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Technical Memorandum

Tracking Chlorophyll-*a* and Light Attenuation in Tampa Bay: Application to 2003 Data

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Water quality targets have been adopted by the TBNEP Management and Policy Committees for the four mainstem segments of Tampa Bay. The Tampa Bay Estuary Program has developed a tracking process to determine if water quality targets are being achieved (Janicki et al., 2000). The process to track the status of chlorophyll-*a* concentration and light attenuation involves two steps. The first step utilizes a decision framework to evaluate differences in mean annual ambient conditions from the established targets. The second step incorporates the results of the decision framework into a decision matrix leading to possible outcomes dependent upon the magnitude and duration of the events in excess of the target (Janicki et al., 2000). The objective of this technical memorandum is to compare the annual mean ambient chlorophyll-*a* concentration and light attenuation for 2003 to the segment-specific targets using the tracking process.

The tracking process is used not only to determine if there are differences between ambient conditions and targets, but also to determine the size of the differences and how long the conditions exist. The first step of the tracking process is presented in Figure 1. When mean ambient chlorophyll-*a* concentrations are less than the target, there is no cause for concern, as represented by Outcome 0 in Figure 1. When mean ambient chlorophyll-*a* concentrations are greater than target values, however, the size of the difference and the duration of the difference are considered. Small differences for short time periods result in Outcome 1, while large differences for short time periods and small differences for long time periods result in Outcome 2. In the most severe condition, when large differences exist for long periods, the framework results in Outcome 3.

The second step of the tracking process involves combining the outputs from the decision frameworks for chlorophyll-*a* concentration and light attenuation in a decision matrix to provide direction for management responses when targets are exceeded. The decision framework shown in Figure 1 for chlorophyll-*a* concentration is the same as that for light attenuation.

The decision matrix incorporating the outcomes for chlorophyll-*a* concentration and light attenuation is shown in Table 1. When outcomes for both chlorophyll-*a* concentration and light attenuation are good, as represented by Outcome 0 for both, a condition exists in which targets are being met, and so no management response is required. This condition is signified by the green cell in Table 1.

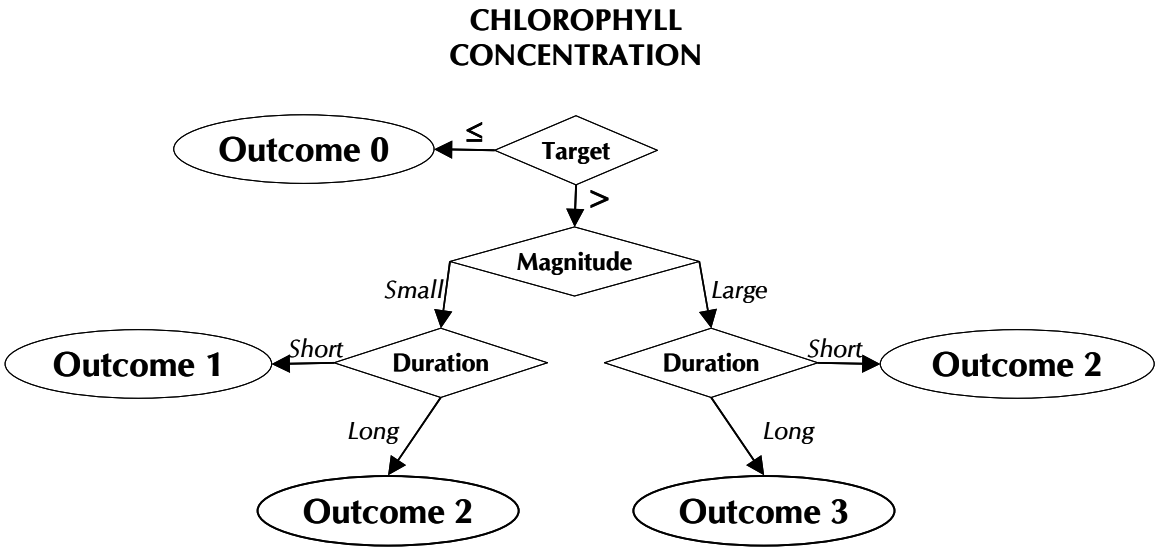

Figure 1. Monitoring and assessment decision framework for chlorophyll-a (from Janicki et al., 2000).

When conditions are intermediate, as signified by the yellow cells in Table 1, differences from the targets exist for either or both chlorophyll-*a* concentration and light attenuation. These conditions may result in some type of management response.

When conditions are problematic, such that the outcomes for the parameters fall within the red cells of Table 1, stronger management responses may be warranted. The types of management actions resulting from the decision matrix are classified by color into three categories, shown following Table 1.

Table 1. Decision matrix identifying appropriate categories of management actions in response to various outcomes of the monitoring and assessment of chlorophyll-*a* and light attenuation data.

CHLOROPHYLL	LIGHT ATTENUATION			
↓	Outcome 0	Outcome 1	Outcome 2	Outcome 3
Outcome 0	GREEN	YELLOW	YELLOW	YELLOW
Outcome 1	YELLOW	YELLOW	YELLOW	RED
Outcome 2	YELLOW	YELLOW	RED	RED
Outcome 3	YELLOW	RED	RED	RED

- **GREEN** "Stay the course"; partners continue with planned projects to implement the CCMP. Data summary and reporting via the Baywide Environmental Monitoring Report and annual assessment and progress reports.

- **YELLOW** TAC and Management Board on caution alert; review monitoring data and loading estimates; attempt to identify causes of target exceedences; TAC report to Management Board on findings and recommended responses if needed.

- **RED** TAC, Management and Policy Boards on alert; review and report by TAC to Management Board on recommended types of responses. Management and Policy Boards take appropriate actions to get the program back on track.

The time series of annual chlorophyll-*a* concentrations and light attenuation for 1974-2003 in Old Tampa Bay, Hillsborough Bay, Middle Tampa Bay, and Lower Tampa Bay are shown in Figures 2 through 9. The mean ambient chlorophyll-*a* concentration and light attenuation for 2003 for each segment are shown in Table 2, along with the segment-specific targets.

Table 2. Mean ambient chlorophyll-*a* concentrations and light attenuation for 2003.

Bay Segment	Chlorophyll-*a* (μg/L)		Light Attenuation (m^{-1})	
	2003	Target	2003	Target
Old Tampa Bay	**11.7**	**8.5**	**0.92**	**0.83**
Hillsborough Bay	**12.4**	**13.2**	**1.83**	**1.58**
Middle Tampa Bay	**7.8**	**7.4**	**0.78**	**0.83**
Lower Tampa Bay	**3.4**	**4.6**	**0.73**	**0.63**

Mean annual chlorophyll-a concentrations from the Environmental Protection Commission Surface Water Monitoring Program are shown for 2003 in Figure 10. Chlorophyll-a concentrations in Old Tampa Bay were consistently higher than the target concentration of 8.5 μg/L with the highest concentration (17.3 μg/L) near the Bayside Bridge. A mean concentration of 17.5 μg/L was measured at the mouth of the Alafia River the highest value in Hillsborough Bay. Chlorophyll-a concentrations were below target near Bishop Harbor the site of discharge for Piney Point. Monitoring and analysis of conditions in Bishop Harbor and Tampa Bay should continue to insure minimal impacts on water quality caused by increased nitrogen loading to the system.

