

1-1-2002

# Historical overview of Tampa Bay water quality and seagrass issues and trends

J.O. R. Johansson

Follow this and additional works at: [http://scholarcommons.usf.edu/basgp\\_report](http://scholarcommons.usf.edu/basgp_report)



Part of the [Environmental Indicators and Impact Assessment Commons](#)

---

## Scholar Commons Citation

Johansson, J.O. R., "Historical overview of Tampa Bay water quality and seagrass issues and trends" (2002). *Reports*. Paper 147.  
[http://scholarcommons.usf.edu/basgp\\_report/147](http://scholarcommons.usf.edu/basgp_report/147)

This Statistical Report is brought to you for free and open access by the Tampa Bay Area Study Group Project at Scholar Commons. It has been accepted for inclusion in Reports by an authorized administrator of Scholar Commons. For more information, please contact [scholarcommons@usf.edu](mailto:scholarcommons@usf.edu).

Johansson, J.O.R. 2002. Historical overview of Tampa Bay water quality and seagrass issues and trends, p. 1-10. *In* Greening, H.S. (ed.), Proceedings, Seagrass Management, It's Not Just Nutrients! Symposium held August 22-24, 2000, St. Petersburg, FL. Tampa Bay Estuary Program. 246 p.

# **HISTORICAL OVERVIEW OF TAMPA BAY WATER QUALITY AND SEAGRASS: ISSUES AND TRENDS**

J.O.R. Johansson

## **ABSTRACT**

Historical (pre-1930s) seagrass meadows in Tampa Bay are believed to have covered 31,000 ha of the shallow bay bottom. Later, impacts to the bay from increasing population and industrial development of the Tampa Bay area have resulted in large seagrass losses. By 1982, approximately 8,800 ha of seagrass remained. Since 1982, Tampa Bay seagrass monitoring programs have recorded a reversal in the trend of seagrass loss, with the baywide seagrass cover increasing from 9,420 ha in 1988 to 10,890 ha in 1997. However, between 1997 and 1999 the trend again reversed with substantial losses recorded, specifically in the Old Tampa Bay segment. The 1999 baywide cover was estimated at 10,050 ha, thus eliminating most of the seagrass coverage gains recorded since the late 1980s.

Similarly, in Hillsborough Bay, the segment of Tampa Bay that historically has had the poorest water quality, seagrass increased from near 0 ha in 1984 to about 56 ha in 1997. Following 1997, the seagrass expansion stagnated in this segment, with a slight reduction in cover recorded between 1998 and 1999.

It is generally agreed that the Tampa Bay seagrass expansion observed since the mid-1980s was triggered by water quality improvements during the late 1970s to the mid 1980s. These improvements included reductions in phytoplankton biomass and water column light attenuation. These improvements also followed a nearly 50% reduction in external nitrogen loading from domestic and industrial point-sources in the early 1980s. The loading reductions primarily affected point-source discharges to Hillsborough Bay.

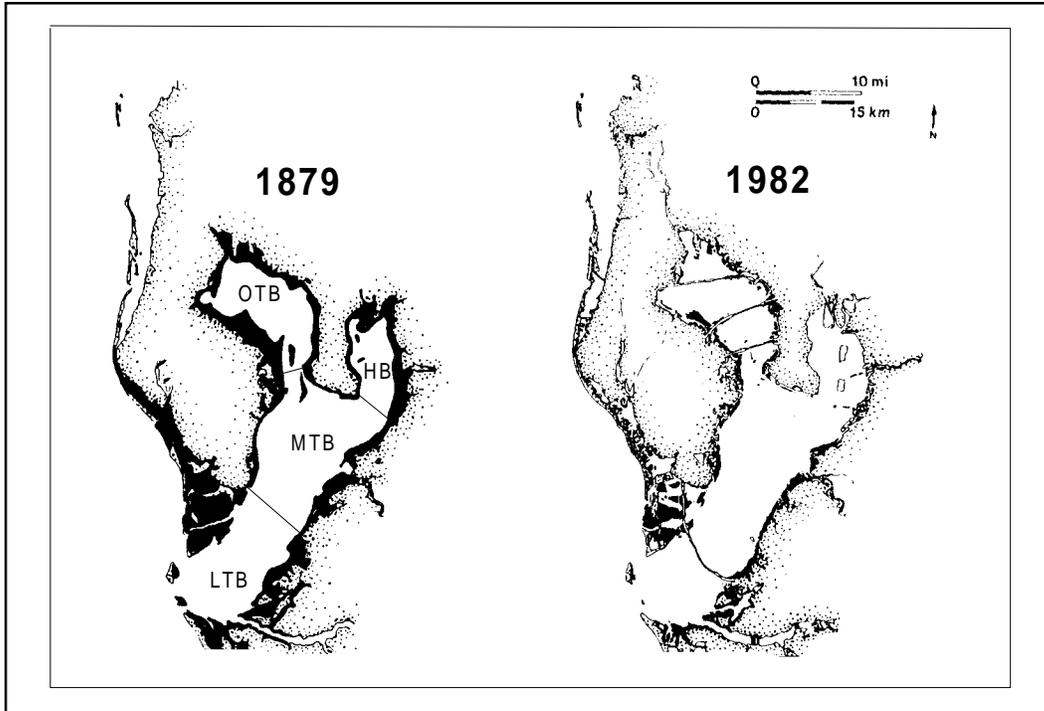
The reductions in the Tampa Bay seagrass expansion rate and areal cover realized since 1997, are most probably related to a recent period of high rainfall that began in 1995 and extended through the strong 1997–98 El Niño event. During this period, nitrogen loading and discharges of water with high color content increased, and subsequently, phytoplankton biomass, light attenuation, and color content increased in all major bay segments. High levels of these constituents are known to be detrimental to seagrass growth and it is not surprising that Tampa Bay seagrass monitoring programs recorded recent reductions in expansion and losses of seagrass cover, specifically in the upper bay segments. Although other factors may have contributed to the recent reductions in seagrass growth, it is likely that the high rainfall period created the major impacts.

