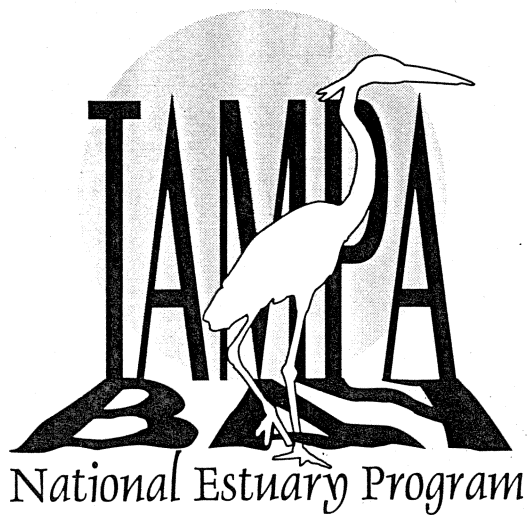




**ESTIMATING CRITICAL EXTERNAL
NITROGEN LOADS FOR
THE TAMPA BAY ESTUARY:
AN EMPIRICALLY BASED APPROACH
TO SETTING MANAGEMENT TARGETS**

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TABLE OF ACRONYMS

CCMP	Comprehensive Conservation and Management Plan
EPCHC	Environmental Protection Commission of Hillsborough County
FDNR	Florida Department of Natural Resources (Now within Florida Department of Environmental Regulation)
FDOT	Florida Department of Transportation
FLUCCS	Florida Land Use and Cover Classification System
GIS	Geographic Information System
Mote	Mote Marine Laboratory
NOAA	National Oceanographic and Atmospheric Administration
PCDEM	Pinellas County Department of Environmental Management
SCS	(U.S.) Soil Conservation Service
SWFWMD	Southwest Florida Water Management District
TAC	(TBNEP) Technical Advisory Committee
TBNEP	Tampa Bay National Estuary Program
TBRPC	Tampa Bay Regional Planning Council
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

EXECUTIVE SUMMARY

The Tampa Bay National Estuary Program (TBNEP) has guided and supported the development of an empirically-based approach to setting external nitrogen load targets to Tampa Bay. Regression models were developed using the available data to investigate the relationships among loadings, water quality, and the subsurface light environments in the bay. The investigation focused on the 1985 to 1994 time period. This time period corresponded to the period for which comprehensive loading estimates were developed by the TBNEP. The methodology and load targets developed by this work will be implemented through the development of a Comprehensive Conservation and Management Plan (CCMP).

The specific goals of the project were first, to determine if the available loading and water quality data were sufficient to define the external nutrient loading levels consistent with maintenance and expansion of existing seagrass meadows in Tampa Bay; and second, to develop a flexible tool that could be used to estimate various nutrient load management targets and evaluate the benefits of alternative nutrient load management strategies. A two-step modeling tool was developed from the available data. The first step quantified the relationship between total external loads and resulting average chlorophyll a concentrations. The second step quantified the relationship between chlorophyll a, turbidity, and color and resulting subsurface light conditions. The combination of these two steps provided estimates of the relationships between external nitrogen loadings and resultant light environments (i.e., Secchi disc depth) in Tampa Bay.

The preliminary results of this study were used to make conclusions concerning external nitrogen load management targets, and are presented in Sections 2 through 4. The TAC Modeling subcommittee has debated the available evidence for average annual requirements for Tampa Bay and other locations. The range of target light requirements discussed by the committee was generally between 20% and 25% of incident light. The 20% to 25% range corresponds to the average light conditions observed in Lower Tampa Bay at the deeper limit (approximately 2 meters) of areas supporting seagrasses in both 1950 and 1990. To maintain flexibility with regard to this issue, the preliminary chlorophyll a targets were expressed for a limited range of target light conditions.

The preliminary models and the available data indicated that, although there is expected to be considerable natural variation in the response of the bay to excess nutrients, maintenance of existing external nitrogen loads to Tampa Bay is likely to result in the attainment of 20% of surface light at target depths. The chlorophyll a targets likely to result in an average 20% of surface light at target depths were 9.7 $\mu\text{g/l}$ for Old Tampa Bay, 15.3 $\mu\text{g/l}$ for Hillsborough Bay, 8.8 $\mu\text{g/l}$ for Middle Tampa Bay,

and 5.5 $\mu\text{g/l}$ for Lower Tampa Bay. The results indicated that significant reductions of existing external nitrogen loads are likely needed to attain the proposed average annual targets for 25% of surface light at the target depths. The average annual chlorophyll a targets likely to result in 25% of surface light at the target depths were 6.0 $\mu\text{g/l}$ for Old Tampa Bay, 9.1 $\mu\text{g/l}$ for Hillsborough Bay, 4.8 $\mu\text{g/l}$ for Middle Tampa Bay, and 2.5 $\mu\text{g/l}$ for Lower Tampa Bay. Indirect evidence from Lower Tampa Bay suggests that between 20% and 22.5% of surface light is sufficient to meet the seagrass targets. The seagrasses in Lower Tampa Bay have occurred at the target depth in both 1950 and 1990, and for the period from 1974 to 1990, the average annual chlorophyll a concentrations were generally between 4 and 7 $\mu\text{g/l}$ (typically between 4 and 5 $\mu\text{g/l}$). The results of this study indicate that the current average annual chlorophyll a concentrations of this range would be consistent with 20% to 22.5% light at the target depth of 2 meters at mean water.

Following analysis of the preliminary models, the empirical relationships were updated with additional light requirement data, loading data, and water quality data for 1992 through 1994, and the models were enhanced to include estimates of intersegment exchange of nitrogen, and to allow load reduction schedules to be input. Sections 5 and 6 were added to this report in March of 1996. Based on these updated data, a working group of the TAC recommended a light environment target of 20.5%. The conclusions from both the preliminary and updated studies were similar. The available data indicated that, although there is expected to be considerable natural variation in the response of the bay to excess nutrients, maintaining external nitrogen loads at current levels is likely to result in 20.5% of surface light reaching between 90 and 100% of the seagrass restoration areas.

The management tools and conclusions provided by this study and several other ongoing studies will be applied to the development of bay wide pollution load management plans in support of the development of the Tampa Bay CCMP. The empirical models will enable the bay managers to explore a wide range of alternative management scenarios.

1.0 INTRODUCTION AND BACKGROUND

The Tampa Bay National Estuary Program (TBNEP) has guided and supported the development of a set of empirically-based pollutant loading and impact models for the Tampa Bay estuary. These models were developed to investigate the relationships in the available data between loadings, water quality, and the subsurface light environments in the bay. Sufficient data were available for these three components for the 1985 to 1991 time period. The TBNEP is using these relationships to establish specific pollutant load management targets that will be implemented through the development of a Comprehensive Conservation and Management Plan (CCMP).

Pollutant load management targets are needed to limit the extent of potentially excessive pollutant loads to the bay. The modeling effort in this project was used to discern the relationships in the available data needed to establish these management targets. The management approach was to set pollutant load targets at levels expected to meet the water quality requirements of living resources within the estuary. Specifically, the models for this project were developed to estimate the external nitrogen loads that would be compatible with chlorophyll a and light extinction rates required for the maintenance and expansion of existing seagrass meadows to extents observed in 1950.

The development of these models is part of a continuing cooperative regional effort to understand the sources, effects, and potential management strategies for pollutant loads to Tampa Bay. These TBNEP models were developed to make best use of the patterns discernible in the available data. The Southwest Florida Water Management District (SWFWMD) is undertaking a parallel modeling effort using a mechanistic "box" model to simulate the response of chlorophyll a and other parameters to changes in nitrogen loads. The box model will be used to simulate several pollutant loading scenarios and their effect on chlorophyll a concentrations and light levels in Tampa Bay.

1.1 THE TAMPA BAY ESTUARY

Tampa Bay is the largest estuary in the State of Florida. It extends approximately 35 miles into the west central coast of Florida (Figure 1-1), and is 5 to 10 miles wide along the majority of its length. Surface water flow from the 2,276 square mile watershed is provided by over forty minor tributaries and the Hillsborough, Alafia, Little Manatee, and Manatee Rivers (Figure 1-2) and point sources. The mainstem of the bay is greatly affected by the exchange of seawater and nutrients to and from the Gulf of Mexico.

1.2 SUBMERSED SEAGRASS MEADOWS: RESOURCE OF CONCERN

Long-term observations suggest that pollutant loadings to Tampa Bay have contributed to a reduction in the extent of naturally occurring seagrass meadows (Lewis et al., 1985; Avery, 1991; Lewis et al., 1991). Tampa Bay experienced an extended period of increasingly poor water quality and the physical destruction of habitats which reached a peak in the early 1980's. Coincident with this period of adverse conditions, the extent of submersed seagrass meadows in the bay declined from 40,400 acres in the 1950's to 25,200 acres in 1991 (Janicki et al., 1994). Figures 1-3 and 1-4 present the extent of the loss of this important living resource. As reviewed by the TBNEP (Janicki et al., 1994), the loss of some of these seagrass meadows can be attributed to direct physical destruction by the construction of causeways, channels, and fills, and the loss of other seagrass meadows can be attributed to poor water quality conditions. A major part of the poor water quality impacts on seagrasses is thought to be the attenuation of downwelling sunlight by excess concentrations of phytoplankton and suspended solids in the water column. Hence, the seagrass plants do not receive enough sunlight to remain healthy (i.e., respiration exceeds production) and they perish. The effects of poor water quality on seagrasses remains an active area of applied research, and the relative effects of other factors such as shading by epiphytic algae and large masses of macroalgae are under investigation. Recent applied research concerning the role of water quality in the loss of seagrass meadows was discussed in Morris and Tomasko (1993), Stevenson et al. (1993), and Batiuk et al. (1992).

The TBNEP has established restoration targets for seagrass meadows by comparing the historical distribution of seagrasses to the current distribution (Janicki et al., 1994). After subtracting the former seagrass areas which have been permanently altered by filling or excavating, the TBNEP established a restoration goal of 14,800 acres of seagrass meadows that should be restored to the Bay. Bay segment specific components of this target are presented in Table 1-1. The TBNEP has reported the results of a recent evaluation of potential seagrass restoration actions by regional scientists and resource managers. The results suggests that maintaining and potentially improving water quality conditions will be the most likely favored method to achieve the seagrass restoration targets.

Due to the cooperative efforts of local and regional resource managers, private interests, and concerned citizens, ambient water quality within the estuary has been improving since 1984 (KEA, 1992). In 1989, the Tampa Bay Agency on Bay Management (ABM) established goals for average chlorophyll a concentrations based on a consideration of chlorophyll a levels from the historical and current periods (ABM, 1989). The targets were generally established to maintain the recently improved conditions. To date, these ABM targets have been met. Results of recent seagrass meadow measurements were presented to the TBNEP Technical Advisory Committee

(TAC) Modeling Subcommittee by the SWFWMD Surface Water Management and Improvement (SWIM) Program (T. Reis, 1994). The changes observed from 1988 to 1992 indicate that a total of 1,230 new acres of seagrass has been established, and that 1,820 acres of seagrass which were classified as "patchy" in 1988 were classified as "continuous" in 1992. These results suggest that seagrass meadows are expanding in Tampa Bay. The role of this project is to formalize the target setting process and determine if the ABM chlorophyll a targets are sufficient to achieve recovery of seagrass to the targeted acreage and to determine the level of external nitrogen loads which is likely to result in the targeted chlorophyll a concentrations.

1.3 RELATED MODELING INVESTIGATIONS

Earlier research in a variety of waterbodies has focused on the relationships between nutrient loading and resulting water quality. Vollenweider (1968, 1975, 1976) developed the nutrient loading concept in limnology, building on Liebig's Law of the Minimum which simply states that the level of the nutrient in least supply will determine the level of primary production. The concept as applied to lakes posits that the level of primary production and algal biomass depends on the rate of supply of the nutrient that limits algal growth.

Riley (1972) applied the nutrient loading concept to a number of estuarine, coastal, and marine ecosystems. He concluded that the rate of nutrient supply is of primary importance in determining the levels of productivity in these systems. Boynton et al. (1982) also found that a reasonably good relationship between annual total nitrogen (TN) loading and annual production and chlorophyll levels in a series of estuaries.

Most recently, Boynton and Kemp (1993) examined the relationships between river flow (and thus nutrient loading) and ecosystem processes and properties in the Chesapeake Bay. They employed an empirical approach, such as applied in this study. They developed a series of conceptual models that postulated the specific potential cause-effect linkages behind the observed statistical relationships. Most notable from these analyses were the significant regressions obtained between river flow and algal biomass, algal primary production, and particulate organic matter deposition. These relationships were most evident after temporal lags (on the order of weeks to months) were formulated in the models.

Research in Tampa Bay has also pointed to the important influence of nutrient loads on algal production and biomass. Johansson (1991) has examined a relationship observed between estimated nitrogen loadings and resulting average chlorophyll a concentrations in Hillsborough Bay for a period (1968 to 1990) during which a very large decrease in nitrogen loads was reported. The results of the Johansson study (Figure 1-5) indicated that, under the very high loading conditions of this period, a

three year lag in the response of chlorophyll a concentrations to total external nitrogen loads was likely. This apparent lag effect may have been due to varying rates of internal nitrogen storage and release within the bay over a period of sharply declining external nitrogen loads. The current TBNEP study follows a similar approach as that of the Johansson study. However, the current TBNEP study was conducted to develop management plans using the recently compiled comprehensive external loadings data base for each of the four major bay segments.

Earlier research has also examined the relationships between the light attenuation and ambient water quality within Tampa Bay. McPherson and Miller (1993 and 1994) have reported the investigation of these relationships in a series of recent papers. These studies have made use of measured water quality and photosynthetically active radiation (PAR) from specific areas of Tampa Bay and Charlotte Harbor. Unfortunately, the water quality measurement methods used in these studies were not directly compatible with the measurement methods used in the monitoring studies applicable to the TBNEP CCMP. The current TBNEP project has proceeded in the spirit of the McPherson and Miller studies, but has made use of data sets which are specific to Tampa Bay, and which are directly applicable to the CCMP development.

1.4 PROJECT GOALS

The goals of this project were,

- first, to determine if the available loading and water quality data were sufficient to define the external nutrient loading levels consistent with maintenance and expansion of existing seagrass meadows in Tampa Bay; and
- second, to develop a flexible tool which could be used to estimate various nutrient load management targets and evaluate the benefits of alternative nutrient load management strategies.

The goals of this project were met by using the available data to meet several specific modeling objectives which included:

- to determine the simplest statistically significant relationship or series of relationships between total external nitrogen loads and resulting average light conditions at a given depth in the water column;
- to use the available loadings and water quality data to develop these relationships on a bay segment and monthly basis; and

- to apply the relationship or the series of relationships defined to a flexible method of setting nitrogen load management targets necessary to meet given light conditions.

STUDY AREA LOCATION

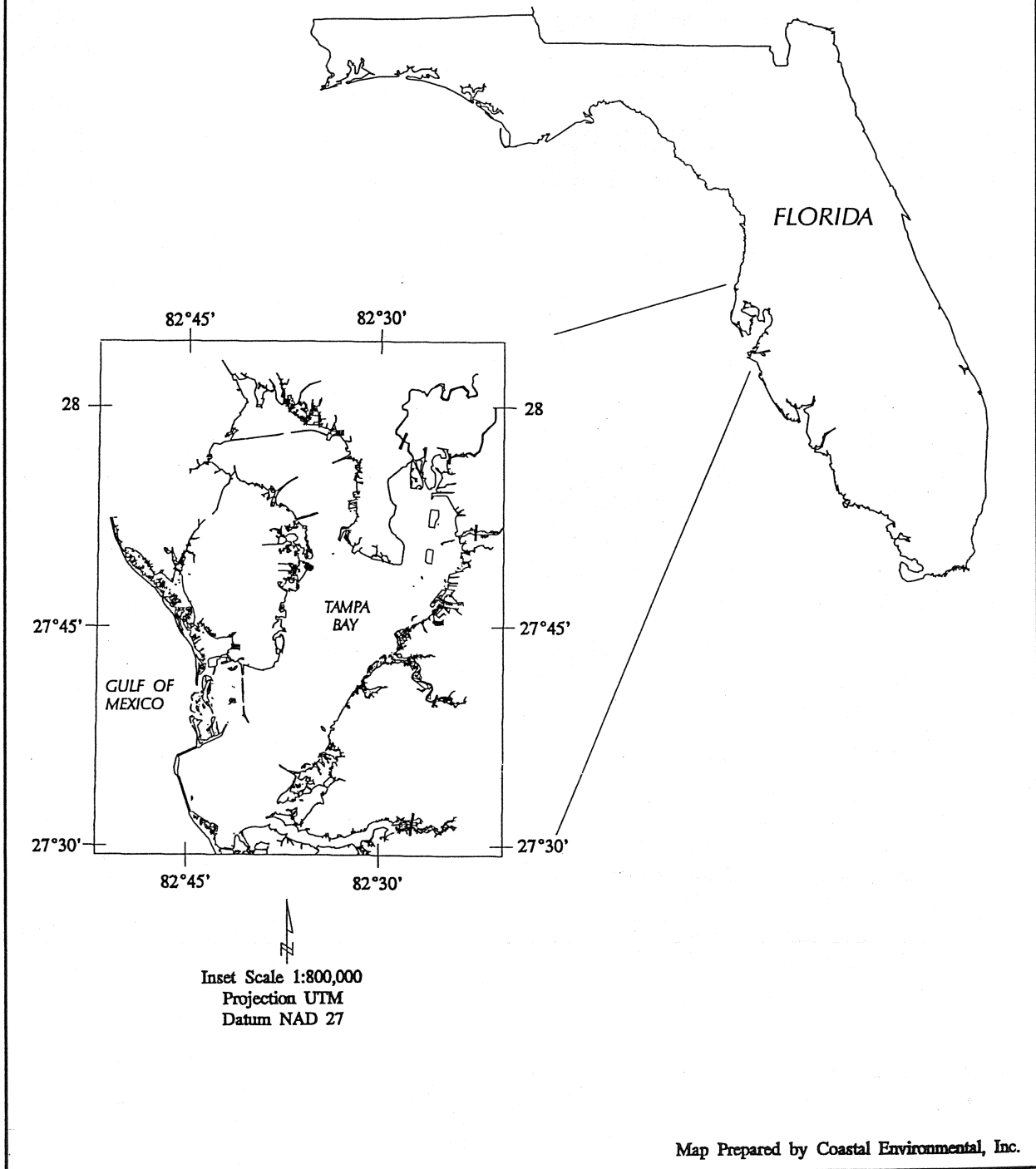
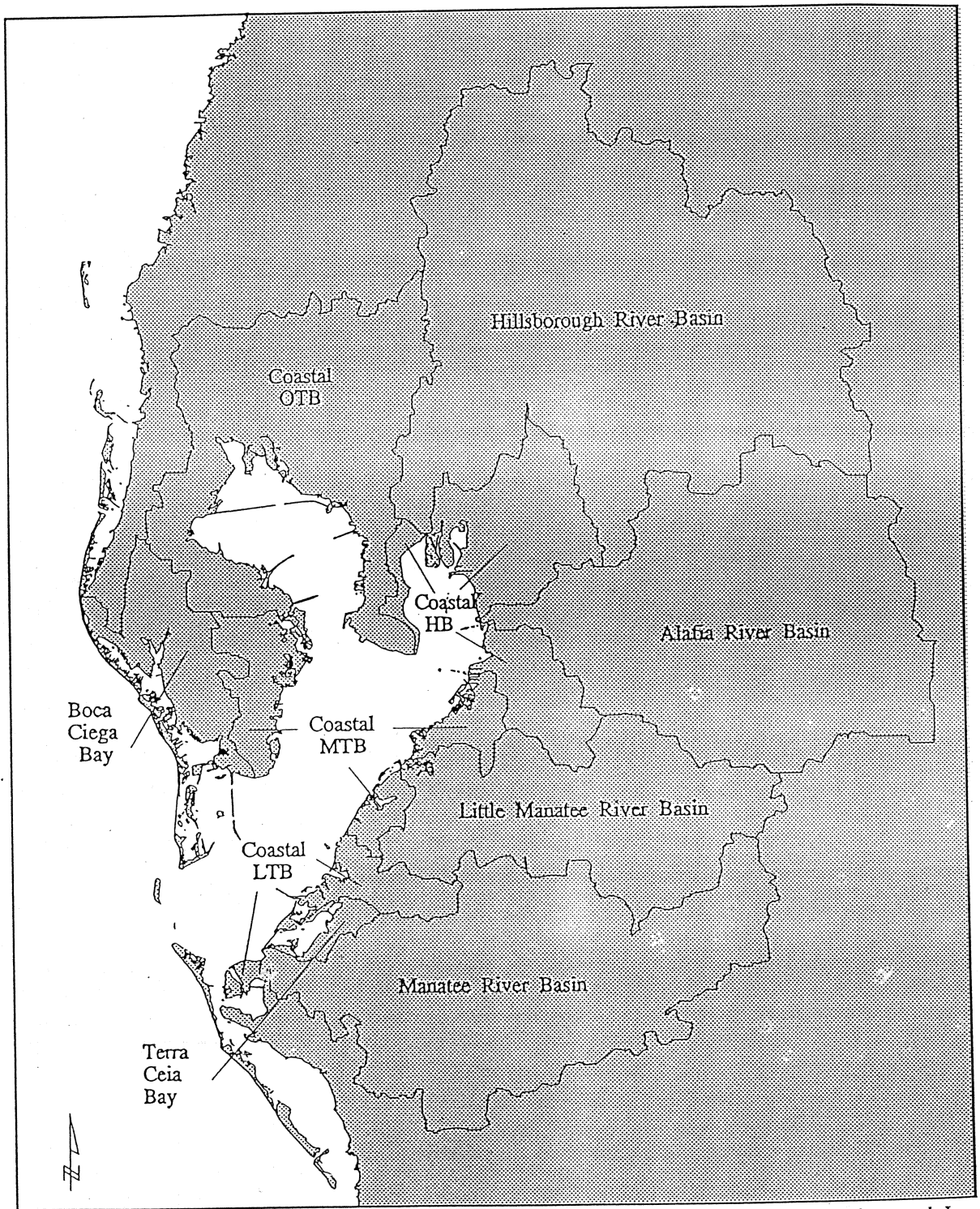


Figure 1-1 Study Area Location

MAJOR DRAINAGE BASINS OF TAMPA BAY

Modified from USGS



Map Prepared by Coastal Environmental, Inc.

Figure 1-2 Tampa Bay watershed major drainage basins.

1950 SEAGRASS DISTRIBUTION

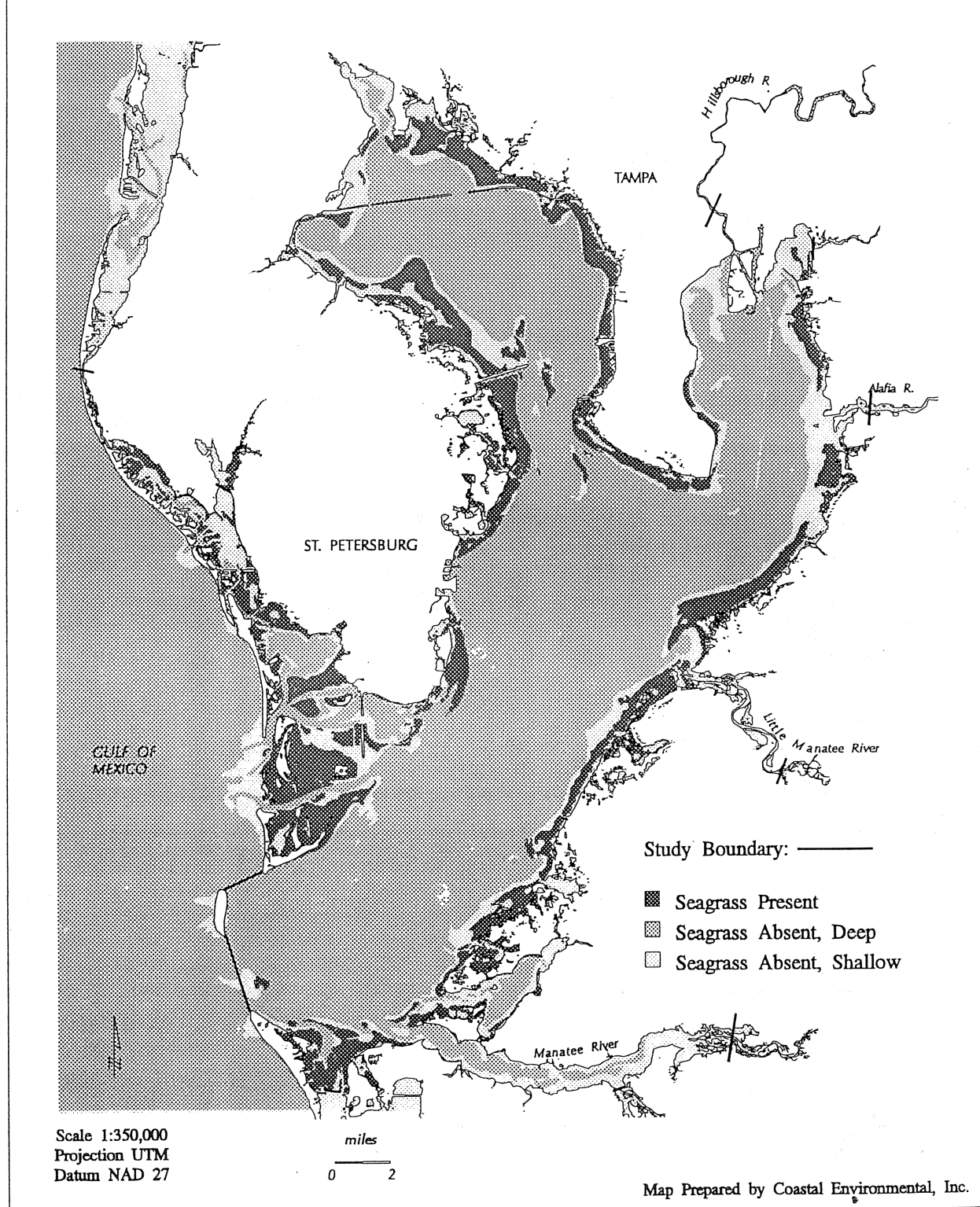
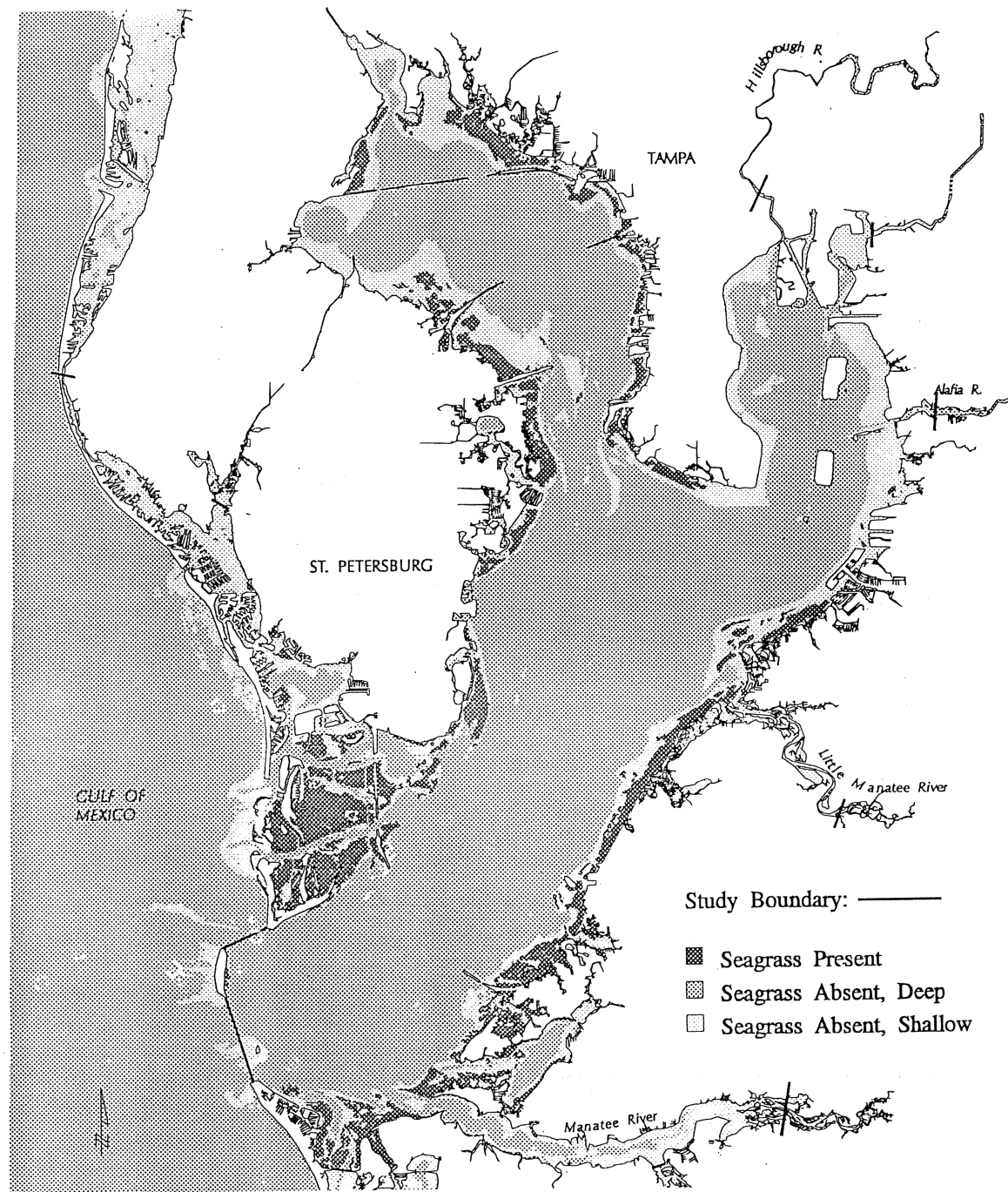


Figure 1-3

1950 Seagrass distribution in Tampa Bay. Data source: FDNR and USFWS cooperative study.

1990 SEAGRASS DISTRIBUTION



Scale 1:350,000
Projection UTM
Datum NAD 27

miles
0 2

Map Prepared by Coastal Environmental, Inc.

Figure 1-4

1990 Seagrass distribution in Tampa Bay. Data source:
SWFWMD SWIM Program.

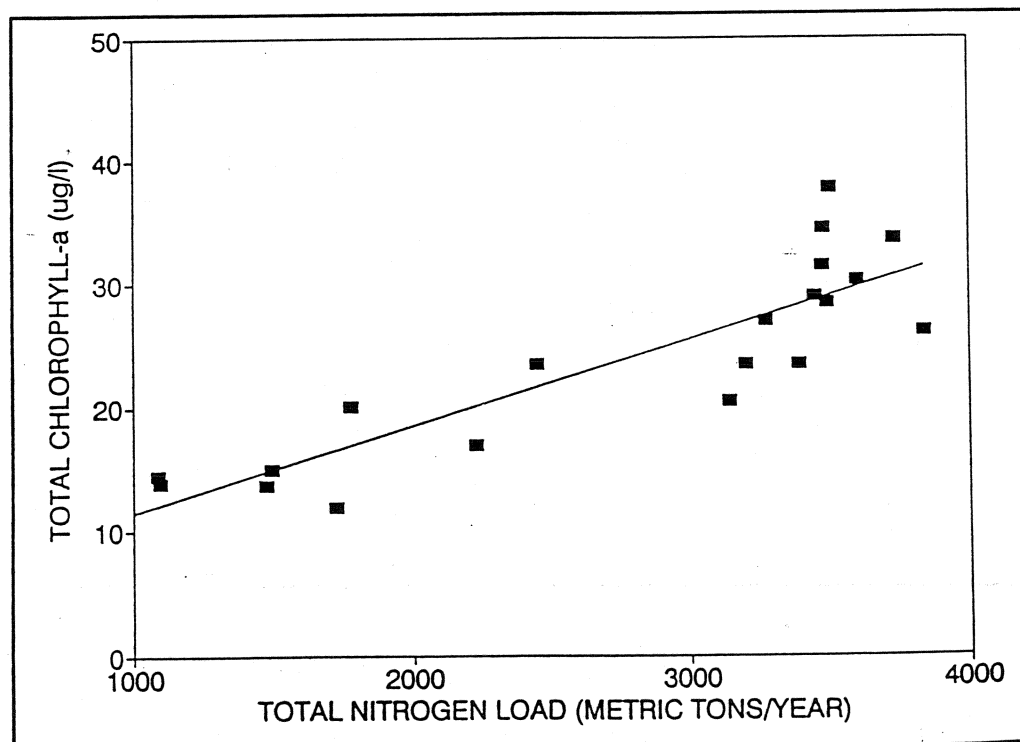
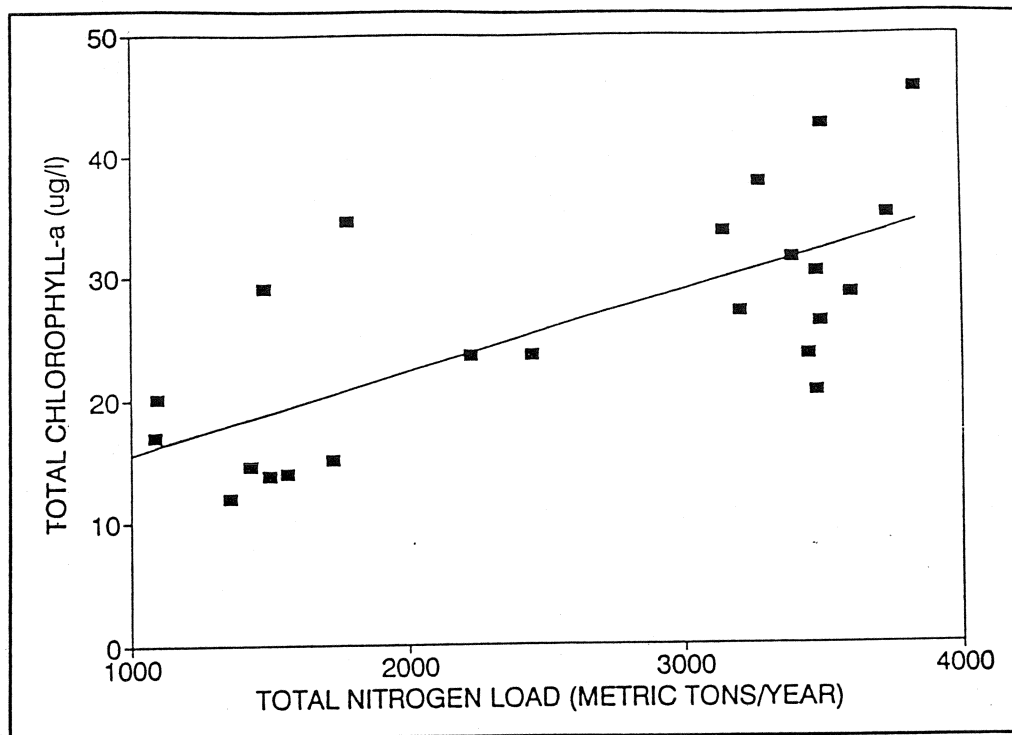


Figure 1.5

Relationships between total nitrogen loading (upper figure) and 3 year lag total nitrogen loading (lower figure) and average chlorophyll a concentrations from 1968 to 1990 (from Johansson, 1991). Nitrogen loadings were compiled from estimates of major sources.

Table 1-1 Acreage targets for protection and restoration of seagrasses (rounded to nearest 100 acres, Hillsborough Bay areas rounded to nearest acre).

Bay Segment	Seagrass Restoration Target (Acres)	Seagrass Protection Target (Acres)	Shallow Non-seagrass Protection Target (Acres)	Non-Restorable Area (Acres)
Old Tampa Bay	5,500	5,600	9,800	1,900
Hillsborough Bay	1,767	44	6,710	2,800
Middle Tampa Bay	4,100	5,300	7,000	1,900
Lower Tampa Bay	1,300	6,200	3,800	800
Boca Ciega Bay	2,000	6,800	6,500	5,100
Terra Ceia Bay	100	1,000	1,500	200
Manatee River	< 50	400	4,100	< 50
Bay-wide Total	14,800	25,200	39,500	12,800

2.0 METHODS

Measured water quality and loadings data were used to quantify the relationship between total external nitrogen loadings and resulting average chlorophyll a concentrations, and to quantify the relationship between chlorophyll a and turbidity and resulting light environments in Tampa Bay. Relationships between parameters were hypothesized. These relationships were stated in the form of equations and testable hypotheses, and specific parameters were then estimated using regression techniques. The nitrogen load data and water quality data used in the regressions are listed in Appendix E.

2.1 STUDY AREA

The study area was defined as the four mainstem bay segments of Tampa Bay. Figure 2-1 presents the locations of the Old Tampa Bay, Hillsborough Bay, Middle Tampa Bay, and Lower Tampa Bay segments. The segments were based on a delineation proposed by Lewis and Whitman (1985) and adopted by the TBNEP. The four mainstem bay segments of the study area were chosen because they covered the portion of the bay for which sufficient long-term water quality data were available.

2.2 POLLUTANT LOADING DATA SOURCES

External loadings of total nitrogen, total phosphorous, and total suspended solids were estimated for each bay segment and month from 1985 to 1991 using a GIS based analysis (Zarbock et al., 1994). The drainage basin boundaries were based on 435 subbasin delineations prepared by the U.S. Geological Survey for the Tampa Bay region. Noncontributing subbasins were eliminated from the total contributing areas, and subbasins were grouped into drainage basins based on surface water hydrology and the locations of USGS gaging stations. Each basin was then assigned to a major basin based on the major river drainage patterns, and then each major basin was assigned to a bay segment. Potentially major sources of loadings were estimated to the finest spatial resolution possible (e.g., subbasin or gaged area), and for this particular project loading data were summed for each bay segment and month.

Five categories of potentially major sources of TN, TP, and TSS loading were estimated:

- nonpoint sources (stormwater runoff and base flow),
- point sources (domestic and industrial facilities, and springs),
- atmospheric deposition directly to the open bay,

- groundwater, and
- losses of phosphate rock and fertilizer products that occur during handling and shipping.

Complete methods of estimating the total monthly loads of each of these five sources were presented by Zarbock et al. (1994).

2.3 WATER QUALITY DATA SOURCES

Water quality data recorded by the Environmental Protection Commission of Hillsborough County (EPCHC) were used in this study. The EPCHC data were collected from a network of fixed stations which were sampled from 1974 to the present (Figure 2-2). Selected stations were assigned to the four bay segments and an average was computed for each bay segment in each month. Parameters used for these analyses included chlorophyll a, turbidity, color, total nitrogen, and Secchi disk depth. A comparison of these and other recent water quality data with data collected from other sampling programs in the bay is currently being undertaken as a cooperative effort among local agencies of Hillsborough and Pinellas Counties, the City of Tampa, the University of South Florida, and other participants in the TBNEP Modeling Subcommittee.

Complete laboratory methods for the EPCHC water quality data are reported in a series of annual and biannual summary reports, the most recent of these reports having been prepared for 1992-1994 (EPCHC, 1995). In summary, chlorophyll a values were measured using the trichromatic method, and were reported in the units of $\mu\text{g/liter}$. Turbidity concentration values were measured as the absorption and scatter of light in a sample relative to a standard reference suspension, and were reported in the units of nephelometric turbidity units (NTU). Color values were measured from samples previously centrifuged to remove suspended matter, and were reported in the units of platinum cobalt units (Pt-Co units). Secchi disc depth values were measured using a 20 cm diameter Secchi disk, and were reported in the units of inches below the water surface.

2.4 MODELING APPROACH

The basic approach to developing the models for this project was to look for relationships in the available data which were both

- relevant to potential management actions, and at the same time
- potentially discernable from among the other sources of natural variation.

Two relationships were identified from the available data which met these criteria, and they were developed into a two-step method of modeling the effects of external nitrogen loads on light environments in the bay. These two relationships and a summary of the other relationships which were considered are presented in Figure 2-3.

Two potentially useful relationships were found in the available data, and methods were then developed to investigate these relationships and apply them to management strategy development in two steps. As presented in Figure 2-3, Step 1 was to investigate the relationship between total external loads and resulting average chlorophyll a concentrations. This approach follows the active area of research following Boynton and Kemp (1993) and others. Step 2 was to investigate the relationship between chlorophyll a, turbidity, and color and resulting subsurface light conditions. These methods and execution of these two modeling steps are described in the methods, results, and conclusions sections of this report.

2.5 PRELIMINARY MODEL - STEP 1: THE RELATIONSHIP OF NITROGEN LOADINGS TO WATER QUALITY

The response of average chlorophyll a concentrations to total external nitrogen loads was investigated by quantifying the relationships between chlorophyll a and total nitrogen using the available data. The methods developed to quantify this relationship addressed the link defined as Step 1 in the approach to this project (Figure 2-3).

A principal working hypothesis was developed based on the assumption that phytoplankton populations in Tampa Bay are nitrogen limited (City of Tampa, 1983), and that external nitrogen loads to the bay can be managed to effect desirable average water quality conditions. This working hypothesis can be investigated by determining if a significant amount of the variation in the average chlorophyll a concentrations can be explained by the variation in external nitrogen loads alone. Because the data suggested that this relationship was linear, this can be accomplished directly by fitting a least squares regression equation to the chlorophyll a concentration response to total nitrogen loads.

The general equation used to investigate the relationship of chlorophyll response to external nitrogen load was:

$$C_{t,s} = \alpha_{t,s} + \beta_s \left(\sum_{i=I_0}^{I_1} L_{t-i,s} \right)$$

where $C_{t,s}$ = average chlorophyll a concentration at month t and segment s,

$L_{t-i,s}$ = total nitrogen load at month t-i and segment s,

I_0 = initial time period of the time lag series,

I_1 = number of time periods in time lag series, and

$\alpha_{t,s}$ and $\beta_{t,s}$ = month and bay segment specific regression parameters.

A useful approach to developing a model of this general form is to attempt to explain a large amount of the variation in the response variable (i.e., chlorophyll) with a simple combination of significant explanatory variables (e.g., nitrogen load for the current month, nitrogen load for the previous month). The fit of any model may be improved by adding additional explanatory variables. One may obtain a near perfect model fit as the number of parameters estimated approaches the number of observations in the data set. However, each new variable added to a model lessens the robustness of the model to prediction error. In the case of the Tampa Bay chlorophyll a and nitrogen load model, the addition of water temperature, salinity, and bay segment surface to volume ratio data would have provided a higher significant fit to the model, but would have reduced the overall utility of the model as a management tool. This is because one would have an increased chance of making a prediction error by overestimating or underestimating either the parameters or expected input values of the additional parameters. Another important consideration is that these additional parameters (e.g., temperature, salinity) could not be easily managed, and inclusion in the model would not meet the second stated goal of this project which was to develop a flexible tool which could be used to estimate various nutrient load management targets and evaluate the benefits of alternative nutrient load management strategies.

2.6 PRELIMINARY MODEL - STEP 2: THE RELATIONSHIP OF WATER QUALITY TO LIGHT ATTENUATION

The response of average light conditions at various depths in the bay to water quality was investigated by attempting to quantify the relationships between percentage of incident surface light at a specific depth to water quality (i.e., chlorophyll a, turbidity, and color). The methods developed to quantify this relationship addressed the link defined as Step 2 in the approach to this project (Figure 2-3).

A principal working hypothesis was developed that observed light attenuation is directly related to chlorophyll a concentration, turbidity, and color. The available data

suggested that the relationships between Secchi disk depth and the individual water quality parameters were non-linear. However, the data suggested that the response of diffuse light attenuation (K_D) to these three variables was linear. This well known physical relationship is approximated by Beer's Law:

$$I_z = I_0 * e^{-(K_D) z}$$

where I_z = the incident light at depth z ,

I_0 = the incident light just below the surface, and

K_D = the diffuse attenuation coefficient (1/meters).

Giesen et al. (1990) reported that the diffuse attenuation coefficient K_D can be approximated by a factor of 1.5 to 1.8 divided by Secchi disk depth (expressed in meters) (Figure 2-4). Concurrently measured K_D and Secchi disk values reported by the City of Tampa Bay Study Group were used to verify this relationship for Tampa Bay and to refine bay segment specific factors.

The K_D values estimated by Secchi disk depth exhibited an approximately linear relationship to the measured water quality parameters. Least squares regression methods were used to estimate parameters of equations following the general form:

$$K_{D\ t,s} = \alpha_{t,s} + \sum_{i=1}^I \left(\beta_{i,t,s} (W_{i,t,s}) \right)$$

where $K_{D\ t,s}$ = Light attenuation coefficient at time t and bay segment s ,

$W_{i,t,s}$ = Water quality parameter i at time t and bay segment s , and

$\alpha_{t,s}$ and $\beta_{i,t,s}$ = regression parameters.

Light attenuation, expressed as the percentage of incident irradiance that penetrates to a particular depth, can also be calculated using the following rearrangement of Beer's Law.:

$$PSL_z = \left(e^{-(K_D) z} \right) 100$$

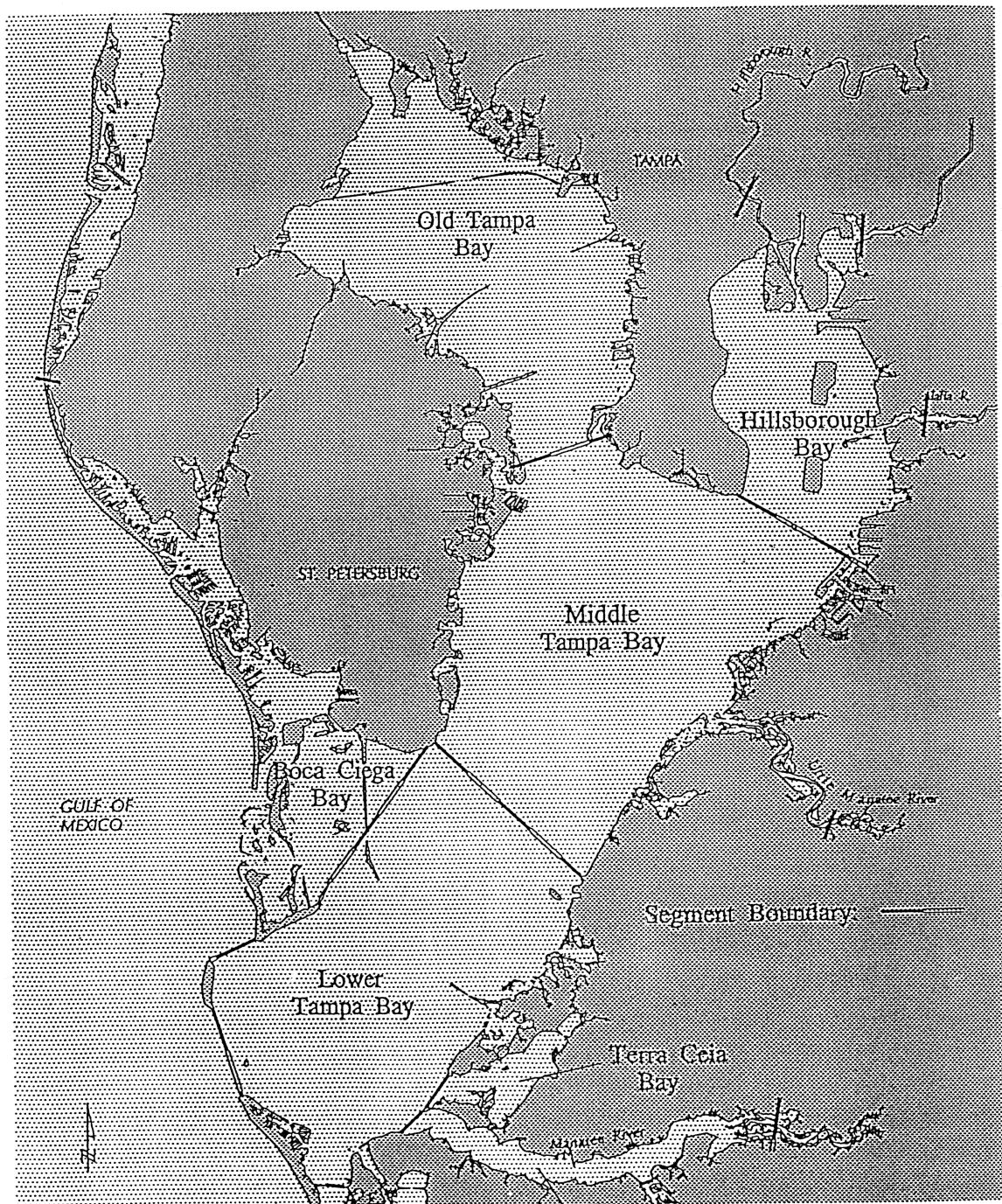
where PSL_z = the percent of surface light at depth z , and

K_D = the diffuse attenuation coefficient (1/meters).

Figure 2-5 presents the relationship between K_D , percent light, and depth.

TAMPA BAY SEGMENTS

Based on Lewis and Whitman, 1985



Scale 1:350,000
Projection UTM
Datum NAD 27

miles
0 5

Manatee River

Map Prepared by Coastal Environmental, Inc.

Figure 2-1 Segmentation Scheme for Tampa Bay.

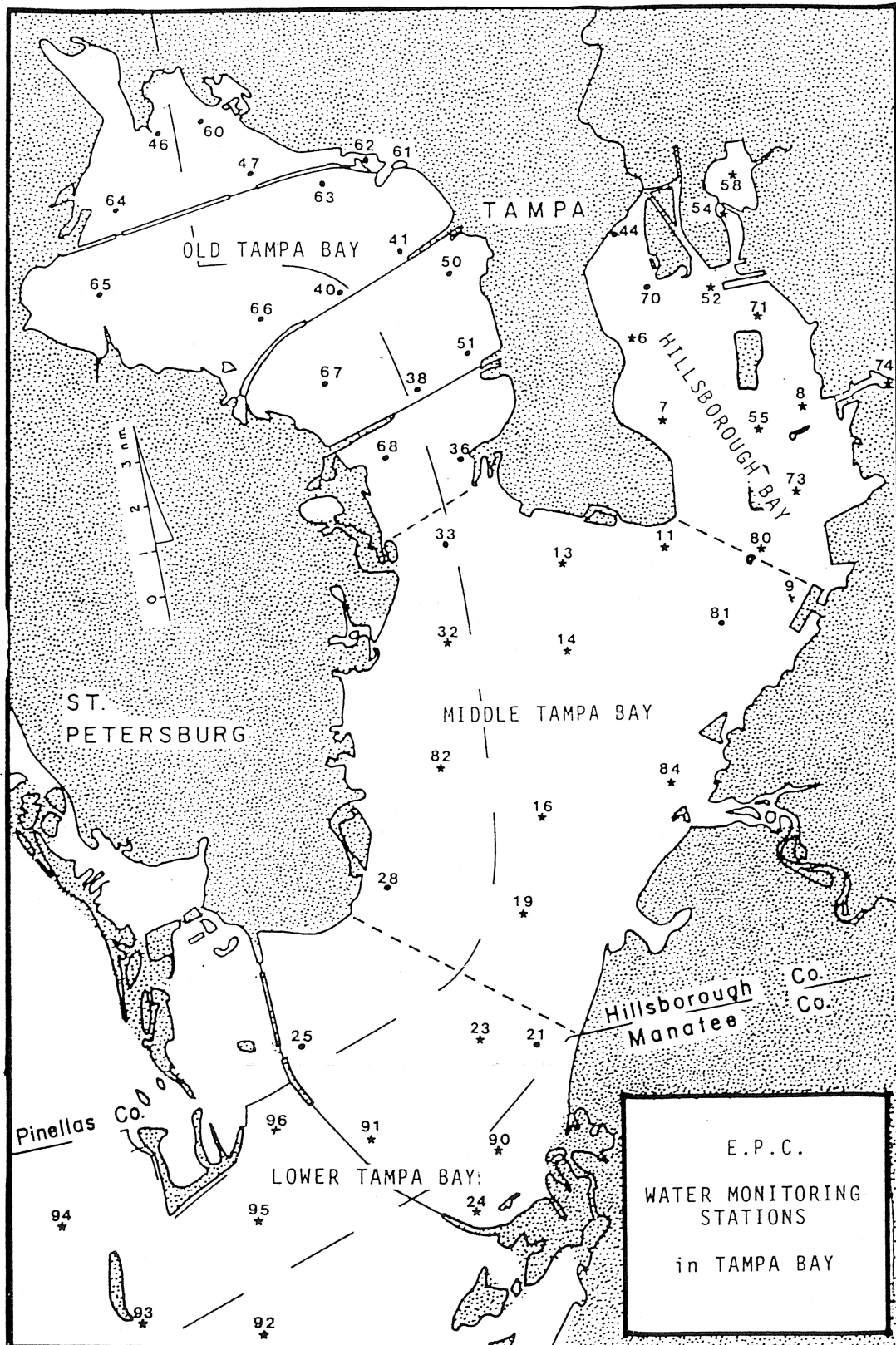


Figure 2-2

**Average Nutrient Load, Water Quality, and Light Environment Conditions
Modeling Paradigm**

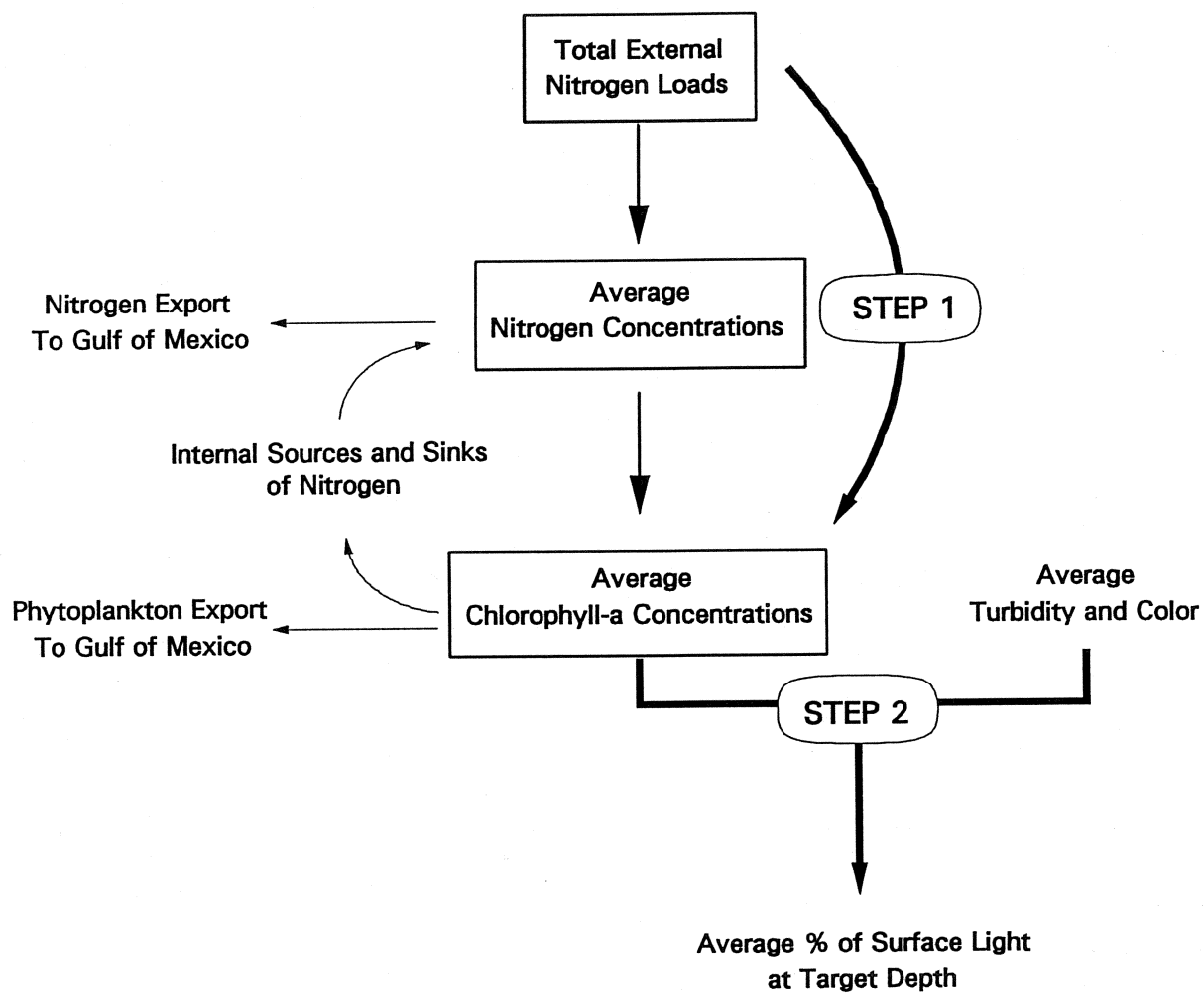


Figure 2-3

Average Nutrient Load, Water Quality, and Light Environment Conditions Modeling Paradigm

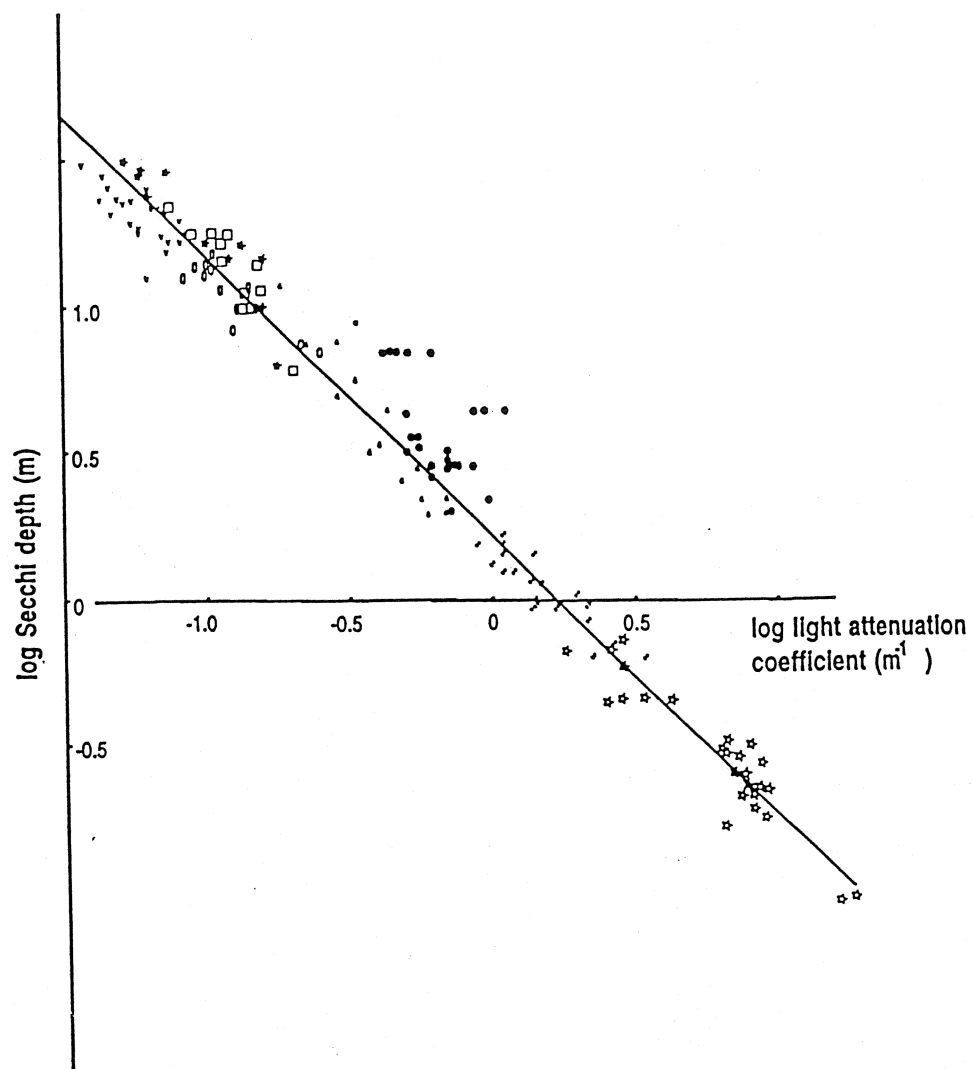


Figure 2-4

Relationship between Secchi Depth and Light Attenuation Coefficient (Giesen, 1990)

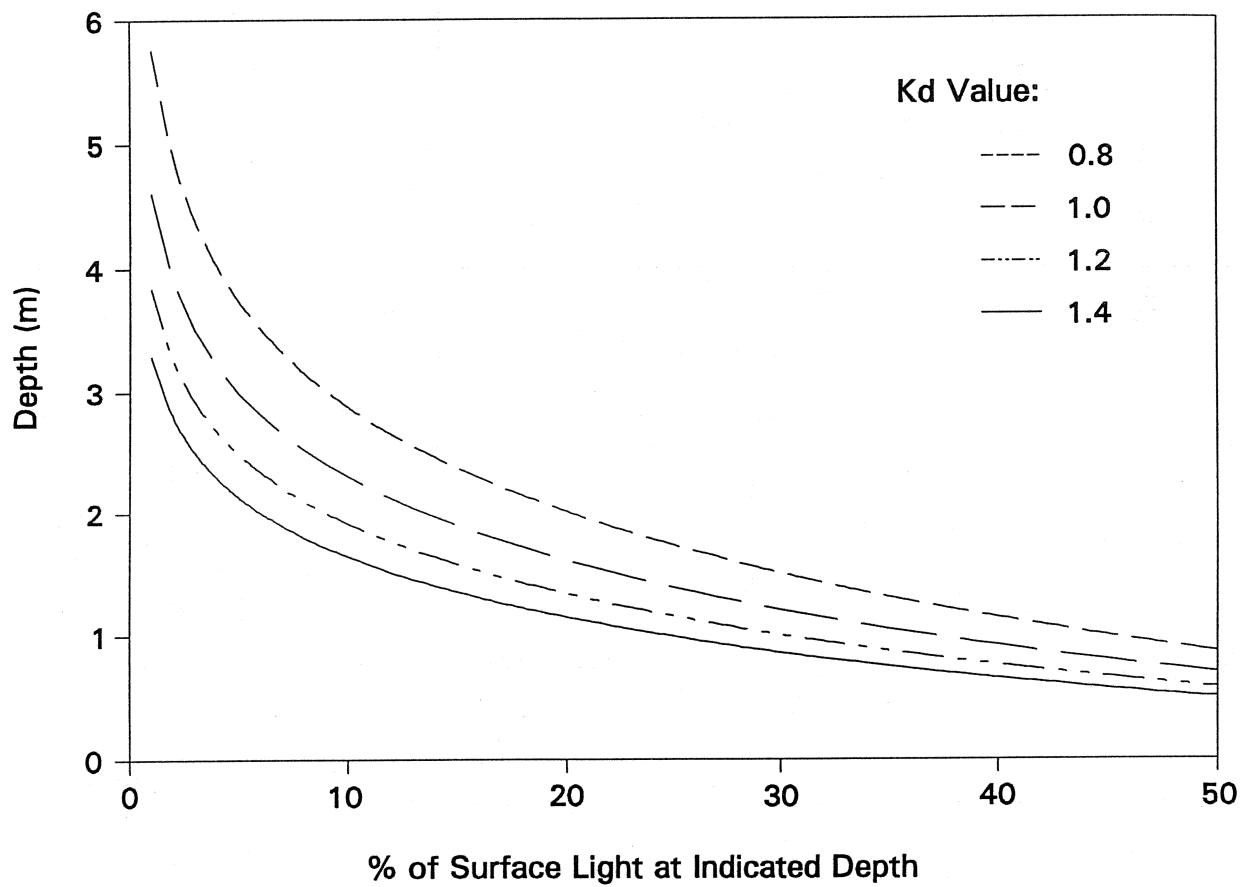


Figure 2-5

Relationship of Light Transmission to Light Extinction Coefficient

3.0 RESULTS

Relationships were developed between external nitrogen loadings and resultant light environments (i.e., Secchi disc depth) in Tampa Bay. These relationships were developed making best use of the available pollutant loadings estimates and water quality data for the four mainstem segments of the bay. These four mainstem segments were Old Tampa Bay, Hillsborough Bay, Middle Tampa Bay, and Lower Tampa Bay. The relationships were evaluated statistically, and the results indicated that the relationships explained a significant amount of the variation in chlorophyll a concentration based on external nitrogen loading estimates, and a significant amount of the variation in light penetration based on chlorophyll a concentrations.

3.1 POLLUTANT LOADINGS DATA COMPILATION RESULTS

Time series plots of these nitrogen loadings by bay segment are presented in Figure 3-1. Characteristic summer peaks in external loadings were visible, and were primarily the result of the relatively higher amounts of precipitation which occur during the summer wet season.

The loading estimates indicate that the four bay segments differ by the relative magnitude of external nitrogen loadings which they receive. Hillsborough Bay received the largest external nitrogen loads. Hillsborough Bay loads ranged from 986,000 to 2,313,000 kilograms (1,087 to 2,549 tons) of nitrogen per year for the 1985 to 1991 period, and the average external load was 1,544,000 kilograms (1,701 tons) of nitrogen per year for the same period. The loadings estimates indicate that the other three bay segments received significantly less external nitrogen loads. The estimated average annual external nitrogen load for Old Tampa Bay was 466,000 kilograms (514 tons) per year, for Middle Tampa Bay was 666,000 kilograms (734 tons) per year, and for Lower Tampa Bay was 326,000 kilograms (359 tons) per year.

3.2 WATER QUALITY DATA COMPILATION RESULTS

Average Secchi disc depth, chlorophyll a, turbidity, and color data indicated an overall pattern of decreasing water clarity within each of the four bay segments during the 1970's followed by an extended period of increasing water clarity through 1991. Time series plots of the annual averages of these water quality parameters are presented in Figures 3-2 through 3-5, and plots of the monthly averages are presented in Figures 3-6 through 3-9. Because the 1985 to 1991 available pollutant load estimates were not needed to investigate the relationship of ambient water quality to subsurface light conditions, the full 1974 to 1991 period of record for water quality could be used.

The average monthly Secchi disc depth in these four bay segments indicated a pattern of decreased water clarity over an extended period during each summer followed by a brief period of peak high water clarity during each winter. In Hillsborough Bay, Secchi disc depth has gradually increased from less than 1 meter in the late 1970's to greater than 1 meter in recent years with typical winter peak values approaching 2 meters. Old Tampa Bay, Middle Tampa Bay, and Lower Tampa Bay have experienced similar patterns with relatively deeper Secchi depths. In recent years, Secchi depths ranged approximately from 1 to 2 meters in Old Tampa Bay, approximately from 1.5 to 3 meters in Middle Tampa Bay, and approximately from 2 to 3.5 meters in Lower Tampa Bay.

The average monthly chlorophyll a concentrations in these four bay segments indicated a pattern of relatively high concentrations from 1974 through the summer of 1983, and this period was followed by an overall pattern of declining concentrations, including perhaps most importantly declines in peak chlorophyll conditions, from 1984 through 1991. The monthly time series plots indicated that the chlorophyll a concentrations were generally more variable than Secchi disk values, and had several peaks during each year with the late summer peak typically being the largest. Peak monthly concentrations for chlorophyll a also declined from 1984 through 1991. Declines in peak monthly chlorophyll concentrations were greatest for Hillsborough Bay (approximately 70 to 20 $\mu\text{g/L}$), and were followed in decreasing order by Old Tampa Bay (30 to 15 $\mu\text{g/L}$), Middle Tampa Bay (25 to 10 $\mu\text{g/L}$), and Lower Tampa Bay (15 to 5 $\mu\text{g/L}$).

The average monthly turbidity data indicated a relatively stable period from 1974 through 1987 during which turbidity values typically ranged from 3 to 7 (NTU) and periodically exceeded 10 (NTU). These data exhibited a typical pattern of relatively higher turbidity during the wet summer season. Peak turbidity levels in 1978 and in 1979 coincided with dredging in Hillsborough Bay conducted as part of the Tampa Harbor Deepening Project (EPCHC, 1991). Hillsborough Bay monthly turbidity levels were typically higher than those of the other bay segments in all seasons and years, and the values often exceeded 10 (NTU). The monthly time series plots also suggest that turbidity levels may have slightly increased for the four bay segments beginning in 1988 and extending through 1991.

The average monthly color data for these bay segments was variable throughout the 1974 to 1991 time period with no clear overall increasing or decreasing trend. Color values typically peaked in late summer to early fall, and were relatively higher (approximately 5 to 45 Pt-Co units) for Hillsborough Bay than for the other three segments (approximately 2 to 20 Pt-Co units). The distributions of average monthly color values for individual EPC of Hillsborough County monitoring stations in Middle and Lower Tampa Bays were examined in order to determine if the bay segment definitions used in this study were of sufficient resolution to investigate the relative

contribution of color to light attenuation. As discussed in the following sections, the results of this analysis indicated that the Middle and Lower Tampa Bay segment definitions were sufficient to characterize the color and light attenuation relationship and to satisfy the objectives of this study.

The average monthly total nitrogen concentrations for each of the four bay segments for the time period of January 1985 to December 1991 are presented in Figure 3-10. These monthly values indicated that nitrogen concentrations were variable with peaks typically occurring throughout spring, summer, and fall, and that the highest peaks typically occur in late Summer. These data also indicate that 1987 nitrogen concentrations were relatively higher for all four bay segments during this time period. In contrast to the other water quality parameters examined, average nitrogen concentrations for Hillsborough Bay and Old Tampa Bay were similar. Both Hillsborough Bay and Old Tampa Bay average nitrogen concentrations (approximately 0.5 to 2.0 mg/L) were typically higher than those for Middle and Lower Tampa Bays (approximately 0.3 to 1.5 mg/L).

3.3 PRELIMINARY MODEL RESULTS - THE RELATIONSHIP OF EXTERNAL NITROGEN LOADINGS TO CHLOROPHYLL a CONCENTRATIONS

The results of the preliminary empirical modeling approach discussed in Section 2 are presented in the following text. The relationships between nitrogen loadings and chlorophyll a concentrations were then updated using additional data for 1992-1994 and several model enhancements. The methods and results of the updated relationships are presented in Section 6 of this report.

Before attempting to identify and quantify the relationships between nitrogen loading and chlorophyll a concentrations in Tampa Bay, investigations into the discernable relationships between 1) nitrogen loading and average ambient nitrogen concentrations and 2) ambient nitrogen and chlorophyll a concentrations were conducted.

The relationship between total external nitrogen loads and average ambient nitrogen concentrations was examined, and the results did not indicate a strong relationship ($R^2 = 0.43$). Ambient nitrogen concentrations observed in the bay were the result of external nitrogen loads, internal sources of nitrogen (e.g., phytoplankton and other biota, nitrogen releases from sediments), and internal nitrogen sinks (e.g., sediments, and export of nitrogen to the Gulf of Mexico). The relationship between ambient nitrogen concentrations and chlorophyll a concentrations was determined not to be useful for this project. One can not readily discern a cause and effect relationship between these two likely correlated variables. Also, since a useful (i.e., significant) relationship between total external nitrogen loads and ambient nitrogen concentrations within the bay could not be detected, knowledge of a relationship between nitrogen

concentrations and chlorophyll concentrations would not provide a link required for this project.

Relationships between internal sources and sinks of nitrogen in Tampa Bay are difficult to investigate for the range of variation observed in the 1985 to 1991 data used for this TBNEP project. Direct measurements of sediment release data are difficult to collect and existing comprehensive sediment release data for Tampa Bay have not been identified. Indirect observations of the role of internal nitrogen loads from sediment release have been detected during periods of extreme change in loading levels for Tampa Bay. For example, the previously discussed investigation by Johansson (1991) presents evidence for a three-year lag effect in chlorophyll a response to external nitrogen loads. This apparent lag effect may have been due to varying rates of internal nitrogen storage and release within the bay over a period of sharply declining external nitrogen loads. Because of the complex processes affecting nitrogen concentrations within the Bay, the relationship of total external nitrogen loads and ambient nitrogen concentrations are difficult to detect. The only relationships between total external nitrogen loads apparent in the 1985 to 1991 data used for this project were on an average annual level of resolution.

