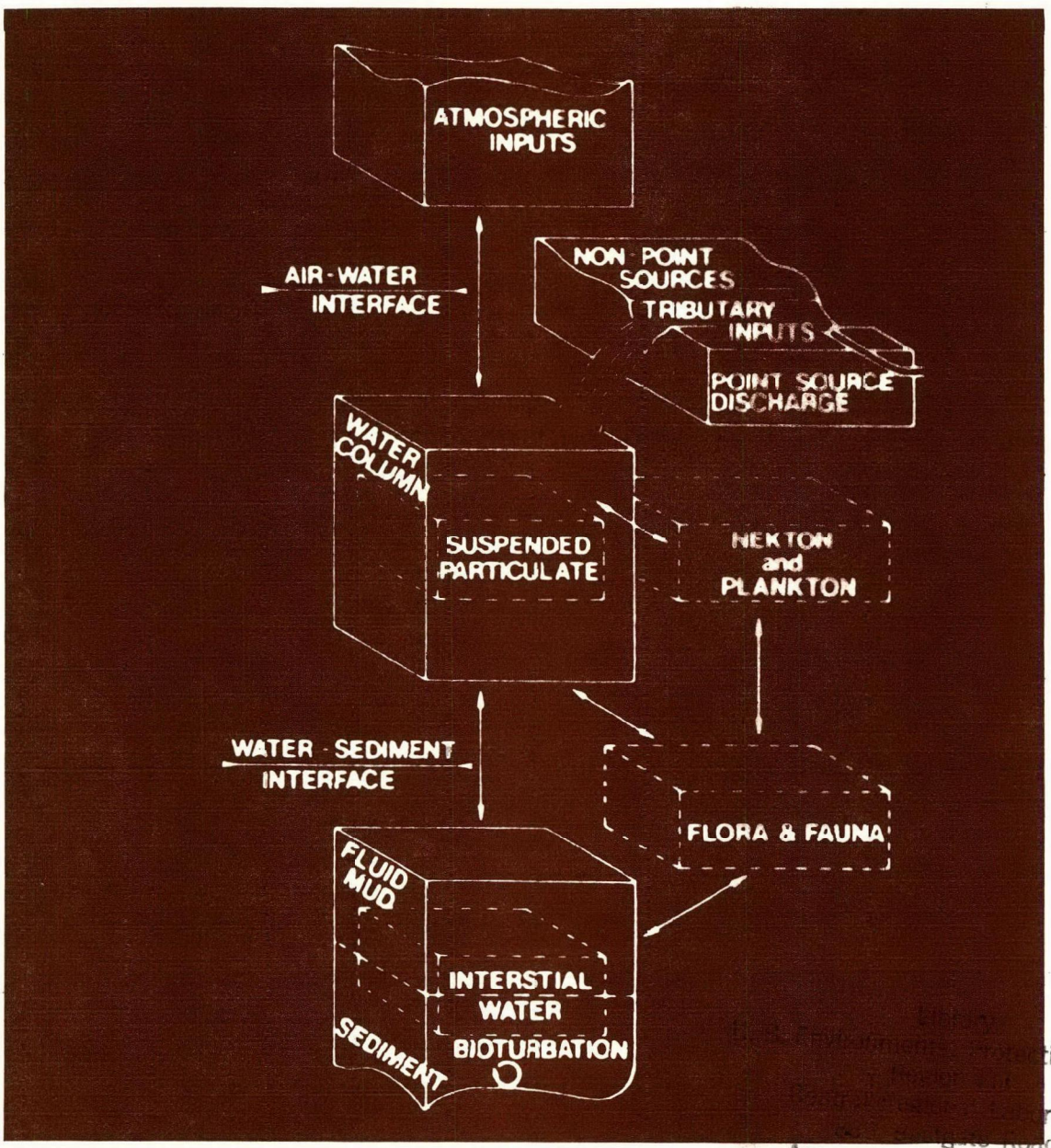
INTENSIVE WATERSHED STUDY

THE PATUXENT RIVER BASIN



Agency
Annapolis, Maryland

TIDEWATER ADMINISTRATION MARYLAND DEPARTMENT OF NATURAL RESOURCES

INTENSIVE WATERSHED STUDY
THE PATUXENT RIVER BASIN

by

Charles Bostater
Diane McCraney
Stephanie Berlett
David Pushkar
Maryland Department of Natural Resources
Annapolis, Maryland 21401

Grant No. R80636

Project Officer

James Smullen
EPA Chesapeake Bay Program
2083 West Street, Suite 5G
Annapolis, Maryland 21401

Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Gulf Breeze, Florida

DISCLAIMER

This report has been reviewed by the U.S. Environmental Protection Agency, and the Maryland Department of Natural Resources, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection or the Maryland Department of Natural Resources, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

ABSTRACT

This study was one of five intensive watershed studies designed to provide detailed non-point source loading rates and ambient water quality data within the Chesapeake Bay drainage area.

The study consisted estuarine slack tide surveys, intensive twenty-four hour water quality surveys, primary productivity measurements, sediment oxygen demand and sediment nutrient flux measurements, phytoplankton and nitrifying bacterial longitudinal surveys, non-point source monitoring at five subwatersheds current speed and direction measurements as well as rainfall quality and quantity measurements.

This report was submitted as partial fulfillment of the Maryland Department of Natural Resources grant No. R806306010 under sponsorship of the U.S. Environmental Protection Agency, Chesapeake Bay Program.

CONTENTS

Foreward iii
Abstract iv
Figures vi
Tables xxii
Abbreviations and Symbols. xxxi
Acknowledgements xxxii

Section

1. Introduction, Executive Summary, Conclusions, Recommendations 1
2. Methods 7
3. Land Utilization, Population, and Wastewater Projections. .23
4. Physical Characteristics of the Patuxent River. 25
5. Sources of Nitrogen and Phosphorus to the Patuxent River. .30
6. Non-Point Source and Meteorological Watershed Monitoring. .33
7. Description of Longitudinal Slack Survey Results. 40
8. Temporal Variation of Water Quality Variables 47
9. Intensive Water Quality Survey Variable Results 54
10. Historical Perspective of Dissolved Oxygen and Deficits . .60
11. Results and Discussion. 67

References 88
Appendices

A. Figures and Tables for Methods; Section 2 94
B. Figures and Tables for Section 3. 129
C. Figures Presenting Physical Characteristics; Section 4. . 135
D. Box Models; Section 5 151
E. Statistical Analyses of Non-Point Sources; Section 6. . . 158
F. Longitudinal Slack Survey Figures and Tables; Section 7 . 215
G. Temporal Water Quality Figures and Tables; Section 8. . . 335
H. Intensive 24-Hour Survey Figures and Tables; Section 9. . 439
I. Figures and Tables of Dissolved Oxygen Characteristics; Section 10. 634
J. Figures and Tables for Section 11 793
K. Intensive Watershed Study: Non-Point Source Watershed Logbook

FIGURES

Number		Page
2-1	Map of Intensive and Slack Water Sampling Stations.	8
2-2	Map of Slack and Lateral Slack Water Sampling Stations . . .	9
2-3	Map of University of Maryland Lower Estuary Water Quality Stations	123
2-4	Map of Biospherics Biological and Benthic Stations	124
2-5	Map of University of Maryland Benthic Oxygen Demand and Nutrient Flux Stations	125
2-6	Diagram of Sediment Oxygen Demand Chamber	126
2-7	Non-Point Source Watershed Sample Collection and Analysis Scheme	128
3-1	Patuxent River Historical Land Utilization	130
3-2	Historical Population Projections	131
3-3	Current Population Projections	132
4-1	Drainage Area and Cumulative Drainage Area Plot	136
4-2	Crossectional Area and Cumulative Crossectional Area Plot . .	137
4-3	River Width and Cumulative Width Plot	138
4-4	Volumes and Cumulative Volume Plot.	139
4-5	Surface Area and Cumulative Surface Area Plot	140
4-6	Hydraulic Depth and Cumulative Hydraulic Depth Plot	141
4-7	1980-1981 Freshwater Inflow at Route 50	142
4-8	Historical Mean Monthly Flow Comparison at Route 50	143
4-9	Schematic Diagram of Flow in the Patuxent Estuary	144
4-10	Patuxent Estuary Velocity Profiles	145

FIGURES (continued)

Number		Page
4-11	Patuxent Estuary Velocity Profiles.....	146
4-12	Location of Current Meeter Moorings.....	147
4-13	Observed and Estimated Salinity Function.....	148
4-14	Estimated Fraction of Freshwater and Chesapeake Bay Water.....	149
4-15	Estimated Flushing Time in the Patuxent Estuary.....	150
5-1	Patuxent River Total Nitrogen Budget.....	153
5-2	Patuxent River Dissolved Nitrite Plus Nitrate Budget..	154
5-3	Patuxent River Dissolved Ammonia Budget.....	155
5-4	Patuxent River Total Phosphoros Budget.....	156
5-5	Patuxent River Dissolved Orthophosphoros Budget.....	157
6-1	Map of 5 Watersheds Monitored For Chemical Export.....	159
6-2	Map of Soil Groups for G-farm and Z-farm Site.....	161
6-3	Deale A and Deale B Watershed Land Utilization.....	163

FIGURES (continued)

Number		Page
7-1	Slack Tide Salinity Profiles for 1980	216
7-2	Slack Tide Salinity Profiles for 1981	217
7-3	Longitudinal Slack Survey Plots for Salinity.	218
7-4	Longitudinal Slack Survey Plots for Temperature	223
7-5	Longitudinal Slack Survey Plots for pH	228
7-6	Longitudinal Slack Survey Plots for Seechi Disc	233
7-7	Longitudinal Slack Survey Plots for Dissolved Oxygen . .	238
7-8	Longitudinal Slack Survey Plots for Dissolved Oxygen Saturation	242
7-9	Longitudinal Slack Survey Plots for Dissolved Nitrate . .	247
7-10	Longitudinal Slack Survey Plots for Dissolved Nitrite . .	252
7-11	Longitudinal Slack Survey Plots for Dissolved Ammonia . .	257
7-12	Longitudinal Slack Survey Plots for Total Particulate Nitrogen	262
7-13	Longitudinal Slack Survey Plots for Total Kjeldahl Nitrogen	267
7-14	Longitudinal Slack Survey Plots for Dissolved Organic Nitrogen	272
7-15	Longitudinal Slack Survey Plots for Total Organic Carbon	277
7-16	Longitudinal Slack Survey Plots for Total Phosphorus . .	279
7-17	Longitudinal Slack Survey Plots for Total Particulate Phosphorus	284
7-18	Longitudinal Slack Survey Plots for Dissolved Phosphorus	289
7-19	Longitudinal Slack Survey Plots for Dissolved Ortho-Phosphorus	294

FIGURES (continued)

Number		Page
7-20	Longitudinal Slack Survey Plots For Total N:P Ratios . .	299
7-21	Longitudinal Slack Survey Plots for Dissolved N:P Ratios	302
7-22	Longitudinal Slack Survey Plots for BOD5	305
7-23	Longitudinal Slack Survey Plots for Chemical Oxygen Demand	310
7-24	Longitudinal Slack Survey Plots for Chlorophyll-a . . .	312
7-25	Longitudinal Slack Survey Plots for Pheophytin-a	315
7-26	Longitudinal Slack Survey Plots for Silica	320
7-27	Longitudinal Slack Survey Plots for Total Nonfilterable Residue	325
8-1	Temporal plots of Salinity	336
8-2	Temporal Plots of Temperature	340
8-3	Temporal Plots of pH	345
8-4	Temporal plots of Seechi Disc	350
8-5	Temporal Plots of Dissolved Oxygen	355
8-6	Temporal Plots of Dissolved Oxygen Saturation	360
8-7	Temporal Plots of Dissolved Nitrite	365
8-8	Temporal Plots of Dissolved Nitrate	370
8-9	Temporal Plots of Dissolved Ammonia	375
8-10	Temporal Plots of Total Organic Nitrogen	380
8-11	Temporal Plots of Total Particulate Nitrogen	385
8-12	Temporal Plots of Total Phosphorus	390
8-13	Temporal Plots of Dissolved Phosphorus	395
8-14	Temporal Plots of Dissolved Ortho-Phosphorus	400

FIGURES (continued)

Number		Page
8-15	Temporal Plots of Total Particulate Phosphorus	405
8-16	Temporal Plots of Dissolved Organic Carbon	410
8-17	Temporal Plots of Pheophytin-a	415
8-18	Temporal Plots of Silica	420
8-19	Temporal Plots of Total Nonfilterable Residue	425
8-20	Temporal Plots of BOD5	430
9-1	Intensive River Survey Plots of Salinity	440
9-2	Intensive River Survey Plots of Temperature	448
9-3	Intensive River Survey Plots of pH	458
9-4	Intensive River Survey Plots of Dissolved Oxygen	468
9-5	Intensive River Survey Plots of Dissolved Oxygen Saturation	478
9-6	Intensive River Survey Plots of Seechi Disc	488
9-7	Intensive River Survey Plots of Dissolved Nitrate	498
9-8	Intensive River Survey Plots of Dissolved Nitrite	508
9-9	Intensive River Survey Plots of Dissolved Ammonia	518
9-10	Intensive River Survey Plots of Total Organic Nitrogen . .	528
9-11	Intensive River Survey Plots of Total Particulate Nitrogen	538
9-12	Intensive River Survey Plots of Total Phosphorus	548
9-13	Intensive River Survey Plots of Total Particulate Ph Phosphorus	558
9-14	Intensive River Survey Plots of Dissolved Phosphorus . . .	568
9-15	Intensive River Survey Plots of Dissolved Ortho-Phosphorus	578
9-16	Intensive River Survey Plots of Silica	588

FIGURES (continued)

Number		Page
9-17	Intensive River Survey Plots of Pheophytin-a	595
9-18	Intensive River Survey Plots of Total Nonfilterable Residue	605
9-19	Intensive River Survey Plots of BOD5	615
9-20	Intensive River Survey Plots of Stage Height	631
9-21	Intensive River Survey Plots of Current Velocity	632
10-1	Historical Yearly Mean Dissolved Oxygen in the Patuxent Estuary	639
10-2	Historical Yearly Mean Dissolved Oxygen in the Lower Patuxent Estuary	640
10-3	Historical Yearly Mean Dissolved Oxygen in the Upper Patuxent Estuary	640
10-4	Historical Yearly Mean Dissolved Oxygen for the Month August in the Upper Patuxent River	639
10-5	Historical Yearly Mean Dissolved Oxygen For the Month August in the Upper Patuxent River	643
10-6	Historical Yearly Mean Dissolved Oxygen for the Month August in the Lower Patuxent Estuary.	643
10-7	Patuxent River Plots of Historical Dissolved Oxygen Versus Salinity, 1936-1981	644
10-8	Map of Patuxent River Segments for Historical Dissolved Oxygen Seasonal Trend	652
10-9	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment One	653
10-10	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Two	654
10-11	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Three	655
10-12	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Four	656

FIGURES (continued)

Number		Page
10-13	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Five	657
10-14	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Six	658
10-15	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Seven	659
10-16	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Eight	660
10-17	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Nine	661
10-18	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Ten	662
10-19	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Eleven	663
10-20	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Twelve	664
10-21	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Thirteen	665
10-22	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Fourteen	666
10-23	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Fifteen	667
10-24	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Sixteen	668
10-25	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Seventeen	669
10-26	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Eighteen	670
10-27	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Nineteen	671

FIGURES (continued)

Number		Page
10-28	Patuxent River Plot of Historical Seasonal Dissolved Oxygen, Segment Twenty	672
10-29	Patuxent River Dissolved Oxygen Deficits at Various Depth Ranges	673
10-30	Patuxent Estuary Historical Dissolved Oxygen Deficits (0.0 to 21 ppt)	674
10-31	Patuxent Estuary Historical Dissolved Oxygen Deficits (2.0 to 21 ppt)	675
10-32	Patuxent Estuary Historical Dissolved Oxygen Deficits (10.01 to 21 ppt)	676
10-33	Monthly Average Dissolved Oxygen Deficits in the Patuxent River	711
10-34	Patuxent River Plots of Historical DOD vs Salinity 1936-1981	782
10-35	Patuxent River Cumulative Frequency Distribution for All Historical Data, 1939-40 Data and 1980-81 Data	790
10-36	Cumulative Frequency Distribution of All Historical DOD in the Upper and Lower Patuxent River	791
10-37	Cumulative Frequency Distribution of DOD for Historical Data, Current Data and Salinity Regimes (0.2 - 10 ppt and greater than 10 ppt)	792
11-1	Patuxent River Longitudinal Characterization of 1980-1981 Data for BOD5 (mg/l), Alkalinity (mg/l), and pH	794
11-2	Patuxent River Longitudinal Characterization of 1980-1981 Data for Pheophytin-a (mg/l), Total Nitrogen (mg/l) and Salinity (ppt)	795
11-3	Patuxent River Longitudinal Characterization of 1980-1981 Data for Chlorophyll-a (mg/l), Dissolved Reactive Silica (mg/l) and Corrected Chlorophyll-a (mg/l)	796
11-4	Patuxent River Longitudinal Characterization of 1980-1981 Data for Temperature (°C), Dissolved Oxygen (mg/l) and Total Nonfilterable Residue (mg/l)	797
11-5	Patuxent River Longitudinal Characterization of 1980-1981 Data for Dissolved Nitrite (mg/l), Dissolved Ammonia (mg/l) and Chlorides (mg/l)	798

FIGURES (continued)

Number		Page
11-6	Patuxent River Longitudinal Characterization of 1980-1981 Data for Dissolved Ortho-Phosphorus (mg/l), Dissolved Phosphorus (mg/l) and Total Organic Carbon (mg/l)	799
11-7	Patuxent River Longitudinal Characterization of 1980-1981 Data for Total Phosphorus (mg/l), Dissolved Nitrate (mg/l) and Total Dissolved Nitrogen (mg/l).	800
11-8	Patuxent River Longitudinal Characterization of 1980-1981 Data for Dissolved Oxygen Saturation (%) and Dissolved Organic Carbon (mg/l)	801
11-9	Correlation Coefficient (log of total N:P ratio versus nautical mile) Plotted Against the Log of the Beginning and Ending Antecedant Storm Days for the Patuxent Estuary.	802
11-10	Correlation Coefficient (log of total N:P ratio versus nautical mile) Plotted Against the Log of the Middle Antecedant Storm Days for the Patuxent Estuary	803
11-11	Cumulative Frequency Distributions of Chlorophyll-a (mg/l) and Dissolved Oxygen (mg/l) Collected During 1980-1981 Slack Water and Intensive River Surveys	804
11-12	Cumulative Frequency Distributions of Total Nonfilterable Residue (mg/l) and Total Kjeldahl Nitrogen (mg/l) Collected During 1980-1981 Slack Water and Intensive River Surveys	805
11-13	Cumulative Frequency Distributions of Pheophytin-a (mg/l) and Dissolved Ammonia (mg/l) Collected During 1980-1981 Slack Water and Intensive River Surveys	806
11-14	Cumulative Frequency Distributions of BOD5 (mg/l) and COD (mg/l) Collected During 1980-1981 Slack Water and Intensive River Surveys	807
11-15	Cumulative Frequency Distribution of Secchi Disc (meters) and Total Particulate Phosphorus (mg/l) Collected During 1980-1981 Slack Water and Intensive River Surveys	808
11-16	Cumulative Frequency Distributions of Dissolved Nitrite (mg/l) and Dissolved Nitrate (mg/l) Collected During 1980-1981 Slack Water and Intensive River Surveys	809

FIGURES (continued)

Number		Page
11-17	Cumulative Frequency Distribution of Total Organic Carbon (mg/l) and Silica (mg/l) Collected During 1980-1981 Slack Water and Intensive River Surveys	810
11-18	Cumulative Frequency Distributions of Total Organic Nitrogen (mg/l) and Total Particulate Nitrogen (mg/l) Collected During 1980-1981 Slack Water and Intensive River Surveys	811
11-19	Cumulative Frequency Distributions of Dissolved Phosphorus (mg/l) and Total Phosphorus (mg/l) Collected During 1980-1981 Slack Water and Intensive River Surveys . . .	812
11-20	Cumulative Frequency Distribution of Temperature (^{o}C) and Salinity (ppt) Collected During 1980-1981 Slack Water and Intensive River Surveys	813
11-21	Cumulative Frequency Distribution of Dissolved Ortho-Phosphorus (mg/l) Collected During 1980-1981 Slack Water and Intensive River Surveys	814
11-22	Lower Patuxent River Data Plot of Total Phosphorus versus Total Particulate Phosphorus, 1980-1981	815
11-23	Plot of Particulate Carbon Versus Chlorophyll-a in the Lower Patuxent Estuary, 1980-1981	817
11-24	Plot of Slack Water Survey Data, Log Ortho-Phosphorus Versus Soluble NO_2+NO_3 for the Patuxent River, 1980-1981	818
11-25	Plot of Slack Water Log Ortho-Phosphorus Versus Total Dissolved Inorganic Nitrogen in the Patuxent River, 1980-1981	819
11-26	Number of Species and Phytoplankton Cells Observed Along the Lower Patuxent River During July, 1980	822
11-27	Number of Species and Phytoplankton Cells Observed Along the Lower Patuxent River During April, 1981	825
11-28	Estimated Cells of Phytoplankton During the July 1980 Longitudinal Survey	826
11-29	Dominant Classes of Phytoplankton Observed During the July 1980 Longitudinal Survey	827

FIGURES (continued)

Number		Page
11-30	Dominant Classes of Phytoplankton Observed During the April 1981 Longitudinal Survey	828
11-31	Estimated Longitudinal Profile of Diatoms and the Green Algae (tentatively identified as Nannochloris) During the Patuxent River April 1981 Survey	829
11-32	Comparison of Diatom Cell Count in the Patuxent River April 1981 Survey	830
11-33	Diatom Cell Count in the Patuxent River July 1980 Survey .	831
11-34	Relationship Between Mean Total Phosphorus, Mean Dissolved Nitrate and Mean Salinity at Mainstem Patuxent Estuary Stations, 1980-1981	846
11-35	Relationship Between Mean Dissolved Phosphorus, Mean Silica and Mean Salinity at Mainstem Patuxent Estuary Stations, 1980-1981	847
11-36	Relationship Between Mean Dissolved Organic Carbon, Mean Dissolved Ortho-Phosphorus and Mean Salinity at Mainstem Patuxent Estuary Stations, 1980-1981	848
11-37	Relationship Between Mean Total Organic Carbon, Mean Pheophytin-a, and Mean Salinity at Mainstem Patuxent Estuary Stations, 1980-1981	849
11-38	Relationship Between Mean Total Alkalinity, Mean Chlorides and Mean Salinity at Mainstem Patuxent Estuary Stations, 1980-1981	850
11-39	Relationship Between Mean Chlorophyll-a and Mean Corrected Chlorophyll-a Versus Mean Salinity at Mainstem Patuxent Estuary Stations, 1980-1981	851
11-40	Relationship Between Mean Total Nitrogen and Mean Total Unfilterable Residue Versus Mean Salinity at Mainstem Patuxent Estuary Stations, 1980-1981	852
11-41	Relationship Between Mean pH and Mean Dissolved Nitrite Versus Mean Salinity at Mainstem Patuxent Estuary Stations, 1980-1981	853
11-42	Relationship Between Mean BOD_5, Mean Dissolved Oxygen Saturation and Mean Salinity at Mainstem Patuxent Estuary Stations, 1980-1981	854

FIGURES (continued)

Number		Page
11-43	Relationship Between Mean Dissolved Oxygen, Mean Dissolved Nitrogen and Mean Salinity at Mainstem Patuxent Estuary Stations, 1980-1981	855
11-44	Relationship Between Mean Dissolved Ammonia, Mean Temperature and Mean Salinity at Mainstem Patuxent Estuary Stations, 1980-1981	856
11-45	Relationship Between Corrected Chlorophyll-a and Salinity in the Patuxent Estuary for Intensive Survey Data Taken April 23, 1981 and Chlorophyll-a and Salinity for All 1980-1981 Slack and Intensive Survey Data	857
11-46	Relationship Between Chlorophyll-a and Salinity in the Patuxent Estuary for Slack Tide Survey Data Taken April 27, 1981 and June 29, 1981	858
11-47	Relationship Between Chlorophyll-a and Salinity in the Patuxent Estuary for Intensive Survey Data Taken April 23, 1981 and for Slack Tide Survey Data Taken March 19, 1981	859
11-48	Relationship Between Corrected Chlorophyll-a, Chlorophyll-a, and Salinity in the Patuxent Estuary for Slack Tide Survey Data Taken April 21, 1981	860
11-49	Relationship Between Total Alkalinity, pH, and Salinity in the Patuxent Estuary for Slack Tide Survey Data Taken March 19, 1981	861
11-50	Relationship Between BOD_5, Dissolved Oxygen Saturation and Salinity in the Patuxent Estuary for Slack Tide Survey Data Taken April 21, 1981 and March 19, 1981	862
11-51	Relationship Between Silica and Salinity in the Patuxent Estuary for Slack Tide Survey Data Taken April 27, 1981 and March 19, 1981	863
11-52	Relationship Between Silica and Salinity in the Patuxent Estuary for Intensive Survey Data Taken April 27, 1981 and March 19, 1981	864
11-53	Relationship Between Silica and Salinity in the Patuxent Estuary for All 1980-1981 Slack Tide and Intensive Survey Data and Between Total Phosphorus and Salinity for Intensive Survey Data Taken April 23, 1981	865

FIGURES (continued)

Number		Page
11-54	Relationship Between Dissolved Ammonia and Salinity in the Patuxent Estuary for Slack Tide Survey Data Taken March 19, 1981 and June 11, 1981.....	866
11-55	Relationship Between Dissolved Ammonia and Salinity in the Patuxent Estuary for Intensive Survey Data Taken April 23, 1981 and Between Total Nonfilterable Residue and Salinity for Slack Tide Survey Data Taken June 11, 1981.....	867
11-56	Relationship Between Dissolved Nitrite, Dissolved Nitrate and Salinity in the Patuxent Estuary for Slack Tide Survey Data Taken March 19, 1981.....	868
11-57	Relationship Between Dissolved Nitrite, Dissolved Nitrate and Salinity in the Patuxent Estuary for Intensive River Survey Data Taken April 23, 1981.....	869
11-58	Relationship Between Total Dissolved Nitrogen and Salinity in the Patuxent Estuary for Slack Tide Survey Data Taken March 19, 1981 and Intensive River Survey Data Taken April 23, 1981.....	870
11-59	Relationship Between Total Nitrogen and Salinity in the Patuxent Estuary for Slack Tide Survey Data Taken March 19, 1981 and Intensive Survey Data Taken April 23, 1981.....	871
11-60	Space-time Domain Plot of 1970 Total Phosphorus.....	883
11-61	Space-time Domain Plot of 1970 NO_3.....	884
11-62	Space-time Domain Plot of 1970 NH_3.....	885
11-63	Space-time Domain Plot of 1970 Chlorophyll-a.....	886
11-64	Space-time Domain Plot of 1980-81 Orthophosphate.....	887
11-65	Space-time Domain Plot of 1980-1981 Ammonium.....	890
11-66	Space-time Domain Plot of 1980-81 Chlorophyll-a.....	891
11-67	Space-time Domain Plot of 1980-81 Chlorophyll-a.....	892
11-68	Space-time Domain Plot of 1980-81 of Dissolved Oxygen...	893
11-69	Sediment Oxygen Demand in the Patuxent Estuary 1980-81..	894
11-70	Sediment Oxygen Demand in the Patuxent Estuary 1980-81..	895
11-71	Sediment Oxygen Demand Rate in Estuarine Ecosystems.....	898
11-72	Patuxent Estuary Ammonium Flux From Sediments.....	899

FIGURES (continued)

Number		Page
11-73	Patuxent River Longitudinal Characterization of 1980-1981 Data for BOD5 (mg/l), alkalinity (mg/l), and pH; Surface Station Data.....	900
11-74	Patuxent River Longitudinal Characterization of 1980-1981 Data for Pheophytin-a (ug/l), Total Nitrogen (mg/l), and Salinity (ppt); Surface Station Data.....	901
11-75	Patuxent River Longitudinal Characterization of 1980-1981 Data for Chlorophyll-a (ug/l), Dissolved Reactive Silica (mg/l), and Corrected Chlorophyll-a (ug/l); Surface Station Data.....	902
11-76	Patuxent River Longitudinal Characterization of 1980-1981 Data for Temperature (°C), Dissolved Oxygen (mg/l), and Total Nonfilterable Residue (mg/l); Surface Station Data.....	903
11-77	Patuxent River Longitudinal Characterization of 1980-1981 Data for Dissolved Nitrite (mg/l), Dissolved Ammonia (mg/l), and Chlorides (mg/l); Surface Station Data.....	904
11-78	Patuxent River Longitudinal Characterization of 1980-1981 Data for Dissolved Orthophosphorus (mg/l), Dissolved Phosphorus (mg/l), and Total Organic Carbon (mg/l); Surface Station Data.....	905
11-79	Patuxent River Longitudinal Characterization of 1980-1981 Data for Total Dissolved Nitrogen (mg/l), Dissolved Nitrate (mg/l), and Phosphorus (mg/l); Surface Station Data.....	906
11-80	Patuxent River Longitudinal Characterization of 1980-1981 Data for Total Particulate Phosphorus (mg/l), Dissolved Oxygen Saturation (%), and Dissolved Organic Carbon (mg/l); Surface Station Data.....	907
11-81	Patuxent River Longitudinal Characterization of 1980-1981 Data for BOD5 (mg/l), Alkalinity (mg/l), and pH; Bottom Depth Station Data.....	908
11-82	Patuxent River Longitudinal Characterization of 1980-1981 Data for Pheophytin-a (ug/l), Total Nitrogen (mg/l), and Salinity (ppt), Bottom Depth Station Data.....	909
11-83	Patuxent River Longitudinal Characterization of 1980-1981 Data for Dissolved Reactive Silica (mg/l), Chlorophyll-a (ug/l), and Corrected Chlorophyll-a (ug/l); Bottom Depth Station Data.....	910

FIGURES (continued)

Number		Page
11-84	Patuxent River Longitudinal Characterization of 1980-1981 Data for Temperature (°C), Dissolved Oxygen (mg/l), and Total Nonfilterable Residue (mg/l), Bottom Depth Station Data	911
11-85	Patuxent River Longitudinal Characterization of 1980-1981 Data for Dissolved Nitrite (mg/l), Dissolved Ammonia (mg/l), and Chlorides (mg/l); Bottom Depth Station Data	912
11-86	Patuxent River Longitudinal Characterization of 1980 1981 Data for Dissolved Orthophosphorus (mg/l), Dissolved Phosphorus (mg/l), and Total Organic Carbon (mg/l); Bottom Depth Station Data	913
11-87	Patuxent River Longitudinal Characterization of 1980-1981 Data for Total Dissolved Nitrogen (mg/l), Total Phosphorus (mg/l) and Dissolved Nitrate (mg/l); Bottom Depth Station Data	914
11-88	Patuxent River Longitudinal Characterization of 1980-1981 Data for Dissolved Oxygen Saturation (%), Dissolved Organic Carbon (mg/l), and Total Particulate Phosphorus (mg/l); Bottom Depth Station Data	915
11-89	Patuxent River Longitudinal Characterization of 1980-1981 Data for BOD5 (mg/l), Alkalinity (mg/l), and pH; Using Surface and Bottom Depth Station Data	916
11-90	Patuxent River Longitudinal Characterization of 1980-1981 Data for Pheophytin-a (ug/l), Total Nitrogen (mg/l), and Salinity (ppt); Using Surface and Bottom Depth Station Data	917
11-91	Patuxent River Longitudinal Characterization of 1980-1981 Data for Chlorophyll-a (ug/l), Dissolved Reactive Silica (mg/l), and Dissolved Oxygen (mg/l); Using Surface and Bottom Depth Station Data	918
11-92	Patuxent River Longitudinal Characterization of 1980-1981 Data for Total Nonfilterable Residue (mg/l), Dissolved Nitrate (mg/l), and Dissolved Ammonia (mg/l); Using Surface and Bottom Depth Station Data	919
11-93	Patuxent River Longitudinal Characterization of 1980-1981 Data for Chlorides (mg/l), Dissolved Ortho-phosphorus (mg/l), and Total Organic Carbon (mg/l); Using Surface and Bottom Depth Station Data	920
11-94	Patuxent River Longitudinal Characterization of 1980-1981 Data for Dissolved Phosphorus (mg/l), Total Dissolved Nitrogen (mg/l), and Dissolved Nitrite (mg/l); Using Surface and Bottom Depth Station Data	921

FIGURES (continued)

Number		Page
11-95	Patuxent River Longitudinal Characterization of 1980-1981 Data for Total Phosphorus (mg/l), Total Particulate Phosphorus (mg/l), and Dissolved Oxygen Saturation (%); Using Surface and Bottom Depth Station Data.....	922

TABLES

Number		Page
2-1	Patuxent Estuary Survey Dates and Dates of Spring and Neap Tides	95
2-2	Station Description of Patuxent River Slack Tide and IWQS Stations	96
2-3	Station Description for Patuxent River Lateral Slack Tide Stations	97
2-4	Times at Which Samples Were Collected at Each Station and Substation for Each Slack Tide Survey in the Patuxent River	98
2-5	Predicted Times of Minimum Current During IWQS	102
2-6	Intensive Water Quality Survey Schedule	103
2-7	Slack Tide Water Survey Sampling Schedule	105
2-8	Slack Tide Water Survey Sampling Schedule With Lateral Stations	107
2-9	Analytical Procedures for Patuxent Estuary Program	110
2-10	Sample Preservation and Holding Time for Patuxent Estuary	111
2-11	Standard Stability and/or Frequency for Estuarine Water Quality Program Preparation	112
2-12	Precision and Accuracy for Ammonia Nitrogen Estuary Program	113
2-13	Precision and Accuracy for Filtered Total Persulfate Nitrogen	114
2-14	Precision and Accuracy for Ortho-phosphate	115
2-15	Precision and Accuracy for Total Persulfate Nitrogen and Phosphorus	116

TABLES (continued)

Number		Page
2-16	Precision and Accuracy for Filtered Total Persolfate Phosphorus	117
2-17	Precision and Accuracy for Silicate	118
2-18	Precision and Accuracy for Alkalinity	119
2-19	Precision and Accuracy for Nitrite Nitrogen	120
2-20	Precision and Accuracy for Nitrate Nitrogen	121
2-21	Precision and Accuracy for Suspended Solids and Dissolved Organic Carbon	122
2-22	Methods and Preservation Techniques Used for Monitoring Subwatersheds Chemical Export	127
3-1	Percent Increase of Population From 1980-2000 for the Patuxent River Basin Counties	133
3-2	Comparison of the 1969 Population Projections for the Year 1980	133
3-3	Existing (1980) and Projected (2000) Waste Water Flows in the Patuxent River Basin	134
5-1	Estimated Yearly Rainfall Loads to the Patuxent Basin and Water Surface From Bulk Precipitation Measurements	152
6-1	Description of Non-Point Source Monitoring Stations	160
6-2	Soil Survey Data and Interpretations for Howard County Soil Conservation District 208 and Grey Farm Subwatershed	162
6-3	Peak Rainfall Frequencies or Storm Discharge for Zepp Farm and Grey Farm	164

TABLES (continued)

Number		Page
6-4	Approximate Crop and Land Utilization for Zepp Farm and Grey Farm During 1981 Sampling Period	165
6-5	Description of Exact Locations of the NPS Monitoring Sites and Rainfall Gauges	166
6-6	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre), All Sites	167
6-7	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre), All Agricultural Sites . .	168
6-8	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre), Patuxent Park	169
6-9	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre), Deale A	170
6-10	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre), Deale B	171
6-11	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre), Zepp Farm	172
6-12	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre), Grey Farm	173
6-13	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lbs/acre/in), All Sites	174
6-14	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lbs/acre/in), All Sites	175
6-15	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lbs/acre/in), Patuxent Park	176
6-16	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre/in), Deale A	177
6-17	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre/in), Deale B	178
6-18	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre/in), Zepp Farm	179
6-19	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre/in), Grey Farm	180

TABLES (continued)

Number		Page
6-20	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre/year)-All Sites	181
6-21	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre/year)-All Agricultural Sites	182
6-22	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre/year)-Patuxent Park	183
6-23	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre/year)-Deale A	184
6-24	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre/year)-Deale B	185
6-25	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre/year)-Zepp Farm	186
6-26	Statistical Summary of Patuxent River NPS Watershed Chemical Exports (lb/acre/year)-Grey Farm	187
6-27	Relative Comparison of Estimated Average Forested Watershed Chemical Export to Estimated Average Agriculture Watershed Chemical Export (lb/acre/in) 1980-1981	188
6-28	Estimated Average Potential Watershed Chemical Export of Total Phorphorus During Storm Events to the Patuxent River Basin	189
6-29	Estimated Average Potential Watershed Chemical Export of Total Nitrogen During Storm Events to the Patuxent River Basin	190
6-30	Chemical Export Functions for the Patuxent River NPS Watersheds (lb/acre/inch of rain) versus Storm Flow (gallons)	191
6-31	Chemical Export Functions for the Patuxent River NPS Watershed (lb/acre) versus Total Rainfall	198
6-32	Chemical Export Functions for the Patuxent River NPS Watersheds (lb/acre) versus Flow In Gallons	202
6-33	Chemical Export Functions Developed From Multiple Linear Regressions (5 independent variables)	206

TABLES (continued)

Number		Page
6-34	Chemical Export Functions Developed From Multiple Linear Regressions (9 independent variables)	208
6-35	Bulk Precipitation Quality at Patuxent Park NPS Station From September 1980 Through November 1980	211
6-36	Bulk Precipitation Quality at Patuxent Park NPS Station From December 1980 Through February 1981	212
6-37	Bulk Precipitation Quality at Patuxent Park NPS Station From March 1981 Through June 1981	213
6-38	Bulk Precipitation Quality at Patuxent Park NPS Station From July 1981 Through August 1981	214
7-1	Statistical Summary of the Patuxent River Slack Survey Data for 1980-1981.	330
7-2	Statistical Summary of the Patuxent River Slack Survey Data for 1980-1981 Divided By Surface, Middle and Bottom Depths	331
8-1	Statistical Summary of the Patuxent River Monthly Water Quality Variables, 1980-1981, at Salinity Regions of 0-3 ppt, 3.1-10 ppt and Greater Than 10 ppt.	435
9-1	Statistical Summary of the Patuxent River Intensive Survey Data For 1980-1981	625
9-2	Statistical Summary of the Patuxent River Intensive Survey Data for 1980-1981, Grouped According to Surface, Middle, and Bottom Depths	626
10-1	Yearly Mean Dissolved Oxygen in the Patuxent Estuary, 1936-1981	635
10-2	Yearly Mean Dissolved Oxygen in the Upper Patuxent Estuary, 1936-1981	636
10-3	Yearly Mean Dissolved Oxygen in the Lower Patuxent Estuary, 1936-1981	637
10-4	Yearly Mean Dissolved Oxygen for the Month of August in the Patuxent Estuary	638

TABLES (continued)

Number		Page
10-5	Yearly Mean Dissolved Oxygen for the Month of August in the Upper Patuxent Estuary	641
10-6	Yearly Mean Dissolved Oxygen for the Month of August in the Lower Patuxent Estuary	642
10-7	Dissolved Oxygen Deficits in the Lower Patuxent Estuary, 1936-1981	677
10-8	Dissolved Oxygen Deficits in the Upper Patuxent Estuary, 1936-1981	681
10-9	Dissolved Oxygen Deficits in the Patuxent Estuary, 1936-1981	685
10-10	Dissolved Oxygen Deficits (DOD) in the Upper Patuxent Estuary, By Decades	689
10-11	DOD in the Lower Patuxent Estuary, By Decades	690
10-12	DOD in the Patuxent Estuary, By Decades	691
10-13	DOD in the Lower Patuxent Estuary at Various Depths, 1936-1981	692
10-14	DOD in the Upper Patuxent Estuary at Various Depths, 1936-1981	698
10-15	Averaged DOD in the Patuxent River at Various Depth Ranges.	704
10-16	Averaged DOD in the Upper Patuxent River at Various Depth Ranges	705
10-17	Averaged DOD in the Lower Patuxent River at Various Depth Ranges	706
10-18	Monthly DOD in the Upper Patuxent Estuary, 1936-1981. . . .	707
10-19	Monthly DOD in the Lower Patuxent Estuary, 1936-1981. . . .	712
10-20	Upper Patuxent River DOD for the Month of August at Various Depths	717
10-21	Lower Patuxent River DOD for the Month of August at Various Depths	718

TABLES (continued)

Number		Page
10-22	Patuxent River DOD in August at Various Times of the Day and Depths	722
10-23	Upper Patuxent River DOD in August at Various Times of Day and Depths	726
10-24	Lower Patuxent River DOD in August at Various Times of Day and Depths	730
10-25	July and August DOD in the Patuxent Estuary at Various Depths	734
10-26	July and August DOD in the Upper Patuxent Estuary at Various Depths	738
10-27	July and August DOD in the Lower Patuxent Estuary at Various Depths	742
10-28	Upper Patuxent River DOD, January Data.	746
10-29	Lower Patuxent River DOD, January Data	747
10-30	Upper Patuxent River DOD, February Data	748
10-31	Lower Patuxent River DOD, February Data	749
10-32	Upper Patuxent River DOD, March Data	750
10-33	Lower Patuxent River DOD, March Data	752
10-34	Upper Patuxent River DOD, April Data	754
10-35	Lower Patuxent River DOD, April Data	756
10-36	Upper Patuxent River DOD, May Data	757
10-37	Lower Patuxent River DOD, May Data	758
10-38	Upper Patuxent River DOD, June Data	760
10-39	Lower Patuxent River DOD, June Data	761
10-40	Upper Patuxent River DOD, July Data	763
10-41	Lower Patuxent River DOD, July Data	765
10-42	Upper Patuxent River DOD, September Data	768

TABLES (continued)

Number		Page
10-43	Lower Patuxent River DOD, September Data	770
10-44	Upper Patuxent River DOD, October Data	773
10-45	Lower Patuxent River DOD, October Data	774
10-46	Upper Patuxent River DOD, November Data	776
10-47	Lower Patuxent River DOD, November Data	777
10-48	Upper Patuxent River DOD, December Data	779
10-49	Lower Patuxent River DOD, December Data	780
11-1	Correlation Coefficients of Various Water Quality Variables to Determine Linear Associations	816
11-2	Correlation Coefficients Between Nutrient and Salinity Stratification at Stations in the Lower Patuxent River	820
11-3	Correlation Coefficients Between Transformed Values of Nutrient and Salinity Stratification at Stations in the Lower Patuxent River	821
11-4	Patuxent River Longitudinal Phytoplankton Results for July 1980	823
11-5	Patuxent River Longitudinal Phytoplankton Results for April 1981	824
11-6	Patuxent River Surface Chlorophyll-a and Pheophytin-a Data	832
11-7	Patuxent River Longitudinal Water and Sediment Bacteria Measurements For July 23-24, 1980	833
11-8	Patuxent River Longitudinal Water and Sediment Bacteria Measurements for August 21, 1980	834
11-9	Patuxent River Longitudinal Water and Sediment Bacteria Measurements for April 20-21, 1981 . . .	835
11-10	Photosynthetic and Related Measurements in the Patuxent River	836

TABLES (continued)

Number		Page
11-11	Summary of Lower Patuxent Estuary Plankton Productivity (P_A) and Night Time Respiration (R_N) During October 1980-August 1981	844
11-12	Comparison of Phytoplankton Demand and Bethic Remineralization of Nitrogen and Phosphorus in the Lower Patuxent Estuary, 1980-1981	845
11-13	Univariate Linear Relationships Between Water Quality Variables and Silica From Calculated Mean Station Values During 1980-1981	872
11-14	Univariate Linear Relationships Between Water Quality Variables and Salinity From Calculated Mean Station Values During 1980-1981	873
11-15	Statistical Summary of Patuxent River Intensive and Slack Survey Data, 1980-1981	874
11-16	Statistical Summary of Patuxent River Intensive and Slack Survey Data With 1980 and 1981 Data Separated	875
11-17	Statistical Summary of Patuxent River Intensive and Slack Survey Data for Surface, Middle, and Bottom Depths, 1980-1981	876
11-18	Statistical Summary of Patuxent River Intensive and Slack Survey Data for Surface, Middle, and Bottom Depths with 1980 and 1981 Data Separated	878
11-19	Statistical Summary of Patuxent River Water Quality Variables, 1980-1981, With Salinity Regimes (a) 0-3 ppt, (b) 3.1-10 ppt and (c) greater then 10 ppt	881
11-20	Sediment Oxygen Demand and Net Nutrient Fluxes Occurring in the Lower Patuxent River, October 1980-November 1981	888
11-21	Summary of Upper Patuxent Estuary Sediment Nutrient Fluxes, 1979-1980	889
11-22	Benthic Respiration in the Patuxent River 1980-1981	896
11-23	Patuxent River Lateral and Center Station Means	923

LIST OF ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS

BOD5	--biochemical oxygen demand in five days
BOD20	--biochemical oxygen demand in twenty days
BOD30	--biochemical oxygen demand in thirty days
COD	--chemical oxygen demand
CFD	--cummulative frequency distribution
CV	--coefficient of variation
DIP	--dissolved organic phosphorus
DN	--dissolved nitrogen
DO	--dissolved oxygen
DOC	--dissolved organic carbon
DOD	--dissolved oxygen deficit
DOS	--dissolved oxygen saturation
DP	--dissolved phosphorus
ft/sec	--feet per second
IWQS	--intensive water quality surveys
kg	--kilograms
lb/acre	--pounds per acre
lb/acre/in	--pounds per acre per inch of rain
lb/acre/year	--pounds per acre per year
MGD	--million gallons per day
mg/l	--milligrams per liter
MPN	--most probable number
NH_3	--ammonia
NO_2	--nitrite
NO_3	--nitrate
NPS	--non-point source
NPDES	--national pollutant discharge elimination system
PO_4	--phosphate
ppt	--parts per thousand
r	--regression coefficient
R^2	--squared correlation coefficient
SD	--standard deviation
STP	--sewage treatment plant
TKN	--total kjeldahl nitrogen
TN	--total nitrogen
TOC	--total organic carbon
TON	--total organic nitrogen
TP	--total phosphorus
TPN	--total particulate nitrogen
TPP	--total particulate phosphorus
TSS	--total suspended solids
μg/l	--micrograms per liter
USGS	--United States Geological Survey
N:P	--the ratio of nitrogen to phosphorus, by weight.

ACKNOWLEDGEMENTS

The authors thank the following individuals. Lee Zeni, who supported this data interpretation. Dave Flemer for his encouraging scientific discussions. Bruce Nierwienski, Mike Davis, Sandy Cainfield, Minnie Cohen, and Rebecca Himmelmen, all who worked diligently in data management aspects of the project. Aftab Hassan, and Jerry Oglesby for statistical discussions. Dave Lively for file management approaches. Steve Domotor is thanked for proofing the final draft and for editorial changes.

Ed Kruger and the Philadelphia Academy of Natural Sciences staff are acknowledged for excellent performance of the estuarine data collection program. Doug Dixon and the Versar staff who monitored the non-point source watersheds. Biospherics Incorporated and the University of Maryland who collected the biological and sediment processes data. Bill Boicourt is acknowledged for the data collection effort involving current speed and direction, in the lower estuary. Donna Klein, Rose Safford, and Jackie Chaney are thanked for their secretarial support.

SECTION 1

Introduction

This study was one of five watershed studies funded by the United States Environmental Protection Agency, Chesapeake Bay Program. The study was designed to provide non-point source chemical export data for typical subwatersheds within the Chesapeake Bay Basin, as well as to provide information concerning the ambient concentrations of nutrients within the tidal river and estuary of the Patuxent River system. This river system was chosen for study by the State of Maryland, Department of Natural Resources because of the public concern for maintaining an economically important fishery and shellfish industry. Recent reports have indicated that land use activities have increased nutrient enrichment. The Patuxent River Watershed has experienced greater population increases and land use changes than most other watersheds within the Chesapeake Bay system. Therefore a research monitoring study was selected for this basin in order to provide additional information for management of its water resources and biological resources.

The results of the study have been used by the Chesapeake Bay Program for developing baywide non-point source (NPS) loading rates and for characterization of the nutrient enrichment of the Patuxent estuary relative to other subestuaries within the Chesapeake Bay Basin. Data from this study are also being used for water quality modeling purposes.

This report constitutes an initial interpretation of what is to date the most intensive study of this estuarine system. Careful documentation of the data collection efforts has been included in this report for future nutrient enrichment and habitat assessment comparisons. All the figures and tables in this text can be found in the appendices.

Executive Summary

Data collected during this study indicates the Patuxent estuary sediment oxygen demand measurements are among the highest values measured and reported in the literature (figure 11-71). High sediment oxygen demand is a classical example of secondary impacts from nutrient enrichment. Future high sediment oxygen demands (SOD) cannot be forecasted to date.

Nutrient budgets were calculated from data collected during this intensive study in order to indicate to managers and researchers the potential major sources of nutrient enrichment. The results of these budgets shown in figures 5-1 through 5-5 indicate the major sources of nutrients to the estuary during this study. Data indicate the major sources of total nitrogen are from fluvial sources at Rt. 50, followed by the lower estuary sediment flux and NPS loads. The data also indicate

that there is a net exchange of total nitrogen out of the estuary. Figure 5-2 shows the dissolved $NO_2^- + NO_3^-$ budget. This budget indicates that the largest source to the estuary is also from fluvial sources above Rt. 50, followed by a source from Chesapeake Bay.

The ammonia (figure 5-3) budget indicates the sediment flux in the upper and lower river may be the greatest source followed by the source from Chesapeake Bay. The total phosphorus budget (figure 5-4) indicates that the lower estuary sediment flux and non-point sources in the lower estuary may be the same order of magnitude and presents the largest sources. The dissolved orthophosphorus budget indicates that the lower estuary sediment flux and fluvial sources above Rt. 50 are the major sources followed by the potential source from Chesapeake Bay.

Theoretical conservative mixing diagrams also indicate potential sources of nutrients in the estuary. These are shown in figures 11-34 through 11-59. These diagrams obviously indicate high variability from month to month but on a seasonal and annual basis trends are apparent. For example, a mid to lower estuary peak of orthophosphorus, dissolved phosphorus, total phosphorus, chlorophyll-a and silica was observed (see figures 11-34, 11-35 and 11-36) during the study.

These diagrams support the view, as well as the phosphorus budgets that a major source of phosphorus to the estuary water column is below the upper tidal river (Route 50 bridge).

The estimated flushing time of the tidal river and estuary is around 300 days (figure 4-15). This information, in conjunction with the total nitrogen conservative mixing diagram (figure 11-40), indicates the estuary serves as a sink for most of the fluvial nitrogen. If the estuary serves as a sink for nitrogen, (including nitrate, nitrite, and dissolved nitrogen, see figures 11-34, 11-41, 11-43) one would expect high sediment-nutrient fluxes of inorganic nitrogen, especially ammonia due to remineralization of organic matter, and associated high sediment oxygen demand due to settling out and resulting decay of organic material. Figure 11-70 shows ammonium fluxes from sediments and the budget for ammonia indicates a major source of ammonia in the estuary is from the sediments. Figure 11-44 also indicates that ammonia behaves nearly as a conservative substance in the water, except in the lower estuary where a source is indicated (due to higher bottom concentrations). Thus, the fate of nitrogen introduced into the estuary appears to be that it remains in the system for a relatively long period and is remineralized by sedimentation and biological processes, yielding high ammonia concentrations in bottom waters.

The role that sediments play in regulating water column concentrations in the Patuxent estuary appears to be important, as reported by other studies (57,65).

As part of this study D'Elia (16) calculated that the sediments may supply approximately 30% of the daily phytoplankton demand for water column ammonium. This fact indicates that the sediments may be responsible for controlling water column concentrations occasionally.

A typical concern in estuarine management is determination of the limiting factors to plant or algal production. Although temperature is one of the most dominant controlling factors, knowledge of the controlling nutrient has been used to focus management scenarios for point and non-point source nutrient controls.

Unfortunately, the limiting nutrient affecting plant production is not consistent spatially and temporally which makes management strategies difficult to develop as well as to determine their effectiveness. An evaluation of the redfield ratio (N/P ratio) was conducted using data collected during this study. This analysis showed that the apparent limiting nutrient varies longitudinally (figures 7-20, 7-21) as well as monthly. A multiple regression analysis indicated that approximately 75% of the variability of the redfield ratio could be explained (see squation 11-1) by location, (i.e. nautical mile) salinity, timing of the survey to the previous storm event and characteristics which describe the size of the previous storm event, for example peak daily CFS, average daily CFS during storm event, and sum of daily CFS from beginning to the end of the storm. From this analysis it can be inferred that storm events and their associated export of nutrients cause pulses of nutrients to enter the estuary, which in turn determine the limiting nutrient. From a management perspective, this clearly shows the need for considering the effect of storm events and land use activities on estuarine management.

One measure of the suitability of an aquatic habitat for fisheries and shellfish production is the level of dissolved oxygen needed for growth and reproduction. The effects of nutrient enrichment are expressed in the dissolved oxygen. The effect of increasing nutrient enrichment should be observed through low dissolved oxygen in bottom waters. Historical dissolved oxygen measurements (approximately 5,000) were collected from historical reports and studies conducted in the mainstem Patuxent River. Statistical analyses were performed in order to determine trends. Figure 10-33 shows a plot of the mean dissolved oxygen deficit throughout the mainstem estuary. Summer deficits average around 2 mg/l with a maximum deficit around 2.3 mg/l in September. Figure 10-29 clearly shows the mean dissolved oxygen deficit is around 3 mg/l in the lower river (10-24 ppt salinity) at depths greater than 30 feet. Yearly mean dissolved oxygen plots (figures 10-1 to 10-4) show no apparent trends for the entire river. However, a strong trend towards lower dissolved oxygen is observed in figure 10-12 for a river segment above Western Branch, based upon seasonal mean dissolved oxygen. A lower dissolved oxygen trend is observed (figure 10-31) when dissolved oxygen deficits are regressed for the upper estuary. A similar trend is indicated in the lower estuary when all values are regressed versus time (see figure 10-32, line 6) although it is not as apparent as in the upper estuary. In section ten of this report a detailed

presentation in the form of tables shows dissolved oxygen deficits categorized by months, depths and time of day. These tables clearly show the lack of consistent monitoring in the estuary, especially in deeper waters in the lower estuary. Lack of consistent historical measurements indicates ambiguous results when more detailed statistical analyses of dissolved oxygen deficits are performed.

The relative importance of freshwater flow effects on nutrient concentrations were examined by conducting regression analyses between station nutrient concentrations, surface to bottom salinity differences and average freshwater inflow before the estuarine water quality surveys. This analysis was performed to indicate the effect of advective processes on stratification. The result of this analysis is shown in table 11-3 and indicates that stratification at each station may be uniquely controlled. However, on the average, stratification (indicated by surface to bottom salinity differences) and freshwater inflow can explain around 50% of the variability of nutrient concentrations. Further analyses should be performed to more fully explain dominant physical processes at different longitudinal stations.

The relative importance of NPS loads to the basin are shown in the nutrient budgets. Table 6-28 indicates the predominant NPS loads of total phosphorus and total nitrogen comes from agricultural lands. This data is consistent with other estimates (28). Table 6-27 shows the ratio of agricultural to forested chemical export during storm events. Data from this study indicate that total phosphorus is 6-7 times higher in agricultural runoff than from forested land runoff. Total suspended solids (suspended sediment) was five times higher in agricultural runoff from the sites monitored in this study.

Fluvial sources above Route 50 are the major source of $NO_2^- + NO_3^-$ (figure 5-2), with Chesapeake Bay being the major source. Non-point source export of ammonia on a basin basis appears insignificant. Total phosphorus NPS export is indicated as the major source to the estuary as shown in figure 5-4. NPS chemical export of orthophosphorus is insignificant compared to the sediment flux in the estuary.

Figures 11-89 through 11-95 show the results of applying the duncan multiple range test for characterizing zones of chemical similarity from data collected in the water quality surveys. These plots as well as others shown in section eleven of the report indicate spatial locations which have relatively unique concentrations when compared to all of the other mainstream stations. In many cases this analysis identified the surface water concentrations as a unique class in the turbidity maximum region of the estuary. Unique zones were identified in the turbidity maximum region for silica, salinity, BOD_5, total suspended solids, and total organic carbon. Unique zones were identified in the lower estuary for surface water pH; bottom water alkalinity and chlorophyll-a near the mouth of the estuary; silica in bottom water and surface water at the mouth of the estuary. It is interesting to note a unique zone was identified for dissolved oxygen

and dissolved nitrate. This zone showed the lowest average concentrations for both dissolved oxygen and dissolved nitrate. This zone or region of the estuary occurs downstream of the mid-estuary sill shown by the low mid-river mean hydraulic depth in figure 4-6. This zone is also the region where lower estuary dissolved oxygen values have historically been close to zero. Observations from the slack water surveys indicate this may be a region or natural upwelling of bottom anoxic waters as tidal energy forces the water upriver. The mid-river sill, as well as the fact that the rate of change of water depth increases in this area makes the upwelling more likely. Plots of temperature and salinity profiles in this region of the estuary also indicate inversions (higher salinity and lower temperature in surface waters) of the water column. High chlorophyll-a values in this upper region of the lower estuary may also be due to upwelling phenomena. Figure 11-30 shows dinoflagellates (cells/ml) increasing in this region where upwelling may predominate under certain circumstances.

Conclusions

Data collected and initially analyzed under this grant indicate that a trend exists for lower dissolved oxygen above Western Branch, based on a seasonal analysis. Fluvial inputs (including point source loads) represent the greatest sources of $NO_2^-+NO_3^-$, ortho-p, total nitrogen, and total phosphorus. Simple nutrient budgets also indicated Chesapeake Bay may be a source for $NO_2^-+NO_3^-$ (34.6%), NH_3^+ (16%) and total nitrogen (20.9%). A significant source of total phosphorus from NPS (40% of the total) to the estuary is indicated. Upwelling of lower estuary water, rich in nutrients from sediment-nutrient fluxes may be responsible for episodes of high chlorophyll-a in the lower estuary.

Recommendations

- Investigations should continue to determine the future trend of lower dissolved oxygen in the upper estuary.

- A statistically based monitoring program should be established around Sheridan point and above, in order to determine if historically low dissolved oxygen is increasing in extent and frequency of occurrence.

- The above monitoring should be coupled with dynamic monitoring in order to determine to what extent lower estuary high chlorophyll-a may reflect periods and processes related to upwelling of bottom, nutrient rich waters, characteristic of phytoplankton derived from Chesapeake Bay.

- A detailed monitoring of sediments and sedimentation is necessary for developing a baseline of SOD and Sediment Nutrient Fluxes.

- Once completed, the variability over time with respect to SOD and Sediment Nutrient Fluxes should be monitored to determine the effectiveness of point and non-point source controls.

- Monitoring of dissolved oxygen in oyster bed areas will be needed to determine if these living resources are being impacted by point or non-point source land use activities.

- Data collected during this study should be used to calibrate and validate a real-time model of water quality and hydrodynamics.

- Real time hydrological simulation modeling will be needed in order to prioritize subwatersheds in the basing for applying best management practices. Data from this study should be used for this purpose.

SECTION 2

METHODS

Mainstem River and Estuary Sampling Methodology

Estuary and upper river sampling stations were monitored by the Philadelphia Academy of Natural Sciences between June 1980 and August 1981. This program included seventeen slack water surveys and two twenty-four hour surveys. Figure 2-1 indicates the location of the sample sites monitored during slack tide and intensive water quality surveys. Figure 2-2 shows the locations of slack tide and lateral slack tide stations. The dates of the slack tide and intensive water quality surveys are shown in Table 2-1. Station identification numbers, latitude and longitude and general site descriptions are given in Table 2-2 for the slack survey stations and intensive water quality surveys (24-hour surveys). Table 2-3 indicates sample site descriptions for the lateral slack tide stations sampled during the slack water surveys immediately preceding each intensive survey.

The intensive water quality surveys (IWQS) were designed to provide information concerning lateral and vertical homogeneity of the water column variables. During the two IWQS, samples were collected at all stations (except the Western Branch wastewater treatment plant) approximately every two hours for the 24 hour period. The time of sample collection during each slack water survey is indicated on Table 2-4 as well as the expected time of minimum current based upon tide tables. Table 2-5 indicates the time of expected minimum current at five locations during the IWQS conducted July 24-25, 1980 and April 23-24, 1981. Table 2-1 also indicates the date of the surveys and the expected date of spring and neap tides during the study period.

All compatible data was stored in the State of Maryland Water Quality File and STORET under the station codes given. Variables measured for this program included stage height, current velocity and direction, dissolved oxygen, pH, temperature, relative humidity, secchi disc, light penetration/extinction, total chlorophyll-a, pheophytin, BOD_5 and BOD_{20}, total organic carbon or dissolved organic carbon, chemical oxygen demand, total persulphate phosphorus, ortho-phosphate, nitrate (NO_3^--N), nitrite (NO_2^--N), ammonia (NH_3^+-N), total persulfate nitrogen, total suspended solids (total non- filterable residue), dissolved reactive silicate (SiO_2), total alkalinity, fecal coliforms and chlorides. Tables 2-6, 2-7, and 2-8 indicate the sample design and schedule for the different types of survey measurements taken at various depths for each survey type.

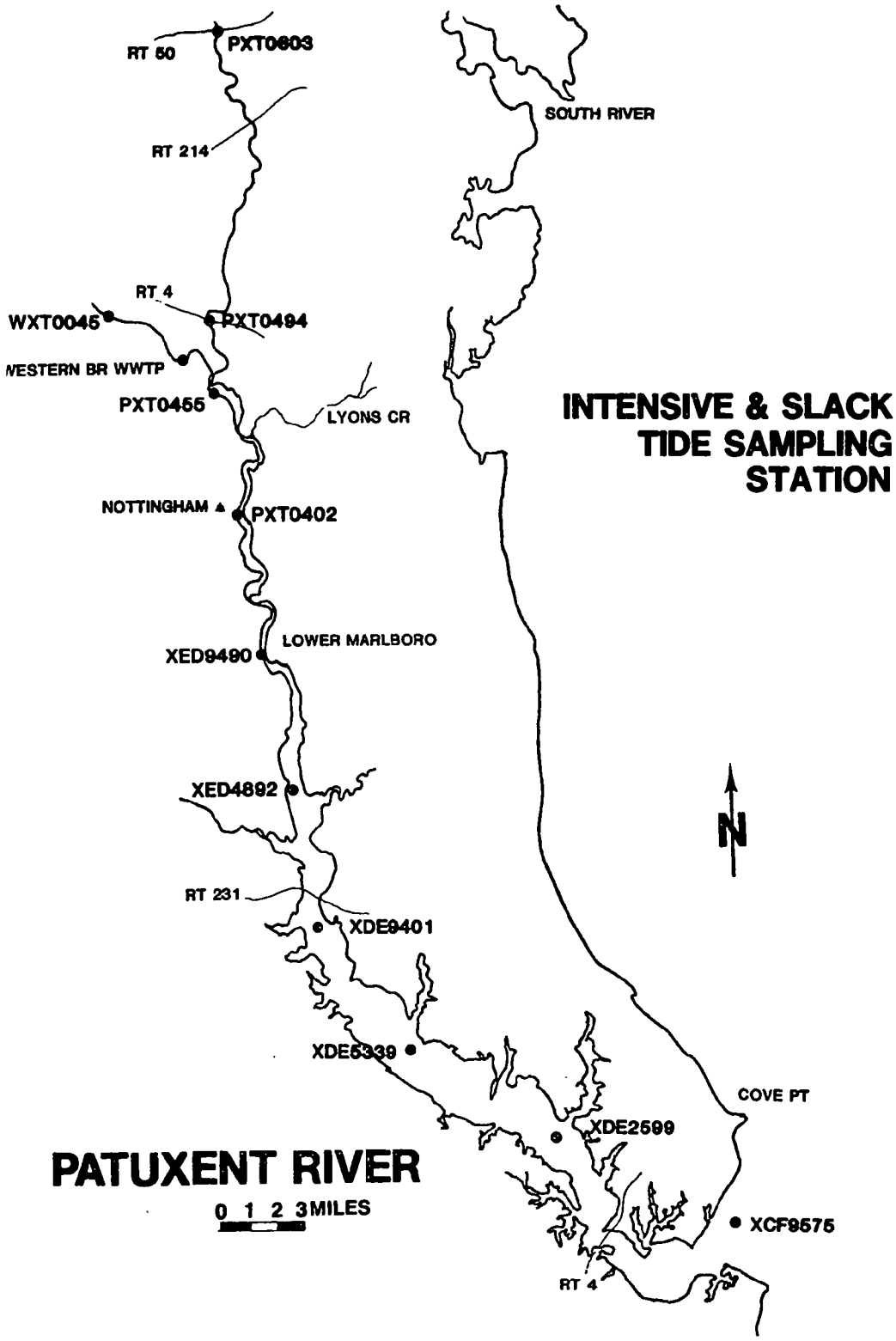


Figure 2-1 Patuxent River intensive and slack tide sampling stations. (ref. Table 2-2 for station discription).

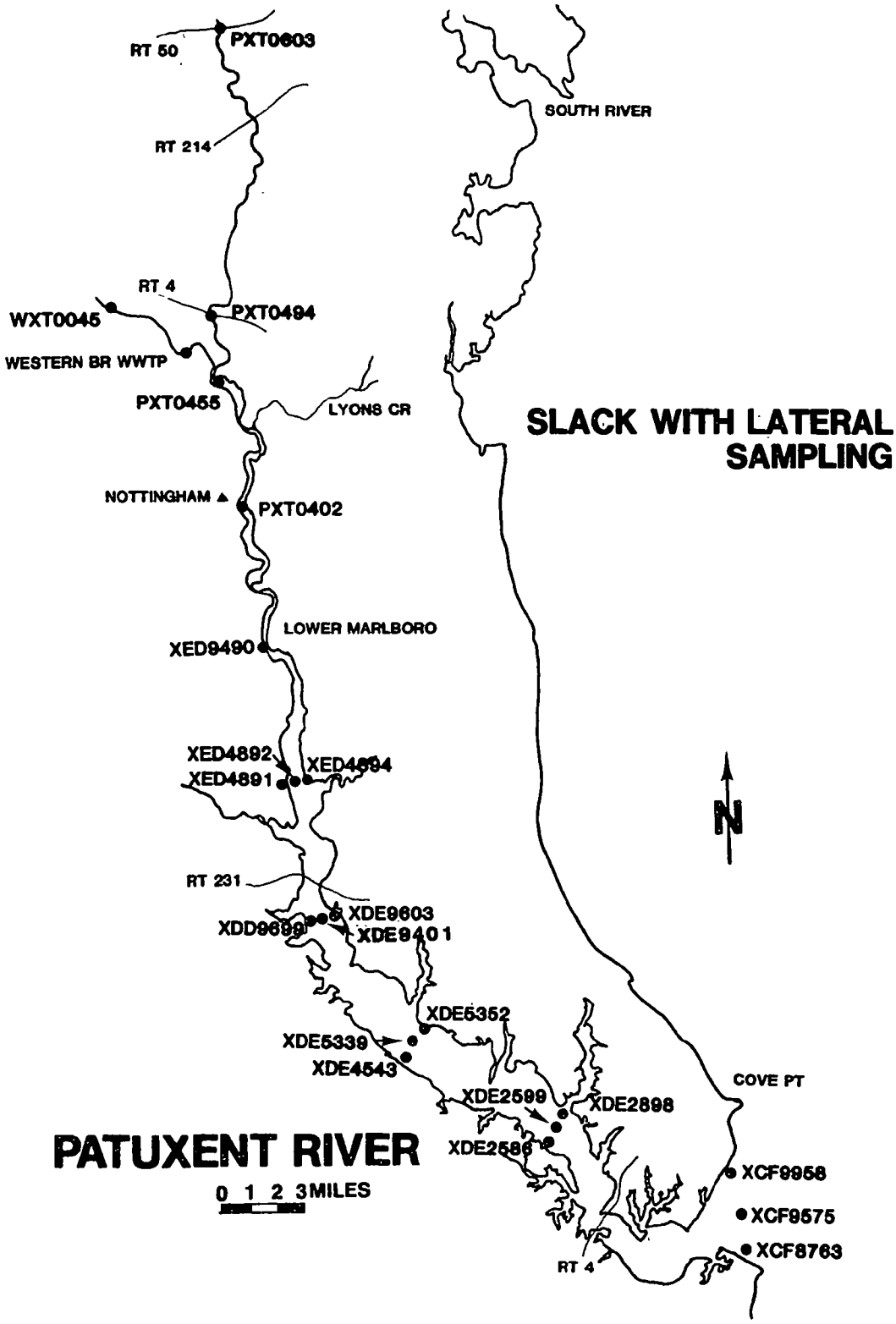


Figure 2-2 Patuxent River slack and lateral slack tide sampling stations. (ref. Table 2-2 and 2-3 for station discription).

The following is a description of the variables measured and the methods used:

Stage height measurements were made using General Oceanics Model 6040 tape recording tide gauges placed at stations XDE2599 and PXT0402. Stage height (meters) and water temperature (^{o}C) were recorded at 15 minute intervals at station XDE2599 from June 24 to December 9, 1980 and from March 11 to August 24, 1981. At station PXT0402 measurements were recorded from June 24 to September 1, 1980 and from May 21 to August 24, 1981. Data has been placed into STORET. Stage height data was not normalized to any sea level datum.

Discharge measurements were made at station WXT0045 each time a sample was taken during the IWQS and during each slack water survey following the procedures outlined by the United States Geological Survey (1 and 2). A factory calibrated Marsh-McBirney Model 201 Portable Current Meter was used.

Discharge data for station PXT0603 was obtained each time a water sample was collected from the United States Geological Survey (USGS) in Towson, Maryland. The USGS maintains a monitoring station at the Route 50 bridge crossing the Patuxent River. Discharge data for stations WXT0045 and PXT0603 were expressed as cubic feet per second.

Water velocity and direction were measured during the intensive surveys and all slack water surveys according to the schedule shown in Tables 2-6, 2-7 and 2-8. At all stations and substations, three replicates were obtained, consecutively, at bottom, middle and surface depths. Mean velocity for each depth was calculated and expressed as feet per second. Factory calibrated Marsh-McBirney Model 527 electromagnetic water current meters were used to collect these data from boats anchored on station.

Meter measurements of dissolved oxygen, temperature and salinity were made as shown in Tables 2-6, 2-7, and 2-8. Dissolved oxygen was determined with YSI Model 57 oxygen meters, calibrated in the laboratory and prior to use at each station. Salinity and temperature measurements were made with either YSI Model 33 SCT meters or Beckman Model RS5-3 salinometers. Measurements of pH were obtained in the laboratory using a Corning Model 610 pH meter.

Measurements of wind velocity and direction, air temperature, relative humidity and barometric pressure were obtained according to the schedule shown in Tables 2-6, 2-7 and 2-8. A Bendix anemometer-wind vane, model ML-446/PMQ-3 or Sierra-Misco Model 1039 wind speed-direction meters and Sylva Type 15 compasses were used to determine wind velocity and direction. Wind velocity data were expressed in knots.

Relative humidity was measured with standard sling psychrometers manufactured by Taylor Instrument Company. Wet and dry bulb temperatures were obtained and relative humidity determined from tables provided by the manufacturer.

Thomen Pocket Altimeter/Barometers, Model 2000-11, were used to measure barometric pressure. These data are recorded in mm of Hg.

Light penetration/extinction measurements were made with a Li-Cor Model Li-185A light meter equipped with a Li-1925 underwater quantum sensor for measuring submerged, photosynthetically available, radiation. Incident light was measured approximately one inch below the water's surface. The sensor was then quickly lowered to a depth where light penetration (uE units) was 1% of the surface measurement. This depth was recorded as the depth of 1% light penetration.

Analytical procedures used for the slack surveys and IWQS are shown in Table 2-9. Table 2-10 indicates the maximum holding times and preservation techniques used. All methods used are suitable for fresh or ocean water.

Quality Assurance

A quality assurance program was conducted throughout this sampling program. Stock standards were prepared for each method using distilled deionized water. Working standards were prepared from the stock solution. Table 2-11 indicates the stability and/or frequency of standard preparation. A precision and accuracy program was conducted for these surveys and the results are shown in Tables 2-12 through 2-21. The method for separation of samples into respective aliquots is shown in Table 2-3.

Nitrite, nitrate and ortho-phosphorus analyses were conducted at the Benedict Estuarine Research Laboratory, by the Philadelphia Academy of Natural Sciences during 1980. Samples were separated into respective aliquots, preserved as indicated in Table 2-10. Samples requiring the shortest holding time were analyzed first (i.e., ortho-phosphorus and nitrite). During 1981 all samples remained frozen until time of analysis. A Technicon Autoanalyzer (AAII) was used to determine NO_2^-, NO_3^-, ortho-phosphorus, SiO_2, NH_3, total phosphorus and total nitrogen. Alkalinity, COD and chlorides were titrated; whereas, solids (nonfilterable), BOD5 and 20, and fecal coliform (MPN) followed the procedures shown in Table 2-9.

Precision and accuracy were determined for alkalinity, solids (total nonfilterable residue) nitrite, nitrate, ammonia, ortho-phosphorus, silicate, total persulfate nitrogen and total persulfate phosphorus. No program was conducted for water quality characteristics which were deleted later in the study, i.e. chlorides and COD. Determination of precision involved analysis of seven replicates run over the entire duration of an analysis. Precision has been reported with mean, standard deviation and coefficient of variation.

To determine accuracy, selected samples were spiked and percent recovery was calculated. New standards were prepared for each survey. In order to determine if any matrix effect occurred due to salinity, spiked

samples were selected from saline and fresh waters. Precision and accuracy were continually monitored throughout the sampling period and numerous duplicate and triplicate analyses were run in order to maintain a check on precision. In addition, EPA quality control samples were analyzed as a quality control check.

Tables 2-12 through 2-21 indicate the letter code assigned to samples chosen for quality assurance and applies to samples within a water quality characteristic. That is, a sample used for precision which was designated A, then refers to that same sample which was spiked for the determination of accuracy. Spiked samples are also marked to indicate whether a fresh water or saline sample was used.

In addition to the water quality sampling program described above, the University of Maryland collected data for this study in the lower estuary at six stations shown in Figure 2-3. Sample methods are the same as those shown in Table 2-9. In addition, the University of Maryland also collected particulate organic nitrogen and particulate organic carbon using the Perkin Elmer 240B CHN Analyzer. These measurements were made at the same time sediment nutrient flux and respiration measurements were made at the approximate same time period that water column measurements were conducted.

Biological Sampling Methods

Measurements related to the biological community composed of primary producers (i.e. phytoplankton) and reducers (i.e. bacteria) were made. These measurements were conducted by Biospherics Incorporated for this study. Three tasks were performed and are described below. They are longitudinal field collections of phytoplankton, productivity measurements, and collection of water and sediment samples for nitrification bacterial identification. Sediment oxygen demand measurements, discussed later in this section, were also measured.

Station location of plankton grab stations are shown in Figure 2-4. Plankton were collected at eleven sample sites. These sites corresponded with the slack water and intensive survey sites described previously. Dates of collection were July 23-24, 1980 and April 20-21, 1981, the same time period that the 24 hour intensive water quality surveys were conducted.

The objective of the longitudinal collection and analysis of phytoplankton was to identify the dominant algal genera along the river-estuarine system during periods of high and low flow. The procedure used for the phytoplankton surveys assumes that the two dates sampled represent typical conditions in the river which may not be true due to meteorological events, sporadic bloom conditions and large scale patchiness which can bias results (3).

At each station a single subsample was collected at each of five surface sites oriented upstream, downstream and cross-channel from the designated station site. Subsamples were pooled to a composite sample for taxonomic analysis in order to compensate for small scale patchiness inherent in single grab samples. This pooling of subsamples gave an improved representation of species distribution in each region of the river. Each of the five subsamples were split before pooling for analysis of chlorophyll-a and pheophytin-a in order to provide an estimate of original variability in the phytoplankton standing crop at each station location.

Pooled composite samples were fixed immediately in the field with an I-KI solution (4) and returned to the laboratory, and preserved by adding formalin (2.5% final concentration). After 72 hours, the supernatant was siphoned, and the residual concentrated by centrifugation before counting. Chlorophyll samples (500 ml each) were immediately vacuum filtered through 0.45 um glass fiber filters, and filters placed in tubes containing a 1:1 mixture of 90% aqueous acetone and dimethyl sulfoxide (DMSO) stored on vessel in an iced light-tight box, and returned to laboratory. This method allows better extraction of chlorophyll from green algae.

In addition, at each station, temperature, salinity and dissolved oxygen was measured with YSI Model 33 SCT meter and YSI Model 51B portable dissolved oxygen water, calibrated using Winkler titrations. Light penetration and extinction was measured using a standard 22 cm. Secchi disk and a Li-Cor Quantum Radiometer/Photometer, Model LI-1928.

Analysis of chlorophyll-a was made after eluting filter pads with acetone/DMSO at $4^{o}C$ for 14 hours and analyzed according to SCOR/UNESCO equations in Strickland and Parsons, (12) or if sample turbidity was high, by the method described by Vollenweider (14).

Phytoplankton identification and enumeration was carried out on aliquots from centrifuged sample concentrations using a Palmer-Maloney nanoplankton cell with a Whipple occular counting grid at 400X resolution. Replicates phytoplankton cell counts and toxonomic identification were made on 10% of the samples.

Primary productivity measurements of photosynthesis and respiration were made for this study by Biospherics Inc. at the stations shown in Figure 2-4 using in-situ light and dark bottle methods and a dissolved oxygen method modified from Vollenweider, 1974 (14). These measurements were taken at the same time benthic respirometer measurements were made. At each station, five water samples were taken at surface, 0.5, 1.0 and 2 meters and below the euphotic zone (less than 1% light penetration). The upper four samples were used to construct the value for integral photosynthesis from individual photosynthetic estimates. The subeuphotic zone samples were used to estimate respiration at a station as well as serving as blanks for the in-situ benthic water column respiration measurements.

Each of the five samples at each depth were apportioned into triplicate sets of light, dark and initial dissolved oxygen bottles, with the initial bottles fixed according to the modified Winkler method but not acified (15). The light and dark bottles were placed at their respective depth for incubation of 6 hours. Surface bottles were evaluated for supersatuation conditions. Dissolved oxygen analyses were carried out following acidification using the method stated above in order to determine precision of 0.02 mg O_2/liter. Data were expressed as photosynthetic oxygen change in mg -at O_2 m^{-3} hr^{-1}. In addition to these measurements, water temperature, dissolved oxygen, salinity, chlorophyll-a, light penetration/extinction, Secchi disc and pheophytin-a was assembled at the stations at various depths. BOD_5 was also taken from the three depths at each station to coincide with the primary production sampling. The surface BOD sample was taken from the surface productivity sample and the bottom aliquot taken within 0.5 meters of the bottom and in nearby the in-situ benthic respirometer chamber.

The University of Maryland collected water column phytoplankton photosynthesis and respiration data at the stations shown in Figure 2-5 for this study. Estimates were made using the light and dark bottle technique described previously. However, triplicate light bottles were suspended for a shorter period (3 to 3.5 hours) at depths corresponding to approximately 90, 60 and 10 per surface insolation. One group of three dark bottles were suspended at the 10% light level. Bottles were filled with surface water. Triplicate bottles filled with surface water were also used to determine initial dissolved oxygen concentrations. Gross primary productivity was calculated by subtracting oxygen concentrations in the light and dark bottles after incubation, and respiration calculated by subtraction of initial and dark bottle oxygen concentrations. Apparent primary production was determined as the difference between the initial bottle oxygen concentration and light bottle oxygen concentrations, after incubation. Areal estimates of water column photosynthesis and respiration were calculated by plotting O_2 concentration rates at the depth of incubation and graphically integrating the area under the curve. Rates of respiration were extended to the bottom or to the depth where surface insolation was reduced to one percent (16).

Bacterial water and sediment analyses were performed at the locations shown in Figure 2-4. At each station water samples were taken from near surface and near bottom. An aliquot was withdrawn from the water sampler into a 125 ml sterile bottle and composited.

Sediment samples were collected at each station shown in Figure 2-3 with a Ballchek 2 inch core sampler with a sterilized polyethylene liner, and sub-sampled for bacterial analysis. Subsamples were made using the upper sediment layer. The remainder of the sediment sample was divided into two portions, one for wet seine particle size and silt/clay descriptive analysis (i.e., seine through Taylor screen). The second subsample was weighed, dried at 105°C, reweighed and combusted at 800°C in order to determine moisture content and % organic matter.

All bacterial samples were placed on ice and analyzed within 10 hours of collection. Standard methods of dilution plating (APHA, 14th ed.) was followed. A selective medium was used to isolate and numerate total Nitrobacter spp. separately from total Nitrosomonas spp. (American Type Culture Collection (ATCC) medium #480 for Nitrobacter and ATCC medium #221 for Nitrosomonas), both prepared with 15 gram purified agar/liter for use in plating. This method was used because viability of those organisms belonging to each genus is directly determined by virtue of their growth on the identifying medium and each viable organism produces a visible and countable colony.

Benthic Measurement Methods

Sediment oxygen demand and nutrient fluxes were measured during this study by the University of Maryland and Biospherics Inc. Biospherics monitored sediment oxygen demand at the locations shown in Figure 2-4. These measurements were taken at the same stations, and dates, as the primary productivity studies. Figure 2-6 is a diagram of the chambers designed and used for this study. Chambers were placed firmly in the sediment. The exposed sediment area of a chamber is 0.051 m^2 (507cm^2) and the volume is 0.0076 m^3 (7.6 liters) for a sediment to volume ratio of 0.07. Imbedment and sealing between the chamber and sediment surface was verified by scuba diver.

A dissolved oxygen meter (YSI model 51-B) and submersible probe with stirrer was used to monitor oxygen depletion within the chamber. A battery operated rheostat-controlled submersible pump with shipboard controls was used to slowly circulate water over the sediment in order to approximate natural river flow and uniform dissolved oxygen in the chamber.

The effect of respiratory activity by plankton and bacteria in the chamber water was determined using data for the deepest primary productivity respiration estimate. The inset in Figure 2-6 indicates that only the region of linear decrease of dissolved oxygen was used to estimate the area oxygen demand since the curve becomes asymptotic under heavy respiratory demand. Data were expressed as grams O_2 m^{-2} hr^{-1}. All oxygen probes were calibrated using the modified Winkler method before deployment and intercalibrated before leaving the laboratory.

The University of Maryland sampled stations shown in Figure 2-5. Triplicate measurements of sediment nutrient flux and sediment oxygen demand were made in-situ similar to the above description. Current velocities in the chambers were maintained at approximately 10 cm/s (typical of bottom current velocities). These chambers were fitted with ports for extracting water for nutrient flux measurements. Oxygen measurements were made every ten minutes for a period of 2 to 2.5 hours. Nutrient samples were withdrawn at 20 minute intervals. A 10-liter dark bottle filled with bottom water was incubated and sampled to estimate nutrient-fluxes associated with the planktonic community.

Nutrients analyzed for flux calculations were nitrate, nitrite, ammonium, dissolved organic nitrogen, dissolved inorganic phosphorus, dissolved organic phosphorus dissolved silicate and total phosphorus. Samples were frozen and stored for analyses in the lab by methods shown in Table 2-10.

Point Source Sampling Methods

Western Branch Waste Water Treatment Plant (station 750632) samples were flow composited during each of the slack water surveys. Flow composited samples were accomplished by means of an ISCO 1870 recording flow meter connected to an ISCO 1680 sampler equipped with a composite base. To maintain the integrity of the flow composited sample, the sampling container was packed in ice during the collection period. To reduce the effects of effluent chlorine a small amount of dechlorinating agent, 10 ml of sodium thiosulfate, was added to the sample container. The water sample from the treatment plant was collected immediately past the discharge weir but before the water went into the conduit to the Western Branch tributary. Due to the nature of the sample and the collection mechanism, analyses were not completed for total chlorophyll-a, pheophytin-a and fecal coliforms. Data was stored in STORET.

On June 22, 1981 samples were collected at sewage treatment plants in the upper Patuxent River and analyzed for TKN, TP, Ortho-P, NH_3-N, NO_2+NO_3-N and NO_2-N by the EPA, Central Regional Laboratory. This data is not included in this report, but is available from the Tidewater Administration.

Non-Point Source Assessment Methods

Five non-point source (NPS) sites were selected for monitoring and analysis in the Patuxent River Watershed. Site selection was conducted in cooperation with the local Soil Conservation District and Versar, Inc. The subwatersheds were representative of the major land use and physiographic features which affect the nature and extent of NPS pollution. Potential subwatersheds were categorized according to the following considerations:

(a) Land use.

(b) Absence/presence of road crossings.

(c) Factors in the Universal Soil Loss Equation (rainfall, soil erodibility, slope gradient, crop management, erosion control practices).

(d) Drainage area.

(e) Accessibility.

(f) Previous data.

(g) The stream must be non-tidal at the sampling site.

(h) There must be no point source discharges upstream of the site.

(i) The stream channel must have a fairly regular cross-section or existing flow control structure to facilitate calibration of a stage-discharge rating curve.

Three of the watersheds selected lie in the coastal plain province of the river basin. The remaining two watersheds are located in the piedmont province, specifically, within the Cattail Creek Basin of the Howard County Soil Conservation District. Figure 6-1 shows the locations of these subwatersheds.

The Patuxent River Park site is an entirely forested watershed which has not been disturbed within the last 40-50 years.

Two agricultural watersheds near Route 258 in Deale, Maryland are basins previously studied by the Smithsonian Institute, Chesapeake Bay Center for Environmental Studies. Two years of NPS monitoring data exists for these sites. These basins are mixed agricultural watersheds, the predominant crops were corn and tobacco.

The other two NPS watersheds are in the Cattail Creek Basin of Howard County. Cattail Creek was also identified by the Howard County Soil District 208 planning program as a critical environmental area. These are agricultural watersheds in the piedmont province of the Patuxent river basin.

Stream Flow Measurements

A continuous flow record was maintained at each site. Stream flow measuring techniques and devices varied depending on the characteristics of the site. The methods included:

(a) The installation of primary flow control devices such as flumes and V-notch weirs with empirical relations for measuring stream flow.

(b) Existing structures, such as a drain culvert or a stable channel section of a stream and subsequent calculation of the stage-discharge rating curve. The stage-discharge relation of all primary devices installed were also verified.

An H Flume was selected for use at the Patuxent River Park, Z-Farm and G-Farm. H-type flumes are particularly suited for gaging runoff from small agricultural or forested watersheds for the following reasons:

o Minimal head loss.

o Operate across a large range of flow conditions.

- No stilling pond is created which could ultimately undercut the structure due to back pressure.

- Operate with up to 50% submergence (ratio of downstream to upstream head).

- Self cleaning, thus reducing the deposition of sediment within or behind the structure.

Flumes were fabricated of sheet metal and installed at the sites according to the specifications contained in the Manual of Agricultural Hydrology, U.S.D.A. 1979 (17).

Installation of these flumes included approach boxes with extended wingwalls. The flume was leveled and the crest elevation was tied to a permanent benchmark by survey techniques.

Sharp crested 120° V-notch weirs with rectangular overflow were used at sites where existing structures facilitated their installation and where base flow was otherwise difficult to gage. The flow in the concrete box culverts beneath Route 258 draining the Deale A and Deale B agricultural watersheds were two such sites. The 120° V-notch increased base flow sensitivity; however, it did not significantly reduce the culvert capacity. When stormflow exceeded the notch capacity, the flow was gaged by rectangular overflow method. Support for the weir plate was provided by the culvert concrete apron and wingwalls. The notch was initially positioned approximately 12 inches above the stream bed, however actual position depended upon the characteristics of the nappe after the plate was installed. The plate was raised to a point where the nappe experienced freefall and is aerated on all sites. Although the secondary flow monitoring instruments were factory calibrated according to the empirical formula for the V-notch weir with rectangular overflow, the stage-discharge relationship were checked periodically with actual current velocity measurements.

Instrumentation

ISCO Model 1870 Flow Meters were used to continuously monitor stream flow. These flow meters monitor stream depth using a pressure transducer (bubble) system. The bubbler tube was submerged near the stream bed or bottom of the flume. Air supplied by an internal compressor bubbles out of the tube at a constant rate resulting in a pressure in the tube proportional to the level in the stream. The flow rate was recorded on a strip chart and total flow displayed. A chart speed of two inches per hour was used to continuously record flow. The ISCO Model 1870 produces a signal proportional to flow rate which allowed connection to automatic samplers to collect a flow proportioned composite sample. An event mark was placed on the chart record each time a stream sample was collected for the composite storm sample.

Water Sampling

In order to accurately monitor stormwater runoff, the collection of flow proportioned samples was required and the flow measuring and sampling instruments were designed to provide this capability. No extrapolation or manipulation of the sample is therefore required after collection, and the composite sample is analyzed to provide a mean concentration during a storm.

The ISCO Model 1580 automatic sampler was coupled with an ISCO Model 1640W sample actuator for sampling. The sampler pumps uniform small increments (at least 100 ml) into a single receptacle at flow proportioned intervals. Actual sample size was determined on site and depended on the volume and duration of anticipated runoff. The model 1640W sample actuator initiated the sampling equipment when stream flow rose to a predetermined height. Once sampling was initiated, the automatic sampler collected flow incremented samples across the entire storm hydrograph and terminated sampling when the stream height dropped below the actuator. Each time a sample was collected for compositing, an event mark was placed on the flow strip chart record mentioned above. This mark served dual purposes: (1) the mark was used to corroborate the correct operation of the sampler. As the water passed through the weirs and flumes, it ran into a mixing box and pipe placed beneath the discharge nappe. A sampler intake tube was routed to this box for the purpose of obtaining a well mixed sample, thus avoiding the problem of depth integration. The actual samples withdrawn were composited with a 2 1/2 or 5-gallon polyethylene or borosilicate glass bottle within the ISCO sampler.

While all NPS sites were equipped with monitoring instrumentation to automatically begin sampling when runoff events occurred, the sites were periodically verified by pre-runoff visits. Immediately before selected storm events, field personnel visited each NPS site to insure that all instruments were functioning properly, that the flow meter was calibrated, and that the sampling action commenced when the stream stage rose to the predetermined height. Site visits were also conducted during storm events to verify that sampling had been initiated and to apply corrective measures should the systems fail.

Located at each monitoring site an instrument housing was installed. Each housing readily contained the flow meter, sampler, 12 volt batteries (if used) tool storage and log books. The housing units were constructed of steel to minimize the chance of damage and were weather-proofed. They were securely mounted at the site with concrete fasteners attached to a poured concrete foundation, or to wood posts which had been anchored to the ground with concrete. Each housing had a case hardened padlock and hasp to discourage vandalism. Weekly equipment maintenance visits also served as a continuous check on the site security.

Each NPS site was visited a minimum of once a week during NPS monitoring even if no storm events occurred. During these visits, personnel performed the following quality control checks:

(a) Strip chart removal and replacement;

(b) Calibration checks on time clocks and level recorders (i.e., adjustment of pen to correct stream level);

(c) Verification of instrument function and application of corrective actions should they be required;

(d) Replacement of batteries where required;

(e) Documentation of equipment condition and recording of all required adjustments.

During each site visit the field crew placed a mark on the hydrograph just above the pen position. Time and date of visit were written near this mark. The purpose of this was to provide a time check when the hydrographs were later integrated for total storm flow calculation and to provide a cross reference between the hydrograph and station log book in the event of any question concerning the quality of data. Routine maintenance of flow meters and samplers was performed monthly in accordance with the manufacturer's recommendations.

Sample Collection and Shipment

Following each storm event or within 24 hours of sampling initiation, (whichever came first), field personnel visited the NPS site for sample collection. The time and date of visit was marked on the hydrograph strip chart and in the log book maintained at each NPS station along with all other relevant information such as name, volume of sample, temperature of sample, etc. The sample container was removed and immediately split into separate shipment containers as follows:

- o Nutrients (TKN, NO_2^-, NO_3^-, T.P., PO_4^{-3}) - polyethylene
- o Total Organic Carbon (TOC) - Borosilicate glass
- o Solids/BOD - polyethylene

The samples were then placed in a cooler filled with ice. After all samples had been collected and stored for shipment, they were immediately delivered to the laboratory for analyses. Filtering and preservation of samples in accordance with EPA approved procedures was performed by the laboratory personnel as shown in Table 2-22 and Figure 2-7.

As previously mentioned, all samples were collected within 24 hours of sampling initiation. This was required to insure that samples were analyzed within required holding times. If the runoff event continued after 24 hours the cycle was allowed to continue for an additional 24 hours or until the stage dropped to the defined point. These additional samples were analyzed separately from the first sample. Results were presented for both the entire storm and separate 24 hour storm increments. Data and log books are provided in an Appendix to this report.

Meteorological Assessment Methods

The objective of the meteorological assessment was the quantification of the atmospheric conditions that directly or indirectly affected watershed chemical export. This assessment occurred concurrently with the NPS sampling and included the monitoring of rainfall quantity and quality. Atmospheric conditions, such as wind speed, temperature, relative humidity and barometric pressure, which affected those loading rates for the entire study area were recorded. To accomplish this goal a continuous recording rain gage was placed at each non-point subwatershed under study. A weather station, with the capability of continuously monitoring wind speed, temperature, relative humidity and barometric pressure, located near the three coastal plain sites was installed. Rainfall water quality information was collected at the centralized weather station by adapting the rain gage instrument to retain the measured rainfall for the purpose of chemical analysis. Emphasis was directed towards the operation, calibration, and maintenance of rainfall measuring instruments to ensure the overall quality and quantity of rainfall data collected. Sites were instrumented with a Weather Measure Model _____.

Each rain gage station was visited a minimum of once a week, as well as immediately following all storm events. At each visit instrument functioning was verified. Because of the need for flow meter and rain gage time synchronization, special attention was given to ensuring proper function of rain gage clocks. All rain gages were synchronized, along with flow meters, to a common time reference.

Each rain gage station was supplied with a field logbook for the purpose of recording all site visits, instrument settings, malfunctions and activities performed, as well as, any observations concerning land use practices in the basin, which was relevant to the overall study effort (e.g., fertilizing practices, plowing, etc.).

All instruments were strictly maintained according to the schedule recommended by the manufacturer. This included occassional cleaning and application of a silicone-oil to moving parts. Raingauge locations were selected based upon the following factors:

- Centrally located to all the NPS study basins and not necessarily central to the entire watershed since the recorded data would be related to stormwater runoff quantity and quality;

- Because the instruments are extremely delicate the site had to provide the maximum security possible.

- Accessibility.

- The site had to be on grass cover rather than hardtop which could potentially cause excessive heat radiation affecting instrument performance.

- The site had to be in a relatively open area with no obstructions.

One weather station was located in the Patuxent River Basin study area. The weather station provided an indication of the meteorological condition in the Patuxent River study area which might impact atmospheric NPS loading rates. The meteorological factors recorded included windspeed and direction, relative humidity, ambient temperature and barometric pressure.

The weather station was equipped with a field logbook to document all activities that took place at the station during the course of study. Instrument chart records were removed once a month. When chart records were changed the following information was recorded at the end of the chart roll:

- station number
- station location
- time (EST)
- tape time (EST)
- date
- field crew initials
- pertinent observations

Bearings in wind speed and direction sensor were regularly checked and replaced if necessary.

The weather station was equipped with a Weather Measure Model M701 Meteorograph which provided continuous record of ambient temperature, relative humidity, and barometric pressure. A Weather Measure Model W200-SC Wind Speed and Direction Sensor coupled with a Model W224 Series recorder was also used.

The instruments were housed in an all wood instrument shelter which complies with the U.S. Weather Bureau "cotton-region-type" shelter specifications. The shelter had louvered sides to allow free air circulation, and a double roof to provide insulation from direct solar radiation as well as rainfall. Wooden legs supported the shelter 48 inches above the ground surface to further protect the instruments from surface radiation or other conditions which may bias the operation of the measuring devices.

The weather station was visited for inspection on a weekly basis. At each visit, instrument function was verified and corrective measures implemented, should malfunction occur. As with the flow and rain gages, special attention was given to ensure proper function of instrument clocks.

SECTION 3

LAND UTILIZATION, POPULATION AND WASTEWATER PROJECTIONS

Land Utilization

The Patuxent river basin experienced significant land use changes in the late 1800's and early 1900's similar to eastern shore tributaries (18). Figure 3-1 shows that since 1950 the Patuxent drainage area has experienced a significant increase in land uses other than agricultural and forest land. Forest land has decreased as well as pasture and cropland. If the trends observed in Figure 3-1 continued, it can be estimated that by the year 2000, fifty percent of the drainage area will be in non-agricultural and forest land uses.

Population

Population of the Patuxent increased from 35,000 in 1940 to over 134,000 people in 1960. The 1980 population is estimated to be approximately 350,000. Figure 3-2 shows the population projections to the year 2020, developed in 1969 (19).

Figure 3-3 shows the county population projections developed by the Maryland Department of State Planning (20). Table 3-1 shows the estimated percent population increase within the Patuxent Basin counties from 1980 to the year 2000. Table 3-2 shows, for comparison purposes, the approximate difference between the 1969 projections and the reported 1980 population for each county. From this table it can be seen that Howard County's population was much larger in 1980 than projected. Several other county populations were much lower than expected to have been by 1980.

In general, the 1969 projections overestimated the 1980 population. Table 3-2 also shows that in 1969, the sewered population for 1980 was expected to be around 375,000, or approximately 100 percent of the population. As of 1982, the Maryland Department of State Planning estimates that approximately 265,850 people, or 76% of the basin population is served by central sewerage facilities.

Wastewater Projections

Table 3-3 shows the existing (1980) and projected year 2000 wastewater flows in the basin by major facility (21).

This table shows that the future waste flows may approximately double by the year 2000. These figures also show that the per capita use of water is approximately 100 gallons of water per day. Although the year 2000 population projections are not available at the time of this report, based upon the 100 gallons per capita per day use of water and the 67.8 mgd wastewater flows, sewerage capacity would be available for 677,613 people, or a 51.7% increase in the Basin's sewered population for the year 2000, assuming the same per capita use of water.

SECTION 4

PHYSICAL CHARACTERISTICS OF THE PATUXENT RIVER

Geology, relief, soils, vegetation, rainfall and other variables interact to create a river valley. The entire watershed drains approximately 900 square miles. The basin is approximately 80 miles long (northwest to southeast) and is usually less than 15 miles wide, with a total length of the river from headwaters to the Chesapeake Bay of approximately 110 miles. The general flow of water is to the southeast over Piedmont upland soils and rocks. The fall zone lies near the convergence of Howard, Montgomery and Carroll counties at an elevation of approximately 150 feet above sea level.

Geology

The topography in the Patuxent is influenced by the Piedmont and Coastal Plain provinces. The basin has several unique upland areas underlain by metamorphic and igneous rocks providing a broadly undulating surface with many deep river valleys, with smaller streams flowing over bedrock in the uplands area. Larger streams flow on a thin layer of alluvial material, thus masking the valley cut into hard rock. In the lower coastal plain portion of the basin, the streams and creeks flow in a much broader, flat and densely vegetated floodplain underlain by alluvial deposits and wetlands.

Below Hardesty, Maryland, the river becomes tidal and is long and narrow, broken by swamps at various stream junctions. The upper part of this area has been filled by deposition of eroded materials over the last two to three hundred years.

Geomorphological Relations

Geomorphological relations have been developed to characterize the Patuxent Estuary. In 1977-78 the Maryland Department of Natural Resources conducted an extensive bathymetric survey of the river (23). Data from this survey have been used to calculate geomorphological functions. In addition, DNR topographic maps were used to determine the drainage area relation. These sources of data were used to determine functions of drainage area, hydraulic depth, water surface area, width, cross-sectional area and volume of the estuary.

Hydraulic depth was calculated as follows:

$$DH = CA/TW \tag{4-1}$$

where: CA = Cross-sectional area
TW = Water Surface Width
DH = Hydraulic depth

Water surface area was calculated from surface water widths and nautical mile designations as follows:

$$SA_i = ((TW_1 + TW_2)/2) * X_{12} \tag{4-2}$$

where: TW_1, TW_2 = top widths at river nautical mile 1 and 2 respectively
X_{12} = longitudinal distance between transect 1 and 2

SA_i = Surface Area between transect 1 and 2

The volume of water between cross-sectional areas were calculated from cross-sectional areas, and longitudinal nautical mile as follows:

$$V_i = ((CA_1 + CA_2)/2) * X_{12} \tag{4-3}$$

where: CA_1, CA_2 = cross-sectional area at transects 1 and 2 respectively
V_i = volume between transect 1 and 2
X_{12} = longitudinal distance between transect 1 and 2

The BMDP statistical package was used to regress longitudinal values of calculated surface areas, volumes, widths, hydraulic depth, and drainage area. The following nonlinear functions were linearized and the above geomorphological variables were regressed using least squares regression:

(a) $y = MX + C$ (4-4)
(b) $y = K \exp(ax)$ (4-5)
(c) $x = K \exp(ay)$ (4-6)
(d) $y = K X^a$ (4-7)

In applying the above functions the dependent variable (Y) was the geomorphological variable and (x) was nautical mile. Each linearized function was applied to the longitudinal river profiles of the variables and the least squares regression giving the highest r^2 (squared correlation coefficient) was selected and is shown below:

$$TW = 4420.9063 \exp(-0.07477X) \qquad r^2 = 0.674 \tag{4-8}$$

$$CA = 57641.6 \exp(-0.12701X) \qquad r^2 = 0.953 \tag{4-9}$$

$$DH = 13.035 \exp(-0.05224X) \qquad r^2 = 0.5837 \tag{4-10}$$

$$SA = 4775455.9 \exp(-0.07352X) \qquad r^2 = 0.4789 \qquad (4\text{-}11)$$

$$DA = 0.66047X - 3.0492 \qquad r^2 = .0562 \qquad (4\text{-}12)$$

$$V = 63211702 \exp(-0.12973X) \qquad r^2 = 0.806 \qquad (4\text{-}13)$$

These equations can be used to approximate the respective value a given nautical mile with various degrees of confidence.

Cumulative functions of these variables were also determined for the Patuxent Estuary by regression of the linearized functions listed above. The advantage of developing cumulative functions of the morphological variables is that a smoother relation is observed, resulting in a much higher r^2 than the discrete step functions shown above. The second important advantage of developing a cumulative variable versus river mile relation is that the derived function can be differentiated with respect to river mile to obtain an instantaneous variable function. For example, top width calculated using the above function gives a 50% error at river mile 10.5. The cumulative function gives an error of 21.6% at the same location. In essence the cumulative function can then be used to approximate the value of the variable at a particular nautical mile and at the same time can be used to determine the rate of change of the variable between any two transect or locations in the longitudinal direction. The best cumulative geomorphological function for the previously described variables are:

$$CTW = (\ln X - 3.7203)/(-0.00003) \qquad r^2 = 0.964 \qquad (4\text{-}14)$$

where: CTW = cumulative (surface) river width at nautical mile X

$$CCA = (\ln x - 3.4760)/(-5\ E\ -06) \qquad r^2 = 0.968 \qquad (4\text{-}15)$$

where: CCA = cumulative cross-sectional area at nautical mile X

$$CDH = (\ln x - 3.8\ 499)/(-0.00854) \qquad r^2 = 0.970 \qquad (4\text{-}16)$$

where: CDH = cumulative hydraulic depth at nautical mile X

$$CSA = 9840331.9\ (X\ **\ 0.71896) \qquad r^2 = 0.980 \qquad (4\text{-}17)$$

where: CSA = cumulative cross-sectional area at nautical mile X

$$CDA = 1021.06 \exp(-0.01921X) \qquad r^2 = 0.941 \qquad (4\text{-}18)$$

CDA = cumulative drainage area at nautical mile X

$$CV = (\ln x - 0.28802)/(4.E\ -09) \qquad r^2 = 0.968 \qquad (4\text{-}19)$$

CV = cumulative volume at river mile X

Figure 4-1 shows the drainage area and cumulative drainage area; Figure 4-2, the cross-sectional area and cumulative cross-sectional area; Figure 4-3, width and cumulative surface water width; Figure 4-4, the volume and cumulative volume; Figure 4-5, the surface area and cumulative surface area; and Figure 4-6, the hydraulic depth and cumulative hydraulic depth of the Patuxent estuary and lower tidal river, normalized to mean low water datum.

Freshwater Inflow

Freshwater inflow to the mainstem of the Patuxent River during this study period is shown in Figure 4-7. It can be seen that during the summer and fall of 1980 freshwater input was lower than normal. The average cubic feet/sec/sq. mile at Bowie during 1980 was 1.0142. The average for the period of record for the Patuxent is 1.265 ft^3/sec/sq. mile indicating slightly below normal freshwater inflow. Figure 4-8 shows the average monthly flows and standard deviation measured at Bowie with those obtained during the 1980 study period.

Estuarine Hydrography

The Patuxent is a unidirectionally flowing freshwater river from the headwaters to approximately Hardesty (64 nautical miles from mouth of estuary). From this location to the mouth of the estuary the river is subject to tidal influence. The Patuxent is a partially mixed estuary in the lower portion of the river. Figure 4-9(b) shows the net non-tidal transport of the estimated two layer flow system characteristic of the Patuxent. Figure 4-9(a) indicates a potential three-layer flow system observed by Owen, 1969 (24). Two 24 hour longitudinal velocity component averages for the Patuxent are shown in Figure 4-10. Figure 4-10(a) also indicates the potential three layer flow pattern in the lower river. This diagram indicates the variability of the calculated surface of no net motion.

Figure 4-11(a) shows the net non-tidal current at Chesapeake Bay Institute's station PX2 in 1952 and current meter moorings during this study at PX1 and PX2 (Figure 4-11(b) and (c) respectively). Profiles a and b are from the same station location area, and PX2 is upestuary in the Patuxent, see Figure 4-12. Data collected in 1980 (25) for this study did not show a three layer flow pattern when mean velocity profiles were calculated. A comparison of the low-frequency component of the velocity measured in the lower Patuxent estuary shows that the lower estuary responds in a classical two-layer circulation, driven predominantly by the local winds. Comparison of the axial component of the velocity record showed that when wind forces the upper layer water to move up or down the estuary, the lower layer water responds by flowing in the opposite direction, e.g., a classical two layer flow. In order to determine the existence and variability of a three layer flow system in the Patuxent, a greater time record of current measurements in the Patuxent Estuary (25) is required.

Salinity data collected from the slack water surveys during 1980 and 1981 are shown in Figures 7-1, 7-2, and 7-3. Depth averaged values of salinity were calculated at each station for each survey in order to determine the depth average salinity at a given nautical mile during the study period. Least squares regression yielded two equations with relatively high r-squares. The following polynomial form of an equation based upon simple least squares procedure yields salinity as a function of nautical

mile with the intercept of 16.717 taken as the average salinity observed during the 1980-1981 study period at the mouth of the Patuxent:

$$S_x = -0.01664X^{1.9}+16.717 \qquad (4\text{-}20)$$

Figure 4-13 shows the observed and calculated longitudinal salinity profile using the above equation as well as an exponential function derived using least squares. The polynomial function can be used for approximating the percent of Chesapeake Bay water and Patuxent River freshwater at any longitudinal location in the estuary using the relation:

$$P_x = \frac{F(Sx)}{So} \qquad (4\text{-}21)$$

where: P = percent freshwater or Chesapeake Bay water at nautical mile x

Sx = estimated or observed salinity at x

So = salinity at the mouth of the estuary

Figure 4-14 shows the results of this simple calculation, i.e. estimated percent freshwater and Chesapeake Bay water from nautical mile zero to 45 using equations 4-19 and 4-20. This is based upon averaging data taken from 1980-1981 and will change according to the input of freshwater. The location of 50% mixing of these two water types occurs at approximately the location of the mid-river sill.

Calculation of the flushing time of an estuary is useful in order to approximate the time period a conservative pollutant may remain in an estuary or estuary segment. The steady state depth averaged flushing time of the Patuxent estuary for average freshwater inflow and mean flow conditions can be approximated using the definition of the freshwater flushing time (T_f) as follows:

$$T_f = \frac{V_f}{Q_f} \qquad (4\text{-}22)$$

where: V = freshwater volume between transect X_1 and X_2

Q_f = freshwater flow rate into the volume

This calculation does not include effects of tidal flushing which can be important. Using volumes calculated from (a) the previously mentioned bathymetric survey data; (b) the percent of a given volume of freshwater by applying equation 4-20; and (c) determination of the freshwater input at a longitudinal location calculated by applying equation 4-18, multiplied by the average freshwater flow rate, the freshwater flushing time of the Patuxent can be approximated, as shown in Figure 4-15. The total flushing time obtained using this method is 315 days. Due to the assumptions of depth averaged salinity, average freshwater inflow, mean low water volume and no tidal effects, this value is more likely to be an approximation of the maximum flushing time.

SECTION 5

SOURCES OF NITROGEN AND PHOSPHORUS TO THE PATUXENT RIVER

This section is a description of data collected from this study and data gathered from other literature concerning the relative contribution of nitrogen and phosphorus to the Patuxent River.

Point and Non-point Relative Contributions

Existing wastewater flows to the basin have been estimated to be 35 million gallons per day (mgd) Table 3-3. In the year 2000 wastewater flows are estimated to be near 68 mgd (27). Existing point source loads to the basin are estimated to be 861 tons/year total nitrogen and 373 tons/year total phosphorus. By the year 2000, assuming secondary treatment level, the loads would be 1,661 tons per year total nitrogen and 650 tons/year total phosphorus. The basin non-point source potential loads in 1978 were reported to be 816 tons of total nitrogen and 235 tons of total phosphorus (27). By the year 2000, the potential NPS load was estimated to increase to 985 tons/year TN and 240 tons/year TP. The Maryland Department of State Planning recently reported that potential NPS loads of TN and TP may be around 732 tons/year and 180 tons/year respectively (28). The limited data collected from the 5 subwatersheds in this study indicated the potential NPS load to the Patuxent may be as low as 282 tons/year TN and 101 tons/year total phosphorus during years of low rainfall. The latter figures are calculated from data shown in Tables 6-28 and 6-29 of this report. These figures are low compared to other estimated NPS loads reported. Calculation of NPS loads of TN and TP using the upper standard deviation of the lb/acre/inch loading estimates from the 5 subwatersheds in this study provides values in the range reported by Halka, 1982 (28).

Over the past 15 years environmental scientists have begun to consider the role of precipitation and its components (e.g. acidity, sulfate, nitrate, ammonia, and metallic cations) to ecosystems (49, 50, 51, 52). Correll and Ford (67) found for the Rhode River that the importance of precipitation as a source of estuarine nitrogen was greatest when land runoff was low and its nitrate concentration was also low, and in years of drought or below average rainfall during the growing season. During this study, limited data was collected concerning chemical concentrations of nutrients in rainfall. Table 5-1 indicates loads of nitrogen and phosphorus to the Patuxent River basin. Assuming 40 inches of rain per year (29), those data indicate that total nitrogen (NO_2 + NO_3 + TKN) loads from precipitation are 4.5X higher than TP loads.

Nitrogen and Phosphorus Budgets

There are a number of potential sources of nitrogen and phosphorus to an estuarine system (i.e. fluvial, point and non-point source inputs, intrusion of Bay waters, rainfall, water-column processes, and sediment flux). During the last few years our perspective on the importance of these components in estuarine productivity-nutrient cycling has changed. For example, while water-column processes were once thought to dominate estuarine N remineralization (53; 54), benthic remineralization is now considered to be an important source of recycled nutrients available for phytoplankton photosynthesis and as important zones of carbon and oxygen consumption (55, 56, 57, 58). It seemed appropriate to calculate nitrogen and phosphorus budgets for the Patuxent river in an effort to determine the potential contribution of these nutrients from the sources discussed above.

Five nutrient budgets were calculated for the Patuxent River (Total nitrogen, dissolved nitrite & nitrate, dissolved ammonia, total phosphorus and dissolved orthophosphorus). These budgets assume 25 inches of rainfall during a 7 month period (April through October, 1981). Sediment flux was calculated by averaging benthic flux data taken for this study reported in D'Elia, et.al., 1981 (16). Fluvial inputs were based upon 1981 average concentrations and flows at station PXT0603 (Route 50) and at Western Branch, for the upper and lower basins respectively. NPS loading rates were developed from data reported in Section 6. Physical characteristics of the basin such as drainage area, water surface area and estimated sediment surface area were taken from data presented in Section 4. The rainfall loading rates were calculated based upon data reported by Smullen et.al., 1982 (29).

To calculate the exchange with the Chesapeake Bay a stratified two layer flow condition was assumed at the mouth of the Patuxent River (i.e. a net seaward flow at the surface and a net landward flow at the bottom). Salinity was used as a conservative constituent to these flows.

$$(S_B)\ (Q_B) = (Q_F + Q_B)\ (S_p) \qquad 5\text{-}1$$

where: Q_F = fluvial flow (cfs)
Q_B = Chesapeake Bay flow into Patuxent (cfs)
S_B = Average bottom salinity
S_p = Average surface salinity

The equation was rearranged to calculate the unknown flow coming in from the Chesapeake Bay. The salinity values were taken from 1981 averages at station XCF9575; 0.1 nautical miles from the mouth.

therefore: $$Q_B = \frac{Q_F\ S_p}{(S_B - S_p)}$$

1981 averages of nitrogen and phosphorus concentrations at the surface and bottom were multiplied by the corresponding flow to calculate the mass loads.

Three separate nitrogen budgets were computed and are shown in Figures 5-1, 5-2 and 5-3. Freshwater runoff from the mostly forested and urban drainage basin supplies a major part of the nitrogen. For $NO_2^- + NO_3^-$, 63% of the total load is from fluvial inflow. On the other hand, fluvial inflow contributes only 17% of the total ammonia load. Ammonia's major source is sediment flux. All three nitrogen budgets have an input source contributed from the Chesapeake Bay.

A summary of the nitrogen budgets suggest that the bay and freshwater inflow were major inputs to the Patuxent. The deposition of nitrate and organic nitrogen to the sediment was recycled out as ammonia. There was a lack of data concerning the benthic flux of dissolved organic nitrogen (DON) in the lower estuary (16) and therefore the resulting calculations were probably high for the average flux of total nitrogen from the lower estuary sediment. Comparison of the total pounds of nitrogen loaded into the Patuxent River to the pounds conserved (i.e. average concentrations) suggests that the ecosystem utilizes 65% of the $NO_2^-+NO_3^-$, 92% of the NH_3 and 76% of the total nitrogen.

Two phosphorus budgets were calculated for the Patuxent. The dissolved orthophosphorus (OP) budget and the total phosphorus (TP) budget are presented in Figure 5-4 and 5-5 respectively. The fluvial discharge contributed 66% of the TP with 23% of that being OP. The major source of orthophosphorus was the sediment at 60%. Analysis of the phosphorus budgets suggests that most of the fluvial TP sinks to the sediment as particulate and is then released as orthophosphorus. The ecosystem used 86% of the total phosphorus inputed into the Patuxent and 88% of the dissolved orthophosphorus.

It should be emphasized that the calculated NPS loads were low compared to other studies, as stated earlier. This could have resulted in lower calculations in pounds of nutrient loaded from fluvial discharge. Significant loads of nutrients were inputed into the Patuxent River from the Chesapeake Bay because of low rainfall and low flow conditions recorded during this time period. Yet the hypothesis is the net exchange with the Bay will stay near zero, implying that the Patuxent is an isolated system which must utilize the nutrient loads within its' own ecosystem.

Complete budgets are rare for individual systems such as the Patuxent due to problems inherent in their calculation. For example, biochemical pathways involved in nitrogen and phosphorus cycling are unclear, various nitrogen and phosphorus pool sizes are difficult to estimate, and flux rates may vary seasonally. A better understanding of nitrogen and phosphorus structure in sediments and nutrient fluxes to the Chesapeake Bay are needed for more realistic budgets.

SECTION 6

NON POINT SOURCE AND METEOROLOGICAL WATERSHED MONITORING

The following section describes the chemical export monitored from five small subwatersheds within the Patuxent River Basin. Statistics were used to describe the relationship of rainfall to chemical export or non-point source loads. Measured data was used to estimate yearly loads from the watershed. Comparisons were made to reported non-point source loads by previous investigations. A description of the meterological measurements taken during the study period is presented, along with a general description of the soils in the Patuxent Basin.

Soils Description

The soils for the whole Patuxent River can be broadly divided into those originating from igneous and metamorphic rocks of the Piedmont Province and soils in the coastal plain derived from unconsolidated sediments. Specifically, the Chester series of silt loams dominate the upland Piedmont area. This series is deep and well drained, and underneath this series is a deeply weathered zone of clays and silts derived from weathering of original bedrock. Manor and Mt. Airy series occur on slopes below the upland ridges and this series is found over phyllite and schists. These soils are thin with rock fragments and mica flakes. The manor soils have a danger of erosion due to the fact that they are well drained, and on slopes. In the Patuxent, however, these soils are cultivated extensively. The Mt. Airy soils are more restricted for use for pasture and woodland. In the stream valleys, the Glenelg silt loams which are well drained soils are found highest in the valleys near the break in slope between hillslope and floodplain or terrace. Soils of this series have eroded, however they are still highly productive and extensively cultivated. The flatter valley slopes hold the Glenville and Baille silt loam series, the Glenville series being a combination of alluvial materials and derivation from schist. These areas of the valley may have dense impermeable layers of the Baille series that hinder water movement within the soil, and are only moderately productive. The Baile silt loams, formed in the floodplain and in the upland depressions, are usually left in woodland.

The Glenelg-Glenville-Baille soils persist downstream in the valleys until the stream develops a unique floodplain where overland flow occurs with some regularity (within approximately a mile of the stream). Comus, Codorus and Hatboro soils form in the alluvial materials washed from hillslopes, and are typically found at the foot of slopes bordering the floodplain.

The sedimentary beds of the Coastal Plain province reflect an abrupt change in composition, characterized by the Beltsville-Chillum-Croom association in the fall zone. Areas are underlain by red clays; mantles of sand or silt (the Christiana loams and clays) and fine sandy sediments. The Sassafras soils are widespread throughout this region in upland and level terrain that is well drained and under extensive cultivation, as well as residential and industrial use. The soils of the Coastal Plain valley bottoms do not have a clear demarcation at the fall zone. South of the fall zone, Comus soils associated with Codorus and Hatboro series occur in the floodplains. These soils are frequently associated with areas of flooding, recreational and wildlife reserve areas. Locally derived alluvial deposits form members of the Bibb series in stream valleys. These are deep silty or sandy loams that frequently show poor drainage due to underlying clay layers, flat topography and a swampy environment. Much of the drainage as in the Coastal Plain is swampy. Standing water may persist in the floodplain a week or more after a rain. These areas form unique habitat for various forms of wetlands wildlife (22).

Subwatershed Descriptions

Five watersheds were identified for monitoring chemical export during storm events. Three of these watersheds lie in the Coastal Plain Province and the other two watersheds are located in the Piedmont Province, particularly within the Cattail Creek Basin of the Howard County Soil Conservation District. Figure 6-1 indicates the location of the watersheds monitored during this study. Table 6-1 indicates the landuse, size of the watershed and the monitoring station number. The Patuxent Park site drains into the Black Walnut Creek forested watershed. This site has not been disturbed within the last 40-50 years, and thus serves as an excellent reference for historical forested chemical export estimates. Access to this site was granted by the Maryland National Capital Parks Commission. The two agricultural watersheds on Route 258, Deale, Maryland are basins previously studied by Correll and Dixon, 1980, of the Smithsonian Institute, Chesapeake Bay Center for Environmental Studies (32). Two years of NPS monitoring data (1977-1978) existed at these sites and this program thus continued data collection at these sites. These are mixed agricultural watersheds. Predominant crops are corn and tobacco. Land use data and physiographic characteristics of these sites has been previously reported by the Smithsonian Institute.

The two Piedmont Province watersheds lie in the Cattail Creek watershed, and area indentified by the Howard County Soil Conservation District 208 planning program as a critical environmental watershed. These two watersheds serve mixed agricultural (field corn and pasture) land uses. Z-Farm is predominately made up of hydrologic soil group B soils and G-Farm, hydrologic soil group A soils.

Z-Farm is approximately 55 acres in size, and the Howard County Soil Conservation District (HCSCD) indicated that the 1981 crop year and land uses were predominately a mixture of alfalfa, pasture, hay, grain corn, silage corn and barley with a 1.3 acre homestead area. This site repre-

sents a dairy operation, with convential tillage practices, drill planting operations as well as no-till tillage. Figure 6-2 shows the soil map for this site.

Table 6-2 shows the Soil Survey data and interpretations made by the Howard Soil Conservation District (HSCD) for this site and the G-Farm subwatershed (33). The Glenelg Soil series have a high soil moisture capacity, are well drained and deep and strongly acid. If well managed they are highly productive with the main limitation being soil erosion. The native vegetation consists of mixed upland hardwoods, and the soils form from weathering of crystalline rocks containing mica. The Glenville series are moderately productive, moderately well drained, strong to extremely acidic, have a fragipan and occur on flats, in depressions and at the foot of slopes. They are formed from micaceous rocks and in alluvium, with native vegetation of tolerant hardwoods. The fragipan impedes drainage, limits the available moisture capacity and restricts root developments. The Manor series consists of deep, well drained soils located on level or steep uplands. They are formed from micaccous rocks and mixed hardwoods are their natural vegetation. They have a thin surface layer with soft rock fragments or gravel in some areas near the surface. They have a high moisture capacity, acidic to very acid and are susceptible to erosion. The Mt. Airy series are also moderately deep, strongly acidic and excessively well drained soils whose native vegetation is mixed hardwoods. They have a low to moderate capacity for soil moisture and moderately productive. The depth to bedrock is approximately 30 inches and the hazard of erosion is quite high.

Universal Soil Loss Equation (USLE) Factors were developed for these two sites by the HSCD. Use of the factors for the G-Farm site (e.g. R=175, K=0.26, LS = 1.67, L=200, S=0.09, P= 0.00, C=0.158) yielded a calculated present loss of sediment at 9.6 ton/acre/year with T=2.75 ton/acre/year. Application of the USLE to the Z-Farm site (e.g. R=175, K=0.34, L=300, S=0.06; LS=1.17, P=0.5 (strip cropping) C=0.07) yielded an estimated present loss of sediment at 2.44 tons/acre/year with T=3.0 tons/acre/year.**

On the Z-Farm subwatershed hydrologic soil group B conditions were good, with a total of 49.7 acres and hydrologic group A soils totalling 5.4 acres. G-Farm had 2 acres of hydrologic group C soils, 7 acres of group B soils and 25 acres of group A soils. The average weighted watershed slope was 9% for G-Farm and 6% for Z-Farm. The weighted SCS runoff curve number for G farm was 61 and 70 for Z-Farm. Use of the Soil Conservation Service peak discharge rate method, i.e. Technical Release 55, yield 35 cfs/inch of runoff, an adjusted 39 cfs/inch of runoff and adjusted peak discharge of 29.8 cfs/inch of runoff at G-Farm. Table 6-3 shows the peak discharge for

---

**The sampling site was located within a pasture with cattle access which probably disturbed sediment transport during storm events.

various rainfall frequencies or storms for these two sites for comparative purposes. Table 6-4 shows the detailed cropping or land utilization during the 1981 sampling period for Z-Farm and G-Farm.

Figure 6-3 shows the general land use pattern obtained by the Smithsonian Institute for the Deale A and Deale B sites and reported in 1978. Detailed land use analysis for these watersheds were not obtained, compared to the excellent information obtained at the Z-Farm and G-Farm sites. Table 6-5 indicates the exact location of the monitoring sites and rainfall gauges.

Statistical Summary of Measured Chemical Export

A total of 116 samples were taken at the NPS stations; 102 were storms and 14 were base flow. Of the total samples, 87 were from the agriculture sites (77 storm, 10 base). Patuxent Park - 25 storms and 4 base flows; Deale A - 31 storms and 3 base flows; Deale B - 24 storms and 4 base flows; Z-Farm - 16 storms and 3 base flows; and G-Farm - 6 storm samples. Storm loads were calculated by multiplying the resulting flow proportional concentration (mg/l) times the volume of water passing the flow measuring device from the beginning of the storm to the end of the storm as determined by the stream hydrograph. The load was divided by the number of acres yielding lb/acre for each monitored storm event. The average lb/acre per storm event was calculated and the results are shown in Table 6-6 thru 6-12.

Another simplistic approach for estimating chemical export is to calculate the mass loading per acre during the storm, as indicated above, and divide the load by the size of the storm event, i.e. inches of rain. The resulting (lb/acre/inch) value can then be used to calculate estimated loads from the monitored watersheds given seasonal rainfall estimates and/or frequency of occurrence of storm events. Tables 6-13 thru 6-19 present the statistical summaries of chemical export calculated in this manner. The lb/acre/in mean value was used to estimate the lb/acre/year export by multipying by 42 inches of rainfall per year. The results from this calculation are shown in Tables 6-20 through 6-26.

The data collected during this study indicate that agricultural watershed chemical export is on the average three times greater than forested areas (see Table 6-27). Specifically total suspended solids, representing potential sediment transport from agricultural land is nearly five times greater than forested land. The average water quality variable exports at agricultural sites tend to be greater than forested areas by a factor of 2, except nitrite. Total phosphorus chemical export from agricultural land was approximately 6.8 times greater than the forested site. Total

---

Note: the average "C" factor for this crop year was elevated abnormally due to the farmers trial use of soybeans and sorghum following a barley harvest.

inorganic nitrogen is approximately 3 times higher for agricultural land. Total organic carbon is greater by a factor around 2.5 and biochemical and chemical oxygen demand is greater by a factor of 2.3 to 2.7. Total dissolved nitrogen is approximately 1.1 to 1.3 times higher from agricultural land than forested land assuming the sampling was representative. A comparison of data published from other chemical export studies indicate that nitrate is generally higher from agricultural land, indicating the Patuxent Park site may not be a typical site for nitrate export measurements, however other nutrient parameter comparisons are similar to ranges reported in the literature (34, 35). The nitrate (NO_3^-) plus nitrite (NO_2^-) comparison indicates the total nitrite plus nitrate export is probably representative. It is believed that the NO_2^- values are not representative but $NO_2^-+NO_3^-$ observations are valid.

Comparison of Estimated Storm Loads from the Patuxent River

The statistical summary of data presented in the previous subsection and reported published literature was used to estimate potential chemical export from the Patuxent River Basin surface to waters during storm events. Table 6-28 shows the potential watershed export of total phosphorus to the river during storm events using the loading rates developed from this study for forested and agricultural land. The total estimated potential load of total phosphorus from agricultural land utilization is 532,813 lbs/year. Approximately 104,131 lbs/year from forested land. This table also indicates the potential load from other land uses of 37,574 lbs/year of total phosphorus. These estimates indicate agricultural land contributes 79% of the NPS load, 15% from forested land and approximately 6% from other land uses. Other researchers and agencies have shown similar trends (28).

Table 6-29 shows the estimated potential total nitrogen from loading rates developed from this study. These sites indicate total nitrogen of approximately 654,962 lbs/year from agricultural land or 30% of the estimated total and 12% from forested land. Data developed by the Maryland Department of State Planning (28) indicate that other land uses contribute 328,287 lb/year of total nitrogen or approximately 58% of the total nitrogen load. It should be noted that these are estimated from the average loading rate discussed in the previous subsection and may be low. Calculation of the total nitrogen loading using the upper range of the standard deviation of the mean total nitrogen loading rate (6.9297) for all agricultural sites monitored in this study indicates agricultural lands may contribute around 1,425,737 lbs/year of total nitrogen. Use of the upper range of the agricultural loading rate indicates, from data in this study, that agricultural land may indeed contribute approximately 71% of the total nitrogen from the land surface to the river system and thus 13% from forested areas and 16% from other land uses. This latter estimate using data solely from the Patuxent River Basin indicates agricultural loads of total nitrogen are close to other estimates (28).

Total organic carbon from agricultural land use, using a loading factor of 25.779 lb/acre/year indicates an estimated 5,303,849 lbs/year. Forested land may contribute on the order of 2,754,899 lb/year, with a loading rate of 10.1009 lb/acre/year.

Rainfall Runoff Statistical Relationships

Least square linear regression was applied to chemical export data from the five subwatersheds monitored for this study. Regressions were performed using the lb/acre/inch of rain (dependent varible) and stream flow in gallons (independent variable) from the storm event monitored at each site and all sites combined. Logarithmic transformations were performed on the dependent and independent variables above, and the resulting best regression equation was selected based on the regression coefficient (r). These equations are shown in Table 6-30.

Least square regression was also applied to lbs/acre (dependent variable) chemical export versus total rainfall and various linear combinations of total storm rainfall and average or maximum storm intensity. Logarithmic transformations were also performed on the dependent and independent variables and the best regression equation was selected based on the regression coefficient (r). The results of this analysis are shown in Table 6-31.

Regressions were also performed with lb/acre chemical export (dependent variable) versus flow in gallons and combinations of factors which normalized storm flow to size of watershed (acres), total inches of rainfall and maximum intensity of rainfall during the storm. Logarithmic transformations were made on dependent and independent variables. The results of this regression analysis is presented in Table 6-32 showing the selected regression equation based upon the highest regression coefficient (r).

Comparison of these least squares regression results indicate that BOD_5 and BOD_{30} is strongly dependent upon storm flow at each site. Highest regression coefficients were obtained by combining data from all sites and normalizing flow to the size of the storm, i.e. total rainfall. Total suspended solids (TSS) correlations were generally higher when lb/acre was regressed against flow. TSS versus total rainfall times maximum storm intensity (TRF*MINT = dependent variable) was greatest at the Z-Farm watershed, indicating rainfall processes affected chemical export more than stream transport processes from this site. Nitrate plus nitrite (lb/acre) regression indicates very good correlations with increased flows. The same is true for ammonia, with the Deale B site yielding the highest coefficient. TKN and dissolved TKN show good correlations. It is interesting to note that gallons normalized to the size of the storm may be a better predictor of total phosphorus at Deale A. All other variables were highly correlated to stream-flow as expected.

Multivariate regression techniques were applied to the data collected from these sites. It was not uncommon for squared multiple correlations above 0.9 (see table 6-33 and 6-34). Although discrete sampling over a hydrograph or storm may yield excellent detailed storm characterization, the lb/acre versus flow or stage correlations obtained from flow-composite sampling as conducted in this study provide excellent data for estimating storm loads. The results of the multiple regression (i.e. high r^2) analyses also indicates that calibration of hydrological simulation models at these sites will probably yield excellent loading information, especially at the Deale A, Deale B and Patuxent Park Watersheds. Due to limited sample collection at the G-Farm site and Z-Farm site, and associated lower correlations, the confidence of results from a hydrologic simulation model will be less.

The Howard County Soil Conservation District estimated the existing soil loss with the Universal Soil Loss Equation (USLE) on Z-Farm and G-Farm subwatersheds. Using their results and the monitoring results one can calculate a potential gross sediment delivery rate for use with the USLE. The estimated average sediment delivery ratio at Z-Farm is estimated to be 14.6E-03 with a maximum of 42.3E-03 and estimated minimum of 4.84E-03. At G-Farm, an average of 22.1E-03 a maximum of 44.9 E-03 and minimum sediment delivery ratio of 20.9E-03 is indicated.

Meteorological/Rainfall Analysis

Bulk precipitation measurements were made from the Patuxent Park subwatershed. Concentrations were measured from 26 storms and the data are shown in Tables 6-35, 6-36, 6-37 and 6-38 along with the size of the rainfall event in centimeters of rain. Loading rates calculated from this data are as follows: TOC=30.59 kg/ha/inch of rain; $NO_2^-+NO_3^-$=137.952E-3 kg/ha/inch of rain; TKN=359.229E-3 kg/ha/inch of rain; and TP=36.836E-3 kg/ha/inch of rain.

Storm analysis indicate that at the five subwatersheds monitored for chemical export, no storm was larger than the 1 year storm or with a probability of occurrence less than 100%. This indicates quite clearly that storm runoff monitored during this study represents average size storms. The largest storm where quality data was taken from the subwatersheds was 2.48 inches. Based upon rainfall frequency data, a one year storm (100% probability of occurrence) is equal to 2.6 inches of rainfall; a 2 year storm (50%) is 3.2 inches; a 5 year storm (20%) is 4.2 inches; a 10 year storm (10%) is 5.1 inches; a 25 year storm (4%) is 5.6 inches; a 50 year storm (2%) is 6.3 inches; and a 100 year storm (1% chance or probability of occurrence) is equal to 7.2 inches of rainfall.

SECTION 7

DESCRIPTION OF LONGITUDINAL SLACK SURVEY RESULTS

The following is a description of the results of slack water surveys. Seventeen slack water surveys were conducted from 6-25-80 to 8-13-81 as described in Section 2.

Slack tide salinity profiles are shown in Figures 7-1 and 7-2. The extent of the idealized salt wedge and the expected area of the turbidity maximum region can be seen in these Figures. These depth averaged salinity profiles show that the salinity wedge decreases to nondetectability between nautical mile 30-40. Stratification was dominant in the lower and mid estuary stations, with the bottom layer being more saline. Occasionally an inversion occurs which causes the surface layer to have higher salt concentrations as seen on 3-19-81, 6-25-81 and 7-28-81. Around nautical mile 15 to 20 the extent of vertical stratification decreases substantially in almost all slack survey as shown in plots in Figure 7-3. Table 7-1 shows the salinity statistics for the slack surveys. Average salinity in the river observed during this study was 10.32 ppt. The increase in salinity observed throughout the river from June 1980 to July 1981 is due to the below average rainfall during the study period. Comparing the slack survey salinity results to historical data indicates that, on the whole, the salinity levels are low. Historical data of salinity at the mouth of the estuary yield a mean of 20.7 ppt $\pm$ 6.5 ppt. Data collected during this study period ranged between 10.5 to 20 ppt with an average of approximately 16.4 ppt at the mouth of the estuary.

Temperature profiles are presented in Figure 7-4. The largest surface to bottom temperature differences are observed in the lower estuary as expected. Differences between the upper and lower layers increased in late spring, to their maximum in June and July and decreased again in August. Average temperatures for the river were 20.9 $\pm$ 6.7^{o}C with minimum and maximum values of 4 and 33.1^{o}C respectively.

Figure 7-5 shows longitudinal values of pH. Values higher than 8 were observed at mid-river in July 1980 and in the lower estuary in April and June 1981. The lowest values were observed mid-river in August, 1980 and in the upper river in September 1980, approaching a pH of 6 between nautical miles 35 to 52. Average pH observed during the study period was 7.4 $\pm$ 0.56 with a minimum of 6.1 and a maximum of 9.4. The March, 1981 values are critical since these upstream values may not be conducive to the success of spawning finfish. Further evaluation of pH in the river may be

warranted in order to determine the extent and duration of any pH problem in the estuary, especially during the spring during and after the spawning period of fish.

Figure 7-6 plots show the results of Secchi disc measurements. These values indicate that in the expected turbidity maximum region the light penetration reaches an average minimum of 0.1 meters. The July 1980 survey indicated that a substantial area in the river received very little light penetration as measured by secchi disc. Phytoplankton and related measurements taken at approximately the same time and location showed a very heavy inorganic detritus load as well as the largest number of species of phytoplankton and total cells/ml of water. Diatoms and Blue Greens were the dominant species in this region followed by total Cryptophytes and Crysophytes. Also during this survey, the highest water temperatures were observed and pH above 8 was observed in this region of low secchi measurements. Dissolved oxygen was below 4 mg/l and up to 8 mg/l with associated DO saturation from 45% to 100%. Additional observations could be made concerning other nutrient parameters, however the above observations are made to show how secchi disc can be a good indicater of phytoplankton blooms and high organic and detrital concentrations in ambient estuarine water.

The Dissolved oxygen plots shown in Figure 7-7 indicate, as expected, greater surface to bottom differences in the lower river, especially during the July 21, 1980 survey, at which time dissolved oxygen at the bottom of the lower estuary was approximately 1-2 mg/l. It is interesting to note that during every slack survey the surface to bottom variation at the station (XCF9575) nearest the Chesapeake Bay was not as stratified as expected. During several surveys in the summer and early fall months, there was very little stratification. In several surveys increased DO was observed in the turbidity maximum area relative to upstream and downstream values. This phenomena is probably related to the greater primary productivity and mixing phenomena. Average river DO during 1980 and 1981 was 7.5 $\pm$ 2.61 and 7.09 $\pm$ 2.45 mg/l respectively. Average mid-depth DO at upriver stations was 6.54 $\pm$ 1.55 and 7.19 $\pm$ 2.44 mg/l during 1981 and 1980 respectively. Lower river bottom DO averaged 7.22 $\pm$ 2.87 and 6.91 $\pm$ 2.89 mg/l during 1980 and 1981 respectively.

Figure 7-8 shows the calculated dissolved oxygen saturation (DOS) profiles for the slack water surveys. During June and July of 1980 supersaturation of dissolved oxygen was observed. Supersaturated waters are observed mid-river in September and November of 1980, however stratification is lower. 1980 and 1981 slack survey data indicate average DOS of 82.9 $\pm$ 21.1% and 79 $\pm$ 19.7% respectively. Mid-depth samples taken at the upper river stations indicate lower than average DOS 72.6 $\pm$ 14.7 in 1980 and 69.6 $\pm$ 12.9 in 1981. D.O. saturation during the study period ranged from 5 to 146%.

Slack tide longitudinal profiles of dissolved nitrate are shown in Figure 7-9. As expected, concentrations are higher up river, especially above mile 35 where salinity is not detected. Decreasing lower river concentrations are probably due to dilution of freshwater with Chesapeake

Bay water, although a potential mid-river source is indicated by an upper river peak on occassions. This peak is at the station below Western Branch. Highest concentrations in the upper river were observed during the August, September and October 1980 surveys, when rainfall had been minimal for several months. Average nitrate for the river during the study period was 0.61 $\pm$ 1.04 mg/l. Nitrate values at the upper river, mid-depth stations yield a 1980 and 1981 mean and standard deviation of 2.64 $\pm$ 0.82 and 2.24 $\pm$ 0.49 mg/l respectively. Very little stratification was observed in the longitudinal profile. Estuarine bottom depth observations indicate a mean of 0.21 $\pm$ 0.38 and 0.56 $\pm$ 1.94 mg/l for 1980 and 1981 respectively. Surface observations in the estuary indicated a mean of 0.21 $\pm$ 0.39 mg/l for 1980 and 0.47 $\pm$ 0.94 mg/l in 1981.

Figure 7-10 shows low concentrations of dissolved nitrite as expected during the longitudinal slack surveys. Similar to nitrate, nitrite is higher in the upper tidal river section. In several cases a mid-river peak of NO_3^- is observed, indicating a potential source in the vicinity of Western Branch and the turbidity maximum area of the river. As was also noticed for nitrate (NO_3^-), there were very low measurements for nitrite (NO_2^-) in the lower estuary. The exception occurred on August 20, 1980 when nitrite had increased concentrations and stratification in the lower estuary. Mid-depth samples taken at the upper river stations indicate an average of 0.14 $\pm$ 0.12 and 0.15 $\pm$ 0.08 mg/l during 1980 and 1981. Surface values in the estuary are much lower, i.e., 0.01 $\pm$ 0.02 mg/l in 1980 and 1981. Bottom mean values were highest in 1980 (0.2 $\pm$ 0.02 mg/l). In 1981 the bottom water average was 0.02 $\pm$ 0.02 mg/l.

Longitudinal plots of dissolved ammonia shown in Figure 7-11 also indicate higher upper river mid-depth concentrations. These figures as well as statistical analyses indicate that bottom waters on many occasions are higher than surface values as expected. A mid-river source or peak concentration is observed on several occasions in the upper estuary. Stratification of ammonia is greater than observed stratification of NO_2 or NO_3, probably due to sediment flux of ammonia to the water column. On several occasions these plots indicate concentrations at the mouth of the estuary are higher than the lower estuary, indicating the intrusion of Bay water as a source of ammonia to the lower estuary. Bottom average values during 1980 and 1981 were 0.10 $\pm$ .19 and 0.13 $\pm$ 0.19 mg/l respectively. Concentrations are generally lower at the surface as expected, with 0.06 $\pm$ 0.09 and 0.12 $\pm$ .20 as the average concentrations during 1980 and 1981. Mid-depth values at the upper river stations averaged 0.63 $\pm$ 0.63 in 1980 and 0.59 $\pm$ 0.48 in 1981. All data for intensive and slack surveys indicate surface and bottom values differ by an average of 0.03 mg/l ammonia.

Total particulate nitrogen (TPN) concentrations observed during the slack surveys (Figure 7-12) do not indicate consistently higher concentrations at mid-depth stations in the upper river. In fact, in all but one survey TPN concentrations are higher in the middle portion of the estuary where relative flushing time is greatest. These concentrations are representative of nitrogen fixed in organic material and with primary producers and as such indicate high densities of algal cells. TPN

concentrations near 0.9 mg/l occur quite often in the estuary. During August 20, 1980 TPN in the middle estuarine zone exceeded 3 mg/l. As expected, surface TPN is usually higher but there is not a consistent trend. TPN during several surveys are higher at the surface and bottom depths near the mouth of the estuary, indicating a potential source.

Figure 7-13 shows the dissolved kjeldahl nitrogen measured during the 1980-81 study period. Upper river stations indicate higher concentrations. These concentrations reflect the ammonia and organic nitrogen forms in the river. No consistent trend is observable in the estuarine zone except that it is not uncommon for maximum concentrations to shift between bottom and surface waters.

Figure 7-14 shows the dissolved organic nitrogen values. These values provide insight into the river in that concentrations of dissolved organic nitrogen are much lower, on the average, in the upper tidal river. This indicates that either the Chesapeake Bay is a source of organic nitrogen or that other inorganic nitrogen is being utilized to produce living organic matter, whose composition is made of organic nitrogen. Since Chesapeake Bay waters are not consistently higher in TON at the mouth of the river, it could be easily concluded that the lower and middle estuary is a very productive portion of the estuary for conversion of organic nitrogen to inorganic nitrogen. This hypothesis is substantiated by a review of TPN concentrations in the middle and lower rivers where it can be seen that the TPN peak concentrations are associated with TON peak concentrations. The dissolved organic nitrogen peaks could be a result of high cell densities of primary producers smaller than 0.45 um. In fact, the July 21, 1980 concentration profile follows the same trend of increasing numbers of total phytoplankton cells/ml observed during the same time period, and the general trend of cells/ml of unidentified 1.5-2 um coccoid species.

Total organic carbon was only analyzed for the first five survey dates (June 25, July 21, July 28, August 20 and September 15, 1980). The highest TOC value occurred on August 20, 1980 when total particulate nitrogen was at its maximum, at the surface, during the study period. At this same time DO stratification was greatest at the same location during the survey with surface DO near 8 mg/l and bottom DO near 4 mg/l. The pH ranged from 8 at the surface to 6.6 at bottom depth. At the same time, salinity was observed to be greater at the surface, and surface temperature was lower, indicating upwelling of potentially nutrient rich waters (Figure 7-15).

Total particulate phosphorus was also high at this region where mixing of fresh and salt water is expected to be greatest (see Figure 4-14) and as seen by a peak in relative retention time (see Figure 4-15). Nitrogen (in the forms of nitrate, nitrite and ammonia) does not show a peak in this portion of the river, but dissolved phosphorus does, indicating that phosphorus adheres to the suspended solids. Ortho-phosphorus and ammonia show a general trend of higher concentrations at the stations where the turbidity maximum is, supported by high pheophytin-a concentrations. More interesting is the fact that the longitudinal plot of silica has a minimum where the peak TOC occurs.

Plots shown in Figure 7-16 show the concentrations of total phosphorus observed during the slack surveys, with higher concentrations in the headwaters as expected. Mid-river peaks of total phosphorus values were observed indicating a source upstream potentially due to biological conditions and/or due to mixing in the turbidity maximum area of the river. Average total phosphorus values at the surface and bottom depths were approximately the same on the average. 1980 and 1981 surface total phosphorus values were 0.10 mg/l and 0.11 mg/l respectively. Bottom depth total phosphorus values averaged 0.10 mg/l and 0.13 mg/l. Mid-depth stations in the upper river showed a mean and standard deviation of 0.41 $\pm$ .32 mg/l and 0.28 $\pm$ .18 mg/l in 1980 and 1981 respectively. Higher concentrations up river in 1980 are probably due to relatively constant point source inputs and groundwater recharge during this low flow period.

Total particulate phosphorus survey plots, shown in Figure 7-17 follow a general trend of decreasing concentrations from the headwaters to the mouth of the estuary. During several of the surveys a distinct mid-river peak of TPP was measured. This peak occurs in the vicinity of nautical miles 23-35, an area of the expected turbidity maximum and where bottom topography (see Figure 4-9) would indicate potential upwelling of Chesapeake Bay water and associated particulate matter. This peak may occur due to tidal forcing functions and high freshwater inflows which probably resuspend particulate organic matter and associated nutrients. Bottom TPP concentrations are generally higher throughout the river. Higher concentrations at the mouth of the estuary do not necessarily indicate the Chesapeake Bay as a potential source of total particulate phosphorus.

Figure 7-18 plots of dissolved total phosphorus, during slack surveys, indicate higher upstream concentrations. Concentrations at the mouth of the estuary do not indicate Chesapeake Bay waters as a source of dissolved phosphorus. Mid-estuary maximum concentrations were detected on several surveys in the vicinity of the turbidity maximum where upwelling of bottom waters potentially rich in dissolved phosphorus would be expected to occur. Surface concentrations of dissolved phosphorus were, on the average, slightly higher than bottom waters by 0.01 mg/l during 1980 and 1981. Great stratification of dissolved phosphorus is observed usually in the mid-estuary. Average upstream mid-depth values during 1980 and 1981 were 0.41 $\pm$ 0.32 and 0.28 $\pm$ 0.18 mg/l respectively. Average up river mid-depth concentrations were higher in 1980 by 0.13 mg/l, probably due to decreased rainfall during 1980. Bottom depth concentration average and standard deviation during 1980 and 1981 were 0.03 $\pm$ 0.02 and 0.02 $\pm$ 0.02 mg/l respectively. Average surface concentrations were 0.03 $\pm$ 0.02 mg/l in 1980 and 0.02 $\pm$ 0.02 mg/l in 1981.

Dissolved ortho-phosphorus trends were similar to dissolved phosphorus concentrations (see plots in Figure 7-19). Concentrations decrease downstream and only show occasional higher concentrations at the mouth of the estuary, with a general trend of increasing values in the mid-estuarine zone. Stratification was not observed often. Surface and bottom concentrations show identical average values of 0.02 $\pm$ 0.02 mg/l in 1980 and

1981. Again, mid-depth samples taken up river indicate higher average concentrations in 1980 (0.44 $\pm$ 0.32 mg/l) and lower concentrations in 1981 (0.27 $\pm$ 0.18 mg/l) or concentrations in 1980 were higher, on the average, by 0.17 mg/l. Thus, it is apparent that during low flow conditions, ortho-phosphorus increases more than total or dissolved phosphorus concentrations. This could be critical for the river since ortho-phosphorus is the form of phosphorus readily used by primary producers.

The slack tide profile of total nitrogen to phosphorus ratios are shown in Figure 7-20. In almost all slack water survey plots there is a trend for phosphorus limitation at the mouth of the estuary. At approximately nautical mile 16 the data indicates a trend of nitrogen limitation. The system shifts again towards phosphorus limitation in the turbidity maximum area of the river where productivity was highest. The upper river then appears to shift again towards a nitrogen limited environment. A mid-river peak in concentrations was observed during several slack water surveys. A more detailed analysis of these profiles, described later, indicates an association of total N-P longitudinal profiles to antecedent rainfall-runoff events. Figure 7-21 shows longitudinal plots of the redfield ratio (dissolved $NH_3^+ + NO_2^- + NO_3^-$ divided by dissolved ortho-phorphorus). Similar to the total N:P ratio the Redfield ratio has a mid-estuary peak in the area of the turbidity maximum. The September 1980 survey did not show such a pronounced peak. This survey had very low N:P Redfield ratios throughout the longitudinal profile, indicating for that day the river was entirely nitrogen limited. The survey was conducted more than thirty days after the last storm event as evidenced through examination of the Route 50 USGS gauging station hydrograph record. The low flow conditions caused a depletion in orthophosphorus suggesting its source is from freshwater inflow.

Longitudinal plots of BOD_5 are shown in Figure 7-22 and show that surface BOD is higher during most of the study period. Surface BOD_5 average and standard deviation was 3.32 mg/l in 1980 and 3.18 mg/l in 1981. Bottom depth BOD_5 was 1.93 mg/l in 1980 and 2.49 mg/l in 1981. Stratification was more pronounced in the summer. Mid-depth upper river samples showed slightly higher average values of 3.35 mg/l in 1980 and 3.71 mg/l in 1981. Minimum BOD_5 observed during the study period was approximately zero (0.1) and a maximum of around 10 (10.6). The longitudinal trends generally show peak values occurring in the mid estuary between 16-35 nautical miles. Comparison of BOD values during periods when phytoplankton blooms were thought to have occurred shows a relatively good correlation. During most surveys a mid-river peak in the turbidity maximum region was observed.

Limited chemical oxygen demand measurements were observed during a few surveys and results are plotted in Figure 7-23.

Chlorophyll-a plots are shown in Figure 7-24. It can be seen that chlorophyll-a values are almost always low in the upper river. Mid-depth upper river values indicate average and standard deviation of 14.83 $\pm$ 17.8

ug/l and 20.72 ± 19.34 ug/l during 1980 and 1981 respectively (uncorrected for presence of pheophytin); 11.96 ± 15.62 ug/l in 1981, corrected for presence of pheophytin. Surface values averaged 30.92 ± 60.58 ug/l in 1980 and 26.72 ± 17.2 ug/l in 1981 (uncorrected). Bottom depth chlorophylls averaged 11.71 ± 13.57 ug/l in 1980 and 22.40 in 20.40 in 1981 (uncorrected). Corrected values at the surface indicated an average of 20.42 ± 15.15 in 1981 and 11.96 ± 15.62 at bottom depths in 1981. Mid-river peaks are apparent in the turbidity maximum area and lower regions of the estuary.

Pheophytin-a values for 1980-1981 indicated mid-estuary peaks in bottom waters throughout the study period. The upper two stations indicate a reduction of concentration due to dilution. Most of the time, however, at river miles 23-35 there is a consistent peak in concentrations (in the turbidity maximum area). Values were higher, in general, in 1981, with a mean of 9.5 and standard deviation of 16 ug/l. Bottom water concentrations in 1980 were 5.52 ± 5.38 ug/l. Surface values averaged 4.1 ± 13.4 ug/l in 1980 and 5.8 ± 7.6 in 1981. Mid-depth upper river samples averaged 4.72 ± 3.87 ug/l in 1980 and 5.52 ± 5.6 ug/l in 1981. During the study period pheophytin ranged from zero to 100 ug/l (see Figure 7-25 plots).

Figure 7-26 shows dissolved reactive silicate. It can be seen that concentrations decrease until mile 35 in all but four surveys. During these surveys the decrease is not at substantial in the turbidity maximum region. In almost all surveys there is a lower river peak in silica concentrations. Silica concentrations were higher at the mid-depth tidal river stations (1980 - 4.3 ± 2.15 mg/l; 1981 - 2.82 mg/l). Lower estuary samples averaged 4.30 ± 2.15 mg/l at the surface and 4.77 ± 2.7 mg/l in bottom waters in 1980 and 3.31 ± 2.82 and 3.58 ± 3.27 mg/l in surface and bottom waters in 1981.

Seston or total nonfilterable residue longitudinal plots (Figure 7.27) indicate peak mid-river concentrations in the region of the turbidity maximum. In some cases two peaks are observed in the river which may reflect phytoplankton blooms. As expected, residue is higher in bottom waters (1980 - 40.78 ± 34.18 mg/l; 1981 - 61.04 ± 82.71 mg/l) and surface and mid-depth samples were approximately the same on the average (Surface: 80 - 34.27 ± 17.91 mg/l; 1981 - 34.27 ± 17.91 mg/l Mid-Depth: 22.8 ± 11.48 mg/l and 40.78 ± mg/l in 1980 and 81 respectively).

Table 7-1 shows the mean, standard deviation, standard mean error and coefficient of variation for the 1980-1981 slack tide surveys. Table 7-2 shows the same survey data by years and depth range for the slack tide station surveys.

SECTION 8

TEMPORAL VARIATION OF WATER QUALITY VARIABLES

The following is a discussion of the temporal variability of water quality variables observed in the Patuxent Estuary from 1980-1981. Figures 8-1 through 8-20 are plots containing both the intensive and slack water survey station concentrations, with surface, bottom, and average values as well as the maximum and minimum values observed during the 24 hour intensive surveys shown. From these plots one can determine potential seasonal trends. It can also be determined how data collected during a twenty-four hour survey, i.e. minimum and maximum values, compare with the limited number of observations (2 samples) collected during the slack tide surveys at a given station. These graphs show that variability of chemical constituents can be substantial during a 24 hour period, and that slack water data collected on one day should be interpreted as representing the station monthly trend at a particular station location only within an order of magnitude.

Salinity plots are shown in Figure 8-1 and show low summer and early fall values due to low rainfall during this period. The up river stations do not show as great a difference between the 1980 and 1981 data. It can be seen that stratification or the minimum and maximum value observed during the April 1981 intensive survey is much greater than the rest of the year. This greater range between maximum and minimum values could have been a result of stratification due to freshwater inflow from a storm event that occurred before the survey.

The temporal plots of temperatures are shown in Figure 8-2. The plots indicate that during the summer temperatures were slightly higher in 1980. As expected, the temperature range observed during the intensive surveys were greater. Surface to bottom temperature differences seldom exceeded 1 to 1.5°C during the slack survey.

The pH plots in Figure 8-3 do not indicate any significant seasonal trend. In fact the range is so large at many stations during the intensive surveys, one might question the ability to approximate seasonal pH at a given station using the slack tide data. For example, the range observed during July 1980 intensive survey at station XED4892 (mile 25.5) is larger than the seasonal trend for the year. This is not the case however at station XED9490 (mile 30.6), where the range of pH values are comparatively quite small for the entire study period. It can also be observed that the pH range is smaller in the upper river when compared to the lower river.

Temporal plots of secchi disc (Figure 8-4) in the lower river stations show a marked reduction of secchi depth during the summer months. This is due to an increase in algal growth. The mid estuary stations, especially station PXT0402 at nautical mile 35.2, shows consistently low values. From nautical mile 25 to 40, (where the turbidity maximum region lies) the Patuxent River experiences minimum light penetration throughout the year. The upper estuary follows the same pattern as the lower estuary with good visibility in the spring and winter and low values in the summer.

Figure 8-5 shows the temporal variability of dissolved oxygen. As expected, low summer concentrations are observed. The lowest values observed during the study period are in the lower river at stations XDE5339 (mile 13.9) and XDE9401 (mile 19.9) where estimated flushing times are greatest. It can be seen that the range of values observed during summer months is much greater due to increased biological interactions and temperature effects on oxygen solubility. The July average dissolved oxygen in the lower estuary was 5.0 $\pm$ 2.0 mg/l. During August the middle estuary showed lower average values in the 3.1 to 10 ppt salinity range (5.1 $\pm$ 1.1 mg/l) during the study period. The average D.O. at XDE9401 during 7/24/80 was 4.89 $\pm$ 2.46 with a minimum value of 1.5. The coefficient of variation was 113 with a standard mean error of 0.58 during this intensive survey. Four days later a slack survey indicated a mean D.O. of 6.4 $\pm$ 0.35, and coefficient of variation (CV) of 5.5 at the same station. It can be seen from analysis of this station that slack surveys provide quite different results concerning the D.O. conditions in the estuary. If one is interested in determining statistically valid D.O. conditions in the lower estuary, detailed sampling is needed.

Mid-depth dissolved oxygen in the upper river indicates minimum values occur around 4.4 mg/l. The twenty four hour variability at these stations are much less than expected, however D.O. variability increases around nautical mile 42.9 (station PXT0494) above Western Branch. Jug Bay (PXT 0455) station data is not as low as expected. The CV at PXT0455 during the study period was however higher than the other two up river stations for DO. Average DO was lower at the Rt. 50 station (5.7 $\pm$ 1.36; min 4.1; max - 10.39) when the upper stations are compared.

Dissolved oxygen saturation (DOS) was highest in March (100.9 $\pm$ 5.9%) and April (94.8 $\pm$ 11%) and plots are shown in figure 8-6. July DOS was 66.9 $\pm$ 26.9% in the salinity zone greater than 10 ppt salinity. At the upper river stations, mid-depth samples show Jug Bay waters have a higher saturation (78 $\pm$ 12%) and at Rt. 50 (PXT0603) saturation is lower (61 $\pm$ 8%). Maximum D.O. saturation in the upper river occurred at Jug Bay (104%). The Rt. 50 station maximum was 81%. The greatest saturation was observed at the station on Western Branch (min-58%, max-146%). The station with the greatest DOS variance was XDE2599. The data collected during the intensive river surveys again show the large diurnal variance when sampling occurs over a 24 hour period. For example, the variance of DOS observed at station XDE2599 during the July, 1980 survey was 635%. A slack survey conducted four days later gives the variance as 28%. This same magnitude

on difference between slack water and intensive river surveys exists at station PXT0603 where the July, 1980 intensive shows a DOS variance of 654% and the slack water survey 4 days later gives a variance of 56%.

Dissolved nitrite values are surprisingly high in the lower river from August through October (see plots in figure 8-7). An obvious nitrite maximum is observed near Benedict from mile 0.1 to nautical mile 19.9. This maximum appeared to peak in late August and is substantiated from both 1980 and 1981 data. In fact, further observation indicates that the peak moves downriver from early August through early September. This movement is somewhat faster than one might expect, due to our early first order estimates of the flushing time in the lower estuary. A nitrite peak was also observed in the mid estuarine zone in the spring of 1981. The two uppermost mid-depth stations also indicate a nitrite peak in the fall of 1980. The peak concentrations observed in the lower and upper river occur during the period of reduced freshwater inflow to the river. Average nitrite concentrations during August 1980-1981 were 0.1 $\pm$ 0.1 in salinity zone 0-3 ppt; 0.02 $\pm$ 0.02 in salinity zone 3.1-10 ppt; and 0.1 $\pm$ 0.03 in the zone greater than 10 ppt.

Data indicate that mid-estuary water samples on August 21, 1980 had the highest concentration (4.3×10^3 Colony Forming Units (CFU)/ml) of Nitrosomonas species at station PXT0402 and sediment samples were highest at mid-estuary stations PXT0455 (4.5×10^5 CFU/gram wet sediment), PXT0402 (3.6×10^5 CFU/gram wet sediment), and XED9490 (7.6×10^5 CFU/gram wet sediment). Nitrobacter species indicate the same similar trend, i.e. where dissolved nitrate concentrations are low, bacteria levels are high. It is hypothesized that high nitrite in the mid-estuary may be a function of microbial-nitrification-denitrification processes.

Figure 8-8 shows that the temporal plots of dissolved nitrate are generally high in the spring and fall months. This trend of decreased levels during the summer is dominant in the mid estuary stations from nautical mile 13.9 to 35.2. Lower estuary stations showed an increase in the spring yet did not indicate a nitrate peak in the fall and early winter in 1980. The last three upriver stations had relatively high concentrations of nitrate throughout the year. The range of values observed during the April 1981 intensive data is quite large. For example, on April 23, 1981 the nitrate C.V. observed during the intensive survey was 48.8 while 4 days later the slack survey data yield a C.V. of zero, thus indicating the extreme variability between the two types of surveys. The lower river (10 ppt salinity region) reached an average maximum of 0.92 $\pm$ 2.2 mg/l. Mid-estuary highest monthly values were observed in May 1981, with a mean of 0.8 $\pm$ 0.3 mg/l. Upper river average values peaked in May, with 1.28 $\pm$ 3.5 m/l.

Figure 8-9 shows the temporal plots of ammonia. The stations near Lower Marlboro (XED9490, 30.6) and up from there indicate fall and spring maximum values. At Benedict (station XED4892) a maximum is observed in the spring of 1981. In the lower estuary below Benedict the concentration of

ammonia remains low with increased levels occurring in the summer. From nautical mile 0 to 20, a summer ammonia maximum is observed. A summer peak is also observed at mile 25.5 above Benedict. The variability of ammonia during the summer in the lower river increases when compared to other months. For example, at salinities greater than 10 ppt the mean and standard deviation is 0.1 $\pm$ 0.1 mg/l during June and July. Observation of the coefficient of variation at the different stations document greater variability in the lower river. This is believed to be a result of ammonia flux from the sediments as indicated from increased summer sediment flux measurements collected for this study. All stations in the estuary exhibit this trend, although upper stations indicate potentially higher spring and fall ammonia maximums.

Total organic nitrogen (TON) (figure 8-10 plots) shows generally higher summer values. Results of the intensive surveys support the view of extreme variability. Upper and lower river concentrations are not substantially different as was the case for inorganic nitrogen.

Calculated total particulate nitrogen (TPN) concentrations are shown in figure 8-11 plots. At Jug Bay (PXT0455, mile 40) a seasonal trend of high early spring and fall concentrations is observed. Variability of TPN is apparently greater in the lower estuary (mile 9). During slack surveys, occasional surface to bottom concentrations range from approximately 0.2 mg/l to 0.8 mg/l. Surface values are generally higher in July and August, however during spring, in the lower river (stations at mile 0 and 9) bottom concentrations are higher. Near nautical mile 13 and 20, the bottom concentrations are higher during the spring. The April 1981 high TPN values at XED9490 may be due to high cell counts of cryptophytes and crysophytes observed in this region of the river (see Section 11 figures).

Figure 8-12 temporal station plots indicate that total phosphorus is relatively constant at the mouth of the estuary. Concentrations at the mouth of the river are generally lower than upstream values. Plots of salinity versus total phosphorus for the April, 1981 intensive survey indicate simple conservative mixing may control the concentrations of total phosphorus. At XDE2599 (nautical mile 9.6) the 24 hour survey on July 19, 1980 indicates a potential summer maximum of total phosphorus. The maximum surface concentration indicates that a bloom of algae may have occurred in the lower river, or the maximum value of 0.57 mg/l was an outlier. At nautical mile 14 to mile 25 the data indicate a definite total phosphorus summer maximum. At mile 30 the variability of total phosphorus from surface to bottom is quite high, especially when compared to the consistent range of values observed at the lower estuary. Examination of Figure 4-6 shows the hydraulic depth generally decreases in this area of the river and Figure 4-14 indicates that mixing of freshwater and Chesapeake Bay waters would, on the average, be maximum in this area. These two factors may explain part of the reason why bottom concentrations in this turbidity maximum are so high, as well as nutrient flux being high in this region. Data at station XED9490 (nautical mile 30) indicates an average concentration of 0.16 $\pm$ 0.07 mg/l, standard mean error of 0.008 mg/l, C.V. of 41 and maximum

and minimum values of 0.4 and 0.06 mg/l respectively. At Nottingham (station PXT0402, nautical mile 35.2) the average and standard deviation for the study period was 0.2 ± 0.1 mg/l, standard mean error of 0.01 mg/l and C.V. of 58, with a maximum and minimum value of 0.96 and 0.07 mg/l respectively. Average values at the mouth of the estuary were 0.05 ± 0.06 mg/l (station XDE2599, mile 9) and 0.04 ± 0.01 mg/l (station XCF9575, mile 0.1). Data observed during this study indicate that the Chesapeake Bay may not be a source of total phosphorus to the estuary, especially when one notes the fact that surface to bottom concentrations at the main channel station at river mile 9 are quite small and are not generally higher than up estuary stations.

Dissolved phosphorus temporal plots tend to indicate that bottom waters are not a source of dissolved phosphorus (see Figure 8-13 plots at stations XCF9575 and XDE2599). The data indicates that during 1981 surface to bottom differences at station XDE5339 were greater than the down estuary station, however in 1981 no significant surface to bottom concentrations are observed. The sediment nutrient flux data collected by the University of Maryland for this study (16) indicates that during the summer of 1980 and previous years data there is an August flux of phosphorus from the sediments, which is probably why concentrations in bottom waters increase in the summer and early fall of 1980 at station XDE5339. This summer bottom water dissolved phosphorus peak is also observed at nautical mile 20 (XDE9401) thus substantiating fairly conclusively that the sediments are a source of phosphorus in the lower estuary and not Chesapeake Bay waters. The data at the next upriver station at mile 25.5 (XED4892) substantiates this transport process of nutrient rich bottom waters as well as blooms of dinoflagellates, cryptophytes and chrysophytes of phytoplankton occurring at station XED4892 during late July of 1980.

Figure 8-14 shows the temporal plots of dissolved ortho-phosphorus. During summer months, bottom waters are generally higher but this trend is not consistent. The July 1980 survey indicates the surface values were higher. Lower estuary stations indicate higher concentrations in the summer and fall of 1980 compared to summer 1981 values. A maximum occurs in mid to late fall in the lower estuary. In the mid-estuary a maximum occurs earlier, except at mile 30 in the turbidity maximum area where biological utilization of orthophosphorus is probably at its maximum, and the peak is not therefore observed in the months of August and September. Comparison of station XED4892 (mile 25.5) and station XED9490 (mile 35) show opposite monthly trends. At mile 35.2 a minimum appears to occur in the late summer and early fall. This data substantiates that the turbidity maximum area is a very complex area of the estuarine system where trends can reverse in only a few miles. The intensive survey maximum and minimum surround what one may determine as a seasonal trend. Thus the slack surveys, especially in the turbidity maximum portion of the estuary are probably insufficient to characterize late spring, summer and fall conditions of an estuary.

Total particulate phosphorus plots (Figure 8-15) indicate no seasonal trend in the upper river stations. From the mouth of the estuary to mile 25.5 there is a summer maximum. At mile 25.5 bottom concentrations were usually higher. At station XED9490 values obtained during the 24 hour surveys indicate extreme variability over a twenty four hour period. Thus, discrimination of seasonal trends are probably not reliable if based upon slack survey data.

Dissolved organic carbon plots shown in figure 8-16 indicate higher fall concentrations at all stations. This variable was not collected during the summer and early fall surveys. The variability of this constituent is less than expected. DOC average concentrations were higher in the 0-3 ppt range (17.0 $\pm$ 4.9 mg/l) in October 1980 and lower estuary values indicate an average of 13.2 $\pm$ 2.6 mg/l. A DOC minimum occurred in August with 3.9 $\pm$ 1.1 mg/l in the 0-3 ppt salinity region 2.2 $\pm$ 0.3 in the 3.1-10 ppt region and 1.7 $\pm$ 0.8 mg/l in the lower estuary. Total organic carbon measurements taken during the summer of 1980 indicate higher concentrations in the estuary in August and September. If 1980 TOC and 1981 DOC concentrations are representative of typical conditions, this suggests that during the summer most of the carbon is in particulate form.

Figure 8-17 plots of pheophytin indicate no general monthly trends at all stations. This variable, which is an indicator of dead algae, shows extreme variability as evident from the range of observations taken during the intensive surveys. Average concentrations during the study period suggest that the most productive area of the river system is at Nottingham (nautical mile 35.2) since pheophytin is greatest at this location (17.8 $\pm$ 14.2 ug/l, C.V. of 80) followed by concentrations at Lower Marlboro (XED9490) with values averaging around 13.78 $\pm$ 10 ug/l, C.V. of 100. These two stations (where concentrations are highest) are also in the turbidity maximum region of the river. All lower estuary stations show a marked reduction of pheophytin concentrations. For example, concentrations were lowest in the lower estuary (10 ppt) during the months of June (2.6 $\pm$ 3.7 ug/l), October (2.2 $\pm$ 1.4 ug/l) and December (2.1 $\pm$ 2.1 ug/l). Maximum average concentrations of pheophytin-a were observed throughout the river during May 1981 with the upper salinity (0-3 ppt) zone showing average values of 30 $\pm$ 25 ug/l, the mid-estuary zone (3.1 - 10 ppt) of 18.5 $\pm$ 19.3 ug/l and the lower estuary (10 ppt) indicating average values of 6.5 $\pm$ 2.7 ug/l. Greater values during this period might be expected since the April 1981 longitudinal phytoplankton results showed higher total phytoplankton cell counts at all upper river and lower estuary stations. Algal cell counts were also high in the July 1980 phytoplankton survey at stations XED9490 (Lower Marlboro), PXT0402 (Nottingham) and at PXT0455 (Jug Bay).

Dissolved reactive silicate concentrations (see plots in figure 8-18) indicate that a silica maximum occurs in the lower estuary during the summer and early fall, with surface concentrations generally higher. Station variability of silica is not as great as other nutrient variables. The lower estuary stations' maximum values were observed during the summer

and early fall. This seasonal trend still existed in the mid-estuary accompanied by a spring peak. Up river stations indicated relatively consistent values throughout the study period, with higher concentrations observed during 1980 when freshwater input was lower. At station PXT0603 higher values in 1980 (the dry period) indicate that groundwater may be a major source of dissolved silica to the estuary.

Seston concentrations indicated by the total non-filterable residues shown in figure 8-19 plots indicate a summer maximum at all upper river and lower estuary stations. Mid-estuary stations (mile 25, 30, 35) indicate much higher surface to bottom differences, with bottom concentrations being higher during most surveys. The upper river area (0-3 ppt) observations indicate higher concentrations in the spring and early summer, due to higher freshwater inflow and high loads of detrital material. In the mid-estuary (3.0 - 10 ppt) concentrations are highest throughout the system with a maximum occurring in spring and again in August and September. The spring maximum is probably a result of high spring storm runoff and early phytoplankton blooms whereas during the summer values are probably high due to primary production. In the lower estuary section is highest in March and September with a minimum observed in May.

BOD_5 temporal plots show, as expected, tremendous variability. For example, during the 24 hour surveys at mile 20 (XDE9401) the maximum and minimum values bound the apparent seasonal trend line. Trends do not appear to be consistent from one station to the next. Statistical analysis indicates that in the upper estuary (0-3 ppt) BOD_5 is greatest during May and September. In the salinity zone 3.1 - 10 ppt, BOD_5 is greatest in April and September. Due to the inherent variability of the BOD_5 analysis, these trends are suspect, however intensive survey data during July 1980 indicates a BOD_5 of 2.8 $\pm$ 1.3 mg/l in the upper region (0-3 ppt); BOD_5 of 3.7 $\pm$ 2.1 mg/l in the mid-estuarine region (3.1 - 10 ppt); and 2.2 $\pm$ 1.3 mg/l in the lower estuarine region.

April 1981 values indicate an average BOD of 3.4 $\pm$ 1.5 mg/l in the upper estuary, 2.3 $\pm$ 0.8 mg/l in the mid-estuarine region and 4.0 $\pm$ 1.6 in the lower estuary. The C.V. for BOD_5 is greatest at the Western Branch ambient station and the lower estuary stations. The BOD_5 average was highest at the Route 50 Bridge, PXT0603 (4.2 $\pm$ 1.6 mg/l) with a maximum of 8 mg/l. The minimum average BOD_5 was observed at the Western Branch station 1.8 $\pm$ 1.2 mg/l, with a maximum of 7 mg/l, and minimum of 0.1 mg/l.

Table 8-1 shows the monthly average and standard deviation of variables for the three estuary zones described above.

SECTION 9

INTENSIVE WATER QUALITY SURVEY VARIABLE RESULTS

The following is a discussion of the results of the intensive water quality surveys conducted July 24-25, 1980 and April 23-24, 1981. These surveys were conducted in order to describe the short term variability of the water quality variables. Longitudinal phytoplankton surveys, described earlier, were also conducted at approximately the same time period (i.e. July 24, 1980 and April 20-21, 1981) and are discussed later in the report. Stage height and current velocity data were also obtained and plotted for two stations (XDE2599 at 9.6 and PXT0402 at 35.2).

Figure 9-1 shows the results of the two intensive surveys for salinity. Salinity stratification is quite small at the mouth of the estuary. Higher surface values occurred frequently during July and less frequently during the April survey. Average salinity at the mouth of the estuary for the July survey was 14.5 $\pm$ 0.5 ppt compared to 17.5 $\pm$ 1.2 ppt in April. At station XDE2599 stratification was slightly greater in July with a mean and standard deviation of 13.5 $\pm$ 0.7 ppt and 17.1 $\pm$ 0.2 ppt in April. During the July survey surface values were consistently higher than bottom waters during the first part of the survey. Increased bottom salinities occurred during the later survey period.

In April very little stratification was observed. At mile 13.9 (XDE5339) stratification appears slightly greater with the July and April mean and standard deviation of 12.78 $\pm$ 1.15 and 14.43 $\pm$ 1.7 ppt respectively. It is interesting to note that at these lower stations the range was greatest over the 24 hour period at the mouth, with the maximum value of 18.5 and minimum value of 12.6. At XDE9401 (nautical mile 19.9) stratification is still greater in July (a trend which is generally true for this whole survey, with a mean of 11.3 $\pm$ 1.18 (9 min - 13.4 max) ppt in July and are 14 $\pm$ 1.9 (11 min. - 17 max) ppt in April. While the influence of tidal stage and velocity on salinity is only slightly noticeable at these lower stations, at mile 25.5 (where the estuary becomes much shallower) the effect of tidal forces is more evident, with a July mean and standard deviation of 5.5 $\pm$ 2.3 (0.7 min. - 9.0 max) ppt and for April the statistics were 10.5 $\pm$ 2.5 (7.6 min. - 14.9 max.) ppt. Thus, effects of low flow conditions in July and high flow conditions in April become much more evident at this station located in the lower region of the turbidity maximum zone. See figures 9-20 and 9-21 for a comparison of tide stage and current velocities in the river during the IWQS. Salinity is consistently higher in the bottom water layer at this location, however stratification

decreases during maximum current velocities. The effects of tidal action on the 24 hour salinity variation increase, and reaches a maximum at mile 30.6 (XED9490) at Lower Marlboro. Mean and standard deviation of salinity reached 11.3 $\pm$ 1.18 (9 min - 13.4 max) and 14 $\pm$ 1.9 (11.1 min - 17 max) in July, 1980 and April, 1981 respectively. Thus, a range of 4-6 ppt occurs at this upstream station over a tidal cycle. Higher salinity at the surface is probably due to upwelling of bottom water due to bottom topography. Salinity at station PXT0402 (mile 35.2) indicates a tidal salinity range from 0.1 to 1.2 ppt, with slight stratification, dependent on tide stage and currents.

Table 9-1 indicates that average river salinity was 65% higher during July 1980, compared to the April 1981 data. The average river salinity standard deviation for surface and bottom waters was relatively constant at about 6.1 ppt. The surface to bottom salinity difference averaged around 3.6 ppt during the intensive surveys during both years.

Figure 9-2 shows plots of water temperature observed during the intensive survey. At station XCF9575 the stratification is greatest during slack tide conditions as expected. Average temperature differences between surface and bottom waters in the estuary for these surveys was 1°C in July 1980 and 0.1°C in April, indicating as expected, greater stratification in the summer. Very little overall stratification was observed in the spring. The most interesting plot is PXT0402 where the April 1981 data indicates that bottom waters were consistently warmer than surface waters, indicating a potential inversion of waters.

Plots of pH shown in Figure 9-3 indicate there is a slight relation between pH and tide stage. During the July 1980 survey average pH in surface water and bottom water was 7.18 and 7.13 respectively. In April average values were 8 and 7.86 respectively at the surface and bottom. Mid-depth upper river values were 7.02 and 7.14 in July and April. The lowest pH occurred at XDE2599 (mile 9.6) during the April survey (6.4). The maximum pH observed was during the same survey (9.4) at XDE5339 (mile 13.9). It was not uncommon for a pH above 8 to occur on several occasions at several stations, and pH values tended to be more variable as indicated by the standard deviation at the middle estuary stations. The pH appears to be strongly affected by the current and stage height data, especially at the mid and lower estuary locations.

Figure 9-4 indicates dissolved oxygen values observed during the intensive river surveys. Station XDE2599 at mile 9.6 indicates a surface water inversion half way through the July 1980 survey. This inversion is verified from observation of salinity and temperature profiles. The same process occurred at XED4892 (25.5 nautical mile) and at mile 30.6 (XED9490). At mile 35.2 it was not uncommon for surface and bottom values to increase and decrease inversely during the 24 hour period, indicating this region experiences potential upwelling of bottom waters. During the April 1981 survey the surface to bottom ranges of observed D.O. is much smaller than observed in July 1980 survey, as expected. The surface to bottom inversion does appear to follow stage height and velocity changes

to some degree. The upper three stations observed an average D.O. of 4.85 ± 0.71 mg/l and 7.3 mg/l during July and April, respectively. Bottom samples in the middle and lower estuary indicated an average of 5.1 ± 1.83 mg/l in July and 8.57 ± 1.23 in April. Surface values averaged 6.11 ± 1.39 and 8.88 ± 0.97 mg/l in July and April respectively. Average 24 hour DO was lowest at station XDE5339 (nautical mile 13.9) with a mean of 4.3 mg/l and standard deviation of 2.7 mg/l (min - 0.5 mg/l; max - 8 mg/l). During the April survey average DO was lowest at station PXT0603 (nautical mile 54.2 - Rt. 50 Bridge) 6.3 ± .7 mg/l (min - 5.2, max 7.1 mg/l). D.O. was greatest at WXT0045 (Western Branch) at 13.9 mg/l in April, or 146% saturation.

Dissolved oxygen saturation (DOSAT) plots are shown in figure 9-5. As expected, DOSAT was greatest during the April survey with average surface, mid-depth, and bottom values of 96 ± 10%, 74 ± 15%, and 92 ± 13% respectively. During the July 1980 survey surface, mid-depth and bottom average river DOSAT were 80 ± 18%, 58 ± 8%, and 65 ± 23%. Minimum DOSAT observed during the 2 year period was observed at station XDE5339 during the July, 1980 survey at 6.6% of saturation. The highest average DOSAT in July was 100% at XCF9575 at the mouth of the estuary. Minimum 24 hour average DOSAT occurred at PXT0603 (Rt. 50 bridge) and at PXT0494 (Rt. 4 bridge) with a mean and standard deviation of 63 ± 6% and 70 ± 6% respectively, thus indicating a greater potential for biochemical activity and utilization of oxygen in the upper tidal and non-tidal river in April. During the July survey the minimum station 24 hour average and standard deviation was 54 ± 6% at the same upper river station (PXT0603) followed by station XDE5339 below Benedict at 57 ± 36%. The maximum station 24 hour average was at station XED4892 (above Benedict) during July with 83 ± 14% followed by station PXT0402 (Nottingham) at 79 ± 9%. The data suggests that the primary productivity is high in the region above Benedict during the summer. Below Benedict, algal respiration and/or decomposition may be occurring, causing an oxygen demand in this region of the estuary.

Secchi disc plots (see figure 9-6) indicate very little response to tide stage and velocity changes. It is interesting to note that these measurements indicate that approximately no light penetration occurred for several hours at some locations. Secchi depth was usually around 0.1 meters most of the time during the July survey and rarely exceeded 0.2 meters above nautical mile 25.

July IWQS nitrate plots shown in figure 9-7 indicate that from mile 19 to 35 there is a strong relationship between stage height and nitrate concentrations, especially at mile 35 (PXT0402) near Nottingham. Data at this station indicates concentrations may range from 0.5 mg/l to 1.5 mg/l (a factor of 3) due to tidal forcing functions. This relation is true at several other mid-estuary stations as shown by the plots. This phenomena results in a large standard deviation of observed values. At this station in July, the mean was 0.97 mg/l with a standard deviation of 0.33 mg/l (min is 0.5, max is 1.5 mg/l) for the 23 observations made during the 24 hour period. During July the surface and bottom average values were 0.23 ± 0.37 mg/l 0.22 ± 0.34 mg/l respectively.

The April observations indicated higher concentrations of nitrate throughout the river, i.e. surface: 0.36 ± 0.47 mg/l and bottom depth values: 0.32 ± 0.44 mg/l. The average concentrations observed in the upper estuary stations were 1.36 ± 0.22 mg/l and 2.13 ± 0.3 mg/l for July and April respectively. During the July 24 hour survey dissolved nitrate was usually highest at station PXT0603 (1.6 ± 0.19 mg/l). During the April survey, the average dissolved nitrate concentration was 2.4 ± 0.16 mg/l at this station.

Figure 9-8 shows the 24-hour temporal plots of nitrite. Concentration fluctuations appear to be correlated with tidal stage with a small lag time at the mid-estuary stations where tidal forces would be expected to dominate mixing. April average concentrations indicate surface and bottom concentrations were similar (surface - 0.02 ± .03, bottom 0.03 ± 0.3 mg/l) as well as the July survey (surface 0.03 ± 0.03, bottom 0.03 ± 0.03 mg/l). However, mid-depth stations in the upper estuary and tidal river indicate almost a 50% increase in the July survey (0.23 ± 0.1 mg/l) as compared to the April survey (0.14 ± 0.04 mg/l). Higher July 1980 values are probably a result of the below normal rainfall during the summer of 1980.

Average nitrite was highest during the July survey at station PXT0603: 0.36 ± 0.08 mg/l (min - 0.25, max 0.46 mg/l), at PXT0455: 0.16 ± 0.02 (min - 0.14, max - 0.2 mg/l) and station PXT0494: 0.18 ± 0.004 (min - 0.17, max - 0.19 mg/l), reflecting higher freshwater concentrations and resulting in dilution at down river stations. Average April survey values were much lower at station PXT0603, 0.15 ± 0.01 mg/l, slightly higher at PXT0455, 0.18 ± 0.04 mg/l and lower at PXT0494, 0.1 ± 0.02, indicating Western Branch as a potential source of nitrite.

Dissolved ammonia temporal plots during the 24 hour surveys are also correlated with tidal forcing in the mid-estuary (station XED9490, PXT0402, XED4892). These plots indicate that there is no consistent trend of higher surface or bottom concentrations in this portion of the river over a 24 hour period. However, below this zone where mixing is greater, the bottom ammonia concentrations are more than 50% higher in July, probably due to sediment nutrient flux processes (see station XDE9401 mile 19.9). The dissolved ammonia average for the entire river during these river surveys indicate April values are higher at surface, mid, and bottom depths (surface: July - 0.06 ± 0.04, April - 0.2 ± 0.24 mg/l; mid-depth: July - 0.29 ± 0.14, April - 0.71 ± 0.33 mg/l; bottom: July - 0.13 ± 0.07, April 0.18 ± 0.26 mg/l). April values show a much greater variability of ammonia concentrations than the July survey when all station data is compared. The reason for higher ammonia in April is not clear.

Comparison of ammonia concentrations in the lower estuary shows that April concentrations are much lower. For example, at XDE5339 (mile, 13.9) July average 24 hour survey data indicate an average and standard deviation of 0.09 ± 0.08 mg/l compared to 0.02 ± 0.01 mg/l in April, concentrations more than three times higher. Analysis of PXT0603 data (at Rt. 50 bridge) indicates that freshwater concentrations of ammonia is an order of magnitude higher in April. The trend is not true at station WXT0045, therefore

the high April ammonia concentrations may be resulting from wastewater treatment loads. High water column ammonia in the lower estuary in July could also be due to biological remineralization in the water column as well as high sediment fluxes of ammonia.

Total dissolved organic nitrogen (TON) is shown in Figure 9-10 plots. Correlation of TON with tide height is not as strong as with inorganic forms of nitrogen as expected. However, at mile 30.6 there is a fairly strong correlation. Water column concentrations are quite variable. It is interesting to note that the apparent inversion of surface and bottom waters at station XCF9575 (mile 0.1) did not apparently affect the concentrations of observed DON.

Total particulate nitrogen (calculated) is shown in Figure 9-11 plots. At the mid-estuary stations concentrations were generally higher early in the survey at the surface and lower after sunset, indicating some type of diurnal effect at surface and bottom depths.

Plots in Figure 9-12 indicate total phosphorus concentrations are also associated with tidal measurements at particular locations. Bottom depth values are generally higher. During the July 1980 survey, surface, mid and bottom values averaged 0.02 $\pm$ 0.37 mg/l, 1.36 $\pm$ 0.22 mg/l, and 0.22 $\pm$ 0.34 mg/l, respectively. April upper river and estuary concentrations were slightly lower, (surface: 0.08 $\pm$ 0.06, depth - 0.4 $\pm$ 0.17, bottom - 0.11 $\pm$ 0.1 mg/l). Visual observation of the change in values over the 24 hour period indicate that tidal forces may be responsible for nearly a 100% increase in concentration. Trends of lower estuary station concentrations occurred in April, indicating higher values at XDE2599 and lower values at the stations above and below this location. In the upper estuary and river dilution of freshwater phosphorus concentrations are apparent, except between stations PXT0455 and PXT0402 where concentrations do not change between stations. This indicates a possible mid-river source of total phosphorus.

Particulate phosphorus at station XDE2599 in April is correlated to tidal stage, but this trend is not as evident during the July, 1980 intensive survey (see plots in Figure 9-13). Calculated particulate phosphorus is generally higher at bottom depths as expected. Tidal effects are apparently strongest at mile 25.5 (XED4892), at the lower end of the turbidity maximum region. Plots of dissolved phosphorus (Figure 9-14) did not show a strong tidal association with changes in concentrations except at mile 9.6 (XDE2599) in April, where concentrations increase by more than a factor of three. On the average, dissolved phosphorus was higher during the July survey (surface: 0.03 $\pm$ 0.01, mid-depth: 0.21 $\pm$ 0.13, bottom: 0.03 $\pm$ 0.02). The mid-depth average (i.e. upper river stations) was the same in July and April (0.21 $\pm$ 0.13). It is obvious that statistical analysis of the 24 hour survey data does not allow one to discriminate the effects of tidal forces on the concentrations.

Orthophosphorus concentration (figure 9-15) plots indicate that values were affected by tide stage at mile 13.9 (XDE5339) and mile 25.5 (XED4892) similar to other variables, especially in July, when salinity, temperature, and D.O. stratification were generally greater. Bottom values were generally higher, however this trend was seldomly consistent over the 24 hour period. Dissolved orthophosphorus was 3 times higher in July at surface and bottom depths. Mid-depth concentration averages remained the same during the July and April intensive survey. Surface and bottom concentrations were the same magnitude, indicating averaging concentrations over a 24 hour period masks the fine scale processes affecting concentrations. In the lower estuary, an order of magnitude increase in orthophosphorus was observed at mile 9.6 (XDE2599) when compared to the upper and lower stations, thus indicating a source of ortho-phosphorus at this location. Mid-estuary concentrations follow trends of dilution in July. However in April, mid-estuary concentrations increase above Benedict.

Figure 9-16 shows temporal 24-hour plots of dissolved reactive silicate. Silica concentrations respond to river stage by changing concentrations (an order of magnitude) at the mid-estuary stations, especially in the area of the expected turbidity maximum zone. In fact, silica concentrations appear to be associated with tidal action more than any other variable. Silica was higher in July, with mid-depth samples in the upper estuary showing highest concentrations, as expected (see Table 9-1).

Pheophytin-a concentrations appear to be dominated by tidal action at station XED9490 (nautical mile 30.6). Average river concentrations were slightly higher in July as expected (see Table 9-1). Bottom values in the mid-estuary are higher, indicating that the mid-estuary is a recipient of dead algal biomass from blooms occurring above or near this region (see figure 9-17 plots).

Total suspended solids (total nonfilterable residue) plots in figure 9-18 indicate strong tide stage related variation at mile 30.6. As with other variables, concentrations can increase by a factor of three over a tidal cycle.

BOD_5 plots in Figure 9-18 indicate greatest variability over the tidal cycle at mile 25.5 (XED4892). There is no apparent trend of higher surface or bottom concentrations during both surveys. Table 9-1 supports this observation with the July 1980 surface BOD_5 average of 2.88 $\pm$ 1.65 mg/l and bottom BOD_5 average of 2.27 $\pm$ 1.33 mg/l. Mid-depth average BOD_5 was 2.51 $\pm$ 0.53 mg/l in July and 4.24 $\pm$ 1.45 mg/l in April.

Table 9-1 gives a statistical summary of data collected during the intensive surveys.

SECTION 10

HISTORICAL PERSPECTIVE OF DISSOLVED OXYGEN AND DEFICITS

Dissolved Oxygen in the Patuxent River

A major concern of water quality management for the Patuxent River is the low concentration of dissolved oxygen in the deep waters of the lower estuary. While summer dissolved oxygen depletion is a normal, naturally occurring event in the lower Patuxent, historical records suggest that the degree and duration of low dissolved oxygen concentration may be increasing (59, 40, 16). Low dissolved oxygen concentrations result when oxygen consumption in deep waters and sediments is greater than oxygen replenishment from surface waters. Stratification of the water column effects oxygen distribution by decreasing surface and deep water mixing, resulting in decreased oxygen replenishment to deep water. It has been suggested that low dissolved oxygen concentrations characteristic of deep waters in the lower Patuxent may be due to inflow of oxygen poor water from the Chesapeake Bay (65) or due to increased upstream domestic waste loading (62). Low dissolved oxygen has been reported to cause oyster mortality at depths greater than 5 meters, and environmental concentrations of dissolved oxygen are reportedly approaching levels that can be expected to kill fish (40).

Historical Dissolved Oxygen

A substantial amount of dissolved oxygen data for the Patuxent has been collected since the 1930's to the present (e.g. 60, 61, 62, 63, 64). Historical data was used in an effort to characterize trends in dissolved oxygen concentrations and distributions over this time period.

Historical dissolved oxygen data was stored on the EPA STORET information and retrieval system for analysis of historical D.O. and dissolved oxygen deficits (DOD). Historical data sources included the Maryland Department of Natural Resources Water Quality File, the Chesapeake Bay Institute historical data and historical data compiled by the University of Maryland for the EPA Chesapeake Bay program.

Table 10-1 shows the yearly mean dissolved oxygen, standard deviation and number of observations made in the estuary, tidal river, and mainstem river up to the USGS gauging station at Route 50. This table also shows the correlation coefficient from linear regression of D.O. vs salinity for the years 1936 to 1981. Figure 10-1 is a plot of the mean values. Yearly

mean dissolved oxygen shows no clear trend through the years, as might be expected due to different sampling locations and timing of sample collection.

The river was divided into an upper zone (0.2-10.0 ppt) and lower zone (greater than 10.01 ppt) based upon salinity. The division of the river was selected based largely upon the classification of brackish water as proposed by Ekman, 1953 (38). Table 10-2 shows the mean dissolved oxygen in the upper river. Figure 10-2 is a plot of these mean values. It should be noted that due to a limited number of values during some years, these plots may be a misleading comparison. Values reported from 1936-1939 are in the same range of values as in the late 1970's and 1980's, indicating little change in conditions in the upper river.

When looking at the physical characteristics of the Patuxent, the figures and simplistic calculations presented in section 4 point out several items of interest. First, Figure 4-15 indicates where flushing is maximum and where dissolved oxygen may be lowest. This is substantiated by historical plots of dissolved oxygen versus salinity. Historical data and data reported in this study indicate low dissolved oxygen is in the salinity region of 11-14 ppt or approximately nautical miles 11 to 19. Flushing times in this portion of the river are greatest as shown in Figure 4-15. Also, Figures in Section 10 show that the dissolved oxygen deficit is lowest in the 3-4 ppt salinity zone of the river. This is around nautical mile 33 to 34 and as shown in Figure 4-15. This portion of the river is expected to have the smallest flushing time in the upper estuary. In addition, Figure 4-14 shows that nautical mile 26-27 is the river segment where there is, on the average, 50% freshwater and Chesapeake Bay water. This is the location of an upestuary sill, which is probably the result of the mixing and resulting geochemical processes which form and precipitate sedimentary particles (26). This location is also the lower extent of the turbidity maximum location in the estuary. Above this location, the water quality of freshwater will probably dominate the mainstem estuary. Above this reach (approximately mile 35-43) is also the area where seasonal historical dissolved oxygen appears to show significant seasonal downward trends.

Table 10-3 and Figure 10-3 show the yearly mean dissolved oxygen observed in the lower estuary. Figure 10-1 also indicates no linear trend of yearly mean average D.O.

One might expect that a yearly mean D.O. trend would be more evident when historical data for the month of August was analyzed. Table 10-4 and Figure 10-4 show the yearly mean dissolved oxygen for the month of August from 1936 to 1981. Correlation of D.O. versus salinity substantiate lower D.O. in the lower river as shown on Table 10-4. Table 10-5 and Figure 10-5 show the August yearly mean D.O. in the upper river zone. No consistent trend with salinity is evident in this zone. August yearly mean values are generally lower than yearly means for the entire mainstem river and estuary as expected. Figure 10-6 and Table 10-6 show the August yearly mean D.O. in the lower estuary. Values during the late seventies and during this

study do not appear to be different from data taken from 1936-1939, except for the data taken during 1978. In summary, when D.O. is analyzed from a yearly temporal scale, no distinct trends are evident for the estuary and tidal river nor the upper or lower salinity zones. Such trends may be deceiving, without knowledge of specific conditions occurring during and previous to the time a measurement was made.

Plots of actual data taken during the years are shown in figure 10-7, where D.O. is plotted against salinity for each year. It is quite evident from examination of these plots that low dissolved oxygen was observed from 1936 to 1939. In fact, during this time period one can conclude that frequent dissolved oxygen around 1-2 mg/l in the lower river was not an uncommon occurrence, especially in the area of the river where the relative flushing time is greatest. Observation of these plots leads to the conclusion that low dissolved oxygen in the lower estuary at deeper depths has not generally increased. Although some years show a greater tendency for low dissolved oxygen, i.e. 1978 and 1963, one must take into consideration that the number of observations taken during these years increased by a factor of three to four, compared to the number of observations taken in 1937 and 1939.

In order to refine the gross yearly analysis above, the river was divided into twenty segments along the reach of the estuary and upper river as shown in Figure 10-8. Based upon these segments, dissolved oxygen was analyzed on a seasonal basis. The results of a seasonal historical analysis is shown in Figures 10-9 through 10-28. Plots of the dissolved oxygen historical seasonal mean and standard deviation were calculated, using data from the State of Maryland, Chesapeake Bay Institute, and University of Maryland.

In all segments, except segments three and four, there is no apparent trend through the years. This analysis provides the best evidence of increasing low dissolved oxygen trends in the upper river at segments three and four. This area is the tidal river, where the flushing time is greater during low flow conditions, and before tidal processes have began to allow mixing with Chesapeake Bay water. This area is above the upper extent of the turbidity maximum area.

Historical Dissolved Oxygen Deficits

Measurements of dissolved oxygen are well known to be affected by temperature and salinity. It is common practice to calculate the dissolved oxygen deficit, sometimes called the apparent oxygen utilization. This calculation was made as follows:

$$DOD = SDO - MDO \qquad (10\text{-}1)$$

where: DOD = dissolved oxygen deficit (mg/l)
SDO = calculated saturation value of dissolved oxygen corrected for temperature and salinity (mg/l)
MDO = the measured dissolved oxygen, corrected for temperature and salinity (mg/l)

Historical data from the previously mentioned data sources were used to calculate DOD whenever dissolved oxygen measurements were made in conjunction with temperature and salinity or conductivity. If conductivity and temperature were reported we calculated salinity based upon the formulation given by Pritchard and reported by Westinghouse, 1972 (39). Saturation of dissolved oxygen was calculated based upon an algorithm used in the Maryland Water Quality File. This algorithm was verified using tables given in Standard Methods, 1975 (11). The following is a discussion of analysis of the calculated deficits by upper and lower river, 2.0-10 ppt and greater than 10.01 ppt salinity.

Figure 10-29 shows the historical DOD according to depth ranges. Figure 10-19 also shows the mean and standard deviation of deficits or apparent oxygen utilization in the upper estuary (2-10 ppt salinity) and in the lower estuary (greater than 10 ppt). This division of upper and lower salinity regions is approximately the same as Ekman's classification (38).

Figure 10-32 shows the mean and standard deviation of deficits in the lower Patuxent estuary. Figure 10-30 shows the same values for the upper estuary. Figure 10-31 shows values for the river in the region between 2-10 ppt salinity. It can be seen that the trend of yearly means from 1936 to 1981 in the lower river indicate a potential change towards saturation, while regression of all values (over 5,000 observations) versus time indicates a small trend towards larger deficits, that in turn indicate lower dissolved oxygen (see figure 10-32). Figure 10-30 indicates a trend towards greater deficits in the upper estuary when yearly means or all data are regressed against time, however, the r^2 indicates a very small linear trend. Figure 10-31 indicates yearly mean DOD and DOD versus time does not follow a trend.

Table 10-7 and 10-8 shows the actual mean and standard deviation of DOD for the lower and upper river respectively. In addition, the trend of DOD with respect to salinity is represented by the correlation coefficient. Table 10-9 also shows the same information for the estuary within the entire tidal river and estuary. From Heinle, et. al., 1980 (40) it may be inferred that the standard deviation or range of the DOD would increase over the years (due to greater phytoplankton productivity and respiration) which may in turn increase the range of dissolved oxygen in a nutrient enriched aquatic system. Evaluation of the historical DOD standard deviation from 1945 to 1980 does not show this trend in the lower river, and only limited evidence supports this view for the upper estuarine area using data from many locations. Table 10-9 shows the standard deviation of DOD for the entire river system and does not show any trend for increase in the standard deviation of DOD from 1936-1981.

Tables 10-10, 10-11, and 10-12 show the average DOD for the years 1936-40, 1941-50, 1951-60, 1961-70, and 1971-81 for the upper, lower, and entire river system respectively. Evaluation of the trends using this temporal period does show larger deficits in the upper estuary. Only a very small linear trend is indicated in the lower estuary and for the

entire estuary when decades of DOD's are analyzed. No trend in the standard deviation of DOD is observed. A gross evaluation of dissolved oxygen deficits appears futile, especially when it has been shown that tides and resulting mixing phenomena effect the stratification and potential low dissolved oxygen in an estuary (16). However, when substantial public funds are spent for waste water treatment, it becomes necessary to fully substantiate statements concerning historical dissolved oxygen trends, as well as to understand the limits of existing data for determining dissolved oxygen trends.

In order to more fully understand historical dissolved oxygen deficit trends, data was grouped into ten depth ranges as follows: 0, 1-5, 6-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-99, and 100-129 feet. Table 10-13 shows the yearly means, by depth, in the lower estuary. Table 10-14 shows the mean DOD observed in the upper estuary at various depths. This Table clearly shows where data collection is needed for future historical analysis. Figure 10-19 shows the mean and standard deviations of yearly mean DOD at various depth ranges. Regression of DOD versus years at various depth ranges in the upper river indicate a slight trend towards greater deficits (r^2 = 0.2 at the surface and r^2 = 0.202 at the 1-5 ft. depth range). This data supports the view that surface water processes may be utilizing greater oxygen in the upper river and may reflect nutrient enrichment in the upper river. It should also be noted that observations in the deeper waters have rarely been made, especially since the 1960's, as indicated in Table 8-7. Figure 10-19 shows the dissolved oxygen deficits at various depths in the lower estuary. Although only approximately 50 values are available for regression of DOD vs. time at the 61-99 ft. range, an r^2 of 0.43 is obtained when yearly mean DOD's are used. An r^2 less than 0.1 is obtained when all data are regressed versus time. Due to the paucity of data taken at this depth this trend may be spurious. More data is needed at deeper depths to substantiate this trend.

Greater oxygen utilization by biological and chemical processes is expected to occur during the summer months, with smaller mean deficits during the spring, fall and winter. Table 10-18 shows the monthly average historical DOD by years in the lower river. This data shows greater deficits during the summer months as expected. It is interesting to note that large deficits have occurred in May (4-5 mg/l range). Although the largest monthly average deficits are observed in 1978, this is not due to poorer water quality trends over the years, but to the station location, depth and number of samples collected. This table shows that a substantial amount of data exists historically for the month of August. Figure 10-33 shows the yearly monthly mean DOD for the entire estuarine area.

Table 10-19 shows the yearly mean deficits currently available for the month of August at various depths in the upper estuarine zone. No linear trend is observed at any depth range. Values at the surface show no linear trend over the years (r^2 = 0.0). As expected, deficits do increase with increasing depth. Table 10-21 shows DOD in the lower estuary for the month of August from 1936 to 1981. Even in the lower estuarine zone a substantial amount of data is currently lacking for making a sound historical

trend analysis in deep water. Only nine years of data is available for trend analysis at depths of 21-30 ft. No linear trend (r^2 = .02) exists through the years at this depth range. The same is true for surface values (0-5 feet), where eleven years of mean August DOD shows no linear trend (r^2 = 0.00). Based upon this information it would appear that all yearly mean August DOD's do not enable one to reject the hypothesis that the lower estuary has not been degraded as indicated by increasing oxygen utilization. Attempts should be made to obtain other existing data that would enable rejection of this hypothesis for August DOD's.

Due to the fact that more data exists during August than other months, an analysis of DOD by time of day was carried out. Table 10-22 shows the DOD in August during daily time intervals at various depths. Lack of data taken at various depth and time ranges precludes more detailed analysis, however, there is a trend for mean average DOD to increase during the day from 9-10 a.m. and decrease from mid-day, evening and night.

In the upper river the mean DOD is greater from 3-8 a.m. probably due to phytoplankton respiration (see Table 10-22). In the upper river the data suggest DOD then becomes lower from 9-10 a.m. and again increases from 11 a.m. to 6 p.m., with the minimum DOD estimated to occur from 7 p.m. to 1 a.m. In the lower river (see Table 10-24) the deficits are again lowest from 7 p.m. to 1 p.m., increase during the period 3-8 a.m. and reach a maximum depth average of approximately 2.38 $\pm$ 1.89 mg/l from 9-10 a.m., with lower average values occurring from 11 a.m. to 6 p.m. An apparent trend exists during August for larger deficits to have occurred from 1936-1940 to 1971-1981 in the upper river from 1-15 feet, from 9-10 a.m. and 11 a.m. to 6 p.m., however the number of samples collected in the 1930-40 time period may not be representative. No apparent trend occurs in the lower river during August, at any depth range or time period.

Historical July and August DOD averaged by depth range and years for the total estuarine system also indicate that DOD is greatest from 9 a.m. to 10 a.m. decreasing mid-day, reaching a minimum at night and increasing again from 3-8 a.m. (see Table 10-25). In the upper river (Table 10-26) historical July and August averaged DOD by time and depth increase around 3-8 a.m., decrease from 9-10 a.m. and reach a maximum from 11 a.m. to 6 p.m. Similar to historical August data, when historical July and August data are averaged in the lower river, the maximum is reached from 9 a.m. to 10 a.m. (see Table 10-27).

After combining historical July and August DOD, no apparent linear trend of increasing DOD through the years is noticeable. It is interesting to note that lower river DOD tends to reach a maximum from 9 a.m. to 10 a.m. and the upper river data supports the view that maximum DOD is observed midday, 11 a.m. to 6 p.m., and again from 3 a.m. to 8 a.m.

Detailed review of all monthly DOD showed that there are not enough values during months other than July and August at various depths to evaluate potential historical trends.

Selected plots of yearly DOD versus salinity are shown in figure 10-34. These plots clearly show DOD is close to 8 mg/l in the late 1930's in the lower river. Positive values are indicative of low dissolved oxygen and negative deficits reflect supersaturated values.

Figure 10-35 and figure 10-36 also indicate that DOD is close to being a normally distributed variable. Figure 10-35 indicates that data taken from 1939 to 1940 tended to be slightly lower than 1980-81 data. This analysis would tend to support a general shift towards greater deficits at all DOD ranges since the late 1930's. The 1980-81 data indicate little change from the historical average except larger deficits at the extreme probability ranges, i.e. near zero and 100%. Comparison of 1980-81 to the late 1930's data indicates that the percentage of time that large deficits occurred was the same, however there is a small shift from lower to higher values in the small to negative deficit range. Thus the percent of time that low dissolved oxygen would be expected to exceed has probably not changed from the late 30's to 80's. However, the percent of the time that deficits between approximately 2 to -2 mg/l would be expected to occur has changed, thus indicating a general upward shift of DOD's. On the other hand, it could be argued that the 1930's data was not representative of conditions in the late 1980's.

Figure 10-36 indicates the distribution of DOD is similar in the upper estuary and lower estuary with the exception that the upper river can be expected to experience greater dissolved oxygen saturation than the lower river, and that the lower river can be expected to have larger deficits, more often than the upper river, as expected.

SECTION 11

RESULTS AND DISCUSSION

The Patuxent River is one of the most extensively studied estuarine systems on the east coast, with water column nutrient studies initiating in the 1930's (66, 60) and continuing through to the 1980's (62, 30). The following is a discussion of the results of special analyses performed on data collected during this study in order to identify and characterize relationships between various estuarine water quality variables and processes.

Longitudinal Characterization

In order to classify longitudinal zones of similar water quality characteristics, the Duncan multiple range test was applied to the slack water and intensive mainstem station data. The results of this statistical test are shown in figures 11-1 through 11-8, and indicate areas (i.e. stations) in the river, which have similar concentrations or characteristics. Stations that are not significantly different are shaded similarly. These figures also show the mean value at each station for the respective water quality variable and nautical miles. The depth profile of the Patuxent has also been shown on these figures to emphasize the general water depth of the river.

Figure 11-1 indicates the upper river near Rt. 50 (PXT0603) is a unique area of the river for BOD_5, with generally higher concentrations as indicated by the mean value of 4.2 mg/l. The Duncan's multiple range test indicates the rest of the river may be considered a separate zone or region. Alkalinity measurements during the study indicate the upper river, approximately nautical mile 55-50 and around mile 35 are similar. There is some similarity in the lower river from mile 0 to 10 and from around mile 15 to mile 5. Three distinct areas, upper river, mid-estuary (turbidity maximum area) and the lower estuary appear to exist for pH.

A pheophytin-a zone in the lower estuary is apparent (figure 11-2) and this same classification exists in the upper river, however from the turbidity maximum region (upriver) the river can be considered quite variable, with distinct zones indicated at each station. A total nitrogen zone is apparent in the lower estuary, while upriver stations are all fairly unique except from nautical mile 40 to 50, in the major portion of the tidal river. Salinity characterization using the multiple range test indicates that the lower estuary (mile 0 to 10) is similar, however above this area each station and associated zone of the river is unique. It is

interesting to note the change of mean salinity between mile 30 and mile 25 mean concentration, i.e. 2.7 and 8.4 respectively. This is the area of the river where the rate of mixing of fresh and saltwater is greatest. Figure 11-3 indicates three chlorophyll-a zones in the river. The results show the turbidity maximum region as a distinct area. This chlorophyll-a measurement was uncorrected for presence of pheophytin. The "corrected" (for presence of pheophytin) chlorophyll-a figure indicates there are several unique zones, one at the mouth of the estuary, a long lower and upper estuary reach and a tidal fresh reach. A sub class or group is present in the turbidity maximum region and the upper reaches of the tidal river. Silica values indicate a freshwater-tidal river reach and two lower estuary reaches which overlap. The mid-estuary, in the turbidity maximum appears to be a combination of classes.

Figure 11-4 indicates the turbidity maximum region is also a fairly unique reach of the river for temperature, with overlapping station similarity in the lower and upper river reaches. Several dissolved oxygen reaches are indicated, one at the mouth of the river, one lower estuary zone, three zones in the turbidity maximum, and an upper river zone. Since this analysis is based upon a composite of all station depth values, the lower dissolved oxygen in deeper waters is not apparent. Total non-filterable residue clearly indicates the expected zone of the turbidity maximum, with the upper and lower river reaches showing similarity. Figure 11-5 indicates that nitrite is quite variable, however, a middle and lower estuary zone is also apparent. Ammonia is also quite variable from station to station, however two lower estuarine reaches are indicated. Similar to salinity, a lower estuary zone and an upper tidal river reach is indicated. A distinct orthophosphorus (see figure 11-6) reach is indicated in the lower estuary. In the turbidity maximum region two zones are apparent and the tidal river appears as a unique class. Dissolved phosphorus is quite similar throughout the main estuary, however stations in the upper river and tidal river indicate distinct reaches. Total organic carbon observations clearly indicate a distinct reach in the turbidity maximum region, a lower estuary reach and a tidal river, reach, which extends into the estuary. The dissolved nitrogen classification plot (figure 11-7) indicates unique zones in the upper river and estuary and one zone in the lower river. This same trend exists with nitrate. Total phosphorus analysis using this classification technique indicates several upper river and mid-estuary zones and one lower estuary reach. Dissolved oxygen saturation shown in figure 11-8 indicates a unique upper estuary reach, and a lower estuary reach. The upper turbidity maximum region (mile 35) is unique with the highest mean dissolved oxygen saturation. Dissolved organic carbon, also shown in figure 11-8 indicates several zones which are similar but discontinuous by unique areas above and below the turbidity maximum region.

Additional Duncan multiple range tests were applied to all the data collected at the surface and then to data collected at bottom depths. Figures 11-73 through 11-80 present the longitudinal characterization of nutrient parameters for surface values. The bottom values are revealed in figures 11-81 through 11-88. A combination of surface and bottoms station data was shown in figures 11-89 through 11-95.

BOD_5 had three zones at the surface and only two at the bottom. At the surface the river from 0-5, 17-22, and 28-33 nautical mile were characterized the same with the lowest average values. The surface water from 5-17 nautical mile had the same biological characteristics as the last station at 35.2 (PXT0402). The bottom layer was similar in BOD_5 values except the last station 35.2 (PXT0402).

Total alkalinity had six distinct groups at the surface (figure 11-73) and four separate groups at the bottom (figure 11-81). The greater division at the surface could be caused by a three layer flow condition that affected surface concentrations. Comparing surface and bottom stations together (figure 11-89) there are four zones. The surface and bottom have similar characteristics from the mouth to nautical mile 20. The region from 20-35 was homogeneous and had the lowest alkalinity values. The bottom and surface values for pH have two and four regions respectively. The bottom had one zone in the lower estuary and another for the mid and upper estuary. The surface also had a distinct zone in the lower estuary but the mid and upper estuaries were different.

For pheophytin-a the surface data was broken into four separate regions. The largest area was from 0-20 nautical mile and this region had very low average values. The upper estuary had three small zones that increased in pheophytin-a measurements as it went up the estuary. Bottom values had four groups equal in size: the lower estuary region, two mid-estuary regions, and an upper region. The pheophytin values are fairly stable in the water column of the lower and mid-estuary but vary a great deal in the upper estuary both longitudinally and horizontally as seen in figure 11-90.

Total nitrogen concentrations were similar for both surface and bottom values from 0-20 nautical mile. The mid-estuary from 20-30 miles was similar for the surface but divided into two zones for the bottom layer. The upper estuary, at station PXT0402, was distinct for nitrogen with no stratification in depth.

Salinity values are broken into many zones longitudinally. This stresses the conservative nature of salinity with fresh water flow. Surprisingly though, salinity does not present much stratification in depth. The only distinct division within the water column was from nautical mile 10-20.

Chlorophyll-a had four regions at the surface and two at the bottom. Surface values were greater than bottom values, indicating the dependence on sunlight. For the surface and the bottom values there was a large distinct area from 0-20 nautical miles. The upper estuary for the surface was segregated into three separate regions but the bottom values had only one region. When chlorophyll-a was corrected for pheophytin the surface region was no longer divided and only one zone was present.

Silica had definite regions for both the surface and bottom data. Silica appeared to be a conservative substance that increased in concentration as it went up the river. For both depths station XDE4892 (25.5) and PXT0402 (35.2) were similar as seen from figures 11-75 and 11-83.

Average Patuxent temperatures are homogeneous longitudinally with only one zone present for the surface and bottom.

Data portrays dissolved oxygen (DO) as homogeneous at the surface yet very divided at the bottom. This suggests a healthy DO was present at the surface yet becomes depleted at the bottom. When both depths were looked at (figure 11-91), there were only three zones for DO. The river near station XDE5339 (13.9) was depleted with an average DO of 5.9 mg/l.

Total residue has three disjoined regions at the surface, from 0-15, 15-20 and 20-35 nautical miles. The bottom had only two zones. Values increased longitudinally as they went up the river.

Dissolved nitrite characteristics had three disjoined zones for both the surface and the bottom values as seen in figures 11-77 and 11-85. Higher values were seen in the upper estuary.

Dissolved ammonia had three dissimilar zones at the surface and two zones at the bottom. When surface and bottom data were compared together six zones were indicated. This suggests that ammonia was very stratified.

Dissolved nitrate plots in figures 11-79, 11-87 and 11-92 were for surface, bottom and combined data respectively. The surface and bottom were divided into five and three zones. At the surface the station at the mouth was an isolated zone with other regions located at 5-25, 10-15, 30 and 35 nautical miles. The bottom depth had one large region from 0-25 nautical miles with two smaller regions in the upper estuary. The combined data indicates five regions with little stratification.

Chloride values for surface, bottom and combined data were broken into six, five and five zones respectively. Chloride was conservative with little or no stratification.

Dissolved phosphorus figures have four zones at the surface and four at the bottom and were shown in figures 11-78 and 11-86. The area from nautical mile 0-15 was similar at the surface and bottom depths. This was even the case when surface and bottom values were compared together (figure 11-94). At the surface three separate zones were located at XDE9401 (20), XDE4892 (25) and at the last two estuary stations from 30-35 nautical miles. When the depths were combined for dissolved phosphorus there was little stratification seen except at station XDE9401 (19.9) and XED9490 (30.6) (figure 11-94).

Dissolved ortho-phosphorus was divided into four groups at the surface and five at the bottom. At the surface the lower estuary was similar from

0-15 nautical miles but the bottom had two zones in this area. The region at nautical mile 20 was distinct for the surface and bottom data with simularity to this region from nautical mile 30-35.

The total organic carbon (TOC) characterization had three regions for the surface and only one homogeneous region for the bottom layer. The surface had a lower estuary area between 0-10 nautical mile. The next region was shown in figure 11-73 from nautical miles 10-20 and 30-35. At station XDE4892 (25.5) the highest TOC average concentration portrayed by a separate zone at the turbidity max and indicating greater ecological activity.

Dissolved organic carbon in figures 11-80 and 11-88 for surface and bottom data respectively were divided into three different zones. At the surface the station located at the mouth of the Patuxent was an independent zone with two larger zones following it. At the bottom the first zone was located from 0-15 and 25-30 nautical miles. Then two smaller zones were observed at 20 and 35 nautical miles with average concentrations of 3.8 mg/l and 6.9 mg/l respectively.

Total particulate phosphorus was presented in figures 11-80, 11-88 and 11-95. The surface had a large region from 0-20 nautical mile with very low concentrations. Three smaller zones were in the upper estuary with higher, more variable concentrations. At the bottom the first zone was from 0-15 nautical mile followed by smaller zone at mile 20 and between 25-35. Combined data had five separate regions with no stratification present in the first 10 nautical miles.

Application of the multiple range test does not provide insight into processes that may be responsible for differences between stations or station similarity, which has been extrapolated to make inferences concerning river reaches or zones. It is apparent, however, for several variables, zones of similarity exist between the lower, mid-estuary and tidal river portions of the river as expected. Further application of such simple cluster techniques to other estuaries might prove useful for comparative estuary characterizations.

Nitrogen to Phosphorus Ratios

The longitudinal profiles of the total N:P ratios (calculated on a per weight basis) and the Redfield N:P ratio are presented in plots of slack water survey data (see figures 7-20 and 7-21). Previous studies concerning coastal eutrophication have indicated that unicellular marine algae assimilate nitrogen and phosphorus in a ratio of 10:1. Assuming these are the growth rate limiting chemicals for algal growth in the Patuxent, it can be assumed that if the N:P ratio is greater than 10:1 there is an abundance of nitrogen, and phosphorus may be the limiting growth nutrient. If the ratio is less than 10:1 then nitrogen may be the algal growth limiting nutrient. Total N:P plots indicate phosphorus is limiting at the mouth of the estuary most of the time, decreasing to nitrogen limitation below the turbidity maximum region and increasing towards phosphorus limitation in

the turbidity maximum region of the estuary. Above the turbidity maximum region, total N:P ratios would indicate nitrogen limitation. Plots of the dissolved N:P ratio, i.e. Redfield ratio ($NO_2^-+NO_3^-+NH_3$/orthophosphates) indicates potential phosphorus limitation at the mouth, with occassional nitrogen limitation. A general trend towards nitrogen limitation is indicated below the turbidity maximum region and the greatest phosphorus limitation in the turbidity maximum region. A trend towards nitrogen limitation is indicated in the upper river, although the upper river values are close enough to the 16:1 ratio that the system probably shifts quite often, probably dependent upon freshwater inflow related to storm flows.

A more detailed evaluation of the total N:P profiles indicates an association between the shape of the longitudinal N:P profile to the antecedant rainfall/runoff conditions. Analysis of daily mean flow hydrographs at the Route 50 USGS gauging station (PXT0603) indicate that the greater the time period before the last storm event (peak in hydrograph) and the slack water survey, the more the profile fits an exponential function (see the September 15, 1980 slack survey plot). A formalized analysis was performed which indicates how close the slack survey data of total N:P fits an exponential function. How well the slack water profiles of the total N:P fit an exponential curve can be represented by correlation of the N:P ratio versus nautical mile.

Plots of the resulting regression coefficients against antecedent conditions, i.e. number of days between the slack water survey and the (a) beginning of a storm, (b) the end of the storm, and (c) the middle of the storm, are shown in figures 11-9 and 11-10. Thus, there is an apparent relation between the total N:P longitudinal profile in the Patuxent River and storm events which deliver higher nitrogen and phosphorus loads to the river system. It is hypothesized that the mid-river phosphorus limited waters may be strongly related not to biological processes but to input of nitrogen rich waters to the estuary as a result of the stormwater inflow.

As indicated above the September 15, 1980 slack water survey had no pronounced mid-river peak (indicating phosphorus limited water), however the survey was conducted more than 30 days after the last storm event as evidenced from the Rt. 50 hydrograph. In an attempt to explain more explicitly the factors affecting the longitudinal variation of the dissolved N:P ratio, curvilinear stepwise statistical regression was applied to the data. The N:P ratio was used as the dependent variable. The independent variables which explained 75% of the variation of the N:P ratio were: nautical mile; salinity; days from beginning, middle, and end of the storm to the survey date; storm characteristics describing the size of the storm. This regression analysis substantiates several viewpoints. First, the apparent nitrogen or phosphorus limitation anywhere in the river (nautical mile 0 to 48) is highly dependent upon the physical characteristics reflected in salinity and location along the river. Second, the timing of water quality sampling with respect to the last rainfall/runoff event affect the data collected from slack water surveys and thus conclusions concerning whether the estuarine system or a portion of the system

tends to be nitrogen or phosphorus limited. Thus, statements regarding whether the Patuxent River is nitrogen or phosphorus limited should take into consideration the previous 30 day freshwater inflow regime, and the salinity distribution. The regression equation obtained for the Redfield Ratio is:

$$R = -0.499\ (\ln M) + 0.425\ (\ln Q_s) + 0.429\ (\ln A_m) \qquad \text{11-1}$$

$$-0.19\ (\ln A_e) - 0.372\ (\ln Q_m) - 0.151\ (\ln S)$$

$$+0.836\ (\ln Q_a) - 0.126\ (\ Q_a) - 0.269$$

where:

R = dissolved N:P ratio i.e. $NO_2^- + NO_3^- + NH_3$/ Orthophosphorus (mg/l -N,P)

M = nautical mile

Q_s = sum of mean daily CFS from beginning to end of storm (CFS)

A_m = number of days from survey date to the middle of the previous storm (days)

A_e = number of days from survey date to the end of the previous storm (days)

Q_m = peak mean daily CFS of antecedant storm event (CFS)

S = salinity (ppt)

Q_a = average mean daily CFS from survey date to beginning day of antecedant storm

Deletion of five out of 202 observations of the N:P ratio that were indicative of outliers (using Cooks distance) reduced serial correlation to below 0.01 and resulted in a multiple correlation coefficient (r^2) of 0.75. This regression was performed using the BMDP, P9R, multiple linear regression program (41). Application of the same general procedure, although not as extensively to the total N:P ratio yielded squared multiple correlation coefficients greater than 0.5.

Water Quality Variable Cumulative Frequency Distributions

Cumulative frequency distributions are useful for describing not only the nature of a water quality variable distribution but to compare and evaluate variables against which a water quality standard exists. In the Patuxent River, the first published CFD was presented by the FWPCA, 1968 (19) at the Rt. 50 bridge crossing the Patuxent River. Data reported at that time indicated that 50% of the time, dissolved oxygen would be expected to be 4.6 mg/l in June, 4.5 mg/l in July, 5.0 mg/l in August, 5.9

mg/l in October and 7.4 mg/l in May, based upon data collected in 1967. Cumulative frequency distributions are useful because they provide information concerning the extreme values, median concentrations and provide insight into what percent of the time one would expect to observe a value or a concentration range to be exceeded, equal to or less than another value or a standard. Water quality variables are known not to be normally distributed, although published literature concerning this fact is quite limited. Thus, care must be taken in applying parametric statistical tests that in many cases are dependent upon the sample population being normally distributed. Figures 11-11 through 11-21 show the cumulative frequency distributions of water quality variables collected during this study. Two plots have been developed for each water quality variable in order to show the slack water survey data and the intensive water quality survey data. Although these have been developed for the entire data base collected during this 1980-81 period, they can be developed for unique salinity regimes and stations in order to compare trends. Figure 11-11 indicates that the expected dissolved oxygen distribution for the entire river from the intensive two surveys is almost the same as the data for the slack surveys. This raises the question of the need for slack surveys necessary to characterize dissolved oxygen in a river system. In fact, for many of the variables the two intensive surveys provide similar distributions. These graphs also indicate the degree to which variables are normally distributed. The only variable which appeared to be normally distributed was dissolved oxygen.

Secchi disc is less than 0.1 meters more than fifty percent of the time in the Patuxent River based upon the 1980-81 data. Approximately 98% of the time secchi disc is expected to be less than 0.4 meters. A CFD was developed for the N:P ratio and indicated 50% of the time the river and estuarine system would be expected to have an average Redfield ratio of 7 indicating nitrogen limitation. Similar types of figures and statements may be useful for comparing different water quality conditions in different regions of the Chesapeake Bay, as well as different regions within the Patuxent estuary.

Scatter Plots of Water Quality Variables

Scatter plots of variables were developed in order to determine water quality variable linear associations. Figure 11-22 shows the expected correlation of total phosphorus (TP) and total particulate phosphorus (TPP) in the lower estuary. Other plots, although not shown, indicate that TPP and chlorophyll-a was correlated (r=0.76) as well as chlorophyll-a and TP (see Table 11-1). Figure 11-23 indicates the expected relation between chlorophyll-a and particulate carbon in the lower estuary. The highest linear correlation of dissolved oxygen was found when regressed against the particulate carbon and particulate nitrogen ration (r=0.62). Insight would be enhanced and more reasonable predictive statistical models of water quality variables could be developed if multiple linear regression models were employed to the data set. Figures 11-24 and 11-25 show a fairly strong nonlinear correlation between total inorganic nitrogen and ortho-phosphorus from the 1980-1981 slack water surveys.

Nutrient Stratification

While estuaries are predominantly characterized on the basis of their density stratification and circulation patterns (44), predictable short-term variability of these parameters may be important in the distribution of salinity, dissolved oxygen, and nutrients in the water column. Haas (45) reported that in the James, York, and Rappahannock estuaries density stratification and homogeneity alternated within a time scale of days, with density stratification pronounced during neap tidal periods and destratification approximately 4 days following maximum spring tides.

Webb and D'Elia (46) found that in the York River vertical mixing during destratification events over a 3 day period acts to replenish oxygen in deep water and accelerates the input of benthic regenerated nutrients into the euphotic zone. Thus water quality variables sampled on a weekly - monthly basis may miss important transient variations in oxygen and nutrient distributions within the estuary. Short term stratification - destratification events correlating to spring neap tides have been observed to a lesser degree in the Patuxent River (47,48).

In order to determine to what degree nutrient stratification may be associated with salinity stratification, the difference (absolute value) between surface and bottom concentrations of variables were calculated from slack tide survey data. Table 11-2 shows correlation coefficients for various nutrient variables. Although this is not a complete analysis of stratification, it is a good and reliable indicator. The correlation coefficients were obtained from least squares regression of the absolute value of surface to bottom differences of nutrients (dependent variable) and salinity (independent variable). Station XED4892 (mile 25.5) shows the greatest degree of stratification. Intensive survey data indicated stratification was controlled by tidal forces. Table 11-2 indicates NO_2^- + NO_3^- stratification is strongly correlated with salinity stratification. Ammonia stratification was correlated with salinity stratification at mile 30.6 (station XED9490), the same area where sediment nutrient fluxes of NH_4^+ are greatest. Table 11-3 shows the lease squares regression coefficients using various nonlinear transformations of nutrients, normalized freshwater flow. In general, there is a stronger association between ortho-phosphorus and ammonia stratification with salinity stratification than with NO_2^- + NO_3^-. Thus nutrient stratification in an estuary is complex and is not purely a function of salinity stratification or freshwater inflow. Table 11-3 indicates nutrient stratification is associated with freshwater input at Route 50. It is interesting to note that the N:P ratio stratification correlation with salinity stratification was highest at the mouth of the river system (XCF9575) indicating nutrient limitations in this river reach may be dominated by transient tidal conditions.

Nutrient stratification in the water column is not an easily quantifiable process, however in order to refine the above analysis, various transformations to the absolute value surface to bottom differences of nutrients and salinity were made, followed by least squares regression.

The resulting highest correlation coefficients were selected and are presented in Table 11-3. Although no simple transformation or normalization of the stratification values reveiled a consistent trend for all variables at all stations, it can be observed that $NO_2^- + NO_3^-$ stratification tends to be related to salinity stratification, NH_3 stratification tends to be related to salinity stratification in the upper estuary, while the lower estuary stratification is related with a combination of salinity normalized to freshwater inflow. Orthophosphorus in the upper estuary shows the opposite trend in the upper estuary, i.e. nutrient stratification may be dependent upon salinity normalized by freshwater inflow, the middle estuary nutrient stratification tending to be dominated by salinity only and in the lower estuary, stratification potentially dominated by salinity normalized to freshwater inflow. The N:P Redfield ratio stratification appears to be dominated by salinity normalized to freshwater inflow and the lower estuary N:P ration stratification due mainly to salinity. This simplistic analysis does however show that freshwater inflow is associated with nutrient stratification.

Longitudinal Phytoplankton Survey Results

Two longitudinal phytoplankton surveys were conducted in order to qualitatively determine the number of cells and species along the estuary (see Methods Section for sampling techniques). Figure 11-26 shows the estimated total phytoplankton cells at each slack survey station during the July cruise and Figure 11-17 indicates the same information for the April survey. Tables 11-4 and 11-5 are tabular presentations of the raw data. In July both number of species and total cell counts of phytoplankton increased substantially downstream of the Western Branch tributary. In April, the total number of cells and species also increased, but not as substantially as seen in the plots. Figures 11-28 and 11-29 indicate the genera of species identified. Below Western Branch a significant increase of cryptophytes and chrysophytes were observed as well as increases of green algae species. At the next downstream station a peak of blue green algae was observed as well as a diatom peak. As diatoms increase in number, the blue greens decline substantially and cryptophytes and chrysophytes decrease slightly. At approximately mile 30 the diatoms and blue greens decrease substantially, and a major peak of unidentified (1.5-2um coccoid) species dominate the total number of cells and continued to be the predominate phytoplankton group in the 25 to 30 mile region. As the coccoid forms, cryptophytes and chrysophytes start to decrease in the lower estuary, dinoflagellates increase (20-25 mile region). At the mouth of the estuary in July, the phytoplankton community was dominated by diatoms, cryptophytes and chrysophyte species. It is interesting to note that dinoflagellates increased in the region where depth of the estuary decreases below a mid-estuary sill and where salinity during the July 21 water quality slack survey indicated higher surface values, indicating upwelling of bottom water. Salinity was also higher at the surface during the July 23-24 water quality survey. Temperatures were lower at the surface, supporting the view of potential upwelling related to the dinoflagellate mid-river bloom in July.

July surface dissolved oxygen was highest (6.2) at the site where there was the maximum number of phytoplankton cells, indicating supersaturation (Nottingham, PXT0402). At the same location diatoms and blue green algae reached their maximum density. Minimum surface dissolved oxygen (4.4 mg/l) occurred at the same location where dinoflagellate species reached their maximum intensity (see figures 11-29 and 11-30), thus indicating stronger evidence that the phytoplankton sample collection was producing representative phytoplankton characterization. The highest chlorophyll-a value (79.4 $mg.m^{-3}$) also occurred at station PXT0402, near Nottingham, where blue green algae and diatom species were dominant. A lower estuary peak (below Benedict, XDE9401) of chlorophyll-a corresponds to the location where dinoflagellates were dominant. Dissolved oxygen saturation data obtained from the intensive survey data showed supersaturation at the same locations where diatoms and blue green algae were dominant as well as the station where dinoflagellates were dominant. The pH was greatest at the diatom and blue green dominant station and secchi disc decreased longitudinally as the total phytoplankton cell counts increased (see figure 7-6). Water column ammonia decreased slightly at the locations of the dinoflagellate and diatom/blue green dominant locations (see July 21 longitudinal plot, figure 7-11). A total particulate nitrogen maximum in surface waters also coincided at the station with maximum cell counts of cryptophytes, chrysophytes and unidentified coccoid species. Dissolved organic nitrogen concentrations were substantially higher at the same locations where blue greens, diatoms, cryptophytes, chrysophytes and unidentified coccoid species were dominant. The highest total organic carbon, total phosphorus and total particulate phosphorus water column concentrations also occurred at the location in the lower estuary where dinoflagellate, cryptophyte and chrysophyte dominant station.

The total N:P ratio calculated from data for July 21, 1980 indicated that above Benedict, where the lower estuary bloom of dinoflagellates and other phytoplankton species occurred, nitrogen may have been a limiting nutrient. Nitrogen limitation was also supported by values of the Redfield ratio (see figure 7-21, July 21, 1980). The Redfield ratio also indicates that the upper river was phosphorus limited where blue greens, greens and diatoms where dominant. Pheophytin-a was greatest at the stations where blue greens, greens and diatoms where dominant. Dissolved reactive silicate reached a minimum (near zero) where blue greens and diatoms reached their maximum cell counts, i.e. Nottingham. A total solids river maximum was observed at Nottingham and above Benedict.

It is interesting to note that the green non-filamentous algae Scenedesmus quadricauda was found at stations PXT0490, PXT0455, and XED9490, all located in the tidal portion of the river down to Lower Marlboro. This species has been reported to be sixth on a list of 20 pollutant tolerant species of algae (36). In addition, the diatom genera Nitzschia was observed in July at PXT0402, reported 6th on a list of 22 most pollutant tolerant genera of algae. During this July survey at station PXT0402, 6 species of diatoms were tentatively identified and Nitzchia was the least dominant species present. At the other stations where Scenedesmus quadricauda was tentatively identified, it was never the

most dominant species, but was most dominant at station PXT0455 where blue green algae reached their maximum density. This station was also where blue green algal density was observed to be highest. Neither of these types of algal cells were present at the freshwater stations (i.e. PXT0603 and WXT0045).

The April 1981 survey indicated diatoms were more dominant at the mouth of the estuary and decreased up-estuary, reaching a minimum in the turbidity maximum region. The dominant diatom was Rhizosolenia fragillissima, followed by the Cyclotella genera of diatoms. The latter genera have been reported to be a pollutant tolerant genera in freshwater environments (Parrish, 1975). These two types of diatoms were dominant up to approximately mile 20, where Rhizosolenia and Skeletonema costatum, a marine diatom were the dominant diatoms. Above Benedict (XED4892) Nitzschia species were found, but were not dominant. At the next upstream station (XDE9490-mile 30) Cyclotella species became dominant and the Melosira genera of diatoms were observed (also indicated as pollutant tolerant diatoms). At station PXT0455 at Jug Bay, below Western Branch, no marine diatoms were observed and the dominant genera were Navicula followed by Nitzschia genera and Synedra species. This station thus showed a dominant shift of diatom species towards pollutant tolerant species. Euglena species, a flagellate algae genera was also found at this station as well as the station above Western Branch (PXT0494). Above Western Branch the Synedra genera of diatoms became dominant (another reported pollutant tolerant freshwater diatom) followed by Navicula species. At the freshwater stations (PXT0603, WXT0045) the dominant diatoms were the Navicula genera followed by the Synedra genera. Thus, the small upper river peak of diatoms were composed of reportedly pollutant tolerant freshwater species. Without further comparative analysis it can not be determined that these species are indicative of a polluted environment in the upper reach of the Patuxent River. Comparison of the water column data indicates that a silica minimum occurs at the mouth of the estuary where diatoms were the second dominant type of algae. The most dominant algae were cryptophytes and chrysophytes. It is also interesting to note that the small upper river silica minimum occurred at the same station where Figure 11-31 indicates a small upper river diatom peak.

Figure 11-31 indicates that the second dominant algae genera was a green algae, tentatively identified as Nannochloris with maximum cell counts at station XED4892 (mile 25). Dinoflagellates also reached maximum density at this location. The dominant dinoflagellate at station XDE9401 and XED4892 was Katodinium rotundatum. Above station XED4892 (above Benedict) there were essentially no dinoflagellates, indicating the source of dinoflagellates as deeper Chesapeake Bay water. During this survey the surface salinity was higher than the one meter depth and salinity stratification from surface to bottom was approximately 0.1 to 0.2 ppt. In addition station XED4892 water temperature at one meter was lower. Together these factors indicate potential upwelling phenomena in this region. Intensive survey plots of temperature (see figure 9-2) also indicate water column temperature was the lowest in the estuary at this location. Cryptomonas species and microflagellates dominated the upper and lower

estuary, with Cryptomonas acuta being the only fairly unique species tentatively identified. Other than Nannochloris, the upper river green algal maximum cell density was due to the dominance of coccoid green algae, and the Chlorella genera, a reportedly pollution tolerant genera of green algae. Nannochloris was the dominant green algae observed in the PXT0603 (Rt. 50) sample and Western Branch tributary samples. It is interesting to note that phytoplankton species and cell densities in April were at their maximum at the same station where April zooplankton observations (funded by the U.S. EPA) indicated maximum densities, i.e. stations PXT0455 (Jug Bay), PXT0402 (Nottingham) and XED9490 (Lower Marlboro).

During the April phytoplankton survey, the highest chlorophyll-a ($mg.m^{-3}$) value was observed at the mouth of the estuary where diatom densities were highest, (XCF9575) see Table 11-6.

Longitudinal Bacterial Measurements

Three longitudinal surveys were conducted in order to qualitatively identify potential nitrification reaches in the lower river and estuarine system. Tables 11-7 through 11-9 show the results of the water and sediment analysis as performed and described in Section 2. A major source of NO_3^- is from river discharge. Sediments are a source of ammonia (NH_3) which in water become ammonium (NH_4^+). Nitrification is defined as the processes (bio-chemical) which provide the pathways for transformation of ammonia to nitrate, i.e., NH_4^+ to NO_2^- to NO_3^-. Two genera of bacteria responsible for nitrification are Nitrobacter species and Nitrosomonas species. Nitrosomonas species reduce ammonium ions (NH_4+) to Nitrite (NO_2^-) and Nitrobacter species reduce nitrite (NO_2^-) to nitrate (NO_3^-). The number of colony forming units (shown in Tables 11-7 through 11-9) indicate the potential magnitude of these species in water samples and sediments. During the mainstem surveys, water column samples indicate that reduction of NH_4^+ to NO_2^- was potentially greatest at Nottingham (PXT0402), below Western Branch, July 23-24 and August 21, 1980, and in the lower estuary an April 20-21, 1981 (Station XDE5339). Reduction of NO_2^- to NO_3^- by Nitrobacter species was potentially greatest in the water column in the lower estuary (XDE2599) in July, Lower Marlboro (XED9490) in August and above Western Branch (PXT0494) in April.

In sediments, reduction of NH_4^+ to NO_2^- by Nitrosomonas was potentially greatest in the lower estuary (XDE5339) in July, August and April. NO_2^- to NO_3^- reduction by Nitrobacter species in sediments was potentially greatest at station PXT0402 (Nottingham) in July, at XED9490 (Lower Marlboro) in August and at XED4892 (above Benedict) in April. Thus a potential for greater NH_4^+ to NO_2^- sediment reduction in the lower estuary exists, and NO_2^- to NO_3 reduction in the mid to upper estuary. This data corresponds to high benthic NH_4^+ sediment flux in the upper estuary observed in July and August during this study and in previous studies (Boynton et al., 1980)(57). Trends of nitrification in the water column are not as apparent. More detailed measurements from more than one water column sample or sediment sample at longitudinal stations are needed in order to verify nitrification trends as well as accuracy of measurements made at one sampling location.

Primary Productivity Measurements

Productivity measurements were made at six locations in the river system as described in Section 2. At the three locations, (see figure 2-3) data indicate that depth averaged net photosynthesis is greatest in the upper estuary at the Selby Landing site, below Western Branch (see Table 11-10). Net photosynthesis was approximately twice as high at this location than at Jacks Bay and a factor of 6 higher than the lower estuary oxygen budget station at Sotterly Point. The same trend appears with gross photosynthesis, except that Sotterly Point and Jacks Bay differs only by a factor of 2. Respiration at Sotterly Point and Jacks Bay is approximately the same. At Selby Landing respiration is higher by a factor of 2. Surface light and dark bottle primary productivity data also show consistently higher surface gross and net photosynthesis values as expected. Water temperature is higher in this region of the river (Jug Bay and Selby Landing) as well as higher nutrient concentrations as a result point non-point source loads and sediment fluxes. Sediment oxygen demand was, on the average, greater at Selby Landing than other mid-estuary stations (see figures 5-12, 5-15 and 5-14). The variability of these measurements is known to be high. Based upon this data the average and standard deviation of respiration at any depth during the year from single bottle estimates would be expected to be 9 $\pm$ 13 mg -at $O_2 \cdot m^{-3} \cdot hr^{-1}$.

Productivity measurements were also made in the lower Patuxent Estuary as part of this study by the University of Maryland, at sites shown in figure 2-5. The location of the light and dark bottles were at different depths than the previously described measurements, the incubation period was shorter and triplicate bottles were suspended at 90% and 60% of surface light insolation. The values they report are areal estimates ($O_2 g \cdot m^{-2} \cdot d^{-1}$) and therefore cannot be directly compared to the previously described data. The April, 1981 Marsh Point productivity observations were slightly higher (11.61 $\pm$ .17 g $O_2 \cdot m^{-2} \cdot d^{-1}$) than the other two lower estuary stations. In October, 1980 St. Leonards Creek productivity was generally higher, and in August of 1981 St. Leonards Creek was slightly higher. The same trends were observed for respiration measurements. More variability was observed at the upstream station. Table 11-11 shows the actual measurements.

D'Elia et al. (16) utilized the above productivity measurements and the euphotic zone benthic flux data to estimate phytoplankton demand for ammonia in the daytime. Demand was approximately 10 times greater than the amount of ammonium in the water column (August, 1980 data). They estimated the phytoplankton demand of 0.5 ug -at L^{-1}, and average sediment regeneration of ammonium of 0.0008 g -at/square meter/day and that sediments may supply approximately 30% of the daily phytoplankton demand, and can replace water column storage ammonium by a factor of 2 to 3 times a day. D'Elia et al., conclude that during this summer period additional recycling sites or sources of ammonia must exist and hypothesize that remineralization is the likely source of nitrogen.

Data reported by the University of Maryland for this study also indicated phytoplankton respiration was greater than benthic respiration. Benthic respiration (sediment oxygen demand) may account for an average of 24% (range 12 - 58%) of the oxygen utilization in the subeuphotic water column, thus less than 24% for the total water column. D'Elia et al. (16) conclude, based upon their relatively few measurements assumptions of strongly stratified water column conditions, that around 75% of the observed respiration in the lower river might be partitioned to the plankton community and 25% to benthic respiration.

Based upon the data collected for this study, gross estimates of the turnover time (time required for total oxygen content of the subeuphotic zone to be utilized by water column and benthic respiration) were calculated, and during periods of strong stratification appear to be approximately 1 to 4.3 days (16). This information therefore points to the need to understand vertical mixing as well as the areal and temporal extent of stratification in order to more realistically determine the extent of low dissolved oxygen potential impacts on the fishery community. Data collected from this study during the 24 hour intensive surveys suggest that in the lower estuary, tidal forces alone may not be strong enough to replenish subeuphotic dissolved oxygen to a level that is considered suitable for finfish, but increased vertical mixing during wind events may provide the energy necessary for vertical mixing in order to destratify the water column and replenish oxygen to deeper waters in the lower estuary.

Conservative Mixing of Water Quality Variables

The identification of conservative or non-conservative mixing of water quality variables can be addressed simplistically by scatter plots of a variable versus salinity (42). It is clear that identification of non-conservative behaviour is difficult when temporal variations of the inputs produce changes in the residence time and ambient concentrations of a nutrient species or water quality variable, or when complex circulation in a particular reach of an estuary is complex and affects the ambient concentration. This technique of identifying the conservative nature of a variable in an estuary tends to become more difficult and tentative when two end members are evident (43), when tributaries freshwater inputs, topography and estuary morphology changes the longitudinal rate of dilution or mixing. Statements regarding potential sources or sinks of nutrients discussed below should be considered in light of the above limitations of this simplistic analysis.

Figures 11-34 through 11-44 show plots of the 1980-1981 mean station salinity and the respective mean water quality variable. Figure 11-34 shows total phosphorus concentrations in the upper river is diluted and may be a potential sink in the salinity region 1-3 ppt. At approximately 8.5 ppt there appears to be a potential source of total phosphorus. At 14.5 ppt there is indication of a sink and at 15.5 ppt a potential source of phosphorus. The surface total phosphorus plot (not shown) indicated a stronger trend of a source of phosphorus in the lower estuary, while the bottom mean total phosphorus versus salinity plot indicated a very strong mid-estuary source above and below Benedict (XED4892) and XDE9401).

Dissolved nitrate mean values indicate dilution is fairly consistent and the major portion of the estuary may serve as a sink of NO_3, however figure 11-34 indicates a potential lower estuary source. Plots of average surface concentrations indicated a substantial source of nitrate at stations XDE2599 and XDE5339 in the lower estuary, while bottom values indicated a substantial source of nitrate at stations XDE2599 and XDE5339 in the lower estuary. Bottom mean concentrations indicate a potential source at the mouth of the estuary, probably representing release from the sediments.

Dissolved phosphorus (figure 11-35) is diluted in the upper estuary. This plot indicates two end points. At the station above Benedict (XED4892) a source of dissolved phosphorus is indicated. The surface dissolved phosphorus plot indicated a definite source in the mid-estuary (stations XED4892, XED9490, PXT0402), a sink at station XDE5339 and a source at XDE2599, above Solomons. Bottom concentrations indicate a sink at Lower Marlboro (XED9490) and a potential source above and below Benedict.

Dissolved reactive silicate shown in figure 11-35 indicates two end points. However surface and bottom values did not indicate two end points. The turbidity maximum region (Nottingham-PXT0402 and XED9590-Lower Marlboro) appears to be a sink for silica. Above Benedict silica appears to behave conservatively. Below Benedict a source of silica is indicated (i.e. XDE9401, XDE5339 and XDE2599). Surface and bottom values indicate the same general trend.

Figure 11-36 indicates a potential mid river source of ortho-phosphorus above and below Benedict. Evaluation of mean surface values indicated a potential source above Solomons to Lower Marlboro. Bottom values indicate the same trend extends up Nottingham with the highest source region above Benedict (XED4892), however this station is where the intensive surveys indicated a factor of 2-3 concentration increase of nutrient concentrations was associated to tide stage.

Although not shown, plots of total particulate phosphorus indicated simple dilution dominated this constituent except above Benedict (XED4892) and above Solomons (XDE2599) a potential source was indicated. Surface TPP indicated the same trend except a source was indicated above and below Benedict.

The dissolved organic carbon indicates a source near Nottingham and potentially from the Chesapeake Bay. Overall, the middle and lower estuary may act as a sink. Bottom and surface mean values indicate the same general trend.

Total organic carbon values (figure 11-37) indicate the opposite trend, i.e., a potential addition or accumulation of total organic carbon. Bottom values indicate a sink or dilution in the lower estuary.

Pheophytin-a average values follow the trend of conservative (dilution) action. The same trend was indicated by mean bottom water observations, while a slight sink is indicated by surface values.

Total alkalinity and chlorides appear (figure 11-38) conservative as expected. Figure 11-39 plots indicate higher chlorophyll-a values at the mouth of the estuary and uncorrected values indicate a dominant source in the mid-estuary turbidity maximum region as expected. Bottom chlorophyll-a values do not indicate a mid-river addition, but a lower river addition.

Figure 11-40 indicates dilution and uptake of total nitrogen in the upper estuary and a trend for conservative dilution from the salinity region 3 to 16 ppt. Bottom values indicated straight dilution with no apparent uptake or source (i.e. linearity). Surface values, indicated dilution as expected, however an upper river source above Benedict was indicated as well as above Solomons.

Two end points of seston are indicated in Figure 11-40. This may be due to the turbidity maximum region. The surface and bottom plots substantiate the source or addition of the suspended solids is in the turbidity maimum region of the estuary. Figure 11-41 plots shows the increasing pH near the mouth of the estuary. Dissolved total nitrite behaves non-conservatively as expected, with surface values indicating a potential source from Chesapeake Bay, however bottom water mean values do not indicate higher concentrations at the mouth of the estuary. Higher water column concentrations at the surface may be indicative of remineralization.

Mean dissolved oxygen is highest at Jug Bay, the mouth of the estuary. Dissolved oxygen 1980-1981 station averages shown in figure 11-43 indicate the minimum average occuring below Benedict (XDE5339). This same trend is observed for bottom average values. Surface mean values however indicate the highest average dissolved oxygen saturation below Benedict. BOD_5 plots (figure 11-42) show higher average demand above Benedict. Surface values for lower estuary regions are also highest above Benidict and bottom water BOD_5 is highest in the upper estuary.

Average dissolved nitrogen (figure 11-43) values indicate no source of nitrogen from the Bay, and that the estuary serves as a potential sink for dissolved nitrogen, however surface and bottom station means indicate a potentially stronger trend for a source from the Chesapeake Bay or from bottom sediments. Dissolved Ammonia is non-conservative with a general trend of the lower estuary bottom waters providing a source of ammonia below Benedict and above Solomons. Surface ammonia is higher at the mouth of the estuary indicating potential water column remineralization as well as at the Nottingham station (PXT00402). Temperature was highest above Benidict as shown in figure 11-44.

In order to more fully understand the relation between water quality variables and salinity, plots of concentration versus salinity of actual survey observations were plotted instead of average values. Figure 11-45 is a plot of all chlorophyll values versus salinity. No general trend is obvious, except occassional chlorophyll-a values above 50 ug/l, indicating eutrophic conditions. Chlorophyll-a, corrected for presence of pheophytin indicate a definite trend of higher concentrations in the lower estuary in April of 1982 during the intensive survey.

Figure 11-46 shows the slack water chlorophyll-a surface and bottom values in April, collected after the intensive survey, when a large diatom bloom was evident at the mouth of the estuary. June 29, 1981 chlorophyll values indicate much lower values at the mouth of the estuary. Figure 11-47 shows the results of the April intensive chlorophyll-a values indicating high April, chlorophyll-a in the upper and lower estuary reaches. During the March 19, 1981 slack survey values at the mouth of the river were much lower, indicating that by April biological productivity probably increased due to warmer temperatures. Alkalinity plotted against salinity (see figure 11-49) shows the same trend as mean value plots. The pH was much lower in the upper river, around 6.7, slightly near the critical point for juvenile finfish survival.

Figure 11-50 would indicate that during the spring, BOD_5 is greatest in the lower estuary. This same figure shows that D.O. saturation is much higher in the lower estuary in the spring as expected.

Dissolved reactive silicate plotted against salinity for the April 27 slack survey data indicates it behaves rather conservatively in the spring, with an indication of sources or additional input in the upper estuary. During the March 1981 slack survey the reverse trend was apparent, i.e. uptake of silica in the mid-estuarine region. The April 23 intensive survey data shown in figure 11-52 indicates a source or addition of silica in the upper estuary. In the upper reaches of the lower estuary there is also a unique trend of uptake or a sink of silica. During the June 1981 slack survey the conservative nature of silica shows much lower concentrations in the upper estuary, indicating uptake. All data shown in figure 11-53 indicates two trends of silica versus salinity in the upper estuary. During the summer, upper river concentration appear much lower, probably due to greater uptake by the algal community, whereas silica appears more conservative, as expected during the late fall and early spring in the upper river.

Figure 11-54 shows that during the early spring, there may be a source of ammonia in the upper estuary and a sink in the lower estuary (see March 1981 data). While during June 11 slack survey bottom waters indicate a source and in surface waters a potential sink. April 23, 1981 extensive survey data indicate quite clearly a potential sink in the lower estuary. The figure also shows that higher suspended solids occur in the summer as expectd in the mid-estuary.

Figure 11-56 shows dilution and a potential sink of nitrite in the lower estuary. This plot could also be indicative of the fact that nitrate is being flushed out of the river as it becomes diluted with Chesapeake Bay waters in March. Figure 11-57 shows the intensive survey data obtained on April 23, with indication of some higher concentrations in the lower estuary.

Figure 11-56 also indicates a potential sink or uptake of nitrate during the March 19 slack survey, although probably not significant. The April 23, intensive survey data indicate nitrates have substantially

increases, especially in the upper estuary. This may be a result of increased freshwater spring loads and/or nitrification processes operating at a faster rate in the river. Between these two survey dates the total nitrogen and total dissolved nitrogen did not appear to change considerably (see figure 11-58).

It is obvious from these plots that the ability to discuss potential sources or sinks in somewhat limited, however general trends in the estuary can be observed. Mean value plots may not reflect actual conditions in the river and may be misleading.

More detailed nitrifying bacteria measurements would be useful in determining cell count estimates. This type of data, in conjunction with the longitudinal water quality variables, would help discriminate the degree to which longitudinal trends of nitrification could be discerned.

Nutrient and Silica Relationships

In order to determine any gross relations between dissolved reactive silicate and mean values of water quality variables from mainstem stations for surface and bottom values were plotted against silica.

Plots of total phosphorus versus silica indicates that in surface water, a close to linear relationship exists. This trend was not apparent in bottom waters from the mainstem stations above 5 mg/l silica. No obvious relation was observed between dissolved phosphorus and silica, however a fairly strong linear relation existed between orthophosphorus and silica.

A fairly strong linear relation also exists for total particular phosphous and silica. These linear relations are indicative of the relation between uptake of phosphorus and silica by phytoplankton with higher TPP indicative of greater biomass. The strength of the linear relation between TPP and orthophosphorus was stronger with silica than with any other nutrient variable. Mean salinity and chlorides plotted against silica indicated that at approximately 3 ppt salinity (turbidity maximum region) a large sink of silica exists. This region is an area of higher primary productivity.

A linear trend between silica and chlorophyll-a and pheophytin-a was indicated, indicating higher chlorophyll-a at low silica concentrations. This indicates that silica may become a limiting nutrient.

Tables 11-13 and 11-14 show the results of univariate linear relations between water quality variables, salinity and silica from calculated mean station values during 1980-1981. It can be seen that the degree of relation depends on depth of water sample taken and whether all station data are included in the analysis. These results (r^2) can be used to help determine which variables appear to act conservative.

Gross Station Statistical Summaries

Tables 11-15 and 11-16 shows the univariate statistics for all data collected during the slack water and intensive surveys in 1980-81. This has been included for future comparison and for comparing other estuaries in the Chesapeake Bay Region. Tables 11-17 and 11-18 gives the univariate statistics comparing the data for the 1980-1981 period by depth. Note that mid-depth samples were taken in the upper tidal river section of the Patuxent system. Table 11-19 shows the average concentrations in the salinity regions from 0-3, 3.1-10 ppt, and in the region greater than 10 ppt salinity.

Potential Sources Indicated by Ambient Water Quality Data

Historical ambient data that may indicate potential sources of total phosphorus and nitrate was presented by Flemer, et.al., 1970. Space-time domain plots, figures 11-60 through 11-63 are taken from Flemer et al., (30) 1970 and indicate that total phosphorus concentrations in the lower estuary are highest during the summer (1969). During this period a greater amount of phosphorus may be transported out of the system, however a conclusive statement cannot be made without hydrographic measurements. This data also supports the view of sediments acting as a source in the late 1960's.

Figure 11-61 indicates that nitrate is higher during the spring and winter in the lower estuary, and transport of nitrate from the estuary to Chesapeake Bay may be greatest during this period.

The space-time domain plot shown in figure 11-64 shows the slack water data for orthophosphorus collected during this study. Both the 1969 and 1980 plots modified after D'Elia et al., 1981 (16) indicate higher summer values of phosphorus. These values also tend to occur when the estuary dissolved inorganic sediment flux appears to be greatest (see Tables 11-20, 11-21). During the spring of 1981, higher lower estuary water concentrations of orthophosphorus were observed. This could be due to transport of bottom orthophosphate our of the river, but a conclusive statement cannot be made. The April, 1981 longitudinal phytoplankton survey indicated a marine diatom and dinoflagellate bloom in the mid and lower estuary at this same time. Figure 11-65 indicates higher bottom water concentrations of ammonia during summer months, coinciding with higher sediment flux measurements shown in Tables 11-20 and 11-21. During the 1980-81 fall, winter and spring period low surface and bottom ammonium was observed, indicative of lower sediment flux measurements and water column remineralization (due to reduced microrganism activities in the sediments and water column). Figures 11-61 and 11-66 indicate similar trends of nitrate in the river during the spring of 1970 and spring of 1981. Surface values during 1980-1981 are however higher. Figure 11-67 shows summer 1981 chlorophyll-a values similar to those reported in 1970 by Flemer, et.al. (30). Figure 11-68 indicates, as expected, low dissolved oxygen in the lower estuary during the summer months, especially in the bottom waters when sediment oxygen demand tends to be highest (see figures 11-69, 11-70, and Table 11-22).

Sediment oxygen demand measurements are shown in Table 11-22. These measurements indicate sediments can be a significant source of oxygen demand. In fact, average SOD for the river appears to be $3.28 g O_2 m^{-2} d^{-1}$ or an average daily river demand estimated to be near 721,600 lbs/day. This demand will vary depending upon location and time of year. The impact upon the river's dissolved oxygen budget and biological productivity will depend upon water column stratification. Data collected by the University of Maryland (16) and Biospherics, Inc. (31) are similar (see figures 11-69 and 11-70). The Patuxent estuary has been cited to have exhibited some of the highest SOD measurements reported in coastal ecosystems. Figure 11-71, modified after D'Elia et al. 1981 (16) shows relative SOD measurements reported for a variety of marine ecosystems. The Patuxent River SOD average appears to exhibit somewhat higher values than other values, however, the substantially larger range of SOD may be a function of a greater number of stations and time periods where data has been collected, compared to other marine ecosystems.

Figure 11-72 indicates the relative magnitude of ammonium flux in the lower estuary. Tables 11-20 and 11-21 show the actual values and the range of ammonium sediment flux in the middle and upper Patuxent estuary. Although the flux changes from location and by season the data indicate average flux out of the sediments around 235 $mg\text{-}at\text{-}m^2 hr^{-1}$. Thus ammonium flux from the sediment to the water column exhibit an extreme influence upon productivity in the basin.

Other data presented in this section also indicate the potential sources of chemicals to the estuary as viewed by the simple mixing diagrams, i.e. concentration versus salinity plots.