Rainfall in the Tampa Bay area was below normal in 1999 and 2000. With an extended period of relatively low rainfall it could be expected that the seagrass expansion rate again would increase. Baywide information for seagrass coverage in 2000 is not available; however, Hillsborough Bay seagrass coverage increased from about 56 ha in 1999 to about 69 ha in 2000.

## **INTRODUCTION**

Seagrass has been selected as a central component in many estuarine management efforts that aim to restore a natural balance between primary producers (e.g., seagrass and phytoplankton) by reducing excessive nutrient inputs. This management approach has been attempted for Tampa Bay as well. The Tampa Bay Estuary Program (TBEP) has adopted a seagrass restoration and protection goal to be reached through the reduction of external nitrogen loadings to the bay (Johansson and Greening 2000).

To place the ongoing Tampa Bay seagrass trends and management efforts in a historical perspective, it is necessary to understand the history of both seagrass coverage and water quality, including the results of efforts to improve bay water quality. Therefore, this report will discuss the major changes that have occurred in seagrass abundance since the earliest estimate of Tampa Bay seagrass coverage. Some of the most likely causes contributing to those changes will also be discussed.



**Figure 1.** Seagrass coverage in Tampa Bay in 1879 and 1982 (after Lewis et al. 1985). Black areas denote seagrass meadows. OTB=Old Tampa Bay; MTB= Middle Tampa Bay; LTB=Lower Tampa Bay.

In addition to the historical perspective, an up-to-date account of current water quality and seagrass trends in the bay will also be given. Attention will be focused on Hillsborough Bay because this bay segment has the most extensive water quality record and the most detailed information on the recent seagrass recolonization. Long-term trends of selected water quality parameters for all four major Tampa Bay segments will also be examined in addition to long-term trends in the baywide seagrass cover.

### HISTORICAL TRENDS

In a comprehensive paper on Tampa Bay seagrass, Lewis et al. (1985) estimated that approximately 31,000 ha of seagrass were present in Tampa Bay during the late 1800s (Fig. 1). Their estimate included areas that were sufficiently shallow (<2m) to support seagrass growth and was not based on measured seagrass coverage. Therefore, this estimate represents the potential Tampa Bay seagrass coverage at a time

when man's influence on the bay was very limited.

In 1991, Lewis et al. calculated the distribution of the 1982 Tampa Bay seagrass cover. This estimate was based on state-of-the art analysis of aerial photographs and showed that the 1982 coverage was about 8,800 ha (Fig. 1). When compared against the late 1800s estimate, the seagrass had apparently receded in all segments of the bay over the near 100-year period with major losses evident in the upper bay portions of Old Tampa Bay and Hillsborough Bay. Specifically, all seagrass appears to have been lost in Hillsborough Bay by 1982.

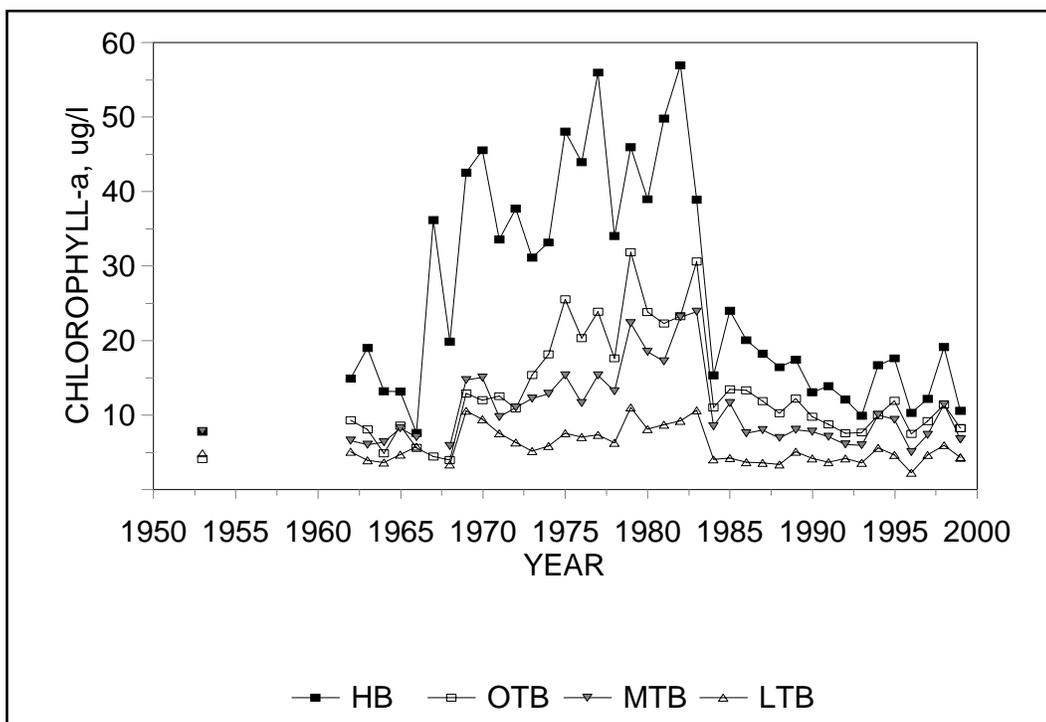
The cause of these large seagrass losses, perhaps as much as 70% of the historical Tampa Bay seagrass cover, is undoubtedly related to man's impact on the bay. One major impact was the excessive loading of nutrients from the watershed, or eutrophication. This impact is directly related to the