Statistically significant and useful relationships were observed between estimates of external nitrogen loadings to the four bay segments and average water quality conditions within the segments. The relationships were observed using graphical and least squares regression methods with nitrogen load and average chlorophyll a concentration data. Each observation in the data set represented the condition for a month and bay segment. This level of temporal and spatial resolution was deemed appropriate by the TAC Modeling Subcommittee. The time period used for these analyses was from January of 1985 to December of 1991. This time period corresponds to the time period which was operationally defined as the "current" period by the TBNEP, and it was the time period for which external nitrogen loads were estimated (Zarbock et al., 1994).

A functional model relating total external nitrogen loadings and average chlorophyll a concentrations was developed following the general model previously discussed. Analyses that attempted to relate the current month's chlorophyll a concentrations to the current month's nitrogen loading were initially conducted. Subsequent analyses investigated the potential relationships between the current month's chlorophyll a concentrations and the nitrogen loading with different temporal lag periods. A three month cumulative lag period for nitrogen loads was found to best explain the variation in the chlorophyll a data. A linear model was formally specified and fit to the monthly loading and chlorophyll a data. Several outlying nitrogen load data points of greater than 630,000 kilograms per month were removed from the data set prior to fitting the model. The linear model was:

$$C_t = \alpha_{t,s} + \beta_s \left(\sum_{i=0}^2 L_{t-i} \right)$$

where $C_{t,s}$ = average chlorophyll a concentration at month t and segment s,

$L_{t-i,s}$ = total nitrogen load at month t-i and segment s,

$\alpha_{t,s}$ and β_s = month and bay segment specific regression parameters.

An R^2 value of 0.73 was obtained by comparing 256 observed and predicted chlorophyll a values using this relationship. Figure 3-11 presents the comparison between predicted and observed chlorophyll a concentrations. Detailed regression results, parameter estimates, and diagnostic information are presented within the appendices of this report.

Similar lags in the response in to nutrient loads has been observed in the Patuxent Estuary by Kemp and Boynton (1984) and the Chesapeake Bay mainstem by Malone et al. (1988). They hypothesized that the lag may be due to the fact that much of the total nitrogen loads entering an estuary is in the particulate form, thus requiring some degree of remineralization via microbial activity before becoming available for uptake by phytoplankton in the water column. Magnien et al. (1992) noted that large winter/spring nutrient loads supported phytoplankton productivity in late summer.

The available nitrogen loading data for Lower Tampa Bay could not by itself explain a significant portion of the variation in chlorophyll a concentration in Lower Tampa Bay. This was likely due to the relatively low range of chlorophyll a concentration values and nitrogen loading values observed in Lower Tampa Bay and the likely high rate of exchange between Lower Tampa Bay and the Gulf of Mexico. The results do not indicate that average chlorophyll a values were not influenced by nitrogen loadings in Lower Tampa Bay, but rather, they indicate that given the 1985 to 1991 data and conditions existing in Lower Tampa Bay, an unequivocal pattern could not be visible above the other sources of variation. The slope parameter, β_s , for Lower Tampa Bay was estimated by using data pooled from all four bay segments (R^2 value of 0.62).

3.4 PRELIMINARY MODEL RESULTS - THE RELATIONSHIP OF WATER QUALITY TO LIGHT ATTENUATION

The results of the preliminary model approach described in Section 2 are presented in the following text. An update of these results with additional 1992-1994 loading and water quality data is presented in Section 6.

Statistically significant and useful relationships were also observed between water quality and light attenuation estimates. As discussed in the methods section, monthly mean K_D values for the four bay segments were modeled as a response to chlorophyll a concentrations, and turbidity for the time period of January 1974 to December 1991. A model approach similar to that used to develop the chlorophyll-nitrogen load model was employed. The nitrogen load to chlorophyll a investigation results previously described provide a link between external nitrogen loads and water quality. The results of this second link demonstrate how downwelling sunlight in the water column has responded to chlorophyll a concentrations and turbidity within the bay.

Figure 3-12 graphically presents the observed relationship between K_D and chlorophyll a and turbidity. The K_D values estimated by Secchi disk exhibited an approximately linear relationship to the measured water quality parameters. Stepwise regressions of K_D estimates on each of the three explanatory variables indicated variation in chlorophyll a and turbidity accounted for most of the variation in K_D values in all bay segments. The independent variable color did not substantially improve the fit of the model, (i.e., contribute significantly to the amount of variation in K_D). Inspection of the color data shows a high degree of colinearity of color with chlorophyll a concentrations. These results do not indicate that color does not contribute to light attenuation in Tampa Bay, but rather that for the range of observed conditions, a significant relationship could not be observed above the other sources of variation. These sources of variation included the light absorption by seawater alone, surface reflection and refraction, measurement errors, and other attenuating factors. Color may have a relatively larger contribution to light attenuation within specific areas of the bay where the range of color values observed is greater than those observed in the bay proper.

Least squares regression methods were used to estimate parameters for the equation:

$$K_{D\ t,s} = \alpha_{t,s} + \beta_{1\ t,s} C_{t,s} + \beta_{2\ t,s} T_{t,s},$$

where $K_{D\ t,s}$ = average light attenuation at month t and bay segment s,

$C_{t,s}$ = average chlorophyll a concentration at month t and bay segment s,

$T_{t,s}$ = average turbidity at month t and bay segment s, and

$\alpha_{t,s}$, $\beta_{1,t,s}$ and $\beta_{2,t,s}$ = regression parameters.

Results of this modeling effort indicated that the variation in light attenuation could best be explained by the variation in chlorophyll a concentrations and turbidity. Also, as was the case for the nitrogen loading-chlorophyll model, variation among bay segments and among months in the relationships between K_D and the explanatory variables was sufficiently large that bay segment and month specific regression parameters improved the fit of the model. An R^2 value of 0.73 was obtained for the monthly Tampa Bay data. Figure 3-13 presents the comparison between observed and predicted light K_D estimates. Detailed regression results, parameter estimates, and diagnostic information are presented within the appendices of this report.

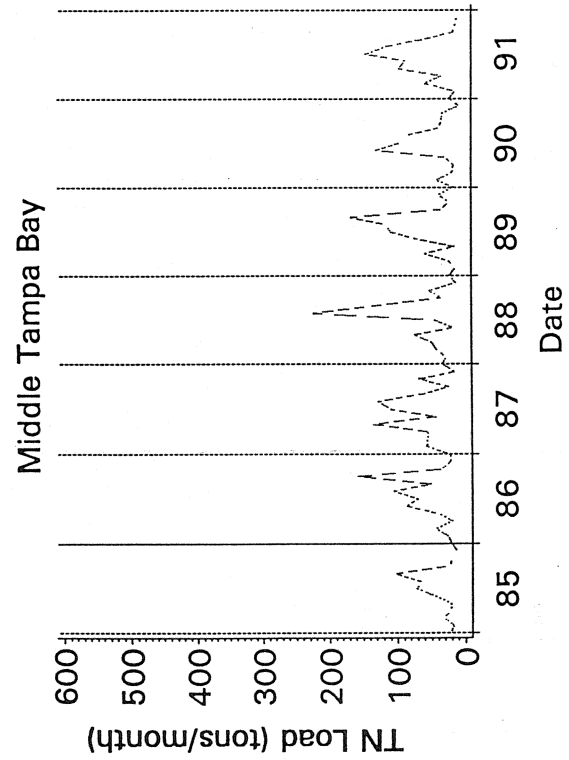
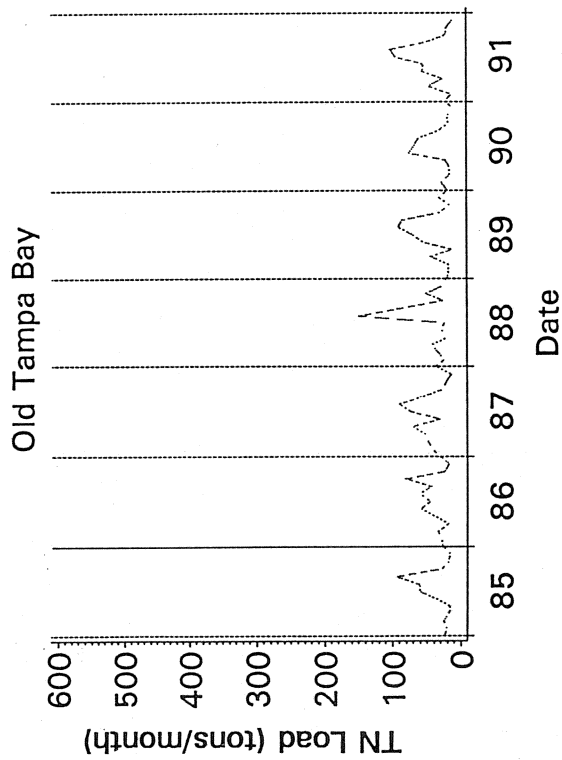
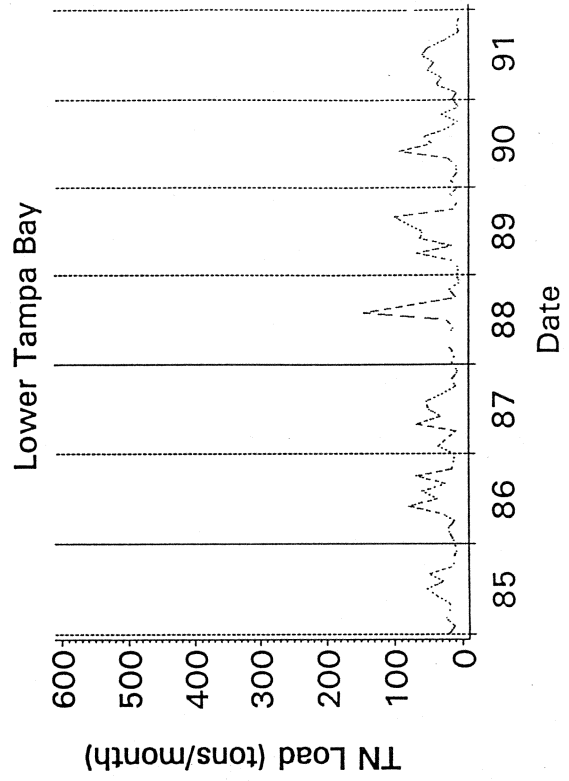
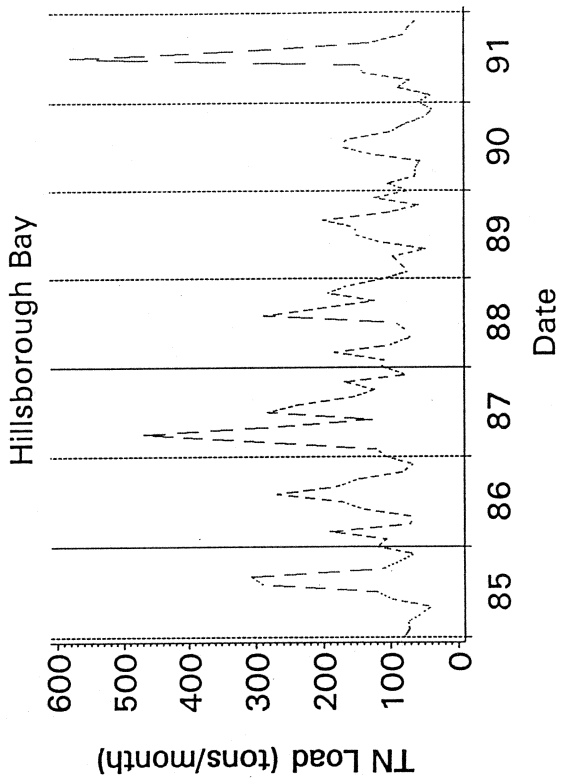


Figure 3-1

Estimated Monthly TN Loads to Tampa Bay Segments, 1985-1991

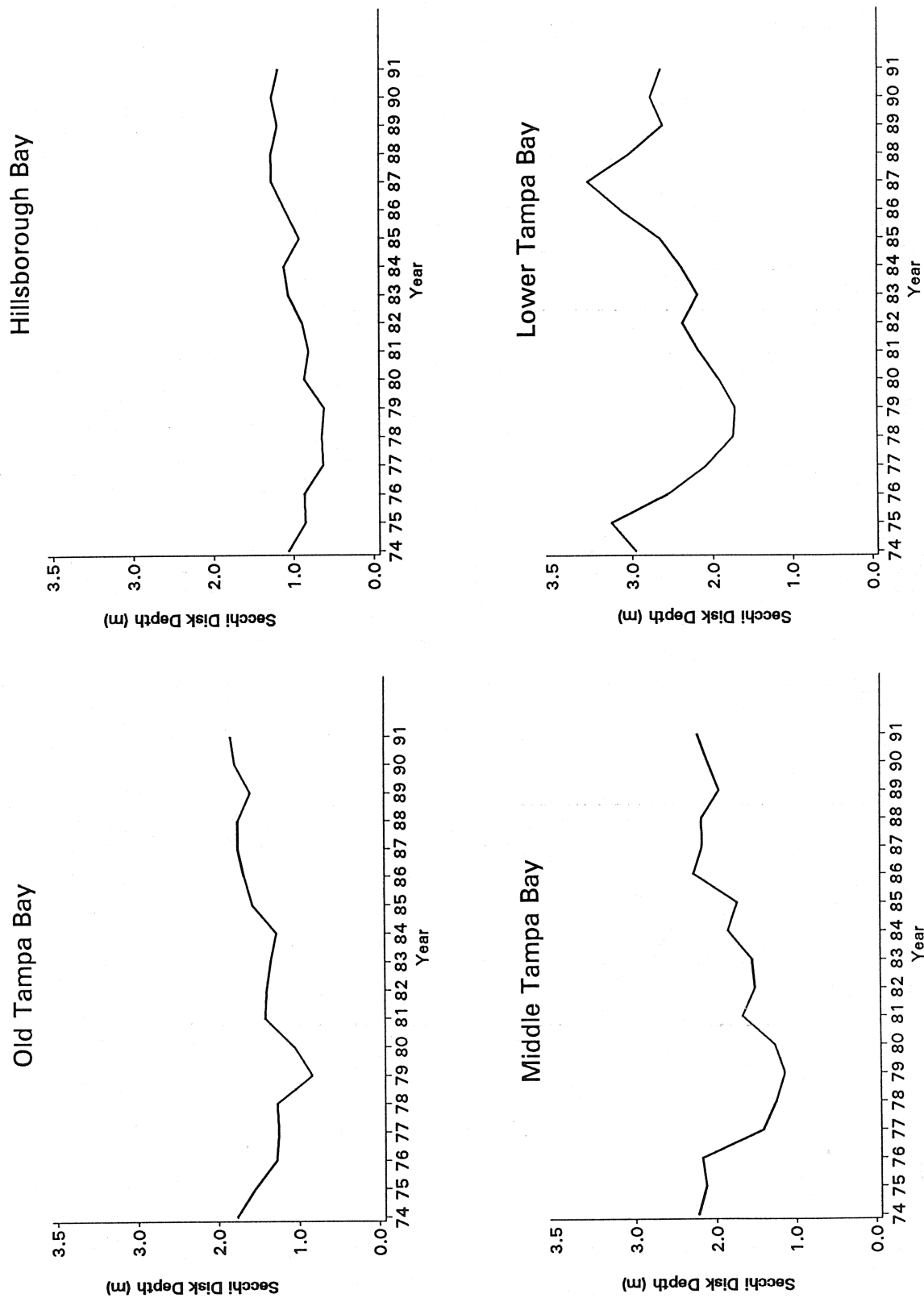


Figure 3-2 Average Annual Secchi Disk Depths of Tampa Bay Segments, 1974-1991

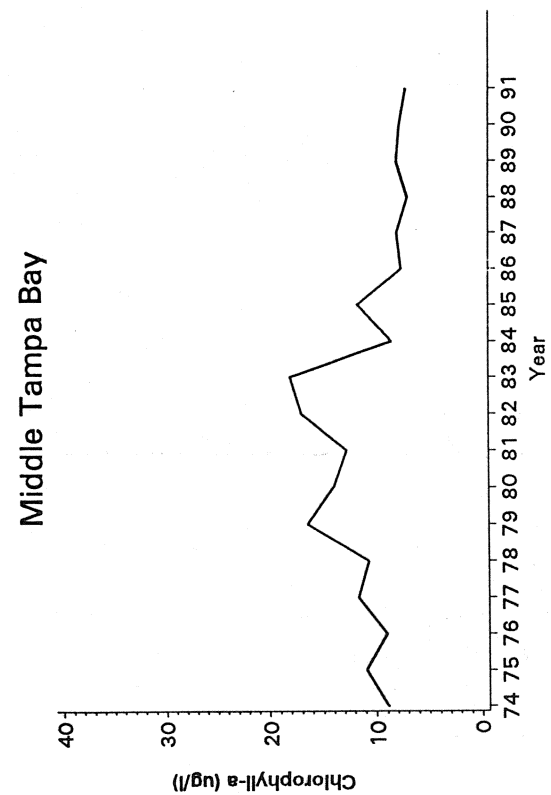
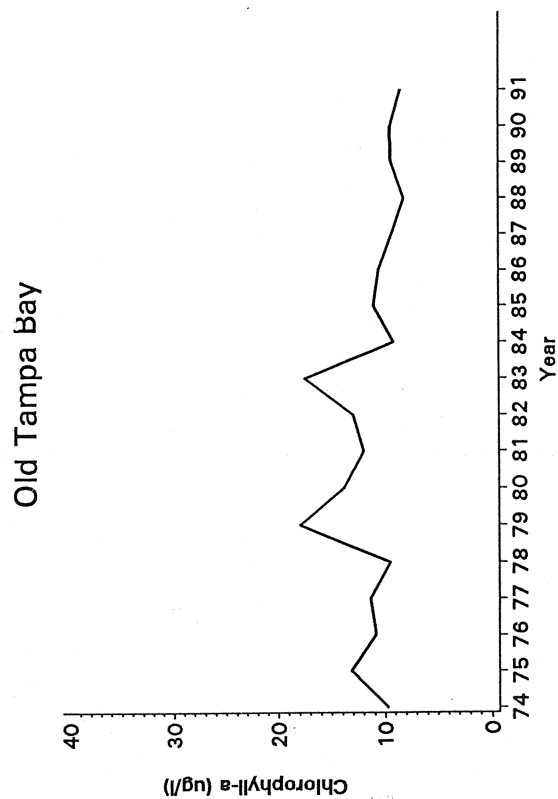
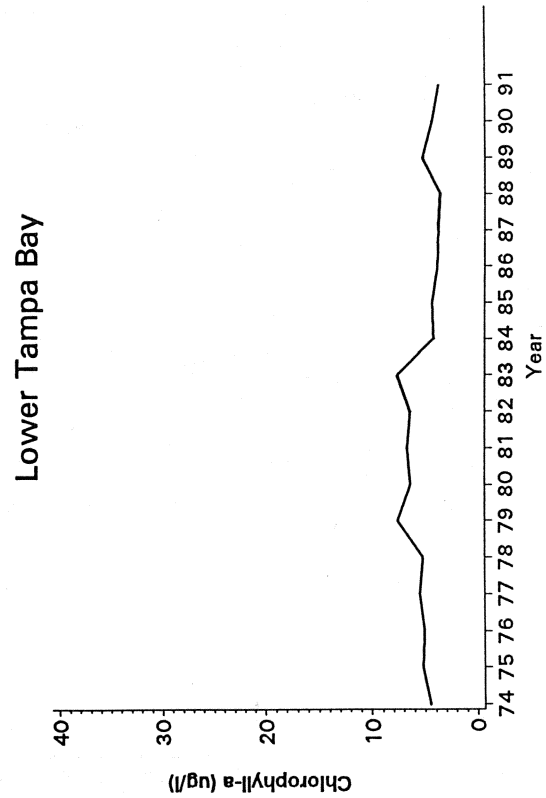
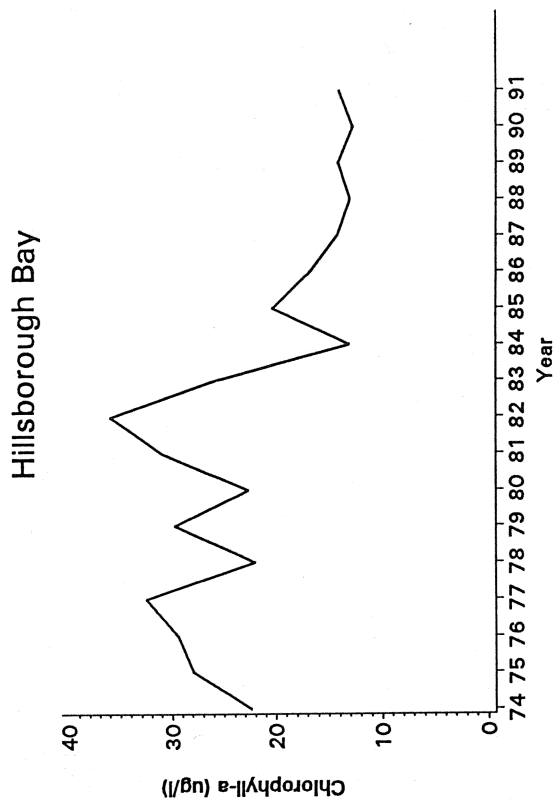


Figure 3-3

Average Annual Chlorophyll *a* Concentrations of Tampa Bay Segments, 1974-1991

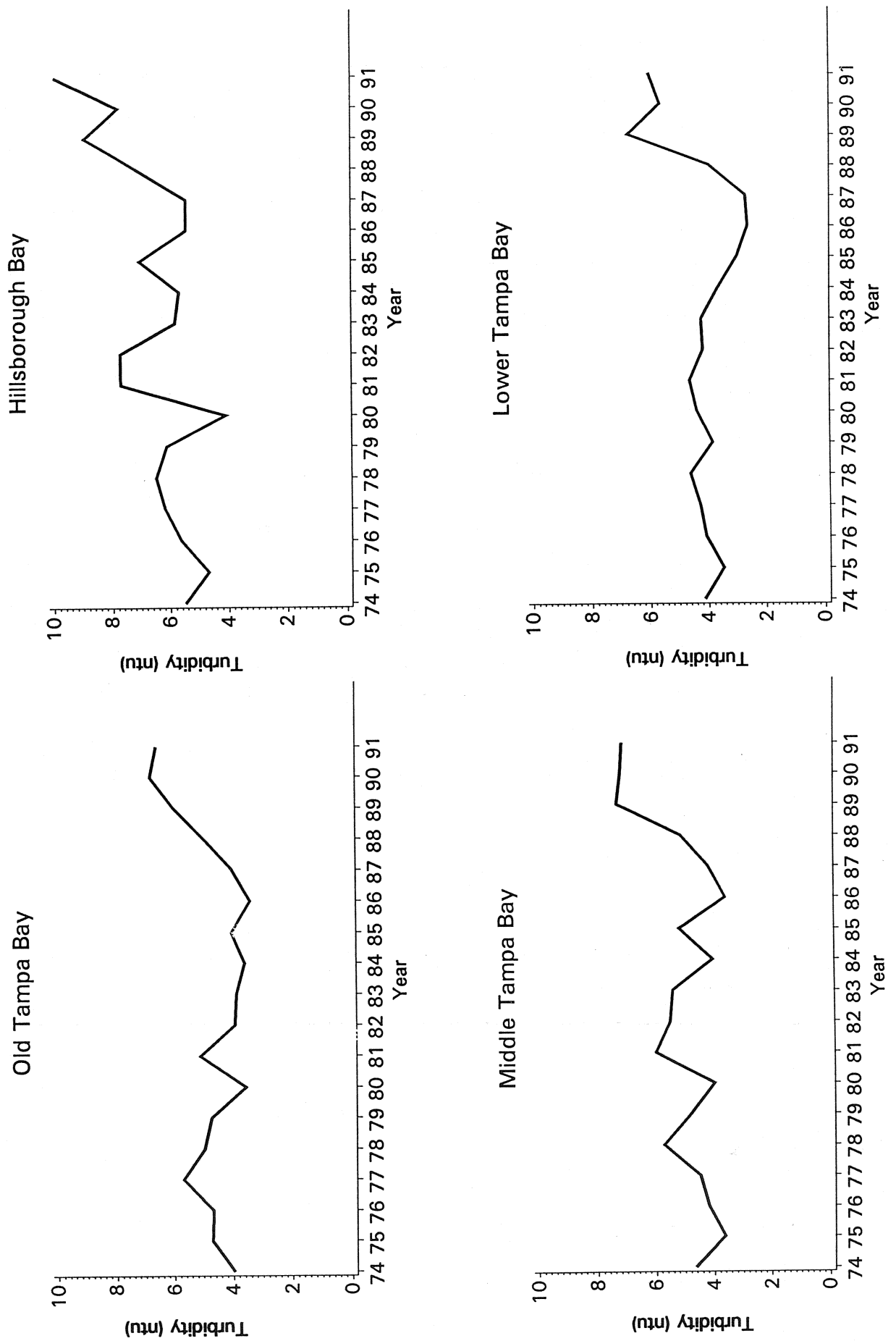
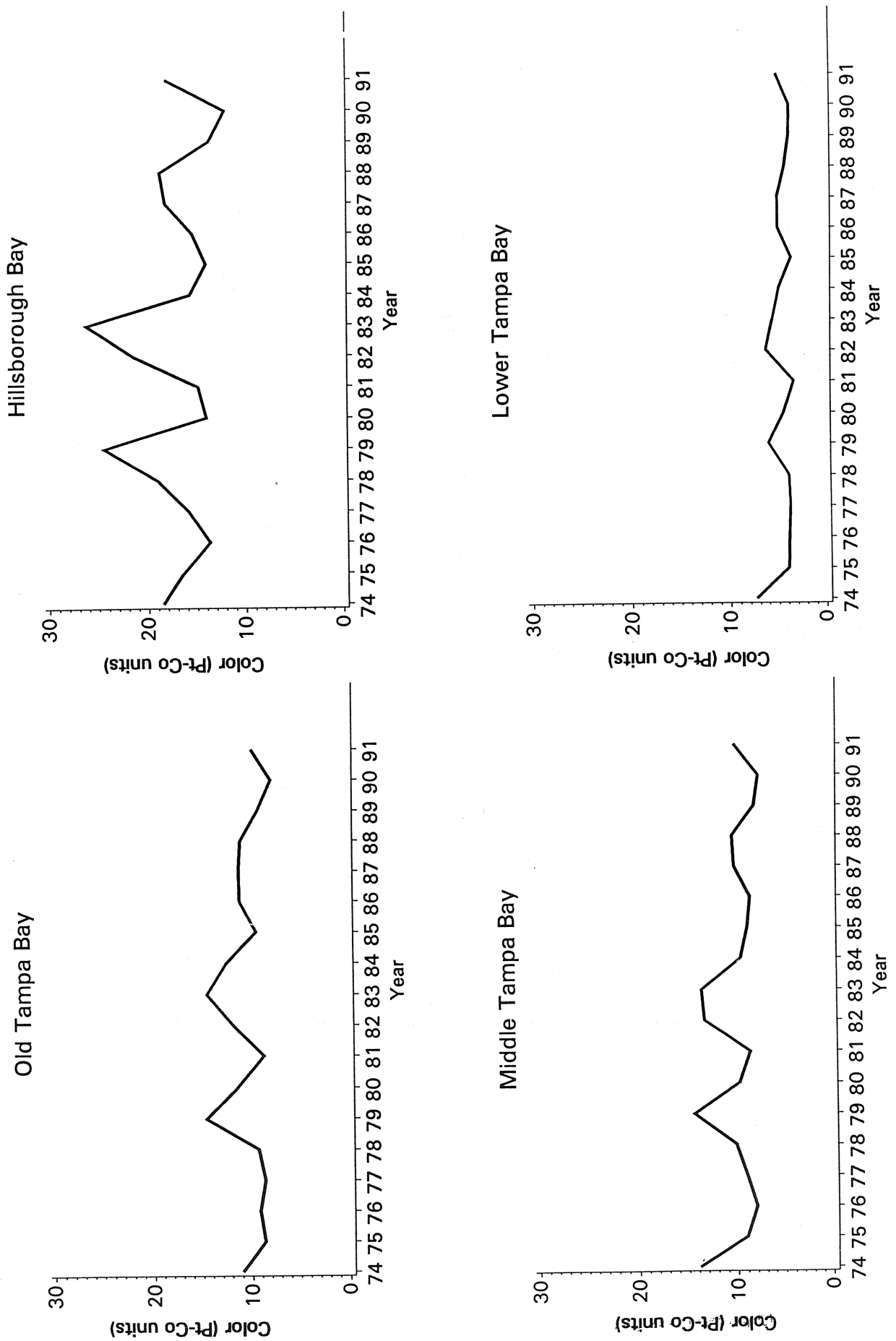


Figure 3-4 Average Annual Turbidity of Tampa Bay Segments, 1974-1991

Figure 3-5

Average Annual Color of Tampa Bay Segments, 1974-1991



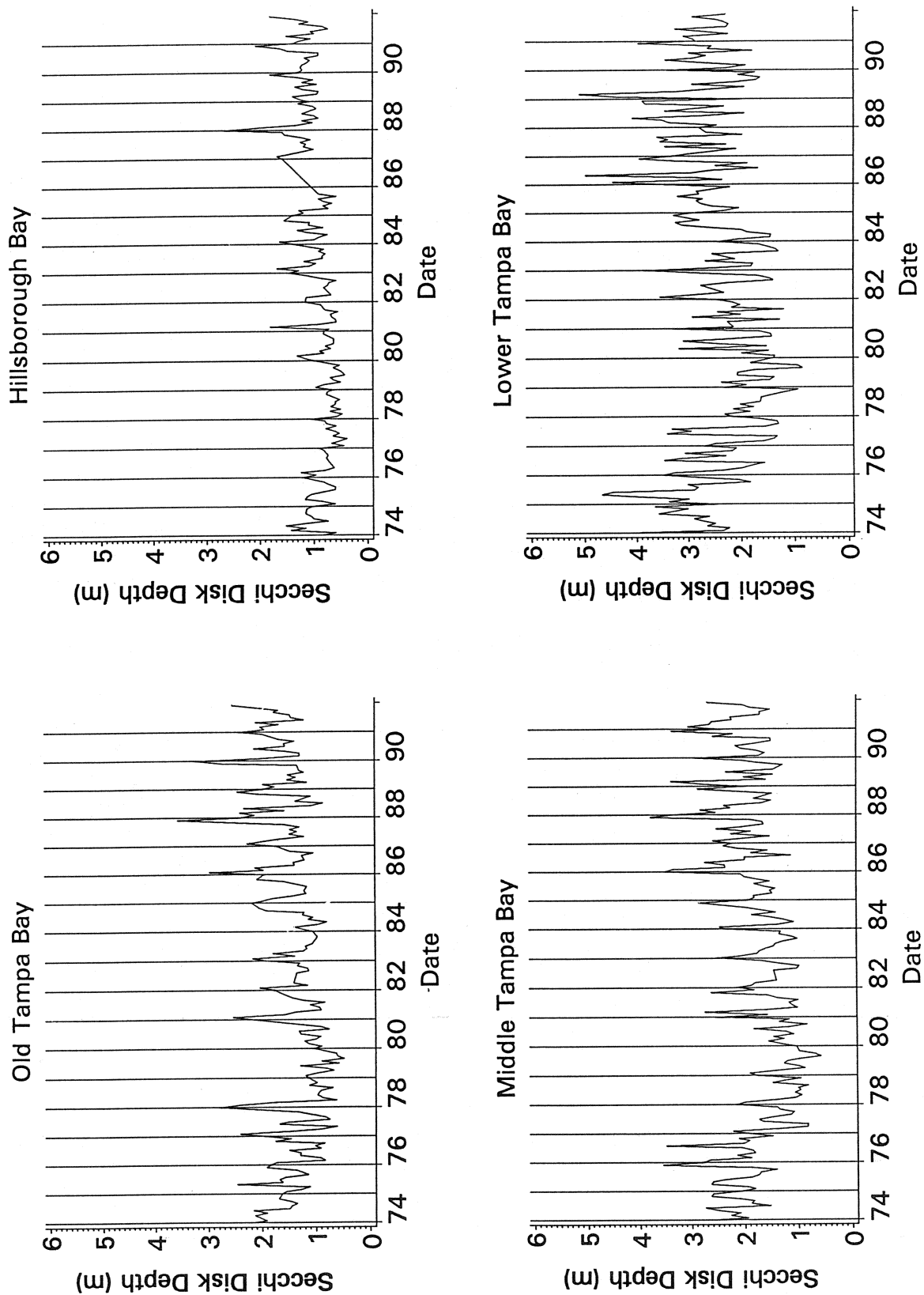


Figure 3-6

Monthly Secchi Disk Depths of Tampa Bay Segments, 1974-1991

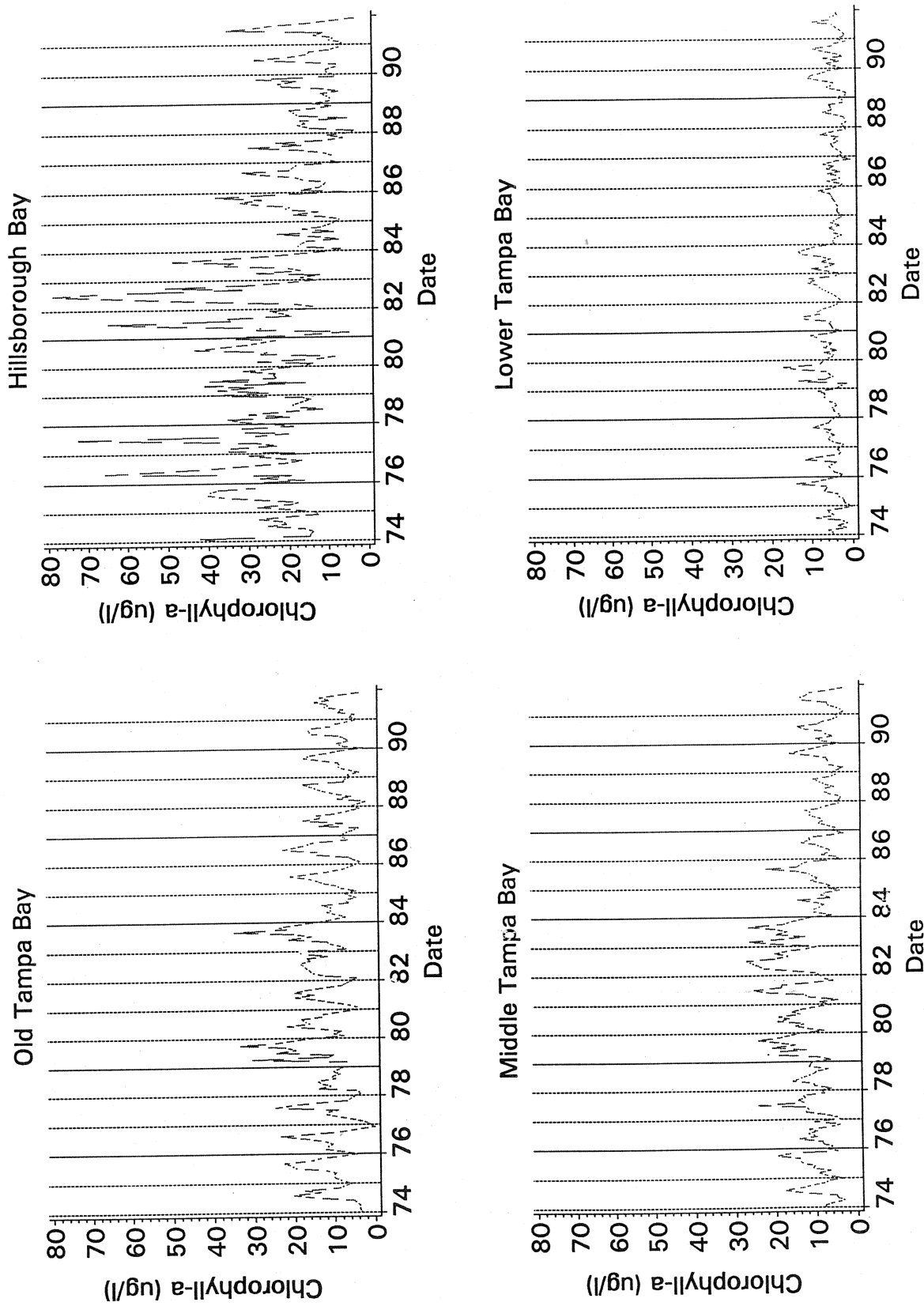


Figure 3-7

Monthly Chlorophyll *a* Concentrations of Tampa Bay Segments,
1974-1991

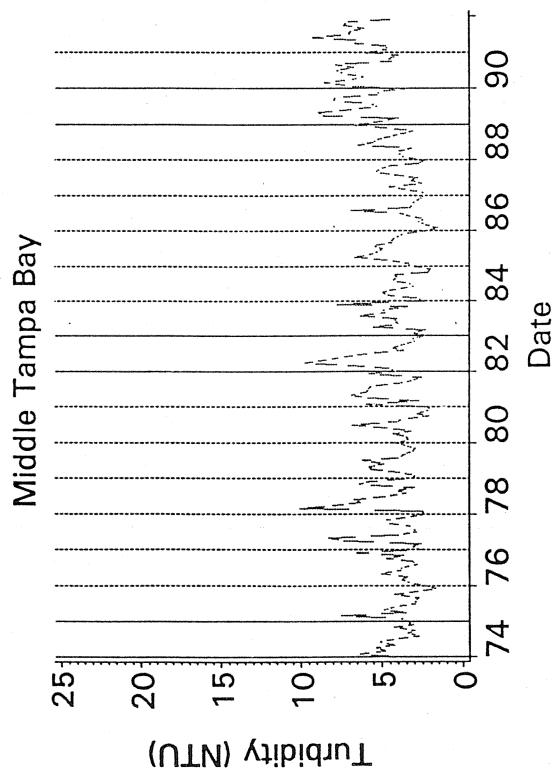
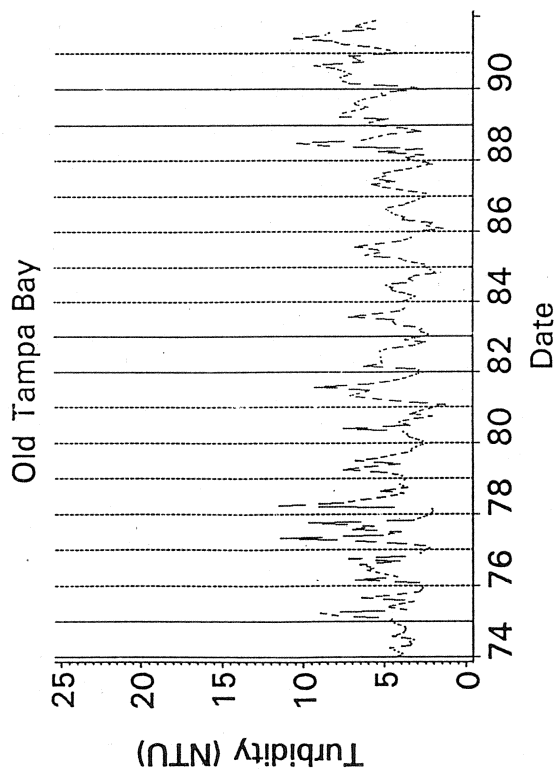
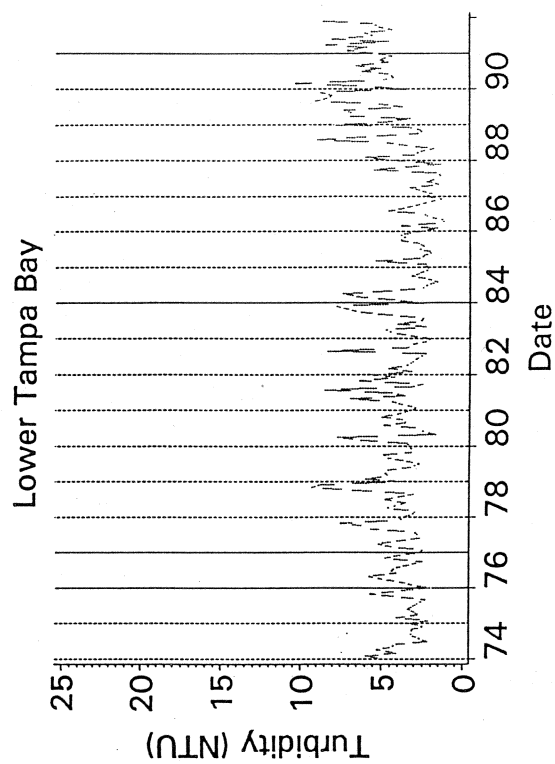
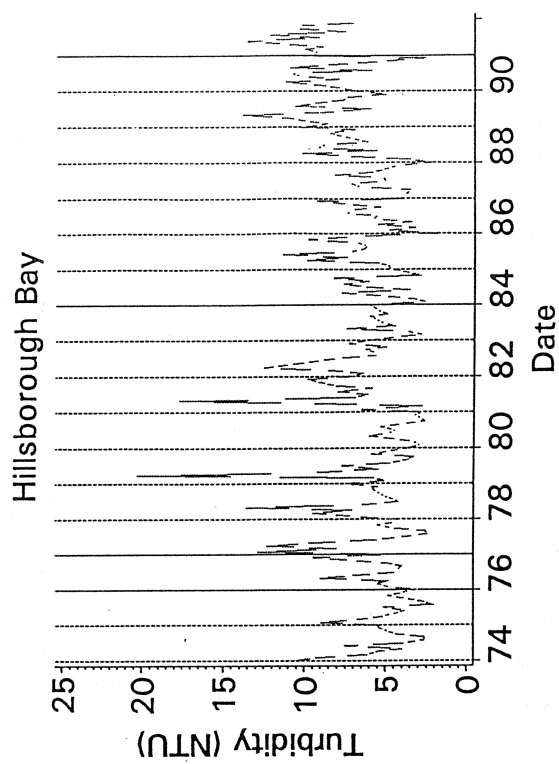


Figure 3-8 Monthly Turbidity of Tampa Bay Segments, 1974-1991

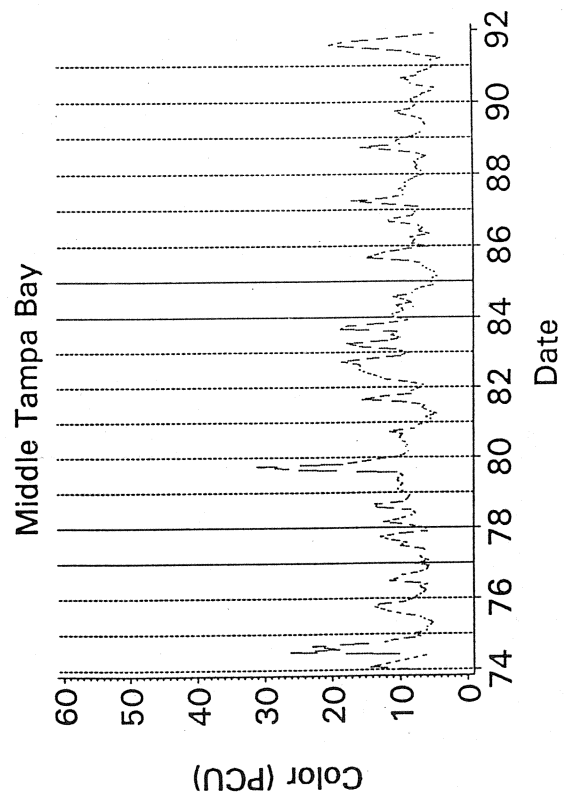
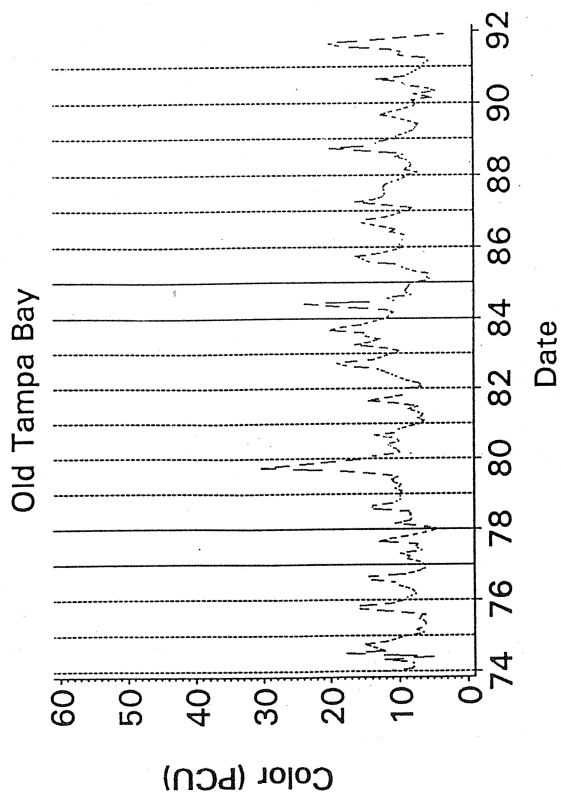
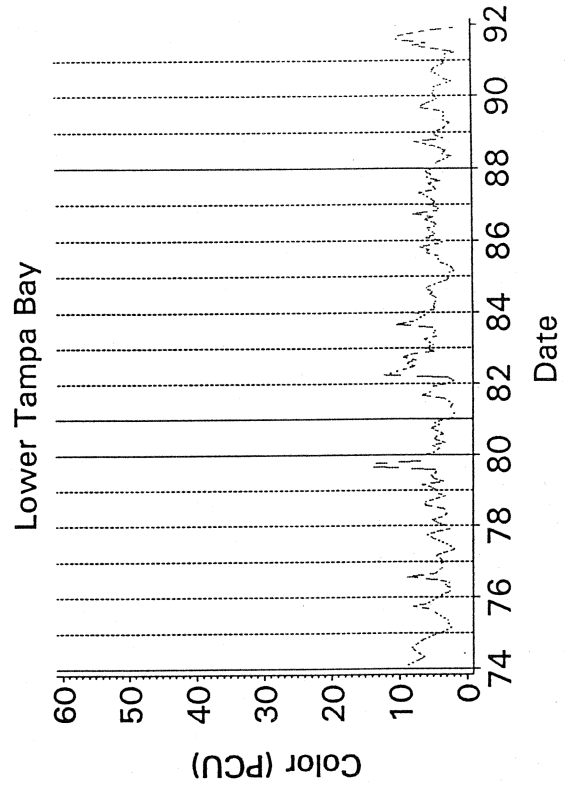
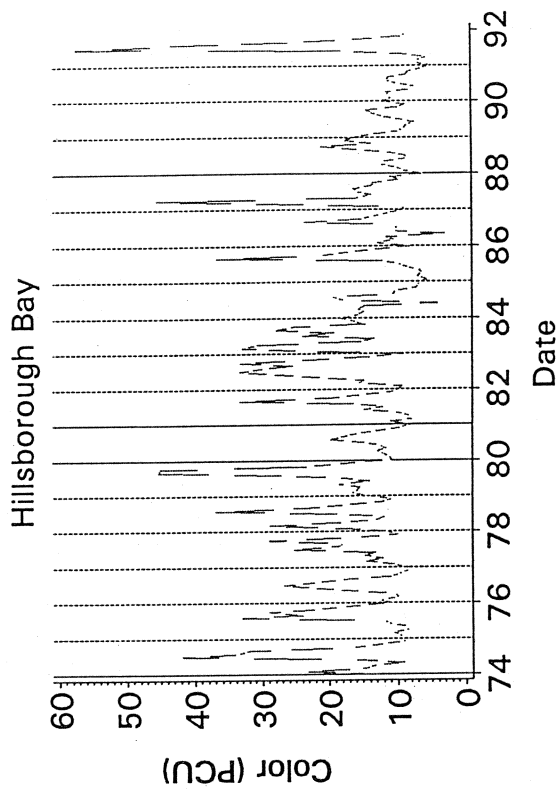


Figure 3-9

Monthly Color of Tampa Bay Segments, 1974-1991

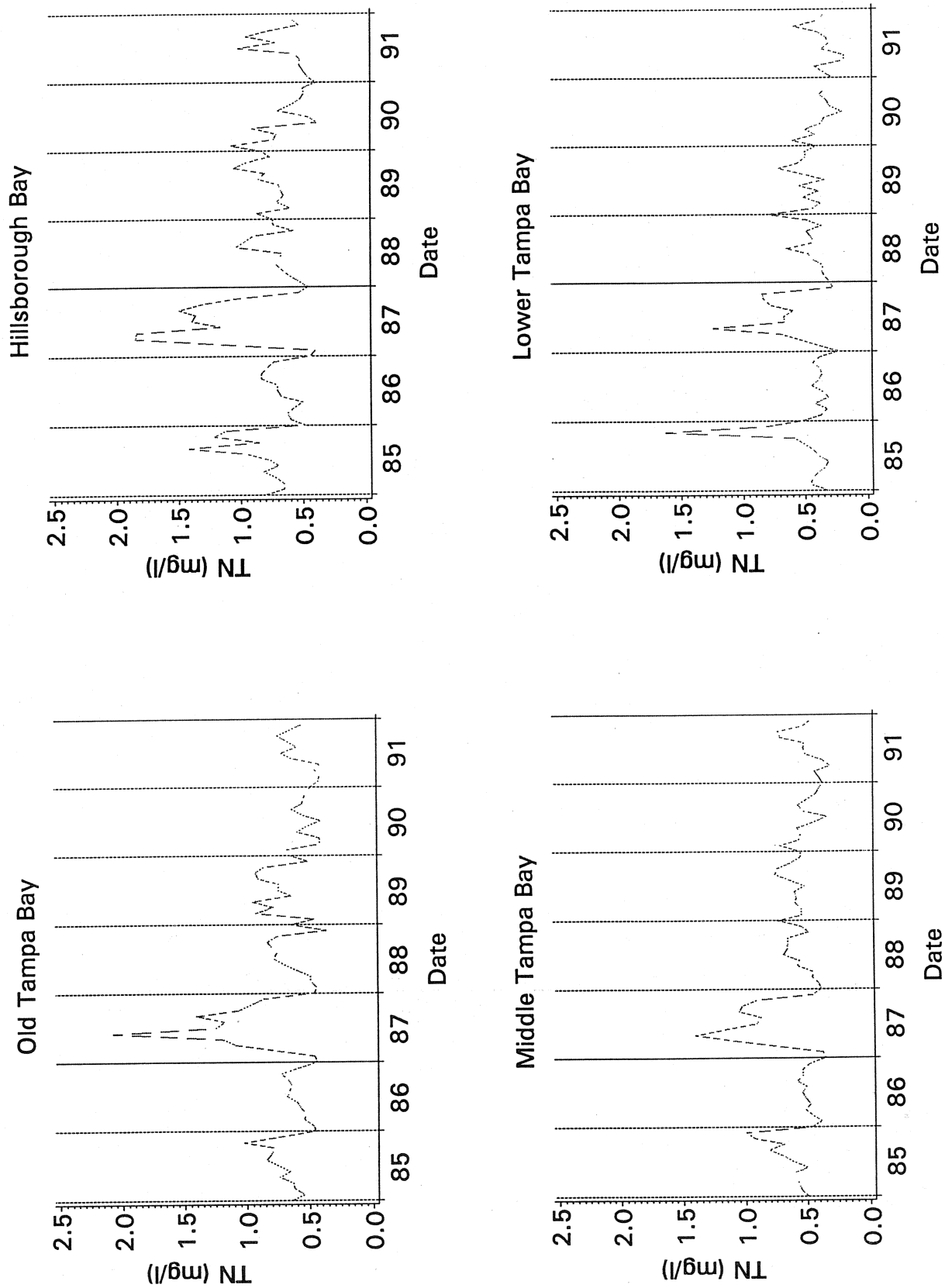


Figure 3-10

Average monthly TN concentrations, 1985-1991.

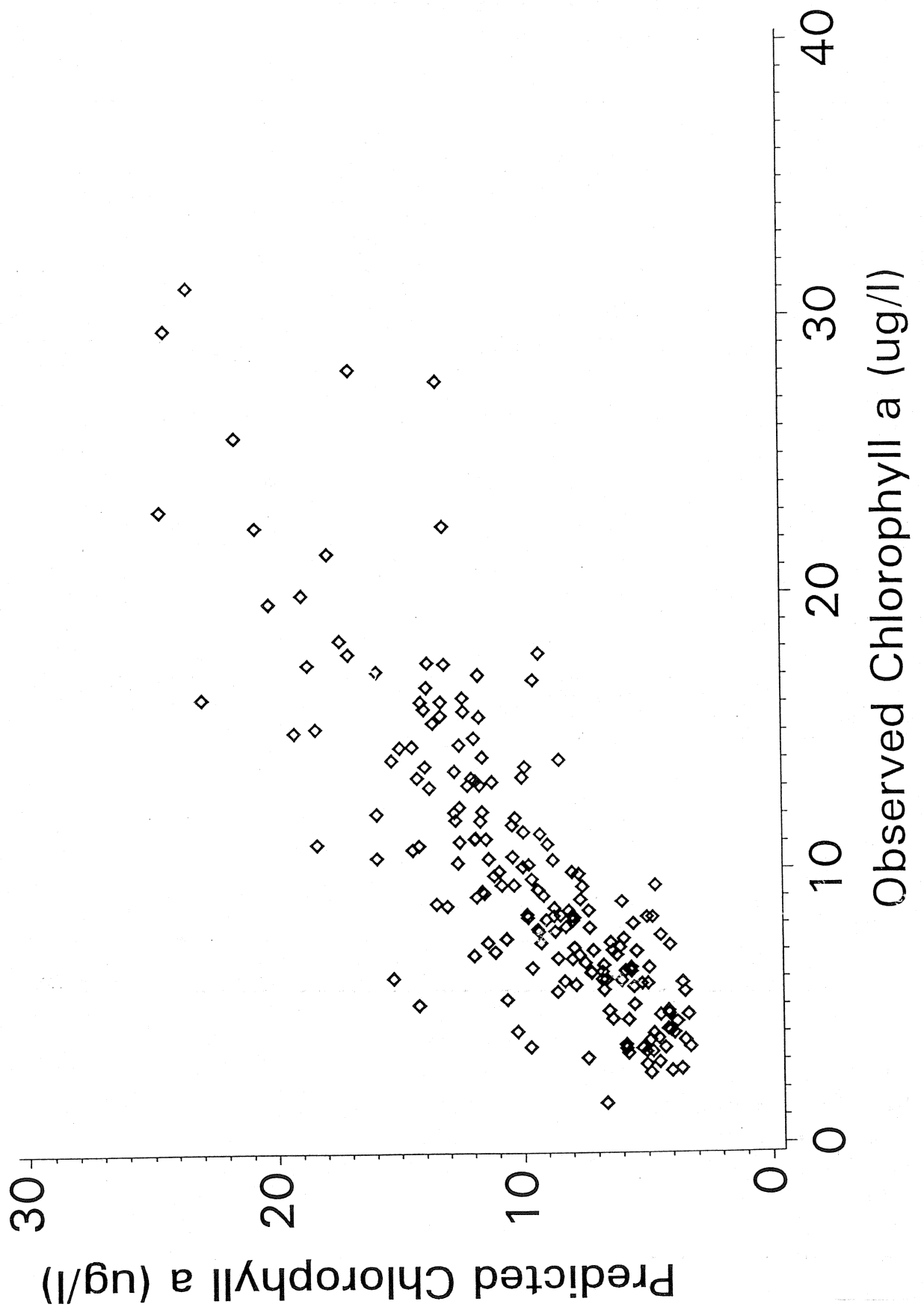


Figure 3-11

Relationship between Predicted and Observed Chlorophyll *a*

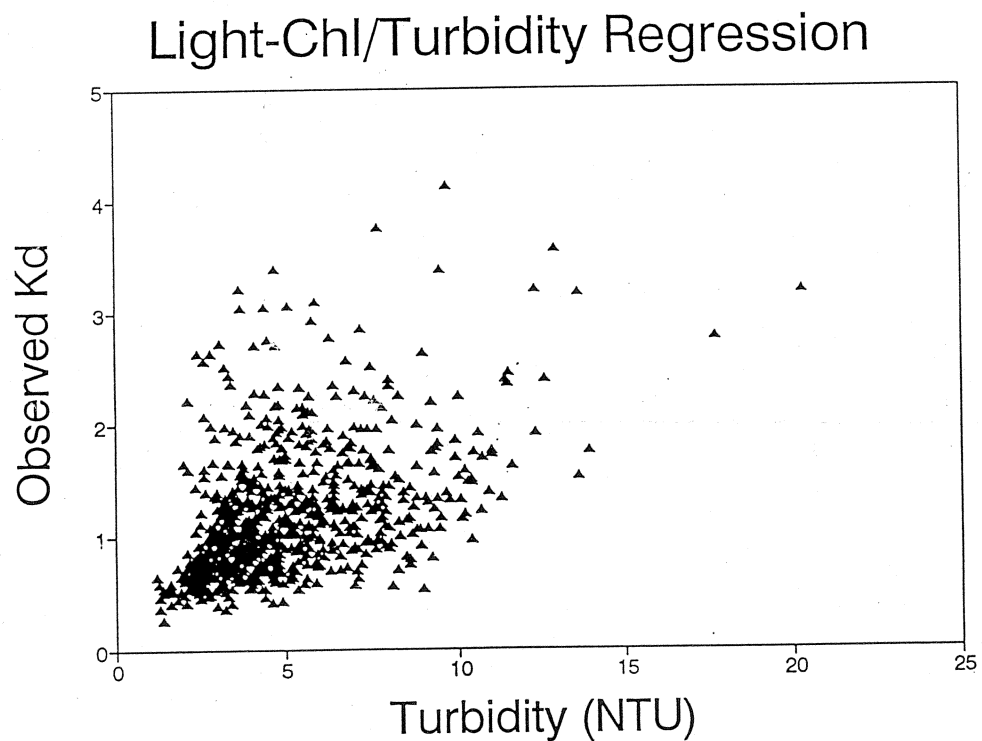
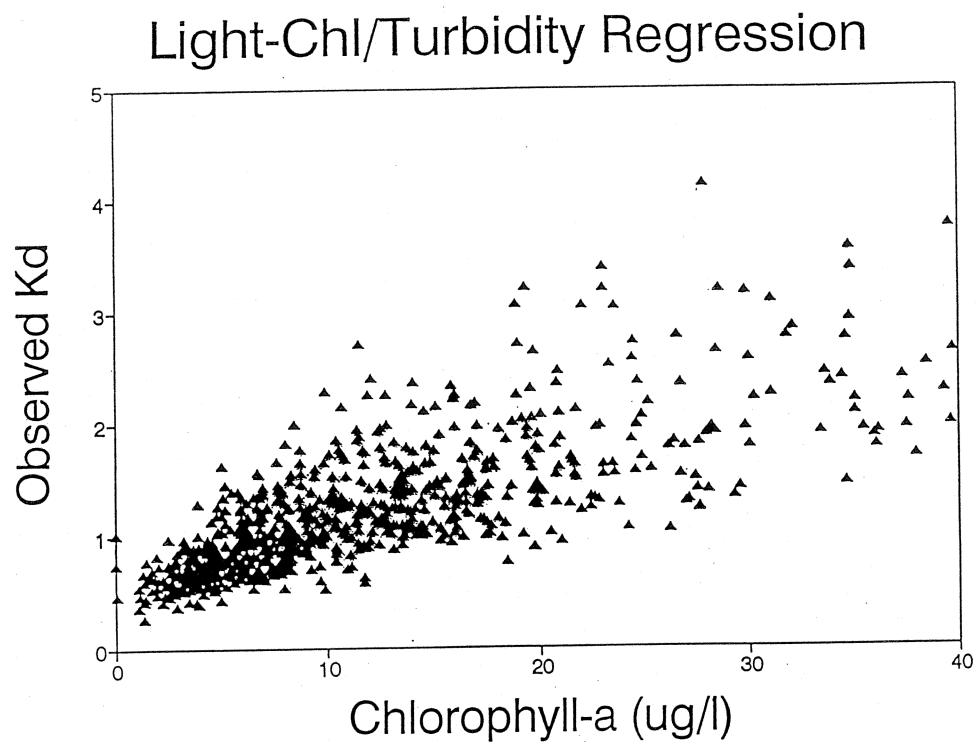


Figure 3-12

Relationship between Chlorophyll *a* and Observed K_d, and between Turbidity and Observed K_d

Light-Chl/Turbidity Regression

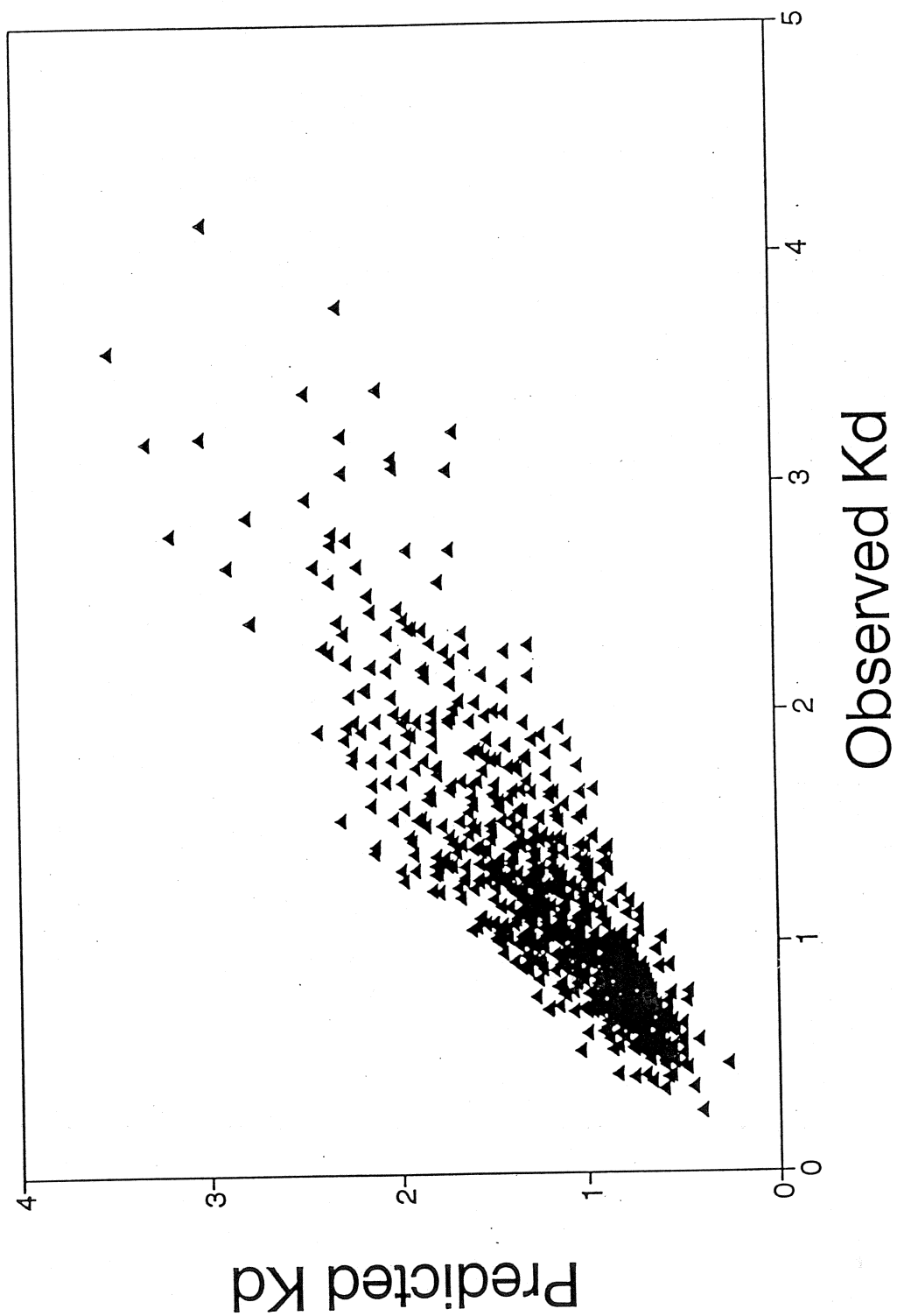


Figure 3-13

Relationship between Predicted and Observed Kd

4.0 PRELIMINARY CONCLUSIONS: APPLICATION OF THE MODELING RESULTS TO THE TARGET SETTING PROCESS

The two goals of this project have been addressed. The available loading and water quality data were used to define the external nutrient loading levels required to maintain and expand seagrass meadows in Tampa Bay, and a flexible tool was developed to allow estimation of nutrient load management targets and evaluation the benefits of alternative nutrient load management strategies. These goals were addressed by using the available data to quantify a two-step relationship between external nitrogen loads and resulting average light conditions at a given depth in the water column on a bay segment and monthly basis.

The preliminary results of this study were used to make conclusions concerning external nitrogen load management targets in the following text. An update of these targets that incorporates additional data from 1992 to 1994 and several model enhancements are presented in Sections 5 and 6. The conclusions from both the preliminary and updated relationships were similar. The available data indicate that, although there is expected to be considerable natural variation in the response of the bay to excess nutrients, maintaining external nitrogen loads at current levels is likely to result in the attainment of average annual targets for subsurface light conditions.

4.1 PRELIMINARY CHLOROPHYLL A TARGETS

The available data and the relationships defined by this study were applied to the process of establishing chlorophyll a targets for Tampa Bay. These average annual chlorophyll a targets were based on the expected subsurface light requirements of seagrasses. A set of working chlorophyll a targets was developed by first considering the average subsurface light levels required at target depths, and then using the water quality and light attenuation relationships to estimate the water quality conditions that would be consistent with these light levels.

The TBNEP TAC recommended specific target depths for which light conditions would be managed for each of the four bay segments of interest. These target depths were chosen based on conservative estimates of the deepest edges of the seagrass meadows that existed during the benchmark ca. 1950 period (Janicki et al., 1994). The deepest edges were visually estimated from segment-wide seagrass maps. The conservative approach to defining target depths was taken to allow a buffer in estimates of required light. Many of these deepest edge areas, particularly in the northern part of Tampa Bay, do not currently support seagrasses. These depths were specified (relative to mean lower low water) as:

- 1.5 meters for Old Tampa Bay,
- 1.0 meters for Hillsborough Bay,
- 1.5 meters for Middle Tampa Bay, and
- 2.0 meters for Lower Tampa Bay.

Thus, each chlorophyll a target was chosen to attain a specified average annual light level at the depth for which seagrasses had historically occurred in that segment.

An important step in setting seagrass-based water quality targets was to determine the average light level required to maintain and expand seagrass meadows at a given depth. The determination of the amount and timing of light required by seagrasses remains an active area of applied research, and the results of recent investigations have been reported in Morris and Tomasko (1993) and Batiuk et al. (1992). It is likely that light requirements vary by seagrass species, season, the physiological condition of individual plants, and other factors such as shading by epiphytic algae living on the seagrass blades. The SWFWMD SWIM Program has undertaken an ongoing study to investigate the light requirements of seagrass meadows specifically within Tampa Bay, and a review of seagrass light requirement literature for various time periods and geographic locations was prepared (Dixon and Leverone, 1993) for the SWIM program. Similar observations concerning the chlorophyll a concentrations and light levels required for SAV growth have recently been reported and reviewed by Giesen et al. (1990), Dennison et al. (1993), and Gallegos (1994). Gallegos reviews these and other studies and reports that SAV growth is generally limited by 20% of incident surface irradiance. The target depths recommended by the TAC for each Tampa Bay segment were the lower limits of observed seagrass distribution (ca 1950) on a bay segment scale. Based on historical maps, the conservative target depth selected for Lower Tampa Bay was 2 meters, and seagrass meadows were observed down to 2 meters in Lower Tampa Bay in both 1950 and 1990 (Janicki et al., 1994). For the five years prior to 1990, the average annual light conditions based on monthly Secchi disk depth observations (EPCHC) indicated that 20% of surface light occurred at a depth of 2.2 meters and 25% of surface light occurred at a depth of 1.9 meters. The TAC Modeling subcommittee has debated the available evidence for average annual requirements for Tampa Bay and other locations. The range of target light requirements discussed by the committee was generally between 20% and 25% of incident light. In order to maintain flexibility with regard to this issue, the chlorophyll a targets have been expressed for a range of target light conditions.

The chlorophyll a targets estimated by applying the results of this study are presented with relevant reference levels in Table 4-1. The first column in this table represents the average chlorophyll levels during the period of very poor water quality in the early

1980's. The next column presents the ABM targets that were established as a response to these poor conditions. The average 1986 to 1991 chlorophyll a concentrations indicate that the ABM targets have been met for each of the four bay segments, and as previously discussed, the SWFWMD SWIM program has reported that seagrass meadows have been expanding in the bay in recent years (T. Reis, 1994). The results of this study were used to estimate chlorophyll a concentrations which would likely result in specific target light levels under current average turbidity conditions on an average annual basis. These chlorophyll concentrations are presented as the final three columns of the table. The chlorophyll a targets for 20% of surface incident light at the bottom have been satisfied in the current time period. Light levels at the target depths of 22.5% to 25% of surface incident light would require further reductions in average annual chlorophyll a concentrations (Table 4.1).

The TBNEP TAC Modeling subcommittee has considered that factors such as species composition, varying seasonal requirements, and epiphyte loading may cause the specific light requirements of seagrasses in Tampa Bay to differ from those observed in other regions. As discussed previously, ongoing SWFWMD and TBNEP investigations and planned monitoring programs are intended to provide answers to these important questions. Preliminary results from the ongoing SWFWMD study which was reported to the TAC Modeling Subcommittee to date have been collected only during times of high water clarity associated with winter dry season conditions, and do not yet represent an average annual value.

Dennison et al. (1993) reported that seagrass beds have been observed in Chesapeake Bay to depths of 1 meter or more where chlorophyll concentrations were less than 15 $\mu\text{g/L}$. Although differences in turbidity, color and other factors between the two study areas make direct comparison difficult, the results of this TBNEP study are similar. The TBNEP results indicate that the average 20% light target is expected to be met at 1 meter below the surface in Hillsborough Bay under average chlorophyll a concentrations of 15.3 $\mu\text{g/L}$.

4.2 PRELIMINARY EXTERNAL NITROGEN LOAD TARGETS

The final step in applying the results of this study to management conclusions was to determine the annual external nitrogen load for each of the four segments based on the chlorophyll a targets and the observed relationships between nitrogen loads and chlorophyll concentrations. Total annual external nitrogen load targets were estimated for the range of target light conditions at the specific target depth for each segment.

The required reduction in chlorophyll a was calculated as the difference between the chlorophyll target and the current average as was presented in Table 4-1. The results indicate that no reduction in average annual chlorophyll a concentrations would be

required for the 20% light level target for the four bay segments. The required reduction in total annual external nitrogen load was computed based on the regression results and the required reduction in chlorophyll a. The reduction is presented in tons per year and as a percentage of the estimated current annual load.

Nixon (1987) employing data from the Chesapeake Bay suggested that current problems of estuarine eutrophication are not due to past enrichment and subsequent release of nutrients from sediments. Rather, the eutrophication problem is more a consequence of current nutrient supply. Thus, management of nutrient loads may lead to more rapid response in water quality than previously predicted. Citing data from Burns et al. (1976) and Burns (1985), Nixon pointed out that despite the fact that over 90% of the total phosphorus entering Lake Erie in 1970 was retained in the lake, a reduction in phosphorus loads of about 50% between 1970 and 1980 was accompanied by a marked decrease in total phosphorus and chlorophyll concentrations.