Plots are presented which indicate dilution as a function of salinity (see figures 11-34 to 11-58). Potential sources of chemicals can be inferred from these figures, however due to the extreme variability of water column measurements, statements regarding sources of chemicals from these conservative mixing diagrams are limited. These figures do however show that the region of the turbidity maximum has higher concentrations for many water quality variables. Plots of bottom water concentrations indicate that lower river values can be higher than mid-river values, however this is probably related to sediment flux and the Chesapeake Bay does not appear to be a source of chemicals to the estuary (see Section 11 for a more detailed description) from the analyses. Flux measurements are needed at the mouth of the estuary to verify this estimate.

REFERENCES

1. Buchanan, T. J. and W. P. Somers. Discharge Measurements at Gauging Stations. Chapter A_8 in Applications of Hydraulics, Book 3 of Techniques of Water Resources Investigation, United States Geological Survey, 1968.

2. Carter, R. W. and J. Davidian. General Procedures for Gauging Streams. Chapter A_6 in Applications of Hydraulics, Book 3 of Techniques of Water Resources Investigation, United States Geological Survey, 1968.

3. Capizzi, T. and B. Wilson. Statistical Concepts in the Sampling Design and Analysis of Water Quality Studies. Fourth Bienna International Estuarine Research Conference, Mt. Pocono, Pa., 1977.

4. Mountford, K. Plankton Studies in Barnegat Bay, NJ. M.S. Thesis, Rutgers University Library of Science and Medicine, 1969, 14 pp.

5. D'Elia, C. F., P.A. Streudler and N. Corwin. Determination of Total Nitrogen in Aqueous Samples Using Persulfate Digestion. Limnology and Oceanography, 22(4):760-763, 1977.

6. Durhman Envirotech. Total Organic Analyzer. Instruction Manual, DC-50, 1976 and Equipment Manual, DC-80, 1981 Santa Clara, California.

7. Environmental Protection Agency. Handbook for Analytical Quality Control in Water and Wastewater Laboratories. U.S. EPA Technical Transfer, 1972.

8. Environmental Protection Agency. Methods for Chemical Analysis of Water and Wastes. EPA 625/6-74-003a, 1974 and EPA 600/4-79-020, 1979.

9. Environmental Protection Agency. Microbiological Methods for Monitoring the Environment, Water and Wastewater. EPA 600/8-78-017, 1978.

10. Technicon Industrial Systems. Autoanalyzer Industrial Methods 7-68W and 8-68W. Tarrytown, N.Y.

11. Standard Methods for the Examination of Water and Wastewater, 14th Edition. APHA, AWWA, WPCF, Washington, D.C., 1975.

12. Strickland, J.D.H., and T.R. Parsons. A Practical Handbook of Seawater Analysis. Bull. No. 167. Fisheries Research Board, Ottawa, Canada, 1972, 310 pp.

13. Shoaf, W.T. and B.W. Luim. Improved Extraction of Chlorophyll-a and b from Algae Using Dimethyl Sulfoxide. Limnology and Oceanography 21:926-928, 1976.

14. Vollenweider, R. A. A Manual on Methods for Measuring Primary Production in Aquatic Environments. IPB Handbook No. 12, Blackwell Scientific Publications, London, England, 1974, 34 pp.

15. Carpenter, J. H. The Chesapeake Bay Institute Technique for the Winkler Dissolved Oxygen Method. Limnology and Oceanography, 10:141-143, 1965.

16. D'Elia, C. F., W.R. Boynton, J.H. Tuttle, K.V. Wood, C.W. Keef, and W.M. Kemp. Final Report on Benthic Nutrient Studies on the Lower Patuxent River. University of Maryland Center for Environmental and Estuarine Studies, Chesapeake Biological Laboratory, Solomons, Maryland. UMCEES Ref. No. 81-190CBL. 1981.

17. Brakensiek, D. L., H. B. Osborn and W. J. Rawls. Field Manual for Research in Agricultural Hydrology. USDA, U.S. Government Printing Office, Washington, D.C., 1979.

18. Yarbro, L. A. Seston Dynamics and a Seston Budget for the Choptank River Estuary in Maryland. Maryland Department of Natural Resources, 1981, 223 pp, 1981.

19. Anonymous. A Comprehensive Analysis and Program for Water Quality Management in the Patuxent River Basin. FWPCA, No. 31, 1968.

20. Halka, M. Personal Communication. Maryland Department of State Planning, Baltimore, Maryland, Jan., 1982.

21. Anonymous. Draft Nutrient Control Strategy, Patuxent River. Maryland Department of Health and Mental Hygiene, August, 1981.

22. Fox, H. and A. Gupta. Reconnaissance Survey of the Patuxent River, June-September, 1971. Prepared by Johns Hopkins University for Department of Natural Resources, 1972, 211 pp.

23. Cox, A. M. Bathymetric Investigation of the Patuxent River System. Maryland Department of Natural Resources, 1980, 1&3 pp.

24. Owen, W. A Study of the Physical Hydrography of the Patuxent River and its Estuary. Technical Report 53, Chesapeake Bay Institute, Johns Hopkins University, 1969, 37 pp.

25. Boicourt, W. C. Flow Measurements in the Patuxent and Chester Rivers, Summer 1980. Interior Report to Tidewater Administration, Maryland Department of Natural Resources, Chesapeake Bay Institute, Johns Hopkins University, 1981, 19 pp.

26. Hopnev, T. and C. Orliczsk. Humic matter as a component of Sediments in Estuaries. In: Biogeochemistry of Estuarine Sediments, Proceedings UNESCD/SCOR Workshop, Metreux, Belgium, 1976, 70-73 pp.

27. Environmental Protection Agency. Draft Environmental Impact Statement, Little Patuxent Water Quality Management Center. U.S. EPA Region III, 1981, 127 pp.

28. Halka, M. Estimated Potential Nonpoint Pollution Loading under Existing Land Use Conditions in the Patuxent River Basin. Maryland Department of State Planning, Baltimore, Maryland, 1982.

29. Smullen, J. T. Nutrient and Sediment Loads to the Tidal Chesapeake Bay System. EPA, Chesapeake Bay Program, 1982, 140 pp.

30. Flemer, D. A. The Effects of Thermal Loading and Water Quality on Estuarine Primary Production. Chesapeake Biological Laboratory, Natural Resource Institute, University of Maryland, Dec. 1970.

31. Anonymous. Patuxent Data Acquisition, 1980-1981. Prepared by Biospherics Inc., for Tidewater Administration, Maryland Department of Natural Resources, Annapolis, Maryland, 1981, 52 pp.

32. Correll, D. L. and D. Dixon. Relationship of Nitrogen Discharge to Land Use on Rhode River Watershed. Agro- Ecosystems, 1980, 6, 147-159 pp.

33. Howard County Soil Conservation District. Water Quality Sampling Sites. Cattail Creek Watershed, Howard County, Md., 1981.

34. Bostater, C. R. Evaluation of Nonpoint Source Sampling, Loading Rates, and Data Transferability for an Estuarine Drainage Basin of the Chesapeake Bay, In: Nonpoint Pollution Control: Tools and Techniques for the Future, Flynn, K. C., ed. ICPRB Tech. Pub 81-1, 1981.

35. Anderson, G. and C. Bosco. Nonpoint Sources and Impact in the Small Coastal Plain Estuary: A Case Study of the Ware River Basin, Virginia. In: Nonpoint Pollution Control: Tools and Techniques for Future, Flynn, K. C., ed. ICPRB Tech. Pub. 81-1, 1981.

36. Parrish, F. K. Keys to Water Quality Indicative Organisms of the Southern United States (2nd ed). USEPA, EMSL, Cincinnati, Ohio, 1975, 19-21 pp.

37. Knowles, R. Common Intermediates of Nitrification and Denitrification, and the Metabolism of Nitrous Oxide. In: Microbiology 1978, P. Schlessinger, ed. ASM-Publications.

38. Ekman, S. Zoogeography of the Sea. London, England, 1953, 418 pp.

39. Joint Investigation by the Maryland Department of Natural Resources and Westinghouse Electric Corporation. Chester River Study, Volume II. W. D. Clarke and H. D. Palmer, eds. 1972.

40. Heinle, D. R. Historical review of waters Quality and Climatic Data from Chesapeake Bay with Emphasis on Effects of Enrichment. USEPA Chesapeake Bay Program Final Report, Grant #R806189010. Chesapeake Research Consortium, Inc. Publication Number 84. Annapolis, Maryland, 1980.

41. University of California. BMDP Biomedical Computer Programs, P-Series. University of California Press, Los Angeles, California, 1979.

42. Burton, J. D. and P. S. Liss. Estuarine Chemistry. Academic Press Inc. London, England, 1976.

43. Elderfield, H. Chemical Variability in Estuaries, In: Biochemistry of Estuarine Sediments, USESCO, Paris, 171-178 pp.

44. Pritchard, P. W. Estuarine Circulation Pattens. Proc. Amer. Soc. Civil Engin. 81 (717): 1-11. 1955.

45. Haas, L. W. The Effect of the Spring-Neap Tidal Cycle on the Vertical Salinity Structure of the James, York, and Rappahannock Rivers, Virginia, U.S.A. Est. and Coast. Mar. Sci. 5:485-496. 1977.

46. Webb, K. L., and C.F. D'Elia. Nutrient and Oxygen Redistribution During a Spring Neap Tidal Cycle in a Temperate Estuary. Science, 207:983-984. 1980

47. D'Elia, C. F., and T.M. Farrell. Bottom Water Oxygen Content and Stratification in a Partially Mixed Coastal Plain Estuary. Unpublished manuscript. Chesapeake Biological Laboratory, Solomons, Maryland. 1982.

48. Domotor, S. L. The Effect of the Spring-Neap Tidal Cycle on the Stratification and Mixing Patterns of the Patuxent River. Unpublished report. Chesapeake Biological Laboratory, Solomons, Maryland. 1978.

49. Gambell, A. W., and P.W. Fisher. Chemical Composition of Rainfall, Eastern North Carolina and Southeastern Virginia. U.S. Geol. Survey. Water Supply Paper 1535-k, 41 pp. 1966.

50. Fisher, P. W. Annual Variations in Chemical Composition of Atmospheric Precipitation in Eastern North Carolina and Southeastern Virginia U.S. Geol. Water-Supply paper 1535-M, 21 pp. 1968.

51. Fisher, D. W., Gambell, A.W., Likens, G.E., and F.H. Bormann. Atmospheric Contributions to Water Quality of Streams in the Hubbard Brook Experimental Forest, New Hampshire. Water Resources Res. 4(5):1115-1126. 1968.

52. Pearson, F. J., and D.W. Fisher. Chemical Composition of Atmospheric Precipitation in the Northeastern United States. U.S. Geol. Survey Water - Supply Paper 1535-p, 1971, 23 pp.

53. McCarthy, J. J., Taylor, W.R., and M.E. Loftus. Significance of Nanoplankton in the Chesapeake Bay Estuary and problems associated with the Measurement of Nanoplankton Productivity. Mar. Biol. 24:7-16. 1974.

54. Carpenter, E. J., and J.J. McCarthy. Benthic Nutrient Regeneration and High Rate of Primary Production in Continental Shelf Waters. Nature 274:188-189. 1978

55. Davies, J. M. Energy Flow Through the Benthos in a Scottish Sea Loch. Mar. Biol. 31:353-362. 1975.

56. Rowe, G. T., C.H. Clifford, and K.L. Smith, Jr. Nutrient Regeneration in Sediments off Cap Blanc, Spanish Sahara. Deep-Sea Res. 24:57-63. 1977.

57. Boynton, W. R., W.M. Kemp, and C.G. Osborne. Nutrient Fluxes Across the Sediment - Water Interface in the Turbid Zone of a Coastal Plain Estuary. pp. 93-109. In U.S. Kennedy (ed.) Estuarine Perspectives. Academic Press, N.Y. 1980.

58. Fisher, T. and P. Carlson. The Importance of Sediments in the Nitrogen Cycle of Estuarine Systems. Amer. Soc. Limnol. Oceanogr., Abstracts, 42nd Annual Meeting, Stony Brook, New York. 1979.

59. Setzler, E. M., K.V. Wood, D. Shelton, G. Drewry, and J.A. Mihursky. Chalk Point Steam Electric Station Studies, Patuxent Estuary - Studies - Ichthyoplankton Population Studies. 1978 data report. Univ. of Maryland Center for Environmental and Estuarine Studies, Chesapeake Biological Laboratory, Solomons, Maryland. UMCEES Ref. No. 79-20CBL. 1979.

60. Nash, C. G. Environmental Characteristics of a River Estuary. J. Mar. Res. 6(3). 1947.

61. Federal Water Pollution Control Administration. Water Quality and Pollution Control Study - Patuxent River Basin. CB-SRBP Working Document No. 15. 1967.

62. Cory, R. L., and J.W. Nauman. Temperature and Water Quality Conditions for the period July 1963 to December 1965. Patuxent River Estuary, MD. U.S. Dept. Int. Geol. Survey. Open File Report. 1967.

63. Environmental Protection Agency. Water Quality Survey of the Patuxent River. Data Report 16. EPA Field Office, Annapolis, MD. 1968.

64. Ulanowicz, R. E. and D.A. Flemer. A Synoptic View of a Coastal Plain Estuary. Contribution No. 766. Chesapeake Biol. Lab., Solomons, MD. 1977.

65. Mihursky, J. A., and W.R. Boynton. Review of Patuxent Estuary Data Base. Final Report. Univ. of Maryland Center for Environmental and Estuarine Studies, Chesapeake Biological Laboratory, Solomons, Maryland. UMCEES Ref. No. 78-157 CBC. 1978.

66. Newcombe, C. L., and H.F. Brust. Variations in the Phosphorus Content of Estuarine Water of the Chesapeake Bay - Near Solomons Island, MD. J. Mar. Res. Vol. 1. 1940.

APPENDIX A

FIGURES AND TABLES FOR METHODS; SECTION 2

Table 2-1 Patuxent Survey Date And Date Of Spring And Neap Tides

Month	Survey Date	Spring Tides	Neap Tides
June, 1980	25*	12	6
		28	20
July	21	12	5
	24-25 (intensive)**		
	28	27	20
August	20	10	3
		26	18
September	15	9	1
		24	17
October	16	9	1
		23	17
November	13	7	15
		22	29
December	4	7	15
		21	29
March, 1981	19	6	12
		20	28
April	21	4	11
	23-24 (Intensive)		
	27	19	27
May	14	3	10
		18	26
June	11	2	9
	29	17	24
July	16	1	
		16	8
	30	30	24
August	13	15	7
		29	22

* slack surveys
** intensive surveys

Table 2-2 Patuxent River Slack Tide and Intensive Water Quality Survey Monitoring Stations (Mid Channel)

Station Number	Station Description	Nautical Miles Upstream From Mouth	Latitude	Longitude
XCF9575	2.2 km E.N.E. of Fl "3" at 27 ft. depth	0.1	381930.3	0762233.8
XDE2599	1000 yds. S of Black Daybeacon "1" at 23 ft. depth.	9.6	382231.4	0763006.8
XDE5339	Mid Channel of Jack Bay, sand pit N.E. of Sandgate	13.9	382530.7	0763607.5
XDE9401	Mid Channel, 0.3 mi N.N.E. of Long Pt.	19.9	382926.7	0763952.5
XDE4892	Mid channel on transect heading 115° form Jacks Creek	25.5	383455.1	0764052.7
XED9490	Mid channel opposite wharf at Lower Marlboro	30.6	383929.9	0764102.8
PXT0402	Mid channel at Nottingham	35.2	384235.5	0764206.3
PXT0455	Western Shore at Jackson Landing	40.6	384651.1	0764255.8
PXT0494	Mid channel upstream side of Md. Route 4 bridge, near Waysons Corner	42.9	384836.9	0764245.3
PXT0603	Upstream side of U.S. Rt. 50 Bridge at USGS Gauge	54.2	385719.6	0764139.9
WXT0045	At Water St. Bride in Upper Marlboro	--	384851.0	0764504.2
*750632	At discharge weir of Western Branch WWT plant	--		

* Data not collected by ANSP during 24 hour surveys

Table 2-3

Patuxent River Slack Tide Water Quality
Survey Monitoring Stations (Lateral Stations)

Station Number	Station Description	Nautical Miles Upstream from Mouth	Latitude	Longitude	Channel Side	Transect Number
XCF8763	500 yds. E. of Hogg Point 22 ft. depth	0.9	381843.9	0762552.4	west	1
XCF9958	2200 yds. N.E. of Drum Pt., 22 ft. depth	1.1	381953.5	0762400.2	east	1
XDE2586	1,000 yds. S.E. of Sotterley Wharf, 8 ft. depth	9.8	382213.8	0763048.4	west	2
XDE2898	500 yds. of Marker "1" at St. Leonards Creek, 20 ft.	9.4	382303.0	0763004.1	east	2
XDE4543	300 yds. N. of Mouth at Roslin Creek, 12 ft. depth	14.1	382501.1	0763610.1	west	3
XDE5352	700 yds. S. of Mouth of Ben Creek, 12 ft. depth	13.8	382552.5	0763554.8	east	3
XDE9699	100 yds. N. of Marker G "23", 9 ft. depth	19.95	382839.1	0764200.0	west	4
XDE9603	800 yds. E. of marker G "23", 8 ft. depth	19.8	382938.5	0763928.6	east	4
XED4891	500 yds. E.S.E. of mouth of Jacks Creek, 7 ft. depth	25.3	383447.2	0764106.6	west	5
XED4894	App. 900 yds. N. of Marker R "26" near Cedarhaven, 6 ft. depth	25.4	383447.1	0764037.6	east	5

Table 2-4 Times at which samples were collected at each station and substation for each slack water survey on the Patuxent River. Also listed are predicted times of minimum current at five locations in the Patuxent River. SBF (slack before flood) refers to the predicted time of minimum current before flooding began at each of the five locations. SBE (slack before ebb) refers to the predicted time of minimum current before ebbing began at each of the five locations.

station location	date time	SGF time	date time	SBE time	date time	SBF time	date time	SBE time	date time	SBF time
	6/25/80		7/21		7/28		8/20		9/15	
XCF8763	0820		0932		1030		0925		1230	
XCF9575	0833		1005		1040		0945		1250	
XCF9958	0920		1044		1120		1030		1330	
Drum Point		0858(c)		1012		1109		1037		1335
XDE2586	0944		1126		1152		1050		1410	
XDE2599	0955		1150		1200		1105		1415	
XDE2898	1023		1226		1230		1130		1445	
Broomes Island		0916		1035		1127		1100		1353
XDE4543	0856		1250		1300		1155		1505	
XDE5339	0915		1305		1310		1200		1515	
XDE5352	1014		1332		1341		1230		1540	
Sheridan Point		0944		1059		1155		1124		1421
XDE9699	1034		0930		1030		1100		1220	
XDE9401	1047		0955		1037		1115		1255	
XDE9603	1122		1032		1102		1145		1325	
Benedict Bridge		0932		1129		1143		1153		1409
XED4891	1201		1115		1126		1210		1352	
XED4892	1208		1125		1132		1220		1400	
XED4894	1235		1149		1152		1240		1415	
XED9490	1258		1218		1212		1306		1435	
Lyons Creek Wharf		1103		1145		1314		1210		1540
PXT0402	1331		1300		1244		1345		1523	
PXT0455	1230		0918		0920		1225		1555	
PXT0494	1600		1135		1025		1030		1435	
WXT0045	1330		1020		1105		1135		1345	
PXT0603	1445		1225		1150		0937		1215	

(a) - date of survey

(b) - sample collection time

(c) - time of predicted minimum current at given location

Table 2-4 (cont.) Times at which samples were collected at each station and substation for each slack water survey on the Patuxent River. Also listed are the NOAA predicted times of minimum current at five locations in the Patuxent River. SBF (slack before flood) refers to the predicted time of minimum current before flooding began at each of the five locations. SBE (slack before ebb) refers to the predicted time of minimum current before ebbing began at each of the five locations.

station location	date(a) time(b)	SBE time	date time	SBF time	date time	SBE time	date time	SBF time	date time	SBE time
	10/16		11/13		12/4		3/19		4/21	
XCF8763	0800		1002		1125		1216		--	
XCF9575	0810		1019		1135		1240		--	
XCF9958	0833		1045		1200		1255		--	
Drum Point		0905(c)		1203		1310		1419		1118
XDE2586	0913		1115		1230		1322		1200	
XDE2599	0930		1130		1250		1340		1215	
XDE2898	0955		1155		1305		1400		1247	
Broomes Island		0928		1221		1333		1442		1136
XDE4543	1017		1215		1335		1430		1315	
XDE5339	1028		1230		1348		1450		1327	
XDE5352	1050		1255		1416		1505		1352	
Sheridan Point		0952		1249		1357		1506		1204
XDE9699	0855		1130		1230		1330		1000	
XDE9401	0900		1140		1245		1335		1025	
XDE9603	0925		1205		1330		1400		1059	
Benedict Bridge		1021		1237		1426		1535		1152
XED4891	0945		1225		1355		1425		1128	
XED4892	0953		1230		1405		1430		1137	
XED4894	1012		1250		1425		1455		1202	
XED9490	1030		1307		1447		1505		1223	
Lyons Creek Wharf		1038		1408		1443		1552		1323
PXT0402	1055		1355		1520		1535		1304	
PXT0455	0840		1040		1130		1716		1017	
PXT0494	1020		1205		1245		1548		1105	
PXT0603	1115		1345		1430		1446		1240	
WXT0045	0935		1300		1345		1336		1150	

(a) - date of survey

(b) - sample collection time

(c) - time of predicted minimum current at given location

Table 2-4 (cont.) Times at which samples were collected at each location and substation for each slack water surbey on the Patuxent River. Also listed are the NOAA predicted times of minimum current at five locations in the Patuxent River. SBF (slack before flood) refers to the predicted time of minimum current before flooding began at each of the five locations. SBE (slack before ebb) refers to the predicted time of minimum current before ebbing began at each of the five locations.

station location	date(a) time(b)	SBE time	date time	SBE time	date time	SBE time	date time	SBE time	date time	SBF time
	4/27		5/14		6/11		6/29		7/16	
XCF8763	0756		1035		0939		0700		0911	
XCF9575	0821		1100		0949		0715		0929	
XCF9958	0902		1150		1022		0735		1010	
Drum Point		0906(c)		1236		1058		0839		1121
XDE2586	0927		1215		1050		0800		1037	
XDE2599	0938		1235		1103		0815		1055	
XDE2898	1007		1305		1124		0835		1121	
Broomes Island		0929		1259		1121		0857		1139
XDE4543	1044		1325		1204		0900		1143	
XDE5339	1058		1345		1212		0915		1158	
XDE5352	1126		1405		1233		0935		1219	
Sheridan Point		0953		1325		1145		0925		1207
XDE9699	0820		1158		1030		0801		1015	
XDE9401	0830		1205		1037		0807		1027	
XDE9603	0855		1224		1055		0825		1054	
Benedict Bridge		1022		1352		1214		0913		1155
XED4891	0916		1242		1128		0850		1121	
XED4892	0925		1246		1132		0855		1130	
XED4894	0950		1302		1145		0909		1150	
XED9490	1010		1317		1215		0930		1214	
Lyons Creek Wharf		1039		1409		1231		1044		1326
PXT0402	1040		1340		1242		1020		1253	
PXT0455	0900		1429		1314		1045		1255	
PXT0494	1000		1305		1235		1145		1150	
WXT0045	1100		1215		1137		1230		1050	
PXT0603	1140		1130		1037		0945		1000	

(a) - date of survey

(b) - sample collection time

(c) - time of predicted minimum current at given location

Table 2-4 (cont.) Times at which samples were collected at each station and substation for each slack water survey on the Patuxent River. Also listed are the NOAA predicted times of minimum current at five locations in the Patuxent River. SBF (slack before flood) refers to the predicted time of minimum current before flooding began at each of the five locations. SBE (slack before ebb) refers to the predicted time of minimum current before ebbing began at each of the five locations.

stations location	date(a) Time(b)	SBF Time	date Time	SBF Time
	7/30		8/13	
XCF8763	0826		0845	
XCF9575	0848		0910	
XCF9958	0916		0940	
Drum Point		0955(c)		0926
XDE2586	0939		1020	
XDE2599	0952		1037	
XDE2898	1015		1110	
Broomes Island		1013		0944
XDE4543	1040		1139	
XDE5339	1050		1155	
XDE5352	1108		1230	
Sheridan Point		1041		1012
XDE9699	0920		0957	
XDE9401	0936		1005	
XDE9603	1000			
Benedict Bridge		1029		1000
XED4891	1028		1105	
XED4892	1034		1112	
XED4894	1054		1130	
XED9490	1118		1152	
Lyons Creek Wharf		1200		1121
PXT0402	1152		1223	
PXT0455	1225		1235	
PXT0494	1110		1120	
WXT0045	1040		1040	
PXT0603	0940		0925	

(a) - date of survey

(b) - sample collection time

(c) - time of predicted minimum current at given location

Table 2-5 Predicted Times Of Minimum Current At Each Of Five Locations During The July 1980 And April 1981 24-hour Intensive Water Quality Surveys.

Date	Location					
July 24, 25, 1980		SBF*	SBE**	SBF	SBE	SBF
	Drum Point	0833	1300	0850	0208	0919
	Broomes Island	0851	1323	1908	0231	0937
	Sheridan Point	0819	1347	1936	0255	1005
	Benedict Bridge	0907	1416	1924	0324	0953
	Lyons Creek Wharf	1038	1433	2055	0341	1114
April 23, 24, 1981		SBE	SBF	SBE	SBF	SBE
	Drum Point	0546	1258	1801	2325	0632
	Broomes Island	0609	1316	1824	2343	0655
	Sheridan Point	0633	1344	1848	0011	1719
	Benedict Bridge	0702	1332	1917	2359	0748
	Lyons Creek Wharf	0719	1503	1934	0130	0805

(*) - predicted time of slack before flood

(**) - predicted time of slack before ebb

Table 2-6 Intensive Water Quality Survey Sampling Schedule, July 24-25, 1980 And April 23-24, 1981, Samples Were Collected At Approximately 2 Hour Intervals Over A 24 Hour Period

Station	(a) Depth	Stage height	Current velocity/ direction	D.O., pH, temp. and salinity	Wind temp., humidity barometer	Secchi	Light penetration	Water chemistry (1)
XCF9575	sur		yes	yes	yes	yes	yes	yes
	mid		yes	no				no
	bot		yes	yes				yes
	Surface, mid-depth and bottom current velocities also west and east sides of river							
XDE2599	sue	meter	yes	yes	yes	yes	yes	yes
	mid		yes	no				no
	bot		yes	yes				yes
	Surface, mid-depth and bottom current velocities also at west and east sides of river							
XDE5339	sur		yes	yes	yes	yes	yes	yes
	mid		yes	no				no
	bot		yes	yes				yes
	Surface, mid-depth and bottom current velocities also at west and east sides of river							
XDE9401	sur		yes	yes	yes	yes	yes	yes
	mid		yes	no				no
	bot		yes	yes				yes
	Surface, mid-depth and bottom current velocities also at west and east sides of river							
XED4892	sur		yes	yes	yes	yes	yes	yes
	mid		yes	no				no
	bot		yes	yes				yes
	Surface, mid-depth and bottom current velocities also at west and east sides of river							
XED9490	sur	meter	yes	yes	yes	yes	yes	yes
	mid		yes	no				no
	bot		yes	yes				yes

(a) general description of measurement depth, i.e. surface, bottom or mid-depth.

Table 2-6 (continued) Intensive Water Quality Survey Sampling Schedule, July 24-25, 1980 And April 23-24, 1981, Samples Were Collected At Approximately 2 Hour Intervals Over A 24 Hour Period

Station	Depth	Stage height	Current velocity/ direction	D.O., pH, temp. and salinity	Wind temp humidity barometer	Secchi	Light penetration	Water chemistry (1)
PXT0402	sur		yes	yes	yes	yes	yes	yes
	mid		yes	no				no
	bot		yes	yes				yes
PXT0455	sur		yes	no	yes	yes	yes	no
	mid		yes	yes				yes
	bot		yes	no				no
PXT0494	sur		no	no	yes	yes	yes	no
	mid		no	yes				yes
	bot		no	no				no
WXT0045	sur		x.s. flow	no	yes	yes	yes	no
	mid		each 2 hrs	yes				yes
	bot			no				no
PXT0603	sur	gauge		no		yes	yes	no
	mid			yes				yes
	bot			no				no

(1) Total chlorophyll-a and phaeophytin-a
BOD5
TOC/DOC: TOC through September 1980, DOC after September 1980
COD: Stations PXT0402, PXT0455, PXT0494, WXT0045, PXT0603, and 750632 only; not tested in 1981.
TPP unfiltered
TPP filtered
Total ortho-phosphate
NO2-N filtered
NO3-N filtered
NH3-N filtered
TPN unfiltered
TPN filtered
Total suspended solids
SIO2
Total alkalinity

Table 2-7 Slack Water Surveys Sampling Schedule Without Lateral Locations.

Station		Stage height	Current velocity/ direction	D.O., pH, temp. and salinity	Wind, temp., humidity barometer	Secchi	Light penetration	Water chemistry (2)	Fecal coliform (3)	BOD20	Chlorides (4)
XDE9575	sur	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
	mid		yes	no				no	no	no	no
	bot		yes	yes				yes	yes	yes	yes
	Surface, mid-depth and bottom current velocities also at west and east sides of river										
XED2599	sur	meter	yes	yes	yes	yes	yes	yes	yes	no	no
	mid		yes	no				no	no	no	no
	bot		yes	yes				yes	yes	no	no
	Surface, mid-depth and bottom current velocities also at west and east sides of river										
XDE5339	sur	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
	mid		yes	no				no	no	no	no
	bot	yes	yes					yes	yes	yes	yes
	Surface, mid-depth and bottom current velocities also at west and east sides of river										
XDE9401	sur	no	yes	yes	yes	yes	yes	yes	yes	no	no
	mid		yes	no				no	no	no	no
	bot		yes	yes				yes	yes	no	no
	Surface, mid-depth and bottom current velocities also at west and east sides of river										
XED4892	sur	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
	mid		yes	no				no	no	no	no
	bot		yes	yes				yes	yes	yes	yes
	Surface, mid-depth and bottom current velocities also at west and east sides of river										
XED9490	sur	meter	yes	yes	yes	yes	yes	yes	yes	no	no
	mid		yes	no				no	no	no	no
	bot		yes	yes				yes	yes	no	no
PXT0402	sur	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
	mid		yes	no				no	no	no	no
	bot		yes	yes				yes	yes	yes	yes

Table 2-7 (continued) Slack Water Surveys Sampling Schedule Without Lateral Locations.

Station	Depth	Stage height	Current velocity/ direction	D.O., pH, temp. and salinity	Wind, temp., humidity barometer	Secchi	Light penetration	Water chemistry (2)	Fecal coliform (3)	BOD20	Chlorides (4)
PXT0455	sur	no	yes	no	yes	yes	yes	no	no	no	no
	mid		yes	yes				yes	yes	no	no
	bot		yes	no				no	no	no	no
PXT0494	sur	no	yes	no	yes	yes	yes	no	no	no	no
	mid		yes	yes				yes	yes	no	no
	bot		yes	no				no	no	no	no
WXT0045	sur		measure	no	yes	yes	yes	no	no	no	no
	mid		instan-	yes				yes	yes	no	no
	bot		twneous	no				no	no	no	no
PXT0603	sur	gauge		no	yes	yes	yes	no	no	no	no
	mid		yes					yes	yes	yes	yes
	bot		no					no	no	no	no
750632		no	no	pH only	no	no	no	24 hr flow composite (5)	no	no	no

(1) June 25, July 28, August 20, September 15, October 16, November 13, December 4, 1980; March 19, April 27, May 14, June 11, June 29, July 30 and August 13, 1981.

(2) Total chlorophyll-a and phaeophytin
BOD5
TOC/DOC: TOC through September 1980, DOC after September 1980.
COD: Stations PXT0402, PXT0455, PXT0494, WXT0045, PXT0603, and 750632 only; not tested in 1981.

TPP unfiltered	NO2-N filtered	TPN unfiltered	SIO2
TPP filtered	NO3-N filtered	TPN filtered	Total alkalinity
Total ortho-phosphate	NH3-N filtered	Total suspended solids	

(3) Not tested in 1981

(4) Not tested after September 1980.

(5) Not tested for total chlorophyll-a, phaeophytin-a and fecal coliforms.

Table 2-8 Slack Water Survey Sampling Schedule, With Lateral Stations, July 21, 1980 And April 21, 1981

Station	Depth	Stage height	Current velocity/ direction	D.O., pH, temp. and salinity	Wind, temp. humidity barometer	Secchi	Light penetration	Water chemistry (1)	Fecal coliform (2)	BOD20	Chlorides (3)
XCF8763	sur	no	yes	no	no	no	no	yes	yes	no	no
west	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	no	no	no	no	yes	yes	no	no
XCF9575	sur	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	yes	no	no	no	yes	yes	yes	yes
XCF9958	sur	no	yes	no	no	no	no	yes	yes	no	no
east	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	no	no	no	no	yes	yes	no	no
XDE2586	sur	no	yes	no	no	no	no	yes	yes	no	no
west	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	no	no	no	no	yes	yes	no	no
XDE2559	sur	meter	yes	yes	yes	yes	yes	yes	yes	no	no
center	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	yes	no	no	no	yes	yes	no	no
XDE2898	sur	no	yes	no	no	no	no	yes	yes	no	no
east	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	no	no	no	no	yes	yes	no	no
XDE4543	sur	no	yes	no	no	no	no	yes	yes	no	no
west	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	no	no	no	no	yes	yes	no	no

Table 2-8 (continued) Slack Water Survey Sampling Schedule, With Lateral Stations, July 21, 1980 And April 21, 1981

Station	Depth	Stage height	Current velocity/ direction	D.O., pH, temp. and salinity	Wind, temp. humidity barometer	Secchi	Light penetration	Water chemistry (1)	Fecal coliform (2)	BOD20	Chlorides (3)
XDE5339 center	sur	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	yes	no	no	no	yes	yes	yes	yes
XDE5352 east	sur	no	yes	no	no	no	no	yes	yes	no	no
	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	no	no	no	no	yes	yes	no	no
XDE9699 west	sur	no	yes	no	no	no	no	yes	yes	no	no
	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	no	no	no	no	yes	yes	no	no
XDE9401 center	sur	no	yes	yes	yes	yes	yes	yes	yes	no	no
	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	yes	no	no	no	yes	yes	no	no
XDE9603 east	sur		yes	no	no	no	no	yes	yes	no	no
	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	no	no	no	no	yes	yes	no	no
XED4891 west	sur	no	yes	no	no	no	no	yes	yes	no	no
	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	no	no	no	no	yes	yes	no	no
XED4892 center	sur	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	yes	no	no	no	yes	yes	yes	yes
XED4894 east	sur	no	yes	no	no	no	no	yes	yes	no	no
	mid		no	yes	no	no	no	no	no	no	no
	bot		yes	no	no	no	no	yes	yes	no	no

Table 2-8 (continued) Slack Water Survey Sampling Schedule, With Lateral Stations, July 21, 1980 And April 21, 1981

Station	Depth	Stage height	Current velocity direction	D.O., pH D.O., pH, salinity	Wind, temp. barometer	Secchi	Light penetration	Water chemistry (1)	Fecal coliform (2)	BOD20	Chlorides (3)
XED9490	sur	meter	yes	yes	yes	yes	yes	yes	yes	no	no
center	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	yes	no	no	no	yes	yes	no	no
PXT0402	sur	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
center	mid		yes	no	no	no	no	no	no	no	no
	bot		yes	yes	no	no	no	yes	yes	yes	yes
PXT0455	sur	no	yes	no	yes	yes	yes	no	no	no	no
center	mid		yes	yes	no	no	no	yes	yes	no	no
	bot		yes	no	no	no	no	no	no	no	no
PXT0494	sur	no	yes	no	yes	yes	yes	no	no	no	no
center	mid		yes	yes	no	no	no	yes	yes	non	no
	bot		yes	no	no	no	no	no	no	no	no
WXT0045	sur		measure	no	yes	yes	yes	no	no	no	no
center	mid	instan	instan-	yes	no	no	no	yes	yes	no	no
	bot		taneous	no	no	no	no	no	no	no	no
PXT0603	sur	gauge		no	yes	yes	yes	no	no	no	no
center	mid			yes	no	no	no	yes	yes	yes	yes
	bot			no	no	no	no	no	no	no	no
750632		no	no	pH only	no	no	no	24 hr flow composite (4)	no	no	no

(1) Total chlorophyll-a and phaeophytin-a
BOD5
TOC/DOC: TOC through September 1980, DOC after September 1980
COD: Stations PXT0402, PXT0455, PXT0494, WXT0045, PXT0603, and 750632 only; not tested in 1981.

TPP filtered
Total ortho-phosphate
NO2-N filtered
NO3-N filtered
NH3-N filtered
TPN unfiltered
TPN filtered
Total suspended solids
SIO2
Total alkalinity

(2) Not tested in 1981

(3) Not tested after September 1980

(4) Not tested for total chlorophyll-a, phaeophytin-a and fecal coliforms.

Table 2-9 Analytical Procedures for Patuxent Estuary Program.

Water Quality Variable	Reference
Total persulfate phosphorus	D'Elia, Steudler and Corwin, 1977.
Total persulfate nitrogen	D'Elia, Steudler and Corwin, 1977.
Nitrate-nitrite, mgN/l, cadmium reduction	EPA, 1974.
Nitrite, mgN/l	EPA, 1974.
Ammonia, mgN/l, Phenate	EPA, 1974.
COD, over digested and titrated	EPA, 1979.
Organic carbon	Dohrman, 1976 and 1979.
Alkalinity, methyl orange or pH meter to 4.5 or from cresol green methyl red	Standard Methods, 14 Edition, 1975.
Chlorides, mg/l	EPA, 1979.
Solids, nonfilterable	EPA, 1974 and 1979.
Ortho-phosphorus, mg/l ascorbic acid	EPA, 1974.
BOD5 and 20	Standard Methods, 14 Edition, 1975.
SIO2, dissolved	Technicon AA industrial method 7-68 W and 8-68 W.
Fecal coliform, MPN	EPA, 1978.
Chlorophyll and phaeophytin	Stricklans and Parsons, 1972.

Table 2-10 sample preservation and holding time for estuary program during 1980. During 1981 nitrite, nitrate, ortho-phosphorus, ammonia, total phosphorous, total nitrogen, silica and organic carbon were frozen until analysis.

water quality variable	container	preservative	maximum holding time
Alkalinity, unfiltered	P	Cool $4^{o}C$	14 days
Ammonia, filtered	P[a]	Cool $4^{o}C$, H2SO4pH<2	28 days
BOD5 and 20, unfiltered	P	Cool $4^{o}C$	48 hours
COD, unfiltered	P	Cool $4^{o}C$, H2SO4pH<2	28 days
Total persulfate nitrogen, filtered and unfiltered	P	Cool $4^{o}C$, H2SO4pH<2	28 days
Nitrate-nitrite, filtered	P	Cool $4^{o}C$, H2SO4pH<2	28 days
Nitrite, filtered	P	Cool $4^{o}C$	48 hours
Organic carbon, unfiltered	P	Cool $4^{o}C$, HCLpH<2	28 days
Ortho-phosphorus, filtered and unfiltered	P	filter, cool $4^{o}C$	48 hours
Silica, filtered	P	Cool $4^{o}C$	28 days
Solids, nonfilterable	P	Cool $4^{o}C$	7 days
Fecal coliform, unfiltered	P (sterile)	Cool $4^{o}C$	6 hours
Total persulfate phosphorus, filtered and unfiltered	P	Cool $4^{o}C$, H2SO4ph 2	28 days
Chlorophyll-a	P	Cool $4^{o}C$, dark	8 hours
Phaeophytin-a	P	Cool $4^{o}C$, dark	8 hours
Chlorides, unfiltered	P	none required	28 days

(a) -polyethylene

Table 2-11 Standard stability and/or frequency of standard for estuarine water quality program preparation.

Water Quality Variable	Stability and/or frequency	Reference
Ammonia	monthly	EPA, 1979
Total persulfate nitrogen	monthly	EPA, 1979
Nitrate, nitrite	6-months	EPA, 1979
Organic carbon	every run	Dohrman, 1976 and 1981
Ortho-phosphorus	monthly	EPA, 1979
SI02	every run	Technicon AA industrial method 7-68W and 8-68W
Total persulfate phosphorus	monthly	EPA, 1979

Table 2-12 Precision and Accuracy for Ammonia Nitrogen Estuary Program.

Precision

Sample	N	Mean	Std. Var	C.V.
A	7	.098	.005	5%
B	7	.036	.001	4%
C	7	.199	.002	<1%
D	7	.077	.003	4%
E	7	.032	.003	10%
F	7	.081	.001	<1%
G	8	.054	.001	2%
H	8	.021	.002	10%
I	7	.081	.003	4%
J	7	.040	.004	10%
K	7	.466	.006	1%
				5% Average

A precision check based on the replicate analysis of 19 samples yielded a mean C.V. of 4% with a range of 0 to 12%.

Accuracy

Sample	N	Mean	Std. Var.	C.V.	% Recovery
A saline	5	.172	.003	2%	100
B fresh	7	.127	.001	1%	112
E saline	7	.116	.002	2%	106
F fresh	7	.123	.001	<1%	104
G saline	7	.095	.002	2%	103
H fresh	7	.063	.001	2%	105
I saline	7	.235	.002	1%	100

Using an EPA quality control sample the percent recovery was 102%.

Table 2-13 Precision and accuracy for filtered total persulfate nitrogen estuary program.

Precision

Sample	N	Mean	Std. Var.	C.V.
A	12	.580	.020	3%
B	12	.844	.090	11%
C	12	.432	.050	12%
D	12	.688	.040	5%
E	7	2.886	.093	3%
F	7	.849	.038	5%
G	6	.356	.041	12%
H	6	.315	.021	6%
I	6	.153	.034	22%
J	9	.501	.091	18%
				10% Average

A precision check based on the replicate analysis of 33 samples yielded a mean C.V. of 8% with a range of 1 to 32%.

Accuracy

Sample	N	Mean	Std. Var.	C.V.	% Recovery
A saline	12	1.409	.016	1%	106
B saline	12	1.597	.023	1%	101
C fresh-saline	12	1.219	.017	1%	102
D fresh	12	1.532	.096	6%	107
J saline	9	1.404	.202	14%	111

Using two EPA quality control samples the percent recovery was 119% for one, with a magnitude of 5 mg/l, and 95 and 96% for a second, which was run twice, with a magnitude of approximately 4.0 mg/l.

Table 2-14 Precision and Accuracy for Ortho-phosphate Estuary Program

Precision

Sample	N	Mean	Std. Var.	C.V.
A	6	.015	.002	13%
B	7	.019	.001	5%
C	8	.052	.001	2%
D	7	.043	.002	4%
E	7	.012	.001	7%
F	8	.011	.001	6%
G	8	.025	.001	3%
H	5	.007	.001	18%
I	5	.006	.001	15%
J	7	.030	.001	4%
K	7	.005	.001	16%
L	5	.010	.001	8%
M	5	.024	.001	3%
				8% Average

A precision check based on the replicate analysis of 19 samples yielded a mean C.V. of 2% with a range of 0 to 12%.

Accuracy

Sample	N	Mean	Std. Var.	C.V.	% Recovery
B saline	7	.097	.002	2%	100
C fresh	6	.094	.001	1%	104
D saline	7	.085	.002	2%	105
E fresh	7	.053	.001	1%	102
F saline	7	.052	.001	1%	102
G saline	7	.065	.001	1%	102
K saline	7	.084	.001	1%	99

Using an EPA quality control sample the percent recovery was 94%.

Table 2-15 Precision for total persulfate nitrogen and phosphorus for estuary program.

Precision for unfiltered total persulfate nitrogen

Sample	N	Mean	Std. Var.	C.V.
A	6	.571	.043	8%
B	6	2.204	.025	1%
C	10	.678	.037	6%
D	5	.271	.008	3%
E	6	3.412	.174	5%
F	6	4.357	.155	4%

A precision check based on the replicate analysis of 17 samples yielded a mean C.V. of 6% with a range of 0 to 22%.

Precision for unfiltered total persulfate phosphorus

Sample	N	Mean	Std. Var.	C.V.
A	5	.676	.009	1%
B	5	.121	.121	3%
C	6	1.590	.113	7%
D	4	.577	.009	2%
E	4	.600	.020	3%
				3% Average

A precision check based on the replicate analysis of 24 samples yielded a mean C.V. of 9% with a range of 1 to 46%.

Table 2-16 Precision and accuracy for filtered total persulfate phosphorus.

Precision

Sample	N	Mean	Std. Var.	C.V.
A	12	.038	.007	19%
B	12	.140	.010	7%
C	12	.027	.005	17%
D	12	.023	.005	23%
E	7	.200	.008	4%
F	7	.383	.004	1%
G	5	.432	.058	14%
H	6	.354	.037	10%
I	9	.058	.005	8%
J	9	.033	.010	31%
				13% Average

A precision check based on the replicate analysis of 28 samples yielded a mean C.V. of 9% with a range of 1 to 30%.

Accuracy

Sample	N	Mean	Std. Var.	C.V.	% Recovery
A saline	12	.184	.009	5%	95
B saline	12	.282	.020	8%	98
C fresh-saline	12	.179	.017	9%	97
D fresh	12	.179	.017	9%	99
J saline	9	.402	.015	4%	93

Using two different EPA quality control samples the percents recovery were 104 and 101.

Table 2-17 Precision and Accuracy for Silicate Estuary Program.

Precision

Sample	N	Mean	Std. Var.	C.V.
A	7	6.213	.344	6%
B	7	2.081	.084	4%
C	7	.642	.035	5%
D	7	1.986	.010	<1%
E	7	.868	.031	4%
F	7	2.715	.068	2%
G	7	1.624	.045	3%
H	6	1.333	.035	3%
				4% Average

A precision check based on the replicate analysis of 31 samples yielded a mean C.V. of 7% with a range of 0 to 33%.

Accuracy

Sample	N	Mean	Std. Var.	C.V.	% Recovery
C saline	7	1.402	.018	1%	101
D saline	7	6.009	.032	<1%	102
E saline	1	4.949	---	--	102
G saline	7	9.487	.076	1%	100
H saline	9	9.299	.073	1%	101

No EPA quality control standard was available for silicate.

Table 2-18 Precision and accuracy for alkalinity for estuary program.

Precision

Sample	N	Mean	Std. Var.	C.V.
A	8	9.4	.3	3%
B	8	72.2	1.0	1%
C	4	71.4	2.9	4%
D	6	68.9	1.4	2%
E	7	52.3	.4	1%
F	5	88.2	1.0	1%
				2% Average

A precision check based on the replicate analysis of 41 samples yielded a mean C.V. of 1% with a range of 0 to 7%.

Accuracy

During the 1981 study year and the 1982 intensive, alkalinity was analyzed employing a phototitrator which detects a preset colormetric end point at pH 4.5 using methyl orange indicator. Throughout titrations, a periodic check of the end point indicated a mean pH of 4.5 $\pm$ 0.14 with a range of 4.4 to 4.6 and a C.V. of 3%. The remainder of the alkalinities were determined by titrating to an end point of 4.5 which was measured with a Corning Model 610 pH Meter.

Table 2-19 Precision and Accuracy for Nitrite Nitrogen Estuary Sample Program.

Precision

Sample	N	Mean	Std. Var.	C.V.
A	7	.007	.001	14%
B	7	.005	.0003	8%
C	7	.005	0.000	0%
D	7	.005	0.000	0%
E	7	.058	.001	1%
F	8	.028	.002	7%
G	8	.027	.003	13%
H	8	.007	.001	12%
I	7	.017	.001	4%
J	7	.081	.001	1%
K	6	.004	.001	19%
L	5	.136	.002	1%
				7% Average

A precision check based on the replicate analysis of 19 samples yielded a mean C.V. of 4% with a range of 0 to 35%.

Accuracy

Sample	N	Mean	Std. Var.	C.V.	% Recovery
D saline	7	.013	0.000	0%	100
F saline	7	.071	.002	2%	106
G fresh-saline	7	.065	.002	3%	99
H saline	7	.051	.001	2%	109
I saline	7	.060	.001	1%	107
J saline-fresh	7	.118	.001	1%	100

No EPA quality control standard was available for nitrite nitrogen.

Table 2-20 Precision and Accuracy for Nitrate Nitrogen Estuary Program.

Precision

Sample	N	Mean	Std. Var.	C.V.
A	7	.061	.002	3%
B	8	.102	.001	1%
C	8	.034	.001	4%
D	4	.350	.002	<1%
E	4	.081	.001	1%
F	4	.024	.001	3%
G	8	.076	.003	5%
H	8	.033	.001	4%
I	5	.051	.002	5%
J	6	.102	.006	6%
K	6	.015	.003	18%
L	6	.227	.004	2%
				4% Average

A precision check based on the replicate analysis of 38 samples yielded a mean C.V. of 1% with a range of 0 to 18%.

Accuracy

Sample	N	Mean	Std. Var.	C.V.	% Recovery
C saline	4	.133	.004	3%	120
D fresh	4	.404	.002	<1%	100
G saline	7	.282	.008	3%	103
H fresh	7	.240	.002	1%	103
J saline	7	.501	.005	1%	101

Using an EPA quality control sample the percent recovery was 101%

Table 2-21 Precision for suspended solids and dissolved organic carbon estuary program.

Precision for suspended solids

Sample	N	Mean	Std. Var.	C.V.
A	5	.0334	.0023	7%
B	4	.0459	.0077	17%
				12% Average

A precision check based on the replicate analysis of 33 samples yielded a mean C.V. of 10% with a range of 0 to 70%.

Precision for total dissolved organic carbon

Sample	N	Mean	Std. Var.	C.V.
A	5	2.4	.3	12%
B	7	5.0	.2	4%
C	5	4.1	.2	5%
D	4	6.7	.4	6%
				7% Average

A precision check based on the replicate analysis of 74 samples yielded a mean C.V. of 8% with a range og 0 to 33%.

Figure 2-3 Water quality sampling locations in the lower Patuxent Estuary, conducted by University of Maryland, 1980-1981.

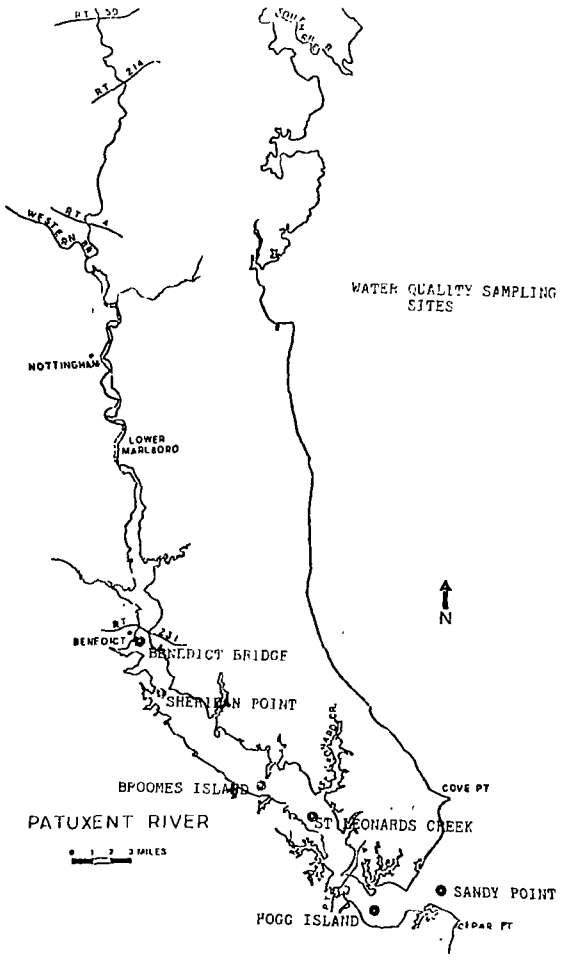


Figure 2-4 Sampling locations and scheme for longitudinal biological and benthic measurements in the Patuxent River, conducted by Biospherics, Inc., 1980-1981.

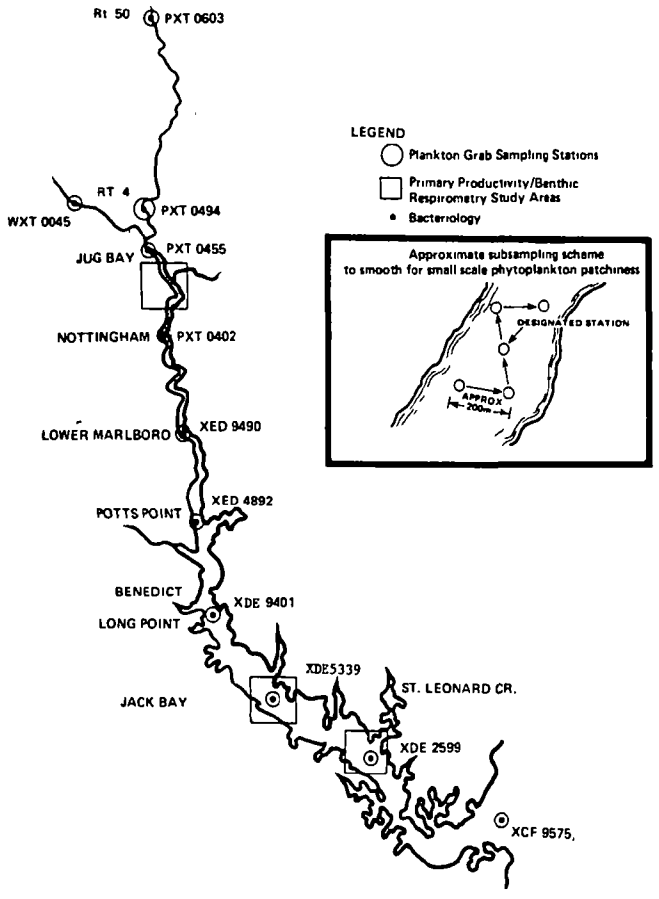
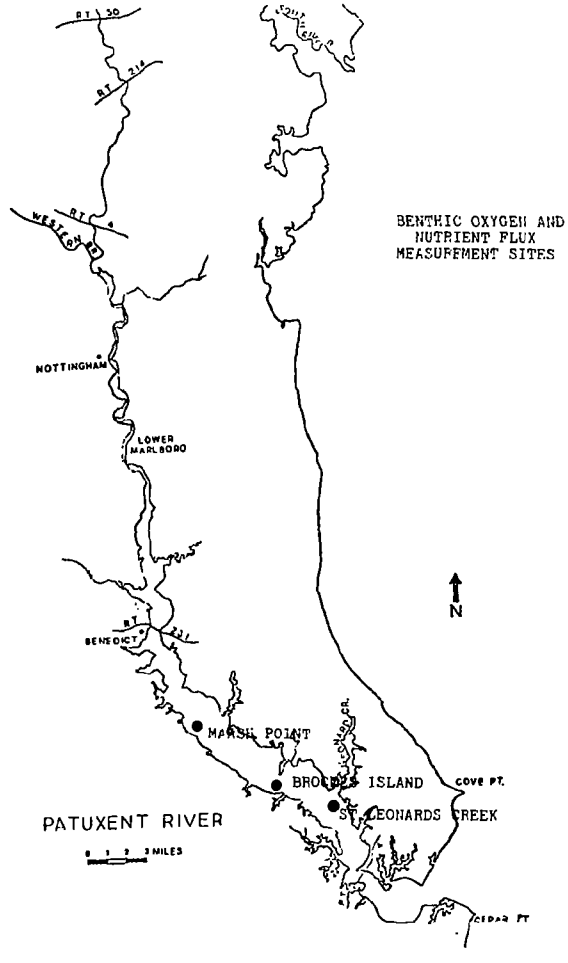


Figure 2-5 Benthic oxygen demand and nutrient-flux measurement stations conducted by University of Maryland, 1980-81.



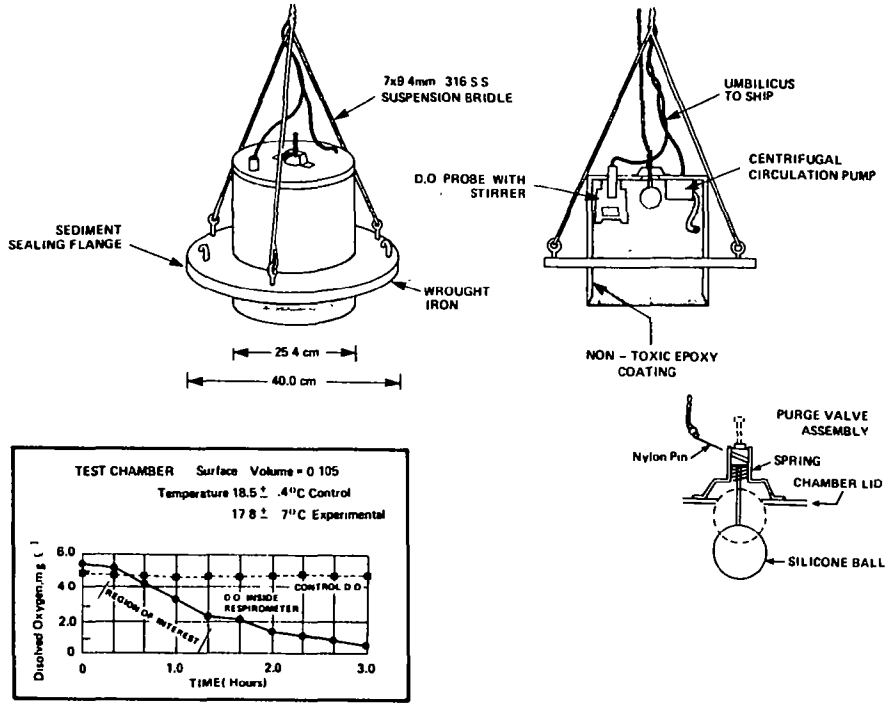
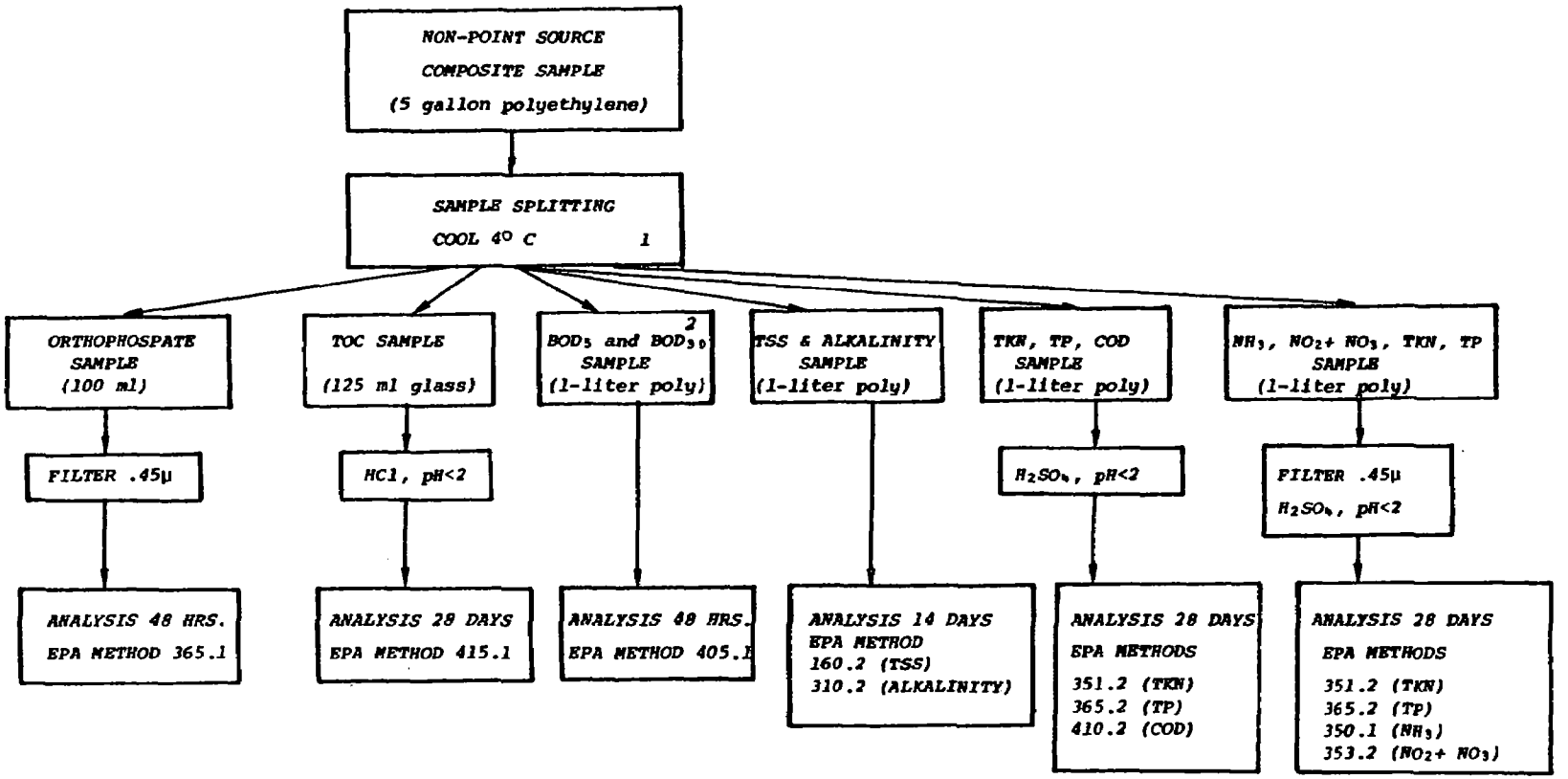


Figure 2-6 Diagram of Sediment Oxygen Demand Chambers designed for measurements taken for this study by Biospherics Inc, 1981.

Table 2-22 Methods and Preservation
Techniques Use For Monitoring Subwatersheds Chemical Export

Parameters	EPA Method Analysis*	Holding times Prior to 1/30/81	Holding times after 1/30/81**
Ammonia (filtered)	350.1	24 hrs.	28 days
Nitrate & Nitrite (filtered)	353.2	24 hrs.	28 days
Total nitrogen (Kjeldahl) (filtered and unfiltered)	351.2	24 hrs.	28 days
Total phosphorus (filtered and unfiltered)	365.1	24 hrs.	28 days
Orthophosphate (filtered)	365.1	24 hrs.	48 hrs.
BOD_5	405.1	24 hrs.	48 hrs.
BOD_{30}	405.1	24 hrs.	48 hrs.
Total Suspended Solids	160.2	7 days	14 days
Total Organic Carbon	415.1	24 hrs.	28 days
Chemical Oxygen Demand	410.2	7 days	28 days
Alkalinity	310.2	24 hrs.	14 days

** CFR Vol. 44, Part 136, December 3, 1979



1. ALL SAMPLES MAINTAINED DURING COLLECTION, DELIVERY AND UNTIL FINAL ANALYSIS AT 4° C.

2. BOD_5 AND BOD_{30} SAMPLES INCLUDE SAMPLES COLLECTED DURING BOTH POINT SOURCE AND RIVER SURVEYS.

Figure 2-7 Non-point source watershed sample collection and analysis scheme

APPENDIX B

FIGURES AND TABLE FOR SECTION 3

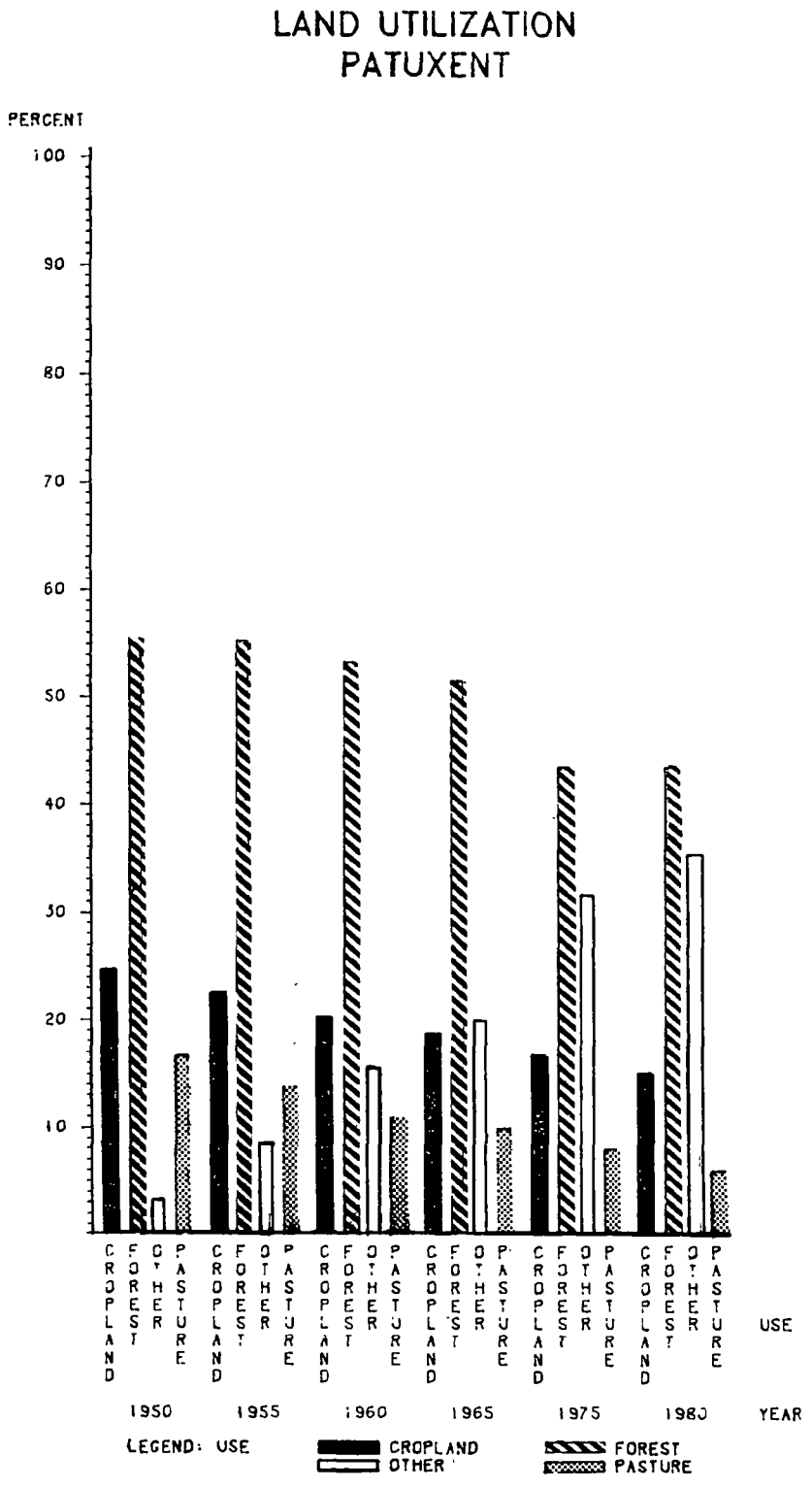


Figure 3-1 Patuxent River Estimated Land Utilization from 1950-1980. (provided by EPA, Chesapeake Bay Program).

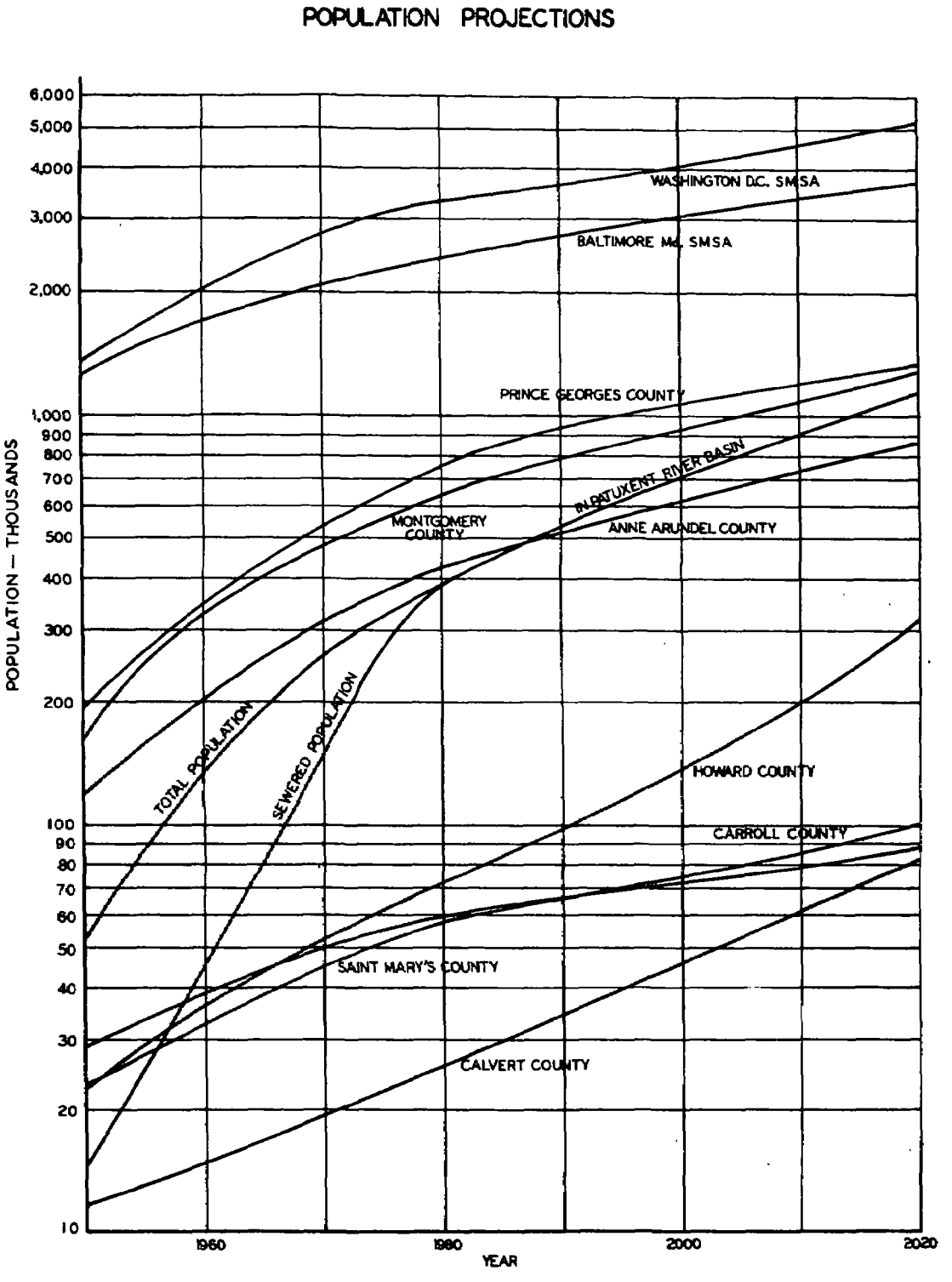


Figure 3-2 Population projections for the Patuxent River Basin Developed in 1969, from Maryland Department of State Planning, 1969, (from reference 19)

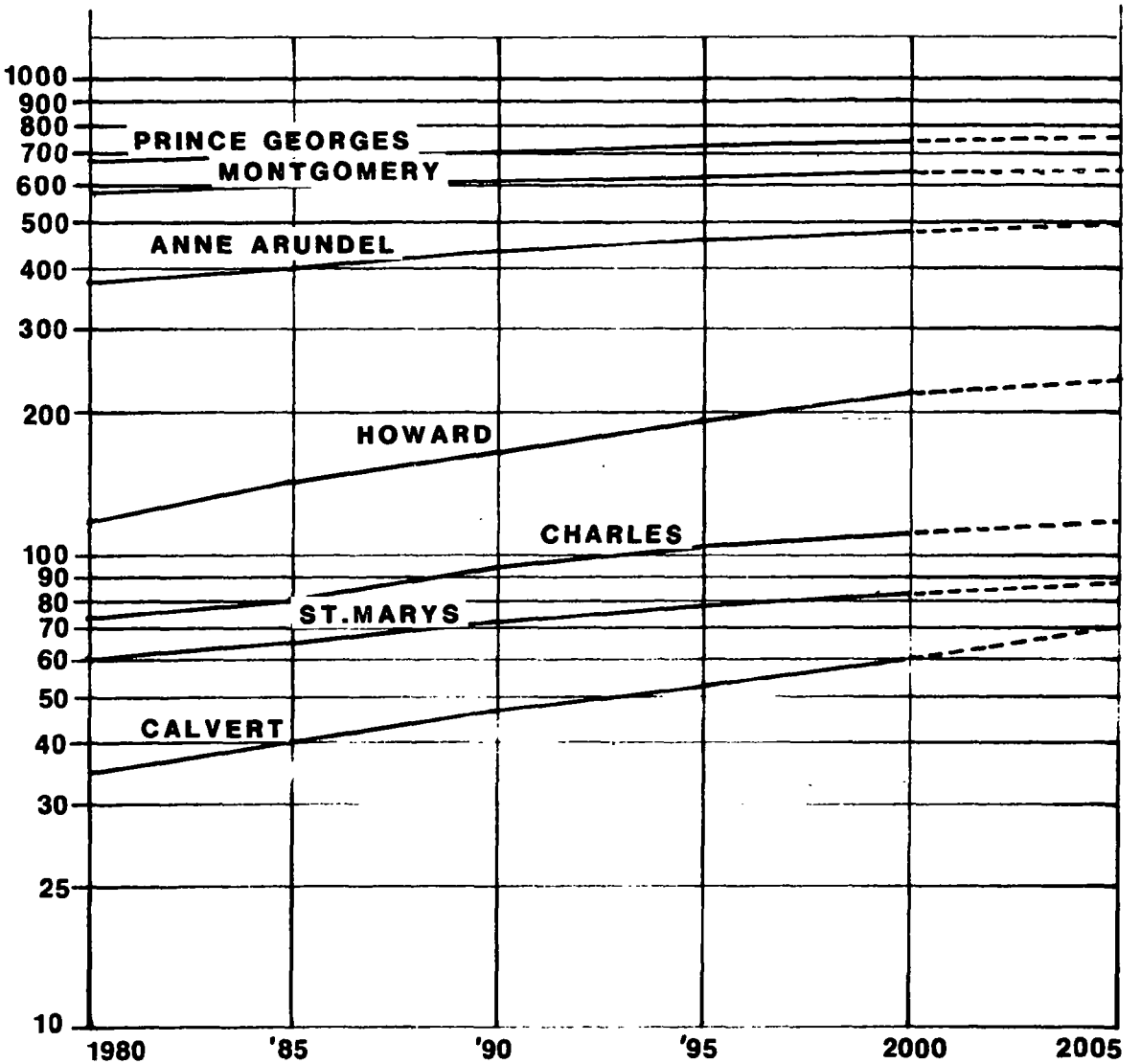


Figure 3-3 Current Year Population Estimates to the year 2000, developed by Maryland Department of State Planning, 1981 (from reference 20).

Table 3-1
Estimated Percent Increase of Population from 1980-2000 for Patuxent River Basin Counties*

County	% Increase
Anne Arundel	30
Calvert	78
Charles	50
Howard	84
Montgomery	8.5
Prince George's	10
St. Mary's	40

* Estimated from Projections Prepared by Maryland Department of State Planning, July, 1981.

Table 3-2 Comparison of the 1969 Population Projections for the year 1980*

County	1969 Estimate for 1980 (1)	1980 Reported (2)	Approximate Difference
Calvert	25,500	34,644	+9,144
St. Mary's	58,000	59,896	+1,896
Carroll	60,000	--	--
Howard	72,000	118,575	+46,575
Anne Arundel	430,000	370,774	-59,226
Montgomery	640,000	579,047	-60,953
Prince George's	760,000	665,075	-94,925
Charles	--	72,746	--
Seaward Population	375,000	265,850	-109,150

(1) From FWPCA, 1969, The Patuxent River, Water Quality Management Technical Evaluation, Working Document No. 31, reference 18

(2) Obtained from Maryland Department of State Planning, 1981, reference 19

Table 3-3
Existing (1980) and Projected (2000)
Waste Water Flows in the Patuxent River Basin

Facility Name	Existing Flow (mgd)	Projected Year 2000 Flow (mgd)
Maryland City	0.59	2.7
Patuxent	3.6	7.2
Ft. Meade	2.4	3.6
Savage	7.8	18.3
Bowie	2.5	3.3
Horsepen	0.33	1.5
Parkway	5.1	7.5
Western Branch	11.9	23.7
Maryland House of Correction	0.8	(Abandoned)
TOTAL	35.02	67.8

Reference: Office of Evnironmental Programs, Md. Department of Health and Mental Hygiene, Draft Nutrient Control Strategy, Patuxent River, August 1981. (reference 21).

APPENDIX C

FIGURES PRESENTING PHYSICAL CHARACTERISTICS

SECTION 4

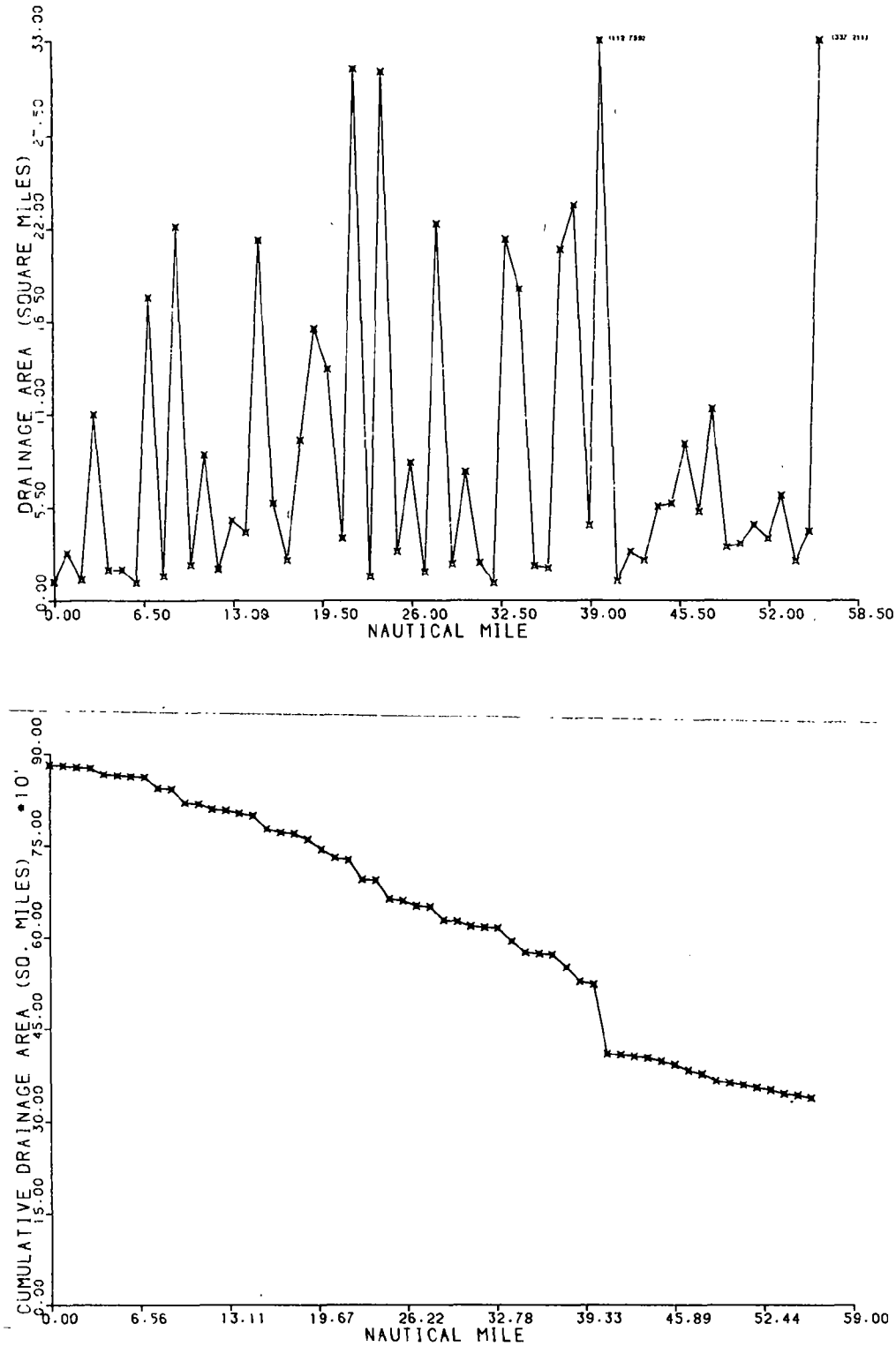
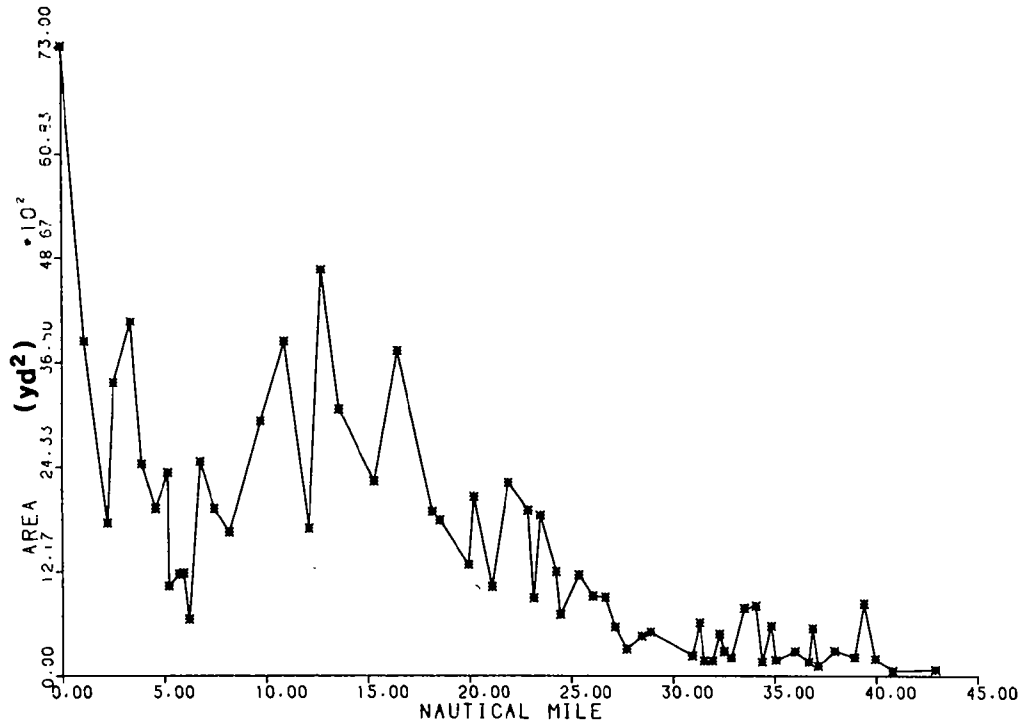


Figure 4-1 Patuxent river drainage area and cumulative drainage area.



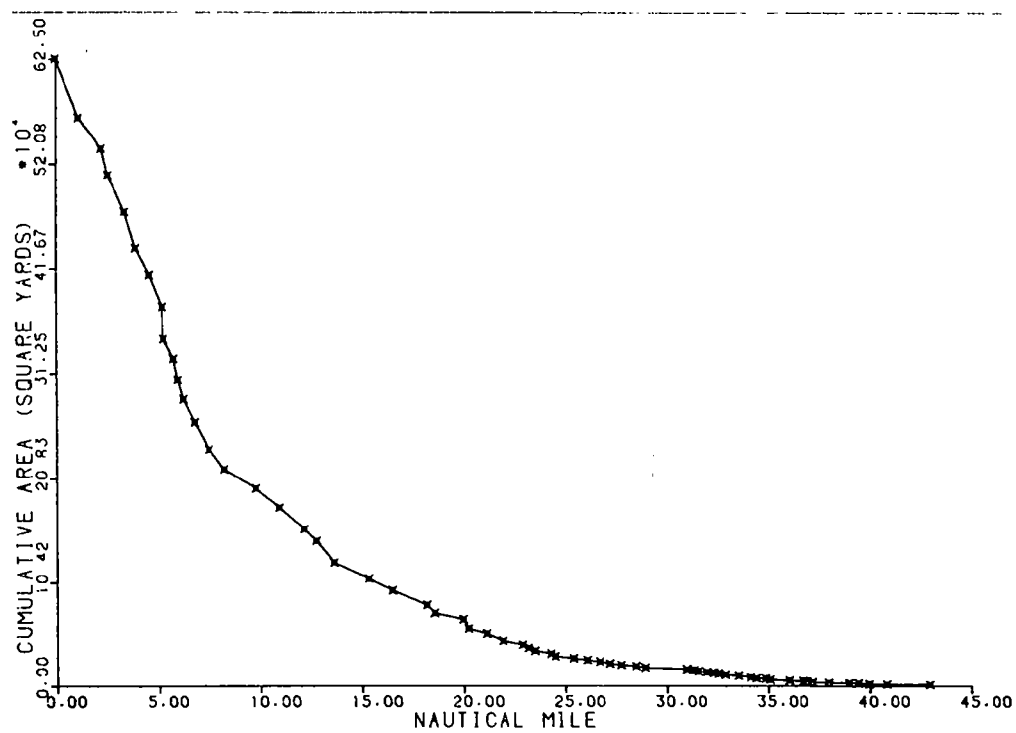
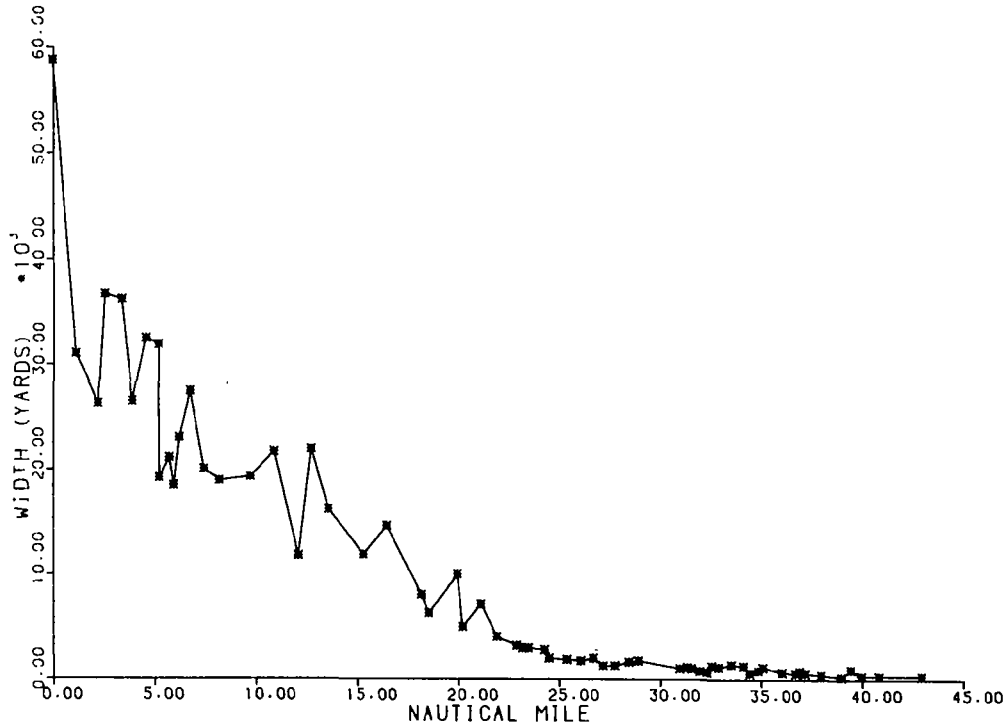


Figure 4-2 Estimated crossectional area and cumulative crossectional area (square yards) for the Patuxent Estuary.



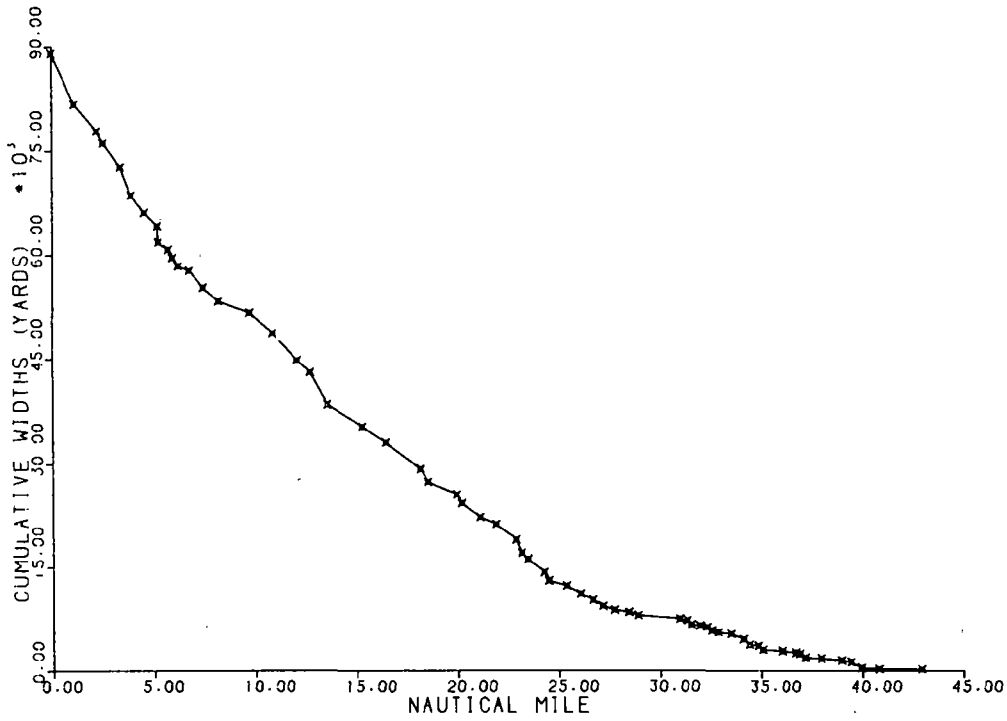
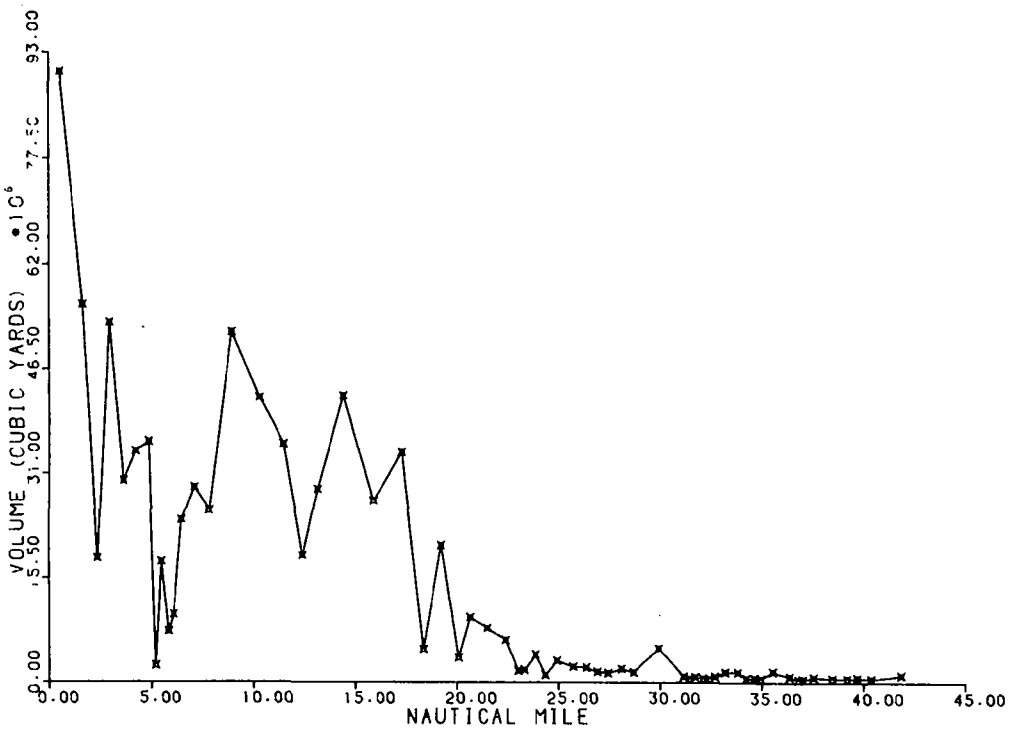


Figure 4-3 Mean low water width and cumulative estimated water width for the Patuxent Estuary.



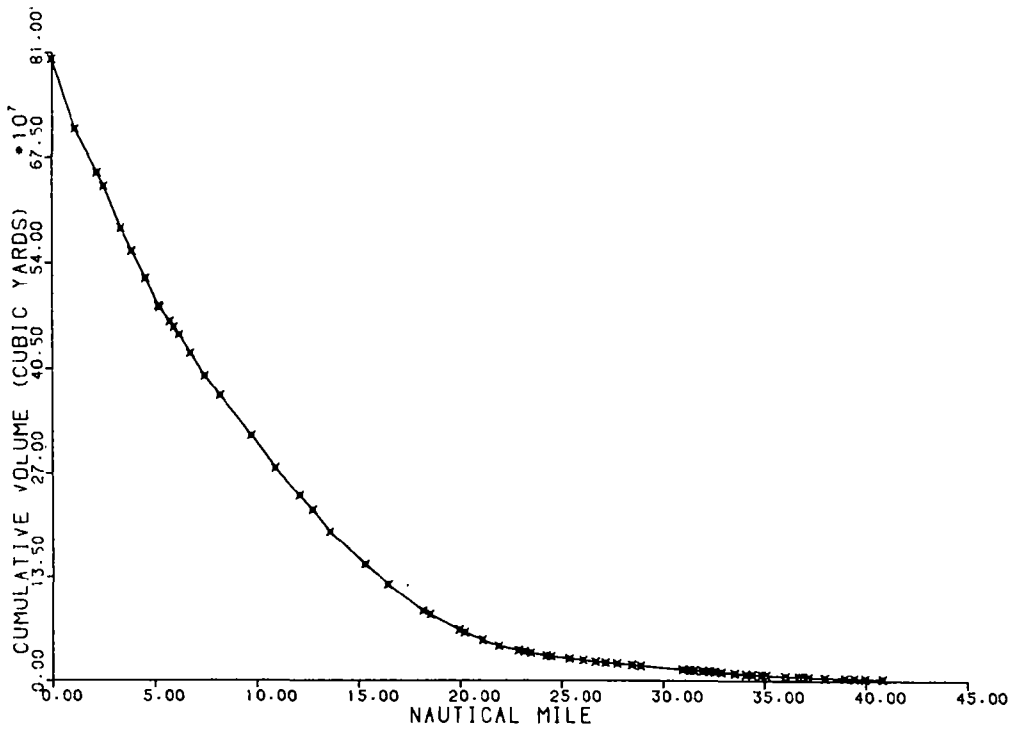
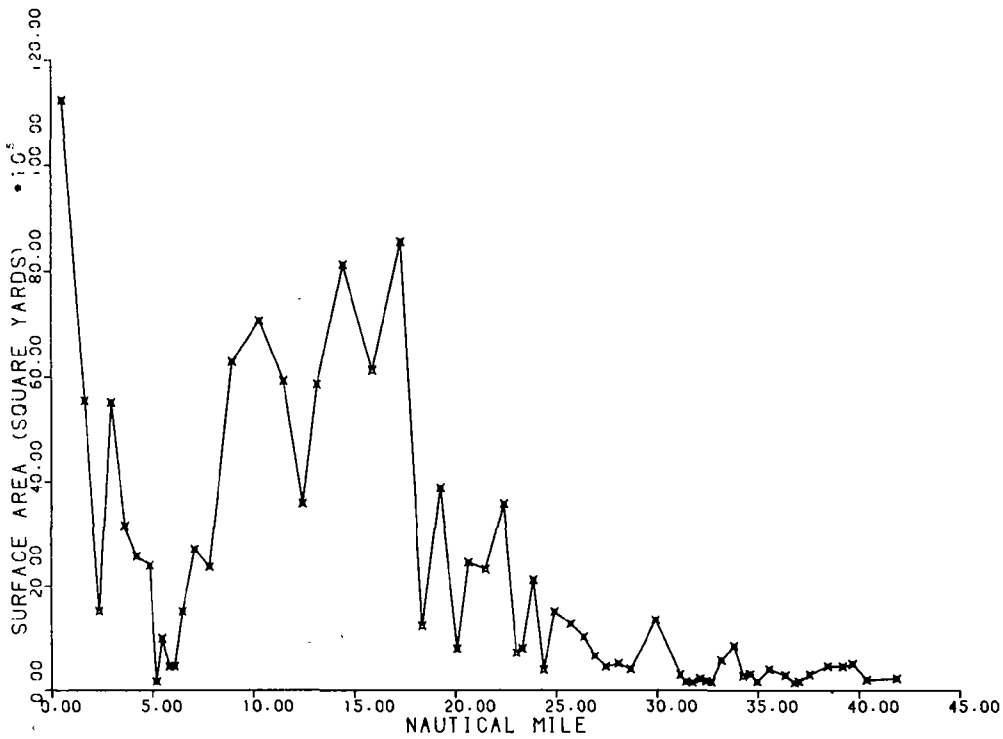


Figure 4-4 Mean low water volume and cumulative volume in the Patuxent estuary.



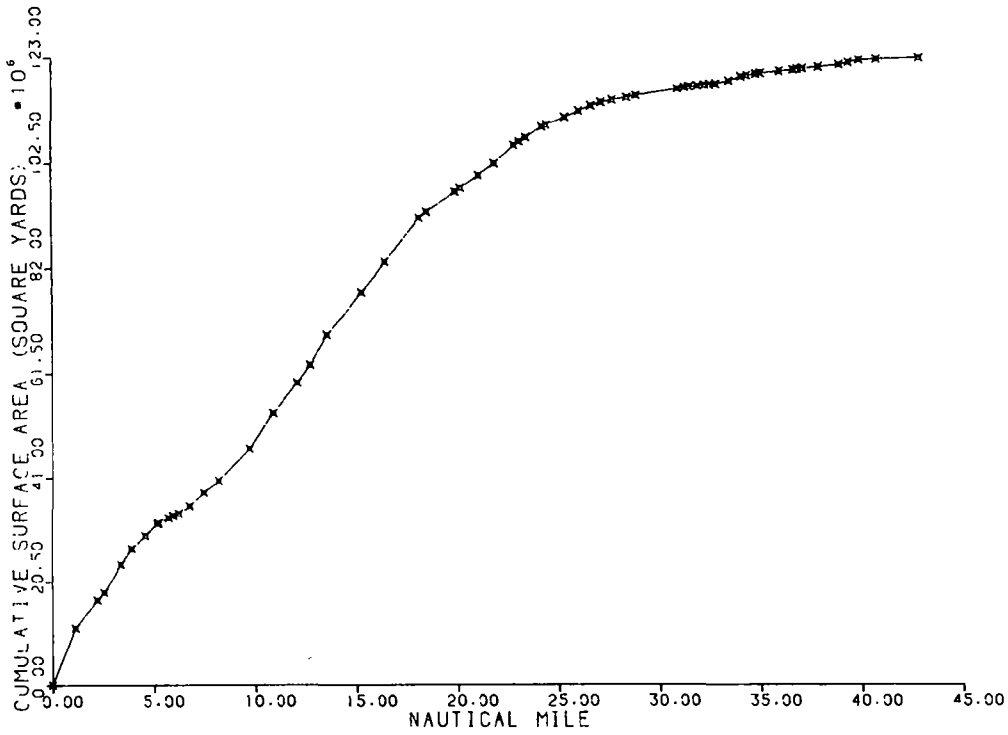
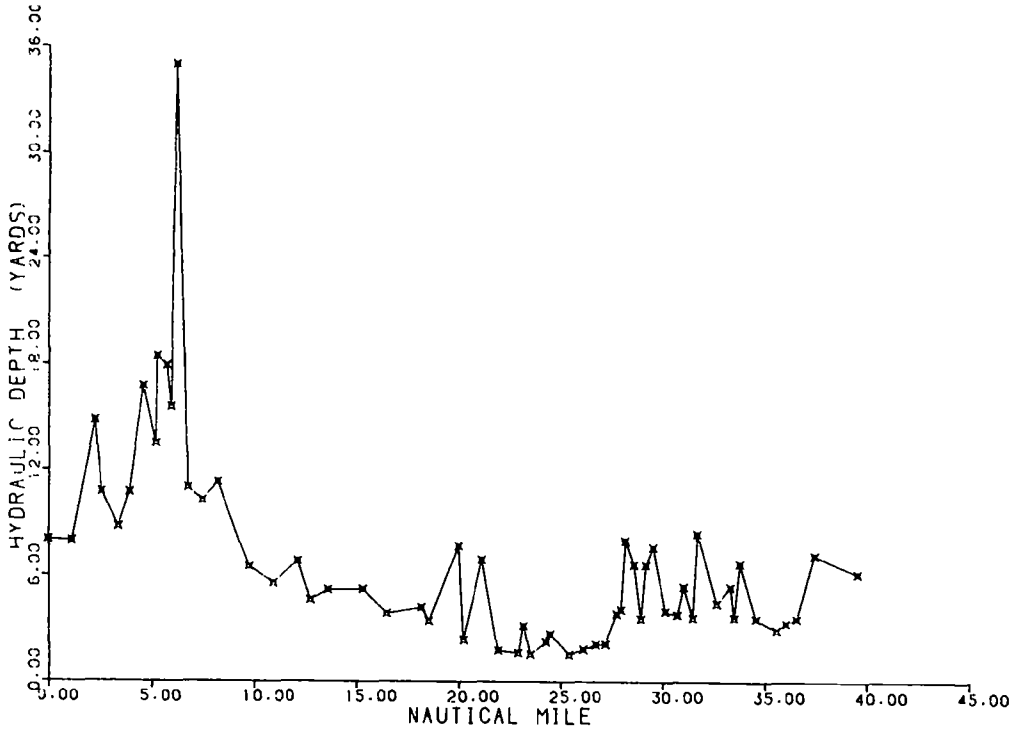


Figure 4-5 Water surface area and cumulative water surface area in the Patuxent estuary.



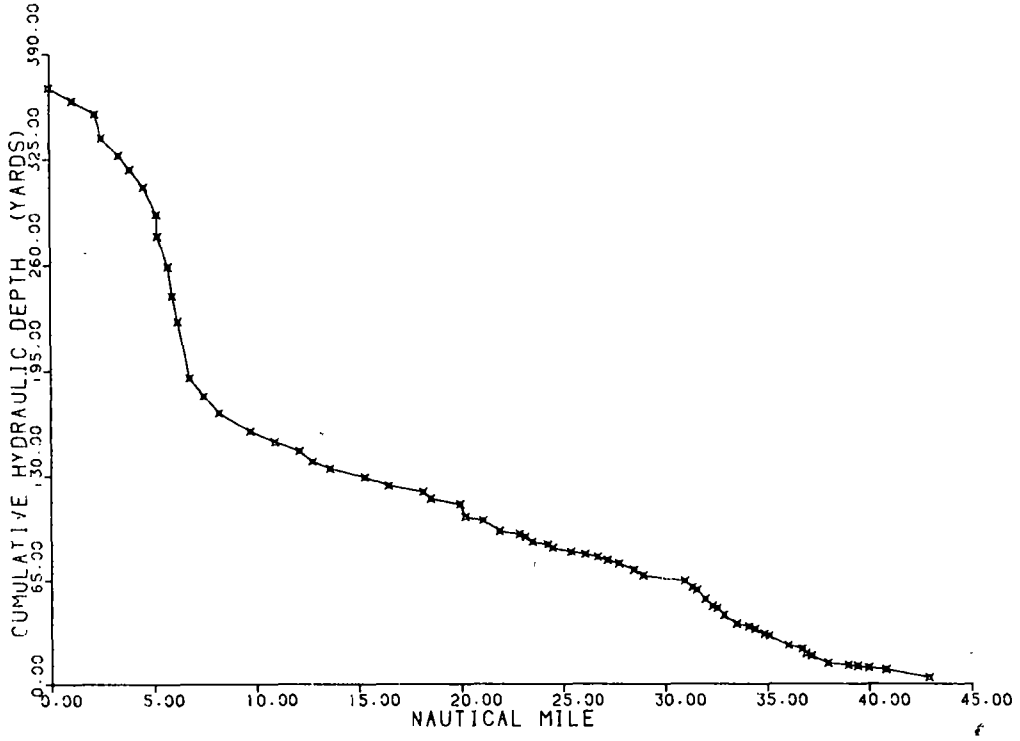


Figure 4-6 Hydraulic depth and cumulative hydraulic depth in the Patuxent estuary.

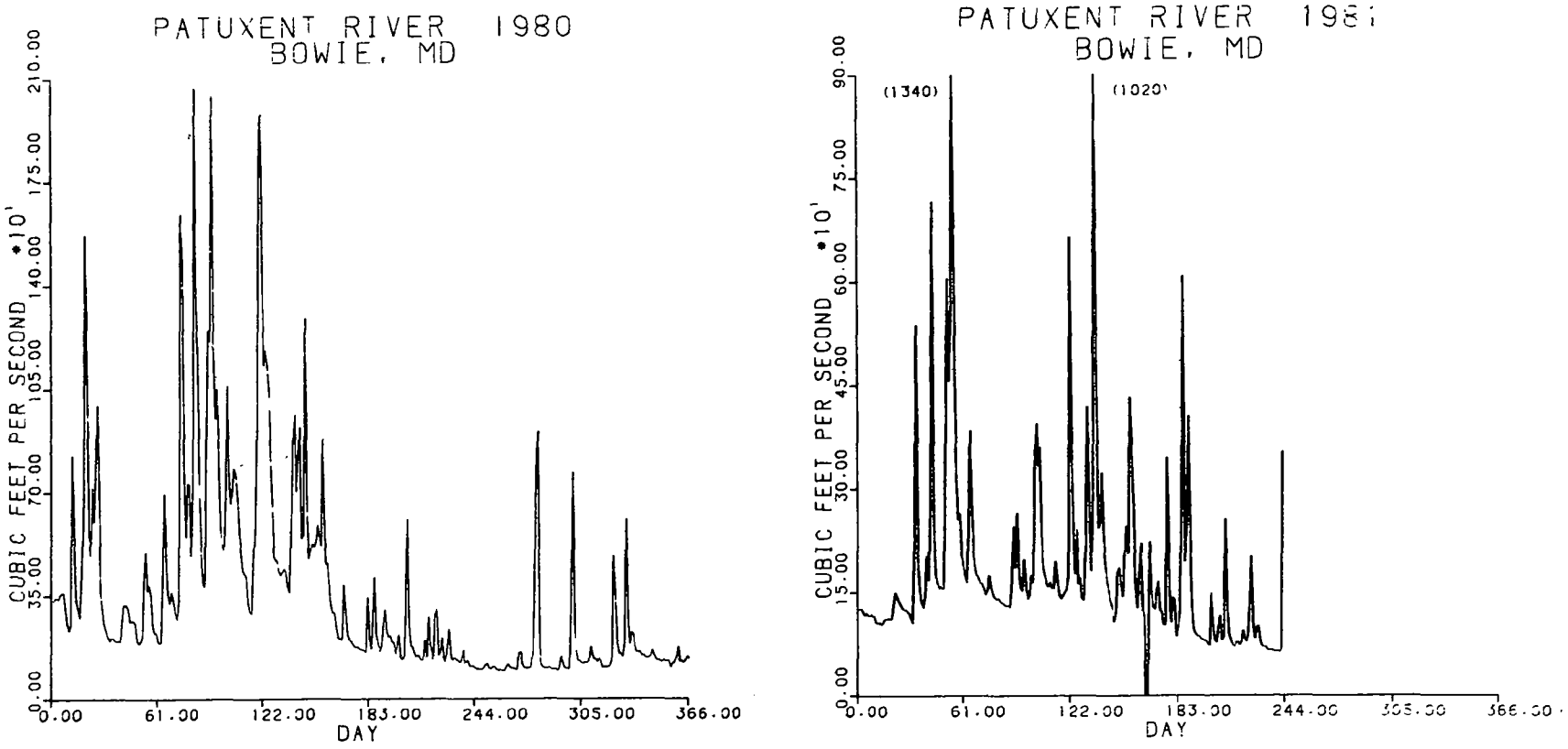


Figure 4-7 Freshwater inflow (cubic feet per second) during the study period 1980-1981 at the USGS gauge, Rt. 50, USGS station 01594440.

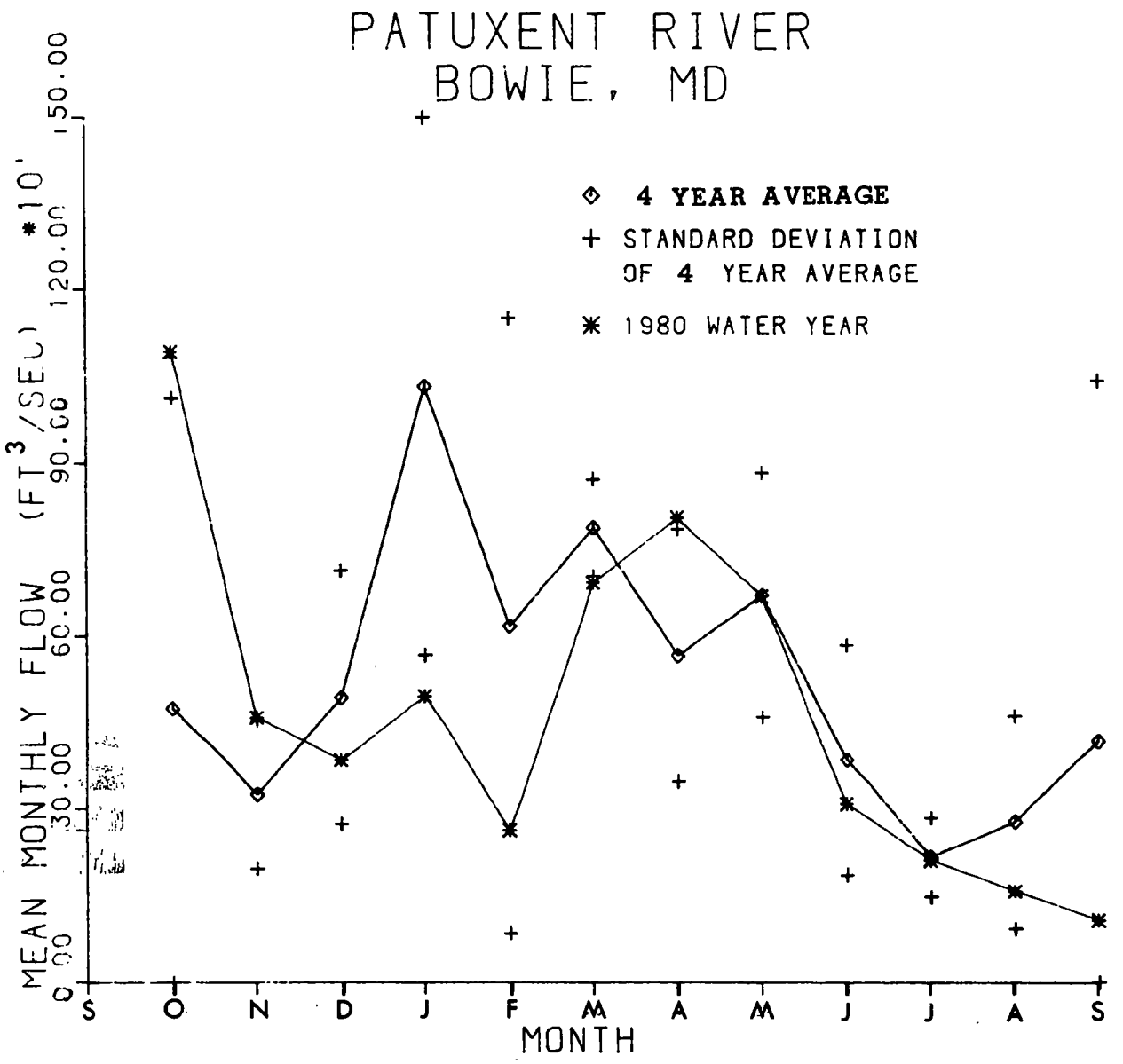


Figure 4-8 Patuxent River mean monthly flow from historical data and for water year 1980.

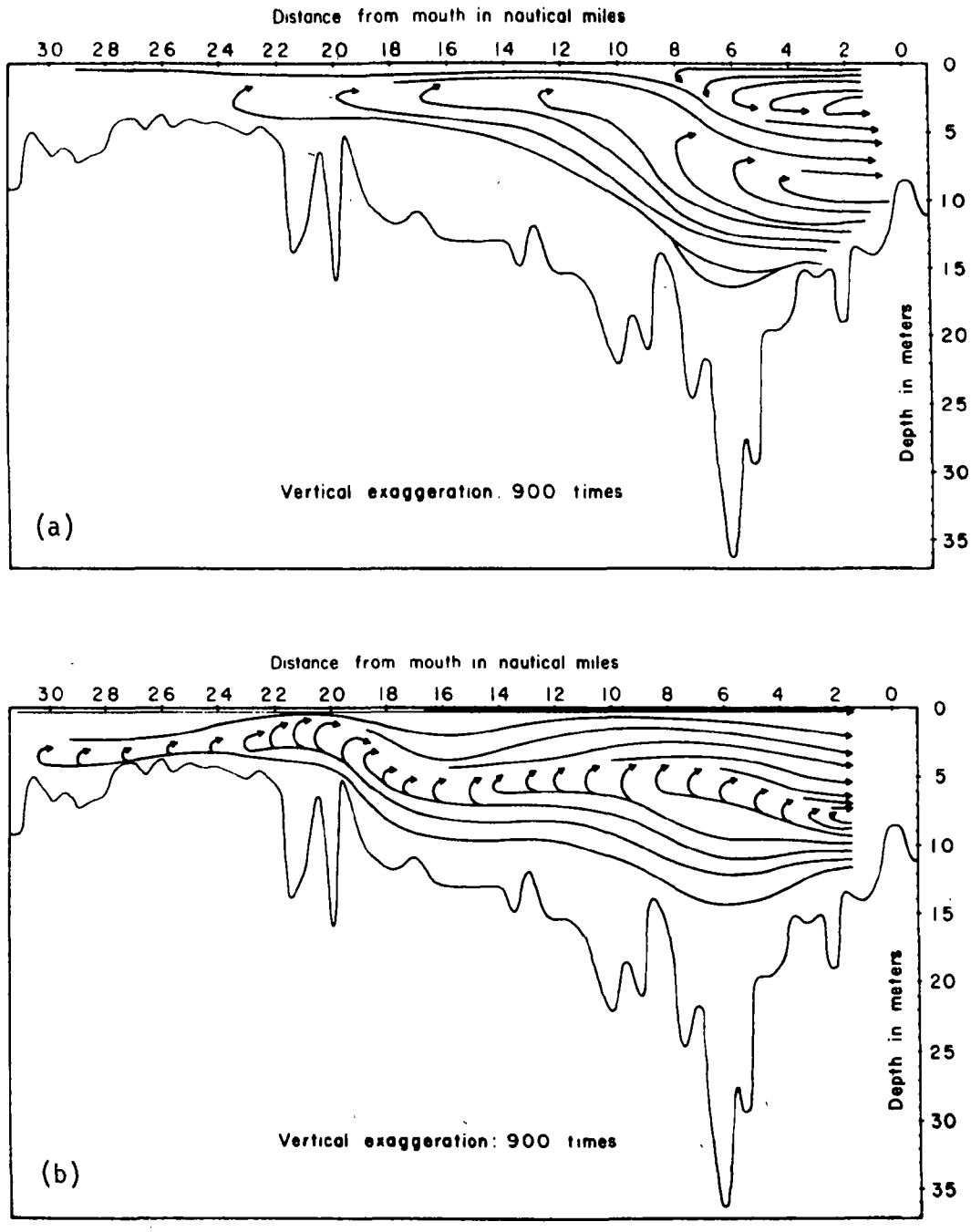


Figure 4-9 Schematic diagram of net non-tidal volume transport of (a) the estimated three-layer flow system in the Patuxent estuary and (b) the two layer flow system in the Patuxent estuary, from Owen, W., 1969[24].

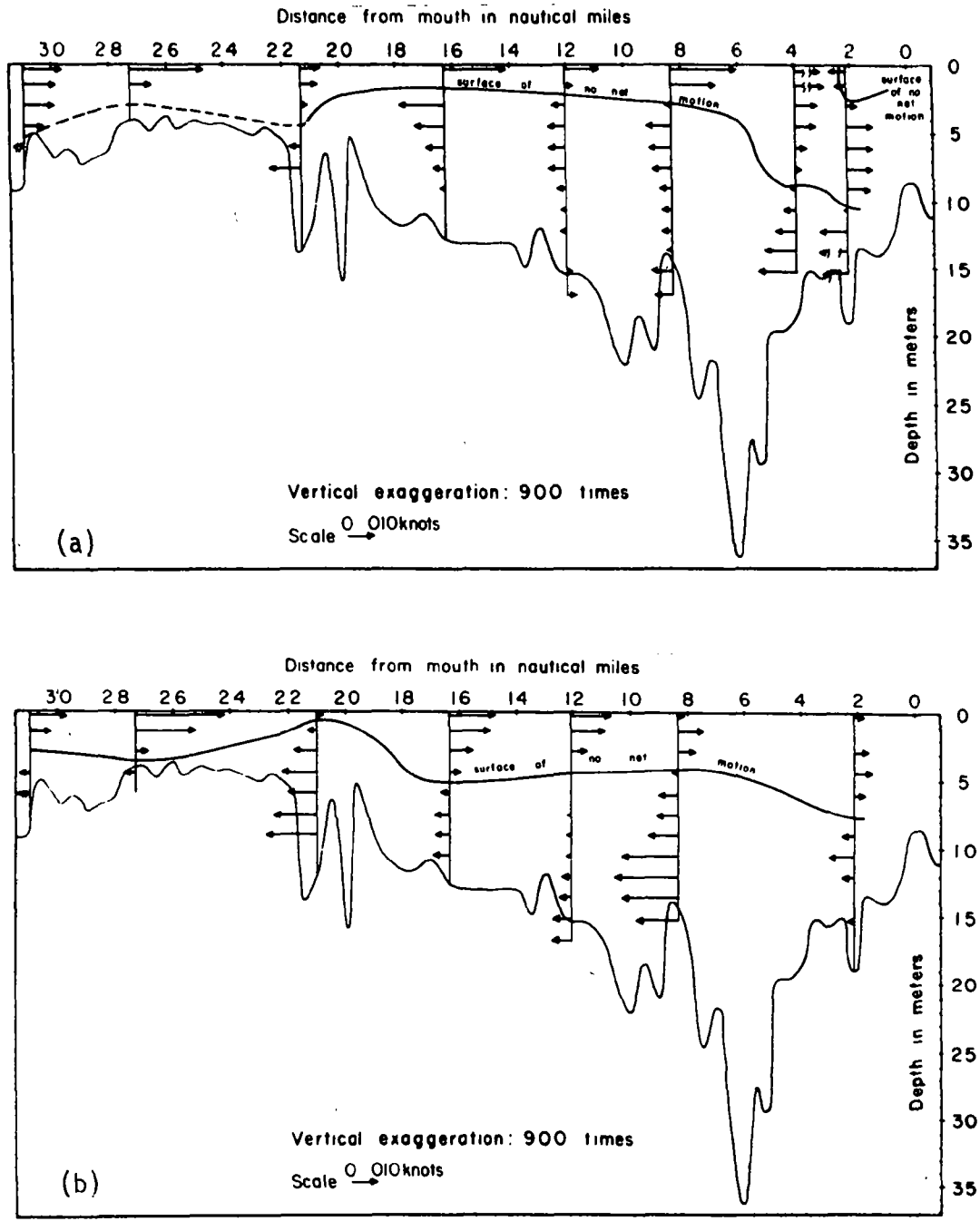


Figure 4-10 Patuxent Estuary 24 hour longitudinal velocity component average for (a) June 23-28, 1952 and (b) December 3-7, 1952, from Owen, W., 1969 (24).

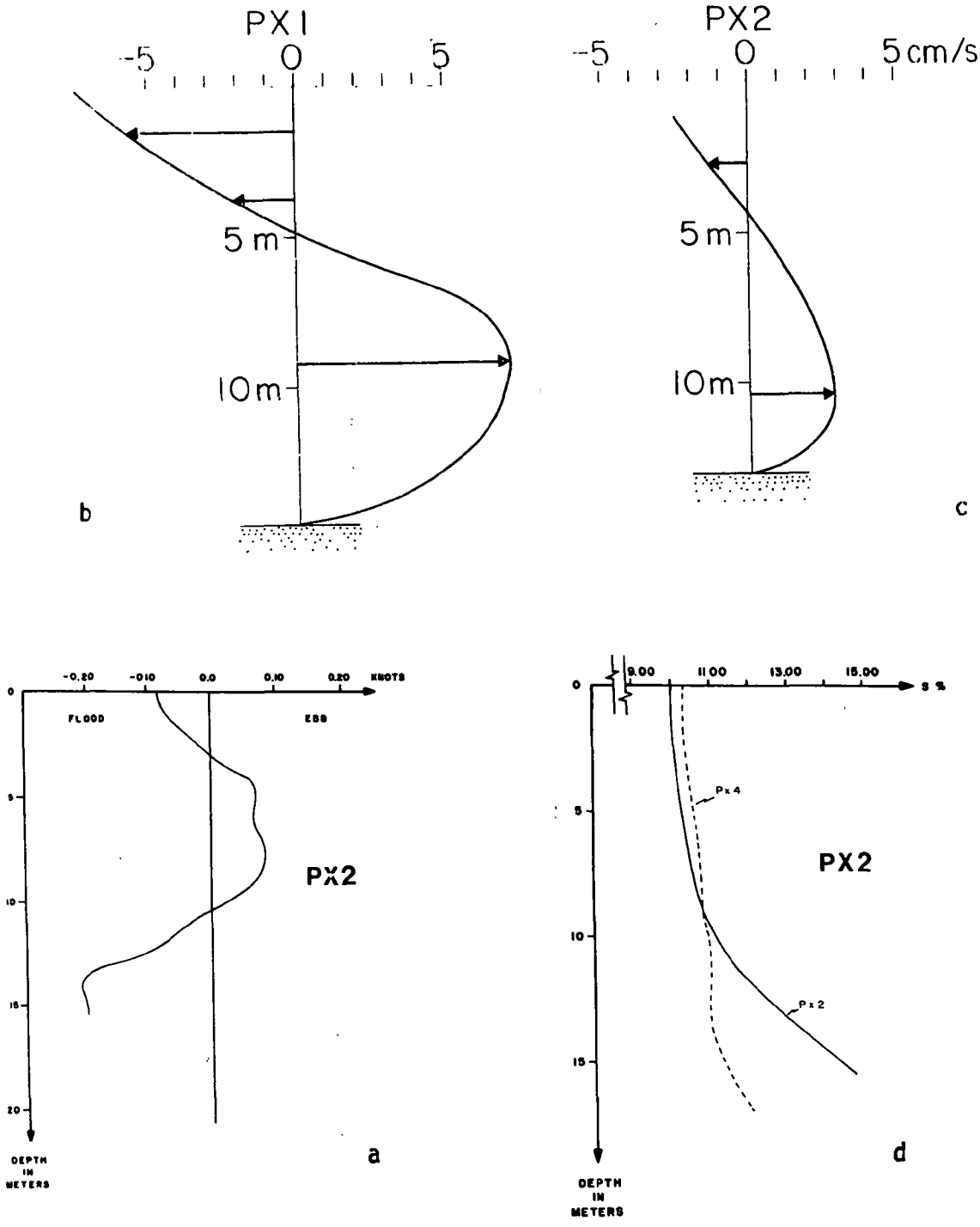


Figure 4-11 Patuxent River velocity profiles obtained from moorings during this study (a), (b) and (c) during 1952, as reported by Owen, 1952, and the vertical salinity profile reported by Owen (d).

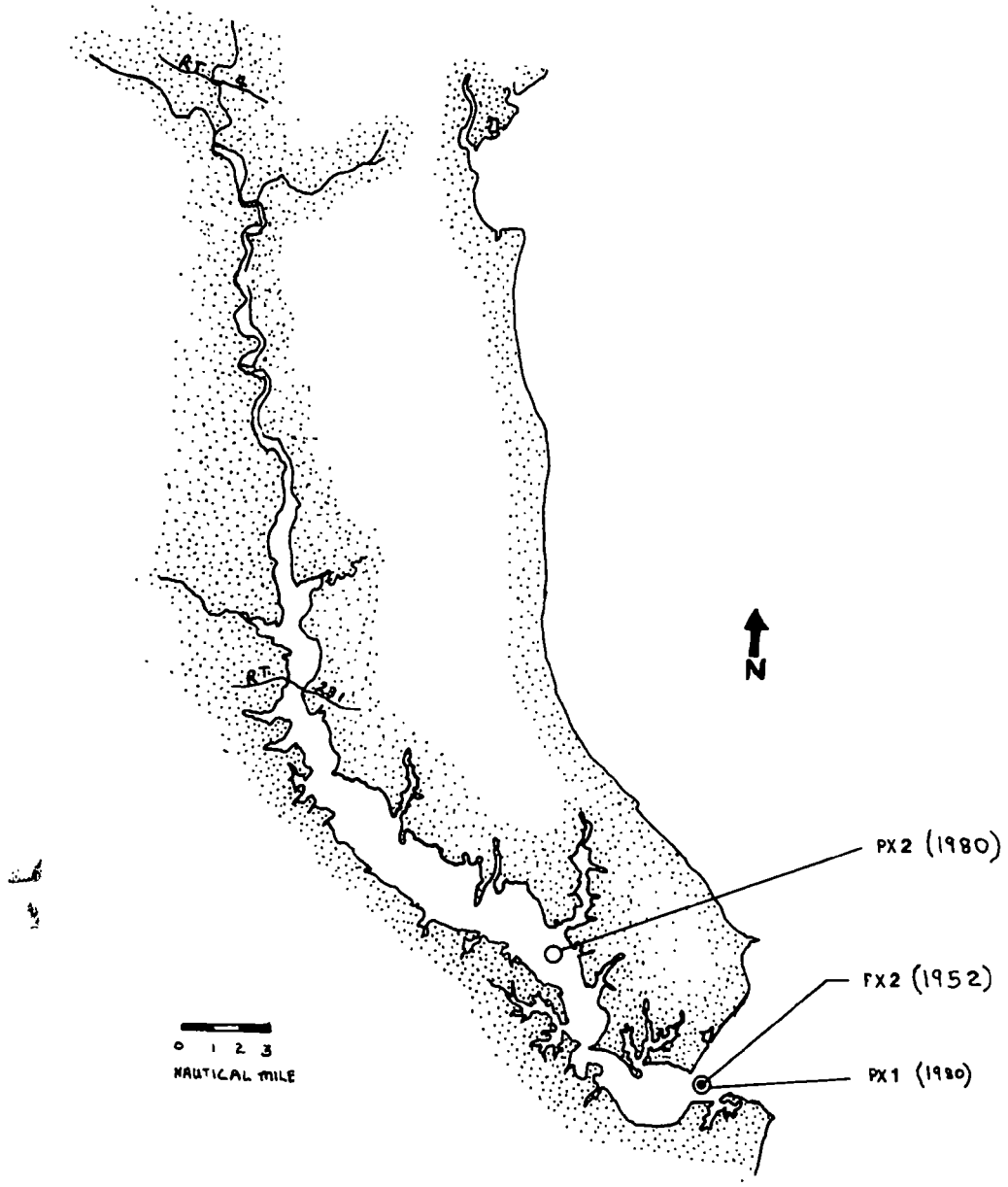


Figure 4-12 Location of current meter moorings conducted during this study by Boicourt, 1981 and by CBI, 1952 as reported by Owen, 1952.

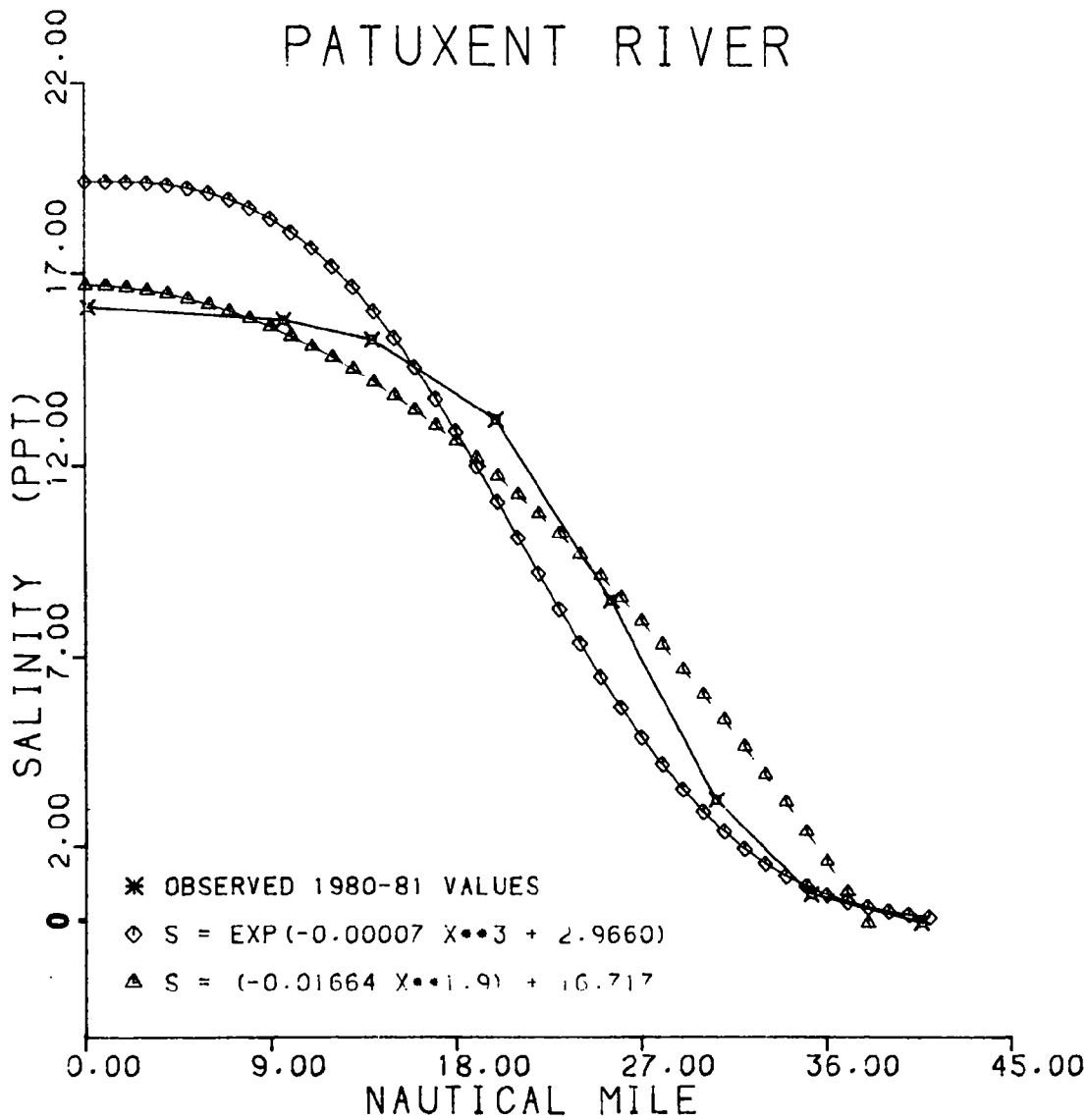
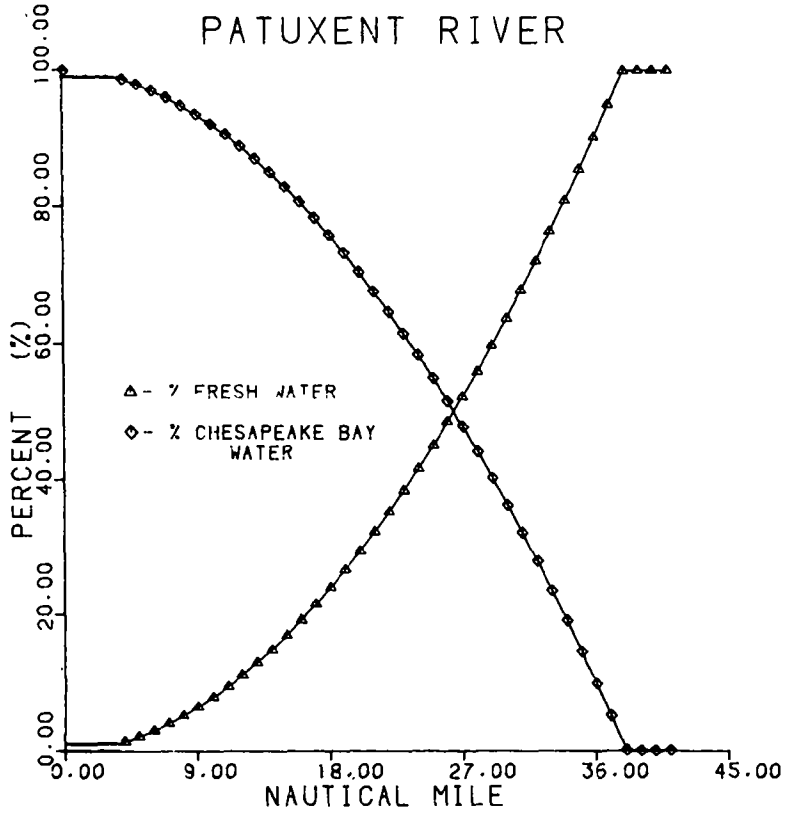


Figure 4-13 Patuxent River observed and statistically estimated functions of the salinity profile for 1980-1981.

Figure 4-14 Estimated average longitudinal fraction of freshwater and Chesapeake Bay water in Patuxent Estuary.



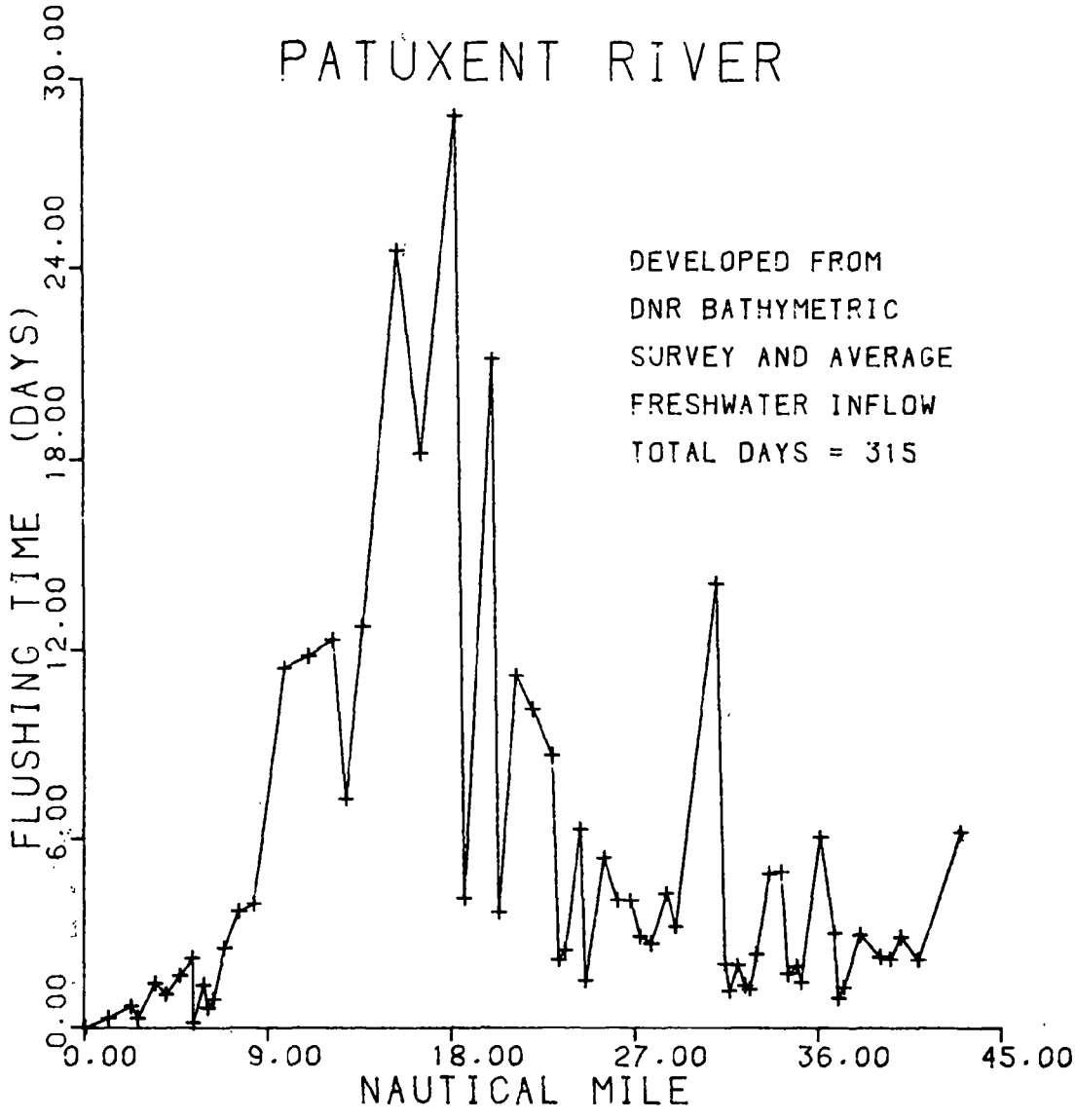


Figure 4-15 Estimated flushing time of the lower Patuxent River.

APPENDIX D

ILLUSTRATIONS OF BOX MODELS

SECTION 5

Table 5-1

Estimated Yearly Rainfall Loads To The Patuxent Basin And Water Surface From Bulk Precipitation Measurements

Water Quality Variable	Loading Rate (lb/acre/in.)	Basin Load (ton/yr)	Water Surface Load (ton/yr)
TOC	32.143E-03	231	10.0
TP	38.571E-03	278	12.0
TKN	36.429E-03	262	11.3
NO2+NO3	139.524E-03	1005	44.0

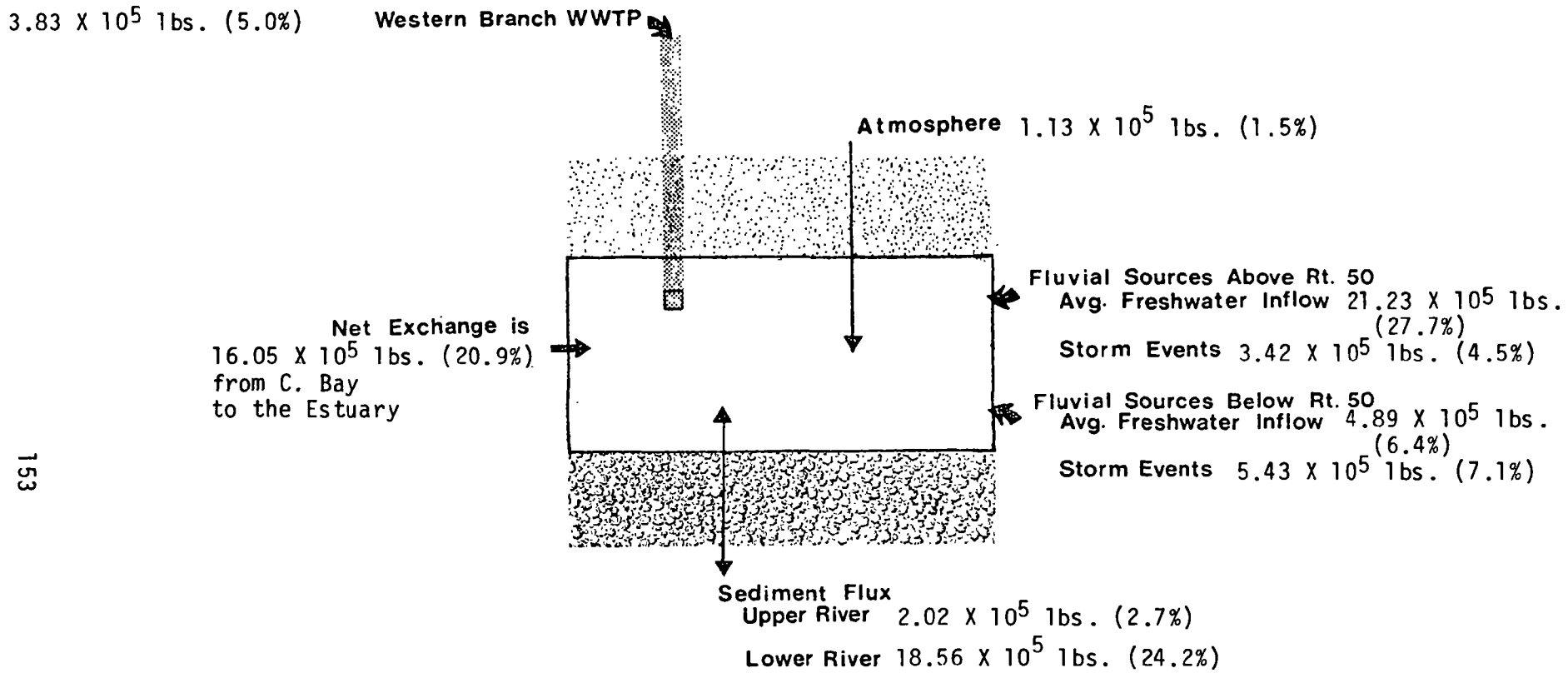


Figure 5-1 Patuxent Estuary Total Nitrogen Budget. Total Estimated input sources are approximately 7,660,000 pounds for a seven month period (April thru October). Average estuary concentration was 1.34 mg/l. The two largest sources were sediment flux at 26.9% and fluvial Inflow at 45.7%.

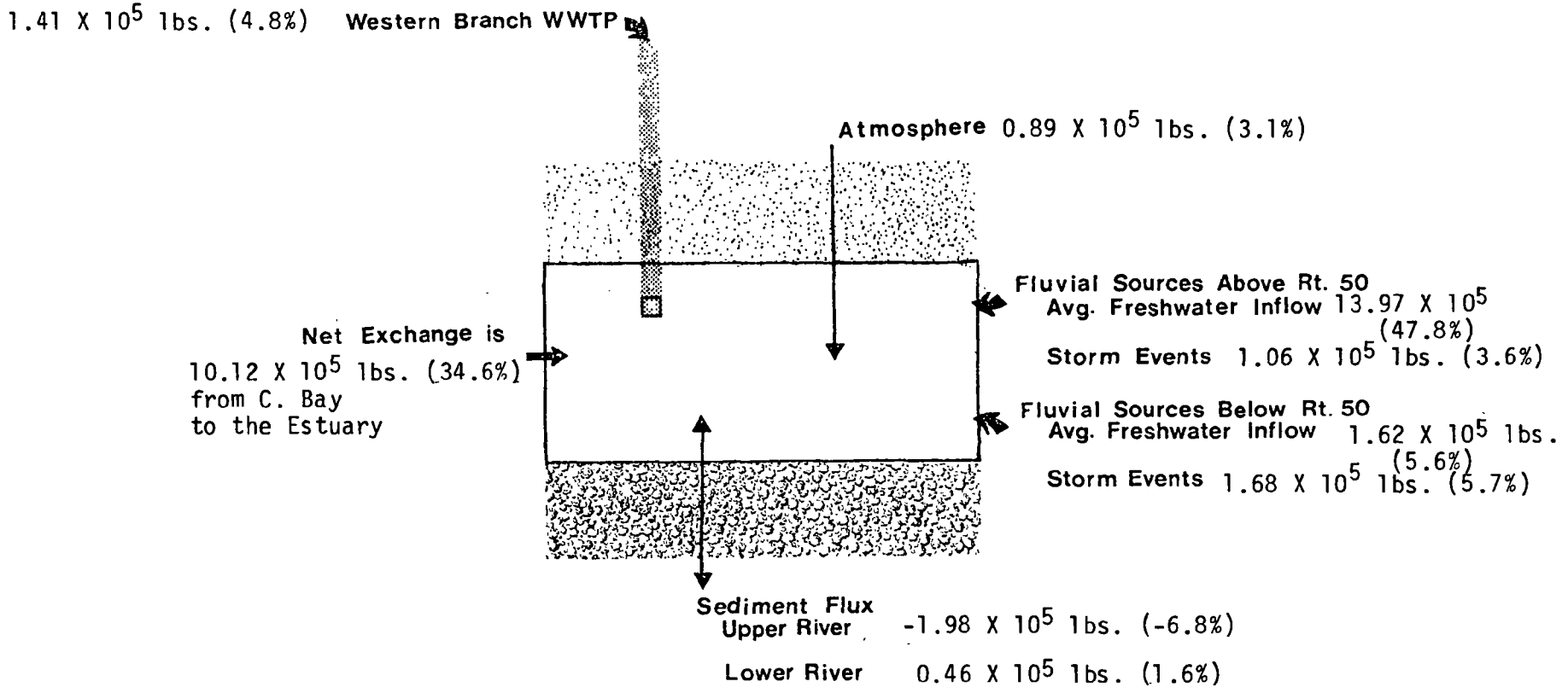


Figure 5-2 Patuxent Estuary Dissolved NO_2 + NO_3 Budget. Total estimated input sources are approximately 2,920,000 pounds for a seven month period (April thru October). Average estuary concentration was 0.76 mg/l. The fluvial discharge was the largest source at 62.7%.

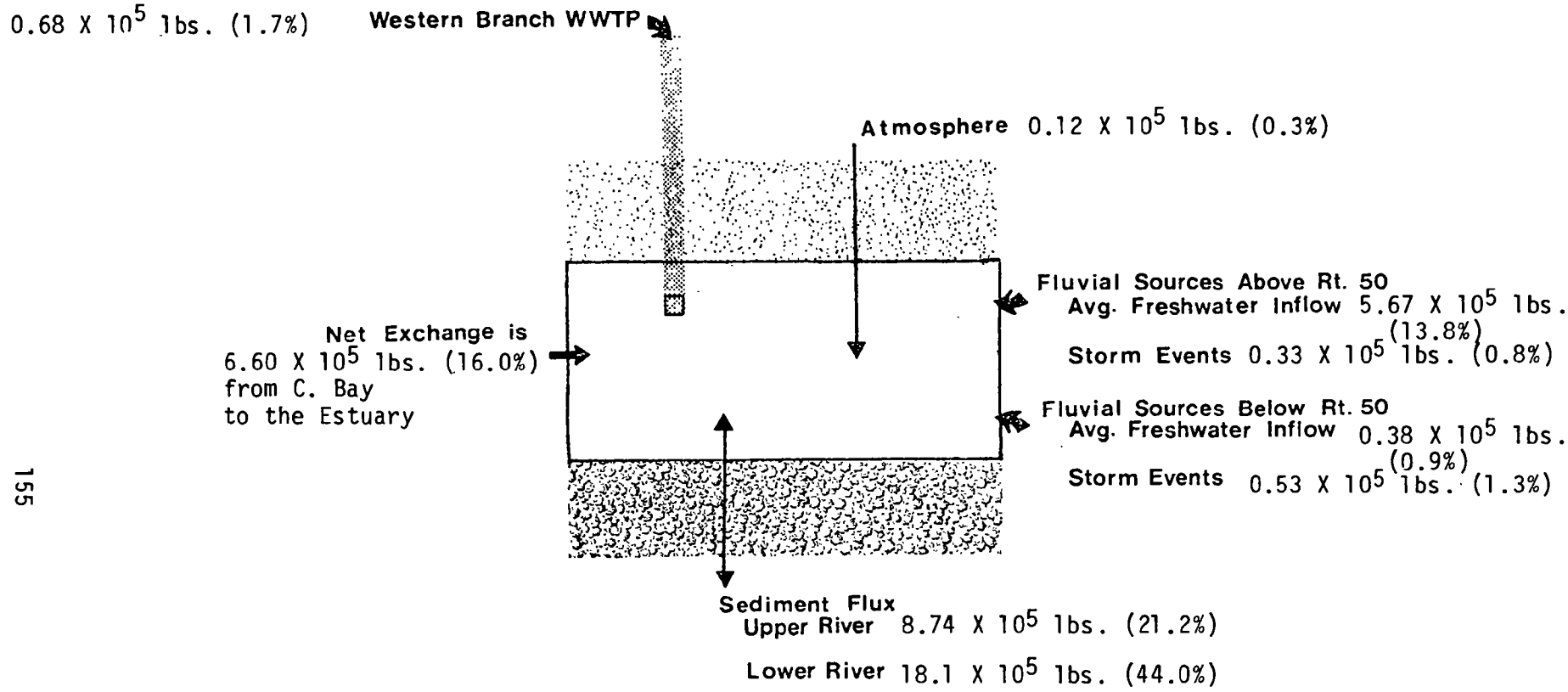


Figure 5-3 Patuxent Estuary Dissolved NH_3 Budget. Total estimated input sources are approximately 4,115,000 pounds for a seven month period (April thru October). Average estuary concentration was 0.24 mg/l. The sediment flux was the largest source of ammonia at 65.2%.

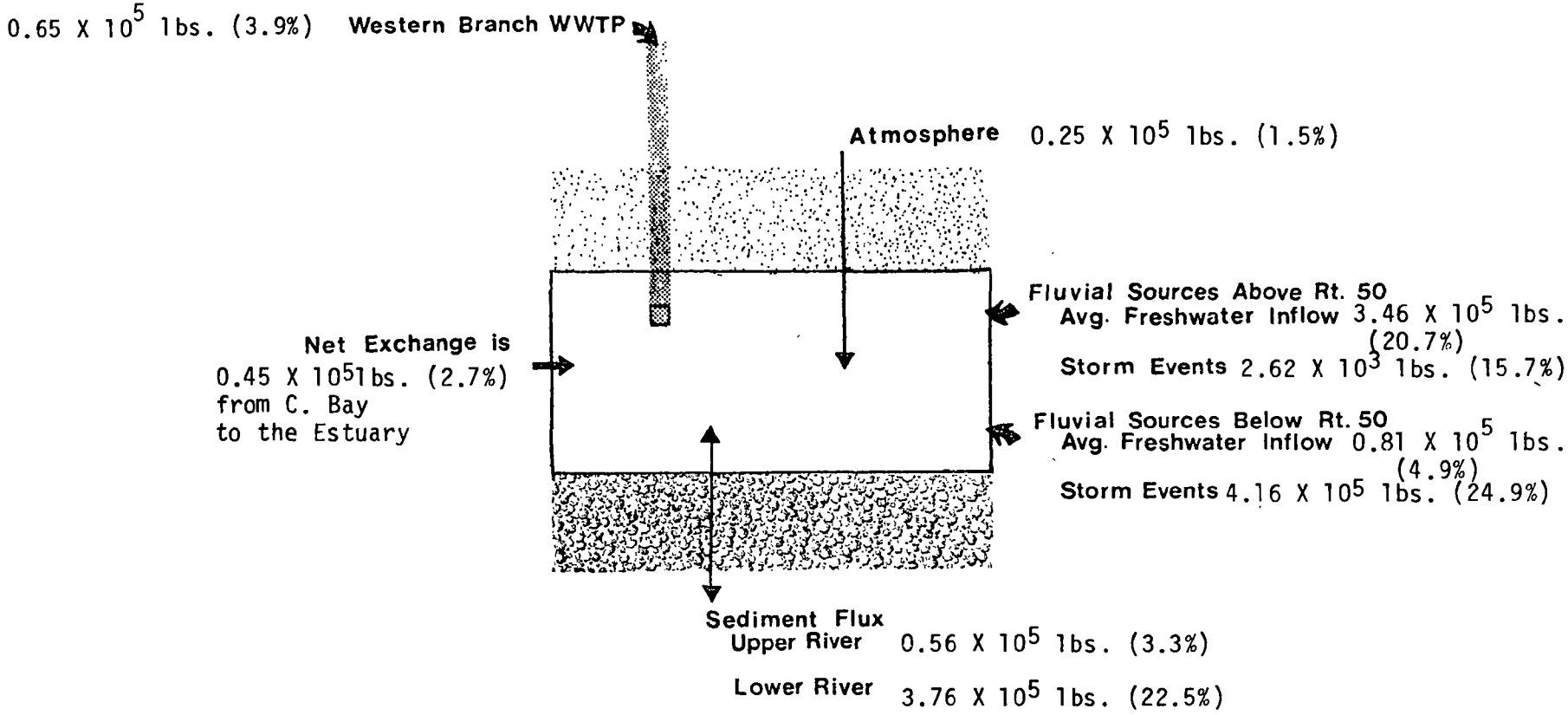


Figure 5-4 Patuxent Estuary Total Phosphorus Budget. Total estimated input sources are approximately 1,670,000 pounds for a seven month period (April thru October). Average estuary concentration was 0.17 mg/l. The two largest sources were from fluvial inflow at 66.1% and sediment flux at 25.8%.

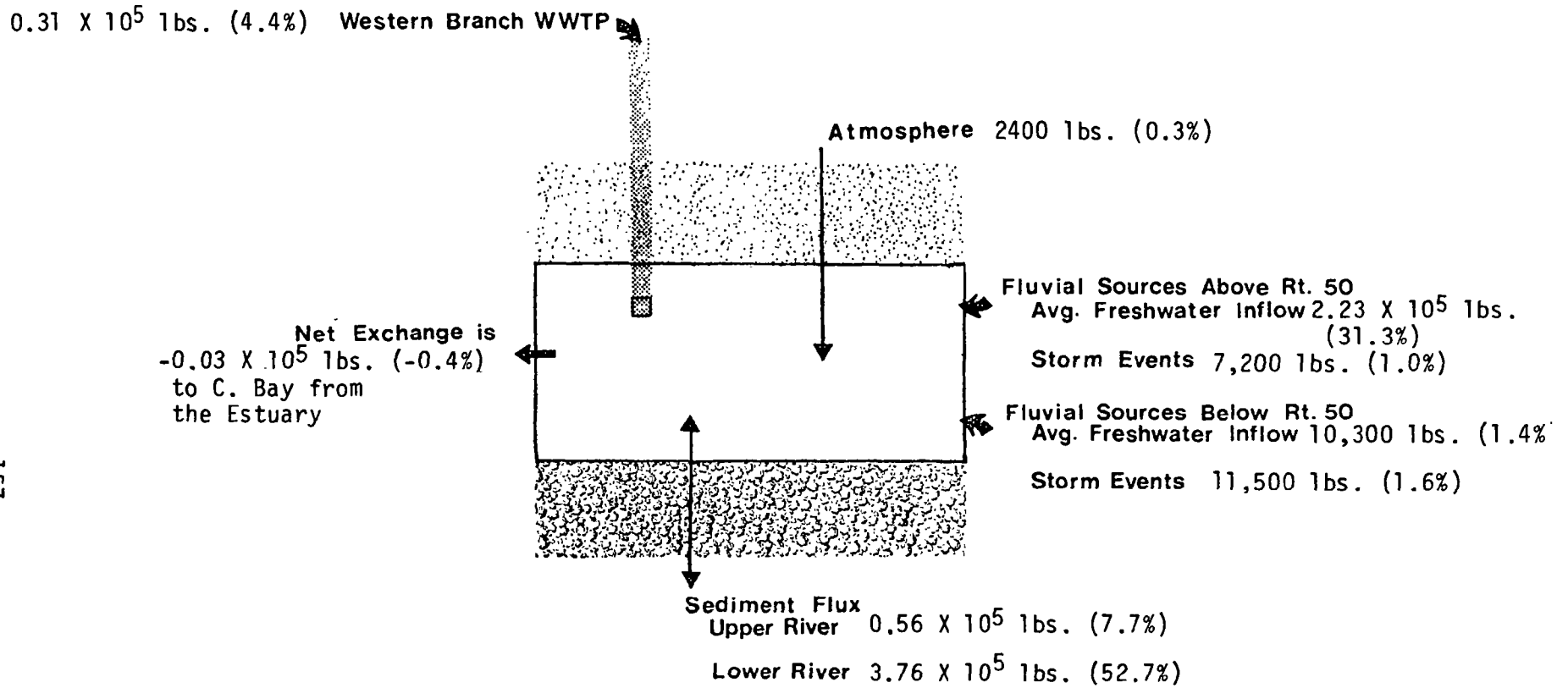


Figure 5-5 Patuxent Estuary Dissolved Ortho-phosphorus Budget. Total estimated input sources are approximately 715,400 pounds for a seven month period (April thru October). Average estuary concentration was 0.06 mg/l. The major sources of orthophosphorus were from sediment flux at 60.4% and fluvial input at 35.3%.

APPENDIX E

STATISTICAL ANALYSES OF NON-POINT SOURCES

SECTION 6

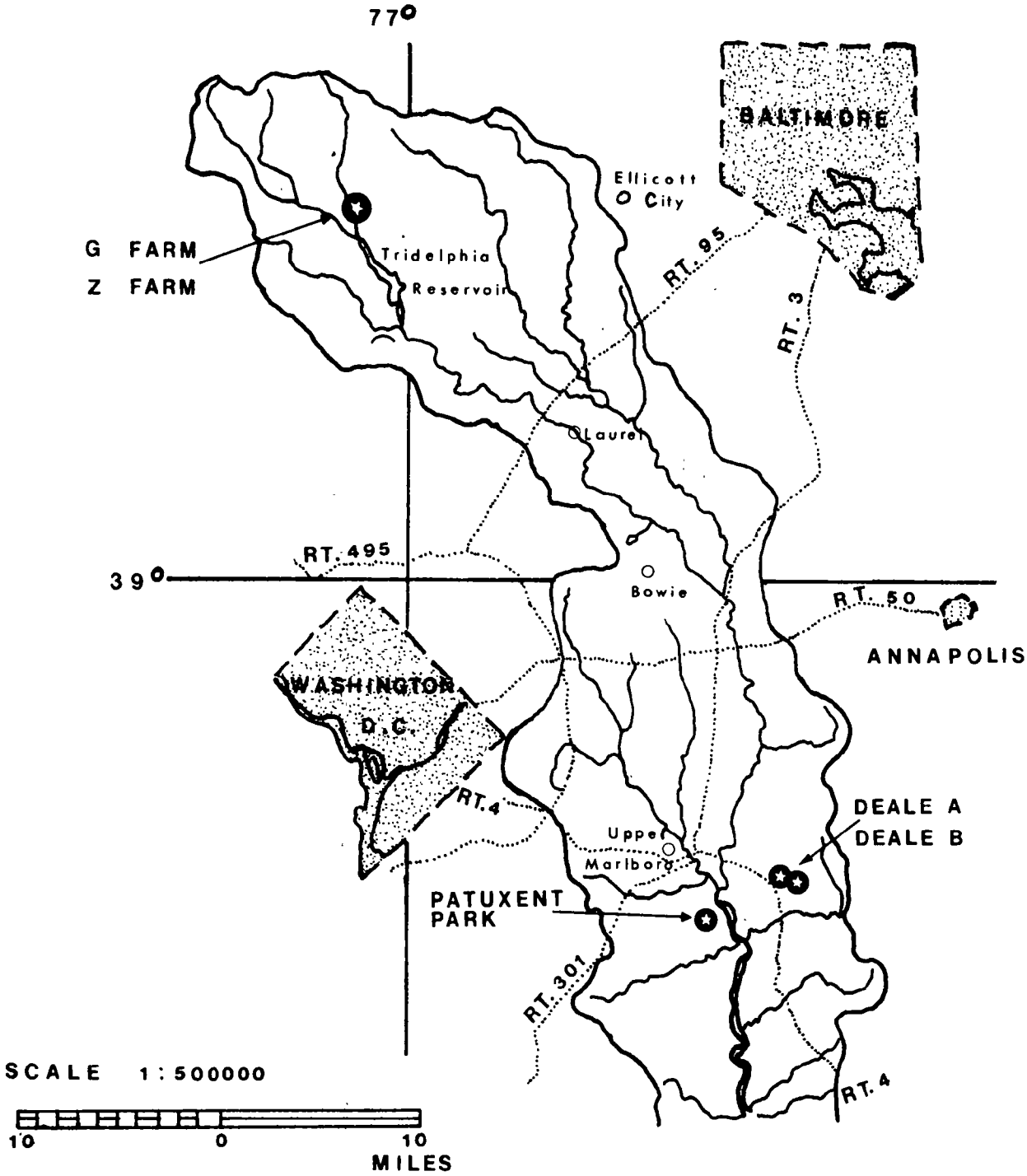


Figure 6-1 General Location of Patuxent River Basin Subwatersheds monitored for chemical export during storm events.

Table 6-1
General Location And Description Of Patuxent River Subwatershed Monitoring Sites

Subwatershed	Station No.	Land Use	Acres (estimated)	Province
Patuxent Park	BAW0006	Forested	144	Coastal
Deale A	ZEC0007	Agricultural (corn and tobacco)	300	Coastal
Deale B	CAB0018	Agricultural (corn and tobacco)	1,300	Coastal
Z Farm	ZEB0005	Agricultural (field corn and pasture)	55	Piedmont
G Farm	ZED0001	Agricultural (field corn and pasture)	34	Piedmont

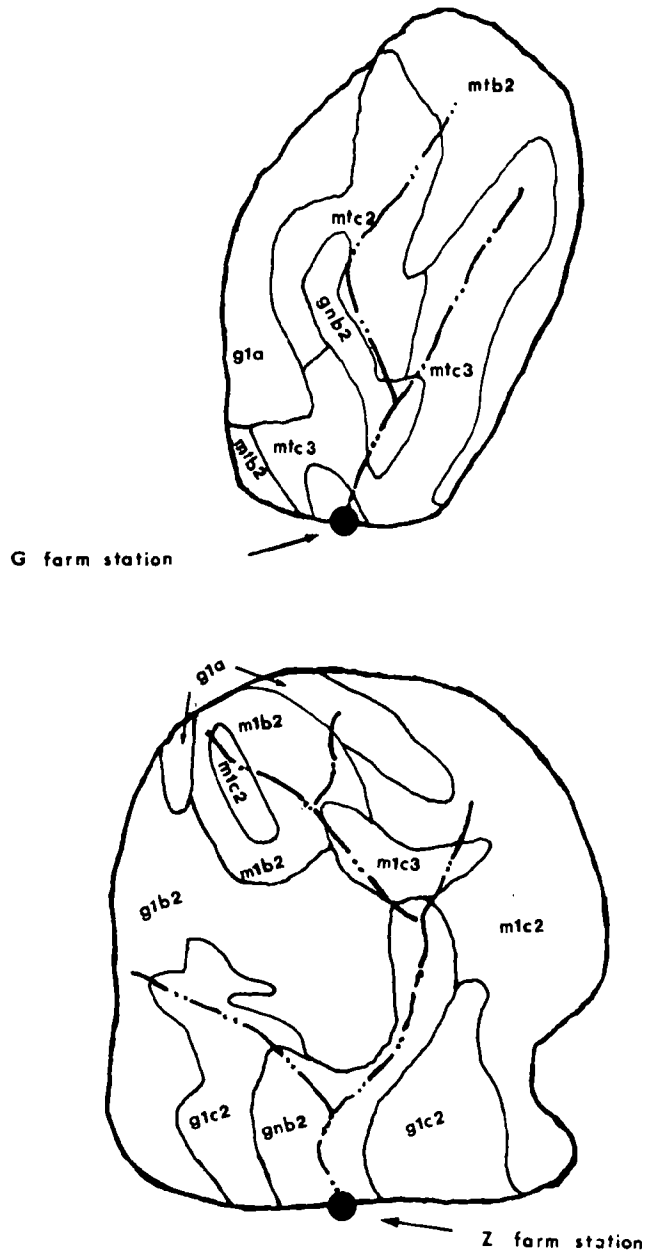


Figure 6-2 Soils map of G-Farm and Z-Farm subwatersheds monitored for chemical export during storm events.

Table 6-2
Soil Survey Data And Interpretations For Piedmont Subwatersheds

Mapping Unit	Soil Name	Hydrologic Group	Slope(%)
	Z-Farm		
GlA	Glenelg loam	B	0-3
GlB2	Glenelg loam (moderately eroded)	B	3-8
GlC2	Glenelg loam (moderately eroded)	B	8-15
GnB2	Glenville silt-loam (moderately eroded)	C	3-8
MlB2	Manor loam (moderately eroded)	B	3-8
MlC2	Manor loam (moderately eroded)	B	8-15
	G-Farm		
GlB2	Glenelg Doam (moderately eroded)	B	3-8
GnB2	Glenville silt loam (moderately eroded)	C	3-8
MtB2	Mt. Airy Channery loam (moderately eroded)	A	3-8
MtC2	Mt. Airy Channery loam (moderately eroded)	A	8-15
MtC3	Mt. Airy Channery loam (severely eroded)	A	8-15
MtE	Mt. Airy Channery loam	A	25-45

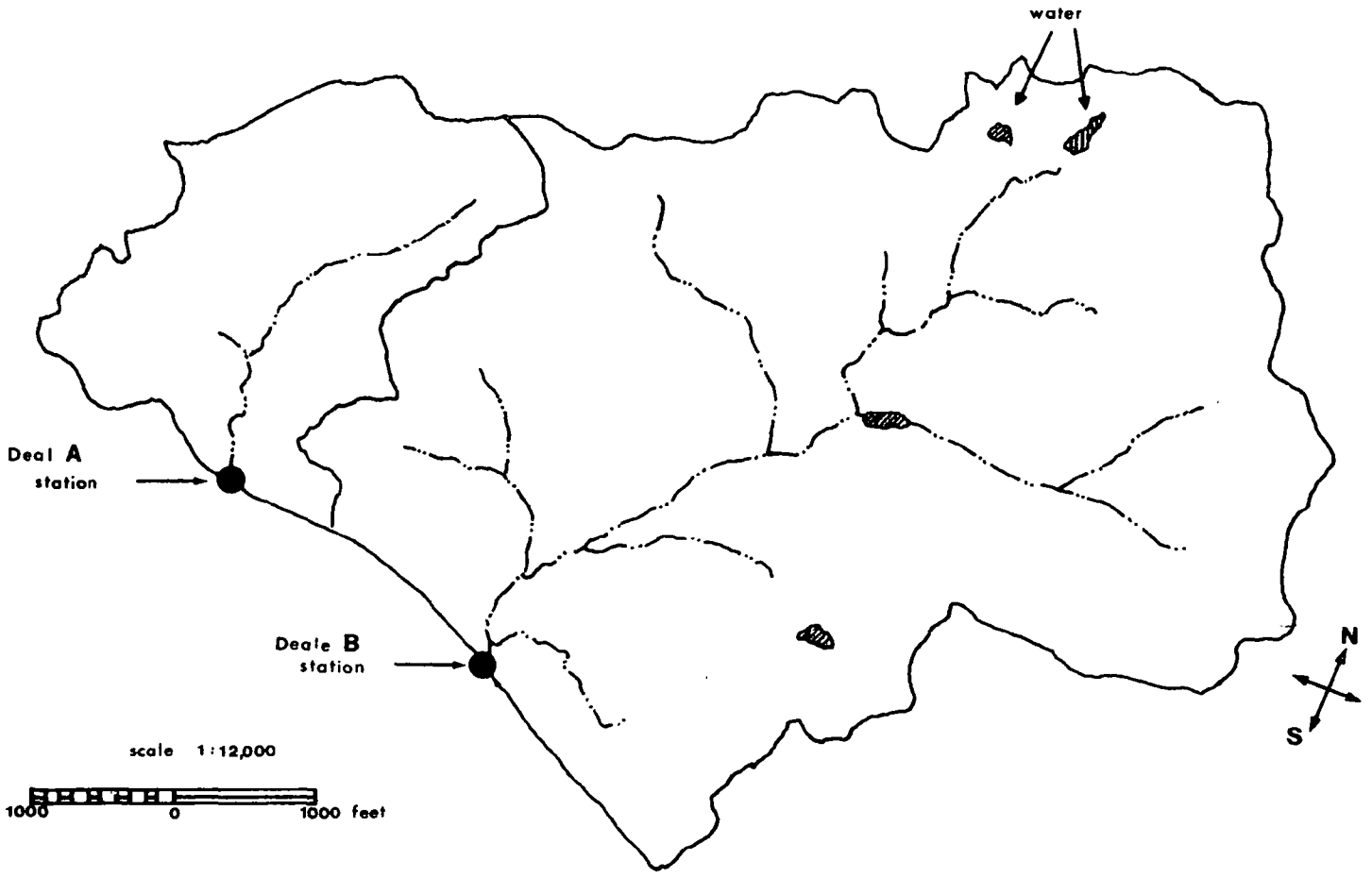


Figure 6-3 General map of Deale A and Deale B subwatersheds.

Table 6-3
Estimated Peak Discharges Using SCS Curve Number Methodology At Z-Farm And G-Farm For Comparative Site Description.*

Storm		Estimated Peak Discharge (cfs)		Runoff (in.)		Rainfall (in.)
frequency (yr)	probability (%)	G-farm	Z-farm	G-farm	Z-farm	
1	100	6.8	20	0.23	0.5	2.6
2	50	13.1	33	0.44	0.83	3.2
5	20	27.1	56.9	0.91	1.46	4.2
10	10	42.6	80	1.43	2.04	5.1
25	4	51.9	97.1	1.74	2.49	5.6
50	2	65.9	115	2.21	2.96	6.3
100	1	84.6	144	2.84	3.7	7.2

*Developed by Howard County Soil Conservation District, 1981 for this study.

Table 6-4
Approximate Land Utilization (1981) For Z-Farm And G-Farm Subwatersheds Monitored For Chemical Export In The Patuxent River Watershed

Land Utilization/ Tillage Practice	G-Farm (acres)	Z-Farm** (acres)
Alfalfa	4	21.9
Barley/soybeans and sorghum	11	16.3
Corn	11	22.1
Homestead	2	1.3
Pasture (permanent)	6	10.8
Hay (timothy)		1.8
Countoured		23.7
No till	11	3
Stripped	15	
N.M.T.*	6	12.1
Row		16.3

* None or minimum tillage
** These figures are not additive due to double cropping

Table 6-5
Patuxent River Latitude And Longitude Description
Of The Sampling Site And Rain Gauges

Site	Monitoring Site	Raintall Gauge
Patuxent Park	384617/764304	384613/764355 (Croom Vocational School)
Deale A	384729/763938	384730/763919 (R-Farm)
Deale B	384723/763858	384813/763846 (C-Farm)
Z-Farm	391514/770215	Same
G-Farm	391819/770452	Same

Table 6-6
Patuxent River NPS Chemical Export (lbs/acre) - All Stations

Variable	Mean	Standard Error	Standard Deviation	Median	Maximum	Minimum
BOD5	.1152	.0347	.29	.0413	2.1408	.0017
BOD30	.2856	.0922	.8701	.0994	7.705	.0027
TSS	12.171	4.607	46.982	.6065	447.047	.0019
NO2	3.833E-4	.994E-4	4.333E-4	2.098E-4	14.805E-4	.194E-4
NO3	.0038	.0013	.0058	.0019	.0256	.194E-4
NO2NO3	.0145	.003	.0292	.0049	.1677	.924E-4
NH3	.0054	.0019	.0199	.0009	.1882	.194E-4
TKN	.0342	.0104	.1086	.0059	.941	.802E-4
TKND	.0097	.0024	.0248	.0033	.2355	.401E-4
TPHOS	.0413	.018	.1887	.0018	1.8408	.427E-4
TPHOSD	.0012	.0004	.0046	3.325E-4	.048	.1E-4
DPO4	8.699E-4	3.595E-4	36.489E-4	2.013E-4	36.762E-4	.049E-4
TOC	.4167	.0949	.9956	.0839	6.3766	6.676E-4
COD	1.5853	.4575	4.7982	.2473	34.644	.002
ALKIN	.1052	.019	.1937	.0526	1.3191	.002

Table 6-7
Patuxent River NPS Chemical Export (lbs/acre) - All Agricultural Sites

Variable	Mean	Standard Error	Standard Deviation	Median	Maximum	Minimum
BOD5	.1399	.0461	.3328	.0417	2.1408	.0017
BOD30	.3458	.1293	1.0264	.0994	7.7050	.0027
TSS	16.0075	6.3991	55.0472	.6065	447.0470	.0019
NO2	.2181E-4	.0746E-4	.2585E-4	.1818E-4	.9865E-4	.0194E-4
NO3	.0048	.0020	.0070	.0024	.0256	.0194E-4
NO2NO3	.0181	.0040	.0328	.0058	.1677	.1582E-4
NH3	.0068	.0026	.0231	.8050E-4	.1882	.0194E-4
TKN	.0420	.0140	.1260	.0058	.9410	.0802E-4
TKND	.0112	.0032	.0287	.0034	.2355	.0401E-4
TPHOS	.0541	.0245	.2199	.0018	1.8408	.0427E-4
TPHOSD	.0014	5.991E-4	.0054	3.632E-4	.0480	0.100E-4
DPO4	.0010	4.900E-4	.0042	2.013E-4	.0364	0.067E-4
TOC	.4975	.1283	1.1473	.0873	6.3766	6.676E-4
COD	1.9572	.6230	5.5650	.2390	34.6439	.0020
ALKIN	.1269	.0258	.2236	.0588	1.3191	.0022

Table 6-8
Chester River NPS Chemical Export (lbs/acre) - Patuxent Park (forested)

Variable	Mean	Standard Error	Standard Deviation	Median	Maximum	Minimum
BOD5	.0440	.0105	.0444	.0397	.1663	.0037
BOD30	.1398	.0287	.1463	.0980	.4656	.0092
TSS	2.7080	1.6528	9.0530	.5712	49.8805	.0092
NO2	6.665E-4	2.044E-4	5.408E-4	6.015E-4	.0014	0.243E-4
NO3	.0019	8.254E-4	.0022	.0012	.0059	0.728E-4
NO2NO3	.0034	8.888E-4	.0043	.0010	.0140	0.924E-4
NH3	.0018	4.120E-4	.0023	.0010	.0102	0.243E-4
TKN	.0132	.0040	.0218	.0065	.1164	1.943E-4
TKND	.0057	.0010	.0060	.0031	.0233	1.458E-4
TPHOS	.0071	.0039	.0212	.0019	.1164	1.652E-4
TPHOSD	7.319E-4	2.015E-4	.0011	2.602E-4	.0056	0.352E-4
DPO4	4.453E-4	1.565E-4	8.282E-4	1.790E-4	.0036	0.049E-4
TOC	.2010	.0497	.2723	.0743	1.2636	.0058
COD	.5934	.1602	.8773	.3061	4.3230	.0185
ALKIN	.0489	.0067	.0363	.0408	.1590	.0020

Table 6-9
Chester River NPS Chemical Export (lbs/acre) - Deale A Watershed (agricultural)

Variable	Mean	Standard Error	Standard Deviation	Median	Maximum	Minimum
BOD5	.1993	.1159	.4915	.0619	2.1408	.0104
BOD30	.5125	.3299	1.5822	.1168	7.7050	.0027
TSS	11.6310	4.3804	23.1791	.6454	93.2722	.0019
NO2	1.462E-4	0.354E-4	0.792E-4	1.541E-4	2.151E-4	0.194E-4
NO3	.0026	.0015	.0033	.0017	.0082	0.194E-4
NO2NO3	.0223	.0077	.0406	.0043	.1677	6.940E-4
NH3	.0089	.0058	.0333	5.721E-4	.1882	0.194E-4
TKN	.0658	.0327	.1850	.0039	.9410	1.166E-4
TKND	.0128	.0072	.0411	.0027	.2355	0.777E-4
TPHOS	.0375	.0416	.0824	.0026	.3206	0.427E-4
TPHOSD	9.704E-4	2.171E-4	.0012	5.546E-4	.0048	0.233E-4
DPO4	6.5000E-4	1.527E-4	8.223E-4	4.075E-4	.0030	0.194E-4
TOC	.4889	.2032	1.1496	.1070	5.5380	.0042
COD	2.3349	1.1793	6.6712	.2481	34.6440	.0058
ALKIN	.1229	.0468	.2475	.0390	1.3025	.0022

Table 6-10
Chester River NPS Chemical Export (lbs/acre) - Deale B Watershed (Agricultural)

Variable	Mean	Standard Error	Standard Deviation	Median	Maximum	Minimum
BOD5	.0950	.0424	.1849	.0346	.7361	.0043
BOD30	.2403	.1009	.4941	.0813	2.2089	.0143
TSS	26.1250	16.7109	86.8323	.3171	447.0470	.0020
NO2	3.084E-4	1.416E-4	3.470E-4	2.180E-4	9.865E-4	0.201E-4
NO3	.0072	.0038	.0092	.0045	.0256	4.211E-4
NO2NO3	.0187	.0055	.0256	.0110	.1104	5.362E-4
NH3	.0054	.0027	.0146	8.497E-4	.0736	0.201E-4
TKN	.0335	.0142	.0752	.0070	.3872	0.802E-4
TKND	.0115	.0036	.0192	.0040	.0894	0.401E-4
TPHOS	.1018	.0680	.3570	.0015	1.8408	0.596E-4
TPHOSD	9.743E-4	2.949E-4	.0016	4.276E-4	.0061	0.238E-4
DPO4	6.280E-4	2.307E-4	.0012	1.537E-4	.0061	0.238E-4
TOC	.5919	.2662	1.4084	.0460	6.3765	.0012
COD	2.0466	1.1342	6.0016	.1610	30.5044	.0020
ALKIN	.1128	.0257	.1362	.0658	.5952	.0056

Table 6-11
Chester River NPS Chemical Export (lbs/acre) - Z Farm (Agricultural)

Variable	Mean	Standard Error	Standard Deviation	Median	Maximum	Minimum
BOD5	.0746	.0326	.1131	.0337	.3984	.0017
BOD30	.1616	.0660	.2382	.0750	.8581	.0040
TSS	9.4627	4.9881	19.9526	1.1926	77.9490	.0180
NO2	0.360E-4	--	--	0.360E-4	0.360E-4	0.360E-4
NO3	.0019	--	--	.0019	.0019	.0019
NO2NO3	.0056	.0014	.0054	.0045	.0919	1.582E-4
NH3	.0038	9.240E-4	.0038	.0025	.0105	1.168E-4
TKN	.0158	.0044	.0181	.0123	.0560	2.670E-4
TKND	.0070	.0017	.0069	.0050	.0195	2.336E-4
TPHOS	.0104	.0046	.0190	.0012	.0606	0.666E-4
TPHOSD	3.246E-4	1.703E-4	7.020E-4	1.332E-4	.0030	0.100E-4
DPO4	1.031E-4	0.376E-4	1.455E-4	0.633E-4	5.463E-4	0.067E-4
TOC	.2914	.1423	.5125	.0799	2.0353	6.676E-4
COD	1.0764	.4704	1.9396	.2532	7.7949	.0100
ALKIN	.0910	.0195	.0780	.0612	.2665	.0087

Table 6-12
Patuxent River NPS Chemical Export (lbs/acre) - G Farm (Agricultural)

Variable	Mean	Standard Error	Standard Deviation	Median	Maximum	Minimum
BOD5	.3290	.2956	.5119	.0572	.9194	.0100
BOD30	.7013	.6051	1.0480	.1618	1.9187	.0503
TSS	.7029	.5524	.9568	.2763	1.7983	.0335
NO2	--	--	--	--	--	--
NO3	--	--	--	--	--	--
NO2NO3	.0433	.0403	.0698	.0050	.1239	9.869E-4
NH3	.0126	.0117	.0202	.0016	.0360	3.352E-4
TKN	.0162	.0100	.0174	.0093	.0360	.0033
TKND	.0149	.0087	.0151	.0093	.0320	.0033
TPHOS	.0321	.0331	.0512	.0038	.0919	7.039E-4
TPHOSD	.0171	.0155	.0268	.0028	.0480	4.693E-4
DPO4	.0130	.0117	.0202	.0024	.0364	4.022E-4
TOC	.8778	.8003	1.3862	.0947	2.4783	.0603
COD	1.9190	1.6390	2.8389	.3257	5.1966	.2346
ALKIN	.4871	.4160	.7206	.0771	1.3191	.0651

Table 6-13
Patuxent River NPS Chemical Export (lbs/acre/in.) - All Stations

Variable	Mean	Standard Error	Standard Deviation	Median	Maximum	Minimum
BOD5	.1412	.0349	.2586	.0648	1.4663	.0073
BOD30	.332	.0868	.7213	.1554	5.2774	.0218
TSS	13.2931	4.7827	42.2393	1.4451	328.711	.0252
NO2	4.184E-4	.796E-4	2.869E-4	3.77E-4	8.973E-4	1.115E-4
NO3	.0036	.0008	.0029	.0029	.0103	6.288E-4
NO2NO3	.019	.0034	.0285	.0098	.1569	1.84E-4
NH3	.006	.0018	.0162	.0015	.1289	1.284E-4
TKN	.0425	.0126	.1149	.0098	.7773	7.931E-4
TKND	.0117	.0022	.0205	.0055	.1613	.0006
TPHOS	.0471	.0185	.1683	.0032	1.3535	1.586E-4
TPHOSD	.0018	.0007	.0067	.0005	.0607	.801E-4
DPO4	.0013	.0006	.0052	.0003	.046	.159E-4
TOC	.5103	.137	1.2479	.1588	9.2301	.0083
COD	1.8365	.5078	4.6266	.4638	26.7186	.0366
ALKIN	.1863	.0569	.5085	.0858	4.2512	.0038

Table 6-14
Patuxent River NPS Chemical Export (lbs/acre/in,) - All Agricultural Sites

Variable	Mean	Standard Error	Standard Deviation	Median	Maximum	Minimum
BOD5	.168	.046	.2946	.071	1.4663	.0073
BOD30	.3974	.121	.8467	.1525	5.2774	.0291
TSS	17.4484	6.6638	49.42	2.0279	328.711	.0252
NO2	2.228E-4	.392E-4	1.107E-4	1.824E-4	3.978E-4	1.115E-4
NO3	.0042	.0011	.0032	.0037	.0103	7.549E-4
NO2NO3	.0236	.0043	.0316	.0112	.1569	1.84E-4
NH3	.0074	.0024	.0187	.0016	.1289	1.284E-4
TKN	.0522	.0172	.1334	.01	.7773	7.931E-4
TKND	.0134	.003	.0236	.0057	.1613	5.964E-4
TPHOS	.0617	.0253	.1959	.0044	1.3535	1.586E-4
TPHOSD	.0022	.001	.0078	5.666E-4	.0607	.801E-4
DPO4	.0015	.0008	.0061	.0003	.046	.159E-4
TOC	.6138	.1869	1.4478	.1603	9.2301	.0083
COD	2.2307	.6934	5.3707	.4701	26.7186	.0366
ALKIN	.235	.079	.5964	.1096	4.2512	.005

Table 6-15
Patuxent River NPS Chemical Export (lbs/acre/in.) - Patuxent Park (Forested)

Variable	Mean	Standard Error	Standard Deviation	Median	Maximum	Minimum
BOD5	.0626	.0117	.0438	.0572	.1646	.009
BOD30	.1718	.025	.1118	.1573	.4609	.0218
TSS	3.3564	2.1196	10.1654	.9435	49.3867	.1354
NO2	7.314E-4	.728E-4	1.628E-4	7.257E-4	8.973E-4	5.205E-4
NO3	.0026	.001	.0022	.0018	.0062	6.288E-4
NO2NO3	.0056	.0016	.0068	.0025	.0253	1.91E-4
NH3	.0023	6.312E-4	.003	.0014	.0153	4.513E-4
TKN	.0172	.005	.0241	.0087	.1152	9.026E-4
TKND	.0073	.0015	.007	.005	.0255	9.026E-4
TPHOS	.0091	.0049	.0237	.0027	.1152	6.318E-4
TPHOSD	9.12E-4	2.43E-4	11.655E-4	4.236E-4	52.601E-4	.903E-4
DPO4	6.08E-4	2.322E-4	10.892E-4	2.595E-4	48.579E-4	.764E-4
TOC	.2405	.0579	.2778	.1554	1.2511	.0257
COD	.8082	.198	.9496	.4337	4.2802	.0971
ALKIN	.0655	.0083	.0397	.0607	.1528	.0038

Table 6-16
Patuxent River NPS Chemical Export (lbs/acre/in.) - Deale A Watershed (Agricultural)

Variable	Mean	Standard Error	Standard Deviation	Median	Maximum	Minimum
BOD5	.2662	.1267	.4202	.1017	1.4663	.0353
BOD30	.6269	.3443	1.3336	.2162	5.2774	.0488
TSS	19.2393	8.2969	36.1652	6.1969	155.454	.0365
NO2	1.912E-4	.625E-4	1.25E-4	1.38E-4	3.774E-4	1.115E-4
NO3	.0027	.0014	.0028	.0016	.0069	7.549E-4
NO2NO3	.0302	.008	.0349	.0158	.1149	.0018
NH3	.0096	.0056	.027	.0013	.1289	1.284E-4
TKN	.0915	.0438	.2053	.0088	.7773	.0022
TKND	.0145	.007	.0334	.0038	.1613	7.549E-4
TPHOS	.0582	.0255	.1198	.0078	.5344	.0011
TPHOSD	.0013	.0002	.0011	.001	.0034	2.672E-4
DPO4	8.482E-4	1.242E-4	5.552E-4	7.367E-4	20.923E-4	2.019E-4
TOC	.7919	.4166	1.9538	.1877	9.2301	.0352
COD	3.2267	1.543	7.2373	.5902	26.7186	.0716
ALKIN	.1574	.0505	.2258	.086	.8921	.005

Table 6-17

Patuxent River NPS Chemical Export (lbs/acre/in.) - Deale B Watershed (Agricultural)

Variable	Mean	Standard Error	Standard Deviation	Median	Maximum	Minimum
BOD5	.097	.0345	.1422	.0544	.5414	.0073
BOD30	.2304	.0845	.3873	.1213	1.6242	.0293
TSS	23.6294	15.0525	70.6024	1.1991	328.711	.0381
NO2	2.543E-4	.508E-4	1.017E-4	2.215E-4	3.978E-4	1.763E-4
NO3	.0057	.0016	.0031	.0045	.0103	.0036
NO2NO3	.0216	.0046	.0202	.0156	.0812	.0038
NH3	.0052	.0024	.0117	.0014	.0541	1.491E-4
TKN	.0343	.0145	.0694	.0079	.3253	.0013
TKND	.0128	.0036	.0174	.0066	.0657	5.964E-4
TPHOS	.0945	.0612	.2935	.0026	1.3535	4.255E-4
TPHOSD	.0011	.0003	.0013	.0006	.0051	1.359E-4
DPO4	6.514E-4	2.221E-4	10.65E-4	2.842E-4	50.928E-4	.895E-4
TOC	.5646	.258	1.2372	.0917	5.3585	.0085
COD	1.9204	1.0177	4.8806	.2173	22.4297	.0366
ALKIN	.2965	.1805	.8656	.0912	4.2512	.0372

Table 6-18
Patuxent River NPS Chemical Export (lbs/acre/in.) - Z Farm (Agricultural)

Variable	Mean	Standard Error	Standard Deviation	Median	Maximum	Minimum
BOD5	.0918	.0352	.1113	.0496	.3868	.0125
BOD30	.2141	.0745	.2355	.1465	.8331	.0291
TSS	6.4461	2.3925	7.9351	2.129	18.5962	.1278
NO2	--	--	--	--	--	--
NO3	--	--	--	--	--	--
NO2NO3	.0086	.0019	.0067	.0091	.0215	1.84E-4
NH3	.0049	.0012	.0043	.0051	.0152	6.406E-4
TKN	.0204	.0047	.0162	.0152	.0421	7.931E-4
TKND	.0091	.0021	.0073	.0083	.0266	7.931E-4
TPHOS	.0096	.0042	.0145	.0023	.0466	1.586E-4
TPHOSD	4.481E-4	2.251E-4	7.798E-4	2.561E-4	28.978E-4	.801E-4
DPO4	1.374E-4	.336E-4	1.163E-4	1.011E-4	4.108E-4	.159E-4
TOC	.2393	.0699	.2422	.1874	.8182	.0083
COD	.8896	.2481	.8594	.6829	2.901	.0625
ALKIN	.1321	.0222	.0737	.1193	.2587	.0352

Table 6-19
Patuxent River NPS Chemical Export (lbs/acre/in.) - G Farm (Agricultural)

Variable	Mean	Standard Error	Standard Deviation	Median	Maximum	Minimum
BOD5	.4638	.3553	.6154	.2201	1.1638	.0076
BOD30	1.0297	.7196	1.2464	.6225	2.4288	.0378
TSS	1.1217	.6507	1.127	1.0628	2.277	.0252
NO2	--	--	--	--	--	--
NO3	--	--	--	--	--	--
NO2NO3	.0548	.051	.0884	.0038	.1569	.0038
NH3	.0173	.0142	.0246	.0061	.0455	2.52E-4
TKN	.0279	.013	.0225	.0357	.0455	.0025
TKND	.0262	.0119	.0207	.0357	.0405	.0025
TPHOS	.0438	.0365	.0633	.0144	.1164	5.293E-4
TPHOSD	.0239	.0186	.0323	.0106	.0607	3.528E-4
DPO4	.0185	.014	.0243	.0091	.046	3.024E-4
TOC	1.1823	.9818	1.7005	.3644	3.1372	.0454
COD	2.669	1.979	3.4278	1.2525	6.578	.1764
ALKIN	.6594	.5082	.8803	.2505	1.6698	.058

Table 6-20 Patuxent River NPS Chemical Export (lbs/acre/yr) - All Sites

Variable	Mean	St. Error	St. Deviation	Median	Max.	Min.
BOD5	5.9293	1.4646	10.8619	2.7204	61.5852	.3078
BOD30	13.9439	3.6469	30.2931	6.5271	221.6494	.9153
TSS	558.31	200.8716	1774.05	60.3104	13805.9	1.0585
NO2	.0176	.0033	.0121	.0159	.0377	.0047
NO3	.1508	.0034	.1213	.1219	.4344	.0264
NO2NO3	.7999	.1422	1.1986	.4097	6.5881	.0077
NH3	.2516	.074	.6786	.0639	5.4135	.0054
TKN	1.7848	.5299	4.8272	.4125	32.6453	.0333
TKND	.4922	.0942	.8631	.2303	6.7734	.025
TPHOS	1.9779	.776	7.0698	.1364	56.8477	.0067
TPHOSD	.0766	.0306	.2808	.0196	2.5502	.0034
DPO4	.0538	.0246	.2196	.0126	1.9339	6.662E-4
TOC	21.4343	5.7529	52.4113	6.6683	387.6628	.3498
COD	77.1333	21.3293	194.3193	19.4813	1122.1818	1.5391
ALKIN	7.8243	2.3878	21.3567	3.6027	178.5504	.1604

Table 6-21 Patuxent River NPS Chemical Export (lbs/acre/yr) - All Agricultural Sites

Variable	Mean	St. Error	St. Deviation	Median	Max.	Min.
BOD5	7.0559	1.9322	12.3719	2.9837	61.5852	.3078
BOD30	16.5903	5.0804	35.5031	6.4063	221.6494	1.2242
TSS	732.835	279.879	2075.639	85.171	13805.86	1.0585
NO2	.0094	.0016	.0047	.0077	.0167	.0047
NO3	.1779	.0475	.1344	.1574	.4344	.0317
NO2NO3	.992	.1822	1.3263	.4708	6.5881	.0077
NH3	.3102	.1007	.7864	.0668	5.4135	.0054
TKN	2.1914	.7234	5.6034	.4183	32.6453	.0333
TKND	.5624	.1268	.9901	.2387	6.7734	.025
TPHOS	2.5897	1.0624	8.2294	.1838	56.8477	.0067
TPHOSD	.0911	.042	.3277	.0238	2.5502	.0034
DPO4	.0645	.0336	.2563	.0134	1.9339	6.662E-4
TOC	25.779	7.85	60.809	6.734	387.663	.3498
COD	93.688	29.121	225.568	19.743	1122.182	1.539
ALKIN	9.872	3.318	25.05	4.602	178.55	.212

Table 6-22 Patuxent River NPS Chemical Export (lbs/acre/yr) - Patuxent Park (Forested)

Variable	Mean	St. Error	St. Deviation	Median	Max.	Min.
BOD5	2.6301	.4914	1.8387	2.4007	6.9141	.3791
BOD30	7.2152	1.0502	4.6965	6.6069	19.3596	.9153
TSS	140.969	89.024	426.946	39.625	2074.24	5.687
NO2	.0307	.0031	.0068	.0305	.0377	.0219
NO3	.1075	.0417	.0933	.0743	.2623	.0264
NO2NO3	.2342	.067	.2842	.1058	1.0606	.008
NH3	.096	.0265	.1271	.0584	.6417	.019
TKN	.7242	.2108	1.0109	.3658	4.8399	.0379
TKND	.306	.0615	.295	.2094	1.0695	.0379
TPHOS	.3818	.2073	.9939	.1131	4.8399	.0265
TPHOSD	.0383	.0102	.0489	.0178	.2209	.0038
DPO4	.0255	.0098	.0457	.0109	.204	.0032
TOC	10.1009	2.4327	11.667	6.5271	52.5474	1.079
COD	33.9464	8.316	39.8821	18.2172	179.767	4.079
ALKIN	2.7508	.3476	1.6668	2.5504	6.4168	.1604

Table 6-23 Patuxent River NPS Chemical Export (lbs/acre/yr) - Deale A Watershed (Agricultural)

Variable	Mean	St. Error	St. Deviation	Median	Max.	Min.
BOD5	11.1821	5.3215	17.6495	4.2709	61.5852	1.4839
BOD30	26.3299	14.4616	56.0095	9.0792	221.6494	2.0491
TSS	808.05	348.468	1518.937	260.269	6529.057	1.5341
NO2	.008	.0026	.0053	.0058	.0159	.0047
NO3	.115	.0596	.1193	.069	.2904	.0317
NO2NO3	1.2688	.3358	1.4639	.6643	4.8249	.0767
NH3	.402	.2362	1.1328	.0527	5.4135	.0054
TKN	3.842	1.8383	8.6226	.368	32.6453	.092
TKND	.61	.2924	1.4023	.1592	6.7734	.0317
TPHOS	2.4448	1.0727	5.0316	.3296	22.4436	.0481
TPHOSD	.055	.0093	.0445	.0403	.1428	.0112
DPO4	.0356	.0052	.0233	.0309	.0879	.0085
TOC	33.2596	17.4955	82.0611	7.8852	387.663	1.4768
COD	135.521	64.806	303.967	24.789	1122.182	3.0088
ALKIN	6.6093	2.1204	9.4829	3.6128	37.4686	.212

Table 6-24 Patuxent River NPS Chemical Export (lbs/acre/yr) - Deale B Watershed (Agricultural)

Variable	Mean	St. Error	St. Deviation	Median	Max.	Min.
BOD5	4.076	1.4488	5.9736	2.2833	22.7391	.3078
BOD30	9.6763	3.5497	16.2666	5.0944	68.2172	1.2313
TSS	992.434	632.204	2965.3	50.362	13805.864	1.6015
NO2	.0107	.0021	.0043	.0093	.0167	.0074
NO3	.2408	.0659	.1319	.1884	.4344	.152
NO2NO3	.9058	.1948	.8492	.6564	3.4109	.1609
NH3	.218	.1027	.4927	.0597	2.2739	.0063
TKN	1.4411	.6078	2.9151	.3324	13.6641	.0536
TKND	.5386	.152	.7288	.2788	2.7612	.025
TPHOS	3.9673	2.5702	12.3263	.1074	56.8477	.0179
TPHOSD	.0458	.0117	.0563	.0238	.2139	.0057
DPO4	.0274	.0093	.0447	.0119	.2139	.0038
TOC	23.7148	10.8352	51.964	3.85	225.056	.3575
COD	80.6589	42.742	204.983	9.1254	942.047	1.5391
ALKIN	12.4518	7.5806	36.3552	3.8306	178.55	1.5629

Table 6-25 Patuxent River NPS Chemical Export (lbs/acre/yr) - Z Farm (Agricultural)

Variable	Mean	St. Error	St. Deviation	Median	Max.	Min.
BOD5	3.8553	1.4776	4.6727	2.0828	16.2457	.5247
BOD35	8.9934	3.1275	9.8901	6.155	34.9907	1.2242
TSS	270.736	100.486	333.275	89.42	781.042	5.369
NO2	--	--	--	--	--	--
NO3	--	--	--	--	--	--
NO2NO3	.3629	.0813	.2816	.3805	.9009	.0077
NH3	.2071	.0521	.1803	.2131	.6387	.0269
TKN	.8582	.1963	.68	.6363	1.7683	.0333
TKND	.3817	.0885	.3066	.3492	1.1177	.0333
TPHOS	.4027	.176	.6098	.0978	1.956	.0067
TPHOSD	.0188	.0095	.0327	.0108	.1217	.0034
DPO4	.0058	.0014	.0049	.0042	.0173	6.662E-4
TOC	10.0501	2.9365	10.1723	7.8711	34.3658	.3498
COD	37.3651	10.4192	36.0933	28.6813	121.843	2.6233
ALKIN	5.5466	.9337	3.0967	5.0107	10.8667	1.4798

Table 6-26 Patuxent River NPS Chemical Export (lbs/acre/yr) - G Farm (Agricultural)

Variable	Mean	St. Error	St. Deviation	Median	Max.	Min.
BOD5	19.481	14.9235	25.8482	9.2461	48.8794	.3176
BOD35	43.247	30.2241	52.3497	26.144	102.009	1.5878
TSS	47.1094	27.3295	47.336	44.6362	95.6336	1.0585
NO2	--	--	--	--	--	--
NO3	--	--	--	--	--	--
NO2NO3	2.3021	2.143	3.7118	.1594	6.5881	.1588
NH3	.7261	.5975	1.0348	.2551	1.9127	.0106
TKN	1.1723	.5465	.9465	1.4985	1.9127	.1059
TKND	1.1015	.5012	.8681	1.4985	1.7002	.1059
TPHOS	1.8386	1.5339	2.6568	.6058	4.8879	.0222
TPHOSD	1.0038	.7832	1.3565	.4464	2.5502	.0148
DPO4	.7764	.5885	1.0194	.3826	1.9339	.0127
TOC	49.657	41.2342	71.4198	15.3038	131.762	1.9053
COD	112.097	83.119	143.967	52.607	276.275	7.41
ALKIN	27.6958	21.3458	36.972	10.5214	70.1313	2.4346

Table 6-27
Relative Comparison Of Estimated Average Forested Watershed Chemical Export To Estimated Average Agricultural Watershed Export (On A Pound Per Acre Per Inch Of Rain Basis In The Patuxent River, 1980-1981, Using Data From Five Subwatersheds)

Variable	Ratio of average Agricultural To Average Forested Export (lb/acre/inch of rain)
BOD5	2.7
BOD30	2.3
TSS	5.2
NO2	0.3*
NO3	1.6
NO2NO3	4.2
NH3	3.2
TKN	3.0
TKND	1.8
TPHOS	6.8
TPHOSD	2.4
DPO4	2.5
TOC	2.5
COD	2.8
ALKLIN	3.6

*Suspect data due to holding time and analytical procedure used.

Table 6-28

Estimated Average Potential Watershed Chemical Export (Total Phosphorus) During Storm Events to the Patuxent River Basin

Land Use Activity	Estimated Acres In	Potential Load lb./yr.	Loading Rate lb/acre/yr	Source
Agricultural	205,743	532,813	2.5897	this study
Forested	272,738	104,131	0.3818	this study
Other (i.e. residential commercial, industrial, and idle)	58,843	37,574	1.180	*
All Activities	537,324	674,518	--	--

*Provided by Maryland Department of State Planning

Table 6-29

Estimated Average Potential Watershed Chemical Export During Storm Events to the Patuxent River Basin (Total Nitrogen)**

Land Use Activity	Estimated Acres In Basin*	Potential Load lb/yr.	Loading Rate lb/acre/yr	Source
Cropland and Pastureland	205,743	654,962	3.1834	this study
Forested	272,738	261,392	0.9584	this study
Other (i.e. residential, commercial, industrial, and idle)	58,843	328,287	5.57	*
All Activities	537,324	1,244,641		

*Provided by Maryland Department of State Planning.

**The total estimated loads developed from this agricultural sites are low due to limited storm samples at watersheds in the Piedmont Province, however, the loading rate reported here has been observed at other Agricultural sites in the Chesapeake Bay Region, reported by Bostater, et. al., 1981 and Anderson and Bosca, 1981.

***This rate may be as high as 5.758 lb/acre/yr (the upper standard deviation of the loading rate developed from the agricultural sites monitored in this study) or 1,184,668 lb/yr. This value assumes that the loading rates are independent for TKN and NO2NO3.

Table 6-30 Chemical Export Functions for the Patuxent River NPS Watershed (lbs/acre/in. of rain) versus (gallons of storm flow)

Dependent Variable	Selected Regression Equation	N	Correlation Coefficient (r)	Site
BOD5	lnY = (3.E-07)X - 2.9522	55	.357	All
	lnY = (3.E-07)X - 2.8626	41	.337	All Agricultural
	Y = (2.E-07)X + .02176	14	.728	Patuxent Park
	lnY = (2.E-06)X - 3.1998	11	.780	Deale A
	Y = (7.E-08)X - .02171	17	.887	Deale B
	lnY = .76257 (lnX) - 10.789	10	.528	Zepp
	Y = (6.E-06)X + .04174	3	.979	Grey
BOD30	lnY = (3.E-07)X - 2.0859	69	.375	All
	lnY = (3.E-07)X - 2.0657	49	.369	All Agricultural
	Y = (4.E-07)X + .03899	20	.815	Patuxent Park
	lnY = (2.E-06)X - 2.6145	15	.836	Deale A
	Y = (2.E-07)X - .09601	21	.875	Deale B
	lnY = .85391 (lnX) - 10.834	10	.607	Zepp
	Y = .00001X + .18778	3	.964	Grey
TSS	Y = .00003X - 5.731	78	.733	All
	Y = .00003X - 6.5295	55	.731	All Agricultural

Table 6-30 Chemical Export Functions for the Patuxent River NPS Watershed (lbs/acre/in. of rain) versus (gallons of storm flow)

Dependent Variable	Selected Regression Equation	N	Correlation Coefficient (r)	Site
TSS (cont.)	lnY = (5.E-06)X - 1.5457	23	.748	Patuxent Park
	lnY = 1.2068 (lnX) - 13.918	19	.603	Deale A
	Y = .00003X - 36.79	22	.858	Deale B
	Y = .00023X - 1.8529	11	.71	Zepp
	Y = (1.E-05)X + .43264	3	.873	Grey
NO2	lnY = .13124 (lnX) - 9.69	13	.179	All
	lnY = (3.E-07)X - 8.7357	8	.640	All Agricultural
	lnY = .13938 (lnX) - 8.9866	5	.352	Patuxent Park
	lnY = .00001X - 10.504	4	.755	Deale A
	Y = .00014 (lnX) - .0017	4	.993	Deale B
	--	--	--	Zepp
	--	--	--	Grey
NO3	Y = (3.E-09)X + .00214	13	.701	All
	Y = (3.E-09)X + .00235	8	.801	All Agricultural
	Y = -.00265 (lnX) + .03569	5	-.695	Patuxent Park
	lnY = -3.8529 (lnX) + 38.967	4	-.951	Deale A

Table 6-30 (cont.) Chemical Export Functions for the Patuxent River NPS Watershed (lbs/acre/in. of rain) versus (gallons of storm flow)

Dependent Variable	Selected Regression Equation	N	Correlation Coefficient (r)	Site
NO3 (cont.)	Y = .00436 (lnX) - .05486	4	.997	Deale B
	--	--	--	Zepp
	--	--	--	Grey
NO2NO3	lnY = .48625 (lnX) - 10.845	71	.554	All
	lnY = .43011 (lnX) - 9.7827	53	.628	All Agricultural
	lnY = 1.0681 (lnX) - 19.045	18	.649	Patuxent Park
	Y = (6.E-08)X - .00152	19	.844	Deale A
	Y = (9.E-09)X + .00556	19	.846	Deale B
	Y = .00365 (lnX) - .02797	12	.545	Zepp
	Y = (9.E-07)X - .00707	3	.999	Grey
NH3	lnY = (5.E-07)X - 6.6752	84	.436	All
	lnY = (5.E-07)X - 6.6998	61	.444	All Agricultural
	Y = (5.E-09)X + .00076	23	.367	Patuxent Park
	lnY = (3.E-06)X - 7.8874	23	.874	Deale A
	Y = (6.E-09)X - .0051	23	.915	Deale B
	lnY = .93108 (lnX) - 15.088	12	.868	Zepp

Table 6-30 (cont.) Chemical Export Functions for the Patuxent River NPS Watershed (lbs/acre/in. of rain) versus (gallons of storm flow)

Dependent Variable	Selected Regression Equation	N	Correlation Coefficient (r)	Site
NH3 (cont.)	Y = (2.E-07)X + .00022	3	.989	Grey
TKN	lnY = (5.E-07)X - 4.7114	83	.392	All
	lnY = (4.E-07)X - 4.6392	60	.387	All Agricultural
	lnY = (3.E-06)X - 5.6637	23	.637	Patuxent Park
	lnY = (3.E-06)X - 5.3651	22	.770	Deale A
	lnY = 1.1788 (lnX) - 20.867	23	.783	Deale B
	lnY = .93582 (lnX) - 13.777	12	.748	Zepp
	Y = (1.E-07)X + .01759	3	.653	Grey
TKND	lnY = (5.E-07)X - 5.4891	84	.451	All
	lnY = (4.E-07)X - 5.4809	61	.466	All Agricultural
	Y = (2.E-08)X + .00171	23	.577	Patuxent Park
	lnY = (2.E-06)X - 6.3666	23	.882	Deale A
	lnY = 1.0622 (lnX) - 19.914	23	.776	Deale B
	lnY = .77042 (lnX) - 12.778	12	.793	Zepp
	Y = (1.E-07)X + .01795	3	.571	Grey
TPHOS	Y = (1.E-07)X - .03027	83	.770	All

Table 6-30 (cont.) Chemical Export Functions for the Patuxent River NPS Watershed (lbs/acre/in. of rain) versus (gallons of storm flow)

Dependent Variable	Selected Regression Equation	N	Correlation Coefficient (r)	Site
TPHOS (cont.)	Y = (1.E-07)X - .03383	60	.767	All Agricultural
	lnY = (3.E-06)X - 6.7166	23	.635	Patuxent Park
	lnY = (3.E-06)X - 5.7125	22	.724	Deale A
	Y = (1.E-07)X - .1466	23	.856	Deale B
	lnY = .00005X - 7.6057	12	.667	Zepp
	Y = (6.E-07)X - .0001	3	.990	Grey
TPHOSD	lnY = .31702 (lnX) - 11.294	84	.421	All
	lnY = .26654 (lnX) - 10.583	61	.395	All Agricultural
	lnY = (4.E-06)X - 8.696	23	.700	Patuxent Park
	Y = (2.E-09)X - .00046	23	.821	Deale A
	lnY = .4171 (lnX) - 13.122	23	.413	Deale B
	lnY = .65913 (lnX) - 14.935	12	.682	Zepp
	Y = (3.E-07)X + .00169	3	.982	Grey
DPO4	lnY = .34565 (lnX) - 12.222	80	.433	All
	lnY = .30715 (lnX) - 11.689	58	.410	All Agricultural
	lnY = (3.E-06)X - 9.1087	22	.697	Patuxent Park
	Y = (9.E-10)X + .00043	20	.768	Deale A

Table 6-30 (cont.) Chemical Export Functions for the Patuxent River NPS Watershed (lbs/acre/in. of rain) versus (gallons of storm flow)

Dependent Variable	Selected Regression Equation	N	Correlation Coefficient (r)	Site
DPO4 (cont.)	lnY = .53622 (lnX) - 15.42	23	.511	Deale B
	lnY = .85183 (lnX) - 17.841	12	.823	Zepp
	Y = (2.E-07)X + .00187	3	.977	Grey
TOC	lnY = (5.E-07)X - 2.1753	83	.391	All
	lnY = (5.E-07)X - 2.1702	60	.394	All Agricultural
	lnY = (4.E-06)X - 3.0583	23	.697	Patuxent Park
	lnY = (2.E-06)X - 2.4383	22	.806	Deale A
	lnY = 1.3465 (lnX) - 20.875	23	.732	Deale B
	lnY = .92772 (lnX) - 11.368	12	.688	Zepp
	Y = .00002X + .00038	3	.992	Grey
COD	lnY = (5.E-07)X - .89732	83	.391	All
	Y = (2.E-06)X + .50577	60	.506	All Agricultural
	lnY = (3.E-06)X - 1.4778	23	.639	Patuxent Park
	lnY = (3.E-06)X - 1.5062	22	.848	Deale A
	Y = (2.E-06)X - 2.1004	23	.859	Deale B
	lnY = .93831 (lnX) - 10.053	12	.795	Zepp

Table 6-30 (cont.) Chemical Export Functions for the Patuxent River NPS Watershed (lbs/acre/in. of rain) versus (gallons of storm flow)

Dependent Variable	Selected Regression Equation	N	Correlation Coefficient (r)	Site
COD (cont.)	Y = .00003X + .31049	3	.982	Grey
ALKIN	lnY = (2.E-07)X - 2.6185	80	.238	All
	lnY = (2.E-07)X - 2.3907	57	.192	All Agricultural
	lnY = .36178 (lnX) - 7.4315	23	.337	Patuxent Park
	Y = (3.E-07)X + .00395	20	.657	Deale A
	lnY = (1.E-07)X - 2.3551	23	.193	Deale B
	lnY = .51506 (lnX) - 7.4363	11	.714	Zepp
	Y = (8.E-06)X + .04886	3	.990	Grey

(Lack of significance in the statistical regressions due to a small number of observations)

Table 6-31 Chemical Export Functions For The Patuxent River NPS Watershed

Dependent Variable lbs/acre	Independent Variable	Selected Regression Equation	N	Correlation Coefficient	Site
BOD5	TRF*MINT	Y = .24308X + .00222	42	.641	All
	TRF*MINT	Y = .24114X + .01327	29	.623	All Agricultural
	TRF	Y = .08393X - .01347	14	.477	Patuxent Park
	TRF*MINT	lnY = 1.1467(lnX) - 1.1123	7	.990	Deale A
	TRF*MINT	lnY = 1.0215X - 3.8631	12	.661	Deale B
	TRF	lnY = 2.3498(lnX) - 2.4648	10	.842	Z Farm
	TRF*MINT	lnY = -1.0778X - 1.3844	3	-.749	G Farm
BOD30	TRF*MINT	Y = .75861X - .11026	56	.628	All
	TRF*MINT	Y=.82614X - .15482	37	.640	All Agricultural
	TRF	Y = .24739X - .05038	20	.730	Patuxent Park
	TRF*MINT	Y = 1.7572X - .64265	11	.956	Deale A
	TRF*MINT	lnY = 1.0956X - 2.9529	16	.724	Deale B
	TRF	lnY = 2.3877(lnX) - 1.5513	10	.863	Z Farm
	TRF*MINT	lnY = -.82172X - .52474	3	-.700	G Farm
TSS	TRF*MINT	lnY = 1.2101(lnX) + 1.6717	64	.673	All
	TRF*MINT	lnY = 1.3715(lnX) + 1.9492	42	.677	All Agricultural
	TRF*MINT	lnY = .72998(lnX) + .63655	22	.651	Patuxent Park
	TRF*MINT	lnY = 1.5523(lnX) + 2.6080	14	.755	Deale A
	TRF*MINT	lnY = 2.0392(lnX) + 2.3095	17	.846	Deale B
	TRF*MINT	Y = 9.2200X + .71646	8	.922	Z Farm
	TRF*MINT	lnY = -1.0677X - .24511	3	-.848	G Farm
NO2	TRF	Y = .00052X - .00013	13	.642	All
	TRF	Y = .00046X - .00029	8	.870	All Agricultural
	TRF	Y = .00080(lnX) + .00082	5	.963	Patuxent Park
	TRF*AVINT	lnY = -.09669(lnX) - 8.5432	4	-.776	Deale A
	TRF	Y = .00058X - .00044	4	.994	Deale B
	--	--	--	--	Z Farm
	--	--	--	--	G Farm
NO3	TRF	Y = .00786X - .00492	13	.671	All
	TRF	Y = .01360X - .01106	8	.901	All Agricultural

Table 6-31 (continued) Chemical Export Functions For The Patuxent River NPS Watershed

Dependent Variable lbs/acre	Independent Variable	Selected Regression Equation	N	Correlation Coefficient	Site
NO3 (cont.)	TRF	Y = .00113X + .00131	5	.348	Patuxent Park
	TRF*AVINT	Y = .00178X + .00116	4	.978	Deale A
	TRF	Y = .01608X - .01421	4	.997	Deale B
	--	--	--	--	Z Farm
	--	--	--	--	G Farm
NO2NO3	TRF*MINT	Y = .02184X + .00471	57	.598	All
	TRF*MINT	lnY = .61518(lnX)-3.9753	40	.614	All Agricultural
	TRF	lnY = 1.3783(lnX) - 5.8168	18	.385	Patuxent Park
	TRF*MINT	Y = .03881X + .00207	14	.981	Deale A
	TRF	lnY = 1.5268(lnX) - 4.0187	19	.764	Deale B
	TRF	Y = .00607(lnX) + .00891	12	.504	Z Farm
	TRF	lnY = 1.5248(lnX) - 4.1078	3	.517	G Farm
NH3	TRF*MINT	Y = .01822X - .00351	70	.624	All
	TRF*MINT	Y = .02002X - .00429	48	.647	All Agricultural
	TRF*MINT	lnY = .32888(lnX) - 6.2421	22	.478	Patuxent Park
	TRF*MINT	Y = .04060X - .01216	18	.941	Deale A
	TRF	lnY = 2.2077(lnX) - 6.2210	23	.748	Deale B
	TRF	lnY = 2.5119(lnX) - 5.1573	12	.853	Z Farm
	TRF*MINT	lnY = 1.0650X - 4.8086	3	-.708	G Farm
TKN	TRF*MINT	Y = .10752X - .01784	69	.681	All
	TRF*MINT	Y = .11749X - .02139	47	.704	All Agricultural
	TRF	lnY = 1.4593(lnX) - 4.5314	23	.540	Patuxent Park
	TRF*MINT	Y = .22115X - .04147	17	.947	Deale A
	TRF	lnY = 2.1806(lnX) - 4.2009	23	.753	Deale B
	TRF	Y = .04928X - .01803	12	.885	Z Farm
	TRF*MINT	lnY = -.58761X - 3.9515	3	-.781	G Farm
TKND	TRF*MINT	Y = .02313X - .00121	70	.636	All
	TRF*MINT	lnY = .73086(lnX) - 4.4958	48	.665	All Agricultural
	TRF*MINT	lnY = .37670(lnX) - 5.0597	22	.447	Patuxent Park
	TRF*MINT	Y = .05082X - .01258	18	.948	Deale A

Table 6-31 (continued) Chemical Export Functions For the Patuxent River NPS Watershed

Dependent Variable lbs/acre	Independent Variable	Selected Regression Equation	N	Correlation Coefficient	Site
TKND (cont.)	TRF	lnY = 1.9388(lnX) - 4.9229	23	.731	Deale B
	TRF	lnY = 2.1052(lnX) - 4.6177	12	.794	Z Farm
	TRF*MINT	lnY = -.56872X - 4.0106	3	-.797	G Farm
TPHOS	TRF*MINT	lnY = 1.0205(lnX) - 4.0850	69	.677	All
	TRF*MINT	lnY = 1.1744(lnX) - 3.7404	47	.713	All Agricultural
	TRF*MINT	lnY = .44016(lnX) - 5.4110	22	.520	Patuxent Park
	TRF*MINT	lnY = 1.3025(lnX) - 3.1467	17	.849	Deale A
	TRF*MINT	lnY = 1.5710(lnX) - 3.3919	18	.835	Deale B
	TRF*MINT	Y = .010821X + .00136	9	.860	Z Farm
	TRF*MINT	lnY = -1.1215X - 3.9010	3	-.717	G Farm
TPHOSD	TRF	lnY = 1.5466(lnX) - 7.2047	84	.588	All
	TRF	lnY = 1.5397(lnX) - 7.1145	61	.596	All Agricultural
	TRF	lnY = 1.5496(lnX) - 7.4481	23	.571	Patuxent Park
	TRF*MINT	Y = .00097X + .00054	18	.725	Deale A
	TRF*MINT	lnY = .79113(lnX) - 6.5464	18	.810	Deale B
	TRF	lnY = 2.2310(lnX) - 7.8421	12	.829	Z Farm
	TRF*MINT	lnY = -1.1026X - 4.3746	3	-.748	G Farm
DPO4	TRF	lnY = 1.5833(lnX) - 7.7703	80	.570	All
	TRF	lnY = 1.6161(lnX) - 7.6967	58	.571	All Agricultural
	TRF	lnY = 1.4579(lnX) - 7.9750	22	.574	Patuxent Park
	TRF	lnY = 1.8700X - 9.1833	20	.790	Deale A
	TRF	lnY = 1.7282(lnX) - 7.7975	23	.781	Deale B
	TRF	lnY = 3.0332X - 11.975	12	.791	Z Farm
	TRF*MINT	lnY = -1.0829X - 4.5902	3	-.756	G Farm
TOC	TRF	lnY = 2.3275(lnX) - 1.4739	83	.708	All
	TRF*MINT	lnY = .96847(lnX) - .76976	47	.726	All Agricultural
	TRF	lnY = 2.1491(lnX) - 1.6444	23	.738	Patuxent Park
	TRF*MINT	lnY = .91662(lnX) - .61795	17	.757	Deale A
	TRF*MINT	lnY = 1.3521(lnX) - .62983	18	.848	Deale B
	TRF	lnY = 3.3271(lnX) - 1.1532	12	.922	Z Farm

Table 6-31 (continued) Chemical Export Functions For The Patuxent River NPS Watershed

Dependent Variable lbs/acre	Independent Variable	Selected Regression Equation	N	Correlation Coefficient	Site
TOC (cont.)	TRF	lnY = 3.3271(lnX) - 1.1532	12	.922	Z Farm
	TRF*MINT	lnY = -.68747X - .69796	3	-.537	G Farm
COD	TRF*MINT	lnY = .84098(lnX) + .33409	69	.697	All
	TRF*MINT	lnY = .95148(lnX) + .44426	47	.726	All Agricultural
	TRF*AVINT	lnY = .52134(lnX) + .39093	22	.627	Patuxent Park
	TRF*MINT	Y = 8.0769X - 1.5326	17	.948	Deale A
	TRF*MINT	lnY = 1.2747(lnX) + .50591	18	.846	Deale B
	TRF	lnY = 2.9377(lnX) + .11547	12	.906	Z Farm
	TRF*MINT	lnY = -.56333X + .28294	3	-.524	G Farm
ALKIN	TRF*MINT	Y = .11637X + .05514	66	.418	All
	TRF*MINT	Y = .12010X + .07627	44	.412	All Agricultural
	TRF	Y = .01544(lnX) + .05286	23	.252	Patuxent Park
	TRF*MINT	Y = .28957X - .05090	15	.951	Deale A
	TRF*MINT	lnY = .21470X - 2.4707	18	.233	Deale B
	TRF	lnY = 1.2839(lnX) - 2.0894	11	.718	Z Farm
	TRF*MINT	Y = -.19669X + .69341	3	-.432	G Farm

(Lack of significance in the statistical regressions due to a small number of observations)

Table 6-32 Chemical Export Functions For The Patuxent River NPS Watershed

Dependent Variable lbs/acre	Independent Variable	Selected Regression Equation	N	Correlation Coefficient	Site
BOD5	GAL./ACRE/IN.	lnY =.0006X - 4.1441	55	.621	All
	GAL./ACRE/IN.	lnY = 1.3667(lnX) - 12.661	41	.696	All Agricultural
	GAL.	Y = (2.E-07)X - .00385	18	.884	Patuxent Park
	GAL.	lnY = (3.E-06)X - 4.0740	18	.921	Deale A
	GAL.	Y = (9.E-08)X - .05884	19	.924	Deale B
	GAL.	lnY = 1.2827(lnX) - 16.517	12	.811	Z Farm
	GAL./ACRE/IN.	lnY = 1.5008(lnX) - 13.141	3	1.00	G Farm
BOD30	GAL.	lnY = .49981(lnX) - 8.566	89	.578	All
	GAL./ACRE/IN.	lnY = .00067(lnX) - 2.9505	49	.651	All Agricultural
	GAL.	Y = (6.E-07)X - .02458	26	.896	Patuxent Park
	GAL.	lnY = 1.2575(lnX) - 17.825	23	.901	Deale A
	GAL.	Y = (3.E-07)X - .16953	24	.914	Deale B
	GAL.	lnY = 1.2908(lnX) - 15.676	13	.856	Z Farm
	GAL./ACRE/IN.	lnY = 1.2239(lnX) - 10.051	3	.999	G Farm
TSS	GAL.	Y = .00004X - 8.2281	104	.776	All
	GAL.	Y = .00004X - 9.3579	74	.776	All Agricultural
	GAL.	lnY = (8.E-06)X - 2.7833	30	.809	Patuxent Park
	GAL./ACRE/IN.	Y = .01366X - 7.7950	19	.751	Deale A
	GAL.	Y = .00004X - 40.472	27	.850	Deale B
	GAL.	Y = .00052X - 8.4557	16	.896	Z Farm
	GAL./ACRE/IN.	Y = .00030X - .02976	3	1.00	G Farm
NO2	GAL./ACRE/IN.	lnY = .93662(lnX) - 14.108	13	.848	All
	GAL.	Y = (3.E-10)X + .00007	12	.971	All Agricultural
	GAL.	Y = (3.E-09)X - (6.E-11)	7	1.00	Patuxent Park
	GAL.	Y = (1.E-09)X - (3.E-11)	5	1.00	Deale A
	GAL.	Y = (3.E-10)X + (6.E-11)	6	1.00	Deale B
	--	--	--	--	Z Farm
	--	--	--	--	G Farm
NO3	GAL.	Y = 8.E-09X + .00057	19	.929	All
	GAL.	Y = (8.E-09)X + .00083	12	.941	All Agricultural

Table 6-32 (continued) Chemical Export Functions For The Patuxent River NPS Watershed

Dependent Variable lbs/acre	Independent Variable	Selected Regression Equation	N	Correlation Coefficient	Site
NO3	GAL.	lnY = .92799(lnX) - 17.955	7	.883	Patuxent Park
	GAL./ACRE/IN.	lnY = -.00360X - 4.5753	4	-.899	Deale A
	GAL.	Y = (9.E-09)X - .00095	6	.997	Deale B
	--	--	--	--	Z Farm
	--	--	--	--	G Farm
NO2NO3	GAL.	lnY = .62996(lnX) - 13.124	92	.633	All
	GAL./ACRE/IN.	lnY = 1.5923(lnX) - 16.003	53	.822	All Agricultural
	GAL.	lnY = 1.4249(lnX) - 23.921	23	.817	Patuxent Park
	GAL.	Y = (8.E-08)X - .01224	28	.912	Deale A
	GAL.	Y = (1.E-08)X - .00349	22	.974	Deale B
	GAL./ACRE/IN.	Y = .00001X - .00311	12	.848	Z Farm
	GAL.	Y = (7.E-07)X - .00562	3	1.00	G Farm
NH3	GAL.	lnY = (8.E-07)X - 7.3989	111	.482	All
	GAL./ACRE/IN.	lnY = .00095X - 7.8615	61	.639	All Agricultural
	GAL.	lnY = .98464(lnX) - 18.798	30	.825	Patuxent Park
	GAL.	lnY = (4.E-06)X - 8.7631	33	.897	Deale A
	GAL.	lnY = 1.7289(lnX) - 30.74	28	.931	Deale B
	GAL.	lnY = 1.1943(lnX) - 18.115	17	.923	Z Farm
	GAL./ACRE/IN.	lnY = 1.5686(lnX) - 17.031	3	.999	G Farm
TKN	GAL.	lnY = .60674(lnX) - 12.463	110	.541	All
	GAL./ACRE/IN.	lnY = .00083X - 5.6940	60	.576	All Agricultural
	GAL.	lnY = 1.1877(lnX) - 19.537	30	.835	Patuxent Park
	GAL.	lnY = (4.E-06)X - 6.5818	32	.817	Deale A
	GAL.	lnY = 1.7023(lnX) - 28.375	28	.869	Deale B
	GAL.	lnY = 1.2550(lnX) - 17.463	17	.856	Z Farm
	GAL./ACRE/IN.	lnY = .78285(lnX) - 10.110	3	.998	G Farm

Table 6-32 Chemical Export Functions For The Patuxent River NPS Watershed

Dependent Variable lbs/acre	Independent Variable	Selected Regression Equation	N	Correlation Coefficient	Site
TKND	GAL./ACRE/IN.	lnY = .00056X - 6.4037	84	.537	All
	GAL./ACRE/IN.	lnY = 1.1280(lnX) - 13.204	61	.593	All Agricultural
	GAL.	lnY = .99771(lnX) - 17.792	30	.838	Patuxent Park
	GAL.	lnY = 1.3032(lnX) - 21.956	33	.872	Deale A
	GAL.	Y = (1.E-08)X - .00423	28	.931	Deale B
	GAL.	lnY = 1.1264(lnX) - 16.756	17	.923	Z Farm
	GAL./ACRE/IN.	Y = (5.E-06)X + .00335	3	.995	G Farm
TPHOS	GAL.	Y = (1.E-07)X - .04152	110	.802	All
	GAL.	Y = (2.E-07)X - .04713	80	.803	All Agricultural
	GAL.	lnY - 1.1372(lnX) - 19.959	30	.816	Patuxent Park
	GAL./ACRE/IN.	Y = .00006X - .04165	22	.845	Deale A
	GAL.	Y = (2.E-07)X - .16604	28	.849	Deale B
	GAL.	Y = (5.E-07)X - .00557	17	.882	Z Farm
	GAL./ACRE/IN.	lnY = 1.6311(lnX) - 16.625	3	1.00	G Farm
TPHOSD	GAL.	lnY = .57079(lnX) - 14.937	111	.611	All
	GAL.	lnY = .5054(lnX) - 14.119	81	.583	All Agricultural
	GAL.	lnY = (6.E-06)X - 9.5813	30	.828	Patuxent Park
	GAL.	Y = (3.E-09)X - .00002	33	.915	Deale A
	GAL.	lnY = 1.0173(lnX) - 21.848	28	.711	Deale B
	GAL.	lnY = .99942(lnX) - 18.930	17	.825	Z Farm
	GAL./ACRE/IN.	lnY = 1.5384(lnX) - 16.423	3	1.00	G Farm
DPO4	GAL.	lnY = .60420(lnX) - 15.900	103	.630	All
	GAL.	lnY = .53023(lnX) - 14.965	75	.589	All Agricultural
	GAL.	lnY = 1.2042(lnX) - 23.212	28	.895	Patuxent Park
	GAL.	Y = (2.E-09)X + .00004	29	.833	Deale A
	GAL.	lnY = 1.0101(lnX) - 22.296	28	.730	Deale B
	GAL.	lnY = 1.1644(lnX) - 21.367	15	.922	Z Farm

Table 6-32 (continued) Chemical Export Functions For The Patuxent River NPS Watershed

Dependent Variable lbs/acre	Independent Variable	Selected Regression Equation	N	Correlation Coefficient	Site
DPO4 (cont.)	GAL./ACRE/IN.	lnY = 1.4950(lnX) - 16.311	3	1.00	G Farm
TOC	GAL.	Y = (5.E-07)X + .11633	110	.551	All
	GAL./ACRE/IN.	Y = .00068X - .33952	60	.671	All Agricultural
	GAL.	lnY = 1.1034(lnX) - 15.759	30	.798	Patuxent Park
	GAL./ACRE/IN.	Y = .0008X - .64613	22	.840	Deale A
	GAL.	lnY = 1.6769(lnX) - 25.668	28	.791	Deale B
	GAL.	Y = .00001X - .14351	17	.886	Z Farm
	GAL./ACRE/IN.	lnY = .00064X - 2.9719	3	1.00	G Farm
COD	GAL.	Y = (3.E-06)X - .01555	110	.610	All
	GAL./ACRE/IN.	Y = .00315 - 1.9690	60	.630	All Agricultural
	GAL.	lnY = 1.1301(lnX) - 14.952	30	.842	Patuxent Park
	GAL.	lnY = 1.4937(lnX) - 19.479	32	.875	Deale A
	GAL.	Y = (3.E-06)X - 2.4707	28	.861	Deale B
	GAL.	Y = .00005X - .59603	17	.900	Z Farm
	GAL./ACRE/IN.	lnY = .00054X - 1.6115	3	1.00	G Farm
ALKIN	GAL.	lnY = .33765(lnX) - 7.0283	104	.507	All
	GAL./ACRE/IN.	Y = .00013X - .04032	57	.678	All Agricultural
	GAL.	lnY = .6558(lnX) - 11.254	29	.748	Patuxent Park
	GAL.	lnY = .90869(lnX) - 14.152	28	.825	Deale A
	GAL.	lnY = (4.E-07)X - 3.1325	28	.649	Deale B
	GAL.	lnY = .83640(lnX) - 11.115	16	.950	Z Farm
	GAL.	lnY = .00002X - 2.8504	3	1.00	G Farm

(Lack of significance in the statistical regressions due to a small number of observations)

Table 6-33
Patuxent River Chemical Export Functions Developed From Multiple Linear Regression

Dependent Variable (lbs/acre)	Multiple Linear Regression Equation*	Multiple R^2	N	Station
BOD5	Y= .111(X3)+1.039(X5)-.666E-1	.837	42	All
	Y= .122(X3)+1.046(X5)-.87E-1	.836	29	All Agricultural
	Y= .154E-1(X4)+.202E-1	.906	13	Patuxent Park
	Y= -.625(X2)+.57(X3)-.593E-2(X4)+.824(X5)-.333E-1	.998	7	Deale A
	Y= -.37(X1)-.52(X2)+.771(X3)+1.483(X5)+.222E-1	.991	12	Deale B
	Y= .289(X1)-.412(X3)+.33E-1(X4)-1.125(X5)+.155E-1	.977	7	Z Farm
	Y= -.625(X2)+.57(X3)-.593E-2(X4)+.824(X5)-.333E-1	.998	7	G Farm
NO2NO3	Y= .117E-1(X2)+.106E-3(X4)+.106(X5)-.126E-2	.920	52	All
	Y= .123E-1(X2)+.102E-3(X4)+.105(X5)-.585E-3	.920	35	All Agricultural
	Y= .137E-2(X4)+.215E-2	.353	17	Patuxent Park
	Y= .266E-1(X1)-.407E-1(X2)+.61E-1(X3)-.263E-3(X4)-.188E-1	.975	11	Deale A
	Y= -.502E-1(X1)-.605E-1(X2)+.902E-1(X3)+.485E-4(X4)+.176(X5)+.138E-1	.992	13	Deale B
	Y= .461E-1(X5)+.197E-2	.444	8	Z Farm
	Y= .266E-1(X1)-.407E-1(X2)+.61E-1(X3)-.263E-3(X4)-.188E-1	.975	11	G Farm
NH3	Y= .944E-2(X3)+.537E-4(X4)+.731E-1(X5)-.73E-2	.724	64	All
	Y= .109E-1(X3)+.547E-4(X4)+.734E-1(X5)-.965E-2	.728	42	All Agricultural
	Y= .393E-1(X5)-.203E-3	.301	22	Patuxent Park
	Y= .502E-2(X1)-.481E-3(X4)+.152(X5)-.503E-2	.994	14	Deale A
	Y= -.296E-2(X1)+.537E-2(X3)+.934E-4(X4)+.633E-1(X5)-.347E-2	.986	17	Deale B
	Y= -.49E-2(X3)+.281E-3(X4)+.631E-1(X5)-.981E-3	.919	8	Z Farm
	Y= .502E-2(X1)-.481E-3(X4)+.152(X5)-.503E-2	.994	14	G Farm
TPHOS	Y= .151E-1(X2)+.394E-2(X4)+.102(X5)-.164E-1	.954	64	All
	Y= .173E-1(X2)+.395E-2(X4)+.108(X5)-.23E-1	.954	42	All Agricultural
	Y= -.211E-2(X1)+.351E-2(X2)+.32E-2(X4)+.116E-2	.967	22	Patuxent Park
	Y= -.123E-1(X2)+.974E-1(X3)+.136E-2(X4)-.289E-1	.957	14	Deale A
	Y= -.81E-1(X1)+.103(X3)+.305E-2(X4)-.96(X5)-.453E-1	.976	17	Deale B

*Independent Variables:
X1=total rainfall X2=average intensities X3=maximum intensity X4=total suspended solids X5=alkalinity

Table 6-33 (continued)
Patuxent River Chemical Export Functions Developed From Multiple Linear Regression

Dependent Variable (lbs/acre)	Multiple Linear Regression Equation*	Multiple R^2	N	Station
TPHOS (cont.)	Y= .903E-2(X1)+.155E-1(X2)+.367E-1(X3)-.207E-2(X4)+.253E-1(X5)-.114E-1	.994	8	Z Farm
	Y= -.123E-1(X2)+.974E-1(X3)+.136E-2(X4)-.289E-1	.957	14	G Farm
TPHOSD	Y= .113E-2(X2)-.368E-2(X3)-.136E-4(X4)+.238E-1(X5)+.817E-3	.631	64	All
	Y= .116E-2(X2)-.398E-2(X3)-.133E-4(X4)+.241E-1(X5)+.997E-3	.638	42	All Agricultural
	Y= .147E-2(X2)-.978E-3(X3)+.661E-3(X4)+.153E-3	.834	22	Patuxent Park
	Y= .135E-2(X1)-.576E-3(X2)+.119E-2(X3)-.515E-3	.664	14	Deale A
	Y= .206E-2(X3)+.145E-3	.411	17	Deale B
	Y= .528E-3(X1)+.325E-3(X2)-.919E-4(X3)+.678E-3(X5)-.251E-3	.948	8	Z Farm
	Y= .135E-2(X1)-.576E-3(X2)+.119E-2(X3)-.515E-3	.664	14	G Farm
DPO4	Y= .107E-2(x1)+.74E-3(X2)-.354E-2(X3)-.981E-5(X4)+.183E-1(X5)-.263E-4	.644	61	All
	Y= -.333E-2(X3)+.177E-1(X5)+.108E-2	.63	40	All Agricultural
	Y= .128E-2(X2)+.264E-3(X4)+.11E-1(X5)-.483E-3	.589	21	Patuxent Park
	Y= .105E-2(X1)-.233E-3(X2)+.12E-2(X5)-.2E-3	.649	12	Deale A
	Y= .411E-5(X4)+.69E-3	.088	17	Deale B
	Y= .56E-3(X1)+.268E-3(X2)+.188E-3(X3)-.243E-4(X4)-.283E-3	.937	8	Z Farm
	Y= .105E-2(X1)-.233E-3(X2)+.12E-2(X5)-.2E-3	.649	12	G Farm
TOC	Y= -.258(X1)+.268(X2)+.861(X3)+.787E-2(X4)+1.382(X5)-.557E-1	.706	64	All
	Y= -.465(X1)+.292(X2)+.974(X3)+.797E-2(X4)+1.354(X5)-.889E-2	.716	42	All Agricultural
	Y= .279(X1)-.157(X3)+.506E-1(X4)+1.2(X5)-.107	.747	22	Patuxent Park
	Y= -.225(X2)+1.616(X3)+.299E-1(X4)-1.167(X5)-.574	.956	14	Deale A
	Y= -.74(X1)-.435(X2)+3.214(X3)-.275E-2(X4)+7.293(X5)-.732	.972	17	Deale B
	Y= .635(X1)+.386(X2)-.727(X3)+.598E-1(X4)-.253	.964	8	Z Farm
	Y= -.225(X2)+1.616(X3)+.299E-1(X4)-1.167(X5)-.574	.956	14	G Farm
COD	Y= 2.849(X3)+.508E-1(X4)+11.652(X5)-1.485	.852	64	All
	Y= 3.218(X3)+.509E-1(X4)+11.646(X5)-2.013	.857	42	All Agricultural
	Y= .478(X1)+1.754(X2)-.967(X3)+.199(X4)+4.155(X5)-.188	.803	22	Patuxent Park
	Y= -.582(X2)+4.67(X3)+17.404(X5)-1.678	.981	14	Deale A
	Y= -.629(X1)-.367(X2)+2.683(X3)+.542E-1(X4)+10.(X5)-.803	.998	17	Deale B
	Y= 1.823(X1)-2.024(X3)+.2(X4)-3.683(X5)-.223	.981	8	Z Farm
	Y= -.582(X2)+4.67(X3)+17.404(X5)-1.678	.981	14	G Farm

Table 6-34
Patuxent River Chemical Export Functions Developed From Multiple Linear Regression

Dependent Variable (lbs/acre)	Multiple Linear Regression Equation	Multiple R^2	N	Station
BOD5	Y= 5.682(X7)+.907E-1(X1)-.165(X2)+1.102(X5)+4.851(X9)-.604E-1	.925	42	All
	Y= 6.74(X7)+.108(X1)-.178(X2)+.966(X5)-.884E-1	.925	29	All Agricultural
	Y= -.312E-1(X2)+4.856(X4)+.222E-1	.901	30	Patuxent Park
	--	--	--	Deale A
	--	--	--	Deale B
	--	--	--	Z Farm
	--	--	--	G Farm
NO2NO3	Y= -.102E-1(X2)+.439E-1(X4)+.113(X5)+.199E-1(X6)+2.542(X9)+.526E-2	.967	42	All
	Y= -.631E-2(X3)+2.196(X8)-.106E-1(X1)-.176E-1(X2)+.494E-1(X4)+.163(X5)+.282E-2	.975	29	All Agricultural
	Y= -1.849(X8)+.179(X6)-.993E-3	.648	30	Patuxent Park
	--	--	--	Deale A
	--	--	--	Deale B
	--	--	--	Z Farm
	--	--	--	G Farm
NH3	Y= .169(X7)-1.232(X8)-.19E-1(X5)+.837E-1(X5)-.273E-2	.968	42	All
	Y= .189(X7)-3.391(X8)+.756E-1(X6)+2.996(X9)-32E-2	.97	29	All Agricultural
	Y = .234(X8)+.668E-3(X1)+.153E-2(X2)+.334E-3	.631	30	Patuxent Park
	--	--	--	Deale A
	--	--	--	Deale B
	--	--	--	Z Farm
	--	--	--	G Farm
TPHOS	Y= 15.088(X7)-33.409(X8)+.347(X2)-2.281(X5)-.941E-1	.845	42	All
	Y= 15.02(X7)-96.1(X8)+.466(X2)-2.258(X5)+33.38(X9)-.129	.886	29	All Agricultural
	Y= 2.429(X8)+.556E-1(X6)+1.334(X9)-.113E-2	.966	30	Patuxent Park
	--	--	--	Deale A
	--	--	--	Deale B

*Independent Variables:
X1=total rainfall X2=average intensity X3=maximum intensity X4=TPHOS X5=TKN X6=TKN X6=BOD5 X7=NO2NO3

Table 6-34 (continued)
Patuxent River Chemical Export Functions Developed From Multiple Linear Regression

Dependent Variable (lbs/acre)	Multiple Linear Regression Equation	Multiple R^2	N	Station
TPHOS (cont.)	--	--	--	Z Farm
	--	--	--	G Farm
TPHOSD	Y= .16E-2(X2)-.82E-3(X4)+1.312(X9)-.328E-4	.984	42	All
	Y= .183E-2(X2)-.103(X4)+1.321(X9)-.673E-4	.997	29	All Agricultural
	Y= .105E-2(X2)+.274(X4)-.456(X9)-.37E-4	.939	30	Patuxent Park
	--	--	--	Deale A
	--	--	--	Deale B
	--	--	--	Z Farm
	--	--	--	G Farm
DPO4	Y=.139E-1(X7)+.72(X8)-.869E-3(X2)-.267E-2(X5)-.354E-4	.985	42	All
	Y= .755-.139E-2(X2)+.783E-3(X4)+.572E-4	.997	29	All Agricultural
	Y= -.947(X8)+.207E-2(X2)+.333(X4)-.111E-3	.786	30	Patuxent Park
	--	--	--	Deale A
	--	--	--	Deale B
	--	--	--	Z Farm
	--	--	--	G Farm
TOC	Y= 87.36(X8)+.342(X1)+1.121(X2)+2.089(X4)+7.416(X5)-2.497(X6)-.242	.943	42	All
	Y= .345(X1)-1.434(X2)+1.85(X4)+6.873(X5)-2.303(X6)+111.29(X9)-.235	.952	29	All Agricultural
	Y= 124.3(X8)+.893E-1(X1)-.209(X2)-17.16(X4)+2.72(X5)+1.995(X6)-.556E-1	.974	30	Patuxent Park
	--	--	--	Deale A
	--	--	--	Deale B
	--	--	--	Z Farm
	--	--	--	G Farm
COD	Y= 51.45(X7)-.493.3(X8)+.716(X1)+10.29(X4)+12.9(X5)+5.333(X6)+445.7(X9)-.624	.978	42	All
	Y= 68.74(X7)-1897.7(X8)+1.043(X1)+2.099(X2)_8.559(X4)+13.79(X5)+3.983(X6)+2280.7(X9)-1.139	.988	29	All Agricultural
	Y= 154.7(X8)+1.50(X2)+88.2(X4)-11.03(X5)-170.1(X9)+.158E-1	.994	30	Patuxent Park

*Independent Variables:
X1=total rainfall X2=average intensities X3=maximum intensity X4=TPHOS X5=TKN X6=BOD5 X7=NO2NO3

Table 6-34 (continued)
Patuxent River Chemical Export Functions Developed From Multiple Linear Regression

Dependent Variable (lbs/acre)	Multiple Linear Regression Equation	Multiple R^2	N	Station
COD (cont.)	--	--	--	Deale A
	--	--	--	Deale B
	--	--	--	Z Farm
	--	--	--	G Farm
TKN	Y= 3.472(X7)+.415E-1(X3)-.586E-1(X1)+.878E-1(X2)-.215(X4)+.165(X6)-13.55(X9)+.162E-2	.959	42	All
	Y= 3.867(X7)+.509E-1(X3)-.83E-1(X1)+.883E-1(X2)-.219(X4)+.138(X6)-13.96(X9)+.516E-2	.972	29	All Agricultural
	Y= 1.242(X4)+.436E-2	.526	30	Patuxent Park
	--	--	--	Deale A
	--	--	--	Deale B
	--	--	--	Z Farm
	--	--	--	G Farm

Independent Variables:
X1=total rainfall X2=average intensity X3=maximum intensity X4=TPHOS X5=TKN X6=BOD5 X7=NO2NO3 X8=TPHOSD X9=DPO4

Table 6-35 Bulk Precipitation Quality At Patuxent River Park NPS Station From September 1980 Through November 1980

Storm Date	Volume (cm)	PH	TOC (mg/l)	$NO_3 + NO_2$ (mg/l)	TKN (mg/l)	T. Phosphorous (mg/l)
9/25/80	2.46	6.4	12.	0.35	3.1	0.40
10/18/80	4.80	4.9	16.	0.20	3.3	0.26
10/25/80	5.18	4.9	<2.	0.20	0.5	0.01
11/4/80	0.76	6.6	--	--	1.1	0.37
11/18/80	3.28	--	2.	0.95	0.7	0.04
11/25/80	1.73	5 5	10.	1.20	0.3	0.03
11/27/80	1.02	5.3	4.	0.70	0.1	0.01

(-) - no data

(<) - less than

Table6-36Bulk Precipitation Quality At Patuxent River Park
NPS Station From December 1980 Through February 1981

Storm Date	Volume (cm)	TOC (mg/l)	$NO_3 + NO_2$ (mg/l)	TKN (mg/l)	T. Phosphorous (mg/l)
2/2/81	2.06	3.	1.4	0.5	0.03
2/8/81	0.99	4.	1.0	0.2	0.03
2/11/81	1.96	<2.	0.45	<0.1	0.02
2/19-20/81	0.97	10.	1.0	0.2	0.06
2/21-23/81	2.87	<2.	0.60	0.3	0.01

(<) - less than

Table 6-37 Bulk Precipitation Quality At Patuxent River Park
NPS Station From March 1981 Through June 1981

Storm Date	Volume (cm)	pH	TOC (mg/l)	$NO_3 + NO_2$ (mg/l)	TKN (mg/l)	T. Phosphorous (mg/l)
3/5/81	1.22	5.3	4.	0.95	0.1	0.05
3/30/81	0.76	5.1	4.	2.9	1.5	0.28
4/1/81	1.62	4.7	<2.	0.65	2.4	0.37
4/5/81	1.82	N/A	<2.	0.90	0.6	0.06
4/9/81	0.44	N/A	6.	1.4	ISV	0.07
4/12-12/81	1.41	4.7	2.	0.75	0.8	ISV
4/23/81	1.49	4.6	10.	1.00	2.3	0.10
4/30-5/1/81	2.41	4.6	15.	1.35	6.8	0.49
5/11/81	2.51*	5.9	10.	0.85	3.8	0.27
5/15/81	1.92	5.9	6.	0.55	2.4	0.05
5/20/81	1.72	5.3	2.	0.50	1.1	0.05
5/28/81	3.23*	5.0	7.	0.55	3.6	0.59
6/2/81	1.90*	5.7	-	-	-	0.88
6/10/81	1.35	5.4	8.	1.1	3.0	0.27
6/13/81	2.72	5.0	2.	0.62	0.8	0.01
6/19/81	1.37*	3.5	4.	1.1	1.8	0.12

* Raingauge malfunction at Patuxent Park no data available.
Rainfall volume listed is average of volume recorded at Deale A and B stations.

N/A = Not Available

(<) = less than

(-) = no data

Table 6-38 Bulk Precipitation Quality At Patuxent River Park NPS Station From July 1981 Through August 1981

Storm Date	Volume (CM)	pH	TOC (mg/l)	$NO_3 + NO_2$ (mg/l)	TKN (mg/l)	Total Phosphorous (mg/l)
7-2-81	2.56	4.9	3.	0.30	0.45	0.03
7-4-81	3.20*	5.5	4.	0.10	1.8	0.28
7-13-81	1.19*	4.9	4.	0.95	3.6	0.26
7-25-81	1.32*	6.0	6.	1.6	1.2	0.17
7-28-81	1.40	4.3	6.	1.3	2.0	0.20

* Raingage malfunction at Patuxent River; no data available.
Rainfall volume listed is average of volume recorded at Deale A & B stations

APPENDIX F

LONGITUDINAL SLACK SURVEY FIGURES AND TABLES

SECTION 7

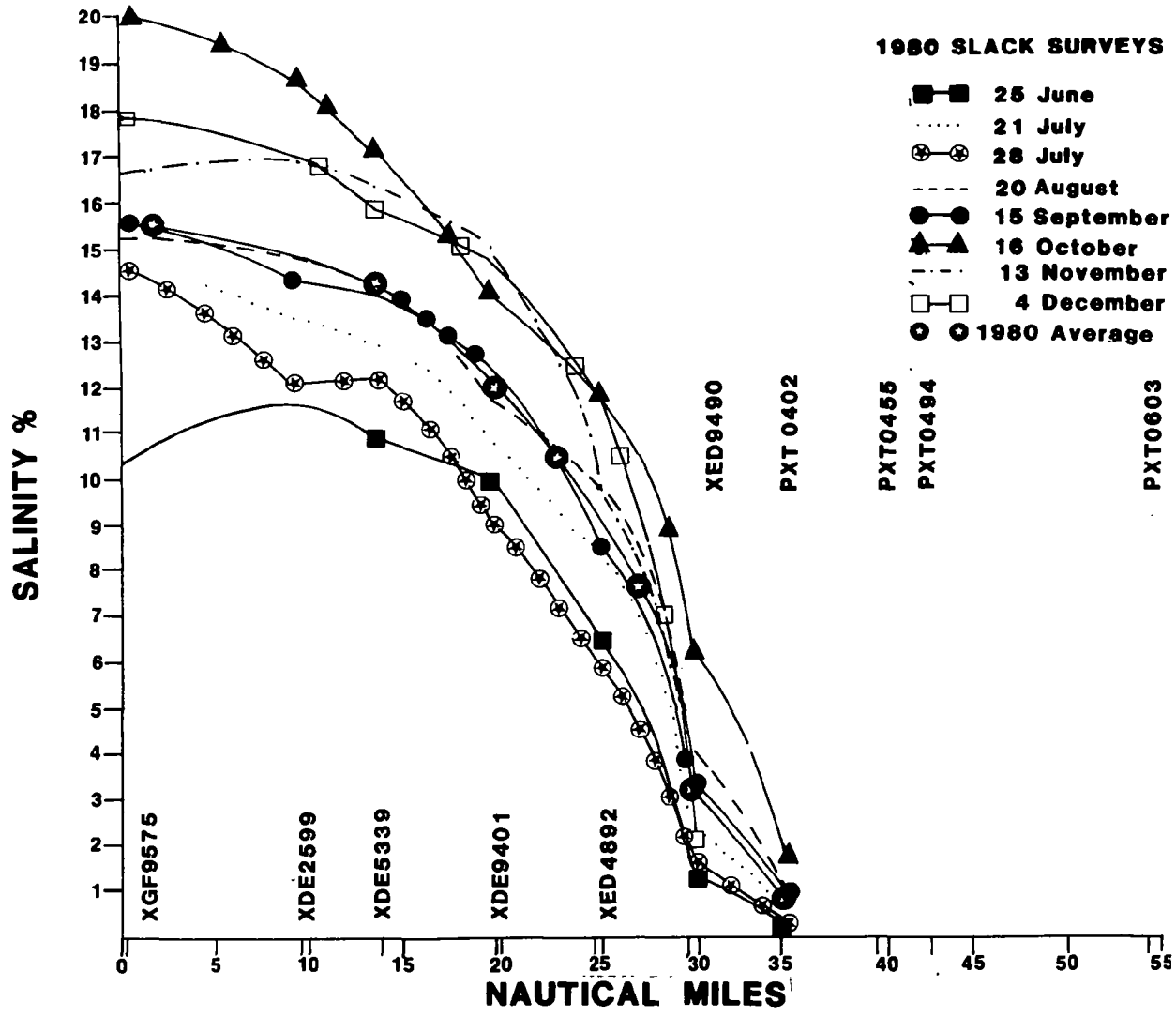


Figure 7-1 Patuxent River main channel station salinity (ppt) slack tide profiles for 1980. (depth averaged)

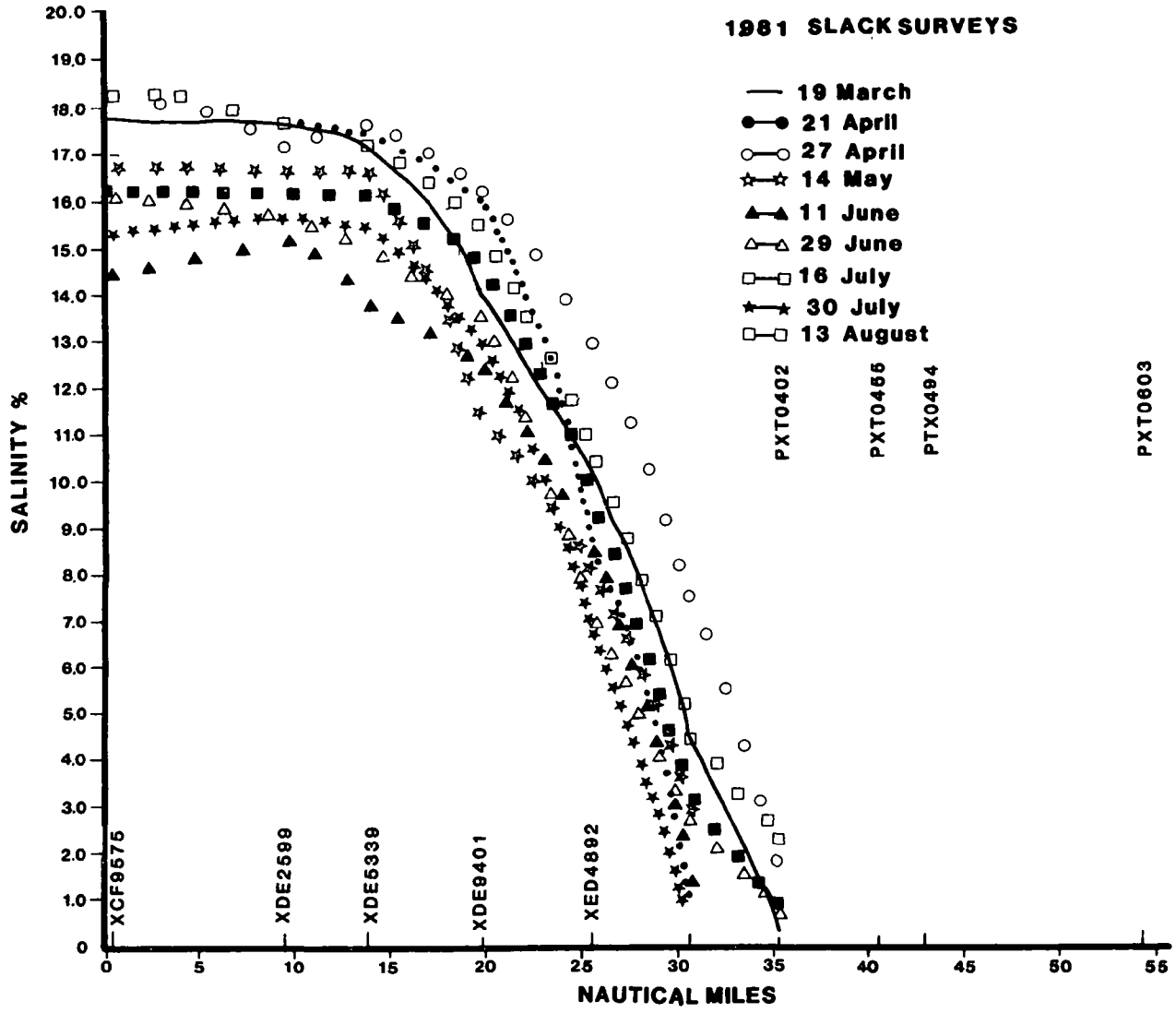


Figure 7-2 Patuxent River Main Channel Station Salinity (ppt) Slack Tide Profiles for 1981.