population growth of the bay area and the associated increase in commercial activities. Eutrophication as indicated by water column chlorophyll *a* concentrations (Fig. 2) peaked in the late 1970s and early 1980s (Johansson 1991; Johansson and Lewis 1992; Boler 1999). Another leading cause of large seagrass loss was various dredging operations and shoreline developments. These included in-bay shell dredging, port construction, ship channel expansion, causeway construction, and residential and commercial dredge-and-fill projects. Impacts from these activities culminated during the 1950s, '60s and '70s.

Tampa Bay researchers generally agree that eutrophication and dredging operations were the major reasons for the large seagrass loss, although it is unclear which of these impacts was most serious. Also, questions remain about the process of seagrass loss. For example, did dredging operations cause losses mainly through

direct physical destruction of the seagrass meadows, or through more indirect impacts such as increased turbidity of the water column and increased sediment deposition on the meadows? It is also unclear how eutrophication caused seagrass losses. It is generally assumed that eutrophication associated losses resulted from a decrease in light availability, which in turn was caused by an increase in phytoplankton and epiphyte biomass. It is also well known, particularly in Hillsborough Bay (FWPCA 1969; Kelly 1995; Avery 1997) and Old Tampa Bay (J.O.R. Johansson personal observations), that the increased nutrient loading stimulated the growth of large amounts of drift macro-algae. Dense mats of these algae often accumulated in the shallow areas and may have limited seagrass colonization through shading, abrasion, and hypoxia.

A large reduction in nitrogen loading to Tampa Bay occurred between the late



**Figure 2.** Annual average chlorophyll *a* concentrations for major segments of Tampa Bay, 1953–99 (sources include National Marine Fisheries Service, Hillsborough County Environmental Protection Commission and City of Tampa).

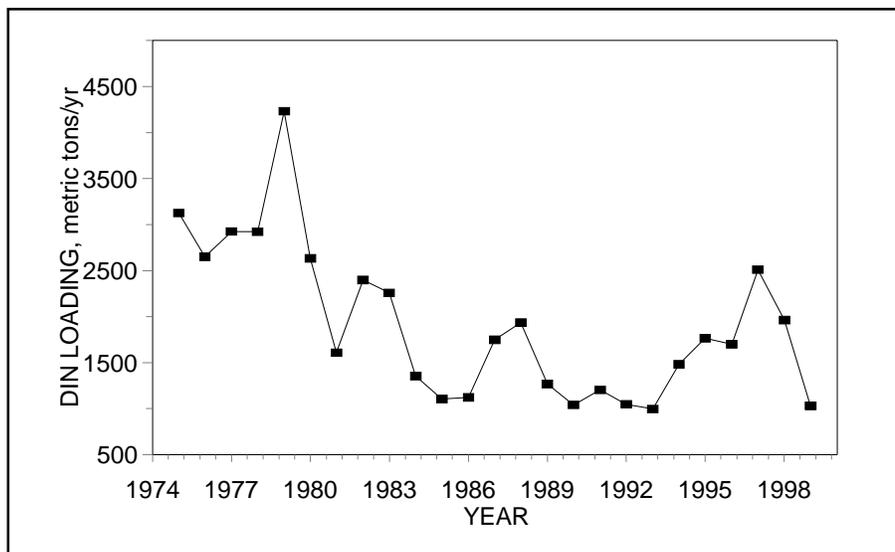
1970s and the early 1980s (Fig. 3). This reduction was primarily caused by improved wastewater treatment from domestic and industrial point-sources that discharged to Hillsborough Bay (Johansson 1991; Johansson and Lewis 1992; Zarbock et al. 1994). A large decrease in phytoplankton biomass (chlorophyll *a*) soon followed the nitrogen reduction. By 1984, chlorophyll *a* concentrations were about half of the levels found only a few years earlier (see Fig. 2). Coincident with declining chlorophyll *a* concentrations in Hillsborough Bay, small isolated patches of *Halodule wrightii* (shoal grass) began appearing in a shallow area of southeastern Hillsborough Bay that previously lacked seagrass vegetation (R.R. Lewis personal communication).