The management tools and conclusions provided by this study will be applied to the development of bay wide pollution load management plans in support of the development of the Tampa Bay CCMP. For the preliminary model, the external load to each segment was operationally defined as the load from its watershed only, so that management targets could be addressed on a bay segment basis in the development of management plans for the CCMP. An update of the preliminary model which incorporates intersegment transfer of loads and other model enhancements is presented in Section 5, and the nitrogen load targets which result from the enhanced model are presented in Section 6.

5.0 UPDATE AND ENHANCEMENT OF THE PRELIMINARY MODELS

Following completion and TAC review of the preliminary empirical water quality relationships and management targets (Sections 2, 3 and 4), several important updates and enhancements were incorporated into the final relationships and management targets. A chronology of these changes is presented in the following text. Following this chronology, Sections 5.2 through 5.5 present the detailed methods and results for each change made to the preliminary models.

5.1 CHRONOLOGY OF UPDATES AND ENHANCEMENTS TO THE PRELIMINARY MODELS

Initially three updates were made to the empirical relationships:

- the regression parameters were updated using additional water quality and load data from the 1992 through 1994 time period,
- the target depths for seagrass restoration were updated using an analysis of historical depth data, and
- the minimum light requirement for seagrass meadows was updated to 22.5% of surface irradiance using newly available light measurement data from a SWFWMD study conducted by Mote Marine Laboratory (Dixon and Leverone, 1995).

The updated empirical relationships and the results of the Tampa Bay box model (Martin et al., 1996) were presented to the TAC Modeling Subcommittee in July of 1995. During that meeting the TAC identified two potential shortcomings of the modeling efforts. The first shortcoming was that there were questions regarding the calibration of the Tampa Bay box model to the observed chlorophyll data. The second was that the empirical model relationships did not provide enough information to establish nutrient load reduction targets for the Middle Tampa Bay segment. This was because the nitrogen load reductions estimated for Middle Tampa Bay could not be achieved by reducing external loads from runoff from the immediate watershed of Middle Tampa Bay alone. Rather, the nitrogen loads from the adjacent bay segments (e.g., Hillsborough Bay and Old Tampa Bay) would also need to be reduced in order to meet the Middle Tampa Bay target. The TAC concluded, that an attempt should be made to enhance the empirical relationships to provide the additional information needed to establish targets for Middle Tampa Bay.

After several iterations of modeling with regard to the Middle Tampa Bay targets, the following enhancements were made:

- the empirical nutrient load and water quality relationships were changed by adding a series of simple dilution equations to account for the intersegment exchange of water and nitrogen between the bay segments, and
- a regression parameter was estimated to account for all of the nonconservative processes of TN by comparing observed concentrations to the predicted concentrations from the dilution equations.

The results of the enhanced models incorporating intersegment transfer were then presented to the TAC Modeling Technical Subcommittee in November of 1995. During this process, it was determined that the vertical benchmarks used to estimate the depths of the light requirement targets were not the same as those used by the NOAA soundings, and the TBNEP seagrass restoration target GIS database. The TAC modeling subcommittee also discussed the relationship between the EPC Secchi-based light measurements and the irradiance values measured by the Mote study. Lastly, the subcommittee discussed the need for incorporating load reduction time schedules into the target setting process. The TAC concluded that a subgroup should be convened to resolve these issues, and then report back to the subcommittee.

A subgroup was convened to address the issues discussed by the TAC in November, 1995. This subgroup consisted of representatives from the TBNEP Staff, City of Tampa Bay Study Group, SWFWMD SWIM Program, Mote Marine Laboratory, Florida Marine Research Institute, and Coastal Environmental, Inc. The subgroup directed that depths for seagrass restoration targets and light requirements be expressed relative to mean water. Statistical analyses were used to relate the EPC Secchi disk depth measurements to the Mote irradiance measurements recorded on the same day in Lower Tampa Bay. A significant relationship was found (slope significantly different than zero at probability of greater T value < 0.005), and was used to link these data sets for Lower Tampa Bay. However, this relationship yielded spurious results when applied to the very different light regimes of the upper bay segments. The subgroup also determined that consideration should be given to the presence of bottom reflectance at the shallow non-vegetated seagrass meadow edges of the Mote stations and the lack of bottom reflectance at the majority of the deeper EPC stations. For future bay management, average EPC Secchi disk depth measurements will be used as light targets. Thus, it was necessary to express the light requirement targets based on the Mote study on a measurement scale comparable to the EPC data. The light requirement targets were adjusted to the EPC measurement scale by subtracting an estimate of the bottom reflectance. Based on data collected during the Mote study, a bottom reflectance of 2% was used to adjust the light requirement target from

22.5% to 20.5%. The target setting algorithms of the models were also enhanced to allow estimation of the percent of the total seagrass target restored or illuminated to the target light level as a result of a load reduction schedule over time.

In summary, the subgroup directed the following refinements and enhancements to the models:

- Seagrass restoration depth targets and light requirement estimates were expressed using mean water as a vertical reference.
- A baywide light requirement target of 22.5% was chosen based on the results of the Mote study, and adjusted for 2% bottom reflectance to yield a final light requirement of 20.5% to be measured by average EPCHC Secchi disk depths.
- The models were enhanced to allow reporting of percent of the total seagrass target met in response to various management schedules of nitrogen load reductions over time.

The approach and results of each of the changes to the empirical model are presented in the following sections, and the application of these final relationships to the establishment of management targets is presented in Section 6.

5.2 UPDATED DEPTH TARGETS FOR SEAGRASS RESTORATION

The preliminary depth targets for restoration of seagrass meadows were updated by using a GIS analysis to compare the distribution of historical and 1990 seagrass meadows to observed depth soundings data. The preliminary depth targets previously discussed in Section 4 were chosen based on visual examination of historical maps alone, and provided the TBNEP TAC and Management Committee with only a single target depth for each segment. The updated depth targets based on the GIS analysis make best use of all of the available data to present the distribution of depths over which seagrass meadows were lost between 1950 and 1990. Thus, the updated depth targets provide the TBNEP TAC and Management Committee with a more detailed depiction of the estimated restoration targets.

The Middle Tampa Bay segment was subdivided into three subsegments as shown in Figure 5-1. This was done to minimize the high level of heterogeneity in the geographic distribution of seagrass depths and water quality in Middle Tampa Bay. These three subsegments are also similar to those developed for the Tampa Bay box model (Martin et al., 1996), and will facilitate comparisons between the empirical model and the box model.

Seagrass restoration areas were identified using a GIS program as areas where seagrass occurred in 1950, did not occur in 1990, and were not physically altered (e.g., was not excavated or filled). A set of these restoration areas was identified for each bay segment.

A three dimensional surface representing bottom depth at mean low water was constructed for the restoration areas within each segment. This surface was interpolated from NOAA National Ocean Service soundings data measured during the 1947 to 1958 time period. The soundings were initially referenced to a vertical control datum of Gulf Coast Mean Low Water, and to the NAD 1927 horizontal datum. The bottom depths were then adjusted to a datum of mean water to coincide with depths recorded during the SWFWMD seagrass light requirement study conducted by Mote Marine Laboratory (Dixon and Leverone, 1995).

For each bay segment, the seagrass restoration areas were then overlaid on the bottom depth surface, and a GIS program was used to report the number of acres of seagrass restoration target. The seagrass restoration acreage estimates were reported for each 0.1 meter depth interval. The results of these analyses are presented in Section 6.1 in relationship to seagrass restoration targets.

5.3 UPDATED MINIMUM LIGHT LEVEL TARGET FOR SEAGRASS RESTORATION

The preliminary minimum light level targets chosen by the TAC were updated using data recently provided by the Mote study. The methods for this study included sampling the subsurface light climate over a calendar year just outside of the deep edges of seagrass meadows at four locations in Lower Tampa Bay. Site measurements included photosynthetically active radiation, aboveground growth, and light attenuation by epiphytes.

The results of the Mote study indicated that the average annual percentages of light present in the water column was 22.5% of subsurface irradiance at the maximum depth limits of *Thalassia*. This estimate represents attenuation by materials in the water column and reflectance from the bottom at the relatively shallow sites. The deeper water EPCHC Secchi disk depth measurements will ultimately be used to track light targets in the future. Thus, the 22.5% target was adjusted to 20.5% by subtracting a bottom reflectance value of 2%. The 2% bottom reflectance estimate was based on average bottom reflectance values recorded during the Mote study.

The final 20.5% target can be transferred to other areas as management targets using the assumptions:

- that epiphytic growth is comparable between segments, and

- that the light requirements of the other seagrass species are similar to or less than those of *Thalassia*.

This study also reported that the percentage of light penetrating seagrass blades after attenuation by the water column and epiphytes was only 13-14%. This lower percentage would not be an appropriate management target for water clarity alone unless epiphytes were completely absent in all segments of the bay.

5.4 UPDATED MODEL - RELATIONSHIP OF WATER QUALITY TO LIGHT ATTENUATION

The empirical relationship between water quality and light attenuation was updated using additional EPC of Hillsborough County water quality data from the 1992 through 1994 period. It was recognized by the TAC that chlorophyll a is the controllable variable in terms of the bay management working paradigm (i.e., control of nitrogen inputs will control chlorophyll a, and chlorophyll a will then affect light attenuation). Thus, a predictive regression model was developed in terms of light and chlorophyll alone. This simpler regression model was expressed in a functional form of Beers' Law that is different from that used in the preliminary mode but is mathematically equivalent. This alternate functional form was used to provide a better fit to the observed water quality data.

Least squares regression methods were used to estimate parameters for the equation:

$$\ln(C_{t,s}) = \alpha_{t,s} + \beta_s \ln(Z_{t,s}),$$

where $Z_{t,s}$ = the depth to which 20.5% of surface irradiance penetrates at month t and bay segment s,

$C_{t,s}$ = average chlorophyll a concentration at month t and bay segment s, and

$\alpha_{t,s}$ and β_s = regression parameters.

Results of the regressions indicated that the variation in the observed depths to which 20.5% of surface light penetrates could be explained by the variation in observed

chlorophyll a concentrations. Monthly specific regression intercept terms were used to avoid any potentially confounding effects of seasonality in the independent and dependent variables. Turbidity data were also investigated as a possible explanation for a portion of the remaining unexplained variation in the light penetration data. No additional relationships were found. Regression diagnostics and plots of the residuals versus turbidity are presented in Appendix C. An R^2 value of 0.67 was obtained for the simple regression model using the monthly Tampa Bay data. Plots of observed and predicted responses are presented by bay segment are presented in Appendix C.

5.5 UPDATED MODEL - RELATIONSHIP OF NUTRIENT LOADS TO CHLOROPHYLL

The empirically estimated relationships between nitrogen loads and chlorophyll concentrations were updated using the additional 1992-1994 data. As previously discussed, the TAC directed that an attempt also be made to enhance the empirical relationships by accounting for the net movement of water and nitrogen between the segments. This was accomplished using the following steps:

- Step 1) A series of simple dilution equations were written for the segments of Tampa Bay and fit to the observed salinity and freshwater inflow data.
- Step 2) The dilution equations were used to predict nitrogen concentrations, and a regression parameter was then used to relate the observed and predicted nitrogen concentrations to account for the net of all nonconservative processes of nitrogen (e.g., sediment uptake or release).
- Step 3) Estimated total nitrogen loads from both external loads and intersegment transport were then related to observed chlorophyll concentrations using a regression model.

The approach and results of each of these three steps are presented in the following sections, and the application of these updated relationships to the establishment of management targets is presented in Section 6.

5.5.1 ESTIMATION OF INTERSEGMENT TRANSPORT OF NUTRIENTS BASED ON OBSERVED SALINITY AND FRESHWATER INFLOW DATA

A series of simple dilution equations was written for the segments of Tampa Bay and fit to the observed salinity data and freshwater inflow data. For example, the equation for the Old Tampa Bay segment was written as:

$$0 = W_o - Q_o C_o + E_{o,b} (C_b - C_o)$$

- where
- W_o = the external load of a dissolved substance to Old Tampa Bay from its watershed (kg/month),
 - Q_o = the freshwater inflow rate to Old Tampa Bay from its watershed (m³/month),
 - C_o = the concentration of a dissolved substance in Old Tampa Bay (kg/m³),
 - C_b = the concentration of a dissolved substance in the adjacent subsegment of Middle Tampa Bay (kg/m³), and
 - $E_{o,b}$ = a transfer coefficient from Old Tampa Bay to the adjacent subsegment B of Middle Tampa Bay (m³/month).

A dilution equation was written in this manner for each of the five modeled segments (Old Tampa Bay, Hillsborough Bay, and the three subsegments of Middle Tampa Bay). The complete set of equations is documented in Appendix D.

To estimate the average net transfer of water and dissolved substances between the five bay segments, the system of equations was first solved using salt as a conservative dissolved substance. The word "conservative" refers to the fact that salt is expected to be freely transported among the five bay segments, and there are not expected to be any significant sources or sinks of salt (other than the Gulf water at the lower boundary of the estuary). The lower boundary segment for this model was defined as the TBNEP Lower Tampa Bay segment.

Using salt as a conservative substance, the only term in each equation which remains unknown is the E value. Using the Old Tampa Bay example:

- W_o the input of dissolved salt from the watershed was assumed to be approximately zero relative to the high concentrations in the estuary,

Q_o = the freshwater inflow rate to Old Tampa Bay was estimated in the 1986-1994 loading data (m³/month),

C_o = the concentration of dissolved salt in Old Tampa Bay was observed as salinity, and

C_b = the concentration of dissolved salt in the adjacent subsegment of Middle Tampa Bay was observed as salinity.

Because there were five dilution equations (one for each segment) and five unknown E values, the system of equations could be solved for each of the E values (Appendix D) and fit using the observed salinity and freshwater inflow data. A seasonal signal of higher E values from June to September was observed in the data for the lower portions of the bay, and hence, a median E value was calculated by two seasons for each segment. The dry season was defined as October through May, and the wet season was defined as June through September to match the observed changes in the E values.

The median E values were estimated as follows:

	Dry Season E value	Wet Season E value
Eob	327,025,037	591,657,444
Eha	1,220,277,920	1,397,496,965
Eab	1,588,326,116	3,722,054,907
Ebc	1,326,144,178	2,327,235,382
Ecl	849,883,073	2,212,927,643

where o = Old Tampa Bay,
 h = Hillsborough Bay,
 a = Middle Tampa Bay 31,
 b = Middle Tampa Bay 32,
 c = Middle Tampa Bay 33, and
 l = Lower Tampa Bay.

A 1986 to 1994 monthly time series of predicted salinities was then estimated using the median E values and observed boundary salinities in Lower Tampa Bay. This was done to examine the fit of the E values to the observed salinity and freshwater inflow data. The predicted monthly salinity data fit the observed data well for the five segments using the 10 estimated E value parameters (overall $R^2 = 0.71$). The worst fit was obtained for low observed salinities in Middle Tampa Bay during the dry season. However, as will be presented in the next section, the predicted nitrogen

concentration data for this segment fit the observed data well. A series of predicted and observed salinity plots for each segment is presented in Appendix D.

5.5.2 ADJUSTMENT FOR NONCONSERVATIVE PROPERTIES OF NITROGEN

The dilution equations and estimated E values were then used to predict monthly nitrogen concentrations. First, the system of equations was solved for the nitrogen concentration parameter for each segment (Appendix D). Nitrogen concentrations were then estimated for each month and bay segment based on the estimated E values, the freshwater inflows (Q), the external nitrogen loads (W), and the concentration of nitrogen at the boundary condition in Lower Tampa Bay (CI).

Because nitrogen is not likely to be a conservative substance in the estuary, regression parameters were estimated for each bay segment to relate the observed and predicted nitrogen concentrations. Thus, these regression parameters can be used to account for the net of all nonconservative processes of nitrogen (e.g., sediment uptake or release, internal biological cycling).

Least squares regression methods were used to estimate parameters for the equation:

$$N_{t,s} = \beta_{t,s} \hat{N}_{t,s}$$

where	$N_{t,s} =$	the observed nitrogen concentration in month t and bay segment s,
	$\hat{N}_{t,s} =$	the nitrogen concentration predicted by the simple dilution model in month t and bay segment s, and
	$\beta_{t,s} =$	a regression parameter.

Results of the regression indicated that the variation in the observed nitrogen concentrations could be explained by the variation in the nitrogen concentrations predicted by the dilution model. An R^2 value of 0.68 was obtained for this regression model using the monthly Tampa Bay data. The parameter estimates and plots of observed and predicted responses are presented by bay segment Appendix D. The degree of the adjustment for nonconservative processes varied monthly and typically fell within plus or minus 5% to 20%. In terms of a net annual value, the parameter

estimates were 1.09 for Old Tampa Bay, 1.08 for Hillsborough Bay, 1.02 for Middle Tampa Bay-31, 0.95 for Middle Tampa Bay-32, and 0.96 for Middle Tampa Bay-33. Thus, over the course of a year there was an estimated 8 to 9 percent of additional nitrogen in Old Tampa Bay and Hillsborough Bay than could be explained by the external loads and intersegment transfers alone.

The loading and intersegment transport model was enhanced to allow estimation of load reductions over time. The model can be initialized with current 1992 to 1994 in-bay nitrogen concentrations, and can then be given monthly specific or annual external nitrogen load reduction schedules. The nitrogen concentration results from each month's estimation are then used for the next month's starting values in an iterative fashion.

The final set of calibrated dilution equations will allow the TBNEP to compute total nitrogen loads to each bay segment (including intersegment transport) for a variety of alternate management scenarios and load reduction schedules. As described in the next section, these total nitrogen loads were then used to update the nitrogen load to chlorophyll concentrations so that responses in water quality could also be modeled.

5.5.3 RELATIONSHIP OF NITROGEN LOAD TO CHLOROPHYLL

The relationship of nitrogen loads to chlorophyll concentrations was updated using the additional 1992 to 1994 loading data and water quality data, and the enhanced load model with intersegment transport components. The estimated total nitrogen loads were related to observed chlorophyll concentrations using the regression model.

$$C_{t,s} = \alpha_{t,s} + \beta_s L_{t,s}$$

where $C_{t,s}$ = average chlorophyll a concentration at month t and segment s,

$L_{t,s}$ = total nitrogen load at month t and segment s,

$\alpha_{t,s}$ and β_s = regression parameters.

An overall R^2 value of 0.69 was obtained using this relationship. The total nitrogen load (i.e., from both internal and external sources and nonconservative processes) was used to develop a simpler regression model than the preliminary model. This simpler model without the additional lag loading term is more desirable for predictive use since it is more robust to parameter prediction error. It is likely that the lag term in the preliminary model was accounting for a portion of the intersegment transport and/or

nonconservative processes of nitrogen in the estuary. Regression results, parameter estimates, and diagnostic information are presented within Appendix D.

TAMPA BAY SEGMENTS

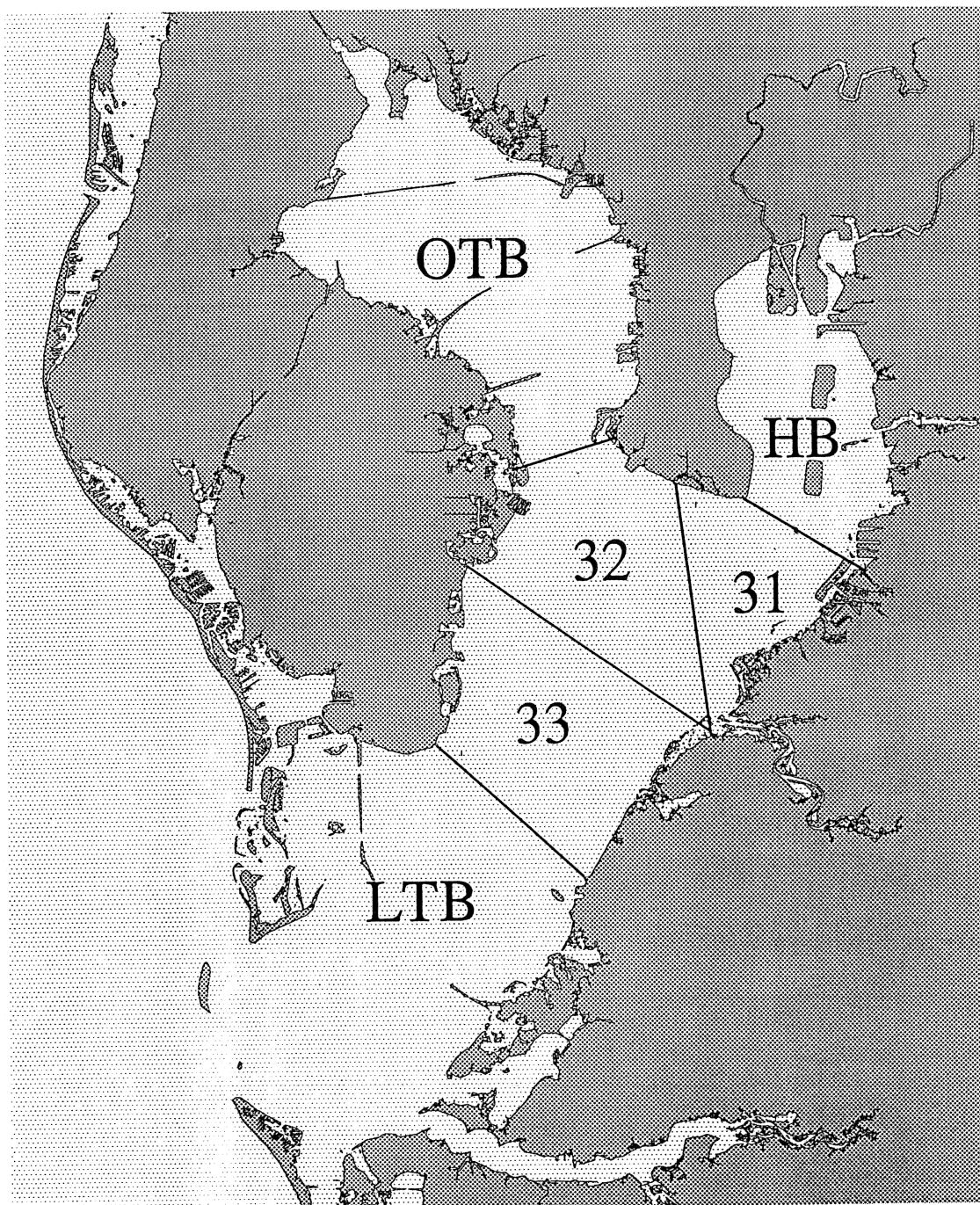


Figure 5-1 Enhanced segment definitions for the Tampa Bay empirical model. Middle Tampa Bay was subdivided based on seagrass depth distributions and water quality.

6.0 APPLICATION OF THE UPDATED AND ENHANCED EMPIRICAL MODELS TO THE ESTABLISHMENT OF NUTRIENT LOAD MANAGEMENT TARGETS

Each of the individual components of the TBNEP empirical model was developed to give the Management Committee flexible tools for choosing nutrient load management targets. The relationships between nitrogen loads, chlorophyll concentrations, light environments, and seagrass restoration acreages were all linked so that a wide variety of nutrient load management scenarios could be considered. Specific management targets are not recommended by this study. Rather, reasonable ranges of management targets are presented, so that the members of the management committee can deliberate and select the most desirable targets for implementation in conjunction with the CCMP. For illustrative purposes, a "Hold the Line" nitrogen load scenario and several nitrogen load reduction scenarios are presented in this section.

6.1 DEPTH TARGETS

The depth targets are presented in the form of cumulative frequency curves for each bay segment (Figures 6-1 through 6-3). The x-axis of these plots indicates a range of depths which could be chosen as the desired deepest point in the bay segment to receive an annual average 20.5% of surface light. For each potential depth target chosen on the x-axis, the left y-axis indicates the corresponding percent of the total seagrass restoration area in that segment that would be illuminated with 20.5% of surface light. The right y-axis indicates the corresponding acres of seagrass restoration area. Seagrass restoration areas are defined as those areas of Tampa Bay where seagrasses were present in 1950, were absent in 1990, and have not been physically altered (e.g., excavated or filled).

6.2 LIGHT LEVEL TARGET

As discussed in Section 5 the subgroup of the TAC subcommittee has recommended a minimum light level target of 20.5% of surface light for seagrass restoration. This is believed to be a conservative estimate of the light required by seagrass meadows in Tampa Bay. This target was based on the best available data collected to date in the bay. However, all of the TBNEP empirical models have been developed in a flexible format, and the light level target may be easily updated as new data become available.

6.3 EXAMPLE CHLOROPHYLL CONCENTRATIONS AND PREDICTED ILLUMINATION OF RESTORATION TARGETS

The TBNEP TAC and Management Committees may choose to use the modeling tools described in this report to establish water quality targets which would provide average illumination of the seagrass restoration target areas at the target light level of 20.5 % of surface illumination. As an illustrative example, Table 6-1 presents chlorophyll values for several example target illumination conditions.

6.4 PREDICTED CHLOROPHYLL RESPONSES TO EXAMPLE NITROGEN LOAD REDUCTIONS

Empirical relationships were developed between total nitrogen load and average chlorophyll concentration. The nitrogen loads used to develop these relationships included both external loads and loads from intersegment transport. Hence, a chlorophyll response may be estimated for any particular combination of external loads from the watersheds of Old Tampa Bay, Hillsborough Bay, and the three subsegments of Middle Tampa Bay.

For illustrative purposes, chlorophyll responses to five nitrogen load management schedules after 15 years and after 30 years are presented in Figure 6-4. The chlorophyll responses at the end of each fifteen year scenario were summarized across the five segments by computing average values weighted by the area of seagrass restoration potential in each of the segments. The nitrogen load schedules include:

- a "Hold the Line" strategy, where the external nitrogen loads were held constant at 1992 to 1994 average levels for fifteen years; and
- four net load reduction scenarios, where the external nitrogen loads were reduced by a stated percentage each year for fifteen years.

The net load reductions for the latter four scenarios were compounded annually. Therefore, in each year the loads from the preceding year were reduced by the stated percentage. The 1992-1994 average chlorophyll value reference line shown in Figure 6-4 indicates that if external nitrogen loads were held constant at the levels estimated in 1992-1994, then the long-term average chlorophyll for the fifteen year period is expected to be slightly higher than that observed in 1992-1994. Additional examples by bay segment are presented in Figure 6-7.

As discussed in the preceding methods sections, a nitrogen load model was not developed for Lower Tampa Bay. For illustrative purposes, the "Hold the Line" nitrogen load management strategy could be applied to Lower Tampa Bay by setting a "Hold the Line" chlorophyll target using the 1992-1994 average chlorophyll. The average chlorophyll was 4.6 ug/L.

6.5 PREDICTED SEAGRASS TARGET RESPONSES TO EXAMPLE NITROGEN LOAD REDUCTIONS

Empirical relationships were developed between average chlorophyll concentration and the average depth to which 20.5% of surface light penetrates as measured by the EPC Secchi data. The depths were referenced to mean water. The depths of 20.5% light penetration were then used in conjunction with the seagrass restoration target depths to compute the seagrass target responses for the five example load management scenarios. The seagrass target response to each load scenario was defined as the total area that was either seagrass in 1990 or would be illuminated by an average 20.5% of surface light at the end of the fifteen year period of that scenario.

For illustrative purposes, chlorophyll responses to five nitrogen load management schedules after 15 years and after 30 years are presented as acres (rounded to the nearest 50 acres) in Figure 6-5 and as a percentage of the total seagrass target in Figure 6-6. The seagrass target responses at the end of each fifteen year scenario were summarized across the five segments by adding the total seagrass target response areas of each segment. Additional examples by bay segment are presented in Figure 6-8 and 6-9.

A seagrass target response was estimated for Lower Tampa Bay by assuming the "Hold the Line" chlorophyll target using the 1992-1994 average chlorophyll value of 4.6 ug/L. Under this assumption, an estimated 97.3% of the total seagrass target would be met for Lower Tampa Bay.

6.6 THE CONSERVATIVE NATURE OF THE TARGET SETTING APPROACH AND IMPLICIT MARGIN OF SAFETY.

The year to year natural variabilities in the weather, human activities, hydrology, and ecological processes of Tampa Bay are reflected in the uncertainties identified by the statistical models. Due to these natural variabilities, it may be desirable to establish a margin of safety with regards to nitrogen load management goals in order to ensure the successful restoration of seagrasses.

The TBNEP has been cognizant of these natural variabilities, and throughout the model development process an implicit margin of safety has been built into the model methods by selecting a number of conservative assumptions. These conservative assumptions include:

- The minimum seagrass light level target of 20.5% of surface irradiance at mean water for *Thalassia* is believed to be a conservative estimate of the average light required by seagrass meadows of all species in Tampa Bay.
- In the Mote Marine Laboratory seagrass study (Dixon et al., 1996), the mean and median minimum light levels at the edge of seagrass meadows were 22.5% and 18.5% respectively. The more conservative value of 22.5% adjusted to 20.5% to account for bottom reflectance was used in the models.
- There was an unexplained additional source of approximately 8 to 9 percent of nitrogen per year measured in Old Tampa Bay and Hillsborough Bay for the current time period (Section 5.2.2 Adjustment for Non-conservative Properties of Nitrogen). The prediction methods of the model assume that this source will continue in the future.
- No future nitrogen losses to bay sediments were incorporated in the model.
- The likely future recovery of recently-protected shallow seagrass meadows currently damaged by propeller scars and other anthropogenic activities was not accounted for.

In addition the nitrogen load management and habitat restoration plans being developed by the TBNEP will include important provisions for periodic monitoring and review of the status of water quality and seagrass restoration. This will allow model updates and refinements as new data become available, and will ensure that the bay continues to respond as desired.

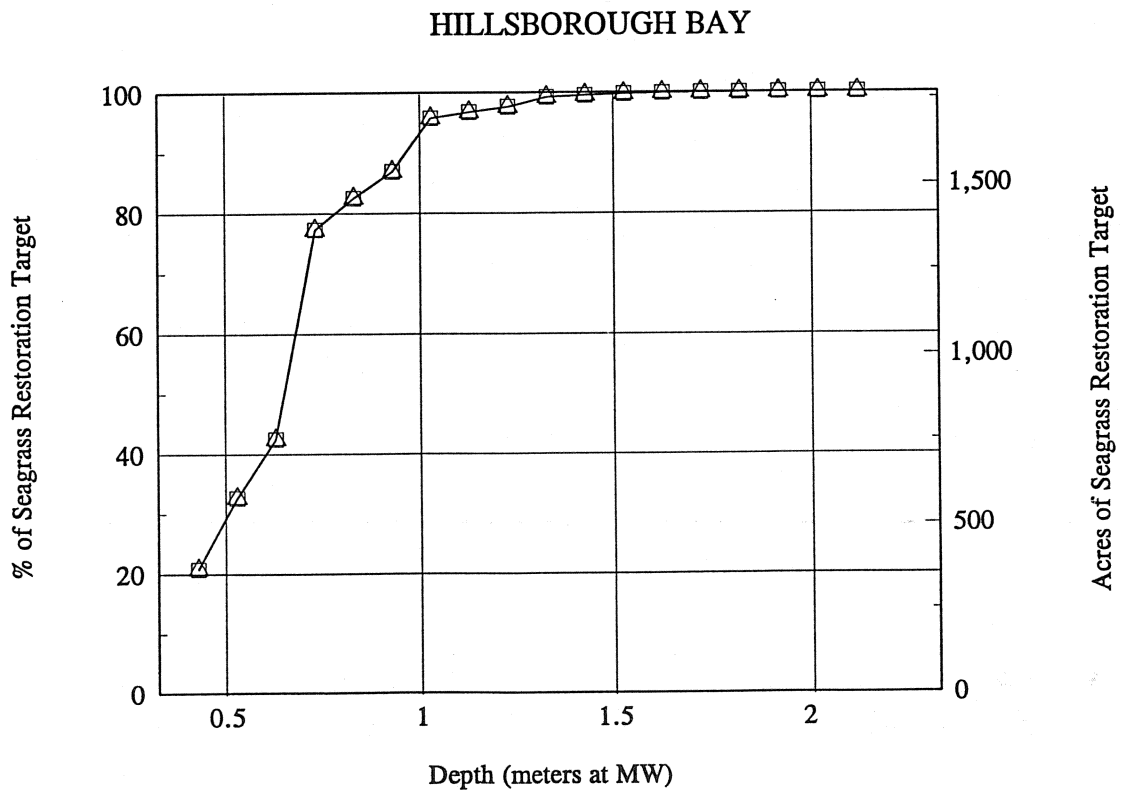
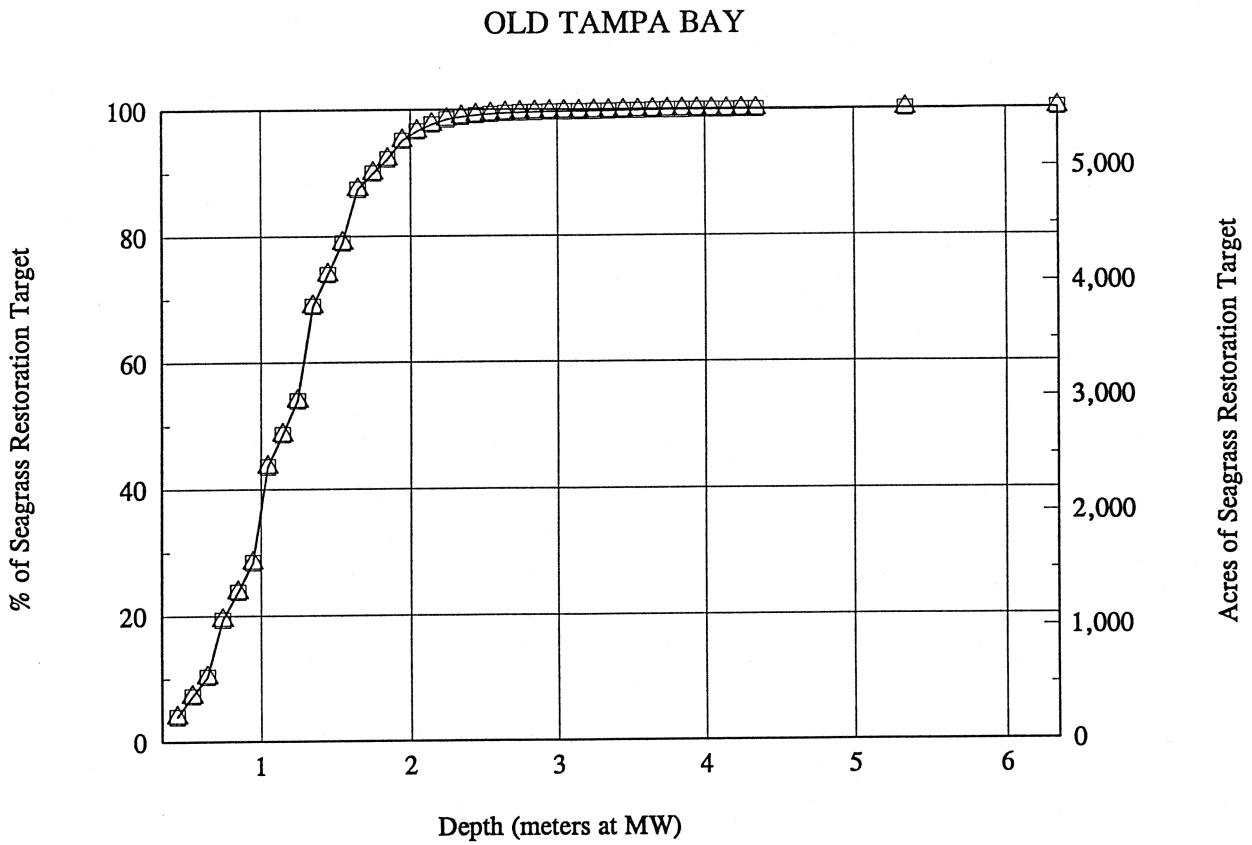


Figure 6-1 The acreages of seagrass restoration targets by depth at mean water for Old Tampa Bay and Hillsborough Bay.

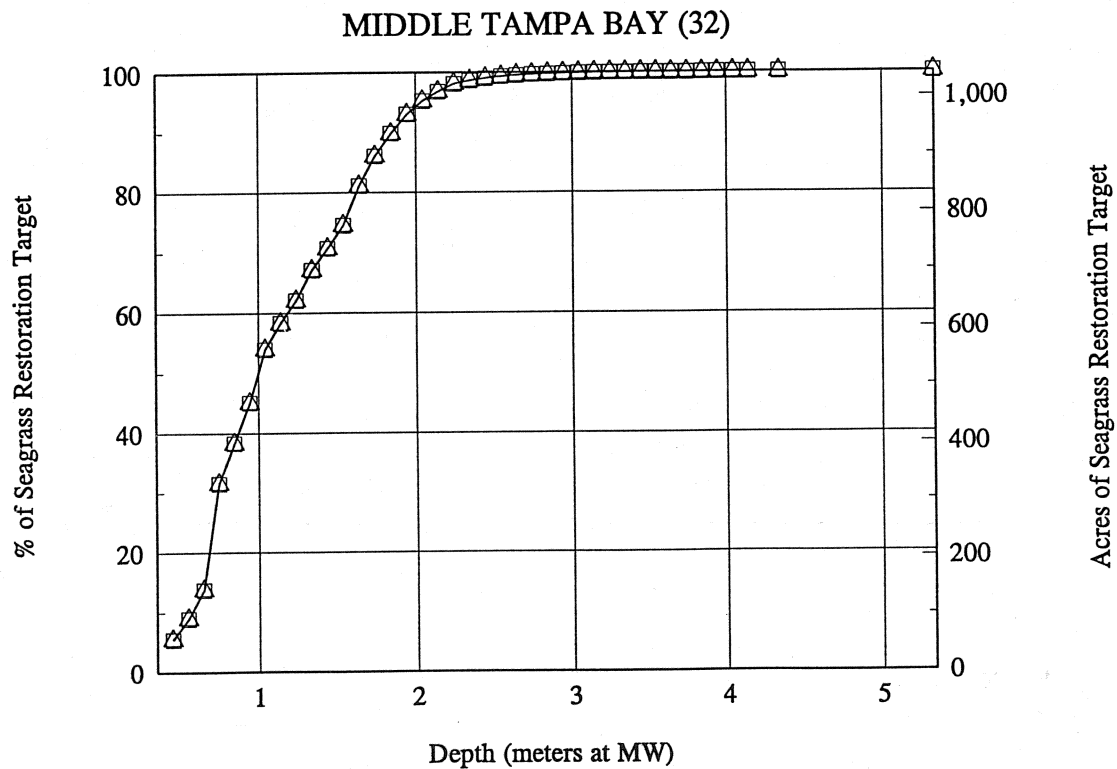
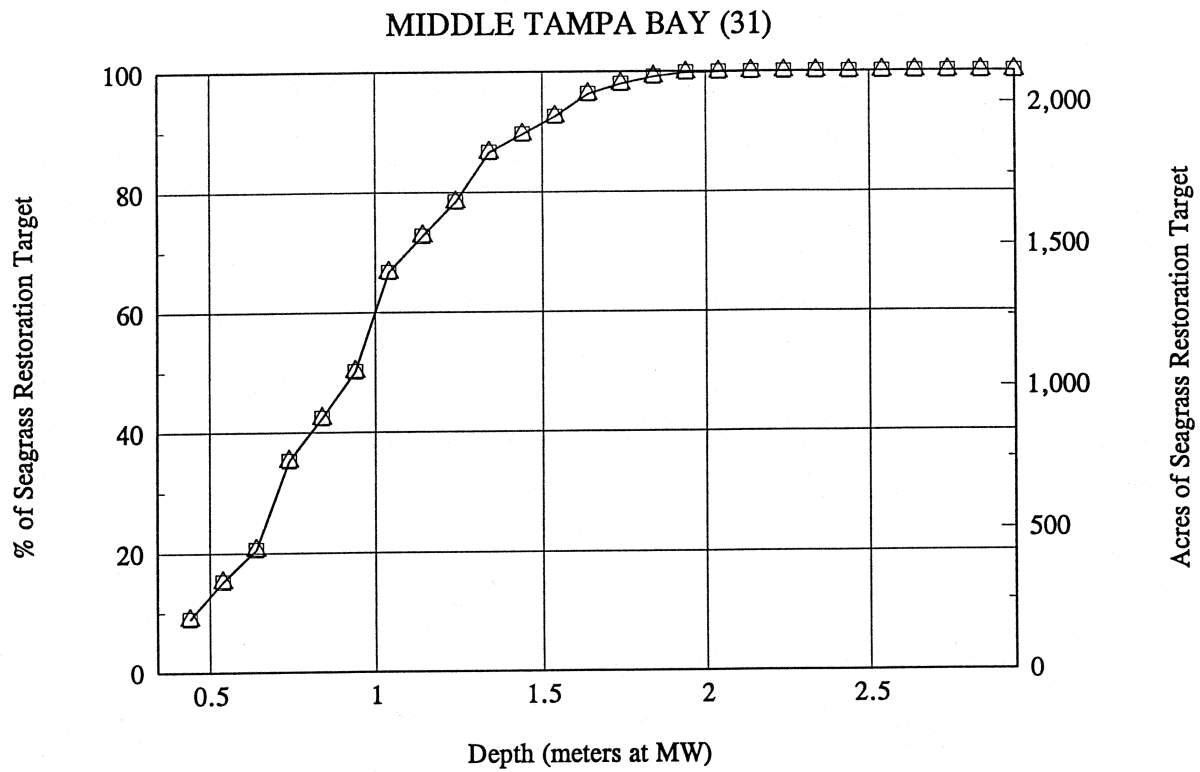


Figure 6-2 The acreages of seagrass restoration targets by depth at mean water for Middle Tampa Bay (31) and Middle Tampa Bay (32).

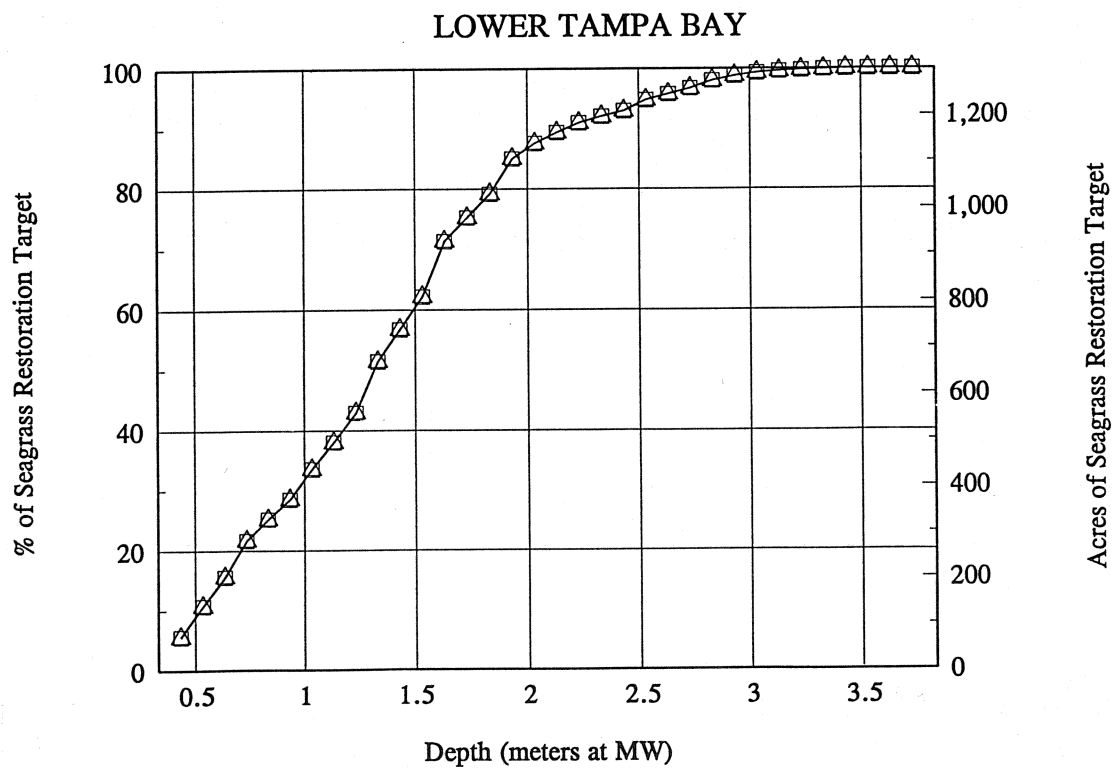
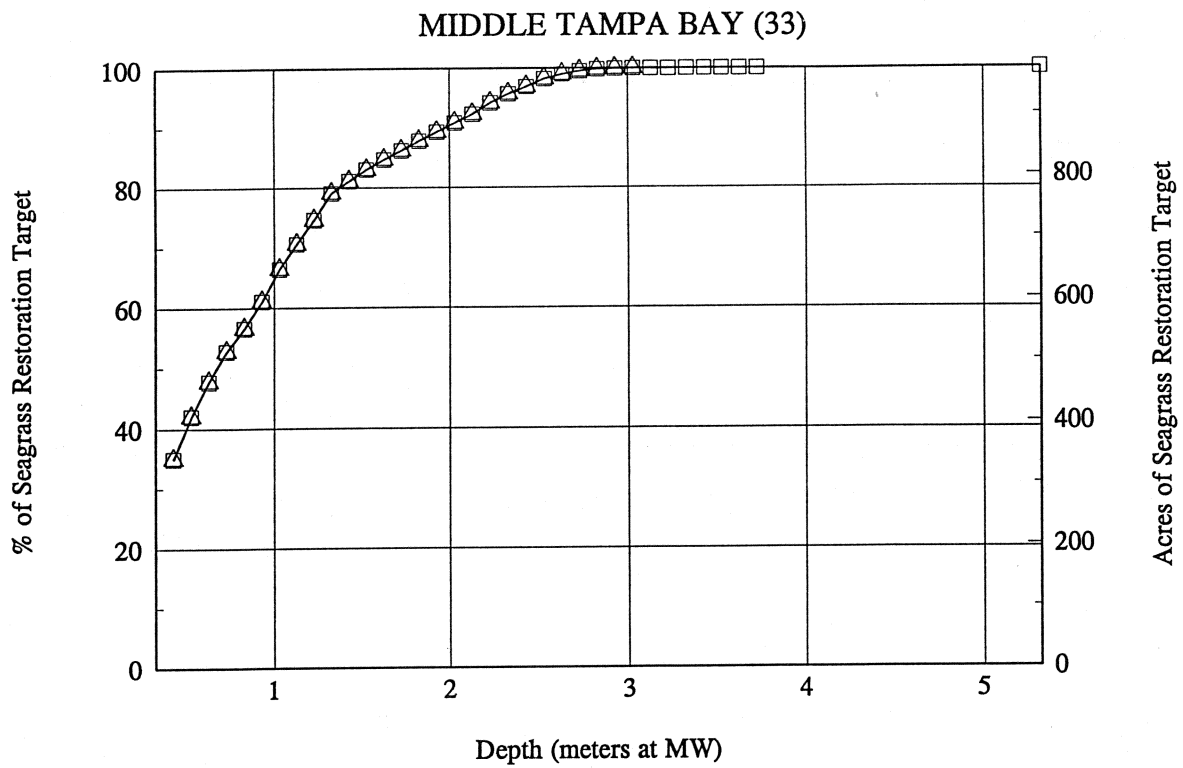


Figure 6-3 The acreages of seagrass restoration targets by depth at mean water for Middle Tampa Bay (33) and Lower Tampa Bay.

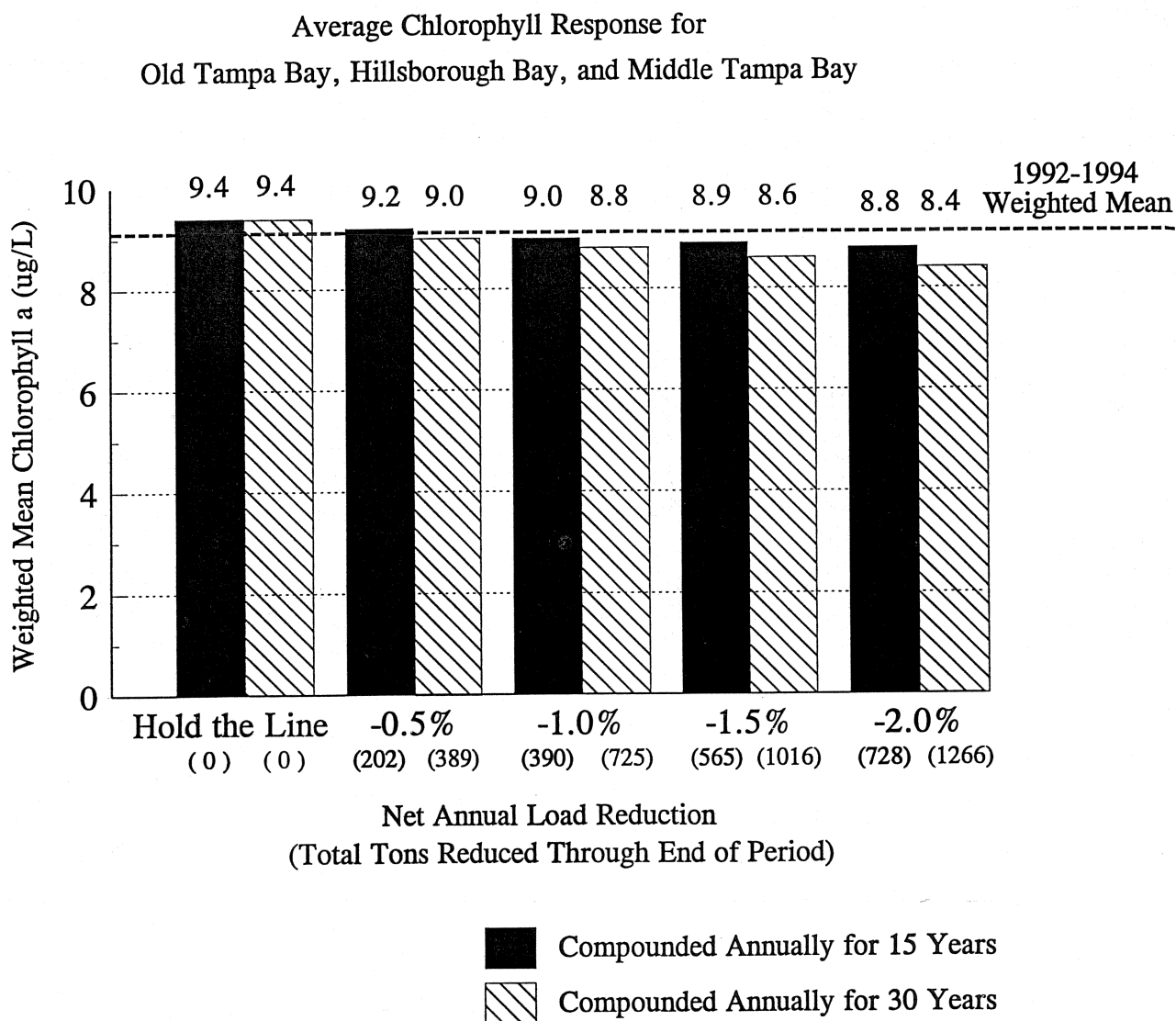


Figure 6-4 Predicted average chlorophyll response after 15 and 30 years under various example nitrogen load management scenarios in Old Tampa Bay, Hillsborough Bay, and Middle Tampa Bay.

**Total Seagrass Target Response for
Old Tampa Bay, Hillsborough Bay, and Middle Tampa Bay**

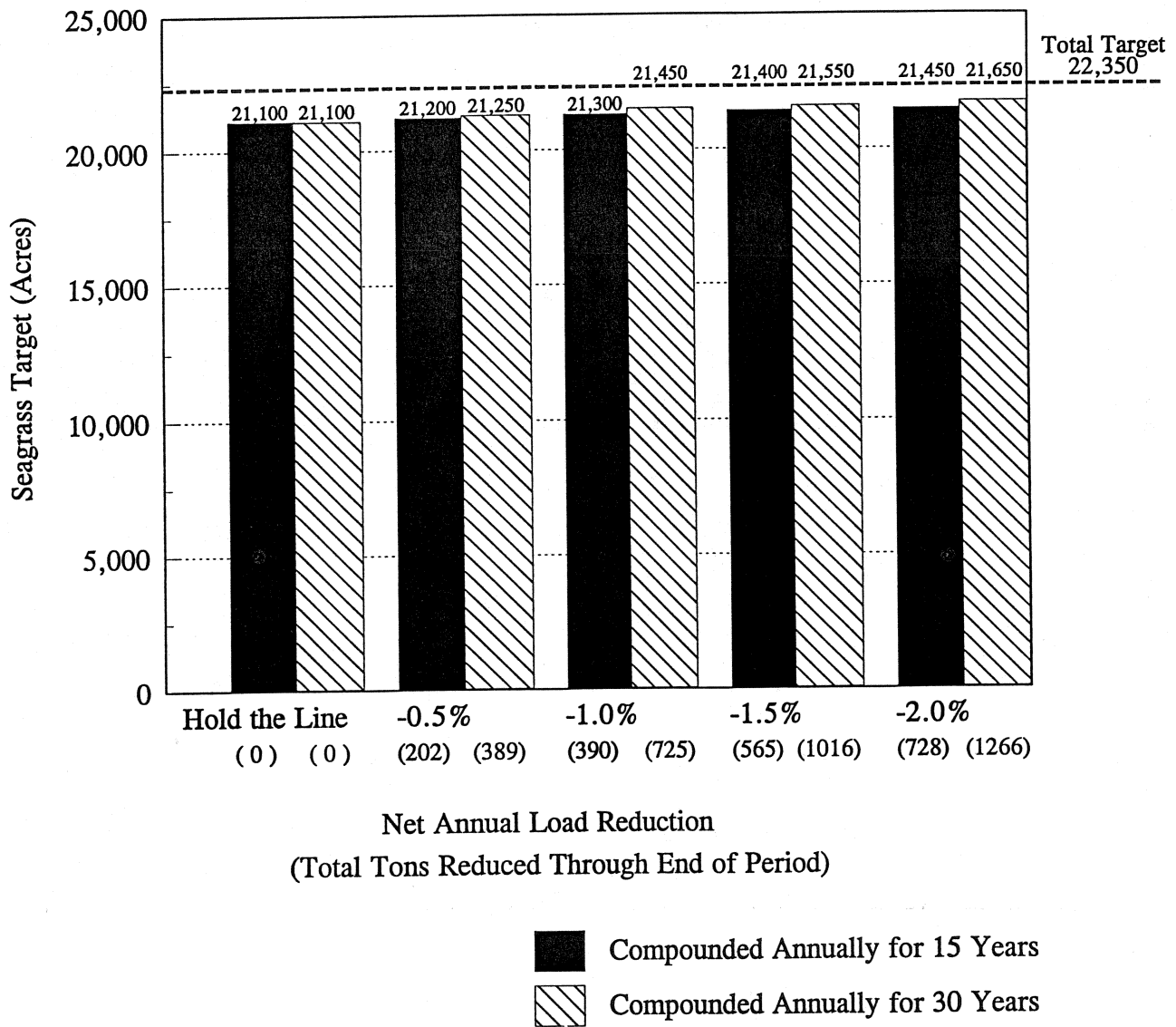


Figure 6-5 Predicted total areas of seagrass target met after 15 and 30 years under various example nitrogen load management scenarios in Old Tampa Bay, Hillsborough Bay, and Middle Tampa Bay.

**Total Seagrass Target Response for
Old Tampa Bay, Hillsborough Bay, and Middle Tampa Bay**

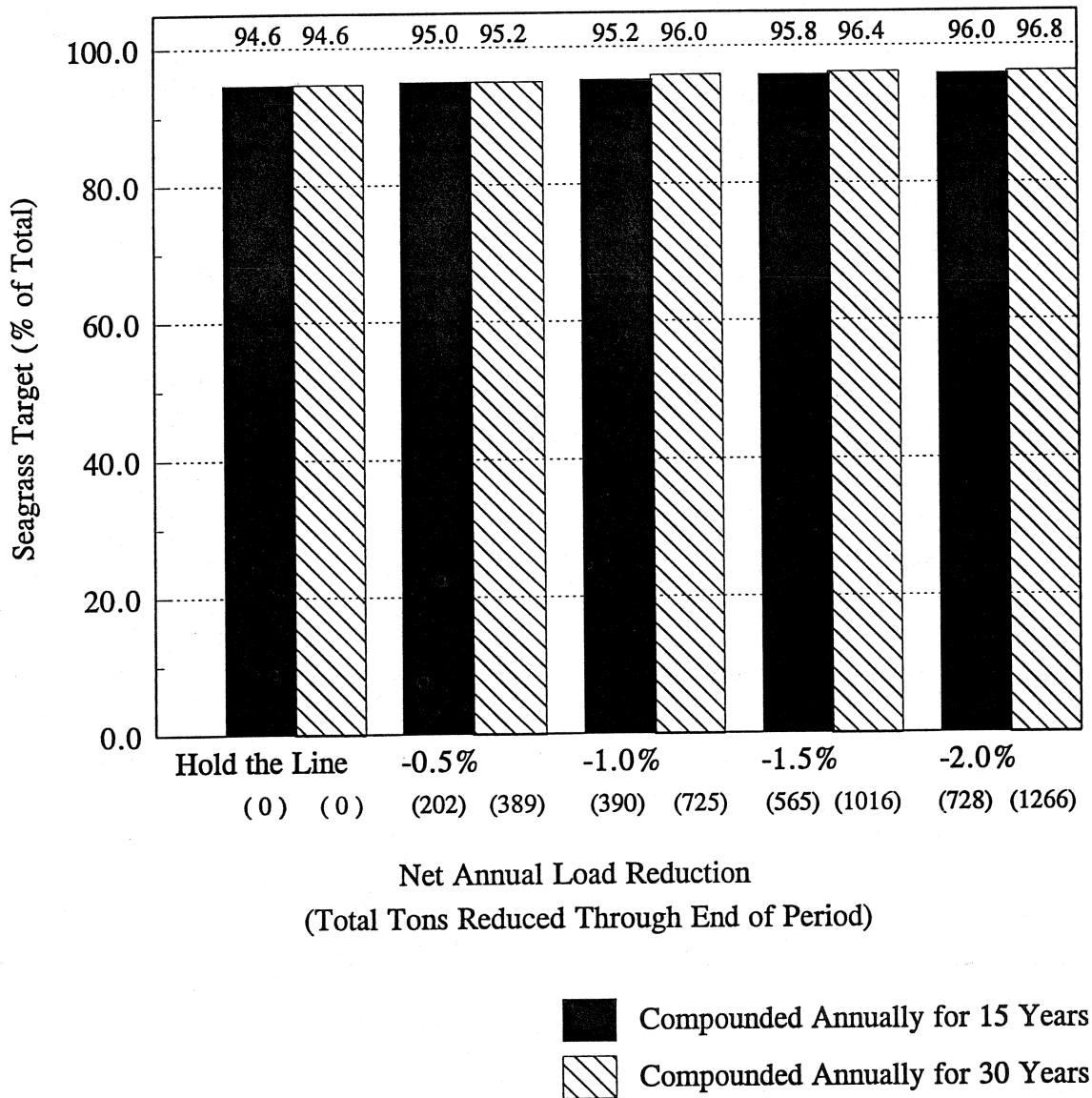


Figure 6-6 Predicted percentage of seagrass target met after 15 and 30 years under various example nitrogen load management scenarios in Old Tampa Bay, Hillsborough Bay, and Middle Tampa Bay.

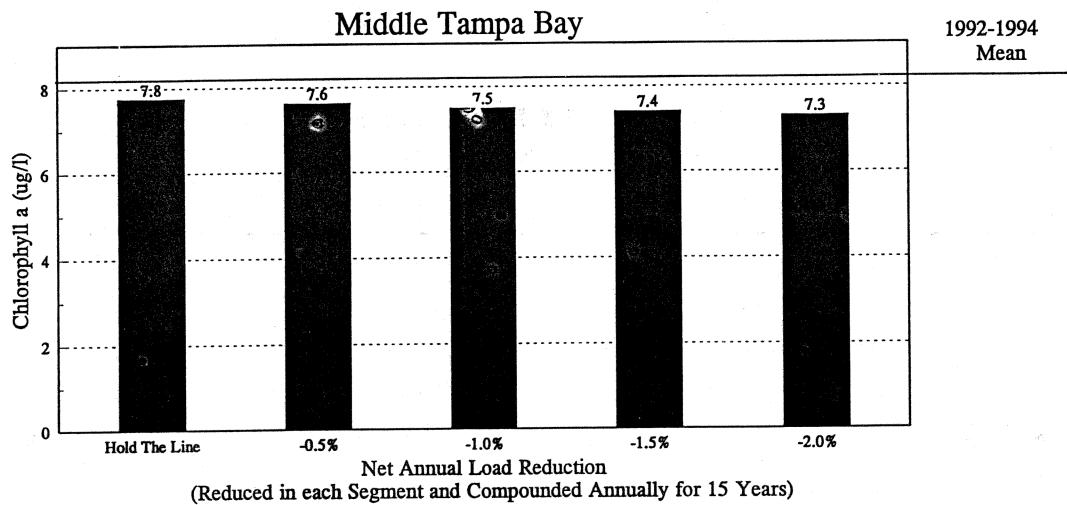
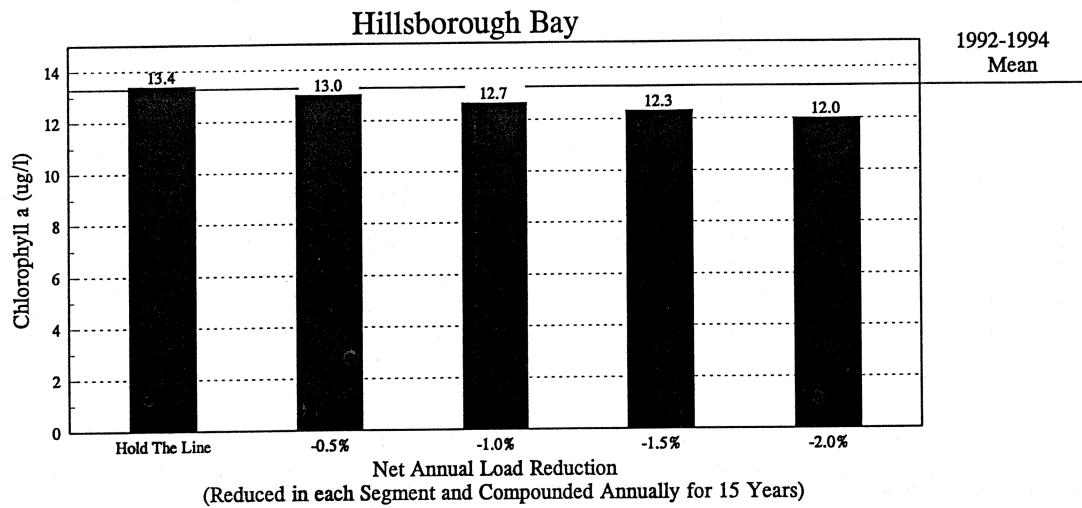
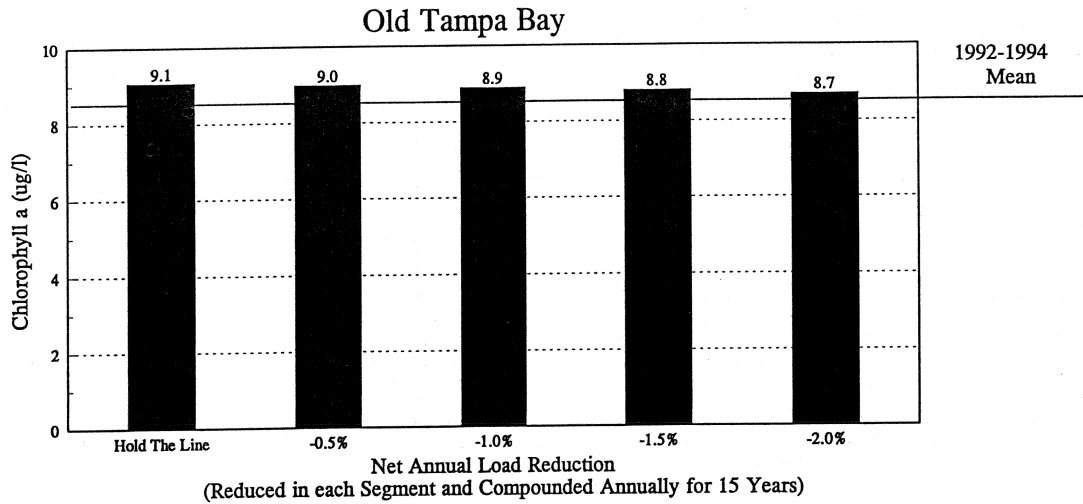


Figure 6-7 Predicted average chlorophyll response after fifteen years under various example nitrogen load management scenarios in Old Tampa Bay, Hillsborough Bay, and Middle Tampa Bay.

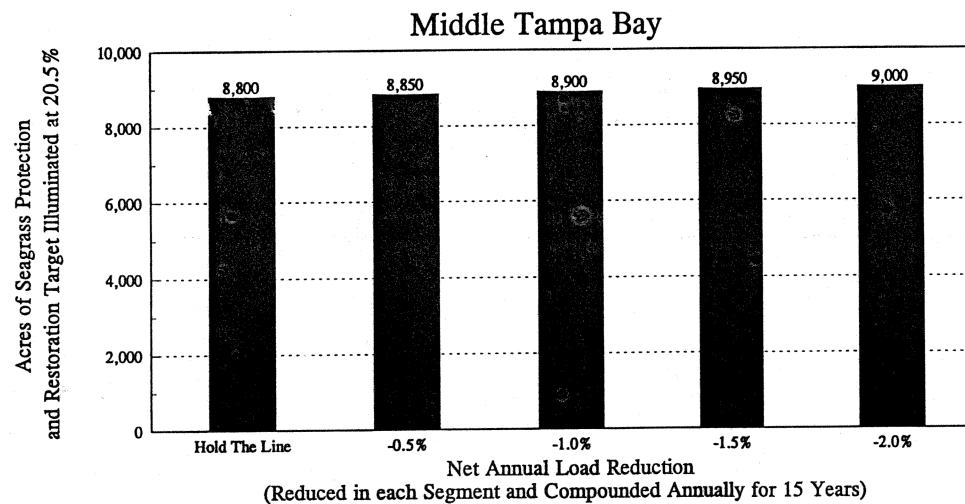
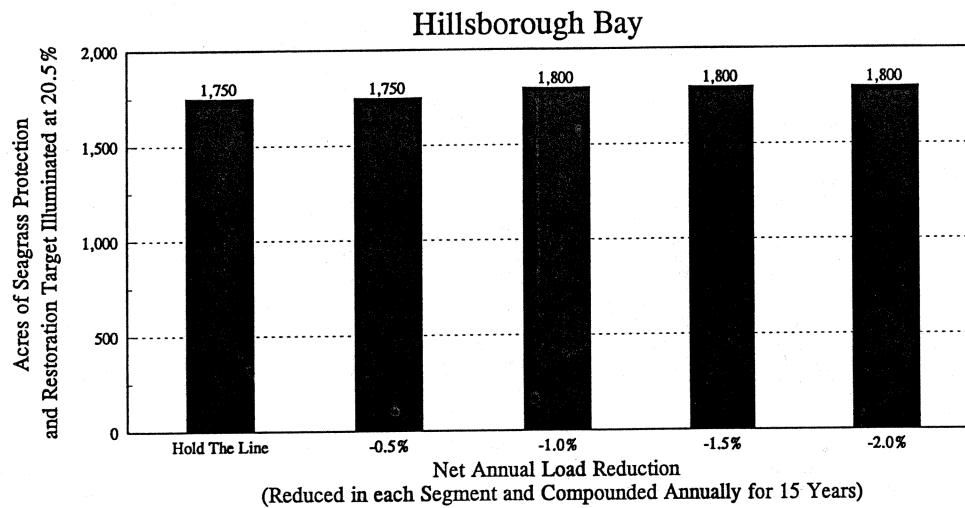
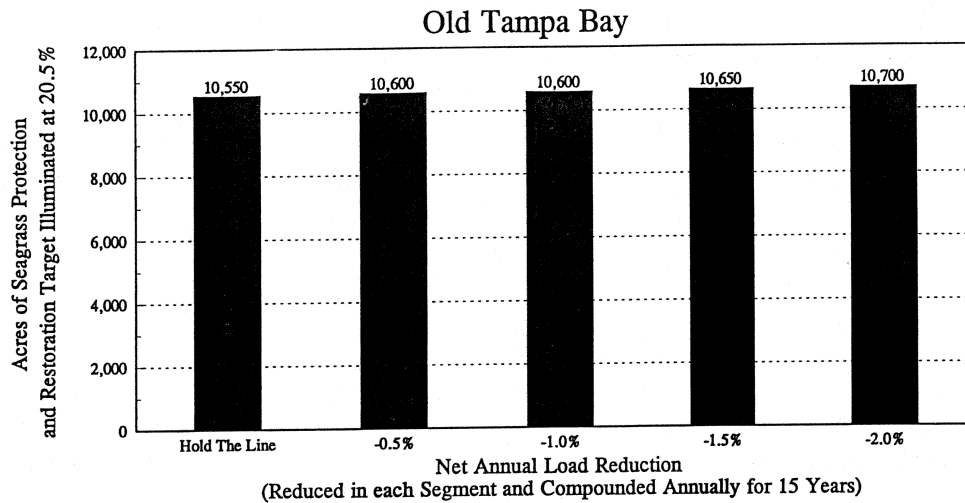


Figure 6-8 Predicted total areas of seagrass target met after fifteen years under various example nitrogen load management scenarios in Old Tampa Bay, Hillsborough Bay, and Middle Tampa Bay.

