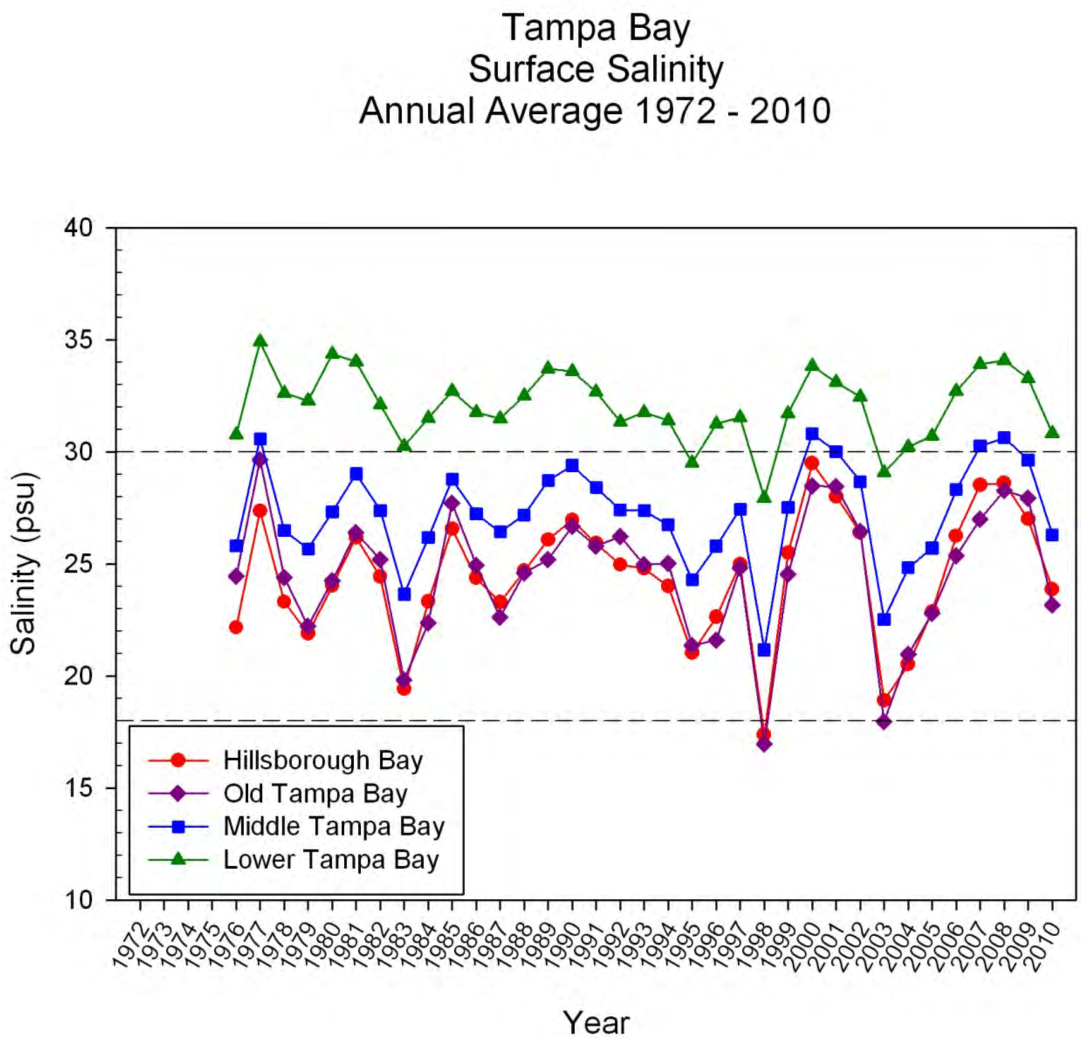


Figure 10. Annual average surface salinities by bay segment 1972-2010.

pH

The pH refers to the concentration of hydrogen ions (H^+) in solution and calculated as $-\log_{10}[H^+]$. The pH is measured on a scale of 1 - 14, with values <7 classified as acidic, >7 as basic (or alkaline) and values =7 as neutral. Pure water has a neutral pH of 7, most freshwater systems are slightly acidic due to the presence of tannic acid from the decomposition of vegetation while saltwater bodies tend to be basic due to the buffering effects of dissolved ions such as carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-). The pH in water is influenced by the dissolution of carbon dioxide gas (CO_2) from the atmosphere and the interaction with dissolved ions and biological processes such as photosynthesis and respiration. The dissolution of CO_2 gas reacts with water reducing the pH through the formation of carbonic acid (H_2CO_3)

which further interacts with any carbonate and bicarbonate ions until equilibrium is reached. This is expressed by the equation:

$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^- \leftrightarrow 2H^+ + CO_3^{2-}$

Photosynthesis by plankton and aquatic vegetation takes up dissolved CO_2 from the water which results in an increase in pH. Because of this, high pH values are often associated with algal blooms. Conversely, respiration by organisms and particularly by bacteria during the decomposition process releases CO_2 and results in a decrease of pH. The balance between photosynthesis and respiration in the water column tends to result in higher pH values near the surface, where the rate of photosynthesis is high and decreasing pH with depth (Figure 11).

The pH can also be influenced by industrial sources, most notably the accidental release of acidic wastewaters from the phosphate mining industry. Historically there have been several phosphoric acid spills into the Alafia River due to wastewater pond failures at phosphate mines within the drainage basin. Most recently, in September 2004 Hurricane Francis caused a dyke at a wastewater retention pond on a gypsum stack to fail, releasing 65 million gallons of acidic wastewater into Archie Creek and Hillsborough Bay. This incident resulted in a large fish kill and extensive damage to the surrounding wetland vegetation.

During the 2001-2010 time period, surface pH values at the Tampa Bay monitoring stations ranged from 5.7 – 9.0 with a median of 8.1. There was a large drop in the surface pH of Hillsborough Bay corresponding to Hurricane Francis in September 2004 (Figure 12). The mid-depth pH values also had a median of 8.1 and bottom pH ranged from 6.1 – 8.9 with a median value of 8.0. The lowest pH readings were in Hillsborough Bay (Station 70) in December 2007. The highest pH measurements were in Old Tampa Bay, with the highest surface and mid-depth readings occurring at Station 36 in August 2009 corresponding to a bloom of the dinoflagellate *Pyrodinium bahamense*. The historical trend for pH in Tampa Bay (Figures 11 and 13) indicates that all bay segments had a dramatic decrease in pH from around 1980 to 1983. This can be attributed to operation of the City of Tampa's (COT) Advanced Wastewater Treatment Plant (AWT) at Hooker's Point in Hillsborough Bay and the resulting decrease in algae blooms. The pH in Tampa Bay however has been showing an apparent increasing trend since the late-1980's (Figure 13).

The surface pH at the tributary stations ranged from 4.3 – 10.55 with a median of 7.5. The lowest surface values were consistently found in Brooker Creek at Gunn Highway (Station 159). This site was only sampled monthly from January 2005 – December 2008. The low pH at this site may have been due high concentration of tannic acids from decaying vegetation. The highest surface pH readings were in Lake Thonotosassa (stations 135 and 118) and reflect the eutrophic conditions and continual blooms of cyanobacteria (blue-green algae) in the lake.

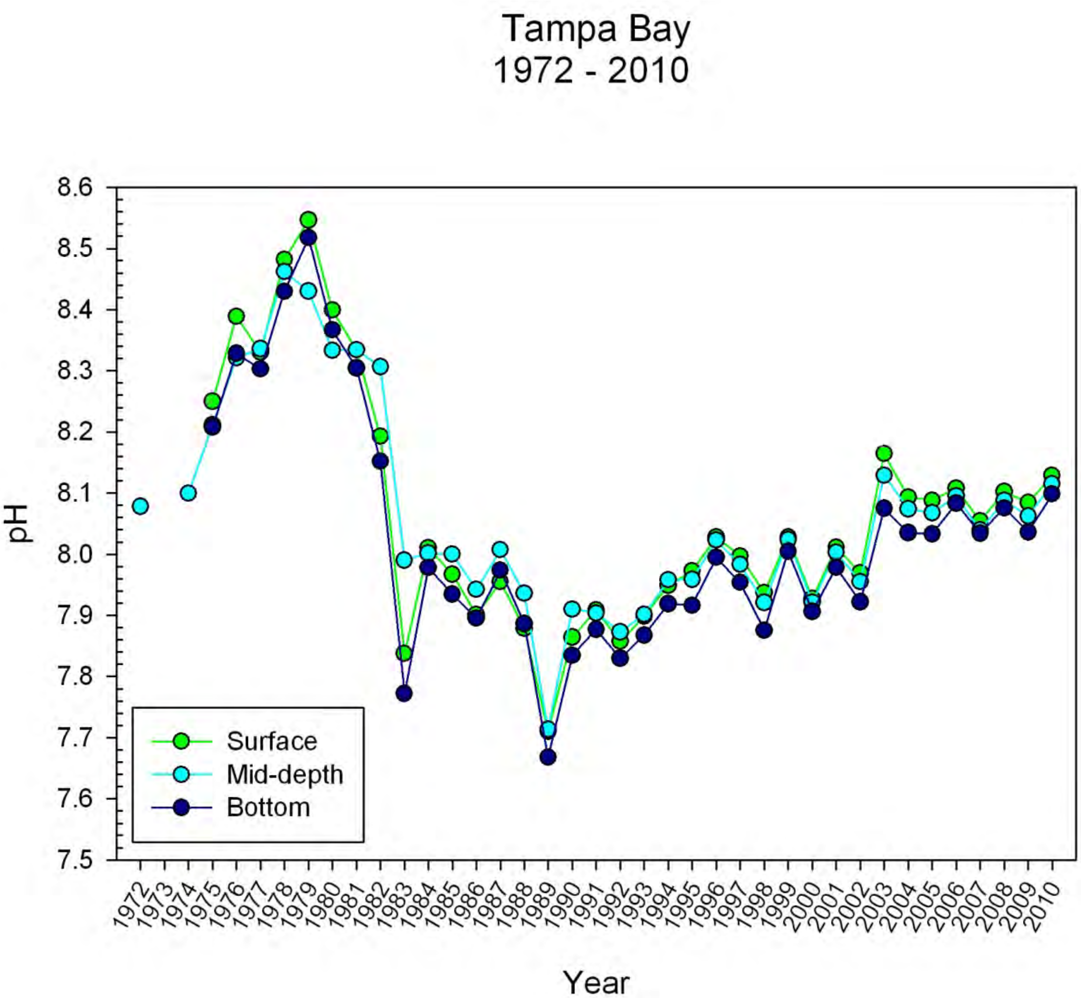


Figure 11. Annual average pH by depth strata.

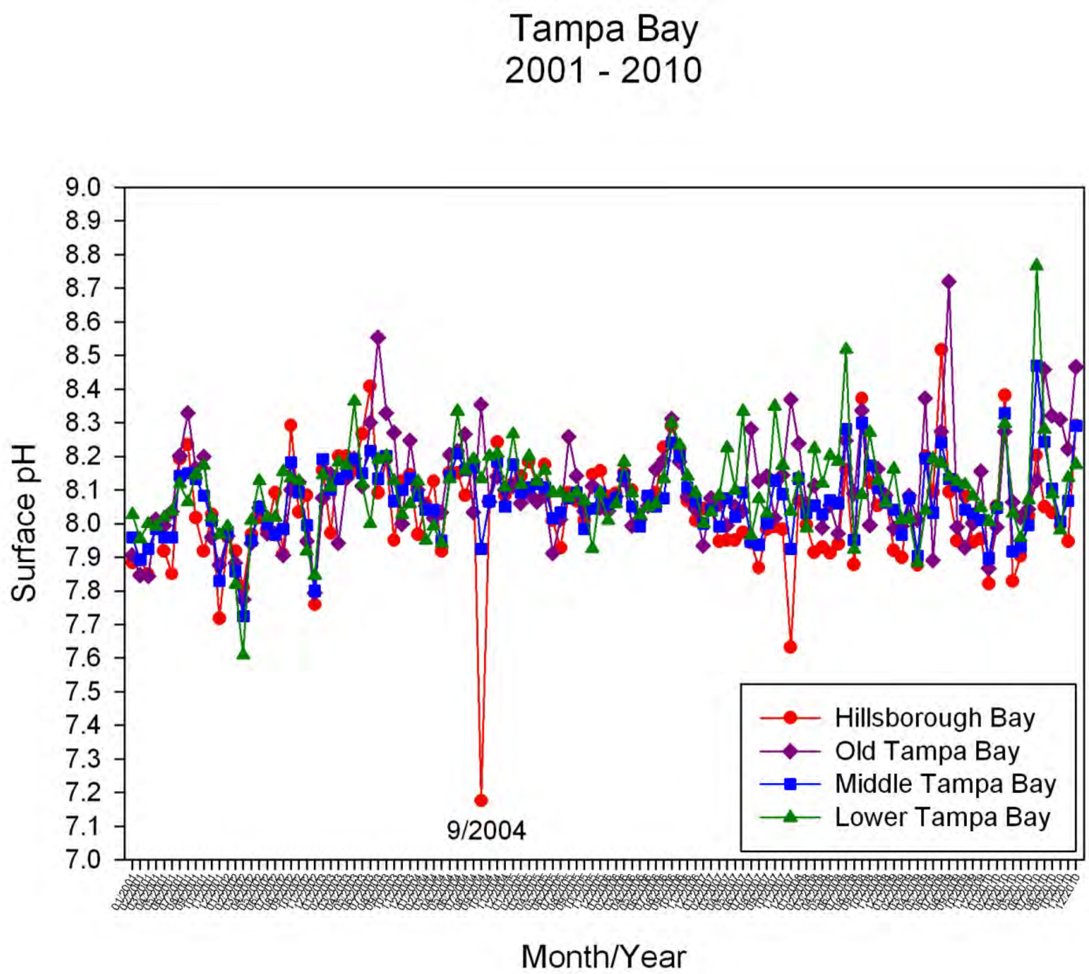


Figure 12. Monthly average surface pH by bay segment from January 2001 – December 2010

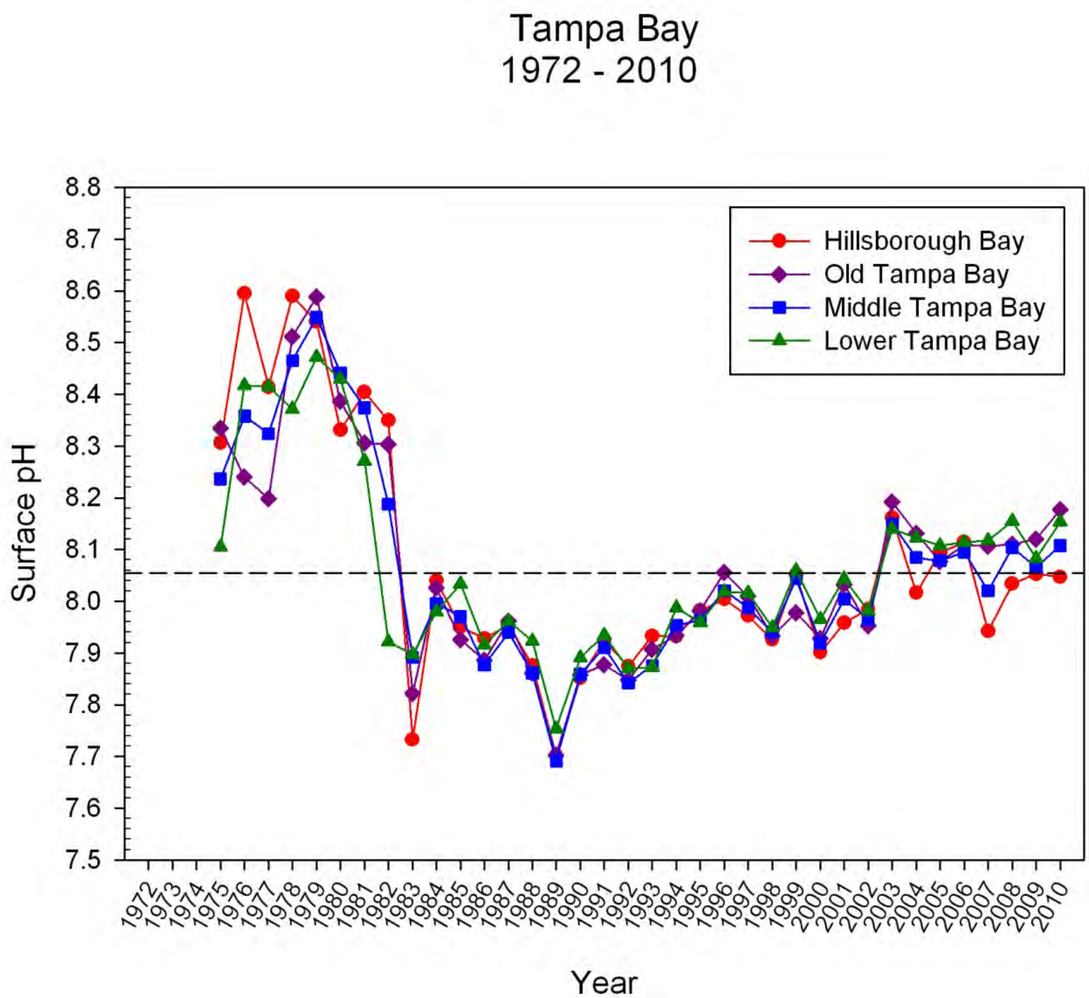


Figure 13. Annual average surface pH by bay segment. Dashed line indicates overall bay-wide average pH value.

Dissolved Oxygen

Dissolved oxygen (DO) is the measure of the amount of oxygen gas diffused in water and is expressed in parts per million (ppm) or equivalently as milligrams (or milliliters) oxygen per liter of water (mg/L or ml/l respectively). The primary sources of dissolved oxygen are from photosynthesis by algae (phytoplankton) in the water column and submerged aquatic vegetation (SAV), and from the physical interaction of the surface waters with the atmosphere through wind, waves and currents. The amount of oxygen that a given volume of water can hold is a function of physical factors such as temperature and the amount of other dissolved material (measured as salinity). In general, gasses are more soluble at colder temperatures, so DO tends to be higher at lower water temperatures and lower when water temperatures are warmer. Additionally, gasses are less soluble in liquids with higher concentrations of other dissolved materials, thus DO tends to be lower in more saline waters and higher in freshwaters.

The dissolved oxygen concentration of the water column is a balance between the production of oxygen from photosynthesis and the consumption of oxygen through respiration. In photosynthesis, plants and some microorganisms use light to convert carbon dioxide (CO_2) and water into a carbohydrate (CH_2O) and Oxygen (O_2). Respiration is the reverse reaction, where oxygen is utilized to breakdown carbohydrates producing water and carbon dioxide as byproducts. This is expressed by the equation:

$$CO_2 + H_2O \leftrightarrow CH_2O + O_2$$

Since this process is dependent on sunlight, photosynthesis rates are higher near the surface of the water column, and correspondingly the highest dissolved oxygen concentrations tend to be at the surface. In deeper water, where light levels are lower, respiration rates are greater than photosynthesis resulting in lower dissolved oxygen concentrations. Overall, this results in a general trend of decreasing DO with depth as shown in Figure 14.

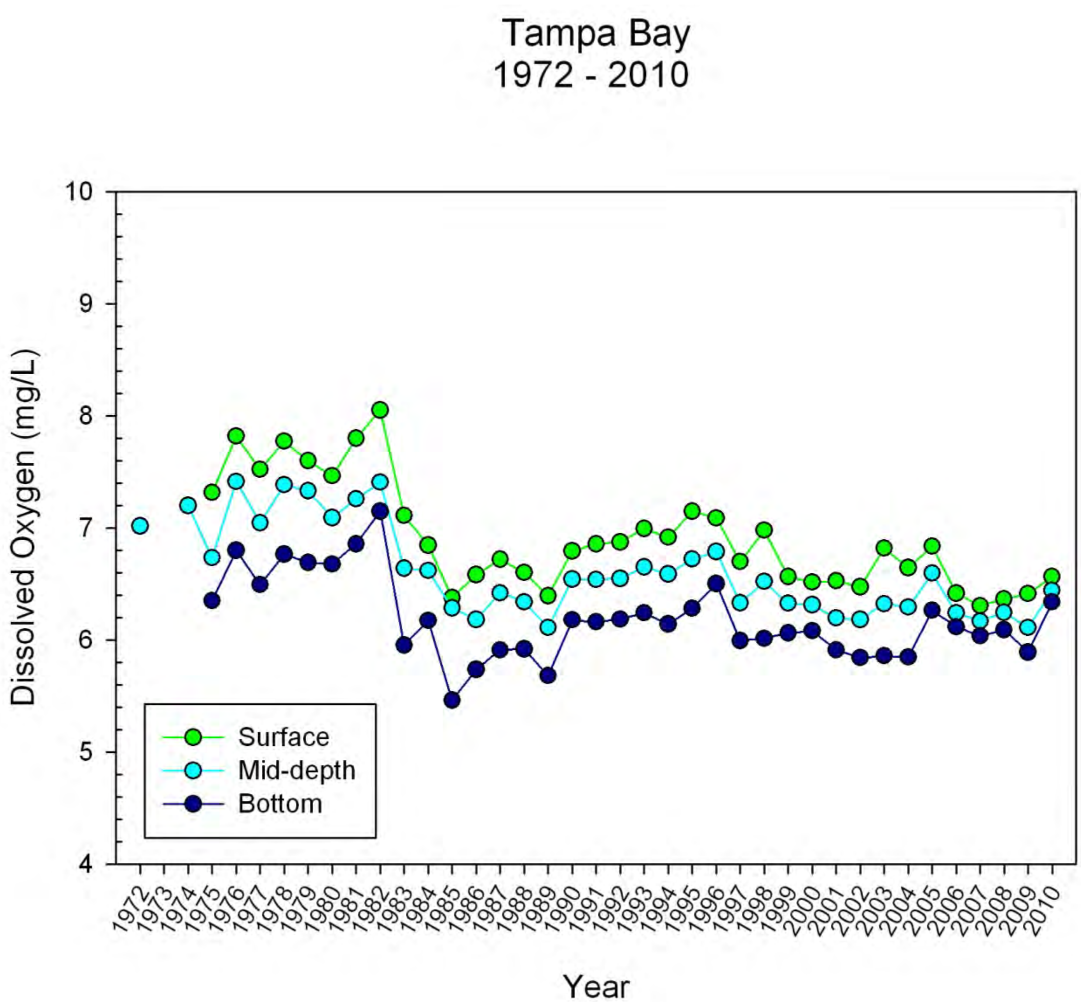


Figure 14. Tampa Bay annual average dissolved oxygen by depth strata.

Similarly, DO exhibits a diurnal pattern with higher levels during the day and dropping at night. Dissolved oxygen levels also vary seasonally due to the influence of temperature on the solubility of oxygen in water. The DO tends to by higher in the winter month when water temperatures are coldest, while minimum DO concentrations are observed in the late summer corresponding to the highest water temperatures (Figures 15 & 16).

Extremes in dissolved oxygen can occur during algae blooms. During these events, daytime DO levels can exceed 10 mg/L at the surface and at night time DO can drop to zero (anoxic). This frequently results in fish kills during the summer months, particularly in ponds and backwater areas with poor water circulation.

Dissolved oxygen is one of the most important parameters used for determining the health of a water body and is essential for the survival of fish and invertebrates. Normal DO levels range from 4 – 10 mg/L in a healthy system. Extremely high levels of DO, defined as “hyperoxic”, are typically indicative of algae blooms and eutrophic conditions. Dissolved oxygen concentrations below 4 mg/L are considered poor, and DO levels below 2 mg/L are defined as “hypoxic”. The depletion of oxygen is referred to as “anoxia” and can occur when there is a high rate of respiration due to the decomposition of organic matter. Sources of organic matter could be plant detritus, dying algal cells from a bloom, decomposing carcasses after a fish kill, or human sources such as sewage. Anoxic conditions can also occur when water temperatures are high, in areas with poor water circulation, or at night time when respiration rates are greater than the daytime production from photosynthesis. The Florida state water quality criteria states that the DO for class III freshwaters should not be less than 5 mg/L and for class III marine waters should not be less than 4 mg/L, with a 24-hour average of no less than 5 mg/L. A large area within the Tampa Bay watershed has been classified as impaired for dissolved oxygen (see Table 4; figure 4 in Chapter 1). This includes all of Hillsborough Bay and most of the major river drainages in Hillsborough County.

During the 2001-2010 reporting period the median surface DO in Tampa Bay was 6.5 mg/L ranging from 0.86 at Station 70 in Hillsborough Bay in July 2009 to 15.2 mg/L in September 2002 at Station 55 also in Hillsborough Bay. Monthly average surface DO levels were above 4 mg/L in all Bay segments, with the single exception of Old Tampa Bay in September 2009 (Figure 15). The highest monthly average DO generally occurred during the mid-winter months, and was lowest in the late summer (Figure 15). Mid-depth DO ranged from 0 mg/L in McKay Bay in July 2001 (Station 54) to a maximum of 17.4 in Old Tampa Bay in October 2005 (Station 36). Bottom DO in Tampa Bay ranged from 0 mg/L at several sites in upper Hillsborough Bay in September 2001 and Old Tampa Bay in 2002, to 12.2 mg/L in Middle Tampa Bay in September 2005 (Station 84, near Bahia Beach). The average monthly DO was consistently lowest in Hillsborough Bay and seasonally during the late summer (Figure 16). Average monthly DO values were consistently above 4 mg/L in OTB, MTB and LTB with the exceptions of MTB in August 2004 and OTB in September 2009 (Figure 16). Hillsborough Bay however had average monthly DO values falling below 4 mg/L during the summer months and fell into the hypoxic range (<2 mg/L) in August 2001, 2003, 2004 and September 2009 (Figure 16).

Historic trends in the surface DO show that a strong drop occurred during the early 1980s (Figure 17), which also corresponds with the Hooker's Point AWT plant coming online. This was apparent in all bay segments. Hillsborough Bay also consistently had the highest annual average surface DO values, which may be the result of frequent algae blooms which occur in that area. Surface DO did show an increasing trend form the mid-1980s to mid-1990s, but has been declining is subsequent years. The overall average surface DO was 6.9 mg/L and the annual average was above 6 mg/L for all bay segments in all years. The average annual bottom DO trend in Tampa Bay also showed a drop in the early to mid-1980s (Figure 18). Average annual bottom DO was above 4 mg/L in all bay segments, but Hillsborough Bay consistently had the lowest bottom DO across all years. The overall bay-wide average was 6.2 mg/L.

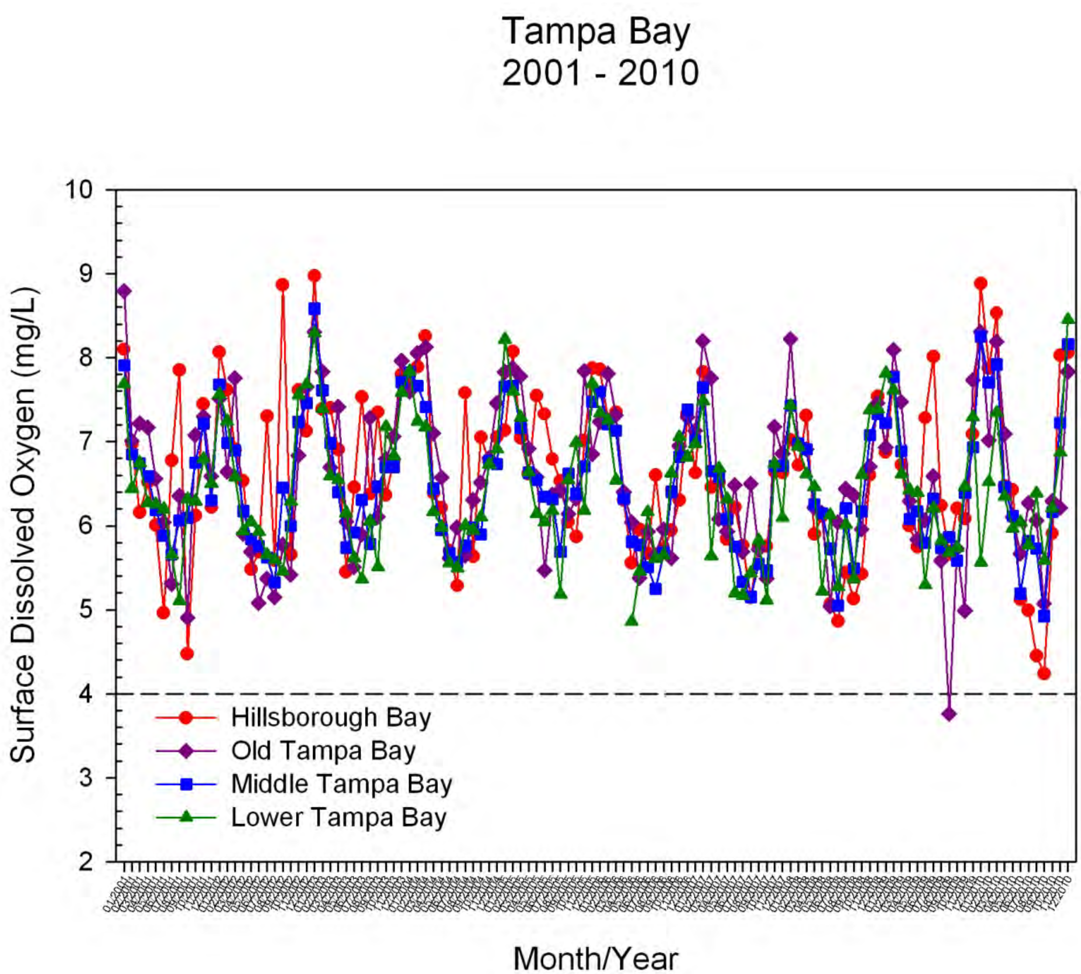


Figure 15. Monthly average surface dissolved oxygen by bay segment January 2001- December 2010. Dashed line indicates Florida state standard for impaired marine water (4 mg/L).

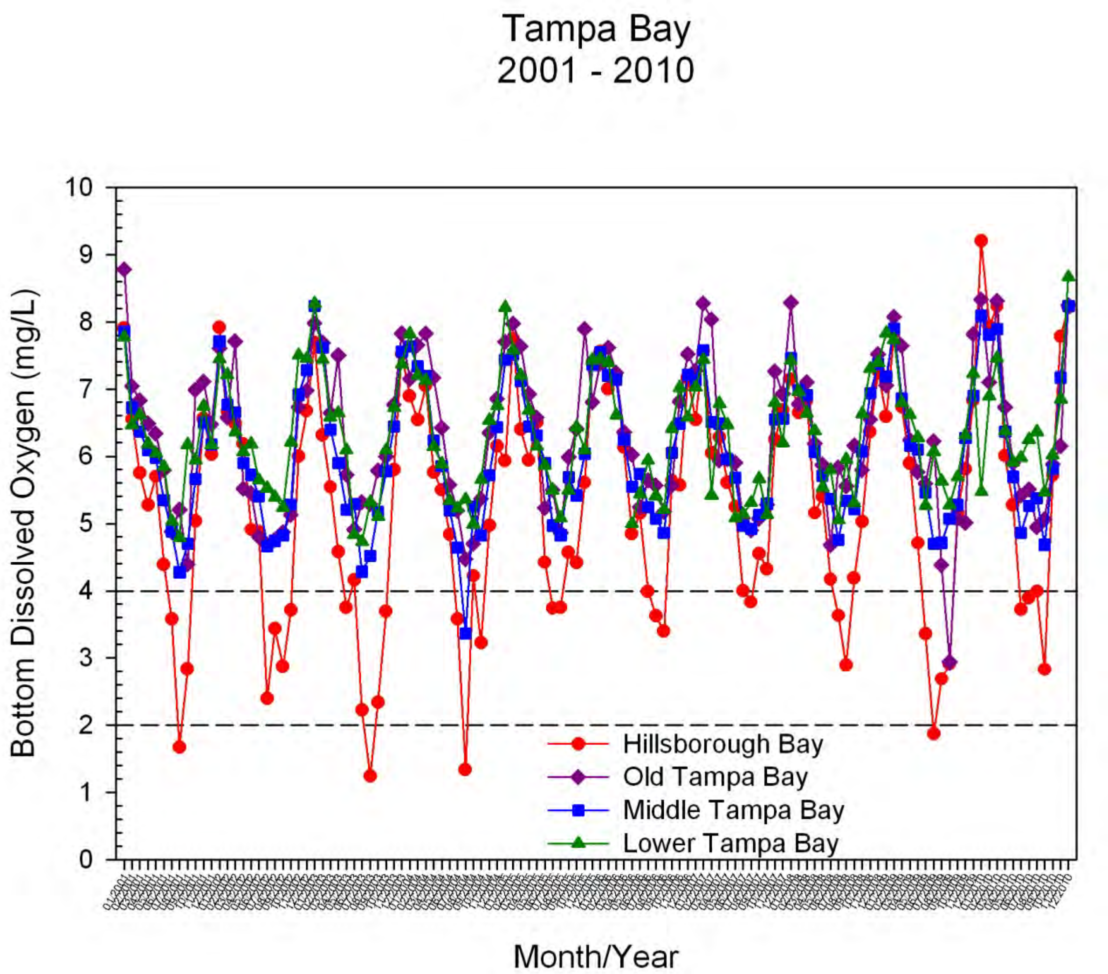


Figure 16. Monthly average bottom dissolved oxygen by bay segment January 2001- December 2010. Dashed line indicates Florida state standard for impaired marine water (4 mg/L) and for hypoxic conditions (<2 mg/L).

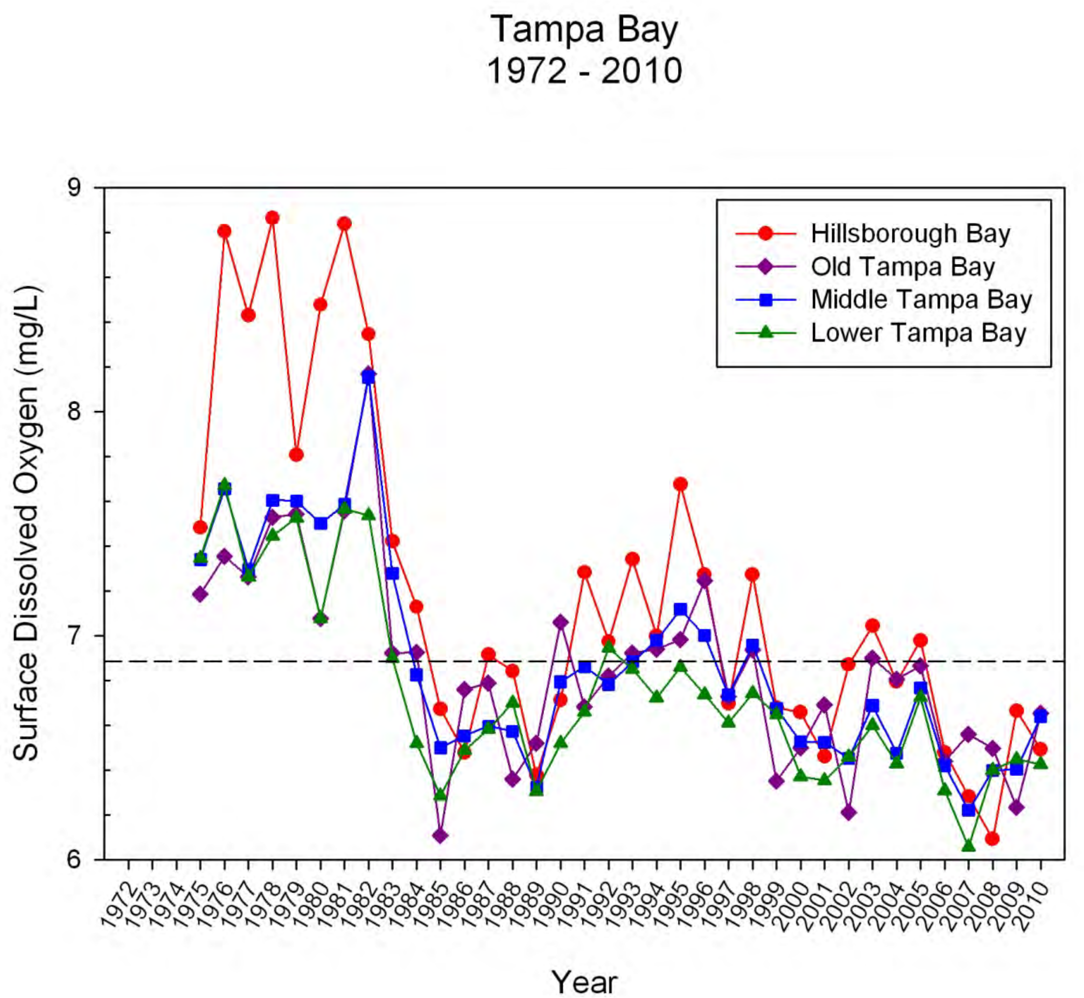


Figure 17. Annual average surface dissolved oxygen concentrations by bay segment. Dashed line indicates overall bay-wide average value.

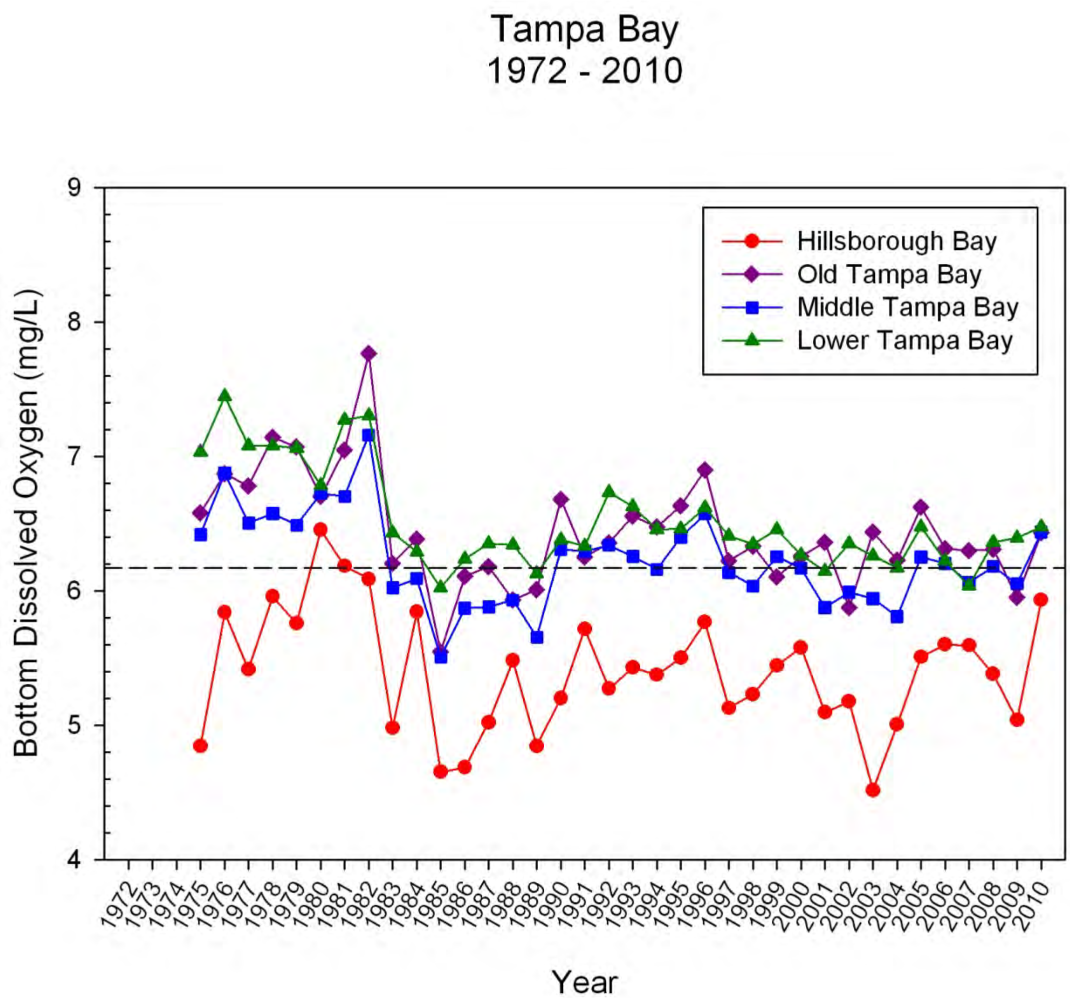


Figure 18. Annual average bottom dissolved oxygen concentrations by bay segment. Dashed line indicates overall bay-wide average value.