**RECENT SEAGRASS TRENDS**

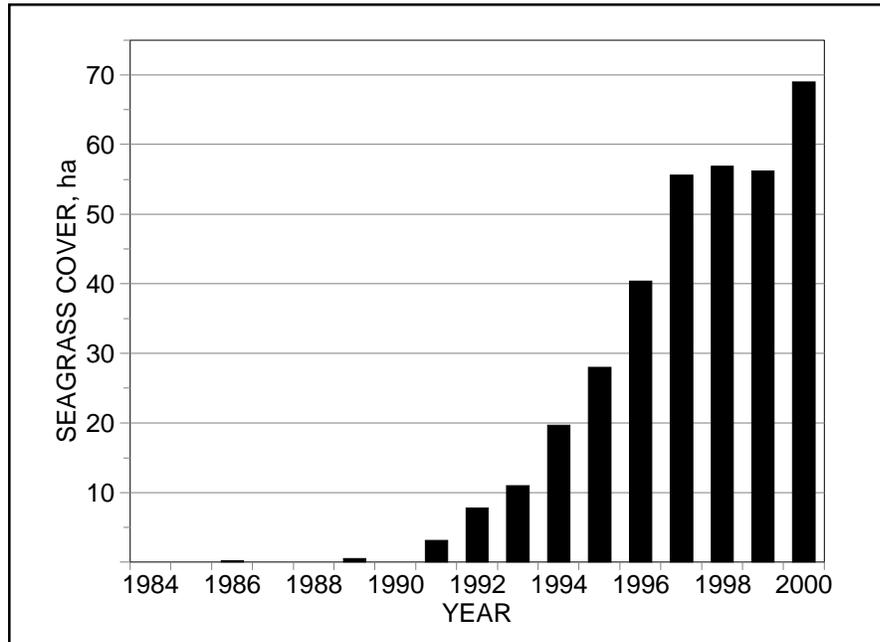
Seagrass coverage in Hillsborough Bay, has been estimated by the City of Tampa (COT) since 1984. In 1984, coverage was limited to a few isolated patches of *H. wrightii*, comprising a total of less than 0.02 ha. Since then, each successive survey, until 1998, showed a substantial increase in *H. wrightii* cover (Fig. 4). By

1997 seagrass cover had reached about 55.6 ha. After 1997, the seagrass expansion stagnated in this segment with a slight reduction in cover recorded between 1998 and 1999. The 1999 Hillsborough Bay coverage was estimated at about 56.2 ha. The rate of expansion once again increased between the 1999 and 2000 surveys. The 2000 coverage was estimated at 69 ha.

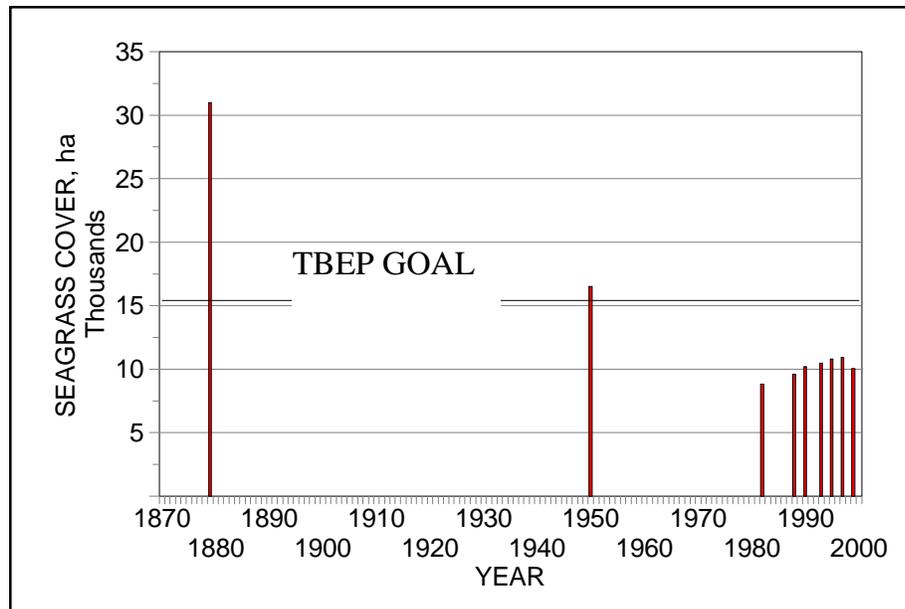
Similarly, the Surface Water Improvement and Management (SWIM) program of the Southwest Florida Water Management District (SWFWMD) has estimated the baywide Tampa Bay seagrass coverage by interpretation of aerial photography. SWIM has shown that seagrass coverage increased from 9,420 ha in 1988 to 10,890 ha in 1997 (Fig. 5). The trend of expanding coverage reversed in 1999 with substantial losses recorded, especially in the Old Tampa Bay segment. The 1999 baywide cover was estimated at 10,050 ha, thus eliminating most of the gains recorded since 1988. Figure 5 shows the current Tampa Bay seagrass coverage relative to both the historical coverage and the restoration goal adopted by the TBEP.