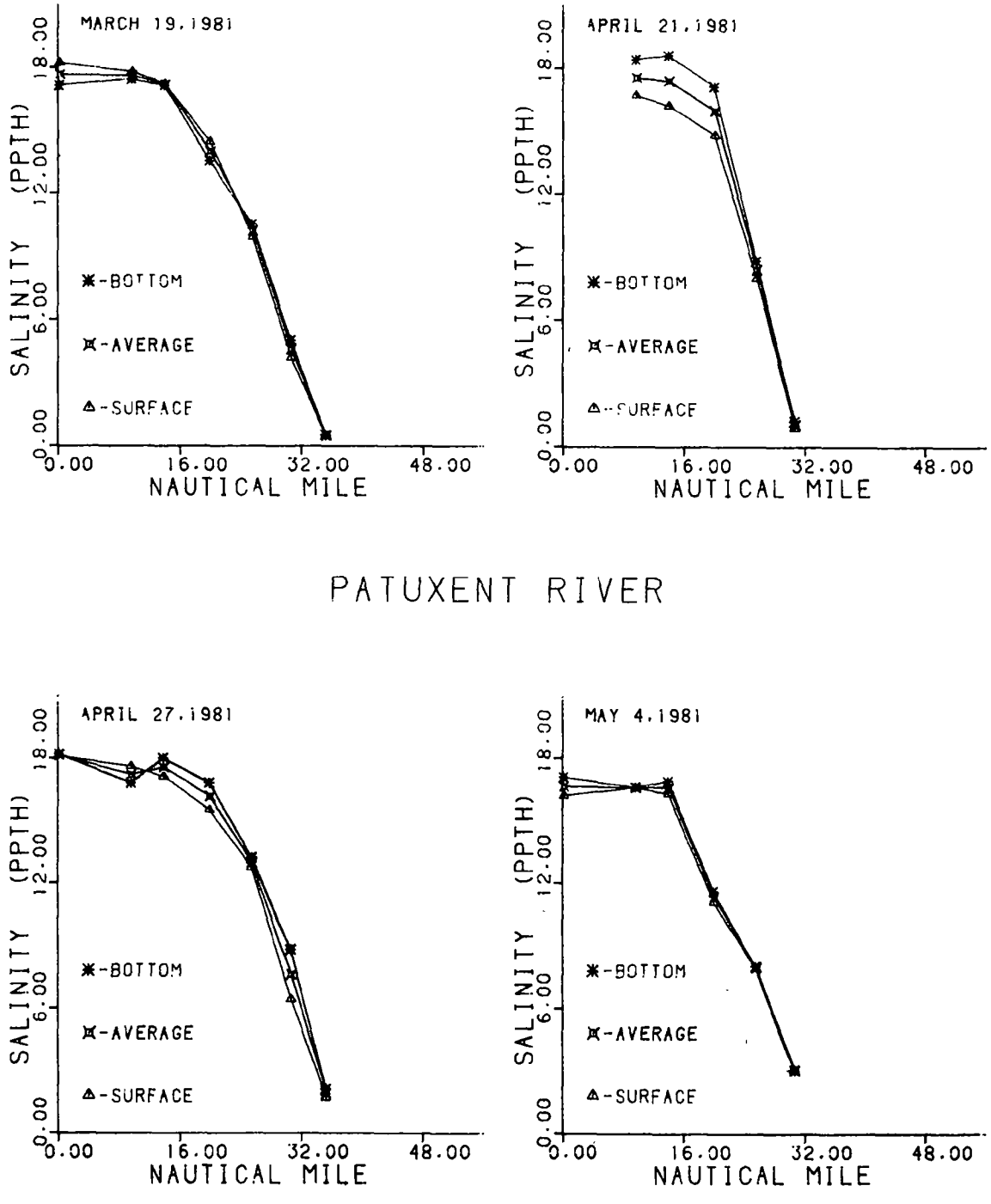


Figure 7-3 Patuxent River longitudinal slack survey plots of salinity (ppt).

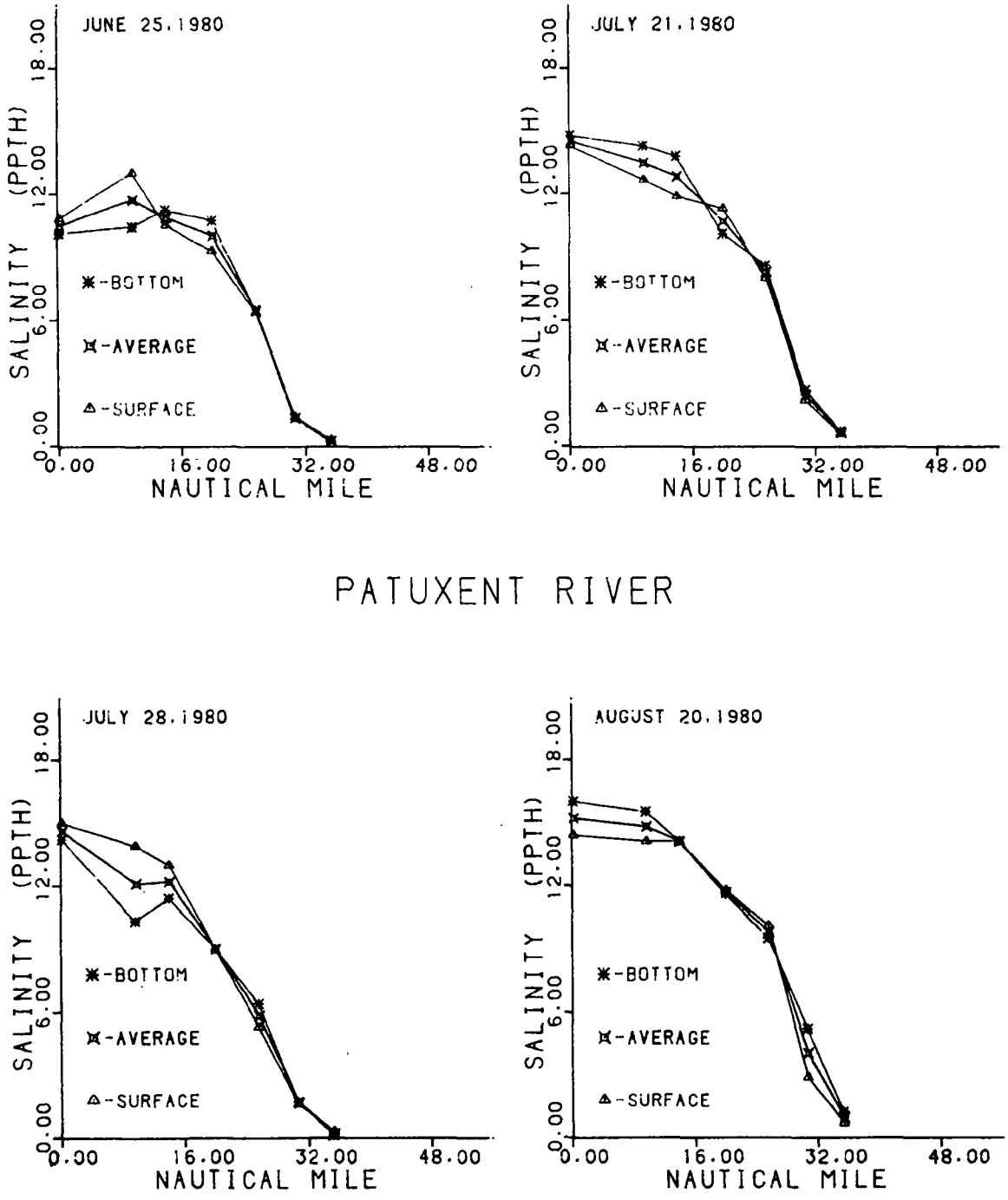
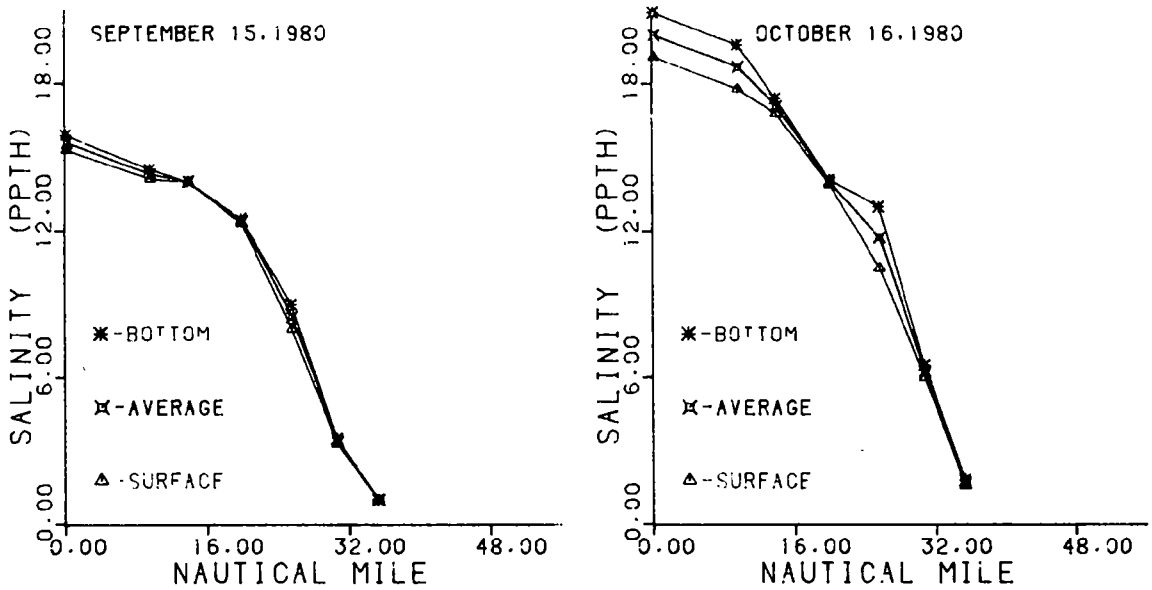


Figure 7-3 Patuxent River longitudinal slack survey plots of salinity (ppt).



PATUXENT RIVER

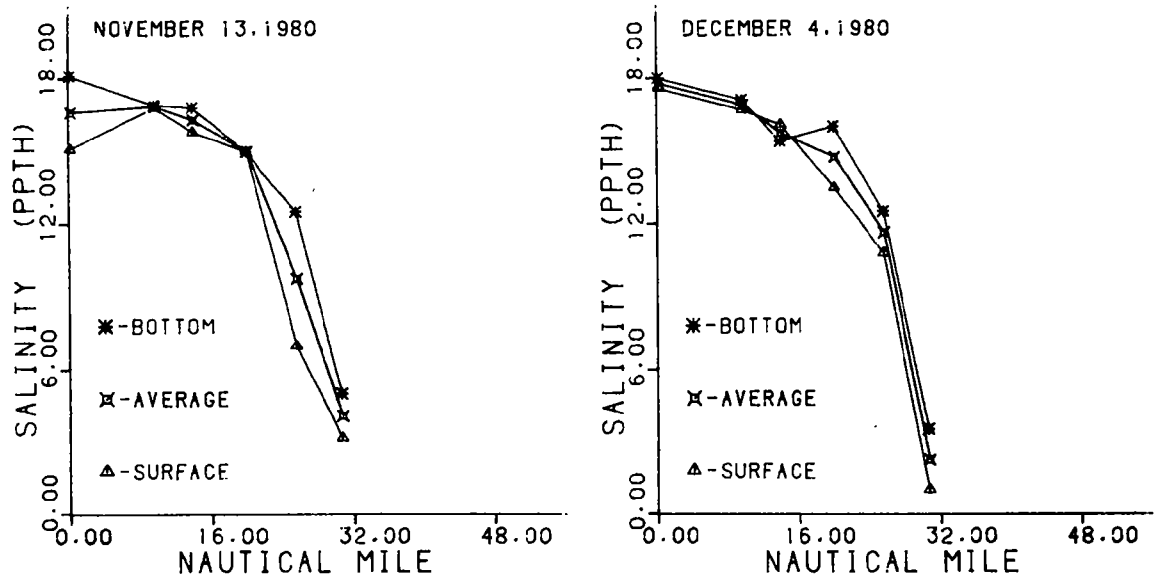


Figure 7-3 Patuxent River longitudinal slack survey plots of salinity (ppt).

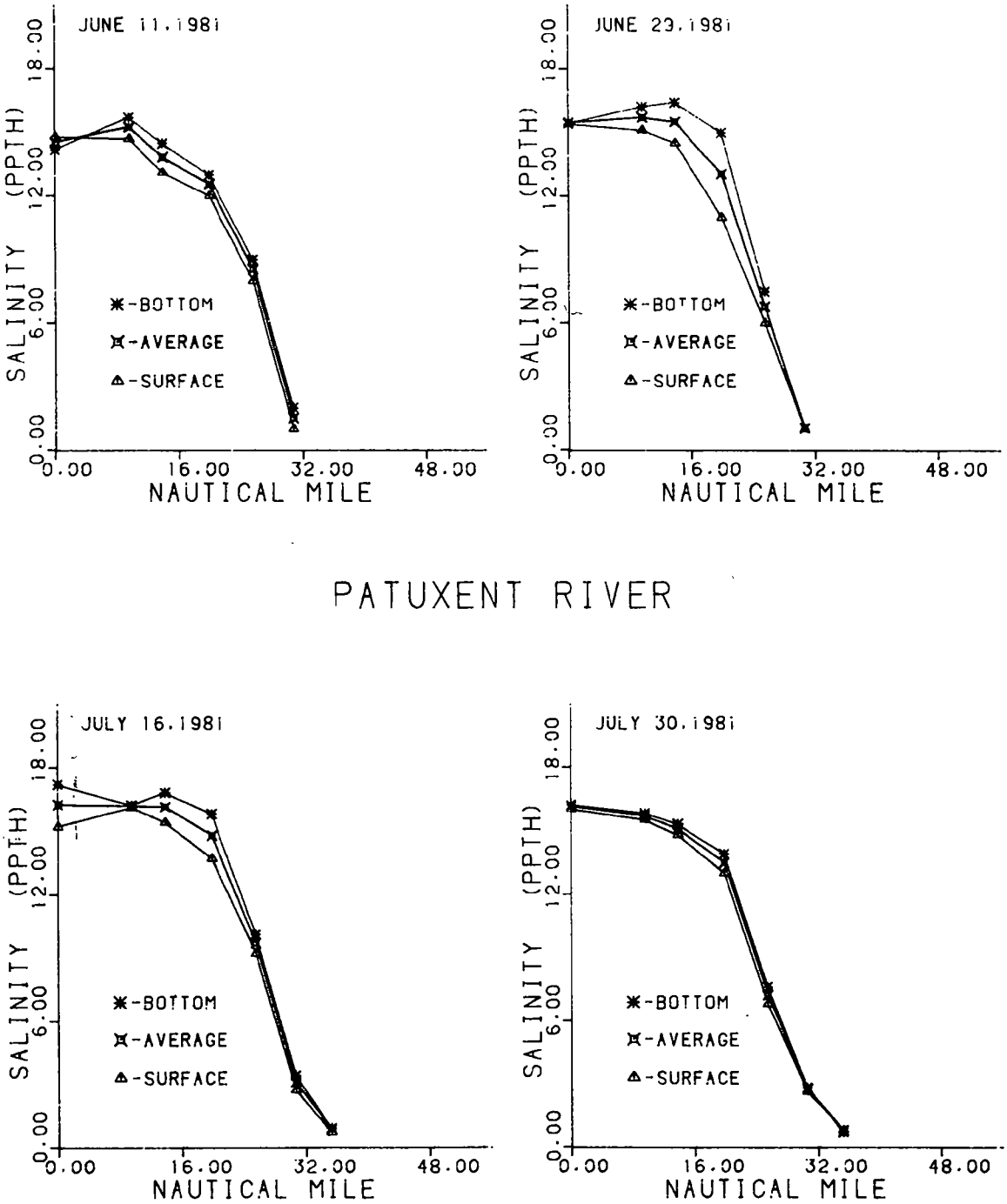
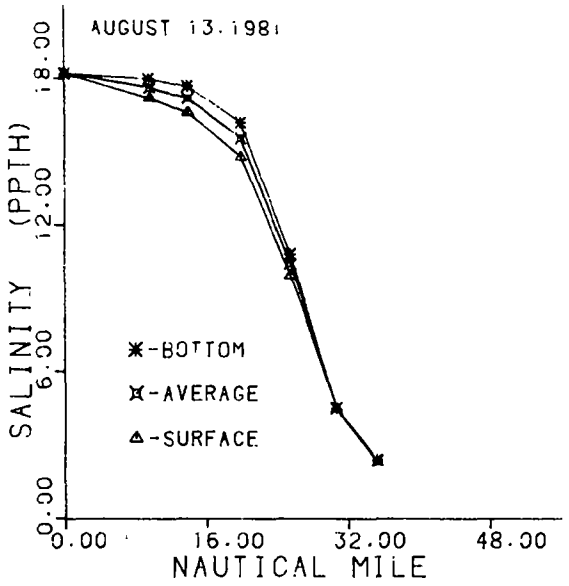
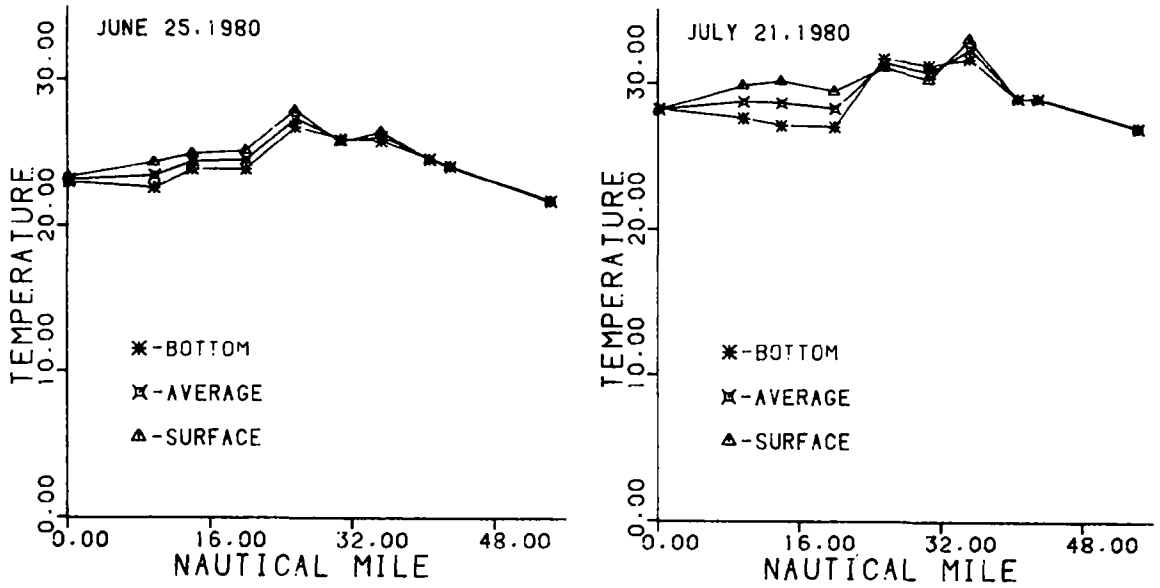


Figure 7-3 Patuxent River longitudinal slack survey plots of salinity (ppt).



PATUXENT RIVER

Figure 7-3 Patuxent River longitudinal slack survey plots of salinity (ppt).



PATUXENT RIVER

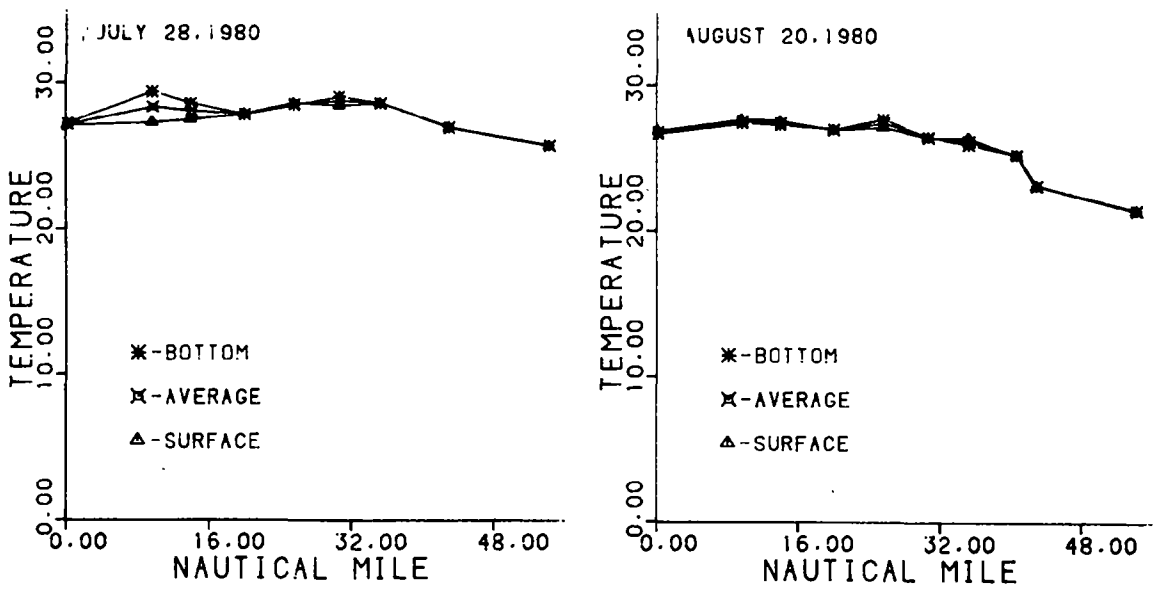
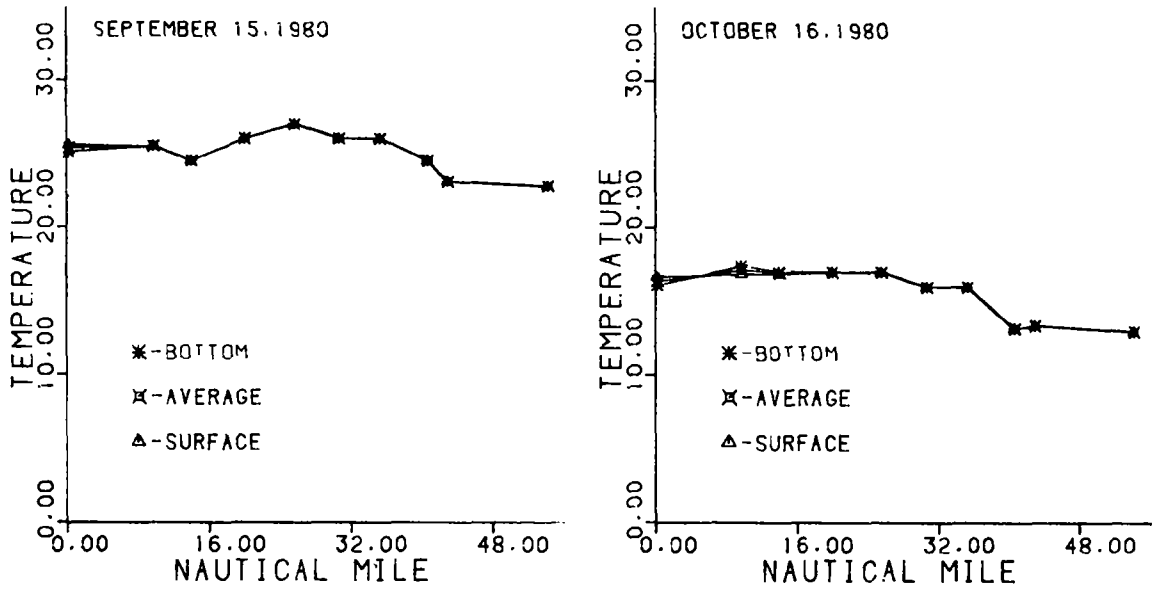


Figure 7-4 Patuxent River Slack Survey Plots of Temperature



PATUXENT RIVER

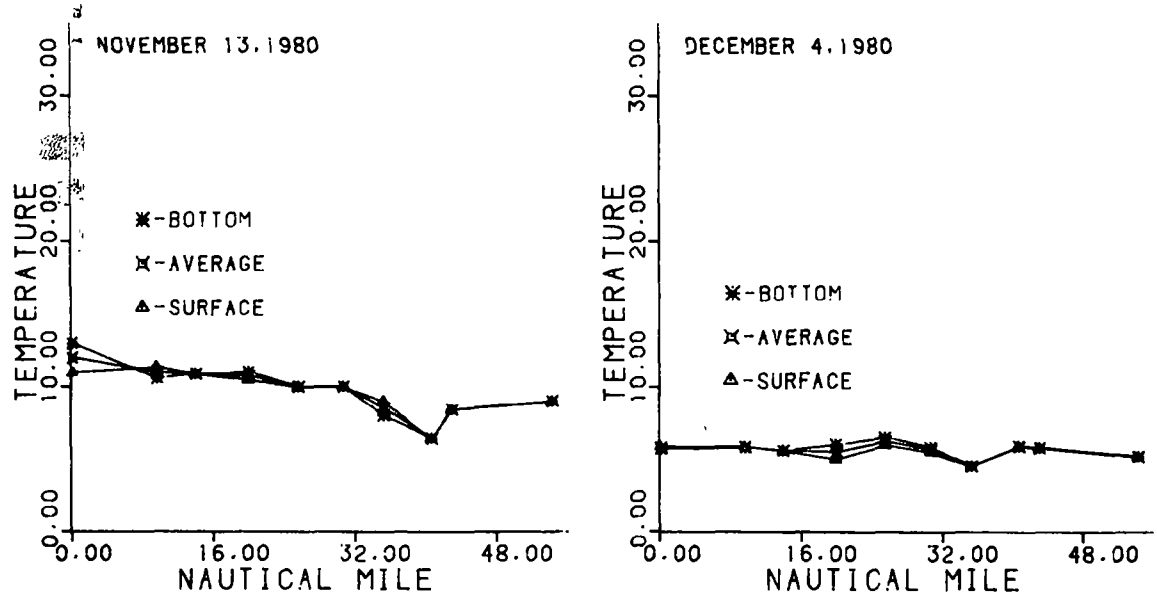


Figure 7-4 Patuxent River Slack Survey Plots of Temperature

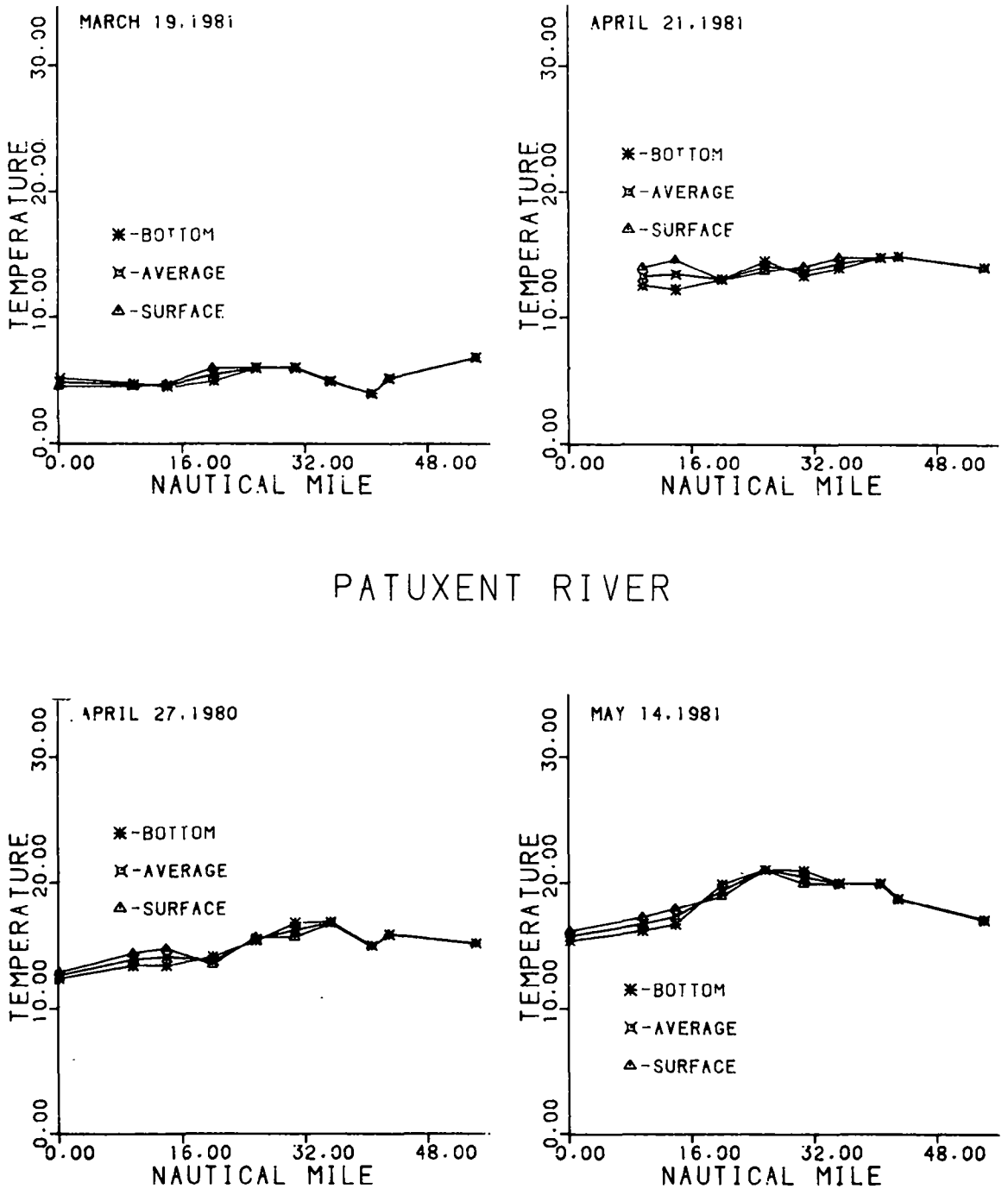
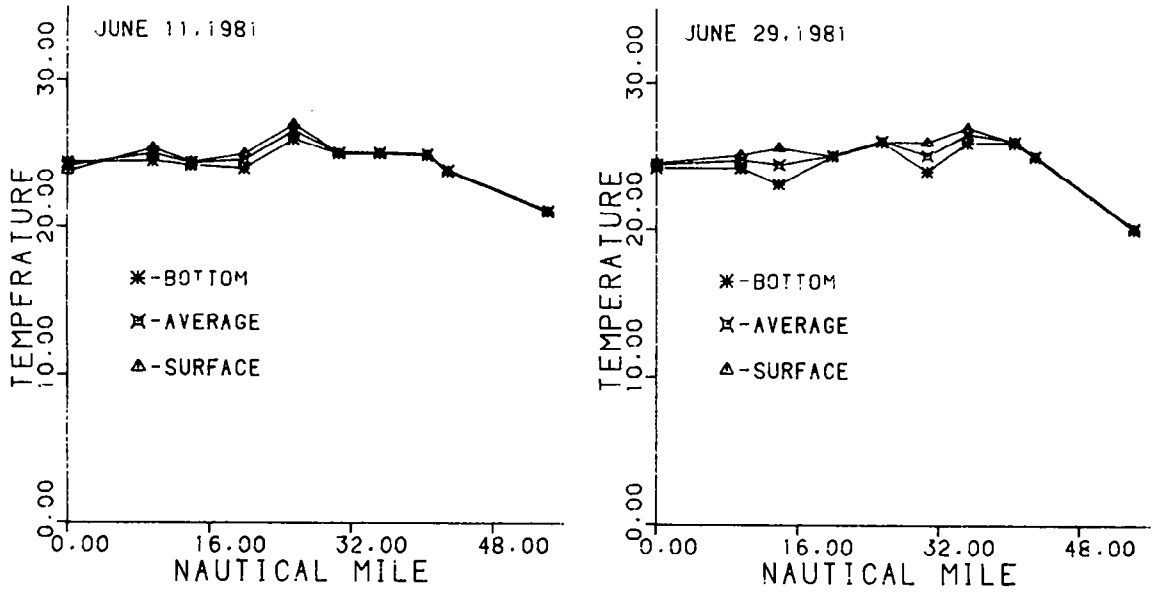


Figure 7-4 Patuxent River Slack Survey Plots of Temperature



PATUXENT RIVER

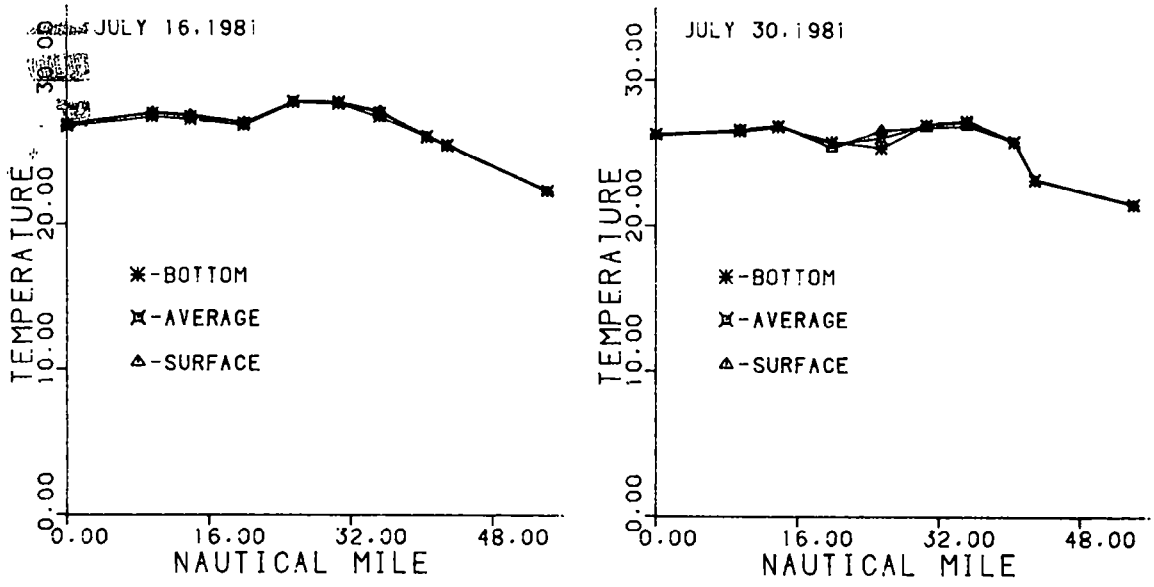
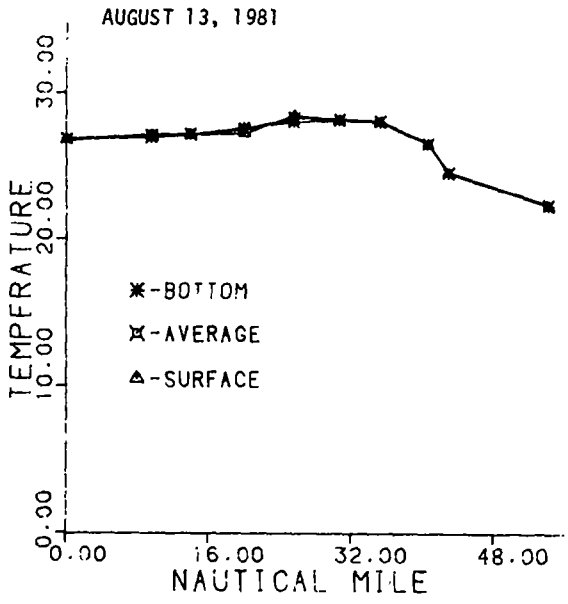
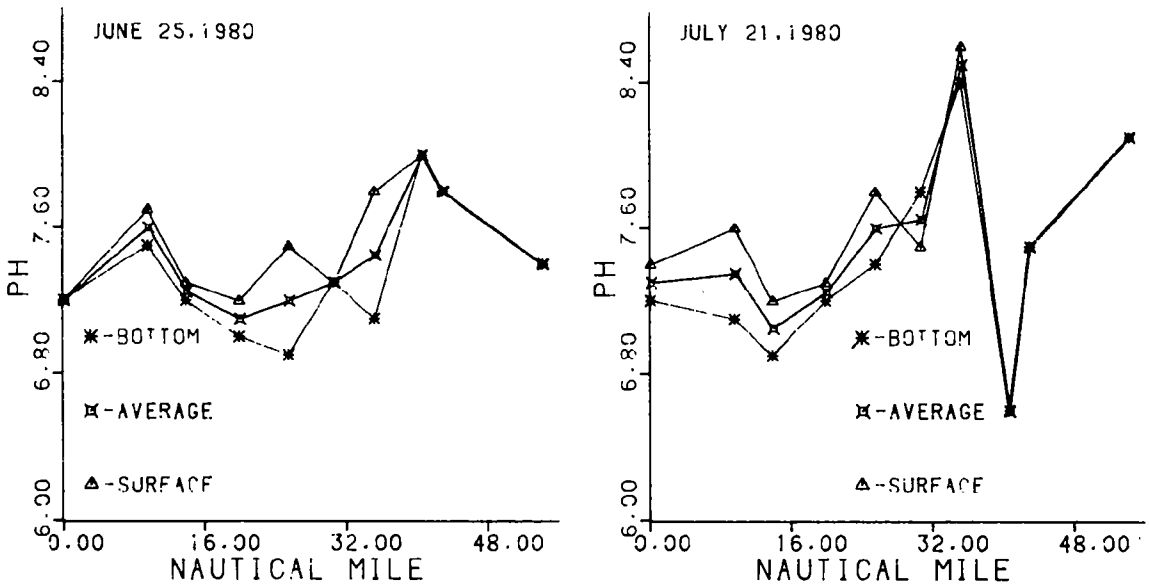


Figure 7-4 Patuxent River Slack Survey Plots of Temperature



PATUXENT RIVER

Figure 7-4 Patuxent River Slack Survey Plots of Temperature



PATUXENT RIVER

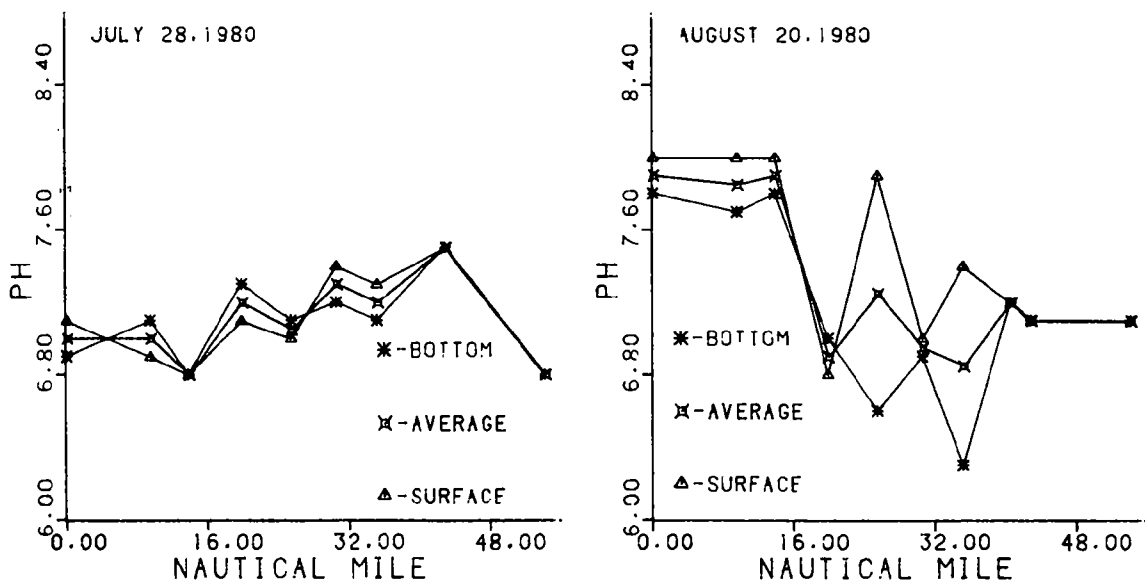
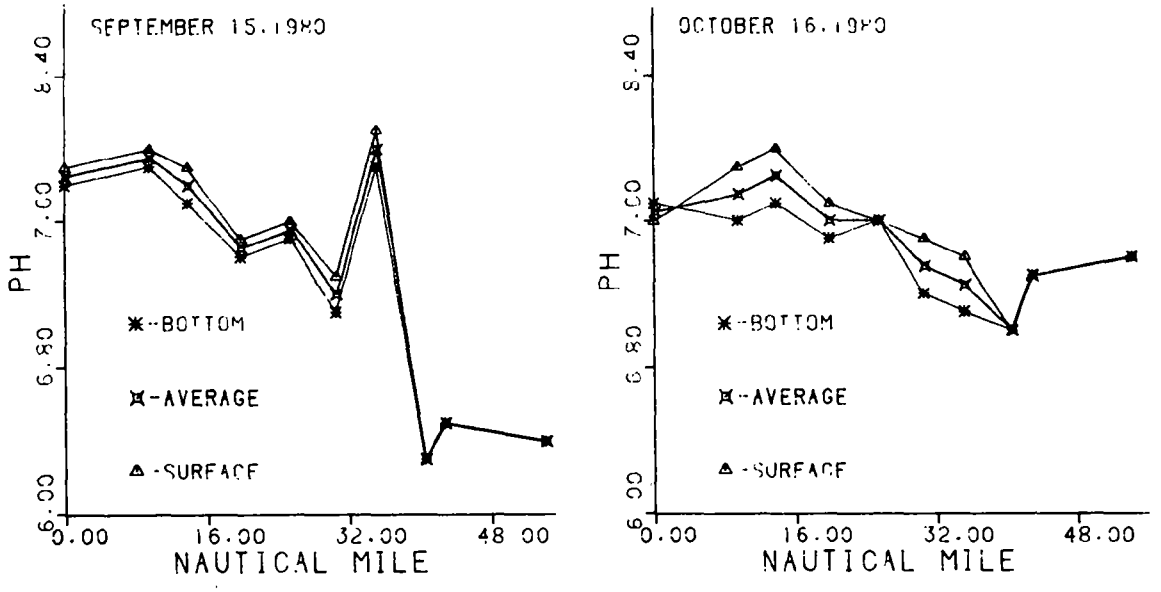


Figure 7-5 Patuxent river longitudinal plots of pH.



PATUXENT RIVER

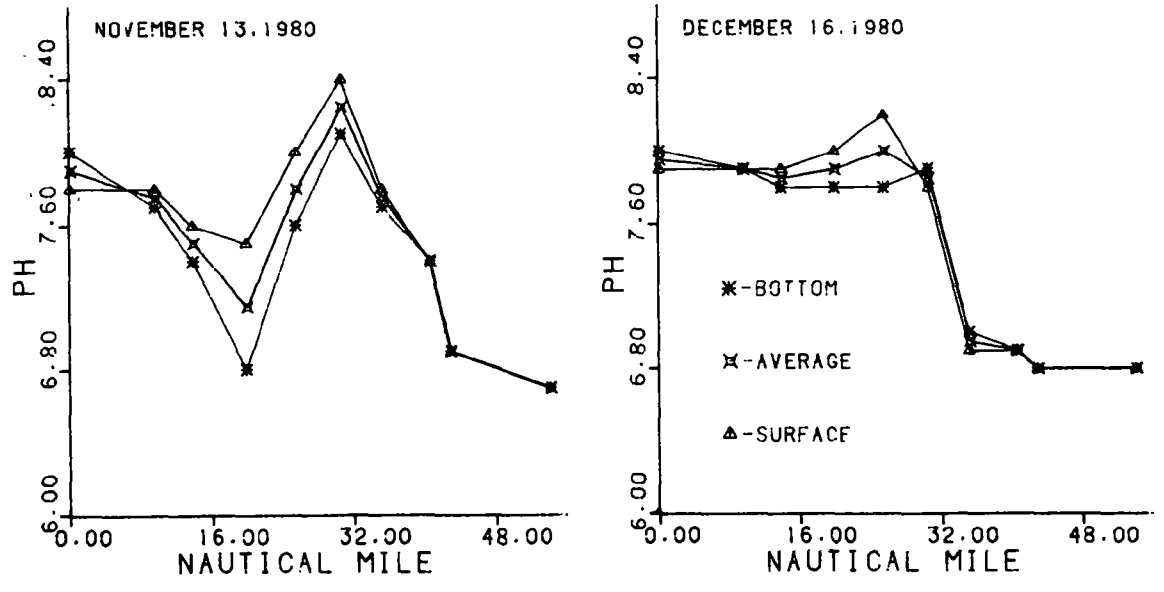


Figure 7-5 Patuxent river longitudinal plots of pH.

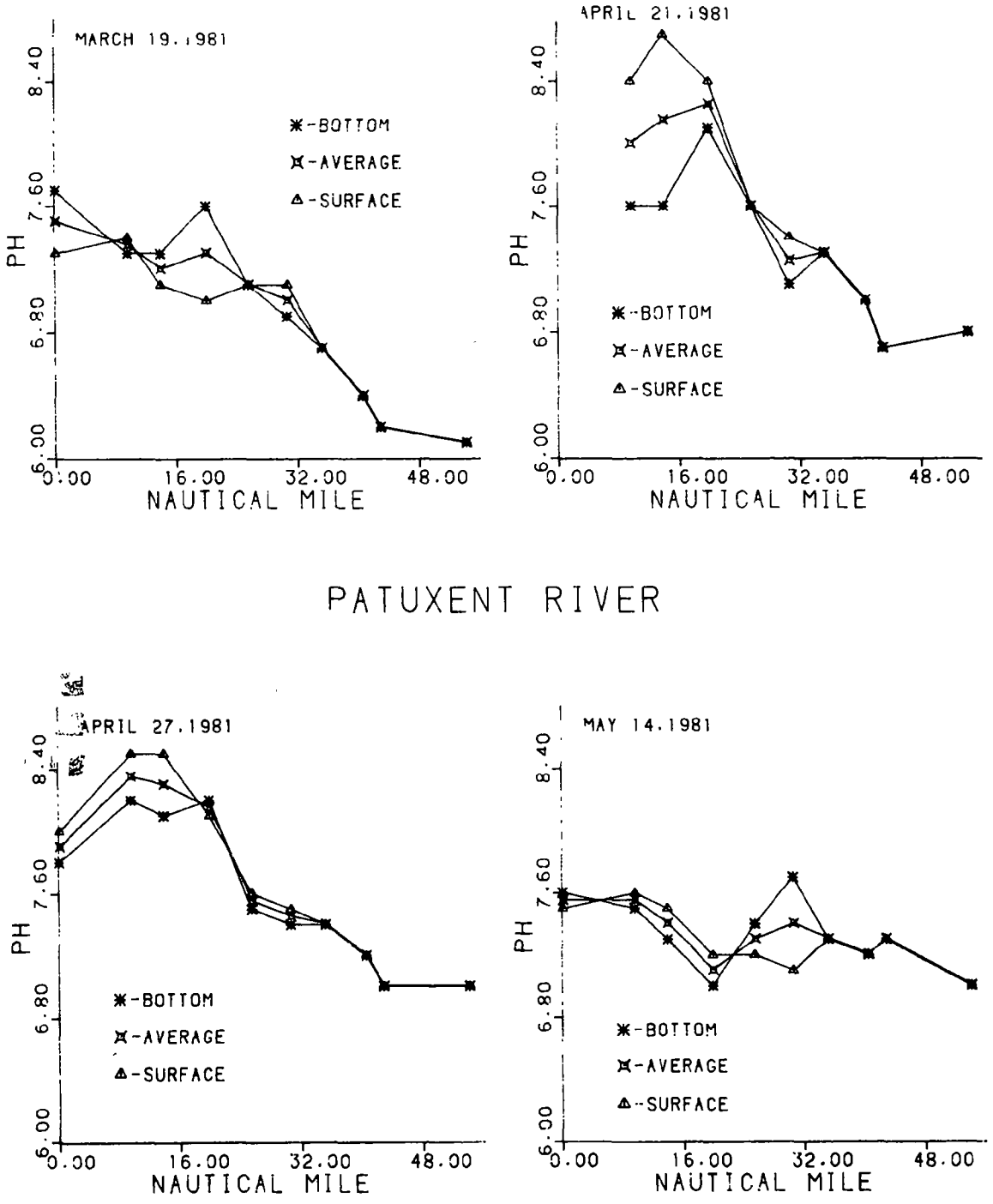


Figure 7-5 Patuxent river longitudinal plots of pH.

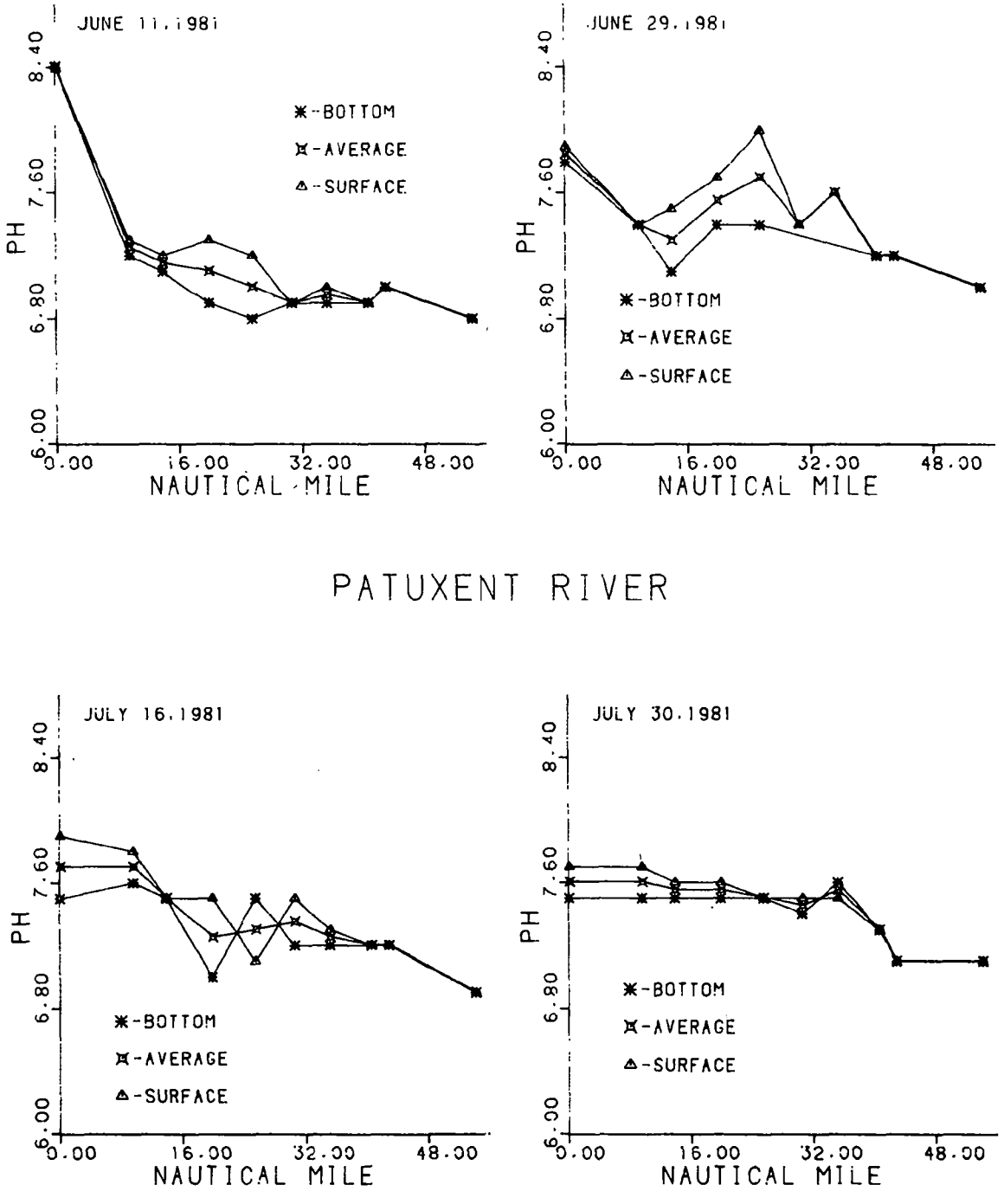
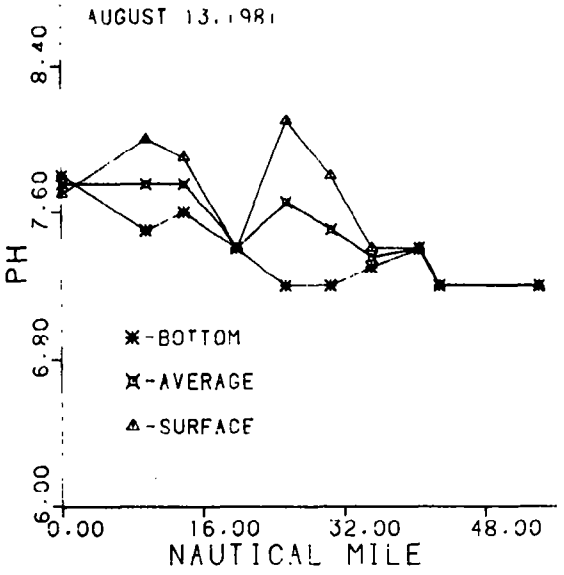
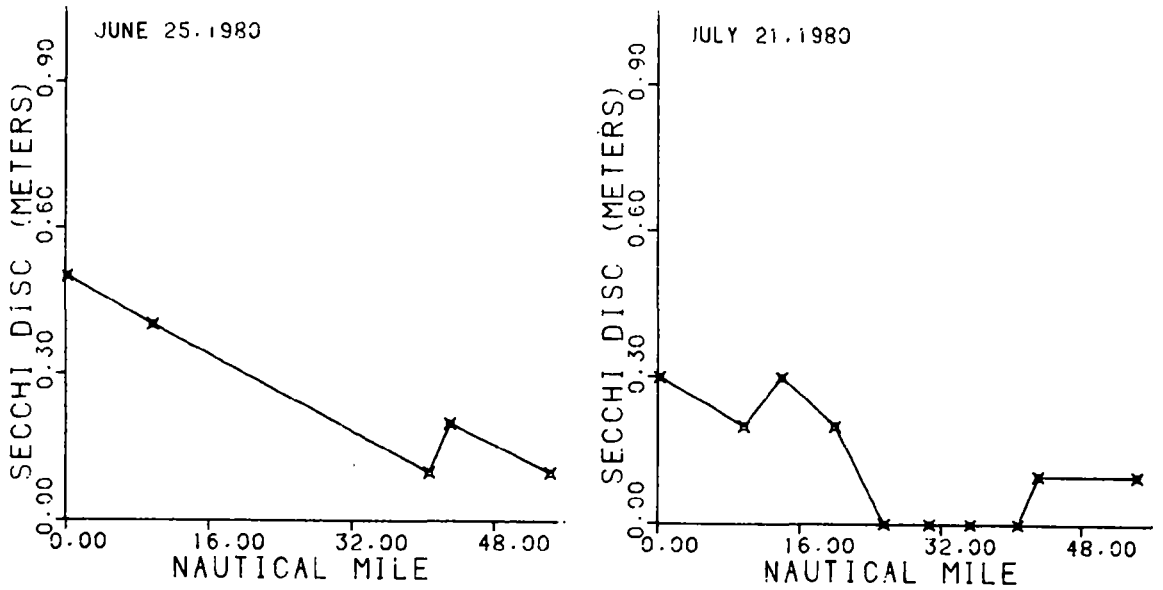


Figure 7-5 Patuxent river longitudinal plots of pH.



PATUXENT RIVER

Figure 7-5 Patuxent river longitudinal plots of pH.



PATUXENT RIVER

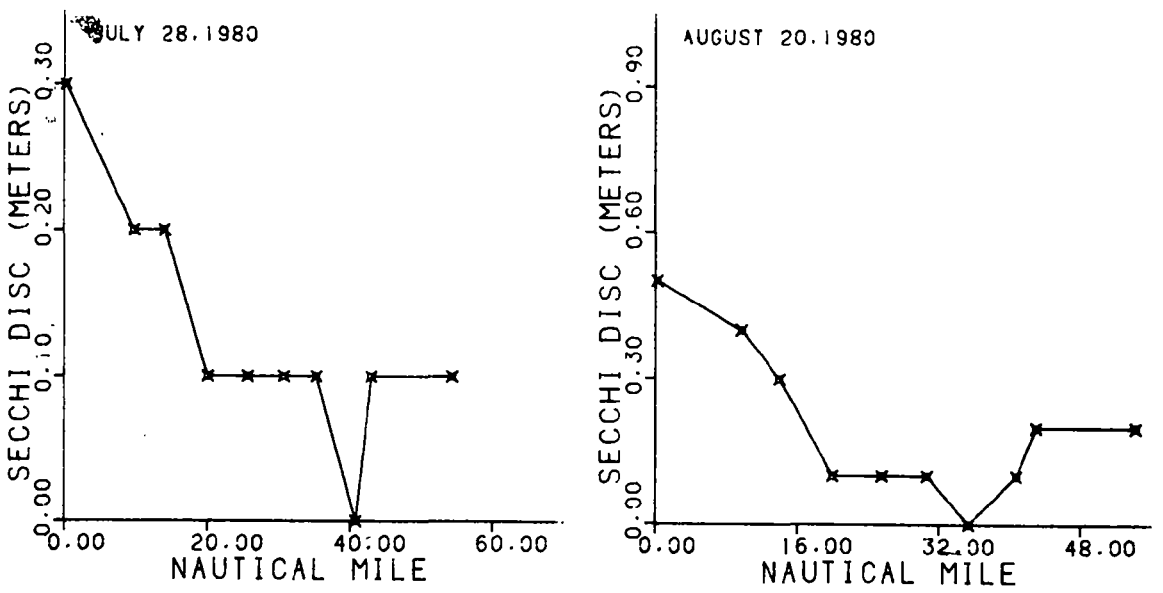


Figure 7-6 Patuxent River longitudinal slack survey plots of secchi disc (meters).

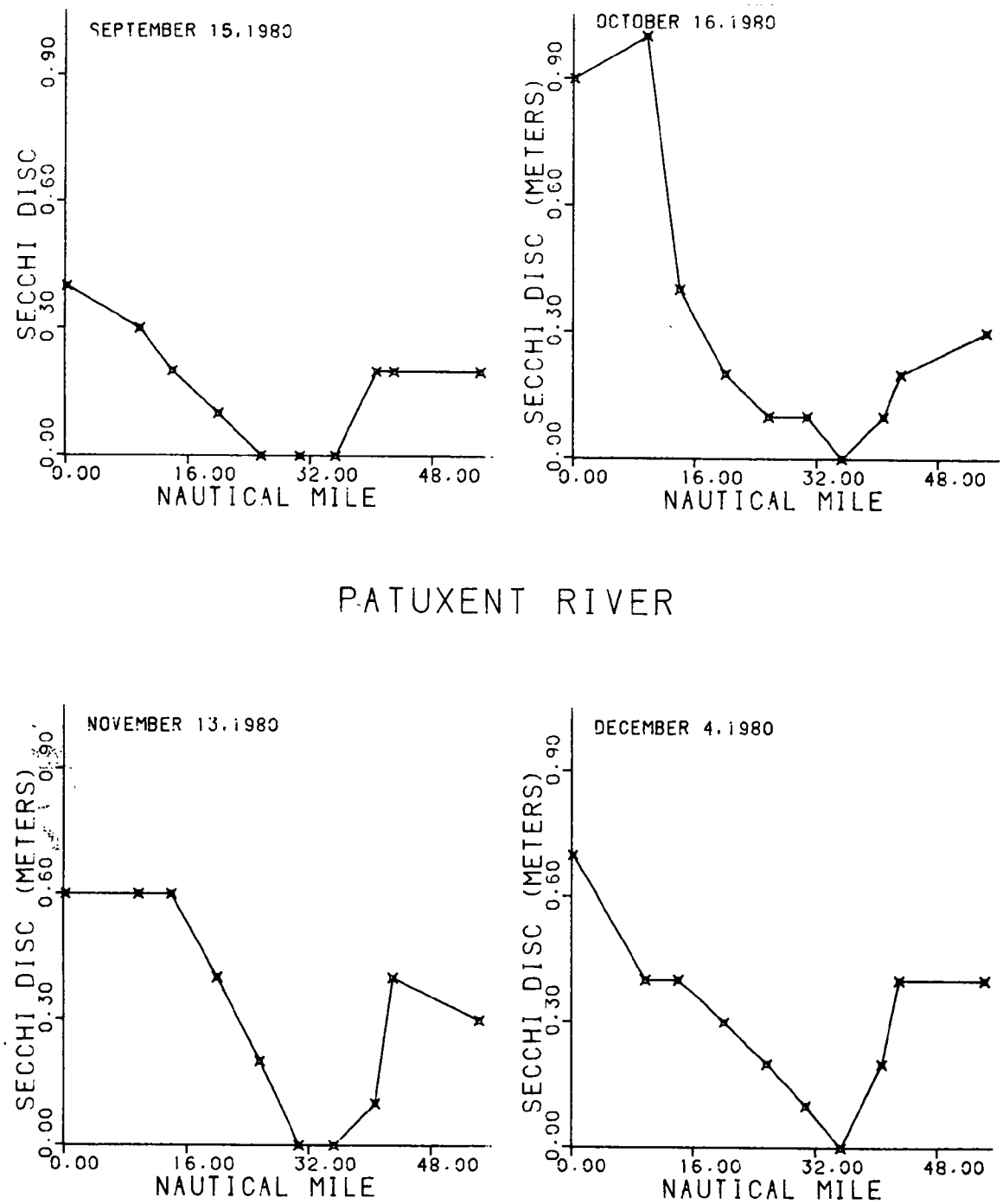
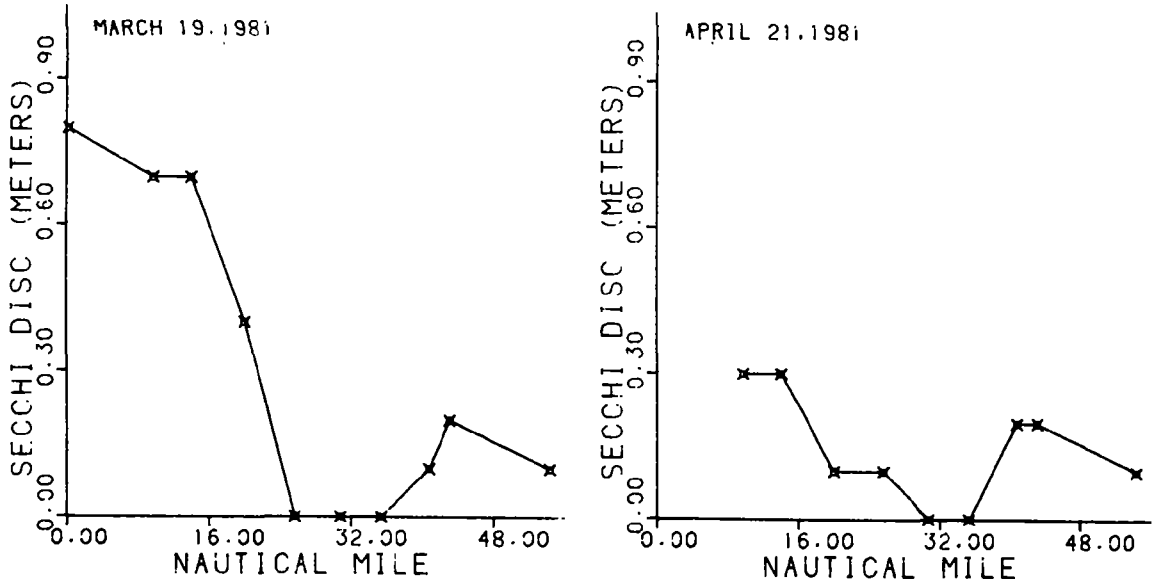


Figure 7-6 Patuxent River longitudinal slack survey plots of secchi disc (meters).



PATUXENT RIVER

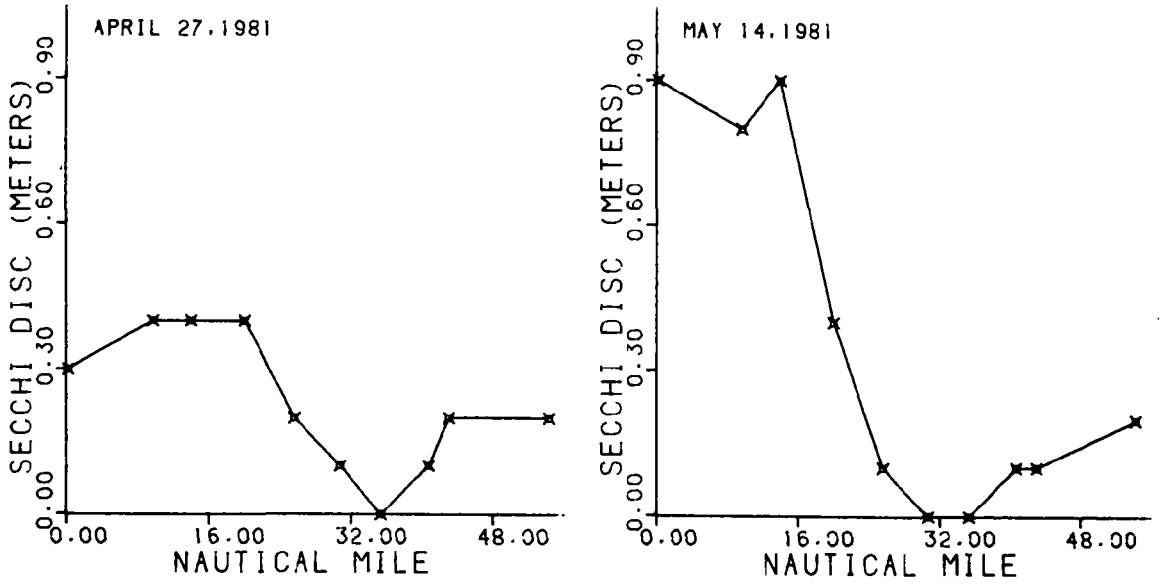


Figure 7-6 Patuxent River longitudinal slack survey plots of secchi disc (meters).

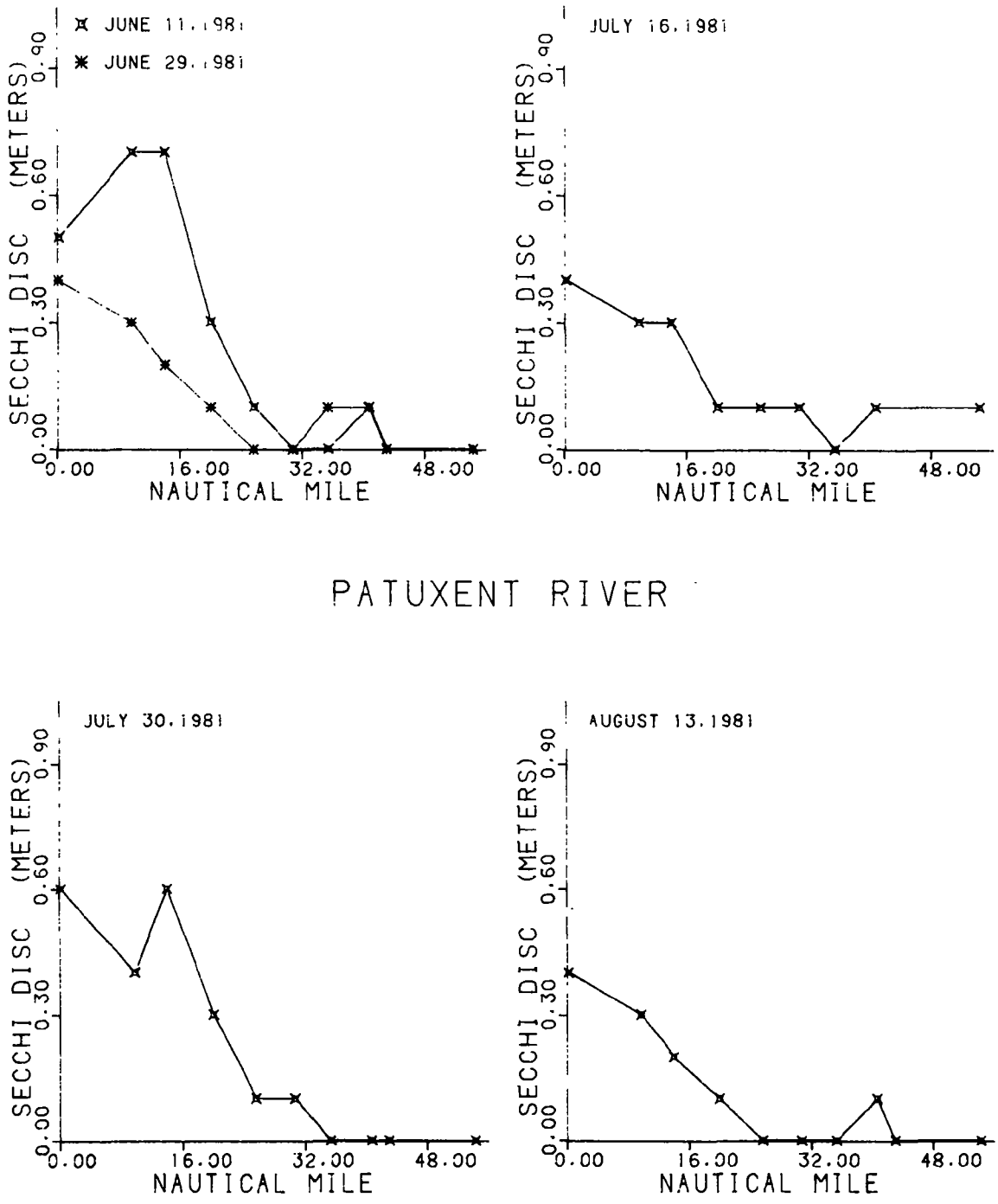


Figure 7-6 Patuxent River longitudinal slack survey plots of secchi disc (meters).

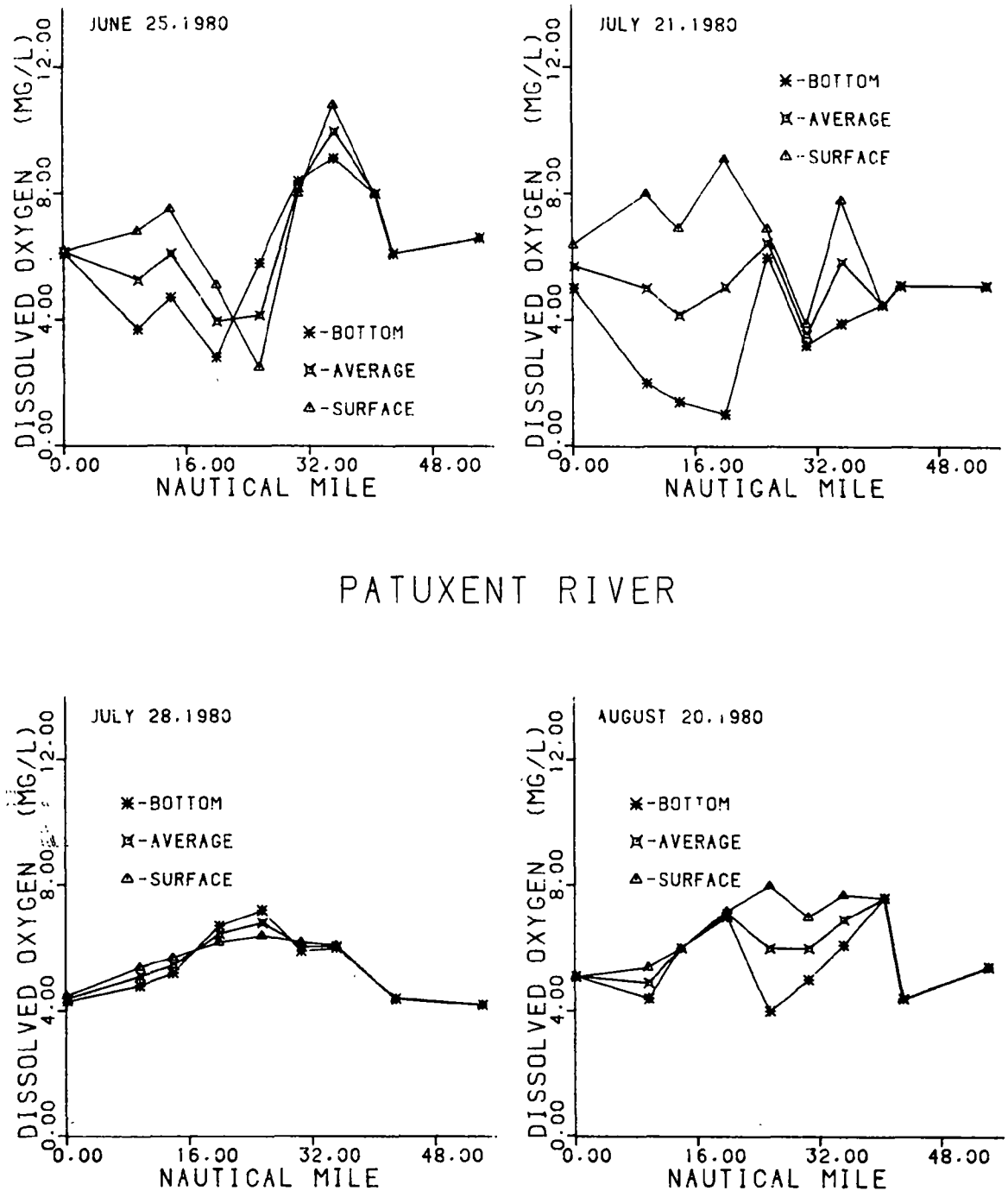


Figure 7-7 Patuxent River Slack Survey Plots of Dissolved Oxygen

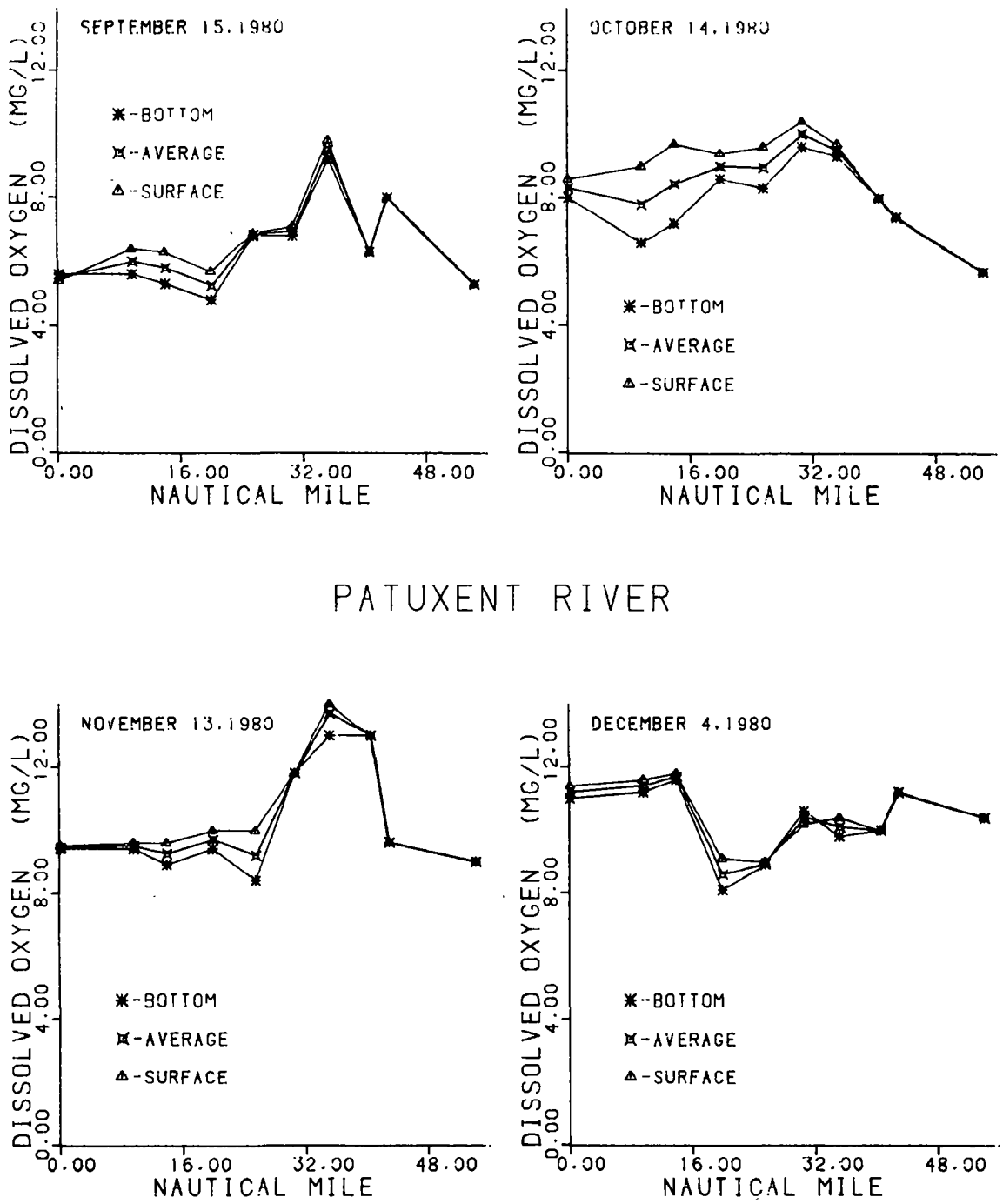
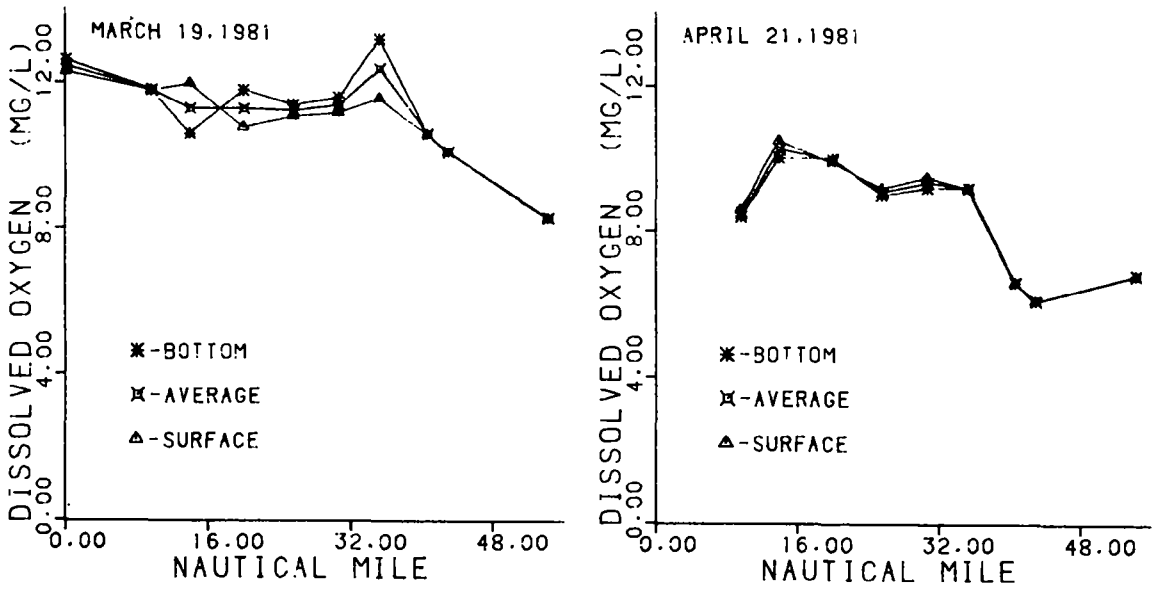


Figure 7-7 Patuxent River Slack Survey Plots of Dissolved Oxygen



PATUXENT RIVER

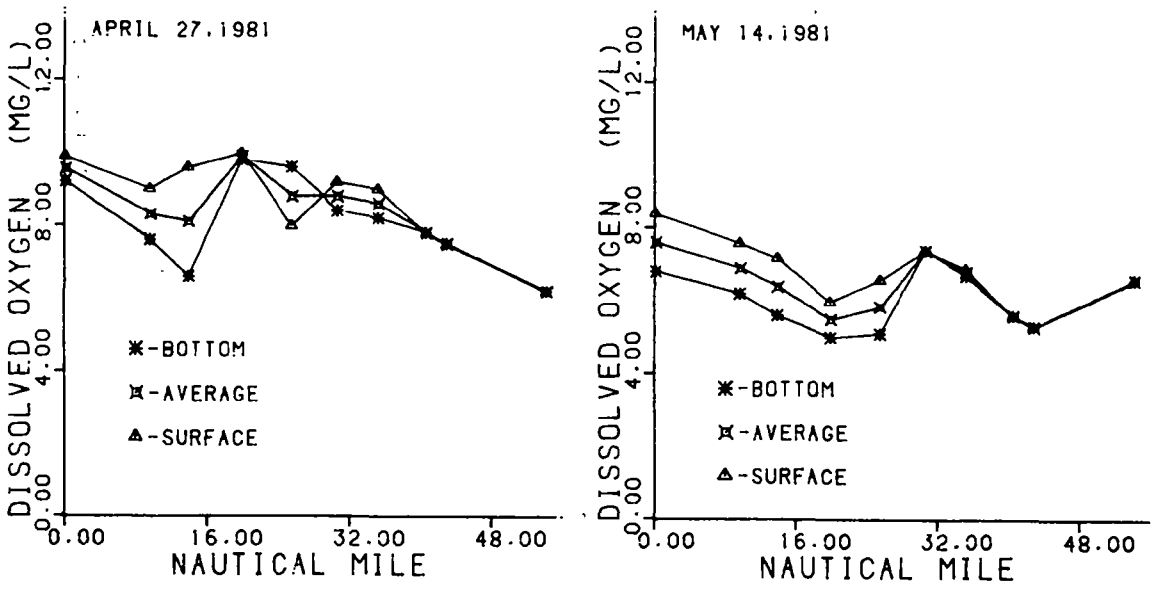
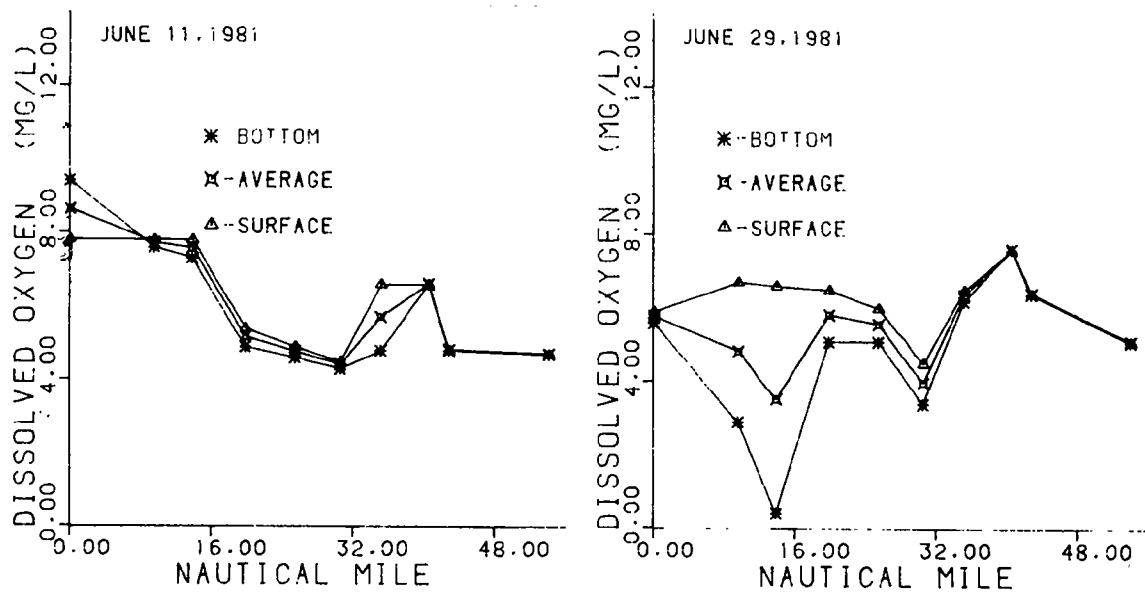


Figure 7-7 Patuxent River Slack Survey Plots of Dissolved Oxygen



PATUXENT RIVER

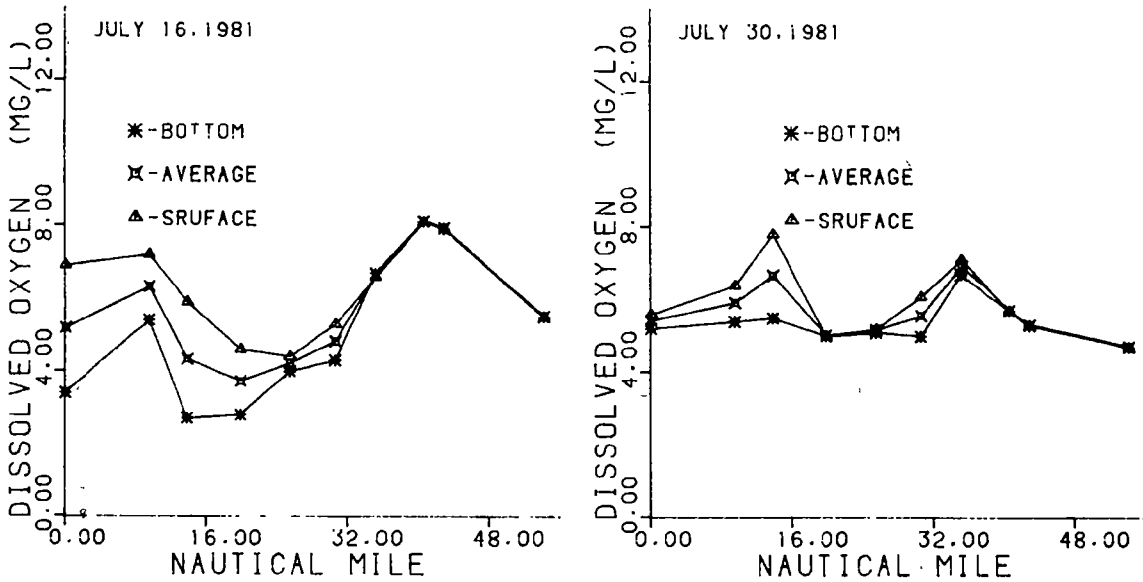
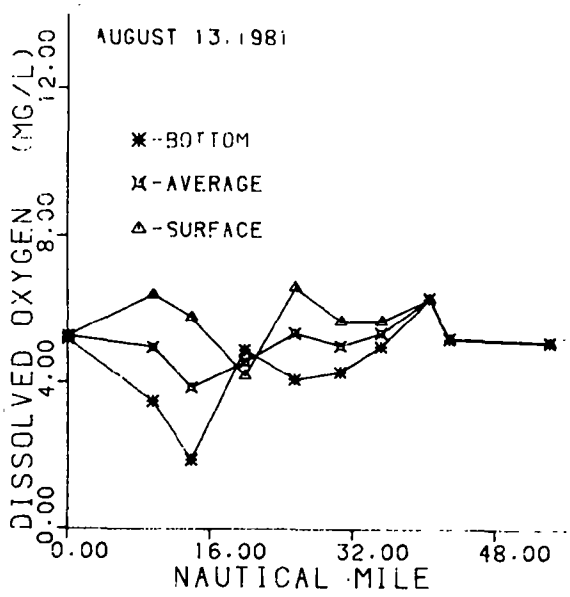
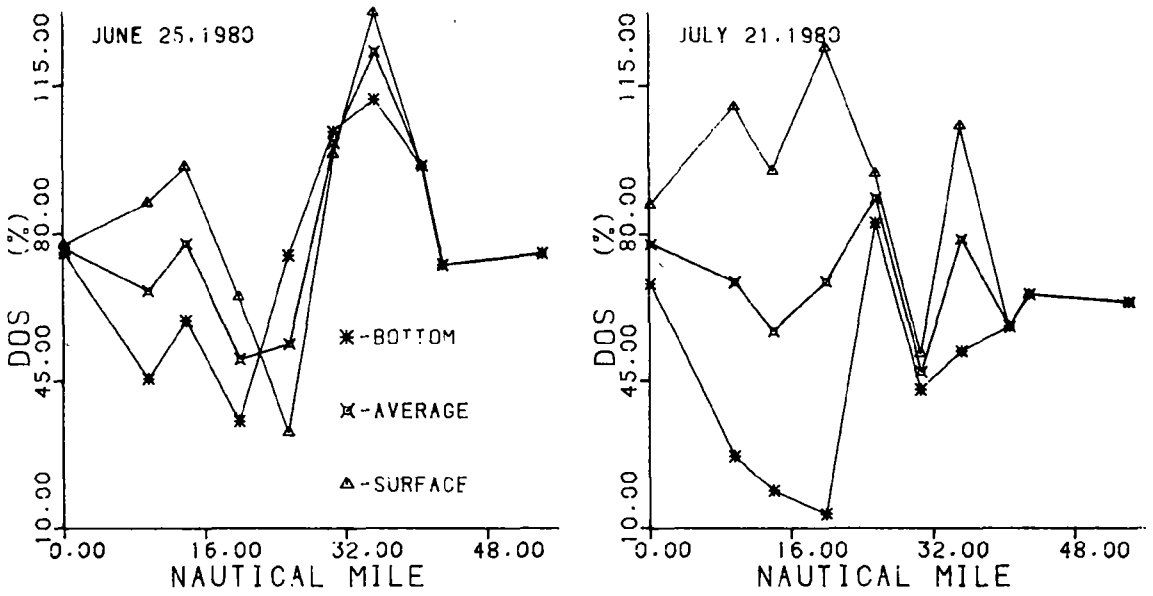


Figure 7-7 Patuxent River Slack Survey Plots of Dissolved Oxygen



PATUXENT RIVER

Figure 7-7 Patuxent River Slack Survey Plots of Dissolved Oxygen



PATUXENT RIVER

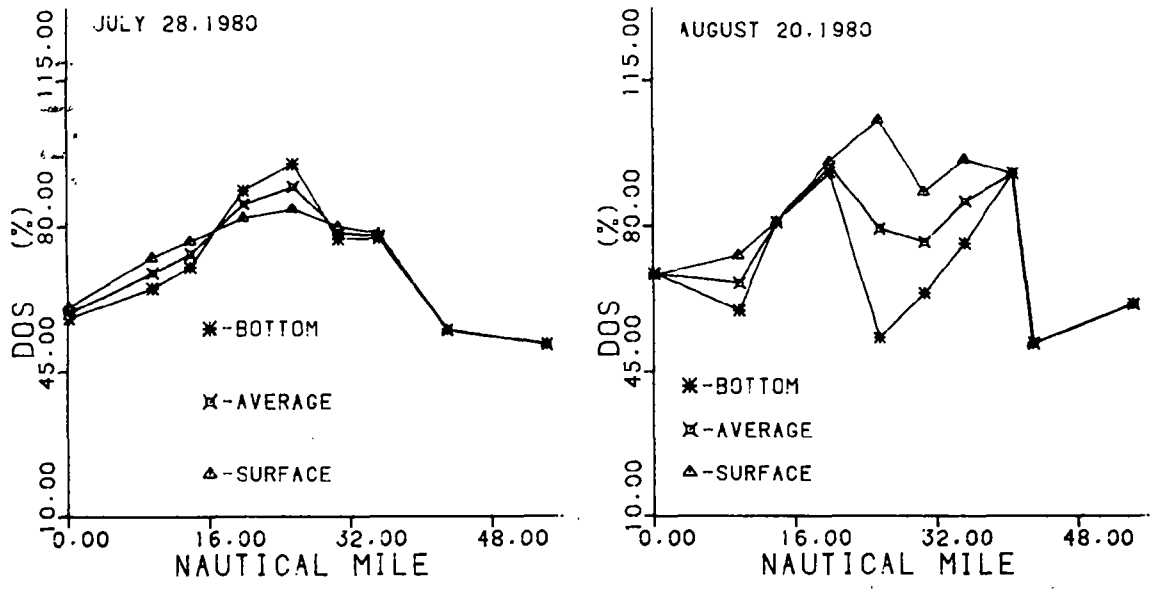
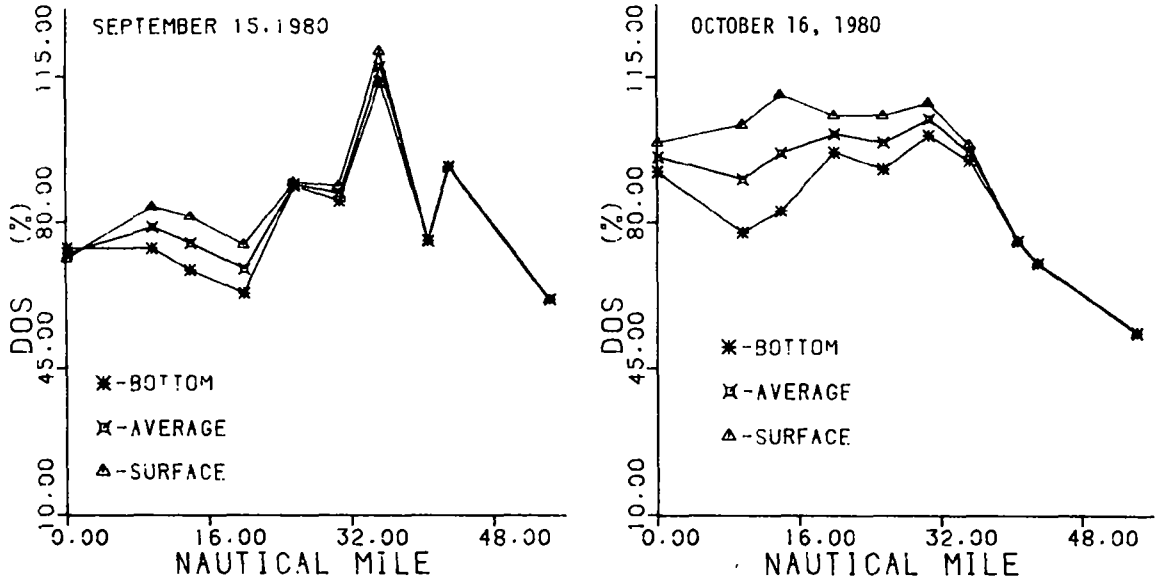


Figure 7-8 Patuxent River longitudinal slack survey plots of Dissolved Oxygen Saturation (%).



PATUXENT RIVER

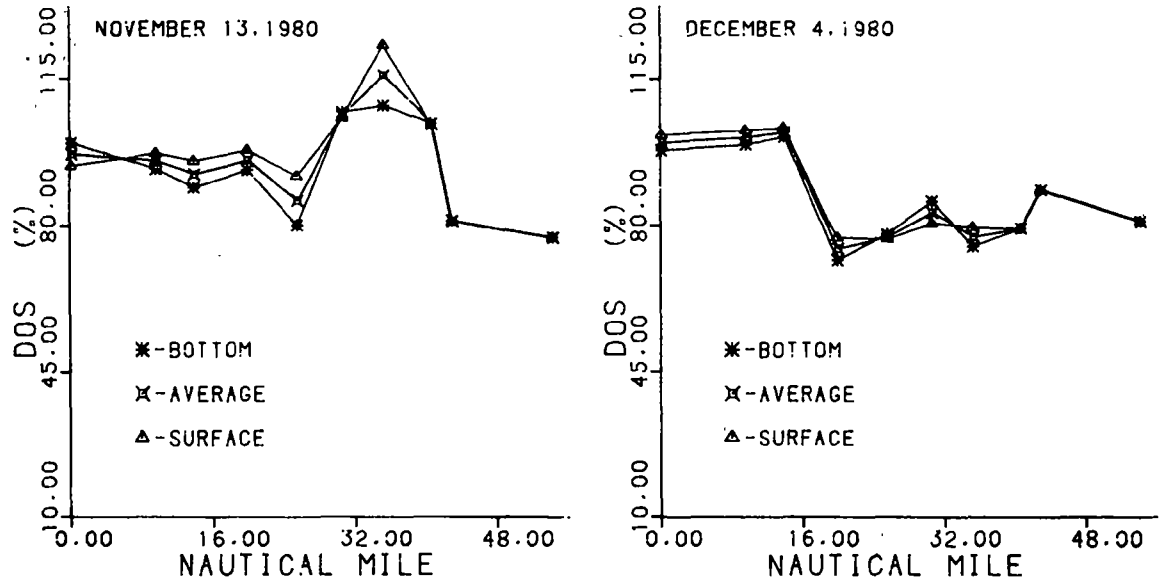


Figure 7-8 Patuxent River longitudinal slack survey plots of Dissolved Oxygen Saturation (%).

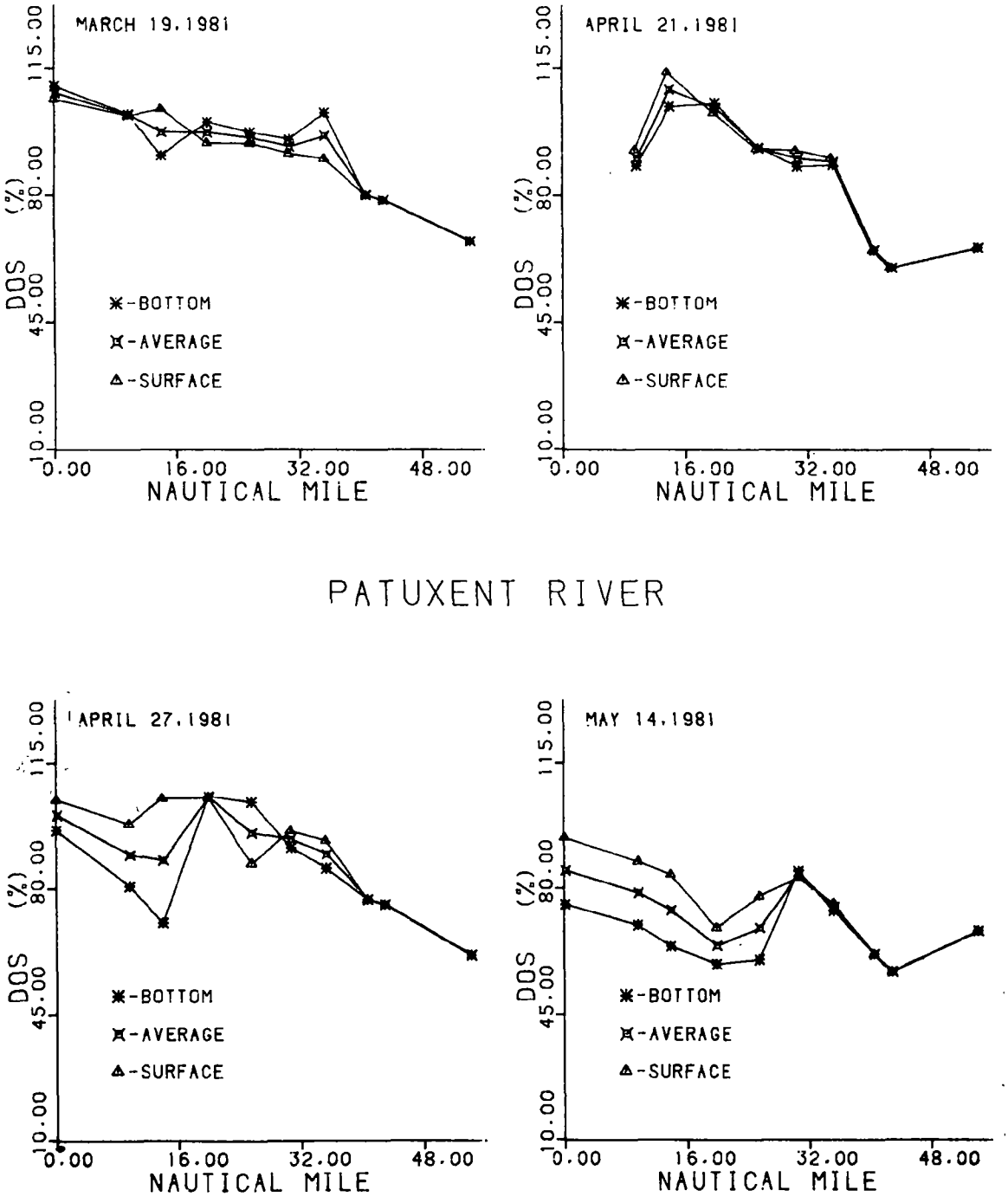


Figure 7-8 Patuxent River longitudinal slack survey plots of Dissolved Oxygen Saturation (%).

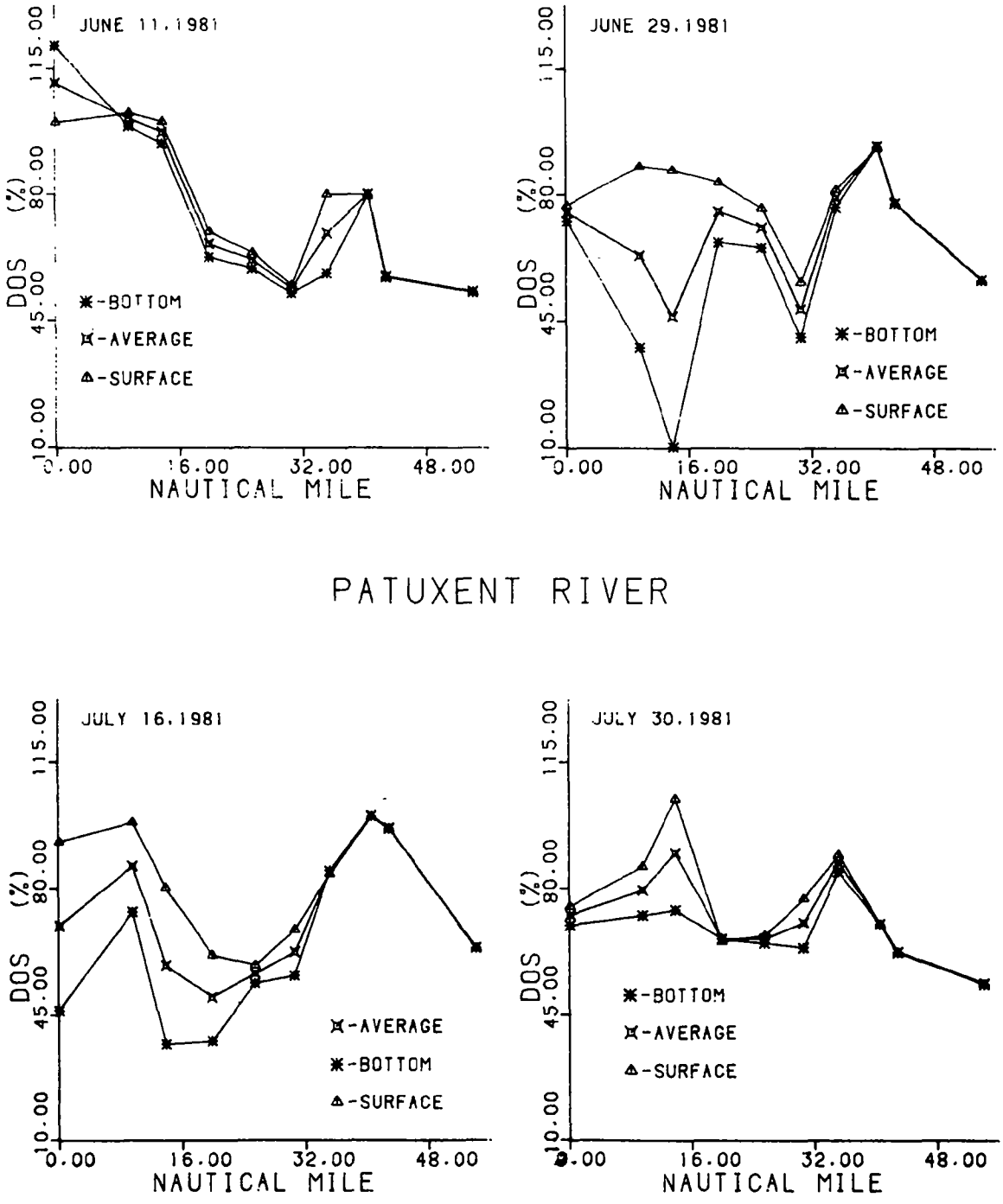
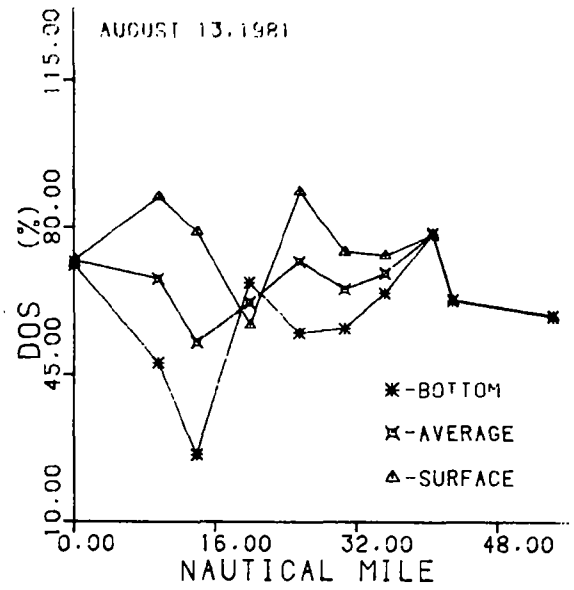


Figure 7-8 Patuxent River longitudinal slack survey plots of Dissolved Oxygen Saturation (%).



PATUXENT RIVER

Figure 7-8 Patuxent River longitudinal slack survey plots of Dissolved Oxygen Saturation (%).

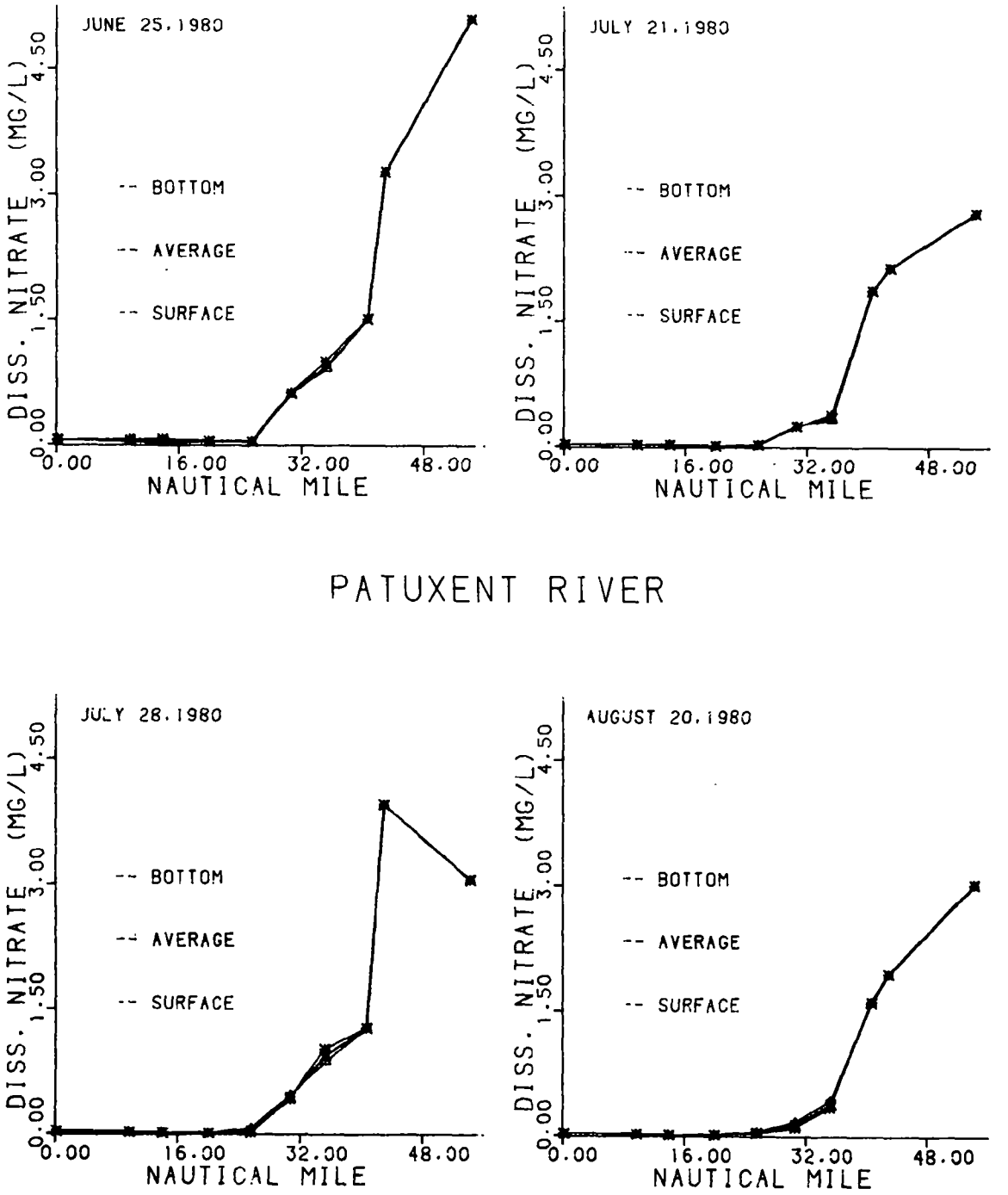
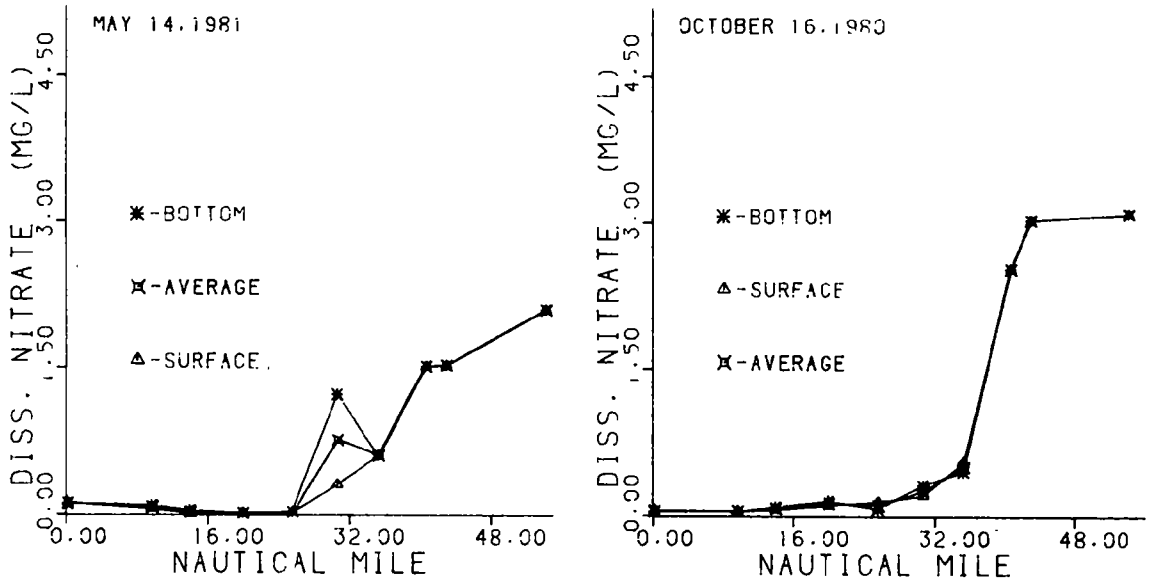


Figure 7-9 Longitudinal plots of dissolved nitrate, 1980-1981.



PATUXENT RIVER

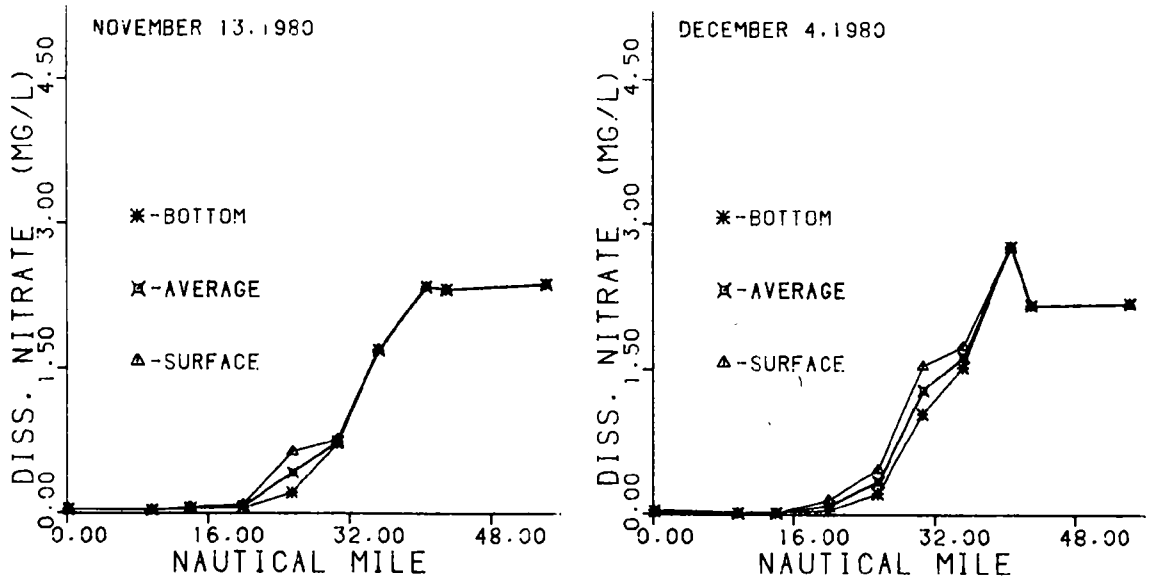


Figure 7-9 Longitudinal plots of dissolved nitrate, 1980-1981.

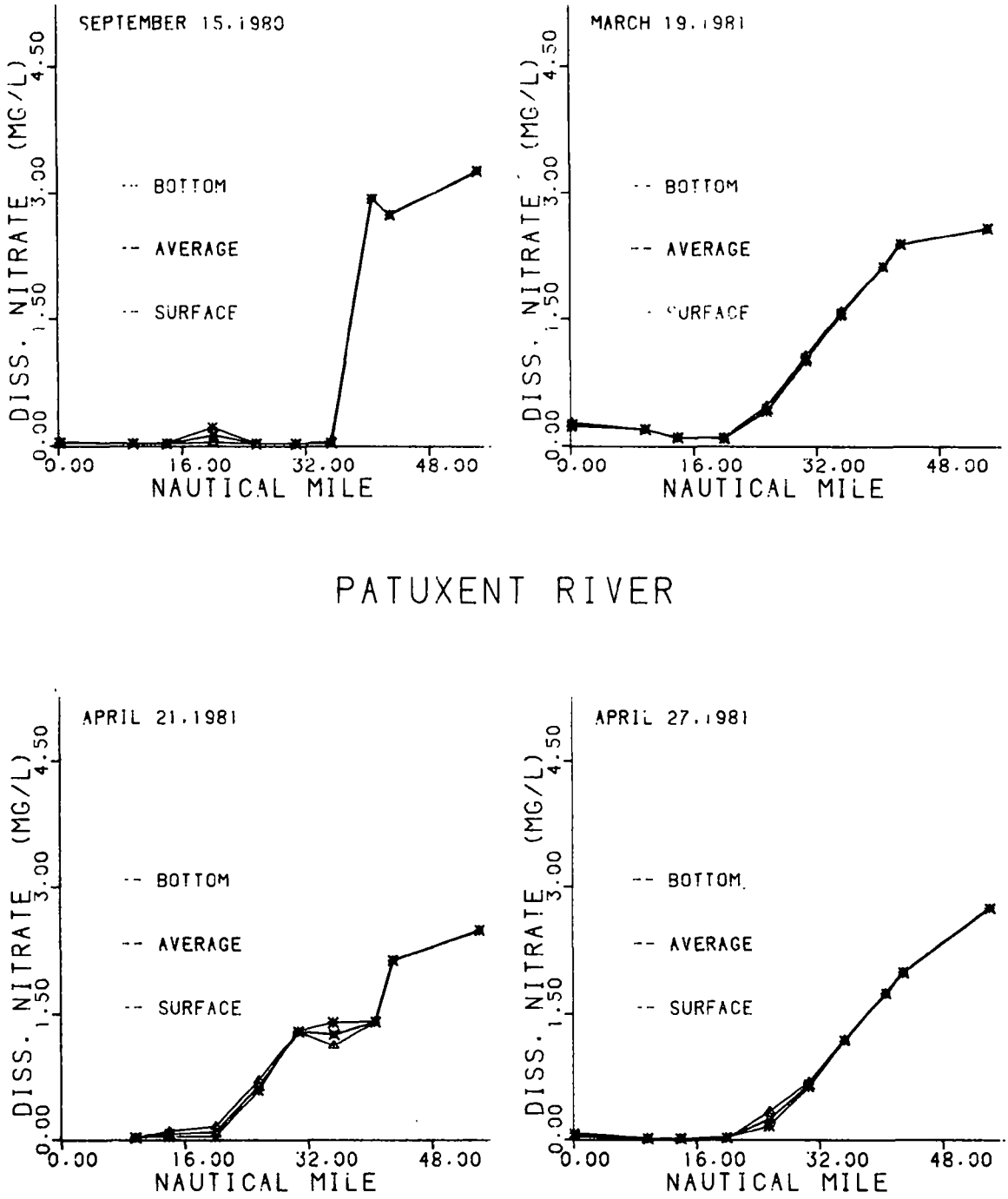


Figure 7-9 Longitudinal plots of dissolved nitrate, 1980-1981.

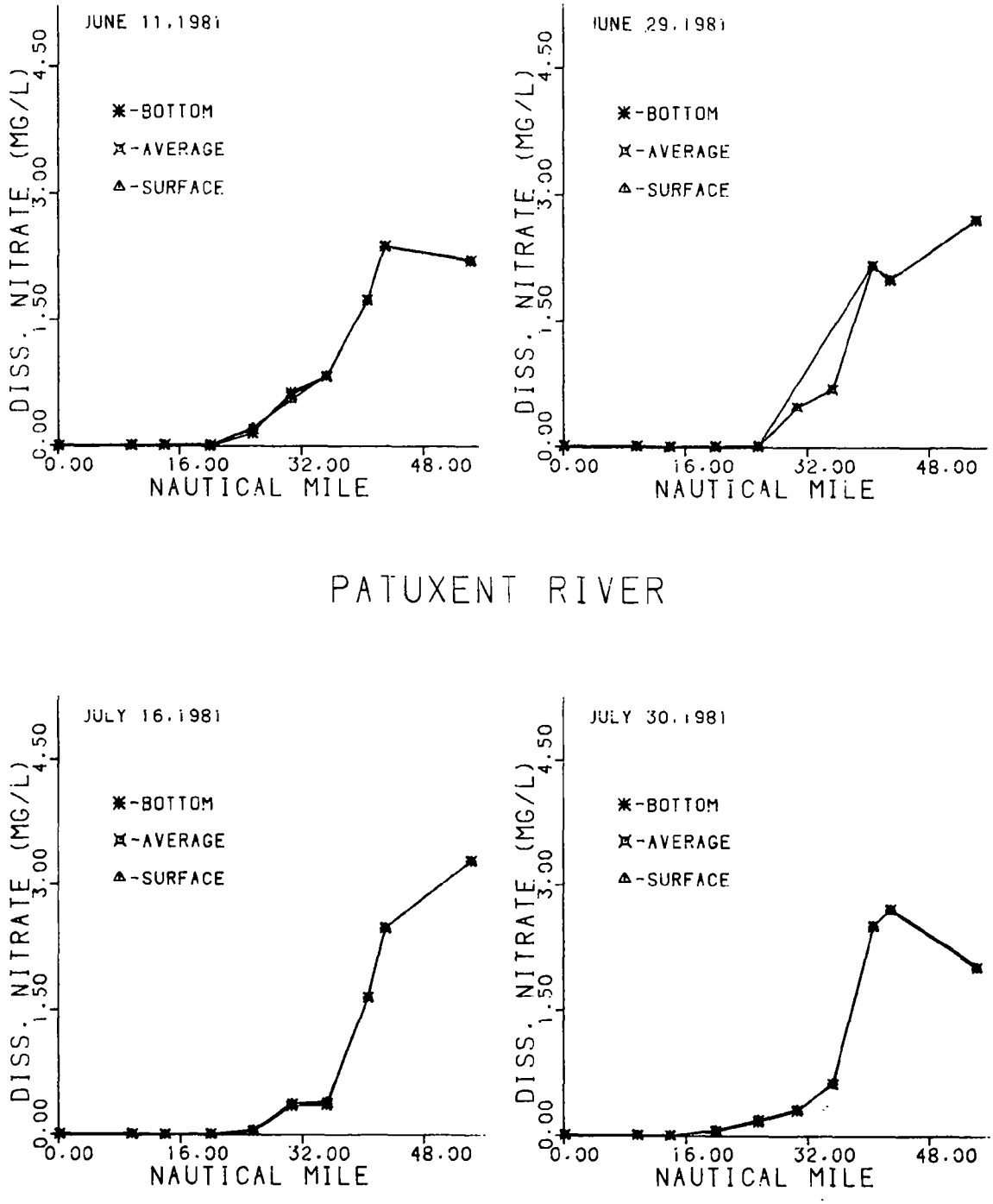
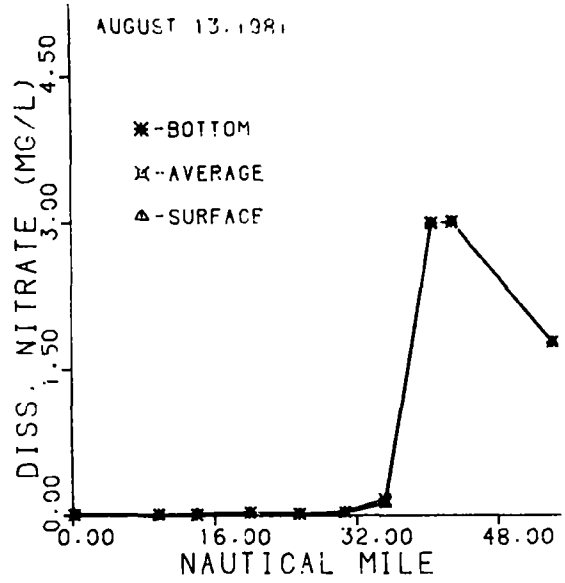


Figure 7-9 Longitudinal plots of dissolved nitrate, 1980-1981.



PATUXENT RIVER

Figure 7-9 Longitudinal plots of dissolved nitrate, 1980-1981.

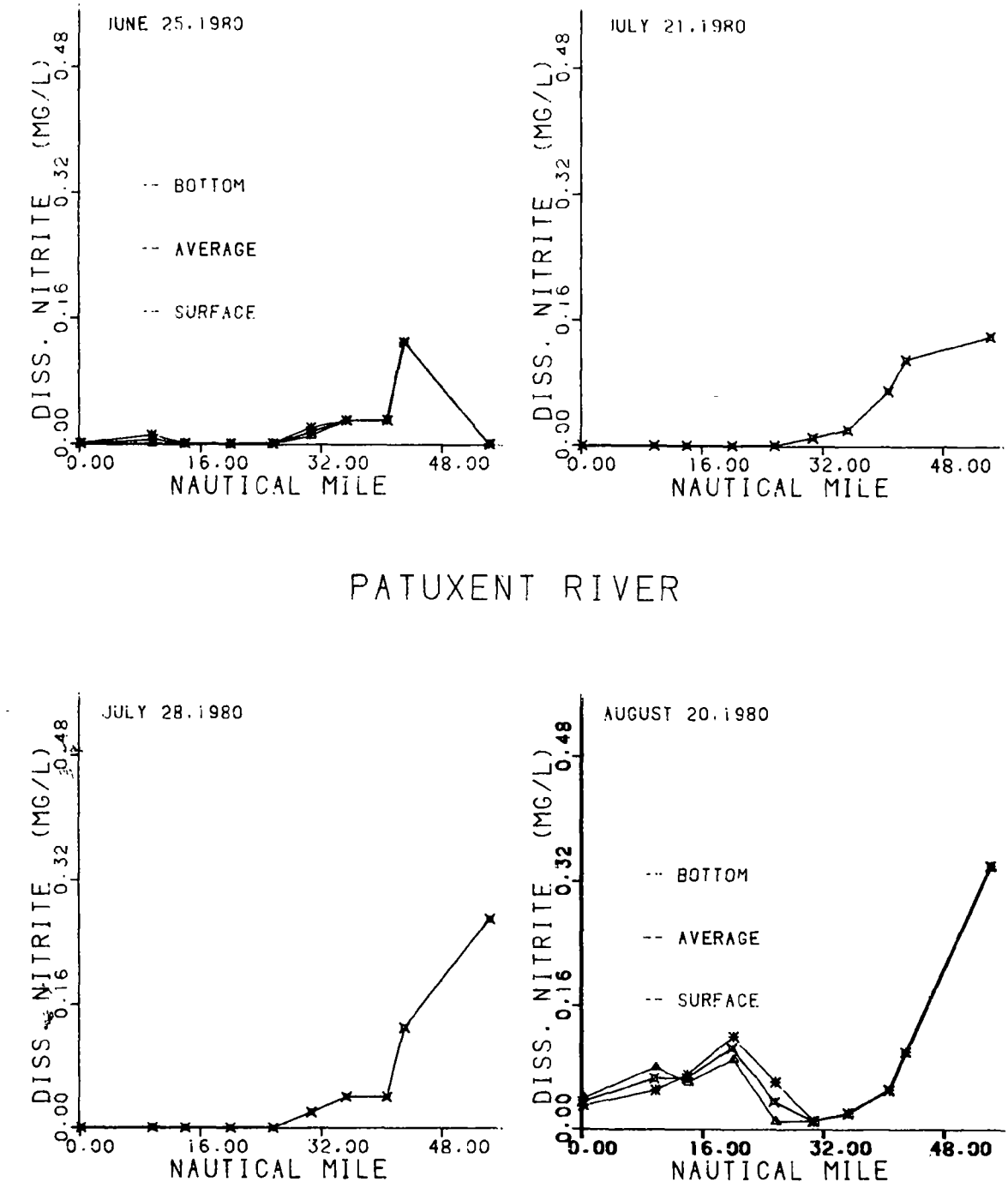
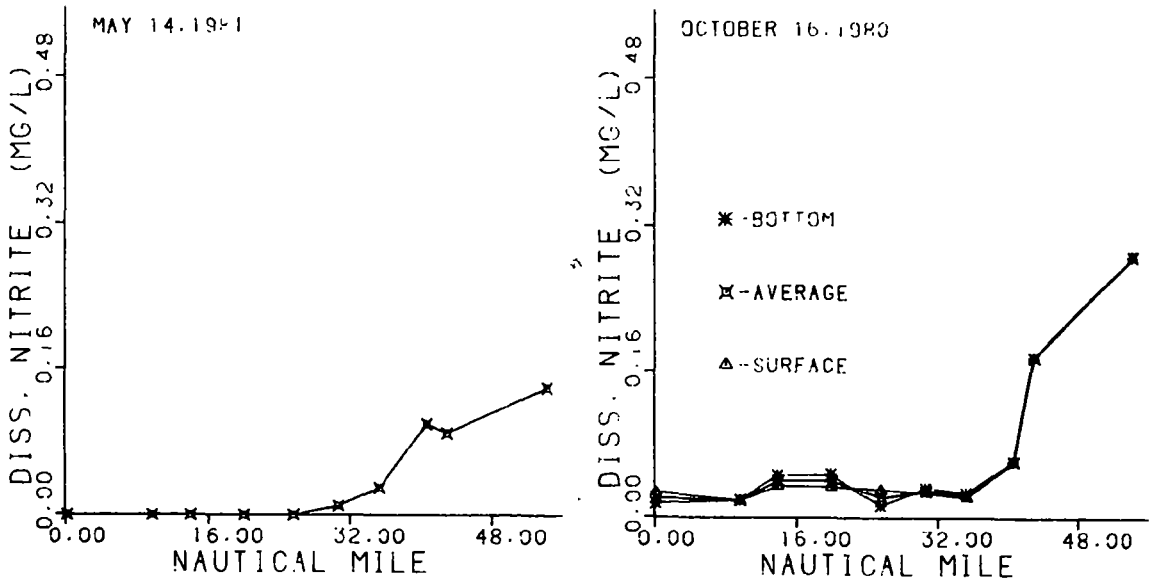


Figure 7-10 Patuxent river longitudinal plots of dissolved nitrite.



PATUXENT RIVER

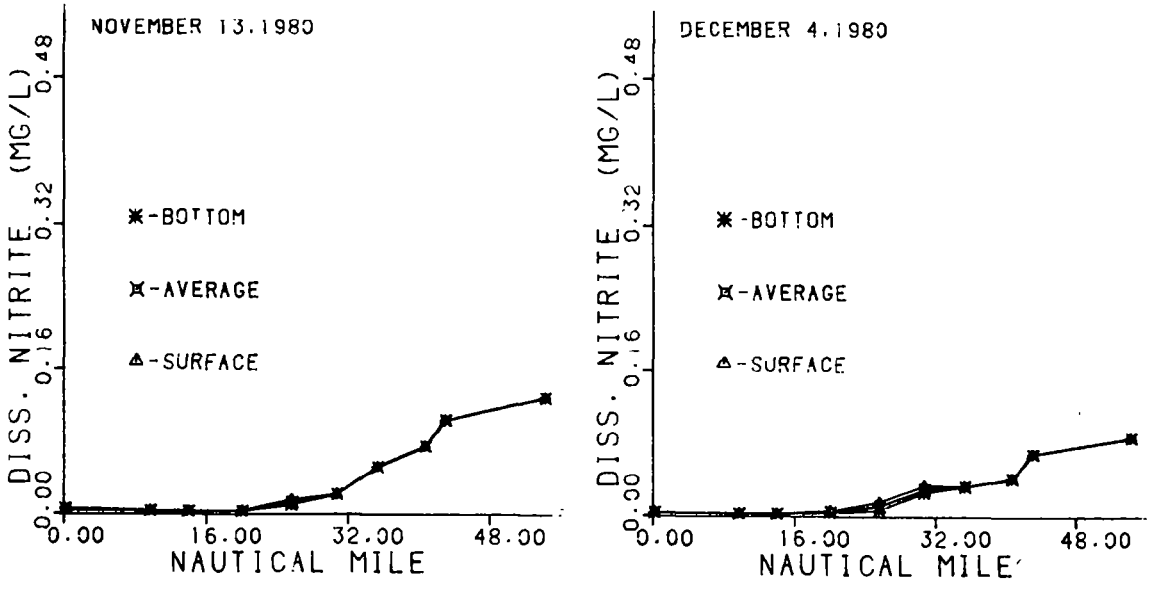
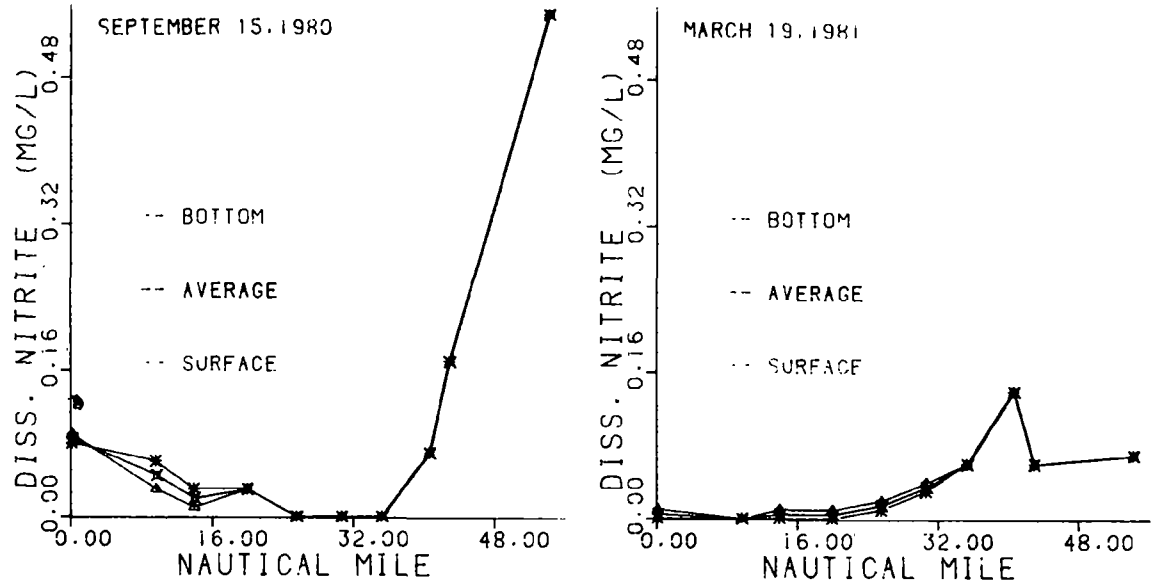


Figure 7-10 Patuxent river longitudinal plots of dissolved nitrite.



PATUXENT RIVER

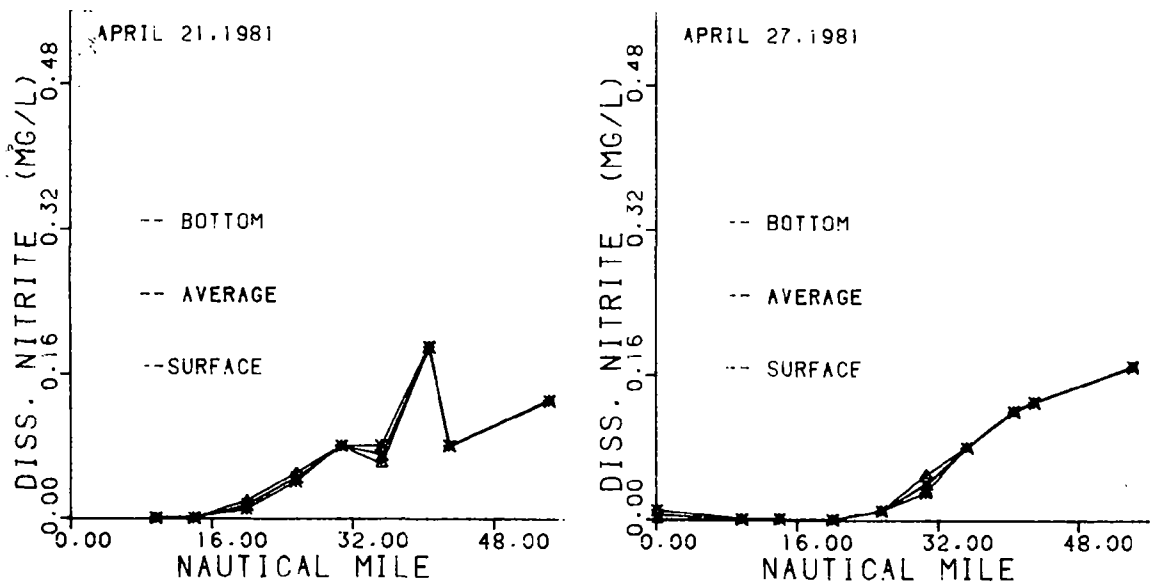


Figure 7-10 Patuxent river longitudinal plots of dissolved nitrite.

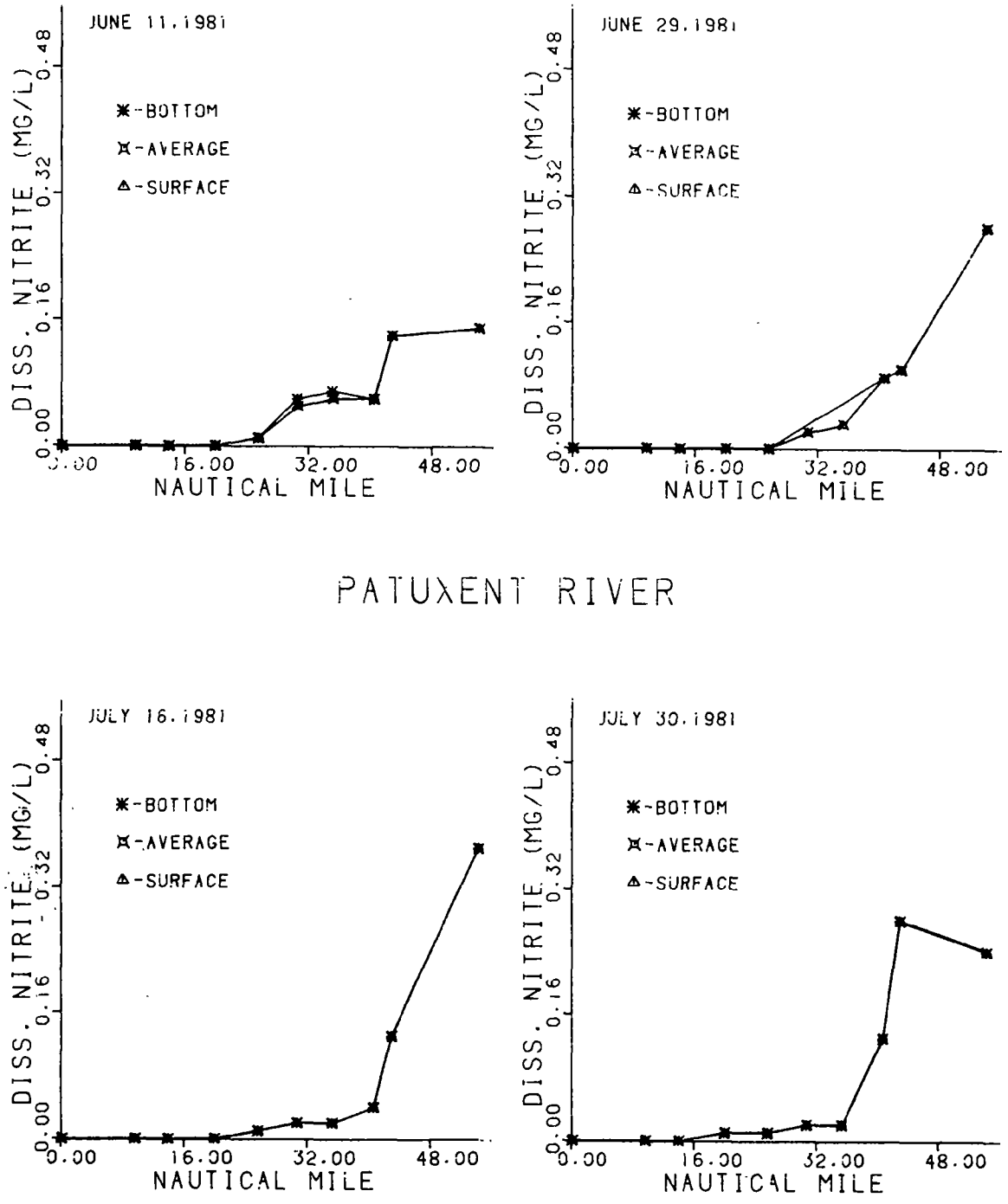
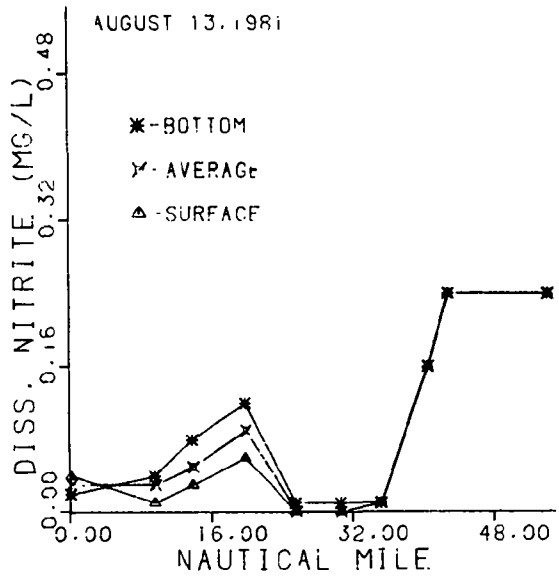


Figure 7-10 Patuxent river longitudinal plots of dissolved nitrite.



PATUXENT RIVER

Figure 7-10Patuxent river longitudinal plots of dissolved nitrite.

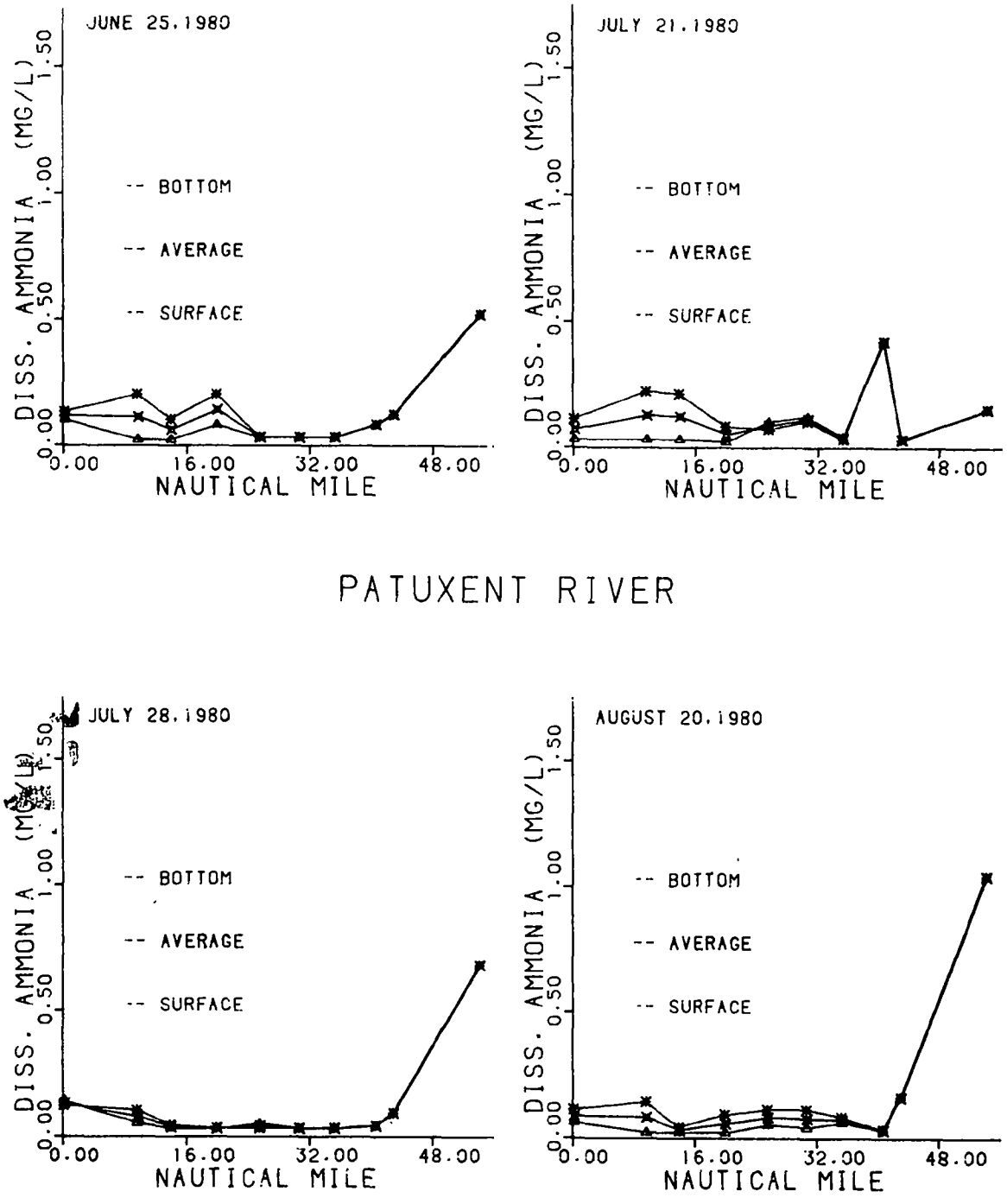
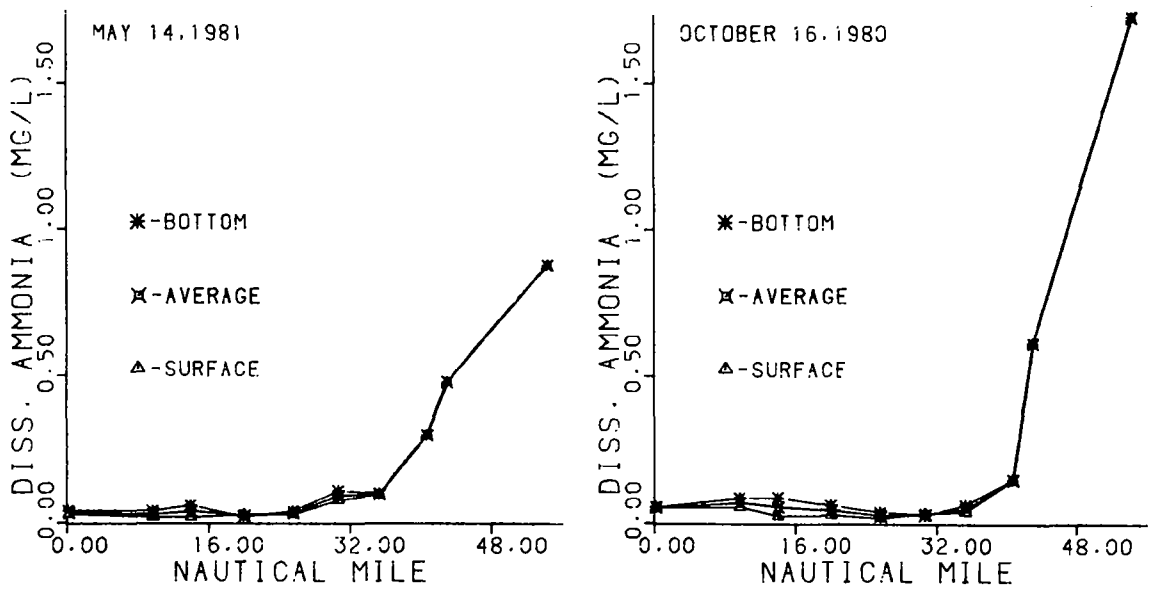


Figure 7-11 Patuxent River Slack Survey Plots of Dissolved Ammonia



PATUXENT RIVER

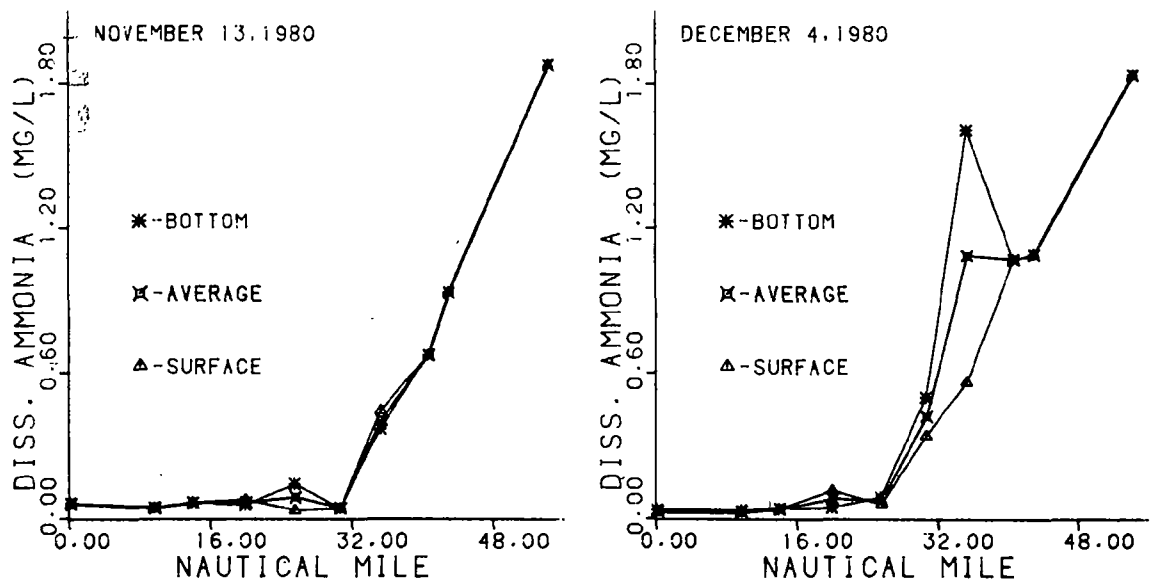


Figure 7-11 Patuxent River Slack Survey Plots of Dissolved Ammonia

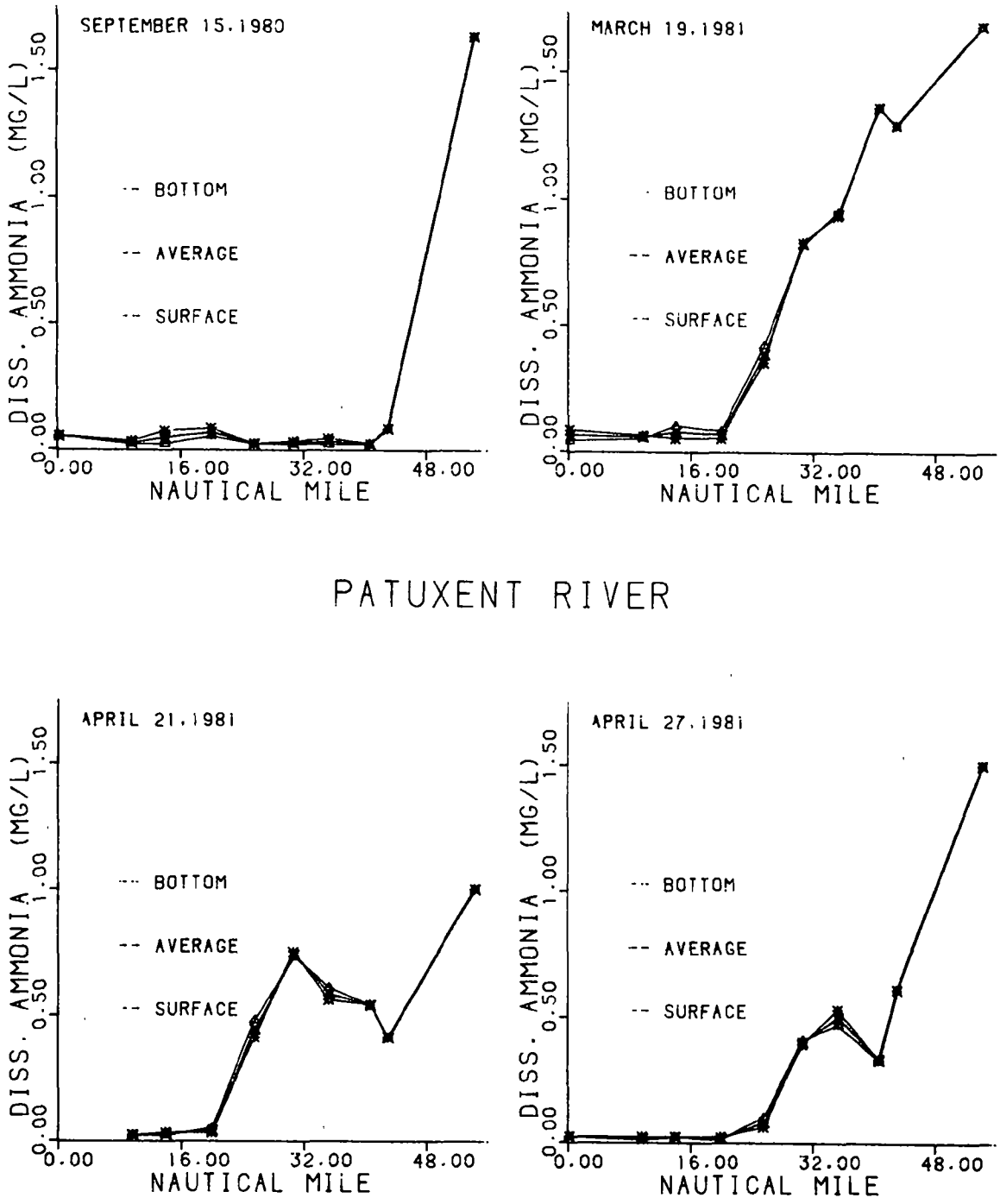


Figure 7-11 Patuxent River Slack Survey Plots of Dissolved Ammonia

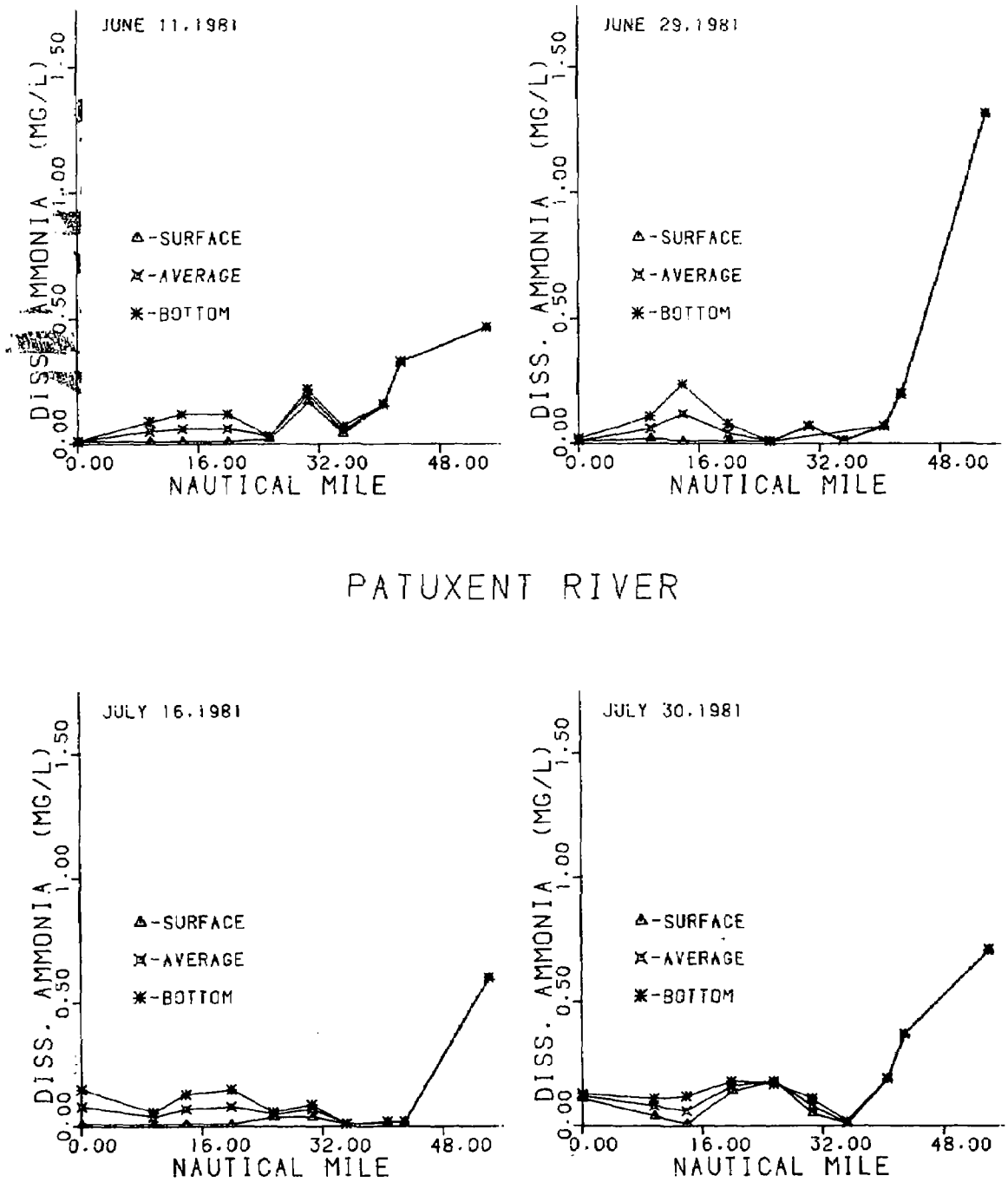


Figure 7-11 Patuxent River Slack Survey Plots of Dissolved Ammonia

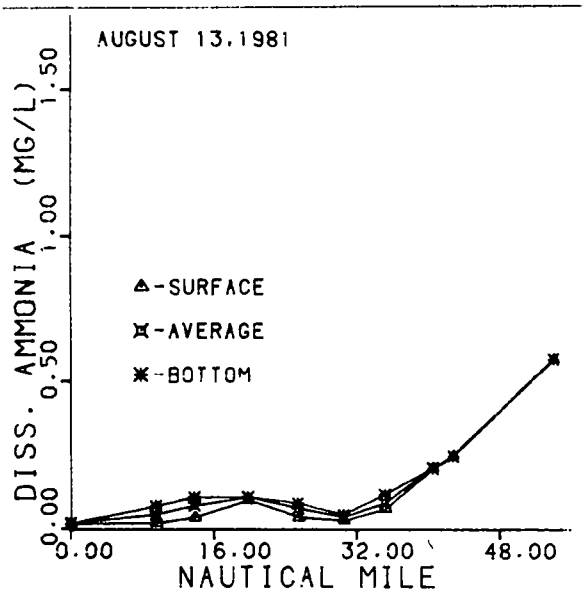
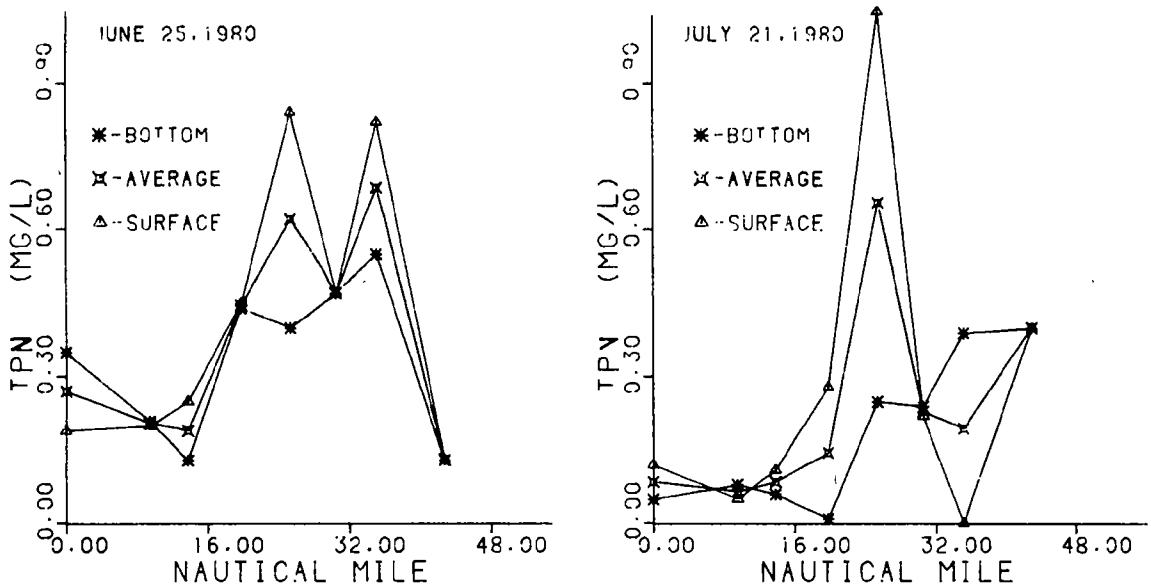


Figure 7-11 Patuxent River Slack Survey Plots of Dissolved Ammonia



PATUXENT RIVER

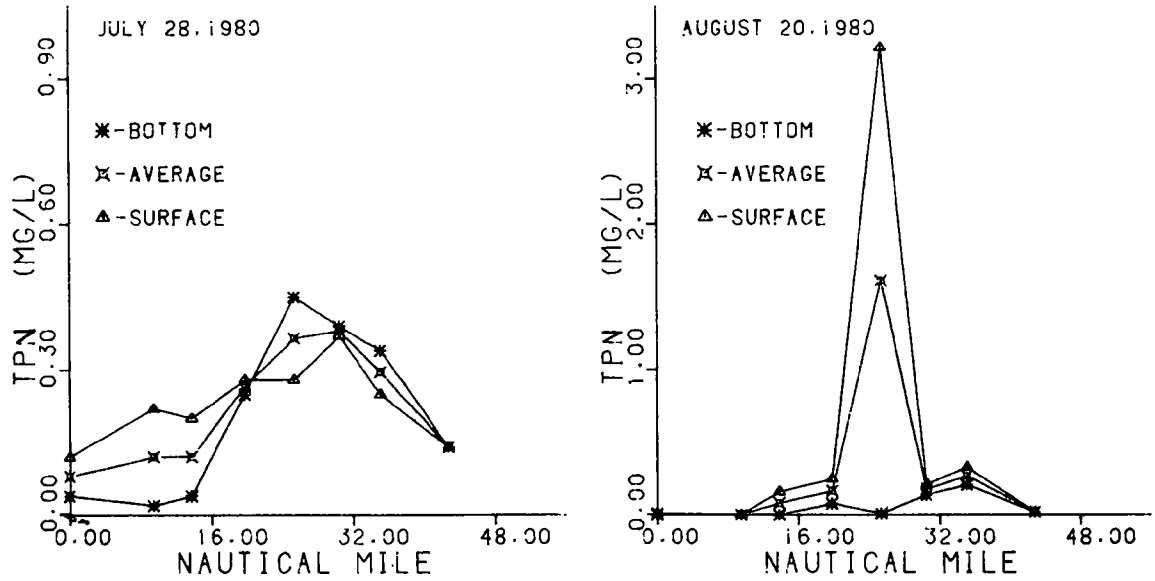


Figure 7-12 Patuxent River longitudinal slack survey plots of Total Particulate Nitrogen (mg/l).

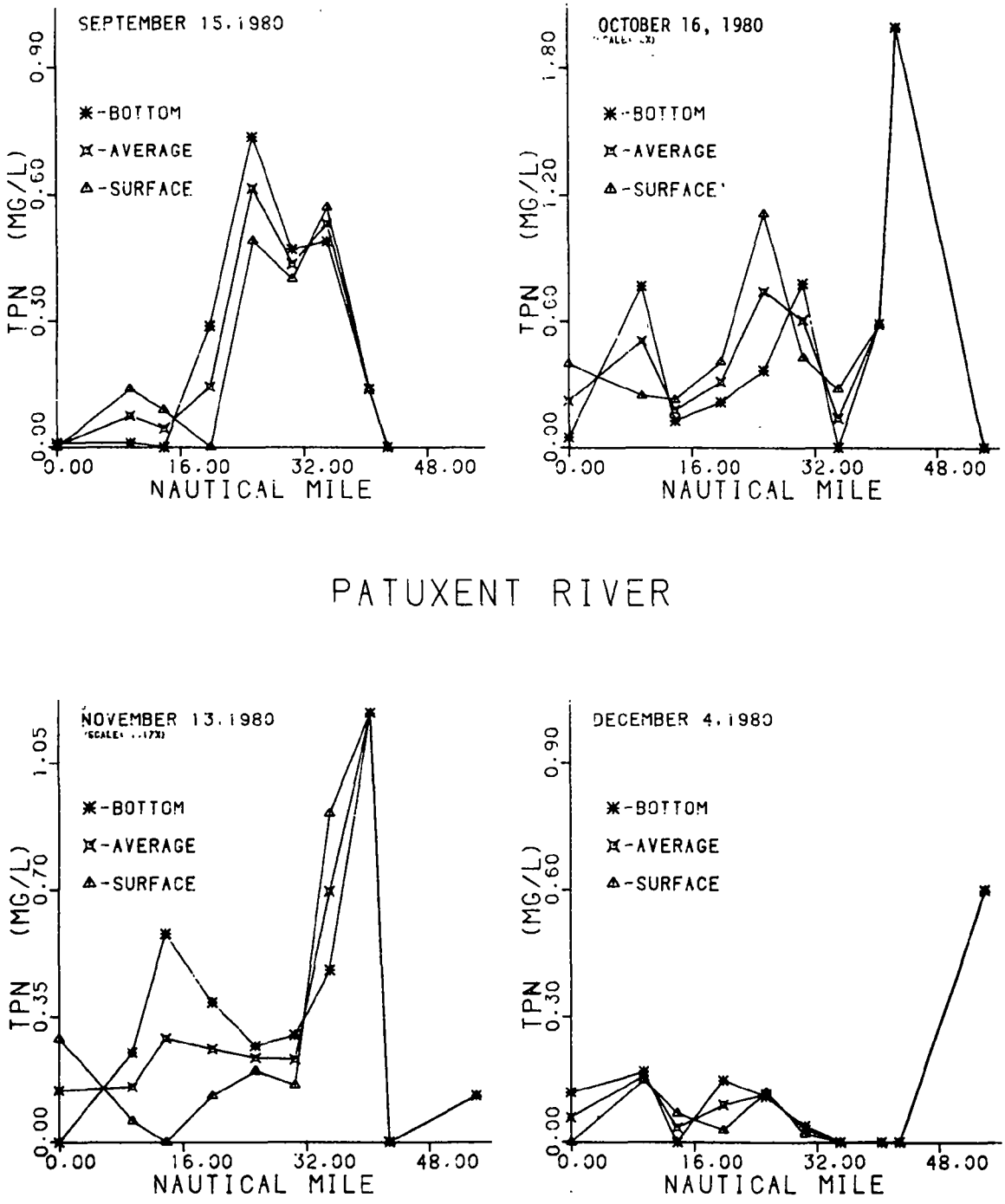
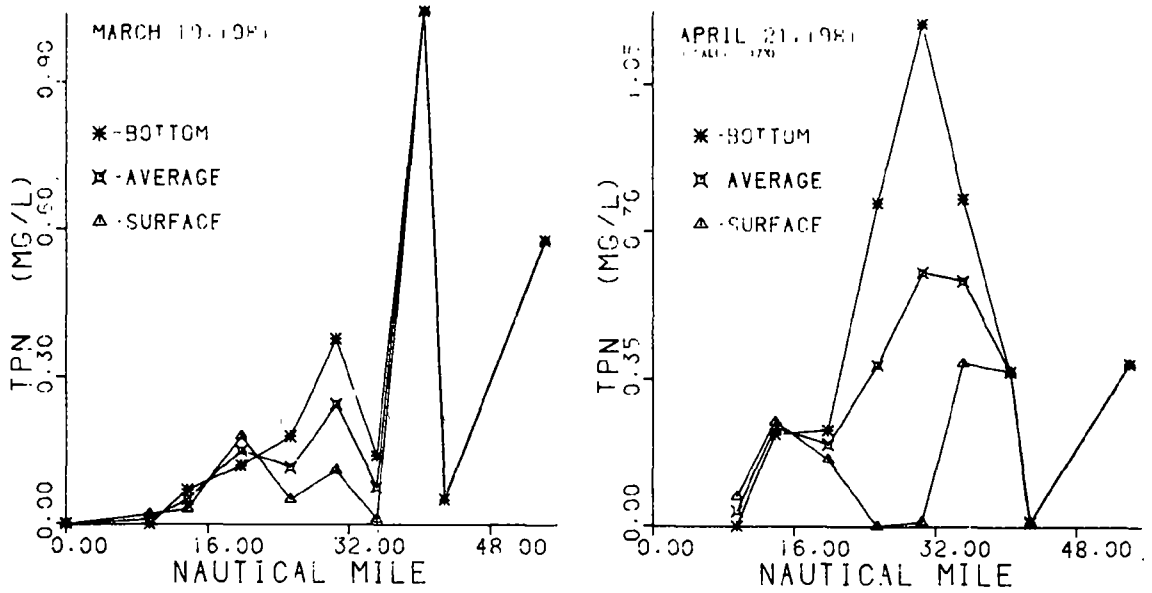


Figure 7-12 Patuxent River longitudinal slack survey plots of Total Particulate Nitrogen (mg/l).



PATUXENT RIVER

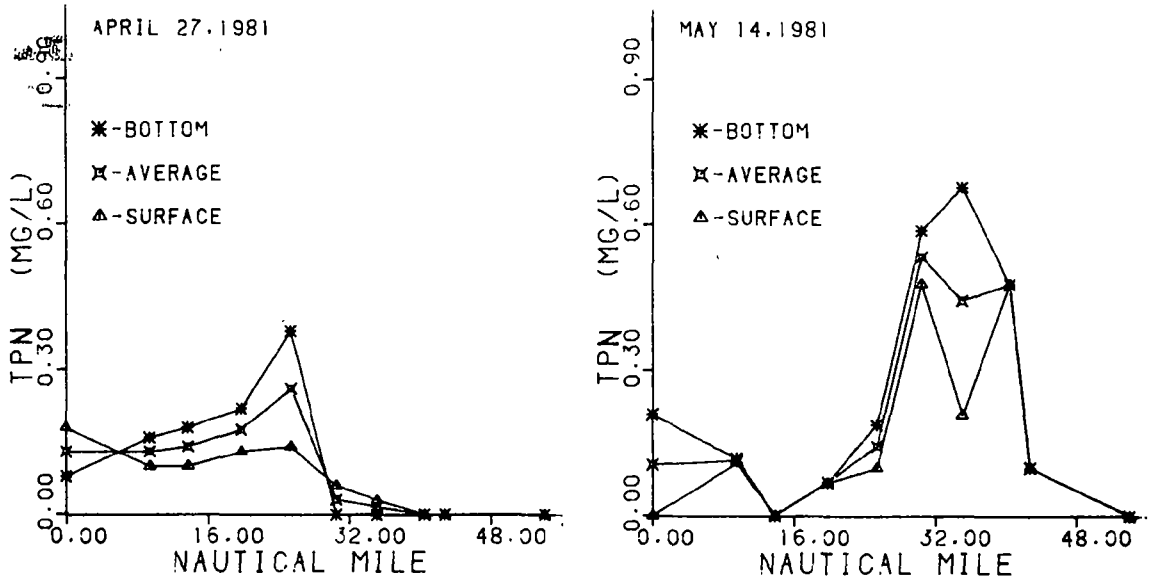


Figure 7-12 Patuxent River longitudinal slack survey plots of Total Particulate Nitrogen (mg/l).

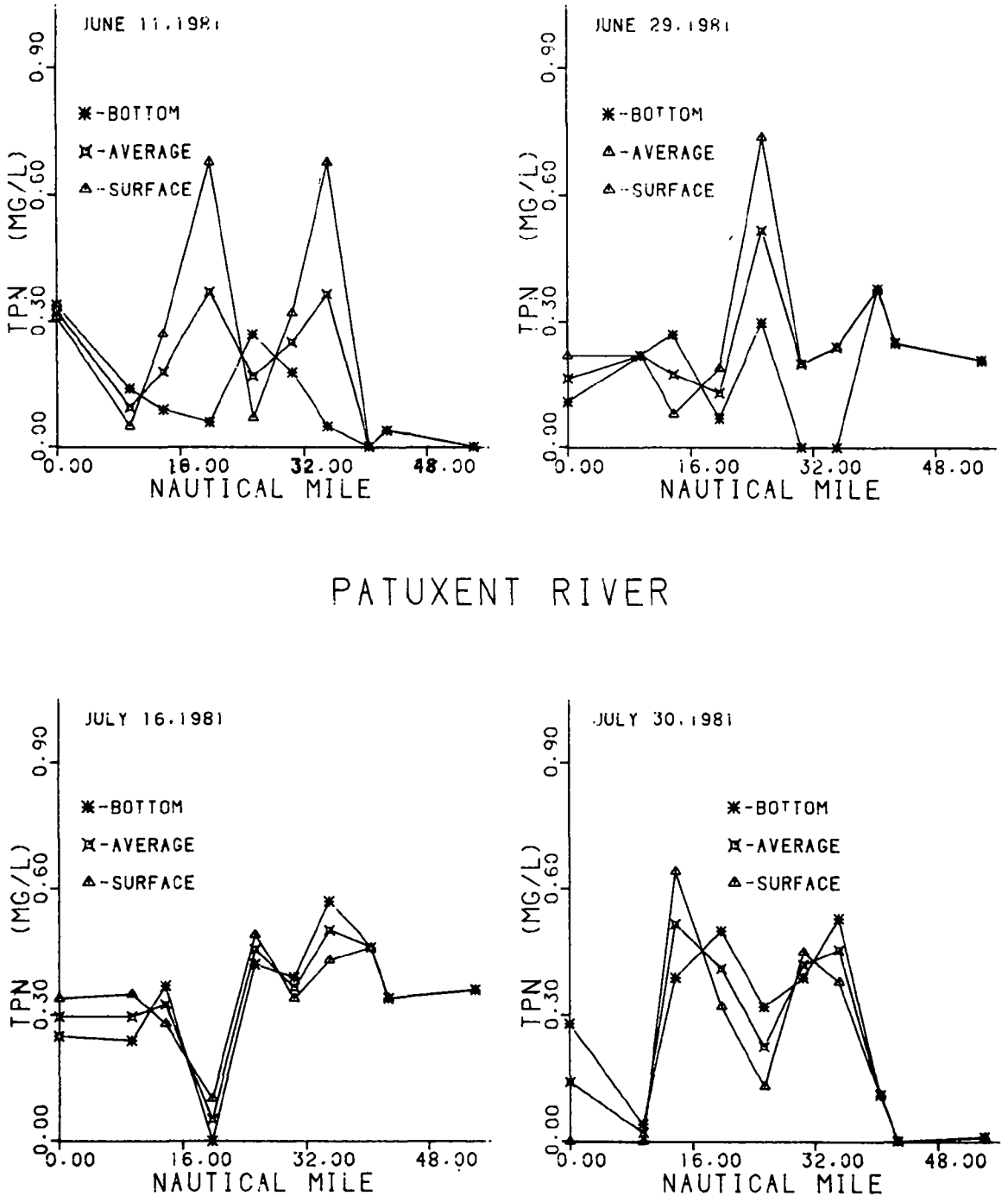
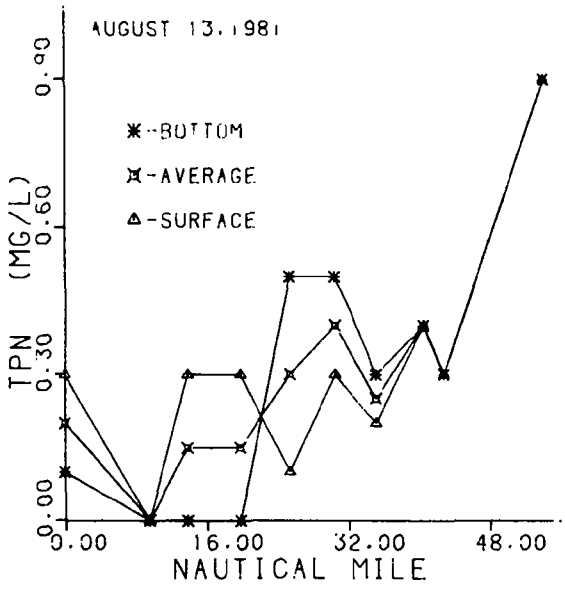


Figure 7-12 Patuxent River longitudinal slack survey plots of Total Particulate Nitrogen (mg/l).



PATUXENT RIVER

Figure 7-12 Patuxent River longitudinal slack survey plots of Total Particulate Nitrogen (mg/l).

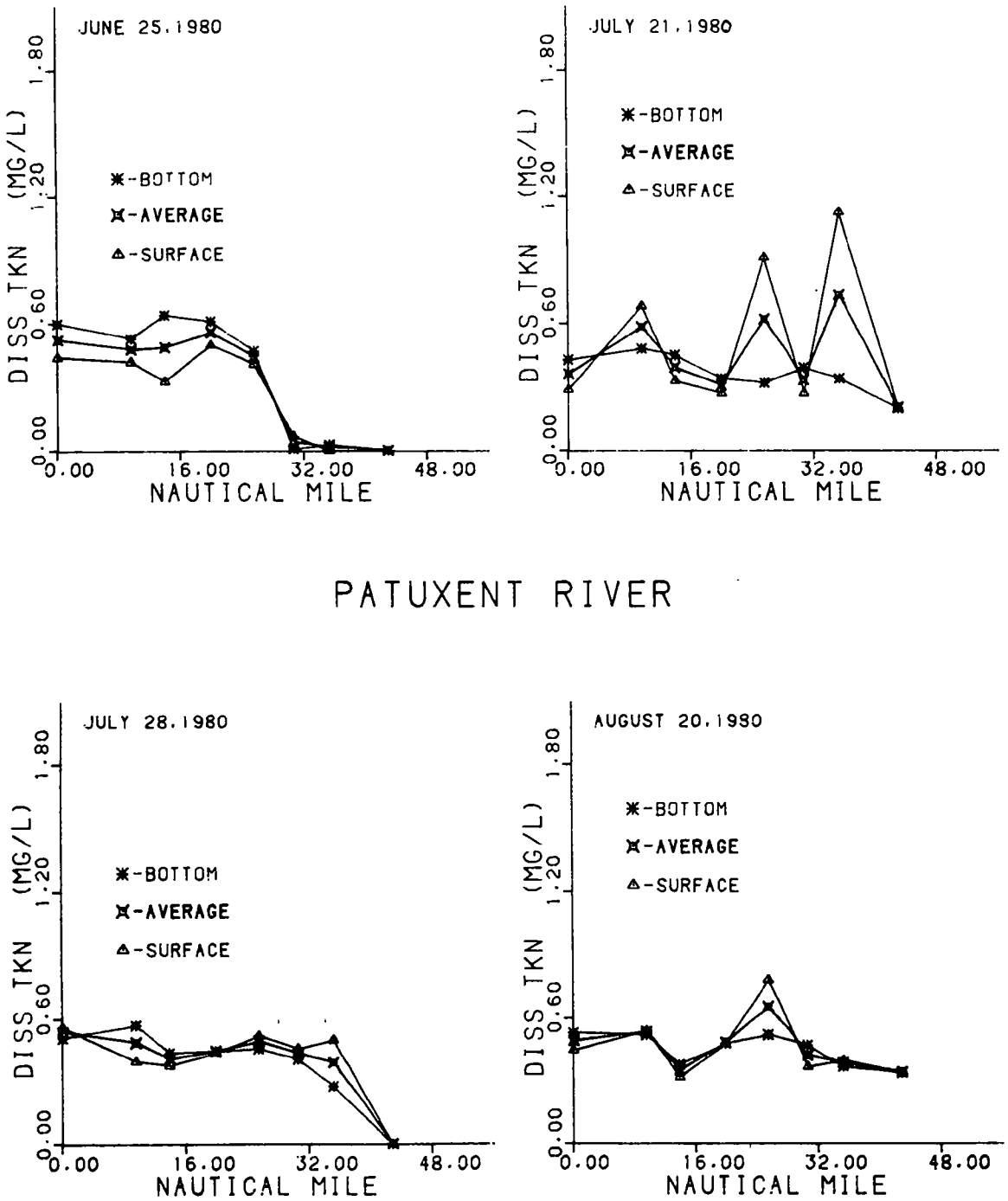
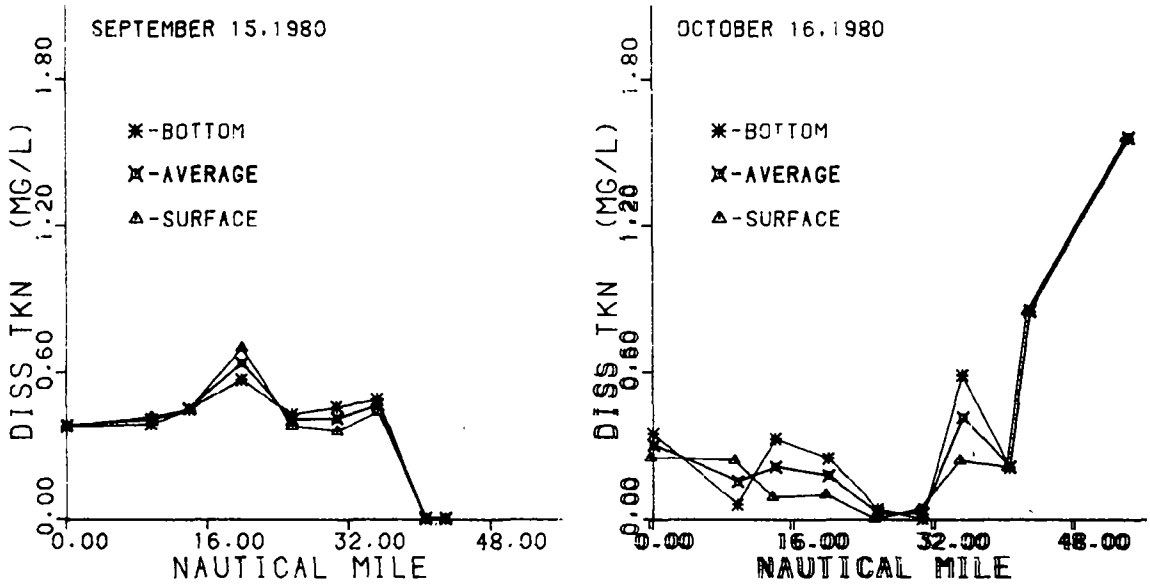


Figure 7-13Patuxent river longitudinal plots of dissolved total kjeldhal nitrogen.



PATUXENT RIVER

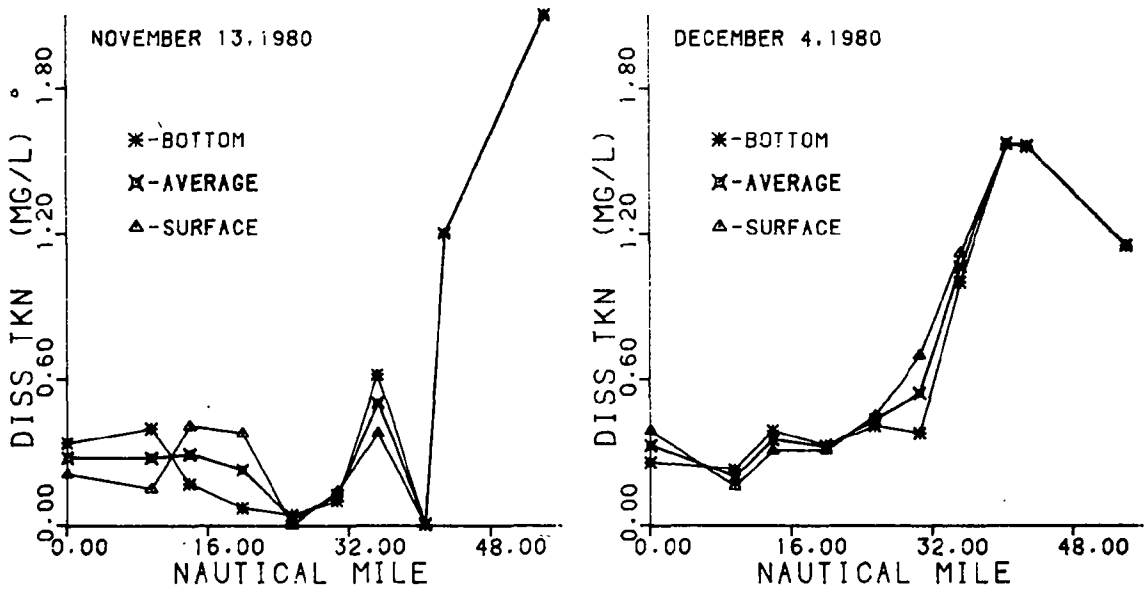


Figure 7-13 Patuxent river longitudinal plots of dissolved total kjeldhal nitrogen.

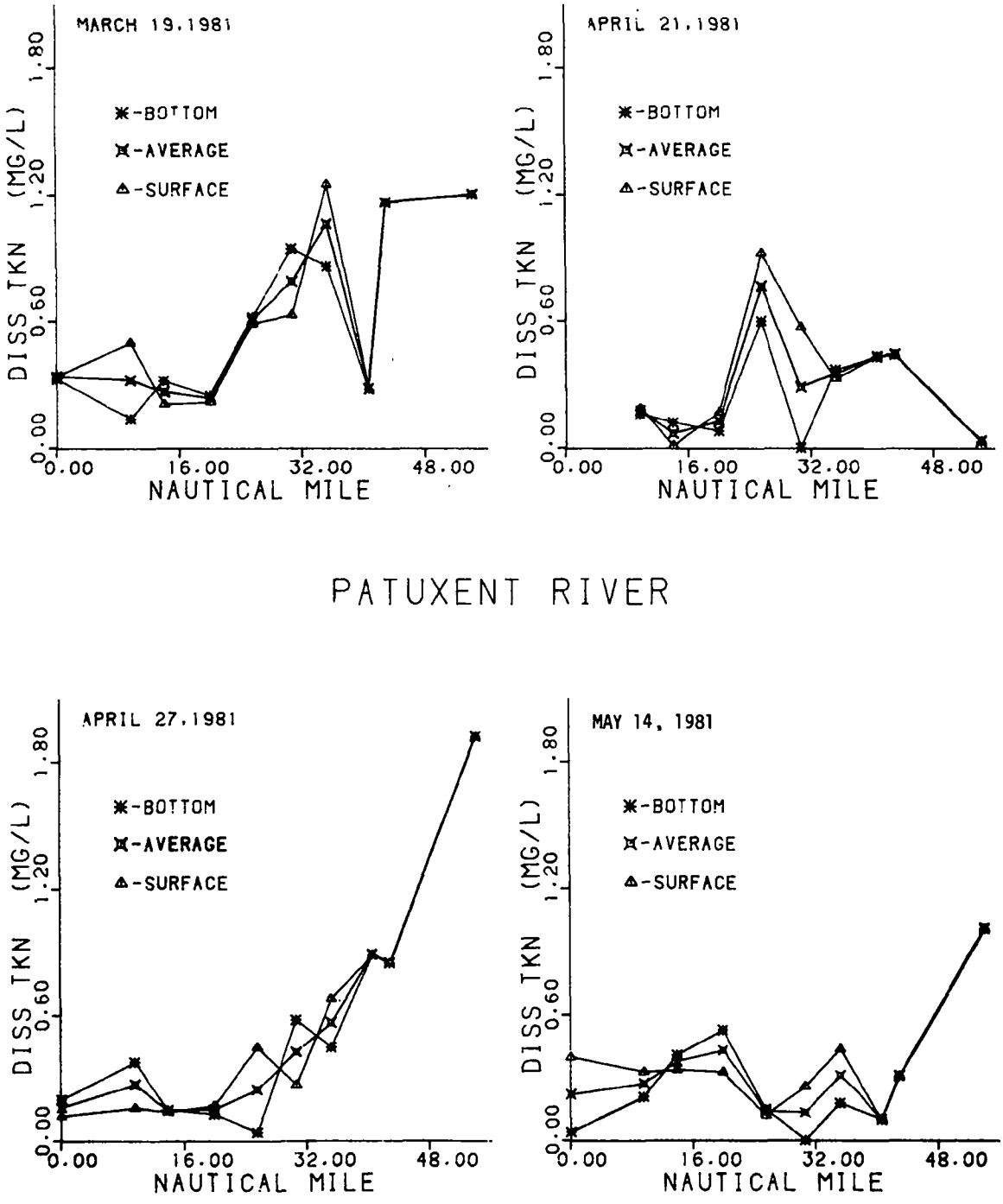
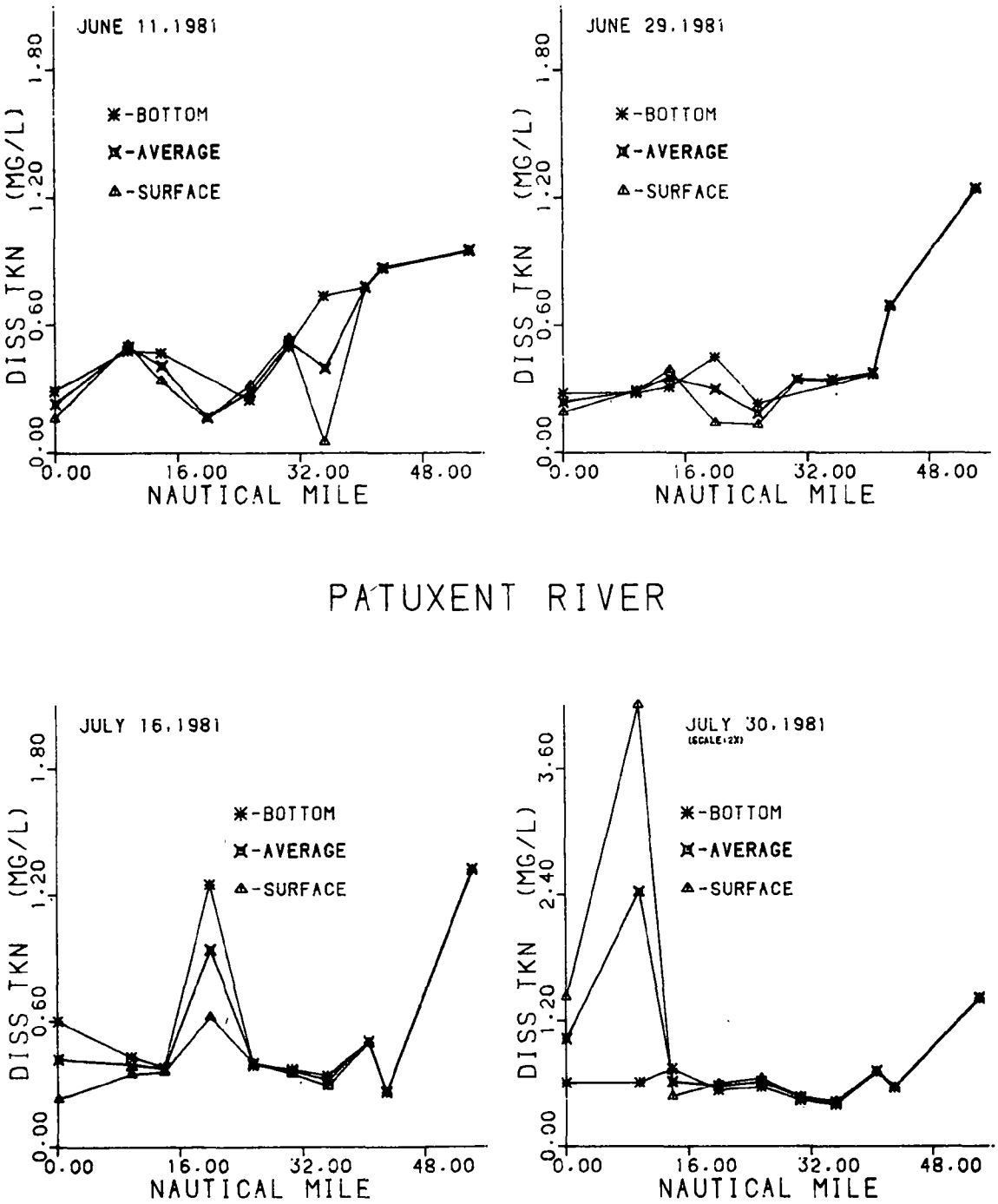
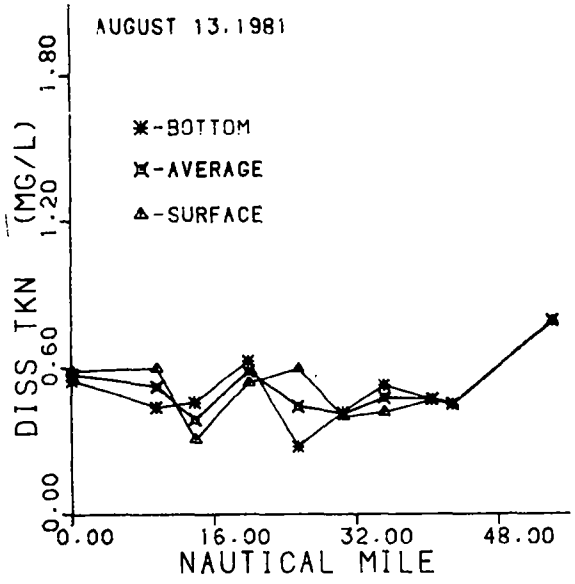


Figure 7-13 Patuxent river longitudinal plots of dissolved total kjeldhal nitrogen.



PATUXENT RIVER

Figure 7-13 Patuxent river longitudinal plots of dissolved total kjeldhal nitrogen.



PATUXENT RIVER

Figure 7-13 Patuxent river longitudinal plots of dissolved total kjeldhal nitrogen.

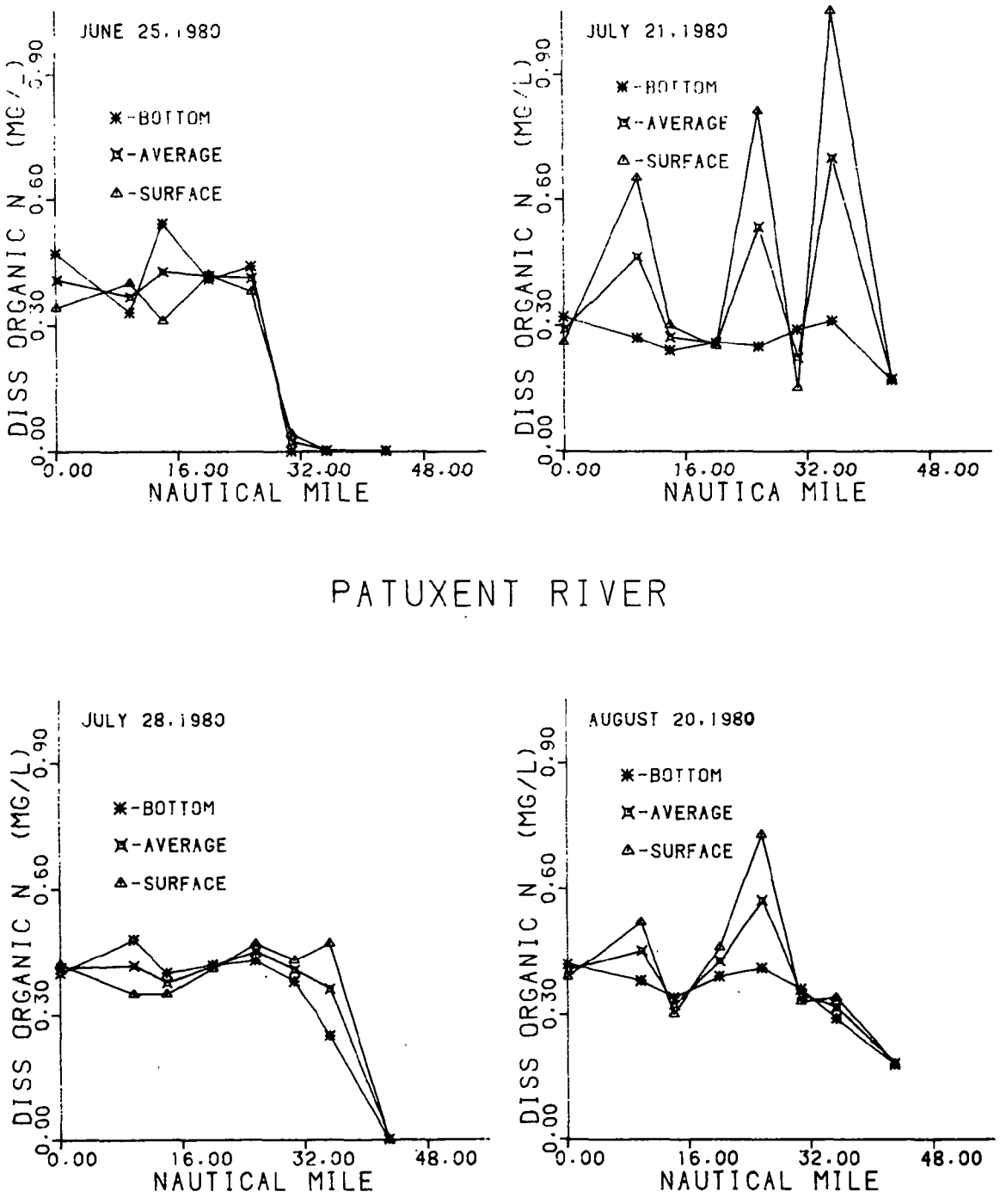


Figure 7-14Patuxent river longitudinal plots of dissolved organic nitrogen.

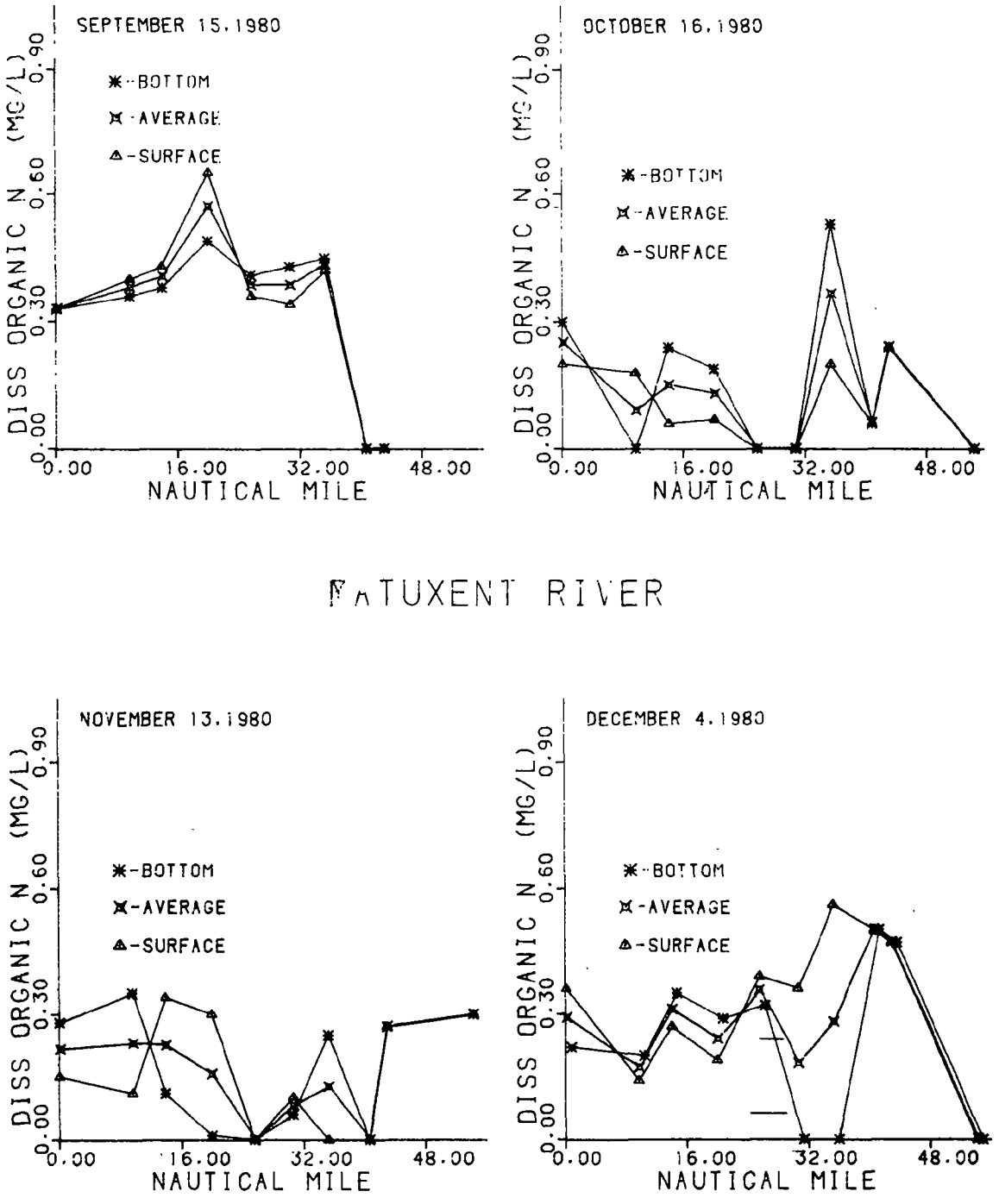


Figure7-14Patuxent river longitudinal plots of dissolved organic nitrogen.

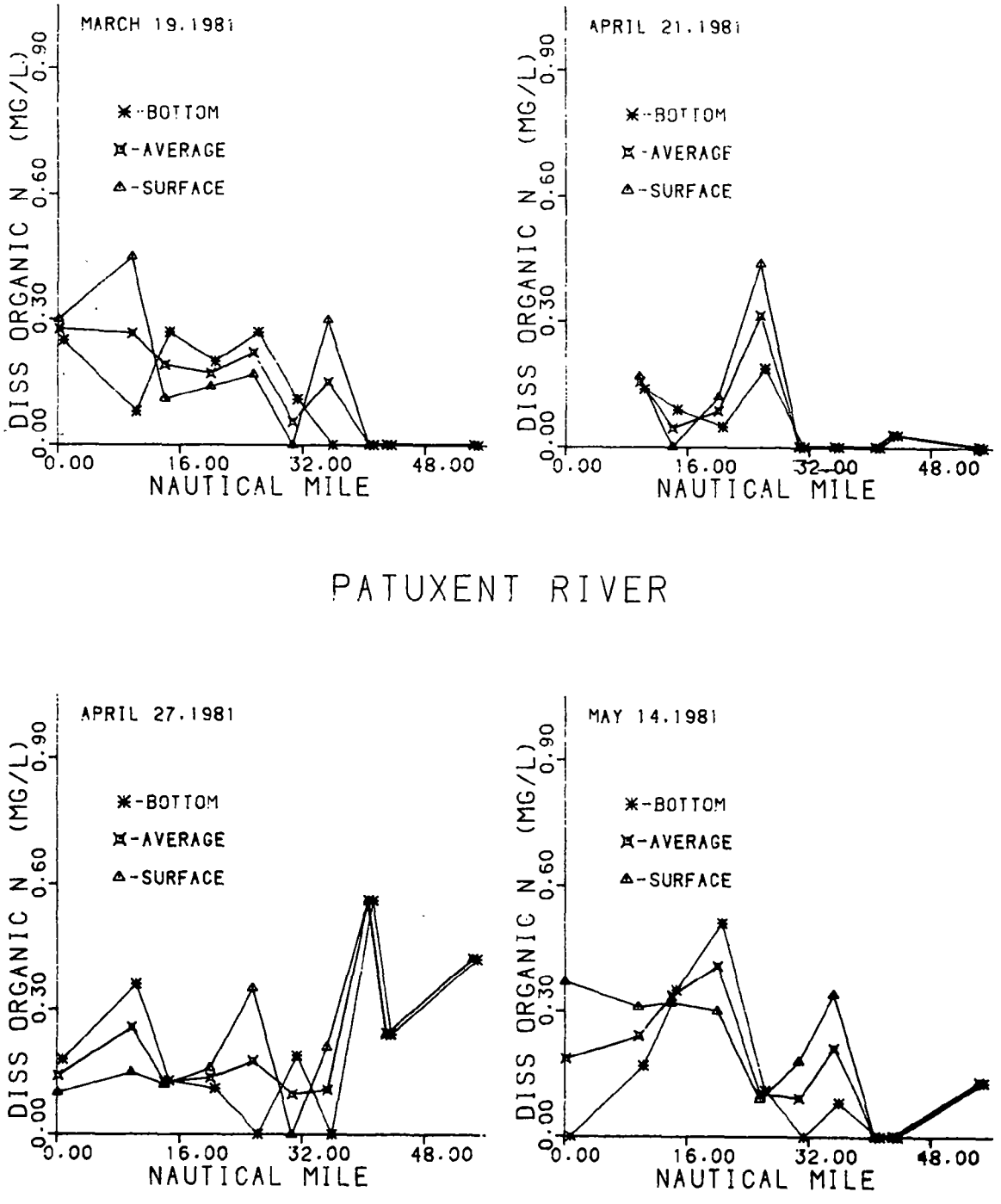
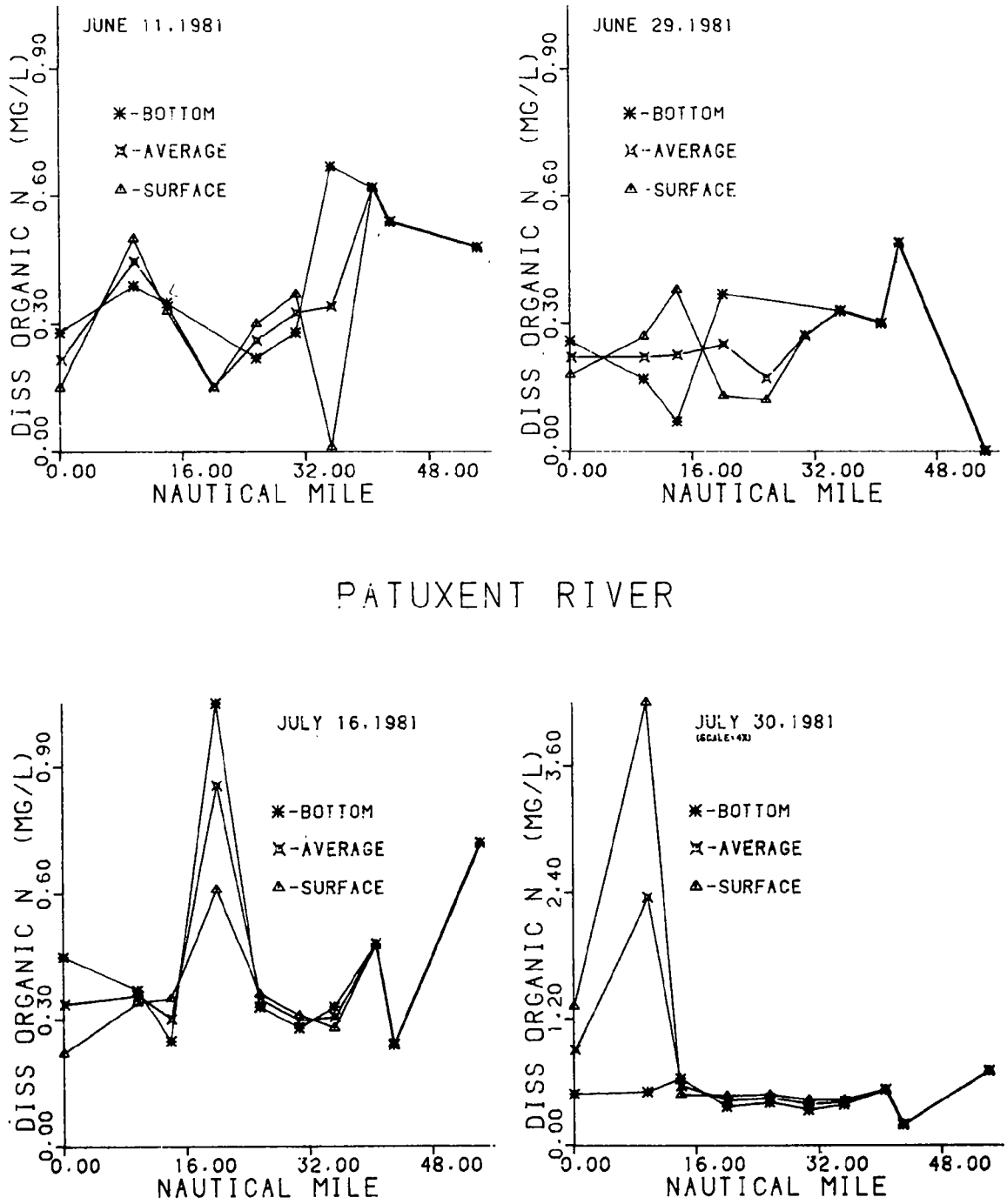
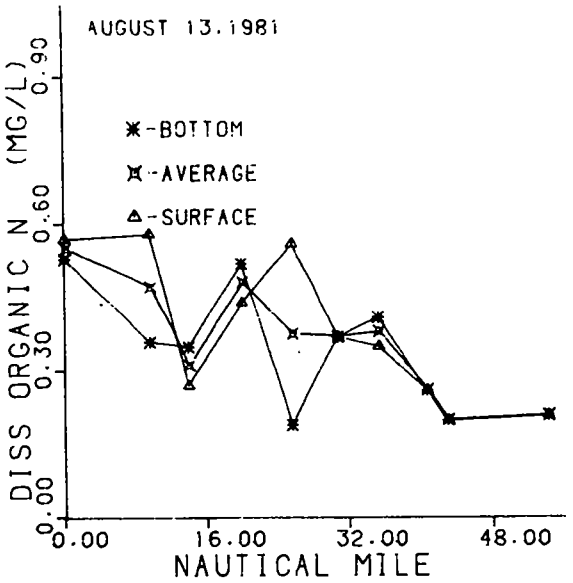


Figure 7-14 Patuxent river longitudinal plots of dissolved organic nitrogen.



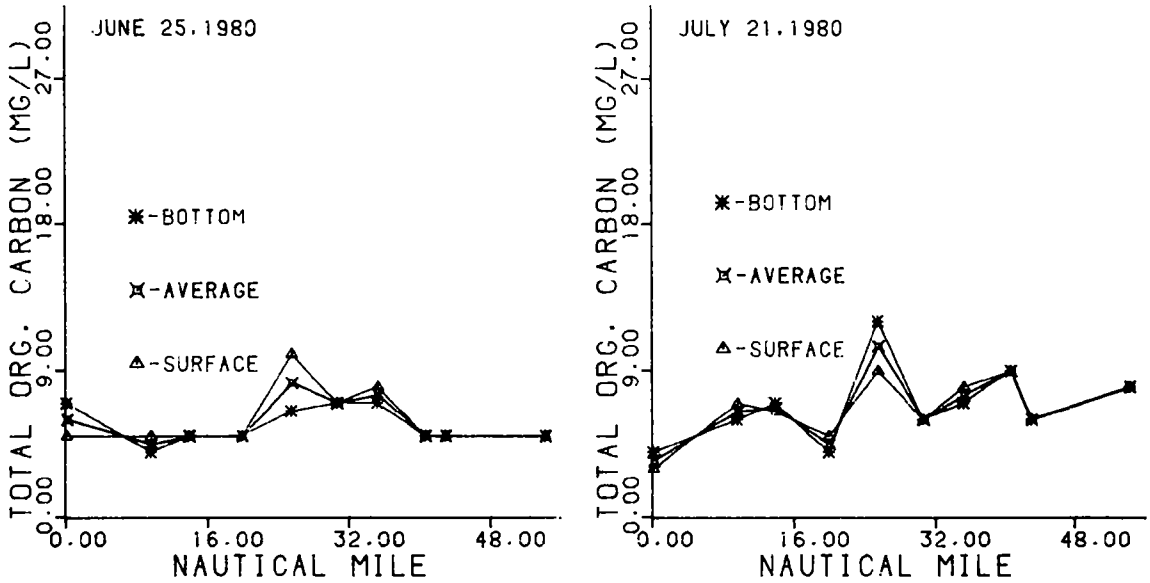
PATUXENT RIVER

Figure 7-14Patuxent river longitudinal plots of dissolved organic nitrogen.



PATUXENT RIVER

Figure 7-14 Patuxent river longitudinal plots of dissolved organic nitrogen.



PATUXENT RIVER

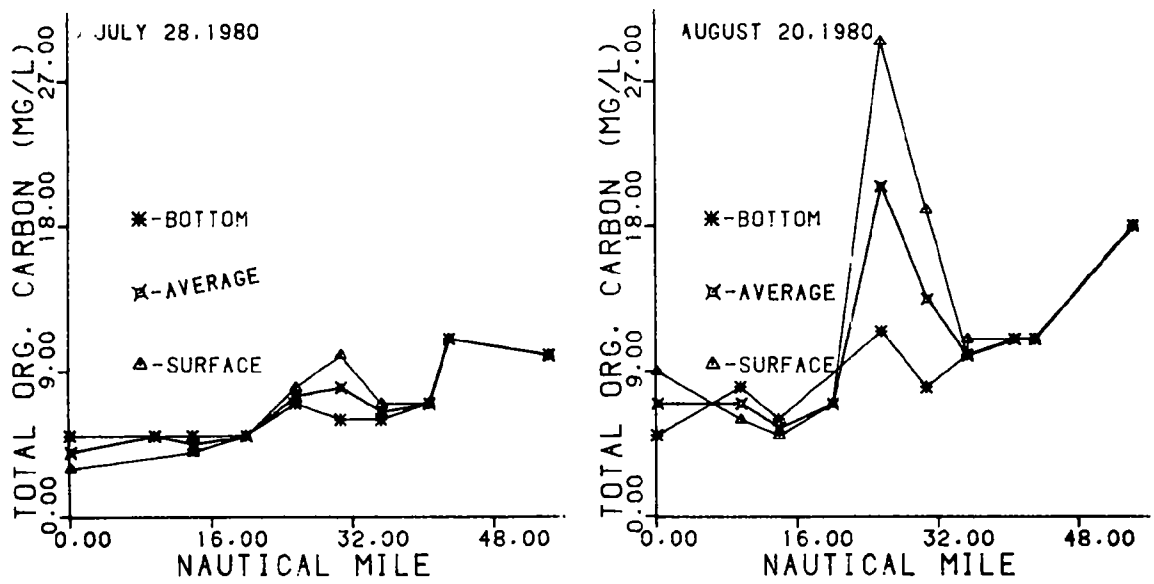
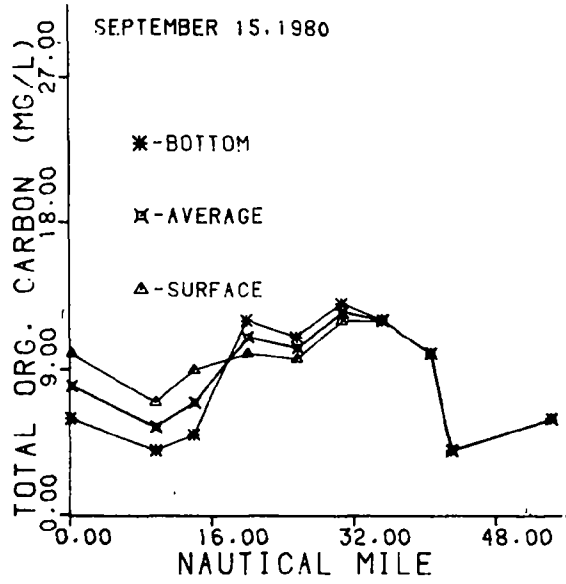
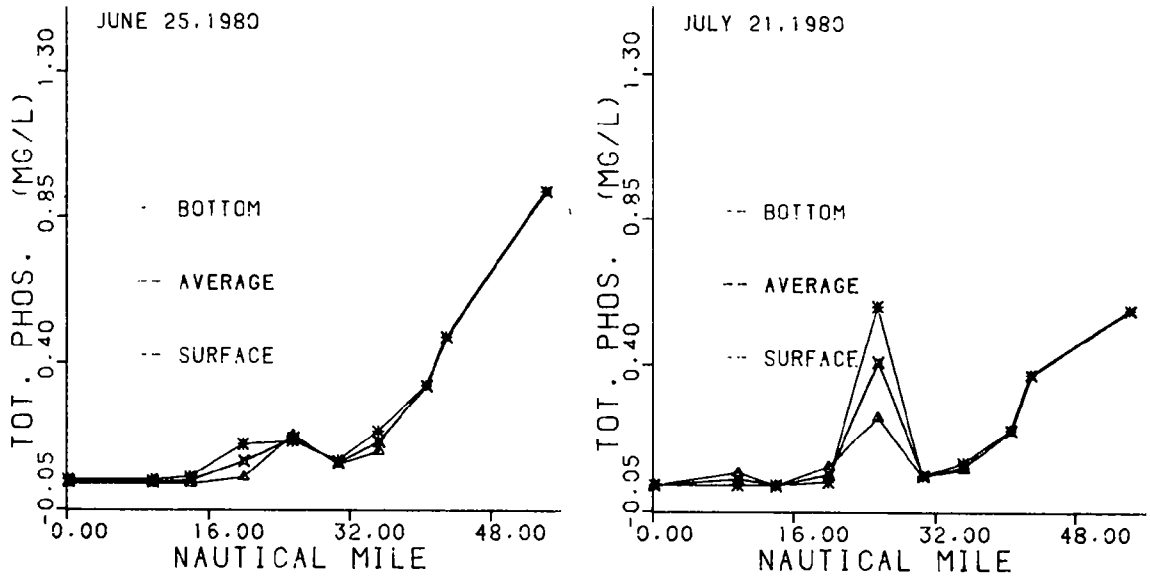


Figure 7-15 Patuxent river longitudinal plots of total organic carbon.



PATUXENT RIVER

Figure 7-15Patuxent river longitudinal plots of total organic carbon.



PATUXENT RIVER

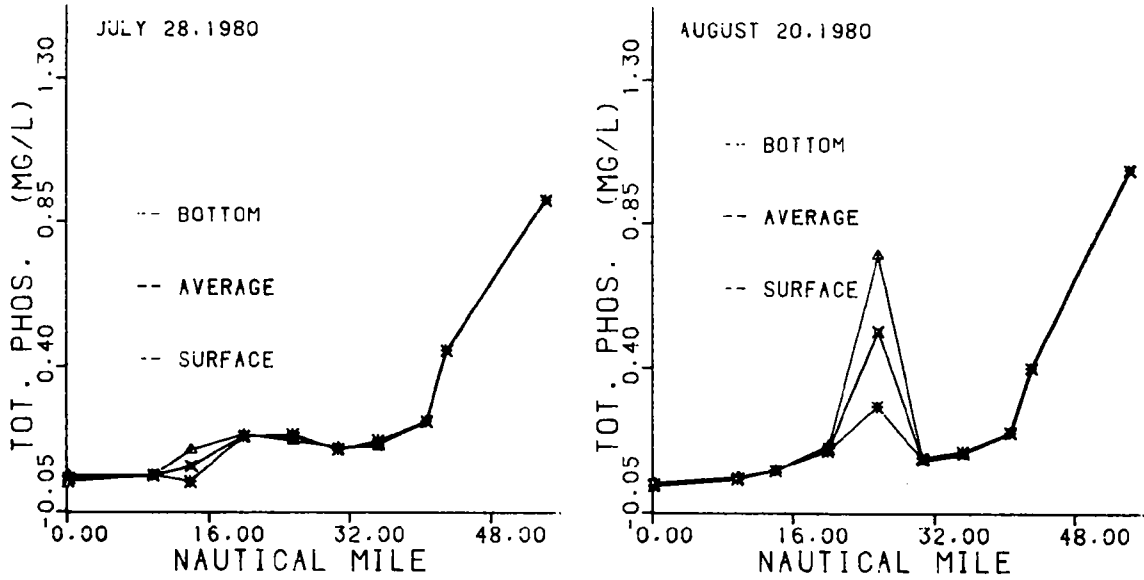


Figure 7-16 Patuxent River Slack Survey Plots of Total Phosphorus

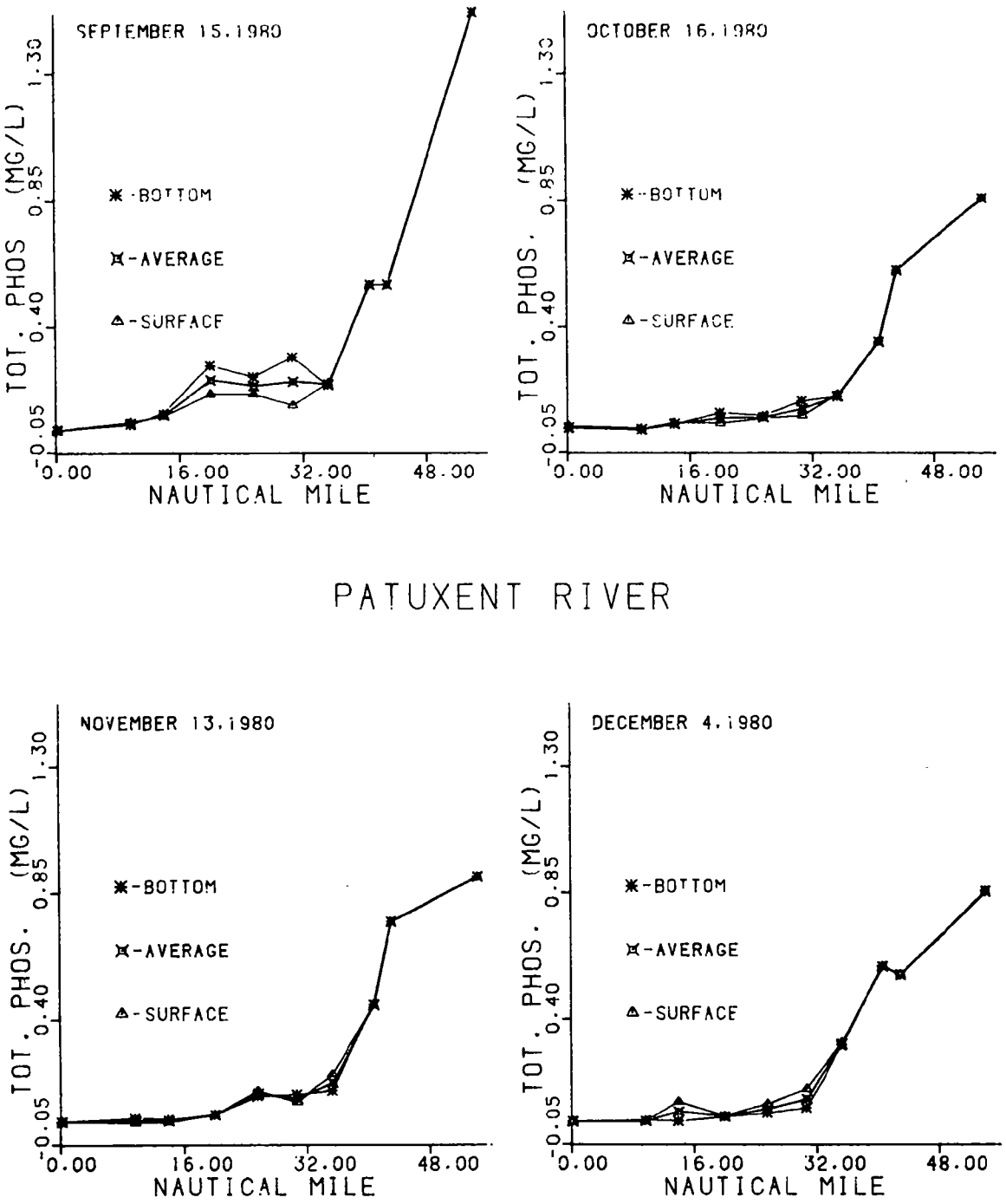
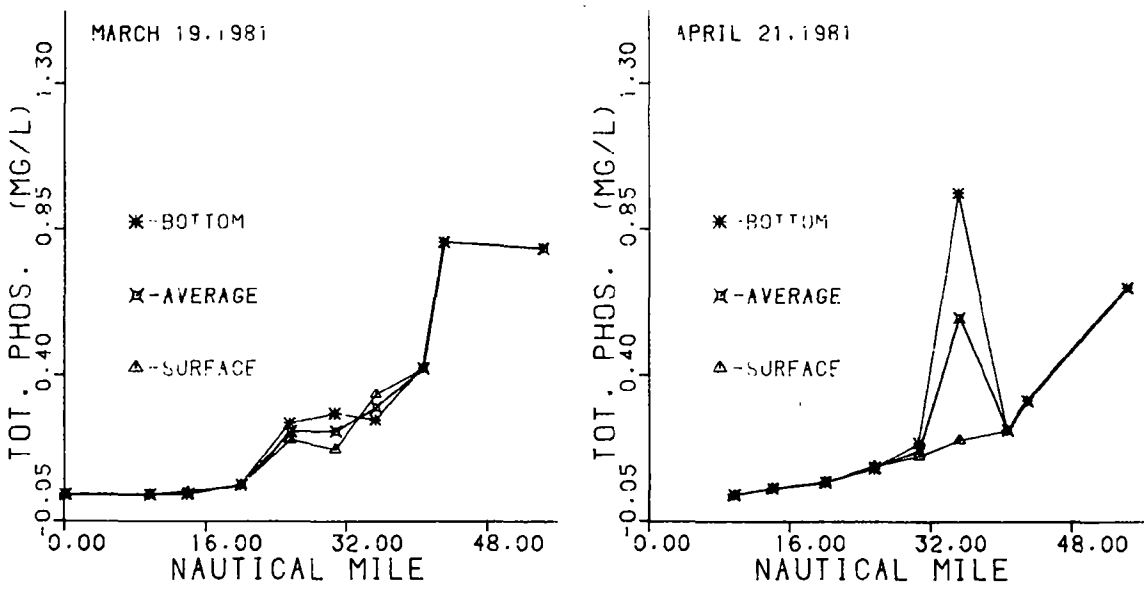


Figure 7-16 Patuxent River Slack Survey Plots of Total Phosphorus



PATUXENT RIVER

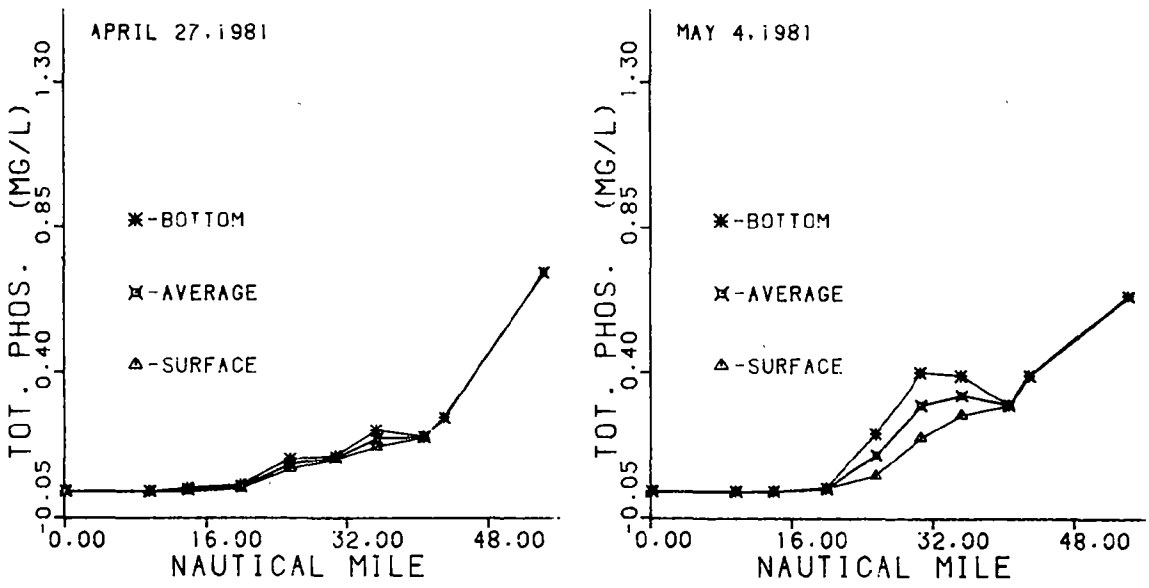


Figure 7-16Patuxent River Slack Survey Plots of Total Phosphorus

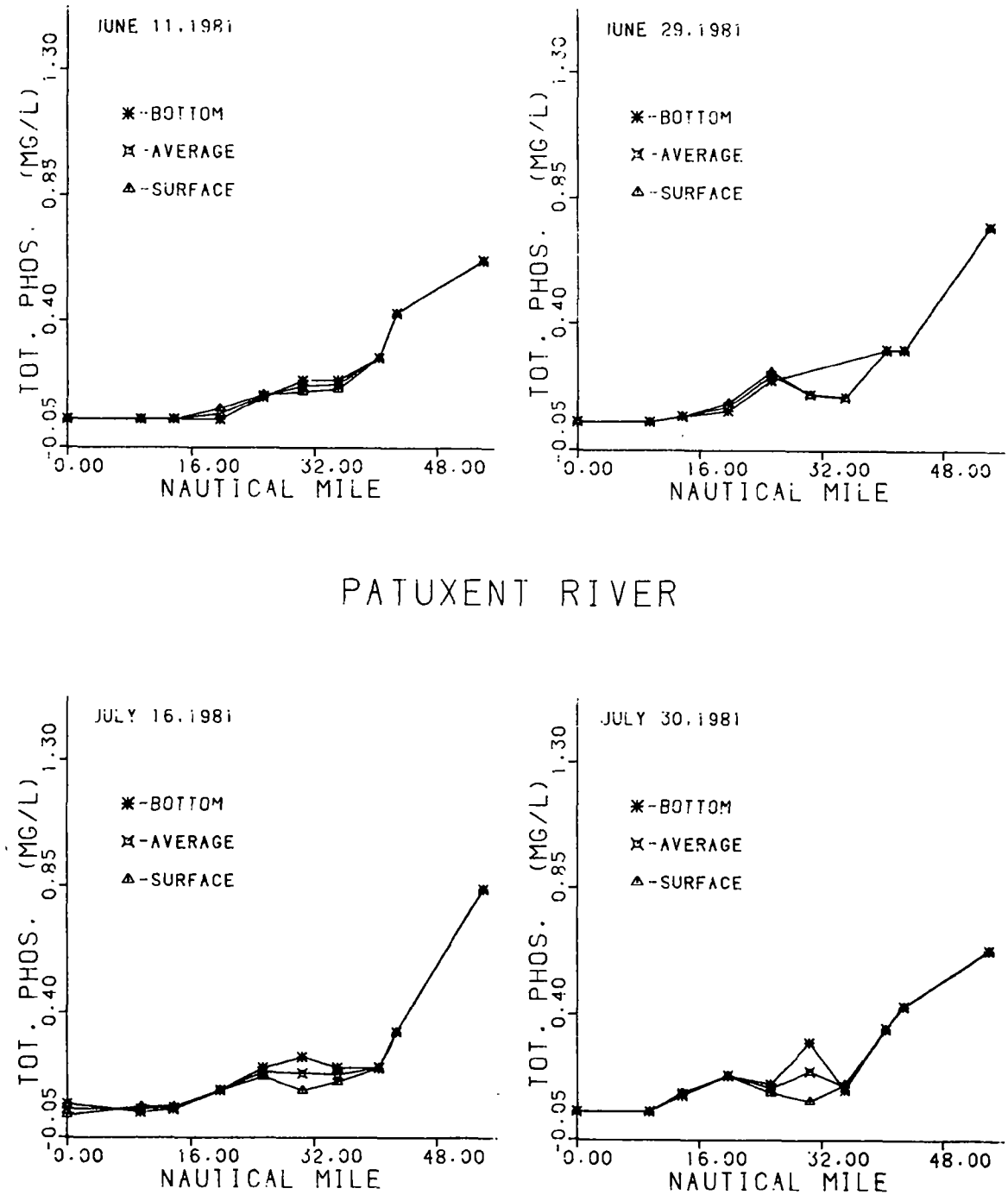
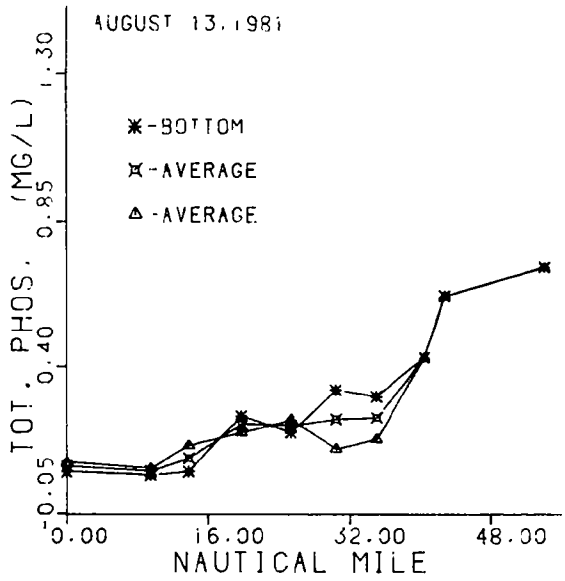


Figure 7-16 Patuxent River Slack Survey Plots of Total Phosphorus



PATUXENT RIVER

Figure7-16 Patuxent River Slack Survey Plots of Total Phosphorus

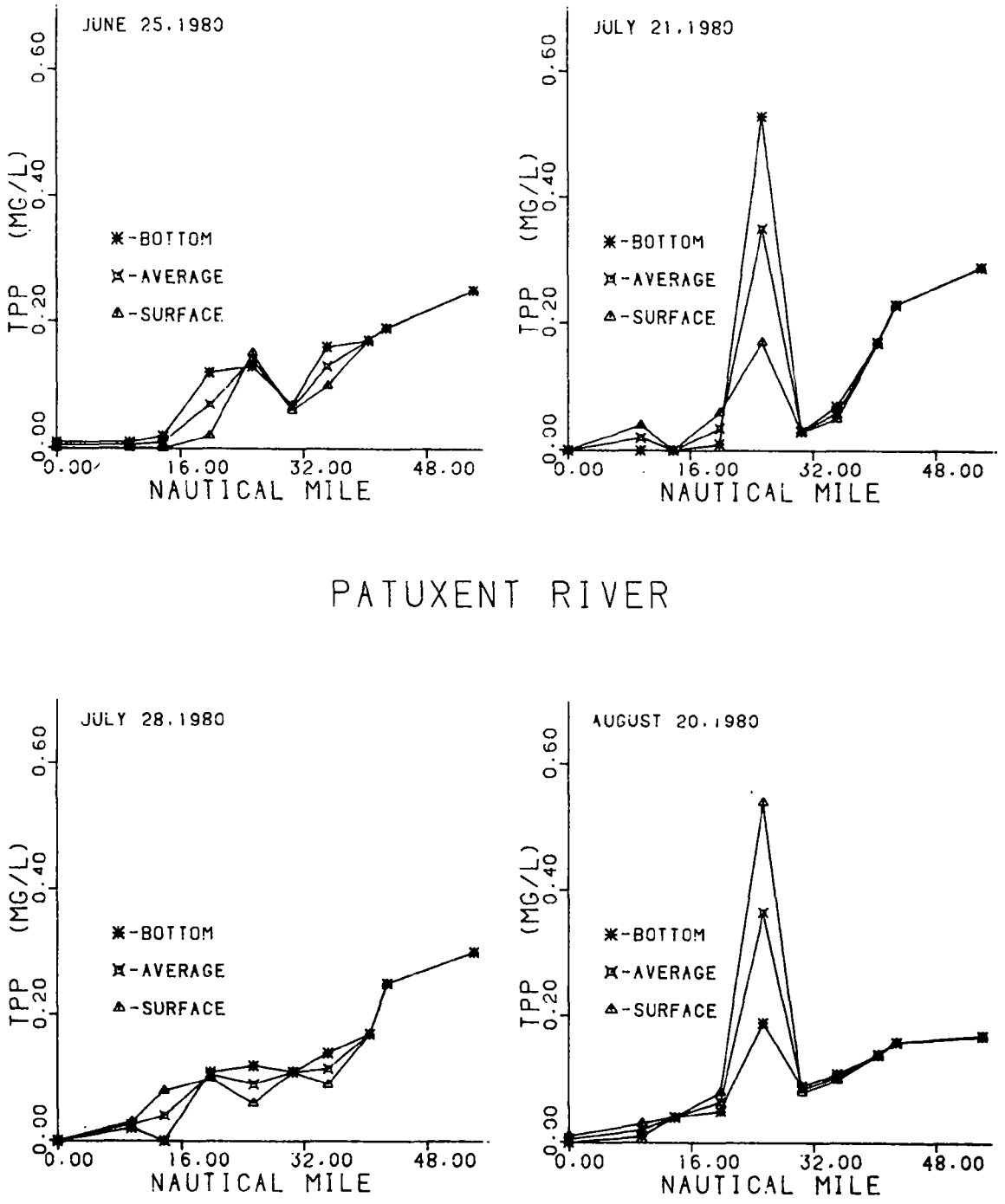


Figure 7-17 Patuxent river longitudinal plots of total particulate phosphorus.

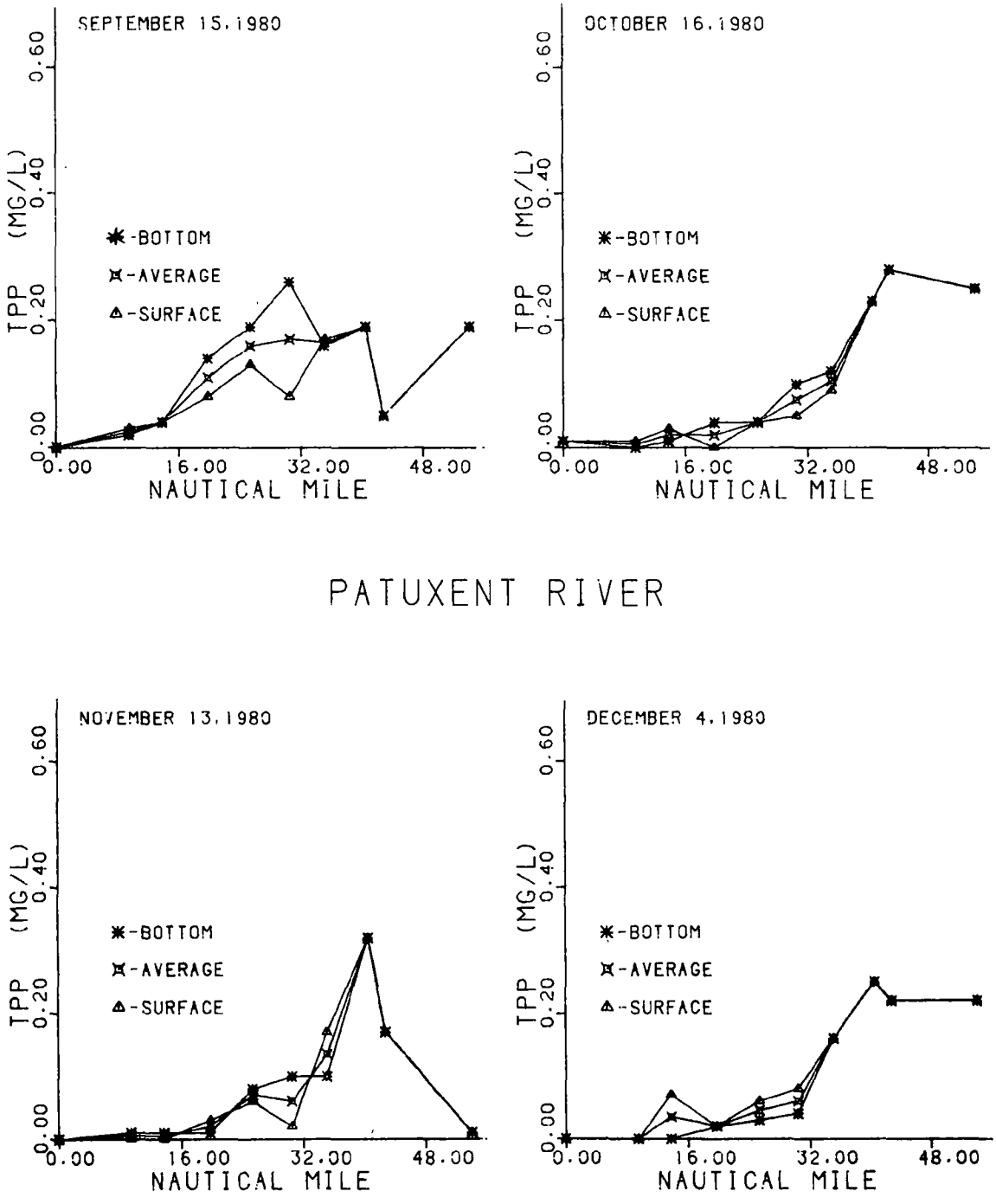


Figure 7-17Patuxent river longitudinal plots of total particulate phosphorus.

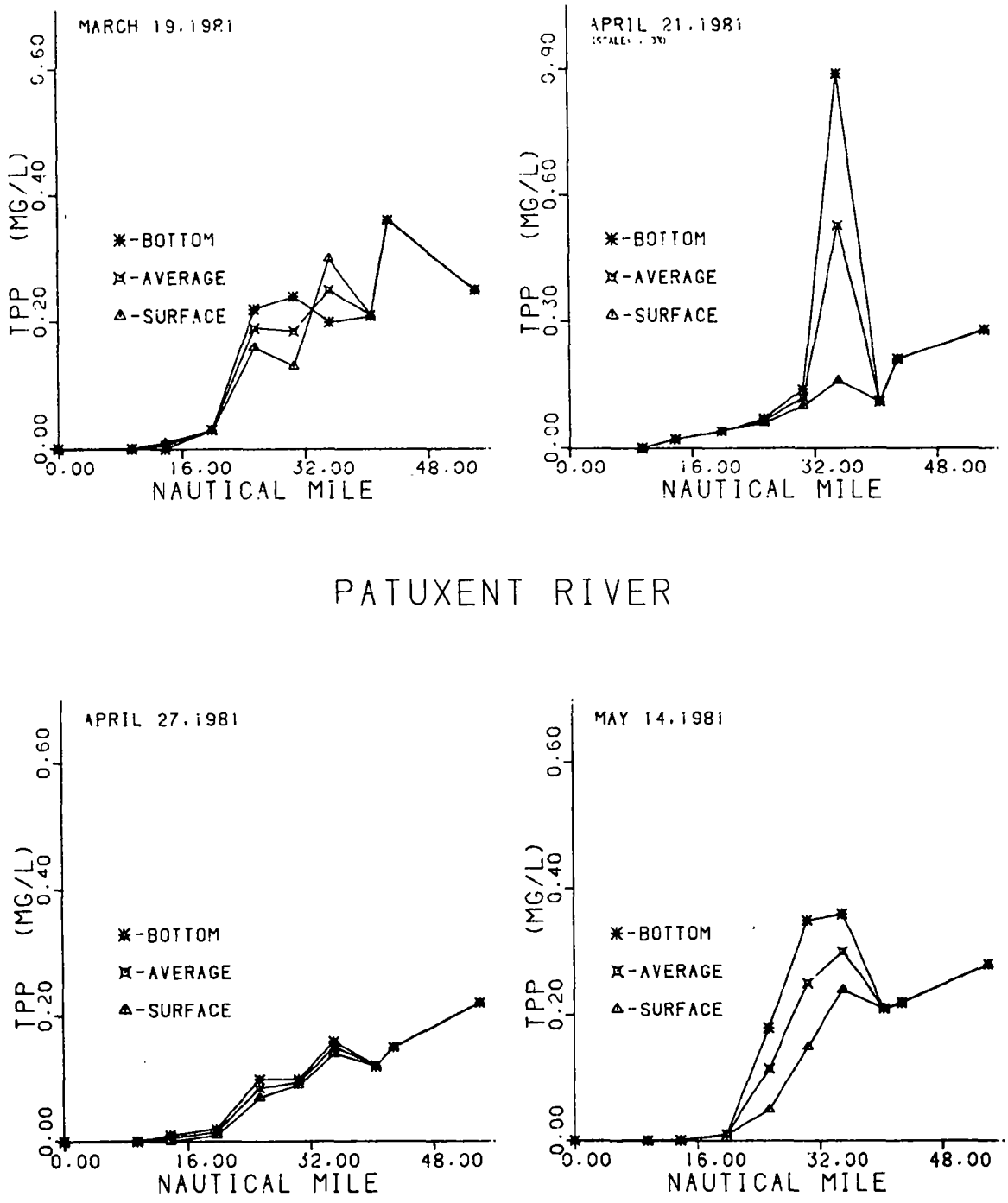
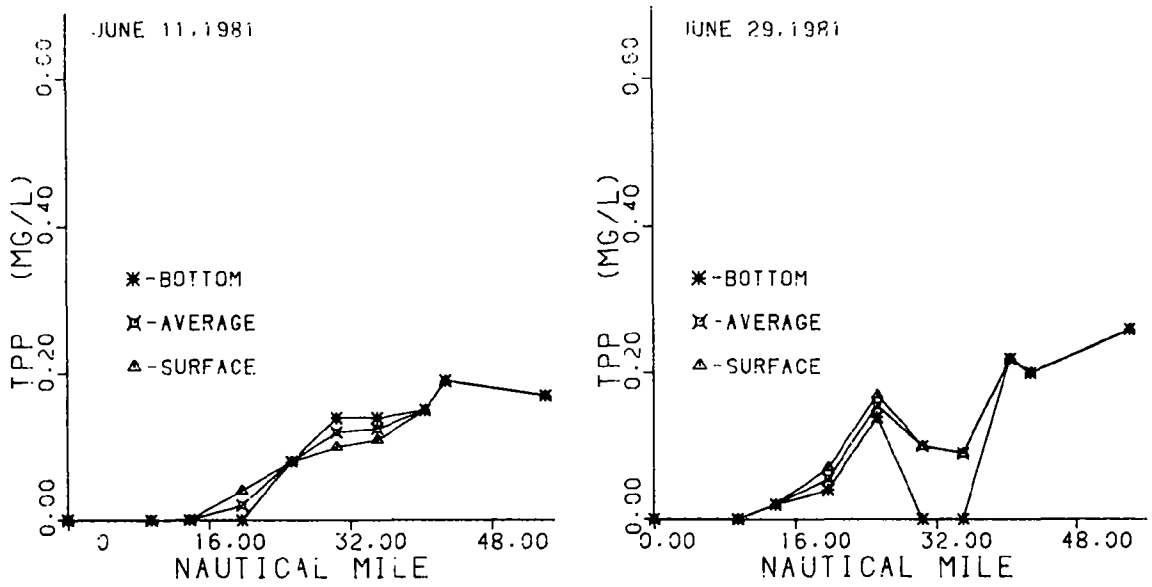


Figure 7-17 Patuxent river longitudinal plots of total particulate phosphorus.



PATUXENT RIVER

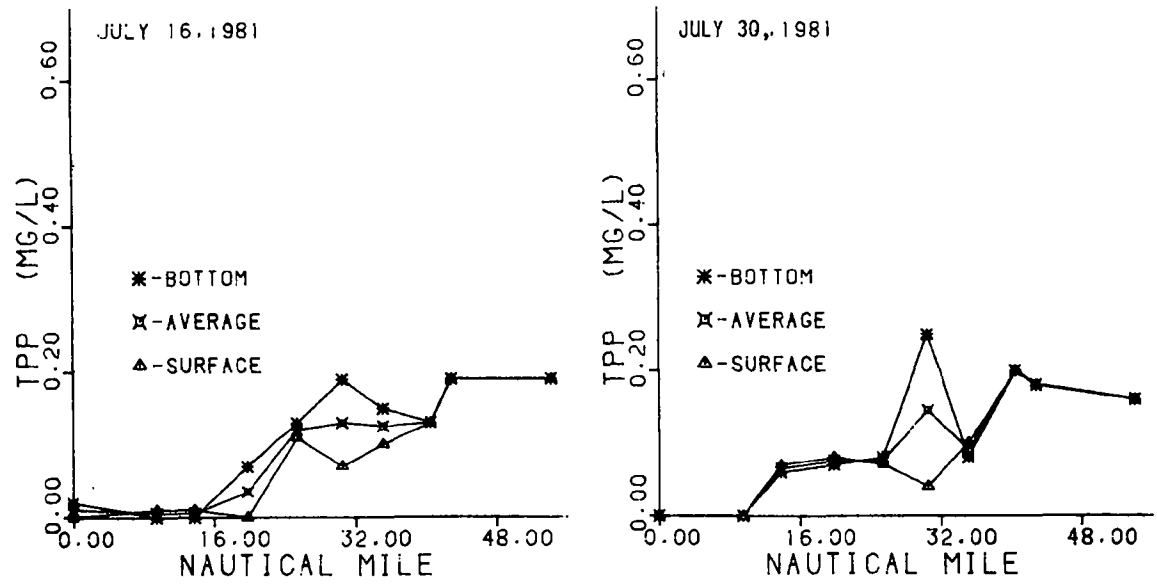
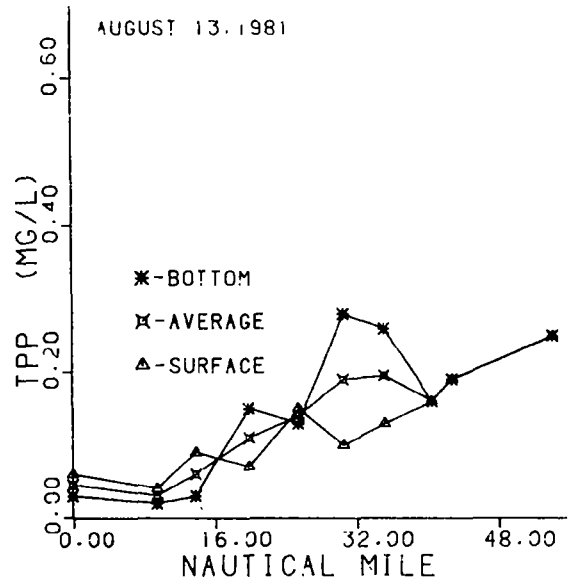


Figure 7-17Patuxent river longitudinal plots of total particulate phosphorus.



PATUXENT RIVER

Figure 7-17 Patuxent river longitudinal plots of total particulate phosphorus.