The monthly tributary stations had an overall average surface DO of 5.6 mg/L during the 2001-2010 reporting period with a range from 0 – 28 mg/L. The lowest surface DO readings occurred in the Palm River, Hillsborough River and some of the tributaries of upper Old Tampa Bay (Rocky Creek, Double Branch Creek). The highest measurement was in the Hillsborough River near Sulfur Springs (Station 152) in July 2001, although the accuracy of this value is questionable. Mid-depth DO values ranged from 0 – 17.7 mg/L with an average value of 5.4 mg/L and bottom DO ranged from 0 – 17.3 mg/L with an average value of 4.5 mg/L. The stations in Lake Thonotosassa (stations 135 and 118) consistently had among the highest DO levels at all depths due to the persistent algae blooms on that lake, although bottom measurements were also frequently in the anoxic or hypoxic range.

Chapter 3

WATER CLARITY

Introduction

The clarity of the water is important to the ecology of Tampa Bay because it affects the penetration of light through the water column and thus the distribution of seagrasses and other submerged aquatic vegetation (SAV). Without sufficient light reaching the bottom sediments SAV cannot photosynthesize and grow which in turn reduces the areal cover of this important habitat. Benthic microalgae, which are the base of much of the food web in the bay also depend on receiving sufficient light for photosynthesis. Clear water is essential for the ecology of Tampa Bay and a good measure of the bay's health.

Factors influencing water clarity include dissolved matter measured as color and suspended matter in the water column measured as turbidity and the total suspended solids. Dissolved and suspended matter affect light penetration through the adsorption and scattering of light as it passes through the water column. Water molecules also contribute to this process by interacting with light particles (photons). Water clarity can also be quantified by measuring the penetration of light through the water column or a set distance either with an electronic meter (transmitometer) or visually using a Secchi disk.

Color

Pure water is a clear liquid although in nature water may have color due to suspended or dissolved materials. True color is due to the presence of dissolved matter, such as humic acids and pigments from decomposing plant material, metal ions or chemical pollutants. Since these substances are in solution, they cannot be physically separated from the water through standard filtration or centrifugation methods. Apparent color may be due to suspended matter such as soil runoff from the land, stirred-up bottom sediments, or plankton. These substances can be separated from the water through filtration or other methods such as centrifugation.

For the measurement of color, the suspended material is removed by centrifuging the sample, leaving only the true color due to dissolved matter. Color is then measured using a spectrophotometer at a given wavelength of light (345 nm) and expressed in as platinum-cobalt (pl-co) color units.

Table 7 Tampa Bay 1972 - 2010 annual median, minimum and maximum water clarity parameter values.

Year	Color (pl-co)		Turbidity (NTU)		Total Suspended Solids (mg/L)		Secchi (meters)	
1972	.		.		.		1.5	
	.	.	.	.	.	.	0.5	7.9
1973	.		.		.		.	
	.	.	.	.	.	.	.	.
1974	12.0		4.0		13.0		1.8	
	4.0	62.0	1.0	18.0	3.0	45.0	0.3	6.1
1975	8.0		4.0		25.0		1.5	
	1.0	65.0	1.0	33.0	1.0	126.0	0.3	8.2
1976	8.0		4.0		22.0		1.2	
	1.0	47.0	1.0	23.0	4.0	57.0	0.3	9.1
1977	8.0		4.0		42.0		0.9	
	1.0	43.0	1.0	55.0	3.0	367.0	0.2	5.2
1978	9.0		4.0		35.5		0.9	
	1.0	59.0	1.0	78.0	1.0	320.0	0.3	5.8
1979	11.0		4.0		59.0		0.9	
	1.0	139.0	1.0	110.0	21.0	170.0	0.2	4.3
1980	10.0		3.0		16.0		1.1	
	1.0	33.0	1.0	28.0	1.0	208.0	0.2	5.8
1981	8.0		4.0		53.0		1.2	
	1.0	75.0	1.0	66.0	4.0	187.0	0.2	6.2
1982	11.0		4.0		57.0		1.2	
	1.0	54.0	1.0	59.0	32.0	150.0	0.3	4.6
1983	13.0		4.0		47.0		1.2	
	1.0	56.0	1.0	33.0	25.0	100.0	0.2	4.9
1984	10.0		3.0		29.0		1.4	
	1.0	35.0	1.0	66.0	10.0	111.0	0.3	6.1
1985	7.0		4.0		39.5		1.5	
	1.0	69.0	1.0	32.0	13.0	100.0	0.3	5.8
1986	9.0		3.0		36.0		1.7	
	1.0	31.0	1.0	22.0	16.0	92.0	0.3	7.0
1987	10.0		4.0		33.0		1.7	
	1.0	97.0	1.0	19.0	8.0	58.0	0.6	7.3
1988	9.0		4.0		34.0		1.7	
	1.0	130.0	1.0	25.0	17.0	56.0	0.5	7.9
1989	8.0		6.0		31.0		1.5	
	1.0	25.0	1.0	29.0	7.0	56.0	0.6	7.0
1990	7.0		6.0		28.0		1.7	
	1.0	47.0	1.0	34.0	3.0	92.0	0.5	5.5
1991	8.0		7.0		19.0		1.8	
	1.0	115.0	1.0	31.0	3.0	67.0	0.5	4.9
1992	6.0		6.0		17.4		1.8	
	1.0	28.0	1.0	28.0	2.8	41.0	0.3	5.6
1993	6.0		5.0		18.7		1.7	
	1.0	76.0	1.0	22.0	7.0	44.0	0.5	5.5
1994	6.0		4.0		17.0		1.7	
	1.0	70.0	1.0	29.0	5.0	77.0	0.3	5.5

Year	Color (pl-co)		Turbidity (NTU)		Total Suspended Solids (mg/L)		Secchi (meters)	
1995	8.0		4.0		12.0		1.5	
	1.0	64.0	1.0	30.0	1.0	44.0	0.5	4.6
1996	7.0		3.0		14.0		1.7	
	1.0	40.0	1.0	59.0	3.0	331.0	0.5	5.2
1997	6.0		3.0		15.0		1.5	
	1.0	73.0	1.0	19.0	5.0	36.0	0.3	6.1
1998	12.0		4.0		15.0		1.2	
	1.0	86.0	1.0	26.0	4.0	64.0	0.3	6.1
1999	7.0		3.0		16.0		1.7	
	1.0	18.0	1.0	14.0	5.0	48.0	0.5	7.6
2000	5.0		3.0		17.0		1.7	
	1.0	18.0	1.0	38.0	4.0	44.0	0.2	4.3
2001	7.0		3.0		19.0		1.4	
	2.0	72.0	1.0	30.0	5.0	58.0	0.5	6.1
2002	8.0		3.0		16.0		1.8	
	1.0	28.0	1.0	27.0	2.0	83.0	0.3	7.6
2003	12.0		3.2		11.0		1.7	
	1.0	63.0	1.0	31.0	3.0	70.0	0.3	8.2
2004	8.0		2.9		10.0		1.7	
	1.0	86.0	0.4	19.3	3.0	53.0	0.3	7.5
2005	8.4		2.6		11.0		1.9	
	1.9	43.6	0.6	17.2	2.0	39.0	0.5	6.4
2006	6.6		2.0		11.0		2.3	
	1.2	55.5	0.4	9.1	4.0	35.0	0.4	8.3
2007	6.2		2.4		11.0		2.0	
	1.8	21.0	0.6	14.9	2.0	46.0	0.6	8.8
2008	5.8		2.5		12.0		1.9	
	1.5	21.6	0.6	17.6	2.0	48.0	0.1	8.4
2009	6.0		2.4		.		1.9	
	1.3	54.9	0.5	68.0	.	.	0.2	5.7
2010	6.5		2.2		.		1.8	
	5.9	9.8	0.5	11.3	.	.	0.5	6.4

During the 2001-2010 monitoring period the color measurements at the Tampa Bay stations ranged from 1 – 86 with a median value of 7.2 (Table 7). The color tended to be lowest in Lower Tampa Bay and higher at the Hillsborough Bay stations. Higher values tended to occur during the summer rainy season in all bay segments (Figure 19). The maximum readings occurred in Hillsborough Bay in September and October 2004 following Tropical Storm Frances.

Historically, water color in Tampa Bay had ranged between 1 – 139 pt-Co with a median value of 8.0. The highest recorded reading was at Station 58 in McKay Bay and occurred in September 1979. There has been a general trend towards decreasing color values over time with increases occurring in years of heavy rainfall, most notably in 1998 and 2003 (Figure 20).

Water color at the tributary stations is typically higher than in Tampa Bay, due in part to tannic acid from decaying plant material and terrestrial runoff. During the 2001-2010 monitoring period the color measurements at the tributary stations ranged from 0.5 – 647.8 pt-co units, with a median value of 41.4 pt-co units. The highest reading occurred in August 2009 at Station 173 in northwestern Hillsborough County near the Tampa Bay Downs horse track. The median tributary color measurement for the entire historical dataset is 40 pt-co units. The maximum color value from 1972-2010 was 723 recorded at station 118 (Lake Thonotosassa at Flint Creek outfall) in June 1982.

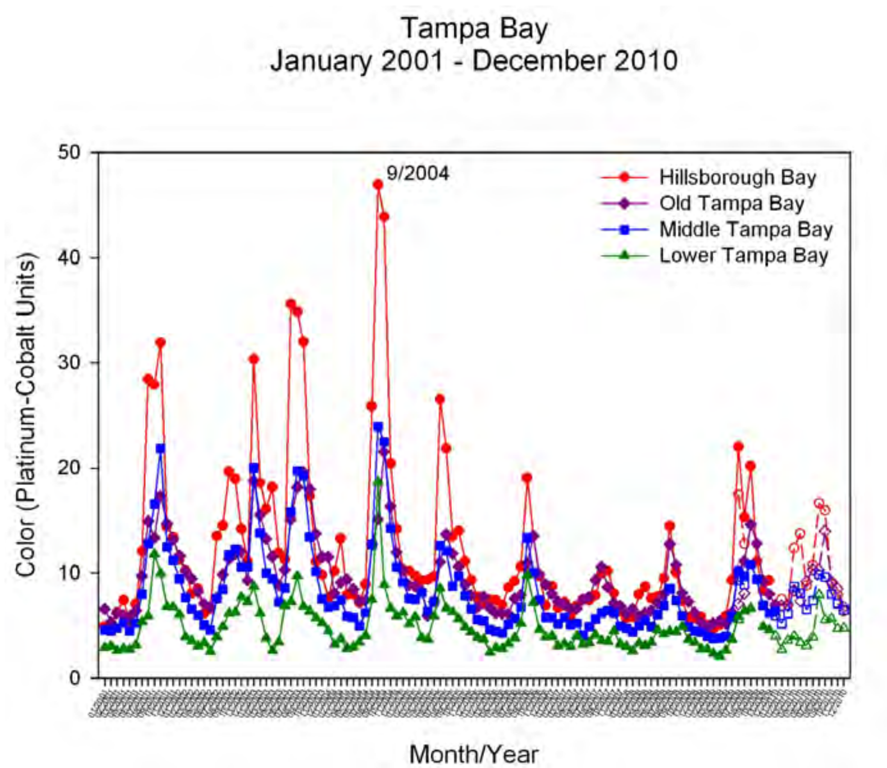


Figure 19. Monthly average color by bay segment January 2001- December 2010. Open symbols denote change in laboratory analysis methods.

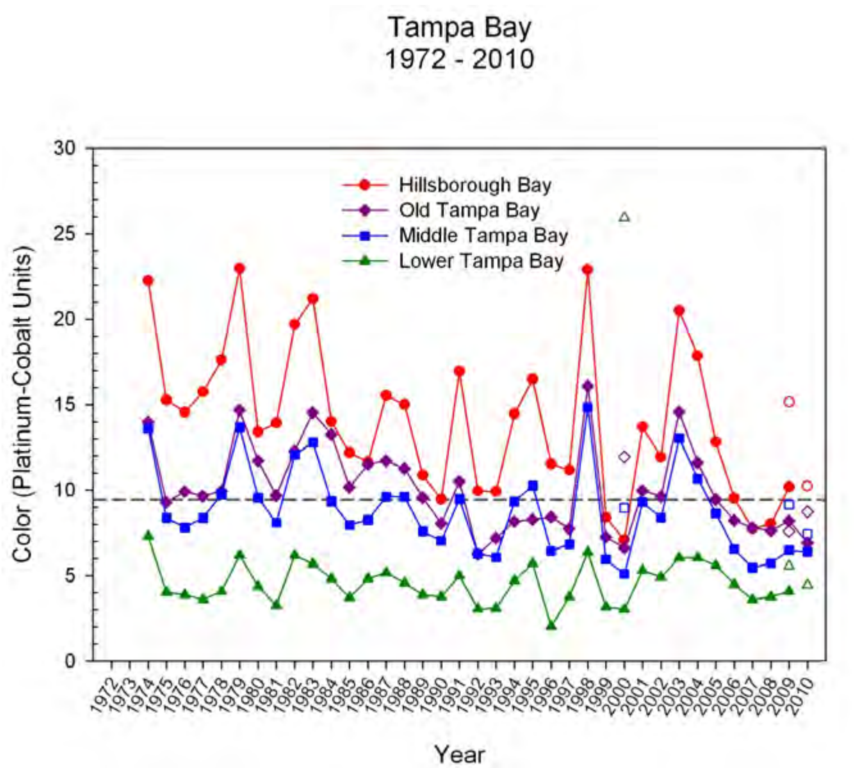


Figure 20. Annual average water color by bay segment. Dashed line indicates overall bay-wide average value. Open symbols denote change in laboratory analysis methods.

Turbidity

Turbidity is a measure of the suspended particles in the water column and is quantified by measuring the scattering of light through a fixed volume of water using a Nephelometer. The resulting measurement is recorded as nepholometric turbidity units (NTUs). Factors which could influence turbidity include erosion of terrestrial soils washing into waterways, suspension of bottom sediments through natural processes such as waves, plankton blooms or by manmade causes such as dredging operations. State water quality criteria mandate that construction or dredging operations cannot increase the turbidity more than 29 NTUs above natural background conditions.

The turbidity at the Tampa Bay stations during the 2001 – 2010 monitoring period ranged from 0.4 – 68 NTUs with a median value of 2.6 NTUs. The highest reading occurred at station 63 in Old Tampa Bay during August 2009. This date corresponds to a bloom of the dinoflagellate *Pyrodinium bahamense* in Old Tampa Bay. Overall turbidity trends showed higher turbidity during the summer rainy season and higher turbidity measurements in Hillsborough Bay and Old Tampa Bay (Figure 21).

Historical turbidity readings for the Tampa Bay stations ranged from 0.4 – 110 (Table 7) with a median of 4.0 NTUs. The highest record was at Station 52 in Hillsborough Bay near the Port of Tampa during April 1979. There was a bay-wide trend of increasing turbidity through the late 1980's peaking in 1991, most notably in Hillsborough Bay (Figure 22).

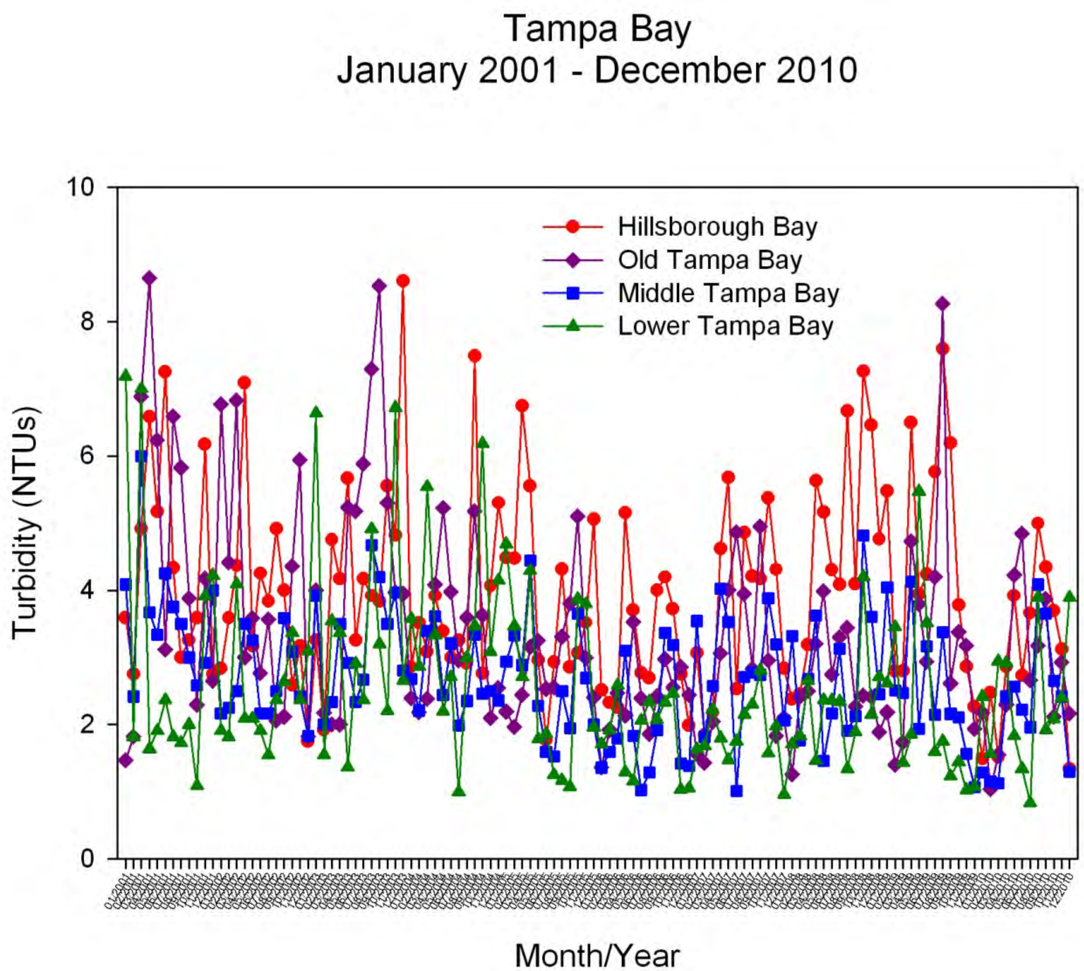


Figure 21. Monthly average turbidity by bay segment January 2001- December 2010.

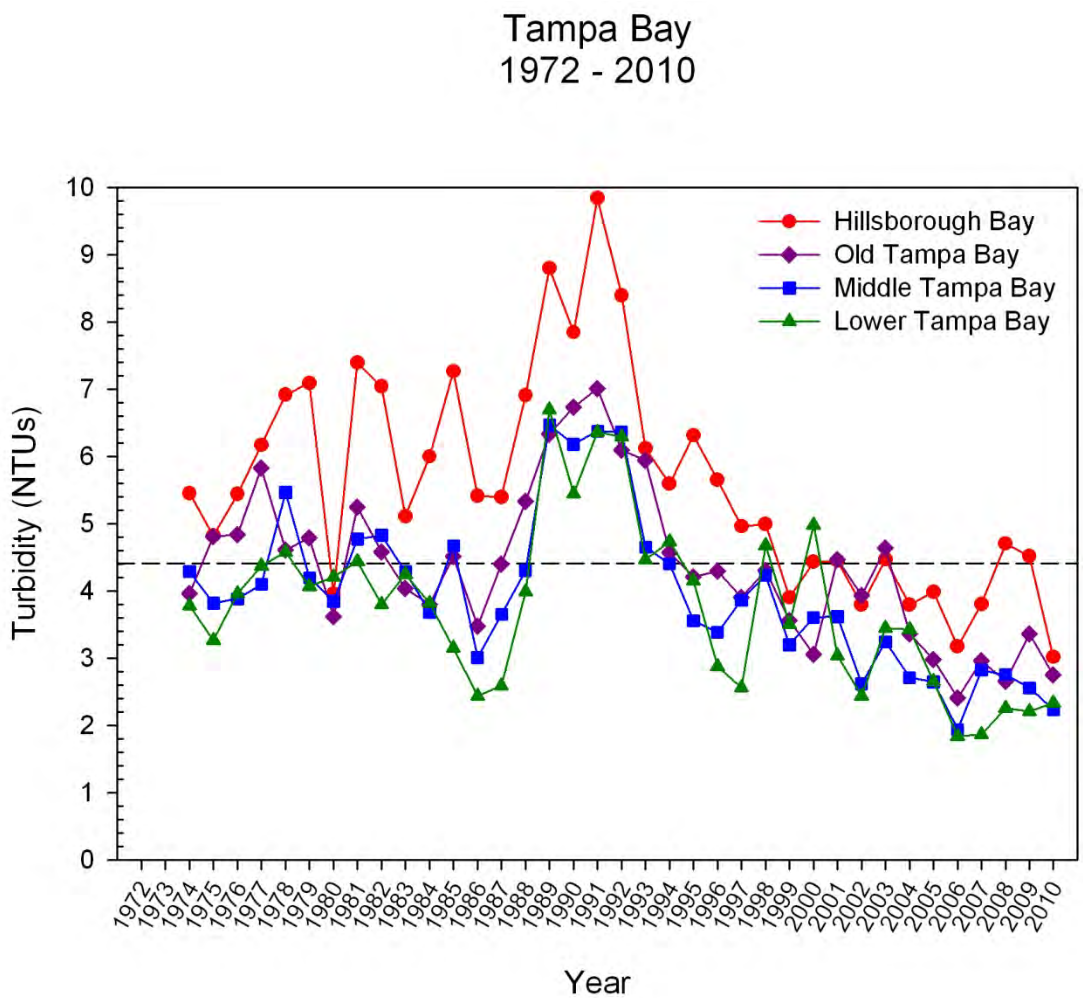


Figure 22. Annual average turbidity by bay segment. Dashed line indicates overall bay-wide average value.

Turbidity at the monthly tributary stations ranged from 0.2 – 574 NTUs during the 2001 – 2010 monitoring period. The median turbidity measurement was 3.1 NTUs. The highest reading was at Station 138 in Delaney Creek during June 2003. This is also the highest historical turbidity record in the EPC dataset. The historical median turbidity was 4.0 NTUs for the tributary stations.

Total Suspended Solids

Another measure of turbidity is the Total Suspended Solids (TSS), measured as the dry weight of suspended particles filtered from 100 - 300 ml of water onto a 1.5 µm filter and reported in mg/L. This parameter was discontinued after September 2008. As with turbidity, TSS is strongly influenced by runoff from the land and generally is higher during the wet season. Soil erosion and resuspension of bottom sediments due to human activities such as construction and dredging can also result in high levels of TSS.

During the 2001 – 2008 monitoring period, the TSS ranged from 2 – 83 mg/l with a median value of 12 mg/l. The highest measurement was recorded at station 65 in Old Tampa Bay near the Bayside Bridge in March 2002. The TSS varied seasonally, with higher values during the summer wet season due to increased runoff (Figure 23). Values also tended to be higher in Hillsborough Bay and Old Tampa Bay.

The historic TSS measurements ranged from 1 – 367 mg/L with a median value on 18 mg/L. The highest recorded value was a station 67 in Old Tampa Bay in October 1977. There has been an overall decreasing trend in the TSS since the start of the monitoring program in the early 1970's with a dramatic drop during the 1980's in all bay segments (Figure 24). This trend may have been driven by better regulation of storm water and erosion controls around construction and dredging sites which were implemented at that time.

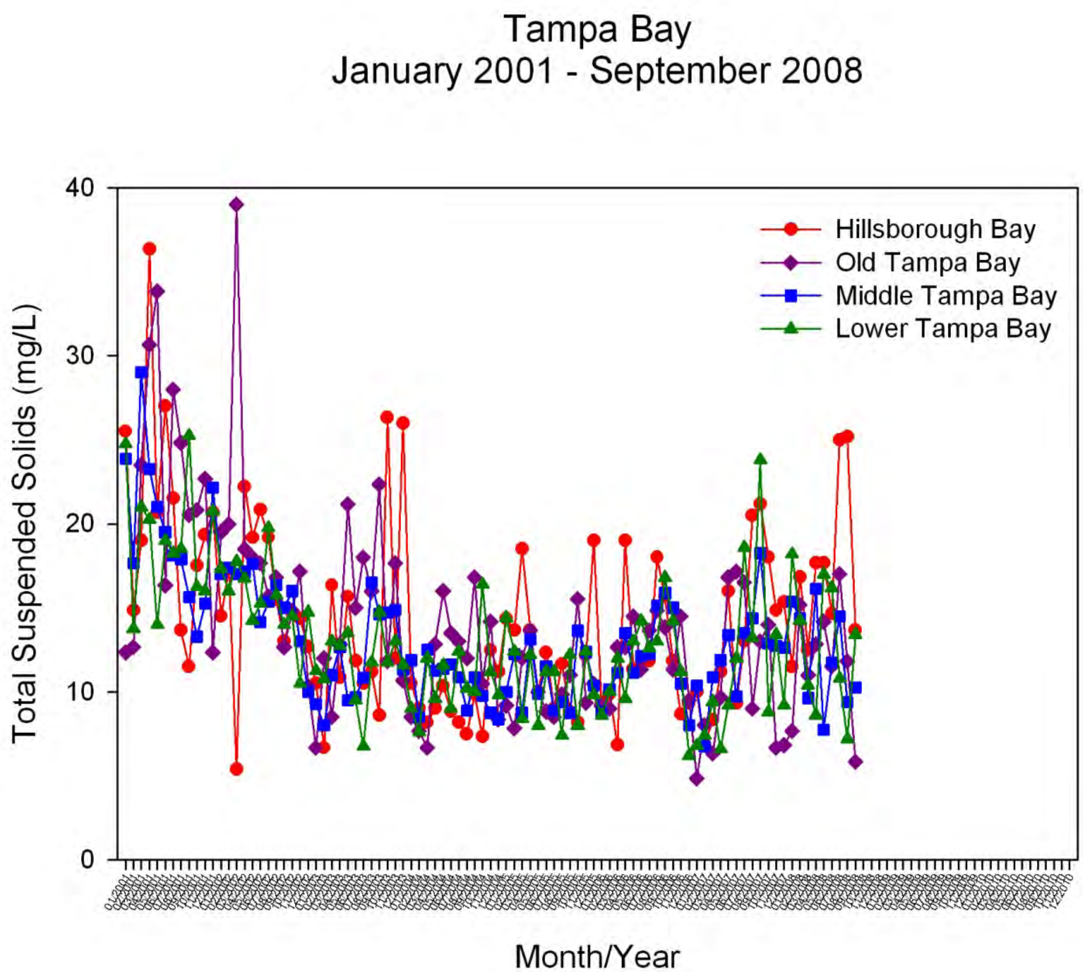


Figure 23. Monthly average total suspended solids by bay segment January 2001- December 2010.

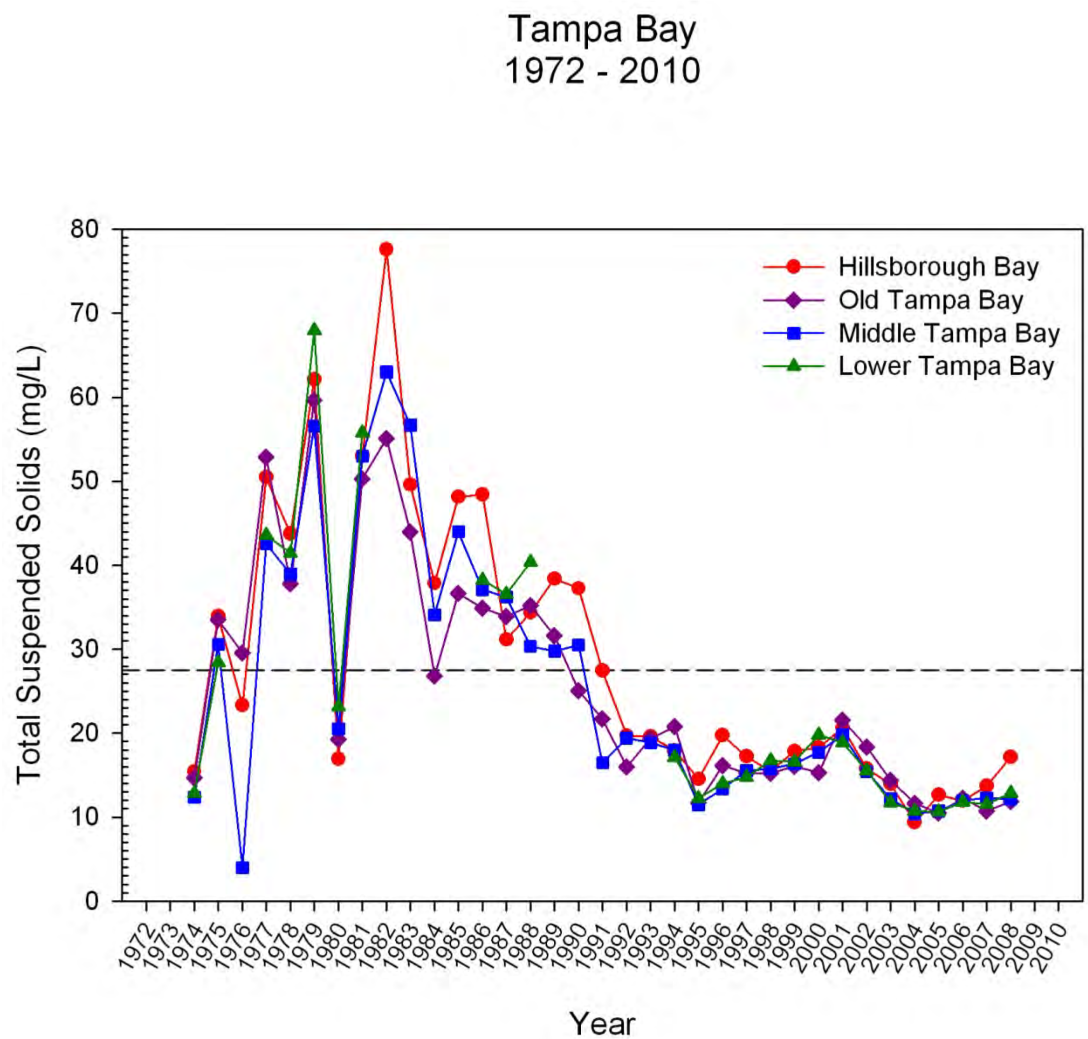


Figure 24. Annual average total suspended solids by bay segment. Dashed line indicates overall bay-wide average value.

The TSS at the monthly tributary stations during the 2001-2008 monitoring period ranged from 1 – 944 mg/L with a median value of 5 mg/L. The maximum reading was recorded in June 2003 at station 138 in Delaney Creek. This was also the highest recorded value during the EPCHC monitoring database and corresponds with the highest turbidity measurement. The second highest record during the 2001-2008 period was 250 mg/L recorded in September 2006 at station 166 (Alafia River at Lithia-Pinecrest Road). The second highest TSS record historically, 794 mg/L, occurred in March 1974 at station 105 in the Hillsborough River. These extreme values may have been due to storm events or to poor erosion control during construction or dredging operations.

Effective Light Penetration

The penetration of light through the water column is influenced by the absorption and scattering of light due to the physical properties of water and the dissolved and suspended particles in the water. The light penetration is measured using a 20 cm diameter Secchi disk with alternating black and white quadrants. The Secchi disk is lowered through the water column until it is no longer visible from the surface and this depth is recorded in 0.1 meter increments. This measure is referred to as the Effective Light Penetration or is commonly referred to as the “Secchi Depth”.

Light penetration is one of the most important properties for seagrasses, and improving the water clarity in Tampa Bay has been a high priority of the Tampa Bay Estuary Program for the restoration on seagrass beds in the bay. The TBEP has established target Effective Light Penetration depths for the four bay segments of Tampa Bay in order to evaluate the progress towards bay restoration. These targets, in terms of Secchi depth are 1.0 meters for Hillsborough Bay; 1.9 meters for Old Tampa Bay and Middle Tampa Bay; and 2.5 meters for Lower Tampa Bay (Janicki and Wade 2000).

Secchi depths at the Tampa Bay stations during the 2001-2010 monitoring period ranged between 0.1 to >8.8 meters with a median Secchi depth of 1.8 meters. The greatest reading was recorded in Lower Tampa Bay at Station 91 in December 2007. The lowest recorded Secchi depth was in Old Tampa Bay at Station 36 in July 2008, which also corresponds to a bloom of the dinoflagellate *Pyrodinium bahamense*. The Secchi depth showed a seasonal pattern and tended to by greater (deeper) during the dry season (Figure 25). Secchi depths also tended to be greater in lower part of the bay due to greater tidal exchange and less input of suspended matter from tributaries and terrestrial runoff.

Historical trends in Tampa Bay from 1972 – 2010 (Figure 26) show an overall increase in the Effective Light Penetration (i.e. greater Secchi depth) since the late 1970’s across all four bay segments. The apparent decrease seen during the mid to late 1970’s may be due to increased dredging activity during that period. The Secchi depth ranged from 0.1 – 9.1 meters with a median of 1.5 meters. The greatest recorded reading was in Lower Tampa Bay at Station 95 in January 1976. The annual average Secchi depths met or exceeded the TBEP target levels for Hillsborough Bay, Middle Tampa Bay and Lower Tampa Bay for most years since the mid-1980’s with a few exceptions during high rainfall years (Figure 26). Old Tampa Bay, however, consistently did not meet its target Secchi depth (Figure 26). This may be due to generally high chlorophyll levels possibly caused by nutrient loading in that part of Tampa Bay.

Secchi depths at the tributary stations tended to be much lower relative to the bay stations due to the greater influence from runoff and higher turbidity and color characteristics of these systems. During the 2001-2010 monitoring period, Secchi depths ranged from 0.1 – 3.5 meters with a median of 0.8 meters. The greatest measurement occurred in the Alafia River at Station 179 in December 2010.The historical Secchi depths from the tributary stations did not differ appreciably from the current monitoring period and also had a median of 0.8 meters. The deepest Secchi depth record for the tributary sites was >4 meters recorded at Station 110 in the Palm River in June 1988.

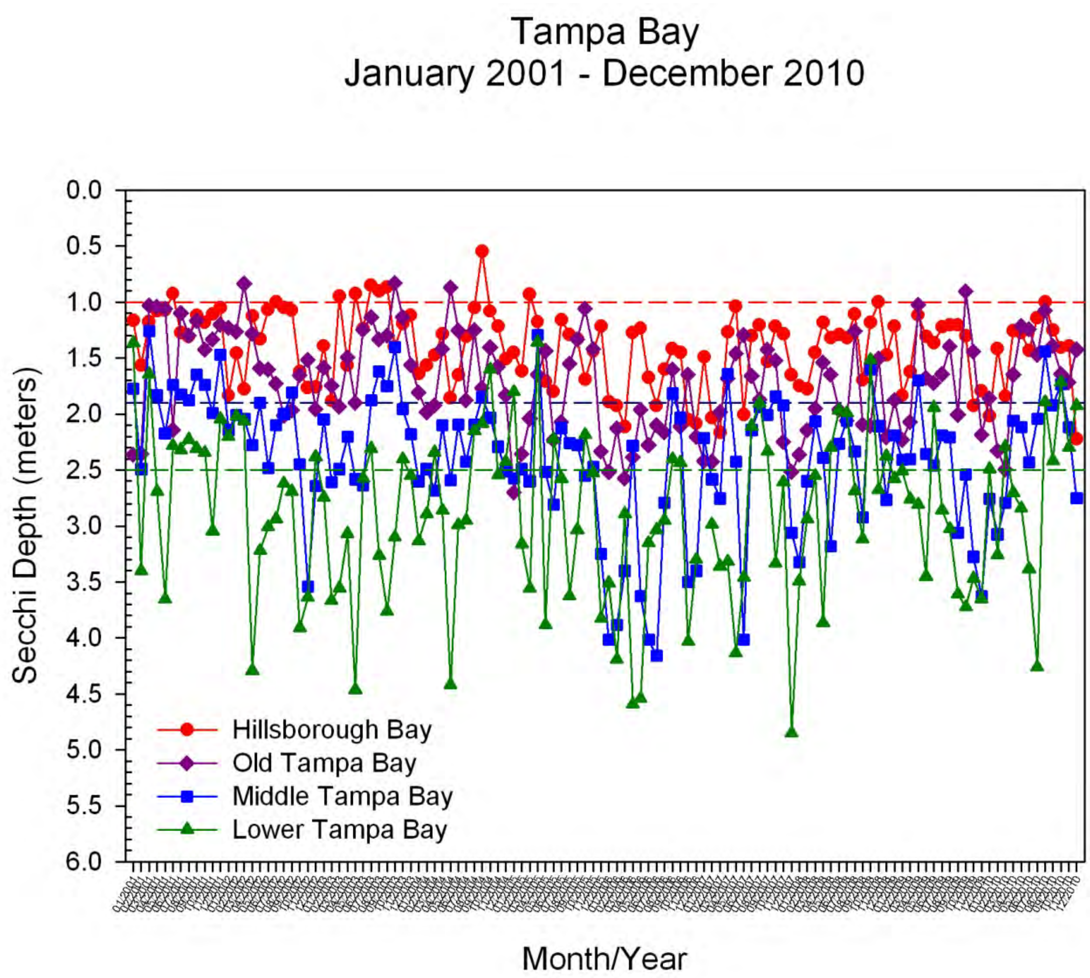


Figure 25. Monthly average Secchi depth by bay segment January 2001- December 2010 (note reverse scale on Y axis to represent depth below surface). Dashed lines indicate water clarity targets for Hillsborough Bay (red), Old and Middle Tampa Bay (blue) and Lower Tampa Bay (green) as set by the Tampa Bay Estuary Program (Janicki and Wade 2000).

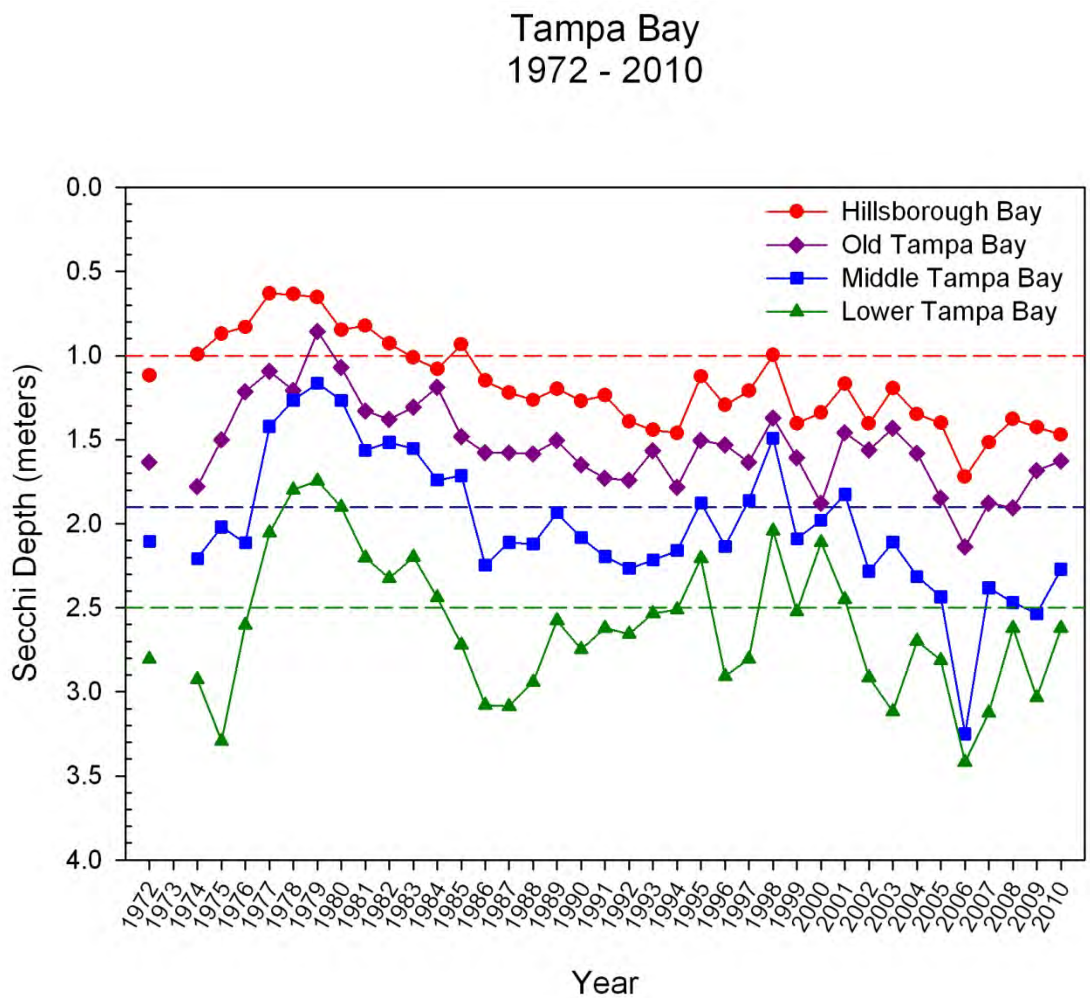


Figure 26. Annual average Secchi depth by bay segment (note reverse scale on Y axis to represent depth below surface). Dashed lines indicate water clarity targets for Hillsborough Bay (red), Old and Middle Tampa Bay (blue) and Lower Tampa Bay (green) as set by the Tampa Bay Estuary Program (Janicki and Wade 2000).