**Figure 3.** Dissolved inorganic nitrogen loading to Hillsborough Bay from major external sources, 1974–1999. Loadings in 1997, 1998 and 1999 were estimated from rainfall amounts. Flow and nitrogen concentration data were not available for these years.



**Figure 4.** Hillsborough Bay seagrass coverage estimated by the City of Tampa, 1984–2000. The estimate for 1984 is exclusively based on interpretation of aerial photographs. No estimates were performed for 1985, 1987, 1988 and 1990.



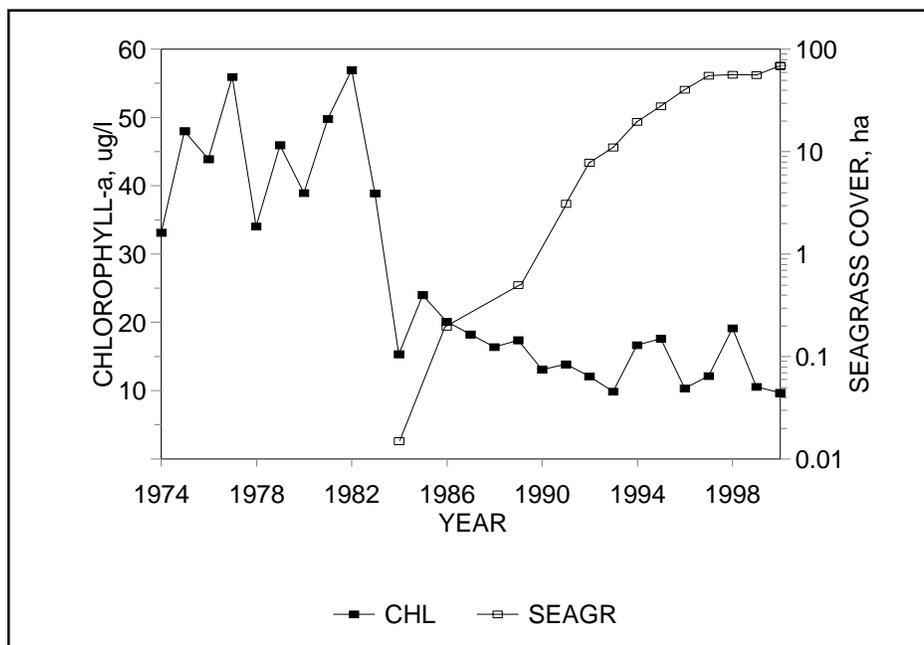
**Figure 5.** Long-term trend of Tampa Bay seagrass coverage, 1879–1999 (sources include Lewis et al. 1985; Lewis et al. 1991; Johansson and Ries 1997; and Kurz, this volume). The horizontal line marked TBEP GOAL denotes the Tampa Bay Estuary Program’s seagrass restoration and protection goal.

### SEAGRASS AND WATER QUALITY RELATIONSHIPS

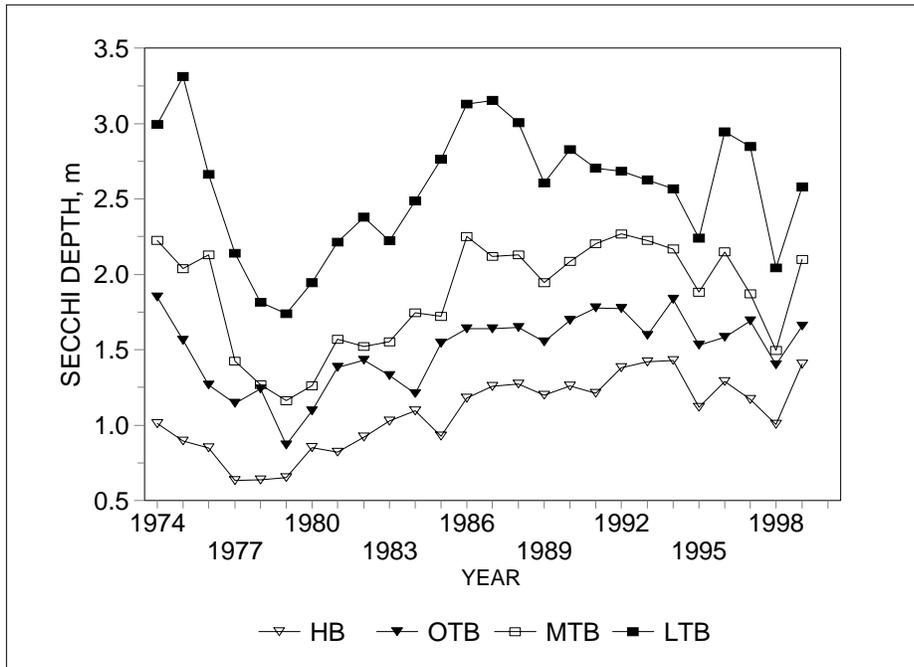
The detailed seagrass information collected by the COT in Hillsborough Bay can be used to search for potential relationships between seagrass expansion and water quality trends. Year-to-year variations in Hillsborough Bay chlorophyll *a* concentrations, which indicate changes in the trophic state of the bay and also the amount of nitrogen being discharged to the bay, are not reflected in the annual trend of Hillsborough Bay seagrass coverage (Fig. 6). Such short-term relationships between the relatively slow process of changes in seagrass coverage trends and more variable water quality parameters should not be expected. Instead, the expansion of seagrass that started in the mid 1980s in Hillsborough Bay, and in other sections of Tampa Bay as well, probably resulted from the large decrease in eutrophic state that occurred in the early 1980s. The trophic state declines are reflected in the Hillsborough Bay chlorophyll *a* and Secchi

depths records (Fig. 6 and 7).