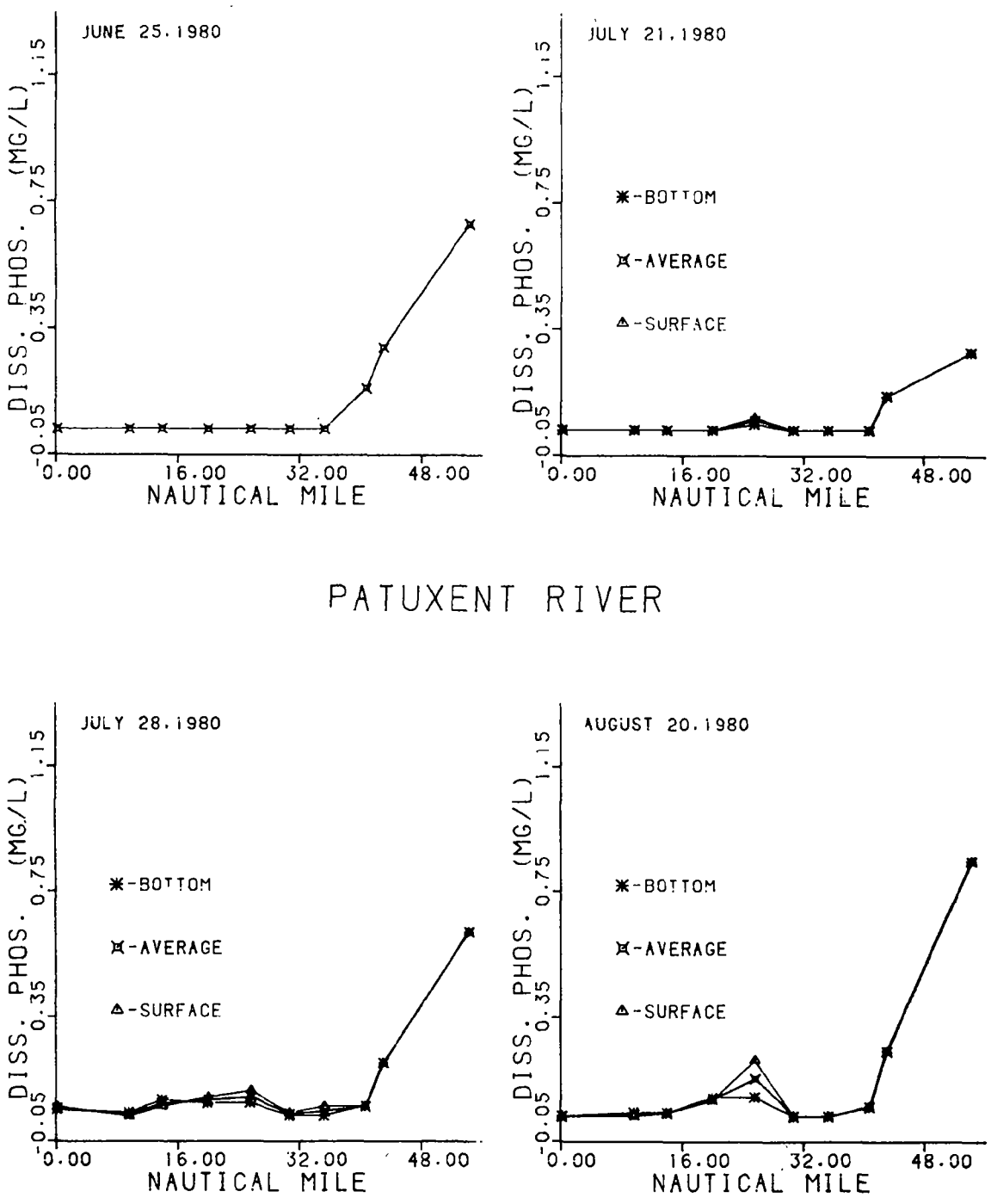
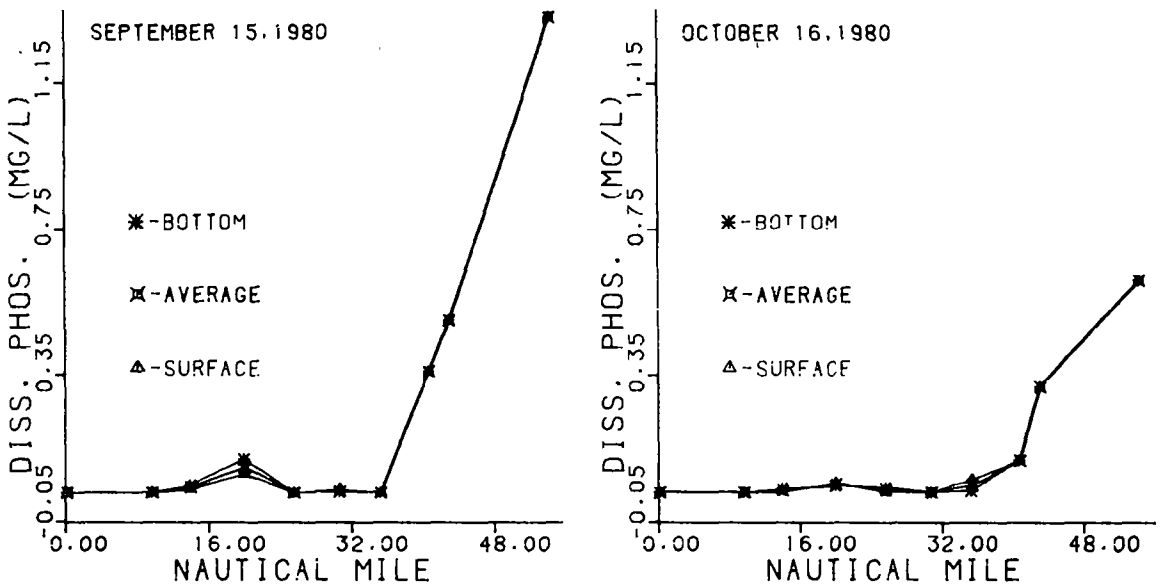


Figure 7-18Patuxent River Slack Survey Plots of Dissolved Phosphorus



PATUXENT RIVER

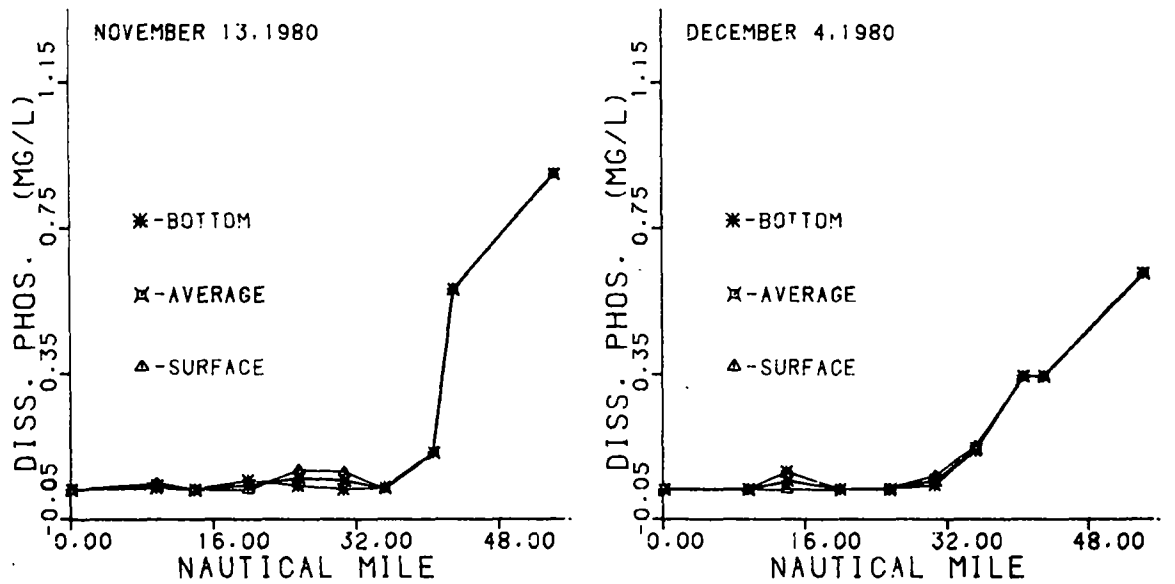


Figure 7-18 Patuxent River Slack Survey Plots of Dissolved Phosphorus

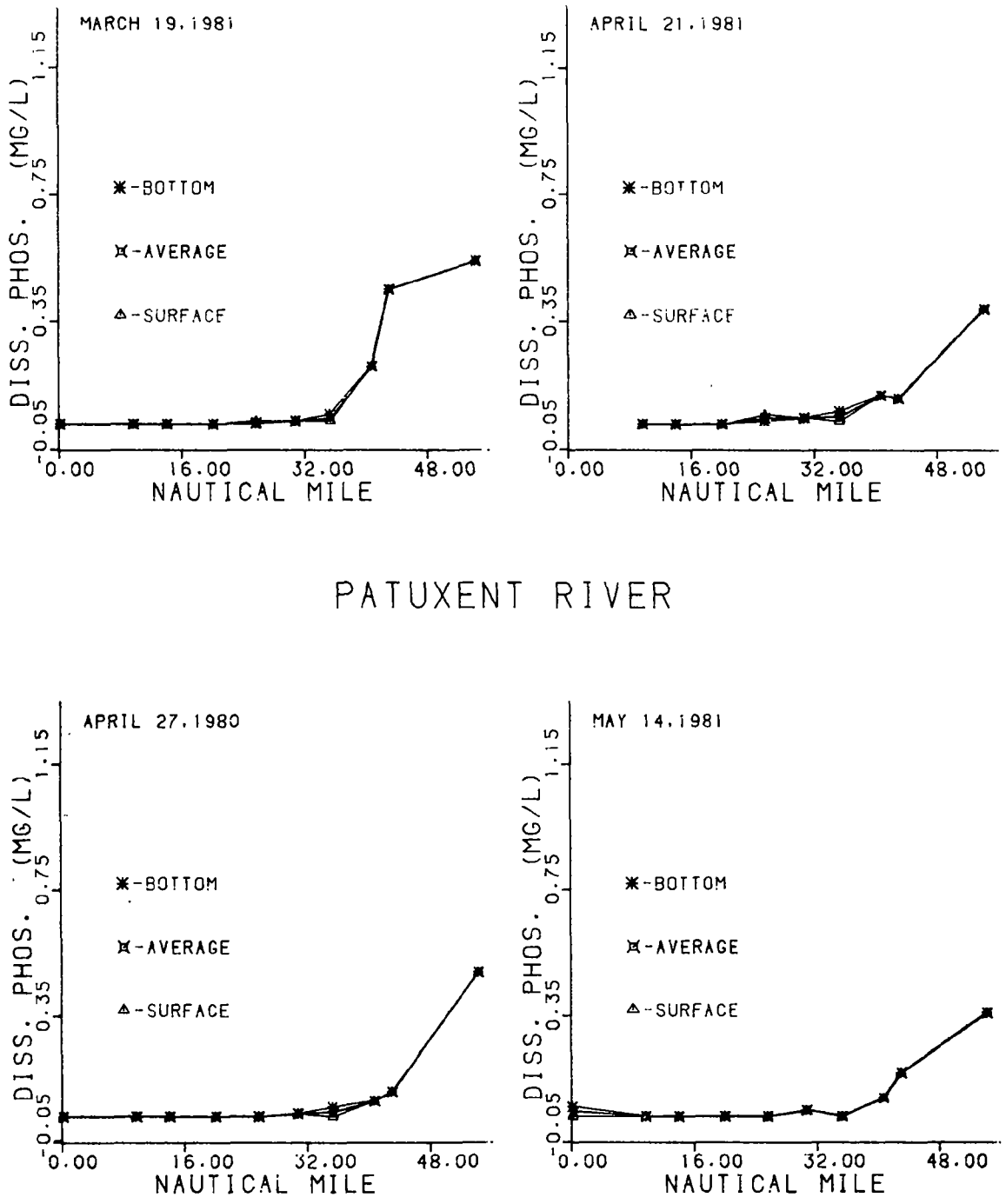
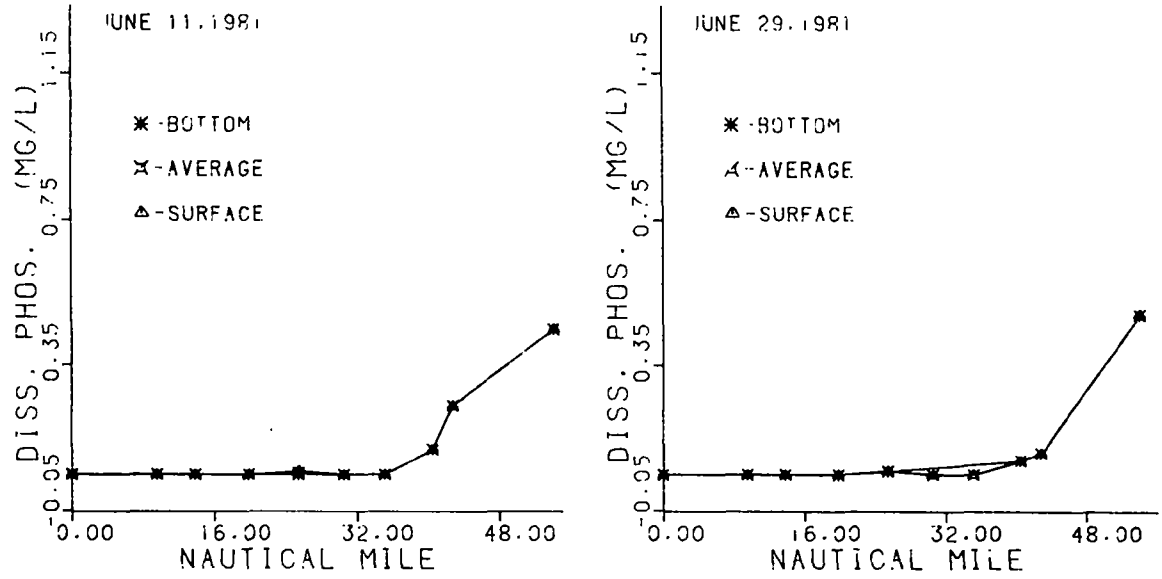


Figure 7-18Patuxent River Slack Survey Plots of Dissolved Phosphorus



PATUXENT RIVER

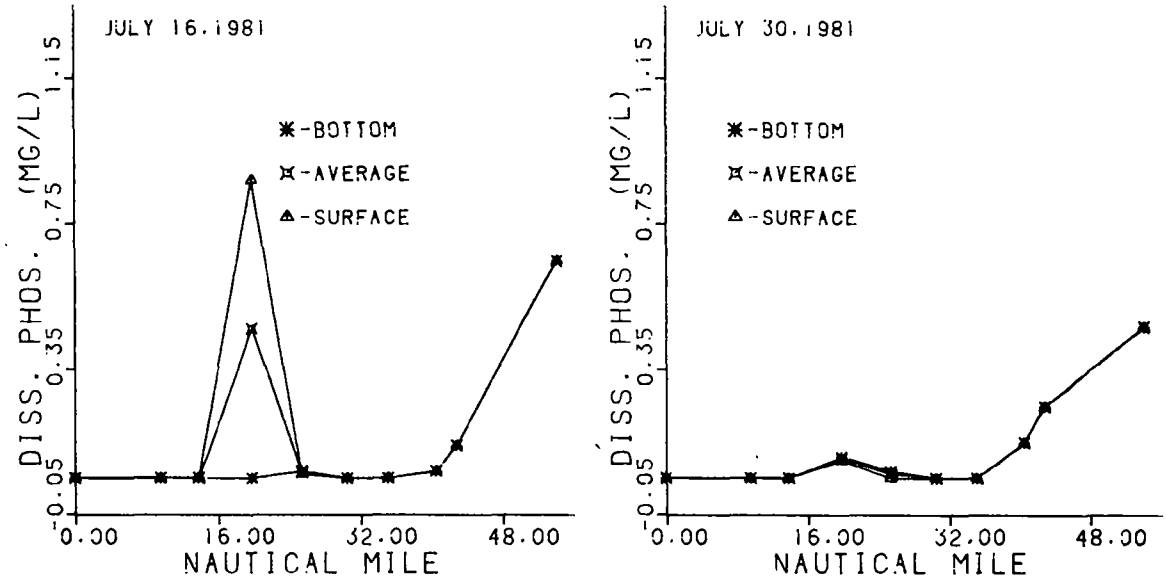
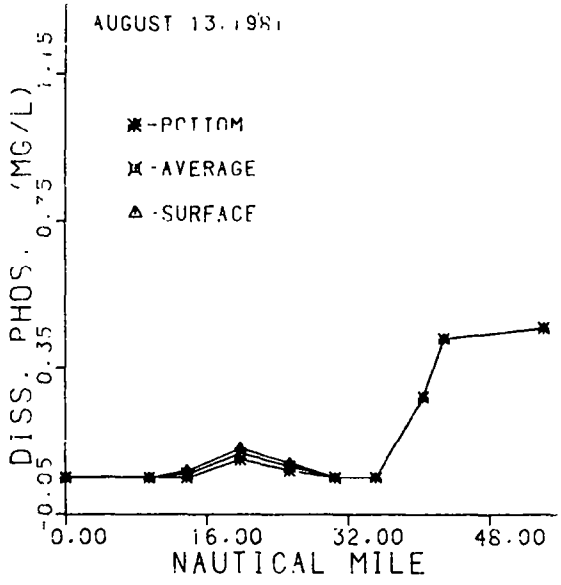
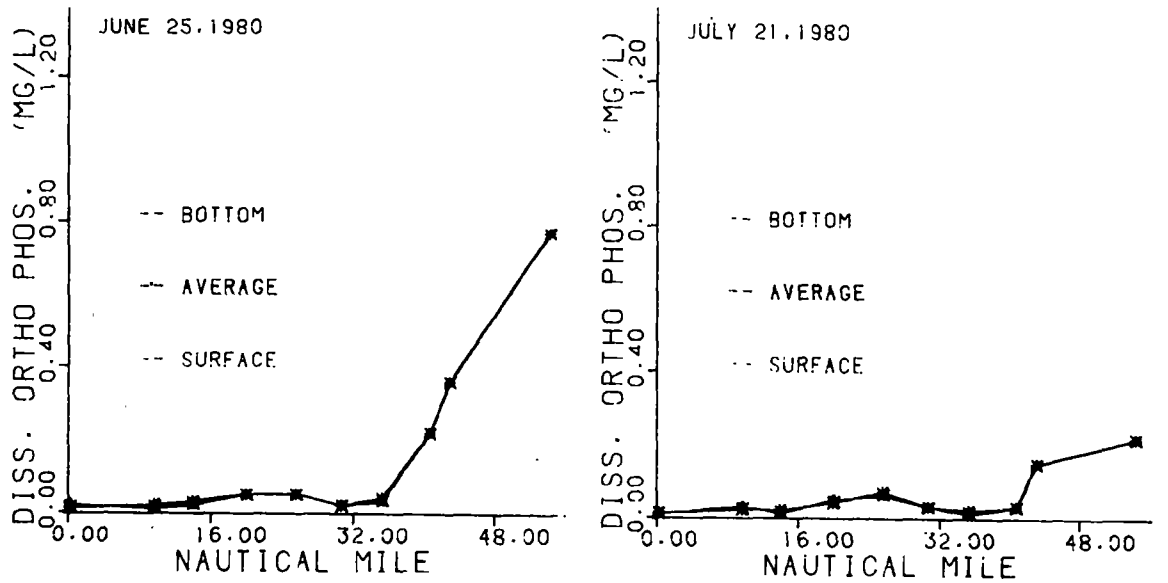


Figure 7-18Patuxent River Slack Survey Plots of Dissolved Phosphorus



PATUXENT RIVER

Figure 7-18 Patuxent River Slack Survey Plots of Dissolved Phosphorus



PATUXENT RIVER

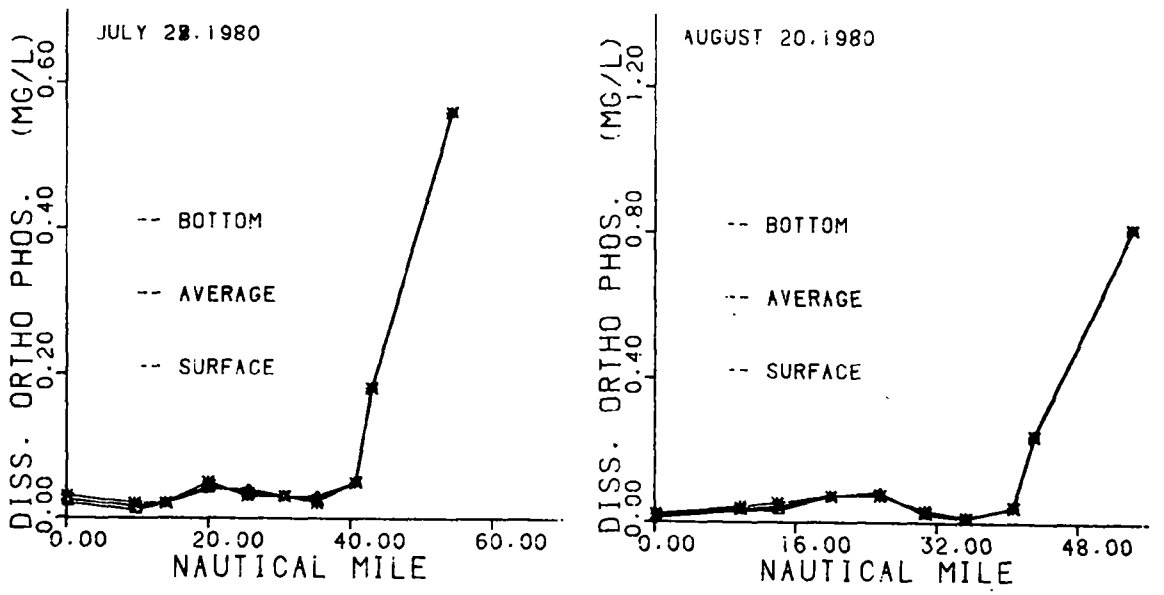
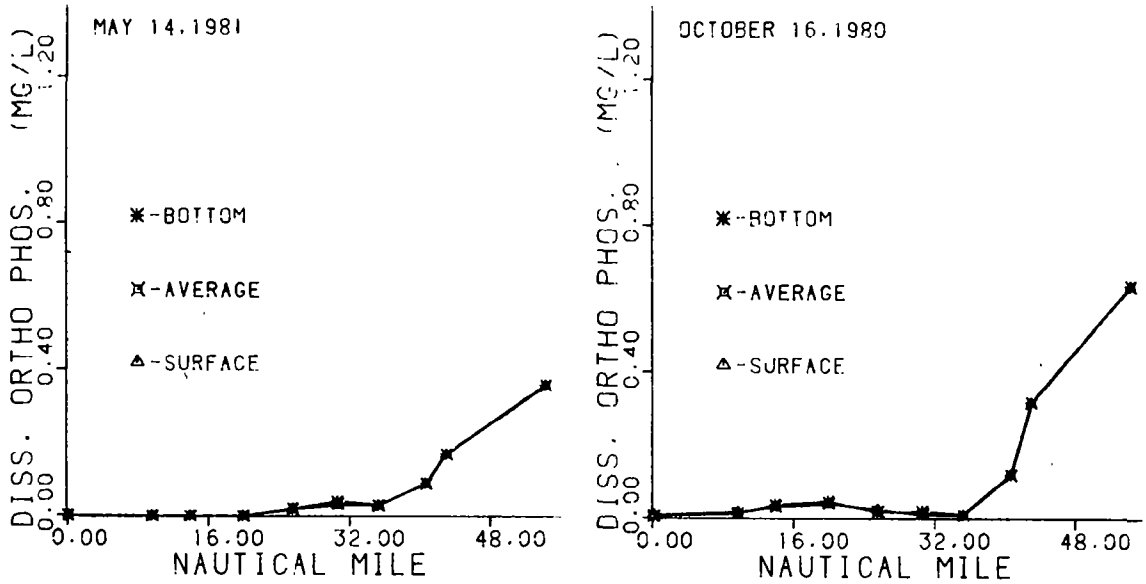


Figure 7-19 Patuxent River Slack Survey Plots of Dissolved Ortho-Phosphorus



PATUXENT RIVER

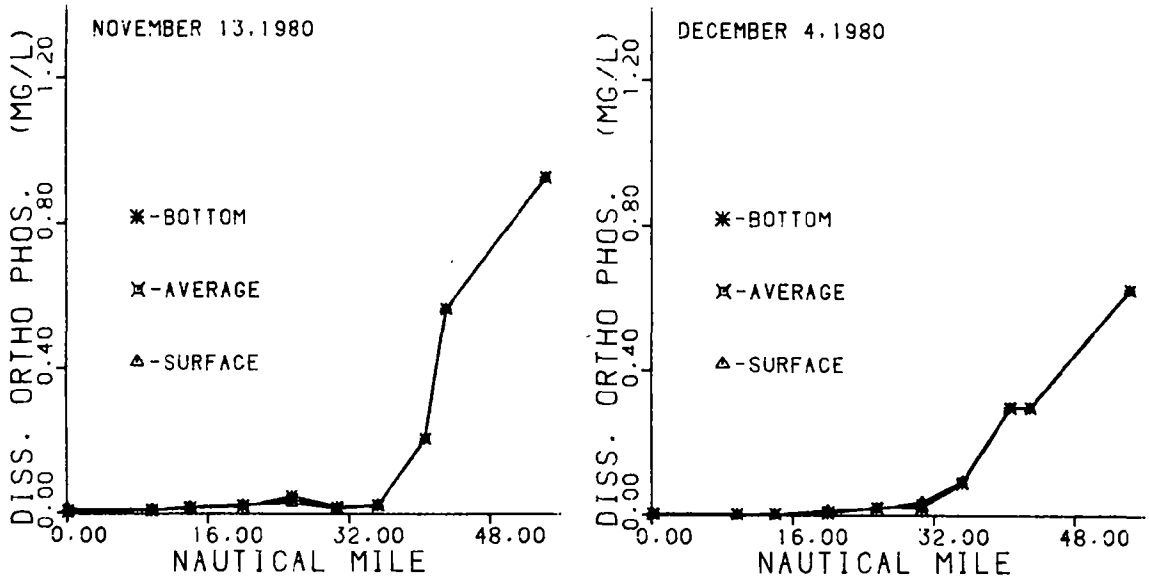


Figure 7-19 Patuxent River Slack Survey Plots of Dissolved Ortho-Phosphorus

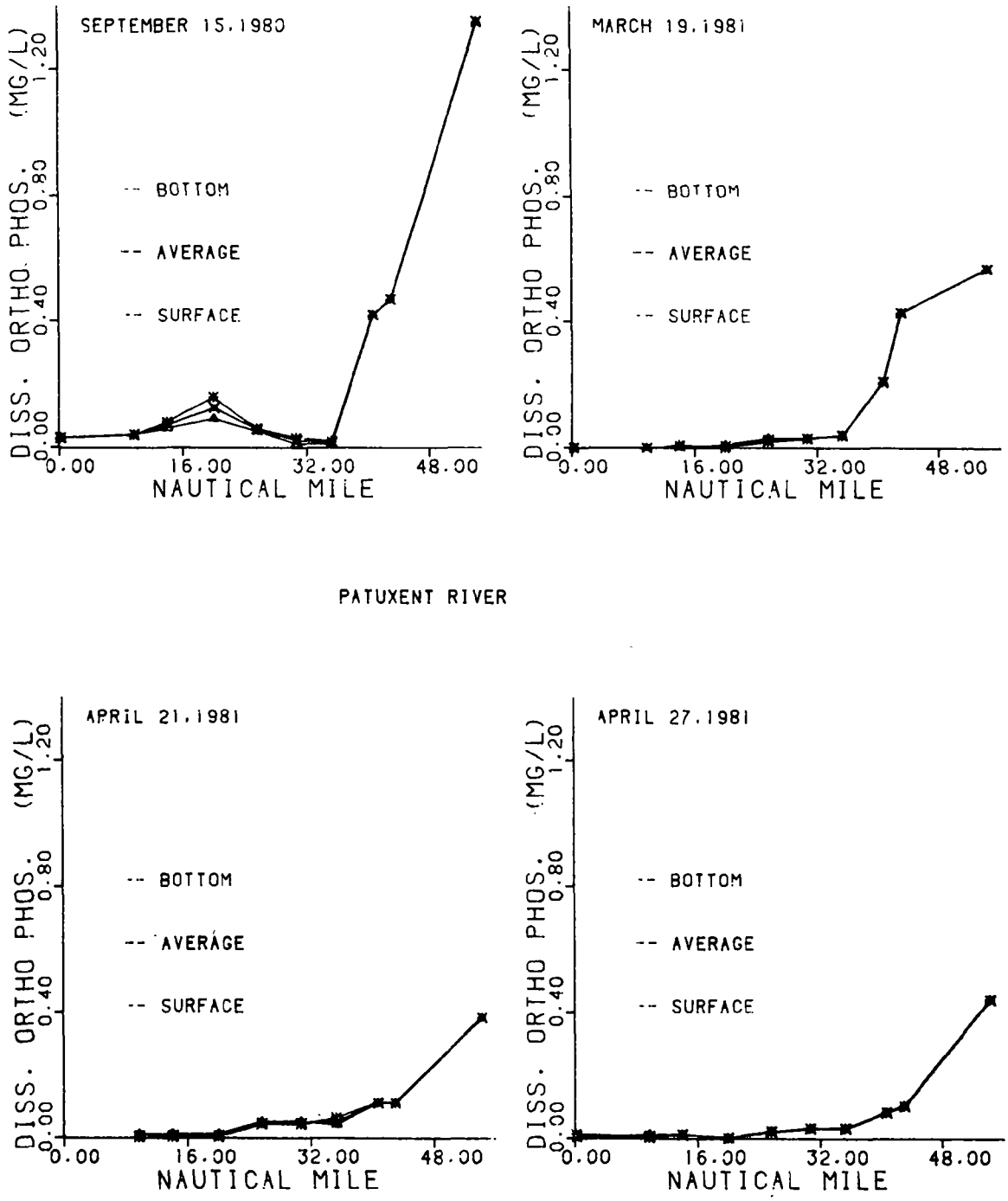
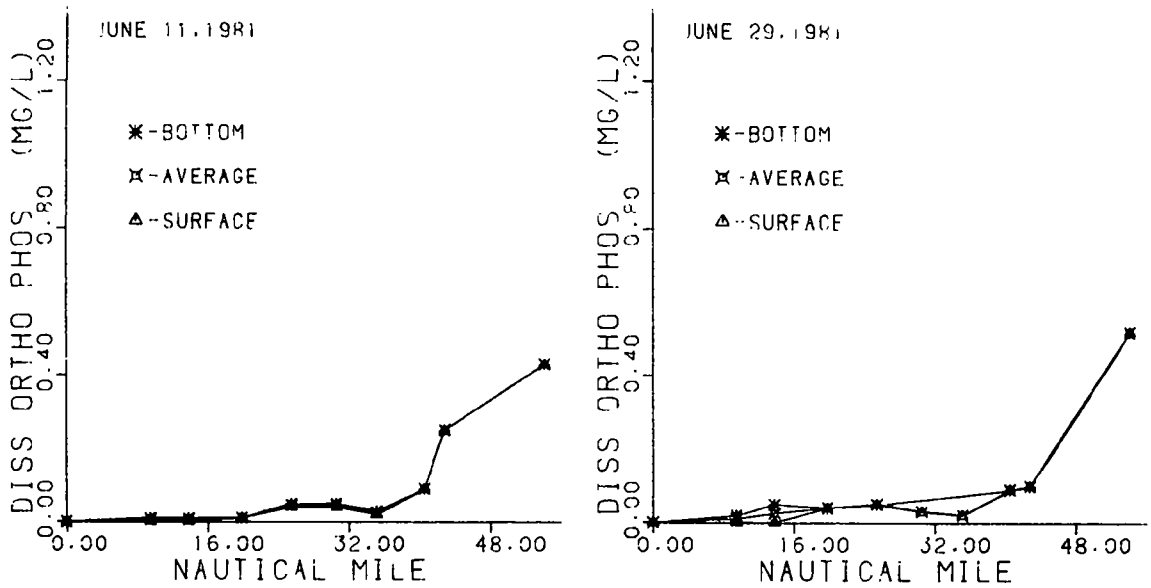


Figure 7-19 Patuxent River Slack Survey Plots of Dissolved Ortho-Phosphorus



PATUXENT RIVER

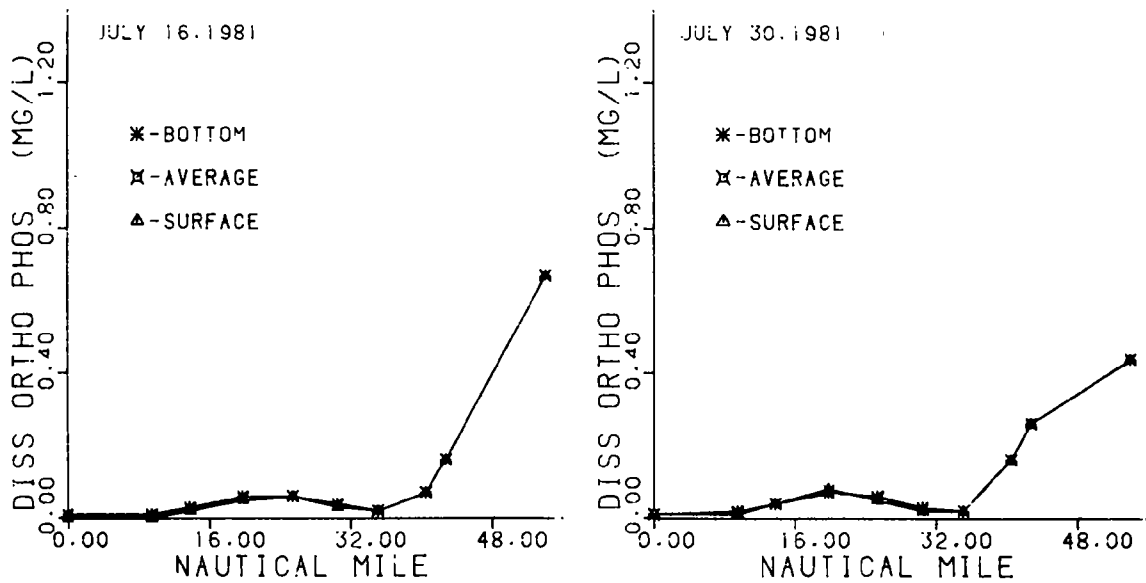
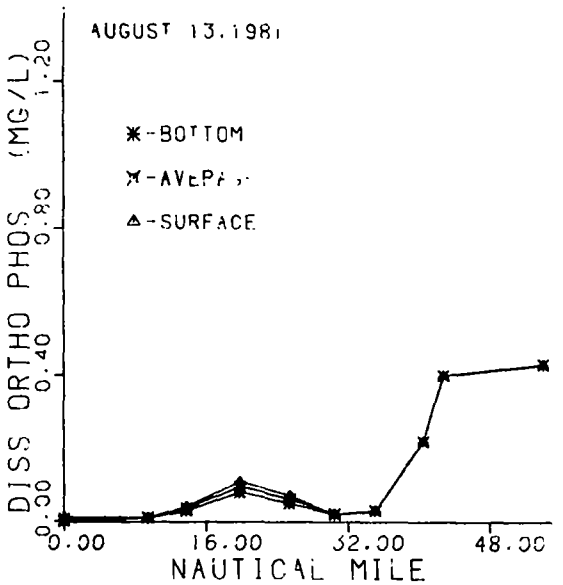


Figure 7-19 Patuxent River Slack Survey Plots of Dissolved Ortho-Phosphorus



PATUXENT RIVER

Figure 7-19 Patuxent River Slack Survey Plots of Dissolved Ortho-Phosphorus

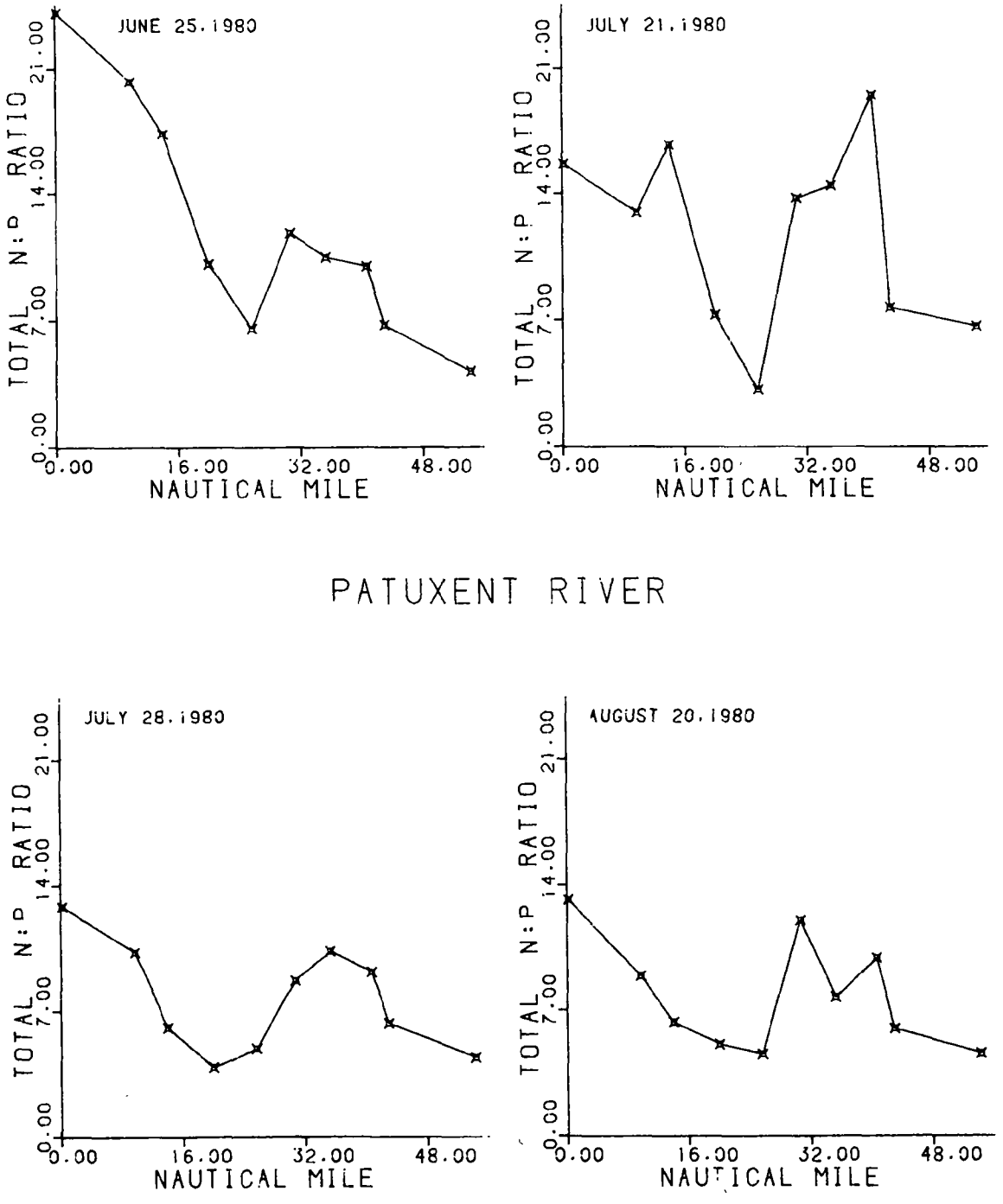


Figure 7-20 Patuxent river longitudinal plots of total nitrogen to total phosphorus ratio.

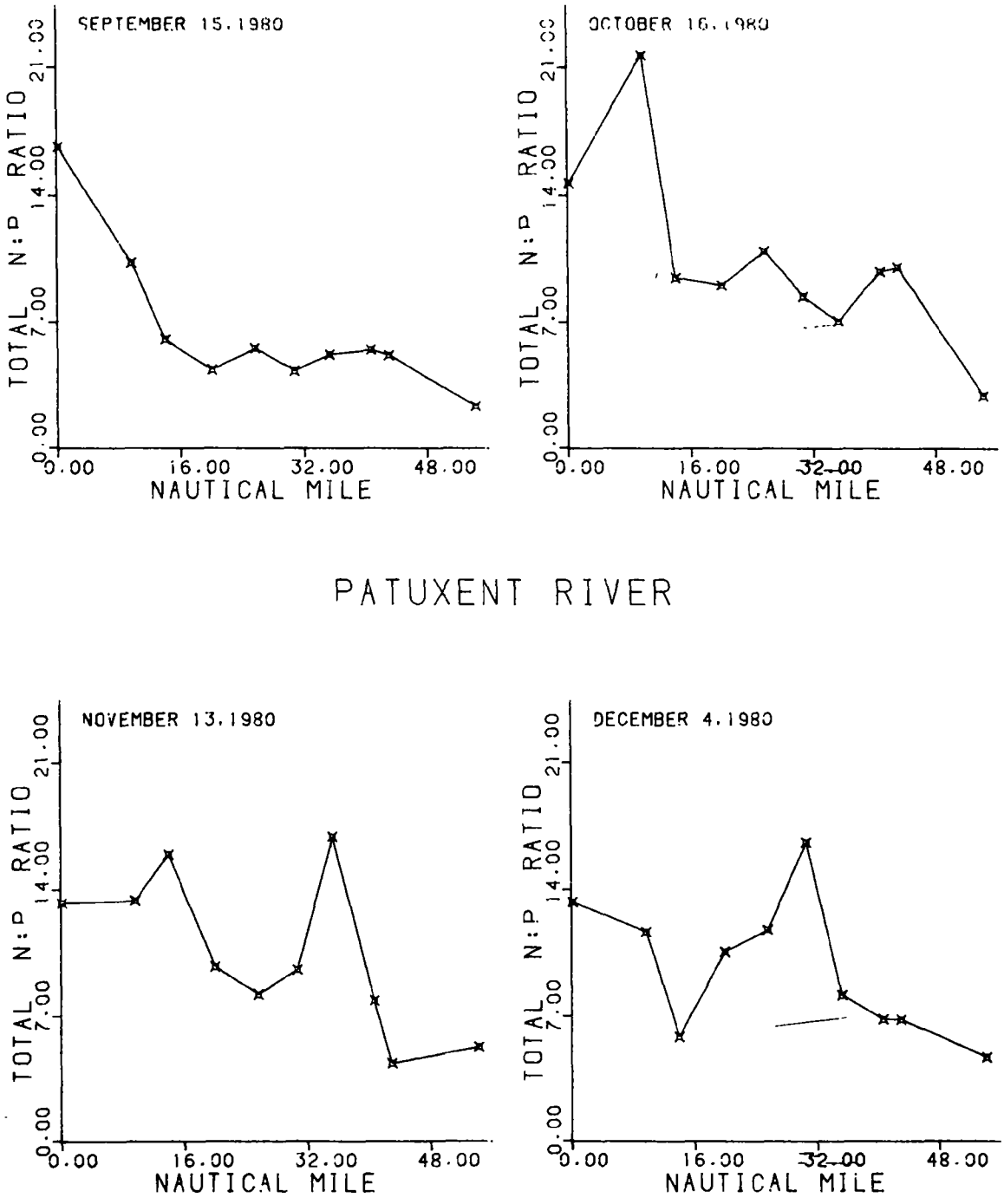
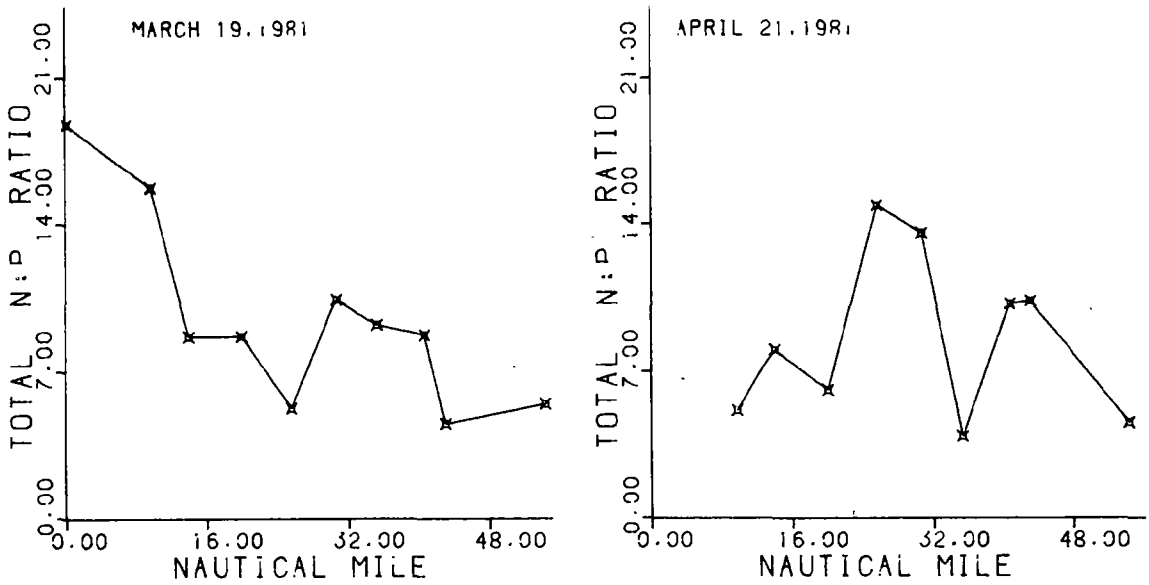


Figure 7-20 Patuxent river longitudinal plots of total nitrogen to total phosphorus ratio.



PATUXENT RIVER

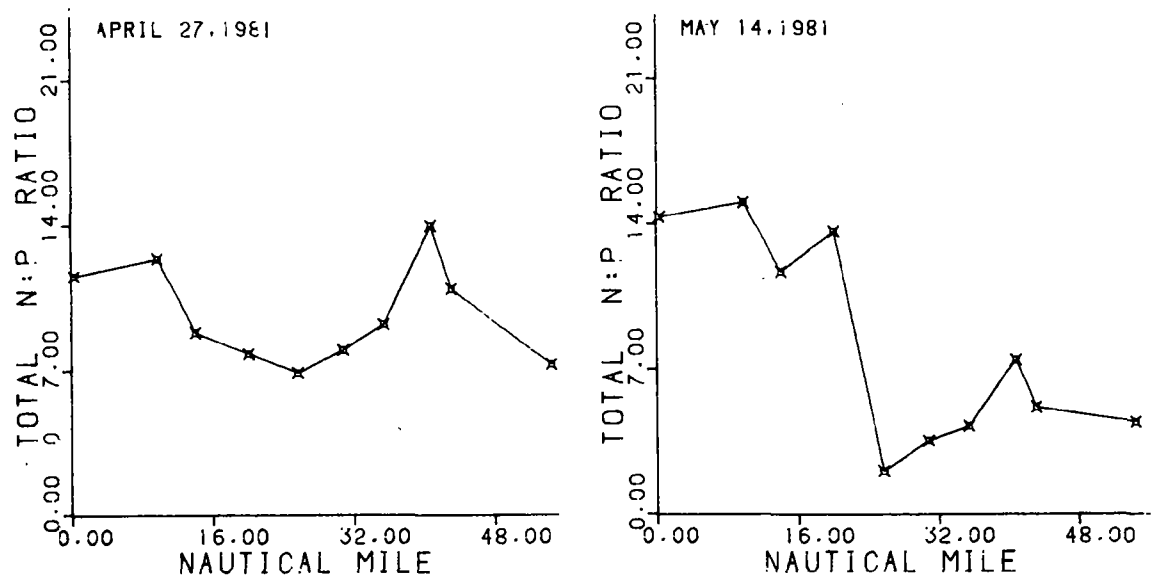


Figure 7-20Patuxent river longitudinal plots of total nitrogen to total phosphorus ratio.

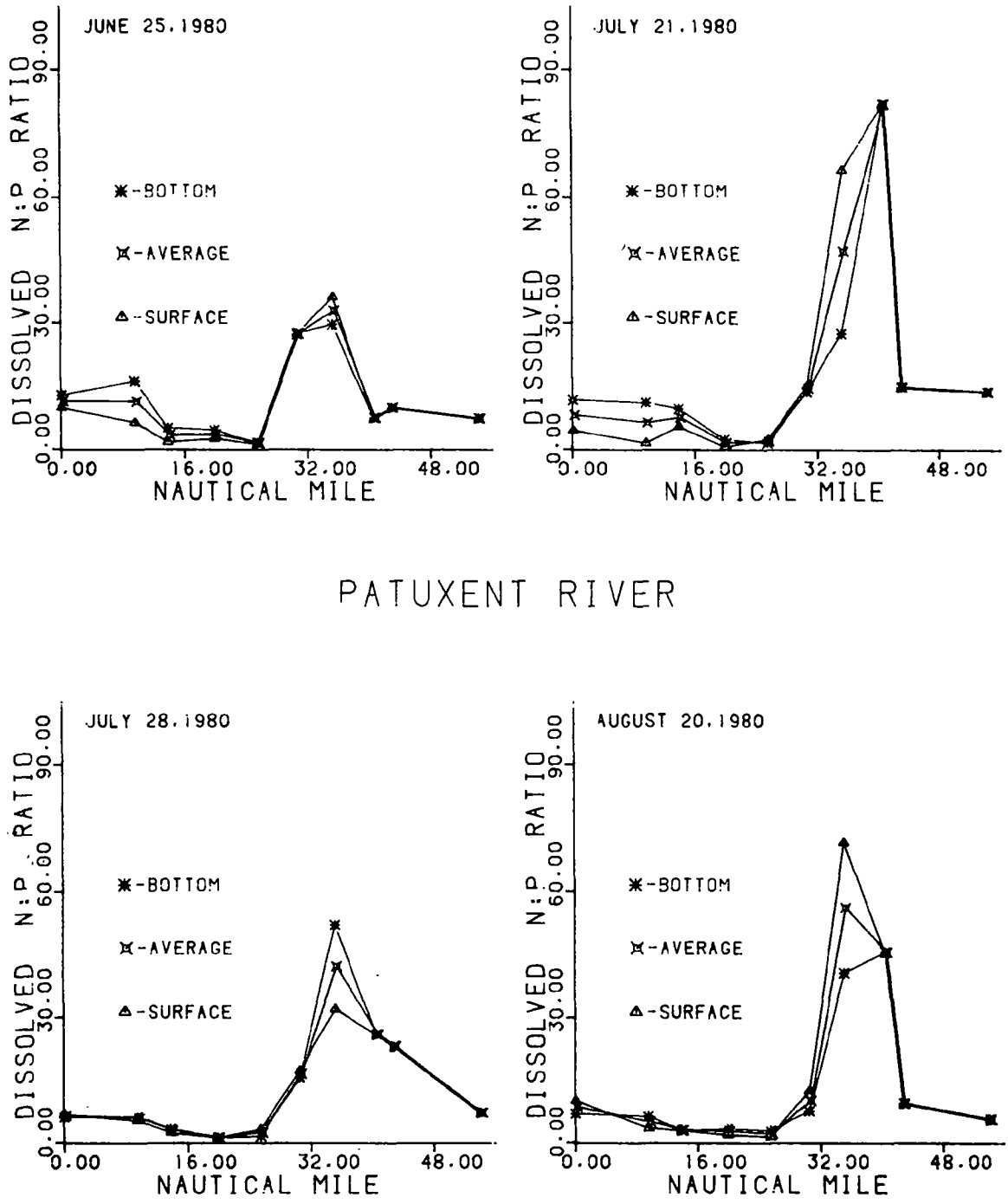


Figure 7-21 Patuxent River Slack Survey Plots of Dissolved N:P Ratio

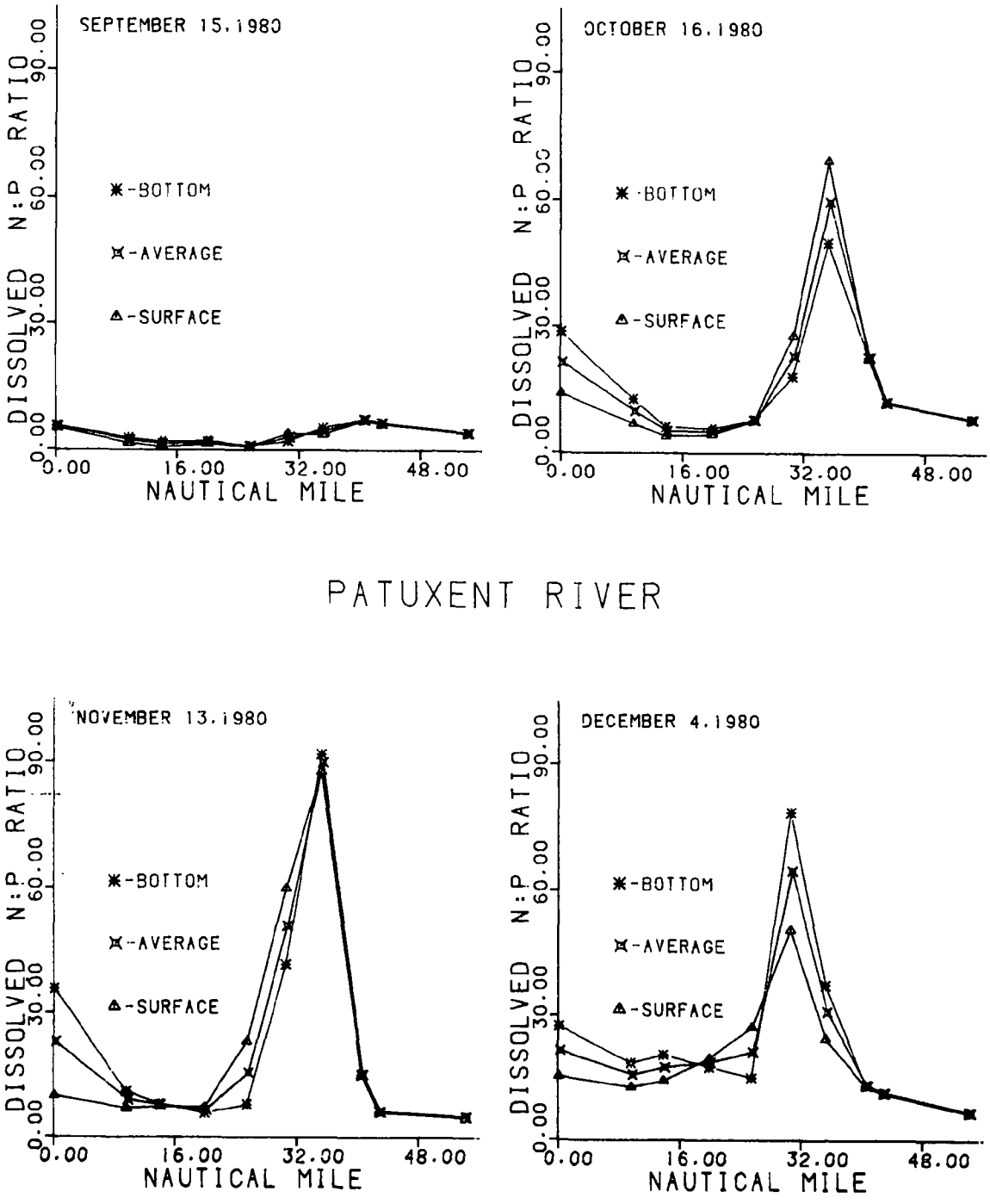


Figure 7-21 Patuxent River Slack Survey Plots of Dissolved N:P Ratio

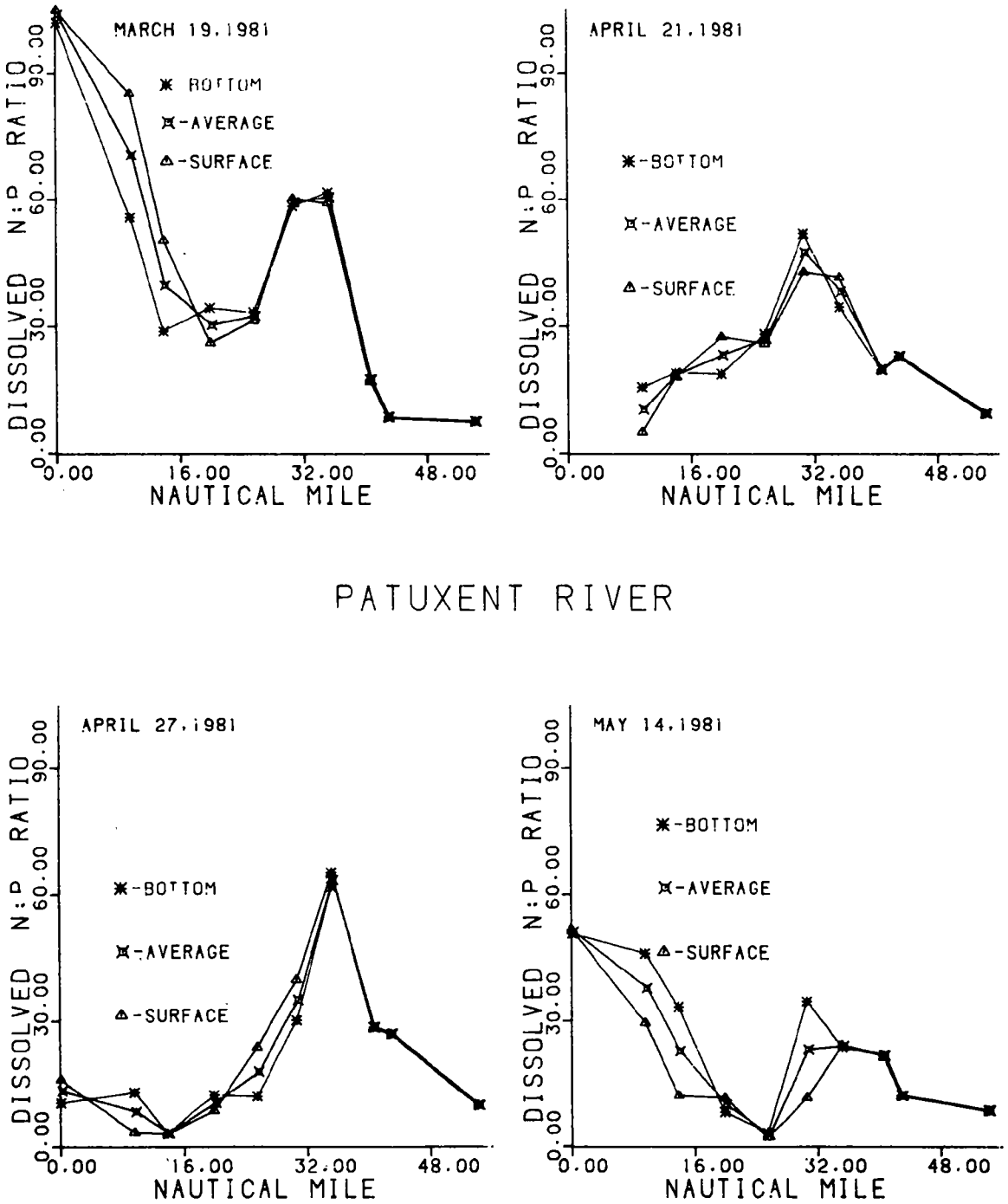
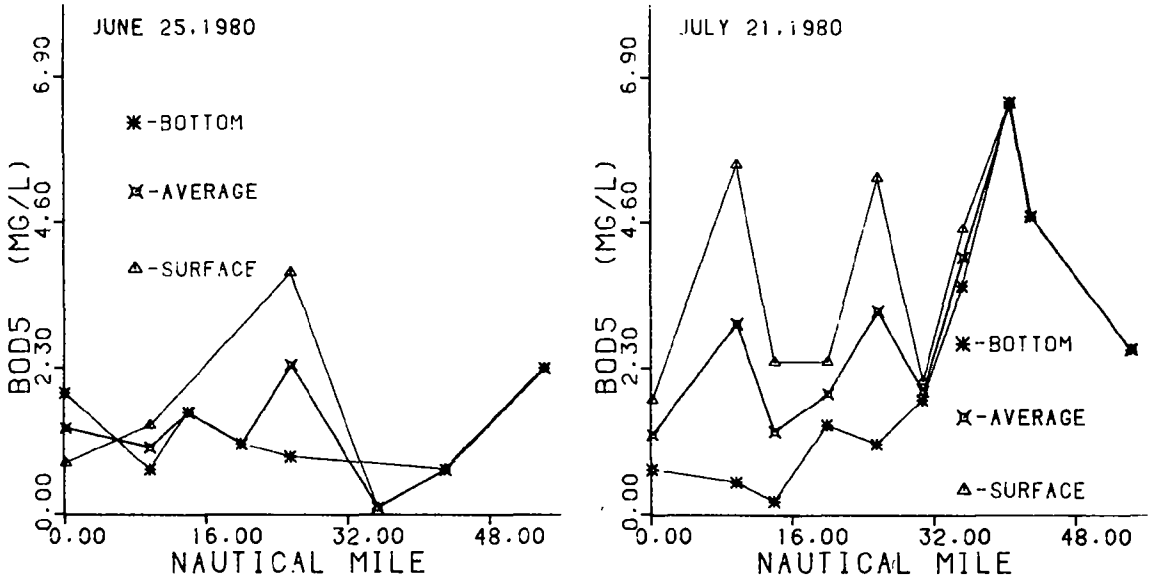


Figure 7-21 Patuxent River Slack Survey Plots of Dissolved N:P Ratio



PATUXENT RIVER

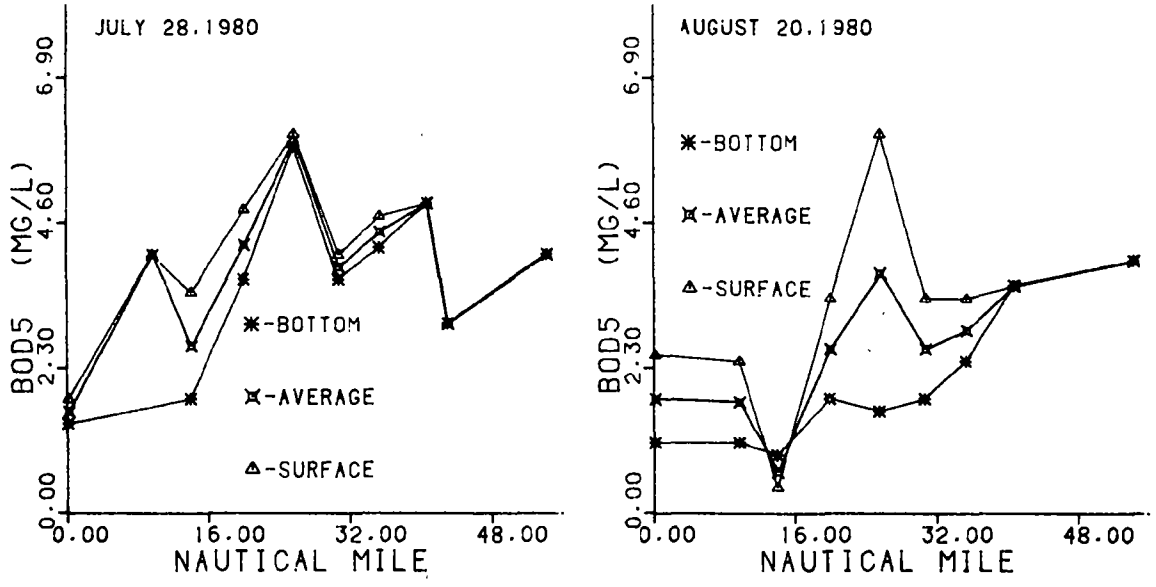
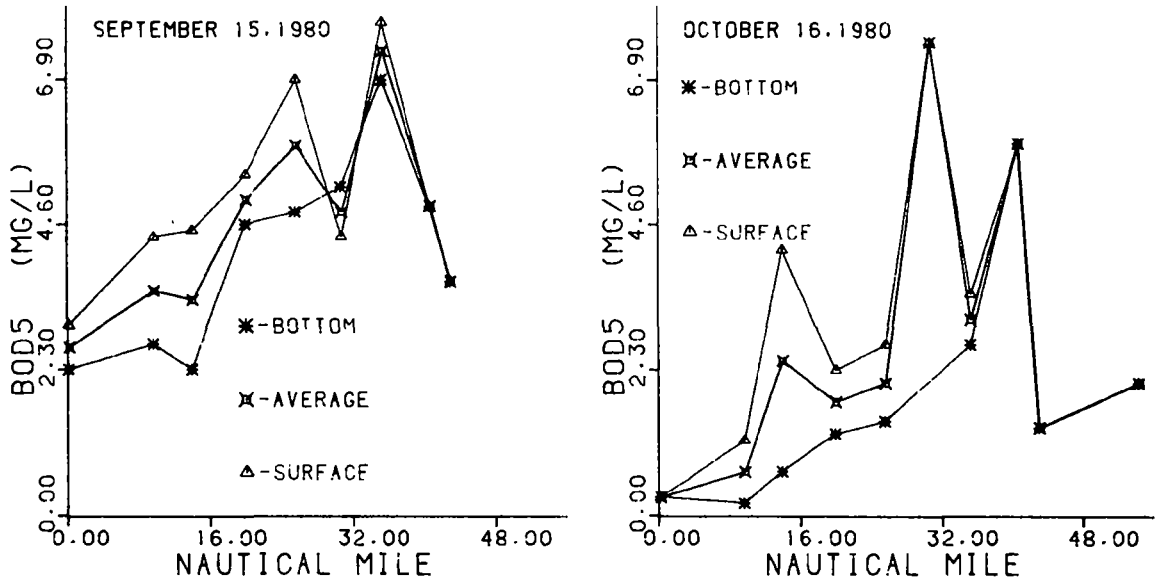


Figure 7-22 Patuxent River longitudinal slack survey plots of BOD_5.



PATUXENT RIVER.

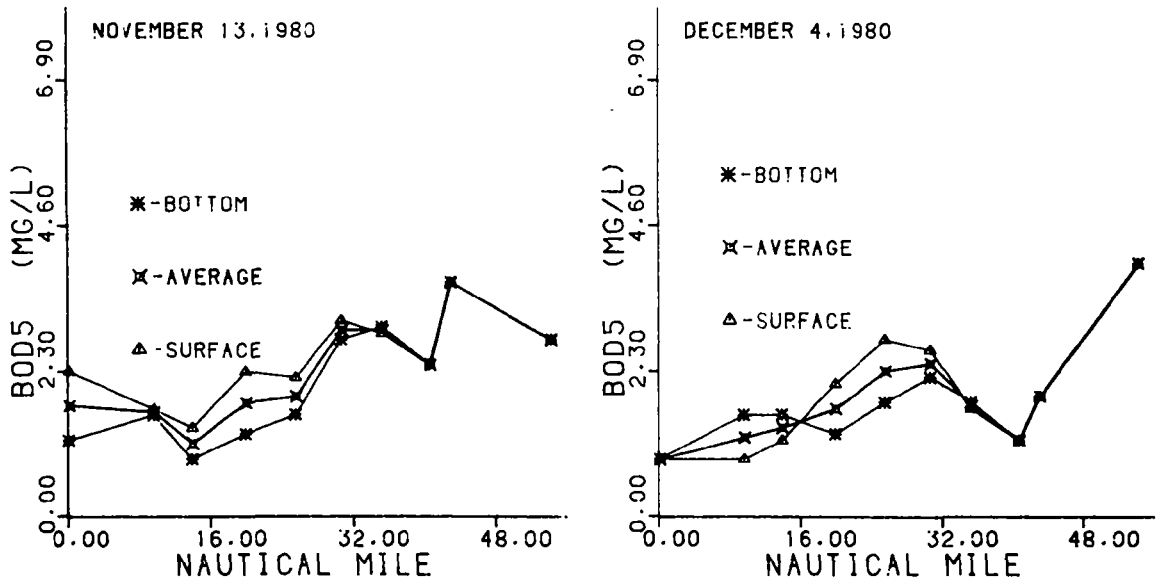


Figure 7-22 Patuxent River longitudinal slack survey plots of BOD_5.

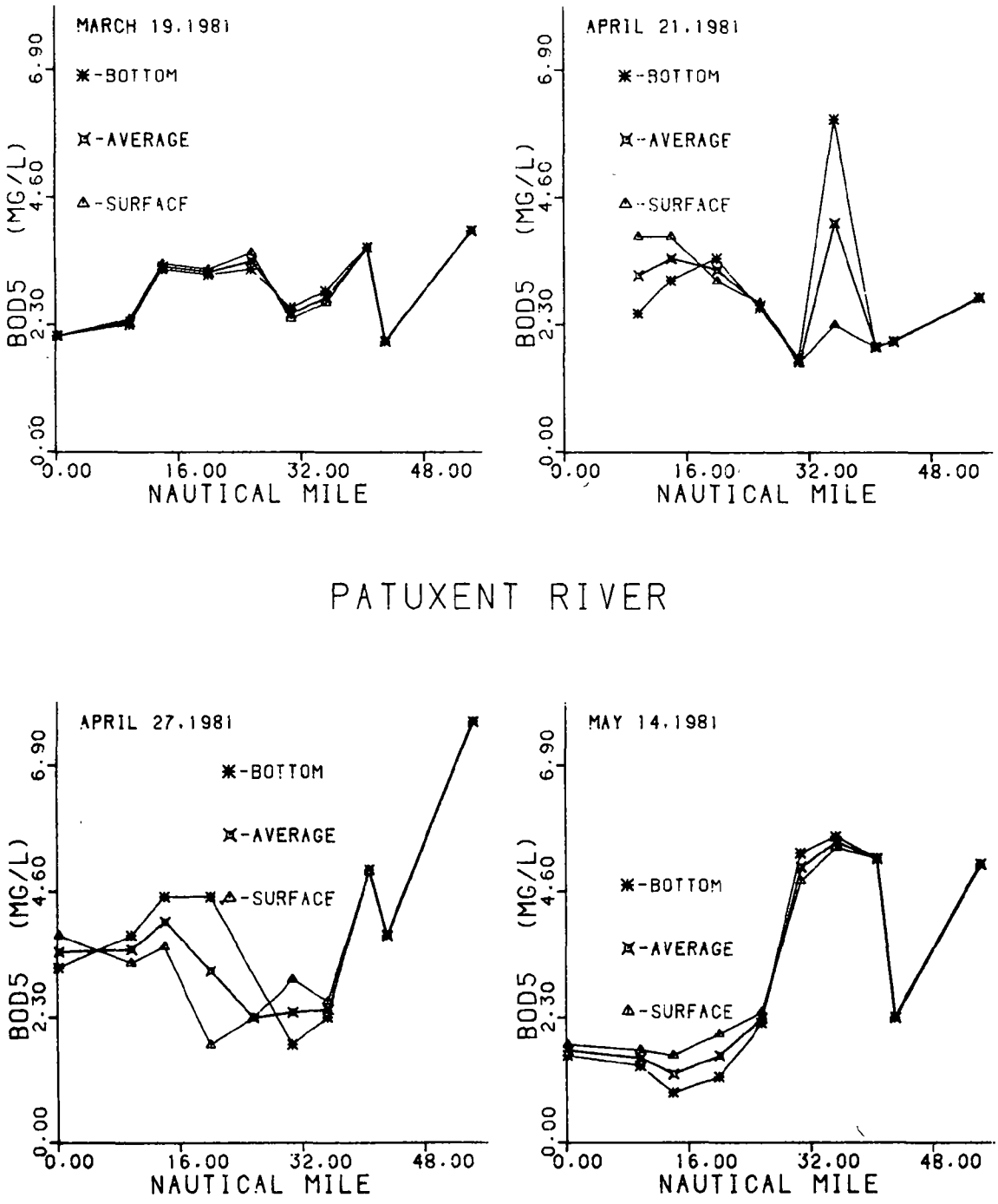
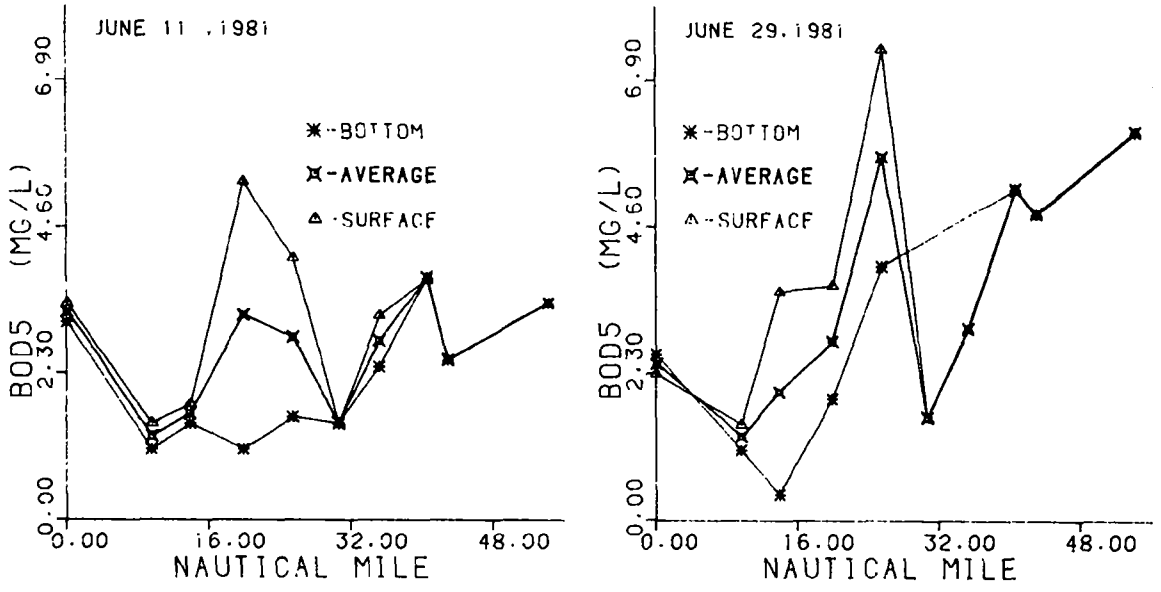


Figure 7-22 Patuxent River longitudinal slack survey plots of BOD_5.



PATUXENT RIVER

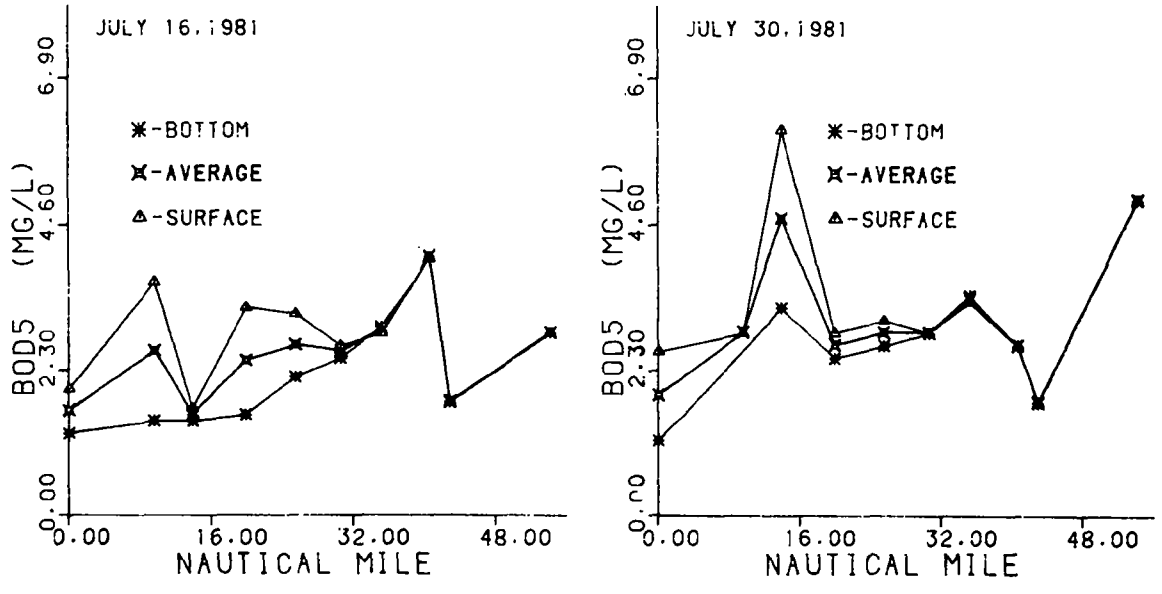
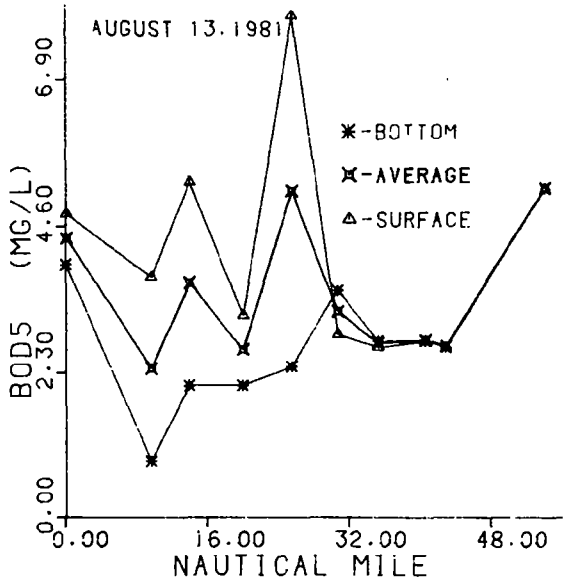
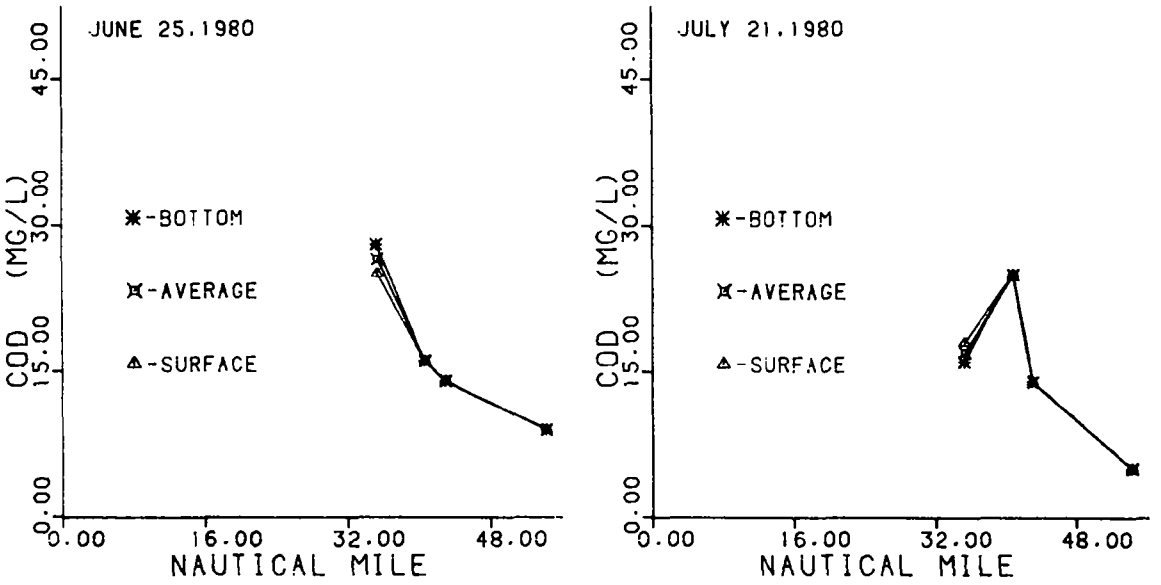


Figure 7-22 Patuxent River longitudinal slack survey plots of BOD_5.



PATUXENT RIVER

Figure 7-22 Patuxent River longitudinal slack survey plots of BOD_5.



PATUXENT RIVER

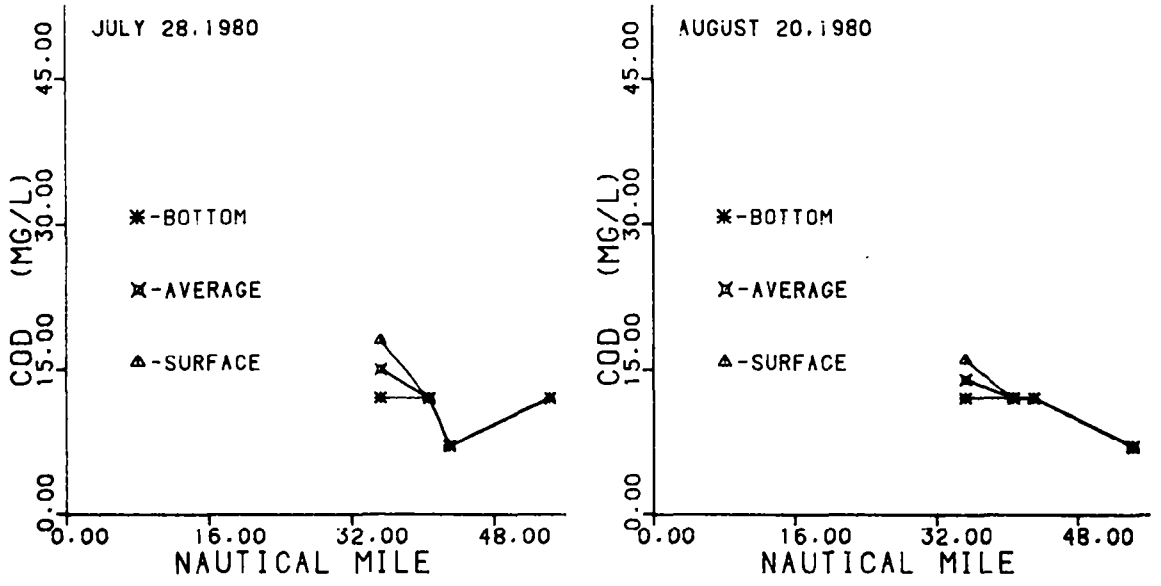


Figure 7-23 Patuxent river longitudinal plots of chemical oxygen demand.

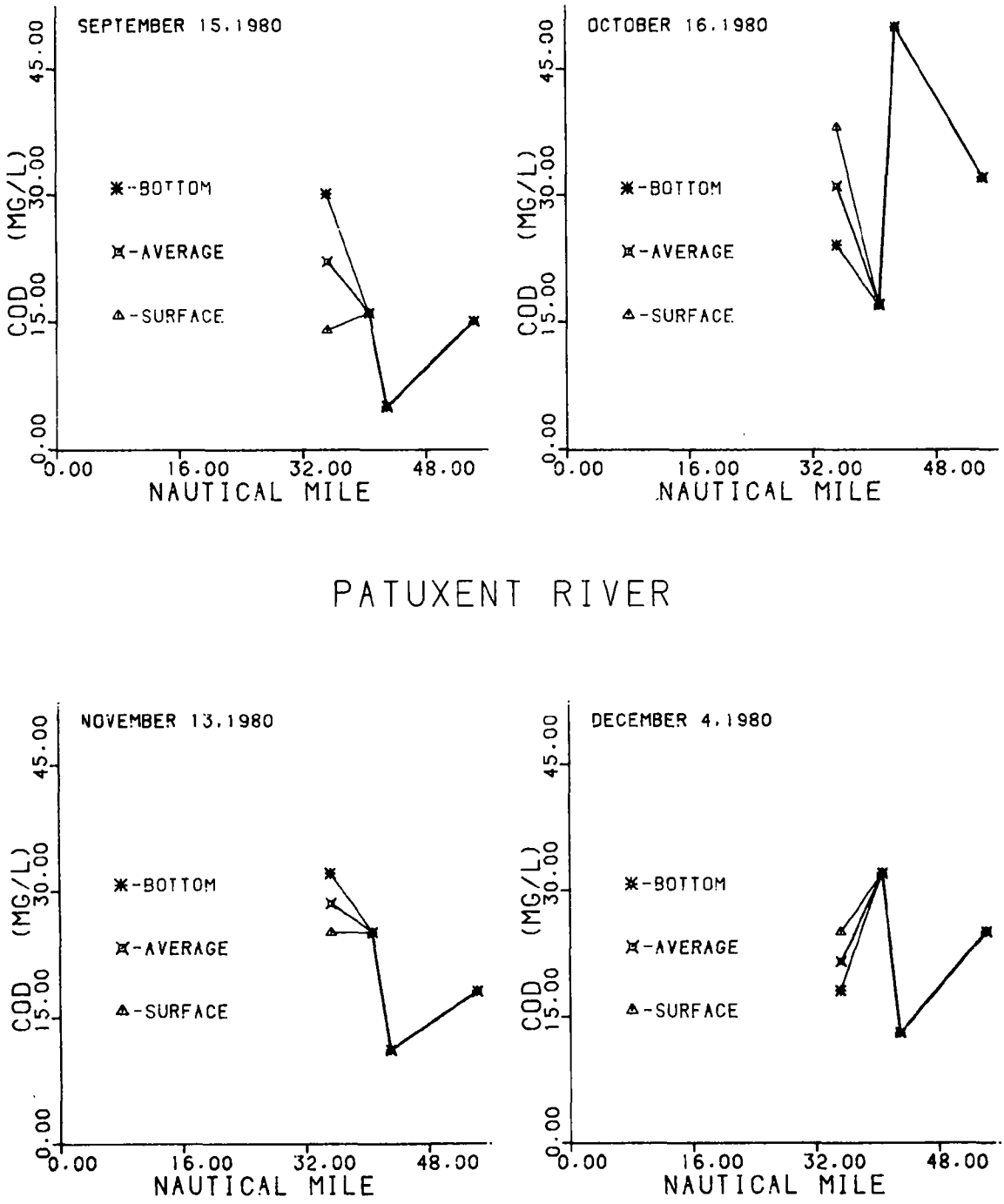


Figure 7-23 Patuxent river longitudinal plots of chemical oxygen demand.

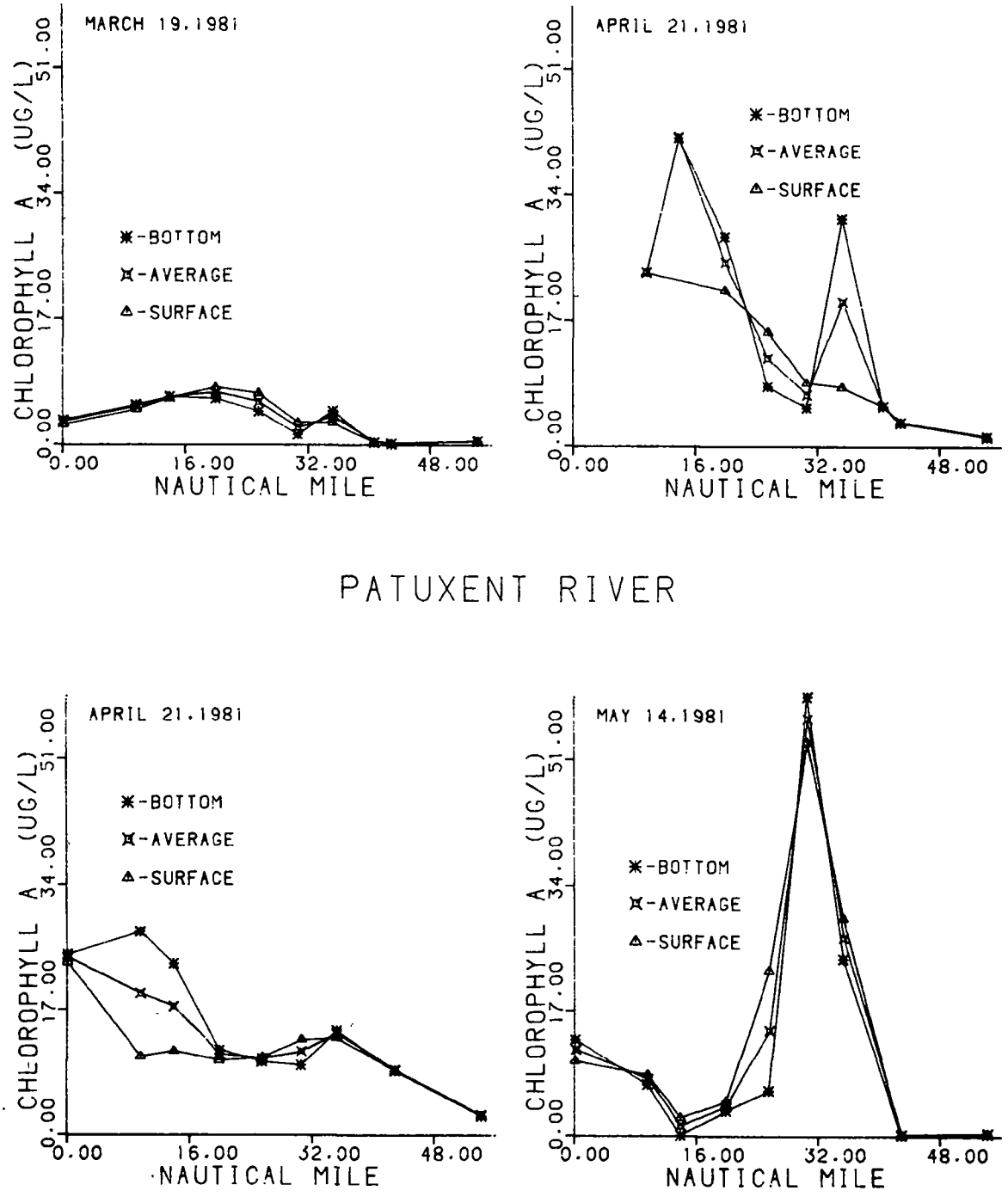
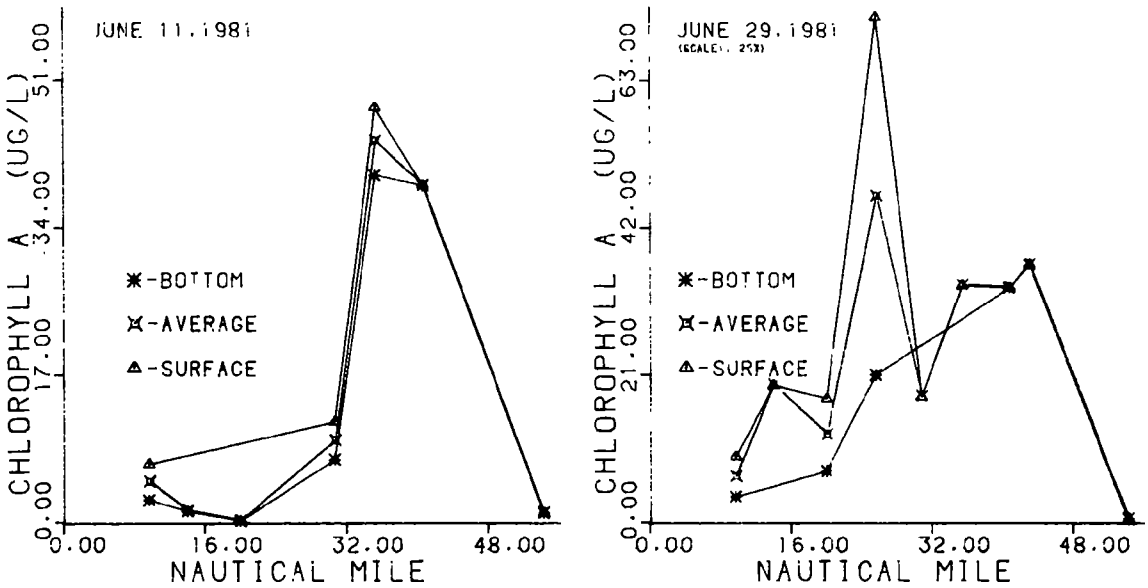


Figure 7-24 Patuxent river longitudinal slack survey plots of chlorophyll-a.



PATUXENT RIVER

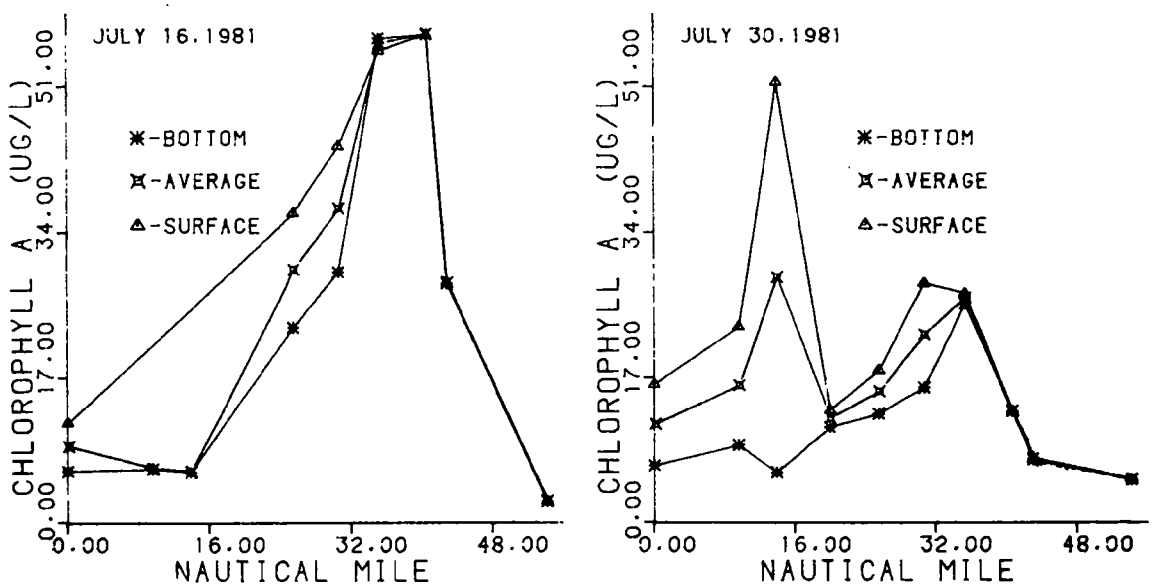
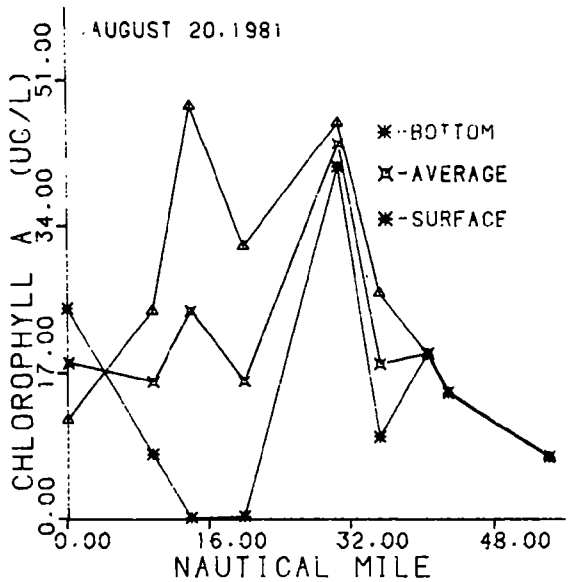


Figure 7-24 Patuxent river longitudinal slack survey plots of chlorophyll-a.



PATUXENT RIVER

Figure 7-24 **Patuxent river** longitudinal slack survey plots of chlorophyll-a.

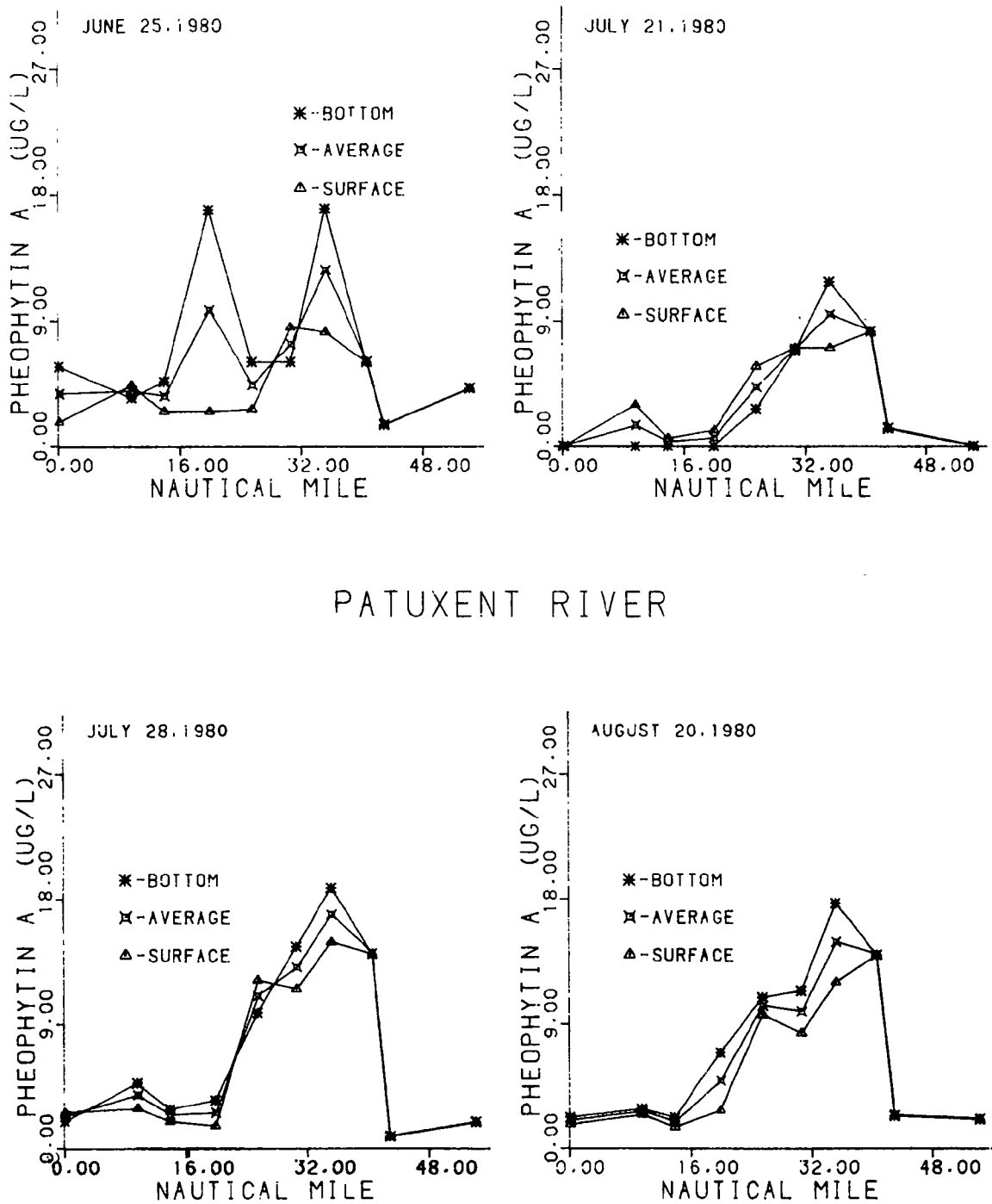


Figure 7-25 Longitudinal plots of pheophytin-a, 1980-1981.

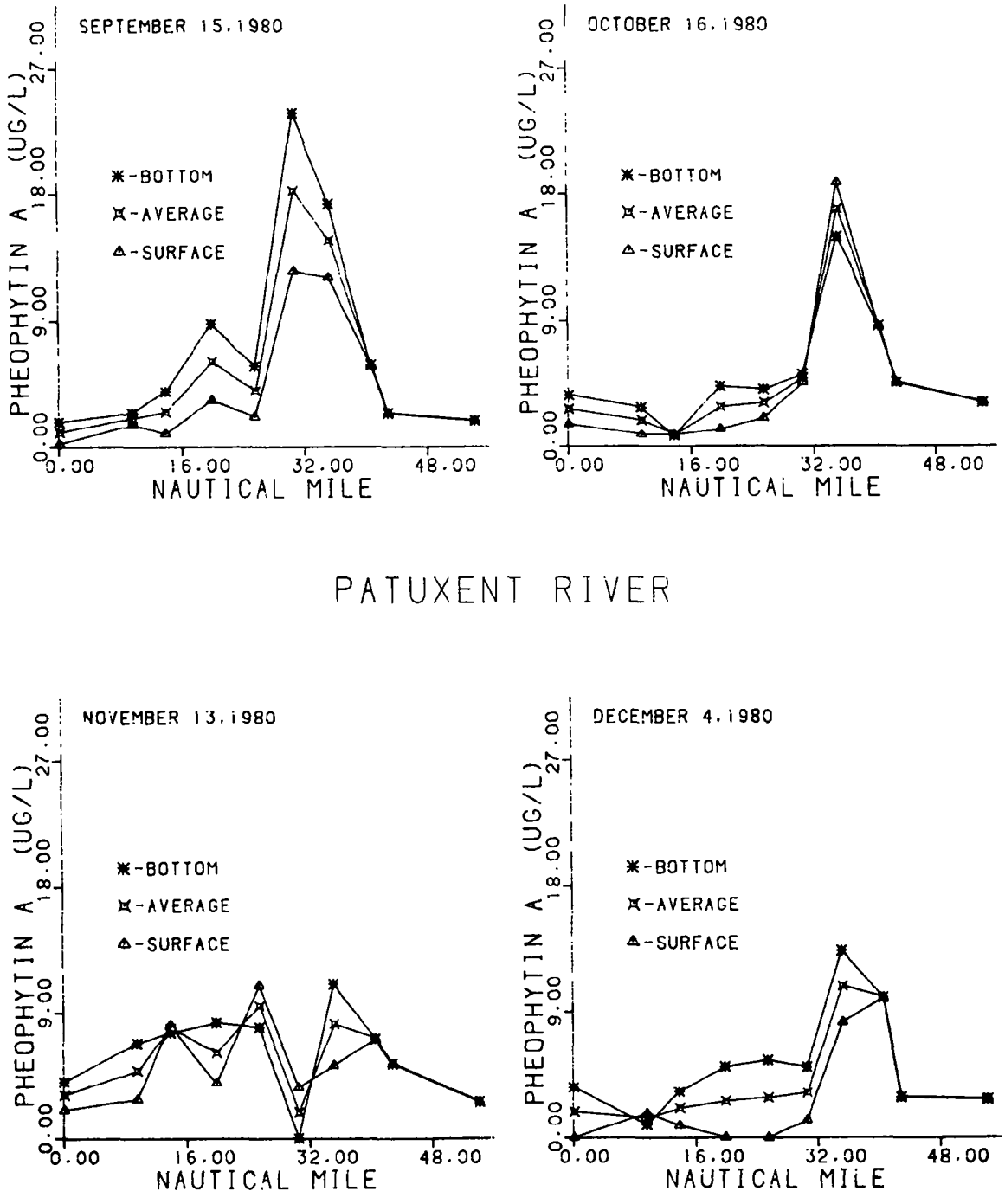


Figure 7-25 Longitudinal plots of pheophytin-a, 1980-1981.

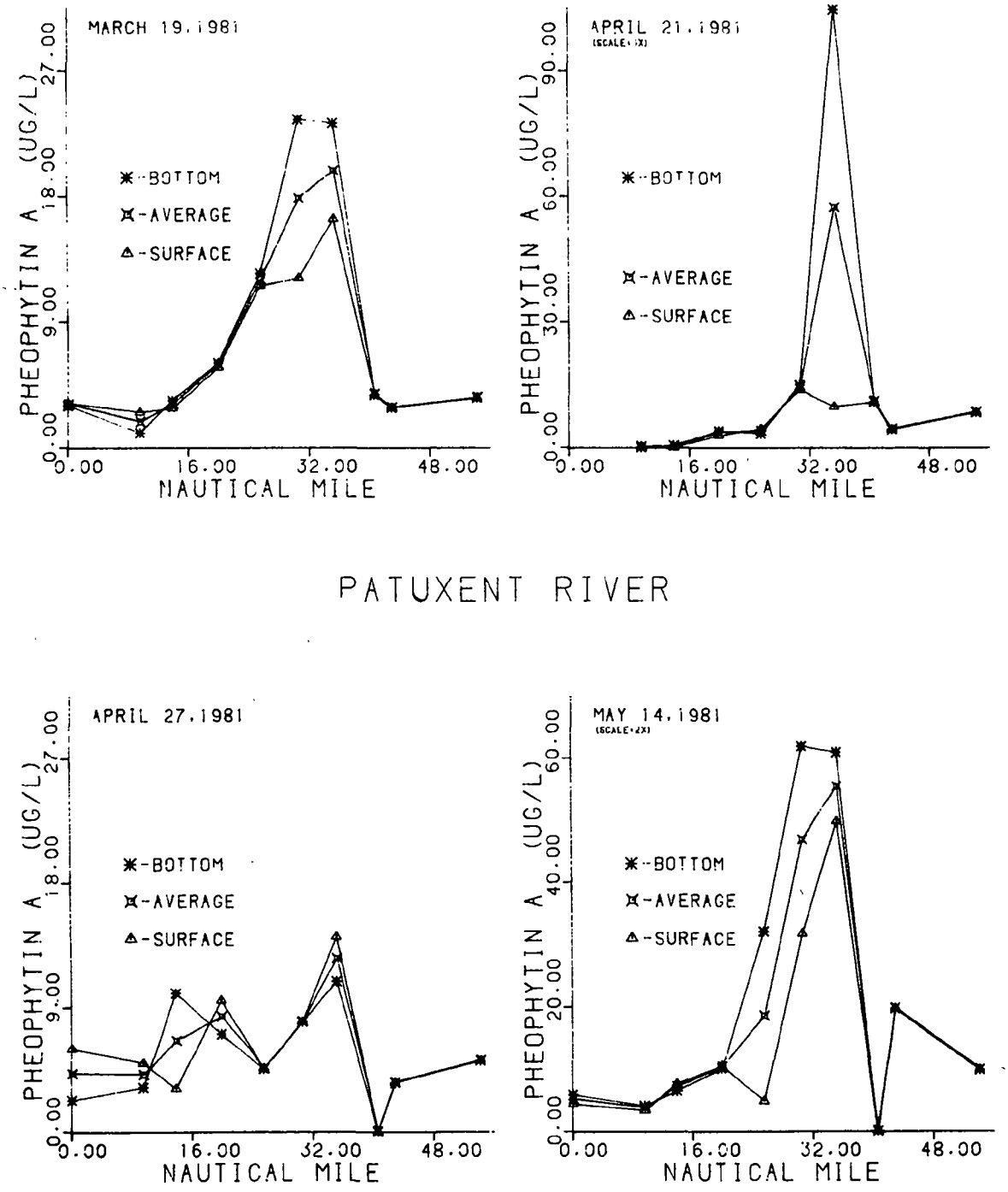


Figure 7-25 Longitudinal plots of pheophytin-a, 1980-1981.

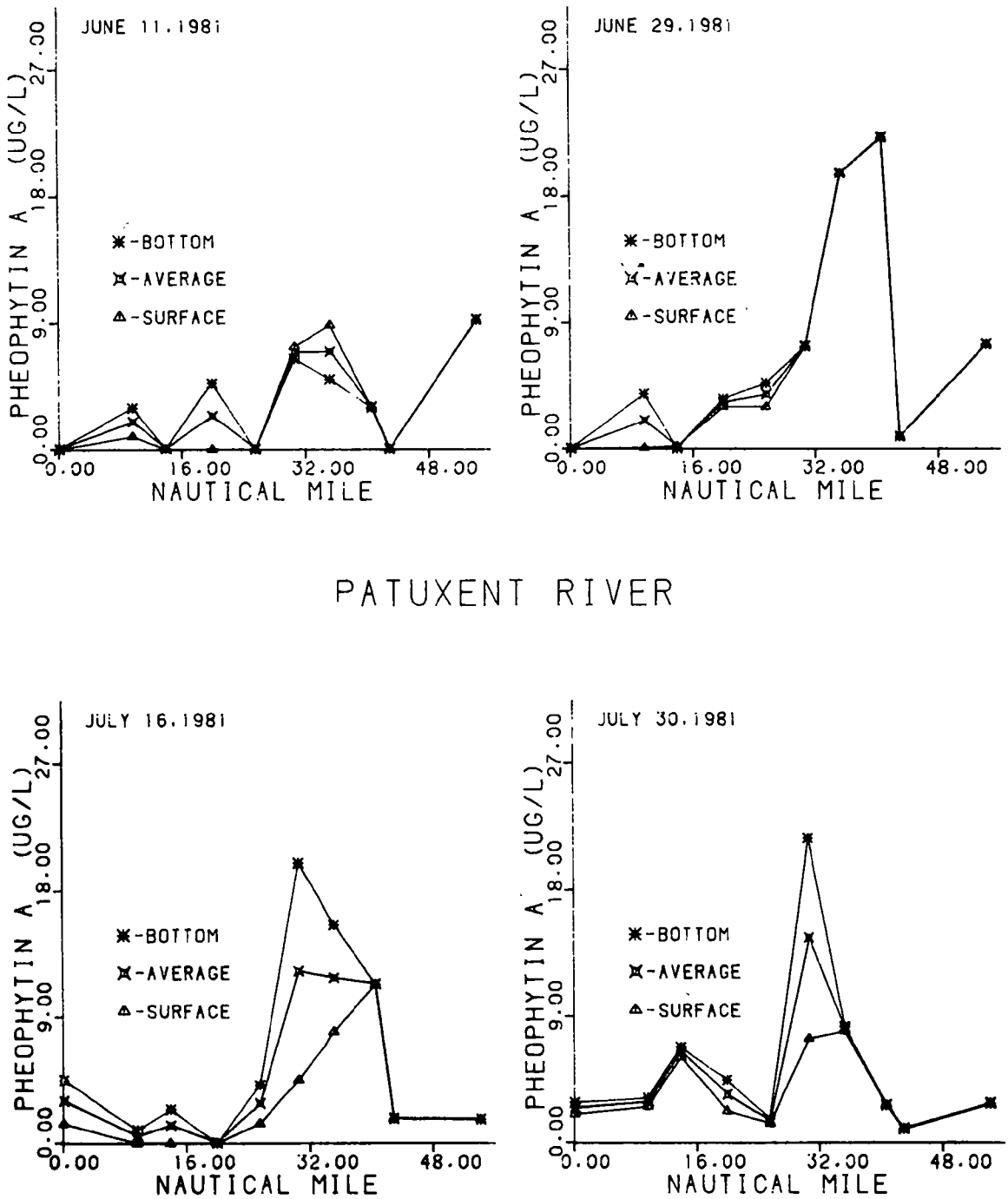
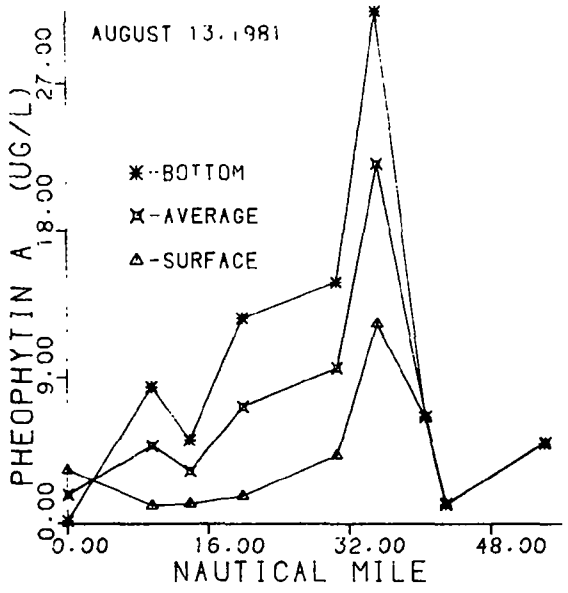


Figure 7-25 Longitudinal plots of pheophytin-a, 1980-1981.



PATUXENT RIVER

Figure 7-25 Longitudinal plots of pheophytin-a, 1980-1981.

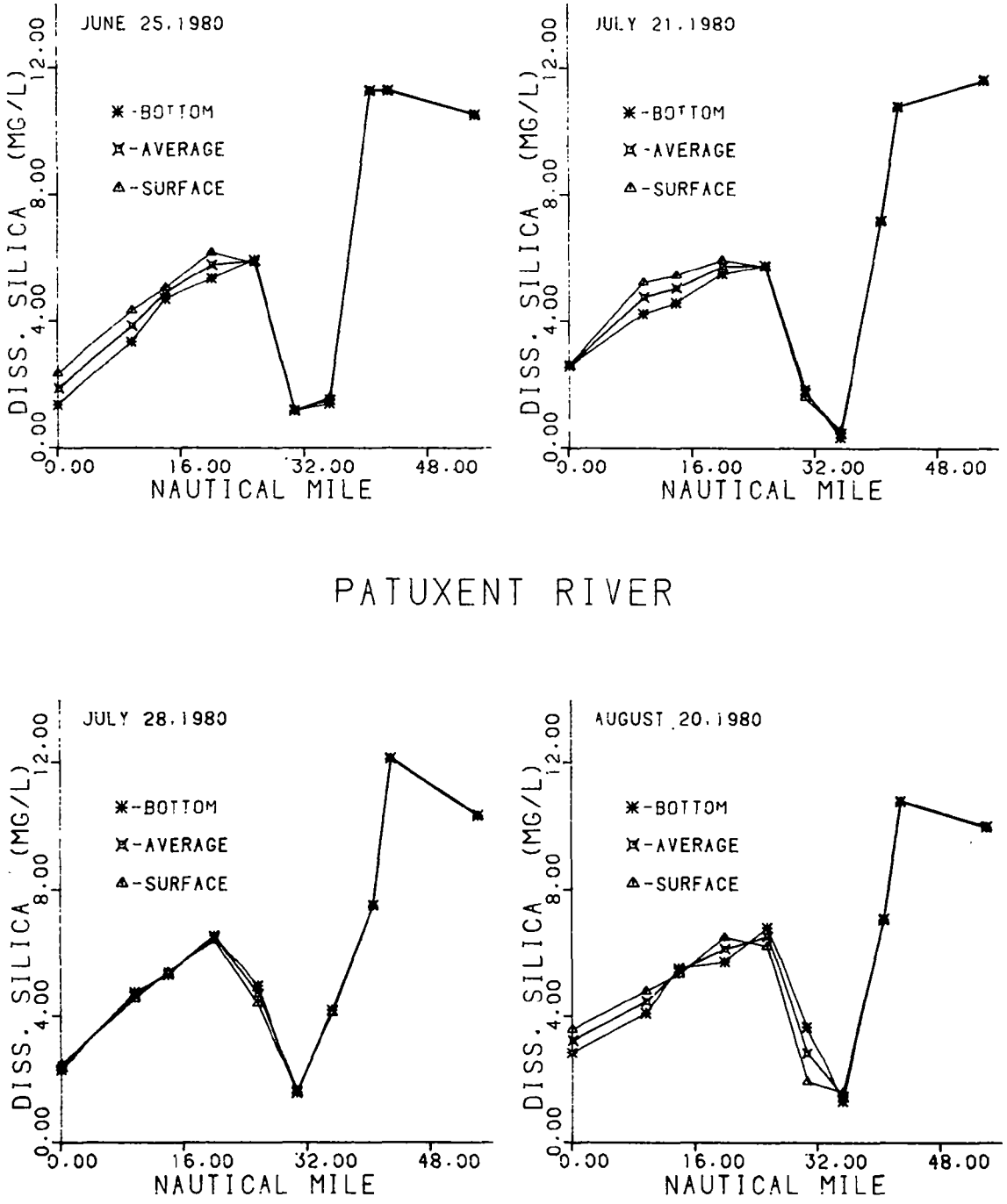
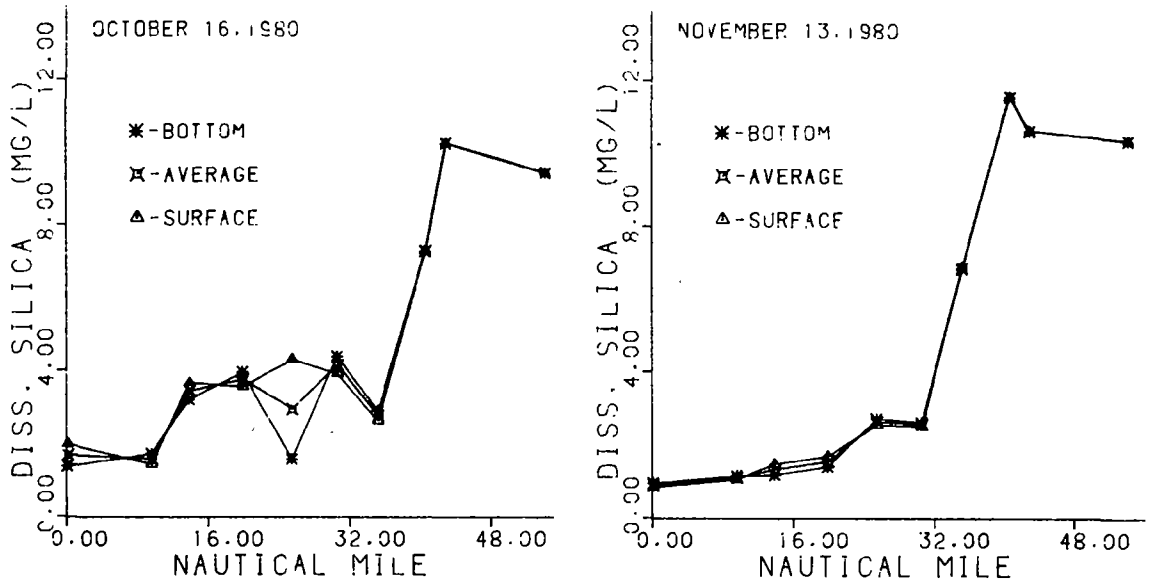


Figure 7-26 Patuxent River Slack Survey Plots of Dissolved Silica



PATUXENT RIVER

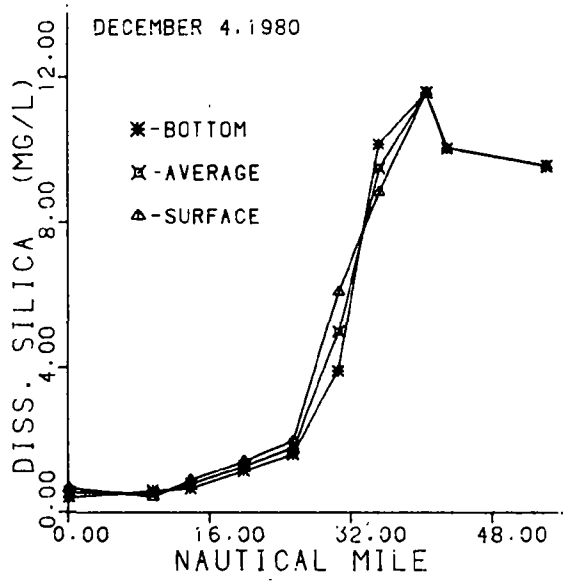
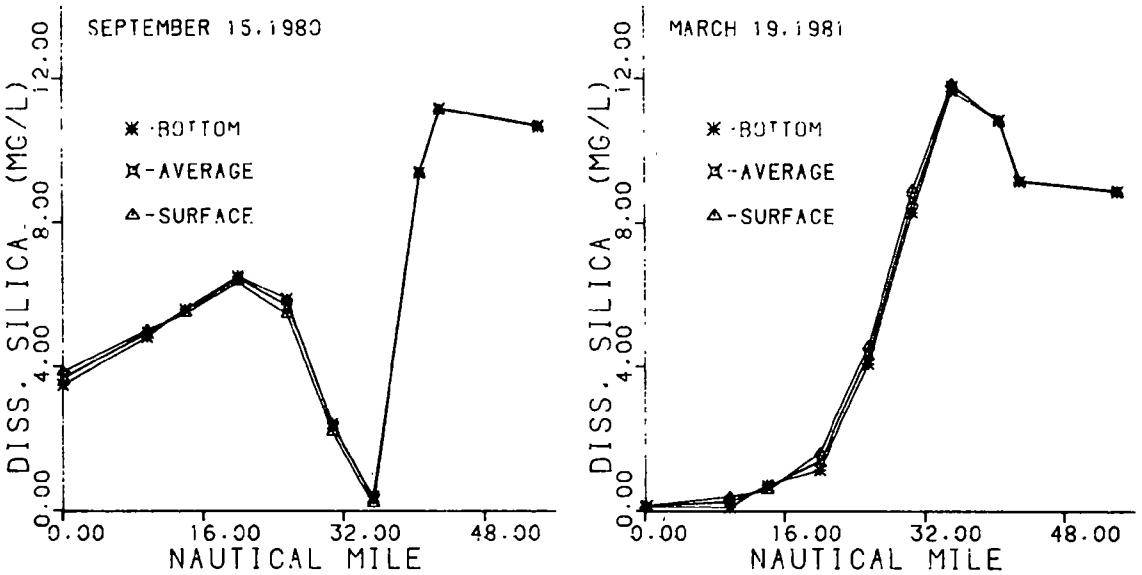


Figure 7-26 Patuxent River Slack Survey Plots of Dissolved Silica



PATUXENT RIVER

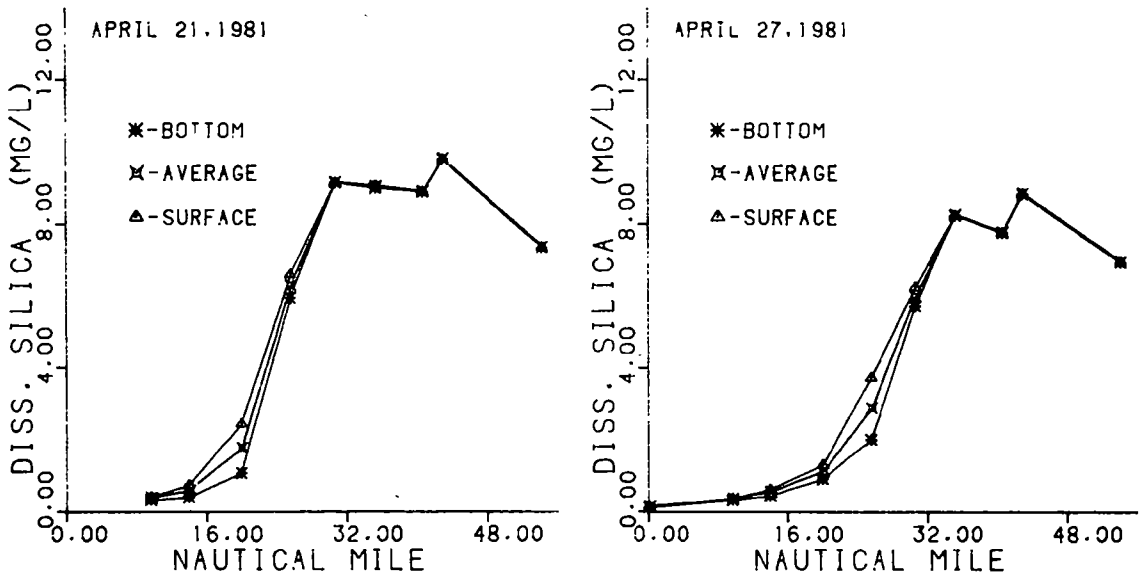


Figure 7-26 Patuxent River Slack Survey Plots of Dissolved Silica

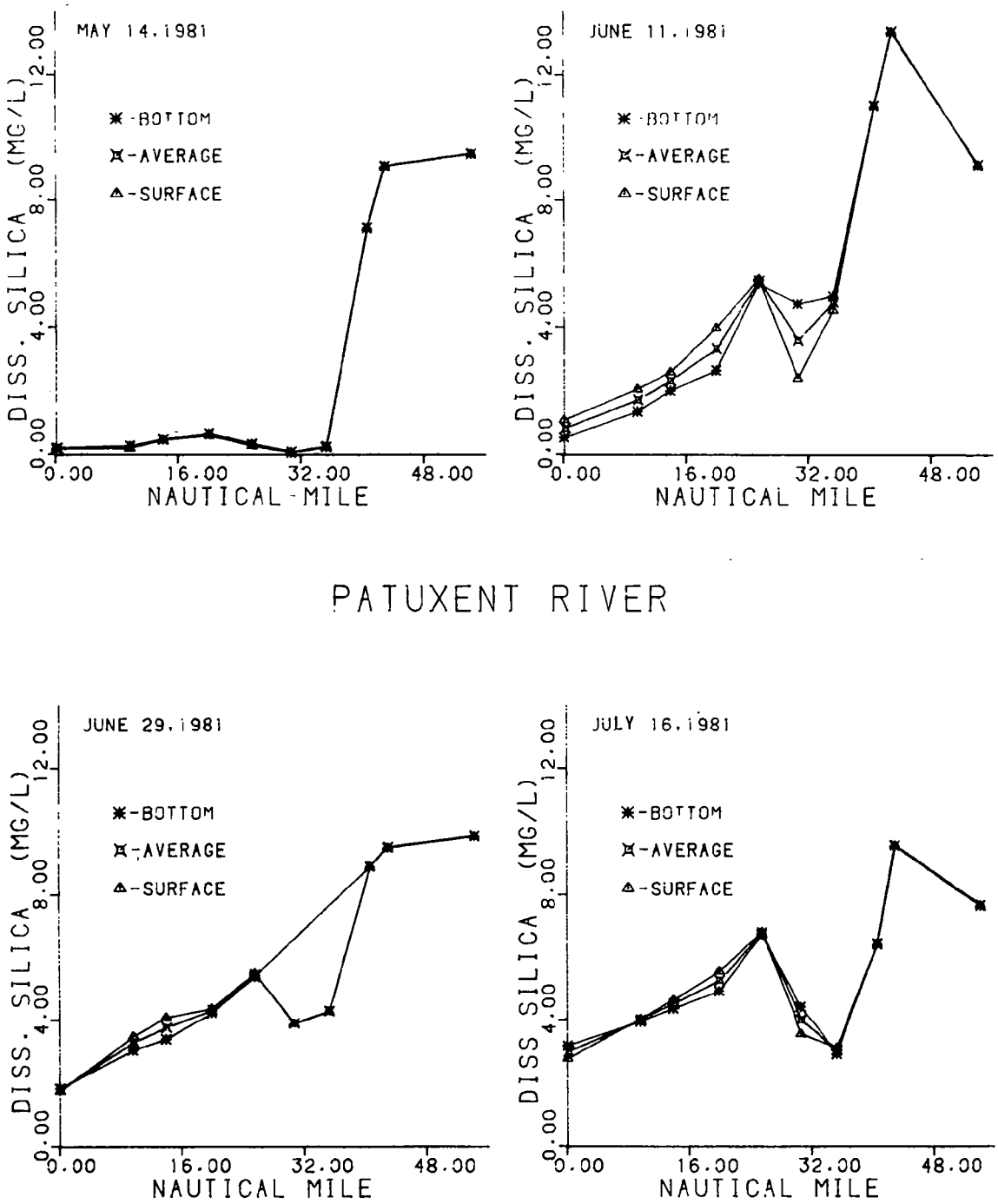
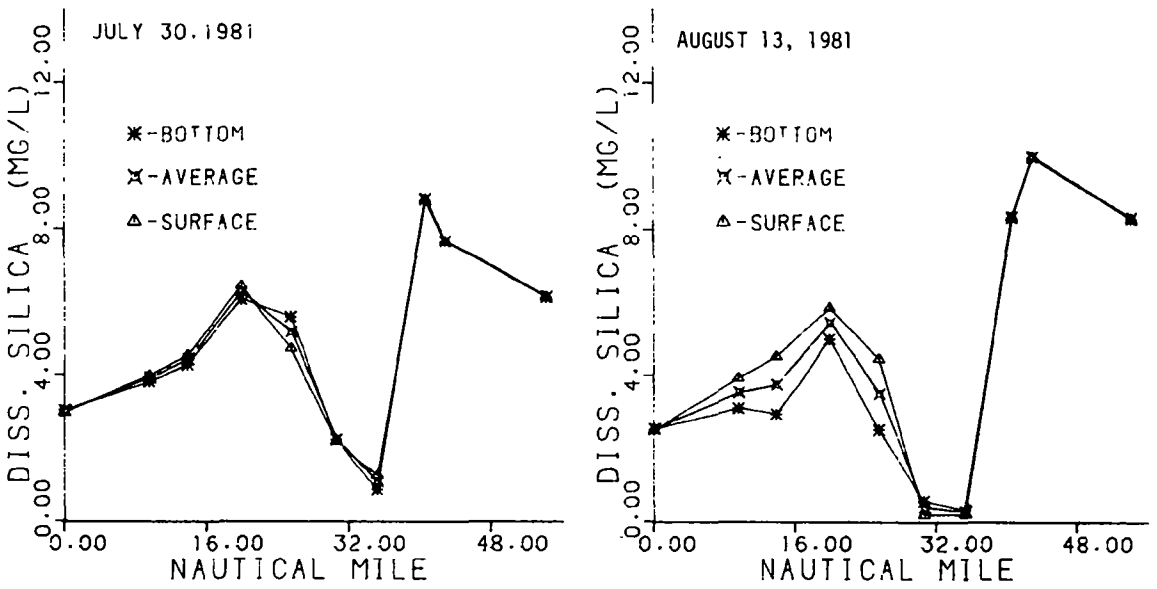
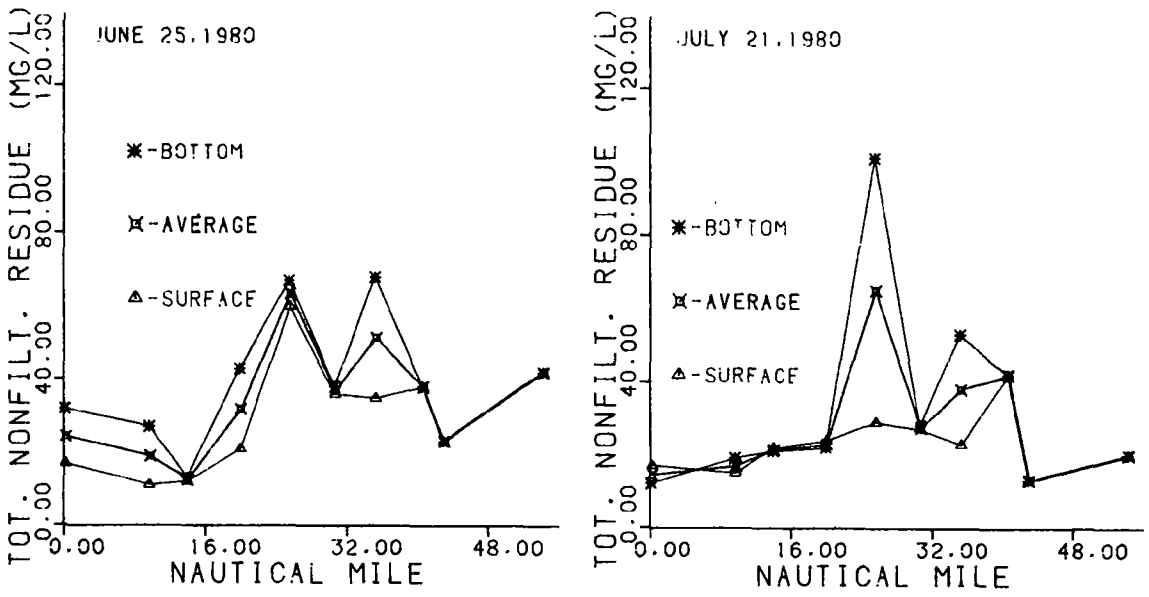


Figure 7-26 Patuxent River Slack Survey Plots of Dissolved Silica



PATUXENT RIVER

Figure 7-26 Patuxent River Slack Survey Plots of Dissolved Silica



PATUXENT RIVER

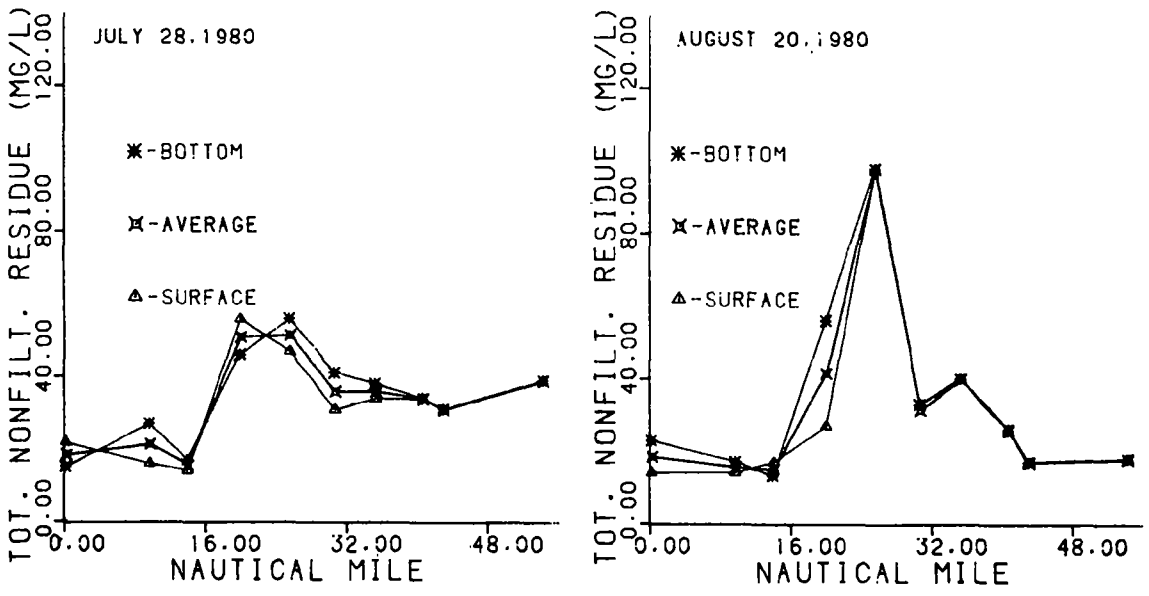
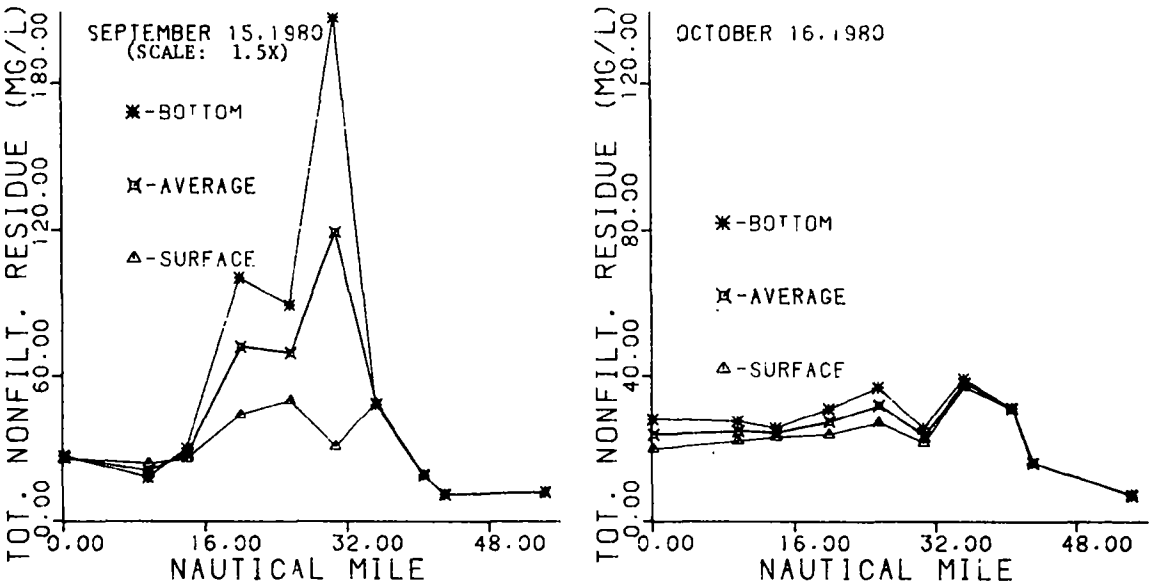


Figure7-27 Patuxent River Slack Survey Plots at Total Nonfilterable residue



PATUXENT RIVER

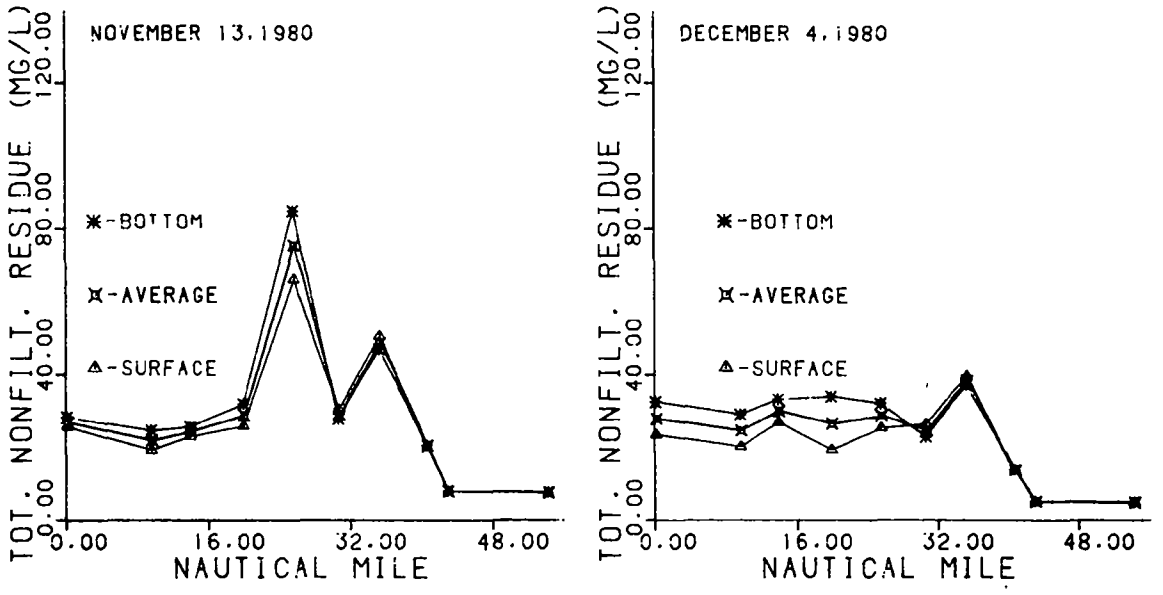
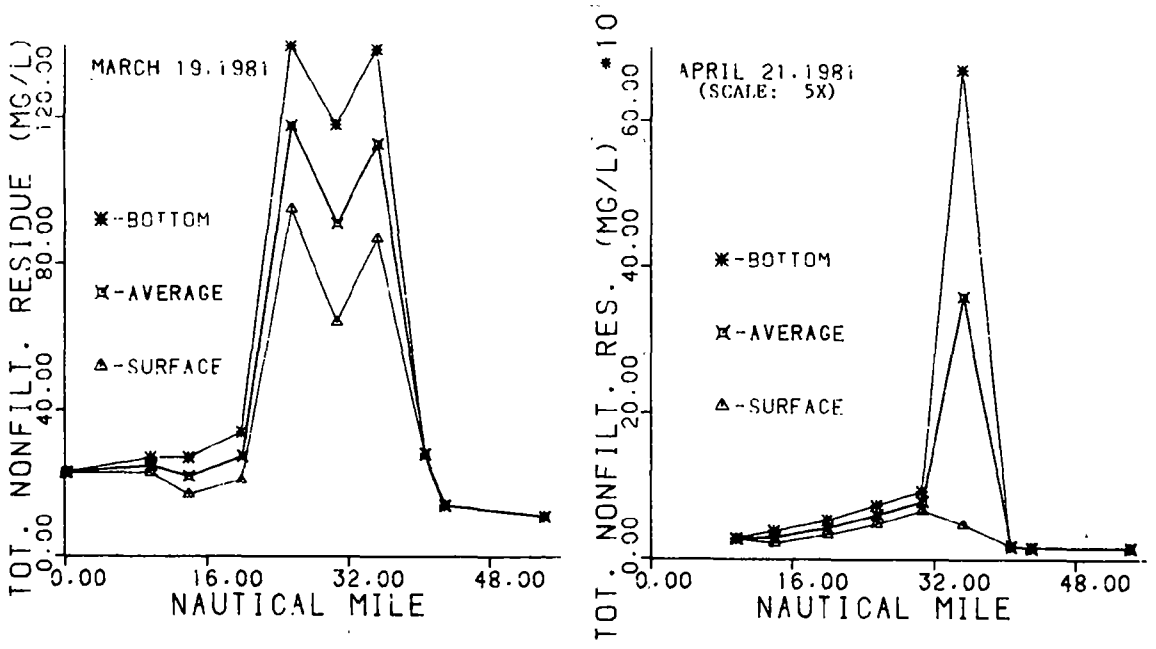


Figure 7-27Patuxent River Slack Survey Plots of Total Nonfilterable residue



PATUXENT RIVER

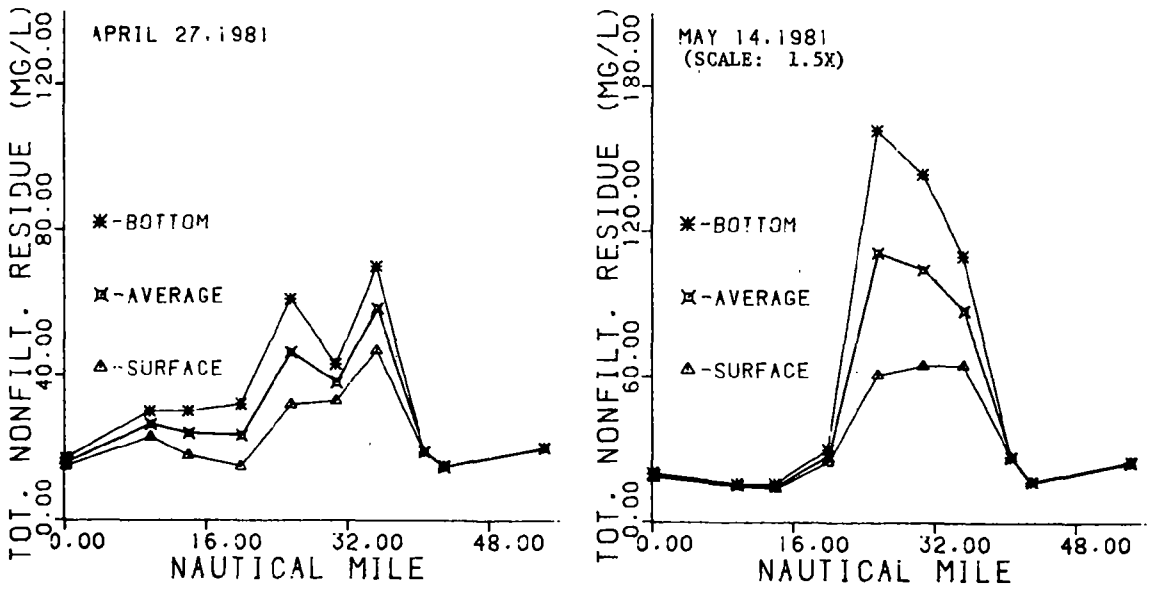
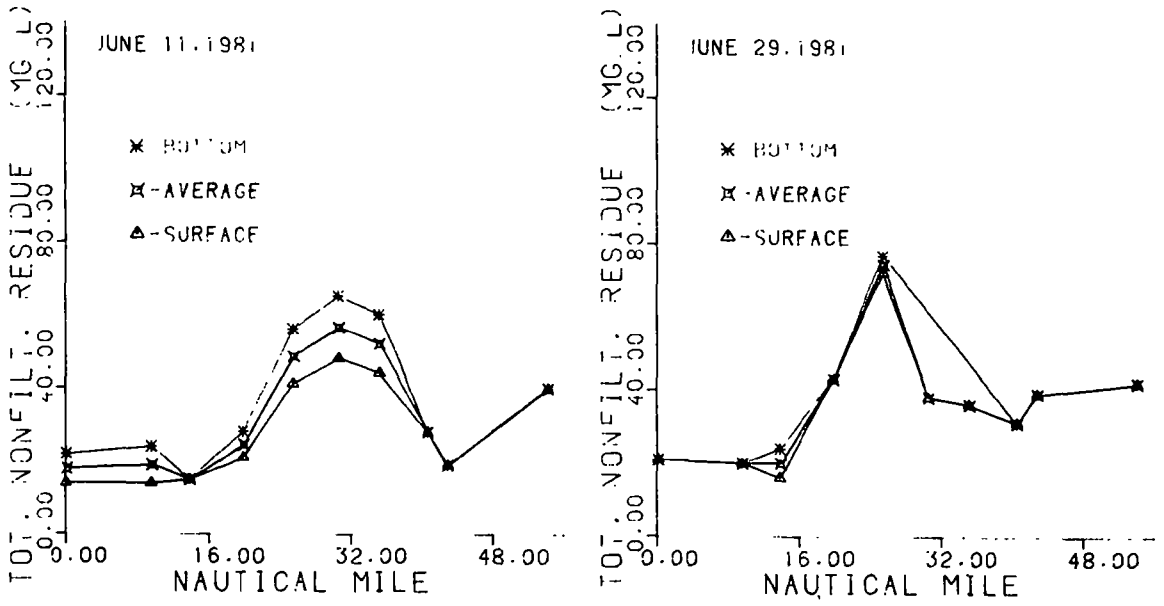


Figure 7-27 Patuxent River Slack Survey Plots of Total Nonfilterable residue



PATUXENT RIVER

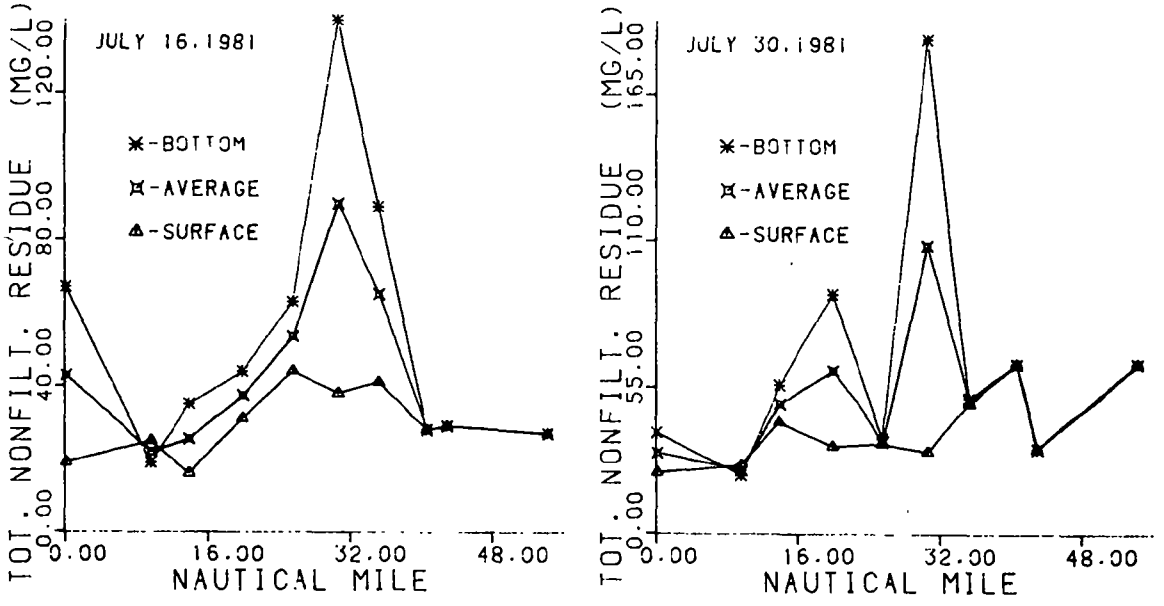
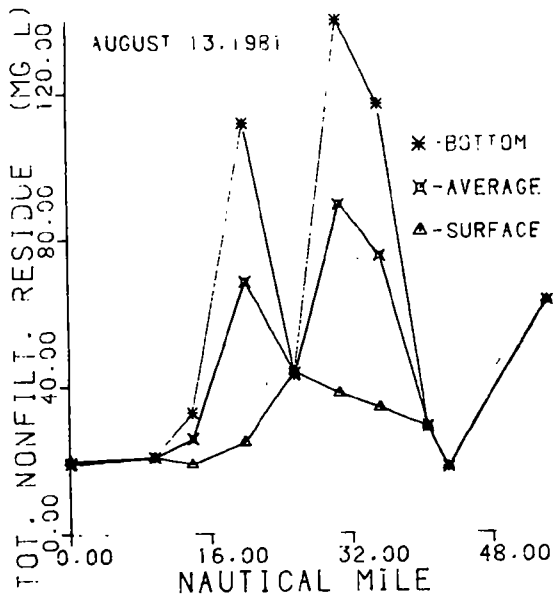


Figure 7-27 Patuxent River Slack Survey Plots of Total Nonfilterable residue



PATUXENT RIVER

Figure 7-27 Patuxent River Slack SUrvey Plots of Total Nonfilterable residue

Table 7-1 Statistical Summary of Patuxent River Slack Survey Data for 1980-1981

Variable	Year	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
TEMP	80	148	20.43	8.50	0.70	41.58
	81	164	20.04	7.30	0.57	36.40
DO	80	143	7.50	2.61	0.22	34.74
	81	160	7.09	2.45	0.19	34.57
DOSAT	80	145	82.85	21.09	1.75	25.46
	81	160	79.00	19.68	1.56	24.91
BOD5	80	153	2.70	1.75	0.14	65.00
	81	172	2.96	1.37	0.10	46.14
PH	80	148	7.43	0.46	0.04	6.20
	81	162	7.38	0.43	0.03	5.78
TALK	80	111	56.36	13.66	1.30	24.23
	81	172	54.87	13.81	1.05	25.16
SALIN	80	108	10.31	5.71	0.55	55.40
	81	115	11.68	5.89	0.55	50.45
RESIDUE	80	115	32.24	25.29	2.36	78.43
	81	178	44.83	57.19	4.29	127.58
TOTN	80	165	1.32	1.63	0.13	123.59
	81	174	1.24	1.09	0.08	88.12
DISSNIT	80	149	0.88	0.97	0.08	111.34
	81	174	1.03	1.09	0.08	105.52
FAMMON	80	164	0.16	0.34	0.03	205.59
	81	174	0.20	0.31	0.02	155.81
FNITRITE	80	164	0.03	0.07	0.01	188.70
	81	175	0.04	0.06	0.0	162.55
FNITRATE	80	164	0.57	0.98	0.08	172.90
	81	175	0.78	0.56	0.12	198.51
TPHOS	80	169	0.19	0.26	0.02	131.94
	81	178	0.19	0.21	0.02	111.21
FPHOS	80	164	0.10	0.18	0.01	185.94
	81	174	0.09	0.12	0.01	144.72
FOPHOS	80	165	0.09	0.20	0.02	210.23
	81	174	0.06	0.12	0.01	190.51
TOC	80	113	7.55	3.73	0.35	49.38
	81	2	4.50	2.83	2.0	62.85
DOC	80	54	11.11	4.58	0.62	41.26
	81	174	4.17	1.96	0.15	46.96
CHLORIDE	80	63	3414.7	3102.7	390.8	90.85
	81	0	--	--	--	--
SILICA	80	111	5.29	3.03	0.29	57.17
	81	174	4.29	3.47	0.26	80.91
CHLORA	80	163	19.95	41.02	3.21	205.61
	81	172	23.71	19.00	1.45	80.14
CHLORAC	80	0	--	--	--	--
	81	152	16.32	14.80	1.20	90.67
PHEOP	80	164	4.84	4.77	0.37	98.47
	81	172	7.39	11.92	0.91	161.23

Table 7-2
Statistical Summary of Patuxent River Slack Survey
Data for 1980-1981. Surface, Bottom, and Mid Depths

Variable	Depth	Year	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
TEMP	S*	80	56	21.14	8.69	1.16	41.09
	S	81	63	20.76	7.48	0.94	36.04
	M*	80	28	18.51	8.09	1.53	43.69
	M	81	31	18.43	6.60	1.19	35.82
	B*	80	64	20.65	8.51	1.06	41.19
	B	81	70	20.12	7.41	0.89	36.82
DO	S	80	56	7.95	2.32	0.31	29.13
	S	81	63	7.54	2.18	0.27	28.86
	M	80	23	7.19	2.44	0.51	33.97
	M	81	27	6.54	1.55	0.30	23.65
	B	80	64	7.22	2.87	0.36	39.77
	B	81	70	6.91	2.89	0.35	41.88
DOSAT	S	80	56	90.64	18.16	2.43	20.04
	S	81	63	86.01	15.36	1.94	17.86
	M	80	25	72.57	14.66	2.93	20.21
	M	81	27	69.61	12.85	2.47	18.46
	B	80	64	80.06	23.30	2.91	29.11
	B	81	70	76.32	23.05	2.75	30.20
BOD5	S	80	63	3.32	1.87	0.24	56.48
	S	81	71	3.18	1.28	0.15	40.373
	M	80	21	3.35	1.53	0.33	45.67
	M	81	27	3.71	1.51	0.29	40.66
	B	80	69	1.93	1.37	0.17	71.21
	B	81	74	2.49	1.23	0.14	49.36
PH	S	80	56	7.60	0.40	0.05	5.29
	S	81	63	7.57	0.42	0.05	5.54
	M	80	28	7.10	0.44	0.08	6.23
	M	81	31	6.98	0.30	0.05	4.31
	B	80	64	7.42	0.44	0.06	5.94
	B	81	68	7.40	0.35	0.04	4.78
TALK	S	80	46	59.17	12.69	1.87	21.45
	S	81	69	56.77	12.87	1.55	22.67
	M	80	15	38.85	4.98	1.29	12.82
	M	81	27	39.84	7.99	1.54	20.05
	B	80	50	59.03	12.46	1.76	21.10
	B	81	76	58.48	12.82	1.47	21.92
SALIN	S	80	54	10.02	5.69	0.77	56.74
	S	81	58	11.23	5.90	0.77	52.53
	M	80	0	--	--	--	--
	M	81	0	--	--	--	--
	B	80	54	10.60	5.77	0.79	54.50
	B	81	57	12.14	5.90	0.78	48.63

* Surface, Mid, and Bottom

Table 7-2 (continued)
Statistical Summary of Patuxent River Slack Survey
Data for 1980-1981; Surface, Bottom, and Mid Depths

Variable	Depth	Year	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
RESIDUE	S	80	45	26.96	12.12	1.81	44.97
	S	81	71	34.27	17.91	2.12	52.26
	M	80	20	22.8	11.48	2.57	50.36
	M	81	31	29.29	16.34	2.93	55.77
	B	80	50	40.78	34.18	4.83	83.81
	B	81	76	61.04	82.71	9.49	135.52
TOTN	S	80	66	0.91	0.67	0.08	73.57
	S	81	71	0.86	0.54	0.06	62.68
	M	80	24	3.49	0.91	0.19	26.19
	M	81	27	3.36	0.79	0.15	23.45
	B	80	75	0.98	1.85	0.21	189.18
	B	81	76	0.83	0.56	0.06	67.39
DISSNIT	S	80	65	0.62	0.49	0.06	78.46
	S	81	71	0.70	0.68	0.08	97.30
	M	80	15	3.37	0.85	0.22	25.36
	M	81	27	3.13	0.80	0.15	25.73
	B	80	69	0.57	0.41	0.05	71.87
	B	81	76	0.60	0.47	0.05	77.83
FAMMON	S	80	66	0.06	0.09	0.01	142.33
	S	81	71	0.12	0.20	0.02	175.75
	M	80	24	0.63	0.63	0.13	101.00
	M	81	27	0.59	0.48	0.09	81.03
	B	80	74	0.10	0.19	0.02	187.34
	B	81	76	0.13	0.19	0.02	138.61
FINITRITES	S	80	66	0.01	0.02	0.0	120.64
	S	81	71	0.01	0.02	0.0	122.81
	M	80	24	0.14	0.12	0.02	89.00
	M	81	27	0.15	0.08	0.02	51.79
	B	80	74	0.02	0.02	0.0	129.64
	B	81	77	0.02	0.02	0.0	141.08
FNITRATE	S	80	66	0.21	0.39	0.05	185.41
	S	81	71	0.47	0.94	0.11	199.73
	M	80	24	2.64	0.82	0.17	31.18
	M	81	27	2.24	0.49	0.09	22.02
	B	80	74	0.21	0.38	0.04	177.85
	B	81	77	0.56	1.94	0.22	343.87
TPHOS	S	80	66	0.10	0.10	0.01	100.41
	S	81	71	0.11	0.07	0.01	63.49
	M	80	29	0.65	0.30	0.06	45.79
	M	81	31	0.54	0.25	0.04	46.12
	B	80	74	0.10	0.09	0.01	91.06
	B	81	76	0.13	0.13	0.02	103.07

Table 7-2 (continued)
Statistical Summary of Patuxent River Slack Survey
Data for 1980-1981, Surface, Bottom, and Mid Depths

Variable	Depth	Year	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
FPHOS	S	80	66	0.05	0.03	0.0	69.74
	S	81	71	0.06	0.10	0.01	173.22
	M	80	24	0.41	0.32	0.07	78.26
	M	81	27	0.28	0.18	0.03	63.47
	B	80	74	0.04	0.02	0.0	52.69
	B	81	76	0.05	0.02	0.0	34.32
FOPHOS	S	80	66	0.03	0.02	0.0	79.98
	S	81	71	0.02	0.02	0.0	100.19
	M	80	26	0.44	0.32	0.06	73.83
	M	81	27	0.27	0.18	0.03	64.82
	B	80	73	0.03	0.02	0.0	86.17
	B	81	76	0.02	0.02	0.0	94.70
TOL	S	80	44	7.99	4.43	0.67	55.46
	S	81	0	--	--	--	--
	M	80	20	8.78	4.21	0.94	47.92
	M	81	2	4.50	2.83	2.00	62.85
	B	80	49	6.65	2.49	0.36	37.43
	B	81	0	--	--	--	--
DOC	S	80	20	10.53	4.96	1.11	47.14
	S	81	71	3.75	1.65	1.10	43.85
	M	80	9	11.78	3.54	1.18	30.03
	M	81	27	5.60	1.18	0.23	21.14
	B	80	25	11.33	4.71	0.94	41.60
	B	81	76	4.05	2.22	0.25	54.75
CHLORIDE	S	80	26	4105.8	2965.4	581.6	72.22
	S	81	0	--	--	--	--
	M	80	9	100.67	94.59	31.53	93.97
	M	81	0	--	--	--	--
	B	80	28	3838.2	3105.8	586.9	80.92
	B	81	0	--	--	--	--
SILICA	S	80	46	4.30	2.15	0.32	49.94
	S	81	71	3.31	2.82	0.33	84.98
	M	80	15	10.1	1.62	0.42	16.05
	M	81	27	8.84	1.53	0.29	17.28
	B	80	50	4.77	2.70	0.38	56.65
	B	81	76	3.58	3.27	0.38	91.32

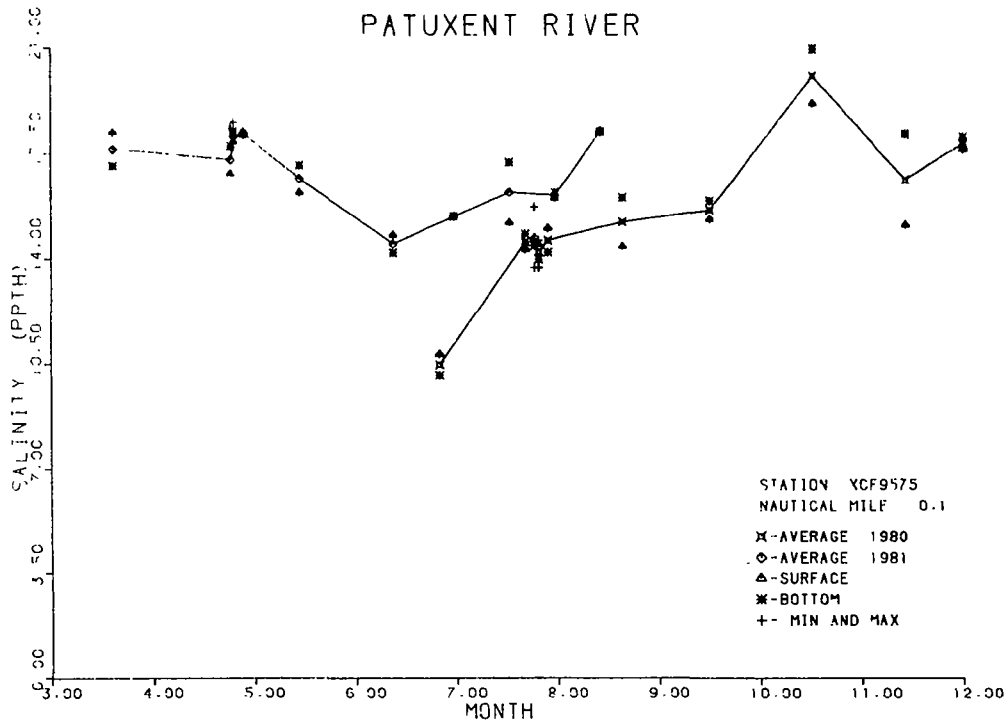
Table 7-2 (continued)
Statistical Summary of Patuxent River Slack Survey
Data for 1980-1981, Surface, Bottom, and Mid Depths

Variable	Depth	Year	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
CHLORA	S	80	66	30.92	60.58	7.46	195.89
	S	81	70	26.27	17.20	2.06	65.47
	M	80	24	14.83	17.80	3.63	119.98
	M	81	27	20.72	19.34	3.72	93.35
	B	80	73	11.71	13.57	1.59	115.90
	B	81	75	22.40	20.40	2.36	91.05
CHLORAC	S	80	0	--	--	--	--
	S	81	61	20.42	15.15	1.94	74.17
	M	80	0	--	--	--	--
	M	81	24	11.96	15.62	3.19	130.53
	B	80	0	--	--	--	--
	B	81	67	14.15	13.43	1.64	94.91
PHEOP	S	80	66	4.13	4.25	0.52	103.11
	S	81	70	5.82	7.62	0.91	130.98
	M	80	24	4.72	3.87	0.79	81.92
	M	81	27	5.52	5.60	1.08	106.51
	B	80	74	5.52	5.38	0.63	97.36
	B	81	75	9.54	15.97	1.84	167.39

APPENDIX G

TEMPORAL WATER QUALITY FIGURES AND TABLES

SECTION 8



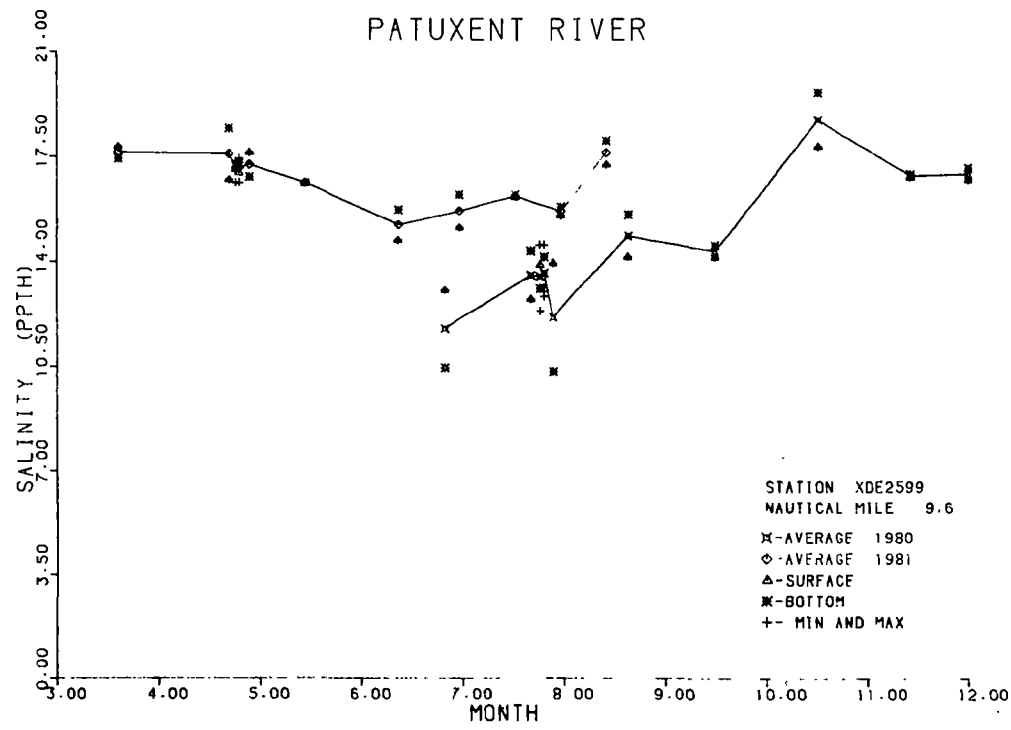
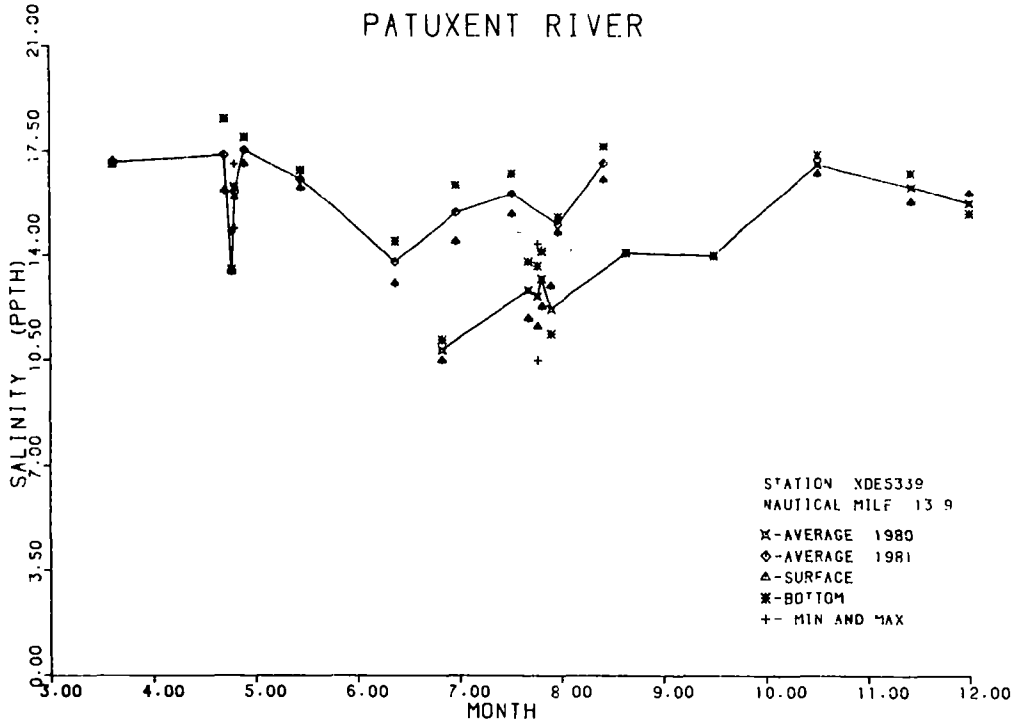


Figure 8-1 Temporal plot of salinity, 1980-1981.



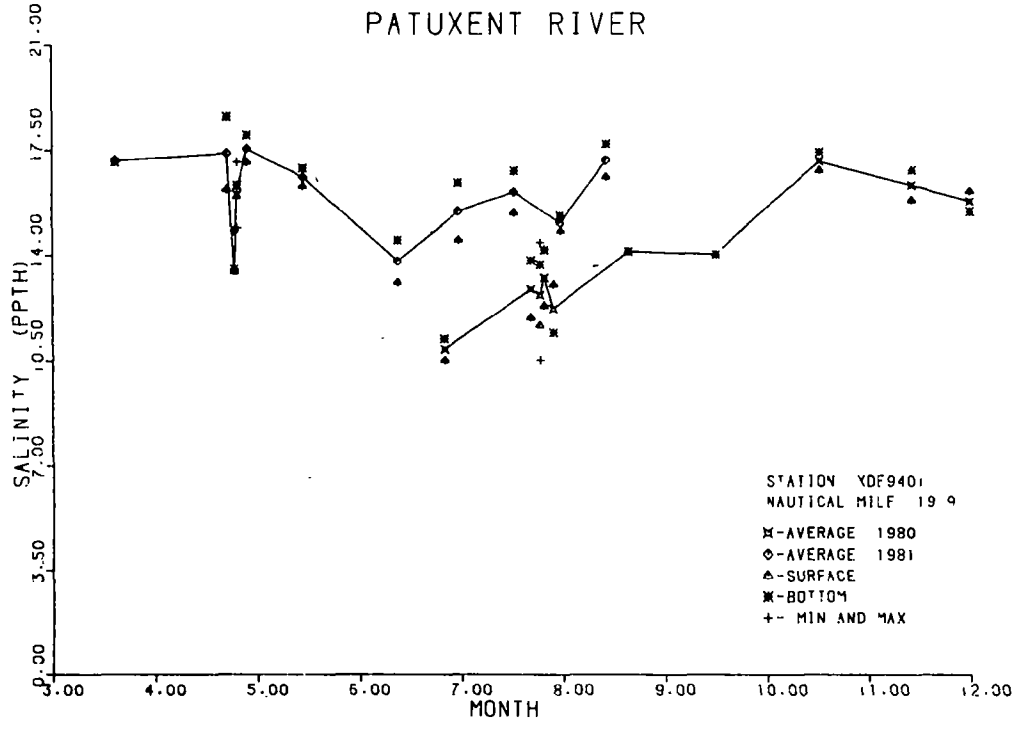
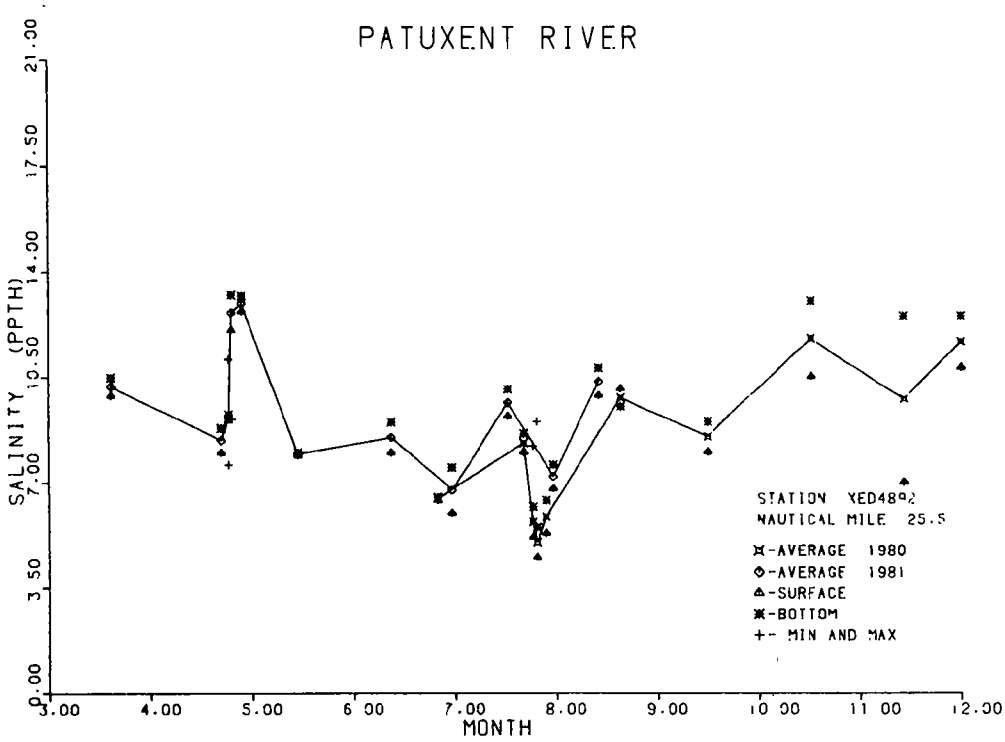


Figure 8-1 Temporal plot of salinity, 1980-1981.



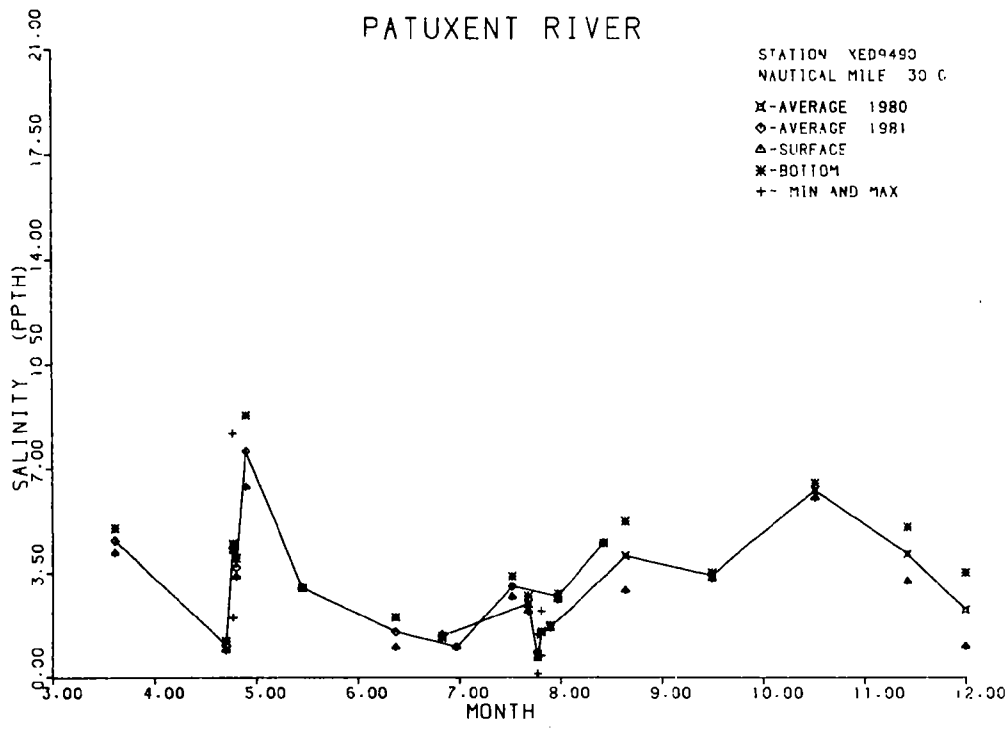


Figure 8-1 Temporal plot of salinity, 1980-1981.

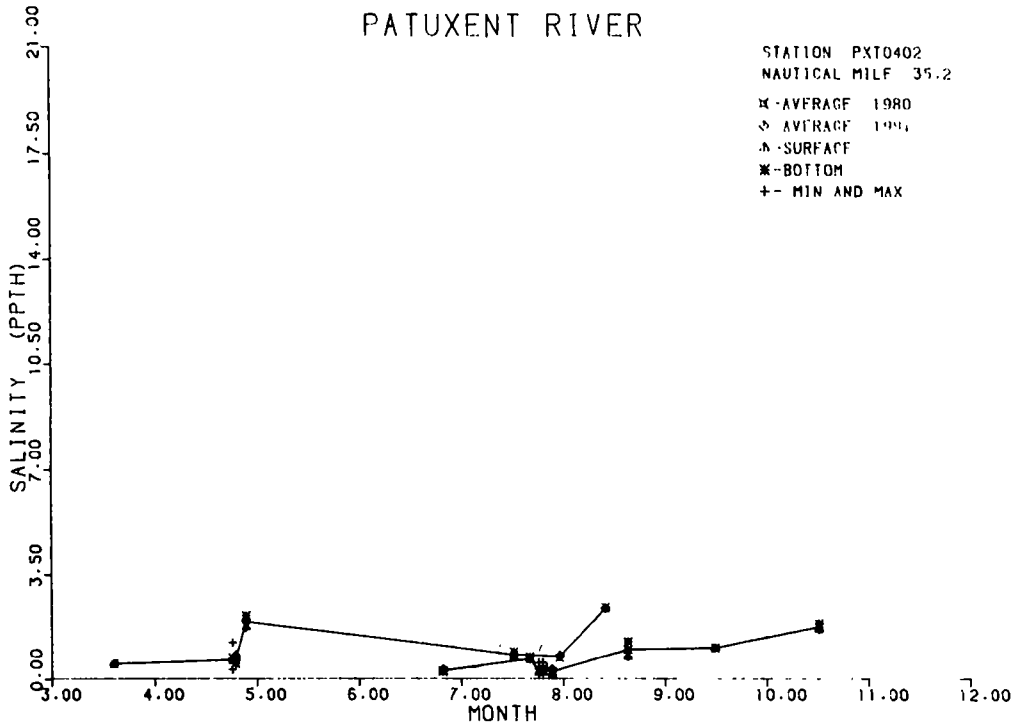
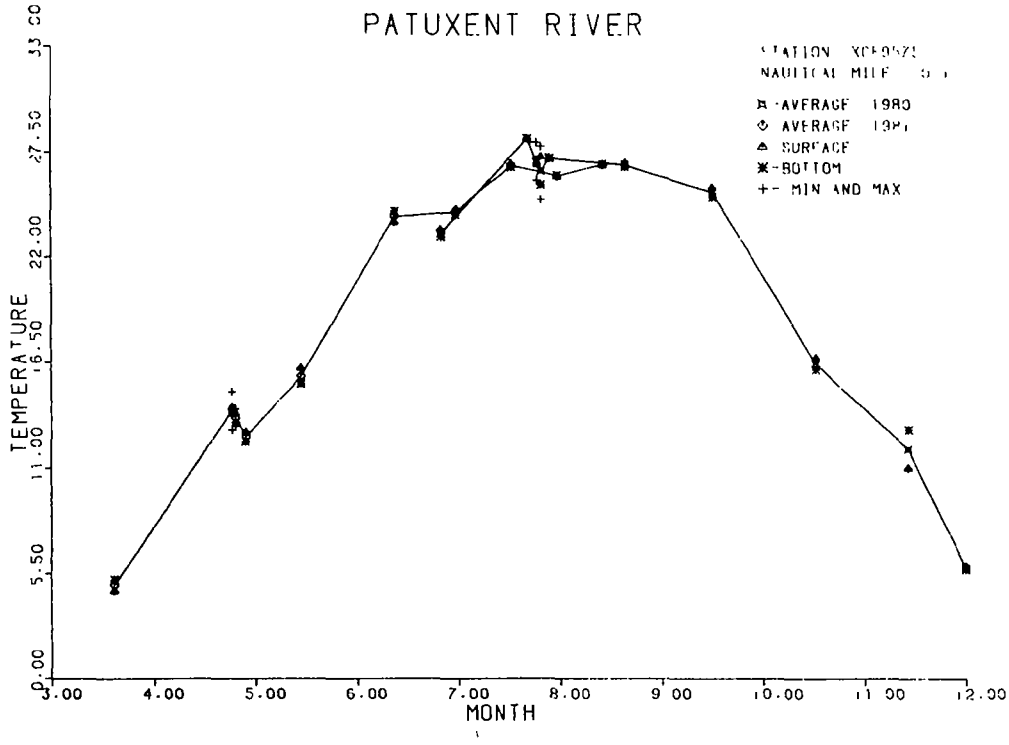


Figure 8-1 Temporal plot of salinity, 1980-1981.



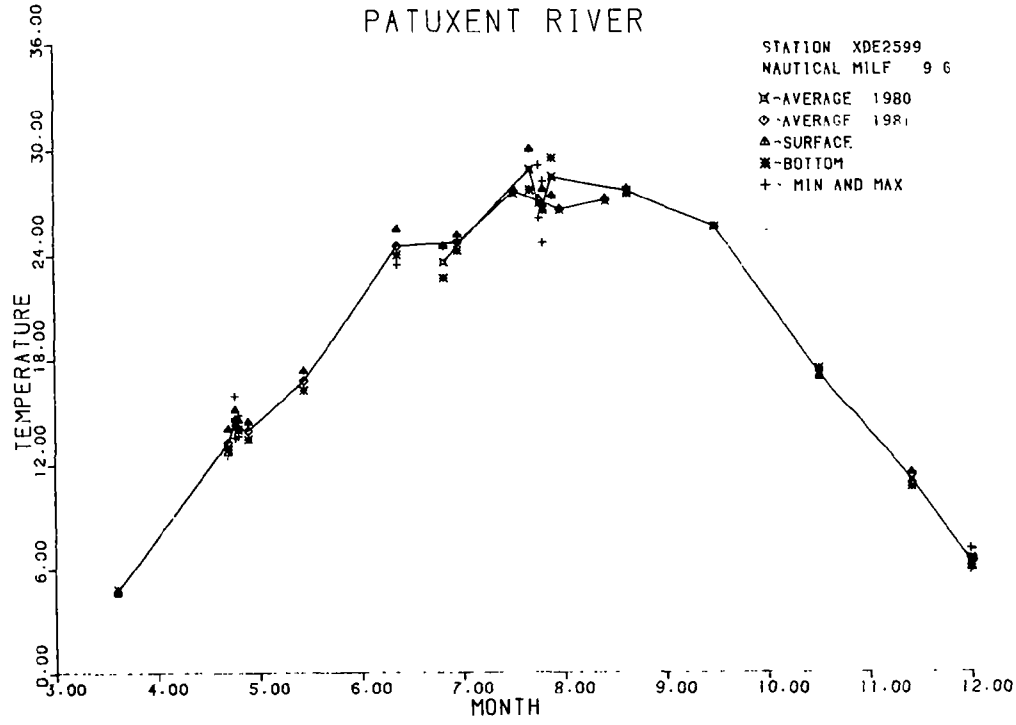
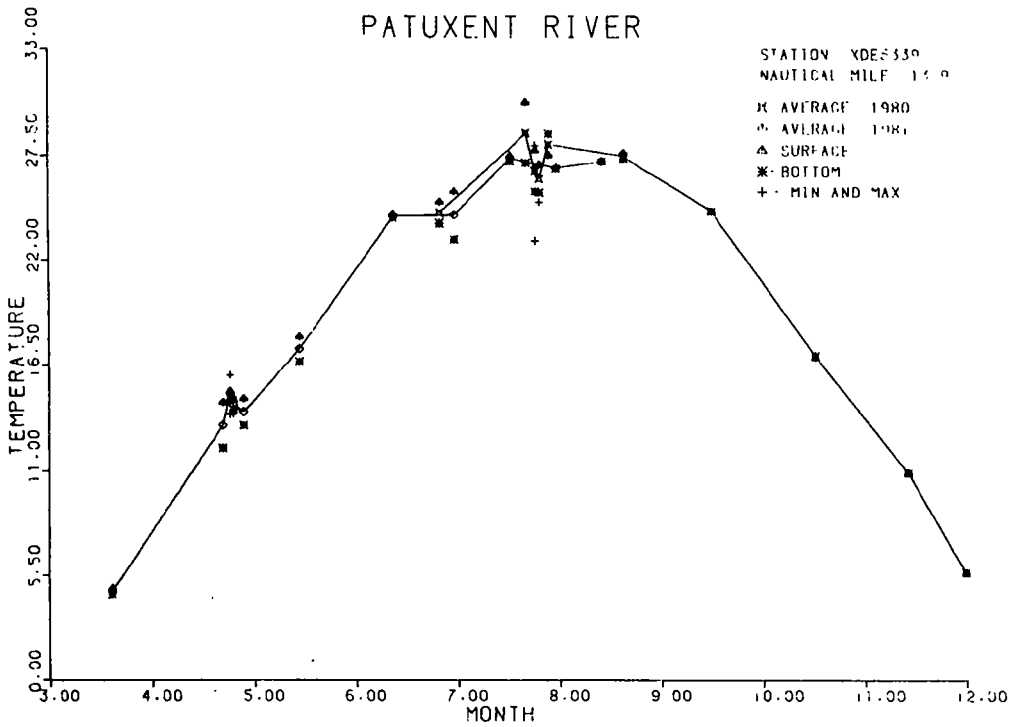


Figure 8-2 Temporal plot of temperature, 1980-1981.



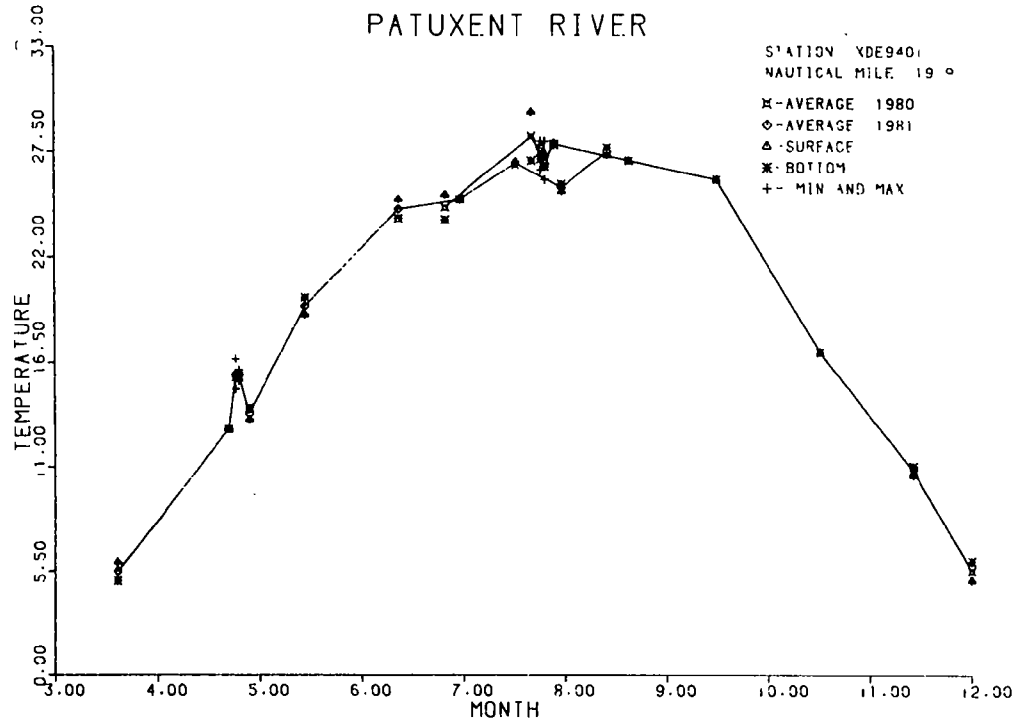
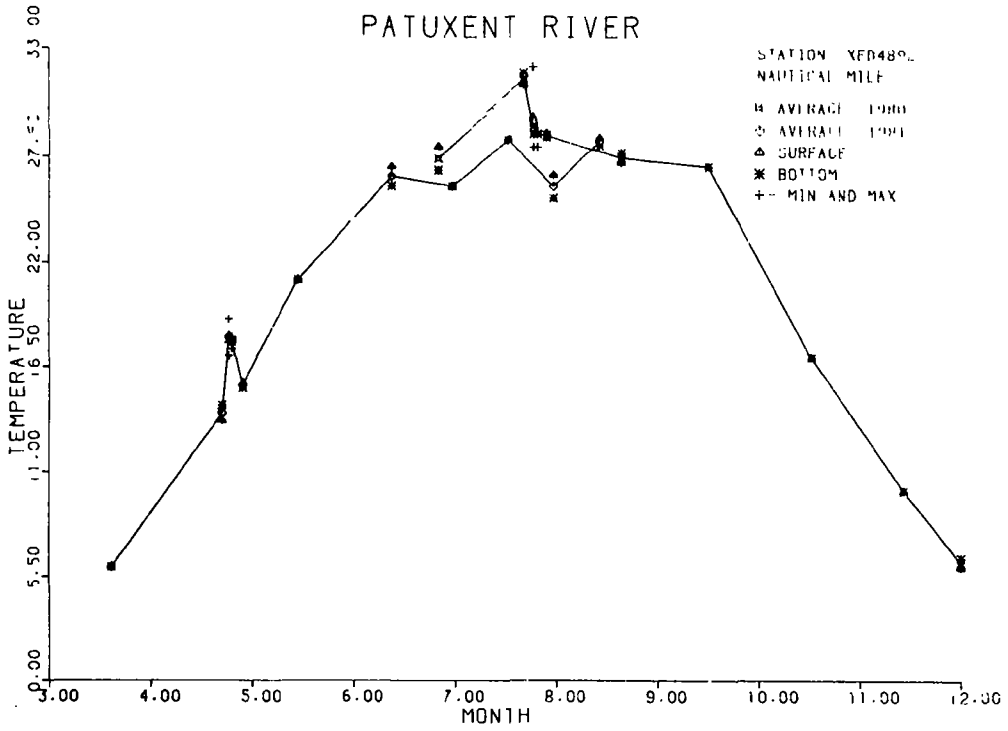


Figure 8-2 Temporal plot of temperature, 1980-1981.



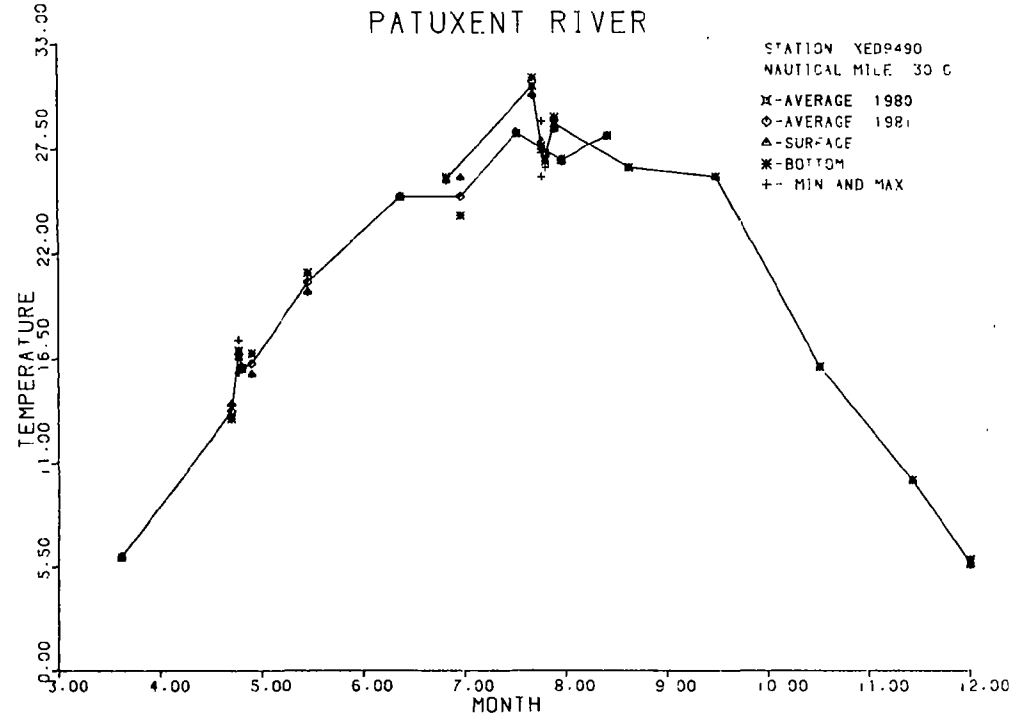
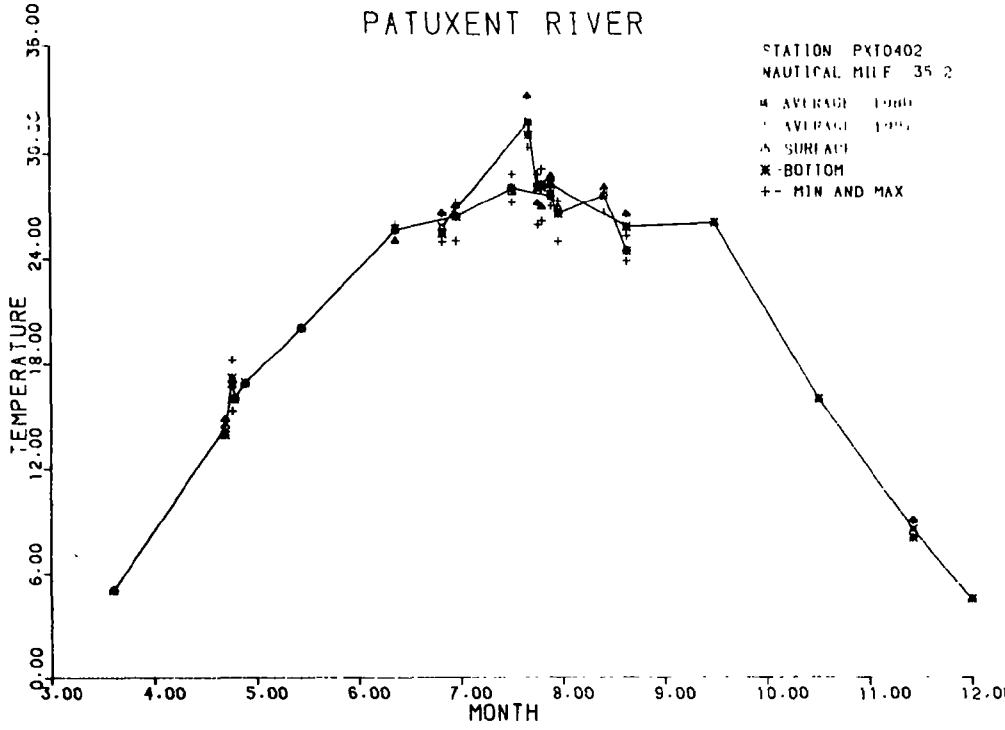


Figure 8-2 Temporal plot of temperature, 1980-1981.



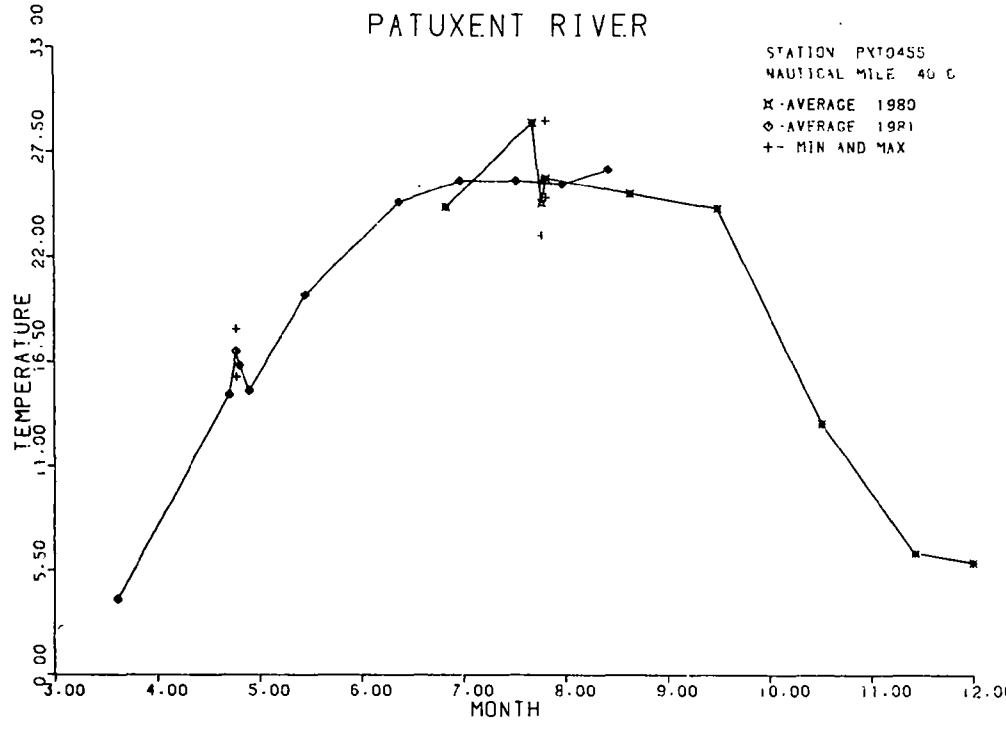
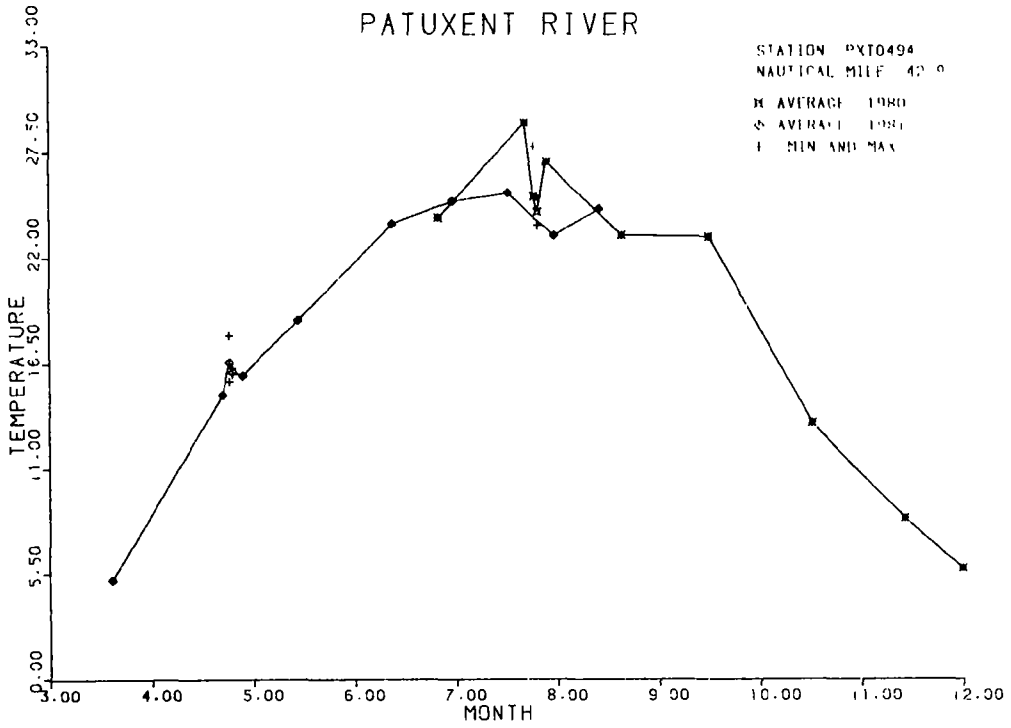


Figure 8-2 Temporal plot of temperature, 1980-1981.



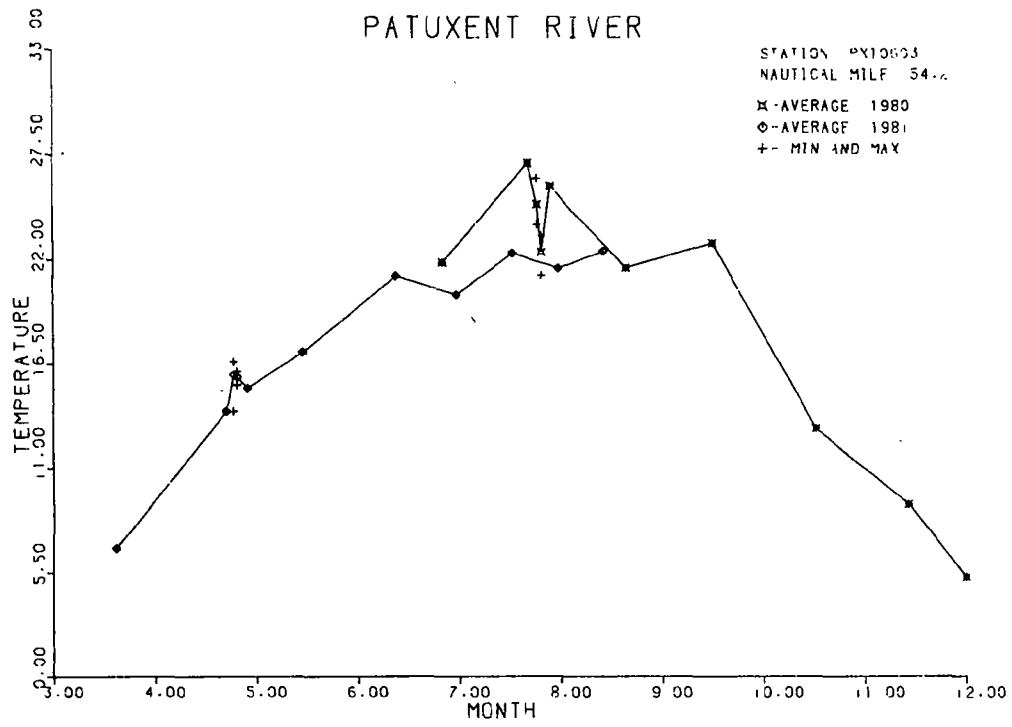
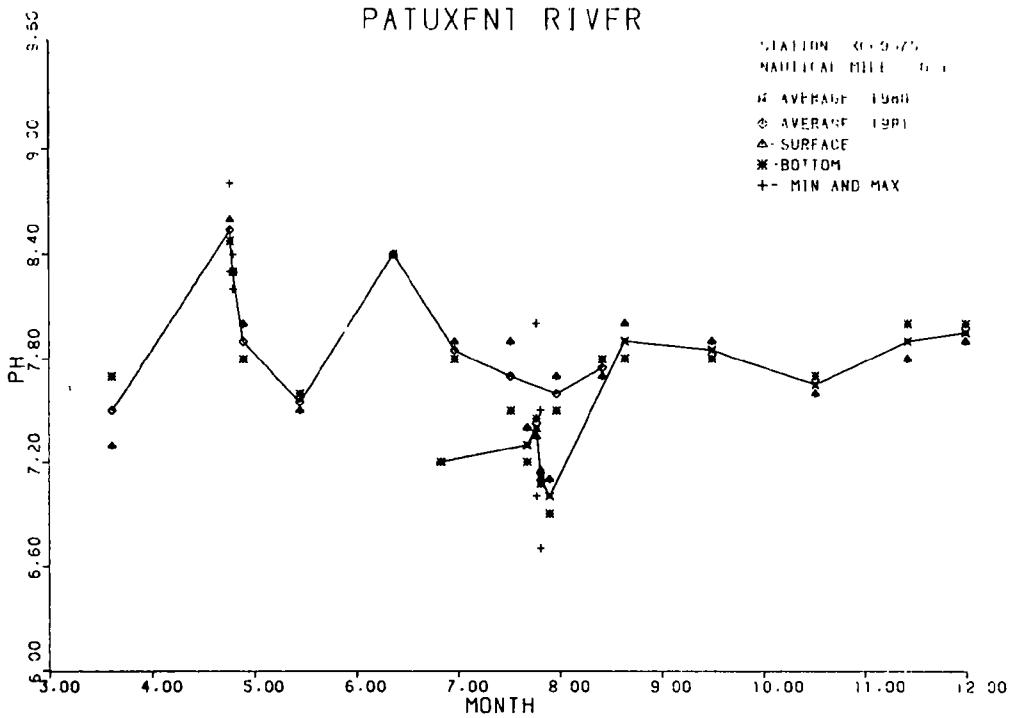


Figure 8-2 Temporal plot of temperature, 1980-1981.



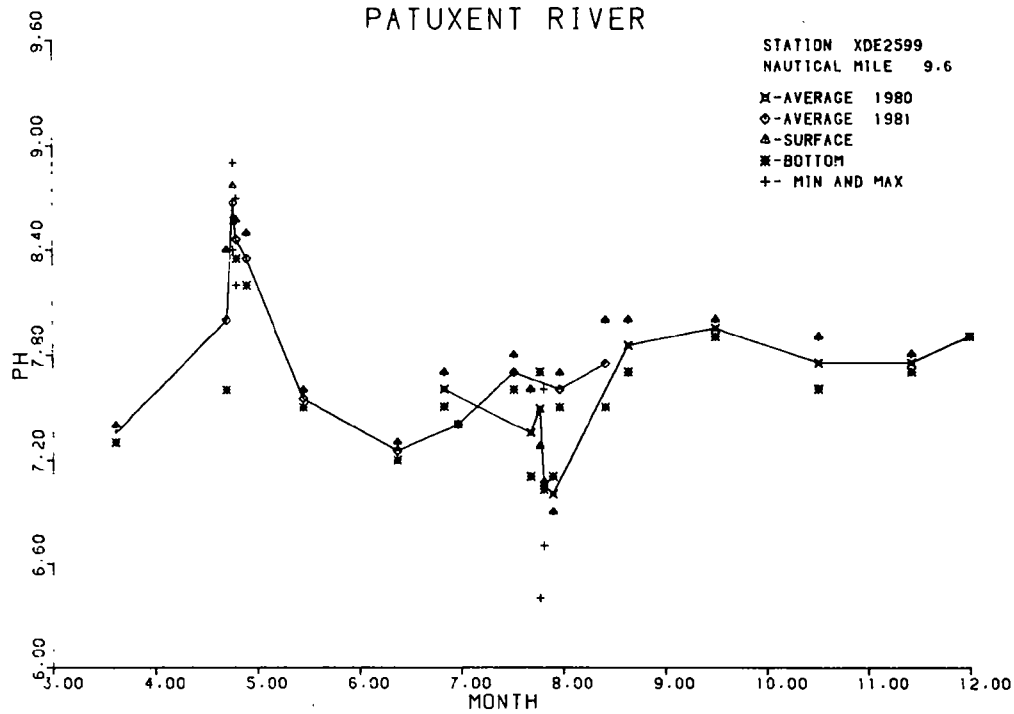
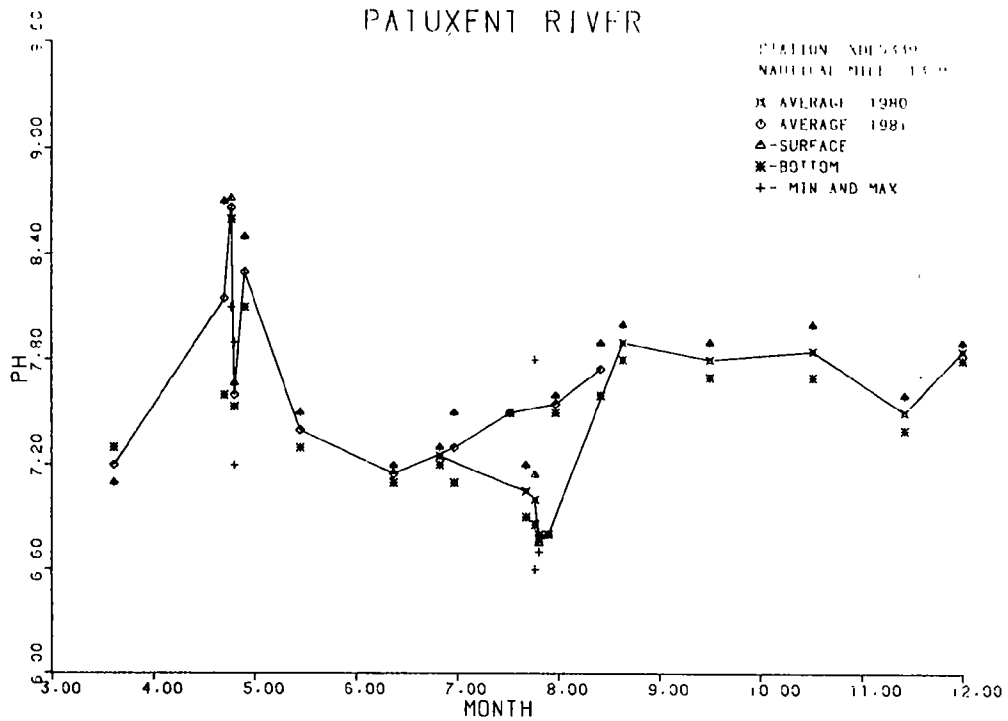


Figure 8-3 Temporal plots of pH, 1980-1981.



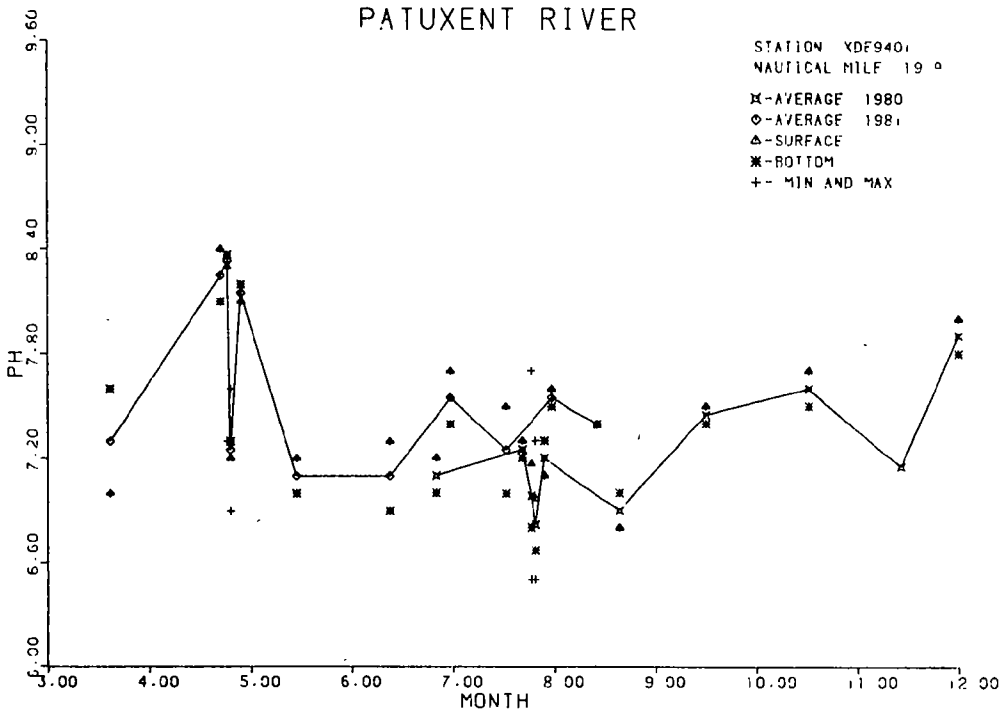
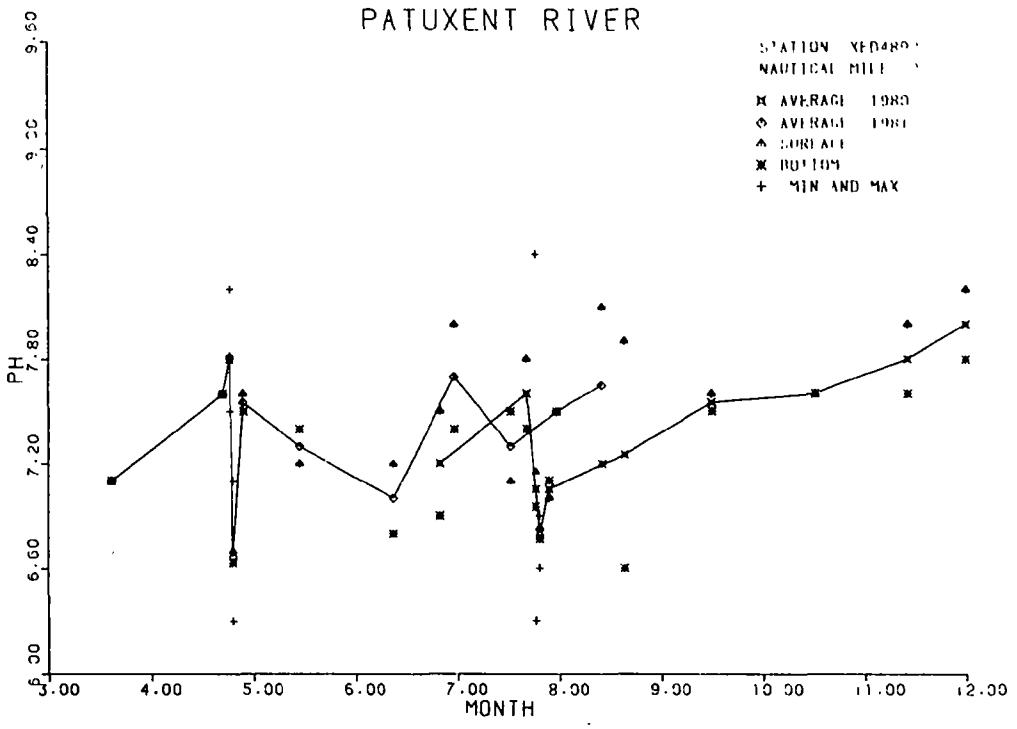


Figure 8-3 Temporal plots of pH, 1980-1981.



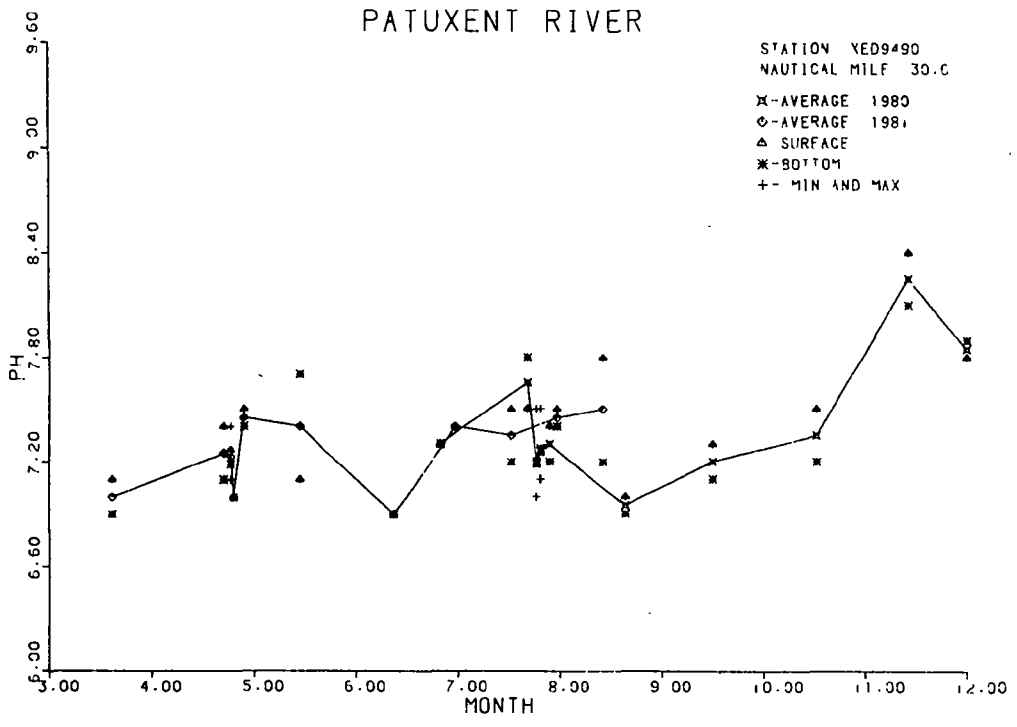
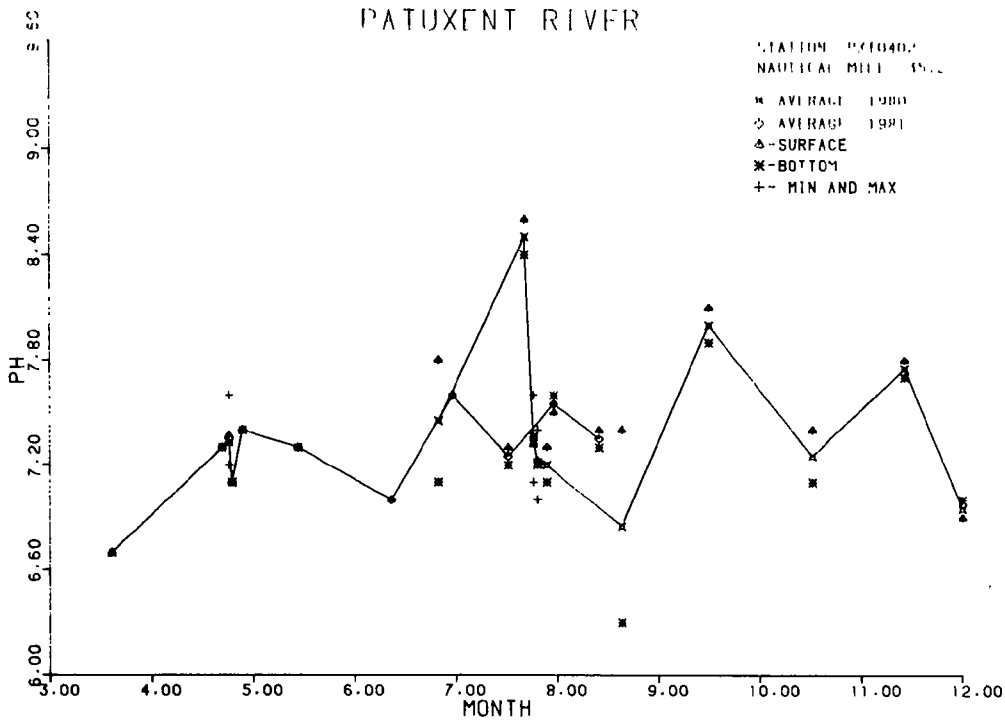


Figure 8-3 Temporal plots of pH, 1980-1981.



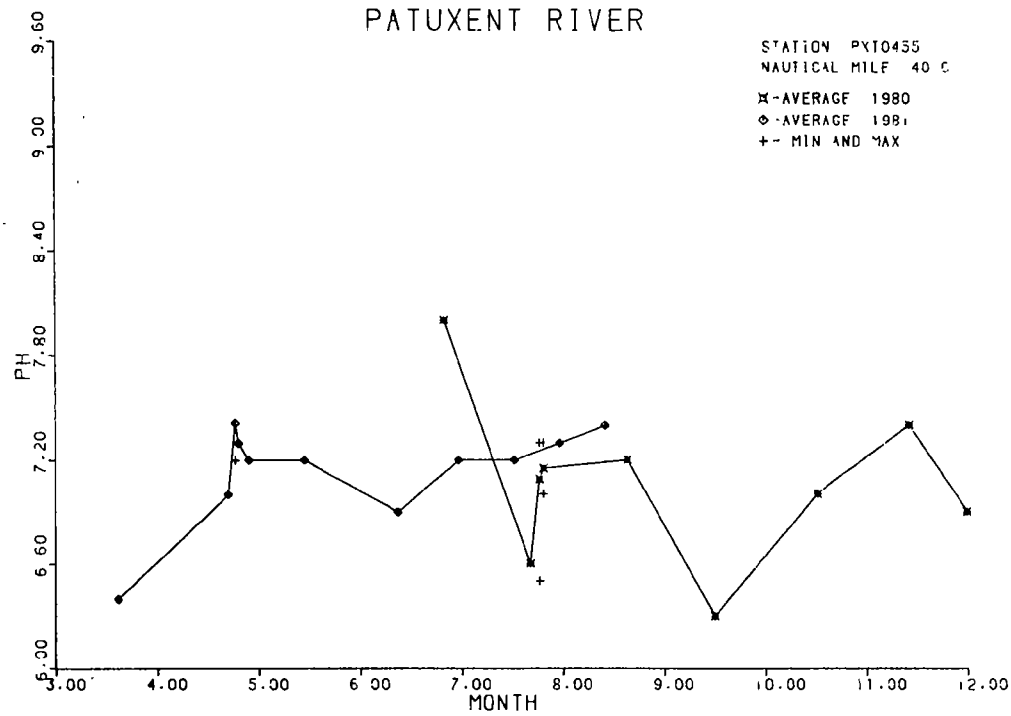
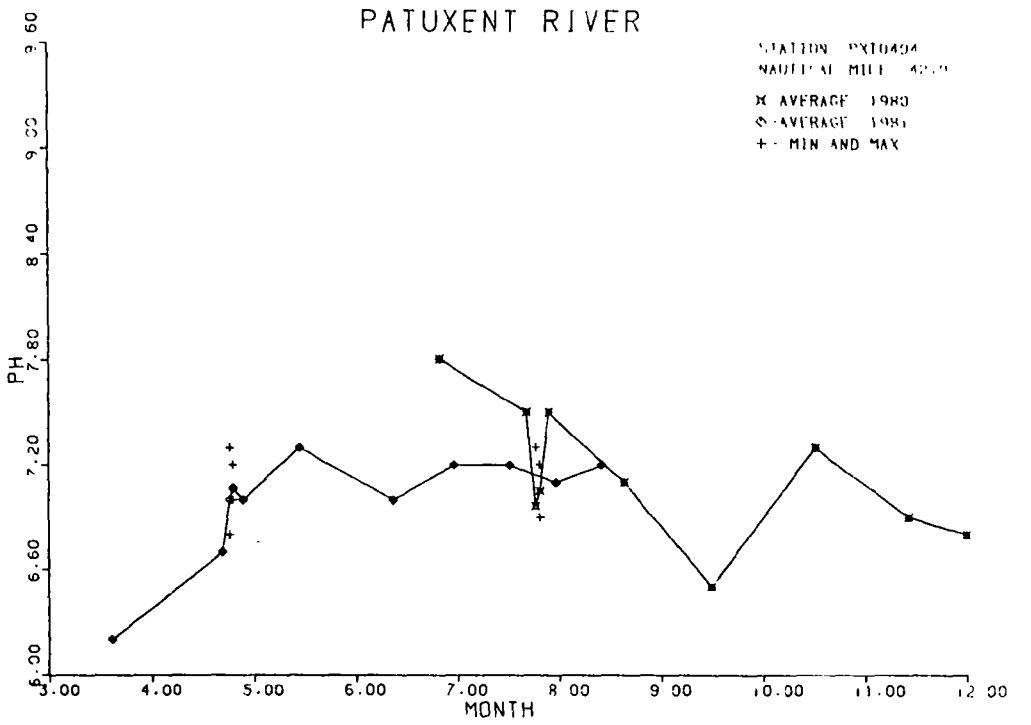


Figure 8-3 Temporal plots of pH, 1980-1981.



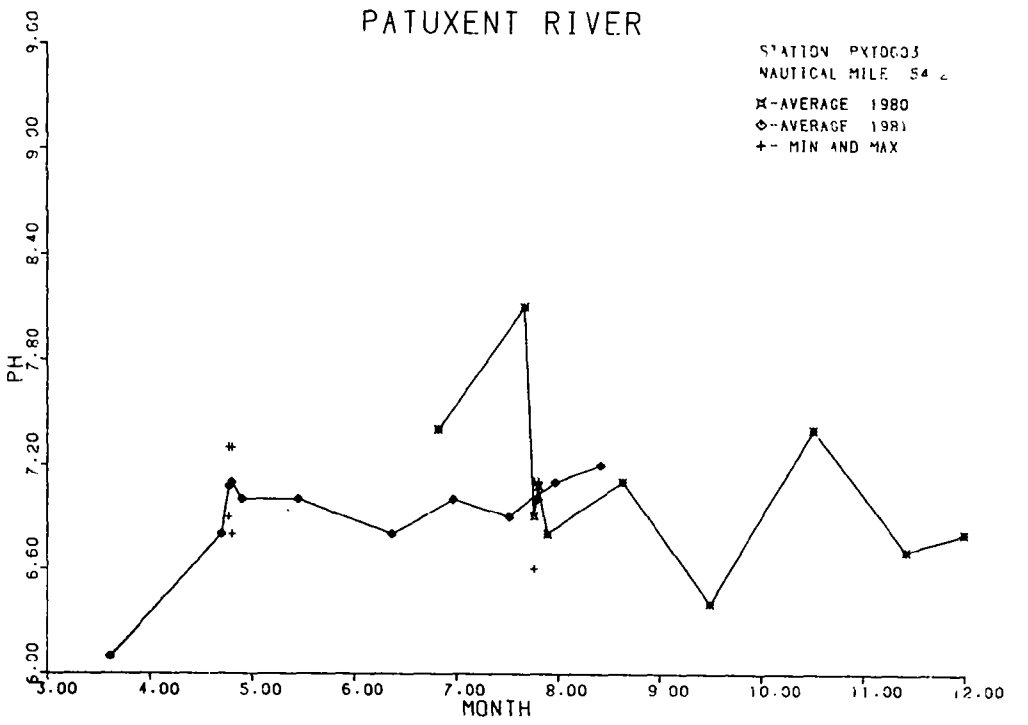
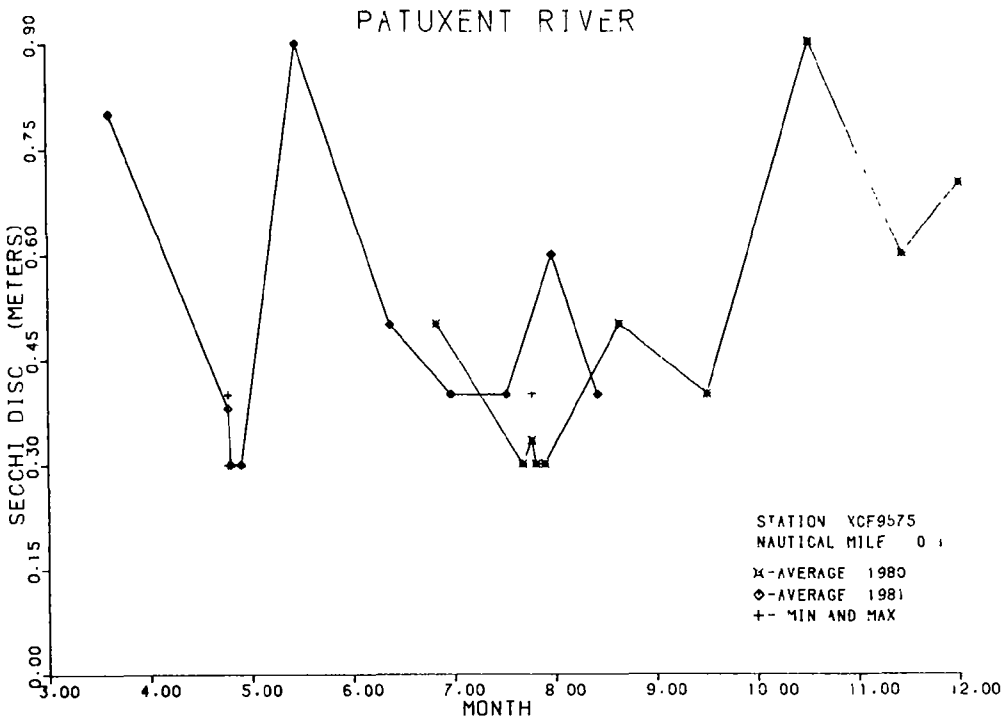


Figure 8-3 Temporal plots of pH, 1980-1981.



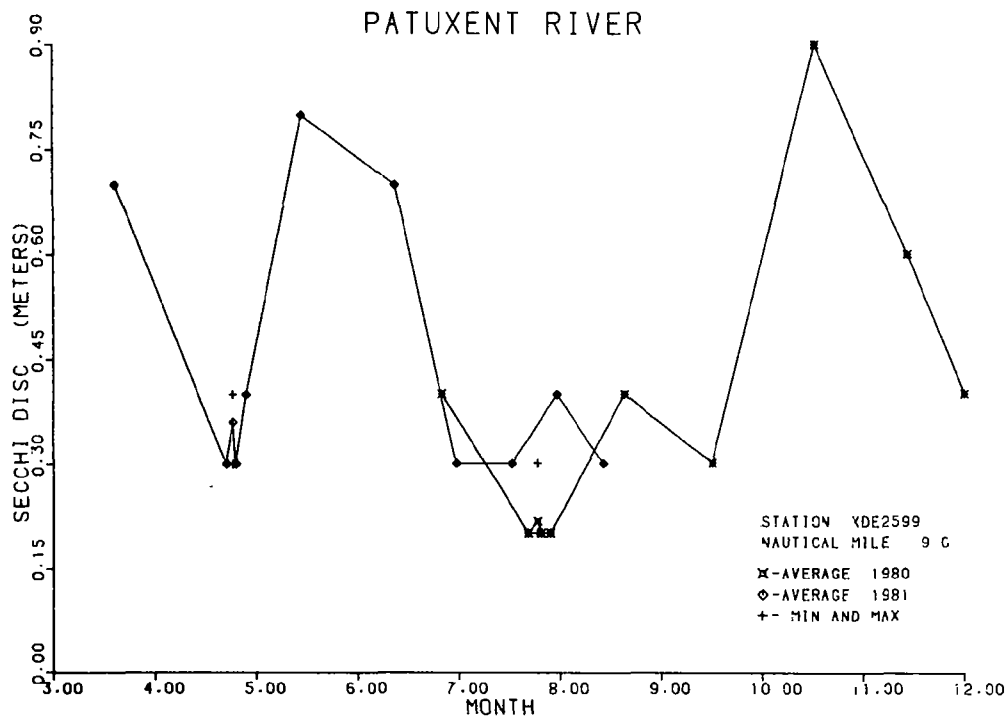
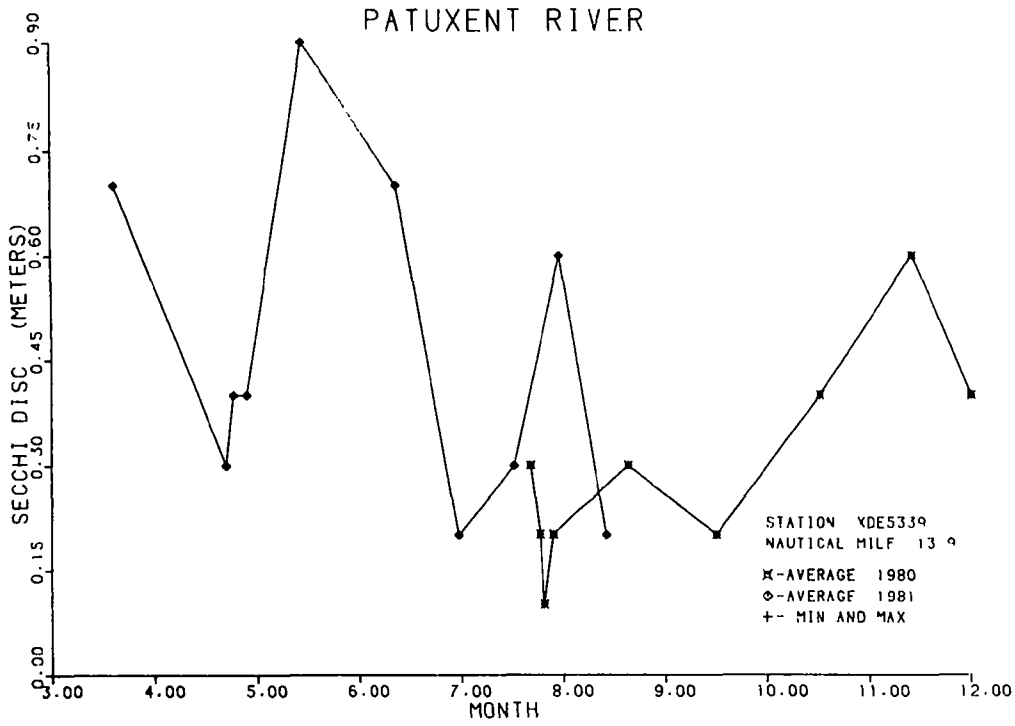


Figure 8-4 Temporal plots of secchi disc 1980, 1981.



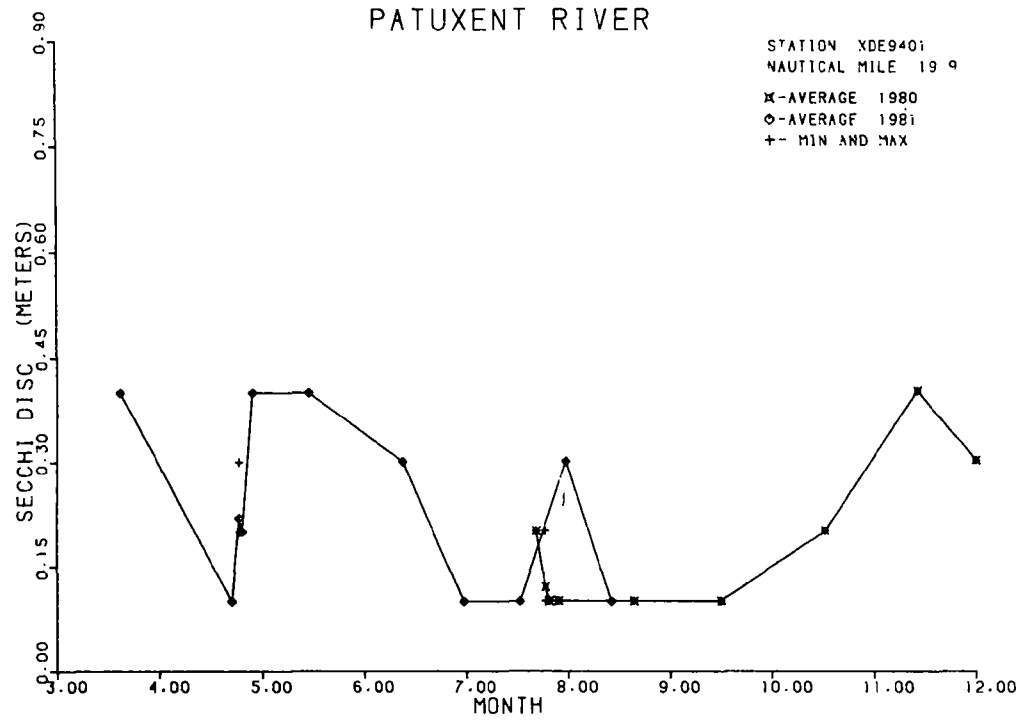
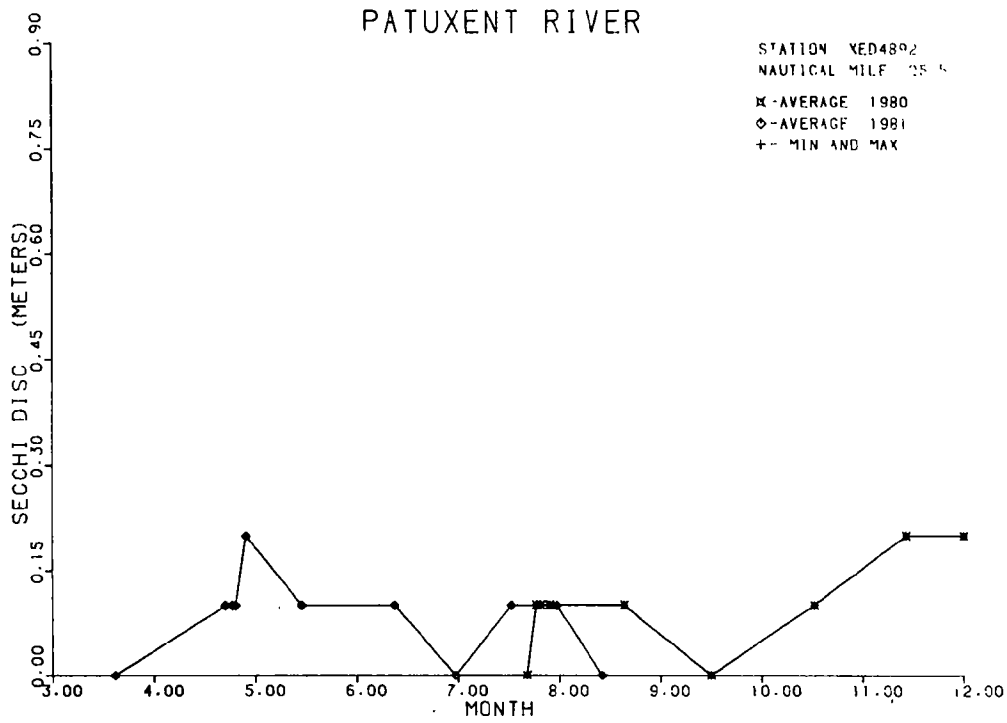


Figure 8-4 Temporal plots of secchi disc 1980, 1981.



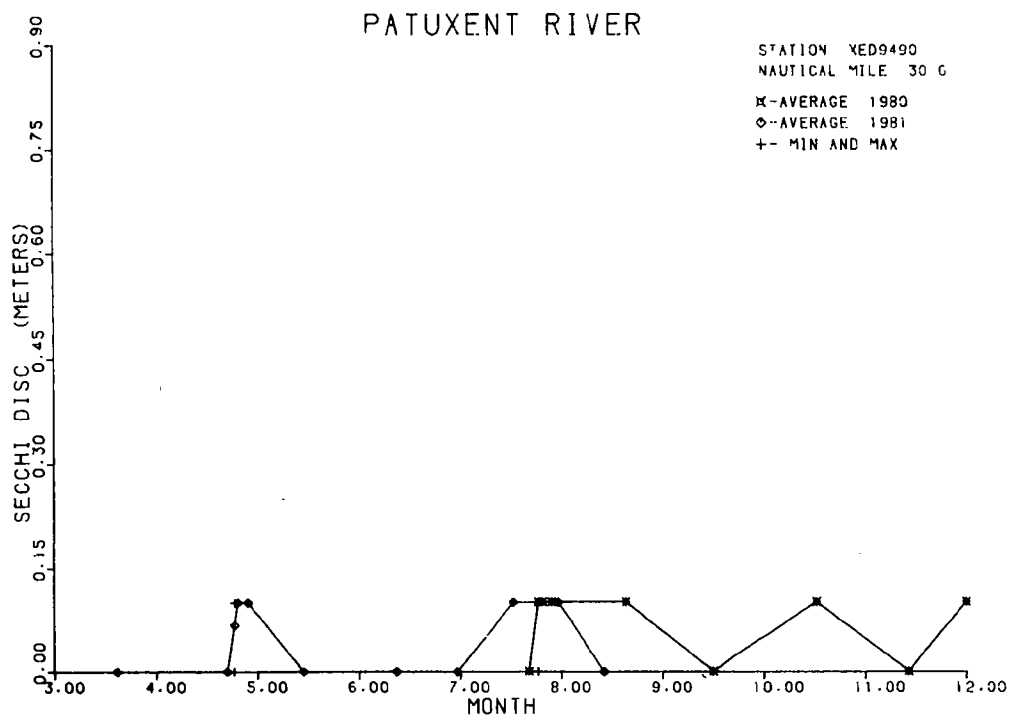
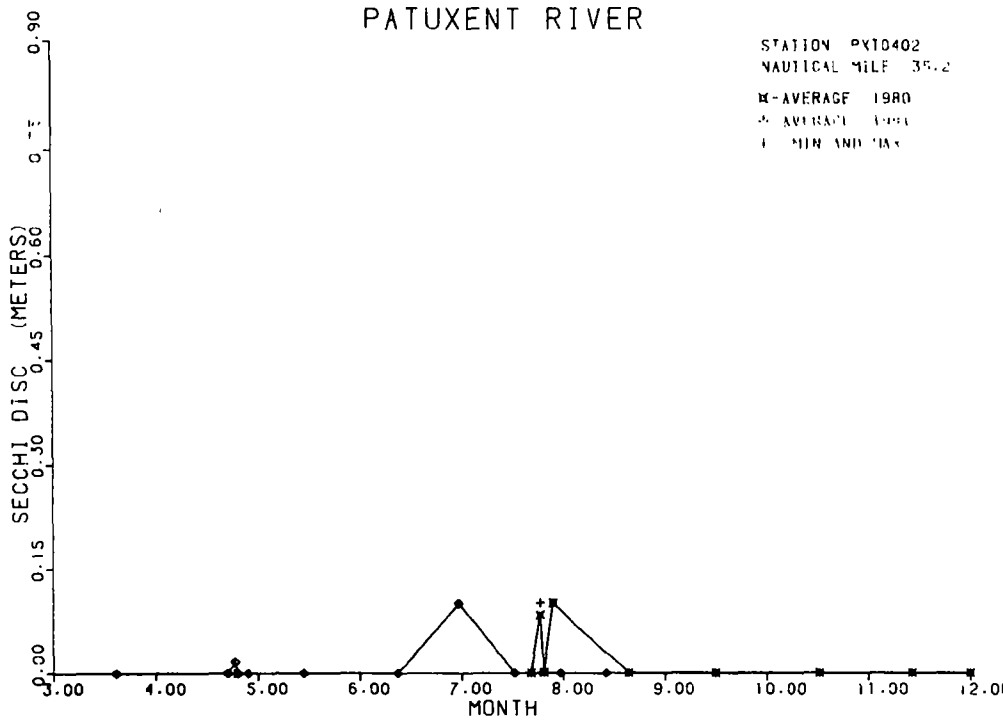


Figure 8-4 Temporal plots of secchi disc 1980, 1981.



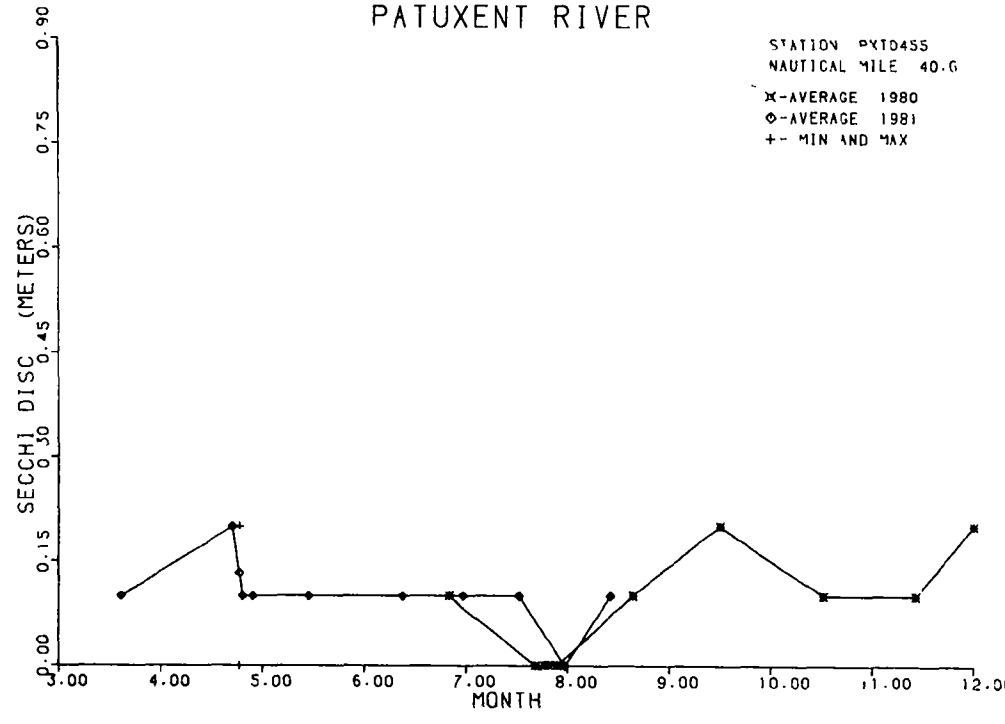
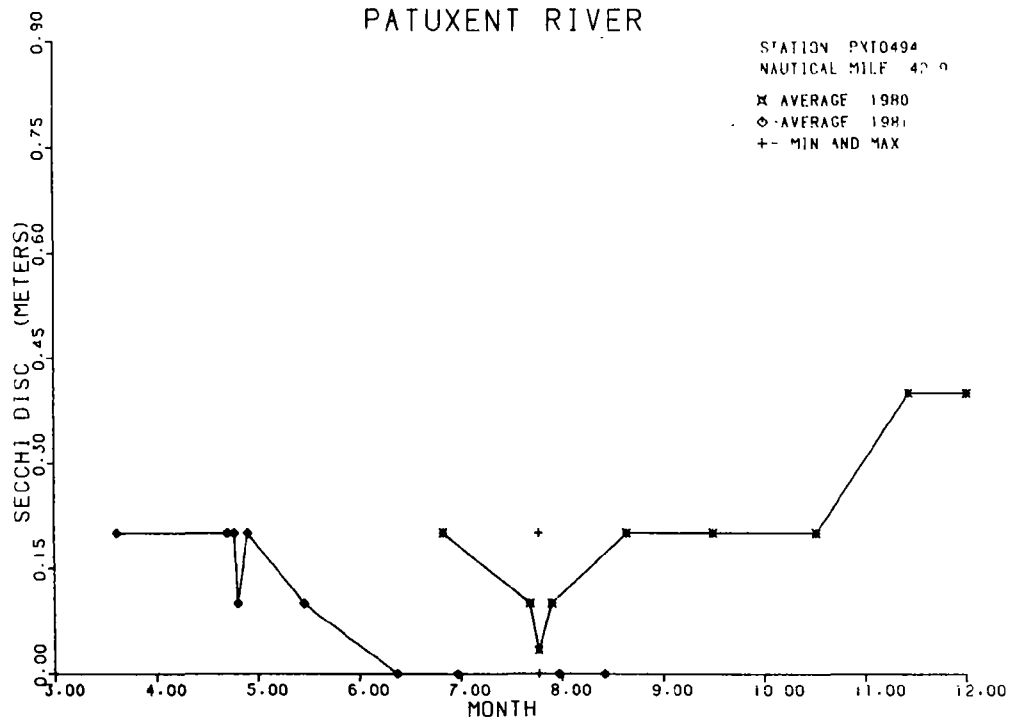


Figure 8-4 Temporal plots of secchi disc 1980, 1981.



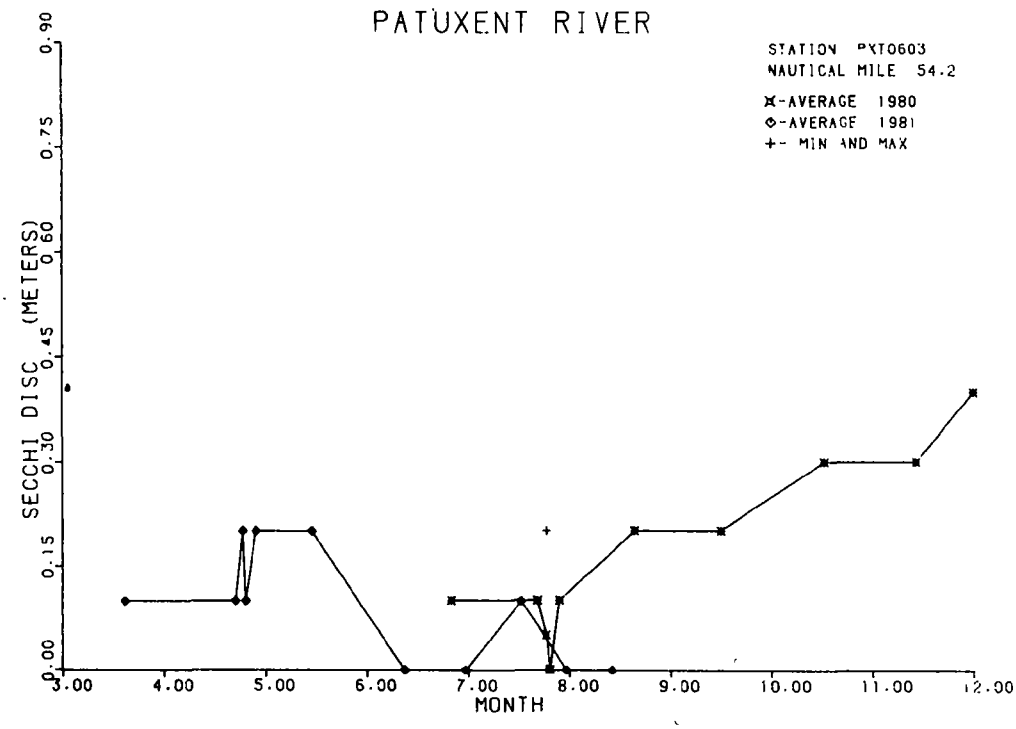
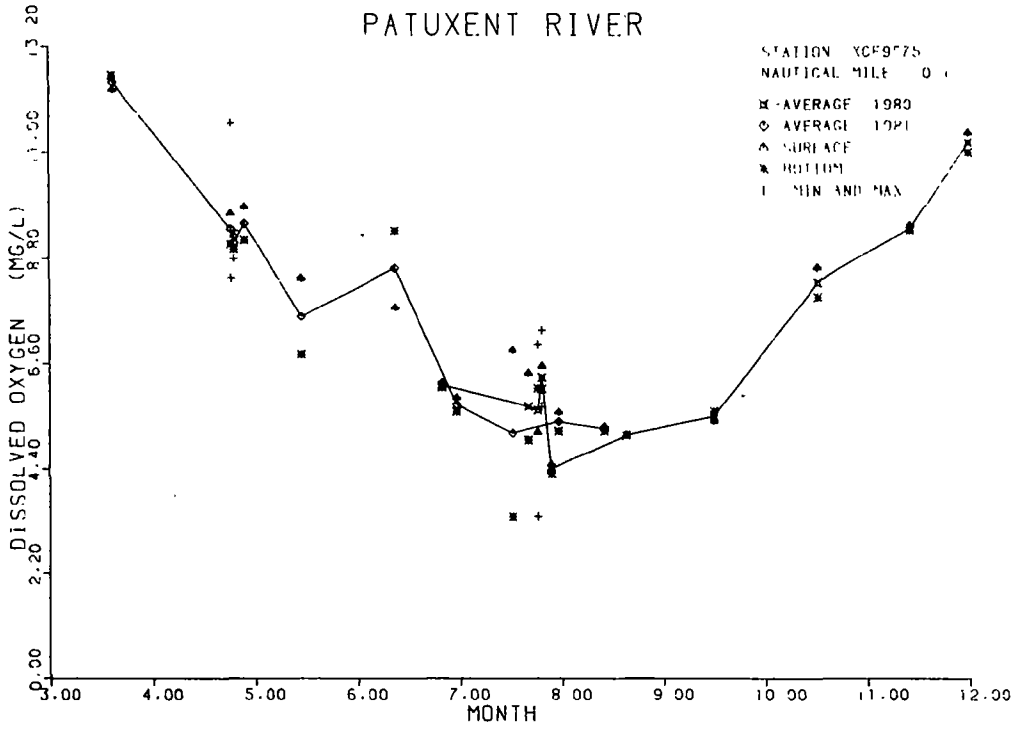


Figure 8-4 Temporal plots of secchi disc 1980, 1981.



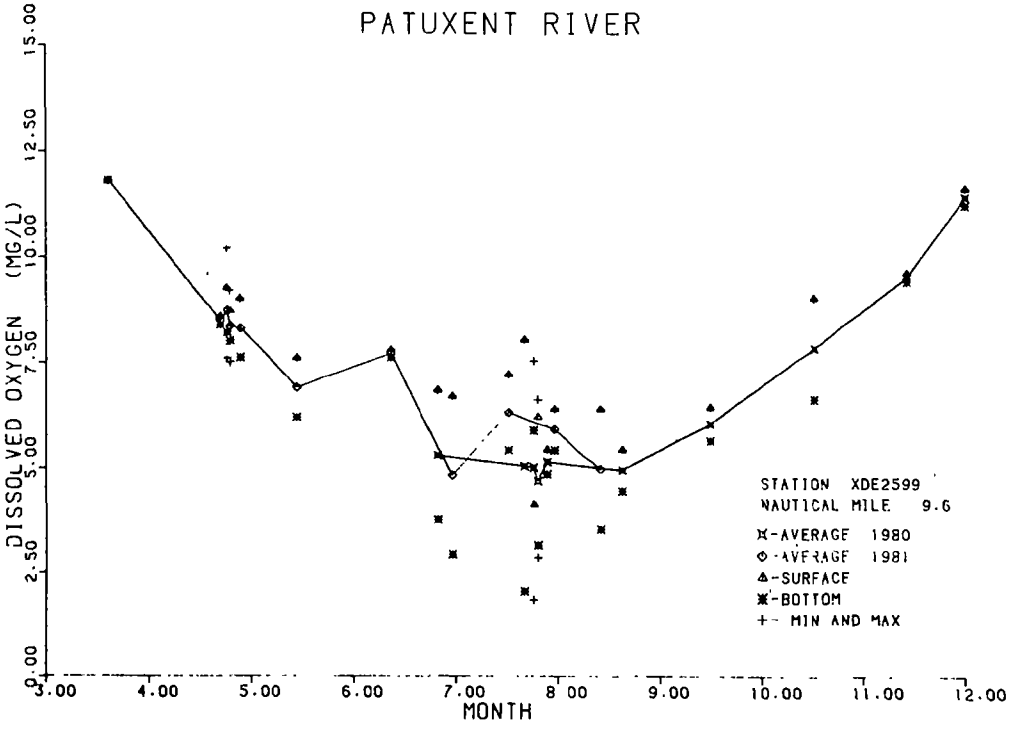
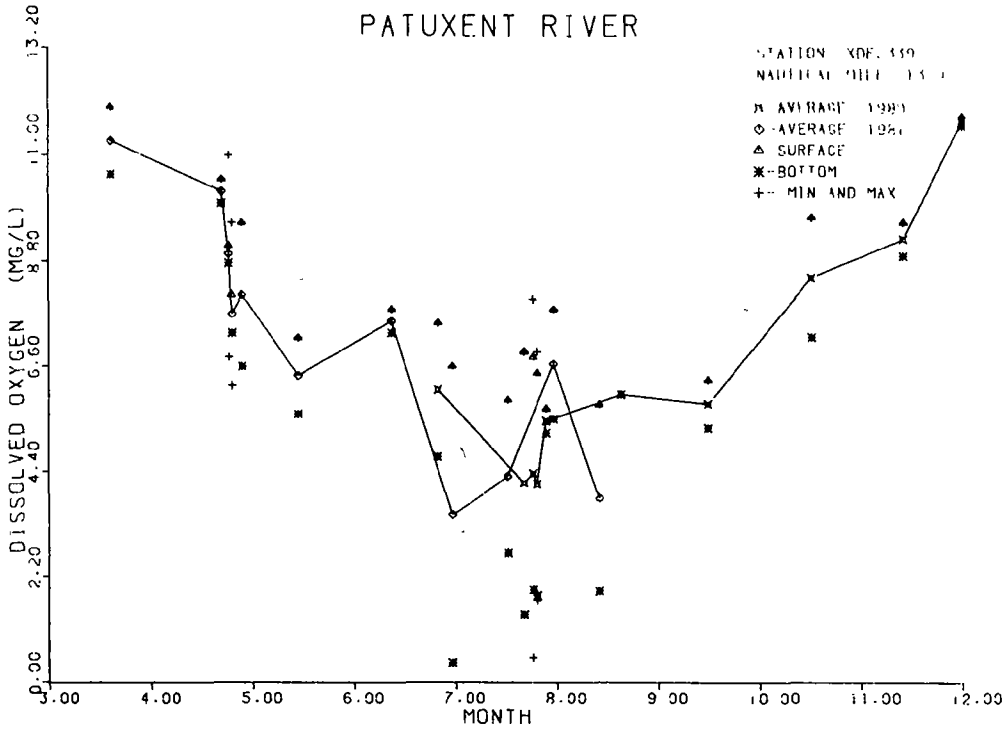


Figure 8-5 Temporal plots of dissolved oxygen, 1980-1981.



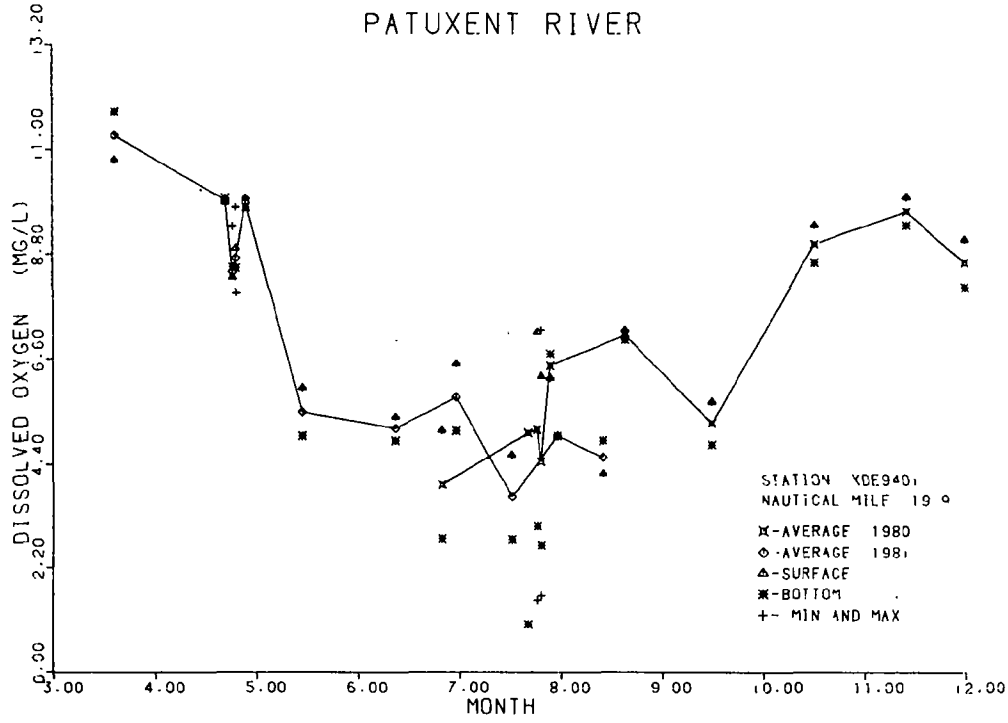
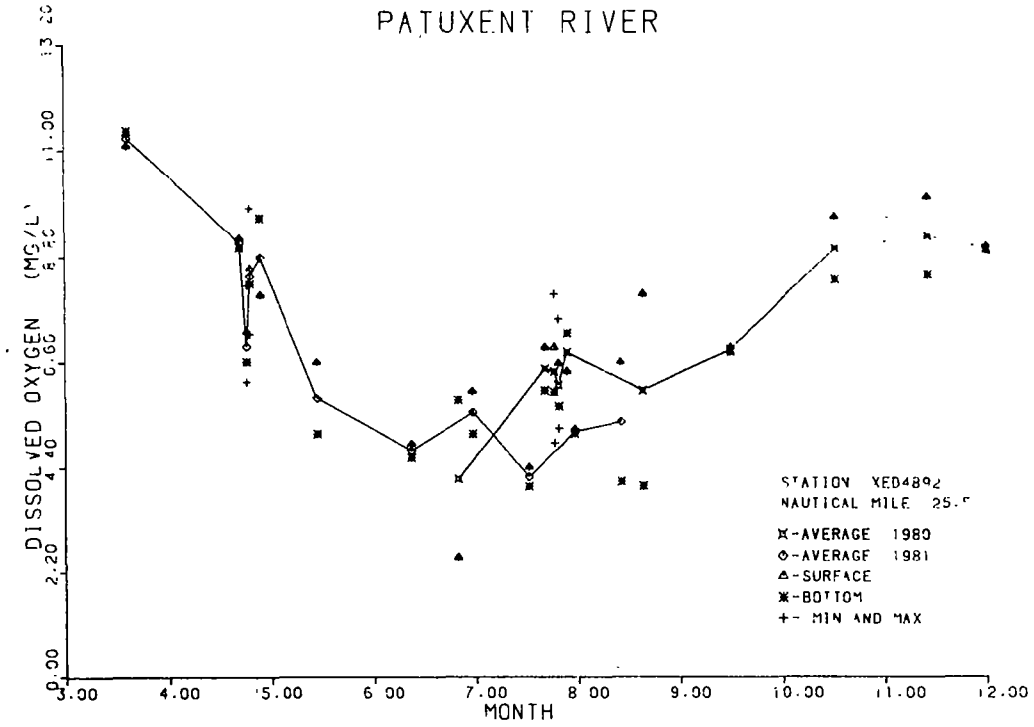


Figure 8-5 Temporal plots of dissolved oxygen, 1980-1981.



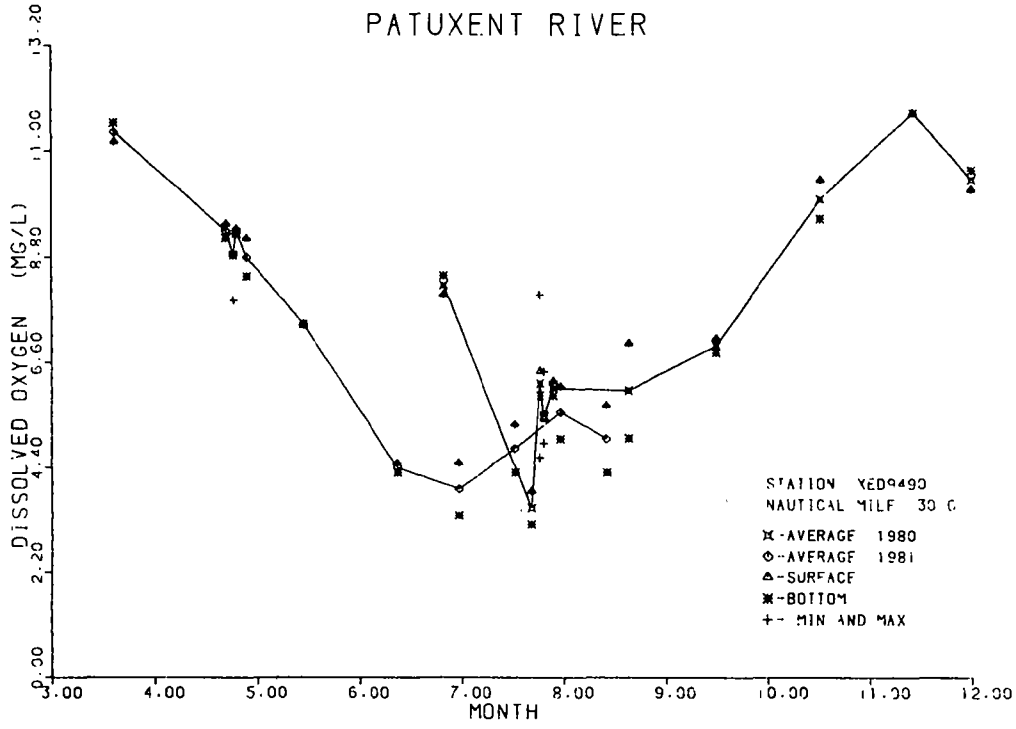
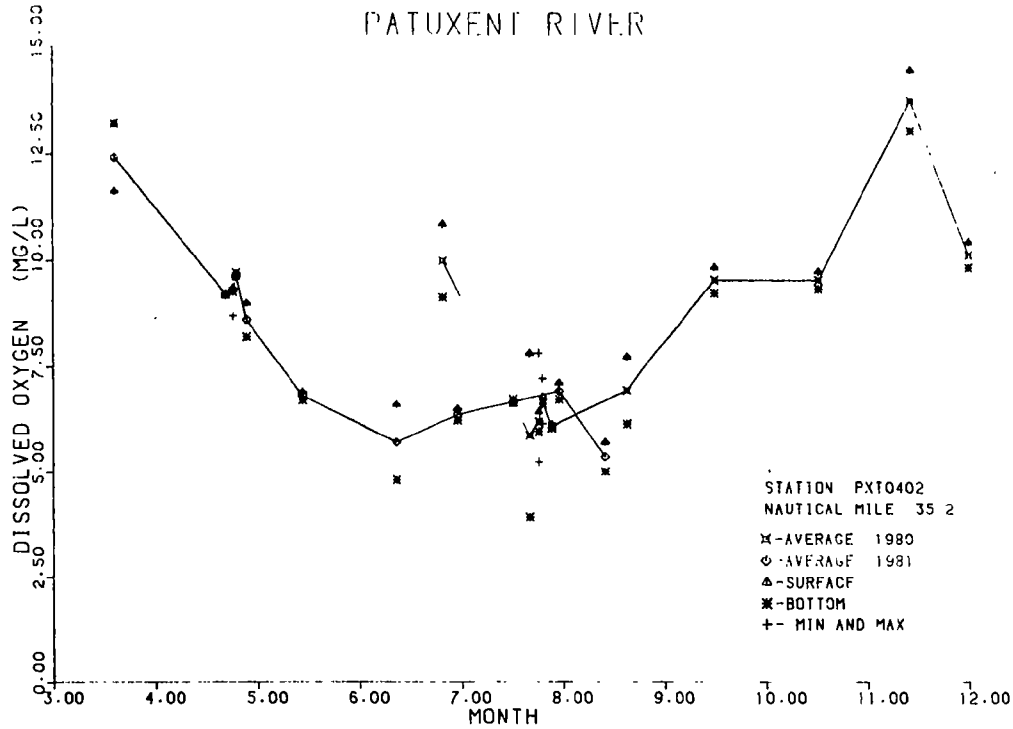


Figure 8-5 Temporal plots of dissolved oxygen, 1980-1981.



