EUTROPHICATION IN CHESAPEAKE BAY BEFORE AND AFTER IMPLEMENTATION OF MARYLAND'S PHOSPHATE DETERGENT BAN

prepared for

THE SOAP AND DETERGENT ASSOCIATION
475 Park Avenue South
New York, New York 10016

by

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A statewide phosphate detergent ban went into effect in Maryland on December 1, 1985. Similar legislation became effective in the District of Columbia in September of 1986. Projected benefits included improvements in the quality of Chesapeake Bay waters due to reductions in phosphorus loadings from municipal discharges without phosphorus removal facilities. Limited data indicate that phosphorus concentrations in sewage discharged from the Maryland treatment plants without phosphorus removal facilities decreased an average of 33% (Walker, 1987b). However, direct relationships between phosphorus loading and biological responses in the Bay, as measured by peak algal densities or by the depletion of dissolved oxygen from bottom waters, cannot be presumed because these responses are controlled by many factors including phosphorus, nitrogen, light temperature, and hydrodynamic features (MDOEP, 1987, USEPA, 1987). This report describes eutrophication-related water quality conditions in the Bay, its estuaries, and its tributaries before and after implementation of the phosphate detergent bans, based upon analysis of monitoring data collected between mid 1984 and mid 1987.

Analyses of river monitoring data indicate that reductions in phosphorus loadings to the Bay resulting from the phosphate detergent ban are similar to projections made prior to the ban's implementation. Other factors, including municipal phosphorus removal, reduced phosphorus loads further during the study period. However, corresponding decreases in algal productivity were not detected at Bay or estuary stations. While this result could reflect algal changes that were too small to detect, the lack of algal response is clearly consistent with observations made in this report and by others that factors other than phosphorus, particularly nitrogen, regulate algal growth and related water-quality conditions.

The full range of costs and benefits must be considered in evaluating the phosphate detergent ban and in comparing it with alternative strategies for achieving the same management objectives. Considering the small changes in phosphorus loading resulting from the ban and the importance of limiting nutrients other than phosphorus, it is clear that the ban in itself contributes little to the cause of restoring the Bay.

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EXECUTIVE SUMMARY

Introduction. A statewide phosphate detergent ban went into effect in Maryland on December 1, 1985. Similar legislation became effective in the District of Columbia in September of 1986. Projected benefits included improvements in the quality of Chesapeake Bay waters due to reductions in phosphorus loadings from municipal discharges without phosphorus removal facilities. Limited data indicate that phosphorus concentrations in sewage discharged from the Maryland treatment plants without phosphorus removal facilities decreased an average of 33% (Walker, 1987b). However, direct relationships between phosphorus loading and biological responses in the Bay, as measured by peak algal densities or by the depletion of dissolved oxygen from bottom waters, cannot be presumed because these responses are controlled by many factors including phosphorus, nitrogen, light, temperature, and hydrodynamic features (MDOEP,1987; USEPA,1987).

This report describes eutrophication-related water-quality conditions in the Bay and its estuaries before and after implementation of the phosphate detergent bans. Because of the accuracy and intensity of Bay monitoring efforts, it is possible to compare pre-ban and post-ban water quality in a statistical sense. Although differences between these two time periods may be detectable, it is very difficult to attribute observed differences to specific causes because of the complexity of the Bay and its watershed and the numerous sources of variability. Four factors that have the potential for producing or contributing to observed changes in water quality are:

(1) natural changes (associated with hydrology, weather, etc.);
(2) changes caused by the phosphate detergent ban;
(3) other changes induced by man (watershed development, watershed management, wastewater treatment, flow regulation, etc.); and
(4) sampling and analytical variations, which impose limitations on the ability to detect changes due to the above factors.

On a Bay-wide scale, estimation of water quality changes brought about by the phosphorus detergent ban through analysis of monitoring data is infeasible, given the other sources of variation, relatively short period of record, and the relatively small change in phosphorus loading resulting from the ban. In this report, potential impacts of the ban are considered in relation to the overall phosphorus balance of Maryland's portion of the Bay, as calculated from point source inventories and river monitoring data collected over the study period. Factors controlling algal productivity in the Bay as a function of season and location are assessed as a means of evaluating the sensitivity of algal productivity in the Bay to detergent phosphate and other nutrient sources.

<u>Data Sources.</u> Water quality and flow data for analysis are derived from monitoring programs conducted by the Maryland Department of the Environment and the U.S. Geological Survey. Most of the information was collected with the support and guidance of the EPA Chesapeake Bay Program. Three types of monitoring stations are considered: river (above the Fall Line), estuary, and Chesapeake Bay mainstem stations. River station data cover the period from July 1984 to March 1987 (in some cases, to September 1987). Estuarine data cover the period from October 1984 through January 1987, and Bay data, from July 1984 through July 1987.

<u>Impacts of Ban at River Stations</u>. At river monitoring stations with relatively high upstream sewage flows, mass-balance calculations show that observed reductions in stream phosphorus loadings under low-flow conditions following the phosphate detergent ban were consistent with the average observed reduction in effluent phosphorus concentrations at the Maryland treatment plants without phosphorus removal facilities. The data base does not permit detailed evaluation of biological responses at river stations. Such responses are likely to be small because soluble reactive phosphorus concentrations generally exceed growth-limiting levels at river stations, where physical factors (velocity, residence time, temperature) usually limit peak algal densities. At the river station with the highest monitoring intensity

and most pronounced reduction in phosphorus concentration following the ban (Patuxent River), summer mean chlorophyll-a concentrations remained at very low levels in 1985 (3.3 ppb) and 1986 (3.6 ppb).

Impacts of Ban on Phosphorus Loads Entering the Maryland Portion of Chesapeake Bay. Elimination of detergent phosphorus from the 112 million gallons of sewage discharged daily without phosphorus removal could account for 2.4 to 11.1% reductions in the amount of phosphate entering the Maryland portion of the Bay between January 1986 to September 1987, based upon quarterly mass balances. Percentage reductions corresponding to the 71 mgd without phosphorus removal after 1987 are lower, ranging from 1.8 to 7.1%.

Other factors caused the overall phosphorus load reductions to exceed those associated with the ban. The other factors include natural variations, attributed to changes in hydrology and weather, and reductions induced by man, such as watershed management and improved municipal wastewater treatment. For example, phosphorus loads entering the Maryland portion of the Bay were 11% lower in the Spring of 1986 than in the Spring of 1985; the ban could account for a load reduction of 7%. Summer loadings from all sources were 25% lower in 1986 than in 1985; the ban could account for an 11% reduction during this period.

These changes in loading were detected over a period of relatively low runoff for all major tributaries of the Bay, a condition which would tend to increase the relative importance of point sources (including detergent phosphates) vs. nonpoint sources as factors contributing to the total nutrient loading. Percentage reductions in phosphorus loading attributed to the ban would be lower during periods of average or above-average runoff and/or if atmospheric and bottom sediment sources of phosphorus were also considered.

Changes in phosphorus loading are neither equivalent nor directly related to changes in Bay water quality, as measured by algal density or dissolved oxygen. The evaluation of water quality impacts of the ban must consider both the observed changes in overall phosphorus loading and the potential sensitivity of algal growth to changes in phosphorus concentration as a function of season and location in the Bay.

Impacts of Ban on Water Quality in the Maryland Portion of Chesapeake Bay. Consistent with decreases in phosphorus loading, statistically significant decreases in seasonal mean phosphorus concentrations were measured at several Bay and estuary stations between 1985 (pre-ban) and 1986 (post-ban). Spring total phosphorus concentrations were significantly lower at 10 stations out of 37 with sufficient data; Summer concentrations were lower at 7 stations out of 40. Only one sampling station out of a total of 77 Bay and estuary stations had a statistically significant reduction in algal density, as measured by chlorophyll-a concentration, coincident with a statistically significant reduction in phosphorus concentration. Both Spring and Summer conditions in 1985 were compared to 1986. The apparent reductions in phosphorus and chlorophyll-a at this one station (Choptank River) could be attributed to variations in streamflow. The lack of detectable biological responses at other locations with detectable reductions in phosphorus is consistent with the spatial and seasonal distributions of limiting nutrients, with statistical difficulties associated with detecting small changes in algal densities, and with results of model simulations designed to evaluate the sensitivity of algal primary production to changes in soluble nutrient concentrations as a function of time and location in the Bay.

The data analyzed in this study suggest that no improvement in Bay conditions occurred over the time period studied with respect to algal production or compliance with management goals, despite reductions in phosphorus loadings attributed to the detergent phosphate ban, improved wastewater treatment, and other factors. The frequencies of observed chlorophyll-a values exceeding the 15 ppb management goal were 19.8% in 1984-1985 and 21.6% in 1986-1987. The timing, rate, and maximum vertical extent of oxygen depletion in 1986 and 1987 were at least as severe as those measured in previous years, if not more so, particularly in the southern portions of the Bay in Maryland (e.g., mouth of Potomac River).

Roles of Nitrogen, Phosphorus, and Silica in Bay Algal Blooms. A major, sustained algal bloom (chlorophyll-a > 30 ppb) occurred in the Bay between the mouth of Patuxent and the Virginia state line over a two month period in the Spring of 1987. Peak algal biomass was limited by silica in the Spring and by nitrogen in the Summer. Blooms also occurred in the Bay between Annapolis and the Patuxent River during the Summers of 1984, 1985, 1986 and 1987. These summer blooms were generally accompanied by rapid increases in ortho-phosphorus and ammonia concentrations, apparently caused by upwelling of nutrient-rich bottom waters. Peak biomass levels were controlled by nitrogen.

Despite significant reductions in phosphorus loadings to the Upper Bay achieved since the 1970's, nitrogen remains the primary limiting nutrient during the Summer south of Annapolis. Silica limits peak diatom populations during the Spring south of Patuxent River. Under these conditions, the productivity of the Bay and resulting depletion of dissolved oxygen from bottom waters are very insensitive to small changes in phosphorus loadings attributed to the detergent ban. Further, potential benefits of phosphorus controls that might occur in freshwater regions are partially offset by displacement of nitrogen, silica, and productivity to lower regions of the Bay, where most of the remaining viable shellfish beds are located.

Importance of Nitrogen Controls. A focus on nitrogen loadings is required if significant reductions in productivity and oxygen depletion are to be realized. Nutrient balance computations indicate that Maryland point sources account for only 14% of the total nitrogen loading to the Maryland portion of the Bay. This suggests the relative importance of addressing nonpoint nitrogen loadings. Such loadings may have been significantly underestimated in previous modeling studies (USEPA,1983; Fisher et al.,1988), based upon comparisons with nitrogen loadings calculated in this report using recent river monitoring data. The importance of controlling nitrogen, as well as phosphorus, in order to control Bay productivity is reflected in the Draft Bay Agreement, which calls for a 40% reduction in both N and P loadings below 1985 levels (USEPA,1987).

<u>Potential Future Detergent Phosphate Impacts</u>. For a 25-71 mgd range of effluent volumes that may not be subject to phosphorus effluent limits in the future, reductions in phosphorus loading to the Maryland portion of the Bay attributed to the ban would amount to 1-3% of the 1985 loading. Corresponding percentage reductions in algal productivity would be lower because of the importance of growth-limiting factors other than phosphorus, perhaps in the range of 0.3 to 0.8%, based upon interpolation of USEPA(1987) model results.

<u>Conclusion</u>. Reductions in phosphorus loadings to the Bay resulting from the phosphate detergent ban are similar to projections made prior to the ban's implementation. Other factors, including municipal phosphorus removal, reduced phosphorus loads further during the 1984-1987 study period. However, there was no detectable decrease in algal productivity in response to the phosphorus reductions. While this result could reflect algal changes that were too small to detect, the lack of algal response is clearly consistent with observations made in this report and by others that factors other than phosphorus, particularly nitrogen, regulate algal growth and related water quality.

The full range of costs and benefits must be considered in evaluating the phosphate detergent ban and in comparing it with alternative strategies for achieving the same management objectives. Considering the small changes in phosphorus loading resulting from the ban and the importance of limiting nutrients other than phosphorus, it is clear that the ban in itself contributes little to the cause of restoring the Bay.

INTRODUCTION

A statewide phosphate detergent ban went into effect in Maryland on December 1, 1985. Similar legislation was enacted in the District of Columbia and became effective in September 1986. Projected benefits included reductions in phosphorus loadings to Chesapeake Bay from municipal discharges without tertiary phosphorus removal facilities (Jones and Hubbard,1986). Basinwide efforts at reducing point and nonpoint nutrient loadings have been undertaken to curtail eutrophication and related water quality problems in the Bay and its tributaries. Direct relationships between phosphorus loading and biological responses in the Bay, as measured by peak algal densities or by depletion of dissolved oxygen from bottom waters, cannot be presumed, however, because these responses are controlled by several factors, including phosphorus, nitrogen, light, temperature, and hydrodynamic features (MDOEP,1987; USEPA,1987).

Monitoring data indicate 27-35% reductions in influent phosphorus concentrations at major treatment plants following the Maryland and DC bans (Jones and Hubbard,1986; Booman and Sedlak,1986). Limited data indicate an average 33% reduction in effluent concentrations from Maryland treatment plants without phosphorus effluent limitations (Walker,1987b). Harris and Walker (1985) projected that a phosphate detergent ban would result in 2.7 to 7.2% reduction in phosphorus loadings to the Maryland portion of Chesapeake Bay under 1985 effluent limitations. With full implementation of planned phosphorus removal facilities at municipal treatment plants, the projected load reduction ranged from 1.6 to 5% for an average hydrologic year and from 2 to 6% for a dry year. The projected changes are small because phosphorus loadings from nonpoint sources are important and more than 80% of the total effluent volume from major point sources has phosphorus effluent limits. The estimate ranges reflect various assumptions regarding changes in influent and effluent concentrations and sewage phosphorus loss in transport (Harris and Walker,1985).

The following report describes eutrophication-related water quality conditions in the Bay and its tributaries before and after implementation of the phosphate detergent bans. One task is to evaluate "changes" in water quality following the ban. Given monitoring programs with sufficient intensity, consistency, and quality control (as emphasized in current Bay monitoring efforts), it is possible to characterize water quality conditions during a given time period and to compare them with conditions measured during other time periods. It is also possible, though with some difficulty, to test whether observed changes are statistically significant (e.g., whether the means are different). These exercises are essentially statistical and descriptive.

Causal inferences are much more difficult because of the complexity of the Bay and its watershed and numerous sources of variability. In interpreting observed changes in water quality, it is useful to consider four types of variations:

(1) natural variations (associated with hydrology, climate, etc.);

(2) variations caused by the phosphate detergent ban;

(3) other variations induced by man (watershed development, wastewater management, flow regulation, etc.); and

(4) sampling and analytical variations.

Types 1, 2, and 3 are "real" (actually occurred in the system being monitored). Type 4 variations are "unreal" (occurred in the data but not in the system), but impose limitations on the ability to detect real changes. On a Bay-wide scale, identification of Type 2 variations through data analysis is infeasible, given the other sources of variation, relatively short period of record, and the relatively small change in phosphorus loading expected to result from the ban.

Given the above considerations, the primary objectives of the analysis are:

(1) to quantify changes in phosphorus concentration and loading at stream monitoring stations following the phosphate detergent ban and relationships with upstream municipal discharges;

(2) to quantify nutrient loadings to the Maryland portion of Chesapeake Bay during years immediately preceding and following the ban, based upon municipal effluent data and monitoring data from river stations at the Fall Line;

(4) to estimate impacts of the ban on the Bay phosphorus budget under existing and future phosphorus effluent limits;

(5) to test for statistically significant changes in phosphorus, chlorophyll-a, and other water quality variables following the ban at monitoring stations in the Bay and its tributaries;

(6) to evaluate factors controlling algal productivity as a function of season and location based upon measurements of soluble nutrients and other water quality components;

(7) to assess the sensitivity of algal productivity in the Bay to the detergent ban, based upon the projected changes in phosphorus loading and spatial/seasonal distributions in growth-limiting nutrient.

Results are described below, following discussion of data sources and hydrologic conditions present during the study period.

DATA SOURCES

The water quality data analyzed below are derived from monitoring programs conducted by the State of Maryland and the U.S. Geological Survey between July 1984 and September 1987. This period includes 17 months before and 22 months after enforcement of the Maryland ban on December 1, 1985. Although the DC ban was officially implemented in September of 1986, its effects would be felt more or less simultaneously with those of the Maryland ban because of distribution patterns by regional supermarket chains (Jones and Hubbard,1986). In July 1984, ambient monitoring activities of the Maryland Department of the Environment (then the Maryland Office of Environmental Programs) and the U.S. Geological Survey were intensified, as part of Baywide monitoring efforts coordinated and supported by the U.S. Environmental Protection Agency. Longer periods of record have also been analyzed for a few stations with adequate data.

Water quality data have been compiled for three types of monitoring stations:

(1) **River Stations**: in freshwater segments of rivers, streams, creeks (above the Fall Line).

(2) **Estuary Stations**: in tidal segments or at mouths of rivers discharging into the Bay;

(3) **Bay Stations**: Chesapeake Bay from the mouth of the Susquehanna River to the Virginia state line.

Under terminology adopted by the EPA Chesapeake Bay Program, these station groups are referenced as "Fall-Line"/"Core", "Tributary", and "Mainstem", respectively.

River stations were identified through a search of STORET, EPA's nationwide water quality data base, for ambient monitoring stations in Maryland with total phosphorus data for 1985 and 1986. Data were subsequently retrieved and screened based upon sampling frequency (minimum 8 samples/year in 1985 and 1986) and upon the availability of streamflow data for pairing with water quality measurements. Data from 4 USGS river stations for water year 1987 (not yet posted on STORET) have been obtained from the USGS through the Maryland Department of the Environment. River stations with drainage basins primarily outside of Maryland and/or without municipal discharges (e.g., Susquehanna, Upper Monocacy, Upper Potomac, Upper Choptank) provide approximate controls for distinguishing random year-to-year variations (associated with hydrologic variations, for example) from those associated with the detergent bans.

Streamflows required for analysis of river monitoring data have been obtained from STORET. Recent provisional data (water year 1987) have been obtained directly from the Maryland office of the U.S. Geological Survey.

Estuary and Bay data have been obtained from computer files maintained by the EPA's Chesapeake Bay Program in Annapolis. The data have been transferred on tape to the USEPA's National Computer Center and subsequently downloaded to a microcomputer for analysis. The Estuary data set spans from October 1984 through January 1987. The Bay data set spans from July 1984 through July 1987.

The cooperation of the EPA Chesapeake Bay Program, Maryland Department of the Environment, and the U.S. Geological Survey in providing this information is gratefully acknowledged.

HYDROLOGIC CONDITIONS

Streamflows impact river water quality through such mechanisms as dilution, runoff, and scouring. Flows also influence Bay responses to nutrient loading because of the impacts of turbidity, residence time, and hydrodynamic factors (MDOEP,1987). For these reasons, flow variations must be considered in interpreting water quality data from the Bay and its tributaries.

Runoff averages 16 inches/year throughout most of Maryland (USGS,1976). Fall Line gauging stations on the Susquehanna, Choptank, Potomac, and Patuxent Rivers account for approximately 82% of the total watershed area of the Maryland portion of the Bay. Intensive water quality monitoring is also conducted at these locations by the Maryland Department of the Environment and U.S. Geological Survey Station to quantify dry-weather and wet-weather loadings of nutrients and other water quality components. Flow data are summarized in Appendix A (monthly) and Table 1 (seasonal and annual). Figure 1 displays annual runoff for water years 1971 through 1987. Figure 2 displays monthly runoff for water years 1984 through 1987.

Runoff volumes were generally above normal in 1984 and below normal in 1985, 1986, and 1987 (Figure 1). Annual runoff from the Susquehanna in 1984 and 1985 ranked 14 and 2, respectively, out of 17 years between 1971 and 1987. Monthly hydrographs (Figure 2) reveal high spring and summer flows in 1984 and low flows in 1985. Floods during November 1985 and April 1987 are notable in the Potomac River monthly hydrograph.

Lower spring inflows during Spring 1985 resulted in less vertical density stratification in the Bay during Spring and Summer of that year (MDOEP,1987). Longitudinal salinity gradients (north to south at the surface) were similar during summers of 1985, 1986, and 1987, however, but were distinctly different from 1984, when high freshwater inflows resulted in less salinity intrusion and stronger vertical stratification.

RIVER STATIONS - LOW FLOW ANALYSIS

Changes in phosphorus loading following the detergent ban have been estimated using monitoring data from 26 river stations (22 different locations) above the Fall Line (Figure 3). These stations consist of the following:

Table 1
Seasonal and Annual Runoff at Four Gauging Stations

STATION:	MEAN FLOWS (CFS)					RUNOFF (INCHES)				
AREA (MI2)	SUSQUE.	CHOPTANK	PATUXENT	POTOMAC	TOTAL	SUSQUE.	CHOPTANK	PATUXENT	POTOMAC	TOTAL
SEASON...										
83 FAL	40534	187.9	581.6	13868	55171	5.12	5.69	5.72	4.10	4.83
84 WIN	63068	328.4	635.7	27866	91899	7.88	9.84	6.18	8.16	7.95
84 SPR	84504	256.3	588.4	24357	109706	10.55	7.68	5.72	7.13	9.49
84 SUM	25888	37.0	300.5	7123	33348	3.27	1.12	2.95	2.11	2.92
84 FAL	26177	29.0	229.1	6711	33146	3.30	0.88	2.25	1.99	2.90
85 WIN	41012	91.4	296.9	13466	54866	5.07	2.71	2.86	3.90	4.69
85 SPR	31098	50.4	200.2	9581	40929	3.88	1.51	1.95	2.80	3.54
85 SUM	9640	44.4	149.5	2777	12612	1.22	1.34	1.47	0.82	1.10
85 FAL	40361	92.3	217.4	20465	61135	5.10	2.80	2.14	6.06	5.35
86 WIN	66560	212.3	294.6	18519	85585	8.22	6.29	2.83	5.36	7.32
86 SPR	39722	55.9	199.2	7189	47166	4.96	1.68	1.94	2.10	4.08
86 SUM	15049	12.7	96.7	1438	16596	1.90	0.38	0.95	0.43	1.45
86 FAL	44173	89.7	220.8	5600	50083	5.58	2.72	2.17	1.66	4.38
87 WIN	37071	283.6	359.7	13362	51076	4.58	8.40	3.46	3.87	4.37
87 SPR	44878	95.5	335.4	22014	67323	5.60	2.86	3.26	6.44	5.82
87 SUM	18544	10.9	133.1	4255	22943	2.34	0.33	1.31	1.26	2.01
WATER YEAR...										
84	53388	201.9	526.1	18261	72377	26.82	24.32	20.58	21.50	25.18
85	26894	53.6	218.5	8100	35266	13.47	6.44	8.52	9.51	12.24
86	40281	92.8	201.5	11879	52455	20.18	11.14	7.86	13.95	18.20
87	36138	119.1	261.5	11267	47786	18.10	14.31	10.20	13.23	16.58
CALENDAR YEAR...										
84	49779	162.0	437.5	16462	66840	25.00	19.51	17.11	19.38	23.26
85	30469	69.6	215.6	11567	42321	15.26	8.36	8.41	13.58	14.68
86	41242	92.1	202.4	8133	49669	20.66	11.06	7.89	9.55	17.23

WIN=MONTHS 1-3, SPR=MONTHS 4-6, SUM=MONTHS 7-9, FAL=MONTHS 10-12

ID	LOCATION	STATION	DR. AREA (MI2)
SUSQUE.	SUSQUEHANNA RIVER AT CONOWINGO DAM	01578310	27100
CHOPTANK	CHOPTANK RIVER NEAR GREENSBORO	01491000	113
PATUXENT	PATUXENT RIVER NEAR BOWIE	01594440	348
POTOMAC	POTOMAC RIVER ABOVE LITTLE FALLS DAM	01646500	11560
TOTAL			39121

TOTAL WATERSHED OF CHESAPEAKE BAY ABOVE VIRGINIA STATE LINE 47997

AREA-WEIGHTED RUNOFF (INCHES) BY SEASON AND YEAR:

	WINTER	SPRING	SUMMER	FALL
1983				4.83
1984	7.95	9.49	2.92	2.90
1985	4.69	3.54	1.10	5.35
1986	7.32	4.08	1.45	4.38
1987	4.37	5.82	2.01	

Figure 1
Annual Runoff for Water Years 1971-1987

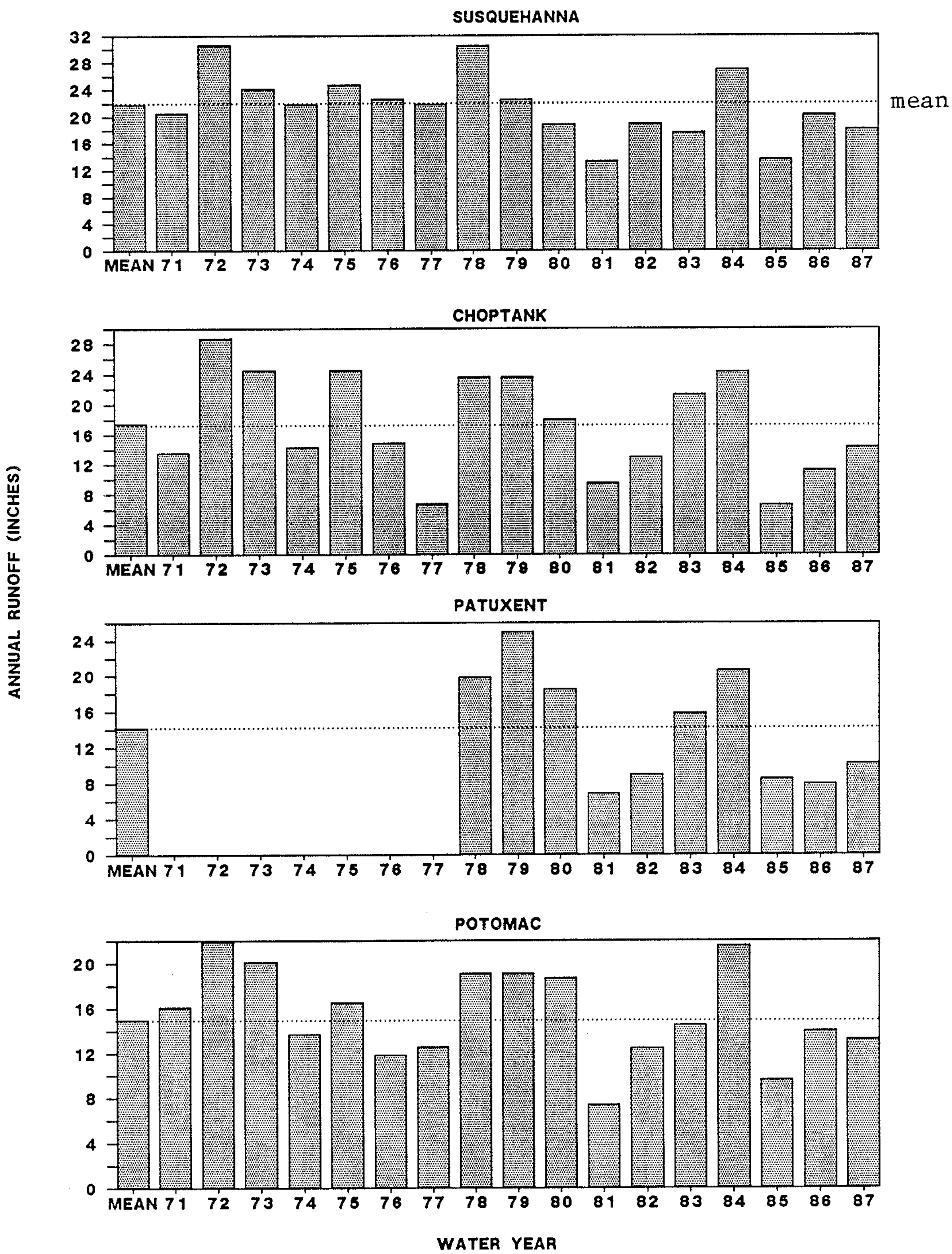
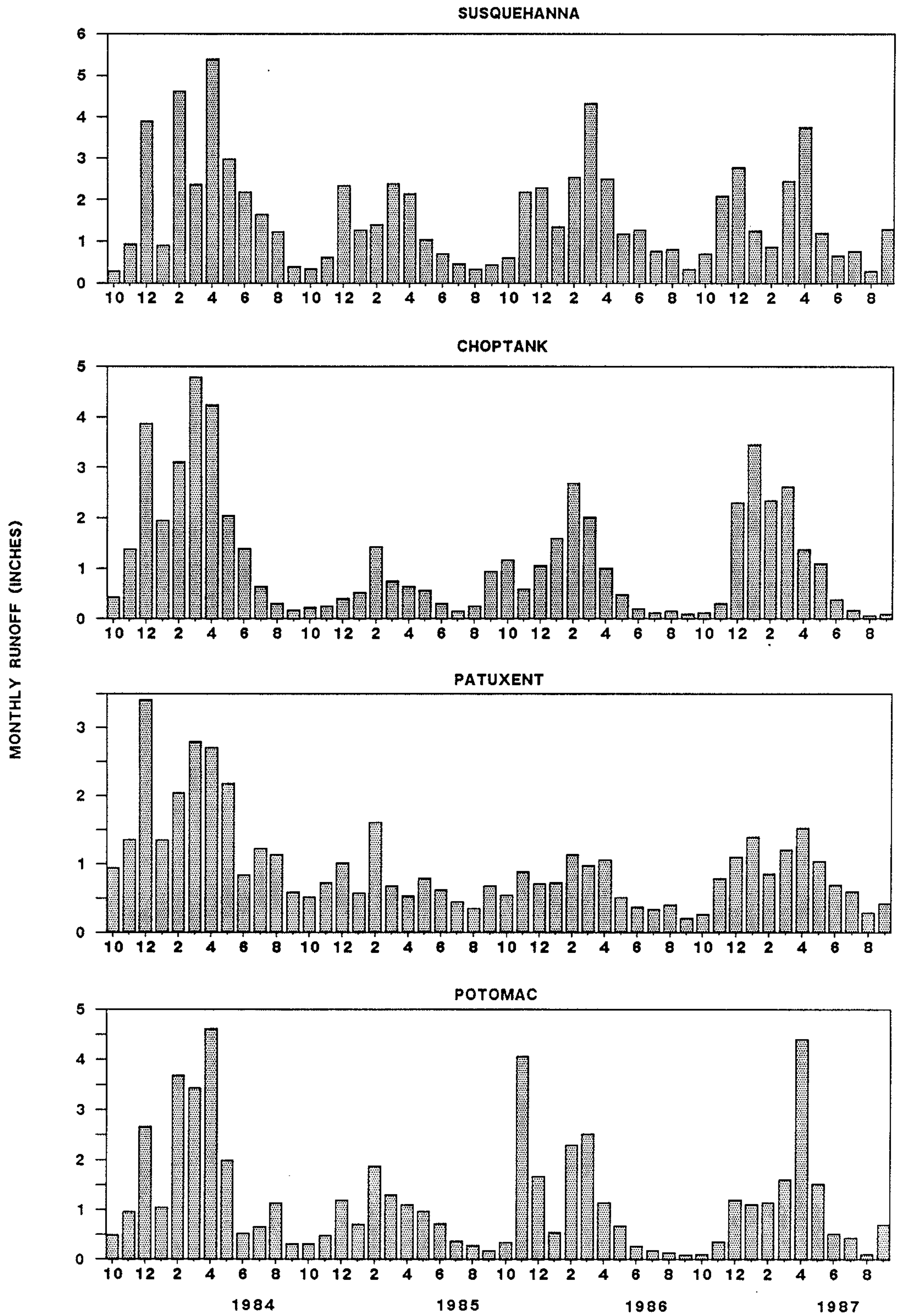


Figure 2
Monthly Runoff for Water Years 1983-1987



21 MDOEP Stations - Monthly Frequency
1 MDOEP Station - Biweekly Frequency (Patuxent River)
4 USGS Stations - High-flow Sampling

Four locations on the Patuxent, Potomac, Susquehanna, and Choptank Rivers were sampled by both agencies. Stations codes and descriptions are listed in Table 2.

Maryland municipal discharges upstream of these stations are listed in Table 3. This inventory has been developed from Sellars et al, (1987), Harris and Walker (1985), and a data base maintained by the EPA Bay Program. The inventory includes Maryland treatment plants without phosphorus effluent limitations during 1984-1986 and should not be considered "complete" with respect to minor discharges, the sum of which could be substantial in some basins. Plants with phosphorus effluent limitations have been excluded because the ban would not be expected to influence loadings from such plants. The total effluent volume above each monitoring station is listed in Table 2. The quantity of upstream effluent per unit of drainage area reflects the potential sensitivity of phosphorus concentrations and unit loadings at a given station to changes in point-source controls.

Consideration of flow regime is essential for interpreting river concentration data and for calculating loadings. Based upon daily flow records for the Potomac River during water years 1985 and 1986, runoff was below the long-term mean (~16 in/yr) 81% of the time. Because of the skewed runoff distribution, however, only 41% of the total flow volume occurred at a rate less than 16 in/yr. High flows (above 16 in/yr) occurred only 19% of the time but accounted for 59% of the total volume. The contrast is more extreme when higher runoff rates are considered. Runoff rates exceeding 32 in/yr accounted for 5.6% of the days and 34% of the total volume.

For a routine monthly monitoring program, the expected number of samples per year would be 9.7 (12 x .81) and 2.3 (12 x .19) in the low-flow (< 16 in/yr) and high-flow (> 16 in/yr) regimes, respectively. The

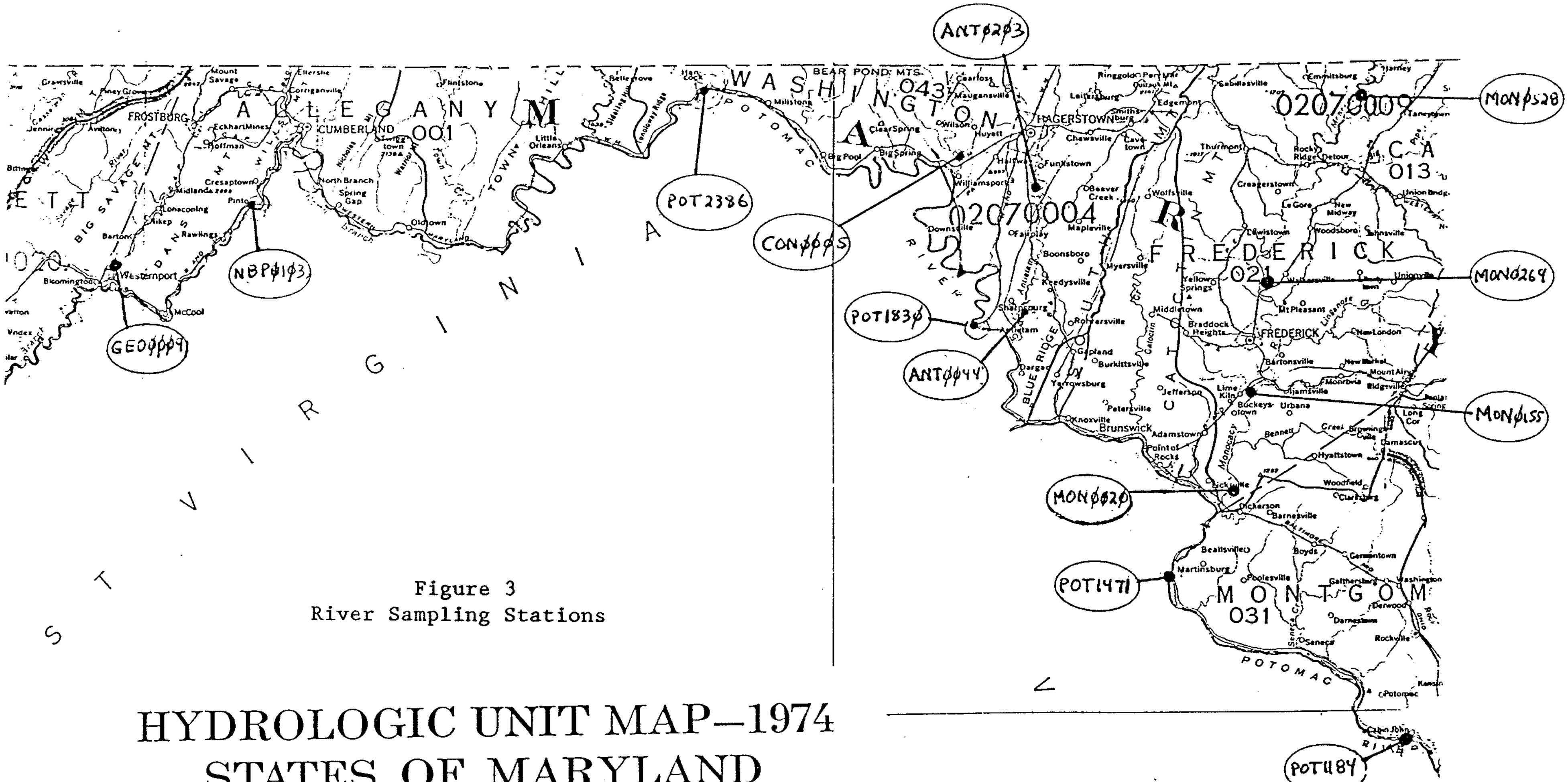


Figure 3
River Sampling Stations

HYDROLOGIC UNIT MAP—1974
STATES OF MARYLAND AND DELAWARE

HYDROLOGIC UNIT CODE

Region — 02 07 00 08 — Accounting Unit

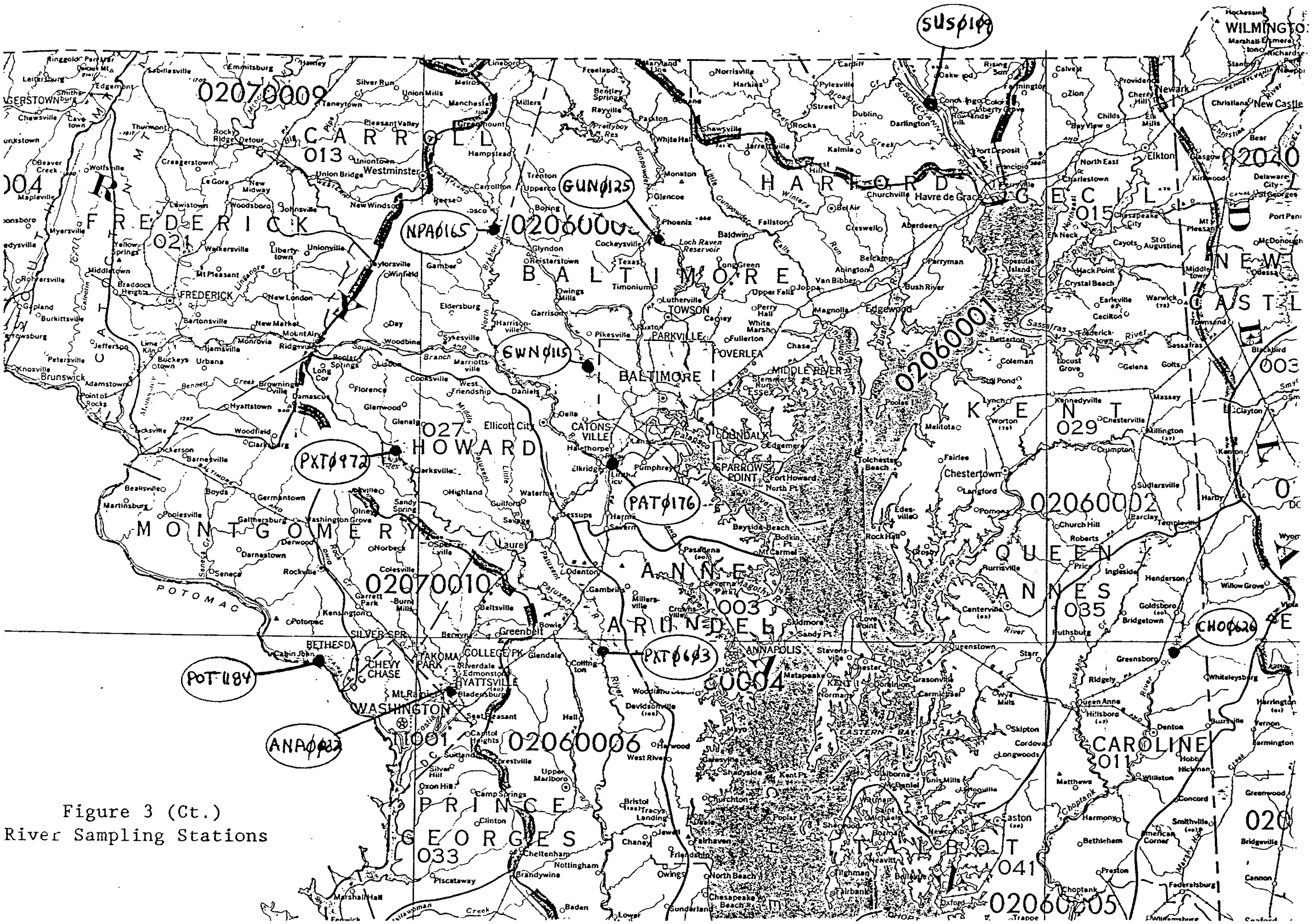


Figure 3 (Ct.)
River Sampling Stations

Table 2
River Sampling Stations and Flow Gauges

RIVER SAMPLING STATIONS - ABOVE FALL LINE.....

STATION	LOCATION	LAT	LONG	HYDROL. UNIT	FLOW STATION	STP FLOW MGD	DRAINAGE AREA MI2	
ANA0082	ANACOSTIA R. AT BRIDGE ON BLADENSBURG ROAD	38.941	76.943	2070010	01649500	0	72.8	
ANT0044	ANTIETAM R. AT GAUGE	39.450	77.732	2070004	01619500	7.04	281	
ANT0203	ANTIETAM R. AT BRIDGE ON POFFENBERGER ROAD	39.595	77.711	2070004	01619500	6.82	191	
CHO0626	CHOPTANK R. AT RED BRIDGES NEAR SEWELL MILLS	38.997	75.786	2060005	01491000	0	113	*
CON0005	CONOCOCHEAGUE C. AT BRIDGE ON MD. ROUTE 68	39.602	77.822	2070004	01614500	0	534	
GEO0009	GEORGES C. 1 MILE NORTH OF WESTERNPORT	39.494	79.045	2070002	01599000	0	72.4	
GUN0125	GUNPOWDER FALLS AT BRIDGE ON CROMWELL BRIDGE RD	39.493	76.532	2060003	01582500	0	240	
GWN0115	GWYNNS FALLS AT BRIDGE ON ESSEX ROAD IN VILLA NO	39.346	76.736	2060003	01589300	0.03	32.5	
MON0020	MONOCACY R. AT BRIDGE OM MD. ROUTE 28	39.244	77.441	2070009	01643000	9.66	937	
MON0155	MONOCACY R. AT BRIDGE ON REELS MILL ROAD	39.388	77.413	2070009	01643000	9.66	785	
MON0269	MONOCACY R. AT BRIDGE ON BIGGS FORD ROAD	39.480	77.389	2070009	01643000	4.69	641	
MON0528	MONOCACY R. BRIDGE ON MD. ROUTE 7, BRIDGEPORT	39.679	77.235	2070009	01639000	0	173	
NBP0103	N. BR. POTOMAC W. OF MOORES HOLLOW RD. & RTE 51	39.583	78.817	2070002	01603000	0	875	
NPA0165	NORTH BRANCH PATAPSCO RIVER ROUTE 91	39.500	76.883	2060003	01586000	0	56.6	
PAT0176	PATAPSCO R. AT WASHINGTON BLVD.(U.S. RT 1)	39.218	76.707	2060003	01589000	1.51	349	
POT1184	POTOMAC R. AT GAGING STATION ABOVE LITTLE FALLS	38.933	77.119	2070008	01646500	31.82	11560	*
POT1471	POTOMAC R. AT EASTERN TERMINUS OF WHITES FERRY	39.155	77.519	2070010	01638500	31.09	10623	
POT1830	POTOMAC R. BELOW BRIDGE ON MD. ROUTE 34	39.436	77.802	2070004	01638500	13.89	7151	
POT2386	POTOMAC R. BELOW BRIDGE ON US. RT. 522 HANCOCK	39.697	78.178	2070004	01613000	12.62	4073	
PXT0603	BRIDGE ON U.S. RT. 50	38.955	76.694	2060006	01594440	9.21	348	*
PXT0972	PATUXENT R. AT BRIDGE ON MD. 97 NEAR UNITY GAGE	39.238	77.057	2060006	01591000	0	34.8	
SUS0109	LOWER SUSQUEHANNA AT CONOWINGO DAM STATION	39.575	76.109	2050306	01578310	0	27100	*

STP. FLOW = TOTAL MD POTW DISCHARGE UPSTREAM OF STATION, EXCLUDING PLANTS WITH P EFFLUENT LIMITATIONS
DRAINAGE AREA = APPROXIMATE DRAINAGE AREA AT SAMPLING STATION, ADJUSTED FROM AREA AT FLOW STATION
* PAIRED WITH USGS WATER QUALITY DATA AT SAME LOCATION

USGS FLOW GAUGING STATIONS...

STATION	LOCATION	LAT	LONG	HYDROL. UNIT	DRAINAGE AREA MI2
01491000	CHOPTANK R NR GREENSBORO, MD	38.997	75.786	2060005	113
01578310	SUSQUEHANNA R AT CONOWINGO, MD	39.657	76.175	2050306	27100
01582500	GUNPOWDER FALLS AT GLENCOE MD	39.550	76.636	2060003	160
01586000	NB PATAPSCO R AT CEDARHURST, MD	39.500	76.883	2060003	56.6
01589300	GWYNNS FALLS AT VILLA NOVA, MD	39.346	76.734	2060003	32.5
01591000	PATUXENT R NR UNITY, MD	39.238	77.056	2060006	34.8
01594440	PATUXENT R NR BOWIE, MD	38.956	76.693	2060006	348
01599000	GEORGES C AT FRANKLIN, MD	39.494	79.045	2070002	72.4
01603000	NB POTOMAC R NR CUMBERLAND, MD	39.621	78.773	2070003	875
01614500	CONOCOCHEAGUE C AT FAIRVIEW, MD	39.708	77.833	2070004	494
01619500	ANTIETAM C NR SHARPSBURG, MD	39.450	77.731	2070004	281
01638500	POTOMAC R AT POINT OF ROCKS, MD	39.274	77.543	2070008	9651
01639000	MONOCACY R AT BRIDGEPORT, MD	39.679	77.235	2070009	173
01643000	MONOCACY R AT JUG BRIDGE NR FREDERICK, MD	39.388	77.380	2070009	817
01646500	POTOMAC R NR WASH, DC L FALLS PUMP STA	38.949	77.128	2070008	11560
01649500	NE B ANACOSTIA R AT RIVERDALE, MD	38.960	76.926	2070010	72.8

Table 3
Municipal Discharges Above River Monitoring Stations

PLANT *	MEAN FLOW MGD	STATION**
Boonsboro	0.160	ANT0044
Smithsburg	0.060	ANT0044
Funkstown	0.070	ANT0203
Hagerstown	6.000	ANT0203
Md Hoc Hagerstow	0.750	ANT0203
Montrose School	0.027	GWN0115
Frederick	4.700	MON0155
Frederick County	0.268	MON0155
Ballenger	0.404	MON0269
Crestview	0.011	MON0269
Emmitsburg	0.490	MON0269
Ft Detrick	1.200	MON0269
New Windsor	0.028	MON0269
Taneytown	0.240	MON0269
Thurmont	0.550	MON0269
Union Bridge	0.069	MON0269
Westminster	1.700	MON0269
Freedom District	1.310	PAT0176
Gaither Manor	0.012	PAT0176
Mt Airy	0.174	PAT0176
Pheasant Ridge	0.015	PAT0176
Damascus	0.459	POT1184
Poolesville	0.27	POT1184
Brunswick	0.330	POT1471
Middletown	0.130	POT1471
Clear Spring	0.165	POT1830
Halfway	1.100	POT1830
Cumberland	12.300	POT2386
Hancock	0.32	POT2386
Bowie St College	0.050	PXT0603
Central Farms	0.002	PXT0603
Maryland City	0.610	PXT0603
Md House of Corr	0.987	PXT0603
Parkway	4.040	PXT0603
Patuxent	3.500	PXT0603
Patuxent Wildlif	0.016	PXT0603
TOTAL	42.565	

* MUNICIPAL POTW'S WITHOUT P EFFLUENT LIMITS BETWEEN JULY 1984 AND MARCH 1987

** FIRST RIVER MONITORING STATION DOWNSTREAM OF PLANT expected sampling frequency for flows exceeding 32 in/yr is .7 (12 x .056) samples/yr. Because of these relationships, routine monthly monitoring programs rarely provide sufficient samples for calculating loadings associated with high-flow regimes or for calculating total annual loadings. They may permit estimation of loadings under average and low flows, however. Based upon dilution considerations, changes in stream loadings due to changes in watershed point sources (e.g., detergent ban) should be easier to detect under low and average flows than under high flows. Lack of sufficient high-flow samples at most stations does not impose a severe limitation on the detection of changes under low flows, but makes it impossible to express the changes as percentages of the total annual or seasonal loadings.

Because of sampling frequency considerations, the analysis is restricted to low flows at 18 stations with a monthly sampling strategy. Estimates of loadings for all flow regimes are developed at 4 stations with both routine and high-flow sampling strategies (Fall-Line stations on the Choptank, Susquehanna, Patuxent, and Potomac Rivers sampled by both the MDOEP and the USGS). Loading calculations cover the period from July 1984 through March 1987, which reflects the availability of data in STORET. The USGS high-flow data at four stations extends through September 1987. Because phosphorus effluent limitations went into effect at major plants in the Patuxent basin (Patuxent, Parkway) in 1987, the period of record is restricted to July 1984-December 1986 at station PXT0603, which is downstream of these treatment plants.

The following procedures have been applied to estimate changes in phosphorus concentrations and loadings under low-flow conditions at each location:

(1) Assign a flow value to each water quality sample, pulled from the daily flow record at the closest streamflow gauge in the same river basin. Assume that daily unit runoff above the water quality station equals unit runoff above the streamflow gauge. Express runoff in inches/year (= Flow(cfs) x 13.58 / drainage area (mi^2)).

(2) Review diagnostic plots of concentration as a function of runoff and time at each station (Appendix B). Different symbols are used to distinguish pre-ban vs. post-ban samples.

(4) Using samples collected at flows less than the long-term mean (typically 16 in/yr), calculate mean and variance of the mean flow-weighted concentration for each time period (pre-ban, post-ban):

$$Q_m = \text{MEAN} [Q_i]$$

$$C_m = \text{MEAN} [Q_i C_i] / Q_m$$

$$\text{VAR}(C_m) = \frac{\text{MEAN} [Q_i C_i - Q_i C_m]^2}{(n - 1) Q_m^2}$$

i = sample index

n = number of samples

C_i = sample concentration (ppb)

C_m = flow-weighted mean concentration (ppb)

$\text{VAR}(C_m)$ = error variance of C_m

Q_i = sample flow (in/yr)

Q_m = mean sampled flow (in/yr)

MEAN = average over n samples

The flow-weighted mean concentration, C_m, amounts to a ratio estimator for the mean loading (Bodo and Unny, 1983, 1984; Walker,1987a). The approximate formula for VAR(C_m) is derived from classical sampling theory (Snedecor and Cochran,1972). Based upon results for test cases, variance estimates compare favorably with values derived from the FLUX program, which employs a jackknifing technique for estimating variances (Walker,1987a,1988).

(5) Based upon the continuous daily flow record for water years 1985 and 1986, calculate the number of days and total volume in each flow interval. Apply the volume in the low-flow stratum to the mean and variance of the flow-weighted concentration to estimate the mean and variance of the loading. Express loading in terms of pounds per square mile per day (= .145 x (in/yr) x ppb) for each time period. This procedure essentially adjusts the pre-ban and post-ban loading estimates to equivalent flow conditions and assumes that the flow-weighted concentration is independent of flow within the low-flow stratum. More complex models which account for variations in concentration as a function of flow (Walker, 1987a) have also be tested and found to give similar results.

(8) Compare pre-ban and post-ban concentration and loading estimates. Compute the error variance of the difference in loading by summing the pre-ban and post-ban error variances (since the pre-ban and post-ban samples are independent). Divide the change in loading by its standard error (square root of error variance). The result is an approximate t-statistic for testing whether the change in loading (or change in flow-weighted concentration) is significantly different from zero.

Results of these calculations for total phosphorus, ortho phosphorus, and total Kjeldahl nitrogen are given in Table 4. Calculations for Kjeldahl nitrogen serve as controls, since the ban would not be expected to influence nitrogen species.

Load reduction confidence limits are displayed for each variable and station in Figure 4. The load reduction exceeded twice the standard error at 8 stations for total phosphorus, 12 stations for ortho phosphorus, and 0 stations for total kjeldahl nitrogen. These results reflect the extent to which changes in phosphorus loadings under low-flow conditions are statistically detectable using a monthly sampling frequency.

Post-ban loadings are plotted against pre-ban loadings in Figure 5. For Kjeldahl nitrogen, pre-ban and post-ban loadings were similar and the points are randomly scattered about the Y=X line. For phosphorus species, post-ban loadings averaged about 60% of pre-ban loadings at 12 stations with pre-ban loadings exceeding .3 lbs/mi^2-day. Considering that detergents typically account for 27-35% of the phosphorus in domestic wastewaters (Booman and Sedlak,1986;Jones and Hubbard,1986), it is unlikely that the detergent ban alone could account for the ~40% load reductions indicated by Figure 5. Seasonal and other factors possibly responsible for this are discussed below.

Figure 6 displays load reductions in total and ortho phosphorus against upstream municipal effluent volume (mgd/mi^2). For a given upstream effluent volume, the expected change in loading (lbs/mi^2-day) resulting from the detergent ban can be calculated from a mass-balance:

$$DL = 8.34 \quad Q \quad DC$$

where,

DL = change in loading (lbs/mi^2-day)

Q = upstream effluent volume (mgd/mi^2)

DC = change in effluent concentration (ppm)

Table 4
Pre-Ban and Post-Ban Nutrient Export under Low Flows
July 1984 through March 1987

TOTAL PHOSPHORUS

STATION	RUNOFF BOUND IN/YR	DURATION DAYS	STRATUM RUNOFF INCHES	TOTAL RUNOFF INCHES	PRE-BAN SAMPLES	PRE-BAN CONC PPB	PRE-BAN LOAD LB/MI2-D	PRE-BAN CV	POST-BAN SAMPLES	POST-BAN CONC PPB	POST-BAN LOAD LB/MI2-D	POST-BAN CV	PRE-BAN - POST-BAN CONC PPB	PRE-BAN - POST-BAN LOAD LB/MI2-D	PRE-BAN - POST-BAN CV	T
ANA0082	16	642	9.94	19.85	13	72.8	0.163	0.086	12	82.7	0.186	0.194	-9.9	-0.022	-1.734	-0.58
ANT0044	16	586	14.71	24.80	7	351.5	1.279	0.117	12	210.9	0.767	0.102	140.6	0.512	0.330	3.03
ANT0203	16	586	14.71	24.80	11	543.4	1.977	0.161	12	344.0	1.252	0.136	199.4	0.726	0.497	2.01
CHO0626	16	645	9.71	17.59	36	80.8	0.176	0.161	30	59.0	0.129	0.103	21.8	0.048	0.658	1.52
CON0005	16	566	10.13	26.51	12	179.4	0.466	0.106	11	120.9	0.314	0.114	58.5	0.152	0.401	2.49
GEO0009	16	558	9.27	30.90	18	143.5	0.346	0.247	10	93.3	0.225	0.187	50.2	0.121	0.787	1.27
GUN0125	16	547	14.25	26.71	12	54.0	0.204	0.128	10	61.8	0.233	0.111	-7.8	-0.029	-1.248	-0.80
GWN0115	16	650	12.35	21.35	14	109.8	0.303	0.177	13	50.4	0.139	0.096	59.4	0.164	0.337	2.97
MON0020	16	601	9.65	22.94	16	238.2	0.555	0.108	14	159.0	0.370	0.064	79.2	0.184	0.350	2.86
MON0155	16	601	9.65	22.94	13	319.2	0.743	0.234	9	166.6	0.388	0.132	152.6	0.355	0.511	1.96
MON0269	16	601	9.65	22.94	14	234.1	0.545	0.335	10	106.0	0.247	0.076	128.1	0.298	0.616	1.62
MON0528	16	621	7.32	24.28	14	241.3	0.413	0.287	10	199.1	0.340	0.389	42.2	0.072	2.461	0.41
NBP0103	32	602	19.87	43.84	11	107.7	0.515	0.104	12	80.0	0.383	0.102	27.7	0.133	0.501	2.00
NPA0165	12	550	10.74	21.38	12	49.2	0.139	0.110	11	49.3	0.140	0.118	-0.1	-0.000	-53.989	-0.02
PAT0176	10	696	6.37	8.14	15	125.4	0.166	0.130	14	99.9	0.133	0.077	25.5	0.034	0.704	1.42
POT1184	16	591	9.74	23.47	23	98.3	0.235	0.078	43	75.6	0.181	0.119	22.8	0.054	[illegible]	1.99
POT1471	16	619	10.12	20.80	14	184.3	0.437	0.083	12	104.1	0.247	0.127	80.2	0.190	0.252	3.97
POT1830	16	582	10.37	24.91	15	84.1	0.217	0.052	12	90.5	0.234	0.263	-6.4	-0.017	-3.782	-0.26
POT2386	16	554	9.86	28.85	13	61.4	0.158	0.095	11	55.8	0.144	0.244	5.6	0.014	2.645	0.38
PXT0603	12	632	10.10	16.39	56	628.6	1.457	0.056	55	379.8	0.880	0.081	248.8	0.577	0.188	5.31
PXT0972	12	600	9.59	17.50	13	51.1	0.118	0.197	13	54.7	0.127	0.119	-3.7	-0.008	-3.276	-0.31
SUS0109	20	520	12.12	33.66	28	73.0	0.247	0.143	41	49.0	0.165	0.070	24.1	0.081	0.457	2.19

ORTHO PHOSPHORUS

STATION	RUNOFF BOUND IN/YR	DURATION DAYS	STRATUM RUNOFF INCHES	TOTAL RUNOFF INCHES	PRE-BAN SAMPLES	PRE-BAN CONC PPB	PRE-BAN LOAD LB/MI2-D	PRE-BAN CV	POST-BAN SAMPLES	POST-BAN CONC PPB	POST-BAN LOAD LB/MI2-D	POST-BAN CV	PRE-BAN - POST-BAN CONC PPB	PRE-BAN - POST-BAN LOAD LB/MI2-D	PRE-BAN - POST-BAN CV	T
ANA0082	16	642	9.94	19.85	13	26.2	0.059	0.183	12	25.4	0.057	0.307	0.8	0.002	10.829	0.09
ANT0044	16	586	14.71	24.80	8	339.0	1.234	0.143	12	174.6	0.635	0.155	164.4	0.598	0.338	2.95
ANT0203	16	586	14.71	24.80	11	476.8	1.735	0.161	12	269.1	0.979	0.129	207.7	0.756	0.405	2.47
CHO0626	16	645	9.71	17.59	33	45.2	0.099	0.316	29	16.0	0.035	0.170	29.2	0.064	0.498	2.01
CON0005	16	566	10.13	26.51	12	153.5	0.398	0.105	11	83.3	0.216	0.138	70.2	0.182	0.283	3.53
GEO0009	16	558	9.27	30.90	13	27.0	0.065	0.268	10	23.7	0.057	0.271	3.3	0.008	2.964	0.34
GUN0125	16	547	14.25	26.71	12	13.5	0.051	0.153	10	10.0	0.038	0.218	3.4	0.013	0.874	1.14
GWN0115	16	650	12.35	21.35	14	70.4	0.194	0.293	13	12.9	0.035	0.154	57.6	0.159	0.360	2.78
MON0020	16	601	9.65	22.94	16	193.3	0.450	0.115	14	111.7	0.260	0.125	81.7	0.190	0.321	3.11
MON0155	16	601	9.65	22.94	12	182.1	0.424	0.122	10	144.8	0.337	0.190	37.3	0.087	0.946	1.06
MON0269	16	601	9.65	22.94	13	150.7	0.351	0.327	10	78.0	0.182	0.182	72.7	0.169	0.706	1.42
MON0528	16	621	7.32	24.28	13	161.2	0.276	0.213	10	144.5	0.247	0.294	16.8	0.029	3.255	0.31
NBP0103	32	602	19.87	43.84	10	50.7	0.243	0.235	11	24.1	0.115	0.175	26.6	0.127	0.476	2.10
NPA0165	12	550	10.74	21.38	12	20.2	0.057	0.122	11	22.1	0.063	0.477	-1.9	-0.005	-5.641	-0.18
PAT0176	10	696	6.37	8.14	15	74.2	0.098	0.145	14	36.2	0.048	0.175	38.1	0.051	0.329	3.04
POT1184	16	591	9.74	23.47	23	49.7	0.119	0.107	43	23.9	0.057	0.109	25.8	0.062	0.229	4.37
POT1471	16	619	10.12	20.80	14	125.5	0.298	0.099	13	47.6	0.113	0.203	77.9	0.185	0.202	4.96
POT1830	16	582	10.37	24.91	15	59.7	0.154	0.279	12	28.9	0.075	0.211	30.7	0.079	0.578	1.73
POT2386	16	554	9.86	28.85	13	24.5	0.063	0.159	11	14.5	0.037	0.218	10.0	0.026	0.503	1.99
PXT0603	12	632	10.10	16.39	49	401.3	0.930	0.071	55	172.1	0.399	0.085	229.2	0.531	0.140	7.13
PXT0972	12	600	9.59	17.50	13	16.5	0.038	0.163	13	19.4	0.045	0.134	-2.9	-0.007	-1.282	-0.78
SUS0109	20	520	12.12	33.66	28	25.8	0.087	0.152	40	12.3	0.041	0.007	13.6	0.046	0.301	3.33

TOTAL KJELDAHL NITROGEN

STATION	RUNOFF BOUND IN/YR	DURATION DAYS	STRATUM RUNOFF INCHES	TOTAL RUNOFF INCHES	PRE-BAN SAMPLES	PRE-BAN CONC PPB	PRE-BAN LOAD LB/MI2-D	PRE-BAN CV	POST-BAN SAMPLES	POST-BAN CONC PPB	POST-BAN LOAD LB/MI2-D	POST-BAN CV	PRE-BAN - POST-BAN CONC PPB	PRE-BAN - POST-BAN LOAD LB/MI2-D	PRE-BAN - POST-BAN CV	T
ANA0082	16	642	9.94	19.85	13	957.4	2.148	0.248	12	612.5	1.375	0.109	344.9	0.774	0.715	1.40
ANT0044	16	586	14.71	24.80	7	640.3	2.330	0.089	12	713.3	2.596	0.220	-73.0	-0.265	-2.291	-0.44
ANT0203	16	586	14.71	24.80	11	756.1	2.752	0.086	12	941.0	3.424	0.116	-184.9	-0.673	-0.688	-1.45
CHO0626	16	645	9.71	17.59	36	599.4	1.308	0.084	30	804.6	1.756	0.236	-205.2	-0.448	-0.958	-1.04
CON0005	16	566	10.13	26.51	12	604.9	1.570	0.107	11	485.6	1.261	0.105	119.2	0.310	0.691	1.45
GEO0009	16	558	9.27	30.90	18	707.4	1.705	0.148	10	600.8	1.448	0.132	106.6	0.257	1.236	0.81
GUN0125	16	547	14.25	26.71	12	574.2	2.168	0.068	10	547.2	2.067	0.154	27.0	0.102	3.451	0.29
GWN0115	16	650	12.35	21.35	14	445.5	1.228	0.098	13	415.3	1.144	0.120	30.2	0.083	2.187	0.46
MON0020	16	601	9.65	22.94	16	775.7	1.807	0.082	14	730.5	1.701	0.060	45.2	0.105	1.712	0.58
MON0155	16	601	9.65	22.94	13	1022.6	2.382	0.123	10	982.7	2.289	0.179	40.0	0.093	5.409	0.18
MON0269	16	601	9.65	22.94	14	765.3	1.782	0.224	10	552.3	1.286	0.096	213.0	0.496	0.841	1.19
MON0528	16	621	7.32	24.28	14	660.5	1.130	0.108	10	783.9	1.341	0.244	-123.4	-0.211	-1.652	-0.61
NBP0103	32	602	19.87	43.84	11	520.0	2.488	0.130	12	498.2	2.384	0.074	21.8	0.104	3.532	0.28
NPA0165	12	550	10.74	21.38	12	527.7	1.494	0.094	11	485.2	1.374	0.109	42.5	0.120	1.711	0.58
PAT0176	10	696	6.37	8.14	15	595.3	0.790	0.096	14	530.9	0.704	0.089	64.4	0.085	1.152	0.87
POT1184	16	591	9.74	23.47	22	748.2	1.787	0.091	42	792.3	1.892	0.180	-44.1	-0.105	-3.588	-0.28
POT1471	16	619	10.12	20.80	14	798.7	1.894	0.091	13	674.8	1.600	0.088	123.9	0.294	0.757	1.32
POT1830	16	582	10.37	24.91	15	543.8	1.405	0.108	12	437.5	1.131	0.166	106.2	0.275	0.880	1.14
POT2386	16	554	9.86	28.85	13	502.4	1.297	0.095	11	454.0	1.172	0.144	48.4	0.125	1.667	0.60
PXT0603	12	632	10.10	16.39	55	1593.9	3.693	0.040	54	1573.8	3.647	0.035	20.1	0.047	4.178	0.24
PXT0972	12	600	9.59	17.50	12	355.9	0.825	0.100	13	343.7	0.797	0.094	12.2	0.028	3.962	0.25
SUS0109	20	520	12.12	33.66	28	767.4	2.594	0.083	41	712.8	2.409	0.080	54.7	0.185	1.567	0.64

RUNOFF BOUND = UPPER LIMIT OF FLOW STRATUM CONSIDERED (ROUGHLY = MEAN ANNUAL RUNOFF) PRE-BAN: JULY 1984 - NOV. 1985
DURATION = NUMBER OF DAYS IN FLOW STRATUM, OUT OF 730 (WATER YEARS 1985 AND 1986) POST-BAN: DEC. 1985 - MARCH 1987
STRATUM RUNOFF = RUNOFF VOLUME IN STRATUM
TOTAL RUNOFF = TOTAL RUNOFF VOLUME
SAMPLES = NUMBER OF CONCENTRATION SAMPLES
CONC = FLOW-WEIGHTED-MEAN CONCENTRATION IN STRATUM
LOAD = .145 X CONC (PPB) X STRATUM RUNOFF (INCHES) / DURATION (DAYS) , .145 = UNITS CONV. FACTOR (LBS/MI2)/(IN X PPB)
CV = ERROR COEFFICIENT OF VARIATION FOR CONC AND LOAD ESTIMATES
T = T-STATISTIC FOR NULL HYPOTHESIS: CHANGE IN LOAD OR CHANGE IN CONC = 0

Figure 4
Confidence Ranges for Load Reductions Under Low-Flows

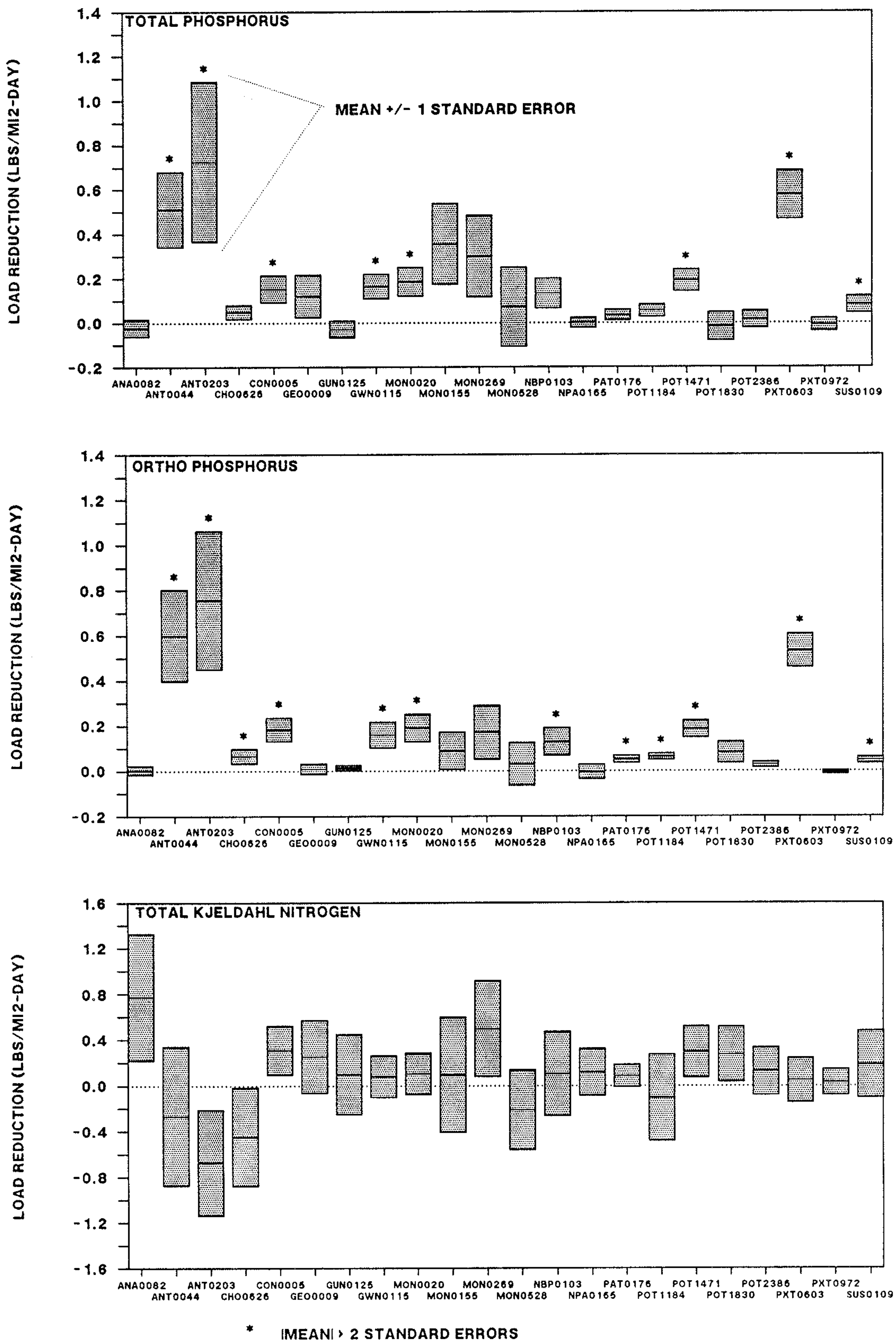
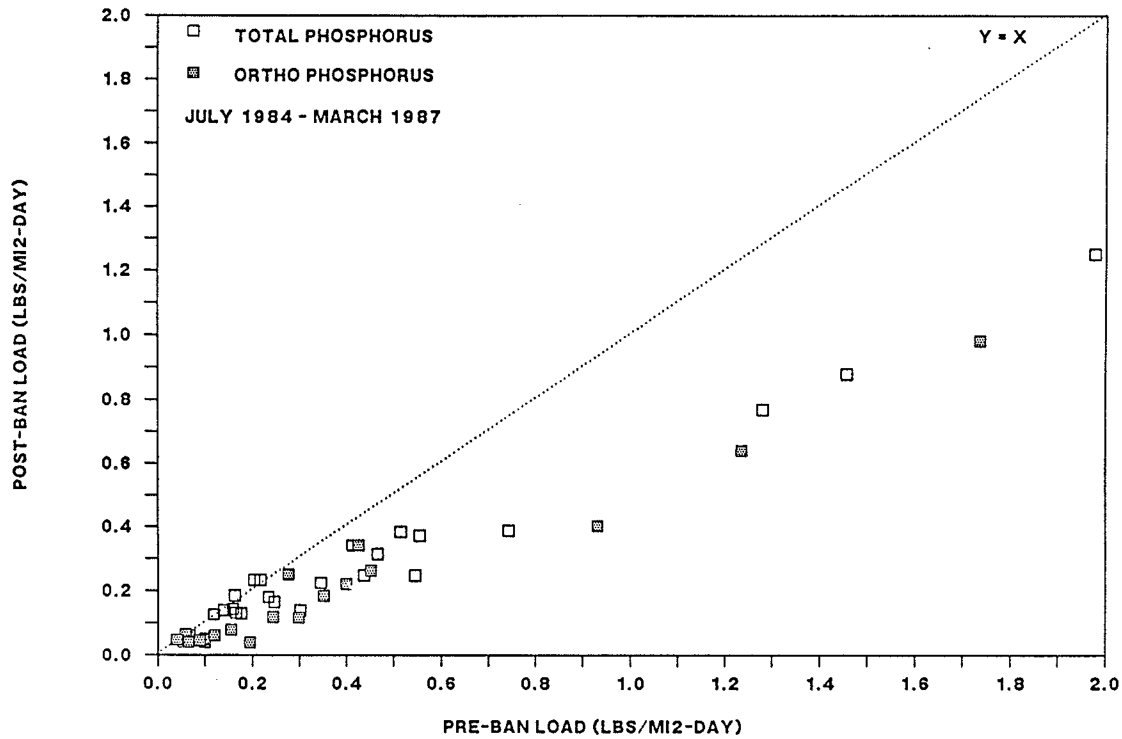
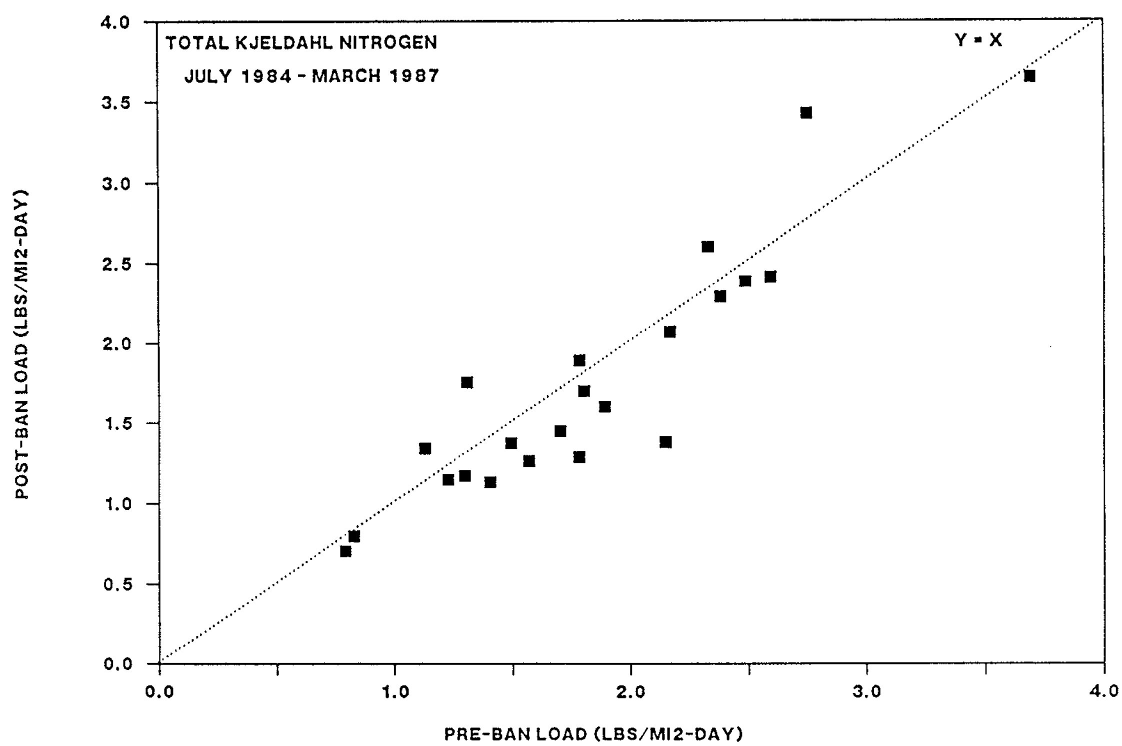


Figure 5
Post-Ban vs. Pre-Ban Loads Under Low Flows
July 1984 through March 1987





The above equation assumes that phosphorus is conservative (i.e., is transported without losses from the point of discharge to the monitoring station). A previous study of data from Maryland treatment plants without phosphorus removal (Walker,1987b) indicates an average reduction of 1.8 ppm in effluent phosphorus concentrations following the ban. Approximate 95% confidence limits for the reduction are 1.4 to 2.2 ppm. Dotted lines in Figure 6 show the predictions of the above equation for effluent reductions of 1.4 and 2.2 ppm. Dashed lines show results of regression analyses applied directly to the data.