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Chapter 4

NUTRIENTS

Introduction

Nutrients are chemical compounds found in nature which are essential for the growth of all organisms. These substances may also be enhanced artificially through the use of chemical fertilizers used to promote plant growth in agriculture and horticulture. Nutrients can be further classified as macronutrients or micronutrients depending on the quantity required to by organisms to maintain proper growth. Macronutrients include phosphorus, nitrogen, carbon, silica, hydrogen and oxygen. Micronutrients include elements required in trace amounts by organisms to maintain proper metabolism. These are typically found in higher concentrations in the environment than is required by organisms.

Of the macronutrients, phosphorus, nitrogen and silica are often at levels in the environment below what is required by plants (algae and plankton) and are referred to as limiting nutrients. These may be artificially increased through the use of fertilizers. When excess fertilizers are washed into aquatic systems through stormwater runoff, the increased nutrient load can result in an over production of plankton or macroalgae often referred to as an algal bloom. The condition where there is an excessive level of nutrients in a water body is called eutrophication. This excessive growth of algae can have negative environmental impacts such as increased turbidity and water color reducing the penetration of light to the bottom and inhibiting the growth of seagrass. High nutrient levels may also cause blooms of toxic plankton species which can result in fish kills and shellfish poisoning. Blooms of macroalgae and nuisance floating vegetation such as *Hydrilla* can impede navigation and clog waterways resulting in flooding or smother bottom habitat. When the excess vegetation dies off, the decomposition of the plant material can cause reduced dissolved oxygen resulting in fish kills, foul odors and sedimentation.

This chapter will focus on the monitoring results for the three limiting nutrients phosphorus, nitrogen and silica.

Phosphorus

Phosphorus is utilized by organisms as the primary form of metabolic energy and it is also an important structural component of DNA and for skeletal structures and shells in many animals. Plants take up phosphorus as the inorganic molecule orthophosphate (PO_4^{3-}), which in turn is passed up through the food web. When plants and animals die, the phosphate incorporated in their tissues is released back into the environment through bacterial decomposition. The released phosphate is then either recycled through the food web or deposited in the bottom sediments. Large natural deposits of phosphate are found locally and support the large phosphate mining and fertilizer industry in the Tampa Bay region. Because of these deposits the natural background concentration of phosphate in Tampa Bay is relatively high compared to other estuarine systems.

Phosphate is also present in human and animal waste and high concentrations can be an indication of sewage effluent or runoff from livestock pastures. Accidental releases of industrial process water from phosphate mining and fertilizer processing facilities can also cause high concentrations of orthophosphate and total phosphorus. One such incident occurred in September 2004 when Hurricane Francis caused a dyke to fail at a wastewater pond on top of a phosphogypsum stack near Gibsonton releasing 65 million gallons of acidic wastewater into Archie Creek and out into Hillsborough Bay.

The EPCHC monitoring program processes samples for both dissolved orthophosphate and for total phosphorus. Total phosphorus is a measure of both dissolved and particulate inorganic orthophosphate and organic phosphoric compounds.

During the 2001-2010 monitoring period, the concentration of orthophosphate at the Tampa Bay monitoring stations ranged from 0.005 – 8.79 mg/L with a median concentration of 0.070 mg/L (Table 8; Figure 27). The highest value occurred in September 2004 at station 44 in Hillsborough Bay. This was also the second highest value on record in the EPCHC monitoring database. Orthophosphate levels were elevated at all of the Hillsborough Bay stations that month due to the acidic wastewater release caused by Hurricane Francis.

Historically since 1973 there has been a large decrease in orthophosphate in all 4 bay segments with minor peaks in 1998 and 2004 corresponding to an El Niño year and Hurricane Francis respectively (Figure 28). During this period orthophosphate ranged from 0.005 – 42.5 mg/L with a median value of 0.115 mg/L (Table 8). Concentrations were consistently lowest in Lower Tampa Bay and Old Tampa Bay and highest in Hillsborough Bay. The highest recorded value occurred at station 8 near the mouth of the Alafia River in March 1975.

The orthophosphate concentrations at the tributary monitoring stations ranged from 0.005 – 13.33 mg/L during the 2001-2010 monitoring period with a median value of 0.160 mg/L. Orthophosphate levels were typically low at station 102 (Channel A, Old Tampa Bay tributary) and at Station 118 on Lake Thonotosassa. The highest reading was at station 154 on English Creek in eastern Hillsborough County. This creek is near the Coronet Industries phosphate plant which accounts for the consistently high phosphate values observed at this station.

The highest historic orthophosphate measurements occurred in December 1997 at station 115 on the north prong of the Alafia River (138.73 mg/L) and at station 114 on the Alafia River at Bell Shoals Road (122.11 mg/L). These elevated values correspond with a processing water spill that occurred on December 7, 1997 at the Mulberry Phosphate facility in Mulberry, Florida. This incident released approximately 50 million gallons of acidic process water from a containment pond into the north prong of the Alafia River and resulted in a large fish kill and wetland damages downstream towards Hillsborough Bay.

Table 8 Tampa Bay 1972 - 2010 annual median, minimum and maximum nutrient values.

Year	OrthoPO4		Total P		NH3		Kjehdl N		Nitrate		Nitrite		NOx		Organic N		Total N		Silica	
1972	.		.		.		.		.		.		.		.		.		.	
	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1973	.		.		.		.		.		.		.		.		.		.	
	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1974	1.17		1.20		0.16		0.33		0.010		.		.		0.22		.		.	
	0.05	4.10	0.12	5.67	0.02	2.05	0.02	2.10	0.000	1.000	.	.	.	.	0.08	1.23	.	.	.	.
1975	1.34		0.88		0.15		0.35		0.010		.		.		0.19		.		.	
	0.67	42.50	0.04	10.16	0.02	1.17	0.02	3.41	0.000	1.150	.	.	.	.	0.02	0.87	.	.	.	.
1976	0.84		0.70		.		0.19		0.010		.		.		.		.		.	
	0.54	3.10	0.02	8.20	.	.	0.02	1.64	0.000	0.530	.	.	.	.	.	.	.	.	.	.
1977	0.93		0.68		0.21		0.47		0.010		.		.		0.24		.		.	
	0.44	2.95	0.02	3.01	0.02	1.62	0.10	1.71	0.000	1.130	.	.	.	.	0.02	1.51	.	.	.	.
1978	1.18		0.83		0.02		0.02		0.020		.		.		0.09		.		.	
	0.43	5.59	0.02	5.77	0.02	1.27	0.02	1.40	0.000	1.340	.	.	.	.	0.02	0.98	.	.	.	.
1979	0.99		0.75		0.02		0.04		0.030		.		.		0.02		.		.	
	0.41	4.60	0.02	4.60	0.02	0.38	0.02	0.40	0.008	0.240	.	.	.	.	0.02	0.22	.	.	.	.
1980	0.62		0.61		0.03		0.75		0.030		.		.		0.63		.		.	
	0.24	1.95	0.04	2.29	0.02	0.74	0.02	2.76	0.008	0.480	.	.	.	.	0.02	2.53	.	.	.	.
1981	0.44		0.45		0.08		0.66		0.020		.		.		0.57		0.69		.	
	0.18	2.84	0.02	3.73	0.02	0.67	0.05	2.17	0.008	0.420	.	.	.	.	0.02	2.00	0.02	2.23	.	.
1982	0.30		0.40		0.05		0.65		0.020		.		.		0.56		0.66		.	
	0.14	0.88	0.05	3.10	0.02	0.44	0.05	2.49	0.008	0.530	.	.	.	.	0.02	2.44	0.07	2.62	.	.
1983	0.39		0.44		0.05		0.80		0.010		.		0.010		0.70		0.82		.	
	0.12	0.84	0.04	7.90	0.02	0.56	0.12	2.93	0.008	0.250	.	.	0.003	0.320	0.07	2.88	0.12	3.02	.	.
1984	0.29		0.40		0.06		0.92		.		.		0.010		0.84		0.94		.	
	0.15	0.56	0.02	3.03	0.02	0.54	0.15	1.89	.	.	.	.	0.003	0.270	0.11	1.71	0.15	1.92	.	.
1985	0.38		0.43		0.08		0.67		.		.		0.010		0.57		0.68		.	
	0.09	0.65	0.02	1.94	0.02	0.53	0.21	1.55	.	.	.	.	0.003	0.240	0.13	1.46	0.22	1.62	.	.

Year	OrthoPO4		Total P		NH3		Kjehdl N		Nitrate		Nitrite		NOx		Organic N		Total N		Silica	
1986	0.40		0.42		0.06		0.53		.		.		0.010		0.46		0.54		.	
	0.19	0.63	0.02	2.38	0.02	0.45	0.14	2.16	.	.	.	.	0.003	0.210	0.11	2.08	0.15	2.17	.	.
1987	0.39		0.41		0.08		0.93		.		.		0.010		0.80		0.94		.	
	0.21	0.89	0.02	2.45	0.02	0.72	0.08	3.02	.	.	.	.	0.003	0.350	0.02	2.75	0.09	3.03	.	.
1988	0.40		0.38		0.05		0.55		.		.		0.010		0.49		0.57		.	
	0.16	1.17	0.02	8.85	0.02	0.42	0.02	1.45	.	.	.	.	0.003	0.200	0.02	1.15	0.05	1.55	.	.
1989	0.41		0.38		0.05		0.65		.		.		0.003		0.59		0.66		.	
	0.23	0.79	0.02	1.08	0.02	0.53	0.10	2.42	.	.	.	.	0.003	0.190	0.02	2.26	0.11	2.43	.	.
1990	0.33		0.37		0.05		0.48		.		.		0.003		0.43		0.50		.	
	0.02	0.66	0.02	0.83	0.02	0.33	0.06	1.23	.	.	.	.	0.003	0.110	0.02	1.19	0.07	1.39	.	.
1991	0.26		0.30		0.03		0.47		.		.		0.003		0.44		0.48		.	
	0.02	1.52	0.02	1.96	0.02	0.72	0.02	1.57	.	.	.	.	0.003	0.230	0.02	1.56	0.02	1.62	.	.
1992	0.19		0.26		0.02		0.60		.		.		0.003		0.59		0.61		.	
	0.02	0.60	0.02	0.71	0.02	0.22	0.18	1.72	.	.	.	.	0.003	0.153	0.16	1.70	0.18	1.73	.	.
1993	0.17		0.25		0.02		0.69		.		.		0.003		0.68		0.69		0.29	
	0.02	1.52	0.02	1.78	0.02	0.21	0.07	1.53	.	.	.	.	0.003	0.322	0.02	1.53	0.07	1.72	0.02	3.87
1994	0.19		0.26		0.02		0.97		.		.		0.003		0.97		0.98		0.40	
	0.02	1.18	0.02	1.32	0.02	0.48	0.42	4.13	.	.	.	.	0.003	0.277	0.34	4.13	0.47	4.14	0.02	6.33
1995	0.19		0.26		0.02		0.71		.		.		0.004		0.71		0.81		1.12	
	0.02	0.77	0.02	0.90	0.02	0.13	0.35	2.02	.	.	.	.	0.003	0.039	0.35	2.02	0.40	2.03	0.06	8.14
1996	0.12		0.19		0.02		0.64		.		.		0.006		0.64		0.75		0.31	
	0.02	0.57	0.02	0.84	0.02	0.14	0.22	1.66	.	.	.	.	0.003	0.087	0.22	1.66	0.32	1.58	0.02	7.00
1997	0.13		0.21		0.02		0.62		.		.		0.016		0.60		0.71		0.59	
	0.02	0.90	0.02	1.16	0.02	0.32	0.04	2.03	.	.	.	.	0.003	0.234	0.04	1.87	0.11	1.38	0.02	5.72
1998	0.18		0.26		0.02		0.68		.		.		0.010		0.66		0.80		0.46	
	0.02	0.82	0.02	0.98	0.02	0.34	0.22	4.94	.	.	.	.	0.003	0.376	0.19	4.91	0.24	1.59	0.02	7.40
1999	0.07		0.13		0.03		0.58		.		.		0.003		0.54		0.58		0.55	
	0.02	0.44	0.02	0.58	0.02	0.23	0.28	1.26	.	.	.	.	0.003	0.108	0.26	1.24	0.32	1.10	0.02	9.93
2000	0.04		0.11		0.02		0.92		.		0.036		0.006		0.91		0.92		0.68	
	0.02	0.33	0.02	1.02	0.02	0.21	0.18	2.89	.	.	0.002	0.041	0.003	0.055	0.18	2.87	0.19	2.89	0.02	11.33

Year	OrthoPO4		Total P		NH3		Kjehdl N		Nitrate		Nitrite		NOx		Organic N		Total N		Silica	
2001	0.05		0.14		0.02		0.83		.		.		0.007		0.80		0.84		0.29	
	0.02	0.56	0.02	1.00	0.02	0.41	0.02	2.31	.	.	.	.	0.003	0.530	0.28	2.28	0.02	2.32	0.02	5.76
2002	0.08		0.14		0.02		0.75		.		.		0.007		0.72		0.76		0.46	
	0.04	0.31	0.06	0.62	0.02	0.24	0.27	1.76	.	.	.	.	0.003	0.081	0.24	1.73	0.28	1.77	0.02	6.00
2003	0.10		0.16		0.02		0.48		.		.		0.007		0.44		0.49		1.01	
	0.02	0.55	0.03	0.80	0.02	0.30	0.19	1.30	.	.	.	.	0.003	0.177	0.18	0.88	0.22	0.95	0.02	7.16
2004	0.08		0.13		0.02		0.46		.		.		0.004		0.45		0.47		0.78	
	0.02	8.79	0.02	8.67	0.02	0.94	0.02	1.92	.	.	.	.	0.003	0.163	0.02	3.50	0.02	2.08	0.03	8.76
2005	0.10		0.14		0.05		0.42		.		.		0.005		0.41		0.44		0.80	
	0.02	0.76	0.02	0.99	0.05	0.75	0.13	2.18	.	.	.	.	0.002	0.479	0.07	2.17	0.14	2.19	0.03	8.00
2006	0.078		0.150		0.027		0.387		.		.		0.007		0.356		0.399		1.135	
	0.005	0.548	0.012	0.835	0.003	0.463	0.030	1.454	.	.	.	.	0.003	0.149	0.019	1.437	0.030	1.454	0.057	7.000
2007	0.056		0.130		0.007		0.363		.		.		0.010		0.344		0.377		1.380	
	0.005	0.349	0.041	3.004	0.003	0.858	0.030	3.145	.	.	.	.	0.003	0.148	0.019	3.131	0.030	3.158	0.057	9.540
2008	0.062		0.129		0.008		0.393		.		.		0.013		0.379		0.406		1.210	
	0.005	0.453	0.018	0.808	0.003	0.103	0.030	1.777	.	.	.	.	0.003	0.147	0.019	1.760	0.030	1.797	0.160	6.560
2009	0.067		0.141		0.039		0.437		.		.		0.003		0.391		0.444		1.070	
	0.005	0.559	0.048	1.124	0.003	0.197	0.086	1.778	.	.	.	.	0.003	0.312	0.057	1.731	0.086	1.778	0.057	11.410
2010	0.058		0.126		0.041		0.432		.		.		0.003		0.386		0.437		0.900	
	0.009	0.381	0.040	0.732	0.003	0.280	0.031	2.660	.	.	.	.	0.003	0.121	0.031	2.599	0.031	2.750	0.029	4.860

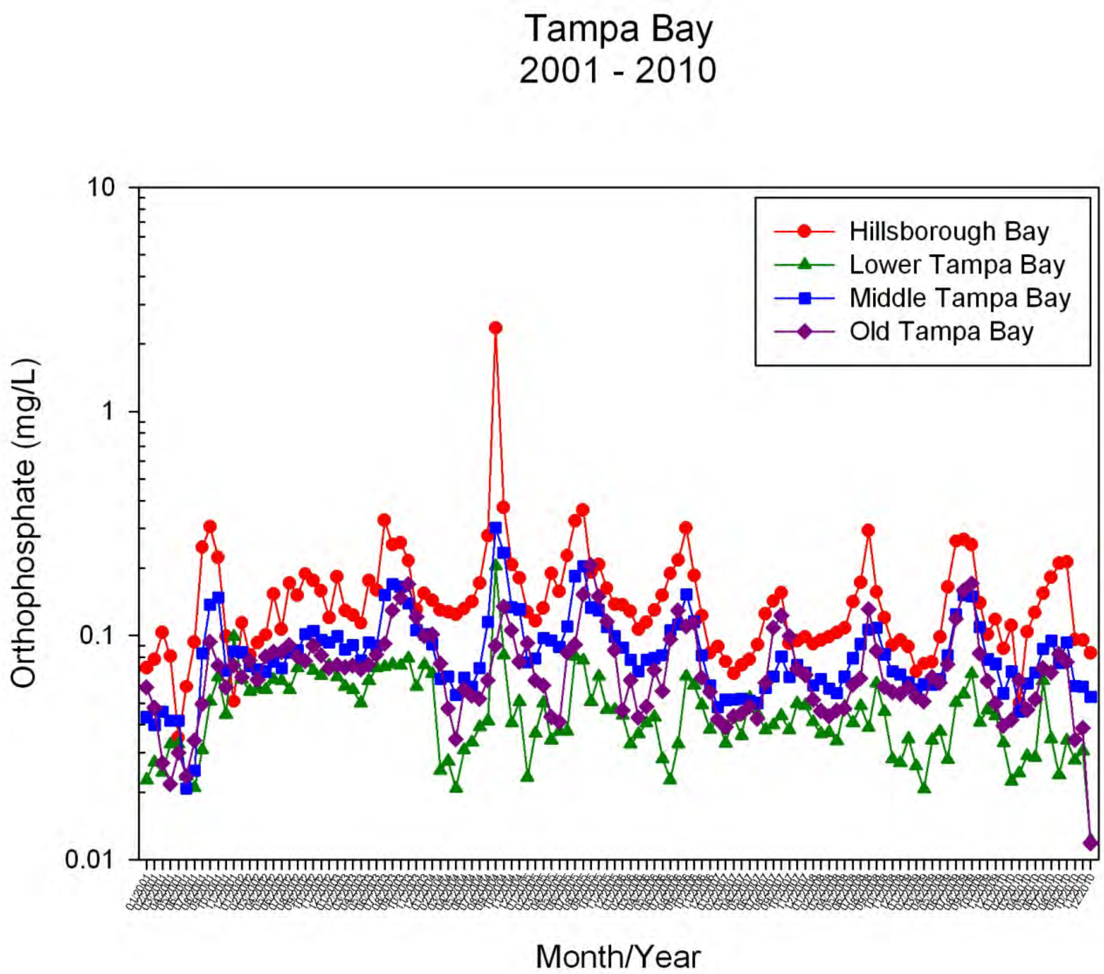

Figure 27. Monthly average orthophosphate by bay segment January 2001- December 2010.

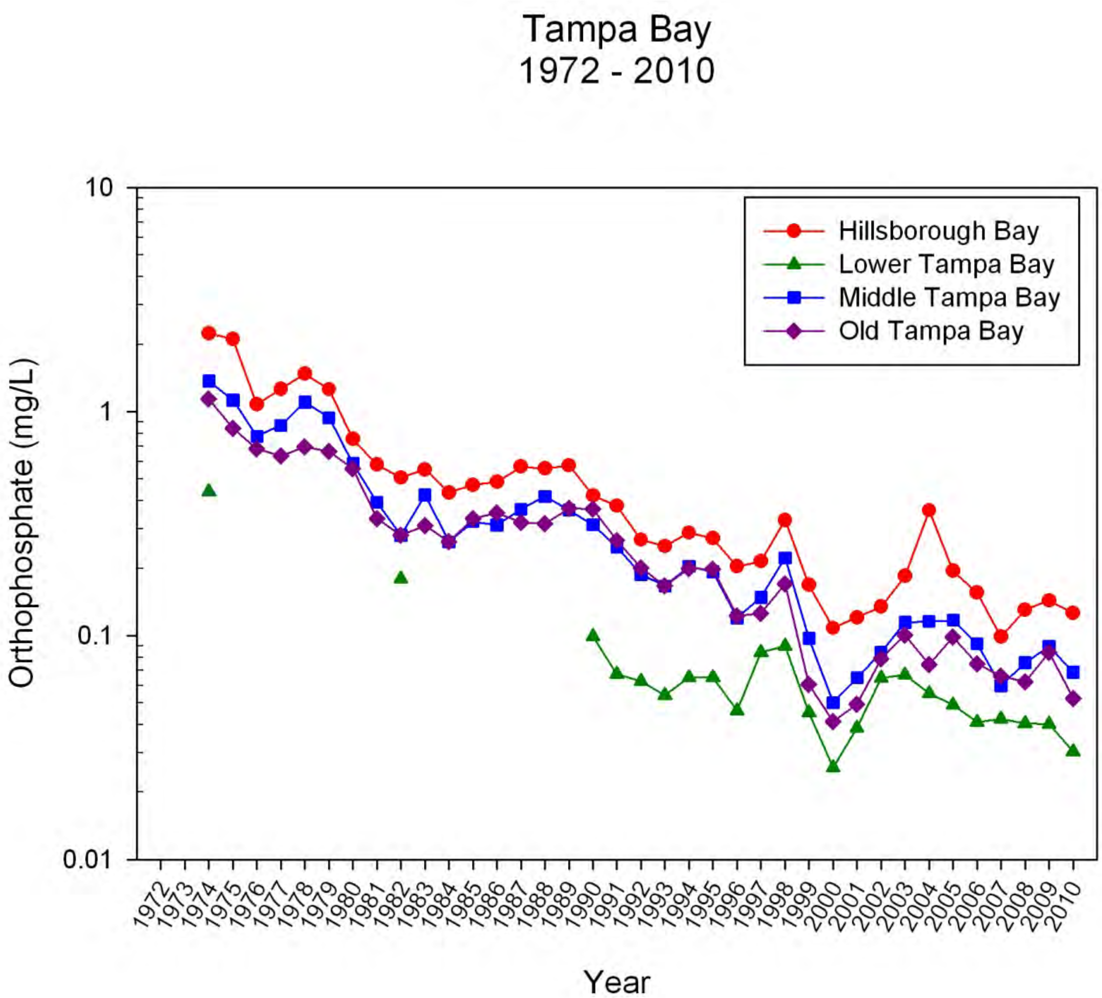

Figure 28. Annual average orthophosphate by bay segment.

Total phosphorus concentrations (TP) in Tampa Bay during the 2001-2010 monitoring period ranged from 0.012 - 8.67 mg/L with a median value of 0.14 mg/L (Table 8). The TP was typically lowest in Lower Tampa Bay and higher in Hillsborough Bay (Figure 29). The highest TP was recorded at station 44 in Hillsborough Bay near Bayshore Blvd in September 2004, corresponding to Hurricane Francis and the acidic wastewater spill at Archie Creek. Other high TP measurements that month were recorded at station 70 near Davis Island (6.17 mg/L) and station 6 near Ballast Point (4.95 mg/L). The occurrence of elevated TP at sites along the western side of Hillsborough Bay indicate that the plume from the spill had migrated across the bay possibly driven by prevailing easterly winds and storm surge.

Historic total phosphorus readings at the Tampa Bay stations ranged from 0.012 – 10.16 mg/L with a median of 0.26 mg/L. The highest value was recorded at Station 8 near the mouth of the Alafia River in June 1975 and concentrations are consistently high at this station due to the phosphate deposits and mining activities within the Alafia River drainage. Historic trends show a decrease in TP in all bay segments since the 1970's (Figure 30).

Total phosphorus at the tributary stations ranged from 0.012 – 19.52 mg/L during the 2001-2010 monitoring period with a median value of 0.25 mg/L. The TP values were typically lowest in the tributaries flowing into northern Old Tampa Bay and the highest recorded value was at station 138 on Delany Creek in June 2003. High concentrations were also consistently recorded at station 154 on English Creek and at several sampling stations on the Alafia River. Historically the median TP value is 0.38 mg/L and the highest concentrations on record were in December 1997 at station 114 on the Alafia River at Bell Shoals Road and at station 115 on the north prong of the Alafia River. These elevated values correspond with the December 7, 1997 Mulberry Phosphate spill discussed above.

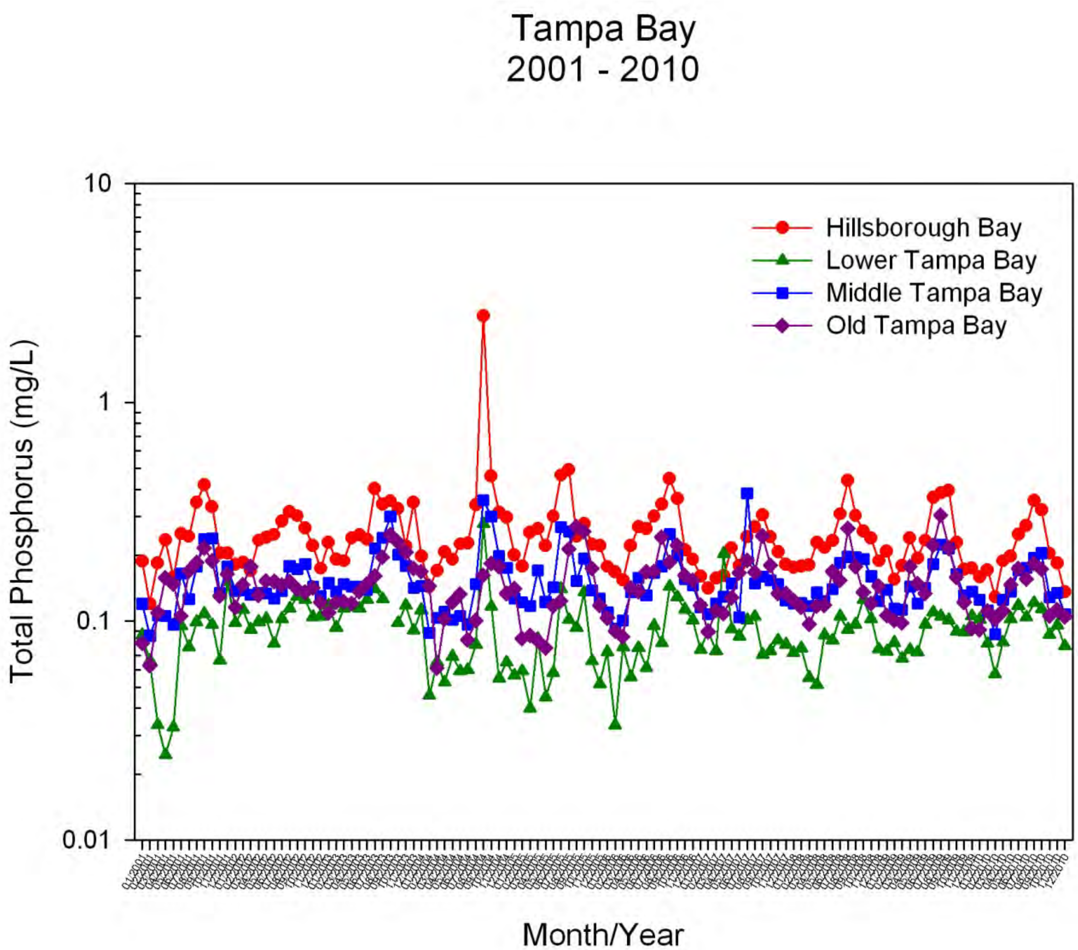

Figure 29. Monthly average total phosphorus by bay segment January 2001- December 2010.

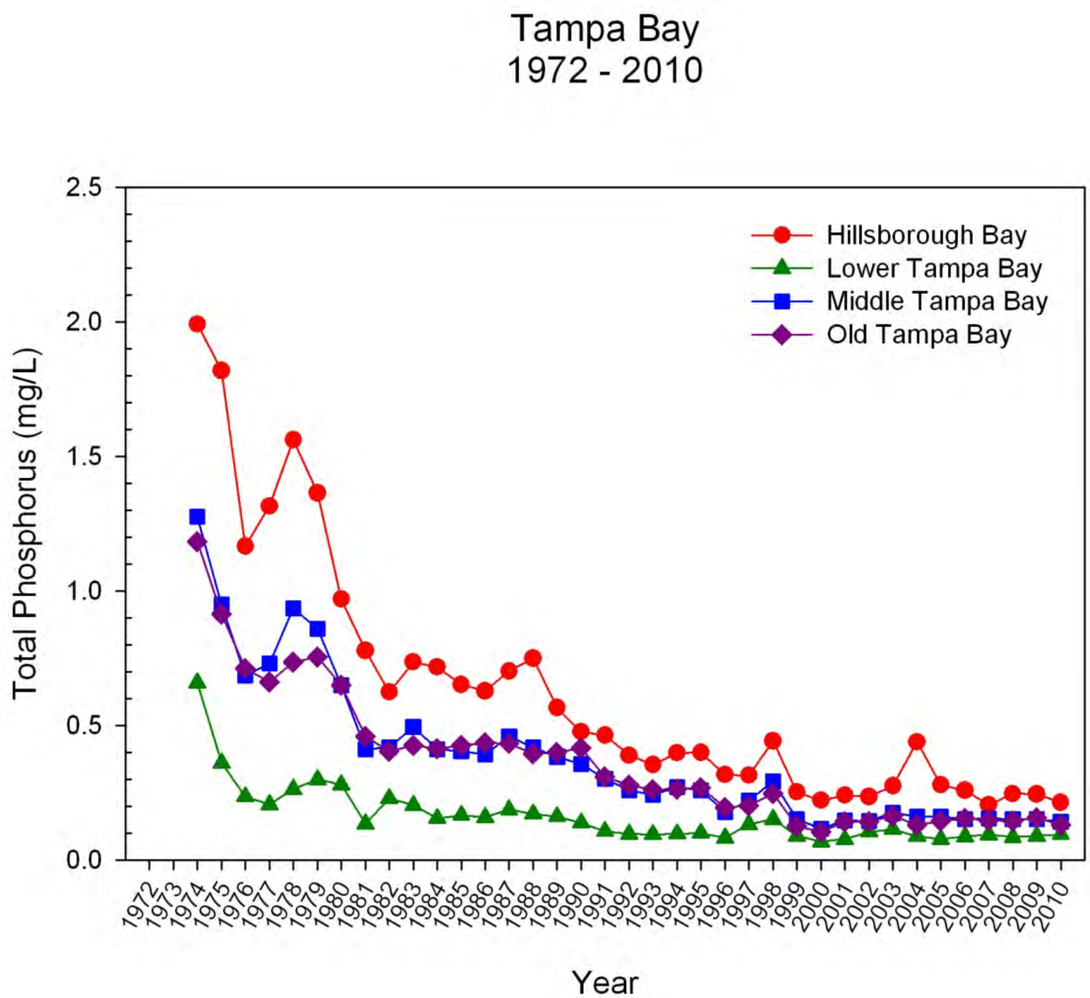

Figure 30. Annual average total phosphorus by bay segment.

Nitrogen

Nitrogen comprises 78% of the atmosphere as a diatomic gas (N_2). In this form nitrogen is inert and cannot be utilized by most organisms. However, nitrogen in other forms is an important nutrient and a limiting factor for biological productivity. Certain bacteria called cyanobacteria or commonly known as "blue-green algae" play an important role in converting N_2 into ammonia (NH_3) through a process called nitrogen fixation. Ammonia can be metabolized by other bacteria to form nitrite (NO_2^-) and then nitrate (NO_3^-) under aerobic conditions through a process called nitrification. It is in the form of NO_3^- that nitrogen can be taken up by phytoplankton and plants and enters the food web. All organisms use nitrogen in the production of amino acids and proteins. Nitrogen incorporated in these biological structures is referred to as organic nitrogen. Organic nitrogen can be released back into the environment through the decomposition of protein structures or excreted as a waste product in the form of urea. These organic forms of nitrogen can be further broken down by bacteria back into NH_3 and reenter the nitrogen cycle.

Since usable forms of nitrogen are found in relatively low concentrations in the environment it is considered a limiting nutrient. In the early 20th Century the Haber-Bosch process was developed which allowed for the industrial scale production of ammonia from atmospheric N_2. This allowed for the commercial development of synthetic fertilizers used to increase agricultural production and in lawn care products. The over application of these fertilizers however has had a negative environmental consequence when excess nitrogen enters surface waters and results in the over production of algae. This in turn can lead to reduced light penetration, blooms of toxic algae, and eventually to low dissolved oxygen and fish kills.

The EPCHC water monitoring program measures nitrogen as ammonia (NH_3), nitrite+nitrite (NOx), and total Kjeldahl Nitrogen (TKN). From these measured parameters organic nitrogen is calculated as TKN-NH_3 and Total Nitrogen (TN) is calculated as the sum of TKN + NOx.

Ammonia

Ammonia is formed either from atmospheric N_2 by bacterial nitrogen fixation or through the breakdown of organic nitrogen compounds such as urea and amino acids. In water ammonia forms the ion ammonium (NH_4^+). Commercially ammonia is a used in the production of fertilizers.

During the 2001-2010 monitoring period the ammonia concentrations at the Tampa Bay monitoring stations ranged from 0.003 – 0.940 mg/L with a median value of 0.020 mg/L (Table 8). The highest ammonia value occurred at Station 44 in September 2004 corresponding to Hurricane Francis. Figure 31 shows the monthly trends for ammonia in each of the four main segments of Tampa Bay from January

2001 – December 2010. There was a change in the minimum detection limits in the laboratory methodology used to measure ammonia during this time period which accounts for the horizontal lower limits seen on the graph from 1/2001-12/2004 and again from 1/2005-12/2005. The EPCHC lab switched to a more sensitive method with a much lower detection limit starting in 2006. There was an apparent decreasing trend in ammonia in all bay segments from 2001 to mid–2008 while concentrations have been increasing during the latter part of the reporting period.

Historical trends for ammonia in Tampa Bay show an overall decreasing trend with a large decrease during the 1980's to mid-1990's (Figure 32). The historical range for ammonia is 0.003 – 2.05 mg/L with a median value of 0.03 mg/L. Values were generally higher in Hillsborough Bay although the highest value on record was at station 13 in Middle Tampa Bay in October 1974.

Ammonia concentrations at the tributary stations ranged from 0.003 – 12.67 mg/L during the 2001-2010 monitoring period with a median value of 0.05 mg/L. The highest concentration was recorded at station 133 on Delany Creek at U.S. 41 in February 2004. Ammonia was consistently high at this site which is downstream from the Nitram, Inc. fertilizer manufacturing plant. Relatively high NH_3 concentrations were also recorded at stations 149 and 175 which are on tributaries flowing into Lake Thonotosassa.

Historic NH_3 levels at the tributary stations ranged from 0.003 - >915 mg/L with a median value of 0.063 mg/L. The highest recorded values were again at Station 133 in Delany creek during the late 1970's through the early 1980's. Improved operations at the Nitram, Inc. facility along with changes in land use within the Delany creek drainage have greatly reduced the ammonia levels since the early 1980's.

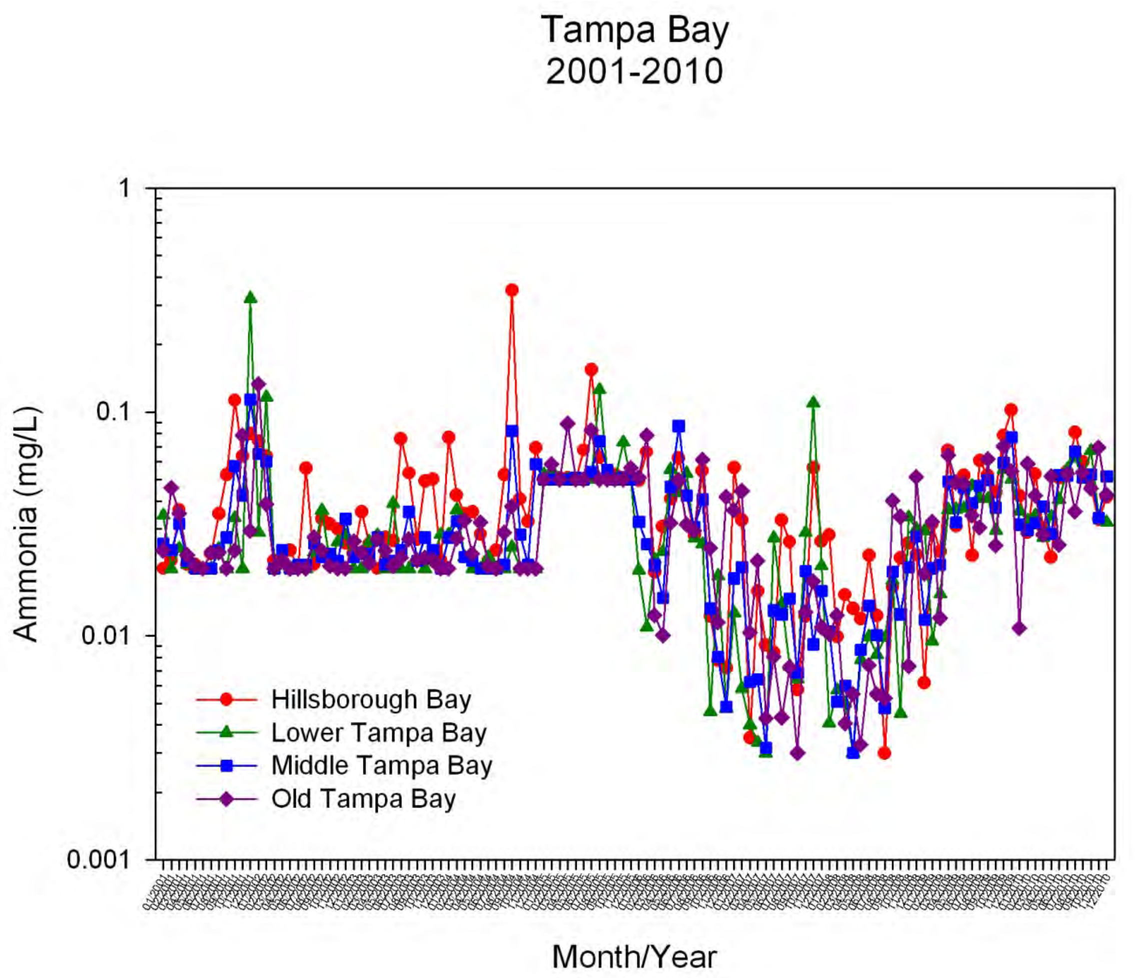

Figure 31. Monthly average ammonia by bay segment January 2001- December 2010.