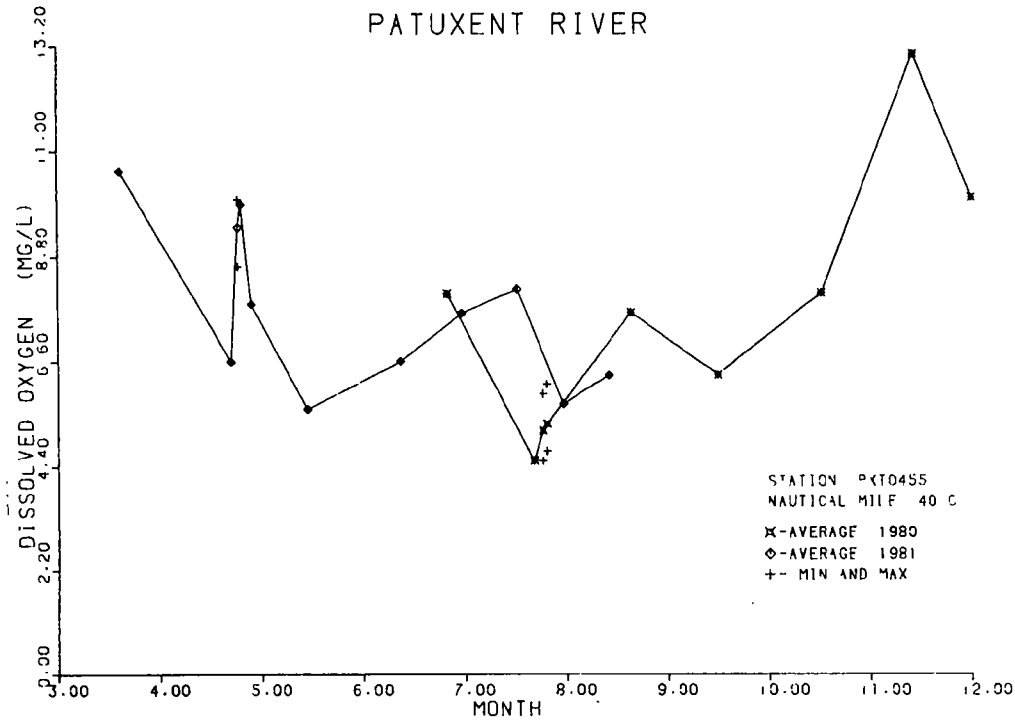
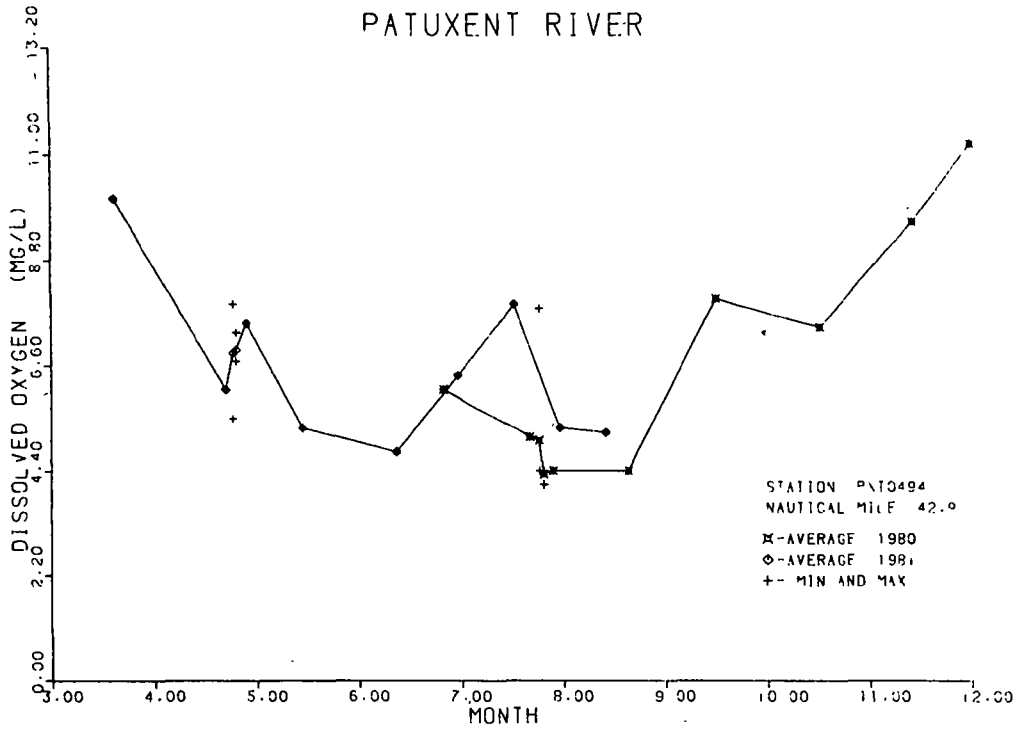


Figure 8-5 Temporal plots of dissolved oxygen, 1980-1981.



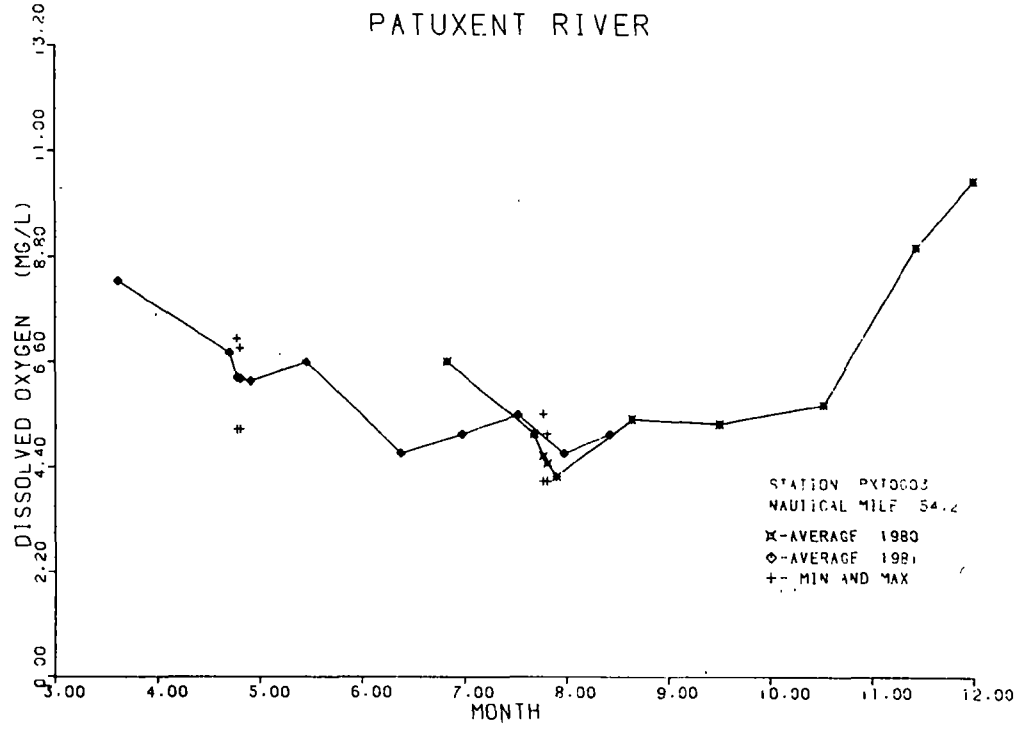
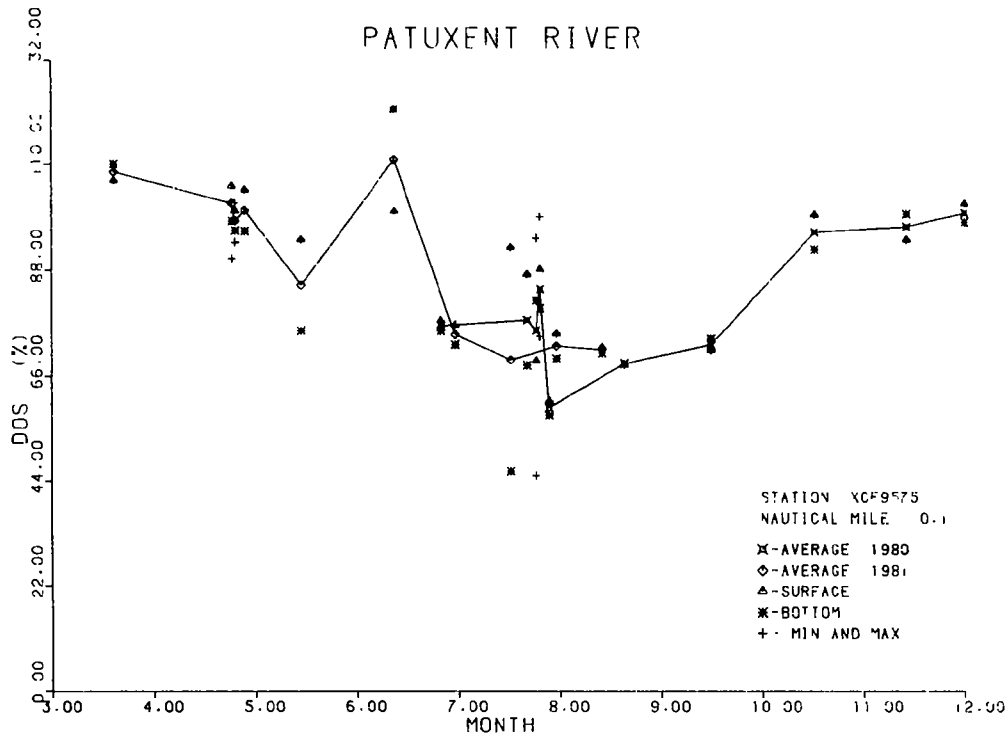


Figure 8-5 Temporal plots of dissolved oxygen, 1980-1981.



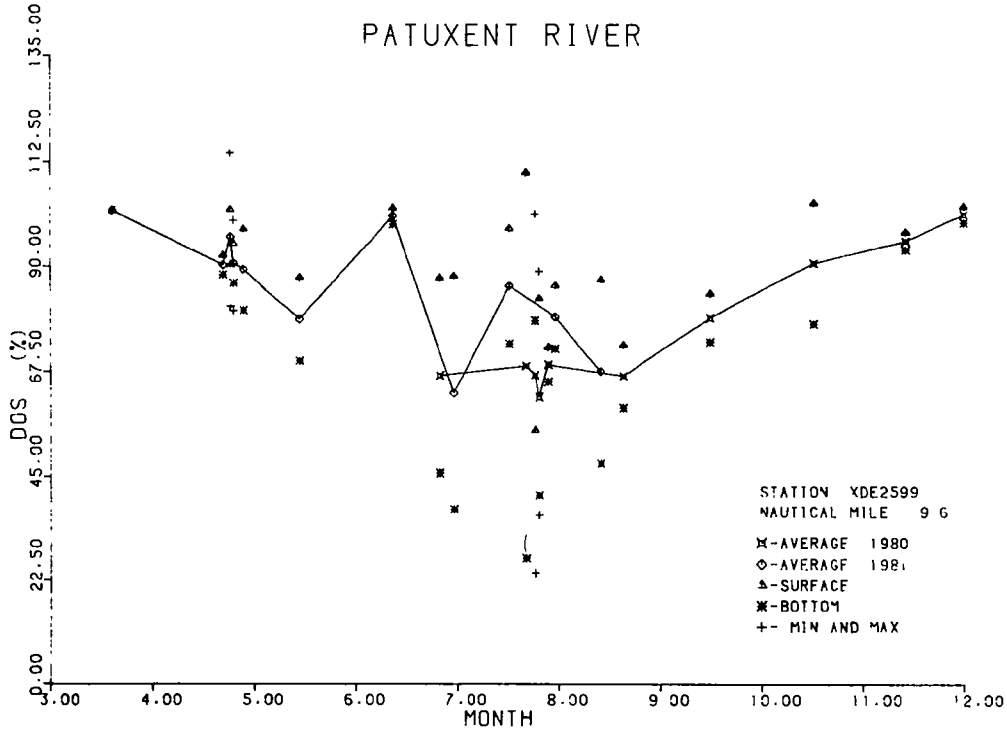
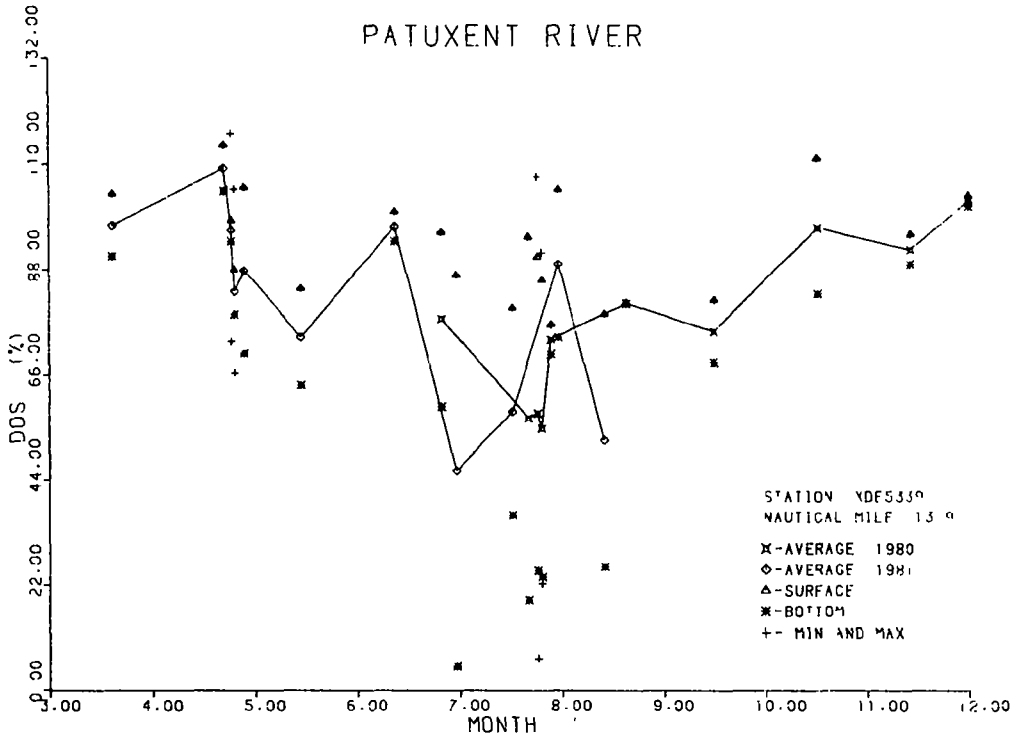


Figure 8-6 Temporal plots of dissolved oxygen saturation, 1980-1981.



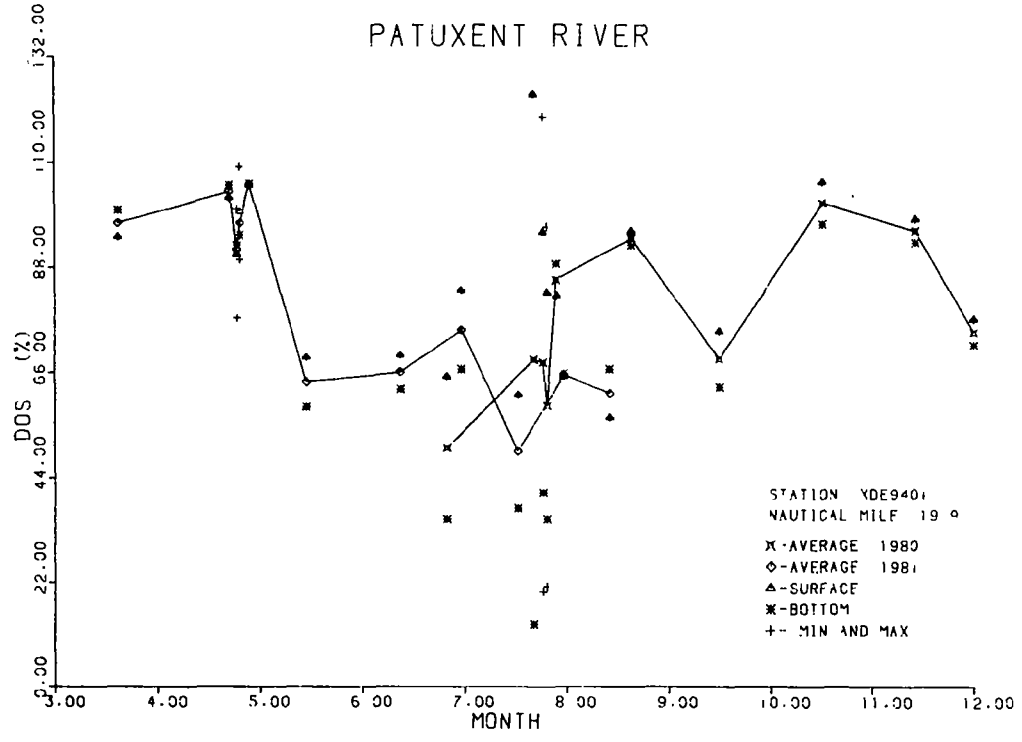
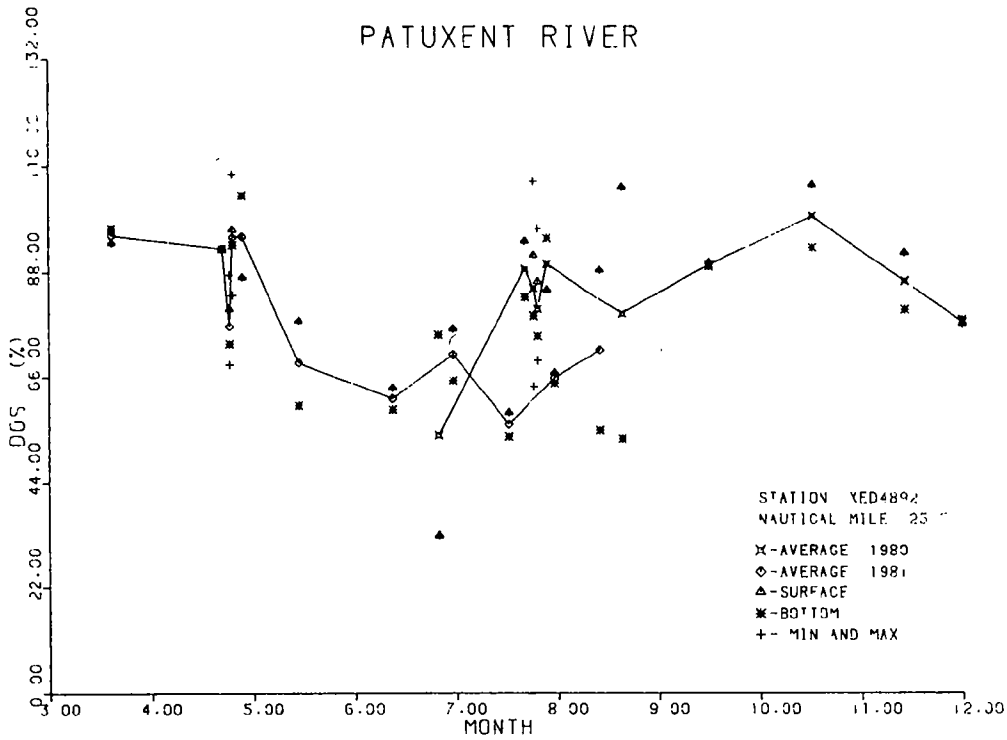


Figure 8-6 Temporal plots of dissolved oxygen saturation, 1980-1981.



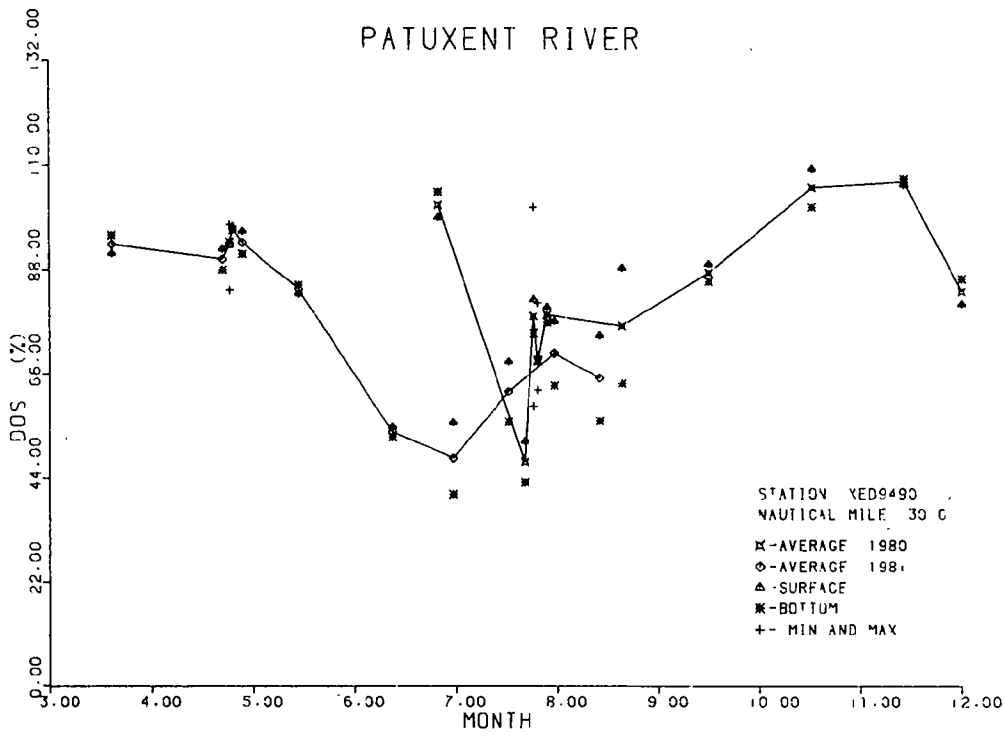
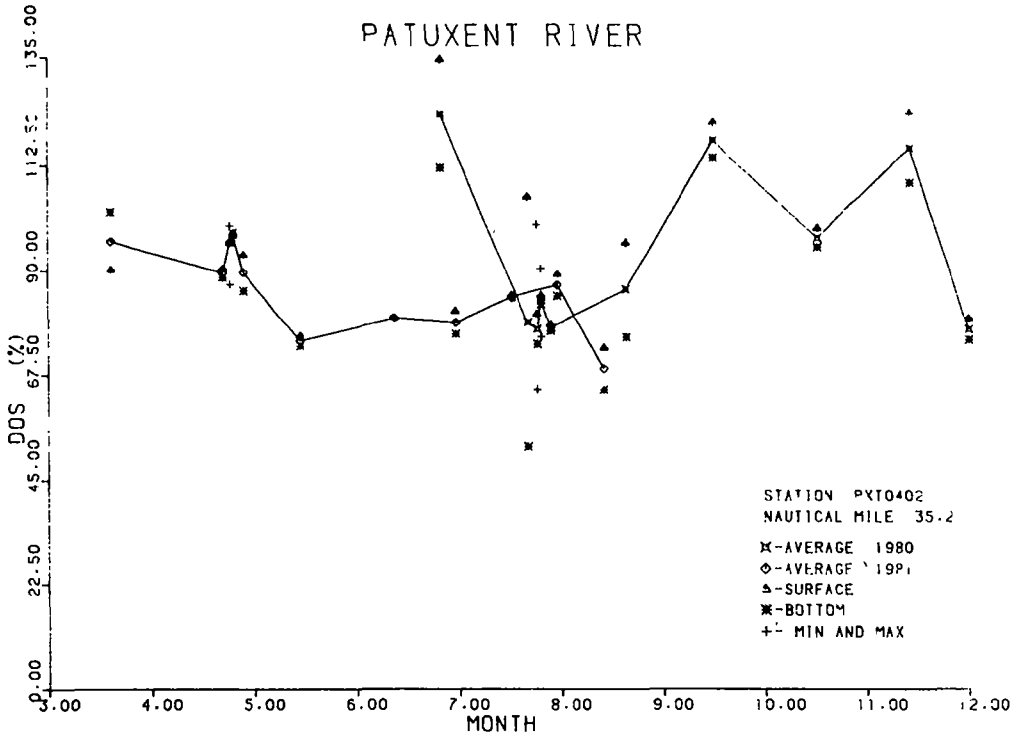


Figure 8-6 Temporal plots of dissolved oxygen saturation, 1980-1981.



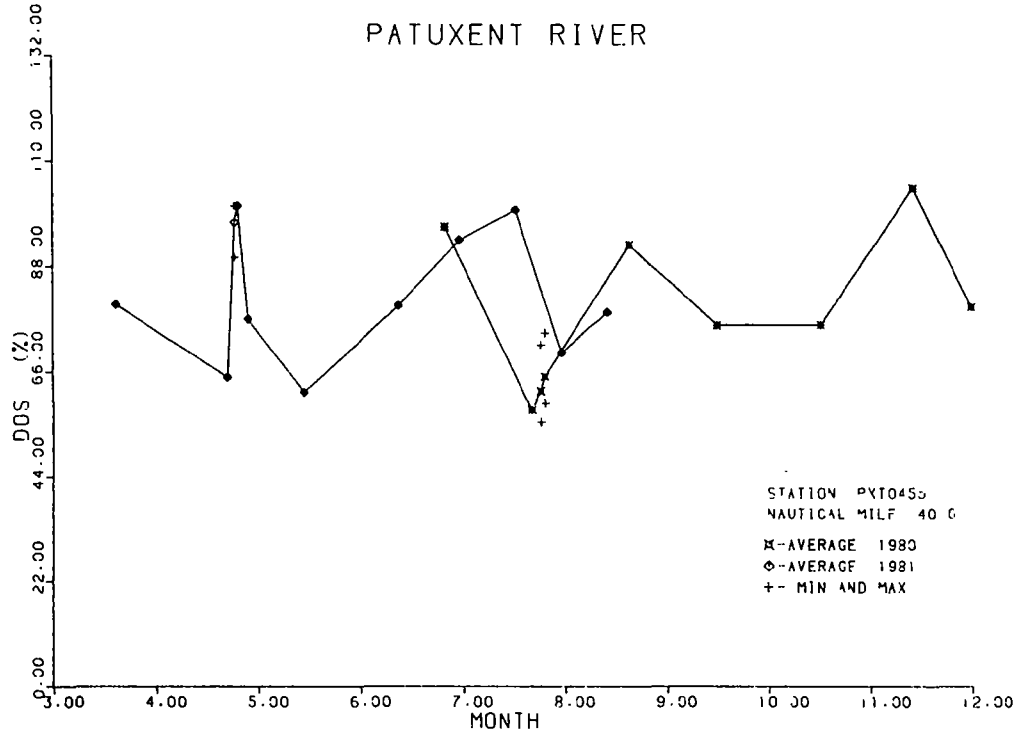
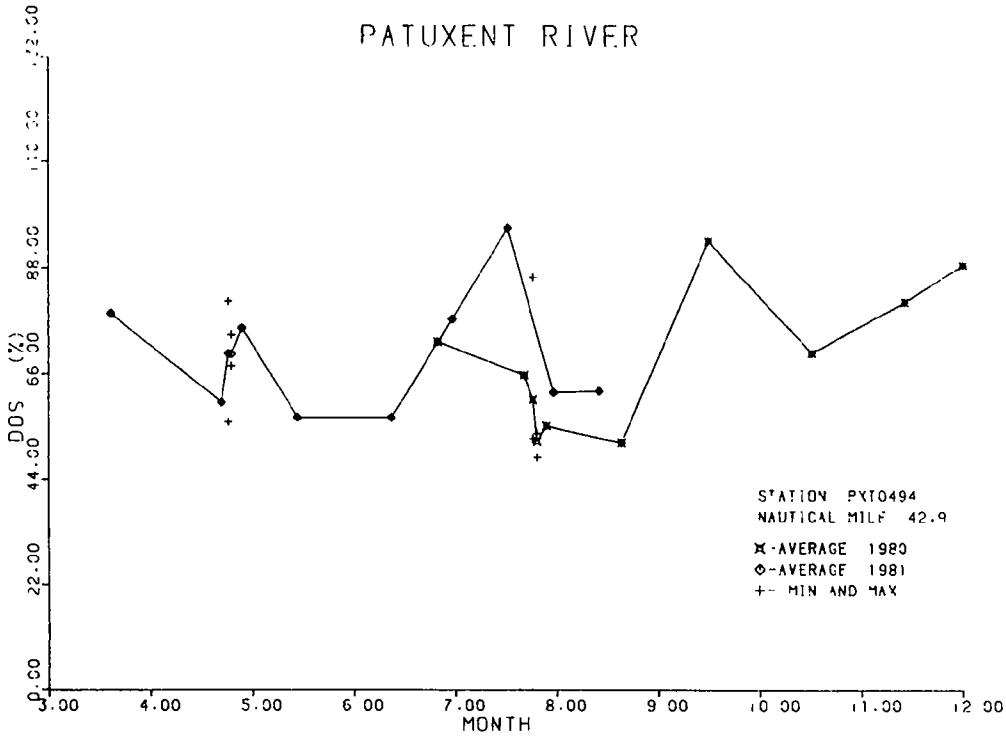


Figure 8-6 Temporal plots of dissolved oxygen saturation, 1980-1981.



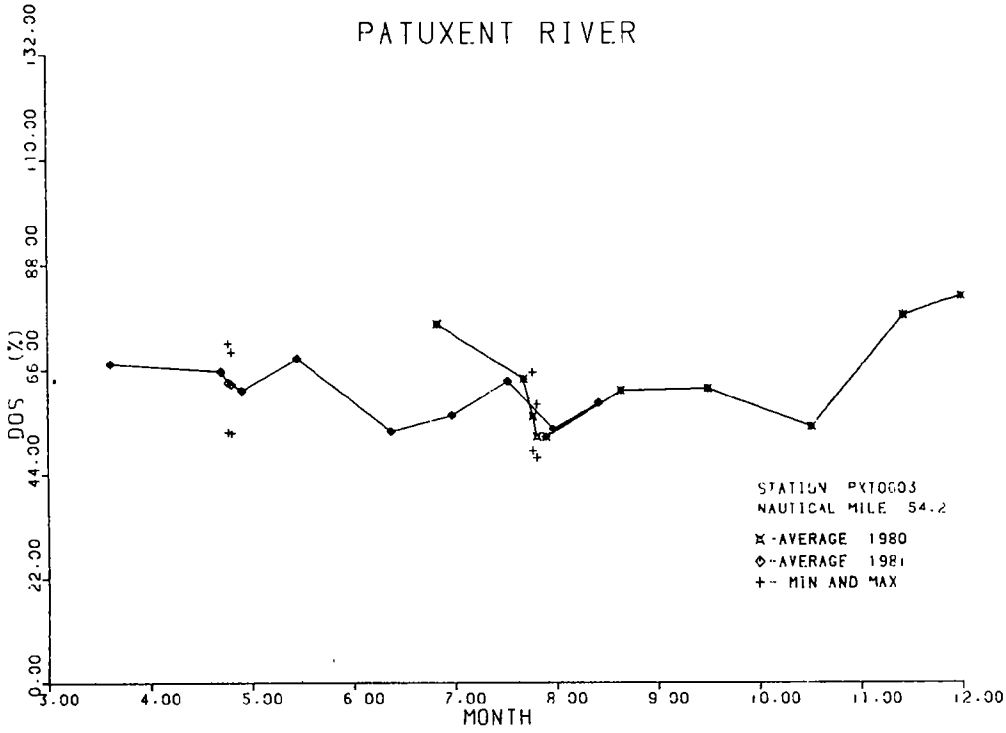
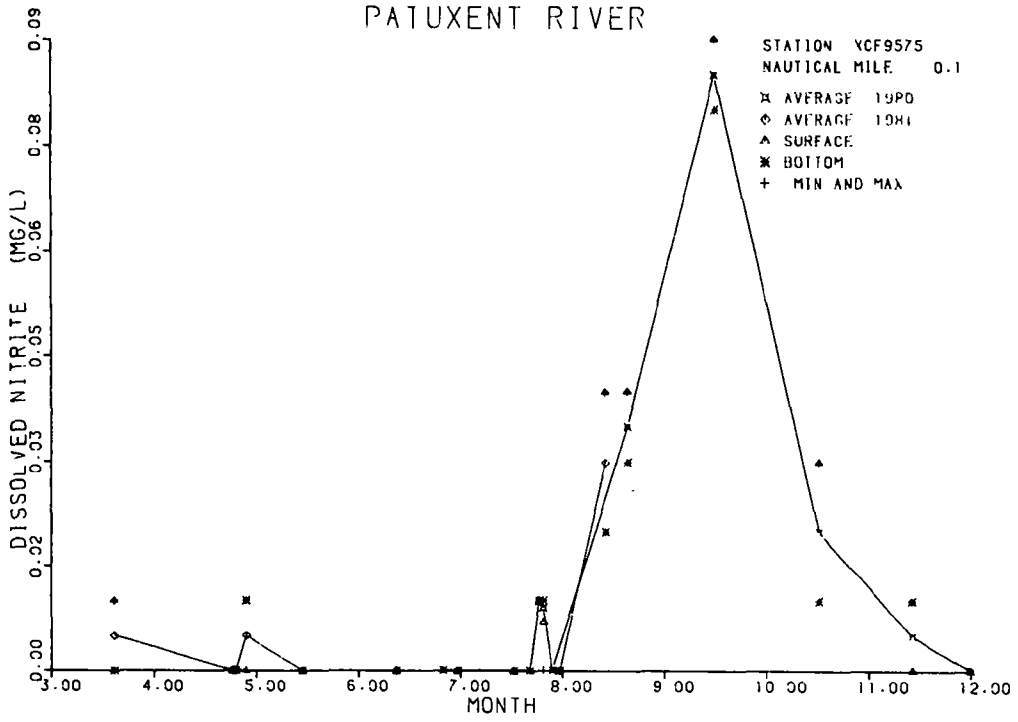


Figure 8-6 Temporal plots of dissolved oxygen saturation, 1980-1981.



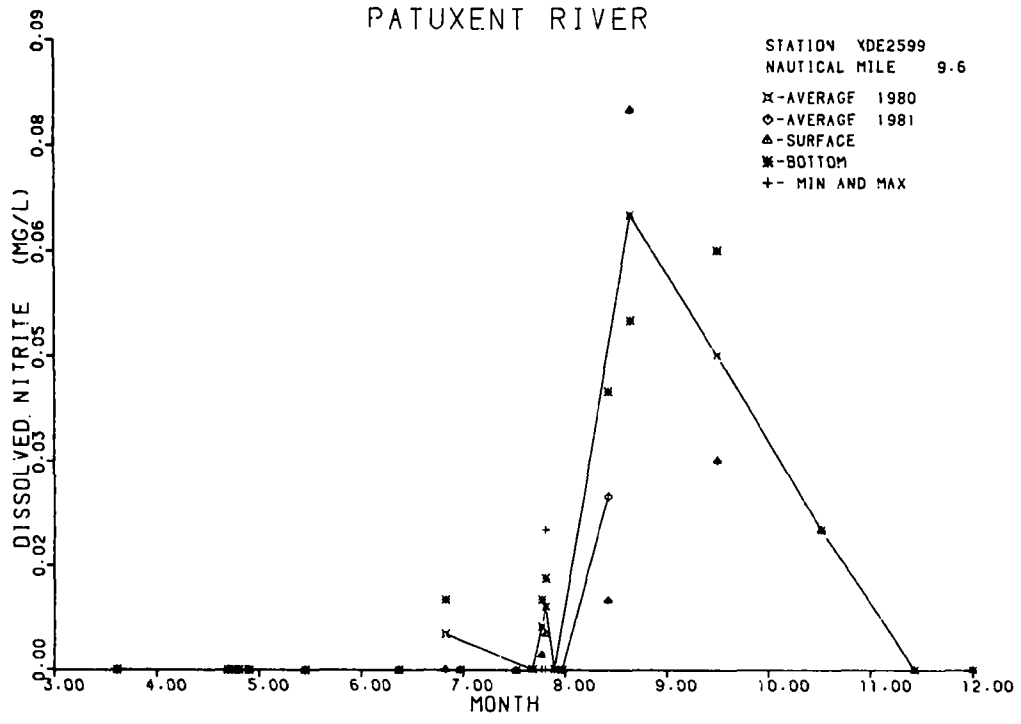
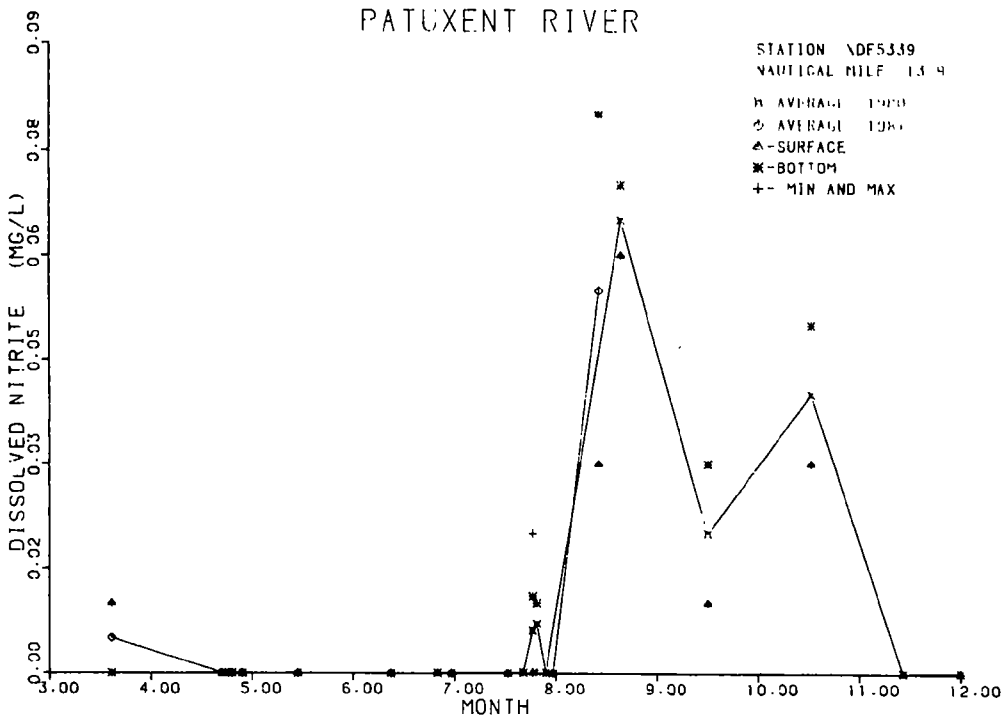


Figure 8-7 Temporal plots of dissolved nitrite, 1980-1981.



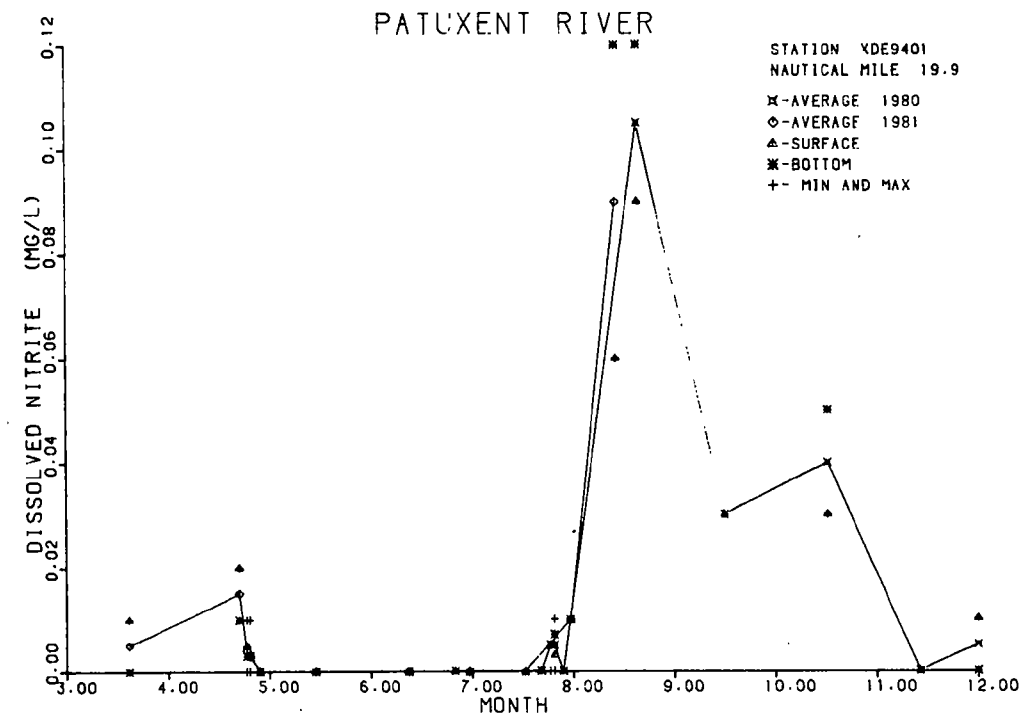
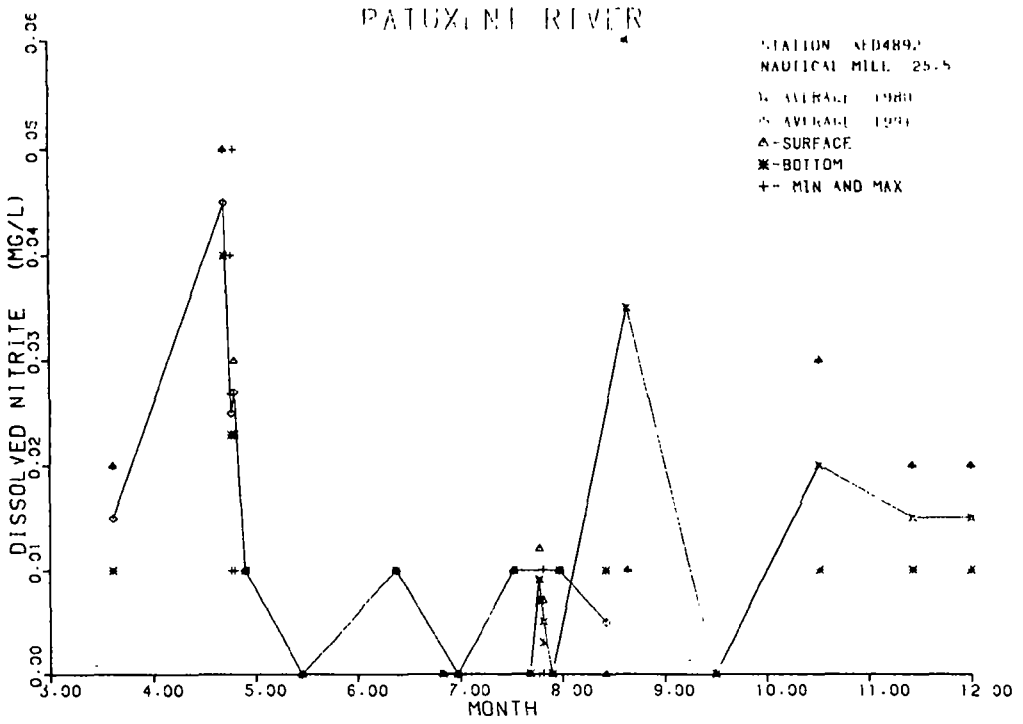


Figure 8-7 Temporal plots of dissolved nitrite, 1980-1981.



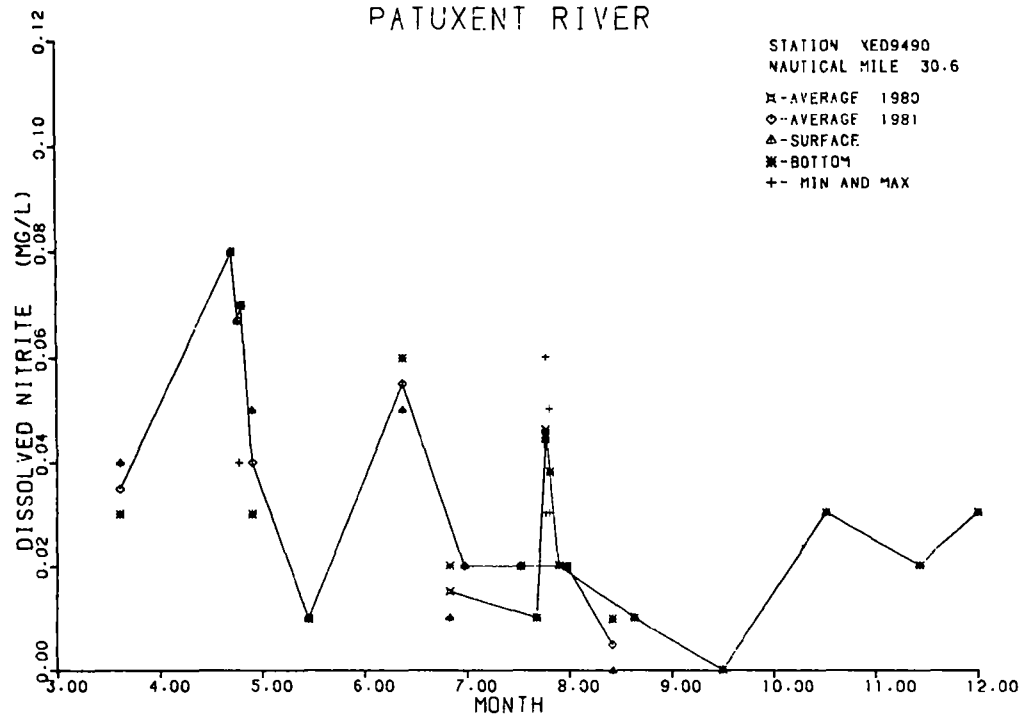
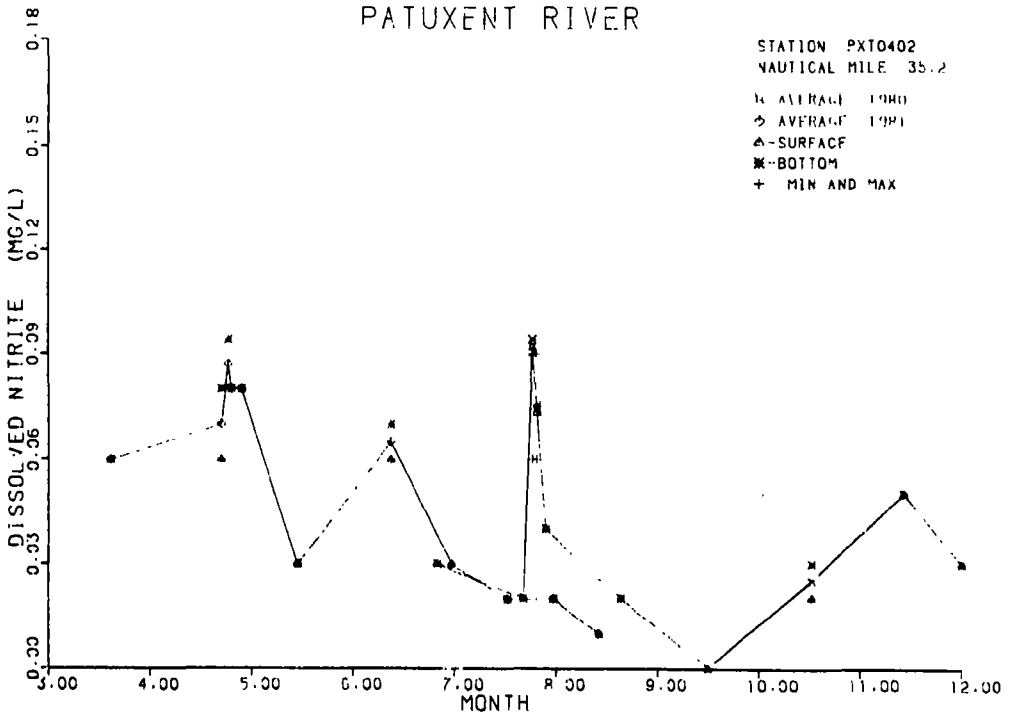


Figure 8-7 Temporal plots of dissolved nitrite, 1980-1981.



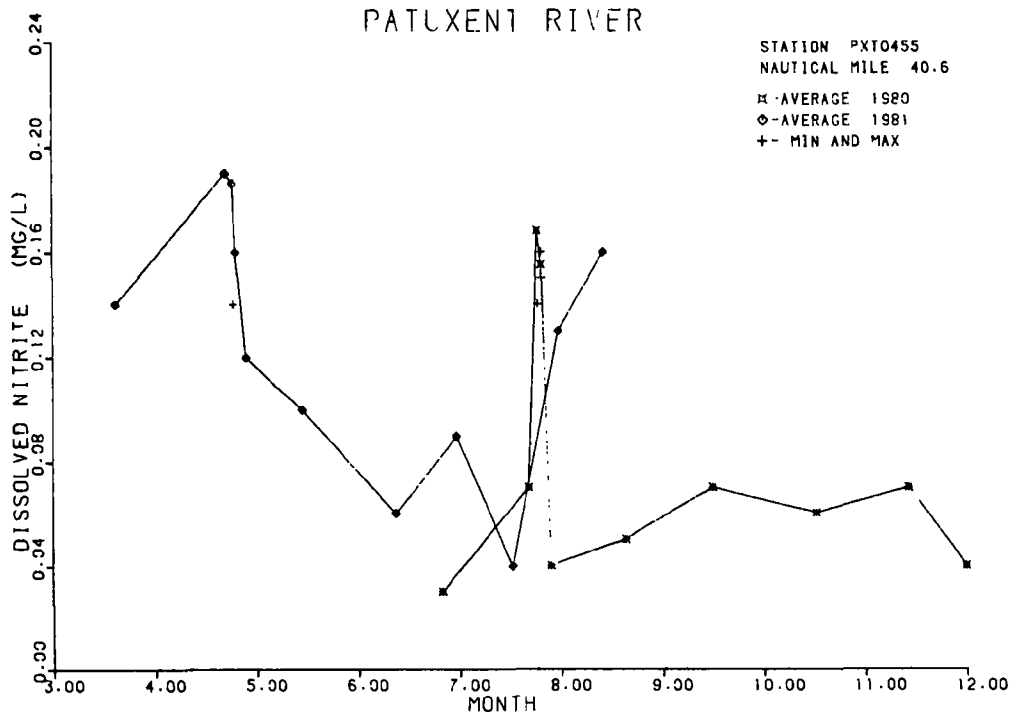
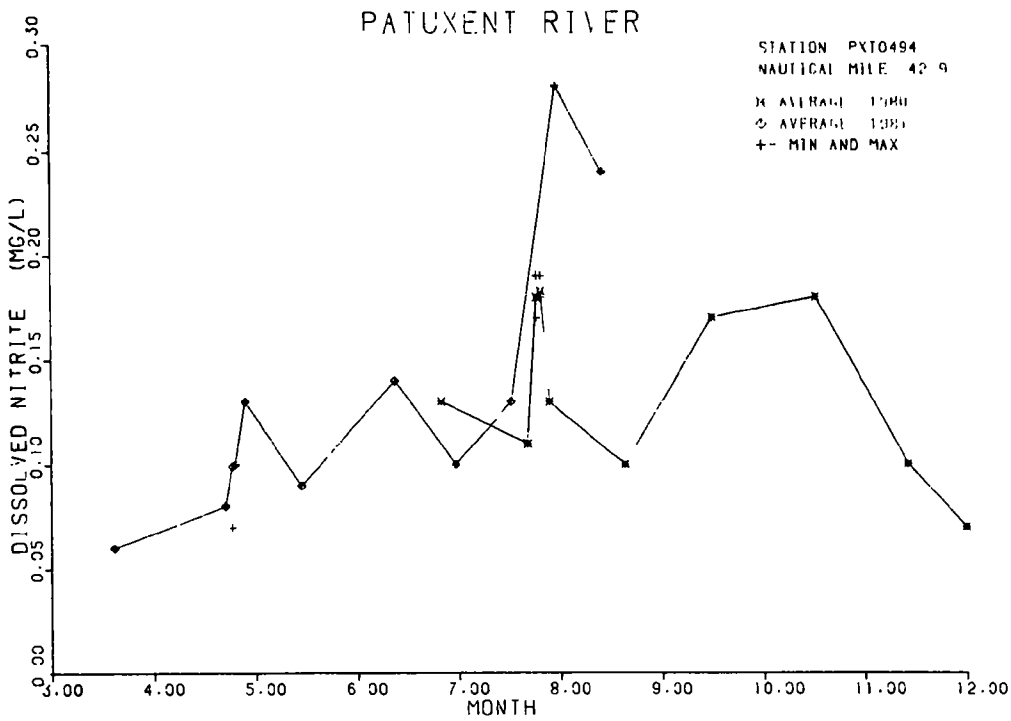


Figure 8-7 Temporal plots of dissolved nitrite, 1980-1981.



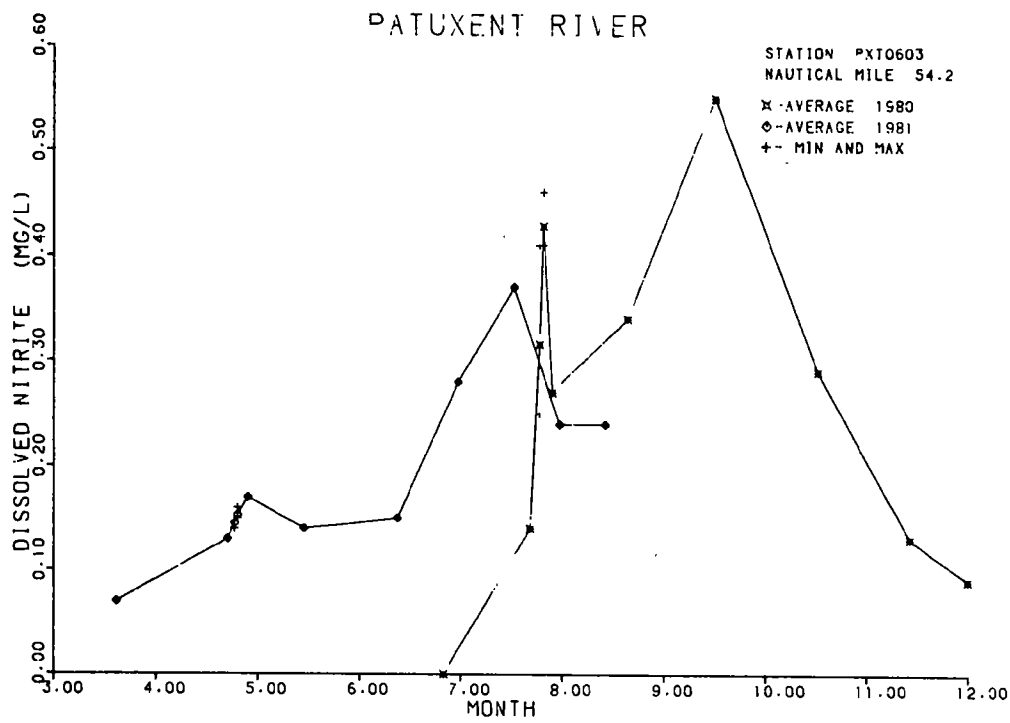
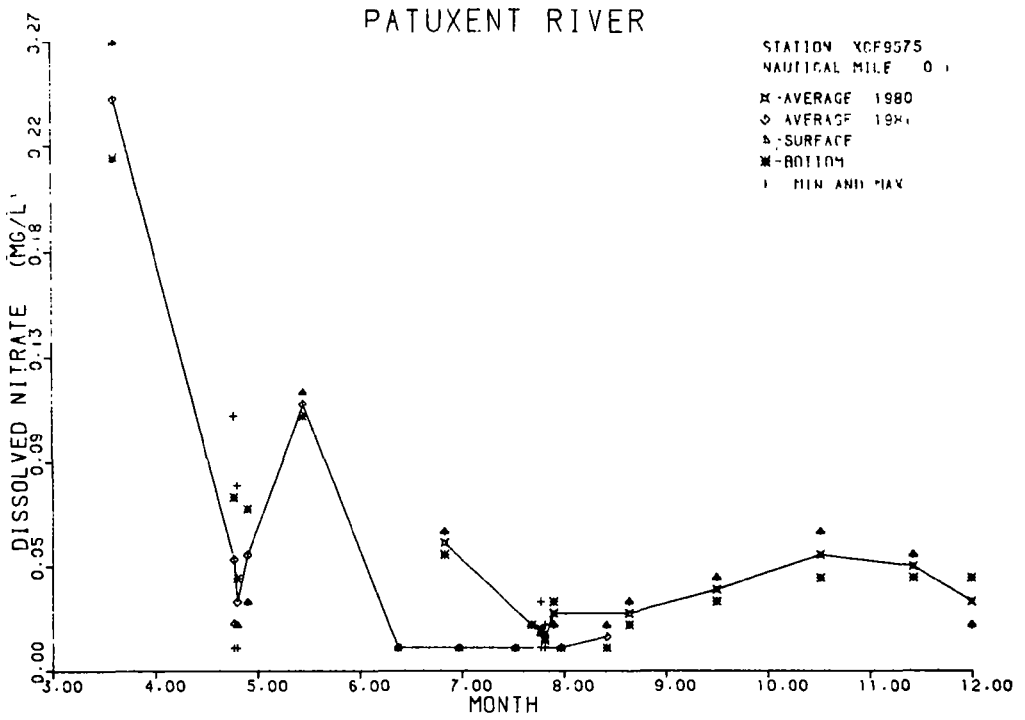


Figure 8-7 Temporal plots of dissolved nitrite, 1980-1981.



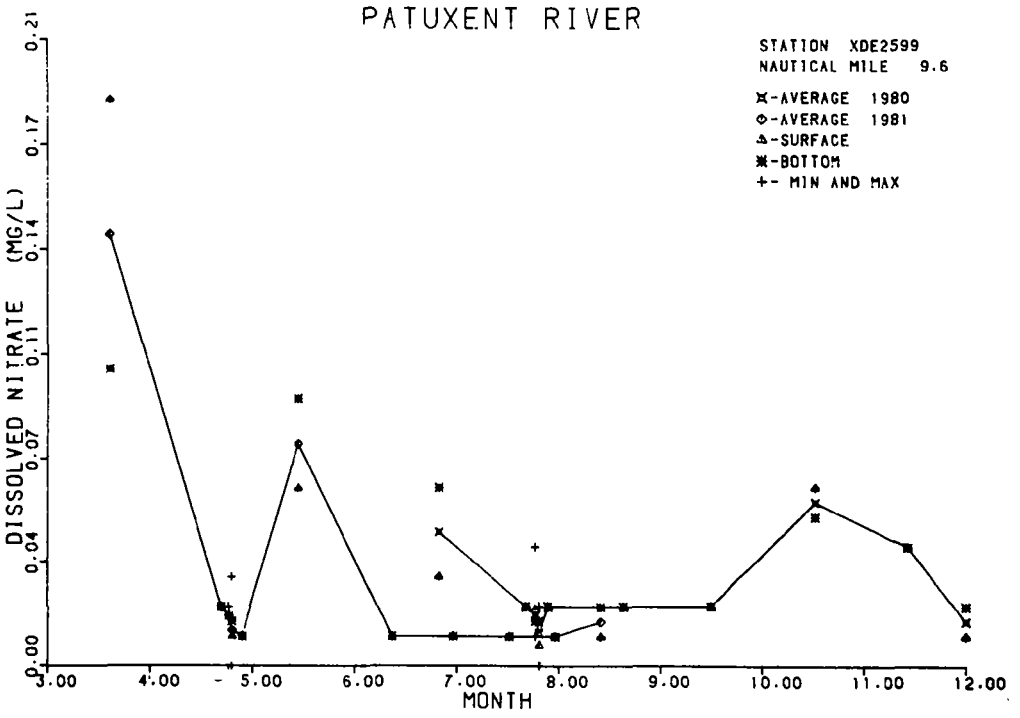
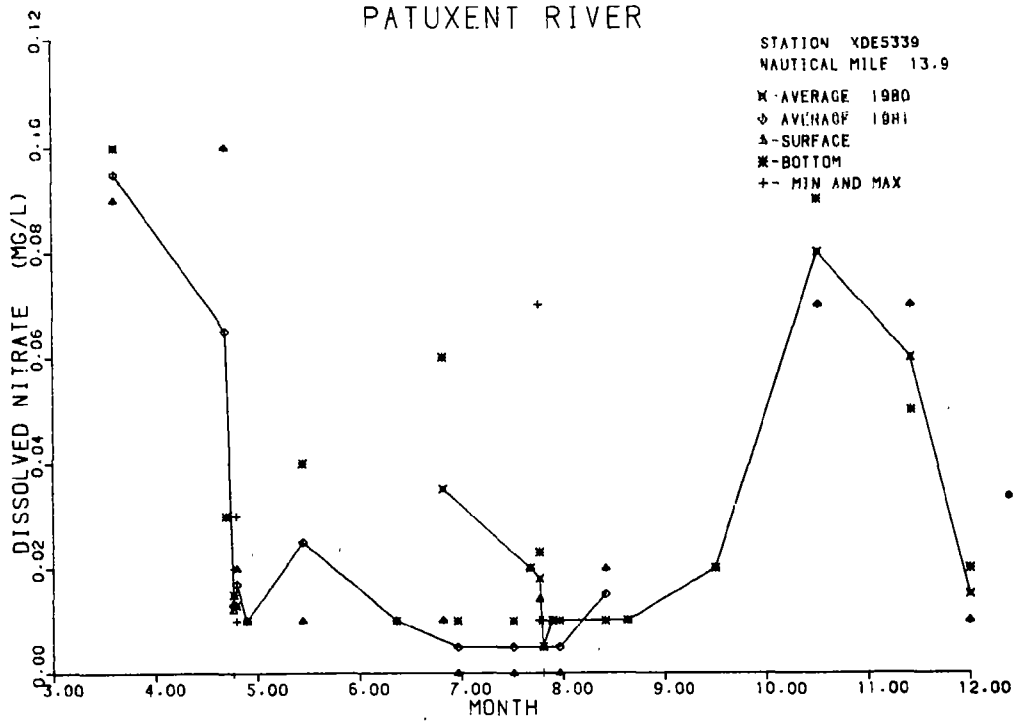


Figure 8-8 Temporal plots of dissolved nitrate, 1980-1981.



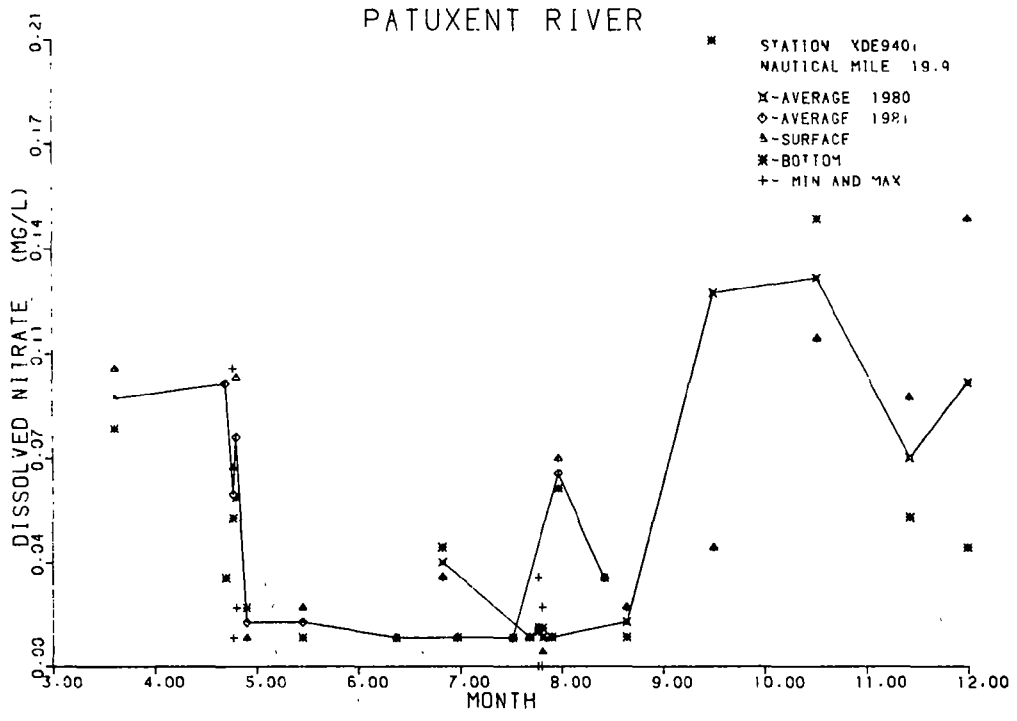
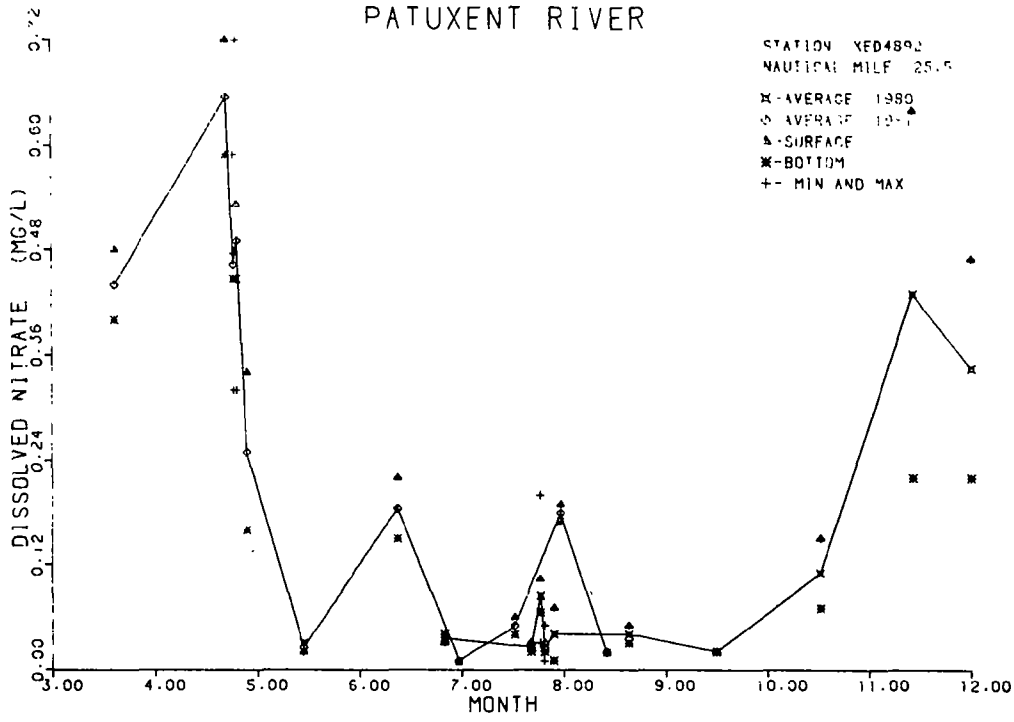


Figure 8-8 Temporal plots of dissolved nitrate, 1980-1981.



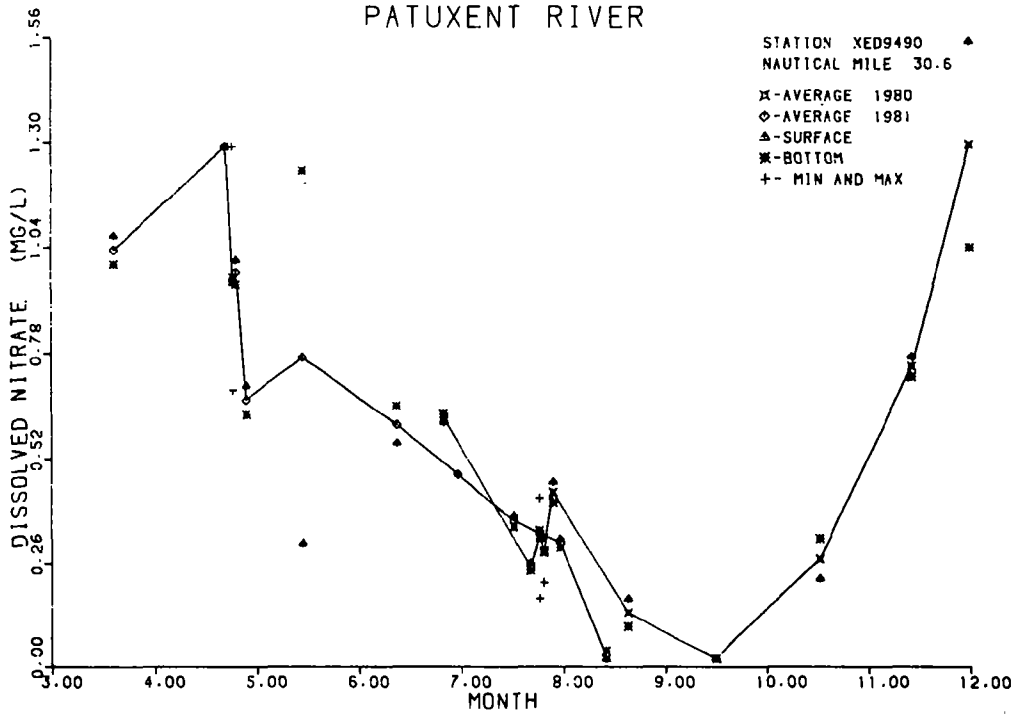
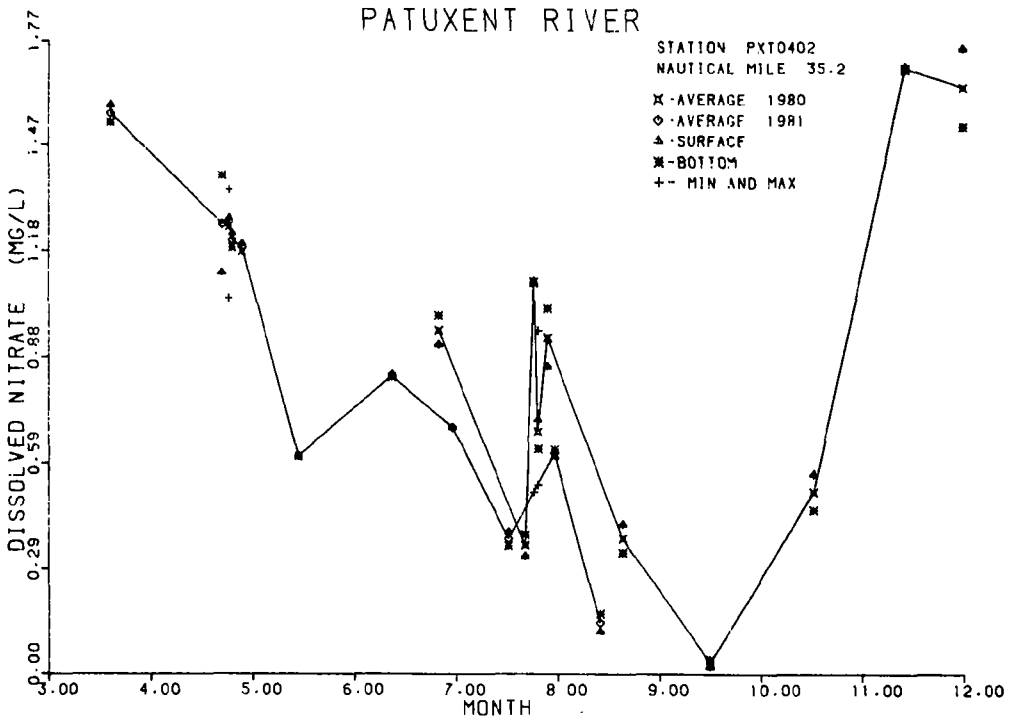


Figure 8-8 Temporal plots of dissolved nitrate, 1980-1981.



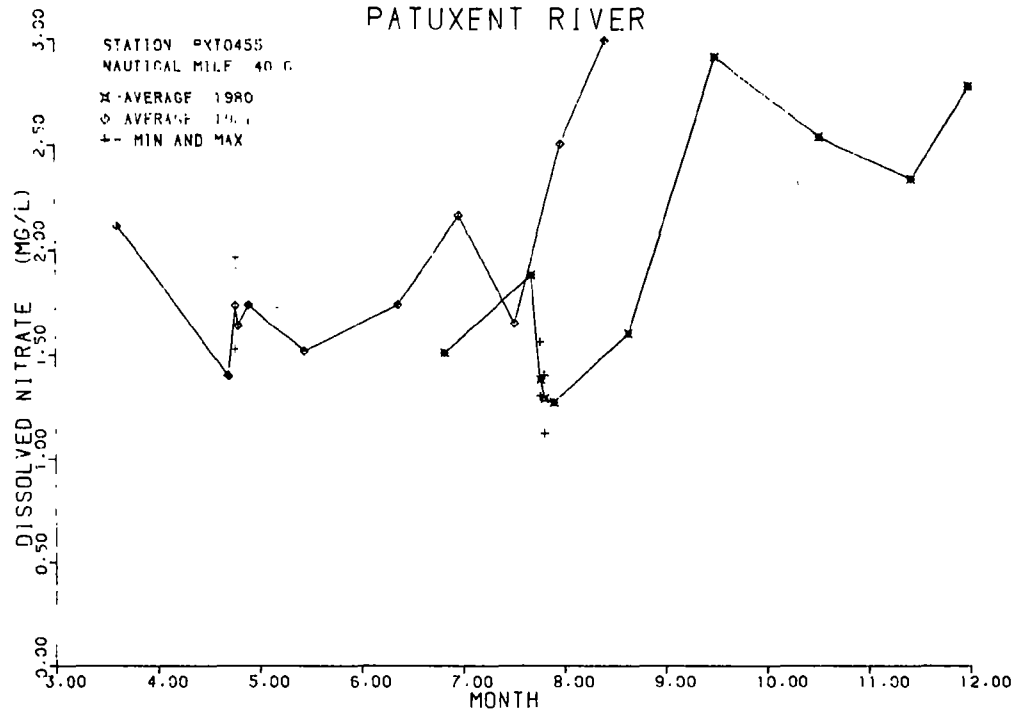
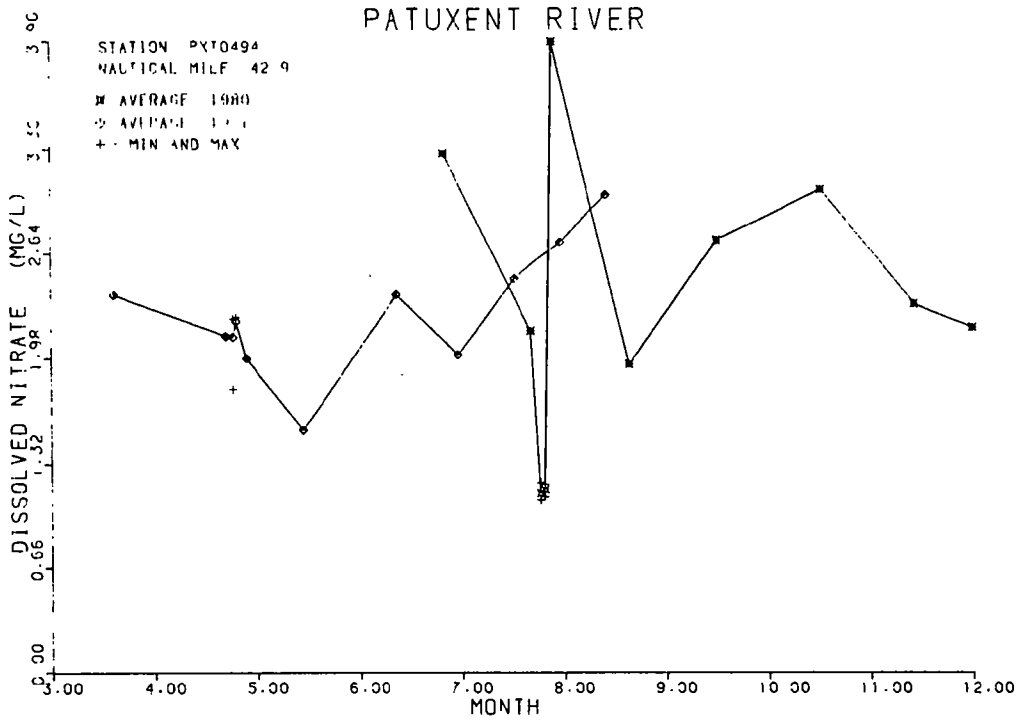


Figure 8-8 Temporal plots of dissolved nitrate, 1980-1981.



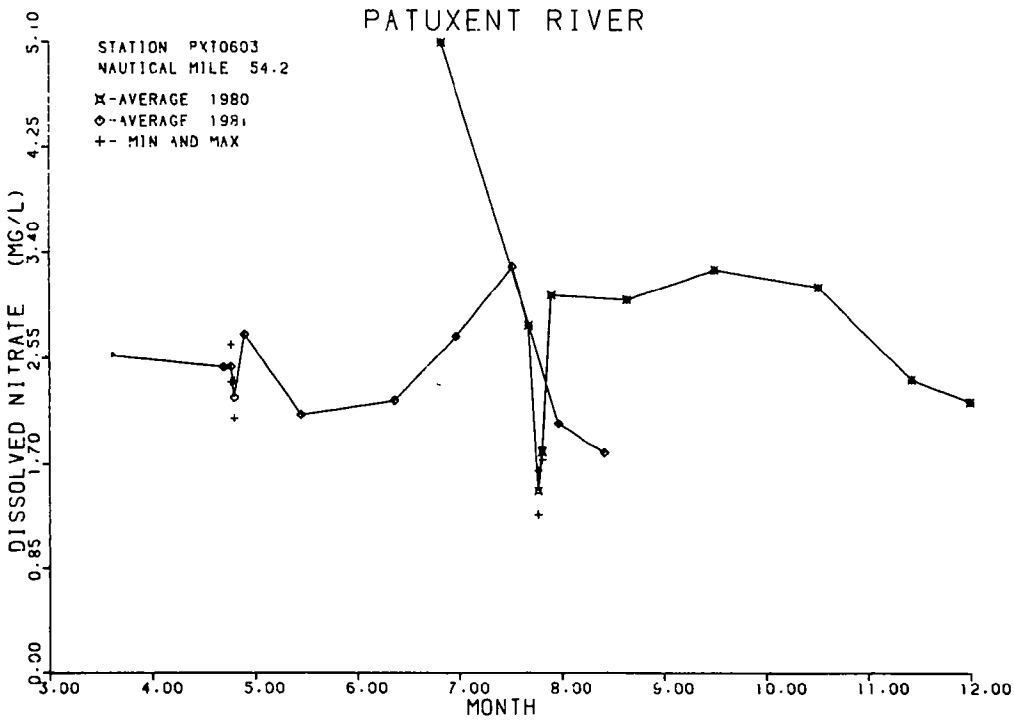
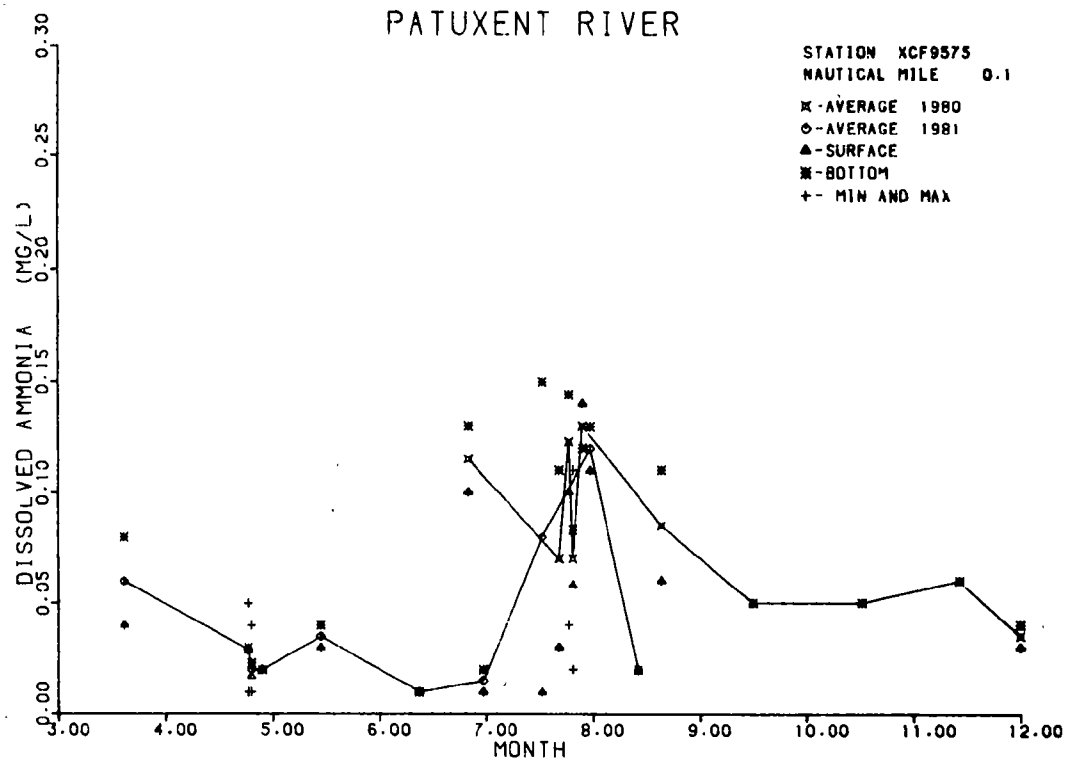


Figure 8-8 Temporal plots of dissolved nitrate, 1980-1981.



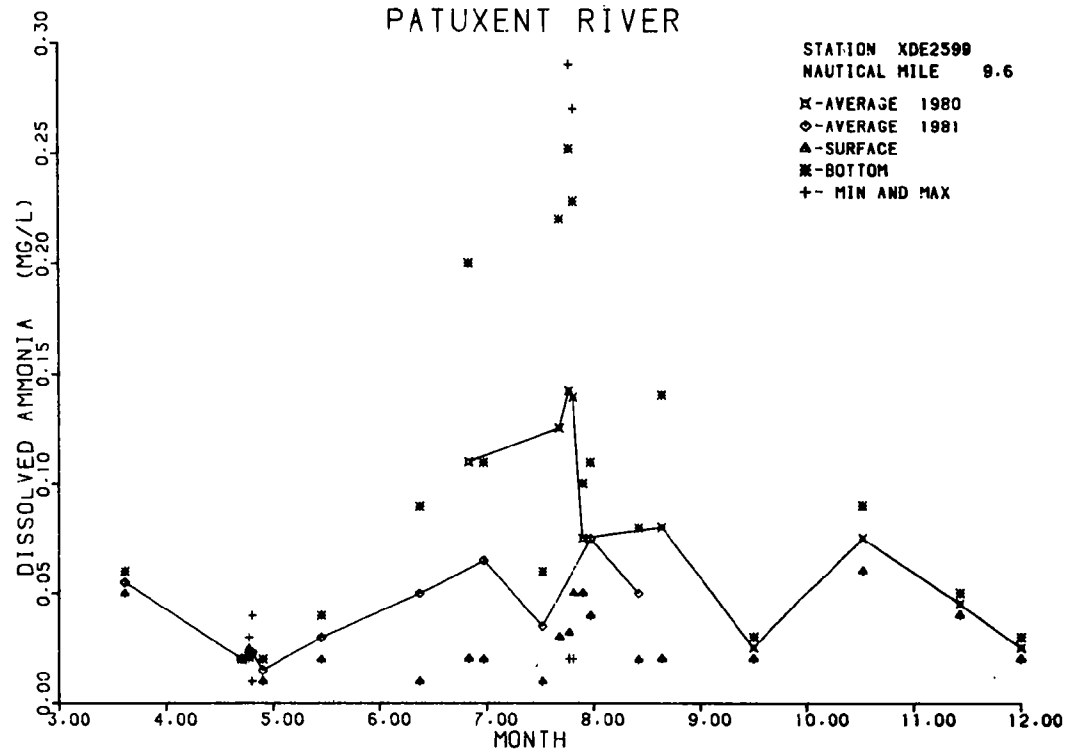
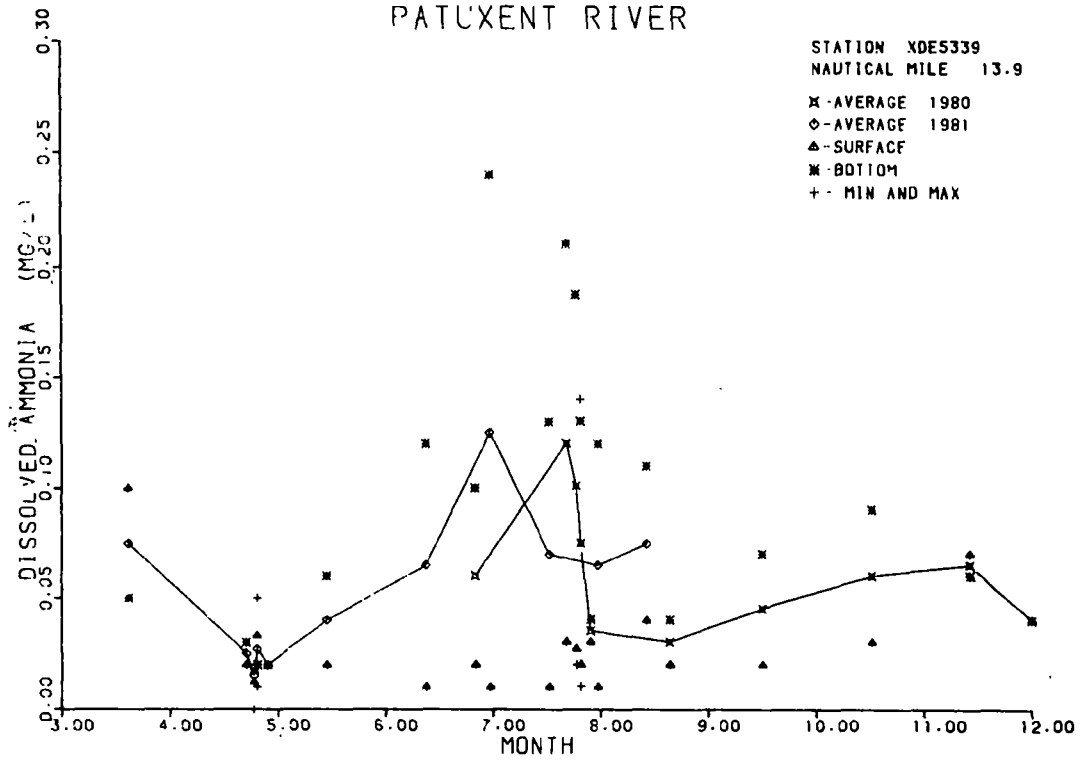


Figure 8-9 Patuxent River Temporal Plot of Dissolved Ammonia



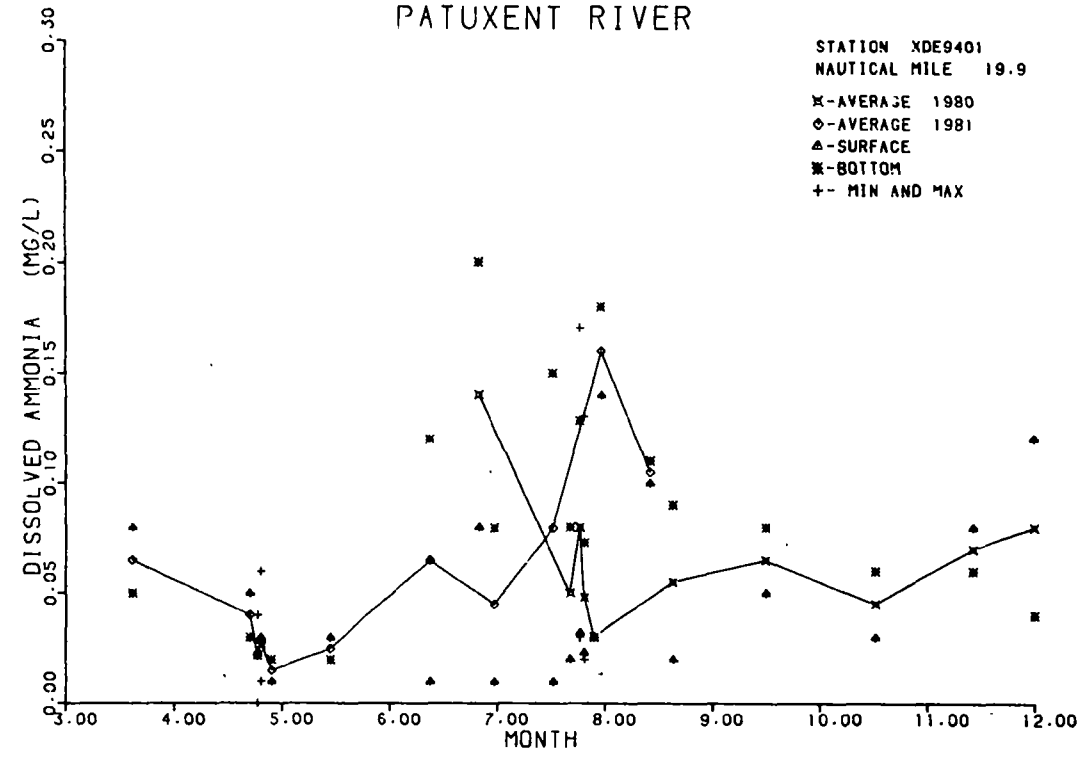
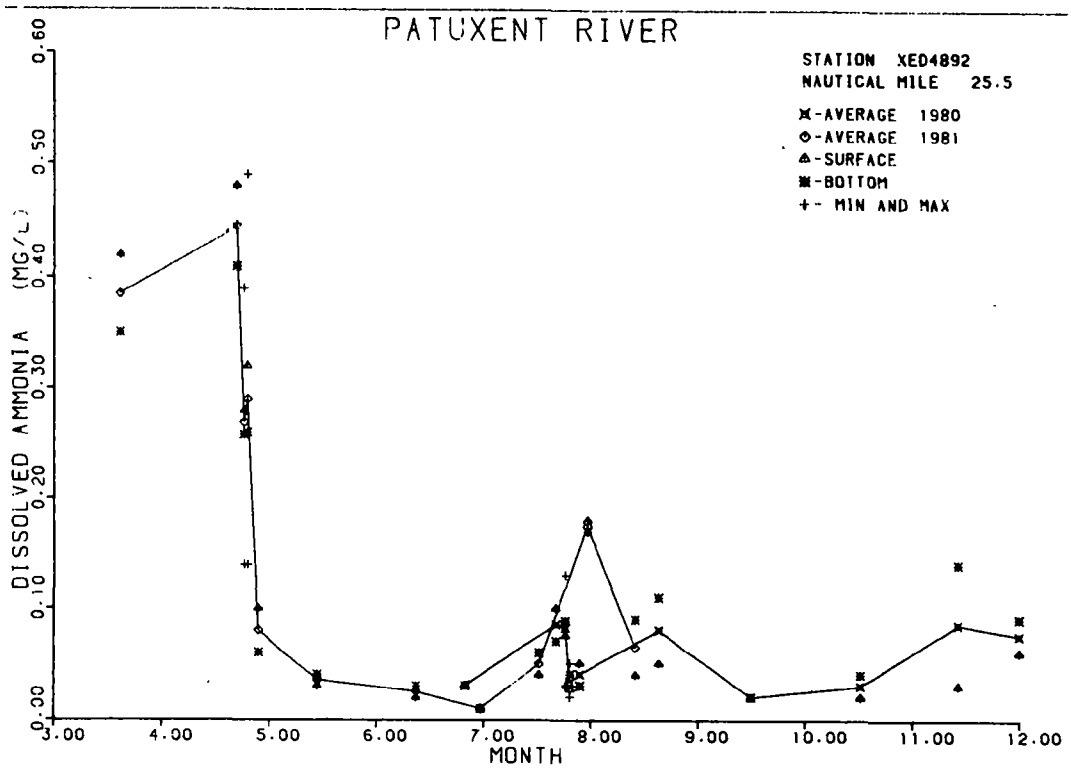


Figure 8-9 Patuxent River Temporal Plot of Dissolved Ammonia



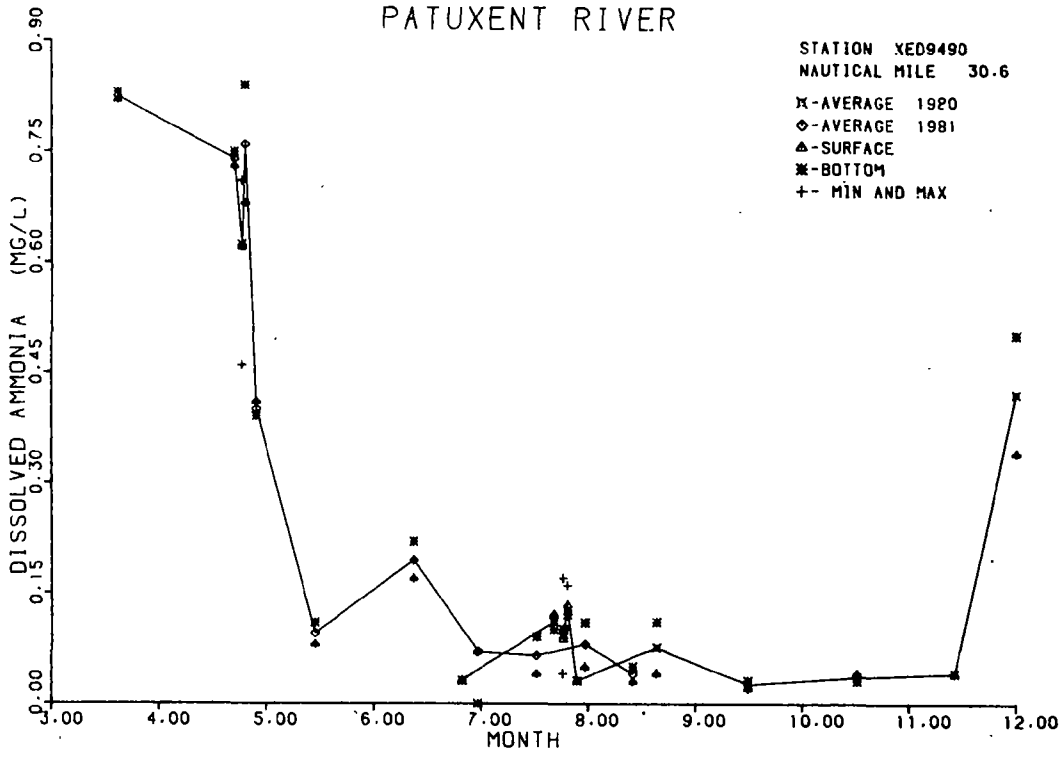
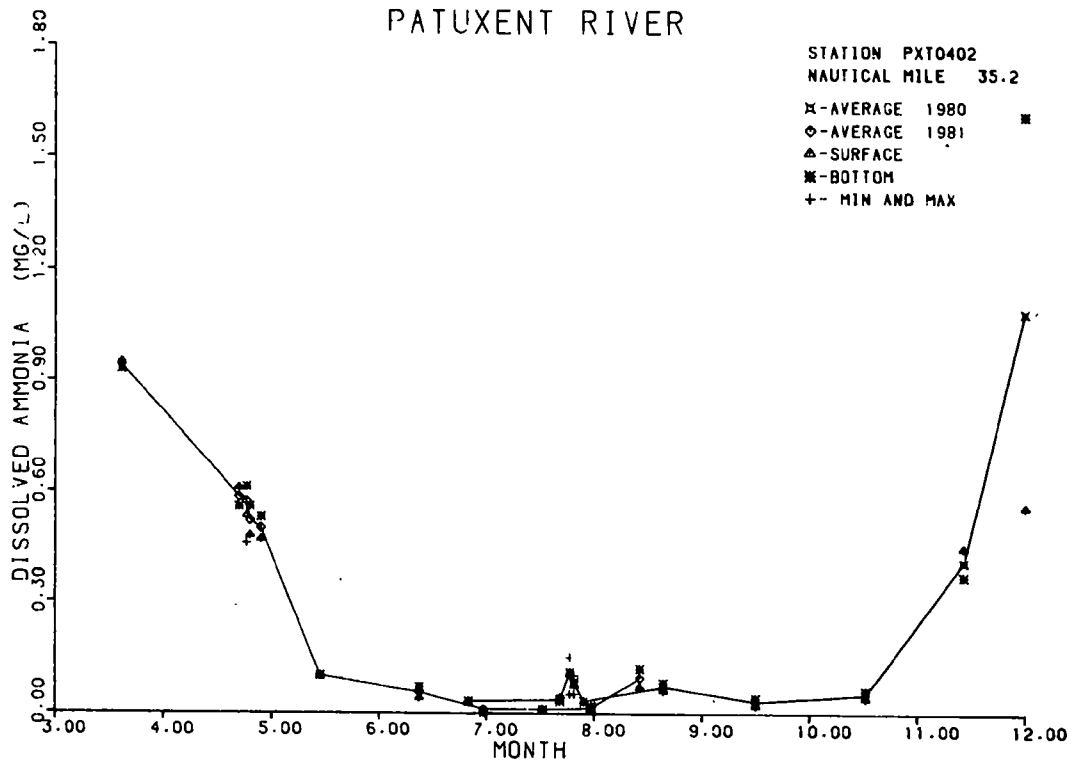


Figure 8-9 Patuxent River Temporal Plot of Dissolved Ammonia



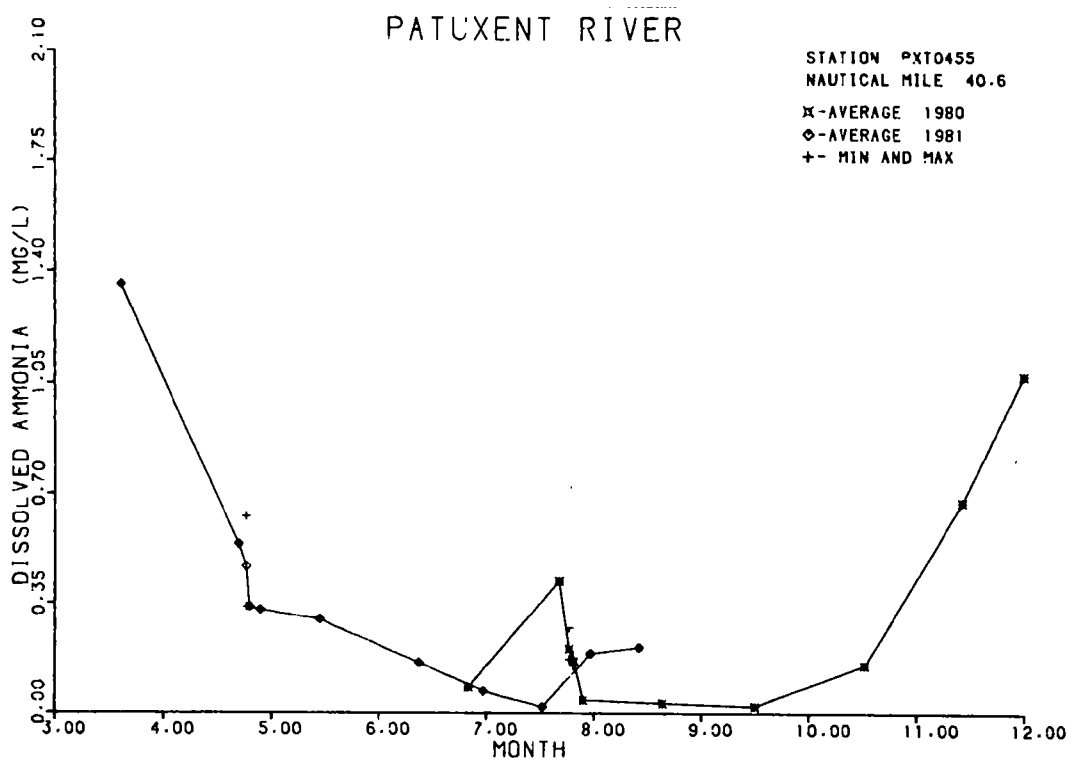
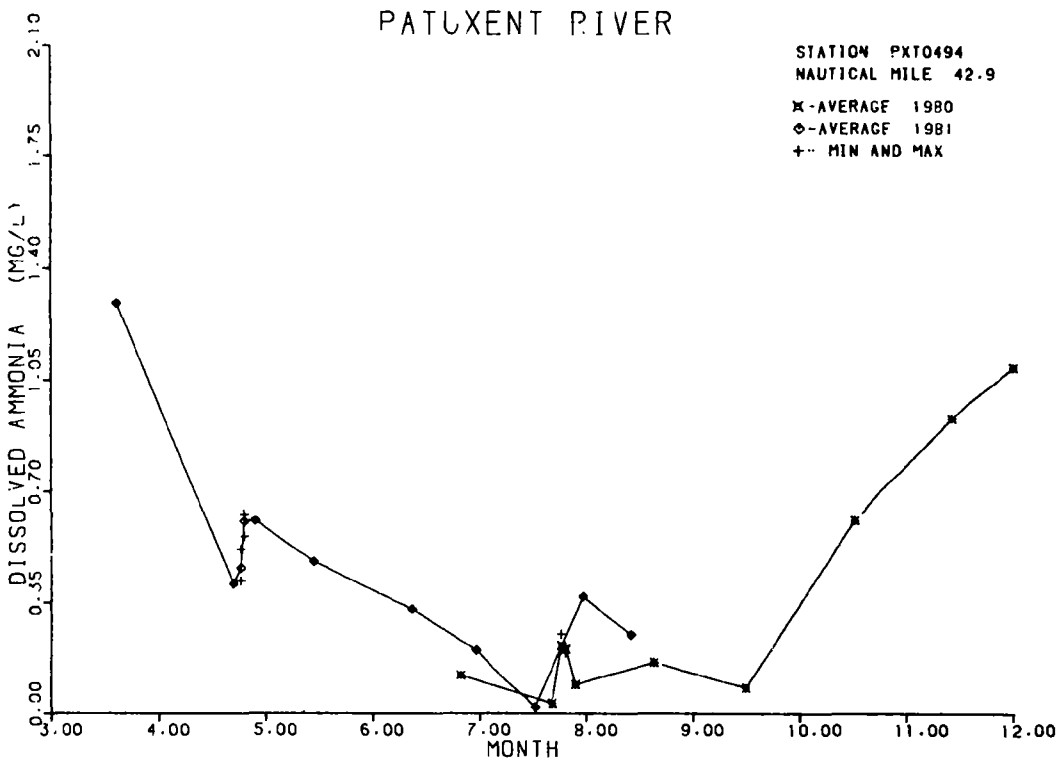


Figure 8-9 Patuxent River Temporal Plot of Dissolved Ammonia



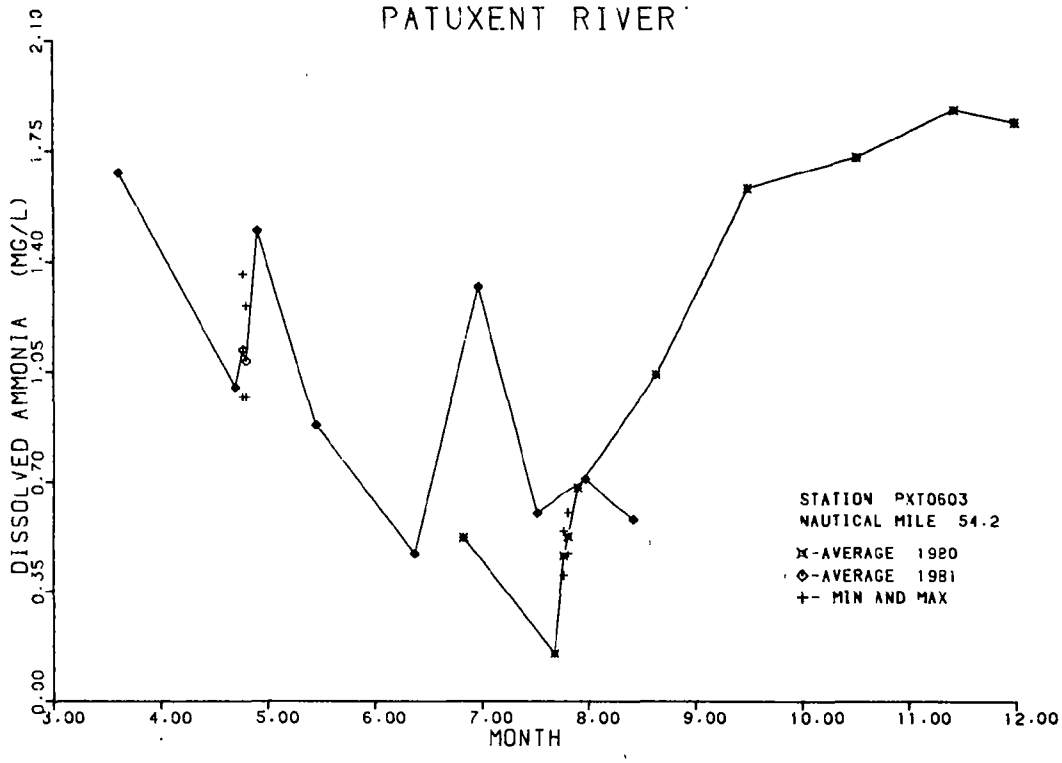
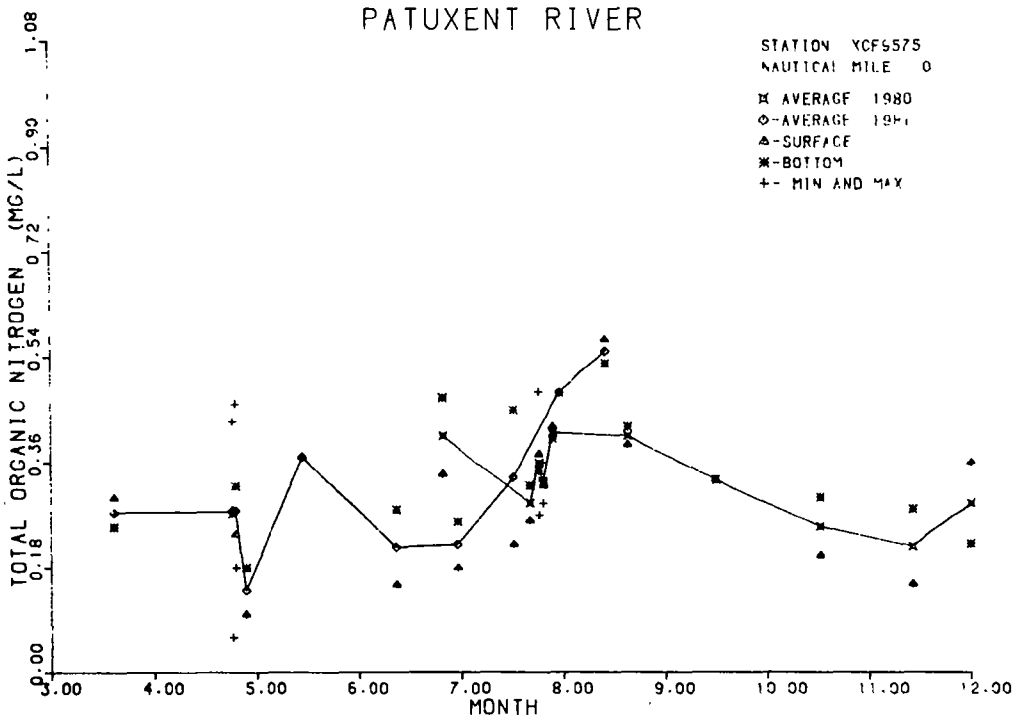


Figure 8-9 Patuxent River Temporal Plot of Dissolved Ammonia



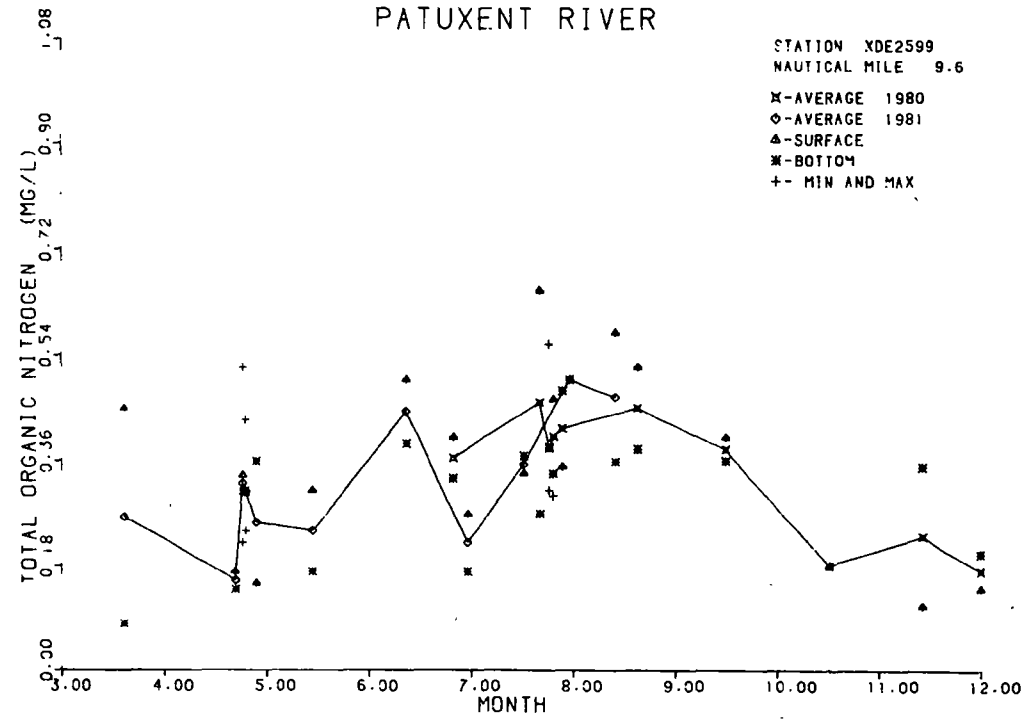
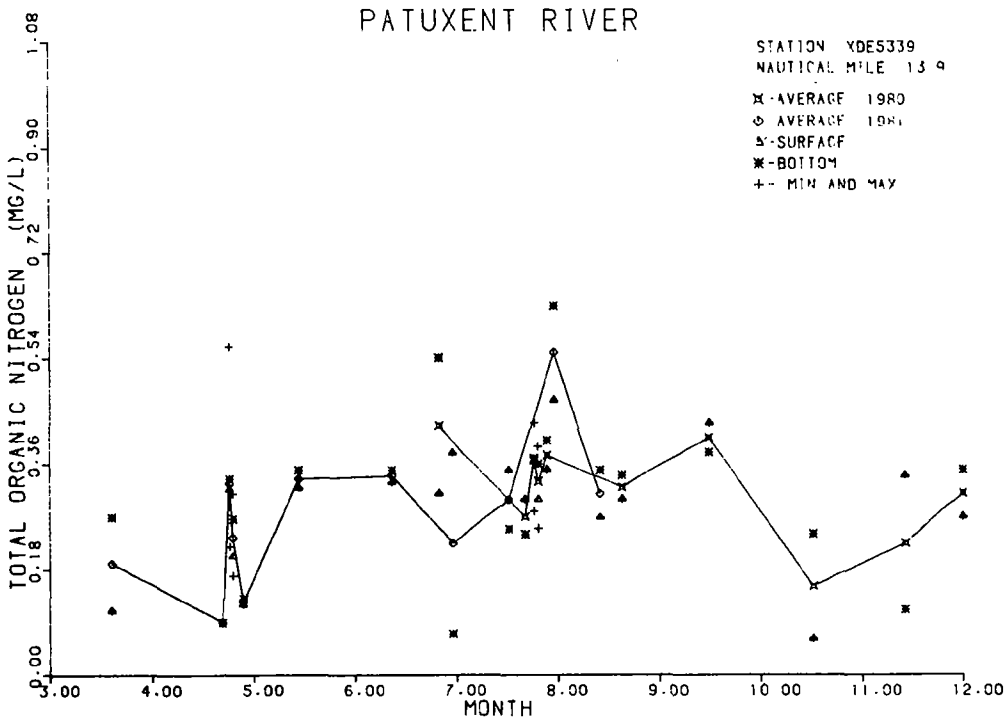


Figure 8-10 Patuxent River Temporal Plots of Total Organic Nitrogen.



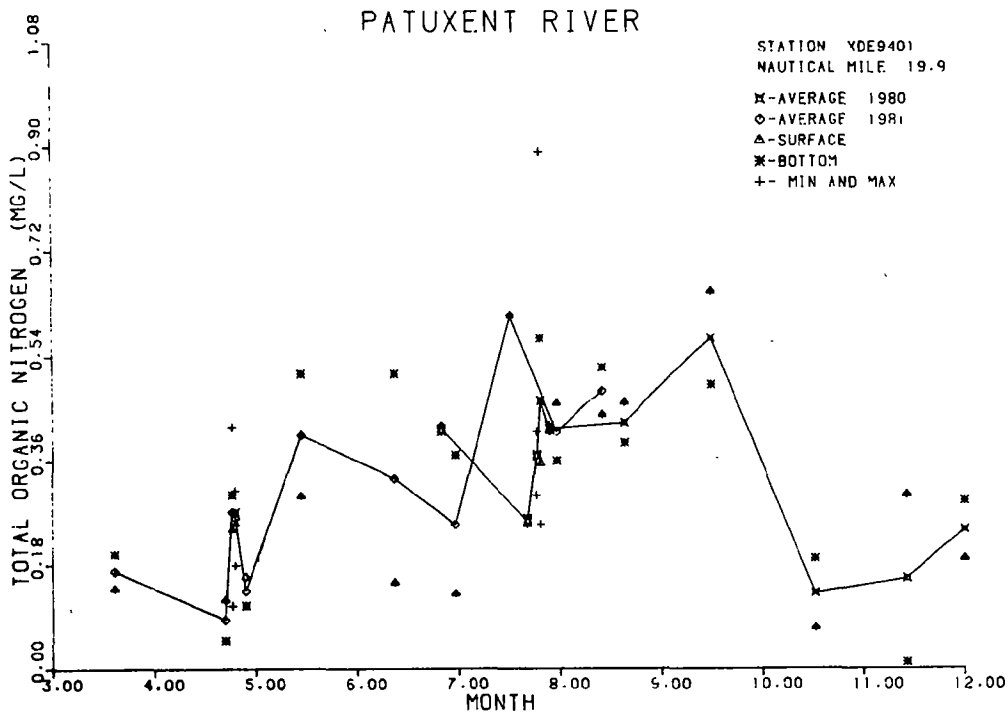
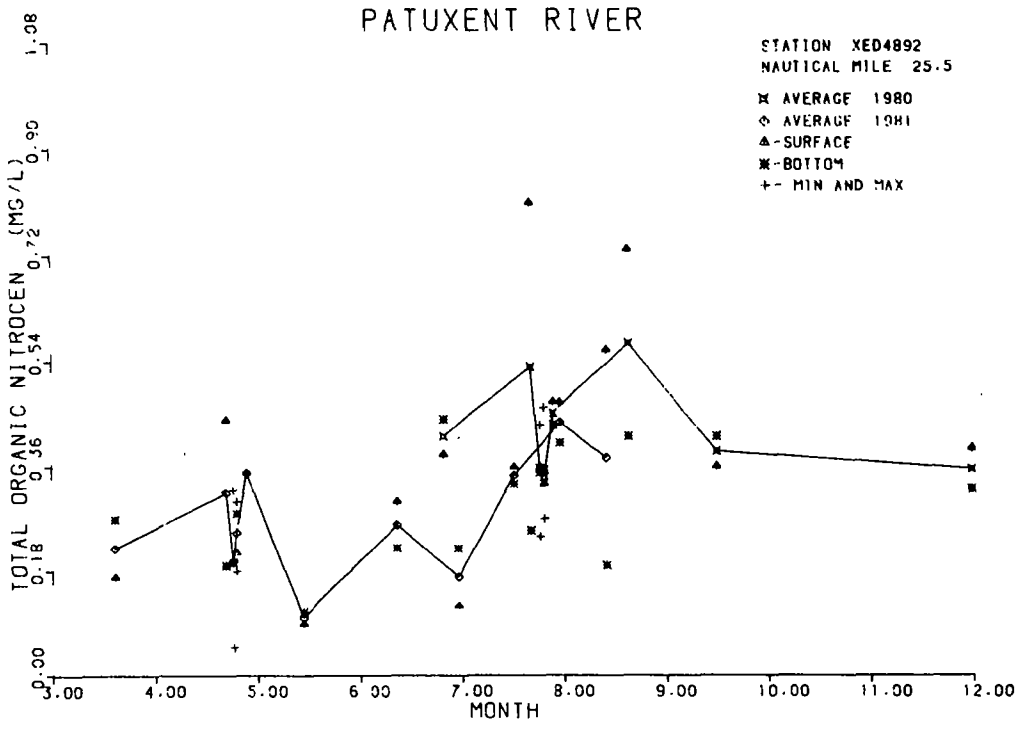


Figure 8-10 Patuxent River Temporal Plots of Total Organic Nitrogen.



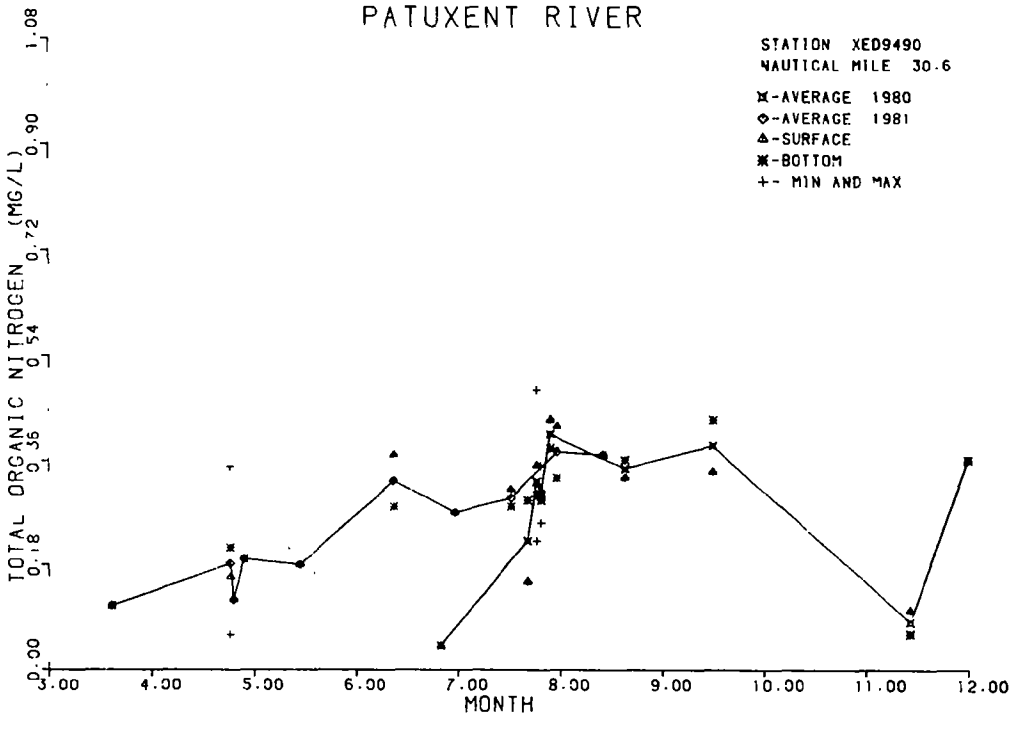
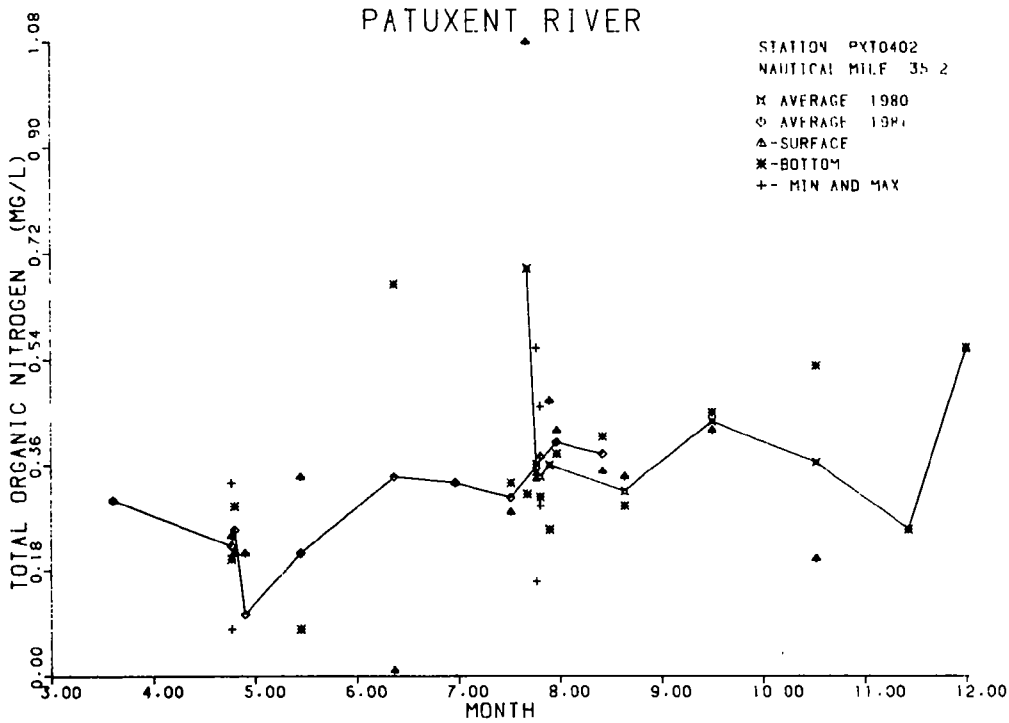


Figure 8-10 Patuxent River Temporal Plots of Total Organic Nitrogen.



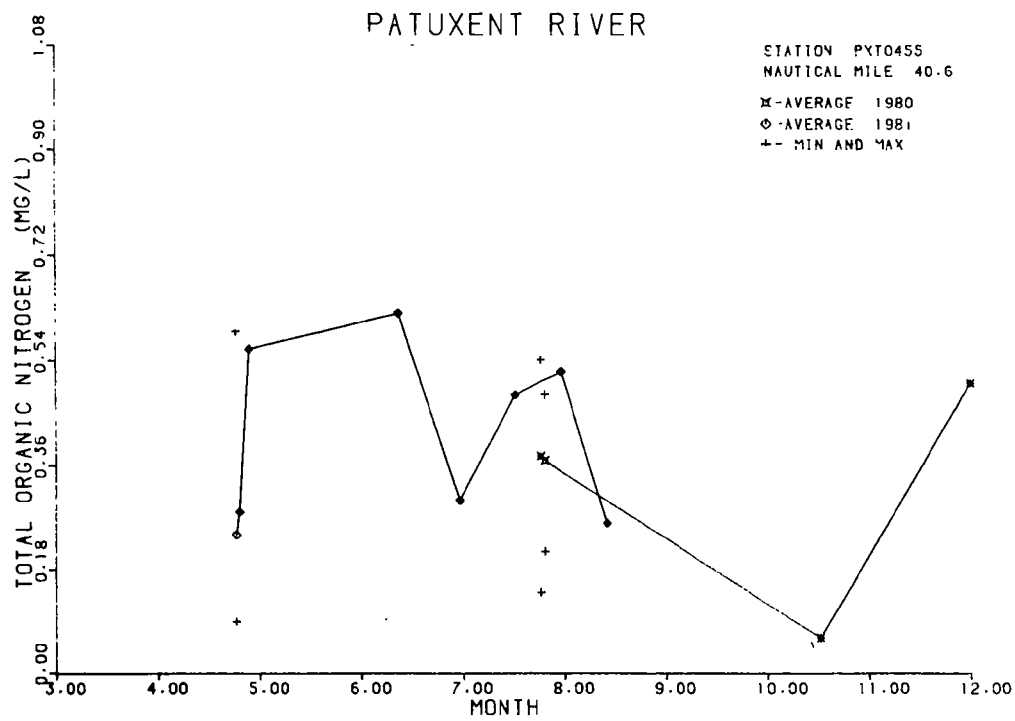
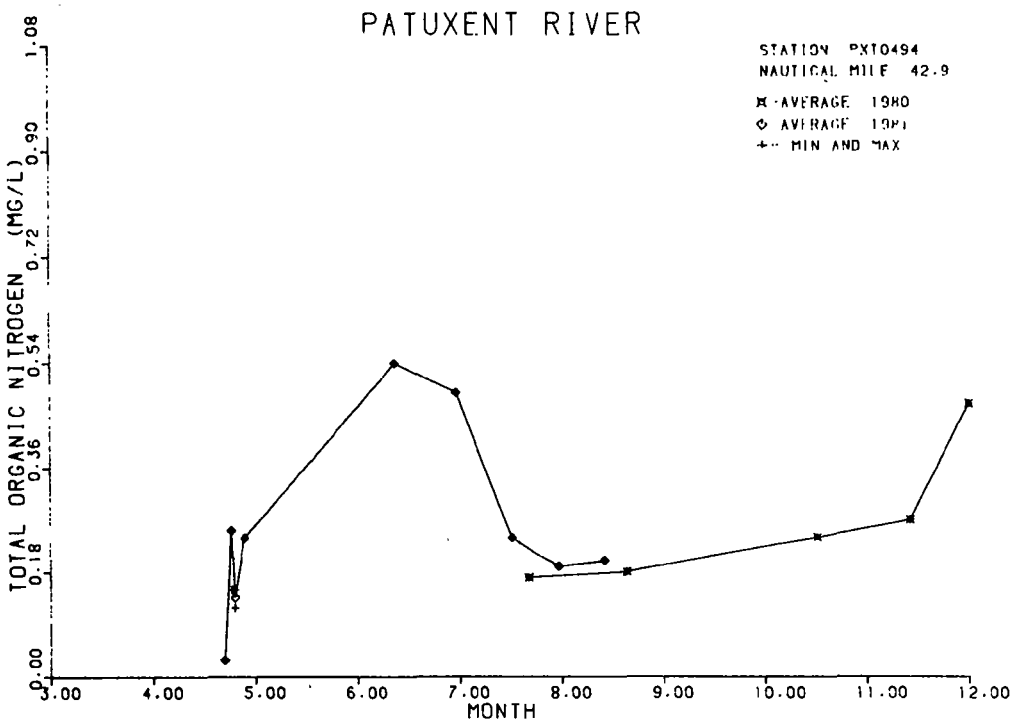


Figure 8-10 Patuxent River Temporal Plots of Total Organic Nitrogen.



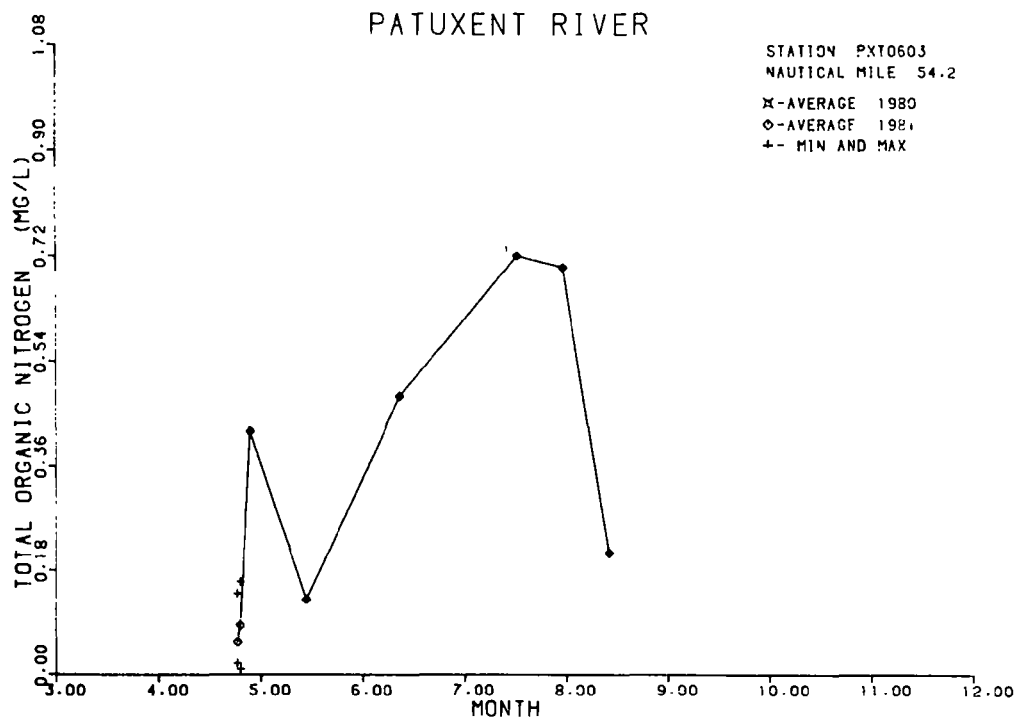
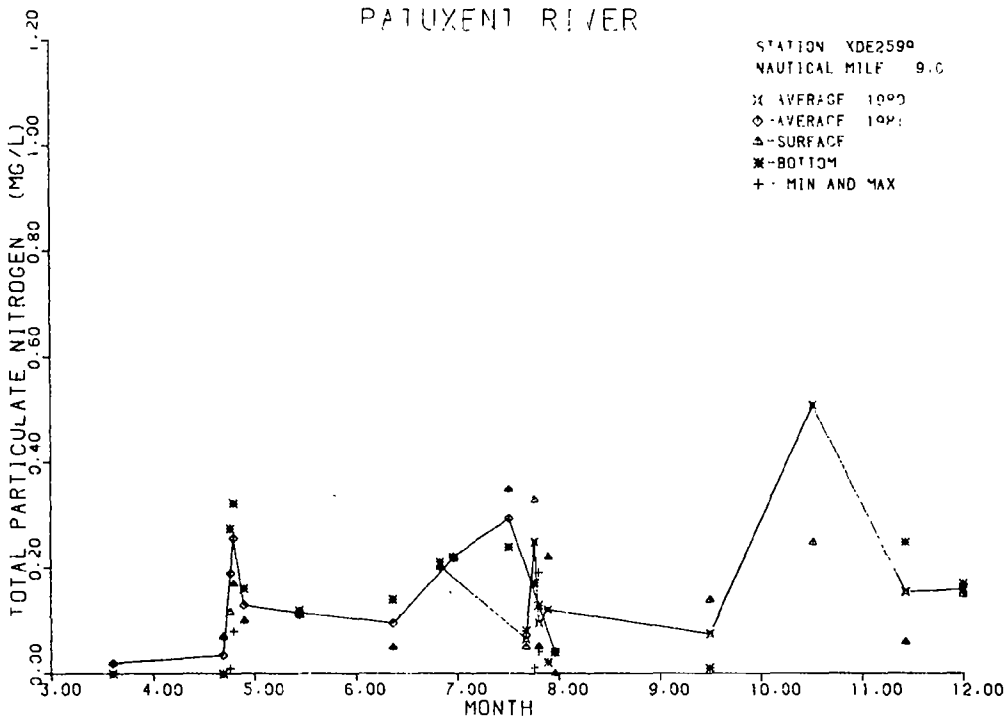


Figure 8-10 Patuxent River Temporal Plots of Total Organic Nitrogen.



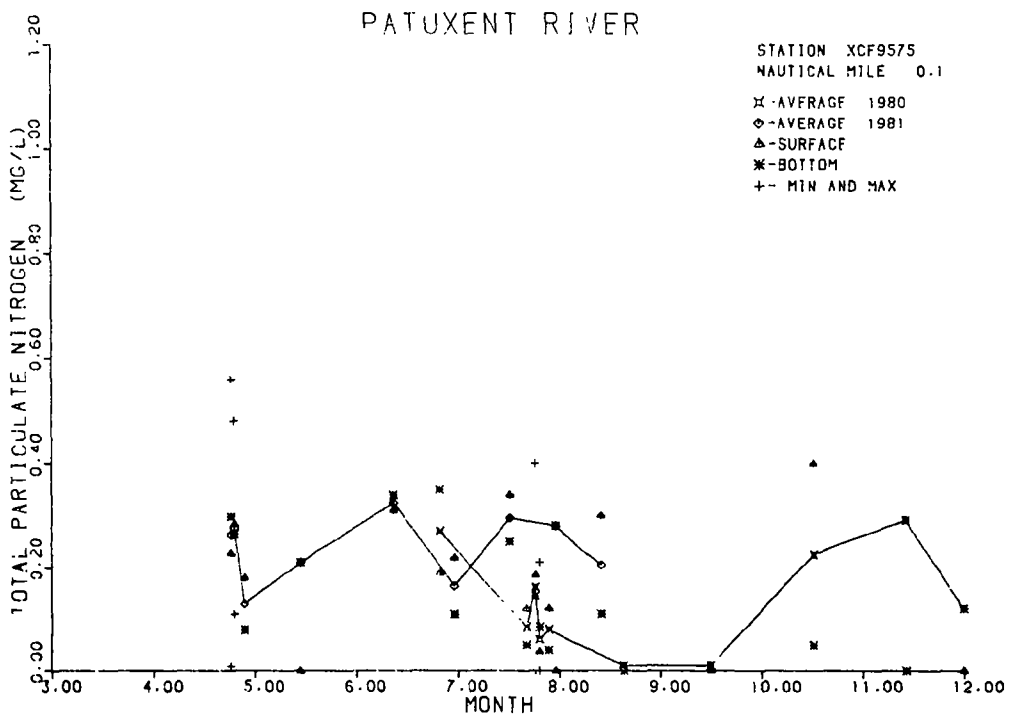
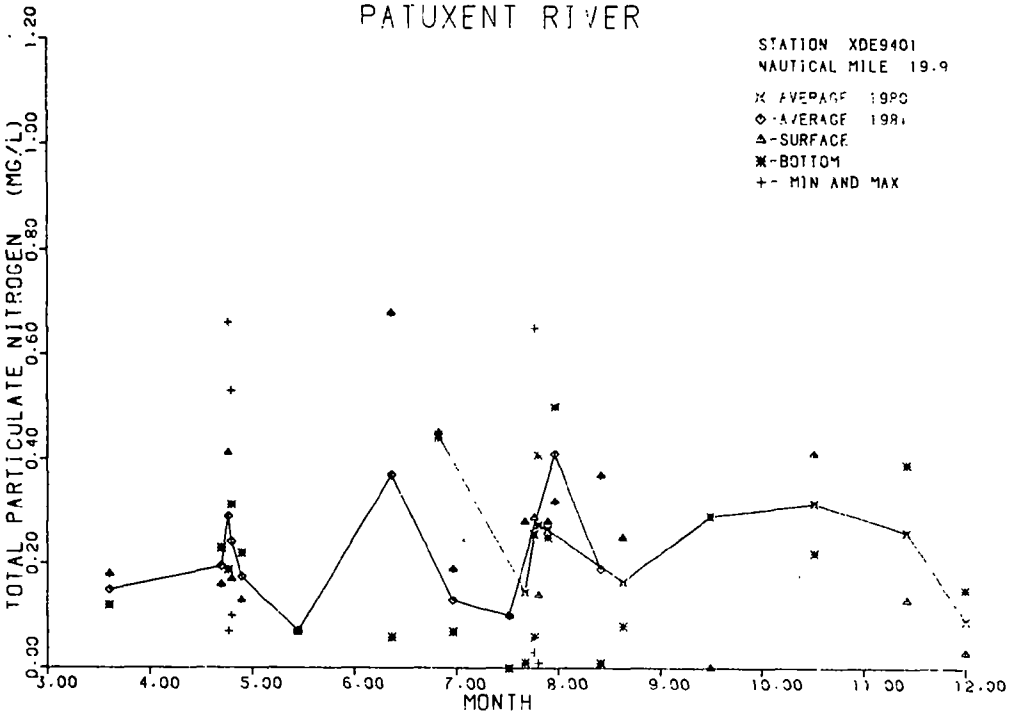


Figure 8-11 Temporal plots of total particulate nitrogen.



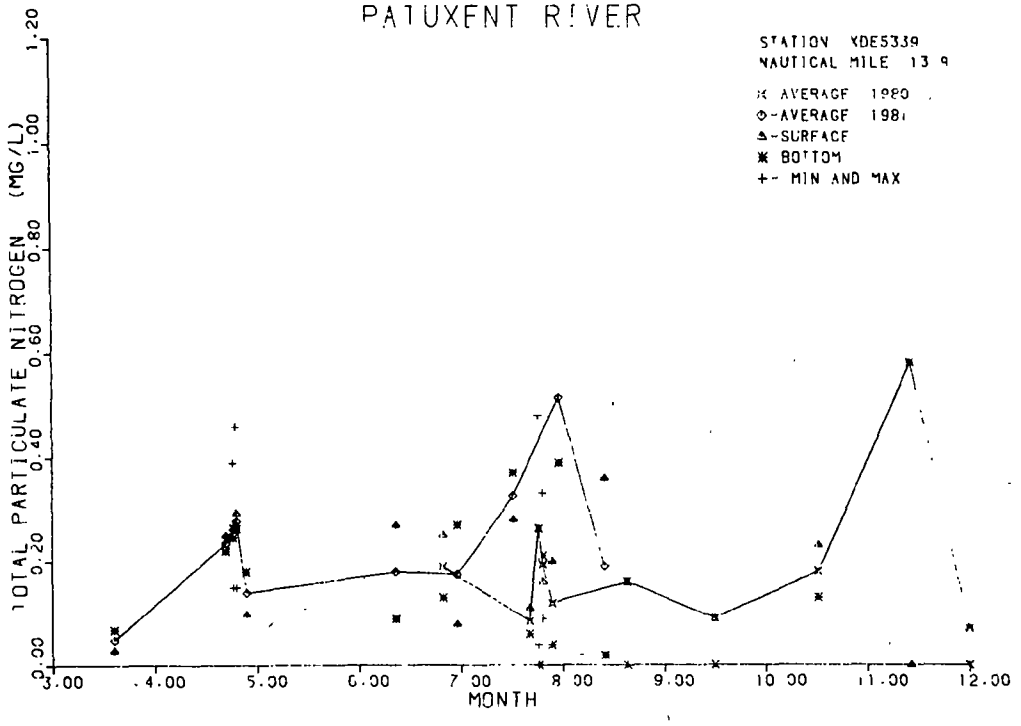
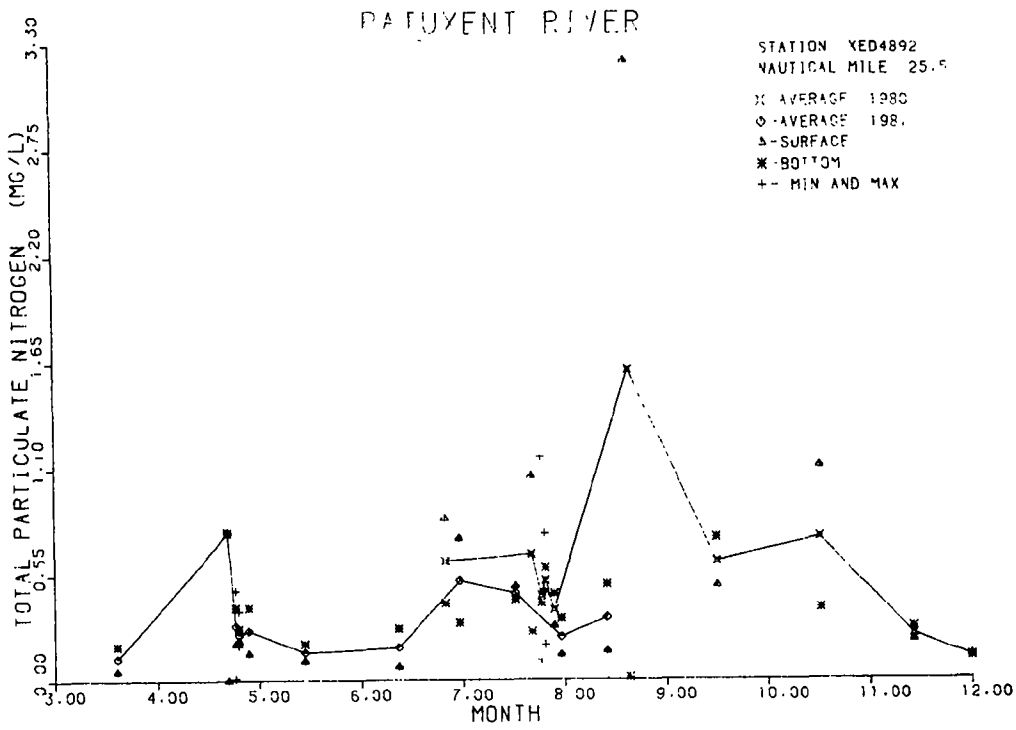


Figure 8-11 Temporal plots of total particulate nitrogen.



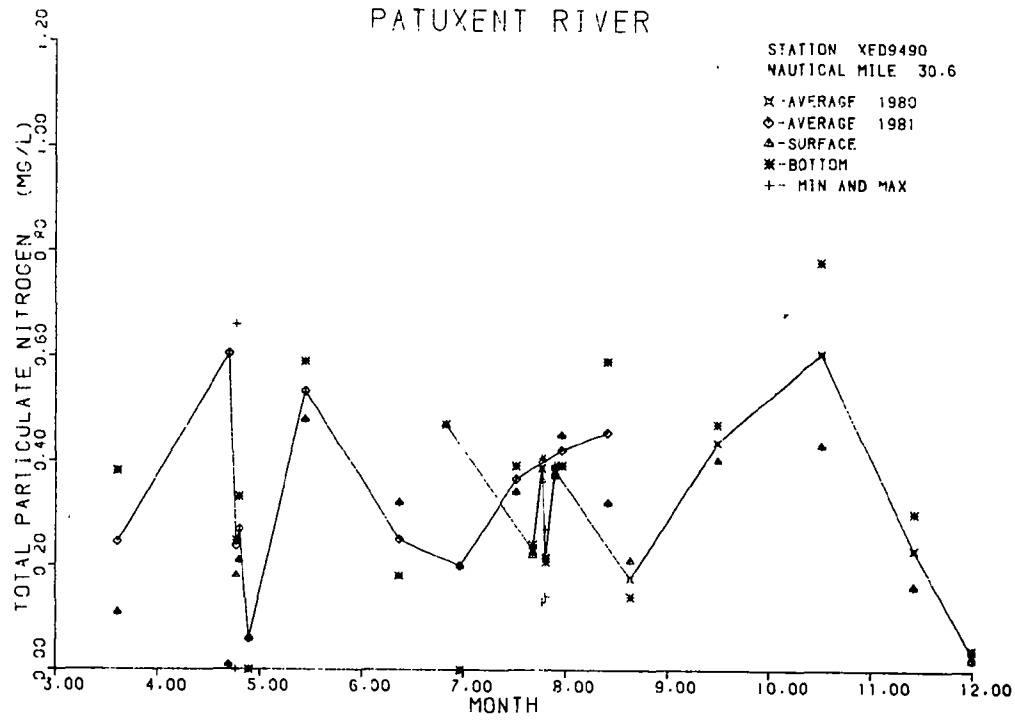
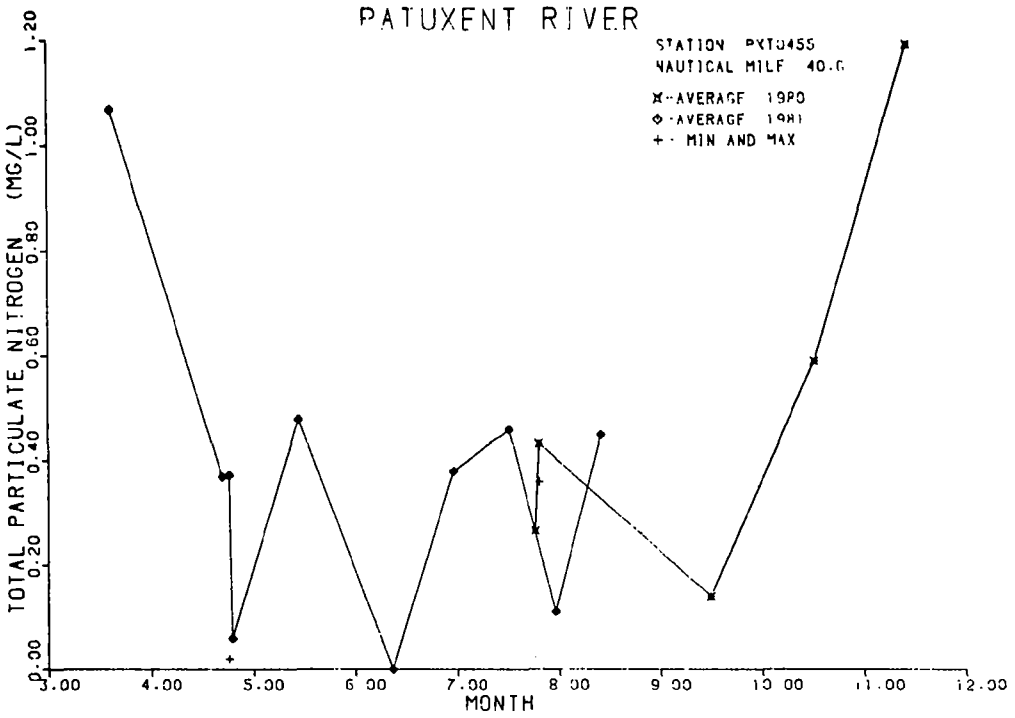


Figure 8-11 Temporal plots of total particulate nitrogen.



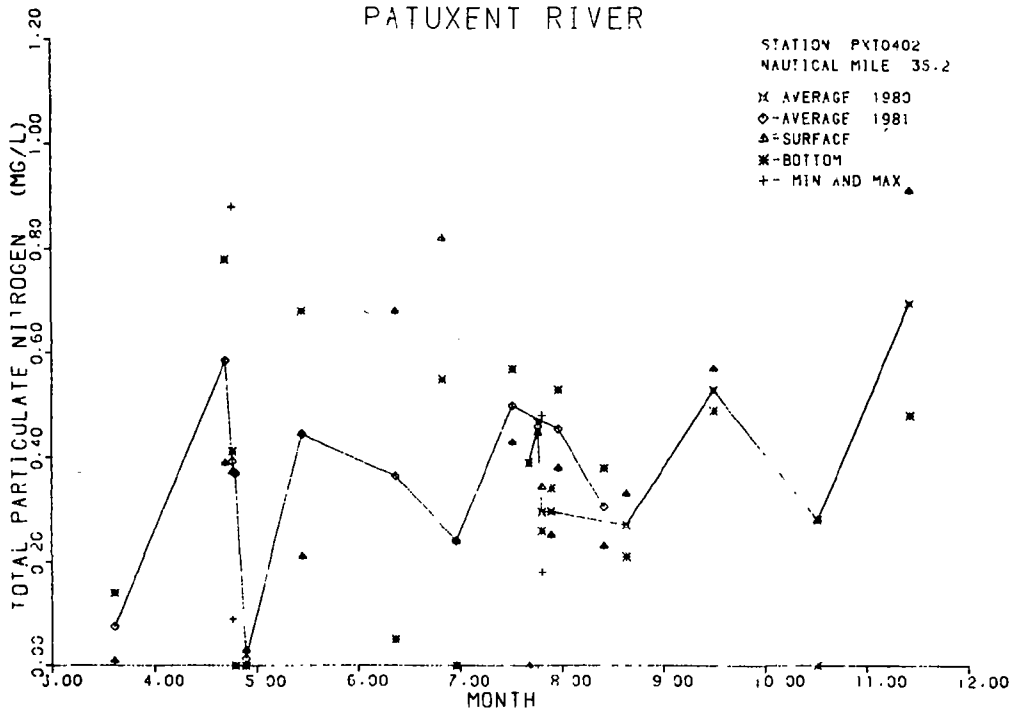
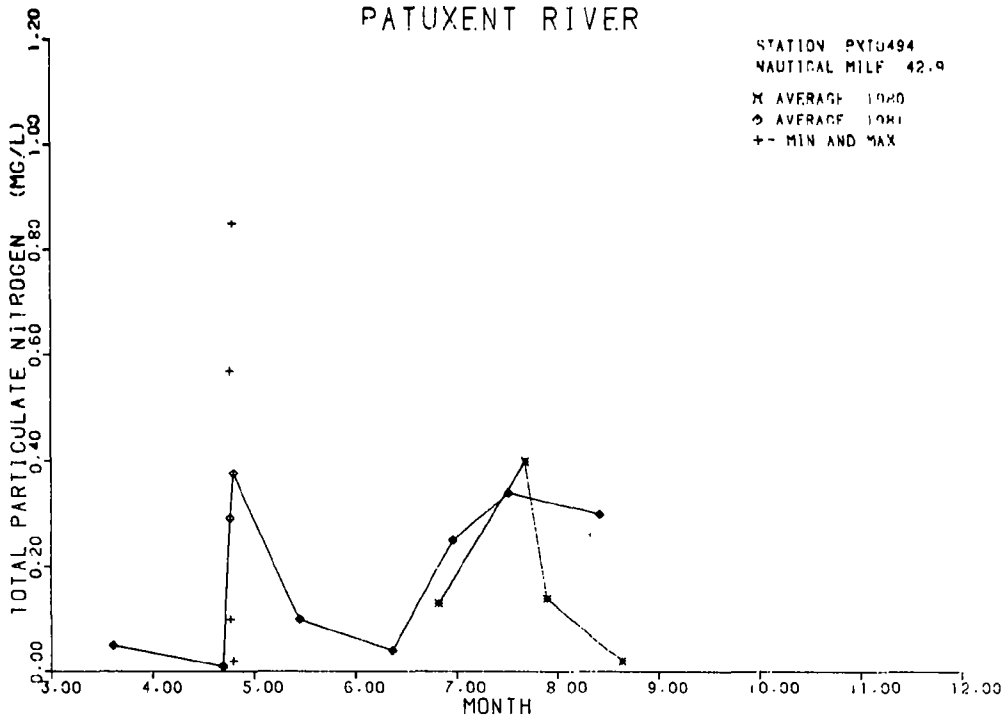


Figure 8-11 Temporal plots of total particulate nitrogen.



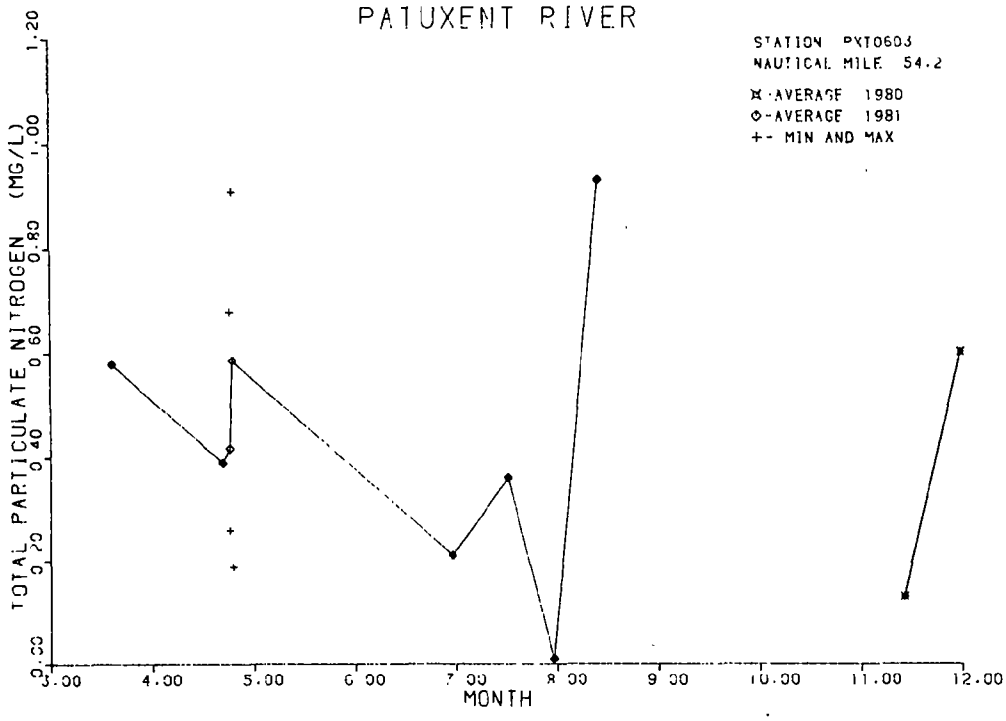
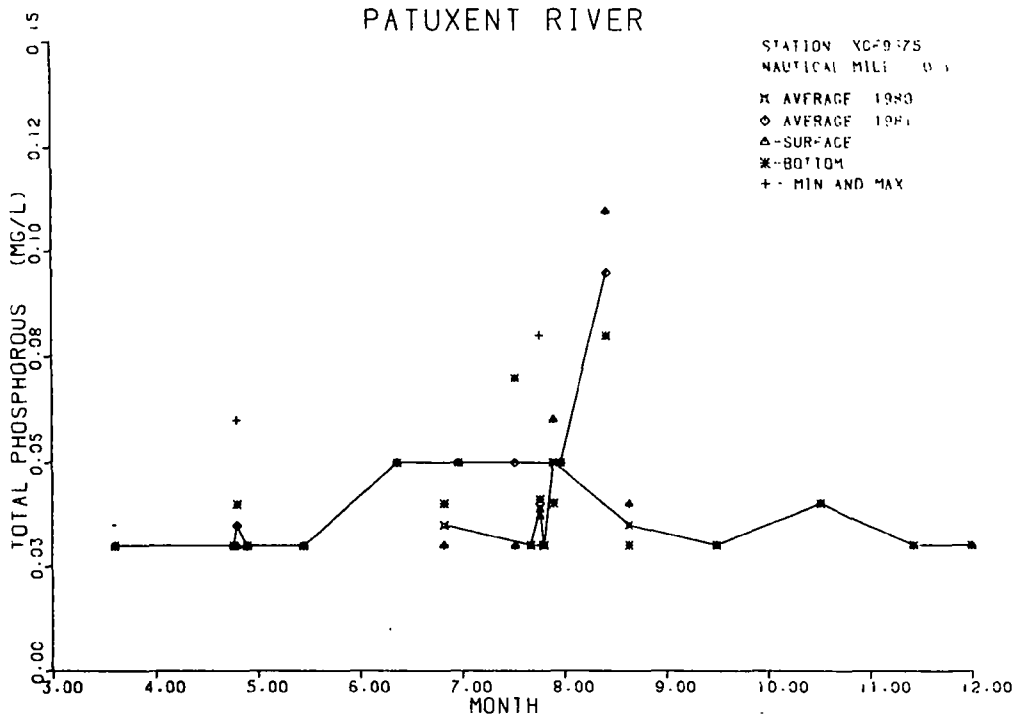


Figure 8-11 Temporal plots of total particulate nitrogen.



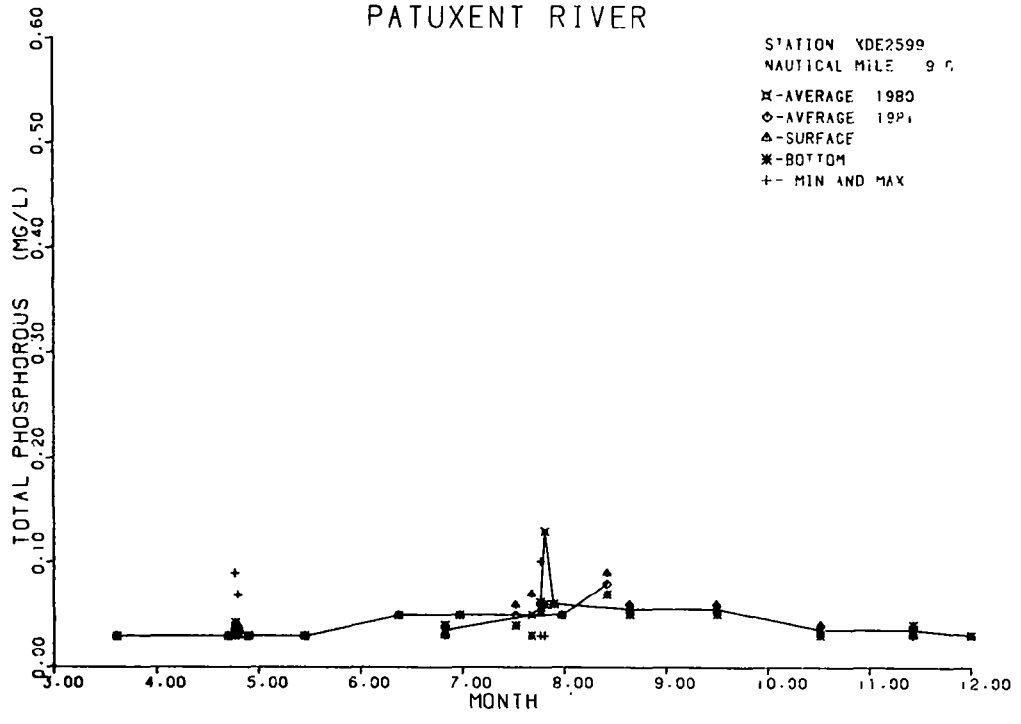
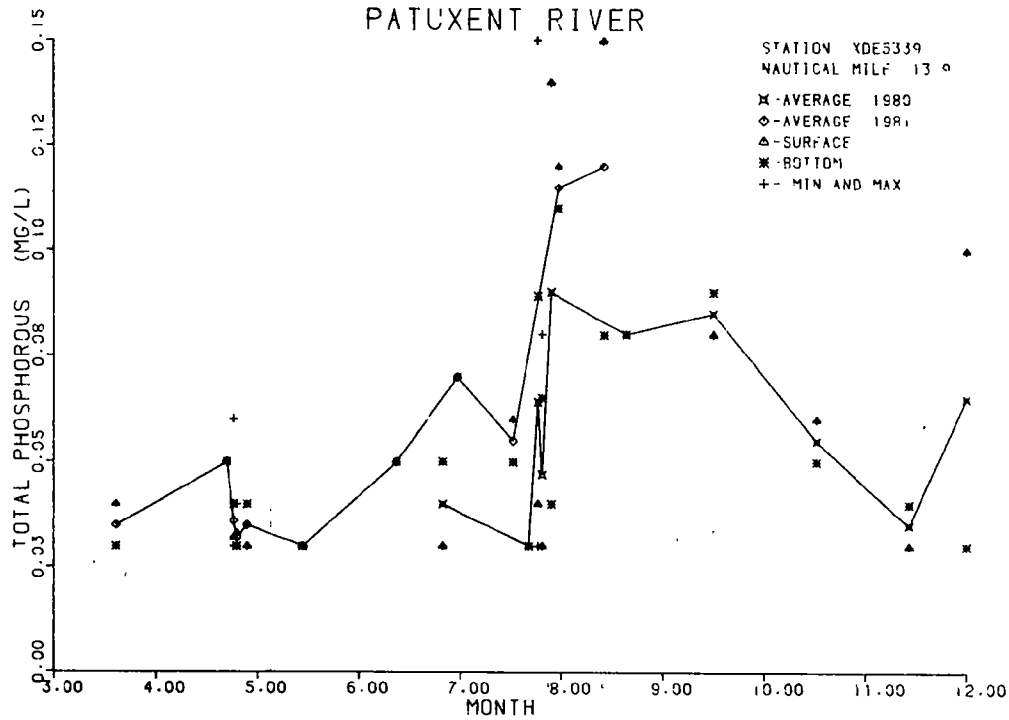


Figure 8-12 Temporal plots of total phosphorus, 1980-1981.



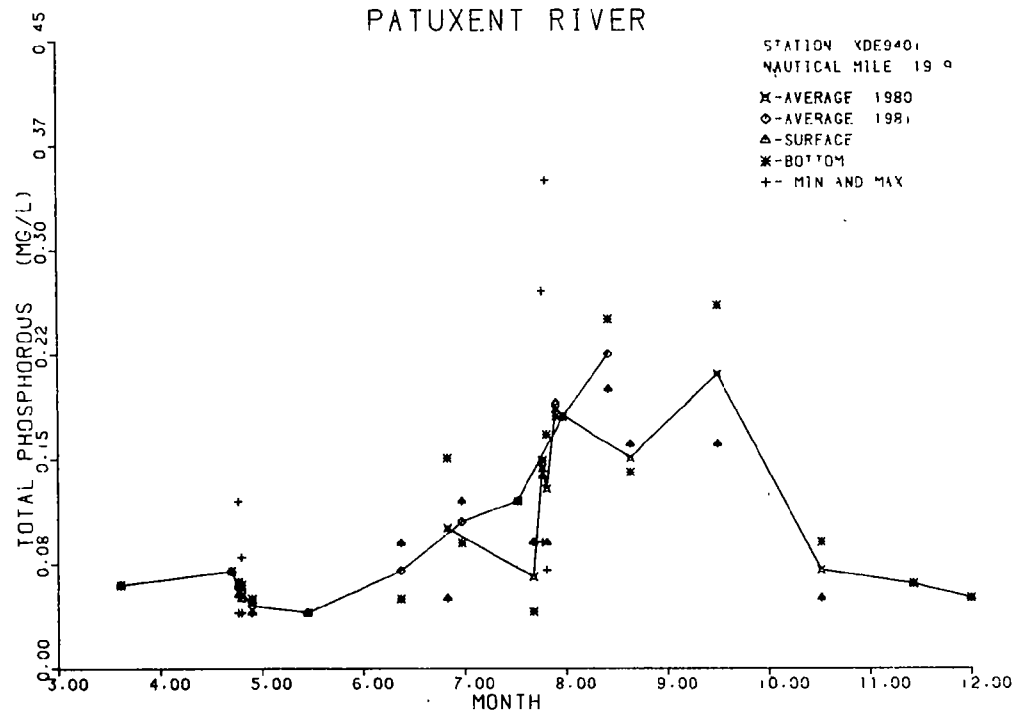
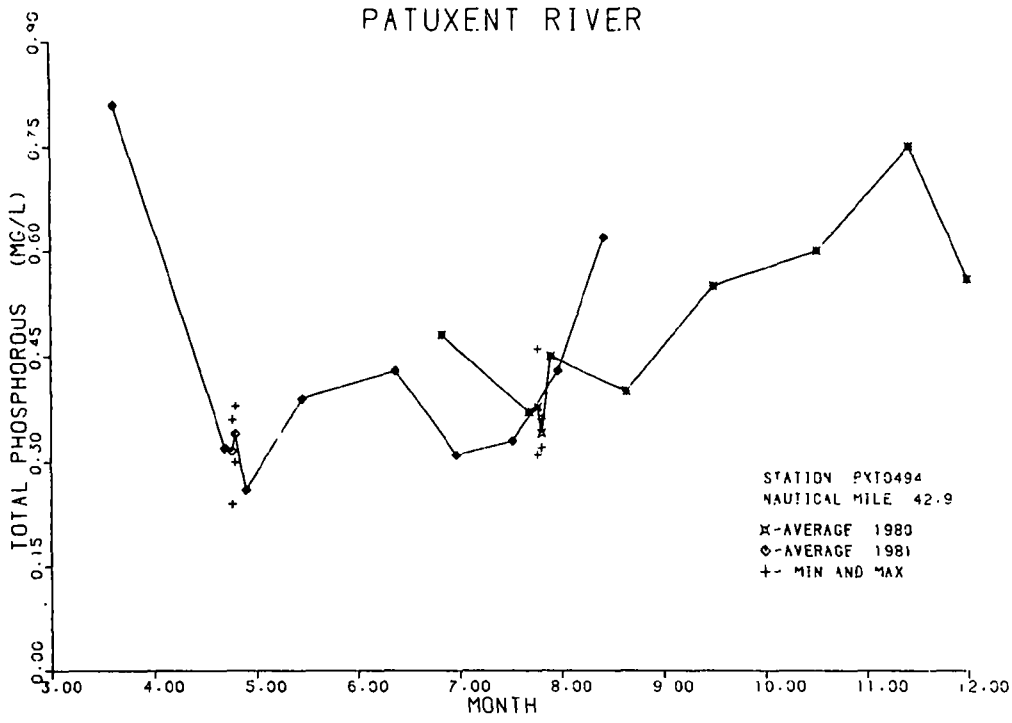


Figure 8-12 Temporal plots of total phosphorus, 1980-1981.



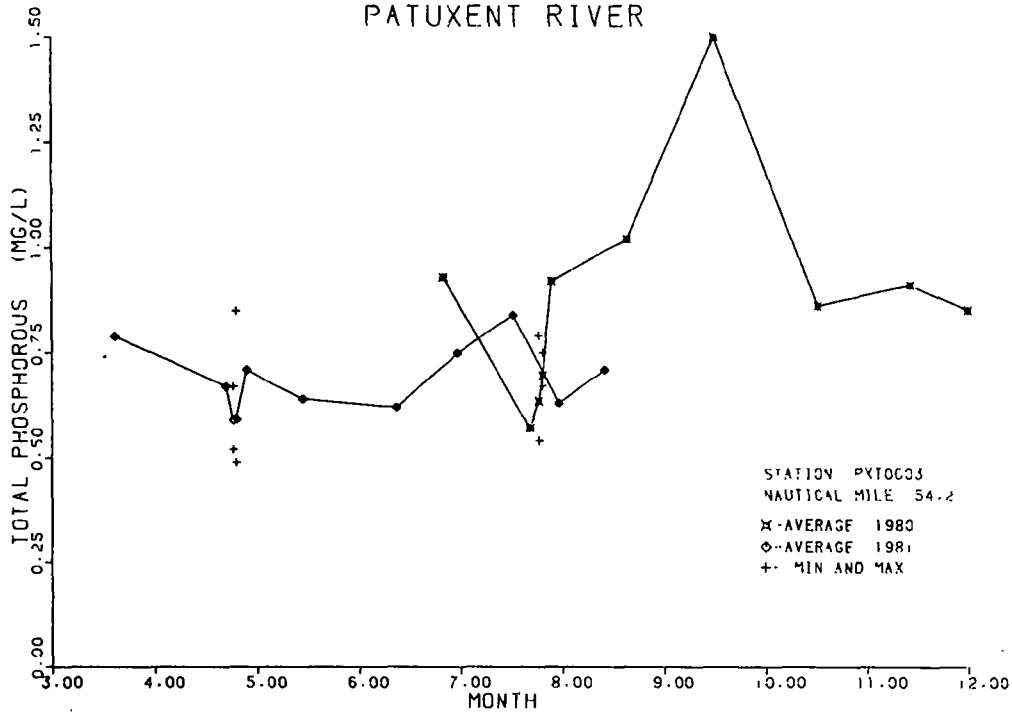
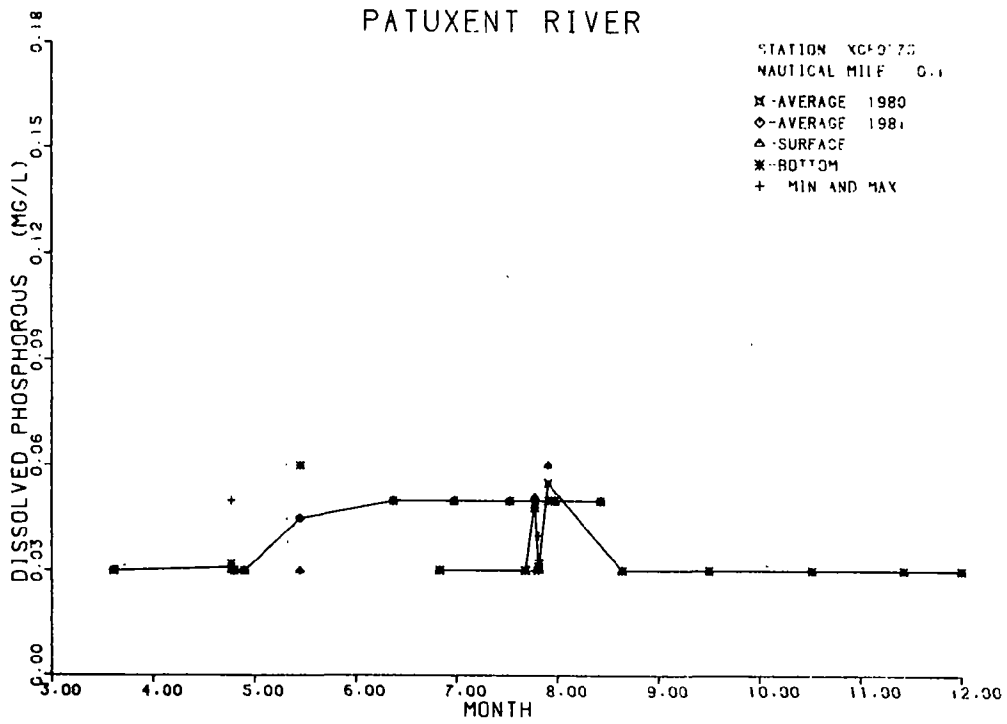


Figure 8-12 Temporal plots of total phosphorus, 1980-1981.



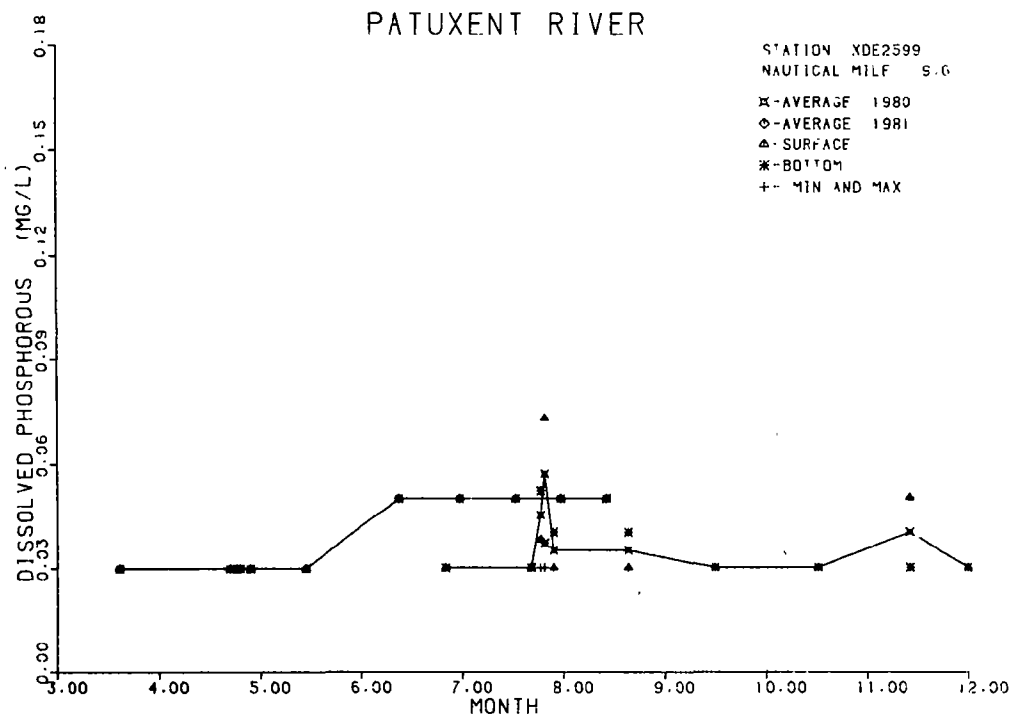
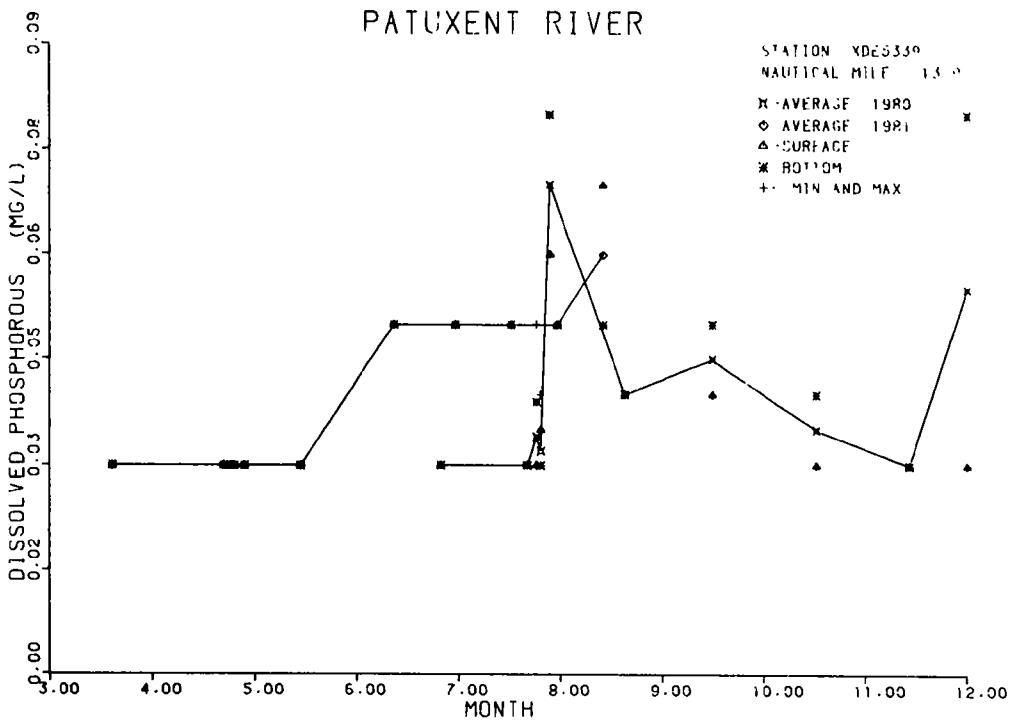


Figure 8-13 Temporal plots of dissolved phosphorus, 1980-1981.



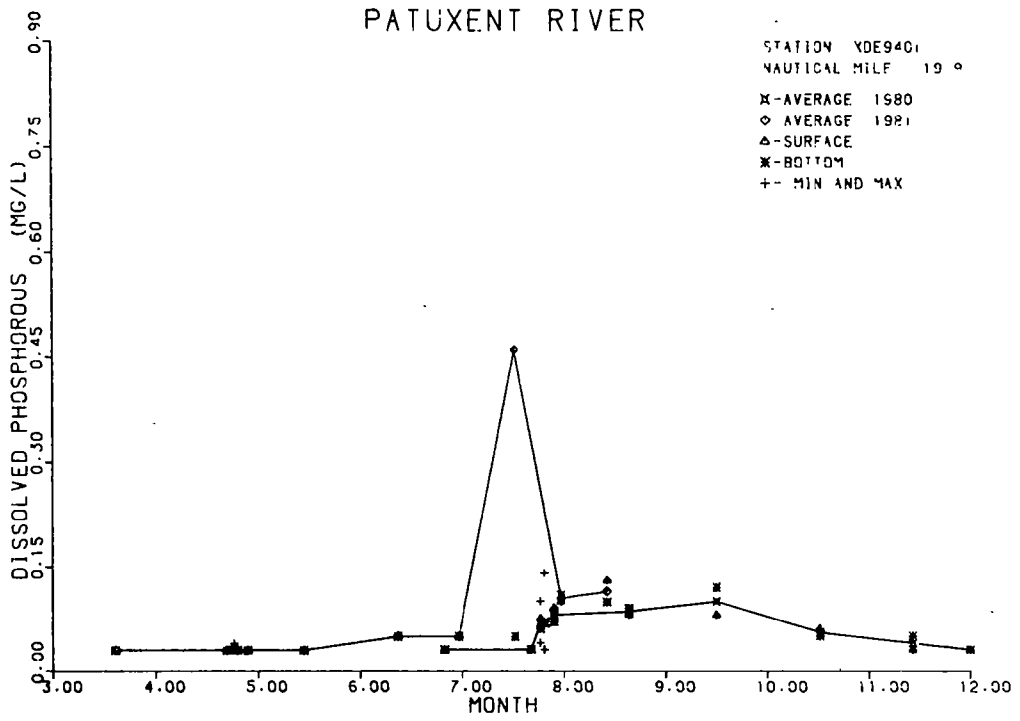
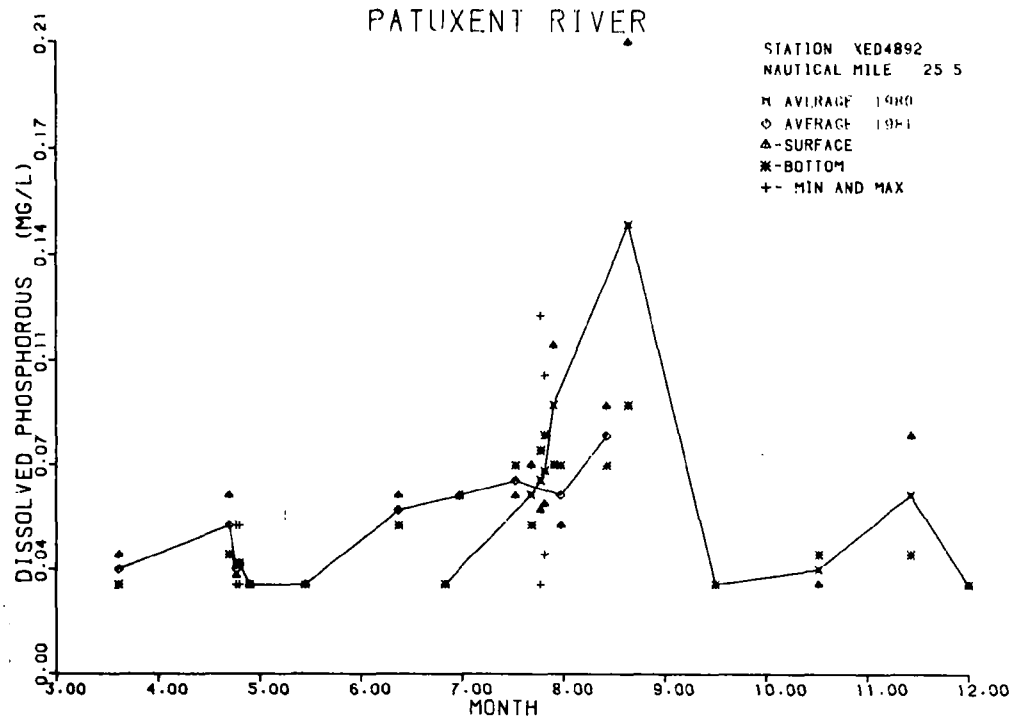


Figure 8-13 Temporal plots of dissolved phosphorus, 1980-1981.



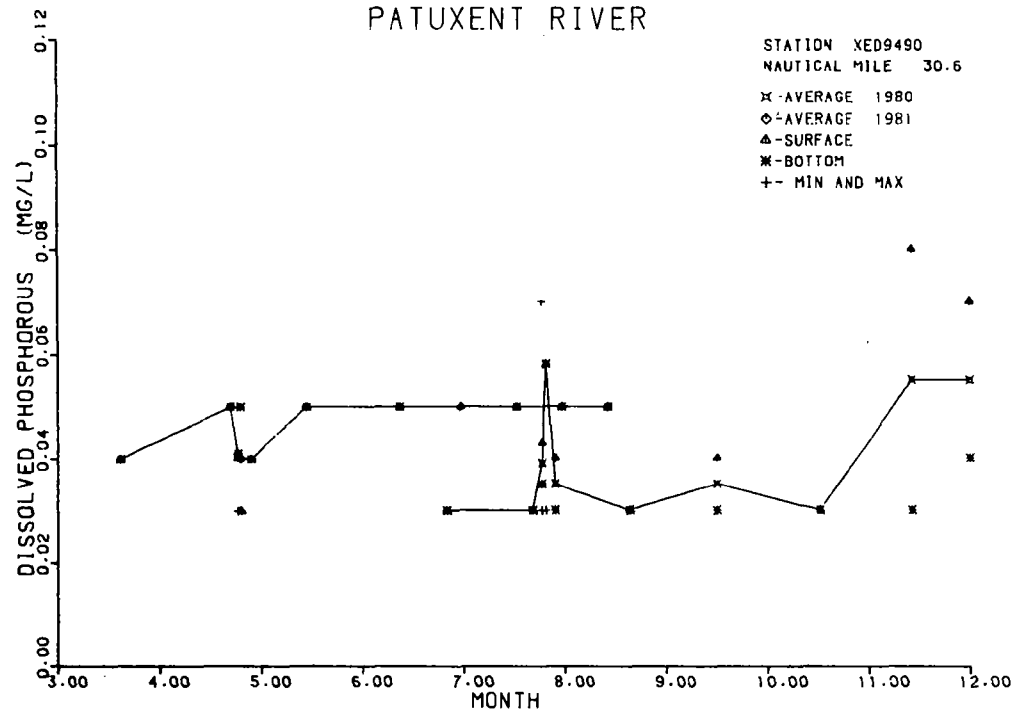
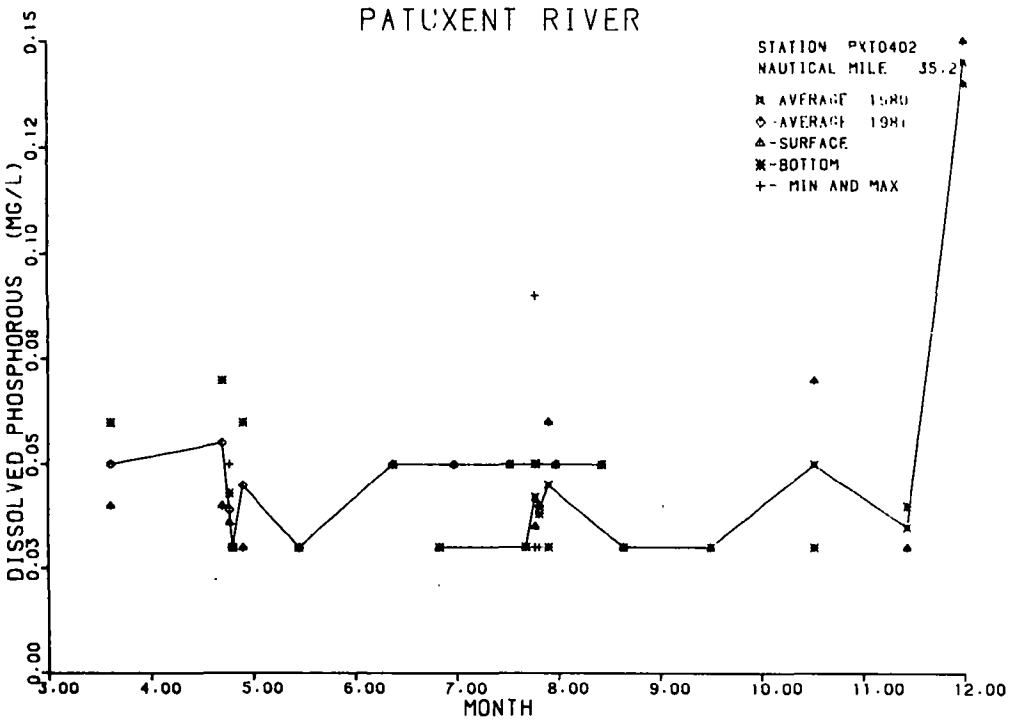


Figure 8-13 Temporal plots of dissolved phosphorus, 1980-1981.



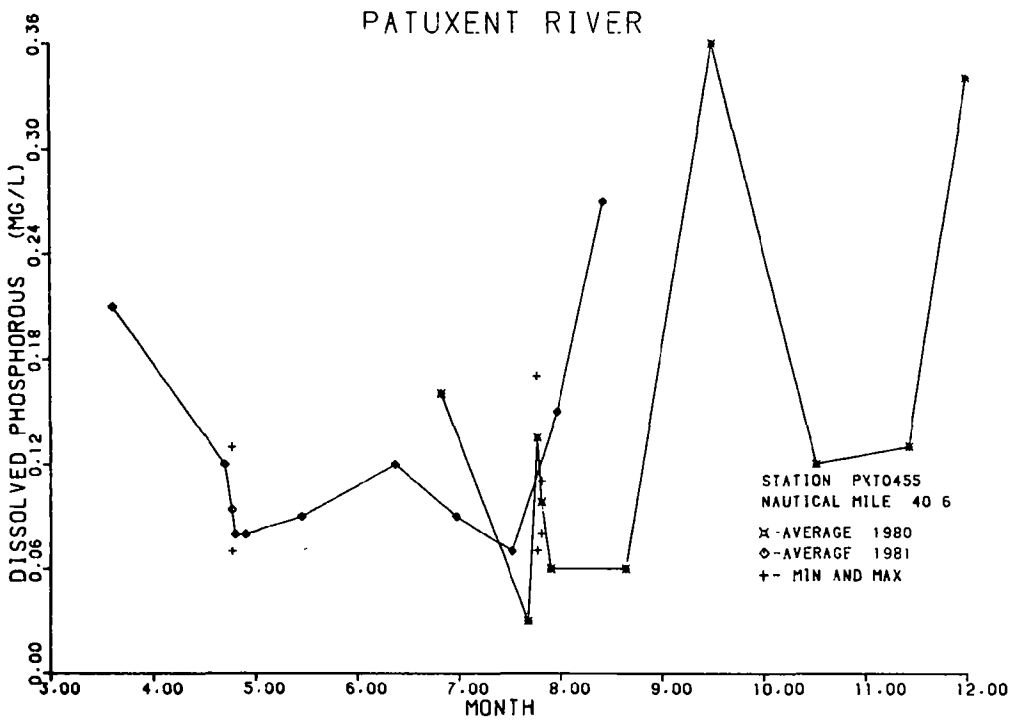
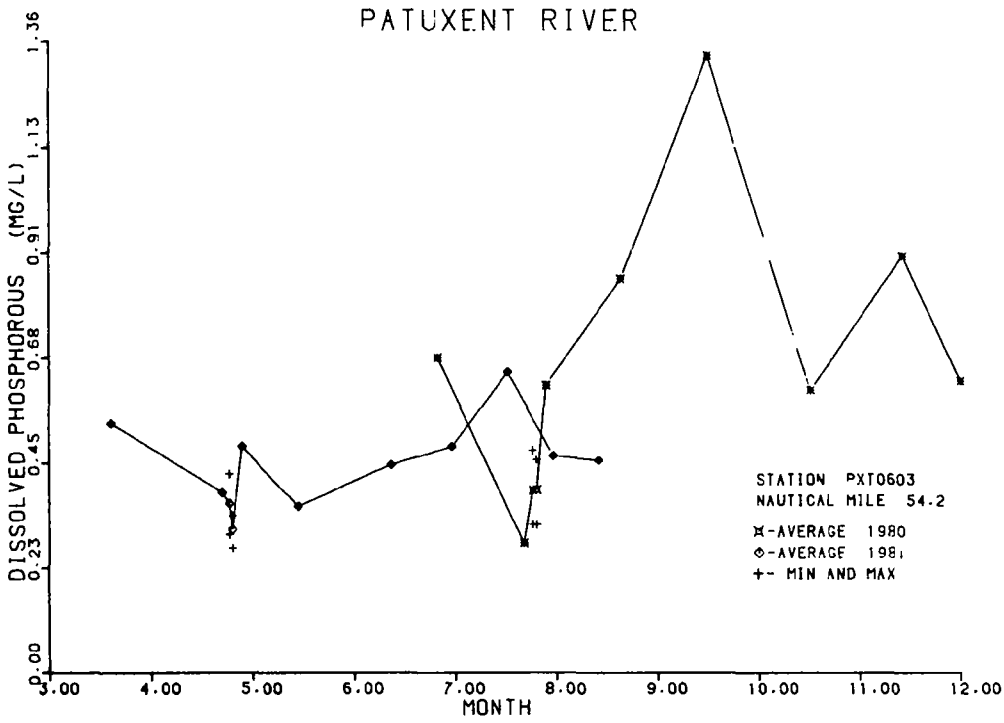


Figure 8-13 Temporal plots of dissolved phosphorus, 1980-1981.



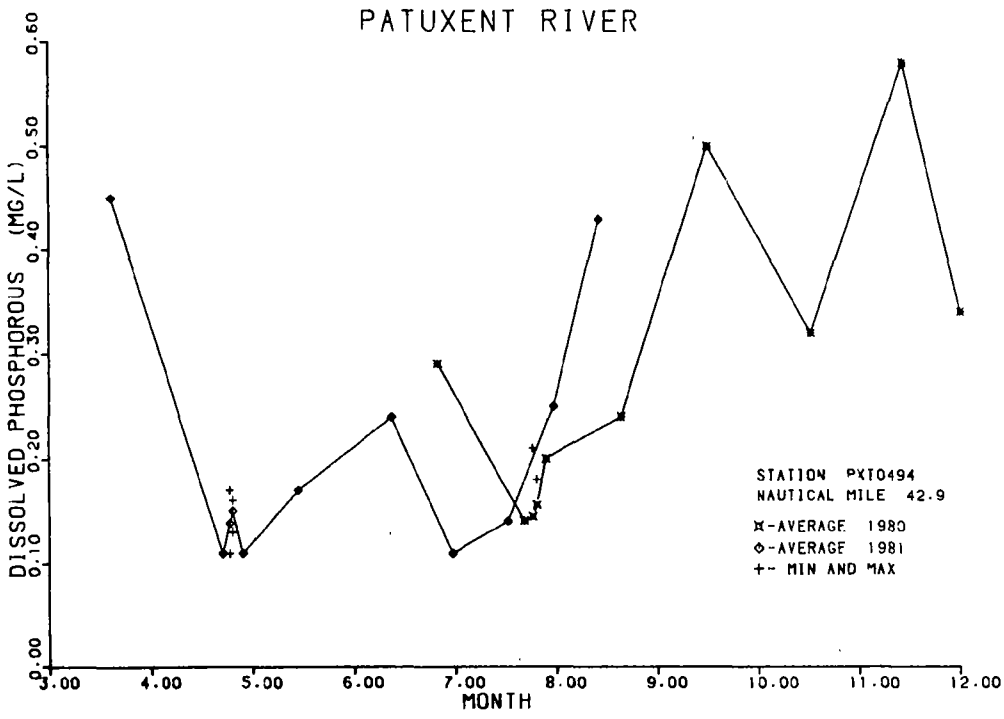
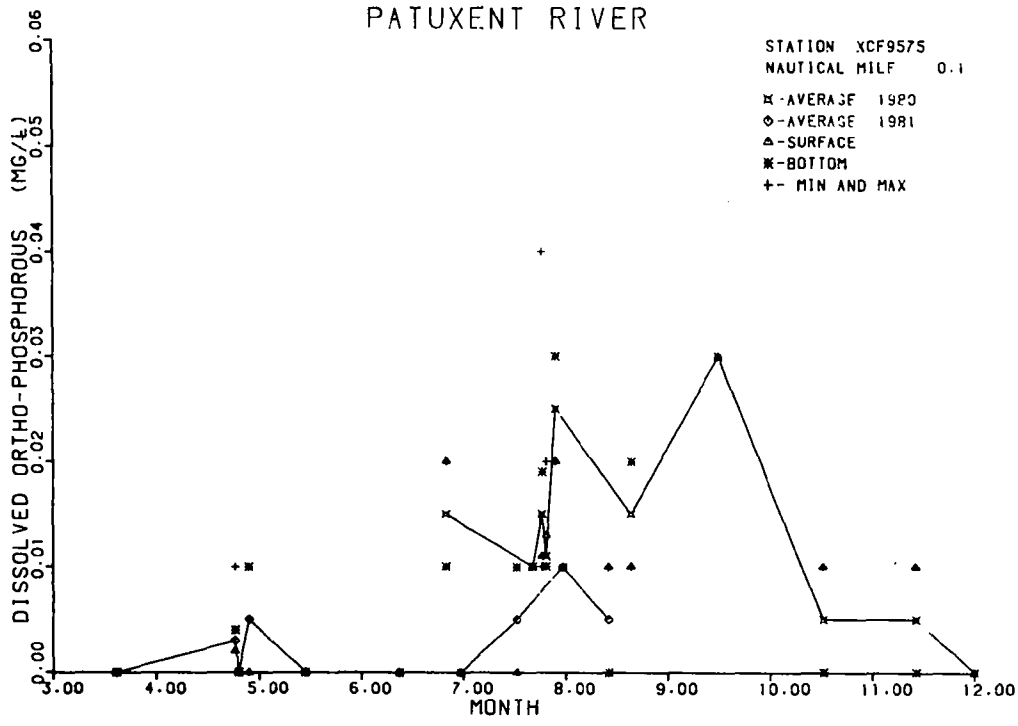


Figure 8-13 Temporal plots of dissolved phosphorus, 1980-1981.



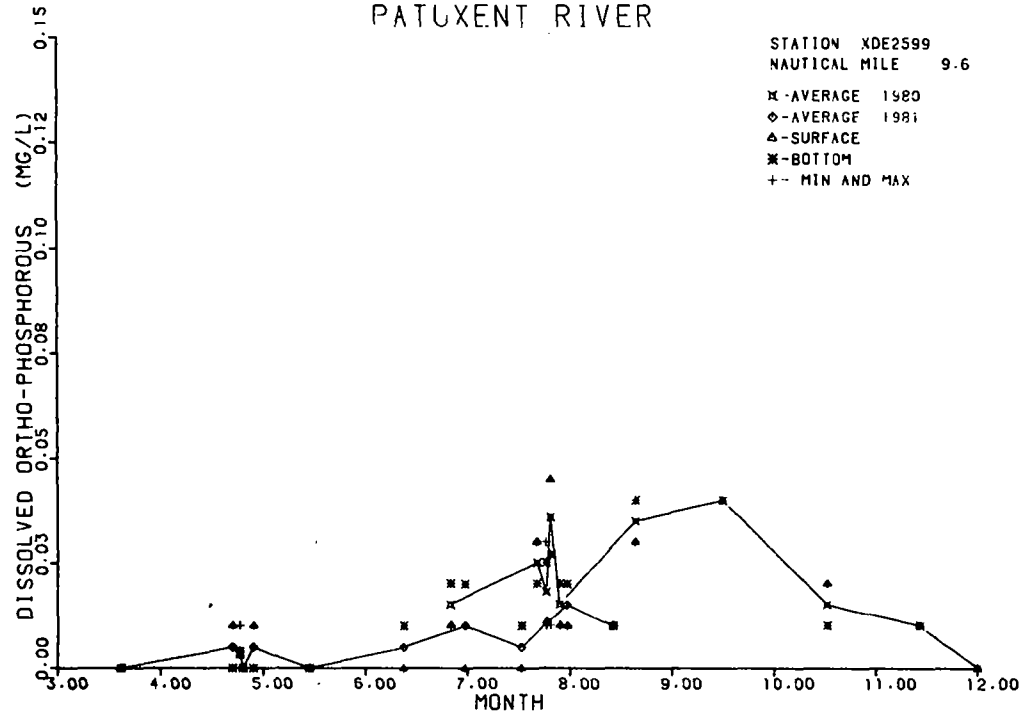
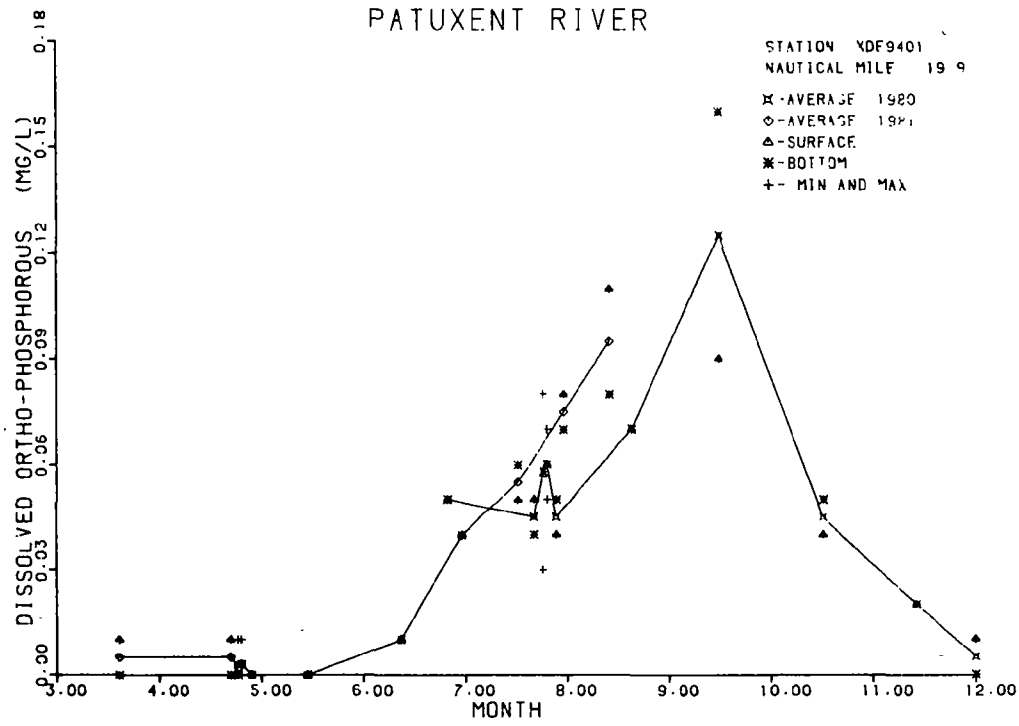


Figure 8-14 Temporal plots of dissolved ortho-phosphorus, 1980-1981.



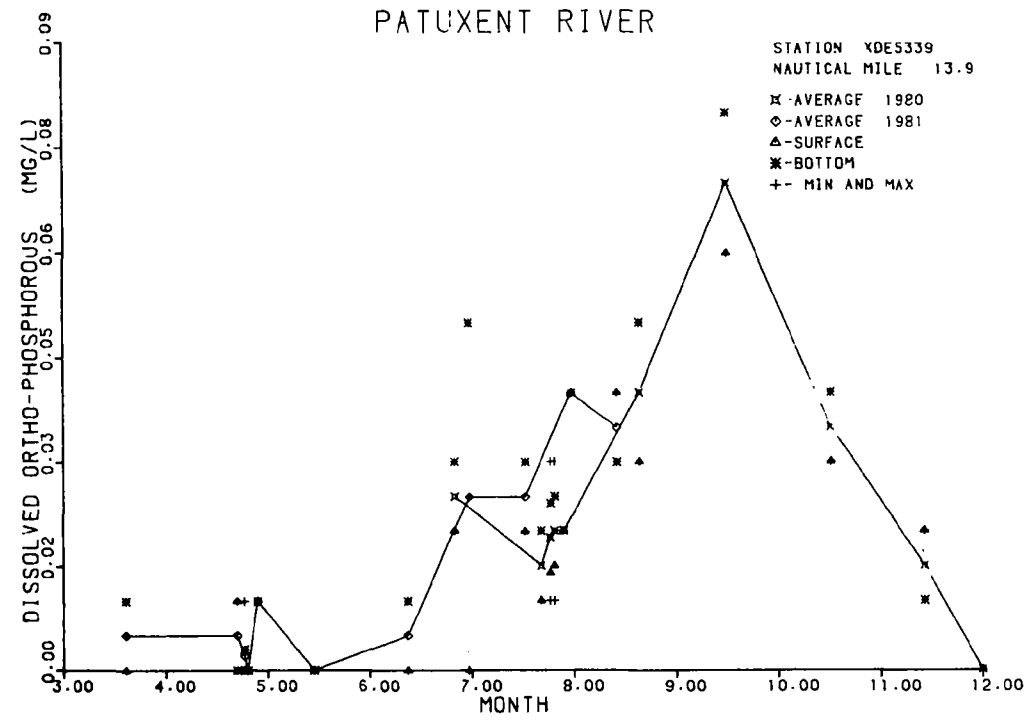
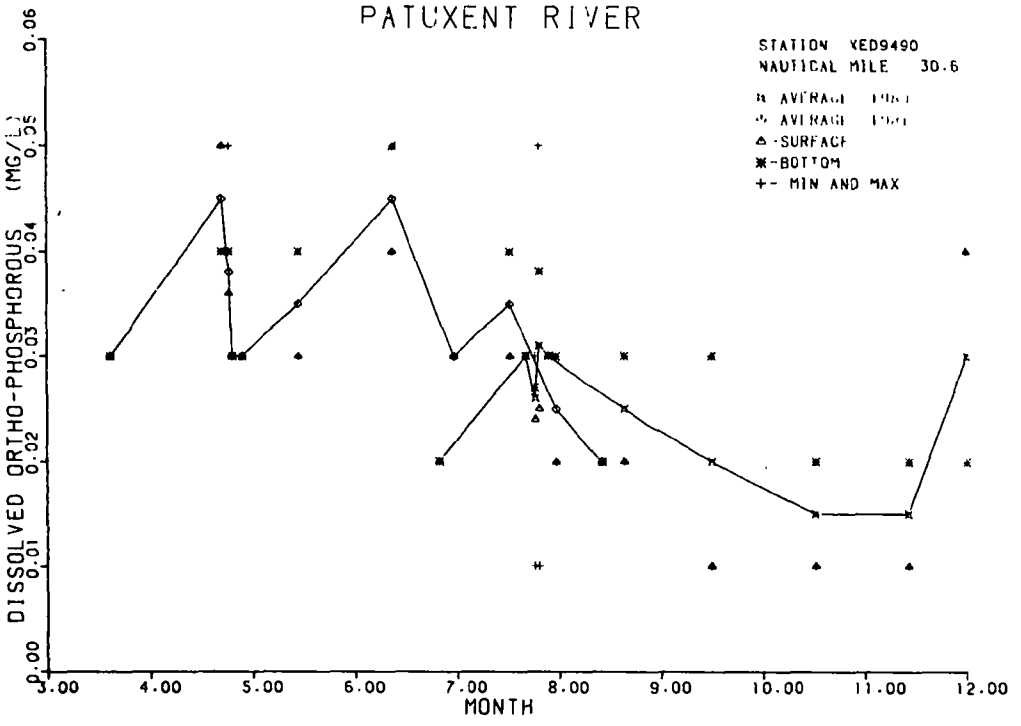


Figure 8-14 Temporal plots of dissolved ortho-phosphorus, 1980-1981.



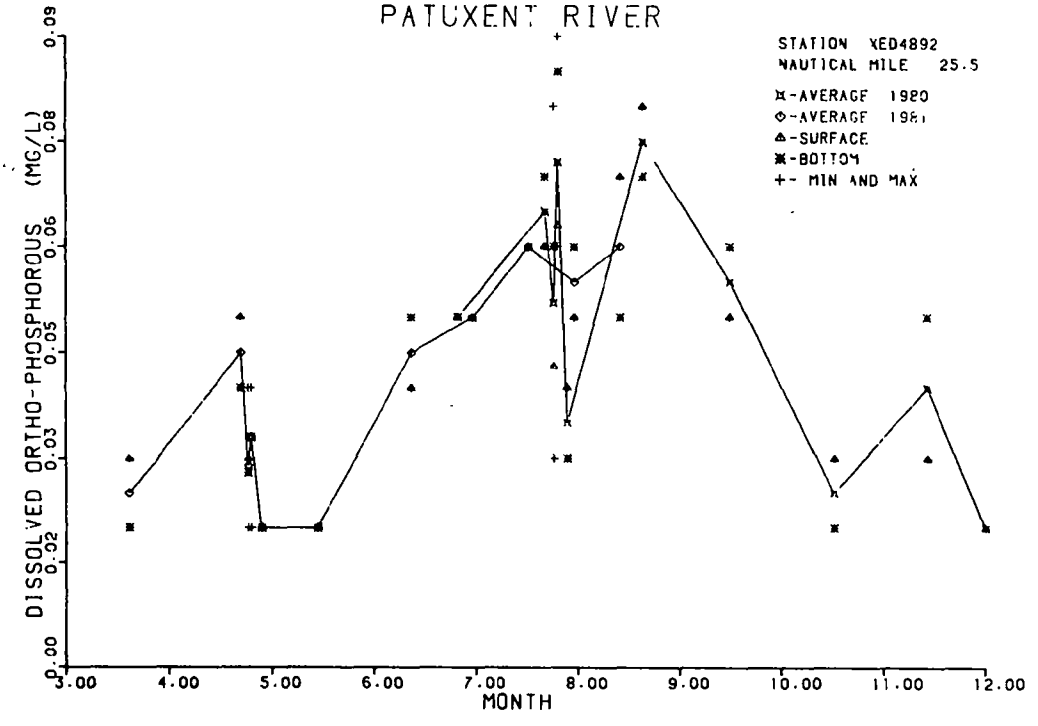
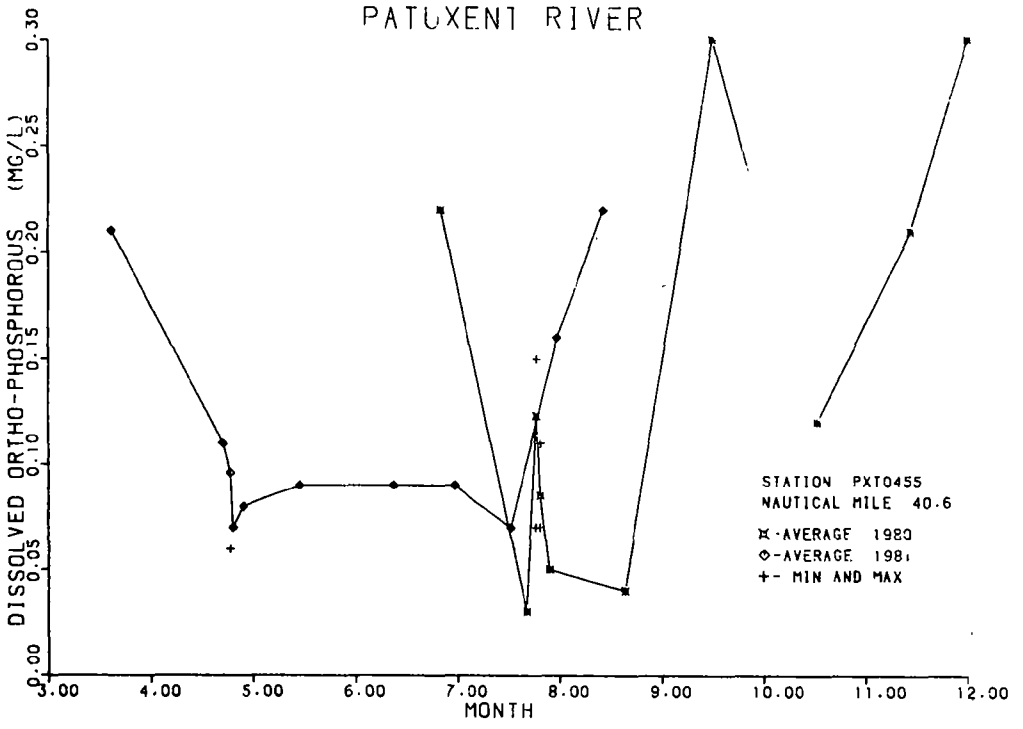


Figure 8-14 Temporal plots of dissolved ortho-phosphorus, 1980-1981.



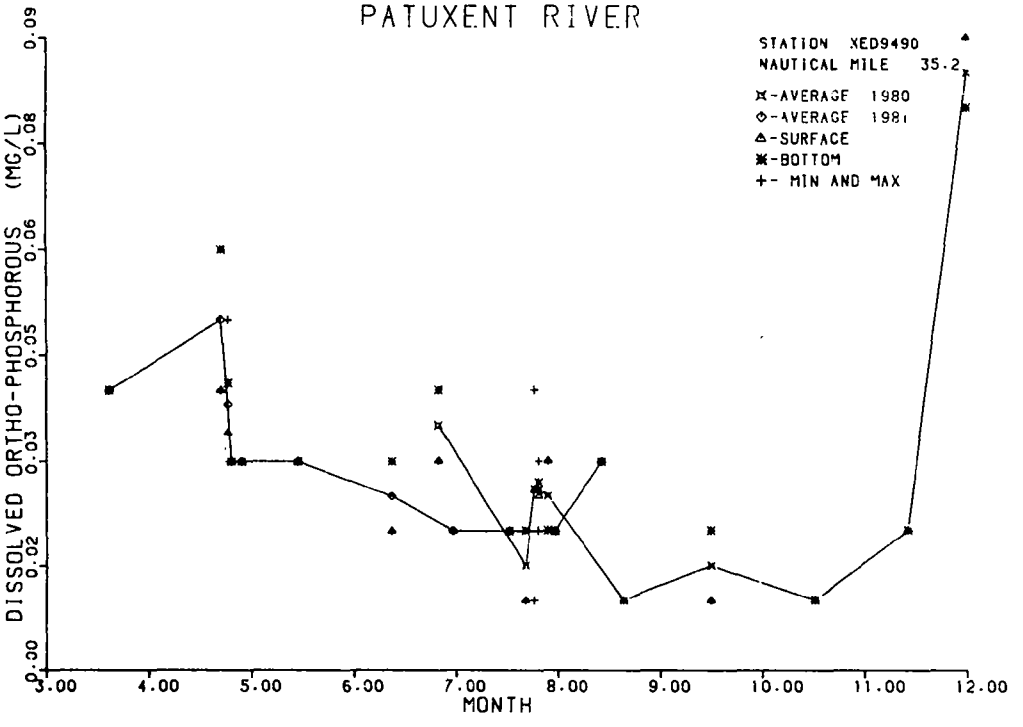
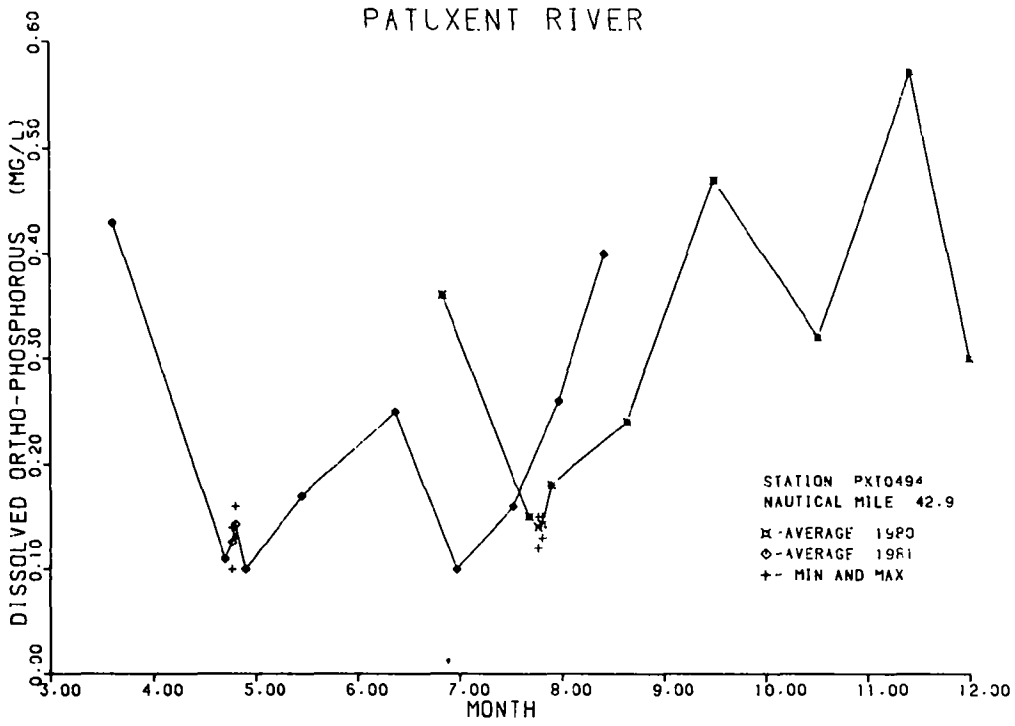


Figure 8-14 Temporal plots of dissolved ortho-phosphorus, 1980-1981.



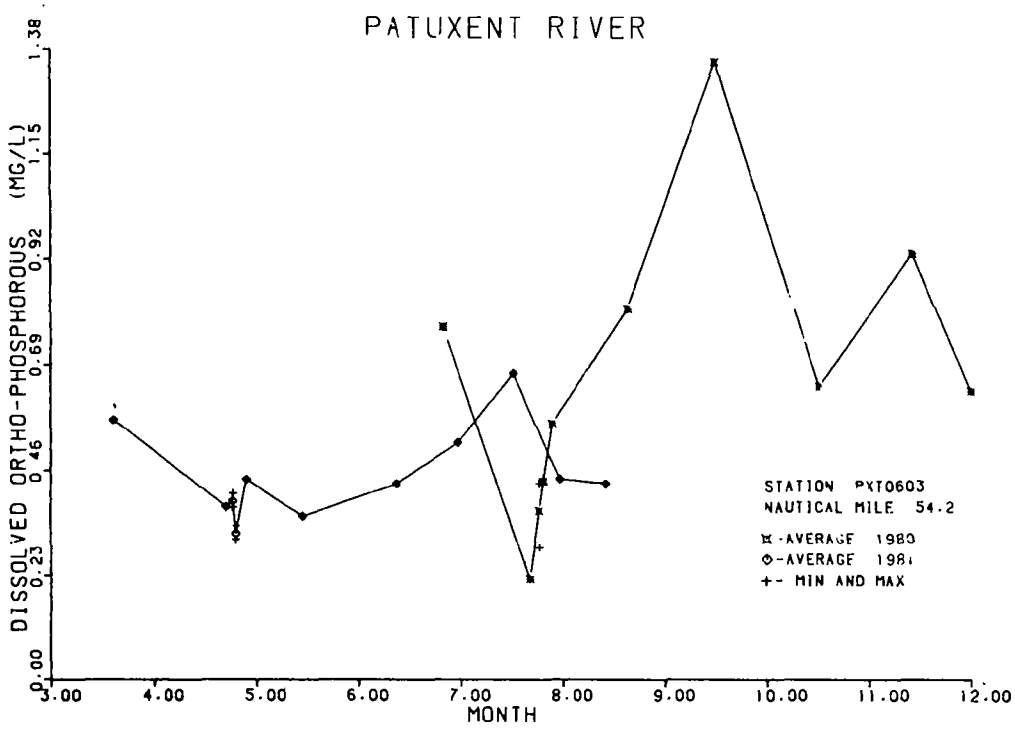
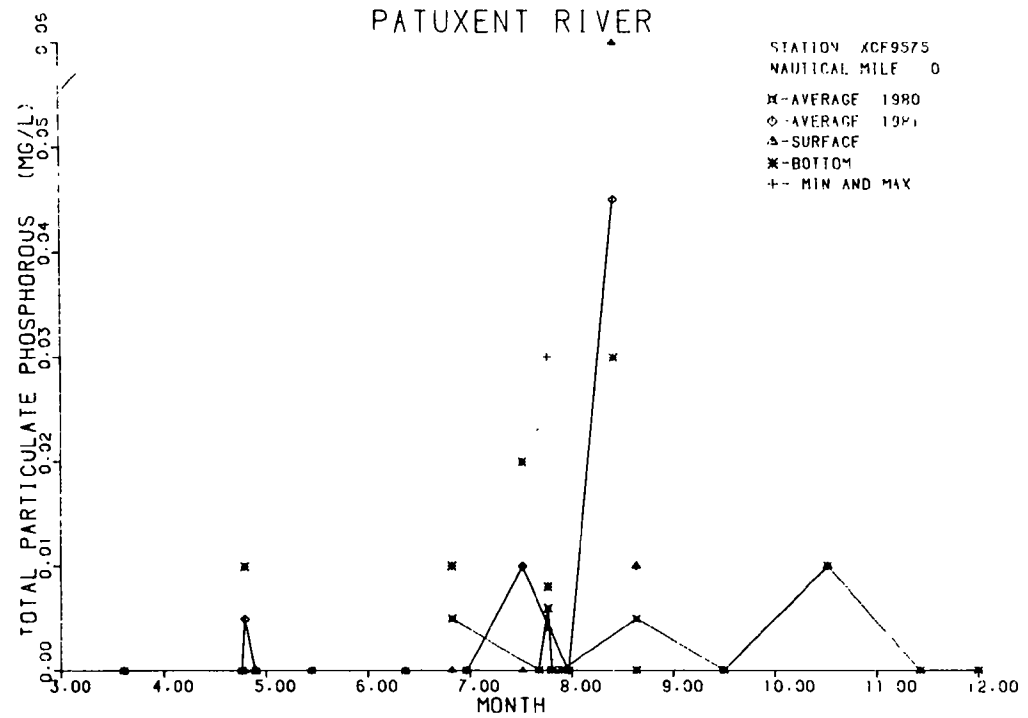


Figure 8-14 Temporal plots of dissolved ortho-phosphorus, 1980-1981.



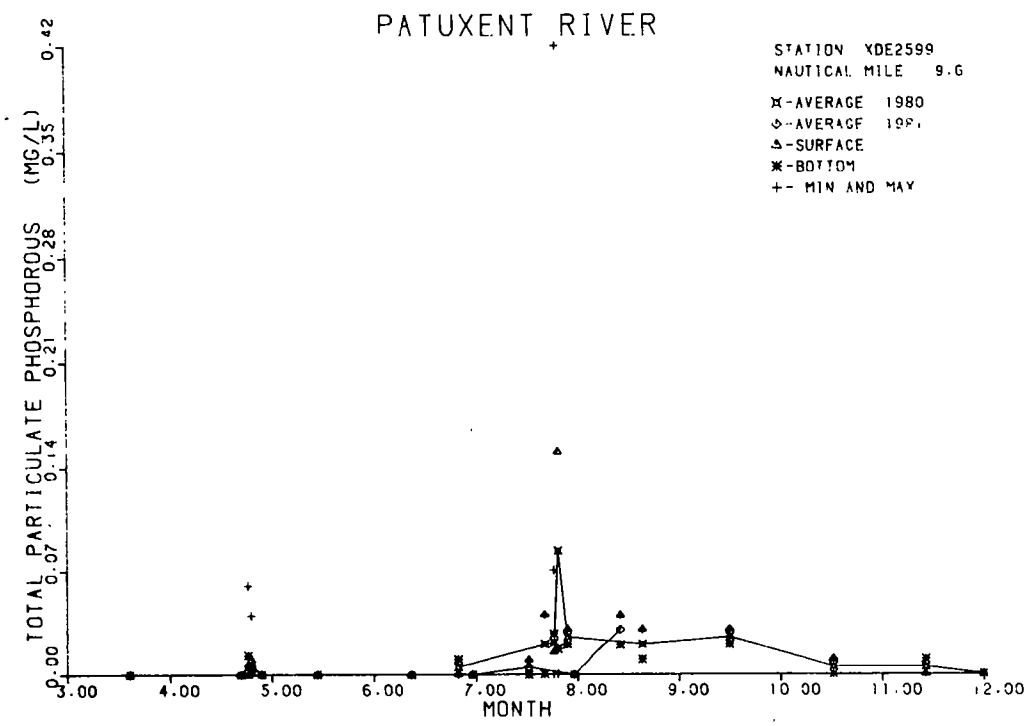
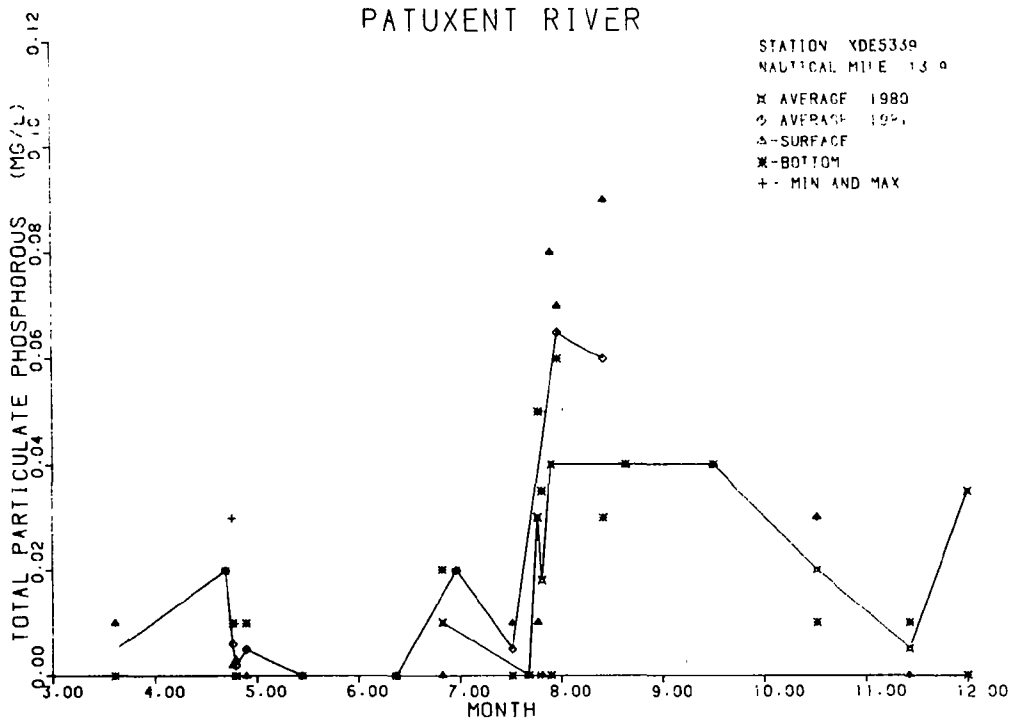


Figure 8-15 Temporal plot of particulate phosphorus, 1980-1981.



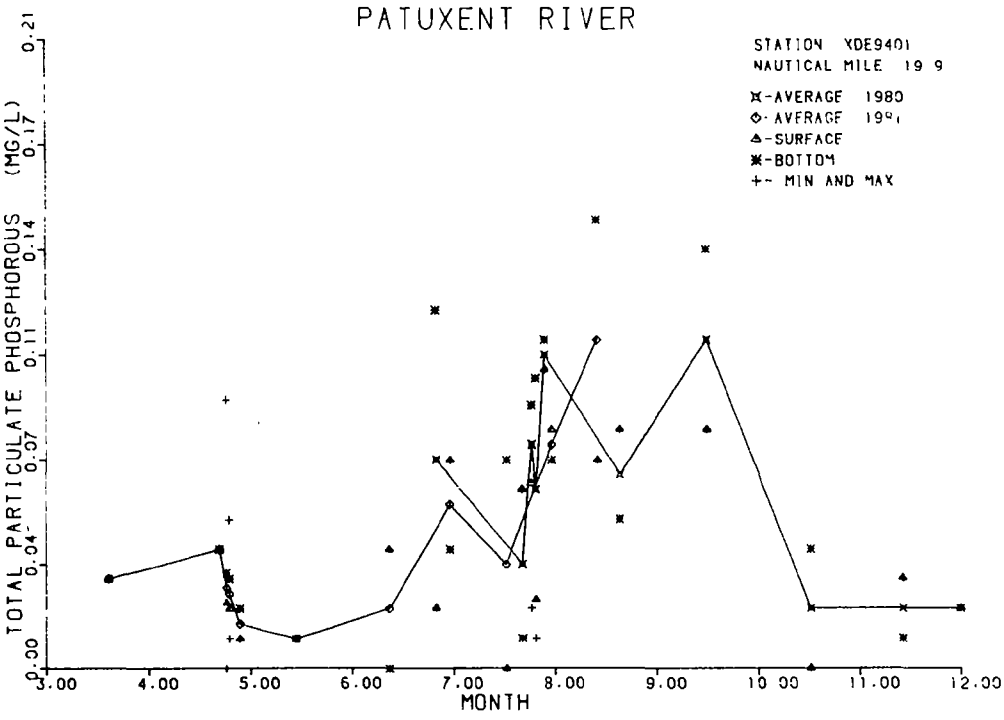
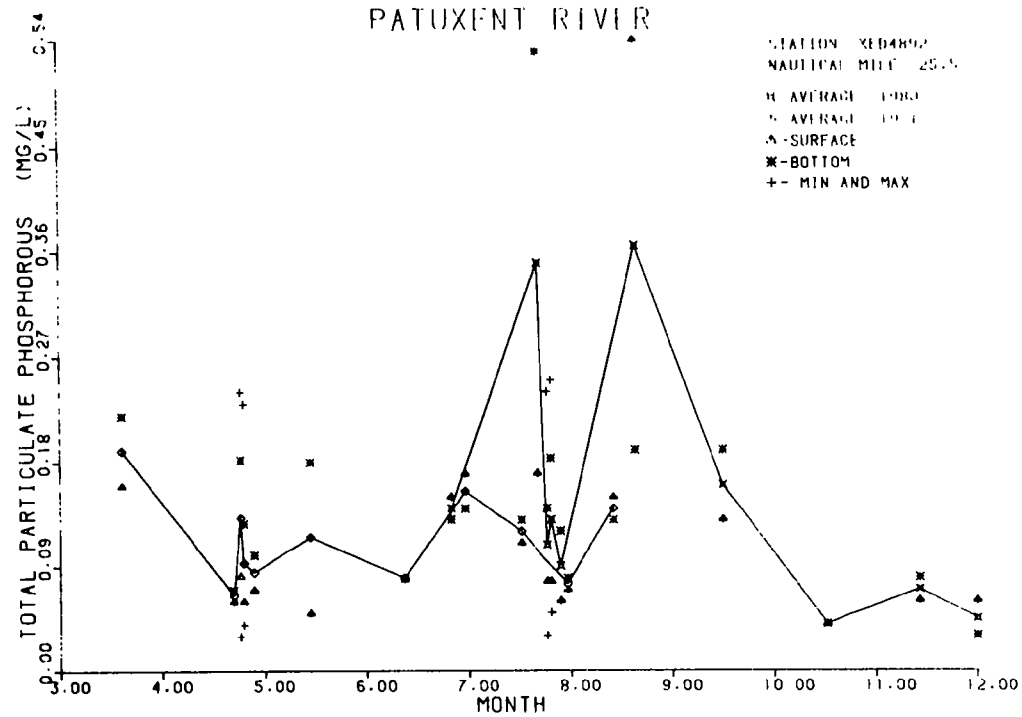


Figure 8-15 Temporal plot of particulate phosphorus, 1980-1981.



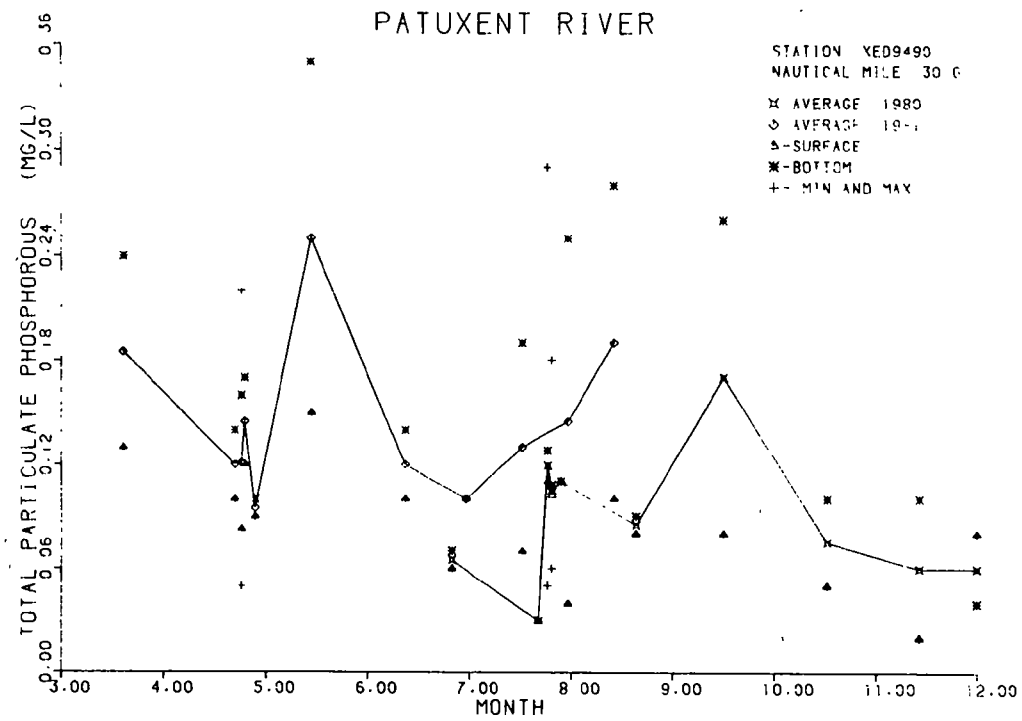
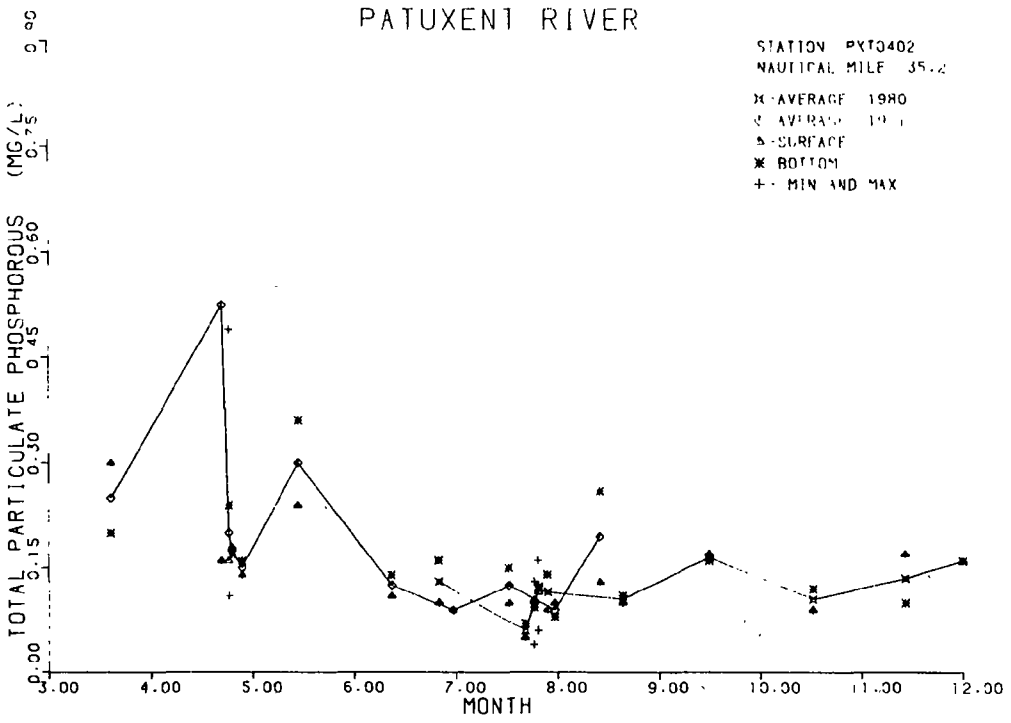


Figure 8-15 Temporal plot of particulate phosphorus, 1980-1981.



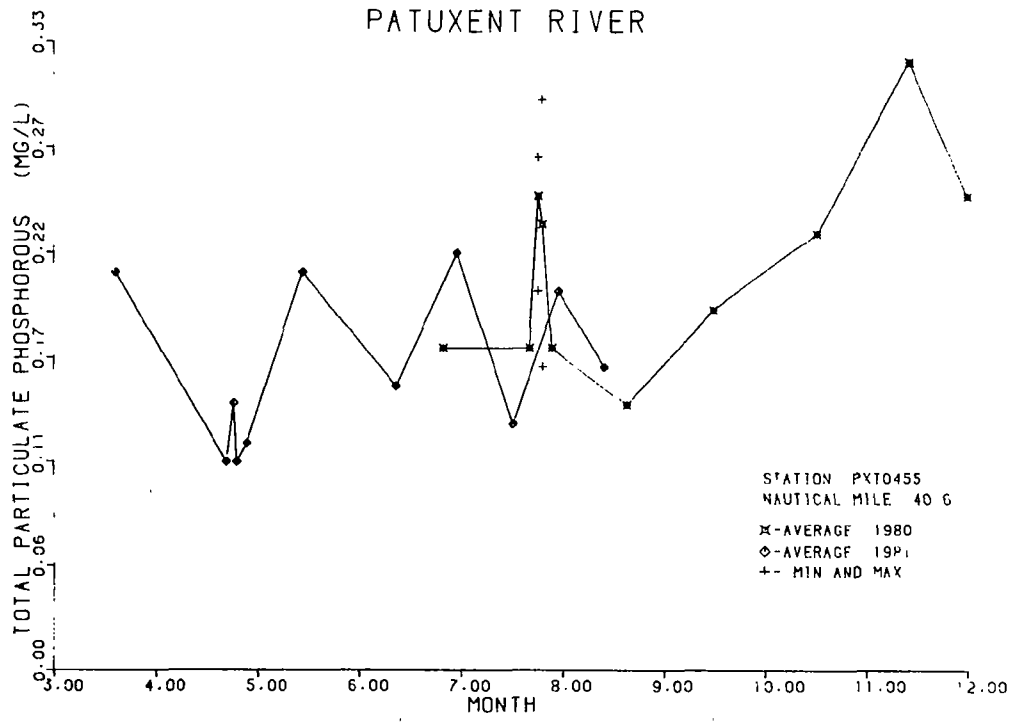
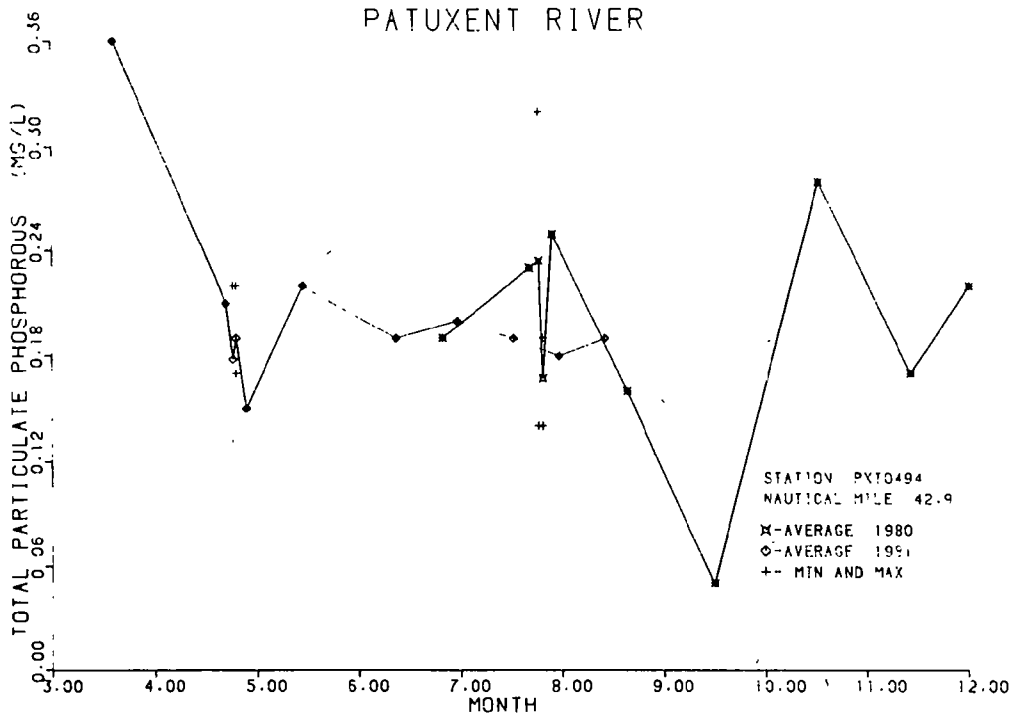


Figure 8-15 Temporal plot of particulate phosphorus, 1980-1981.



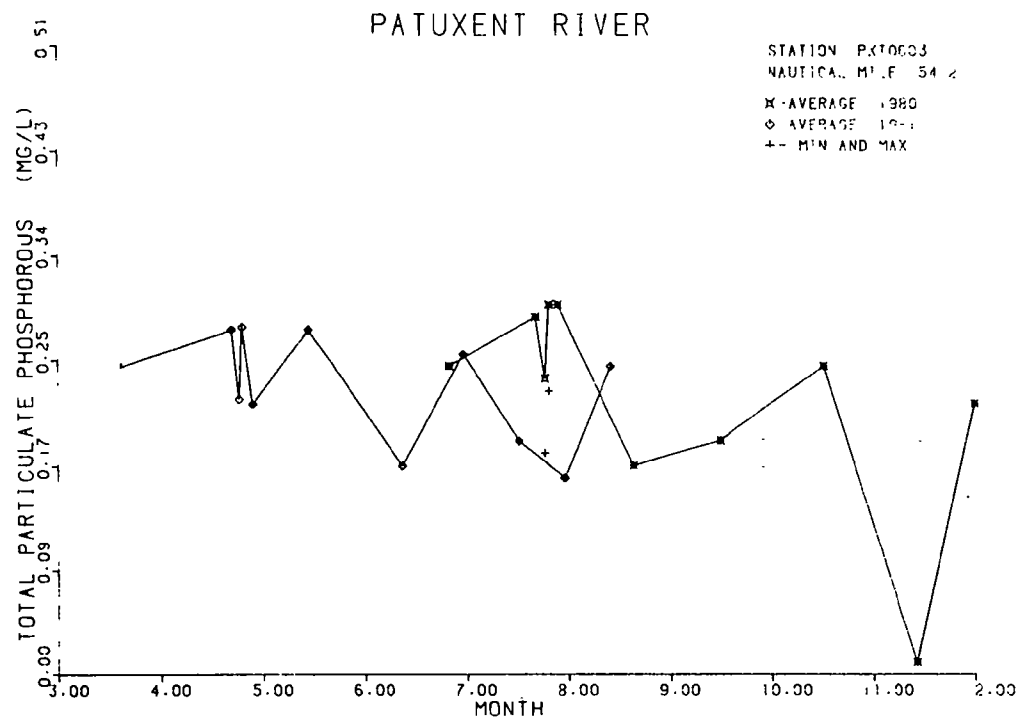
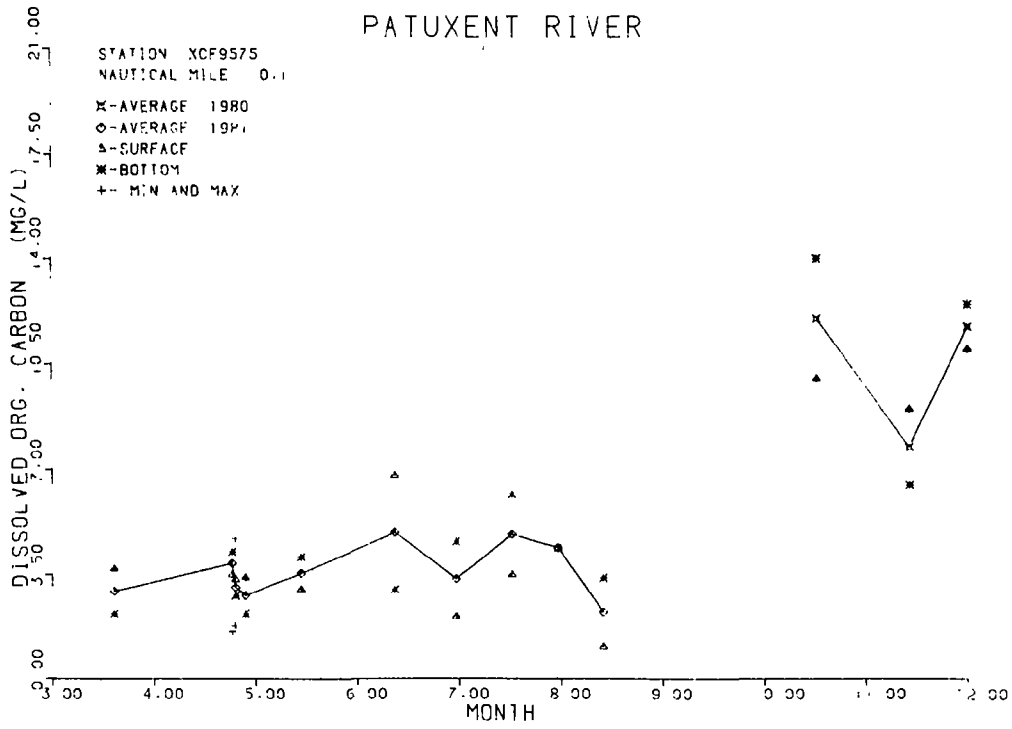


Figure 8-15Temporal plot of particulate phosphorus, 1980-1981.



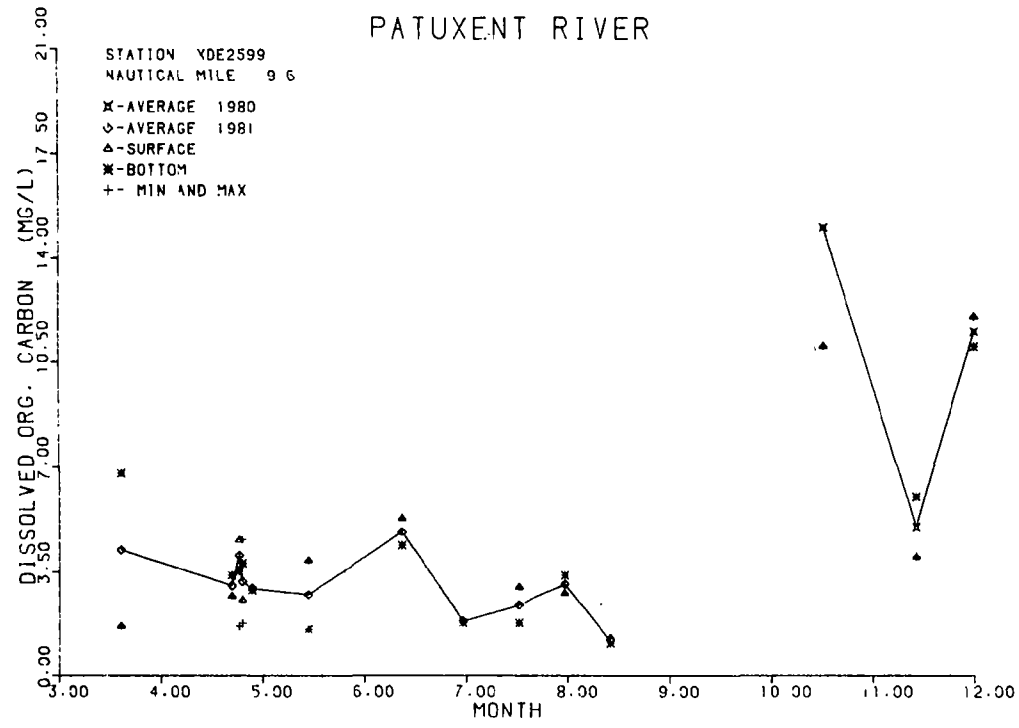
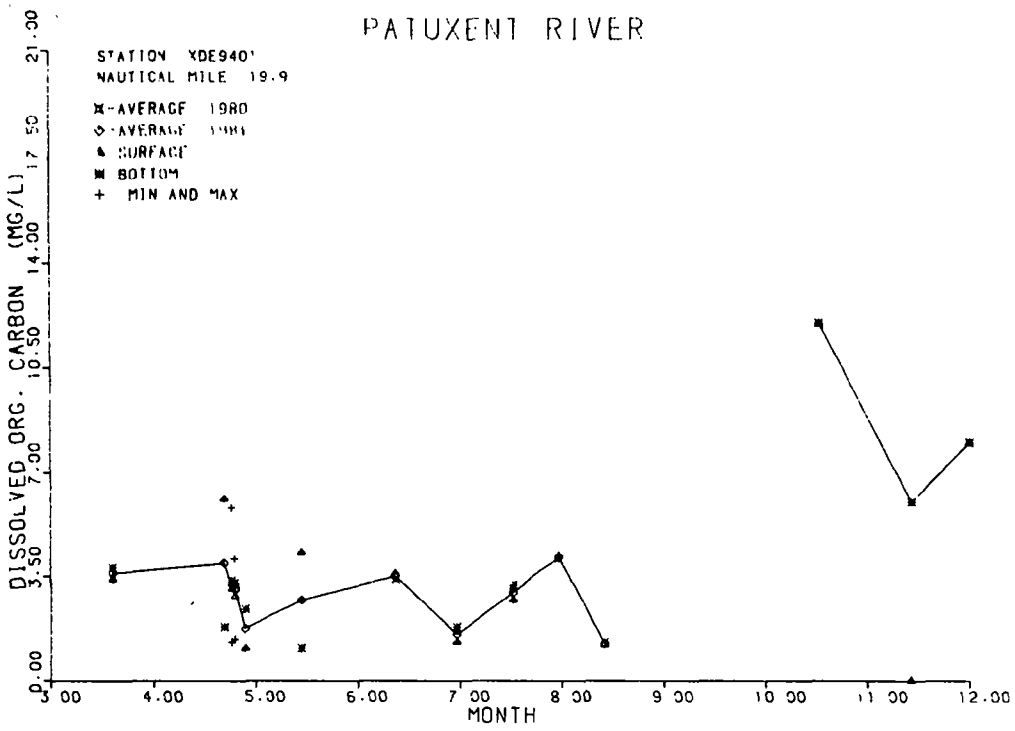


Figure 8-16 Temporal plots of dissolved organic carbon, 1980-1981.



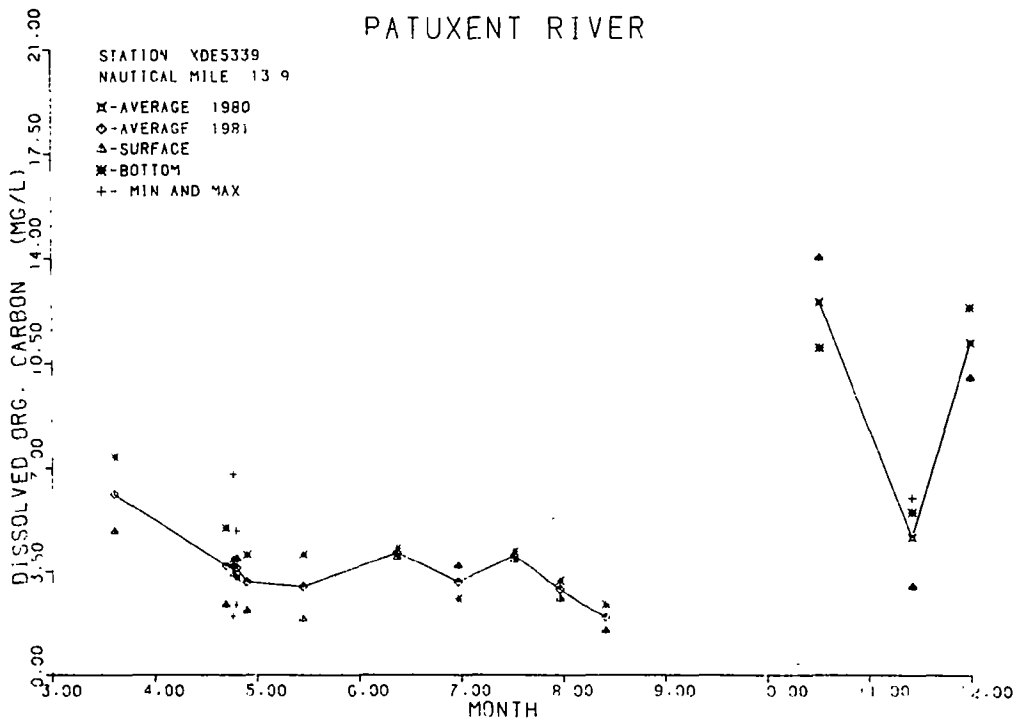
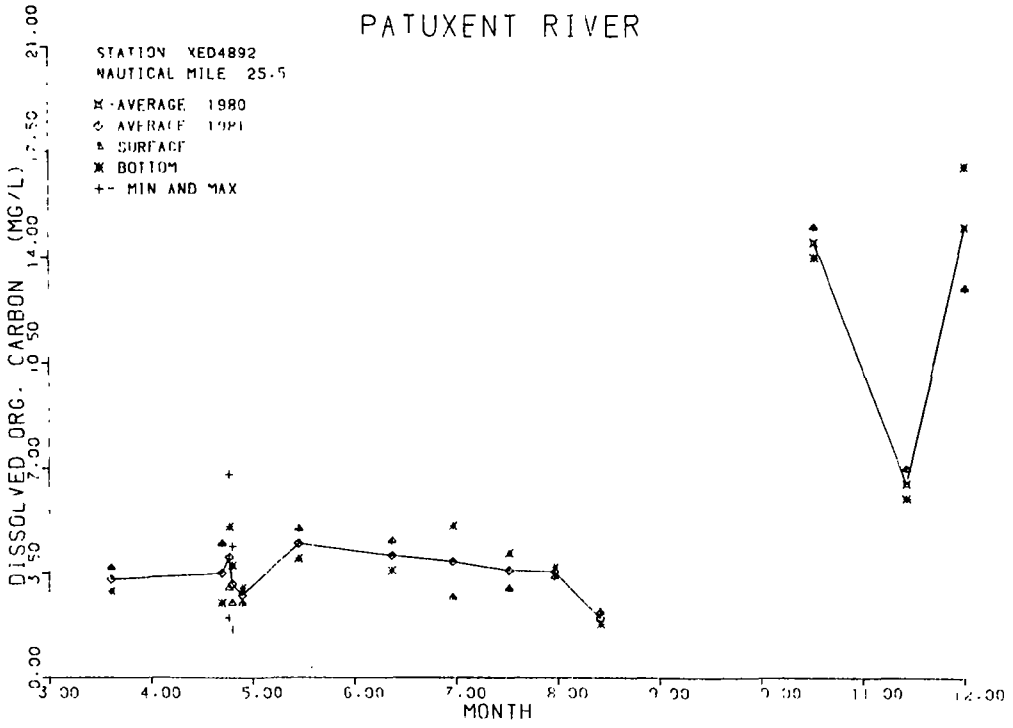


Figure 8-16 Temporal plots of dissolved organic carbon, 1980-1981.



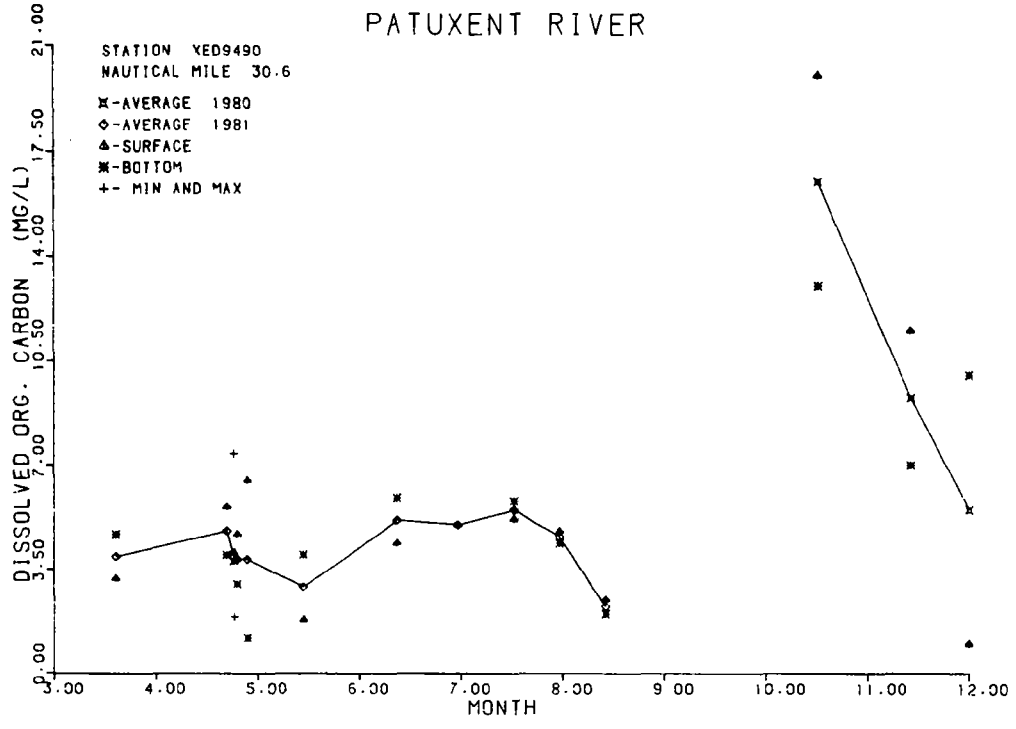
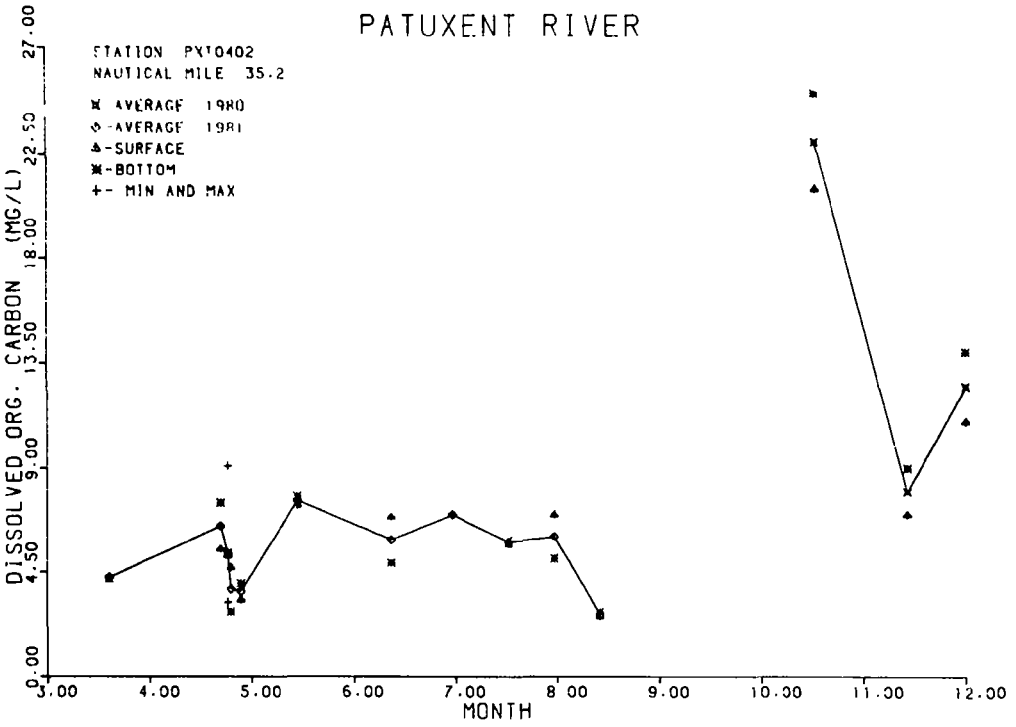


Figure 8-16Temporal plots of dissolved organic carbon, 1980-1981.



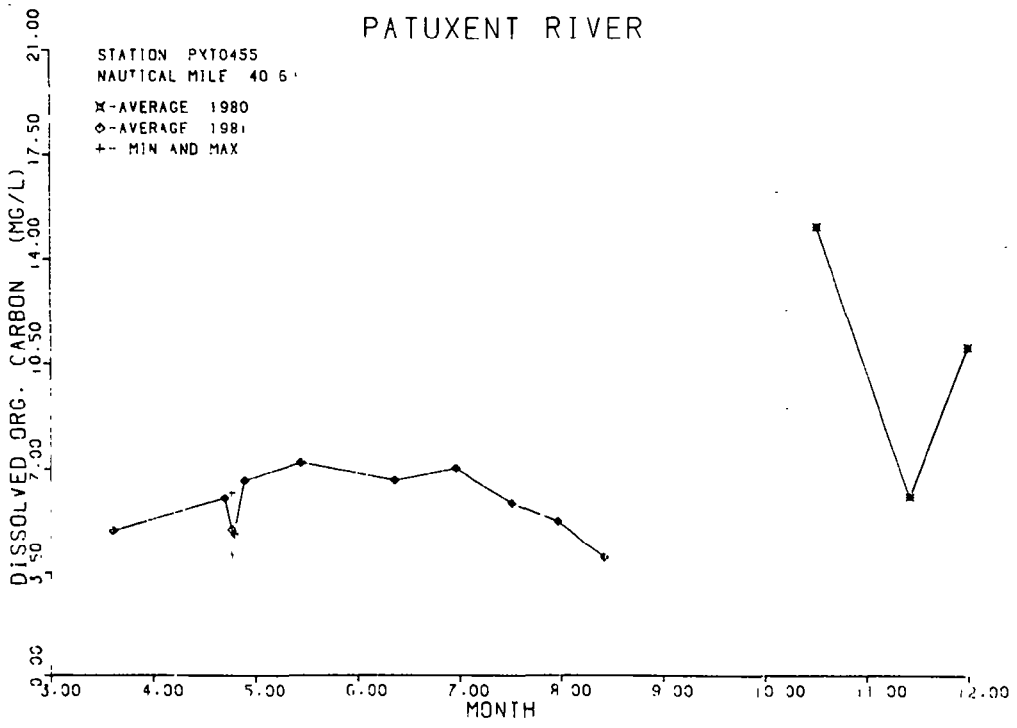
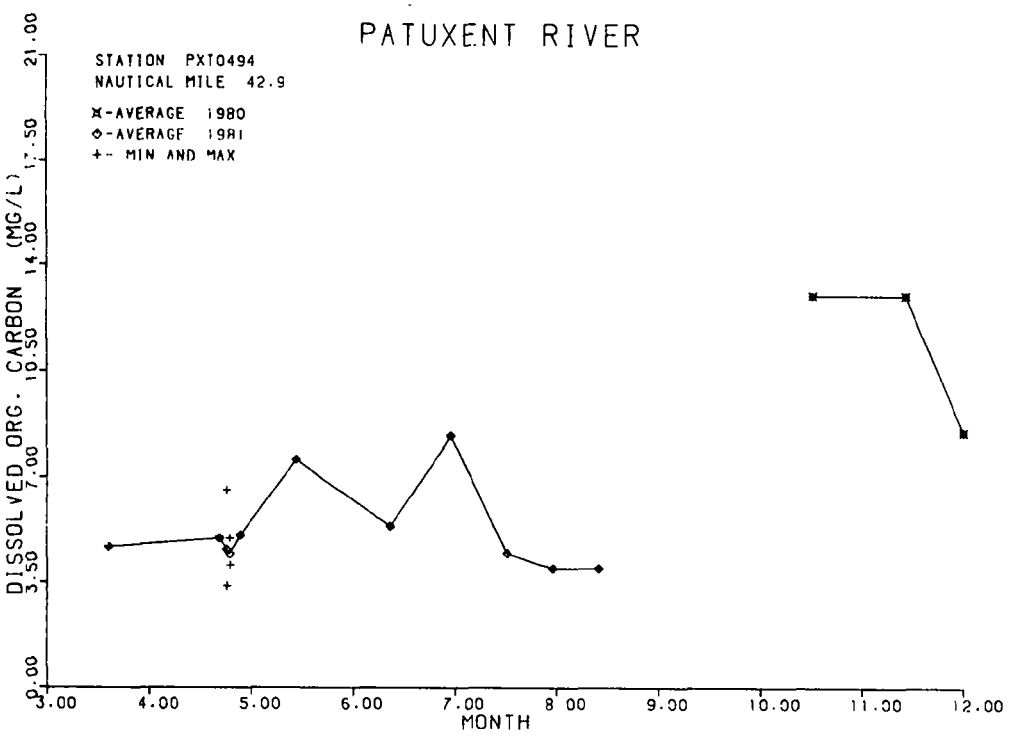


Figure 8-16 Temporal plots of dissolved organic carbon, 1980-1981.