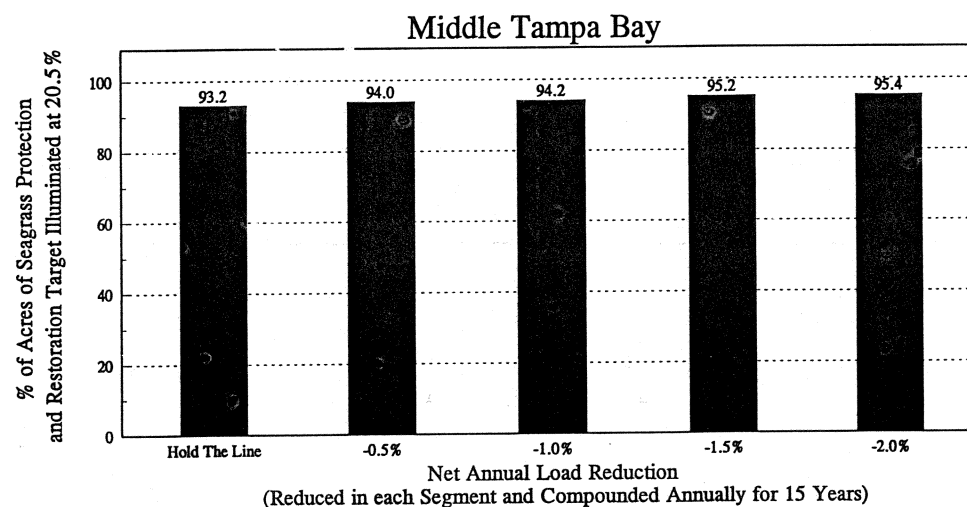
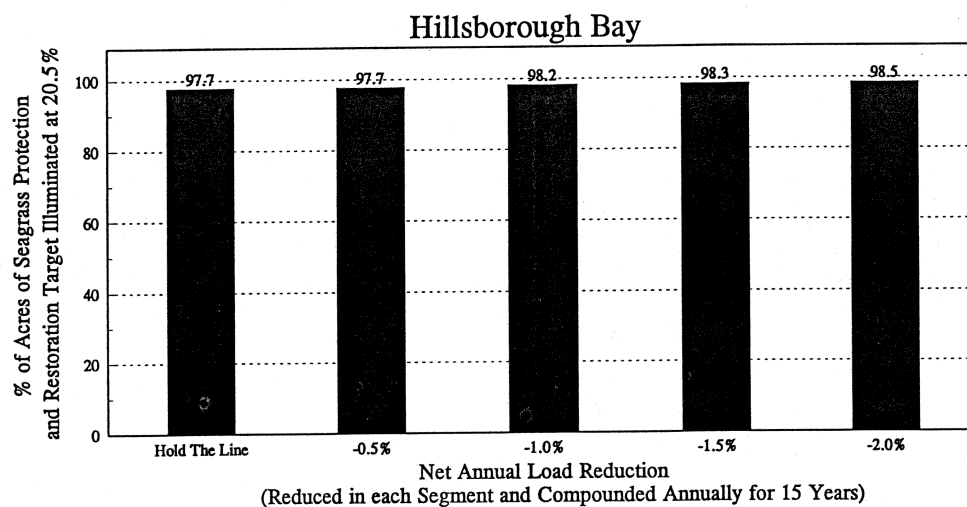
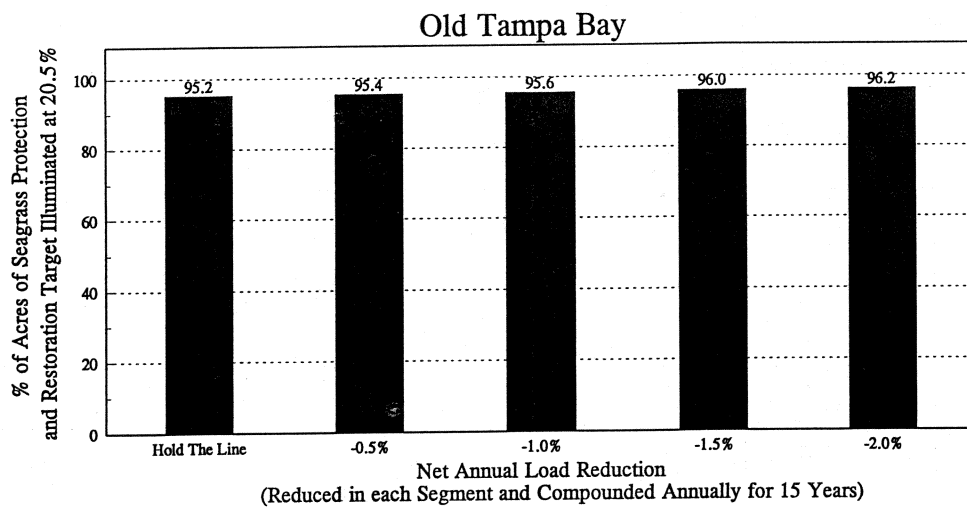


Figure 6-9 Predicted percentage of seagrass target met after fifteen years under various example nitrogen load management scenarios in Old Tampa Bay, Hillsborough Bay, and Middle Tampa Bay.

MEAN ANNUAL CHLOROPHYLL α ($\mu\text{g/L}$)
REQUIRED TO REACH 90 AND 95% OF ACRES OF
SEAGRASS PROTECTION TARGET AND RESTORATION ILLUMINATED AT 20.5% LIGHT

(Upper and Lower 95% Confidence Limits Shown in Parentheses)

Chlorophyll α ($\mu\text{g/L}$)	Old Tampa Bay	Hillsborough Bay	Middle Tampa Bay	Lower Tampa Bay
Mean 1979-83	15.0	29.0	15.6	6.9
ABM Target	10.0	15.0	8.0	4.0
Mean 1992-94	(8.8)	(14.5)	(8.9)	(5.0)
	8.5	13.2	8.1	4.8
	(8.2)	(11.9)	(7.3)	(4.5)
Required Level to Reach 90% of Protection Area and Restoration Area Illuminated at 20.5% Light	(11.1)	(19.7)	(9.6)	(7.1)
	10.3	17.6	8.6	5.4
	(9.6)	(15.7)	(7.7)	(4.1)
Required Level to Reach 95% of Protection Area and Restoration Area Illuminated at 20.5% Light	(9.8)	(17.8)	(8.0)	(5.2)
	9.2	16.1	7.4	4.6
	(8.7)	(14.6)	(6.8)	(4.0)

Table 6-1

Example estimated chlorophyll concentration values which would result in attainment of several example target illumination conditions.

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APPENDICES AVAILABLE ON REQUEST
TO TAMPA BAY NATIONAL ESTUARY PROGRAM

APPENDIX A. NUTRIENT LOADING - CHLOROPHYLL REGRESSION DIAGNOSTICS

[This Appendix is Available from the TBNEP upon Request]

General Linear Models Procedure
Class Level Information

Class	Levels	Values
MONTH	12	1 2 3 4 5 6 7 8 9 10 11 12
BAY_SEG	4	1 2 3 4

Number of observations in data set = 260

NOTE: Due to missing values, only 256 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: CHLA Chlorophyll a Arithmetic-mean (ug/l)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	18	5636.98695996	313.16594222	35.92	0.0001
Error	237	2065.99235478	8.71726732		

Corrected Total	255	7702.97931475			
R-Square		C.V.	Root MSE		CHLA Mean
0.731793		35.27550	2.95250187		8.36983812

Source	DF	Type I SS	Mean Square	F Value	Pr > F
MONTH	11	2193.99129840	199.45375440	22.88	0.0001
BAY_SEG	3	2884.33405407	961.44468469	110.29	0.0001
LASTC3N(BAY_SEG)	4	558.66160749	139.66540187	16.02	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MONTH	11	449.13188520	40.83017138	4.68	0.0001
BAY_SEG	3	19.61408525	6.53802842	0.75	0.5233
LASTC3N(BAY_SEG)	4	558.66160749	139.66540187	16.02	0.0001

Std Error of Estimate

Pr > |T|

T for H0:
Parameter=0

Parameter	Estimate	T for H0: Parameter=0	Pr > T	Std Error of Estimate
INTERCEPT	2.226599244	2.48	0.0137	0.89648560
MONTH	-0.192338320	-0.22	0.8238	0.86261782
	0.279799163	0.32	0.7462	0.86358652
	0.768803604	0.85	0.3954	0.90304385
	1.270570938	1.41	0.1611	0.90389527
	2.452550666	2.70	0.0074	0.90798452
	3.167990897	3.49	0.0006	0.90826888
	5.171125452	5.32	0.0001	0.97288424
	5.378311443	4.75	0.0001	1.13170685
	6.114218870	5.36	0.0001	1.13994440
	4.191362957	4.08	0.0001	1.02769757
	2.573604841	2.72	0.0071	0.94703130
	0.000000000			
BAY_SEG	1.558367876	1.40	0.1634	1.11455740
	0.320830622	0.25	0.8045	1.29446097
	0.967240508	0.95	0.3421	1.01616380
	0.000000000			
LASTC3N(BAY_SEG)	0.024139861	2.91	0.0040	0.00830433
	0.023465884	7.08	0.0001	0.00331539
	0.010144687	2.02	0.0450	0.00503443
	-0.008584323	-1.02	0.3068	0.00838124

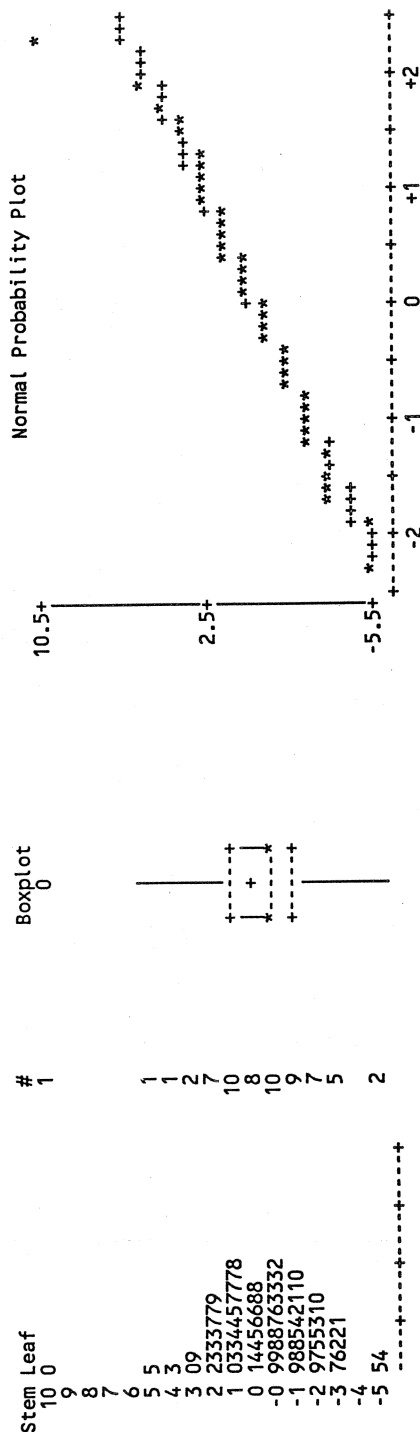
----- Bay Segment=1 -----

Univariate Procedure

Variable=RESID

Moments				Quantiles(Def=5)				Extremes			
N	63	Sum Wgts	63	100% Max	10.04685	99%	10.04685	Lowest	Obs	Highest	Obs
Mean	0	Sum	0	75% Q3	1.651207	95%	3.932582	-5.47511	63)	3.041892	9)
Std Dev	2.618495	Variance	6.856518	50% Med	-0.3162	90%	2.749595	-5.37757	24)	3.932582	6)
Skewness	0.787004	Kurtosis	2.456262	25% Q1	-1.832	10%	-3.10354	-3.65511	37)	4.290512	16)
USS	425.1041	CSS	425.1041	0% Min	-5.47511	5%	-3.61441	-3.61441	11)	5.514574	5)
CV	0	Std Mean	0.329899	Range	15.52197	1%	-5.47511	-3.24946	15)	10.04685	7)
T-Mean=0	0	Prob> T	1.0000	Q3-Q1	3.48321						
Num = 0	63	Num> 0	30	Mode	-5.47511						
M(Sign)	-1.5	Prob> M	0.8013								
Sgn Rank	-42	Prob> S	0.7763								

Missing Value
 Count 3
 % Count/Nobs 4.55



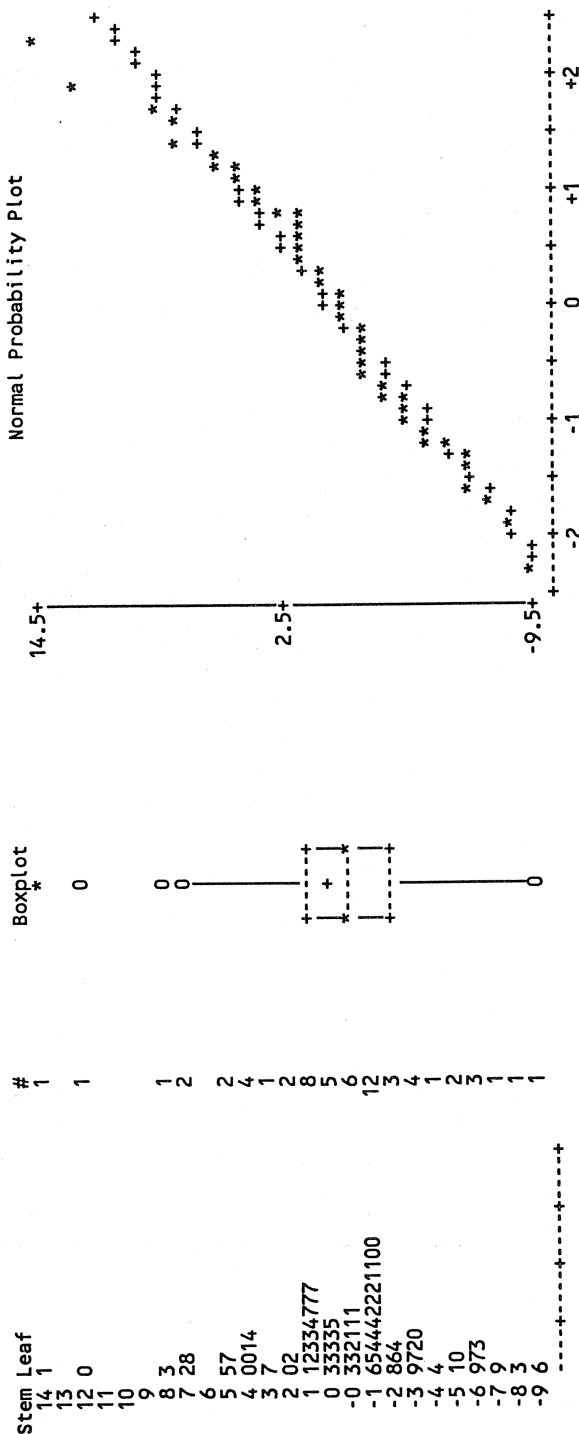
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Univariate Procedure

Variable=RESID

Moments				Quantiles(Def=5)				Extremes			
N	61	Sum Wgts	61	100% Max	14.08248	99%	14.08248	Lowest	Obs	Highest	Obs
Mean	0	Sum	0	75% Q3	1.679896	95%	7.843809	-9.57551	19)	7.212757	2)
Std Dev	4.48847	Variance	20.14636	50% Med	-0.22098	90%	5.483913	-8.30832	27)	7.845809	9)
Skewness	0.625485	Kurtosis	1.386219	25% Q1	-2.38266	10%	-5.0864	-7.86037	18)	8.341624	12)
USS	1208.782	CSS	1208.782	0% Min	-9.57551	5%	-6.87475	-6.87475	16)	12.0117	48)
CV	0.57469	Std Mean	0.57469	Range	23.65799	1%	-9.57551	-6.66985	21)	14.08248	40)
T:Mean=0	0	Prob> T	1.0000	Q3-Q1	4.062555						
Num = 0	61	Num > 0	27	Mode	-9.57551						
M(Sign)	-3.5	Prob> M	0.4426								
Sgn Rank	-48.5	Prob> S	0.7307								

Missing Value
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 % Count/Nobs 1.61

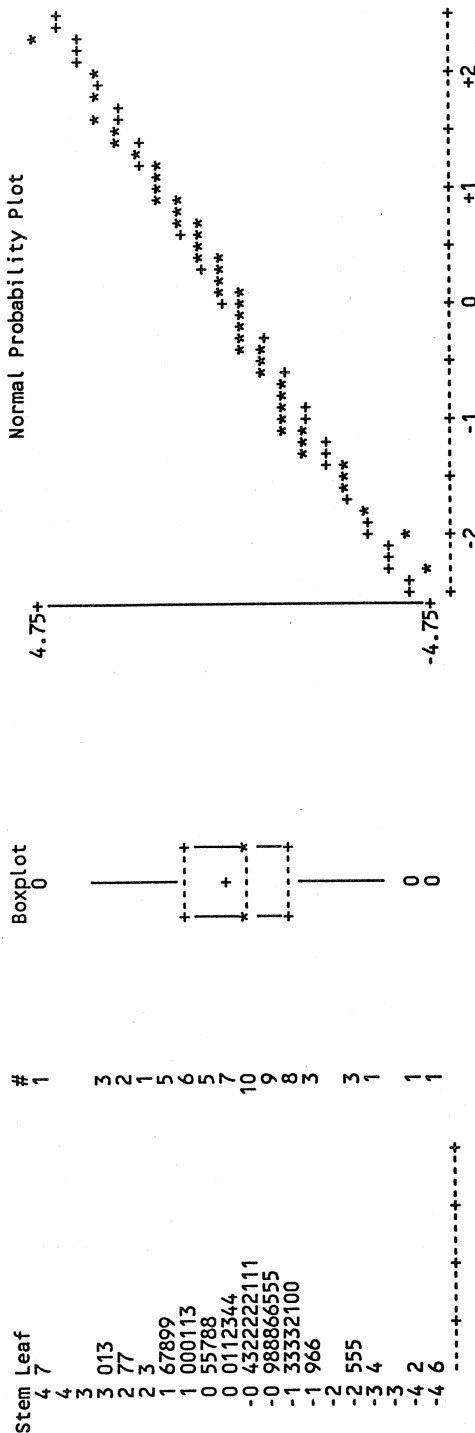


Bay Segment=3

Univariate Procedure

Variable=RESID

Moments					Quantiles(Def=5)					Extremes				
	66	Sum Wgts	66	100%	Max	4.671329	99%	4.671329	Lowest	Obs	Highest	Obs		
N	0	Sum	0	75%	Q3	0.983879	95%	3.019023	-4.56336	28)	2.727608	39)		
Mean	1.717664	Variance	2.95037	50%	Med	-0.14037	90%	2.319595	-4.22784	29)	3.019023	42)		
Std Dev	-0.01256	Kurtosis	0.787578	25%	q1	-1.03596	10%	-1.86311	-3.40477	37)	3.088591	44)		
Skewness	191.774	CSS	191.774	0%	Min	-4.56336	5%	-2.54025	-2.54025	51)	3.330582	3)		
USS	0.21143	Std Mean	0.21143				1%	-4.56336	-2.53177	12)	4.671329	45)		
CV	0	Prob> T	1.0000	Range		9.23469								
T-Mean=0	66	Num > 0	30	Q3-Q1		2.019843								
Num = 0	-3	Prob> M	0.5386	Mode		-4.56336								
M(Sign)	-24.5	Prob> S	0.8770											
Sgn Rank														

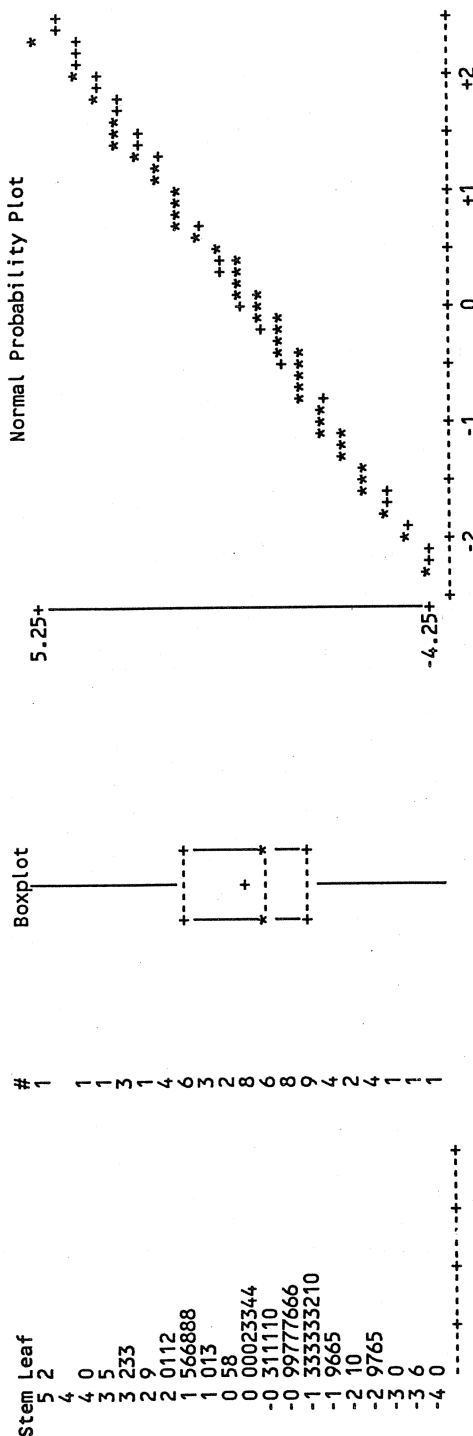


Bay Segment=4

Univariate Procedure

Variable=RESID

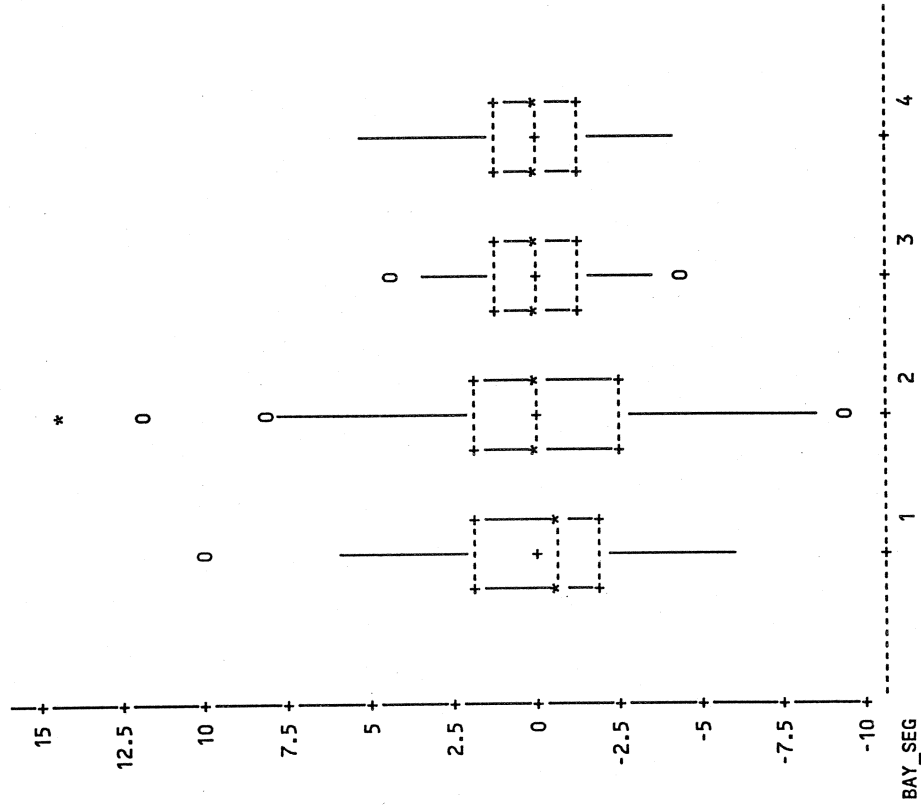
Moments				Quantiles(Def=5)				Extremes			
	66	Sum Wgts	66	100% Max	5.150462	99%	5.150462	Obs	18)	Highest	Obs
N	0	Sum	0	75% Q3	1.527441	95%	3.321041	3)	7)	3.321041(	41)
Mean	1.922869	Variance	3.697424	50% Med	-0.10022	90%	2.862999	4)	9)	3.511362(	42)
Std Dev	0.377339	Kurtosis	-0.0876	25% Q1	-1.32278	10%	-2.47097	5)	16)	4.019242(	39)
Skewness	0.377339	USS	240.3326	0% Min	-4.04627	5%	-2.87235	6)	26)	5.150462(	40)
CV	0.236689	Std Mean	0.236689	Range	9.196728	1%	-4.04627				
T:Mean=0	0	Prob> T	0	Q3-Q1	2.850221						
Num = 0	66	Num > 0	30	Mode	-4.04627						
M(Sign)	-3	Prob> M	0.5386								
Sgn Rank	-47.5	Prob> S	0.7641								



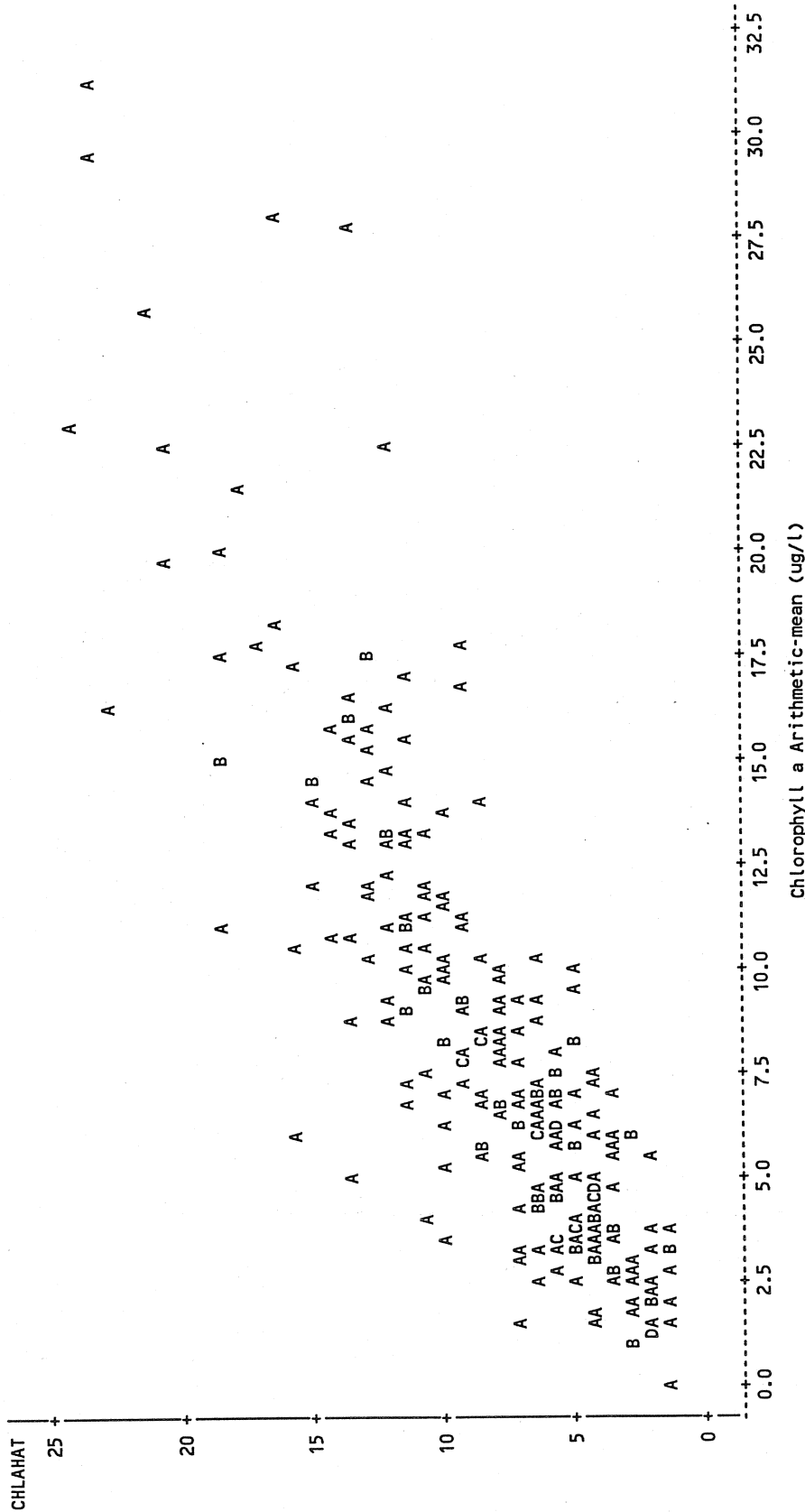
Tampa Bay National Estuary Program - Nutrient Modeling
Monthly EPCHC Data - Arithmetic Mean of All Stations
Model (chla = lastc3n) by bay_seg (nm-133.sas)

Univariate Procedure
Schematic Plots

Variable=RESID



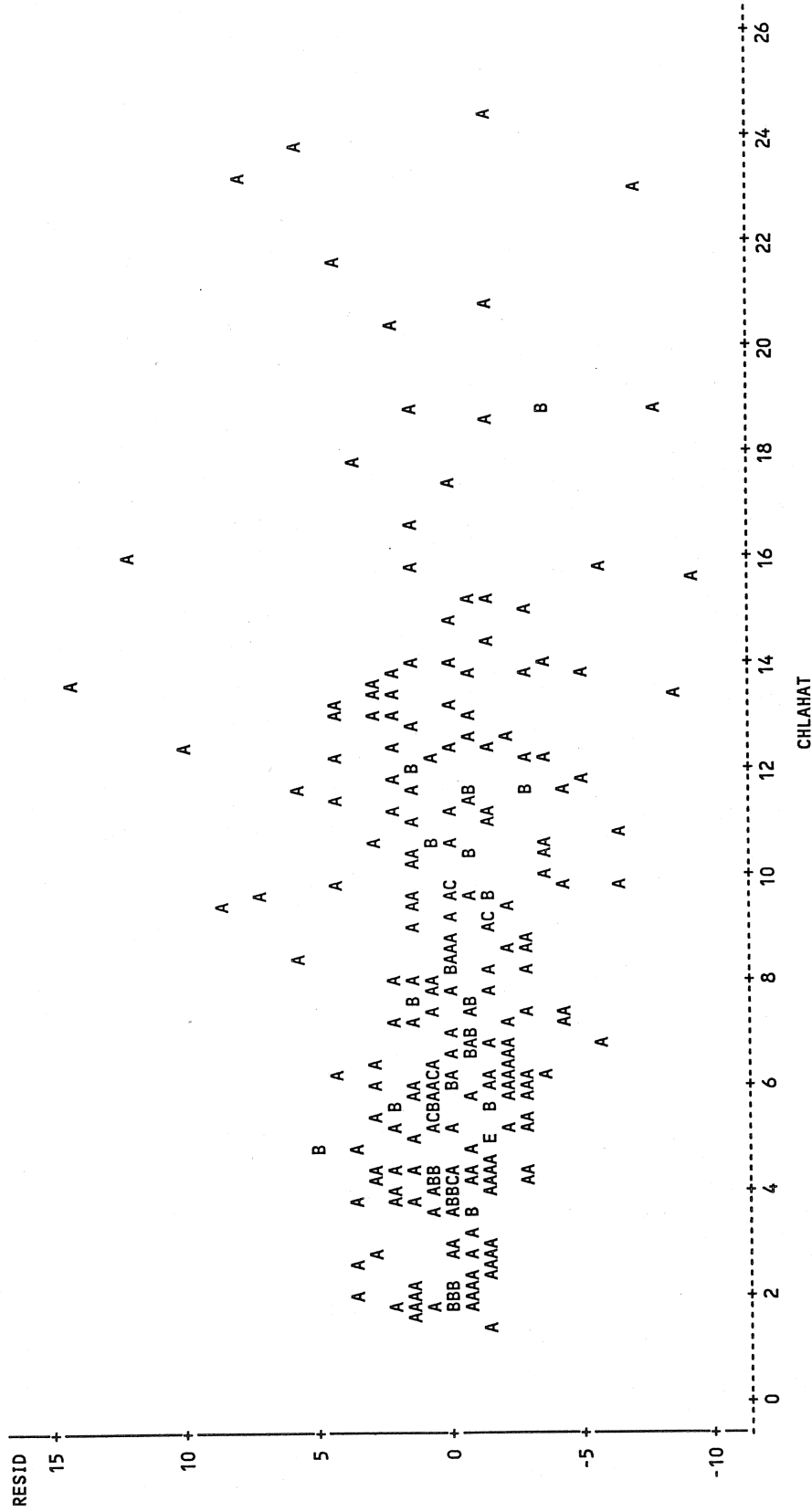
Plot of CHLAHAT*CHLA. Legend: A = 1 obs, B = 2 obs, etc.



NOTE: 4 obs had missing values.

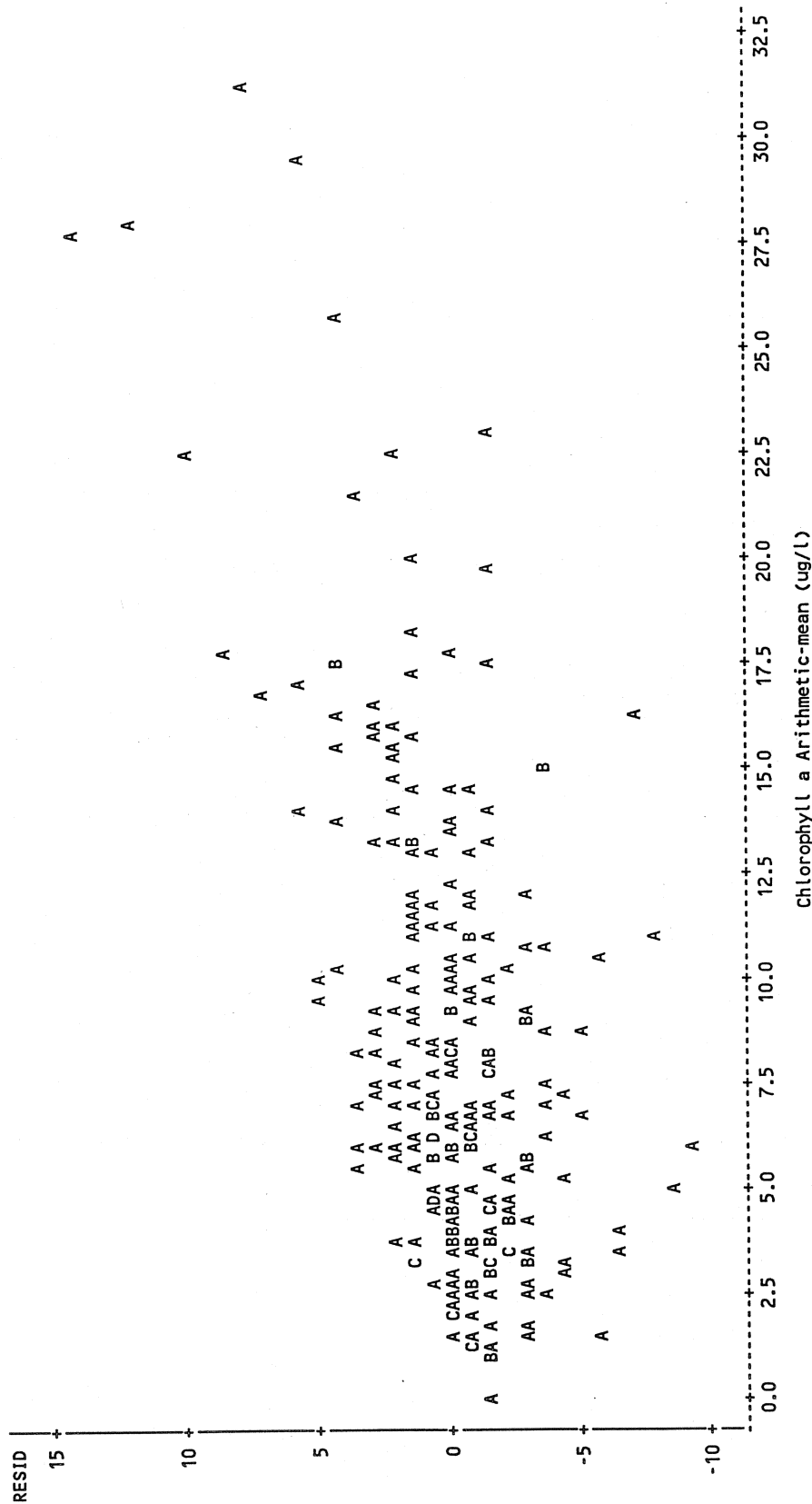
Tampa Bay National Estuary Program - Nutrient Modeling
 Monthly EPCHC Data - Arithmetic Mean of All Stations
 Model (chl a = lastc3n) by bay_seg (nm-133.sas)

Plot of RESID*CHLAHAT. Legend: A = 1 obs, B = 2 obs, etc.



NOTE: 4 obs had missing values.

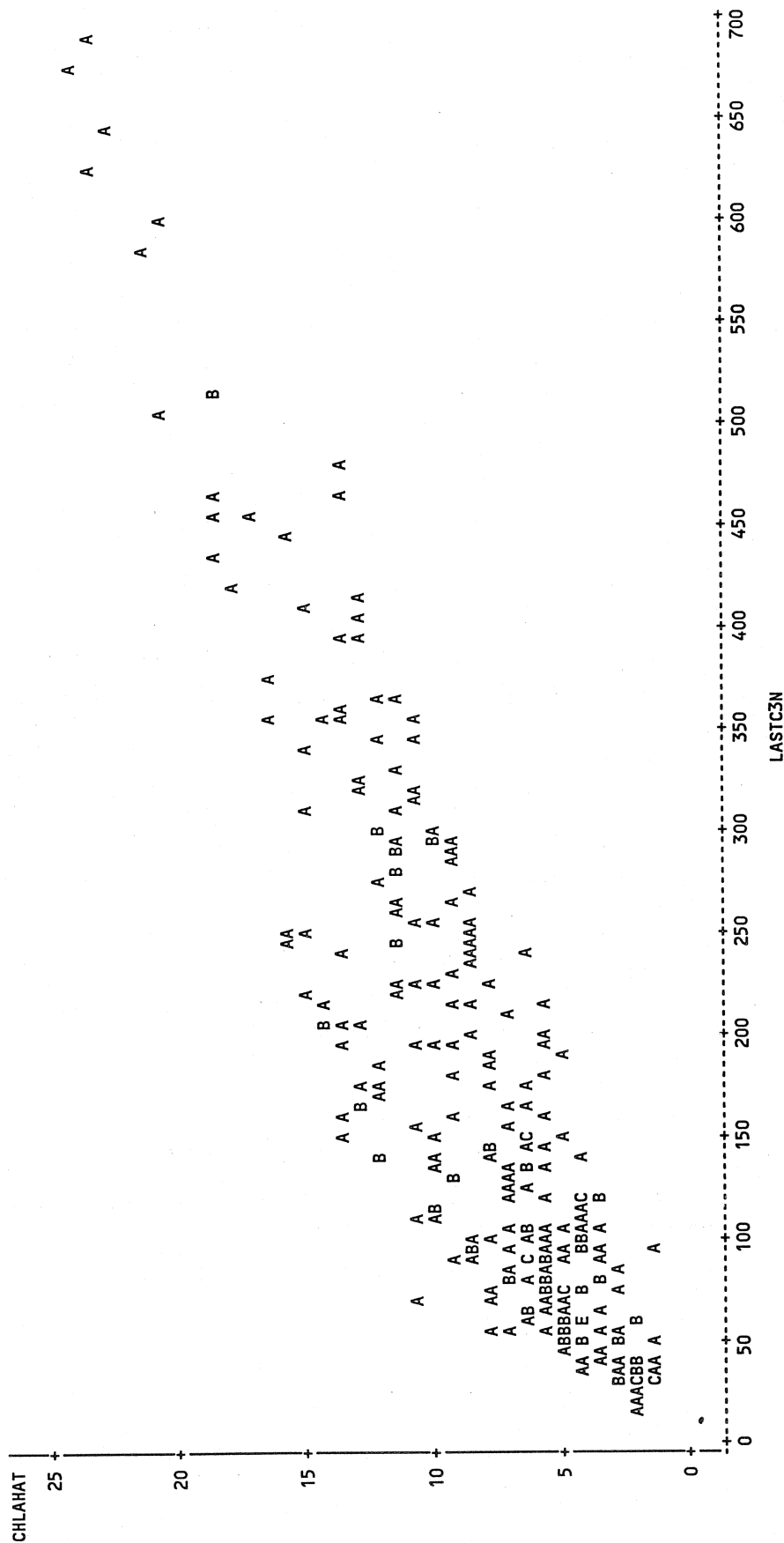
Plot of RESID*CHLA. Legend: A = 1 obs, B = 2 obs, etc.



NOTE: 4 obs had missing values.

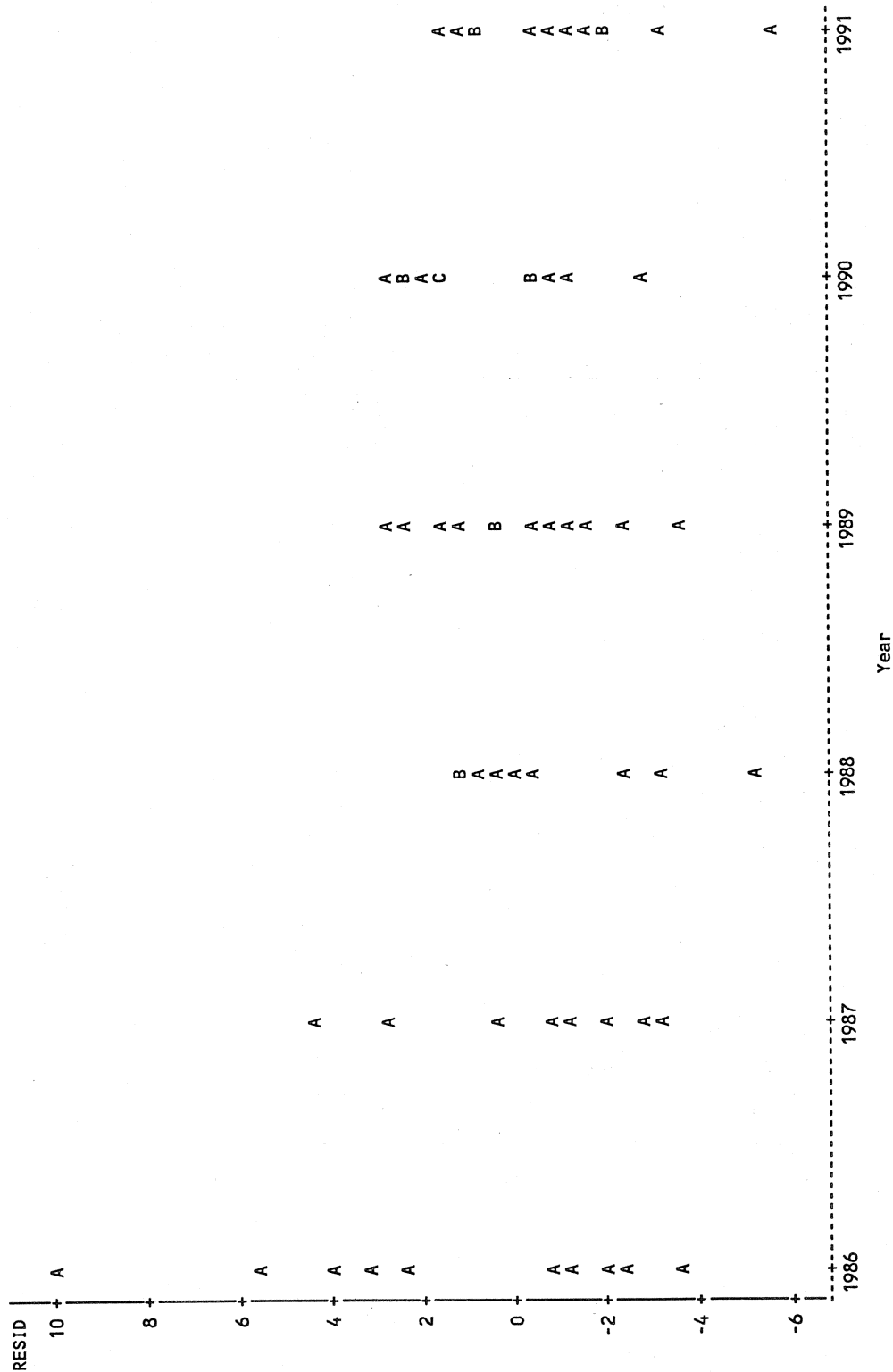
Tampa Bay National Estuary Program - Nutrient Modeling
 Monthly EPOCH Data - Arithmetic Mean of All Stations
 Model (chl a = lastc3n) by bay_seg (nm-133.sas)

Plot of CHLAHAT*LASTC3N. Legend: A = 1 obs, B = 2 obs, etc.



Bay Segment=1

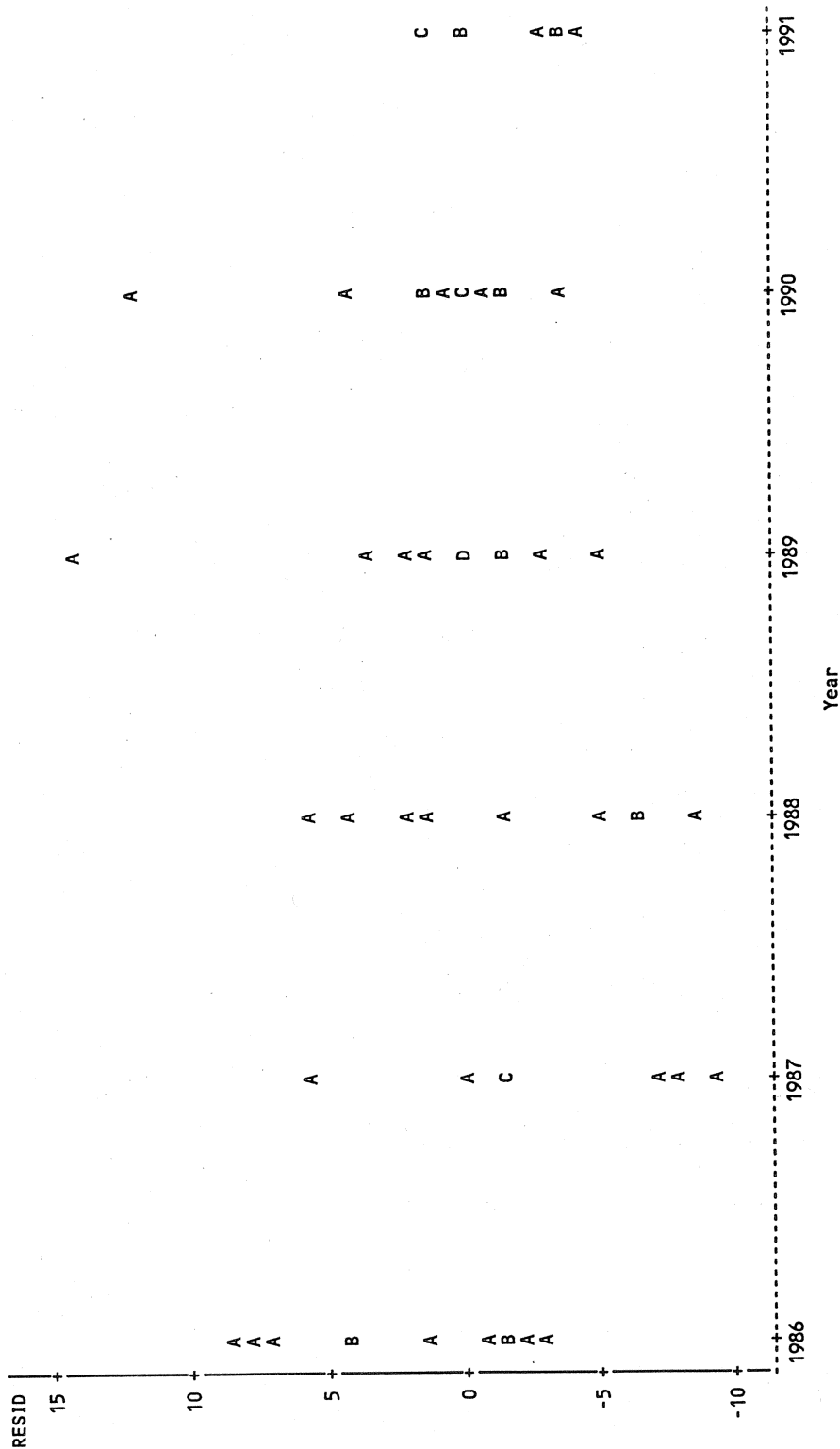
Plot of RESID*YEAR. Legend: A = 1 obs, B = 2 obs, etc.



NOTE: 3 obs had missing values.

Bay Segment=2

Plot of RESID*YEAR. Legend: A = 1 obs, B = 2 obs, etc.

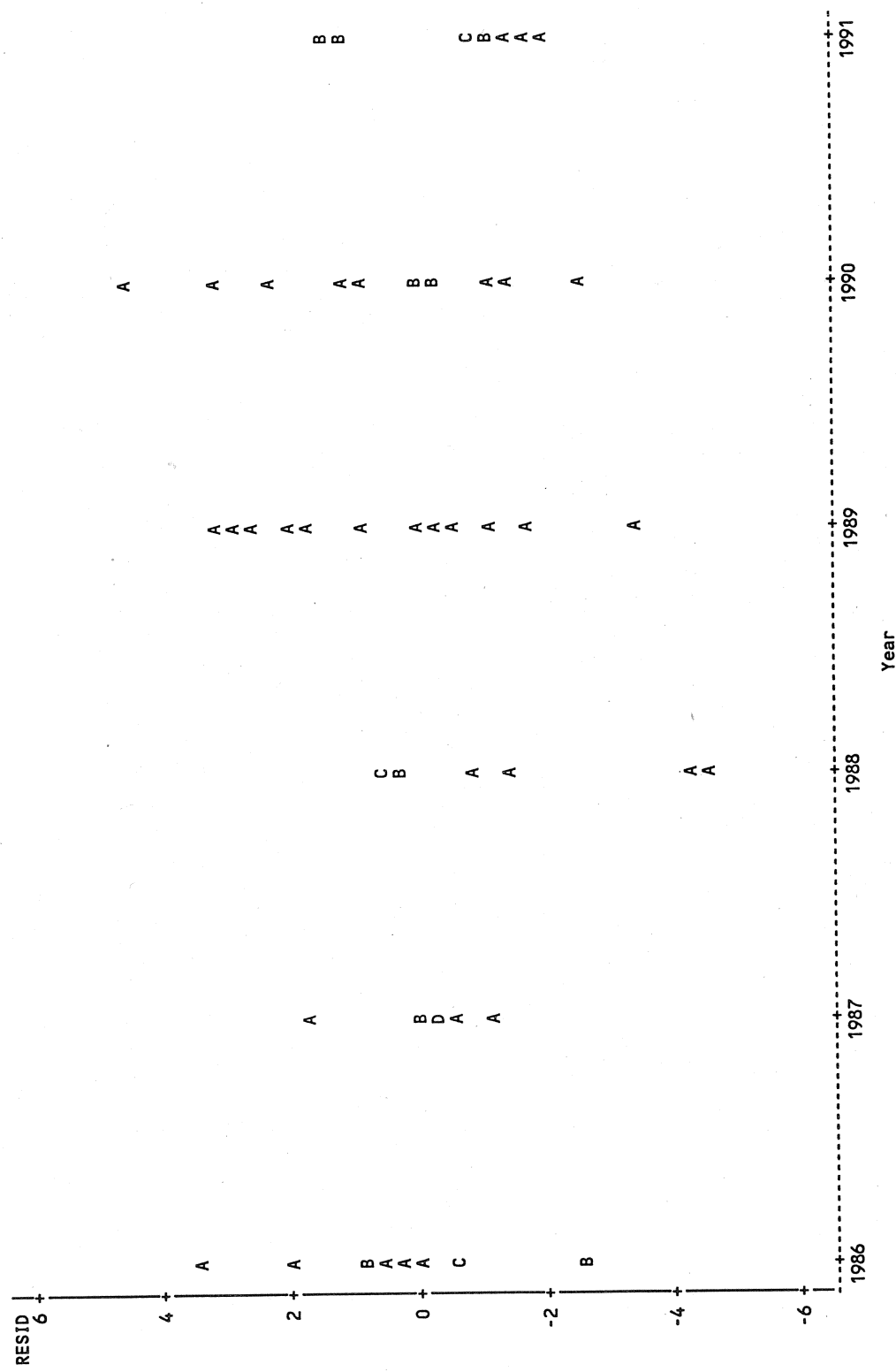


NOTE: 1 obs had missing values.

Tampa Bay National Estuary Program - Nutrient Modeling
Monthly EPCHC Data - Arithmetic Mean of All Stations
Model (chl a = lastc3n) by bay_seg (nmr-133.sas)

----- Bay Segment=3 -----

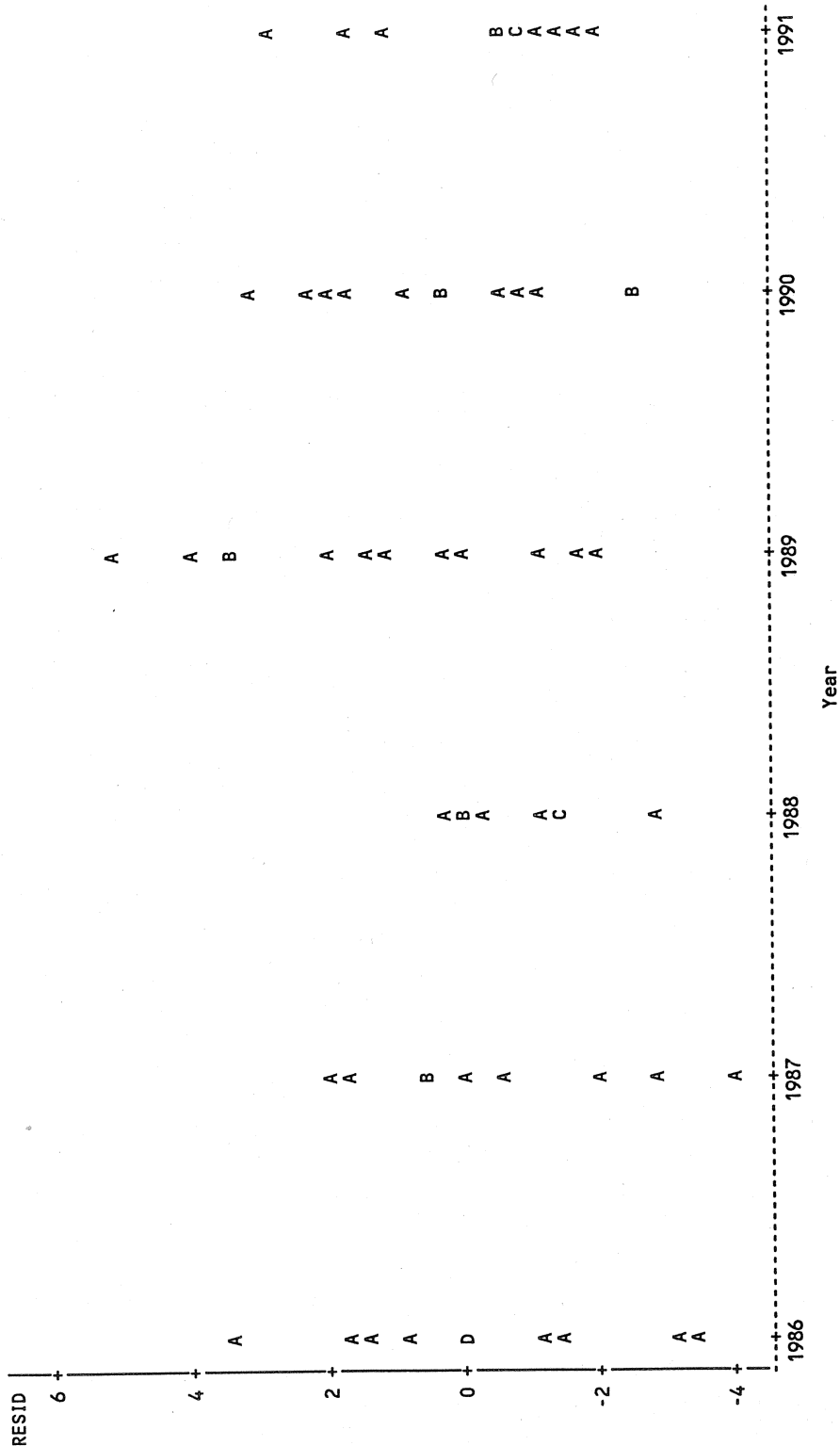
Plot of RESID*YEAR. Legend: A = 1 obs, B = 2 obs, etc.



Tampa Bay National Estuary Program - Nutrient Modeling
 Monthly EPCIC Data - Arithmetic Mean of All Stations
 Model (chla = lastc3n) by bay_seg (nm-133.sas)

Bay Segment=4

Plot of RESID*YEAR. Legend: A = 1 obs, B = 2 obs, etc.



General Linear Models Procedure
Class Level Information

Class	Levels	Values
MONTH	12	1 2 3 4 5 6 7 8 9 10 11 12

Number of observations in data set = 260

NOTE: Due to missing values, only 256 observations can be used in this analysis.

Tampa Bay National Estuary Program - Nutrient Modeling
 Monthly EPCIC Data - Arithmetic Mean of All Stations
 Model (chla = lastc3n) pooled bay segments (nm-132.sas)

General Linear Models Procedure

Dependent Variable: CHLA Chlorophyll a Arithmetic-mean (ug/l)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	12	4784.58051837	398.71504320	33.20	0.0001
Error	243	2918.39879638	12.00987159		
Corrected Total	255	7702.97931475			

R-Square		Root MSE	CHLA Mean
0.621134		3.46552616	8.36983812

Source	DF	Type I SS	Mean Square	F Value	Pr > F
MONTH	11	2193.99129840	199.45375440	16.61	0.0001
LASTC3N	1	2590.58921996	2590.58921996	215.70	0.0001
Source	DF	Type III SS	Mean Square	F Value	Pr > F
MONTH	11	379.32394686	34.48399517	2.87	0.0015
LASTC3N	1	2590.58921996	2590.58921996	215.70	0.0001

Std Error of Estimate

T for H0: Parameter=0

Pr > |T|

Parameter	Estimate	T for H0: Parameter=0	Pr > T	Std Error of Estimate
INTERCEPT	1.751448011	2.30	0.0223	0.76166765
MONTH	0.051164596	0.05	0.9597	1.01148606
1	0.578153977	0.57	0.5682	1.01177828
2	0.925731683	0.87	0.3832	1.05960105
3	1.224447888	1.16	0.2490	1.05955743
4	2.168571434	2.05	0.0418	1.05969726
5	2.288725496	2.24	0.0263	1.02389790
6	3.748627546	3.62	0.0004	1.03454843
7	3.001114661	2.79	0.0057	1.07485573
8	4.105265392	3.69	0.0003	1.11149584
9	2.796399458	2.58	0.0104	1.08264160
10	1.930667753	1.77	0.0784	1.09215537
11	0.000000000			
12	0.026831795	14.69	0.0001	0.00182692
LASTC3N				

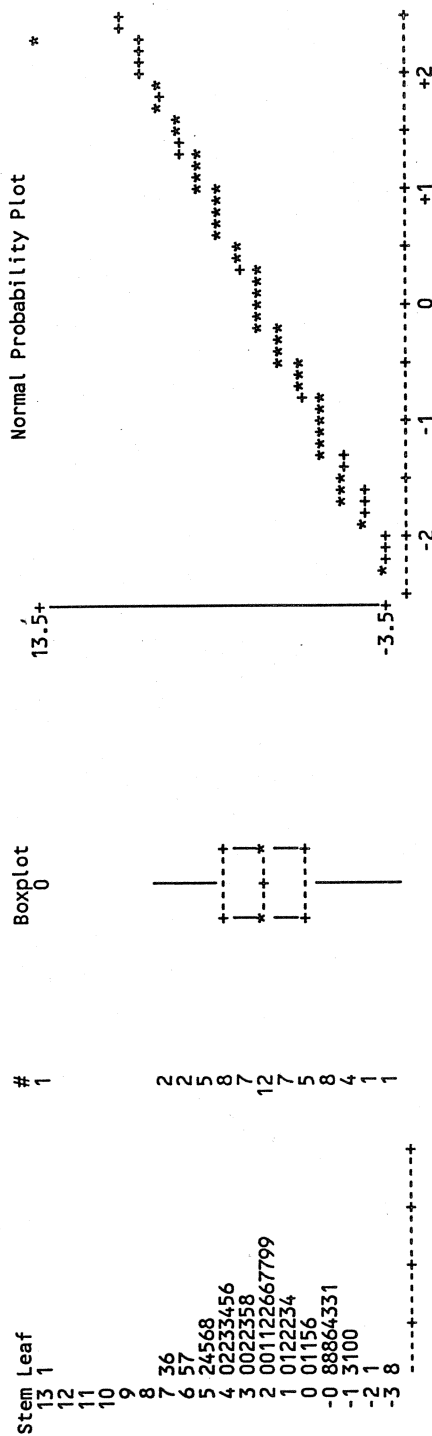
Bay Segment=1

Univariate Procedure

Variable=RESID

Moments				Quantiles(Def=5)				Extremes			
N	63	Sum Wgts	63	100% Max	13.11927	99%	13.11927	Obs	Highest	Obs	Obs
Mean	2.39659	Sum	150.9851	75% Q3	4.200176	95%	6.680804	24)	6.53002(	6)	6)
Std Dev	2.825081	Variance	7.981081	50% Med	2.235598	90%	5.623398	63)	6.680804(	9)	9)
Skewness	0.813048	Kurtosis	2.124605	25% Q1	0.061056	10%	-0.77801	11)	7.278163(	16)	16)
USS	856.6764	CSS	494.827	0% Min	-3.7564	5%	-1.05724	43)	7.58809(	5)	5)
CV	117.8792	Std Mean	0.355927	Range	16.87568	1%	-3.7564	26)	13.11927(	7)	7)
T:Mean=0	6.733379	Prob> T	0.0001	Q3-Q1	4.139121						
Num = 0	63	Num > 0	49	Mode	-3.7564						
M(Sign)	17.5	Prob> M	0.0001								
Sgn Rank	800	Prob> S	0.0001								

Missing Value
 Count 3
 % Count/Nobs 4.55



----- Bay Segment=2 -----

Univariate Procedure

Variable=RESID

Moments

N	61	Sum Wgts	61
Mean	0.24631	Sum	15.0249
Std Dev	4.584247	Variance	21.01532
Skewness	0.666104	Kurtosis	1.288795
USS	1264.62	CSS	1260.919
CV	1861.171	Std Mean	0.586953
T:Mean=0	0.419642	Prob> T	0.6762
Num = 0	61	Num > 0	27
M(Sign)	-3.5	Prob> M	0.4426
Sgn Rank	-20.5	Prob> S	0.8844

Quantiles(Def=5)

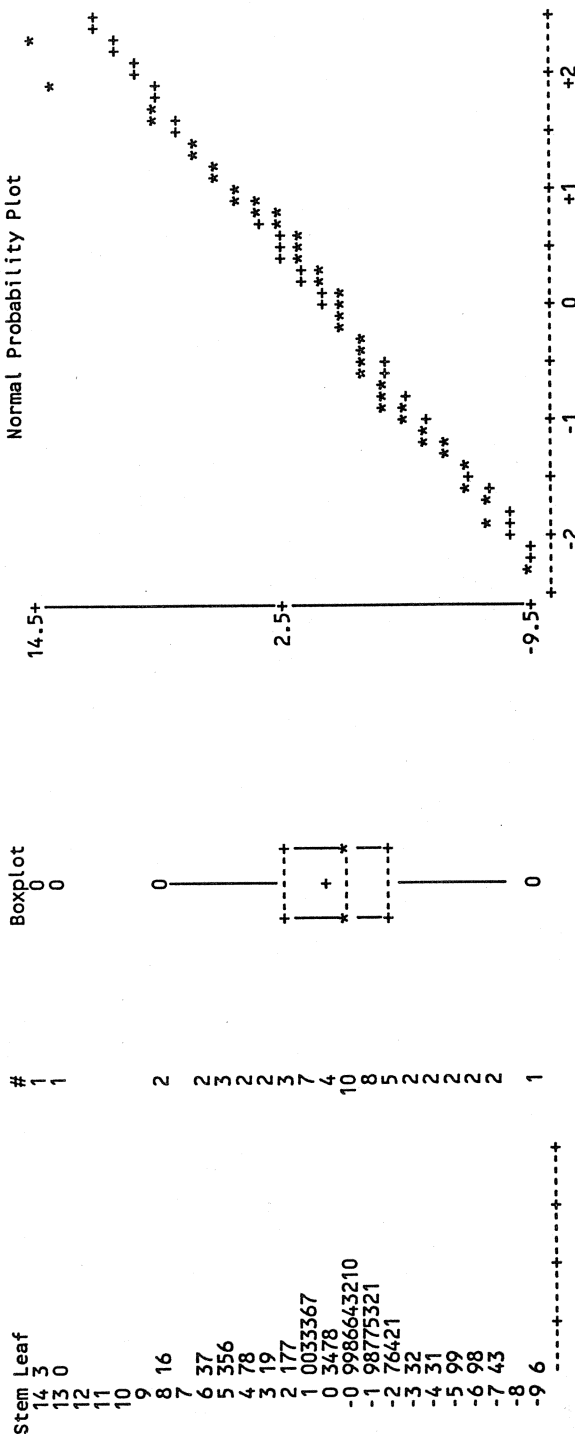
100% Max	14.30698	99%	14.30698
75% Q3	2.099148	95%	8.149178
50% Med	-0.33517	90%	5.588292
25% Q1	-2.08155	10%	-5.87022
0% Min	-9.63473	5%	-6.89307
		1%	-9.63473
Range	23.94171		
Q3-Q1	4.180695		
Mode	-9.63473		

Extremes

Lowest	Obs	Highest	Obs
-9.63473	19)	6.739304	2)
-7.39665	18)	8.149178	12)
-7.3172	21)	8.551022	9)
-6.89307	27)	13.0282	48)
-6.81908	22)	14.30698	40)

Missing Value

Count	1
% Count/Nobs	1.61



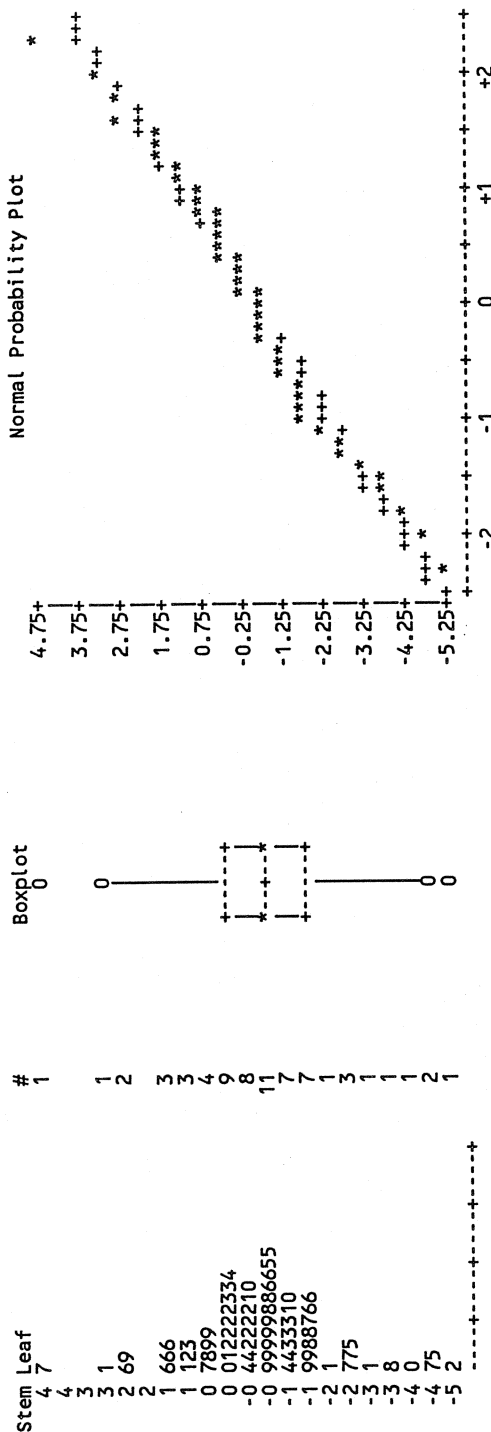
Tampa Bay National Estuary Program - Nutrient Modeling
Monthly EPCHC Data - Arithmetic Mean of All Stations
Model (chla = lastc3n) pooled bay segments (nm-132.sas)

Bay Segment=3

Univariate Procedure

Variable=RESID

Moments				Quantiles(Def=5)				Extremes			
	66	Sum Wgts	66	100% Max	4.683038	99%	4.683038	Obs	Lowest	Highest	Obs
N	-0.59623	Sum	-39.3509	75% Q3	0.252963	95%	0.252963	29)	-5.22897	1.649727	47)
Mean	1.812039	Variance	3.283484	50% Med	-0.55177	90%	1.562811	12)	-4.6792	2.607835	44)
Std Dev	-0.04806	Kurtosis	1.016628	25% q1	-1.57596	10%	-2.71953	11)	-4.49407	2.865077	42)
Skewness	236.8885	CSS	213.4265	0% Min	-5.22897	5%	-3.99871	28)	-3.99871	3.083359	3)
USS	-303.918	Std Mean	0.223047			1%	-5.22897	37)	-3.78551	4.683038	45)
CV	-2.6731	Prob> T	0.0095	Range	9.912007						
T:Mean=0	66	Num>0	23	Q3-Q1	1.828925						
Num=0	-10	Prob> M	0.0187	Mode	-5.22897						
M(Sign)	-429.5	Prob> S	0.0052								
Sgn Rank											

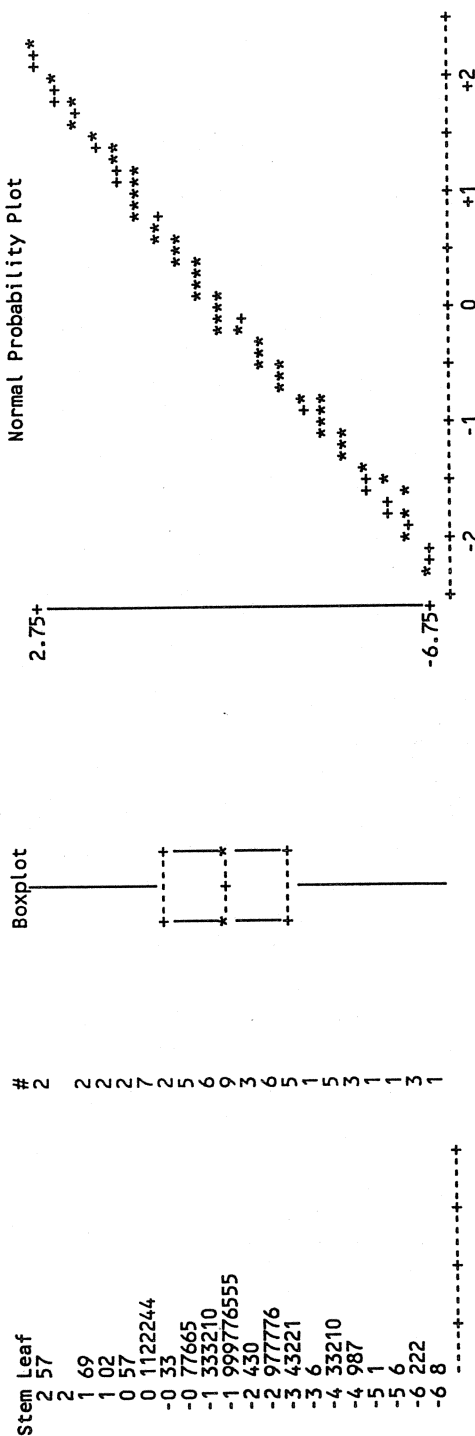


----- Bay Segment=4 -----

Univariate Procedure

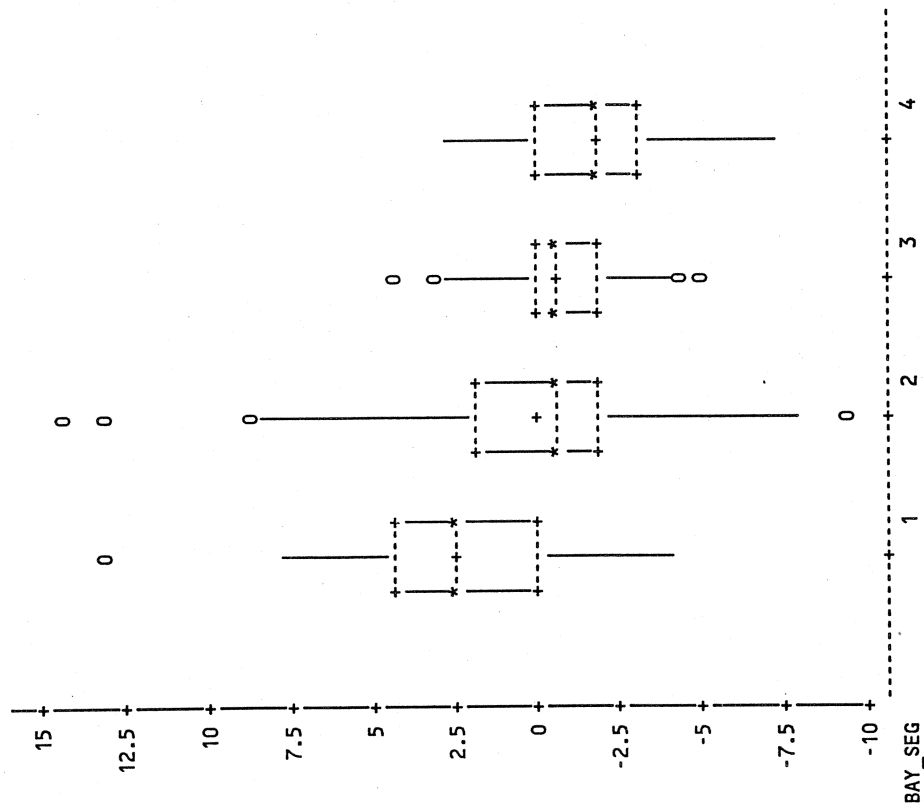
Variable=RESID

Moments		Quantiles(Def=5)		Extremes	
N	66	100% Max	2.715965	99%	2.715965
Mean	-1.91908	75% Q3	-0.30842	95%	1.574451
Std Dev	2.208881	50% Med	-1.6999	90%	0.706667
Skewness	-0.18323	25% Q1	-3.30042	10%	-4.92232
USS	560.2139	0% Min	-6.7806	5%	-6.17085
CV	-115.101	Range	9.496567	1%	-6.7806
T:Mean=0	-7.05817	Q3-Q1	2.991999		
Num = 0	66	Mode	-6.7806		
M(Sign)	-18				
Sgn Rank	-864.5				



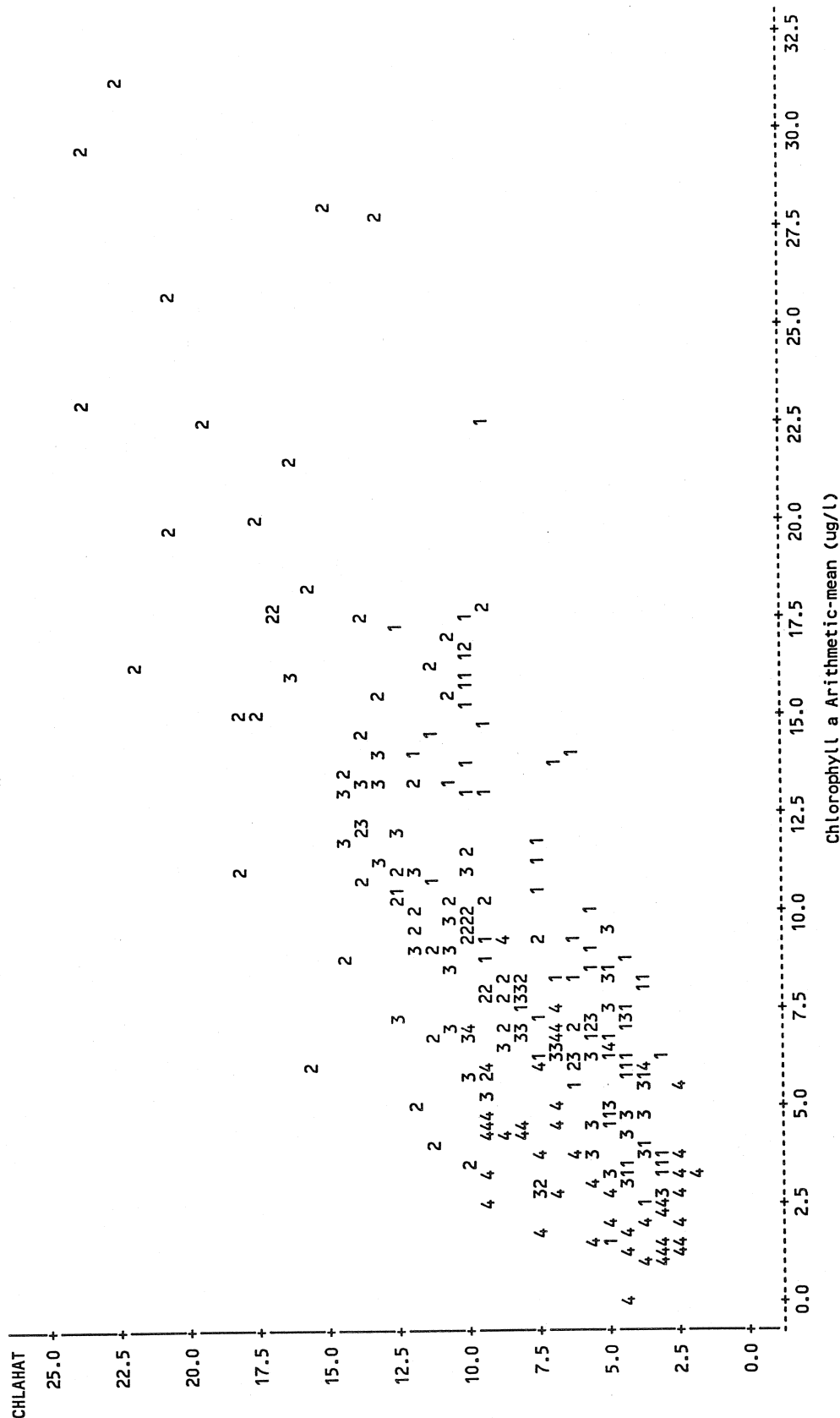
Univariate Procedure
 Schematic Plots

Variable=RESID



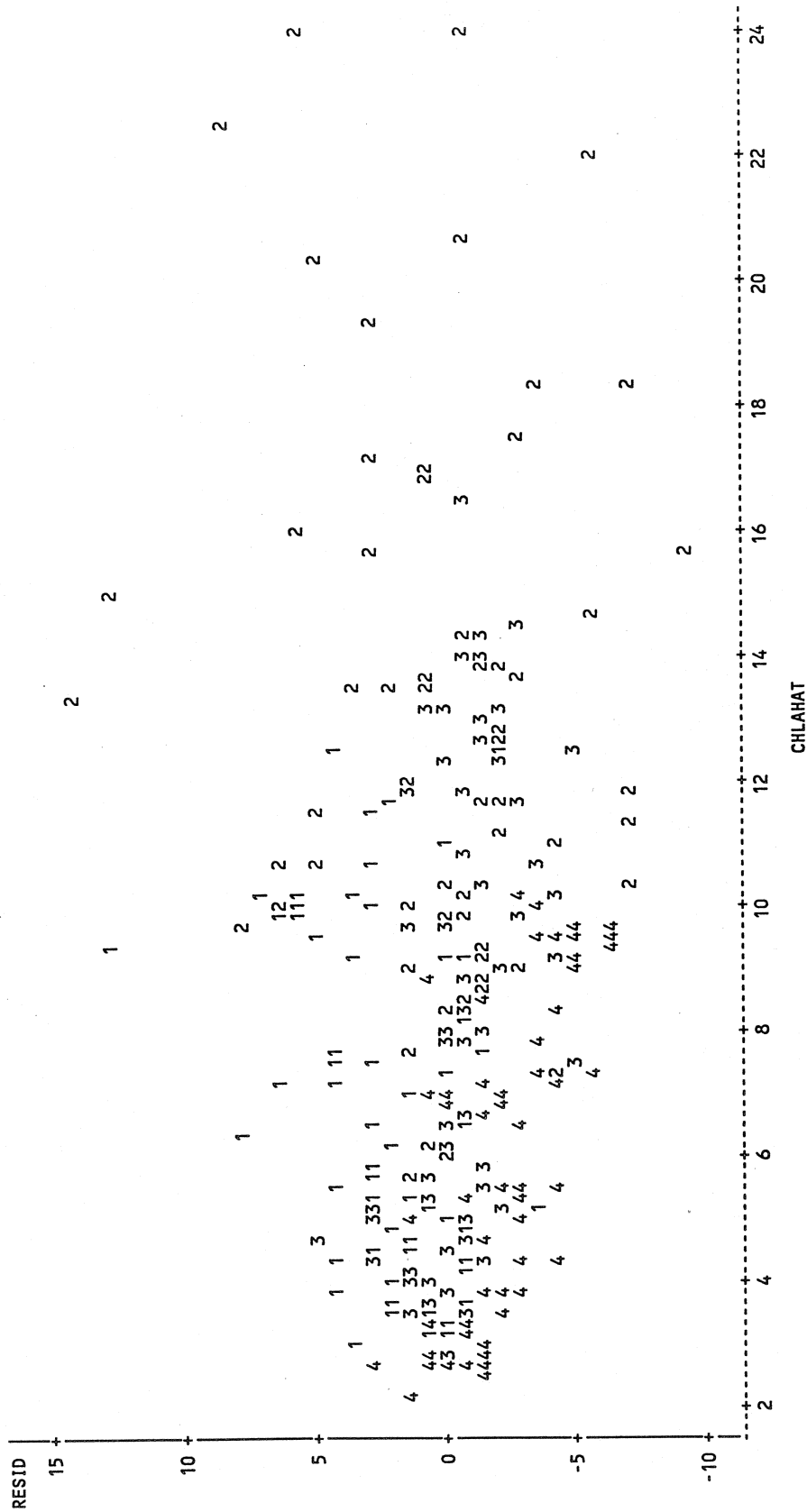
Tampa Bay National Estuary Program - Nutrient Modeling
 Monthly EPCHC Data - Arithmetic Mean of All Stations
 Model (chla = lastc3n) pooled bay segments (nm-132.sas)

Plot of CHLAHAT*CHLA. Symbol is value of BAY_SEG.