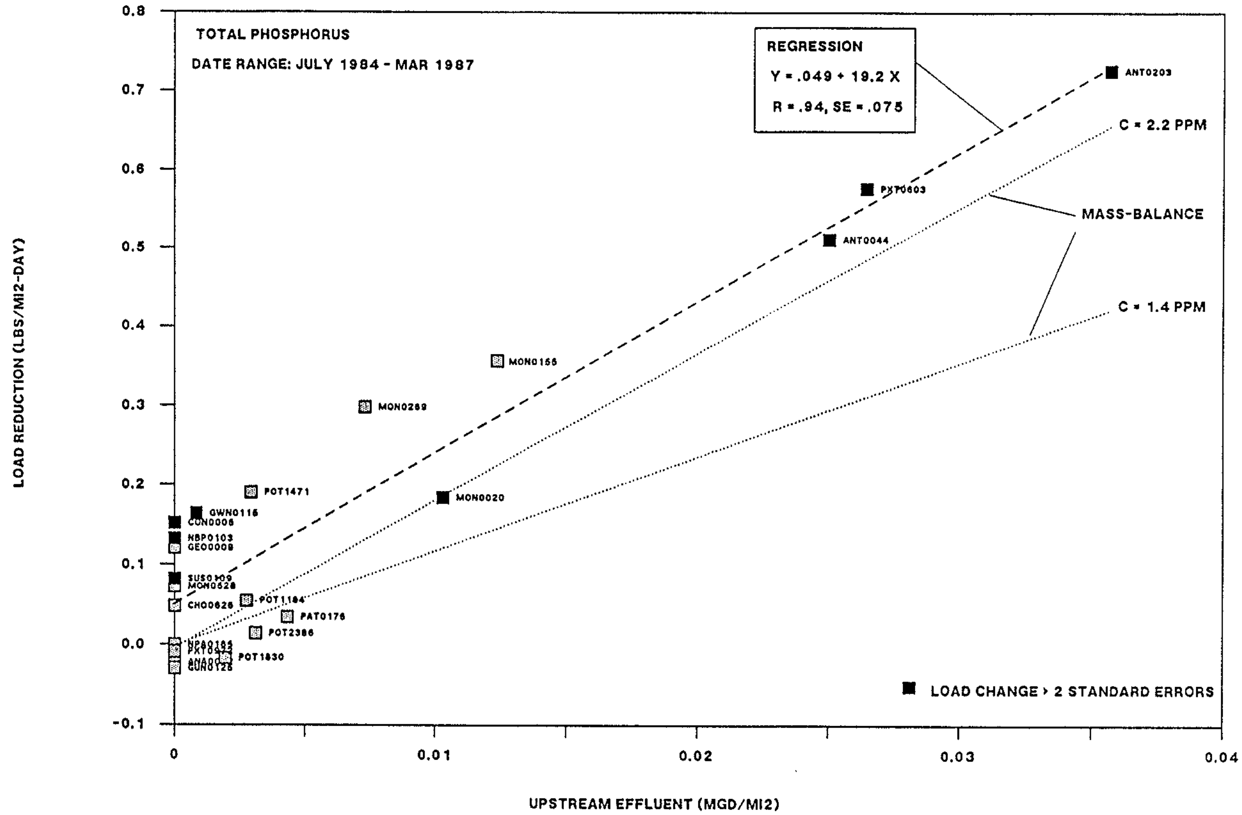
The regression and data points generally lie above the predictions based upon mass balance. Possible contributing factors include:

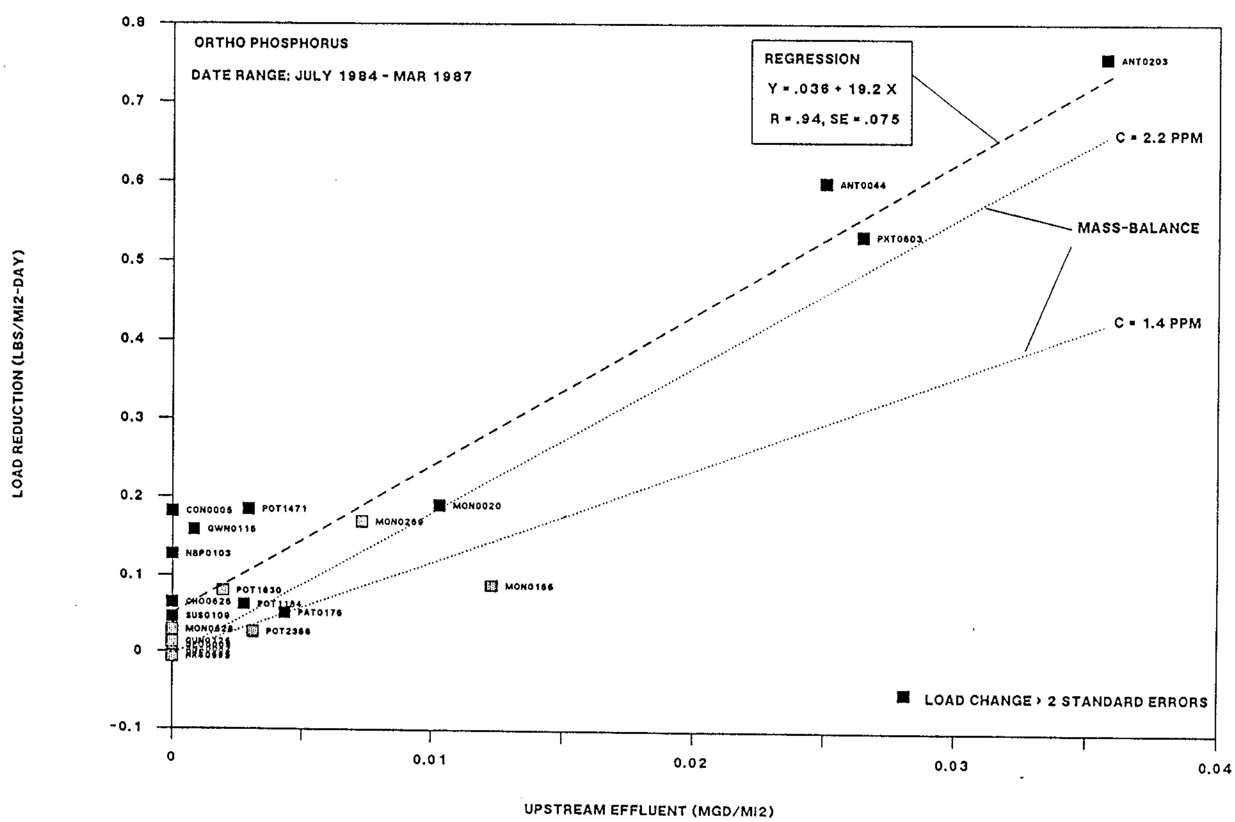
(1) The effluent inventories are incomplete because they do not reflect the cumulative effects of all minor discharges above each site. This means that actual discharge volumes above some stations are greater than assumed and that some of the points in Figure 6 should be shifted to the right.

(2) In some cases, effects of the Maryland detergent ban may have spilled over into neighboring states because of regional supermarket distribution patterns. For example, significant reductions in total and ortho phosphorus concentrations were observed at a station on the Conococheague River (CON0005) in the Upper Potomac Basin. Most of the watershed above this station is in Pennsylvania. Detergent distribution, sales, and use in Pennsylvania towns such as Chambersburg and Greencastle may reflect conditions in Hagerstown, MD, the closest major city. Similar relationships may exist at other stations which have watersheds extending into neighboring states.

(3) The load reductions at some stations may partially reflect other wastewater management activities (e.g., diversion, treatment plant upgrades) or non-point-source control

Figure 6
Load Reduction vs. Upstream Effluent Density
July 1984 through March 1987





activities occurring in Maryland or neighboring states over the same time period. Major changes in wastewater management could not be specifically identified in these watersheds, however.

(4) Year-to-year variations in non-point loadings may also be important. These are reflected by the positive intercepts (.036-.049 lbs/mi^2-day) in the regression equations and by the statistically significant reductions in loading at stations on the Susquehanna (SUS0109), Upper Choptank (CHO0626), and Upper Monocacy (MON0528), which are not impacted by Maryland point sources. These year-to-year variations may reflect differences in flow regimes, seasonal factors, and/or impacts of watershed management programs. If the intercept of the regression equation is assumed to reflect variations in background or non-point loading from one period to the next, the slope (19.3 for total and ortho phosphorus, standard error = 1.6) is equivalent to an average sewage effluent change of 19.3/8.34 or 2.3 ppm (s.e.= .19).

(5) Many of the stations with apparent pre-ban vs. post-ban differences are in the Potomac Basin (Antietam, Monocacy Rivers). The major flood which occurred in the Potomac during November 1985 (Figure 2, one month prior to the ban) may have had significant impacts on river nutrient concentrations the following year through a scouring mechanism. Nutrients from point sources tend to accumulate in stream channels due to biological uptake and adsorption processes under low flows. Under high flows, the removal processes are reversed because of scouring. These processes have been documented in Maryland watersheds with point sources (Baltimore Department of Public Works,1987). Following a major flushing event, stream water quality under low flows may improve because fresh adsorption surfaces are exposed and the water is in contact with "cleaner" bottom deposits. Time series of data from the Potomac River above Little Falls Dam (POT1184, at Fall-Line)

support this hypothesis (Figure 7). Sampled runoff, total phosphorus concentration, and Kjeldahl nitrogen concentration are shown on logarithmic scales in relation to the pre-ban and post-ban periods. Consistent with techniques employed in Appendix B, the lines through the points (3-sample moving averages) are used only for display purposes and have no statistical basis. High-flow data collected by the USGS are included here. Samples collected during the November 1985 flood (peak sampled runoff rate > 316 in/yr or 2.5 on log scale) had very high total phosphorus (> 2000 ppb) and Kjeldahl nitrogen (>7900 ppb) concentrations. Because of the high flow and high concentrations, rates of nutrient transport during this period were tremendous. Concentrations of phosphorus and KJeldahl nitrogen dropped sharply following the November 1985 flood down to levels of approximately 50 and 300 ppb, respectively. Slow rates of increase followed during 1986 and 1987, possibly because of gradual re-accumulation of nutrients in the river system. Similar behavior of phosphorus and Kjeldahl nitrogen indicates that the apparent drop in phosphorus at the beginning of 1986 is more likely attributed to flow variations than to effects of the detergent ban. Although the techniques employed to calculate loadings account for variations in flow at the time of sampling, they do not account for flow "history". This phenomenon may introduce significant biases into the apparent pre-ban vs. post-ban phosphorus export changes (Figures 5 and 6) at stations in the Potomac Basin. A longer period of record and more complex analytical procedure would be required to quantify the effects. Results for the Patuxent River (Figure 8) are not influenced significantly by this factor, however, because Patuxent flows are highly regulated and a major flood did not occur in this basin immediately prior to the ban.

(6) The pre-ban (July 1984-November 1985) and post-ban (December 1985-March 1987) data are not seasonally balanced. The pre-ban data include a higher percentage of summer samples and the

Figure 7
Runoff and Concentration Time Series for Potomac River Station POT1184

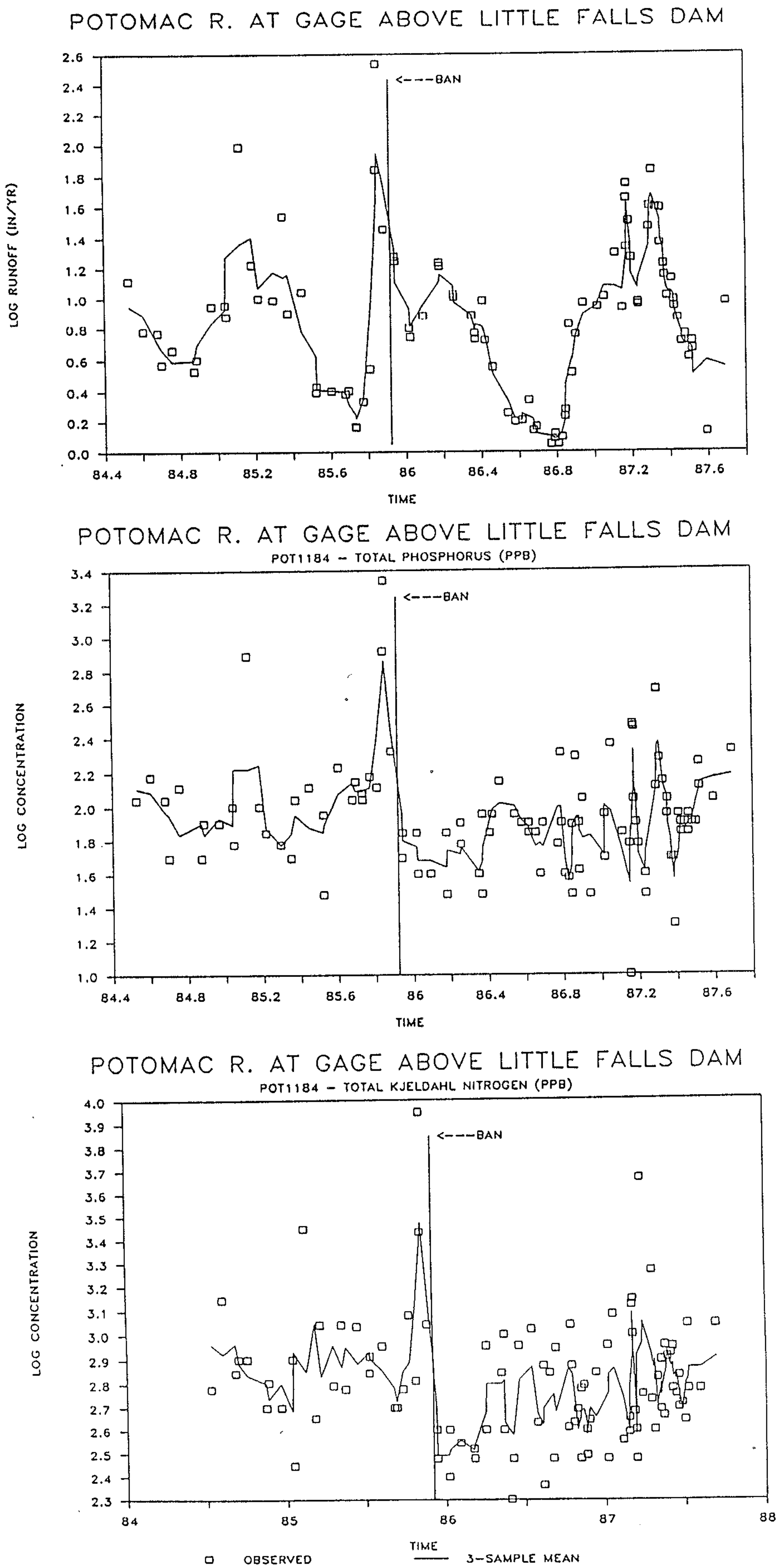
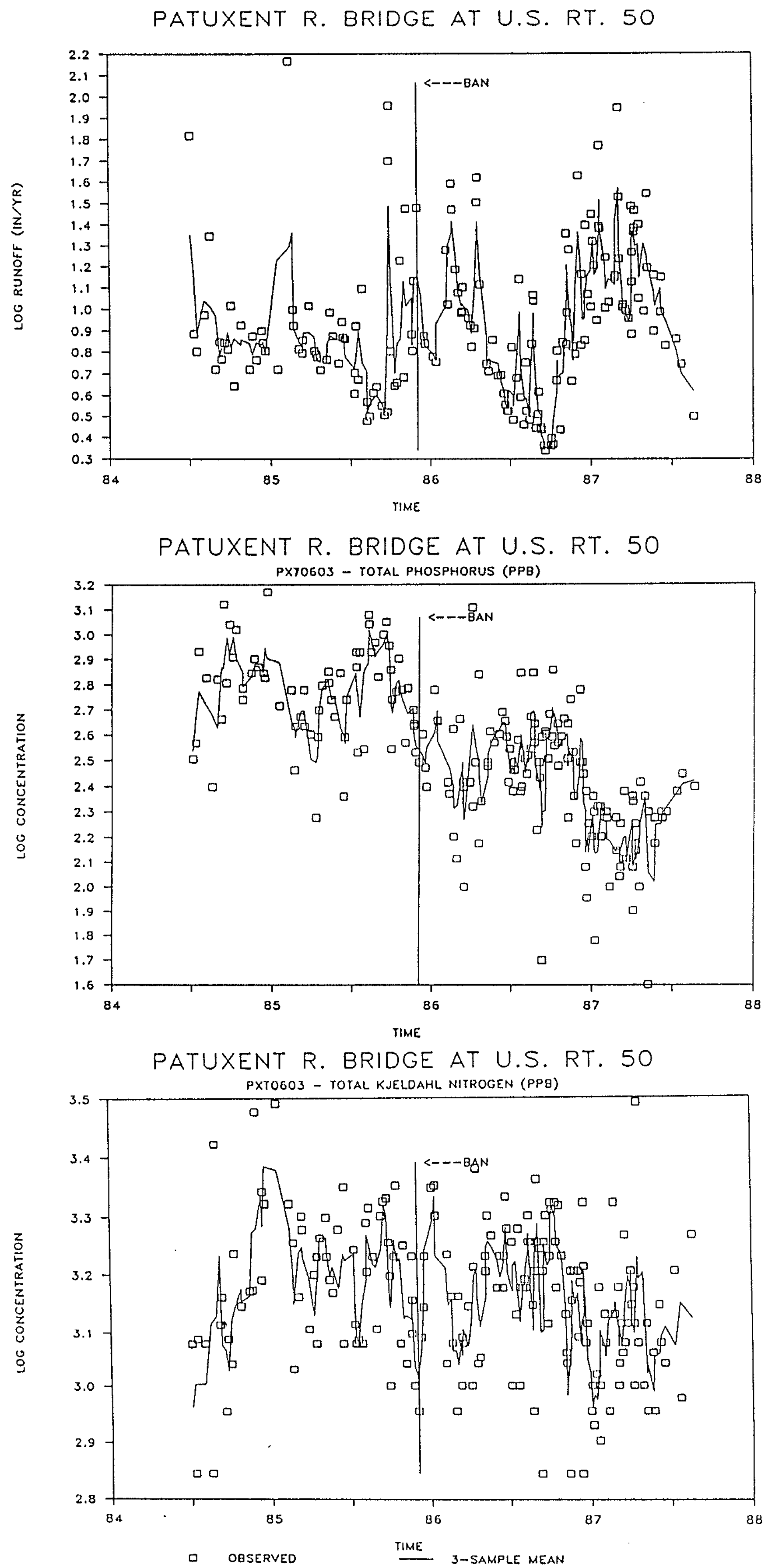


Figure 8
Runoff and Concentration Time Series for Patuxent River Station PXT0603



post-ban data, a higher percentage of winter samples. Seasonal factors may influence the flow/concentration relationship at some stations. If the analysis is repeated with a seasonally balanced design (December 1984-December 1986, 1 year pre-ban and 1 year post-ban) (Table 5, Figures 9 and 10), the data scatter increases (because fewer samples are used to calculate the pre-ban and post-ban loadings) but the slope of the regression equation decreases to 15.2 (standard error = 2.0), which corresponds to an average effluent concentration of 1.8 ppm (s.e. = .24), in agreement with direct effluent measurements (mean reduction = 1.8 ppm, s.e.=.21, Walker, 1987b). A raft of alternative models which attempt to account directly for seasonal and flow effects have also been applied to the data set and found to yield similar results and conclusions.

Considering these factors, the observed responses at stream stations under low-flow conditions are in reasonable agreement with predictions based upon mass balance.

Sufficient data are not available for evaluating biological responses (e.g., as measured by chlorophyll-a) to reductions in phosphorus concentration at the river stations studied above. Ortho phosphorus concentrations at river stations above the Fall Line (Tables 4 and 5) generally exceed algal growth-limiting levels and physical factors (velocity, residence time, temperature) are more important than nutrient concentrations in regulating algal productivity. For this reason, algal growth is less of a problem and less sensitive to nutrient levels in river segments, as compared with downstream estuary and bay segments, which provide a more suitable habitat for algal growth. This is illustrated by data from Patuxent River station PXT0603, which was monitored more intensively for nutrient and biological parameters than the other river stations studied above. Despite significant reductions in phosphorus concentrations and loadings at this station between 1985 and 1986 (Figures 6 and 8), summer mean chlorophyll-a concentrations remained at very low levels (3.3 ppb in 1985 and 3.6 ppb in 1986).

Table 5
Pre-Ban and Post-Ban Nutrient Export under Low Flows
December 1984 through November 1986

TOTAL PHOSPHORUS ONE YEAR

	RUNOFF BOUND	DURATION	STRATUM RUNOFF	TOTAL RUNOFF	..........PRE-BAN............				..........POST-BAN...........				.....PRE-BAN - POST-BAN......			
STATION	IN/YR	DAYS	INCHES	INCHES	SAMPLES	CONC PPB	LOAD LB/MI2-D	CV	SAMPLES	CONC PPB	LOAD LB/MI2-D	CV	CONC PPB	LOAD LB/MI2-D	CV	T
ANA0082	16	642	9.94	19.85	10	72.3	0.162	0.097	11	88.7	0.199	0.213	-16.4	-0.037	-1.226	-0.82
ANT0044	16	586	14.71	24.80	7	351.5	1.279	0.117	9	224.9	0.819	0.123	126.6	0.461	0.391	2.56
ANT0203	16	586	14.71	24.80	7	494.4	1.799	0.190	9	378.2	1.376	0.168	116.2	0.423	0.974	1.03
CHO0626	16	645	9.71	17.59	27	70.1	0.153	0.123	20	63.3	0.138	0.129	6.7	0.015	1.758	0.57
CON0005	16	566	10.13	26.51	8	170.9	0.444	0.121	8	141.6	0.368	0.152	29.3	0.076	1.021	0.98
GEO0009	16	558	9.27	30.90	11	100.7	0.243	0.132	9	94.9	0.229	0.210	5.7	0.014	4.163	0.24
GUN0125	16	547	14.25	26.71	8	50.2	0.190	0.152	8	66.8	0.252	0.117	-16.5	-0.062	-0.660	-1.51
GWN0115	16	650	12.35	21.35	10	96.7	0.266	0.183	10	55.6	0.153	0.120	41.1	0.113	0.461	2.17
MON0020	16	601	9.65	22.94	11	254.9	0.594	0.118	11	164.2	0.382	0.100	90.7	0.211	0.377	2.65
MON0155	16	601	9.65	22.94	8	339.9	0.792	0.370	8	175.1	0.408	0.159	164.8	0.384	0.781	1.28
MON0269	16	601	9.65	22.94	9	256.7	0.598	0.463	9	105.1	0.245	0.093	151.7	0.353	0.787	1.27
MON0528	16	621	7.32	24.28	9	191.3	0.327	0.198	9	215.0	0.368	0.482	-23.7	-0.041	-4.654	-0.21
NBP0103	32	602	19.87	43.84	8	106.5	0.509	0.124	9	82.7	0.396	0.096	23.8	0.114	0.646	1.55
NPA0165	12	550	10.74	21.38	8	50.1	0.142	0.145	10	51.8	0.147	0.119	-1.7	-0.005	-5.493	-0.18
PAT0176	10	696	6.37	8.14	10	108.1	0.143	0.127	11	109.1	0.145	0.061	-1.0	-0.001	-15.751	-0.06
POT1184	16	591	9.74	23.47	16	95.3	0.228	0.093	20	66.8	0.159	0.087	28.5	0.068	0.373	2.68
POT1471	16	619	10.12	20.80	9	166.9	0.396	0.106	9	94.2	0.223	0.128	72.7	0.172	0.294	3.40
POT1830	16	582	10.37	24.91	10	79.5	0.205	0.054	10	95.8	0.247	0.315	-16.2	-0.042	-1.873	-0.53
POT2386	16	554	9.86	28.85	8	57.8	0.149	0.111	9	64.7	0.167	0.251	-6.9	-0.018	-2.524	-0.40
PXT0603	12	632	10.10	16.39	41	583.1	1.351	0.070	54	381.5	0.884	0.083	201.7	0.467	0.255	3.92
PXT0972	12	600	9.59	17.50	9	54.2	0.126	0.288	10	56.7	0.131	0.182	-2.5	-0.006	-7.574	-0.13
SUS0109	20	520	12.12	33.66	19	69.8	0.236	0.131	13	56.1	0.190	0.105	13.7	0.046	0.794	1.26

ORTHO PHOSPHORUS ONE YEAR

	RUNOFF BOUND	DURATION	STRATUM RUNOFF	TOTAL RUNOFF	..........PRE-BAN............				..........POST-BAN...........				.....PRE-BAN - POST-BAN......			
STATION	IN/YR	DAYS	INCHES	INCHES	SAMPLES	CONC PPB	LOAD LB/MI2-D	CV	SAMPLES	CONC PPB	LOAD LB/MI2-D	CV	CONC PPB	LOAD LB/MI2-D	CV	T
ANA0082	16	642	9.94	19.85	10	23.4	0.053	0.233	11	26.8	0.060	0.365	-3.3	-0.007	-3.346	-0.30
ANT0044	16	586	14.71	24.80	8	339.0	1.234	0.143	9	171.7	0.625	0.201	167.3	0.609	0.356	2.81
ANT0203	16	586	14.71	24.80	7	454.7	1.655	0.204	9	289.4	1.053	0.163	165.2	0.601	0.630	1.59
CHO0626	16	645	9.71	17.59	25	30.4	0.066	0.134	19	19.7	0.043	0.229	10.7	0.023	0.571	1.75
CON0005	16	566	10.13	26.51	8	145.0	0.376	0.110	8	88.9	0.231	0.231	56.1	0.146	0.464	2.15
GEO0009	16	558	9.27	30.90	7	18.8	0.045	0.252	9	23.0	0.055	0.311	-4.2	-0.010	-2.036	-0.49
GUN0125	16	547	14.25	26.71	8	10.7	0.041	0.072	8	12.1	0.046	0.158	-1.4	-0.005	-1.501	-0.67
GWN0115	16	650	12.35	21.35	10	50.3	0.139	0.329	10	14.3	0.039	0.185	36.0	0.099	0.466	2.15
MON0020	16	601	9.65	22.94	11	198.3	0.462	0.162	11	125.2	0.291	0.151	73.2	0.170	0.509	1.96
MON0155	16	601	9.65	22.94	7	185.6	0.432	0.182	9	157.0	0.366	0.211	28.6	0.067	1.649	0.61
MON0269	16	601	9.65	22.94	8	155.2	0.361	0.498	9	73.1	0.170	0.233	82.0	0.191	0.965	1.04
MON0528	16	621	7.32	24.28	8	151.6	0.259	0.272	9	149.2	0.255	0.380	2.4	0.004	28.835	0.03
NBP0103	32	602	19.87	43.84	8	45.5	0.217	0.251	8	29.9	0.143	0.183	15.5	0.074	0.815	1.23
NPA0165	12	550	10.74	21.38	8	20.3	0.058	0.213	10	23.7	0.067	0.498	-3.3	-0.009	-3.779	-0.26
PAT0176	10	696	6.37	8.14	10	60.4	0.080	0.113	11	34.0	0.045	0.208	26.4	0.035	0.372	2.69
POT1184	16	591	9.74	23.47	16	45.7	0.109	0.116	20	19.4	0.046	0.183	26.3	0.063	0.243	4.11
POT1471	16	619	10.12	20.80	9	106.2	0.252	0.138	10	37.5	0.089	0.305	68.6	0.163	0.271	3.68
POT1830	16	582	10.37	24.91	10	61.5	0.159	0.394	10	24.0	0.062	0.250	37.4	0.097	0.667	1.50
POT2386	16	554	9.86	28.85	8	19.5	0.050	0.169	9	16.0	0.041	0.253	3.5	0.009	1.501	0.67
PXT0603	12	632	10.10	16.39	40	365.3	0.846	0.084	54	171.9	0.398	0.087	193.4	0.448	0.177	5.66
PXT0972	12	600	9.59	17.50	9	12.9	0.030	0.136	10	16.7	0.039	0.163	-3.8	-0.009	-0.851	-1.17
SUS0109	20	520	12.12	33.66	19	27.1	0.092	0.184	12	10.5	0.035	0.132	16.6	0.056	0.313	3.20

TOTAL KJELDAHL NITROGEN ONE YEAR

	RUNOFF BOUND	DURATION	STRATUM RUNOFF	TOTAL RUNOFF	..........PRE-BAN............				..........POST-BAN...........				.....PRE-BAN - POST-BAN......			
STATION	IN/YR	DAYS	INCHES	INCHES	SAMPLES	CONC PPB	LOAD LB/MI2-D	CV	SAMPLES	CONC PPB	LOAD LB/MI2-D	CV	CONC PPB	LOAD LB/MI2-D	CV	T
ANA0082	16	642	9.94	19.85	10	737.4	1.655	0.153	11	642.2	1.441	0.127	95.2	0.214	1.463	0.68
ANT0044	16	586	14.71	24.80	7	640.3	2.330	0.089	9	826.7	3.008	0.244	-186.3	-0.678	-1.123	-0.89
ANT0203	16	586	14.71	24.80	7	765.4	2.785	0.122	9	998.5	3.634	0.151	-233.1	-0.848	-0.762	-1.31
CHO0626	16	645	9.71	17.59	27	617.0	1.347	0.095	20	499.1	1.089	0.088	118.0	0.257	0.621	1.61
CON0005	16	566	10.13	26.51	8	643.2	1.670	0.142	8	589.1	1.529	0.087	54.1	0.140	1.936	0.52
GEO0009	16	558	9.27	30.90	11	604.4	1.457	0.101	9	640.8	1.544	0.120	-36.4	-0.088	-2.688	-0.37
GUN0125	16	547	14.25	26.71	8	594.3	2.245	0.107	8	597.5	2.257	0.164	-3.1	-0.012	-37.353	-0.03
GWN0115	16	650	12.35	21.35	10	433.2	1.194	0.144	10	475.1	1.309	0.144	-41.9	-0.116	-2.208	-0.45
MON0020	16	601	9.65	22.94	11	823.6	1.918	0.081	11	726.8	1.693	0.071	96.9	0.226	0.872	1.15
MON0155	16	601	9.65	22.94	8	1035.0	2.411	0.202	9	1023.3	2.383	0.217	11.7	0.027	26.015	0.04
MON0269	16	601	9.65	22.94	9	752.7	1.753	0.348	9	519.4	1.210	0.092	233.3	0.543	1.140	0.88
MON0528	16	621	7.32	24.28	9	566.4	0.969	0.095	9	794.9	1.360	0.322	-228.5	-0.391	-1.146	-0.87
NBP0103	32	602	19.87	43.84	8	517.7	2.477	0.159	9	532.7	2.549	0.094	-15.0	-0.072	-6.405	-0.16
NPA0165	12	550	10.74	21.38	8	520.2	1.473	0.140	10	505.1	1.430	0.115	15.1	0.043	6.181	0.16
PAT0176	10	696	6.37	8.14	10	509.6	0.676	0.139	11	568.0	0.753	0.118	-58.3	-0.077	-1.672	-0.60
POT1184	16	591	9.74	23.47	15	737.9	1.762	0.117	20	525.4	1.255	0.140	212.5	0.508	0.533	1.88
POT1471	16	619	10.12	20.80	9	782.9	1.857	0.147	10	708.9	1.681	0.103	74.0	0.176	1.840	0.54
POT1830	16	582	10.37	24.91	10	566.1	1.463	0.143	10	480.0	1.240	0.184	86.1	0.222	1.390	0.72
POT2386	16	554	9.86	28.85	8	528.4	1.364	0.117	9	536.2	1.384	0.106	-7.8	-0.020	-10.785	-0.09
PXT0603	12	632	10.10	16.39	40	1671.3	3.873	0.040	53	1574.9	3.649	0.036	96.4	0.223	0.898	1.11
PXT0972	12	600	9.59	17.50	8	373.0	0.865	0.110	10	377.0	0.874	0.119	-4.0	-0.009	-15.160	-0.07
SUS0109	20	520	12.12	33.66	19	786.3	2.658	0.103	13	597.6	2.020	0.075	188.7	0.638	0.491	2.04

RUNOFF BOUND = UPPER LIMIT OF FLOW STRATUM CONSIDERED (ROUGHLY = MEAN ANNUAL RUNOFF)

DURATION = NUMBER OF DAYS IN FLOW STRATUM, OUT OF 730 (WATER YEARS 1985 AND 1986)

STRATUM RUNOFF = RUNOFF VOLUME IN STRATUM

TOTAL RUNOFF = TOTAL RUNOFF VOLUME

SAMPLES = NUMBER OF CONCENTRATION SAMPLES

CONC = FLOW-WEIGHTED-MEAN CONCENTRATION IN STRATUM

LOAD = .145 X CONC (PPB) x STRATUM RUNOFF (INCHES) / DURATION (DAYS) , .145 = UNITS CONV. FACTOR (LBS/MI2)/(IN X PPB)

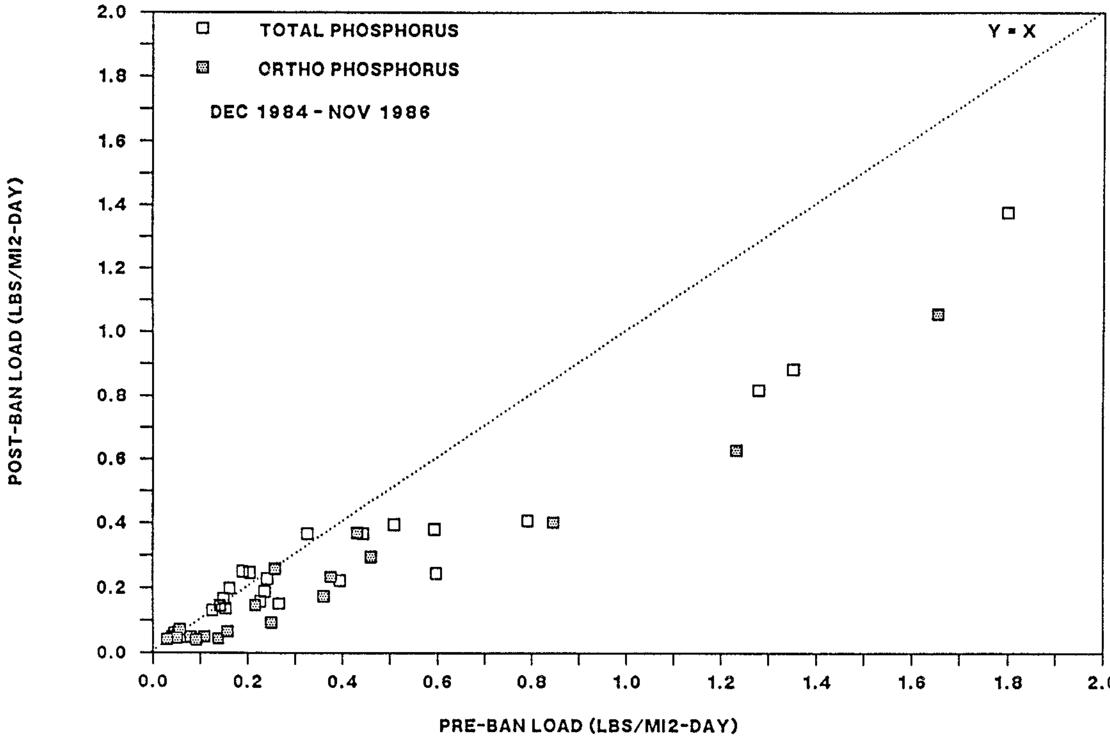
CV = ERROR COEFFICIENT OF VARIATION FOR CONC AND LOAD ESTIMATES

T = T-STATISTIC FOR NULL HYPOTHESIS: CHANGE IN LOAD OR CHANGE IN CONC = 0

PRE-BAN: DEC. 1984 - NOV. 1985

POST-BAN: DEC. 1985 - NOV. 1986

Figure 9
Post-Ban vs. Pre-Ban Loads Under Low Flows
December 1984 through November 1986



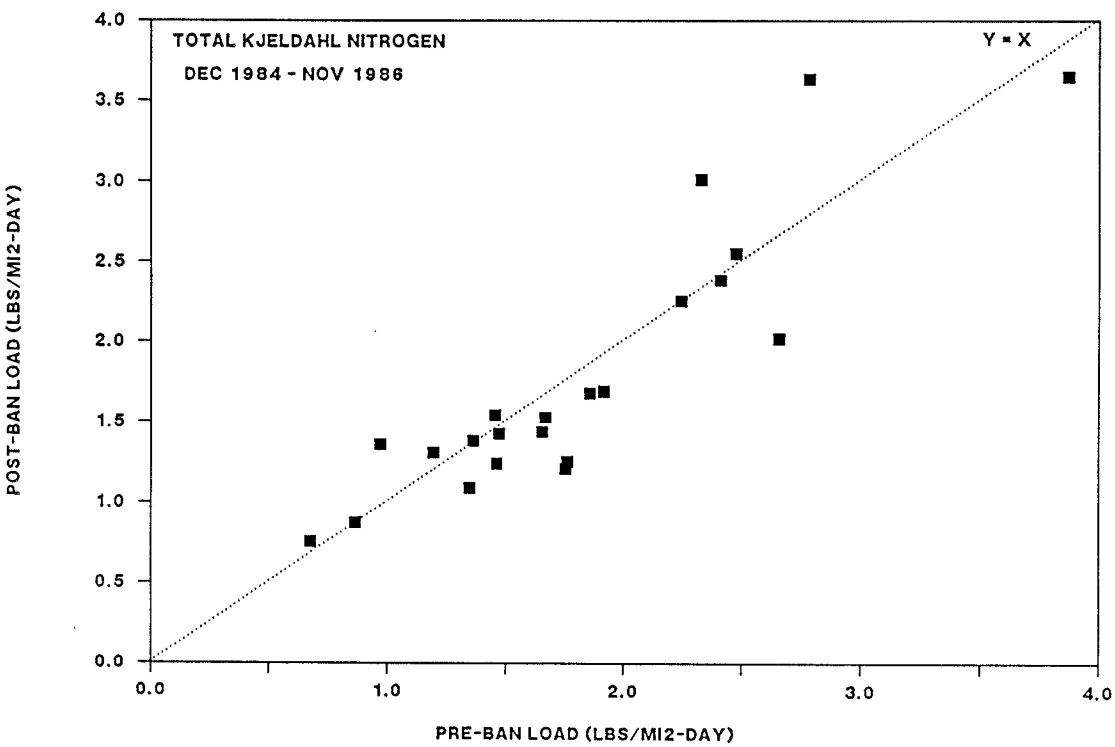
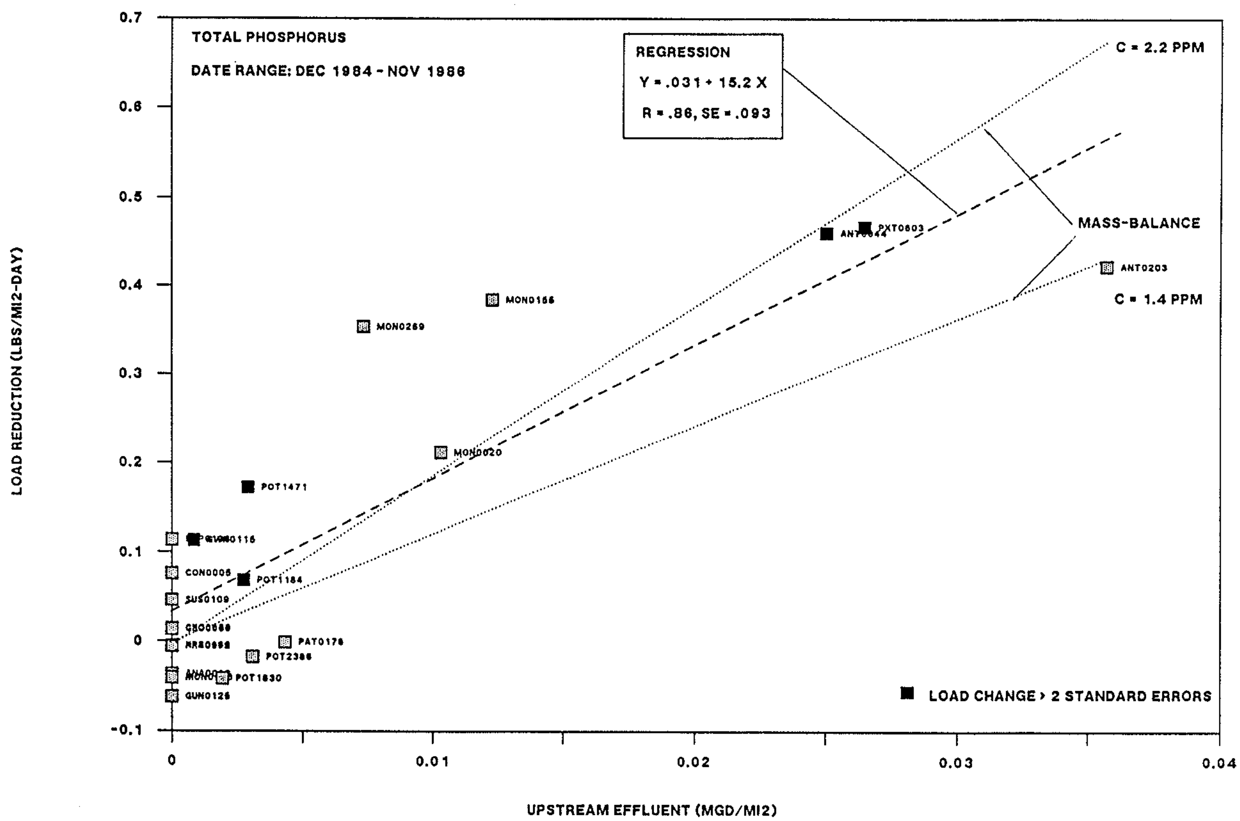
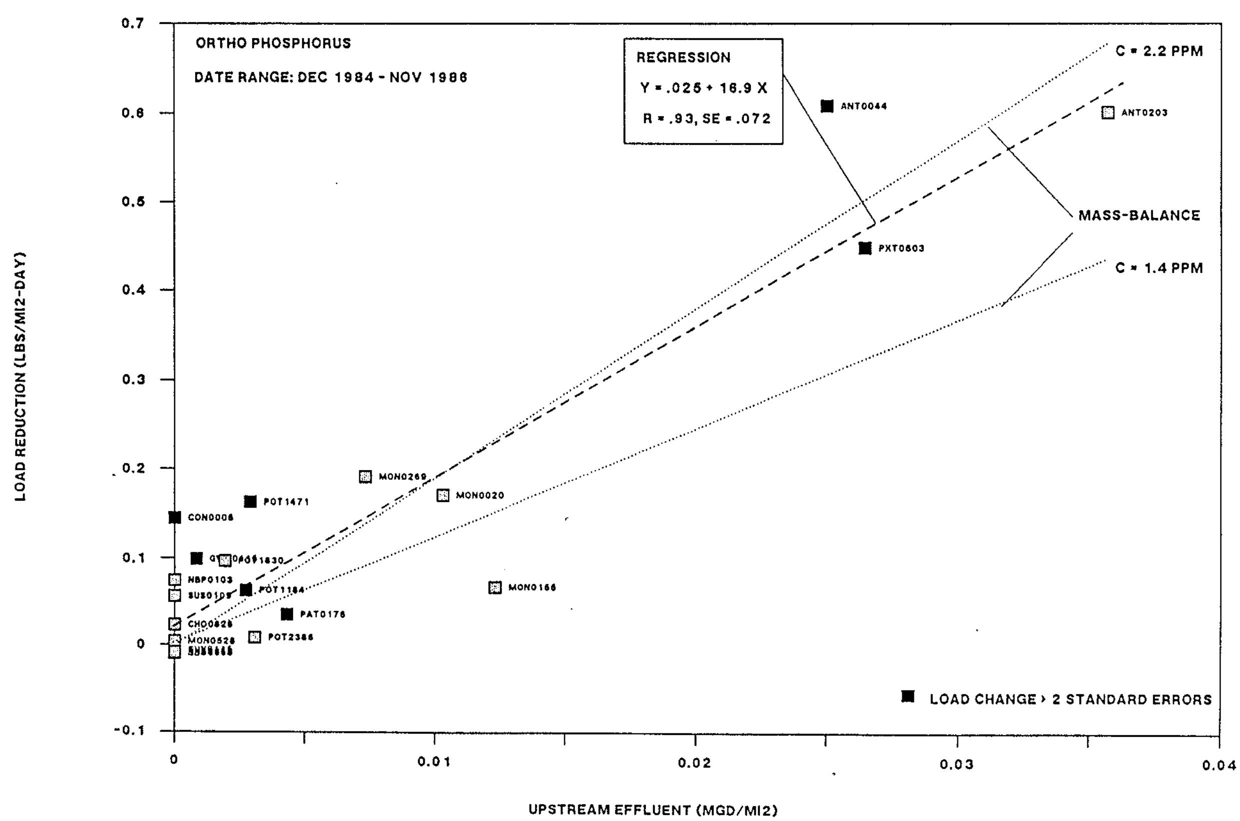


Figure 10
Load Reduction vs. Upstream Effluent Density
December 1984 through November 1986





LOADINGS AT FALL-LINE STATIONS

Loading calculations for all flow regimes have been conducted at four stations with adequate sampling data. FLUX, a computer program developed for evaluating eutrophication problems in reservoirs operated by the Army Corps of Engineers (Walker,1987a,1988), has been used for these calculations. The program permits estimation of loadings (means and standard errors) from intermittent sampling and a continuous daily flow record. Estimates can be developed for annual, seasonal, monthly, or daily time intervals.

Results of phosphorus loading calculations at the four MDOEP/USGS Fall Line stations are displayed in Figures 11 and 12. Monthly loading estimates have been derived for July 1984 through September 1987 by developing a concentration/flow rating curve for each station, applying it to daily flow values, and interpolating errors (differences between observed and predicted concentration at a given flow) between sampling dates. In this way, the loading estimates reflect both flow variations and temporal variations associated with seasons and/or trends. Monthly total phosphorus loadings at each station are plotted along with monthly flows in Figure 11. Figure 12 displays cumulative unit phosphorus export (lbs/mi^2) and cumulative runoff (inches) vs. time.

Figure 11 illustrates the relative scales and variabilities of loading and flow at each station on logarithmic scales. As result of upstream impoundments and point sources, Patuxent River flow and loading are less variable than observed at other stations. Patuxent loadings gradually decreased over time due to the detergent ban (Dec 1985) and treatment plant upgrades (1987). The decreasing load is reflected by the decreasing slope of the cumulative load vs. time plot (Figure 12). Flows and loadings are more variable at the other stations because of less flow regulation and predominance of non-point sources. Potomac loadings are extremely flashy. For example, about 43% of the total estimated loading between July 1984 and September 1987 occurred during the November 1985 flood. This is reflected by the sudden jump in the

Figure 11
Monthly Phosphorus Loads and Flows at Fall Line Stations

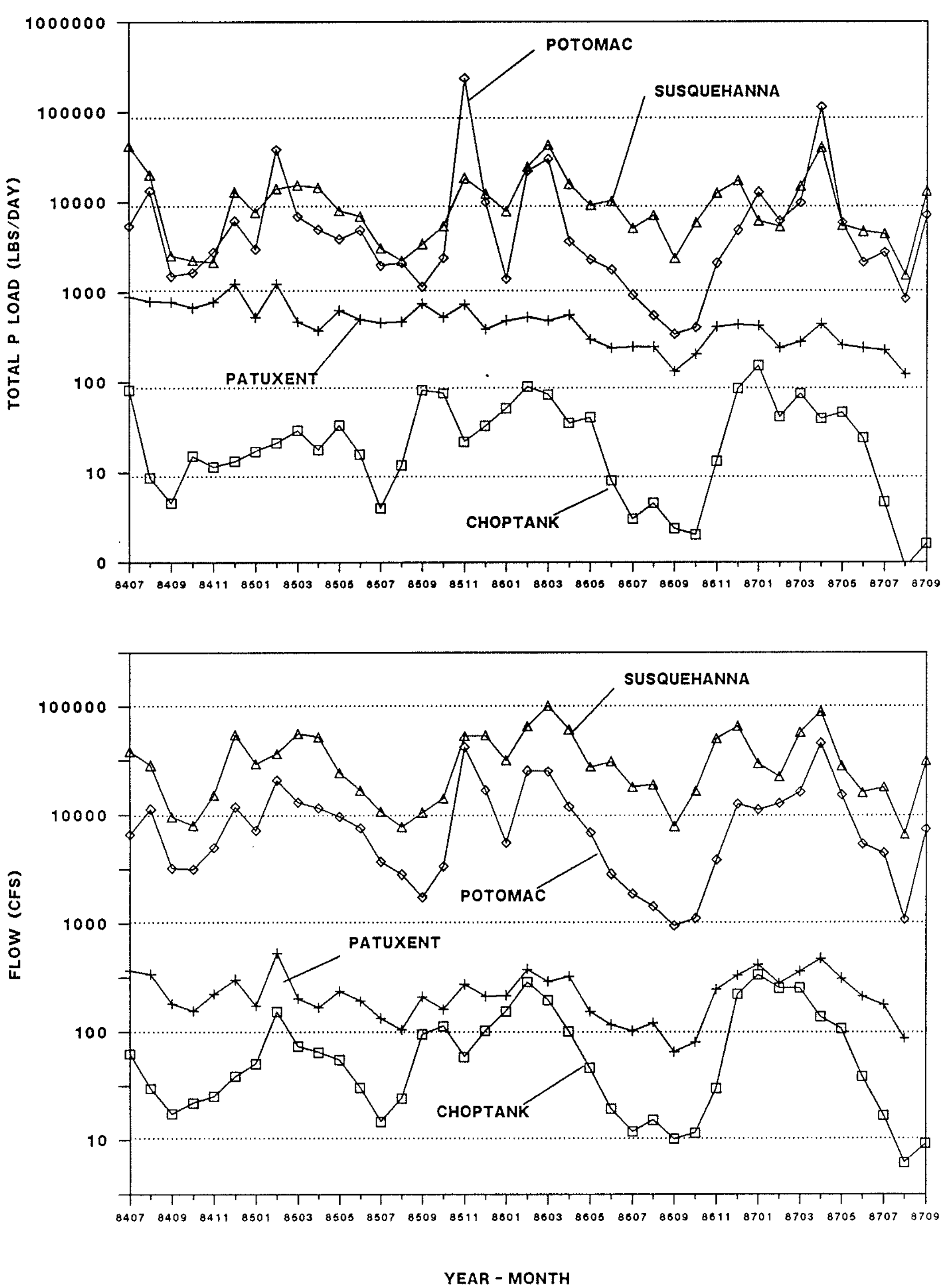
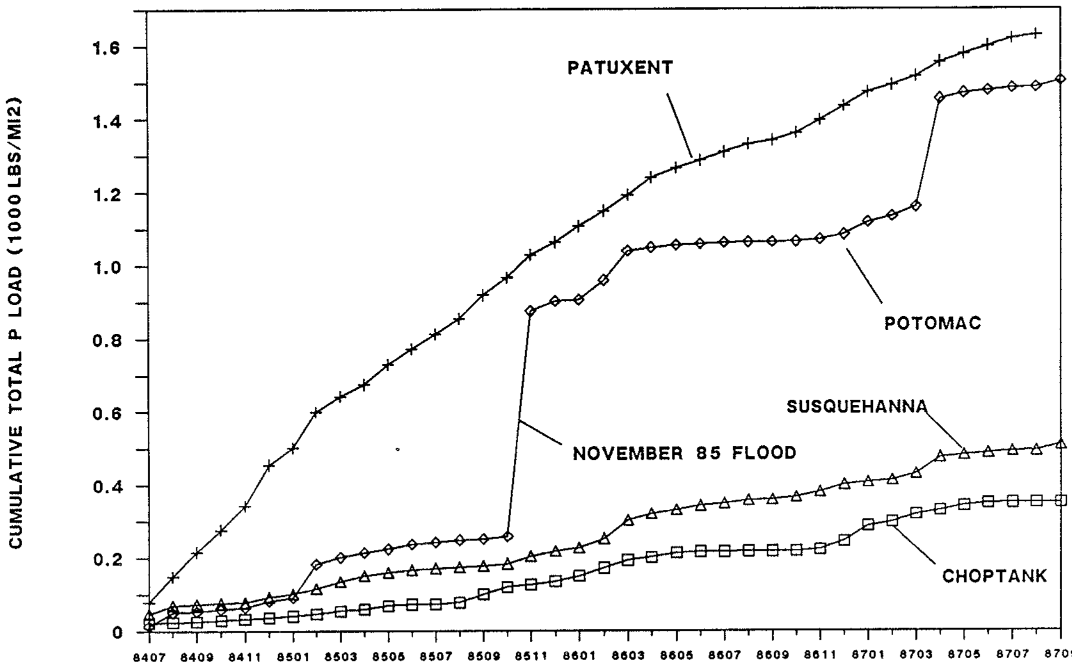
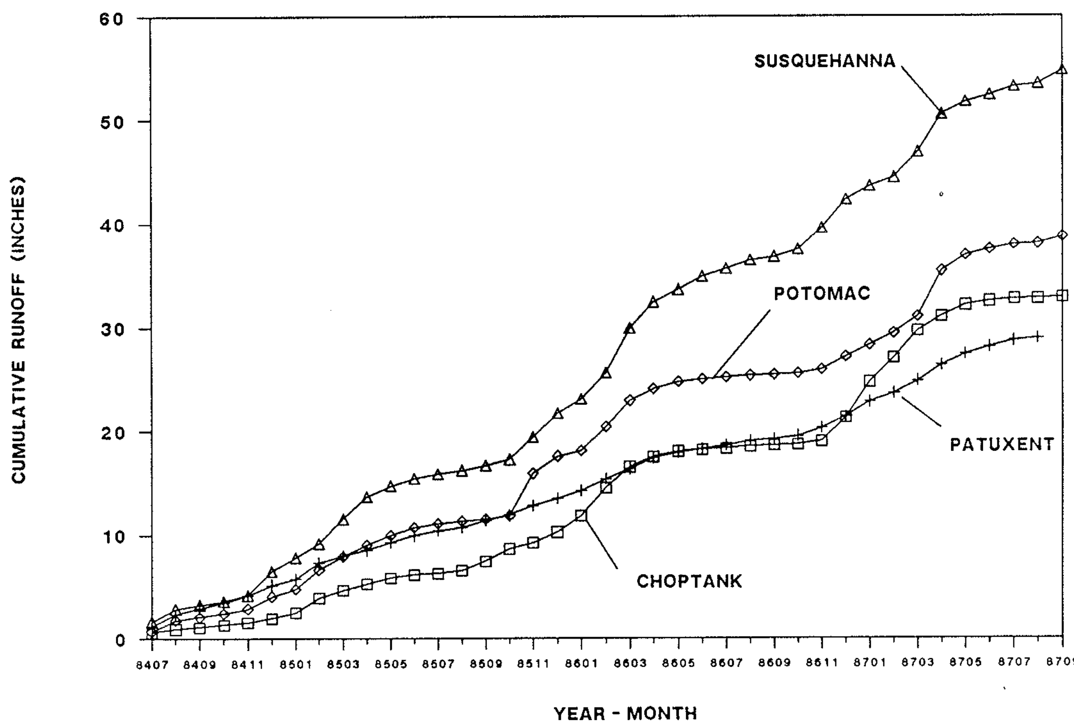


Figure 12
Cumulative Phosphorus Loads and Unit Runoff at Fall Line Stations





cumulative load vs. time plot. Another loading peak occurred in April of 1987. Largely because of these brief periods of high loading, cumulative unit loadings from the Potomac approach those of the Patuxent, which has a much higher upstream effluent density.

Results of phosphorus loading computations at Fall Line stations are used to develop quarterly phosphorus budgets for the Maryland portion of Chesapeake Bay in Table 6. Estimates of nonpoint loadings from the ungauged watershed (roughly 15% of the total drainage area above the Virginia state line), are developed based upon drainage area ratio and measured loadings from the Choptank River. Since portions of the ungauged watershed have higher land-use intensities than the Choptank, ungauged nonpoint loadings are probably underestimated. Point-source loadings have been estimated from effluent inventories summarized in Table 6 and ignore attenuation above the Fall Line. If attenuation above the Fall Line were considered, reductions in Bay loadings attributed to the phosphate detergent ban would be lower than those estimated below.

Impacts of the detergent ban on the Bay phosphorus budget have been estimated by applying an average effluent reduction of 1.8 ppm (Walker,1987b) to the 111.6 mgd effluent volume without phosphorus limits in 1986 (Sellars,1987). This effluent volume will be reduced to approximately 71 mgd, with implementation of phosphorus controls planned for 1987 (Harris and Walker,1985). Load reductions attributed to the detergent ban range from 2.9 to 11.1% for the January 1986 - September 1987 period. These percentages are lower (1.8 to 7.1%) with planned phosphorus removal facilities in place. Periods of higher impact correspond to periods of lower flows (e.g., third quarter 1986).

Average nutrient budgets for phosphorus and nitrogen species are detailed in Table 7. These are based upon measured concentrations at Fall Line stations for December 1985 through September 1987. This permits a focus on post-ban conditions. Monitoring by the USGS was also more intensive after 1985. Calculations reveal the importance of nonpoint sources and the Susquehanna River as factors contributing to

Table 6

QUARTERLY PHOSPHORUS BUDGET FOR MARYLAND PORTION OF CHESAPEAKE BAY - LOADS IN POUNDS PER DAY

DRAINAGE AREA MI2	WATERSHED LOADS							POINT SOURCE LOADS					AVERAGE		
	113	348	11560	27100	7042	46163	ADJUSTED	EFFLUENT	P LIMIT	TOTAL	TOTAL	TOTAL INFLOW	INFLOW CONC	NOBAN	BAN
QUARTER	CHOPTANK	PATUXENT	POTOMAC	SUSQUEH	OTHER (a)	TOTAL (b)	TOTAL (c)	NO (d)	YES (e)	POINT	LOAD	CFS	PPB	LOAD (f)	IMPACT
8403	32	822	6836	21651	2022	31362	29298	6504	6256	12760	42058	35510	220	42058	0.0%
8404	13	897	3561	5859	840	11171	9107	6504	6256	12760	21867	34807	117	21867	0.0%
8501	23	725	15255	12376	1415	29794	27730	6504	6256	12760	40490	60314	125	40490	0.0%
8502	23	500	4575	9813	1404	16315	14250	6504	6256	12760	27010	43887	114	27010	0.0%
8503	32	553	1758	2910	2011	7264	5200	6504	6256	12760	17960	15314	218	17960	0.0%
8504	44	547	81631	12023	2739	96984	94920	6504	6256	12760	107680	66615	300	109355	-1.5%
8601	71	498	17718	25398	4446	48132	46744	3444	5446	8890	55634	98407	105	57309	-2.9%
8602	28	363	2568	11800	1770	16529	15140	3444	5446	8890	24030	50443	88	25705	-6.5%
8603	3	210	609	4924	209	5956	4567	3444	5446	8890	13457	17314	144	15133	-11.1%
8604	34	350	2460	11901	2108	16854	15465	3444	5446	8890	24356	55730	81	26031	-6.4%
8701	92	316	9758	8926	5729	24820	23432	3444	5446	8890	32322	68427	88	33997	-4.9%
8702	37	314	40250	16826	2309	59737	58348	3444	5446	8890	67238	72668	172	68914	-2.4%
8703	2	140	3408	6336	151	10039	8650	3444	5446	8890	17540	23390	139	19215	-8.7%

a estimated from choptank loads based upon drainage area ratio

b sum of choptank, patuxent, potomac, susquehanna, and other loads

c total gauged load - upstream md point source load = approximate nonpoint load

d effluent load from plants without phosphorus removal facilities

e effluent load from plants with phosphorus removal facilities

f load which would have occured without the detergent ban;
detergent load (1657 lbs/day) calculated from 111.6 mgd without p limits
during 1986 (Sellars,1987) and 1.8 ppm reduction in effluent p conc.

g effluent accounting compiled froms Sellars (1987), Harris and Walker (1985)
(does not reflect additional plant upgrades which occured in 1987)

EFFLUENT ACCOUNTING (g)

PERIOD	P LIMIT	FLOW MGD	CONC PPM	LOAD LBS/DAY
< 1986	NO	141.8	5.5	6504
	YES	549.5	1.4	6256
	TOTAL	691.3	2.2	12760
>=1986	NO	111.6	3.7	3444
	YES	579.7	1.1	5446
	TOTAL	691.3	1.5	8890

Table 7

NUTRIENT BUDGET FOR MARYLAND PORTION OF CHESAPEAKE BAY

SOURCE (a)	AREA MI2	TOTAL P	ORTHO P	NO23N	TKN	TOTAL N	ANNUAL RUNOFF IN/YR
		NUTRIENT EXPORT (LBS/MI2-YR)					
POTOMAC	11560	234	54	2715	1347	4062	12.44
SUSQUEHANNA	27100	181	36	3303	1877	5180	17.25
CHOPTANK	113	110	29	1707	1207	2914	10.63
PATUXENT	348	354	122	3379	1802	5181	9.01
OTHER (c)	7042	110	29	1707	1207	2914	10.63
		NUTRIENT LOAD (LBS/DAY)					FLOW (CFS)
POTOMAC		7411	1710	85987	42661	128649	10594
SUSQUEHANNA		13439	2673	245236	139361	384597	34438
CHOPTANK		34	9	528	374	902	88
PATUXENT		338	116	3222	1718	4940	231
OTHER (c)		2122	560	32933	23287	56220	5515
TOTAL		23344	5068	367907	207401	575308	50866
UPSTREAM MD POINT		1389				6005 (b)	
ADJUSTED TOTAL (d)		21955				569303	50866
MD POINT SOURCES		8890				92247 (b)	
TOTAL LOAD		30845				661550	
% MARYLAND POINT		28.8%				13.9%	
% NONPOINT + SUSQUEHAN		71.2%				86.1%	

a river loads estimated from concentration/runoff rating curves developed for December 1985 - September 1987, mapped onto daily flow distribution for October 1984 to Sept 1987; measured at usgs fall line stations

b total nitrogen conc. of 16 ppm assumed for point sources (usepa,1987) md point source flow above river stations = 45 mgd, total = 691 mgd

c "other" river loads estimated from choptank export factors under-estimates nonpoint loads from urban areas below the fall line

d measured river loads reduced by upstream md point loads = approximate nonpoint loads + susquehanna point loads

LOAD ESTIMATE COEFFICIENT OF VARIATION = STANDARD ERROR / MEAN

SOURCE	TOTAL P	ORTHO P	NO23N	TKN
POTOMAC	0.144	0.061	0.047	0.126
SUSQUEHANNA	0.094	0.160	0.039	0.089
CHOPTANK	0.088	0.074	0.046	0.064
PATUXENT	0.060	0.058	0.033	0.027

Bay eutrophication. Point sources in Maryland (including Blue Plains) account for an estimated 28.8% of the total phosphorus loading and 13.9% of the total nitrogen loading to the Maryland portion of the Bay. Nonpoint sources are especially important for nitrogen, which limits summer algal productivity throughout most of the Bay (USEPA,1987). Nitrogen export from the Susquehanna (5180 lbs/mi^2-yr) equals that from the Patuxent (5181 lbs/mi^2-yr), despite the relative importance of point sources in the Patuxent. These nutrient balances are developed for a period of relatively low runoff (e.g., Potomac runoff 12.4 in/yr vs. average of 16 in/yr). Point sources would be less important in balances developed for periods of average or above-average runoff. The balances do not consider nutrient releases from bottom sediments or atmospheric loadings directly on the Bay surface. Consideration of these factors would further diminish the relative importance of point sources.

A recent report by the Environmental Defense Fund (EDF) (Fisher et al, 1988) evaluates the potential significance of nitrogen loadings in acid rain as factors contributing to eutrophication in Chesapeake Bay and other coastal waters. The following comparison is made between nitrogen loading estimates developed by EDF and those presented in Table 7 (adjusted to common units):

Annual Total Nitrogen Loading (million Kg/yr)

	EDF	Table 7
Point	32.9	15.3
NonPoint	66.8	94.5
Atmospheric	12.9	(not estimated)
Total	112.9	109.8

Although the totals are similar, the bases for these calculations are considerably different. The EDF values, based primarily upon model projections developed by the EPA (1983), are for the **entire Chesapeake Bay** and an **average hydrologic year**. The Table 7 values are for the **Maryland Portion of the Bay only** and are based upon **measured** (vs. **modelled**) nutrient loadings for a **period of below-average runoff** (12.4 vs. 16 in/yr in the Potomac, Figure 1). The drainage area of the

Maryland portion of the Bay accounts for approximately 72% of the total drainage area. If the balances in Table 7 were adjusted to the same basis as the EDF estimates (complete bay, normal hydrologic year, including atmospheric loadings) the total nitrogen loading would be considerably higher than that reported by EDF, perhaps by 50% or more.

It is possible that the modeling results used to develop previous nitrogen budgets do not reflect recent increasing trends in nitrate levels in the Susquehanna River (see Figure 31 below). Similar trends may exist in other tributaries. The fact that actual nitrogen loadings may be higher than assumed by EDF provides further support for EDF conclusions regarding the relative importance of nitrogen loadings from nonpoint sources (partially attributed to acid rain, fertilizers, etc.) as factors contributing to Bay eutrophication.

BAY AND ESTUARY STATIONS

Bay and estuary stations retrieved from the EPA's Chesapeake Bay data base are identified in Figures 13 and 14, respectively. Station codes (abbreviated for plotting purposes) and locations are listed in Table 8. All of these data were collected by the MDOEP between July 1984 and July 1987. Data summaries by station, season, and year are given in Appendix C. Average concentrations are listed by Bay Segment and month in Appendices D and E and displayed in Appendix F.

Bay stations (22 in number) are oriented along the main north-south axis from the Susquehanna River inflow to Virginia state line below the mouth of the Potomac River (Figure 13). Lateral transects (3 stations "W", "C", and "E") are taken at four locations between Annapolis and the mouth of the Patuxent River. The first character of the Bay station code reflects the Bay segment number, according to the scheme used historically for modeling and data management purposes. Bay stations are sampled 20 times per year (biweekly in Spring and Summer, monthly in Fall and Winter). Although sampling is done with depth, the analysis below is restricted to data from the upper mixed layer (less than or equal to 3 meters depth). For each station and date, values have been

Figure 13
Bay Station Map

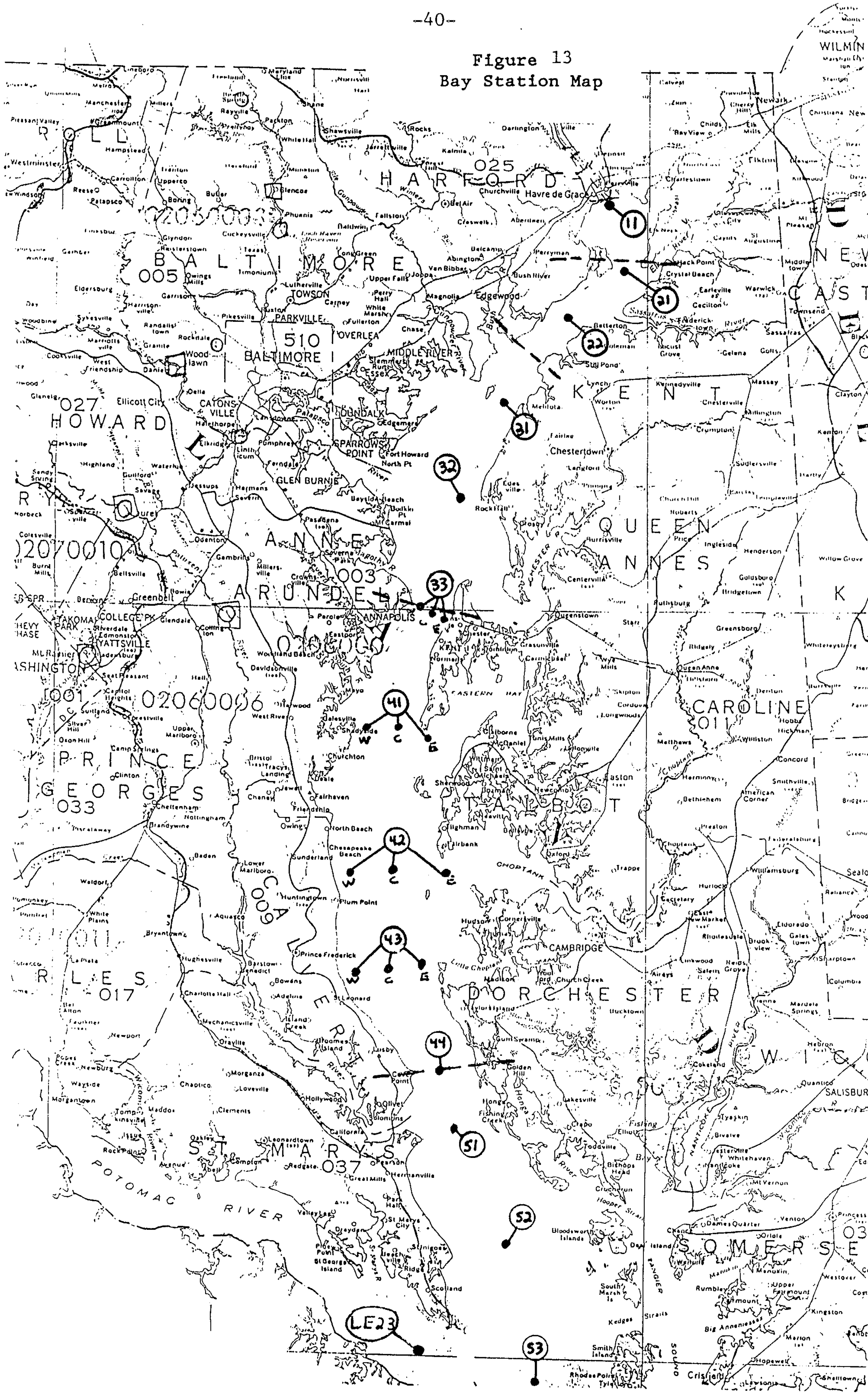


Figure 14
Estuary Station Map

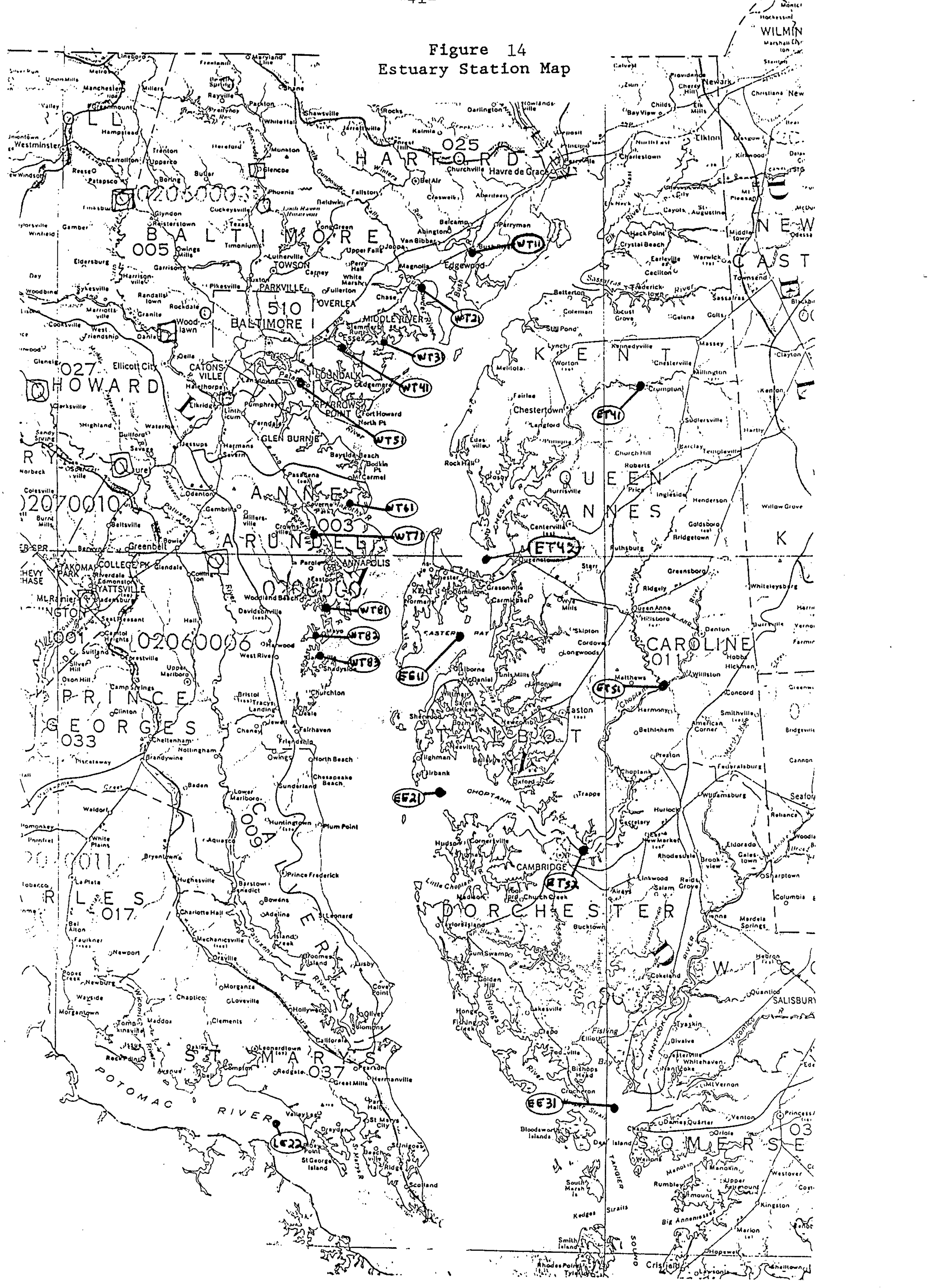


Table 8

Bay and Estuary Station Codes and Coordinates

STATION	ABBREV.	LATITUDE	LONGITUDE
BAY STATIONS			
CB1.1	11	39.545	76.082
CB2.1	21	39.440	76.025
CB2.2	22	39.347	76.175
CB3.1	31	39.248	76.238
CB3.2	32	39.163	76.306
CB3.3C	33C	38.995	76.360
CB3.3E	33E	39.002	76.346
CB3.3W	33W	39.003	76.388
CB4.1C	41C	38.825	76.400
CB4.1E	41E	38.816	76.371
CB4.1W	41W	38.813	76.463
CB4.2C	42C	38.645	76.418
CB4.2E	42E	38.645	76.400
CB4.2W	42W	38.643	76.502
CB4.3C	43C	38.556	76.435
CB4.3E	43E	38.556	76.390
CB4.3W	43W	38.556	76.493
CB4.4	44	38.413	76.343
CB5.1	51	38.318	76.293
CB5.2	52	38.137	76.228
CB5.3	53	37.912	76.168
LE2.3	LE23	38.021	76.348
ESTUARY STATIONS			
MEE1.1	EE11	38.883	76.250
MEE2.1	EE21	38.650	76.275
MEE3.1	EE31	38.200	75.975
MET4.1	ET41	39.258	75.925
MET4.2	ET42	38.992	76.217
MET5.1	ET51	38.583	76.050
MET5.2	ET52	38.567	76.058
MWT1.1	WT11	39.433	76.242
MWT2.1	WT21	39.383	76.342
MWT3.1	WT31	39.300	76.400
MWT4.1	WT41	39.283	76.450
MWT5.1	WT51	39.208	76.525
MWT6.1	WT61	39.075	76.475
MWT7.1	WT71	39.017	76.508
MWT8.1	WT81	38.933	76.525
MWT8.2	WT82	38.883	76.533
MWT8.3	WT83	38.850	76.533
MLE2.2	LE22	38.167	76.733

averaged within this depth range prior to downloading and subsequent analysis. Separate data sets have been created and downloaded for analysis of dissolved oxygen depletion in Bay bottom waters.

The estuary stations shown in Figure 14 are located in tidal portions of rivers and streams draining into the Bay. Out of approximately 44 Maryland estuary stations included in the current monitoring program (based upon the EPA station index), 18 stations on the EPA data tape with phosphorus, chlorophyll-a, and related water quality data for 1985 and 1986 are considered here. Monitoring frequency is either monthly year-round or monthly with biweekly sampling during Spring and Summer (similar to Bay stations). This data subset does not reflect the complete extent of estuary monitoring over this period. In particular, intensive MDOE monitoring data from the Patuxent Estuary are not included. Additional data requests would have to be filed in order to permit analysis of Patuxent or other estuary data not included on the EPA tape.

