DEVELOPMENT OF A RESOURCE-BASED POLLUTANT LOAD REDUCTION GOAL FOR CHARLOTTE HARBOR

By Dave Tomasko, Southwest Florida Water Management District

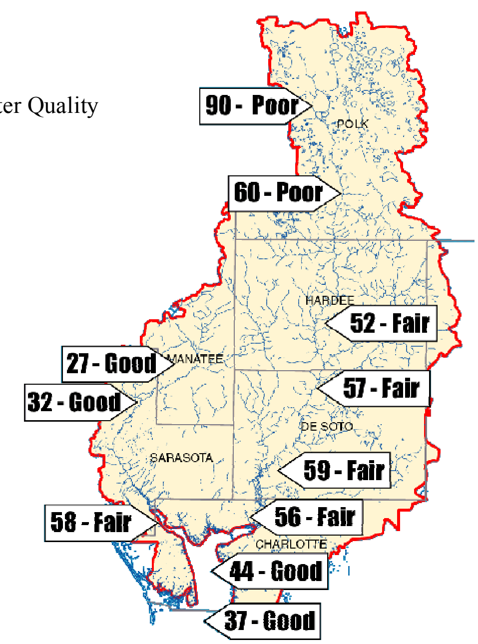
Background Information

Charlotte Harbor is a shallow, coastal plain estuary. Commonly, Charlotte Harbor "Proper" is meant to indicate that portion of the Charlotte Harbor estuarine system exclusive of Pine Island Sound and Matlacha Pass. The open water surface area of Charlotte Harbor Proper (hereafter referred to simply as "Charlotte Harbor") is approximately 130 square miles, and the watershed that drains into Charlotte Harbor is approximately 3,360 square miles in size. The watershed to open-water ratio of Charlotte Harbor of approximately 26 to 1 is more than four times that of Tampa Bay, and more than eight times that of Sarasota Bay. Consequently, Charlotte Harbor experiences a greater degree of terrestrial and riverine influence than either Tampa Bay or Sarasota Bay.

Status and Trends in Water Quality

In a recent study, Morrison et al. (1998) reported on the status and trends in water quality in Charlotte Harbor and the Peace and Myakka Rivers during the period 1976 to 1996. Water quality values were within the "good" range in all parts of the Harbor, with the best water quality (lowest values) found in the lower portions of the Harbor (Figure 1). Values from stations located within the estuarine portions of the Peace and Myakka Rivers were in the "fair" range. Locations in the headwaters of the Peace River had water quality values in the "poor" range.

Figure 1 - Charlotte Harbor Water Quality



In the Myakka River, Morrison et al. (1998) reported no significant trends in concentrations for nitrate plus nitrite, phosphorus, and chlorophyll a, but a positive and significant trend for ammonia concentrations. In the Peace River, Morrison et al. (1998) reported no significant trends in concentrations of nitrate plus nitrite, but a positive and significant trend for ammonia concentrations. Phosphorus concentrations declined significantly in the Peace River, as has been reported previously. Chlorophyll a concentrations in the Peace River either declined significantly or exhibited no trend, depending on location.

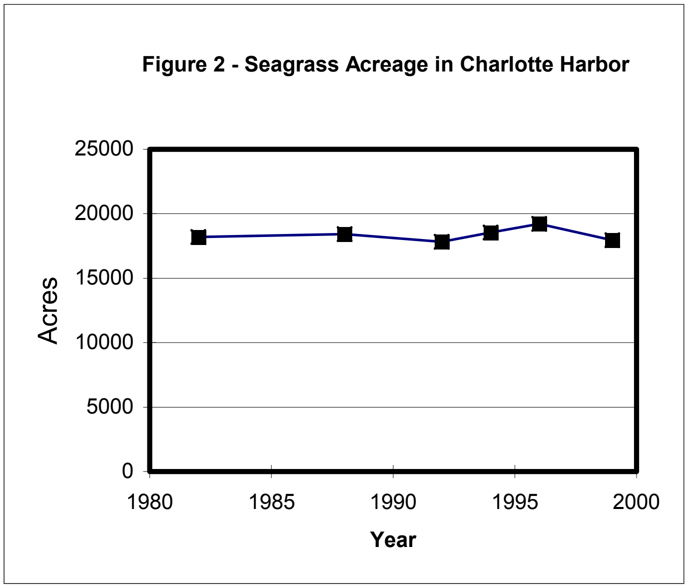
In the open waters of Charlotte Harbor, Coastal Environmental (1996) compiled data from a variety of water quality monitoring programs to assess whether any clear trends in water quality could be identified. For nutrients, total phosphorus concentrations exhibited trends of significant declines in Charlotte Harbor during 1976 to 1996. In contrast, there were no significant trends in total Kjeldahl nitrogen concentrations. Chlorophyll a concentrations, an indicator of phytoplankton biomass, displayed no trend over time. Salinity showed a significant trend of decreasing values during 1976 to 1996, which matches the finding of positive trends in streamflow in the Lower Peace River during the same time period (Flannery and Barcelo 1998).