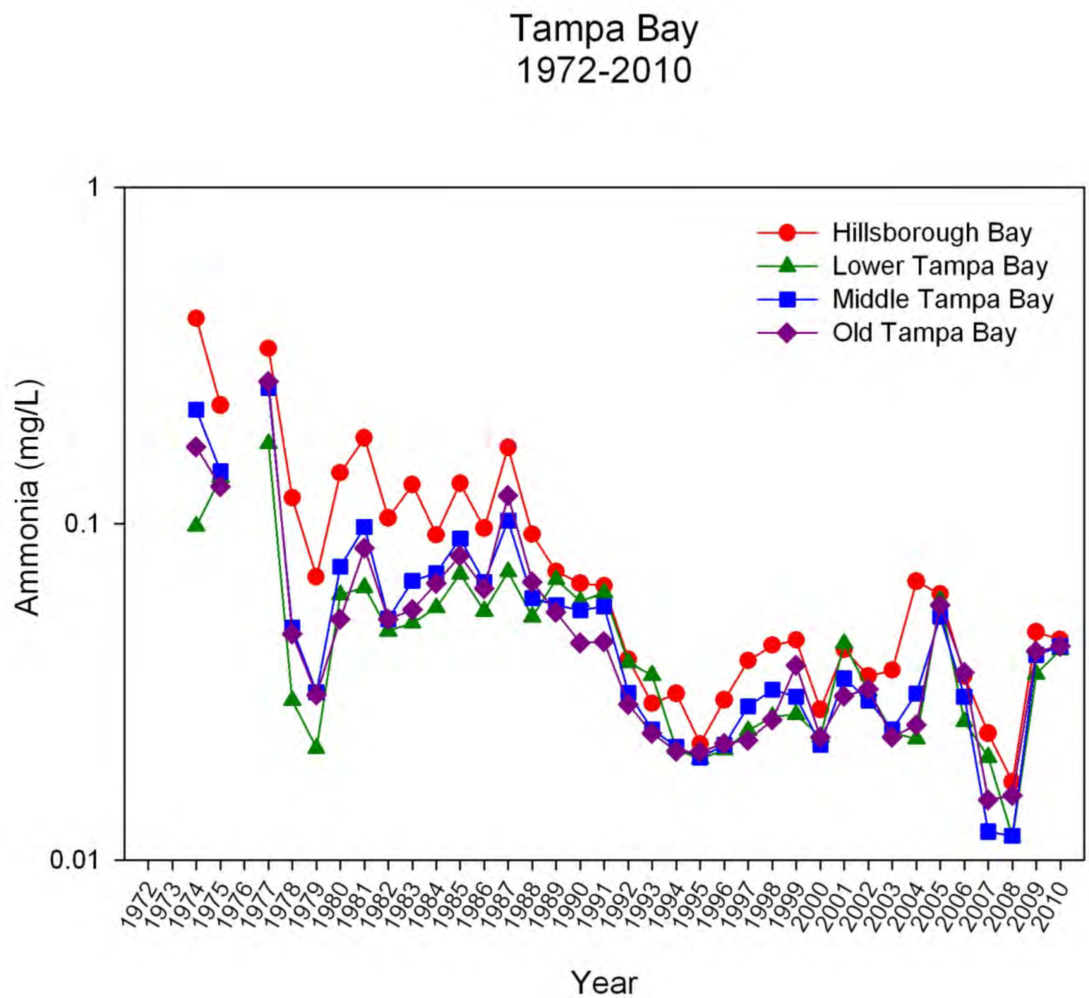

Figure 32. Annual average ammonia by bay segment.

Total Kjeldahl Nitrogen

Total Kjeldahl nitrogen (TKN) incorporates several nitrogen species excluding N_2 and NOx . The nitrogen forms incorporated in TKN are primarily from biological sources such as ammonia, urea, amino acids, polypeptides and proteins. High TKN values can be indicative high organic nitrogen loading from sewage or industrial pollution.

During the 2001-2010 monitoring period the TKN in Tampa Bay ranged from 0.02 – 3.145 mg/L with a median value of 0.460 mg/L. The highest TKN measurement was at station 14 in Middle Tampa Bay in July 2007. This station is located in the middle of MTB near the junction of the Cut F, Cut G and Gadsden Point Cut shipping channels and not close to any known nitrogen inputs which could account for this high TKN reading. There was an overall decreasing trend in the TKN in all four bay segments during the current monitoring period with a large apparent decrease between September – October 2002 (Figure 33). TKN was generally highest in Hillsborough Bay and Old Tampa Bay with peak values occurring during the summer wet season.

Historic TKN values ranged from 0.02 – 4.94 mg/L with a median of 0.55 mg/L. The highest value was recorded in June 1998 at station 19 in Middle Tampa Bay. Annual mean TKN values were generally highest in Hillsborough Bay and Old Tampa Bay. The apparent increase in TKN between 1979 and 1980 (Figure 34) was due to changes in the laboratory analytical equipment which greatly increased the accuracy and precision of the TKN values. Earlier TKN measurements prior to 1980 should therefore be interpreted cautiously. There has been an observed decrease in TKN across all bay segments since 2000 (Figure 34) and annual mean TKN values were actually highest in OTB and during this time period.

The TKN at the tributary monitoring sites during the 2001 – 2010 monitoring period ranged from 0.02-8.138 mg/L with a median value of 0.834 mg/L. The highest recorded value was in May 2006 at station 170 located in the Channel A tributary of Old Tampa Bay. High values were also measured consistently at station 133 on Delany Creek and in Lake Thonotosassa.

The historic measurements for TKN at the tributary monitoring stations ranged from 0.02 - >915 mg/L with an overall median value of 0.841 mg/L. The highest values were measured at station 133 in Delany Creek, with extreme values occurring throughout the late 1970’s. The high TKN was related to the high ammonia values also measured at this site.

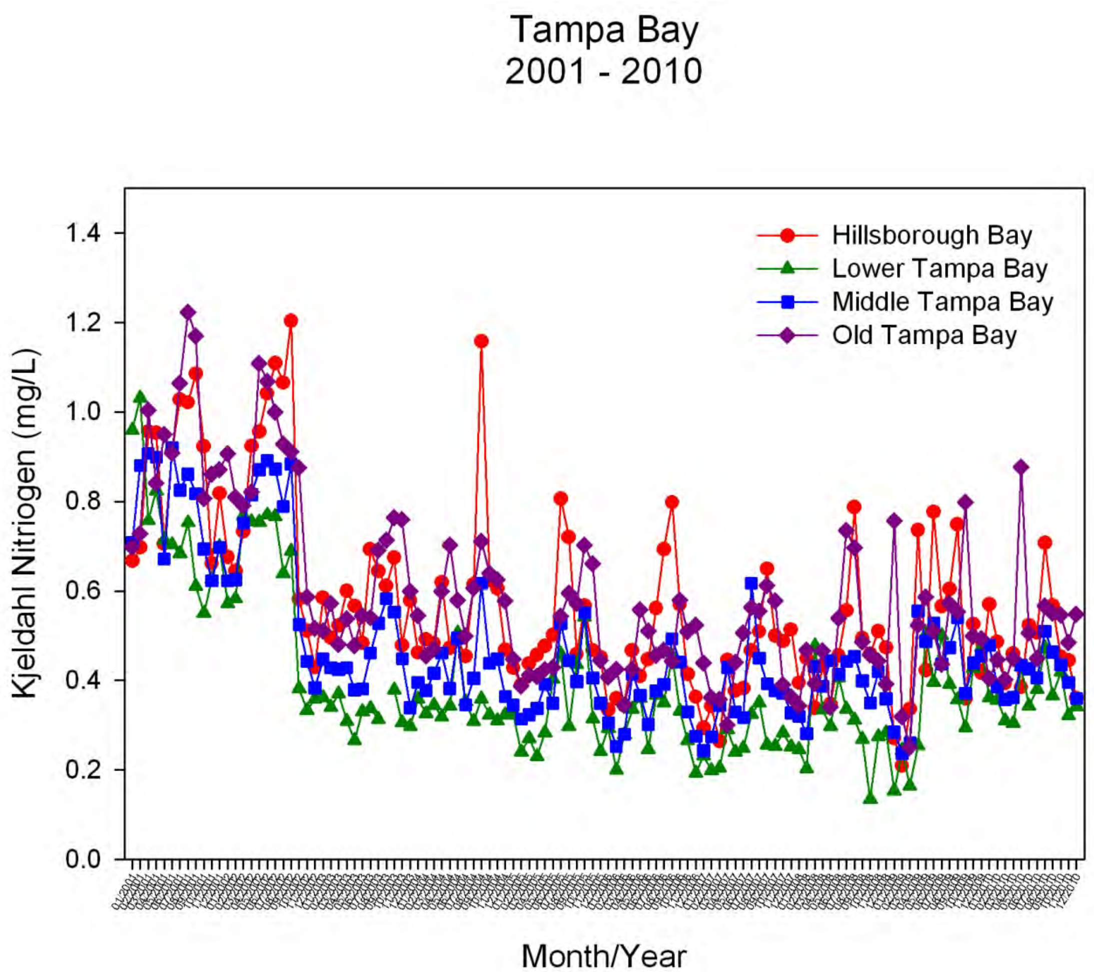

Figure 33. Monthly average total Kjeldahl nitrogen by bay segment January 2001- December 2010.

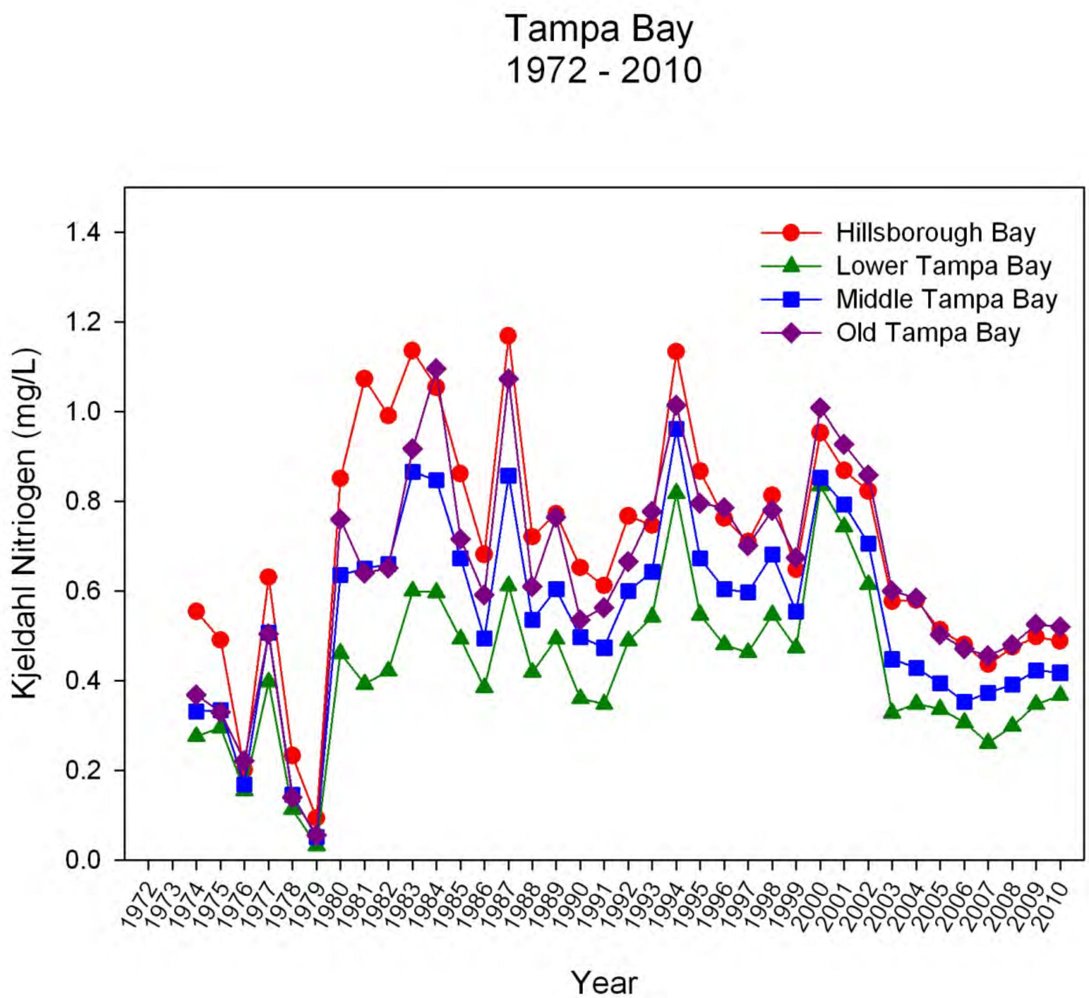

Figure 34. Annual average total Kjeldahl nitrogen by bay segment.

Organic Nitrogen

Organic nitrogen is calculated from the Total Kjeldahl Nitrogen minus ammonia and similarly represents nitrogen from biological sources. During the 2001-2010 monitoring period, the organic nitrogen values at the Tampa Bay stations ranged between 0.019 – 3.50 mg/L with a median value of 0.430 mg/L. The highest organic nitrogen was in July 2004 at station 16 in Middle Tampa Bay. This did not correspond to the same date or station of the highest TKN measurement but was during the same time of year (July) and in the same general vicinity of Middle Tampa Bay near the main shipping channel. Highest monthly mean values were in Hillsborough Bay and Old Tampa Bay and in the late summer months (Figure 35).

The historical range for organic nitrogen at the Tampa Bay sites was 0.019 – 4.91 mg/L with a median value of 0.51 mg/L. The highest value occurred in June 1998 at station 19 in Middle Tampa Bay which corresponded to the highest TKN record as well. Since TKN is a major component of organic nitrogen, the two parameters show similar trends over time and organic nitrogen values prior to 1980 are not considered to be reliable due to the changes in laboratory analysis for TKN mentioned above. Since 2000 the annual mean organic nitrogen has been showing a decreasing trend with similarly high values in Old Tampa Bay and Hillsborough Bay (Figure 36).

The organic nitrogen values at the tributary stations ranged from 0.019 – 11.25 mg/L during the 2001-2010 monitoring period with a median value of 0.752 mg/L. The highest value was at station 133 on Delany Creek in February 2004. High values were also found at station 170 (Channel A) and Lake Thonotosassa.

Historical values for organic nitrogen at the tributary sampling stations ranged from 0.019 – 143.62 mg/L with an overall median value of 0.745 mg/L. Station 133 on Delany creek consistently had high values including the maximum recorded in February 1987.

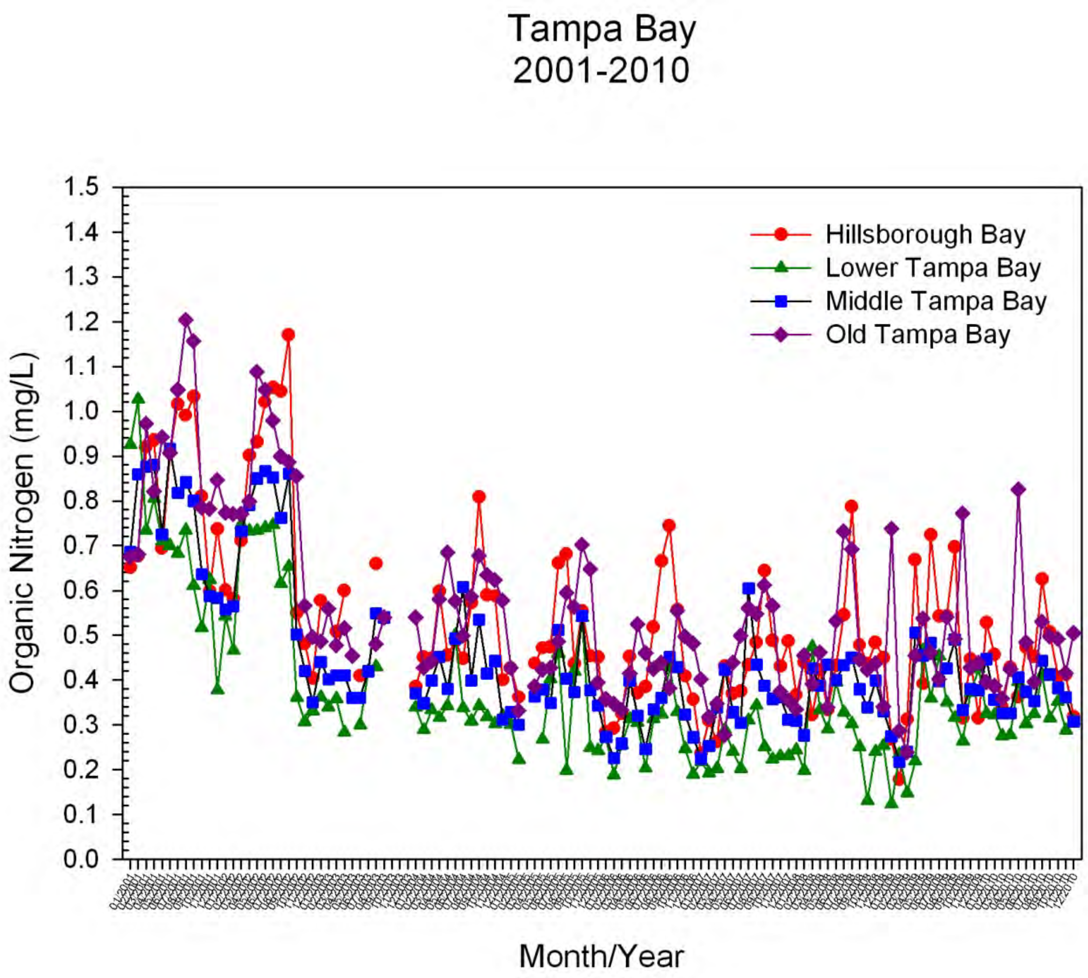

Figure 35. Monthly average organic nitrogen by bay segment January 2001- December 2010.

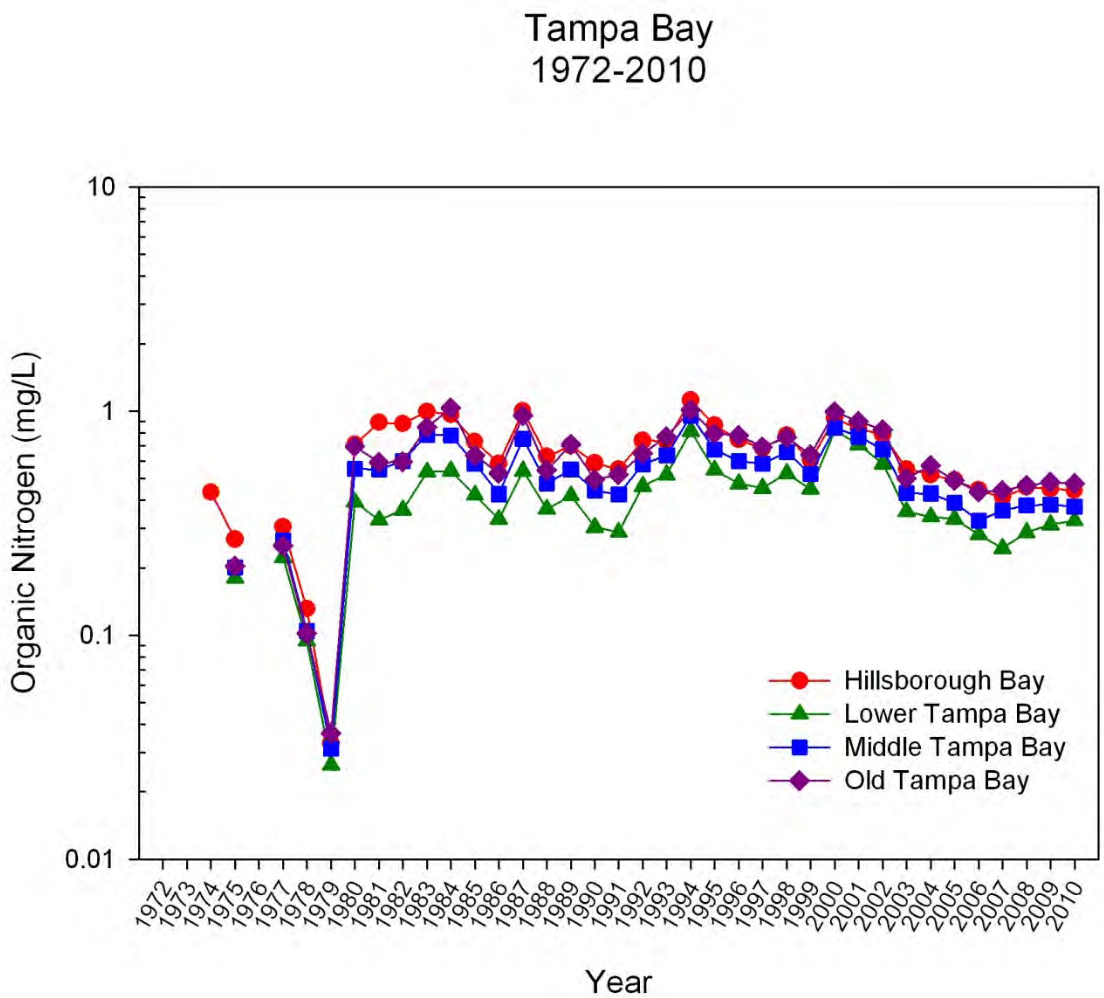

Figure 36. Annual average organic nitrogen by bay segment.

Nitrate + Nitrite (NOx)

Atmospheric nitrogen (N_2) is metabolized by some bacteria to form nitrate (NO_3) and nitrite (NO_2) through the process of nitrogen fixation. Other forms of nitrogen such as ammonia can also be converted to NO_2 and NO_3 through chemical or biological processes. These are oxidized, inorganic forms of nitrogen which are essential nutrients for living organisms. NO_3 + NO_2 are collectively referred to as NOx. Because NOx is an essential nutrient it is usually quickly assimilated by phytoplankton and the concentrations in the surface waters is generally low. High levels of NOx however can be an indication of industrial or domestic wastewater discharge or due to the runoff of synthetic fertilizers in stormwater.

During the 2001-2010 monitoring period the NOx concentrations at the Tampa Bay monitoring stations ranged from 0.002 – 0.53 mg/L with a median of 0.006 mg/L. The highest recorded value was at Station 8 near the Alafia River in September 2001 and levels were consistently high at this site. This may be due to the proximity of this station to the Mosaic fertilizer plant and the outflow from the Alafia River. The NOx concentrations were typically highest in Hillsborough Bay and showed a seasonal pattern with higher values during the summer wet season (Figure 37).

Historical EPCHC data for NOx goes back to 1982, prior to which the EPC laboratory analyzed samples for nitrates only. Those data prior to 1982 are not presented in this report. The NOx data shows a large decreasing trend during the early to mid-1980's, especially in Hillsborough Bay (Figure 38). This trend can be attributed to the conversion to an advanced wastewater treatment (AWWT) process at the City of Tampa's sewage treatment plant at Hooker's Point. The NOx levels were particularly high in 1998 due to the high El Niño rains experienced that year and again in 2004 because of Hurricane Francis (Figure 38).

The NOx concentrations at the tributary stations during the 2001-2010 monitoring period ranged from 0.002 – 35.074 mg/L with a median value of 0.155 mg/L. The highest level was recorded at station 143 on Blackwater Creek in July 2010. High concentrations were also consistently measured at station 133 on Delaney Creek and at station 111 on Turkey Creek at S.R. 60 in Valrico.

The historic NOx data at the tributary stations ranged from 0.002 – 106 mg/L with a median value of 0.176 mg/L. The highest value on record was again at the Delaney Creek site, station 133 in April 1983. Although NOx concentrations at this particular station have been consistently high due to the Nitram fertilizer plant upstream, improvements in pollution controls at this facility have dramatically reduced NOx levels over the years.

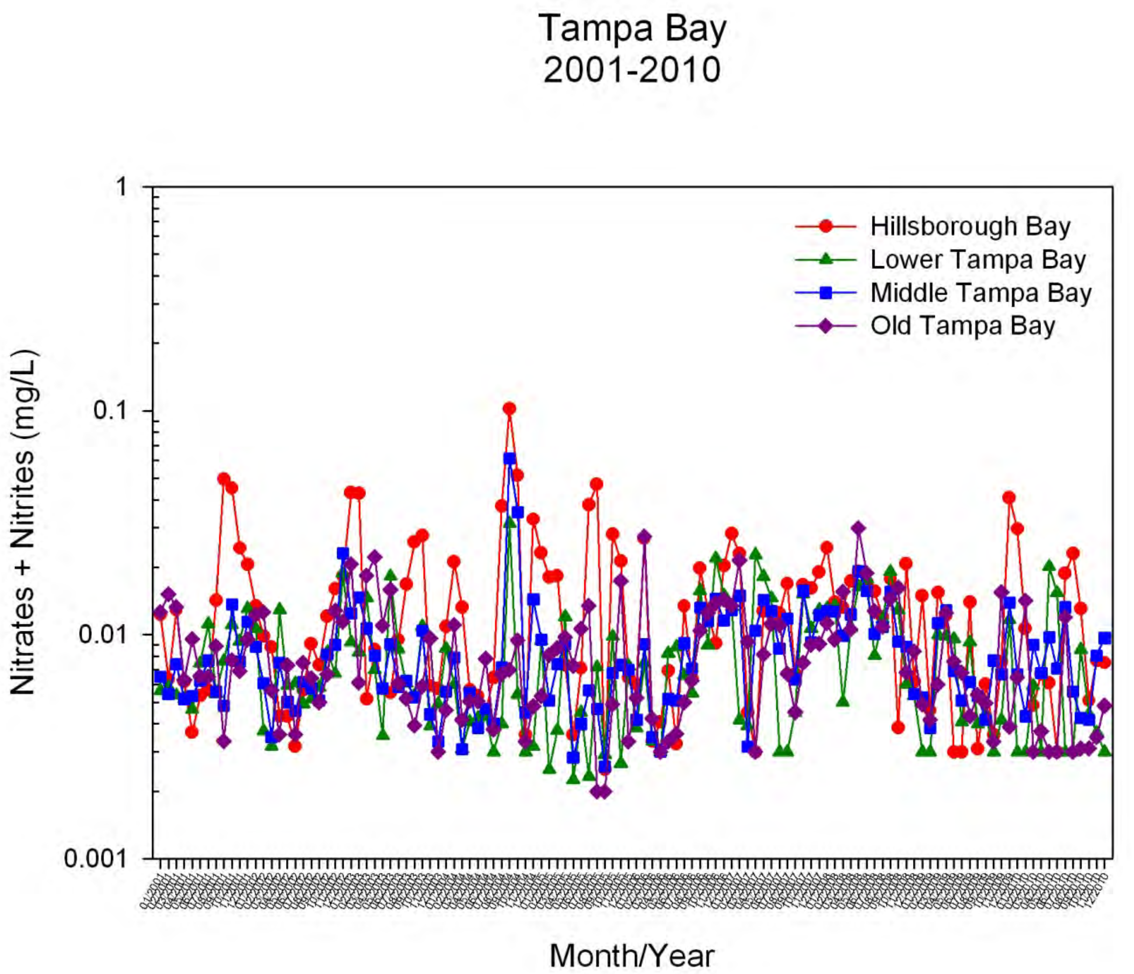

Figure 37. Monthly average nitrates + nitrites by bay segment January 2001- December 2010.

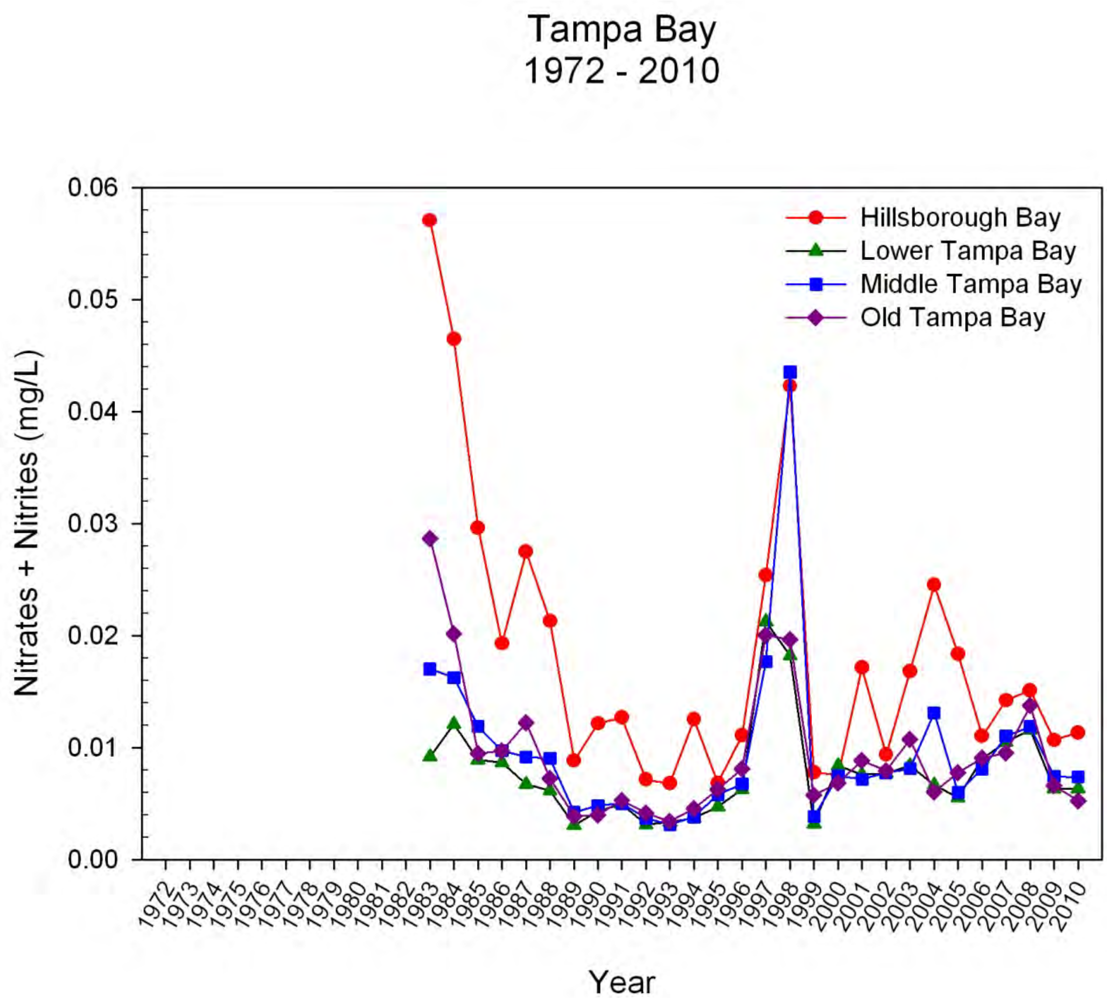

Figure 38. Annual average nitrate + nitrite by bay segment.

Total Nitrogen

Total nitrogen is calculated as the sum of TKN + NOx and encompasses all measured organic and inorganic nitrogen compounds. Since total nitrogen comprises the TKN and NOx values it typically follows similar trends over time.

During the 2001-2010 monitoring period, the total nitrogen values at the Tampa Bay stations ranged from 0.02 – 3.158 mg/L with a median value of 0.470. The highest value was at station 14 in Middle Tampa Bay in July 2007 and was associated with high TKN measurements at that location. Monthly means were highest in Hillsborough Bay and Old Tampa Bay and tended to be higher in the late summer months (Figure 39).

Historic total nitrogen values since 1980 have ranged from 0.02 – 4.14 mg/L with a median of 0.590 mg/L. The highest concentration on record was at station 70 in Hillsborough Bay near the southern point of Davis Island in October 1994. Total nitrogen has generally been highest in Hillsborough Bay and between 1980-2000 bay-wide values show several peaks during high rainfall years (Figure 40). Since 2000 the total nitrogen values have been decreasing in all bay segments (Figure 40).

Total nitrogen ranged from 0.03 – 37.412 mg/L at the tributary sites during the 2001-2010 monitoring period with a median value of 1.144 mg/L. The maximum value was at station 143 (Blackwater Creek) in July 2010 which corresponded to the maximum NOx record. Other consistently high records were observed in the Tampa Bypass Canal (station 147), Delany Creek (station 133), Turkey Creek (station 111) and Lake Thonotosassa (station 118).

Historic tributary values ranged from 0.03 – 310.6 mg/L with a median of 1.23 mg/L. The maximum value was recorded from station 133 in Delaney Creek in April 1983 which also corresponds to the highest NOx record.

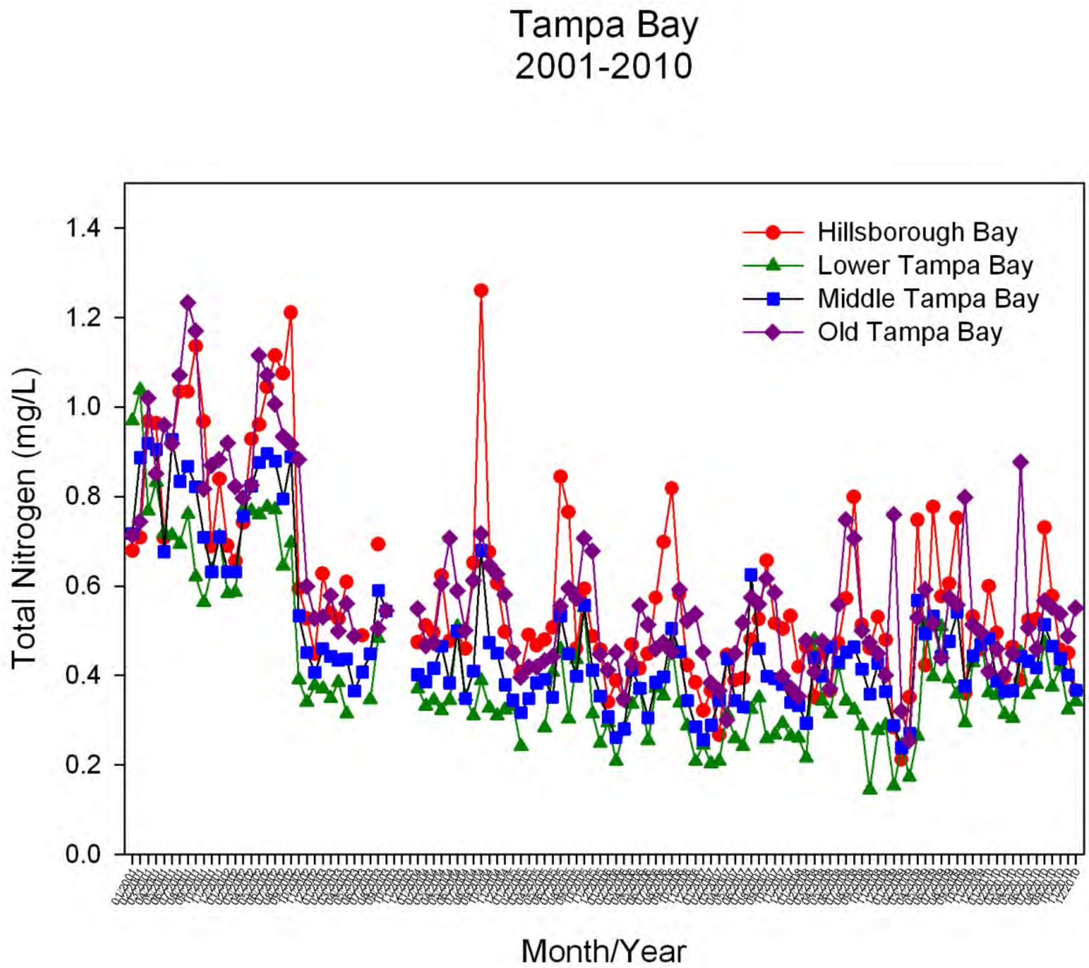

Figure 39. Monthly average total nitrogen by bay segment January 2001- December 2010.

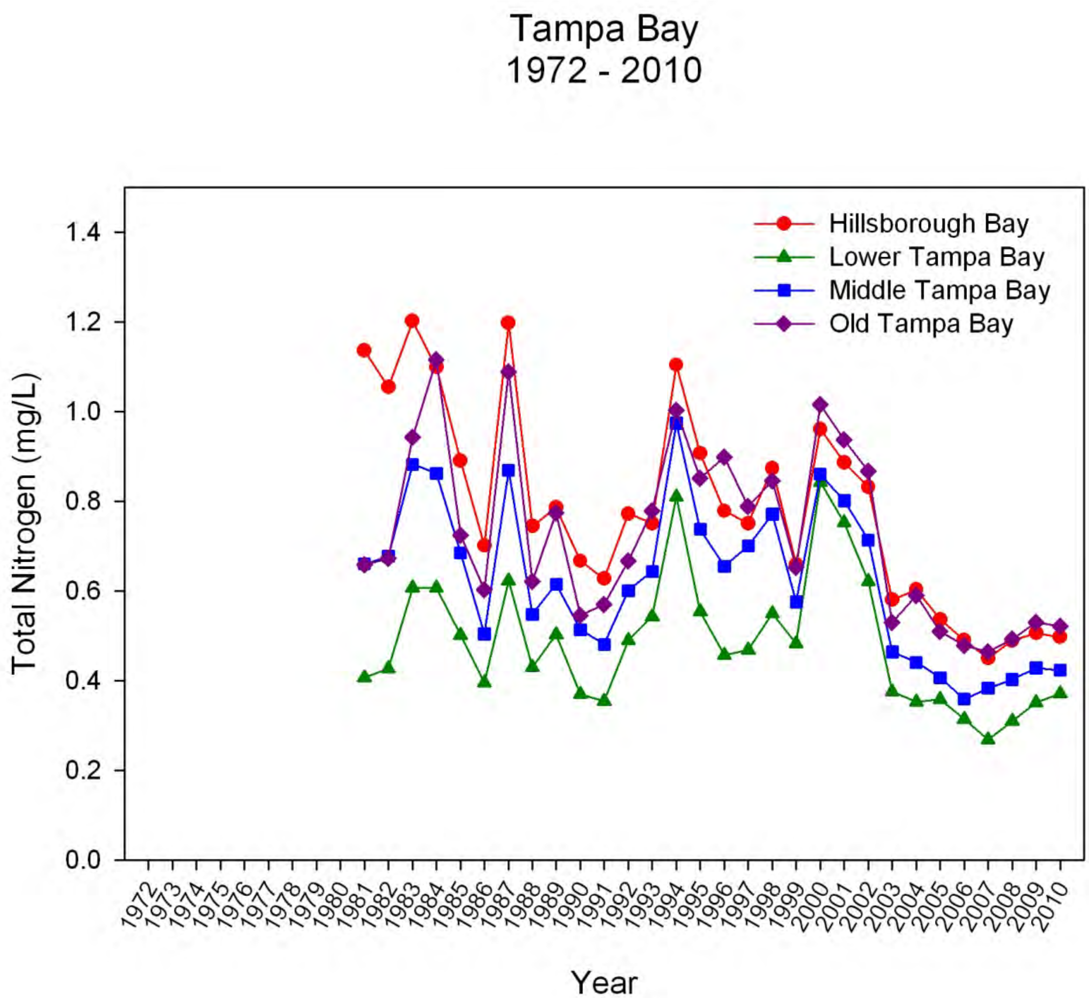

Figure 40. Annual average total nitrogen by bay segment.

Silica

Silica is an inorganic nutrient utilized by some phytoplankton such as diatoms for the formation of their cell walls. The main source of silica in Tampa Bay is from the weathering of silica based minerals (i.e. quartz) in rocks which ultimately enter surface waters through runoff. The dissolution of silica in the bay sediments, particularly from quartz sands is also a contributing source. Silica is also used in many construction materials and industrial processes which may also contribute to silica levels in surface waters. The EPCHC water monitoring program started measuring silica at the Tampa Bay stations in 1993 but it is not included in the parameters measured at the tributary sites.

During the 2001 – 2010 monitoring period the silica concentrations in Tampa Bay have ranged from 0.02 – 11.41 mg/L with a median value of 0.87 mg/L. Peak values were in Old Tampa Bay typically in September and October near the end of the wet season(Figures 41 & 42). The highest concentration was recorded at station 65 in Old Tampa Bay in August 2009. This is also the highest value recorded since 1993. Silica concentrations were consistently high at this site and also at station 47. Both stations are near major roadway bridges which suggest that stormwater runoff could be the causing the observed elevated silica levels at these sites.