STATISTICAL CONTRASTS

One question to be addressed is whether "statistically significant" differences can be detected in phosphorus and related water quality components between 1985 and 1986. This question is not equivalent to asking whether or not the detergent ban influenced Bay water quality, since year-to-year changes can also be attributed to other factors (e.g., hydrology, treatment plant upgrades). It is not equivalent to asking whether there is a "trend" in Bay conditions, since longer term data would be required for such a purpose. Finally, it is not equivalent to asking whether 1985 conditions were actually different from 1986 conditions, since such variations may have occurred but were not large enough to be detected with the monitoring program design.

Statistical contrasts between 1985 and 1986 data are summarized in Table 9. The tests compare the seasonal (spring and summer) distributions of measurements at each station using a standard t-test (Montgomery and Loftis,1987). Each test is based upon at least 3

Table 9

STATISTICAL CONTRAST OF 1985 (PRE-BAN) AND 1986 (POST-BAN) MEANS BY SEASON AND STATION - LINEAR SCALES

	SPRING						SUMMER					
STATION	TOTAL P	ORTHO P	DIS P	CHL-A	SECCHI	COND	TOTAL P	ORTHO P	DIS P	CHL-A	SECCHI	COND
CB1.1			14				17		13			
CB2.1							24					
CB2.2												
CB3.1							17				-0.2	3293
CB3.2												2967
CB3.3C	17		28		0.2					-12		
CB3.3E			11									
CB3.3W	17	4	9			3651						
CB4.1C	26		13									
CB4.1E						2883						
CB4.1W				8		3821						
CB4.2C			9									
CB4.2E	13		16			3171					-1	
CB4.2W			20			3248						
CB4.3C						3528					-0.5	
CB4.3E		5	15			2994	7					
CB4.3W			25			3203					-0.4	
CB4.4	12		11									
CB5.1												
CB5.2		1					14		15			
CB5.3												
LE2.3	28										-0.7	
MEE1.1					-0.9	2204	33				-0.6	
MEE2.1						1305						
MEE3.1			12			1662				-6		
MET4.1			15									
MET4.2	35		13									
MET5.1	42			11								
MET5.2					-0.2	2045					-0.3	
MLE2.2		6	15					11				
MWT1.1				43					13			
MWT2.1	INSUFFICIENT DATA ---------------------------->							6				
MWT3.1	INSUFFICIENT DATA ---------------------------->							6				
MWT4.1												
MWT5.1					0.4							
MWT6.1								10			0.3	
MWT7.1	INSUFFICIENT DATA ---------------------------->											
MWT8.1		25										
MWT8.2												
MWT8.3												
COUNT	8	5	15	3	4	12	6	4	3	2	8	2

SPRING =APRIL-JUNE   TOTAL P = TOTAL PHOSPHORUS (PPB)   CHL-A = CHLOROPHYLL-A (PPB)
SUMMER =JULY-SEPT   ORTHO-P = ORTHO PHOSPHORUS (PPB)   SECCHI =SECCHI DEPTH (METERS)
DIS-P = TOTAL DISSOLVED P. (PPB)   COND = CONDUCTIVITY (UHOS)

VALUES = ARITHMETIC MEAN (1985) - ARITHMETIC MEAN (1986)

VALUES SHOWN ARE DIFFERENT FROM 0.0 AT SIGNIFICANCE LEVEL OF .10, BASED UPON t-TEST

POSITIVE VALUES INDICATE THAT MEANS WERE HIGHER IN 1985

NEGATIVE VALUES INDICATE THAT MEANS WERE HIGHER IN 1986 samples per station-season, although most involve 6 samples. Table 9 lists changes in seasonal mean concentrations (1985 - 1986) which are significantly different from zero at a significance level of .10. Each positive value indicates that there is an approximate 90% chance that the 1986 mean was lower than the 1985 mean. Seasonal means used for these comparisons are listed in Appendix C.

As discussed by Montgomery and Loftis (1987), the use of t-test for detecting changes or trends in water quality measurements is subject to several limitations. Seasonality, lack of normal distribution, and serial dependence are three factors relevant here. Seasonality has been considered by averaging measurements separately within each season before comparing years, although tests using combined spring and summer data give results which are qualitatively similar to those shown in Table 9. Data of this type are positively skewed and a logarithmic transformation can reduce skewness and increase the power of the test. Montgomery and Loftis (1987) indicate, however, that the t-test is robust to skewness as long as the sample sizes are equal and distribution shapes are similar (generally the case here). A repeat of the tests using log-transformed data (Table 10) yields a few more significant differences, but results are not qualitatively different. The remaining factor (serial dependence) is more difficult to deal with, especially with only 3 to 6 samples per season. The effect of such dependence, if present, would be to artificially inflate the number of significant differences identified.

Subject to the above limitations, test results are summarized and interpreted below. Results refer to the log-transformed tests (Table 10), which are slightly more powerful than the linear tests (Table 9).

(1) Spring contrasts (37 stations) indicated significant decreases in total phosphorus (10 stations), ortho P (6), dissolved P (14), chlorophyll-a (3), and conductivity (12). Significant increases in these variables were detected at no stations. Secchi depth increased at 2 stations and decreased at 2 stations. At the .10 significance level, 3.7 "differences"

Table 10

STATISTICAL CONTRAST OF 1985 (PRE-BAN) AND 1986 (POST-BAN) MEANS BY SEASON AND STATION - LOG10 SCALES

	SPRING						SUMMER					
STATION	TOTAL P	ORTHO P	DIS P	CHL-A	SECCHI	COND	TOTAL P	ORTHO P	DIS P	CHL-A	SECCHI	COND
CB1.1			0.40				0.15					
CB2.1							0.13	0.36				0.52
CB2.2												
CB3.1							0.11				-0.09	0.11
CB3.2												0.07
CB3.3C	0.17		0.44		0.08					-0.32		
CB3.3E	0.16		0.39			0.11						
CB3.3W	0.19	0.26	0.30									
CB4.1C	0.31		0.41			0.07						
CB4.1E						0.10	0.20					
CB4.1W				0.24								
CB4.2C			0.39			0.08						
CB4.2E	0.25		0.44			0.08					-0.21	
CB4.2W			0.52			0.08		0.38				
CB4.3C						0.07					-0.12	
CB4.3E		0.36	0.49			0.08	0.10					
CB4.3W			0.53								-0.14	
CB4.4	0.24		0.34									
CB5.1	0.36	0.21	0.50									
CB5.2		0.18					0.20		0.39			
CB5.3												
LE2.3	0.50										-0.17	
MEE1.1					-0.19	0.05	0.17				-0.18	
MEE2.1						0.03						
MEE3.1			0.15			0.03				-0.35		
MET4.1			0.13									
MET4.2	0.24											
MET5.1	0.14			0.29								
MET5.2					-0.11	0.05					-0.15	
MLE2.2		0.20						0.32				
MWT1.1				0.98					0.15			
MWT2.1	INSUFFICIENT DATA ---------------------------->							0.40			0.55	
MWT3.1	INSUFFICIENT DATA ---------------------------->							0.40				
MWT4.1								0.73				
MWT5.1					0.15							
MWT6.1								0.40			0.14	
MWT7.1	INSUFFICIENT DATA ---------------------------->											
MWT8.1		0.48										
MWT8.2												
MWT8.3												
COUNT	10	6	14	3	4	12	7	7	2	2	9	3

SPRING =APRIL-JUNE
SUMMER =JULY-SEPT

TOTAL P = TOTAL PHOSPHORUS (PPB)
ORTHO-P = ORTHO PHOSPHORUS (PPB)
DIS-P = TOTAL DISSOLVED P. (PPB)

CHL-A = CHLOROPHYLL-A (PPB)
SECCHI =SECCHI DEPTH (METERS)
COND = CONDUCTIVITY (UHOS)

VALUES = MEAN (LOG10 1985) - MEAN (LOG10 1986)
VALUES SHOWN ARE DIFFERENT FROM 0.0 AT SIGNIFICANCE LEVEL OF .10, BASED UPON t-TEST
POSITIVE VALUES INDICATE THAT MEANS WERE HIGHER IN 1985
NEGATIVE VALUES INDICATE THAT MEANS WERE HIGHER IN 1986

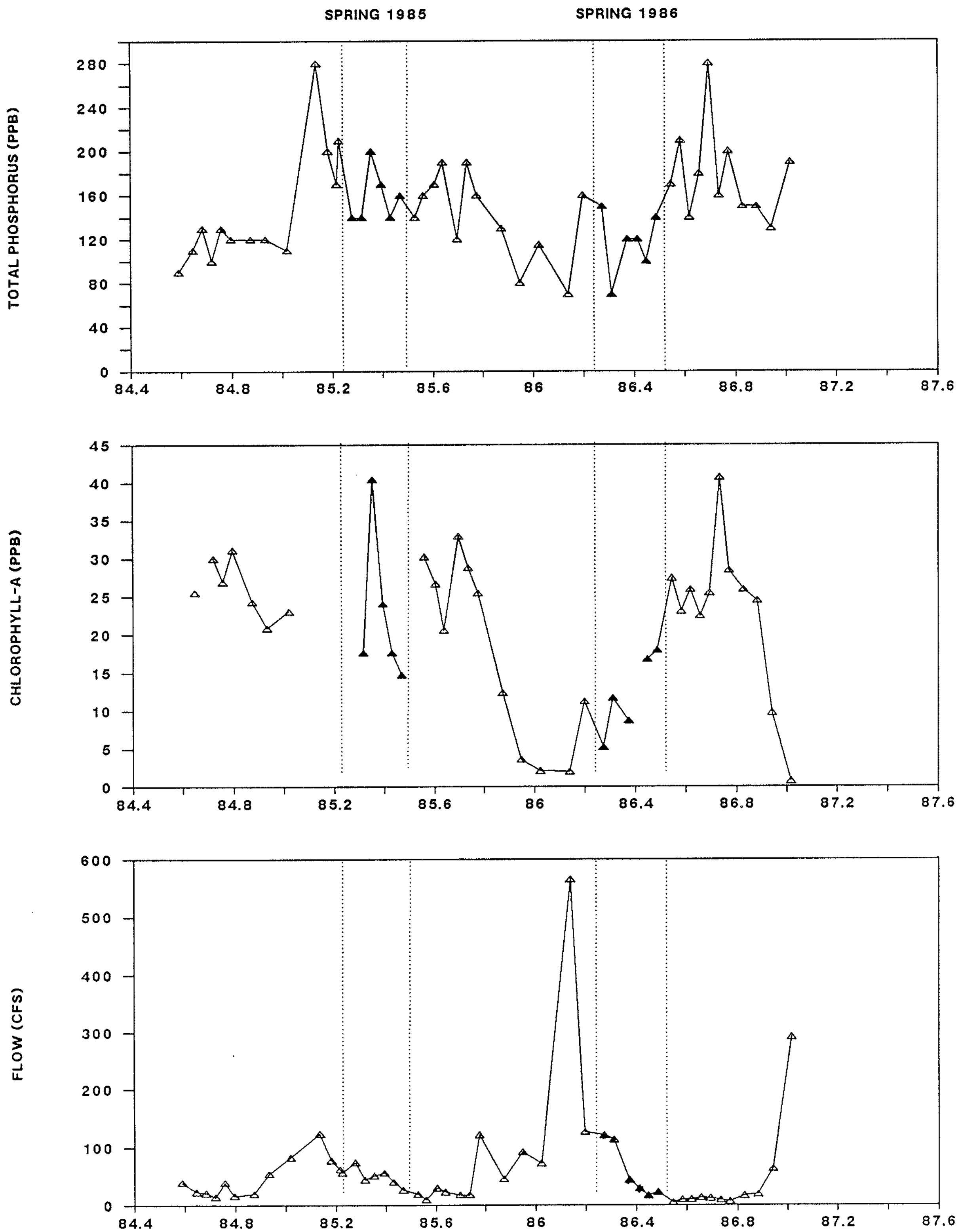
would be expected by chance for each variable if the 1985 and 1986 population means were actually equal at each station.

(2) Summer contrasts (40 stations) indicated significant decreases in total phosphorus (7 stations), ortho phosphorus (7), dissolved phosphorus (2), and conductivity (3). Chlorophyll-a increased at 2 stations. Secchi depth increased at 7 stations and decreased at 2 stations. At the .10 significance level, 4 "differences" would be expected by chance for each variable.

(3) Generally, greater numbers of significant differences between 1985 and 1986 were detected in the spring comparisons than in the summer comparisons. As indicated in Table 1, winter and spring runoff rates were higher in 1986 (7.3 and 4.1 inches, total 11.4 inches) than in 1985 (4.7 and 3.5 inches, total 8.2 inches). Decreases in spring conductivity at 12 stations would reflect these flow variations. Lower conductivities would be expected during periods of higher flow because of less salinity intrusion.

(4) Out of 37 spring and 40 summer contrasts, a significant reduction in phosphorus (any specie) was accompanied by a significant reduction in chlorophyll-a in only one instance (Station MET5.1, Choptank River, spring contrast). Spring phosphorus apparently decreased from 158 to 117 ppb and chlorophyll-a decreased from 23 ppb to 12 ppb. Higher runoff (Figure 2) during early 1986 could contribute to these changes. Time series of phosphorus, chlorophyll-a, and flow at this station are displayed in Figure 15. Flows are derived from the USGS gauge upstream on the Choptank River (01491000). In 1986, spring samples were taken during a period off falling flows and rising phosphorus and chlorophyll-a concentrations. High winter flows would promote flushing of nutrients and algae from the headwaters of the estuary. In late Spring and Summer, no differences between 1985 and 1986 are evident. Apparent differences between Spring 1985 and 1986 at this

Figure 15
Phosphorus, Chlorophyll-a, and Flow and Chlorophyll-a Time Series
Choptank River Station MET5.1



station seem to be related to differences in the hydrograph, rather than to changes in point-source inputs.

The significantly lower concentrations of phosphorus species measured at several Bay and Estuary stations during 1986 are expected based upon changes in phosphorus loading over this period (Table 6). As a result of changes in flow, nonpoint loadings, and treatment plant upgrades, reductions in phosphorus loadings during 1986 (vs. 1985) were greater than those attributed to the detergent ban, as illustrated below:

	Loading (lbs/day)				Inflow Concentration (ppb)			
			% Reduction				% Reduction	
Quarter	1985	1986	Ban	Total	1985	1986	Ban	Total
Spring	27,010	24,030	6.5%	11.0%	114	88	6.7%	22.8%
Summer	17,960	13,457	11.1%	25.1%	218	144	11.6%	33.9%

Observed reductions in Bay phosphorus concentrations between 1985 and 1986 reflect the combined influences of these changes in loading and other factors driving nutrient cycling within the Bay.

NUTRIENT AND ALGAE TIME SERIES

A better appreciation for variations in Bay conditions can be derived by considering the complete record from July 1984 through July 1987. Monthly time series by segment are shown in Appendix F. Figures 16 and 17 compare seasonal-average phosphorus and chlorophyll-a concentrations at individual stations. The first digit of each station code corresponds to the Bay segment in which the station is located. The monitoring period permits estimation of spring means for three years (1985-1987) and summer means for four years (1984-1987). Estimates of summer means for 1987 are based upon July measurements only (vs. July-September for other years). Symbols (*) in Figures 16 and 17 indicate whether year-to-year variations in seasonal means are significant (p=.10), based upon a one-way analysis of variance. Dotted lines in Figure 17 show the 15 ppb management goal for chlorophyll-a, which has

Figure 16
Total Phosphorus Means - Bay Stations - 1984-1987

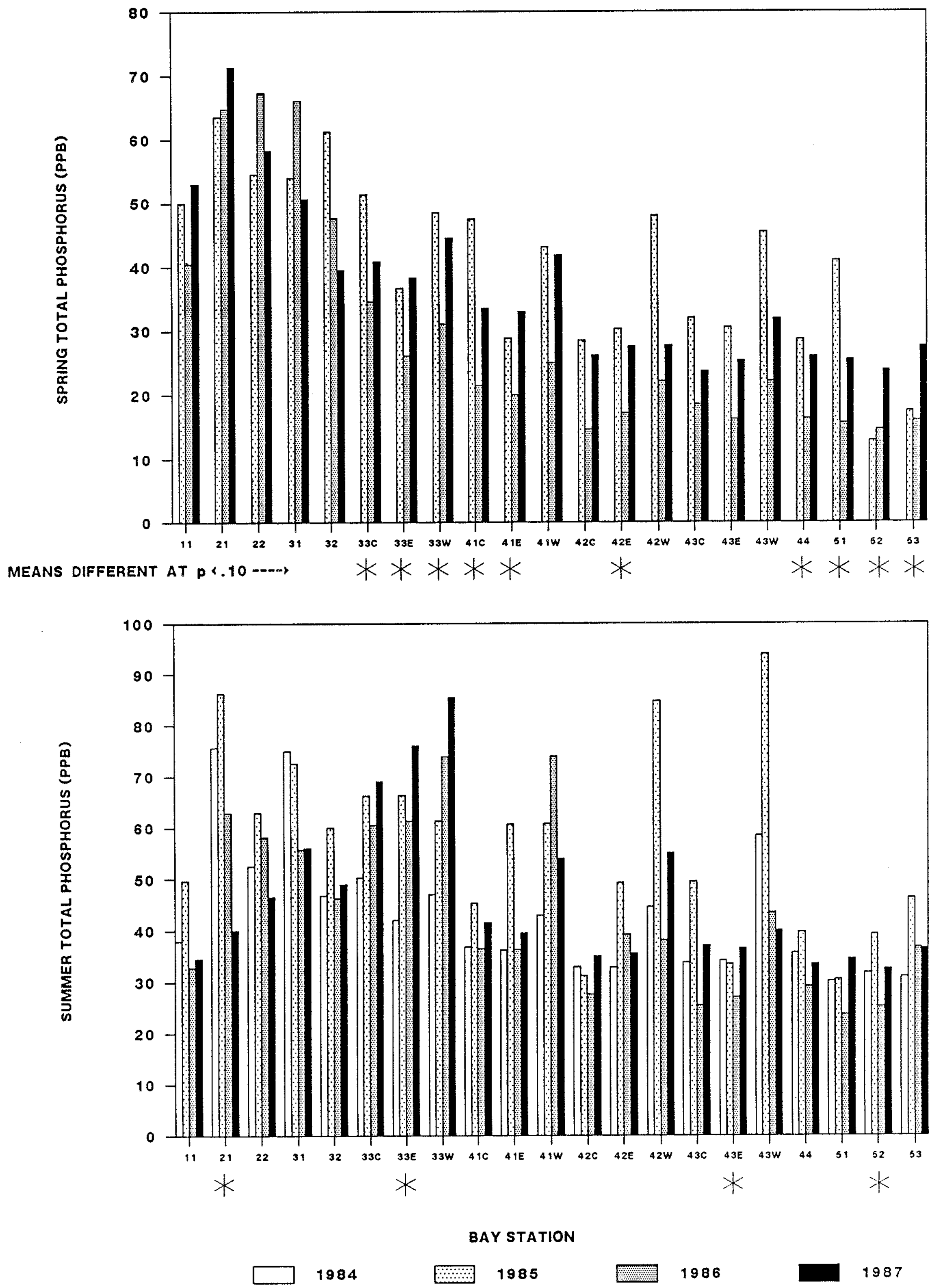
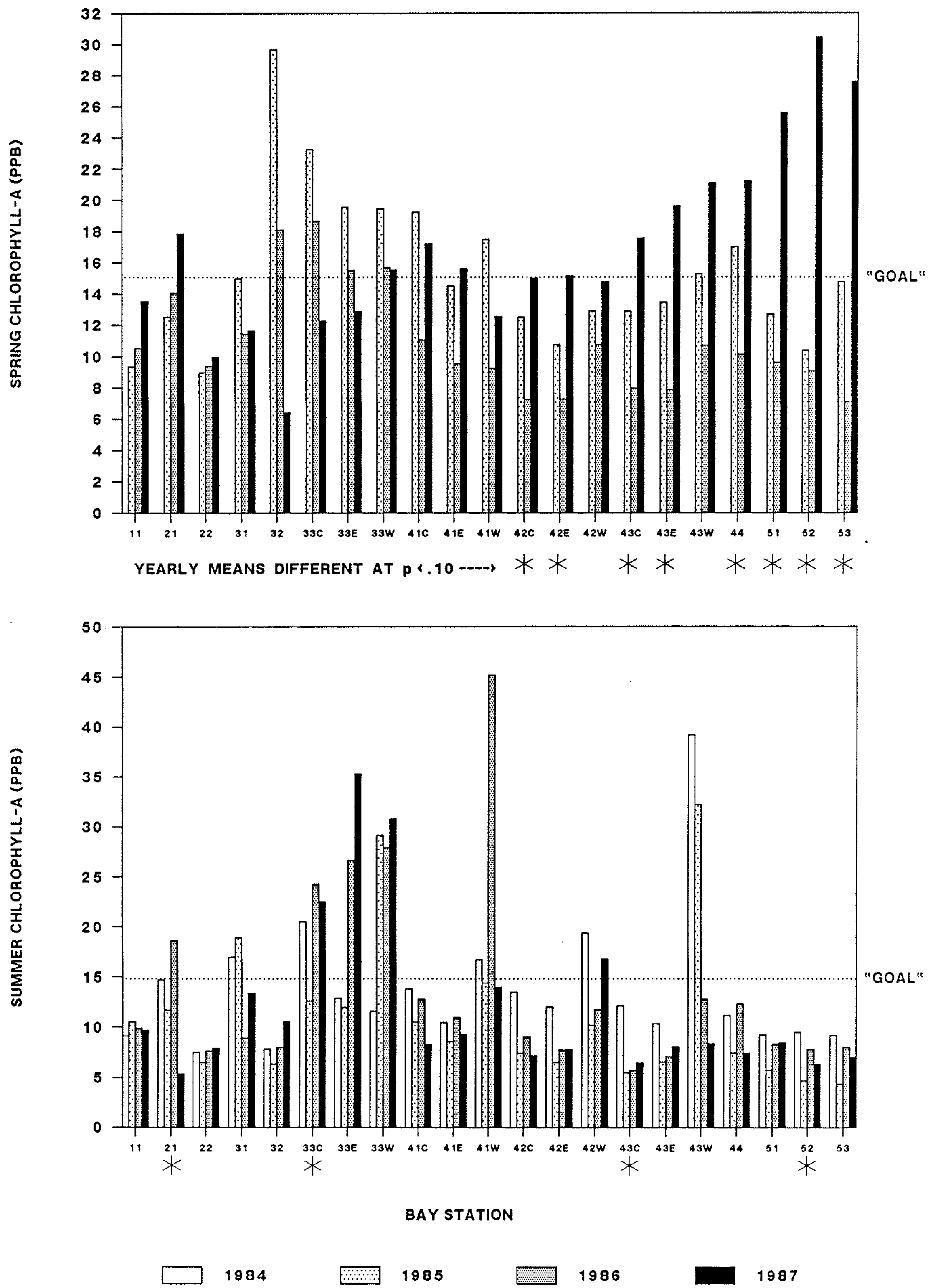


Figure 17
Chlorophyll-a Means - Bay Stations - 1984-1987



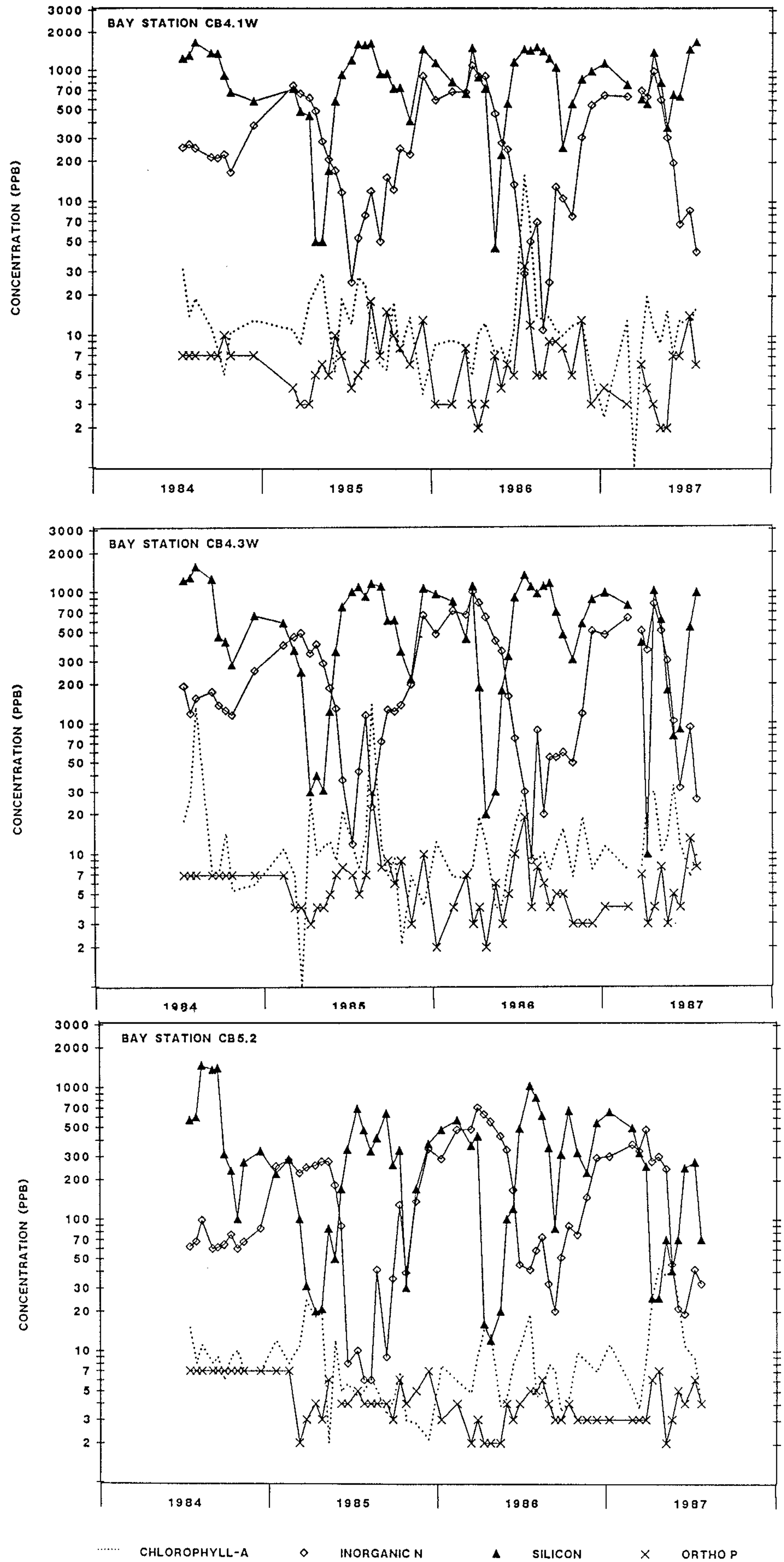
been established as a habitat requirement for submerged aquatic vegetation in shallow regions of the Bay (USEPA,1987).

One distinction between 1987 and the previous years with respect to chlorophyll-a is the algal bloom which developed in Segments 4 and 5 during Spring of 1987. In Segment 5, chlorophyll-a concentrations averaged above 30 ppb for a two-month period. As described below, this bloom was followed by rapid depletion of dissolved oxygen from bottom waters in this region of the Bay. Total phosphorus concentrations were also higher in Segment 5 during Spring of 1987 (Figure 16), but not in proportion to the differences in chlorophyll-a (Figure 17).

As indicated in Table 6, the average inflow phosphorus concentration for the Maryland portion of the Bay was 170 ppb in Spring of 1987, as compared with 86 ppb in 1986 and 117 ppb in 1985. Corresponding spring-average loadings were 72,668, 50,443, and 43,887 lbs/day, respectively. The higher inflow concentration and loading primarily reflect high runoff from the Susquehanna and Potomac in April of 1987 (Figure 2). Downstream transport of high inorganic nitrogen concentrations (> 2000 ppb) observed in Segment 1 (mouth of the Susquehanna) during March 1987 (Appendix F-4) may also have contributed to the spring bloom in Segments 4 and 5. Nitrate nitrogen levels in the Potomac and Susquehanna peaked at 2,000-2,500 ppb during Winter of 1987.

Silica depletion occurred during Spring in Segment 5 (Appendix F-6). Station CB5.2 time series (Figure 18) indicate that spring diatom populations in this region were regulated by phosphorus and silica. Stoichiometric ratios of silica to ortho phosphorus during the spring chlorophyll-a peaks approached 4/1 (Si/P), well the below typical 20/1 requirement for diatom cells (Bowie et al.,1985). Silica may be more important than phosphorus in regulating maximum spring biomass in this region. Algal transitions to forms with lower or no silica requirements may have occurred later in the season, but apparently not at sufficient rates to avoid the sudden drops in chlorophyll-a following depletion of dissolved silica. Following the spring diatom bloom, nitrogen

Figure 18
Chlorophyll-a and Soluble Nutrients at Three Bay Stations



limitation (inorganic N/P < 10) developed at Station CB5.2 later in Summer, as is typical of most of the Bay (USEPA,1987).

Stations along the western edge of Segment 4 (41W, 42W, 43W) exhibit a high degree of variability in chlorophyll-a, phosphorus, and other nutrient measurements during Summer. As shown in Figures 16 and 17, summer-average values at these stations often deviated considerably from averages at corresponding central (41C, 42C, 43C) and eastern (41E, 42E, 43E) stations. The Bay is relatively shallow along the western edge of Segment 4 (10-11 meters, as compared with 28-30 meters at central and 11-26 meters at eastern stations, based upon maximum total depths reported in the EPA data base). This area appears to be relatively susceptible to summer blooms driven by transport of soluble nutrients (phosphorus, ammonia) from bottom waters.

Blooms exceeding 100 ppb Chl-a were detected at Station 4.1W during July of 1986 and at Station 4.3W during August of 1984 and 1985 (Figure 18). The rapid increases in chlorophyll-a which occurred at these times were accompanied by rapid increases in ortho phosphorus concentration, apparently derived from bottom waters. As the blooms developed, inorganic nitrogen levels dropped sharply and inorganic N/P ratios were well below 10 (indicative of nitrogen limitation) at peak biomass. As shown in Figure 19, summer inorganic N/P ratios averaged below 10 at most stations in and below Segment 3, except during 1984, when summer inflows (and nitrogen loadings) from the Susquehanna River were relatively high and Bay vertical stratification was relatively strong (Officer et al., 1984).

Figure 20 presents a non-parametric summary of chlorophyll-a data as a function of year, segment, and season. Frequencies of measurements exceeding 15 and 30 ppb are displayed for each category. The 15 ppb value corresponds to the management goal which has been established for restoration/protection of submerged aquatic vegetation (USEPA,1987). The 30 ppb level has been suggested as a "severe nuisance" criterion in freshwater systems, based upon correlations between chlorophyll-a measurements and subjective evaluations of aesthetic qualities and

Figure 19
Inorganic N/P Ratios - Bay Stations - 1984-1987

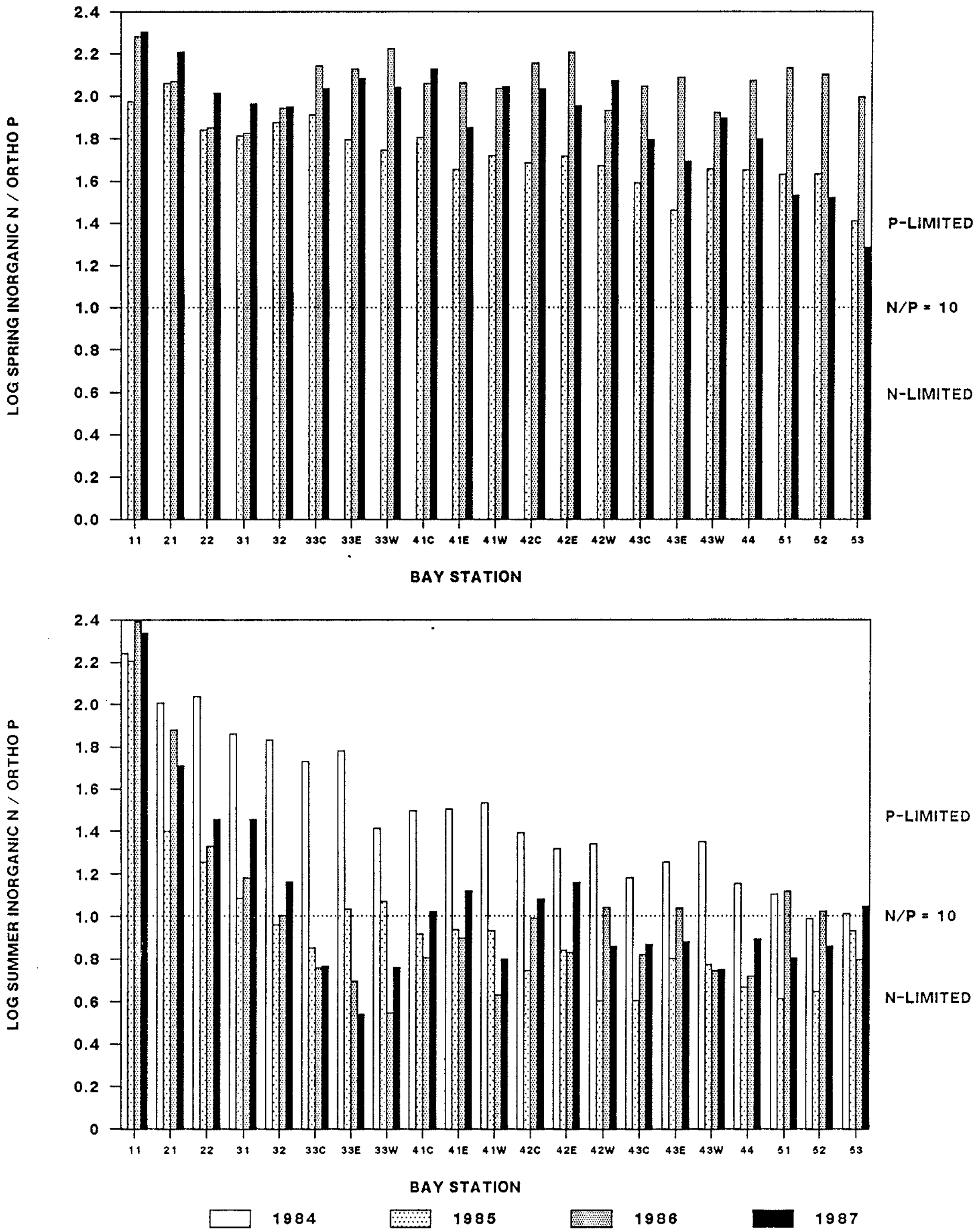
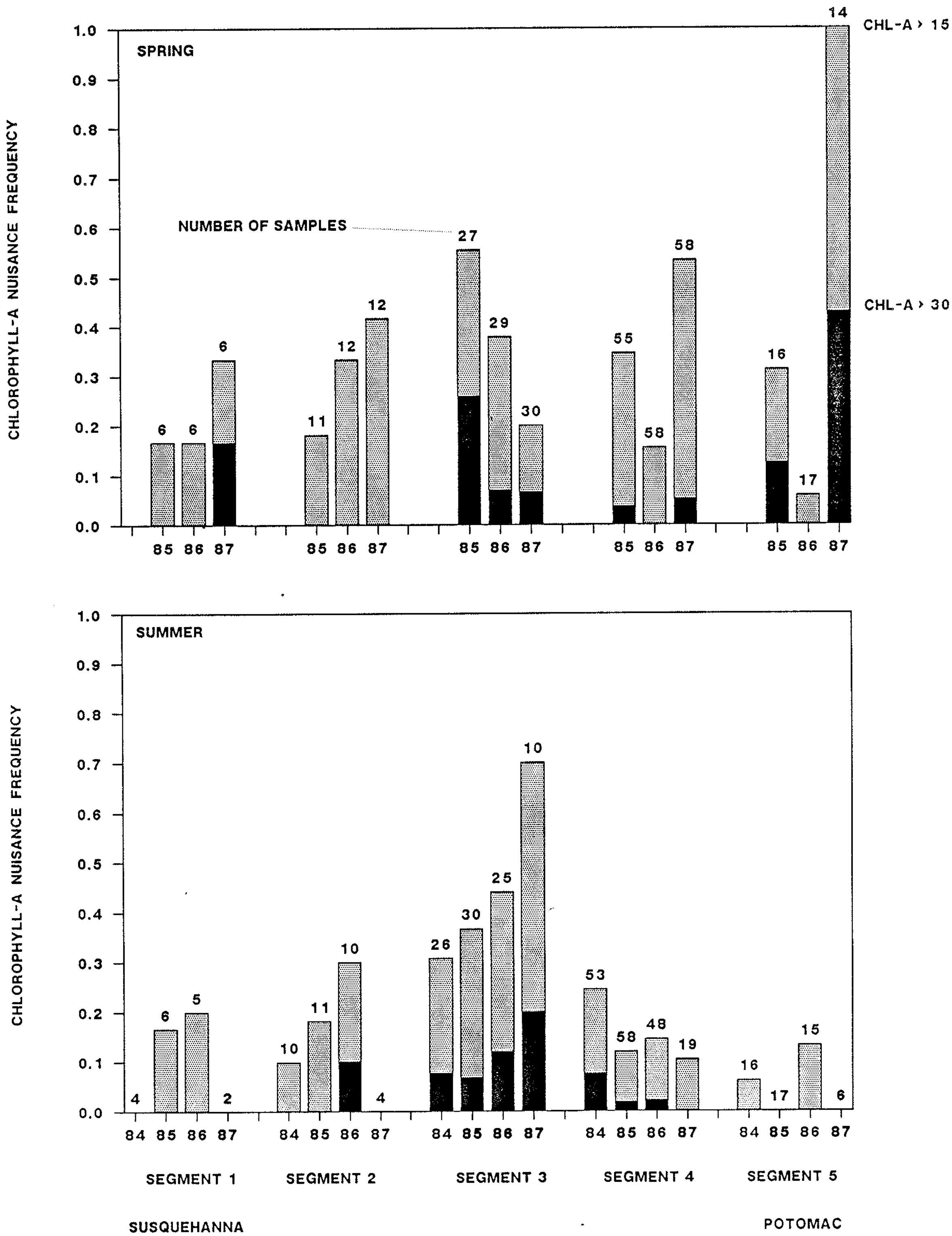


Figure 20
Chlorophyll-a Nuisance Frequencies - Bay Stations - 1984-1987



recreation potential (Walmsley,1984; Heiskary and Walker,1988). Overall, the frequencies of chlorophyll-a concentrations exceeding the 15 ppb management goal were 19.8% in 1984-1985 and 21.6% in 1986-1987. Frequencies of chlorophyll-a exceeding 30 ppb were 3.8% in 1984-1985 and 4.3% in 1986-1987. These summaries further suggest that no "improvement" in Bay conditions occurred over this period with respect to algal productivity or compliance with management goals, despite reductions in phosphorus loadings attributed to the detergent ban, improved wastewater treatment, and other factors (Table 6).

PRODUCTIVITY CALCULATIONS

Table 11 describes a model which is used below to evaluate factors controlling algal productivity in the Bay as a function for various seasons, years and locations. The model is based upon kinetic theories of algal growth and employs functions and parameter values which are typically used in phytoplankton simulation models (Bowie et al.,1985). Through a series of steps, the model calculates the gross primary production (gross photosynthesis) per unit area (expressed on a relative scale), based upon measurements of chlorophyll-a, transparency, temperature, and soluble inorganic nutrient levels (phosphorus, nitrogen, and silica). The equations account for effects of temperature, light, and nutrient limitation on algal growth rate. The model does not attempt to simulate transport or mass-balance relationships, but is intended primarily for estimating relative productivity and its sensitivity to soluble nutrient concentration, based upon mixed layer measurements at a particular location and date. Areal productivity is important because it is related to the areal loading of organic material to Bay bottom sediments and subsequent development of anaerobic conditions below the halocline (Officer et al., 1984).

As documented in Table 11, an estimate of mixed-layer depth is required to calculate the light limitation factor and areal productivity. While this could be derived directly from vertical temperature and salinity profiles at each station and date, a constant

Table 11
Relative Productivity Model

Symbol Definitions:

Symbol	Description	Units	Code
G	= relative algal productivity per unit area	-	C
F_l	= light limitation factor	-	C
F_x	= nutrient limitation factor	-	C
F_n	= nitrogen limitation factor	-	C
F_p	= phosphorus limitation factor	-	C
F_s	= silica limitation factor	-	C
F_t	= temperature factor	-	C
Y_n	= productivity sensitivity to nitrogen	-	C
Y_p	= productivity sensitivity to phosphorus	-	C
Y_s	= productivity sensitivity to silicon	-	C
B	= chlorophyll-a	ppb	M
Z_s	= Secchi depth	meters	M
E	= visible light extinction coefficient	1/meters	C
Z_m	= mean depth of mixed layer	meters	5
Z_o	= optical depth	-	C
C_n	= inorganic nitrogen concentration	ppb	M
C_p	= ortho phosphorus concentrations	ppb	M
C_s	= dissolved silicon concentration	ppb	M
K_s	= half-saturation constant for silica uptake	ppb	50 a
K_n	= half-sat. constant for nitrogen uptake	ppb	25 a
K_p	= half-sat. constant for phosphorus uptake	ppb	2.5 a
K_l	= half-sat. constant for light intensity	cal/cm^2-hr	1.5 a
I_o	= visible solar radiation	cal/cm^2-day	S
D	= day length	hours	S
T	= water temperature	deg-C	M

Codes: M = measured, C = calculated , S = seasonal factor (see below)
Other = assumed model parameter (a = Bowie et al., 1985)

Average Monthly Values for 40 degrees latitude (McGaughey,1968):

Month =	1	2	3	4	5	6	7	8	9	10	11	12
D =	9.7	10.7	11.9	13.3	14.4	15.0	14.8	13.8	12.5	11.2	10.0	9.4
I_o =	55	90	135	150	224	236	230	203	158	112	69	45

(continued)

Table 11 (ct.)
Relative Productivity Model (ct.)

MODEL EQUATIONS:

Relative Primary Productivity per Unit Area:

$$G = F_l \ F_x \ F_t \ B \ Z_m$$

Light Limitation Factor:

$$E = 1.66 / Z_s \quad , \quad Z_o = E \ Z_m$$

$$F_l = D \ln [(K_l + I_o/D) / (K_l + I_o \ e^{-Z_o} /D)] / (24 \ Z_o)$$

Nutrient Limitation Factors:

$$F_n = C_n / (C_n + K_n)$$

$$F_p = C_p / (C_p + K_p)$$

$$F_s = C_s / (C_s + K_s)$$

$$F_x = \text{Minimum} [F_n, F_p, F_s]$$

Temperature Factor:

$$F_t = 1.047^{(T - 20)}$$

Productivity Sensitivity Factors:

Normalized First Partial Derivatives of Areal Productivity with Respect to Soluble Inorganic Nutrient Concentrations

$$Y_x = K_j \frac{d\ G}{d\ C_j} \quad , \text{ where } j = n, p \text{ or } s$$

If $(F_n = F_x)$ then: $Y_n = (1 - F_n)^2 \ G / F_n$, else: $Y_n = 0$

If $(F_p = F_x)$ then: $Y_p = (1 - F_p)^2 \ G / F_p$, else: $Y_p = 0$

If $(F_s = F_x)$ then: $Y_s = (1 - F_s)^2 \ G / F_s$, else: $Y_s = 0$

Limiting Nutrient Frequencies:

If ($F_x > .67$), Limiting Nutrient = None
(Soluble nutrient concentrations all exceed twice their respective half-saturation constants and productivity is relatively insensitive to nutrients.)

Else If ($F_x = F_p$), Limiting Nutrient = Phosphorus
Else If ($F_x = F_n$), Limiting Nutrient = Nitrogen
Else If ($F_x = F_s$), Limiting Nutrient = Silica

mixed layer depth of 5 meters is assumed for the purposes of the calculations described below. Because of the optical characteristics of the Bay (relatively low transparency and high optical depths), calculations are very insensitive to the assumed mixed layer depth. Mixed-layer depth appears in the equations for productivity and optical depth. Except for the exponential term appearing in the expression for the light limitation factor, the depth terms eventually cancel out because they appear in the numerator of the productivity expression and in the denominator of the light limitation factor. The exponential term is close to zero for reasonable ranges of transparency and mixed depth and, as a result, the numerator of the light limitation factor is insensitive to the assumed depth.

The model accounts for algal growth limitation by phosphorus, nitrogen, and silicon. Calculations are dependent upon assumed half-saturation constants (2.5, 25, and 50 ppb, respectively), which have been selected from a compilation by Bowie et al. (1985). The constants for phosphorus and nitrogen are higher than those employed in the Bay model (1.5 and 15 ppb, respectively (USEPA,1987)). The ratios are identical, however, so that conclusions regarding the relative importance of nitrogen and phosphorus limitation are not influenced by differences in the coefficients. Silica limitation (not considered in the current Bay model), is important only for diatoms and would not influence growth rates of other algal types. Because uptake by diatoms is the primary mechanism for silica depletion (Wetzel,1975), silica levels reach growth-limiting levels only during periods which are conducive to diatom growth (generally Spring or Fall). As a result, the silica limitation term only becomes important when diatoms dominate and is not important during Summer when other algal types (greens, bluegreens, flagellates) dominate.

The model has been applied to estimate relative productivity and its sensitivity to soluble nutrient concentrations at Bay stations between March 1985 and July 1987. The July 1984-February 1985 data have been excluded because the detection limit for ortho phosphorus during the period (7 ppb) was higher than the half-saturation constant (2.5

ppb); this prevents evaluation of limiting nutrient during this period. The ortho phosphorus detection limit after February 1985 was 1.6 ppb.

Productivity calculations have been applied to each sample after February 1985 with a complete measurement set. Results have been averaged by month and segment (Appendix G) and by season and segment (Appendix H). Monthly time series are displayed in Figure 21 (productivity), Figure 22 (nutrient limitation factors) and Figure 23 (limiting nutrient frequencies).

Highest productivities (exceeding 3 relative units) are calculated for July 1986 in Segments 3, 4 and 5, May-June 1987 in Segment 5, and July 1987 in Segment 3. Consistent with contrasts of chlorophyll-a measurements, there is no indication that the decreases in phosphorus concentrations observed at several Bay stations (Tables 9 and 10) resulted in decreased algal productivity. Figure 21 suggests increasing productivity in Segment 5. This may be related to the higher winter and spring inflows experienced during 1987, which would cause increased loading and transport of nutrients (nitrogen, phosphorus, silica) to lower regions of the Bay.

Sensitivity coefficients (first partial derivatives of areal productivity with respect to soluble nutrient concentrations) are displayed by segment and season in Figure 24. Highest sensitivity to phosphorus is observed in Segment 1 during Summer (Quarter 3) and in Segments 3 to 5 during Spring (Quarter 2). Sensitivity is to nitrogen is highest during Summer in Segments 3 to 5. The importance of nitrogen limitation during Summer is also reflected by the low inorganic nitrogen to ortho phosphorus ratios (Figure 19).

Sensitivity to silica is highest during Spring in Segments 4 and 5. Silica depletion has been described as an important symptom of eutrophication in natural lakes (Wetzel,1975; Stauffer,1985). Spring diatom blooms can rapidly strip soluble nutrients from the water column. Because of the relatively high density of diatom cells and low density stratification in the water column during spring, nutrients are

Figure 21
Relative Productivity by Month and Segment

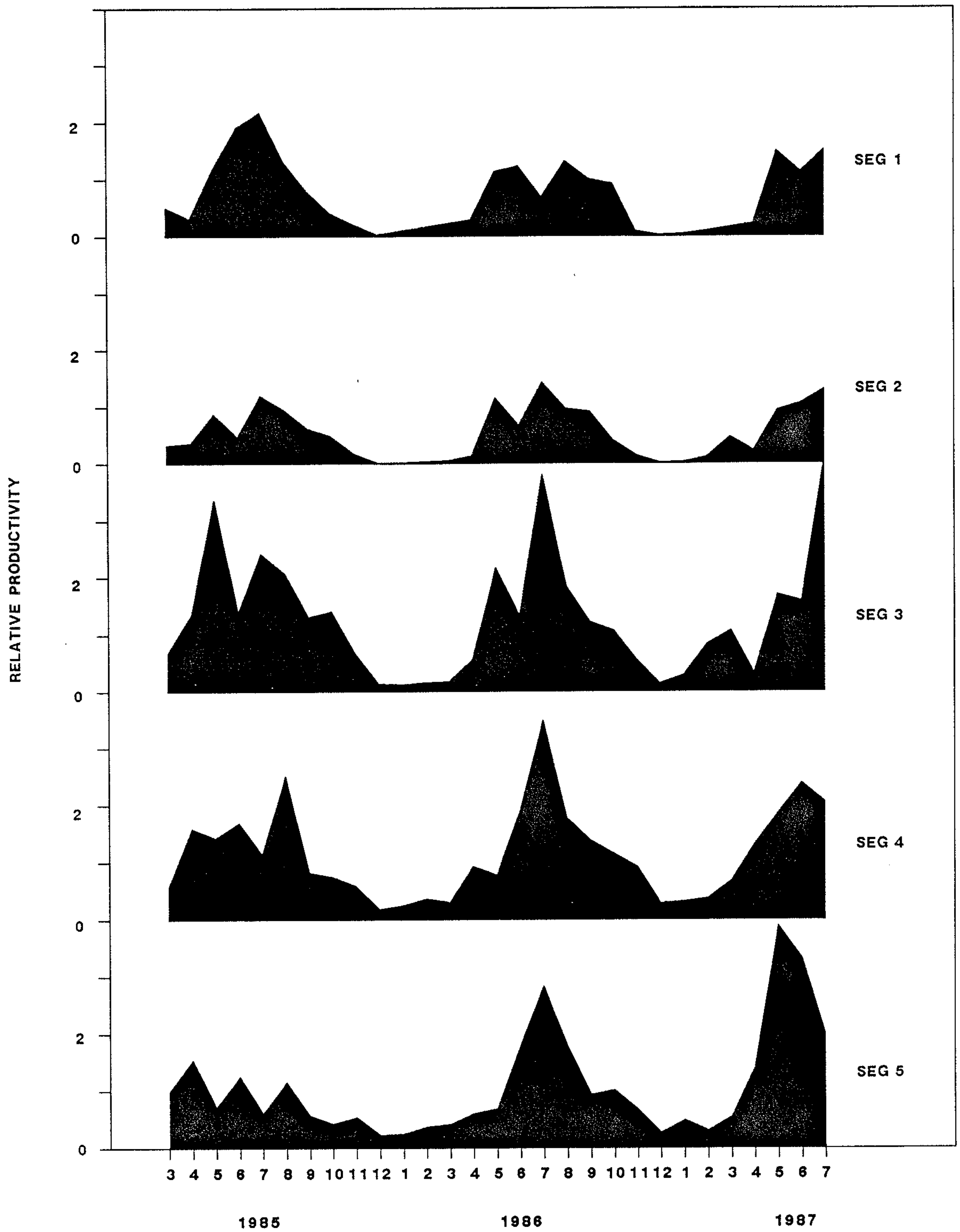


Figure 22
Growth Limitation Factors by Month and Segment

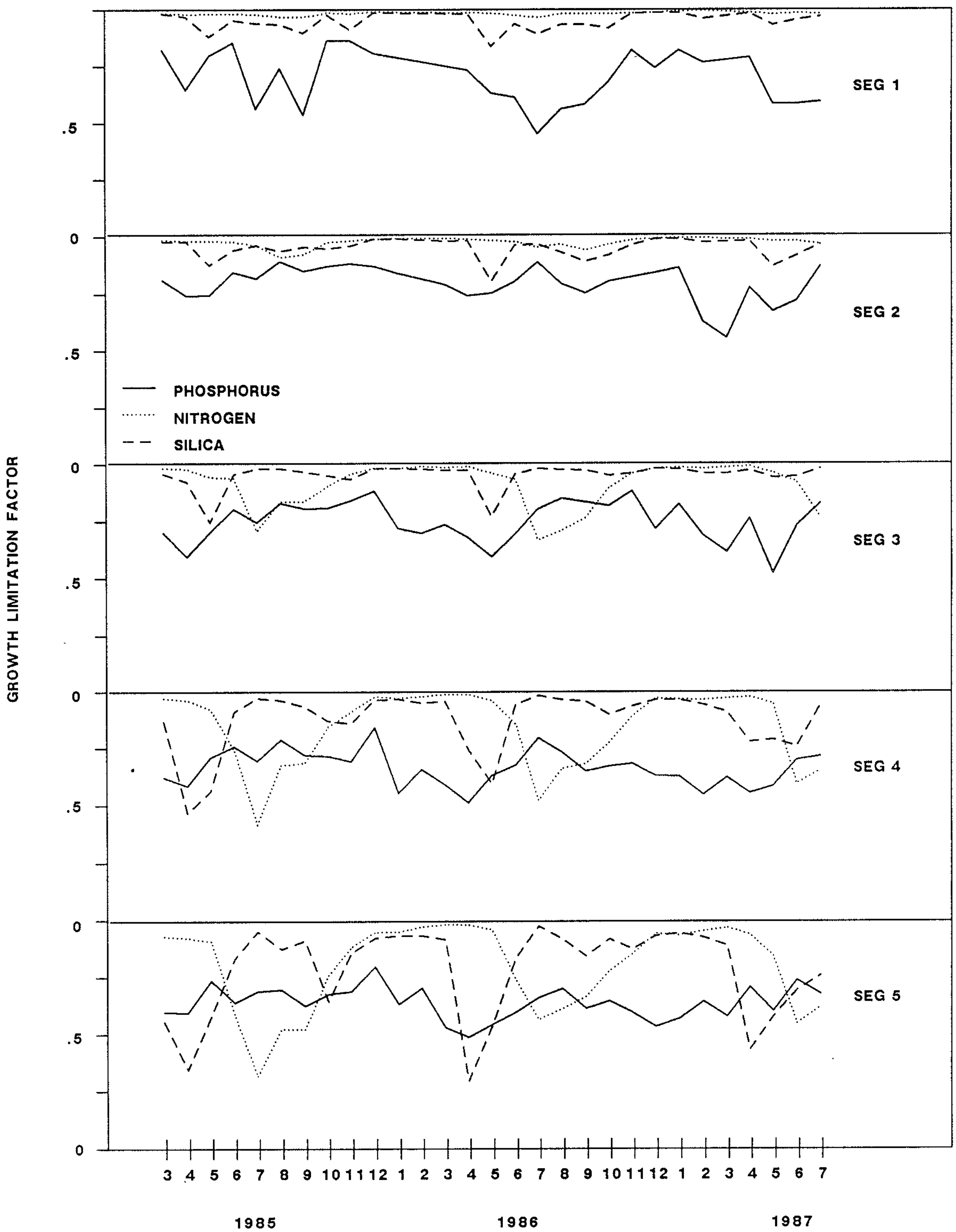


Figure 23
Limiting Nutrient Frequencies by Month and Segment

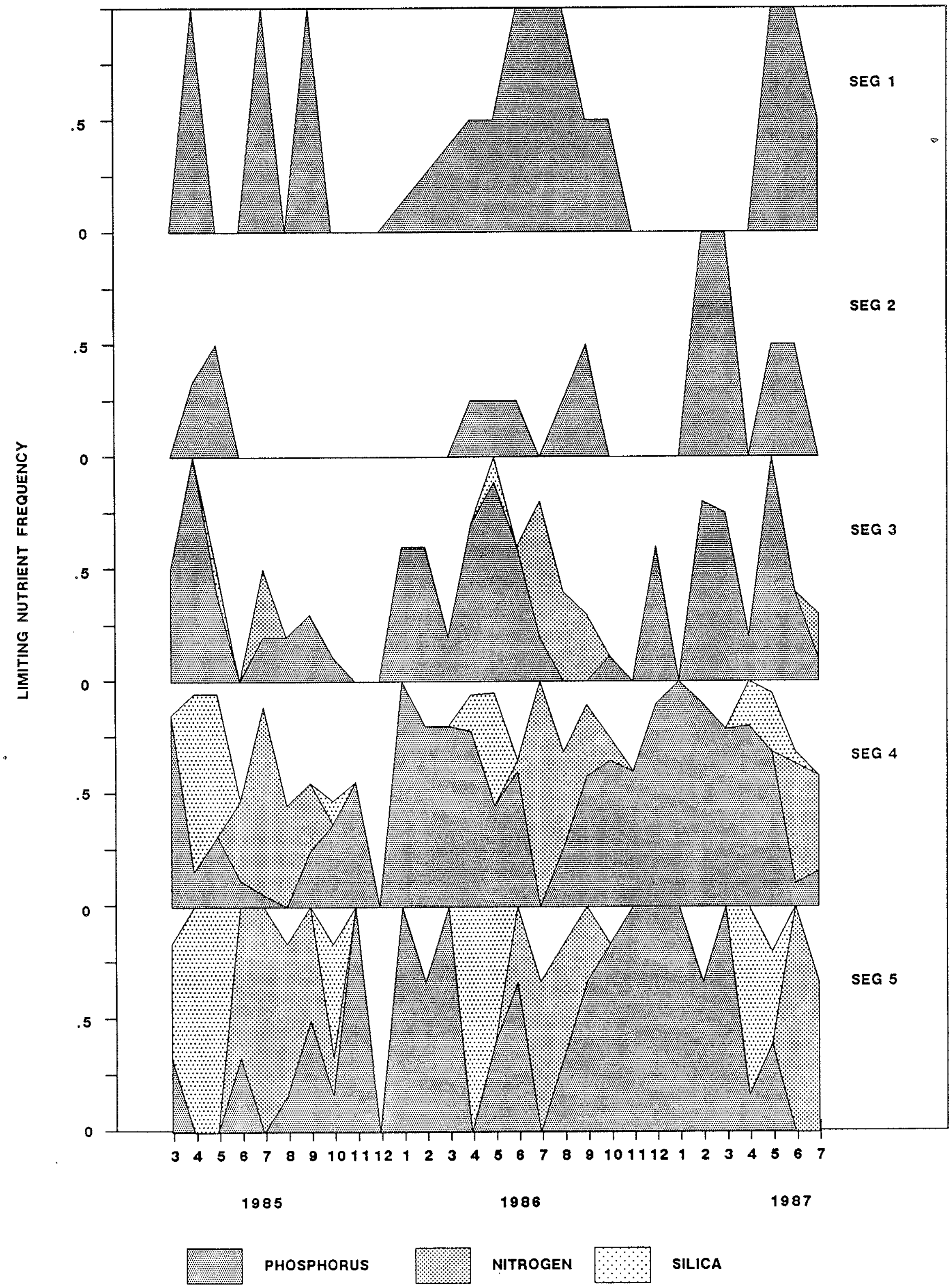
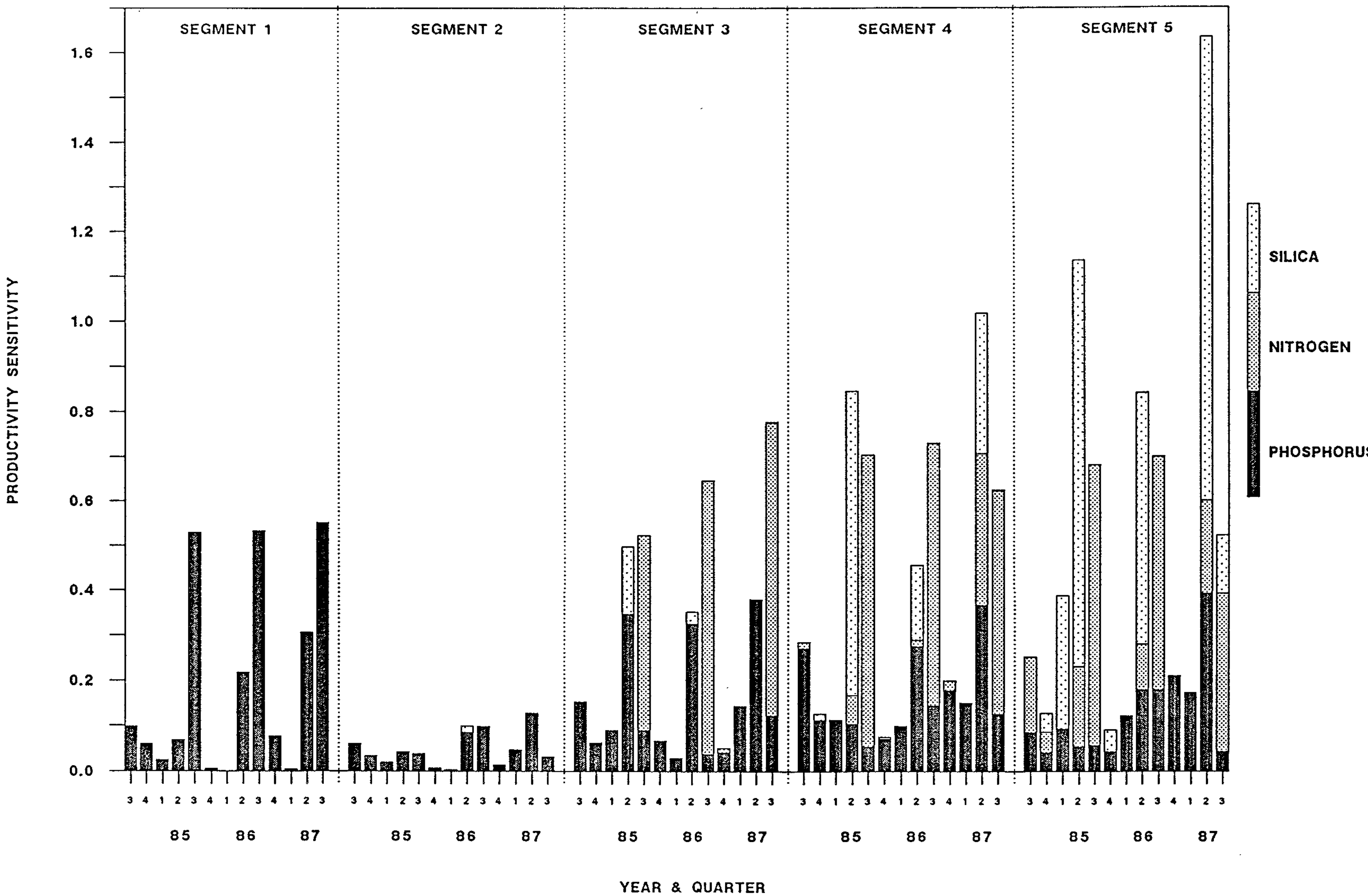


Figure 24
Productivity Sensitivity to Available Nutrient Levels



efficiently removed and deposited to bottom sediments. In the case of Chesapeake Bay, some of these deposited nutrients are transported upstream in the bottom saline layer and subsequently entrained into the surface layer later in the season, at which time they may stimulate additional algal blooms. When spring diatom populations are limited by silica (instead of by phosphorus or nitrogen), more soluble phosphorus and nitrogen is left behind in the surface layer to stimulate other types of algal growth later in the Summer.

Spring silica limitation in Segments 4 and 5 could be considered a symptom of excessive phosphorus and nitrogen levels during this period. Although the system is closer to being limited by phosphorus than by nitrogen under existing conditions, this partially reflects the fact that nitrogen loadings to the Bay (primarily nonpoint) have continued to increase, while phosphorus controls have been widely implemented. Critical questions in this regard are (1) What is the limiting nutrient under "natural" conditions in this region of the Bay during Spring?, and (2) What is the relative feasibility of achieving nitrogen vs. phosphorus limitation and resulting reductions in peak spring biomass in this region through additional point and/or nonpoint controls? The same questions apply to summer conditions.

In all segments, nutrient sensitivities are low during fall and winter quarters because of low temperatures and light limitation. Light limitation is especially important in Segment 2. Based upon the relative magnitudes of the chlorophyll-a and transparency measurements, low transparencies in this segment (< 1 meter) primarily reflect inorganic turbidity from the Susquehanna River and/or upwelling of particulates from the saline bottom layer. The low productivities and low nutrient sensitivities calculated for Segment 2 are consistent with the relatively low primary production rates measured by the MDOEP(1987) in this region.

DISSOLVED OXYGEN DEPLETION

Depletion of dissolved oxygen from bottom waters of the Bay, as driven by decay of settling organic material, historical organic deposits, and hydrodynamic factors, has important water quality and ecological consequences (Officer et al.(1984); Seliger et al.,1985). This process promotes release of soluble nutrients from the bottom sediments (further aggravating the eutrophication problem) and limits habitat for shellfish, finfish, and other aquatic life.

Figure 25 displays average dissolved oxygen at 20 meters depth between 1984 and 1987 for each of 9 Bay stations. These values have been derived by averaging measurements between 17 and 23 meters for each date and station. This procedure avoids complex spatial weighting procedures required for consideration of average conditions below the pycnocline. Depletion rates at 20 meters have been employed in previous discussions of historical data (Officer et al.,1984).

Figure 25 shows that anaerobic conditions developed at each station during May or June of each year. Dates at which dissolved oxygen levels dropped below 2 ppm are summarized by station and year in Table 12, along with depletion rates (ppm/day). Spring depletion rates ranged from .1 -.2 ppm/day, and are comparable to the range of .1-.14 ppm/day derived from displays of historical data reported by Officer et al.(1984) and USEPA(1987).

Variations in hydrodynamic factors (e.g., development of density stratification related to spring inflows, Officer et al., 1984) and algal productivity contribute to spatial and temporal variations in oxygen depletion rate. In Segment 3, rates were somewhat higher and dates of anoxia were earlier in 1985, as compared with 1986 and 1987. The reverse appears to be true further downstream in Segment 5 and at the mouth of the Potomac (Station LE2.3).

Officer et al. (1984) state: "Effects of the spring diatom bloom in the lower Chesapeake Bay have to be considered in terms of the

Figure 25
Dissolved Oxygen Depletion at 20 Meters - Bay Stations

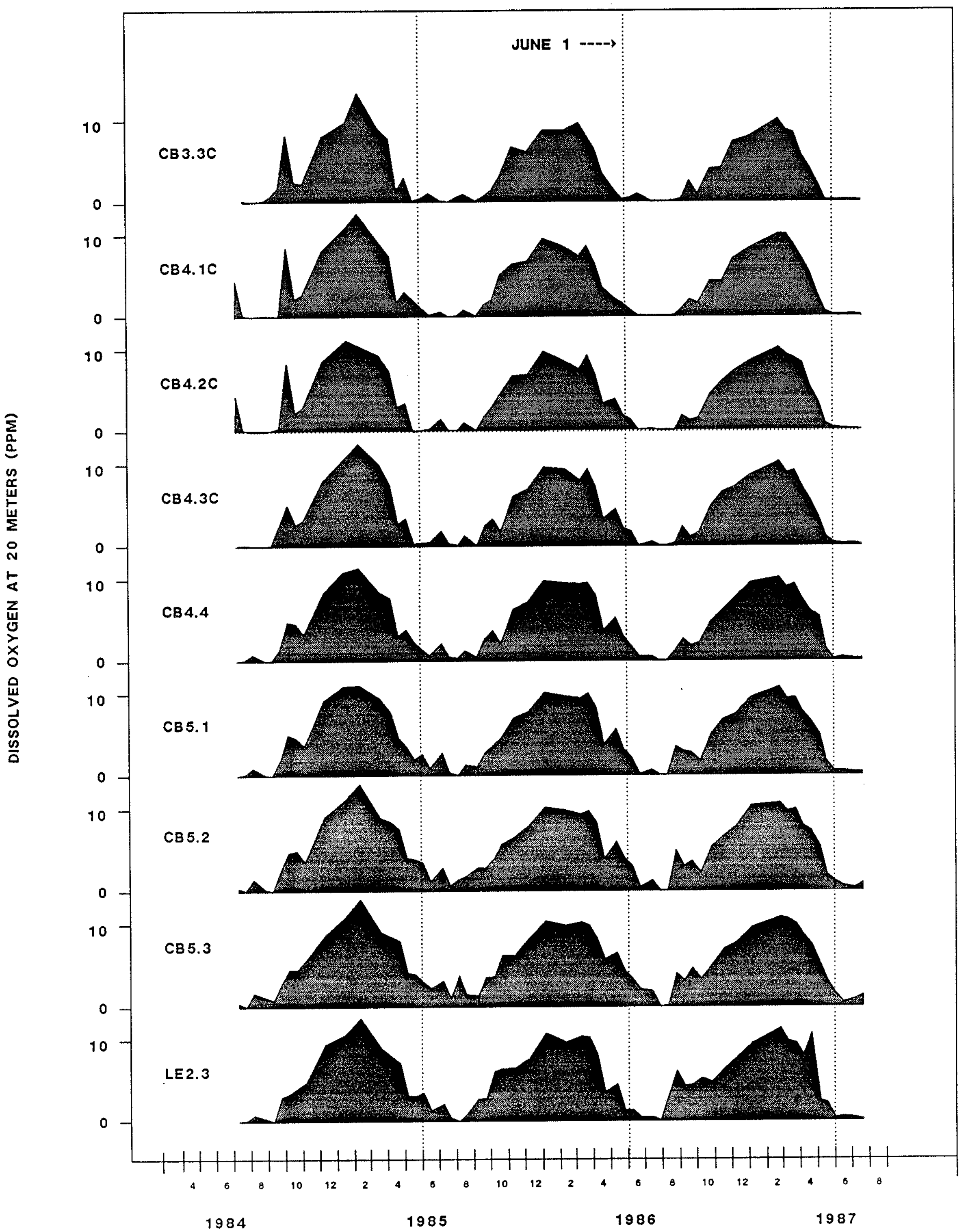


Table 12
Spring Oxygen Depletion at Bay Mainstem Stations

STATION	1985	1986	1987
		YEAR	
ONSET OF ANOXIA - JULIAN DAY (a)			
CB3.1	110	125	125
CB3.3	110	130	130
CB4.1	120	140	130
CB4.2	135	150	135
CB4.3	135	160	135
CB4.4	150	160	135
CB5.1	160	160	140
CB5.2	165	165	140
CB5.3	195	195	150
LE2.3	170	140	140
ONSET OF ANOXIA - DATE (a)			
CB3.1	20-Apr	05-May	04-May
CB3.3	20-Apr	10-May	09-May
CB4.1	30-Apr	20-May	09-May
CB4.2	15-May	30-May	14-May
CB4.3	15-May	09-Jun	14-May
CB4.4	30-May	09-Jun	14-May
CB5.1	09-Jun	09-Jun	19-May
CB5.2	14-Jun	14-Jun	19-May
CB5.3	14-Jul	14-Jul	29-May
LE2.3	19-Jun	20-May	19-May
AVERAGE DEPLETION RATE (PPM/DAY) (b)			
CB3.1	0.20	0.16	0.16
CB3.3	0.21	0.16	0.16
CB4.1	0.20	0.14	0.15
CB4.2	0.15	0.12	0.15
CB4.3	0.15	0.12	0.15
CB4.4	0.12	0.11	0.15
CB5.1	0.11	0.11	0.15
CB5.2	0.10	0.10	0.16
CB5.3	0.10	0.09	0.14
LE2.3	0.10	0.15	0.15

a Anoxia Defined as D.O. < 2 ppm; Depths Fixed at 20 meters Dates of Anoxia Estimated by Interpolation between Sampling Dates; Estimates Accurate to within Approximately One Week

b Mean Slope of Depletion Rate Curve from Early Spring (Approx. April 10) until D.O. Drops below 2 ppm contribution to the expanded hypoxic conditions and the loading of organic detritus through gravitational circulation to the mid-bay region". This concept is supported by 1985-1987 data. The early development of anoxic conditions in Segment 5 is correlated with the major diatom bloom which occurred in this region during Spring of 1987 and with the high productivity rates calculated for this location and time period (Figure 21). Dissolved oxygen variations with depth at Station CB5.2 and corresponding surface chlorophyll-a concentrations are displayed in Figure 26. Anoxia developed at this location approximately one month earlier in 1987, as compared with 1985 and 1986.

It is unlikely that hydrodynamic factors can explain the development of anoxia early in 1987. Vertical differences (20 meters vs. surface) in salinity, temperature, dissolved oxygen) and surface chlorophyll-a at Station CB5.2 are shown in Figure 27. Vertical salinity differences and contours (Figure 28) were similar in 1985-1987, as distinct from 1984, when high spring and summer inflows established strong gradients (Seliger et al.,1985). As shown in Figure 27, the temperature difference peaked at 8 deg C in early June 1987, about two weeks after the maximum oxygen difference. While stronger temperature gradients would also contribute to development of bottom anoxia, density stratification is controlled primarily by variations in salinity in these measurement ranges. For example, a salinity difference of 7 ppt would correspond to a density difference of about .006 g/cm^3, whereas a temperature difference of 8 deg-C (maximum observed) would correspond to a density difference of about .002 g/cm^3. The development of a strong temperature gradient in 1987 may have been a secondary effect of the coincident algal bloom, which would have increased the absorption of light and heat in the surface layer. Thus, the algal bloom may have contributed to the early development of anoxia by supplying abundant quantities of settling organic materials and enhancing vertical density stratification.