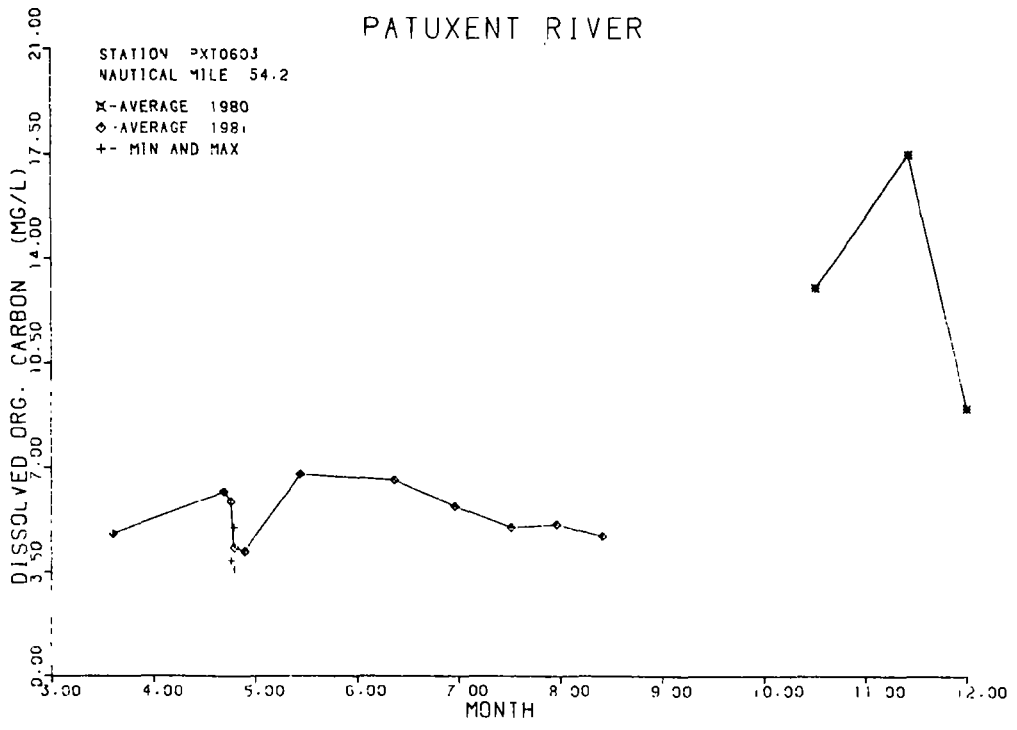
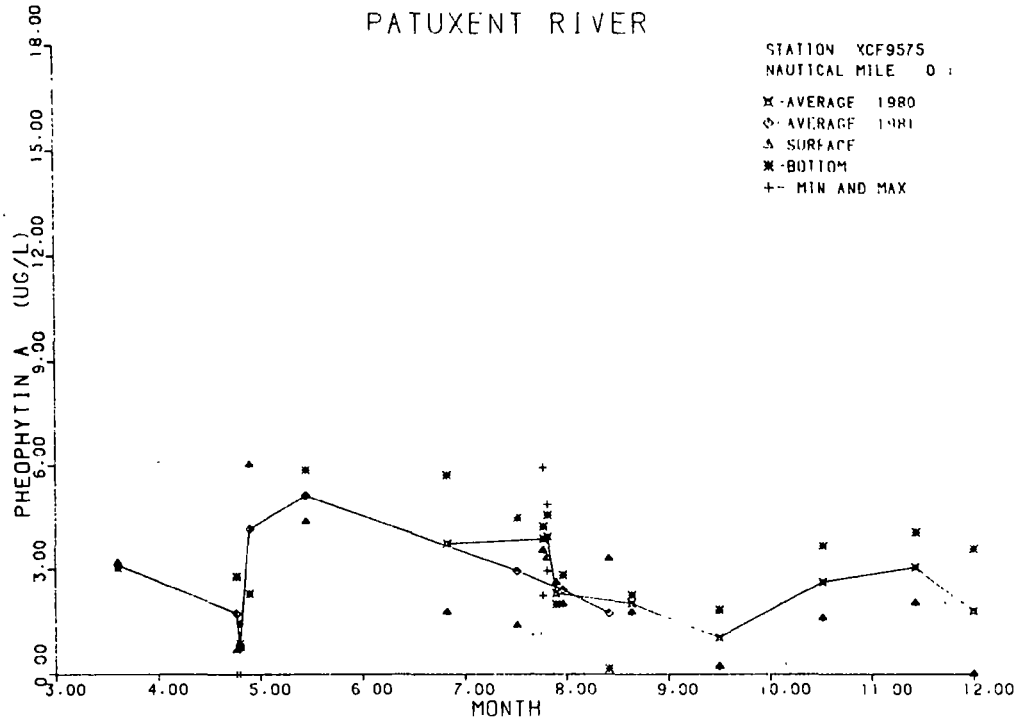


Figure 8-16 Temporal plots of dissolved organic carbon, 1980-1981.



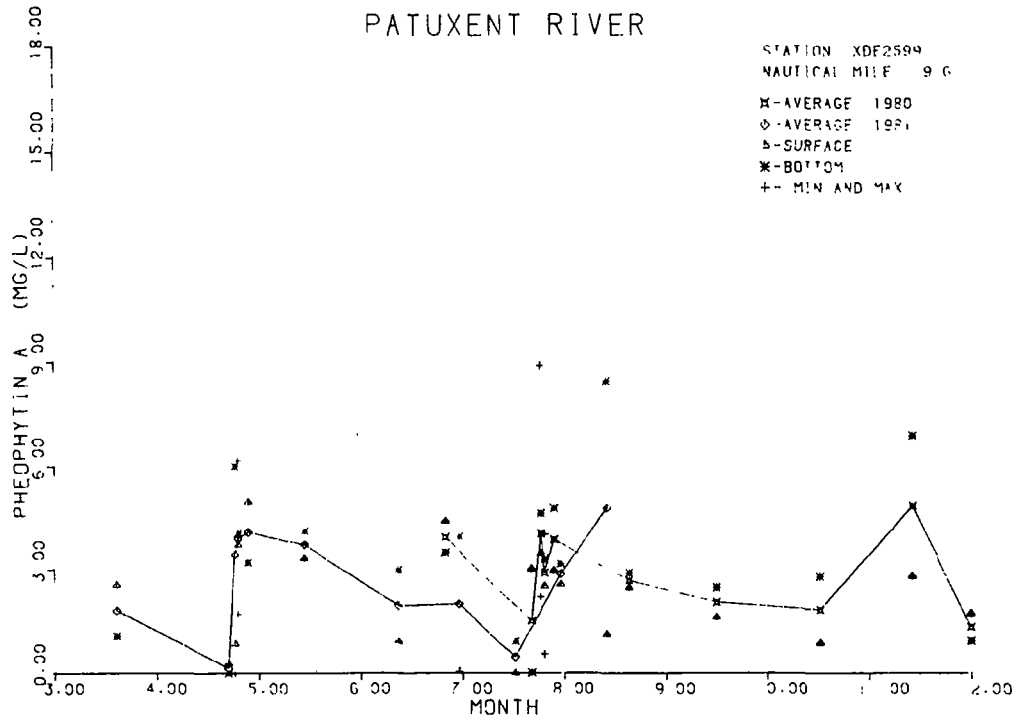
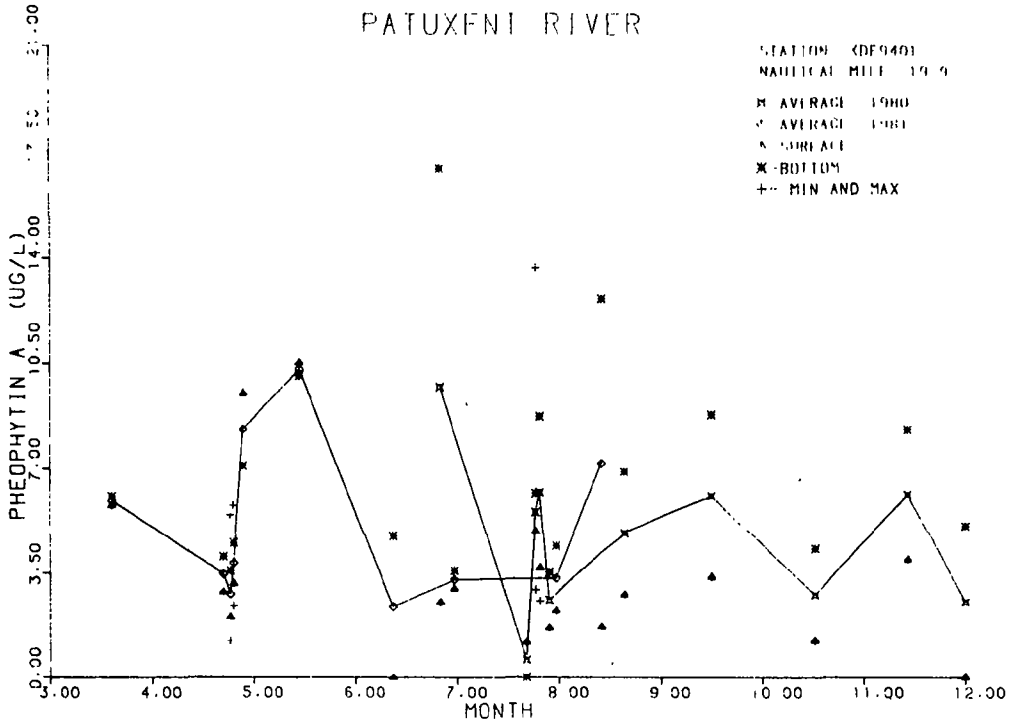


Figure 8-17 Temporal plot of pheophytin-a, 1980, 1981.



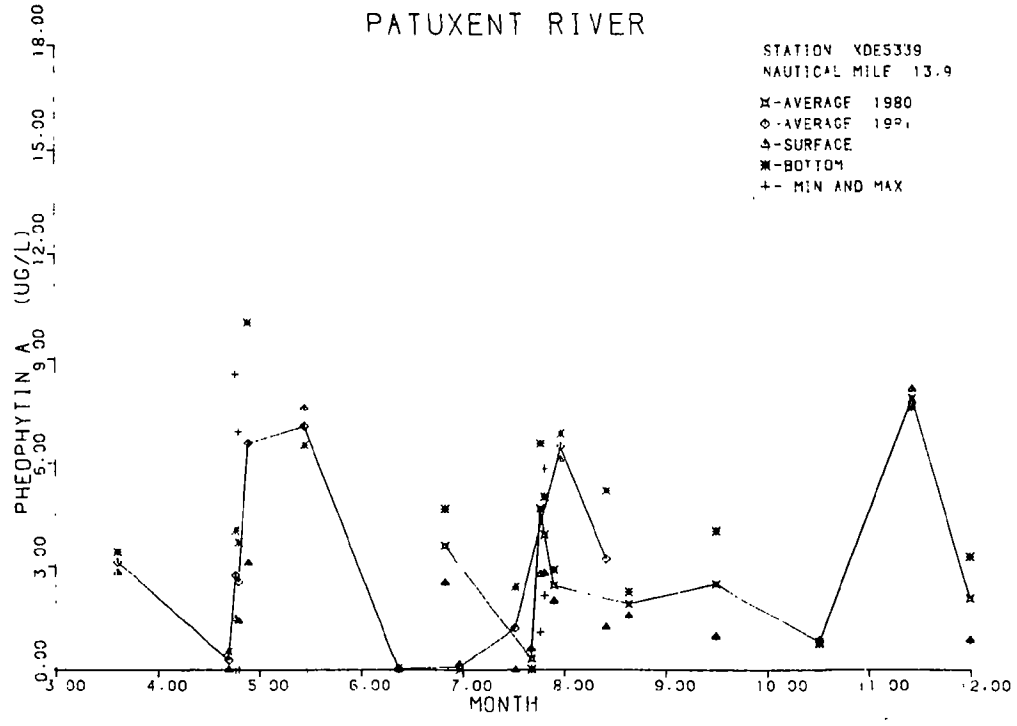
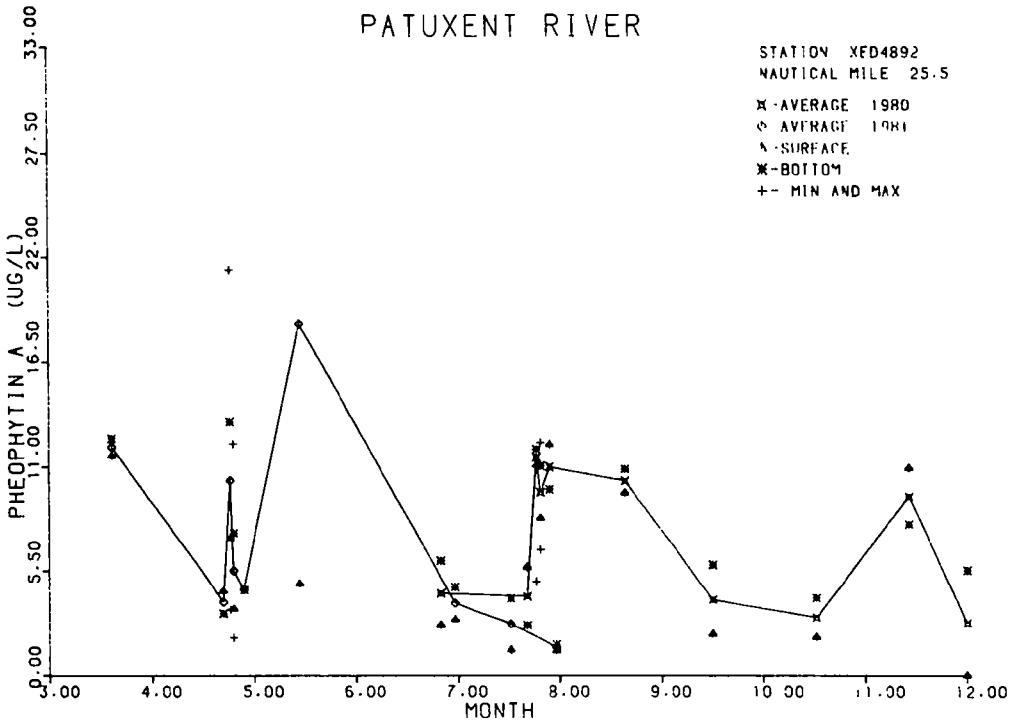


Figure 8-17 Temporal plot of pheophytin-a, 1980, 1981.



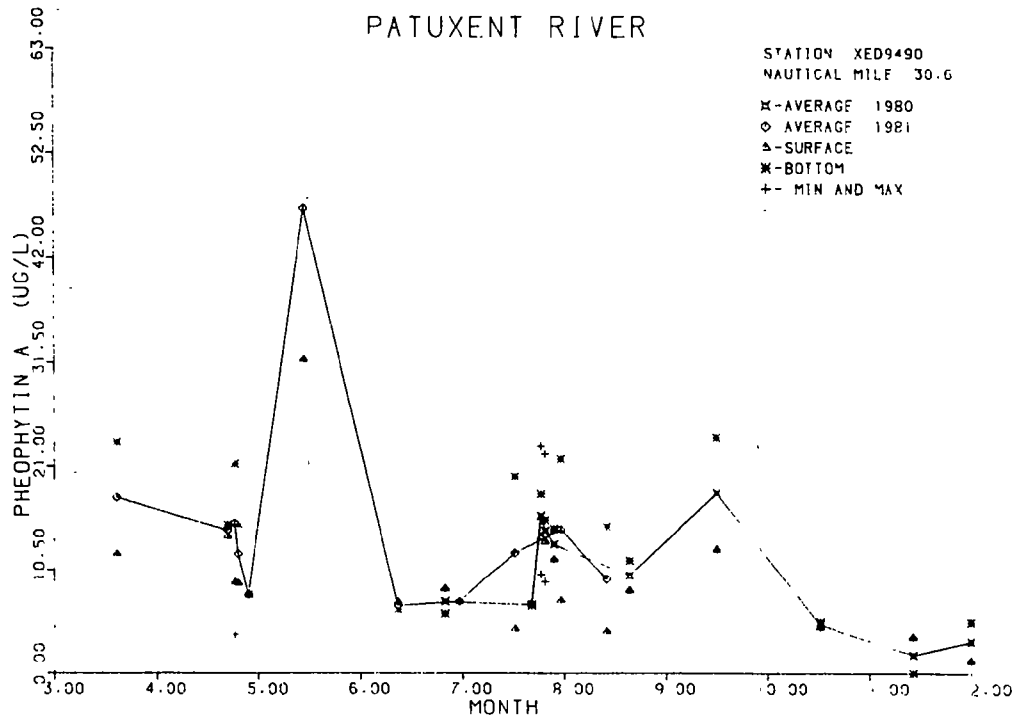
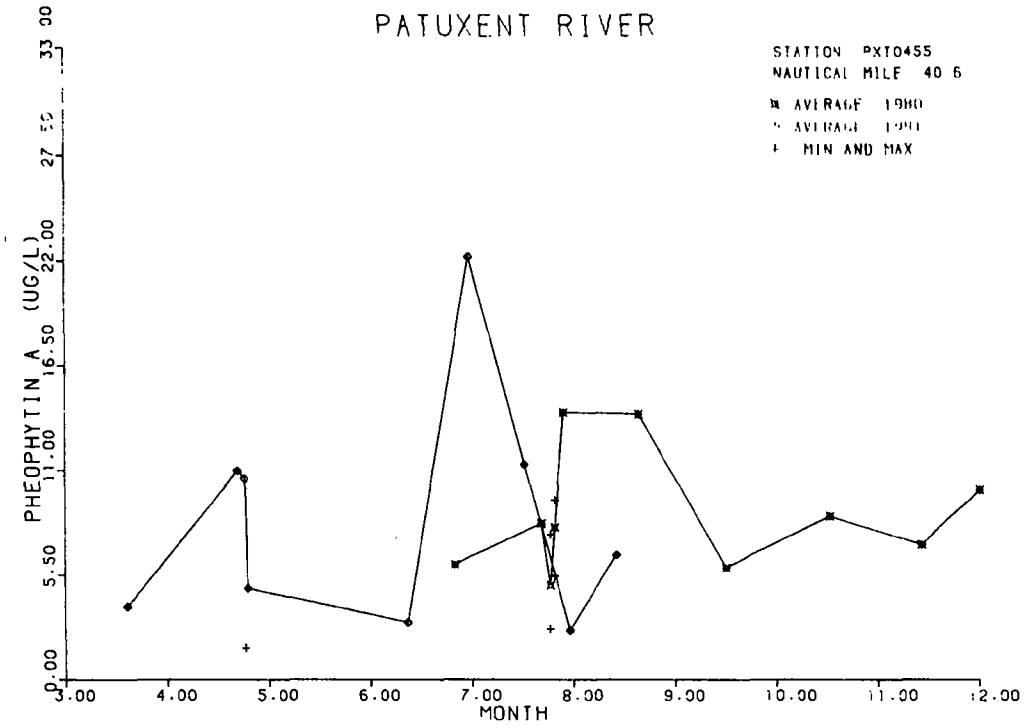


Figure 8-17 Temporal plot of pheophytin-a, 1980, 1981.



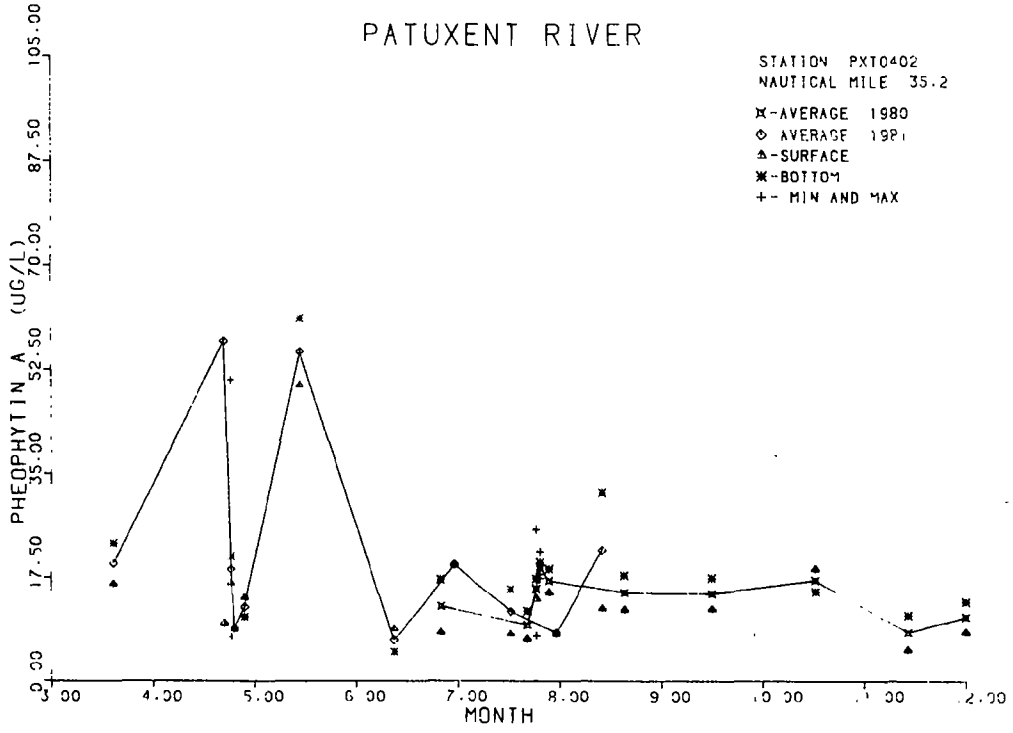
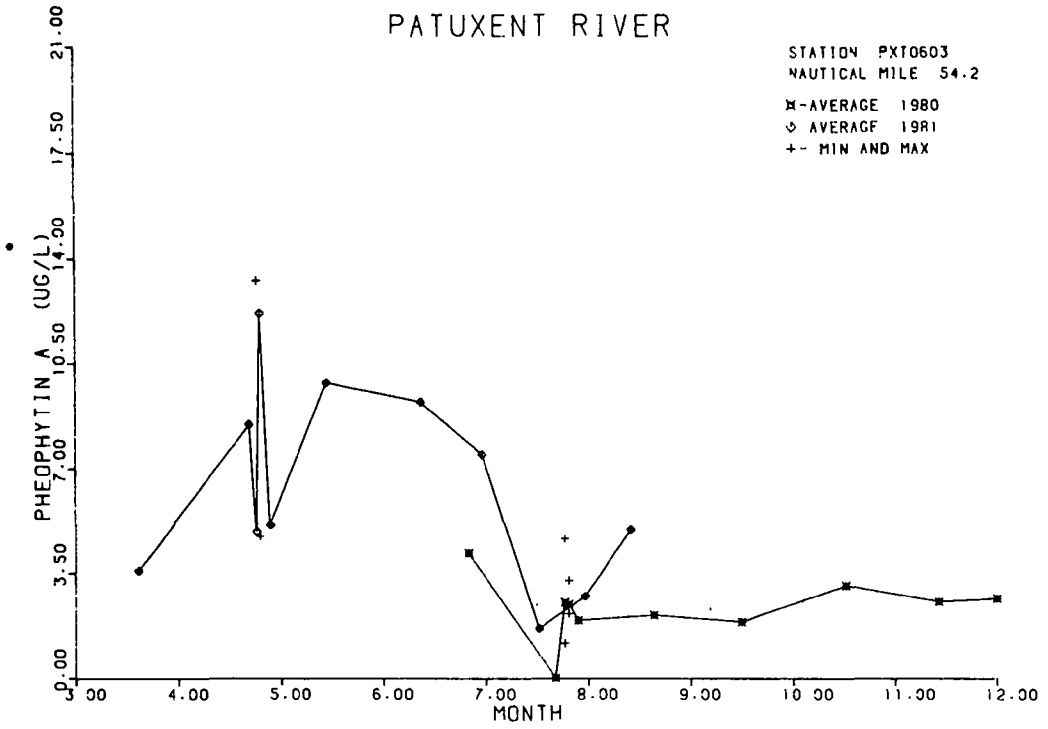


Figure 8-17 Temporal plot of pheophytin-a, 1980, 1981.



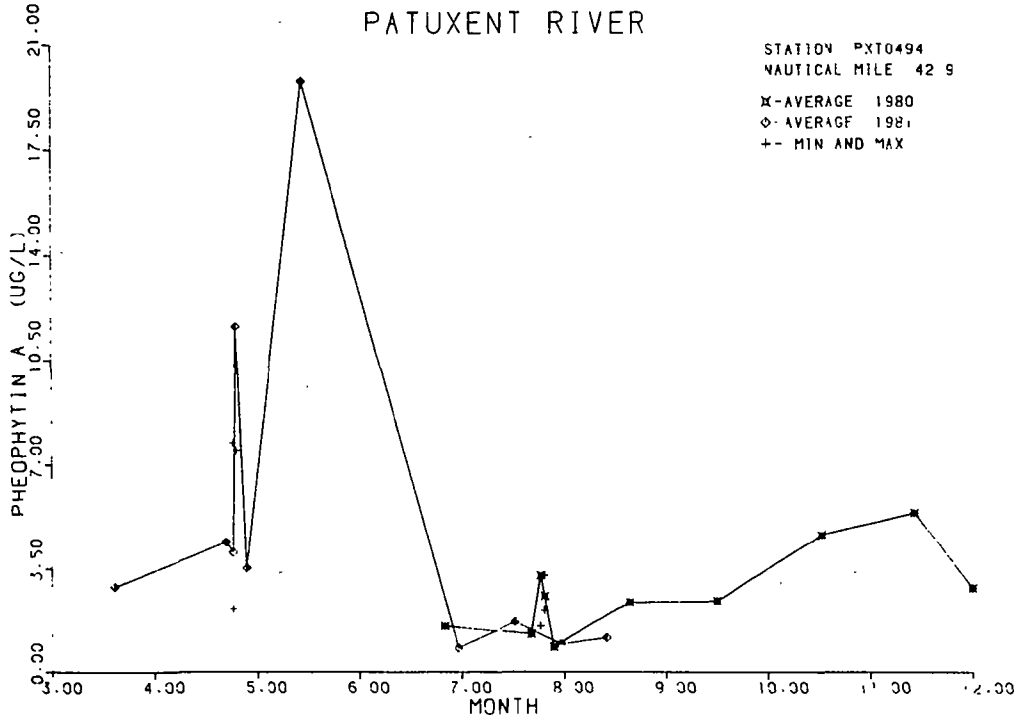
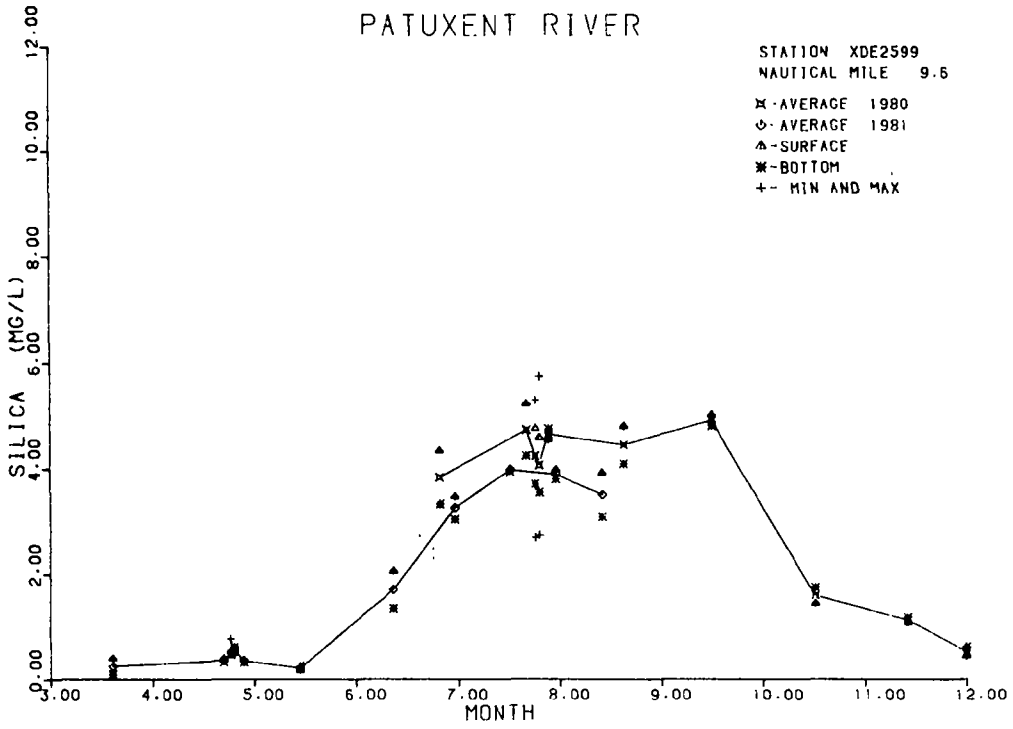


Figure 8-17 Temporal plot of pheophytin-a, 1980, 1981.



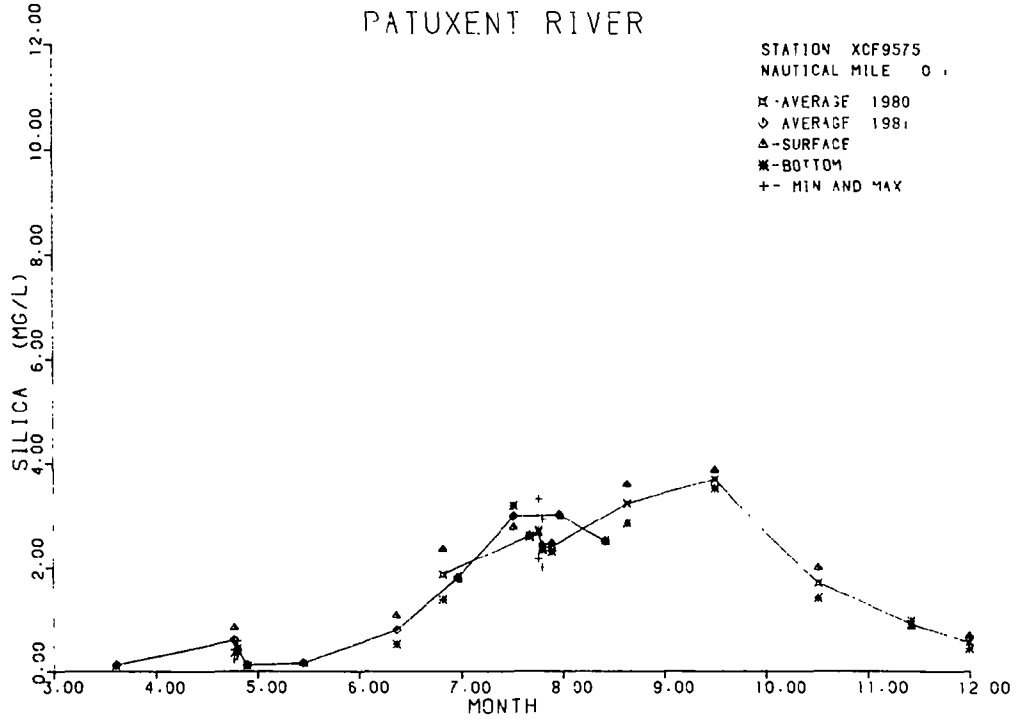
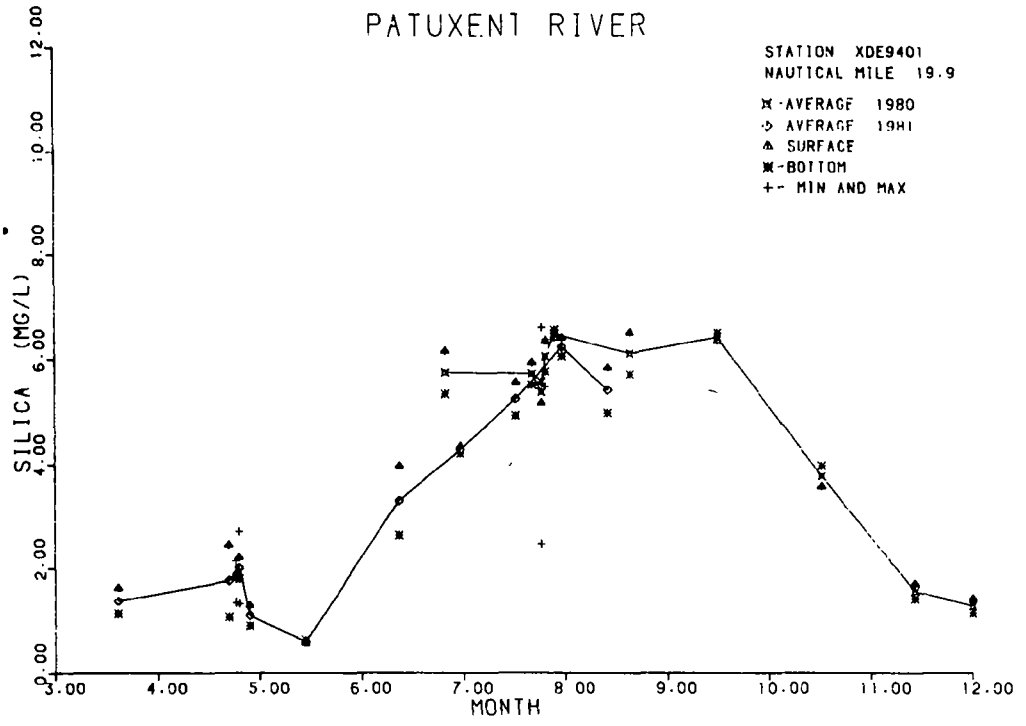


Figure 8-18 Temporal plots of silica.



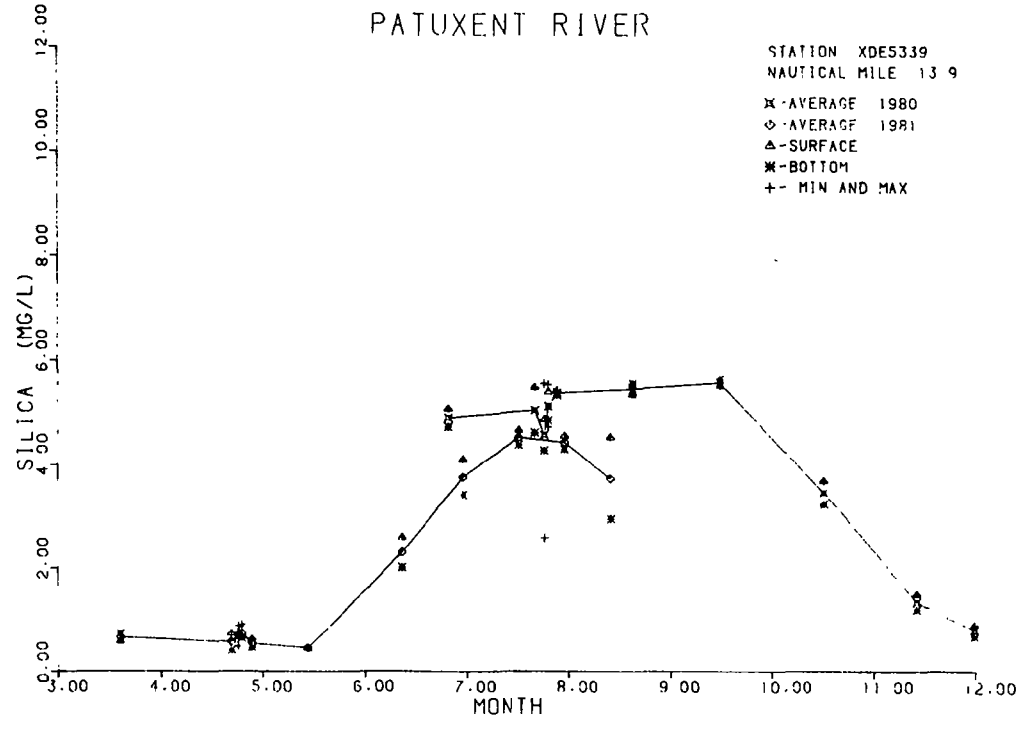
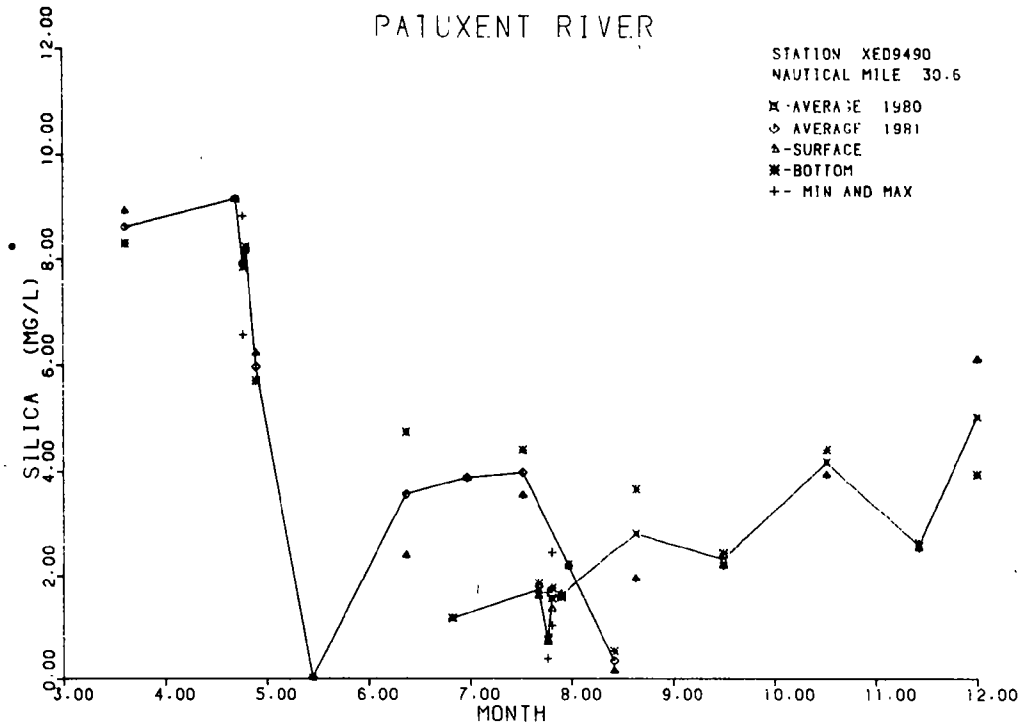


Figure 8-18 Temporal plots of silica.



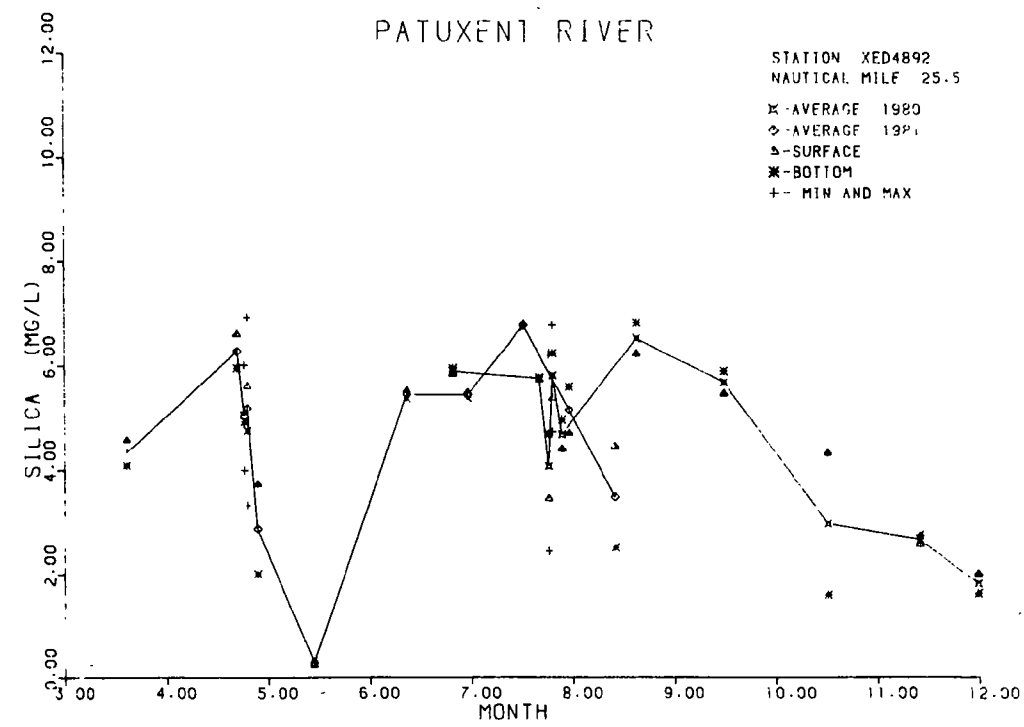
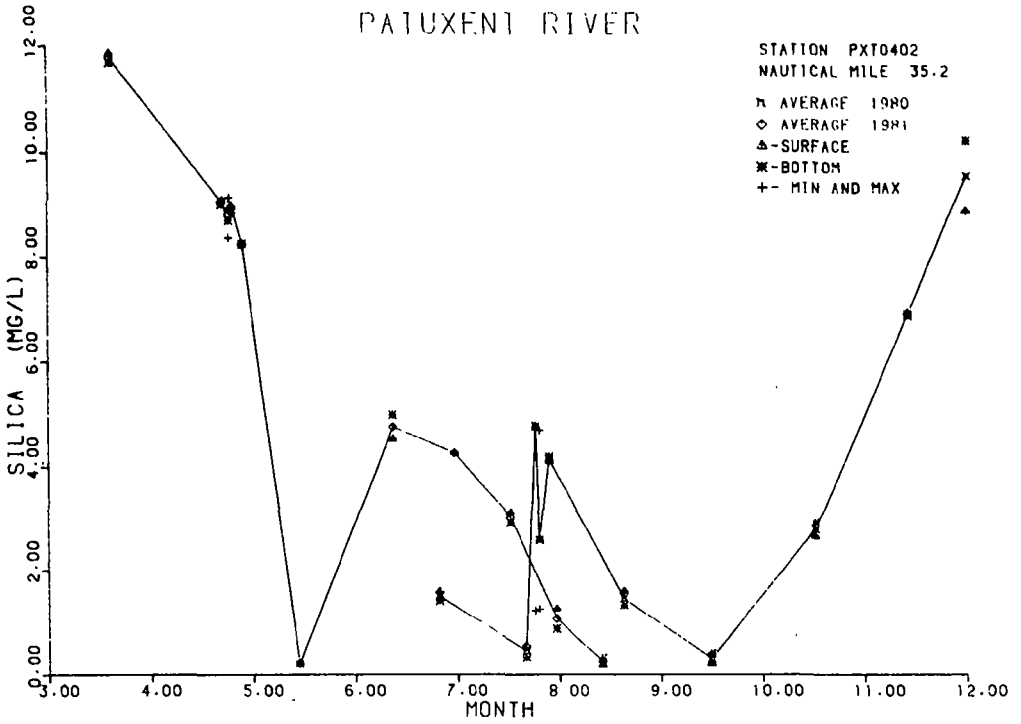


Figure 8-18 Temporal plots of silica.



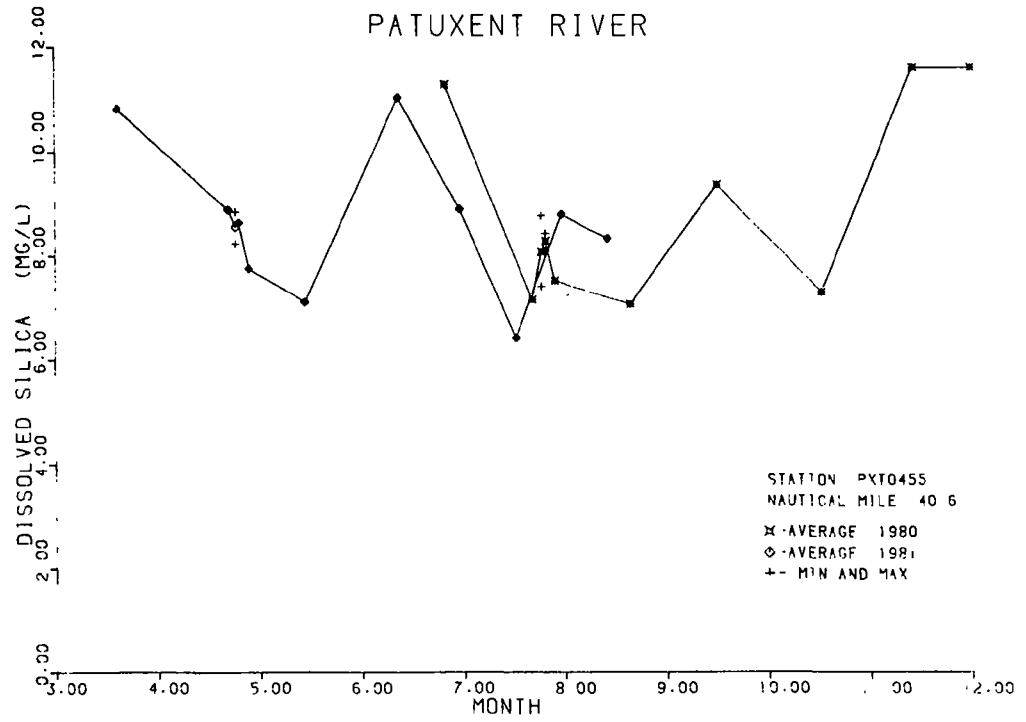


Figure 8-18 Temporal plots of silica.

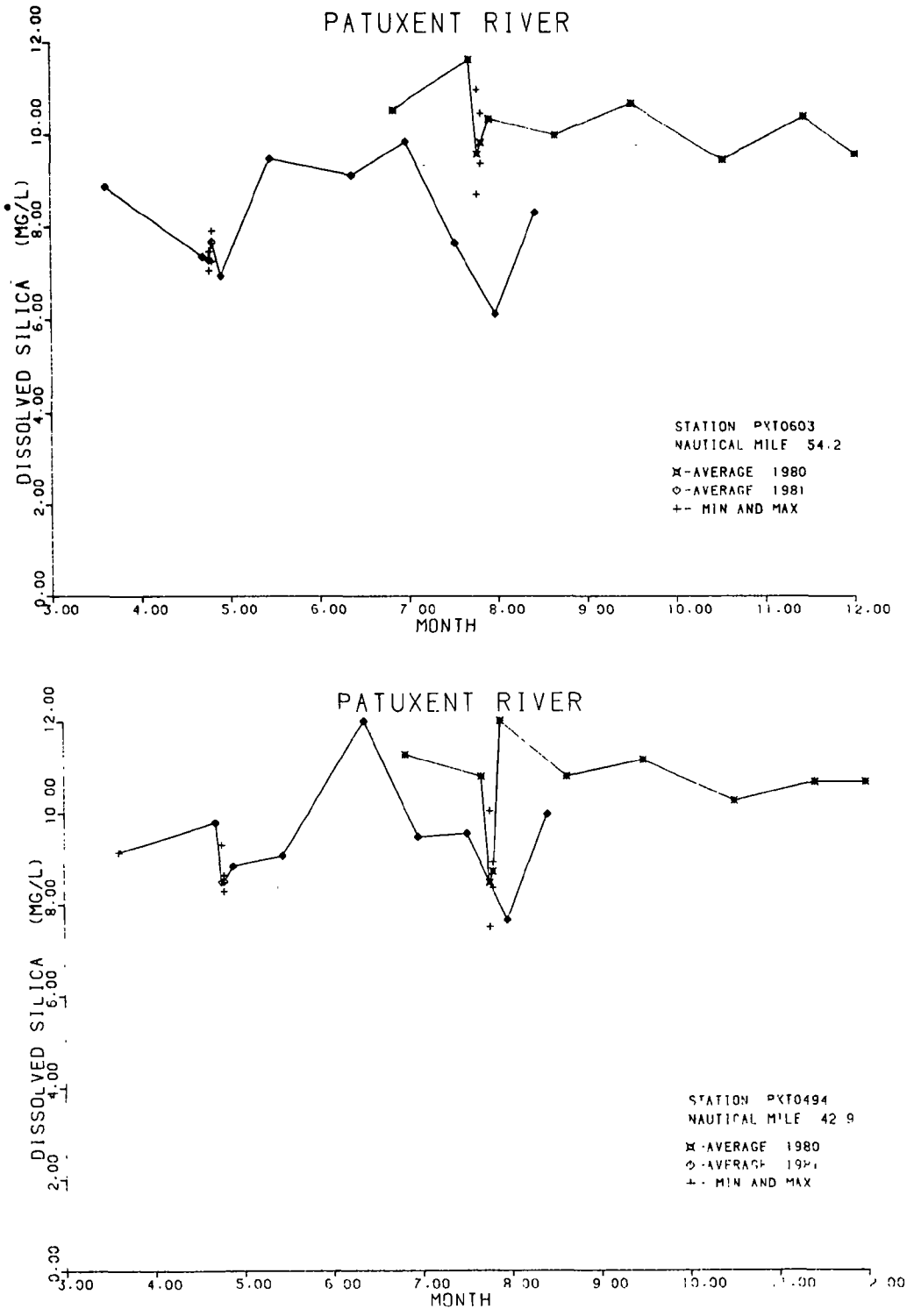
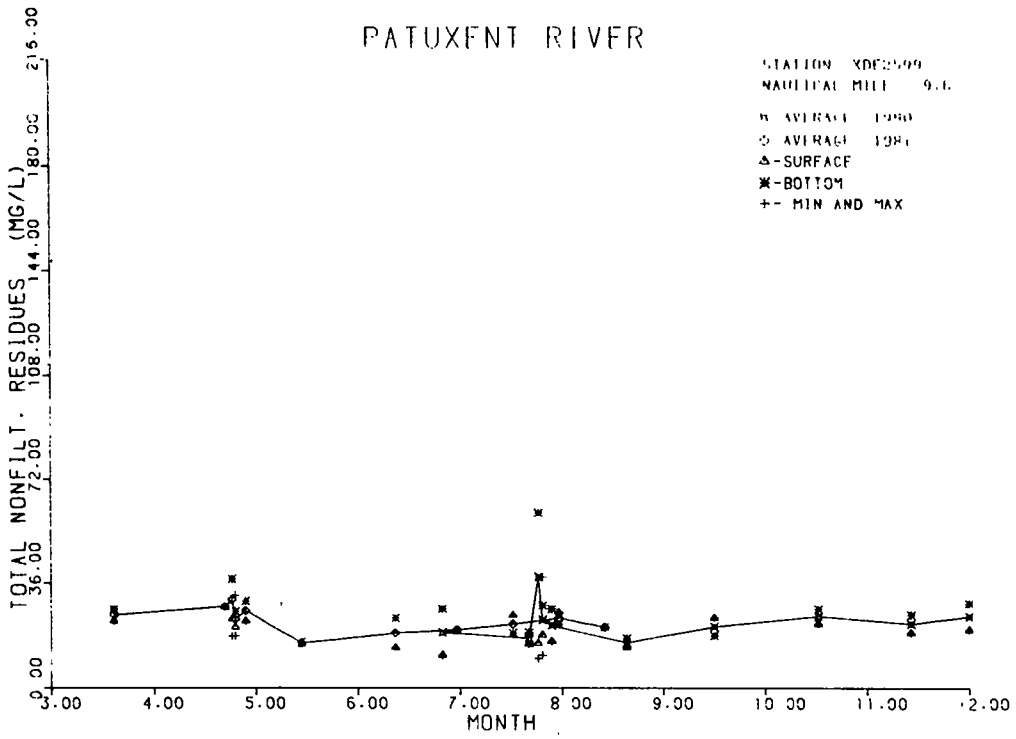


Figure 8-18 Temporal plots of silica.



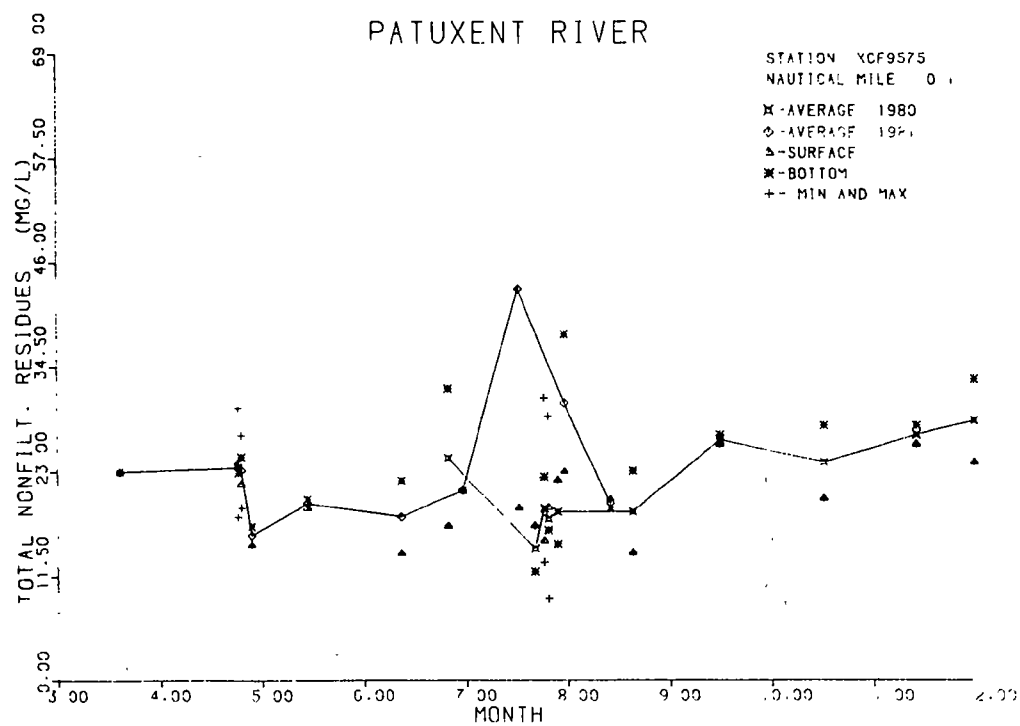
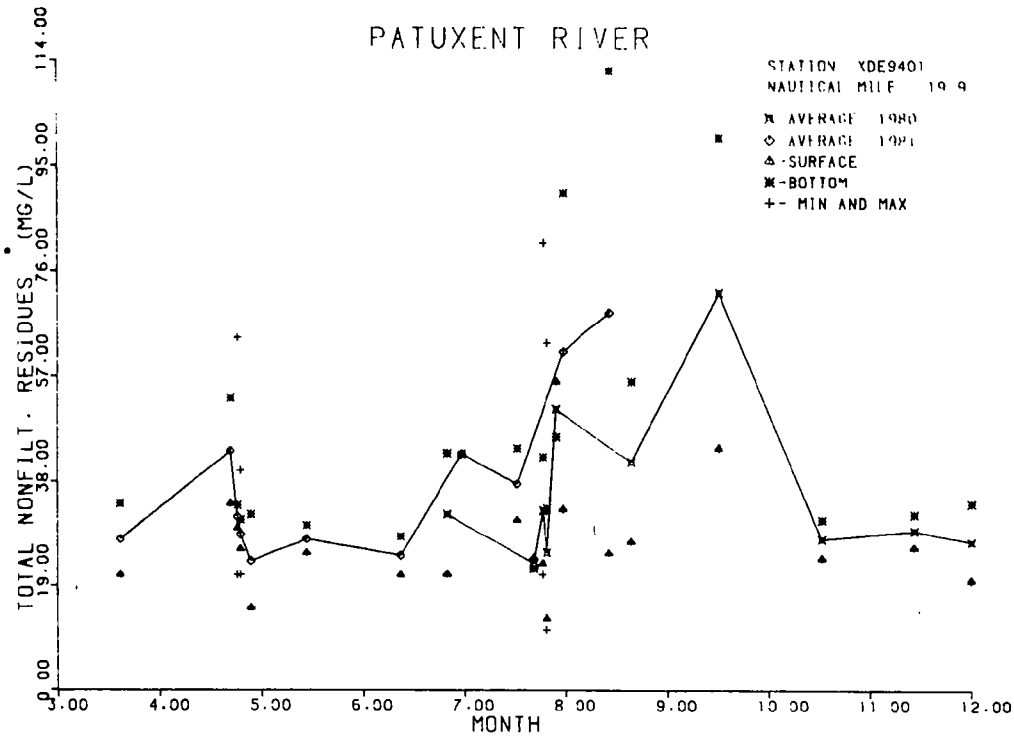


Figure 8-19 Temporal plots of total non filterable residue.



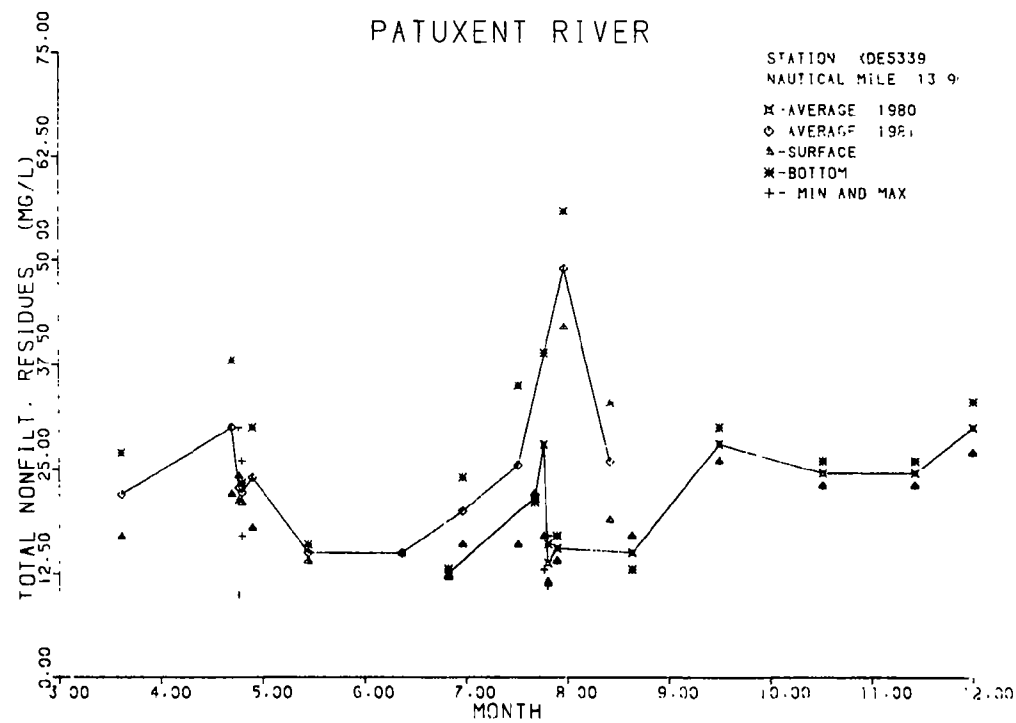
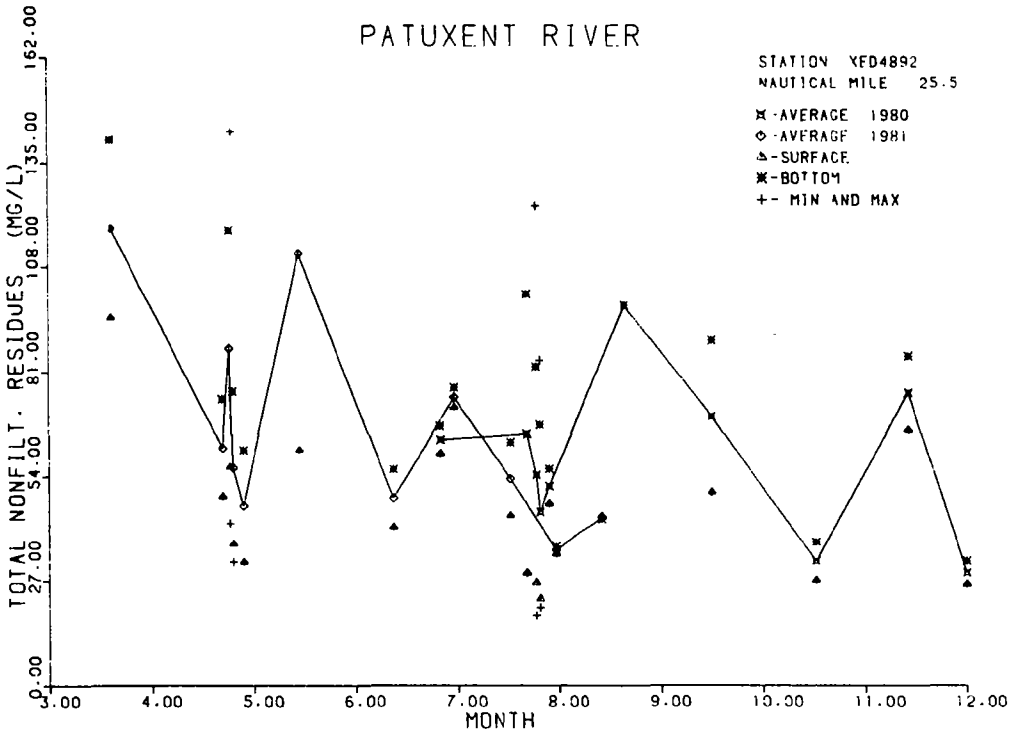


Figure 8-19 Temporal plots of total non filterable residue.



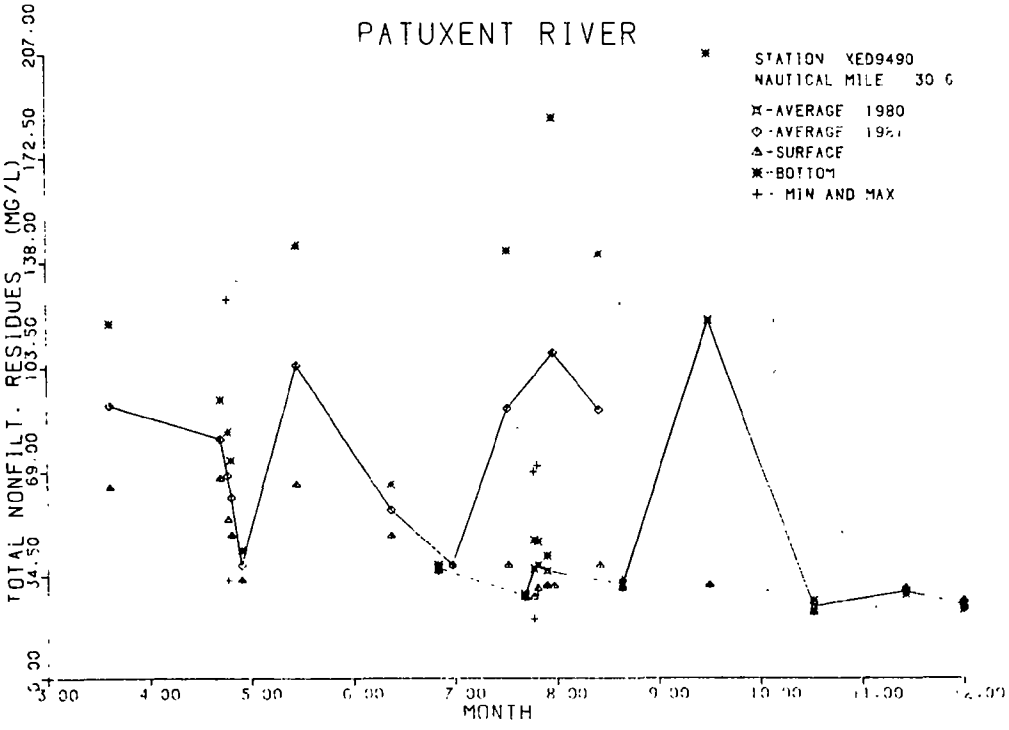
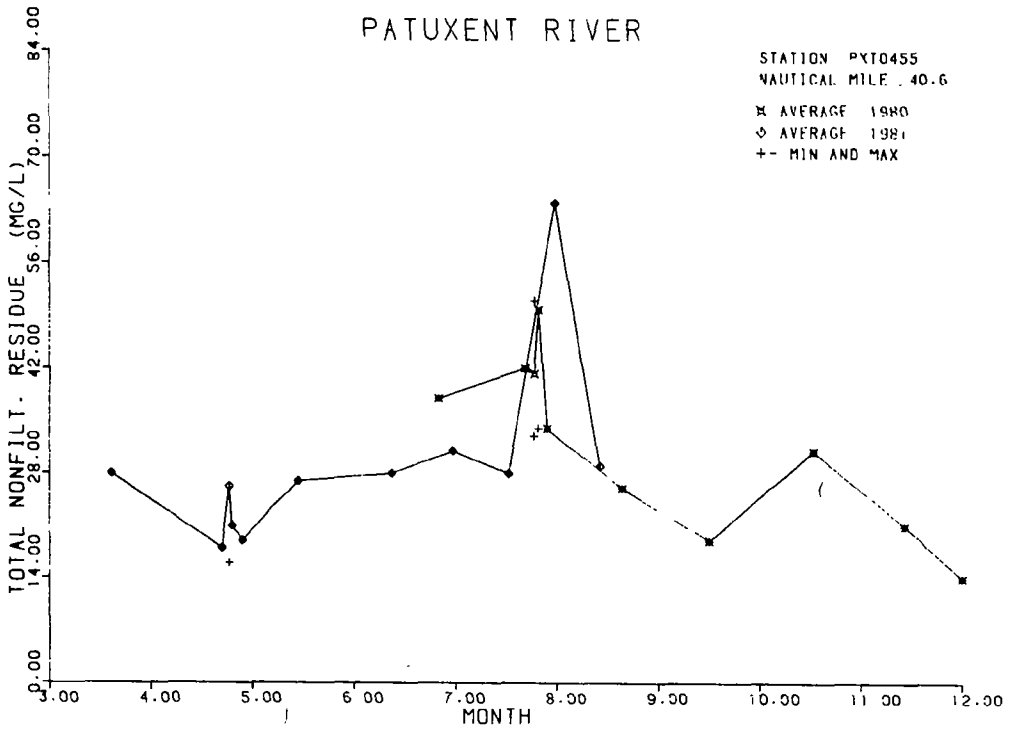


Figure8-19 Temporal plots of total non filterable residue.



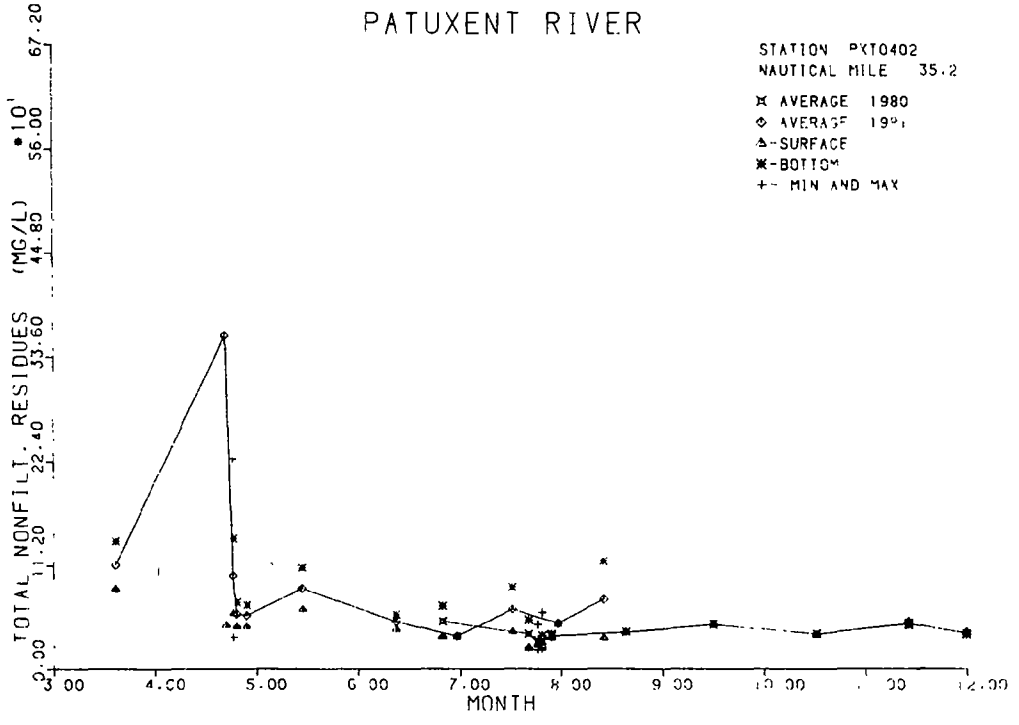
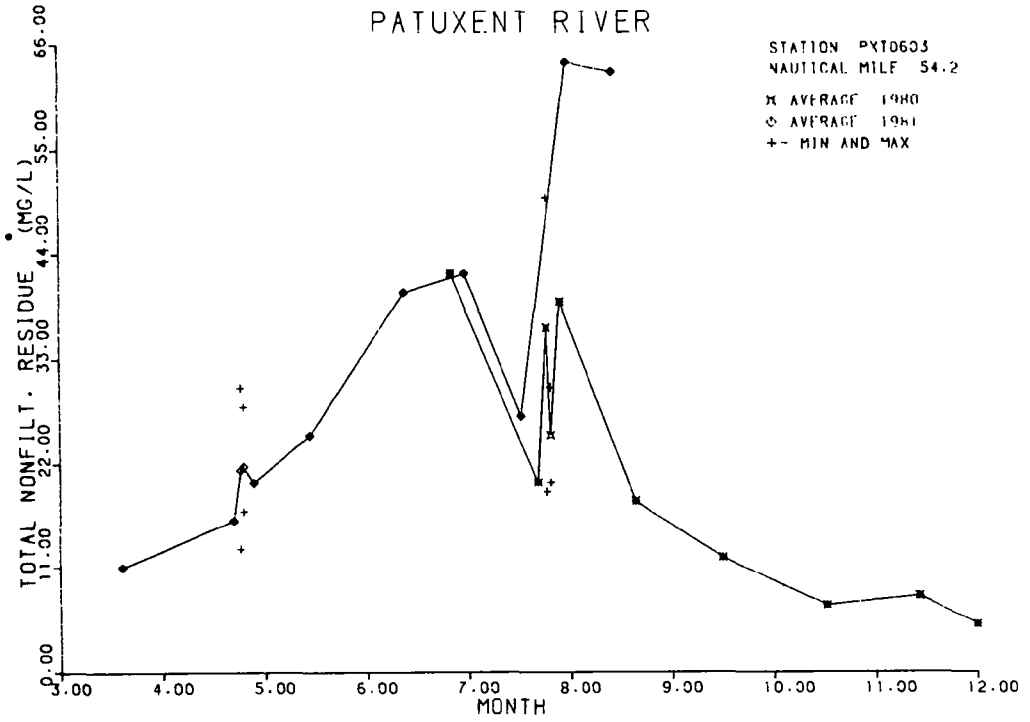


Figure 8-19 Temporal plots of total non filterable residue.



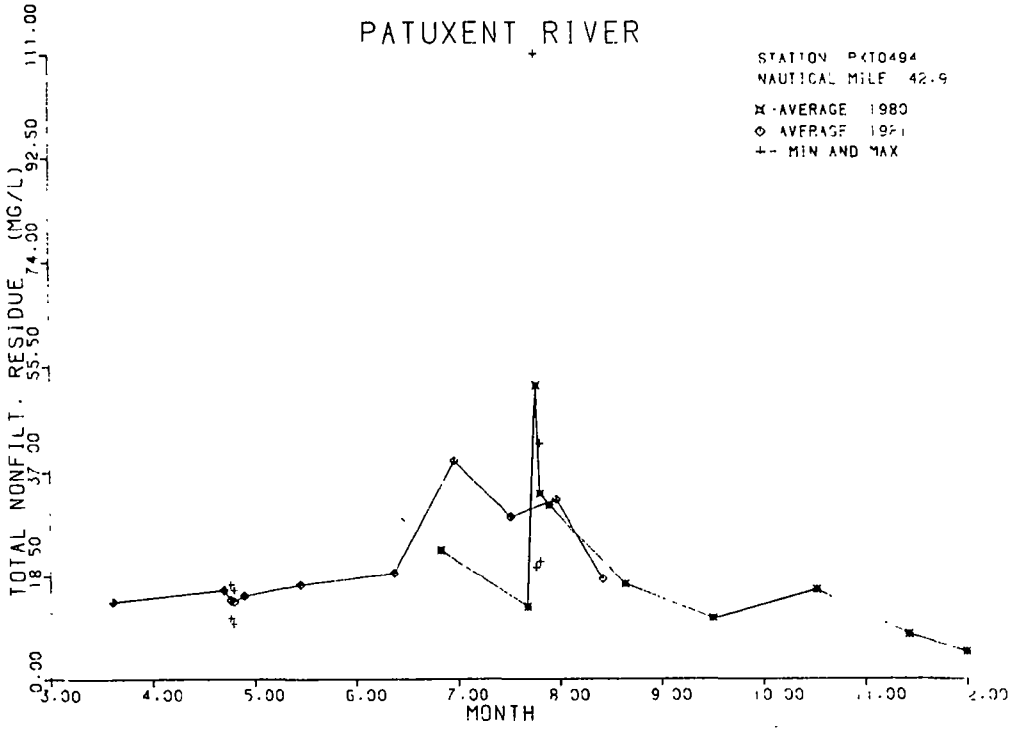
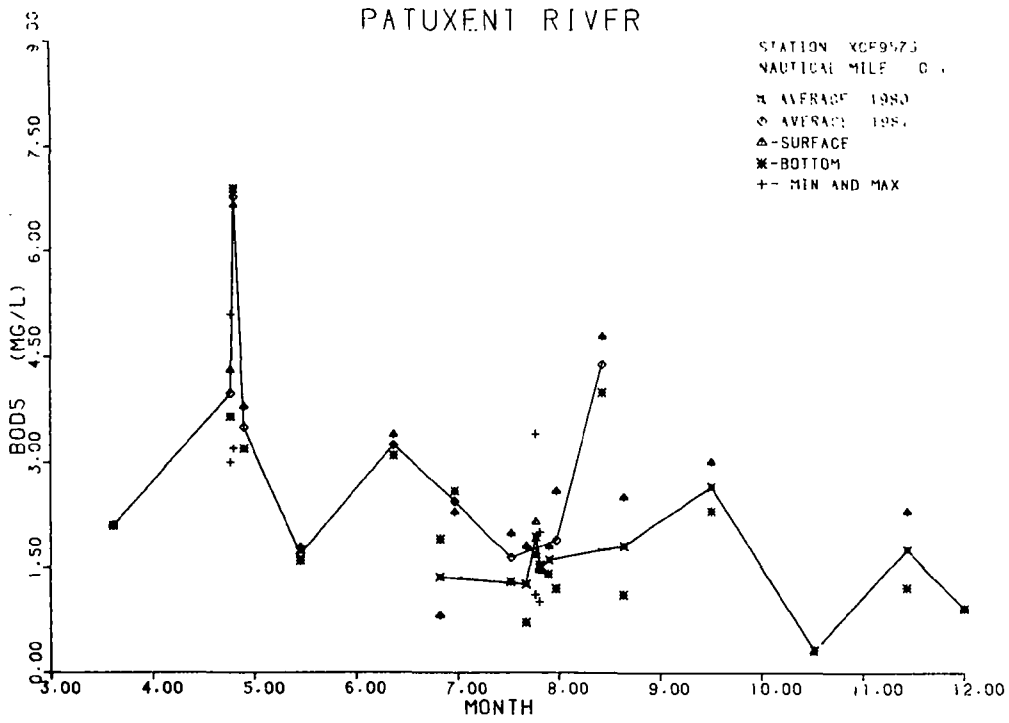


Figure 8-19 Temporal plots of total non filterable residue.



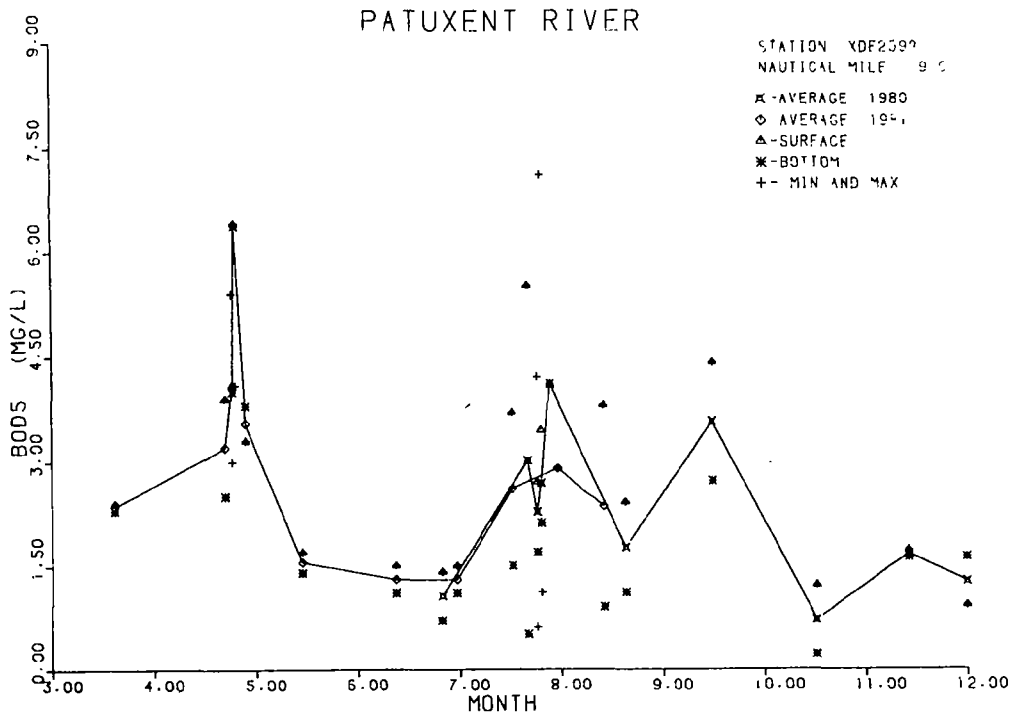
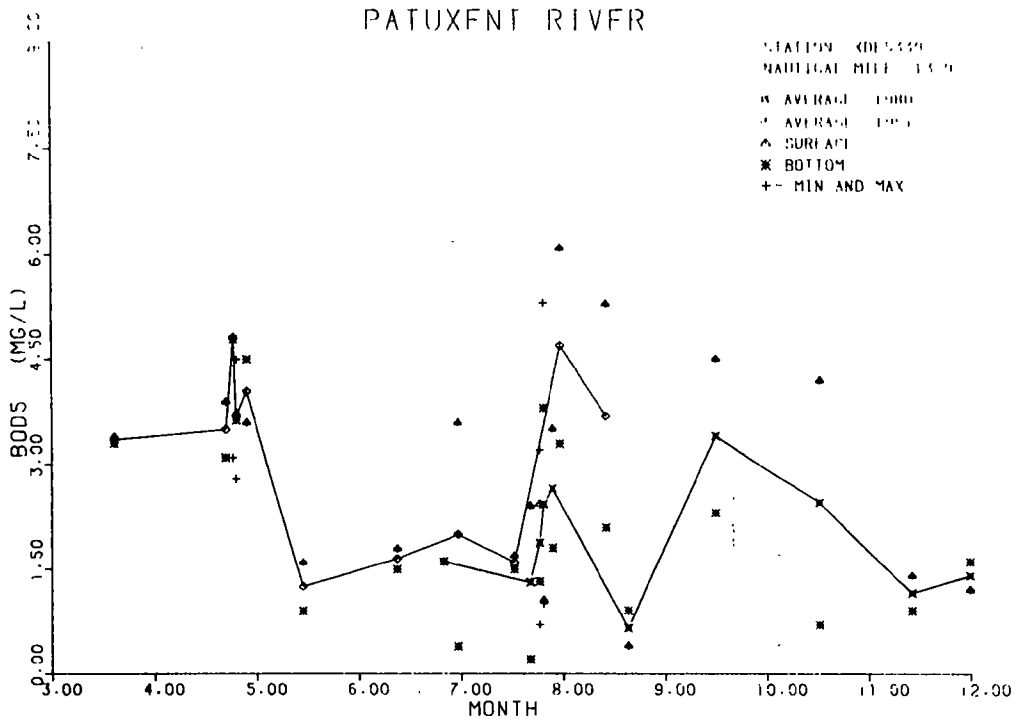


Figure 8-20 Temporal plots of BOD_5, 1980-1981.



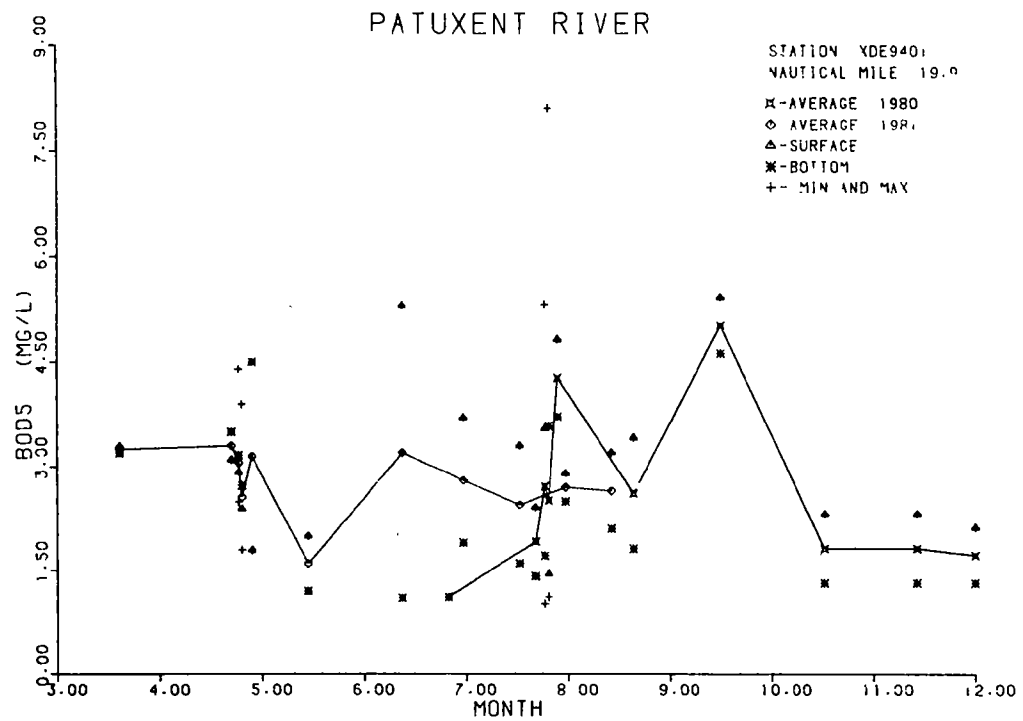
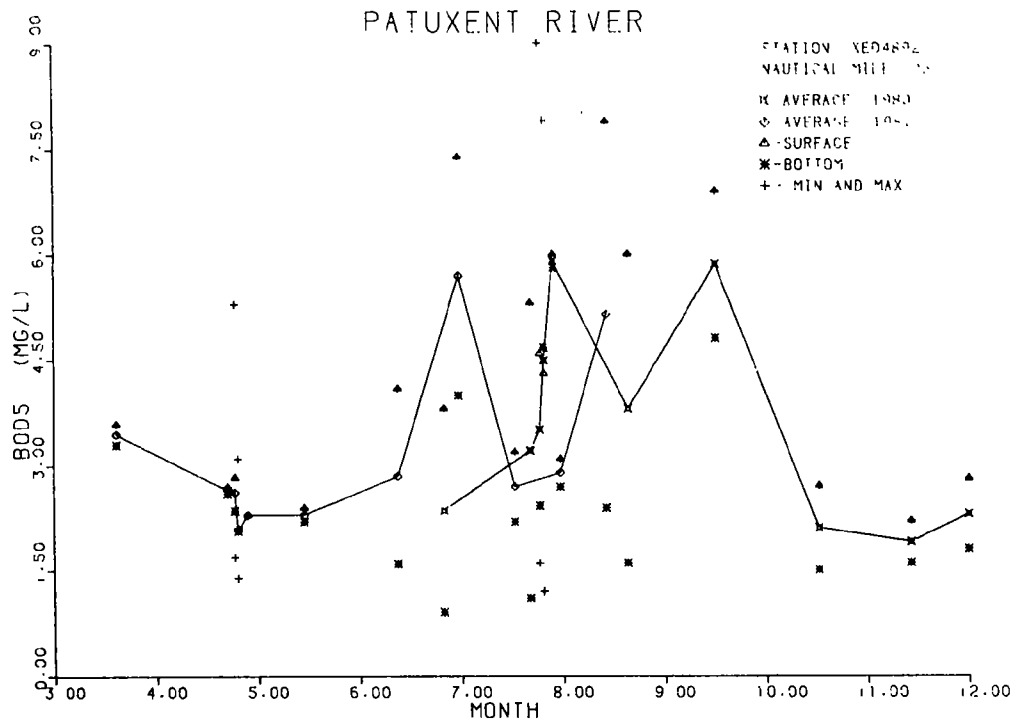


Figure 8-20Temporal plots of BOD_5, 1980-1981.



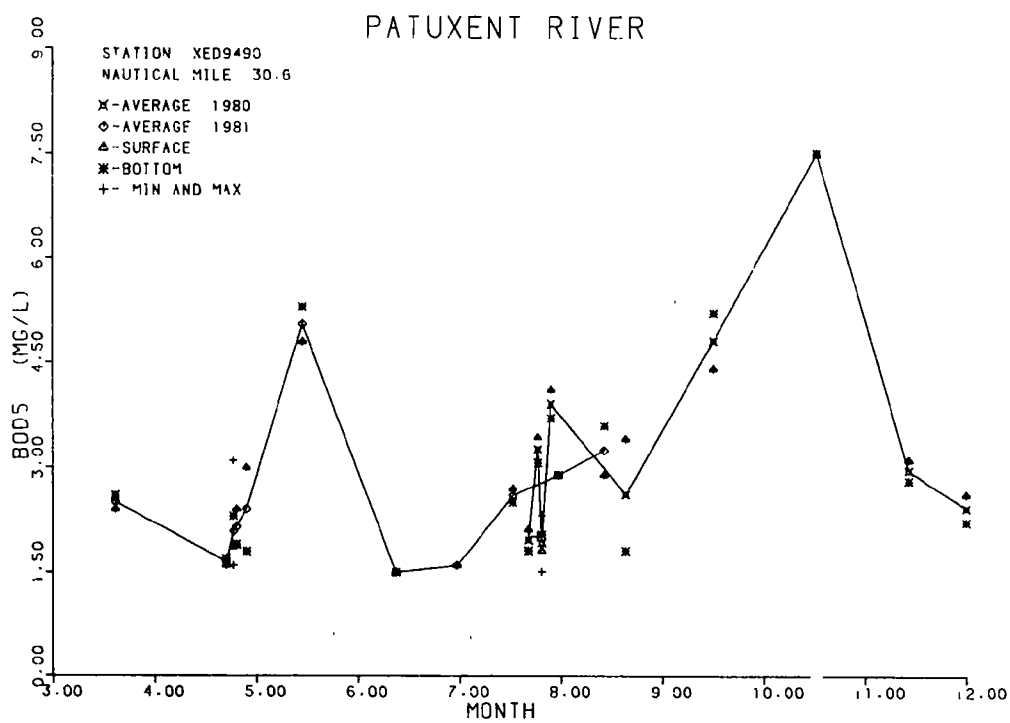
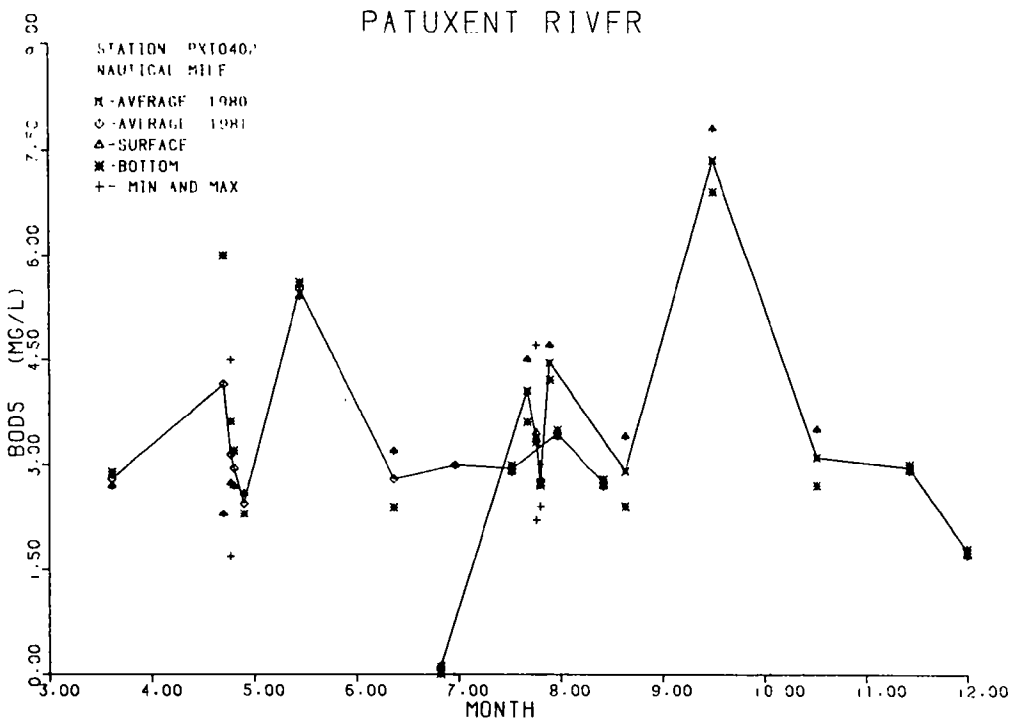


Figure 8-20 Temporal plots of BOD_5, 1980-1981.



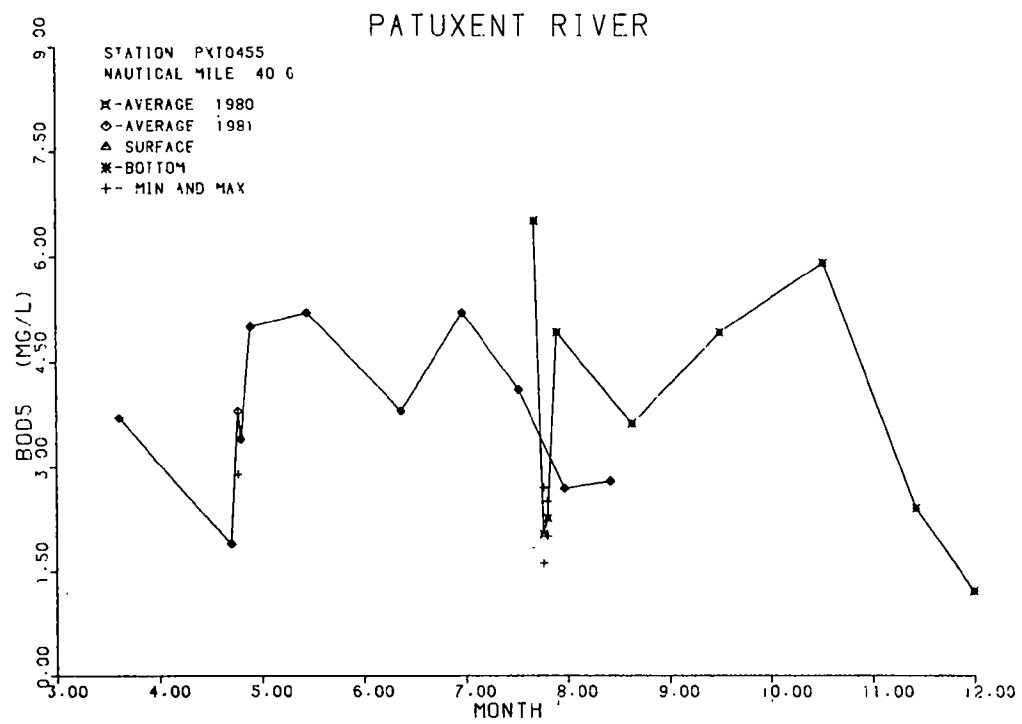
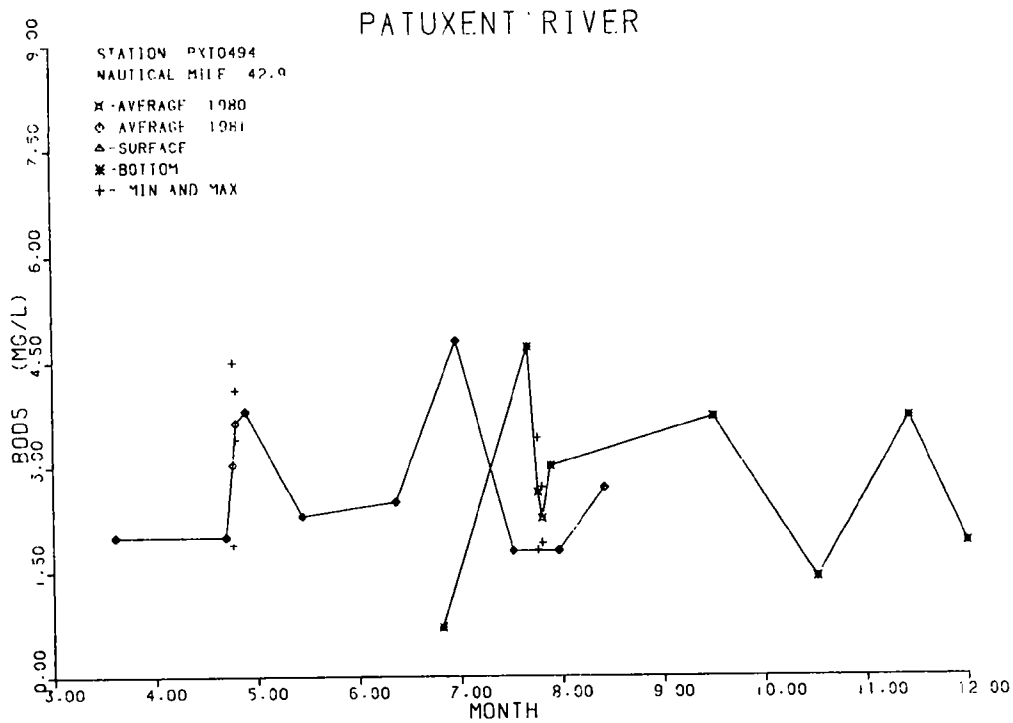


Figure 8-20Temporal plots of BOD_5, 1980-1981.



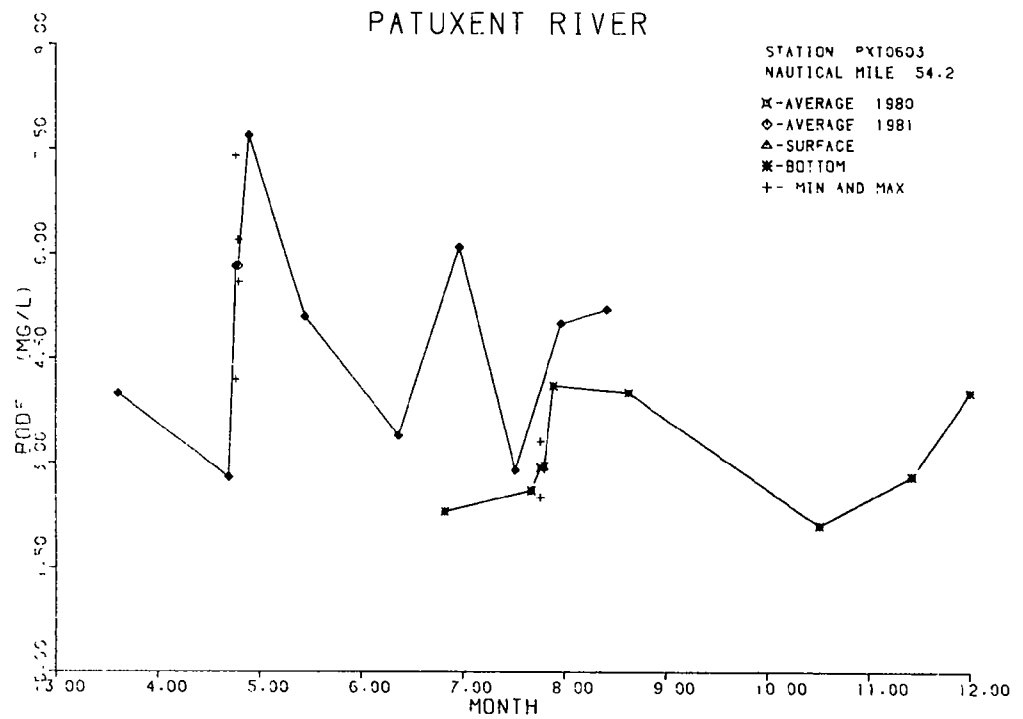


Figure 8-20 Temporal plots of BOD_5, 1980-1981.

Table B-1
Statistical Summary Of Patuxent River Monthly Water Quality Variables,
1980-1981, At Salinity Regions Of 0-3 ppt, 3.1-10 ppt And Greater Than 10 ppt Salinity

	Month								
3	4	5	6	7	8	9	10	11	12
SALIN									
.5/0/2*	1.1/.8/26	.3/0/2	1.0/.6/7	.8/.8/68	1.9/.9/5	1.0/0/2	1.7/.1/2	--	--
6.4/3.1/3	6.8/2.1/23	7.9/.1/2	7.5/1.3/7	7.0/1.0/28	6.7/2.7/5	5.9/3.0/4	6.2/.4/2	5.1/1.9/3	3.5/0/1
TEMP									
5.4/.09/7	16.3/1.2/82	18.9/2.1/9	24.3/2.2/25	26.1/2.3/.31	24.9/2.1/14	24.3/1.4/6	14/1.7/7	8.1/1/6	5.4/0.8/8
6/0/3	16.8/1.7/23	21.1/0/2	26.4/0.9/7	28.6/1.4/28	27.8/.79/28	26.5/.6/4	16/0/2	10/0/3	5.8/0/1
5.1/.6/9	14.9/1.4/103	17.3/1.5/8	24.3/0.8/23	27/1.1/112	27.2/.1/18	25.3/.6/8	16.9/.3/10	11/.8/9	5.8/.4/10
DO									
11.1/1.8/6	8.3/1.7/81	6.8/1.1/8	6.7/2.2/24	5.7/1.1/129	6.3/1.3/13	7.7/1.7/6	8.2/1.5/6	12.2/2.3/6	10.7/1.8/7
11.3/.3/3	8.4/1.1/23	5.8/1.1/2	4.9/1.2/7	6.2/1.2/27	5.1/1.1/5	6.9/.1/4	10.0/.6/2	11.2/1.0/3	10.6/0/1
11.7/.7/9	8.7/1.1/103	6.6/1.1/8	5.9/2.0/23	5.0/2.0/112	5.3/1.4/18	5.6/.5/8	8.5/1.0/10	9.4/.5/9	10.4/1.4/10
DOC									
4.5/.3/6	4.7/1.5/97	7.4/3.7/9	6.3/1.2/14	5.4/.9/15	3.9/1.1/6	--	17.0/4.9/6	10.1/4.3/7	9.5/4.2/7
3.9/.8/3	3.9/1.5/23	4.5/.7/2	4.0/1.1/4	4.0/1.2/4	2.2/.3/3	--	16.5/4.9/2	8.5/2.6/3	10.0/0/1
4.1/1.9/9	3.5/1.5/103	3.0/1.3/8	3.4/1.5/16	3.6/1.0/17	1.7/.8/9	--	13.2/2.6/10	5.7/1.8/8	11.5/2.6/16
CHLORIDE									
--	--	--	446.3/570.7/8	272.6/737.3/104	367.6/118.8/3	267.2/367.2/6	--	--	--
--	--	--	.266.7/321.5/3	3440.9/931.3/22	4600.0/0/1	3575.0/1728.9/4	--	--	--
--	--	--	2771.4/1267.2/7	6294/4/668.3/89	6200.0/1332.3/5	8493.8/692.0/8	--	--	--
SILICA									
10.4/1.3/6	6.6/2.9/98	4.7/5.0/8	7.3/4.3/22	5.7/3.5/149	6.0/4.2/13	6.8/5.1/6	--	--	--
7.3/2.3/3	6.8/1.0/23	.3/.1/2	5.7/.3/7	5.1/1.2/28	3.1/2.8/5	4.0/2.0/4	--	--	--
.1/1.3/9	1.2/1.2/103	.4/.2/8	3.0/1.4/23	4.2/1.3/111	4.3/1.4/18	5.1/1.1/8	--	--	--
CHLORA									
8.7/6.4/6	20.8/14.0/98	59.2/42.2/8	29.4/20.1/22	15.9/15.0/149	19.9/13.9/13	30.9/28.7/6	17.0/17.6/6	16.1/23.0/6	10.3/19.9/7
19.5/4.9/3	19.2/5.0/23	32.8/7.8/2	25.6/23.0/7	32.1/35.9/28	29.5/27.3/4	27.3/12.0/4	37.2/27.6/2	46.5/23.2/3	55.6/0/1
9.8/3.8/9	27.6/9.4/103	12.6/3.8/8	9.1/7.7/23	13.5/16.1/111	44.2/117.7/17	10.0/8.8/8	9.7/7.2/10	7.5/5.1/9	15.9/6.3/10

*mean/standard deviation/number of observations

Table 8-1 *(continued)*
Statistical Summary Of Patuxent River Monthly Water Quality Variables
1980-1981, At Salinity Regions Of 0-3 ppt, 3.1-10 ppt And Greater Than 10 ppt Salinity

Month									
3	4	5	6	7	8	9	10	11	12
DISSNIT									
2.7/1.2/6*	1.9/1.2/98	1.3/1.0/8	1.8/1.1/19	1.2/.8/109	1.6/1.4/10	1.7/1.4/4	2.3/1.9/6	2.6/1.5/6	2.8/1.3/7
1.6/1.5/3	1.4/.4/23	.2/0/2	.4/.2/7	.5/.2/23	.5/0/5	.4/0/4	.3/0/2	.8/.2/3	1.4/0/1
.5/.3/9	.4/.2/103	.4/.1/8	.4/.2/23	.6/.4/96	.6/.2/18	.6/.2/8	.3/.1/10	.3/.1/9	.4/.2/10
FAMION									
1.0/.6/6	.5/.4/98	.3/.3/8	.2/.3/22	.2/.2/148	.2/.3/13	.3/.6/6	.4/.7/6	.7/.6/6	.9/.7/7
.7/.2/3	.5/.2/23	.04/101/2	.03/.02/7	.1/0/28	1./.04/5	.02/.01/4	.04/.01/2	.04/.01/3	.5/0/1
.1/.1/9	.04/.05/103	.03/.01/8	.1/.1/23	.1/.1/110	.1/.04/18	.05/.02/8	.1/.02/10	.1/.03/9	.1/.03/10
FNITRITE									
.1/0/6	.1/.1/98	.1/0/8	.1/.1/23	.1/.1/147	.1/.1/13	.1/.2/6	.1/.1/6	.1/.04/6	.04/.03/7
.03/.01/3	.05/.02/23	.003/0/2	.005/.002/7	.01/01/28	.02/.02/5	.003/0/4	.03/.003/2	.02/.003/3	.03/0/1
.006/.003/9	.01/.004/103	.004/.001/8	.003/.001/23	.007/.004/111	1/.03/18	.05/.03/8	.03/.01/10	.004/.002/9	.005/.004/10
DOSAT									
83.3/13.5/6	84.6/17.5/81	74.8/12.4/8	81.4/27.8/24	71.0/14.5/131	76.4/15.8/13	92.2/22.6/6	79.6/16.7/6	102.0/19.0/6	83.8/9.1/7
93.7/2.0/3	89.6/11.1/23	69.0/12.5/2	62.5/14.4/7	81.7/16.6/27	17.1/14.5/5	88.3/2.0/4	105./5.7/2	101.5/8.4/3	85.8/0/1
100.9/5.9/9	94.8/11.0/103	75.4/12.3/8	75.8/26.4/23	66.9/26.9/112	71.4/18.8/18	73.8/6.7/8	96.8/10.6/10	93.4/5.9/9	91.0/13.2/10
BOD5									
2.8/1.0/6	3.4/1.5/101	4.4/1.7/8	2.6/1.6/17	2.8/1.3/147	3.0/1.1/12	5.4/1.9/5	2.6/2.0/6	2.7/.7/6	2.0/1.0/7
2.9/.6/3	2.3/.8/20	2.3/.1/2	3.6/2.3/6	3.7/2.1/28	3.6/2.6/5	5.3/1.1/4	7.5/0/1	2.7/.5/3	2.2/0/1
2.8/.6/9	4.0/1.6/99	1.5/.3/8	2.0/1.2/22	2.2/1.3/105	2.7/1.6/18	3.6/1.2/8	1.5/1.3/10	1.6/.5/9	1.5/.6/10
PH									
6.5/.3/7	7.3/.4/82	7.2/.2/9	7.3/.5/23	7.2/.3/131	7.2/.3/14	7.0/.8/6	7.2/.2/7	7.3/.4/6	7.0/.3/8
7.0/.1/3	7.4/.3/23	7.3/.1/2	7.3/.4/7	7.1/.4/28	7.3/.6/5	7.4/.2/4	7.3/.2/2	8.2/.2/3	7.9/0/1
7.3/.2/9	8.2/.6/103	7.4/.2/8	7.4/.4/23	7.2/.5/112	7.6/.4/18	7.8/.2/8	7.7/.1/10	7.6/.3/9	7.9/.1/10
TALK									
34.3/2.9/6	44.7/11.3/98	35.7/2.9/8	38.4/5.7/22	39.5/11.3/150	45.6/7.2/13	50.6/4.7/6	--	--	--
44.0/8.7/3	48.1/3.5/23	47.5/3.5/2	51.3/5.8/6	52.7/5.7/28	56.4/10.2/5	57.3/6.8/4	--	--	--
66.7/5.2/9	67.5/5.4/103	62.0/5.2/8	62.7/3.6/22	67.2/3.7/112	70.7/4.4/18	73.7/14.2/8	--	68.0/0/1	--

*mean/standard deviation/number of observations

Table 8-1 (continued)
Statistical Summary Of Patuxent River Monthly Water Quality Variables,
1980-1981, At Salinity Regions Of 0-3 ppt, 3.1-10 ppt And Greater Than 10 ppt Salinity

Month									
3	4	5	6	7	8	9	10	11	12
FNITRATE *									
1.8/.8/6	1.2/.9/98	2.6/4.9/9	1.4/1.2/22	.8/.8/145	1.2/1.2/13	1.6/1.6/6	1.6/1.4/6	1.7/.9/6	1.7/.8/7
.8/.3/3	.7/.2/23	.03/.01/2	.07/.08/7	.1/.1/28	.04/.03/5	.02/0/1	.3/.1/2	.7/.1/3	1.0/0/1
.9/2.2/9	.1/.1/103	.1/.04/8	.5/1.4/23	.1/.4/109	.02/.01/18	.1/.1/8	.1/.04/10	.1/.1/9	.1/.1/10
TPHOS									
.5/.4/7	.3/.2/99	.4/.3/9	.3/.3/23	.2/.2/149	.4/.3/14	.5/.5/6	.4/.3/7	.4/.4/6	.5/.3/8
.2/.1/3	.2/.1/23	.1/.1/2	.2/.1/7	.2/.1/28	.2/.1/5	.2/.1/4	.1/.04/2	.1/.02/3	.1/0/1
.1/.1/9	.04/.04/103	.03/.005/8	.1/.03/23	.7/.7/110	.1/.2/18	.1/.1/8	.1/.02/10	.05/03/9	.05/.03/18
FPHOS									
.2/.2/6	.1/.1/98	.1/.1/8	.1/.2/22	.1/.1/149	.2/.3/13	.4/.5/6	.2/.2/6	.3/4/6	.2/.2/7
.04/0/3	.04/.01/23	.03/0/2	.05/.02/7	.1/.02/28	.1/.03/5	.03/.01/4	.03/0/2	.1/.03/3	.04/.0/1
.03/0/9	.03/.003/103	.03/.01/8	.04/.01/23	.1/.1/110	.1/.04/18	.1/.03/8	.04/.01/10	.04/.01/9	.04/.02/10
FOPHOS									
.2/.2/6	.1/.1/98	.1/.1/8	.1/.2/22	.1/.1/150	.2/.2/13	.4/.5/6	.2/.3/5	.3/.4/6	.2/.2/7
.03/0/3	.03/.01/23	.02/0/2	.05/004/7	.06/.02/28	.04/.03/5	.04/.02/4	.02/.01/2	.02/01/3	.02/0/1
.004/.01/9	.005/.01/103	0/0/8	.03/.02/111	.04/.03/18	.1/.04/8	.03/.02/10	.02/.01/9	.01/01/10	.03/0/3
TOC									
2.5/0/1	6.5/0/1	--	6.1/1.2/8	8.3/4.0/135	12.9/3.7/8	8.3/3.4/6	12.5/0/1	--	6.5/0/1
--	--	--	7.2/2.6/3	8.9/3.2/24	9.8/2.5/2	11.4/1.4/4	--	--	--
--	--	--	5.1/.9/7	7.4/4.3/93	9.4/8.2/8	7.9/2.8/8	--	--	--
RESIDUE									
42.3/51.0/7	49.4/75.9/99	56.1/45.4/9	37.7/16.6/23	35.5/20.5/149	33.0/28.4/14	25.0/18.4/6	6.0/0/1	--	8.0/0/1
92.3/27.1/3	66.0/34.6/23	111.5/71.4/2	56.3/19.5/7	52.1/33.6/28	70.8/47.1/5	94.2/78.9/4	--	--	
37.3/39.2/9	30.2/19.9/103	19.4/5.5/8	22.4/9.7/23	27.4/24.0/111	29.1/24.1/17	36.9/26.6/8	--	26.0/0/1	
TOTN									
2.9/1.4/6	2.1/1.3/98	1.6/.8/8	2.1/1.2/22	1.6/.9/151	3.1/4.1/14	2.0/1.2/6	2.4/2.1/6	3.0/1.5/6	2.8/1.3/7
1.8/.6/3	1.5/.4/23	.3/.1/2	.8/.3/7	1.0/.3/28	.8/.2/5	1.0/.2/4	.9/.3/2	1.0/.2/3	1.5/0/10
.6/.3/9	.6/.2/103	.4/.1/8	.6/.2/23	.7/.4/107	.8/.8/18	.6/.2/8	.6/.2/16	.5/.2/9	.5/.2/10

*mean/standard deviation/number of observations

Table 8-1 (continued)
Statistical Summary Of Patuxent River Monthly Water Quality Variables,
1980-1981, At Salinity Regions Of 0-3 ppt, 3.1-10 ppt And Greater Than 10 ppt Salinity

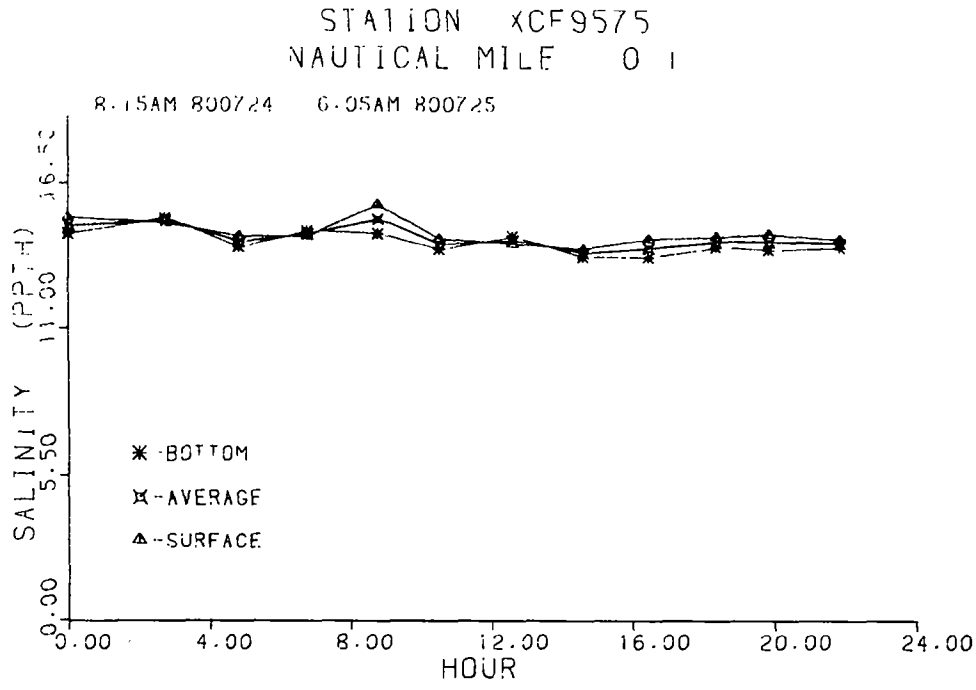
Month									
3	4	5	6	7	8	9	10	11	12
CHLORAL									
1.8/1.8/6*	10.7/8.9/97	23.8/25.3/7	26.4/19.9/14	13.5/8.1/6	--	--	--	--	--
3.8/2.9/3	9.7/4.1/23	14.3/11.6/2	24.1/10.7/4	43.5/3.6/2	--	--	--	--	--
5.3/1.6/9	22.0/9.2/83	6.1/4.3/8	14.6/12.6/13	18.5/16.7/8	--	--	--	--	--
PHEOP									
10.3/8.4/6	10.9/13.7/98	30.0/25.0/8	7.0/5.9/22	8.0/7.0/149	8.9/8.8/13	7.0/6.4/6	8.5/7.1/6	6.5/2.9/6	5.7/4.8/7
15.8/6.7/3	9.5/6.9/23	18.5/19.3/2	2.7/2.2/7	8.8/5.8/28	10.3/4.4/4	11.1/9.5/4	4.9/.4/2	4.9/5.6/3	5.1/0/1
4.5/3.4/9	3.2/3.6/103	6.5/2.7/8	2.6/3.7/23	3.7/2.7/112	3.9/3.5	2.9/2.7/8	2.2/1.4/10	5.7/2.5/9	2.1/2.1/10

*mean/standard deviation/number of observations

APPENDIX H

INTENSIVE 24-HOUR SURVEY FIGURES AND TABLES

SECTION 9



PATUXENT RIVER

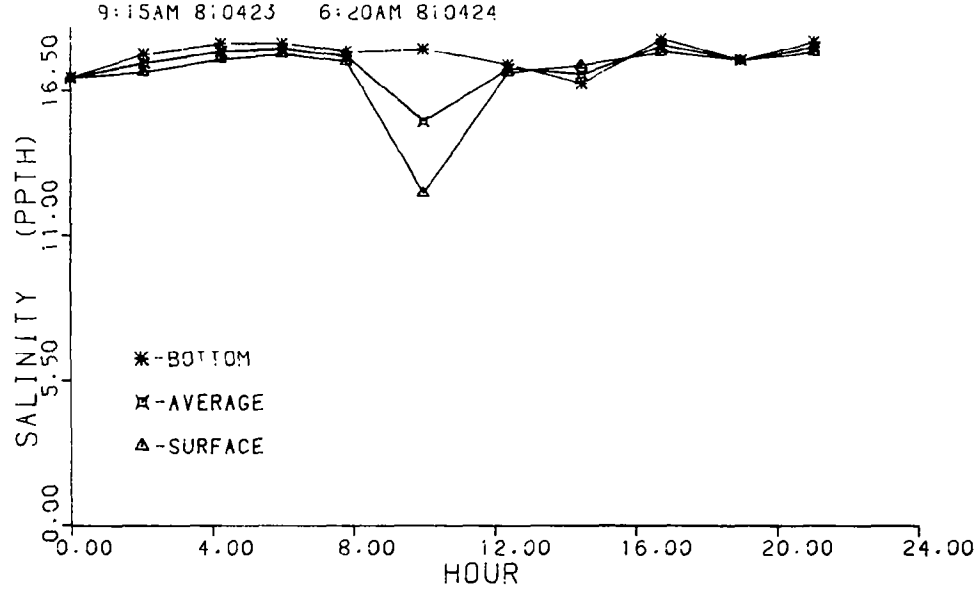
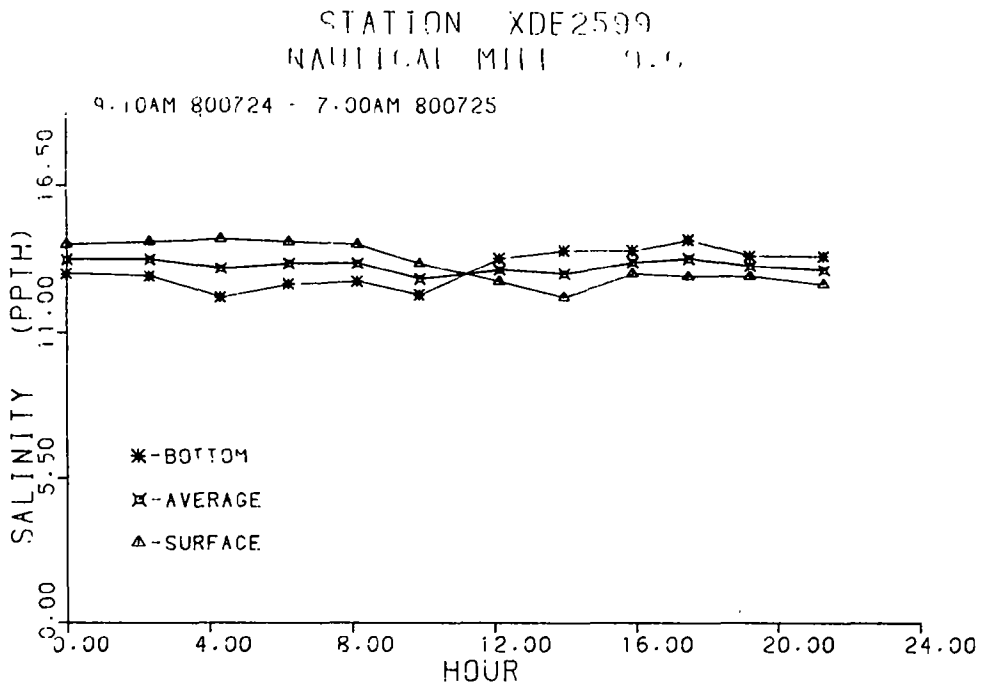


Figure 9-1 Intensive river survey plots of salinity.



PATUXENT RIVER

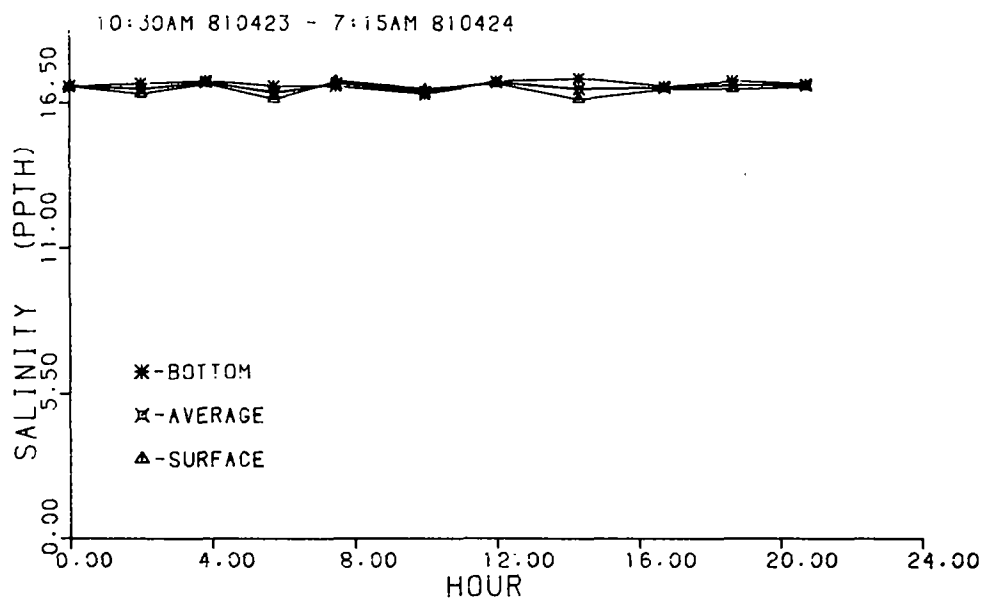
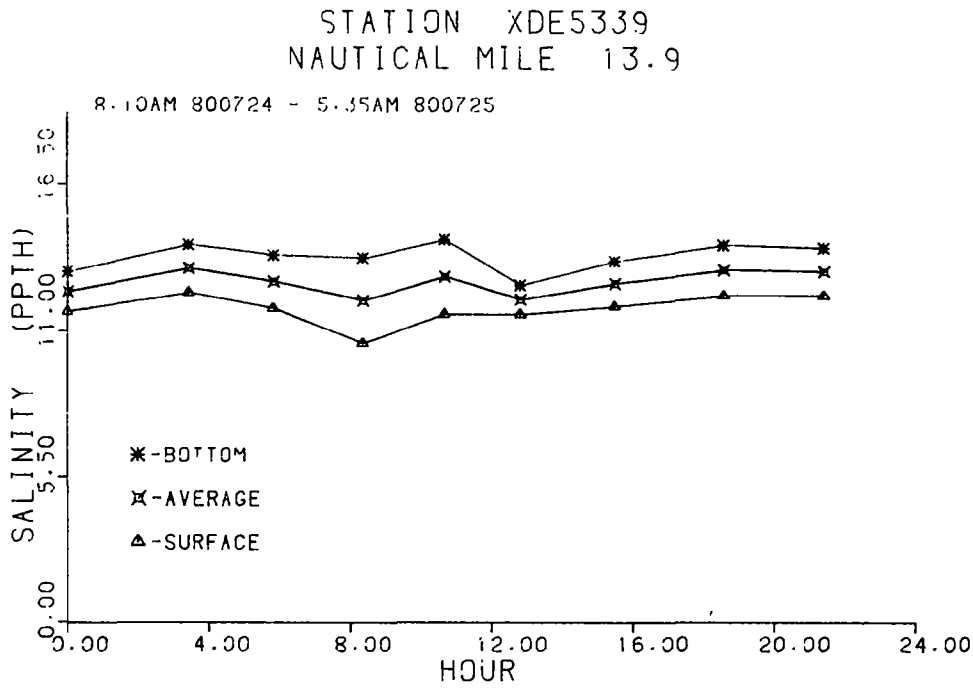


Figure 9-1 Intensive river survey plots of salinity.



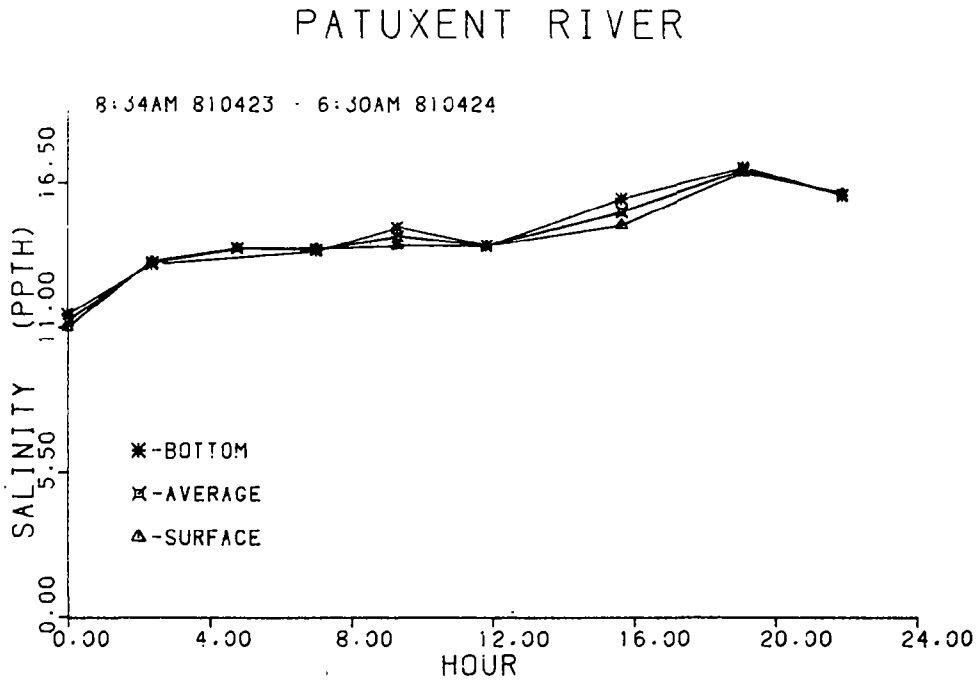
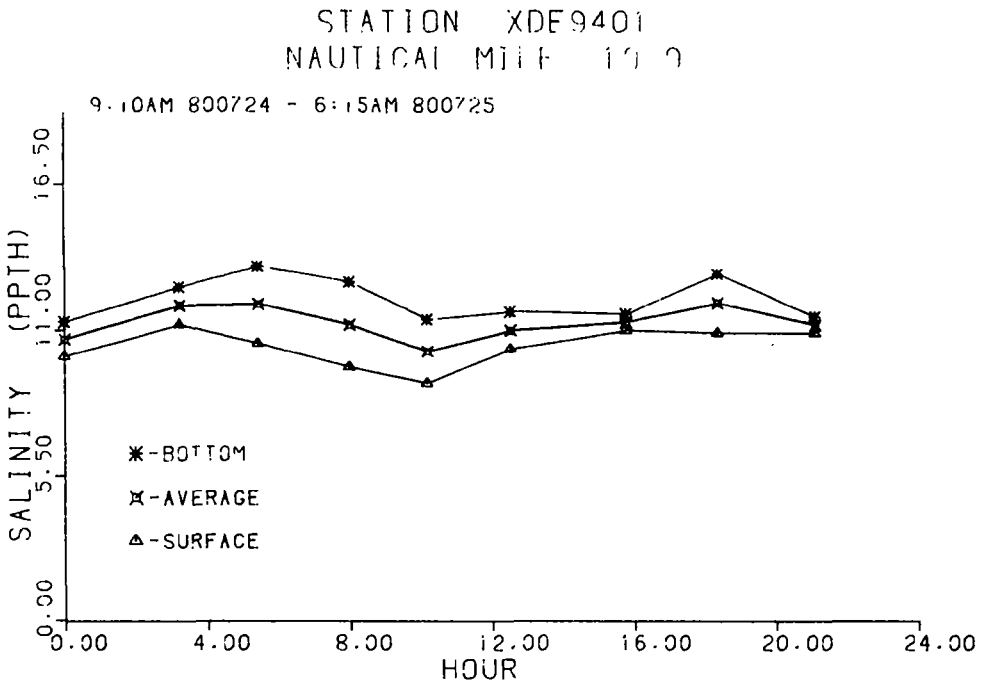


Figure 9-1 Intensive river survey plots of salinity.



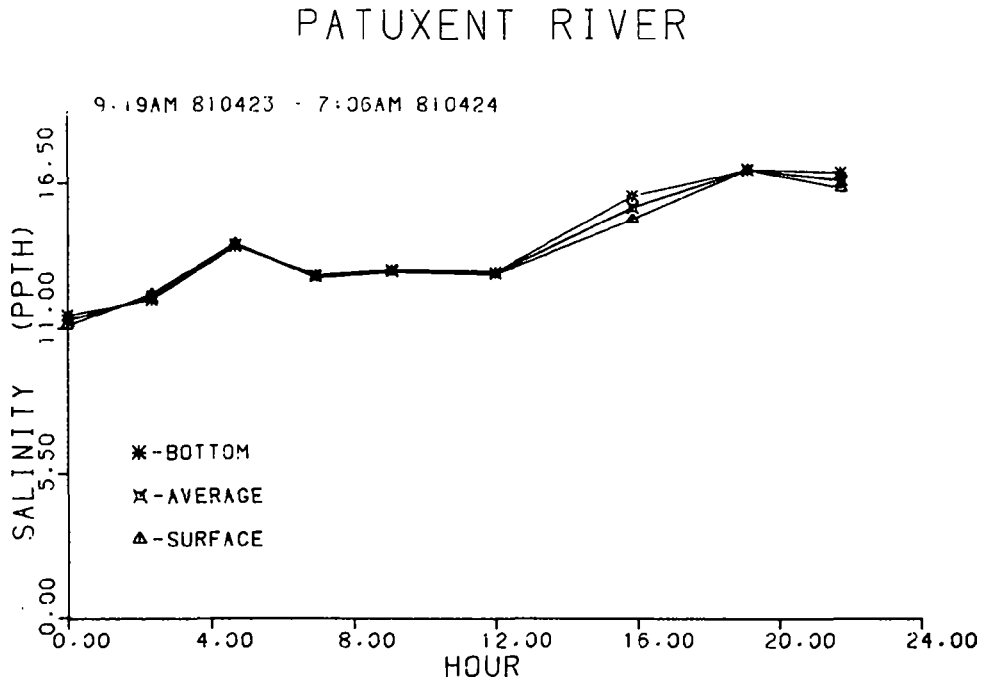
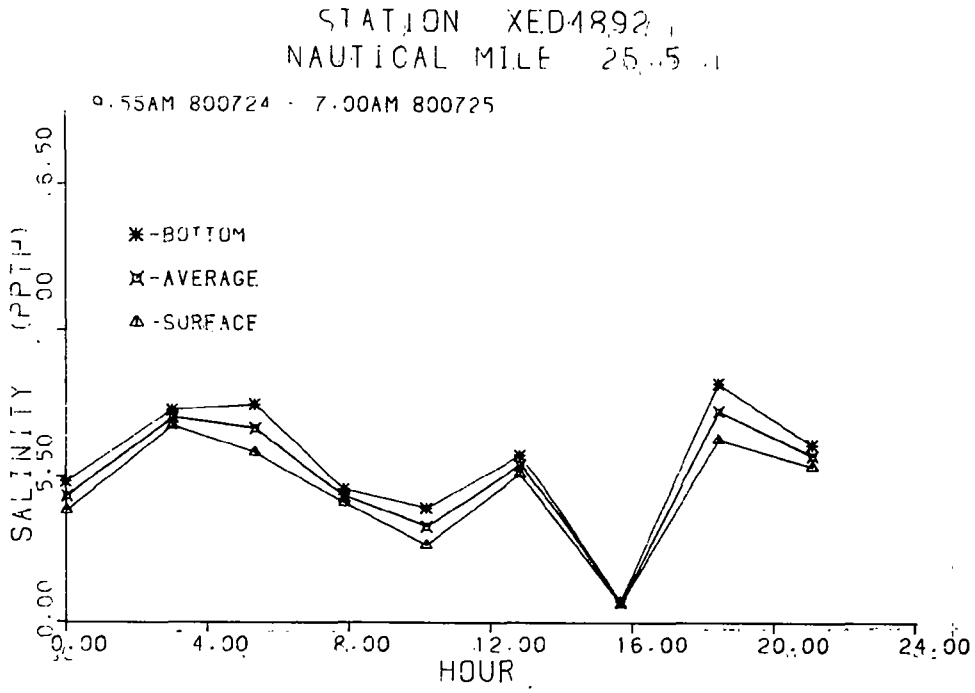


Figure 9-1 Intensive river survey plots of salinity.



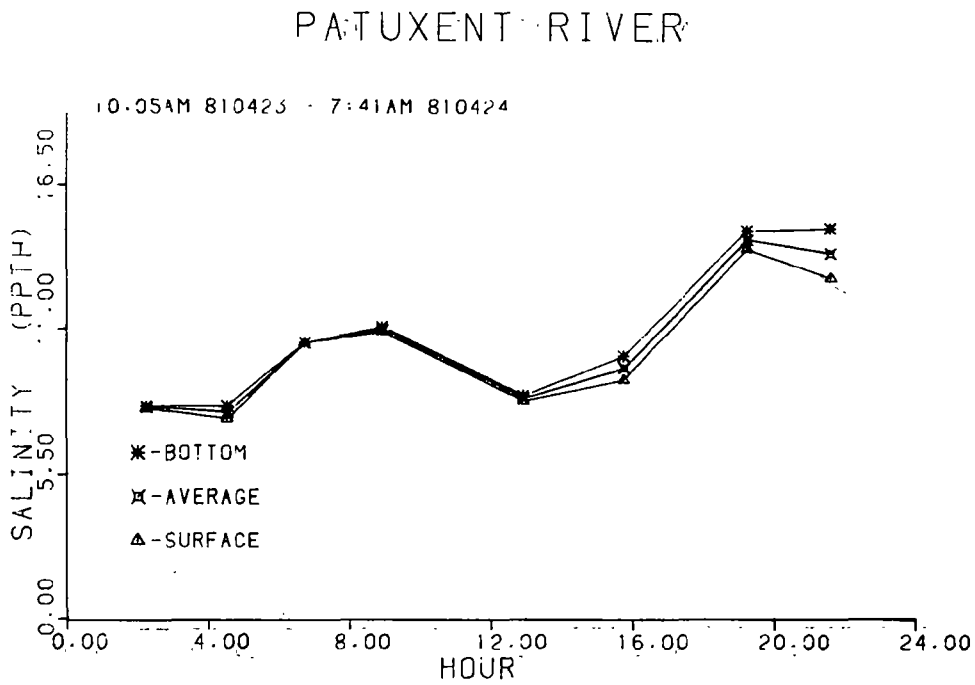
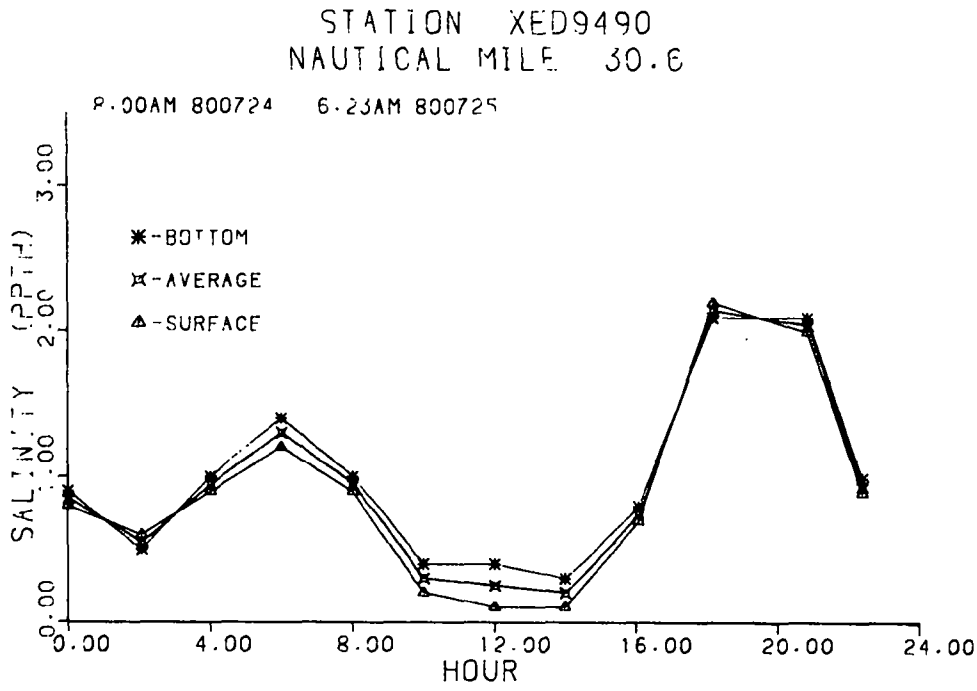


Figure 9-1 Intensive river survey plots of salinity.



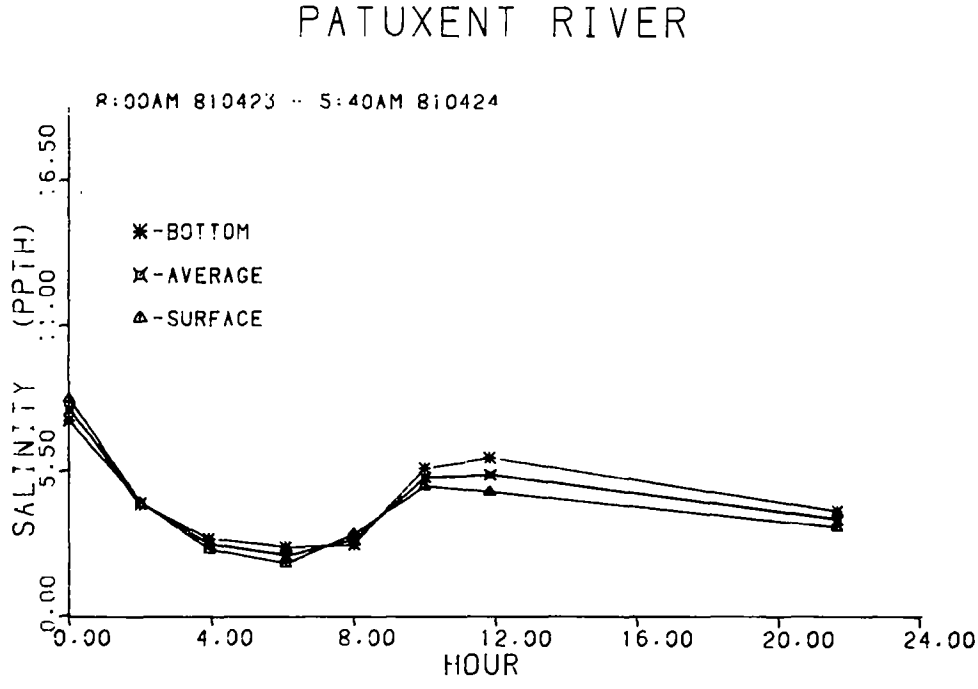
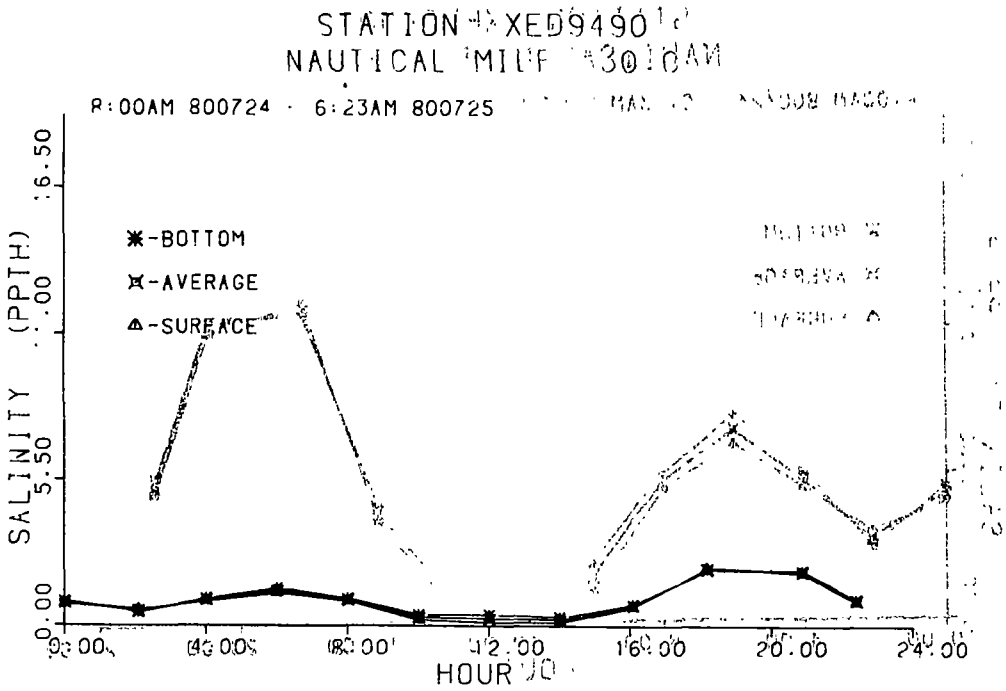


Figure 9-1 Intensive river survey plots of salinity.



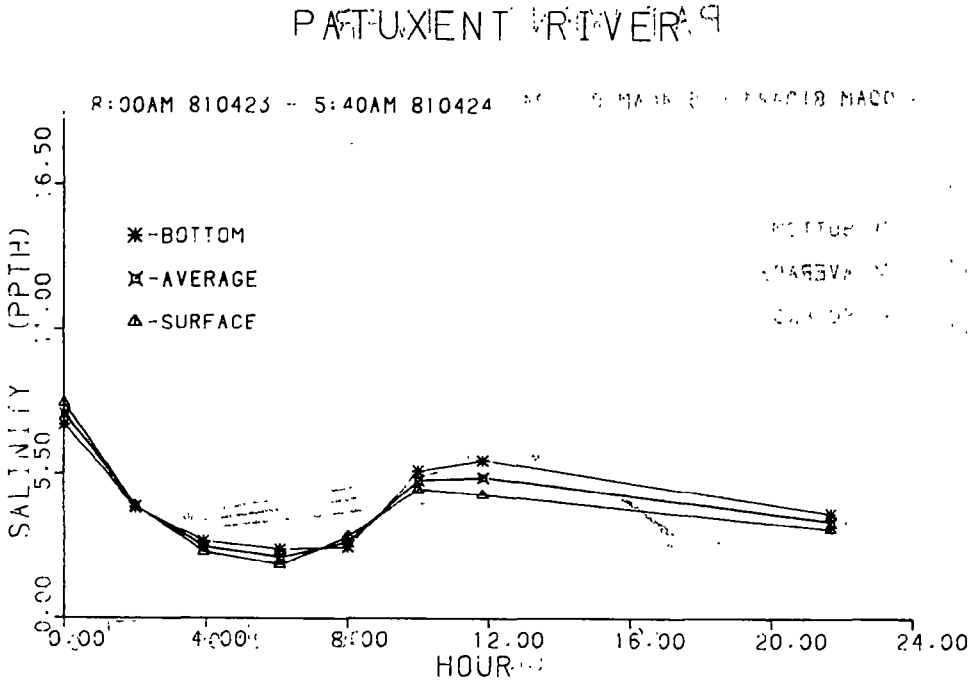
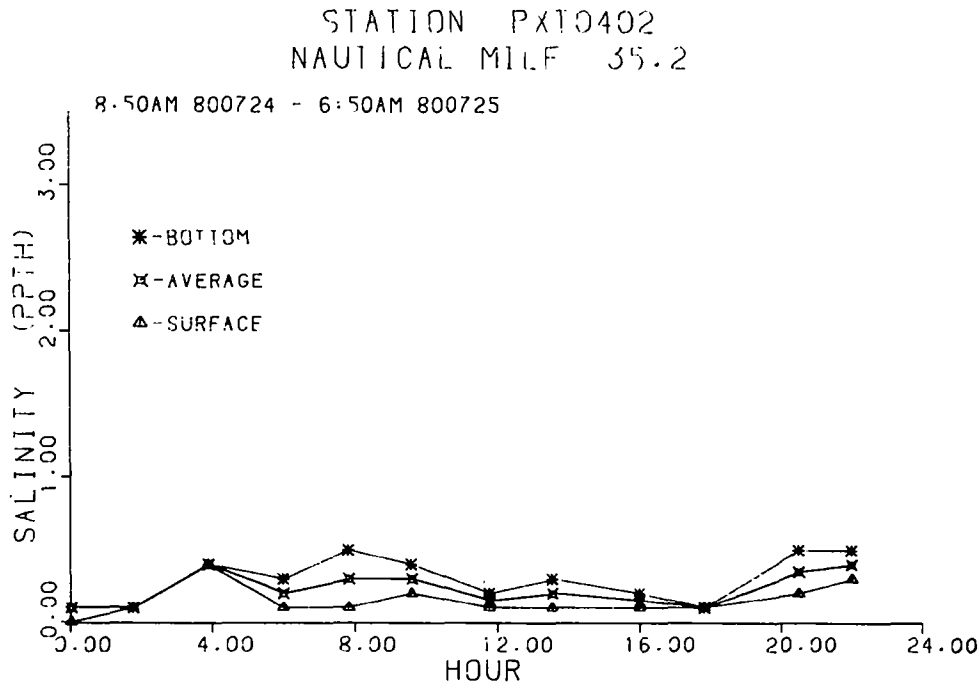


Figure 9-1 Intensive river survey plots of salinity.



PATUXENT RIVER

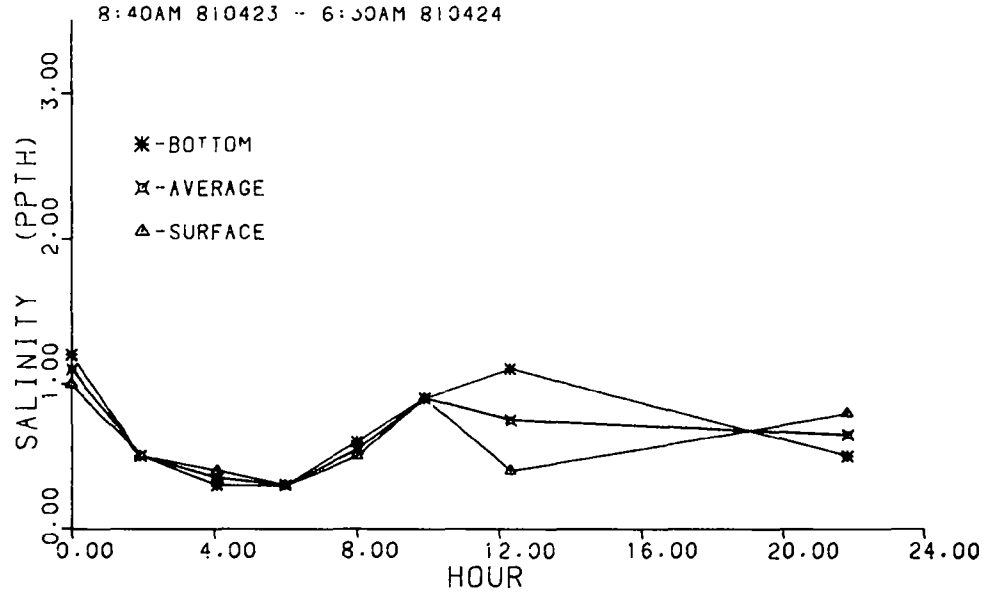
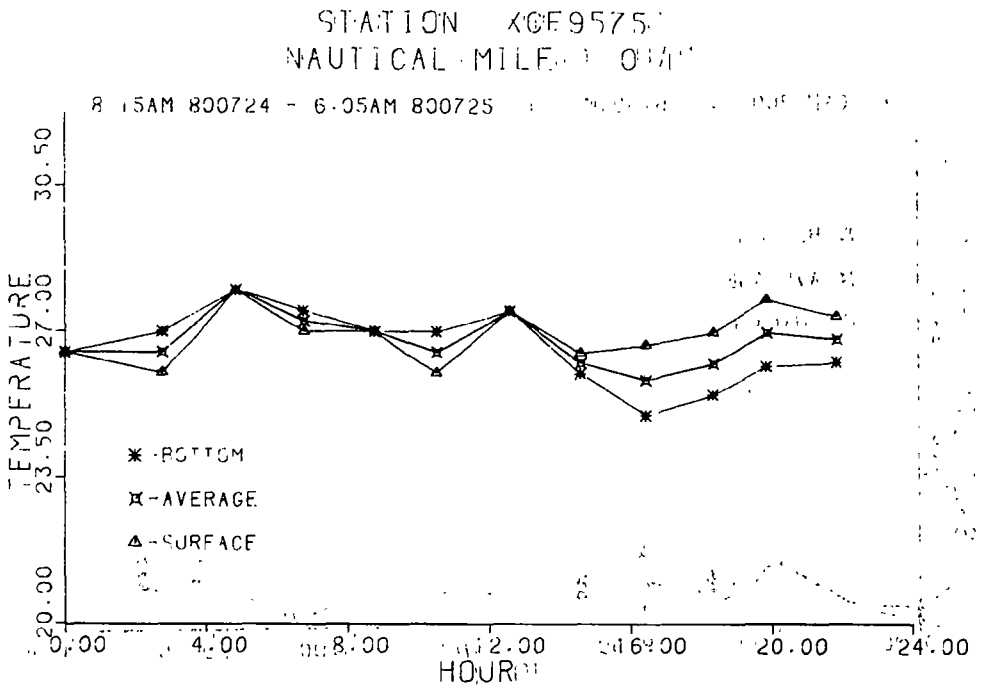


Figure 9-1 Intensive river survey plots of salinity.



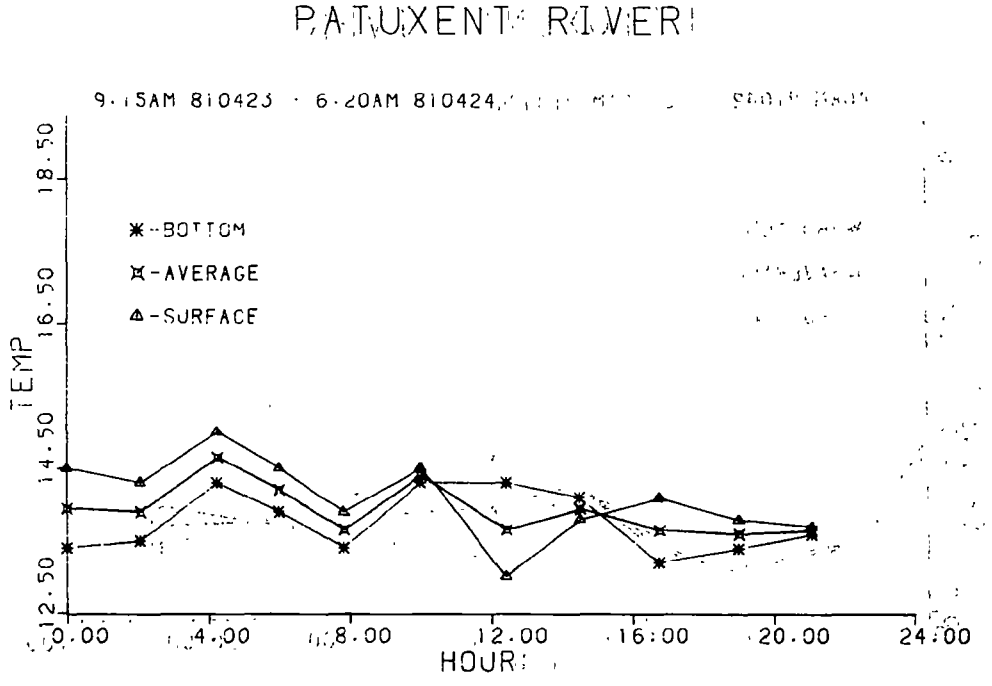
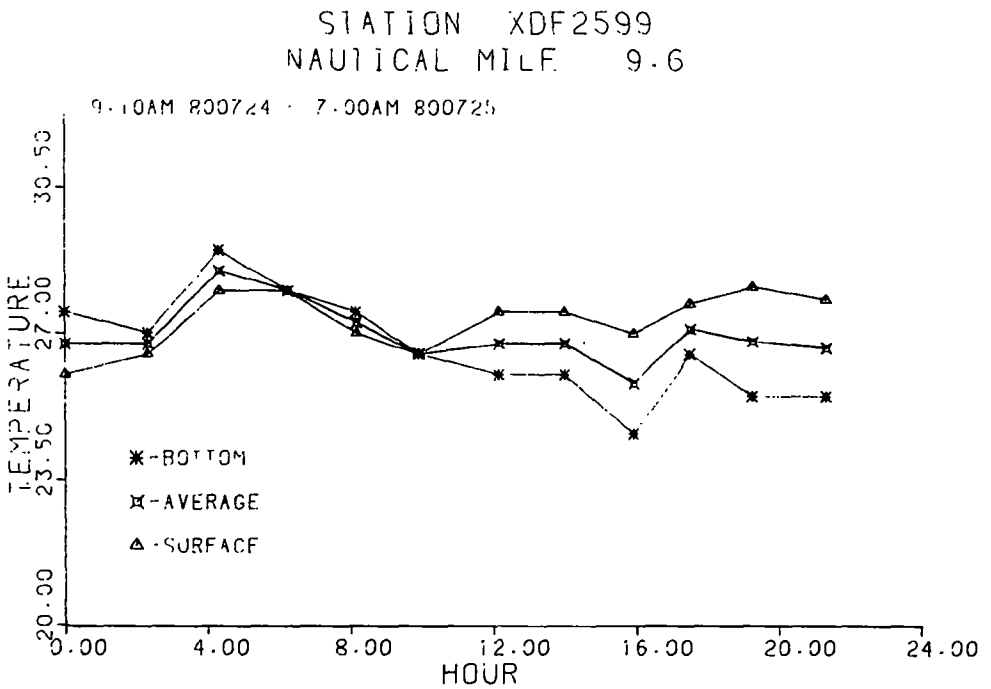


Figure 9-2 Intensive river survey plots of temperature.



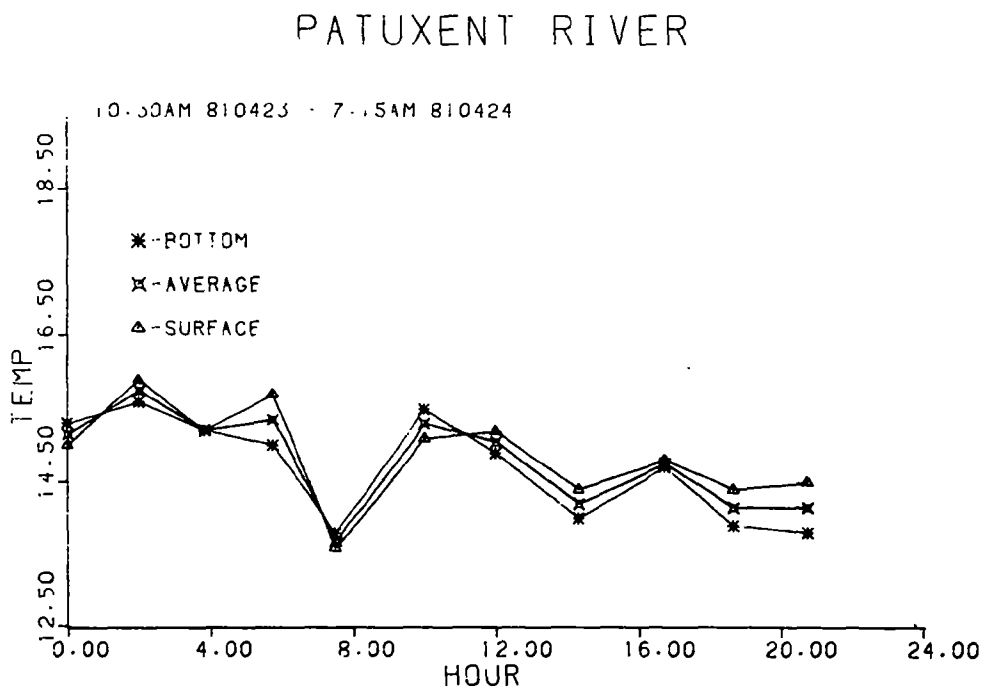
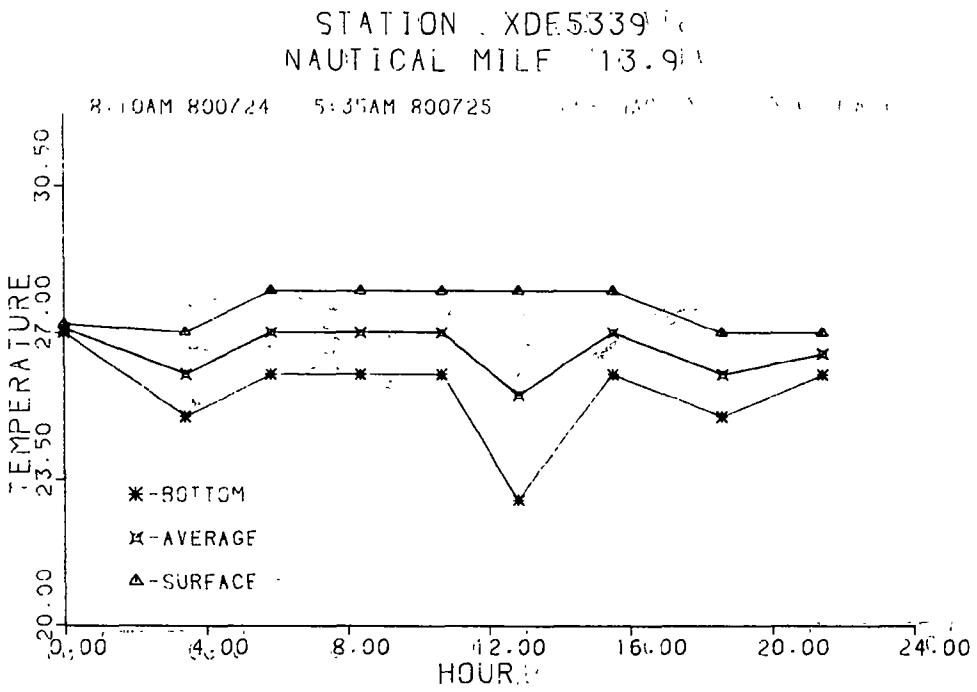


Figure 9-2 Intensive river survey plots of temperature.



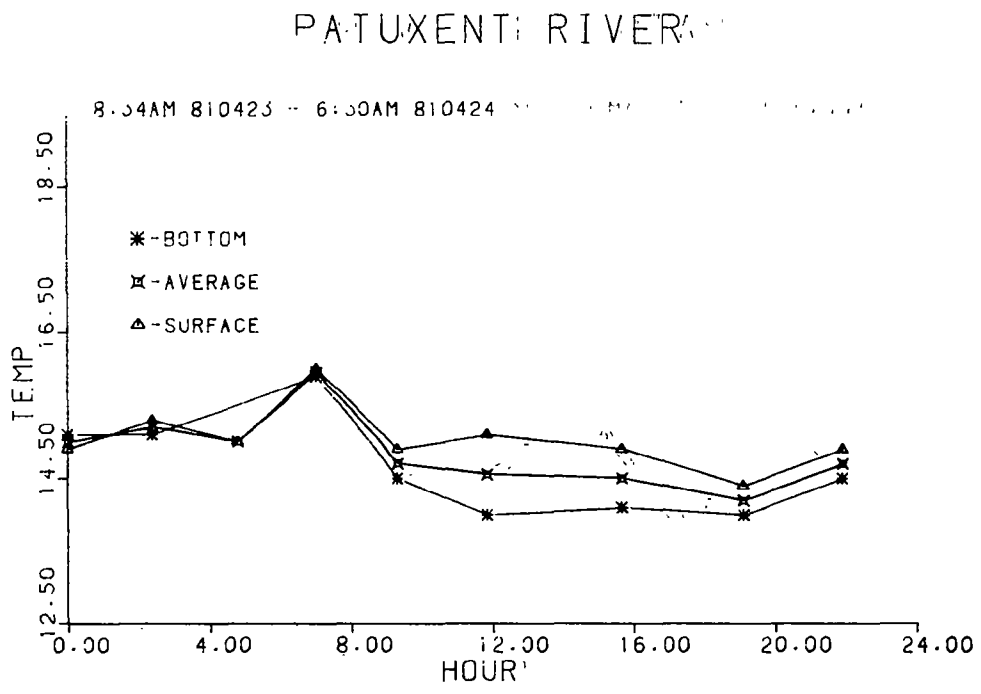
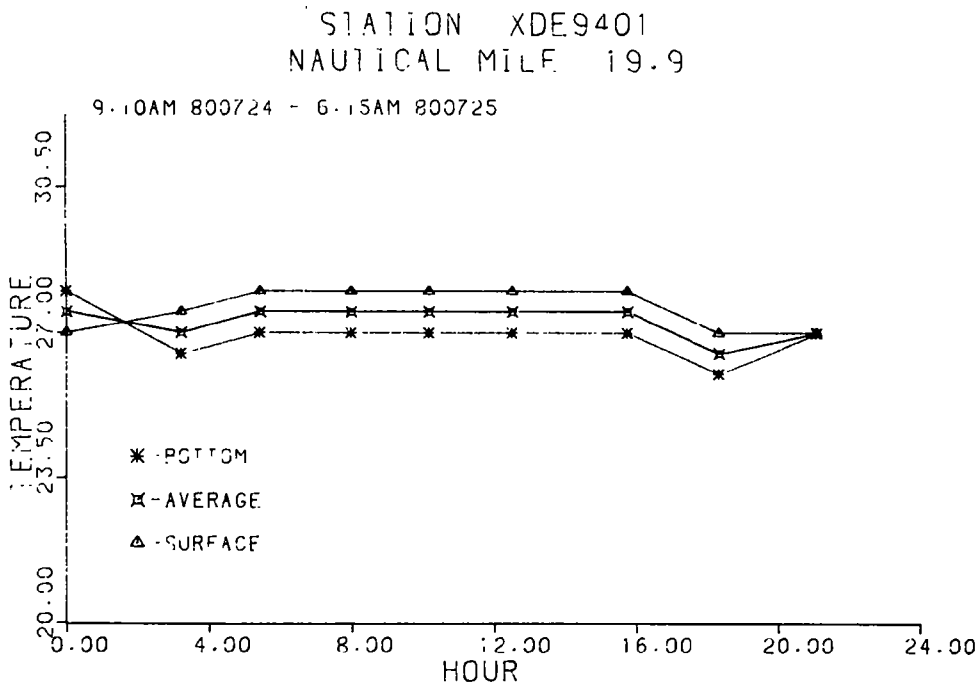


Figure 9-2 Intensive river survey plots of temperature.



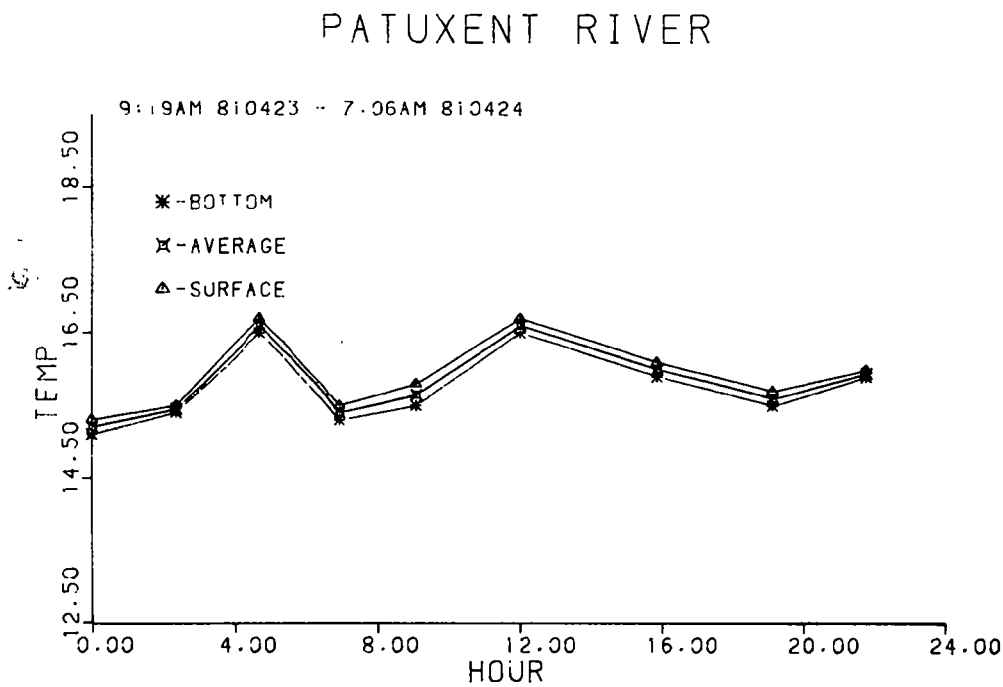
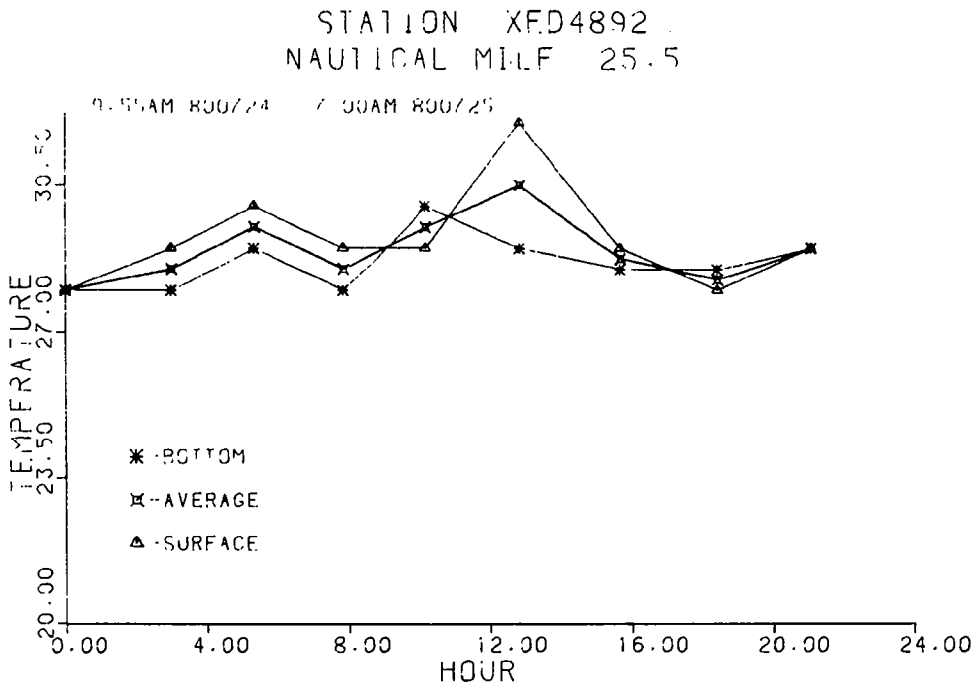


Figure 9-2 Intensive river survey plots of temperature.



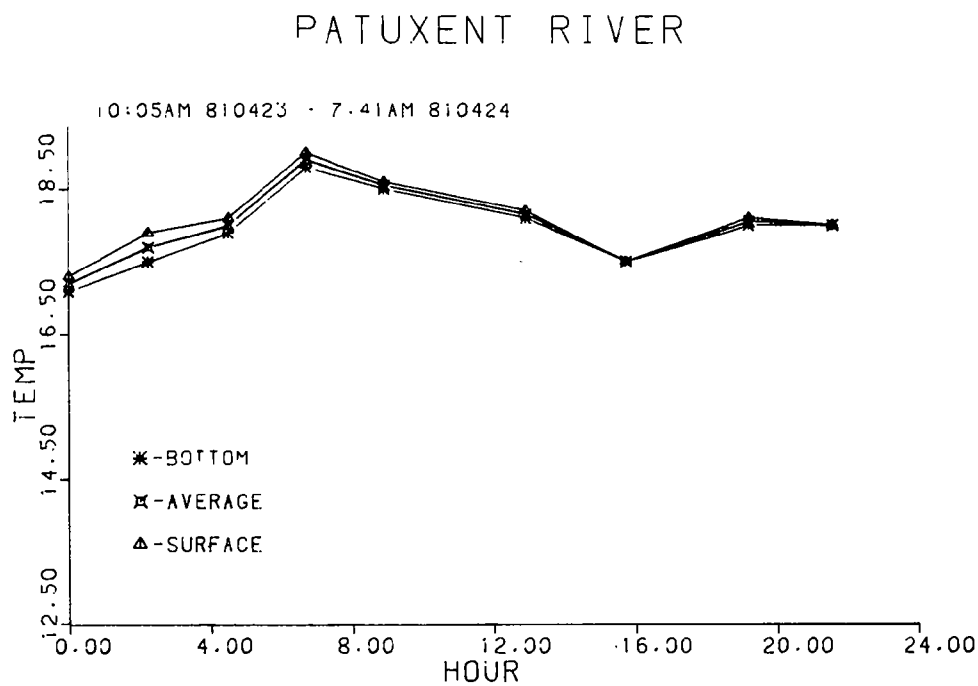
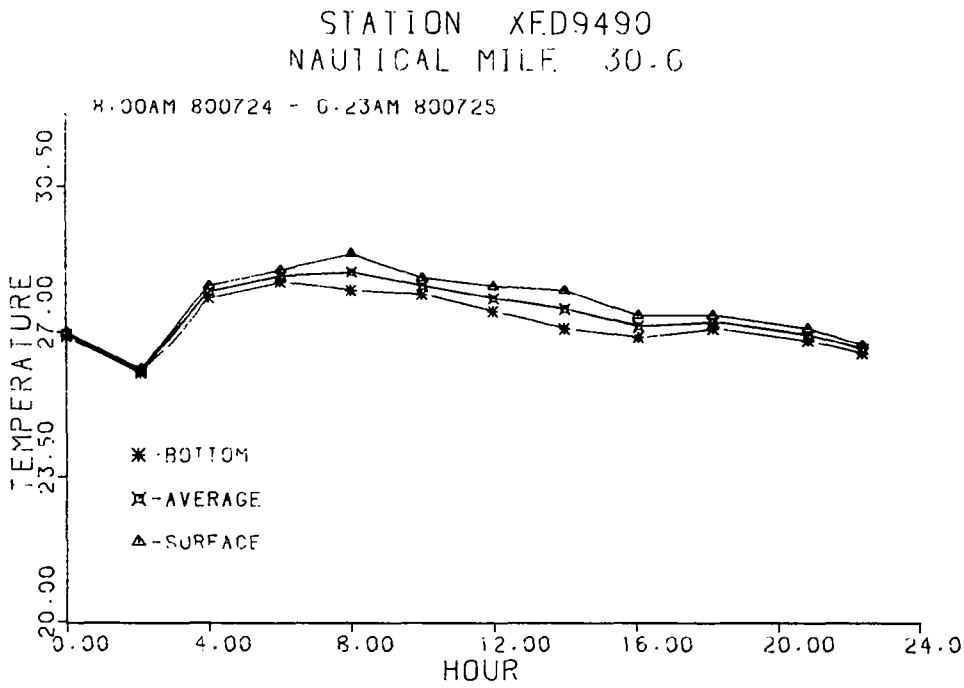


Figure 9-2 Intensive river survey plots of temperature.



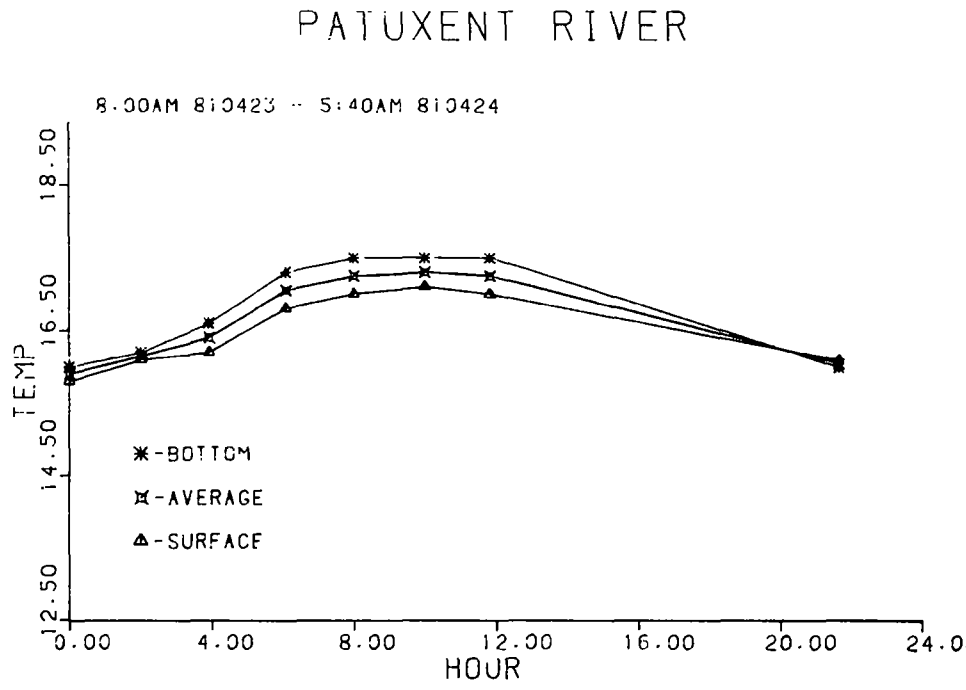
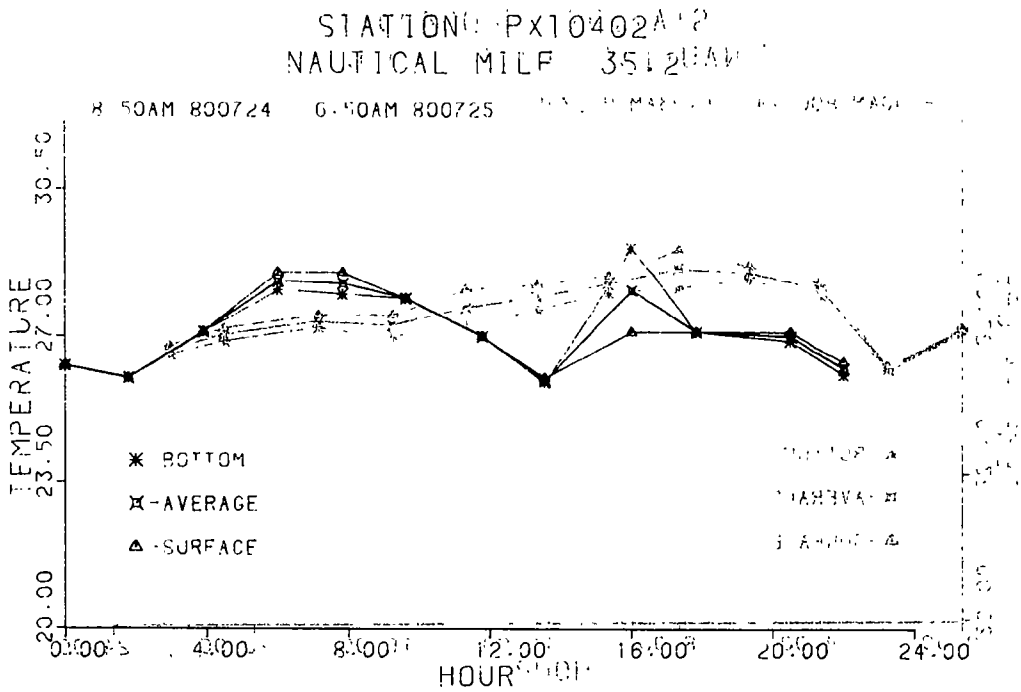


Figure 9-2 Intensive river survey plots of temperature.



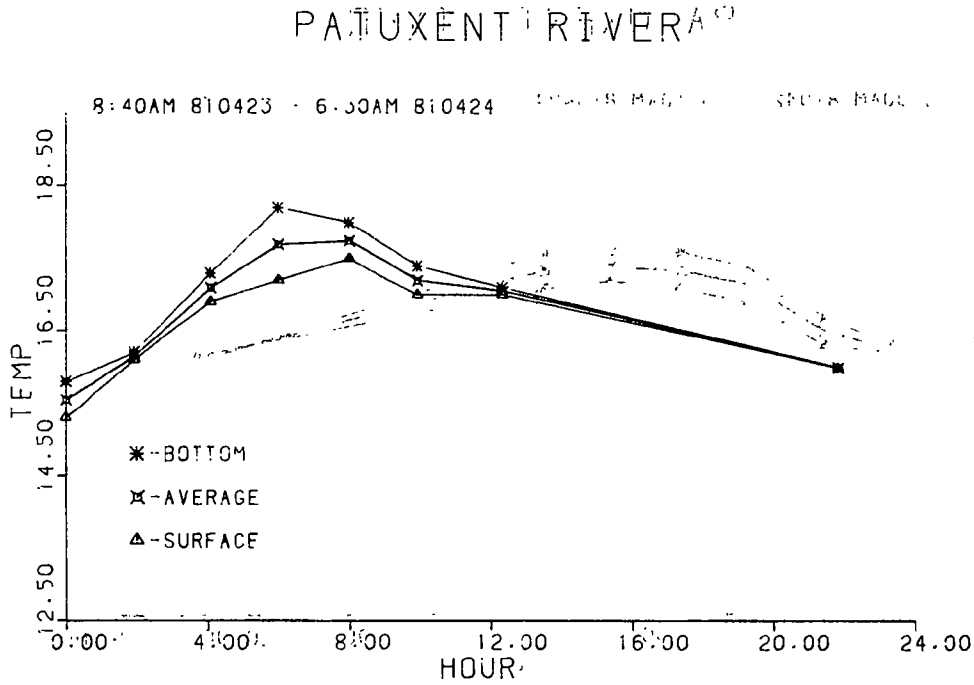
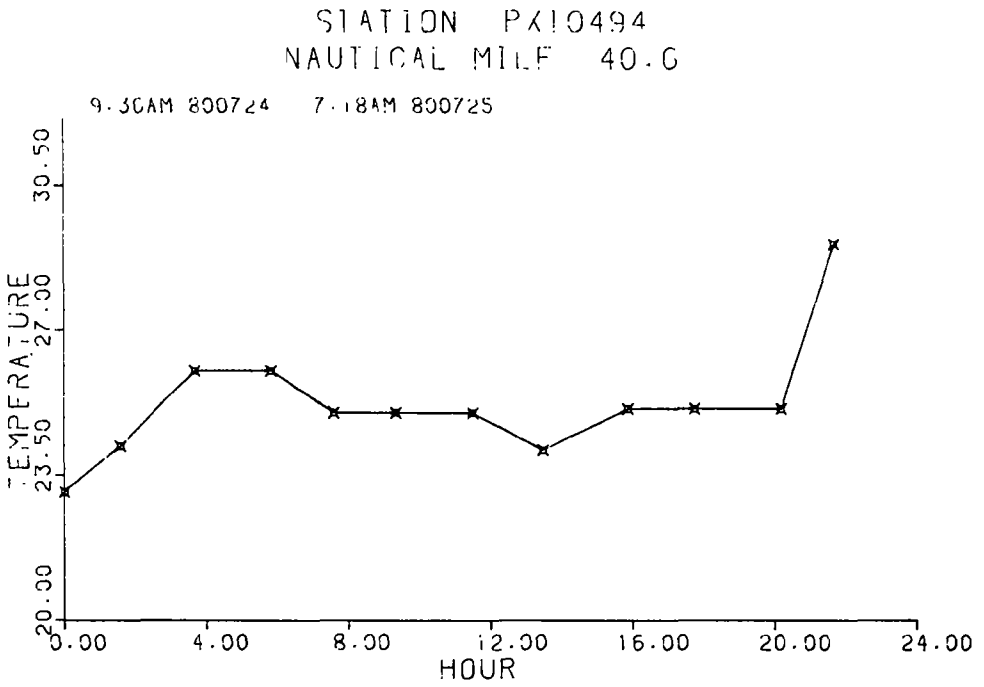


Figure 9-2 Intensive river survey plots of temperature.



PATUXENT RIVER

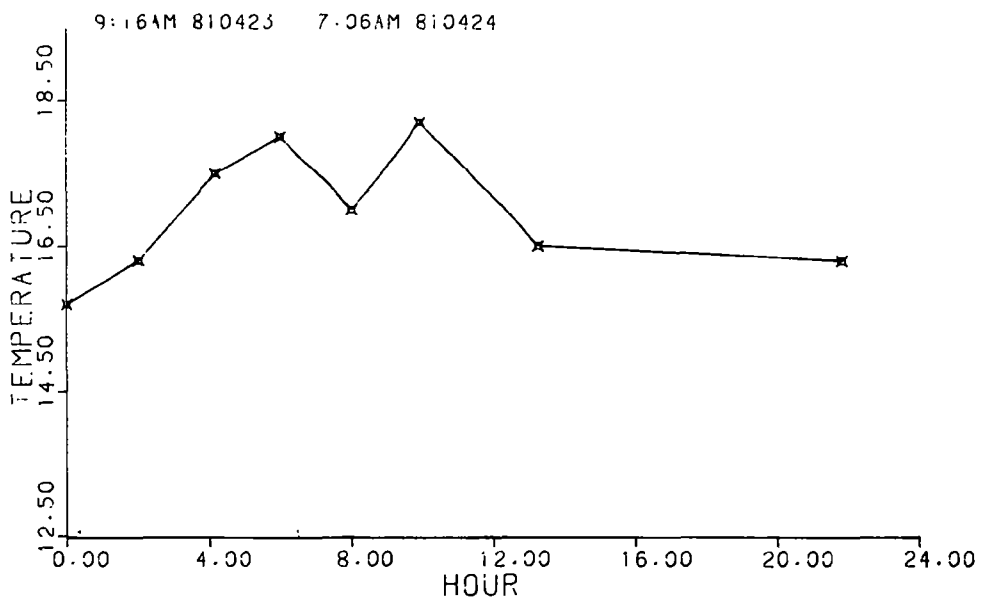
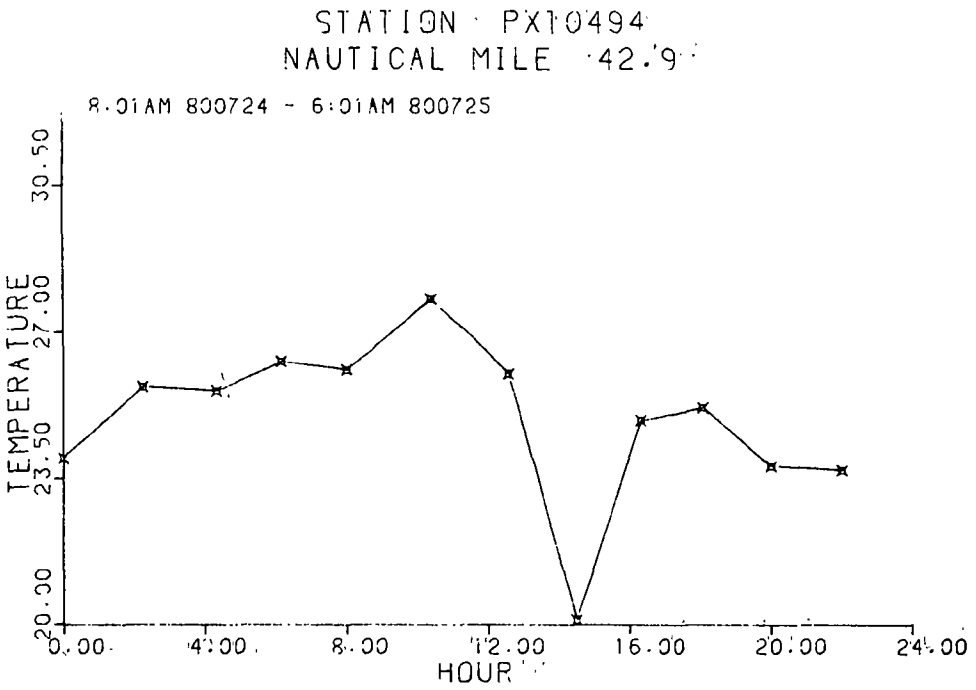


Figure 9-2 Intensive river survey plots of temperature.



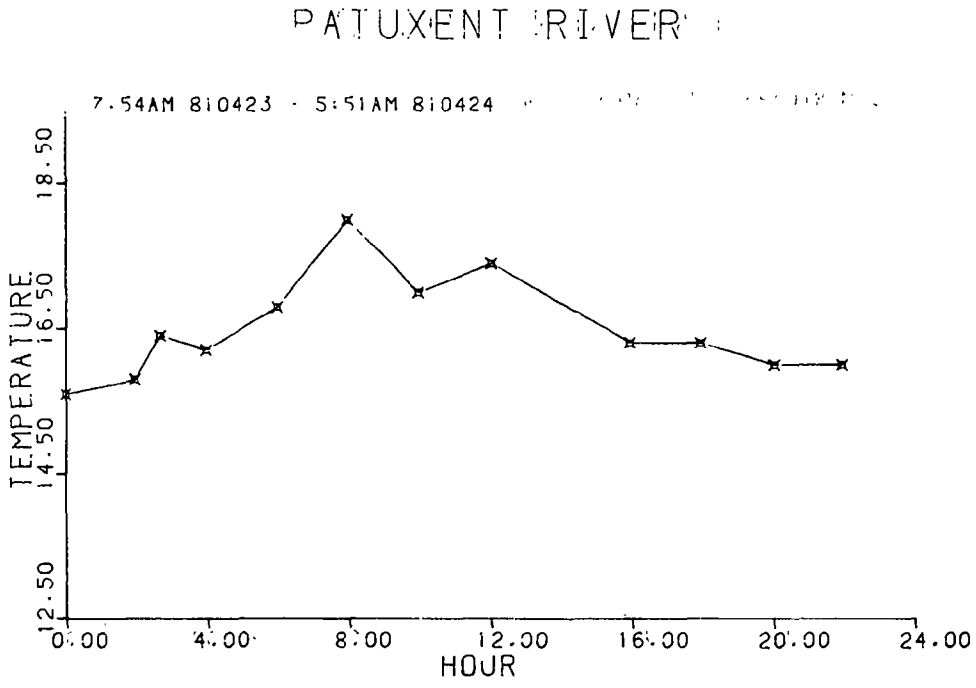
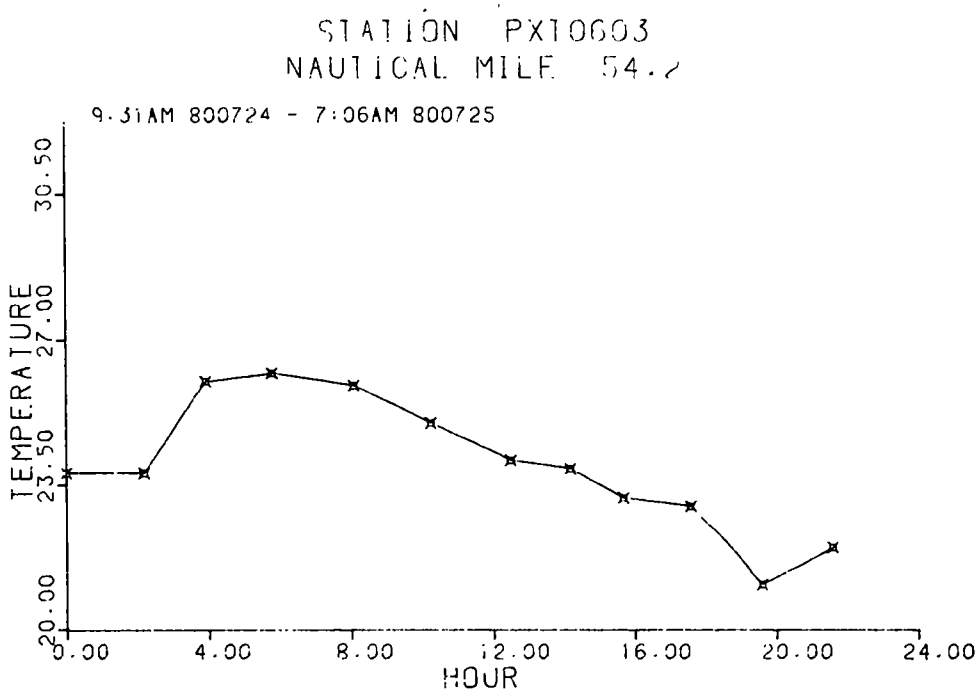


Figure 9-2 Intensive river survey plots of temperature.



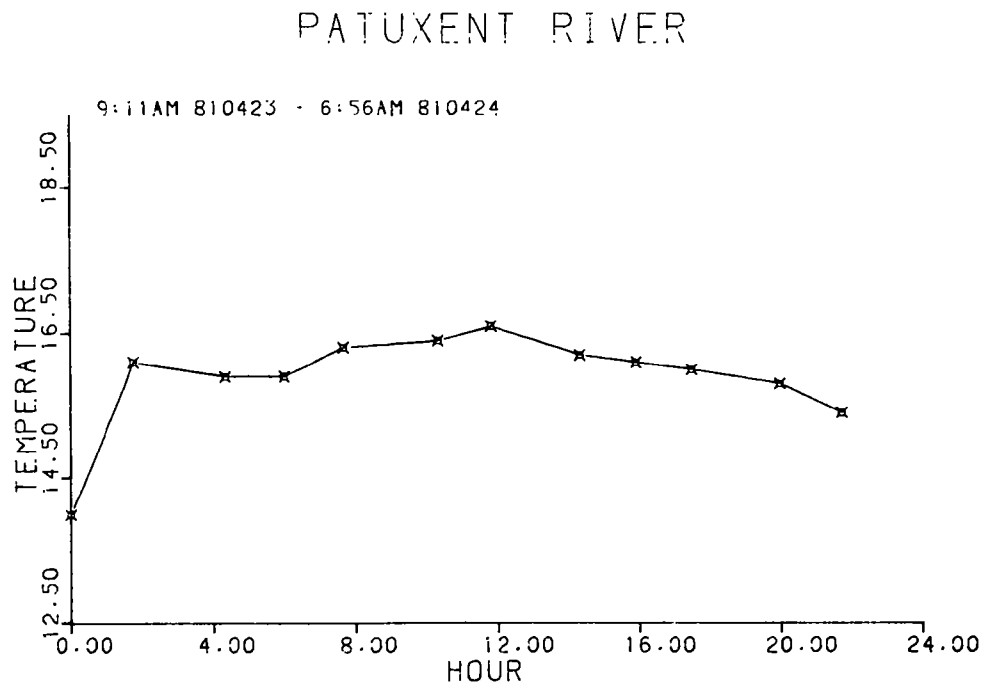
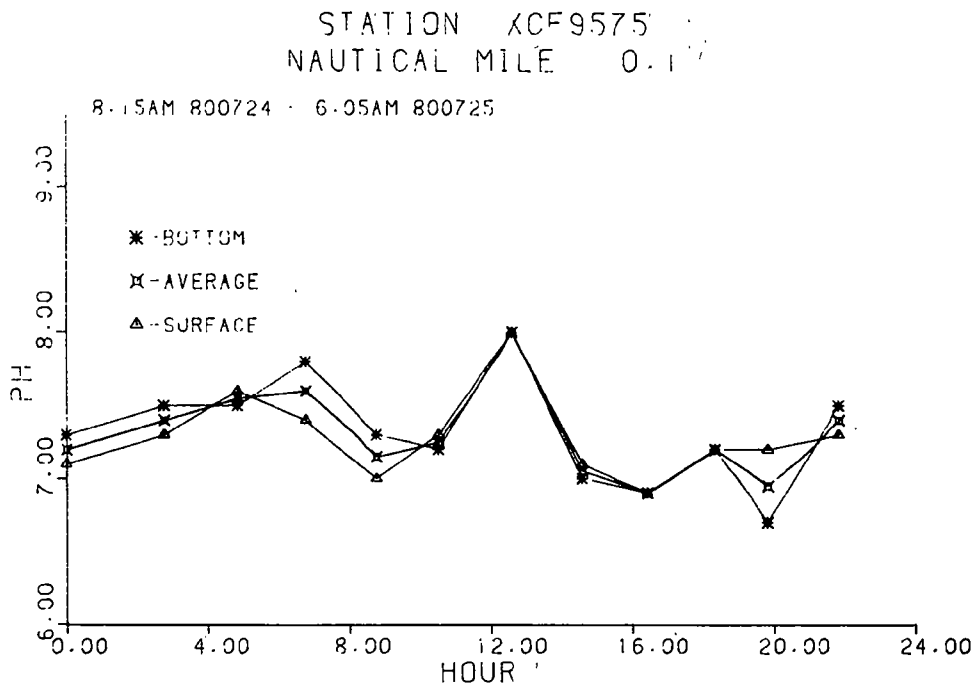


Figure 9-2 Intensive river survey plots of temperature.



PATUXENT RIVER

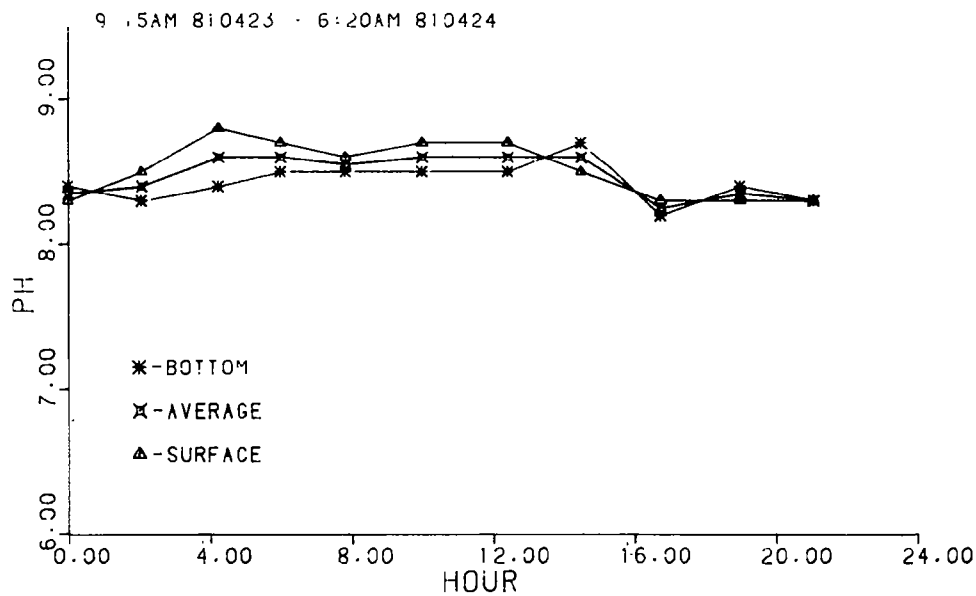
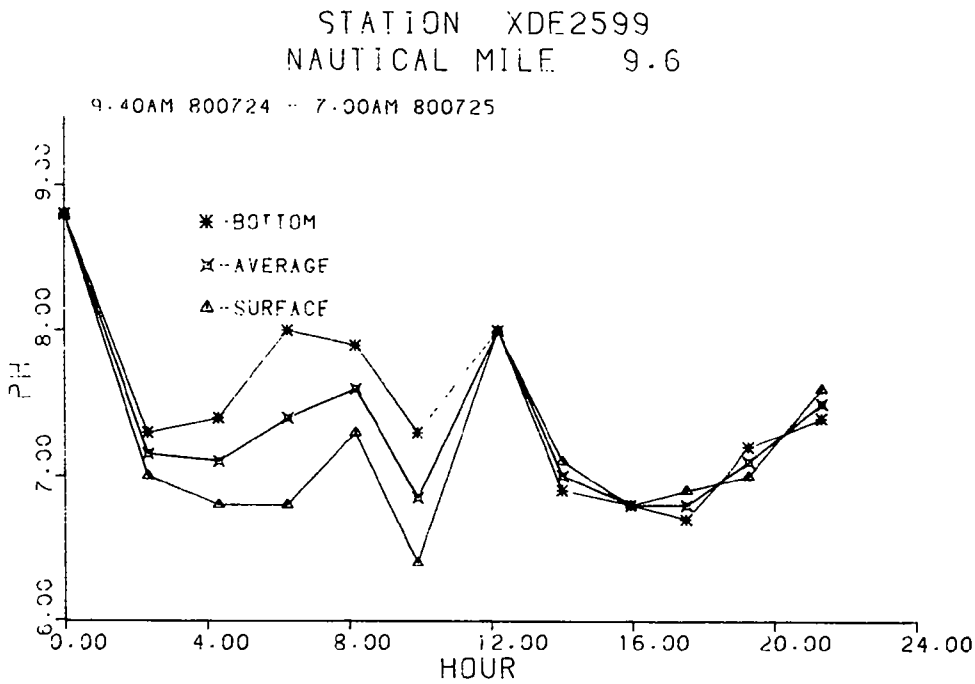


Figure 9-3 Intensive river survey plots of pH.



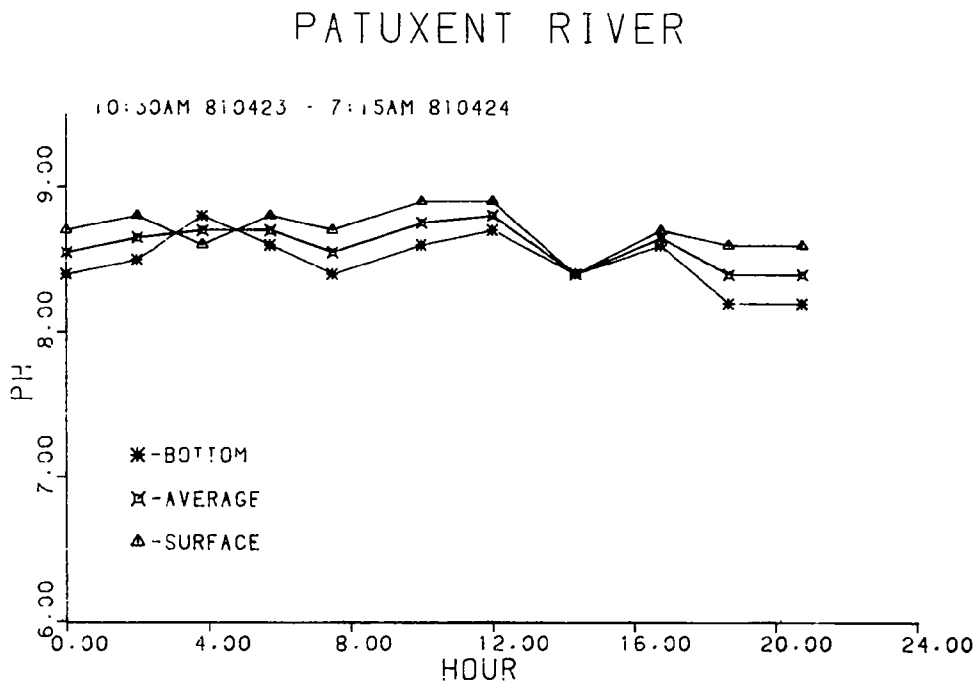
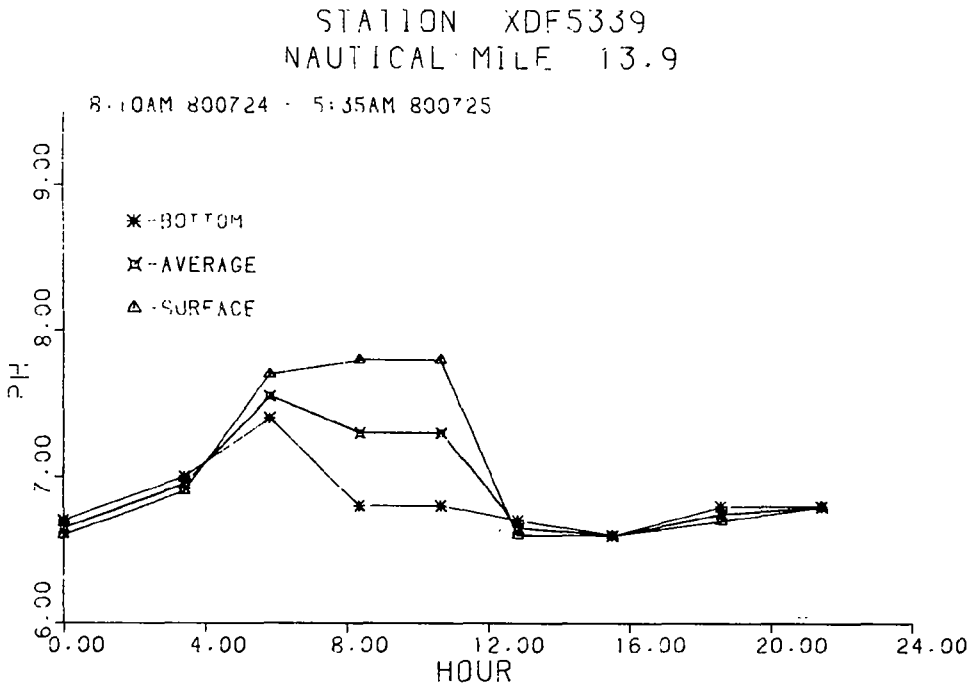


Figure 9-3 Intensive river survey plots of pH.



PATUXENT RIVER

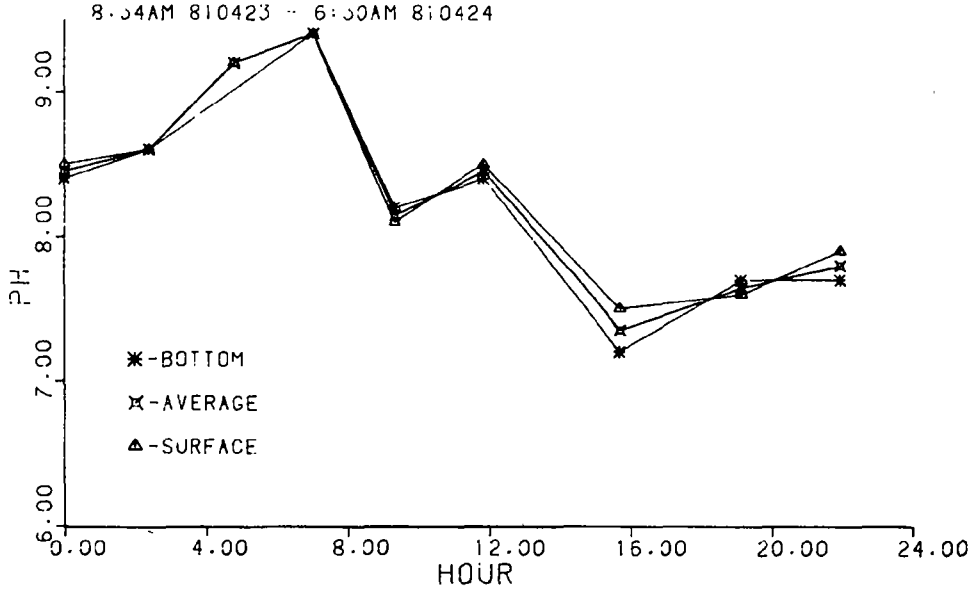
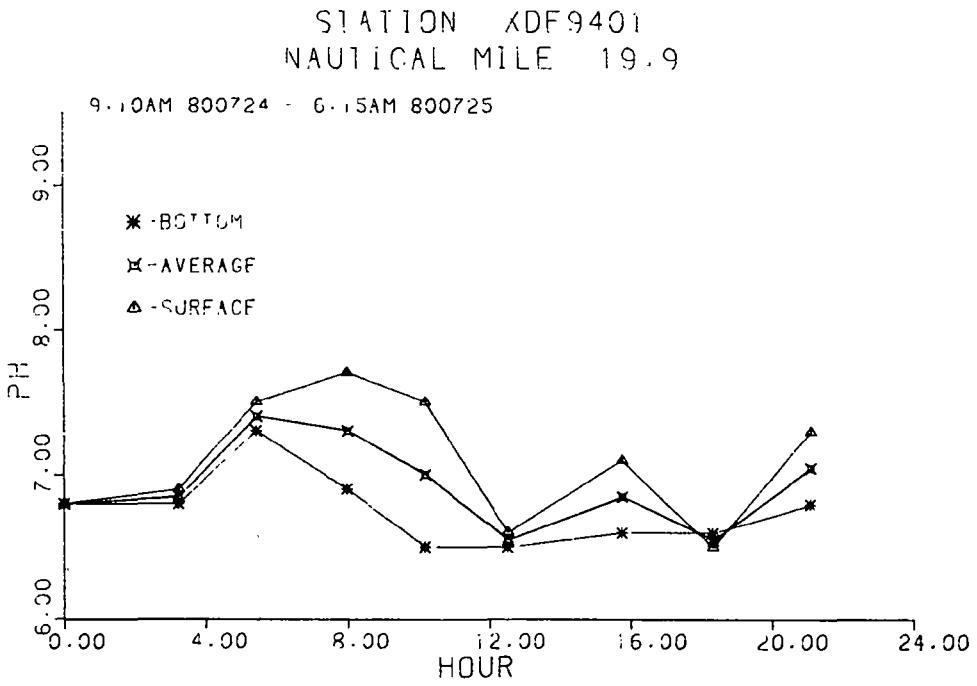


Figure 9-3 Intensive river survey plots of pH.



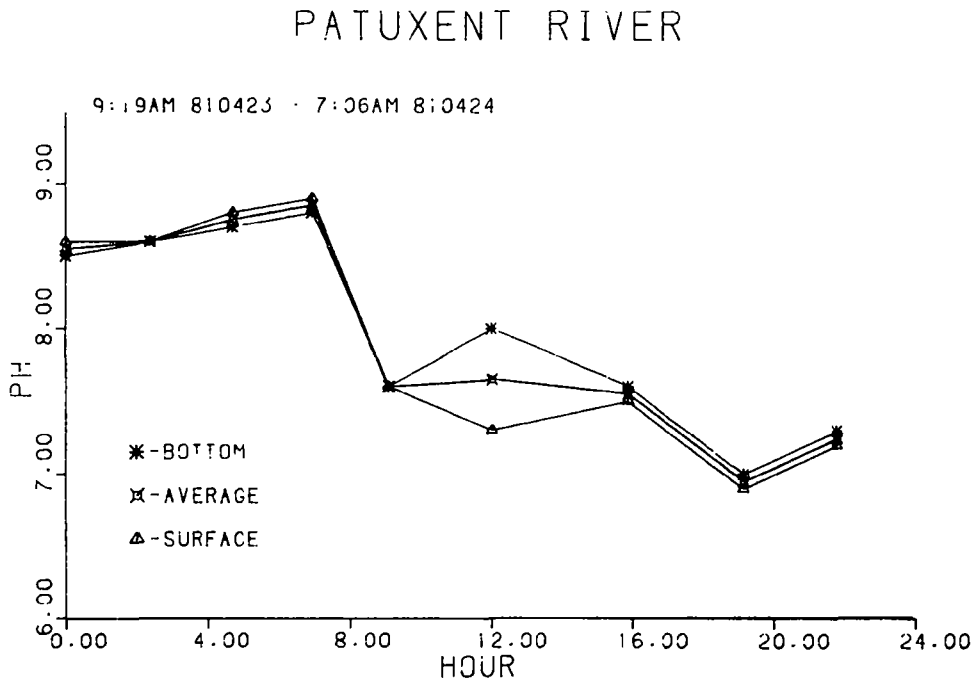
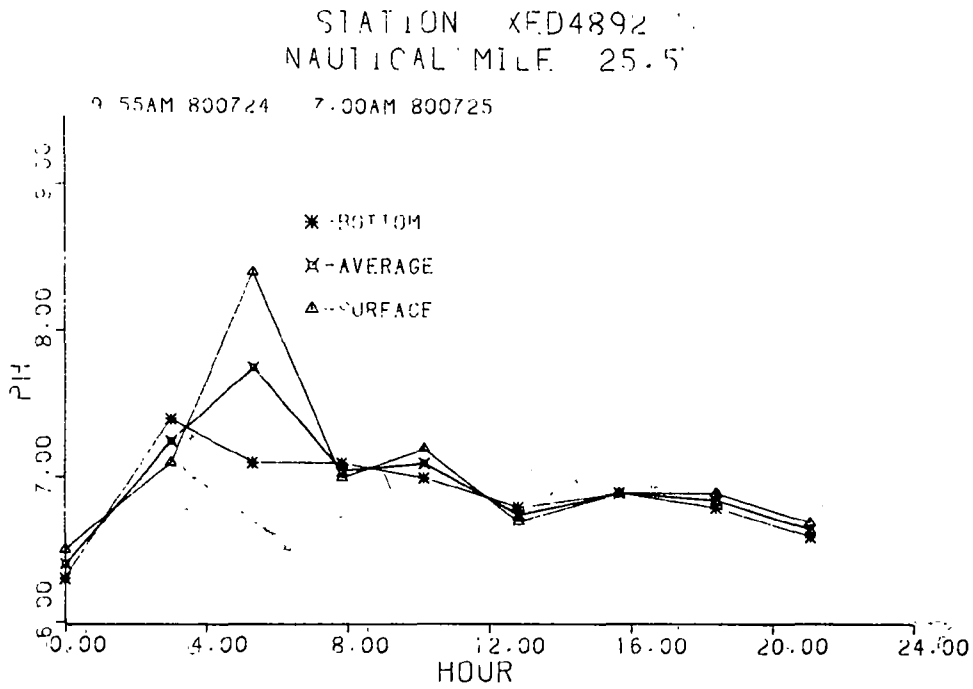


Figure 9-3 Intensive river survey plots of pH.



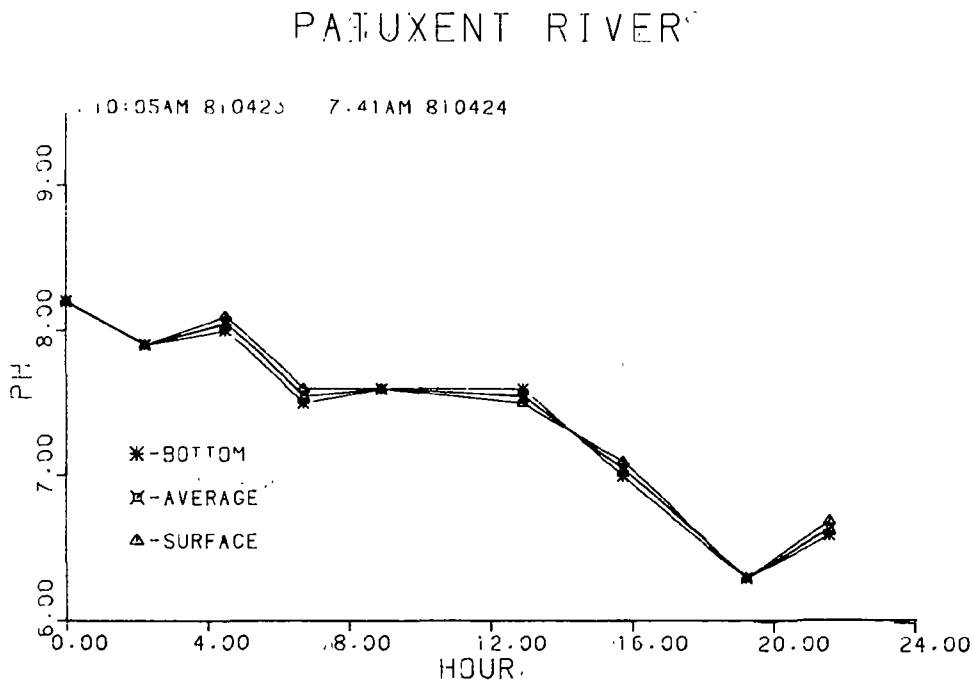
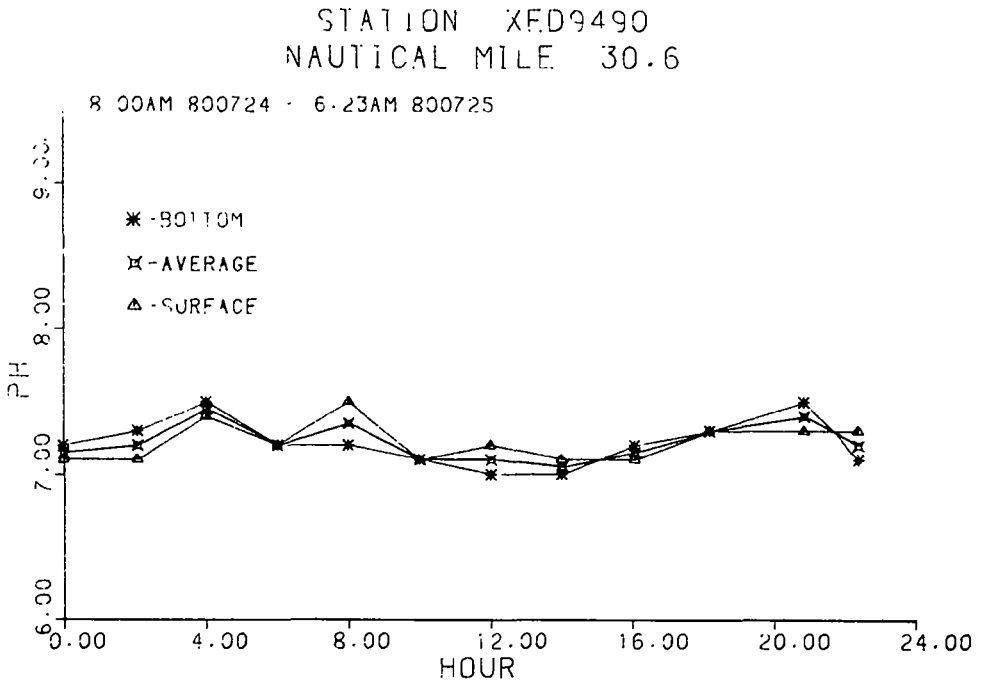


Figure 9-3 Intensive river survey plots of pH.



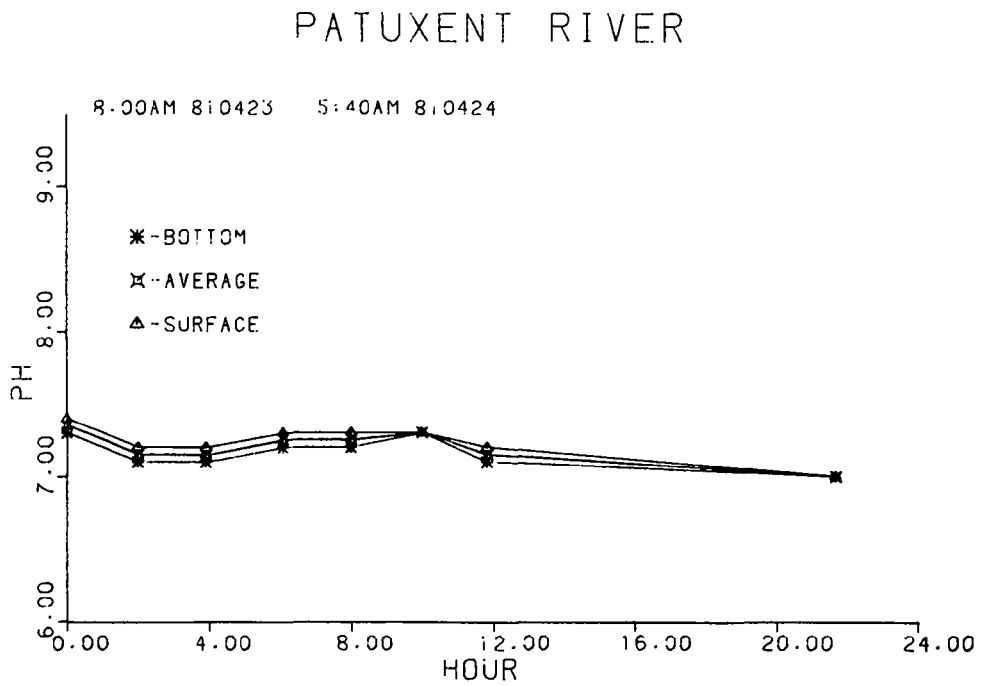
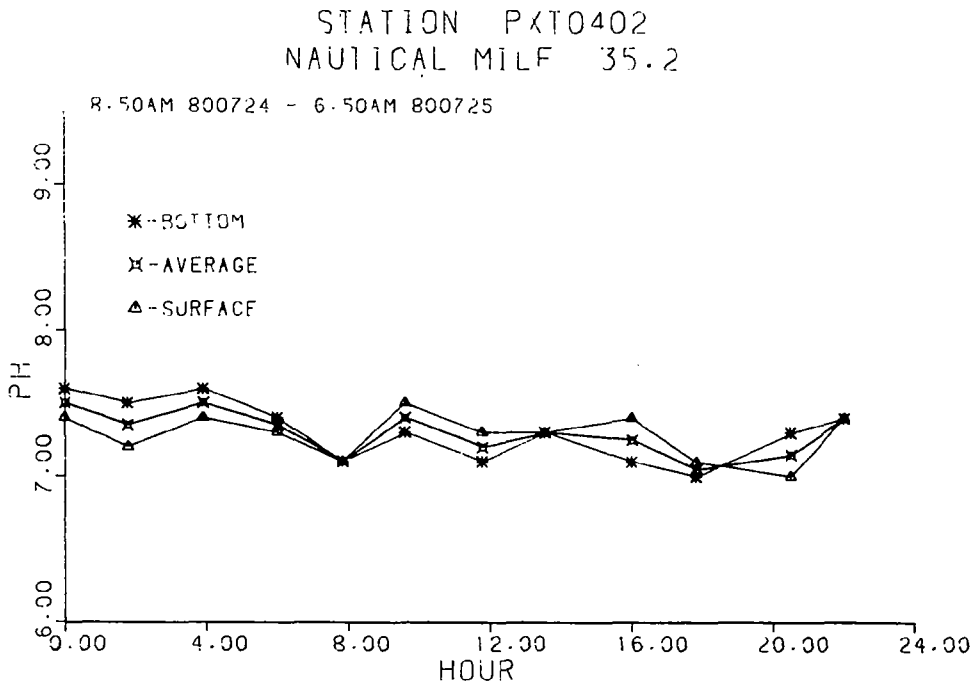


Figure 9-3 Intensive river survey plots of pH.



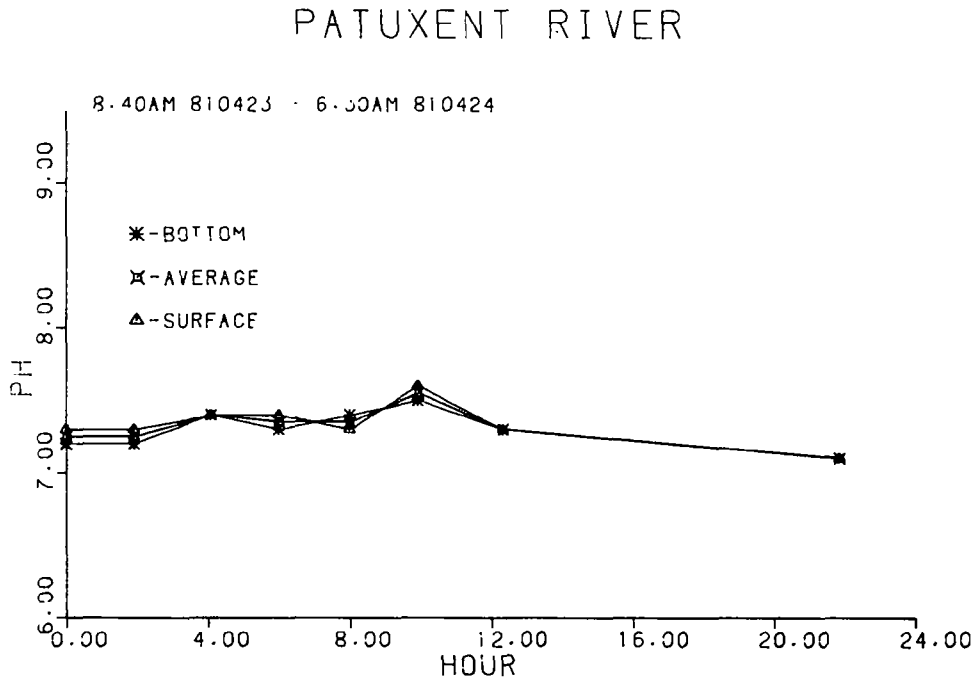
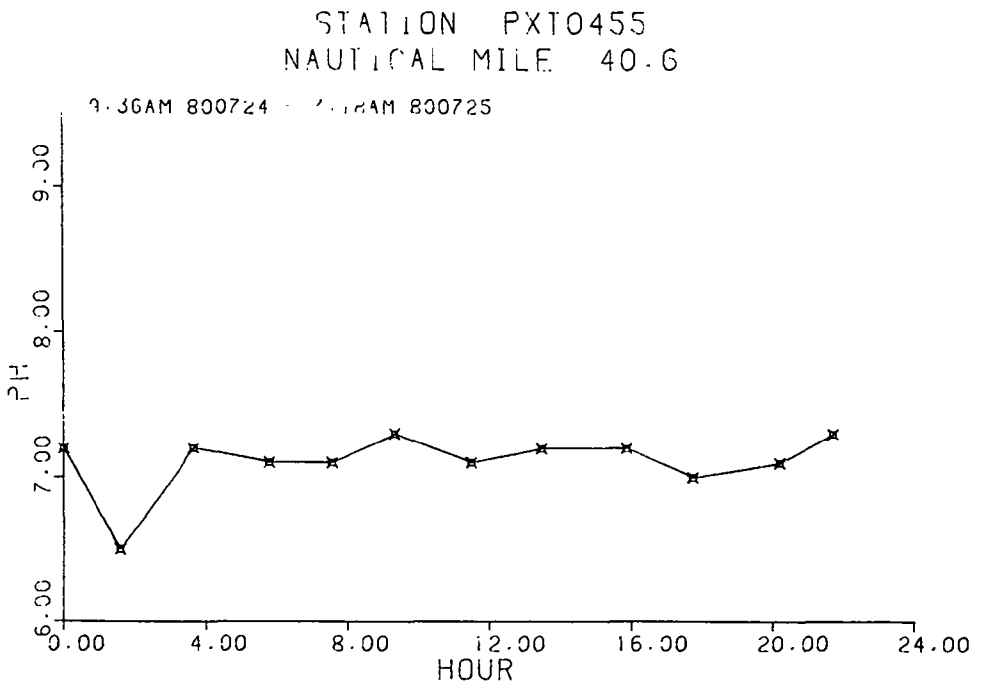


Figure 9-3 Intensive river survey plots of pH.



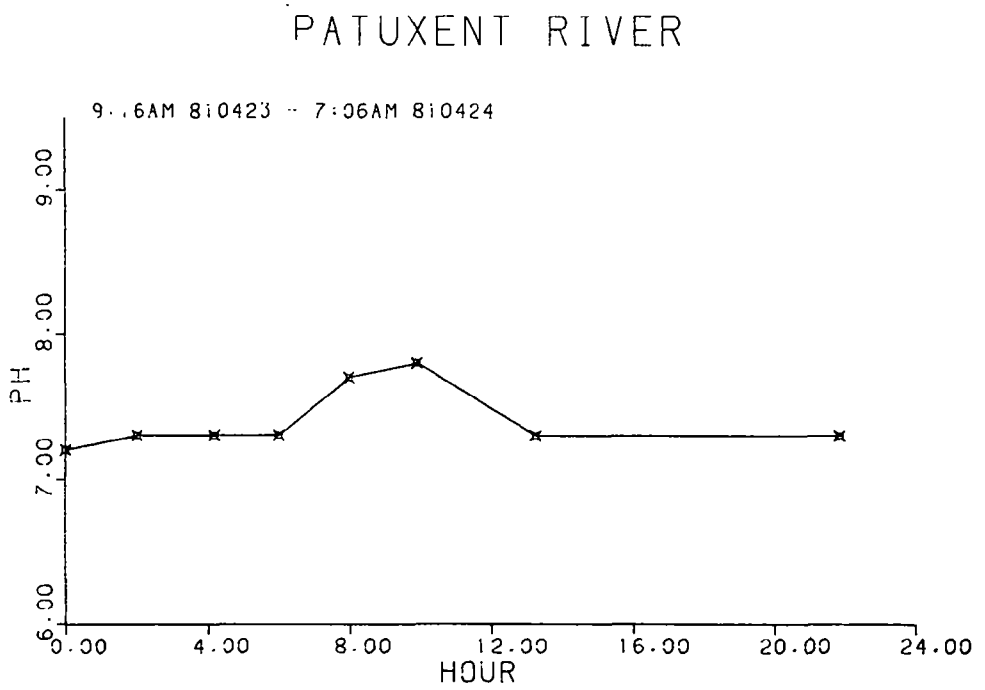
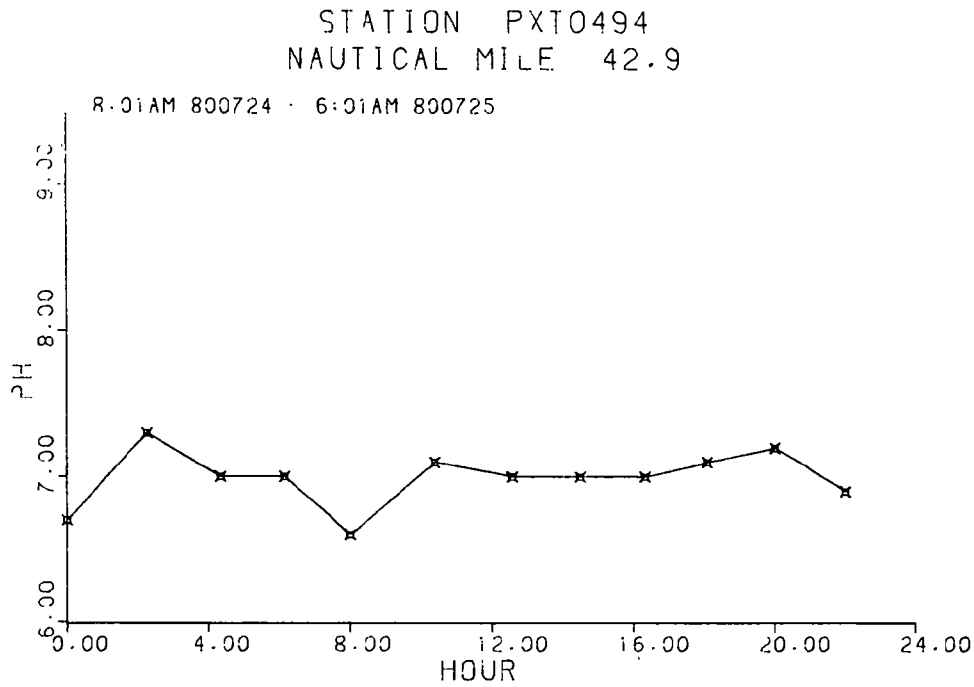


Figure 9-3 Intensive river survey plots of pH.



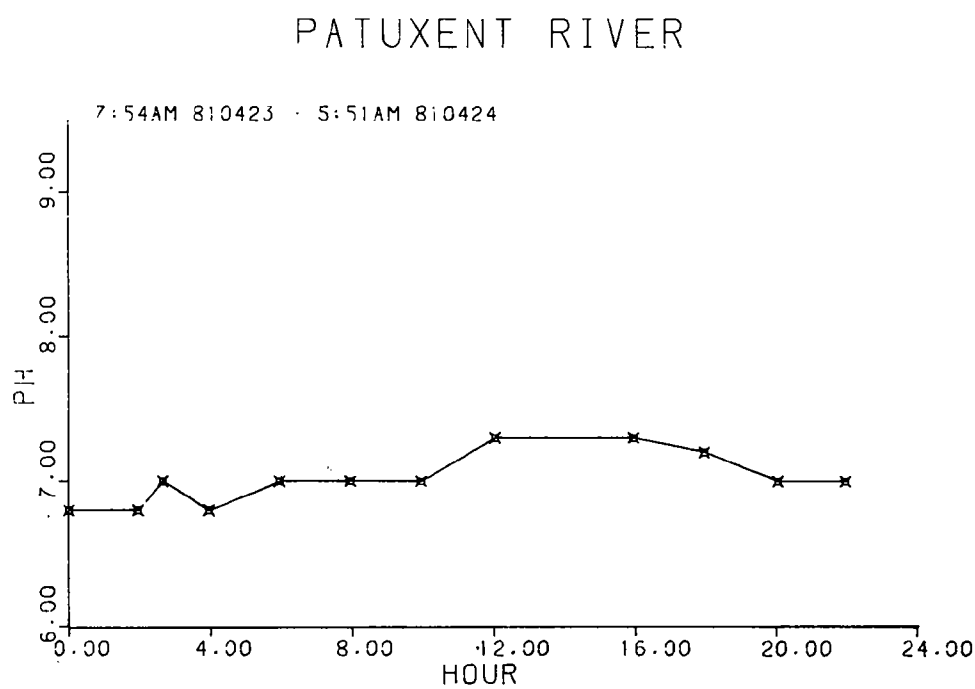
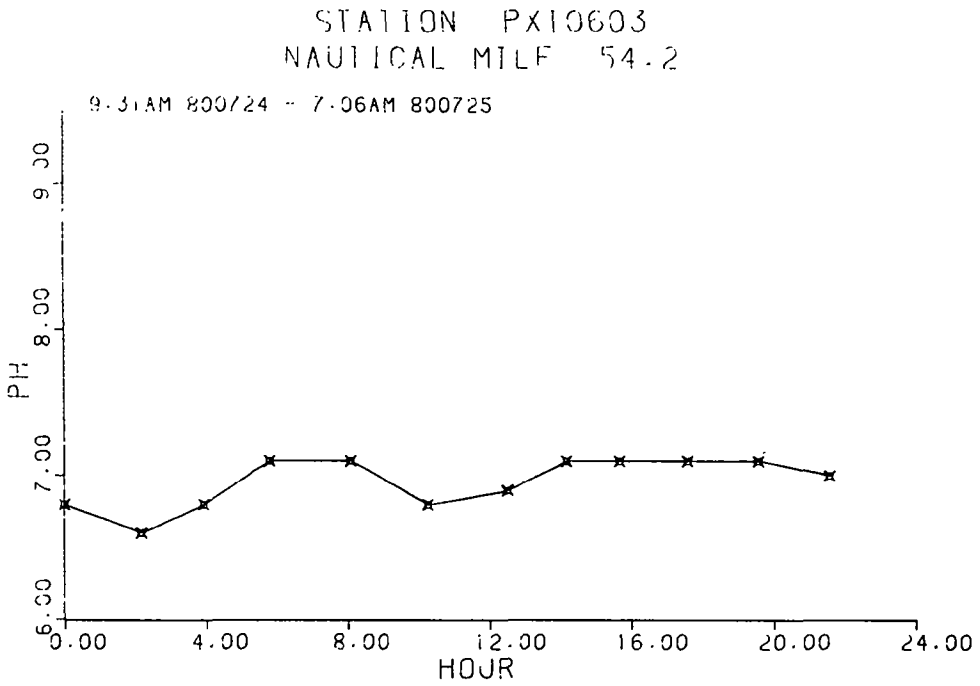


Figure 9-3 Intensive river survey plots of pH.



PATUXENT RIVER

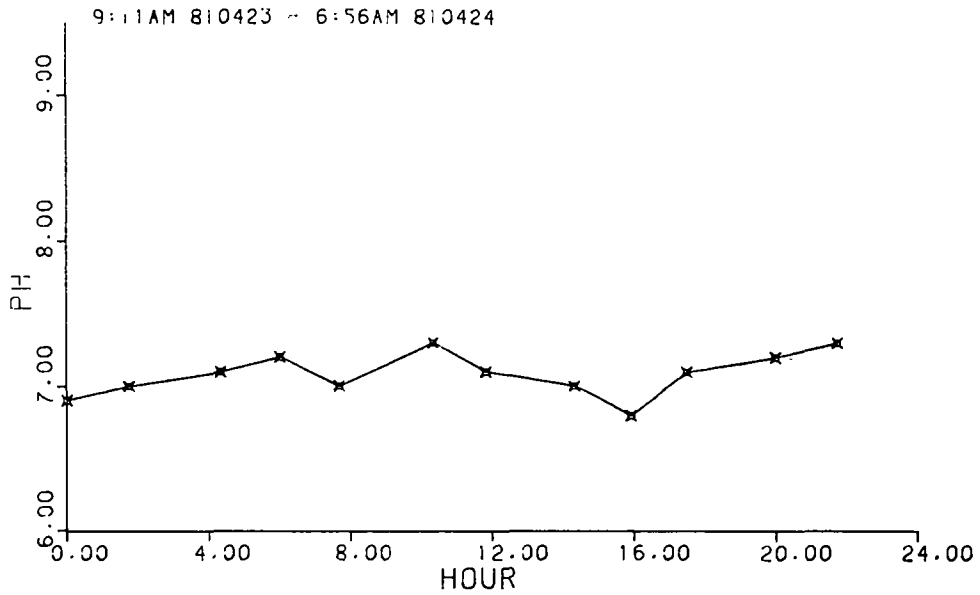
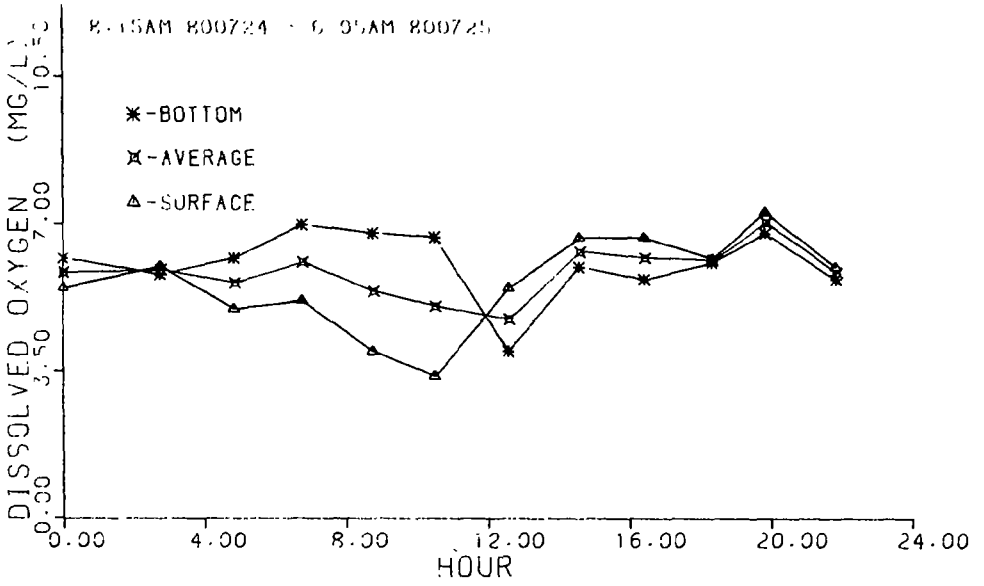


Figure 9-3 Intensive river survey plots of pH.

STATION XCF9575
NAUTICAL MILE 0.1



PATUXENT RIVER

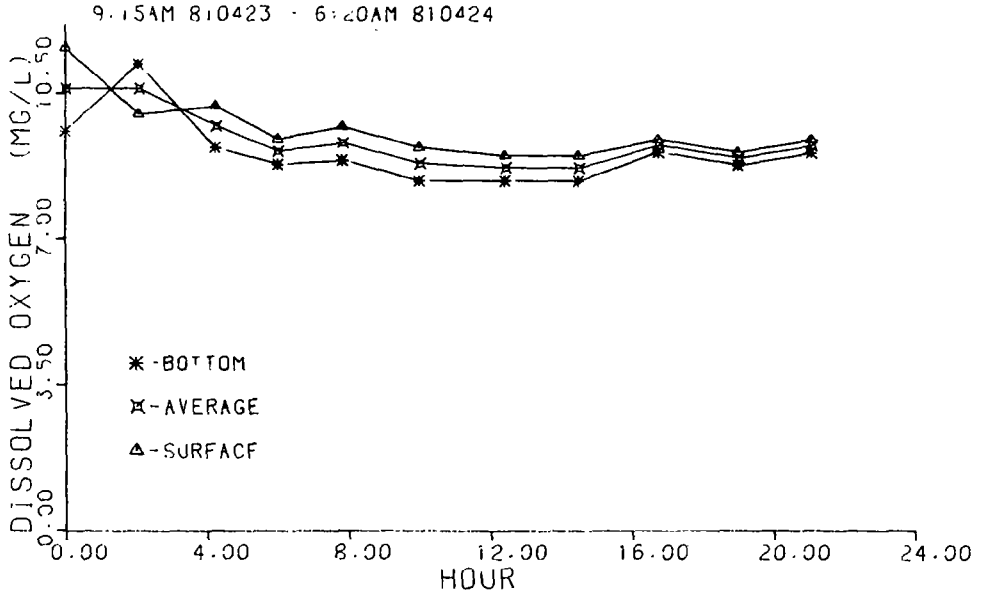
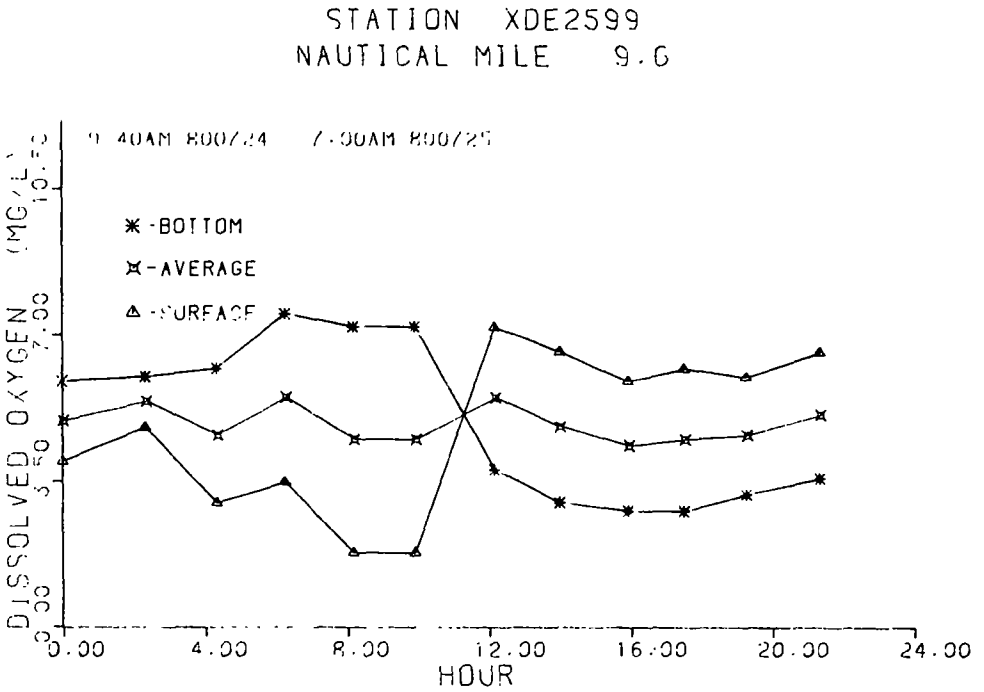


Figure 9-4 Intensive river survey plots of Dissolved Oxygen.



PATUXENT RIVER

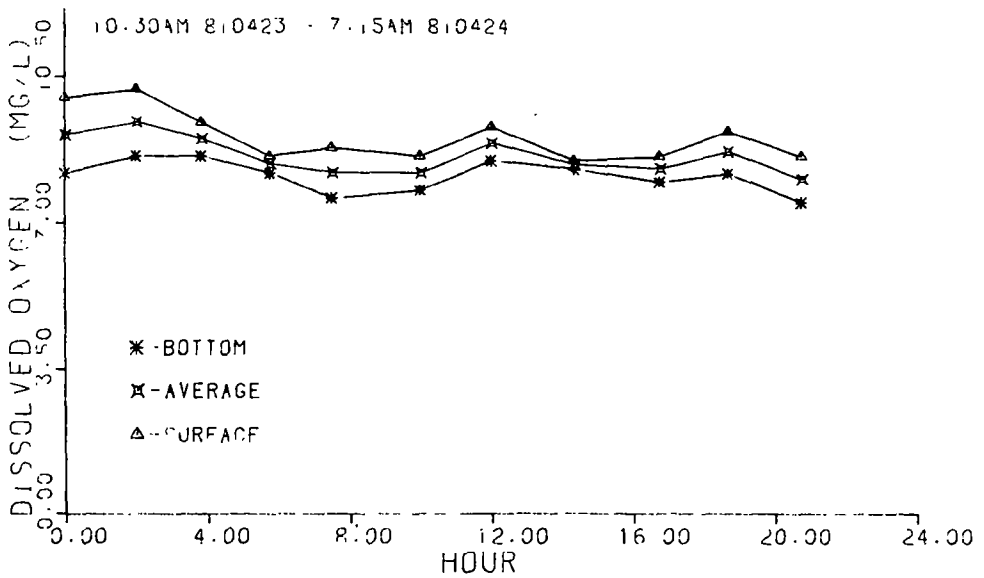
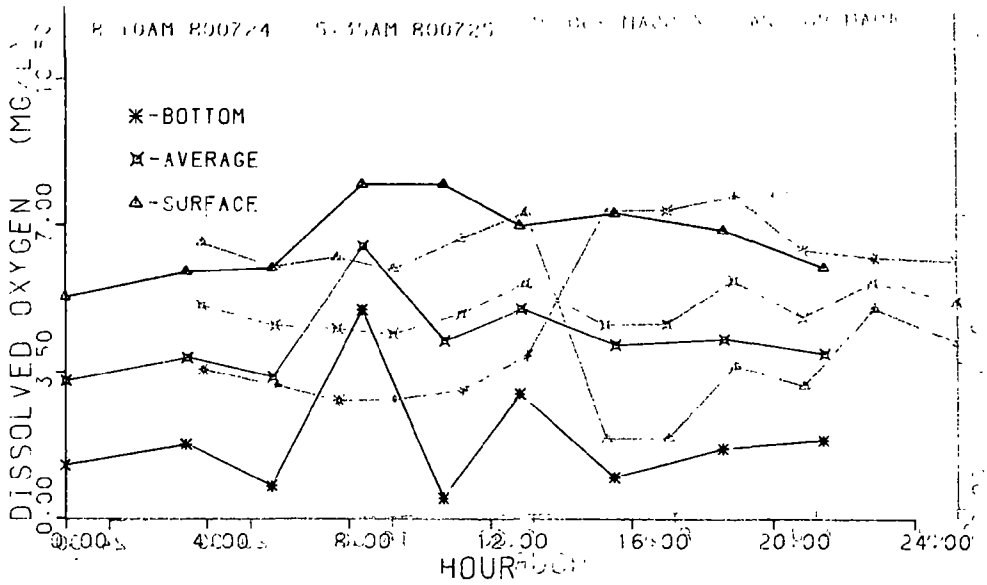


Figure 9-4 Intensive river survey plots of Dissolved Oxygen.

STATION XDE5339
NAUTICAL MILE 13.9



PATUXENT RIVER

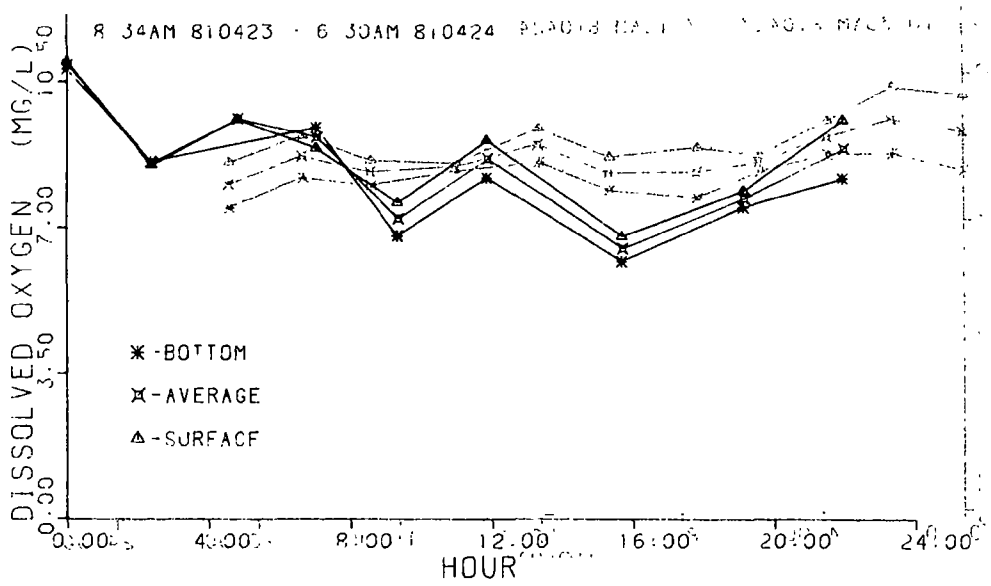
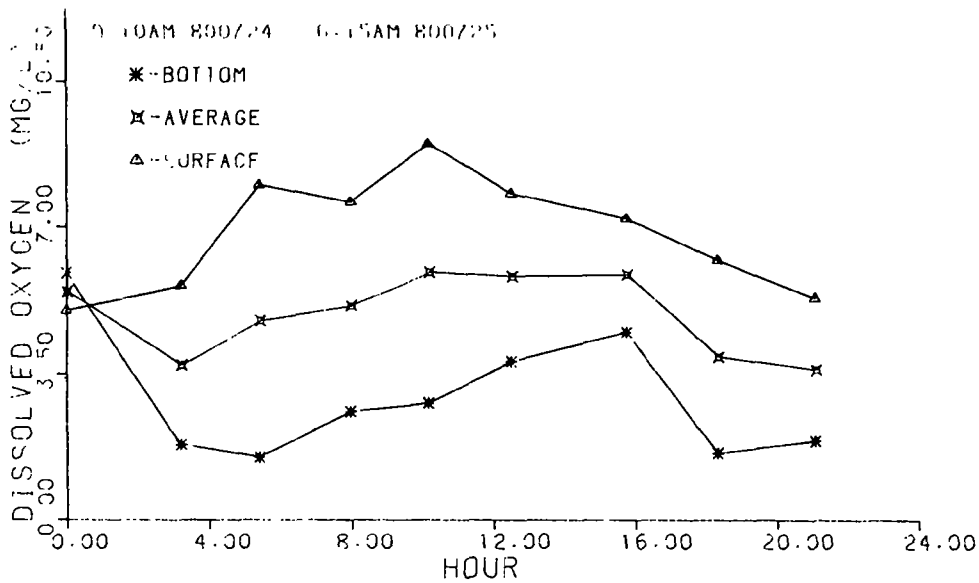


Figure 9-4 Intensive river survey plots of Dissolved Oxygen

STATION XDE9401
NAUTICAL MILE 19.9



PATUXENT RIVER

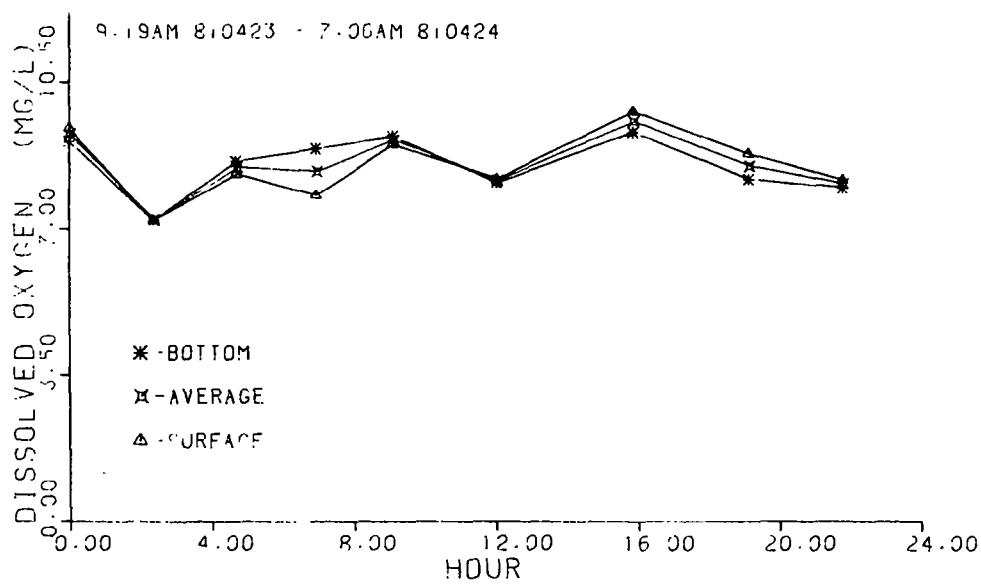
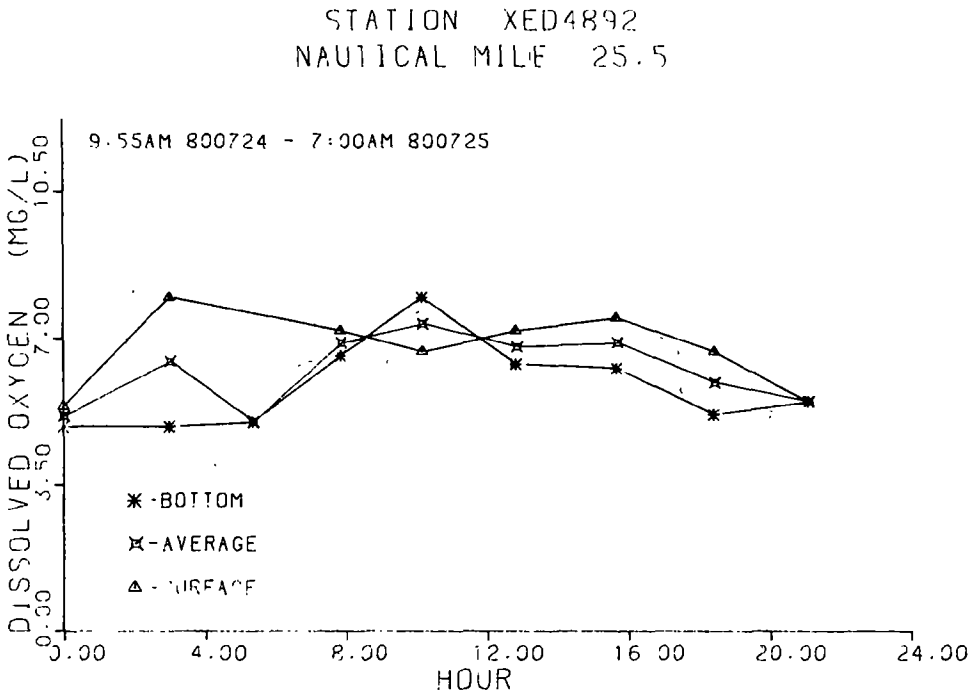


Figure 9-4 Intensive river survey plots of Dissolved Oxygen.



PATUXENT RIVER

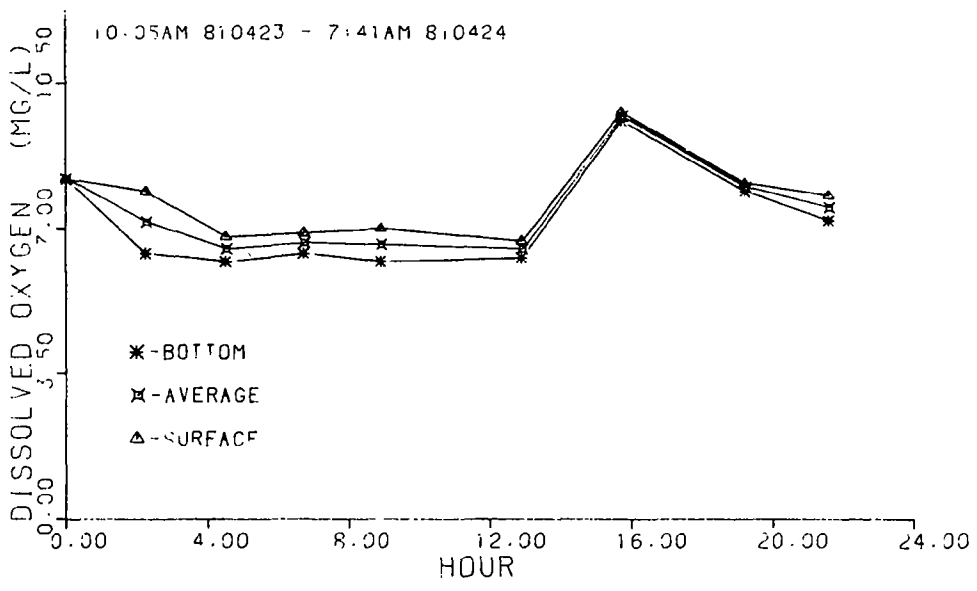
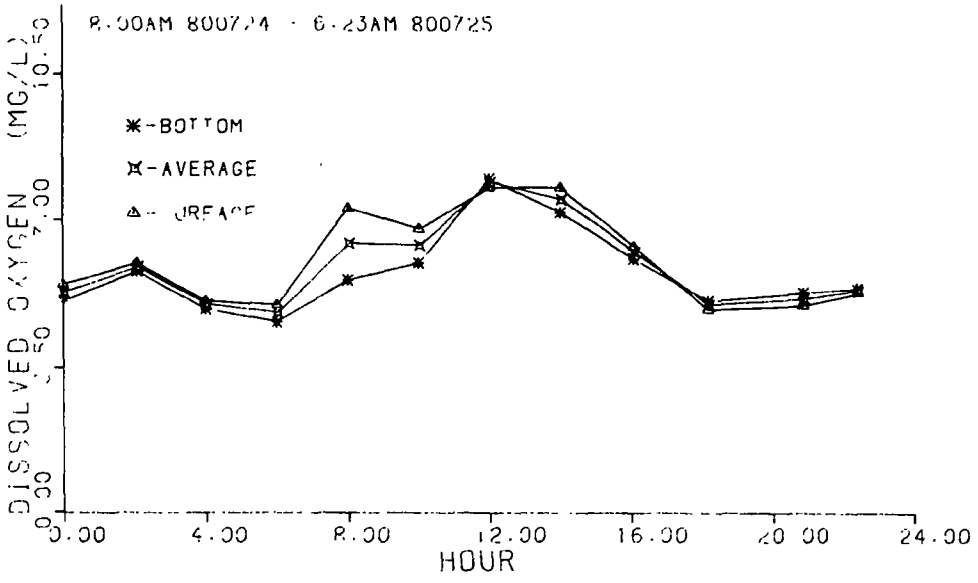


Figure 9-4 Intensive river survey plots of Dissolved Oxygen.