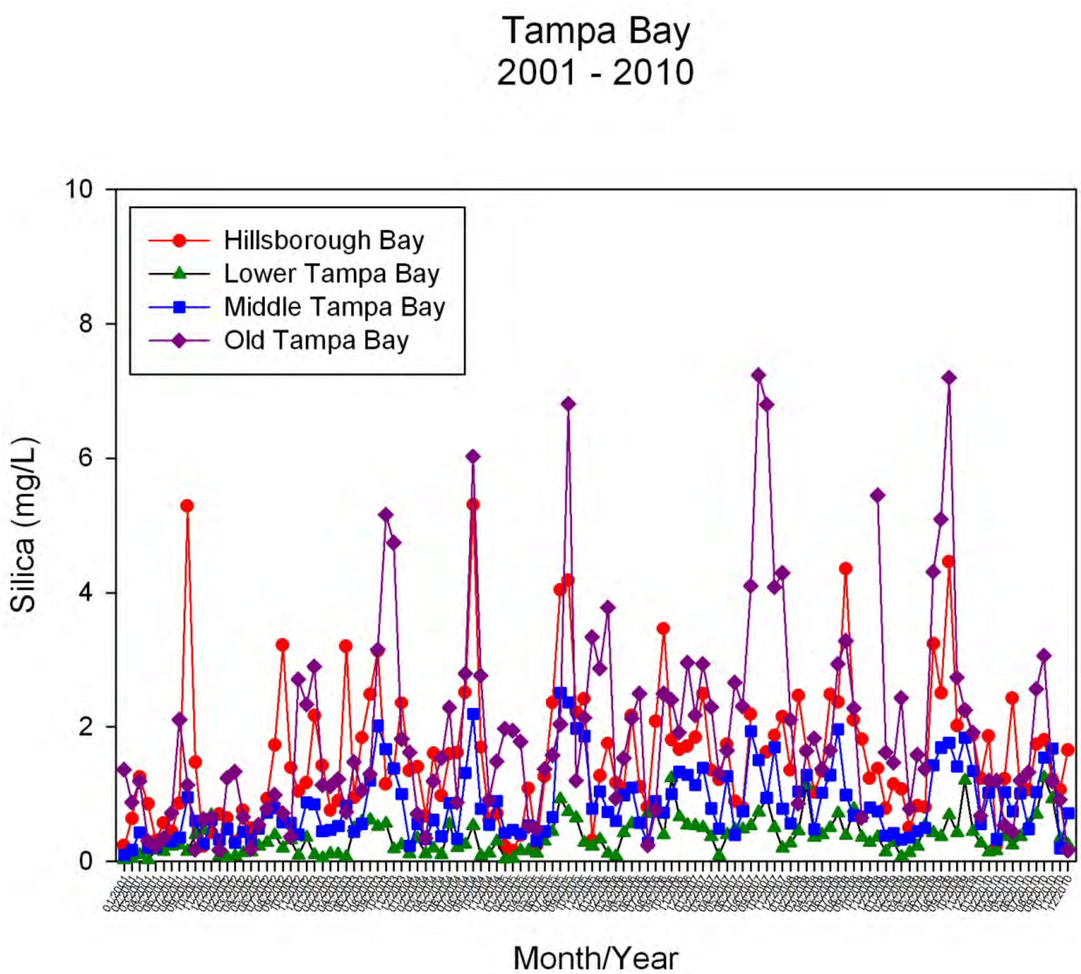

Figure 41. Monthly average silica by bay segment January 2001- December 2010.

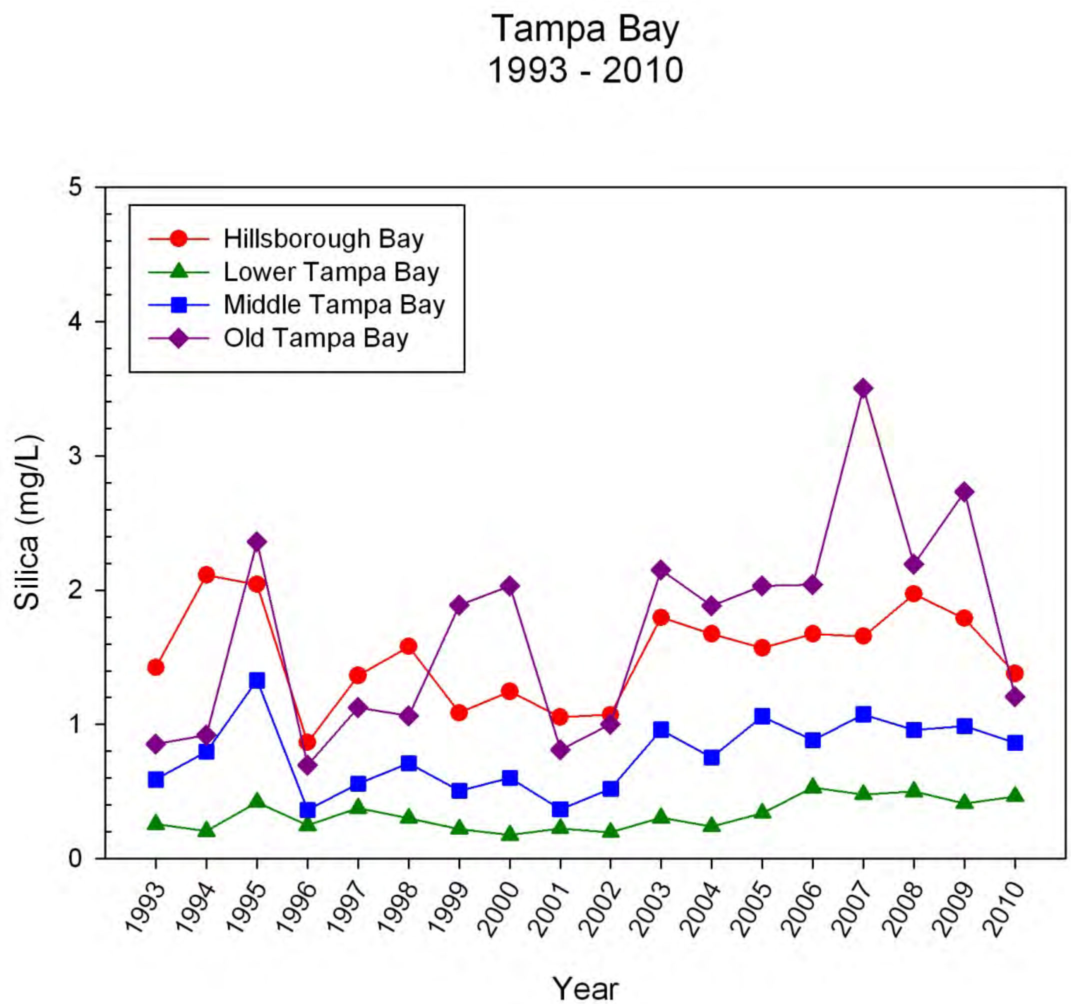

Figure 42. Annual average silica by bay segment.

Chapter 5

CHLOROPHYLL AND PHYTOPLANKTON

Chlorophyll refers to the green pigment algae and plants use to convert light, water and nutrients into food and oxygen through the process of photosynthesis. Chlorophyll consists of several different forms including chlorophyll a, chlorophyll b, chlorophyll c and pheophytin. The predominant form of chlorophyll used by aquatic plants for photosynthesis is chlorophyll a (Chl a). In aquatic systems, most photosynthesis is done by several diverse groups of single-celled microscopic algae collectively called phytoplankton. The phytoplankton are ecologically very important because they are the basis of the food chain in aquatic systems and they produce oxygen as a by-product of photosynthesis. Measuring the level of Chl a in the water then is used as a way to quantify the amount of phytoplankton. Phytoplankton can grow and reproduce rapidly when there is a high concentration of nutrients in the water (eutrophication). Chlorophyll a levels are therefore also a useful indicator of the nutrient conditions in a waterbody and a high concentrations of Chl a is an indication of eutrophic conditions. High chlorophyll levels can also directly impact water clarity and reduce the amount of sunlight available to seagrasses.

Chlorophyll a

Since Chl a is a good indicator of nutrient and plankton conditions its measurement has been used as the primary tool for assessing the overall health of the bay and tracking changes in the water quality condition over time. The Tampa Bay Estuary Program has established specific annual average Chl a target levels for each of the four bay segments based on the EPCHC monitoring data and calculating the relationship between chlorophyll concentration and water clarity requirements for seagrass growth . The set target levels are 13.2 µg/L in Hillsborough Bay, 4.6 µg/L in Lower Tampa Bay, 7.4 µg/L in Middle Tampa Bay and 8.5 µg/L in Old Tampa Bay (Janicki et al. 2000)..

During the 2001-2010 monitoring period the Chl a concentrations at the Tampa Bay monitoring stations ranged from 0.5 – 333.4 µg/L with a median concentration of 5.6 µg/L. The maximum value was recorded at station 63 in Old Tampa Bay in July 2009 and corresponds to a bloom of the dinoflagellate *Pyrodinium bahamense*. This is also the highest recorded Chl a measurement for an EPCHC bay monitoring site since the program began in the 1970's. The highest chlorophyll measurements were in Hillsborough Bay and Old Tampa Bay with peaks occurring in the late summer to early fall when plankton populations tended to be highest (Figure 43).

Historically, the Chl a concentration in Tampa Bay has been higher with a median value of 7.2 µg/L. Hillsborough Bay has had the highest annual mean values over the years, followed by Old Tampa Bay (Figure 44). There was a sharp decline in Chl a levels bay wide in the early to mid-1980's. This was most apparent in Hillsborough Bay and can be attributed to the conversion of the City of Tampa's sewage treatment plant at Hooker's Point to an advanced wastewater treatment (AWT) system. The chlorophyll levels in each bay segment has generally been at or below the target levels set by the TBEP since the late 1980s except for occasional peaks during high rainfall years and bloom events (figure 44). Old Tampa Bay however has consistently failed to meet its target chlorophyll levels and this remains to be an area of concern for bay restoration efforts.

Comparing the month to month trends in chlorophyll concentrations (Figure 45), the number of months per year which chlorophyll concentrations exceeded the annual target level has decreased in all bay segments. Historically (1972-2000) the monthly average Chl a level in Hillsborough Bay exceeded the annual target level 12 months of the year (Figure 45). During the 2001-2010 period, the mean monthly Chl a concentrations only exceeded the annual target level during four months during the peak wet season (July – October) and monthly averages were lower relative to the historic levels (Figure 43). A similar trend is also noted for Middle Tampa Bay, where historic chlorophyll levels exceeded the annual target nine months of the year but only in the wet season months during the past ten year period. Old Tampa Bay and Lower Tampa Bay both also had fewer months per year which exceeded their respective chlorophyll target levels. Both segments however had higher monthly average Chl a concentrations in the summer months during the 2001-2010 period relative to the historical baseline period (Figure 45).

The chlorophyll a levels at the tributary stations ranged between 0.3 (<MDL) – 2604.8 µg/L with the maximum value recorded at station 110 on the Palm River in July 2009. This was also the highest value on record in the EPCHC monitoring database. The median value during the 2001-2010 monitoring period was 4.8 µg/L which was slightly lower than the historical median value of 5.9 µg/L. The extremely high value recorded in the Palm River in July 2009 does not appear to be associated with a plankton bloom, although high numbers of the flagellate *Chattonella* sp. were recorded at this site in the following month. The high chlorophyll concentration may have been due to the release of water from the Tampa Bypass Canal just upstream of this station.

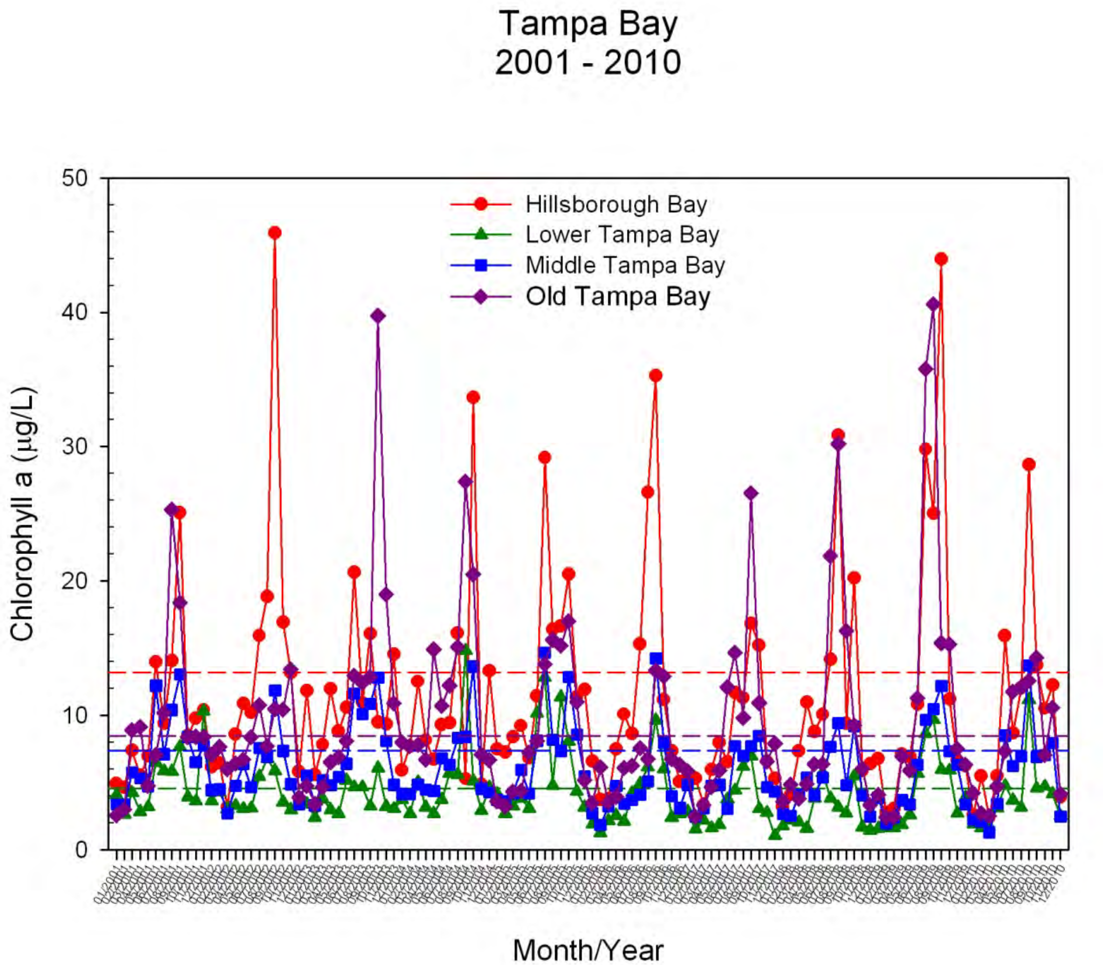

Figure 43. Monthly average chlorophyll a by bay segment January 2001- December 2010. Dashed lines represent TBEP bay segment specific chlorophyll a targets.

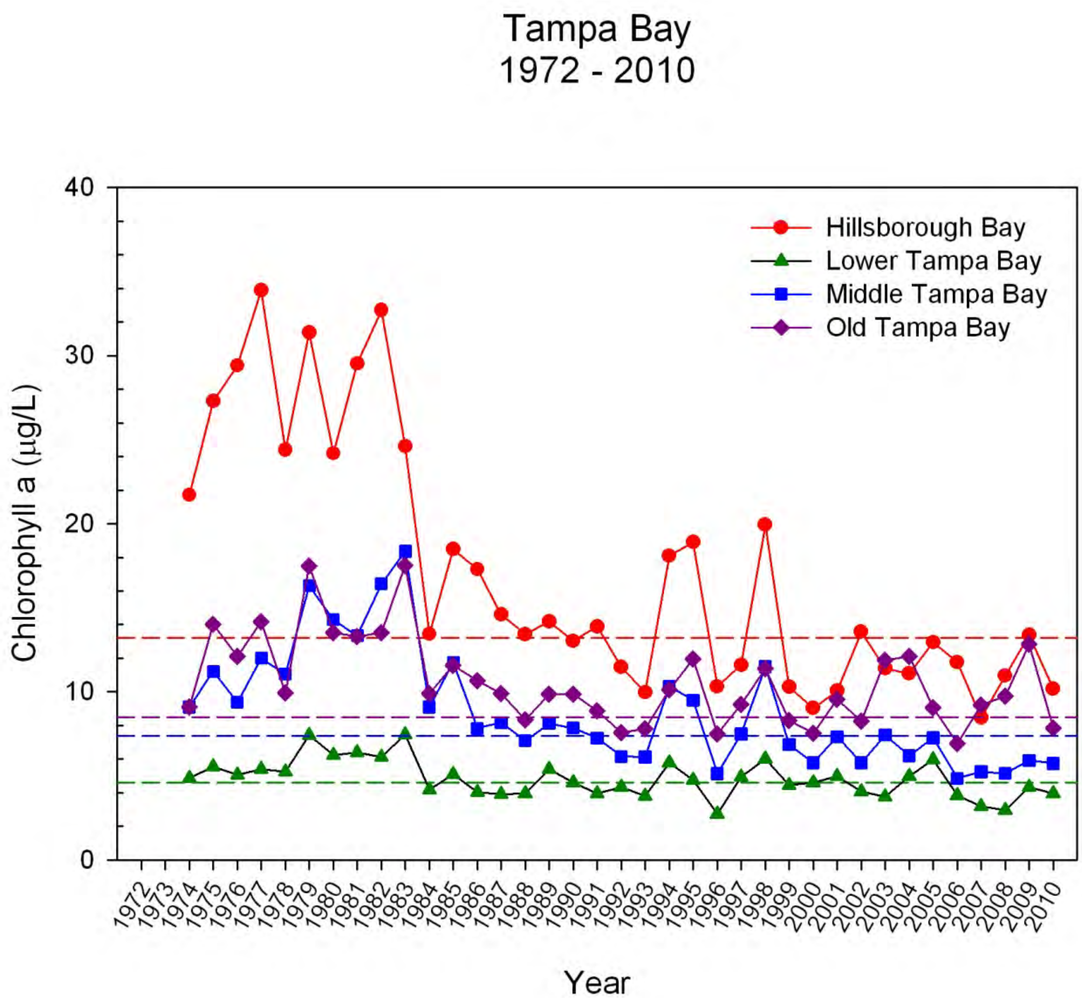

Figure 44. Annual average chlorophyll a by bay segment. Dashed lines represent TBEP bay segment specific chlorophyll a targets.

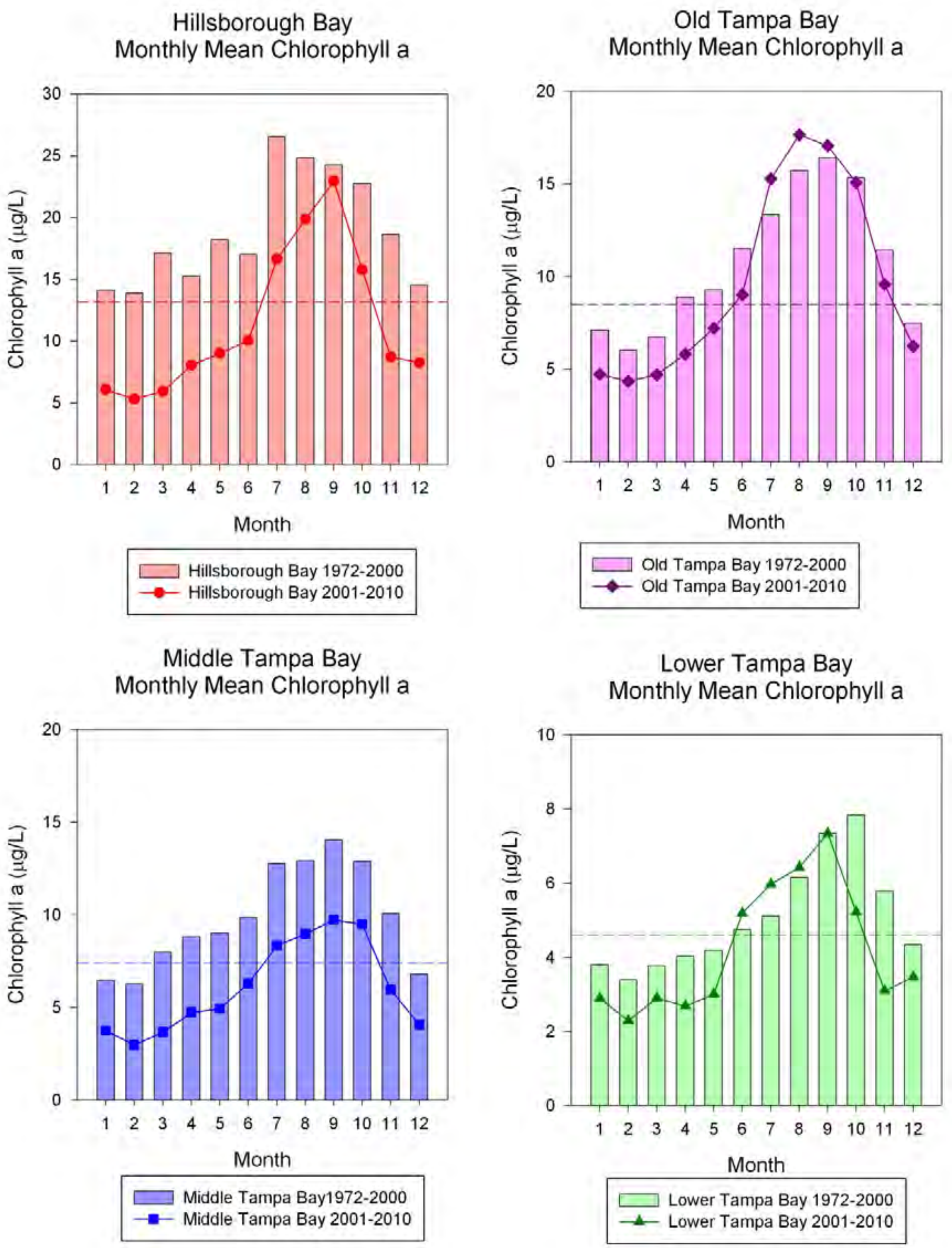

Figure 45. Monthly average chlorophyll a by bay segment; comparison of historic monthly averages (1972-2000) depicted as bar graph and monthly average during current reporting period (2001 – 2010) depicted as line graph. Dashed lines represent TBEP bay segment specific chlorophyll a targets.

Phytoplankton

Phytoplankton refers to several widely diverse groups of single celled, photosynthetic algae. The two dominate groups of phytoplankton are the diatoms and the dinoflagellates.

Diatoms (Figure 46) have an external cell wall composed of silica called a test. Diatomaceous earth, which is used as an abrasive in many products and as a filtering medium in water filters, is derived from the fossilized silica tests from ancient diatoms. Diatoms exist either as a single cell or often times as a chain of individual cells depending on the species. Diatoms have limited mobility and remain in the water column through increasing their buoyancy by producing oils and increasing the cell surface area through the production of spines, chaetae and other structures and through the formation of chains. The production of oils by diatoms has also made them a candidate for the production of algal biofuels.

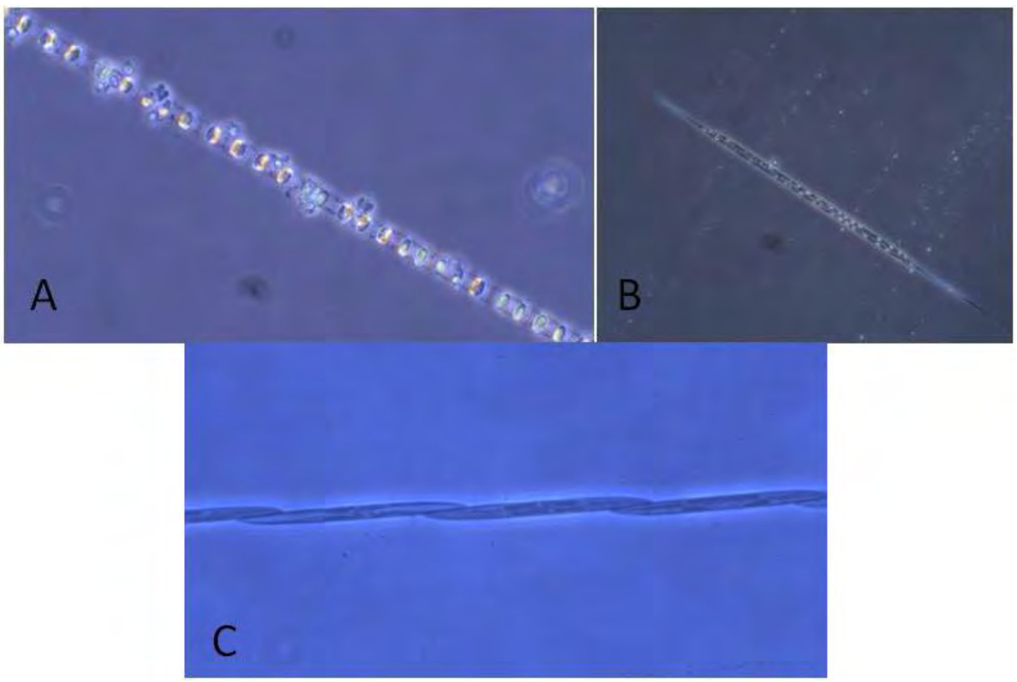

Figure 46. Three common diatom species from Tampa Bay: (A) *Skeletonema costatum*; (B) *Rhizosolenia setigera*; (C) *Pseudonitzshia cf. pungens*. A and C commonly form chains of multiple cells.

Diatom abundance tended to be highest in Hillsborough Bay and Old Tampa Bay, with peaks occurring throughout the year, and often during the dry season (Figure 47). Dates and contributing species of peak abundances (>500,000 cells/liter = 50/0.1 ml) for Hillsborough Bay and Old Tampa Bay are presented in Tables 9 and 10 respectively. The chain forming diatom *Skeletonema costatum* (Figure 46A) also reached abundances > 1,000,000 cell/Liter (100/0.1 mL) at several stations in Lower Tampa Bay (stations 25, 91, 96) and Middle Tampa Bay (stations 9, 19, 81, 84) in January and February 2009 respectively.

Historically, diatom abundance has been higher in Hillsborough Bay than in the other bay segments with wide fluctuations from year to year (Figure 48). A general observation has been that diatoms are proportionally dominant (relative to dinoflagellates) during the winter months and in Lower Tampa Bay.

Table 9. Hillsborough Bay 2001-2010 diatom peak counts.

Date (Stations)	Diatom Id	Count/0.1 mL	Estimated cells/liter
January 2001	Unid. Diatom	>50	>500 thousand
July 2002	Unid. Diatom	>150	>1.5 million
May 2003 (Sta. 8, 55)	Unid. Diatom	>150	>1.5 million
June 2003 (Sta. 8, 55, 71)	Unid. Diatom	>50	>500 thousand
July 2003 (Sta. 6, 7, 52, 54, 55, 58, 70, 71, 80)	Unid. Diatom	>50	>500 thousand
September 2007 (Sta. 8, 55, 71)	*Skeletonema costatum*	>50	>500 thousand
May 2009 (Sta. 8, 55, 71, 73)	*Chaetoceros* spp. + *Skeletonema costatum*	>150	>1.5 million
March 2010 (Sta. 6, 7, 8, 44, 52, 54, 55, 70, 73, 80)	*Skeletonema costatum*	>50	>500 thousand

Table 10. Old Tampa Bay 2001-2010 diatom peak counts.

Date (Stations)	Diatom Id	Count/0.1 mL	Estimated cells/liter
September 2001	Unid. Diatom	>150	>1.5 million
April 2003 (Sta. 61, 62)	Unid. Diatom	>50	>500 thousand
July 2004	*Rhizosolenia setigera*	>50	>500 thousand
August 2007	Unid. Diatom	>50	>500 thousand
September 2007	*Rhizosolenia setigera*	>50	>500 thousand
February 2008	Unid. Diatom	>50	>500 thousand
January 2009 (Sta. 65)	*Skeletonema costatum*	>50	>500 thousand
March 2009 (Sta. 36, 50, 65)	*Skeletonema costatum*	>50	>500 thousand
May 2009 (Sta. 61, 62)	*Skeletonema costatum* + *Pseudonitzshia cf. pungens*	>200	>2 million

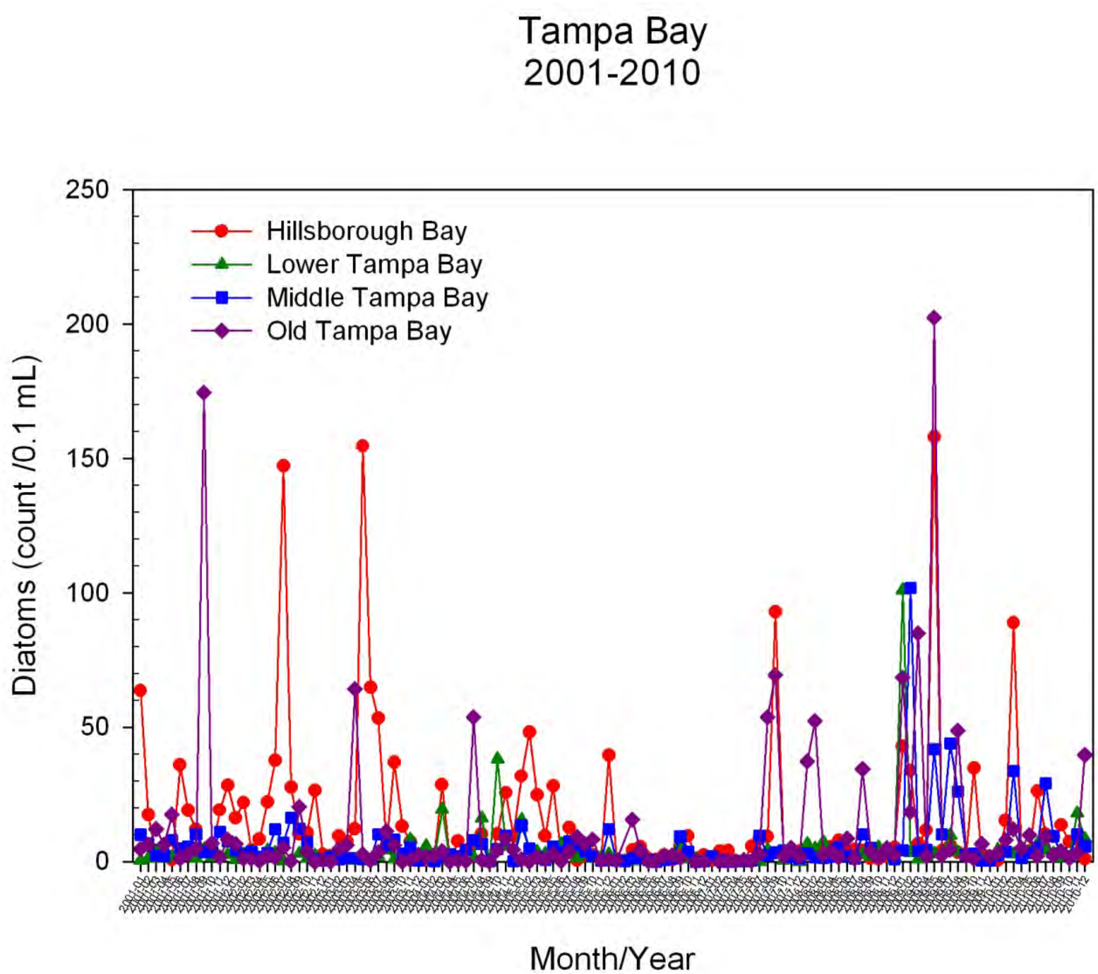

Figure 47. Monthly average diatom counts by bay segment January 2001- December 2010.

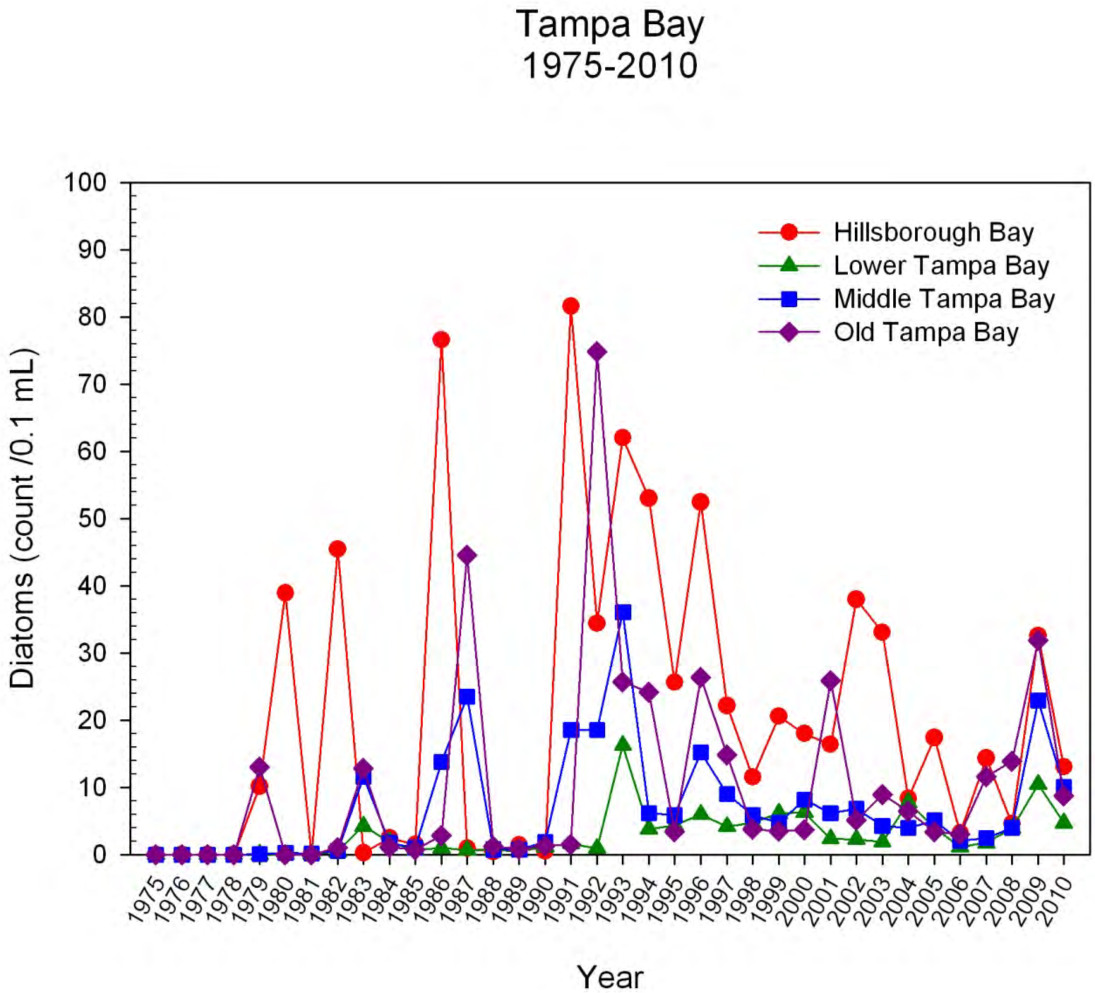

Figure 48. Annual average diatom count by bay segment.

Dinoflagellates (Figure 49) have cell walls composed of cellulose or other polysaccharides. The cells are motile and characterized by two flagella used for locomotion. The flagella are located within two perpendicular grooves in the cell wall. While most dinoflagellates are photosynthetic, many species can also be predators on other plankton. A few dinoflagellate species can produce toxins which can cause fish kills or which can accumulate in the tissues of fish and shell fish which directly or indirectly ingest the dinoflagellates. This in turn can result in sometimes fatal incidences of food poisoning in humans when these toxins are found in seafood. Several toxic or potentially toxic species of dinoflagellates are found in Tampa Bay and these will be discussed further below.

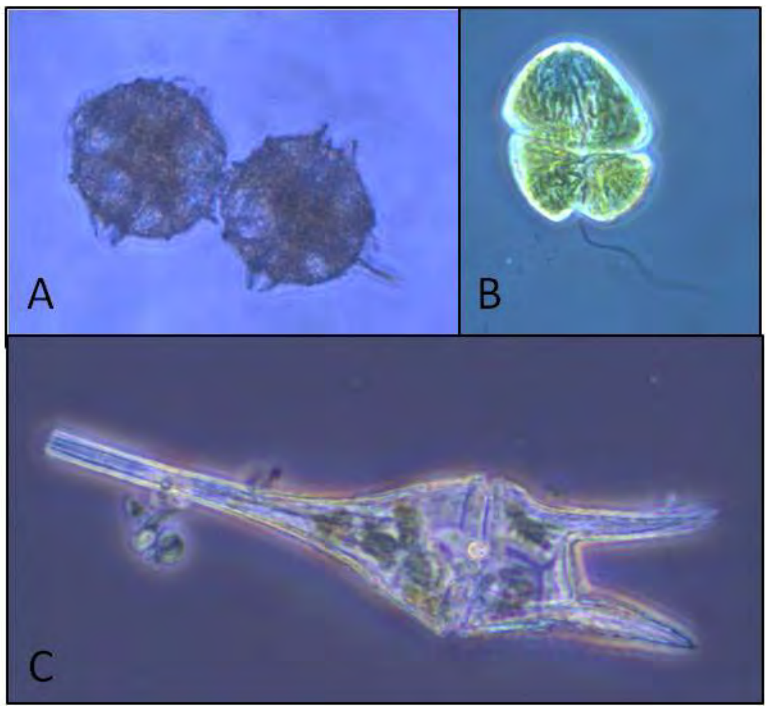

Figure 49. Three common dinoflagellates from Tampa Bay: (A) *Pyrodinium bahamense* (two connected daughter cells); (B) *Gonyaulax sp.*; (C) *Ceratium hircus*.

Dinoflagellate abundance in Tampa Bay follows a seasonal pattern with peak abundances occurring in the late summer to early fall months (Figure 50). This may be due to the influx of nutrients over the course of the summer rainy season. During the 2001-2010 monitoring period several peaks in dinoflagellate abundance were observed in all four bay segments. The dates of peak abundances and contributing species are shown in Tables 11 – 14 for each of the four bay segments. Two extreme peaks for Middle Tampa Bay stand out in figure 50. These occurred in September 2002 and August 2004 and both are due to high abundances of an unidentified species of *Gonyaulax* at a single site, station 136 in Cockroach Bay (Table 13). On both dates the abundances were recorded as being too numerous to count (TNTC). Data base records listed as “TNTC” were assigned a value of “999” for the purposes of graphing and data analysis which may overinflate the actual abundance present at that site. Since these two data points are skewed by these records from a single sample they do not accurately represent Middle Tampa Bay as a whole.

The historical plankton count data for the EPCHC monitoring program goes back to the summer of 1975. Long term trends show high abundances of dinoflagellates in Hillsborough Bay and Middle Tampa Bay in the mid-late 1970's (Figure 51). The peak abundance observed in 1975 for Hillsborough Bay was based on a few records for "*Ceratium* sp." and "*Gonyaulax* sp." recorded as being too numerous to count during July and August. The high abundance in Middle Tampa Bay seen in 1978 can be attributed to a bloom of *Gyrodinium fissum* at station 136 in Cockroach Bay, along with high counts for *Akashiwo sanguinea* (formally known as *Gymnodinum splendens*) and *Gonyaulax digitalis*. A second peak in Middle Tampa Bay occurred in 2000 (Figure 51) and is attributed to high abundances of unidentified. *Gonyaulax* and *Gymnodinium* species at station 136 in Cockroach Bay.

Table 11. Hillsborough Bay 2001-2010 dinoflagellate peak counts.

Date (Stations)	Dinoflagellate Id	Count/0.1 mL	Estimated cells/liter
September 2002 (Sta. 6, 7, 44, 73)	*Gonyaulax digitalis*	>100	> 1 million
September 2003 (Sta. 55, 73)	*Ceratium hircus*	>50	>500 thousand
August 2006 (Sta. 58)	*Prorocentrum* sp.	>600	> 6 million
July 2009 (Sta. 6, 52, 55, 71, 73)	*Ceratium hircus*	>100	> 1 million
August/September 2010 (Sta. 44, 52, 58)	*Ceratium hircus*	>50	>500 thousand

Table 12. Old Tampa Bay 2001-2010 dinoflagellate peak counts.