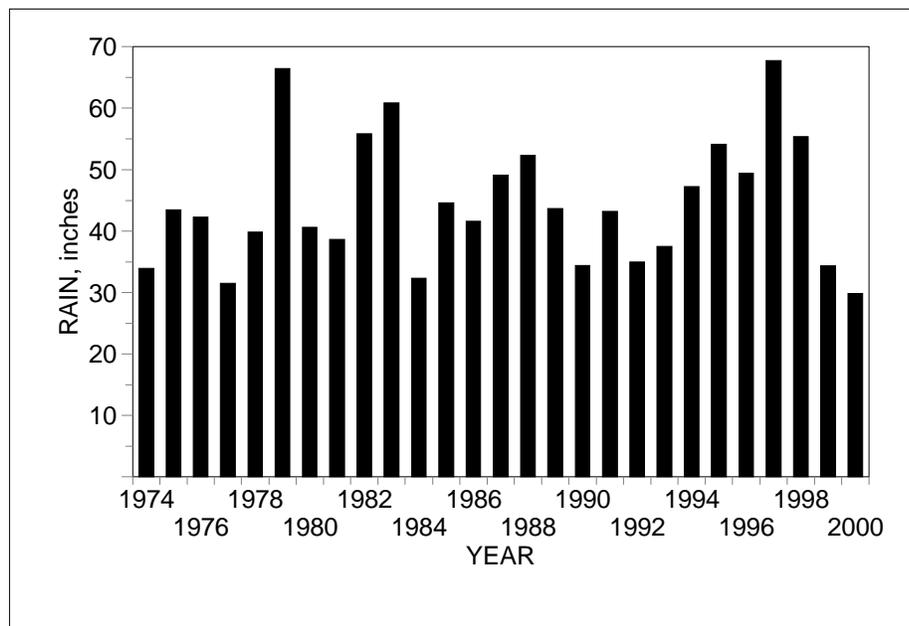
Higher than normal rainfall amounts (measured at Tampa International Airport) during the years 1995, 1996, and the 1997–98 El Nino event (Fig. 8) have increased nitrogen loading to the bay. Phytoplankton biomass, light attenuation, and color content increased in Hillsborough Bay and the other major bay segments during this period of high rainfall (see Figs. 2, 7, and 9). High levels of these constituents are known to be detrimental to seagrass growth. Likewise, Tampa Bay seagrass monitoring programs have recorded recent reductions in expansion and also losses of seagrass cover, specifically in the upper bay segments. Other factors, such as accidental spills from industrial and municipal sources (see Cardinale 1998), some caused as a consequence of the high rainfall amounts, may have contributed to the recent seagrass loss and reductions in the seagrass expansion rates.



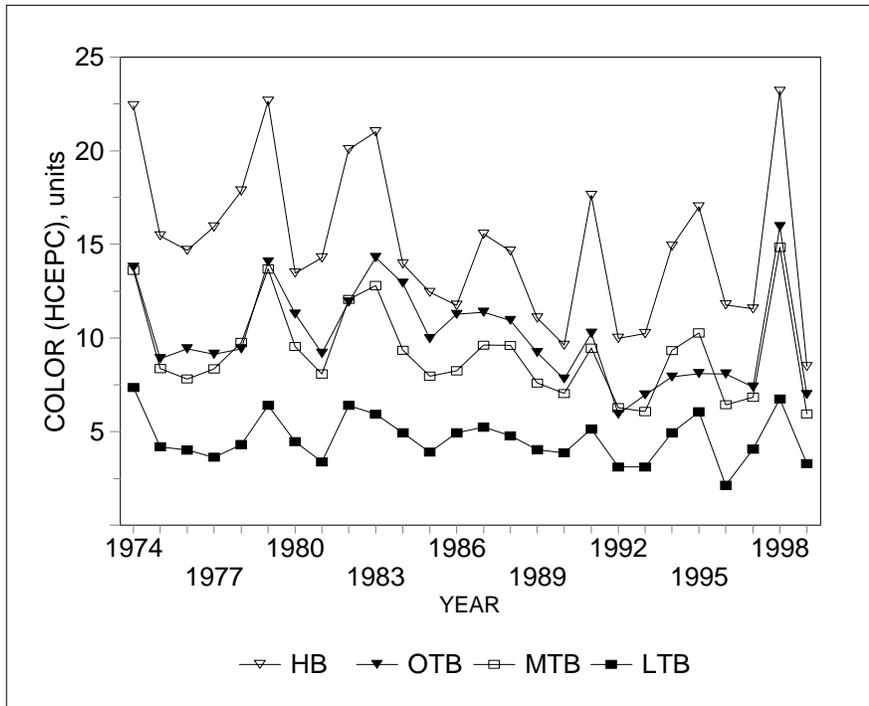
**Figure 6.** Hillsborough Bay annual average chlorophyll *a* concentrations and seagrass coverage illustrating the start of seagrass recovery in 1984 following the rapid decline in chlorophyll from 1982 to 1984. Chlorophyll *a* concentrations measured by the Hillsborough County Environmental Protection Commission and the City of Tampa. Seagrass coverage measured by the City of Tampa.