Seliger et al. (1985) described the development of northern bay anoxia in 1984 as "catastrophic". They noted that dissolved oxygen concentrations below the pycnocline decreased to zero during June, two

Figure 21
Salinity, Temperature, Oxygen Differences, and Surface Chlorophyll-a
Station CB5.2
(Temp. & Oxygen Diff. = Surface - 20 m; Salinity Diff. = 20 m - Surface)

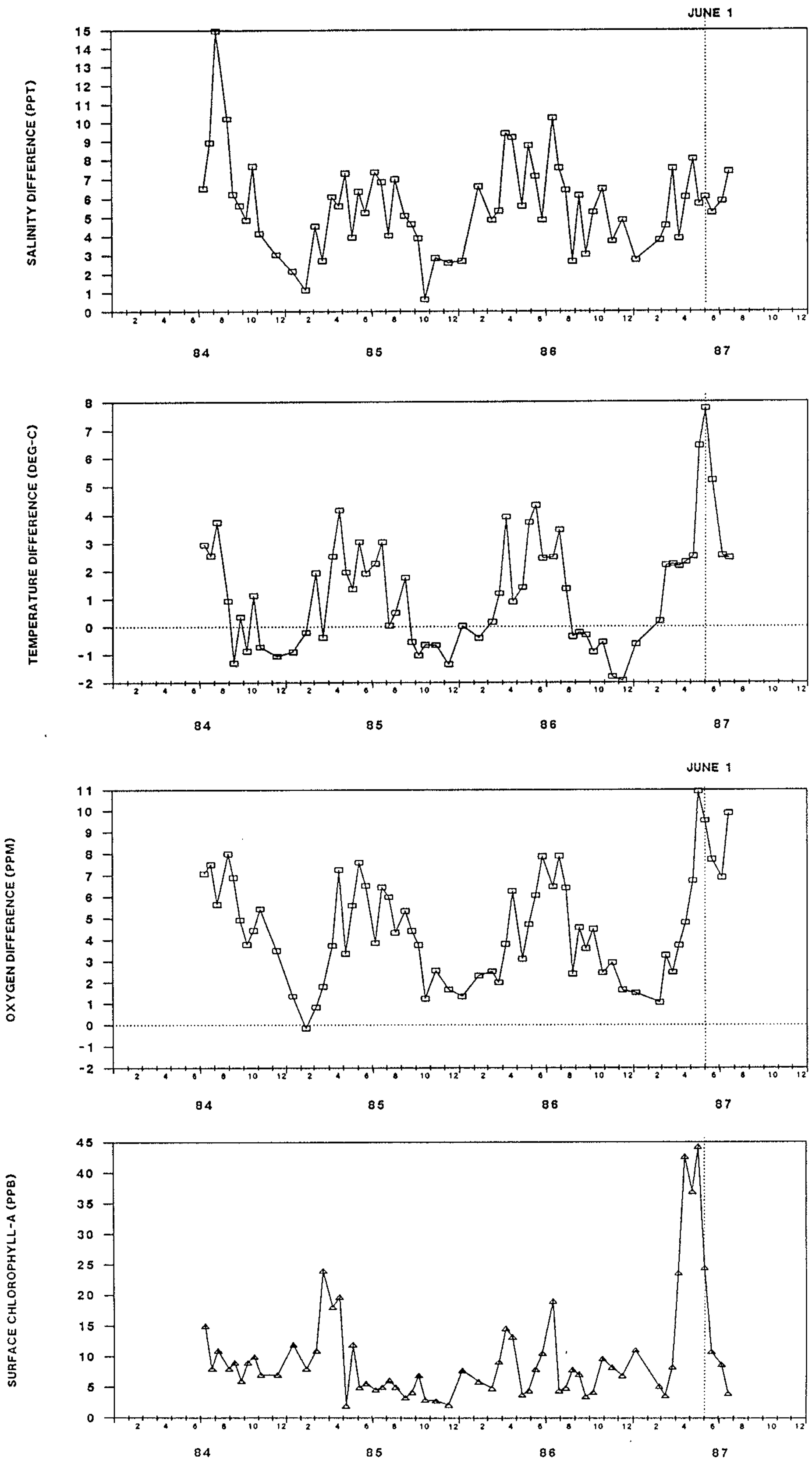


Figure 28
Salinity Contours at Bay Station CB5.2

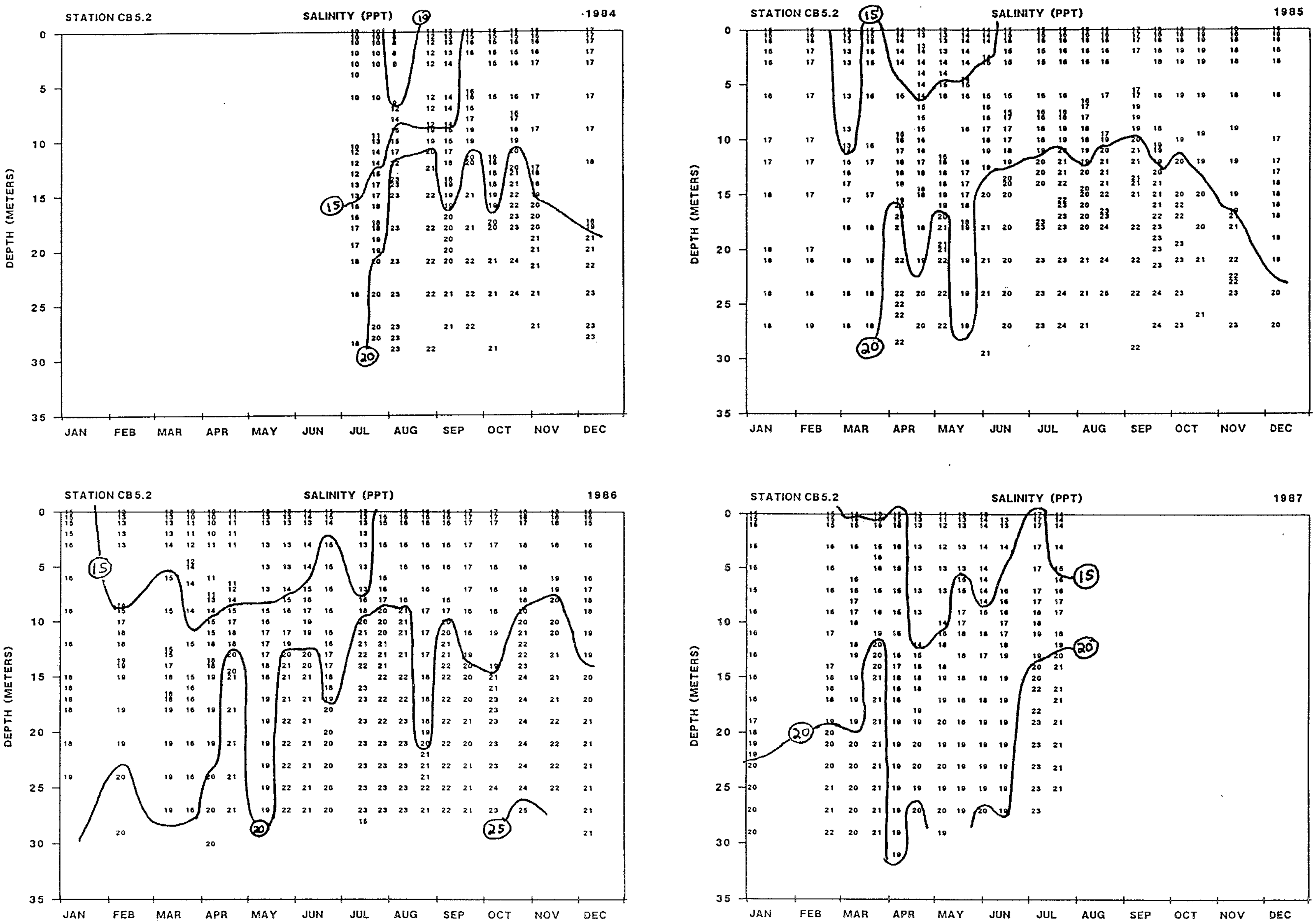
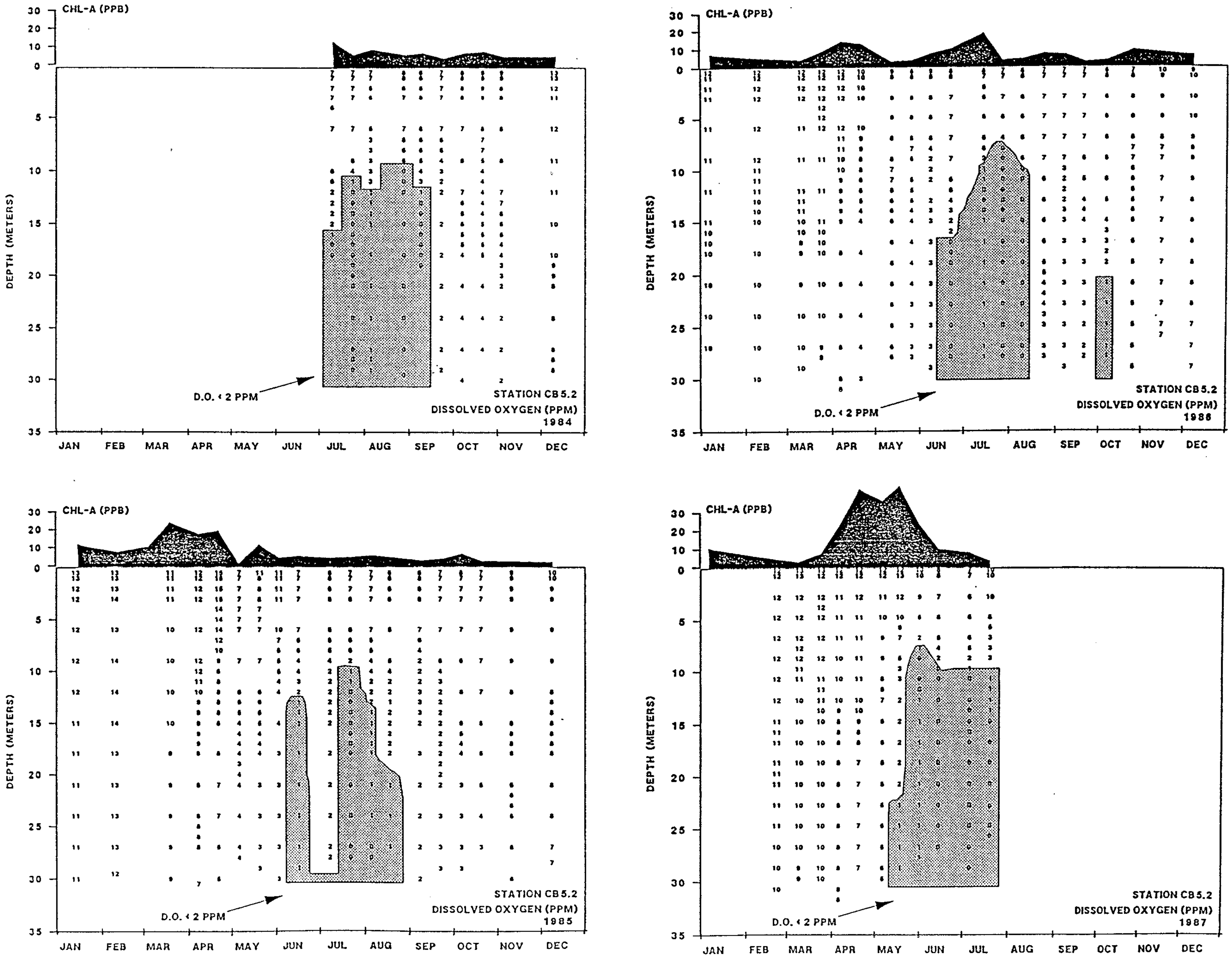


Figure 26
Chlorophyll-a and Oxygen Depletion at Bay Station CB5.2



months earlier than for previous wet years. Based upon the dates of oxygen depletion and maximum vertical extent of anoxia (approaching 6 meters at Station CB5.2, Figure 26), conditions during 1985 and 1986 were at least as "catastrophic" as those observed in 1984, if not more so, despite lower flow regimes and less density stratification.

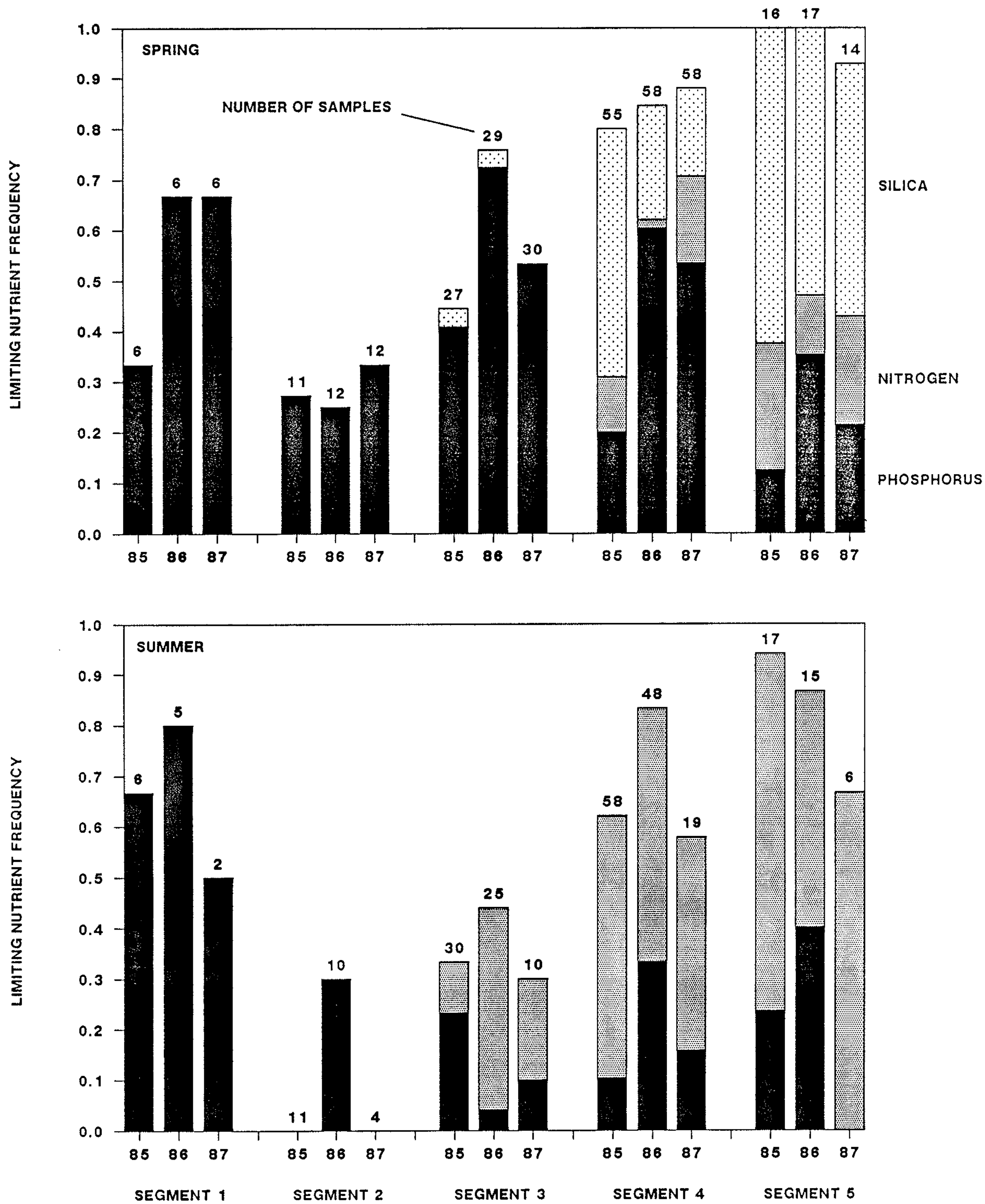
As noted by Seliger et al.(1985), most of the remaining viable shellfish beds in Maryland are located in Eastern Bay and the Choptank and Potomac Rivers, including the St. Mary's River, a tributary near the mouth of the Potomac. These areas with high resource value include regions impacted by the Spring 1987 diatom bloom and subsequent early anoxia.

CONSEQUENCES OF SHIFTS IN LIMITING NUTRIENT

Soluble nutrient data, productivity calculations, and formal modeling efforts (USEPA,1987) indicate that algal growth in Chesapeake Bay is not controlled exclusively by phosphorus. As summarized in Figure 29, phosphorus is the primary limiting nutrient in and above Segment 2 during all seasons and in Segment 3 during Spring. Nitrogen limits peak biomass levels in and below Segment 3 during Summer. Spring silica limitation is important in Segments 4 and 5. The importance of factors other than phosphorus has implications for evaluating the benefits of the detergent ban and other phosphorus control strategies intended to address the Bay's eutrophication problems.

When a phosphorus-limited system is coupled (in time or space) with a nitrogen-limited system, one effect of controlling phosphorus sources alone is to displace productivity from the P-limited to the N-limited system. This occurs because reducing productivity in the P-limited system reduces uptake and trapping of nitrogen and thereby increases transport of nitrogen downstream. This concept also applies when the downstream system is limited by silica, or when any spatial or temporal shift in limiting nutrient occurs.

Figure 29
Limiting Nutrient Frequencies by Segment and Season



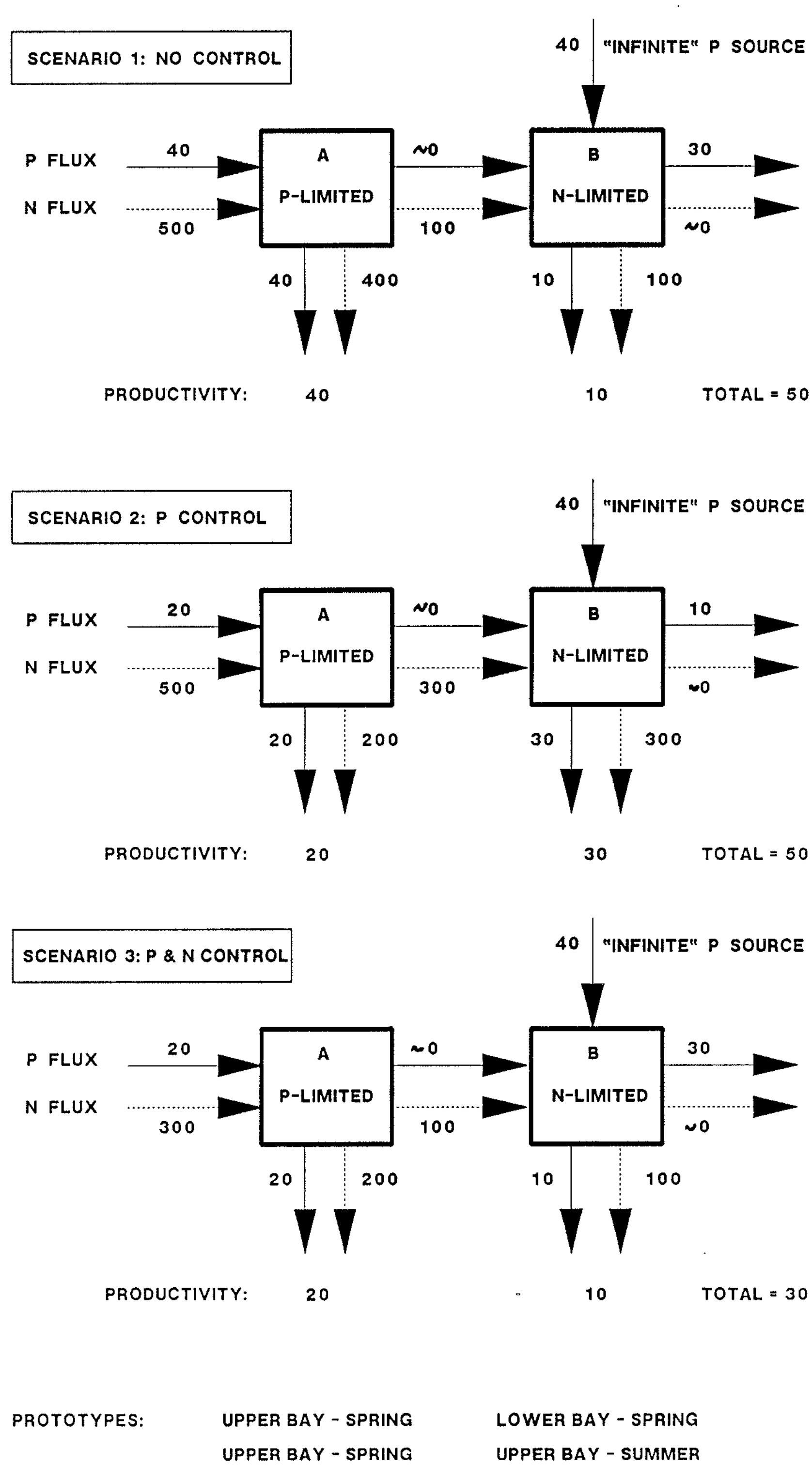
This conceptual model is illustrated in Figure 30. Systems "A" (phosphorus-limited) and "B" (nitrogen-limited) are coupled in space and/or time ("B" receives "left-overs" from "A"). Productivity and nutrient trapping in each system (represented by downward arrows) are assumed to be controlled by either nitrogen or phosphorus. Productivity removes nitrogen and phosphorus from each system at a fixed N/P ratio of 10, until the supply of one of the nutrients is exhausted. The remaining nutrients are transported to the downstream segment. System "A" is fed by external phosphorus and nitrogen fluxes, which are manipulated under Scenarios 1 (No Control), 2 (Phosphorus Control), and 3 (Phosphorus and Nitrogen Control). System "B" is fed by outflow from System "A" and by an "Infinite P Source". The latter could reflect, for example, bottom sediment releases and exchange with ocean waters. The magnitude of the infinite P source and its nitrogen content are irrelevant for the purposes of these calculations, as long it is sufficient to maintain "B" in a nitrogen-limited state (typical of marine waters).

Without loading controls (Scenario 1), productivities of 40 and 10 (arbitrary units) are calculated for Systems "A" and "B", respectively. The effect of phosphorus control (Scenario 2, reducing external phosphorus loading from 40 to 20), is to decrease the productivity in Segment "A" from 40 to 20 and to increase the productivity in Segment "B" from 10 to 30. Depending upon flow balances, surface areas, etc., phosphorus controls alone could decrease the maximum productivity. Total productivity (A+B), a relative indicator of organic loading and resulting oxygen depletion, is unchanged, however. Scenario 3 shows that reductions in both phosphorus and nitrogen are required to reduce the total productivity of both systems.

In the Bay, Systems "A" and "B" are also coupled because of tidal influences and salinity intrusion, which cause transport of a portion of the nutrients trapped in System "B" back upstream to System "A". If the conceptual model were modified to account for this relationship, the benefits of phosphorus control alone would be further diminished. Reductions in external phosphorus loadings to System "A" would be

Figure 30

Conceptual Model of Coupled Phosphorus-Limited and Nitrogen-Limited Systems



partially offset by increased nutrient deposition in System "B" and subsequent upstream transport in saline bottom waters.

This conceptual model can be considered in relation to Bay monitoring data for the 1984-1987 period. As shown in Figure 29, phosphorus is the primary limiting nutrient in Bay Segment 3 during Spring. Moving downstream during this season, however, silica and nitrogen become increasingly important. Similarly, moving from Spring to Summer within Segment 3, nitrogen becomes the controlling factor. Figure 20 indicates that spring algal bloom frequencies decreased in Segment 3 between 1985 and 1987. Corresponding increases in bloom frequencies were observed in Segments 4 and 5 during Spring and in Segment 3 during Summer. Formal modeling would provide more detailed insights and help to sort out effects of changes in flow, mixing, etc.. The algal response pattern is not inconsistent with expectations based upon the observed patterns in limiting nutrients.

Model simulations (USEPA(1987), p.8) of alternative management strategies show that control of phosphorus alone results in the transport of additional nitrogen to the lower Bay and subsequent stimulation of algal growth to levels which equal calibration levels. The predicted response of average chlorophyll-a concentration to additional phosphorus loading controls is sluggish; a 40% reduction of phosphorus loading below 1985 levels would result in a 10% reduction in chlorophyll-a for 1984 circulation (USEPA,1987). Model results also indicate that control of phosphorus alone moves the zone of phosphorus limitation further downstream. The extent to which the existing Bay model reflects the impacts of shifts in limiting nutrient as a function of season and location is unclear, however, because the model is steady-state, silica limitation is not considered, and there is considerable uncertainty with respect to the simulation of sediment nutrient fluxes, which have important influences on summer conditions in the Bay.

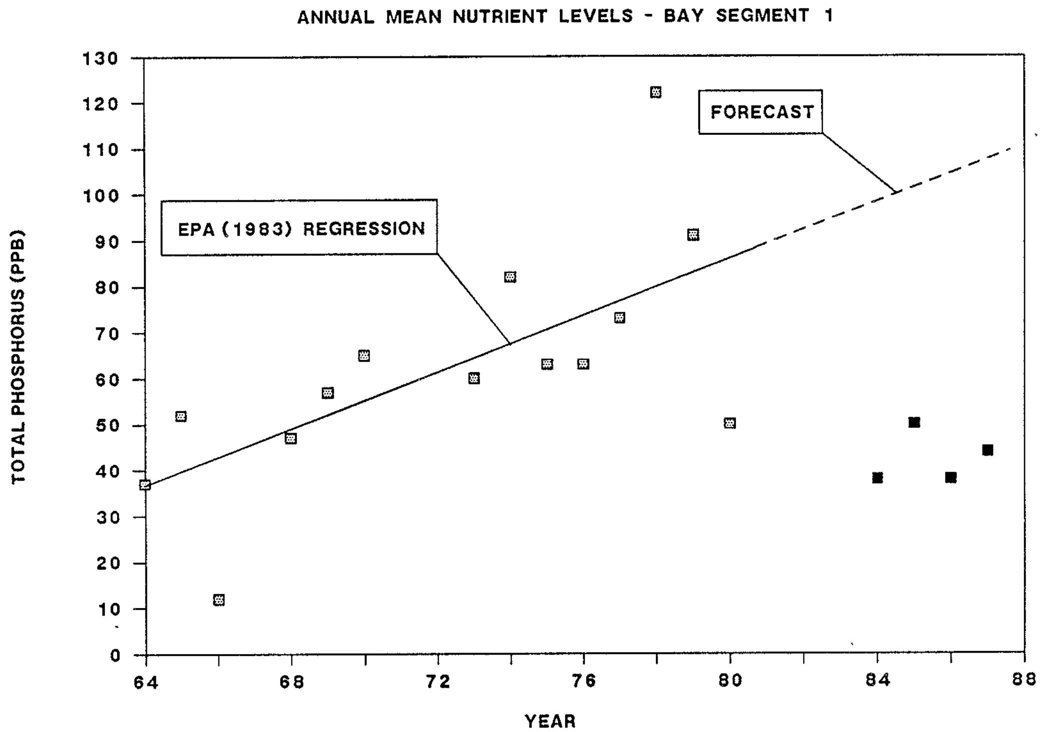
Although phosphorus controls implemented since the 1970's have apparently resulted in reductions in mean and maximum chlorophyll-a concentrations in the Upper Bay (USEPA,1987), there is no evidence that rates of oxygen depletion or seasonal volumes of anoxic water have decreased. Based upon spatial and seasonal patterns in limiting nutrient, nitrogen controls will have to be implemented in order to achieve significant reductions in the overall productivity of the Bay and resulting oxygen depletion.

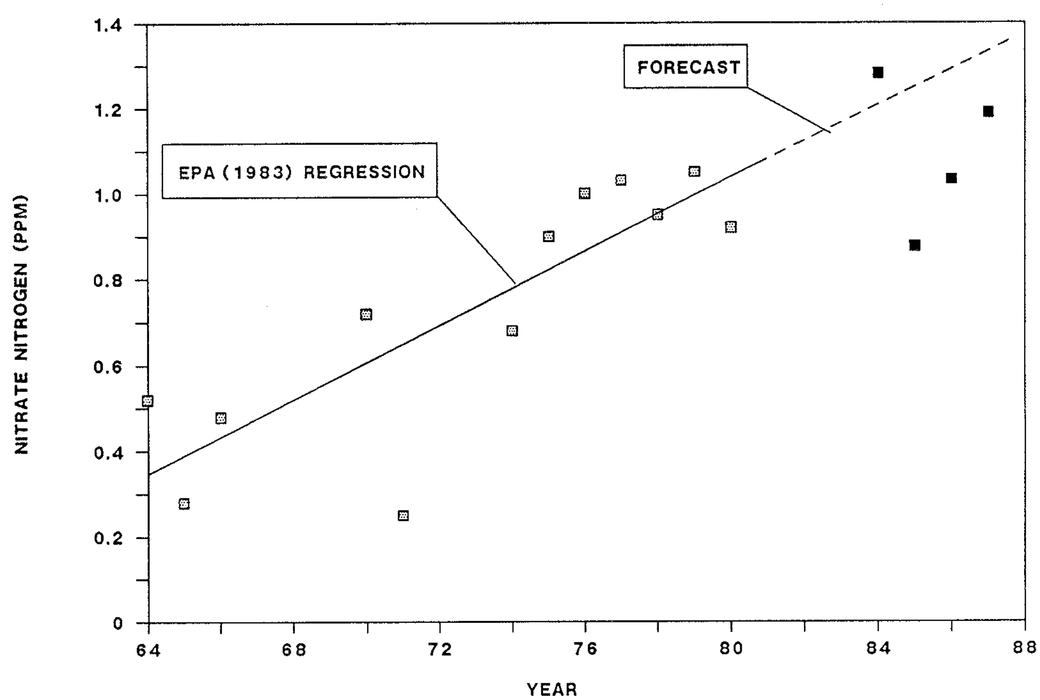
Historical data from Bay Segment 1 (mouth of Susquehanna River) indicate that phosphorus concentrations in recent years and are well below levels forecast based upon USEPA(1983) regression analysis of pre-1981 data (Figure 31). In contrast, nitrate nitrogen levels have continued to increase since the early 1960's. As indicated in Table 7, nonpoint loadings and the Susquehanna River account for an estimated 86% of the total nitrogen loading to the Maryland portion of the Bay. Unit export of nitrogen from the Susquehanna River (5180 lbs/mi^{2}-yr) is 78% higher than that observed in the Choptank River (2914 lbs/mi^{2}-yr).

The importance of both nitrogen and phosphorus in controlling Bay productivity is reflected in the Draft Bay Agreement, which calls for a 40% reduction in both N and P loadings below 1985 levels (USEPA,1987). Using 30,845 lbs/day as a reference total phosphorus loading (Table 7), the detergent ban under 1986 effluent limits would account for a reduction of 5.4% (1681 lbs/day = 112 mgd @ 1.8 ppm). Under 1987 effluent limits, load reductions attributed to the ban are reduced to 3.4% (1066 lbs/day = 71 mgd @ 1.8 ppm). In order to achieve the desired 40% reduction in phosphorus loadings, it seems likely that phosphorus effluent limits would have to be established at additional plants. Sellars(1985) estimated that the total effluent volume from minor plants in Maryland (<1 mgd) was 25 mgd. Taking this as an estimate of the "ultimate" volume of wastewater not subject to phosphorus effluent limits, the ultimate load reductions attributed to the ban could amount to 1.2% (375 lbs/day = 25 mgd @ 1.8 ppm). Consideration of phosphorus attenuation in stream segments (ignored in these calculations) would further reduce this impact.

Because of the importance of other growth-limiting factors, changes in algal productivity resulting from the ban would be less than the

Figure 31
Historical Phosphorus and Nitrate Levels - Bay Segment 1





percentage changes in phosphorus loading. Taking the chlorophyll/phosphorus response predicted by the existing Bay model (10%/40%) as an approximate estimate of sensitivity, reductions in algal productivity attributed to the ban would range from 0.3 to 0.8% for effluent volumes in the range of 25 to 71 mgd without phosphorus limits.

CONCLUSIONS

(1) At river monitoring stations with high upstream effluent densities (Patuxent, Monocacy, Antietam Rivers), mass-balance calculations show that observed reductions in stream phosphorus loadings under low-flow conditions following the phosphate detergent ban were consistent with the average observed reduction in effluent phosphorus concentrations at Maryland treatment plants without phosphorus effluent limits (95% confidence range for reduction in mean sewage effluent concentration = 1.4 - 2.2 ppm). This suggests that under conditions of low flow (less than mean annual flow), reductions in point-source phosphorus lead to equivalent reductions in stream phosphorus loads in these rivers. Limited sampling frequency and high variability preclude direct assessment of point-source effects under high-flow conditions. Estimates of annual or seasonal loading changes attributed to the ban assume that mass-balance relationships observed under low flows hold over the entire range of flows.

(2) Detailed evaluation of biological responses at river monitoring stations to phosphorus reductions is infeasible with the existing data base. Soluble reactive phosphorus concentrations at river stations generally exceed algal growth-limiting levels and physical factors (velocity, residence time, temperature) are more important than nutrient concentrations in regulating algal productivity. For this reason, algal growth is less of a problem and less sensitive to nutrient levels in river segments, as compared with downstream estuary and Bay segments, which provide a more suitable habitat for algal growth. This is illustrated by data from a Patuxent River station (PXT0603) which was monitored more intensively for nutrient and biological parameters than the other river stations studied. As a combined result of variations in flow and the phosphate detergent ban, summer-mean total phosphorus concentrations

decreased from 875 ppb in 1985 to 413 ppb in 1986, while chlorophyll-a concentrations remained at very low levels (3.3 ppb in 1985 and 3.6 ppb in 1986).

(3) Based upon quarterly mass-balances for the Maryland portion of Chesapeake Bay, the ban could account for phosphorus loading reductions in the range of 2.4 to 11.1% for the January 1986 to September 1987 period, assuming no attenuation of point-source loadings above the Fall Line and ignoring atmospheric and bottom sediment sources of phosphorus. These reductions are attributable to the 112 mgd sewage effluent volume without phosphorus limits during this period. Percentage reductions corresponding to the 71 mgd effluent volume without phosphorus removal after 1987 range from 1.8 to 7.1%. These figures are based upon mass balances developed over a period of relatively low runoff for all major Bay tributaries; percentage reductions attributed to the ban would be lower for periods of average or above-average runoff.

(4) Mass-balance calculations also indicate that as a combined result of variations in flow, non-point loadings, wastewater treatment plant upgrades, and the phosphate detergent ban, phosphorus loadings to the Maryland portion of the Bay were 11% lower in Spring 1986, as compared with Spring 1985. Summer loadings were lower by 25%.

(5) Consistent with variations in loading, statistically significant ($p<.10$) decreases in seasonal mean phosphorus (total, ortho, dissolved) concentrations were measured at several Bay and estuary stations between 1985 (pre-ban) and 1986 (post-ban). Spring total phosphorus concentrations were significantly lower at 10 stations out of 37 with sufficient data; summer concentrations were lower at 7 stations out of 40.

(6) In comparing 1985 vs. 1986 spring and summer conditions at Bay and estuary stations, significant reductions in phosphorus concentration were observed simultaneously with significant reductions in algal density (chlorophyll-a) in 1 comparison out of 77. Further investigation of data from this station (Choptank River) indicated that the apparent reductions in phosphorus and chlorophyll-a could be attributed to variations in streamflow. The lack of detectable biological response to reductions in phosphorus at several locations is consistent with the spatial and seasonal distributions of limiting nutrients (nitrogen, phosphorus, silica), with statistical difficulties associated with detecting small changes in algal densities, and with results of model simulations conducted to evaluate the sensitivity of algal primary production to changes in soluble nutrient concentrations as a function of time and location in the Bay.

(7) A major algal bloom occurred in Bay Segment 5 (mouth of Patuxent to Virginia state line) during Spring 1987. This bloom was sustained for a period of approximately 2 months. Peak algal biomass (chlorophyll-a > 40 ppb) was limited by silica in Spring and by nitrogen later in Summer. In conjunction with this bloom, depletion of dissolved oxygen from bottom waters occurred approximately one month earlier than observed in 1985 and 1986.

(8) Blooms also occurred in the Bay between Annapolis and the mouth of the Patuxent River during Summers of 1984, 1985, 1986 and 1987. They were generally accompanied by rapid increases in ortho phosphorus and ammonia concentrations, apparently caused by upwelling of nutrient-rich bottom waters, but peak biomass levels were controlled by nitrogen.

(9) Data evaluated in this study suggest that no improvement in Bay conditions occurred over the 1984-1987 time period with respect to algal productivity or compliance with management goals, despite reductions in phosphorus loadings attributed to the phosphate detergent ban, improved wastewater treatment, and other factors. The frequencies of observed chlorophyll-a values exceeding the 15 ppb management goal were 19.8% in 1984-1985 and 21.6% in 1986-1987. The timing, rate, and maximum vertical extent of oxygen depletion in 1986-1987 were at least as severe as those measured in previous years, if not more so, particularly in southern portions of the Bay.

(10) Despite significant reductions in phosphorus loadings to the Upper Bay achieved since the 1970's, nitrogen remains the primary limiting nutrient during Summer below Annapolis. Silica limits peak diatom populations during Spring below the Patuxent River. Under these conditions, the productivity of the Bay and resulting depletion of dissolved oxygen from bottom waters are very insensitive to small changes in phosphorus loadings attributed to the detergent ban. Benefits of phosphorus controls are partially offset by displacement of nitrogen, silica, and productivity to lower regions of the Bay, where most of the remaining viable shellfish beds are located.

(11) Additional focus on nitrogen loadings is required if significant reductions in productivity and oxygen depletion are to be realized. Nutrient balance computations indicate that Maryland point sources account for only 14% of the total nitrogen loading to the Maryland portion of the Bay. This suggests the relative importance of addressing nonpoint nitrogen loadings.

(12) Nitrogen loadings calculated from point-source inventories and recent intensive monitoring at Fall Line stations indicate that previous studies (USEPA,1983; Fisher et al.,1988) may underestimate total nitrogen loadings to the Bay by as much as 50%. Previous estimates were based upon watershed modeling and do not reflect increasing trends in nonpoint nitrogen loadings, particularly from the Susquehanna River. The significance of acid rain and other nonpoint sources of nitrogen may be considerably greater than stated in a recent report by the Environmental Defense Fund (Fisher et al., 1988).

(13) The importance of controlling nitrogen, as well as phosphorus, in order to reduce Bay productivity is reflected in the Draft Bay Agreement, which calls for a 40% reduction in both N and P loadings below 1985 levels (USEPA,1987). For a 25-71 mgd range of effluent volumes that may not be subject to phosphorus effluent limits in the future, reductions in phosphorus loading to the Maryland portion of the Bay attributed to the ban would amount to 1.2-3.3% of the 1985 loading. Because of the importance of growth-limiting factors other than phosphorus, corresponding percentage reductions in algal productivity would be lower (perhaps in the range of .3 to .8%, based upon interpolation of USEPA (1987) model results).

(14) The full range of costs and benefits must be considered in evaluating the phosphate detergent ban and in comparing it with alternative strategies for achieving the same management objectives. Considering the small changes in phosphorus loading resulting from the ban and the importance of limiting nutrients other than phosphorus, it is clear that the ban in itself contributes little to the cause of restoring the Bay.

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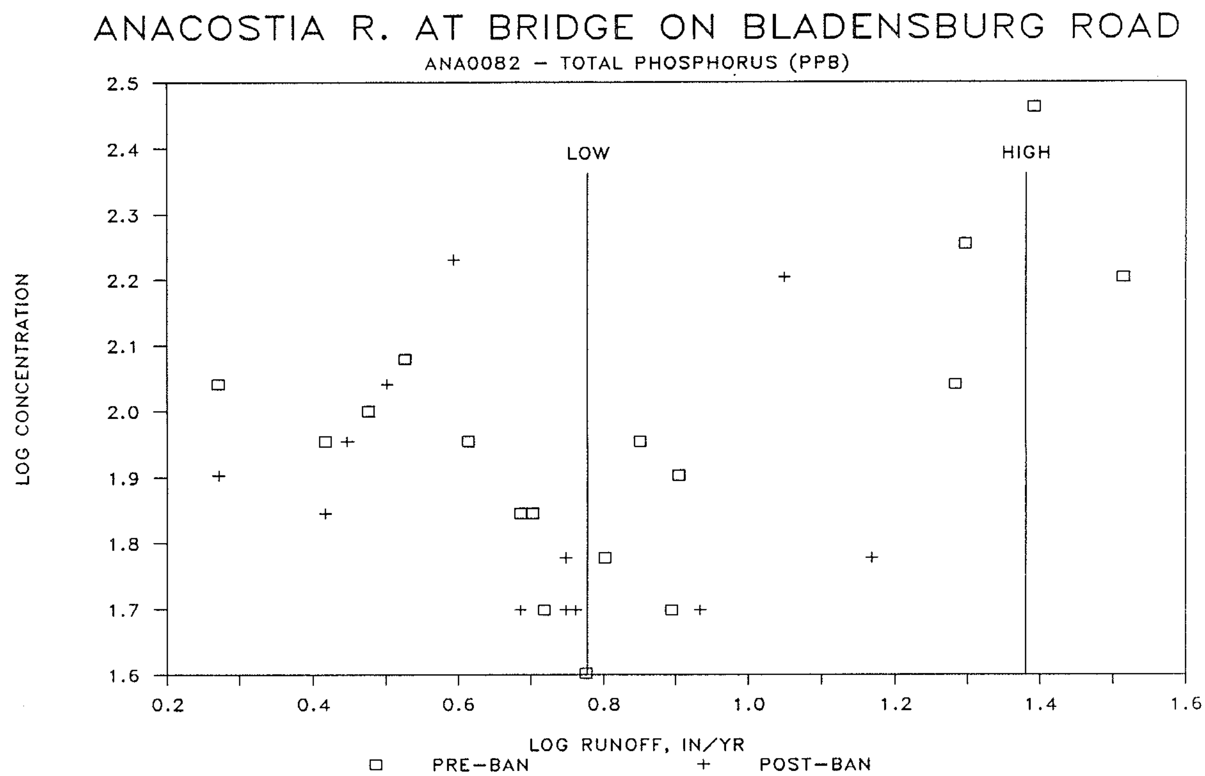
EUTROPHICATION IN CHESAPEAKE BAY BEFORE AND AFTER IMPLEMENTATION OF MARYLAND'S PHOSPHATE DETERGENT BAN

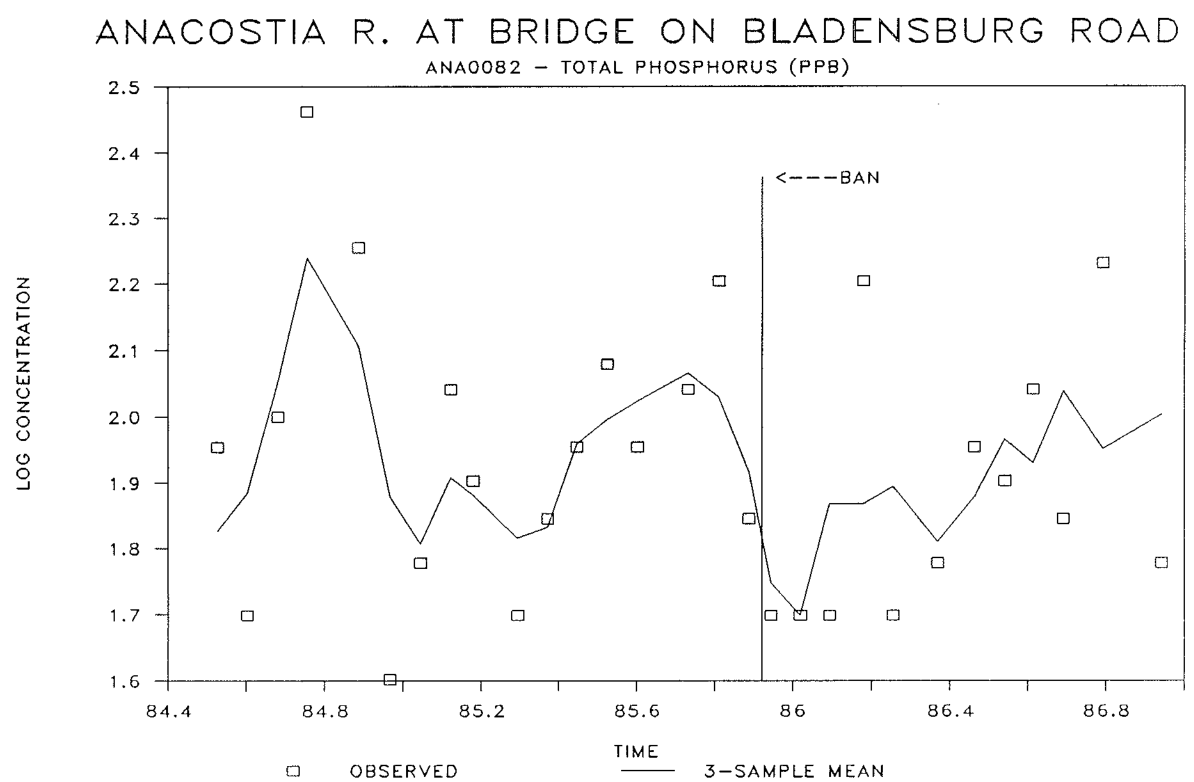
APPENDICES

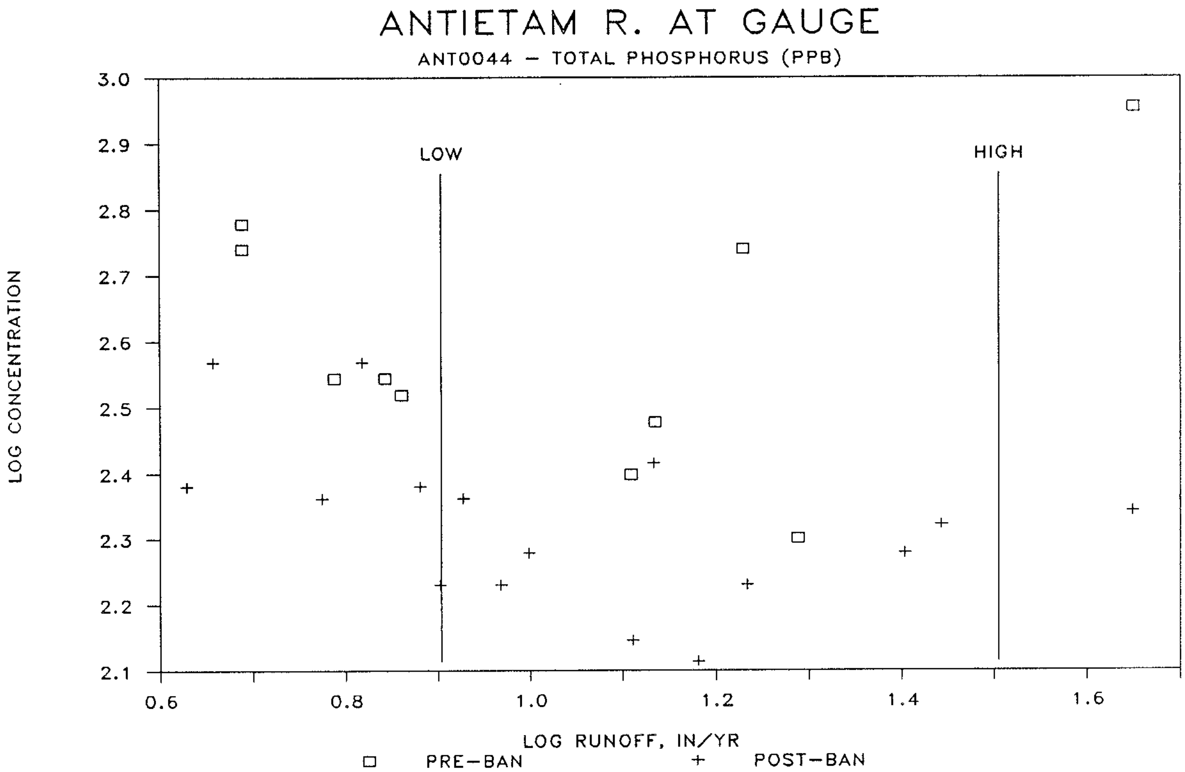
STATION:		---------------- MEAN FLOWS (CFS)					---------------- RUNOFF (INCHES)				
AREA (MI2)		SUSQUE.	CHOPTANK	PATUXENT	POTOMAC	TOTAL	SUSQUE.	CHOPTANK	PATUXENT	POTOMAC	TOTAL
YEAR	MONTH										
83	10	6917	43.1	285.8	4925	12170	0.29	0.44	0.95	0.49	0.36
83	11	22658	140.0	424.2	9906	33128	0.93	1.38	1.36	0.96	0.94
83	12	91451	379.1	1029.8	26645	119505	3.89	3.87	3.41	2.66	3.52
84	1	21011	191.2	407.0	10461	32070	0.89	1.95	1.35	1.04	0.95
84	2	115762	325.4	658.3	39457	156203	4.61	3.11	2.04	3.68	4.31
84	3	55832	468.5	843.1	34429	91573	2.38	4.78	2.79	3.43	2.70
84	4	130960	429.3	843.2	47860	180093	5.39	4.24	2.70	4.62	5.14
84	5	69987	200.4	657.5	19925	90770	2.98	2.04	2.18	1.99	2.67
84	6	53050	141.2	262.1	5433	58886	2.18	1.39	0.84	0.52	1.68
84	7	38672	62.8	371.6	6641	45747	1.65	0.64	1.23	0.66	1.35
84	8	28823	30.2	343.3	11346	40542	1.23	0.31	1.14	1.13	1.19
84	9	9646	17.5	182.8	3257	13103	0.40	0.17	0.59	0.31	0.37
84	10	7983	22.3	155.7	3179	11341	0.34	0.23	0.52	0.32	0.33
84	11	15184	25.4	225.5	4986	20421	0.63	0.25	0.72	0.48	0.58
84	12	55009	39.1	306.1	11911	67265	2.34	0.40	1.01	1.19	1.98
85	1	29817	51.3	173.7	7216	37258	1.27	0.52	0.58	0.72	1.10
85	2	36589	155.3	536.1	20864	58144	1.41	1.43	1.60	1.88	1.55
85	3	56203	73.9	203.9	13033	69514	2.39	0.75	0.68	1.30	2.05
85	4	52153	65.0	167.4	11477	63862	2.15	0.64	0.54	1.11	1.82
85	5	24479	55.5	238.4	9686	34459	1.04	0.57	0.79	0.97	1.02
85	6	16882	30.5	193.6	7575	24681	0.70	0.30	0.62	0.73	0.70
85	7	10702	14.9	134.5	3719	14570	0.46	0.15	0.45	0.37	0.43
85	8	7758	24.5	104.5	2825	10712	0.33	0.25	0.35	0.28	0.32
85	9	10488	95.3	211.4	1755	12550	0.43	0.94	0.68	0.17	0.36
85	10	14284	113.6	163.0	3365	17926	0.61	1.16	0.54	0.34	0.53
85	11	53239	59.2	276.1	42029	95603	2.19	0.58	0.89	4.06	2.73
85	12	53974	103.2	214.9	16696	70988	2.30	1.05	0.71	1.67	2.09
86	1	31890	155.9	218.4	5500	37764	1.36	1.59	0.72	0.55	1.11
86	2	66085	290.5	379.5	25496	92251	2.54	2.68	1.14	2.30	2.46
86	3	101658	197.9	294.3	25236	127386	4.32	2.02	0.97	2.52	3.75
86	4	60910	102.0	328.9	11881	73222	2.51	1.01	1.05	1.15	2.09
86	5	27738	46.7	153.8	6841	34779	1.18	0.48	0.51	0.68	1.02
86	6	30917	19.5	116.4	2856	33909	1.27	0.19	0.37	0.28	0.97
86	7	18032	12.1	102.3	1885	20031	0.77	0.12	0.34	0.19	0.59
86	8	19032	15.5	121.5	1452	20621	0.81	0.16	0.40	0.14	0.61
86	9	7850	10.3	65.2	963	8888	0.32	0.10	0.21	0.09	0.25
86	10	16590	11.7	80.4	1034	17716	0.71	0.12	0.27	0.10	0.52
86	11	50720	30.4	248.0	3705	54703	2.09	0.30	0.80	0.36	1.56
86	12	65420	225.0	335.0	12000	77980	2.78	2.30	1.11	1.20	2.30
87	1	29510	338.0	421.0	11160	41429	1.26	3.45	1.39	1.11	1.22
87	2	22680	254.0	285.0	12680	35899	0.87	2.34	0.85	1.14	0.96
87	3	57630	256.0	366.0	16180	74432	2.45	2.61	1.21	1.61	2.19
87	4	90980	139.0	477.0	45580	137176	3.75	1.37	1.53	4.40	3.91
87	5	28200	108.0	314.0	15300	43922	1.20	1.10	1.04	1.53	1.29
87	6	16010	39.0	216.0	5387	21652	0.66	0.39	0.69	0.52	0.62
87	7	18010	17.0	180.0	4434	22641	0.77	0.17	0.60	0.44	0.67
87	8	6618	6.3	88.0	1089	7801	0.28	0.06	0.29	0.11	0.23
87	9	31420	9.4	131.3	7341	38902	1.29	0.09	0.42	0.71	1.11

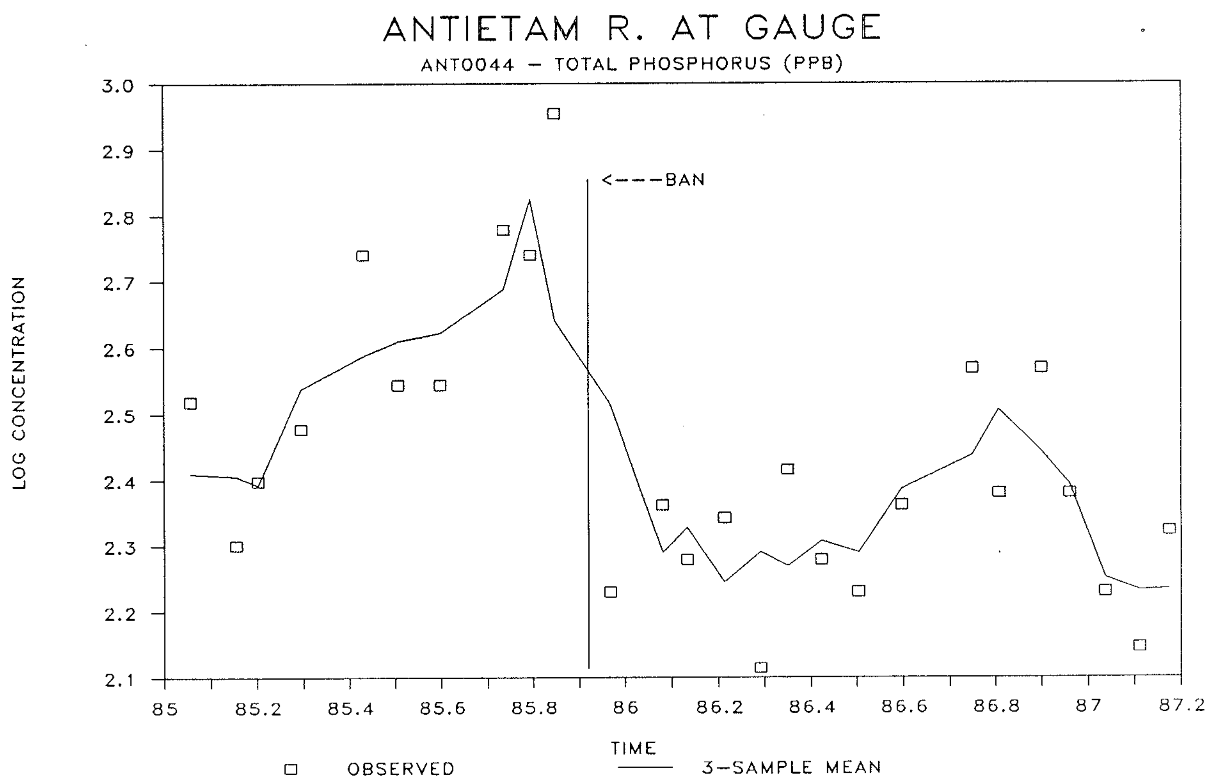
APPENDIX B

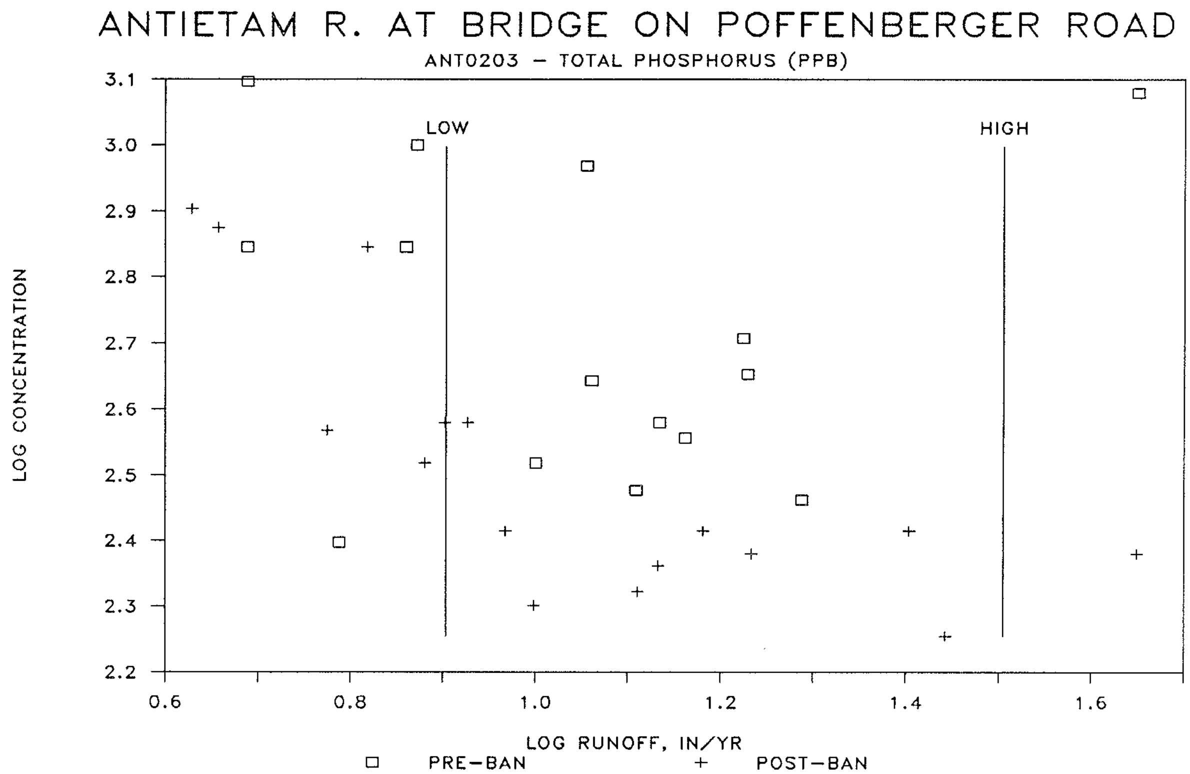
Diagnostic Plots of River Phosphorus Concentrations

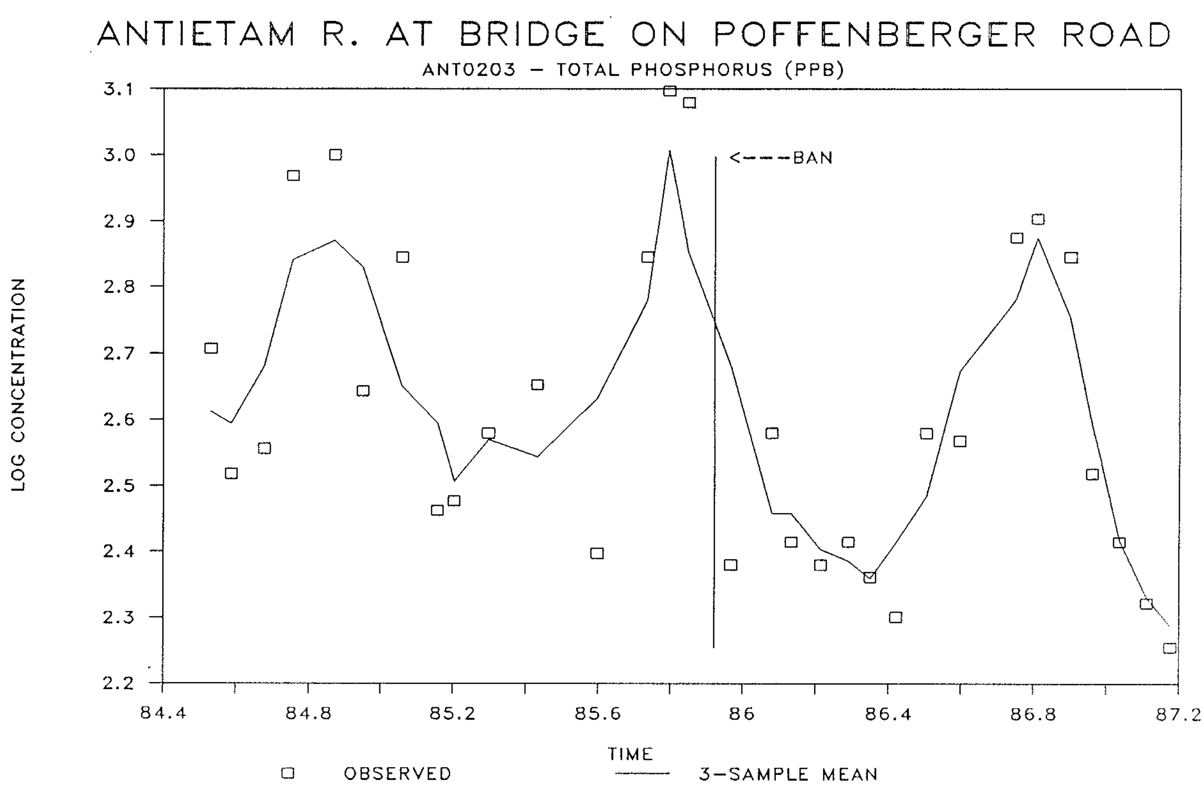

ANACOSTIA R. AT BRIDGE ON BLADENSBURG ROAD
ANA0082 – TOTAL PHOSPHORUS (PPB)
LOW
HIGH
LOG CONCENTRATION
LOG RUNOFF, IN/YR
PRE–BAN
POST–BAN

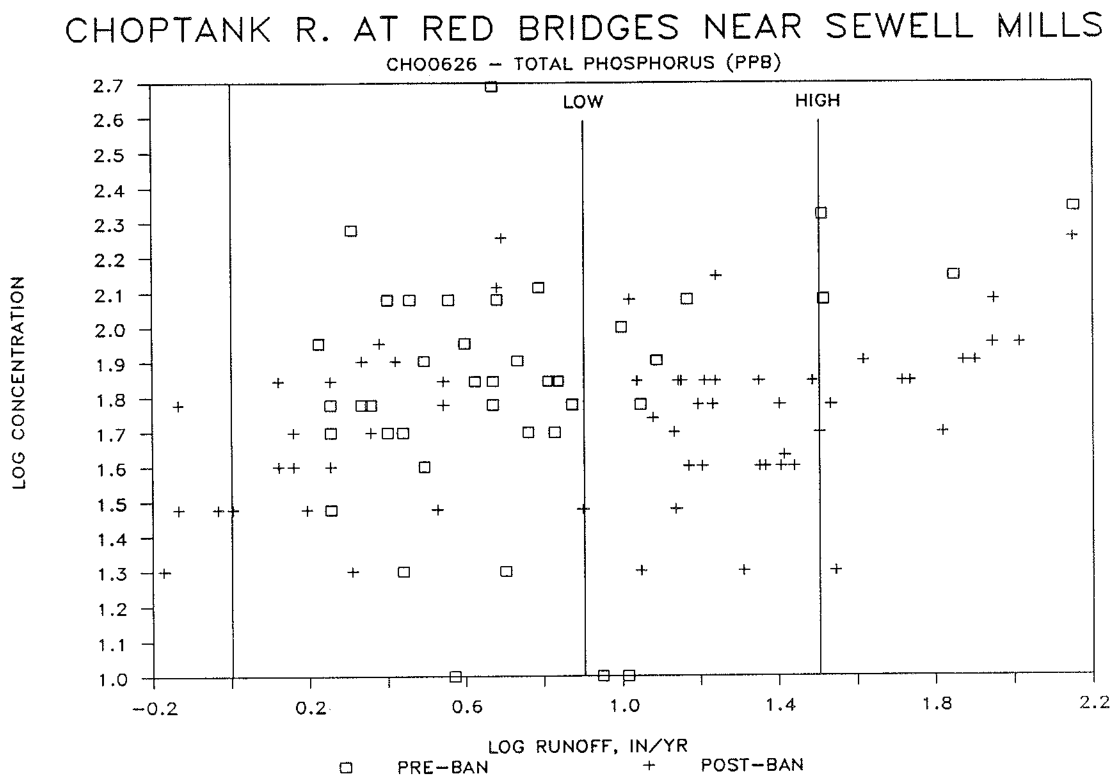

ANACOSTIA R. AT BRIDGE ON BLADENSBURG ROAD
ANA0082 – TOTAL PHOSPHORUS (PPB)
<–––BAN
LOG CONCENTRATION
TIME
OBSERVED
3–SAMPLE MEAN

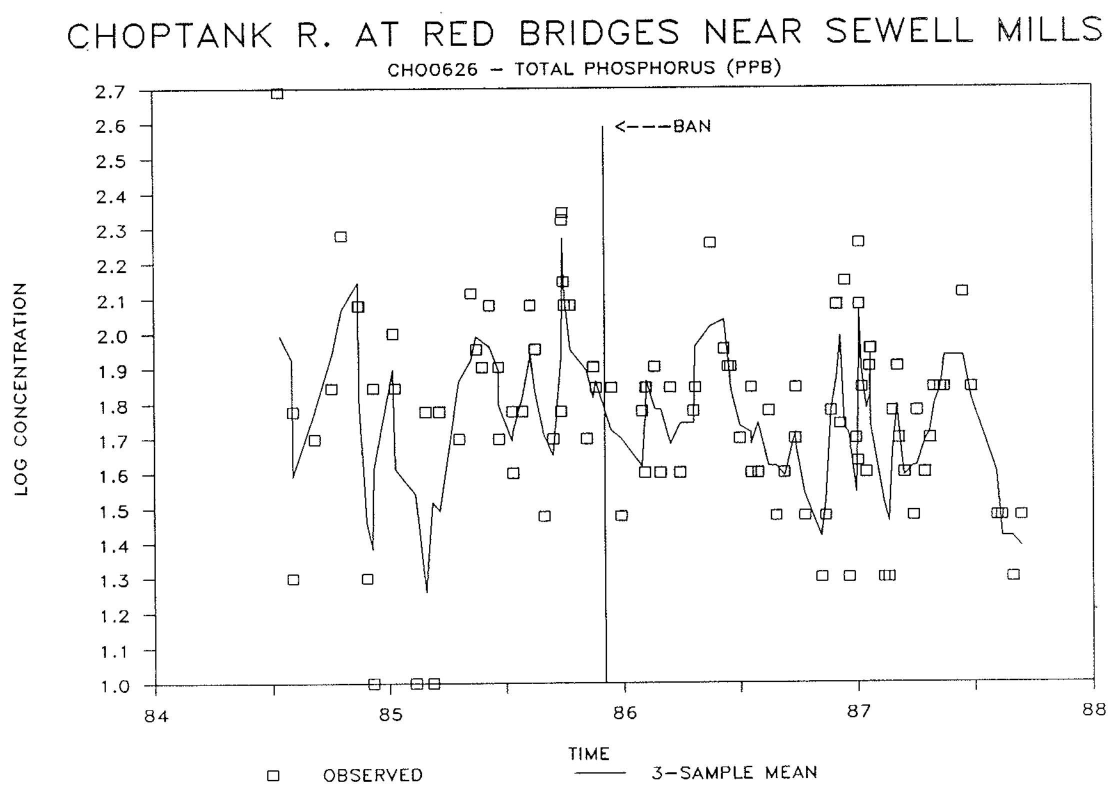

ANTIETAM R. AT GAUGE
ANT0044 – TOTAL PHOSPHORUS (PPB)
LOW
HIGH
LOG CONCENTRATION
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
0.6
0.8
1.0
1.2
1.4
1.6
LOG RUNOFF, IN/YR
PRE–BAN
POST–BAN

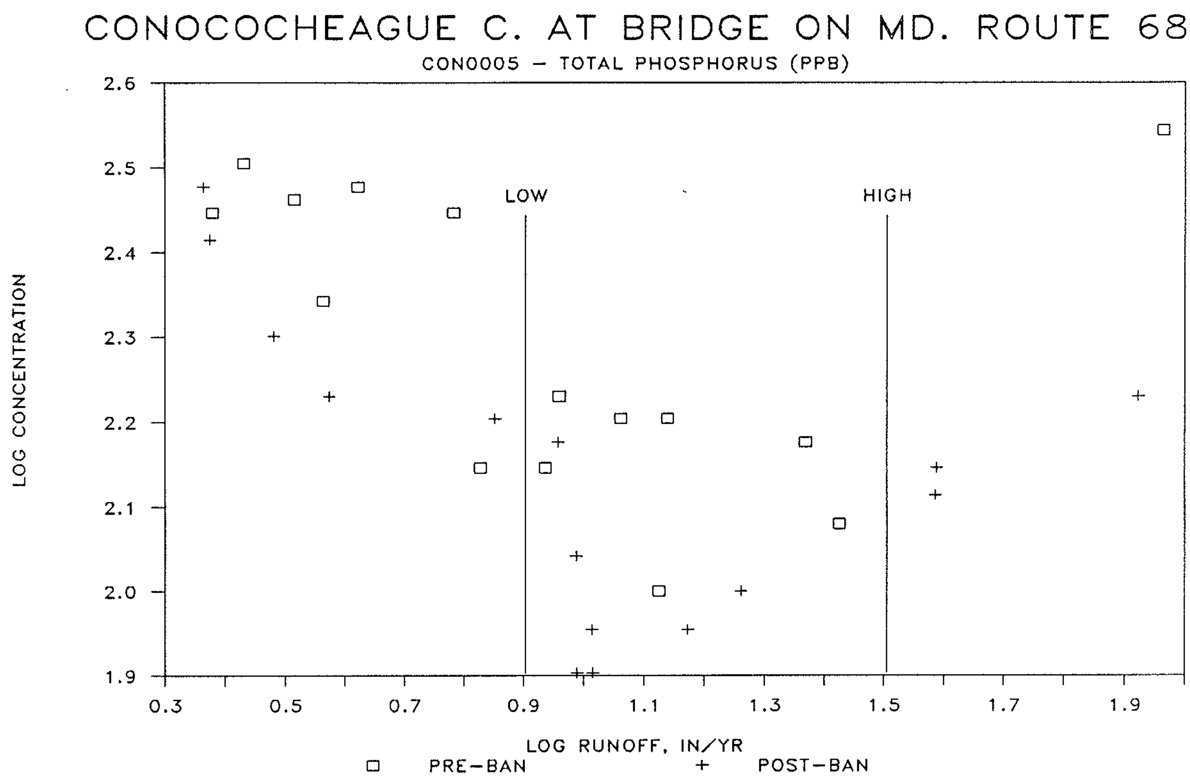

ANTIETAM R. AT GAUGE
ANT0044 – TOTAL PHOSPHORUS (PPB)
<---BAN
LOG CONCENTRATION
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
85
85.2
85.4
85.6
85.8
86
86.2
86.4
86.6
86.8
87
87.2
TIME
OBSERVED
3–SAMPLE MEAN

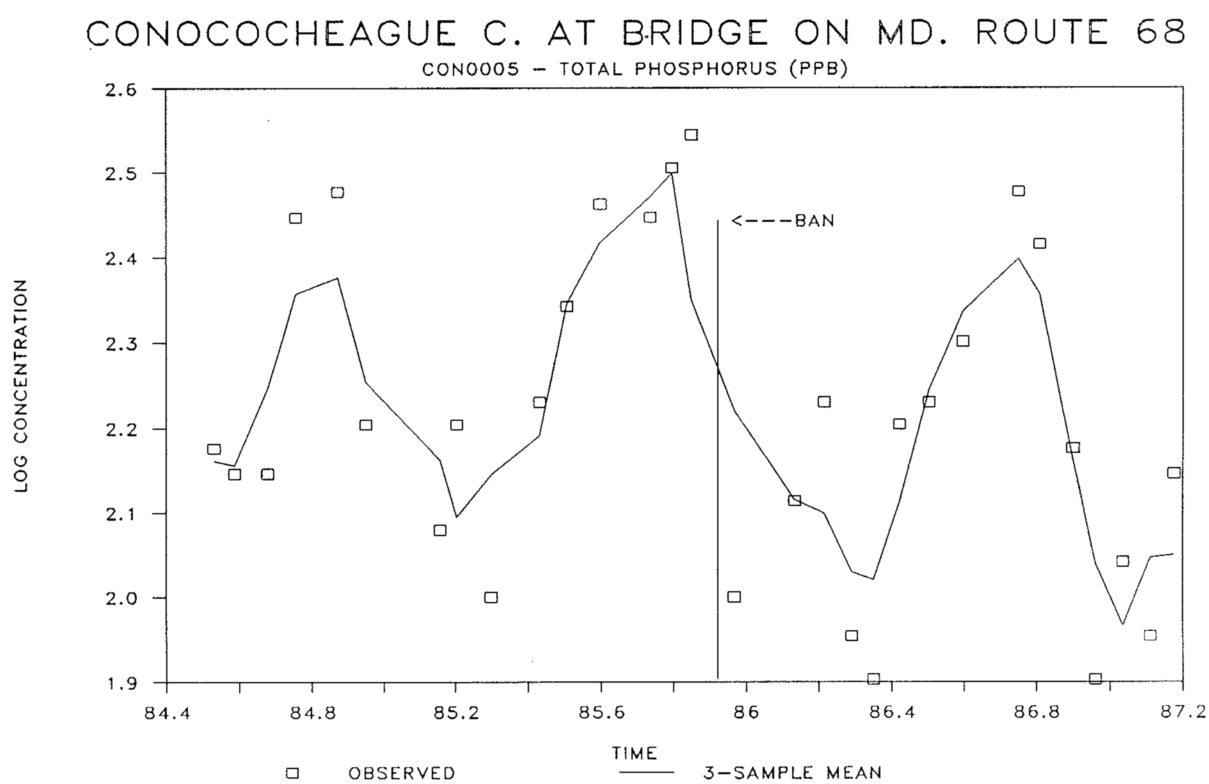

ANTIETAM R. AT BRIDGE ON POFFENBERGER ROAD
ANT0203 – TOTAL PHOSPHORUS (PPB)
LOW
HIGH
LOG CONCENTRATION
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
0.6
0.8
1.0
1.2
1.4
1.6
LOG RUNOFF, IN/YR
PRE–BAN
POST–BAN

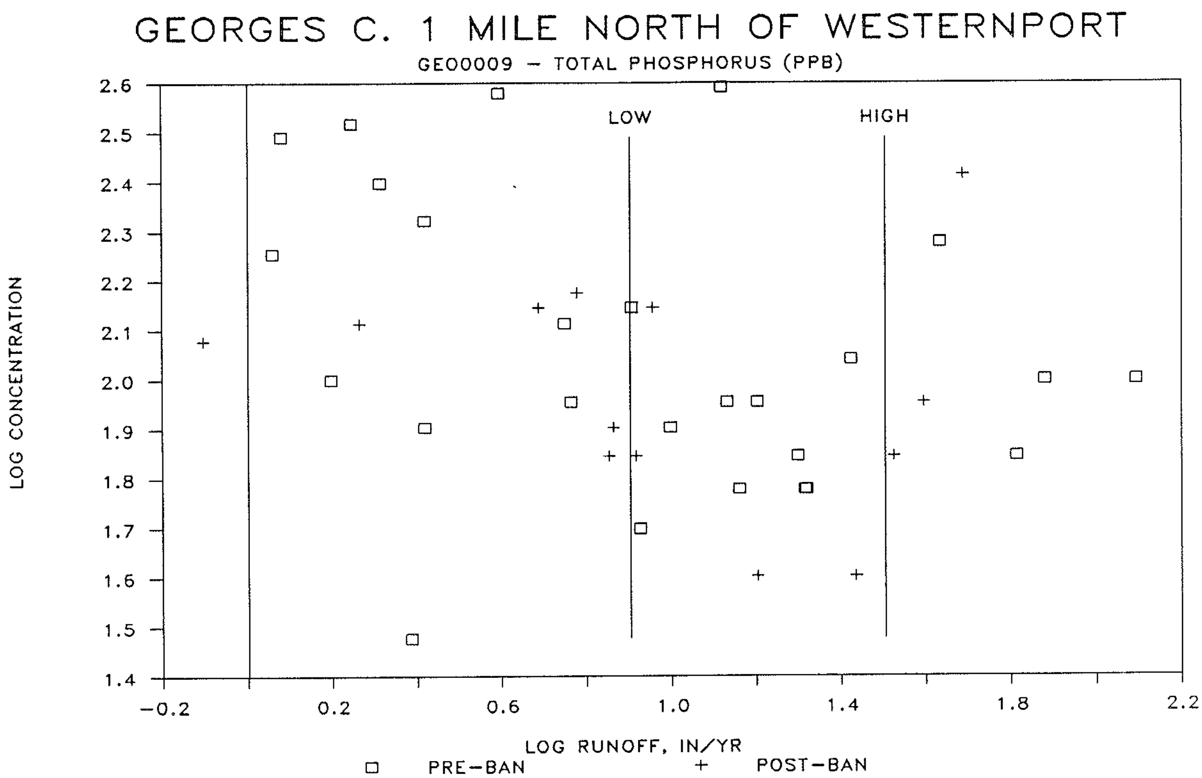

ANTIETAM R. AT BRIDGE ON POFFENBERGER ROAD
ANT0203 – TOTAL PHOSPHORUS (PPB)
<---BAN
LOG CONCENTRATION
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
84.4
84.8
85.2
85.6
86
86.4
86.8
87.2
TIME
OBSERVED
3–SAMPLE MEAN

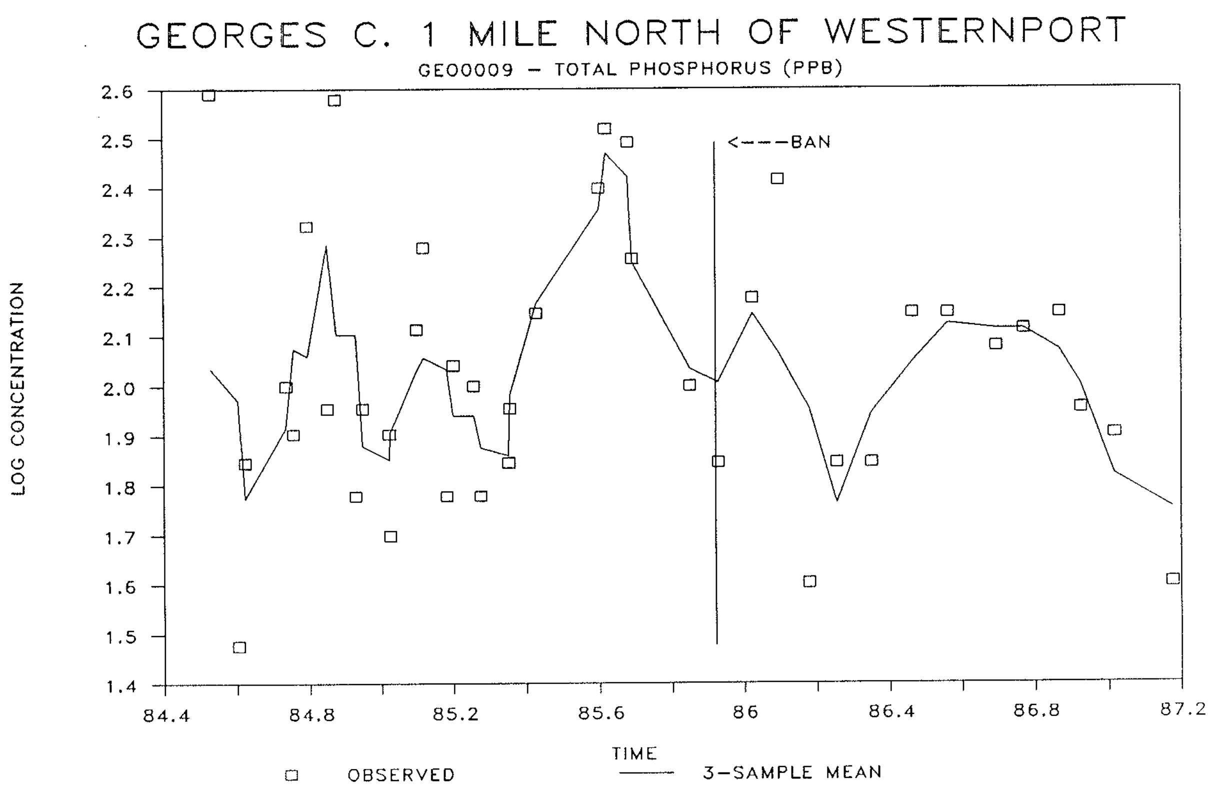

CHOPTANK R. AT RED BRIDGES NEAR SEWELL MILLS
CHO0626 – TOTAL PHOSPHORUS (PPB)
LOW
HIGH
LOG CONCENTRATION
LOG RUNOFF, IN/YR
PRE-BAN
POST-BAN