Applying the decision frameworks for chlorophyll-*a* concentration and light attenuation as shown in Figure 1, the outcomes for the 2003 data were:

Bay Segment	Chlorophyll-a Concentration	Light Attenuation
Old Tampa Bay	**2**	**2**
Hillsborough Bay	**0**	**2**
Middle Tampa Bay	**0**	**0**
Lower Tampa Bay	**0**	**2**

Placing these outcomes in the decision matrix shown in Table 1 leads to the following results:

Old Tampa Bay: **Red**
Hillsborough Bay: **Yellow**
Middle Tampa Bay: **Green**
Lower Tampa Bay: **Yellow**

The "Red" status during 2003 for Old Tampa Bay was the result of both chlorophyll-*a* concentration and light attenuation exceeding the target set by a large magnitude increase as shown in Figures 2 and 6. Large magnitude differences in light attenuation in Hillsborough Bay (Figure 7) combined with chlorophyll-a concentration below target levels (Figure 3) resulted in an outcome of "Yellow". Middle Tampa Bay had a chlorophyll-a concentration near target (Figure 4) and light attenuation was below target for the second consecutive year since monitoring began (Figure 8) resulting in a status of "Green". In Lower Tampa Bay chlorophyll-a concentration remained below target levels for the third consecutive year but a large magnitude increase in light attenuation above target levels resulted in an outcome of "Yellow"(Figure 9).

To place the 2003 decision matrix results in perspective with results from previous years, the decision matrix results for 1975-2003 are shown below in Table 3. The "Red" matrix results for Old Tampa Bay follows from the outcome of both chrlorophyll-a and light attenuation decision framework.

Table 3. Decision matrix results.				
Year	Old Tampa Bay	Hillsborough Bay	Middle Tampa Bay	Lower Tampa Bay
1975	Red	Red	Red	Green
1976	Red	Red	Red	Yellow
1977	Red	Red	Red	Red
1978	Red	Red	Red	Yellow
1979	Red	Red	Red	Red
1980	Red	Red	Red	Red
1981	Red	Red	Red	Red
1982	Red	Red	Red	Red
1983	Red	Yellow	Red	Red
1984	Red	Green	Red	Yellow
1985	Red	Red	Red	Yellow
1986	Red	Yellow	Red	Green
1987	Red	Yellow	Red	Green
1988	Yellow	Green	Yellow	Green
1989	Red	Yellow	Red	Yellow
1990	Red	Green	Red	Yellow
1991	Green	Yellow	Yellow	Yellow
1992	Yellow	Green	Yellow	Yellow
1993	Yellow	Green	Yellow	Yellow
1994	Yellow	Yellow	Red	Red
1995	Red	Yellow	Red	Yellow
1996	Yellow	Green	Yellow	Green
1997	Yellow	Green	Red	Yellow
1998	Red	Red	Red	Red
1999	Yellow	Green	Yellow	Yellow
2000	Green	Green	Yellow	Yellow
2001	Yellow	Green	Yellow	Yellow
2002	Yellow	Green	Green	Green
2003	Red	Yellow	Green	Yellow

The change from Yellow to Red in Old Tampa Bay and from Green to Yellow in Hillsborough Bay and Lower Tampa Bay may be attributed to higher than normal rainfall in the region. Average yearly rainfall from 1987-2001 was 135 cm as compared to 172 cm in 2003. Previous data has shown increased hydrologic loading resulting from higher rainfall, increases pollutant loadings to the bay.

In addition to chlorophyll-a, another indicator of higher than normal hydrologic load is color. Color results from the presence of one or more constituents such as natural metallic ions, humic material, plankton, and industrial waste. Humic substances high in tannin are derived from upstream portions of the tributaries. High rainfalls act to flush organic material that would normally stay upstream as detritus trapped in wetlands and headwater swamps. Higher than normal color was evident in all four bay segments of Tampa Bay in June through September in response to increased hydrologic loading (Figure 11). A comparison of color for all bay segments from 1974 -2003 show that color was abnormally high second only to the 1998 values (Figure 12).

In conclusion, 2003 water quality in Tampa Bay, based on the decision matrix showed a marked decline from the previous four years. Higher than average rainfall is most likely to blame for associated increases in chlorophyll-a and light attenuation and continued monitoring will determine if any management responses are necessary.