NOTE: 4 obs had missing values. 49 obs hidden.

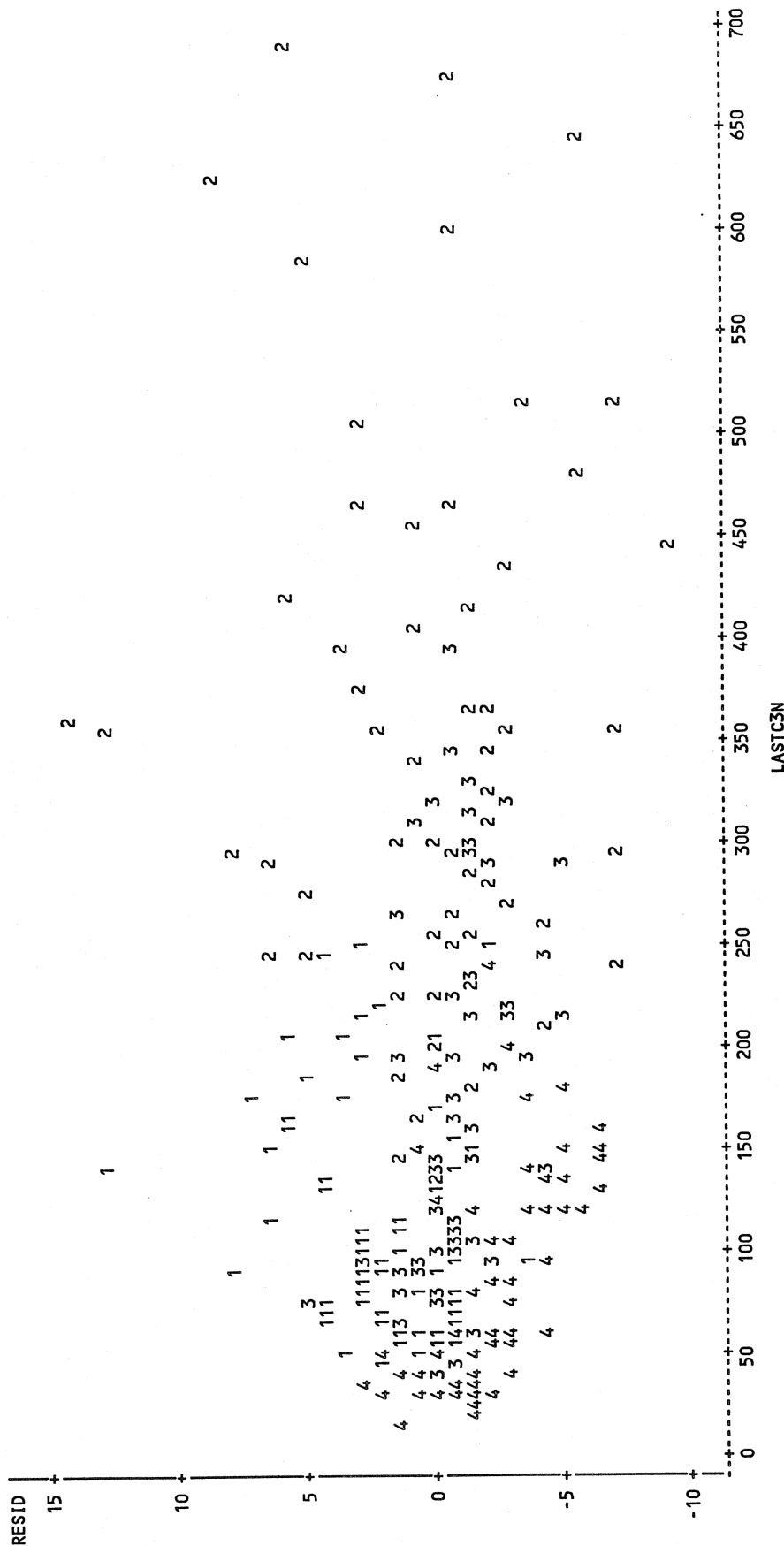
Plot of RESID*CHLAHAT. Symbol is value of BAY_SEG.



NOTE: 4 obs had missing values. 30 obs hidden.

Tampa Bay National Estuary Program - Nutrient Modeling
 Monthly EPCHC Data - Arithmetic Mean of All Stations
 Model (chla = lastc3n) pooled bay segments (nm-132.sas)

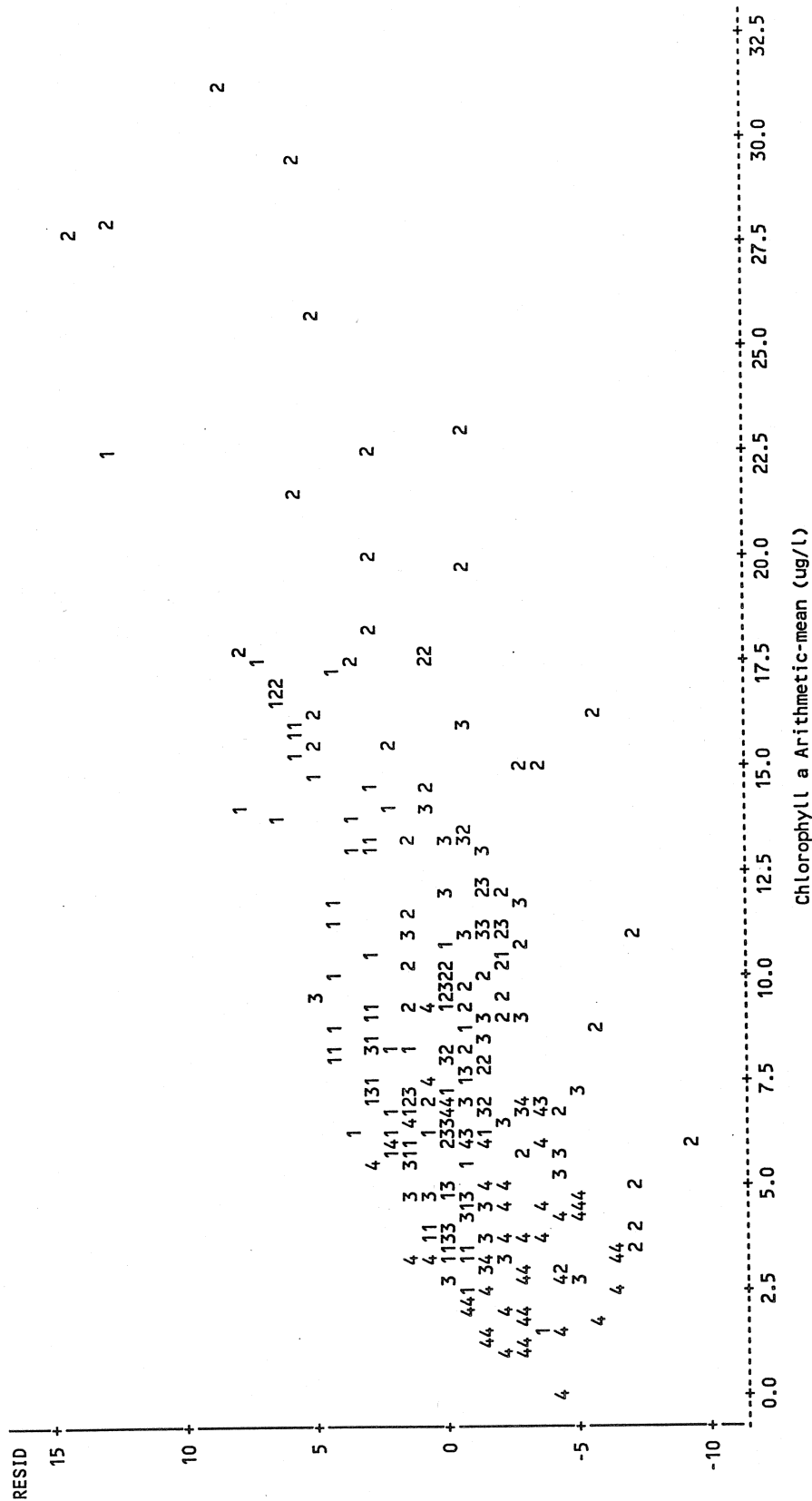
Plot of RESID*LASTC3N. Symbol is value of BAY_SEG.



NOTE: 4 obs had missing values. 35 obs hidden.

Tampa Bay National Estuary Program - Nutrient Modeling
 Monthly EPCHC Data - Arithmetic Mean of All Stations
 Model (chla = lastc3n) pooled bay segments (nm-132.sas)

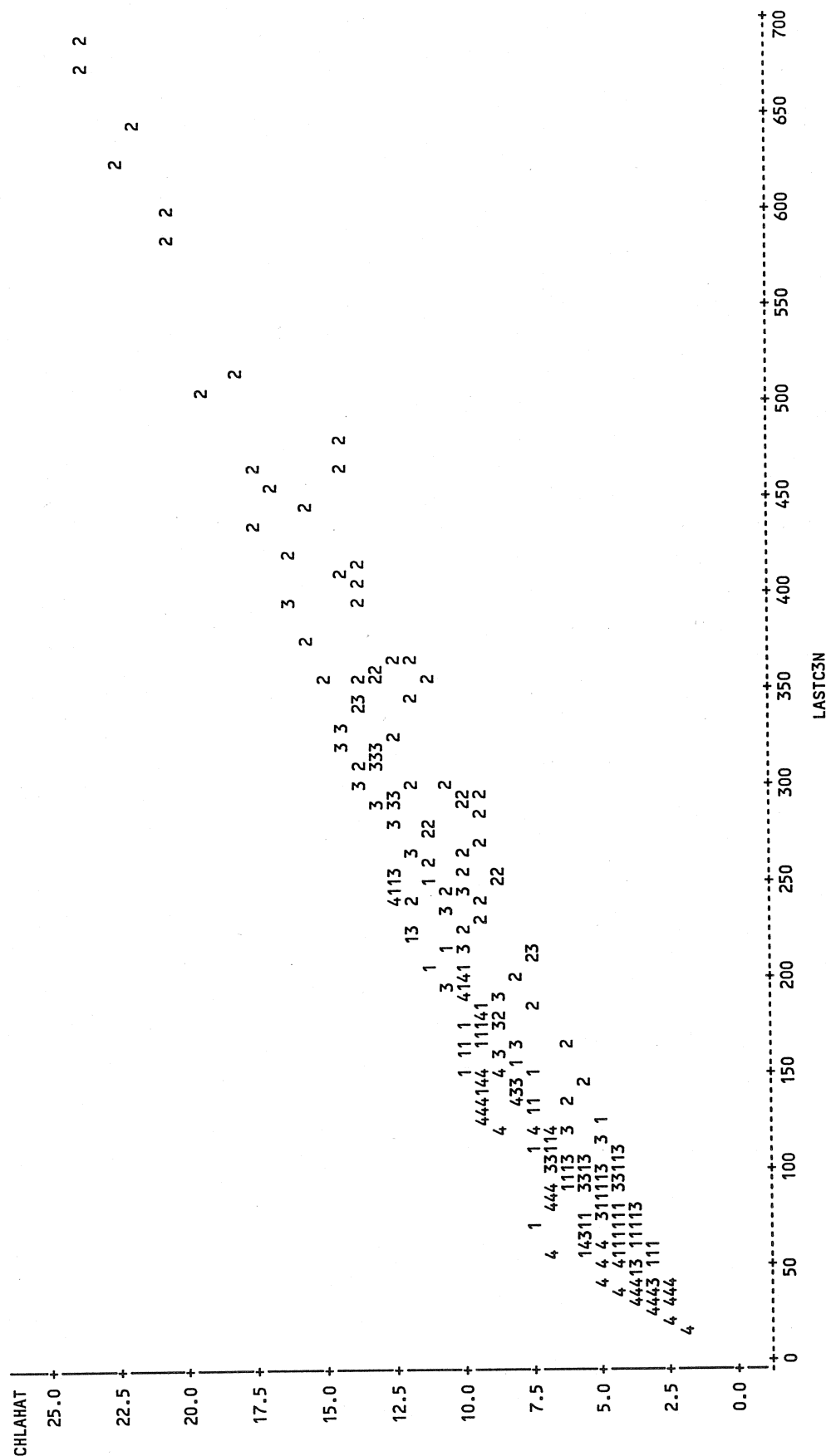
Plot of RESID*CHLA. Symbol is value of BAY_SEG.



NOTE: 4 obs had missing values. 47 obs hidden.

Tampa Bay National Estuary Program - Nutrient Modeling
 Monthly EPCHC Data - Arithmetic Mean of All Stations
 Model (chla = lastc3n) pooled bay segments (nm-132.sas)

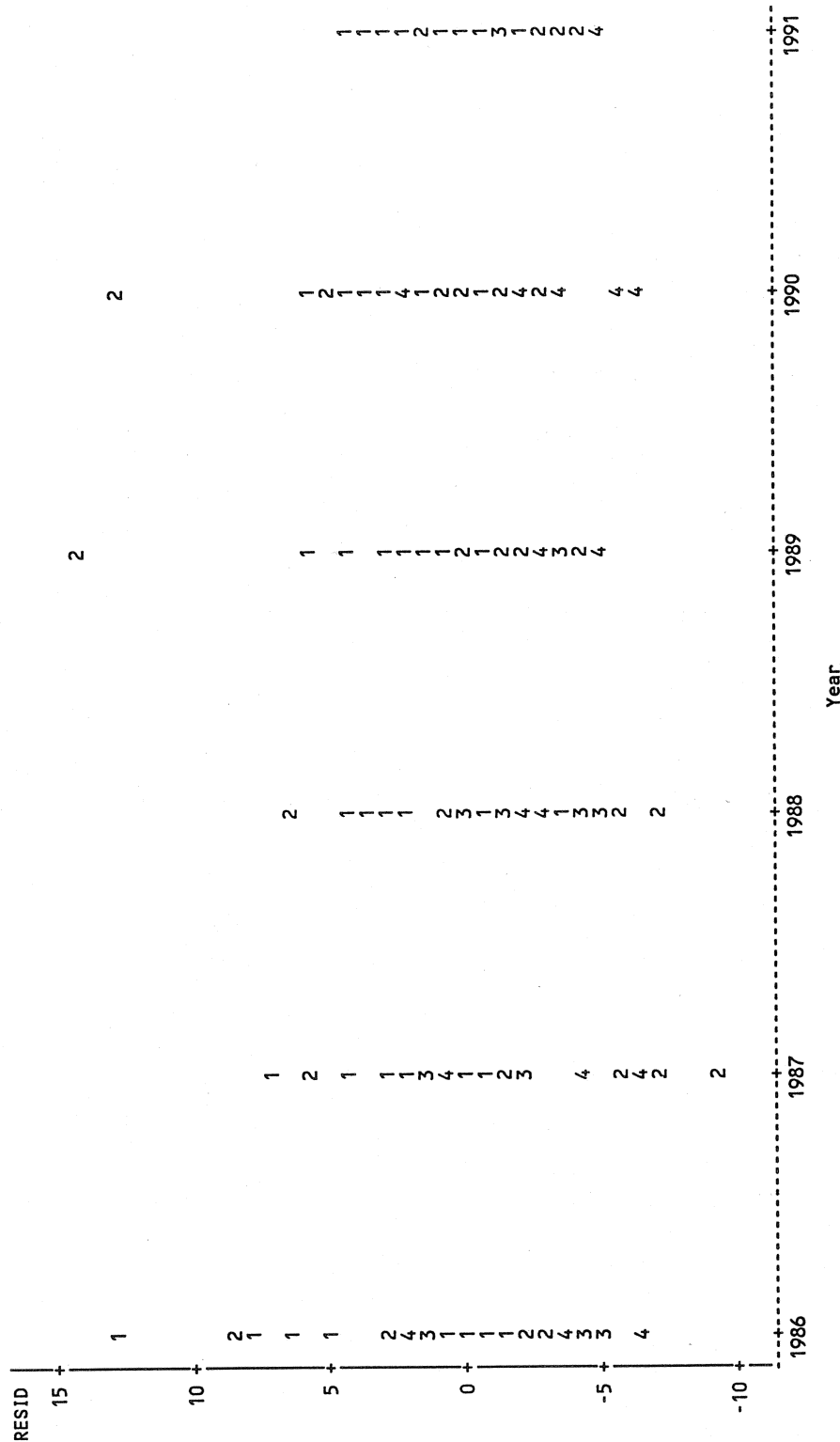
Plot of CHLAHAT*LASTC3N. Symbol is value of BAY_SEG.



NOTE: 72 obs hidden.

Tampa Bay National Estuary Program - Nutrient Modeling
 Monthly EPCHC Data - Arithmetic Mean of All Stations
 Model (chla = lastc3n) pooled bay segments (nm-132.sas)

Plot of RESID*YEAR. Symbol is value of BAY_SEG.



NOTE: 4 obs had missing values. 160 obs hidden.

**APPENDIX B. WATER QUALITY - LIGHT ATTENUATION REGRESSION
DIAGNOSTICS**

[This Appendix is Available from the TBNEP upon Request]

Tampa Bay National Estuary Program - Nutrient Modeling
 EPC Hill. Co. Monthly Data 1974-1991
 Model (Kd = chl a turb) by bay_seg and season (nm-85.sas)
 Arithmetic Mean Chl-a Data from 1974 to 1991

General Linear Models Procedure
 Class Level Information

Class	Levels	Values
BAY_SEG	4	1 2 3 4
MONTH	12	1 2 3 4 5 6 7 8 9 10 11 12

Number of observations in data set = 787

NOTE: Due to missing values, only 764 observations can be used in this analysis.

Tampa Bay National Estuary Program - Nutrient Modeling
 EPC Hill. Co. Monthly Data 1974-1991
 Model (Kd = chl a turb) by bay_seg and season (nm-85.sas)
 Arithmetic Mean Chl-a Data from 1974 to 1991

General Linear Models Procedure

Dependent Variable: KD

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	143	181.49671016	1.26920776	11.47	0.0001
Error	620	68.62866554	0.11069140		
Corrected Total	763	250.12537570			

R-Square	C.V.	Root MSE	KD Mean
0.725623	27.61649	0.33270317	1.20472665

Source	DF	Type I SS	Mean Square	F Value	Pr > F
BAY_SEG*MONTH	47	114.38720215	2.43377026	21.99	0.0001
CHLA(BAY_SEG*MONTH)	48	56.54827140	1.17808899	10.64	0.0001
TURB(BAY_SEG*MONTH)	48	10.56123661	0.22002576	1.99	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
BAY_SEG*MONTH	47	8.98635412	0.19119902	1.73	0.0024
CHLA(BAY_SEG*MONTH)	48	43.13893698	0.89872785	8.12	0.0001
TURB(BAY_SEG*MONTH)	48	10.56123661	0.22002576	1.99	0.0001

Std Error of Estimate

Pr > |T|

T for H0:
Parameter=0

Parameter	Estimate	Std Error of Estimate	Pr > T
INTERCEPT	0.199136609	0.17604816	0.2584
BAY_SEG*MONTH	0.145020146	0.06909	0.6909
	0.111196018	0.32953639	0.7359
	0.268292057	0.30019947	0.3718
	0.113937256	0.29319332	0.6977
	-0.481152075	0.39274322	0.2210
	0.232812054	0.37388117	0.5337
	-0.094859153	0.46423222	0.8382
	0.439203510	0.44271198	0.3215
	1.492028043	0.40718791	0.0003
	0.386643402	0.36546950	0.2905
	0.229913915	0.46457701	0.6209
	0.465378083	0.39074503	0.2341
	0.512301389	0.29495275	0.0829
	-0.040584572	0.28117088	0.8853
	-0.085160482	0.32616208	0.7941
	0.511488008	0.30923184	0.0986
	0.088842689	0.31964558	0.7812
	0.731448256	0.46200166	0.1139
	1.351805084	0.39825513	0.0007
	1.339188903	0.46628609	0.0042

General Linear Models Procedure

Dependent Variable: KD

Parameter	Estimate	T for H0: Parameter=0	Pr > t	Std Error of Estimate
BAY_SEG*MONTH				
2 9	1.611696365	3.64	0.0003	0.44278563
2 10	1.793623110	2.91	0.0037	0.61580030
2 11	1.005428695	2.62	0.0091	0.38433084
2 12	0.640127644	1.90	0.0581	0.33719689
3 1	0.003791039	0.01	0.9913	0.34557397
3 2	0.360858435	1.13	0.2610	0.32072112
3 3	0.451359349	1.53	0.1258	0.29447077
3 4	0.250145390	0.77	0.4418	0.32498060
3 5	-0.349076068	-0.95	0.3415	0.36672213
3 6	0.258409314	0.66	0.5120	0.39383376
3 7	0.366421404	1.01	0.3133	0.36312386
3 8	0.410871934	0.91	0.3618	0.45024431
3 9	0.754631264	1.86	0.0627	0.40475567
3 10	0.358677261	0.90	0.3693	0.39924986
3 11	0.091487156	0.23	0.8155	0.39198025
3 12	0.091478155	0.32	0.7501	0.28705711
4 1	0.167541843	0.53	0.5953	0.31523774
4 2	0.116455892	0.36	0.7194	0.32405031
4 3	0.239597239	0.76	0.4479	0.31551832
4 4	0.091967109	0.30	0.7610	0.30216580
4 5	0.048102438	0.15	0.8791	0.31622450
4 6	0.491280201	1.45	0.1468	0.33820123
4 7	0.284193467	0.85	0.3931	0.33251382
4 8	0.423494049	1.15	0.2501	0.36789888
4 9	-0.048535192	-0.17	0.8628	0.28081089
4 10	0.112809911	0.34	0.7352	0.33340396
4 11	-0.125531310	-0.53	0.7416	0.38049581
4 12	0.000000000			
CHLA(BAY_SEG*MONTH)				
1 1	0.041896638	2.25	0.0251	0.01865432
1 2	0.071891998	1.60	0.1109	0.04502678
1 3	0.077638688	2.28	0.0232	0.03410801
1 4	0.042822626	2.91	0.0037	0.01469953
1 5	0.097389529	3.38	0.0008	0.02881496
1 6	0.038309527	2.14	0.0329	0.01791990
1 7	0.043597538	2.25	0.0246	0.01933507
1 8	0.026995614	1.33	0.1836	0.02027964
1 9	0.027186393	2.01	0.0453	0.01355154
1 10	0.045674418	3.36	0.0008	0.01360888
1 11	0.056621409	3.70	0.0002	0.01531559
1 12	0.021341311	0.90	0.3670	0.02363922
2 1	0.030539939	4.23	0.0001	0.00721783
2 2	0.060123722	5.58	0.0001	0.01078331
2 3	0.042519677	5.21	0.0001	0.00815600
2 4	0.032219524	2.90	0.0038	0.01109687
2 5	0.084336316	5.47	0.0001	0.01542791
2 6	0.037693128	2.35	0.0191	0.01604369
2 7	0.025009597	3.10	0.0020	0.00806555

General Linear Models Procedure

Dependent Variable: KD

Parameter	Estimate	T for H0: Parameter=0	Pr > T	Std Error of Estimate
CHLA(BAY_SEG*MONTH)				
2 8	0.037347427	2.21	0.0277	0.01692981
2 9	0.033131726	2.82	0.0050	0.01175212
2 10	0.020864280	1.40	0.1624	0.01491821
2 11	0.035943497	3.99	0.0001	0.00901542
2 12	0.035508160	4.02	0.0001	0.01330179
3 1	0.060438159	2.21	0.0277	0.02739631
3 2	0.021515636	0.99	0.3232	0.02176242
3 3	0.021964058	1.46	0.1451	0.01505369
3 4	0.043264398	2.88	0.0041	0.01503243
3 5	0.076606520	3.81	0.0002	0.02012486
3 6	0.051193206	2.98	0.0030	0.01719523
3 7	0.019295455	1.48	0.1400	0.01305703
3 8	0.023544812	1.08	0.2817	0.02185295
3 9	0.041262580	2.48	0.0133	0.01662003
3 10	0.080336759	4.86	0.0001	0.01653010
3 11	0.056004324	3.20	0.0014	0.01750631
3 12	0.083440959	3.12	0.0019	0.02677406
4 1	0.062481737	1.16	0.2454	0.05373317
4 2	0.099822390	1.67	0.0950	0.05969641
4 3	0.059963988	1.57	0.1168	0.03817641
4 4	0.065608615	2.22	0.0269	0.02958361
4 5	0.020873035	0.28	0.7758	0.07324276
4 6	0.018030387	0.50	0.6170	0.03603915
4 7	0.022792914	0.59	0.5522	0.03832094
4 8	0.013613283	0.32	0.7482	0.04238122
4 9	0.137211852	4.06	0.0001	0.03382885
4 10	0.076872042	3.13	0.0019	0.02458580
4 11	0.057244691	1.54	0.1234	0.03710590
4 12	0.109867097	2.40	0.0166	0.04573175
1 1	0.059665262	0.75	0.4520	0.07929110
1 2	0.032860552	0.45	0.6506	0.07252680
1 3	0.009609847	0.17	0.8679	0.05774468
1 4	0.088336958	2.55	0.0111	0.03469232
1 5	0.094913622	2.56	0.0108	0.03713571
1 6	0.045034333	1.03	0.3056	0.04391782
1 7	0.088898720	2.00	0.0455	0.04435746
1 8	0.031798360	0.69	0.4912	0.04616348
1 9	-0.129565255	-2.20	0.0283	0.05892393
1 10	0.007152921	0.16	0.8708	0.04396133
1 11	0.030928717	0.24	0.8117	0.12979654
1 12	-0.018644762	-0.26	0.7962	0.07217700
2 1	0.036271102	1.12	0.2622	0.03232110
2 2	0.097355322	2.72	0.0067	0.03579032
2 3	0.093372190	2.78	0.0056	0.03361547
2 4	0.068589667	3.27	0.0011	0.02097119
2 5	0.037563387	1.39	0.1662	0.02709706
2 6	0.024431574	0.76	0.4499	0.03231675
TURB(BAY_SEG*MONTH)				
1 1	0.059665262	0.75	0.4520	0.07929110
1 2	0.032860552	0.45	0.6506	0.07252680
1 3	0.009609847	0.17	0.8679	0.05774468
1 4	0.088336958	2.55	0.0111	0.03469232
1 5	0.094913622	2.56	0.0108	0.03713571
1 6	0.045034333	1.03	0.3056	0.04391782
1 7	0.088898720	2.00	0.0455	0.04435746
1 8	0.031798360	0.69	0.4912	0.04616348
1 9	-0.129565255	-2.20	0.0283	0.05892393
1 10	0.007152921	0.16	0.8708	0.04396133
1 11	0.030928717	0.24	0.8117	0.12979654
1 12	-0.018644762	-0.26	0.7962	0.07217700
2 1	0.036271102	1.12	0.2622	0.03232110
2 2	0.097355322	2.72	0.0067	0.03579032
2 3	0.093372190	2.78	0.0056	0.03361547
2 4	0.068589667	3.27	0.0011	0.02097119
2 5	0.037563387	1.39	0.1662	0.02709706
2 6	0.024431574	0.76	0.4499	0.03231675

General Linear Models Procedure

Dependent Variable: KD

Parameter	Estimate	T for H0: Parameter=0	Pr > T	Std Error of Estimate
TURB(BAY_SEG*MONTH) 2 7	-0.030559153	-0.71	0.4752	0.04277244
2 8	-0.063788452	-1.84	0.0660	0.03464110
2 9	-0.081915247	-2.21	0.0272	0.03700911
2 10	-0.099713125	-1.91	0.0571	0.05231592
2 11	-0.050464914	-1.04	0.2977	0.04841699
2 12	-0.033118614	-0.68	0.4984	0.04888682
3 1	0.066021705	1.06	0.2899	0.06232758
3 2	0.046354882	0.82	0.4112	0.05637121
3 3	0.030143907	0.81	0.4169	0.03710660
3 4	0.057681829	1.28	0.2015	0.04511040
3 5	0.105714457	2.24	0.0253	0.04714509
3 6	0.027102561	0.55	0.5835	0.04940337
3 7	0.068414204	1.26	0.2077	0.05424701
3 8	0.067311781	1.21	0.2270	0.05565597
3 9	-0.018427893	-0.34	0.7349	0.05439193
3 10	-0.055478609	-0.99	0.3239	0.05619793
3 11	0.051145640	0.81	0.4188	0.06321331
3 12	0.015133672	0.27	0.7843	0.0525751
4 1	0.034338496	0.65	0.5181	0.05309834
4 2	0.025725602	0.53	0.5991	0.04890474
4 3	0.029819154	0.62	0.5354	0.04809099
4 4	0.059158957	1.40	0.1620	0.04225481
4 5	0.113195888	1.80	0.0731	0.06304315
4 6	-0.000609827	-0.01	0.9903	0.05009288
4 7	0.041862324	0.68	0.4997	0.06198316
4 8	0.004990192	0.13	0.8941	0.03745752
4 9	-0.044472692	-0.87	0.3866	0.05132678
4 10	0.019866717	0.33	0.7378	0.05931864
4 11	0.095011656	2.19	0.0286	0.04330469
4 12	0.040255956	0.90	0.3663	0.04452741

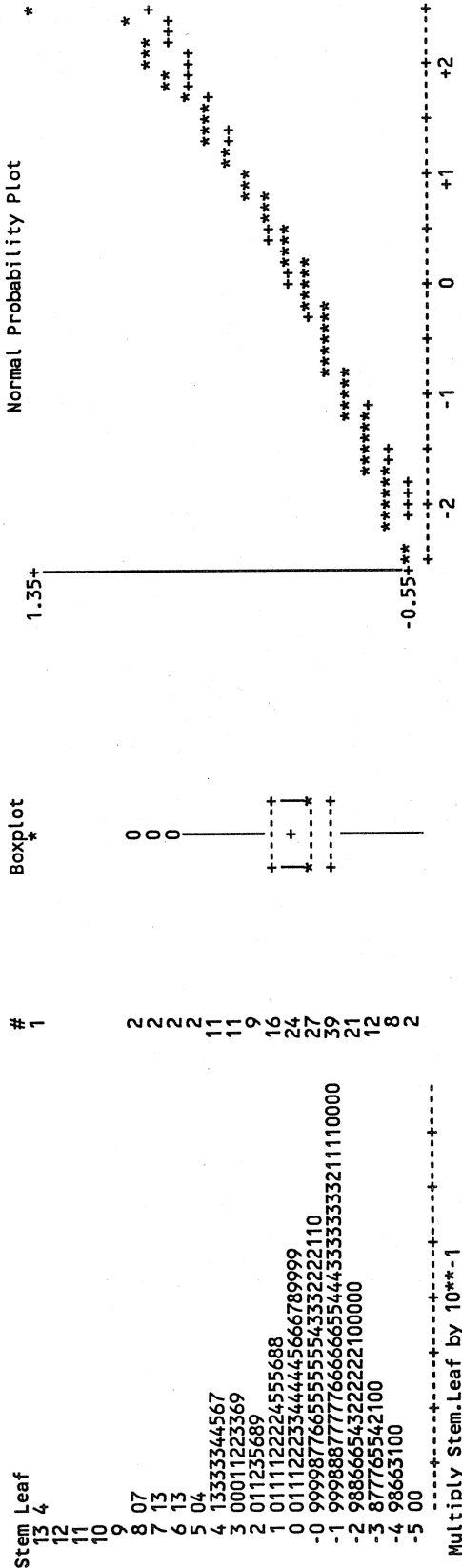
----- Bay Segment=1 -----

Univariate Procedure

Variable=RESID

Moments										Quantiles(Def=5)					Extremes				
	N	Mean	Std Dev	Skewness	USS	CV	T:Mean=0	Num >= 0	M(Sign)	Sgn Rank	100% Max	75% Q3	50% Med	25% Q1	0% Min	Range	Q3-Q1	Mode	
	189	0	0.284584	1.09151	15.2257	0.0207	1.0000	189	-14.5	-964.5	1.335017	0.124765	-0.05082	-0.1809	-0.50211	1.837129	0.305663	-0.50211	Obs
								80			99%	95%	90%	10%	5%	1%			Obs
											0.866713	0.470799	0.425414	-0.31597	-0.39692	-0.50134			
											Obs	Obs	Obs	Obs	Obs	Obs			
											189	189	189	189	189	189			
											0.714647	0.731785	0.796231	0.866713	1.335017				
											68)	32)	62)	53)	64)				

Missing Value
 Count 7
 % Count/Nobs 3.57



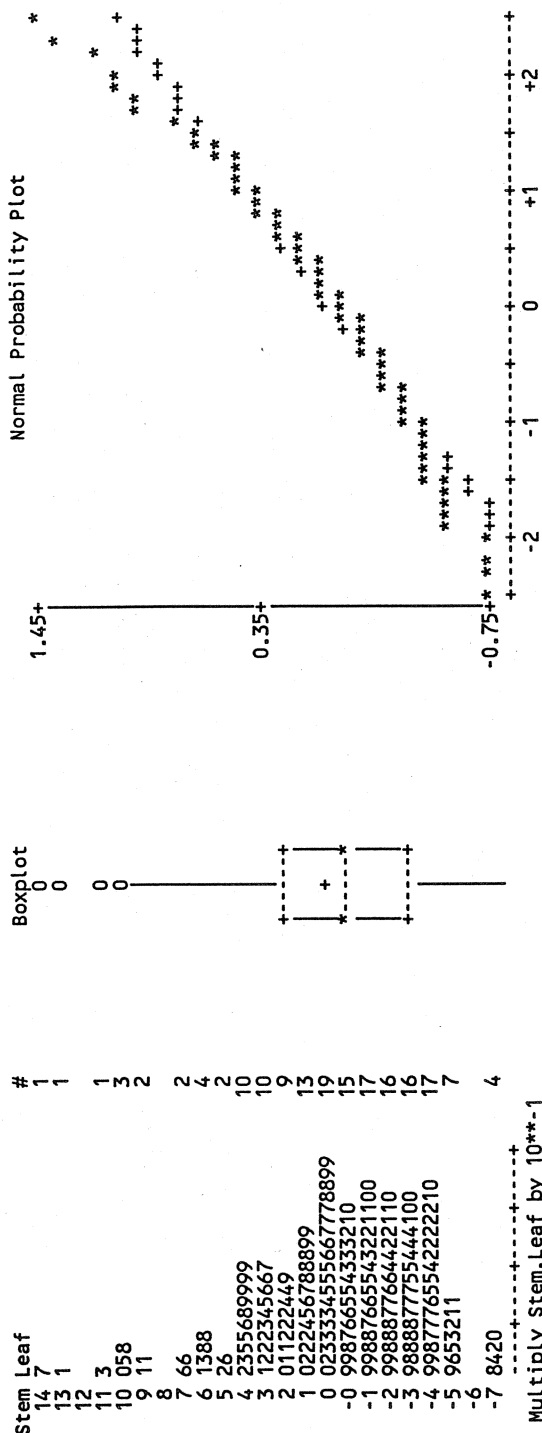
Bay Segment=2

Univariate Procedure

Variable=RESID

Moments				Quantiles(Def=5)				Extremes			
N	169	Sum Wgts	169	100% Max	1.4677	99%	1.308462	Lowest	Obs	Highest	Obs
Mean	0	Sum	0	75% Q3	0.212333	95%	0.763289	-0.78328	8)	1.049789	(47)
Std Dev	0.41344	Variance	0.170933	50% Med	-0.0545	90%	0.492188	-0.74163	9)	1.082483	(59)
Skewness	0.88263	Kurtosis	0.991404	25% Q1	-0.30419	10%	-0.46681	-0.71579	133)	1.126844	(33)
USS	28.71667	CSS	28.71667	0% Min	-0.78328	5%	-0.51891	-0.70467	180)	1.308462	(56)
CV	0.031803	Std Mean	0.031803	Range	2.250984	1%	-0.74163	-0.59223	158)	1.4677	(55)
T:Mean=0	0	Prob> T	1.0000	Q3-Q1	0.516525						
Num = 0	169	Num > 0	77	Mode	-0.78328						
M(Sign)	-7.5	Prob> M	0.2815								
Sgn Rank	-635.5	Prob> S	0.3199								

Missing Value
 Count 14
 % Count/Nobs 7.65



Multiply Stem.Leaf by 10**-1

Bay Segment=3

Univariate Procedure

Variable=RESID

Moments

N	207	Sum Wgts	207
Mean	0	Sum	0
Std Dev	0.294125	Variance	0.086509
Skewness	1.209453	Kurtosis	3.764031
USS	17.82096	CSS	17.82096
CV	0.020443	Std Mean	0.020443
T:Mean=0	0	Prob> T	1.0000
Num = 0	207	Num > 0	87
M(Sign)	-16.5	Prob> M	0.0259
Sgn Rank	-1083	Prob> S	0.2102

Quantiles(Def=5)

100% Max	1.537031	99%	0.84204
75% Q3	0.139213	95%	0.50414
50% Med	-0.04608	90%	0.375937
25% Q1	-0.18916	10%	-0.31038
0% Min	-0.67159	5%	-0.42989
		1%	-0.55986
Range	2.208619		
Q3-Q1	0.328368		
Mode	-0.67159		

Extremes

Lowest	Obs	Highest	Obs
-0.67159	99	0.761903	56
-0.59827	22	0.802741	55
-0.55986	138	0.84204	40
-0.51001	32	1.002544	57
-0.4871	17	1.537031	69

Stem Leaf

```

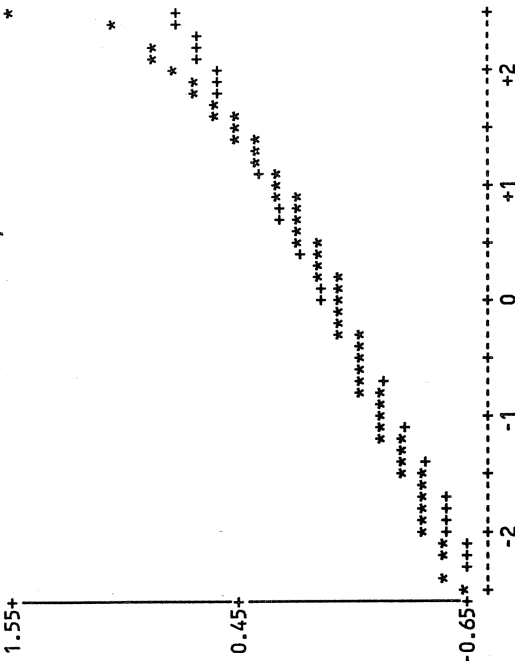
15 4
14
13
12
11
10 0
9
8 04
7 6
6 337
5 0033
4 0003899
3 3445689
2 0024456667888
1 0111122333444455556667889
0 0011223334444555667788889
-0 98888777776665555554444333222111
-1 999998776655555444332221100000
-2 998775544433333221100000
-3 76633211000
-4 977554331
-5 61
-6 70
    
```

Multiply Stem Leaf by 10**-1

Boxplot

#	Boxplot
1	
1	0
2	0
1	0
3	0
4	
7	
13	
25	
23	
38	
33	
25	
11	
9	
2	

Normal Probability Plot



Bay Segment=4

Univariate Procedure

Variable=RESID

Moments

N 199 0 Sum Wgts 199 0
 Mean 0.186208 Sum 0.034673
 Std Dev 0.336627 Variance 0.235166
 Skewness 6.86533 Kurtosis 6.86533
 USS 0.0132
 CV 1.0000
 T:Mean=0 Prob>|T|
 Num = 0 199 Num > 0 87
 M(Sign) -12.5 Prob>|M| 0.0886
 Sgn Rank -610 Prob>|S| 0.4547

Quantiles(Def=5)

100% Max 0.519365 99% 0.449434
 75% Q3 0.096617 95% 0.370053
 50% Med -0.02229 90% 0.270691
 25% Q1 -0.1163 10% -0.19789
 0% Min -0.46918 5% -0.30143
 1% -0.46178

Range 0.98855
 Q3-Q1 0.212915
 Mode -0.46918

Missing Value
 Count 2
 % Count/Nobs 1.00

Extremes

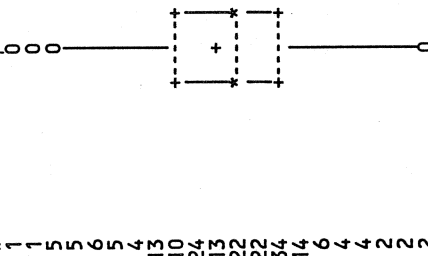
Lowest Obs Highest Obs
 -0.46918(21) 0.408514(74)
 -0.46178(112) 0.425938(62)
 -0.41997(1) 0.435753(70)
 -0.41925(170) 0.449434(69)
 -0.3467(31) 0.519365(57)

Stem Leaf

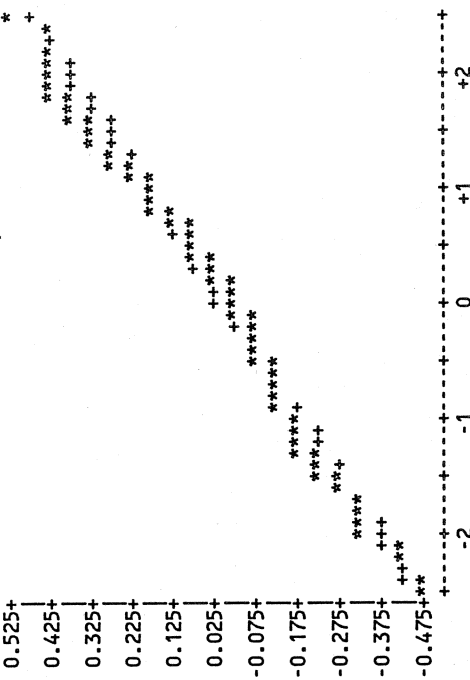
5 2
 4 5
 4 01134
 3 55799
 3 012224
 2 56679
 2 0133
 1 5556667788889
 1 0011122234
 0 55555666778888888899999
 0 0111233444444
 -0 444443322222222111100
 -0 99888888777777666665
 -1 44433333322222111111000000000
 -1 9987766555555
 -2 433320
 -2 9977
 -3 4300
 -3 55
 -4 22
 -4 76

Multiply Stem Leaf by 10**-1

Boxplot



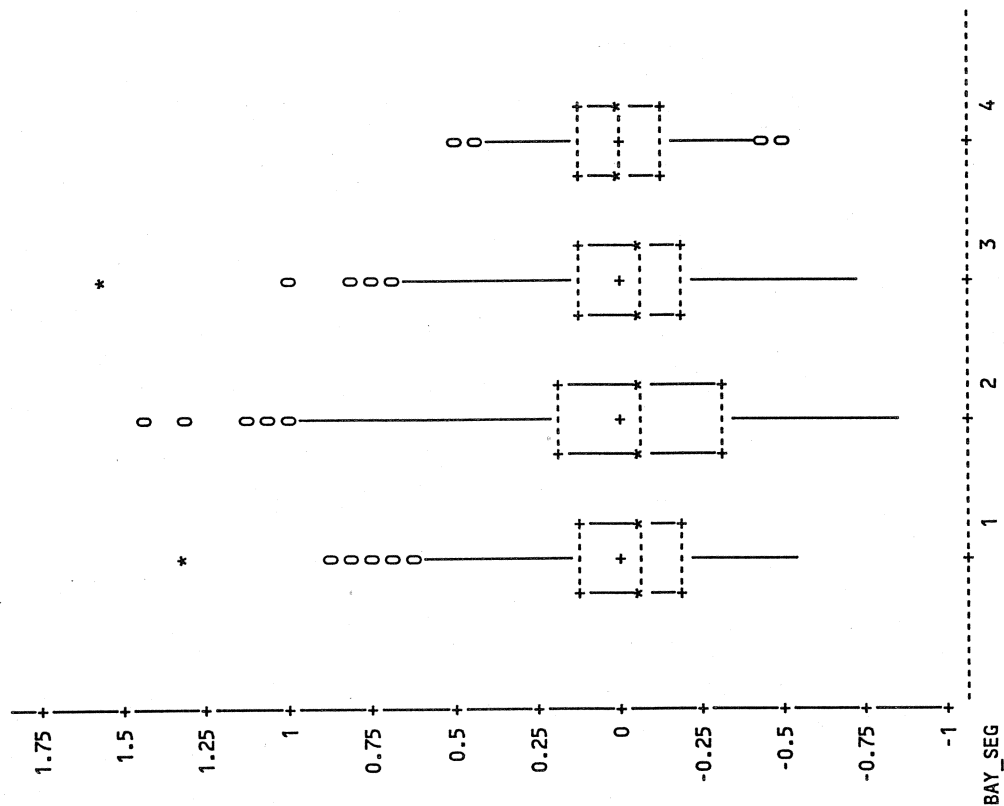
Normal Probability Plot



Tampa Bay National Estuary Program - Nutrient Modeling
 EPC Hill. Co. Monthly Data 1974-1991
 Model (Kd = chl-a turb) by bay_seg and season (nm-85.sas)
 Arithmetic Mean Chl-a Data from 1974 to 1991

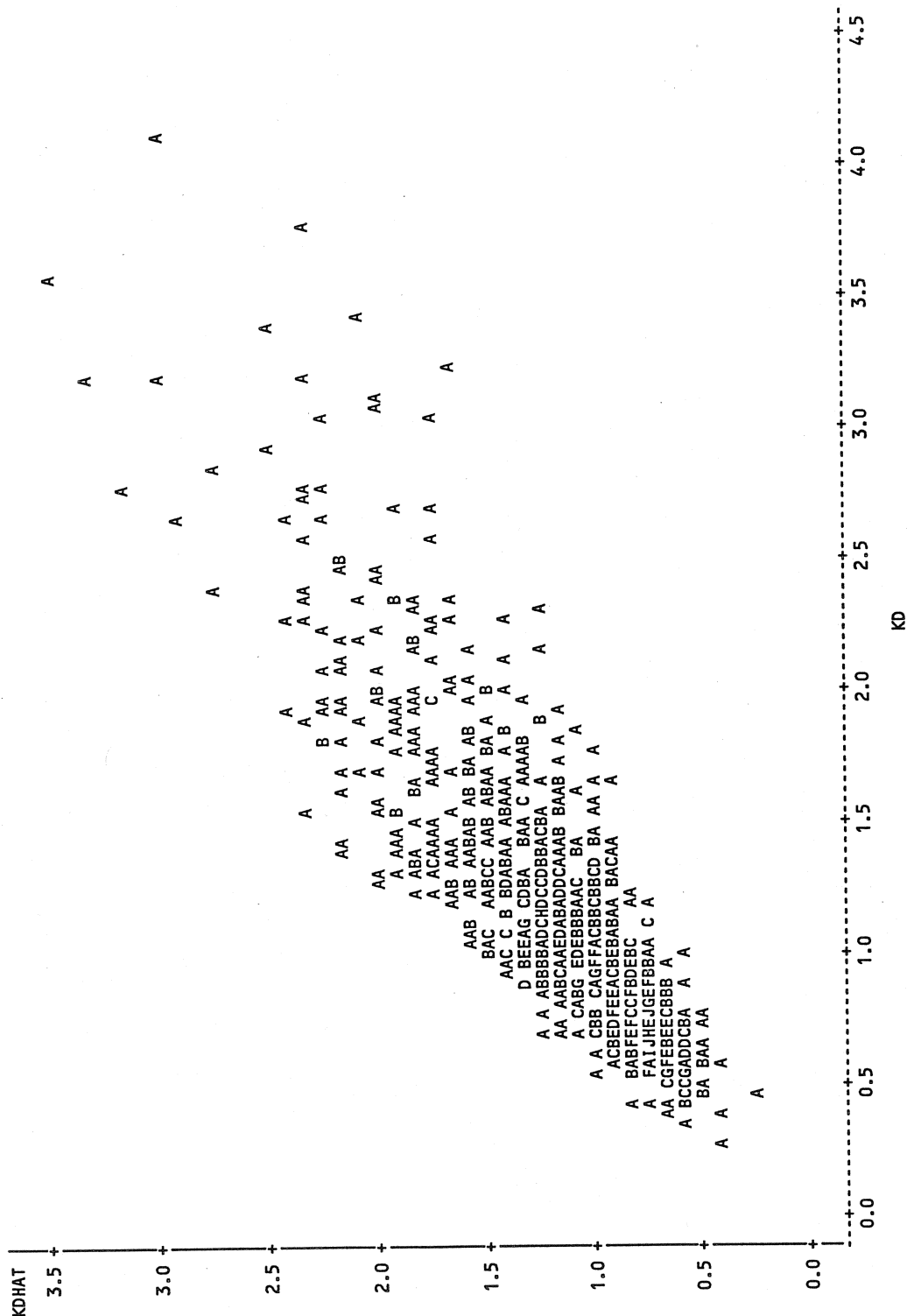
Univariate Procedure
 Schematic Plots

Variable=RESID



Tampa Bay National Estuary Program - Nutrient Modeling
EPC Hill. Co. Monthly Data 1974-1991
Model (Kd = chl a turb) by bay_seg and season (nm-85.sas)

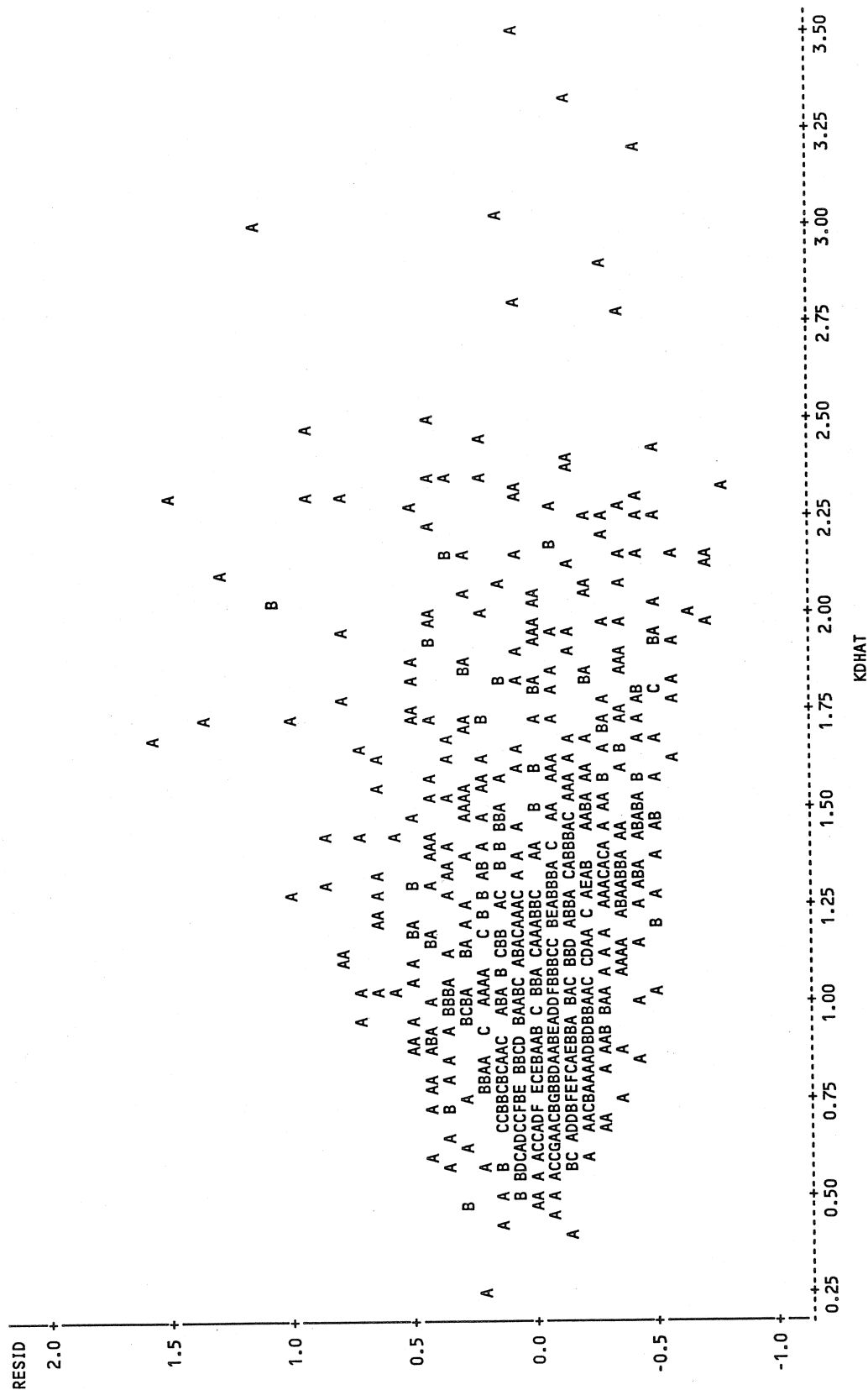
Plot of KDHAT*KD. Legend: A = 1 obs, B = 2 obs, etc.



NOTE: 23 obs had missing values.

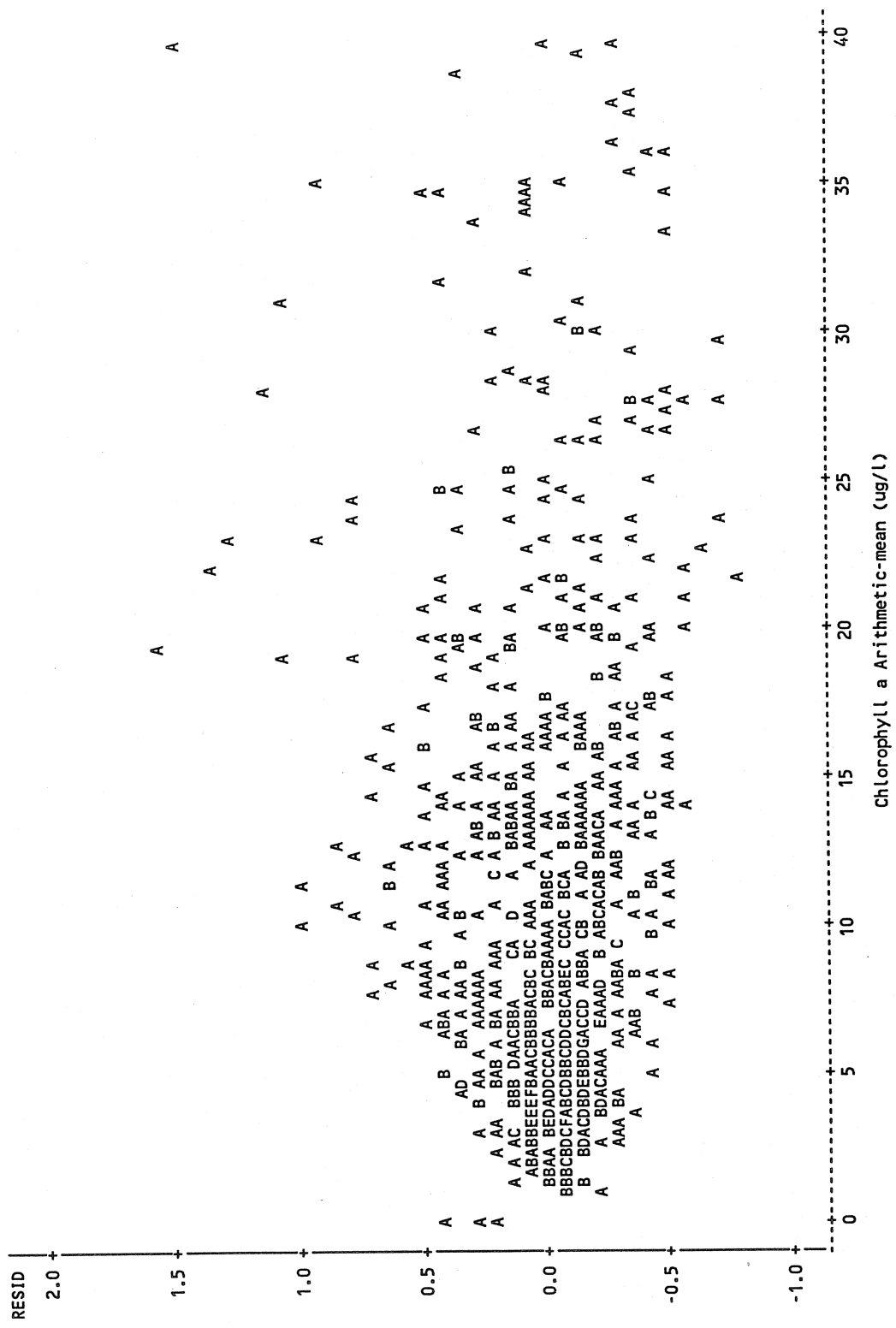
Tampa Bay National Estuary Program - Nutrient Modeling
EPC Hill. Co. Monthly Data 1974-1991
Model (Kd = chl a turb) by bay_seg and season (nm-85.sas)

Plot of RESID*KDHAT. Legend: A = 1 obs, B = 2 obs, etc.



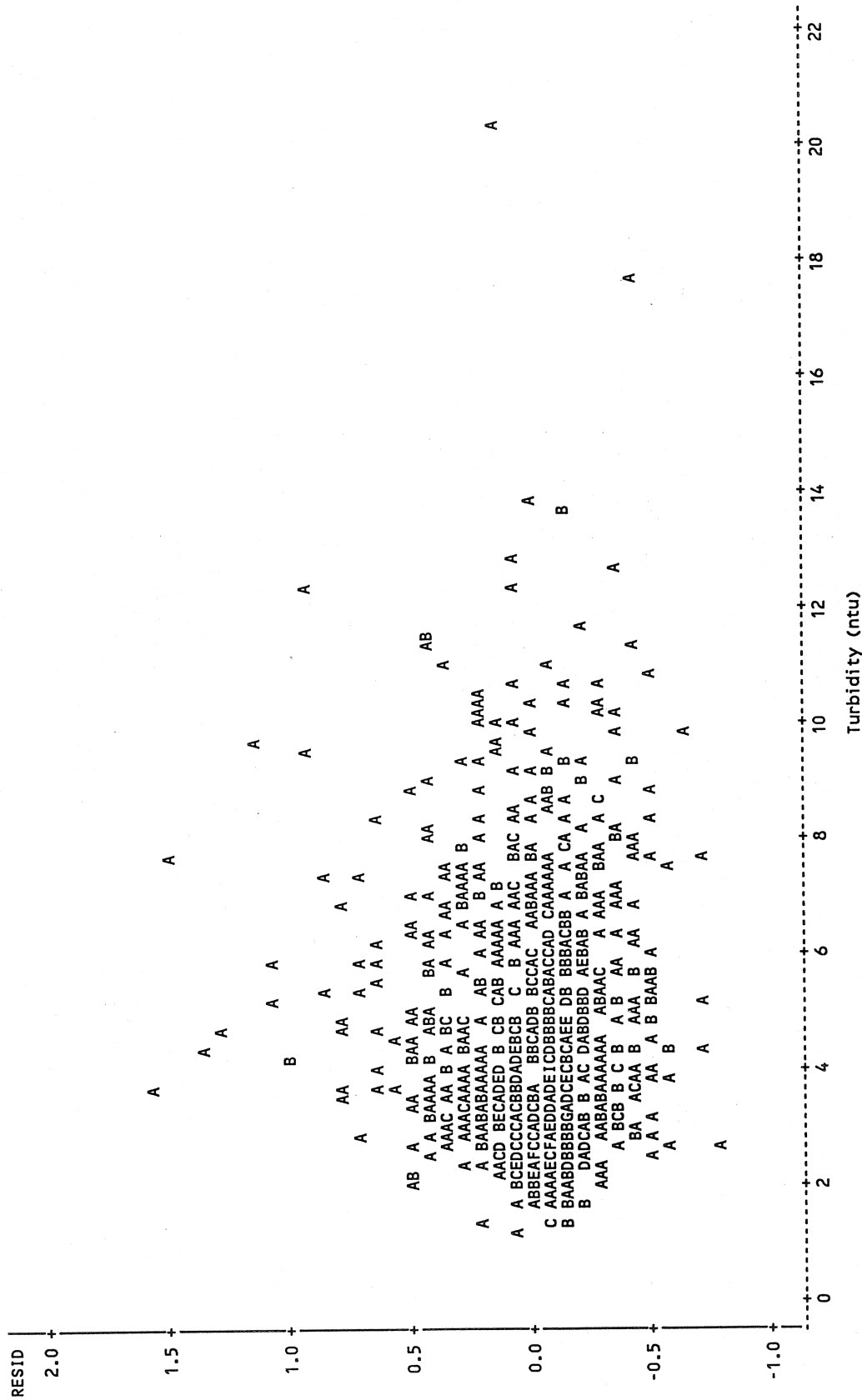
NOTE: 23 obs had missing values.

Plot of RESID*CHLA. Legend: A = 1 obs, B = 2 obs, etc.



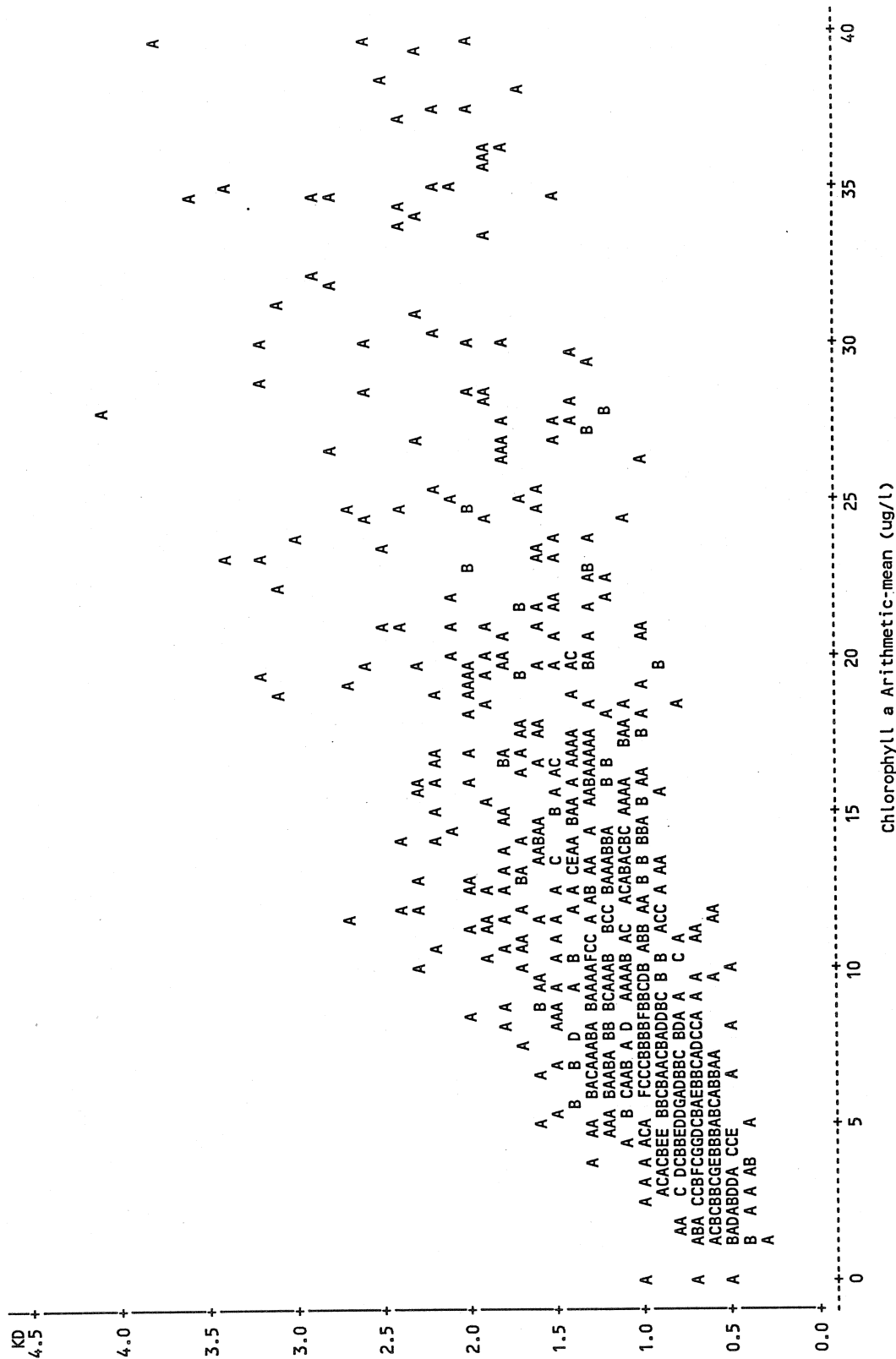
NOTE: 23 obs had missing values.