STATION XED9490
NAUTICAL MILE 30.0



PATUXENT RIVER

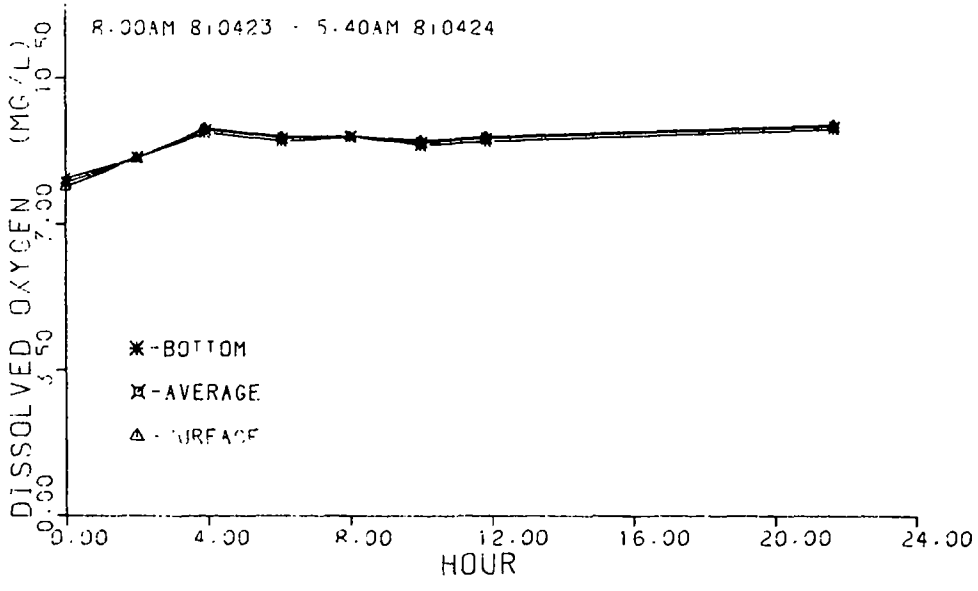
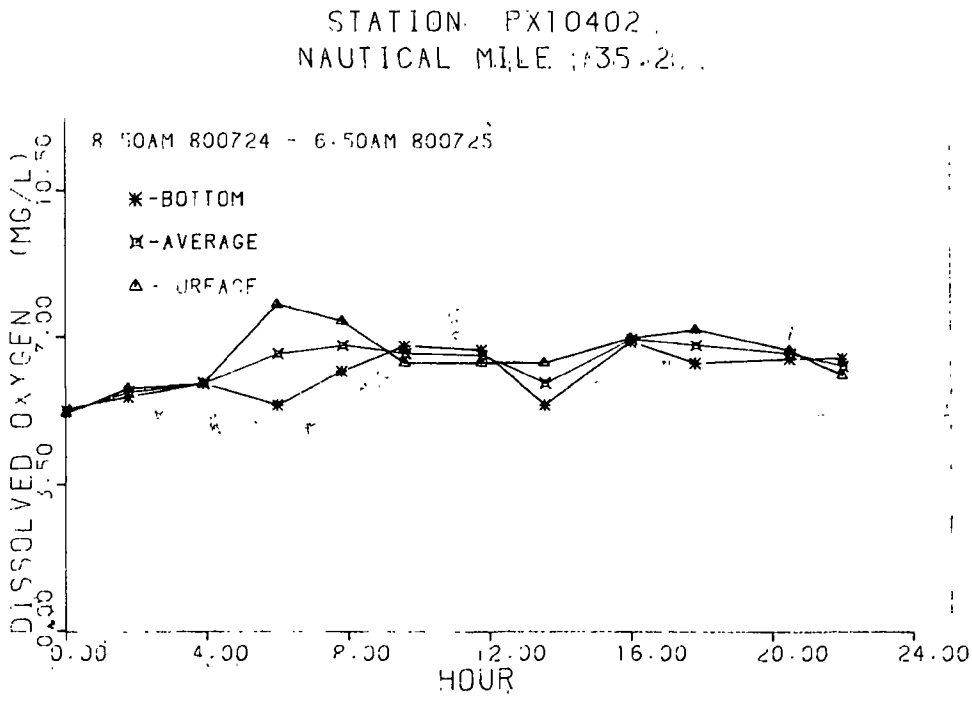


Figure 9-4 Intensive river survey plots of Dissolved Oxygen.



PATUXENT RIVER

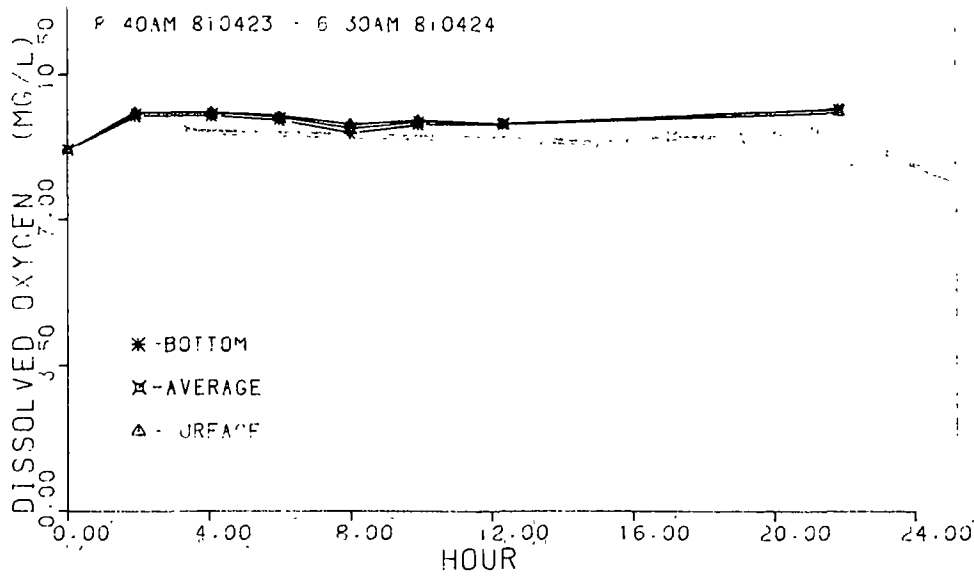
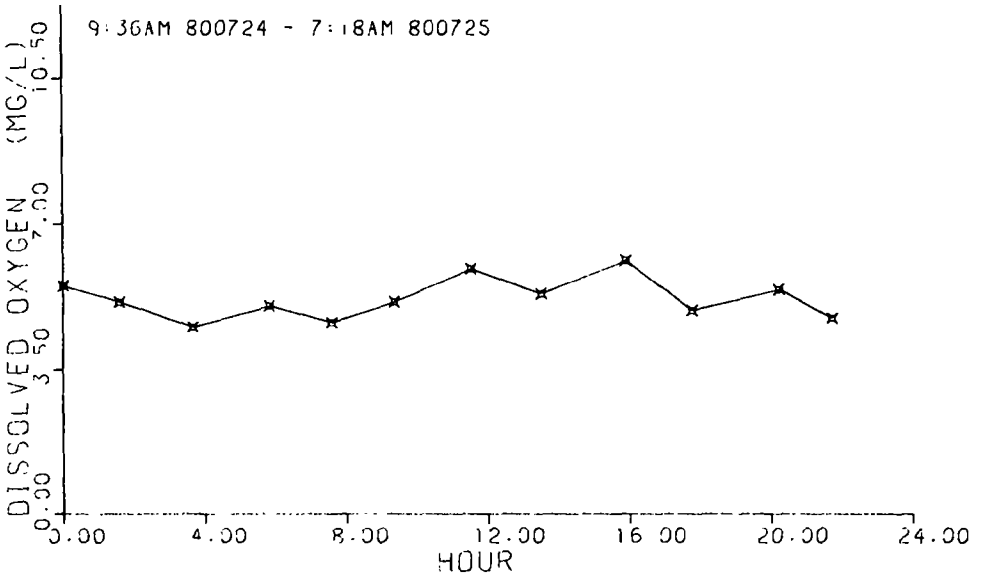


Figure 9-4 Intensive river survey plots of Dissolved Oxygen.

STATION PXT0455
NAUTICAL MILE 40.6



PATUXENT RIVER

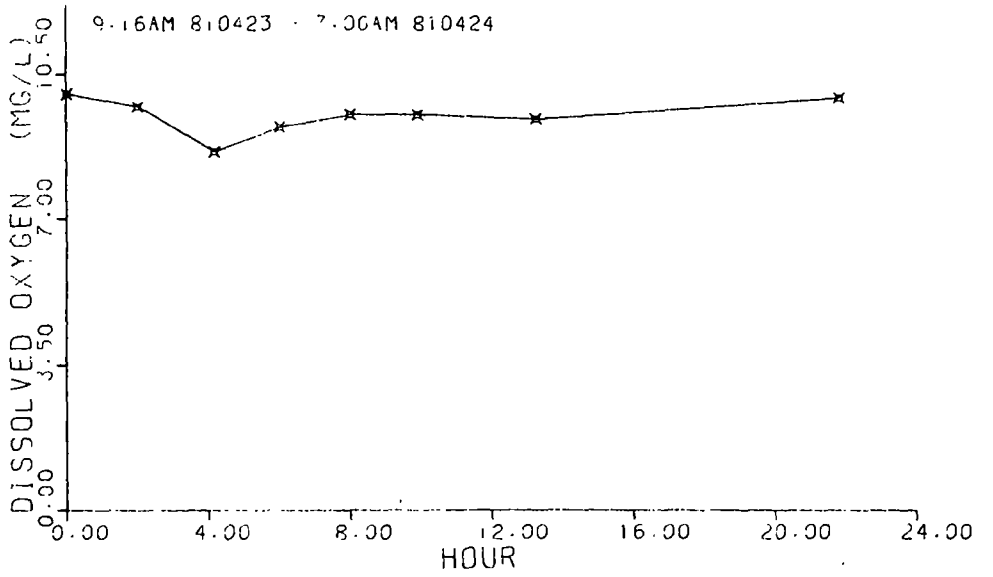


Figure 9-4 Intensive river survey plots of Dissolved Oxygen.

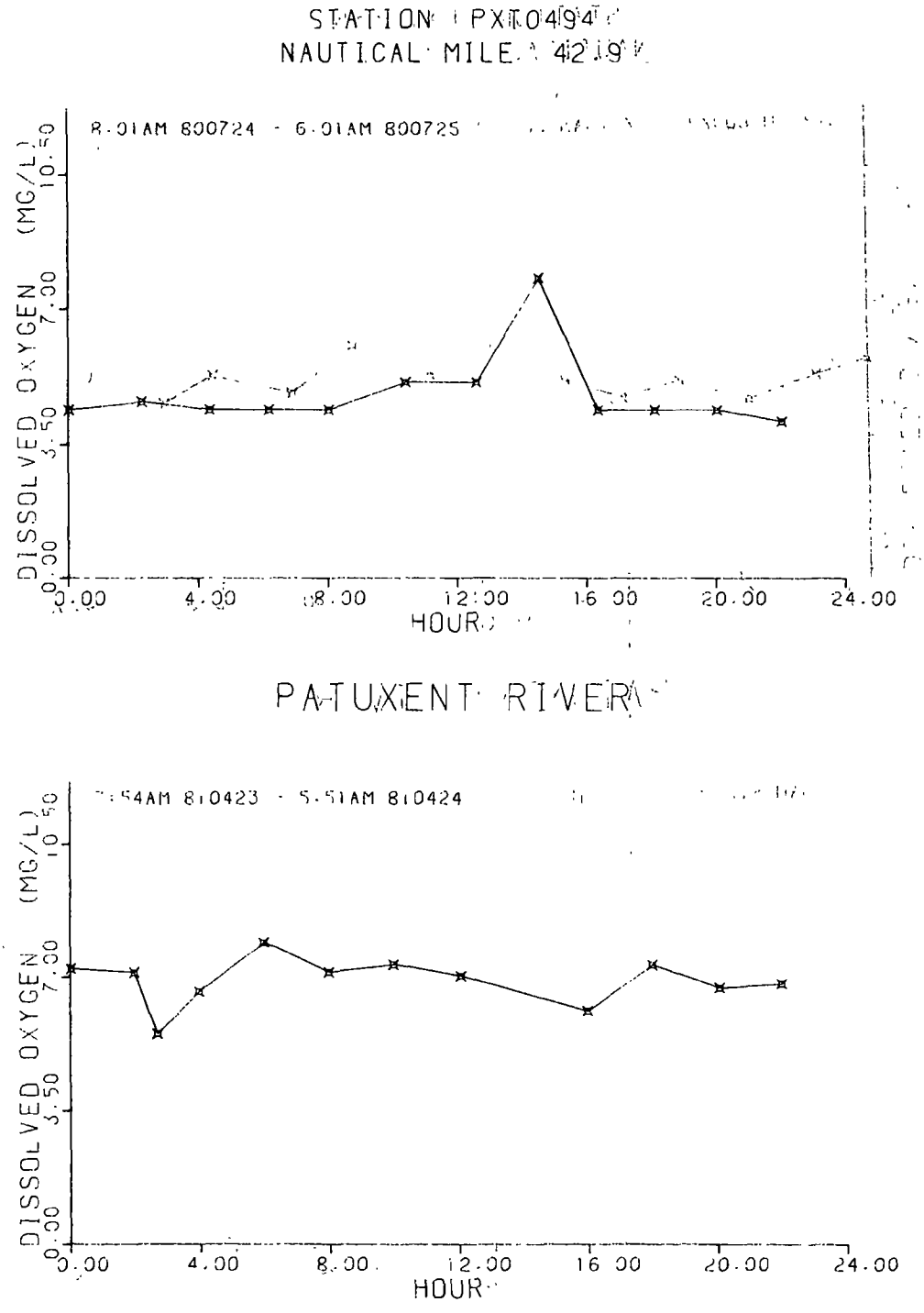


Figure 9-4 Intensive river survey plots of Dissolved Oxygen.

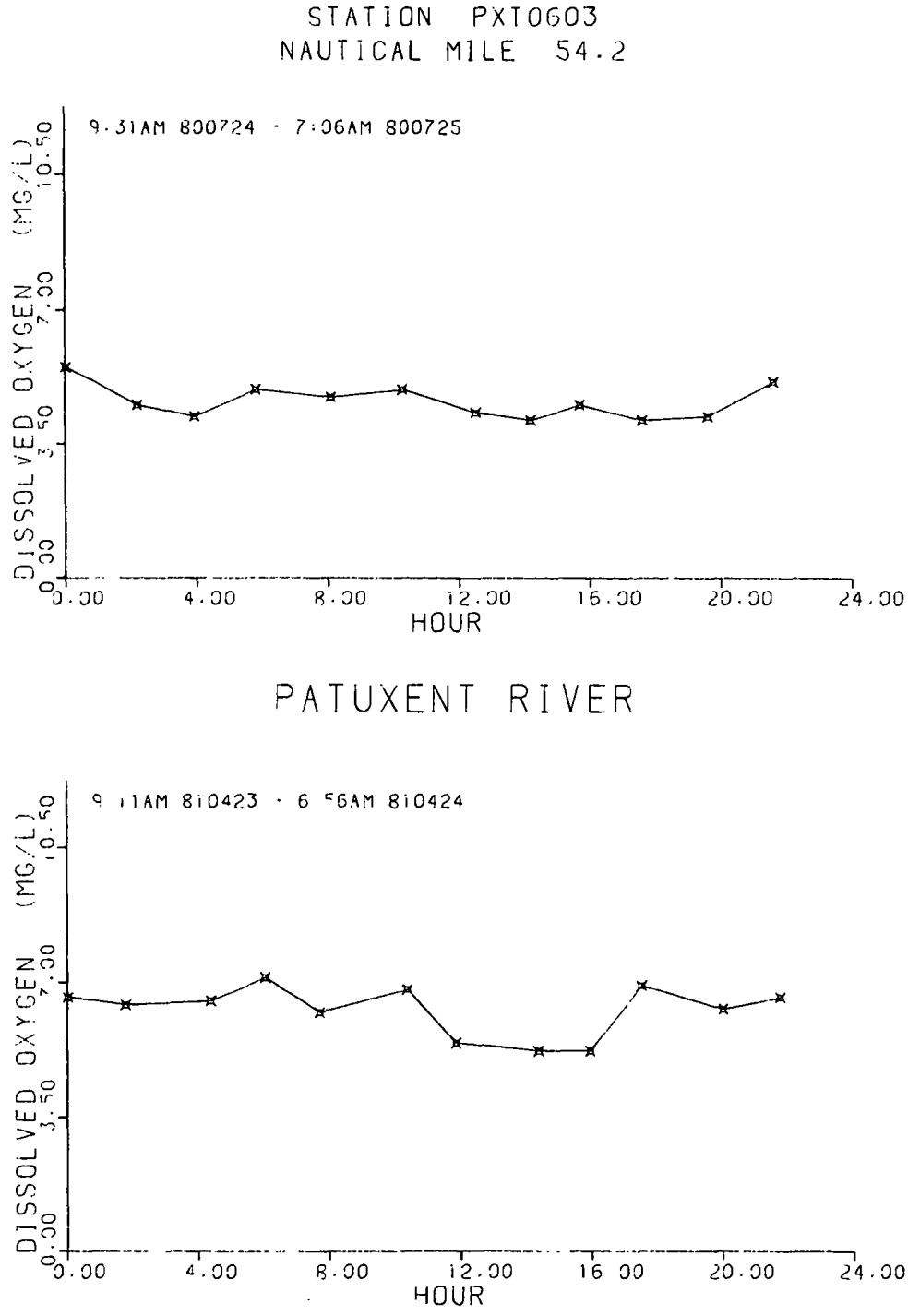
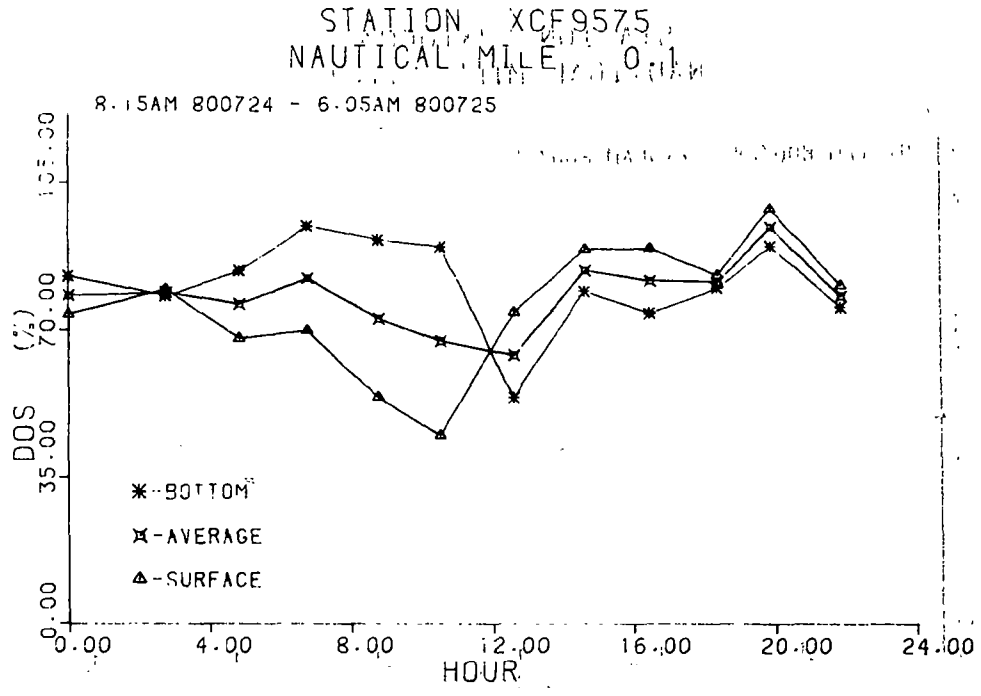


Figure 9-4 Intensive river survey plots of Dissolved Oxygen.



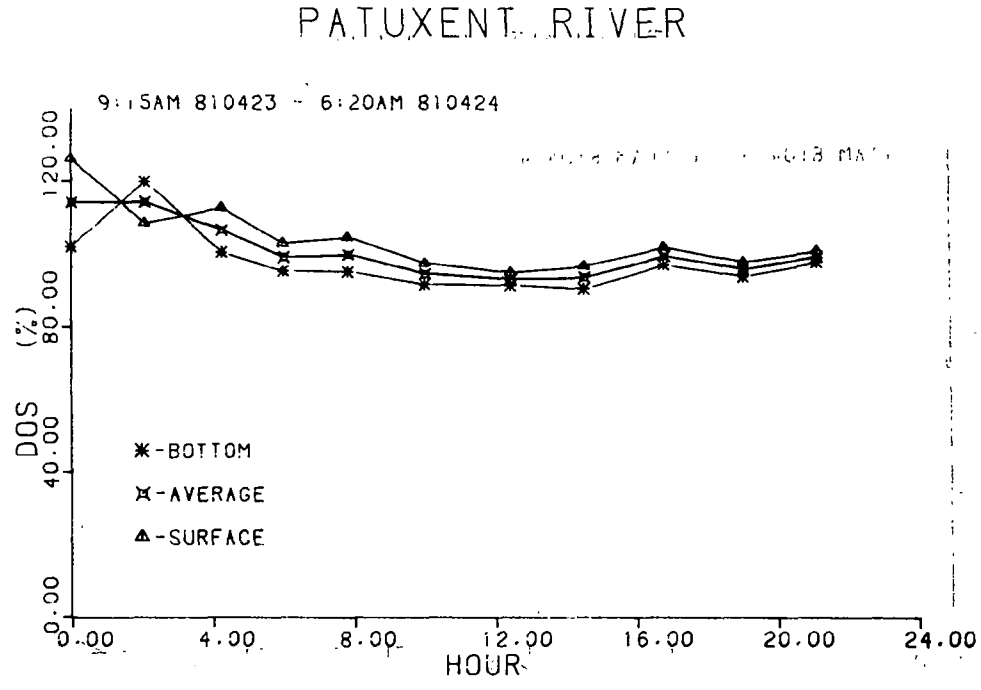
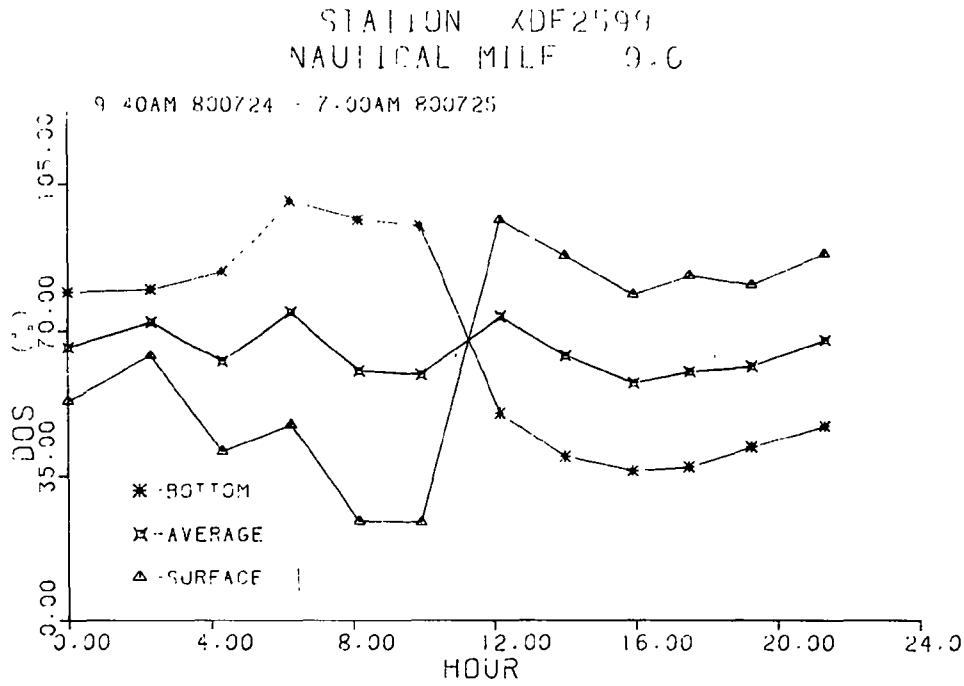


Figure 9-5 Intensive river survey plots of dissolved oxygen saturation.



PATUXENT RIVER

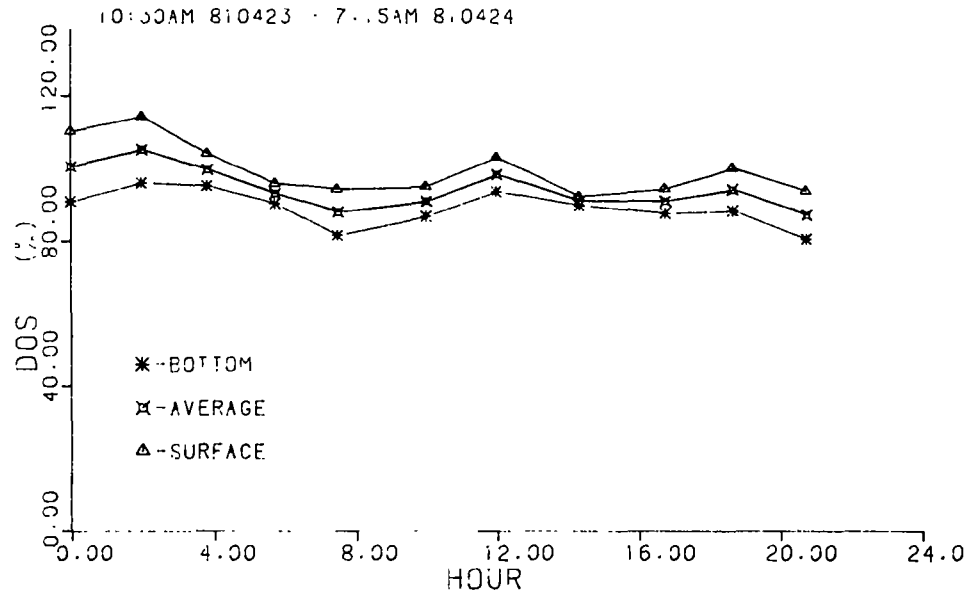
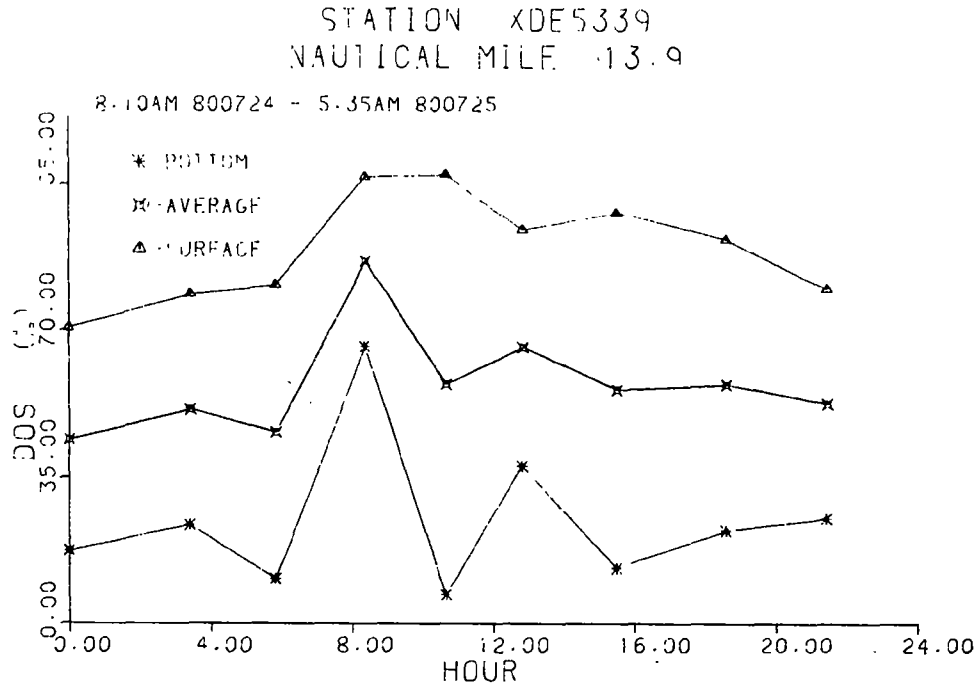


Figure 9-5 Intensive river survey plots of dissolved oxygen saturation.



PATUXENT RIVER

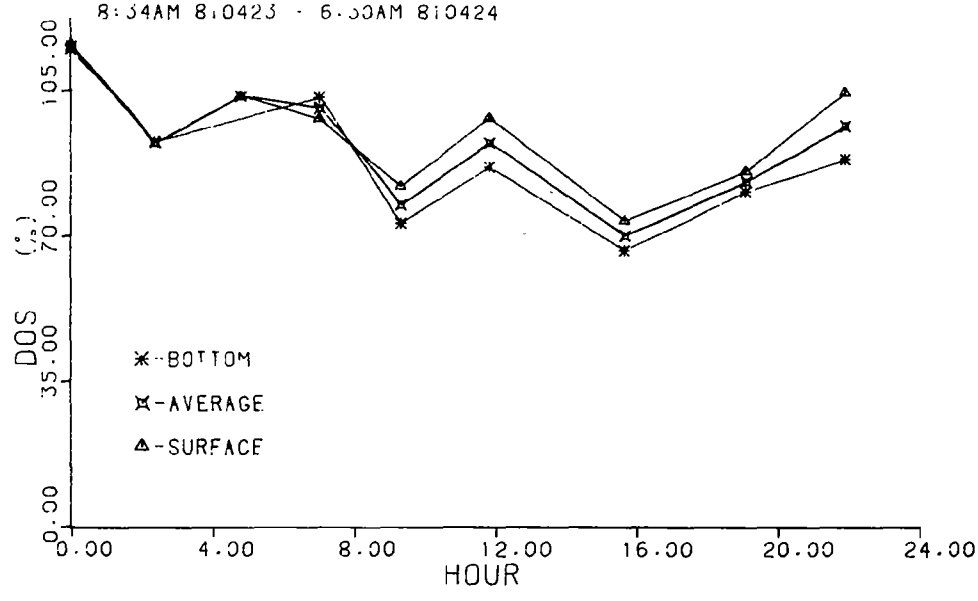
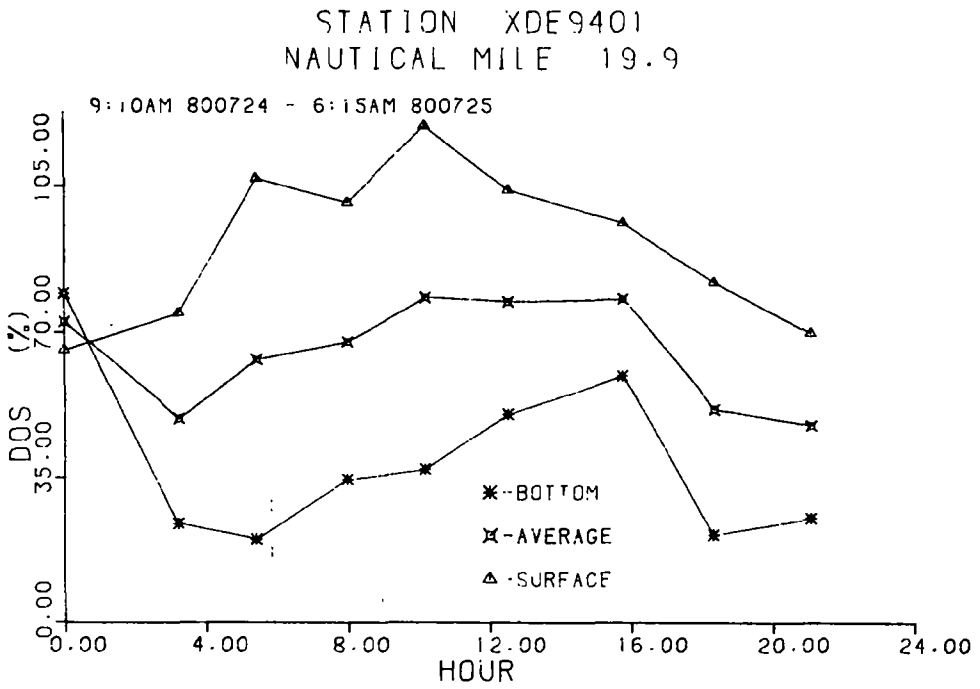


Figure 9-5 Intensive river survey plots of dissolved oxygen saturation.



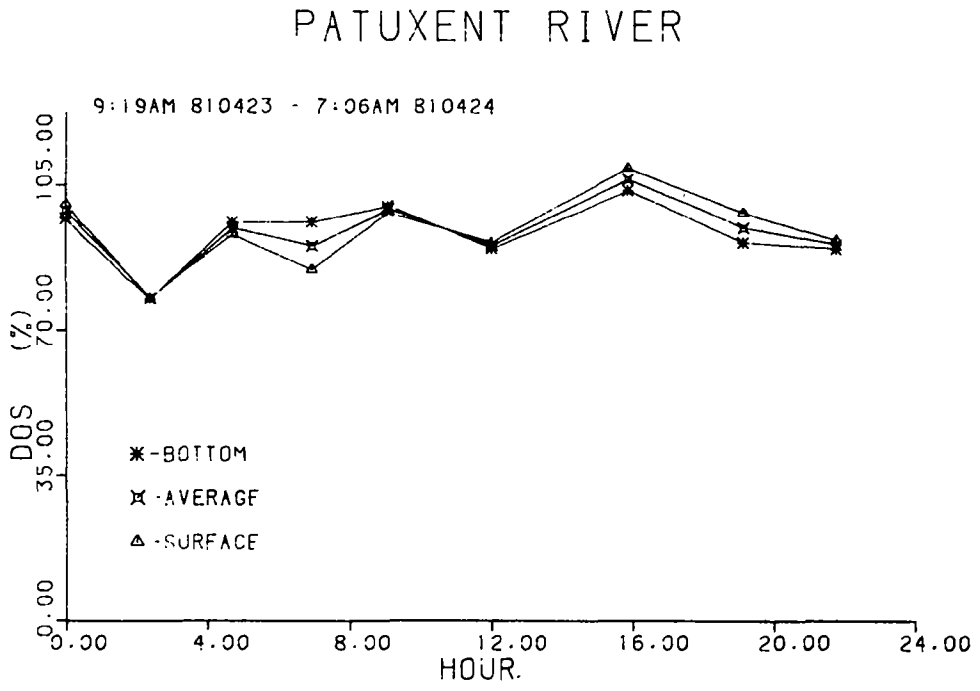
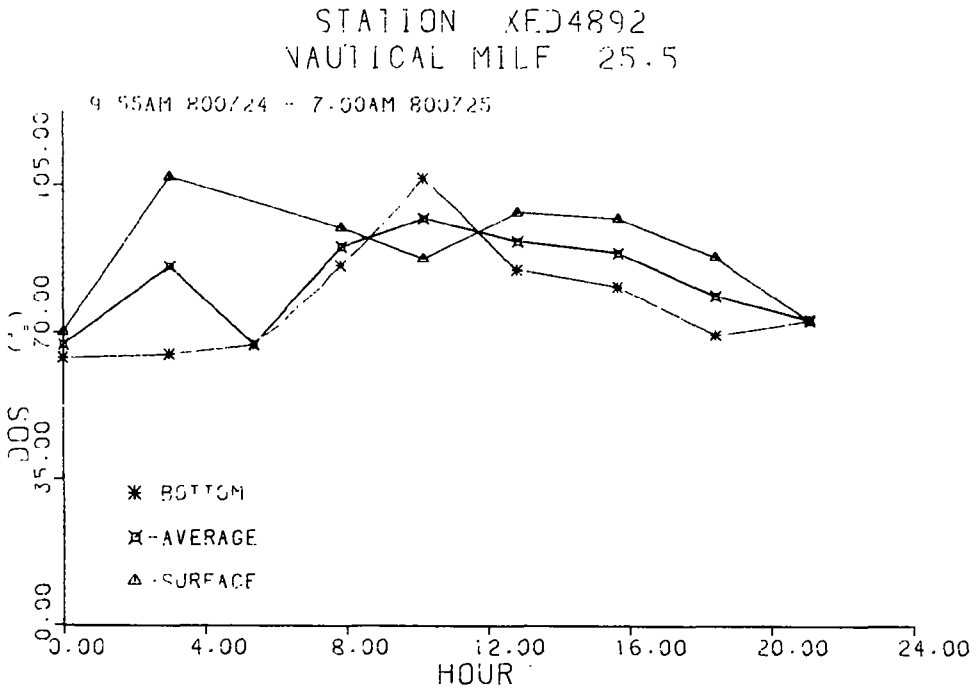


Figure 9-5 Intensive river survey plots of ammonia.



PATUXENT RIVER

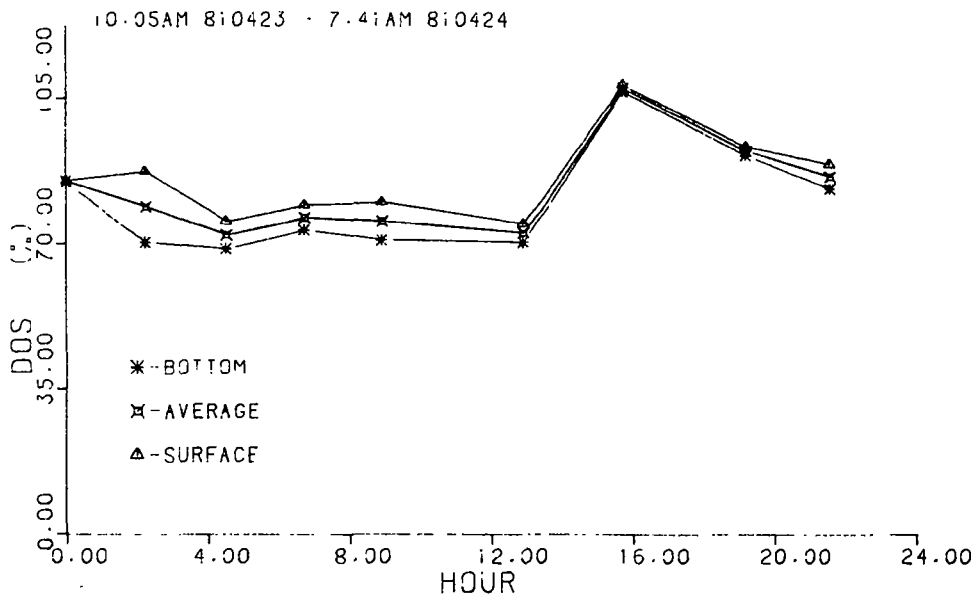
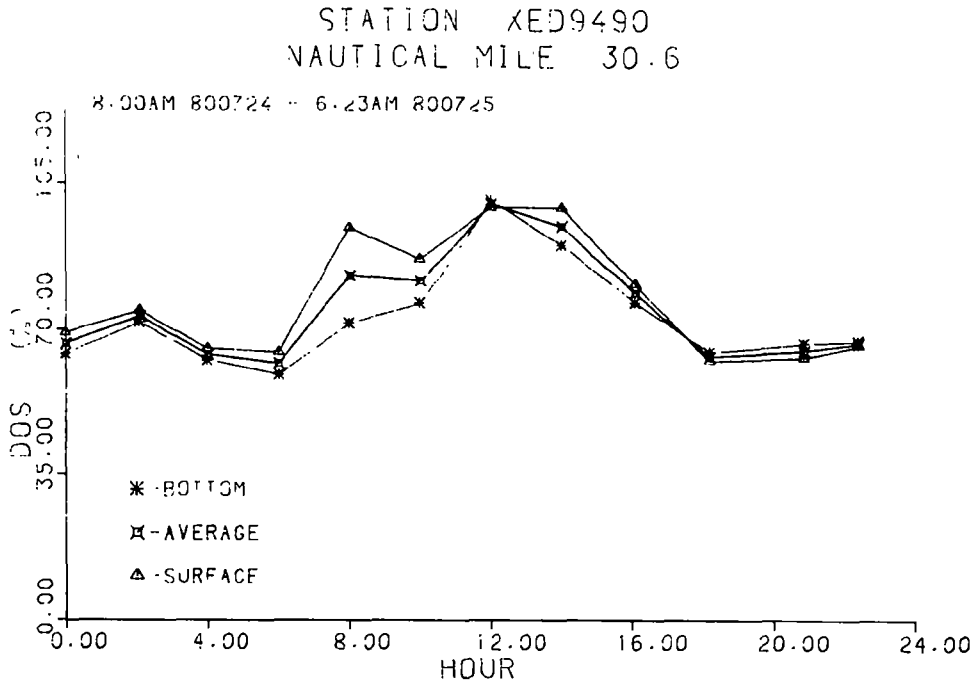


Figure 9-5 Intensive river survey plots of dissolved oxygen saturation.



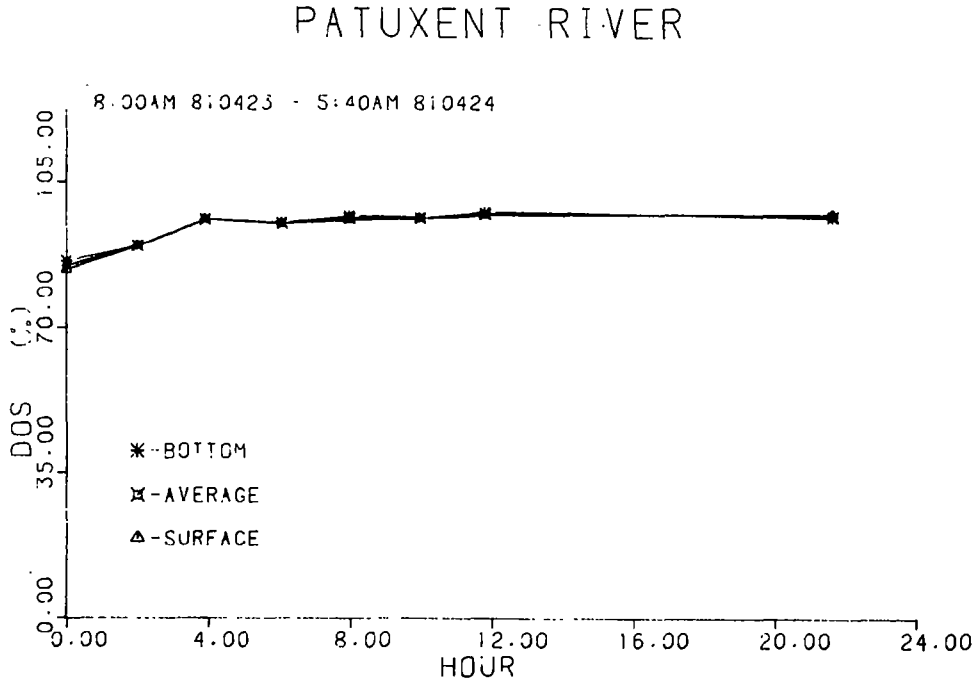
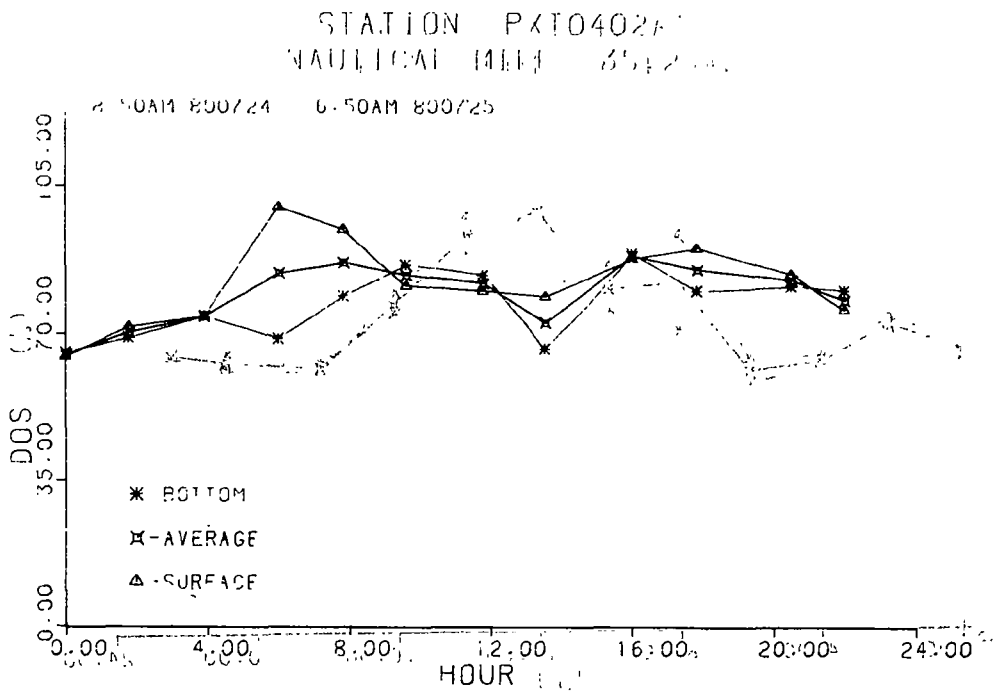


Figure 9-5 Intensive river survey plots of dissolved oxygen saturation.



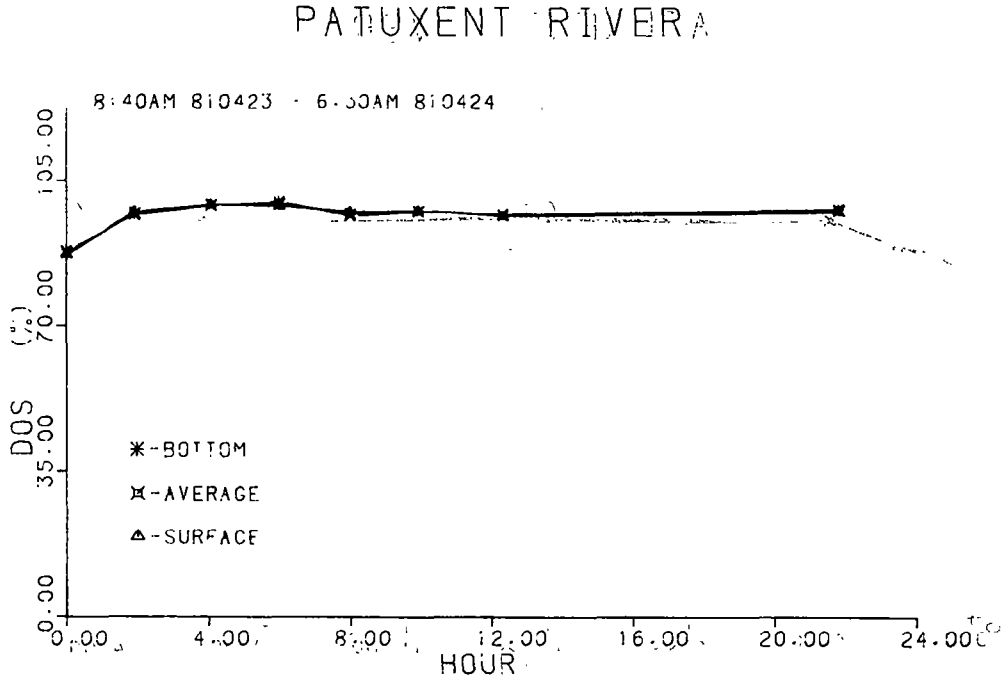
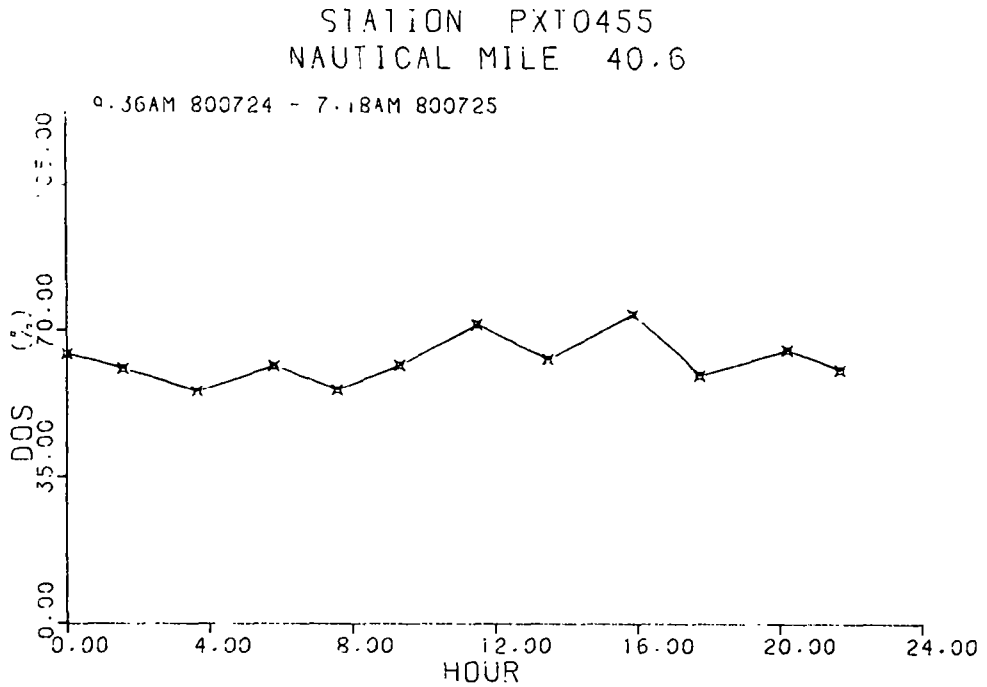


Figure 9-5 Intensive river survey plots of dissolved oxygen saturation.



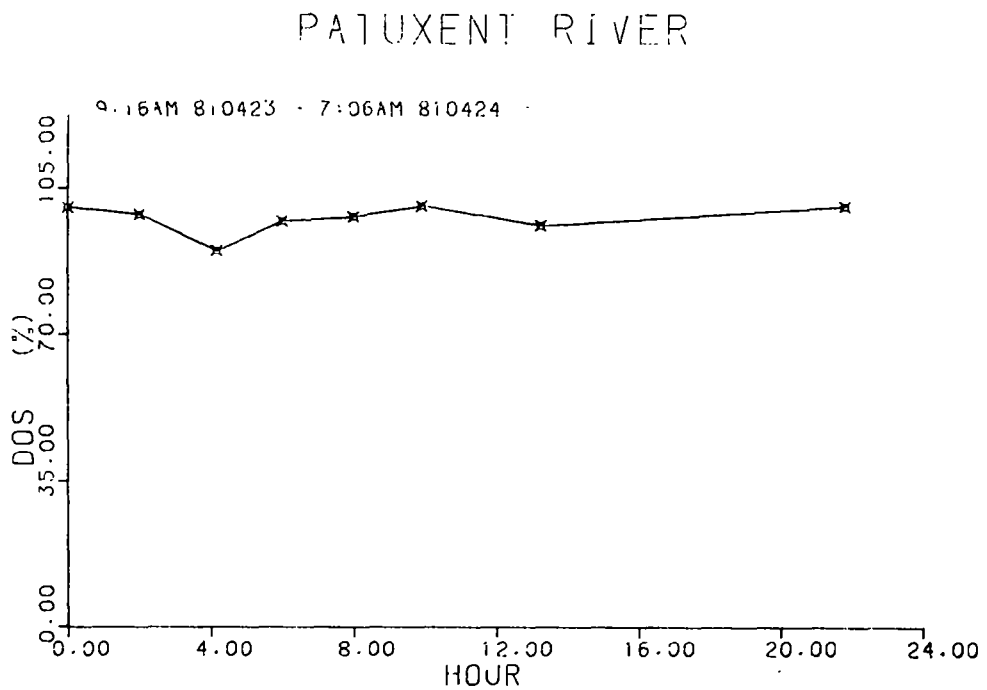
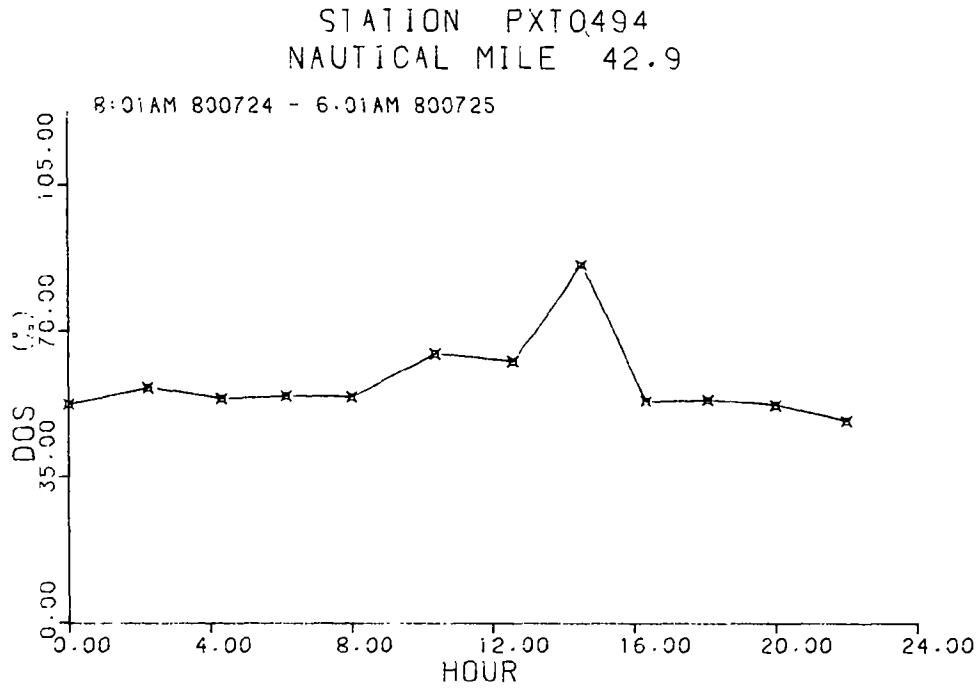


Figure 9-5 Intensive river survey plots of dissolved oxygen saturation.



PATUXENT RIVER

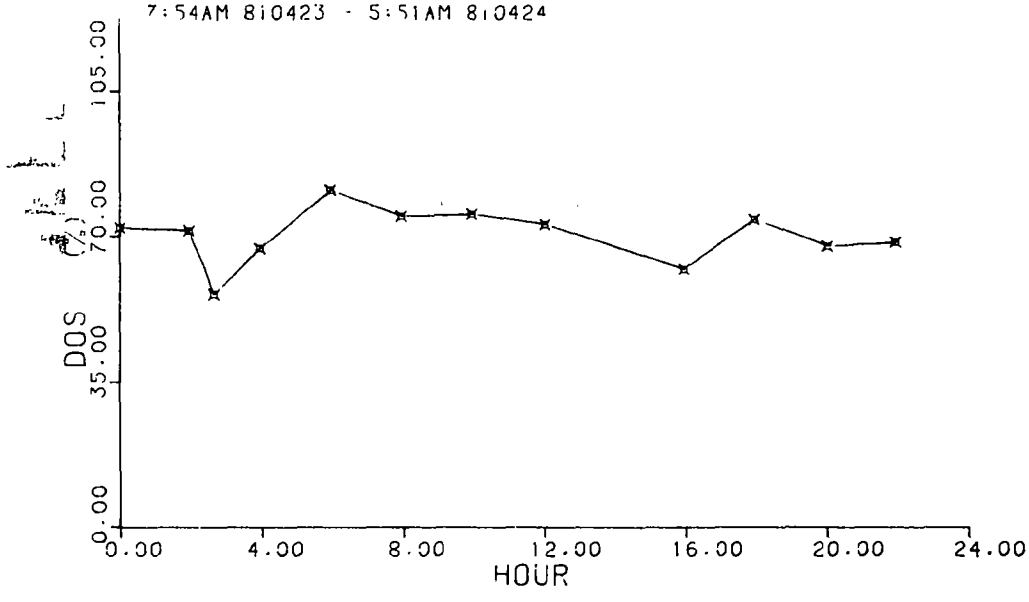
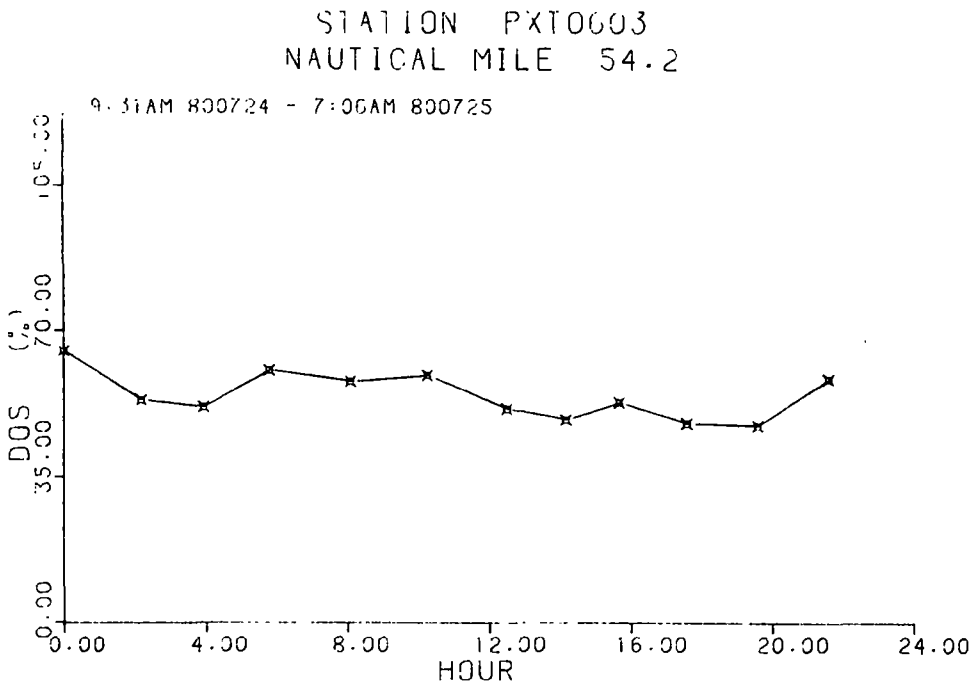


Figure 9-5 Intensive river survey plots of dissolved oxygen saturation.



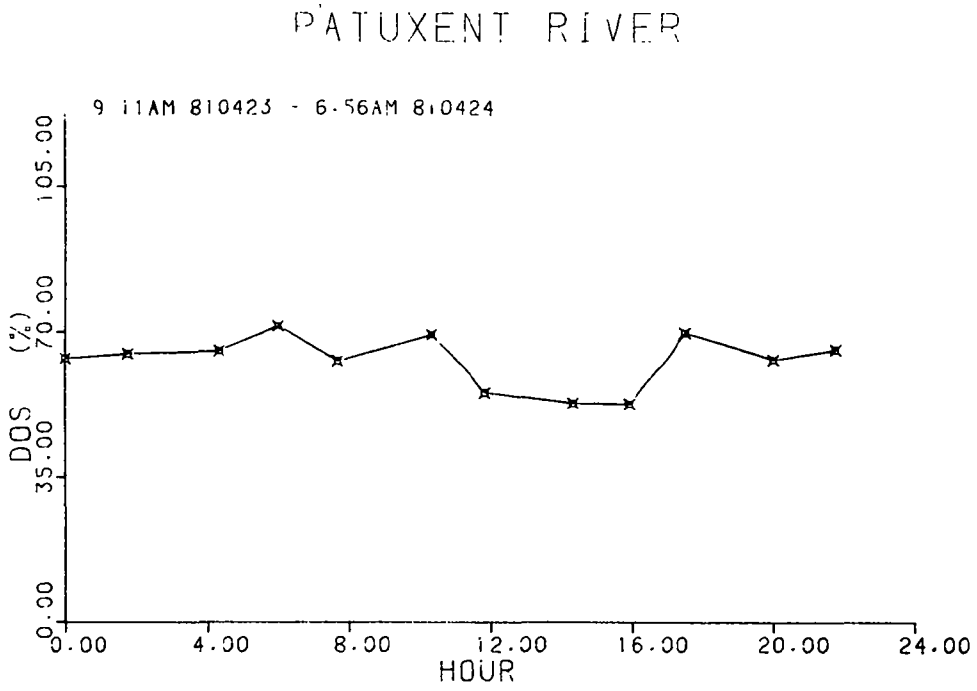
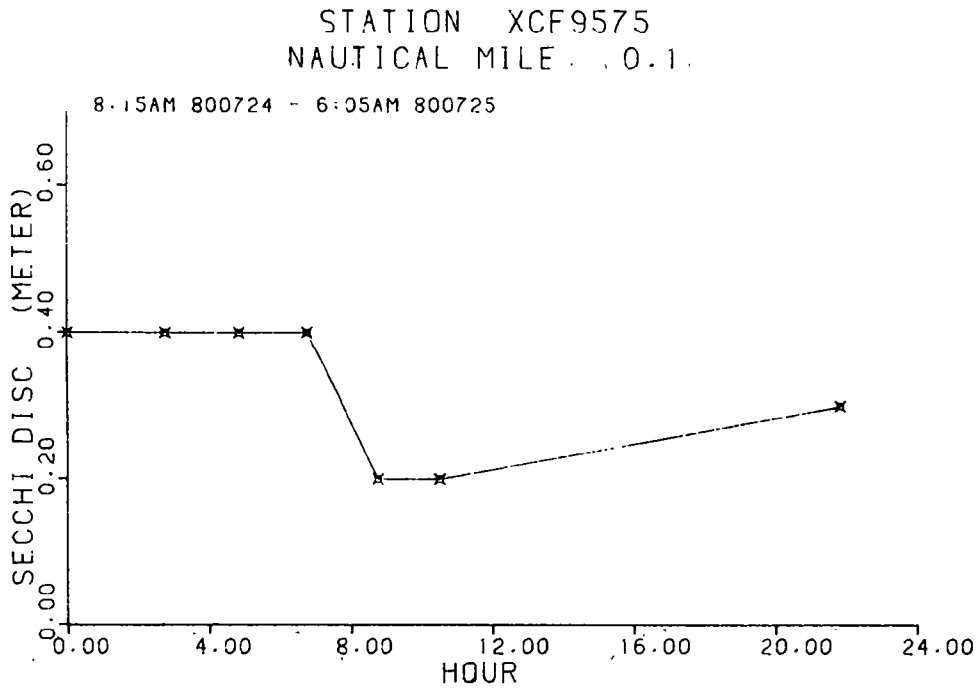


Figure 9-5 Intensive river survey plots of dissolved oxygen saturation.



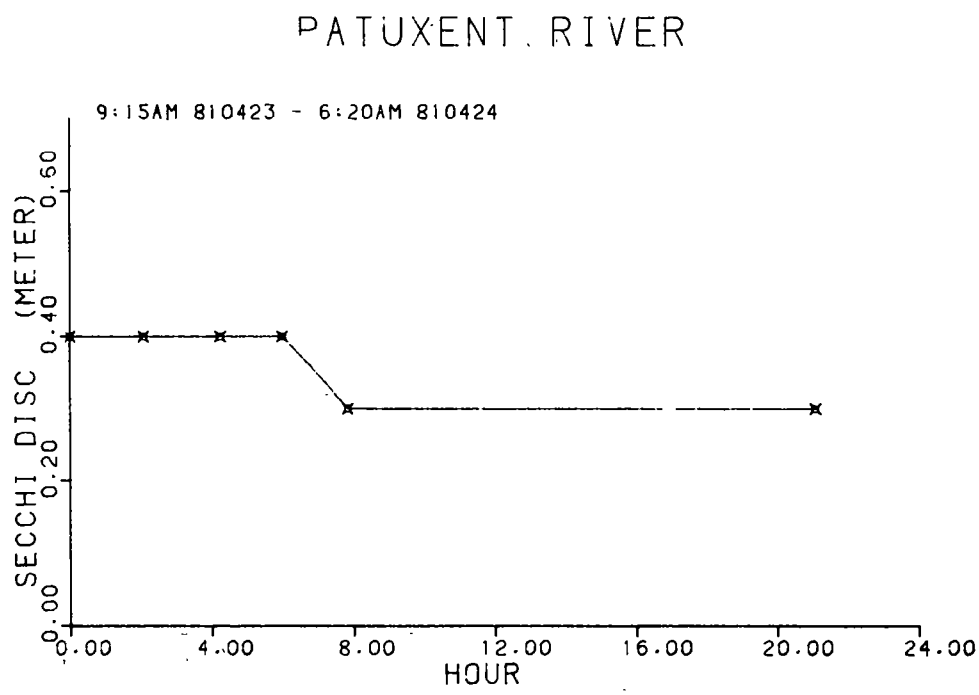
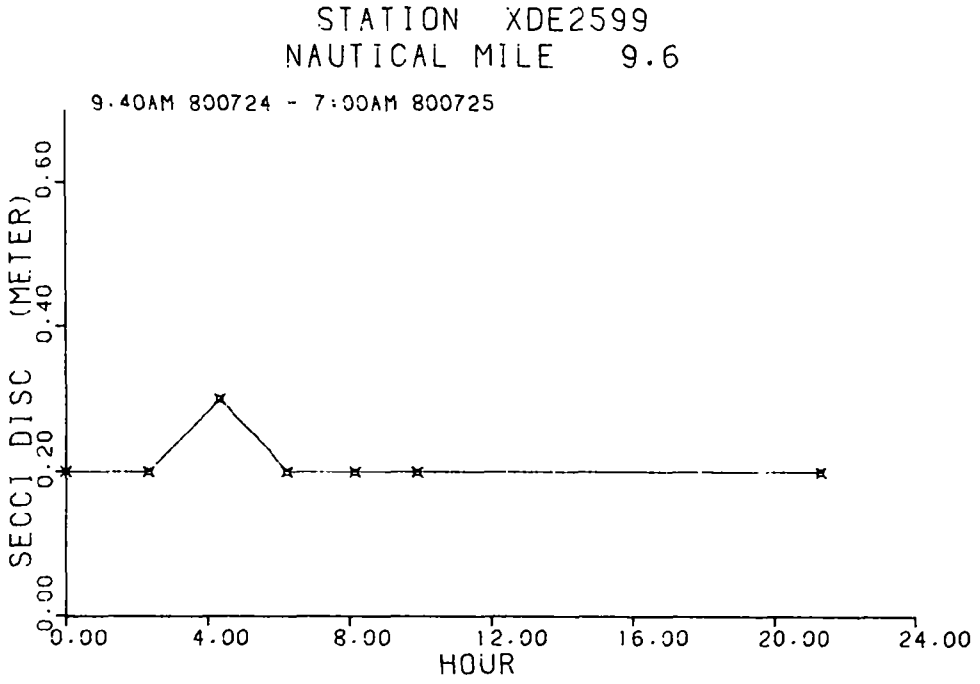


Figure 9-6 Intensive river survey plots secchi disc.



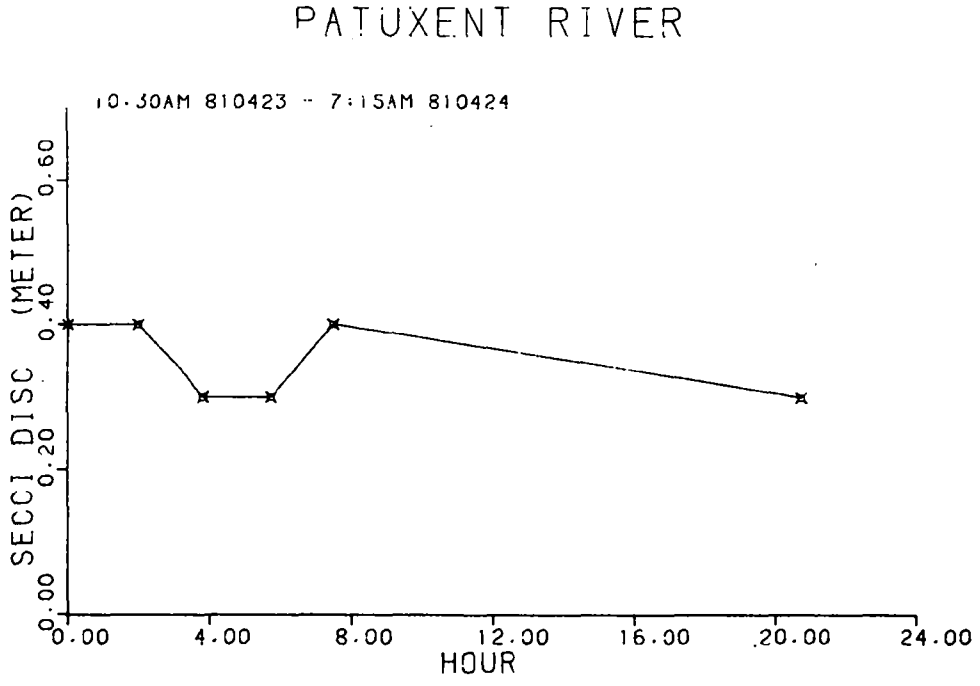
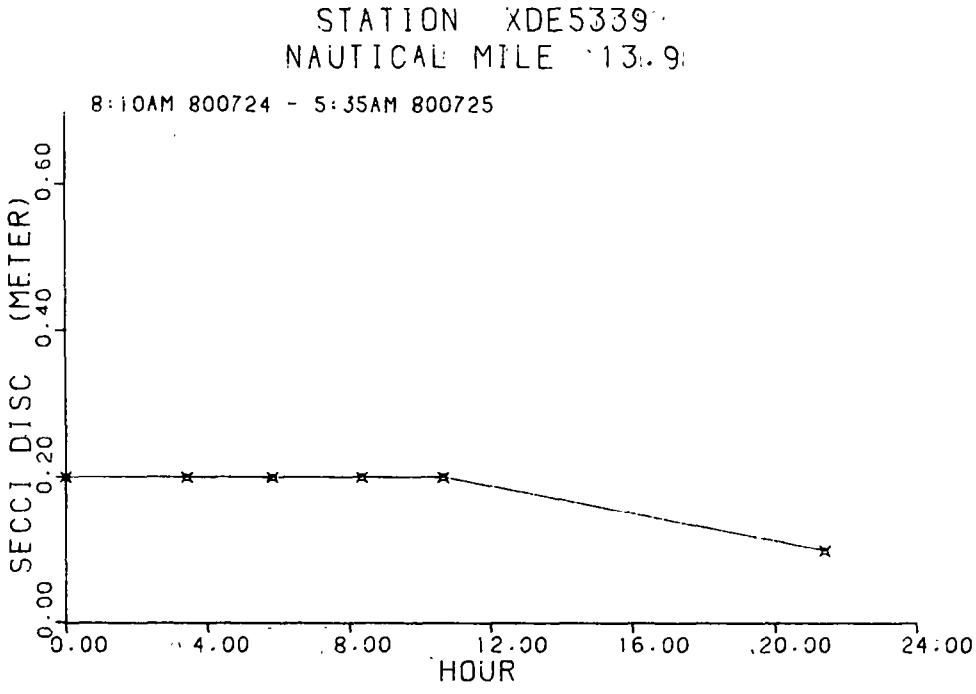


Figure 9-6 Intensive river survey plots of secchi disc.



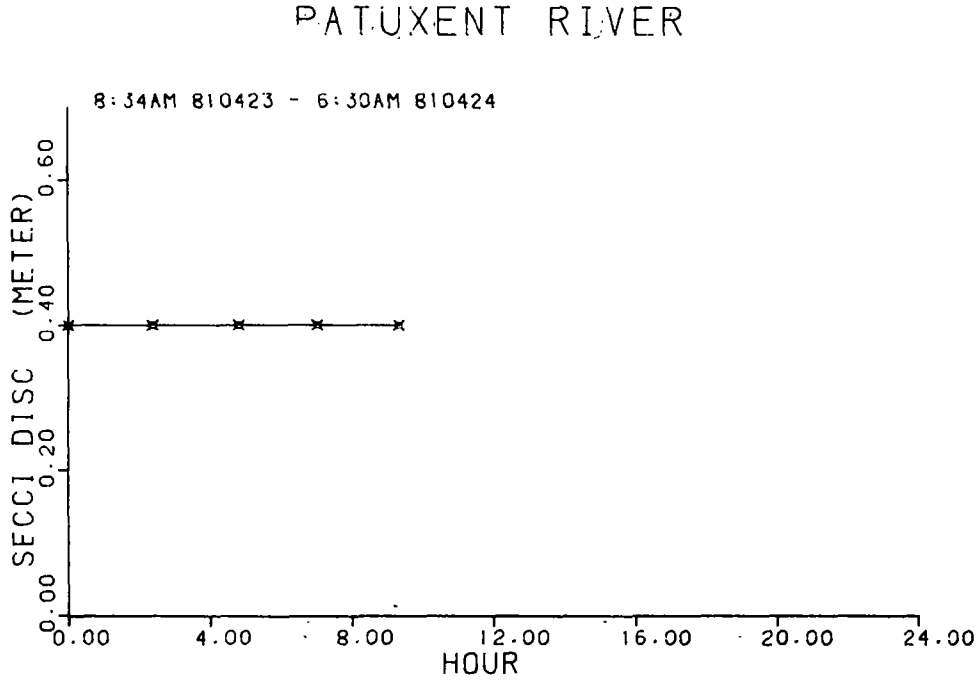
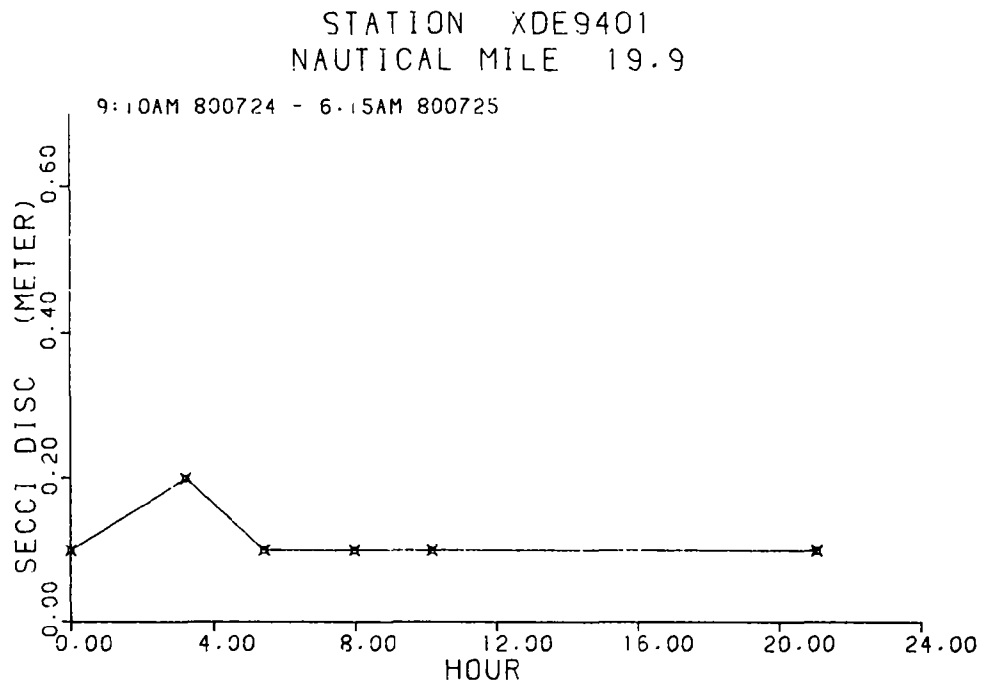


Figure 9-6 Intensive river survey plots of secchi disc.



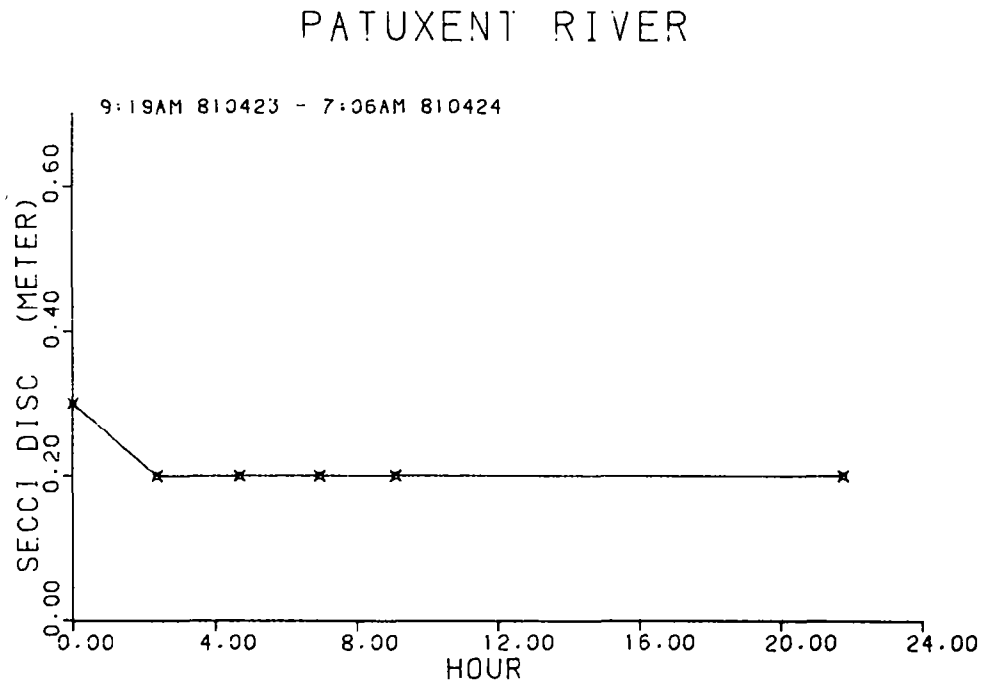
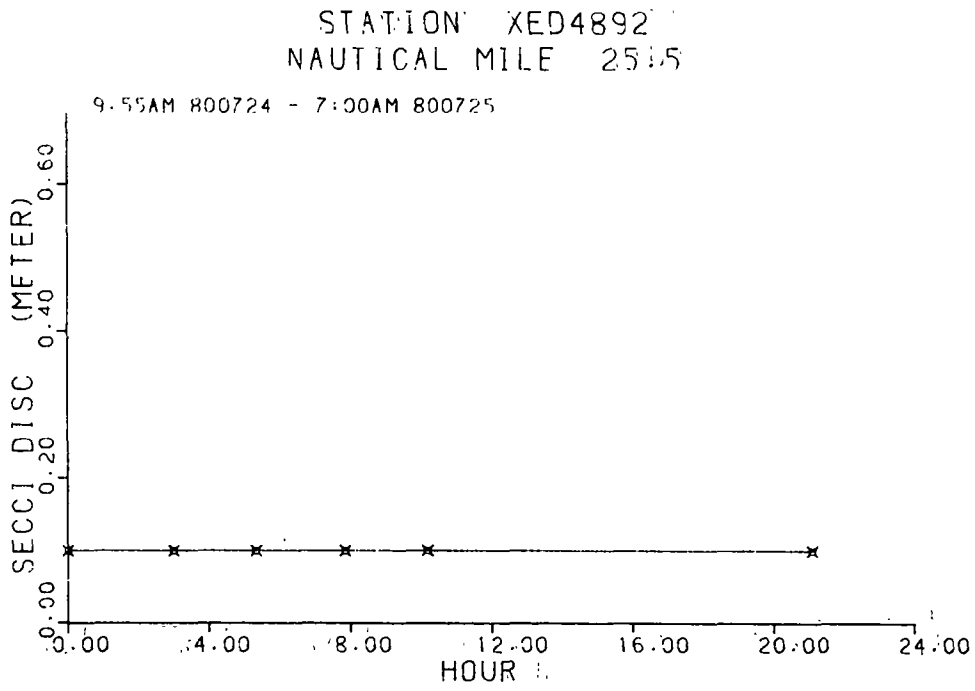


Figure 9-6 Intensive river survey plots of secchi disc.



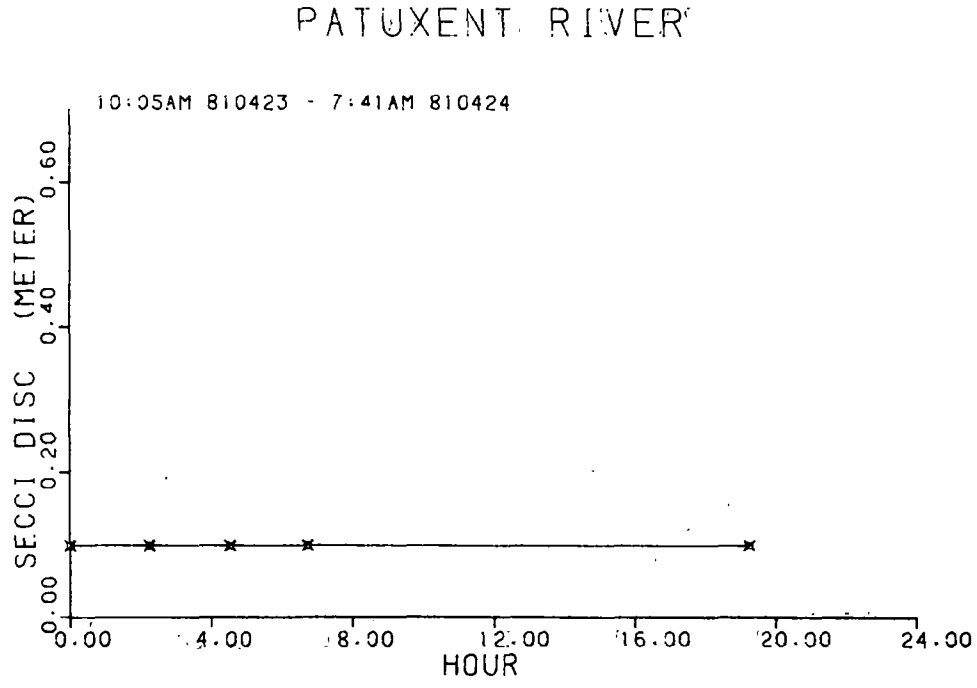
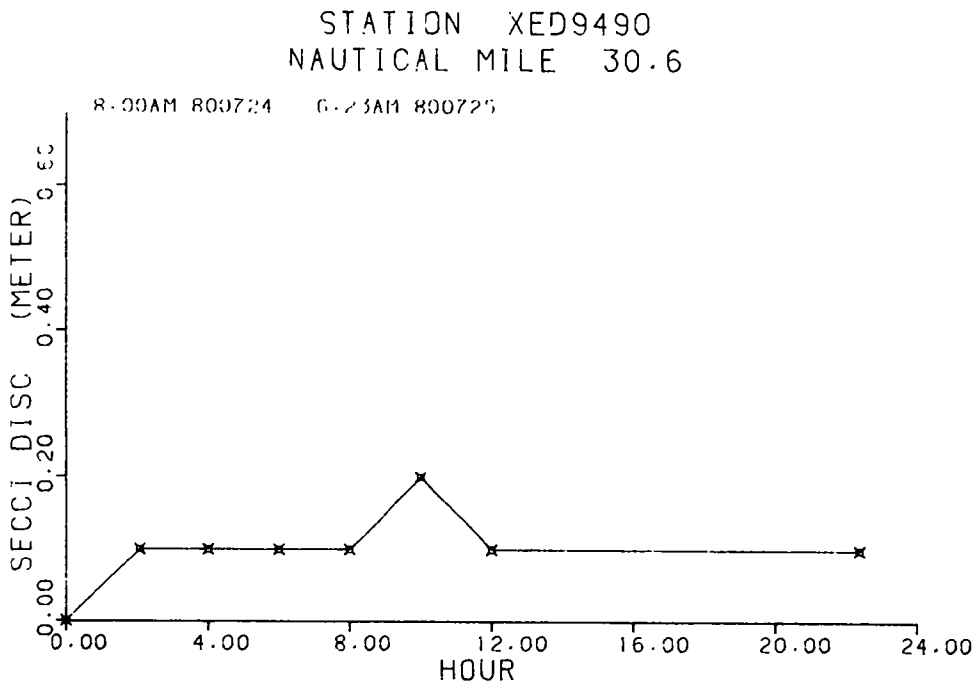


Figure 9-6 Intensive river survey plots of secchi disc.



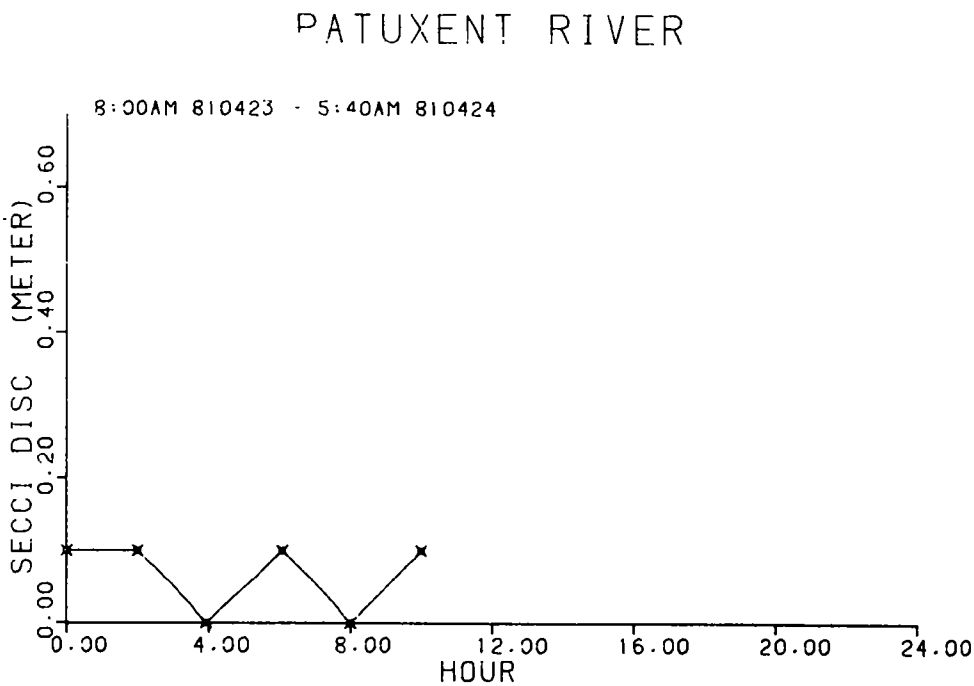
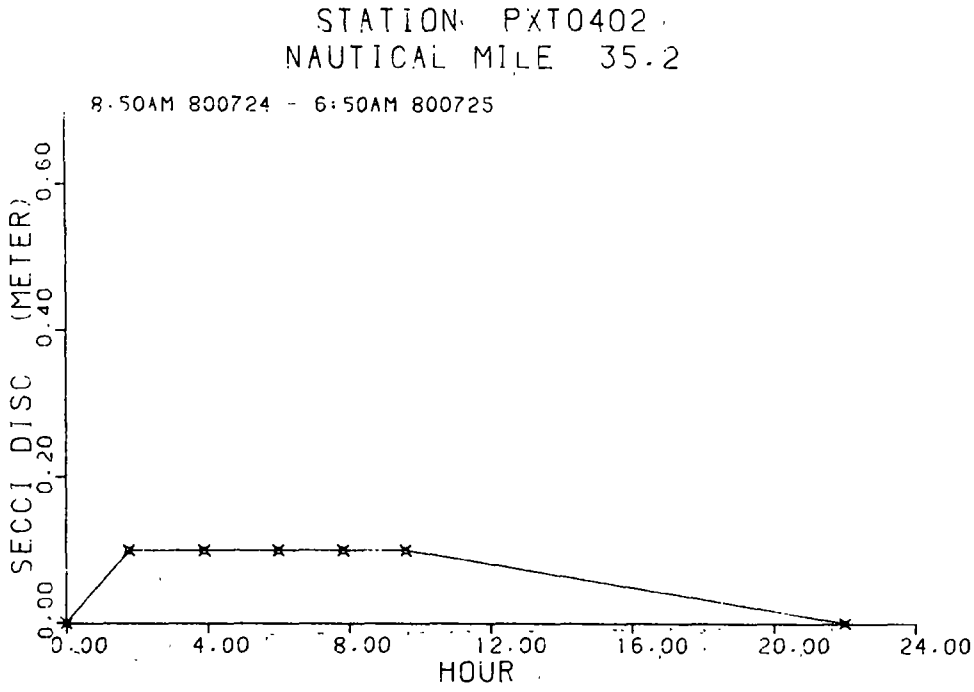


Figure 9-6 Intensive river survey plots of secchi disc.



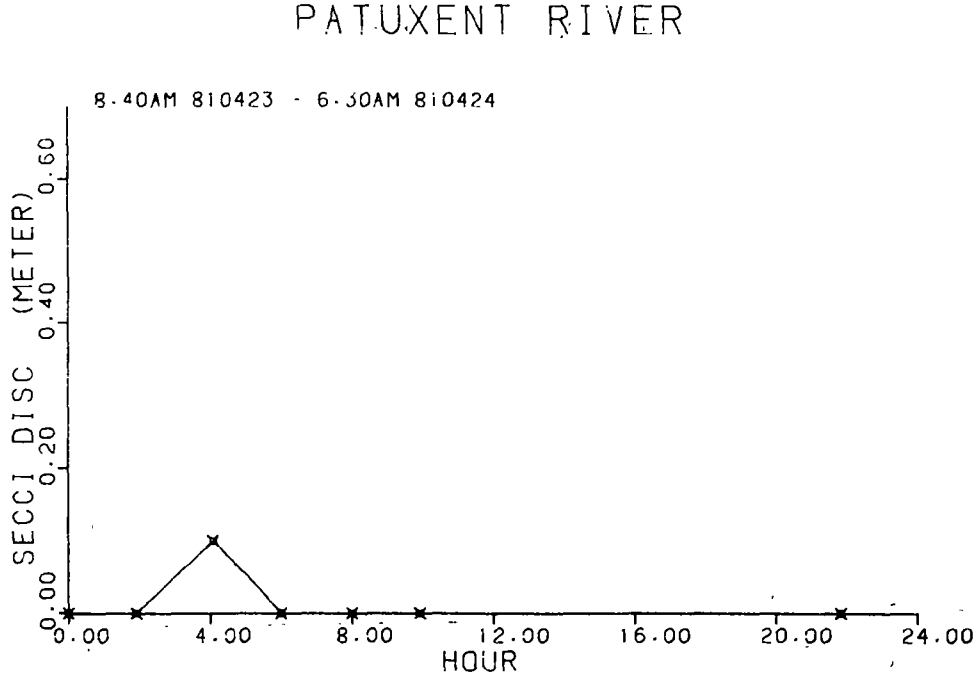
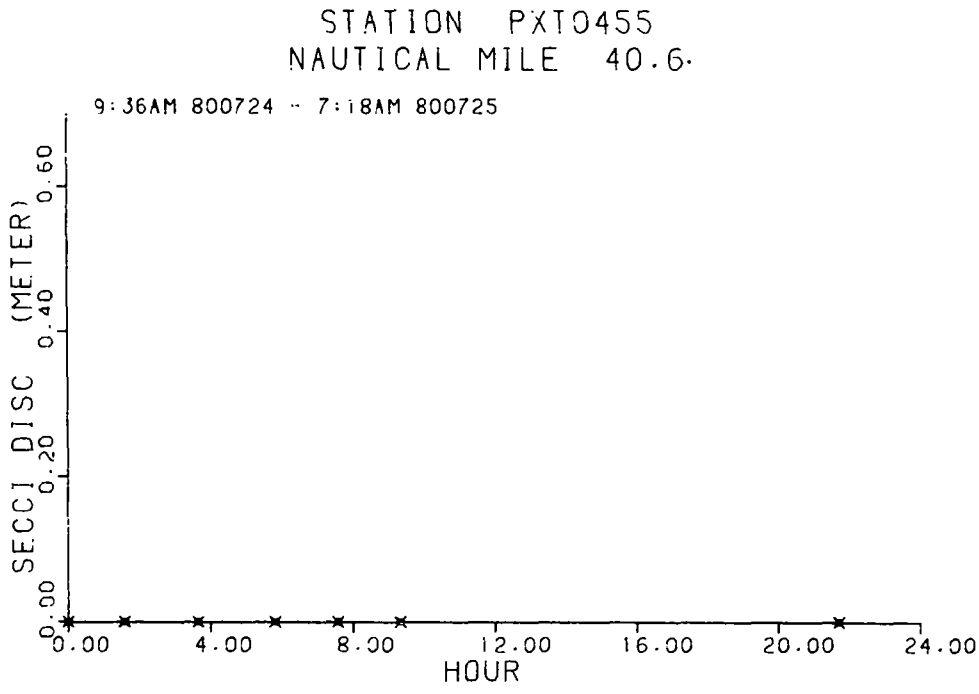


Figure 9-6 Intensive river survey plots of secchi disc.



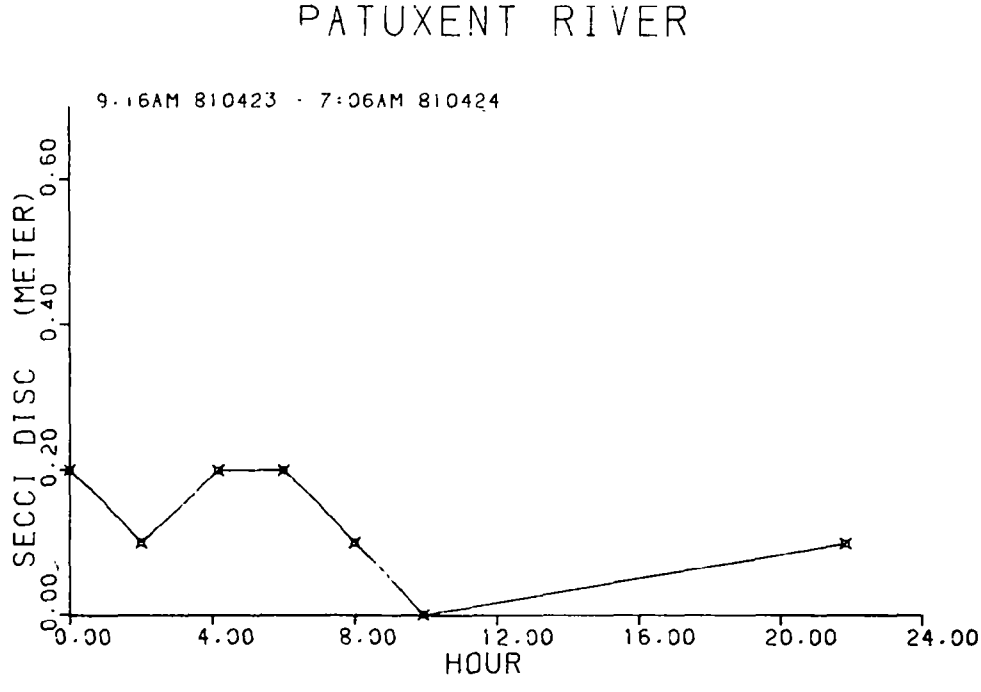
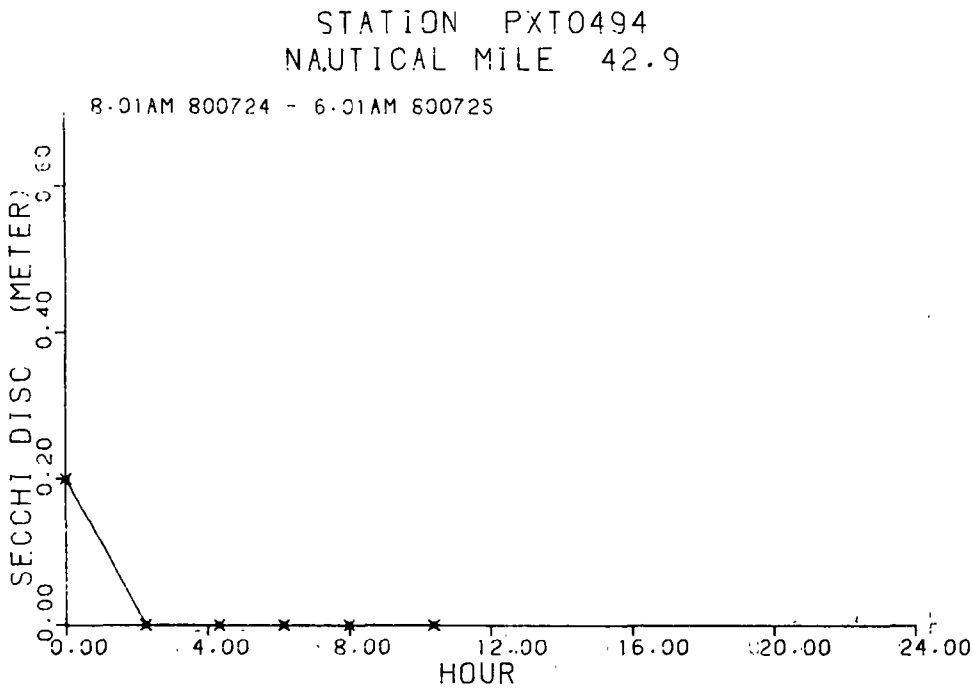


Figure 9-6 Intensive river survey plots of secchi disc.



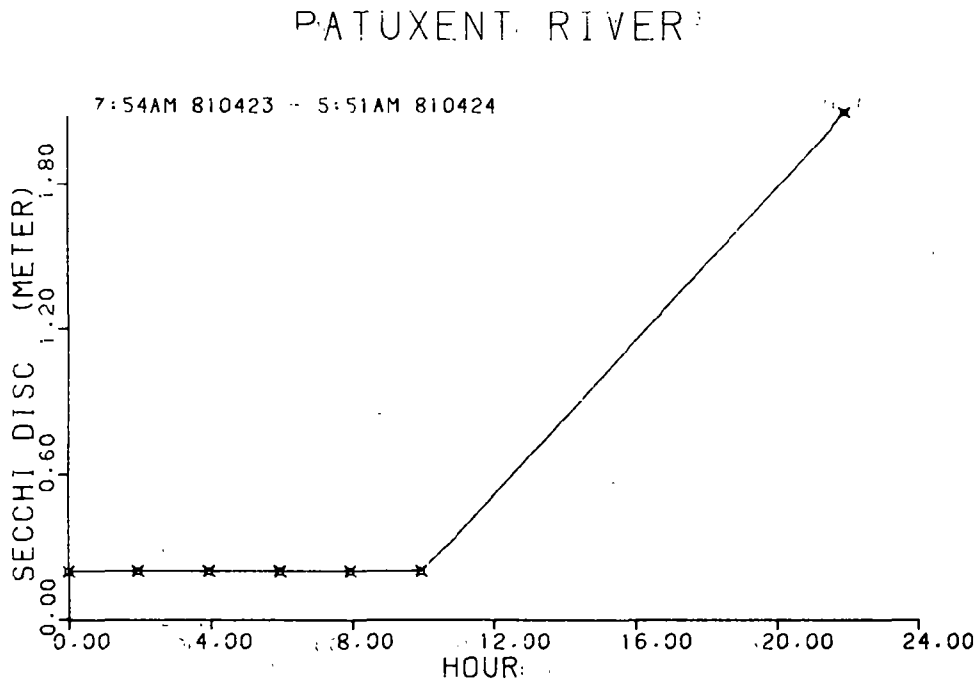
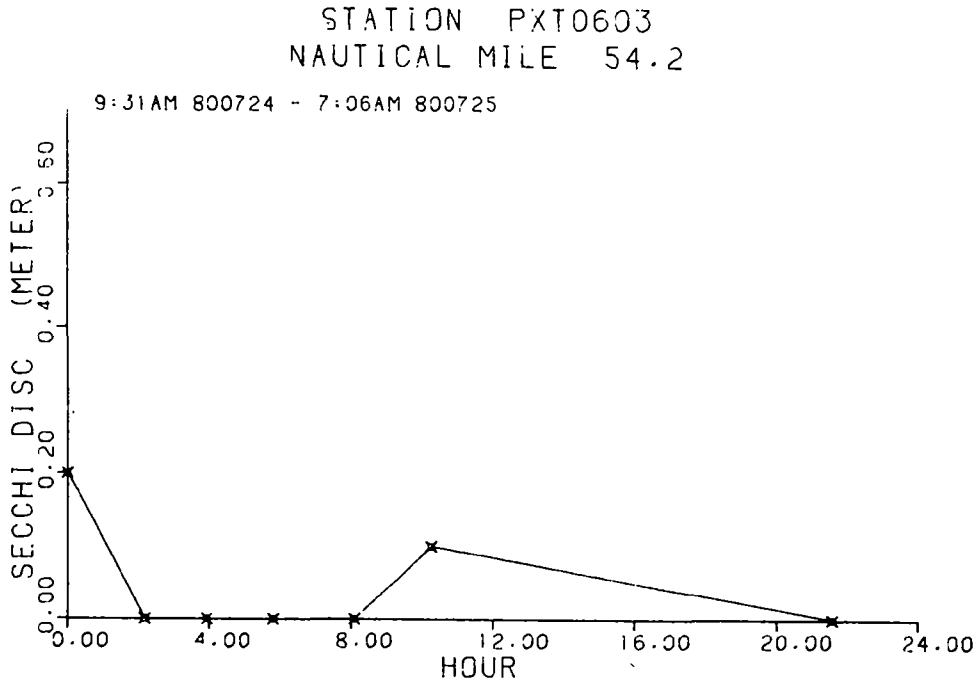


Figure 9-6 Intensive river survey plots of secchi disc.



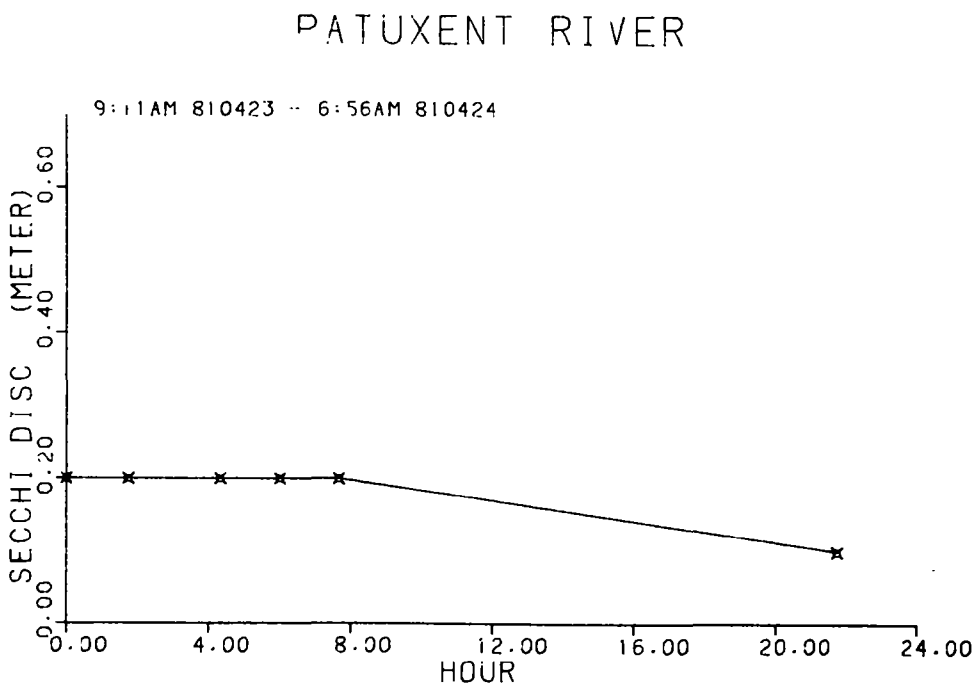
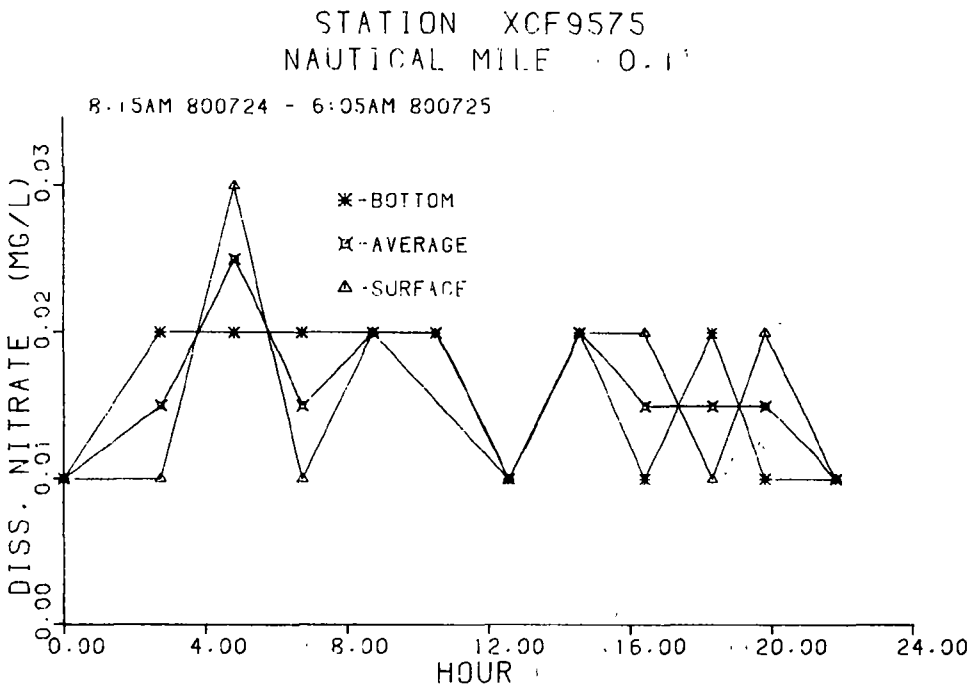


Figure 9-6 Intensive river survey plots of secchi disc.



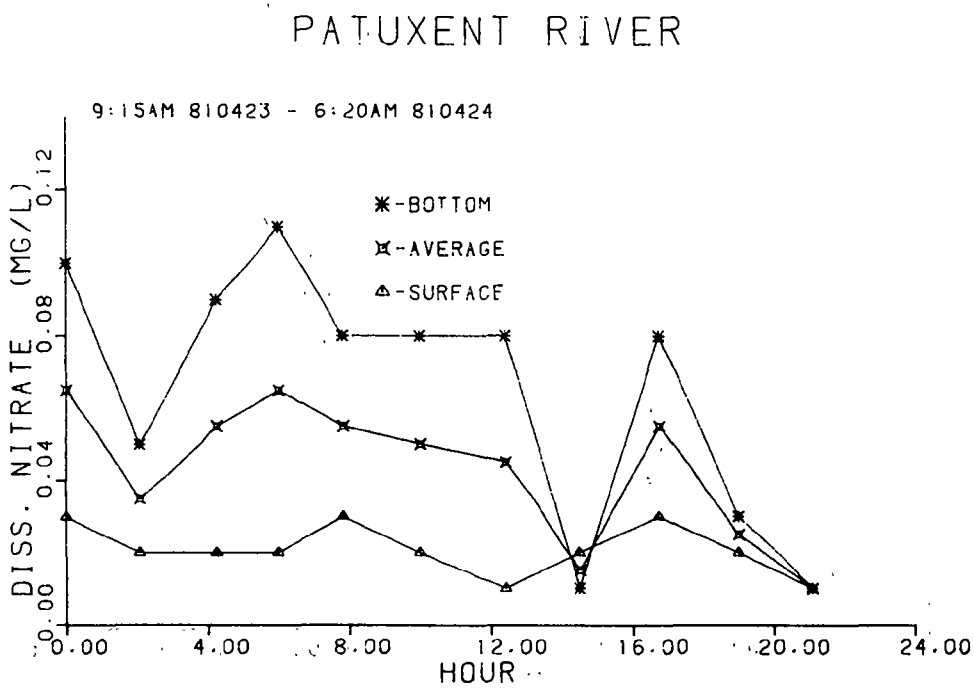
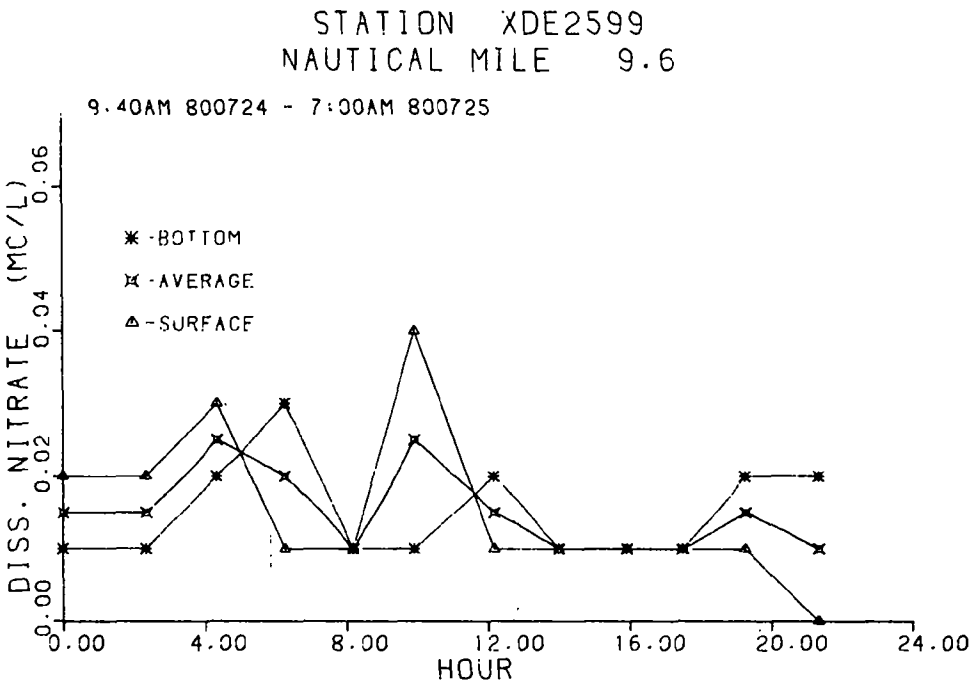


Figure 9-7 Intensive river survey plots of dissolved nitrate.



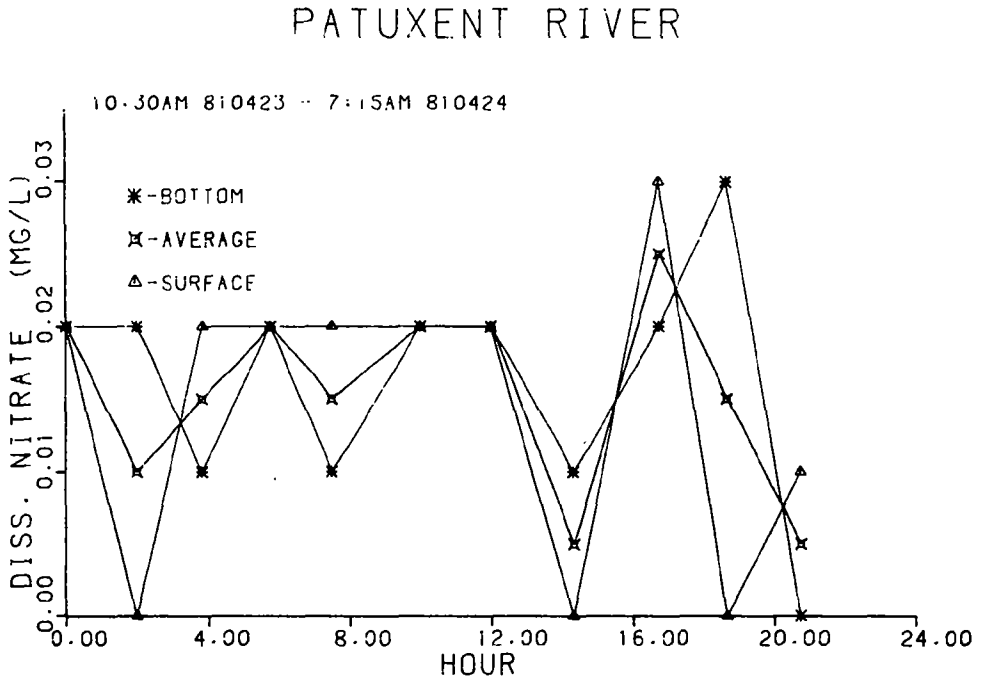
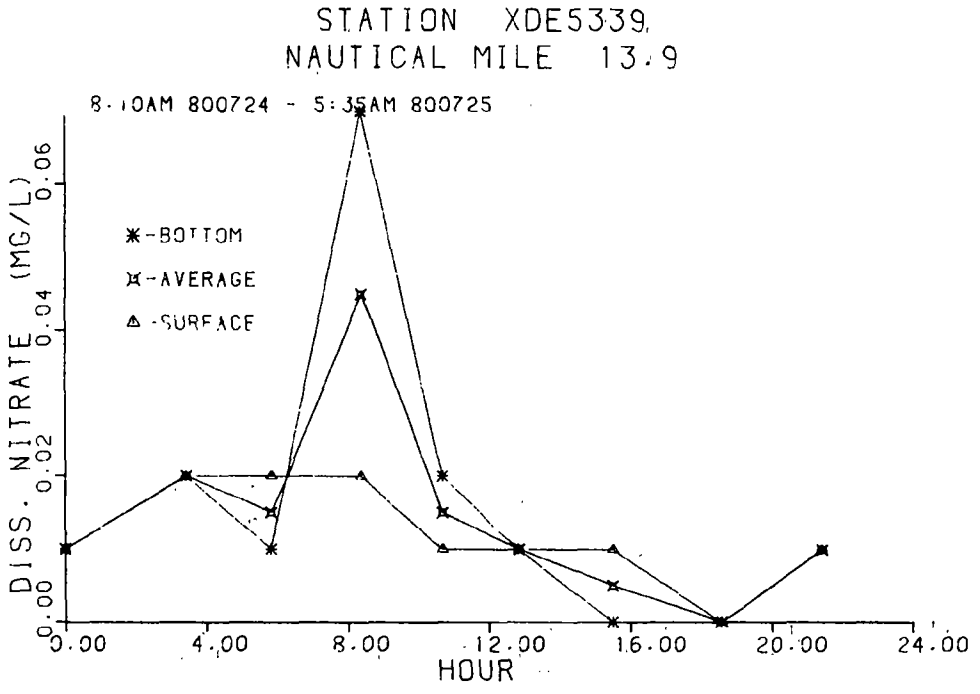


Figure 9-7 Intensive river survey plots of dissolved nitrate.



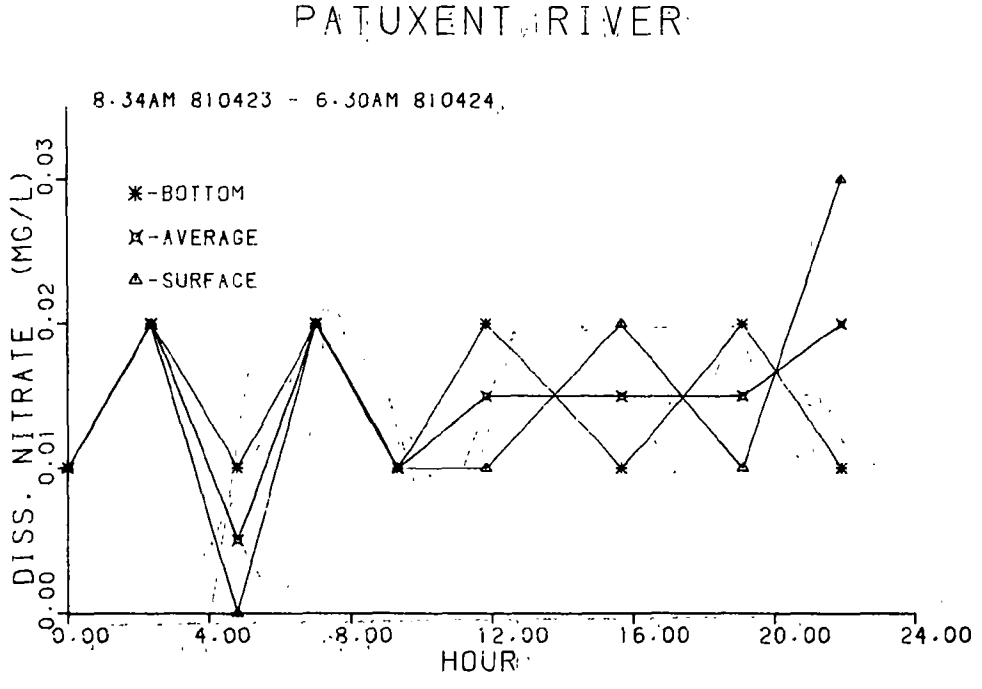
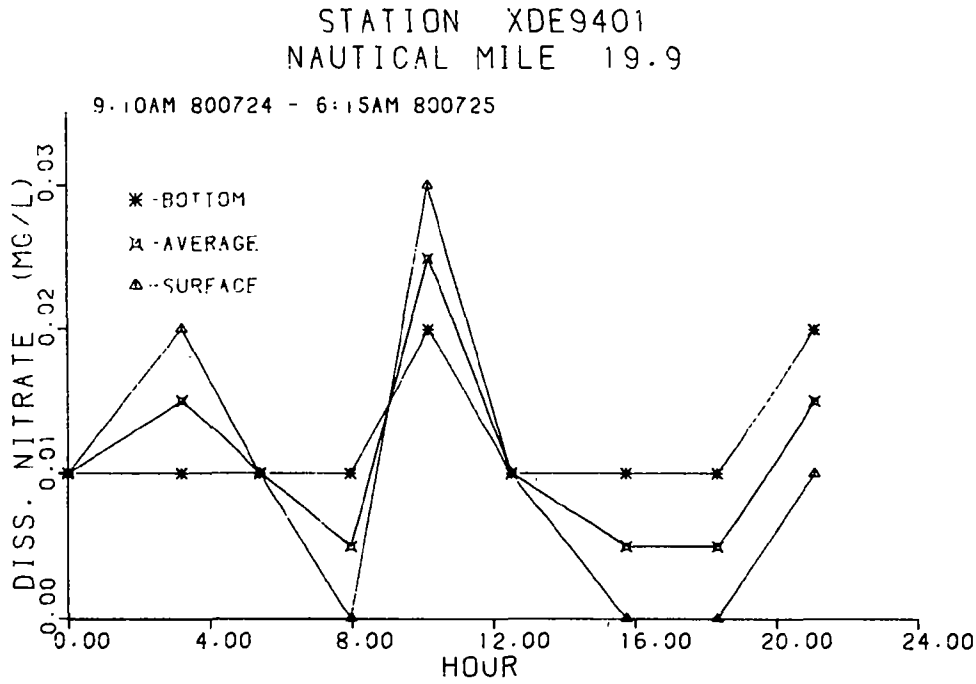


Figure 9-7 Intensive river survey plots of dissolved nitrate.



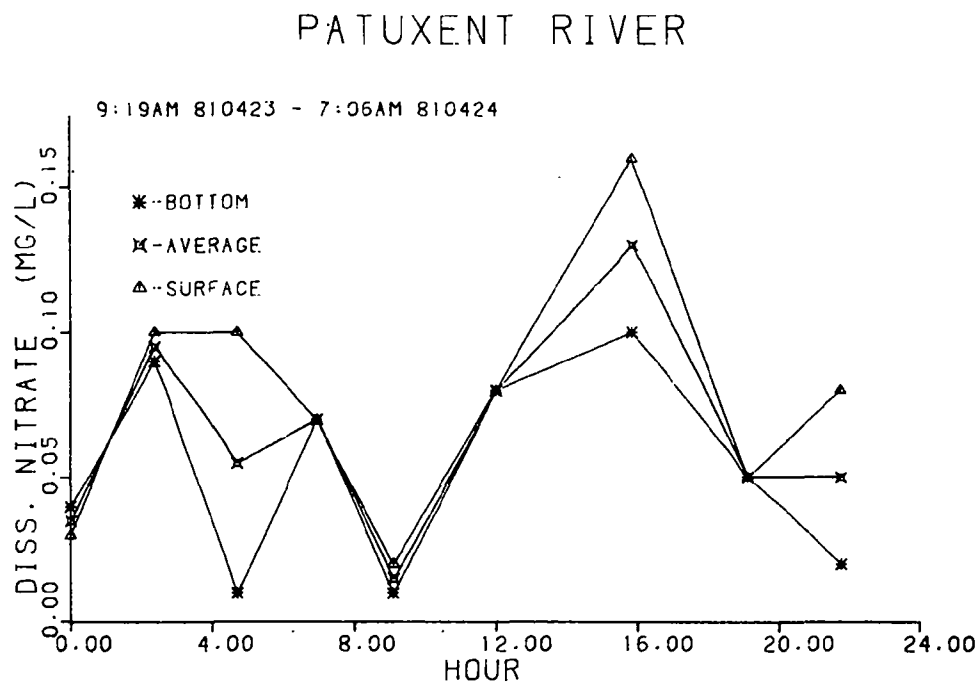
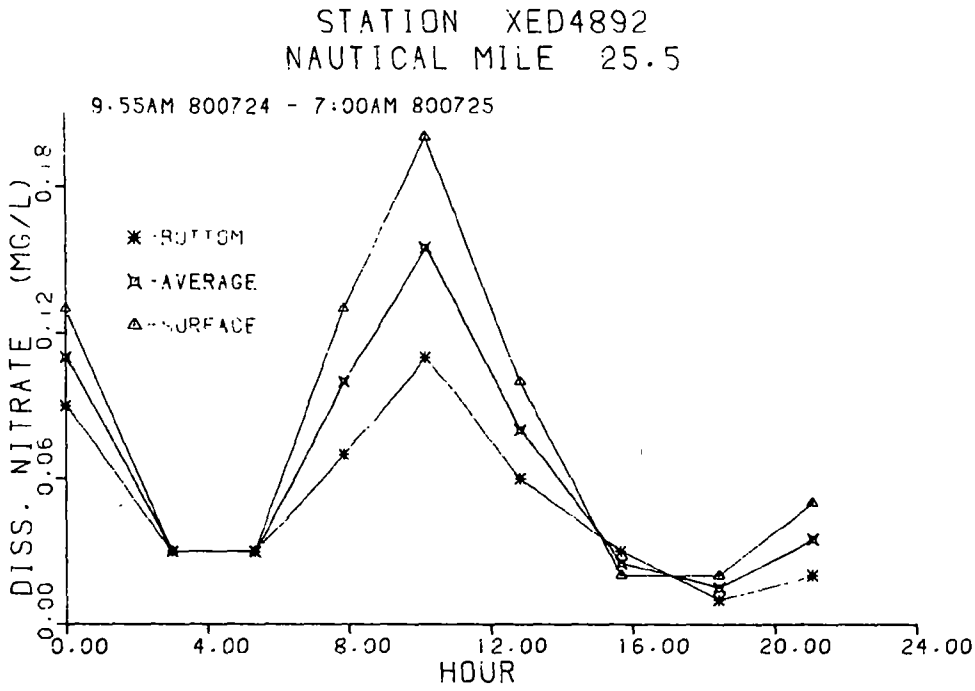


Figure 9-7 Intensive river survey plots of dissolved nitrate.



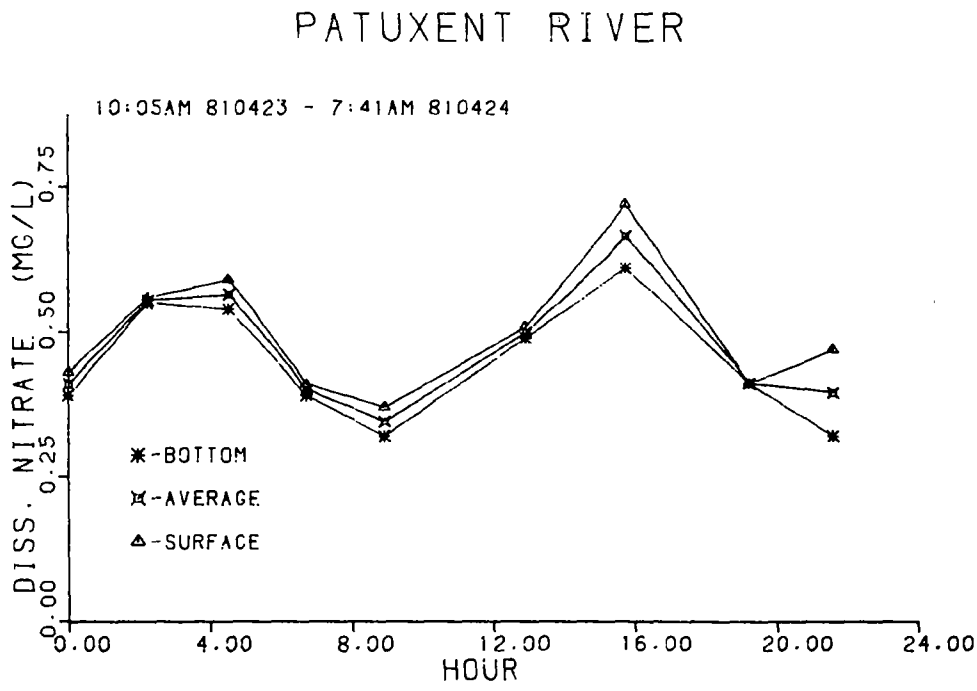
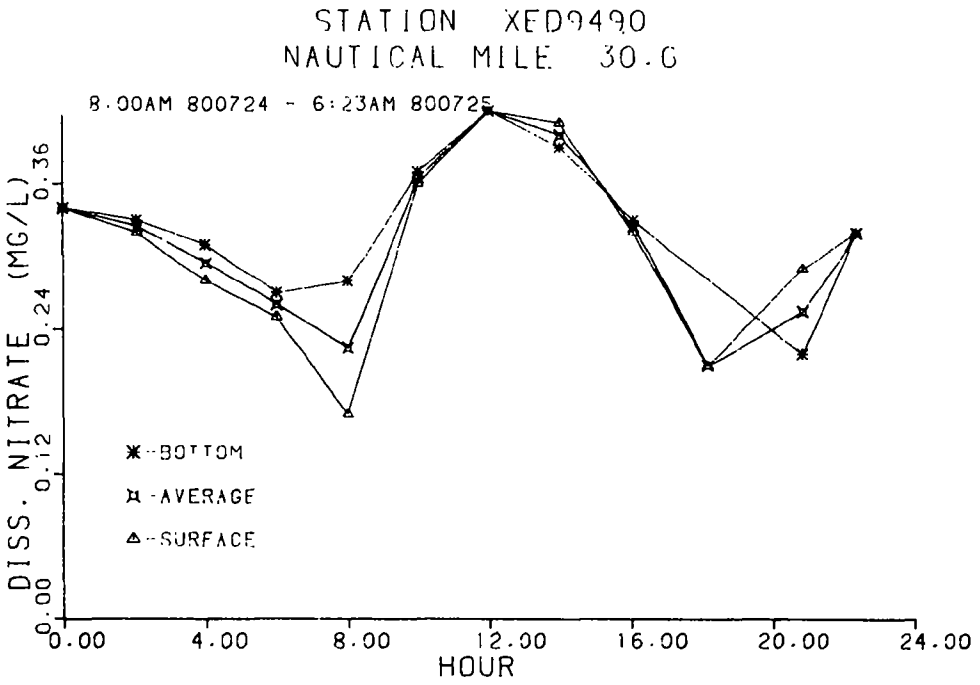


Figure 9-7 Intensive river survey plots of dissolved nitrate.



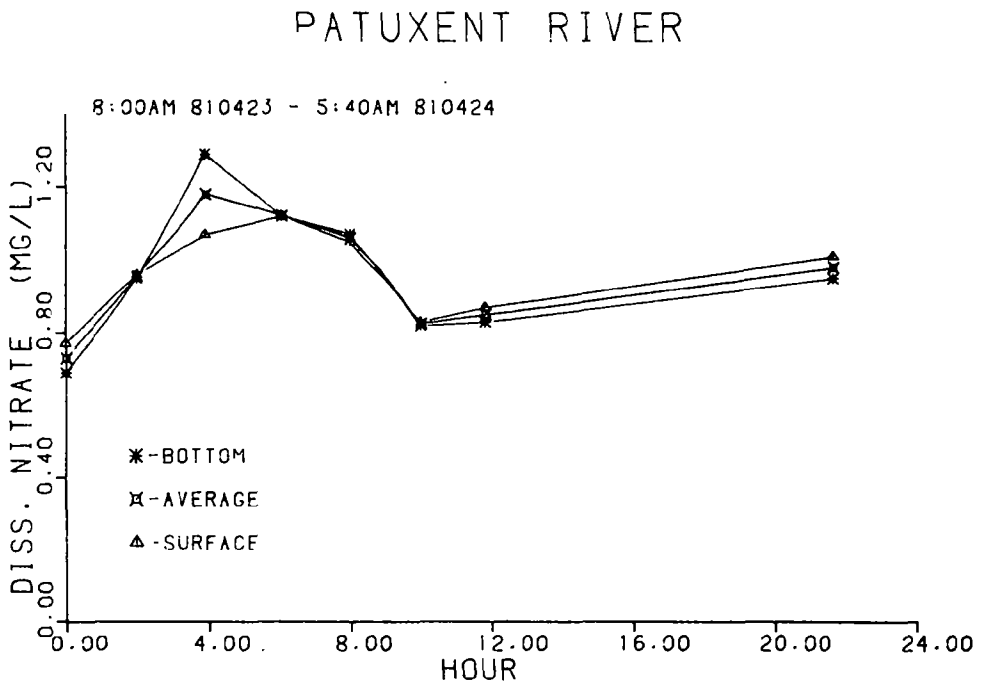
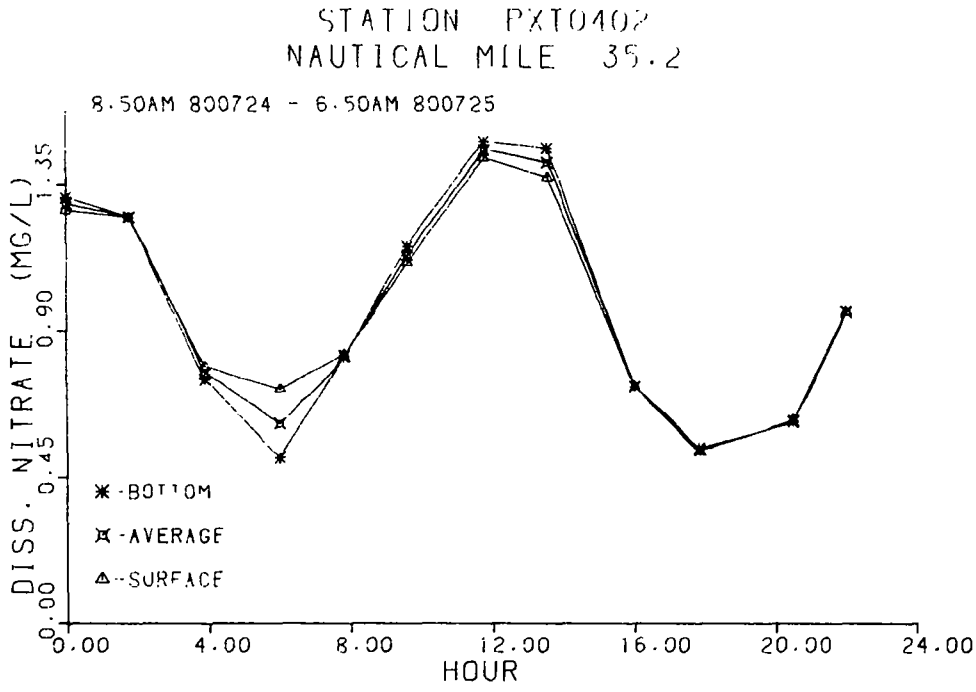


Figure 9-7 Intensive river survey plots of dissolved nitrate.



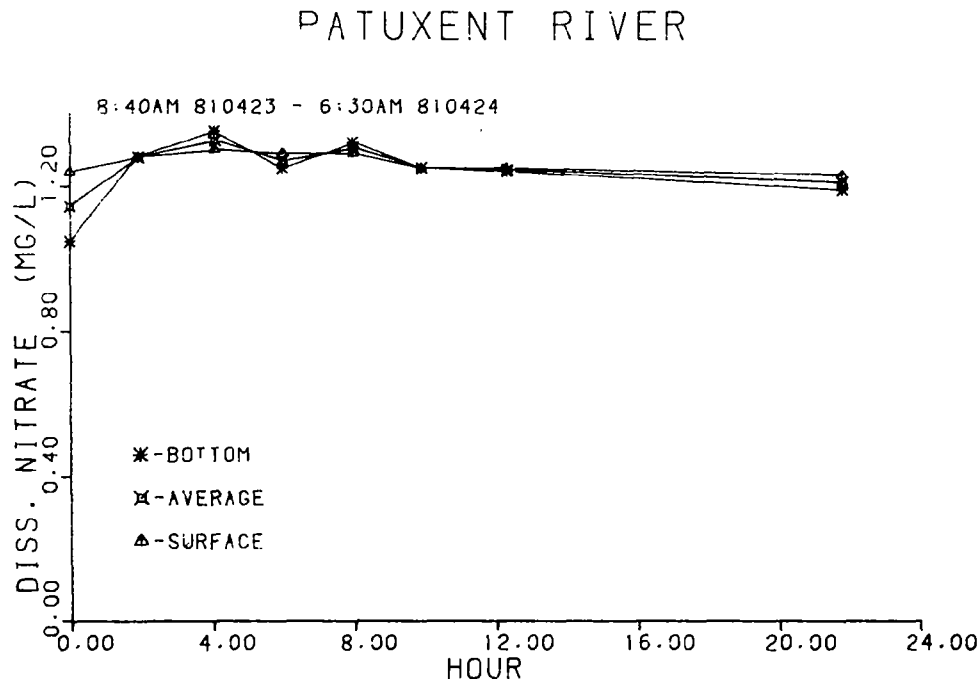
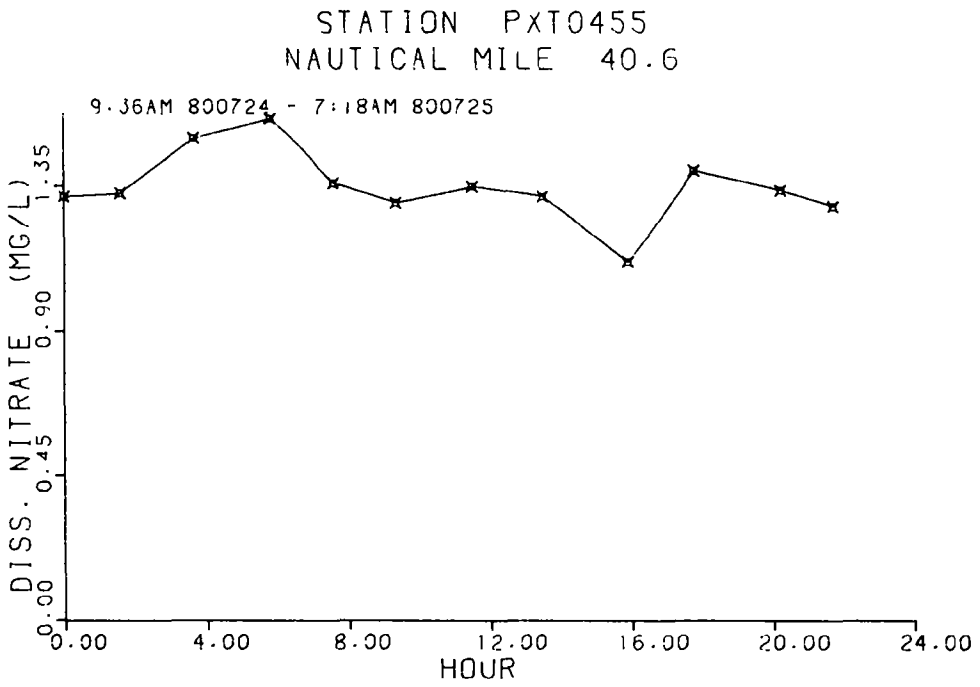


Figure 9-7 Intensive river survey plots of dissolved nitrate.



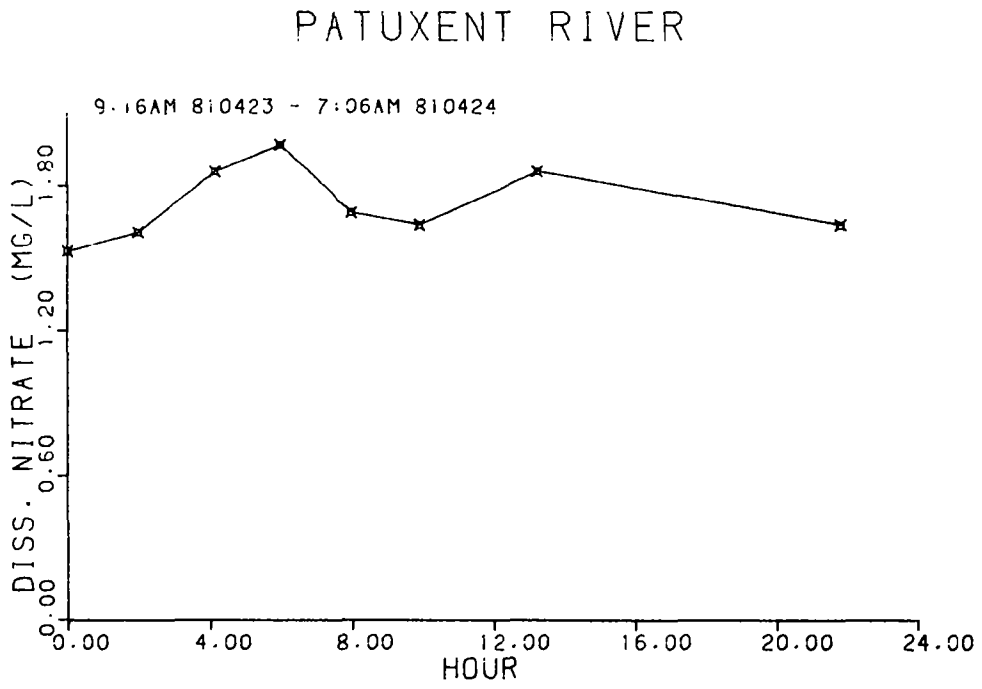
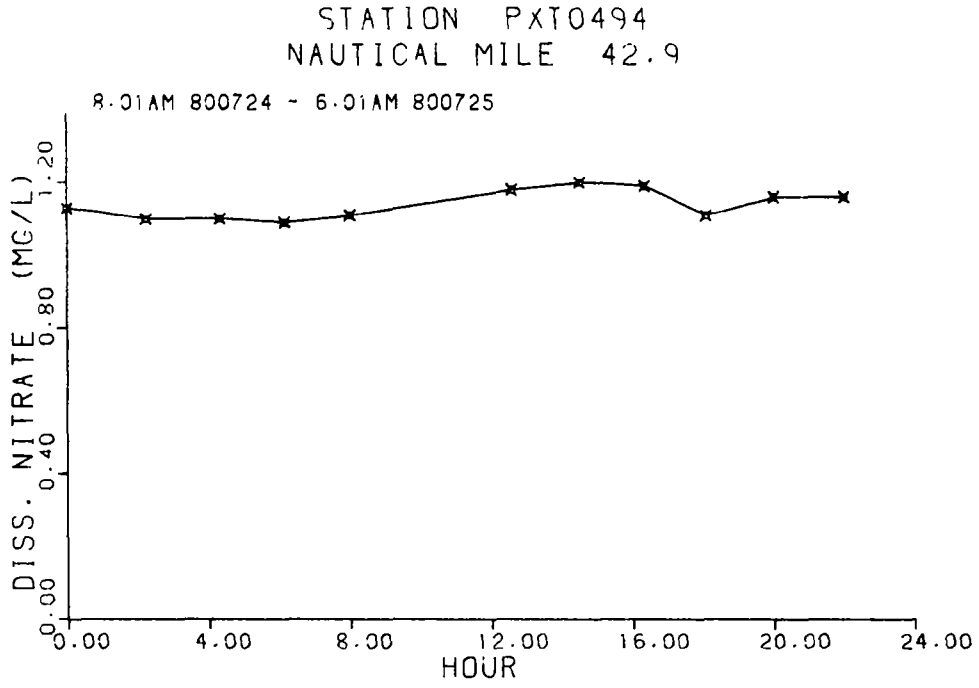


Figure 9-7 Intensive river survey plots of dissolved nitrate.



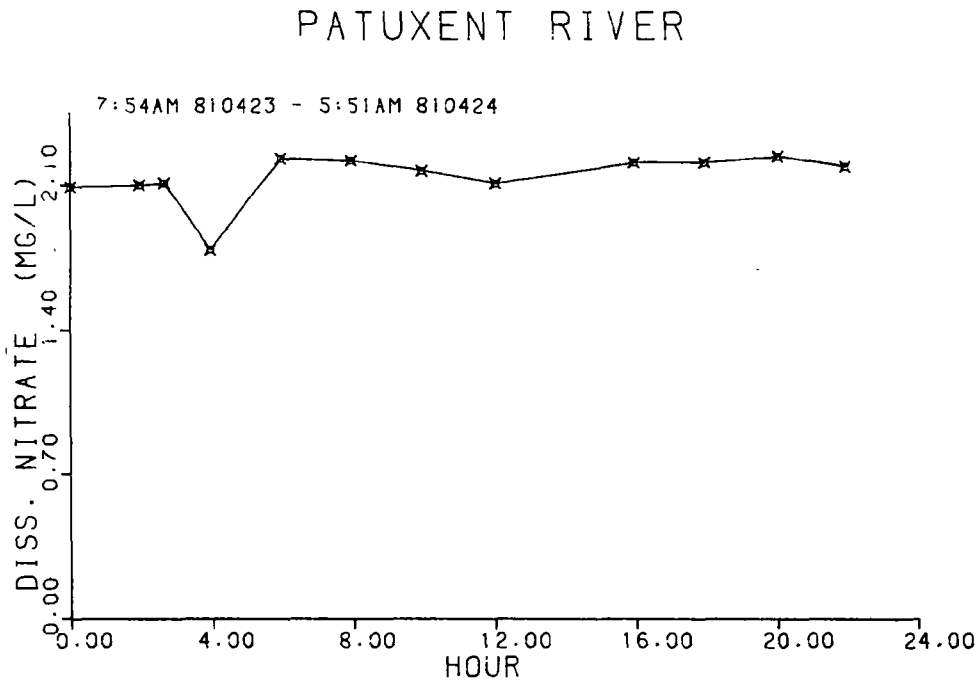
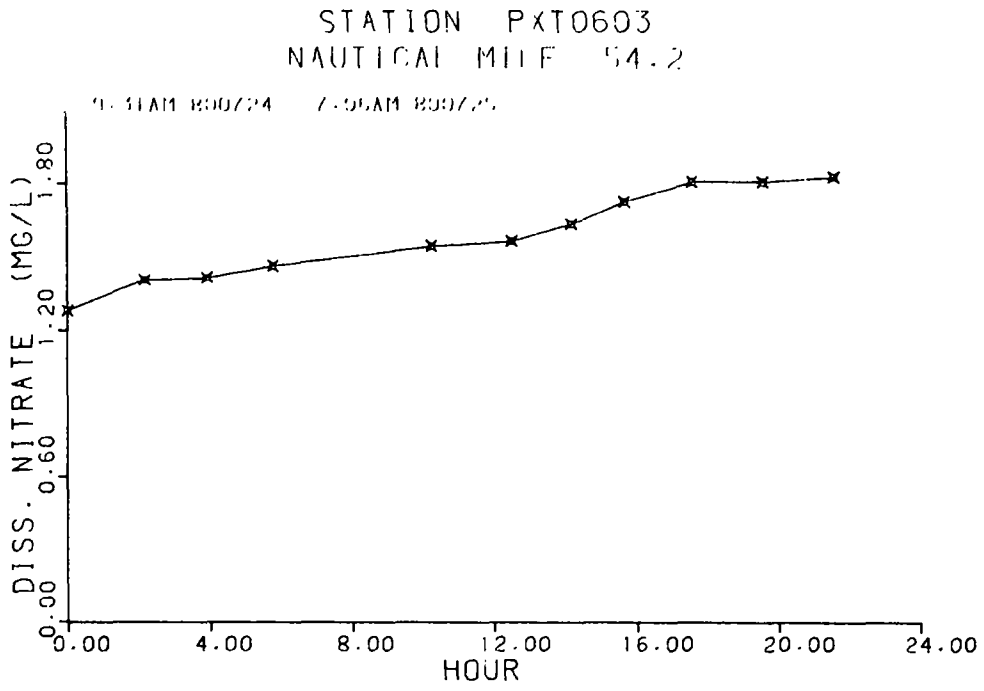


Figure 9-7 Intensive river survey plots of dissolved nitrate.



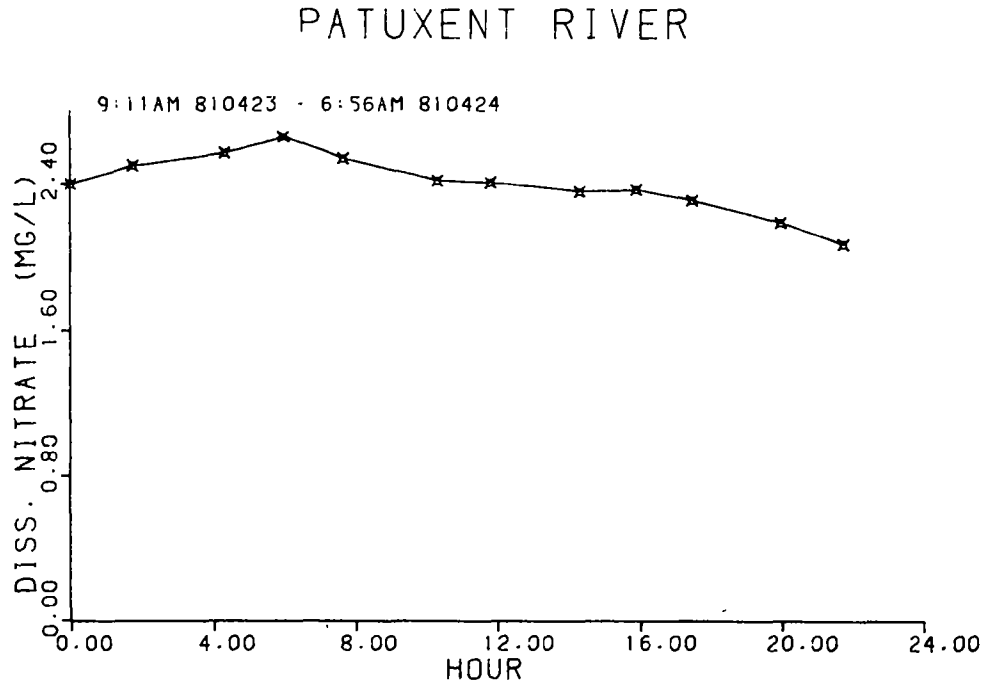
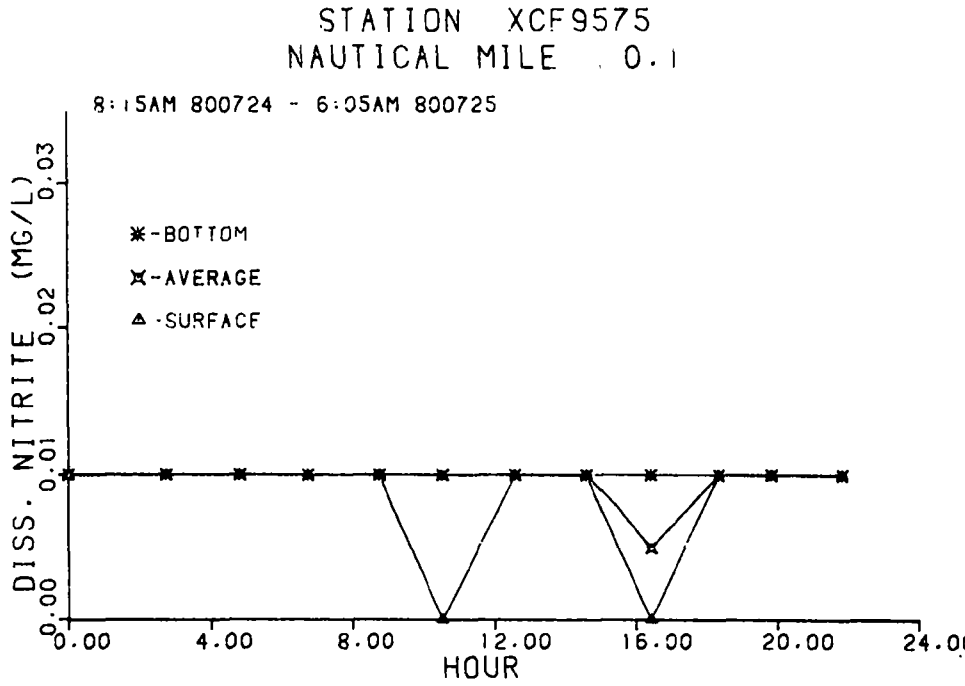


Figure 9-7 Intensive river survey plots of dissolved nitrate.



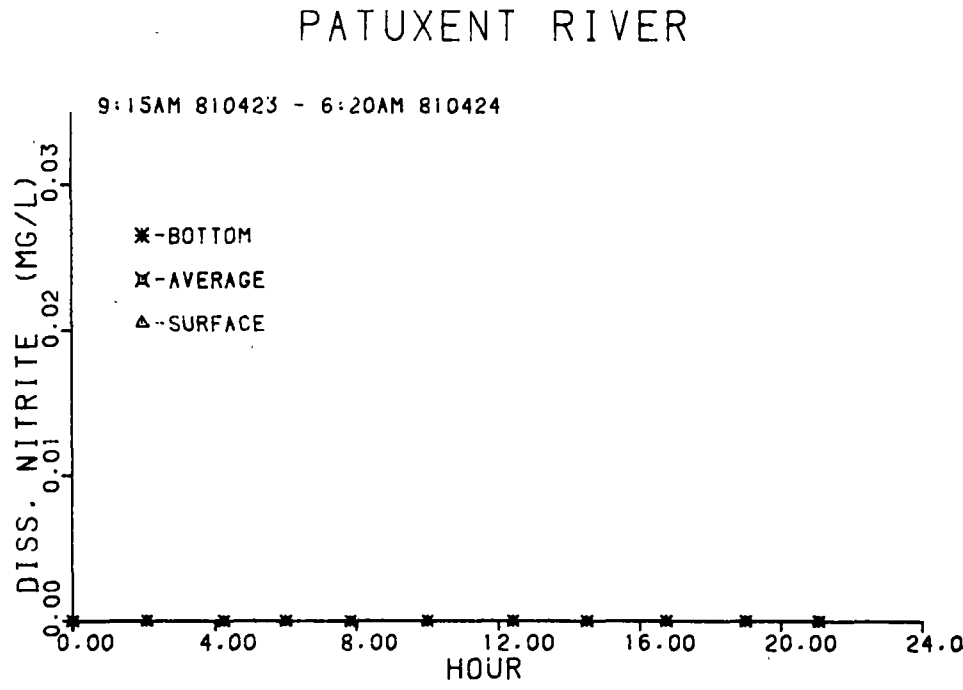
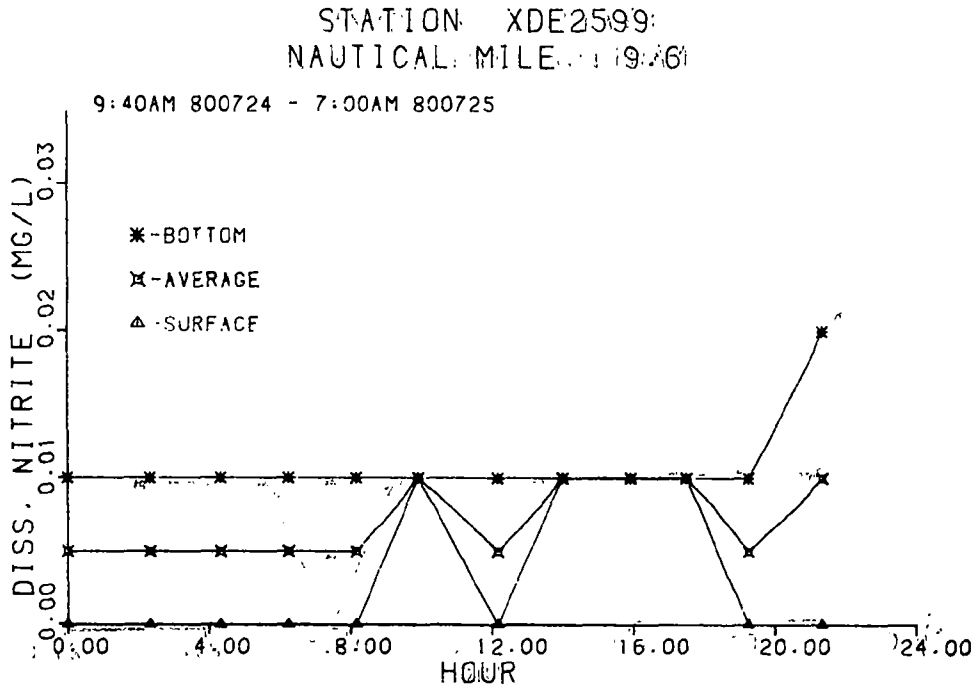


Figure 9-8 Intensive river survey plots of dissolved nitrite.



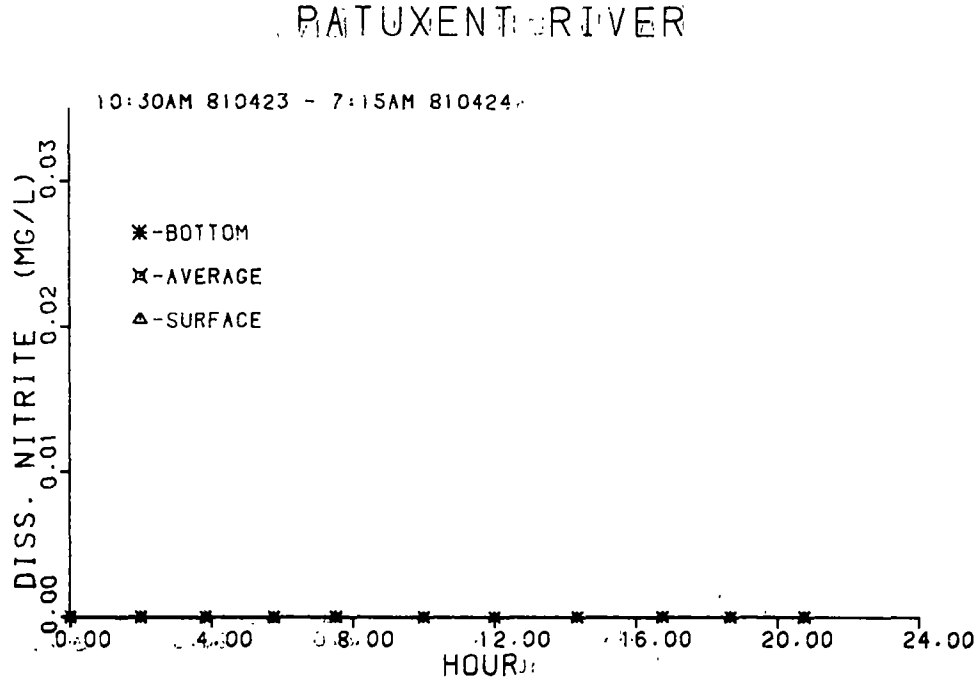
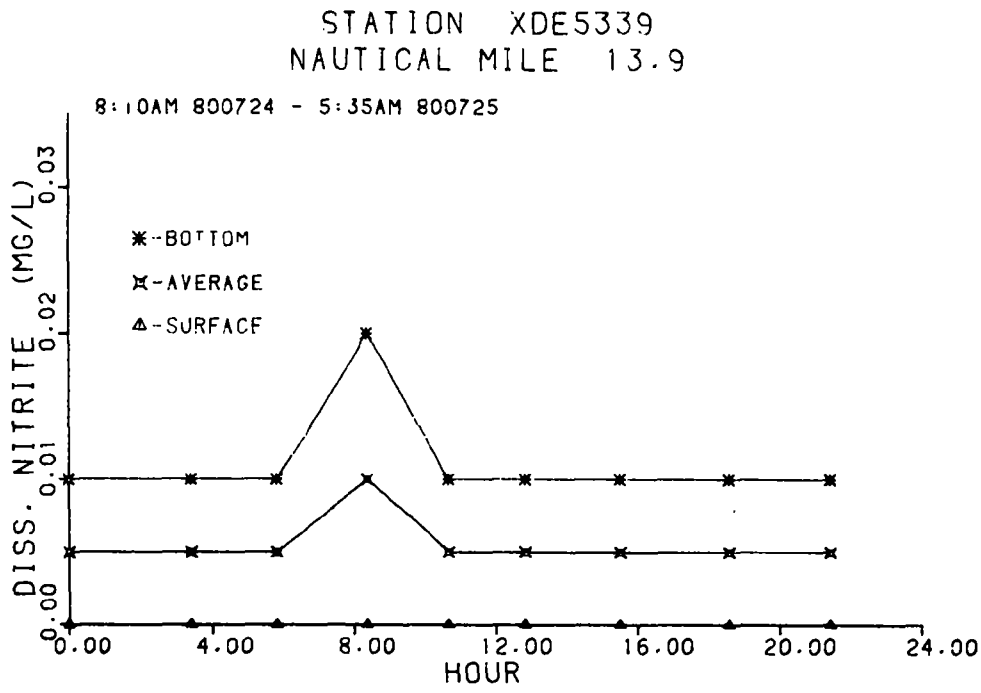


Figure 9-8 Intensive river survey plots of dissolved nitrite.



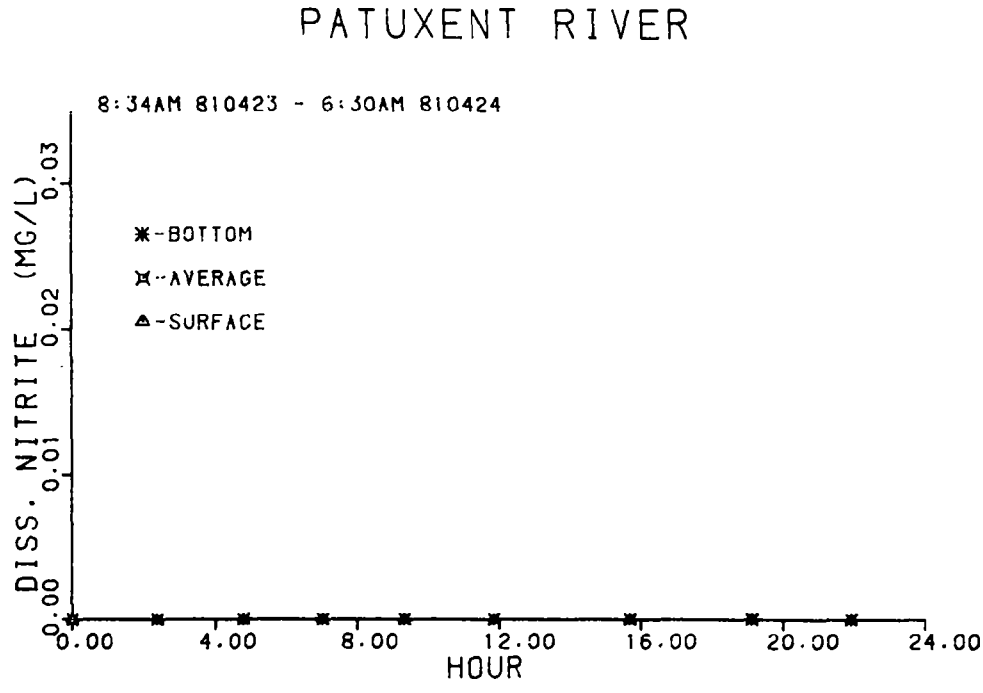
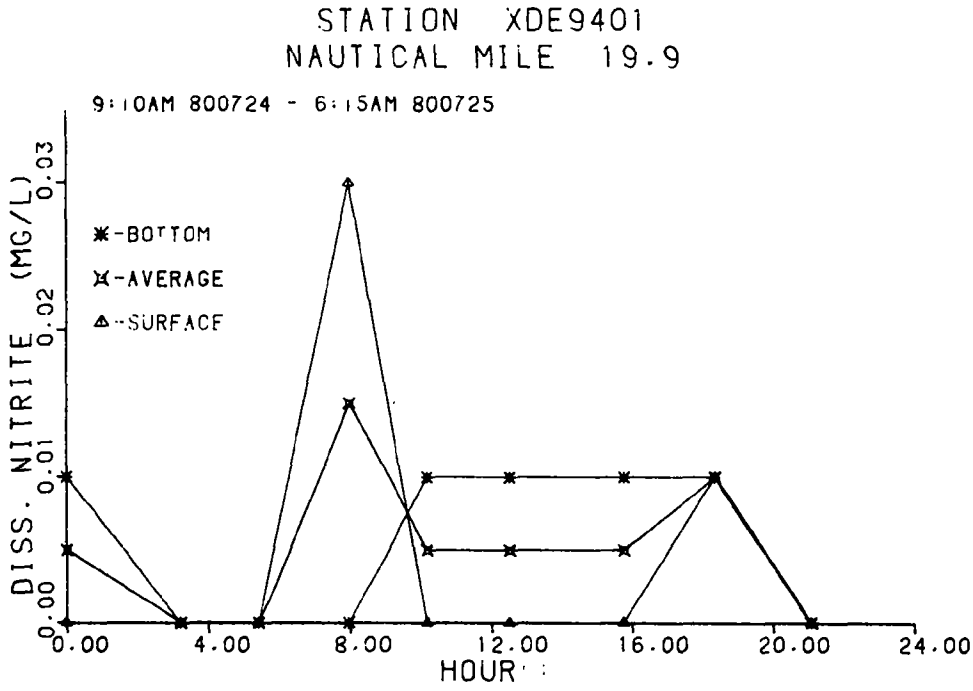


Figure 9-8 Intensive river survey plots of dissolved nitrite.



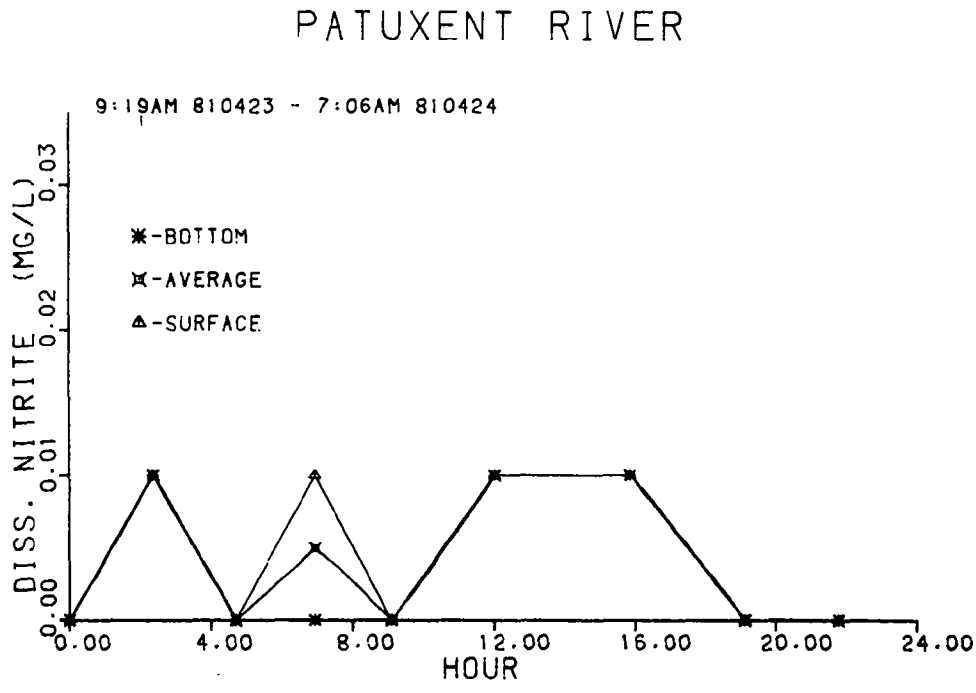
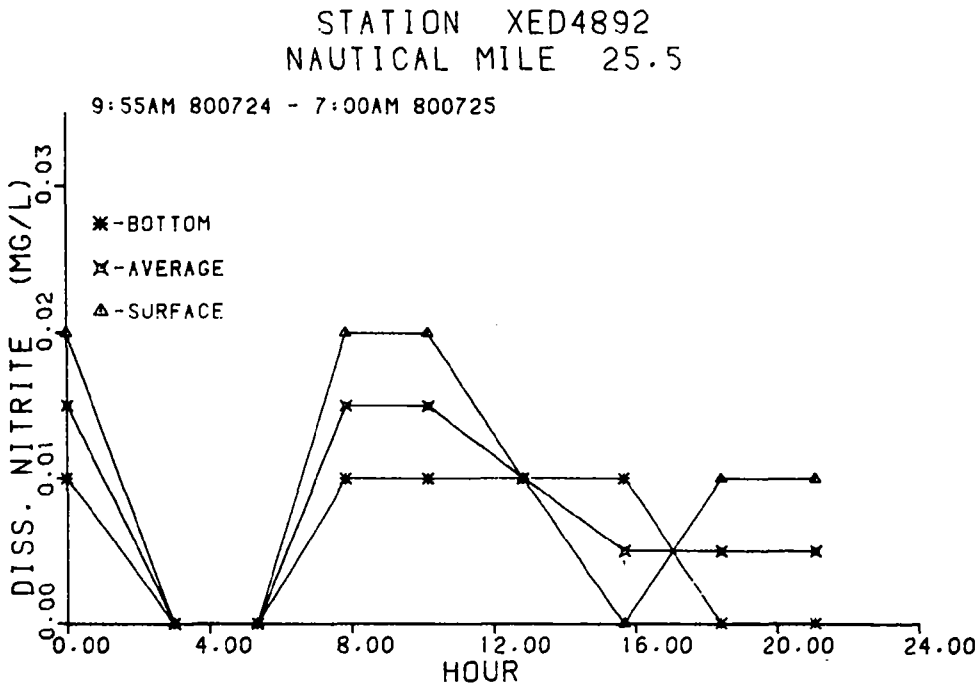


Figure 9-8 Intensive river survey plots of dissolved nitrite.



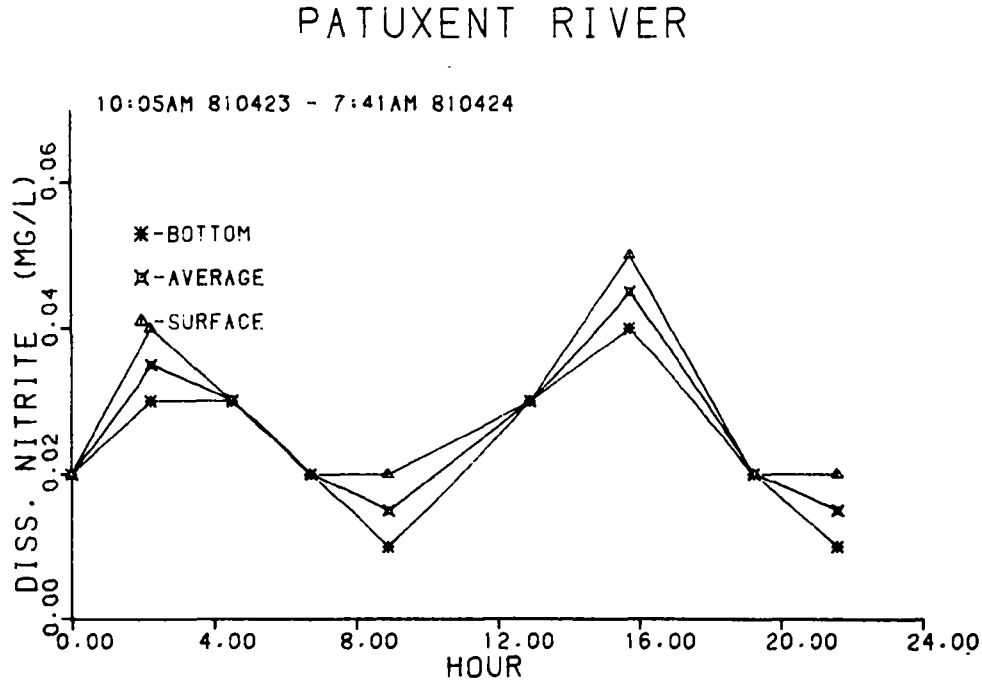
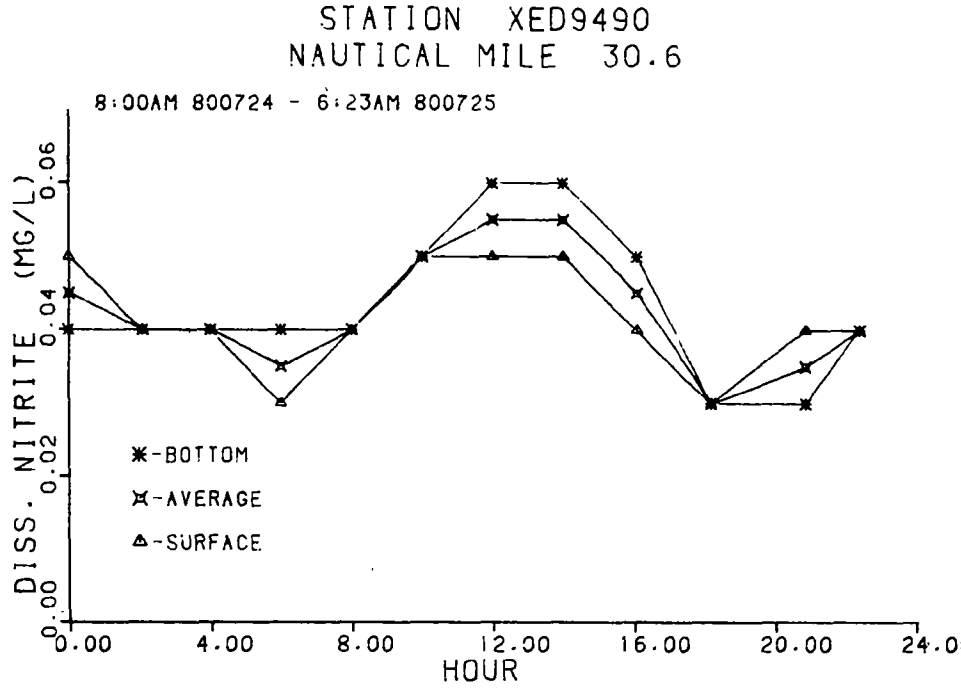


Figure 9-8 Intensive river survey plots of dissolved nitrite.



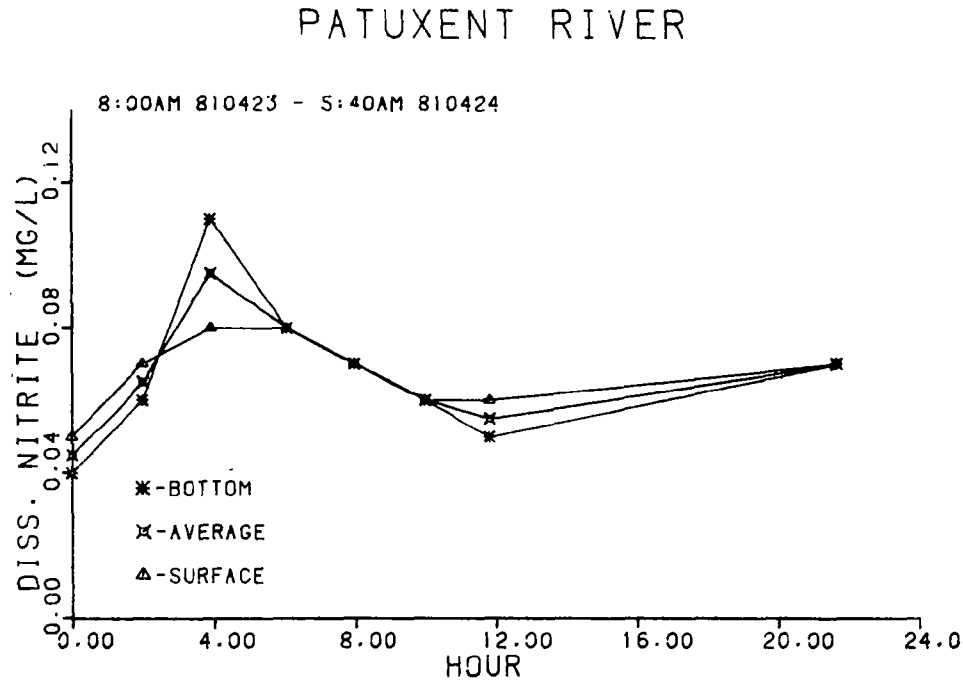
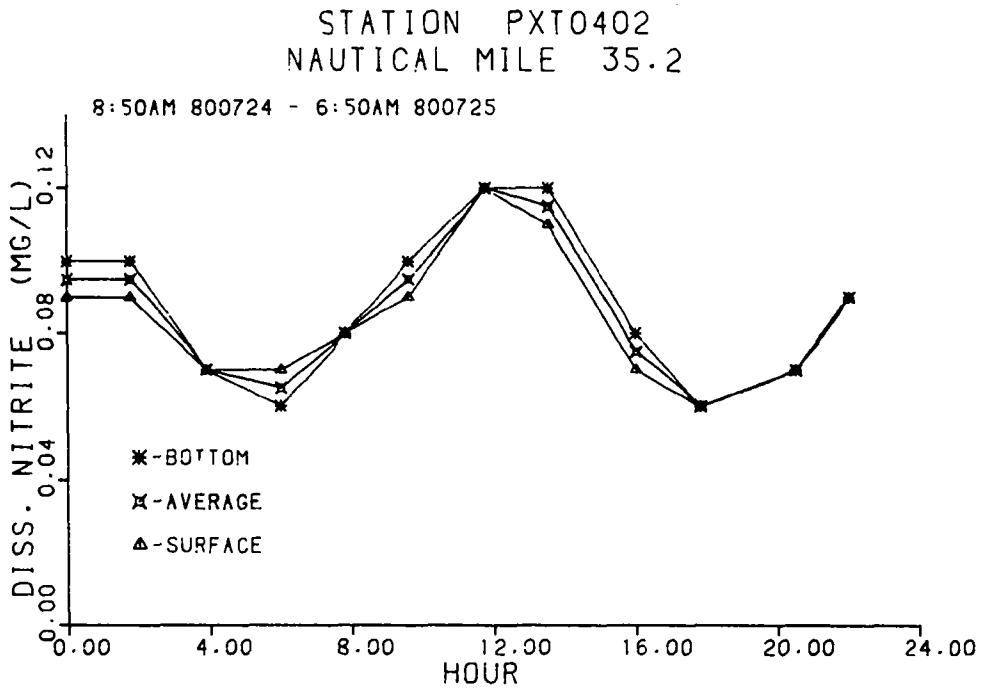


Figure 9-8 Intensive river survey plots of dissolved nitrite.



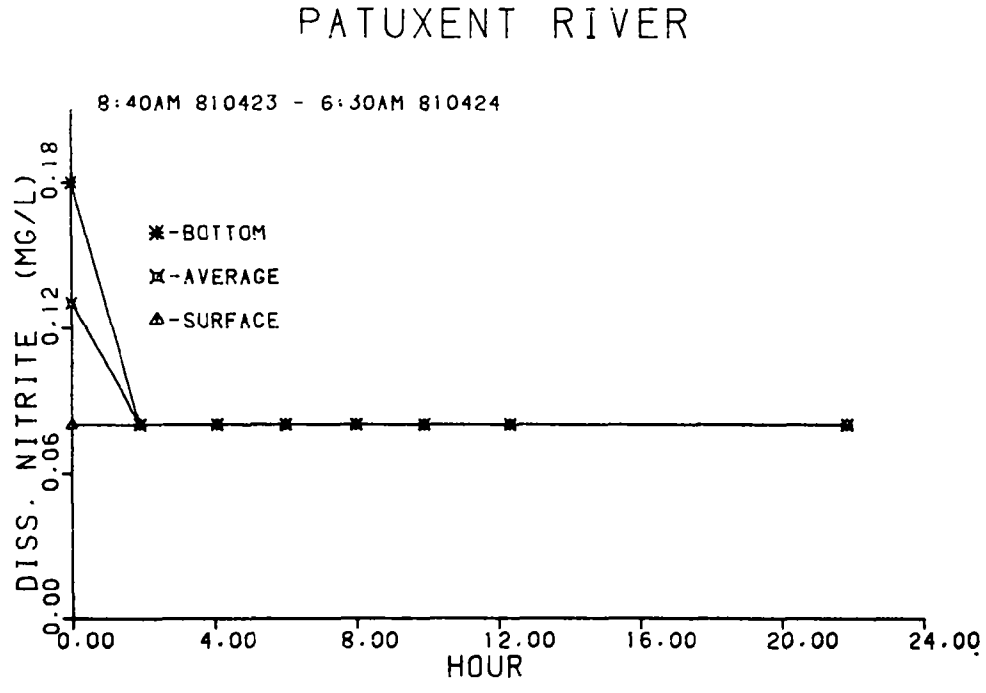
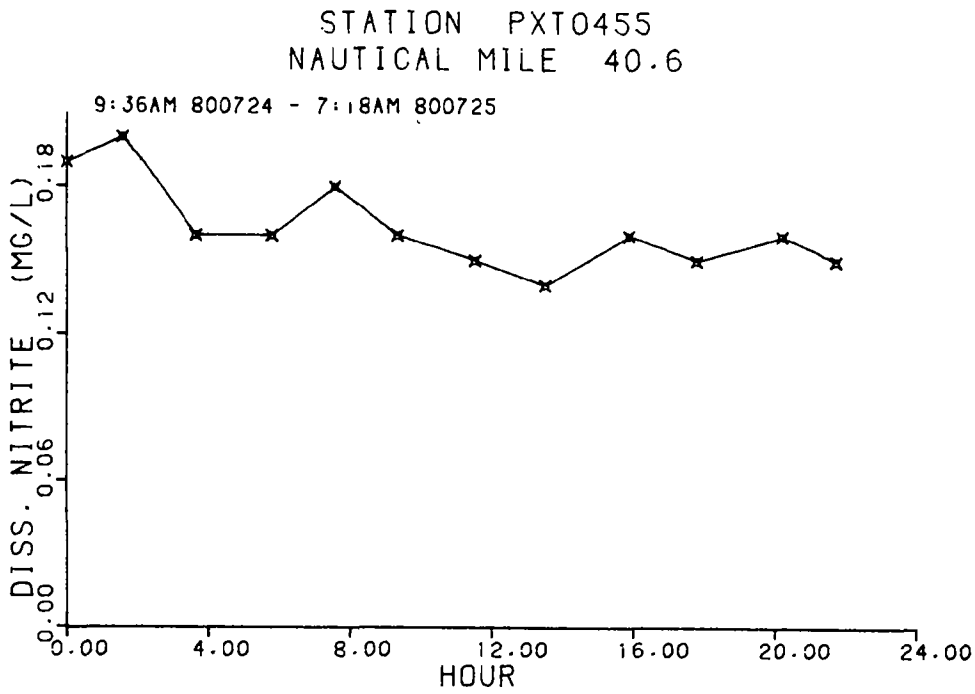


Figure 9-8 Intensive river survey plots of dissolved nitrite.



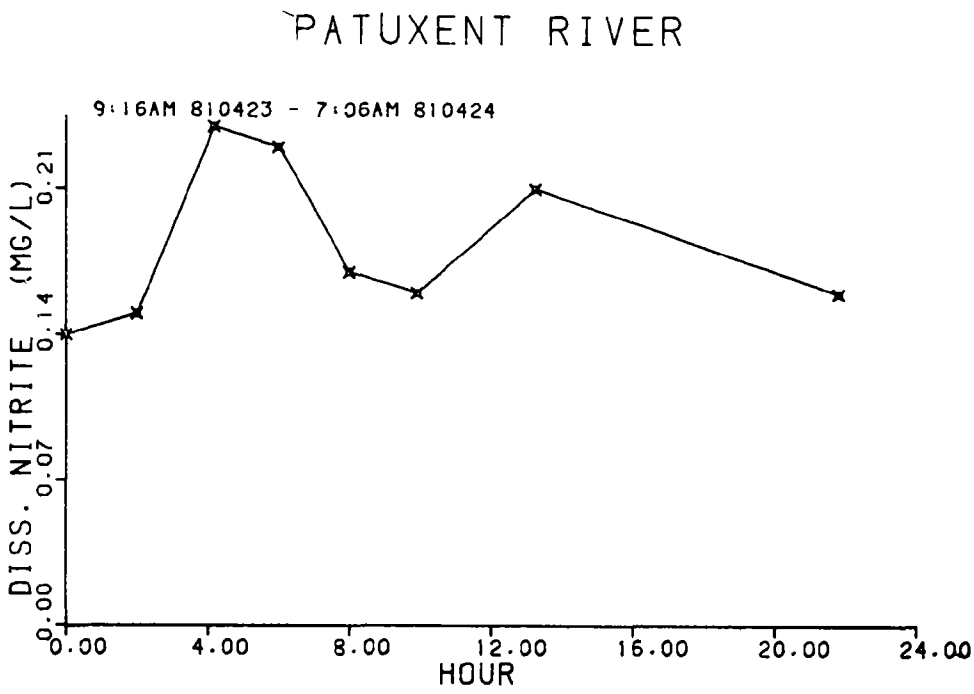
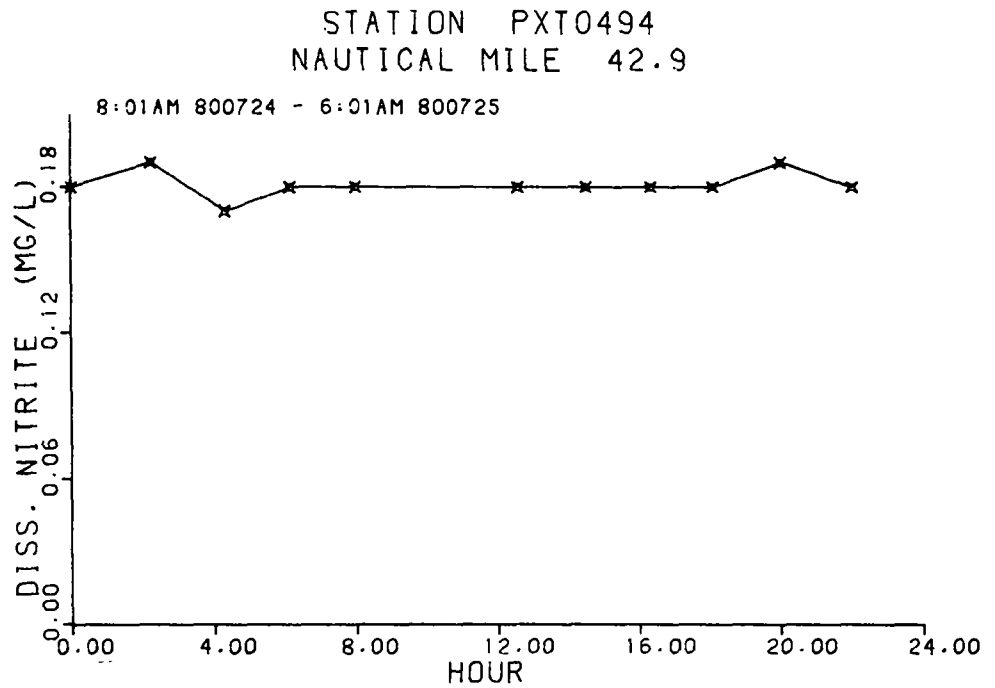


Figure 9-8 Intensive river survey plots of dissolved nitrite.



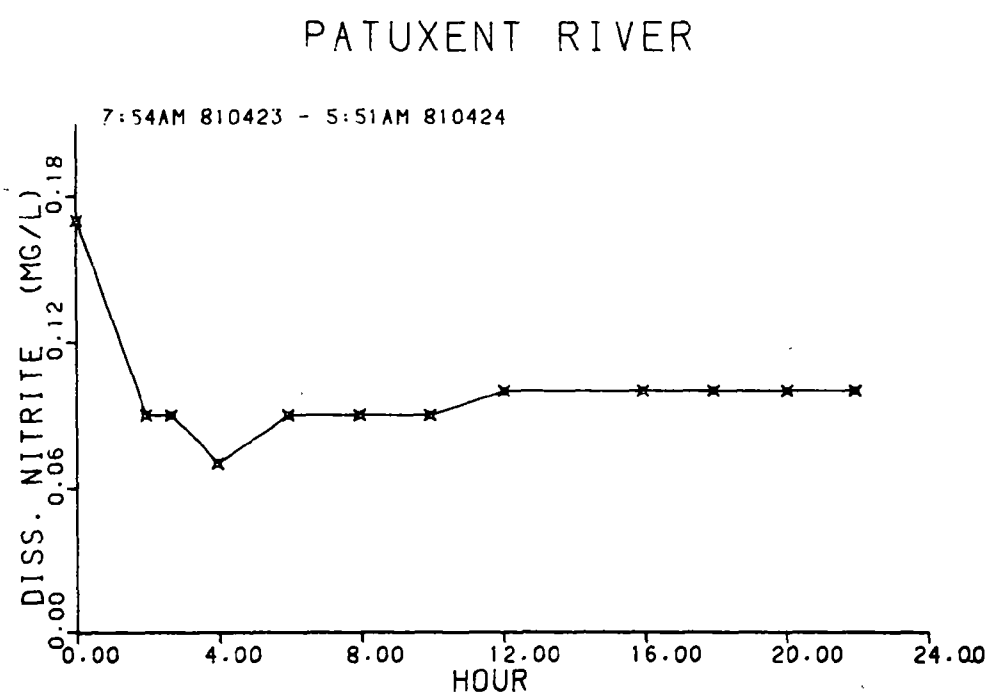
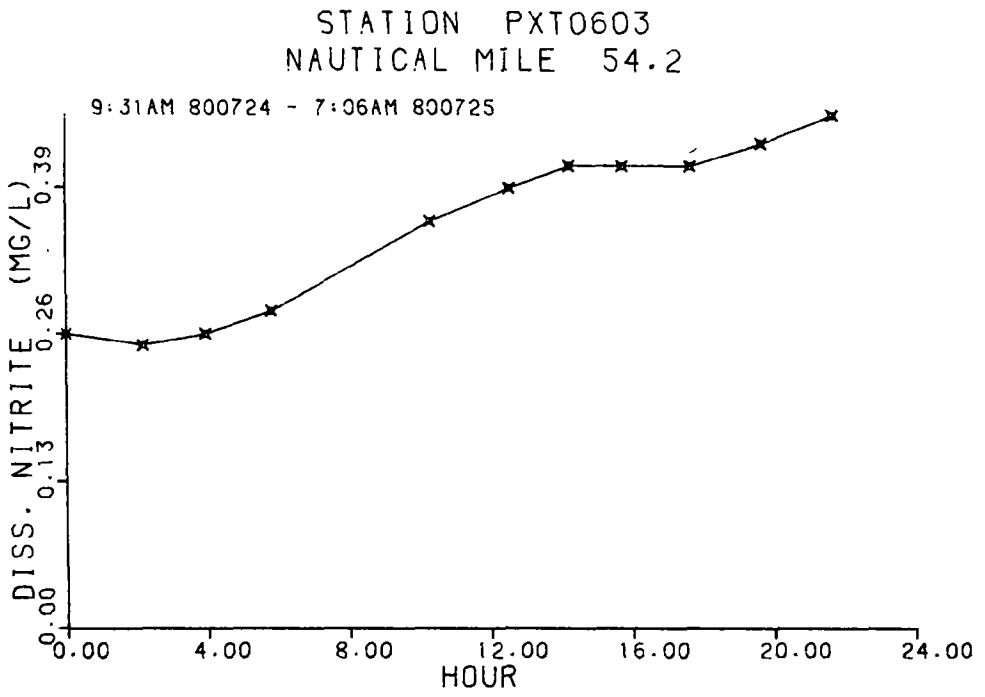


Figure 9-8 Intensive river survey plots of dissolved nitrite.



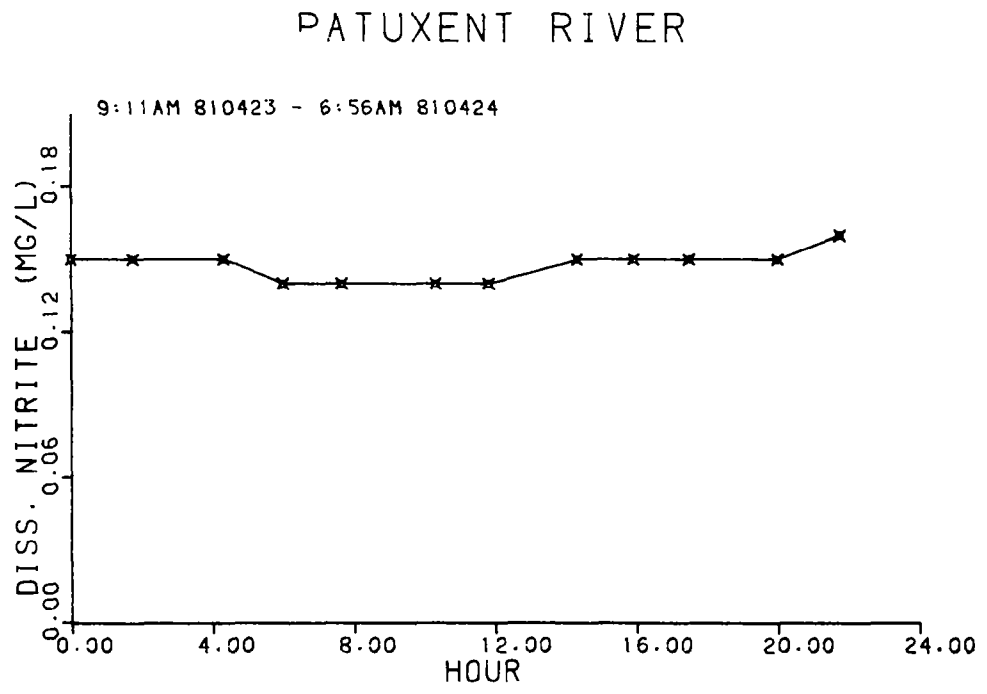
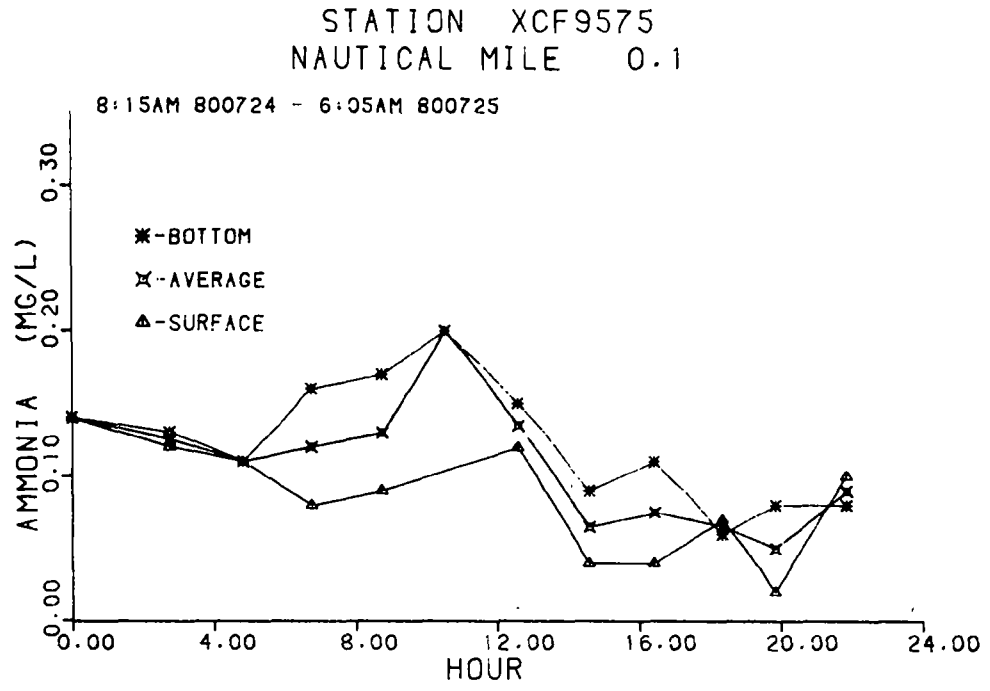


Figure 9-8 Intensive river survey plots of dissolved nitrite.



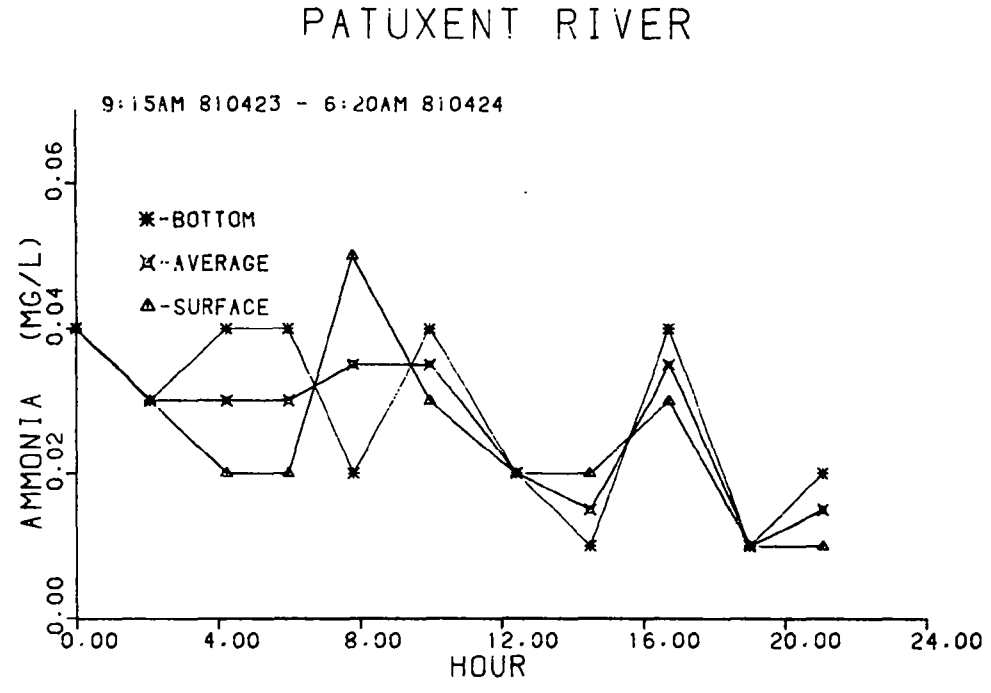
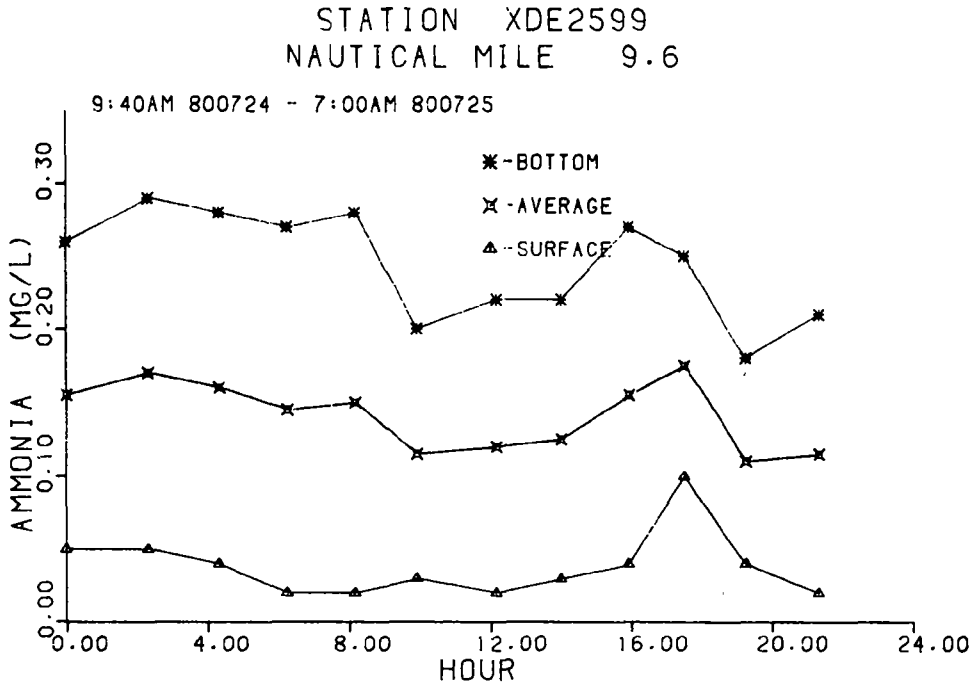


Figure 9-9 Intensive river survey plots of ammonia.



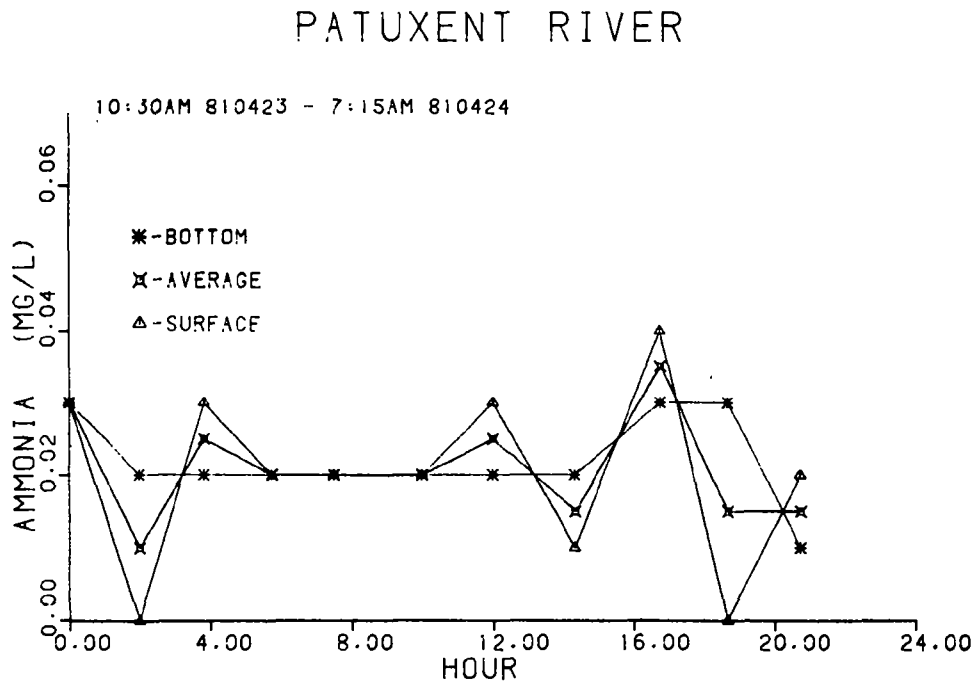
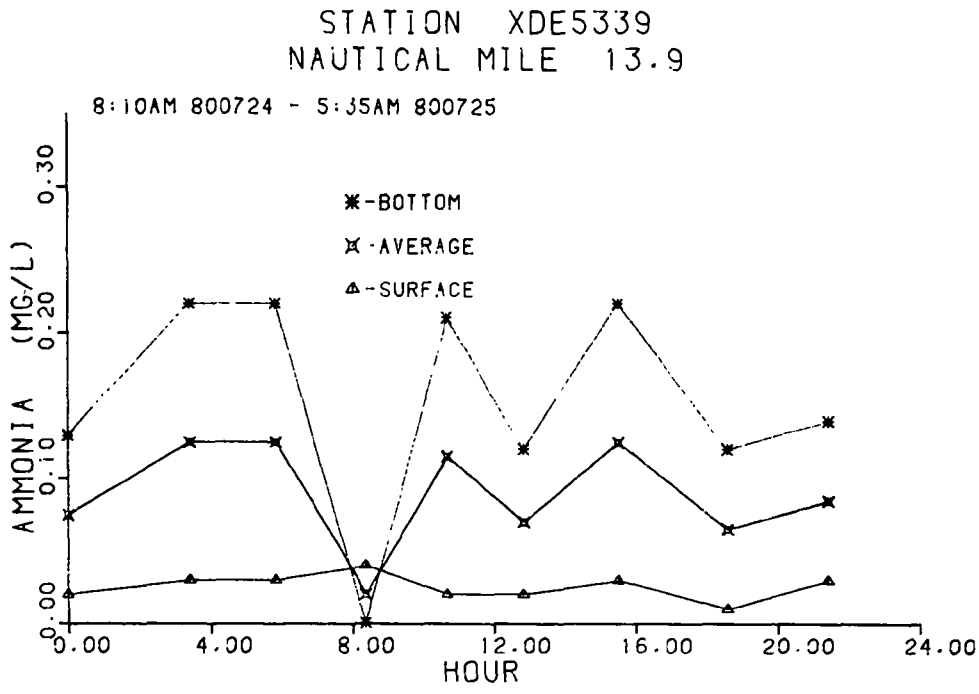


Figure 9-9 Intensive river survey plots of ammonia.



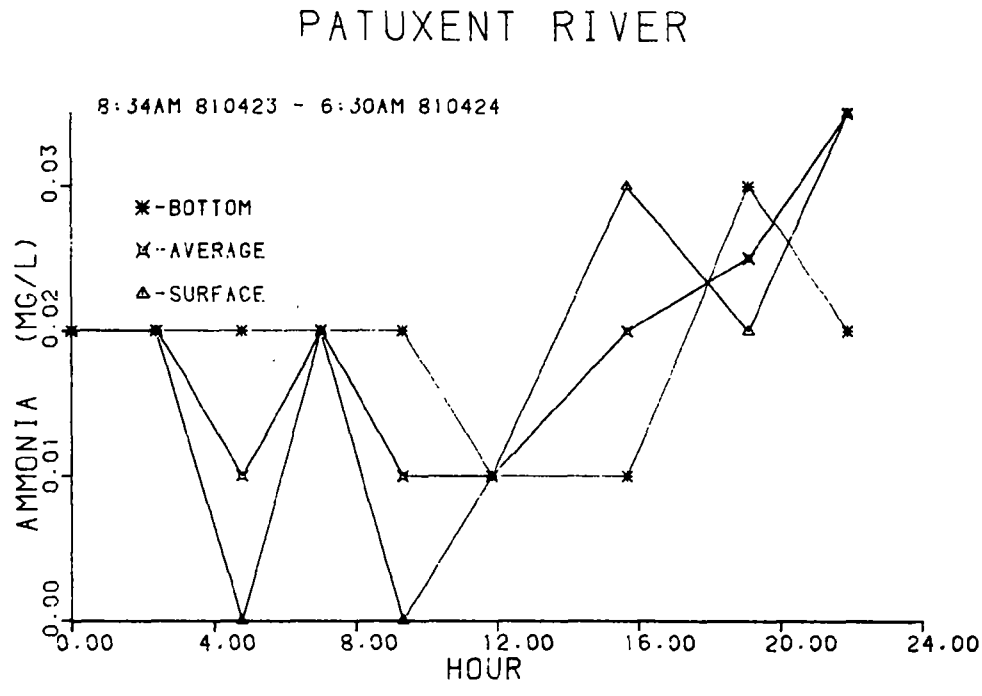
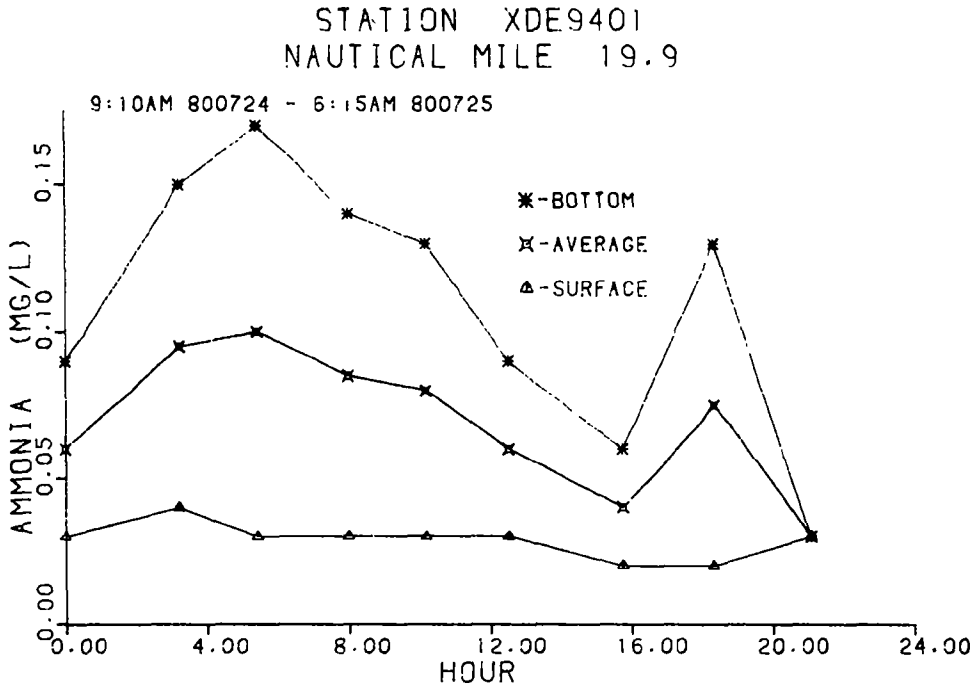


Figure 9-9 Intensive river survey plots of ammonia.



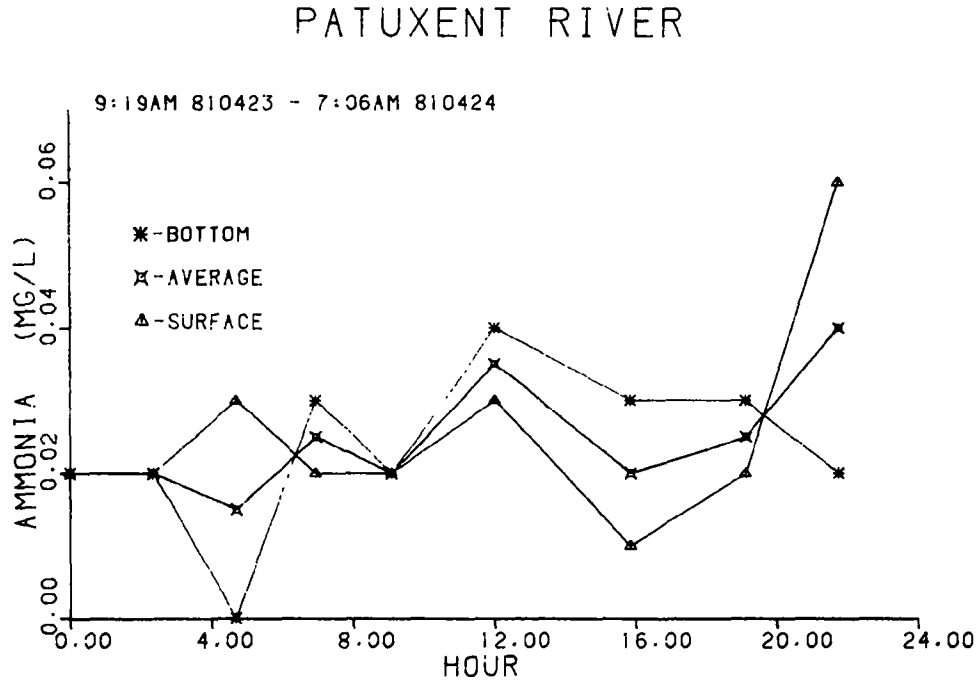
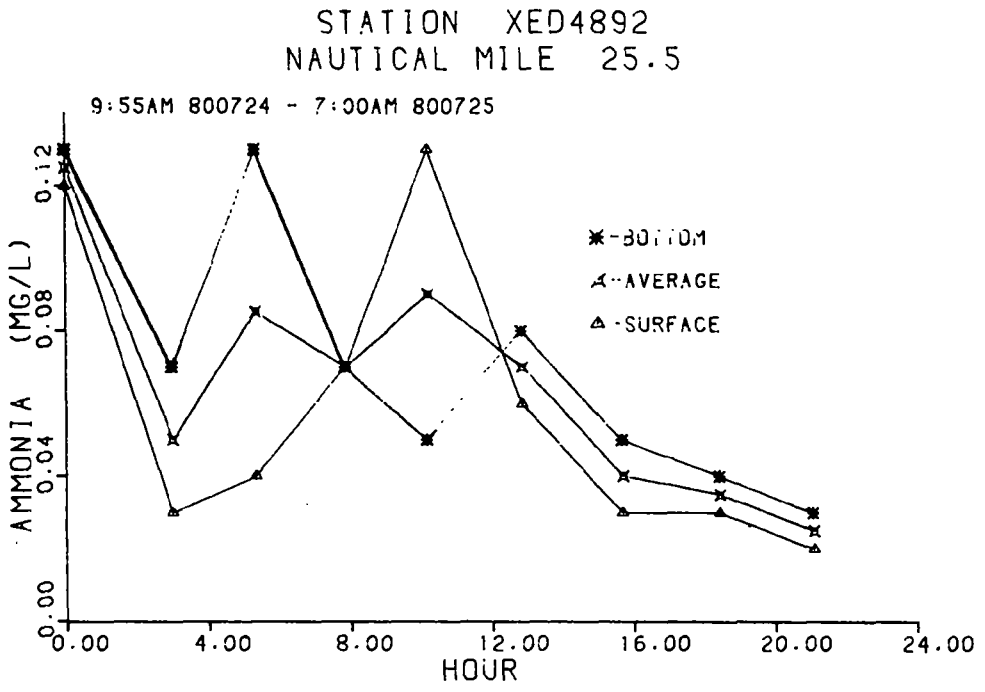


Figure 9-9 Intensive river survey plots of ammonia.



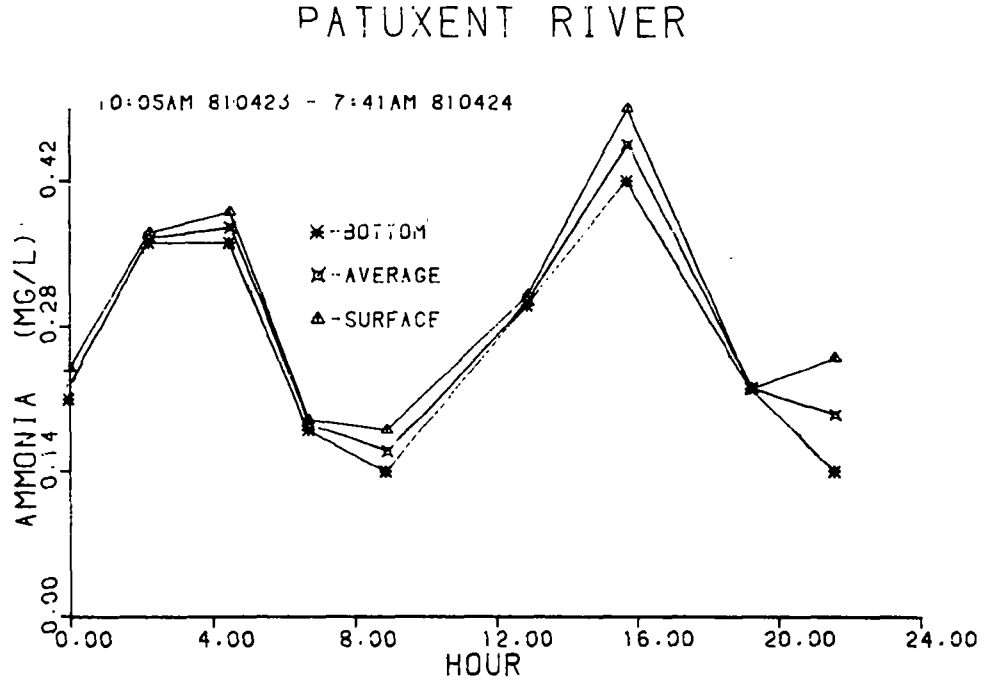
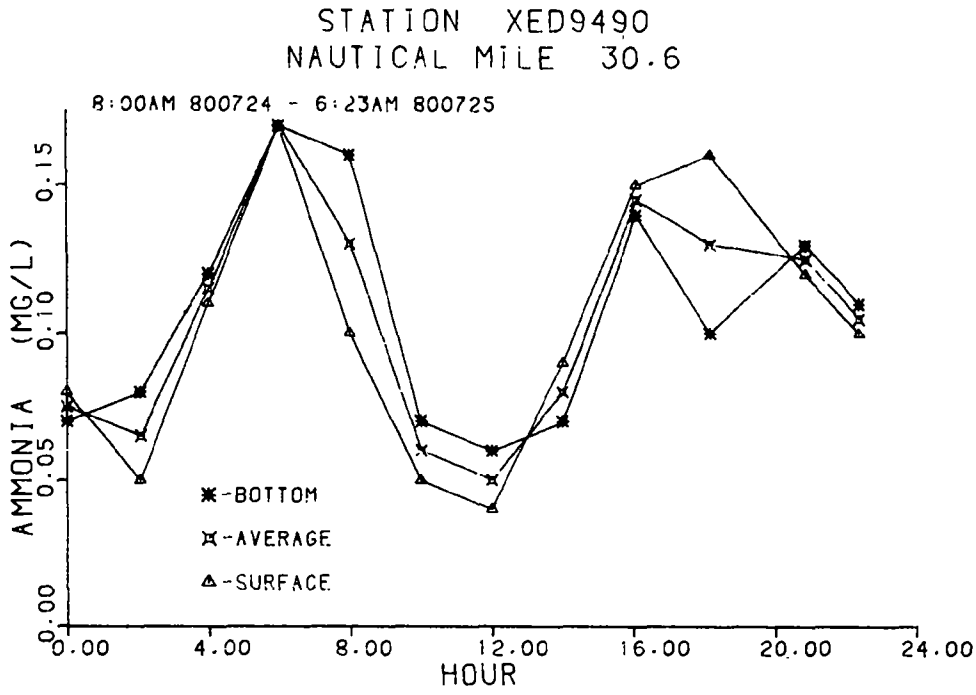


Figure 9-9 Intensive river survey plots of ammonia.



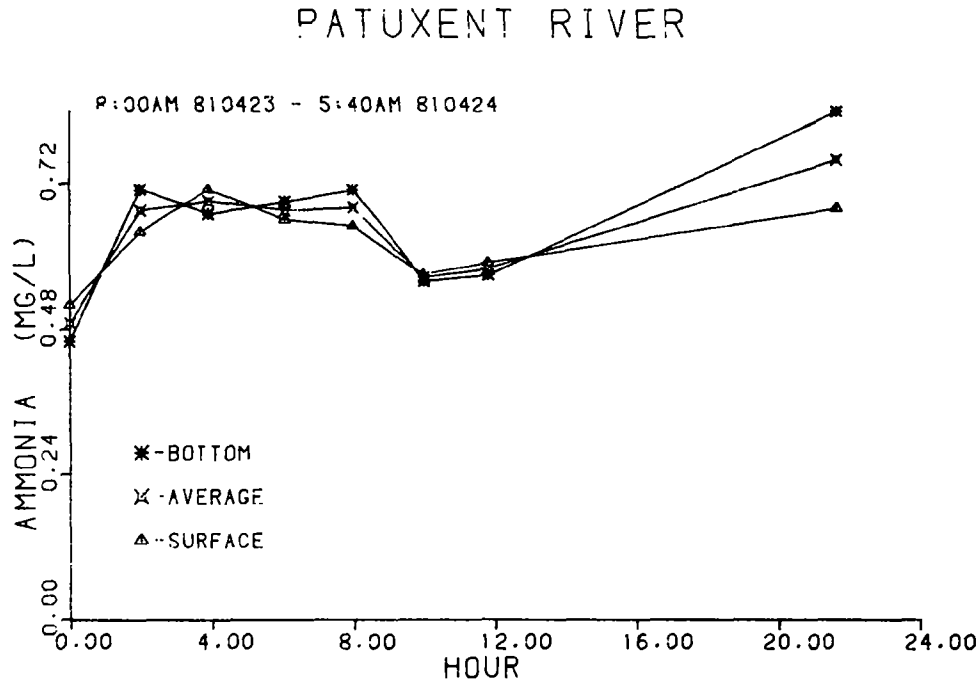
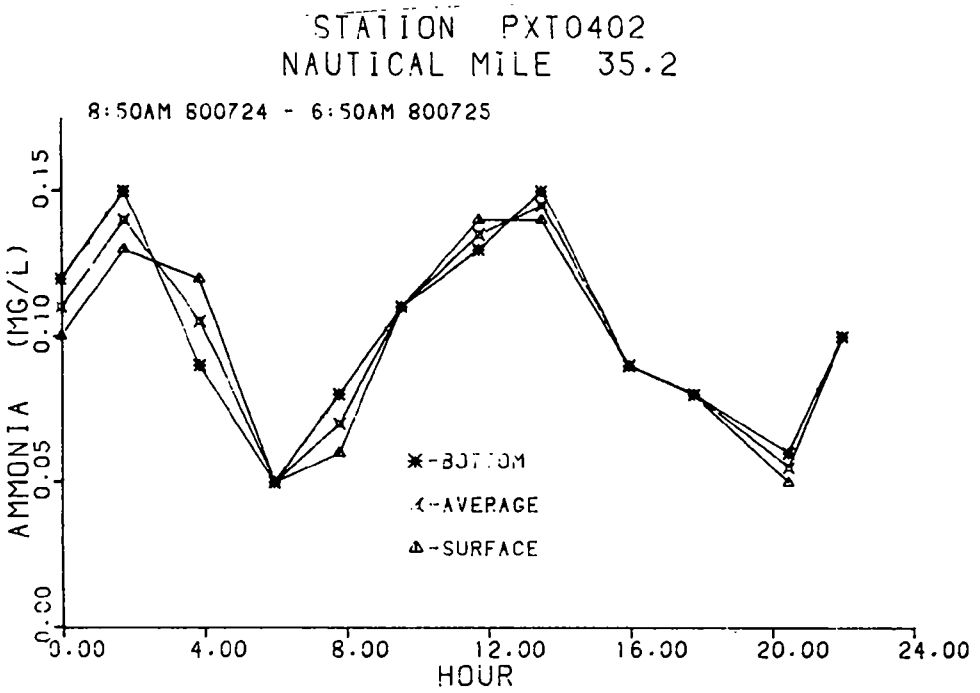


Figure 9-9 Intensive river survey plots of ammonia.



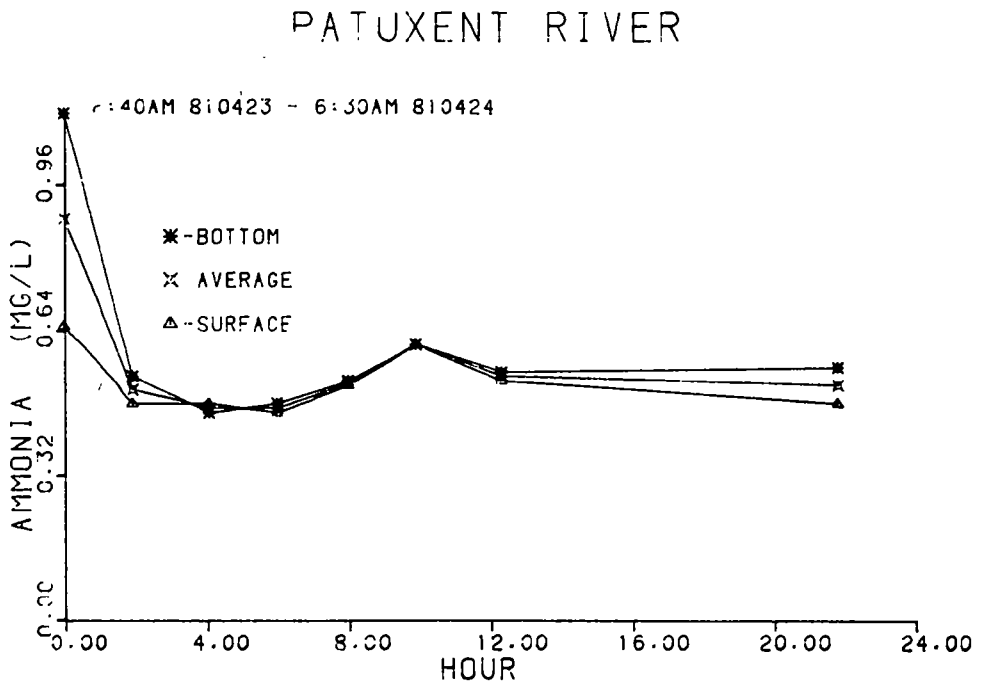
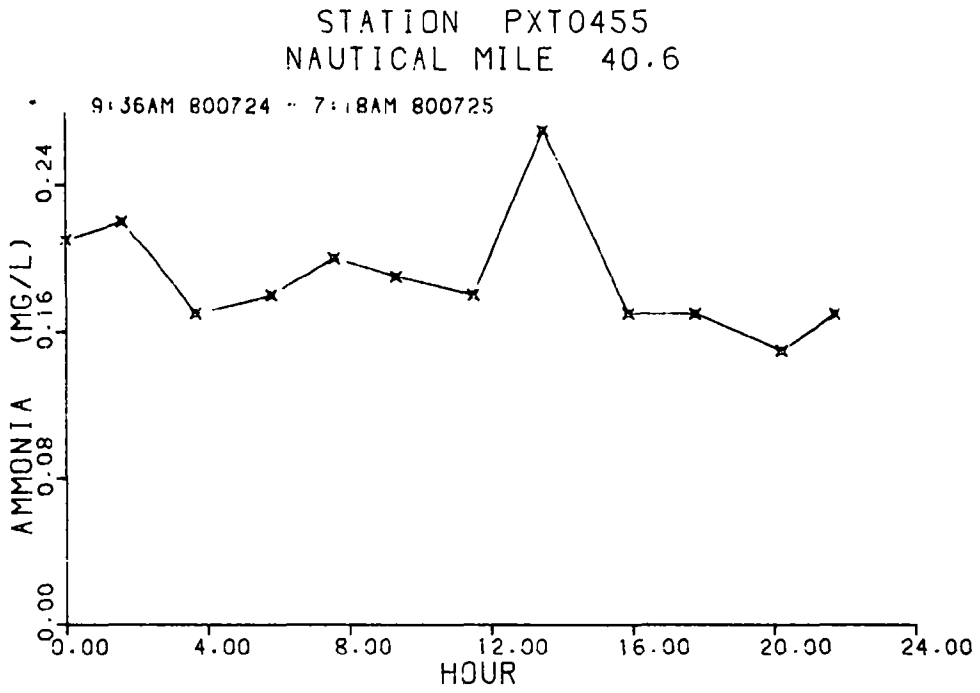


Figure 9-9 Intensive river survey plots of ammonia.



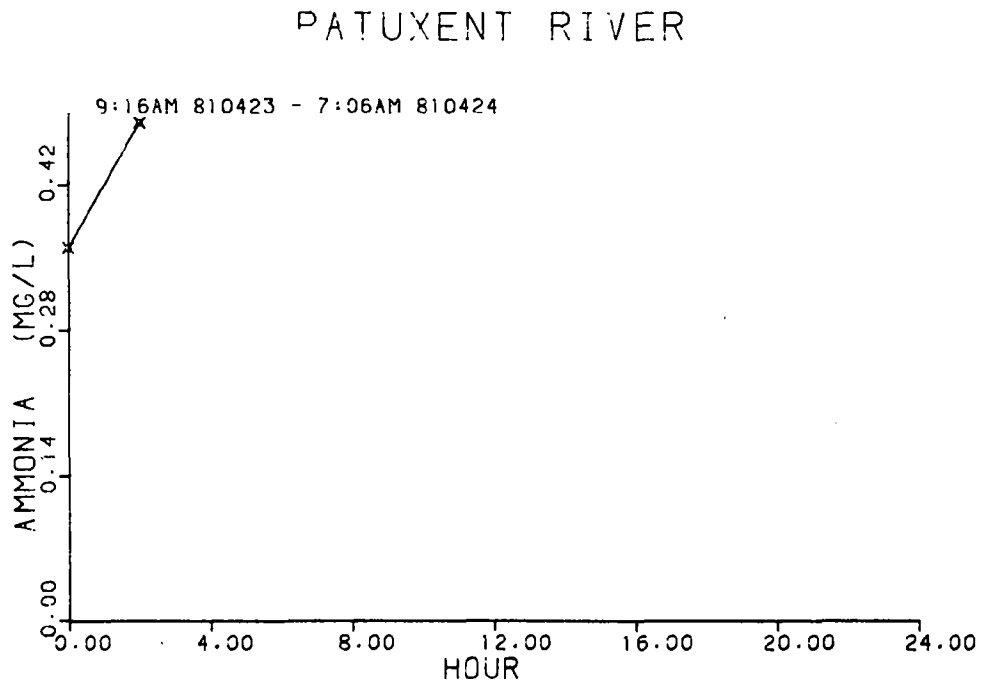
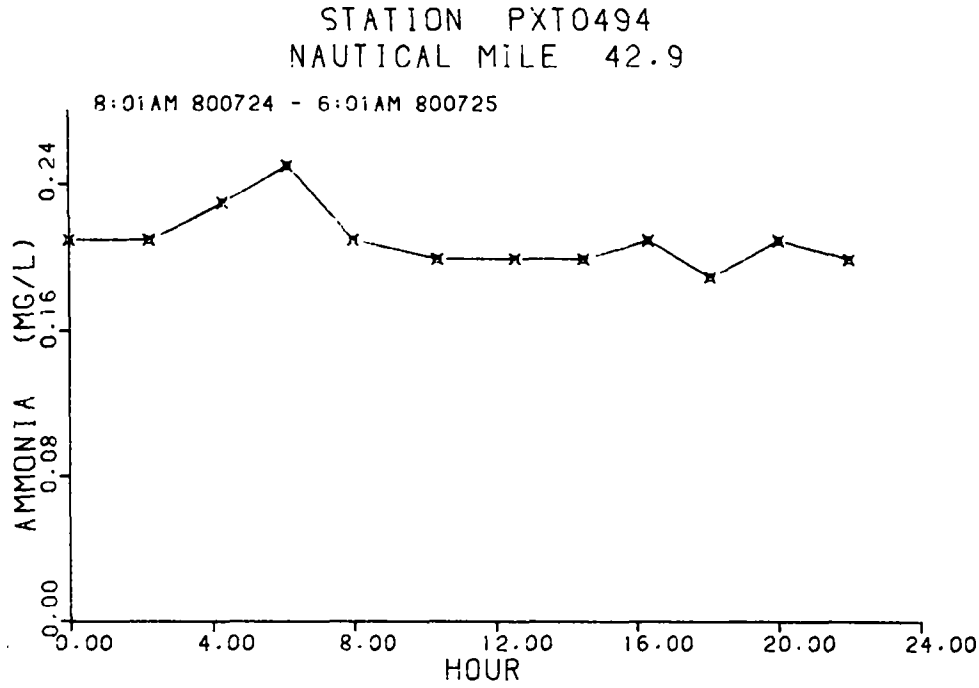


Figure 9-9 Intensive river survey plots of ammonia.



PATUXENT RIVER

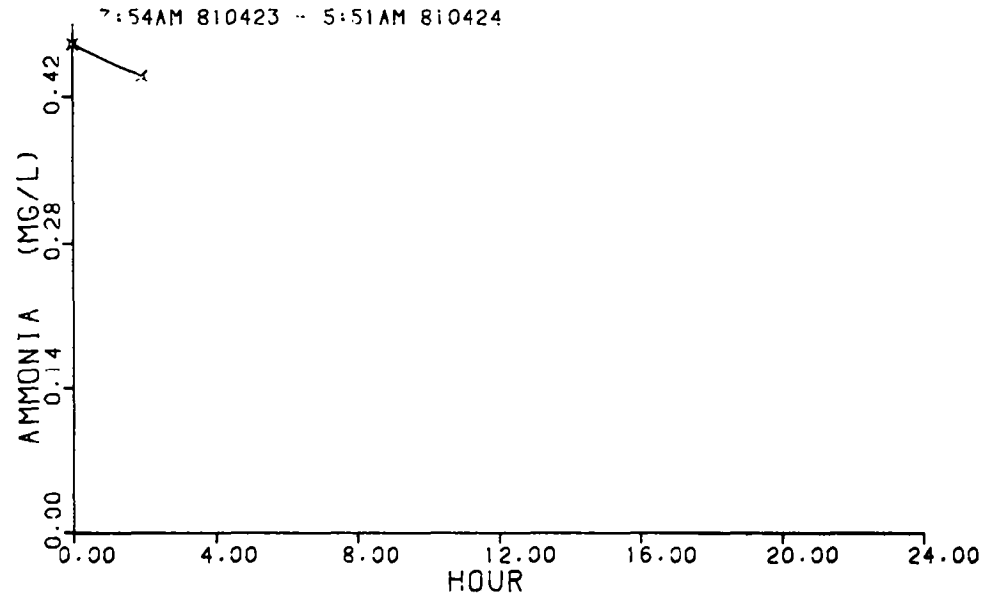
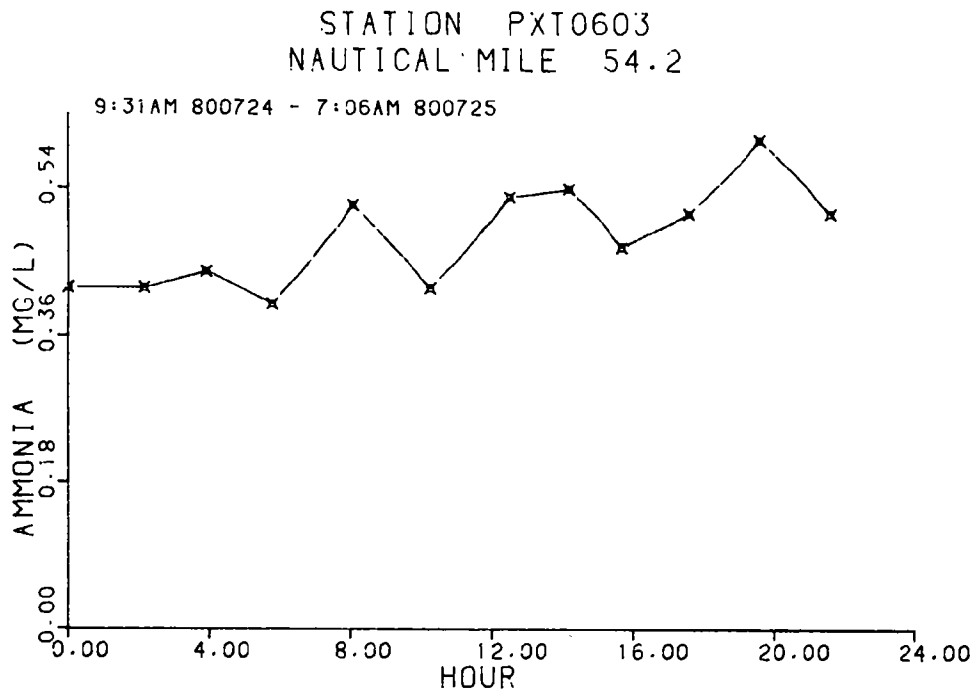


Figure 9-9 Intensive river survey plots of ammonia.



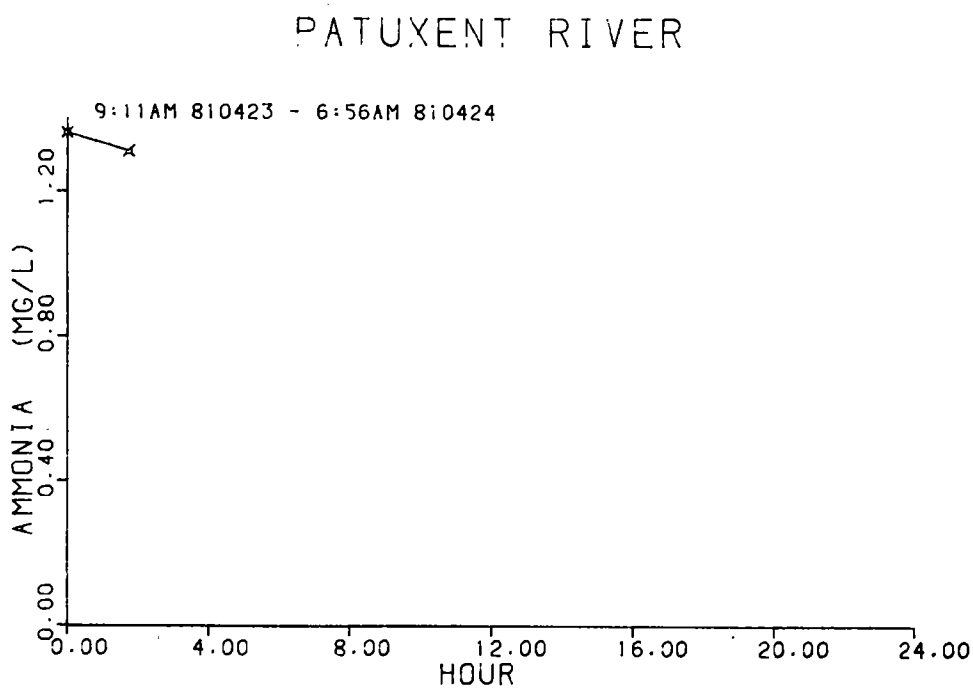
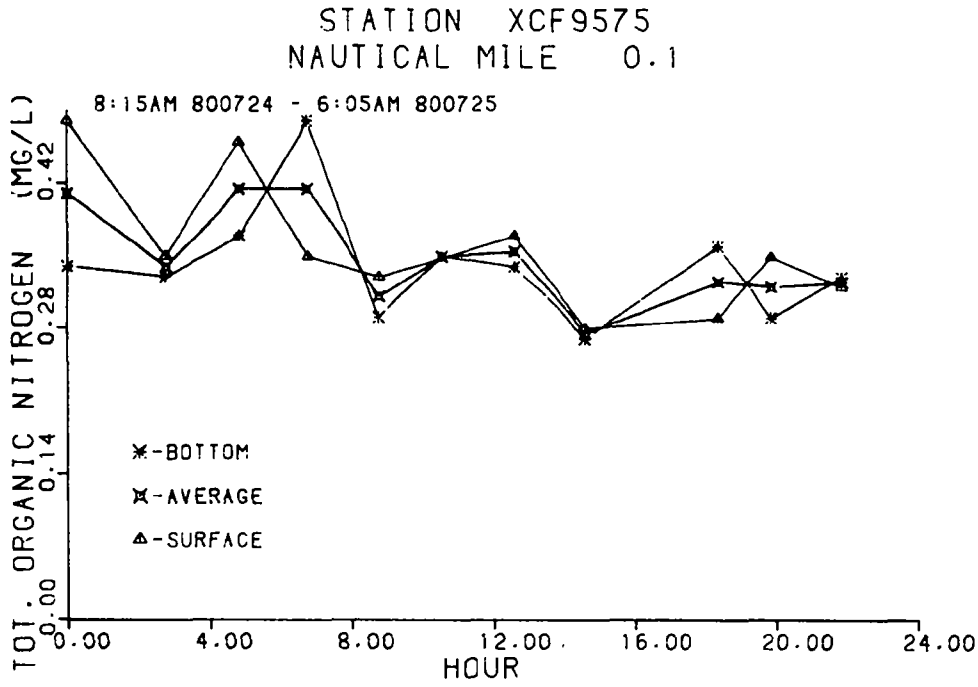


Figure 9-9 Intensive river survey plots of ammonia.



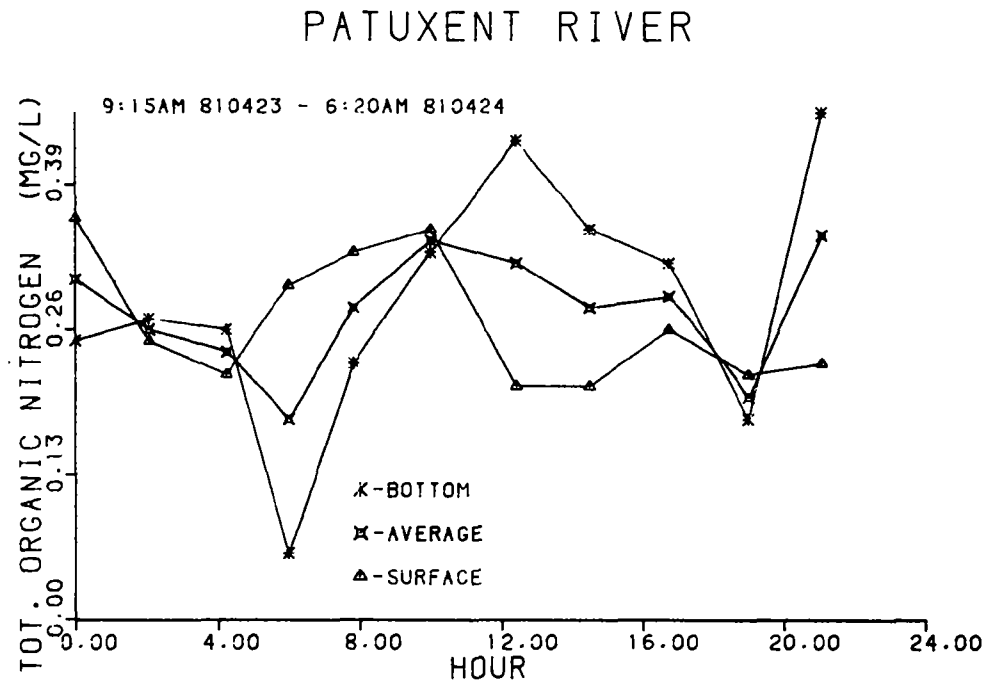
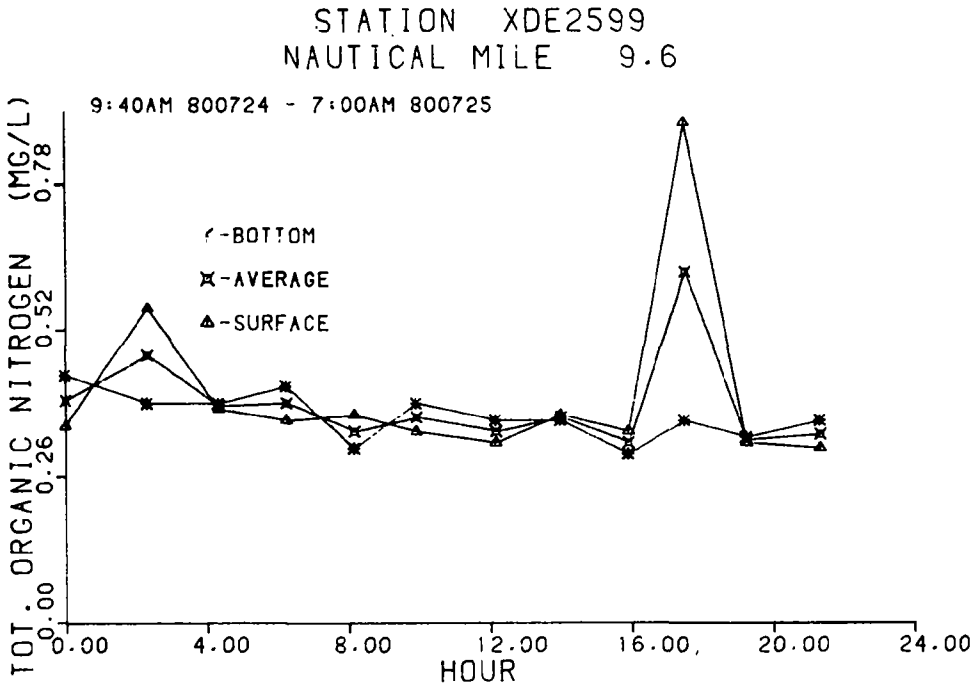


Figure 9-10 Intensive river survey plots of total organic nitrogen.



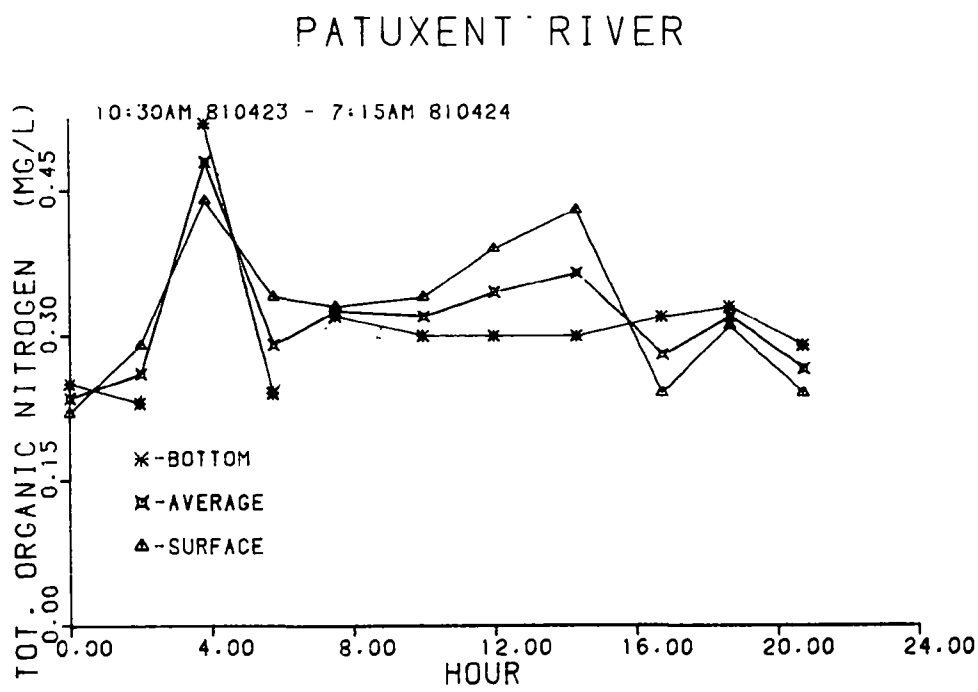
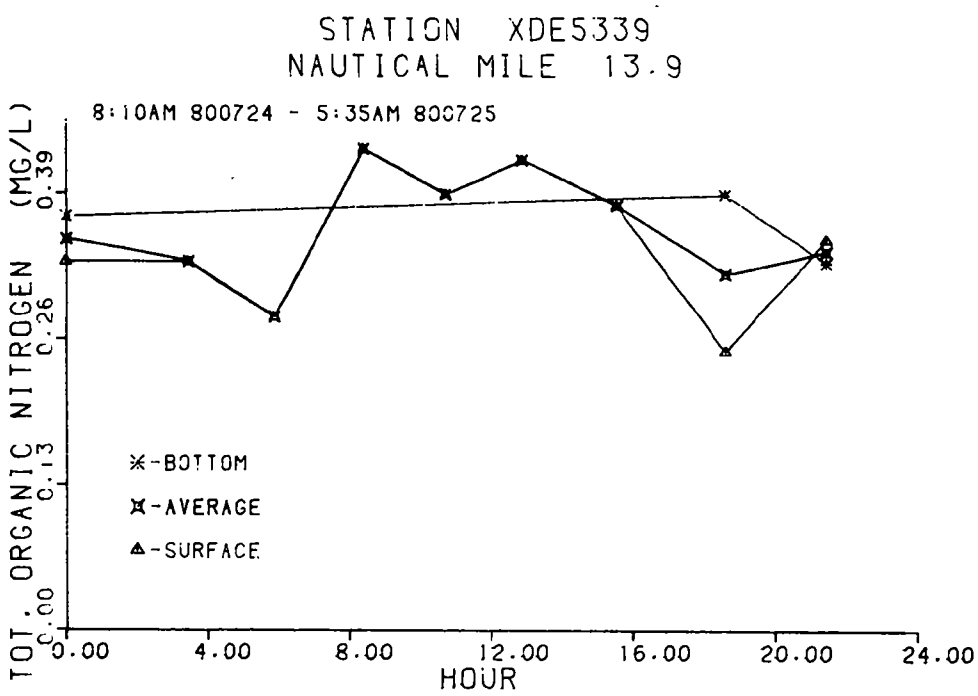


Figure 9-10 Intensive river survey plots of total organic nitrogen.



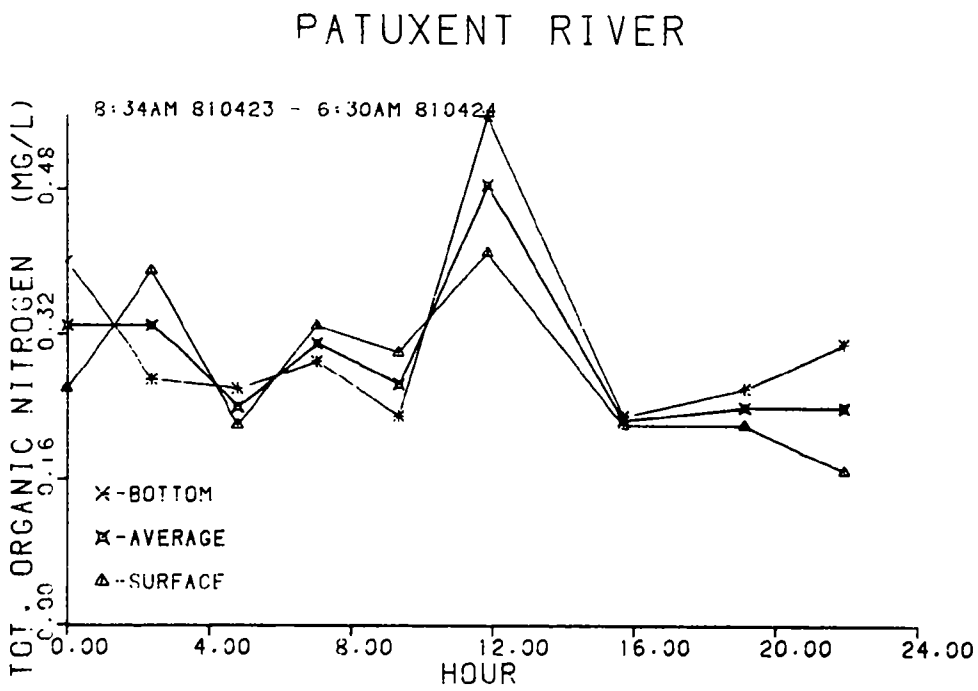
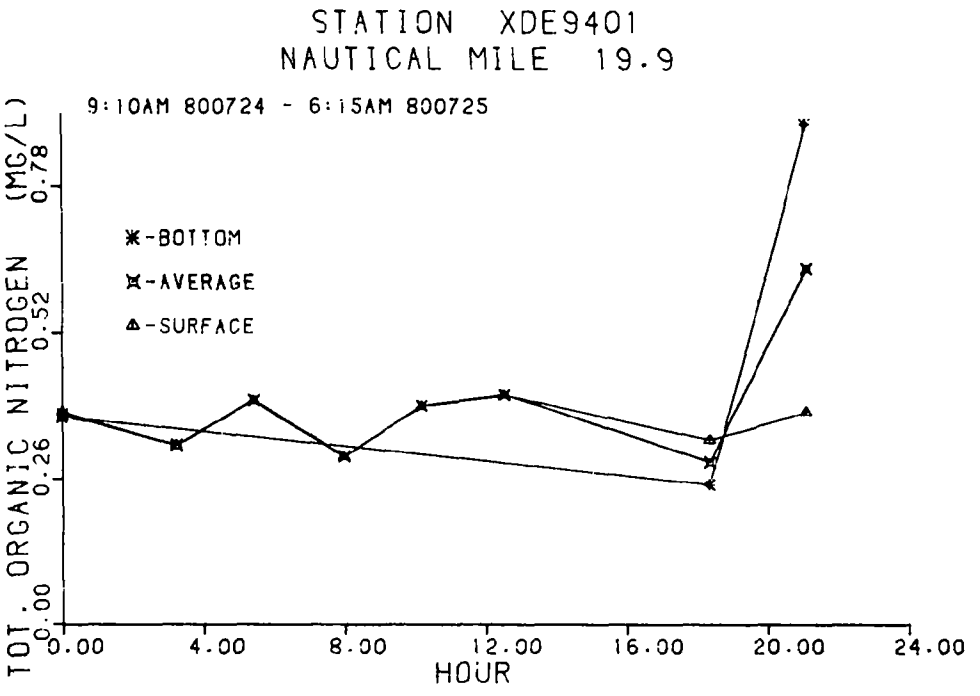


Figure 9-10 Intensive river survey plots of total organic nitrogen.



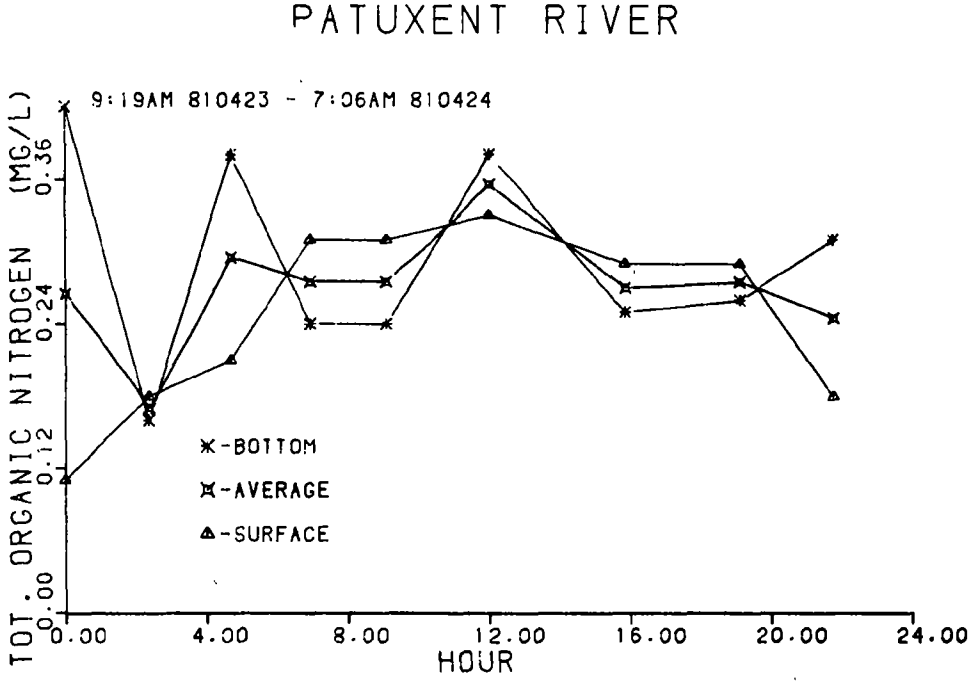
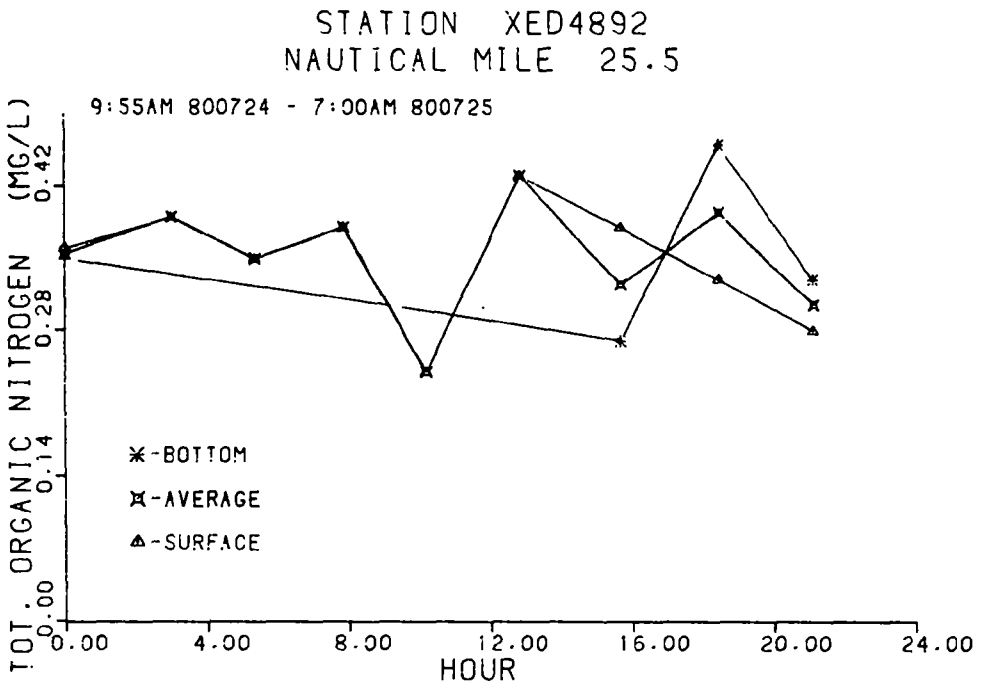


Figure 9-10 Intensive river survey plots of total organic nitrogen.



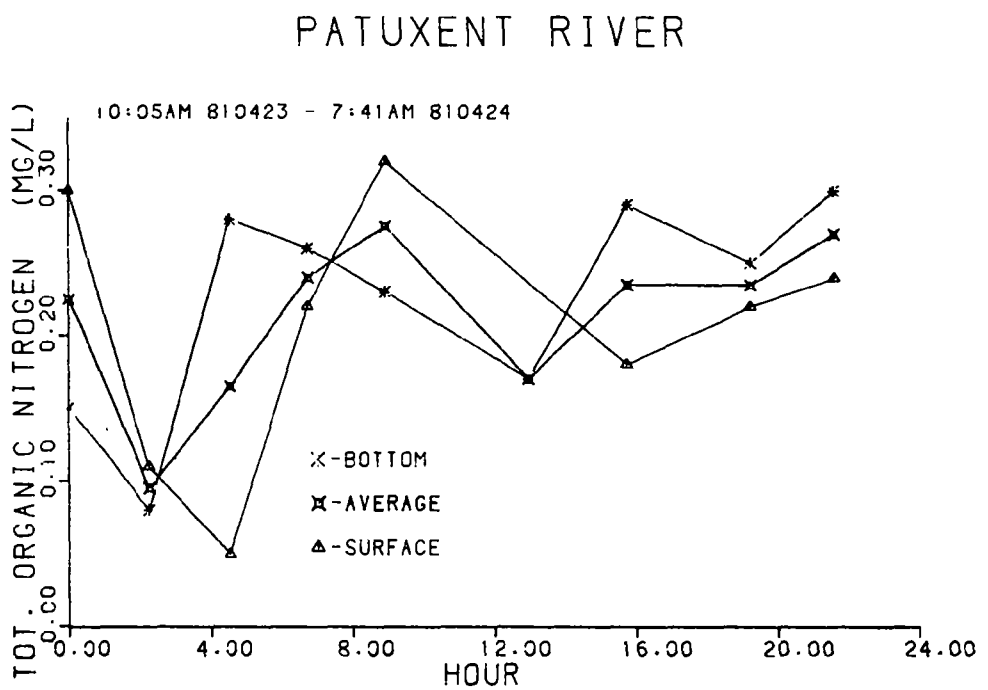
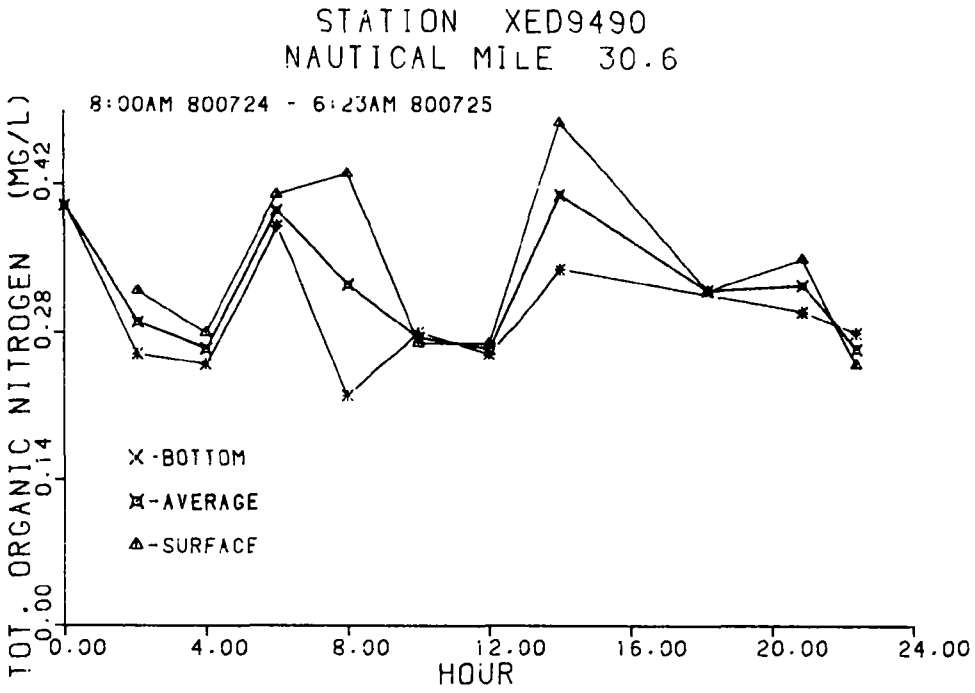


Figure9-10 Intensive river survey plots of total organic nitrogen.