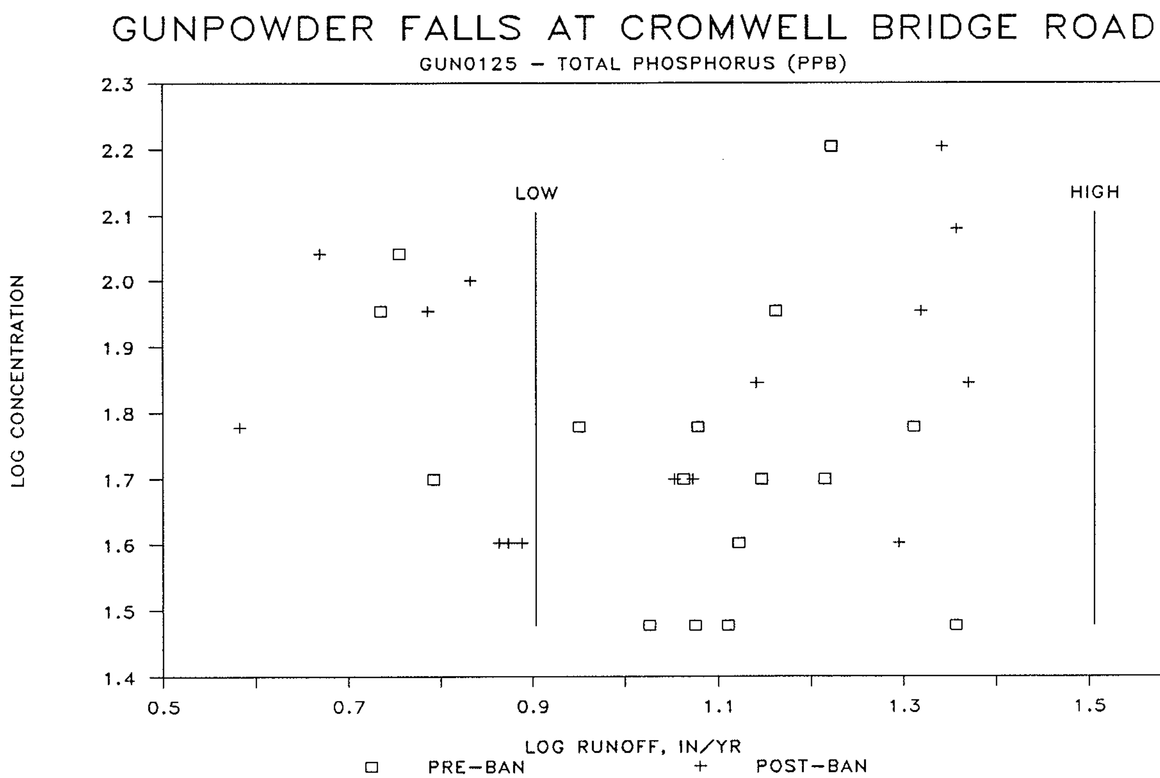

CHOPTANK R. AT RED BRIDGES NEAR SEWELL MILLS
CHO0626 – TOTAL PHOSPHORUS (PPB)
<---BAN
LOG CONCENTRATION
TIME
OBSERVED
3-SAMPLE MEAN

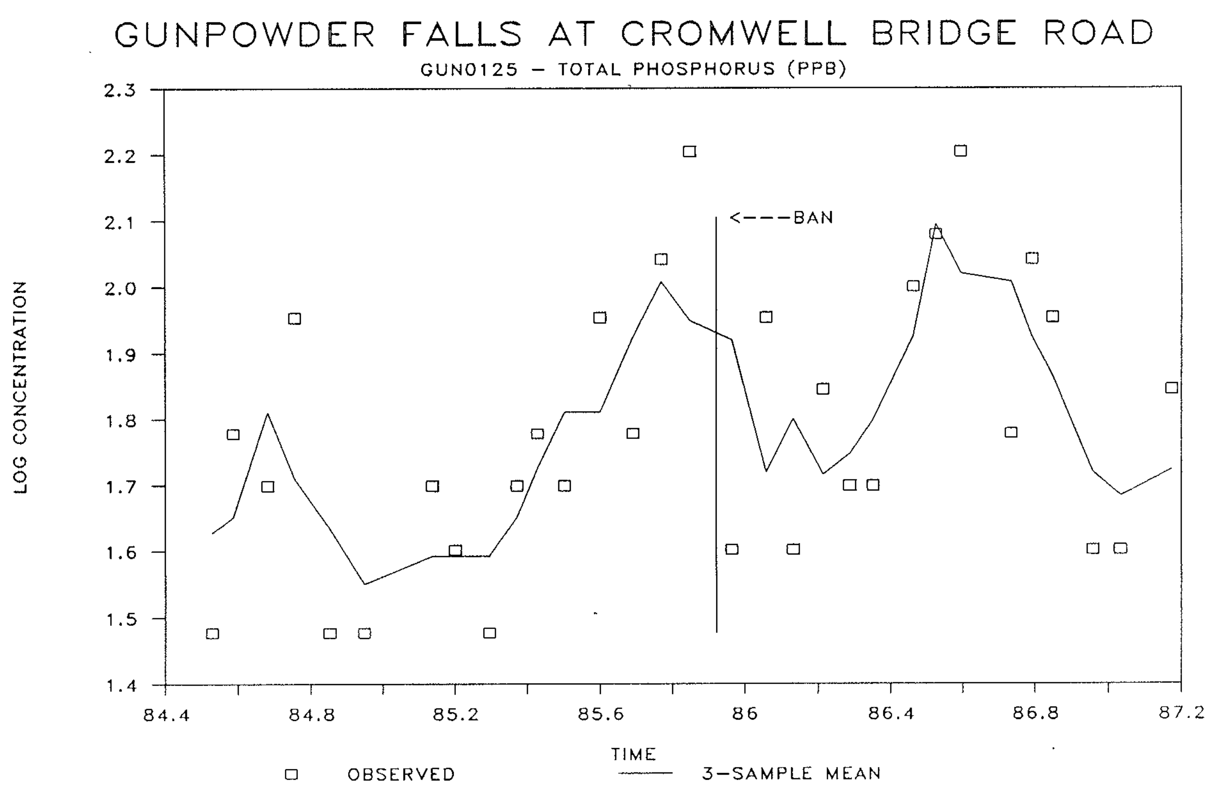

CONOCOCHEAGUE C. AT BRIDGE ON MD. ROUTE 68
CON0005 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
LOW
HIGH
LOG RUNOFF, IN/YR
PRE-BAN
POST-BAN

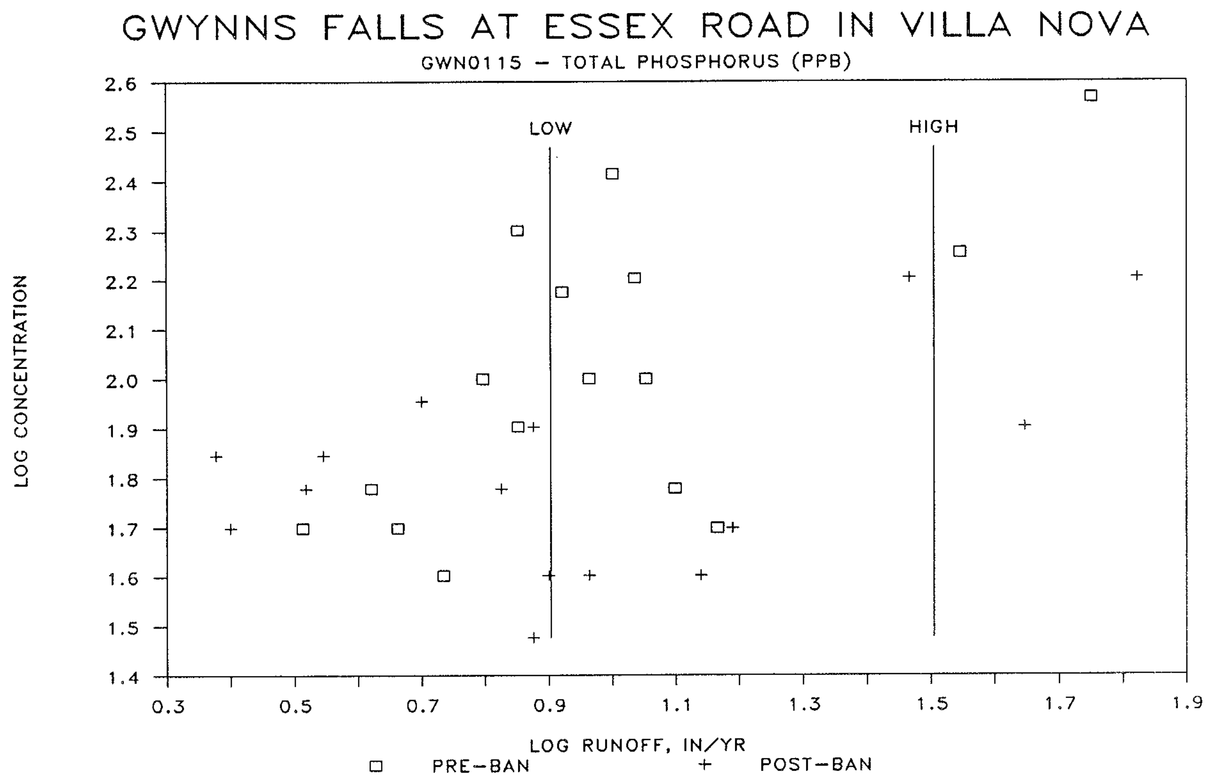

CONOCOCHEAGUE C. AT BRIDGE ON MD. ROUTE 68
CON0005 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
<---BAN
TIME
OBSERVED
3-SAMPLE MEAN

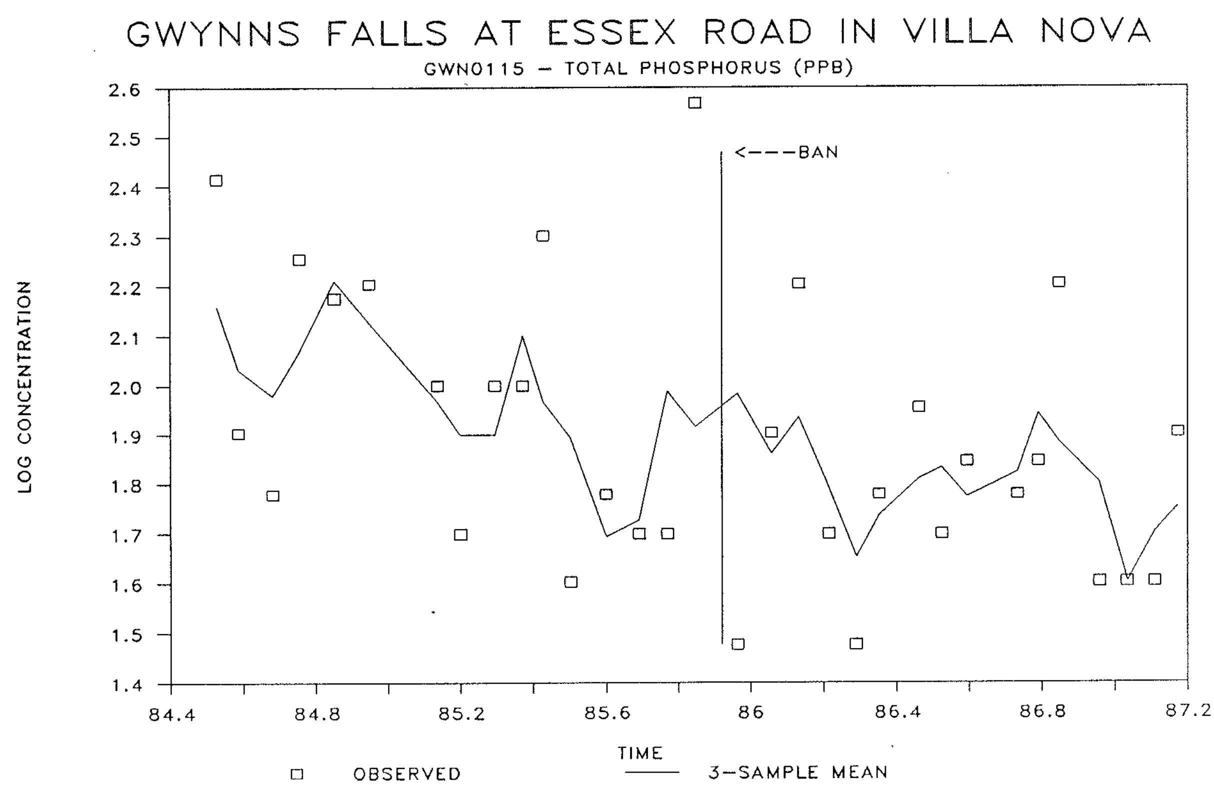

GEORGES C. 1 MILE NORTH OF WESTERNPORT
GE00009 – TOTAL PHOSPHORUS (PPB)
LOW
HIGH
LOG CONCENTRATION
LOG RUNOFF, IN/YR
PRE–BAN
POST–BAN

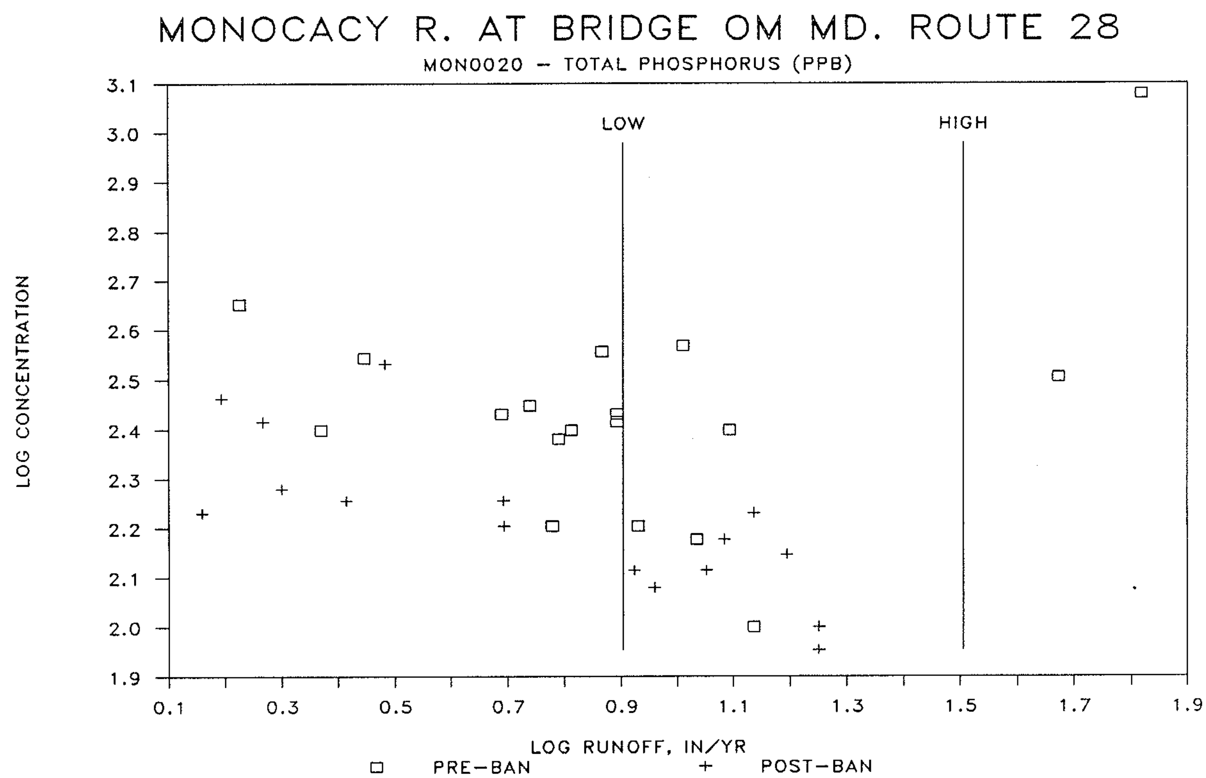

GEORGES C. 1 MILE NORTH OF WESTERNPORT
GE00009 – TOTAL PHOSPHORUS (PPB)
<---BAN
LOG CONCENTRATION
TIME
OBSERVED
3–SAMPLE MEAN

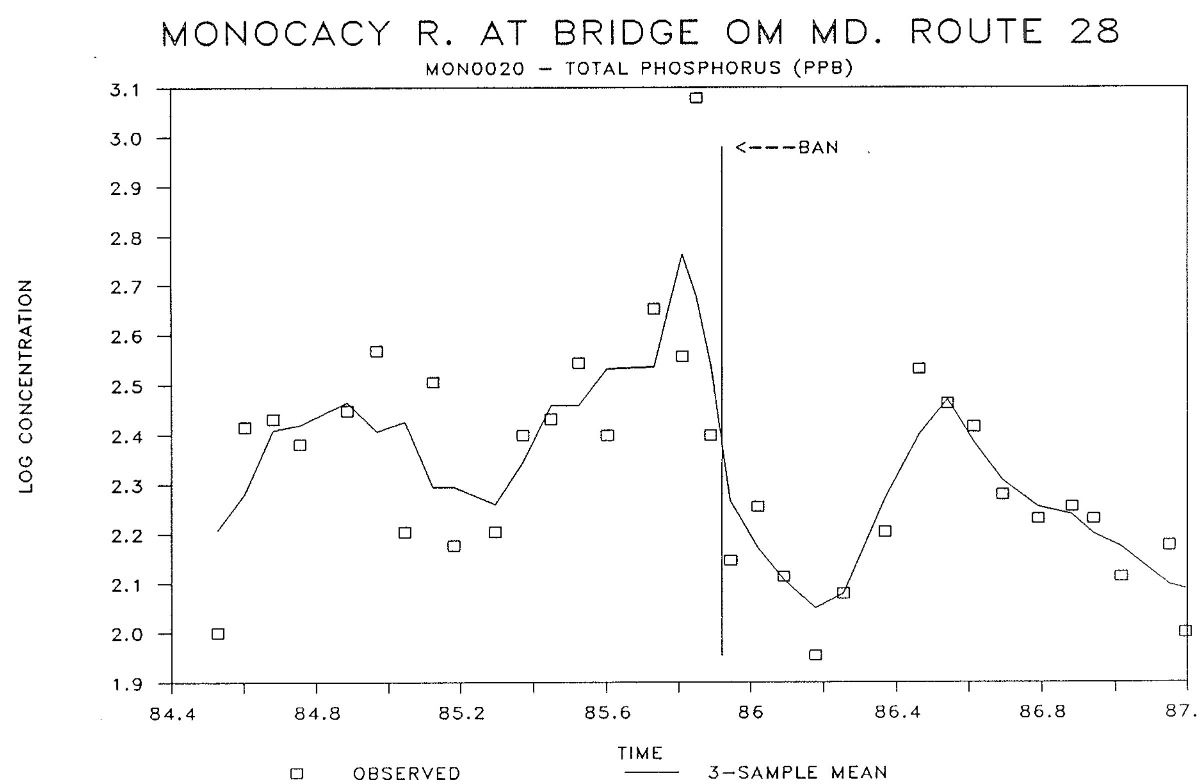

GUNPOWDER FALLS AT CROMWELL BRIDGE ROAD
GUN0125 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
LOW
HIGH
LOG RUNOFF, IN/YR
PRE-BAN
POST-BAN

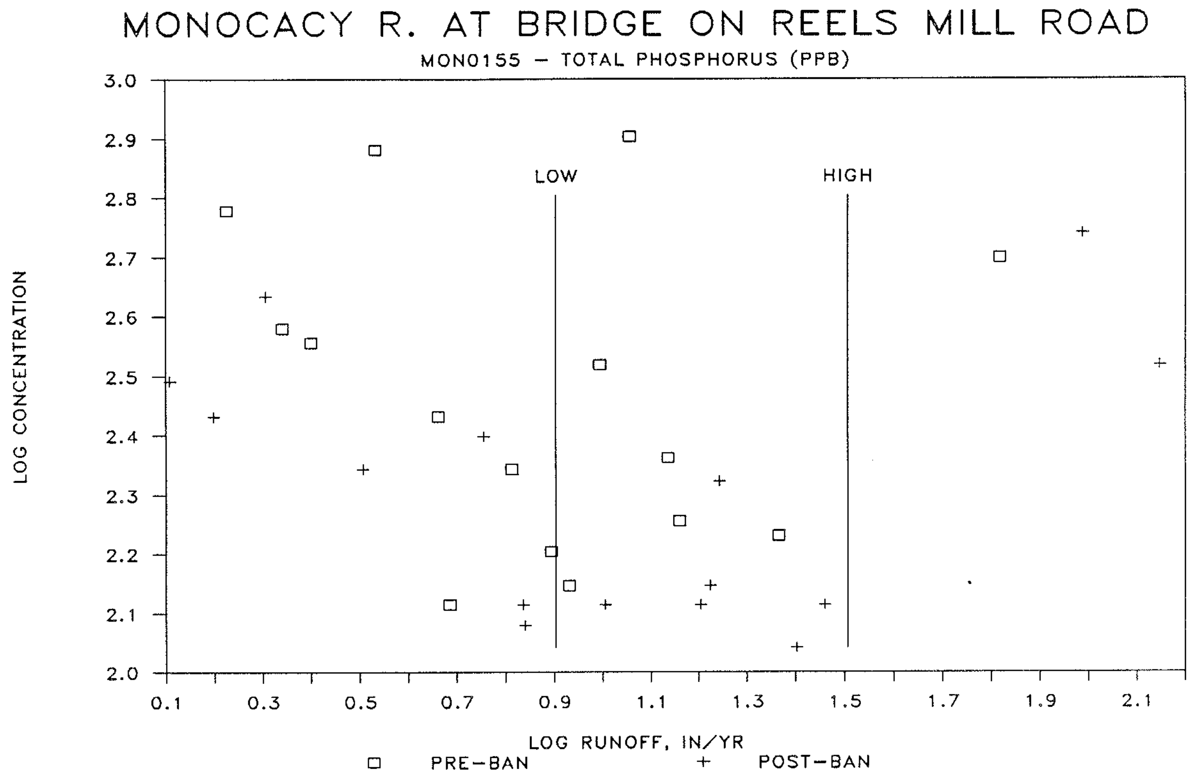

GUNPOWDER FALLS AT CROMWELL BRIDGE ROAD
GUN0125 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
<---BAN
TIME
OBSERVED
3-SAMPLE MEAN

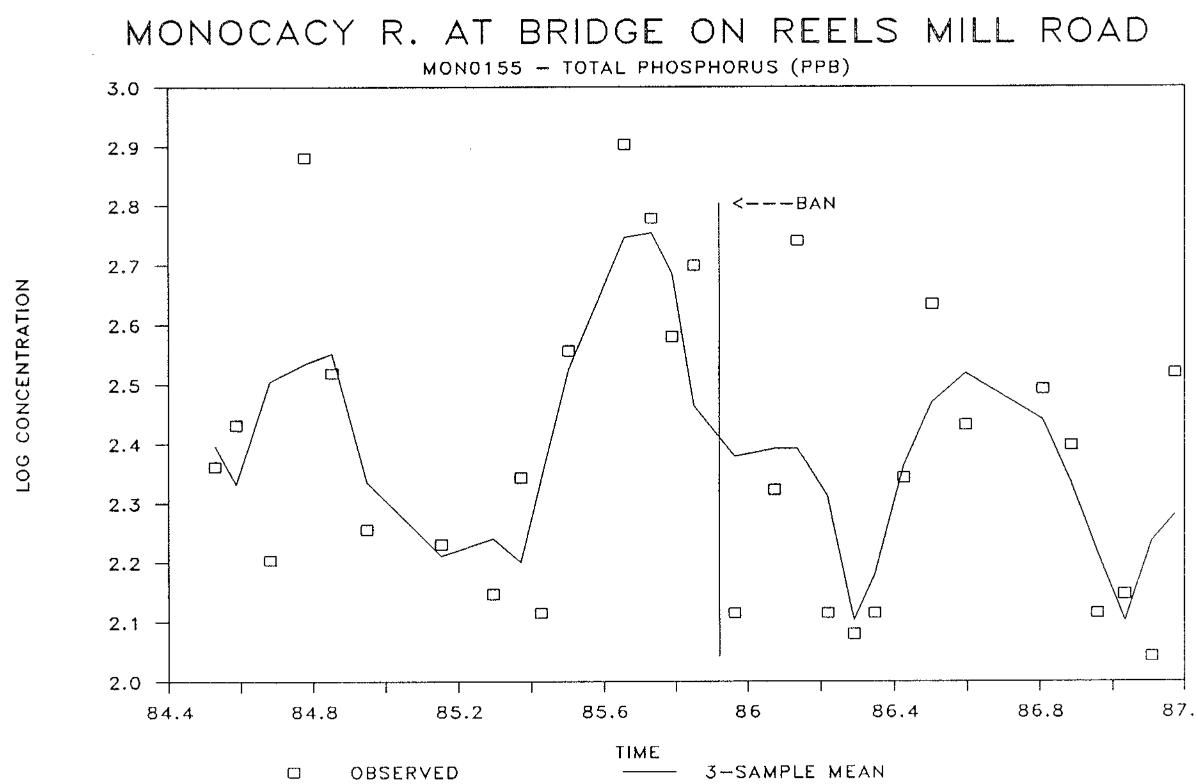

GWYNNS FALLS AT ESSEX ROAD IN VILLA NOVA
GWN0115 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
LOW
HIGH
LOG RUNOFF, IN/YR
PRE-BAN
POST-BAN

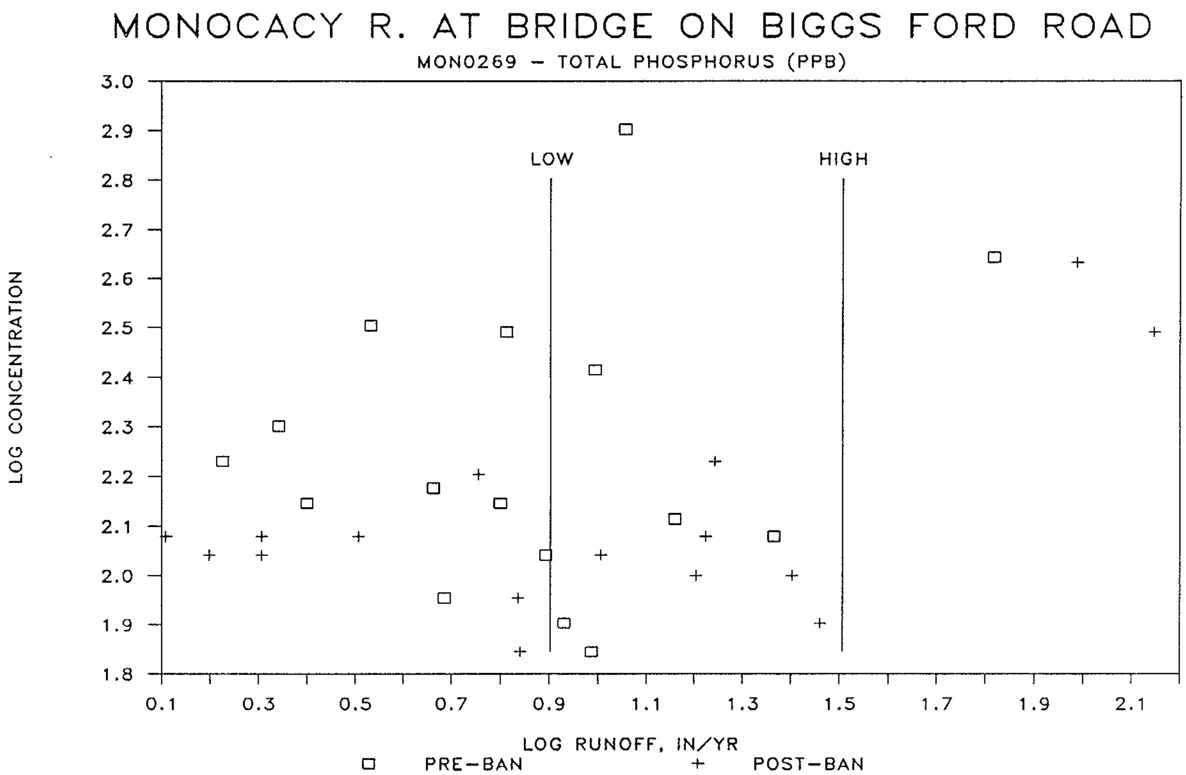

GWYNNS FALLS AT ESSEX ROAD IN VILLA NOVA
GWN0115 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
<---BAN
TIME
OBSERVED
3-SAMPLE MEAN

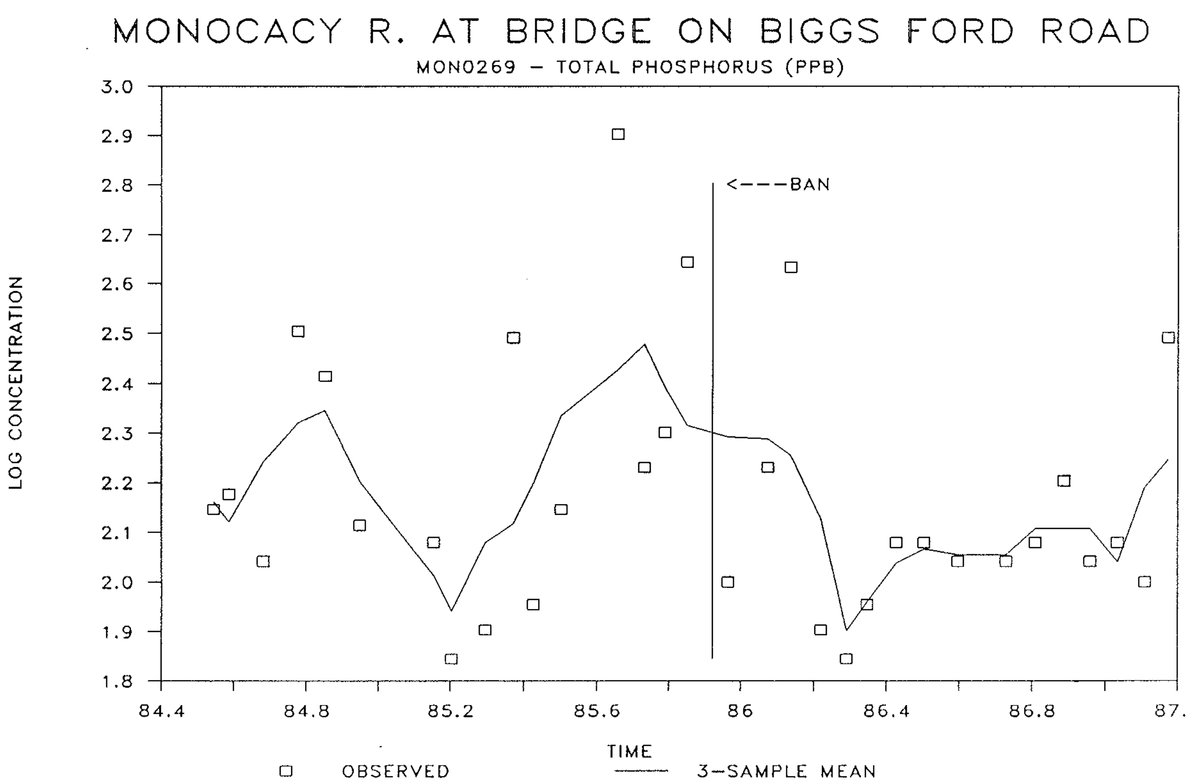

MONOCACY R. AT BRIDGE OM MD. ROUTE 28
MON0020 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
LOW
HIGH
LOG RUNOFF, IN/YR
PRE–BAN
POST–BAN

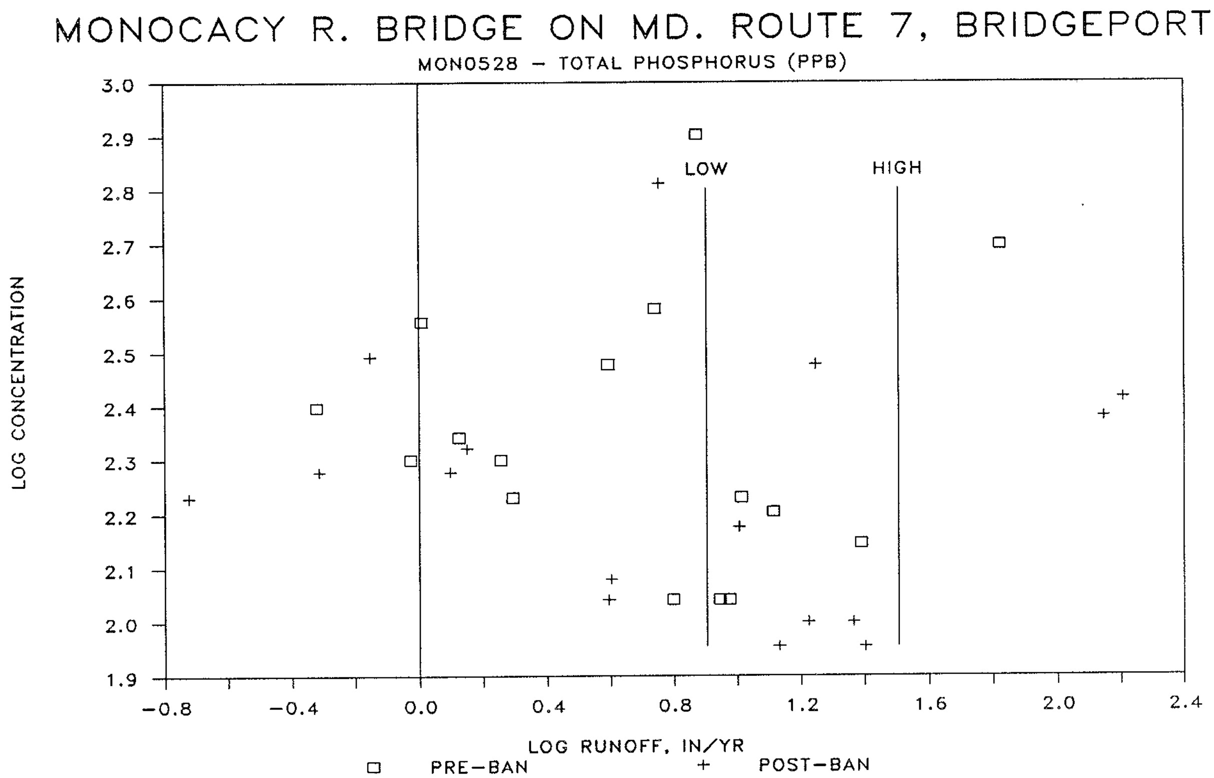

MONOCACY R. AT BRIDGE OM MD. ROUTE 28
MON0020 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
<---BAN
TIME
OBSERVED
3–SAMPLE MEAN

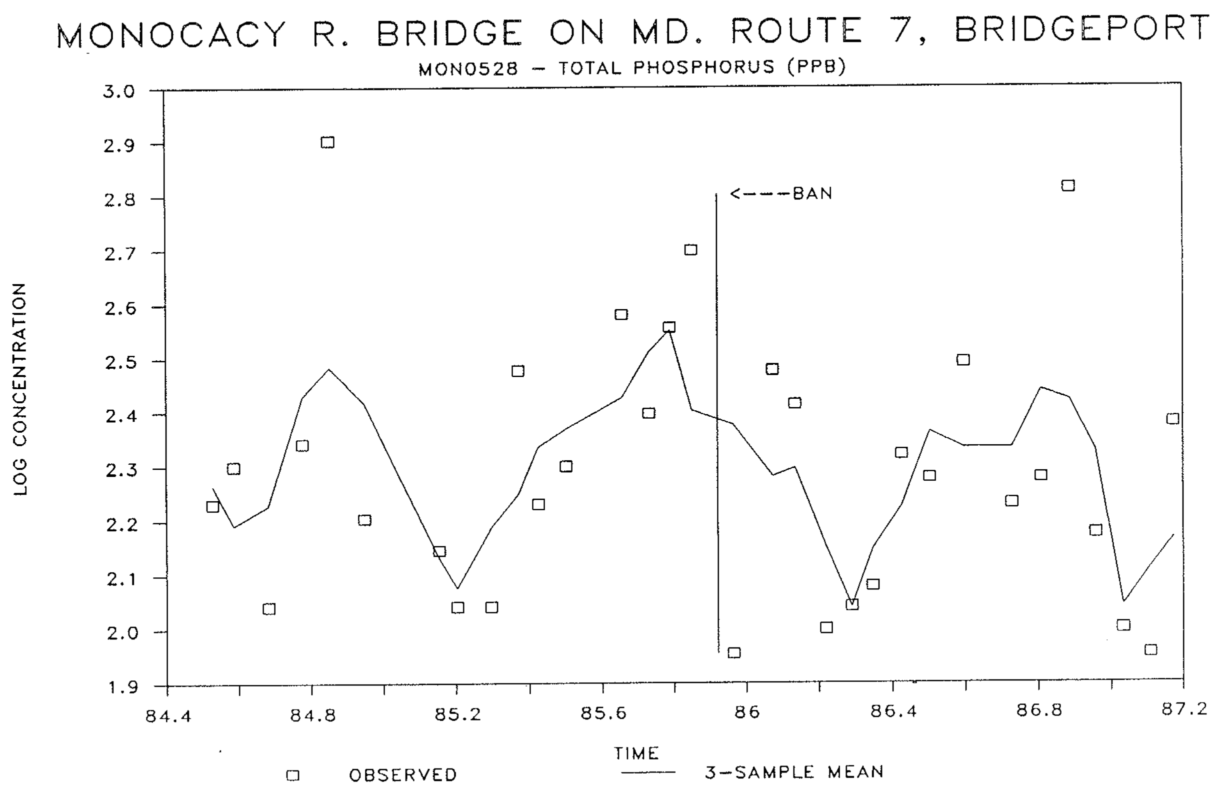

MONOCACY R. AT BRIDGE ON REELS MILL ROAD
MON0155 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
LOW
HIGH
LOG RUNOFF, IN/YR
PRE-BAN
POST-BAN


MONOCACY R. AT BRIDGE ON REELS MILL ROAD
MON0155 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
<---BAN
TIME
OBSERVED
3-SAMPLE MEAN


MONOCACY R. AT BRIDGE ON BIGGS FORD ROAD
MON0269 - TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
LOW
HIGH
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
0.1
0.3
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9
2.1
LOG RUNOFF, IN/YR
PRE-BAN
POST-BAN

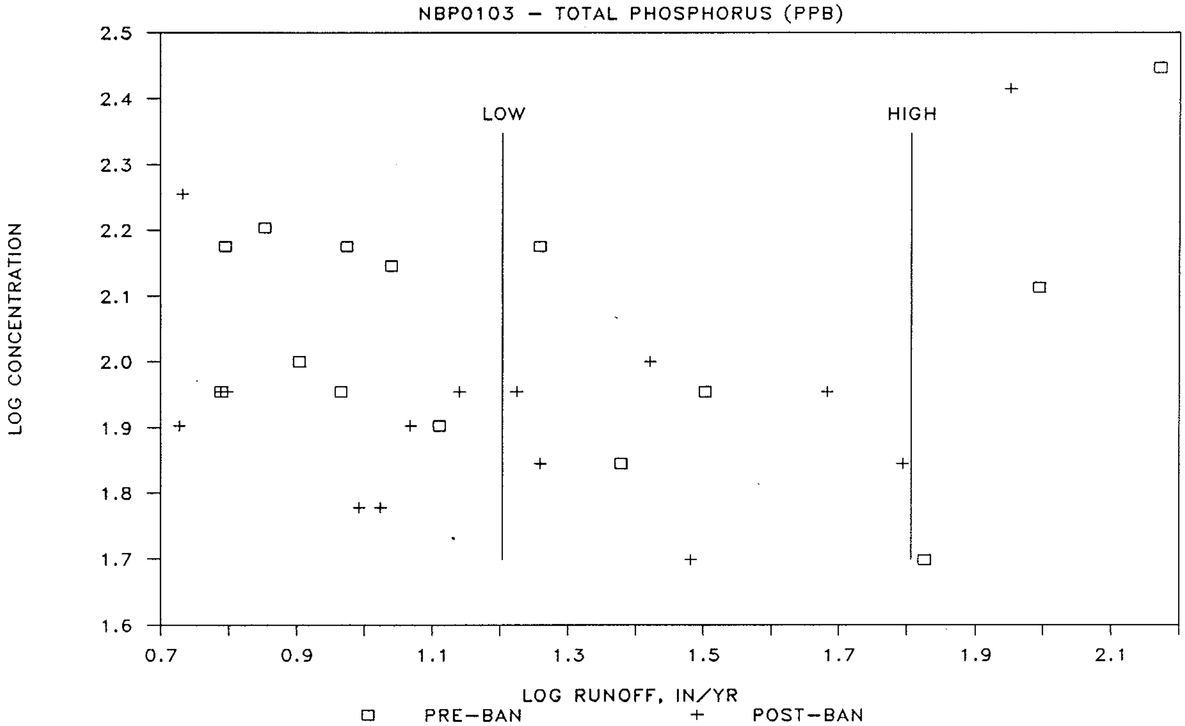

MONOCACY R. AT BRIDGE ON BIGGS FORD ROAD
MON0269 - TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
<---BAN
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
84.4
84.8
85.2
85.6
86
86.4
86.8
87.2
TIME
OBSERVED
3-SAMPLE MEAN


MONOCACY R. BRIDGE ON MD. ROUTE 7, BRIDGEPORT
MON0528 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
LOW
HIGH
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
−0.8
−0.4
0.0
0.4
0.8
1.2
1.6
2.0
2.4
LOG RUNOFF, IN/YR
PRE–BAN
POST–BAN


MONOCACY R. BRIDGE ON MD. ROUTE 7, BRIDGEPORT
MON0528 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
<–––BAN
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
84.4
84.8
85.2
85.6
86
86.4
86.8
87.2
TIME
OBSERVED
3–SAMPLE MEAN

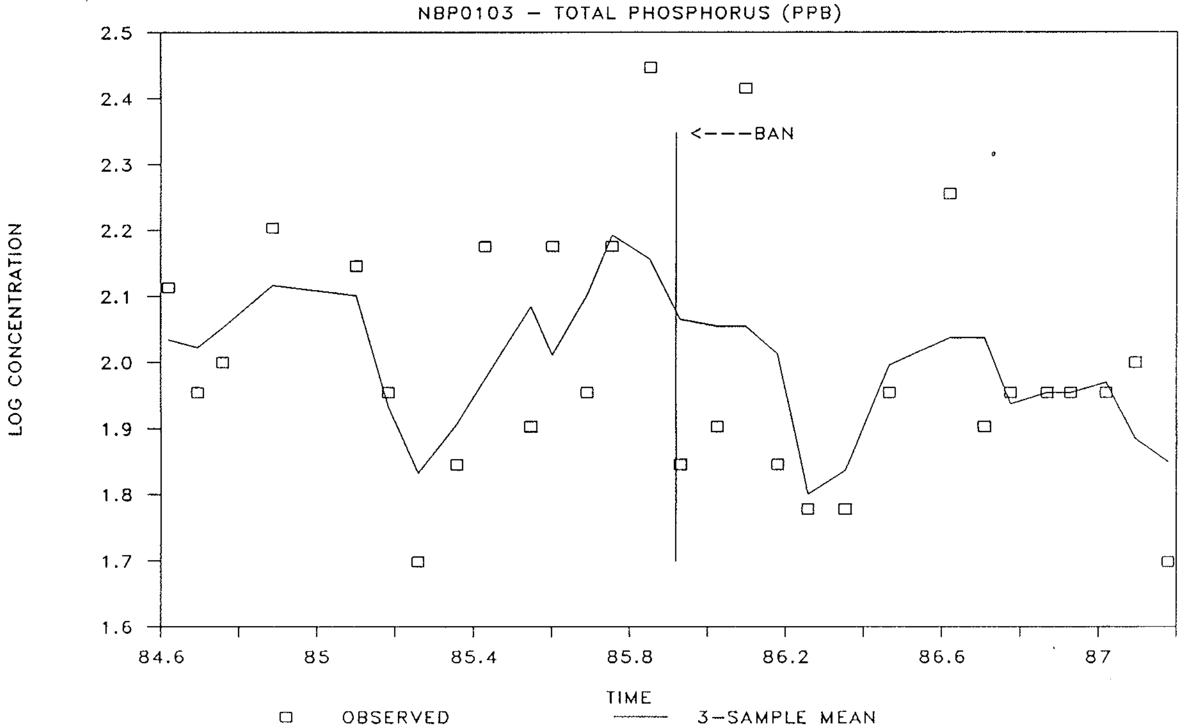
N. BR. POTOMAC W. OF MOORES HOLLOW RD. & RTE 51

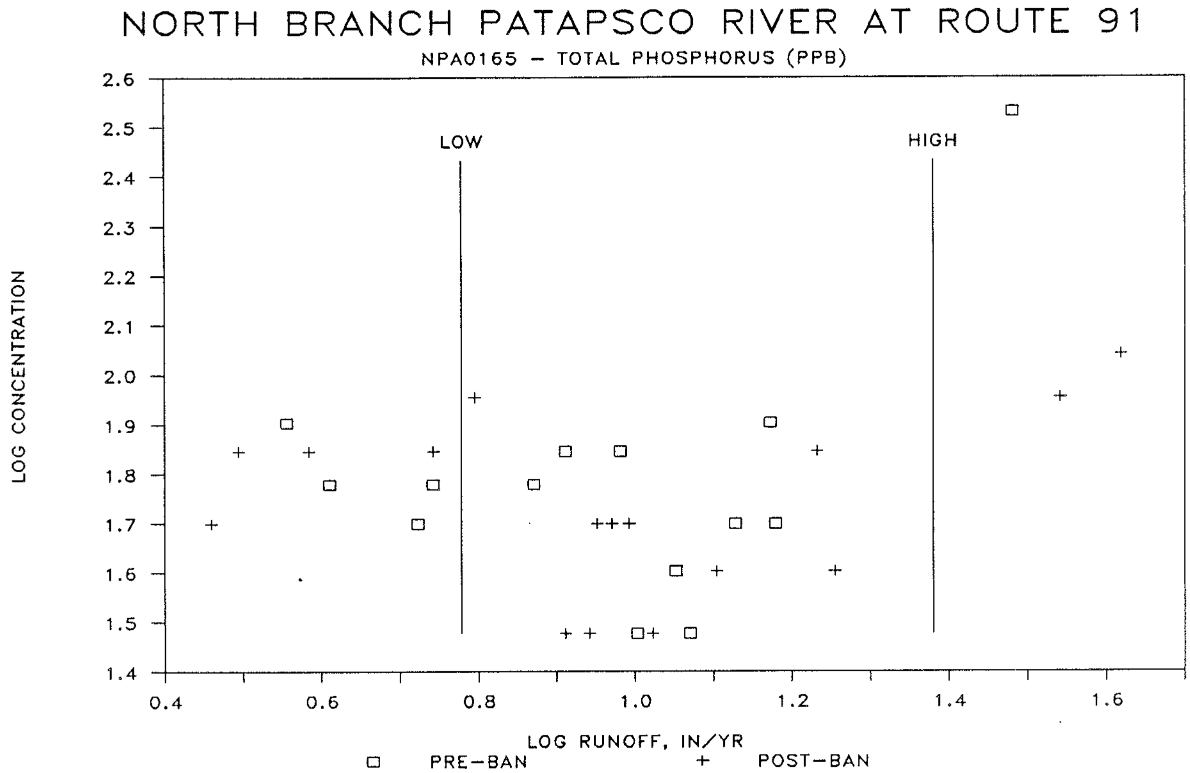
NBP0103 – TOTAL PHOSPHORUS (PPB)

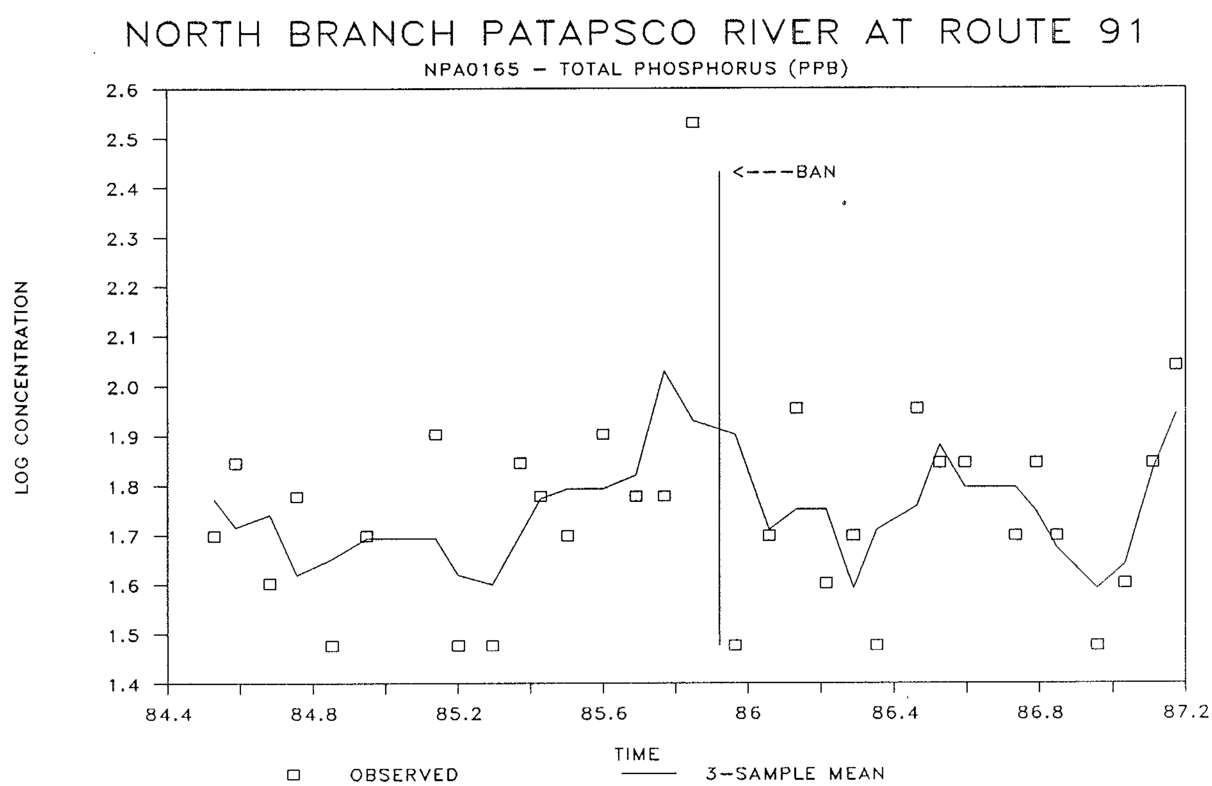


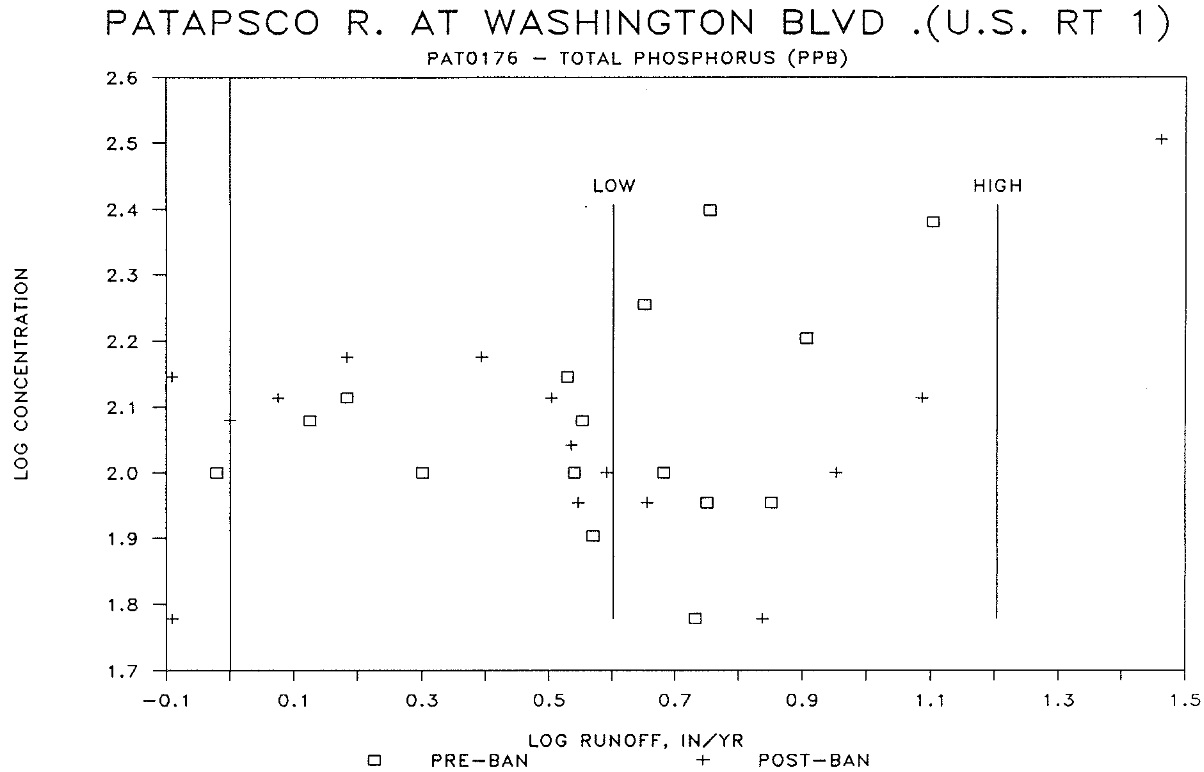
N. BR. POTOMAC W. OF MOORES HOLLOW RD. & RTE 51

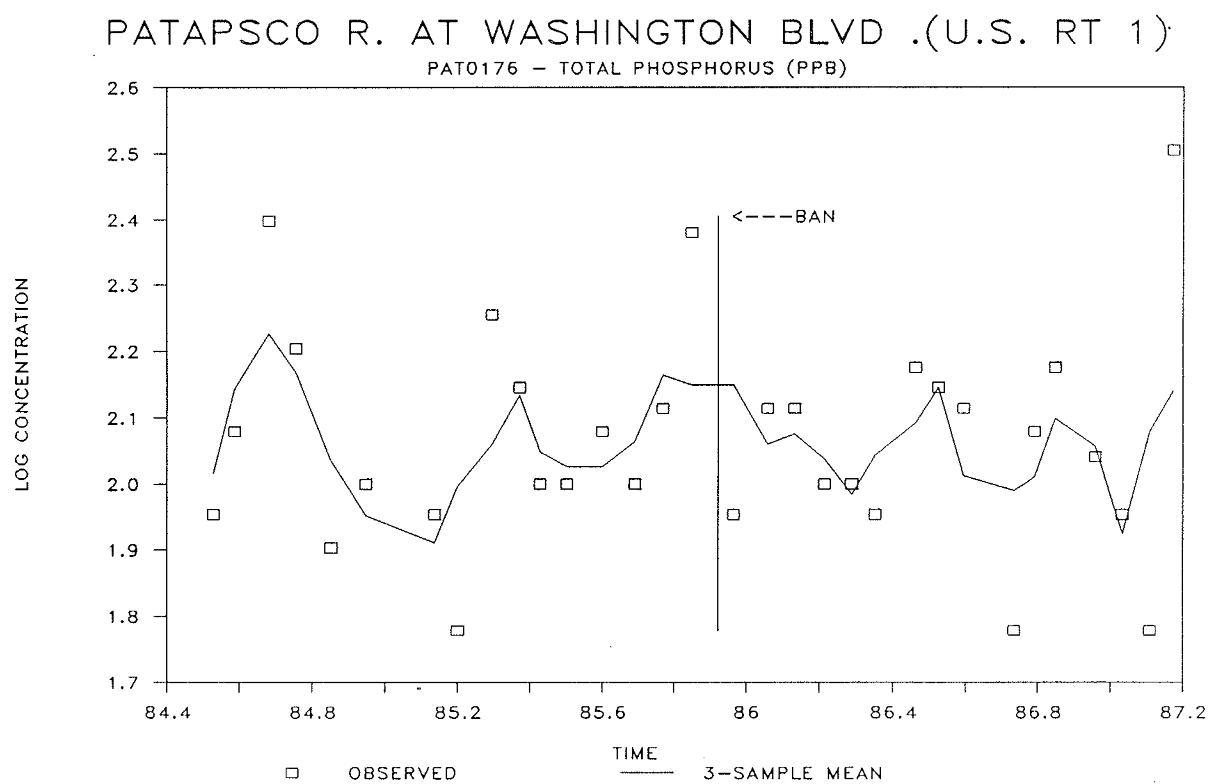
NBP0103 – TOTAL PHOSPHORUS (PPB)



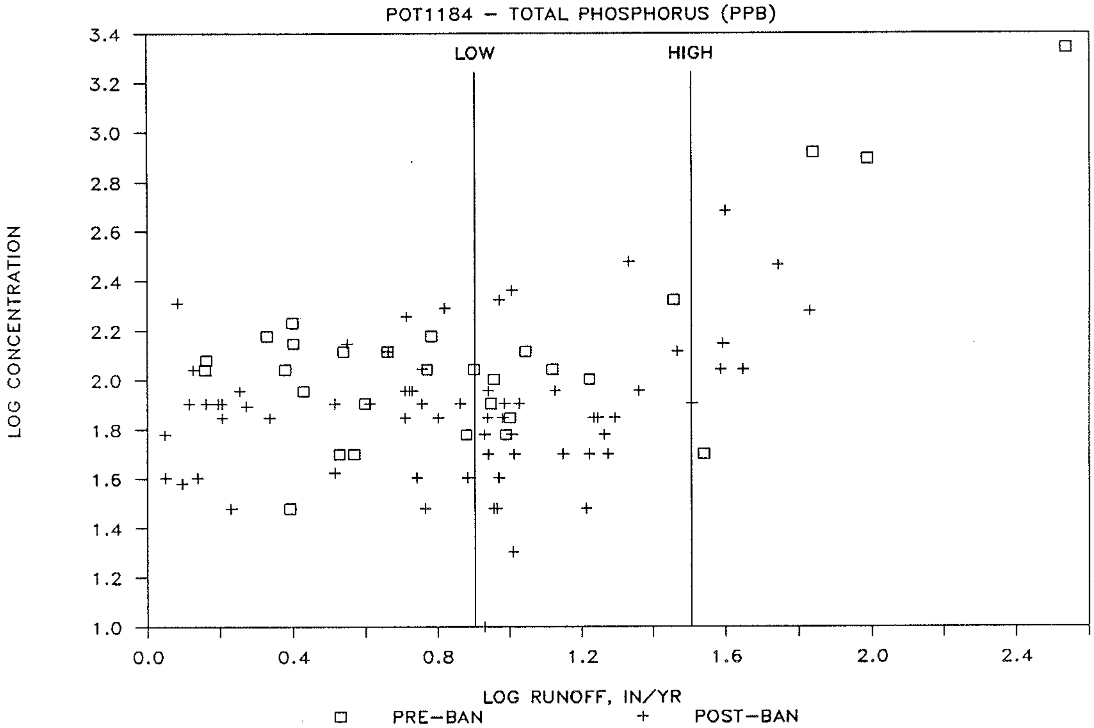

NORTH BRANCH PATAPSCO RIVER AT ROUTE 91
NPA0165 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
LOW
HIGH
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
0.4
0.6
0.8
1.0
1.2
1.4
1.6
LOG RUNOFF, IN/YR
PRE–BAN
POST–BAN


NORTH BRANCH PATAPSCO RIVER AT ROUTE 91
NPA0165 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
<---BAN
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
84.4
84.8
85.2
85.6
86
86.4
86.8
87.2
TIME
OBSERVED
3–SAMPLE MEAN

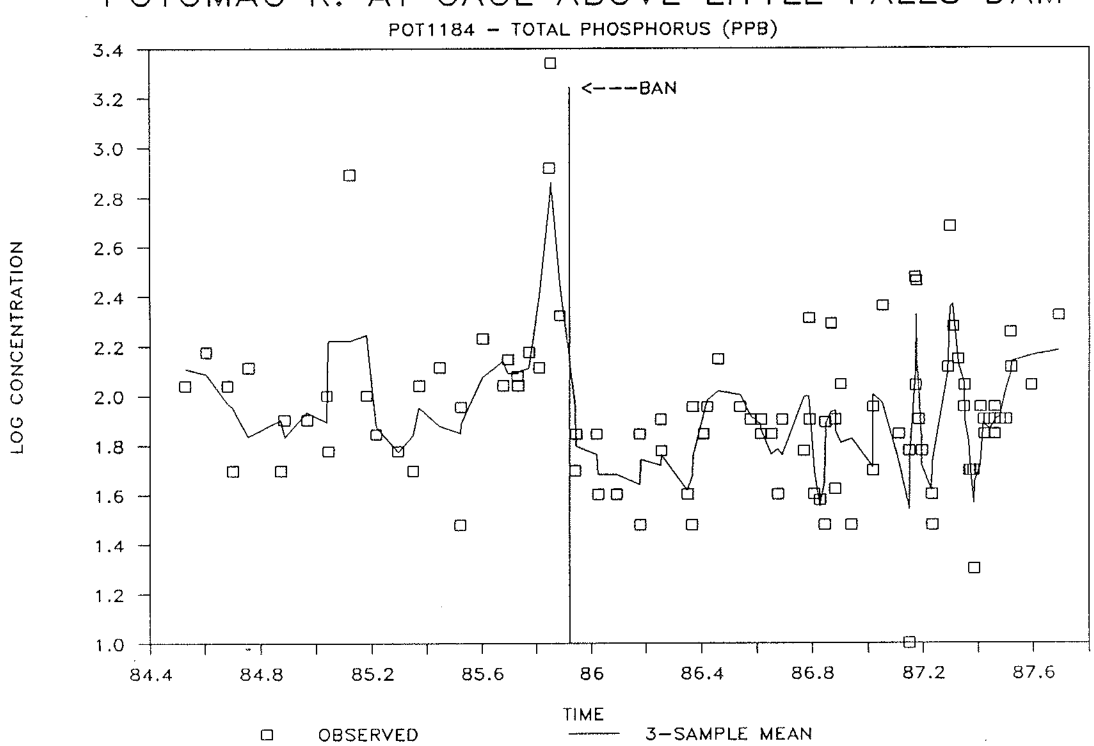

PATAPSCO R. AT WASHINGTON BLVD .(U.S. RT 1)
PAT0176 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
LOW
HIGH
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
-0.1
0.1
0.3
0.5
0.7
0.9
1.1
1.3
1.5
LOG RUNOFF, IN/YR
PRE-BAN
POST-BAN

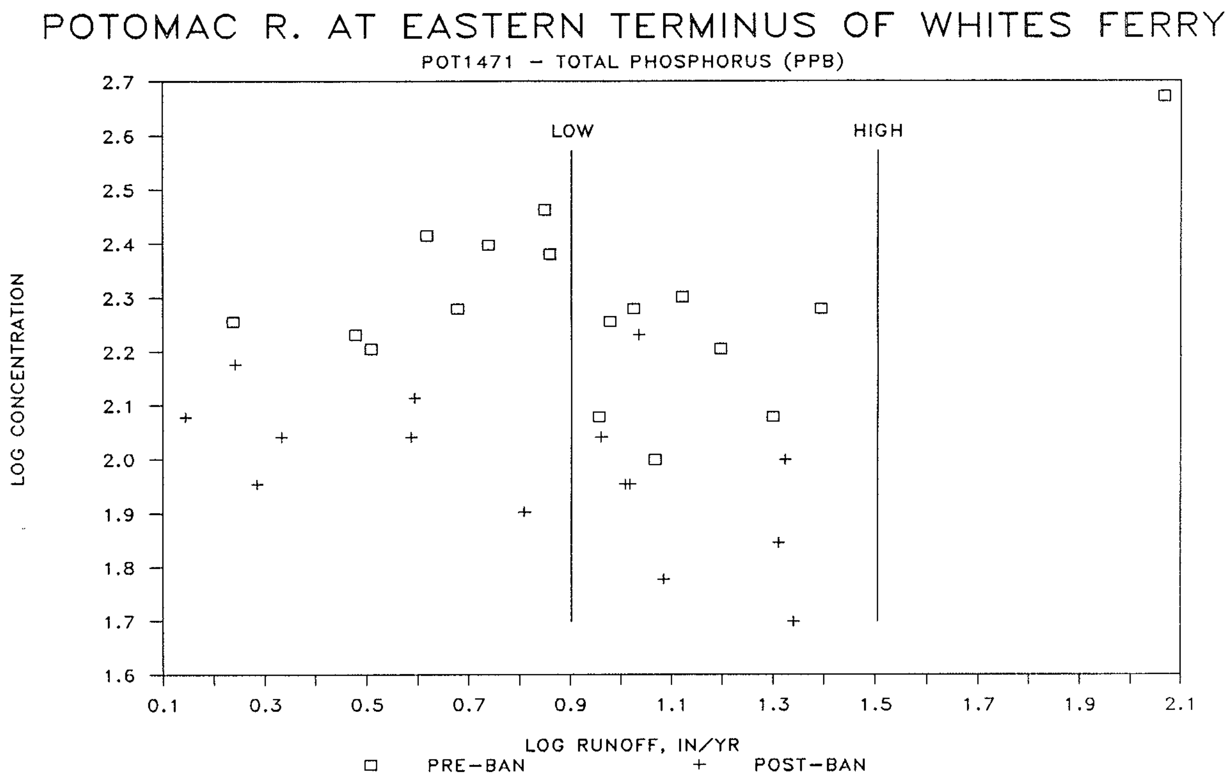

PATAPSCO R. AT WASHINGTON BLVD .(U.S. RT 1)
PAT0176 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
<---BAN
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
84.4
84.8
85.2
85.6
86
86.4
86.8
87.2
TIME
OBSERVED
3-SAMPLE MEAN

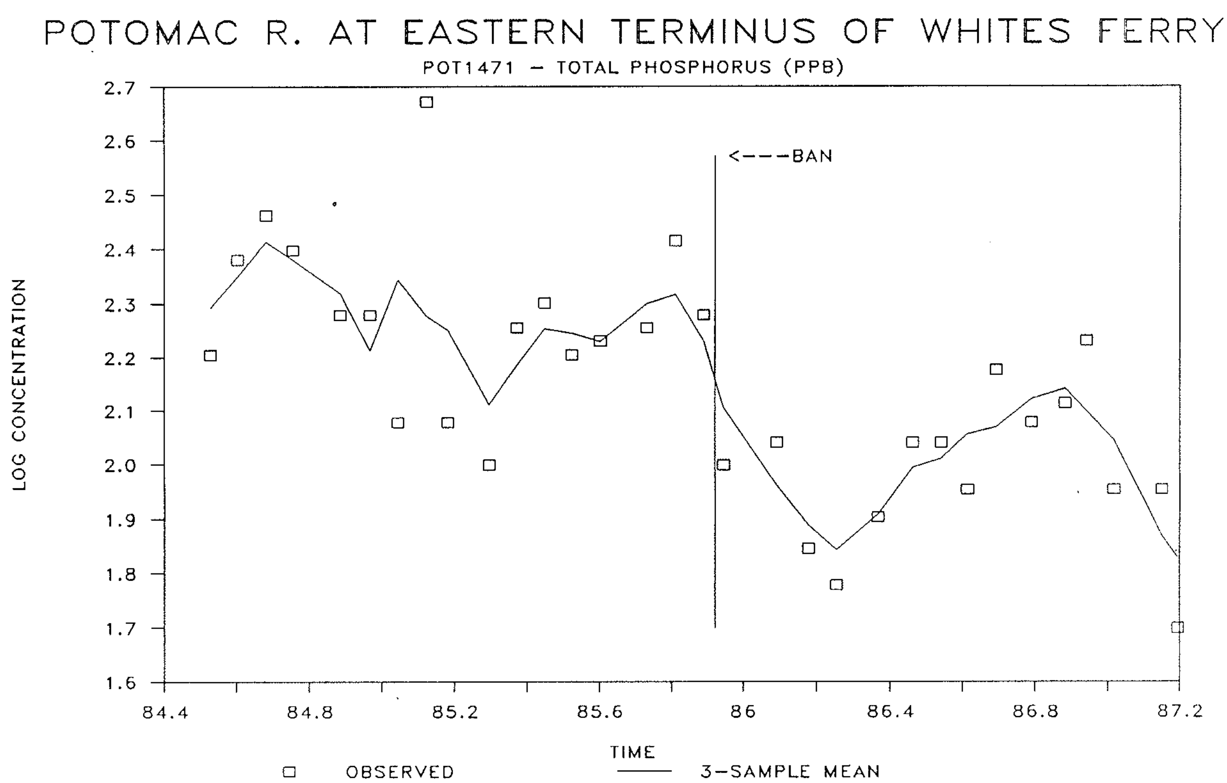
POTOMAC R. AT GAGE ABOVE LITTLE FALLS DAM

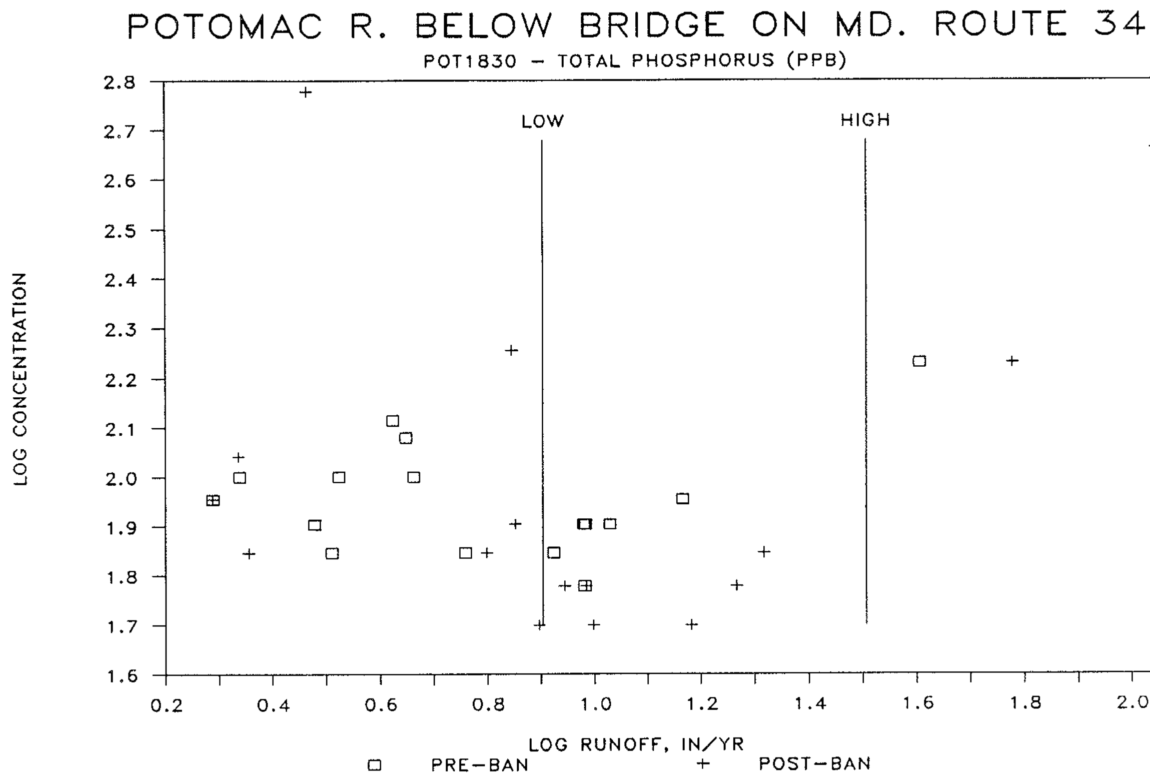


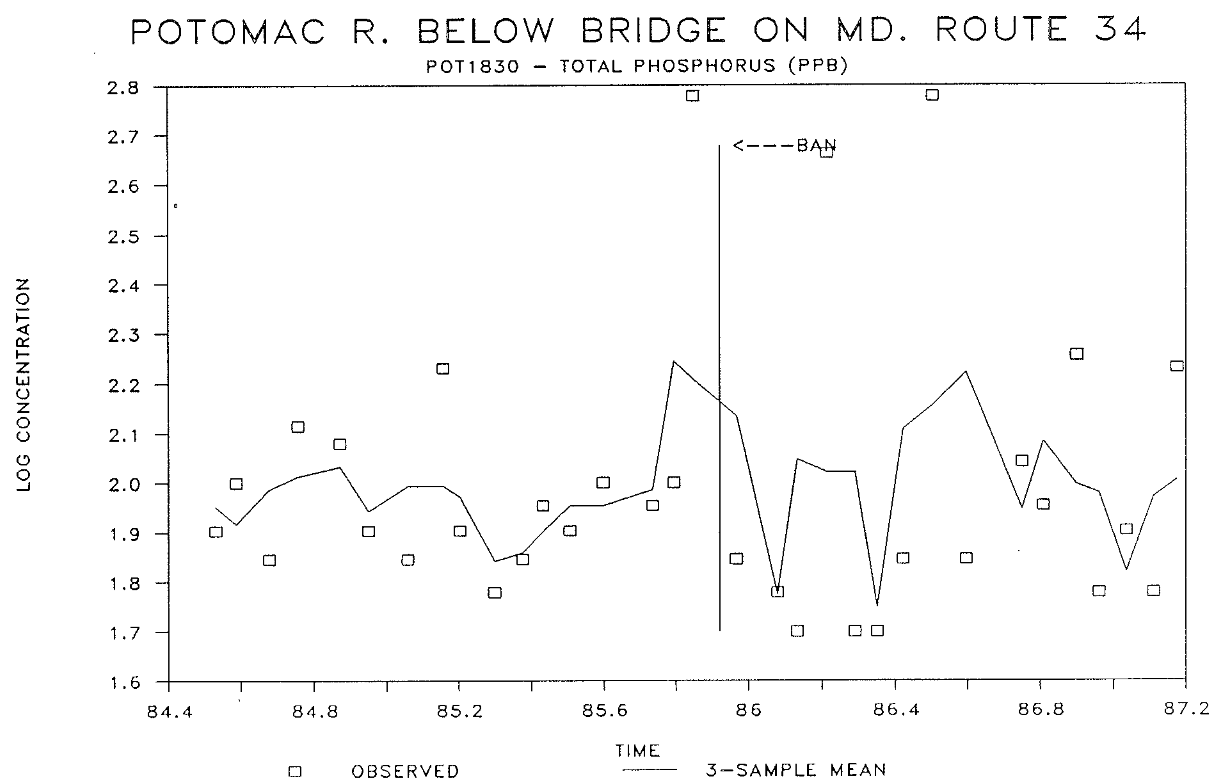
POTOMAC R. AT GAGE ABOVE LITTLE FALLS DAM




POTOMAC R. AT EASTERN TERMINUS OF WHITES FERRY
POT1471 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
LOW
HIGH
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
0.1
0.3
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9
2.1
LOG RUNOFF, IN/YR
PRE-BAN
POST-BAN