**Figure 7.** Annual average Secchi depths in the four major Tampa Bay segments measured by the Hillsborough County Environmental Protection Commission.



**Figure 8.** Rainfall at the Tampa International Airport measured by the National Oceanographic and Atmospheric Administration, National Climatic Data Center.



**Figure 9.** Annual average color content in the four major Tampa Bay segments measured by the Hillsborough County Environmental Protection Commission.

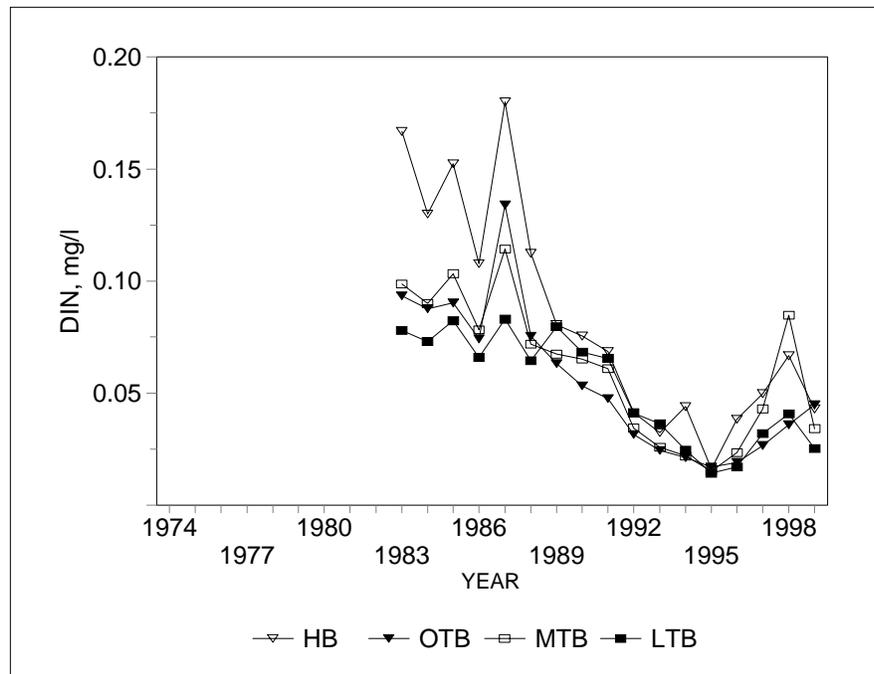
Rainfall in the Tampa Bay area was below normal in 1999 and 2000 (Fig. 8). With an extended period of relatively low rainfall the seagrass expansion rate may once again increase. Baywide information for 2000 seagrass coverage is not yet available, however, Hillsborough Bay seagrass coverage (see Fig. 4) increased substantially from about 56 ha in 1999 to about 69 ha in 2000.

**DISCUSSION AND CONCLUSION**

The large nitrogen reductions during the late 1970s and early 1980s apparently improved water quality in Tampa Bay after many years of increasing eutrophication. Also, Tampa Bay seagrass meadows started to expand in the mid 1980s, primarily in the upper segments of the bay. Concerned scientists have questioned if the seagrass expansion of the mid 1980s was largely caused by the reduction in anthropogenic nitrogen loading from point sources, or was it more strongly related to a period of relatively low rainfall that generally lasted from the mid 1980s

through the early 1990s. It was cautioned that increased inputs of both nutrients and water with a high color content during future periods of high rainfall might reverse the recent water quality improvements and negatively impact the ongoing seagrass expansion by increasing water column light attenuation (Lewis et al. 1991).

An extended period of higher than normal rainfall started in 1995 and lasted through the 1997–98 El Niño event (Fig. 8). During this period, nitrogen loading (Fig. 3) to the bay increased, ambient nitrogen and chlorophyll *a* concentrations (Figs. 10 and 2) increased, and water clarity (Fig.7) decreased. However, both nitrogen and chlorophyll concentrations remained substantially lower during the recent high rainfall period than concentrations found prior to the large anthropogenic nitrogen loading reductions that occurred in the late 1970s and early 1980s. This suggests that the large anthropogenic nitrogen loading reductions have had a long-lasting effect of



**Figure 10.** Annual average ambient dissolved organic nitrogen concentrations in the four major Tampa Bay segments measured by the Hillsborough County Environmental Protection Commission.