Date (Stations)	Dinoflagellate Id	Count/0.1 mL	Estimated cells/liter
November 2005 (Sta. 64, 42)	*Gonyaulax* sp.	>50	>500 thousand
July/August 2008 (Sta. 41, 42, 64, 65, 66)	*Pyrodinium bahamense*	>100	> 1 million
July/August 2009 (Sta. 42, 46, 47, 63, 64, 65, 66)	*Pyrodinium bahamense*	>100	> 1 million

Table 13. Middle Tampa Bay 2001-2010 dinoflagellate peak counts.

Date (Stations)	Dinoflagellate Id	Count/0.1 mL	Estimated cells/liter
September 2002 (Sta. 136)	*Gonyaulax* sp	TNTC	TNTC
August 2004 (Sta. 136)	*Gonyaulax* sp	TNTC	TNTC
July 2009 (Sta. 14)	*Ceratium hircus*	>200	> 2 million

Table 14. Lower Tampa Bay 2001-2010 dinoflagellate peak counts.

Date (Stations)	Dinoflagellate Id	Count/0.1 mL	Estimated cells/liter
October 2001 (Sta. 91, 92)	*Karenia brevis*	>100	> 1 million
June 2005 (Sta. 92, 93, 95)	*Karenia brevis*	>100	> 1 million
October 2006 (St. 95, 96)	*Karenia brevis*	<50	<500 thousand

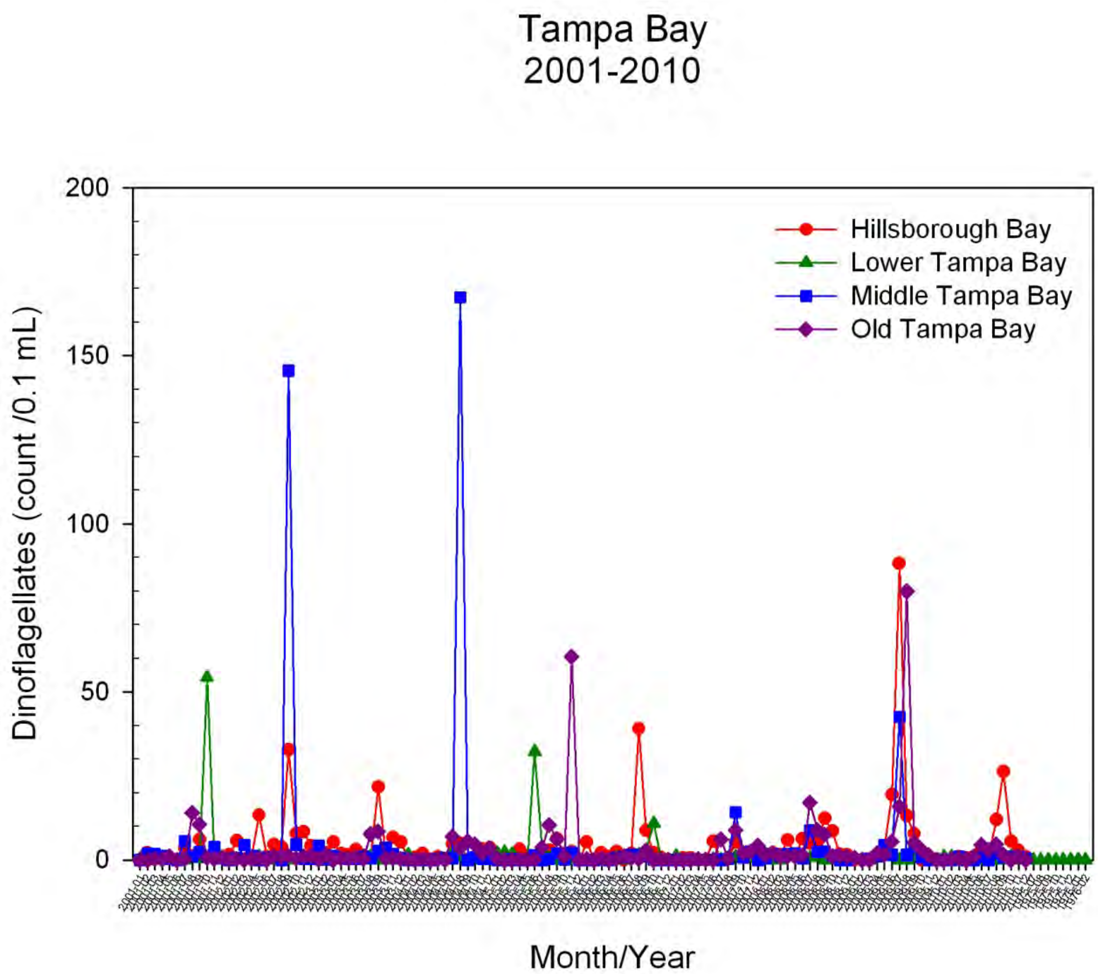

Figure 50. Monthly average dinoflagellate count by bay segment January 2001- December 2010.

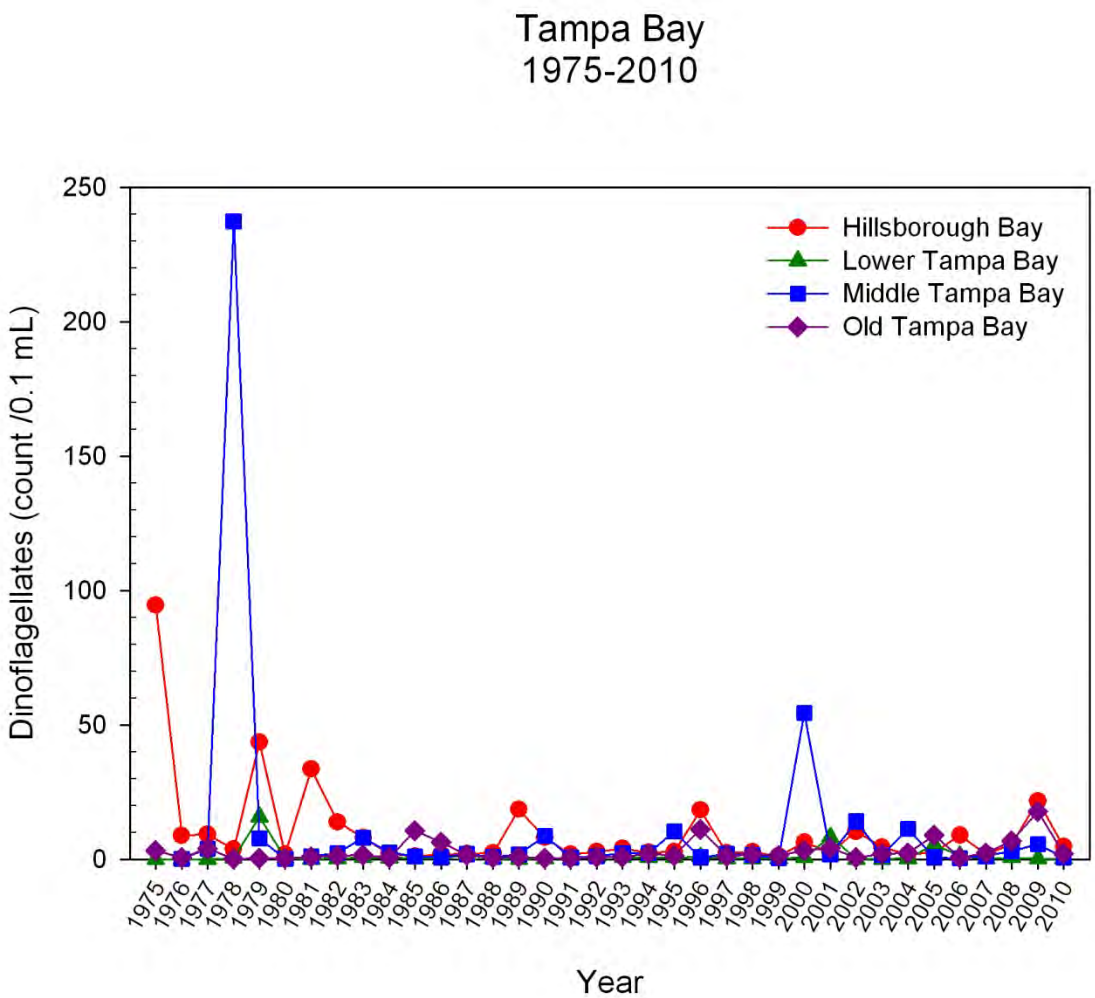

Figure 51. Annual average dinoflagellate count by bay segment.

Several species of dinoflagellates have formed blooms repeatedly over the years, including known toxic species. Of particular concern is *Karenia brevis* (formally known as *Gymnodinium breve)*, a toxic species responsible for what is commonly referred to as "red tide". *Karenia brevis* produces a neurotoxin called brevetoxin which can cause fish kills and mortality in birds and marine mammals. The toxin can also accumulate in the tissues of commercially harvested clams and oysters resulting in neurologic shellfish poisoning (NSP). When the *K. brevis* cells are broken up by wave action, the brevetoxin can become airborne and can cause respiratory irritation, especially in people who suffer from asthma. Past red tide blooms have resulted in millions of dollars in economic losses due to beach closures, lost tourism revenues and impacts to commercial and recreational fisheries.

Karenia brevis blooms typically form offshore in the Gulf of Mexico during the late summer and fall and move into the onshore areas due to prevailing winds and currents. Within Tampa Bay, the Lower Tampa Bay segment is usually the most impacted by red tides and trends for *Karenia brevis* in this bay segment over time are presented in figures 52 and 53. During the 2001-2010 monitoring period, three major bloom events occurred in Lower Tampa Bay (Figure 52; Table 14). The largest bloom occurred in October 2001, with smaller blooms occurring in June 2005 and October 2006. The highest abundances for *Karenia brevis* during these events were at sites near the mouth of Tampa Bay. Historically, there have been several other bloom occurrences, including significant blooms in 1992 and 1996. The long term trend suggests a large increase in the abundance of *Karina brevis* during more recent bloom events; however this may be an artifact of the data analysis.

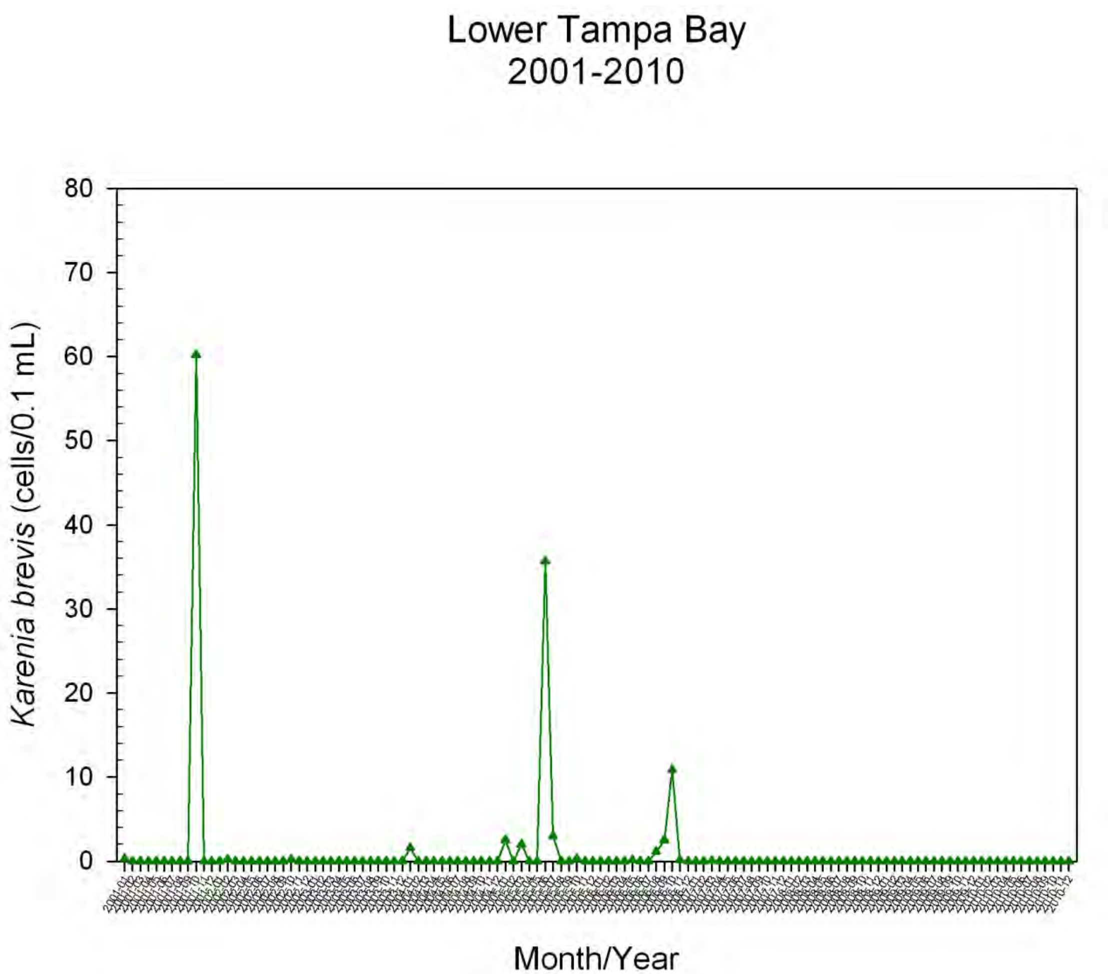

Figure 52. Monthly average *Karenia brevis* cell count for Lower Tampa Bay January 2001- December 2010.

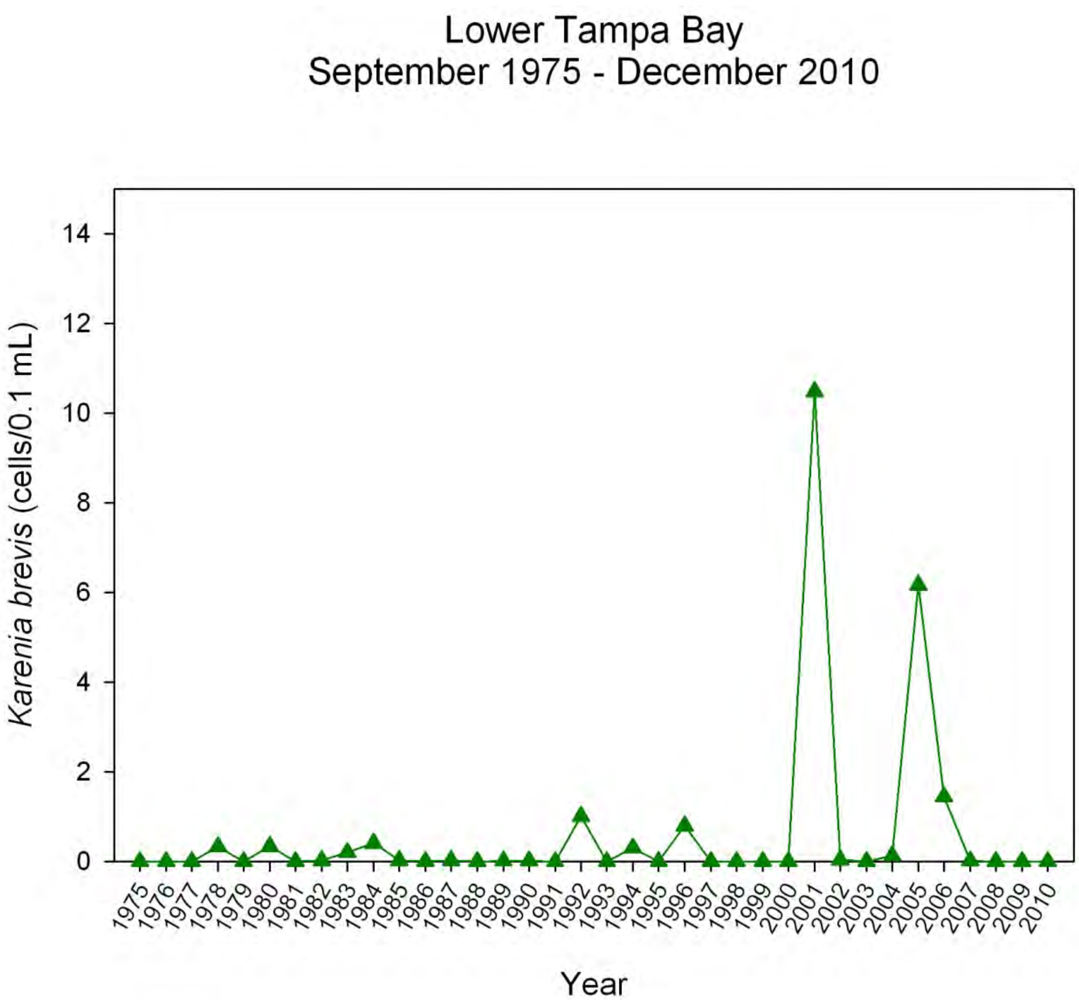

Figure 53. Annual average *Karenia brevis* cell count for Lower Tampa Bay.

Ceratium hircus (Figure 49C) is not known to be toxic but does frequently form blooms in Hillsborough Bay and at some northern sites in Middle Tampa Bay. Although this species does not appear to produce toxins it can deplete oxygen from the water column as the bloom dies-off which can result in fish kills. Blooms typically occur during the late summer (Figure 54) although cells may be present in low abundance during the winter and spring months. During the 2001-2010 reporting period the largest blooms occurred in July 2009 and again in September 2010 with smaller peaks in abundance during most summers (Figure 54). Historically there is an apparent increasing trend in abundance of *Ceratium hircus* during bloom events with significant blooms occurring at 3-4 year intervals in 1989, 1993, 1996 and in 2000 (Figure 55).

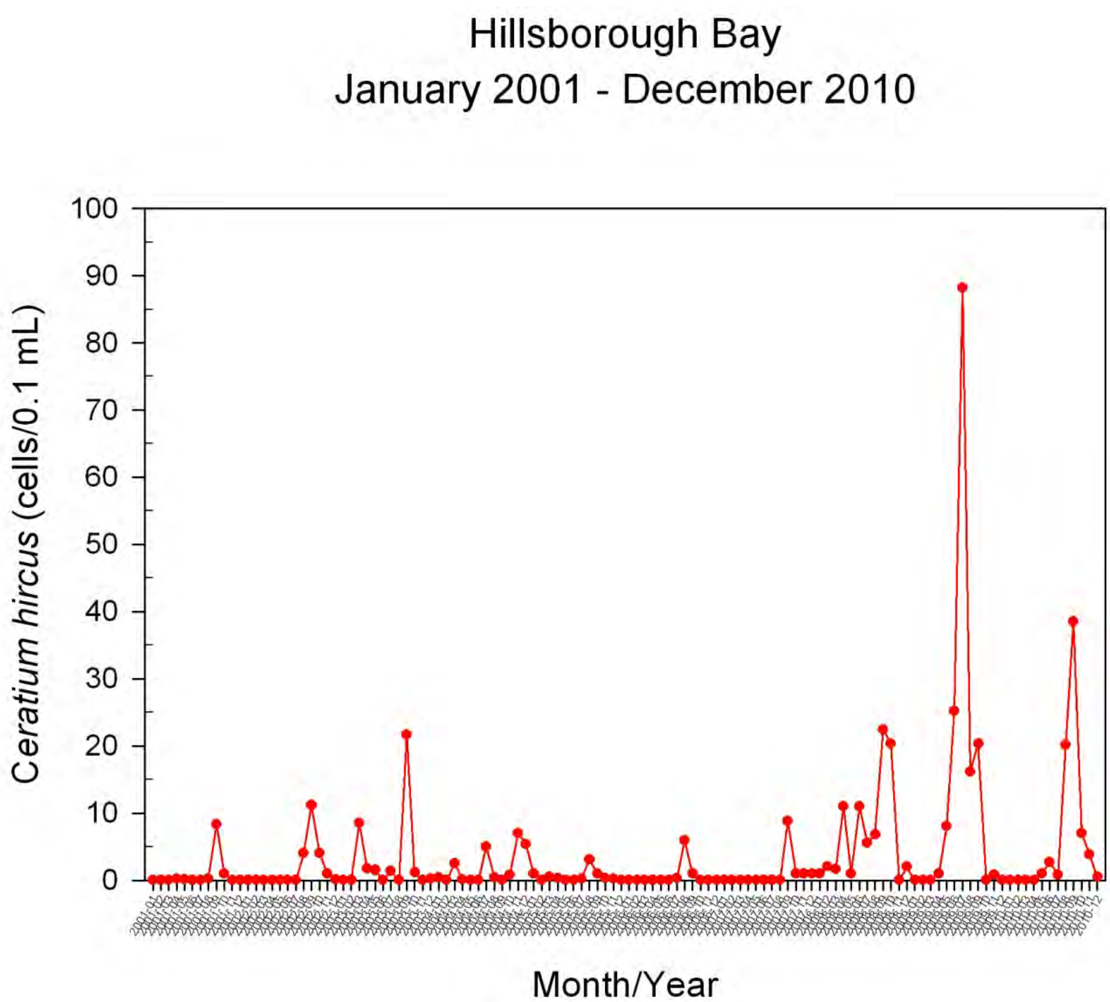

Figure 54. Monthly average *Ceratium hircus* count for Hillsborough Bay January 2001- December 2010.

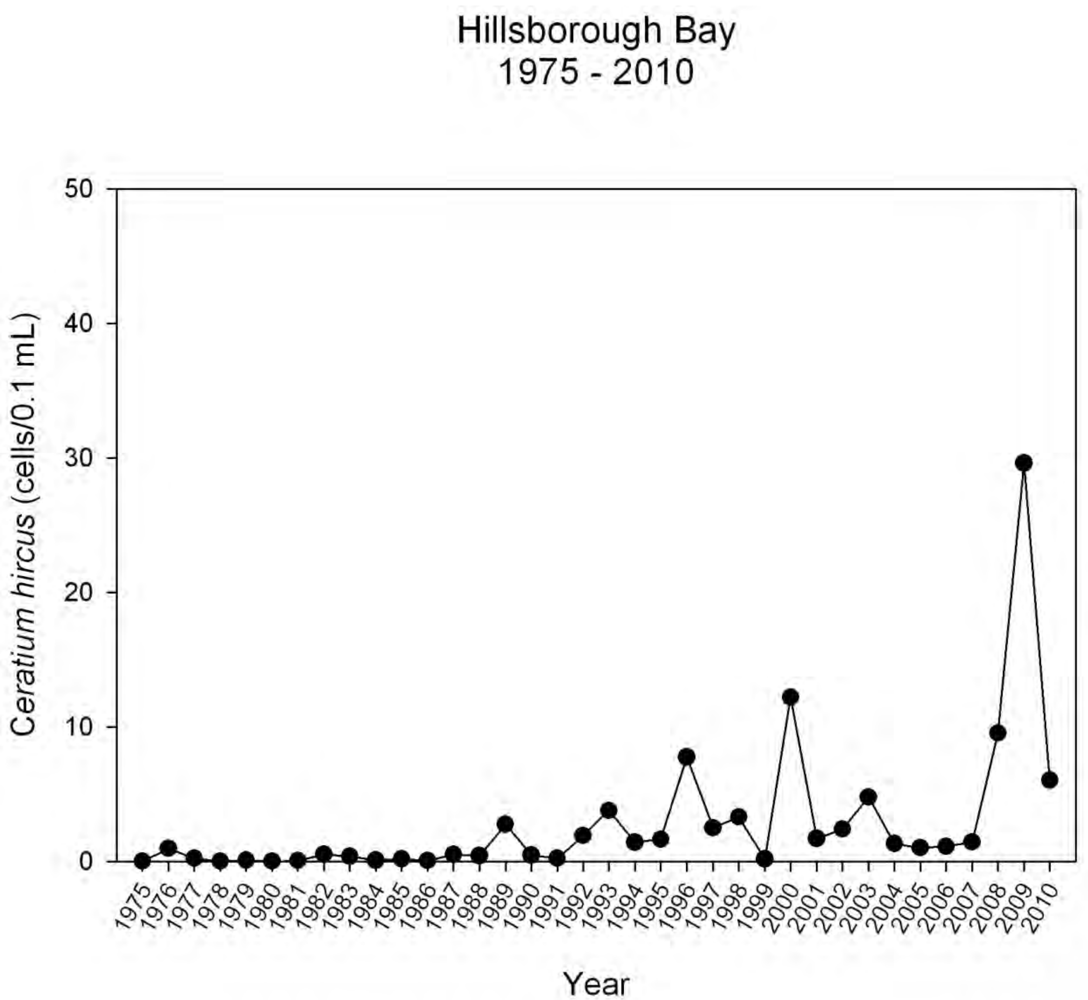

Figure 55. Annual average *Ceratium hircus* cell count for Hillsborough Bay.

Pyrodinium bahamense (Figure 49A) is a potentially toxic dinoflagellate that produces the toxin that causes paralytic shellfish poisoning (PSP). Thus far there have been no reported cases of PSP from Tampa Bay. This dinoflagellate is also bioluminescent giving off a flash of light when the water is disturbed by splashing or boat wakes. This phenomenon in itself has created a tourist industry in Puerto Rico where several bays have high abundances of *Pyrodinium bahamense* year round.

Blooms of *Pyrodinium bahamense* typically start in the mid to late summer months. During the 2001-2010 monitoring period there were several blooms with peaks in August 2001, August 2005, July 2008 and August 2009 (Figure 56). Earlier *Pyrodinium bahamense* blooms were also recorded in 1975, 1977 and a smaller peak in 1983 (Figure 57). Interestingly there were no records of *Pyrodinium bahamense* occurring in our monitoring samples from 1984 – 1999 and then blooms started to reappear in 2000 (Figure 57). The reason for this 16 year absence is still unclear and merits further investigation. *Pyrodinium bahamense* can go into a dormant stage, called a cyst, during the winter months or when water conditions are not optimal for the cells to grow. These cysts can remain in the sediment for years until conditions in the overlying water column are right to promote cell growth at which point the cells can reemerge *en masse* forming a bloom.

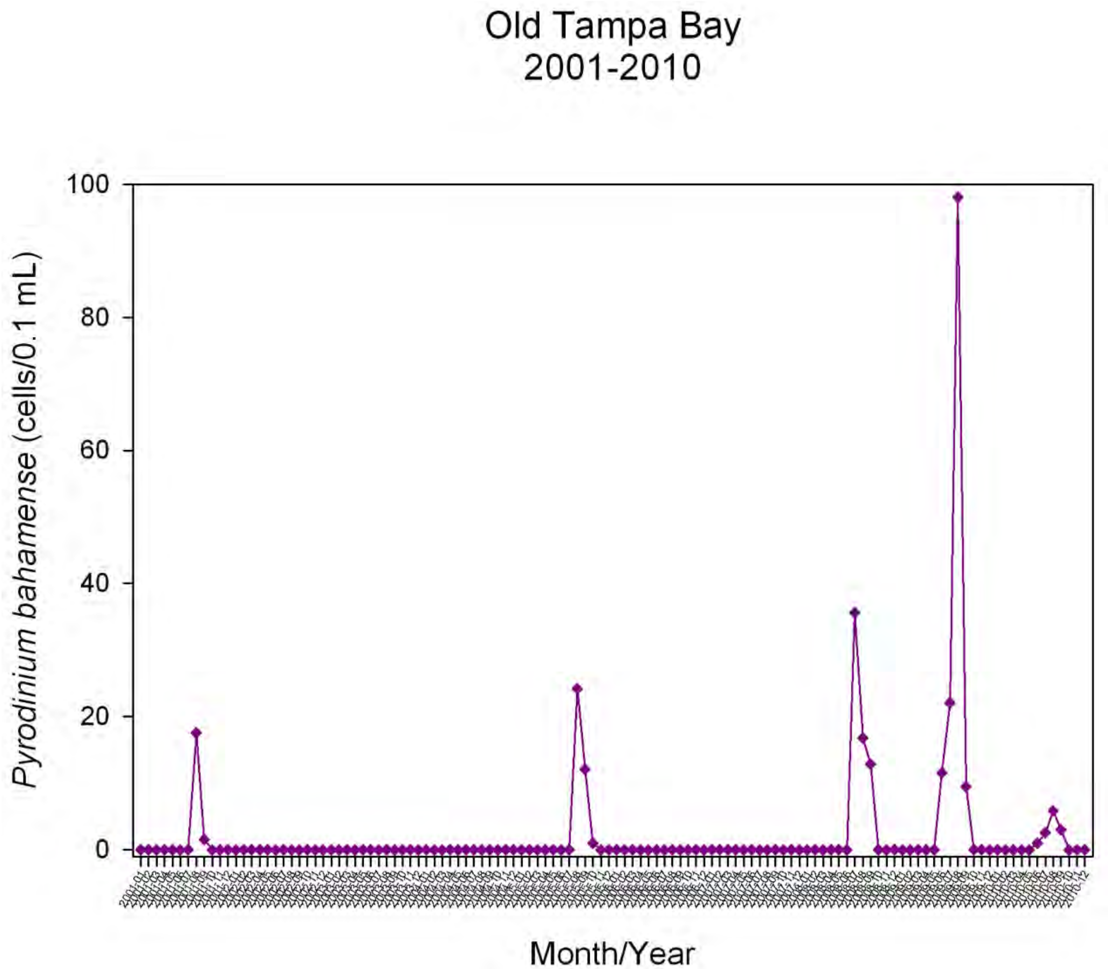

Figure 56. Monthly average *Pyrodinium bahamense* count for Old Tampa Bay January 2001- December 2010.

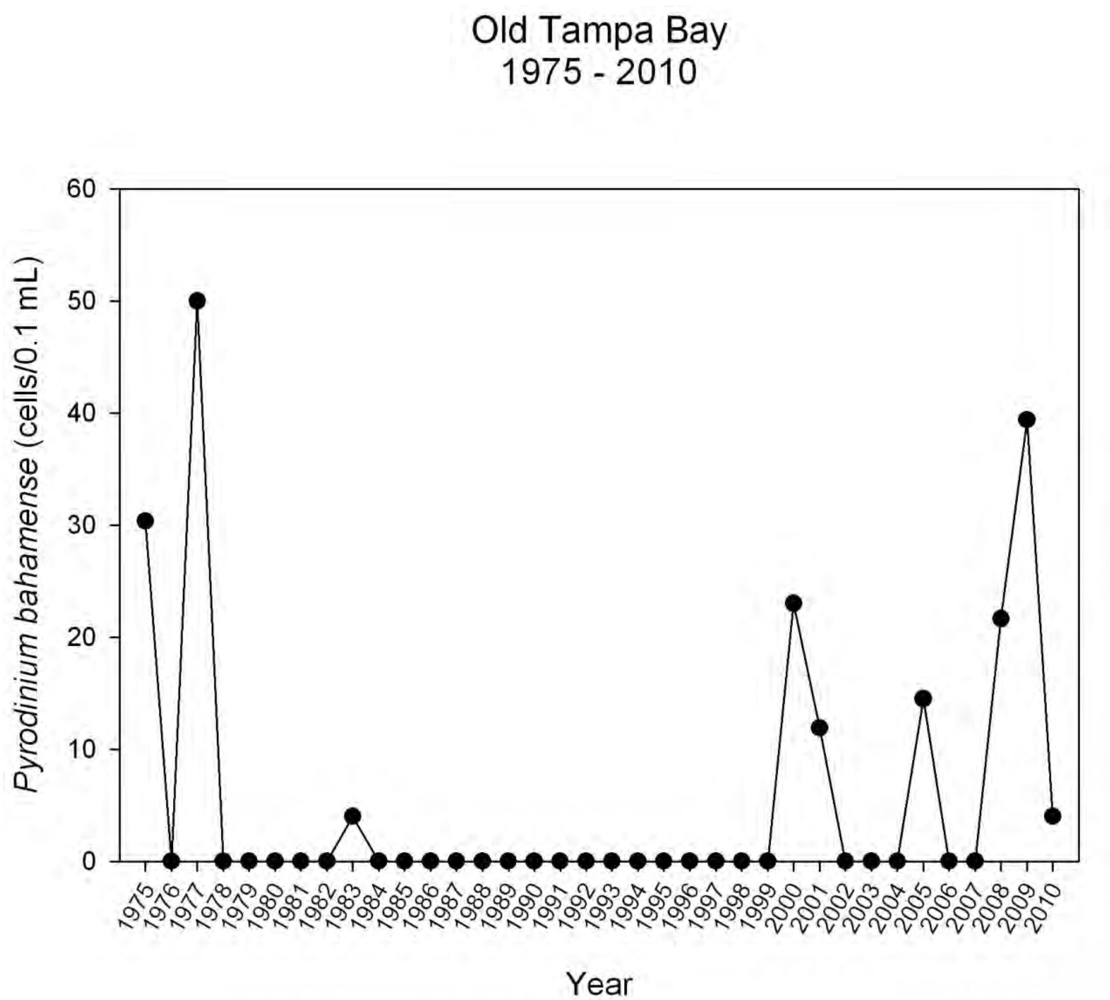

Figure 57. Annual average *Pyrodinium bahamense* count for Old Tampa Bay

Chapter 6

BACTERIA

Fecal coliform bacteria are often associated with human sewage and wastewater effluents and therefore the analysis for these bacteria is an important measure of water quality and for public health and safety. High fecal coliform counts can be an indication of a waste discharge due to a ruptured sewage pipe, failed septic system or from the accidental or illegal dumping of human feces into the environment. However, all warm-blooded animals (mammals and birds) contain fecal coliform bacteria and contribute to their presence in surface waters. Other sources of high coliform bacteria can include bird rookeries, feces from wildlife or domestic animals and runoff from pastures.

Fecal coliform bacteria are measured by culturing the bacteria in a given volume of water sample on a growth media. The samples are incubated for 24 hours and the numbers of bacterial colonies are expressed as the number of colonies (or colony forming units –cfu) per 100 mL. The State of Florida has established water quality standards for fecal coliform bacteria based on the water usage classification. For Class I (Potable) and Class III (Fishing and Recreation) waters monthly average fecal coliform levels below 200 colonies/100 mL are considered safe for water supplies and for fishing and swimming. Fecal coliform levels should not exceed 800 colonies/100 ML on any one day or exceed 400 in more than 10% of the samples. Higher standards have been established for Class II waters (shellfish harvesting) since high bacteria in shellfish can result in potentially fatal food poisoning.

Waterbodies which consistently exceed these standards are considered impaired and require the development of a basin management action plan (BMAP) to address corrective actions. Many of the tributary drainage basins within the Tampa Bay watershed have been classified as being impaired for fecal coliform bacteria as previously outlined in Chapter 1 (Figure 4d; Table 4). Within Tampa Bay itself, high fecal coliform and general bacteria levels have led to beach closures on several occasions, notably at the Ben T. Davis Beach along the Courtney Campbell Causeway, and closure of shellfish harvesting in the bay. Because of this, much of the bay proper is also considered impaired by the Florida DEP.

Biochemical oxygen demand (BOD) is the measure of dissolved oxygen used for the respiration and the breakdown of organic matter. BOD is largely a measure of bacterial respiration so it is being included in this chapter on bacteria. A high BOD measurement is usually an indication of organic loading, such as from sewage or from natural sources such as plant detritus. The EPCHC had been measuring BOD at all tributary and bay stations since the start of the monitoring program. In 1995, the number of bay stations monitored for BOD was reduced since BOD measurements in the bay had remained fairly consistent since the mid-1980s and the measurement of this parameter required a lot of staff time and logistic considerations for processing. This parameter was eventually discontinued after the 2009 sampling year.

Fecal Coliform

Fecal coliform levels at the Tampa Bay monitoring stations ranged from 2 – 1040 cfu/100 mL during the 2001 – 2010 monitoring period. Levels tended to be highest in Hillsborough Bay and Old Tampa Bay with peaks during the summer rainy season (Figure 58). Overall fecal coliform levels were low throughout the bay with a median value of only 2 cfu/100 mL. The maximum value occurred during October 2006 in Hillsborough Bay at station 54 located in the East Bay area of the Port of Tampa. This was also the only record at a bay station that exceeded the 800 cfu/100 mL state water quality standard during the 10 year period. Fecal coliform levels exceed 400 cfu/100 mL in September 2004 at eight separate stations within Hillsborough Bay. This may have been a result of high stormwater runoff resulting from hurricane Francis just prior to our monthly sampling. Other fecal coliform counts in excess of 400 cfu/100 mL were recorded in July 2010 at stations 61 and 62 near Sweetwater Creek and Rocky Point in upper Old Tampa Bay and in August 2010 at stations 44, 52, and 70 in the Davis Island/Bayshore vicinity in Hillsborough Bay.

Historical fecal coliform levels were higher, ranging as high as an estimated 231,000 cfu/100 mL , recorded in July 1977 at station 25 in Lower Tampa Bay. Bay-wide, the median value was 4 cfu/100 mL. Hillsborough Bay consistently has had the highest annual mean values. Annual mean fecal coliform levels in Hillsborough Bay exceeded 800 cfu/100 mL during the late 1970's, but dropped dramatically since then (Figure 59). A similar drop was noted bay-wide and can be attributed to the implementation of advanced wastewater treatment systems at regional sewage treatment plants during this time period.

The tributary stations had much higher fecal coliform levels, ranging from 2 – 21,800 cfu/100 mL during the 2001 – 2010 monitoring period with a median value of 160 cfu . There were 941 records where the fecal coliform levels were above 800 cfu during this time period. The maximum level found was during March 2004 at station 104 in Sweetwater Creek. Historically the highest fecal coliform count on record occurred at station 2 near the mouth of the Hillsborough River in August 1979. The count recorded was an estimated 730,000 cfu/100 mL.

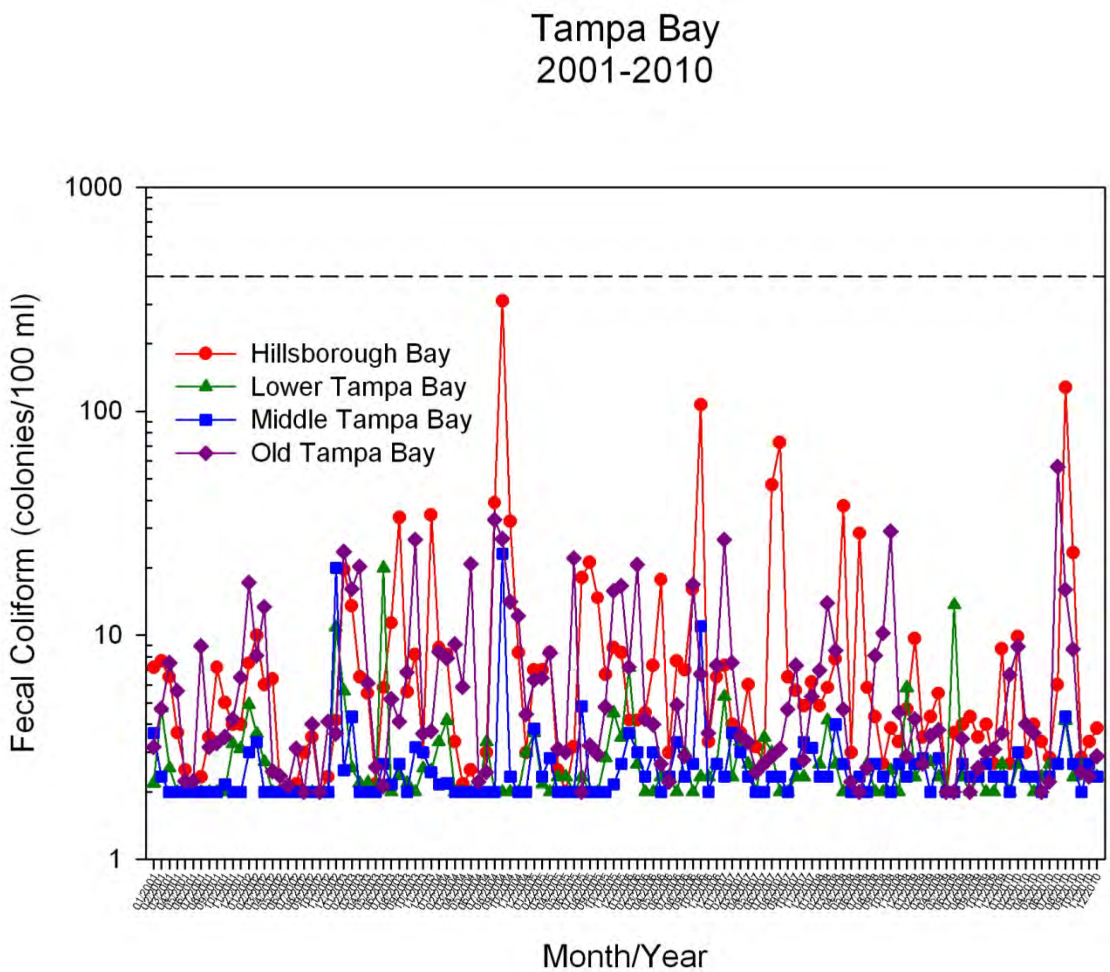

Figure 58. Monthly average fecal coliform count by bay segment January 2001- December 2010. Dashed line represents state water quality standard of 400 colonies/100 ml.