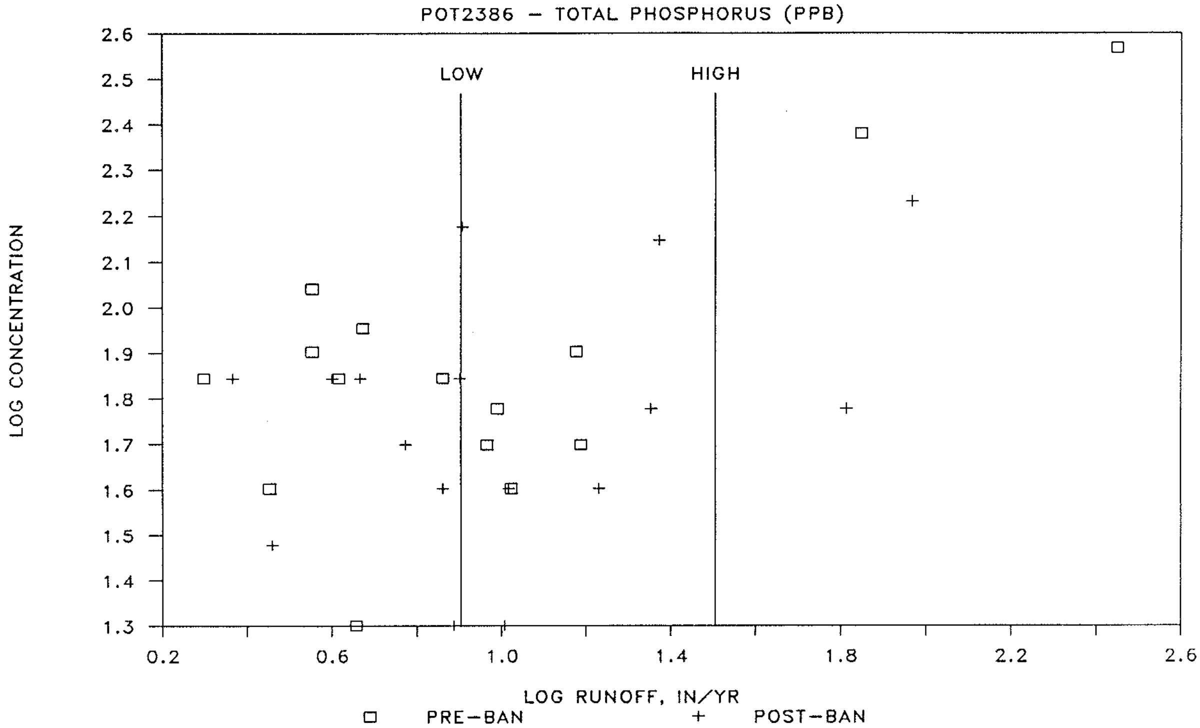

POTOMAC R. AT EASTERN TERMINUS OF WHITES FERRY
POT1471 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
<---BAN
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
84.4
84.8
85.2
85.6
86
86.4
86.8
87.2
TIME
OBSERVED
3-SAMPLE MEAN


POTOMAC R. BELOW BRIDGE ON MD. ROUTE 34
POT1830 – TOTAL PHOSPHORUS (PPB)
LOW
HIGH
LOG CONCENTRATION
LOG RUNOFF, IN/YR
PRE–BAN
POST–BAN


POTOMAC R. BELOW BRIDGE ON MD. ROUTE 34
POT1830 – TOTAL PHOSPHORUS (PPB)
<---BAN
LOG CONCENTRATION
TIME
OBSERVED
3–SAMPLE MEAN

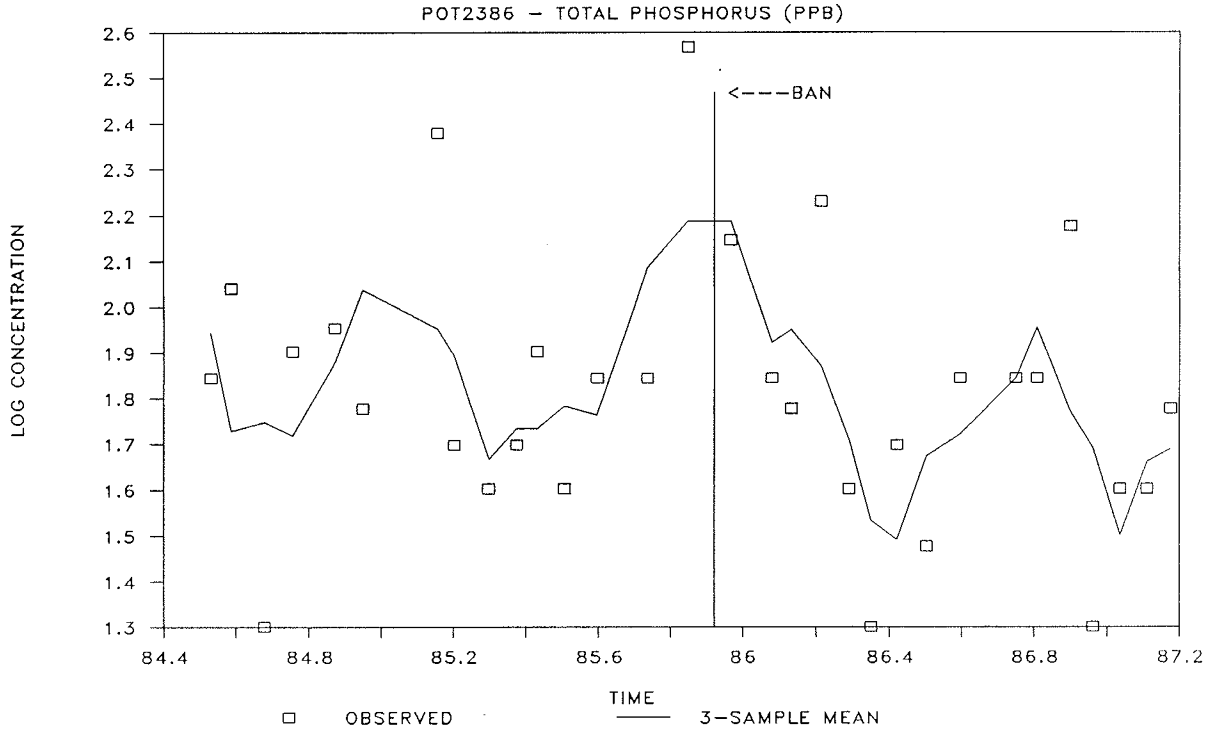
POTOMAC R. BELOW US. RT. 522 IN HANCOCK

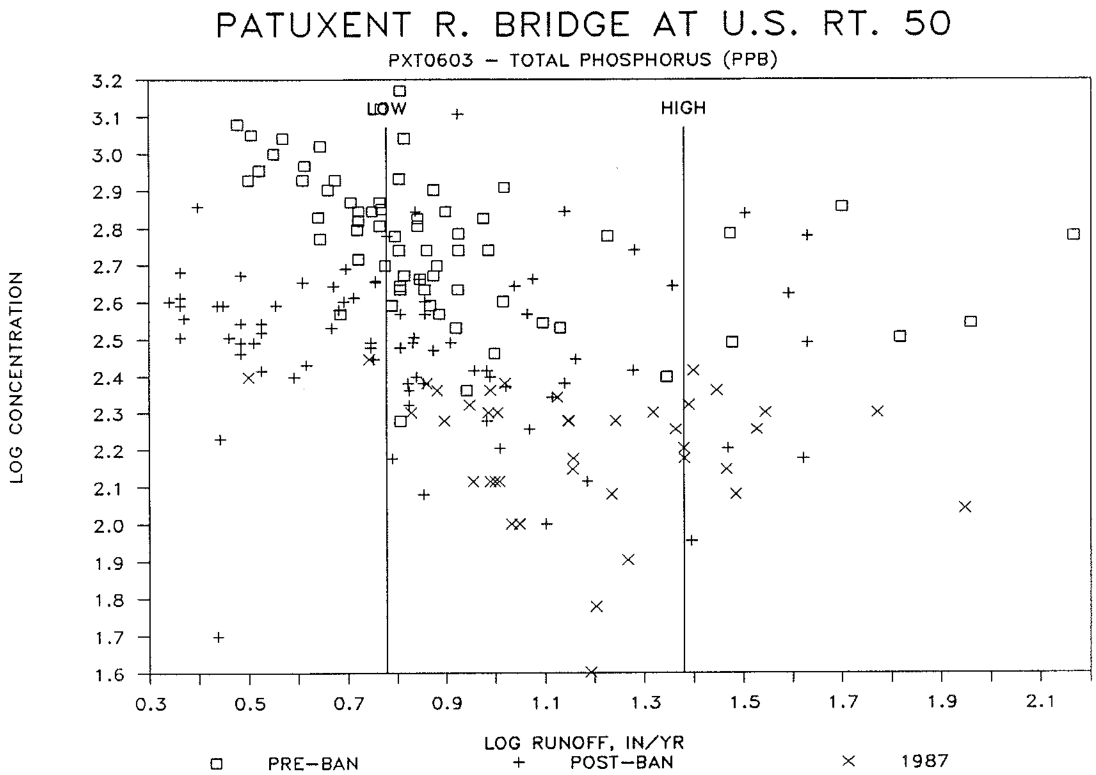
POT2386 – TOTAL PHOSPHORUS (PPB)

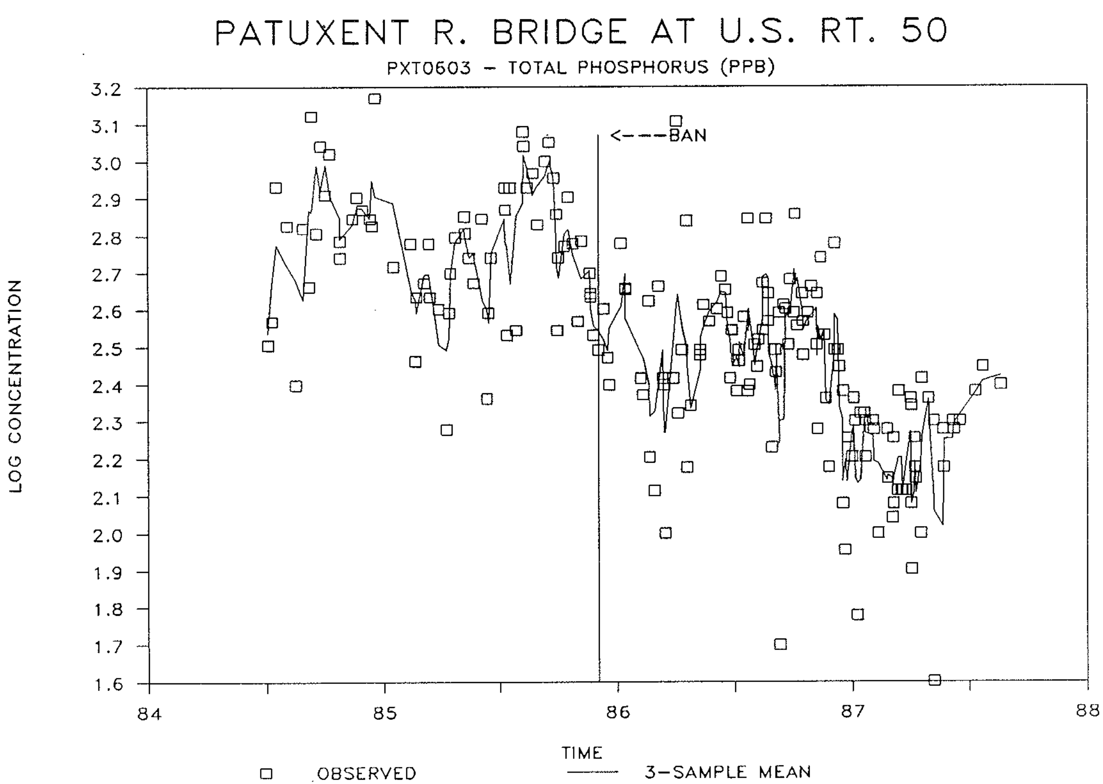


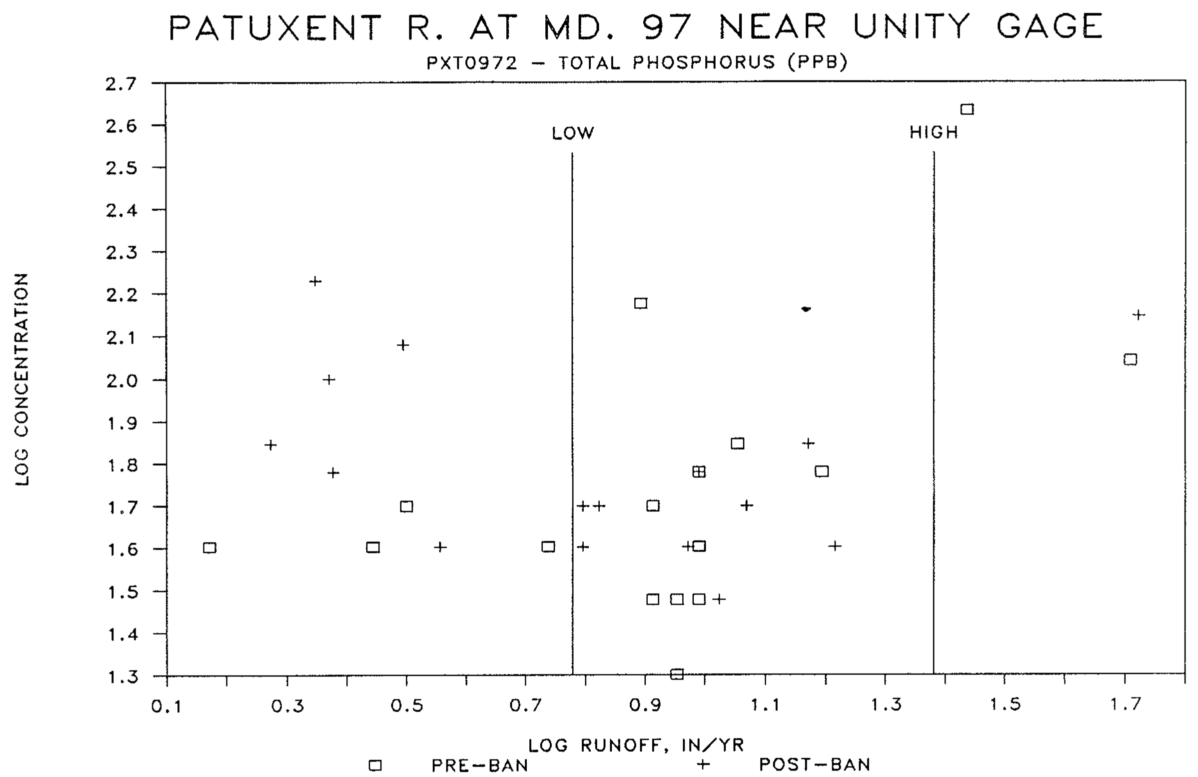
POTOMAC R. BELOW US. RT. 522 IN HANCOCK

POT2386 – TOTAL PHOSPHORUS (PPB)

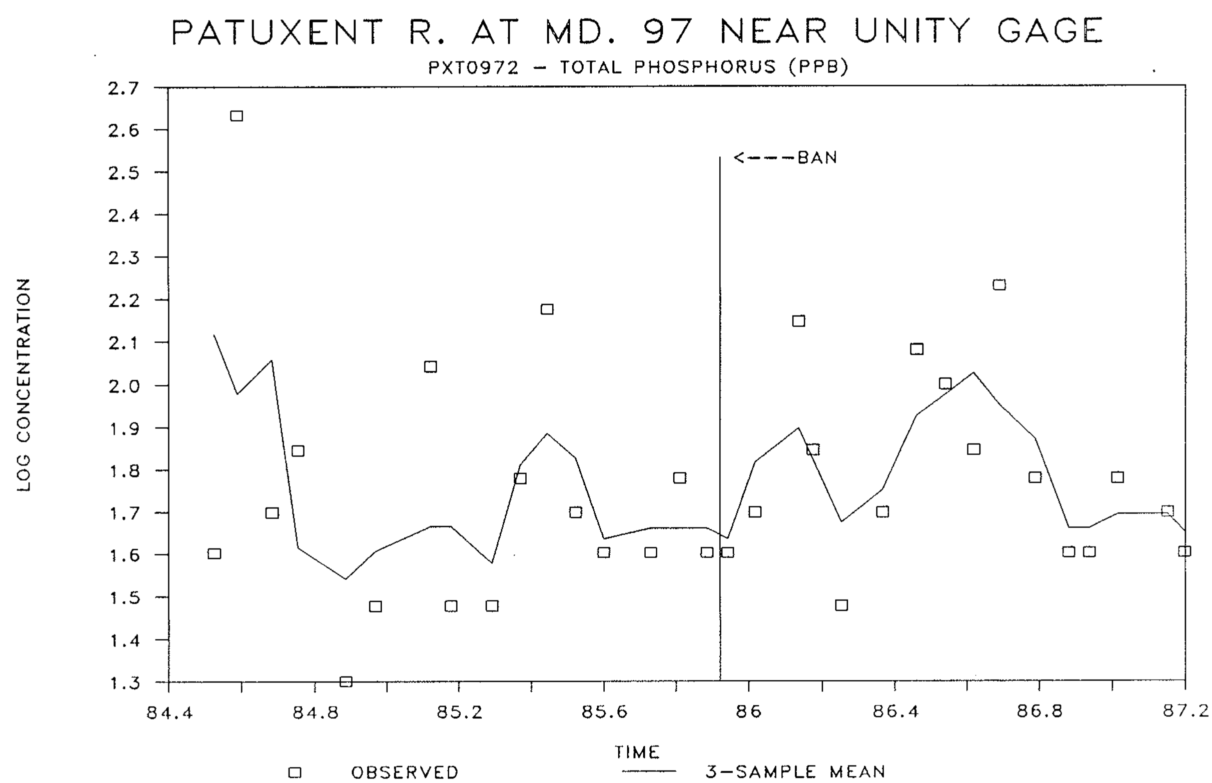



PATUXENT R. BRIDGE AT U.S. RT. 50
PXT0603 - TOTAL PHOSPHORUS (PPB)
LOW
HIGH
LOG CONCENTRATION
LOG RUNOFF, IN/YR
PRE-BAN
POST-BAN
1987

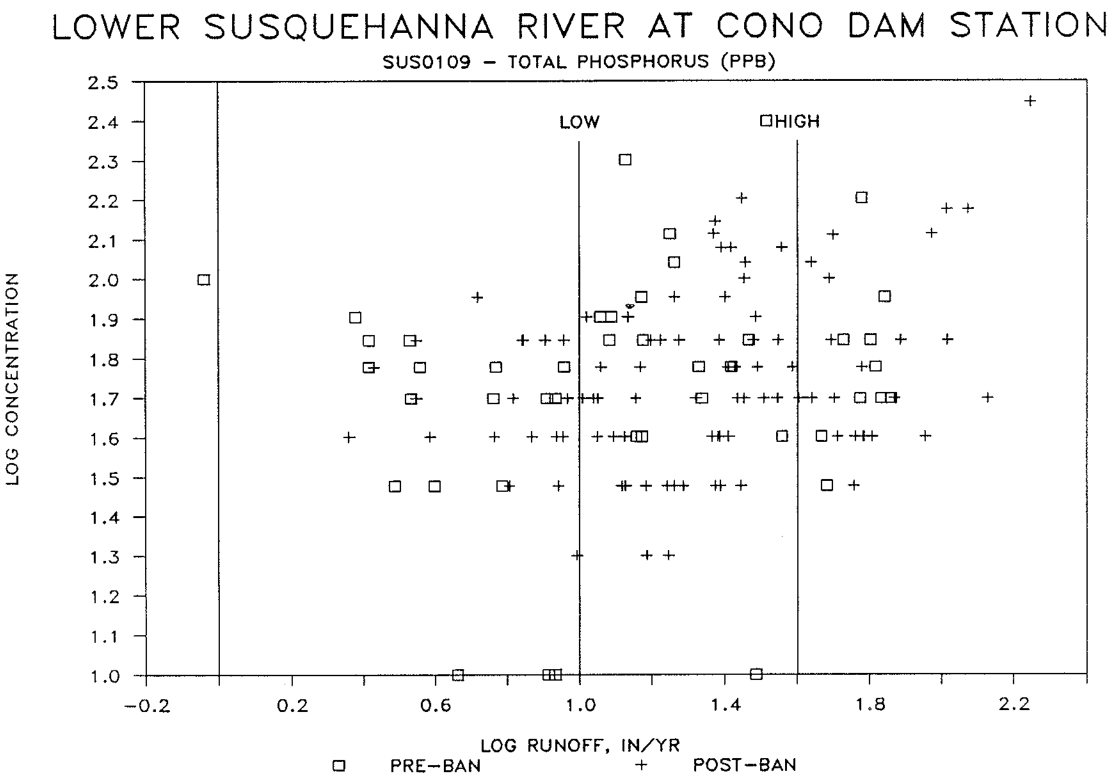

PATUXENT R. BRIDGE AT U.S. RT. 50
PXT0603 - TOTAL PHOSPHORUS (PPB)
<---BAN
LOG CONCENTRATION
TIME
OBSERVED
3-SAMPLE MEAN

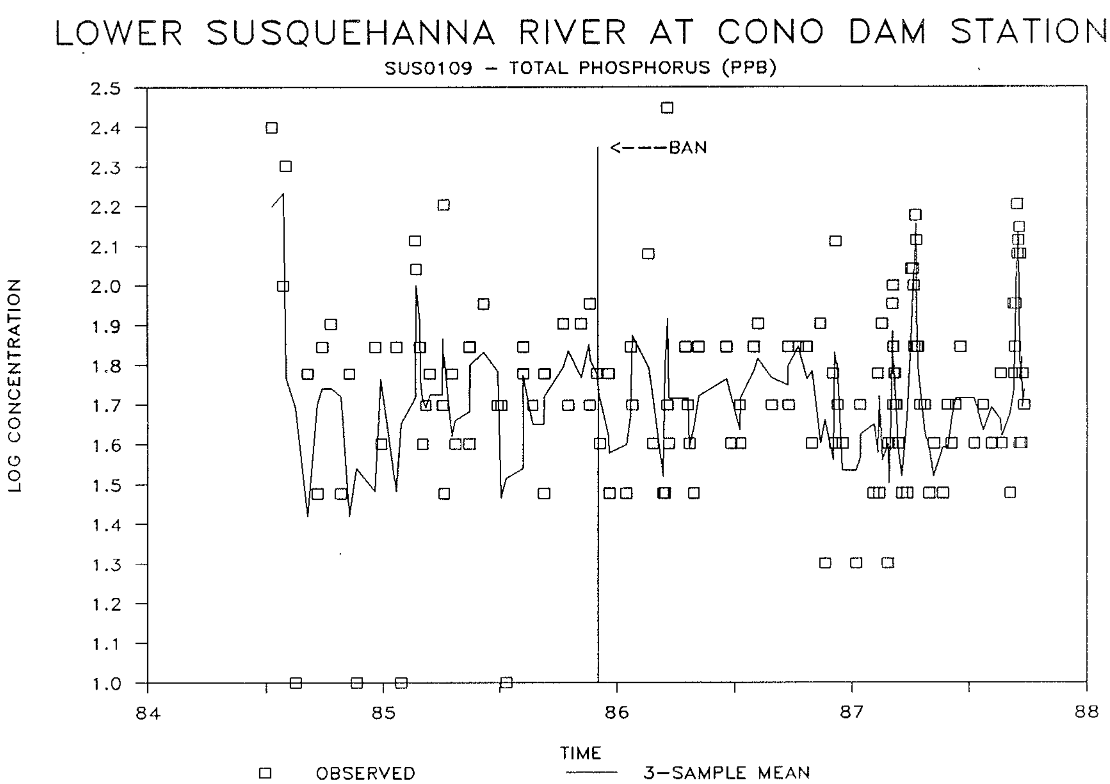


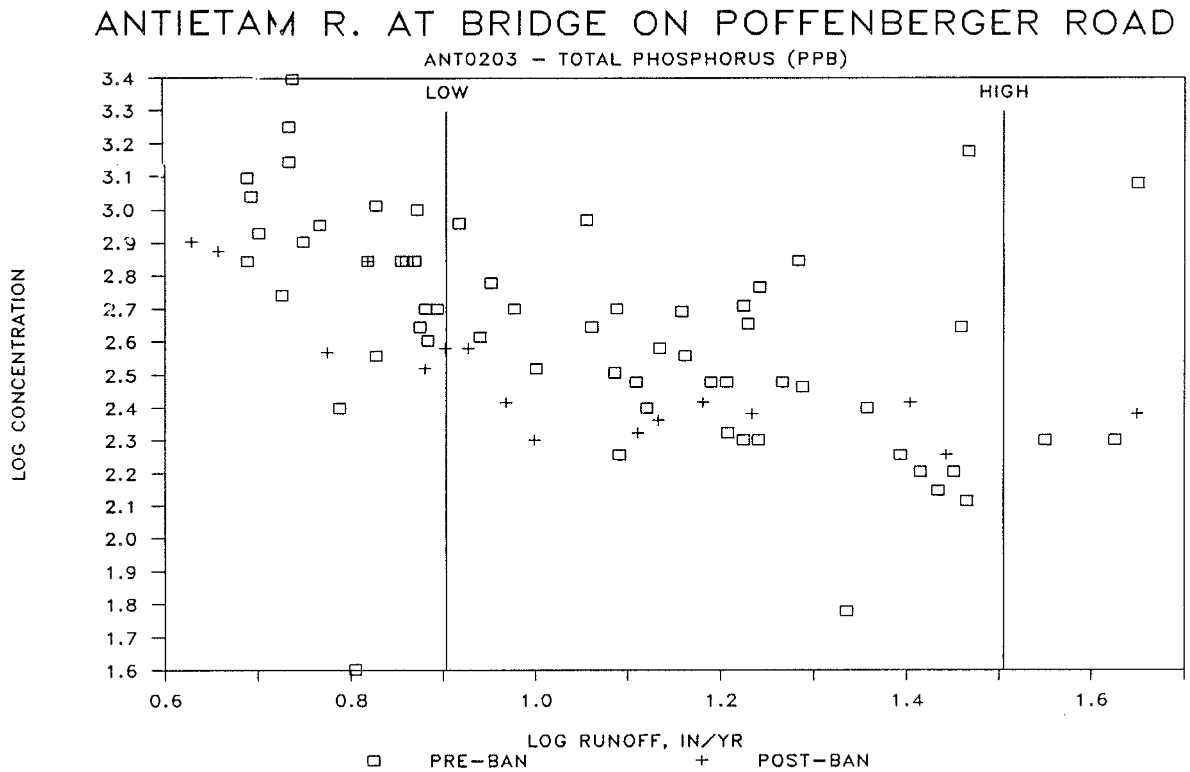
PATUXENT R. AT MD. 97 NEAR UNITY GAGE
PXT0972 – TOTAL PHOSPHORUS (PPB)
LOW
HIGH
LOG CONCENTRATION
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
0.1
0.3
0.5
0.7
0.9
1.1
1.3
1.5
1.7
LOG RUNOFF, IN/YR
PRE-BAN
POST-BAN

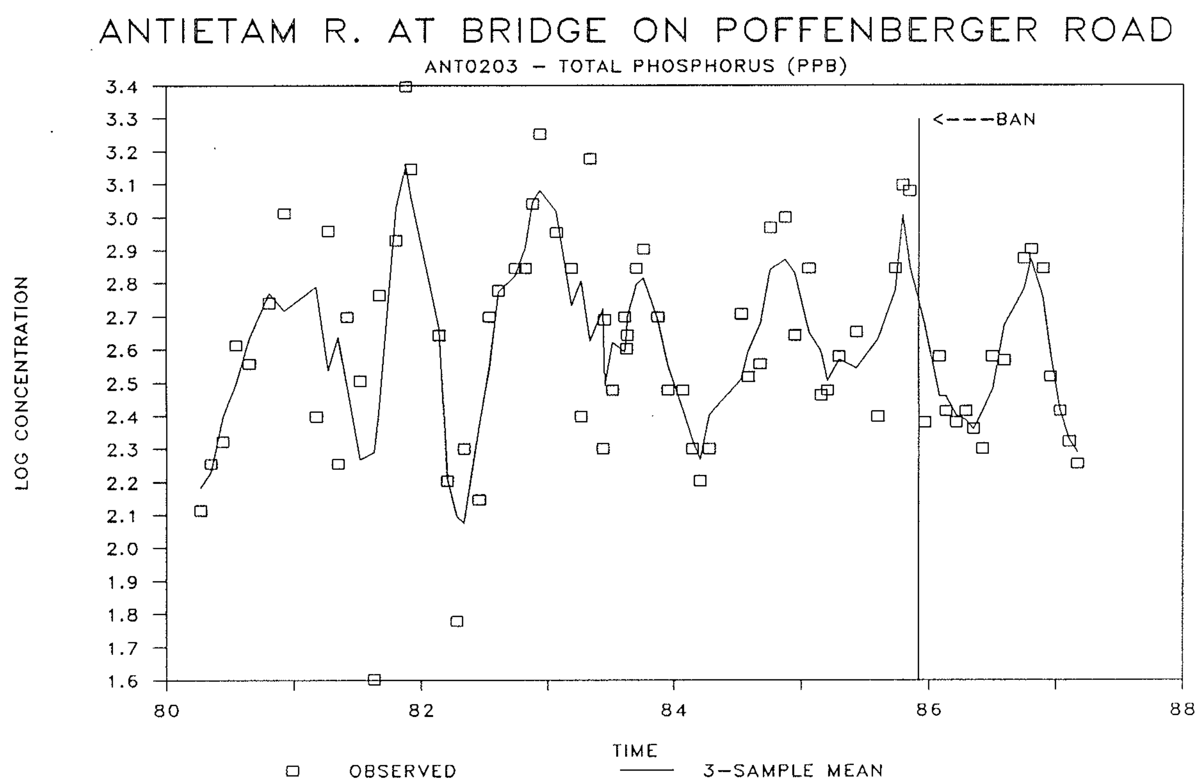


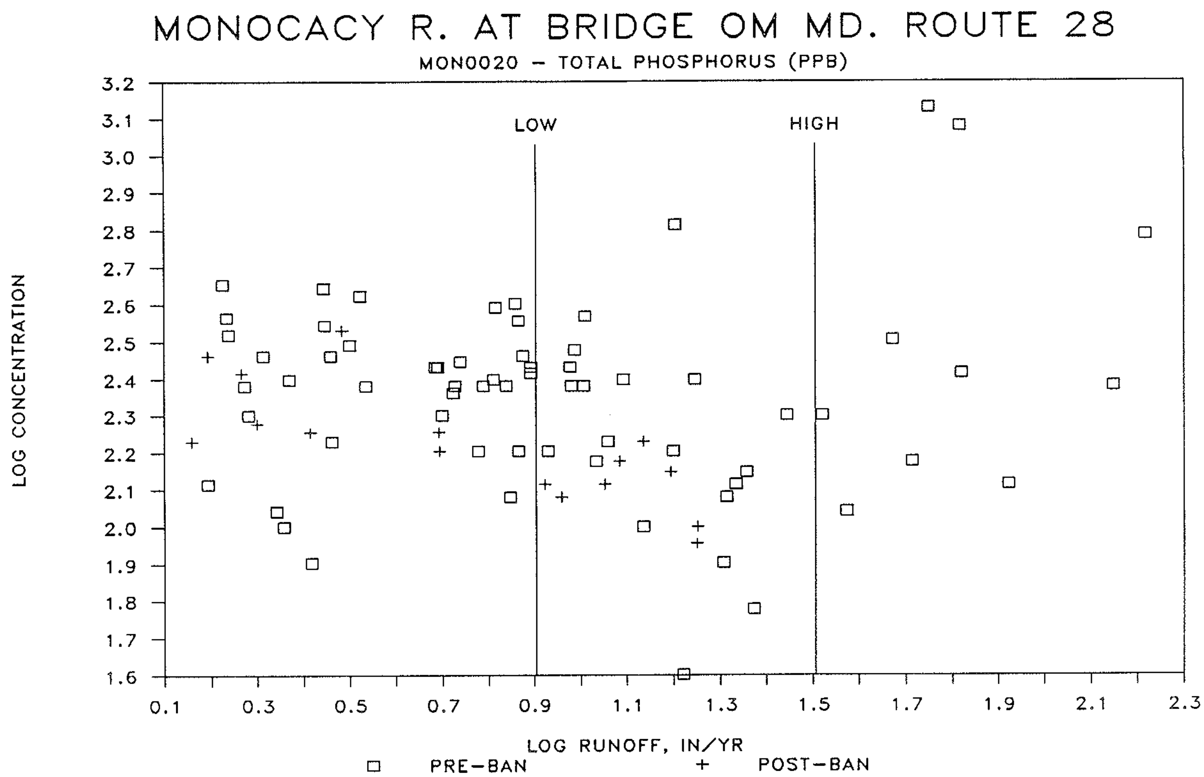
PATUXENT R. AT MD. 97 NEAR UNITY GAGE
PXT0972 – TOTAL PHOSPHORUS (PPB)
<---BAN
LOG CONCENTRATION
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
84.4
84.8
85.2
85.6
86
86.4
86.8
87.2
TIME
OBSERVED
3-SAMPLE MEAN

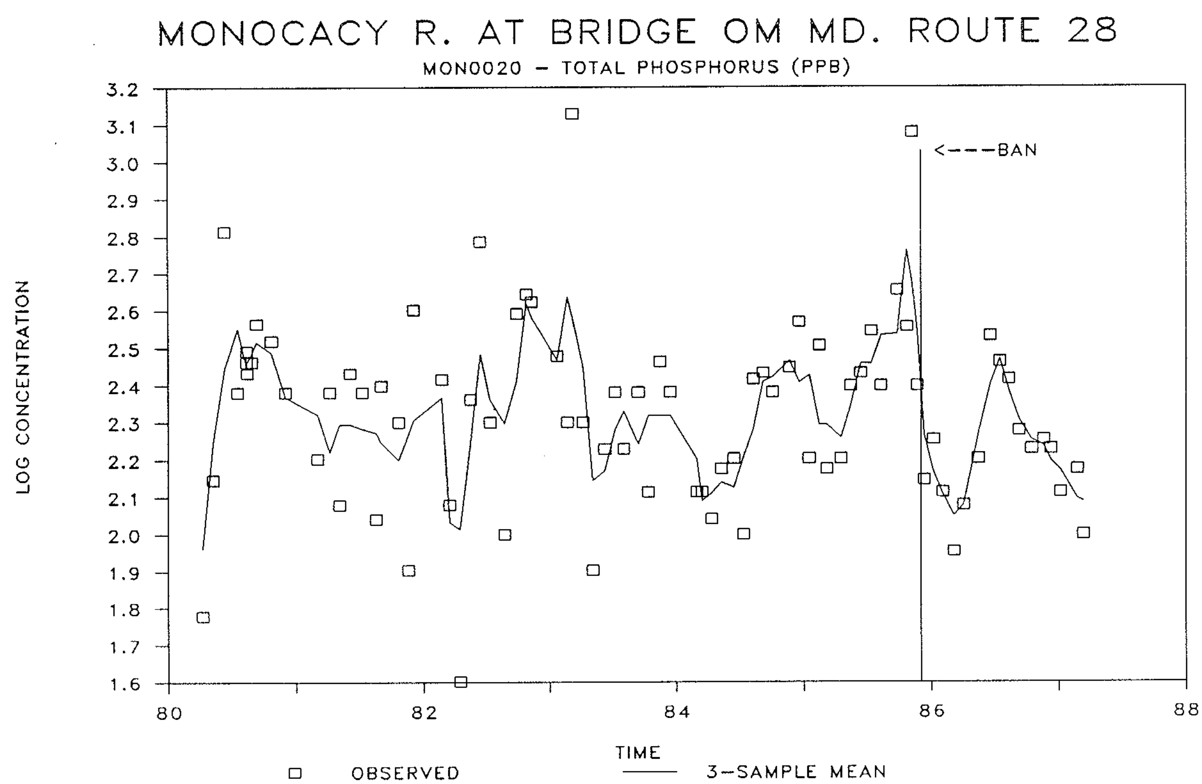

LOWER SUSQUEHANNA RIVER AT CONO DAM STATION
SUS0109 - TOTAL PHOSPHORUS (PPB)
LOW
HIGH
LOG CONCENTRATION
LOG RUNOFF, IN/YR
PRE-BAN
POST-BAN
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
-0.2
0.2
0.6
1.0
1.4
1.8
2.2

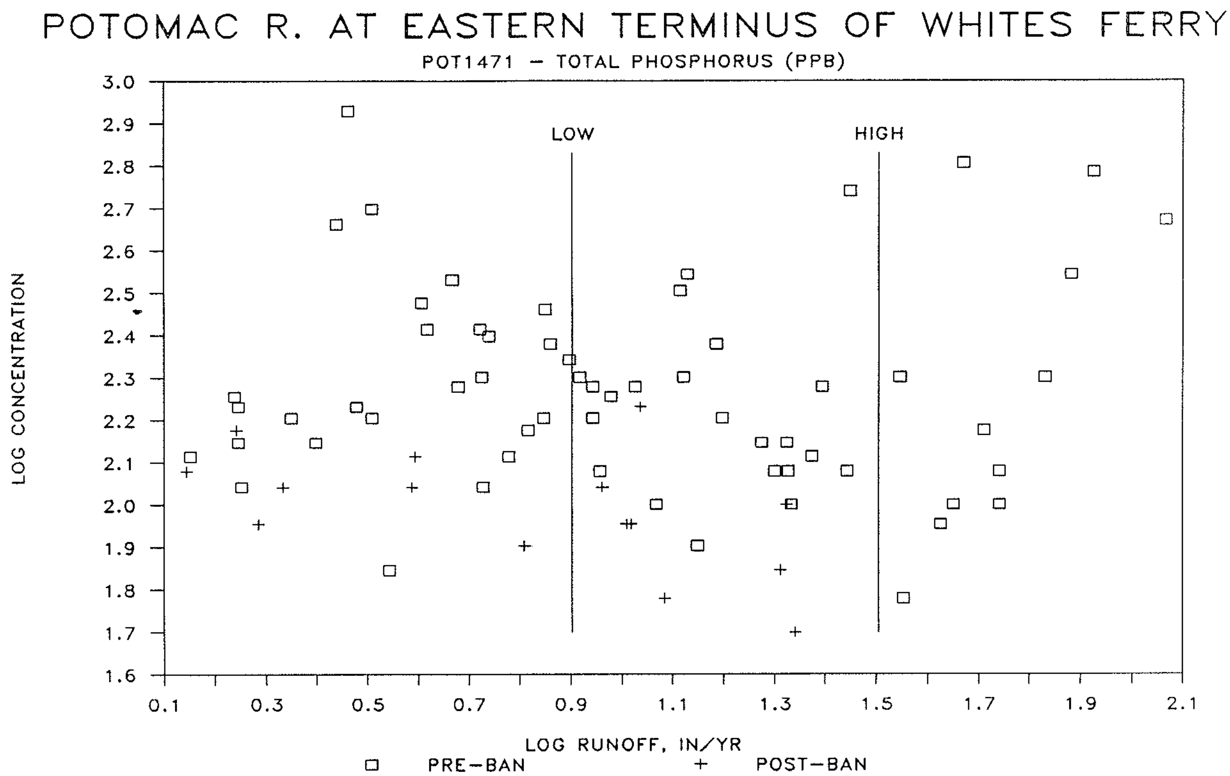

LOWER SUSQUEHANNA RIVER AT CONO DAM STATION
SUS0109 - TOTAL PHOSPHORUS (PPB)
<---BAN
LOG CONCENTRATION
TIME
OBSERVED
3-SAMPLE MEAN
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
84
85
86
87
88

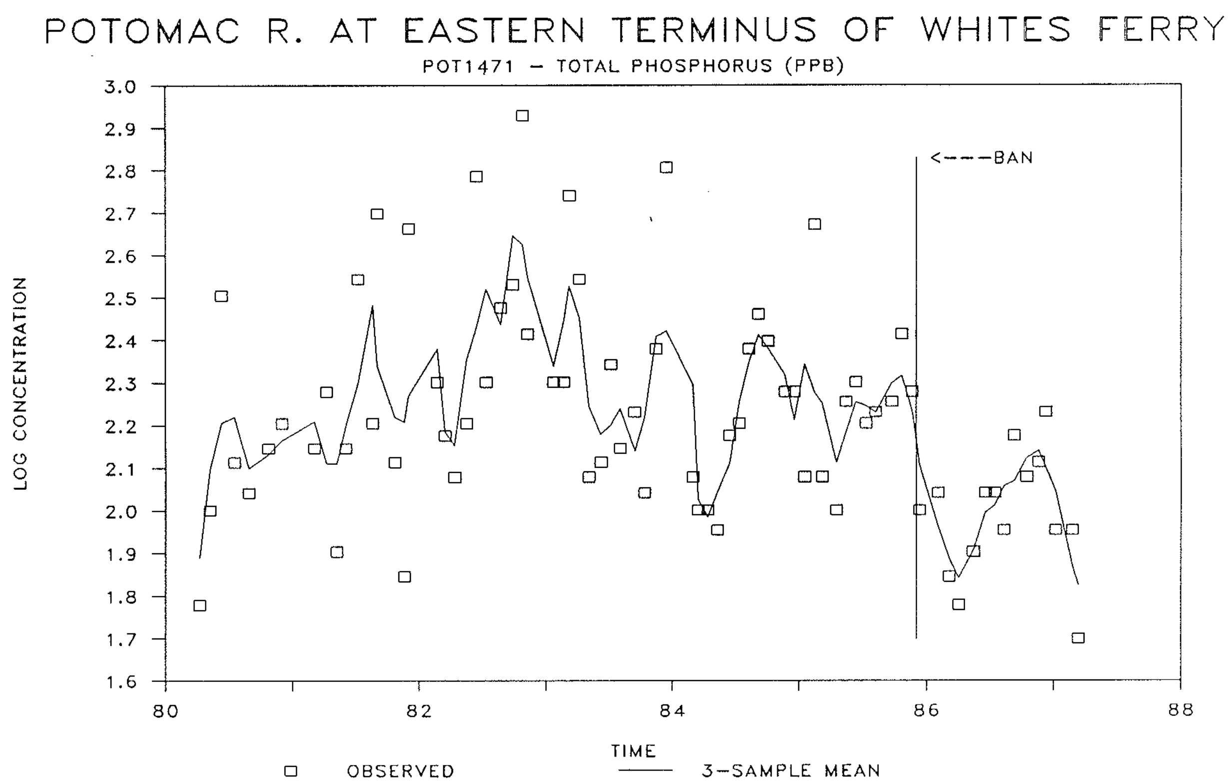

ANTIETAM R. AT BRIDGE ON POFFENBERGER ROAD
ANT0203 – TOTAL PHOSPHORUS (PPB)
LOW
HIGH
LOG CONCENTRATION
LOG RUNOFF, IN/YR
PRE-BAN
POST-BAN

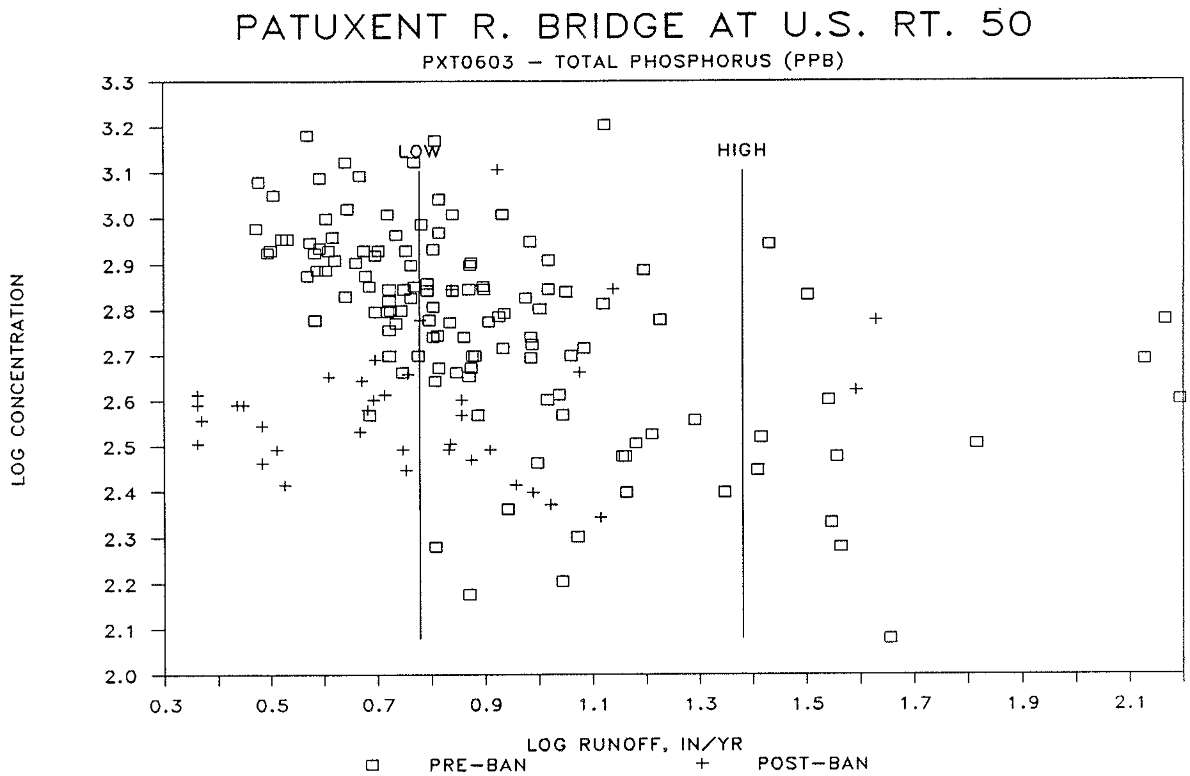

ANTIETAM R. AT BRIDGE ON POFFENBERGER ROAD
ANT0203 – TOTAL PHOSPHORUS (PPB)
<---BAN
LOG CONCENTRATION
TIME
OBSERVED
3-SAMPLE MEAN

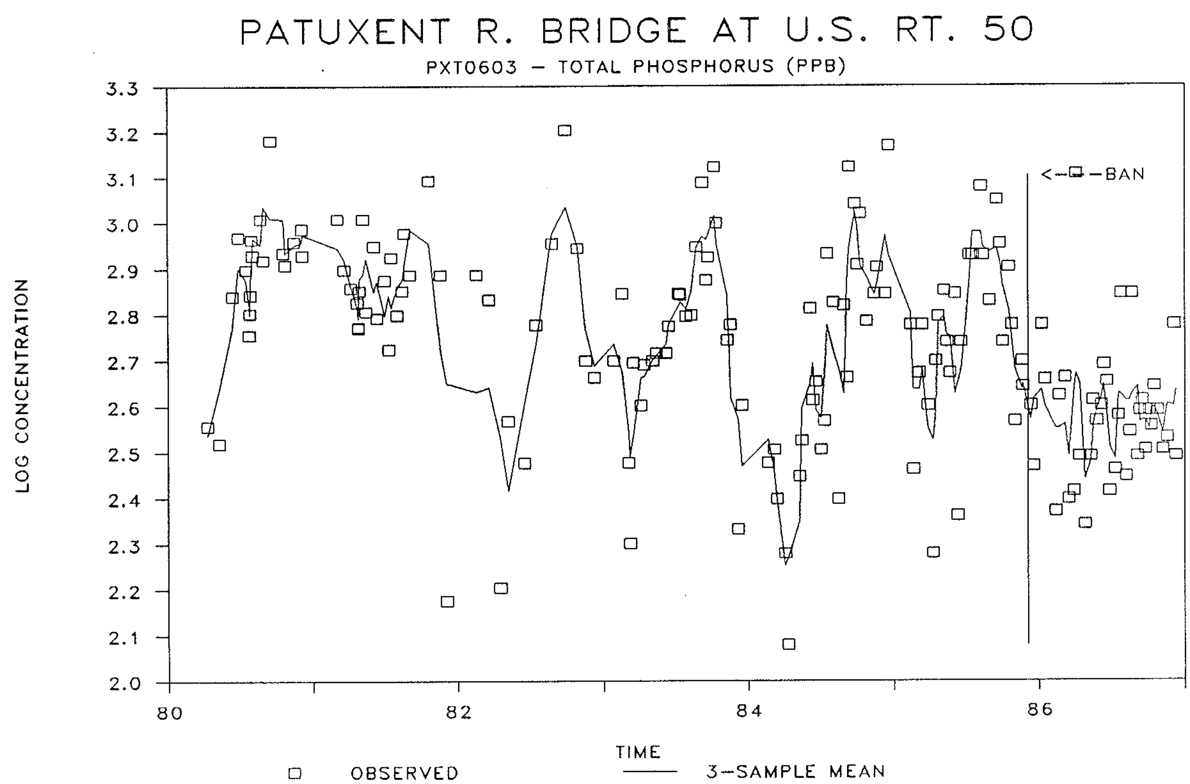

MONOCACY R. AT BRIDGE OM MD. ROUTE 28
MON0020 - TOTAL PHOSPHORUS (PPB)
LOW
HIGH
LOG CONCENTRATION
LOG RUNOFF, IN/YR
PRE-BAN
POST-BAN


MONOCACY R. AT BRIDGE OM MD. ROUTE 28
MON0020 - TOTAL PHOSPHORUS (PPB)
<---BAN
LOG CONCENTRATION
TIME
OBSERVED
3-SAMPLE MEAN


POTOMAC R. AT EASTERN TERMINUS OF WHITES FERRY
POT1471 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
LOW
HIGH
LOG RUNOFF, IN/YR
PRE-BAN
POST-BAN


POTOMAC R. AT EASTERN TERMINUS OF WHITES FERRY
POT1471 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
<---BAN
TIME
OBSERVED
3-SAMPLE MEAN


PATUXENT R. BRIDGE AT U.S. RT. 50
PXT0603 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
LOW
HIGH
LOG RUNOFF, IN/YR
PRE-BAN
POST-BAN


PATUXENT R. BRIDGE AT U.S. RT. 50
PXT0603 – TOTAL PHOSPHORUS (PPB)
LOG CONCENTRATION
<--BAN
TIME
OBSERVED
3-SAMPLE MEAN

CHESAPEAKE BAY ESTUARY AND MAINSTEM DATA MEANS BY STATION, YEAR, AND SEASON DEPTH <= 3 METERS

STATION	YEAR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
CB1.1	1984	3SUM	4	38	12	8	1284	25	234	1303	9.1	14	0.88	25.5	6.7	283	0.0
CB1.1	1984	4FAL	4	37	17	10	1279	45	346	986	6.4	13	1.23	13.6	9.1	325	0.0
CB1.1	1984	YEAR	8	38	14	9	1281	35	290	1144	7.8	14	1.03	19.6	7.9	304	0.0
CB1.1	1985	1WIN	2	65	33	11	1045	92	329	1845	16.0	31	0.35	6.8	13.3	100	0.0
CB1.1	1985	2SPR	6	50	23	10	852	105	237	932	9.4	19	0.88	18.4	8.1	210	0.0
CB1.1	1985	3SUM	6	50	23	5	702	21		602	10.5	24	1.10	25.9	7.2	325	0.0
CB1.1	1985	4FAL	4	41	21	16	1091	45		1473	2.9	4	0.90	13.3	9.3	232	0.0
CB1.1	1985	YEAR	18	50	24	10	876	62	274	1043	9.4	31	0.90	18.5	8.3	241	0.0
CB1.1	1986	1WIN	2	47	21	8	1490	69		1855			0.45	5.8	12.0	1005	0.3
CB1.1	1986	2SPR	6	41	9	6	1037	46	400	1280	10.5	19	0.77	19.0	8.7	190	0.0
CB1.1	1986	3SUM	6	33	10	4	852	16	435	617	9.9	15	1.08	25.1	7.1	296	0.0
CB1.1	1986	4FAL	4	38	12	7	1068	41	373	1548	6.4	12	1.00	12.4	10.2	259	0.0
CB1.1	1986	YEAR	18	38	11	6	1032	37	408	1182	9.2	19	0.88	18.1	8.8	331	0.0
CB1.1	1987	1WIN	3	31	13	9	1740	50	260	1717	2.0	4	1.53	4.7	12.8	221	0.0
CB1.1	1987	2SPR	6	53	13	5	1022	49	432	1280	13.5	37	0.72	16.7	9.7	222	0.0
CB1.1	1987	3SUM	2	35	9	5	920	61	360	1300	9.7	12	1.10	27.4	6.7	309	0.0
CB1.1	1987	YEAR	11	44	12	6	1199	51	372	1403	9.7	37	1.01	14.5	10.2	236	0.0
CB1.1	ALL	ALL	55	43	16	7	1051	48	352	1175	9.2	37	0.93	17.7	8.9	278	0.0
CB2.1	1984	3SUM	4	76	20	11	1005	67	210	1625	14.8	27	0.44	24.5	7.3	1625	0.7
CB2.1	1984	4FAL	4	43	17	10	1047	67	326	904	11.0	15	0.90	13.0	9.5	4133	2.0
CB2.1	1984	YEAR	8	60	18	10	1026	67	268	1264	12.9	27	0.67	18.7	8.4	2879	1.3
CB2.1	1985	1WIN	2	90	42	9	1000	42	318	1600	21.5	25	0.35	7.3	13.2	100	0.0
CB2.1	1985	2SPR	5	64	18	7	790	61	247	858	12.5	19	0.40	18.6	8.6	573	0.1
CB2.1	1985	3SUM	6	86	34	15	324	57		702	11.7	18	0.48	25.5	6.7	3141	1.4
CB2.1	1985	4FAL	4	46	20	15	901	62		1230	5.6	14	0.68	13.0	9.9	3211	1.5
CB2.1	1985	YEAR	17	71	27	12	676	57	282	978	11.7	25	0.49	18.4	8.5	2044	0.9
CB2.1	1986	1WIN	2	58	21	9	1460	52		1820	2.4	3	0.45	7.3	11.6	966	0.3
CB2.1	1986	2SPR	6	65	11	9	1007	34	550	1140	14.1	22	0.42	18.7	9.3	176	0.0
CB2.1	1986	3SUM	6	63	19	7	516	27	590	612	18.6	41	0.50	24.4	8.0	798	0.2
CB2.1	1986	4FAL	4	58	14	9	998	42	443	1288	7.1	18	0.63	11.7	10.3	1568	0.7
CB2.1	1986	YEAR	18	62	15	8	892	35	534	1072	12.7	41	0.49	17.8	9.4	781	0.2
CB2.1	1987	1WIN	3	41	11	7	1620	42	377	1863	5.1	11	1.00	4.2	12.8	1824	0.7
CB2.1	1987	2SPR	6	71	11	6	921	49	573	1108	17.9	29	0.45	17.4	9.6	757	0.1
CB2.1	1987	3SUM	2	40	17	14	548	145	455	1070	5.4	7	1.00	27.2	7.0	428	0.0
CB2.1	1987	YEAR	11	57	12	8	1044	64	498	1307	12.1	29	0.70	15.6	10.0	988	0.3
CB2.1	ALL	ALL	54	63	19	10	875	53	433	1119	12.3	41	0.56	17.7	9.1	1532	0.6
CB2.2	1984	3SUM	6	53	19	9	959	60	286	1590	7.5	14	0.58	24.8	6.9	3454	1.7
CB2.2	1984	4FAL	4	48	21	14	783	109	365	861	9.0	17	0.95	13.4	9.2	9298	5.0
CB2.2	1984	YEAR	10	51	20	11	888	80	318	1299	8.1	17	0.73	20.2	7.8	5792	3.0
CB2.2	1985	1WIN	2	119	56	12	1020	76	337	1658	9.3	13	0.35	7.2	12.6	1075	0.3
CB2.2	1985	2SPR	6	55	22	12	757	76	281	898	9.0	18	0.50	17.6	8.1	2435	1.0
CB2.2	1985	3SUM	6	63	33	19	310	39		1180	6.5	9	0.68	25.2	6.6	9163	4.9
CB2.2	1985	4FAL	4	53	32	18	794	95		1314	3.3	5	0.90	13.5	9.1	8265	4.4
CB2.2	1985	YEAR	18	64	32	16	646	68	303	1169	6.9	18	0.63	18.0	8.1	5822	3.0
CB2.2	1986	1WIN	3	74	18	10	1377	74		2085	2.6	5	0.33	3.7	12.4	1245	0.4
CB2.2	1986	2SPR	6	67	18	14	954	63	700	1106	9.4	26	0.40	18.3	8.7	1278	0.4
CB2.2	1986	3SUM	6	58	27	19	373	33	523	827	7.6	9	0.72	24.3	7.4	6488	3.3
CB2.2	1986	4FAL	4	57	20	14	770	80	495	1178	5.8	10	0.63	12.7	9.7	6432	3.3
CB2.2	1986	YEAR	19	63	21	15	798	59	543	1187	7.0	26	0.53	16.7	9.1	4003	1.9
CB2.2	1987	1WIN	3	56	13	9	1345	57	565	1780	22.9	62	0.73	4.1	12.7	7780	4.1
CB2.2	1987	2SPR	6	58	14	9	897	55	481	1091	10.0	20	0.52	16.6	9.5	1748	0.6
CB2.2	1987	3SUM	2	47	24	19	479	68	545	1355	7.9	9	0.85	26.7	6.4	5852	2.9
CB2.2	1987	YEAR	11	56	15	11	943	58	516	1327	13.1	62	0.64	14.1	10.1	4443	2.2
CB2.2	ALL	ALL	58	60	23	14	794	65	444	1227	8.4	62	0.62	17.2	8.8	4951	2.5

CHESAPEAKE BAY ESTUARY AND MAINSTEM DATA MEANS BY STATION, YEAR, AND SEASON DEPTH <= 3 METERS

STATION	YEAR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
CB3.1	1984	3SUM	4	75	24	13	853	57	300	1655	17.0	58	0.69	24.1	6.8	7158	3.9
CB3.1	1984	4FAL	4	39	19	13	561	104	314	905	8.1	12	1.45	13.4	8.9	13638	7.7
CB3.1	1984	YEAR	8	57	21	13	707	80	307	1280	12.6	58	1.07	18.8	7.8	10398	5.8
CB3.1	1985	1WIN	2	79	21	8	1015	80	337	1350	8.8	11	0.35	6.7	12.3	4683	2.2
CB3.1	1985	2SPR	5	54	18	11	666	76	286	853	15.0	32	0.66	17.6	7.5	5620	2.8
CB3.1	1985	3SUM	6	73	29	17	176	28		1368	18.9	56	0.72	25.0	6.5	15350	8.7
CB3.1	1985	4FAL	4	49	28	20	583	107		1188	4.6	9	1.00	14.0	8.7	14778	8.4
CB3.1	1985	YEAR	17	62	25	15	515	67	311	1172	13.2	56	0.72	18.1	7.7	11099	6.2
CB3.1	1986	1WIN	4	62	22	12	1239	102		1844	4.2	9	0.60	2.6	12.7	3168	1.4
CB3.1	1986	2SPR	6	66	17	13	787	62	710	1013	11.4	38	0.48	17.6	8.5	5056	2.5
CB3.1	1986	3SUM	6	56	27	18	238	35	608	1118	8.9	12	0.88	24.2	6.9	12057	6.7
CB3.1	1986	4FAL	4	55	24	17	600	89	473	1155	4.9	10	0.75	13.1	9.3	11029	6.1
CB3.1	1986	YEAR	20	60	22	15	675	67	580	1239	7.9	38	0.67	15.7	9.0	7973	4.2
CB3.1	1987	1WIN	4	70	15	9	1105	53	806	1263	34.0	73	0.88	4.3	12.8	12796	7.1
CB3.1	1987	2SPR	6	51	15	9	748	66	568	1124	11.7	32	0.72	15.9	7.6	6874	3.6
CB3.1	1987	3SUM	2	56	18	12	291	41	585	1500	13.4	16	0.90	26.6	6.3	11167	6.1
CB3.1	1987	YEAR	12	58	15	9	790	57	650	1233	19.4	73	0.80	13.8	9.1	9564	5.2
CB3.1	ALL	ALL	57	60	21	13	656	67	513	1224	12.6	73	0.77	16.4	8.5	9581	5.2
CB3.2	1984	3SUM	6	47	22	11	692	71	265	1529	7.8	17	1.05	24.5	6.5	9711	5.3
CB3.2	1984	4FAL	4	32	17	10	403	87	315	856	11.0	23	1.44	13.7	9.1	18015	10.4
CB3.2	1984	YEAR	10	41	20	11	576	77	285	1260	9.1	23	1.21	20.2	7.5	13033	7.4
CB3.2	1985	1WIN	3	69	21	7	784	66	323	994	14.7	22	0.63	4.6	13.3	14089	8.0
CB3.2	1985	2SPR	5	61	22	8	510	60	328	759	29.7	94	0.98	17.2	7.9	9900	5.4
CB3.2	1985	3SUM	6	60	27	16	89	55		1446	6.4	14	0.85	24.9	6.5	19350	11.3
CB3.2	1985	4FAL	4	47	30	15	400	92		973	4.9	7	1.25	14.4	8.8	19873	11.7
CB3.2	1985	YEAR	18	59	25	12	391	66	325	1075	13.9	94	0.94	17.0	8.3	15964	9.2
CB3.2	1986	1WIN	4	54	23	9	1051	109		1583	4.3	9	0.78	2.9	12.1	9535	5.1
CB3.2	1986	2SPR	6	48	12	8	658	72	615	872	18.1	68	0.70	17.1	8.5	9483	5.1
CB3.2	1986	3SUM	6	46	20	14	105	37	572	1348	8.0	11	1.18	24.2	7.1	16383	9.4
CB3.2	1986	4FAL	4	51	27	22	493	86	425	1144	5.1	9	1.20	13.4	9.0	15136	8.6
CB3.2	1986	YEAR	20	49	20	13	538	72	530	1211	9.7	68	0.93	15.6	8.9	12694	7.1
CB3.2	1987	1WIN	4	50	13	7	955	74	653	1095	23.2	46	1.30	4.3	12.4	15545	8.9
CB3.2	1987	2SPR	6	40	14	7	576	66	599	1046	6.4	9	1.02	16.0	9.1	11451	6.3
CB3.2	1987	3SUM	2	49	16	8	45	65	535	1645	10.6	17	1.60	26.3	7.1	15928	9.1
CB3.2	1987	YEAR	12	45	14	7	614	69	606	1162	12.7	46	1.21	13.8	9.9	13562	7.6
CB3.2	ALL	ALL	60	50	20	11	515	70	464	1168	11.5	94	1.04	16.4	8.7	13905	7.9
CB3.3C	1984	3SUM	6	50	17	7	319	66	304	1332	20.5	33	0.99	24.5	7.5	13522	7.7
CB3.3C	1984	4FAL	4	40	20	11	378	109	365	927	13.7	29	1.88	14.2	9.6	19679	11.5
CB3.3C	1984	YEAR	10	46	18	9	343	83	328	1170	17.8	33	1.35	20.4	8.3	15985	9.2
CB3.3C	1985	1WIN	4	48	15	6	633	43	268	743	10.3	12	1.83	3.6	14.2	18792	11.0
CB3.3C	1985	2SPR	6	51	39	5	352	44	245	500	23.3	54	1.28	17.2	10.0	15854	9.1
CB3.3C	1985	3SUM	6	66	29	10	46	27		1361	12.6	22	0.98	25.6	7.1	22339	13.3
CB3.3C	1985	4FAL	4	36	17	10	269	95		781	13.8	30	1.55	15.3	10.2	22833	13.6
CB3.3C	1985	YEAR	20	52	27	8	300	49	258	863	15.6	54	1.36	16.6	9.8	19783	11.6
CB3.3C	1986	1WIN	4	37	11	4	811	91		1291	5.7	8	1.13	3.7	12.1	14734	8.4
CB3.3C	1986	2SPR	6	35	11	4	526	57	720	686	18.7	29	1.07	18.4	10.0	13107	7.3
CB3.3C	1986	3SUM	6	61	20	8	27	18	857	1404	24.3	37	0.90	25.1	8.9	20117	11.8
CB3.3C	1986	4FAL	4	48	22	12	271	78	473	938	8.2	12	1.75	13.9	9.3	21800	12.9
CB3.3C	1986	YEAR	20	46	16	7	382	56	706	1073	15.7	37	1.18	16.6	10.0	17274	10.0
CB3.3C	1987	1WIN	4	34	11	4	753	62	514	910	12.2	17	1.53	5.0	12.4	19358	11.3
CB3.3C	1987	2SPR	6	41	13	5	467	60	571	736	12.3	28	1.17	16.8	8.8	14538	8.3
CB3.3C	1987	3SUM	2	69	21	12	10	58	508	1643	22.5	25	1.20	27.1	9.5	17115	9.9
CB3.3C	1987	YEAR	12	43	13	6	486	60	541	945	14.0	28	1.29	14.6	10.1	16574	9.6
CB3.3C	ALL	ALL	62	47	19	7	369	59	489	996	15.7	54	1.29	16.8	9.7	17740	10.3

CHESAPEAKE BAY ESTUARY AND MAINSTEM DATA MEANS BY STATION, YEAR, AND SEASON DEPTH <= 3 METERS

STATION	YEAR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
CB3.3E	1984	3SUM	5	42	14	7	351	72	300	1342	12.9	15	1.09	24.4	7.3	12803	7.2
CB3.3E	1984	4FAL	4	33	16	8	325	89	289	870	13.1	22	1.89	14.1	9.5	20532	12.1
CB3.3E	1984	YEAR	9	38	15	7	340	80	295	1132	13.0	22	1.44	19.8	8.3	16238	9.4
CB3.3E	1985	1WIN	3	125	26	6	699	37	237	702	10.0	10	2.03	5.1	13.9	18178	10.6
CB3.3E	1985	2SPR	6	37	18	6	320	65	276	491	19.6	43	1.28	16.9	9.3	16394	9.4
CB3.3E	1985	3SUM	6	66	31	8	43	38		1362	12.0	27	1.05	25.7	7.3	22111	13.1
CB3.3E	1985	4FAL	4	43	26	12	294	111		813	11.3	21	1.48	15.1	9.9	22075	13.2
CB3.3E	1985	YEAR	19	61	25	8	287	62	256	867	13.9	43	1.37	17.4	9.3	19677	11.6
CB3.3E	1986	1WIN	4	40	13	6	786	86		1238	5.7	7	1.00	3.7	12.2	14842	8.5
CB3.3E	1986	2SPR	6	26	7	4	525	35	685	728	15.5	25	1.23	18.1	9.8	13200	7.4
CB3.3E	1986	3SUM	6	61	22	11	29	23	748	1424	26.6	67	0.90	25.0	8.1	20281	11.9
CB3.3E	1986	4FAL	4	42	19	8	240	57	450	870	8.8	12	1.90	13.9	9.4	22300	13.3
CB3.3E	1986	YEAR	20	43	15	7	372	46	638	1067	15.5	67	1.24	16.4	9.7	17473	10.1
CB3.3E	1987	1WIN	3	34	13	6	695	57	480	973	10.2	15	1.73	5.3	12.4	19367	11.3
CB3.3E	1987	2SPR	6	38	13	5	503	63	656	828	12.9	34	1.27	16.7	9.1	14511	8.3
CB3.3E	1987	3SUM	2	76	34	19	7	58	595	1615	35.3	43	1.20	26.9	8.9	17548	10.2
CB3.3E	1987	YEAR	11	44	16	8	465	60	597	1010	16.2	43	1.38	15.4	10.0	16387	9.4
CB3.3E	ALL	ALL	59	48	18	7	357	59	485	1002	14.7	67	1.34	17.1	9.4	17792	10.4
CB3.3W	1984	3SUM	5	47	20	17	326	123	374	1451	11.6	16	1.06	24.5	6.3	12773	7.2
CB3.3W	1984	4FAL	4	33	19	11	349	146	429	929	8.9	13	1.65	14.4	8.7	20742	12.2
CB3.3W	1984	YEAR	9	41	20	14	336	133	398	1219	10.4	16	1.32	20.0	7.4	16315	9.4
CB3.3W	1985	1WIN	3	62	54	6	609	31	312	617	12.0	13	1.63	5.2	12.3	19944	11.7
CB3.3W	1985	2SPR	6	49	16	7	334	46	267	571	19.5	45	1.08	17.4	9.4	16628	9.6
CB3.3W	1985	3SUM	6	61	21	11	56	70		1467	29.2	112	0.95	25.7	6.5	21628	12.8
CB3.3W	1985	4FAL	4	47	25	12	356	106		1023	15.6	37	1.17	15.1	10.5	21592	12.8
CB3.3W	1985	YEAR	19	54	26	9	294	64	290	956	20.8	112	1.15	17.6	9.0	19775	11.6
CB3.3W	1986	1WIN	4	44	19	5	824	110		1258	6.1	9	0.88	3.4	12.4	14866	8.5
CB3.3W	1986	2SPR	6	31	7	3	497	36	710	762	15.7	25	0.92	18.2	9.3	12976	7.2
CB3.3W	1986	3SUM	6	74	26	16	34	23	837	1428	27.9	54	0.78	25.3	9.1	19114	11.2
CB3.3W	1986	4FAL	4	50	24	15	300	93	476	1036	8.9	16	1.65	13.9	9.1	21875	13.0
CB3.3W	1986	YEAR	20	50	18	10	384	58	695	1116	16.1	54	1.03	16.5	9.8	16975	9.8
CB3.3W	1987	1WIN	3	34	11	6	780	89	500	1047	9.4	13	1.33	5.3	12.7	18433	10.7
CB3.3W	1987	2SPR	6	45	14	6	542	84	691	958	15.5	29	1.10	17.1	9.3	13595	7.7
CB3.3W	1987	3SUM	2	86	33	16	17	73	655	1735	30.8	52	1.00	26.9	8.0	18325	10.7
CB3.3W	1987	YEAR	11	49	16	8	511	83	632	1124	16.6	52	1.15	15.7	10.0	15774	9.0
CB3.3W	ALL	ALL	59	50	21	10	372	76	543	1082	16.8	112	1.14	17.2	9.2	17552	10.2
CB4.1C	1984	3SUM	6	37	16	8	189	49	321	1202	13.8	19	1.37	24.4	7.7	15567	9.0
CB4.1C	1984	4FAL	4	31	12	9	174	56	304	678	14.5	30	2.13	15.3	9.5	24033	14.4
CB4.1C	1984	YEAR	10	35	15	8	183	52	314	992	14.1	30	1.67	20.8	8.4	18953	11.1
CB4.1C	1985	1WIN	4	38	52	7	468	26	271	522	8.3	11	2.33	3.7	13.4	21352	12.6
CB4.1C	1985	2SPR	6	48	19	5	277	31	393	315	19.3	29	1.83	16.8	9.8	19233	11.2
CB4.1C	1985	3SUM	6	45	15	6	36	15		1118	10.6	20	1.38	25.7	7.0	24493	14.7
CB4.1C	1985	4FAL	4	32	18	9	198	82		566	6.8	14	1.85	15.8	8.8	25975	15.7
CB4.1C	1985	YEAR	20	42	24	6	227	35	323	648	11.1	29	1.80	16.7	9.3	22583	13.5
CB4.1C	1986	1WIN	4	31	10	4	679	68		978	5.9	7	1.12	3.5	11.8	17829	10.4
CB4.1C	1986	2SPR	6	22	6	5	475	45	840	585	11.1	23	1.83	17.8	9.1	16201	9.3
CB4.1C	1986	3SUM	6	37	11	8	30	24	599	1235	12.8	18	1.48	25.1	8.2	22653	13.5
CB4.1C	1986	4FAL	3	38	19	9	224	74	384	773	6.4	7	2.10	14.5	8.7	24725	14.9
CB4.1C	1986	YEAR	19	31	11	6	332	49	568	896	9.6	23	1.65	16.5	9.3	20167	11.9
CB4.1C	1987	1WIN	4	25	10	3	506	33	458	669	8.1	12	2.30	4.7	12.4	23342	14.0
CB4.1C	1987	2SPR	6	34	11	3	389	36	566	558	17.2	36	1.77	16.5	10.1	18403	10.7
CB4.1C	1987	3SUM	2	42	16	6	15	43	485	1290	8.3	10	1.70	26.9	7.2	21425	12.7
CB4.1C	1987	YEAR	12	32	11	4	366	36	516	717	12.7	36	1.93	14.3	10.4	20553	12.1
CB4.1C	ALL	ALL	61	35	16	6	281	43	449	797	11.4	36	1.76	16.8	9.4	20825	12.3

CHESAPEAKE BAY ESTUARY AND MAINSTEM DATA MEANS BY STATION, YEAR, AND SEASON DEPTH <= 3 METERS

STATION	YEAR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
CB4.1E	1984	3SUM	5	36	18	7	172	60	284	1174	10.5	14	1.56	24.5	7.4	15385	8.8
CB4.1E	1984	4FAL	3	22	12	7	140	50	378	584	10.3	18	2.42	14.8	9.3	23711	14.2
CB4.1E	1984	YEAR	8	31	16	7	160	56	319	953	10.4	18	1.88	20.9	8.1	18507	10.8
CB4.1E	1985	1WIN	2	36	45	4	567	16	220	425	5.0	6	2.45	7.6	10.7	20083	11.8
CB4.1E	1985	2SPR	6	29	10	6	258	20	200	348	14.5	25	1.60	17.5	10.0	19922	11.7
CB4.1E	1985	3SUM	6	61	30	7	33	24		1073	8.6	13	1.43	25.6	6.6	24783	14.9
CB4.1E	1985	4FAL	4	28	14	8	195	77		473	7.4	15	1.75	15.3	9.1	26142	15.9
CB4.1E	1985	YEAR	18	40	22	6	203	34	208	626	9.6	25	1.67	18.6	8.6	22943	13.7
CB4.1E	1986	1WIN	4	30	13	4	620	53		875	7.0	11	1.65	3.4	11.8	18477	10.8
CB4.1E	1986	2SPR	6	20	7	4	447	36	705	523	9.5	15	1.97	17.7	8.9	17039	9.8
CB4.1E	1986	3SUM	6	36	13	6	26	22	570	1182	11.0	16	1.56	24.9	7.8	22928	13.7
CB4.1E	1986	4FAL	4	35	16	7	188	66	370	673	6.9	12	2.40	14.3	9.3	25613	15.5
CB4.1E	1986	YEAR	20	30	12	5	303	41	526	821	8.9	16	1.88	16.3	9.2	20808	12.3
CB4.1E	1987	1WIN	3	23	9	3	436	38	470	613	8.4	15	2.40	4.8	12.4	23717	14.2
CB4.1E	1987	2SPR	6	33	12	6	360	31	552	487	15.6	29	1.65	16.5	10.5	18845	11.0
CB4.1E	1987	3SUM	2	40	14	4	3	44	440	1175	9.3	11	1.60	26.5	7.0	22050	13.1
CB4.1E	1987	YEAR	11	31	11	5	316	35	509	646	12.5	29	1.85	15.2	10.4	20756	12.3
CB4.1E	ALL	ALL	57	33	15	6	254	40	431	744	10.1	29	1.81	17.5	9.1	21149	12.5
CB4.1W	1984	3SUM	5	43	16	7	148	92	330	1383	16.7	31	1.15	24.4	7.1	15205	8.7
CB4.1W	1984	4FAL	3	32	15	8	195	62	277	726	9.5	13	1.97	14.9	9.5	22522	13.4
CB4.1W	1984	YEAR	8	39	16	7	166	81	310	1137	14.0	31	1.50	20.9	8.0	17949	10.5
CB4.1W	1985	1WIN	2	171	23	4	693	23	244	603	9.8	11	1.65	7.8	11.7	17350	10.0
CB4.1W	1985	2SPR	6	43	19	6	286	28	254	372	17.5	29	1.44	17.3	10.2	19097	11.2
CB4.1W	1985	3SUM	6	61	19	9	44	36		1323	14.4	27	1.07	25.8	6.8	24100	14.5
CB4.1W	1985	4FAL	4	37	17	9	307	70		838	10.6	18	1.50	15.0	10.0	22975	13.7
CB4.1W	1985	YEAR	18	62	19	8	255	39	250	818	14.1	29	1.34	18.6	9.0	21432	12.7
CB4.1W	1986	1WIN	4	38	15	4	699	69		1032	7.8	9	1.50	3.7	13.0	17219	10.0
CB4.1W	1986	2SPR	6	25	9	5	460	31	713	603	9.2	12	1.38	18.5	9.3	15276	8.7
CB4.1W	1986	3SUM	6	74	27	12	25	27	957	1359	45.1	157	1.02	25.3	9.1	21896	13.0
CB4.1W	1986	4FAL	4	43	19	7	193	66	449	664	10.0	13	1.75	14.2	9.8	24358	14.6
CB4.1W	1986	YEAR	20	46	18	7	324	44	747	928	19.9	157	1.39	16.7	10.1	19467	11.4
CB4.1W	1987	1WIN	3	24	9	4	613	45	410	842	7.8	13	2.27	5.3	12.8	20967	12.4
CB4.1W	1987	2SPR	6	42	13	4	417	46	648	732	12.6	19	1.42	16.5	9.8	17337	10.0
CB4.1W	1987	3SUM	2	54	20	10	12	52	463	1565	14.0	16	1.10	26.8	8.1	20217	11.9
CB4.1W	1987	YEAR	11	39	13	5	397	47	549	913	11.5	19	1.59	15.3	10.3	18850	11.0
CB4.1W	ALL	ALL	57	49	17	7	294	48	520	920	15.6	157	1.43	17.6	9.5	19756	11.6
CB4.2C	1984	3SUM	6	33	13	7	121	54	289	1158	13.5	28	1.78	24.6	7.8	17011	9.8
CB4.2C	1984	4FAL	4	22	12	7	137	49	409	532	11.3	17	2.39	15.1	9.9	24025	14.4
CB4.2C	1984	YEAR	10	29	13	7	127	52	337	908	12.6	28	2.02	20.8	8.6	19817	11.7
CB4.2C	1985	1WIN	4	41	89	5	401	27	257	420	7.8	14	2.55	3.6	13.6	22825	13.6
CB4.2C	1985	2SPR	6	29	14	5	227	16	211	193	12.5	23	1.82	17.0	10.5	21067	12.4
CB4.2C	1985	3SUM	6	31	10	6	15	17		867	7.5	11	1.75	25.6	7.3	25267	15.3
CB4.2C	1985	4FAL	4	22	10	7	198	76		461	3.6	6	1.90	15.3	9.0	26667	16.2
CB4.2C	1985	YEAR	20	31	27	6	192	30	237	494	8.5	23	1.96	16.5	9.7	23798	14.3
CB4.2C	1986	1WIN	4	21	6	3	655	43		860	7.7	10	1.70	3.5	11.9	19075	11.2
CB4.2C	1986	2SPR	6	15	5	3	430	25	730	305	7.3	16	2.12	17.6	9.1	18208	10.6
CB4.2C	1986	3SUM	6	28	9	5	27	24	473	1013	9.0	27	2.04	24.9	7.2	23553	14.1
CB4.2C	1986	4FAL	4	31	14	4	168	46	363	538	7.9	11	2.55	14.6	9.5	26025	15.8
CB4.2C	1986	YEAR	20	23	8	4	316	32	479	675	8.0	27	2.10	16.4	9.2	21548	12.8
CB4.2C	1987	1WIN	4	25	9	4	485	18	393	603	7.9	11	1.95	4.6	12.4	23213	13.9
CB4.2C	1987	2SPR	6	26	9	4	318	61	593	331	15.0	18	1.73	16.4	10.8	19272	11.3
CB4.2C	1987	3SUM	2	35	13	5	12	49	405	830	7.2	7	1.85	26.5	6.9	22850	13.6
CB4.2C	1987	YEAR	12	27	10	4	323	45	495	505	11.3	18	1.83	14.2	10.7	21182	12.5
CB4.2C	ALL	ALL	62	27	15	5	246	37	408	621	9.6	28	1.99	16.7	9.5	21924	13.0