Plot of RESID*TURB. Legend: A = 1 obs, B = 2 obs, etc.



NOTE: 23 obs had missing values.

Plot of KD*CHLA. Legend: A = 1 obs, B = 2 obs, etc.



**APPENDIX C. UPDATED MODEL - WATER QUALITY - LIGHT ATTENUATION
REGRESSION DIAGNOSTICS**

[This Appendix is Available from the TBNEP upon Request]

Symbology Note: “*” symbols represent predicted values.
 “o” symbols represent observed values.

Segment (TBNEP)=1

Model: MODEL1

NOTE: No intercept in model. R-square is redefined.

Dependent Variable: LOGCHLA ln(Chlorophyll a) (ln(ug/l))

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	13	435.02429	33.46341	377.844	0.0001
Error	84	7.43938	0.08856		
U Total	97	442.46367			

Root MSE 0.29760 R-square 0.9832
 Dep Mean 2.06220 Adj R-sq 0.9806
 C.V. 14.43102

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > T	Variable Label
ALPHA_1	1	2.418153	0.15877667	15.230	0.0001	
ALPHA_2	1	2.261594	0.14672557	15.414	0.0001	
ALPHA_3	1	1.983631	0.14469145	13.709	0.0001	
ALPHA_4	1	2.264788	0.12337227	18.357	0.0001	
ALPHA_5	1	2.490205	0.12654300	19.679	0.0001	
ALPHA_6	1	2.560667	0.11523402	22.221	0.0001	
ALPHA_7	1	2.824169	0.11154765	25.318	0.0001	
ALPHA_8	1	2.908023	0.12165969	23.903	0.0001	
ALPHA_9	1	2.980764	0.11622729	25.646	0.0001	
ALPHA_10	1	2.962502	0.11582383	25.578	0.0001	
ALPHA_11	1	2.579637	0.14018646	18.401	0.0001	
ALPHA_12	1	2.562548	0.15336040	16.709	0.0001	
LOGZ	1	-0.945079	0.14238423	-6.638	0.0001	ln(Z) (ln(m))

----- Segment (TBNEP)=2 -----

Model: MODEL1

NOTE: No intercept in model. R-square is redefined.

Dependent Variable: LOGCHLA ln(Chlorophyll a) (ln(ug/l))

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	13	628.46432	48.34341	328.448	0.0001
Error	88	12.93247	0.14719		
U Total	101	641.41680			
Root MSE	0.38365	R-square	0.9798		
Dep Mean	2.44585	Adj R-sq	0.9768		
C.V.	15.68577				

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > T	Variable Label
ALPHA_1	1	2.418899	0.14872476	16.264	0.0001	
ALPHA_2	1	2.322886	0.13829581	16.797	0.0001	
ALPHA_3	1	2.367400	0.13850641	17.092	0.0001	
ALPHA_4	1	2.453457	0.13686534	17.926	0.0001	
ALPHA_5	1	2.524560	0.13780377	18.320	0.0001	
ALPHA_6	1	2.597877	0.12820745	20.263	0.0001	
ALPHA_7	1	2.828987	0.12788508	22.121	0.0001	
ALPHA_8	1	2.906138	0.12805584	22.694	0.0001	
ALPHA_9	1	3.120207	0.13564209	23.003	0.0001	
ALPHA_10	1	2.945701	0.13748726	21.425	0.0001	
ALPHA_11	1	2.812084	0.15103349	18.619	0.0001	
ALPHA_12	1	2.536983	0.13952713	18.183	0.0001	
LOGZ	1	-1.233902	0.16355827	-7.544	0.0001	ln(Z) (ln(m))

Segment (TBNEP)=4

Model: MODEL1

NOTE: No intercept in model. R-square is redefined.

Dependent Variable: LOGCHLA ln(Chlorophyll a) (ln(ug/l))

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	13	192.89206	14.83785	141.258	0.0001
Error	85	8.92848	0.10504		
U Total	98	201.82054			
Root MSE	0.32410	R-square	0.9558		
Dep Mean	1.32272	Adj R-sq	0.9490		
C.V.	24.50250				

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > T	Variable Label
ALPHA_1	1	1.857134	0.16063590	11.561	0.0001	
ALPHA_2	1	1.666839	0.15992499	10.423	0.0001	
ALPHA_3	1	1.666225	0.15197333	10.964	0.0001	
ALPHA_4	1	1.806398	0.16040078	11.262	0.0001	
ALPHA_5	1	2.319970	0.17403952	13.330	0.0001	
ALPHA_6	1	2.179042	0.15244513	14.294	0.0001	
ALPHA_7	1	2.243766	0.15332109	14.634	0.0001	
ALPHA_8	1	2.543455	0.14913433	17.055	0.0001	
ALPHA_9	1	2.550106	0.14099650	18.086	0.0001	
ALPHA_10	1	2.450963	0.13730503	17.850	0.0001	
ALPHA_11	1	2.252719	0.14464752	15.574	0.0001	
ALPHA_12	1	1.931588	0.16649626	11.601	0.0001	
LOGZ	1	-1.034516	0.13490064	-7.669	0.0001	ln(Z) (ln(m))

Tampa Bay National Estuary Program - Nutrient Modeling
 EPC Hill. Co. Monthly Data 1986-1994
 Light Extinction Model (nm-850.sas)

----- Segment (TBNEP)=31 -----

Model: MODEL1

NOTE: No intercept in model. R-square is redefined.

Dependent Variable: LOGCHLA ln(Chlorophyll a) (ln(ug/l))

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	13	493.68441	37.97572	235.714	0.0001
Error	89	14.33874	0.16111		
U Total	102	508.02315			
Root MSE	0.40138	R-square	0.9718		
Dep Mean	2.16028	Adj R-sq	0.9677		
C.V.	18.58020				

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > T	Variable Label
ALPHA_1	1	2.233313	0.15739972	14.189	0.0001	
ALPHA_2	1	1.913564	0.14845549	12.890	0.0001	
ALPHA_3	1	2.018789	0.14530609	13.893	0.0001	
ALPHA_4	1	2.142989	0.14332835	14.952	0.0001	
ALPHA_5	1	2.22451	0.14792191	15.024	0.0001	
ALPHA_6	1	2.293117	0.13403241	17.109	0.0001	
ALPHA_7	1	2.672226	0.13420561	19.911	0.0001	
ALPHA_8	1	2.585887	0.13401296	19.296	0.0001	
ALPHA_9	1	2.679515	0.14196664	18.874	0.0001	
ALPHA_10	1	2.543533	0.14218453	17.889	0.0001	
ALPHA_11	1	2.403196	0.14910870	16.117	0.0001	
ALPHA_12	1	2.113043	0.14847709	14.231	0.0001	
LOGZ	1	-0.851002	0.16724387	-5.088	0.0001	ln(Z) (ln(m))

----- Segment (TBNEP)=32 -----

NOTE: No intercept in model. R-square is redefined.

Model: MODEL1
NOTE: No intercept in model. R-square is redefined.
Dependent Variable: LOGCHLA $\ln(\text{Chlorophyll a})$ ($\ln(\mu\text{g/L})$)

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > T	Variable Label
ALPHA_1	1	2.277135	0.21621797	10.532	0.0001	
ALPHA_2	1	2.243021	0.19417749	11.551	0.0001	
ALPHA_3	1	1.956756	0.19247529	10.166	0.0001	
ALPHA_4	1	2.133773	0.17021979	12.535	0.0001	
ALPHA_5	1	2.397686	0.17322762	13.841	0.0001	
ALPHA_6	1	2.306628	0.16518036	13.964	0.0001	
ALPHA_7	1	2.667167	0.16288480	16.375	0.0001	
ALPHA_8	1	2.605687	0.16123659	16.161	0.0001	
ALPHA_9	1	2.697188	0.15279378	17.652	0.0001	
ALPHA_10	1	2.745506	0.15950353	17.213	0.0001	
ALPHA_11	1	2.500870	0.16373029	15.274	0.0001	
ALPHA_12	1	2.299491	0.19534274	11.593	0.0001	
LOGZ	1	-0.998197	0.18556745	-5.379	0.0001	ln(Z) ln(m)

----- Segment (TBNEP)=33 -----

Model: MODEL1

NOTE: No intercept in model. R-square is redefined.

Dependent Variable: LOGCHLA ln(Chlorophyll a) (ln(ug/l))

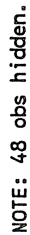
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	13	270.26406	20.78954	155.234	0.0001
Error	86	11.51749	0.13392		
U Total	99	281.78156			

Root MSE	0.36596	R-square	0.9591
Dep Mean	1.54806	Adj R-sq	0.9529
C.V.	23.63971		

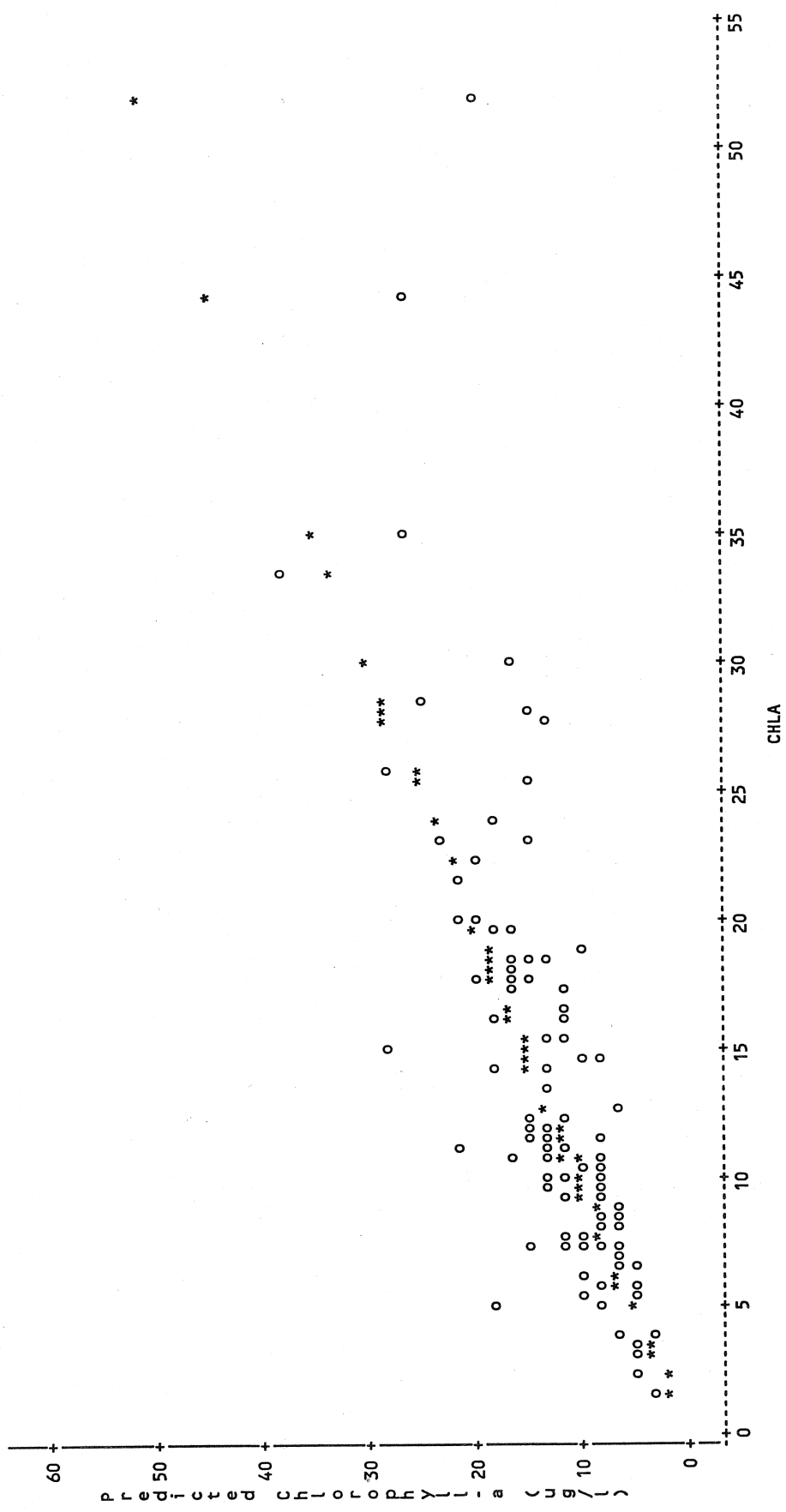
Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > T	Variable Label
ALPHA_1	1	2.165249	0.17725103	12.216	0.0001	
ALPHA_2	1	1.895159	0.17818632	10.636	0.0001	
ALPHA_3	1	2.088658	0.16605949	12.578	0.0001	
ALPHA_4	1	2.173949	0.16666170	13.044	0.0001	
ALPHA_5	1	2.656718	0.17795646	14.929	0.0001	
ALPHA_6	1	2.454185	0.15208858	16.137	0.0001	
ALPHA_7	1	2.480342	0.15941194	15.559	0.0001	
ALPHA_8	1	2.714630	0.13618664	19.933	0.0001	
ALPHA_9	1	2.747861	0.13719017	20.030	0.0001	
ALPHA_10	1	2.548038	0.14721465	17.308	0.0001	
ALPHA_11	1	2.390681	0.15085128	15.848	0.0001	
ALPHA_12	1	2.098782	0.18047839	11.629	0.0001	
LOGZ	1	-1.191306	0.13927868	-8.553	0.0001	ln(Z) (ln(m))



Segment (TBNEP)=2

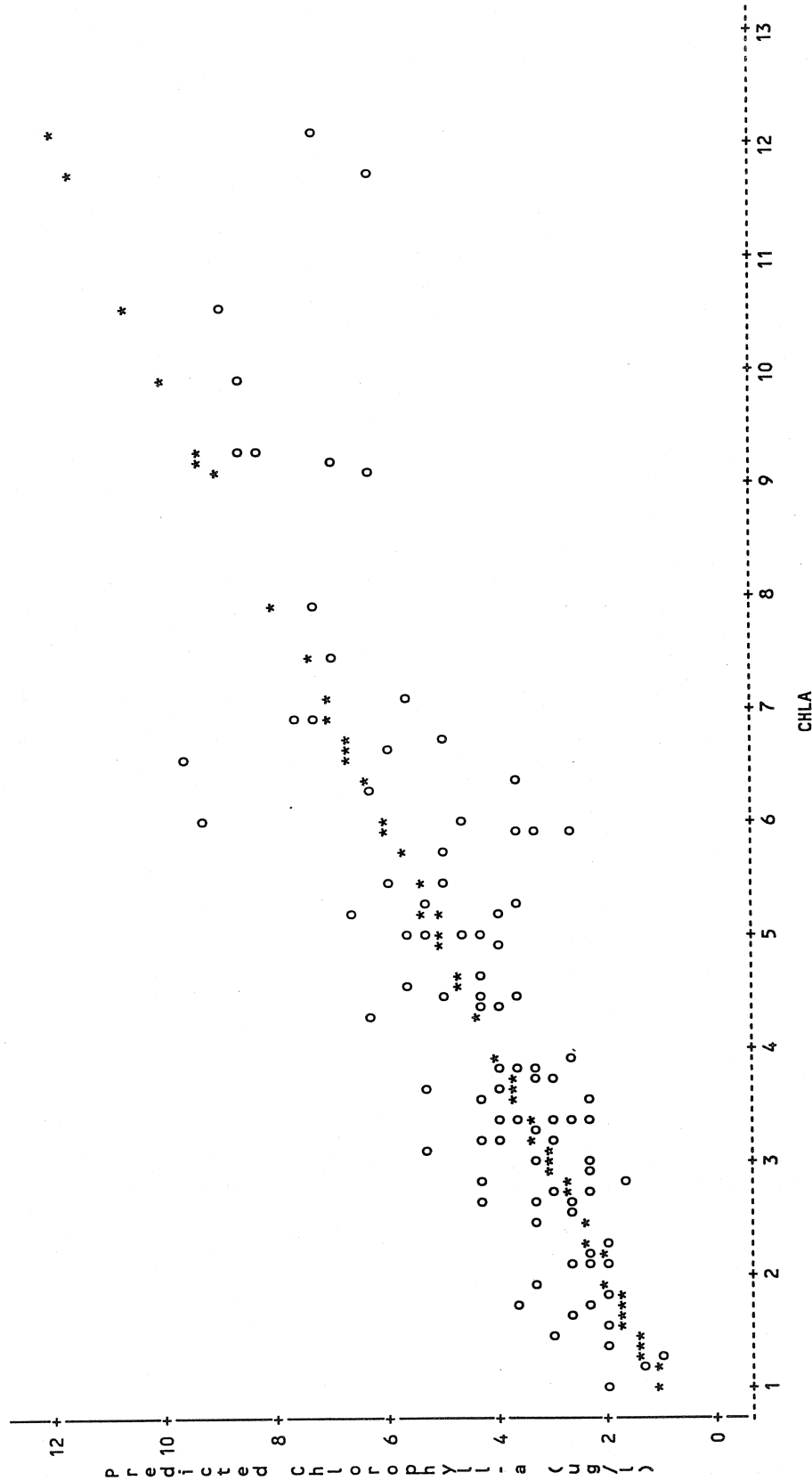
Plot of PCHLA*CHLA. Symbol used is 'o'.
 Plot of CHLA*CHLA. Symbol used is '*'.



NOTE: 71 obs hidden.

----- Segment (TBNEP)=4 -----

Plot of PCHLA*CHLA. Symbol used is 'o'.
 Plot of CHLA*CHLA. Symbol used is '*'.

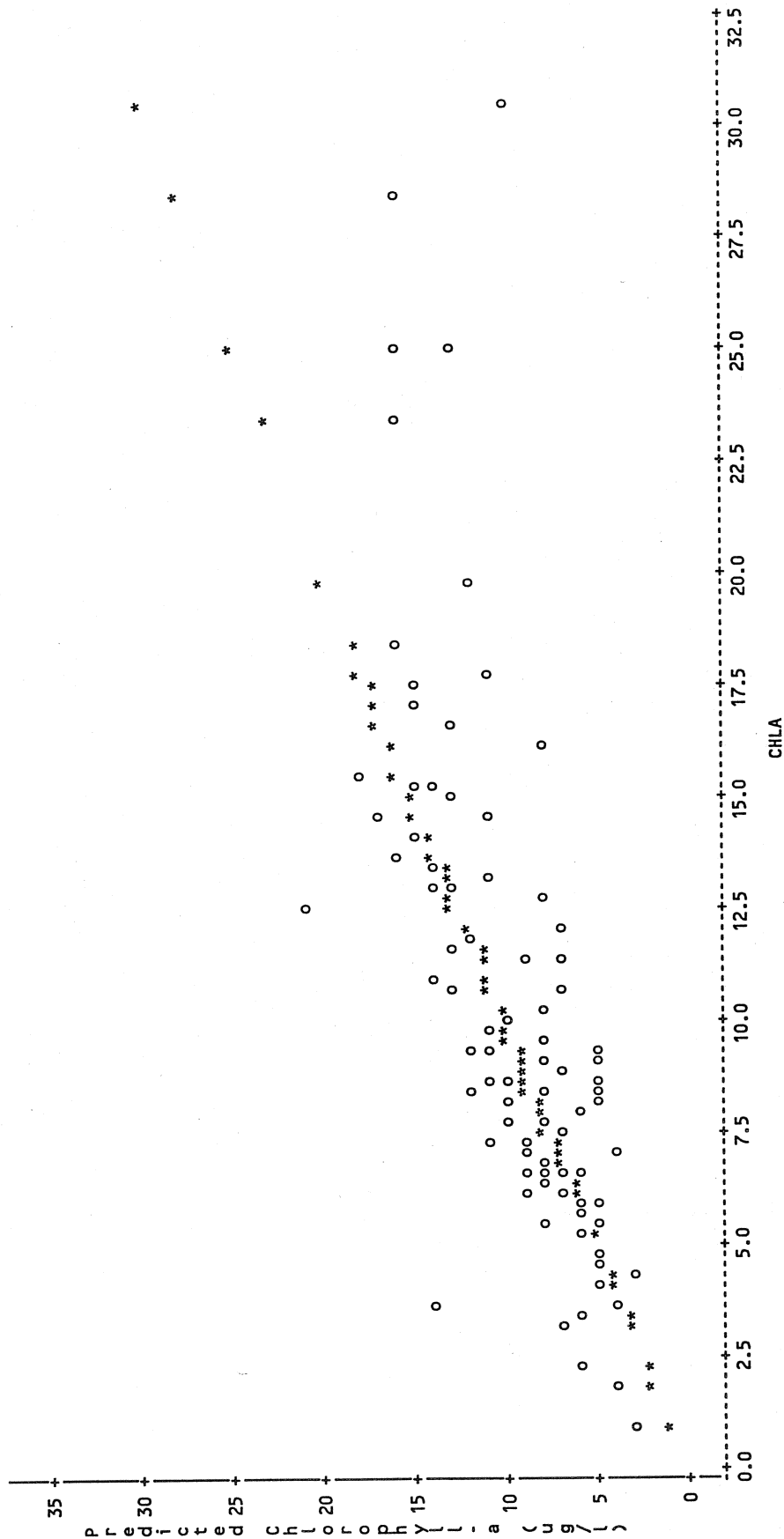


NOTE: 55 obs hidden.

Tampa Bay National Estuary Program - Nutrient Modeling
 EPC Hill. Co. Monthly Data 1986-1994
 Light Extinction Model (nm-85o.sas)

----- Segment (TBNEP)=31 -----

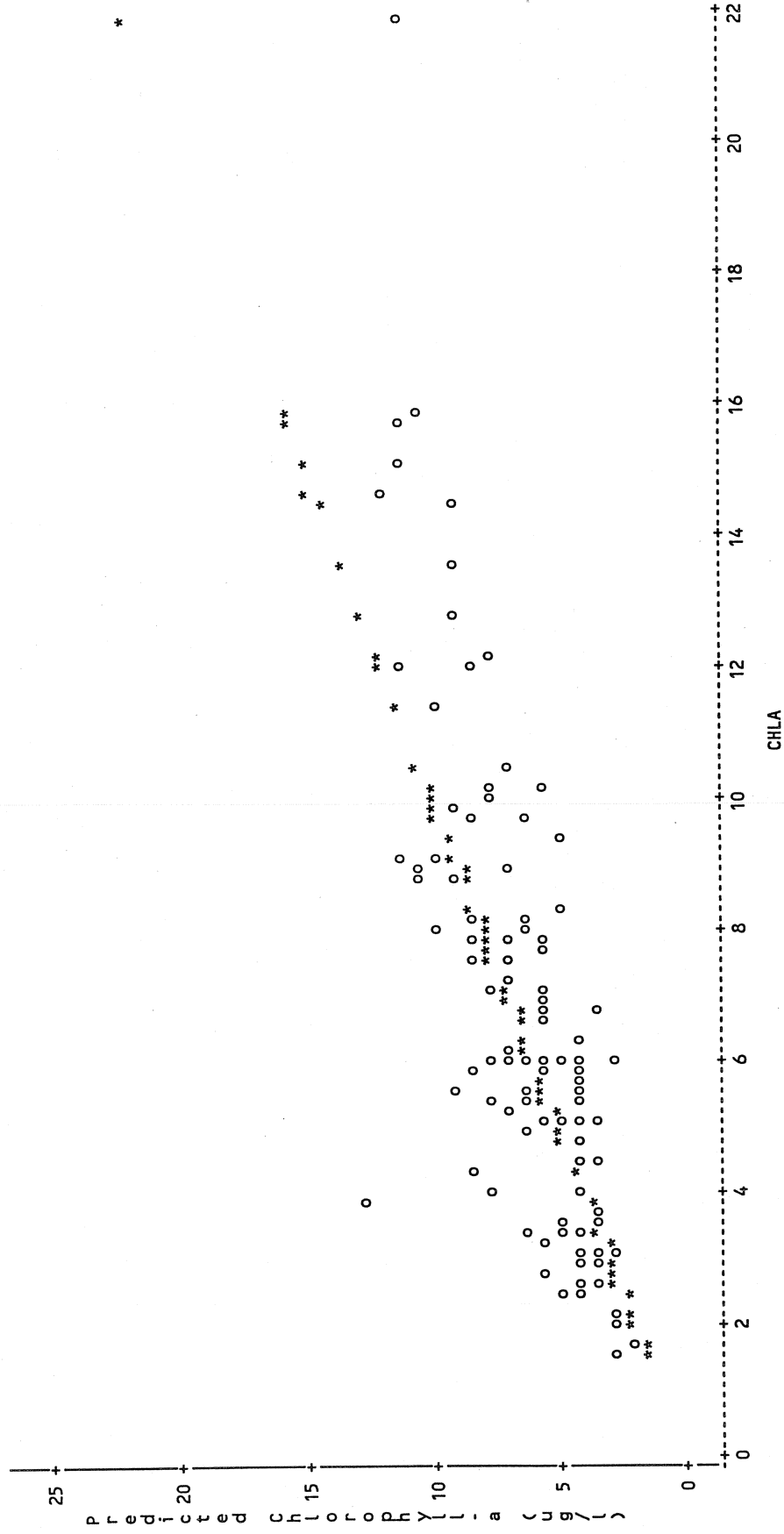
Plot of PCHLA*CHLA. Symbol used is 'o'.
 Plot of CHLA*CHLA. Symbol used is '*'.



NOTE: 70 obs hidden.

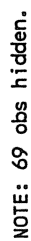
----- Segment (TBNEP)=32 -----

Plot of PCHLA*CHLA. Symbol used is 'o'.
Plot of CHLA*CHLA. Symbol used is '*'.



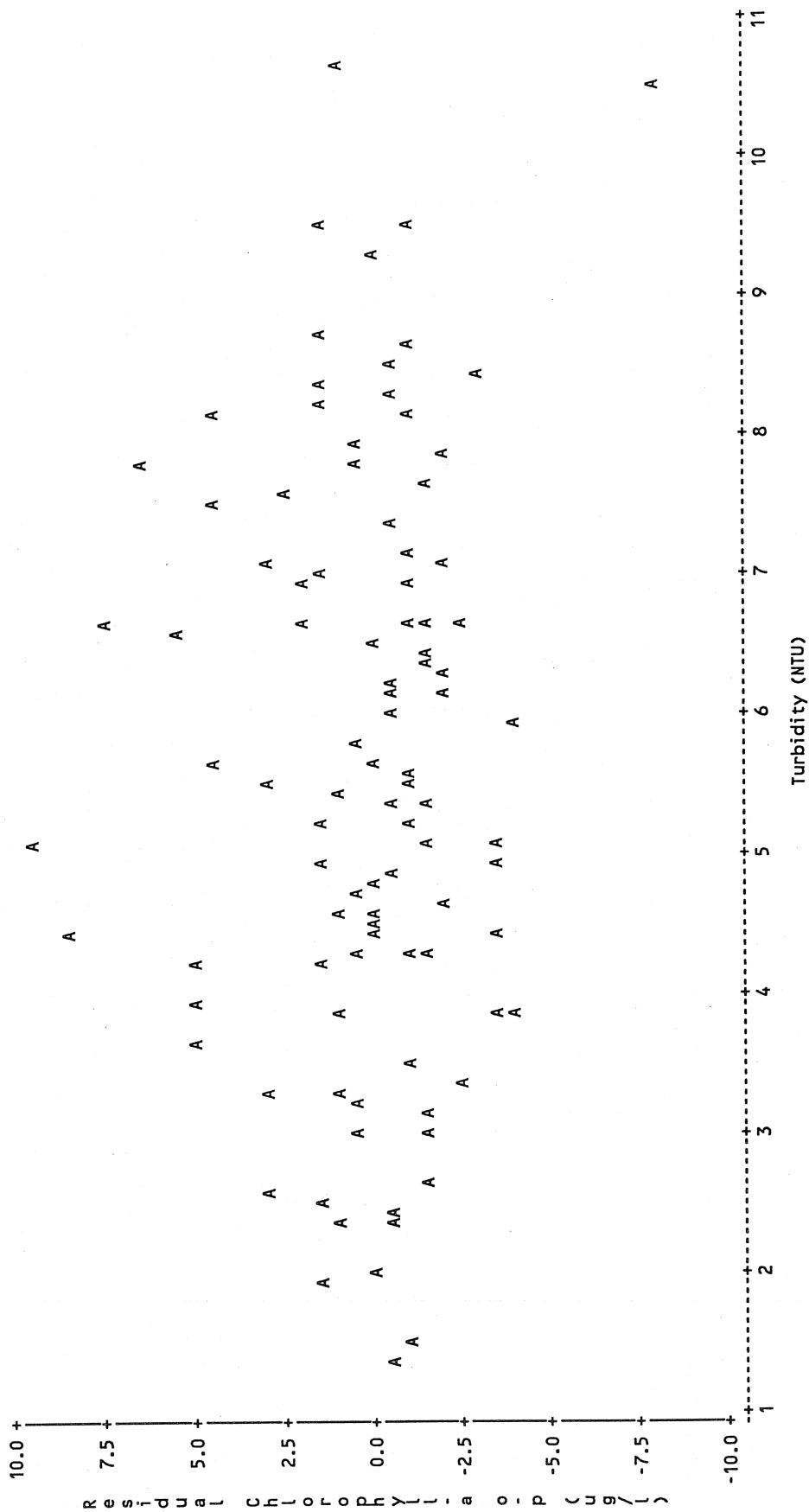
NOTE: 57 obs hidden.

Plot of PCHLA*CHLA.	Symbol used is 'o'.
Plot of CHLA*CHLA.	Symbol used is 'x'.



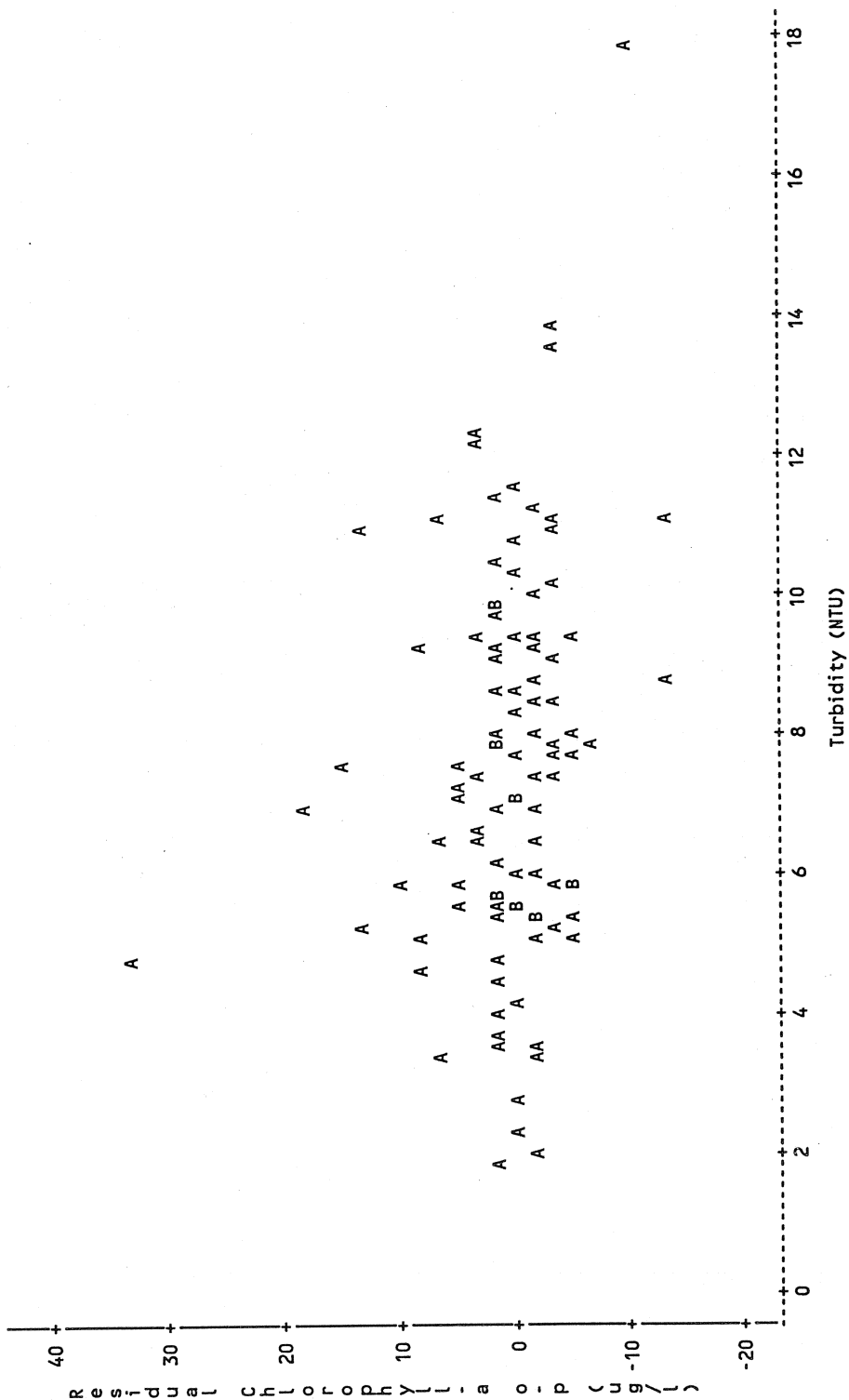
Segment (TBNEP)=1

Plot of RCHLA*TURB. Legend: A = 1 obs, B = 2 obs, etc.



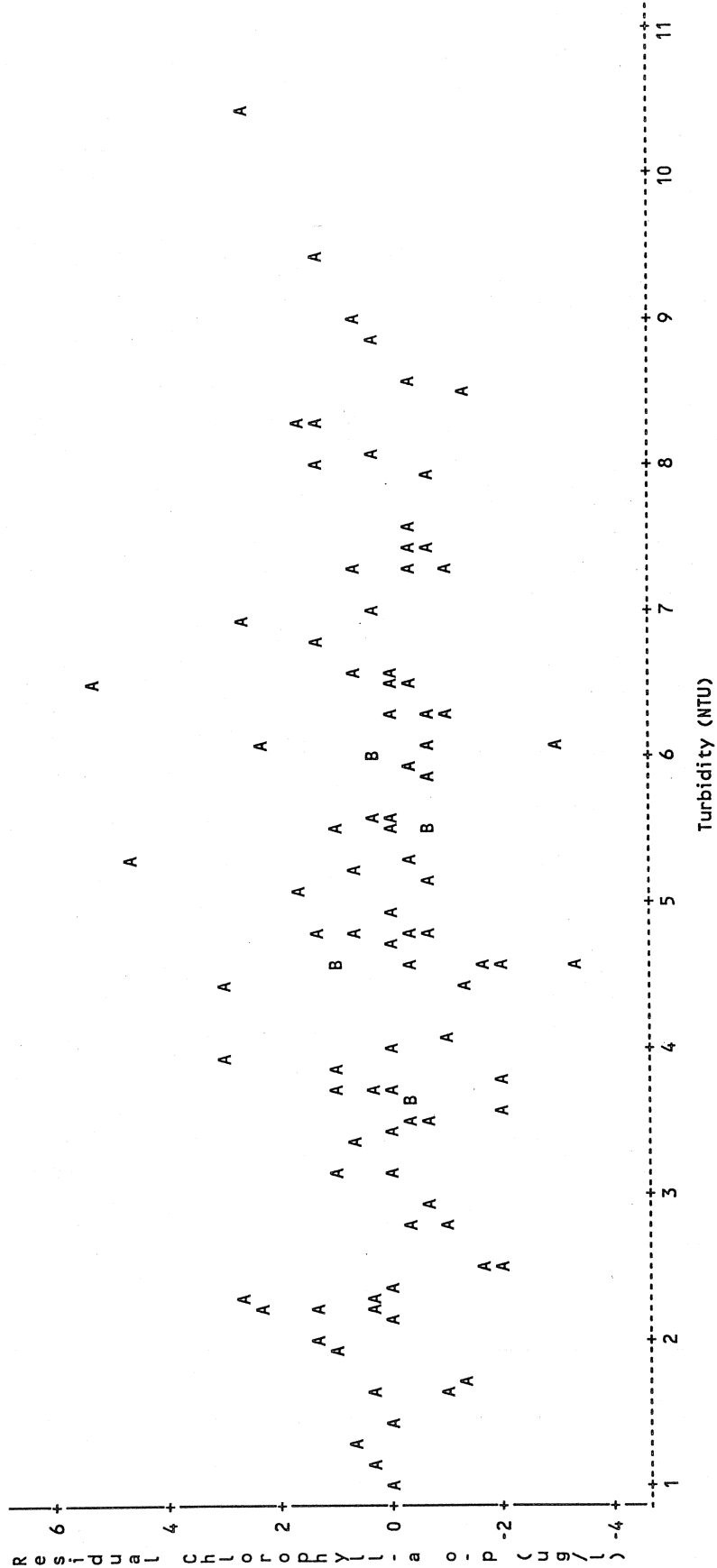
----- Segment (TBNEP)=2 -----

Plot of RCHLA*TURB. Legend: A = 1 obs, B = 2 obs, etc.



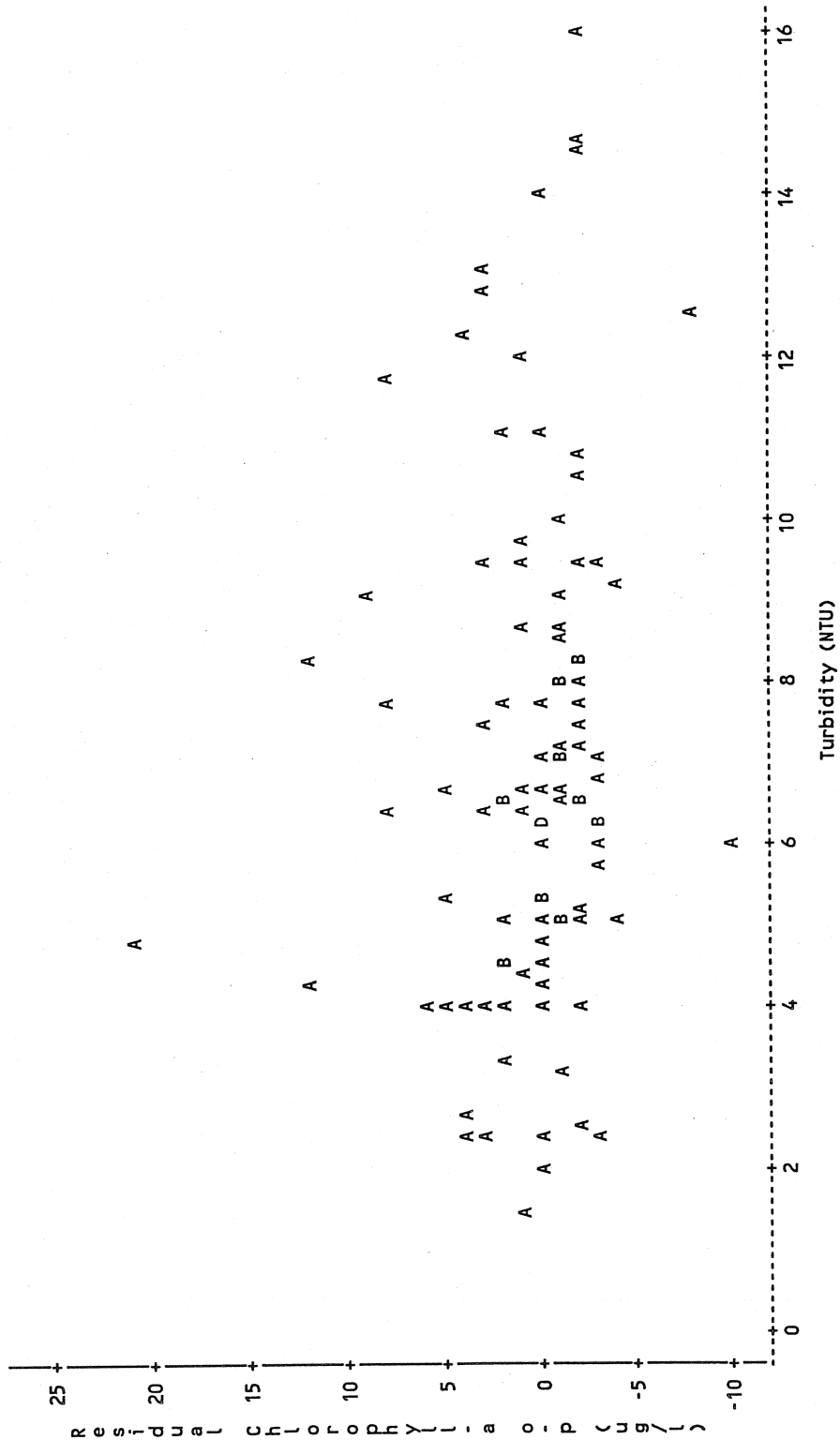
Segment (TBNEP)=4

Plot of RCHLA*TURB. Legend: A = 1 obs, B = 2 obs, etc.



----- Segment (TBNEP)=31 -----

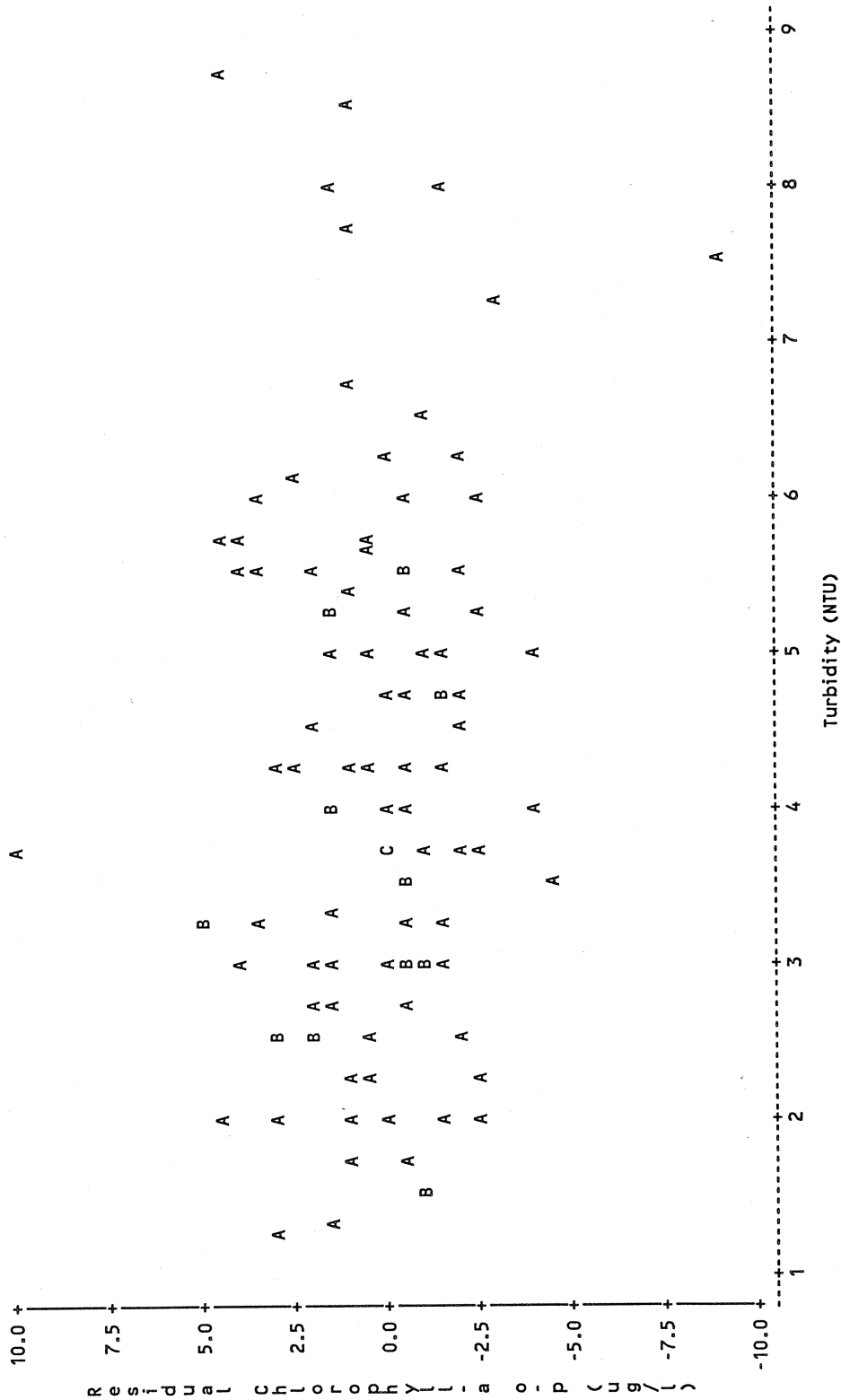
Plot of RCHLA*TURB. Legend: A = 1 obs, B = 2 obs, etc.



Tampa Bay National Estuary Program - Nutrient Modeling
 EPC Hill, Co. Monthly Data 1986-1994
 Light Extinction Model (nm-850.sas)

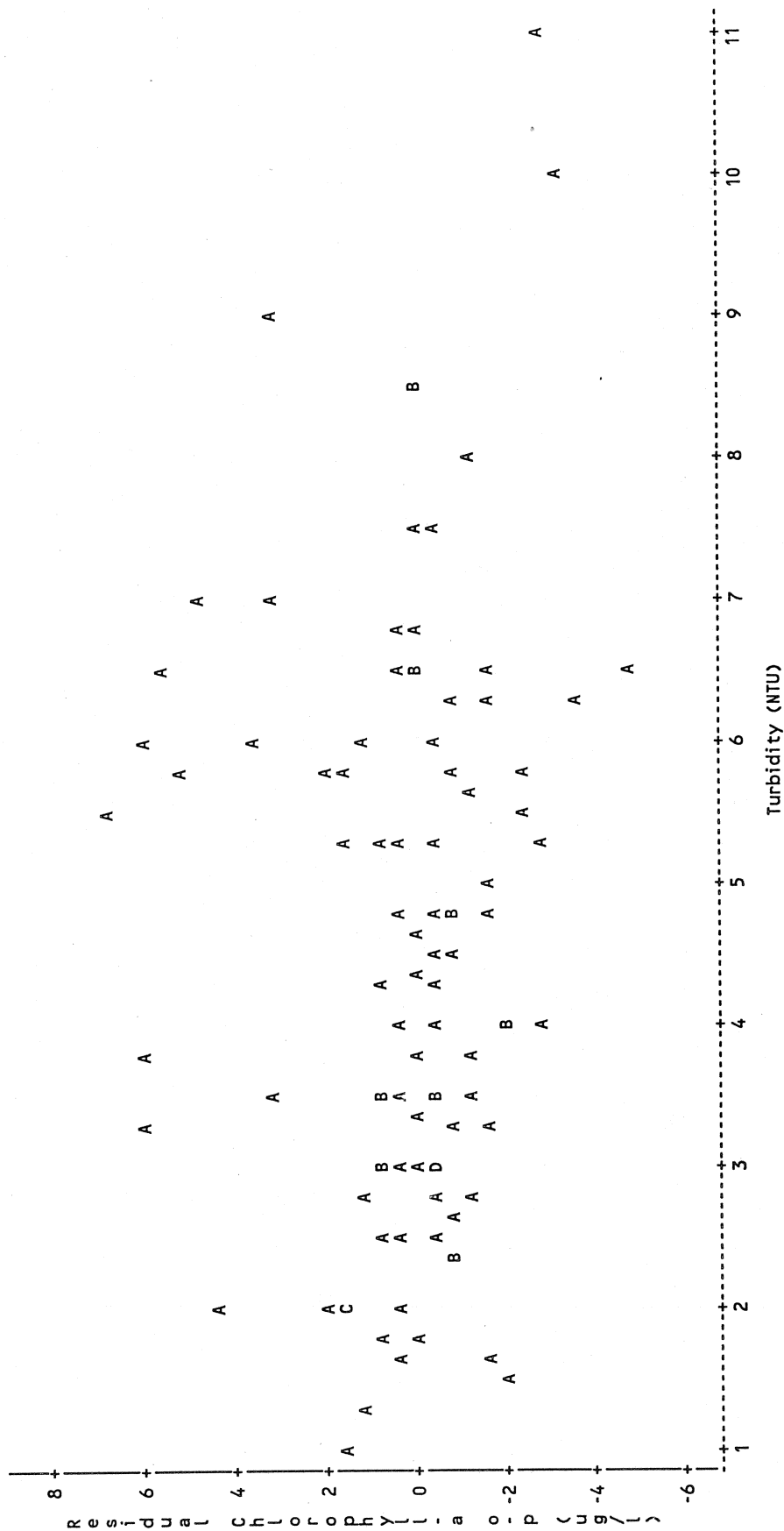
Segment (TBNEP)-32

Plot of RCHLA*TURB. Legend: A = 1 obs, B = 2 obs, etc.



Segment (TBNEP)=33

Plot of RCHLA*TURB. Legend: A = 1 obs, B = 2 obs, etc.



Tampa Bay National Estuary Program - Nutrient Modeling
 EPC Hill, Co. Monthly Data 1986-1994
 Light Extinction Model (nm-850.sas)

Segment (TBNEP)	CSS Chlorophyll-a	USS Residual Chlorophyll-a	Rsquare
Fit by Segment			
1	2171.44	727.81	0.66483
2	7334.78	3458.20	0.52852
4	562.81	185.24	0.67087
31	3022.92	1623.90	0.46281
32	1355.06	633.04	0.53283
33	1428.05	449.67	0.68512

CSS Chlorophyll-a	USS Residual Chlorophyll-a	Rsquare
Overall Fit	21602.77	7077.86
		0.67236

**APPENDIX D. UPDATED MODEL - NUTRIENT LOADING - CHLOROPHYLL
REGRESSION DIAGNOSTICS**

[This Appendix is Available from the TBNEP upon Request]

Dilution Equations Solved for E Values

Solve for Ebc:

Substitute solution for Eab:

$$0 = 0 + Q_o \cdot C_o + (Q_h + Q_a) \cdot C_a - (Q_o + Q_h + Q_a + Q_b) \cdot C_b + E_{ob} \cdot (C_o - C_b) + E_{ab} \cdot (C_a - C_b) + E_{bc} \cdot (C_c - C_b)$$

$$0 = Q_o \cdot C_o + (Q_h + Q_a) \cdot C_a - (Q_o + Q_h + Q_a + Q_b) \cdot C_b + E_{ob} \cdot (C_o - C_b) + (Q_h + Q_a) \cdot \frac{C_a}{(C_b - C_a)} \cdot (-C_b + C_a) + E_{bc} \cdot (C_c - C_b)$$

$$0 = (Q_h + Q_a) \cdot C_a - (Q_o + Q_h + Q_a + Q_b) \cdot C_b + (Q_h + Q_a) \cdot \frac{C_a}{(C_b - C_a)} \cdot (-C_b + C_a) + E_{bc} \cdot (C_c - C_b)$$

Solve for Ebc:

$$= \frac{- \left[-C_a \cdot Q_h - C_a \cdot Q_a + C_b \cdot Q_o + C_b \cdot Q_h + C_b \cdot Q_a + C_b \cdot Q_b + \frac{C_a}{(C_b - C_a)} \cdot C_b \cdot Q_h - \frac{C_a^2}{(C_b - C_a)} \cdot Q_h + \frac{C_a}{(C_b - C_a)} \cdot C_b \cdot Q_a - \frac{C_a^2}{(C_b - C_a)} \cdot Q_a \right]}{(-C_c + C_b)} \\ - (Q_o + Q_h + Q_a + Q_b) \cdot \frac{C_b}{(-C_c + C_b)}$$

Solve for Ecl:

Substitute solution for Ebc:

$$0 = 0 + (Q_o + Q_h + Q_a + Q_b) \cdot C_b - (Q_o + Q_h + Q_a + Q_b + Q_c) \cdot C_c + E_{bc} \cdot (C_b - C_c) + E_{cl} \cdot (C_l - C_c)$$

$$0 = (Q_o + Q_h + Q_a + Q_b) \cdot C_b - (Q_o + Q_h + Q_a + Q_b + Q_c) \cdot C_c + (-Q_o - Q_h - Q_a - Q_b) \cdot C_b + E_{cl} \cdot (C_l - C_c)$$

Solve for Ecl:

$$= \frac{-(C_c \cdot Q_o + C_c \cdot Q_h + C_c \cdot Q_a + C_c \cdot Q_b + C_c \cdot Q_c)}{(-C_l + C_c)}$$

$$- (Q_o + Q_h + Q_a + Q_b + Q_c) \cdot \frac{C_c}{(-C_l + C_c)}$$

Dilution Equations Solved for E Values

Tampa Bay Nutrient Model using Lower Tampa Bay as a boundary condition.

Dilution Equations:

$$0 = W_o - Q_o \cdot C_o + E_{ob} \cdot (C_b - C_o)$$

$$0 = W_h - Q_h \cdot C_h + E_{ha} \cdot (C_a - C_h)$$

$$0 = W_a + Q_h \cdot C_h - (Q_h + Q_a) \cdot C_a + E_{ha} \cdot (C_h - C_a) + E_{ab} \cdot (C_b - C_a)$$

$$0 = W_b + Q_o \cdot C_o + (Q_h + Q_a) \cdot C_a - (Q_o + Q_h + Q_a + Q_b) \cdot C_b + E_{ob} \cdot (C_o - C_b) + E_{ab} \cdot (C_a - C_b) + E_{bc} \cdot (C_c - C_b)$$

$$0 = W_c + (Q_o + Q_h + Q_a + Q_b) \cdot C_b - (Q_o + Q_h + Q_a + Q_b + Q_c) \cdot C_c + E_{bc} \cdot (C_b - C_c) + E_{cl} \cdot (C_l - C_c)$$

Solve for several E values using salinity data (W is assumed zero for salt):

Solve for E_{ob}:

$$0 = 0 - Q_o \cdot C_o + E_{ob} \cdot (C_b - C_o)$$

$$= -Q_o \cdot \frac{C_o}{(C_o - C_b)}$$

Solve for E_{ha}:

$$0 = 0 - Q_h \cdot C_h + E_{ha} \cdot (C_a - C_h)$$

$$= -Q_h \cdot \frac{C_h}{(-C_a + C_h)}$$

Solve for E_{ab}:

$$0 = 0 + Q_h \cdot C_h - (Q_h + Q_a) \cdot C_a + E_{ha} \cdot (C_h - C_a) + E_{ab} \cdot (C_b - C_a)$$

$$= \frac{-(-Q_h \cdot C_h + C_a \cdot Q_h + C_a \cdot Q_a + E_{ha} \cdot C_a - E_{ha} \cdot C_h)}{(-C_b + C_a)}$$

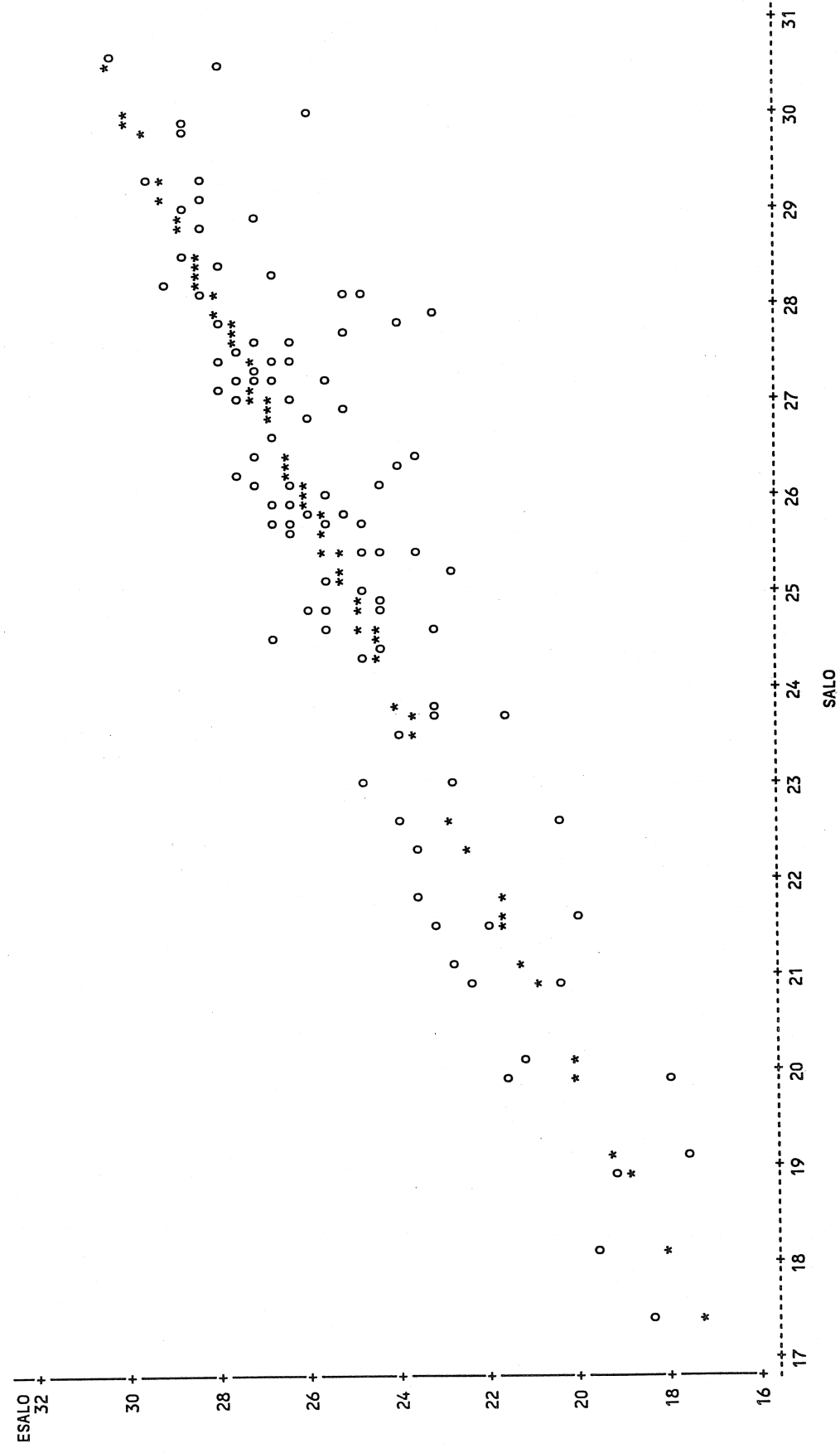
$$\left[\frac{Q_h \cdot C_h - C_a \cdot Q_h - C_a \cdot Q_a + Q_h \cdot \frac{C_h}{(-C_a + C_h)} \cdot C_a - Q_h \cdot \frac{C_h^2}{(-C_a + C_h)}}{(-C_b + C_a)} \right]$$

$$(Q_h + Q_a) \cdot \frac{C_a}{(C_b - C_a)}$$

Predicted and Observed Salinity Plots and Goodness of Fit Metrics

Tampa Bay National Estuary Program
Nutrient Model Using Transfer Coefficients
nmtr-74.sas

Plot of Estimated SALO*SALO. Symbol used is 'o'.
Plot of SALO*SALO. Symbol used is '*'.
*o



NOTE: 10 obs had missing values. 43 obs hidden.

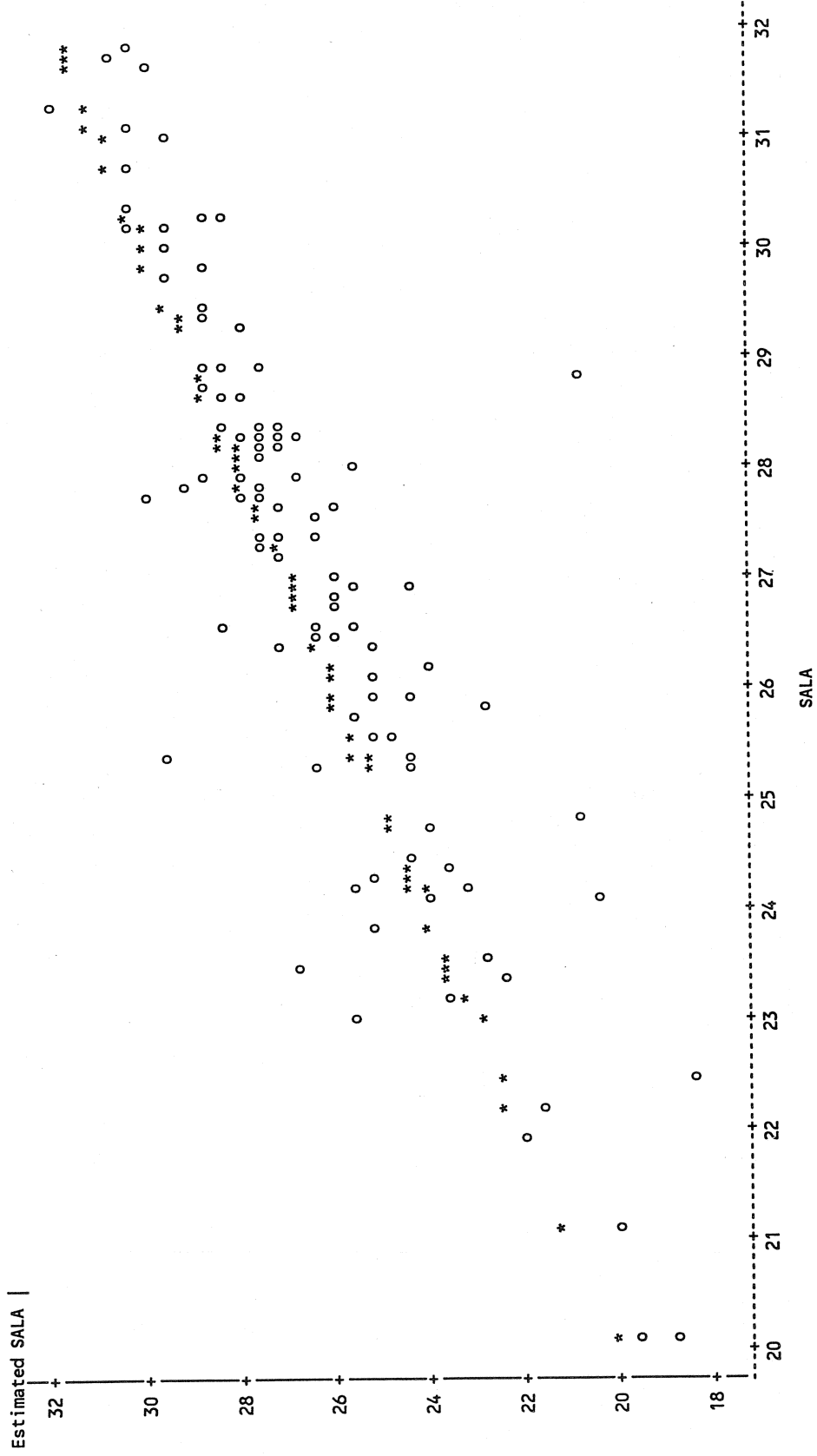
Estimated SALH

SALH

6-D

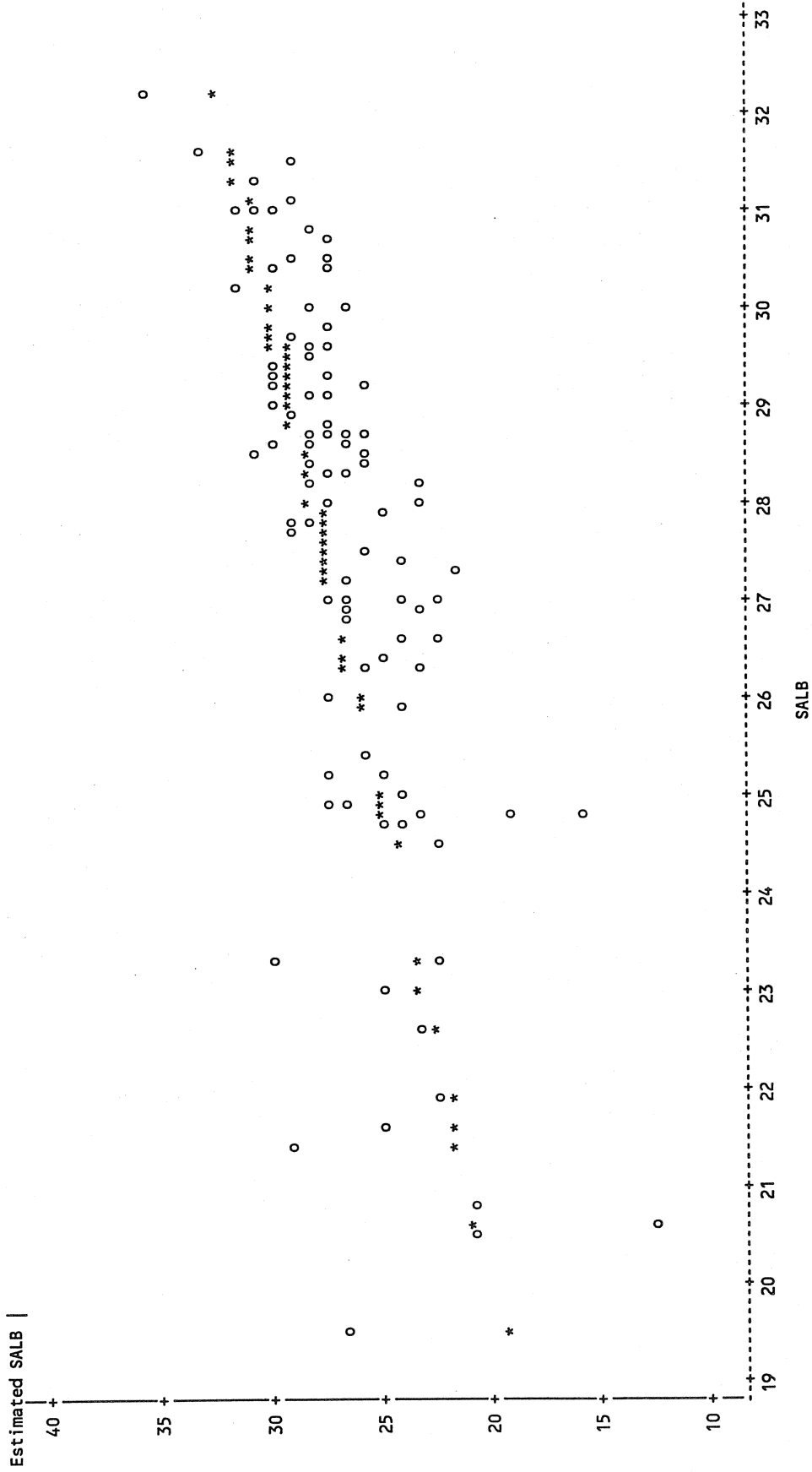
Tampa Bay National Estuary Program
Nutrient Model Using Transfer Coefficients
nmtr-74.sas

Plot of Estimated SALA*SALA. Symbol used is 'o'.
Plot of SALA*SALA. Symbol used is '*'.



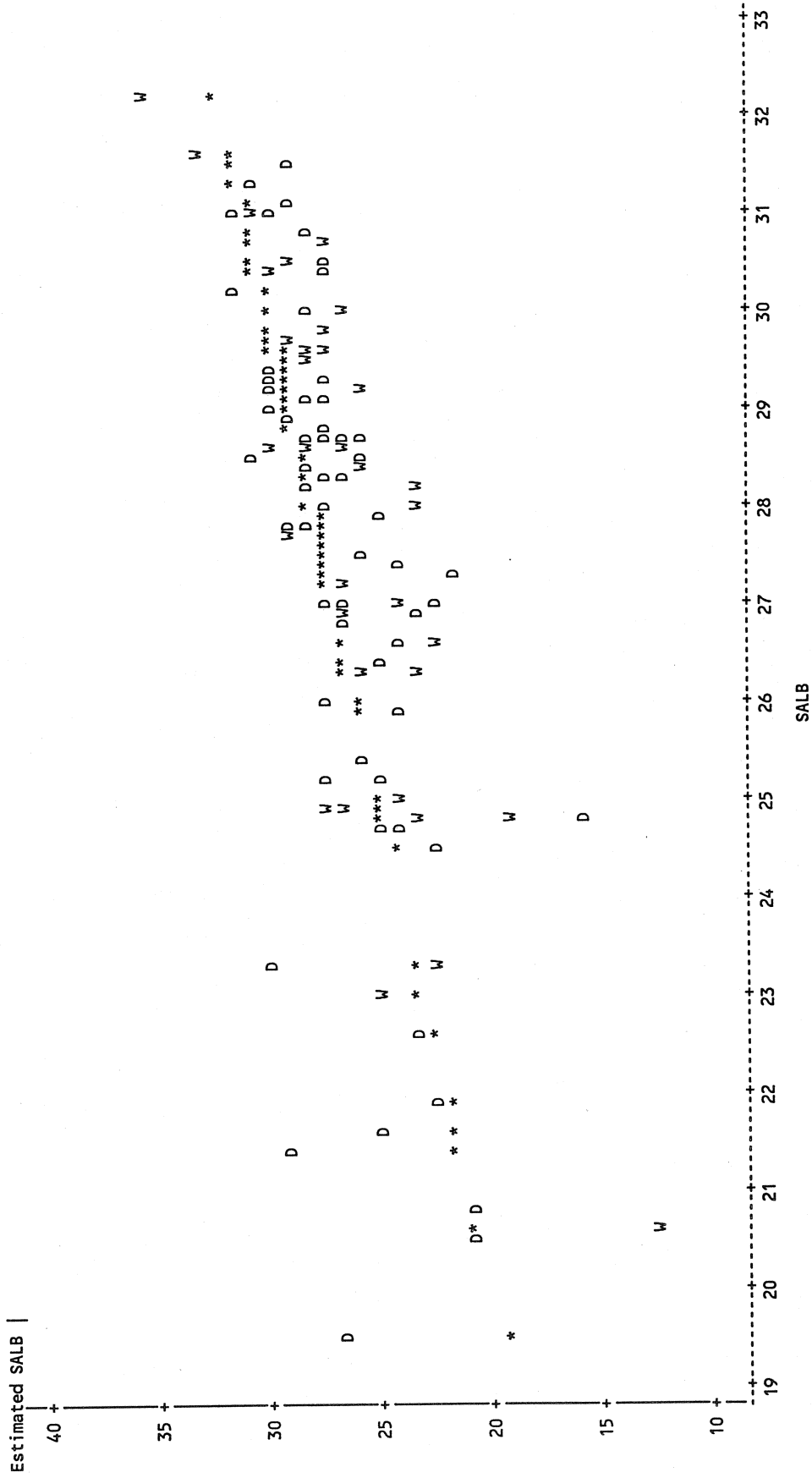
NOTE: 53 obs hidden.