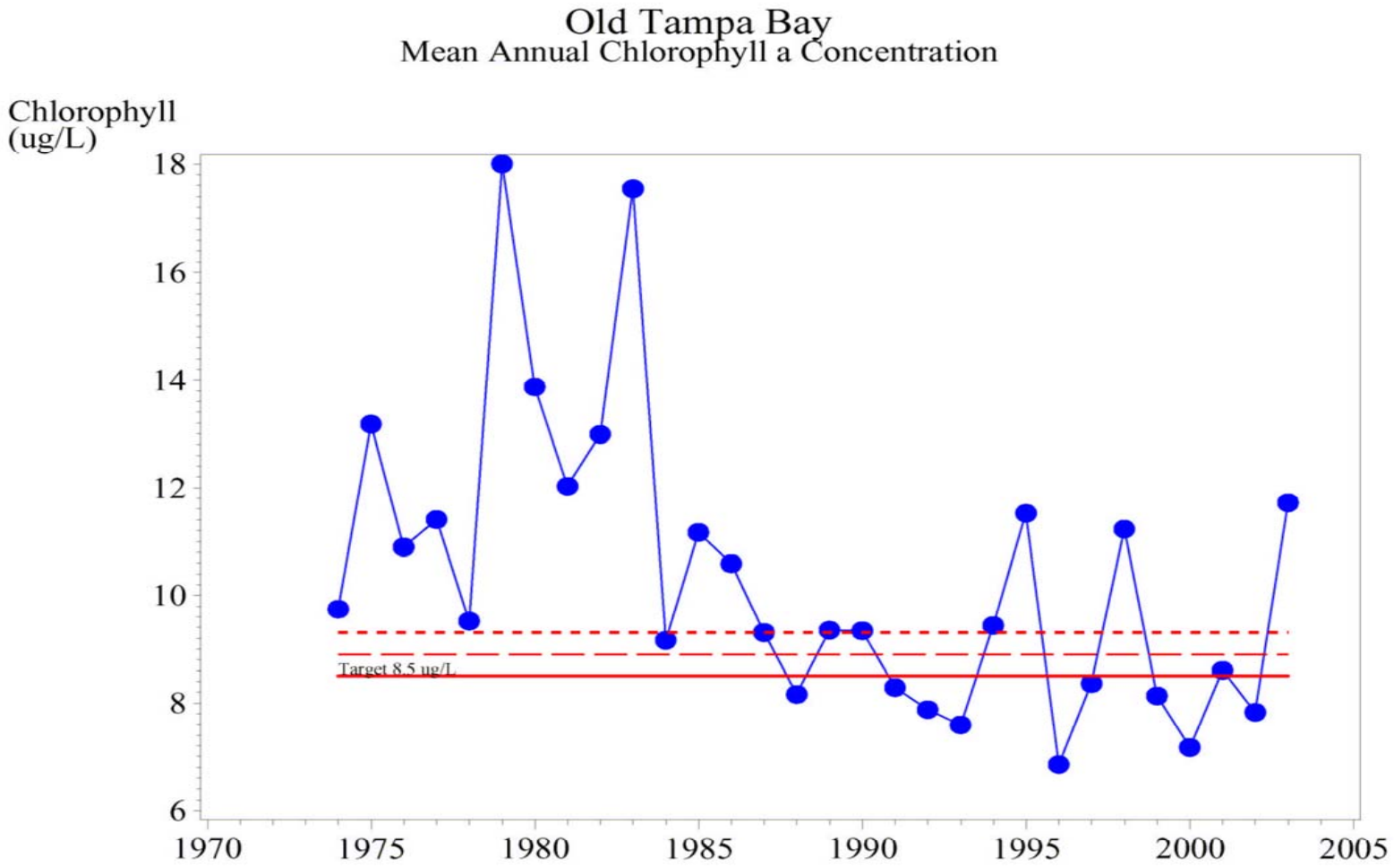

Figure 2. Old Tampa Bay mean annual chlorophyll-a concentrations, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line).

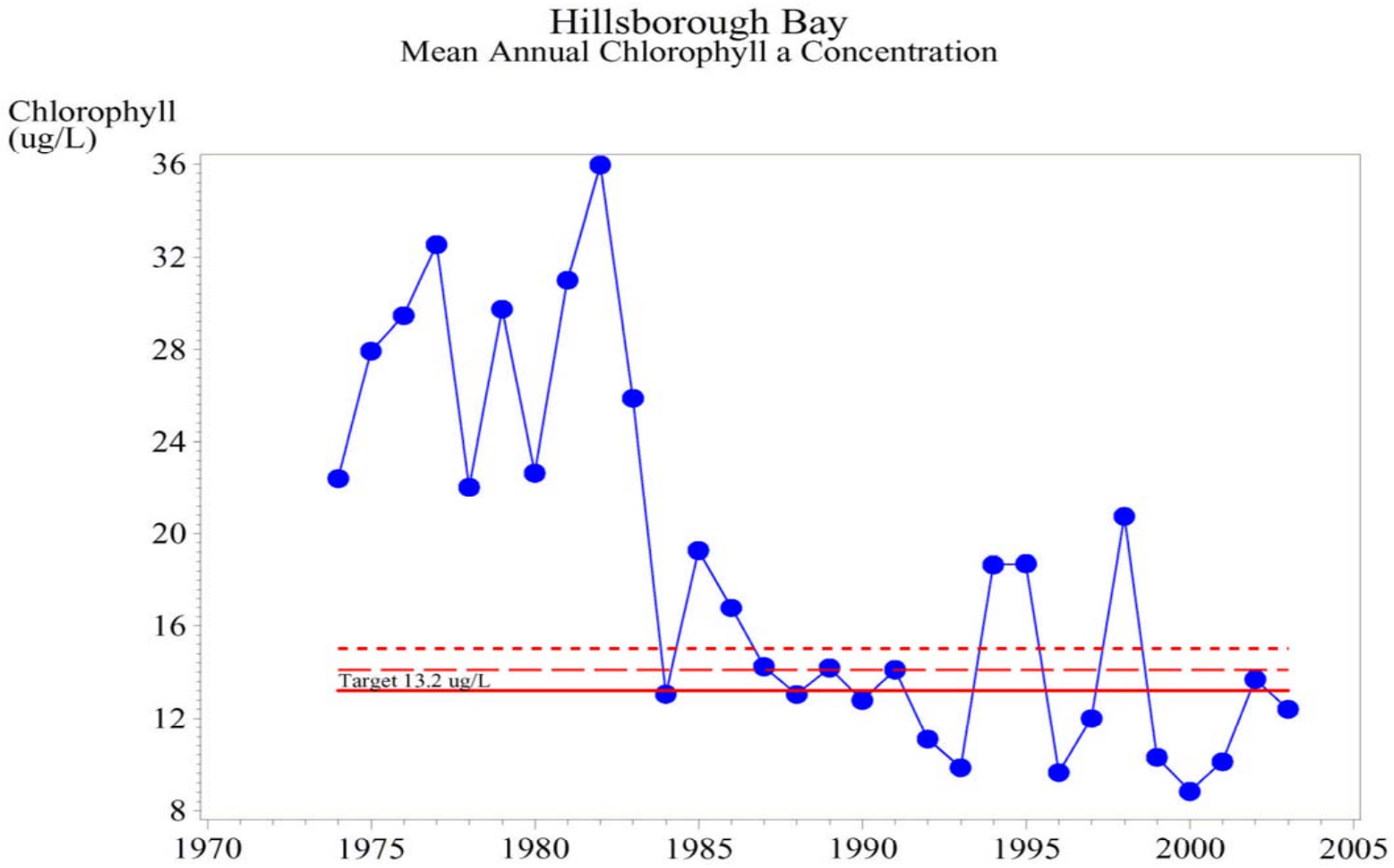

Figure 3. Hillsborough Bay mean annual chlorophyll-a concentrations, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line). Data from EPCHC Station 8 for September 2002 are included.