reducing eutrophication in Tampa Bay. In contrast, potential long-term effects on water clarity (measured as Secchi depth) from the large nitrogen reductions are less apparent. Water clarity reached minimum levels in all bay segments during the late 1970s. The low values were probably caused by a combination of high turbidity associated with the Tampa Bay ship channel deepening and widening project (late 1970s–early 1980s), and high phytoplankton biomass from high nitrogen loadings. After reaching the minimum values, water clarity increased at a constant rate in all four major bay segments during the 1980s. This trend continued into the early 1990s for all segments except Lower Tampa Bay. On the other hand, a distinct long-term improvement is not evident in the Tampa Bay water clarity record, with the possible exception for Hillsborough Bay, because water clarity over the two last decades has generally not exceeded the values recorded in the mid-1970s. It is evident that the large magnitude improvements seen in both ambient nitrogen

concentrations and phytoplankton biomass are not strongly reflected in the water clarity record. This suggests that factors, including, events causing increased turbidity and rainfall related discharges of water with high color content (see Fig. 9) may have a substantial impact on water clarity. The caution postulated by Lewis et al. (1991), therefore, appears partially supported by field observations.

Finally, rainfall in the Tampa Bay area was below normal in 1999 and 2000. With an extended period of relatively low rainfall it could be expected, following the scenario developed by Lewis et al. (1991), that the Tampa Bay seagrass expansion rate again would increase. Baywide information for 2000 seagrass coverage is not yet available, however, it is encouraging that Hillsborough Bay seagrass coverage increased from about 56 ha in 1999 to about 69 ha in 2000.

#### ACKNOWLEDGMENTS

I would like to thank Walter Avery and Kerry Hennenfernt for helpful discussion and valuable

suggestions during the preparation of the manuscript.

### LITERATURE CITED

- Avery, W. 1997. Distribution and abundance of macroalgae and seagrass in Hillsborough Bay, Florida, from 1986 to 1995, p. 151-165. *In* Treat, S.F. (ed.), Proceedings, Tampa Bay Area Scientific Information Symposium 3. Text, Tampa, Florida.
- Boler, R. 1999. Surface water quality, 1995-1997. Hillsborough County, Florida. Environmental Protection Commission of Hillsborough County. Tampa, Florida.
- Cardinale, T. 1998. Mulberry Phosphates Inc.—December 1997 acid spill. Water quality impacts on Alafia River and Tampa Bay. Environmental Protection Commission of Hillsborough County. Tampa, Florida
- FWPCA. 1969. Problems and management of water quality in Hillsborough Bay, Florida. Hillsborough Bay Technical Assistance Project, Technical Programs, Southeast Region, Federal Water Pollution Control Administration. Tampa, Florida.
- Johansson, J.O.R. 1991. Long-term trends of nitrogen loading, water quality and biological indicators in Hillsborough Bay, Florida, p. 157-176. *In* Treat, S.F. and P.A. Clark (eds.), Proceedings, Tampa Bay Area Scientific Information Symposium 2. Text, Tampa, Florida.
- Johansson, J.O.R. and H.S. Greening. 2000. Seagrass restoration in Tampa Bay: A resource-based approach to estuarine management, p. 279-293. *In* Bortone, S.A. (ed.), Seagrasses: monitoring, ecology, physiology, and management. CRC Press LLC. Boca Raton, Florida.
- Johansson, J.O.R. and R.R. Lewis. 1992. Recent improvements in water quality and biological indicators in Hillsborough Bay, a highly impacted subdivision of Tampa Bay, Florida, U.S.A. *Science of the Total Environment*, Supplement 1992: 1199-1215.
- Johansson, J.O.R. and T. Ries. 1997. Seagrass in Tampa Bay: Historic trends and future expectations, p. 139-150. *In* Treat, S.F. (ed.), Proceedings, Tampa Bay Area Scientific Information Symposium 3. Text, Tampa, Florida.
- Kelly, B.O. 1995. Long-term trends of macroalgae in Hillsborough Bay. *Florida Scientist* 58: 179-192.
- Lewis, R.R., M.J. Durako, M.D. Moffler, and R.C. Phillips. 1985. Seagrass meadows of Tampa Bay—a review, p. 210-246. *In* S.F. Treat, J.L. Simon, R.R. Lewis, and R.L. Whitman, Jr. (eds.), Proceedings, Tampa Bay Area Scientific Information Symposium. Burgess Publishing Company, Minneapolis, Minnesota.
- Lewis, R.R., K. D. Haddad, and J.O.R. Johansson. 1991. Recent areal expansion of seagrass meadows in Tampa Bay: Real bay improvement or drought-induced? p. 189-192. *In* Treat, S.F. and P.A. Clark (eds.), Proceedings, Tampa Bay Area Scientific Information Symposium 2. Text, Tampa, Florida.
- Zarbock, H., A. Janicki, D. Wade, D. Heimbuch, and H. Wilson. 1994. Estimates of total nitrogen, total phosphorus, and total suspended solids loadings to Tampa Bay, Florida. Technical Publication 04-94 of the Tampa Bay National Estuary Program. Coastal Environmental, Inc., St. Petersburg, Florida.
- (JORJ) Bay Study Group, City of Tampa, 2700 Maritime Blvd., Tampa FL 33605 USA