Hypoxic conditions (low dissolved oxygen levels) in the bottom waters of Charlotte Harbor appear to be related to periods of high freshwater inflow from the Peace and Myakka Rivers, which isolate saltier, oxygen-poor waters on the bottom of Charlotte Harbor from the fresher, oxygen-rich waters coming in during typical wet seasons (Camp, Dresser & McKee, Inc. 1998). There was no apparent trend in the frequency and/or duration of hypoxic conditions during the period 1975 to 1989 (Camp, Dresser & McKee, Inc. 1998).

Refinement of a Pollutant Load Reduction Goal (PLRG) for Charlotte Harbor

To produce a resource-based pollutant load reduction goal (PLRG) for Charlotte Harbor, relationships must be developed between the quantity of pollutants (e.g., nitrogen) delivered to the Harbor and some adverse impact to a biological resource. In Tampa Bay and Sarasota Bay, nitrogen load reduction goals were based on the inverse relationship between nitrogen loads and seagrass health (Johansson and Ries 1997, Tomasko et al. 1996).

In Charlotte Harbor, the development of a resource-based PLRG has been more problematic. After examining the relationships between nutrient loads and eutrophication indicators (i.e., chlorophyll a concentrations and water quality values), Pribble et al. (1997) found no direct relationship between nutrient loads and any indicators of eutrophication in Charlotte Harbor.



In addition, and in contrast to both Tampa Bay and Sarasota Bay, Tomasko and Hall (1999) found that seagrass meadows did not appear to be useful "bio-indicators" of human influences on water quality in Charlotte Harbor. Instead, productivity and biomass of the seagrass *Thalassia testudinum* (turtle grass) varied mostly as a function of water temperature, salinity and water clarity, which themselves varied mostly as a function of season, rainfall and freshwater inflow. Also, seagrass acreage in Charlotte Harbor has been relatively stable over the past 20 years (Figure 2), indicating that either human impacts to water quality have been almost inconsequential over the past two decades, or that human impacts to water quality cannot be detected using seagrass acreage as a bio-indicator.

Subsequently, the Charlotte Harbor SWIM Advisory Committee agreed to pursue a resource-based PLRG based on detecting trends, if any, in organic loading to the bottom sediments in Charlotte Harbor. The basis for concern with potential increases in organic loading to the Harbor is related to the phenomenon of summertime hypoxia (dissolved oxygen levels below 2 milligrams per liter). The area of bottom waters of Charlotte Harbor that experiences hypoxia can be as high as 70 square miles, although the summertime average is probably closer to 30 square miles (Camp, Dresser & McKee, Inc. 1998).

A recently-completed study of hypoxia performed by Camp, Dresser & McKee, Inc. (1998) concluded that while high freshwater inflow and the resultant stratification of the water column in the Harbor were necessary conditions for hypoxia to occur, they were not, by themselves, *sufficient* to explain hypoxia. That is, there must be a source of potentially oxidizable organic material in the bottom waters and/or sediment to allow hypoxic conditions to develop. Based on measurements made of biological oxygen demand (BOD) of the water column and sediment oxygen demand (SOD), it was determined that both the water column and the bottom sediments had the ability to drop oxygen values down to hypoxic conditions within a matter of days in Charlotte Harbor. Continuous recording of water quality parameters within Charlotte Harbor indicate dissolved oxygen levels in the bottom waters can change from 100 percent saturation to hypoxic conditions in less than two days (Camp, Dresser & McKee, 1998).