Plot of Estimated SALB*SALB. Symbol used is 'o'.
Plot of SALB*SALB. Symbol used is '*'.



NOTE: 3 obs had missing values. 57 obs hidden.

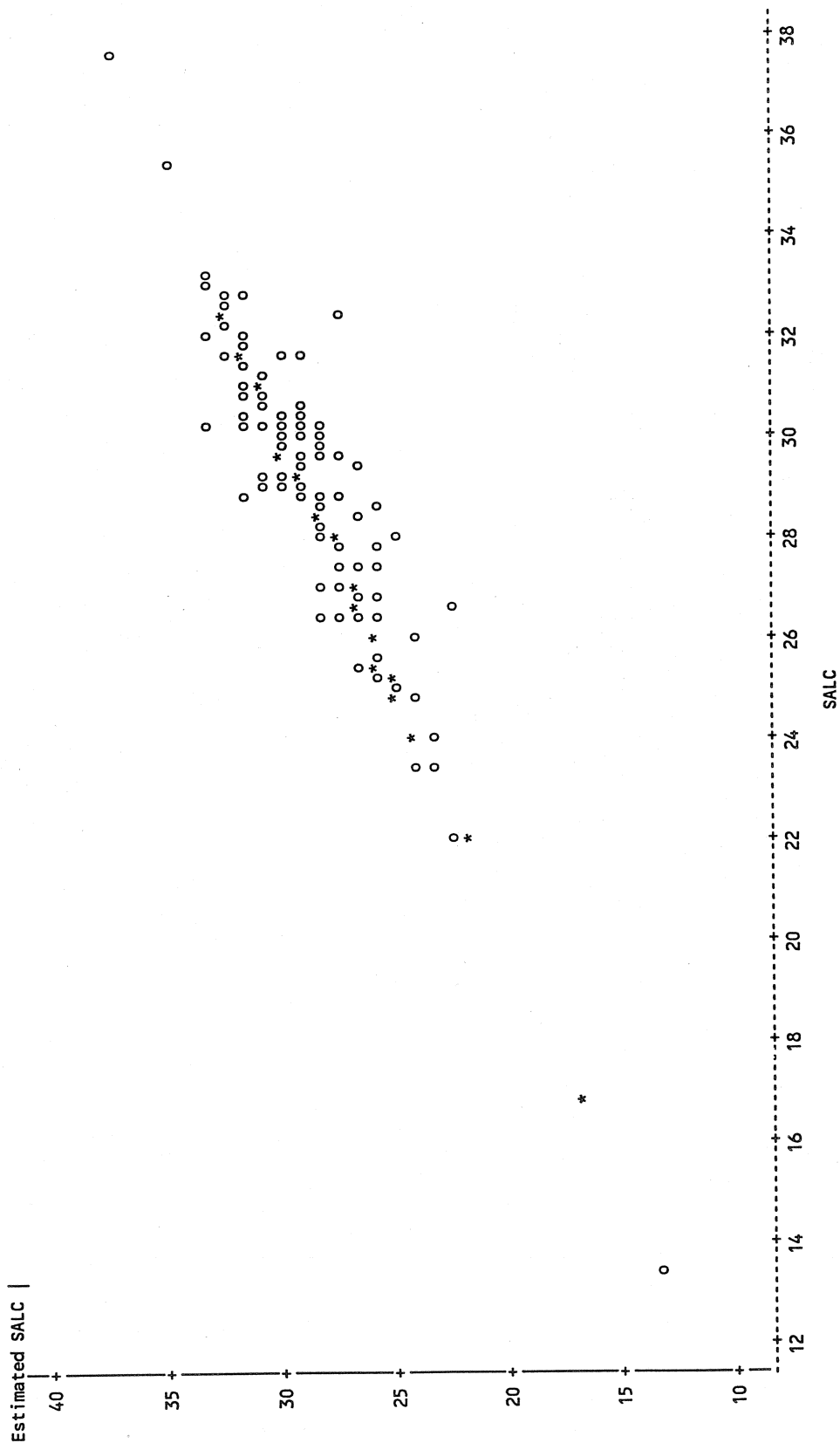
Plot of Estimated SALB*SALB. Symbol is value of SEASON.
Plot of SALB*SALB. Symbol used is '*'.



NOTE: 3 obs had missing values. 57 obs hidden.

Tampa Bay National Estuary Program
Nutrient Model Using Transfer Coefficients
nmtr-74.sas

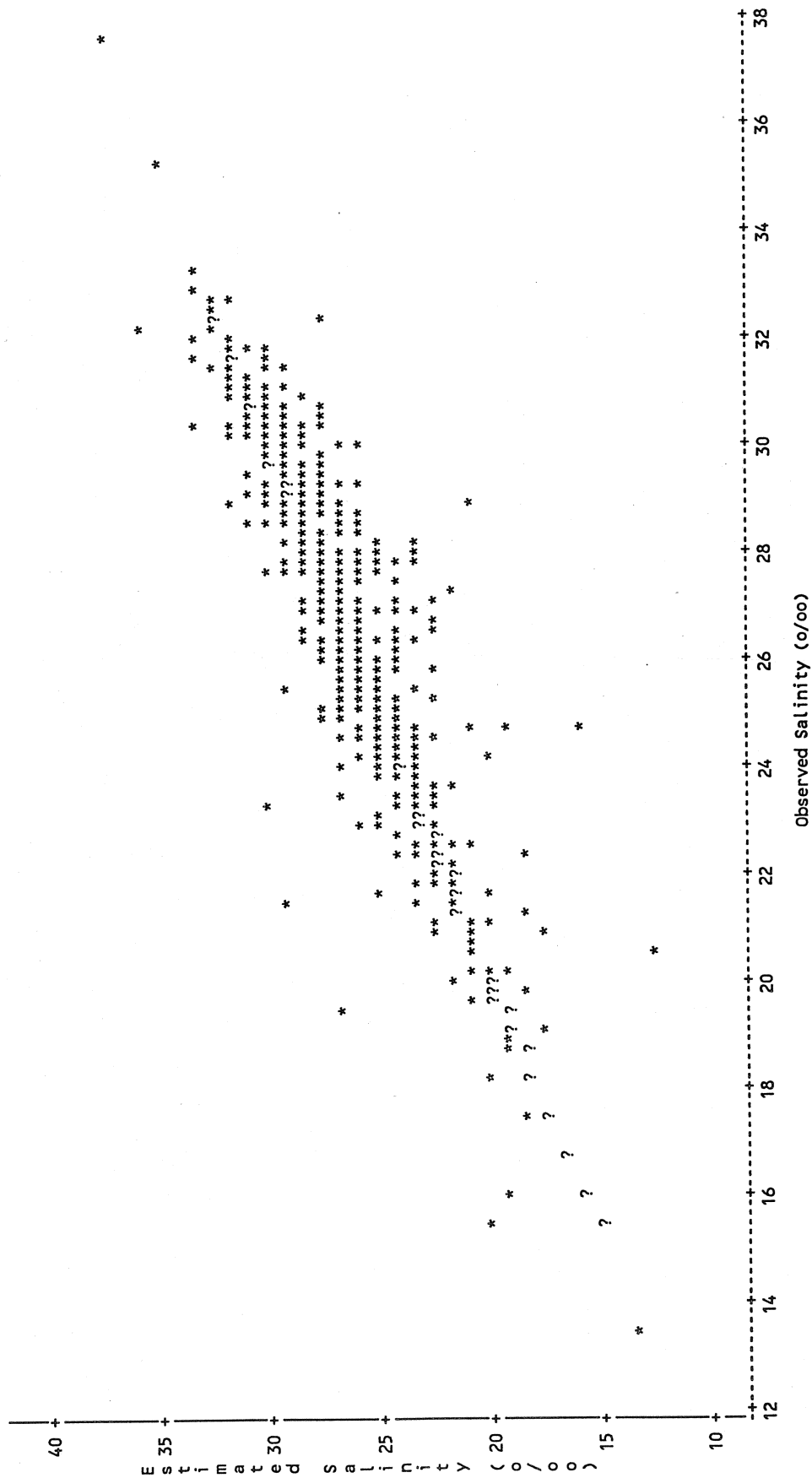
Plot of Estimated SALC*SALC. Symbol used is 'o'.
Plot of SALC*SALC. Symbol used is '*'.



NOTE: 7 obs had missing values. 100 obs hidden.

Tampa Bay National Estuary Program
Nutrient Model Using Transfer Coefficients
nmtr-74.sas

Plot of Estimated SAL*SAL. Symbol used is '*'.
Plot of SAL*SAL. Symbol used is '?'.
*



NOTE: 22 obs had missing values. 693 obs hidden.

Tampa Bay National Estuary Program
 Nutrient Model Using Transfer Coefficients
 nmtr-74.sas

SEGMENT	USS		
	CSS Salinity	Residual Salinity	Rsquare
1	798.419	199.456	0.75019
2	905.930	91.702	0.89878
31	678.326	245.138	0.63861
32	748.749	708.082	0.05431
33	997.574	168.557	0.83103

USS		
CSS Salinity	Residual Salinity	Rsquare
4850.11	1412.93	0.70868

Dilution Equations Solved for C Values

Tampa Bay Nutrient Model using Lower Tampa Bay as a boundary condition.
Dilution Equations

$$0 = W_o - Q_o \cdot C_o + E_{ob} \cdot (C_b - C_o)$$

$$0 = W_h - Q_h \cdot C_h + E_{ha} \cdot (C_a - C_h)$$

$$0 = W_a + Q_h \cdot C_h - (Q_h + Q_a) \cdot C_a + E_{ha} \cdot (C_h - C_a) + E_{ab} \cdot (C_b - C_a)$$

$$0 = W_b + Q_o \cdot C_o + (Q_h + Q_a) \cdot C_a - (Q_o + Q_h + Q_a + Q_b) \cdot C_b + E_{ob} \cdot (C_o - C_b) + E_{ab} \cdot (C_a - C_b) + E_{bc} \cdot (C_c - C_b)$$

$$0 = W_c + (Q_o + Q_h + Q_a + Q_b) \cdot C_b - (Q_o + Q_h + Q_a + Q_b + Q_c) \cdot C_c + E_{bc} \cdot (C_b - C_c) + E_{cl} \cdot (C_l - C_c)$$

Solve for C values:

$$0 = W_o - Q_o \cdot C_o + E_{ob} \cdot (C_b - C_o)$$

$$C_o = \frac{-(-W_o - E_{ob} \cdot C_b)}{(Q_o + E_{ob})}$$

$$\frac{(W_o + E_{ob} \cdot C_b)}{(Q_o + E_{ob})}$$

$$0 = W_h - Q_h \cdot C_h + E_{ha} \cdot (C_a - C_h)$$

$$C_h = \frac{-(-W_h - E_{ha} \cdot C_a)}{(Q_h + E_{ha})}$$

$$\frac{(W_h + E_{ha} \cdot C_a)}{(Q_h + E_{ha})}$$

$$0 = W_a + Q_h \cdot C_h - (Q_h + Q_a) \cdot C_a + E_{ha} \cdot (C_h - C_a) + E_{ab} \cdot (C_b - C_a)$$

$$C_a = \frac{-(-W_a - Q_h \cdot C_h - E_{ha} \cdot C_h - E_{ab} \cdot C_b)}{(Q_h + Q_a + E_{ha} + E_{ab})}$$

$$\frac{(W_a + Q_h \cdot C_h + E_{ha} \cdot C_h + E_{ab} \cdot C_b)}{(Q_h + Q_a + E_{ha} + E_{ab})}$$

$$0 = W_b + Q_o \cdot C_o + (Q_h + Q_a) \cdot C_a - (Q_o + Q_h + Q_a + Q_b) \cdot C_b + E_{ob} \cdot (C_o - C_b) + E_{ab} \cdot (C_a - C_b) + E_{bc} \cdot (C_c - C_b)$$

$$C_b = \frac{-(-W_b - Q_o \cdot C_o - C_a \cdot Q_h - C_a \cdot Q_a - E_{ob} \cdot C_o - E_{ab} \cdot C_a - E_{bc} \cdot C_c)}{(Q_o + Q_h + Q_a + Q_b + E_{ob} + E_{ab} + E_{bc})}$$

$$\frac{(W_b + Q_o \cdot C_o + C_a \cdot Q_h + C_a \cdot Q_a + E_{ob} \cdot C_o + E_{ab} \cdot C_a + E_{bc} \cdot C_c)}{(Q_o + Q_h + Q_a + Q_b + E_{ob} + E_{ab} + E_{bc})}$$

$$0 = W_c + (Q_o + Q_h + Q_a + Q_b) \cdot C_b - (Q_o + Q_h + Q_a + Q_b + Q_c) \cdot C_c + E_{bc} \cdot (C_b - C_c) + E_{cl} \cdot (C_l - C_c)$$

$$C_c = \frac{-(-W_c - C_b \cdot Q_o - C_b \cdot Q_h - C_b \cdot Q_a - C_b \cdot Q_b - E_{bc} \cdot C_b - E_{cl} \cdot C_l)}{(Q_o + Q_h + Q_a + Q_b + Q_c + E_{bc} + E_{cl})}$$

$$\frac{(W_c + C_b \cdot Q_o + C_b \cdot Q_h + C_b \cdot Q_a + C_b \cdot Q_b + E_{bc} \cdot C_b + E_{cl} \cdot C_l)}{(Q_o + Q_h + Q_a + Q_b + Q_c + E_{bc} + E_{cl})}$$

Dilution Equations Solved for C Values

Substitute Ch equation into Ca and solve for Ca:

$$Ch = \frac{(Wh + Eha \cdot Ca)}{(Qh + Eha)}$$

$$Ca = \frac{(Wa + Qh \cdot Ch + Eha \cdot Ch + Eab \cdot Cb)}{(Qh + Qa + Eha + Eab)} = Ca$$

$$\frac{(Qh + Eha)}{(Qh + Qa + Eha + Eab)} \cdot Ch + \frac{(Wa + Eab \cdot Cb)}{(Qh + Qa + Eha + Eab)} = Ca$$

$$\frac{1}{(Qh + Qa + Eha + Eab)} \cdot (Wh + Eha \cdot Ca) + \frac{(Wa + Eab \cdot Cb)}{(Qh + Qa + Eha + Eab)} = Ca$$

$$\left[\frac{1}{(Qh + Qa + Eha + Eab)} \cdot Wh + \frac{1}{(Qh + Qa + Eha + Eab)} \cdot Wa + \frac{1}{(Qh + Qa + Eha + Eab)} \cdot Eab \cdot Cb \right] - \left[\frac{1}{(Qh + Qa + Eha + Eab)} \cdot Eha - 1 \right] = Ca$$

$$Ca = \frac{(Wh + Wa + Eab \cdot Cb)}{(Qh + Qa + Eab)}$$

Substitute equations for Ca and Co into equation for Cb and solve for Cb:

$$Ca = \frac{(Wh + Wa + Eab \cdot Cb)}{(Qh + Qa + Eab)} \quad Co = \frac{(Wo + Eob \cdot Cb)}{(Qo + Eob)}$$

$$Cb = \frac{(Wb + Qo \cdot Co + Ca \cdot Qh + Ca \cdot Qa + Eob \cdot Co + Eab \cdot Ca + Ebc \cdot Cc)}{(Qo + Qh + Qa + Qb + Eob + Eab + Ebc)}$$

$$\frac{(Qh + Qa + Eab)}{(Qo + Qh + Qa + Qb + Eob + Eab + Ebc)} \cdot Ca + \frac{(Wb + Qo \cdot Co + Ebc \cdot Cc + Eob \cdot Co)}{(Qo + Qh + Qa + Qb + Eob + Eab + Ebc)}$$

$$\frac{1}{(Qo + Qh + Qa + Qb + Eob + Eab + Ebc)} \cdot (Wh + Wa + Eab \cdot Cb) + \frac{(Wb + Qo \cdot Co + Ebc \cdot Cc + Eob \cdot Co)}{(Qo + Qh + Qa + Qb + Eob + Eab + Ebc)}$$

$$\frac{(Wh + Wa + Eab \cdot Cb + Wb + Qo \cdot Co + Ebc \cdot Cc + Eob \cdot Co)}{(Qo + Qh + Qa + Qb + Eob + Eab + Ebc)} = Cb$$

$$Cb = \frac{(Wh + Wa + Wb + Qo \cdot Co + Ebc \cdot Cc + Eob \cdot Co)}{(Qo + Qh + Qa + Qb + Eob + Ebc)}$$

$$\frac{(Qo + Eob)}{(Qo + Qh + Qa + Qb + Eob + Ebc)} \cdot Co + \frac{(Wh + Wa + Wb + Ebc \cdot Cc)}{(Qo + Qh + Qa + Qb + Eob + Ebc)}$$

$$\frac{1}{(Qo + Qh + Qa + Qb + Eob + Ebc)} \cdot (Wo + Eob \cdot Cb) + \frac{(Wh + Wa + Wb + Ebc \cdot Cc)}{(Qo + Qh + Qa + Qb + Eob + Ebc)} = Cb$$

$$Cb = \frac{(Wo + Wh + Wa + Wb + Ebc \cdot Cc)}{(Qo + Qh + Qa + Qb + Ebc)}$$

Dilution Equations Solved for C Values

Substitute equation for Cb into Equation for Cc and solve for Cc:

$$C_b = \frac{(W_o + W_h + W_a + W_b + E_{bc} \cdot C_c)}{(Q_o + Q_h + Q_a + Q_b + E_{bc})}$$

$$C_c = \frac{(W_c + C_b \cdot Q_o + C_b \cdot Q_h + C_b \cdot Q_a + C_b \cdot Q_b + E_{bc} \cdot C_b + E_{cl} \cdot C_l)}{(Q_o + Q_h + Q_a + Q_b + Q_c + E_{bc} + E_{cl})}$$

$$\frac{(Q_o + Q_h + Q_a + Q_b + E_{bc})}{(Q_o + Q_h + Q_a + Q_b + Q_c + E_{bc} + E_{cl})} \cdot C_b + \frac{(W_c + E_{cl} \cdot C_l)}{(Q_o + Q_h + Q_a + Q_b + Q_c + E_{bc} + E_{cl})} = C_c$$

$$\frac{1}{(Q_o + Q_h + Q_a + Q_b + Q_c + E_{bc} + E_{cl})} \cdot (W_o + W_h + W_a + W_b + E_{bc} \cdot C_c) + \frac{(W_c + E_{cl} \cdot C_l)}{(Q_o + Q_h + Q_a + Q_b + Q_c + E_{bc} + E_{cl})} = C_c$$

$$C_c = \frac{(W_o + W_h + W_a + W_b + W_c + E_{cl} \cdot C_l)}{(Q_o + Q_h + Q_a + Q_b + Q_c + E_{cl})}$$

Summary for Tampa Bay Model.

Compute concentrations in the following order:

$$C_c = \frac{(W_o + W_h + W_a + W_b + W_c + E_{cl} \cdot C_l)}{(Q_o + Q_h + Q_a + Q_b + Q_c + E_{cl})}$$

$$C_b = \frac{(W_o + W_h + W_a + W_b + E_{bc} \cdot C_c)}{(Q_o + Q_h + Q_a + Q_b + E_{bc})}$$

$$C_a = \frac{(W_h + W_a + E_{ab} \cdot C_b)}{(Q_h + Q_a + E_{ab})}$$

$$C_o = \frac{(W_o + E_{ob} \cdot C_b)}{(Q_o + E_{ob})}$$

$$C_h = \frac{(W_h + E_{ha} \cdot C_a)}{(Q_h + E_{ha})}$$

**Regression Used to Predict for the Net of the Nonconservative Processes
of Nitrogen in Tampa Bay**

Tampa Bay National Estuary Program
Nutrient Model Using Transfer Coefficients

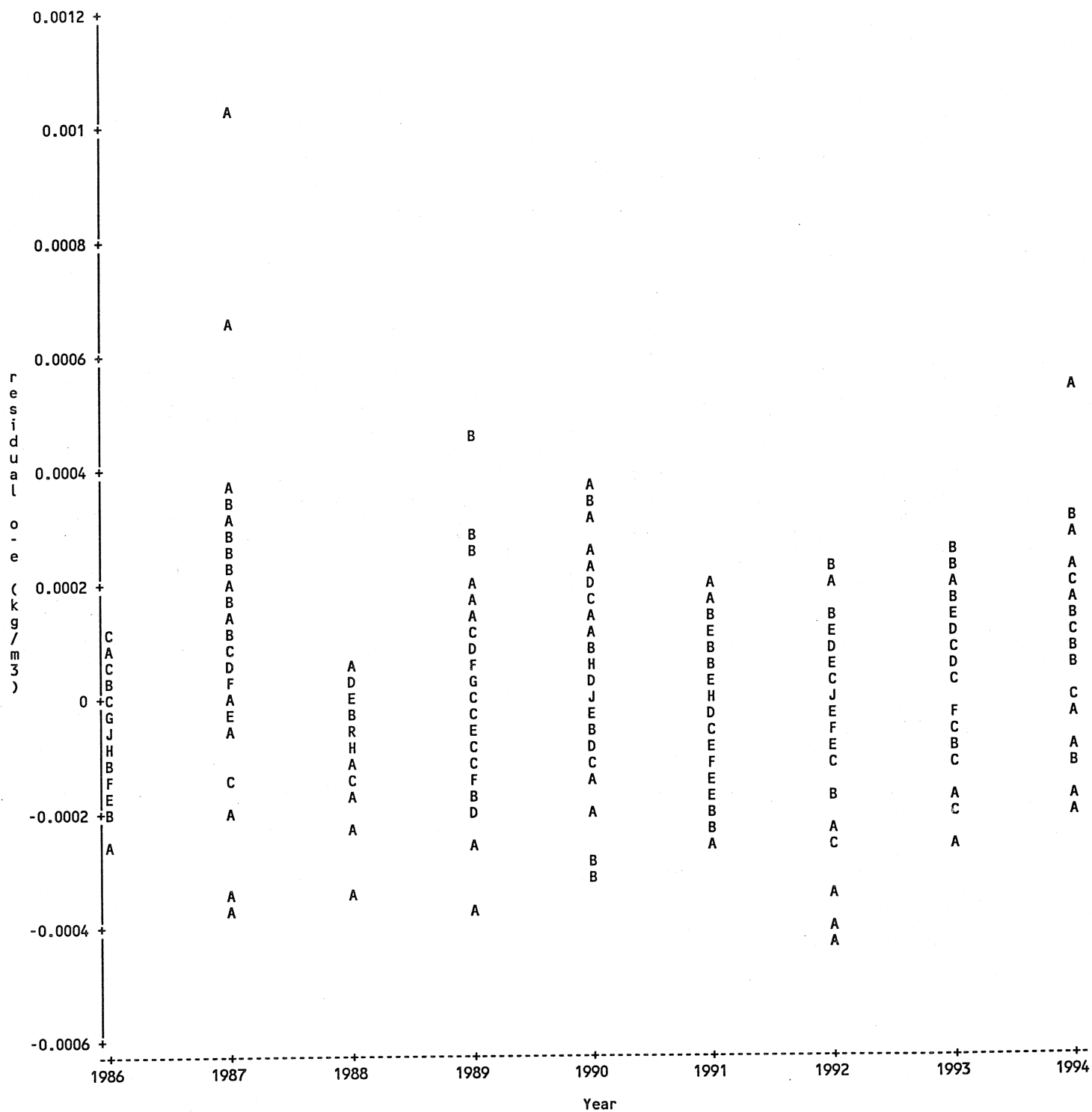
OBS	Month	Beta Est_TN_c	Beta Est_TN_b	Beta Est_TN_a	Beta Est_TN_o	Beta Est_TN_h
1	1	0.95017	0.74269	0.83685	0.88362	0.81412
2	2	0.90298	0.90517	0.91274	0.90880	0.98493
3	3	0.91253	0.94698	0.89179	0.95828	0.94152
4	4	0.84316	0.78068	1.02021	0.82410	1.07014
5	5	0.96290	0.92667	0.99902	1.04341	1.04270
6	6	1.05657	1.17071	1.20159	1.38913	1.14257
7	7	0.95680	1.00675	1.07123	1.22658	1.11842
8	8	1.00740	0.97195	1.11373	1.10782	1.17372
9	9	1.13752	1.05320	1.14127	1.26757	1.25196
10	10	0.94231	1.02588	1.15494	1.14788	1.27239
11	11	0.99444	0.98073	0.95380	1.32448	1.09855
12	12	0.90871	0.85911	0.99476	0.99500	1.04180

Estimated TN (kg/m³)

Observed TN (kg/m³)

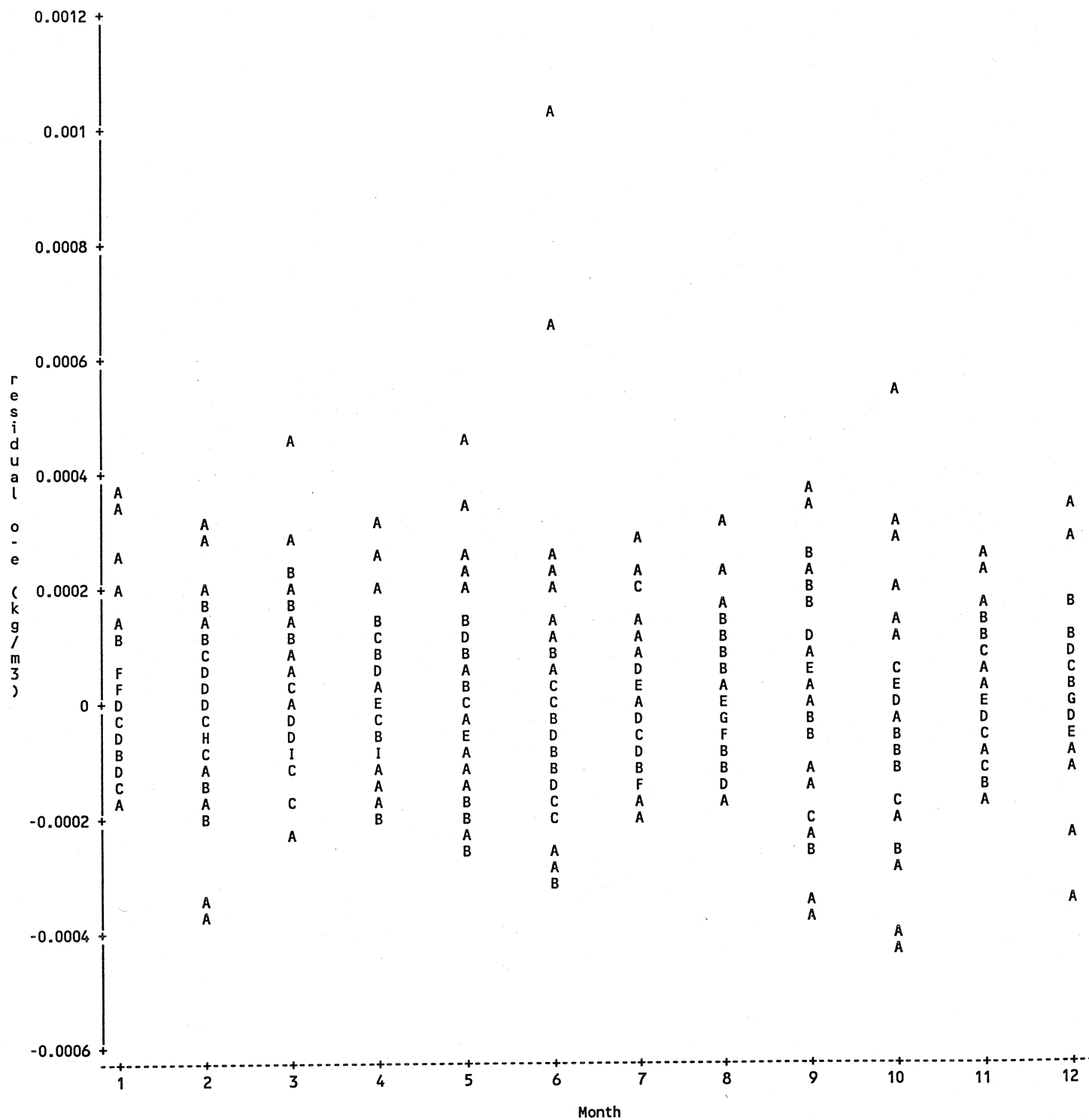
Printed on Recycled Paper

Plot of RTN*YEAR. Legend: A = 1 obs, B = 2 obs, etc.



NOTE: 58 obs had missing values.

Plot of RTN*MONTH. Legend: A = 1 obs, B = 2 obs, etc.



NOTE: 58 obs had missing values.

Tampa Bay National Estuary Program
Nutrient Model Using Transfer Coefficients

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	SEGMENT	CSS TN	USS Residual TN	Rsquare
Fit by Segment	1	.0000074144	.0000033516	0.54796
	2	.0000082355	.0000026986	0.67232
	31	.0000059221	.0000017695	0.70121
	32	.0000046895	.0000023233	0.50457
	33	.0000025623	.0000004260	0.83373
		CSS TN	USS Residual TN	Rsquare
Overall Fit		.000032694	.000010569	0.67673

Chlorophyll a and Nitrogen Load Regression Results

Tampa Bay National Estuary Program
Nutrient Model Using Transfer Coefficients
nmtr-75.sas

----- SEGMENT=1 -----

Model: MODEL1
NOTE: No intercept in model. R-square is redefined.
Dependent Variable: CHLA Chlorophyll a (ug/l)

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	13	9321.59853	717.04604	71.950	0.0001
Error	84	837.13554	9.96590		
U Total	97	10158.73407			

Root MSE 3.15688 R-square 0.9176
Dep Mean 9.07432 Adj R-sq 0.9048
C.V. 34.78919

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > T
ALPHA_1	1	4.091616	1.22642304	3.336	0.0013
ALPHA_2	1	3.931228	1.22868985	3.200	0.0019
ALPHA_3	1	3.203243	1.25859456	2.545	0.0128
ALPHA_4	1	5.326129	1.39026290	3.831	0.0002
ALPHA_5	1	7.367124	1.20696608	6.104	0.0001
ALPHA_6	1	7.555001	1.40041508	5.395	0.0001
ALPHA_7	1	10.656559	1.61197681	6.611	0.0001
ALPHA_8	1	9.536000	2.07906725	4.587	0.0001
ALPHA_9	1	12.863283	1.56400149	8.225	0.0001
ALPHA_10	1	13.317732	1.38442024	9.620	0.0001
ALPHA_11	1	9.686175	1.46351131	6.618	0.0001
ALPHA_12	1	6.046822	1.16876412	5.174	0.0001
L	1	0.031923	0.01893155	1.686	0.0955

TN Load (tons/mo)

----- SEGMENT=2 -----

Model: MODEL1
NOTE: No intercept in model. R-square is redefined.
Dependent Variable: CHLA Chlorophyll a (ug/l)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	13	19598.88510	1507.60655	60.225	0.0001
Error	86	2152.81223	25.03270		
U Total	99	21751.69733			

Root MSE 5.00327 R-square 0.9010
Dep Mean 13.05271 Adj R-sq 0.8861
C.V. 38.33127

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > T	Variable Label
ALPHA_1	1	1.833392	2.03462738	0.901	0.3701	
ALPHA_2	1	4.430821	1.85424226	2.390	0.0191	
ALPHA_3	1	4.875143	2.03530485	2.395	0.0188	
ALPHA_4	1	7.078712	1.92549700	3.676	0.0004	
ALPHA_5	1	7.905230	1.88458726	4.195	0.0001	
ALPHA_6	1	8.264862	1.98492567	4.164	0.0001	
ALPHA_7	1	10.949588	2.51339327	4.356	0.0001	
ALPHA_8	1	10.692159	2.69844226	3.962	0.0002	
ALPHA_9	1	14.778857	2.39619323	6.188	0.0001	
ALPHA_10	1	9.455526	2.13689203	4.425	0.0001	
ALPHA_11	1	10.286351	2.05084026	5.016	0.0001	
ALPHA_12	1	5.894330	1.83569638	3.211	0.0019	
L	1	0.040562	0.00889717	4.559	0.0001	TN Load (tons/mo)

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----- SEGMENT=31 -----

Model: MODEL1

NOTE: No Intercept in model. R-square is redefined.
Dependent Variable: CHLA Chlorophyll a (ug/l)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	13	9449.72885	726.90222	63.631	0.0001
Error	79	902.46833	11.42365		
U Total	92	10352.19718			
Root MSE	3.37989	R-square	0.9128		
Dep Mean	9.47403	Adj R-sq	0.8985		
C.V.	35.67529				

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > T	Variable Label
ALPHA_1	1	5.102201	1.24659403	4.093	0.0001	
ALPHA_2	1	4.297282	1.21164322	3.547	0.0007	
ALPHA_3	1	5.429933	1.28667447	4.220	0.0001	
ALPHA_4	1	5.957425	1.33489634	4.463	0.0001	
ALPHA_5	1	6.320804	1.36977494	4.614	0.0001	
ALPHA_6	1	5.696686	1.86378241	3.057	0.0031	
ALPHA_7	1	10.649887	2.05112879	5.192	0.0001	
ALPHA_8	1	7.300034	2.31230469	3.157	0.0023	
ALPHA_9	1	6.965503	2.60871057	2.670	0.0092	
ALPHA_10	1	7.358609	2.31146685	3.184	0.0021	
ALPHA_11	1	5.242441	1.46226324	3.585	0.0006	
ALPHA_12	1	4.865129	1.36233084	3.571	0.0006	
L	1	0.011439	0.00374916	3.051	0.0031	TN Load (tons/mo)

Tampa Bay National Estuary Program
Nutrient Model Using Transfer Coefficients
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----- SEGMENT=32 -----

Model: MODEL1

NOTE: No intercept in model. R-square is redefined.
Dependent Variable: CHLA Chlorophyll a (ug/l)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	13	4384.32290	337.25561	47.743	0.0001
Error	79	558.05358	7.06397		
U Total	92	4942.37648			
Root MSE	2.65781	R-square	0.8871		
Dep Mean	6.52103	Adj R-sq	0.8685		
C.V.	40.75759				

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > T	Variable Label
ALPHA_1	1	3.498667	1.02659571	3.408	0.0010	
ALPHA_2	1	4.285689	0.90194493	4.752	0.0001	
ALPHA_3	1	3.644328	0.95730869	3.807	0.0003	
ALPHA_4	1	4.506120	1.06709390	4.223	0.0001	
ALPHA_5	1	5.773260	1.05215445	5.487	0.0001	
ALPHA_6	1	2.459915	2.51209966	0.979	0.3305	
ALPHA_7	1	6.200695	1.77214445	3.499	0.0008	
ALPHA_8	1	5.777063	1.95215605	2.959	0.0041	
ALPHA_9	1	7.059619	2.23644894	3.157	0.0023	
ALPHA_10	1	9.128434	1.45124030	6.290	0.0001	
ALPHA_11	1	6.834069	1.06040105	6.445	0.0001	
ALPHA_12	1	3.858612	1.05082092	3.672	0.0004	
L	1	0.003290	0.00219350	1.500	0.1376	TN Load (tons/mo)

----- SEGMENT=33 -----

Model: MODEL1
NOTE: No intercept in model. R-square is redefined.
Dependent Variable: CHLA Chlorophyll a (ug/l)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	13	3388.82675	260.67898	38.672	0.0001
Error	79	532.52529	6.74083		
U Total	92	3921.35204			

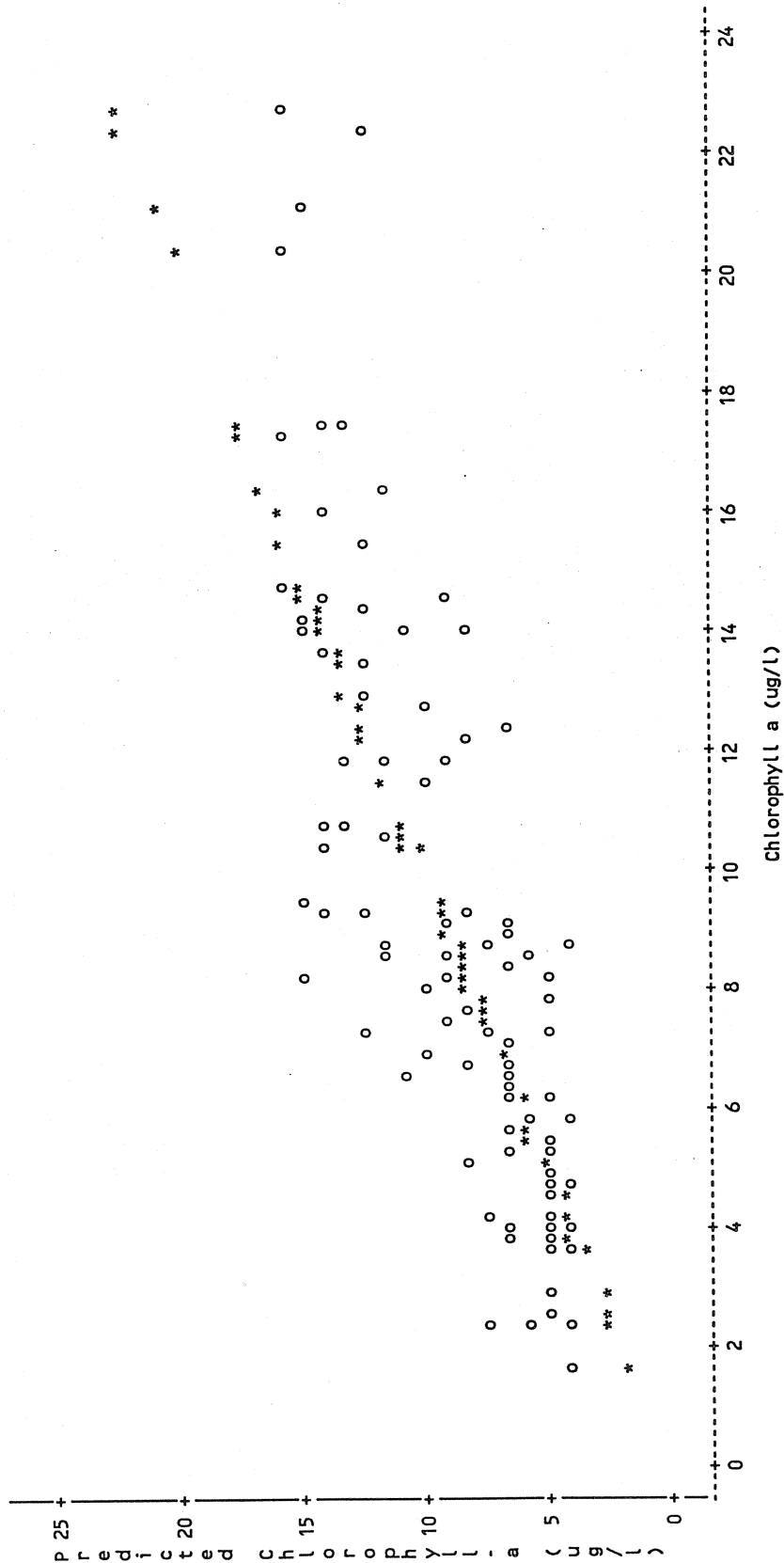
Root MSE 2.59631 R-square 0.8642
Dep Mean 5.53016 Adj R-sq 0.8419
C.V. 46.94823

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > T	Variable Label
ALPHA_1	1	3.104935	0.93417102	3.324	0.0013	
ALPHA_2	1	2.382309	0.90091627	2.644	0.0099	
ALPHA_3	1	3.900991	1.00108745	3.897	0.0002	
ALPHA_4	1	3.425879	0.94106155	3.640	0.0005	
ALPHA_5	1	4.874187	1.01196011	4.817	0.0001	
ALPHA_6	1	3.725782	1.87495021	1.987	0.0504	
ALPHA_7	1	4.250829	1.54386389	2.753	0.0073	
ALPHA_8	1	8.436319	1.47812827	5.707	0.0001	
ALPHA_9	1	8.752685	1.57304741	5.564	0.0001	
ALPHA_10	1	8.186498	1.23541406	6.627	0.0001	
ALPHA_11	1	4.956735	1.0452178	4.740	0.0001	
ALPHA_12	1	2.895675	0.99017390	2.924	0.0045	
L	1	0.003268	0.00301148	1.085	0.2811	TN Load (tons/mo)

SEGMENT=1

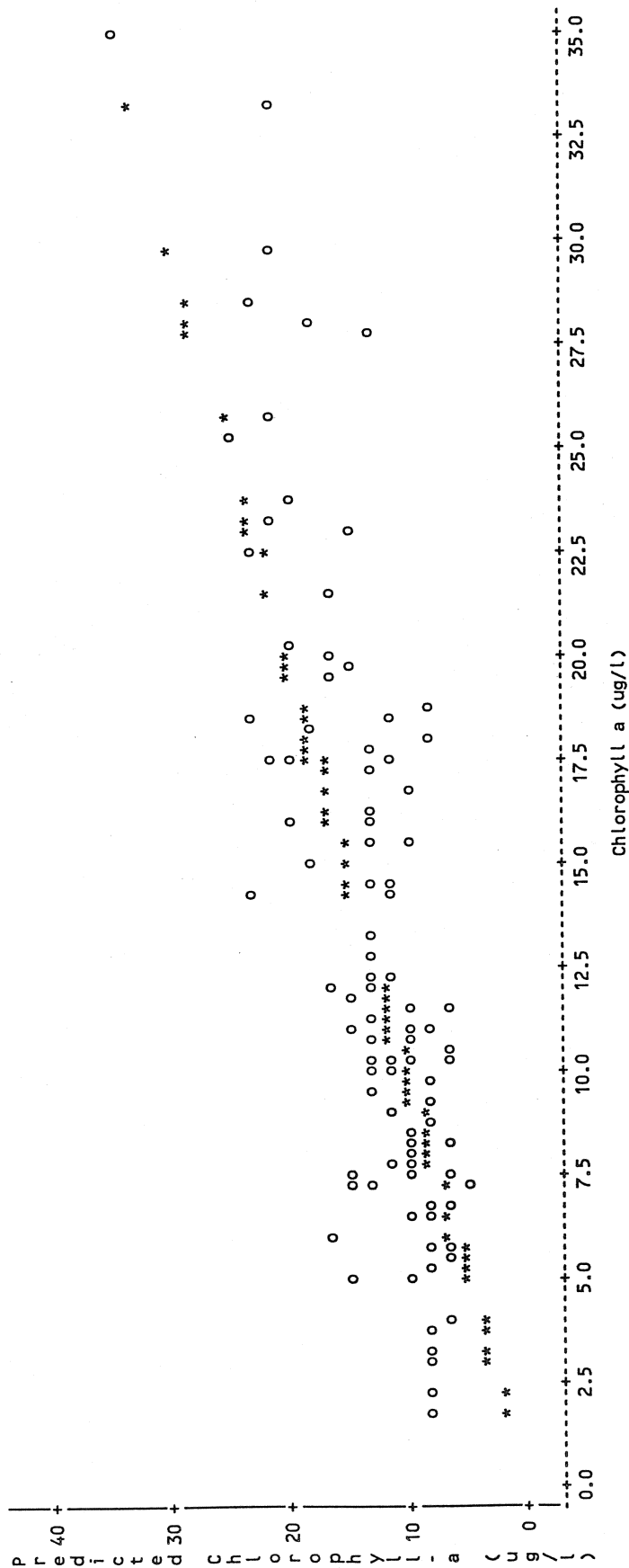
Plot of Predicted CHLA*CHLA. Symbol used is 'o'.
Plot of CHLA*CHLA. Symbol used is '*1'.



NOTE: 10 obs had missing values. 54 obs hidden.

SEGMENT=2

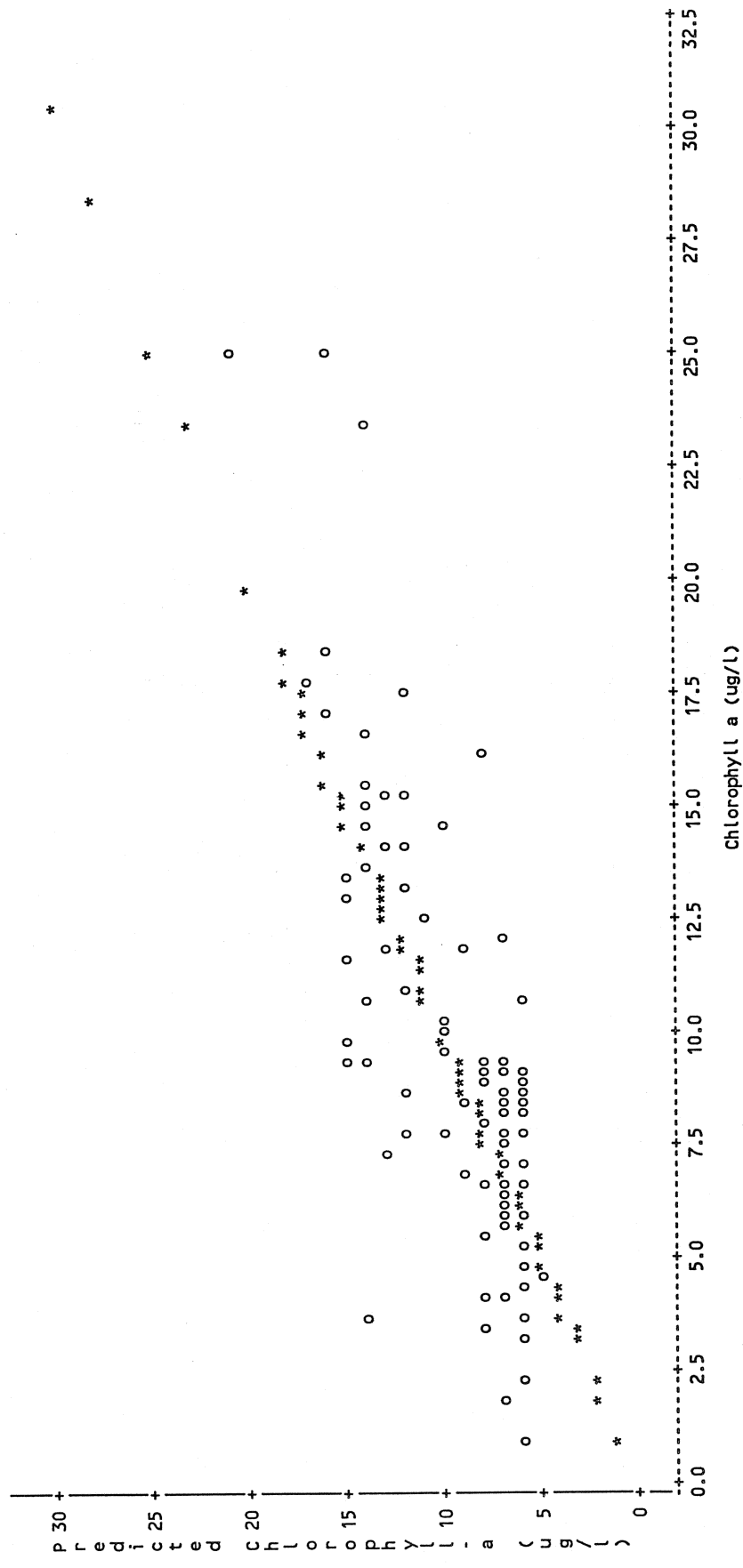
Plot of Predicted CHLA*CHLA. Symbol used is 'o'.
Plot of CHLA*CHLA. Symbol used is 'x'.



NOTE: 2 obs had missing values. 47 obs hidden.

SEGMENT=31

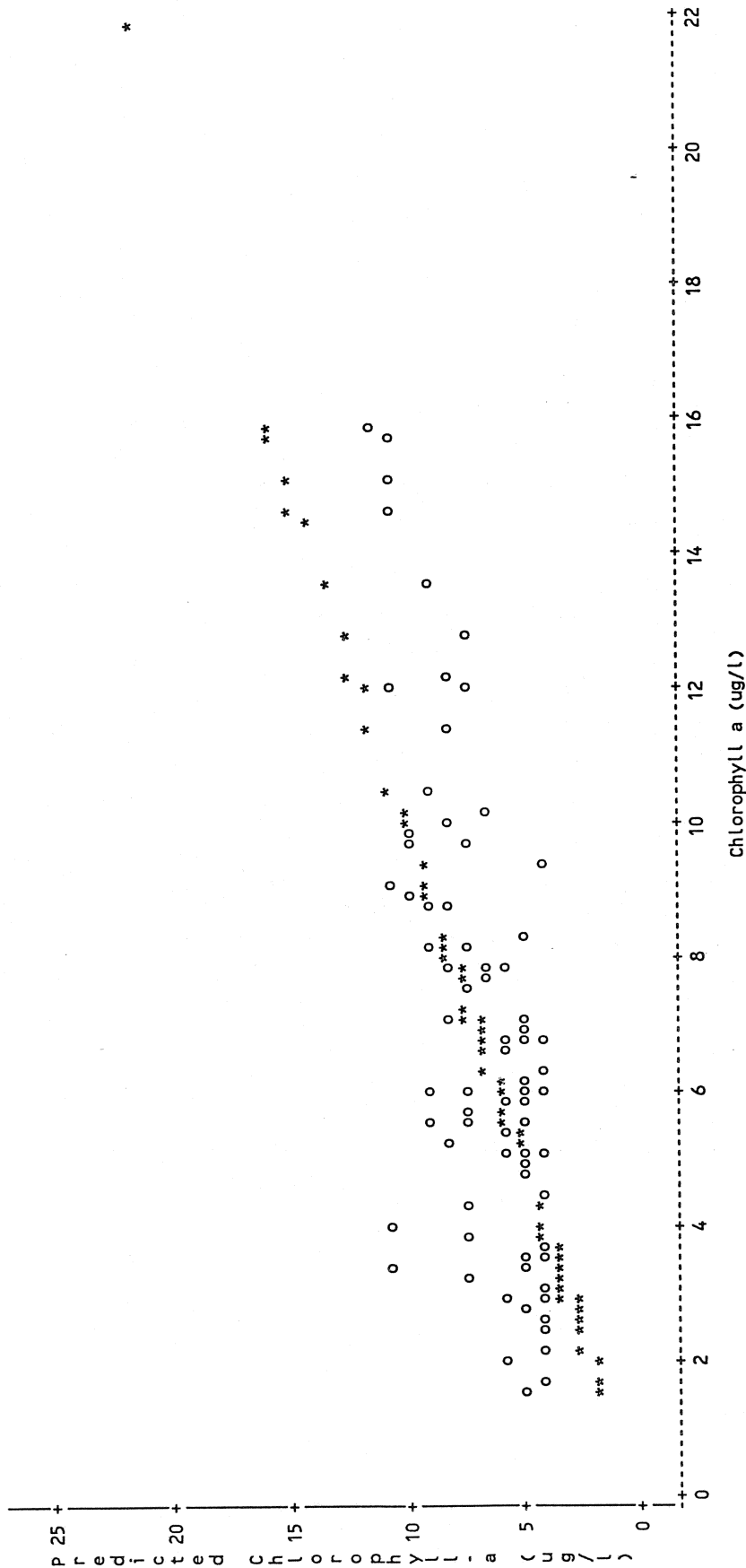
Plot of Predicted CHLA*CHLA. Symbol used is 'o'.
Plot of CHLA*CHLA. Symbol used is '*'.



NOTE: 10 obs had missing values. 60 obs hidden.

SEGMENT=32

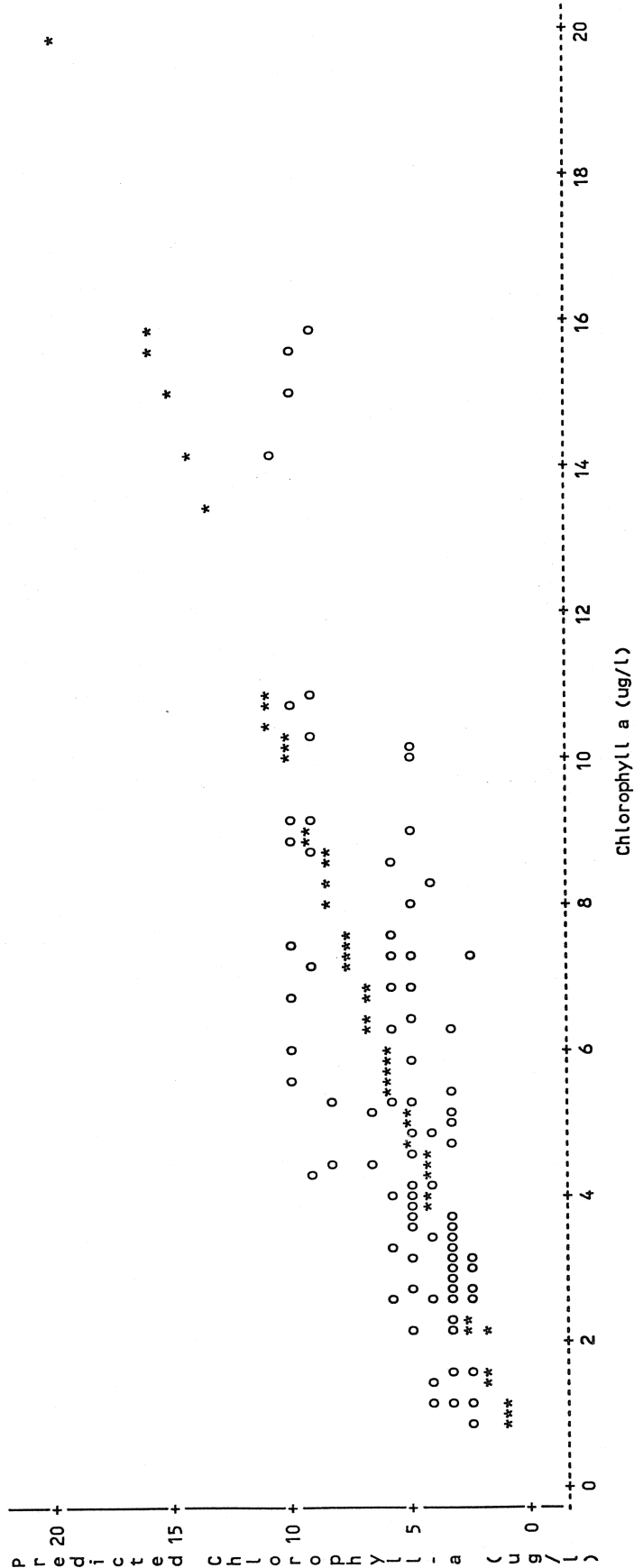
Plot of Predicted CHLA*CHLA. Symbol used is 'o'.
Plot of CHLA*CHLA. Symbol used is '*'.



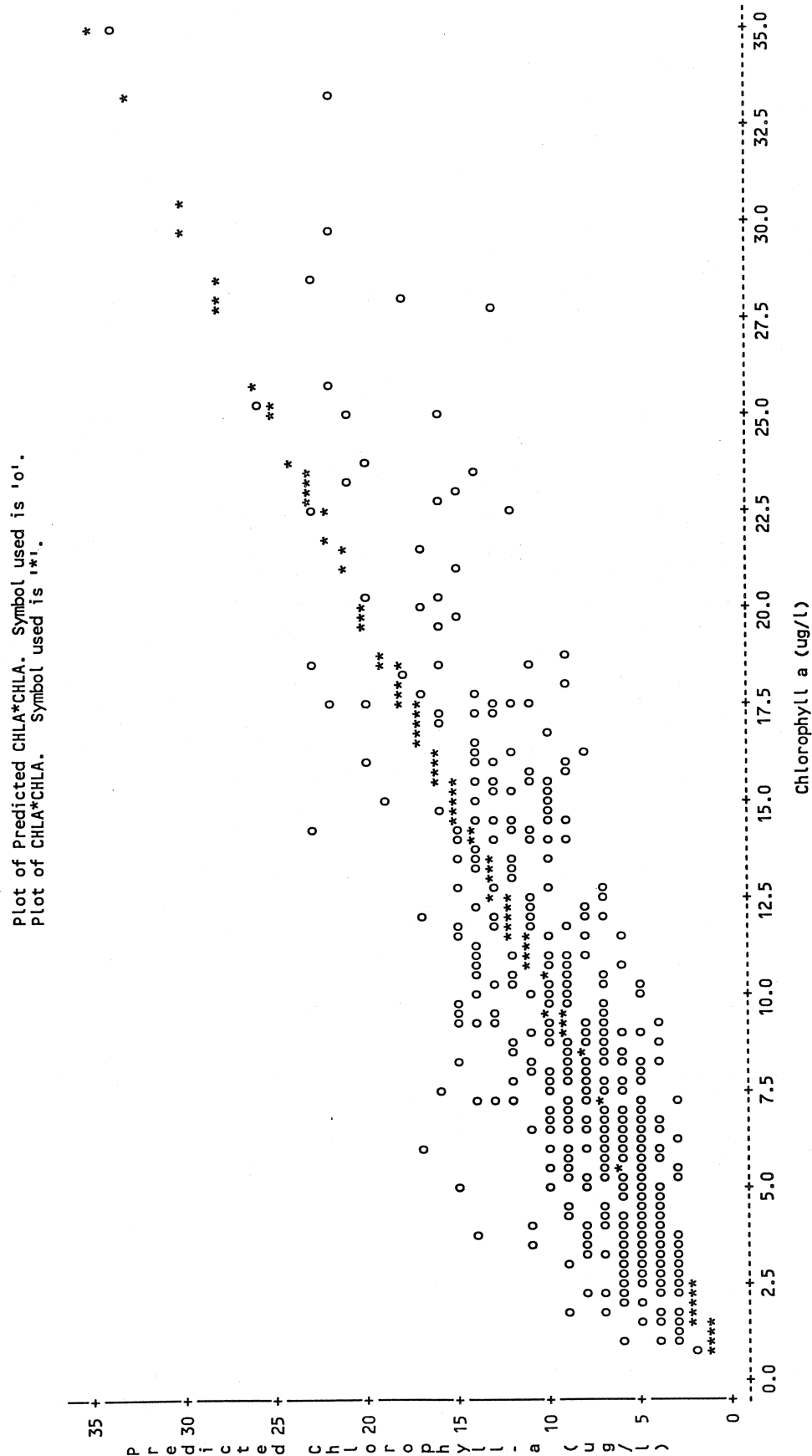
NOTE: 10 obs had missing values. 67 obs hidden.

SEGMENT=33

Plot of Predicted CHLA*CHLA. Symbol used is 'o'.
Plot of CHLA*CHLA. Symbol used is '*'.



NOTE: 13 obs had missing values. 62 obs hidden.



NOTE: 45 obs had missing values. 580 obs hidden.

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SEGMENT	CSS		USS Residual	
	Chlorophyll-a		Chlorophyll-a	Rsquare
Fit by Segment	1	2171.44	837.14	0.61448
	2	4884.75	2152.81	0.55928
	31	3022.92	902.47	0.70146
	32	1355.06	558.05	0.58817
	33	1428.05	532.53	0.62710
Overall Fit	CSS		USS Residual	
	Chlorophyll-a		Chlorophyll-a	Rsquare
	16097.71		4982.99	0.69045

APPENDIX E. NITROGEN LOAD AND WATER QUALITY DATA USED IN REGRESSIONS

[This Appendix is Available from the TBNEP upon Request]

Year	Month	TBNEP Bay Segment	Hydrologic Load (m3/mo)	TN (mg/l)	Salinity (ppt)	External TN Load (kg/mo)	Season	Percent Light	Z-Depth for 20.5% Light	Chlorophyll (ug/l)	Turbidity (NTU)
1986	1	1	15889981.98	0.43500	28.1500	13158.40	2-Dry	20.5	2.06666	5.3750	5.3750
1986	1	2	7077892.11	0.38000	28.7000	2906.91	2-Dry	20.5	2.16014	6.4200	1.8000
1986	1	4	9217022.98	0.45667	28.3444	3119.06	2-Dry	20.5	2.97519	3.3333	3.1667
1986	1	31	34044934.05	0.49625	24.7917	24024.86	2-Dry	20.5	1.96888	5.1500	2.0000
1986	1	32	71231849.78	0.48800	27.4333	108456.62	2-Dry	20.5	3.01895	3.5333	2.0000
1986	1	33	18845520.98	0.55667	30.9111	9488.06	2-Dry	20.5	3.67524	2.5667	2.0000
1986	2	1	16198303.87	0.38667	26.4444	12350.91	2-Dry	20.5	3.16078	2.8667	1.3333
1986	2	2	7608548.35	0.36667	27.0444	5535.34	2-Dry	20.5	1.06882	18.8625	5.1250
1986	2	4	9864529.29	0.41250	28.5583	6586.56	2-Dry	20.5	3.41272	2.8000	2.0000
1986	2	31	28212366.48	0.47833	25.4389	25874.15	2-Dry	20.5	1.57510	8.5333	2.6667
1986	2	32	59606568.19	0.53750	24.6042	95469.61	2-Dry	20.5	2.93144	5.0667	1.3333
1986	2	33	18060945.94	0.44500	32.1750	14573.96	2-Dry	20.5	3.82837	2.6000	1.2500
1986	3	1	27885806.14	0.53333	26.8111	27621.85	2-Dry	20.5	2.08225	4.7923	2.3846
1986	3	2	11460877.53	0.47000	27.8833	6052.77	2-Dry	20.5	1.57510	12.7500	3.3750
1986	3	4	14946402.98	0.42000	28.6000	7179.55	2-Dry	20.5	2.15847	5.5667	3.2222
1986	3	31	45233219.50	0.54308	26.0821	30962.98	2-Dry	20.5	1.57510	9.2333	2.3333
1986	3	32	97175807.45	0.62875	25.6708	172674.91	2-Dry	20.5	2.59236	6.0000	1.2500
1986	3	33	30756742.88	0.52100	32.0433	19187.39	2-Dry	20.5	1.77199	10.2000	3.2500
1986	4	1	10471588.71	0.52667	26.5222	10122.37	2-Dry	20.5	2.18598	6.3833	1.9167
1986	4	2	3795821.03	0.52857	27.0476	3921.27	2-Dry	20.5	1.08007	10.9900	5.6000
1986	4	4	4491800.21	0.47000	28.9667	4234.79	2-Dry	20.5	2.65798	2.9375	1.0000
1986	4	31	18461398.05	0.53375	25.9681	17153.48	2-Dry	20.5	0.91881	8.6333	7.0000
1986	4	32	34298991.93	0.57400	25.4567	64991.60	2-Dry	20.5	2.28765	6.7143	2.0000
1986	4	33	9149527.52	0.42667	32.1926	10112.69	2-Dry	20.5	2.42828	4.7500	1.0000
1986	5	1	11322186.66	0.45667	27.3778	13718.18	2-Dry	20.5	1.46963	13.9400	3.9333
1986	5	2	7213571.01	0.44500	28.4250	10126.46	2-Dry	20.5	1.44009	10.2300	3.5000
1986	5	4	9036742.29	0.49250	30.1583	12539.30	2-Dry	20.5	4.28231	2.9250	1.2500
1986	5	31	27765335.88	0.57800	27.0067	34278.68	2-Dry	20.5	1.48760	8.9000	3.3333
1986	5	32	29761969.02	0.50200	26.3767	57255.98	2-Dry	20.5	2.00169	6.6750	2.2500
1986	5	33	16778390.74	0.31750	33.2250	25914.96	2-Dry	20.5	3.34709	3.8000	1.7500
1986	6	1	27767167.99	0.65750	29.3750	34907.75	1-Wet	20.5	1.49934	14.5167	3.6667
1986	6	2	16485368.48	0.51250	29.7000	19540.77	1-Wet	20.5	1.20008	16.1800	5.8000
1986	6	4	21324480.21	0.40500	24917.12	24917.12	1-Wet	20.5	2.61059	5.6667	2.1111
1986	6	31	48372494.36	0.61500	27.1639	54056.38	1-Wet	20.5	1.44384	9.6500	5.0000
1986	6	32	70065407.22	0.67700	28.7500	128435.09	1-Wet	20.5	1.77199	7.7750	2.7500
1986	6	33	53780534.63	0.59250	33.7500	72206.72	1-Wet	20.5	1.90325	7.3500	2.0000
1986	7	1	33816050.20	0.59250	26.4250	43045.38	1-Wet	20.5	1.29673	22.4429	4.4286
1986	7	2	17064951.02	0.48000	27.2000	9680.56	1-Wet	20.5	1.05007	18.2700	5.6000
1986	7	4	2232926.65	0.53750	28.7750	11543.69	1-Wet	20.5	2.31890	2.4111	2.2222
1986	7	31	60016525.90	0.67643	24.9694	41209.69	1-Wet	20.5	1.14851	13.3750	6.0000
1986	7	32	102752093.45	0.70600	23.1733	156284.16	1-Wet	20.5	1.96888	12.2000	2.0000
1986	7	33	52569133.24	0.44400	31.5300	33354.88	1-Wet	20.5	2.32984	4.9250	2.5000
1986	8	2	50904311.18	0.60250	24.2667	61501.97	1-Wet	20.5	0.73505	25.6800	7.4000
1986	8	4	21038136.32	0.50000	26.6333	15949.59	1-Wet	20.5	1.44384	6.0200	4.6000
1986	8	31	27537405.27	0.36000	25.4167	19690.49	1-Wet	20.5	0.75474	15.5000	7.7500
1986	8	32	67152776.08	0.70500	22.1400	55256.46	1-Wet	20.5	1.57510	8.8000	4.0000
1986	8	33	175344187.77	0.39400	30.6667	245904.19	1-Wet	20.5	1.05007	10.6500	6.5000
1986	9	1	63956940.35	0.74250	24.1250	53262.57	1-Wet	20.5	1.05007	10.6500	6.5000
1986	9	2	29827104.62	0.52750	24.9583	25213.36	1-Wet	20.5	1.33146	17.3643	5.2143
1986	9	4	15714472.73	0.47667	26.9500	9770.43	1-Wet	20.5	0.68338	33.3444	7.6667
1986	9	31	19640291.20	0.65000	22.9619	10693.10	1-Wet	20.5	2.22130	4.0231	3.8462
1986	9	32	54651173.10	0.80111	22.4741	39820.02	1-Wet	20.5	1.01725	15.3000	4.7500
1986	9	33	125794720.51	0.80111	22.4741	164380.50	1-Wet	20.5	1.70636	13.4750	3.0000

Year	Month	TBNEP Bay Segment	Hydrologic Load (m3/mo)	TN (mg/L)	Salinity (ppt)	External TN Load (kg/mo)	Season	Percent Light	Z=Depth for 20.5% Light	Chlorophyll (ug/L)	Turbidity (NTU)
1986	9	33	36383046.18	0.40067	31.4867	21774.49	1-Wet	20.5	1.92512	6.7167	2.3333
1986	10	1	39524048.10	0.61000	24.1238	35294.30	1-Wet	20.5	1.09682	14.7333	3.8667
1986	10	2	46305004.40	0.49750	21.8708	53789.83	1-Wet	20.5	1.08757	19.6400	5.3500
1986	10	4	51767962.80	0.50750	26.6667	56195.85	1-Wet	20.5	1.63344	7.0000	3.0000
1986	10	31	76063976.51	0.68367	19.0728	73793.94	1-Wet	20.5	1.10632	11.8571	4.2857
1986	10	32	80522503.26	0.82950	23.2767	133111.95	1-Wet	20.5	1.42744	12.0000	2.5000
1986	10	33	61819602.03	0.38400	30.0567	61475.41	1-Wet	20.5	1.54229	9.1750	3.0000
1986	11	1	13710534.18	0.42000	21.1000	12736.31	2-Dry	20.5	1.57460	6.5071	3.3571
1986	11	4	9328085.04	0.67000	20.7500	10516.75	2-Dry	20.5	2.97519	3.4000	2.1111
1986	11	31	9700263.09	0.49250	22.0500	9643.42	2-Dry	20.5	1.05007	9.4000	5.0000
1986	11	32	26492466.80	0.72286	18.8786	21803.00	2-Dry	20.5	1.50947	4.3000	3.5000
1986	11	33	39274265.81	0.43000	25.2800	73261.96	2-Dry	20.5	1.80480	6.9250	2.7500
1986	12	2	15530304.45	0.61667	24.7000	12942.86	2-Dry	20.5	1.80480	6.9250	2.7500
1986	12	31	14828952.80	0.69000	24.8000	9939.87	2-Dry	20.5	0.83339	17.9667	9.7778
1986	12	32	9364194.41	0.38000	16.7333	4869.33	2-Dry	20.5	1.13757	5.4333	4.0000
1986	12	33	11419267.01	0.76111	23.3222	4801.38	2-Dry	20.5	1.70636	5.4000	3.0000
1986	12	2	28820868.73	0.41333	26.9556	16080.87	2-Dry	20.5	2.62517	1.0000	1.6667
1986	12	4	43547994.93	0.36250	27.1917	60587.99	2-Dry	20.5	2.62517	1.0000	1.6667
1987	1	1	21843875.93	0.30667	28.8222	10587.98	2-Dry	20.5	1.83703	8.2267	2.4667
1987	1	2	17650162.99	0.44125	26.0958	13084.51	2-Dry	20.5	1.56635	7.4250	4.1250
1987	1	4	7702190.32	0.44667	24.4067	3665.93	2-Dry	20.5	2.87310	3.5111	2.2222
1987	1	31	9998815.16	0.23444	31.3556	4048.01	2-Dry	20.5	1.31259	7.6333	4.0000
1987	1	32	37316227.66	0.26000	27.8333	28159.71	2-Dry	20.5	2.06732	5.9750	1.7500
1987	1	33	56896619.31	0.36000	28.5250	96242.66	2-Dry	20.5	2.45016	3.6333	1.6667
1987	2	1	22824414.89	0.42500	27.7667	10672.26	2-Dry	20.5	2.40435	7.2167	2.5833
1987	2	2	6222774.40	0.47833	25.8639	26512.39	2-Dry	20.5	1.65011	8.3875	4.0000
1987	2	4	8016857.93	0.37125	27.1542	11280.05	2-Dry	20.5	2.74002	1.8750	1.8750
1987	2	31	25055784.70	0.34000	31.0630	14292.38	2-Dry	20.5	1.44384	8.2500	4.0000
1987	2	32	45452757.59	0.34000	31.0630	39462.62	2-Dry	20.5	2.42828	4.7000	2.2500
1987	2	33	17071043.66	0.34000	31.0630	109592.13	2-Dry	20.5	2.39547	3.1750	1.7500
1987	3	31	57433775.73	0.34000	31.0630	31909.52	2-Dry	20.5	2.39547	3.1750	1.7500
1987	3	32	28381730.19	0.34000	31.0630	77837.67	2-Dry	20.5	2.39547	3.1750	1.7500
1987	3	33	37404703.83	0.34000	31.0630	20269.95	2-Dry	20.5	2.39547	3.1750	1.7500
1987	3	1	110394715.54	0.34000	31.0630	25852.07	2-Dry	20.5	2.39547	3.1750	1.7500
1987	3	2	187265772.22	0.34000	31.0630	90814.58	2-Dry	20.5	2.39547	3.1750	1.7500
1987	3	4	78519984.13	0.34000	31.0630	364799.50	2-Dry	20.5	2.39547	3.1750	1.7500
1987	4	31	24615325.81	0.34000	31.0630	58020.32	2-Dry	20.5	2.39547	3.1750	1.7500
1987	4	32	2415666.04	0.34000	31.0630	44149.34	2-Dry	20.5	2.39547	3.1750	1.7500
1987	4	33	2579167.35	0.34000	31.0630	3324.27	2-Dry	20.5	2.39547	3.1750	1.7500
1987	4	1	36102942.37	0.34000	31.0630	3277.21	2-Dry	20.5	2.39547	3.1750	1.7500
1987	4	2	190230812.70	0.34000	31.0630	48266.64	2-Dry	20.5	2.39547	3.1750	1.7500
1987	4	4	5759503.26	0.34000	31.0630	427297.90	2-Dry	20.5	2.39547	3.1750	1.7500
1987	5	31	37159384.77	0.34000	31.0630	7737.70	2-Dry	20.5	2.39547	3.1750	1.7500
1987	5	32	11802875.49	0.34000	31.0630	75404.57	2-Dry	20.5	2.39547	3.1750	1.7500
1987	5	33	15176086.55	0.34000	31.0630	21318.80	2-Dry	20.5	2.39547	3.1750	1.7500
1987	5	1	41340577.46	0.34000	31.0630	27462.59	2-Dry	20.5	2.39547	3.1750	1.7500
1987	5	2	99112490.60	0.34000	31.0630	64082.06	2-Dry	20.5	2.39547	3.1750	1.7500
1987	5	4	32639325.03	0.34000	31.0630	255897.28	2-Dry	20.5	2.39547	3.1750	1.7500
1987	6	1	19937600.16	1.18000	26.9083	61403.73	1-Wet	20.5	1.57460	7.6786	4.2857
1987	6	2	12629605.26	1.53250	24.9000	18859.98	1-Wet	20.5	1.15507	17.2000	7.2000
1987	6	4	16117600.64	0.82250	28.8917	9275.37	1-Wet	20.5	2.04180	4.8556	2.2222
1987	6	31	36774052.05	2.05500	21.7905	11101.09	1-Wet	20.5	1.34540	10.3000	4.5000