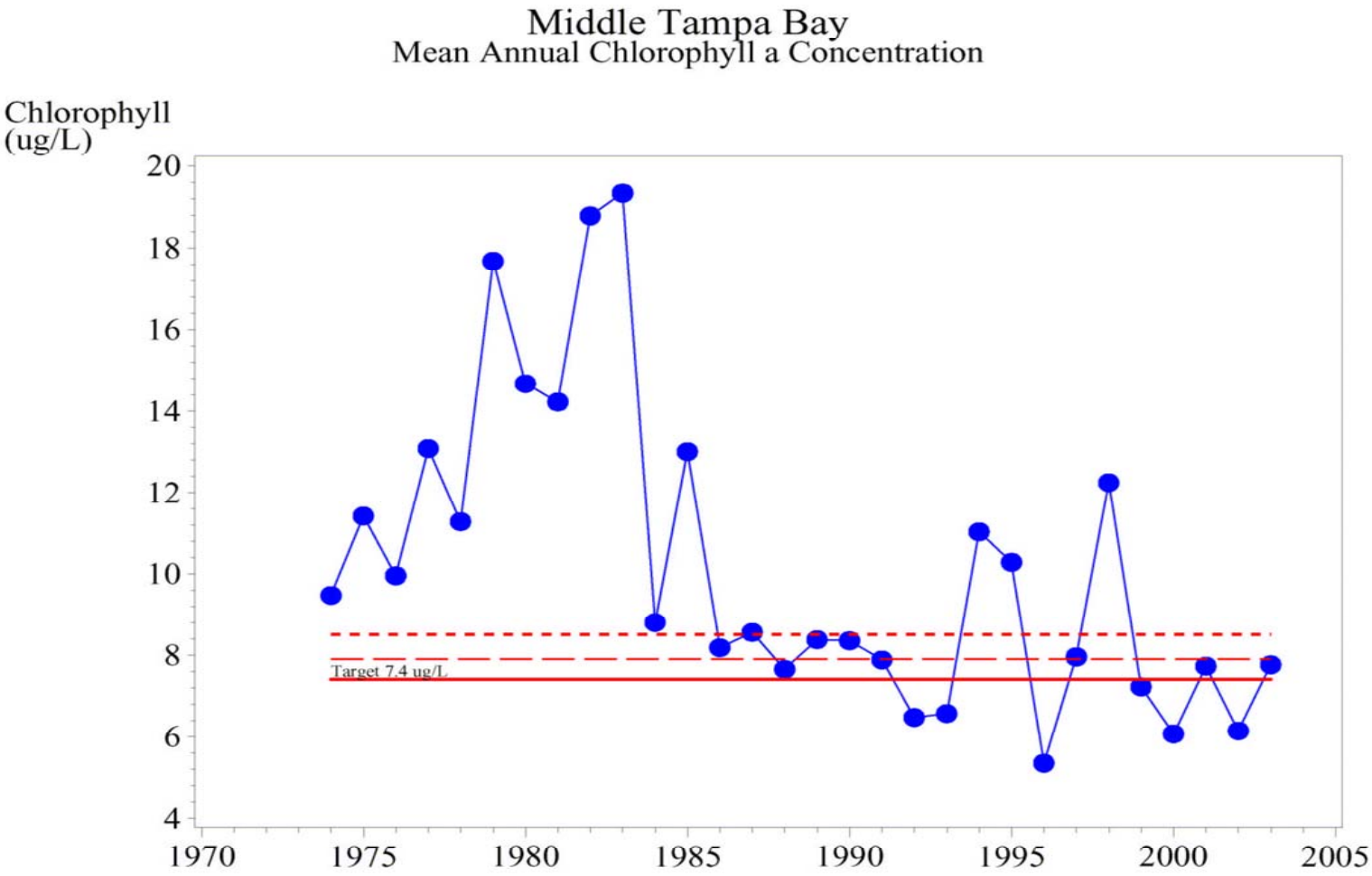

Figure 4. Middle Tampa Bay mean annual chlorophyll-a concentrations, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line).

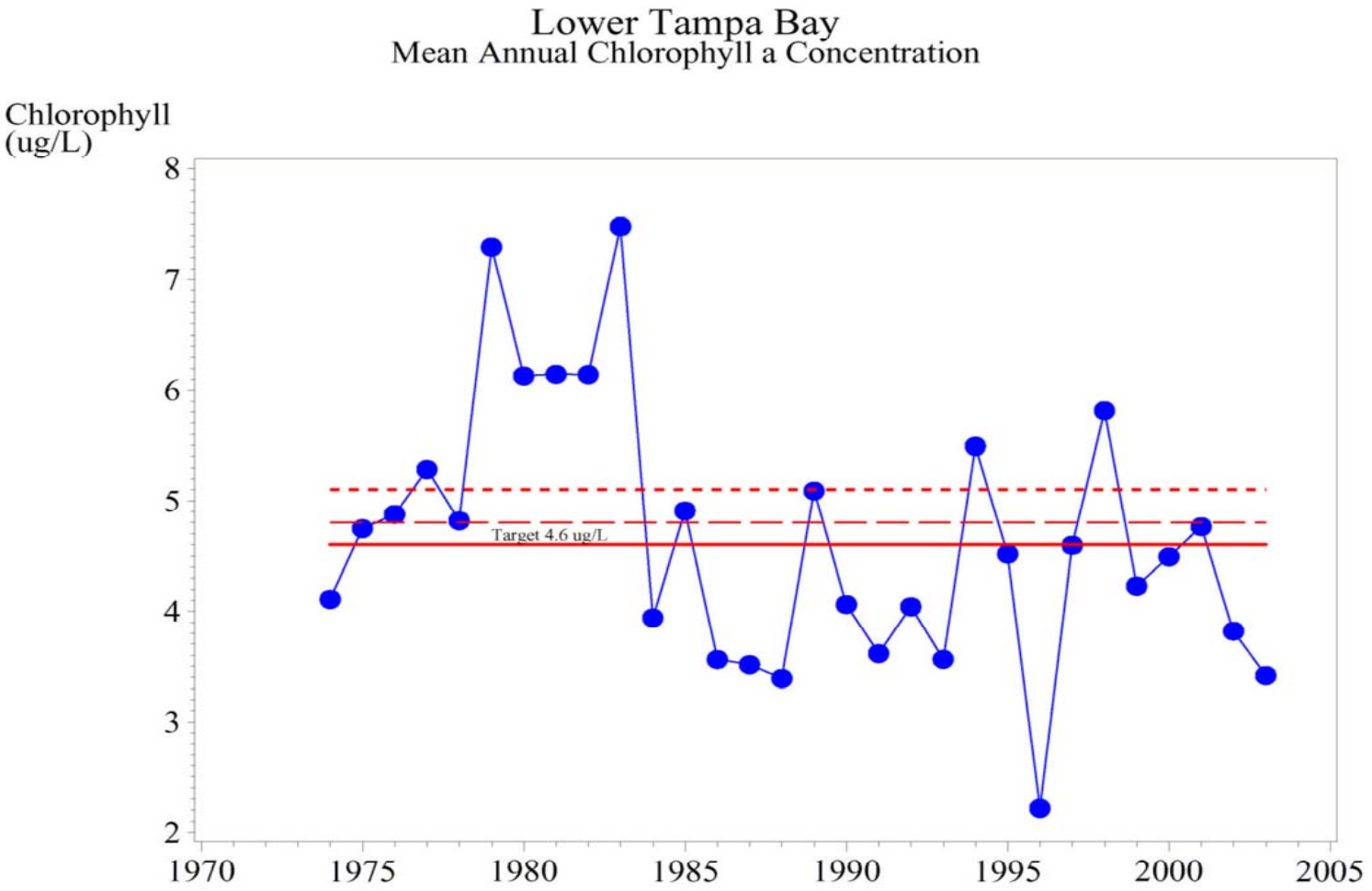

Figure 5. Lower Tampa Bay mean annual chlorophyll-*a* concentrations, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line).