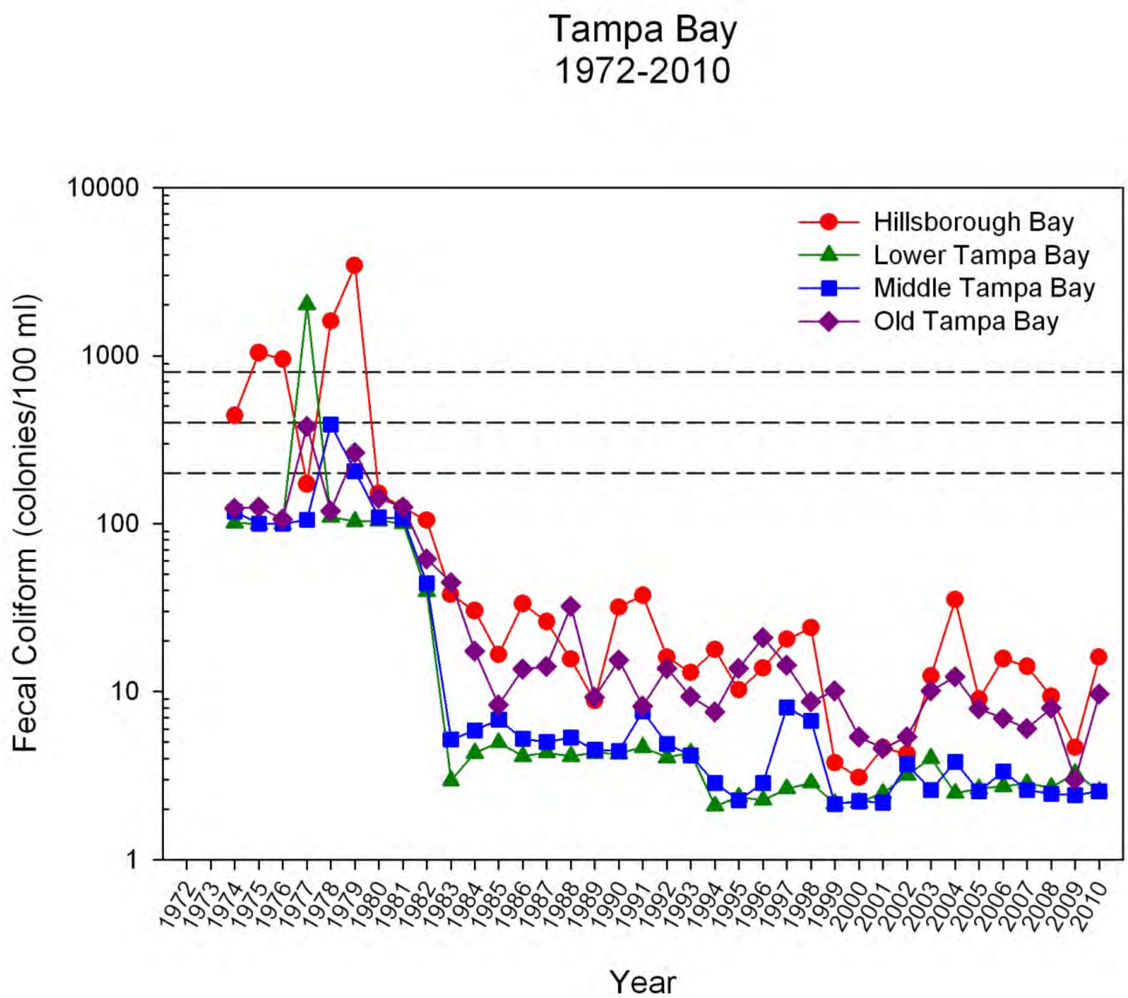

Figure 59. Annual average fecal coliform count by bay segment. Dashed lines represent state water quality criteria of 200, 400 and 800 cfu/100 ml.

Biochemical Oxygen Demand

The biochemical oxygen demand (BOD) measurements from 2001 – 2009 ranged from 0.1 – 10 mg/l with a median value of 1.3 mg/L. The maximum value was found at station 8 near the mouth of the Alafia River in Hillsborough Bay during September 2002. Hillsborough Bay and Old Tampa Bay generally had the highest monthly average BOD with peak measurements occurring in the late summer (Figure 60).

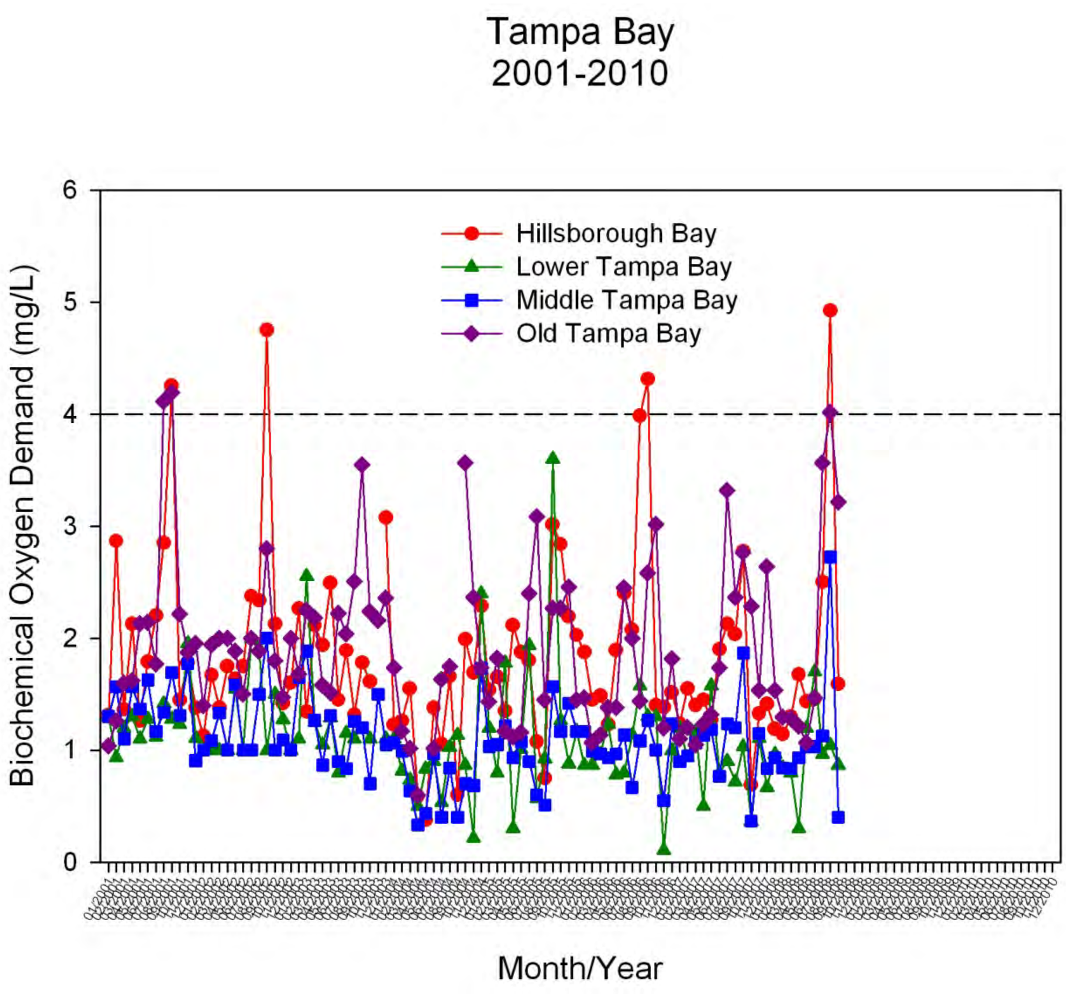

Figure 60. Monthly average biochemical oxygen demand (BOD) by bay segment January 2001- December 2010. Dashed line represents state water quality standard of 4 mg/L.

Historically, the BOD has ranged from 0.1 – 22.5 mg/L with a median value of 1.6 mg/L. The maximum value was recorded in April 1979 from station 6 at Ballast Point in Hillsborough Bay. The second highest record was 14.6 mg/L in January 1978 at station 58 in McKay Bay. Hillsborough Bay has historically had the highest BOD , with annual averages exceeding 4 mg/L during several years in the late 1970's (Figure

61). Since the implementation of advanced wastewater treatment procedures there has been a noticeable decline in BOD measurements bay-wide, and especially in Hillsborough Bay (Figure 61).

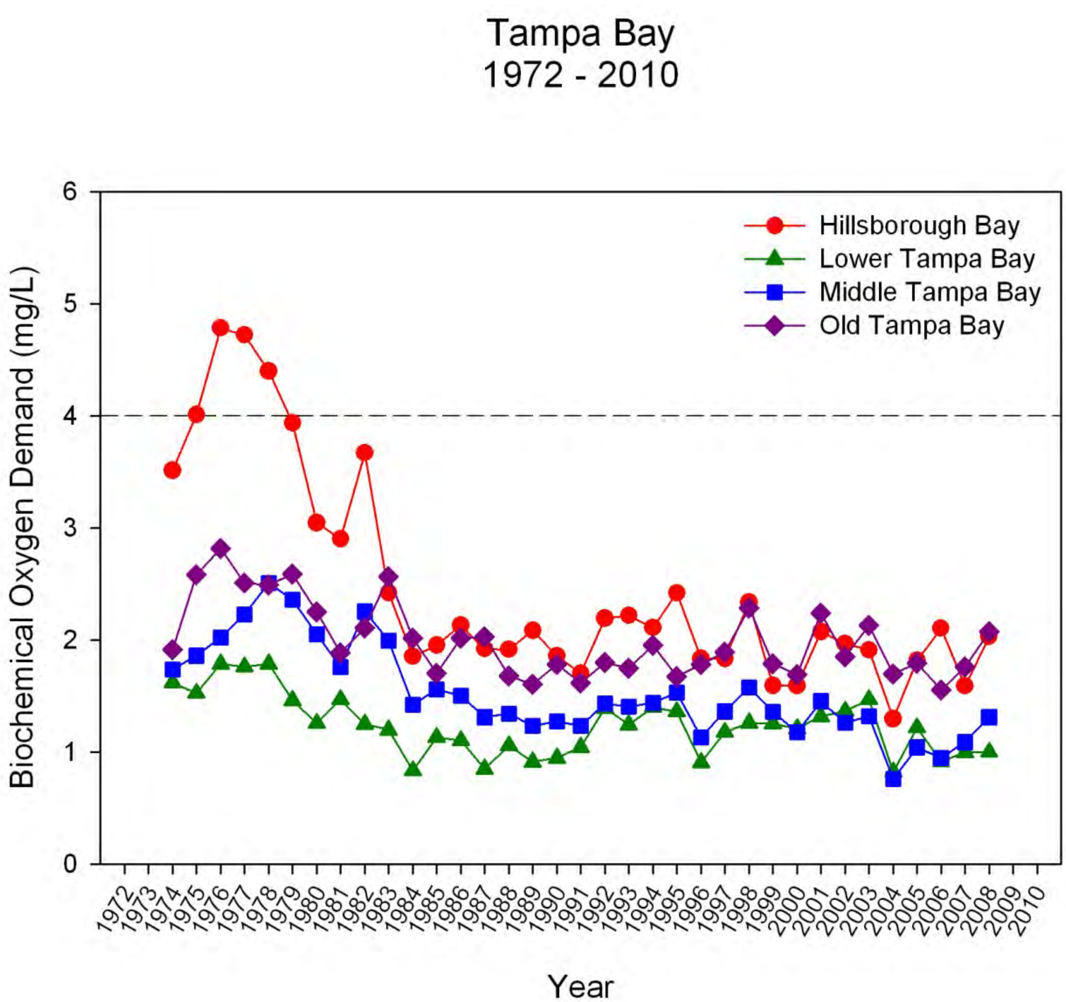

Figure 61. Annual average biochemical oxygen demand (BOD) by bay segment. Dashed line represents state water quality standard of 4 mg/L.

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The BOD at the tributary monitoring sites ranged from 0.1 – 14.1 mg/L during the 2001-2010 monitoring period with a median value of 1.2 mg/L. The highest measurement was at station 110 in the Palm River in July 2007. Lake Thonotosassa also had consistently high BOD which is a reflection of the high plankton densities and hypereutrophic conditions in the lake. Historically, the median BOD has been 1.5 mg/L for the tributary stations. The highest tributary BOD measurement was 25.6 mg/L in March 1990. This was recorded at station 107 at the inflow of Baker Creek into Lake Thonotosassa. This watershed had historically received high nutrient and organic loading from surrounding agriculture and industrial discharges which has resulted in consistently high BOD values over the years.

Chapter 7

Summary and Synthesis

Water Quality Index

A Water Quality Index (WQI) specific to our Tampa Bay monitoring program is presented here for evaluating overall water quality trends incorporating multiple parameters. This proposed WQI is similar to the Bay Habitat Index which was developed for Chesapeake Bay (Williams et al., 2009) in that it presents the index results in an easy to interpret report card and color coded format . The WQI differs from the BHI however in that it is based solely on water quality and includes additional parameters with targets specific to Tampa Bay.

An earlier WQI was developed in the mid-1980's and presented in the 1984 – 1985 Water Quality Report (Boler 1987) and was used in subsequent reports up through the 1998-2000 Water Quality Report (Boler 2001). That WQI was based on seven weighted parameters including dissolved oxygen (percent saturation), biochemical oxygen demand (BOD), total phosphorous, total Kjeldahl nitrogen, chlorophyll a, total coliform, and effective light penetration (Secchi depth). Details on this index formulation are outlined in Boler 1987.

Due to changes in the EPC monitoring program such as the discontinuation of measuring BOD, along with recent modifications to state water quality standards and the setting of target goals by the Tampa Bay Estuary Program, it was decided that a new WQI for Tampa Bay was necessary.

Water Quality Index Formulation

The proposed Water Quality Index is based on seven parameters: fecal coliform, dissolved oxygen, chlorophyll a, Secchi depth, turbidity, total nitrogen and total phosphorus. These parameters were chosen because they are good indicators of potential anthropogenic impacts and they either have regulated or proposed state water quality criteria or have proposed restoration target levels set by the Tampa Bay Estuary Program (Janicki et al. 2000; Janicki Environmental 2010). Several of these parameters have also been identified as impairments in various waterbodies within the Tampa Bay watershed (see Chapter 1; Tables 4 & 5).

The water quality targets for a given parameter may vary for different bay segments or surface water classification (i.e. marine vs. freshwater) and the equations for calculating the WQI are customized to account for this. The WQI is calculated by first scoring each parameter in each individual sample. If the parameter fails to meet the designated target, it is assigned a score of zero, and if it meets its designated target it is assigned a score of one. The specific scoring criteria for each of the seven water quality parameters and final WQI calculations are outlined below.

Fecal Coliform: The target concentration for scoring fecal coliform levels was set at 400 cfu based on the state criteria for Class III waters. Fecal coliform counts <400 cfu/100 ml were assigned a score of 1 and counts ≥400 were assigned a score of 0. The state criteria are the same for both Class III marine and freshwaters, so this target was used for all samples.

Dissolved Oxygen: The dissolved oxygen targets are based on the state criteria and are different for marine and freshwater samples. The bottom dissolved oxygen readings are used for most samples collected after 1987. Prior to that year, dissolved oxygen data was only collected at mid-depth, so those readings were used in place of the bottom dissolved oxygen. The target concentration for the bay samples and the Class III marine tributary samples is 4 mg/L. Dissolved oxygen values <4 mg/L are assigned a value of 0 and ≥4 mg/L are assigned a value of 1. The target for freshwater samples is 5 mg/L; dissolved oxygen values < 5 mg/L are assigned a score of 0 and ≥5 mg/L are assigned a score of 1.

Chlorophyll a: The chlorophyll a criteria for the bay samples follow the Tampa Bay Estuary Programs targets (Janicki et al. 2000) and vary for the four bay segments. The chl a target for Hillsborough Bay is set at 13.2 µg/L, for Old Tampa Bay is 8.5 µg/L, for Middle Tampa Bay is 7.4 µg/L and for Lower Tampa Bay is 4.6 µg/L. Values below these targets are assigned a score of 1 and greater than or equal to these targets are assigned a score of 0. The chl a targets for the tributary samples varied by the surface water classification at the individual sampling sites. Class III marine samples used the same criteria as the corresponding bay segment in which the tributary flows into. Class III marine sites in the Alafia River, Hillsborough River, Palm River and Hillsborough Bay tributaries use the Hillsborough Bay chlorophyll a target; Old Tampa Bay tributaries use the Old Tampa Bay chlorophyll a target; and the Little Manatee River use the Middle Tampa Bay chlorophyll a target.

The chlorophyll a target for the freshwater tributary samples is based on the Florida Trophic State Index (TSI) for freshwater lakes (Paulic et al. 1996) and is set at 20 µg/L based on the boundary value between "Good" and "Fair" (Chl a_{TSI} = 60). Values exceeding 20 µg/L were assigned a score of 0, and values below this target were assigned a score of 1.

Effective Light Penetration (Secchi Depth): The Secchi depth targets for the WQI calculations also followed the Tampa Bay Estuary Program's restoration targets and varied by bay segments. The target for Hillsborough Bay is set at 1 meter; for Old Tampa Bay and Middle Tampa Bay at 1.9 meters; and for Lower Tampa Bay at 2.5 meters. Secchi depth reading that are less than these target depths are assigned a score of 0 and readings greater than or equal to these targets are assigned a score of 1. A number of the bay sampling stations have bottom depths which are shallower than the segment Secchi depth target, and often the Secchi disk is visible on the bottom at these sites. In these cases, the recorded Secchi depth is qualified in the database with a ">" signifying that the recorded reading is greater than the station depth. These instances where the Secchi depth is greater than the sample depth are scored as a 1 by default for the WQI calculations.

There are no set Secchi depth criteria for freshwater so for the WQI calculations the historical average value from the EPCHC freshwater tributary stations was used. The historical average at these sites is 0.77 meters and was calculated from all available database records from 1974 – 2010. Records where the recorded Secchi depth was greater than the sample depth were excluded. Secchi depth readings < 0.77 meters were assigned a score of 0 and ≥0.77 were assigned a score or 1.

Turbidity: The turbidity targets used for the WQI calculations are based on the bay segment Secchi depth targets and were calculated by comparing the turbidity values to their corresponding sample Secchi depth readings and calculating the best fit curve, excluding samples where the Secchi depth exceeded the station depth (Figure 62). This analysis found the following exponential relationship between turbidity and Secchi depth ($r^2 = 0.3612$):

$Y = 5.0941(X)^{-0.736}$

Where: Y = Turbidity in NTUs; X = Secchi depth in meters.

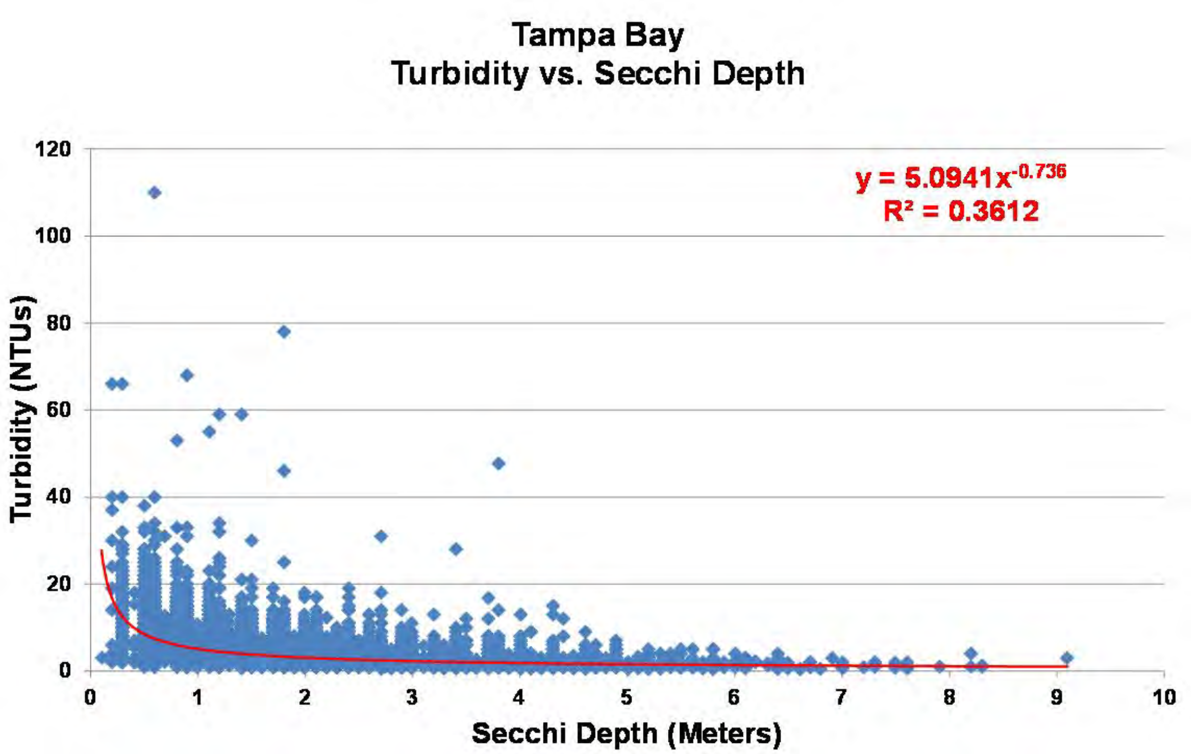

Figure 62. Turbidity vs. Secchi Depth regression analysis.

Using the target Secchi depths for each bay segment and for the fresh water samples, the following turbidity targets are calculated: Hillsborough Bay = 5.1 NTU; Old Tampa Bay and Middle Tampa Bay = 3.2 NTU; Lower Tampa Bay = 2.6 NTU; Freshwater = 6.2 NTU. Turbidity values ≥ these targets are assigned a score of 0 and values below these targets are assigned a score of 1.

Total Nitrogen: The total nitrogen targets used for calculating the WQI for the bay samples are based on the site specific nutrient criteria proposed by the Tampa Bay Estuary Program (Janicki Environmental

2010). These targets are 1.02 mg/L for Hillsborough Bay, 0.94 mg/L for Old Tampa Bay, 0.88 mg/L for Middle Tampa Bay, and 0.72 mg/L for Lower Tampa Bay. The freshwater sample target is 1.65 mg/L based on the West Central region Numeric Nutrient Criteria threshold for freshwater streams (FDEP 2013). Values ≥ these targets are assigned a score of 0 and below these targets are assigned a score of 1.

Total Phosphorus: The total phosphorus targets used for calculating the WQI for the bay samples are based on the site specific nutrient criteria proposed by the Tampa Bay Estuary Program (Janicki Environmental 2010). These targets are 0.45 mg/L for Hillsborough Bay, 0.32 mg/L for Old Tampa Bay, 0.29 mg/L for Middle Tampa Bay, and 0.10 mg/L for Lower Tampa Bay. The freshwater sample target is 0.49 mg/L based on the West Central region Numeric Nutrient Criteria threshold for freshwater streams (FDEP 2013). Values ≥ to these targets are assigned a score of 0 and below these targets are assigned a score of 1.

The scores for the seven parameters are then averaged for each sample to give a WQI score for that individual sample ranging from 0 – 1. This raw score is multiplied by 100 to give a final WQI on a scale of 0-100. Index scores are further assigned a WQI Grade and color coded,: WQI scores ≤20 are assigned a grade of "F" and color coded red; 20<WQI≤40 are assigned a grade of "D" and color coded orange; 40<WQI≤60 are assigned a grade of "C" and color coded yellow; 60<WQI≤80 are assigned a grade of "B" and color coded light green; and 80<WQI≤100 are assigned a grade of "A" and color coded dark green. This scheme is similar to the Bay Habitat Index which was developed for Chesapeake Bay (Williams et al., 2009). The individual sample WQI scores can then be averaged across designated areas (bay segments or tributaries) and time periods (months, years) to give overall average WQI scores for given areas and times which can be used to determine spatial or temporal water quality trends. The simple color coding and letter grading also allows for an easily interpretable "report card" style presentation for communicating monitoring results to the general public.

A multivariate Principal Components Analysis (PCA) of the historical bay samples using the seven WQI parameters is shown in Figure 63. Only samples that had complete data for all seven parameters were included in the PCA. The data was further log (n+1) transformed and normalized for the analysis to correct for different measurement scales and units among the parameters. Figure 63 shows the PCA results plotted on the first two principal component axes (PC1 and PC2), with individual sample points coded by their WQI grade. The individual parameter vectors are shown in blue and indicate the parameter gradients in multidimensional space. The first principal component axis (PC1) explains 43.1% of the variation among the samples and corresponds largely with Secchi depth, Chlorophyll a and Turbidity. The second principle component axis (PC2) explains 20.4% of the variation among the samples and corresponds primarily with Fecal coliform and Total Nitrogen. Samples with higher WQI scores grouped towards the right end of PC1 while lower WQI scores were group towards the left of PC1 and lower end of PC2. The individual parameters are shown as bubble plots (Figures 64 – 70) superimposed on the PCA plot. These figures indicate the general correlations of the parameters with the WQI. Overall, higher WQI scores/grades correspond to lower fecal coliform (Figure 64), higher dissolved oxygen (Figure 65), lower chlorophyll a (Figure 66), greater Secchi depths (Figure 67), lower turbidity (Figure 68), lower total nitrogen and total phosphorus (Figures 69 & 70).

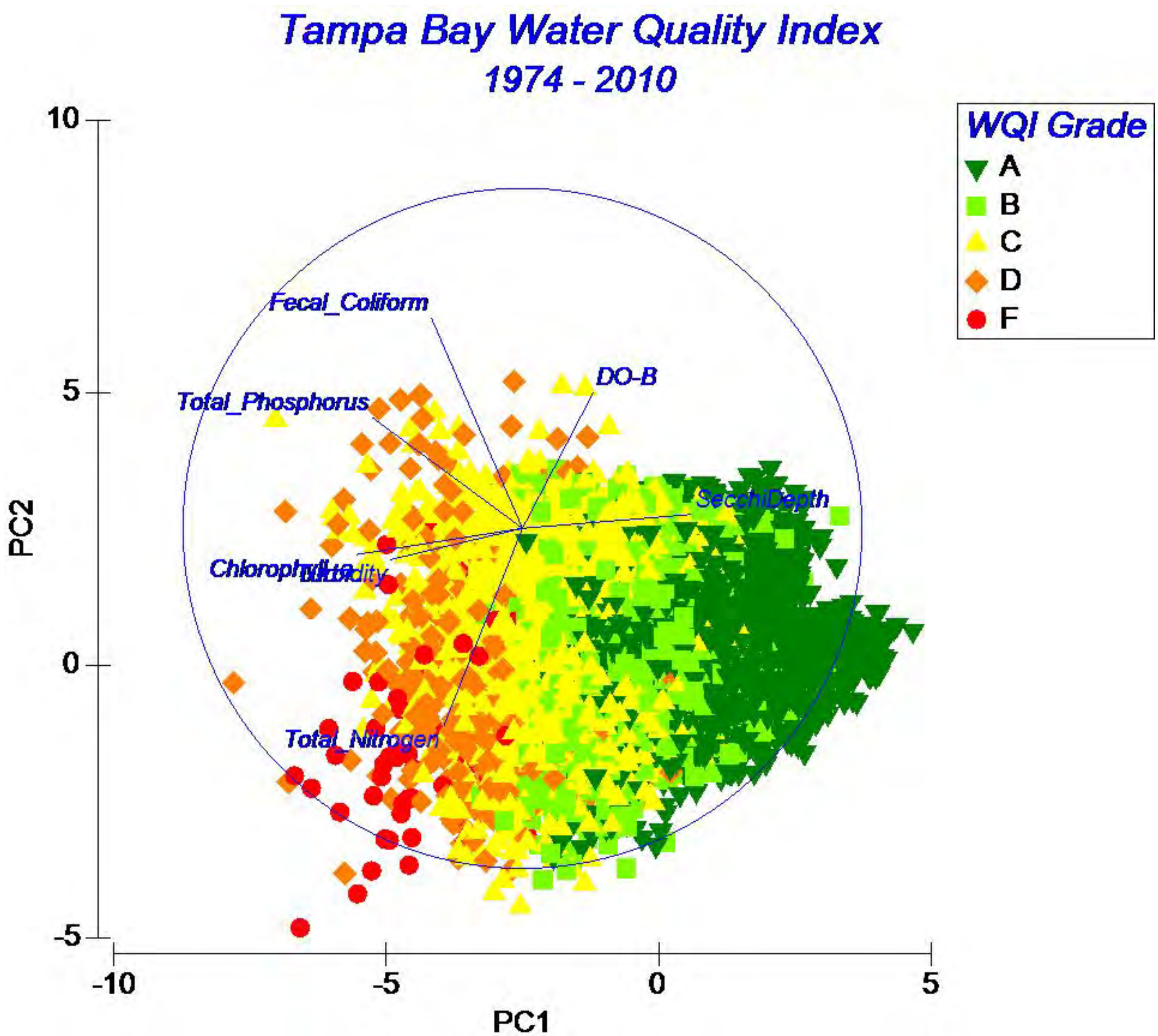

Figure 63. Principal Components Analysis of EPCHC monthly bay monitoring sites (1974 - 2010) based on WQI parameters. Data point symbols represent WQI Grade.

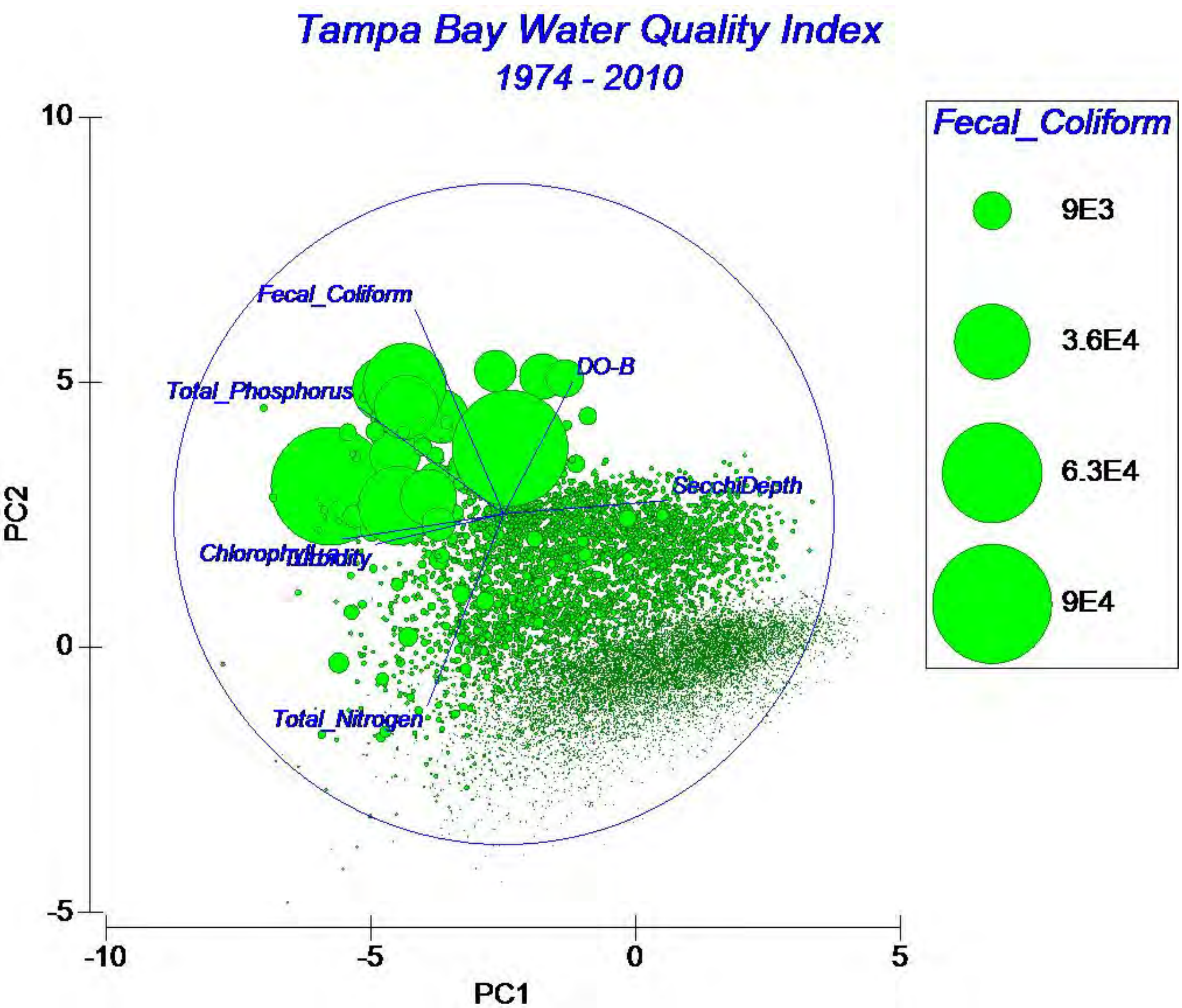

Figure 64. Principal Components Analysis of EPCHC monthly bay monitoring sites (1974 - 2010) based on WQI parameters. Bubbles represent fecal coliform counts (cfu/100 ml).

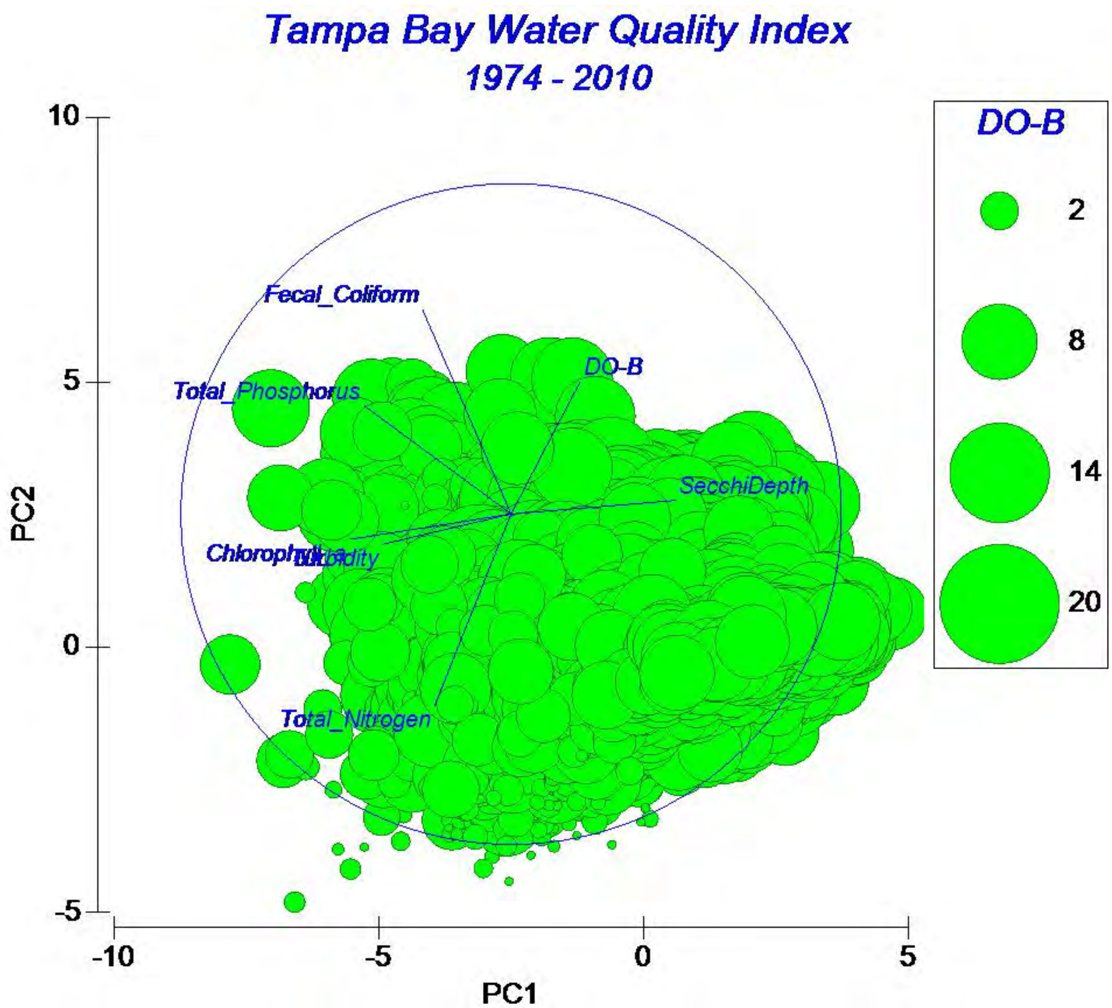

Figure 65. Principal Components Analysis of EPCHC monthly bay monitoring sites (1974 - 2010) based on WQI parameters. Bubbles represent bottom dissolved oxygen concentrations (mg/L).

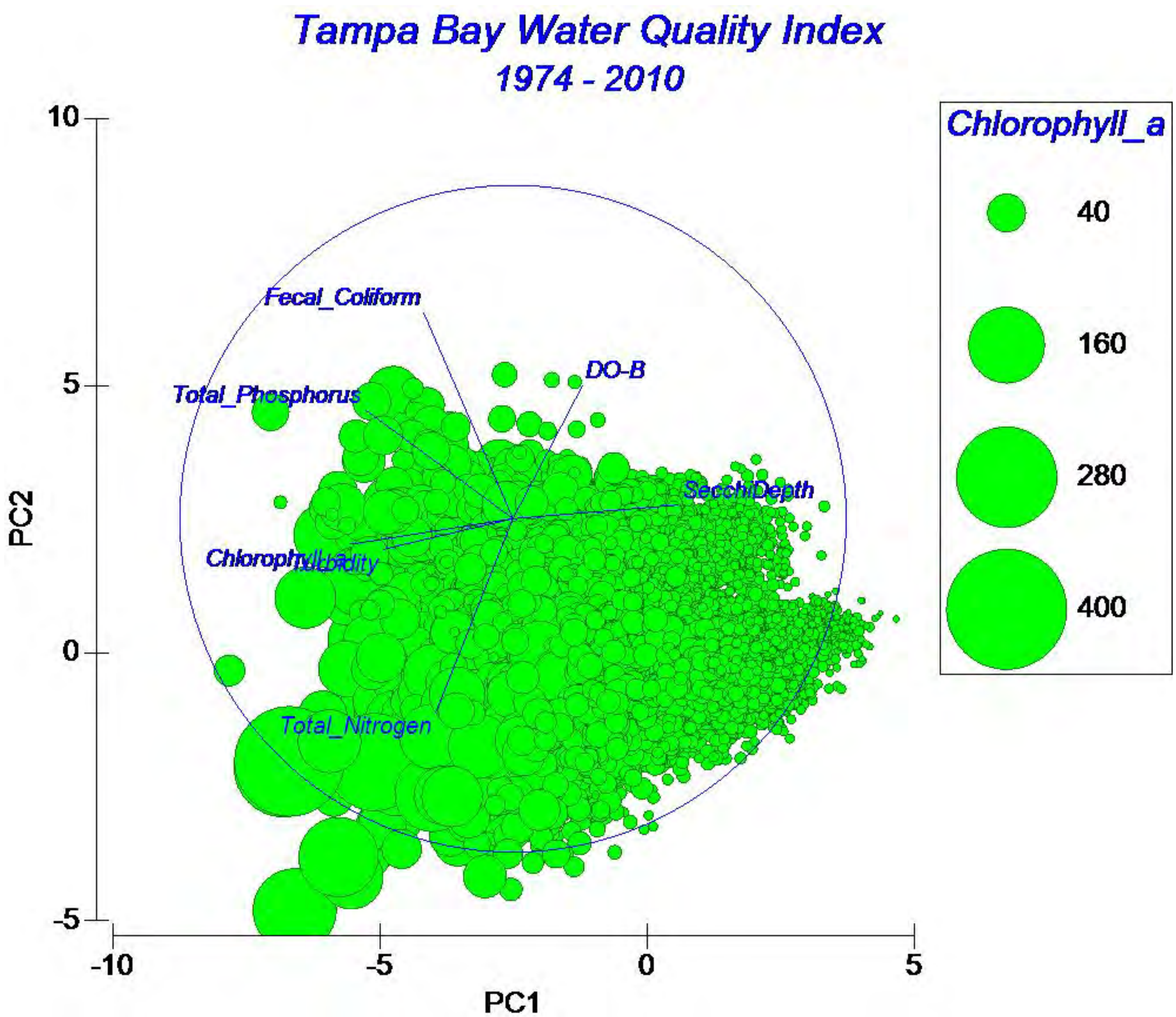

Figure 66. Principal Components Analysis of EPCHC monthly bay monitoring sites (1974 - 2010) based on WQI parameters. Bubbles represent chlorophyll a concentrations (µg/L).