Year	Month	TBNEP Bay Segment	Hydrologic Load (m ³ /mo)	TN (mg/L)	Salinity (ppt)	External TN Load (kg/mo)	Season	Percent Light	Z=Depth for 20.5% Light	Chlorophyll (ug/L)	Turbidity (NTU)
1987	6	32	57955915.64	1.15600	25.1167	113851.34	1-Wet	20.5	1.80480	7.8500	2.7500
1987	6	33	37392983.86	0.67400	33.4233	28323.33	1-Wet	20.5	1.67355	7.5500	2.5000
1987	7	1	40655204.92	1.08250	20.1083	65333.16	1-Wet	20.5	1.42640	17.4467	5.6667
1987	7	2	18586164.20	0.89250	20.5583	15796.58	1-Wet	20.5	1.11674	29.8444	5.2222
1987	7	4	23860699.39	0.78250	13.4500	19228.94	1-Wet	20.5	3.05176	3.3750	1.6250
1987	7	31	72130658.17	1.25000	17.3733	66728.25	1-Wet	20.5	1.41103	17.6250	4.0000
1987	7	32	121197556.33	1.39444	21.2667	256768.35	1-Wet	20.5	2.06732	10.4750	2.5000
1987	7	33	54533950.78	0.66625	15.0250	45337.16	1-Wet	20.5	3.01895	5.2750	2.0000
1987	7	33	46838228.03	0.99000	23.4250	61906.20	1-Wet	20.5	1.56302	12.9286	4.7857
1987	8	1	25235929.30	0.81750	27.9750	25592.22	1-Wet	20.5	1.21883	17.6000	5.6250
1987	8	2	31499159.60	0.86000	26.3083	30415.22	1-Wet	20.5	2.98978	4.3222	1.3333
1987	8	4	83564067.34	1.09786	25.3595	82363.14	1-Wet	20.5	1.08288	15.0000	6.5000
1987	8	31	118796713.07	1.35000	21.5042	215105.27	1-Wet	20.5	1.87043	7.0500	2.7500
1987	8	32	51262721.15	0.59300	30.1167	48781.02	1-Wet	20.5	2.29702	9.0750	3.5000
1987	8	33	30240710.43	1.13750	26.1583	30800.50	1-Wet	20.5	1.37777	13.9400	5.1000
1987	9	1	17572803.74	1.12571	24.8619	12618.50	1-Wet	20.5	1.03340	23.1667	8.3333
1987	9	2	21822712.90	0.96250	29.1000	14063.13	1-Wet	20.5	3.10098	3.1625	1.8250
1987	9	4	61616181.32	1.40867	20.8811	49329.21	1-Wet	20.5	1.21414	12.8500	6.2500
1987	9	31	77039009.01	1.46556	23.9296	140324.27	1-Wet	20.5	1.27508	14.6714	6.1429
1987	9	32	42123512.42	0.76250	33.8417	26032.38	1-Wet	20.5	1.80480	7.4000	3.2500
1987	9	33	13934246.08	1.25250	24.7917	14033.77	1-Wet	20.5	1.67880	9.2643	3.8571
1987	10	1	7262314.93	1.07500	21.6417	4754.67	1-Wet	20.5	1.23008	10.9200	5.8000
1987	10	2	8618436.43	0.80750	27.3417	4358.74	1-Wet	20.5	1.72094	7.4889	5.4444
1987	10	4	30443204.63	1.06000	18.1357	23633.23	1-Wet	20.5	1.01725	10.7750	8.2500
1987	10	31	60959453.97	1.30100	23.7067	111072.88	1-Wet	20.5	1.70636	9.1000	3.5000
1987	10	32	18550879.61	0.82600	30.2933	8638.98	1-Wet	20.5	1.54229	7.1750	3.5000
1987	10	33	30194131.55	0.90750	22.4167	50891.22	2-Dry	20.5	1.51510	5.9900	5.1000
1987	11	2	14826847.66	0.79000	19.5000	5605.38	2-Dry	20.5	2.42828	4.4875	2.8750
1987	11	4	19014335.84	0.93250	29.5417	5798.78	2-Dry	20.5	1.47666	6.7500	5.2500
1987	11	31	44087148.96	1.02700	19.6500	19209.02	2-Dry	20.5	2.10014	8.2000	3.0000
1987	11	32	77051493.61	0.82778	33.1370	12606.78	2-Dry	20.5	1.60792	6.9000	4.0000
1987	11	33	35716860.52	0.42700	25.9500	9775.31	2-Dry	20.5	1.60792	6.9000	4.0000
1987	12	1	9940271.60	0.64750	25.1500	2440.05	2-Dry	20.5	3.79756	3.8286	2.0000
1987	12	2	2666659.81	0.33333	28.8111	2230.35	2-Dry	20.5	1.55635	9.6500	4.5000
1987	12	4	15266805.10	0.77857	22.6429	12656.40	2-Dry	20.5	5.95039	1.3000	1.0000
1987	12	31	43798501.16	0.49250	25.1625	68861.23	2-Dry	20.5	1.90325	2.9500	3.0000
1987	12	32	6354847.75	0.29000	31.4000	5357.05	2-Dry	20.5	2.82206	2.9500	3.0000
1987	12	33	19139133.60	0.38000	27.9667	19757.34	2-Dry	20.5	4.72531	3.0333	2.0000
1988	1	1	8524893.40	0.40000	27.0250	5121.59	2-Dry	20.5	2.54715	5.5429	3.0000
1988	1	2	11088478.70	0.36250	29.5583	5981.14	2-Dry	20.5	2.60017	3.8833	2.3333
1988	1	4	33132715.78	0.43857	24.9190	33567.39	2-Dry	20.5	2.60017	3.8833	2.3333
1988	1	31	56332500.54	0.43000	27.0444	101965.51	2-Dry	20.5	2.52308	1.5111	3.7778
1988	1	32	23067622.79	0.30300	32.8167	13699.81	2-Dry	20.5	3.41272	4.3500	1.5000
1988	1	33	18076867.61	0.49333	22.9667	18467.01	2-Dry	20.5	2.92050	6.7750	2.5000
1988	2	1	5410598.00	0.43000	26.9417	3582.10	2-Dry	20.5	2.62517	2.5500	2.5000
1988	2	2	6953196.40	0.31750	24.8500	4013.34	2-Dry	20.5	2.25577	3.7083	3.5000
1988	2	4	22523284.57	0.44167	26.8583	21823.17	2-Dry	20.5	2.00013	3.1222	3.5556
1988	2	31	57857805.22	0.51333	21.8000	99526.71	2-Dry	20.5	2.11472	2.5889	5.5556
1988	2	32	15601482.20	0.34778	27.6556	10125.19	2-Dry	20.5	1.66261	5.9333	4.3333
1988	2	33	31941686.51	0.51333	26.3333	27677.18	2-Dry	20.5	2.36265	2.4000	3.7500
1988	3	1	13202500.41	0.45750	27.3750	5309.36	2-Dry	20.5	2.36265	2.7750	3.5000
1988	3	2	17320714.40	0.38250	27.9500	6229.72	2-Dry	20.5	2.55293	1.6000	3.0000
1988	3	4					2-Dry	20.5	1.29008	14.4900	6.5000
1988	3						2-Dry	20.5	2.90227	1.0333	2.7778

Year	Month	TBNEP Bay Segment	Hydrologic Load (m3/mo)	TN (mg/l)	Salinity (ppt)	External TN Load (kg/mo)	Season	Percent Light	Z=Depth for 20.5% Light	Chlorophyll (ug/L)	Turbidity (NTU)
1988	3	31	46440617.22	0.47375	26.2917	30867.04	2-Dry	20.5	1.66261	8.5000	6.3333
1988	3	32	116266257.85	0.60700	25.0433	166315.31	2-Dry	20.5	2.62517	2.1500	3.0000
1988	3	33	35892098.36	0.36111	31.7259	14462.58	2-Dry	20.5	2.78924	2.0750	3.0000
1988	4	1	12119336.25	0.51333	27.5889	18722.05	2-Dry	20.5	1.66722	9.1714	5.5000
1988	4	2	5943695.16	0.39000	27.3417	11735.11	2-Dry	20.5	1.00006	18.6111	11.0000
1988	4	4	7330559.39	0.43250	23.4000	14651.36	2-Dry	20.5	3.01895	1.8125	2.7500
1988	4	31	24221397.65	0.49071	26.0119	39540.12	2-Dry	20.5	1.18133	9.1667	6.3333
1988	4	32	40620806.46	0.37500	24.0704	91434.69	2-Dry	20.5	1.80480	8.3000	3.2500
1988	4	33	11677773.10	0.53333	26.2750	23532.74	2-Dry	20.5	2.62517	2.7750	3.0000
1988	5	1	11267185.90	0.53333	25.8444	56196.76	2-Dry	20.5	2.46739	5.0000	2.4444
1988	5	2	5897094.49	0.59500	23.2583	5507.10	2-Dry	20.5	1.18508	15.5300	5.6000
1988	5	4	7259218.40	0.48750	31.4667	6319.65	2-Dry	20.5	3.50648	1.4857	1.7143
1988	5	31	20579529.39	0.58778	21.5074	17942.35	2-Dry	20.5	1.18133	16.1667	6.3333
1988	5	32	32321733.70	0.71500	25.0967	64487.53	2-Dry	20.5	2.03451	7.7500	2.5000
1988	5	33	17542457.41	0.44429	34.7190	16442.30	2-Dry	20.5	2.69080	2.6500	1.5000
1988	6	1	12550343.60	0.65000	31.3083	7146.30	1-Wet	20.5	1.13464	9.2333	8.4000
1988	6	2	8547223.27	0.55750	32.2417	4416.31	1-Wet	20.5	0.90006	17.5667	9.6667
1988	6	4	10693048.29	0.46750	37.6000	4685.62	1-Wet	20.5	2.39182	3.7889	3.5556
1988	6	31	37880173.15	0.70267	30.5778	25305.24	1-Wet	20.5	0.82037	11.8500	11.0000
1988	6	32	37397281.34	0.67556	29.4741	68801.16	1-Wet	20.5	1.44384	6.0000	4.7500
1988	6	33	22155189.30	0.47400	38.9222	10756.79	1-Wet	20.5	2.00169	6.4000	3.5000
1988	7	1	33061857.53	0.60750	31.7917	24887.37	1-Wet	20.5	0.90771	11.7467	10.4667
1988	7	2	19937953.50	0.72750	30.9500	8188.27	1-Wet	20.5	0.97506	5.0100	8.8000
1988	7	4	25681887.28	0.67750	33.1833	9053.14	1-Wet	20.5	1.73553	6.5333	4.6667
1988	7	31	42866390.34	0.78333	28.5289	22349.12	1-Wet	20.5	1.11570	3.7250	6.0000
1988	7	32	55395976.98	0.67000	31.1333	83651.70	1-Wet	20.5	1.18133	3.8250	7.5000
1988	7	33	62508291.09	0.65600	36.0567	22211.25	1-Wet	20.5	1.54229	8.0500	3.0000
1988	8	1	72942497.03	0.81250	28.2167	104902.42	1-Wet	20.5	1.45882	13.7067	6.4667
1988	8	2	30283025.55	0.64500	29.1833	44252.90	1-Wet	20.5	1.18508	17.3800	6.2000
1988	8	4	39683920.56	0.53250	29.9417	57105.39	1-Wet	20.5	2.96972	4.6375	8.8750
1988	8	31	97758347.56	0.76333	27.6733	136513.61	1-Wet	20.5	1.27977	9.7250	7.2500
1988	8	32	136351742.62	1.03200	27.0667	261344.84	1-Wet	20.5	1.83762	6.0500	2.5000
1988	8	33	89598993.58	0.41750	33.2583	132024.70	1-Wet	20.5	1.54229	6.0500	6.2500
1988	9	31	195784448.45	.	.	225494.17	.	.	.	.	.
1988	9	32	150650415.41	.	.	172566.53	.	.	.	.	.
1988	9	33	148978802.62	.	.	149890.72	.	.	.	.	.
1988	9	1	245669397.24	.	.	200692.93	.	.	.	.	.
1988	9	2	392323231.02	.	.	607296.47	.	.	.	.	.
1988	9	4	157828906.84	.	.	62771.39	.	.	.	.	.
1988	10	31	17731088.57	.	.	21138.78	.	.	.	.	.
1988	10	32	4854903.89	.	.	5524.35	.	.	.	.	.
1988	10	33	5361127.04	.	.	5097.41	.	.	.	.	.
1988	10	1	20225072.91	.	.	23281.81	.	.	.	.	.
1988	10	2	64294863.23	.	.	111195.36	.	.	.	.	.
1988	10	4	9597863.37	.	.	8118.98	.	.	.	.	.
1988	11	31	32639750.91	.	.	28362.53	.	.	.	.	.
1988	11	32	19108361.79	.	.	10622.12	.	.	.	.	.
1988	11	33	23533294.66	.	.	10664.84	.	.	.	.	.
1988	11	1	75737740.55	.	.	46888.33	.	.	.	.	.
1988	11	2	118852663.17	.	.	175711.72	.	.	.	.	.
1988	11	4	44035293.68	.	.	16852.07	.	.	.	.	.
1988	12	1	9589505.01	0.75667	23.8111	8598.83	2-Dry	20.5	2.59346	6.7300	3.3000
1988	12	2	3692479.67	0.35750	27.0250	1915.38	2-Dry	20.5	1.26437	10.2000	7.7143

Year	Month	TBNEP Bay Segment	Hydrologic Load (m ³ /mo)	TN (mg/L)	Salinity (ppt)	External TN Load (kg/mo)	Season	Percent Light	Z-Depth for 20.5% Light	Chlorophyll (ug/L)	Turbidity (NTU)
1988	12	4	4342994.63	0.54000	25.0750	1562.17	2-Dry	20.5	3.34709	1.8333	3.6667
1988	12	31	27657413.14	0.34200	22.9500	24023.78	2-Dry	20.5	1.44384	5.8000	8.6667
1988	12	32	110210154.18	0.75571	22.4762	149663.69	2-Dry	20.5	2.69080	5.4750	4.0000
1988	12	33	9890147.26	0.50000	29.7056	4050.13	2-Dry	20.5	3.01895	3.1250	4.2500
1989	1	1	15299672.23	0.59333	24.1778	15698.98	2-Dry	20.5	2.04640	5.8375	5.6250
1989	1	2	5723255.03	0.53000	24.6667	2367.55	2-Dry	20.5	1.06674	11.0444	10.3333
1989	1	4	7379633.19	0.87000	26.7250	2347.40	2-Dry	20.5	1.77928	3.2556	7.3333
1989	1	31	27609622.57	0.65250	21.0750	18475.05	2-Dry	20.5	1.26883	9.1333	9.6667
1989	1	32	79006555.93	0.64889	22.9889	98128.32	2-Dry	20.5	1.18764	5.0000	5.6667
1989	1	33	16724289.08	0.83200	31.3167	6904.70	2-Dry	20.5	1.64073	5.4250	6.5000
1989	2	1	6938623.32	0.66333	27.8778	7952.32	2-Dry	20.5	1.86405	6.2000	5.7500
1989	2	2	1640513.44	0.57000	27.7917	2420.63	2-Dry	20.5	1.25008	10.2333	8.6667
1989	2	4	1915802.69	0.46500	30.2917	2518.28	2-Dry	20.5	3.80650	4.5667	5.3333
1989	2	31	14464558.59	0.44667	24.5306	16486.61	2-Dry	20.5	1.61885	1.1500	3.6250
1989	2	32	45333883.05	0.85667	25.0778	67028.46	2-Dry	20.5	3.09547	6.3750	5.5000
1989	2	33	3522223.63	0.39500	35.6542	5074.10	2-Dry	20.5	2.09368	3.5833	4.5000
1989	3	1	14155873.20	0.49500	30.4167	12742.25	2-Dry	20.5	1.36676	9.3222	9.8889
1989	3	2	6278100.59	0.74750	28.8333	3957.00	2-Dry	20.5	4.37528	1.1833	3.1667
1989	3	4	8164502.78	0.44250	28.8333	4569.86	2-Dry	20.5	1.31259	5.2000	8.5000
1989	3	31	23265520.47	0.92833	28.7972	16513.93	2-Dry	20.5	2.62517	3.0500	2.7500
1989	3	32	40550566.79	0.59556	23.9000	76989.09	2-Dry	20.5	4.00338	1.1000	2.5000
1989	3	33	18172286.88	0.35167	32.7944	13258.70	2-Dry	20.5	1.22192	6.5308	7.8462
1989	4	1	6996965.83	0.68000	27.8833	19499.94	2-Dry	20.5	0.91506	10.0800	11.0000
1989	4	2	3130370.30	0.65000	28.7333	15271.38	2-Dry	20.5	2.85852	2.6667	6.8889
1989	4	4	3657000.55	0.47500	29.0500	19608.20	2-Dry	20.5	0.75474	9.2250	14.5000
1989	4	31	14745631.41	0.79154	26.2205	40006.79	2-Dry	20.5	1.31259	6.2250	5.5000
1989	4	32	34179877.01	0.70700	26.7933	86970.67	2-Dry	20.5	2.00169	3.3500	5.7500
1989	4	33	9986003.46	0.49800	32.4400	60254.68	2-Dry	20.5	1.62091	8.6462	7.7692
1989	5	1	5831736.22	0.60250	28.2500	5880.29	2-Dry	20.5	0.90006	11.6000	13.9000
1989	5	2	3332338.26	0.72000	28.4583	3880.71	2-Dry	20.5	2.30432	5.7111	6.1111
1989	5	4	3879521.96	0.40500	31.9917	4269.75	2-Dry	20.5	1.05007	7.0000	16.0000
1989	5	31	13288772.13	0.96308	26.3615	10888.21	2-Dry	20.5	2.03451	5.0500	5.5000
1989	5	32	26410597.54	0.65300	26.4000	42236.36	2-Dry	20.5	2.06732	7.2750	5.2500
1989	5	33	10078673.31	0.40400	35.0833	12826.39	2-Dry	20.5	1.44724	8.0929	6.6429
1989	6	1	25973041.76	0.62250	31.7417	23071.84	1-Wet	20.5	1.18341	7.3111	9.4444
1989	6	2	20979651.00	0.58250	31.6167	17758.85	1-Wet	20.5	1.70636	4.8667	7.1111
1989	6	4	27271839.90	0.56000	35.3417	22462.22	1-Wet	20.5	1.05007	7.8250	7.5000
1989	6	31	61421934.98	0.64000	28.9524	50785.50	1-Wet	20.5	1.21414	5.8500	7.2500
1989	6	32	50749605.06	0.66889	30.6296	105213.51	1-Wet	20.5	1.47666	6.3250	6.5000
1989	6	33	61083983.81	0.54800	38.3074	56014.27	1-Wet	20.5	1.60844	9.2615	6.1538
1989	7	1	45613390.95	0.63000	28.3750	57184.43	1-Wet	20.5	1.32009	12.0200	6.0000
1989	7	2	20958667.76	0.69500	28.6250	19519.69	1-Wet	20.5	2.62517	4.3000	3.6667
1989	7	4	27045561.15	0.26750	32.5000	24174.41	1-Wet	20.5	1.31259	9.2500	5.7500
1989	7	31	70156818.24	0.75462	25.6667	64071.36	1-Wet	20.5	1.77199	7.8250	6.5000
1989	7	32	74015356.08	0.69300	26.0000	136405.19	1-Wet	20.5	2.95332	3.7250	3.7500
1989	7	33	55833089.47	0.33000	35.6467	53014.30	1-Wet	20.5	1.28515	13.4857	7.0714
1989	8	1	44293236.59	0.63250	30.1583	55568.56	1-Wet	20.5	0.93006	21.4600	10.7000
1989	8	2	19663946.85	0.65250	30.6833	22724.32	1-Wet	20.5	1.83762	6.8222	5.3333
1989	8	4	25657218.11	0.61750	29.9917	28756.22	1-Wet	20.5	1.01725	10.9000	6.7500
1989	8	31	72286865.53	0.73286	27.2548	82753.95	1-Wet	20.5	1.44384	11.4500	5.2500
1989	8	32	72746807.07	0.84600	28.9867	138611.73	1-Wet	20.5	1.24696	10.9250	5.0000
1989	8	33	61312449.54	0.51200	33.2633	73307.31	1-Wet	20.5	1.38401	17.3077	6.9231
1989	9	1	71123433.49	0.79500	26.9500	92573.95	1-Wet	20.5			

Year	Month	TBNEP Bay Segment	Hydrologic Load (m3/mo)	TN (mg/L)	Salinity (ppt)	External TN Load (kg/mo)	Season	Percent Light	Z-Depth for 20.5% Light	Chlorophyll (ug/L)	Turbidity (NTU)
1989	9	2	23940052.47	0.70250	26.9250	27421.57	1-Wet	20.5	1.18508	22.4300	9.4000
1989	9	4	31004650.52	0.75500	29.7167	34460.56	1-Wet	20.5	1.47301	10.5333	9.4444
1989	9	31	70348872.45	0.91077	23.4615	78161.78	1-Wet	20.5	0.98444	18.4000	9.5000
1989	9	32	108779744.78	0.79900	25.9100	181925.31	1-Wet	20.5	1.37821	15.6250	5.7500
1989	9	33	77194023.09	0.70778	32.1222	90782.42	1-Wet	20.5	1.14851	14.0750	8.5000
1989	10	1	18517402.00	0.87250	25.2333	20760.26	1-Wet	20.5	1.40093	14.6143	6.1429
1989	10	2	5694490.10	0.75250	27.5000	5235.90	1-Wet	20.5	0.99006	17.7800	7.7000
1989	10	4	6753235.02	0.60250	27.7583	5340.90	1-Wet	20.5	1.44384	9.9222	8.4444
1989	10	31	25160667.16	0.90500	25.1357	26404.60	1-Wet	20.5	0.88599	14.0250	8.0000
1989	10	32	53712675.08	1.05000	23.3967	93813.97	1-Wet	20.5	1.41103	15.1500	5.5000
1989	10	33	12420132.61	0.55200	31.4633	10480.55	1-Wet	20.5	0.98444	10.8000	10.0000
1989	11	1	13559930.80	0.64500	30.2417	13858.90	2-Dry	20.5	1.42141	11.3846	4.9231
1989	11	2	4959432.98	0.69750	29.3583	3650.31	2-Dry	20.5	1.29008	27.6700	7.5000
1989	11	4	5956392.26	0.54750	31.9333	3438.81	2-Dry	20.5	1.77928	7.0111	8.1111
1989	11	31	24194961.39	0.84385	26.0538	15488.26	2-Dry	20.5	1.67355	7.6250	4.5000
1989	11	32	34086933.70	0.94100	29.4800	52260.40	2-Dry	20.5	1.44384	12.8250	5.5000
1989	11	33	10606409.58	0.49400	34.9967	6888.25	2-Dry	20.5	1.44384	9.0250	5.7500
1989	12	1	22854605.91	0.66000	28.3111	25293.24	2-Dry	20.5	2.94465	12.4333	6.6667
1989	12	2	9044895.14	0.46667	28.3333	5001.82	2-Dry	20.5	1.77869	8.9286	4.7143
1989	12	4	11522199.34	0.48000	29.6583	5764.59	2-Dry	20.5	1.48760	5.4778	9.0000
1989	12	31	42113233.46	0.54500	25.7500	28510.13	2-Dry	20.5	1.31259	12.0333	6.6667
1989	12	32	62547483.80	0.72000	32.1222	111474.64	2-Dry	20.5	2.36265	5.9333	3.3333
1989	12	33	25163130.51	0.48667	32.1222	15244.73	2-Dry	20.5	1.60792	6.2250	6.0000
1990	1	1	10255549.02	0.82500	26.5667	11477.34	2-Dry	20.5	3.43633	4.0915	3.2000
1990	1	2	1964471.73	0.59333	29.2556	2113.10	2-Dry	20.5	1.27230	8.2546	7.1111
1990	1	4	2370195.53	0.43333	28.8778	2064.37	2-Dry	20.5	3.11374	1.9307	3.8333
1990	1	31	16585897.95	0.74200	27.3733	17031.42	2-Dry	20.5	1.50947	8.9612	6.5000
1990	1	32	40366374.52	0.80778	25.2519	65768.08	2-Dry	20.5	2.62517	2.6790	3.0000
1990	1	33	4853736.10	0.39286	32.0714	4935.53	2-Dry	20.5	3.17937	2.5518	3.0000
1990	2	1	23578340.24	0.88250	28.2500	24839.73	2-Dry	20.5	2.13960	7.7463	3.3000
1990	2	2	11877789.78	0.65750	30.3500	5983.60	2-Dry	20.5	1.18341	9.8366	7.7778
1990	2	4	15583423.60	0.64000	27.1800	25856.40	2-Dry	20.5	2.04180	3.4014	5.3333
1990	2	31	42411116.93	0.63000	27.1800	7182.49	2-Dry	20.5	0.88599	8.4747	9.5000
1990	2	32	52695716.59	1.07778	26.6741	94013.39	2-Dry	20.5	1.80480	6.9842	5.0000
1990	2	33	30560722.57	0.58300	34.1867	15833.85	2-Dry	20.5	1.70636	7.2239	6.0000
1990	3	1	9841627.28	0.72000	28.3750	10526.66	2-Dry	20.5	1.35907	8.7418	7.0769
1990	3	2	3774181.22	0.53000	28.0250	2759.01	2-Dry	20.5	1.21675	10.4635	9.0000
1990	3	4	4708469.33	0.42750	28.8167	2896.80	2-Dry	20.5	1.70636	6.0319	10.2222
1990	3	31	20659055.83	0.40538	25.7103	14948.77	2-Dry	20.5	1.08288	10.6399	12.7500
1990	3	32	35180221.67	0.72444	27.6481	56627.44	2-Dry	20.5	1.50947	9.3577	5.7500
1990	3	33	9687848.74	0.42100	32.0433	6641.29	2-Dry	20.5	1.54229	8.2378	7.0000
1990	4	1	7819462.31	0.64250	27.7000	8165.20	2-Dry	20.5	1.37777	6.1758	7.6429
1990	4	2	3222802.56	0.43750	30.5250	3255.05	2-Dry	20.5	2.44530	2.4379	11.3000
1990	4	4	3773873.53	0.54750	28.9250	3439.01	2-Dry	20.5	2.44530	7.7720	4.8889
1990	4	31	18074305.50	0.40786	29.7857	14427.88	2-Dry	20.5	1.11570	6.4727	8.2500
1990	4	32	29237811.30	0.70800	26.8100	56784.97	2-Dry	20.5	1.37821	4.8568	8.0000
1990	4	33	7874208.61	0.49500	31.4400	8311.08	2-Dry	20.5	2.10014	3.7033	4.2500
1990	5	1	9395984.17	0.72250	30.2833	13023.31	2-Dry	20.5	1.65564	6.7383	7.1429
1990	5	2	5743458.00	0.57750	29.3417	6410.58	2-Dry	20.5	1.09507	7.6591	8.0000
1990	5	4	7116431.89	0.43500	31.8167	7644.25	2-Dry	20.5	2.96061	6.3812	4.4444
1990	5	31	21464352.66	0.59929	26.9714	20087.32	2-Dry	20.5	1.05007	6.5103	7.0000
1990	5	32	26400306.97	0.90400	28.8900	50463.26	2-Dry	20.5	1.54229	5.3671	5.5000
1990	5	33	16350279.16	0.35778	34.6296	19454.89	2-Dry	20.5	2.72361	9.9546	5.7500

Year	Month	TBNEP Bay Segment	Hydrologic Load (m3/mo)	TN (mg/L)	Salinity (ppt)	External TN Load (kg/mo)	Season	Percent Light	Z=Depth for 20.5% Light	Chlorophyll (ug/L)	Turbidity (NTU)
1990	6	1	29378221.10	0.36250	30.0250	47936.54	1-Wet	20.5	2.26927	8.0598	7.0000
1990	6	2	22417843.35	0.41250	30.4083	31068.26	1-Wet	20.5	1.05007	15.4696	10.4000
1990	6	4	29001376.48	0.57250	32.2417	39973.36	1-Wet	20.5	2.61059	1.3523	4.0000
1990	6	31	54663704.43	0.49615	28.4462	68368.77	1-Wet	20.5	0.95162	14.5751	12.2500
1990	6	32	47778251.34	0.37900	28.6500	116476.89	1-Wet	20.5	2.39547	5.0224	5.0000
1990	6	33	58395953.61	0.33700	35.0067	83364.43	1-Wet	20.5	2.19858	3.9817	4.7500
1990	7	1	46874565.84	0.44000	27.9083	50040.83	1-Wet	20.5	1.65564	15.4353	7.5000
1990	7	2	22294632.53	0.29750	29.9917	16503.13	1-Wet	20.5	1.14007	28.1057	10.9000
1990	7	4	28778586.28	0.26500	29.4167	19965.63	1-Wet	20.5	2.33348	3.5359	6.2222
1990	7	31	81489371.81	0.39929	27.5548	61109.71	1-Wet	20.5	0.95162	23.4164	11.7500
1990	7	32	87155152.74	0.45700	26.2700	157699.32	1-Wet	20.5	2.13295	7.5693	5.7500
1990	7	33	58595309.93	0.20600	32.8967	40862.86	1-Wet	20.5	1.50947	5.2838	5.7500
1990	8	1	26432910.13	0.63500	27.7333	35027.17	1-Wet	20.5	1.67880	16.3069	8.1429
1990	8	2	15645421.82	0.45750	28.6417	20424.17	1-Wet	20.5	0.90006	19.9330	5.9000
1990	8	4	19571385.26	0.47000	30.3000	24883.98	1-Wet	20.5	2.67378	6.1937	4.7778
1990	8	31	47441304.30	0.53357	26.0857	56070.96	1-Wet	20.5	0.95162	14.1773	5.0000
1990	8	32	75216592.77	0.70000	25.2967	148970.96	1-Wet	20.5	1.67355	12.0619	6.0000
1990	8	33	38877530.42	0.31700	34.2400	51290.70	1-Wet	20.5	1.21414	15.9087	9.0000
1990	9	1	16946457.91	0.51500	27.7833	18116.54	1-Wet	20.5	1.47040	15.9167	9.5000
1990	9	2	8402856.30	0.51500	29.5667	7448.30	1-Wet	20.5	0.90006	14.9365	11.0000
1990	9	4	10310843.22	0.63750	29.0167	8389.07	1-Wet	20.5	1.60427	8.6558	6.0000
1990	9	31	33126372.55	0.62286	27.1476	29426.45	1-Wet	20.5	1.67355	5.5603	5.0000
1990	9	32	48766878.42	0.60000	26.8933	88672.36	1-Wet	20.5	1.50947	8.7401	6.2500
1990	9	33	22959026.64	0.33200	32.8700	19909.04	1-Wet	20.5	1.78879	10.3941	6.4286
1990	10	1	20095887.20	0.53000	28.7667	25972.21	1-Wet	20.5	1.46676	11.9109	8.0000
1990	10	2	6349235.97	0.45571	29.9810	3090.60	1-Wet	20.5	2.23139	4.9936	4.7500
1990	10	4	7630210.44	0.48000	30.2750	2515.27	1-Wet	20.5	1.31259	8.5504	8.0000
1990	10	31	30351958.11	0.55143	27.1512	16599.04	1-Wet	20.5	2.32515	8.8557	3.0000
1990	10	32	46949827.04	0.49333	28.0296	72517.28	1-Wet	20.5	2.95332	4.4953	3.0000
1990	10	33	20333643.97	0.40375	33.1417	5975.82	1-Wet	20.5	1.60010	7.6548	5.4444
1990	11	2	9664035.48	0.45500	30.2250	14896.99	2-Dry	20.5	2.19389	4.4996	4.7143
1990	11	4	4446683.06	0.41000	31.0333	7042.69	2-Dry	20.5	1.41103	6.1619	6.2500
1990	11	31	5334989.54	0.40000	31.5417	8099.72	2-Dry	20.5	2.36265	3.1547	2.0000
1990	11	32	16343938.00	0.47778	29.6407	17662.06	2-Dry	20.5	2.26421	4.2117	3.5000
1990	11	33	27075072.58	0.33714	34.4571	44572.01	2-Dry	20.5	2.26421	4.2117	3.5000
1990	12	1	16587312.61	0.42000	30.9889	27644.35	2-Dry	20.5	1.87755	7.0511	8.2500
1990	12	2	5700145.17	0.46750	30.1583	4917.28	2-Dry	20.5	2.03585	5.5757	2.7143
1990	12	4	2227816.06	0.31333	32.9444	1565.74	2-Dry	20.5	3.41272	1.5187	4.8000
1990	12	31	2437486.58	0.53417	28.2444	1219.62	2-Dry	20.5	2.23139	7.0776	2.3333
1990	12	32	12272629.60	0.49286	30.3952	9366.21	2-Dry	20.5	2.46110	4.4144	4.0000
1990	12	33	22570029.73	0.28800	35.3067	33676.26	2-Dry	20.5	4.15652	1.5125	4.6667
1990	12	33	7709077.33	0.28800	31.6667	4758.28	2-Dry	20.5	2.54715	4.7054	4.4286
1991	1	1	17493146.86	0.36000	31.1333	9811.73	2-Dry	20.5	1.35009	7.1964	9.2222
1991	1	2	11879119.30	0.40000	31.1333	4819.21	2-Dry	20.5	2.59600	3.0045	4.8889
1991	1	4	15576697.30	0.33750	31.5000	5584.64	2-Dry	20.5	1.26883	6.5279	10.0000
1991	1	31	32601579.10	0.51286	29.2714	20240.60	2-Dry	20.5	3.05176	2.9701	4.2500
1991	1	32	32091270.43	0.39444	31.0222	52632.88	2-Dry	20.5	1.70636	5.1941	5.2500
1991	1	33	29784337.26	0.27800	33.9700	12556.35	2-Dry	20.5	2.06396	5.7333	4.7333
1991	2	1	6830192.37	0.43667	30.3778	7955.96	2-Dry	20.5	1.26675	5.8727	9.4444
1991	2	2	2628605.10	0.39000	31.0083	2436.66	2-Dry	20.5	2.65252	1.6559	7.0000
1991	2	4	3178879.31	0.36667	32.7000	2412.65	2-Dry	20.5	1.44384	4.5828	9.0000
1991	2	31	13854906.61	0.42133	29.3133	11326.08	2-Dry	20.5	2.72361	3.1062	3.2500
1991	2	32	23913600.56	0.45778	29.8222	36154.78	2-Dry	20.5			

Year	Month	TBNEP Bay Segment	Hydrologic Load (m3/mo)	TN (mg/l)	Salinity (ppt)	External TN Load (kg/mo)	Season	Percent Light	Z=Depth for 20.5% Light	Chlorophyll (ug/l)	Turbidity (NTU)
1991	2	33	8254201.78	0.34556	34.4704	6975.08	2-Dry	20.5	3.54398	0.8405	2.6667
1991	3	1	21693687.01	0.40667	30.7667	24880.86	2-Dry	20.5	1.14459	4.5328	5.4615
1991	3	2	11560198.03	0.40250	31.4583	12702.79	2-Dry	20.5	1.03507	9.3475	10.0000
1991	3	4	15104203.28	0.43000	31.5417	16141.68	2-Dry	20.5	2.65434	1.3672	5.8889
1991	3	31	41797240.15	0.40615	30.4769	43301.01	2-Dry	20.5	1.26883	5.6353	8.0000
1991	3	32	42268075.21	0.49200	29.9300	80272.88	2-Dry	20.5	2.39547	3.0429	3.7500
1991	3	33	30763092.83	0.41778	33.9444	34743.87	2-Dry	20.5	2.88769	1.4524	3.7500
1991	4	1	14404945.09	0.37333	31.0667	14026.49	2-Dry	20.5	1.77053	8.5127	7.5385
1991	4	2	7593401.06	0.38750	31.2750	7581.60	2-Dry	20.5	1.48343	7.4461	8.6667
1991	4	4	9623950.86	0.16000	32.7083	9205.63	2-Dry	20.5	2.02721	1.8440	7.8889
1991	4	31	26685332.98	0.45692	29.8692	23068.94	2-Dry	20.5	1.44384	7.6117	8.6667
1991	4	32	37558724.63	0.51222	29.9000	64220.71	2-Dry	20.5	2.23139	3.3124	5.2500
1991	4	33	26273095.67	0.18800	35.0500	26835.82	2-Dry	20.5	2.82206	3.2922	6.7500
1991	5	1	42133735.41	0.37000	29.8583	54639.21	2-Dry	20.5	2.23980	7.3734	8.7273
1991	5	2	18503089.62	0.36250	30.8333	14823.94	2-Dry	20.5	0.97506	13.2908	11.6000
1991	5	4	24168353.87	0.25500	32.4417	18737.42	2-Dry	20.5	2.46474	2.6717	4.4444
1991	5	31	62690269.03	0.39636	30.0091	50819.76	2-Dry	20.5	1.27977	6.8685	7.0000
1991	5	32	68230548.73	0.51700	28.4700	127283.61	2-Dry	20.5	2.13295	10.1340	8.7500
1991	5	33	53311328.80	0.24000	34.6267	46185.03	2-Dry	20.5	2.31890	2.6400	4.0000
1991	6	1	32235292.22	0.55750	29.4500	50076.13	1-Wet	20.5	1.28592	11.8652	10.6667
1991	6	2	9260603.96	0.51750	29.5917	12589.20	1-Wet	20.5	1.03507	10.8406	13.6000
1991	6	4	11716831.82	0.43750	30.5833	15639.11	1-Wet	20.5	2.91686	3.6259	8.0000
1991	6	31	42101891.31	0.63867	27.4978	48974.93	1-Wet	20.5	1.08288	10.0690	14.0000
1991	6	32	76250231.79	0.56100	28.1933	132060.98	1-Wet	20.5	1.87043	6.6949	7.7500
1991	6	33	26874029.63	0.36900	33.4533	37170.54	1-Wet	20.5	2.85487	3.3104	6.0000
1991	7	1	74264659.22	0.61250	24.2167	81300.08	1-Wet	20.5	1.54527	10.7188	8.6667
1991	7	2	28677856.06	0.54500	28.2000	24203.22	1-Wet	20.5	0.72005	35.0665	9.2000
1991	7	4	36402928.71	0.40000	27.7583	28874.01	1-Wet	20.5	1.95429	4.4150	5.1111
1991	7	31	100680609.11	0.71800	27.8356	86271.82	1-Wet	20.5	0.95162	24.9729	9.0000
1991	7	32	284853225.85	1.01800	15.4133	525901.95	1-Wet	20.5	1.77199	9.7354	6.7500
1991	7	33	70407922.46	0.30222	32.1481	53871.16	1-Wet	20.5	1.64073	4.4541	5.2500
1991	8	1	56423509.66	0.60750	21.8833	66901.09	1-Wet	20.5	1.57048	14.4055	8.3333
1991	8	2	18954670.13	0.48250	23.2583	17645.71	1-Wet	20.5	0.82505	28.4472	12.3000
1991	8	4	24490113.94	0.45500	25.6833	21804.76	1-Wet	20.5	1.95429	9.2554	6.2222
1991	8	31	95487489.97	0.59133	21.6289	93200.07	1-Wet	20.5	0.82037	14.5524	10.5000
1991	8	32	182362206.16	0.71100	18.7200	280360.79	1-Wet	20.5	1.77199	10.0452	4.5000
1991	8	33	49918073.54	0.33900	30.1300	45349.58	1-Wet	20.5	1.80480	10.4177	5.5000
1991	9	1	24952787.77	0.80250	23.4083	26965.78	1-Wet	20.5	1.88026	15.0197	5.5000
1991	9	2	15082485.51	0.67000	22.9833	13920.96	1-Wet	20.5	1.80480	10.4177	5.5000
1991	9	4	18277560.63	0.67000	26.3833	15558.02	1-Wet	20.5	2.07097	5.1749	4.4444
1991	9	31	49850223.30	0.66933	20.0911	46330.70	1-Wet	20.5	1.01725	17.4603	7.7500
1991	9	32	71337607.45	0.95000	21.9133	116864.89	1-Wet	20.5	1.37821	8.7091	4.7500
1991	9	33	27613937.36	0.42000	30.6133	22442.18	1-Wet	20.5	1.47666	9.1784	5.5000
1991	10	1	10100812.59	0.78750	25.3333	9021.11	1-Wet	20.5	1.79418	10.7757	6.8966
1991	10	2	4674676.15	0.68571	25.2476	3329.08	1-Wet	20.5	1.06882	16.0176	10.8750
1991	10	4	5390830.37	0.65750	26.9583	2694.38	1-Wet	20.5	2.13295	5.0157	5.5000
1991	10	31	23093640.21	0.69862	22.3345	19683.09	1-Wet	20.5	0.91881	15.1436	12.0000
1991	10	32	49580753.94	0.81250	24.5750	70707.33	1-Wet	20.5	1.83762	9.8851	5.4286
1991	10	33	8475686.19	0.58000	30.0500	3960.28	1-Wet	20.5	1.96888	5.2364	6.2500
1991	11	2	4940540.15	0.52250	27.2917	5571.60	2-Dry	20.5	1.31675	9.4344	10.2222
1991	11	4	2394086.10	0.41000	28.3000	3601.97	2-Dry	20.5	2.51032	3.1690	5.5000
1991	11	31	2509423.94	0.45250	28.8417	3398.42	2-Dry	20.5	1.21414	8.1395	9.5000
1991	11	32	15861275.25			18552.76	2-Dry	20.5	2.10014	5.6140	6.0000

Year	Month	TBNEP Bay Segment	Hydrologic Load (m3/mo)	TN (mg/L)	Salinity (ppt)	External TN Load (kg/mo)	Season	Percent Light	Z-Depth for 20.5% Light	Chlorophyll (ug/L)	Turbidity (NTU)
1991	11	33	3678584.1.57	0.52444	26.9778	66516.79	2-Dry	20.5	2.16577	3.1580	4.7500
1991	11	4	4502734.35	0.39375	31.3542	6644.79	2-Dry	20.5	2.16577	3.1580	4.7500
1991	12	1	6281974.93	0.46333	28.8444	6342.64	2-Dry	20.5	2.70152	4.0366	6.3333
1991	12	2	2479481.16	0.50000	21.3667	1998.25	2-Dry	20.5	1.77869	3.6749	7.8571
1991	12	4	2876454.28	0.41667	30.1778	1805.90	2-Dry	20.5	2.07097	3.1801	8.6667
1991	12	31	13708478.80	0.56778	20.9185	10480.09	2-Dry	20.5	1.66261	2.2552	6.0000
1991	12	32	34251570.15	0.62857	27.8714	54383.87	2-Dry	20.5	2.69080	2.8798	3.7500
1991	12	33	4957932.10	0.35800	32.8133	3940.07	2-Dry	20.5	2.45016	2.6972	4.0000
1992	1	1	9492137.80	0.47333	29.2444	7993.80	2-Dry	20.5	3.29585	4.8769	3.8333
1992	1	2	5852520.15	0.35750	28.8750	5425.19	2-Dry	20.5	1.62011	6.8360	7.1000
1992	1	4	7094013.83	0.35000	30.3333	5904.89	2-Dry	20.5	2.68142	2.5730	6.0000
1992	1	31	18563042.44	0.38000	27.1778	16717.03	2-Dry	20.5	1.92512	6.0131	8.5000
1992	1	32	33069278.33	0.49800	28.5900	70297.47	2-Dry	20.5	2.98613	4.4044	8.5000
1992	1	33	11075185.69	0.32000	32.7250	11123.17	2-Dry	20.5	3.50023	2.2007	3.3333
1992	2	1	25514690.04	0.46667	28.9333	37373.34	2-Dry	20.5	2.23686	3.9718	5.2000
1992	2	2	12593724.37	0.43750	29.1000	4746.07	2-Dry	20.5	1.69386	5.6532	6.0000
1992	2	4	16038682.89	0.36000	30.1556	5038.70	2-Dry	20.5	3.04629	2.0953	5.5000
1992	2	31	34142119.19	0.43300	27.3967	22525.23	2-Dry	20.5	2.01263	3.6241	5.3333
1992	2	32	54771972.94	0.56750	28.2083	91709.95	2-Dry	20.5	2.36265	3.0166	5.0000
1992	2	33	38656428.56	0.34444	32.7148	13153.50	2-Dry	20.5	3.71899	1.6338	4.3333
1992	3	1	14149507.22	0.56000	27.6667	15850.39	2-Dry	20.5	2.26927	4.0384	4.2727
1992	3	2	6680516.72	0.50250	28.1750	7230.95	2-Dry	20.5	0.60004	10.9673	17.7778
1992	3	4	7843747.06	0.59500	29.7750	7940.11	2-Dry	20.5	1.80845	2.6234	7.1111
1992	3	31	17626893.83	0.53000	27.1515	18736.39	2-Dry	20.5	0.74380	8.2784	14.6667
1992	3	32	38180215.14	0.76333	26.6111	75087.93	2-Dry	20.5	2.10014	3.6821	6.2500
1992	3	33	20189393.01	0.47100	33.0633	21817.87	2-Dry	20.5	1.64073	4.8950	7.5000
1992	4	1	20981469.43	0.74500	28.0667	34660.55	2-Dry	20.5	1.50869	5.6877	6.6154
1992	4	2	8012117.13	0.45750	28.6250	10359.36	2-Dry	20.5	1.30008	8.3420	9.3333
1992	4	4	9660412.47	0.51750	29.9333	12314.40	2-Dry	20.5	2.01810	3.1658	6.5000
1992	4	31	23413359.70	0.52385	27.3718	28649.16	2-Dry	20.5	1.34540	6.4861	7.7500
1992	4	32	41636071.35	0.75111	27.2704	81429.18	2-Dry	20.5	1.77199	3.5480	4.7500
1992	4	33	21708077.29	0.50000	32.4926	29136.96	2-Dry	20.5	1.70636	4.9482	6.5000
1992	5	1	7718006.19	0.85333	28.3556	7121.96	2-Dry	20.5	1.55144	7.1916	9.5000
1992	5	2	2038878.78	0.65500	31.28.77	3128.77	2-Dry	20.5	1.92870	7.8952	8.0000
1992	5	4	1546943.75	0.63750	31.0750	2337.49	2-Dry	20.5	3.03770	2.8285	5.4286
1992	5	31	8749361.10	0.76214	28.0667	9540.21	2-Dry	20.5	2.40641	5.3659	6.6667
1992	5	32	26858942.35	0.83714	27.4190	60352.74	2-Dry	20.5	2.06732	5.8027	4.7500
1992	5	33	3494925.02	0.49000	33.4083	7208.35	2-Dry	20.5	2.62517	3.8421	8.0000
1992	6	1	84230502.92	0.93000	28.9167	167641.97	1-Wet	20.5	1.87562	9.0642	8.2143
1992	6	2	25528911.20	0.69000	29.7917	23028.27	1-Wet	20.5	1.44384	7.2050	7.3750
1992	6	4	33231805.12	0.62750	30.6750	29475.18	1-Wet	20.5	2.70721	3.7178	5.5000
1992	6	31	59587654.59	0.81214	28.8619	55958.21	1-Wet	20.5	1.44384	7.7667	6.2500
1992	6	32	88491729.26	0.96750	27.4208	136843.73	1-Wet	20.5	2.55954	5.7143	5.2500
1992	6	33	110752312.38	0.47778	33.1852	100153.72	1-Wet	20.5	2.32984	5.0947	4.7500
1992	7	1	52764084.43	0.98500	25.6833	56682.47	1-Wet	20.5	1.63249	10.4886	8.5000
1992	7	2	13536657.67	0.84250	26.3167	12153.14	1-Wet	20.5	1.09507	19.5814	12.1000
1992	7	4	17200080.21	0.65500	27.7333	14259.32	1-Wet	20.5	2.69080	5.2421	8.2500
1992	7	31	33922194.97	1.06143	28.1310	29920.82	1-Wet	20.5	1.18133	16.5122	13.0000
1992	7	32	69726692.80	0.90400	24.2367	111160.66	1-Wet	20.5	2.19858	7.8510	4.2500
1992	7	33	41157671.78	0.60000	29.7792	34659.54	1-Wet	20.5	2.42828	4.5165	8.5000
1992	8	1	62278283.37	0.91250	24.2583	92714.95	1-Wet	20.5	2.21138	8.5124	6.0000
1992	8	2	16525949.81	0.65750	26.3417	11700.32	1-Wet	20.5	1.02007	20.1777	11.4000
1992	8	4	20738431.78	0.58500	26.3417	13363.42	1-Wet	20.5	3.21271	4.9095	3.8571

Year	Month	TBNEP Bay Segment	Hydrologic Load (m ³ /mo)	TN (mg/L)	Salinity (ppt)	External TN Load (kg/mo)	Season	Percent Light	Z-Depth for 20.5% Light	Chlorophyll Turbidity (ug/L) (NTU)
1992	8	31	74770482.54	0.76143	27.8857	61003.76	1-Wet	20.5	0.85318	13.6244
1992	8	32	126711063.22	0.90500	22.5800	208438.06	1-Wet	20.5	2.10014	5.2732
1992	8	33	54077806.52	0.51000	28.8905	35971.82	1-Wet	20.5	2.49391	5.5805
1992	9	1	40905648.29	0.72000	23.1833	45763.22	1-Wet	20.5	1.83288	8.2537
1992	9	2	17461043.12	0.54250	24.7500	11558.09	1-Wet	20.5	1.45009	7.4444
1992	9	4	21560229.99	0.80750	25.2833	12801.46	1-Wet	20.5	2.06732	6.5000
1992	9	31	56198640.57	0.84154	25.2256	50153.46	1-Wet	20.5	1.41103	6.5000
1992	9	32	116312876.49	0.86778	21.8037	173578.79	1-Wet	20.5	2.59236	3.7500
1992	9	33	42638387.64	0.75875	28.7000	24962.07	1-Wet	20.5	1.54229	6.5000
1992	10	1	22516674.60	0.70500	23.5417	21102.89	1-Wet	20.5	1.27872	7.7778
1992	10	2	11093626.29	0.31000	24.5000	7855.75	1-Wet	20.5	1.42509	8.7500
1992	10	4	13278612.77	0.63000	26.0833	8507.74	1-Wet	20.5	1.32717	5.9633
1992	10	31	63919468.73	0.62667	22.6259	64817.08	1-Wet	20.5	1.27977	7.2002
1992	10	32	86282708.34	0.62000	22.6042	128861.63	1-Wet	20.5	2.10014	4.0000
1992	10	33	23857133.94	0.53400	29.4667	15496.71	1-Wet	20.5	1.05007	11.0000
1992	11	1	15686448.86	0.59667	25.3000	10336.96	2-Dry	20.5	1.38935	6.9673
1992	11	2	8400541.44	0.43750	25.4250	4630.05	2-Dry	20.5	1.53342	11.2716
1992	11	4	10002534.41	0.47750	28.0167	4287.89	2-Dry	20.5	1.91054	3.0260
1992	11	31	30041897.20	0.56357	23.8238	19311.28	2-Dry	20.5	1.48760	7.7929
1992	11	32	40166787.08	0.69222	24.1963	72217.99	2-Dry	20.5	1.57510	7.5509
1992	11	33	17342113.81	0.39300	31.4233	8688.30	2-Dry	20.5	1.87043	3.5400
1992	12	1	9284869.57	0.57333	26.7750	8428.77	2-Dry	20.5	2.01263	5.3550
1992	12	2	3201137.72	0.47500	26.7750	3226.84	2-Dry	20.5	1.28580	5.4286
1992	12	4	3475763.65	0.63250	27.9083	2913.97	2-Dry	20.5	1.86679	6.6667
1992	12	31	16740524.90	0.54583	24.5917	18339.96	2-Dry	20.5	1.22508	3.2651
1992	12	32	33491026.14	0.70429	26.1667	68967.07	2-Dry	20.5	1.96888	6.0191
1992	12	33	7787045.15	0.40200	30.6933	8077.08	2-Dry	20.5	1.96888	3.4899
1993	1	1	27590717.39	0.51333	27.6000	22286.88	2-Dry	20.5	2.34132	5.3245
1993	1	2	12822953.47	0.49750	27.5750	5297.91	2-Dry	20.5	1.29383	11.5464
1993	1	31	16230573.81	0.59889	25.6519	5865.78	2-Dry	20.5	1.35634	12.7747
1993	1	32	39146431.01	0.56750	26.4542	25497.06	2-Dry	20.5	2.49391	4.0350
1993	1	4	70930930.92	0.56750	26.4542	93443.52	2-Dry	20.5	2.49391	4.0350
1993	2	1	43419704.26	0.75200	25.5467	11354.23	2-Dry	20.5	1.87755	4.9289
1993	2	1	16551331.83	0.76750	26.3917	4142.38	2-Dry	20.5	1.36509	8.8623
1993	2	2	6281027.59	0.68625	27.3521	4434.12	2-Dry	20.5	1.68448	2.6542
1993	2	4	7537253.34	0.86417	24.8417	24369.84	2-Dry	20.5	1.15507	5.9636
1993	2	31	27734690.89	0.71700	24.6533	81655.52	2-Dry	20.5	2.10014	3.3214
1993	2	32	57089789.59	0.66000	30.8123	10588.56	2-Dry	20.5	1.68995	2.9809
1993	2	33	16451549.46	0.69250	25.5750	24499.77	2-Dry	20.5	1.89878	3.7824
1993	3	1	21983405.01	0.92500	26.6250	8258.79	2-Dry	20.5	1.38009	5.0772
1993	3	2	8235163.68	0.74000	27.4417	9596.95	2-Dry	20.5	1.72094	2.9163
1993	3	4	9921649.10	0.69000	27.4417	42391.38	2-Dry	20.5	1.27977	3.4417
1993	3	31	40612579.76	0.81214	25.3667	113896.04	2-Dry	20.5	1.47666	6.2500
1993	3	32	89080626.57	0.74300	23.8333	20029.11	2-Dry	20.5	1.90325	2.5884
1993	3	33	20080555.98	0.76900	30.5133	24812.27	2-Dry	20.5	1.16937	8.9748
1993	4	1	25426290.43	0.79333	24.4556	7993.19	2-Dry	20.5	1.31675	10.3143
1993	4	2	9939732.33	0.66250	25.8917	9505.52	2-Dry	20.5	2.49391	3.5329
1993	4	4	12194341.65	0.54750	26.7917	32927.92	2-Dry	20.5	1.48760	6.6194
1993	4	31	35216160.79	0.81429	23.6786	107778.80	2-Dry	20.5	1.57510	7.1520
1993	4	32	77931274.91	0.75000	22.6185	21410.57	2-Dry	20.5	2.46110	2.9280
1993	4	33	26314206.78	0.50100	30.3500	7192.29	2-Dry	20.5	2.23980	4.1045
1993	5	1	11177552.18	0.57750	26.0833	4943.06	2-Dry	20.5	1.62868	6.4068
1993	5	2	4995590.91	0.37000	25.9917		2-Dry	20.5		

Year	Month	TBNEP Bay Segment	Hydrologic Load (m3/mo)	TN (mg/L)	Salinity (ppt)	External TN Load (kg/mo)	Season	Percent Light	Z=Depth for 20.5% Light	Chlorophyll Turbidity (ug/L) (NTU)
1993	5	4	5390721.33	0.66000	29.1333	4542.95	2-Dry	20.5	2.11472	5.0606
1993	5	31	17971070.32	0.51182	24.3061	15469.04	2-Dry	20.5	1.96888	3.2500
1993	5	32	36289368.41	0.58714	24.4190	62306.89	2-Dry	20.5	2.75643	3.2500
1993	5	33	13434249.29	0.58900	32.7533	11653.28	2-Dry	20.5	2.26421	6.7500
1993	6	1	19250672.24	0.81500	27.2250	18197.08	1-Wet	20.5	1.65832	4.9231
1993	6	2	8193902.39	0.45250	27.6500	8236.95	1-Wet	20.5	0.94506	9.0000
1993	6	4	9710803.43	0.57000	30.1167	9200.16	1-Wet	20.5	3.06817	2.2500
1993	6	31	28045992.99	0.59462	25.6077	26686.75	1-Wet	20.5	0.85318	9.5000
1993	6	32	38853031.56	0.87800	25.8233	65179.49	1-Wet	20.5	1.96888	2.2500
1993	6	33	22971408.49	0.48444	32.7333	21716.62	1-Wet	20.5	1.90325	4.0000
1993	7	1	17573793.62	0.43333	27.7556	25023.84	1-Wet	20.5	2.08017	5.3333
1993	7	2	10642355.66	0.42500	28.2250	17111.45	1-Wet	20.5	1.20008	5.3000
1993	7	31	12997383.19	0.57750	25.8694	21123.10	1-Wet	20.5	1.13757	6.6667
1993	7	32	30726718.14	0.45300	26.2467	44065.69	1-Wet	20.5	2.00169	4.2500
1993	7	2	49874219.19	0.82600	28.9133	100594.94	1-Wet	20.5	2.00169	4.2500
1993	7	4	32161414.32	0.82600	28.9133	54416.72	1-Wet	20.5	2.00169	4.2500
1993	8	1	30062056.29	0.71250	29.5333	36049.34	1-Wet	20.5	1.58618	5.9286
1993	8	2	20621565.40	0.51625	30.8250	26188.59	1-Wet	20.5	1.30008	7.8889
1993	8	4	25512086.80	0.87500	27.5952	32013.01	1-Wet	20.5	2.66892	3.3333
1993	8	31	52262581.35	0.77667	27.6704	63372.25	1-Wet	20.5	1.36509	7.4000
1993	8	32	67992680.52	0.46941	33.9686	113644.57	1-Wet	20.5	2.23139	6.0192
1993	8	33	55296847.83	0.89500	26.3917	69376.63	1-Wet	20.5	2.41188	4.3400
1993	9	1	43324623.92	0.94750	28.3583	52681.82	1-Wet	20.5	1.39648	8.1538
1993	9	2	16855564.69	0.72750	28.5583	14133.28	1-Wet	20.5	1.24508	5.9000
1993	9	4	20835745.59	0.97154	25.7538	16439.58	1-Wet	20.5	2.13764	3.7143
1993	9	31	58000531.62	1.14200	22.3433	50752.67	1-Wet	20.5	1.21414	11.4889
1993	9	32	142382779.57	0.51714	32.0095	186814.07	1-Wet	20.5	1.47666	8.9047
1993	9	33	42063893.71	0.72333	26.5556	32712.78	1-Wet	20.5	1.60792	6.2500
1993	10	1	24203208.44	0.86000	26.8917	21623.34	1-Wet	20.5	1.25350	14.0404
1993	10	2	13845746.61	0.65250	27.3750	9505.01	1-Wet	20.5	1.56677	6.8889
1993	10	31	16665813.65	0.69750	24.6333	9993.89	1-Wet	20.5	1.53135	4.0000
1993	10	32	50912656.83	0.88667	25.6222	41057.99	1-Wet	20.5	1.44384	5.2500
1993	10	2	67130818.79	0.65250	27.3750	101647.34	1-Wet	20.5	1.44384	5.2500
1993	10	4	36618341.98	0.69750	27.3750	20380.85	1-Wet	20.5	1.44384	5.2500
1993	11	1	12314661.34	0.80182	28.1250	17054.68	2-Dry	20.5	1.56197	14.0054
1993	11	2	2865218.12	0.39000	27.1583	3465.05	2-Dry	20.5	1.43343	12.1920
1993	11	4	2501921.74	0.78778	28.7758	3085.83	2-Dry	20.5	1.67719	5.3725
1993	11	31	17526020.98	0.54000	24.7758	22431.75	2-Dry	20.5	1.80480	6.0242
1993	11	32	38045867.38	0.30900	26.5481	76681.68	2-Dry	20.5	1.93606	9.7593
1993	11	33	6122740.30	0.40250	30.6000	8545.22	2-Dry	20.5	3.6822	3.0000
1993	12	1	8728415.21	0.50000	28.3444	7539.59	2-Dry	20.5	1.95667	6.2857
1993	12	2	4241249.31	0.42571	28.3750	2813.46	2-Dry	20.5	2.40016	6.6302
1993	12	4	4867388.52	0.57000	29.4222	2764.98	2-Dry	20.5	2.90956	4.0000
1993	12	31	18504079.30	0.63571	25.7024	14714.00	2-Dry	20.5	2.14389	4.6829
1993	12	32	32914165.84	0.79000	27.9556	63568.86	2-Dry	20.5	3.05176	2.5764
1993	12	33	9113116.66	0.42571	31.6762	6084.87	2-Dry	20.5	4.20027	1.1908
1994	1	1	18917058.32	0.62000	28.2556	15607.01	2-Dry	20.5	2.08555	2.4038
1994	1	2	9666530.47	0.89000	28.6556	5094.78	2-Dry	20.5	3.35022	1.7144
1994	1	4	11717132.39	0.71000	29.3222	5341.50	2-Dry	20.5	2.66892	2.3863
1994	1	31	35733533.92	0.70667	26.8000	22107.39	2-Dry	20.5	2.08555	2.3863
1994	1	32	53930127.46	0.78400	27.7222	86053.32	2-Dry	20.5	3.58773	1.6133
1994	1	33	25165543.51	1.00500	30.8467	12732.14	2-Dry	20.5	2.31890	2.2234
1994	2	1	9025995.36	0.86000	28.3667	9896.80	2-Dry	20.5	2.70152	2.6667

Year	Month	TBNEP Bay Segment	Hydrologic Load (m3/mo)	TN (mg/L)	Salinity (ppt)	External TN Load (kg/mo)	Season	Percent Light	Z=Depth for 20.5% Light	Chlorophyll (ug/L)	Turbidity (NTU)
1994	2	2	2904063.66	0.99000	27.8167	3180.33	2-Dry	20.5	2.04388	2.3000	5.1250
1994	2	4	2945867.59	0.88000	29.8333	3127.54	2-Dry	20.5	2.81268	1.2214	3.1429
1994	2	31	13943597.24	0.96444	26.6370	14847.42	2-Dry	20.5	3.01895	0.9900	2.5000
1994	2	32	36387827.75	1.07500	26.7750	70123.03	2-Dry	20.5	2.23139	5.8850	4.0000
1994	2	33	6174250.37	0.87125	32.1667	7898.57	2-Dry	20.5	3.06270	1.1067	2.3333
1994	3	1	15257576.60	0.95500	28.1250	12732.67	2-Dry	20.5	3.07973	2.4013	2.3750
1994	3	2	5288155.18	1.01000	28.6667	2970.46	2-Dry	20.5	2.20729	3.2986	3.4286
1994	3	4	6186562.56	0.85250	29.5583	3137.21	2-Dry	20.5	1.95013	2.7757	6.5714
1994	3	31	15408973.01	0.97500	27.2042	12533.75	2-Dry	20.5	1.60792	4.1550	6.5000
1994	3	32	35289781.00	0.96143	27.3000	63625.81	2-Dry	20.5	3.11739	1.6725	1.7500
1994	3	33	15006676.54	0.77125	32.1458	8241.48	2-Dry	20.5	2.32984	4.1275	3.5000
1994	4	1	18989321.72	1.22000	28.6667	22101.13	2-Dry	20.5	3.16078	2.3543	1.5000
1994	4	2	9640721.41	0.65000	29.1417	10599.75	2-Dry	20.5	1.33342	10.8133	9.2222
1994	4	4	11868254.66	0.62500	30.5167	12699.26	2-Dry	20.5	2.85852	2.1543	3.4444
1994	4	31	28771782.00	1.43000	28.3292	31100.38	2-Dry	20.5	1.60792	7.9669	4.5000
1994	4	32	36763271.00	0.90500	27.7185	68086.56	2-Dry	20.5	3.20490	2.0082	1.5000
1994	4	33	25596808.76	0.90500	32.9667	29207.16	2-Dry	20.5	2.13295	3.4605	4.5000
1994	5	1	5804614.70	1.16000	28.6583	16521.72	2-Dry	20.5	1.11303	12.1400	7.9333
1994	5	2	2195815.14	.	28.9667	5303.11	2-Dry	20.5	1.03507	14.3390	7.9000
1994	5	4	1825887.79	0.88000	30.8250	5879.90	2-Dry	20.5	3.03553	4.4000	1.7778
1994	5	31	9505249.23	1.05000	27.7556	17449.30	2-Dry	20.5	1.01725	9.9850	6.2500
1994	5	32	26316860.00	0.94500	27.5657	66988.31	2-Dry	20.5	1.18133	7.9325	4.5000
1994	5	33	2705776.88	.	33.5667	11169.11	2-Dry	20.5	2.59236	9.2125	2.0000
1994	6	1	45807953.94	0.96500	29.7583	57126.28	1-Wet	20.5	1.99497	8.5031	4.2308
1994	6	2	16157752.28	.	30.4583	15383.20	1-Wet	20.5	1.30008	14.5344	6.5556
1994	6	4	20391221.58	1.08000	31.1750	19027.80	1-Wet	20.5	2.42099	4.8722	3.8889
1994	6	31	43438929.55	0.96500	29.1000	41851.37	1-Wet	20.5	1.24696	7.1800	7.2500
1994	6	32	82299514.78	0.92667	28.9778	122942.76	1-Wet	20.5	2.36265	5.3725	2.0000
1994	6	33	54791981.73	0.75000	33.6900	52670.36	1-Wet	20.5	2.32984	5.9775	5.2500
1994	7	1	56011352.16	0.92667	27.3667	83905.86	1-Wet	20.5	1.84784	9.5412	4.8667
1994	7	2	22344750.03	0.75000	28.5500	30342.85	1-Wet	20.5	1.02007	16.0367	8.4000
1994	7	4	28049549.26	.	30.1083	38065.66	1-Wet	20.5	2.04180	5.7309	3.5556
1994	7	31	83534608.95	0.93000	28.1333	112018.18	1-Wet	20.5	1.05007	17.0138	11.0000
1994	7	32	122162771.42	0.92000	24.4300	200704.90	1-Wet	20.5	1.77199	8.1544	3.5000
1994	7	33	59639255.09	0.65500	33.1867	81992.27	1-Wet	20.5	1.77199	8.5541	5.7500
1994	8	1	70392387.36	1.04500	25.9000	97788.22	1-Wet	20.5	1.85247	11.8709	4.5714
1994	8	2	20098836.24	0.74000	27.0333	21710.12	1-Wet	20.5	1.23008	25.2110	5.9000
1994	8	4	25008652.26	.	28.4167	26601.83	1-Wet	20.5	1.92512	7.5476	6.5556
1994	8	31	86464786.77	1.17500	26.3857	98566.48	1-Wet	20.5	1.18133	19.8093	3.7500
1994	8	32	222680963.70	1.31800	23.5833	338420.73	1-Wet	20.5	2.03451	7.2864	3.7500
1994	8	33	57918290.88	1.25000	31.7700	61821.21	1-Wet	20.5	1.41103	10.4323	7.5000
1994	9	1	110270467.16	1.25000	21.9417	130797.91	1-Wet	20.5	1.44801	20.3297	6.6000
1994	9	2	27807584.62	.	24.7667	19370.25	1-Wet	20.5	0.93006	44.2728	6.9000
1994	9	4	33948855.11	.	24.0167	21450.56	1-Wet	20.5	1.63344	9.1880	4.3333
1994	9	31	92743594.70	1.12000	23.6778	76914.54	1-Wet	20.5	0.91881	28.4081	8.2500
1994	9	32	336457239.41	1.52600	20.9133	437515.06	1-Wet	20.5	1.34540	21.8553	3.7500
1994	9	33	71428266.48	1.59000	29.5867	41474.66	1-Wet	20.5	0.91881	19.9241	7.0000
1994	10	1	40863282.24	1.51000	20.1000	59272.65	1-Wet	20.5	1.85781	21.0426	5.0769
1994	10	2	8875018.76	1.51000	20.4667	9746.52	1-Wet	20.5	1.05007	52.0939	4.8000
1994	10	4	10313865.45	1.64000	23.3083	11384.24	1-Wet	20.5	1.69178	12.0479	5.3333
1994	10	31	41242185.25	2.09600	19.8718	48666.17	1-Wet	20.5	1.05007	25.1016	4.2500
1994	10	32	85410295.21	1.06000	16.0400	141794.07	1-Wet	20.5	1.50947	15.8636	3.2500
1994	10	33	22029277.70	1.06000	28.1067	25477.67	1-Wet	20.5	1.34540	15.8363	3.7500

Year	Month	TBNEP Bay Segment	Hydrologic Load (m3/mo)	TN (mg/l)	Salinity (ppt)	External TN Load (kg/mo)	Season	Percent Light	Z-Depth for 20.5% Light	Chlorophyll (ug/l)	Turbidity (NTU)
1994	11	1	13411929.11	1.07000	22.2083	14476.88	2-Dry	20.5	1.30831	12.8174	6.6429
1994	11	2	3410290.57	.	22.6250	2622.04	2-Dry	20.5	1.18341	23.1187	4.5556
1994	11	4	3556438.32	.	25.4167	2392.56	2-Dry	20.5	1.60427	9.2563	6.8889
1994	11	31	14117875.69	0.84000	19.9238	13547.45	2-Dry	20.5	1.21414	30.4684	4.7500
1994	11	32	62514626.42	1.01250	21.0185	102156.24	2-Dry	20.5	1.34540	14.5245	3.2500
1994	11	33	9015681.25	.	29.5133	7300.80	2-Dry	20.5	1.47666	13.4113	6.0000
1994	12	1	14645045.39	0.94000	24.4000	13947.31	2-Dry	20.5	1.47908	8.4097	5.5000
1994	12	2	5891016.27	.	24.7167	3552.95	2-Dry	20.5	1.14007	16.6834	7.0000
1994	12	4	7058532.33	.	26.4250	3763.96	2-Dry	20.5	2.20223	5.9305	2.1111
1994	12	31	19478697.93	1.17000	21.5083	15136.83	2-Dry	20.5	1.37821	11.3702	4.0000
1994	12	32	57690401.23	1.03400	23.2467	94196.74	2-Dry	20.5	1.70636	8.0101	2.5000
1994	12	33	17301664.97	.	30.4567	10687.96	2-Dry	20.5	1.83762	5.7065	2.0000