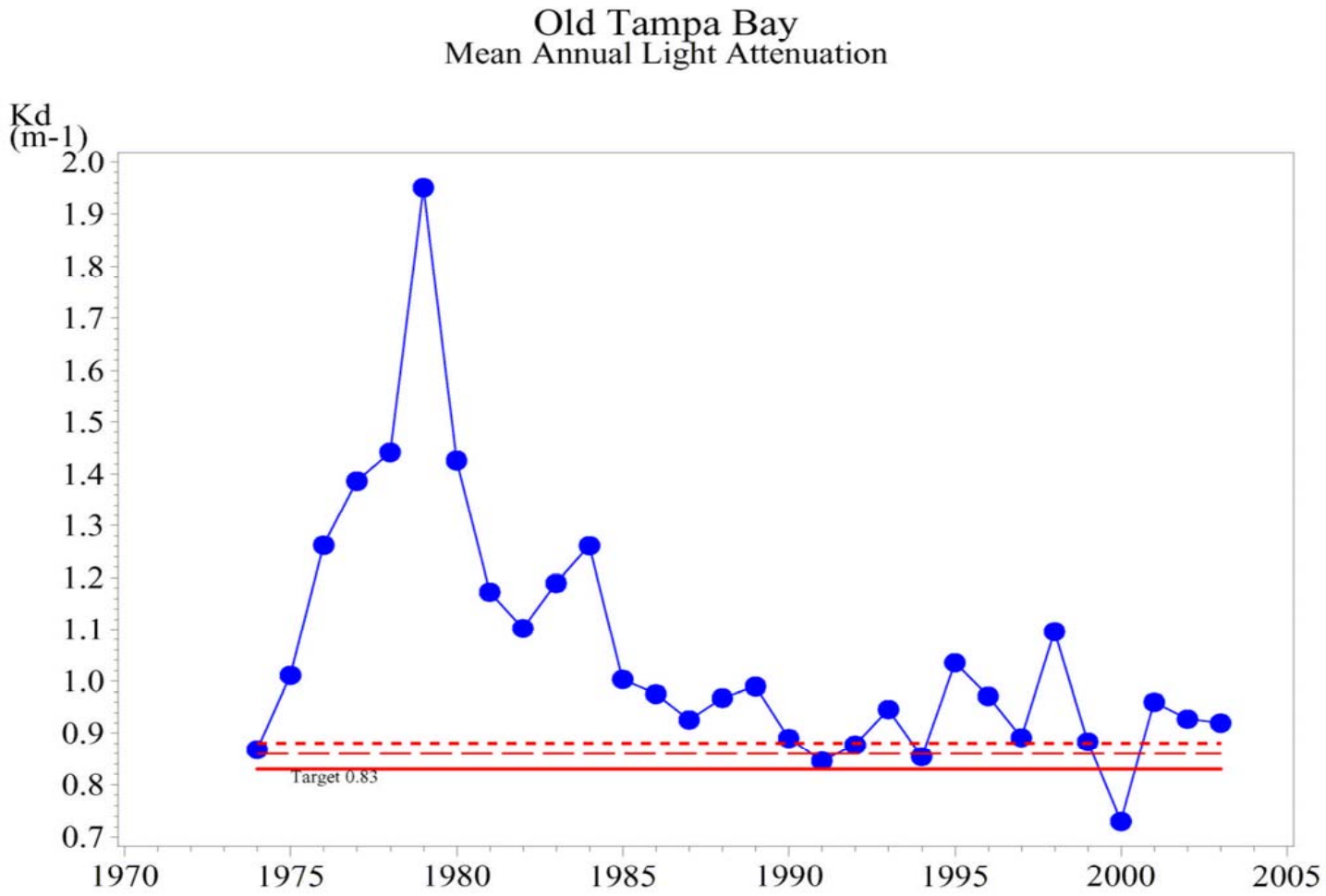

Figure 6. Old Tampa Bay mean annual light attenuation, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line).

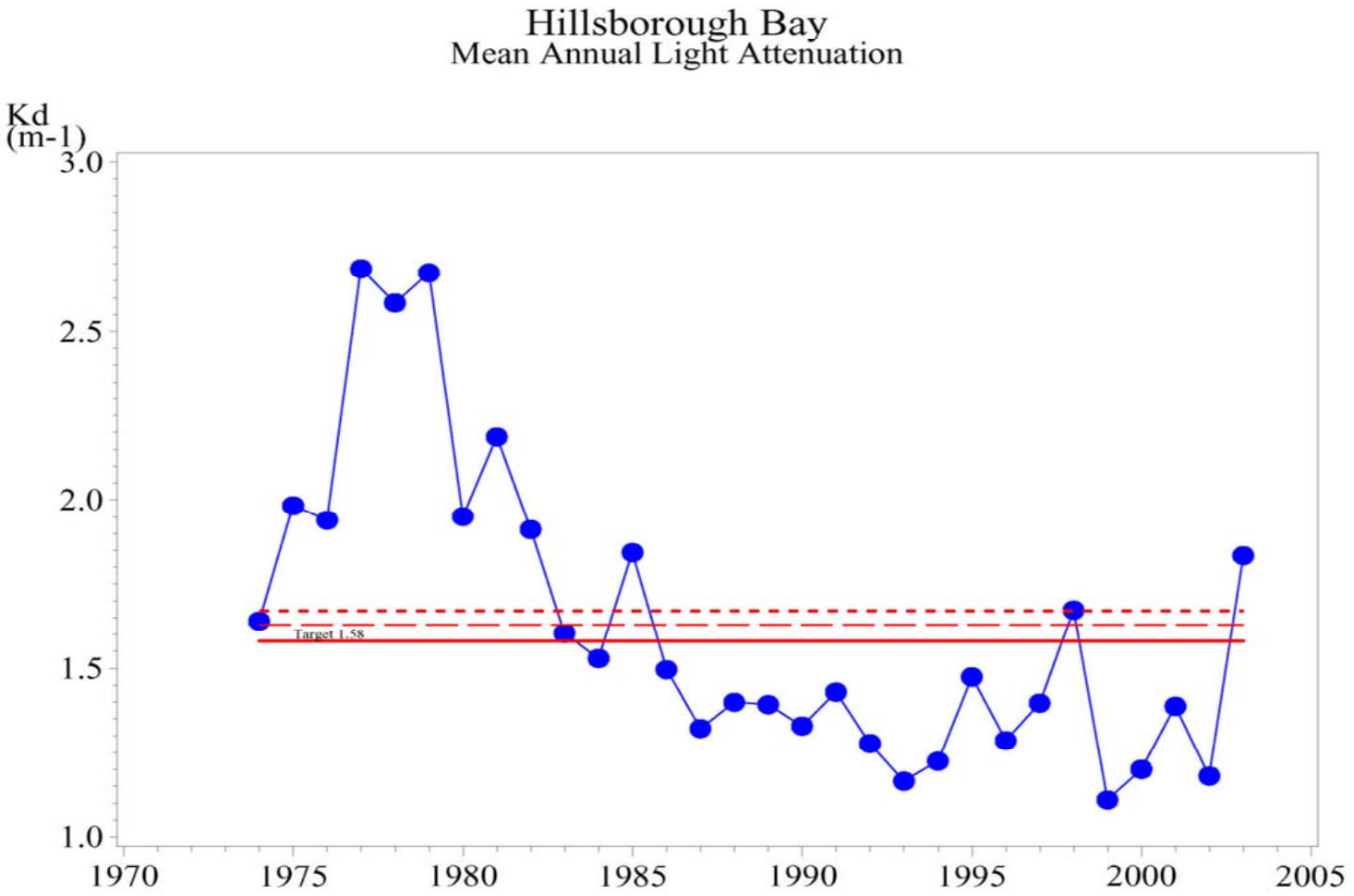

Figure 7. Hillsborough Bay mean annual light attenuation, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line).