Based on these findings, the District contracted with faculty and staff from Louisiana State University (LSU) to conduct a study to try and reconstruct historic trends in hypoxia in Charlotte Harbor, based on determining the status and trends in organic loading to bottom sediments. A draft final report was produced in August 2001 and reviewed by a joint meeting of the Charlotte Harbor SWIM Advisory Committee and the Charlotte Harbor National Estuary Program's Technical Advisory Committee.

Three possible conclusions were possible, as relates to the LSU project: 1) present organic loads could be higher than in the past, suggesting that hypoxic conditions might occur faster, over a larger area, and last longer than in the past, 2) present organic loads could be lower than in the past, suggesting that hypoxic conditions might occur more slowly, over a smaller area, and not last as long as in the past, and 3) present organic loads could be roughly the same as in the past, suggesting no real change has occurred as relates to hypoxia.

Conclusions of the LSU hypoxia project (Turner et al. 2001) suggest that the following phenomena have occurred in the bottom sediments of Charlotte Harbor: 1) the organic content of the sediments has increased in the years after 1950, 2) the amount of biogenic silica (phytoplankton "skeletons") in the sediments has increased in the years after 1950, and, 3) the amount of phytoplankton pigments in the sediments has increased in the years after 1950. In addition, pigments related to blue-green algae show a pattern of increase in the post-1950 time period.

These results suggest that once summertime freshwater inflows reach a sufficient magnitude to stratify the water column in Charlotte Harbor, the increased organic content of the Harbor's bottom sediments could cause present-day hypoxic conditions to occur faster, over a larger area, and last longer than would have been the case under similar freshwater inflow conditions fifty years ago.

Based on these findings, the two technical advisory committees recommended that a "hold the line" strategy for nutrient loads would be appropriate for the Harbor, so that hypoxic conditions would not be allowed to worsen.

Nutrient of Concern in Charlotte Harbor

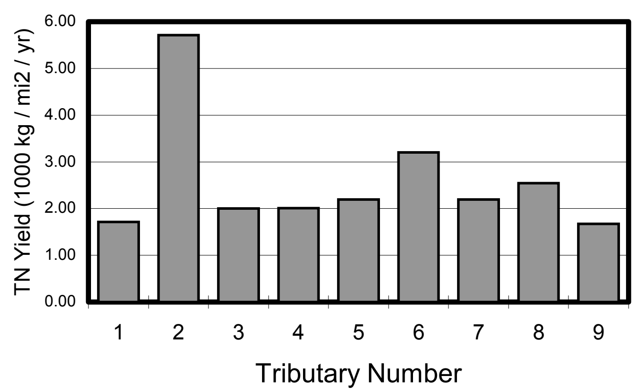
A number of experiments have concluded that that nitrogen, rather than phosphorus, is the nutrient that most strongly limits phytoplankton concentrations in Charlotte Harbor (Montgomery et al. 1991).

Sources of Nitrogen Loads

As the Peace River contributes approximately four times as much nitrogen into Charlotte Harbor as does the Myakka River, the Peace River has been the focal point for past and present assessments of nutrient loading. As part of a collaborative effort between the District, the Charlotte Harbor National Estuary Program, and the Charlotte Harbor Environmental Center, an intensive water quality monitoring program is currently being conducted throughout the Peace River watershed. Nutrient data (i.e., nitrogen concentrations) are collected monthly from at least nine sites in the Peace River watershed. Flow values are collected on a daily basis (if not more frequently) at these same locations. By multiplying flow rates by concentrations, nitrogen loads can be calculated on a sub-basin level, and by dividing the nitrogen load by the size of the contributing watershed above each gaged location, nitrogen yields (e.g., kilograms of Total Nitrogen per square mile of watershed per year [kg TN / mi^2 / yr]) can be calculated. Nitrogen yields can be used to prioritize basins for nitrogen load reductions, based on their relative values.