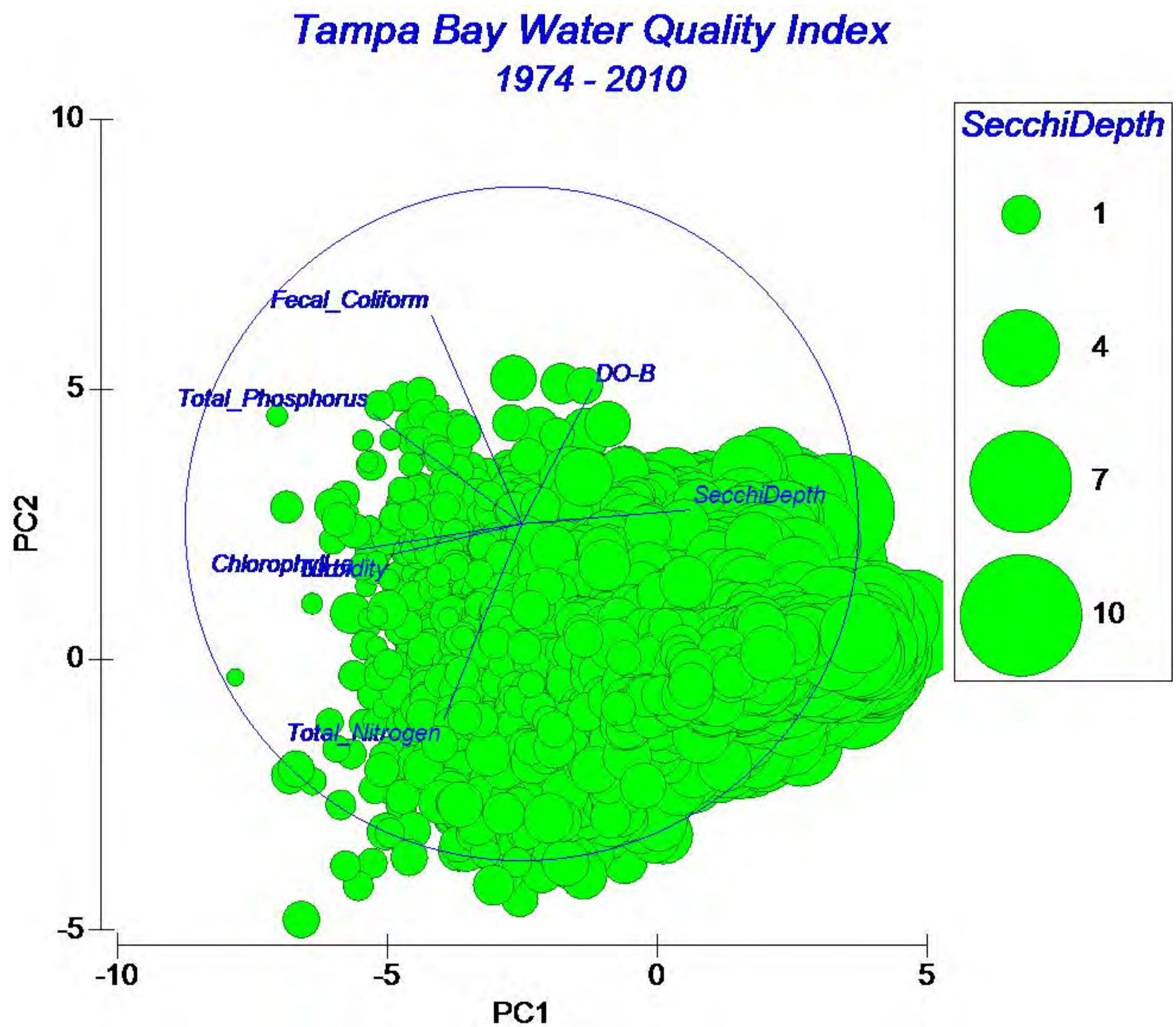

Figure 67. Principal Components Analysis of EPCHC monthly bay monitoring sites (1974 - 2010) based on WQI parameters. Bubbles represent Secchi depths (meters).

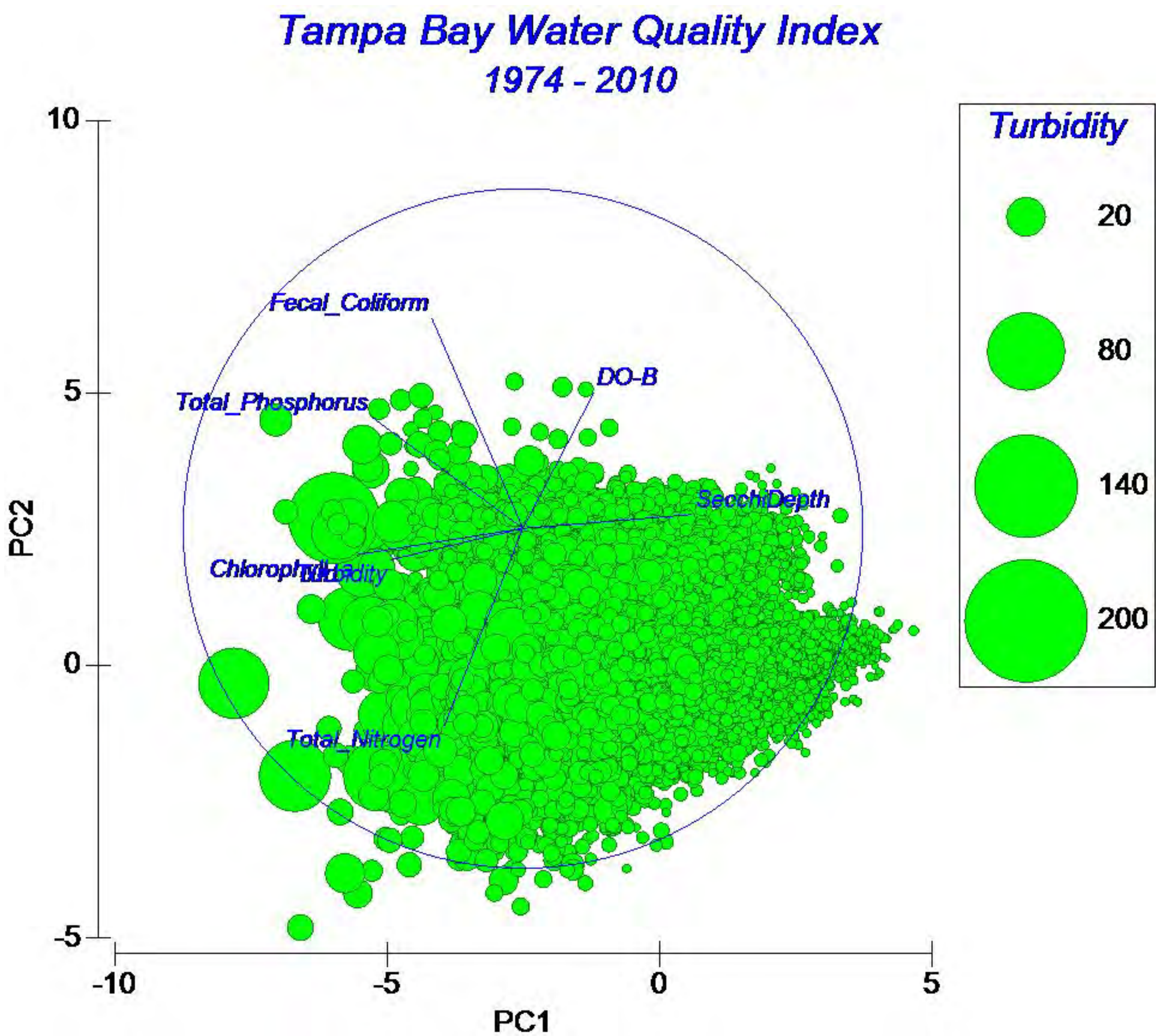

Figure 68. Principal Components Analysis of EPCHC monthly bay monitoring sites (1974 - 2010) based on WQI parameters. Bubbles represent turbidity measurements (NTUs).

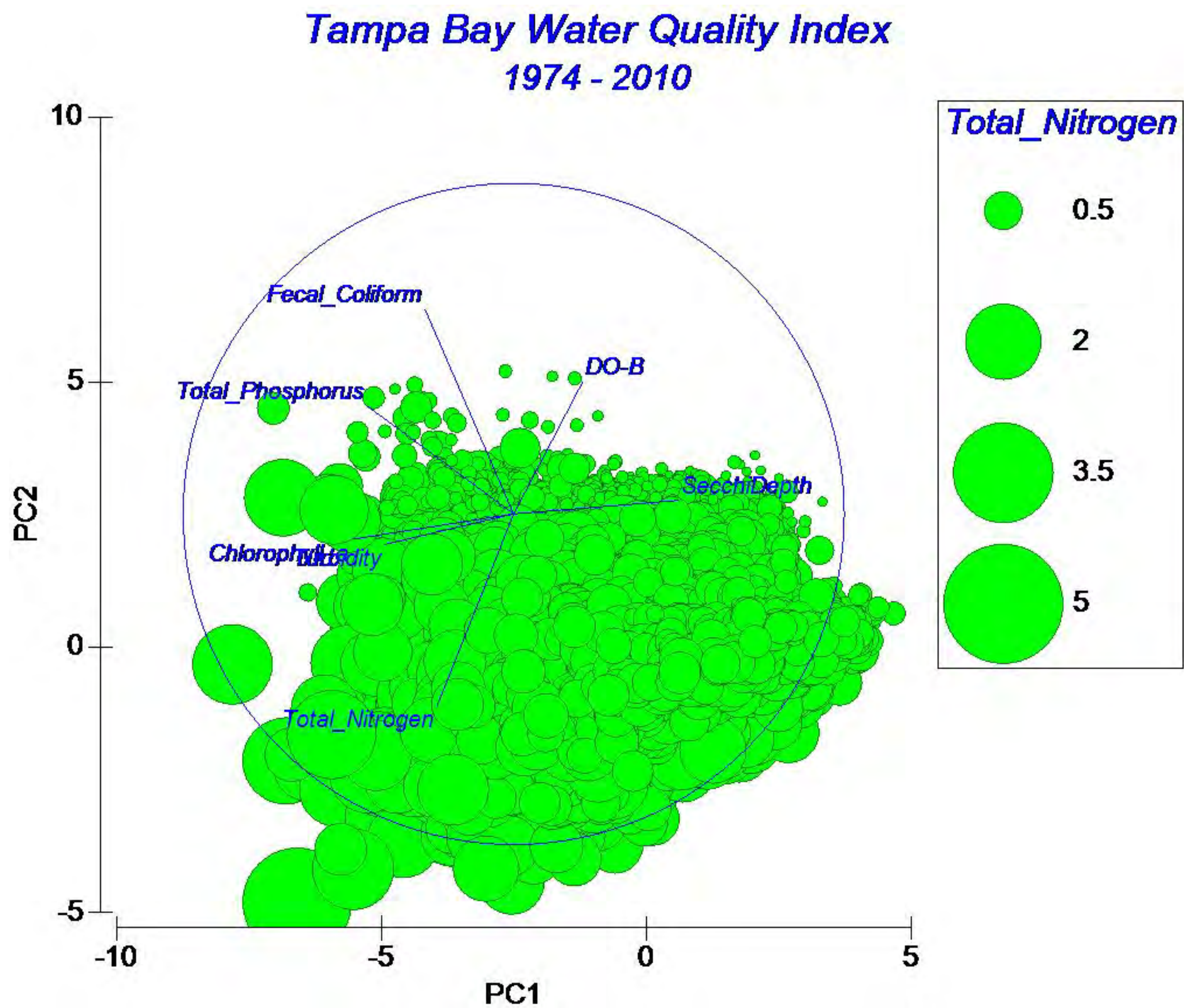

Figure 69. Principal Components Analysis of EPCHC monthly bay monitoring sites (1974 - 2010) based on WQI parameters. Bubbles represent total nitrogen concentrations (mg/L).

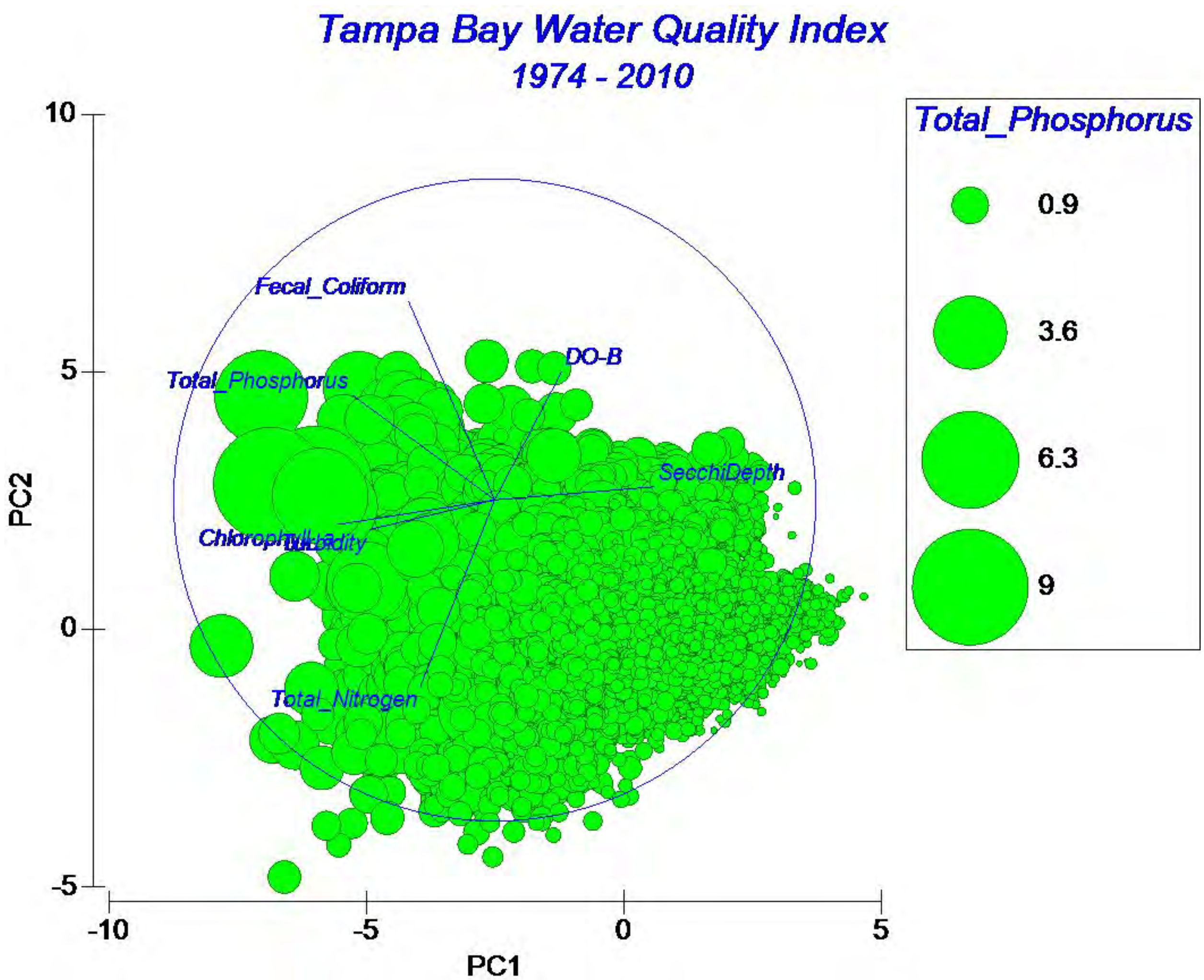

Figure 70. Principal Components Analysis of EPCHC monthly bay monitoring sites (1974 - 2010) based on WQI parameters. Bubbles represent total phosphorus concentrations (mg/L).

Water Quality Index Trends

During the 2001-2010 reporting period the monthly mean WQI scores showed seasonal variability but there was an overall increasing trend over time(Figure 71). The WQI scores tended to be lowest during the summer wet season months and higher during the dry season months across all four bay segments (Figure 71). One noticeable drop in Hillsborough Bay was seen in September 2004 which is attributed to the Hurricane Francis and the resulting impacts that event had on several water quality parameters.

Historical trends in the annual average WQI indicate a trend of improving water quality bay-wide and among the four bay segments (Figure 72; Table 15). The annual bay-wide WQI grades during the earlier years of the monitoring program (1974-1985) were consistently in the “C” range. Water quality started to show improvements in the late 1980’s and bay-wide WQI grades of “B” were seen annually from 1980 – 2004 with one exception (Table 15). The WQI showed a drop in 1998 in all bay segments and the annual bay-wide grade that year was a “C”. This drop was particularly evident in Middle and Lower Tampa Bay, while Hillsborough and Old Tampa Bay had WQI scores in the low “B” range. This drop is likely due to the effect of higher rainfall that year due to an El Niño event. From 2005 – 2010 the bay-wide WQI grade has been an “A”, and this has been consistent across all bay segments from 2006-2010 (Table 15).

The tributaries have also seen an increasing trend in water quality over the history of the monitoring program (Figure 73). This trend is evident at both the Class III Freshwater and Class III Marine tributary site (Figure 74). Table 16 shows the annual average WQI scores for different tributary locations and overall WQI annual average score and grade for all tributary samples. Most tributaries have exhibited improvements in water quality since the beginning of the monitoring program. Average annual tributary WQI scores were predominantly in the “C” range from 1974 – 1994 and since 1995 have been in the “B” range. The greatest improvements are evident in the Hillsborough River and the tributaries of the Alafia River (Table 16). One notable exception is Lake Thonotosassa, which has consistently had annual average WQI scores in the “C” or “D” range. This is the largest fresh water lake in Hillsborough County and has a long history of high nutrient loading and blooms of cyanobacteria (“blue-green” algae) which contribute to high chlorophyll a values and low bottom dissolved oxygen concentrations.

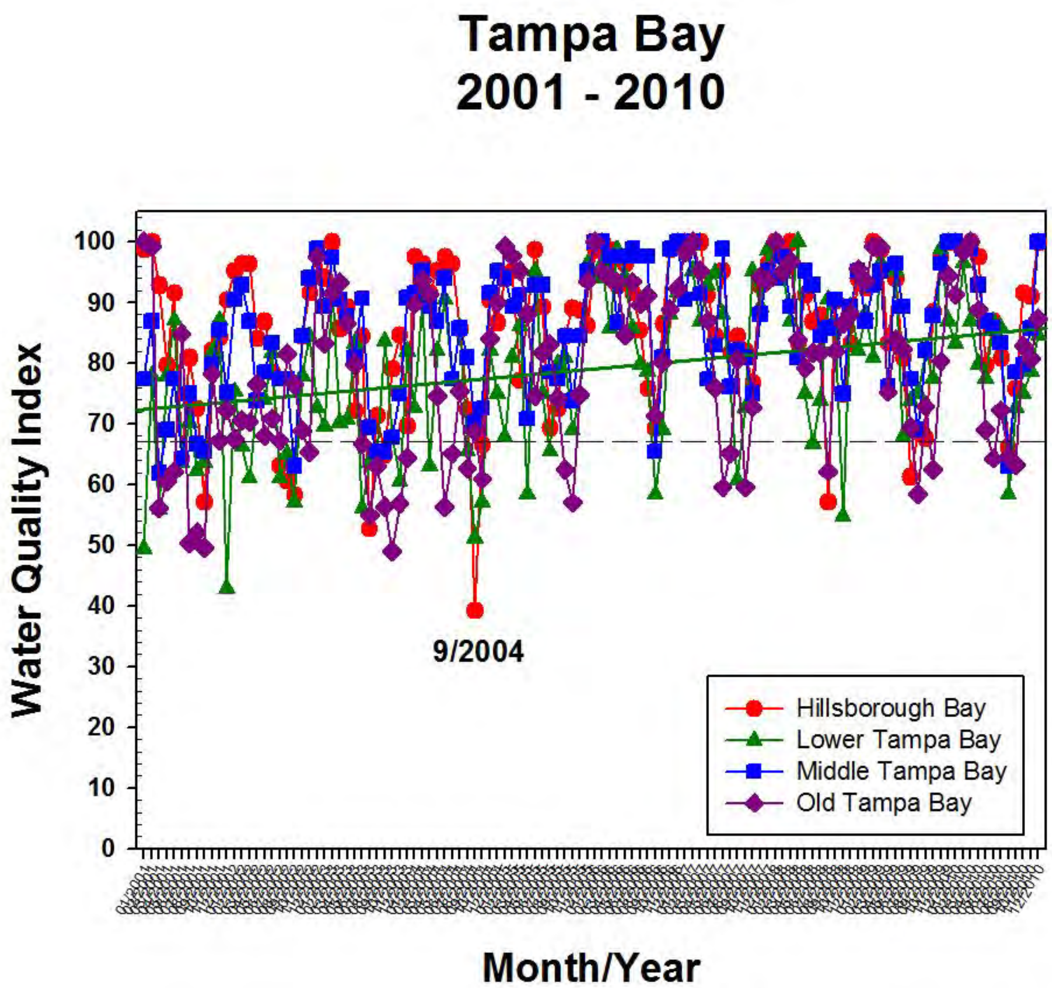

Figure 71. Monthly average WQI 2001 – 2010 by bay segment. Dashed line represents bay-wide historical average. Green regression line indicates historical trend.

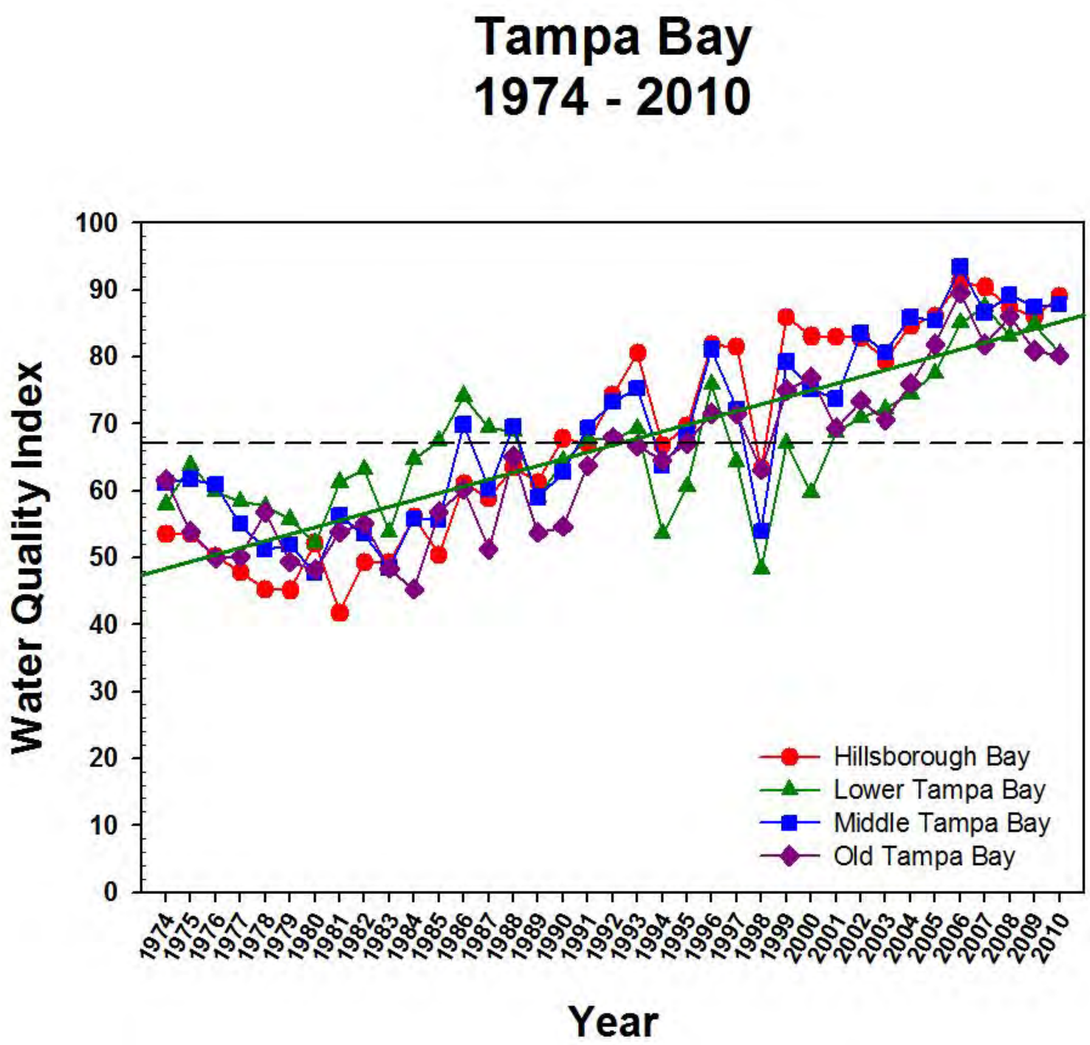

Figure 72. Annual average WQI scores 1974 – 2010 by bay segment. Dashed line represents bay-wide historical average. Green regression line indicates historical bay-wide trend.

Table 15. Annual mean Water Quality Index score by bay segment and overall bay wide mean.

Year	HB	OTB	MTB	LTB	Bay Wide	WQI Grade
1974	54	62	61	58	59	C
1975	53	54	62	64	58	C
1976	50	50	61	60	55	C
1977	48	50	55	58	53	C
1978	45	57	51	58	53	C
1979	45	49	52	56	50	C
1980	52	48	48	52	50	C
1981	42	54	56	61	53	C
1982	49	55	54	63	55	C
1983	49	48	48	54	50	C
1984	56	45	56	65	54	C
1985	50	57	56	67	57	C
1986	61	60	70	74	66	B
1987	59	51	60	69	59	C
1988	63	65	70	69	67	B
1989	61	54	59	59	58	C
1990	68	55	63	64	62	B
1991	67	64	69	68	67	B
1992	74	68	73	68	71	B
1993	81	67	75	69	72	B
1994	67	65	64	54	63	B
1995	70	67	68	61	67	B
1996	82	72	81	76	77	B
1997	81	71	72	64	72	B
1998	63	63	54	48	58	C
1999	86	75	79	67	77	B
2000	83	77	75	60	74	B
2001	83	69	74	69	73	B
2002	83	73	83	71	77	B
2003	79	71	81	72	75	B
2004	85	76	86	74	80	B
2005	86	82	85	78	83	A
2006	91	90	93	85	90	A
2007	90	82	87	87	86	A
2008	87	86	89	83	86	A
2009	86	81	87	85	84	A
2010	89	80	88	80	84	A

Dark Green = "A" (80 – 100); Light Green = "B" (60 – 80); Yellow = "C" (40 – 60); Orange = "D" (20 – 40); Red = "F" (≤20)

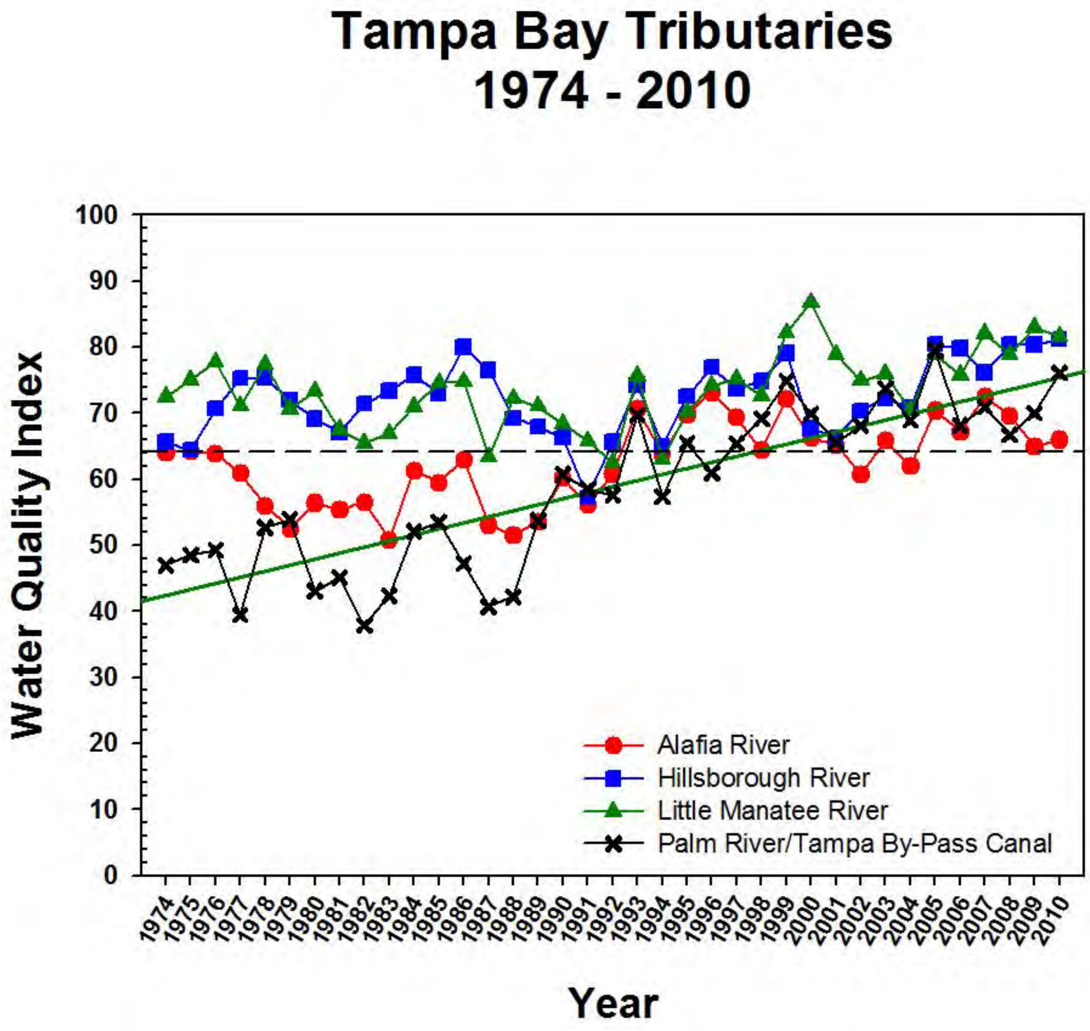

Figure 73. Tampa Bay tributary sites annual average WQI scores 1974 - 2010. Dashed line represents historical average. Green regression line indicates historical trend.

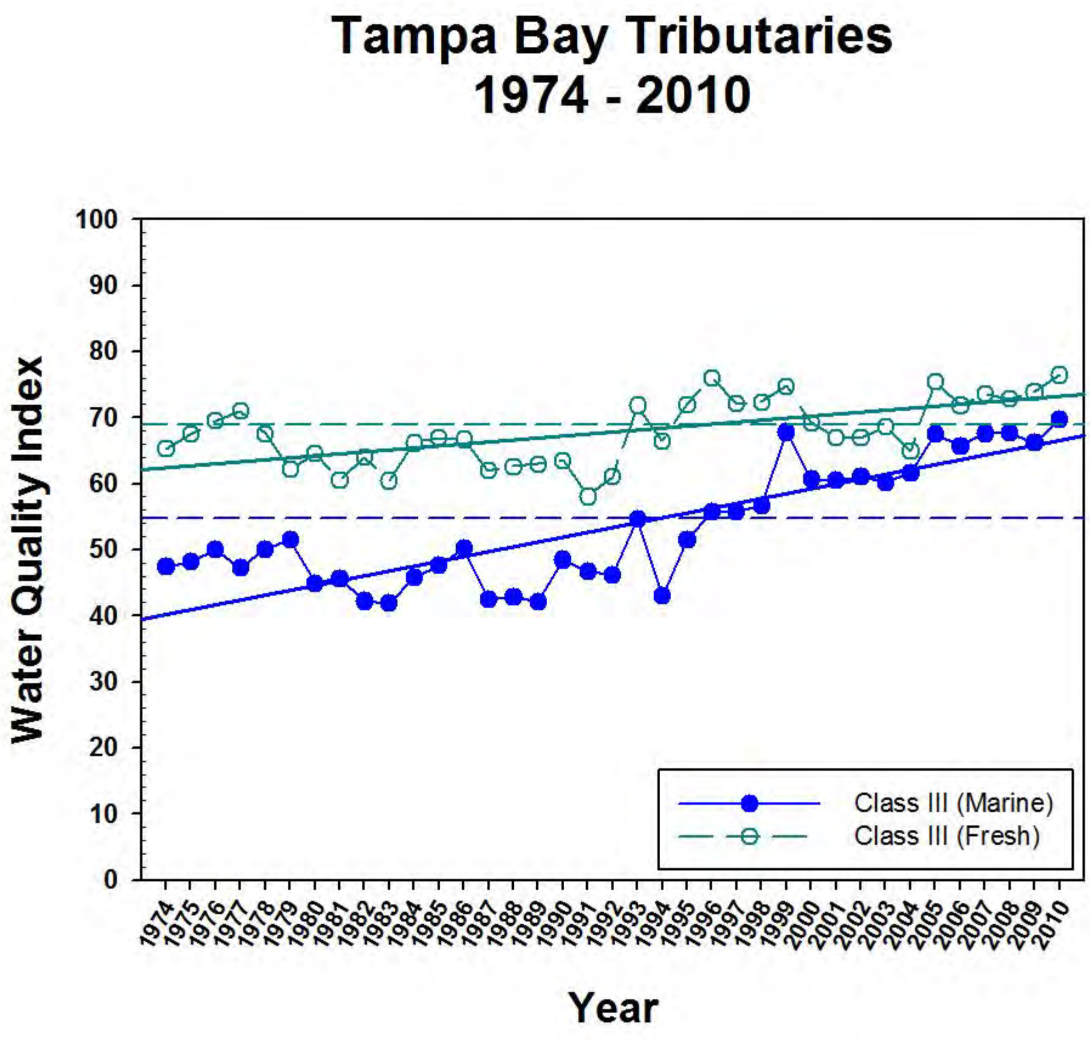

Figure 74. Tampa Bay tributary sites annual average WQI scores 1974 – 2010 by surface water classification. Dashed lines represent historical averages. Regression lines indicate historical trends.

Table 16. Annual mean Water Quality Index score by tributary area and overall tributary mean. AR = Alafia River; HB = Hillsborough Bay; HR = Hillsborough River; Lake T = Lake Thonotosassa; LMR = Little Manatee River; OTB = Old Tampa Bay; PR = Palm River; TBC = Tampa Bypass Canal; Tribs = Tributaries

Year	AR	AR Tribs	HB Tribs	HR	HR Tribs	Lake Thonotosassa	Lake T. Tribs	LMR	OTB Tribs	PR	TBC	TBC Tribs	All Sites	WQI Grade
1974	69	35		66		49	63	72	37	47			58	C
1975	70	36		64		54	68	75	41	48			59	C
1976	65	61	61	71	70	56	72	78	42	49			63	B
1977	66	47	61	73	79	65	70	71	45	39			62	B
1978	63	29	62	75		50	57	77	45	53			60	B
1979	58	32	57	71	76	47	47	71	46	54			58	C
1980	65	24	59	68	74	42	39	73	39	43			56	C
1981	60	30	53	66	75	36	35	67	44	45			54	C
1982	64	21	52	70	78	37	52	65	42	38			55	C
1983	57	22	44	72	79	35	41	67	37	42			53	C
1984	67	34	42	76	76	45	44	71	39	52			58	C
1985	64	35	48	72	80	46	58	75	42	53			59	C
1986	69	33	58	80	81	32	38	75	40	47			60	B
1987	58	31	46	76	78	33	62	63	36	41			54	C
1988	55	36	48	72	63	35	62	72	47	42			55	C
1989	58	32	38	73	61	31	56	71	53	40	68		56	C
1990	65	33	45	76	51	33	61	68	55	50	72		59	C
1991	57	52	37	67	45	26	65	66	54	51	65		54	C
1992	63	54	45	76	51	25	57	62	51	52	63		56	C
1993	73	64	49	81	65	37	74	76	60	64	75		66	B
1994	69	49	47	72	56	44	67	63	53	50	64		59	C
1995	74	59	52	78	65	43	82	70	56	63	68		66	B
1996	76	66	70	83	70	36	83	74	61	53	68		70	B
1997	72	62	61	81	64	35	73	75	62	61	70		67	B
1998	67	58	62	81	67	41	73	73	65	62	77		67	B
1999	74	67	65	85	70	38	75	82	72	75	74		72	B
2000	68	62	65	72	59	35	70	87	59	70	70		66	B
2001	70	55	69	70	58	38	61	79	60	67	64		65	B
2002	64	53	66	78	58	39	71	75	60	67	69		65	B
2003	68	62	57	77	65	37	61	76	60	74	74		66	B
2004	62	62	57	75	64	30	58	70	65	65	73		64	B
2005	72	67	76	84	73	40	70	79	70	76	83		73	B
2006	67	67	68	85	68	42	68	76	70	67	72	61	70	B
2007	75	68	73	83	66	38	72	82	70	76	69	65	72	B
2008	71	66	72	85	71	43	71	79	69	72	65	60	71	B
2009	66	63	69	82	76	42	73	83	69	74	65	68	71	B
2010	66	66	73	84	76	45	77	82	76	79	74	73	74	B

Dark Green = "A" (80 – 100); Light Green = "B" (60 – 80); Yellow = "C" (40 – 60); Orange = "D" (20 – 40); Red = "F" (≤20)

Conclusions

Surface water quality conditions in Tampa Bay have shown tremendous gains since the early 1970's when the Environmental Protection Commission of Hillsborough County initiated its monitoring program. Challenges remain however despite the improvements seen over the last 40 years. Population growth and development continue to add stress to the Tampa Bay through increased stormwater runoff and nutrient loading. These effects have been seen especially in Old Tampa Bay which has experienced repeated blooms of the toxic dinoflagellate *Pyrodinium bahamense* since 2000. Climatic events, such as Hurricane Francis in 2004, can also have noticeable impacts on the bay water quality as can isolated industrial accidents and infrastructure failures.

The historical improvements to Tampa Bay's water quality can be attributed to several factors. The single event which has had the greatest impact has been the Grizzle-Figg Advanced Wastewater Treatment Act passed in 1978 and the subsequent upgrades to wastewater treatment facilities discharging into Tampa Bay. The positive effects of this legislation are reflected in the dramatic decreases in fecal coliform, nutrients and chlorophyll a concentrations observed through the 1980's in our monitoring data. In the late 1980's and early 1990's the Surface Water Improvement and Management Act (SWIM) administered by the Southwest Florida Water Management District provided continued funding for further restoration. The formation of the Tampa Bay National Estuary Program provided coordination of bay restoration efforts through bringing together local managers and stakeholders and the development of a Comprehensive Conservation Management Plan (CCMP) for Tampa Bay. Since then water quality has continued to show improvement as indicated by increasing Water Quality Index scores. Throughout this time the EPCHC monitoring program has been central for providing the data needed for making scientifically sound management decisions and tracking long term water quality improvements in Tampa Bay.

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