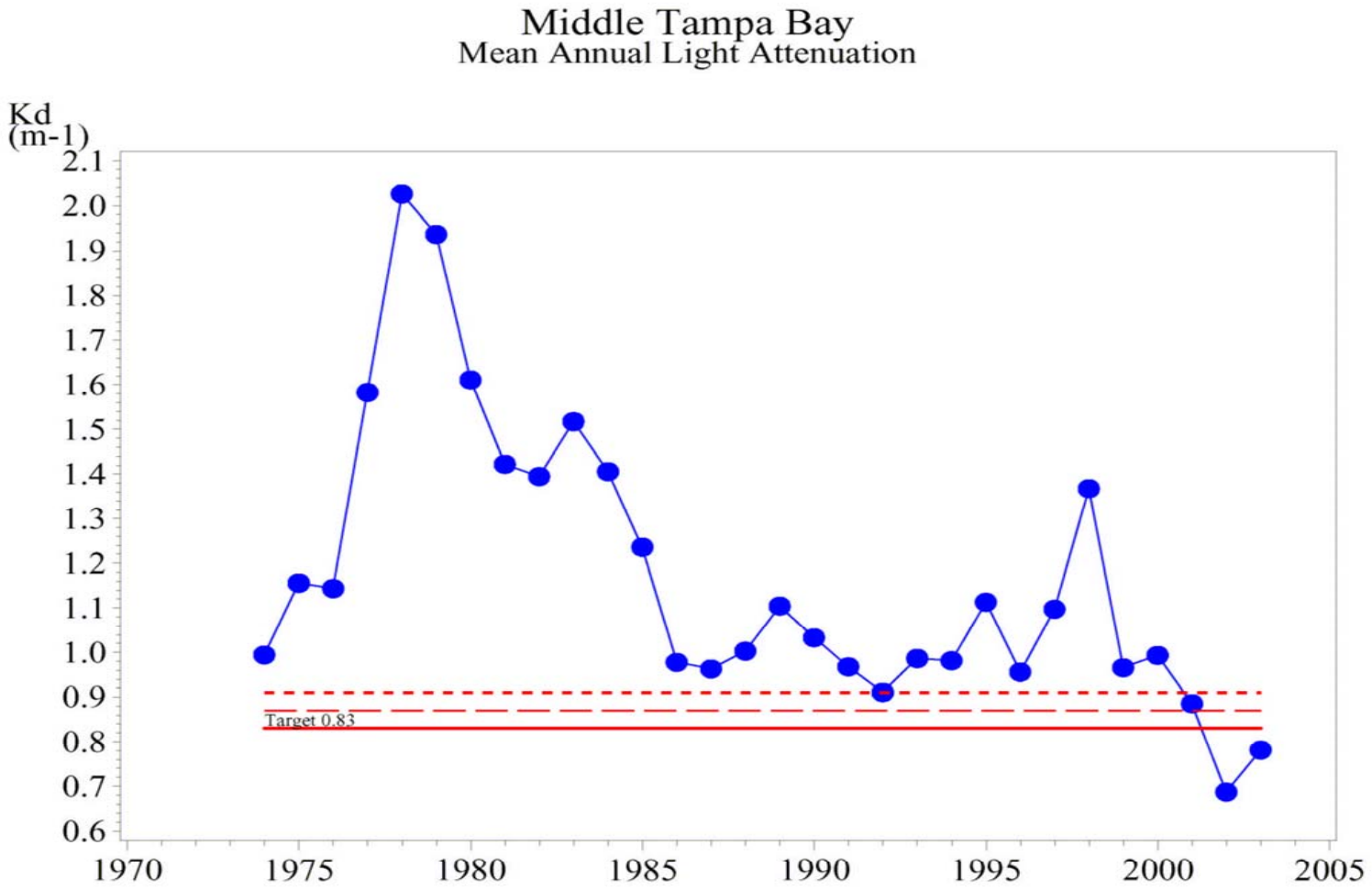

Figure 8. Middle Tampa Bay mean annual light attenuation, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line).