When the various Peace River sub-basins are plotted against each other (Figure 3), priority sub-basins become apparent. Tributary "2", which is the gage location for Saddle Creek at the P-11 structure, has the highest nitrogen yield of any sub-basin. This gage measures the flow that discharges from Lake Hancock into the Upper Peace River, in Polk County. Tributary "6", which is the gage location for Charlie Creek at Gardner, is a distant second. The remainder of sub-basin nitrogen yields are fairly similar to each other.

Figure 3 - Peace River Nitrogen Yields



Based on initial assessments of the potential benefits associated with various strategies to clean up Lake Hancock and the Upper Peace River, it appears that water quality benefits associated with these efforts might extend down to the Harbor itself.

At a minimum, it appears that efforts to clean up Lake Hancock and the Upper Peace River would be able to "hold the line" on nutrient loads to Charlotte Harbor, by offsetting the pollutant load increases that are expected to accompany the ongoing urbanization of the Harbor's watershed. Potentially, these efforts could actually bring about a decrease in nitrogen loads to the Harbor itself, thus reducing the severity and/or spatial extent of hypoxic conditions during stratification events driven by high rates of freshwater inflow.

LITERATURE CITED

Camp, Dresser & McKee, Inc. 1998. The study of seasonal and spatial patterns of hypoxia in Upper Charlotte Harbor. Final Report to: Surface Water Improvement and Management Section, Southwest Florida Water Management District, Tampa, FL.

Coastal Environmental. 1996. Review and Analyses of Meteorological, Tributary Flow, and Water Quality Data from the Charlotte Harbor Estuarine System. Final Report to: Surface Water Improvement and Management (SWIM) Section, Southwest Florida Water Management District. Tampa, FL.

Flannery, M.S. and M. Barcelo. 1998. Spatial and temporal patterns of streamflow trends in the Upper Charlotte Harbor watershed. Pp. 63-72. In: S.F. Treat (ed.). Proceedings of the Charlotte Harbor Public Conference and Technical Symposium. Charlotte Harbor National Estuary Program Technical Report No. 98-02.

Johansson, J. and T. Ries. 1997. Seagrass in Tampa Bay: historic trends and future expectations. Pp. 139-150. In: S. Treat. (ed.). Proceedings, Tampa Bay Area Scientific Information Symposium 3. Tampa Bay Regional Planing Council. St. Petersburg, FL.

Montgomery, R.T., B.F. McPherson and E.E. Emmons. 1991. Effects of nitrogen and phosphorus additions on phytoplankton productivity and chlorophyll a in a subtropical estuary, Charlotte Harbor, Florida. U.S. Geological Survey, Water Resources Investigations Report 91-4077. Tallahassee, FL.

Morrison, G., R. Montgomery, A. Squires, R. Starks, E. DeHaven, and J. Ott. 1998. Nutrient, chlorophyll and dissolved oxygen concentrations in Charlotte Harbor: Existing conditions and long-term trends. Pp. 201-218. In: S.F. Treat (ed.). Proceedings of the Charlotte Harbor Public Conference and Technical Symposium. Charlotte Harbor National Estuary Program Technical Report No. 98-02.

Pribble, J.R., D.L. Wade, A.J. Janicki, A.P. Squires, H. Zarbock, R. Montgomery, and G. Morrison. 1997. Empirical and mechanistic approaches to establishing PLRGs in the tidal Peace and Myakka Rivers. Final Report to: Surface Water Improvement and Management Section, Southwest Florida Water Management District, Tampa, FL.

Tomasko, D.A., Dawes, C.J., and M.O. Hall. 1996. The effects of anthropogenic nutrient enrichment on turtle grass (Thalassia testudinum) in Sarasota Bay, Florida (USA). Estuaries. 19: 448-456.

Tomasko, D.A. and M.O. Hall. 1999. Productivity and biomass of the seagrass Thalassia testudinum along a gradient of freshwater influence in Charlotte Harbor, Florida (USA). Estuaries. 22: 592-602.

Turner, R.E., N.N. Rabalais, N. Atilla, and C. Normandeau. 2001. A Paleo-Reconstruction of Water Quality in the Charlotte Harbor Estuary, Florida. Report to: Surface Water Improvement and Management (SWIM) Section, Southwest Florida Water Management District. Tampa, FL.