STATION	YEAR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
CB4.2E	1984	3SUM	5	33	15	7	112	34	292	1082	12.0	20	1.35	24.7	8.1	16797	9.7
CB4.2E	1984	4FAL	3	23	13	7	112	47	435	488	11.2	18	2.43	14.7	10.2	24033	14.4
CB4.2E	1984	YEAR	8	29	14	7	112	39	346	859	11.7	20	1.76	21.0	8.9	19510	11.5
CB4.2E	1985	1WIN	3	61	42	4	414	24	200	366	5.3	8	2.77	4.7	13.4	22589	13.5
CB4.2E	1985	2SPR	6	30	22	5	232	20	281	181	10.7	24	1.97	17.3	10.3	21215	12.5
CB4.2E	1985	3SUM	6	49	26	6	16	24		840	6.5	12	1.48	25.6	7.3	25461	15.4
CB4.2E	1985	4FAL	4	28	16	8	186	81		463	4.5	10	1.95	15.6	8.9	27050	16.5
CB4.2E	1985	YEAR	19	41	25	6	183	35	241	478	7.2	24	1.94	17.6	9.3	24001	14.4
CB4.2E	1986	1WIN	4	23	8	3	640	46		838	6.8	10	1.73	3.7	11.9	19267	11.3
CB4.2E	1986	2SPR	6	17	6	3	429	27	755	305	7.3	15	2.27	17.6	9.0	18044	10.5
CB4.2E	1986	3SUM	6	39	24	8	25	32	433	963	7.8	23	2.44	24.9	7.4	23719	14.2
CB4.2E	1986	4FAL	4	28	15	5	164	57	338	543	5.4	8	2.93	14.5	9.1	26688	16.2
CB4.2E	1986	YEAR	20	27	13	5	297	38	455	657	7.0	23	2.34	16.4	9.2	21720	12.9
CB4.2E	1987	1WIN	3	25	9	4	483	29	380	653	7.9	11	2.20	4.8	12.0	22867	13.6
CB4.2E	1987	2SPR	6	28	11	4	318	28	566	302	15.2	20	1.73	16.5	10.5	19514	11.4
CB4.2E	1987	3SUM	2	36	15	5	6	67	445	685	7.8	8	1.85	26.6	6.8	23125	13.8
CB4.2E	1987	YEAR	11	28	11	4	306	35	493	467	11.8	20	1.88	15.1	10.3	21085	12.5
CB4.2E	ALL	ALL	58	32	17	5	236	37	408	590	8.6	24	2.03	17.2	9.4	22042	13.1
CB4.2W	1984	3SUM	5	45	21	7	98	61	272	1142	19.4	33	1.47	24.9	8.6	16613	9.6
CB4.2W	1984	4FAL	3	24	13	7	122	69	384	552	11.2	15	2.43	14.4	9.5	23967	14.4
CB4.2W	1984	YEAR	8	37	18	7	107	64	314	920	16.3	33	1.83	20.9	8.9	19371	11.4
CB4.2W	1985	1WIN	3	28	21	4	458	29	207	461	6.0	8	2.20	4.5	13.3	21500	12.7
CB4.2W	1985	2SPR	6	48	27	5	230	21	200	222	12.9	27	1.80	17.2	10.1	21139	12.5
CB4.2W	1985	3SUM	6	85	35	16	26	37		1123	10.2	20	1.13	25.5	7.3	25117	15.2
CB4.2W	1985	4FAL	4	31	15	8	245	65		675	7.5	14	1.40	14.8	9.6	25033	15.1
CB4.2W	1985	YEAR	19	53	26	9	205	37	203	640	9.8	27	1.57	17.3	9.4	23272	13.9
CB4.2W	1986	1WIN	4	24	7	4	688	42		900	8.2	12	1.83	3.7	11.9	18508	10.8
CB4.2W	1986	2SPR	6	22	7	5	393	21	985	329	10.8	19	1.80	17.9	9.3	17891	10.4
CB4.2W	1986	3SUM	6	38	11	5	15	39	582	1182	11.8	15	1.30	24.8	6.8	23297	13.9
CB4.2W	1986	4FAL	4	40	16	6	149	38	413	523	13.2	24	2.00	14.5	10.0	25363	15.3
CB4.2W	1986	YEAR	20	31	10	5	290	34	593	738	11.0	24	1.74	16.4	9.2	21131	12.5
CB4.2W	1987	1WIN	3	25	9	4	518	15	473	700	8.5	10	2.07	4.2	12.6	22233	13.2
CB4.2W	1987	2SPR	6	28	10	3	354	41	548	460	14.8	26	1.65	16.0	10.1	18324	10.7
CB4.2W	1987	3SUM	2	55	22	9	2	60	535	1085	16.8	18	1.70	26.4	7.5	22650	13.5
CB4.2W	1987	YEAR	11	32	12	4	368	37	525	639	13.3	26	1.77	14.7	10.3	20177	11.9
CB4.2W	ALL	ALL	58	39	17	6	249	39	449	712	11.8	33	1.70	17.0	9.4	21408	12.7
CB4.3C	1984	3SUM	6	34	14	9	85	51	271	1084	12.2	18	1.65	24.6	7.8	17911	10.4
CB4.3C	1984	4FAL	4	18	12	7	90	52	349	422	9.8	17	2.53	15.0	10.0	24871	15.0
CB4.3C	1984	YEAR	10	27	13	8	87	52	302	819	11.2	18	2.00	20.7	8.7	20695	12.2
CB4.3C	1985	1WIN	4	44	21	6	359	27	284	331	9.5	15	2.38	3.2	13.8	23767	14.2
CB4.3C	1985	2SPR	6	32	18	6	206	22	245	178	12.9	27	1.88	17.2	10.5	21688	12.9
CB4.3C	1985	3SUM	6	50	29	12	20	28		736	5.5	9	1.72	25.3	7.2	25817	15.6
CB4.3C	1985	4FAL	4	21	10	8	195	75		475	4.6	8	1.90	15.2	8.9	26909	16.4
CB4.3C	1985	YEAR	20	37	20	8	178	35	267	435	8.3	27	1.94	16.4	9.6	24386	14.7
CB4.3C	1986	1WIN	4	25	10	4	606	42		761	6.7	9	1.78	3.5	13.0	19983	11.8
CB4.3C	1986	2SPR	6	19	8	4	404	62	720	270	8.0	16	2.10	17.4	9.7	18160	10.6
CB4.3C	1986	3SUM	6	26	10	6	21	22	402	892	5.7	8	2.26	24.8	7.4	23878	14.3
CB4.3C	1986	4FAL	4	30	13	3	158	44	349	528	8.1	11	2.35	14.5	10.0	25863	15.7
CB4.3C	1986	YEAR	20	24	10	5	280	42	437	606	7.1	16	2.13	16.3	9.7	21781	12.9
CB4.3C	1987	1WIN	4	23	9	3	502	19	376	631	7.6	9	2.08	4.3	12.5	22488	13.4
CB4.3C	1987	2SPR	6	24	10	5	270	22	567	170	17.6	26	1.72	16.4	11.2	20508	12.1
CB4.3C	1987	3SUM	2	37	16	6	3	42	485	510	6.5	8	2.05	26.2	7.1	23650	14.2
CB4.3C	1987	YEAR	12	26	10	4	303	24	489	380	12.4	26	1.89	14.0	11.0	21692	12.9
CB4.3C	ALL	ALL	62	29	14	6	221	38	391	542	9.2	27	2.00	16.6	9.8	22429	13.4

CHESAPEAKE BAY ESTUARY AND MAINSTEM DATA MEANS BY STATION, YEAR, AND SEASON DEPTH <= 3 METERS

STATION	YEAR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
CB4.3E	1984	3SUM	5	34	13	7	76	50	240	1028	10.4	15	1.56	24.7	7.9	17787	10.3
CB4.3E	1984	4FAL	3	19	12	7	72	41	370	281	11.0	19	2.10	14.6	10.4	25244	15.2
CB4.3E	1984	YEAR	8	28	13	7	75	46	289	748	10.6	19	1.76	20.9	8.9	20583	12.2
CB4.3E	1985	1WIN	3	41	22	6	320	23	235	210	10.8	13	2.37	4.4	13.5	24544	14.8
CB4.3E	1985	2SPR	6	31	21	8	213	20	241	154	13.5	31	1.90	17.1	10.5	21892	13.0
CB4.3E	1985	3SUM	6	34	12	11	18	52		698	6.6	11	1.75	25.3	7.0	26156	15.9
CB4.3E	1985	4FAL	4	26	16	6	140	90		355	2.4	4	2.18	15.5	8.6	28450	17.4
CB4.3E	1985	YEAR	19	32	17	8	153	45	238	377	8.7	31	1.98	17.4	9.2	25038	15.1
CB4.3E	1986	1WIN	4	21	8	3	541	37		638	7.1	9	1.43	3.6	11.8	20833	12.3
CB4.3E	1986	2SPR	6	16	7	4	397	33	663	281	7.9	18	2.27	17.4	9.6	18897	11.0
CB4.3E	1986	3SUM	6	27	12	6	23	43	458	827	7.1	9	2.08	24.8	7.4	24258	14.6
CB4.3E	1986	4FAL	4	31	15	4	141	55	375	519	8.0	15	2.43	14.4	9.6	26750	16.3
CB4.3E	1986	YEAR	20	23	10	4	262	41	465	564	7.5	18	2.07	16.2	9.4	22463	13.4
CB4.3E	1987	1WIN	3	22	9	4	416	23	430	560	7.3	8	2.20	4.6	12.5	24200	14.5
CB4.3E	1987	2SPR	6	25	10	5	229	18	610	122	19.6	25	1.77	16.9	11.2	21242	12.6
CB4.3E	1987	3SUM	2	37	18	13	13	83	385	310	8.1	9	1.80	26.1	6.9	24200	14.5
CB4.3E	1987	YEAR	11	27	11	6	241	31	520	275	14.2	25	1.89	15.2	10.8	22586	13.5
CB4.3E	ALL	ALL	58	27	13	6	196	41	406	473	9.6	31	1.96	17.0	9.5	23071	13.8

STATION	YEAR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
CB4.3W	1984	3SUM	5	58	19	7	89	69	269	1177	39.2	135	1.39	24.9	8.4	17285	10.0
CB4.3W	1984	4FAL	3	20	12	7	114	54	365	463	8.6	15	2.50	14.4	9.9	24183	14.5
CB4.3W	1984	YEAR	8	44	16	7	98	63	305	909	27.7	135	1.81	20.9	8.9	19872	11.7
CB4.3W	1985	1WIN	3	40	10	5	433	23	213	403	6.3	11	2.00	4.6	13.5	22378	13.3
CB4.3W	1985	2SPR	6	46	33	5	216	18	228	228	15.3	27	1.73	17.2	9.9	21471	12.7
CB4.3W	1985	3SUM	6	94	29	11	24	42		988	32.2	142	1.03	25.4	6.6	25521	15.4
CB4.3W	1985	4FAL	4	29	14	7	222	62		568	5.6	9	1.63	15.1	9.3	25942	15.7
CB4.3W	1985	YEAR	19	56	24	7	191	36	221	567	17.2	142	1.53	17.4	9.1	23834	14.3
CB4.3W	1986	1WIN	4	24	7	4	653	72		845	8.5	12	1.70	3.7	12.3	19158	11.2
CB4.3W	1986	2SPR	6	22	8	5	404	15	810	277	10.7	19	1.87	17.8	9.6	18268	10.6
CB4.3W	1986	3SUM	6	44	14	8	21	22	575	1070	12.8	29	1.44	24.8	6.8	23669	14.2
CB4.3W	1986	4FAL	4	38	15	4	149	36	400	563	12.2	19	2.18	14.5	10.3	25788	15.6
CB4.3W	1986	YEAR	20	32	11	5	288	33	556	686	11.2	29	1.78	16.4	9.5	21570	12.8
CB4.3W	1987	1WIN	3	23	8	5	517	24	363	733	9.1	11	1.97	4.2	12.7	21767	12.9
CB4.3W	1987	2SPR	6	32	10	5	313	42	610	333	21.1	34	1.63	16.0	11.0	19373	11.4
CB4.3W	1987	3SUM	2	40	17	11	17	43	450	765	8.4	10	1.70	26.1	6.8	23350	14.0
CB4.3W	1987	YEAR	11	31	11	6	315	37	514	521	15.5	34	1.74	14.6	10.7	20749	12.3
CB4.3W	ALL	ALL	58	41	16	6	235	39	435	646	16.3	142	1.69	17.0	9.5	21922	13.0

STATION	YEAR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
CB4.4	1984	3SUM	6	36	15	7	56	44	285	1097	11.2	14	1.67	24.9	8.0	18700	10.9
CB4.4	1984	4FAL	4	20	13	7	64	39	369	283	12.0	18	2.35	15.6	10.0	25567	15.5
CB4.4	1984	YEAR	10	29	14	7	59	42	319	771	11.5	18	1.94	21.2	8.8	21447	12.7
CB4.4	1985	1WIN	4	29	66	5	294	26	277	239	9.3	11	2.05	5.5	12.5	25017	15.1
CB4.4	1985	2SPR	6	29	17	5	206	19	290	130	17.0	33	2.02	17.5	11.0	21872	13.0
CB4.4	1985	3SUM	6	40	18	5	9	12		518	7.5	18	1.40	25.9	7.8	25867	15.7
CB4.4	1985	4FAL	4	25	13	6	149	62		319	4.6	7	1.90	16.0	9.4	28167	17.2
CB4.4	1985	YEAR	20	31	26	5	153	27	283	306	10.3	33	1.82	17.3	9.9	24958	15.1
CB4.4	1986	1WIN	4	24	10	4	628	45		770	6.4	8	1.88	4.0	12.3	19948	11.7
CB4.4	1986	2SPR	6	16	6	4	391	25	850	204	10.1	24	2.33	18.1	9.9	19907	11.7
CB4.4	1986	3SUM	6	29	9	4	10	13	512	786	12.3	18	1.72	25.5	8.1	24556	14.8
CB4.4	1986	4FAL	4	33	14	3	130	36	423	470	9.6	11	2.18	14.7	9.5	27200	16.6
CB4.4	1986	YEAR	20	25	9	4	272	28	541	545	9.9	24	2.04	16.8	9.8	22768	13.6
CB4.4	1987	1WIN	4	22	9	4	414	13	414	504	7.4	10	2.30	5.1	12.4	24546.	14.8
CB4.4	1987	2SPR	6	26	10	4	229	23	659	169	21.2	27	1.66	17.2	12.4	20708	12.2
CB4.4	1987	3SUM	2	34	13	4	15	17	330	365	7.5	9	1.65	26.9	7.9	24300	14.6
CB4.4	1987	YEAR	12	26	10	4	255	18	523	313	14.3	27	1.89	14.8	11.7	22586	13.5
CB4.4	ALL	ALL	62	28	16	5	196	28	435	460	11.2	33	1.92	17.3	10.0	23226	13.9

CHESAPEAKE BAY ESTUARY AND MAINSTEM DATA MEANS BY STATION, YEAR, AND SEASON   DEPTH <= 3 METERS   PAGE 7

STATION	YEAR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
CB5.1	1984	3SUM	6	30	14	7	40	50	351	1079	9.3	14	1.86	24.7	7.3	19467	11.4
CB5.1	1984	4FAL	4	21	12	7	64	49	382	282	9.8	14	2.20	15.7	10.0	25958	15.7
CB5.1	1984	YEAR	10	27	13	7	50	49	363	760	9.5	14	2.00	21.1	8.3	22063	13.1
CB5.1	1985	1WIN	4	31	17	5	247	20	226	209	12.5	18	2.20	5.6	12.5	25025	15.1
CB5.1	1985	2SPR	6	41	27	5	180	17	309	126	12.7	25	2.23	18.2	10.1	22878	13.6
CB5.1	1985	3SUM	6	31	12	5	8	12		465	5.8	9	1.42	26.2	7.4	26800	16.3
CB5.1	1985	4FAL	4	27	16	6	112	60		205	4.8	10	1.78	16.2	9.1	29492	18.1
CB5.1	1985	YEAR	20	33	18	5	128	24	261	260	9.0	25	1.89	17.7	9.4	25807	15.6
CB5.1	1986	1WIN	4	23	10	5	558	39		620	6.2	7	2.00	4.0	12.4	21252	12.6
CB5.1	1986	2SPR	5	16	6	3	362	24	783	181	9.6	22	2.40	17.8	9.5	20956	12.4
CB5.1	1986	3SUM	6	24	7	4	13	38	465	648	8.3	15	1.72	25.5	7.8	25658	15.5
CB5.1	1986	4FAL	4	27	13	5	95	61	390	448	5.9	8	2.58	14.8	8.9	28050	17.1
CB5.1	1986	YEAR	19	22	9	4	243	39	495	462	7.8	22	2.17	16.8	9.4	23845	14.3
CB5.1	1987	1WIN	4	22	8	4	391	21	364	466	9.1	17	2.40	5.2	12.2	24896	15.0
CB5.1	1987	2SPR	6	26	11	5	159	18	753	83	25.6	34	1.50	17.7	11.6	21983	13.1
CB5.1	1987	3SUM	2	35	13	9	20	35	410	165	8.5	12	1.70	26.7	7.8	25375	15.3
CB5.1	1987	YEAR	12	26	10	5	213	21	566	224	17.2	34	1.86	15.0	11.2	23519	14.1
CB5.1	ALL	ALL	61	27	13	5	169	32	443	399	10.3	34	1.99	17.4	9.6	24127	14.5
CB5.2	1984	3SUM	6	32	14	7	40	29	303	948	9.5	15	1.83	24.7	7.5	20067	11.8
CB5.2	1984	4FAL	4	20	12	7	42	30	303	233	8.3	10	2.25	15.8	10.2	26694	16.2
CB5.2	1984	YEAR	10	27	13	7	41	29	303	662	9.0	15	2.00	21.2	8.5	22718	13.6
CB5.2	1985	1WIN	4	34	22	5	233	20	238	160	13.8	24	2.50	4.9	12.7	25342	15.3
CB5.2	1985	2SPR	6	13	8	4	156	25	272	114	10.4	20	2.50	17.7	10.7	23804	14.3
CB5.2	1985	3SUM	6	39	22	4	7	11		469	4.7	6	1.97	25.9	7.2	27576	16.8
CB5.2	1985	4FAL	4	24	14	6	96	66		228	3.7	7	1.98	16.3	8.7	29900	18.4
CB5.2	1985	YEAR	20	27	16	5	114	28	253	253	8.0	24	2.24	17.3	9.5	26463	16.1
CB5.2	1986	1WIN	4	21	10	3	464	27		460	6.9	9	2.13	4.1	12.4	22531	13.4
CB5.2	1986	2SPR	6	15	7	3	337	22	755	126	9.1	15	2.33	17.6	9.8	21878	13.0
CB5.2	1986	3SUM	6	25	8	4	9	37	417	538	7.8	19	2.20	25.5	7.5	26226	15.9
CB5.2	1986	4FAL	4	31	15	3	90	61	414	439	7.3	10	2.65	15.0	8.7	28600	17.5
CB5.2	1986	YEAR	20	22	9	3	214	35	477	379	7.9	19	2.32	16.7	9.4	24658	14.9
CB5.2	1987	1WIN	4	19	8	3	361	8	369	430	7.1	11	2.50	5.1	12.9	24850	15.0
CB5.2	1987	2SPR	6	24	10	5	139	11	710	79	30.4	44	1.32	17.2	11.5	22694	13.5
CB5.2	1987	3SUM	2	33	13	5	4	33	335	170	6.4	9	2.30	26.7	9.0	26017	15.8
CB5.2	1987	YEAR	12	24	10	4	191	13	534	211	18.6	44	1.93	14.7	11.6	23967	14.4
CB5.2	ALL	ALL	62	25	12	4	150	28	411	351	10.2	44	2.17	17.2	9.7	24793	14.9
CB5.3	1984	3SUM	4	31	13	7	40	32	329	790	9.2	17	2.02	24.3	7.3	21353	12.7
CB5.3	1984	4FAL	4	19	12	7	40	21	378	226	7.9	10	2.35	15.4	9.9	25808	15.6
CB5.3	1984	YEAR	8	25	13	7	40	27	351	540	8.6	17	2.17	20.4	8.5	23333	14.0
CB5.3	1985	1WIN	4	45	21	6	229	19	219	94	9.3	15	1.98	4.8	13.3	25175	15.2
CB5.3	1985	2SPR	6	18	14	5	89	28	353	109	14.8	35	2.13	17.7	9.3	24850	15.0
CB5.3	1985	3SUM	6	46	26	5	8	38		641	4.4	7	1.98	25.7	7.0	27956	17.1
CB5.3	1985	4FAL	4	33	20	6	93	55		434	6.7	14	1.60	16.1	8.9	28258	17.3
CB5.3	1985	YEAR	20	35	20	5	93	35	277	331	8.9	35	1.95	17.2	9.1	26528	16.1
CB5.3	1986	1WIN	4	20	10	4	437	26		399	5.4	8	2.10	4.0	12.3	23385	14.0
CB5.3	1986	2SPR	6	16	7	3	281	18	560	132	7.1	10	2.53	17.6	9.2	23853	14.3
CB5.3	1986	3SUM	6	37	19	6	8	27	502	520	8.0	15	2.40	25.4	7.2	27675	16.9
CB5.3	1986	4FAL	4	28	13	3	71	51	435	488	6.7	10	2.83	14.9	9.2	28613	17.5
CB5.3	1986	YEAR	20	25	12	4	188	29	488	373	7.0	15	2.47	16.7	9.2	25858	15.7
CB5.3	1987	1WIN	4	23	9	4	333	13	426	403	7.6	12	2.18	5.0	12.9	24967	15.1
CB5.3	1987	2SPR	5	28	12	7	109	19	709	167	27.6	44	1.20	16.6	10.4	23500	14.1
CB5.3	1987	3SUM	2	37	14	5	6	50	532	424	7.0	9	2.10	26.4	7.4	26150	15.9
CB5.3	1987	YEAR	11	27	11	5	172	22	574	299	16.6	44	1.77	14.2	10.8	24515	14.8
CB5.3	ALL	ALL	59	29	15	5	131	29	441	370	9.7	44	2.12	16.9	9.4	25457	15.4

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STATION	YEAR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
LE2.3	1984	3SUM	5	29	13	7	40	29	296	966	8.0	13	2.05	24.4	7.7	19320	11.3
LE2.3	1984	4FAL	4	20	14	8	40	32	408	410	8.0	10	2.03	15.6	9.8	24471	14.7
LE2.3	1984	YEAR	9	25	14	7	40	30	346	719	8.0	13	2.04	20.5	8.6	21609	12.8
LE2.3	1985	1WIN	4	48	37	6	270	22	244	146	12.6	20	2.00	3.6	13.1	24144	14.5
LE2.3	1985	2SPR	6	43	12	7	90	19	395	264	17.1	45	2.03	18.0	9.8	22660	13.5
LE2.3	1985	3SUM	6	37	16	5	8	26		708	5.3	8	1.47	25.7	7.0	26767	16.3
LE2.3	1985	4FAL	4	29	15	5	208	65		598	3.9	7	1.75	16.0	9.0	26667	16.2
LE2.3	1985	YEAR	20	39	19	6	125	31	309	441	9.9	45	1.80	17.0	9.2	24990	15.1
LE2.3	1986	1WIN	4	21	6	4	460	21		458	6.0	8	1.90	4.1	12.4	22517	13.4
LE2.3	1986	2SPR	6	15	6	5	305	29	740	190	7.5	10	2.37	17.6	9.2	21558	12.8
LE2.3	1986	3SUM	6	27	9	4	5	33	406	563	8.0	16	2.16	25.5	7.5	26267	15.9
LE2.3	1986	4FAL	4	33	14	4	95	51	413	553	6.9	8	2.55	14.9	9.0	27888	17.0
LE2.3	1986	YEAR	20	23	8	4	204	33	469	428	7.2	16	2.25	16.7	9.3	24428	14.7
LE2.3	1987	1WIN	4	22	9	3	390	14	436	528	6.7	13	2.45	5.5	13.0	23392	14.0
LE2.3	1987	2SPR	6	29	11	5	204	29	692	301	25.7	39	1.48	16.7	10.9	20663	12.2
LE2.3	1987	3SUM	2	45	13	5	4	28	428	745	10.0	11	1.80	26.4	7.5	24475	14.7
LE2.3	1987	YEAR	12	29	10	4	233	23	563	451	16.8	39	1.89	14.6	11.0	22208	13.2
LE2.3	ALL	ALL	61	30	13	5	160	30	441	479	10.1	45	2.00	17.0	9.5	23760	14.3
MEE1.1	1984	4FAL	4	88	50	13	70	50	817	100	8.9	15	2.09	12.7	10.1	23303	13.9
MEE1.1	1984	YEAR	4	88	50	13	70	50	817	100	8.9	15	2.09	12.7	10.1	23303	13.9
MEE1.1	1985	1WIN	2	45	35	15	198	40	500	100			2.15	6.3	11.7	22202	13.2
MEE1.1	1985	2SPR	6	55	52	10	163	30	678	430	9.1	14	1.38	18.0	9.8	20972	12.4
MEE1.1	1985	3SUM	6	98	65	14	22	31	821	1165	16.3	43	1.18	25.5	7.0	24004	14.4
MEE1.1	1985	4FAL	4	65	50	15	140	76	465	336	5.4	8	2.35	14.4	9.7	26037	15.8
MEE1.1	1985	YEAR	18	70	53	13	115	42	659	618	10.6	43	1.62	18.4	9.0	23245	13.9
MEE1.1	1986	1WIN	3	53	40	17	563	37	477	503	4.6	6	2.00	4.3	12.0	20318	12.0
MEE1.1	1986	2SPR	6	54	39	9	334	29	605	663	8.9	22	2.25	18.1	8.9	18768	10.9
MEE1.1	1986	3SUM	6	64	53	12	23	52	567	1075	8.4	20	1.80	25.0	7.1	22941	13.7
MEE1.1	1986	4FAL	4	60	43	6	118	52	510	750	5.8	11	2.25	13.4	9.1	25842	15.6
MEE1.1	1986	YEAR	19	58	44	11	227	42	555	786	7.4	22	2.07	17.1	8.9	21820	13.0
MEE1.1	1987	1WIN	1	70	60	4	210	36	500	200	4.4	4	2.40	3.8	11.2	25600	15.5
MEE1.1	1987	YEAR	1	70	60	4	210	36	500	200	4.4	4	2.40	3.8	11.2	25600	15.5
MEE1.1	ALL	ALL	42	67	49	12	163	42	620	676	8.7	43	1.88	16.9	9.1	22662	13.5
MEE2.1	1984	3SUM	4	73		13	77	43	800		16.1	30	1.26	23.8	7.7	17282	10.0
MEE2.1	1984	4FAL	4	94	60	14	59	286	591	125	6.4	10	1.70	11.8	10.3	23225	13.9
MEE2.1	1984	YEAR	8	83	60	13	67	164	696	125	10.6	30	1.48	17.8	8.8	20253	11.9
MEE2.1	1985	1WIN	1	55	35	15	140	35	565	200	15.3	15	1.40	5.6	11.6	24033	14.4
MEE2.1	1985	2SPR	5	50	37	12	164	45	699	458	7.0	14	1.68	19.6	8.9	21088	12.5
MEE2.1	1985	3SUM	6	68	55	13	37	52	608	1099	5.5	7	1.23	25.5	6.8	24484	14.7
MEE2.1	1985	4FAL	4	80	45	13	91	85	508	370	5.6	8	1.98	14.6	8.9	27000	16.4
MEE2.1	1985	YEAR	16	64	46	13	97	57	609	660	6.6	15	1.57	19.7	8.3	24024	14.4
MEE2.1	1986	1WIN	2	75	40	10	520	25	475	325	5.4	7	2.05	4.8	12.0	20117	11.8
MEE2.1	1986	2SPR	5	46	44	9	338	23	470	347	6.3	10	2.32	18.0	9.0	19783	11.6
MEE2.1	1986	3SUM	5	72	46	10	24	59	576	1110	10.4	38	1.30	24.5	7.3	23473	14.0
MEE2.1	1986	4FAL	3	75	57	10	120	46	583	867	7.4	10	1.47	12.2	9.9	26500	16.1
MEE2.1	1986	YEAR	15	64	47	10	222	40	529	680	7.7	38	1.81	17.3	9.0	22237	13.2
MEE2.1	1987	1WIN	1	70	60	6	370	64	450	900	4.9	5	2.00	4.3	10.9	25767	15.6
MEE2.1	1987	YEAR	1	70	60	6	370	64	450	900	4.9	5	2.00	4.3	10.9	25767	15.6
MEE2.1	ALL	ALL	40	68	47	12	148	72	592	646	7.7	38	1.65	18.0	8.7	22633	13.5
MEE2.2	1984	4FAL	1	50		15	58	1800	500		6.3	6	2.40	17.1		21667	12.8
MEE2.2	1984	YEAR	1	50		15	58	1800	500		6.3	6	2.40	17.1		21667	12.8

STATION	YEAR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
MEE2.2	ALL	ALL	1	50		15	58	1800	500		6.3	6	2.40	17.1		21667	12.8
MEE3.1	1984	4FAL	2	65	40	10	106	20	640	250	4.3	4	1.95	11.4	9.7	27317	16.6
MEE3.1	1984	YEAR	2	65	40	10	106	20	640	250	4.3	4	1.95	11.4	9.7	27317	16.6
MEE3.1	1985	1WIN	3	63	50	20	155	230	583	163	4.3	4	0.85	4.4	11.6	25522	15.4
MEE3.1	1985	2SPR	5	66	42	10	90	64	680	552	4.8	8	1.34	20.8	7.5	25369	15.3
MEE3.1	1985	3SUM	6	158	60	20	37	102	695	935	4.5	8	1.07	25.7	6.5	27232	16.6
MEE3.1	1985	4FAL	4	71	63	18	85	119	514	508	3.3	4	1.40	15.0	8.5	29323	18.0
MEE3.1	1985	YEAR	18	98	54	17	82	116	632	605	4.3	8	1.18	18.4	8.1	26894	16.4
MEE3.1	1986	1WIN	2	65	35	10	380	25	525	500	5.8	7	1.05	2.5	12.5	23933	14.4
MEE3.1	1986	2SPR	5	52	30	9	239	66	499	386	3.2	4	1.74	17.8	7.9	23707	14.2
MEE3.1	1986	3SUM	5	70	50	11	50	46	500	610	10.1	20	0.98	25.0	7.1	26767	16.3
MEE3.1	1986	4FAL	4	83	55	9	65	92	508	425	2.7	5	1.30	13.0	9.0	29725	18.3
MEE3.1	1986	YEAR	16	67	43	10	154	61	505	480	5.6	20	1.31	17.0	8.5	26196	15.9
MEE3.1	1987	1WIN	1	90	60	4	120	8	600	200	7.6	8	0.60	3.7	11.3	27733	16.9
MEE3.1	1987	YEAR	1	90	60	4	120	8	600	200	7.6	8	0.60	3.7	11.3	27733	16.9
MEE3.1	ALL	ALL	37	82	49	13	115	86	576	528	5.0	20	1.26	17.0	8.4	26638	16.2
MET4.1	1984	4FAL	1	120	50	10	570	20	930	1650	41.2	54	0.60	5.8	11.7	9348	5.0
MET4.1	1984	YEAR	1	120	50	10	570	20	930	1650	41.2	54	0.60	5.8	11.7	9348	5.0
MET4.1	1985	1WIN	4	161	63	40	1321	128	1083	4044	40.3	40	0.23	8.2	10.8	2400	1.2
MET4.1	1985	2SPR	6	242	57	18	567	72	1908	1883	70.1	110	0.18	20.0	9.8	2078	0.8
MET4.1	1985	3SUM	6	257	58	18	22	23	1699	938	57.1	81	0.20	26.4	7.1	5145	2.5
MET4.1	1985	4FAL	4	203	65	30	1163	85	1065	2590	29.8	57	0.21	14.5	8.6	1469	0.5
MET4.1	1985	YEAR	20	222	60	25	673	71	1491	2173	53.3	110	0.20	18.4	8.9	2941	1.3
MET4.1	1986	1WIN	1	250	60	20	3000	30	1030	4420	19.0	19	0.20	8.0	10.7	258	0.0
MET4.1	1986	2SPR	5	252	42	15	810	25	1505	1800	35.2	58	0.27	19.7	8.1	1595	0.6
MET4.1	1986	3SUM	6	301	49	13	31	12	1643	980	61.4	100	0.22	24.6	6.6	4621	2.3
MET4.1	1986	4FAL	4	210	55	16	688	44	1333	3475	49.1	91	0.35	11.6	10.2	4649	2.3
MET4.1	1986	YEAR	16	260	49	15	635	26	1485	2059	46.8	100	0.27	18.8	8.2	3303	1.6
MET4.1	1987	1WIN	1	100	70	26	1700	52	600	5500			0.40	1.6	12.6	133	0.0
MET4.1	1987	YEAR	1	100	70	26	1700	52	600	5500			0.40	1.6	12.6	133	0.0
MET4.1	ALL	ALL	38	232	55	20	680	50	1450	2195	49.2	110	0.25	17.8	8.8	3191	1.5
MET4.2	1984	4FAL	3	70	35	10	229	67	670	575	10.7	17	1.78	10.4	10.6	19883	11.7
MET4.2	1984	YEAR	3	70	35	10	229	67	670	575	10.7	17	1.78	10.4	10.6	19883	11.7
MET4.2	1985	1WIN	3	53	40	13	523	120	573	577			1.97	4.2	12.0	17578	10.2
MET4.2	1985	2SPR	6	81	41	10	294	50	757	627	23.0	51	1.31	17.3	9.1	16561	9.5
MET4.2	1985	3SUM	6	103	63	23	40	69	800	1938	17.8	31	0.75	25.4	6.4	20977	12.4
MET4.2	1985	4FAL	4	80	47	10	231	81	550	875	10.9	16	1.23	14.2	9.6	21517	12.8
MET4.2	1985	YEAR	19	83	49	14	237	74	698	1085	17.7	51	1.22	17.1	8.6	19159	11.2
MET4.2	1986	1WIN	3	63	37	10	678	33	485	1210	14.4	28	1.37	1.8	13.0	16922	9.7
MET4.2	1986	2SPR	6	46	28	8	403	35	509	553	7.9	11	1.44	18.0	8.7	15096	8.6
MET4.2	1986	3SUM	6	103	52	13	27	26	652	1708	15.9	22	0.93	24.9	7.8	19807	11.6
MET4.2	1986	4FAL	4	81	56	16	179	64	604	1038	8.7	15	2.23	12.9	9.4	22000	13.1
MET4.2	1986	YEAR	19	74	43	12	280	38	570	1124	11.6	28	1.43	16.6	9.2	18325	10.7
MET4.2	1987	1WIN	1	100	80	14	600	56	580	1400	16.6	17	1.60	3.4	12.8	19533	11.4
MET4.2	1987	YEAR	1	100	80	14	600	56	580	1400	16.6	17	1.60	3.4	12.8	19533	11.4
MET4.2	ALL	ALL	42	79	46	13	265	57	635	1086	14.0	51	1.37	16.1	9.1	18843	11.0
MET5.1	1984	3SUM	4	108		33	326	28	888		27.7	30	0.48	24.3	7.1	1061	0.2
MET5.1	1984	4FAL	4	123	40	20	347	43	1198	850	25.8	31	0.44	12.2	9.8	3284	1.4
MET5.1	1984	YEAR	8	115	40	26	338	35	1043	850	26.5	31	0.46	18.2	8.3	2172	0.8
MET5.1	1985	1WIN	5	194	100	42	1710	92	1212	2256	23.1	23	0.27	7.0	11.6	486	0.1

CHESAPEAKE BAY ESTUARY AND MAINSTEM DATA MEANS BY STATION, YEAR, AND SEASON DEPTH <= 3 METERS

STATION	YEAR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
MET5.1	1985	2SPR	6	158	57	20	823	93	1018	497	22.9	40	0.28	19.8	7.0	2876	1.2
MET5.1	1985	3SUM	6	162	67	27	48	32	1027	1205	27.8	33	0.31	26.3	5.5	6506	3.3
MET5.1	1985	4FAL	3	123	57	30	870	137	917	3533	13.8	25	0.27	12.9	7.7	1793	0.6
MET5.1	1985	YEAR	20	163	69	29	819	81	1054	1605	22.7	40	0.28	17.5	7.6	3205	1.5
MET5.1	1986	1WIN	3	115	52	25	2095	328	958	5133	5.1	11	0.27	3.4	12.6	173	0.0
MET5.1	1986	2SPR	6	117	50	23	828	84	905	1208	12.1	18	0.32	20.4	7.5	2403	1.0
MET5.1	1986	3SUM	6	190	66	30	60	59	1282	1575	27.5	41	0.32	26.0	6.6	6207	3.2
MET5.1	1986	4FAL	4	158	53	24	283	112	1000	2275	22.1	28	0.33	13.6	8.8	7308	3.8
MET5.1	1986	YEAR	19	148	56	26	671	123	1052	2168	18.3	41	0.31	18.1	8.3	4285	2.1
MET5.1	1987	1WIN	1	190	90	48	2300	116	950	6000	0.8	1	0.20	2.5	11.8	179	0.0
MET5.1	1987	YEAR	1	190	90	48	2300	116	950	6000	0.8	1	0.20	2.5	11.8	179	0.0
MET5.1	ALL	ALL	48	150	63	28	719	90	1049	1928	20.7	41	0.32	17.5	8.1	3397	1.6
MET5.2	1984	3SUM	5	94		50	60	44	760		16.8	27	0.72	24.7	6.5	12802	7.1
MET5.2	1984	4FAL	4	88	35	30	59	258	588	300	6.5	9	1.21	12.1	10.1	20199	11.9
MET5.2	1984	YEAR	9	91	35	41	60	139	683	300	10.9	27	1.00	19.1	8.1	16090	9.2
MET5.2	1985	1WIN	3	63	57	17	290	83	537	483	18.3	18	1.55	4.3	11.5	19714	11.6
MET5.2	1985	2SPR	5	70	43	13	96	36	855	813	11.9	34	0.87	18.9	8.7	18875	11.0
MET5.2	1985	3SUM	6	100	68	27	44	45	773	1962	11.1	23	0.83	25.8	6.5	21656	12.8
MET5.2	1985	4FAL	4	93	68	35	104	88	593	645	5.6	11	1.33	14.7	8.7	22742	13.6
MET5.2	1985	YEAR	18	84	58	23	112	57	716	1088	10.4	34	1.06	17.5	8.5	20647	12.2
MET5.2	1986	1WIN	3	65	37	12	773	20	650	1002	10.7	12	1.23	4.8	12.9	15711	9.0
MET5.2	1986	2SPR	6	67	43	10	240	26	651	950	7.5	16	1.12	19.6	8.6	16829	9.7
MET5.2	1986	3SUM	6	93	76	33	64	59	603	2400	7.8	12	1.17	25.6	6.8	20437	12.0
MET5.2	1986	4FAL	4	95	75	28	68	95	494	1633	5.9	12	1.95	13.4	8.7	23933	14.4
MET5.2	1986	YEAR	19	81	57	21	242	48	603	1556	7.9	16	1.33	17.8	8.7	19288	11.3
MET5.2	1987	1WIN	1	80	90	33	605	156	605	2200			1.80	2.7	11.5	17400	10.1
MET5.2	1987	YEAR	1	80	90	33	605	156	605	2200			1.80	2.7	11.5	17400	10.1
MET5.2	ALL	ALL	47	84	57	26	164	71	662	1287	9.4	34	1.18	17.6	8.6	19156	11.2
MET7.1	1986	1WIN	2	130	55	15	1400	320	1080	3800	2.2	3	0.30	4.3	11.3	9372	5.0
MET7.1	1986	2SPR	3	100	33	12	563	111	833	1500	7.2	10	0.53	20.1	6.9	14311	8.1
MET7.1	1986	3SUM	3	163	63	13	47	13	950	1500	21.1	31	0.47	25.5	6.4	15856	9.1
MET7.1	1986	YEAR	8	131	50	13	579	127	939	2075	11.2	31	0.45	18.2	7.8	13655	7.7
MET7.1	ALL	ALL	8	131	50	13	579	127	939	2075	11.2	31	0.45	18.2	7.8	13655	7.7
MLE2.2	1984	3SUM	2	95		35	53	25	850		11.9	12	0.73	25.5	6.3	14020	7.9
MLE2.2	1984	4FAL	4	111	35	18	117	83	719	438	7.9	8	2.13	13.7	9.9	21518	12.8
MLE2.2	1984	YEAR	6	106	35	23	95	63	763	438	9.2	12	1.57	17.6	8.7	19018	11.1
MLE2.2	1985	1WIN	3	51	37	10	556	28	566	796			1.10	6.3	13.2	17239	10.0
MLE2.2	1985	2SPR	5	86	48	16	64	46	994	512	32.9	93	1.07	20.0	10.7	18751	10.9
MLE2.2	1985	3SUM	6	83	53	20	20	42	657	1537	8.8	13	1.23	25.3	6.5	23657	14.2
MLE2.2	1985	4FAL	4	73	50	15	361	116	640	1300	5.9	11	1.70	15.1	8.9	20829	12.4
MLE2.2	1985	YEAR	18	76	48	16	197	59	732	1076	17.2	93	1.27	18.5	9.4	20499	12.1
MLE2.2	1986	1WIN	2	35	25	10	705	20	330	865	4.4	6	1.60	3.0	13.7	20483	12.1
MLE2.2	1986	2SPR	6	63	33	10	347	30	653	467	10.1	16	1.08	18.6	9.5	17089	9.9
MLE2.2	1986	3SUM	5	82	46	9	48	32	550	1390	9.2	19	1.14	25.2	7.2	23493	14.1
MLE2.2	1986	4FAL	4	70	53	9	68	50	590	975	7.7	10	1.53	14.0	8.9	26621	16.2
MLE2.2	1986	YEAR	17	67	41	9	235	34	570	905	8.6	19	1.24	18.6	8.9	21685	12.9
MLE2.2	1987	1WIN	1	70	50	4	380	8	630	800	9.1	9	1.20	4.2	15.1	21860	13.0
MLE2.2	1987	YEAR	1	70	50	4	380	8	630	800	9.1	9	1.20	4.2	15.1	21860	13.0
MLE2.2	ALL	ALL	42	77	44	14	203	48	668	958	12.0	93	1.29	18.0	9.2	20772	12.3
MWT1.1	1984	4FAL	2	83	45	10	645	188	1028	1940	20.8	33	0.95	8.1	11.5	4875	2.4
MWT1.1	1984	YEAR	2	83	45	10	645	188	1028	1940	20.8	33	0.95	8.1	11.5	4875	2.4

CHESAPEAKE BAY ESTUARY AND MAINSTEM DATA MEANS BY STATION, YEAR, AND SEASON DEPTH <= 3 METERS

STATION	YEAR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
MWT1.1	1985	1WIN	1	90	50	20	1300	50	800	2240			0.40	7.7	12.2	1825	0.6
MWT1.1	1985	2SPR	3	187	52	10	460	732	2703	1392	48.3	59	0.37	21.3	9.1	1586	0.5
MWT1.1	1985	3SUM	2	140	43	20	153	23	1030	5175	27.8	28	0.20	25.7	5.3	2681	1.1
MWT1.1	1985	4FAL	3	70	37	13	374	62	688	2575	19.4	31	0.50	11.7	9.6	4701	2.3
MWT1.1	1985	YEAR	9	127	44	14	456	275	1448	2414	33.0	59	0.38	17.6	8.8	2894	1.2
MWT1.1	1986	1WIN	1	110	30	10	1750	95	750	3790	11.2	11	0.20	7.2	11.5	1100	0.2
MWT1.1	1986	2SPR	3	83	27	8	868	42	763	3717	5.2	7	0.33	19.4	8.1	1350	0.4
MWT1.1	1986	3SUM	3	112	30	7	65	9	805	3675	23.2	36	0.27	24.1	7.8	2368	1.0
MWT1.1	1986	4FAL	3	92	35	5	455	120	905	3292	17.1	35	0.40	10.0	11.5	4469	2.1
MWT1.1	1986	YEAR	10	97	31	7	592	61	817	3584	14.7	36	0.32	16.8	9.4	2566	1.1
MWT1.1	1987	1WIN	1	115	40	9	1100	470	1150	3550	5.2	5	0.20	1.7	13.1	978	0.2
MWT1.1	1987	YEAR	1	115	40	9	1100	470	1150	3550	5.2	5	0.20	1.7	13.1	978	0.2
MWT1.1	ALL	ALL	22	109	38	10	564	179	1110	2980	21.3	59	0.40	15.6	9.5	2838	1.2
MWT2.1	1984	4FAL	2	70	43	10	513	60	648	1158	12.2	15	0.75	8.3	11.6	6254	3.2
MWT2.1	1984	YEAR	2	70	43	10	513	60	648	1158	12.2	15	0.75	8.3	11.6	6254	3.2
MWT2.1	1985	3SUM	2	58	45	10	33	200	595	3143	2.3	2	1.50	23.4	6.8	8871	4.7
MWT2.1	1985	4FAL	3	47	33	13	355	212	592	1470	2.3	3	1.70	11.5	9.8	8024	4.2
MWT2.1	1985	YEAR	5	51	38	12	226	207	593	2139	2.3	3	1.62	16.3	8.6	8363	4.4
MWT2.1	1986	1WIN	1	105	35	10	1300	20	600	2325	9.7	10	0.30	8.0	11.1	283	0.0
MWT2.1	1986	2SPR	3	108	43	8	302	41	910	1187	26.6	38	0.37	19.4	8.9	2909	1.2
MWT2.1	1986	3SUM	3	100	33	4	20	11	650	2308	13.1	19	0.43	24.0	8.1	3612	1.7
MWT2.1	1986	4FAL	3	115	35	6	342	52	758	1558	10.2	14	0.45	10.7	10.6	7542	3.9
MWT2.1	1986	YEAR	10	108	37	6	329	33	756	1749	15.9	38	0.41	17.0	9.4	4247	2.1
MWT2.1	1987	1WIN	1	95	40	4	820	70	730	1800	10.9	11	0.40	1.7	14.0	5317	2.6
MWT2.1	1987	YEAR	1	95	40	4	820	70	730	1800	10.9	11	0.40	1.7	14.0	5317	2.6
MWT2.1	ALL	ALL	18	87	38	8	348	87	697	1794	12.0	38	0.78	15.0	9.7	5673	2.9
MWT3.1	1984	4FAL	2	65	35	33	375	50	508	350	3.4	5	2.50	11.8	10.2	11928	6.6
MWT3.1	1984	YEAR	2	65	35	33	375	50	508	350	3.4	5	2.50	11.8	10.2	11928	6.6
MWT3.1	1985	3SUM	2	68	38	10	30	20	628	2533	23.1	24	0.80	23.7	7.3	11283	6.2
MWT3.1	1985	4FAL	3	77	36	10	332	27	706	1434	25.9	33	1.00	12.0	10.8	11425	6.3
MWT3.1	1985	YEAR	5	73	37	10	211	24	675	1874	24.8	33	0.92	16.7	9.4	11368	6.3
MWT3.1	1986	1WIN	1	50	20	10	1000	50	465	1050	2.3	2	0.70	5.7	12.1	695	0.0
MWT3.1	1986	2SPR	3	63	27	8	540	41	827	1233	13.8	19	0.80	19.2	8.8	3919	1.8
MWT3.1	1986	3SUM	3	77	33	4	20	11	700	2367	28.6	39	0.63	24.5	7.8	5522	2.8
MWT3.1	1986	4FAL	3	120	35	6	317	38	888	1275	14.0	19	1.27	11.3	12.0	11582	6.4
MWT3.1	1986	YEAR	10	83	30	7	363	32	771	1568	17.2	39	0.88	17.1	9.8	6376	3.3
MWT3.1	1987	1WIN	1	50	30	4	880	68	490	1500	4.4	4	2.60	2.1	13.3	8190	4.3
MWT3.1	1987	YEAR	1	50	30	4	880	68	490	1500	4.4	4	2.60	2.1	13.3	8190	4.3
MWT3.1	ALL	ALL	18	77	32	10	351	33	699	1582	17.0	39	1.17	15.5	9.9	8481	4.5
MWT4.1	1984	4FAL	2	235	108	30	903	4655	6750	1250	57.4	98	0.63	9.1	9.1	9088	4.9
MWT4.1	1984	YEAR	2	235	108	30	903	4655	6750	1250	57.4	98	0.63	9.1	9.1	9088	4.9
MWT4.1	1985	1WIN	1	575	155	40	1080	1000	9150	100			0.25	7.4	14.9	5078	2.5
MWT4.1	1985	2SPR	3	338	87	32	422	1433	3253	1177	147.2	210	0.28	21.3	8.7	5322	2.6
MWT4.1	1985	3SUM	3	485	125	57	764	2533	5800	625	144.1	208	0.27	24.4	8.1	8148	4.3
MWT4.1	1985	4FAL	3	223	87	13	1282	5175	6692	1293	57.0	94	0.70	13.0	9.4	7383	3.8
MWT4.1	1985	YEAR	10	372	105	35	848	2843	5639	939	116.1	210	0.40	18.4	9.4	6764	3.5
MWT4.1	1986	1WIN	1	260	60	20	1000	4900	8500	2500	37.4	37	0.40	7.3	10.3	549	0.0
MWT4.1	1986	2SPR	3	315	67	15	853	3000	5813	1083	70.0	141	0.25	19.1	7.5	4264	2.0
MWT4.1	1986	3SUM	3	288	60	7	1588	1035	3718	733	127.9	168	0.30	24.3	7.0	4668	2.3
MWT4.1	1986	4FAL	3	208	60	10	1048	2300	3913	1400	54.1	95	0.37	11.4	10.2	9013	4.8
MWT4.1	1986	YEAR	10	270	62	12	1147	2390	4991	1215	79.4	168	0.32	17.2	8.5	5439	2.7
MWT4.1	1987	1WIN	1	195	55	8	1250	3200	4350	2150	51.3	51	0.50	2.6	14.1	5810	2.9

CHESAPEAKE BAY ESTUARY AND MAINSTEM DATA MEANS BY STATION, YEAR, AND SEASON DEPTH <= 3 METERS

STATION	YEAR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
MWT4.1	1987	YEAR	1	195	55	8	1250	3200	4350	2150	51.3	51	0.50	2.6	14.1	5810	2.9
MWT4.1	ALL	ALL	23	308	85	23	1000	2819	5416	1138	89.6	210	0.39	16.4	9.2	6348	3.2
MWT5.1	1984	3SUM	7	117		20	445	374	1275		23.7	30	0.74	25.1	7.0	9247	5.0
MWT5.1	1984	4FAL	4	84	68	28	498	578	1155	850	14.2	36	1.36	13.1	9.1	17016	9.8
MWT5.1	1984	YEAR	11	105	68	23	464	448	1227	850	19.0	36	0.96	20.7	7.8	12072	6.7
MWT5.1	1985	1WIN	3	100	57	20	670	600	1320	833			1.33	3.8	12.3	18867	11.0
MWT5.1	1985	2SPR	6	135	64	13	518	407	1402	650	48.0	101	1.15	18.4	10.3	13806	7.8
MWT5.1	1985	3SUM	6	178	73	27	216	418	1705	1583	34.2	79	0.63	25.7	6.9	18083	10.5
MWT5.1	1985	4FAL	4	121	58	18	438	434	1087	1394	23.5	41	1.18	14.6	10.5	17685	10.3
MWT5.1	1985	YEAR	19	140	65	19	430	447	1418	1130	35.9	101	1.02	17.6	9.6	16772	9.7
MWT5.1	1986	1WIN	4	261	38	11	1240	363	1145	2193	11.6	28	1.08	4.2	12.2	12142	6.8
MWT5.1	1986	2SPR	6	153	46	16	752	132	1668	1088	75.0	262	0.78	19.1	10.9	11367	6.2
MWT5.1	1986	3SUM	5	156	92	29	103	237	1748	1567	90.1	385	0.72	25.1	8.4	16741	9.6
MWT5.1	1986	4FAL	4	119	75	18	500	262	1030	1413	17.8	31	0.80	13.2	10.7	17250	10.0
MWT5.1	1986	YEAR	19	169	64	19	604	234	1460	1518	55.4	385	0.83	16.7	10.4	14311	8.1
MWT5.1	1987	1WIN	1	150	90	28	710	1000	1600	1400	47.9	48	0.80	3.8	13.5	19433	11.4
MWT5.1	1987	YEAR	1	150	90	28	710	1000	1600	1400	47.9	48	0.80	3.8	13.5	19433	11.4
MWT5.1	ALL	ALL	50	144	65	20	511	377	1400	1308	42.0	385	0.93	17.7	9.6	14845	8.5
MWT6.1	1984	4FAL	2	50	40	10	240	100	760	865	5.9	7	2.10	10.4	10.0	19324	11.3
MWT6.1	1984	YEAR	2	50	40	10	240	100	760	865	5.9	7	2.10	10.4	10.0	19324	11.3
MWT6.1	1985	1WIN	1	50		10	820	30	500	600			1.10	8.5	12.0	12643	7.0
MWT6.1	1985	2SPR	3	90	50	17	192	37	970	583	16.1	25	1.00	21.0	9.0	13722	7.7
MWT6.1	1985	3SUM	3	123	73	17	20	83	1063	1863	9.0	9	0.93	24.7	5.9	18666	10.9
MWT6.1	1985	4FAL	3	107	53	13	360	70	1010	1017	36.7	87	1.67	12.9	11.8	17666	10.3
MWT6.1	1985	YEAR	10	101	59	15	254	60	963	1099	22.1	87	1.19	18.4	9.2	16280	9.4
MWT6.1	1986	2SPR	3	62	30	8	472	17	822	900	18.6	28	1.07	18.9	10.8	11117	6.1
MWT6.1	1986	3SUM	3	102	58	6	20	48	658	1850	12.9	18	0.67	25.3	5.3	16067	9.2
MWT6.1	1986	4FAL	3	90	53	13	198	39	735	1483	16.8	21	1.47	12.6	10.3	18900	11.0
MWT6.1	1986	YEAR	9	84	47	9	230	35	738	1411	16.1	28	1.07	18.9	8.8	15361	8.8
MWT6.1	1987	1WIN	1	70	50	17	470	36	650	1400	7.4	7	1.80	2.7	13.8	15233	8.7
MWT6.1	1987	YEAR	1	70	50	17	470	36	650	1400	7.4	7	1.80	2.7	13.8	15233	8.7
MWT6.1	ALL	ALL	22	88	52	12	253	52	838	1219	17.0	87	1.25	17.2	9.3	16133	9.3
MWT7.1	1984	4FAL	1	50	40	10	280	30	650	600	10.3	10	1.50	8.7	11.5	19450	11.4
MWT7.1	1984	YEAR	1	50	40	10	280	30	650	600	10.3	10	1.50	8.7	11.5	19450	11.4
MWT7.1	1985	3SUM	2	138	83	15	60	110	1045	2028	20.9	25	0.90	24.3	6.9	21327	12.6
MWT7.1	1985	4FAL	3	93	67	20	247	67	887	1493	40.6	57	1.23	13.8	12.0	20742	12.3
MWT7.1	1985	YEAR	5	111	73	18	172	84	950	1707	32.7	57	1.10	18.0	10.0	20976	12.4
MWT7.1	1986	2SPR	3	65	33	8	280	28	677	533	11.5	12	1.23	18.5	9.8	13259	7.4
MWT7.1	1986	3SUM	3	113	75	9	20	10	900	1867	23.0	32	0.67	25.7	7.6	18100	10.5
MWT7.1	1986	4FAL	3	98	50	11	238	45	725	1417	16.0	20	1.63	12.9	9.4	21444	12.7
MWT7.1	1986	YEAR	9	92	50	9	179	28	767	1272	16.8	32	1.18	19.0	9.0	17601	10.2
MWT7.1	1987	1WIN	1	70	50	4	370	24	600	1100	5.1	5	2.10	3.3	12.5	18967	11.1
MWT7.1	1987	YEAR	1	70	50	4	370	24	600	1100	5.1	5	2.10	3.3	12.5	18967	11.1
MWT7.1	ALL	ALL	16	94	57	12	195	45	807	1355	20.6	57	1.23	17.1	9.7	18857	11.0
MWT8.1	1984	4FAL	2	95	420	437	75	97	747	950	18.1	30	1.10	14.2	9.5	20443	12.0
MWT8.1	1984	YEAR	2	95	420	437	75	97	747	950	18.1	30	1.10	14.2	9.5	20443	12.0
MWT8.1	1985	1WIN	2	80	40	10	250	25	825	450			1.35	5.6	13.3	18760	10.9
MWT8.1	1985	2SPR	3	160	67	37	23	37	1280	1150	46.7	105	0.77	22.3	10.1	16599	9.5
MWT8.1	1985	3SUM	3	153	103	33	20	23	877	2410	11.8	12	0.73	25.8	7.7	20549	12.1
MWT8.1	1985	4FAL	3	93	63	10	217	33	700	1260	18.5	28	1.73	14.0	11.3	20494	12.1

CHESAPEAKE BAY ESTUARY AND MAINSTEM DATA MEANS BY STATION, YEAR, AND SEASON DEPTH <= 3 METERS

STATION	YEAR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
MWT8.1	1985	YEAR	11	125	71	24	116	30	929	1396	27.4	105	1.13	17.9	10.4	19132	11.2
MWT8.1	1986	1WIN	1	50		10	490	30	430	830	3.1	3	2.20	6.0	12.5	16667	9.6
MWT8.1	1986	2SPR	3	73	47	12	250	19	967	833	30.5	44	0.87	19.4	10.8	14396	8.1
MWT8.1	1986	3SUM	3	133	80	39	20	19	643	2267	19.6	25	0.67	25.6	5.8	19227	11.2
MWT8.1	1986	4FAL	3	103	60	14	110	38	603	1200	15.5	21	1.30	12.6	9.5	21956	13.0
MWT8.1	1986	YEAR	10	98	62	20	163	26	707	1373	20.0	44	1.07	17.9	9.1	18340	10.7
MWT8.1	1987	1WIN	1	70	50	4	350	16	550	1400	6.0	6	1.70	4.4	14.6	20093	11.8
MWT8.1	1987	YEAR	1	70	50	4	350	16	550	1400	6.0	6	1.70	4.4	14.6	20093	11.8
MWT8.1	ALL	ALL	24	109	97	71	139	36	803	1350	22.1	105	1.12	16.9	9.9	19011	11.1
MWT8.2	1984	4FAL	3	80	43	12	57	90	683	775	8.9	9	1.02	13.8	9.3	21634	12.8
MWT8.2	1984	YEAR	3	80	43	12	57	90	683	775	8.9	9	1.02	13.8	9.3	21634	12.8
MWT8.2	1985	1WIN	1	65	55	35	360	25	750	575			1.50	2.5	12.2	18350	10.7
MWT8.2	1985	2SPR	3	117	48	10	20	22	1063	1100	27.4	45	1.00	23.3	11.1	17471	10.1
MWT8.2	1985	3SUM	3	138	85	17	23	53	1003	2513	13.2	14	0.57	25.6	6.6	22007	13.1
MWT8.2	1985	4FAL	3	88	70	13	182	28	687	1347	20.2	24	1.00	13.8	14.1	21201	12.6
MWT8.2	1985	YEAR	10	110	67	16	104	34	901	1546	21.1	45	0.92	19.1	10.7	20039	11.8
MWT8.2	1986	1WIN	1	90	45	10	565	25	515	1125	2.4	2	1.40	7.8	11.6	16667	9.6
MWT8.2	1986	2SPR	3	82	35	8	227	20	897	958	15.6	21	0.73	19.5	8.9	15096	8.6
MWT8.2	1986	3SUM	3	145	68	19	20	16	842	2208	16.7	31	0.57	25.7	5.9	20333	12.0
MWT8.2	1986	4FAL	3	139	57	14	103	38	869	992	19.5	25	1.20	12.1	9.8	22860	13.6
MWT8.2	1986	YEAR	10	119	53	13	162	25	834	1360	15.8	31	0.89	18.0	8.5	19154	11.2
MWT8.2	1987	1WIN	1	90	60	4	415	52	590	1150	6.6	7	1.60	4.7	14.7	22247	13.2
MWT8.2	1987	YEAR	1	90	60	4	415	52	590	1150	6.6	7	1.60	4.7	14.7	22247	13.2
MWT8.2	ALL	ALL	24	109	58	14	135	38	833	1381	16.4	45	0.95	17.3	9.8	19961	11.7
MWT8.3	1984	4FAL	3	68	40	12	100	97	642	790	8.2	10	1.09	13.6	9.0	22027	13.1
MWT8.3	1984	YEAR	3	68	40	12	100	97	642	790	8.2	10	1.09	13.6	9.0	22027	13.1
MWT8.3	1985	1WIN	1	55	45	15	470	50	665	630			1.40	1.7	12.3	18233	10.6
MWT8.3	1985	2SPR	3	95	45	13	32	25	1025	892	20.5	34	0.70	22.6	10.5	17571	10.2
MWT8.3	1985	3SUM	3	120	72	13	23	30	897	2263	13.3	16	0.63	25.1	6.9	22396	13.3
MWT8.3	1985	4FAL	3	128	55	12	182	35	1108	1327	36.5	87	0.90	13.5	11.2	21633	12.8
MWT8.3	1985	YEAR	10	109	56	13	118	32	976	1408	24.7	87	0.81	18.5	9.8	20303	12.0
MWT8.3	1986	1WIN	1	85	40	10	630	50	500	900	3.4	3	1.30	7.6	11.6	18933	11.0
MWT8.3	1986	2SPR	3	68	32	8	175	19	788	800	14.0	17	0.77	19.2	7.9	15282	8.7
MWT8.3	1986	3SUM	3	140	57	13	20	39	943	2133	12.2	19	0.57	25.1	5.9	20957	12.4
MWT8.3	1986	4FAL	3	103	60	10	117	21	735	867	14.0	22	1.03	12.2	10.1	23092	13.8
MWT8.3	1986	YEAR	10	102	49	10	157	29	790	1230	12.4	22	0.84	17.7	8.3	19692	11.6
MWT8.3	1987	1WIN	1	110	60	5	410	20	700	1100	5.7	6	2.10	3.2	15.6	20800	12.3
MWT8.3	1987	YEAR	1	110	60	5	410	20	700	1100	5.7	6	2.10	3.2	15.6	20800	12.3
MWT8.3	ALL	ALL	24	101	52	11	144	38	845	1263	16.0	87	0.91	16.9	9.3	20285	11.9

CHESAPEAKE BAY MAINSTEM DATA MEANS BY SEGMENT AND MONTH DEPTH <= 3 METERS

SEG	YRMO	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
1	8407	1	53	12	7	1430	40	200	1665	13.5	14	0.60	27.4	7.2	200	0.0
1	8408	1	32	12	9	1480	20	213	1520	1.0	1	0.90	27.8	6.1	300	0.0
1	8409	2	34	13	7	1113	20	262	1013	11.0	13	1.00	23.5	6.7	317	0.0
1	8410	2	37	15	10	1200	48	386	434	8.5	13	1.50	18.1	7.5	400	0.0
1	8411	1	36	15	7	1520	20	260	636	7.0	7	1.20	15.7	8.0	400	0.0
1	8412	1	39	22	14	1195	65	353	2440	1.5	2	1.00	2.8	13.3	100	0.0
1	8503	2	65	33	11	1045	92	329	1845	16.0	31	0.35	6.8	13.3	100	0.0
1	8504	2	33	18	5	865	46	203	1515	5.8	7	0.70	12.7	10.8	129	0.0
1	8505	2	56	14	11	845	111	304	375	12.5	19	0.80	19.2	7.5	167	0.0
1	8506	2	62	37	16	845	157		905	9.8	13	1.15	23.4	5.9	333	0.0
1	8507	2	52	26	4	933	13		710	16.1	24	1.10	26.9	8.0	313	0.0
1	8508	2	64	36	7	581	27		645	7.3	7	1.10	26.7	6.4	300	0.0
1	8509	2	33	8	3	592	23		450	8.2	9	1.10	24.1	7.1	363	0.0
1	8510	2	46	24	19	1053	34		1385	4.3	4	0.85	17.9	7.5	243	0.0
1	8511	1	41	22	15	940	68		470	3.7	4	1.00	13.6	9.5	304	0.0
1	8512	1	32	15	10	1320	44		2650	0.8	1	0.90	3.6	12.7	137	0.0
1	8601	0														
1	8602	0														
1	8603	2	47	21	8	1490	69		1855			0.45	5.8	12.0	1005	0.3
1	8604	2	45	12	9	1280	34		1970	6.0	10	0.55	12.5	10.5	90	0.0
1	8605	2	34	6	5	1140	30		645	12.5	19	1.05	20.0	8.6	241	0.0
1	8606	2	43	9	4	691	76	400	1225	13.0	15	0.70	24.6	6.9	241	0.0
1	8607	2	33	10	3	580	31	475	570	7.2	9	1.20	27.7	6.3	294	0.0
1	8608	2	33	9	4	950	14	415	645	11.8	15	1.00	25.4	7.2	273	0.0
1	8609	2	33	12	4	1025	3	415	635	10.8	14	1.10	22.3	7.8	320	0.0
1	8610	2	37	9	6	990	22	400	710	11.4	12	1.10	19.0	8.6	337	0.0
1	8611	1	40	17	11	1060	69	400	2190	2.1	2	1.00	6.2	11.9	182	0.0
1	8612	1	37	12	7	1230	50	290	2580	0.6	1	0.80	5.4	11.6	179	0.0
1	8701	1	29	12	11	1700	72	260	2560	0.7	1	1.40	2.2	13.0	227	0.0
1	8702	1	29	14	8	2140	37	260	1070	1.1	1	2.60	3.0	13.4	293	0.0
1	8703	1	34	13	8	1380	40	260	1520	4.3	4	0.60	6.9	12.4	182	0.0
1	8704	2	82	18	9	1105	52	490	2160	6.7	7	0.45	10.3	11.4	166	0.0
1	8705	2	40	9	4	876	43	395	690	22.4	37	0.90	16.5	10.3	223	0.0
1	8706	2	38	12	4	1085	52	410	990	11.5	18	0.80	23.4	7.4	278	0.0
1	8707	2	35	9	5	920	61	360	1300	9.7	12	1.10	27.4	6.7	309	0.0
2	8407	4	90	26	13	1363	67	308	2058	11.0	27	0.28	26.1	7.2	150	0.0
2	8408	2	39	18	8	948	59	216	1458	10.5	14	0.65	26.5	7.2	1750	0.6
2	8409	4	46	14	8	607	61	224	1224	9.8	12	0.71	22.4	6.9	5781	2.9
2	8410	4	44	18	11	718	75	334	638	12.7	17	0.93	17.2	8.0	8667	4.6
2	8411	2	36	18	11	999	102	372	530	10.3	13	1.10	13.9	9.5	6913	3.6
2	8412	2	59	24	14	1225	100	342	1725	4.5	6	0.75	4.5	11.9	2617	1.2
2	8503	4	104	49	10	1010	59	327	1629	15.4	25	0.35	7.2	12.9	588	0.2
2	8504	3	47	18	7	899	54	262	1773	9.7	18	0.40	10.8	10.4	1211	0.5
2	8505	4	59	14	8	773	64	276	363	14.6	19	0.50	18.8	8.2	1665	0.6
2	8506	4	67	28	14	676	86		726	7.2	14	0.45	22.7	6.9	1796	0.7
2	8507	4	68	29	12	468	49		1050	10.2	13	0.60	26.4	6.4	3775	1.8
2	8508	4	92	39	23	220	47		859	12.0	18	0.48	25.8	6.7	4635	2.3
2	8509	4	65	32	17	263	48		914	6.0	9	0.68	23.8	6.8	10046	5.5
2	8510	4	49	24	16	628	71		811	6.6	14	0.90	17.3	8.5	6514	3.3
2	8511	2	30	14	18	900	107		955	3.6	4	0.80	13.6	9.1	8029	4.2
2	8512	2	71	41	16	1235	64		2513	0.8	1	0.55	4.8	12.1	1894	0.8
2	8601	1	56	22	12	1440	94		2650	0.7	1	0.50	-0.0	13.1	1678	0.6
2	8602	0														
2	8603	4	70	19	9	1403	58		1811	3.0	5	0.35	6.4	11.8	997	0.3
2	8604	4	66	14	8	1273	47		1911	5.5	13	0.33	11.3	10.6	714	0.2
2	8605	4	66	11	14	940	31		218	20.3	26	0.45	19.9	8.8	1146	0.4
2	8606	4	67	20	13	729	66	625	1240	9.4	20	0.45	24.2	7.6	322	0.0
2	8607	4	62	24	13	378	35	504	916	9.8	15	0.80	26.9	7.1	3051	1.4
2	8608	4	61	23	15	585	38	531	738	11.2	19	0.58	24.6	7.9	3058	1.4
2	8609	4	60	22	11	372	17	635	504	18.5	41	0.55	21.6	8.1	4820	2.4
2	8610	4	62	16	11	596	53	475	610	10.2	18	0.65	17.7	8.4	6607	3.5
2	8611	2	54	18	11	1020	76	535	1165	4.6	5	0.80	8.2	10.7	2270	1.0
2	8612	2	53	18	13	1323	62	390	2545	0.7	1	0.40	5.2	12.3	516	0.1
2	8701	2	49	17	15	1670	97	475	2513	1.4	2	0.70	2.1	12.9	1397	0.5
2	8702	2	36	10	4	1643	33	338	1408	4.3	5	1.05	1.6	13.3	6151	3.1
2	8703	2	61	9	5	1135	19	600	1545	36.4	62	0.85	7.2	12.3	7166	3.7
2	8704	4	74	14	9	1099	57	499	2046	8.6	11	0.35	10.6	11.7	464	0.0
2	8705	4	70	11	5	854	40	646	609	21.2	29	0.48	16.0	9.9	1700	0.6
2	8706	4	51	13	9	774	58	436	644	12.0	18	0.63	24.5	7.1	1593	0.6
2	8707	4	43	20	16	513	106	500	1213	6.6	9	0.93	26.9	6.7	3140	1.5