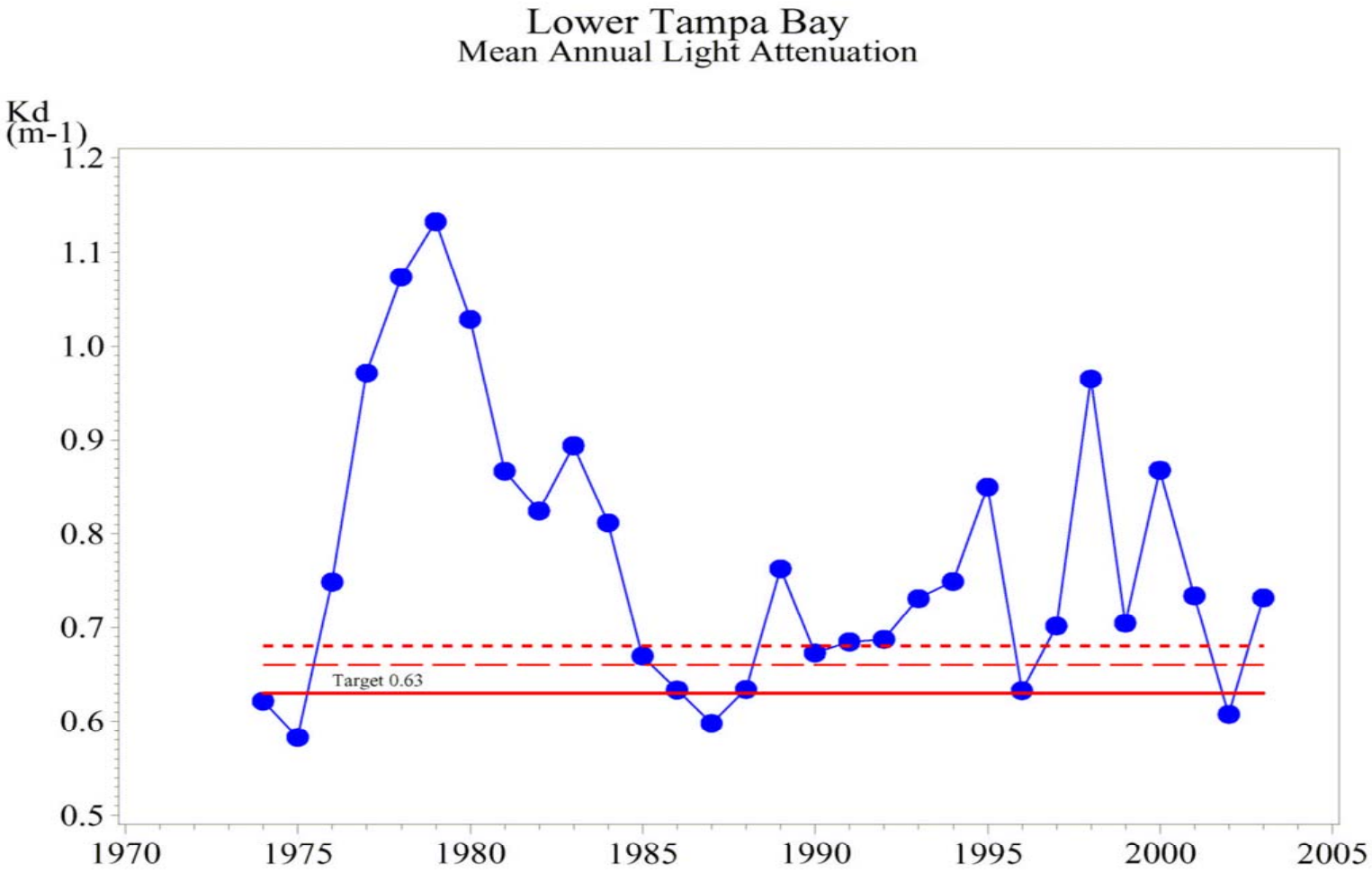

Figure 9. Lower Tampa Bay mean annual light attenuation, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line).

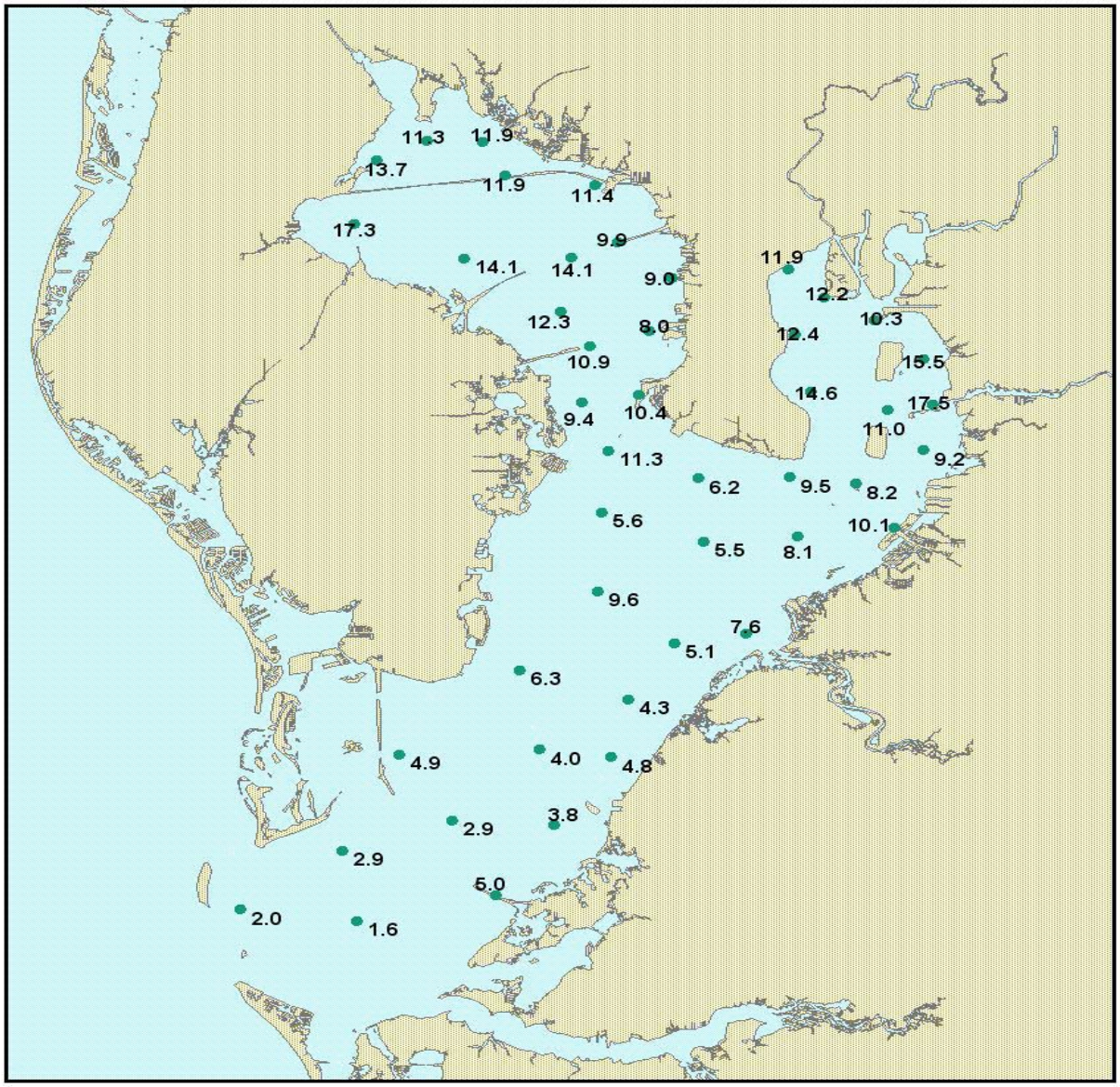

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Figure 10. Mean annual chlorophyll-a values for 2003 from the Environmental Protection Commission of Hillsborough County

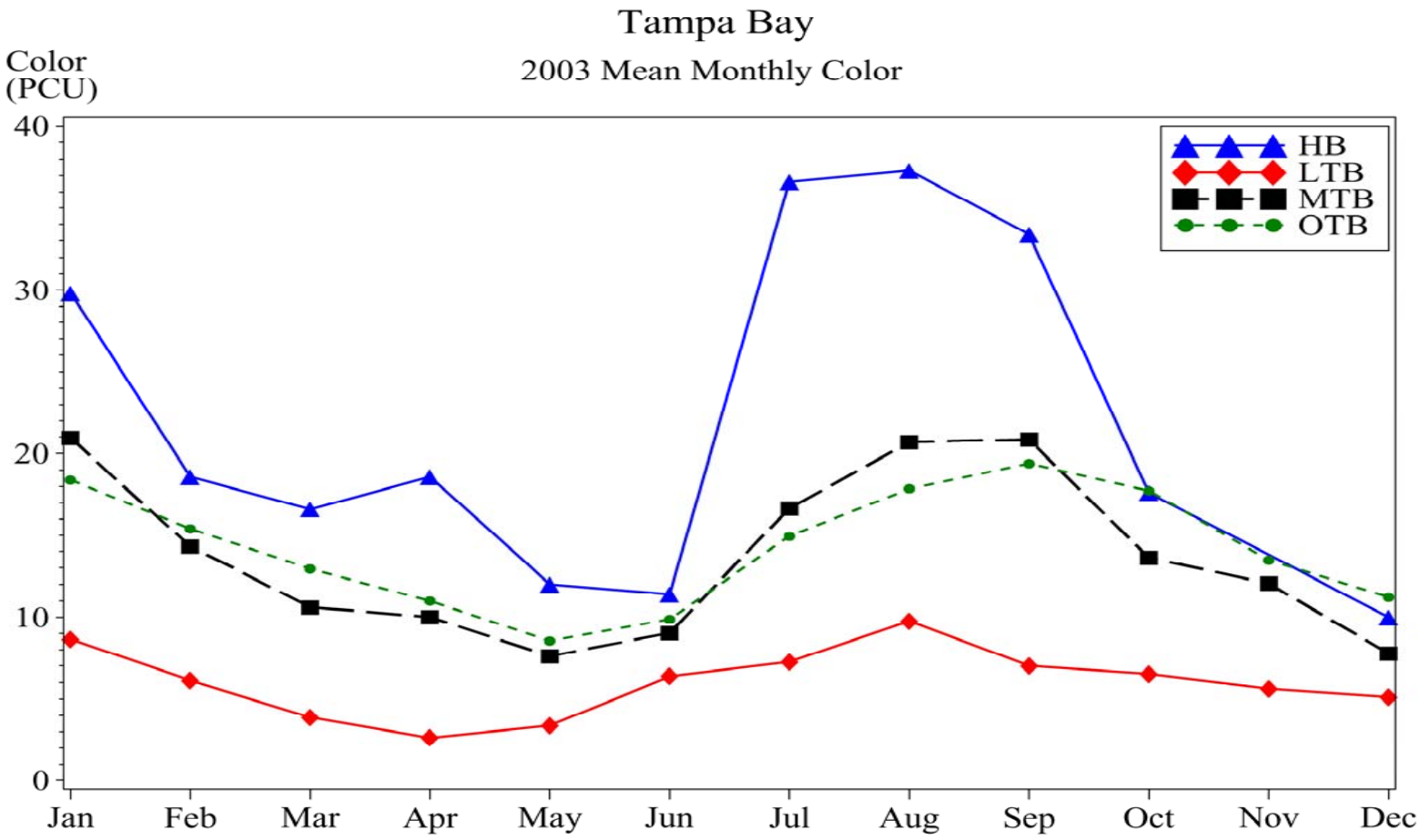

Figure 11. Mean monthly color in Hillsborough Bay (triangles), Lower Tampa Bay (diamonds), Middle Tampa Bay (squares) and Old Tampa Bay (circles) for 2003 measured in platinum-cobalt color units (PCU).

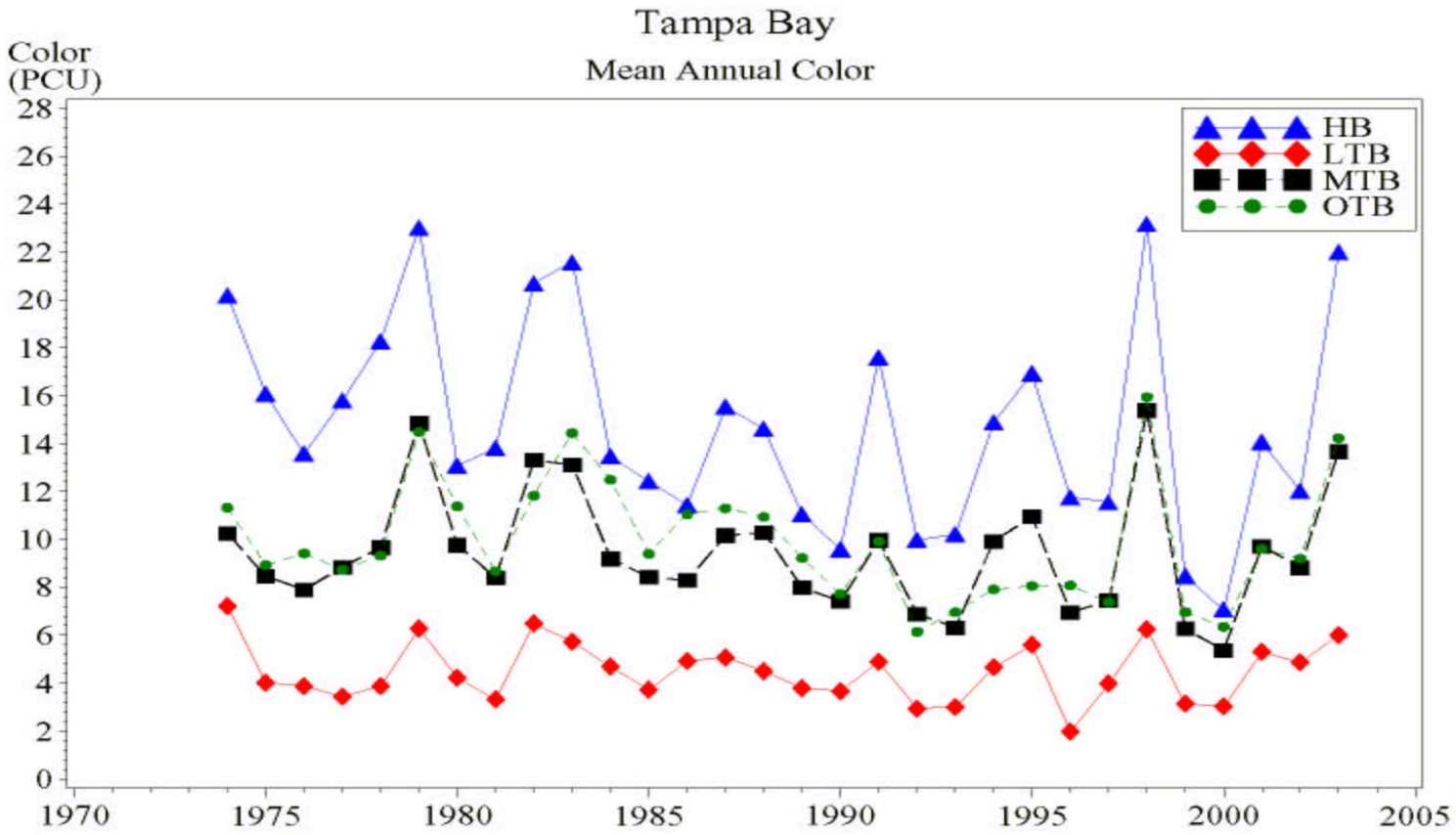

Figure 12. Mean annual color in Hillsborough Bay (triangles), Lower Tampa Bay (diamonds), Middle Tampa Bay (squares) and Old Tampa Bay (circles) for 1974-2003 measured in platinum-cobalt color units (PCU).

References

Janicki, A.J., D. Wade, and J.R. Pribble. 2000. Establishing a process for tracking chlorophyll-*a* concentrations and light attenuation in Tampa Bay. Prepared for: Tampa Bay Estuary Program. Prepared by: Janicki Environmental, Inc.

Acknowledgements

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