CHESAPEAKE BAY MAINSTEM DATA MEANS BY SEGMENT AND MONTH DEPTH <= 3 METERS

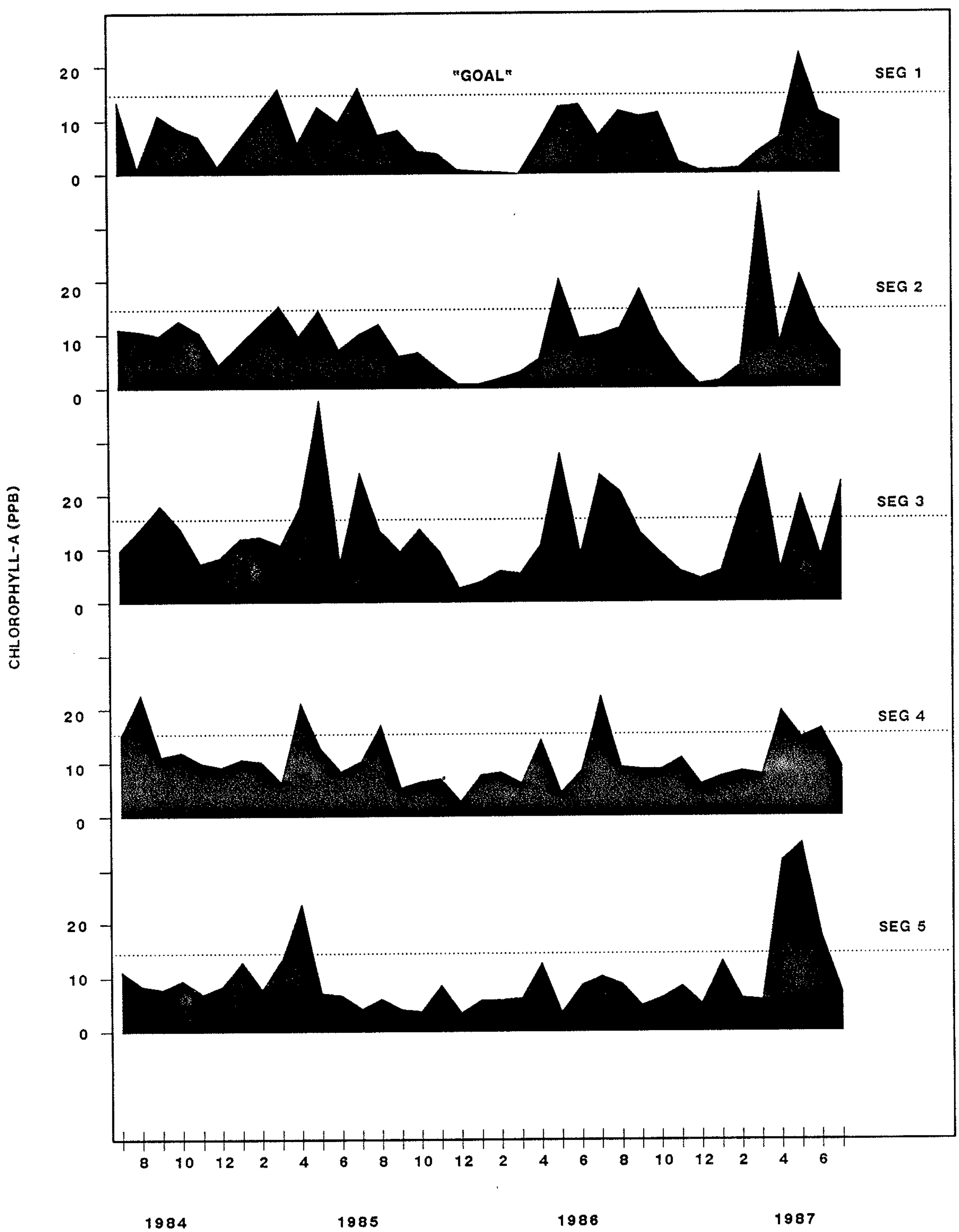
SEG	YRMO	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
3	8407	10	57	19	11	865	49	288	1570	9.8	19	0.80	25.2	7.2	4492	2.2
3	8408	6	43	16	11	414	86	289	1520	13.7	20	0.97	25.6	6.8	11289	6.2
3	8409	10	50	21	10	173	102	337	1293	18.1	58	1.20	22.9	6.6	18327	10.7
3	8410	10	41	18	10	261	80	321	985	14.0	29	1.57	18.0	8.0	19492	11.4
3	8411	5	29	20	14	373	147	378	831	7.4	12	1.58	14.5	8.8	20207	11.9
3	8412	5	32	16	8	717	120	350	788	8.4	12	1.92	5.4	11.9	14892	8.5
3	8501	1	30	12	7	546	79	388	972	12.0	12	1.80	-0.6	14.1	19067	11.1
3	8502	4	26	10	7	417	41	216	620	12.3	19	1.30	-0.3	14.9	24375	14.7
3	8503	10	99	35	6	862	49	311	916	10.8	22	1.39	7.4	12.1	12460	7.0
3	8504	8	47	26	4	719	48	299	892	17.9	35	1.09	11.3	12.6	10568	5.8
3	8505	10	56	21	6	332	40	240	181	37.7	94	0.96	17.6	8.8	13962	7.9
3	8506	10	46	22	11	285	82		849	7.7	21	1.18	21.7	6.1	14670	8.3
3	8507	10	59	17	8	65	40		1574	24.2	112	0.85	25.4	6.9	17580	10.2
3	8508	10	80	39	15	94	49		1527	13.5	22	0.88	26.0	6.4	19833	11.6
3	8509	10	57	26	13	87	42		1101	9.6	27	1.00	24.6	7.1	23053	13.8
3	8510	10	43	23	12	197	72		800	13.7	37	1.38	18.5	8.9	22077	13.1
3	8511	5	49	28	15	338	127		638	9.6	16	1.14	14.5	9.6	22233	13.2
3	8512	5	42	25	17	788	137		1583	2.8	4	1.30	7.6	11.1	14534	8.2
3	8601	5	33	13	7	828	74		1641	3.8	7	1.28	1.7	13.1	13760	7.8
3	8602	5	40	17	7	1031	114		1488	6.0	8	1.00	0.0	13.0	11212	6.2
3	8603	10	58	20	7	955	105		1321	5.4	9	0.61	5.6	11.5	10372	5.8
3	8604	10	46	10	7	1068	67		1277	10.5	22	0.77	11.4	10.5	7507	3.9
3	8605	10	37	8	4	450	17		215	27.8	68	0.89	18.5	9.6	12578	7.0
3	8606	10	41	15	9	278	73	688	945	9.3	17	0.98	23.8	7.5	12209	6.8
3	8607	10	59	22	10	59	29	831	1493	23.9	67	1.16	26.8	8.4	16314	9.4
3	8608	10	69	26	15	79	30	740	1342	20.7	54	0.79	25.2	7.9	16844	9.7
3	8609	10	51	21	15	121	23	602	1198	12.9	28	0.95	22.3	7.7	19613	11.5
3	8610	10	55	25	16	198	31	415	823	9.2	16	1.43	18.5	7.6	20671	12.2
3	8611	5	41	26	18	396	148	600	882	5.8	9	1.84	10.5	10.2	19542	11.5
3	8612	5	44	15	9	732	112	407	1587	4.4	7	1.14	6.9	11.6	12829	7.2
3	8701	5	46	18	11	844	145	434	1484	5.9	9	1.56	4.1	11.4	16702	9.6
3	8702	5	41	10	6	774	48	516	924	17.6	28	1.58	2.2	13.4	19047	11.1
3	8703	8	48	10	4	948	28	760	886	27.4	73	1.04	6.8	12.7	15682	9.0
3	8704	10	47	14	9	940	112	567	1353	6.4	14	0.70	11.1	10.3	6861	3.5
3	8705	10	36	10	3	505	52	622	706	20.0	34	1.27	14.9	9.2	15189	8.7
3	8706	10	45	17	8	256	39	663	757	8.8	13	1.19	23.5	6.9	14531	8.2
3	8707	10	67	24	13	74	59	576	1628	22.5	52	1.18	26.7	8.0	16016	9.2
4	8407	20	36	12	7	165	35	278	1226	15.0	31	1.44	25.2	8.1	11794	6.5
4	8408	14	49	19	7	141	55	306	1503	22.7	135	1.21	26.2	8.5	14967	8.5
4	8409	20	35	17	8	46	78	280	831	11.3	20	1.80	23.1	7.1	23254	13.9
4	8410	20	26	13	8	89	50	389	476	12.1	30	2.22	18.6	8.7	23998	14.4
4	8411	4	20	13	7	121	58	376	522	10.0	14	2.25	16.9	9.1	25200	15.2
4	8412	10	19	12	7	187	51	306	533	9.4	13	2.58	6.8	12.2	24420	14.7
4	8501	4	18	12	7	303	31	418	454	10.8	14	2.13	1.4	13.6	24375	14.7
4	8502	8	16	10	7	274	40	215	439	10.3	15	1.80	-0.0	14.7	25492	15.4
4	8503	20	66	60	4	504	17	223	355	6.5	13	2.53	7.2	11.8	20915	12.3
4	8504	20	40	23	3	413	15	244	86	21.2	33	2.06	12.2	13.7	19320	11.3
4	8505	20	26	16	6	212	31	275	76	12.8	29	1.68	17.5	8.7	21451	12.7
4	8506	20	43	21	8	80	18		533	8.5	21	1.67	22.0	8.4	21808	12.9
4	8507	20	53	22	6	6	15		1025	10.5	27	1.20	25.8	7.2	23245	13.9
4	8508	20	67	23	14	33	31		1081	17.2	142	1.52	26.0	6.8	25144	15.2
4	8509	20	45	22	7	33	39		679	5.5	12	1.53	25.0	7.3	27385	16.7
4	8510	20	26	11	6	80	50		418	6.6	18	1.63	19.2	8.1	28320	17.3
4	8511	10	27	14	6	152	68		285	7.1	14	1.89	15.0	9.7	27322	16.6
4	8512	10	33	22	12	501	127		956	3.0	4	2.04	8.1	10.7	21363	12.7
4	8601	10	21	6	3	481	11		958	7.8	12	1.87	2.8	12.2	21745	12.9
4	8602	10	25	11	5	585	39		720	8.3	11	1.69	0.9	12.8	19777	11.6
4	8603	20	29	10	4	748	79		860	6.3	12	1.48	5.4	11.9	17299	10.0
4	8604	20	17	5	3	771	16		307	14.4	24	1.45	11.7	11.3	14190	8.0
4	8605	20	12	5	4	384	31		119	4.6	8	2.85	18.4	9.1	18727	10.9
4	8606	20	29	10	5	113	49	777	679	8.7	19	1.66	23.3	7.7	20451	12.0
4	8607	20	46	17	9	7	18	732	1222	22.4	157	1.34	26.9	7.6	21707	12.9
4	8608	20	36	14	7	20	41	501	1081	9.4	18	1.73	25.5	7.4	23412	14.0
4	8609	20	31	12	5	39	21	447	850	8.9	15	1.97	22.5	7.9	25203	15.2
4	8610	19	37	16	5	61	26	343	397	8.9	24	2.21	19.3	8.2	26302	16.0
4	8611	10	33	18	7	119	76	491	621	11.0	19	2.59	11.6	10.8	28778	17.6
4	8612	10	31	13	4	425	80	369	902	6.2	9	2.14	7.7	11.1	21967	13.0
4	8701	10	27	10	4	439	54	351	937	7.6	11	2.20	4.7	11.4	23273	13.9
4	8702	10	26	9	3	465	17	387	637	8.5	13	1.92	2.1	13.0	23427	14.0
4	8703	14	20	8	4	539	10	483	442	7.9	15	2.33	6.5	12.9	22471	13.4

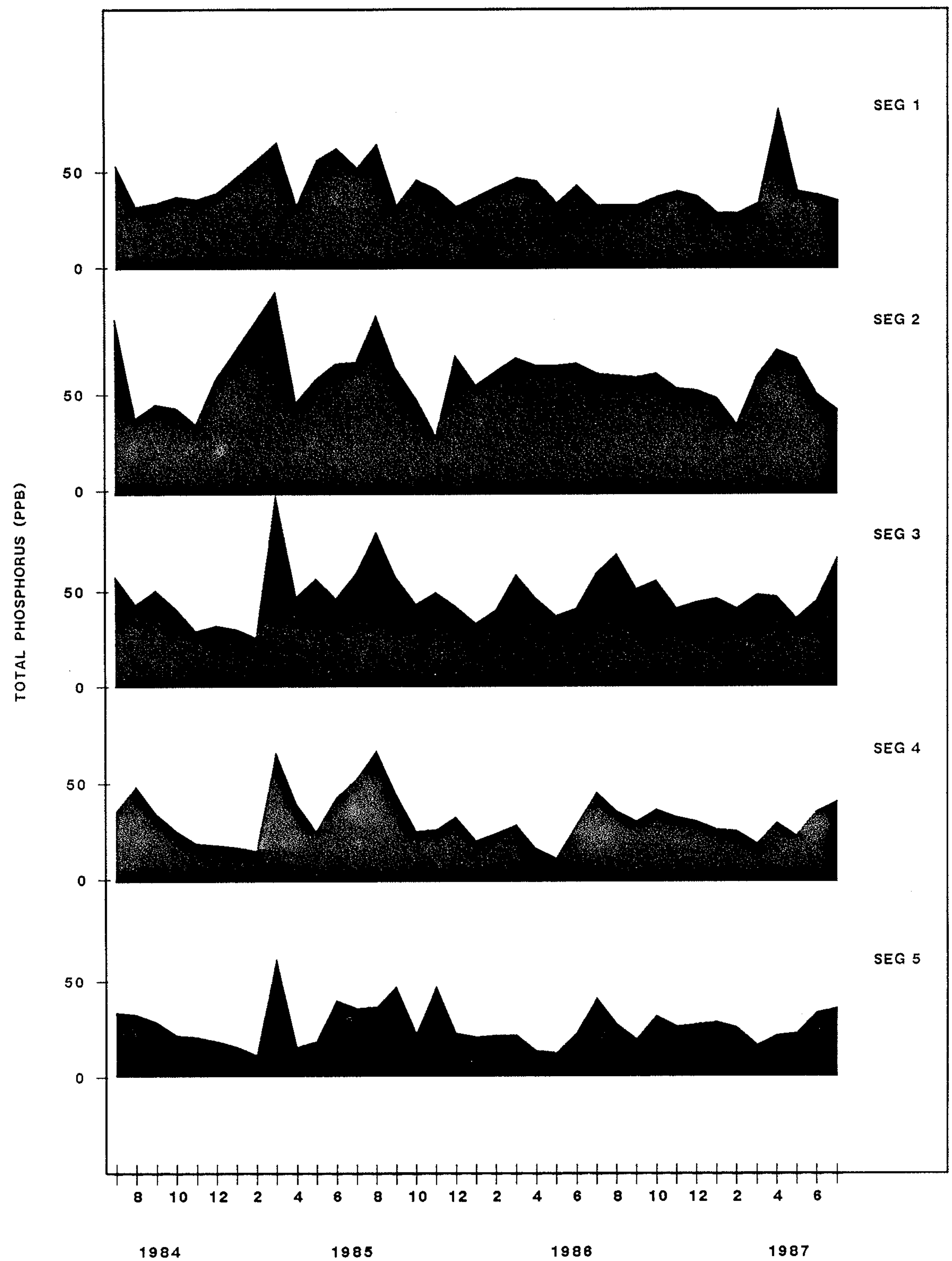
CHESAPEAKE BAY MAINSTEM DATA MEANS BY SEGMENT AND MONTH DEPTH <= 3 METERS PAGE 3

SEG	YRMO	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
4	8704	20	30	9	3	576	50	586	493	19.7	36	1.51	10.4	11.8	17508	10.1
4	8705	20	24	9	4	351	26	542	359	14.8	34	2.10	15.8	10.6	19654	11.5
4	8706	20	36	14	6	33	29	647	247	16.4	34	1.39	23.3	9.8	20896	12.3
4	8707	20	41	16	7	10	50	442	858	9.4	18	1.70	26.5	7.2	22782	13.6
5	8407	5	33	12	7	40	37	423	760	11.3	17	1.78	25.0	7.3	17306	10.0
5	8408	5	32	13	7	40	48	358	1366	8.5	11	1.78	25.6	7.3	17840	10.3
5	8409	6	28	15	7	40	29	207	787	8.0	10	2.10	23.3	7.4	25156	15.2
5	8410	6	21	12	7	41	30	411	202	9.5	14	2.30	18.7	8.9	25322	15.3
5	8411	3	20	12	7	63	32	314	295	7.0	7	2.67	17.8	9.1	26911	16.4
5	8412	3	18	12	7	50	40	281	289	8.5	10	1.80	7.3	13.2	27058	16.5
5	8501	3	15	12	7	220	24	270	240	13.0	14	2.20	4.1	13.2	26000	15.7
5	8502	3	11	10	7	225	40	211	241	8.0	8	2.07	0.1	13.9	27356	16.7
5	8503	6	60	29	4	250	7	215	68	13.8	24	2.32	8.1	11.4	23683	14.2
5	8504	6	15	10	3	233	15	349	24	23.8	35	2.12	13.3	13.5	23115	13.8
5	8505	6	18	16	6	167	36	235	54	7.3	16	2.78	17.8	8.3	23706	14.2
5	8506	6	39	24	4	26	18		272	6.8	10	1.97	22.5	8.9	24711	14.9
5	8507	6	35	15	5	6	5		638	4.4	7	1.65	26.3	7.0	26492	16.1
5	8508	6	36	16	5	9	26		411	6.2	9	2.03	26.0	6.9	27689	16.9
5	8509	6	46	29	4	8	30		526	4.2	6	1.68	25.5	7.7	28151	17.2
5	8510	6	22	11	5	32	46		168	4.0	7	1.63	20.0	7.8	31210	19.3
5	8511	3	46	31	5	111	46		362	8.7	14	1.57	15.1	9.8	27839	17.0
5	8512	3	22	13	9	225	102		458	3.6	7	2.30	9.7	10.0	26608	16.2
5	8601	3	20	7	4	313	5		513	6.0	8	1.93	3.9	12.0	26178	15.9
5	8602	3	21	13	6	437	32		515	5.9	7	2.27	2.1	12.8	22758	13.6
5	8603	6	21	10	3	597	43		472	6.4	9	2.05	5.1	12.4	20311	12.0
5	8604	6	13	6	2	552	28		19	12.7	22	2.28	11.8	11.4	19289	11.3
5	8605	5	12	6	3	350	17		60	3.7	5	3.13	17.7	9.0	22628	13.5
5	8606	6	22	7	4	78	20	699	359	8.8	11	1.85	23.4	8.2	24769	14.9
5	8607	6	40	17	4	7	25	585	912	10.3	19	1.80	27.5	8.1	24243	14.6
5	8608	6	27	9	6	5	45	448	496	8.9	15	1.95	26.3	7.1	27392	16.7
5	8609	6	19	7	4	18	31	413	299	5.0	7	2.42	22.6	7.3	27925	17.1
5	8610	6	31	13	5	37	46	303	510	6.4	10	2.63	19.5	7.8	28842	17.7
5	8611	3	26	16	3	53	71	490	295	8.5	10	2.57	12.3	9.9	29183	17.9
5	8612	3	27	12	3	214	68	555	517	5.2	7	2.90	8.4	10.2	26817	16.3
5	8701	3	28	10	3	259	13	375	590	13.3	17	1.77	4.9	12.7	26478	16.1
5	8702	3	25	8	4	333	12	358	468	6.3	8	1.73	2.4	12.4	26222	15.9
5	8703	6	16	8	3	427	15	406	336	6.0	8	2.97	6.5	12.8	23458	14.0
5	8704	6	21	10	7	255	17	665	43	31.9	44	1.27	10.4	12.0	23764	14.2
5	8705	5	22	8	4	151	13	771	75	35.1	44	1.60	17.3	12.0	21552	12.8
5	8706	6	33	13	6	8	16	747	195	17.9	34	1.10	23.9	9.8	22538	13.4
5	8707	6	35	13	6	10	39	426	253	7.3	12	2.03	26.6	8.0	25847	15.7

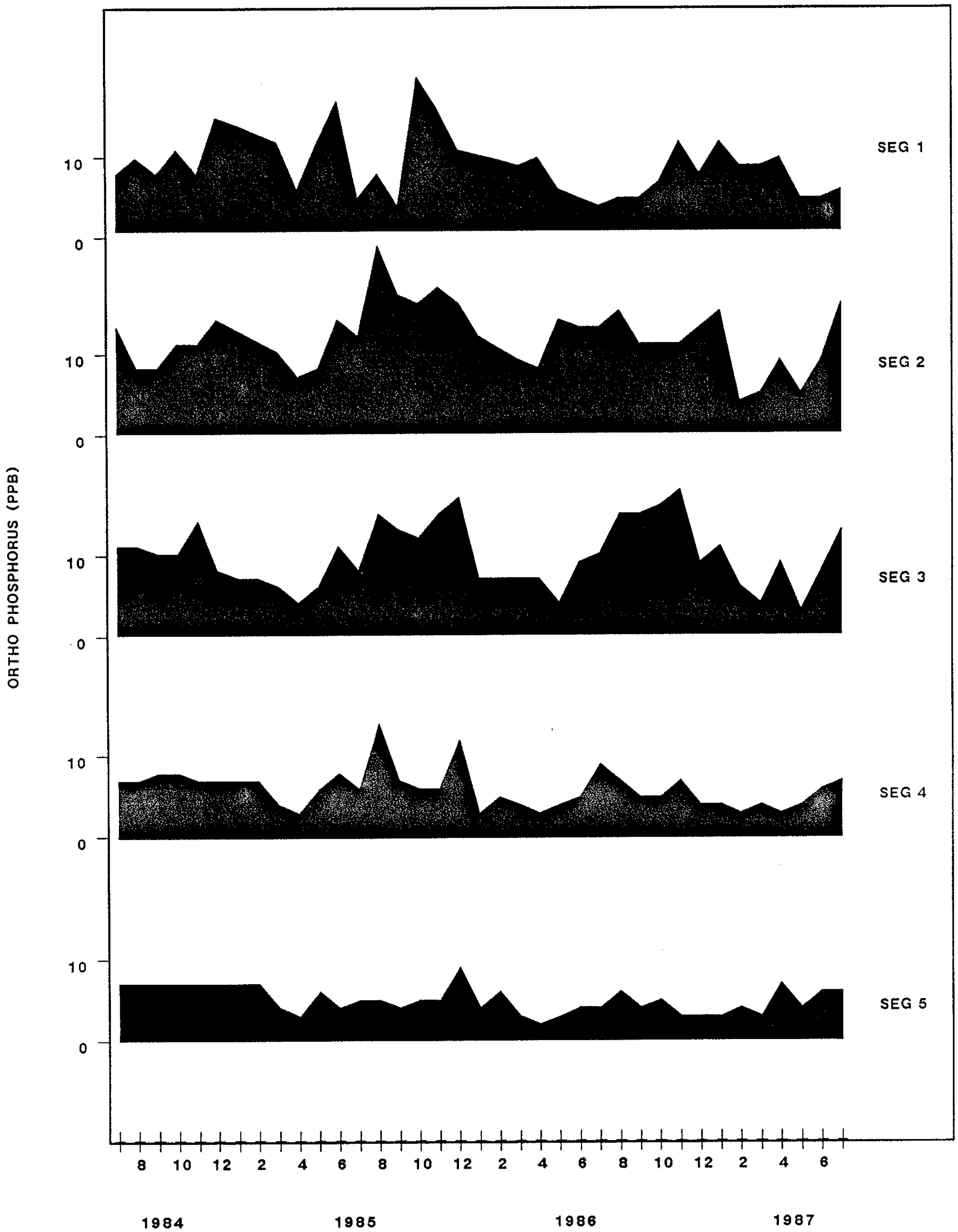
CHESAPEAKE BAY MAINSTEM DATA MEANS BY SEGMENT AND SEASON   DEPTH <= 3 METERS

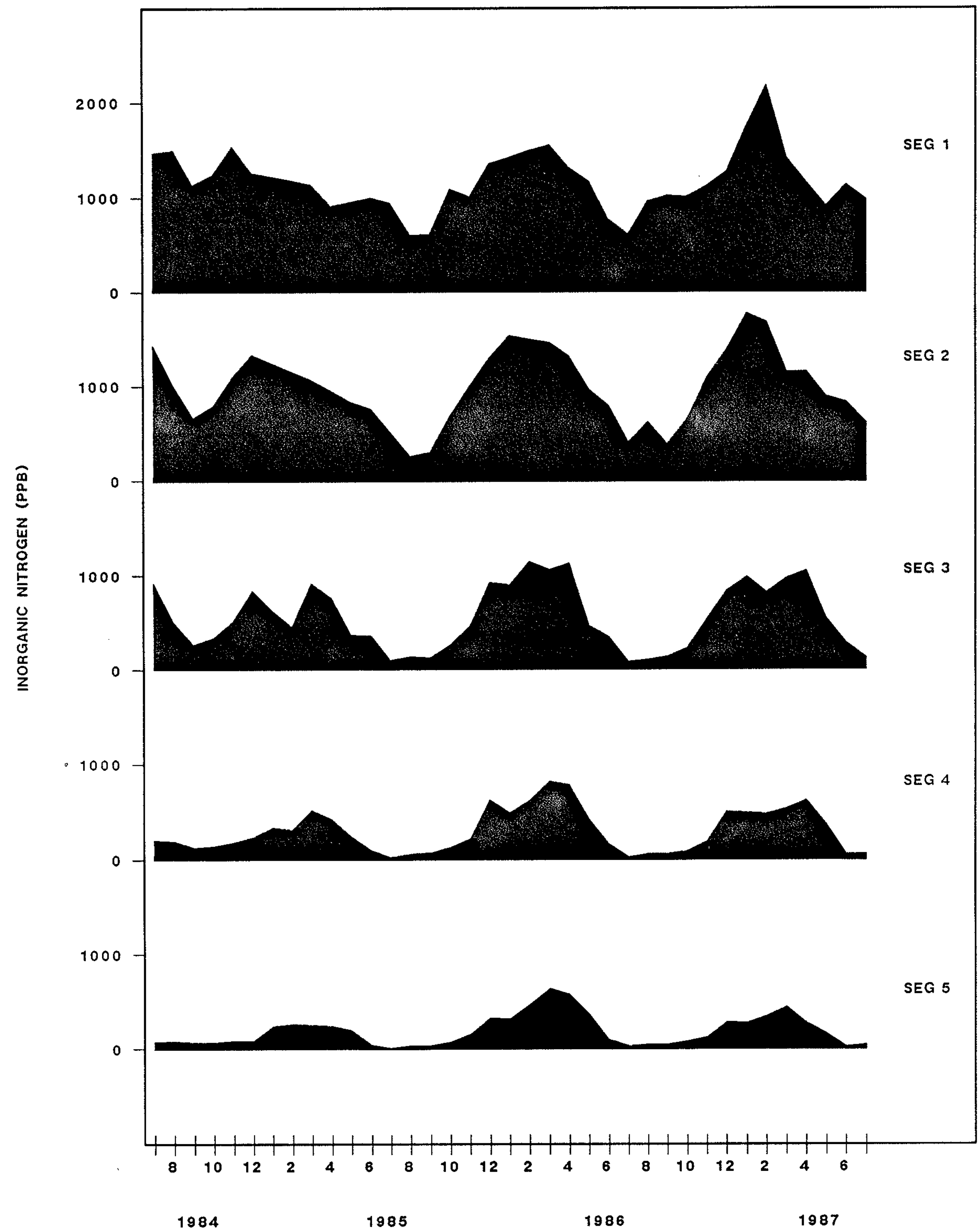
SEG	YR	SEAS	OBS	TOTAL P PPB	DIS-P PPB	ORT-P PPB	NO23-N PPB	NH34-N PPB	TKN PPB	SI PPB	CHL-A PPB	MAX CHL-A PPB	SECCHI METERS	TEMP DEG-C	D.O. PPM	COND UHOS	SALIN PPT
1	84	3SUM	4	38	12	8	1284	25	234	1303	9.1	14	0.88	25.5	6.7	283	0.0
1	84	4FAL	4	37	17	10	1279	45	346	986	6.4	13	1.23	13.6	9.1	325	0.0
1	85	1WIN	2	65	33	11	1045	92	329	1845	16.0	31	0.35	6.8	13.3	100	0.0
1	85	2SPR	6	50	23	10	852	105	237	932	9.4	19	0.88	18.4	8.1	210	0.0
1	85	3SUM	6	50	23	5	702	21		602	10.5	24	1.10	25.9	7.2	325	0.0
1	85	4FAL	4	41	21	16	1091	45		1473	2.9	4	0.90	13.3	9.3	232	0.0
1	86	1WIN	2	47	21	8	1490	69		1855			0.45	5.8	12.0	1005	0.3
1	86	2SPR	6	41	9	6	1037	46	400	1280	10.5	19	0.77	19.0	8.7	190	0.0
1	86	3SUM	6	33	10	4	852	16	435	617	9.9	15	1.08	25.1	7.1	296	0.0
1	86	4FAL	4	38	12	7	1068	41	373	1548	6.4	12	1.00	12.4	10.2	259	0.0
1	87	1WIN	3	31	13	9	1740	50	260	1717	2.0	4	1.53	4.7	12.8	221	0.0
1	87	2SPR	6	53	13	5	1022	49	432	1280	13.5	37	0.72	16.7	9.7	222	0.0
1	87	3SUM	2	35	9	5	920	61	360	1300	9.7	12	1.10	27.4	6.7	309	0.0
2	84	3SUM	10	62	20	10	977	63	256	1604	10.4	27	0.53	24.7	7.1	2723	1.3
2	84	4FAL	8	46	19	12	915	88	345	883	10.0	17	0.93	13.2	9.3	6716	3.5
2	85	1WIN	4	104	49	10	1010	59	327	1629	15.4	25	0.35	7.2	12.9	588	0.2
2	85	2SPR	11	59	20	10	772	69	267	880	10.6	19	0.45	18.1	8.3	1589	0.6
2	85	3SUM	12	75	33	17	317	48		941	9.3	18	0.58	25.3	6.6	6152	3.2
2	85	4FAL	8	49	26	17	848	78		1272	4.4	14	0.79	13.2	9.5	5738	2.9
2	86	1WIN	5	67	19	10	1410	65		1979	2.5	5	0.38	5.1	12.1	1133	0.4
2	86	2SPR	12	66	15	12	981	48	625	1123	11.7	26	0.41	18.5	9.0	727	0.2
2	86	3SUM	12	61	23	13	445	30	557	719	13.1	41	0.61	24.4	7.7	3643	1.7
2	86	4FAL	8	57	17	12	884	61	469	1233	6.4	18	0.63	12.2	10.0	4000	2.0
2	87	1WIN	6	49	12	8	1483	50	471	1822	14.0	62	0.87	4.1	12.7	5227	2.6
2	87	2SPR	12	65	12	8	909	52	527	1099	13.9	29	0.48	17.0	9.6	1252	0.4
2	87	3SUM	4	43	20	16	513	106	500	1213	6.6	9	0.93	26.9	6.7	3140	1.5
3	84	3SUM	26	51	19	11	495	78	307	1452	13.9	58	0.99	24.4	6.9	11381	6.4
3	84	4FAL	20	35	18	10	403	107	342	898	11.0	29	1.66	13.9	9.2	18521	10.8
3	85	1WIN	15	75	27	6	722	49	291	841	11.2	22	1.39	4.8	13.4	16078	9.3
3	85	2SPR	28	50	23	7	426	57	276	623	21.3	94	1.07	17.2	8.9	13245	7.5
3	85	3SUM	30	65	28	12	82	44		1401	15.8	112	0.91	25.4	6.8	20156	11.9
3	85	4FAL	20	44	25	14	380	102		955	9.7	37	1.29	14.8	9.6	20230	11.9
3	86	1WIN	20	47	17	7	942	99		1443	5.2	9	0.88	3.3	12.3	11429	6.4
3	86	2SPR	30	41	11	7	599	52	688	812	15.9	68	0.88	17.9	9.2	10765	5.9
3	86	3SUM	30	60	23	13	87	27	724	1344	19.2	67	0.93	24.7	8.0	17590	10.2
3	86	4FAL	20	49	23	15	381	80	459	1029	7.2	16	1.46	13.6	9.2	18428	10.8
3	87	1WIN	18	46	12	7	871	66	602	1063	18.7	73	1.33	4.8	12.5	16900	9.7
3	87	2SPR	30	43	13	6	567	68	617	938	11.7	34	1.05	16.5	8.8	12194	6.8
3	87	3SUM	10	67	24	13	74	59	576	1628	22.5	52	1.18	26.7	8.0	16016	9.2
4	84	3SUM	54	39	16	7	114	56	286	1151	15.7	135	1.51	24.7	7.9	16861	9.8
4	84	4FAL	34	23	13	7	121	51	363	498	11.0	30	2.33	14.9	9.8	24264	14.6
4	85	1WIN	32	48	42	5	421	25	245	388	7.9	15	2.29	4.7	13.2	22492	13.4
4	85	2SPR	60	36	20	6	235	22	254	232	14.4	33	1.80	17.2	10.3	20860	12.3
4	85	3SUM	60	55	22	9	24	29		929	11.1	142	1.42	25.6	7.1	25258	15.2
4	85	4FAL	40	28	14	8	203	74		519	5.8	18	1.80	15.4	9.2	26331	16.0
4	86	1WIN	40	26	9	4	641	52		850	7.2	12	1.63	3.6	12.2	19030	11.1
4	86	2SPR	60	19	7	4	423	32	777	368	9.2	24	2.00	17.8	9.4	17789	10.3
4	86	3SUM	60	38	14	7	22	27	557	1051	13.6	157	1.74	25.0	7.6	23441	14.0
4	86	4FAL	39	34	15	5	166	52	386	579	8.8	24	2.29	14.5	9.6	25837	15.6
4	87	1WIN	34	24	9	4	487	25	416	645	8.0	15	2.17	4.7	12.5	22988	13.7
4	87	2SPR	60	30	11	4	320	35	592	366	17.0	36	1.67	16.5	10.8	19353	11.3
4	87	3SUM	20	41	16	7	10	50	442	858	9.4	18	1.70	26.5	7.2	22782	13.6
5	84	3SUM	16	31	14	7	40	37	327	948	9.3	17	1.89	24.6	7.4	20233	11.9
5	84	4FAL	12	20	12	7	49	33	354	247	8.6	14	2.27	15.6	10.0	26153	15.9
5	85	1WIN	12	37	20	5	236	19	228	154	12.1	24	2.23	5.1	12.8	25181	15.2
5	85	2SPR	18	24	16	4	142	23	311	117	12.6	35	2.29	17.9	10.1	23844	14.3
5	85	3SUM	18	39	20	5	8	20		525	4.9	9	1.79	25.9	7.2	27444	16.7
5	85	4FAL	12	28	17	6	100	60		289	5.1	14	1.78	16.2	8.9	29217	18.0
5	86	1WIN	12	21	10	4	486	31		493	6.2	9	2.08	4.0	12.4	22390	13.3
5	86	2SPR	17	15	6	3	326	22	699	146	8.7	22	2.42	17.7	9.5	22229	13.2
5	86	3SUM	18	29	11	5	10	34	461	569	8.1	19	2.11	25.5	7.5	26520	16.1
5	86	4FAL	12	29	14	4	85	58	413	458	6.6	10	2.68	14.9	9.0	28421	17.4
5	87	1WIN	12	21	8	3	362	14	386	433	7.9	17	2.36	5.1	12.7	24904	15.0
5	87	2SPR	17	26	11	5	137	15	725	106	27.9	44	1.35	17.2	11.2	22680	13.5
5	87	3SUM	6	35	13	6	10	39	426	253	7.3	12	2.03	26.6	8.0	25847	15.7

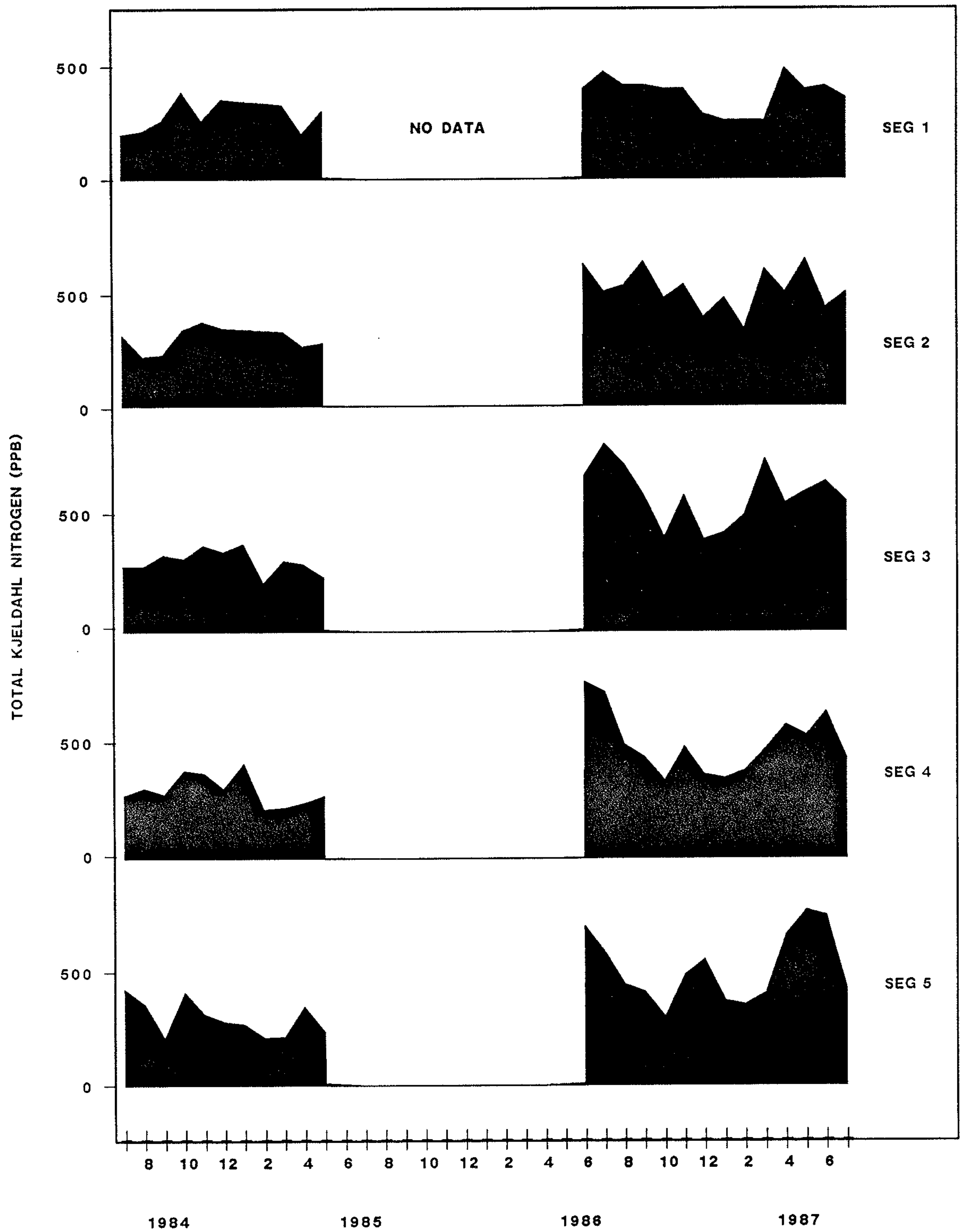

CHLOROPHYLL-A (PPB)
"GOAL"
SEG 1
SEG 2
SEG 3
SEG 4
SEG 5
0
10
20
8
10
12
2
4
6
1984
1985
1986
1987

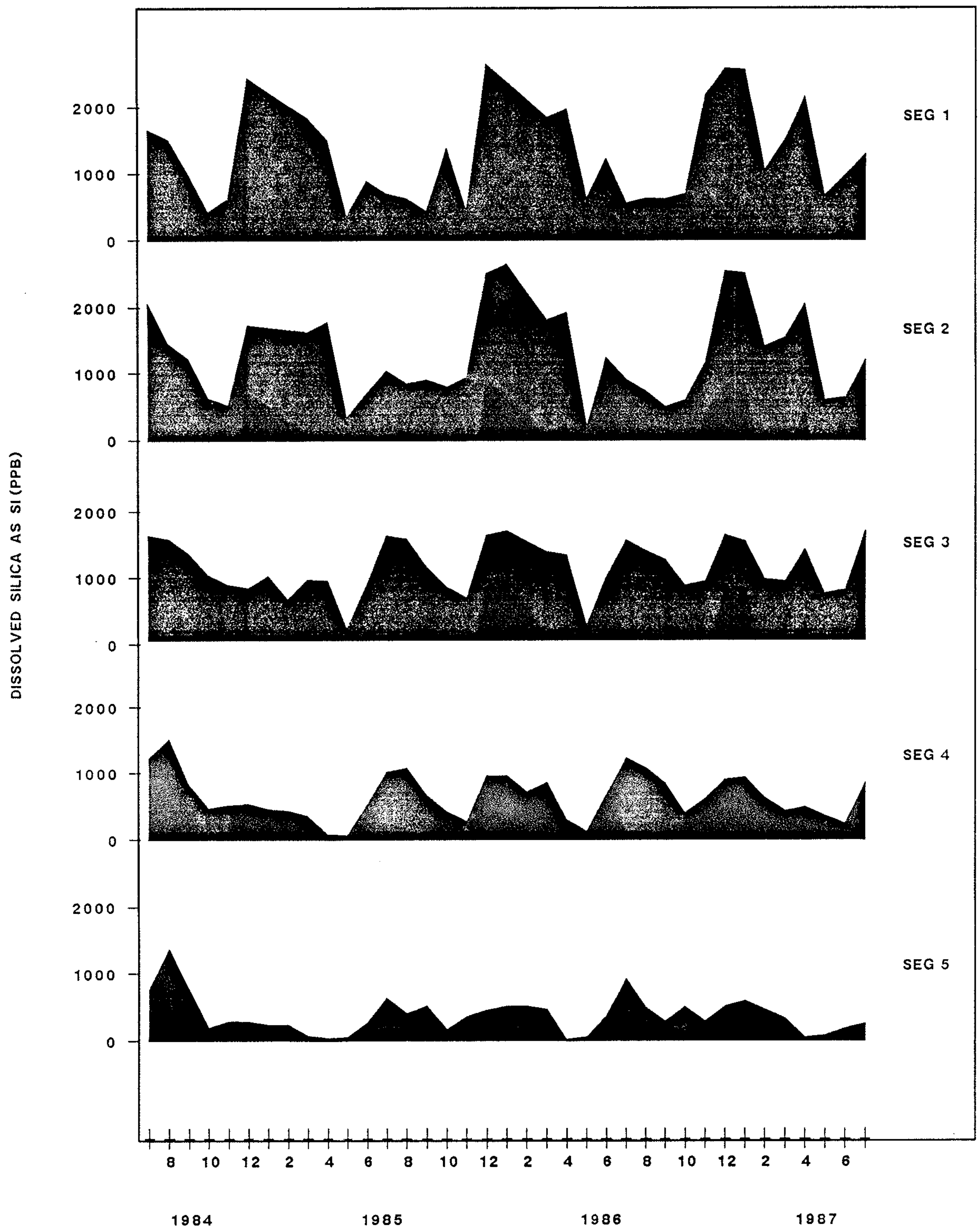


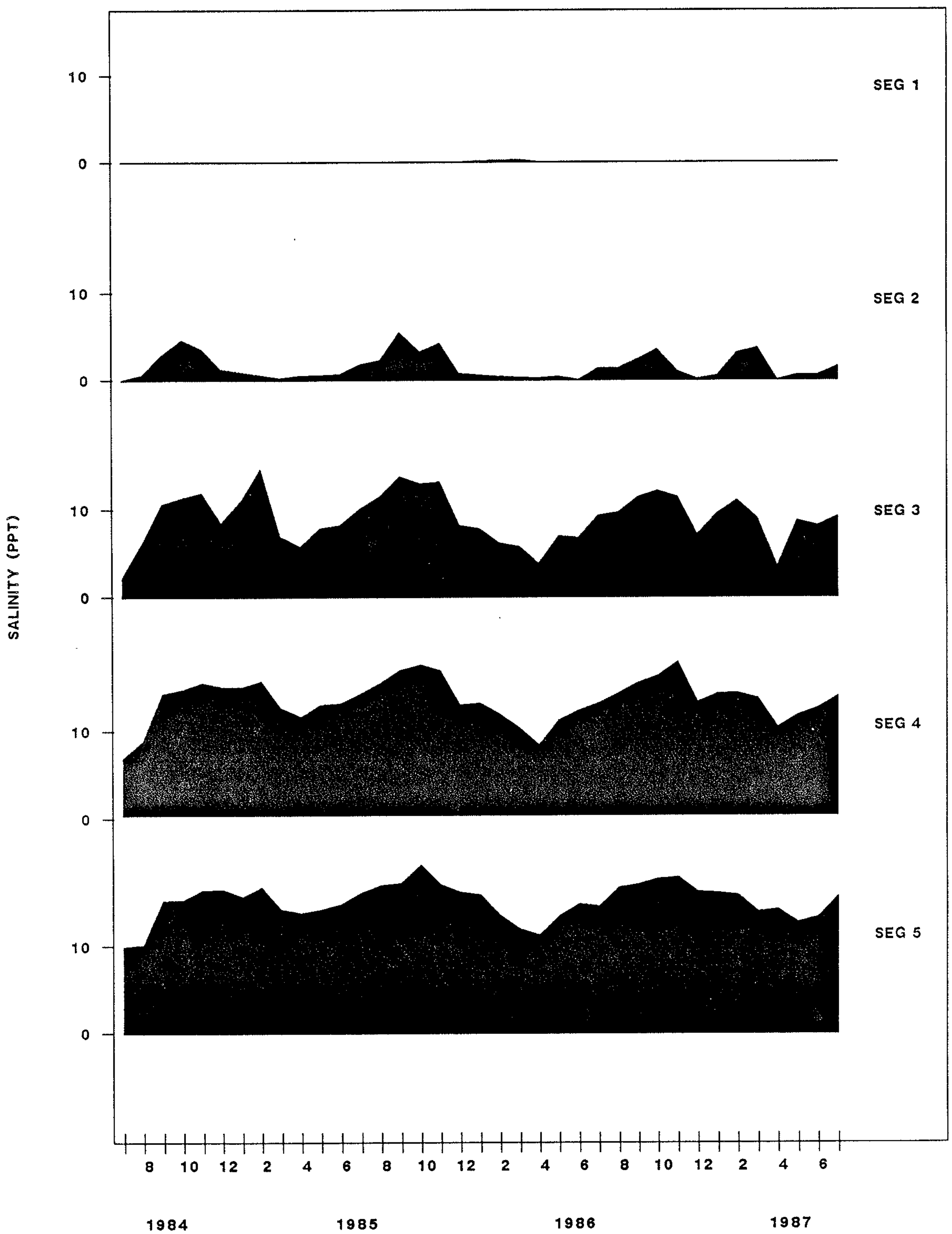
TOTAL PHOSPHORUS (PPB)
SEG 1
SEG 2
SEG 3
SEG 4
SEG 5
0
50
8 10 12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6
1984
1985
1986
1987


ORTHO PHOSPHORUS (PPB)
10
0
SEG 1
SEG 2
SEG 3
SEG 4
SEG 5
8
10
12
2
4
6
1984
1985
1986
1987


INORGANIC NITROGEN (PPB)
2000
1000
0
SEG 1
SEG 2
SEG 3
SEG 4
SEG 5
8 10 12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6
1984
1985
1986
1987


TOTAL KJELDAHL NITROGEN (PPB)
500
0
NO DATA
SEG 1
SEG 2
SEG 3
SEG 4
SEG 5
8 10 12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6
1984
1985
1986
1987


DISSOLVED SILICA AS SI (PPB)
2000
1000
0
SEG 1
SEG 2
SEG 3
SEG 4
SEG 5
8
10
12
2
4
6
1984
1985
1986
1987


SALINITY (PPT)
10
0
SEG 1
10
0
SEG 2
10
0
SEG 3
10
0
SEG 4
10
0
SEG 5
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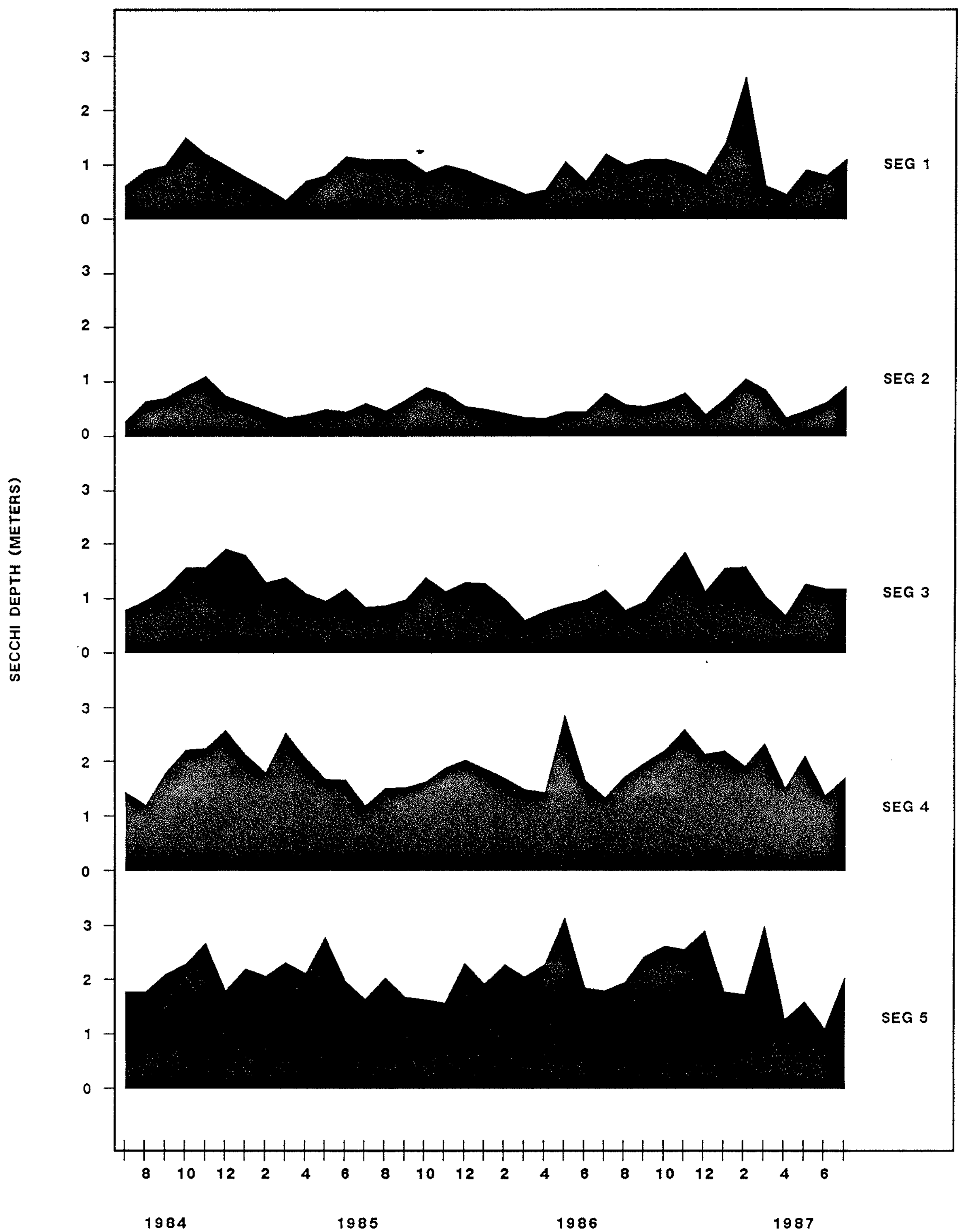
1984
1985
1986
1987


SECCHI DEPTH (METERS)
SEG 1
SEG 2
SEG 3
SEG 4
SEG 5
0
1
2
3
8
10
12
2
4
6
1984
1985
1986
1987

SEG	YRMO	OBS	CHL-A PPB	SECCHI METERS	TEMP DEG-C	GROWTH REGULATION FACTORS P	N	SI	P,N,SI	LIGHT	RELATIVE PRODUCT.	LIMITING FACTOR FREQUENCIES P	N	SI	OTHER
1	8503	2	16.0	0.35	6.8	0.814	0.978	0.974	0.814	0.045	0.50	0.000	0.000	0.000	1.000
1	8504	2	5.8	0.70	12.7	0.641	0.972	0.960	0.641	0.100	0.30	1.000	0.000	0.000	0.000
1	8505	2	12.5	0.80	19.2	0.793	0.974	0.873	0.793	0.140	1.18	0.000	0.000	0.000	1.000
1	8506	2	9.8	1.15	23.4	0.847	0.976	0.946	0.847	0.210	1.91	0.000	0.000	0.000	1.000
1	8507	2	16.1	1.10	26.9	0.556	0.972	0.933	0.556	0.198	2.17	1.000	0.000	0.000	0.000
1	8508	2	7.3	1.10	26.7	0.734	0.960	0.928	0.734	0.180	1.31	0.000	0.000	0.000	1.000
1	8509	2	8.2	1.10	24.1	0.530	0.961	0.890	0.530	0.154	0.79	1.000	0.000	0.000	0.000
1	8510	1	4.3	1.10	17.2	0.857	0.980	0.970	0.857	0.126	0.41	0.000	0.000	0.000	1.000
1	8511	1	3.7	1.00	13.6	0.857	0.976	0.904	0.857	0.086	0.21	0.000	0.000	0.000	1.000
1	8512	1	0.8	0.90	3.6	0.800	0.982	0.981	0.800	0.061	0.02	0.000	0.000	0.000	1.000
1	8604	2	6.0	0.55	12.5	0.727	0.981	0.975	0.727	0.079	0.29	0.500	0.000	0.000	0.500
1	8605	2	12.5	1.05	20.0	0.626	0.978	0.832	0.626	0.183	1.14	0.500	0.000	0.000	0.500
1	8606	2	13.0	0.70	24.6	0.606	0.967	0.930	0.606	0.129	1.23	1.000	0.000	0.000	0.000
1	8607	1	5.2	1.20	27.1	0.444	0.959	0.886	0.444	0.215	0.69	1.000	0.000	0.000	0.000
1	8608	2	11.8	1.00	25.4	0.556	0.975	0.927	0.556	0.164	1.31	1.000	0.000	0.000	0.000
1	8609	2	10.8	1.10	22.3	0.575	0.976	0.926	0.575	0.154	1.00	0.500	0.000	0.000	0.500
1	8610	2	11.4	1.10	19.0	0.676	0.976	0.911	0.676	0.126	0.92	0.500	0.000	0.000	0.500
1	8611	1	2.1	1.00	6.2	0.815	0.978	0.978	0.815	0.086	0.08	0.000	0.000	0.000	1.000
1	8612	1	0.6	0.80	5.4	0.737	0.981	0.981	0.737	0.054	0.01	0.000	0.000	0.000	1.000
1	8701	1	0.7	1.40	2.2	0.815	0.986	0.981	0.815	0.106	0.03	0.000	0.000	0.000	1.000
1	8702	1	1.1	2.60	3.0	0.762	0.989	0.955	0.762	0.235	0.09	0.000	0.000	0.000	1.000
1	8704	2	6.7	0.45	10.3	0.783	0.979	0.977	0.783	0.064	0.23	0.000	0.000	0.000	1.000
1	8705	2	22.4	0.90	16.5	0.580	0.973	0.924	0.580	0.158	1.50	1.000	0.000	0.000	0.000
1	8706	2	11.5	0.80	23.4	0.580	0.978	0.950	0.580	0.147	1.14	1.000	0.000	0.000	0.000
1	8707	2	9.7	1.10	27.4	0.591	0.975	0.963	0.591	0.198	1.51	0.500	0.000	0.000	0.500
2	8503	4	15.4	0.35	7.2	0.801	0.977	0.970	0.801	0.045	0.33	0.000	0.000	0.000	1.000
2	8504	3	9.7	0.40	10.8	0.729	0.973	0.969	0.729	0.057	0.36	0.333	0.000	0.000	0.667
2	8505	4	14.6	0.50	18.8	0.733	0.971	0.865	0.733	0.088	0.87	0.500	0.000	0.000	0.500
2	8506	4	7.2	0.45	22.7	0.834	0.968	0.933	0.834	0.083	0.47	0.000	0.000	0.000	1.000
2	8507	3	10.2	0.63	26.7	0.806	0.952	0.951	0.806	0.114	1.19	0.000	0.000	0.000	1.000
2	8508	4	12.0	0.48	25.8	0.883	0.903	0.928	0.860	0.078	0.94	0.000	0.000	0.000	1.000
2	8509	4	6.0	0.68	23.8	0.841	0.913	0.946	0.841	0.095	0.62	0.000	0.000	0.000	1.000
2	8510	4	6.6	0.90	17.3	0.863	0.965	0.939	0.863	0.103	0.48	0.000	0.000	0.000	1.000
2	8511	2	3.6	0.80	13.6	0.875	0.976	0.949	0.875	0.069	0.17	0.000	0.000	0.000	1.000
2	8512	2	0.8	0.55	4.8	0.861	0.981	0.980	0.861	0.037	0.01	0.000	0.000	0.000	1.000
2	8601	1	0.7	0.50	-0.0	0.828	0.984	0.981	0.828	0.038	0.01	0.000	0.000	0.000	1.000
2	8603	4	3.0	0.35	6.4	0.780	0.983	0.971	0.780	0.045	0.06	0.000	0.000	0.000	1.000
2	8604	4	5.5	0.33	11.3	0.731	0.981	0.974	0.731	0.046	0.13	0.250	0.000	0.000	0.750
2	8605	4	20.3	0.45	19.9	0.744	0.974	0.794	0.711	0.079	1.15	0.250	0.000	0.000	0.750
2	8606	4	9.4	0.45	24.2	0.794	0.969	0.956	0.794	0.083	0.66	0.250	0.000	0.000	0.750
2	8607	2	8.6	0.80	25.8	0.879	0.947	0.958	0.879	0.144	1.42	0.000	0.000	0.000	1.000
2	8608	4	11.2	0.58	24.6	0.785	0.959	0.921	0.785	0.095	0.95	0.250	0.000	0.000	0.750
2	8609	4	18.5	0.55	21.6	0.744	0.932	0.883	0.744	0.077	0.91	0.500	0.000	0.000	0.500
2	8610	4	10.2	0.65	17.7	0.794	0.959	0.910	0.794	0.074	0.40	0.000	0.000	0.000	1.000
2	8611	2	4.6	0.80	8.2	0.814	0.978	0.955	0.814	0.069	0.15	0.000	0.000	0.000	1.000
2	8612	2	0.7	0.40	5.2	0.832	0.982	0.981	0.832	0.027	0.01	0.000	0.000	0.000	1.000
2	8701	2	1.4	0.70	2.1	0.855	0.986	0.980	0.855	0.053	0.02	0.000	0.000	0.000	1.000
2	8702	2	4.3	1.05	1.6	0.615	0.985	0.966	0.615	0.106	0.12	1.000	0.000	0.000	0.000
2	8703	1	11.0	1.00	8.8	0.545	0.981	0.970	0.545	0.128	0.46	1.000	0.000	0.000	0.000
2	8704	4	8.6	0.35	10.6	0.767	0.979	0.976	0.767	0.050	0.23	0.000	0.000	0.000	1.000
2	8705	4	21.2	0.48	16.0	0.664	0.972	0.863	0.664	0.083	0.93	0.500	0.000	0.000	0.500
2	8706	4	12.0	0.63	24.5	0.711	0.971	0.907	0.711	0.115	1.07	0.500	0.000	0.000	0.500
2	8707	4	6.6	0.93	26.9	0.861	0.961	0.959	0.861	0.166	1.30	0.000	0.000	0.000	1.000
3	8503	10	10.8	1.39	7.4	0.686	0.972	0.943	0.686	0.167	0.67	0.500	0.000	0.000	0.500
3	8504	7	18.6	1.09	11.6	0.578	0.966	0.911	0.578	0.154	1.35	1.000	0.000	0.000	0.000
3	8505	10	37.7	0.96	17.6	0.687	0.929	0.731	0.663	0.168	3.36	0.400	0.000	0.100	0.500
3	8506	10	7.7	1.18	21.7	0.790	0.924	0.942	0.790	0.215	1.39	0.000	0.000	0.000	1.000
3	8507	10	24.2	0.85	25.4	0.730	0.690	0.969	0.627	0.153	2.42	0.200	0.300	0.000	0.500
3	8508	10	13.5	0.88	26.0	0.814	0.824	0.968	0.796	0.145	2.07	0.200	0.000	0.000	0.800
3	8509	10	9.6	1.00	24.6	0.791	0.824	0.956	0.778	0.140	1.31	0.300	0.000	0.000	0.700
3	8510	9	13.7	1.38	18.6	0.794	0.891	0.937	0.794	0.155	1.40	0.111	0.000	0.000	0.889
3	8511	5	9.6	1.14	14.5	0.830	0.945	0.922	0.830	0.098	0.67	0.000	0.000	0.000	1.000
3	8512	5	2.8	1.30	7.6	0.868	0.973	0.969	0.868	0.087	0.13	0.000	0.000	0.000	1.000
3	8601	5	3.8	1.28	1.7	0.704	0.970	0.968	0.704	0.096	0.12	0.600	0.000	0.000	0.400
3	8602	5	6.0	1.00	0.0	0.683	0.978	0.966	0.683	0.101	0.16	0.600	0.000	0.000	0.400
3	8603	10	5.4	0.61	5.6	0.721	0.976	0.961	0.721	0.078	0.18	0.200	0.000	0.000	0.800
3	8604	10	10.5	0.77	11.4	0.666	0.978	0.960	0.666	0.110	0.56	0.700	0.000	0.000	0.300
3	8605	9	28.1	0.89	18.3	0.580	0.947	0.755	0.571	0.156	2.17	0.889	0.000	0.111	0.000
3	8606	10	9.3	0.98	23.8	0.680	0.922	0.944	0.680	0.179	1.34	0.600	0.000	0.000	0.400
3	8607	5	26.8	1.16	25.7	0.790	0.655	0.969	0.621	0.206	3.80	0.200	0.600	0.000	0.200

SEG	YRMO	OBS	CHL-A PPB	SECCHI METERS	TEMP DEG-C	GROWTH REGULATION FACTORS P	N	SI	P,N,SI	LIGHT	RELATIVE PRODUCT.	LIMITING FACTOR FREQUENCIES P	N	SI	OTHER
3	8608	10	20.7	0.79	25.2	0.838	0.693	0.963	0.688	0.130	1.83	0.000	0.400	0.000	0.600
3	8609	10	12.9	0.95	22.3	0.820	0.746	0.960	0.733	0.133	1.23	0.000	0.300	0.000	0.700
3	8610	9	9.3	1.43	18.3	0.802	0.881	0.939	0.790	0.160	1.07	0.111	0.000	0.000	0.889
3	8611	5	5.8	1.84	10.5	0.869	0.947	0.946	0.869	0.150	0.55	0.000	0.000	0.000	1.000
3	8612	5	4.4	1.14	6.9	0.703	0.970	0.968	0.703	0.076	0.14	0.600	0.000	0.000	0.400
3	8701	5	5.9	1.56	4.1	0.808	0.974	0.966	0.808	0.115	0.29	0.000	0.000	0.000	1.000
3	8702	5	17.6	1.58	2.2	0.673	0.969	0.948	0.673	0.157	0.83	0.800	0.000	0.000	0.200
3	8703	8	27.4	1.04	6.8	0.600	0.974	0.946	0.600	0.132	1.07	0.750	0.000	0.000	0.250
3	8704	10	6.4	0.70	11.1	0.748	0.977	0.961	0.748	0.100	0.33	0.200	0.000	0.000	0.800
3	8705	10	20.0	1.27	14.9	0.507	0.950	0.927	0.507	0.220	1.70	1.000	0.000	0.000	0.000
3	8706	10	8.8	1.19	23.5	0.716	0.909	0.933	0.716	0.217	1.58	0.400	0.000	0.000	0.600
3	8707	10	22.5	1.18	26.7	0.814	0.753	0.970	0.713	0.210	4.08	0.100	0.200	0.000	0.700
4	8503	20	6.5	2.53	7.2	0.600	0.952	0.847	0.600	0.277	0.58	0.850	0.000	0.000	0.150
4	8504	19	21.4	2.06	11.9	0.564	0.944	0.448	0.394	0.275	1.58	0.158	0.000	0.789	0.053
4	8505	19	12.5	1.65	17.4	0.692	0.903	0.541	0.519	0.269	1.43	0.316	0.000	0.632	0.053
4	8506	17	8.5	1.64	22.0	0.738	0.725	0.893	0.676	0.291	1.69	0.118	0.353	0.000	0.529
4	8507	18	10.5	1.18	25.8	0.674	0.397	0.953	0.396	0.211	1.15	0.056	0.833	0.000	0.111
4	8508	20	17.2	1.52	26.0	0.769	0.657	0.945	0.646	0.241	2.51	0.000	0.450	0.000	0.550
4	8509	20	5.5	1.53	25.0	0.701	0.665	0.917	0.615	0.209	0.83	0.250	0.300	0.000	0.450
4	8510	19	6.6	1.63	19.2	0.697	0.827	0.850	0.689	0.180	0.75	0.368	0.000	0.105	0.526
4	8511	9	7.1	1.88	15.0	0.671	0.894	0.840	0.671	0.156	0.59	0.556	0.000	0.000	0.444
4	8512	10	3.0	2.04	8.1	0.824	0.960	0.947	0.824	0.132	0.19	0.000	0.000	0.000	1.000
4	8601	10	7.8	1.87	2.8	0.535	0.951	0.949	0.535	0.137	0.26	1.000	0.000	0.000	0.000
4	8602	10	8.3	1.69	0.9	0.638	0.960	0.932	0.638	0.165	0.37	0.800	0.000	0.000	0.200
4	8603	20	6.3	1.48	5.4	0.570	0.969	0.937	0.570	0.182	0.32	0.800	0.000	0.000	0.200
4	8604	18	14.6	1.42	11.7	0.491	0.969	0.726	0.471	0.200	0.93	0.778	0.000	0.167	0.056
4	8605	20	4.6	2.85	18.4	0.611	0.941	0.573	0.443	0.400	0.77	0.450	0.000	0.500	0.050
4	8606	20	8.7	1.66	23.3	0.658	0.837	0.923	0.650	0.294	1.91	0.600	0.050	0.000	0.350
4	8607	10	31.3	1.34	26.1	0.778	0.500	0.964	0.500	0.237	3.47	0.000	1.000	0.000	0.000
4	8608	19	9.4	1.69	25.6	0.713	0.644	0.948	0.618	0.261	1.78	0.263	0.421	0.000	0.316
4	8609	19	8.8	1.97	22.6	0.632	0.659	0.939	0.587	0.257	1.38	0.579	0.316	0.000	0.105
4	8610	20	8.9	2.21	19.3	0.651	0.755	0.879	0.634	0.226	1.15	0.650	0.100	0.000	0.250
4	8611	10	11.0	2.59	11.6	0.664	0.874	0.919	0.664	0.199	0.92	0.600	0.000	0.000	0.400
4	8612	10	6.2	2.14	7.7	0.610	0.952	0.947	0.610	0.138	0.29	0.900	0.000	0.000	0.100
4	8701	10	7.6	2.20	4.7	0.607	0.950	0.948	0.607	0.156	0.33	1.000	0.000	0.000	0.000
4	8702	10	8.5	1.92	2.1	0.528	0.948	0.925	0.528	0.187	0.38	0.900	0.000	0.000	0.100
4	8703	14	7.9	2.33	6.5	0.601	0.953	0.894	0.601	0.269	0.68	0.786	0.000	0.000	0.214
4	8704	20	19.7	1.51	10.4	0.534	0.958	0.760	0.465	0.211	1.31	0.800	0.000	0.200	0.000
4	8705	19	14.8	2.09	15.6	0.564	0.931	0.770	0.502	0.328	1.87	0.684	0.000	0.263	0.053
4	8706	19	16.4	1.39	23.2	0.679	0.574	0.738	0.535	0.253	2.39	0.105	0.526	0.053	0.316
4	8707	19	9.0	1.68	26.5	0.698	0.634	0.922	0.608	0.292	2.06	0.158	0.421	0.000	0.421
5	8503	6	13.8	2.32	8.1	0.572	0.908	0.531	0.478	0.266	0.99	0.333	0.000	0.500	0.167
5	8504	6	23.8	2.12	13.3	0.569	0.900	0.320	0.320	0.281	1.54	0.000	0.000	1.000	0.000
5	8505	4	4.0	2.90	17.2	0.710	0.886	0.553	0.553	0.400	0.72	0.000	0.000	1.000	0.000
5	8506	6	6.8	1.97	22.5	0.616	0.565	0.809	0.506	0.337	1.25	0.333	0.667	0.000	0.000
5	8507	5	5.3	1.66	26.1	0.665	0.288	0.929	0.288	0.287	0.62	0.000	1.000	0.000	0.000
5	8508	6	6.2	2.03	26.0	0.671	0.496	0.851	0.485	0.306	1.15	0.167	0.667	0.000	0.167
5	8509	6	4.2	1.68	25.5	0.601	0.497	0.887	0.449	0.226	0.57	0.500	0.500	0.000	0.000
5	8510	6	4.0	1.63	20.0	0.651	0.735	0.620	0.545	0.181	0.43	0.167	0.167	0.500	0.167
5	8511	3	8.7	1.57	15.1	0.667	0.861	0.833	0.667	0.132	0.54	1.000	0.000	0.000	0.000
5	8512	3	3.6	2.30	9.7	0.773	0.927	0.900	0.773	0.145	0.24	0.000	0.000	0.000	1.000
5	8601	3	6.0	1.93	3.9	0.609	0.926	0.909	0.609	0.142	0.25	1.000	0.000	0.000	0.000
5	8602	3	5.9	2.27	2.1	0.681	0.949	0.909	0.681	0.212	0.37	0.667	0.000	0.000	0.333
5	8603	6	6.4	2.05	5.1	0.507	0.961	0.894	0.507	0.247	0.42	1.000	0.000	0.000	0.000
5	8604	6	12.7	2.28	11.8	0.461	0.958	0.270	0.270	0.284	0.61	0.000	0.000	1.000	0.000
5	8605	5	3.7	3.12	18.3	0.519	0.935	0.513	0.464	0.416	0.69	0.400	0.000	0.600	0.000
5	8606	6	8.8	1.85	23.4	0.572	0.713	0.815	0.534	0.322	1.80	0.667	0.333	0.000	0.000
5	8607	3	12.6	1.80	26.7	0.639	0.539	0.951	0.539	0.303	2.82	0.000	0.667	0.000	0.333
5	8608	6	8.9	1.95	26.3	0.678	0.588	0.895	0.535	0.301	1.79	0.333	0.500	0.000	0.167
5	8609	6	5.0	2.42	22.6	0.589	0.641	0.820	0.571	0.301	0.93	0.667	0.333	0.000	0.000
5	8610	6	6.4	2.63	19.5	0.623	0.756	0.897	0.623	0.263	1.01	0.833	0.000	0.000	0.167
5	8611	3	8.5	2.57	12.3	0.569	0.830	0.851	0.569	0.200	0.67	1.000	0.000	0.000	0.000
5	8612	3	5.2	2.90	8.4	0.512	0.918	0.911	0.512	0.169	0.27	1.000	0.000	0.000	0.000
5	8701	3	13.3	1.77	4.9	0.545	0.914	0.921	0.545	0.131	0.48	1.000	0.000	0.000	0.000
5	8702	3	6.3	1.73	2.4	0.622	0.932	0.903	0.622	0.171	0.30	0.667	0.000	0.000	0.333
5	8703	6	6.0	2.97	6.5	0.552	0.943	0.869	0.552	0.313	0.55	1.000	0.000	0.000	0.000
5	8704	6	31.9	1.27	10.4	0.686	0.915	0.407	0.381	0.179	1.40	0.167	0.000	0.833	0.000
5	8705	5	35.1	1.60	17.3	0.578	0.820	0.553	0.509	0.263	3.89	0.400	0.000	0.400	0.200
5	8706	3	25.1	1.10	24.1	0.713	0.522	0.668	0.508	0.202	3.31	0.000	1.000	0.000	0.000
5	8707	6	7.3	2.03	26.6	0.651	0.595	0.736	0.584	0.339	2.00	0.000	0.667	0.000	0.333

SEG	YR	SEAS	OBS	CHL-A PPB	SECCHI METERS	TEMP DEG-C	GROWTH REGULATION FACTORS					RELATIVE PRODUCT.	LIMITING FACTOR FREQUENCIES			
							P	N	SI	P,N,SI	LIGHT		P	N	SI	OTHER
1	85	1WIN	2	16.0	0.35	6.8	0.814	0.978	0.974	0.814	0.045	0.50	0.000	0.000	0.000	1.000
1	85	2SPR	6	9.4	0.88	18.4	0.760	0.974	0.926	0.760	0.150	1.13	0.333	0.000	0.000	0.667
1	85	3SUM	6	10.5	1.10	25.9	0.606	0.964	0.917	0.606	0.177	1.42	0.667	0.000	0.000	0.333
1	85	4FAL	3	2.9	1.00	11.5	0.838	0.979	0.952	0.838	0.091	0.21	0.000	0.000	0.000	1.000
1	86	2SPR	6	10.5	0.77	19.0	0.653	0.976	0.912	0.653	0.130	0.89	0.667	0.000	0.000	0.333
1	86	3SUM	5	10.1	1.08	24.5	0.541	0.972	0.919	0.541	0.171	1.06	0.800	0.000	0.000	0.200
1	86	4FAL	4	6.4	1.00	12.4	0.726	0.978	0.945	0.726	0.098	0.48	0.250	0.000	0.000	0.750
1	87	1WIN	2	0.9	2.00	2.6	0.788	0.987	0.968	0.788	0.170	0.06	0.000	0.000	0.000	1.000
1	87	2SPR	6	13.5	0.72	16.7	0.648	0.977	0.950	0.648	0.123	0.96	0.667	0.000	0.000	0.333
1	87	3SUM	2	9.7	1.10	27.4	0.591	0.975	0.963	0.591	0.198	1.51	0.500	0.000	0.000	0.500
2	85	1WIN	4	15.4	0.35	7.2	0.801	0.977	0.970	0.801	0.045	0.33	0.000	0.000	0.000	1.000
2	85	2SPR	11	10.6	0.45	18.1	0.769	0.970	0.918	0.769	0.078	0.59	0.273	0.000	0.000	0.727
2	85	3SUM	11	9.3	0.59	25.3	0.847	0.920	0.941	0.838	0.094	0.89	0.000	0.000	0.000	1.000
2	85	4FAL	8	4.4	0.79	13.2	0.866	0.972	0.952	0.866	0.078	0.29	0.000	0.000	0.000	1.000
2	86	1WIN	5	2.5	0.38	5.1	0.789	0.983	0.973	0.789	0.044	0.05	0.000	0.000	0.000	1.000
2	86	2SPR	12	11.7	0.41	18.5	0.756	0.975	0.908	0.745	0.069	0.65	0.250	0.000	0.000	0.750
2	86	3SUM	10	13.6	0.61	23.7	0.787	0.946	0.914	0.787	0.098	1.03	0.300	0.000	0.000	0.700
2	86	4FAL	8	6.4	0.63	12.2	0.808	0.970	0.939	0.808	0.061	0.24	0.000	0.000	0.000	1.000
2	87	1WIN	5	4.4	0.90	3.3	0.697	0.985	0.973	0.697	0.089	0.15	0.600	0.000	0.000	0.400
2	87	2SPR	12	13.9	0.48	17.0	0.714	0.974	0.916	0.714	0.083	0.74	0.333	0.000	0.000	0.667
2	87	3SUM	4	6.6	0.93	26.9	0.861	0.961	0.959	0.861	0.166	1.30	0.000	0.000	0.000	1.000
3	85	1WIN	10	10.8	1.39	7.4	0.686	0.972	0.943	0.686	0.167	0.67	0.500	0.000	0.000	0.500
3	85	2SPR	27	21.6	1.07	17.6	0.697	0.937	0.856	0.688	0.182	2.11	0.407	0.000	0.037	0.556
3	85	3SUM	30	15.8	0.91	25.4	0.778	0.779	0.964	0.734	0.146	1.93	0.233	0.100	0.000	0.667
3	85	4FAL	19	9.7	1.29	14.6	0.823	0.927	0.941	0.823	0.122	0.87	0.053	0.000	0.000	0.947
3	86	1WIN	20	5.2	0.88	3.3	0.707	0.975	0.964	0.707	0.088	0.16	0.400	0.000	0.000	0.600
3	86	2SPR	29	15.6	0.88	17.8	0.644	0.949	0.891	0.641	0.148	1.33	0.724	0.000	0.034	0.241
3	86	3SUM	25	18.8	0.93	24.1	0.821	0.707	0.963	0.692	0.147	1.98	0.040	0.400	0.000	0.560
3	86	4FAL	19	7.1	1.46	13.2	0.793	0.921	0.949	0.788	0.136	0.69	0.211	0.000	0.000	0.789
3	87	1WIN	18	18.7	1.33	4.8	0.678	0.973	0.952	0.678	0.135	0.79	0.556	0.000	0.000	0.444
3	87	2SPR	30	11.7	1.05	16.5	0.657	0.945	0.940	0.657	0.179	1.20	0.533	0.000	0.000	0.467
3	87	3SUM	10	22.5	1.18	26.7	0.814	0.753	0.970	0.713	0.210	4.08	0.100	0.200	0.000	0.700
4	85	1WIN	20	6.5	2.53	7.2	0.600	0.952	0.847	0.600	0.277	0.58	0.850	0.000	0.000	0.150
4	85	2SPR	55	14.3	1.79	16.9	0.662	0.862	0.618	0.525	0.278	1.56	0.200	0.109	0.491	0.200
4	85	3SUM	58	11.1	1.42	25.6	0.716	0.579	0.938	0.558	0.221	1.51	0.103	0.517	0.000	0.379
4	85	4FAL	38	5.8	1.80	15.3	0.724	0.878	0.873	0.720	0.162	0.57	0.316	0.000	0.053	0.632
4	86	1WIN	40	7.2	1.63	3.6	0.578	0.962	0.939	0.578	0.167	0.32	0.850	0.000	0.000	0.150
4	86	2SPR	58	9.1	2.00	18.0	0.590	0.914	0.741	0.523	0.301	1.21	0.603	0.017	0.224	0.155
4	86	3SUM	48	13.7	1.73	24.5	0.695	0.620	0.948	0.581	0.255	1.98	0.333	0.500	0.000	0.167
4	86	4FAL	40	8.8	2.29	14.5	0.644	0.834	0.906	0.636	0.197	0.88	0.700	0.050	0.000	0.250
4	87	1WIN	34	8.0	2.17	4.7	0.581	0.951	0.919	0.581	0.212	0.49	0.882	0.000	0.000	0.118
4	87	2SPR	58	17.0	1.66	16.3	0.591	0.823	0.756	0.500	0.263	1.85	0.534	0.172	0.172	0.121
4	87	3SUM	19	9.0	1.68	26.5	0.698	0.634	0.922	0.608	0.292	2.06	0.158	0.421	0.000	0.421
5	85	1WIN	6	13.8	2.32	8.1	0.572	0.908	0.531	0.478	0.266	0.99	0.333	0.000	0.500	0.167
5	85	2SPR	16	12.5	2.26	17.7	0.622	0.771	0.561	0.448	0.332	1.22	0.125	0.250	0.625	0.000
5	85	3SUM	17	5.2	1.80	25.9	0.644	0.435	0.886	0.415	0.272	0.79	0.235	0.706	0.000	0.059
5	85	4FAL	12	5.1	1.78	16.2	0.685	0.815	0.744	0.632	0.160	0.41	0.333	0.083	0.250	0.333
5	86	1WIN	12	6.2	2.08	4.0	0.576	0.949	0.902	0.576	0.212	0.37	0.917	0.000	0.000	0.083
5	86	2SPR	17	8.7	2.38	17.8	0.517	0.865	0.534	0.420	0.336	1.05	0.353	0.118	0.529	0.000
5	86	3SUM	15	8.0	2.11	24.9	0.635	0.600	0.876	0.550	0.301	1.65	0.400	0.467	0.000	0.133
5	86	4FAL	12	6.6	2.68	14.9	0.582	0.815	0.889	0.582	0.224	0.74	0.917	0.000	0.000	0.083
5	87	1WIN	12	7.9	2.36	5.1	0.568	0.933	0.890	0.568	0.232	0.47	0.917	0.000	0.000	0.083
5	87	2SPR	14	31.6	1.35	15.8	0.653	0.797	0.515	0.454	0.214	2.70	0.214	0.214	0.500	0.071
5	87	3SUM	6	7.3	2.03	26.6	0.651	0.595	0.736	0.584	0.339	2.00	0.000	0.667	0.000	0.333