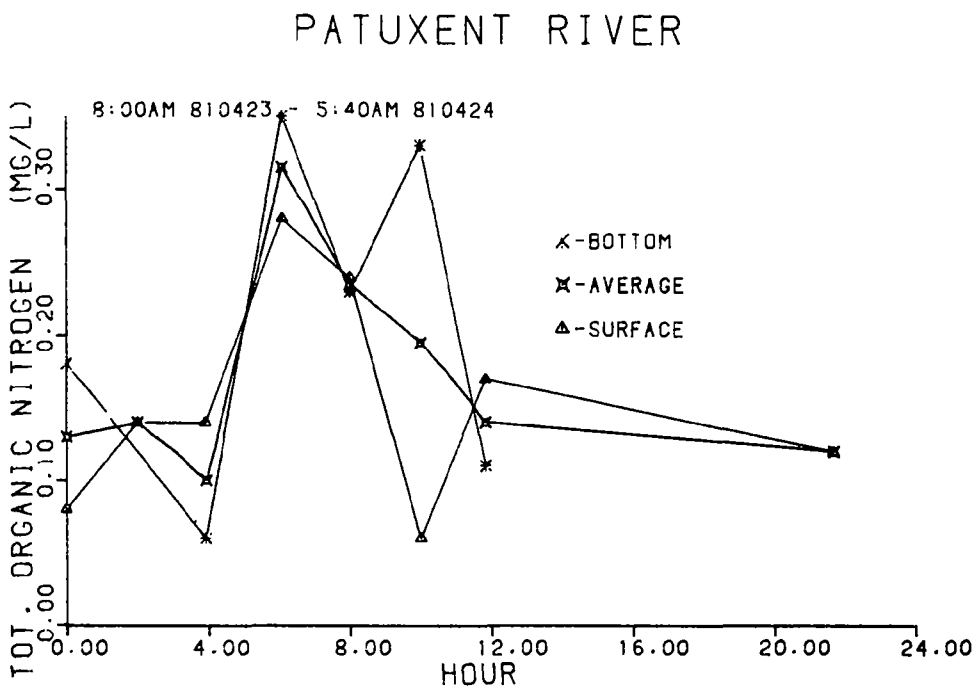
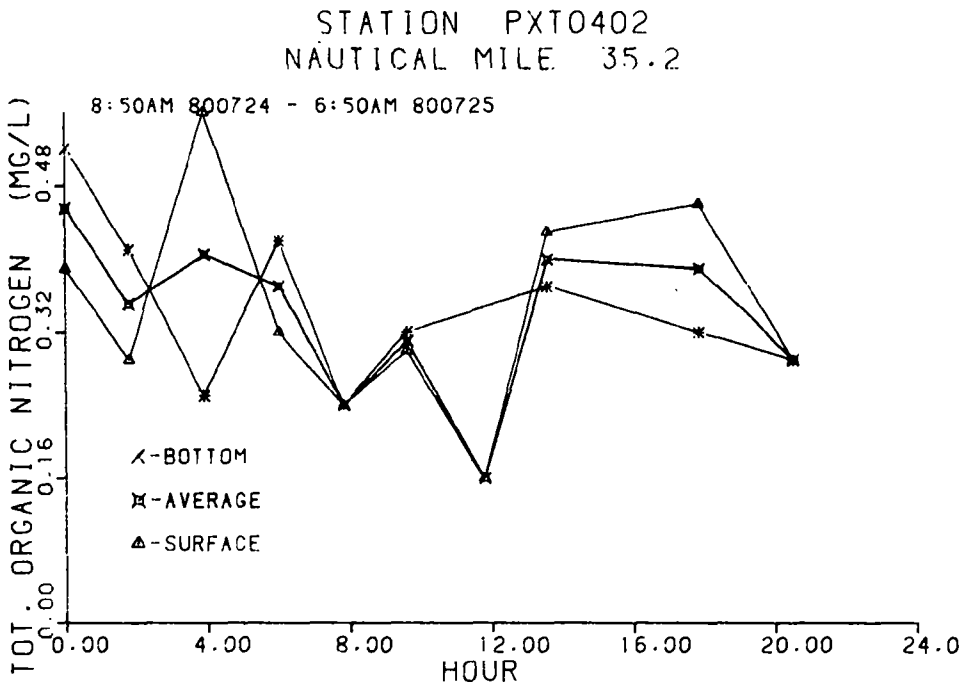


Figure 9-10 Intensive river survey plots of total organic nitrogen.



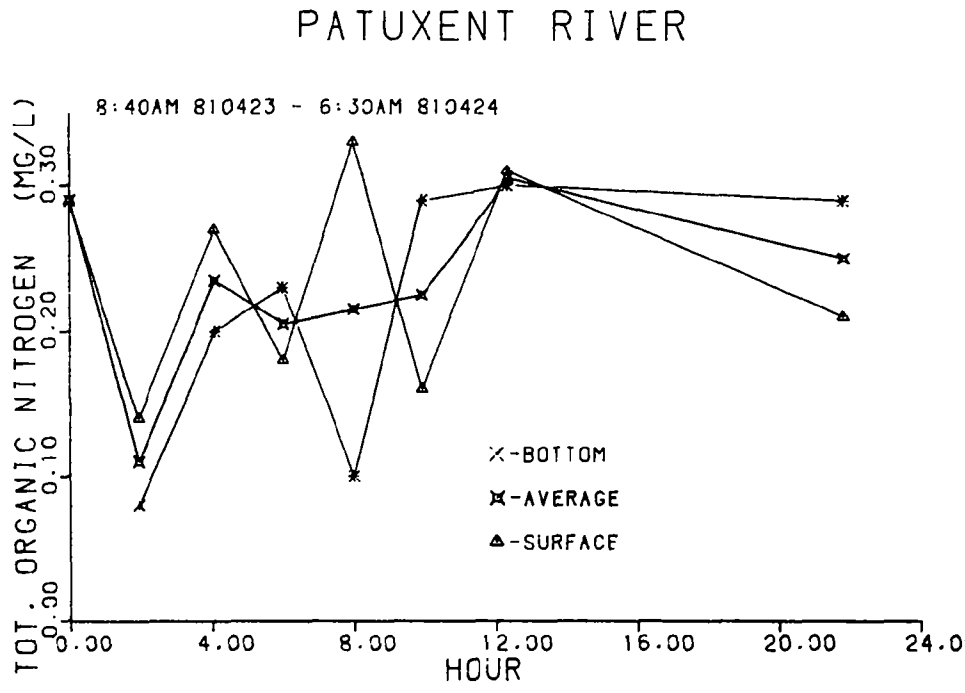
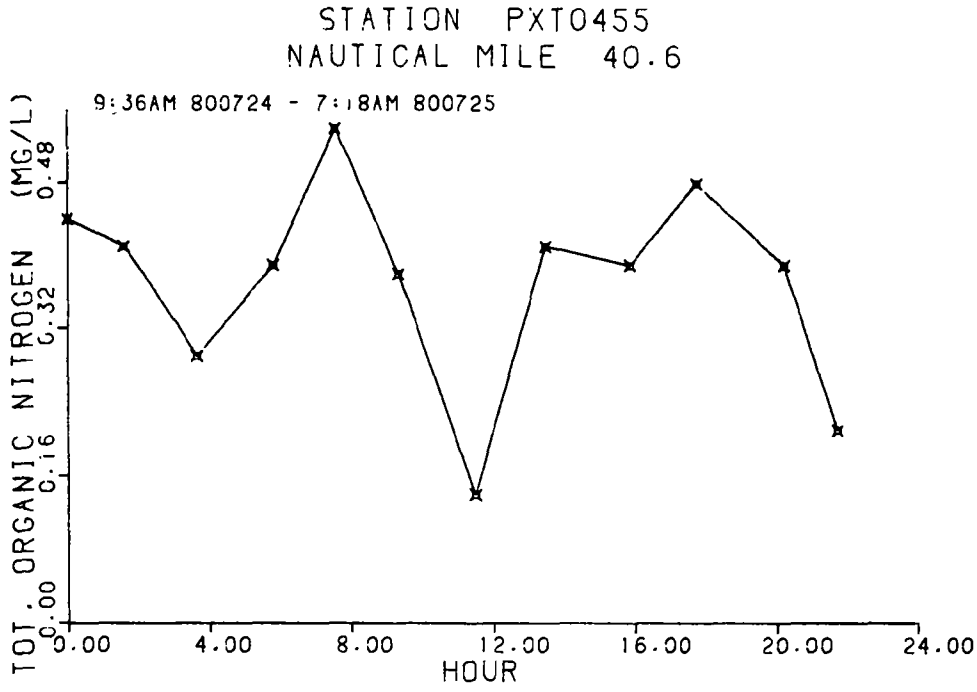


Figure 9-10Intensive river survey plots of total organic nitrogen.



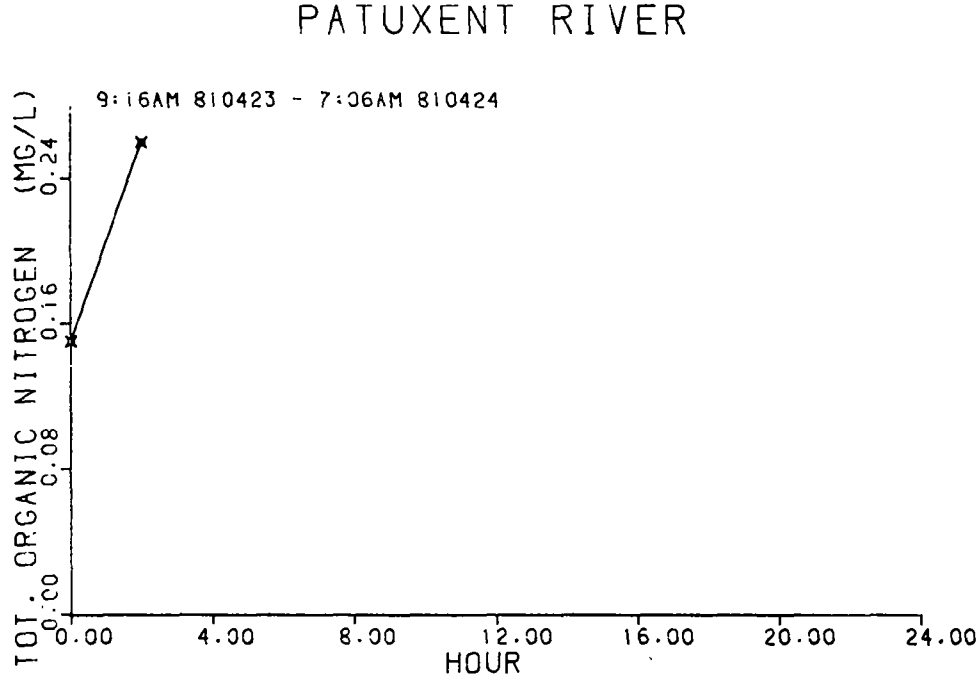
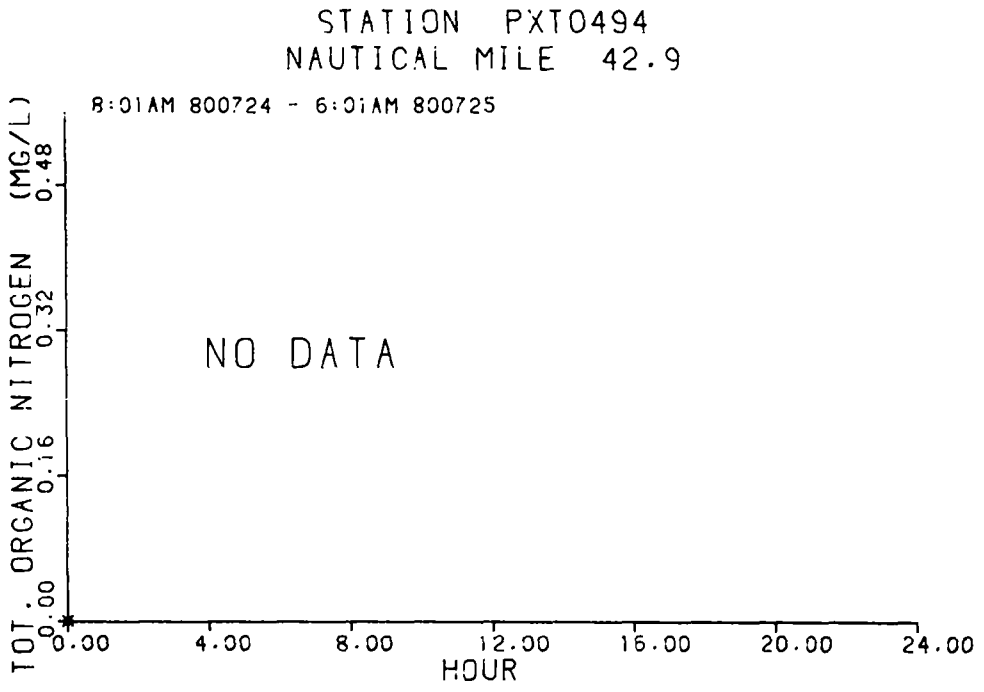


Figure 9-10 Intensive river survey plots of total organic nitrogen.



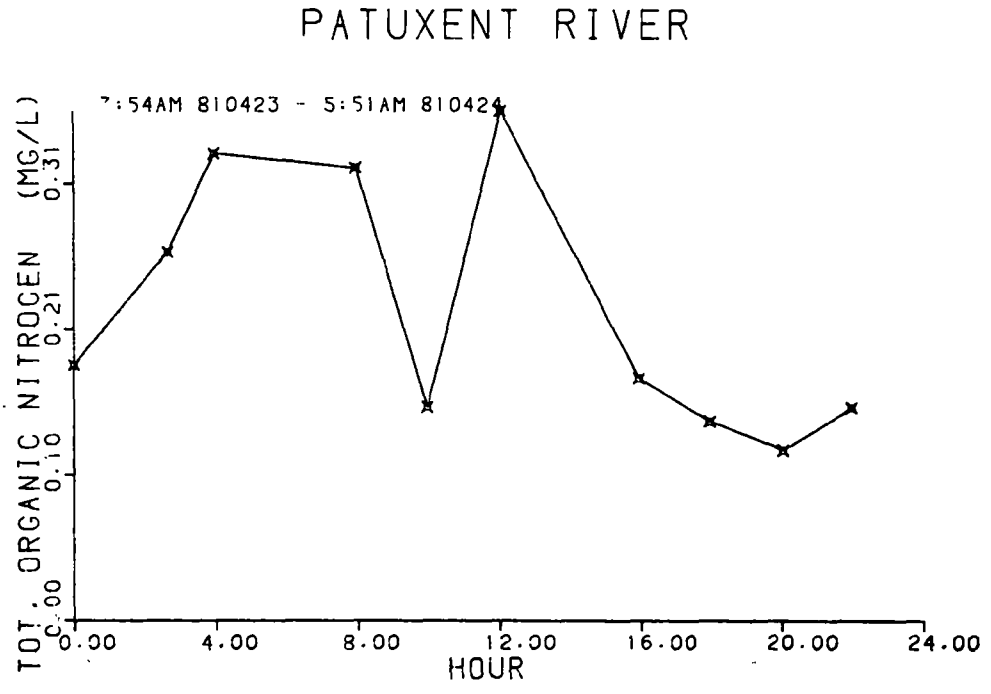
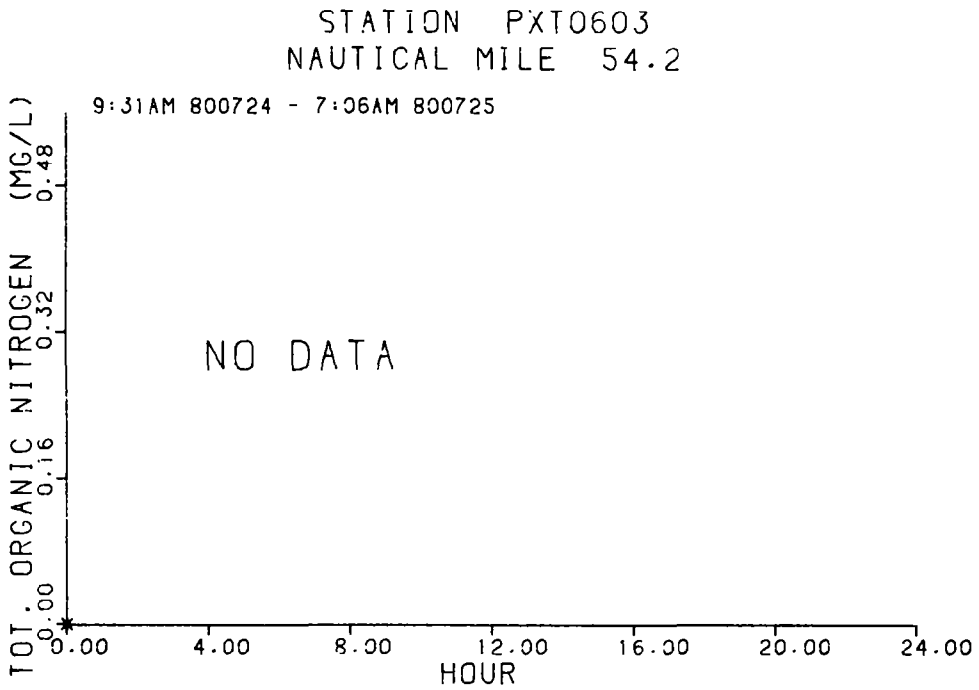


Figure 9-10 Intensive river survey plots of total organic nitrogen.



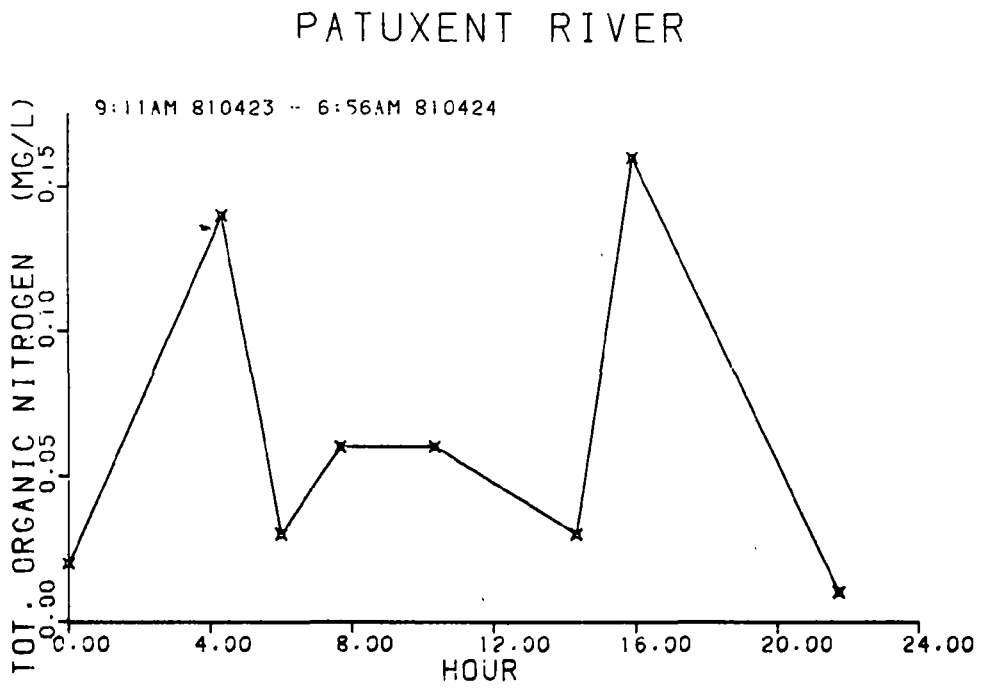
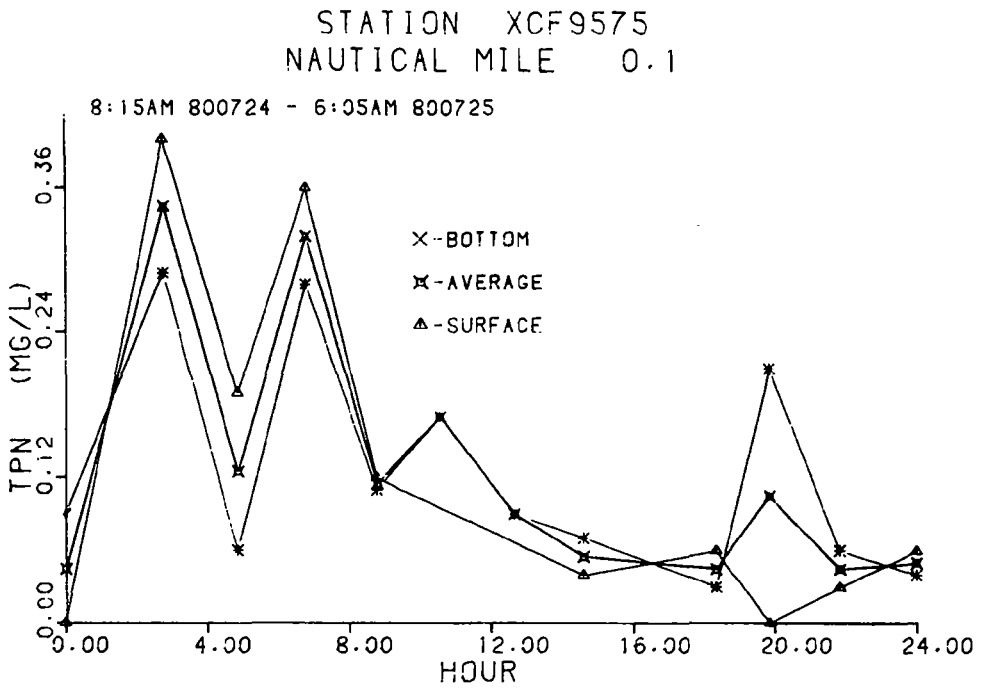


Figure 9-10 Intensive river survey plots of total organic nitrogen.



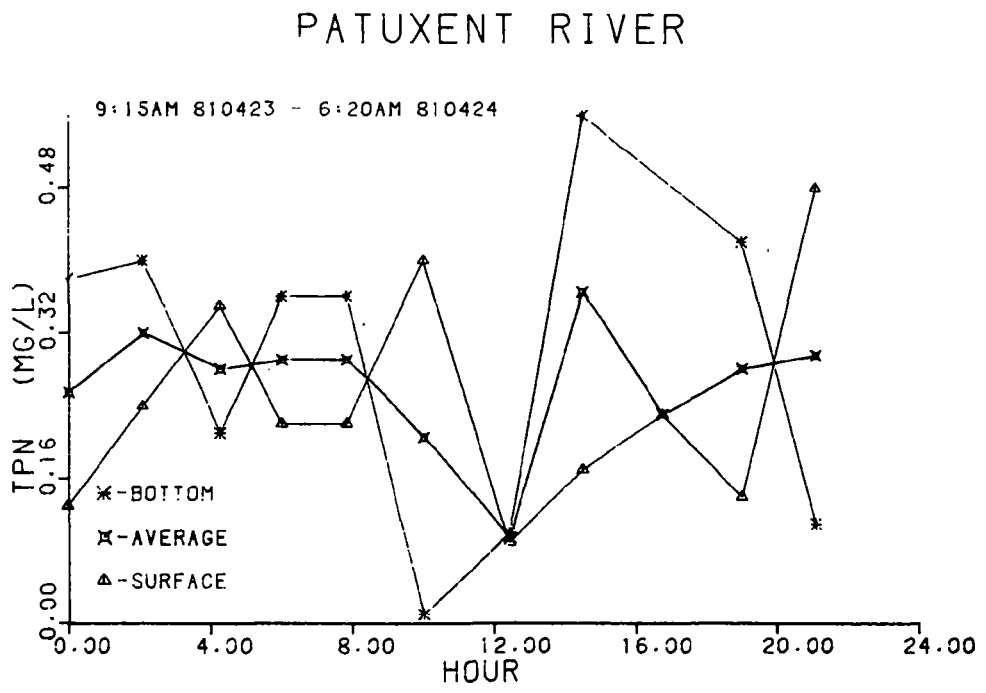
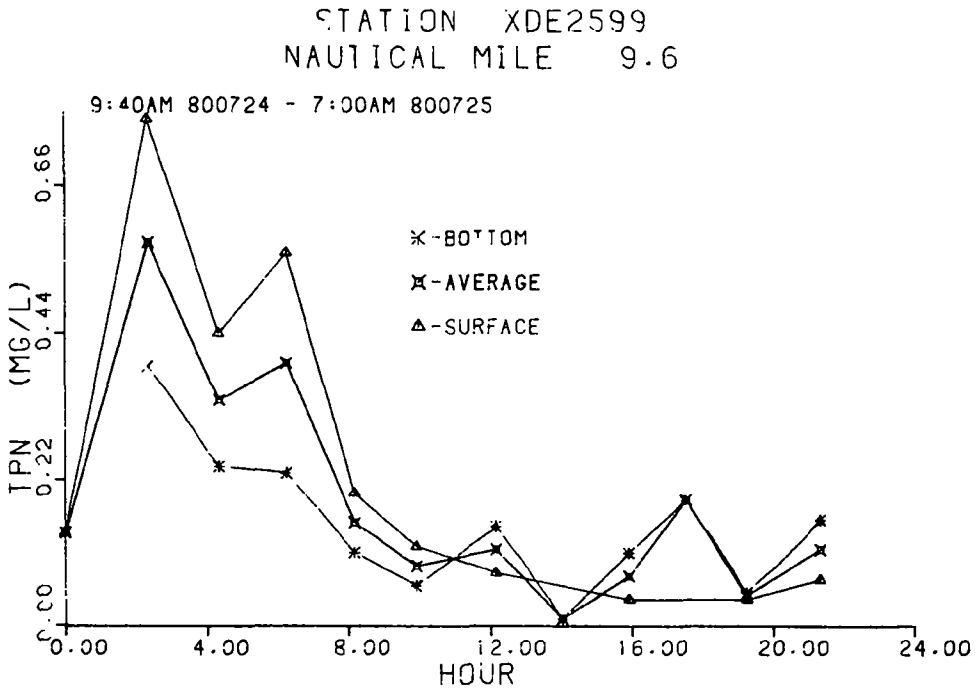


Figure 9-11 Intensive river survey plots of total particulate nitrogen.



PATUXENT RIVER

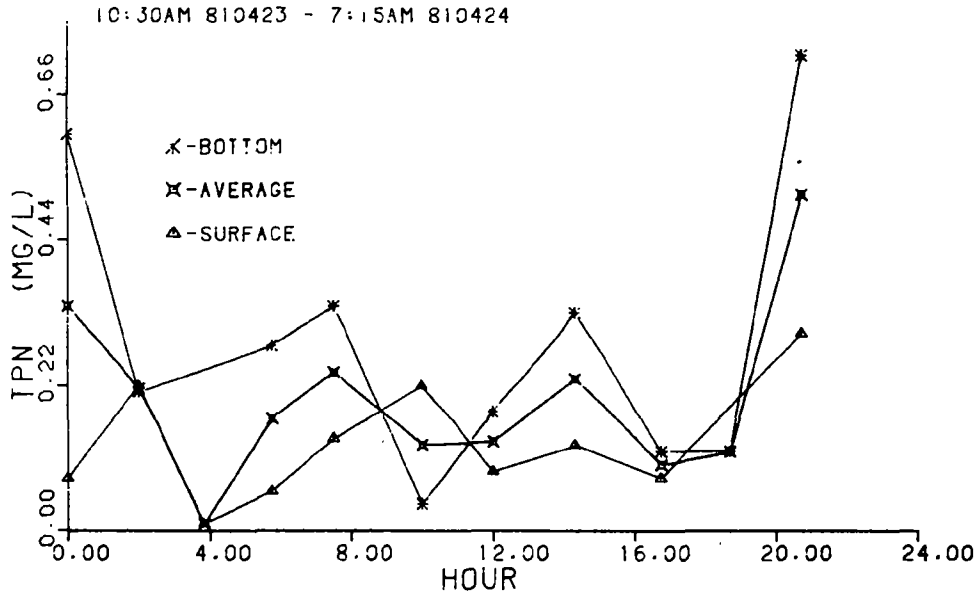
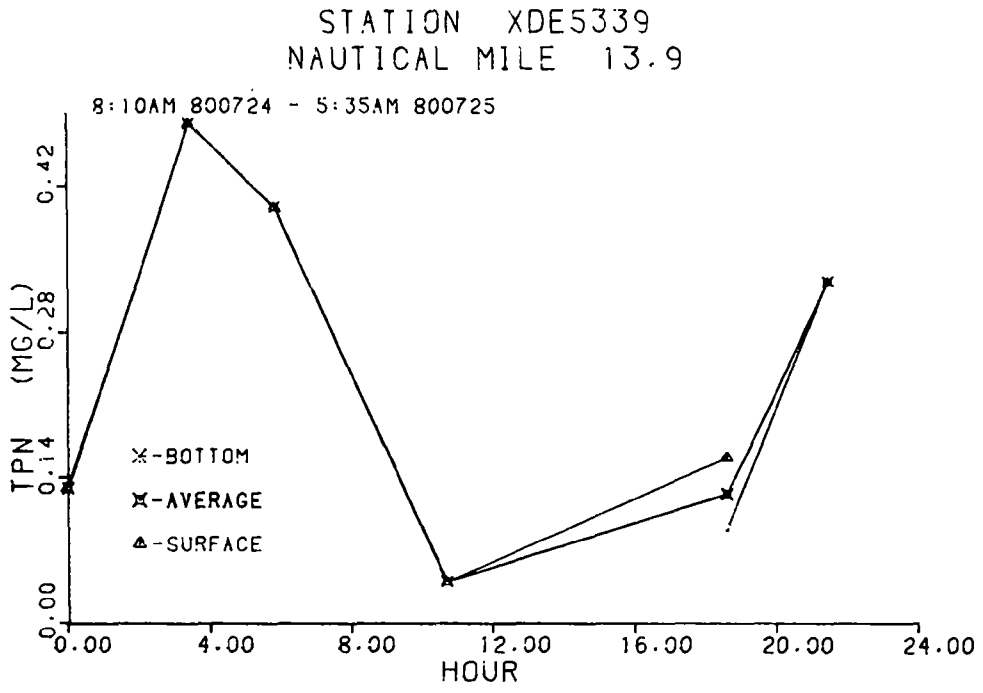


Figure 9-11Intensive river survey plots of total particulate nitrogen.



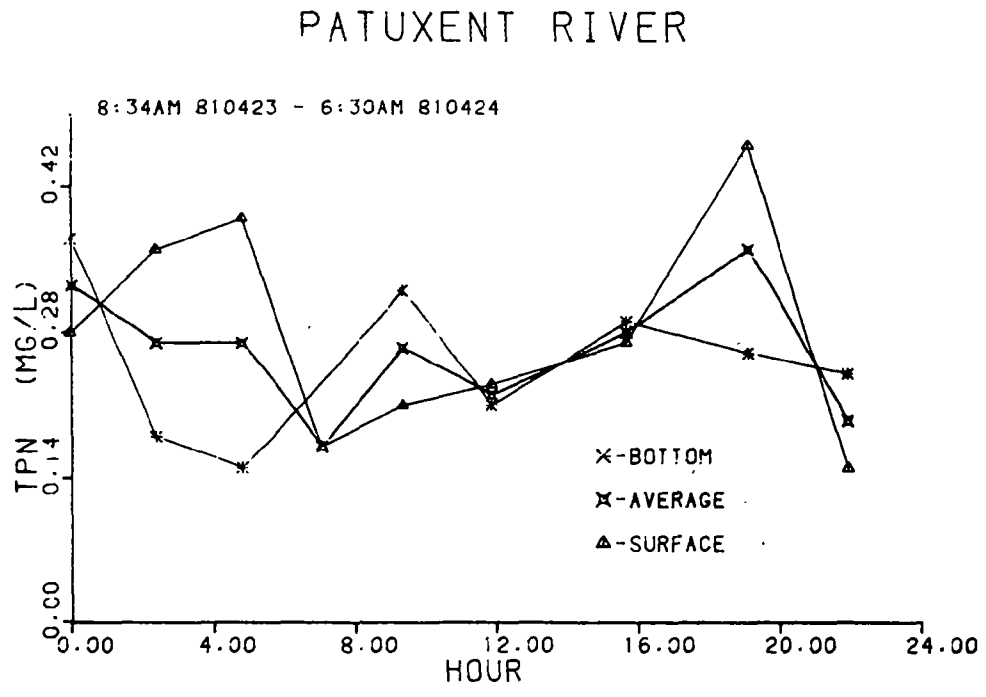
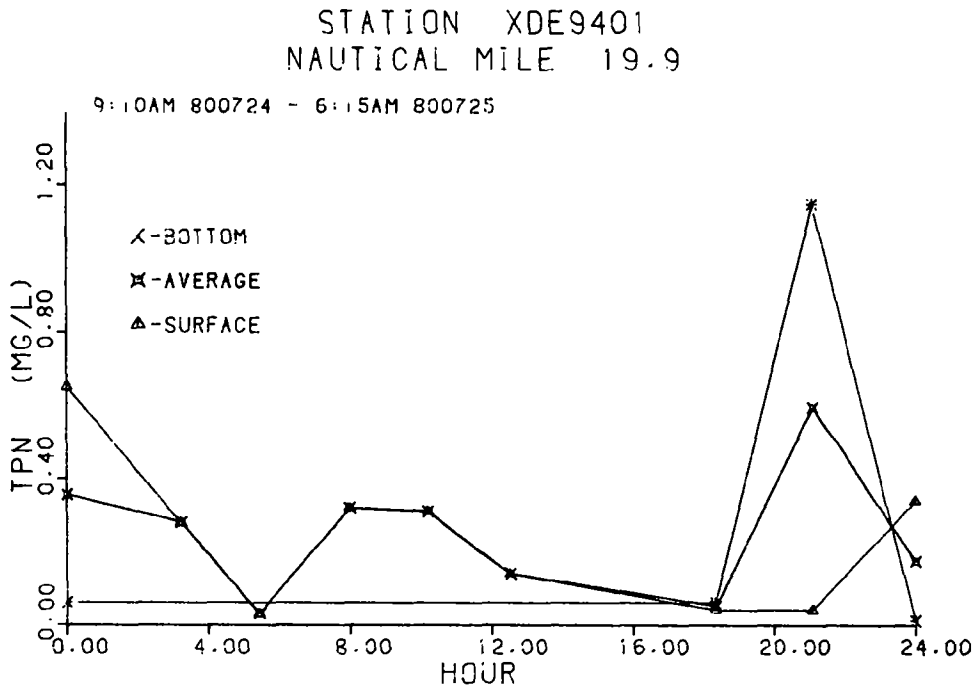


Figure 9-11 Intensive river survey plots of total particulate nitrogen.



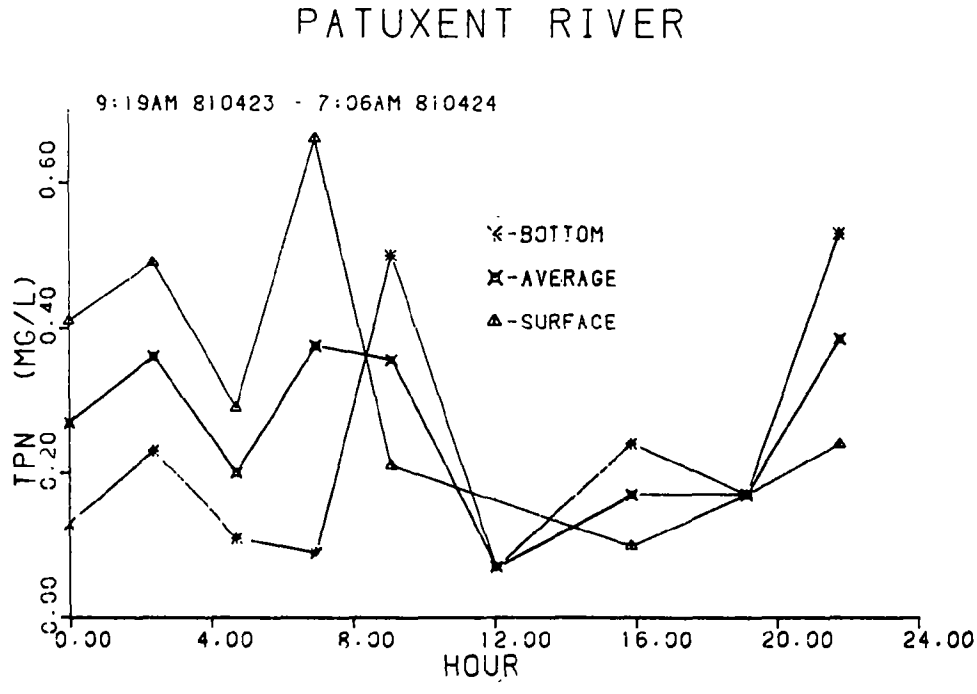
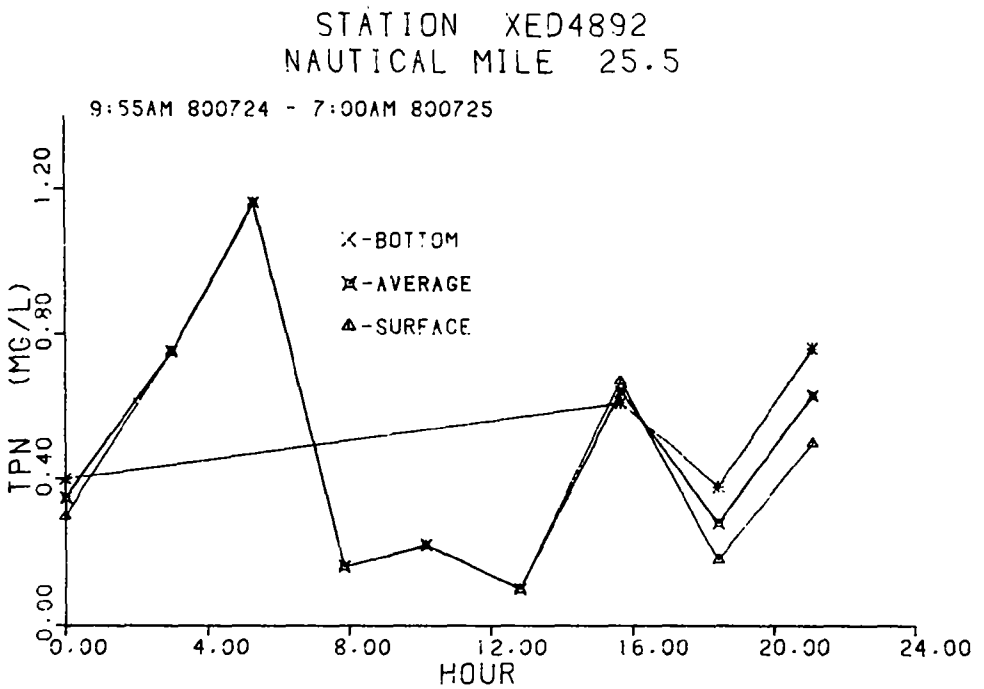


Figure 9-11 Intensive river survey plots of total particulate nitrogen.



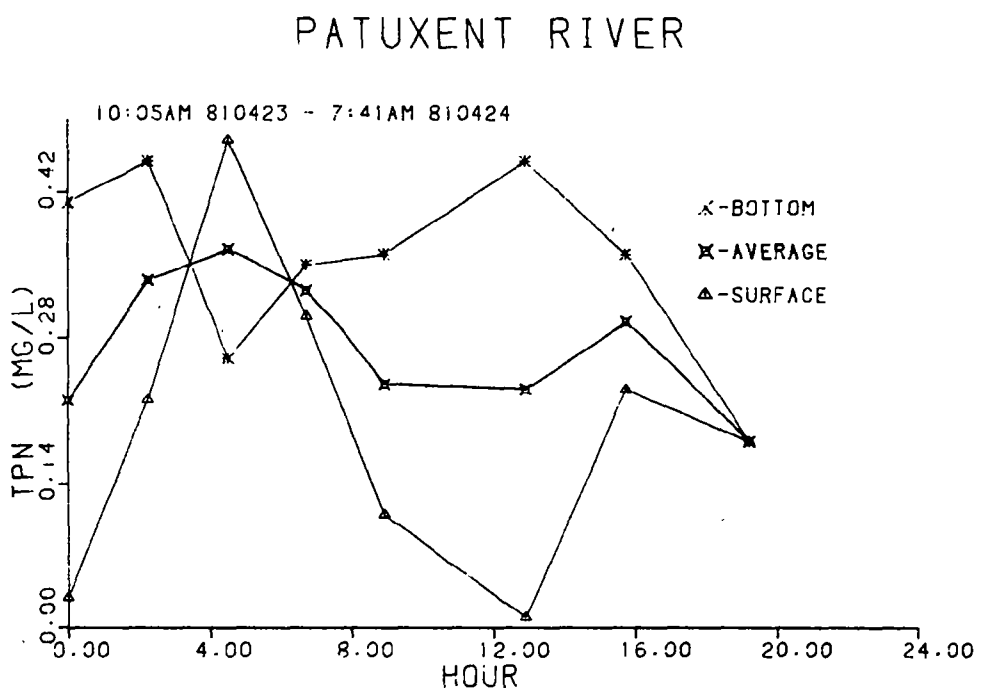
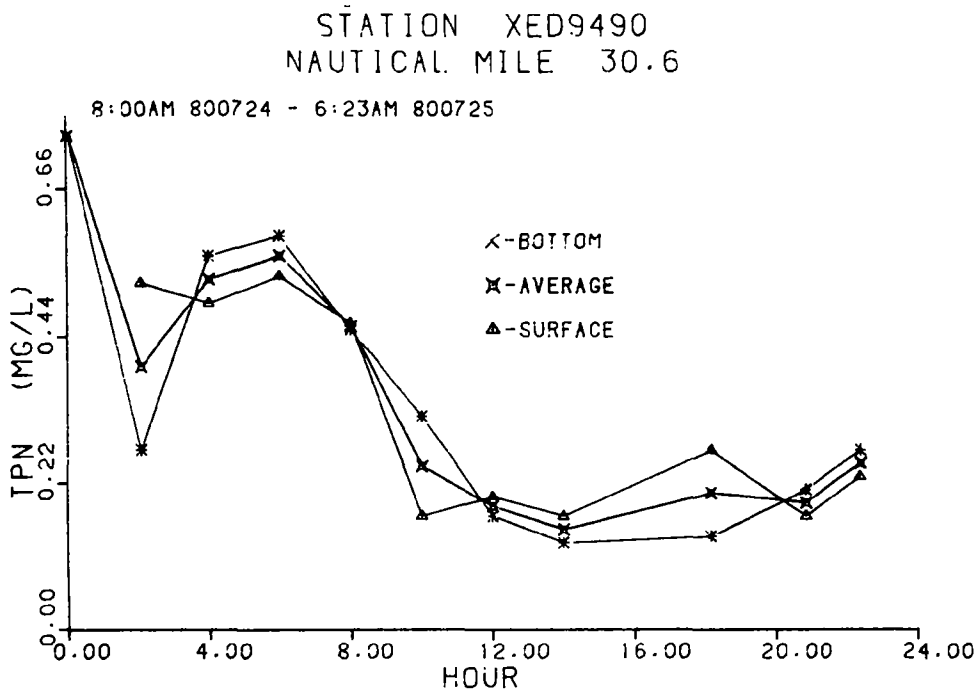


Figure 9-11Intensive river survey plots of total particulate nitrogen.



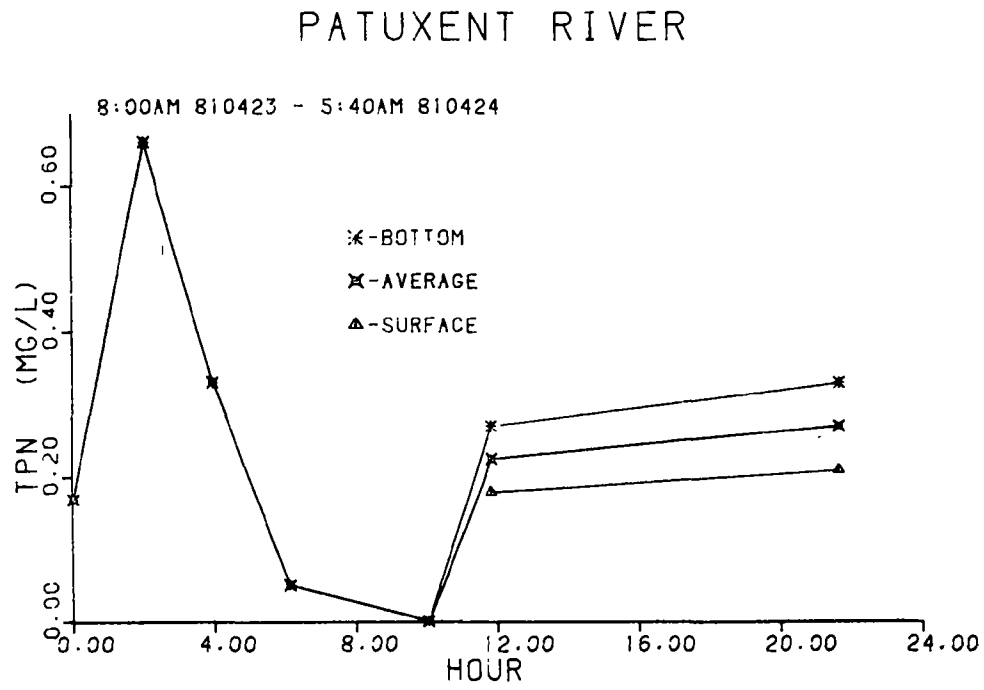


Figure 9-11Intensive river survey plots of total particulate nitrogen.

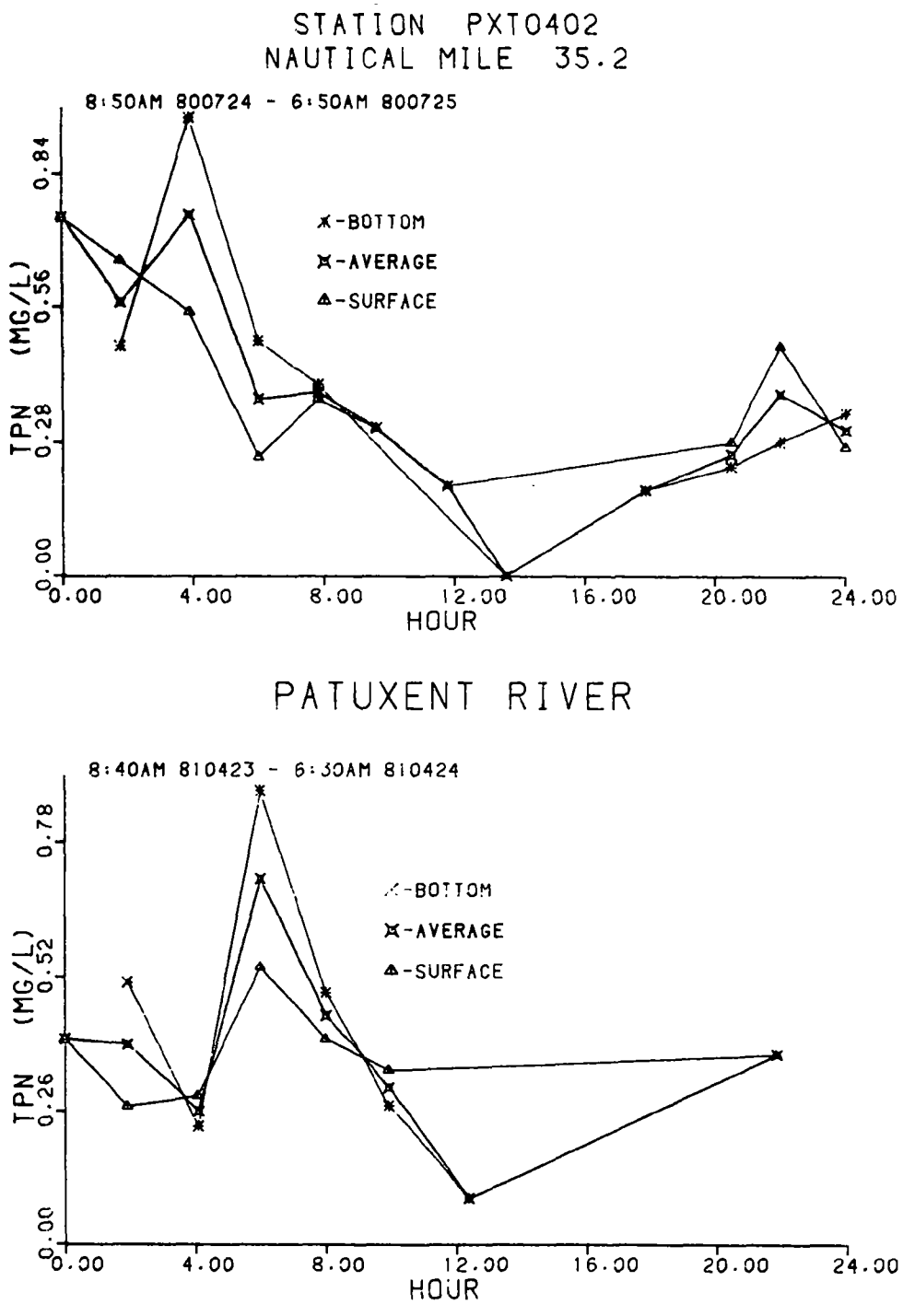
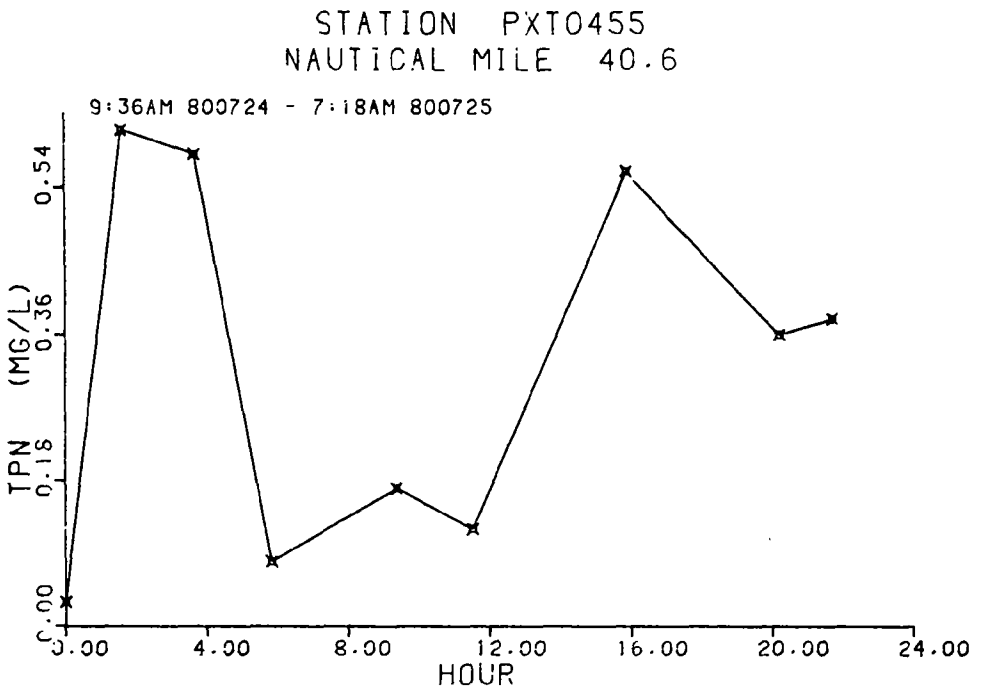


Figure 9-11 Intensive river survey plots of total particulate nitrogen.



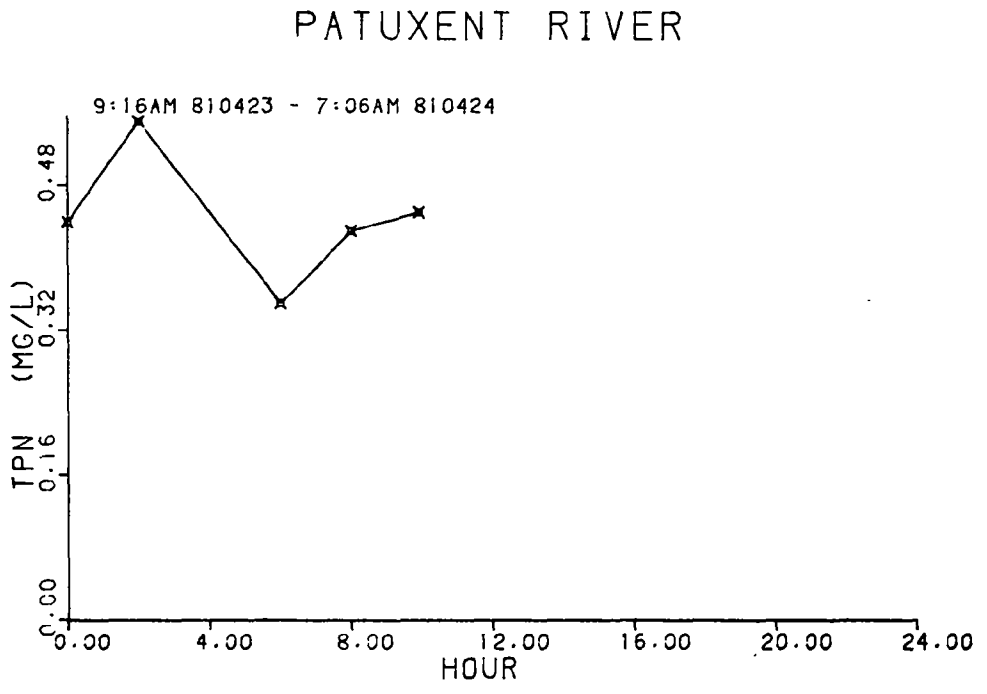
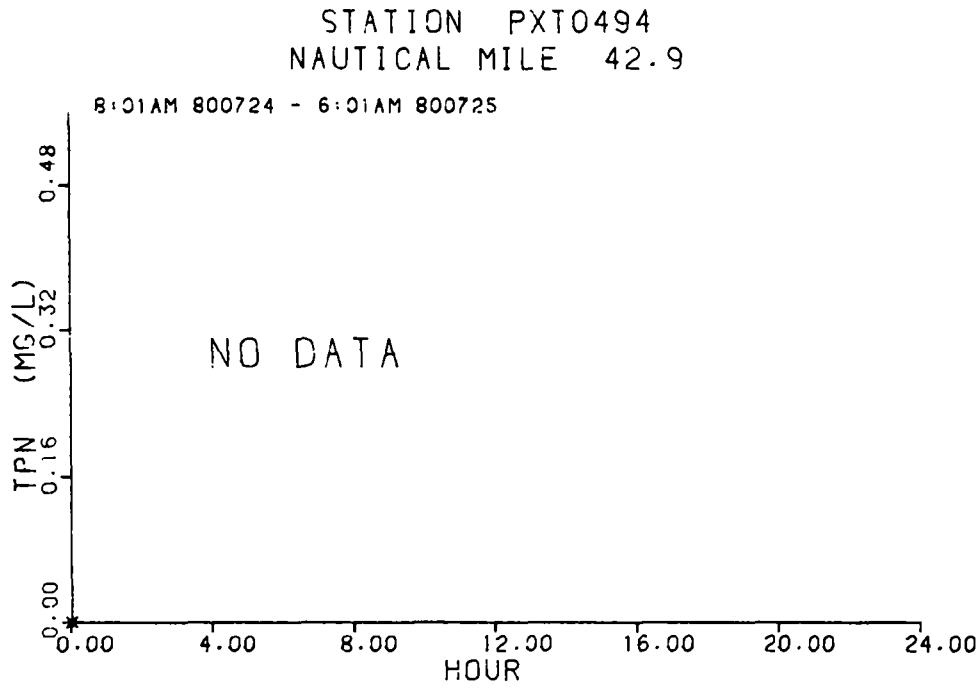


Figure 9-11 Intensive river survey plots of total particulate nitrogen.



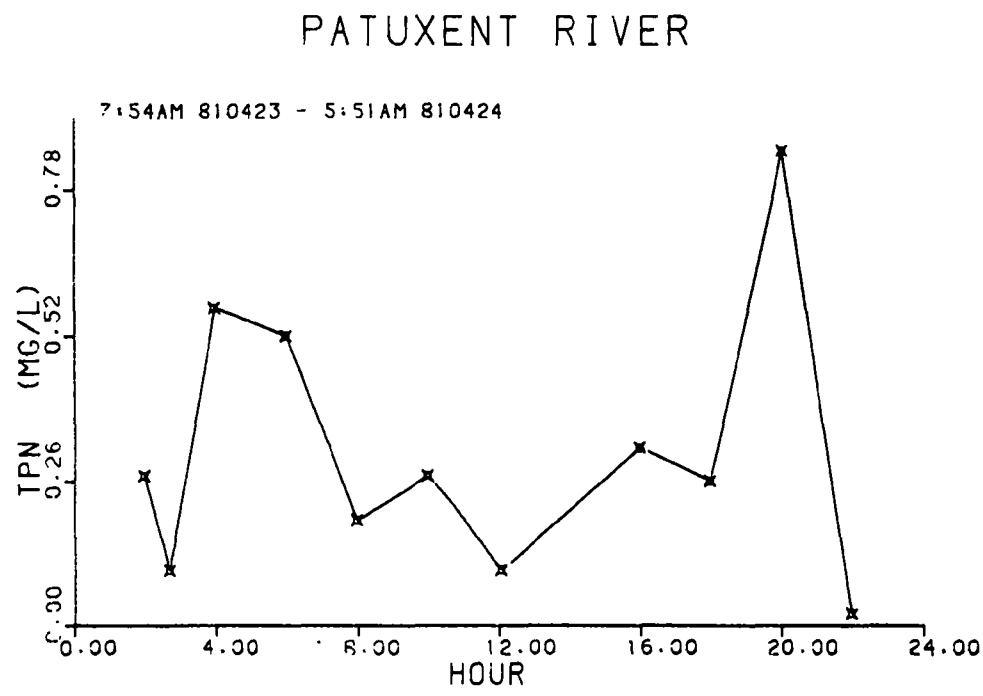
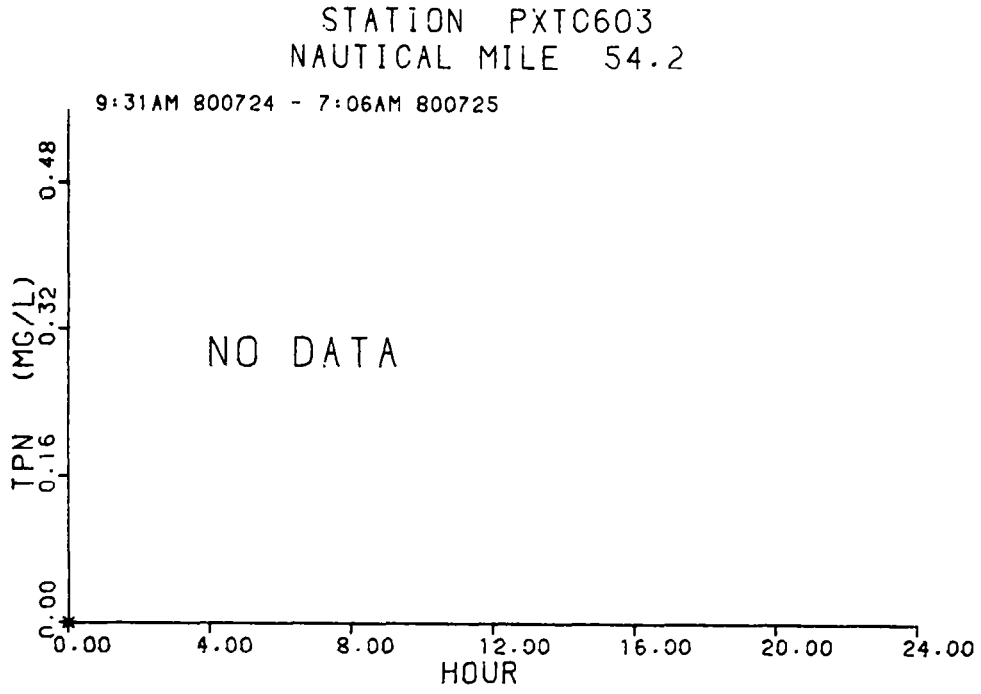


Figure 9-11 Intensive river survey plots of total particulate nitrogen.



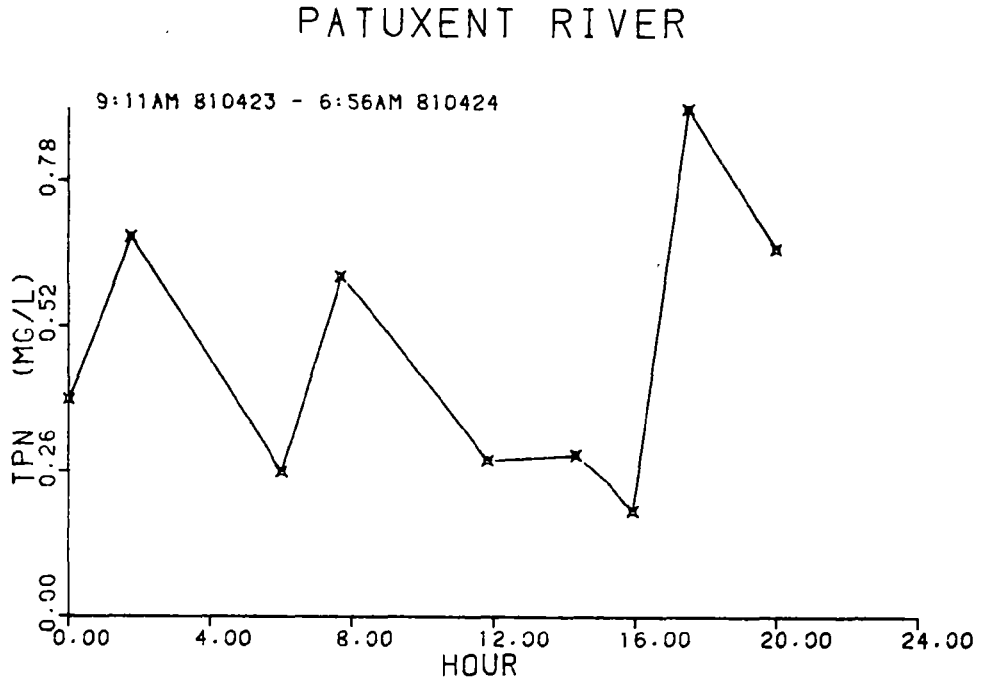
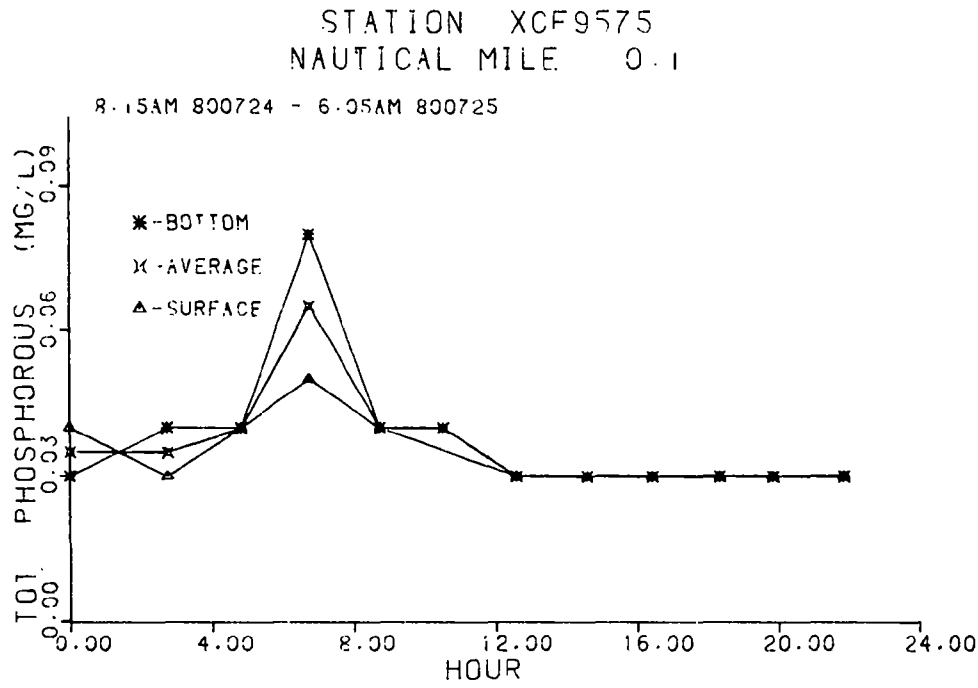


Figure 9-11Intensive river survey plots of total particulate nitrogen.



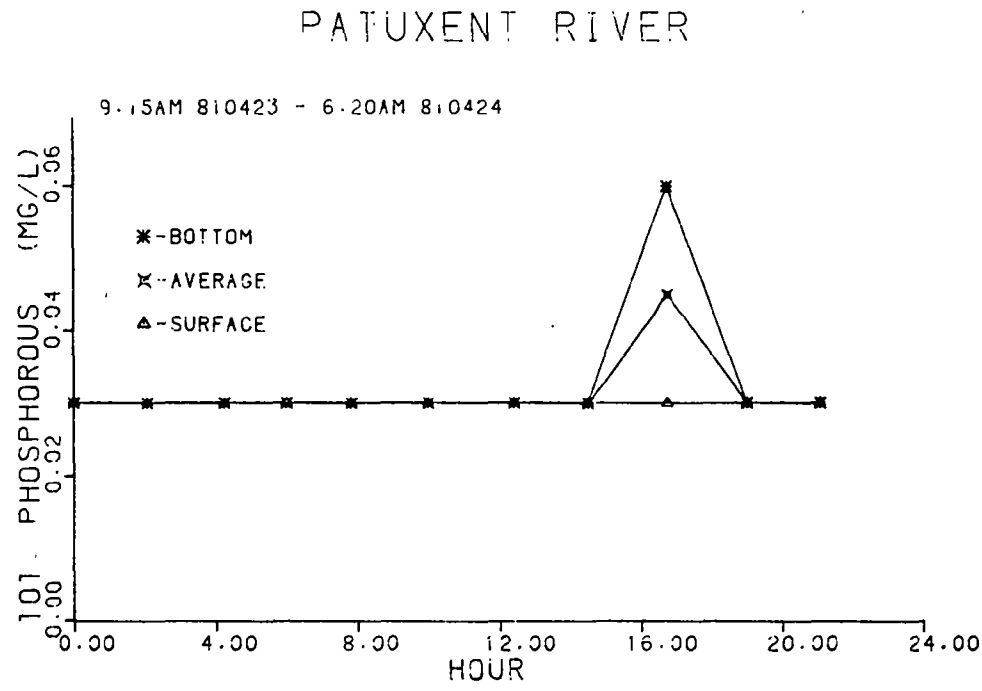
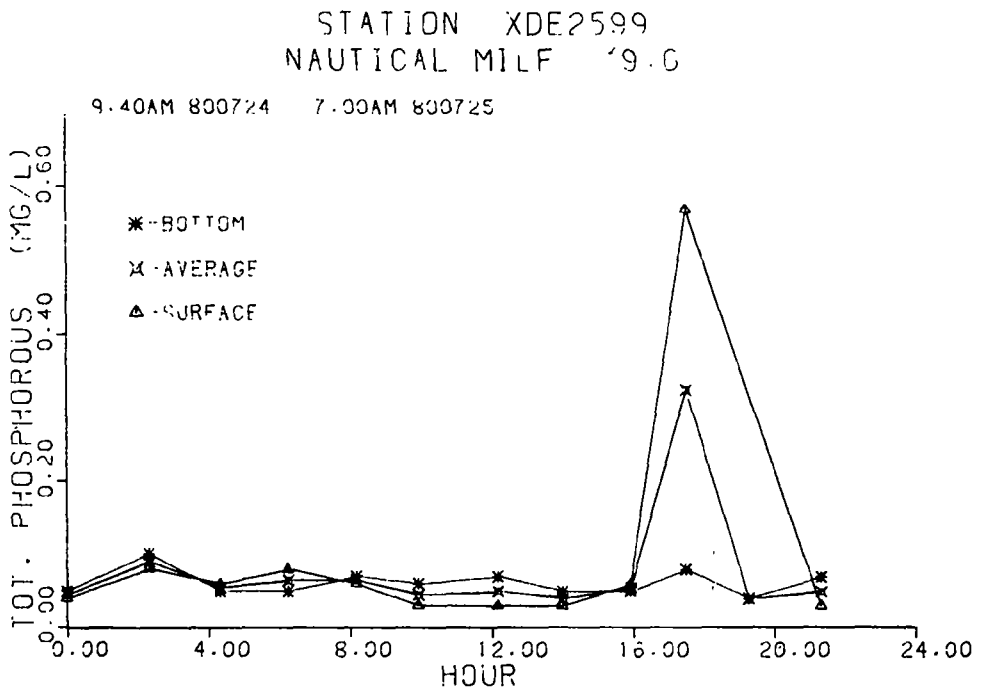


Figure 9-12 Intensive river survey plots of total phosphorus.



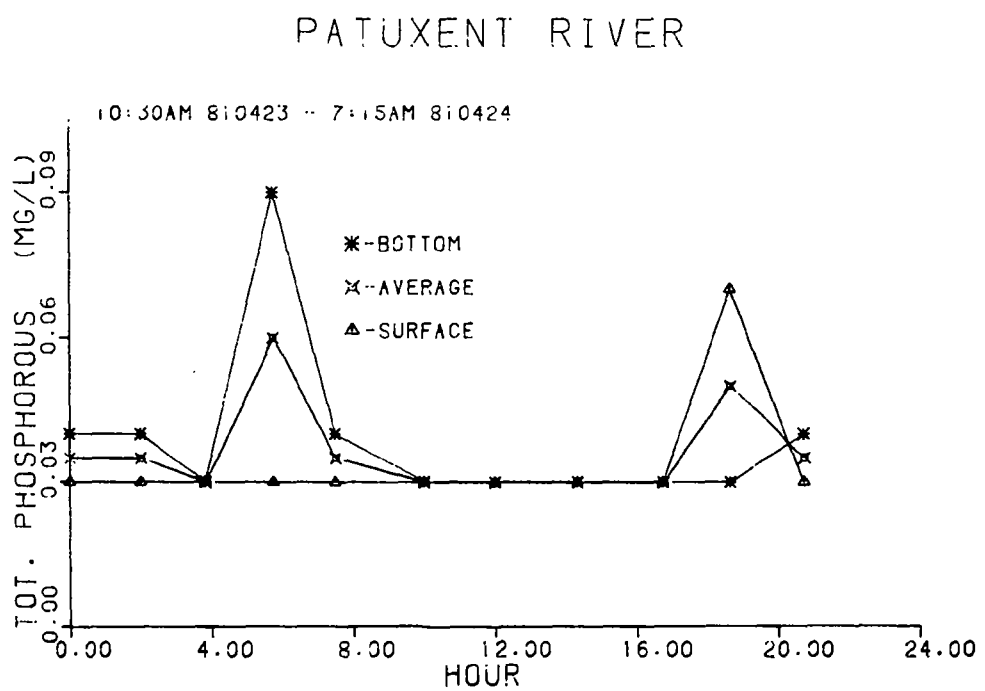
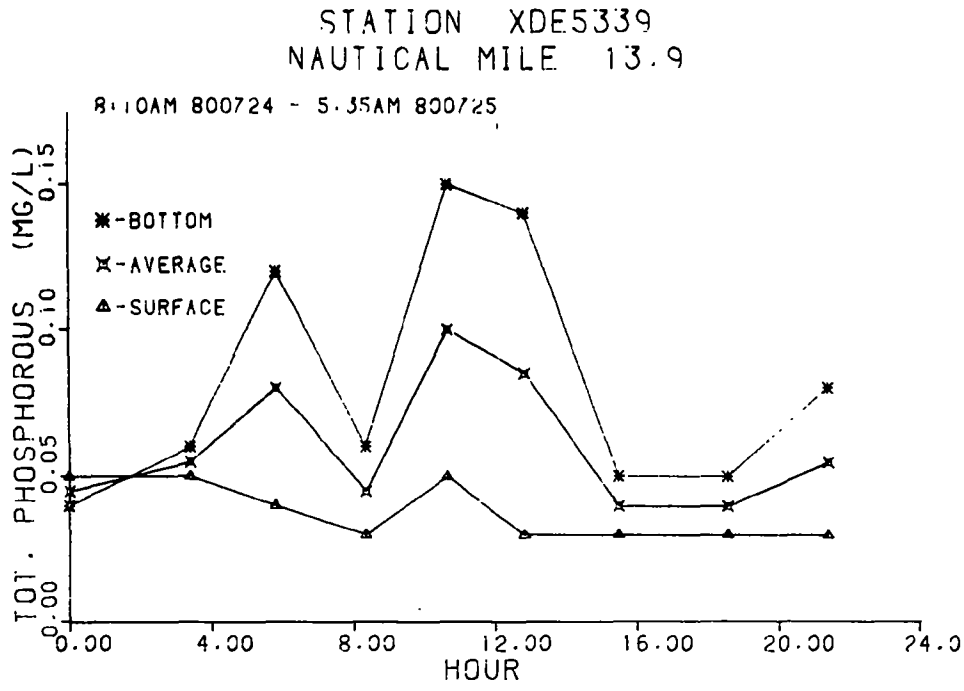


Figure 9-12 Intensive river survey plots of total phosphorus.



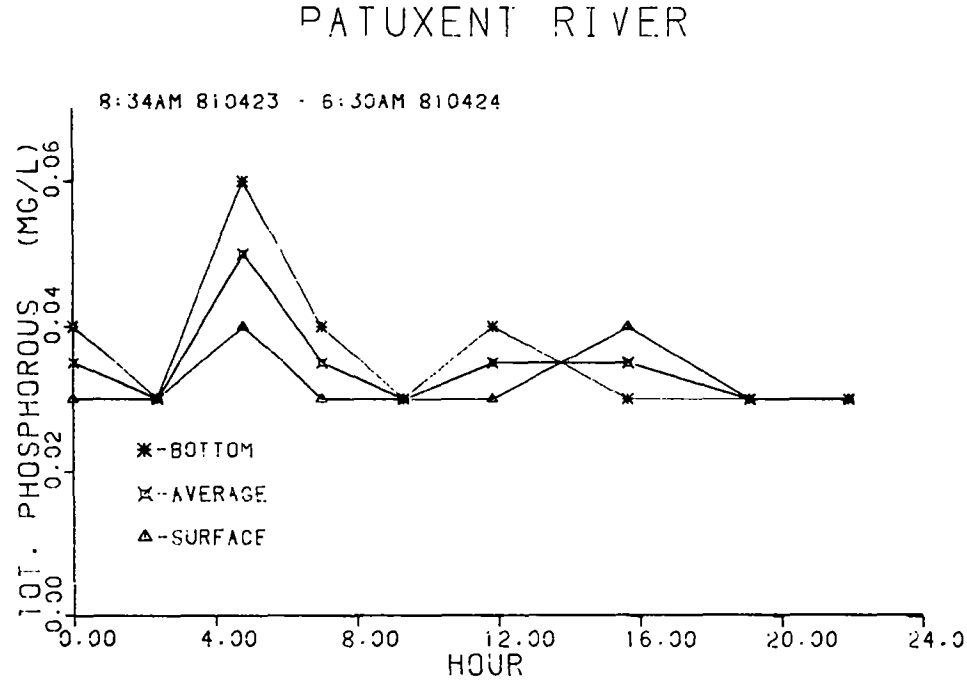
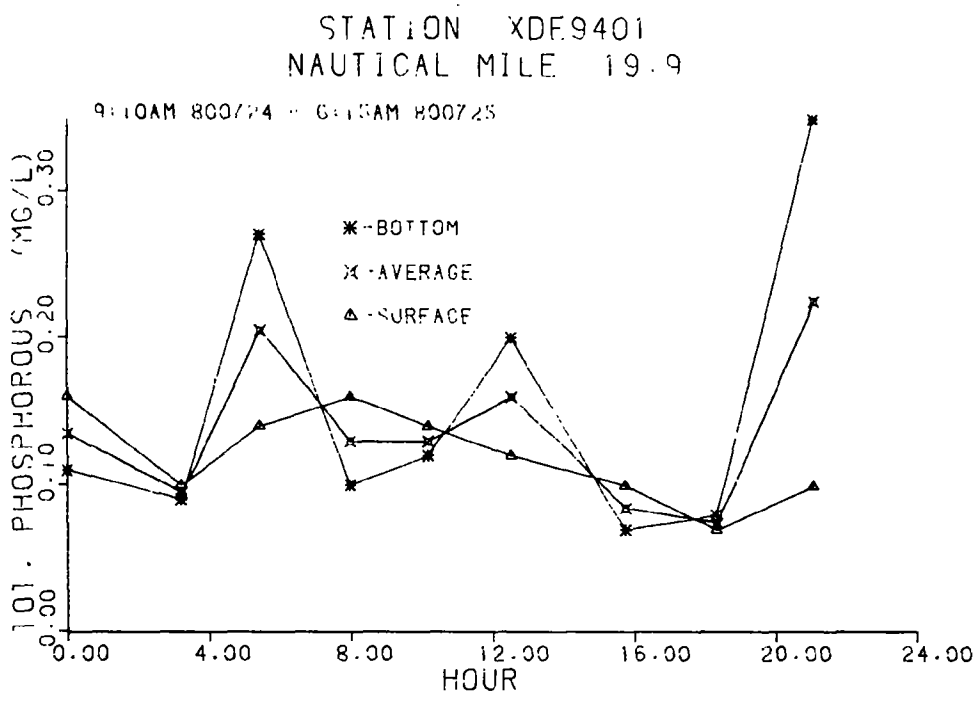


Figure 9-12 Intensive river survey plots of total phosphorus.



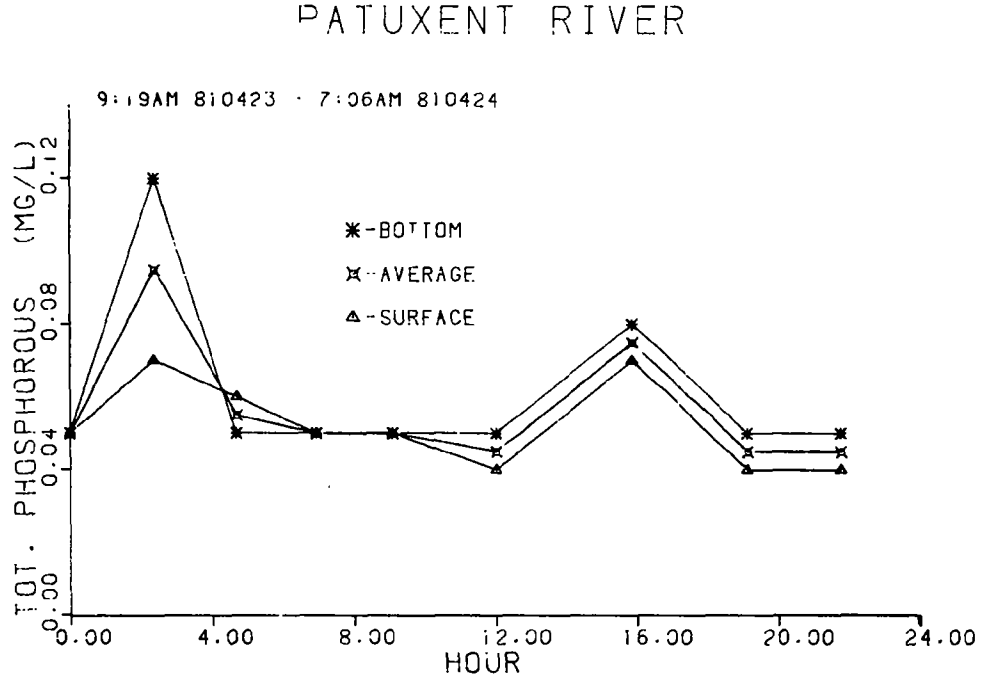
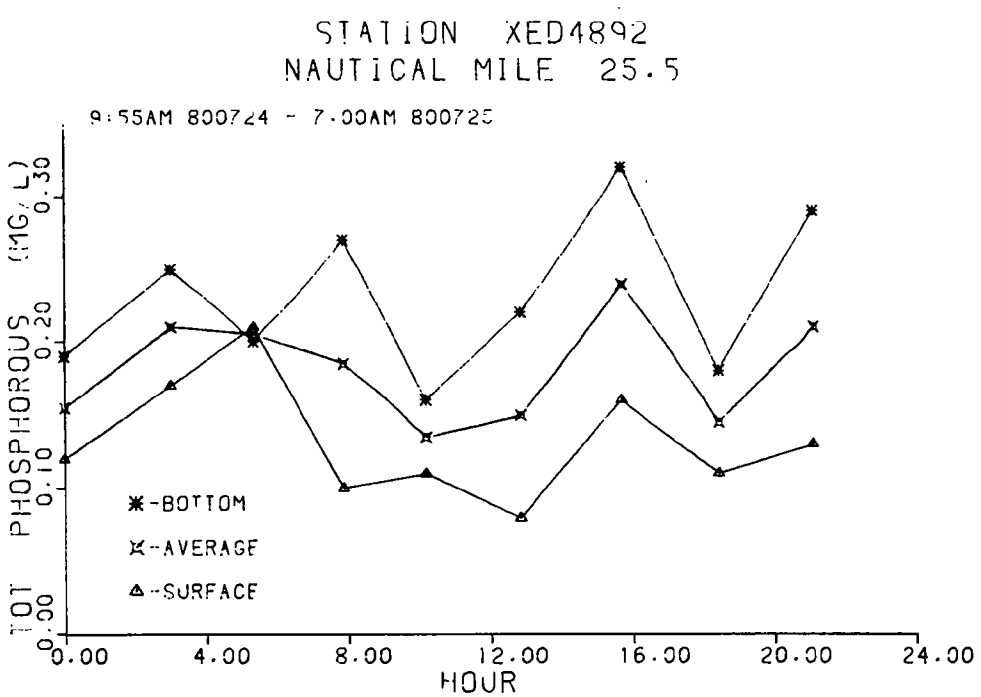


Figure 9-12 Intensive river survey plots of total phosphorus.



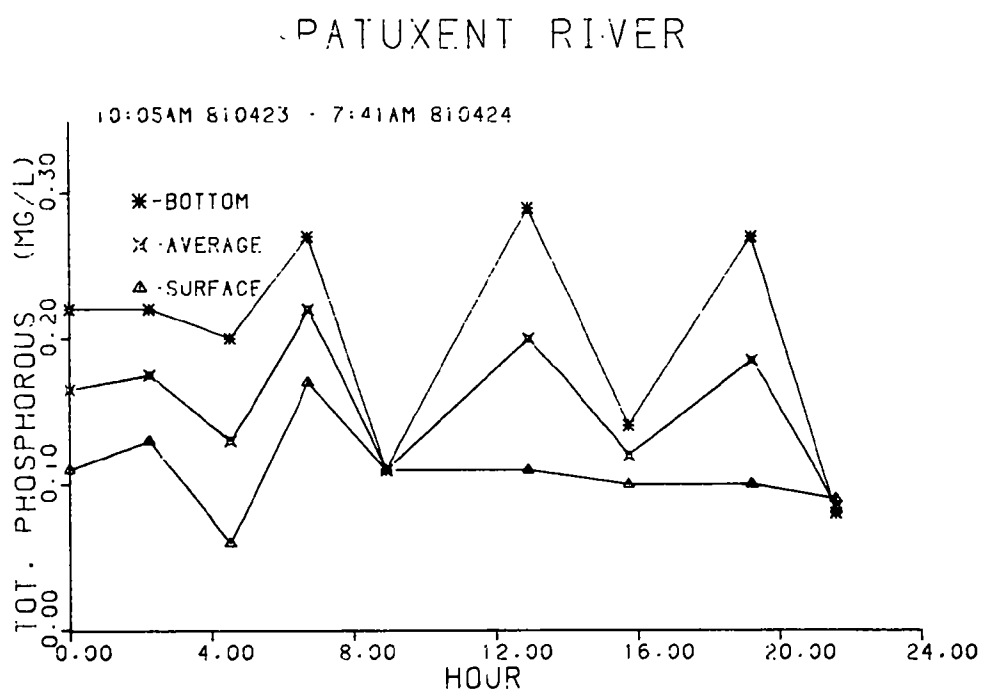
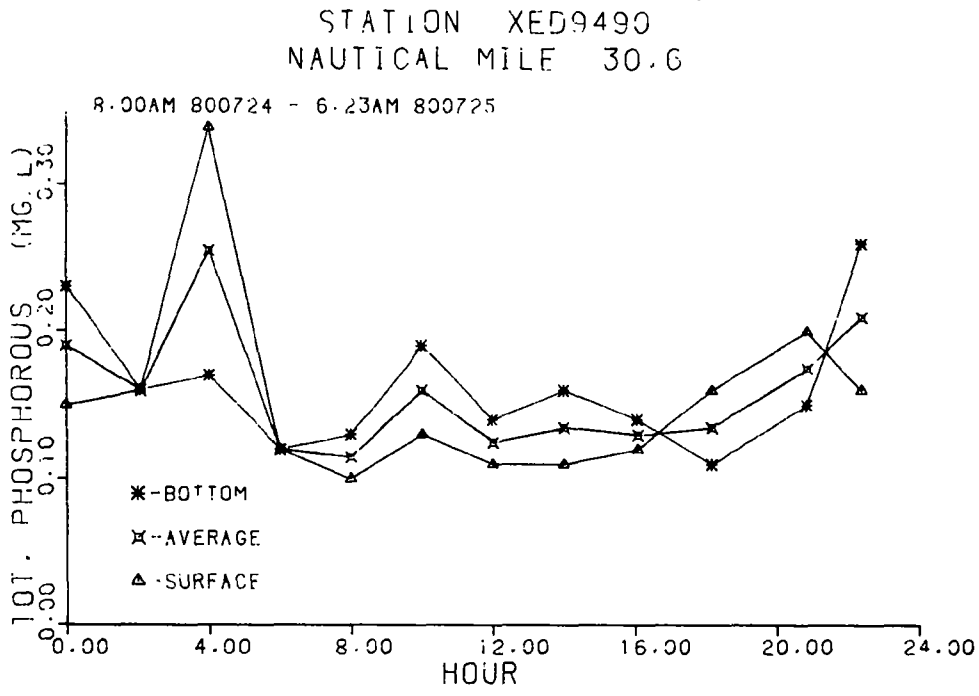


Figure 9-12Intensive river survey plots of total phosphorus.



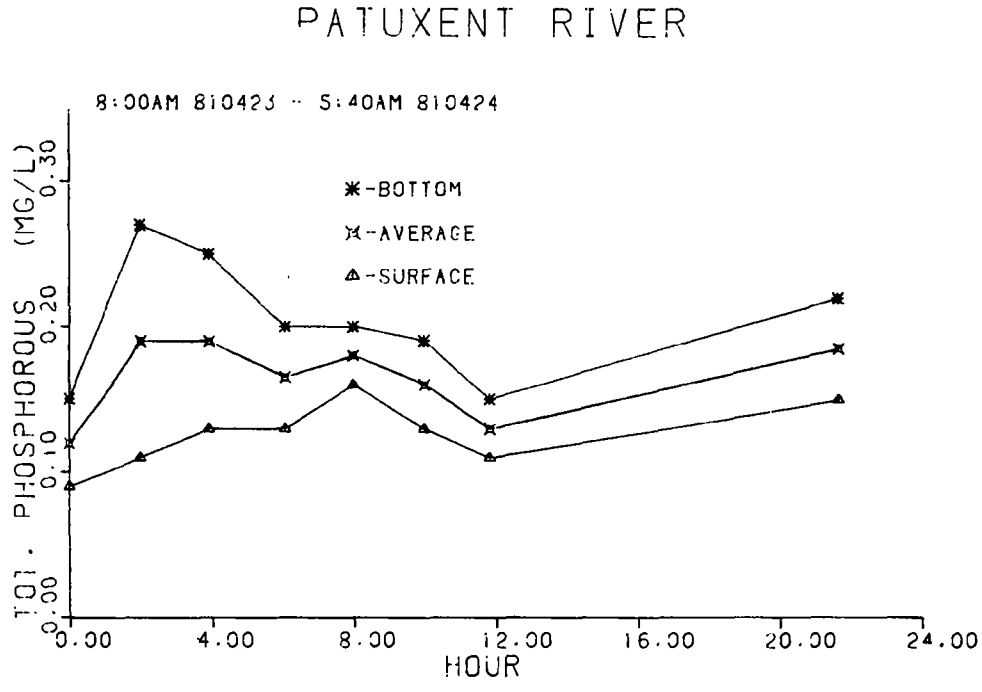
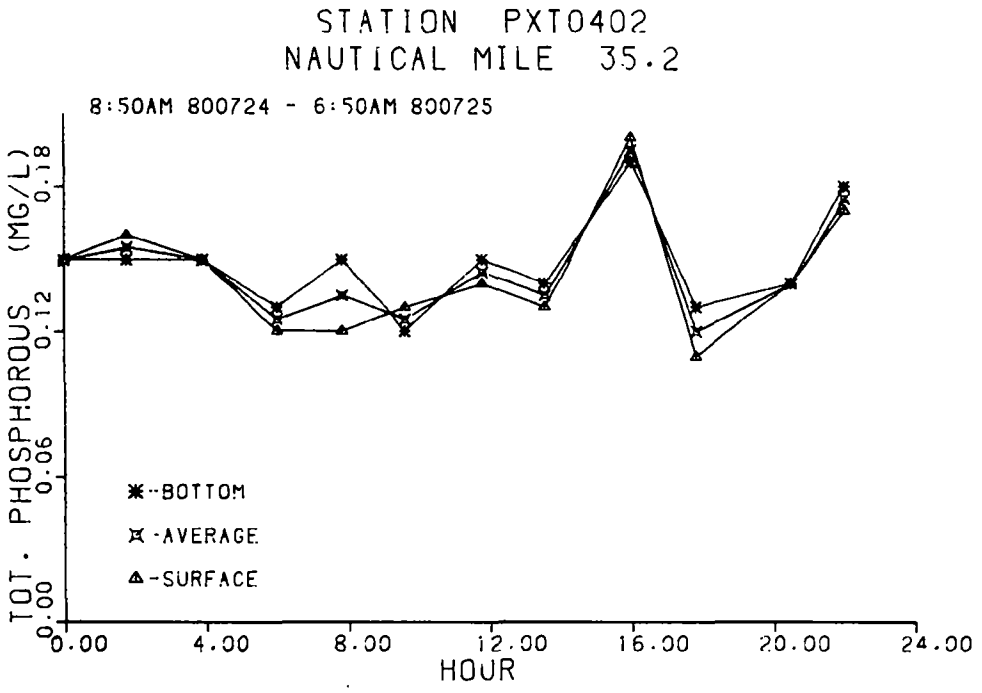


Figure 9-12 Intensive river survey plots of total phosphorus.



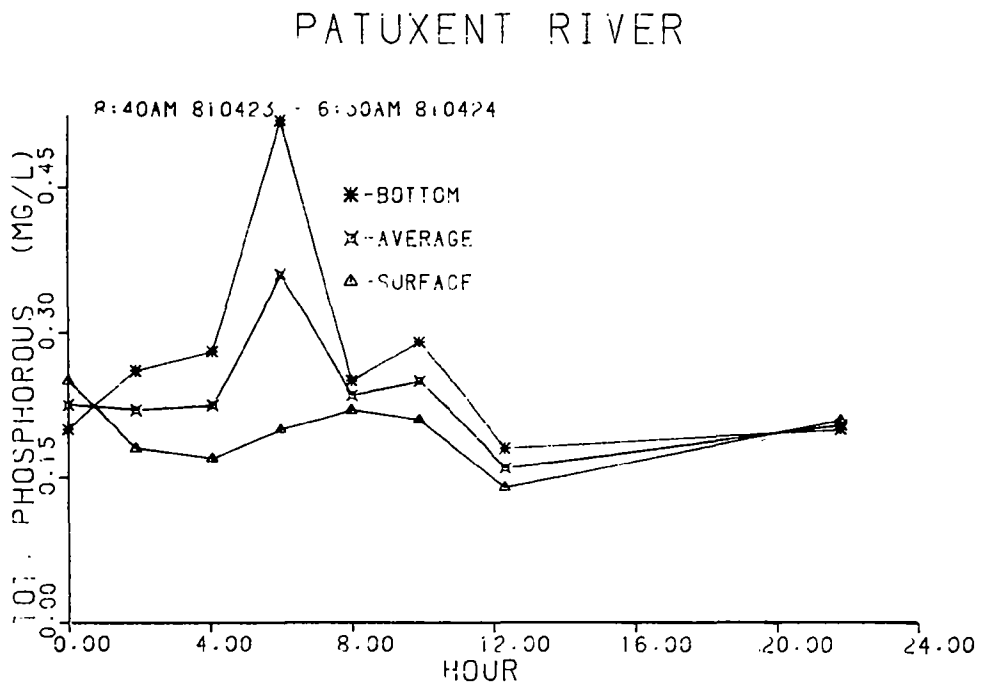
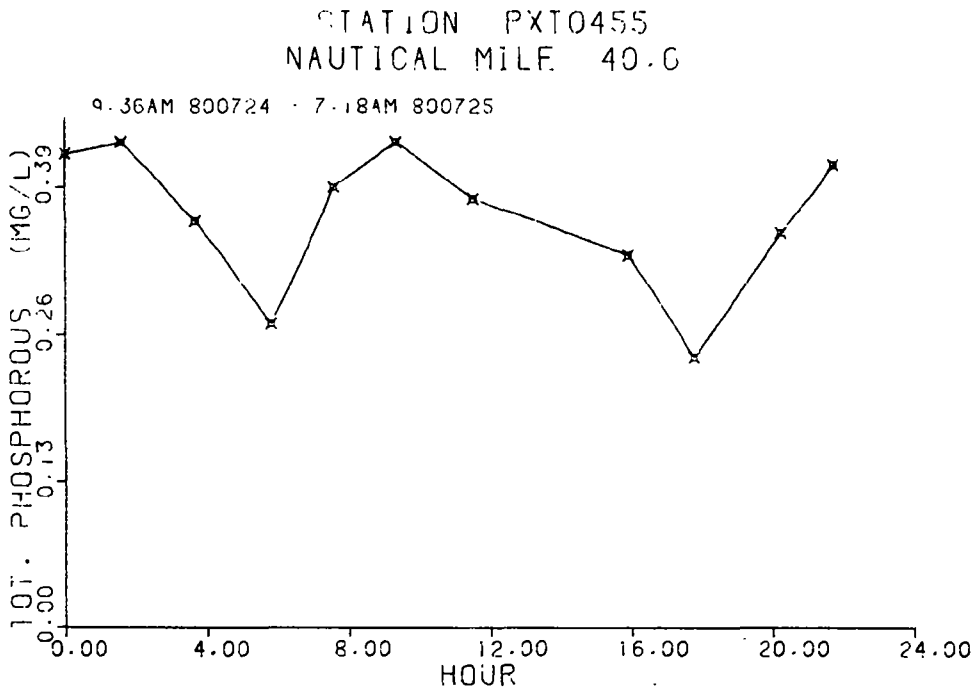


Figure 9-12Intensive river survey plots of total phosphorus.



PATUXENT RIVER

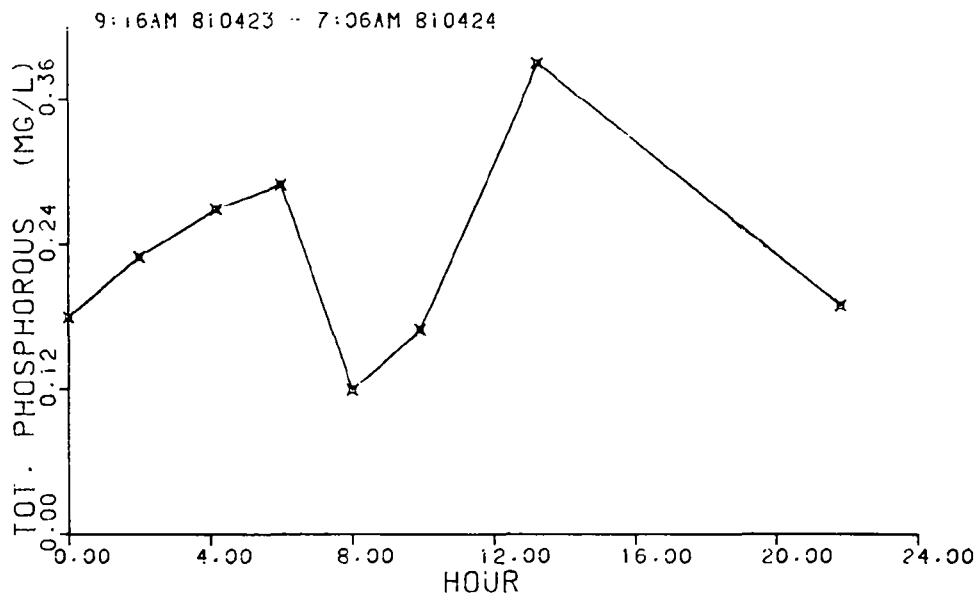
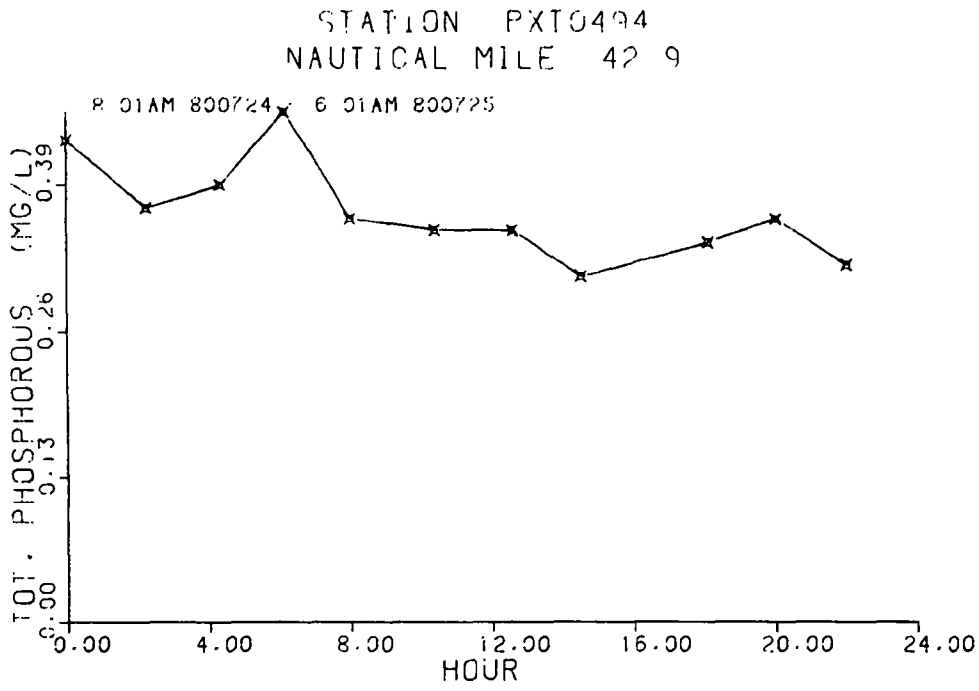


Figure9-12 Intensive river survey plots of total phosphorus.



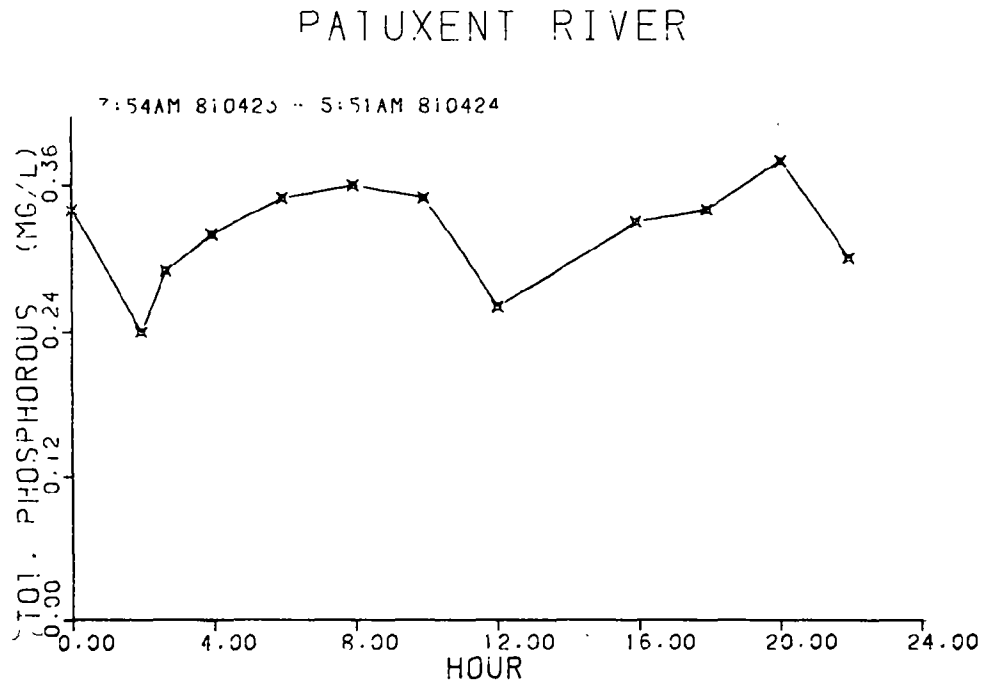
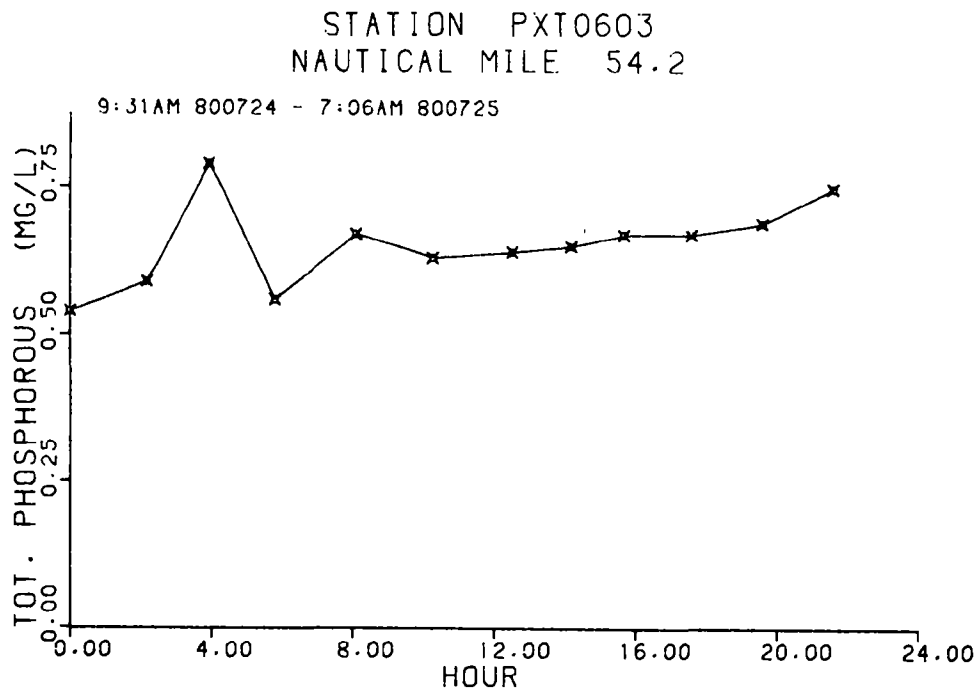


Figure 9-12Intensive river survey plots of total phosphorus.



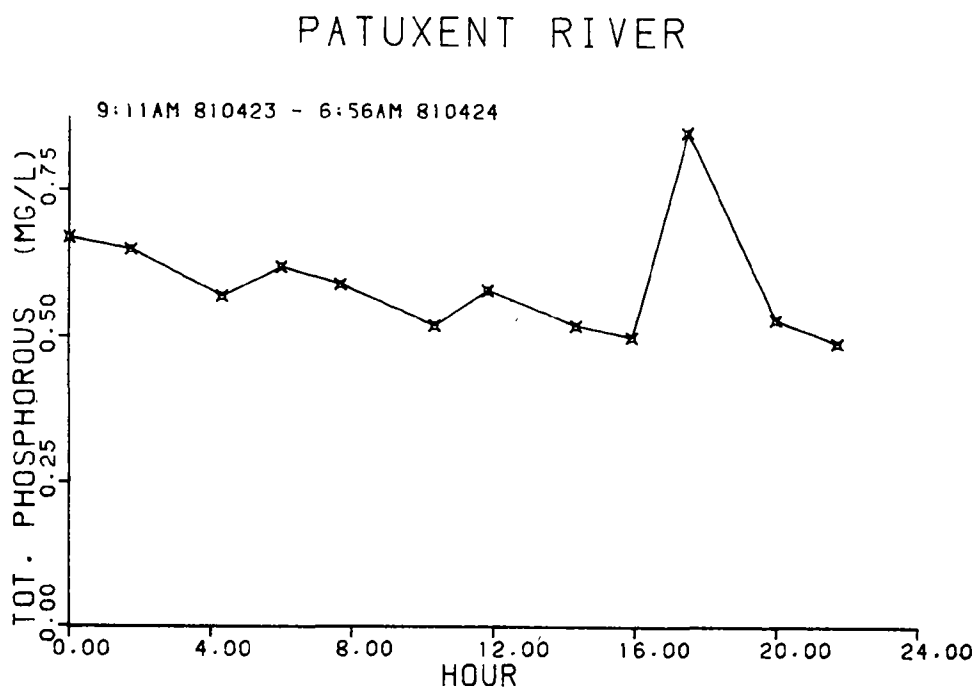
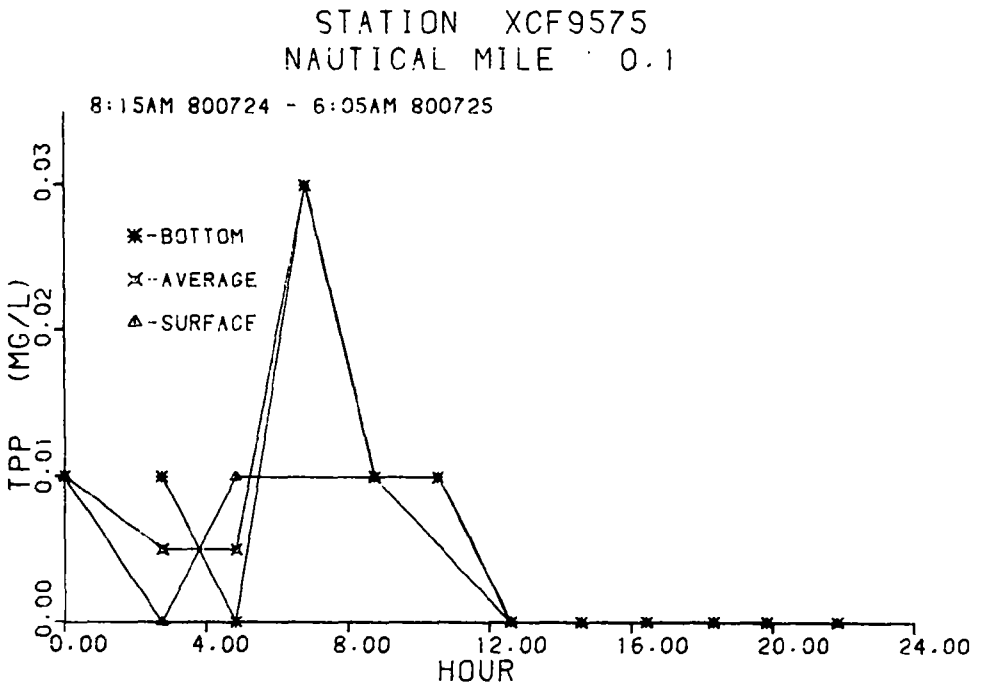


Figure 9-12 Intensive river survey plots of total phosphorus.



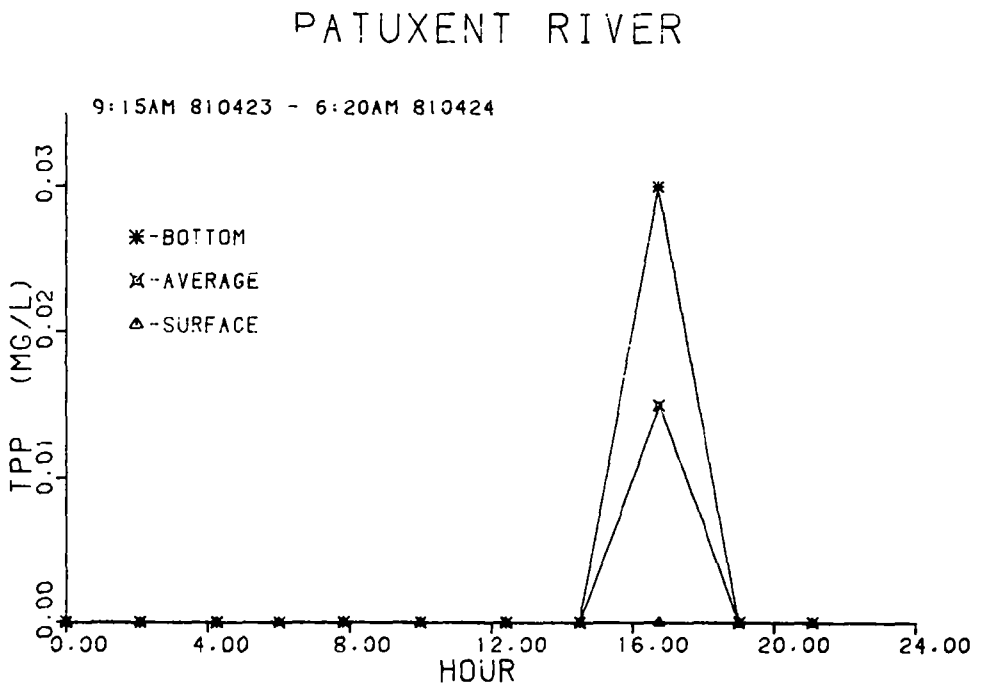
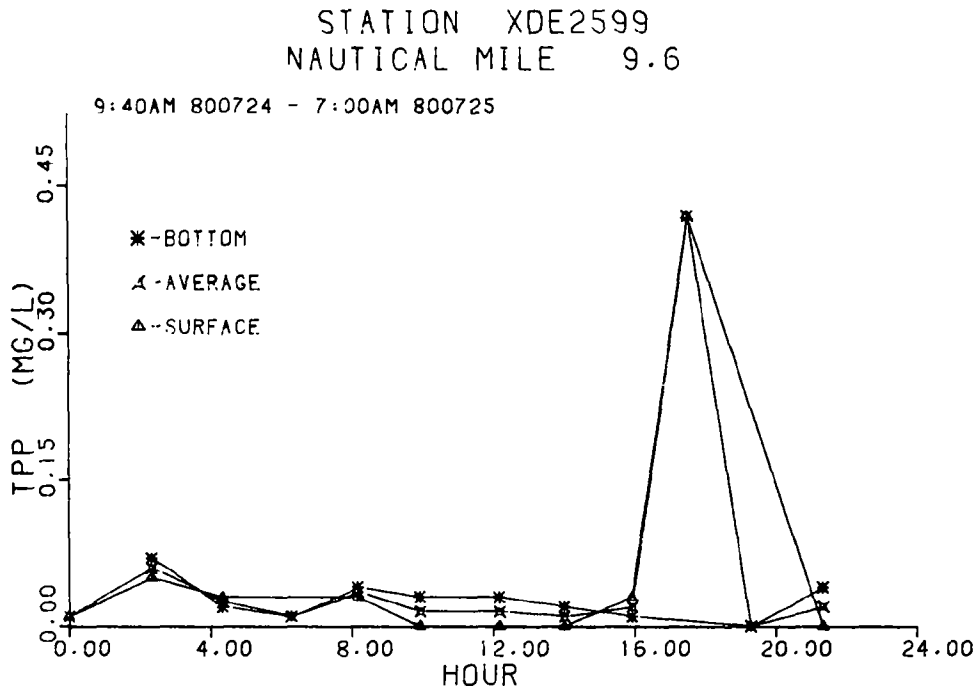


Figure 9-13Intensive river plots of total particulate phosphorus.



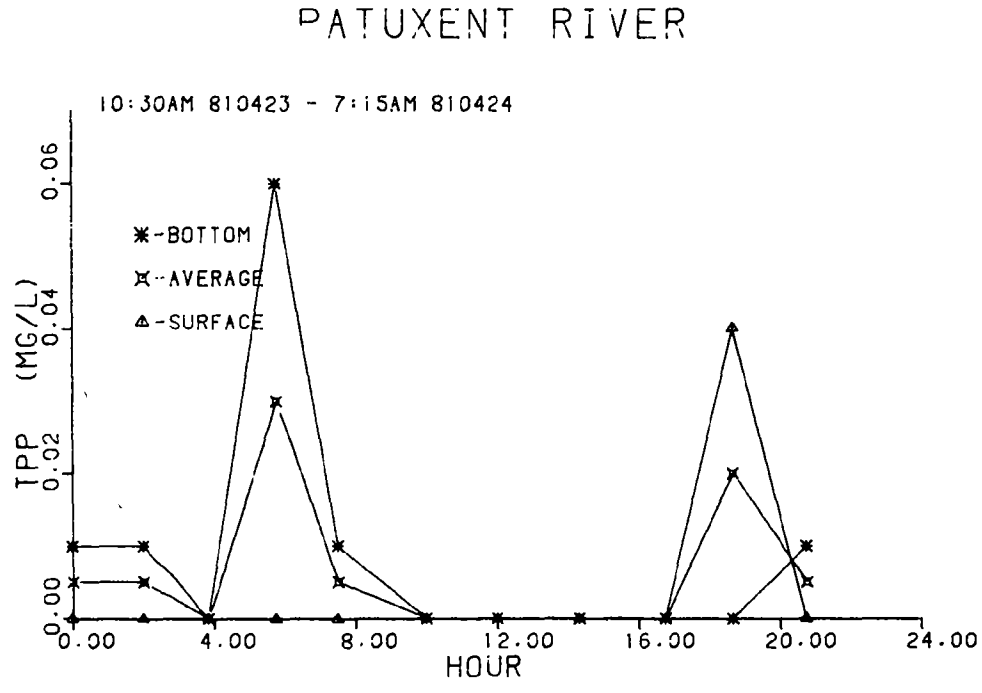
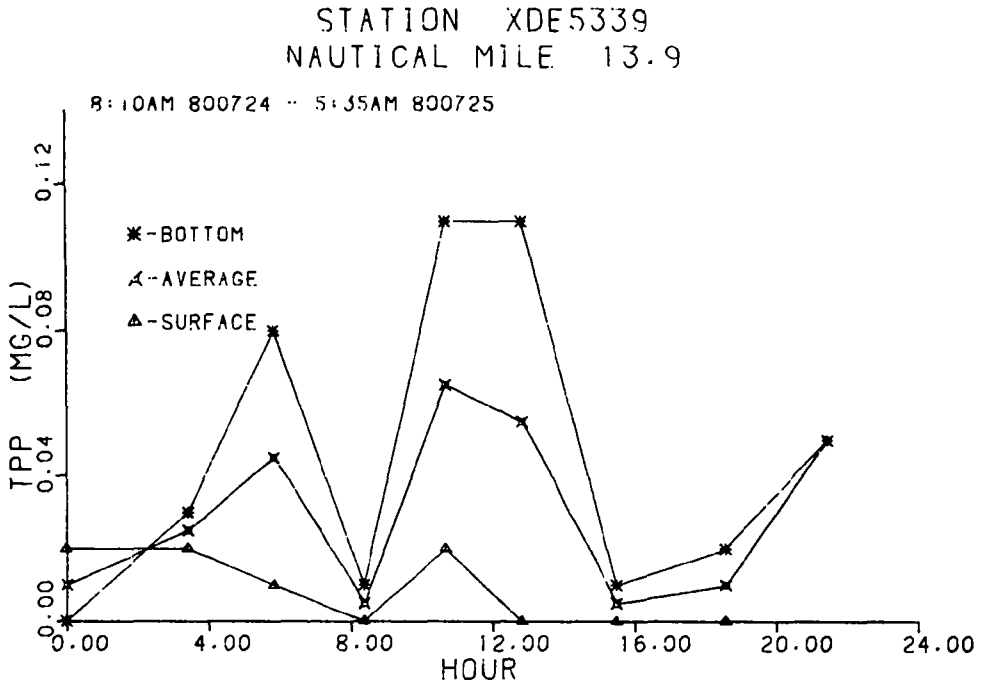


Figure 9-13 Intensive river plots of total particulate phosphorus.



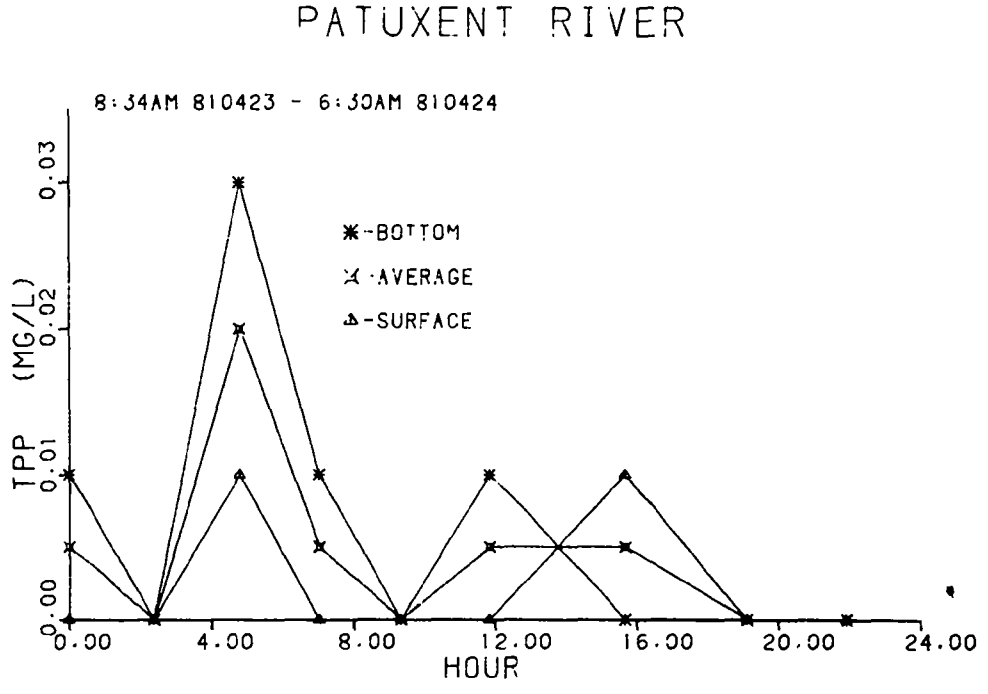
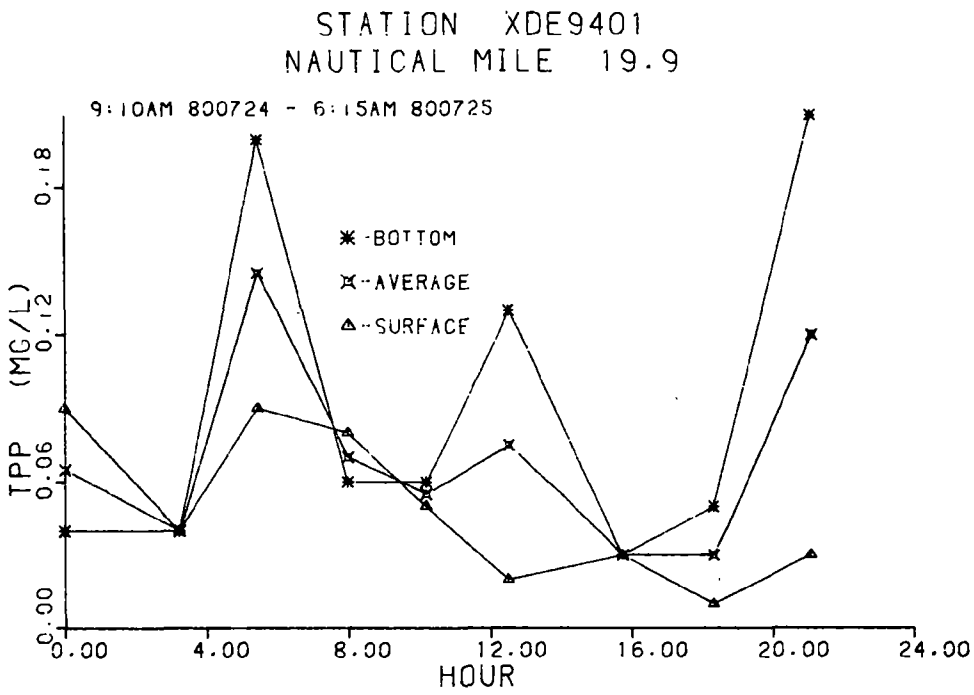


Figure 9-13 Intensive river plots of total particulate phosphorus.



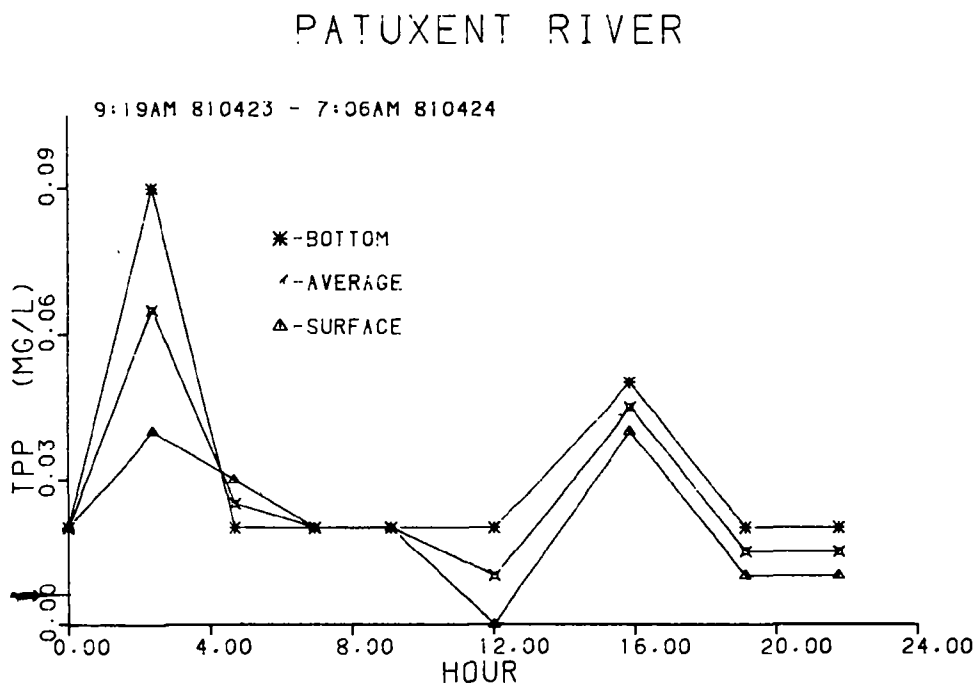
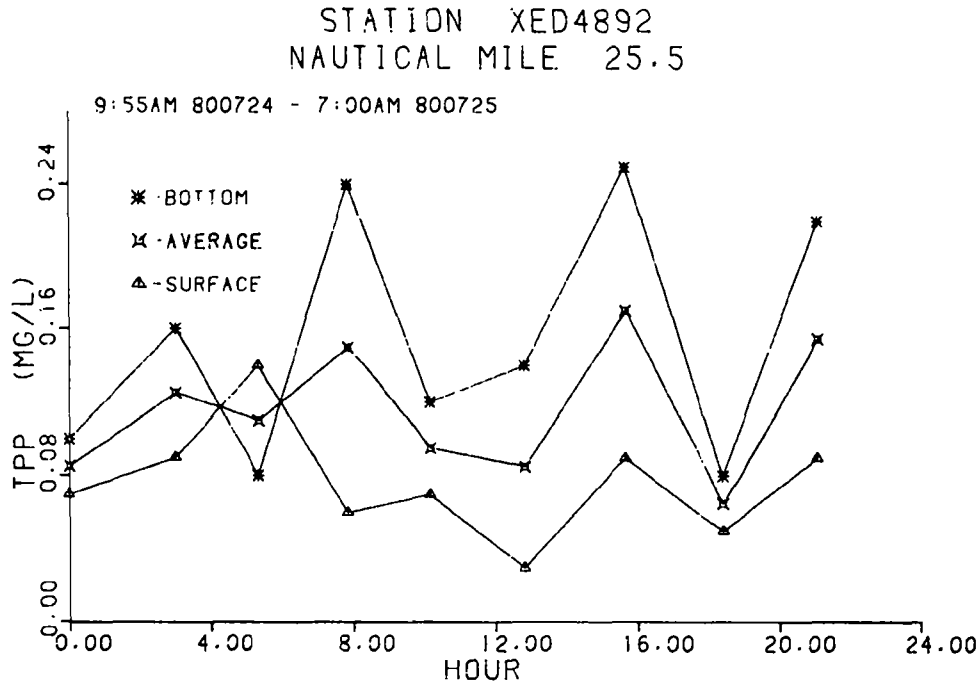


Figure 9-13Intensive river plots of total particulate phosphorus.



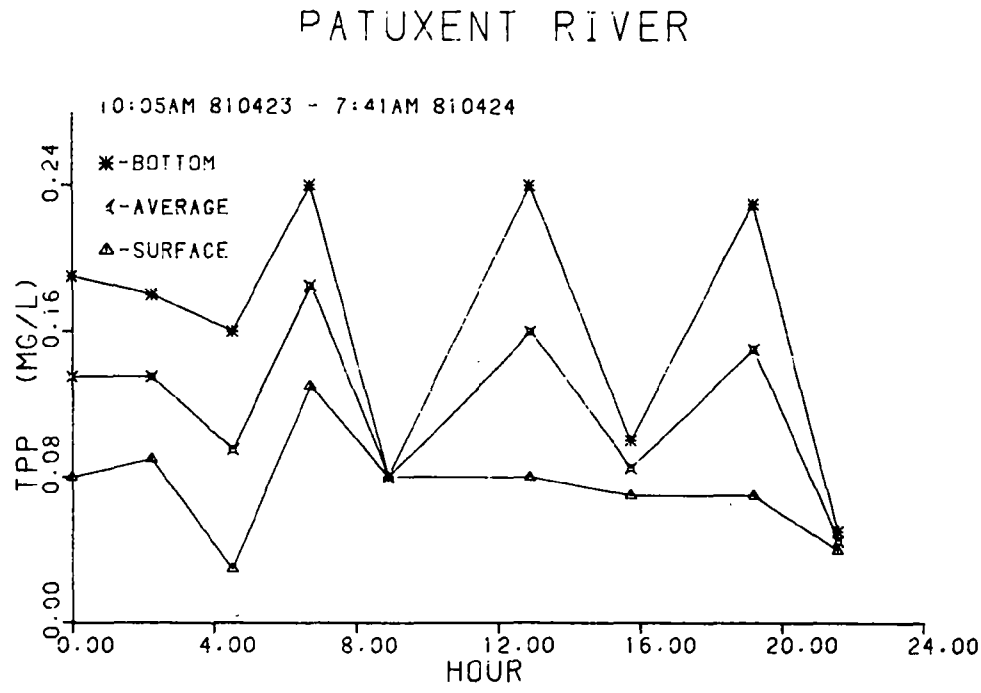
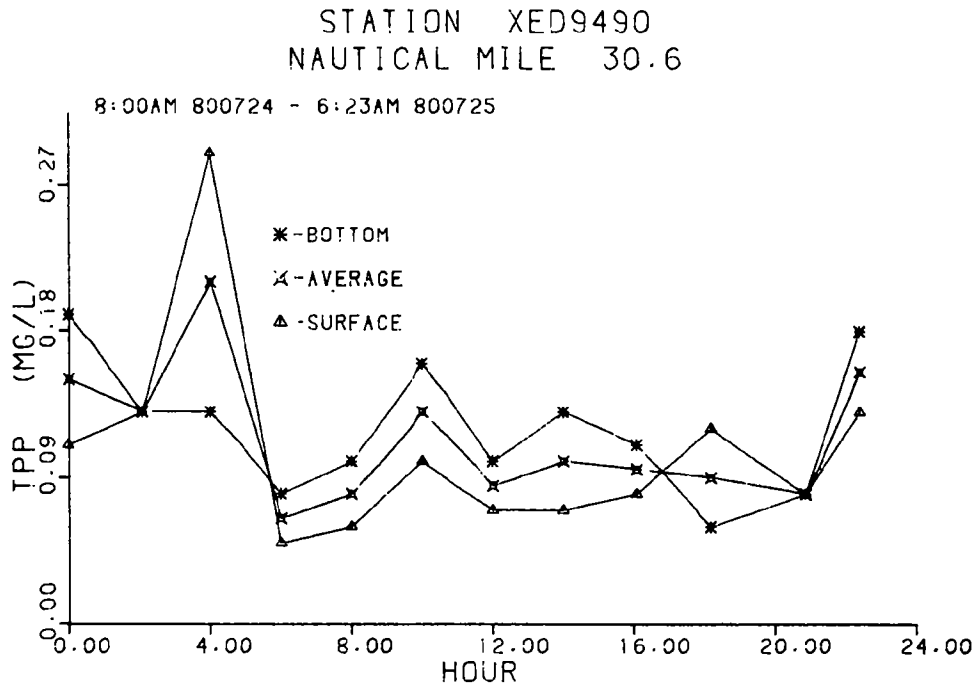


Figure 9-13 Intensive river plots of total particulate phosphorus.



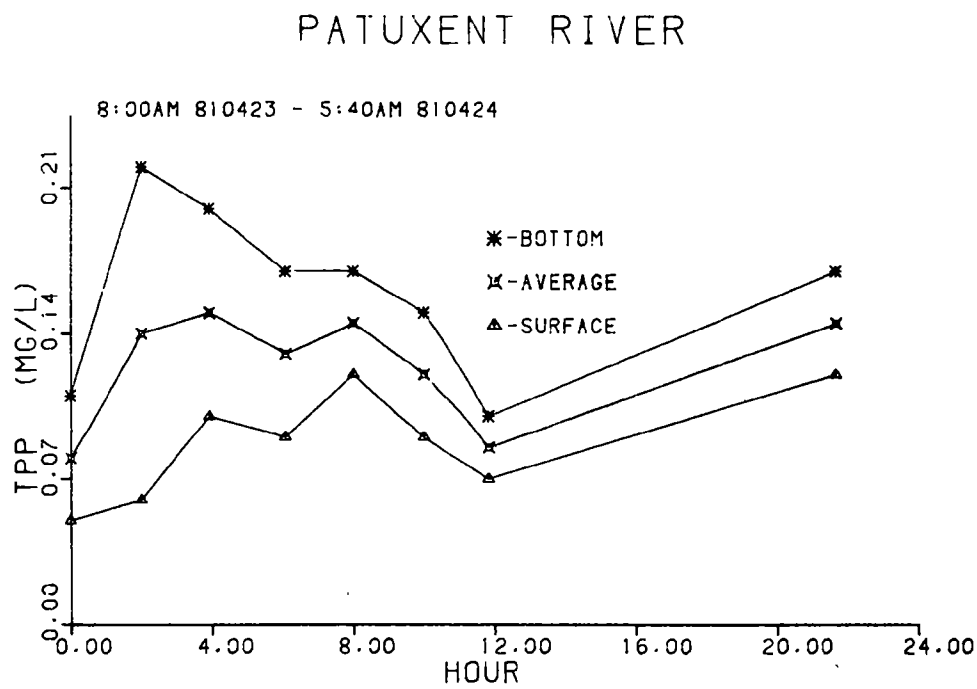
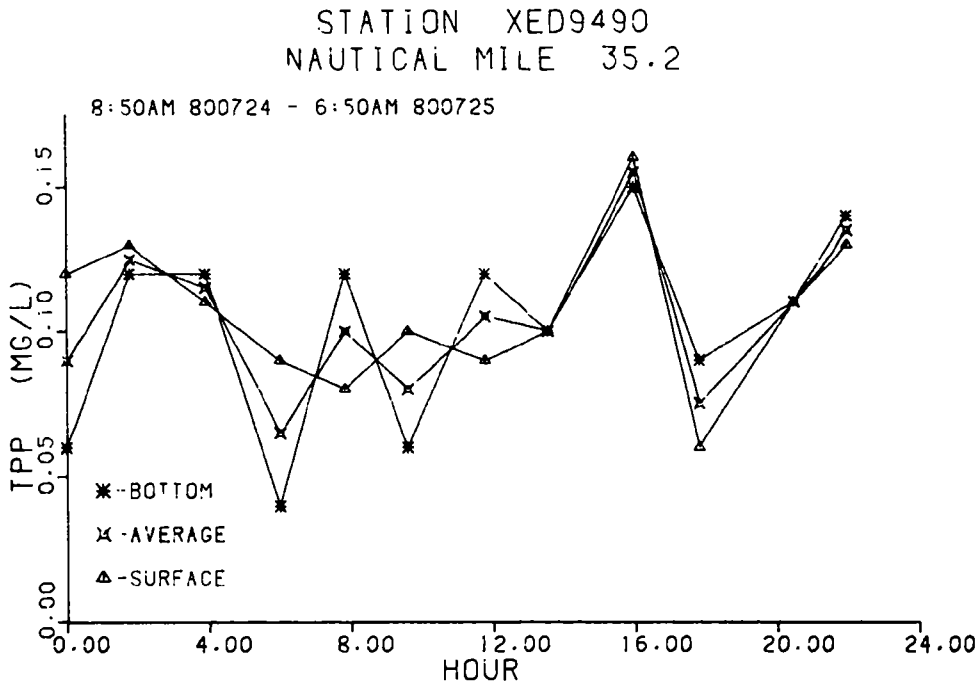


Figure 9-13 Intensive river plots of total particulate phosphorus.



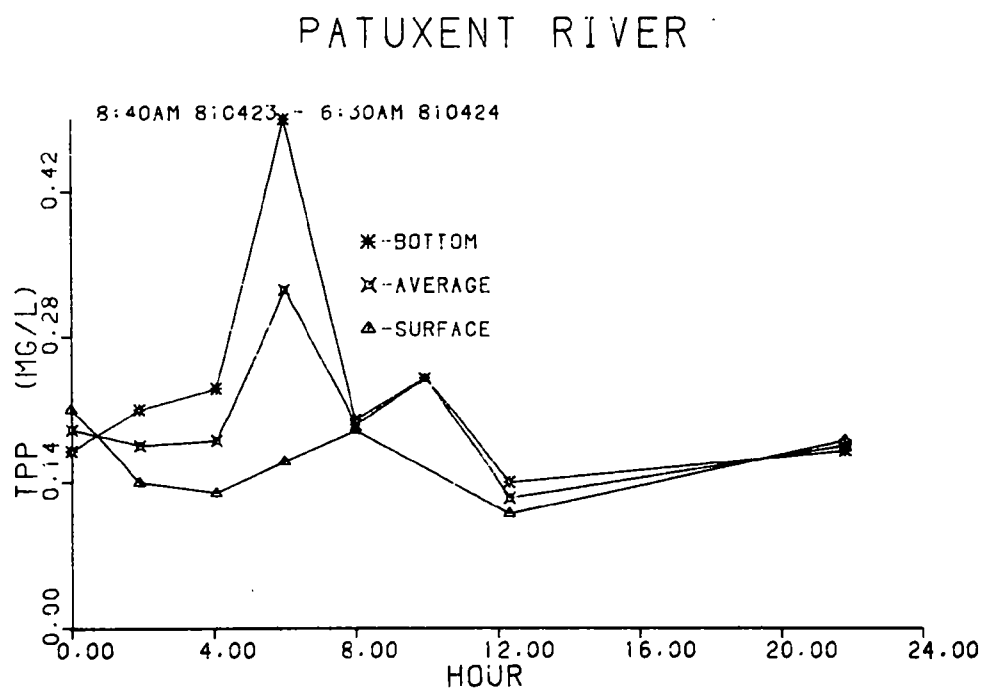
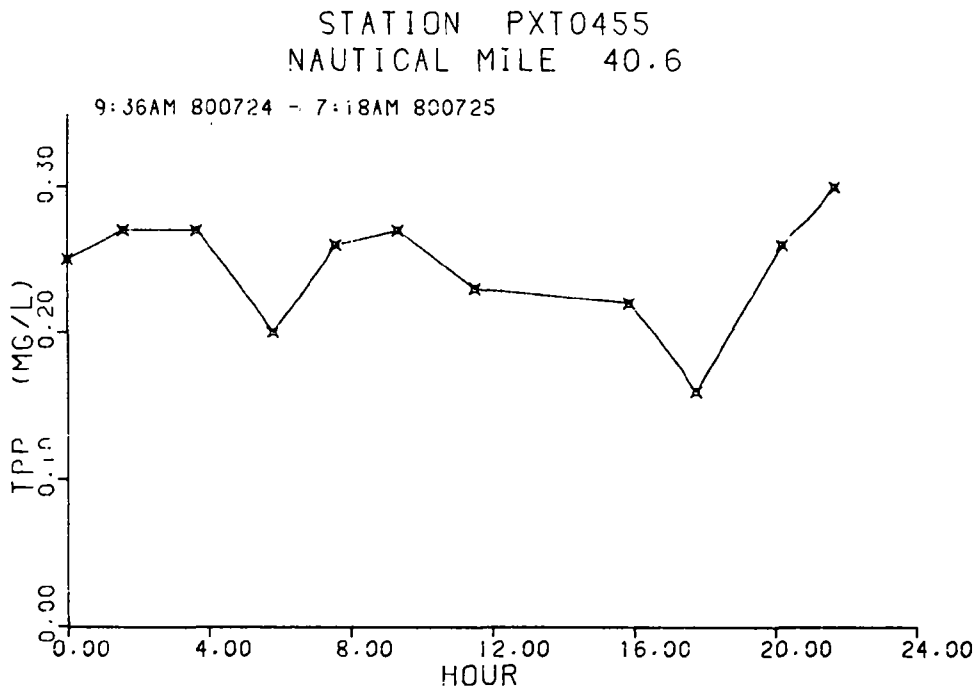


Figure 9-13 Intensive river plots of total particulate phosphorus.



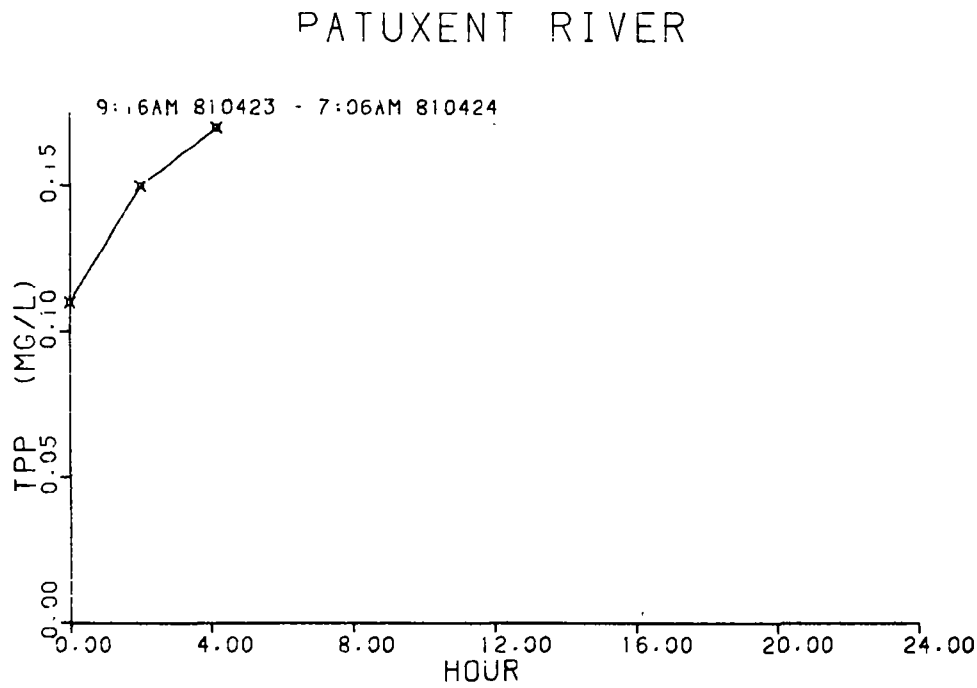
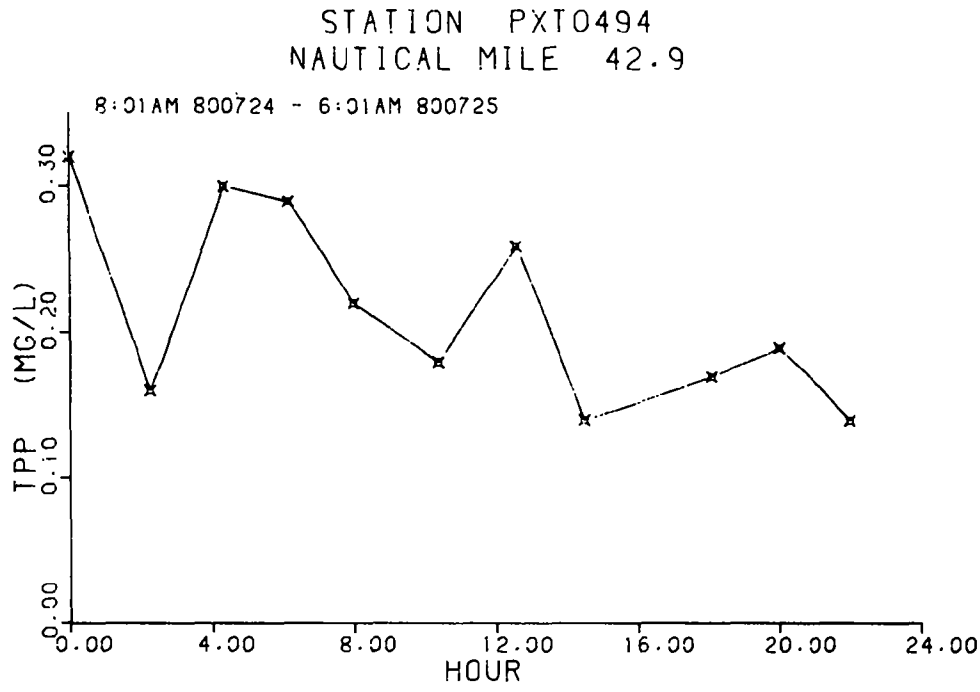


Figure 9-13 Intensive river plots of total particulate phosphorus.



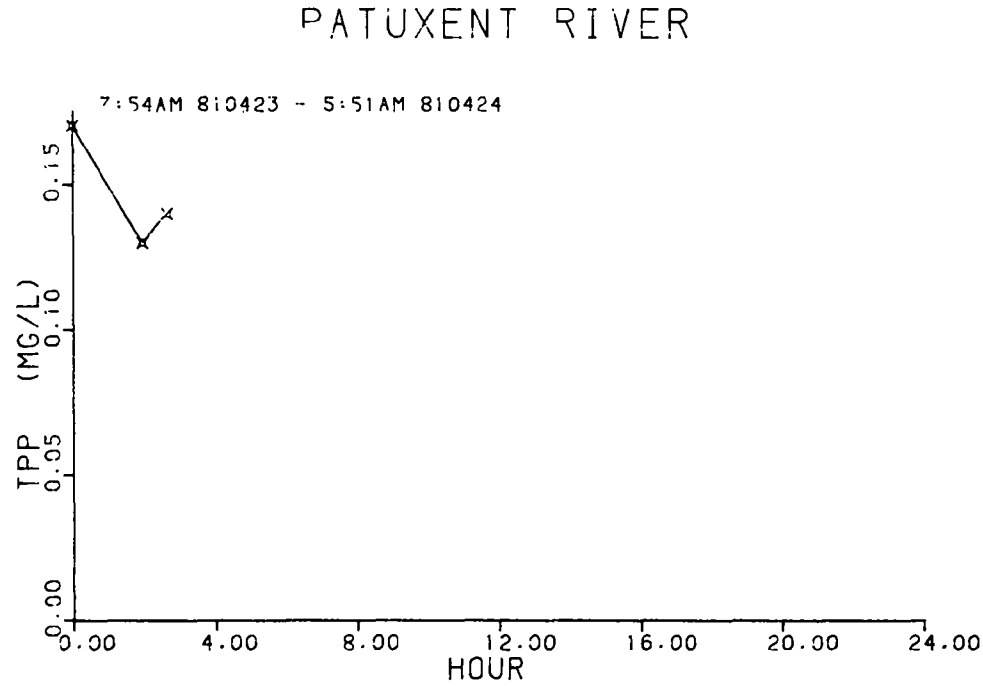
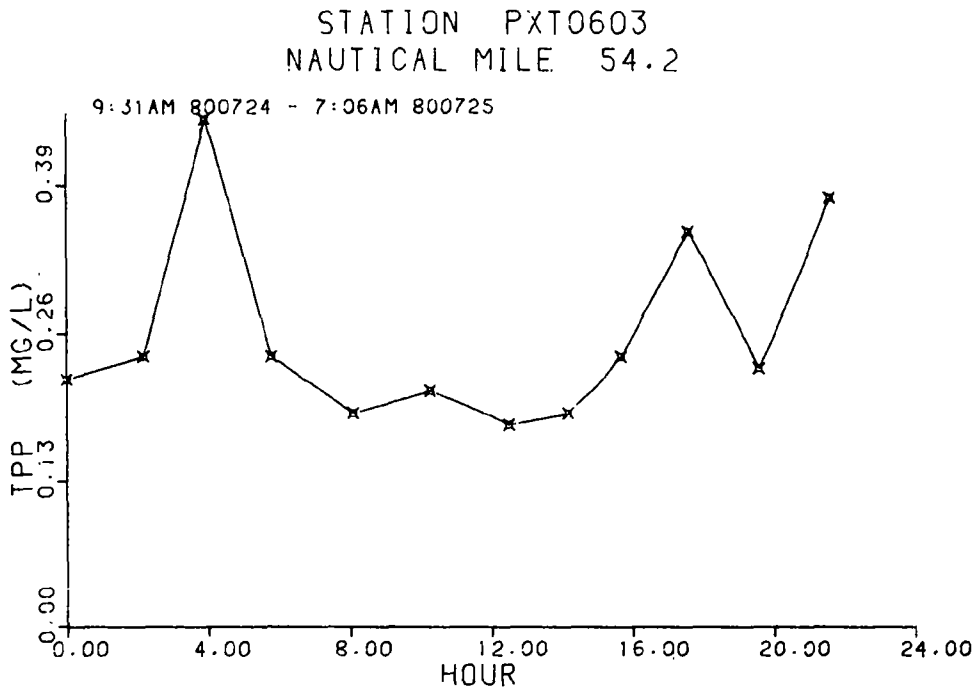


Figure 9-13Intensive river plots of total particulate phosphorus.



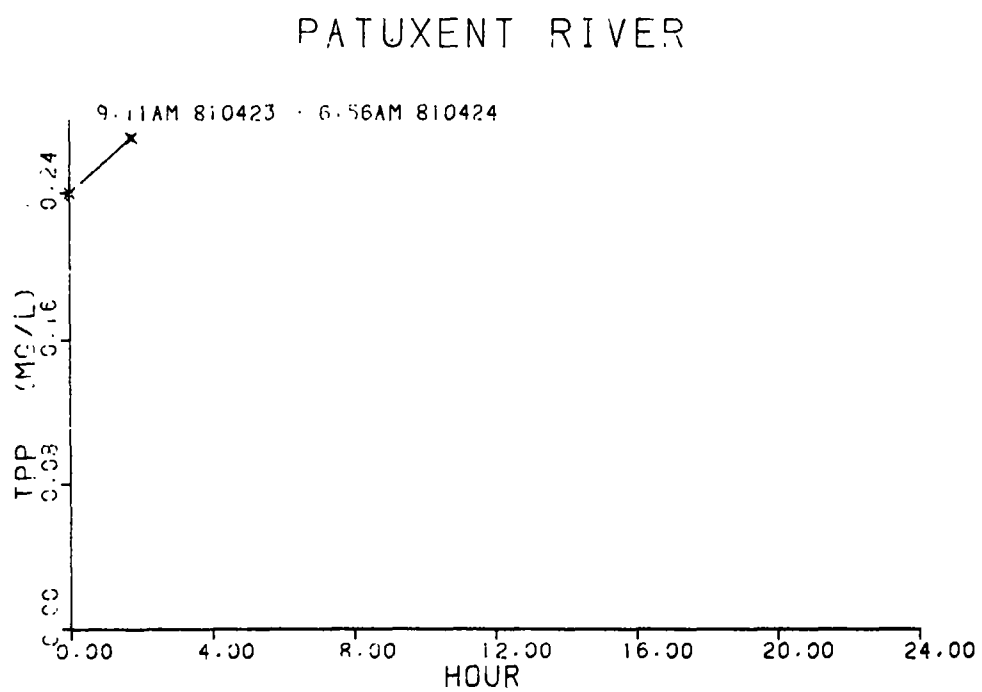
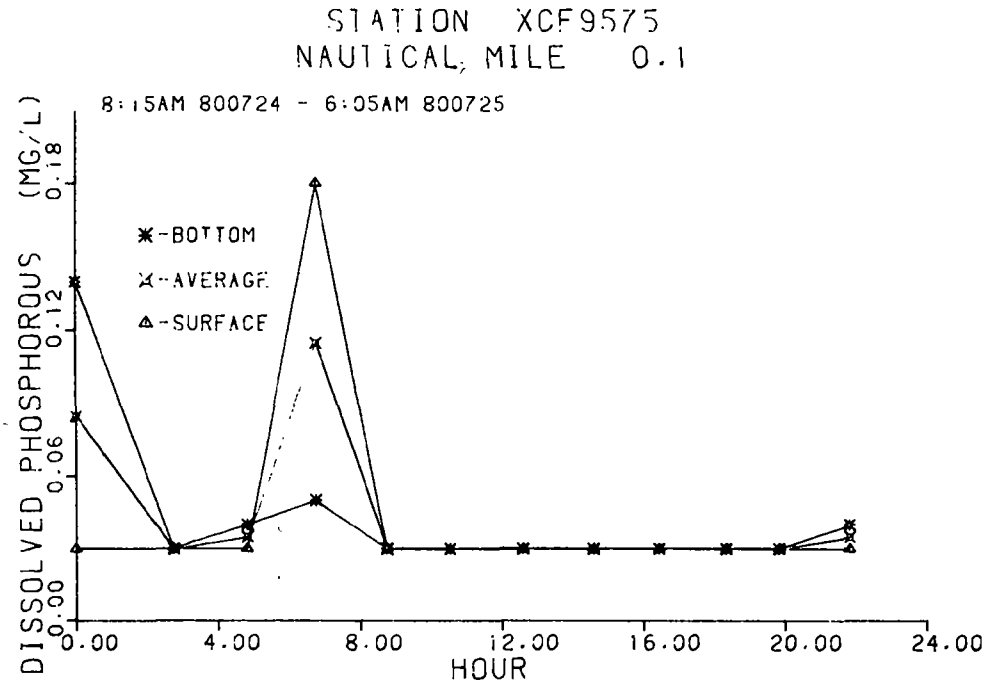


Figure 9-13 Intensive river plots of total particulate phosphorus.



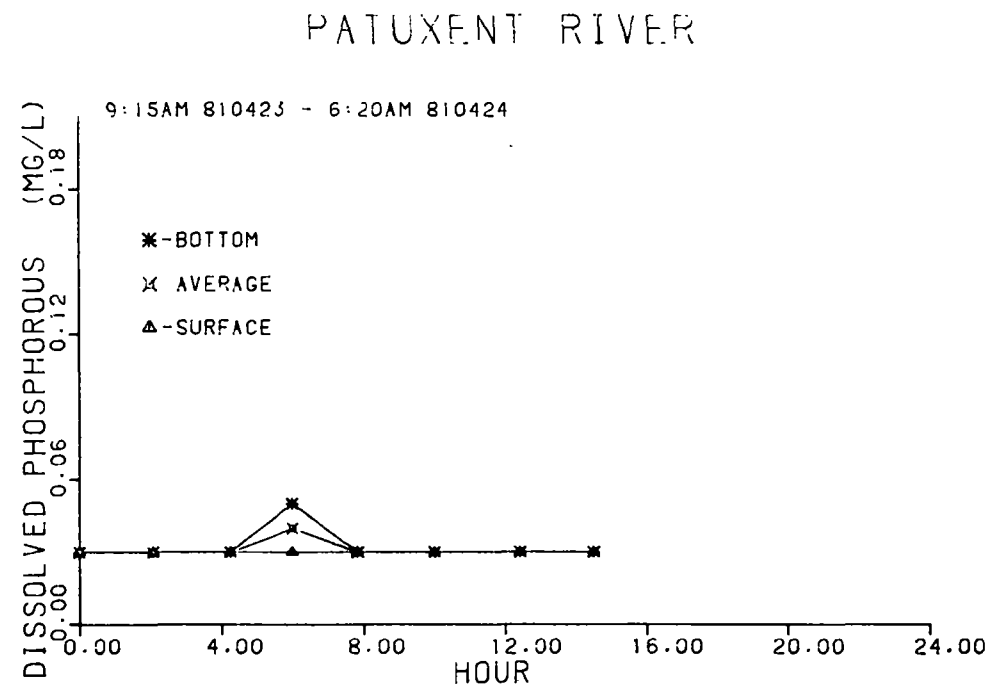
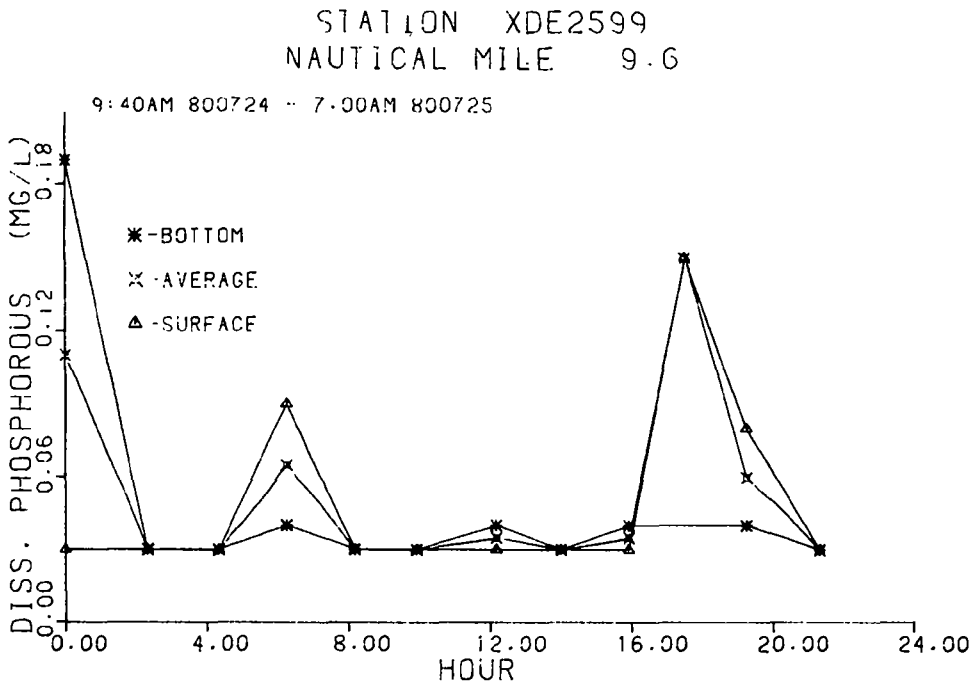


Figure 9-14 Intensive river survey plots of dissolved phosphorus.



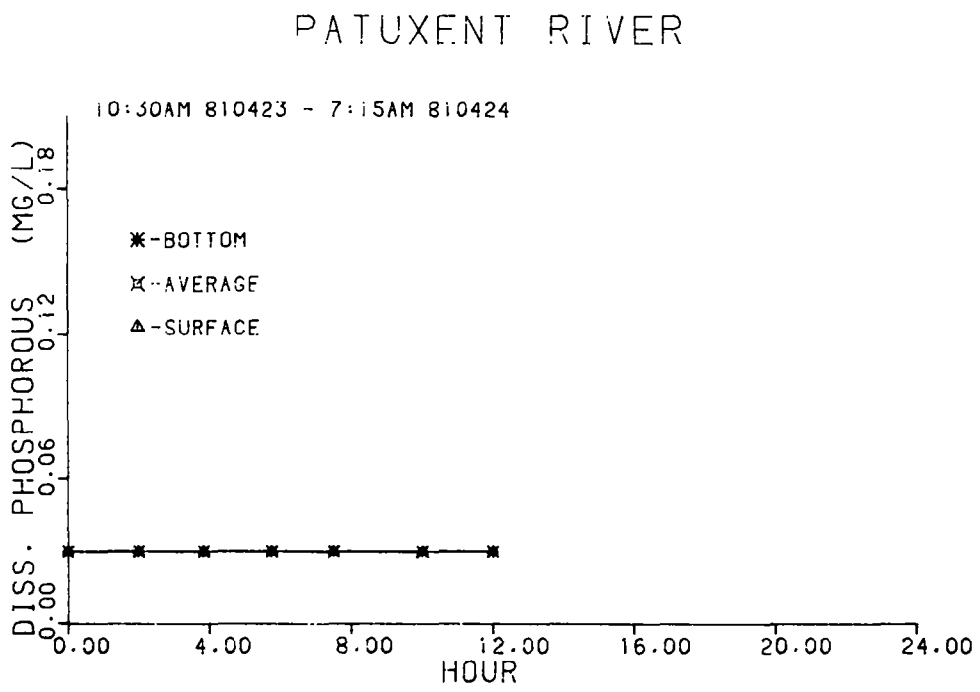
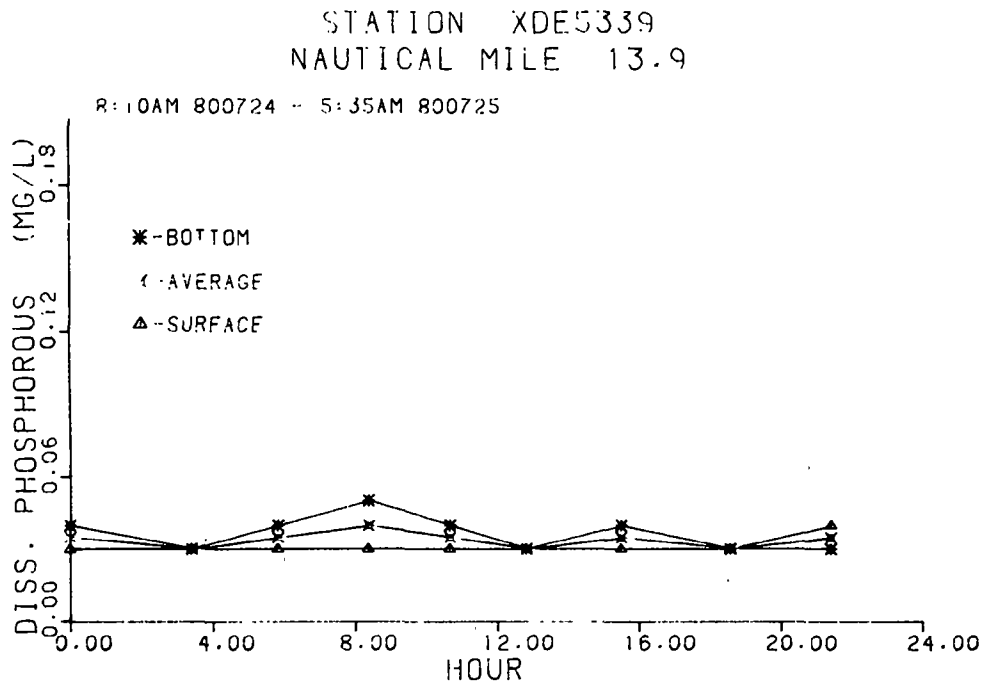


Figure 9-14 Intensive river survey plots of dissolved phosphorus



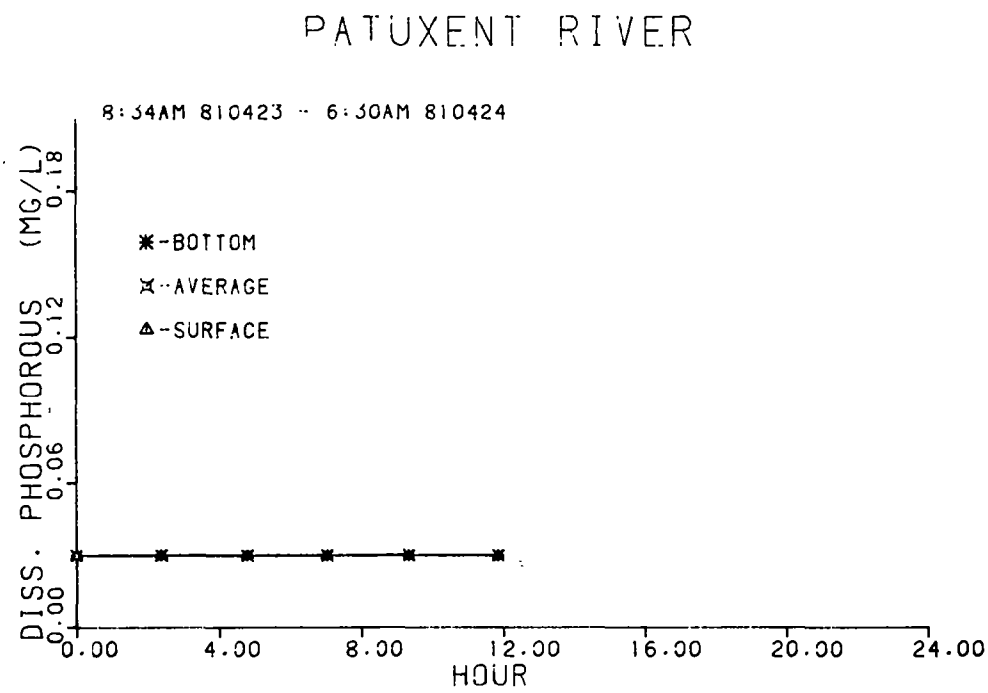
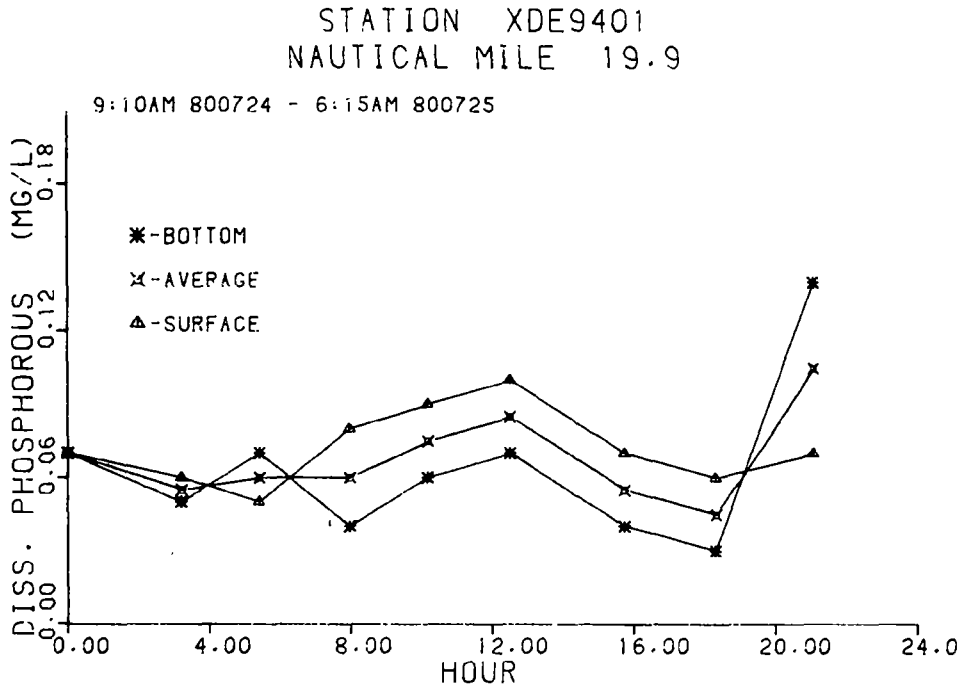


Figure 9-14 Intensive river survey plots of dissolved phosphorus.



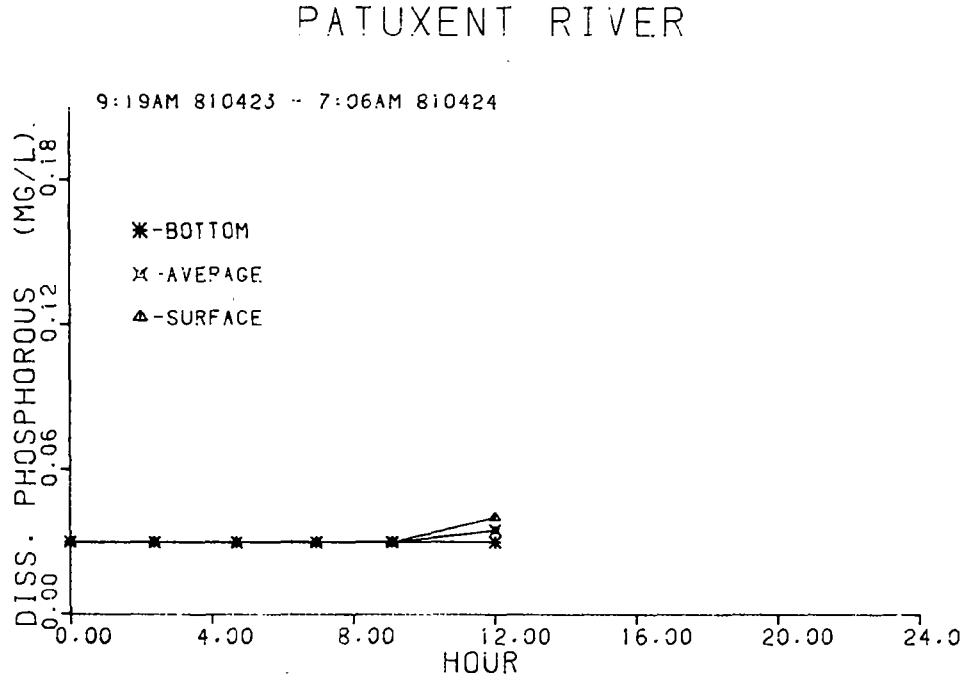
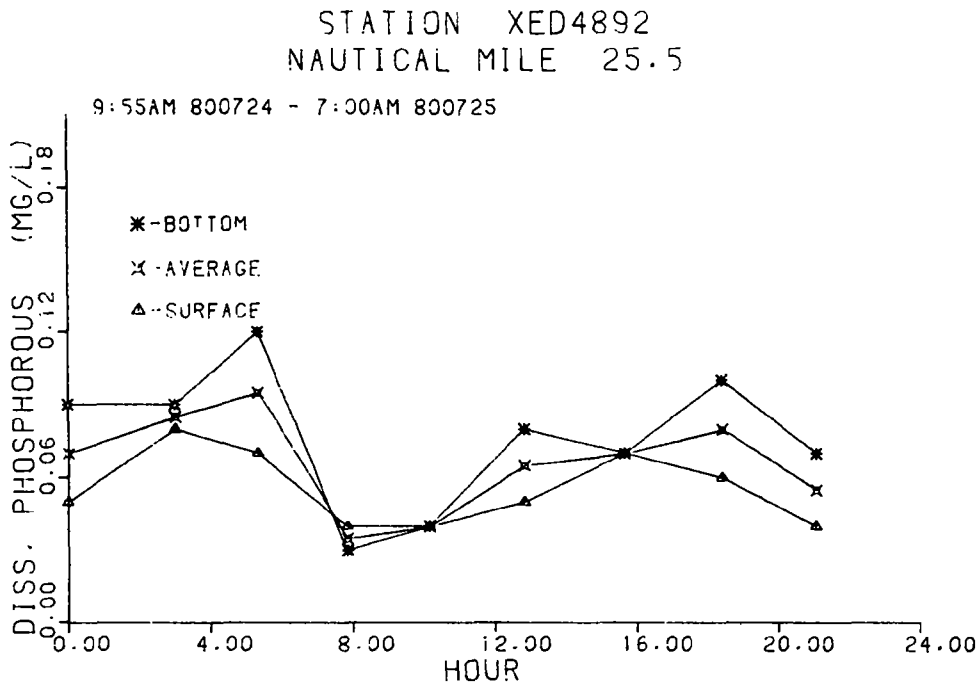


Figure 9-14 Intensive river survey plots of dissolved phosphorus.



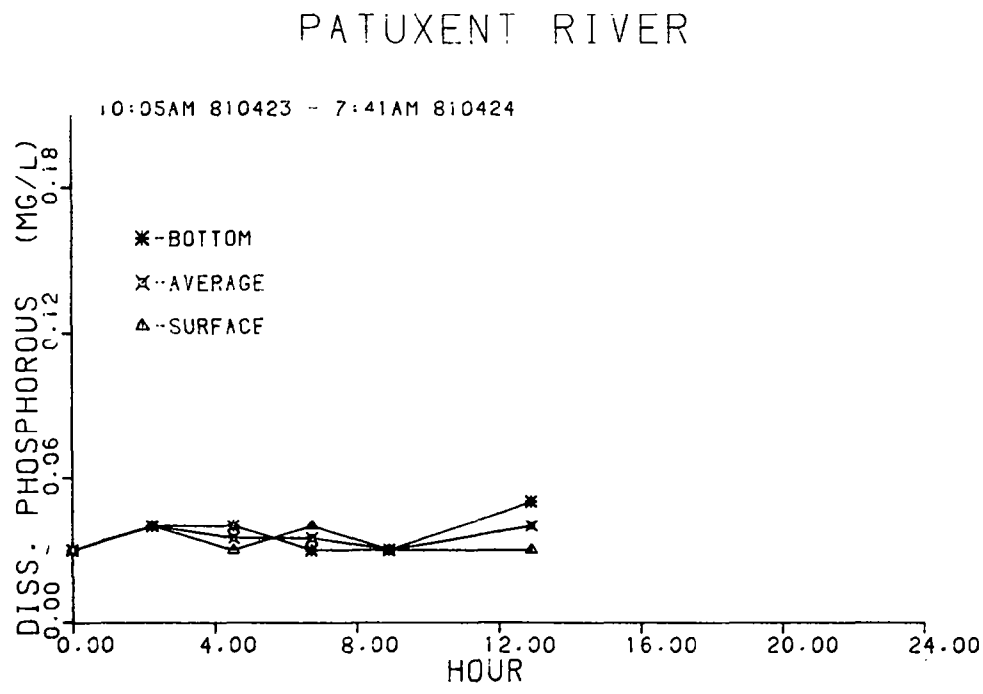
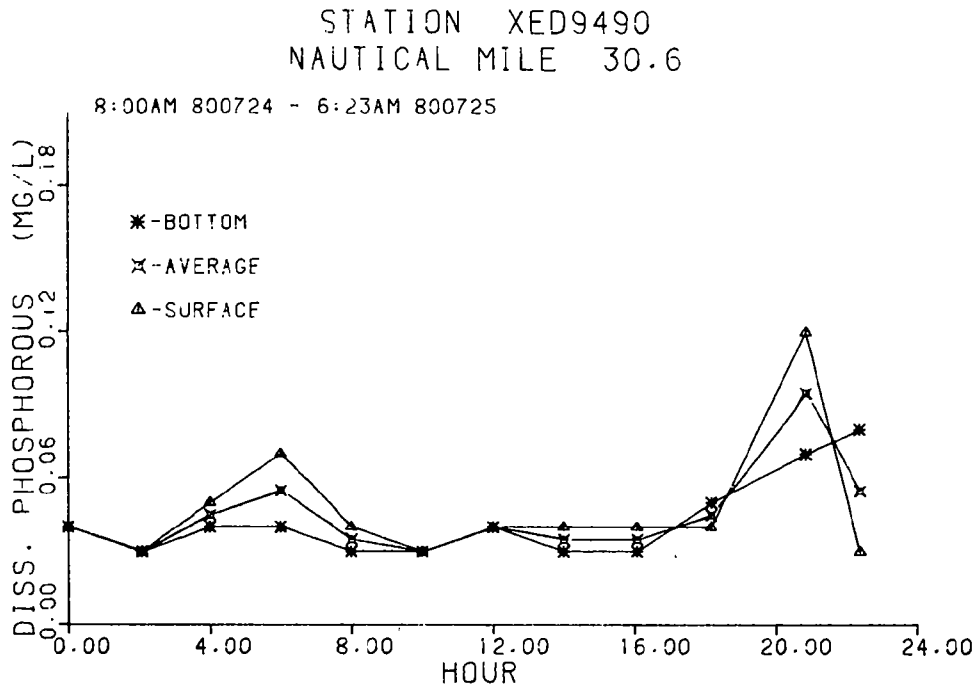


Figure 9-14Intensive river survey plots of dissolved phosphorus.



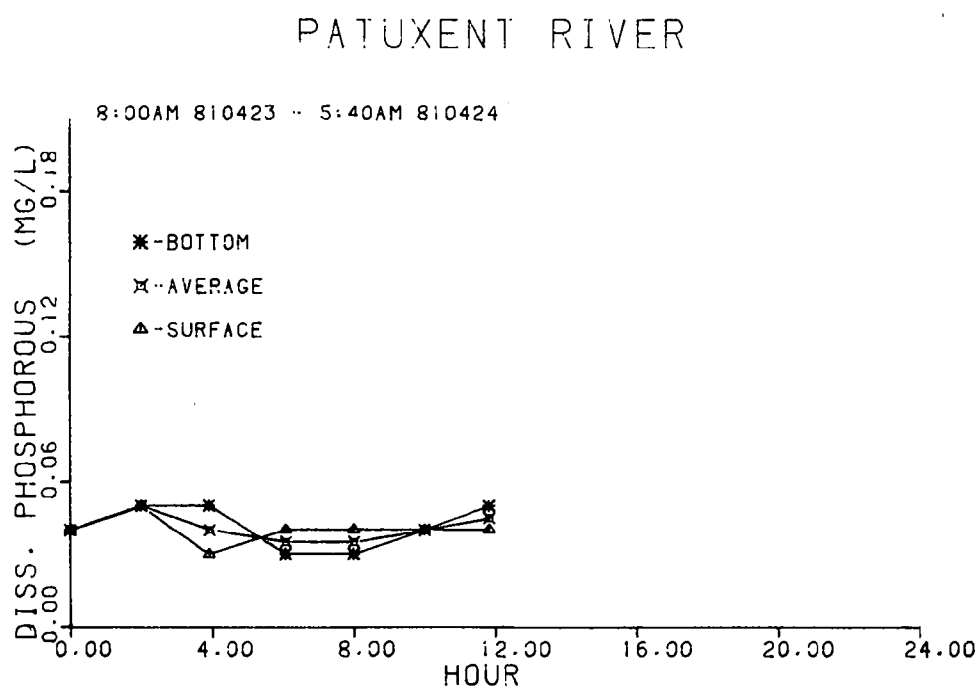
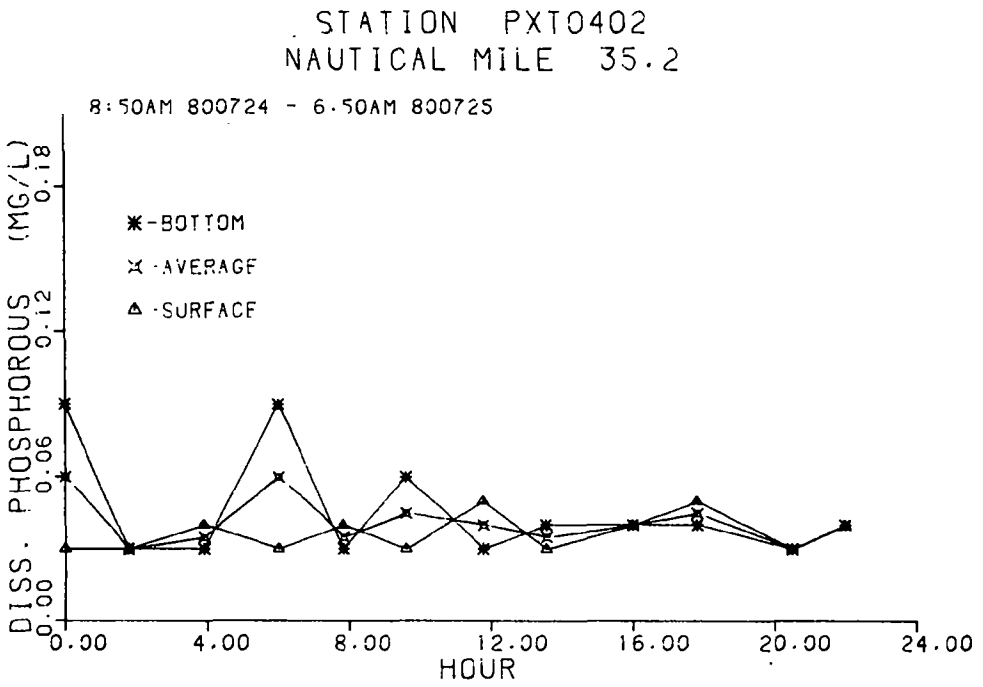


Figure 9-14 Intensive river survey plots of dissolved phosphorus.



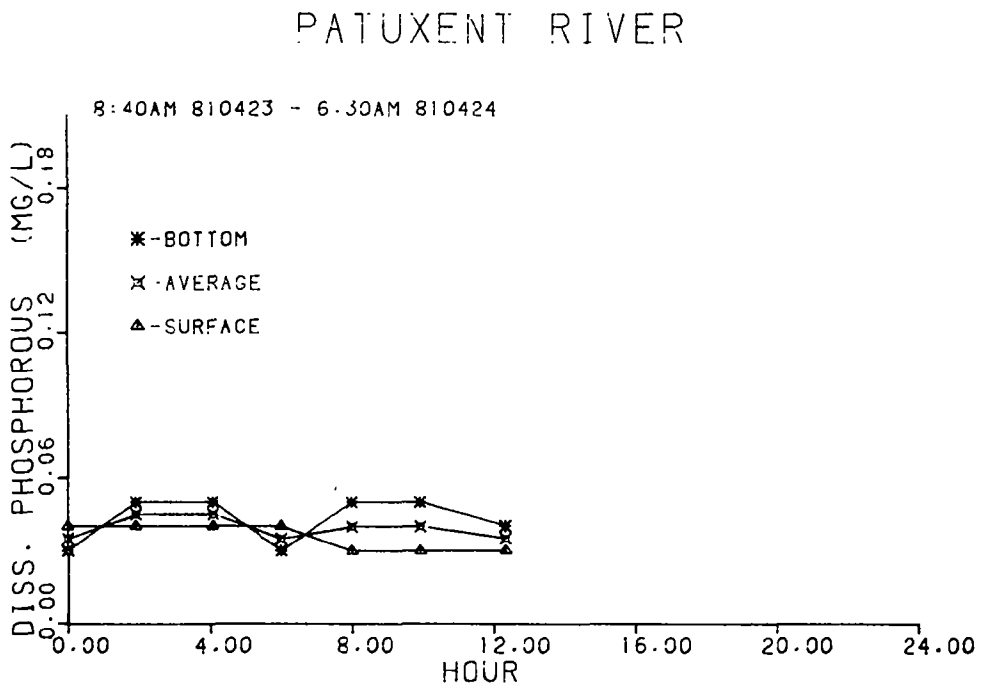
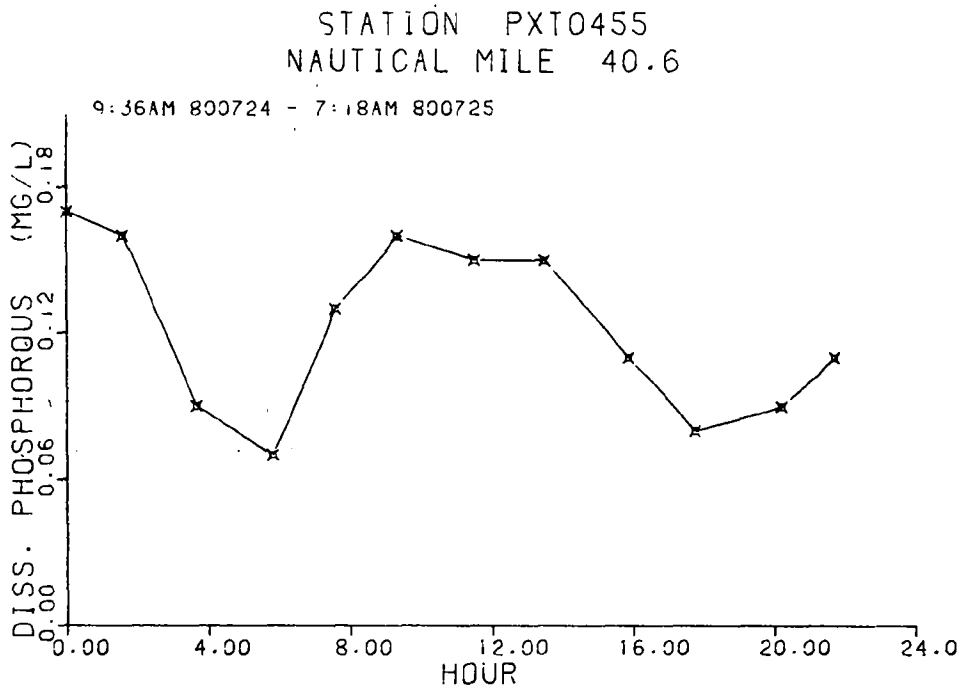


Figure 9-14Intensive river survey plots of dissolved phosphorus.



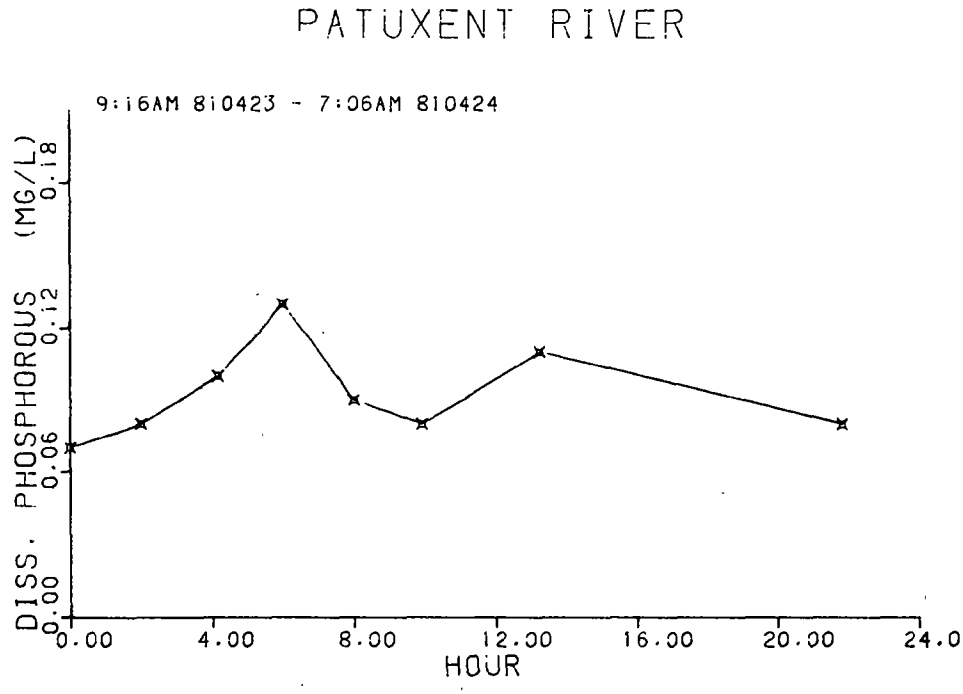
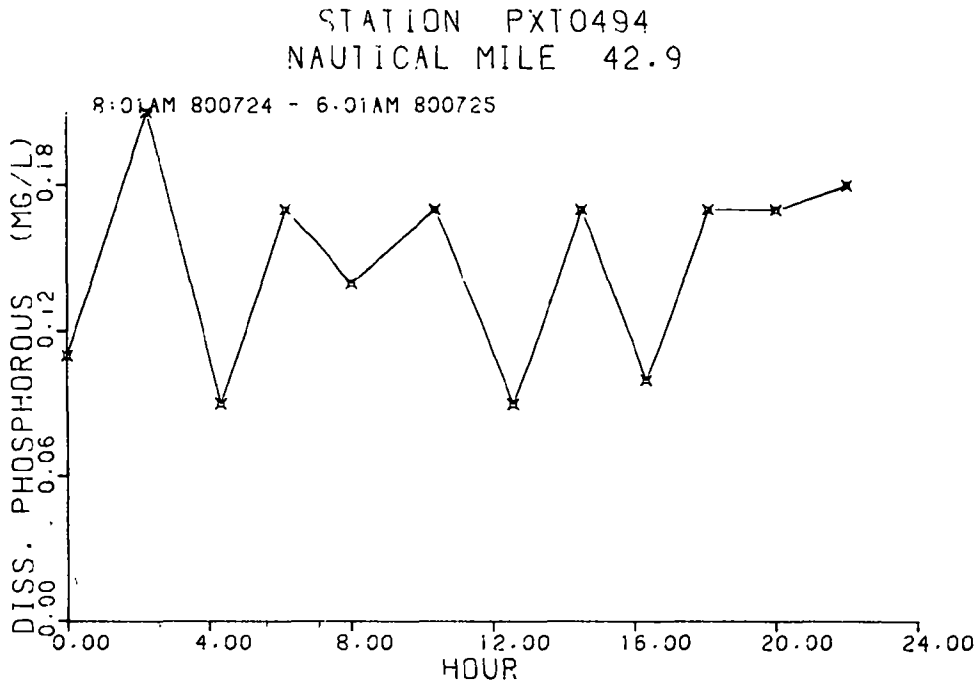


Figure 9-14 Intensive river survey plots of dissolved phosphorus.



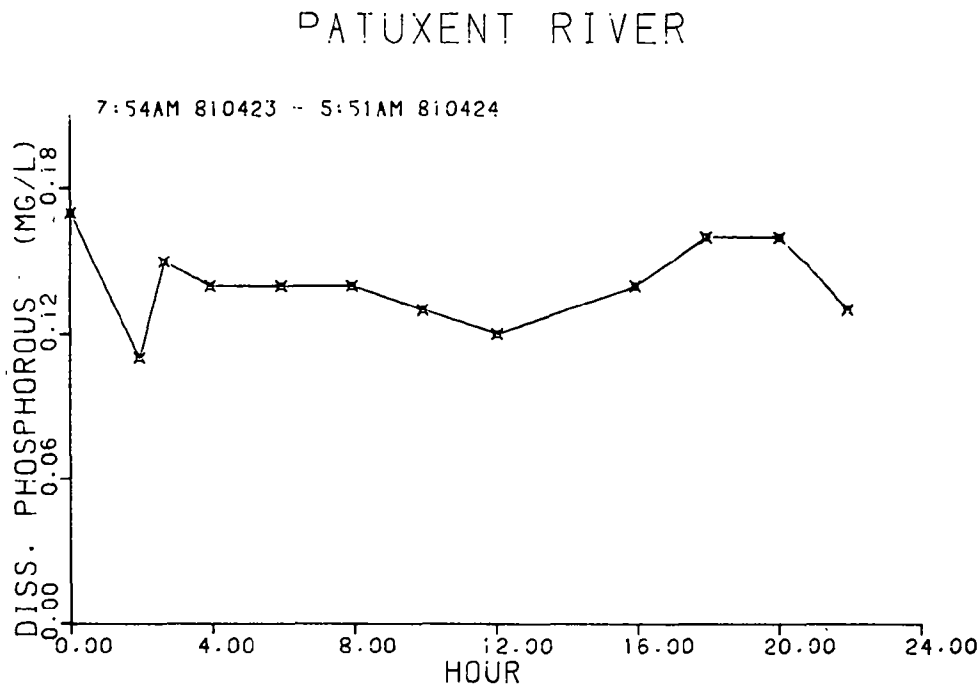
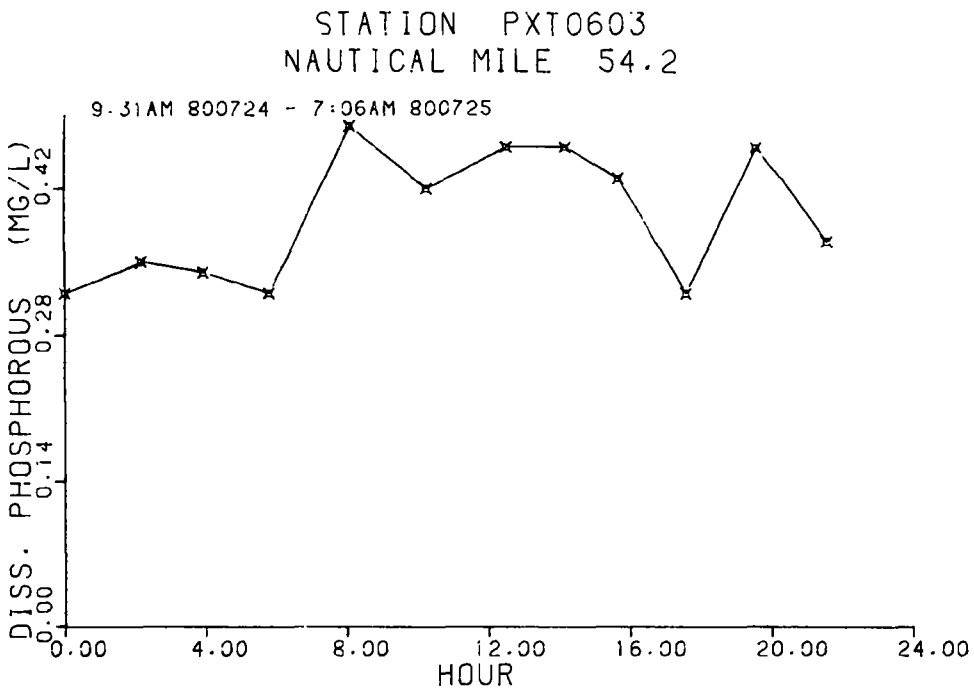


Figure 9-14Intensive river survey plots of dissolved phosphorus.



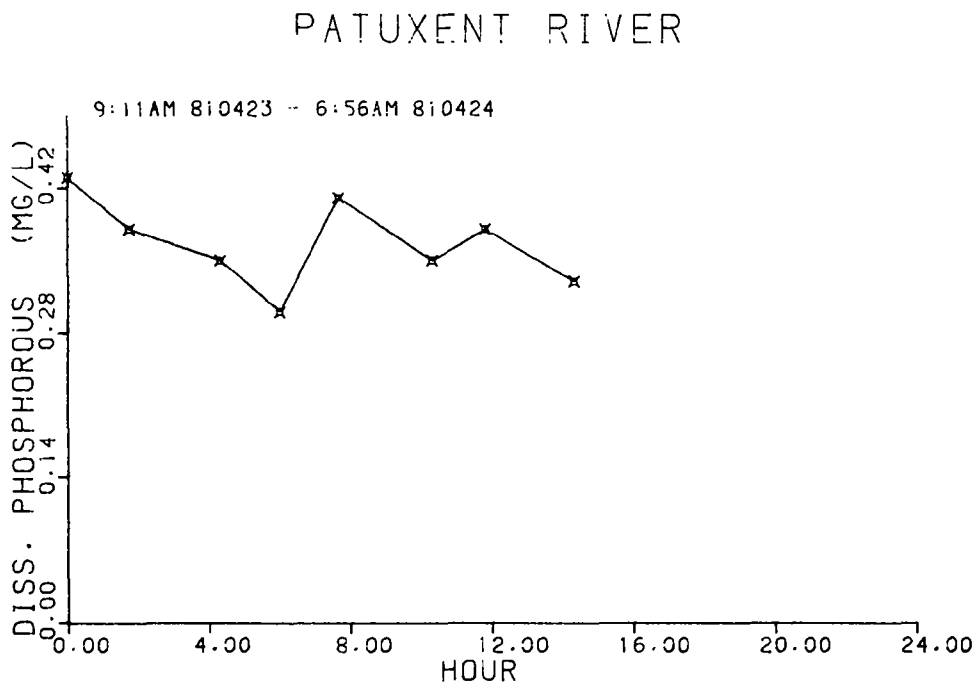
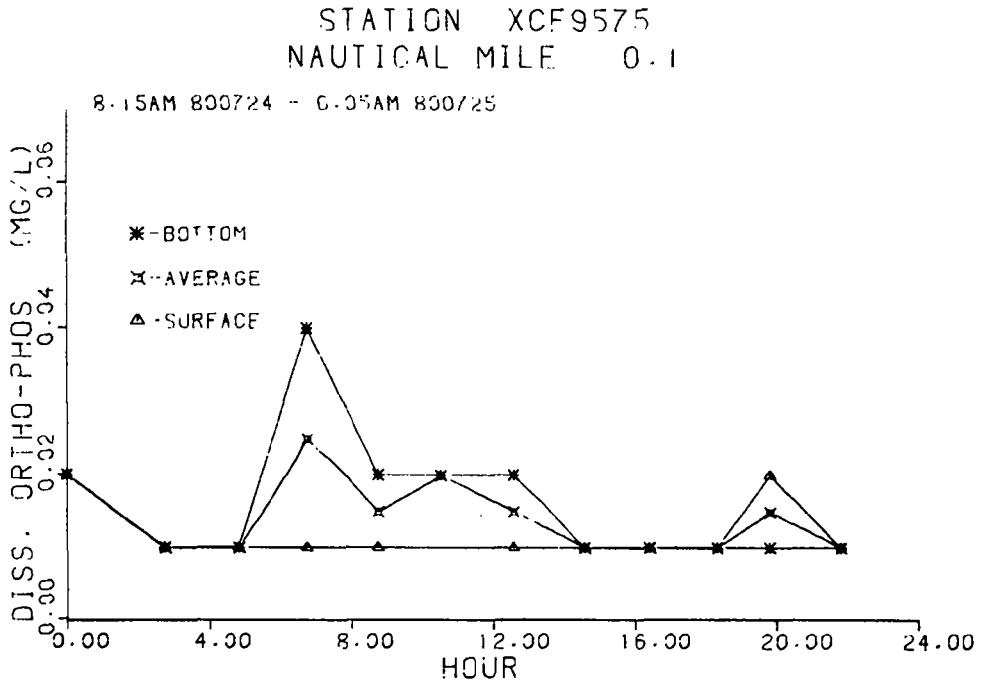


Figure 9-14Intensive river survey plots of dissolved phosphorus.



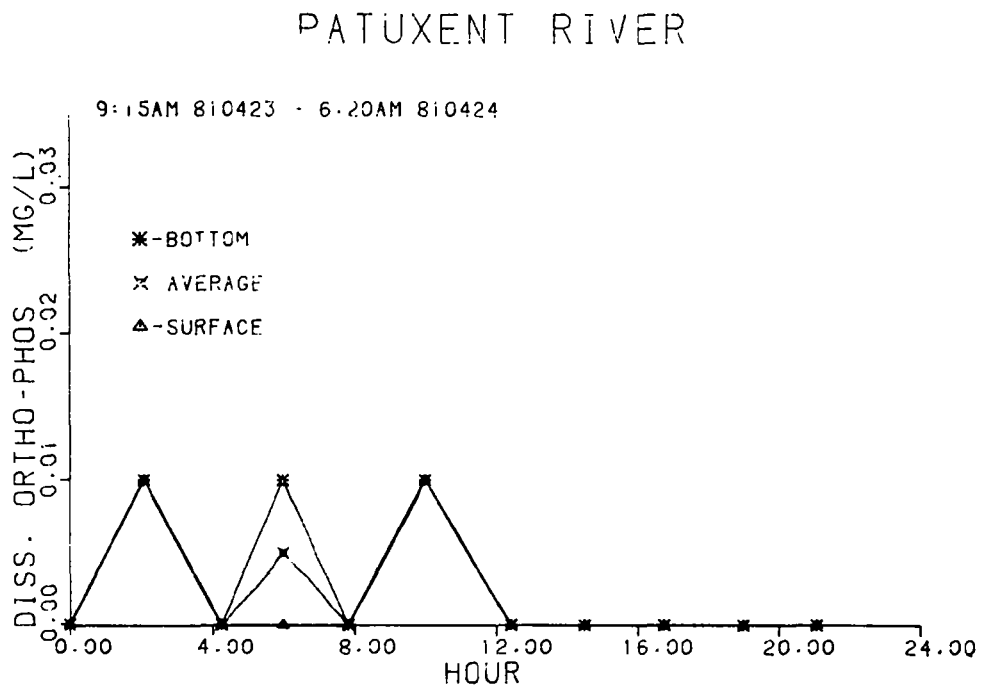
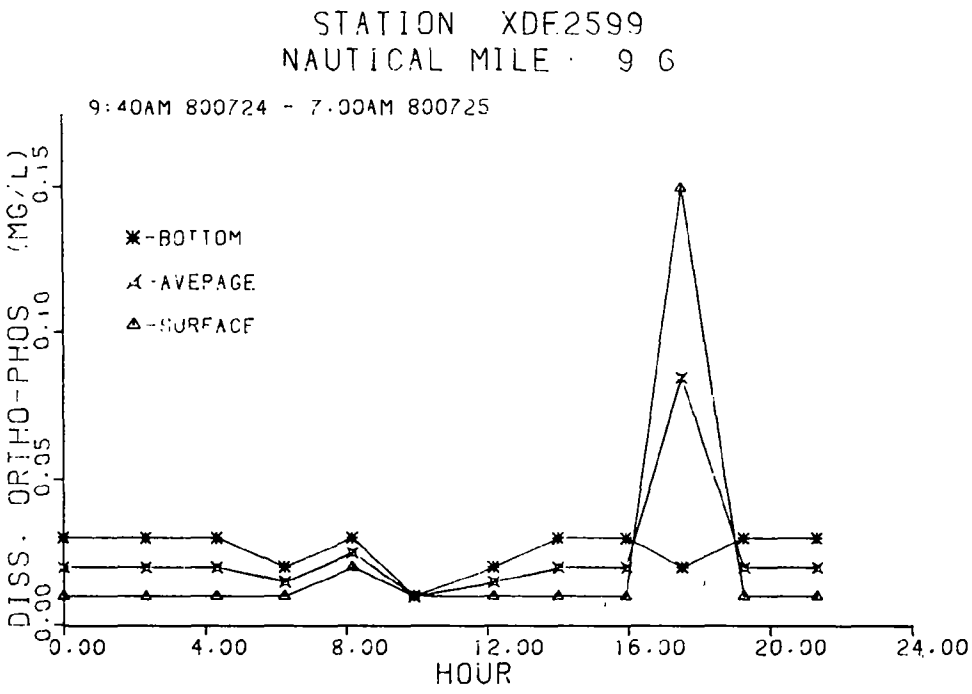


Figure 9-15 Intensive river survey plots of dissolved ortho-phosphorus.



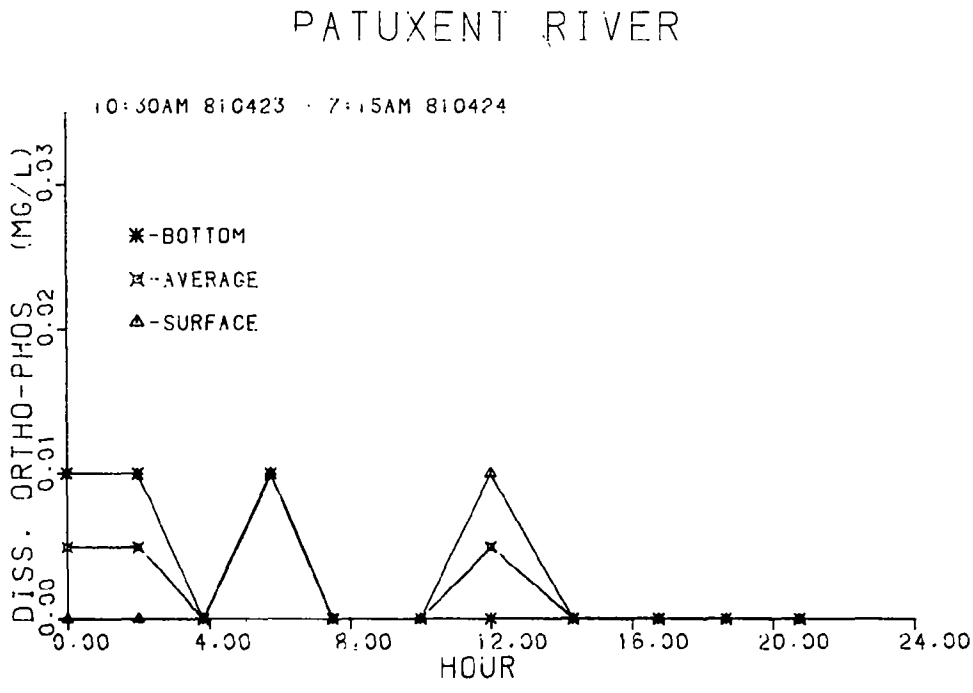
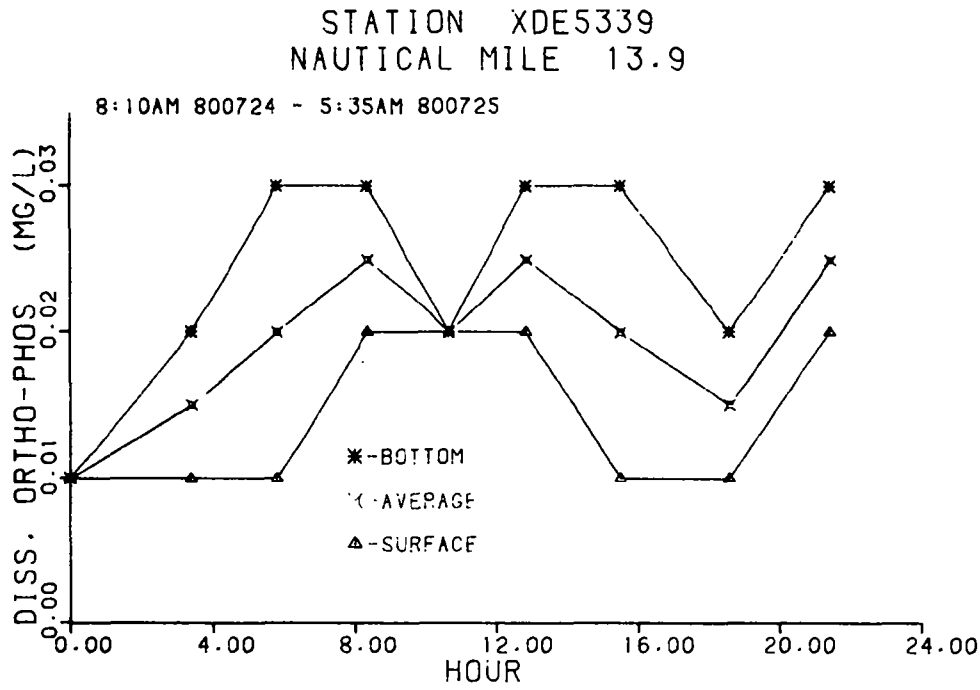


Figure 9-15 Intensive river survey plots of dissolved ortho-phosphorus.



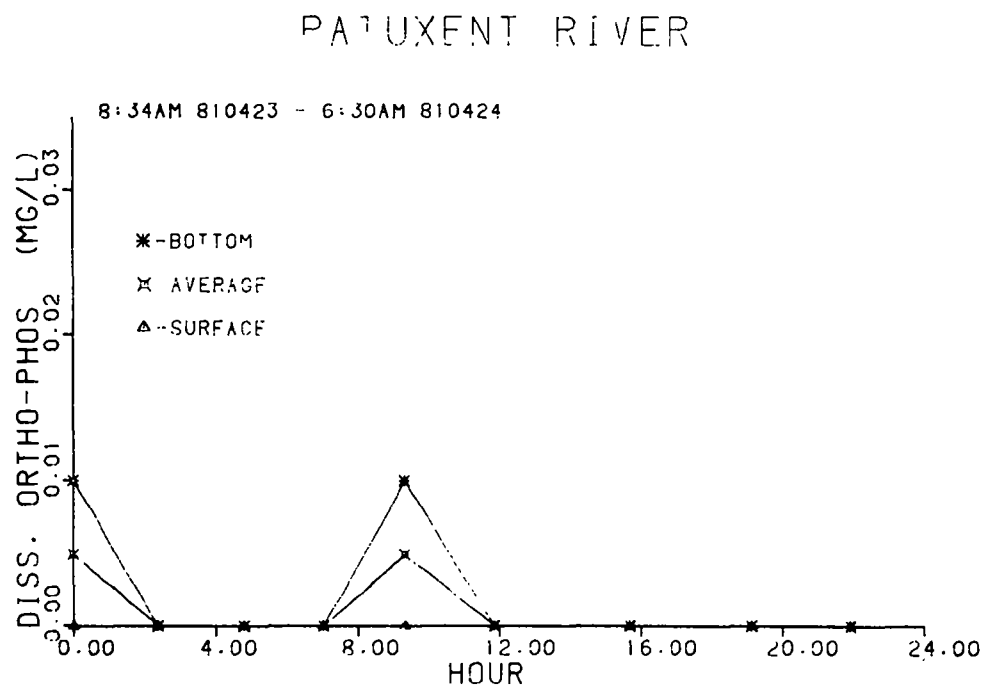
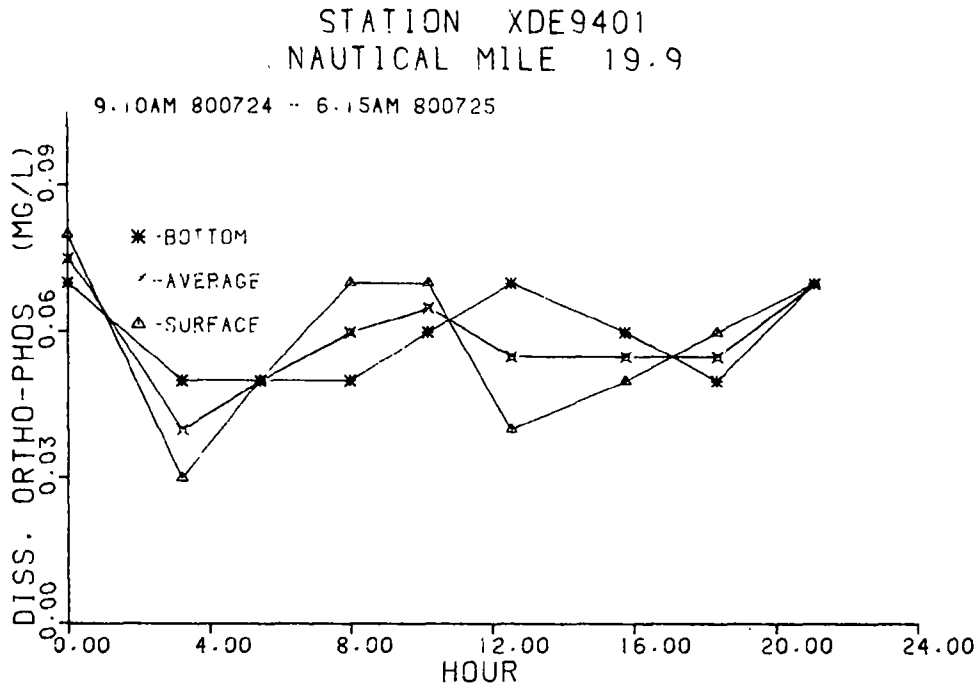


Figure 9-15Intensive river survey plots of dissolved ortho-phosphorus.



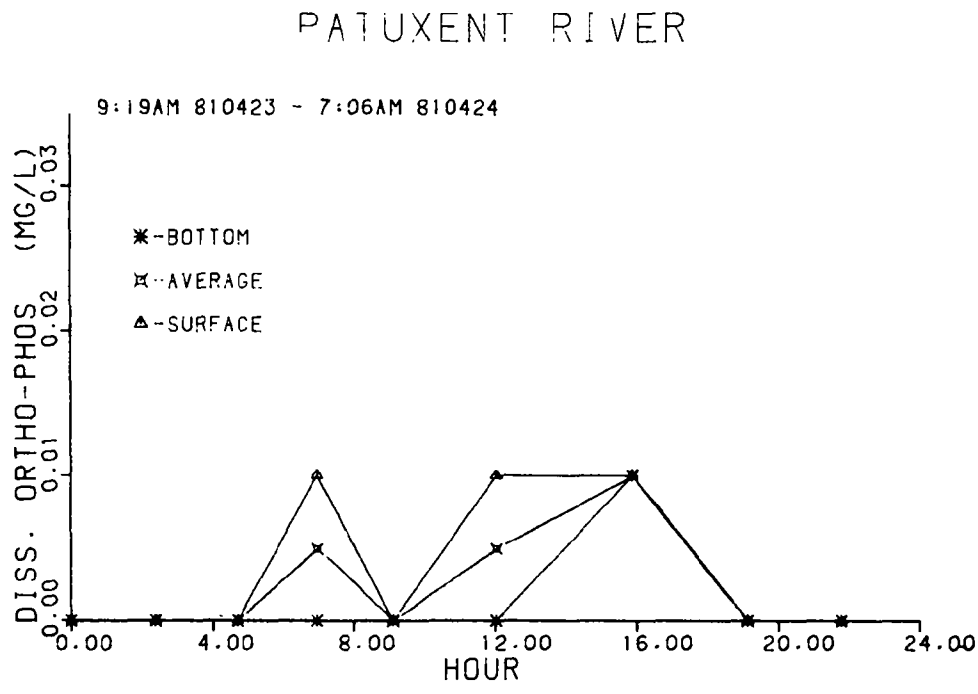
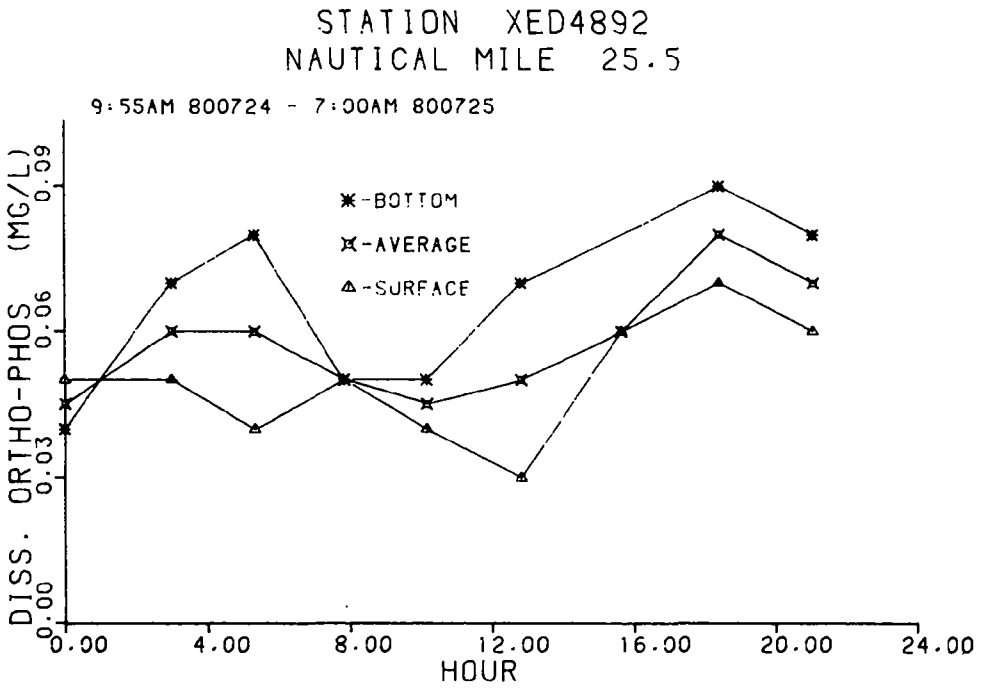


Figure 9-15 Intensive river survey plots of dissolved ortho-phosphorus.



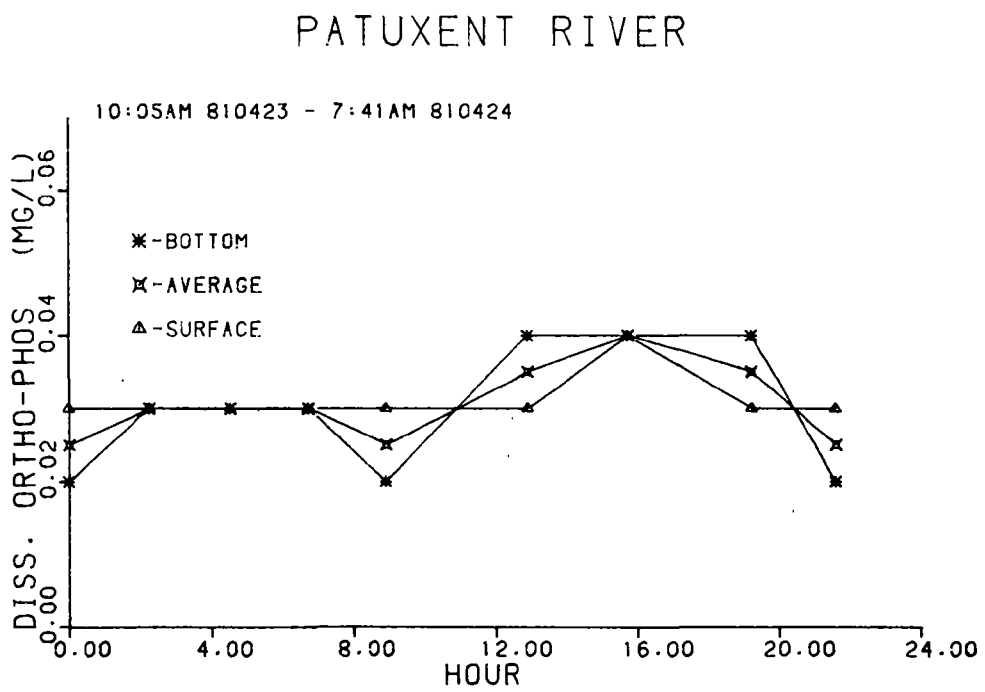
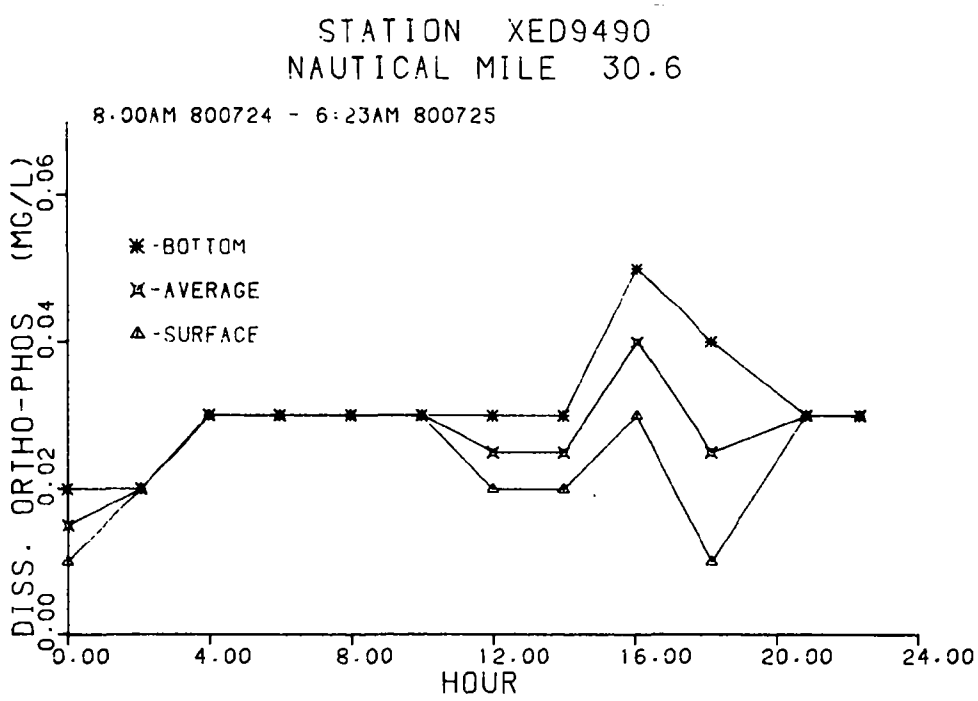


Figure 9-15 Intensive river survey plots of dissolved ortho-phosphorus.



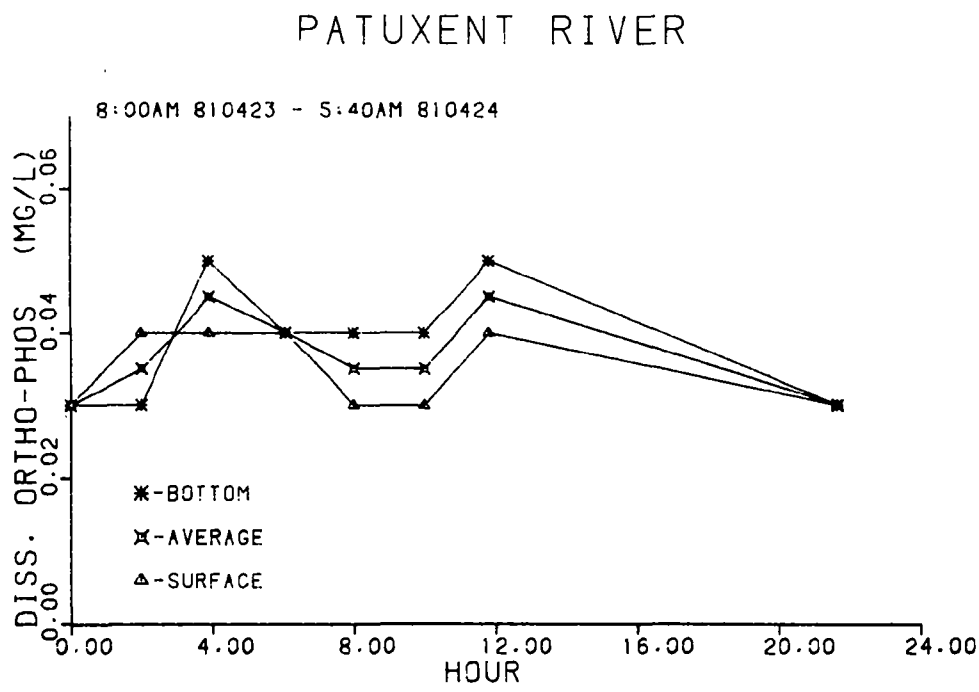
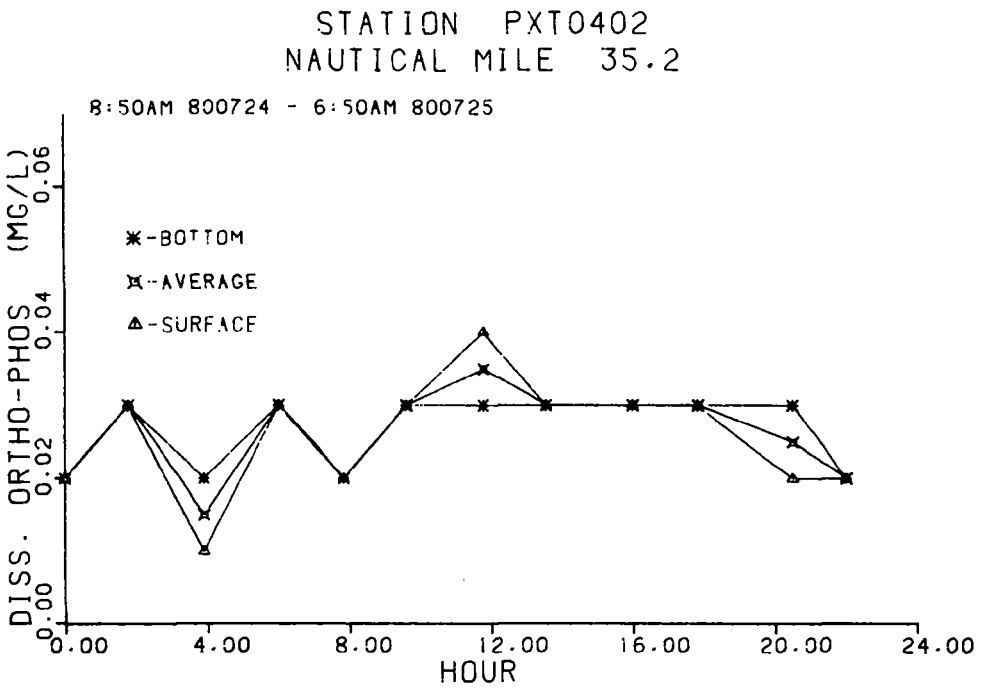


Figure 9-15Intensive river survey plots of dissolved ortho-phosphorus.



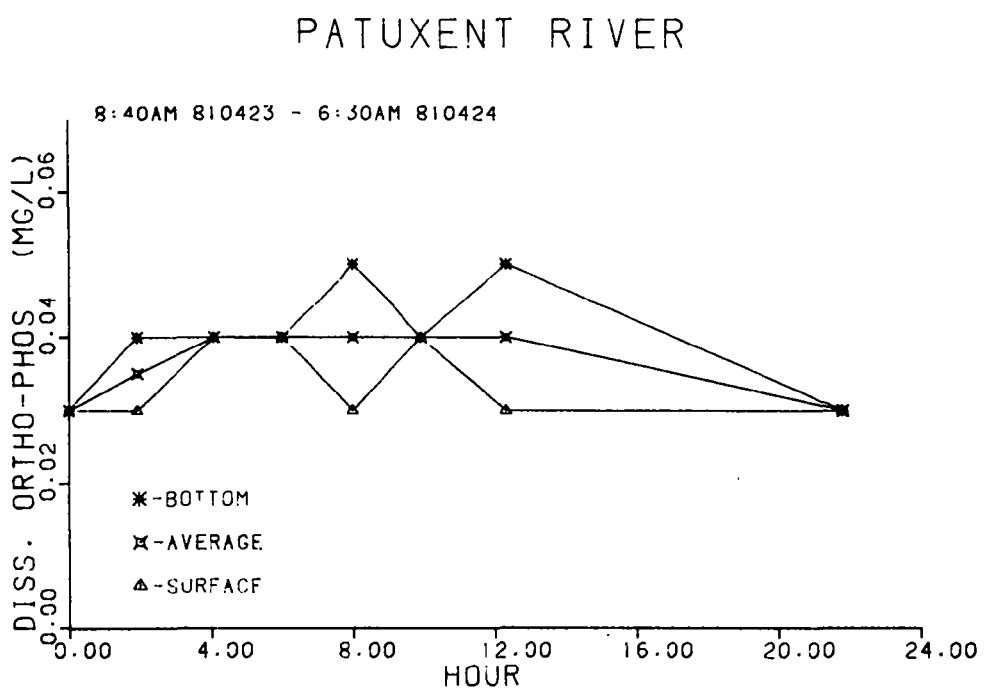
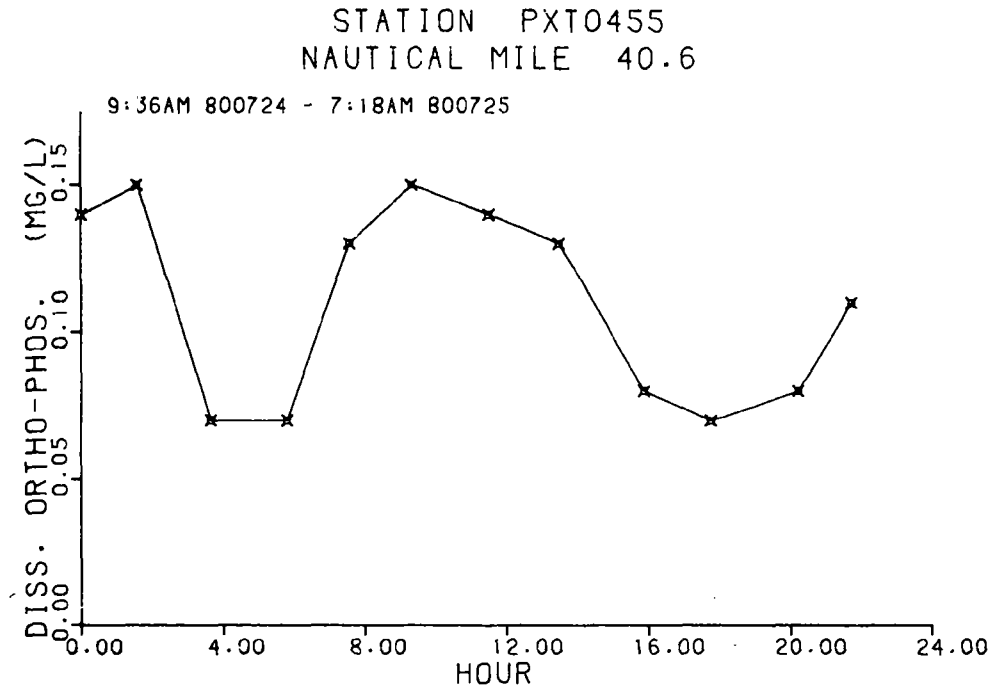


Figure 9-15Intensive river survey plots of dissolved ortho-phosphorus.



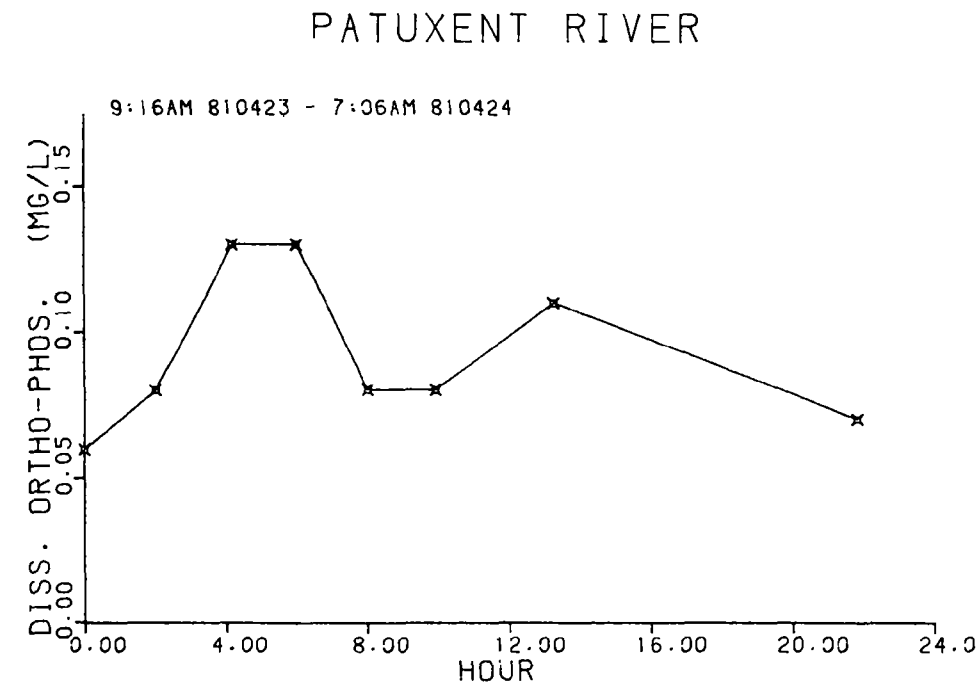
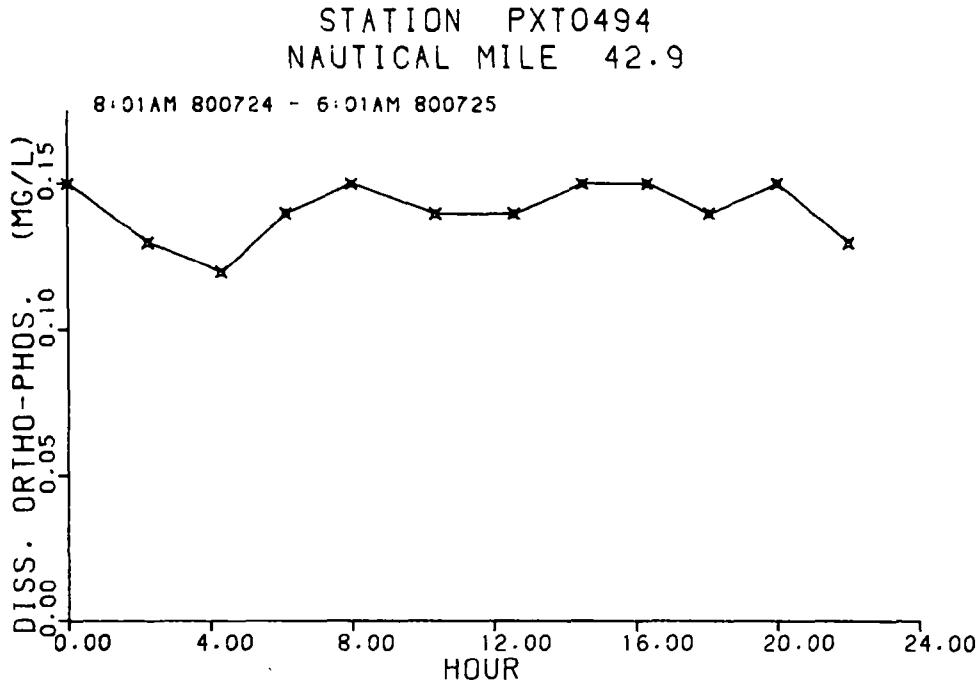


Figure 9-15 Intensive river survey plots of dissolved ortho-phosphorus.



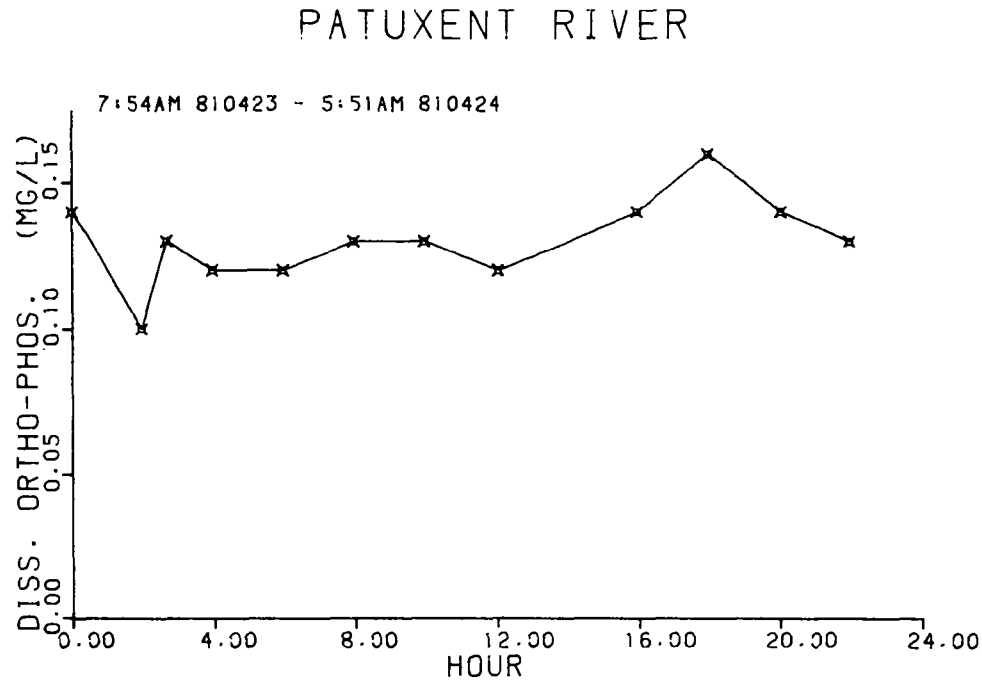
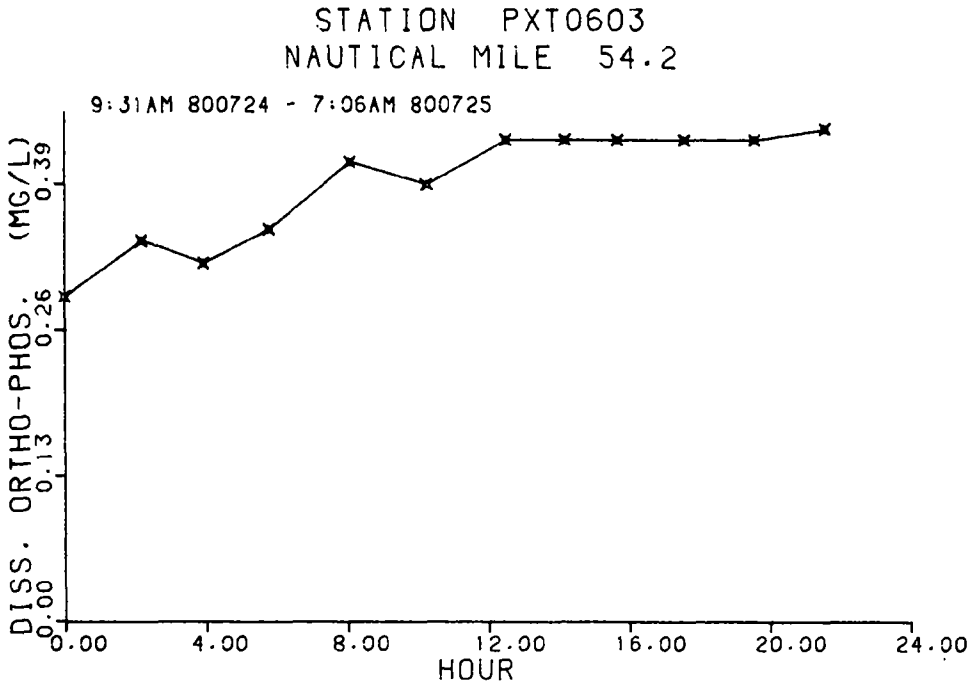


Figure 9-15 Intensive river survey plots of dissolved ortho-phosphorus.



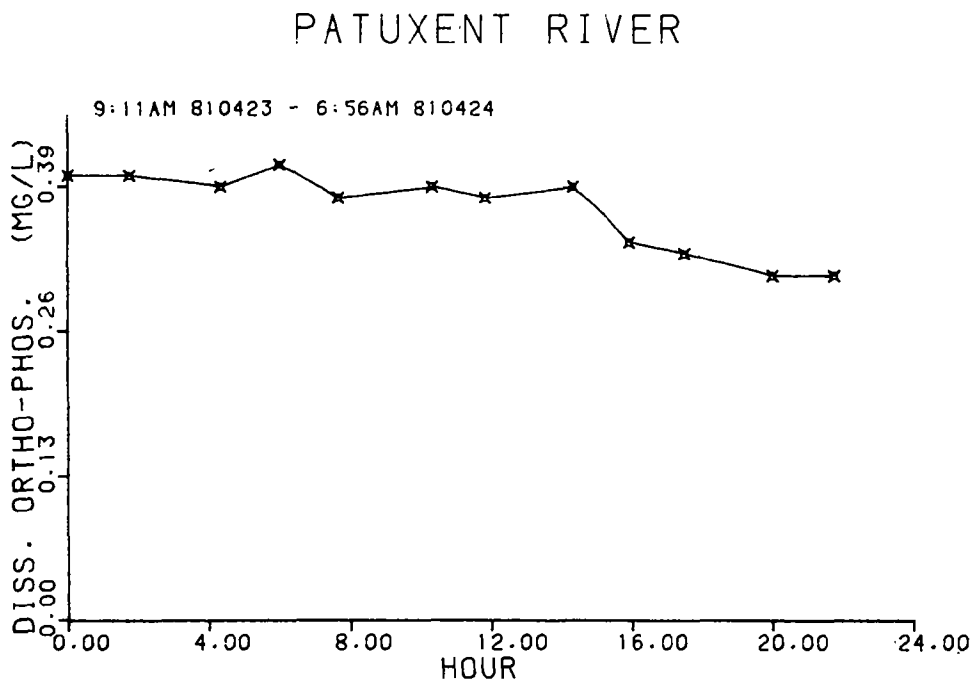
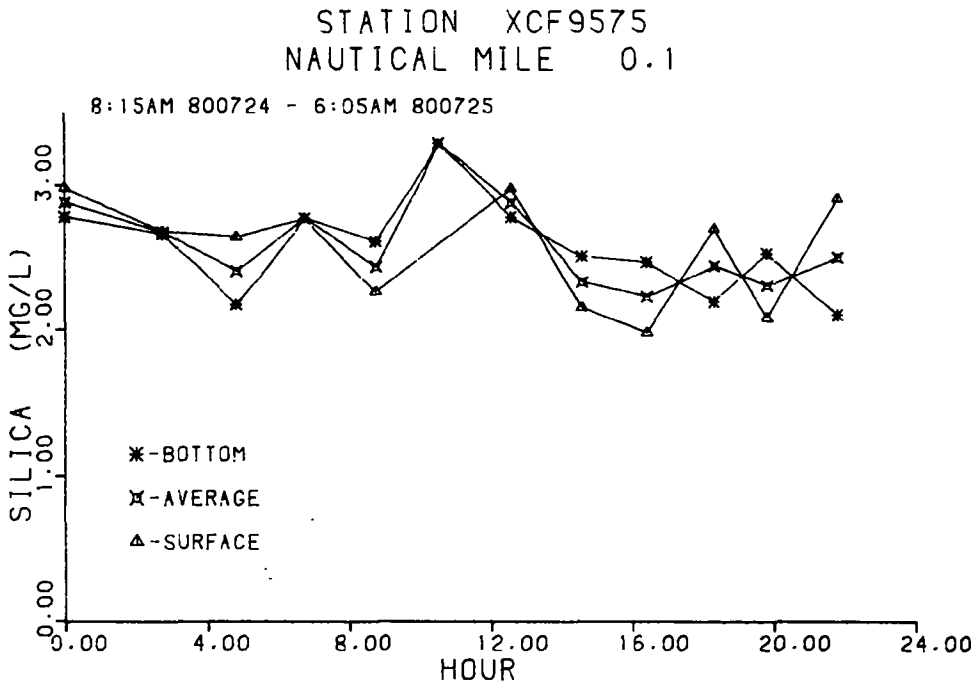


Figure 9-15 Intensive river survey plots of dissolved ortho-phosphorus.



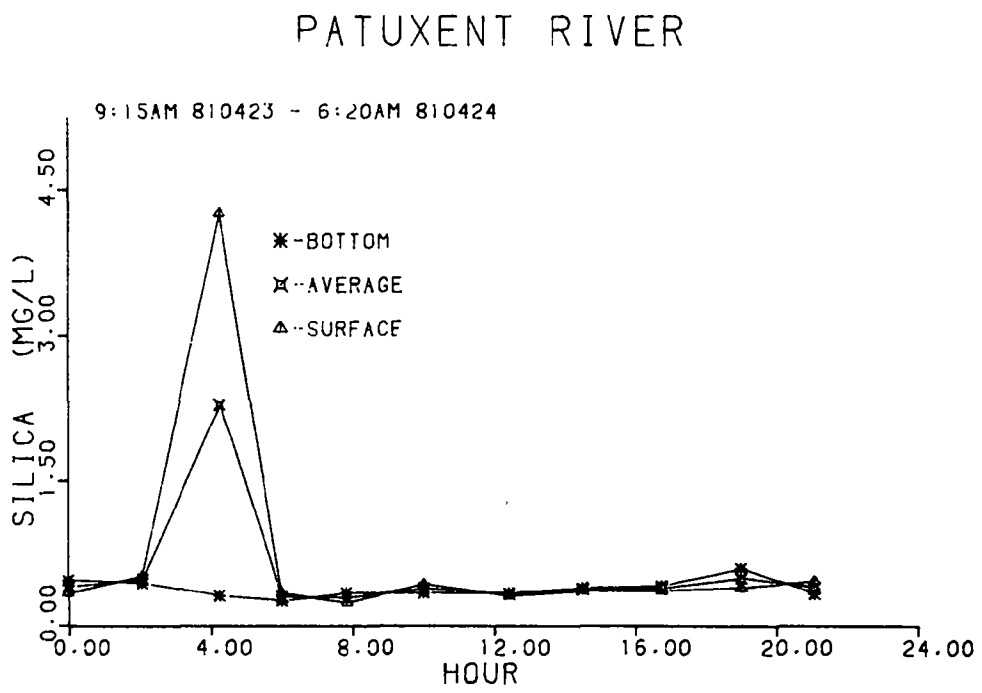
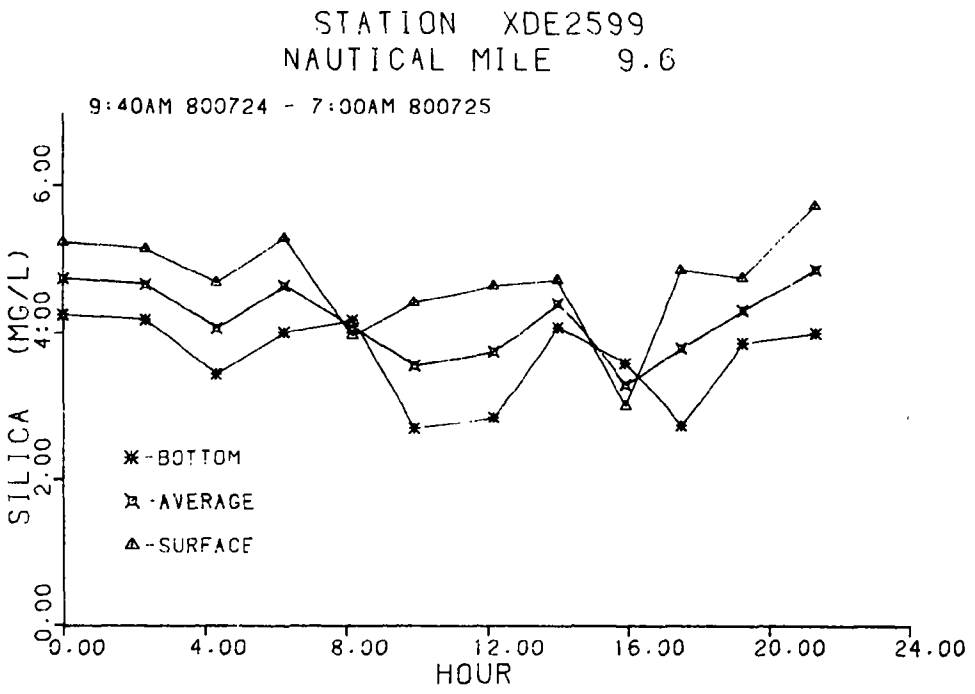


Figure 9-16 Intensive river survey plots of silica.



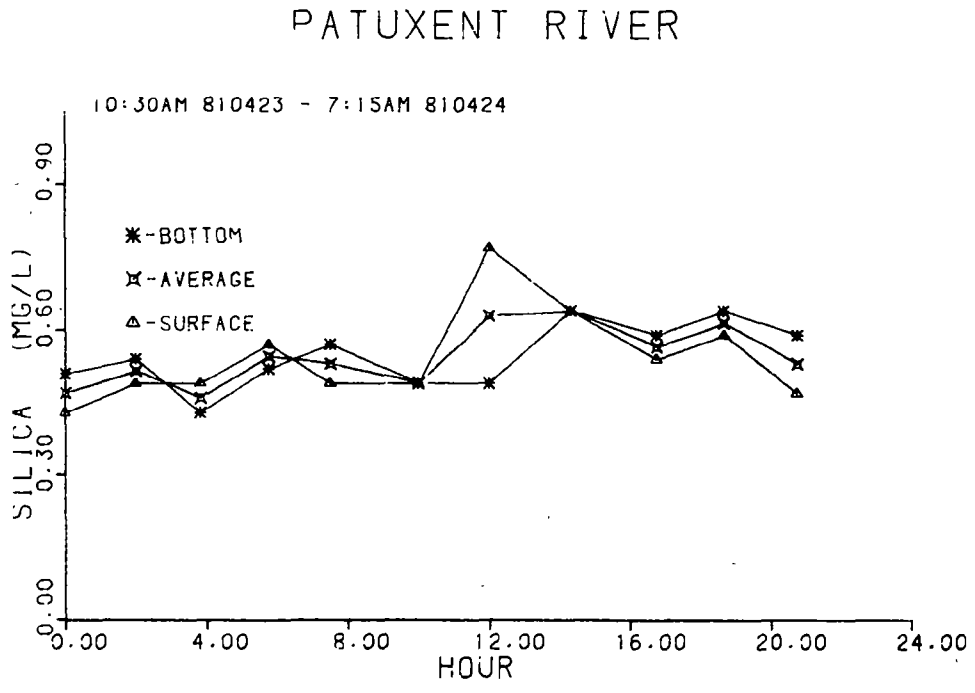
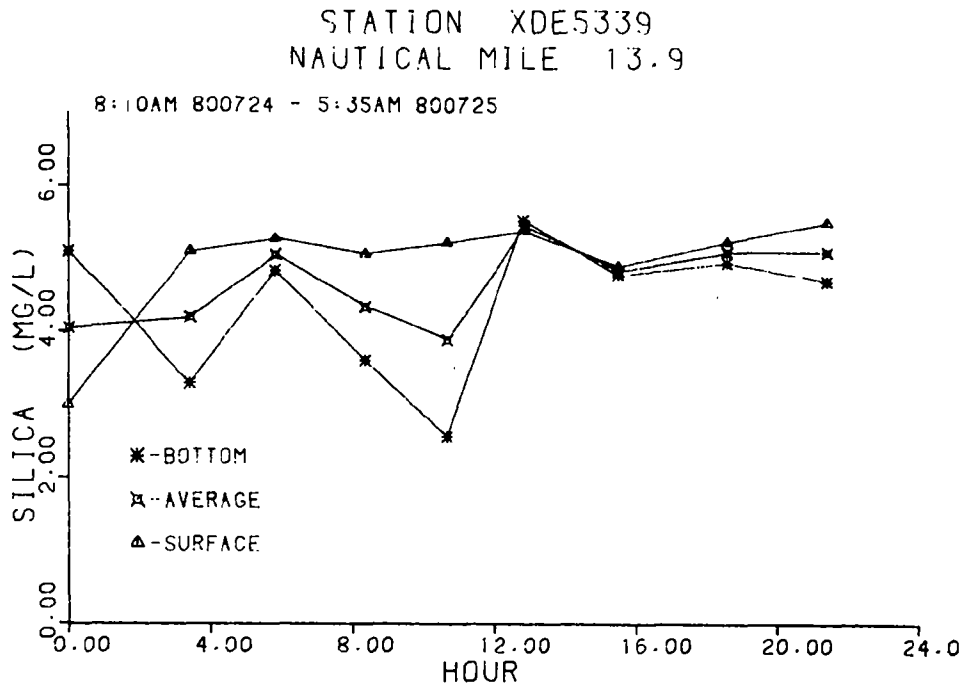


Figure 9-16 Intensive river survey plots of silica.



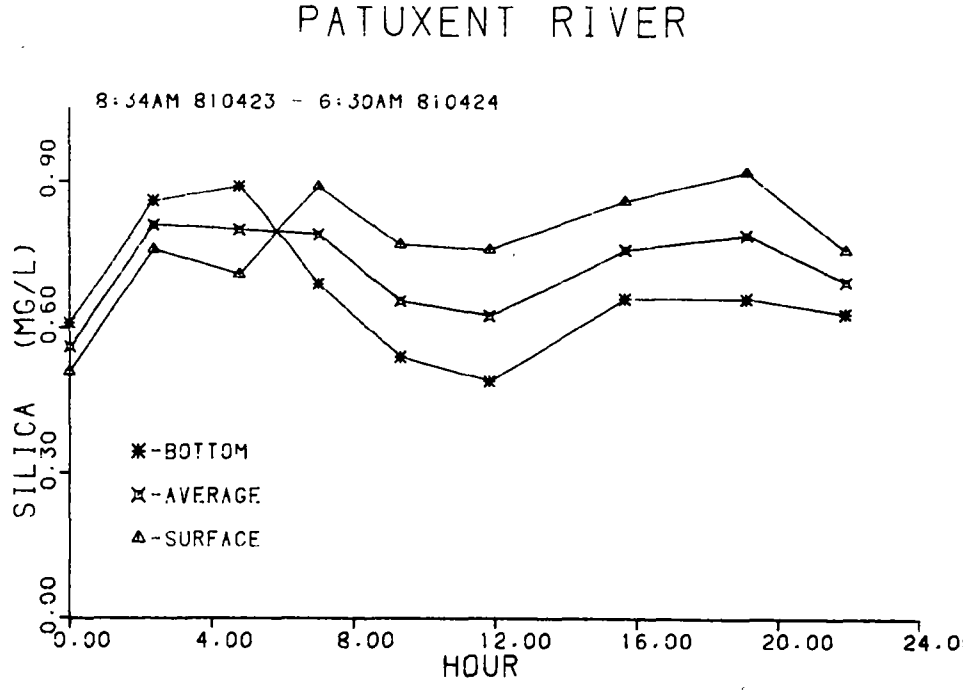
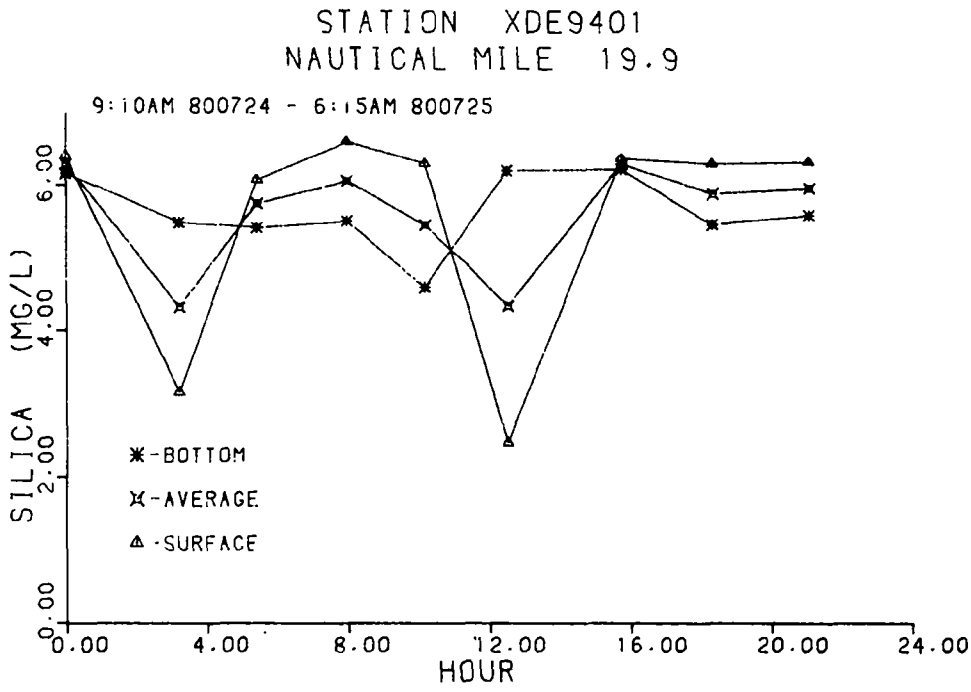


Figure 9-16 Intensive river survey plots of silica.



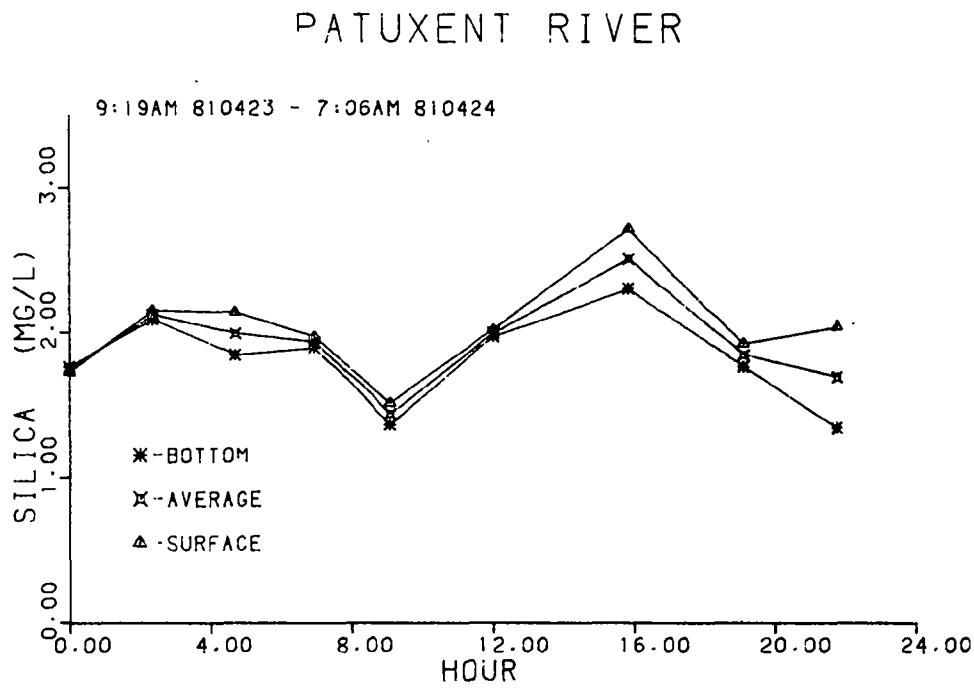
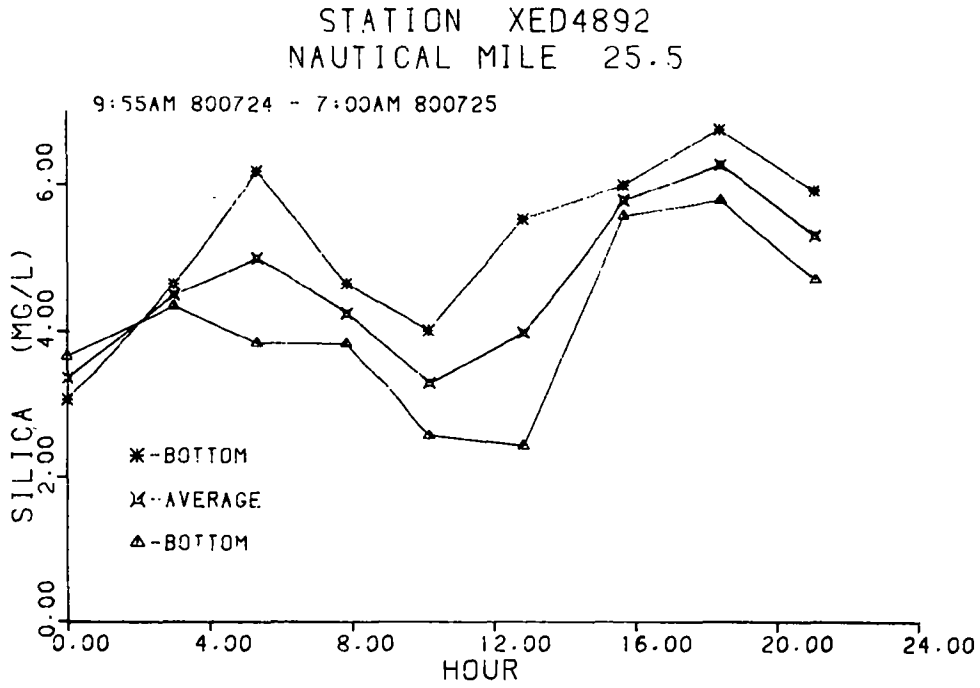


Figure 9-16 Intensive river survey plots of silica.



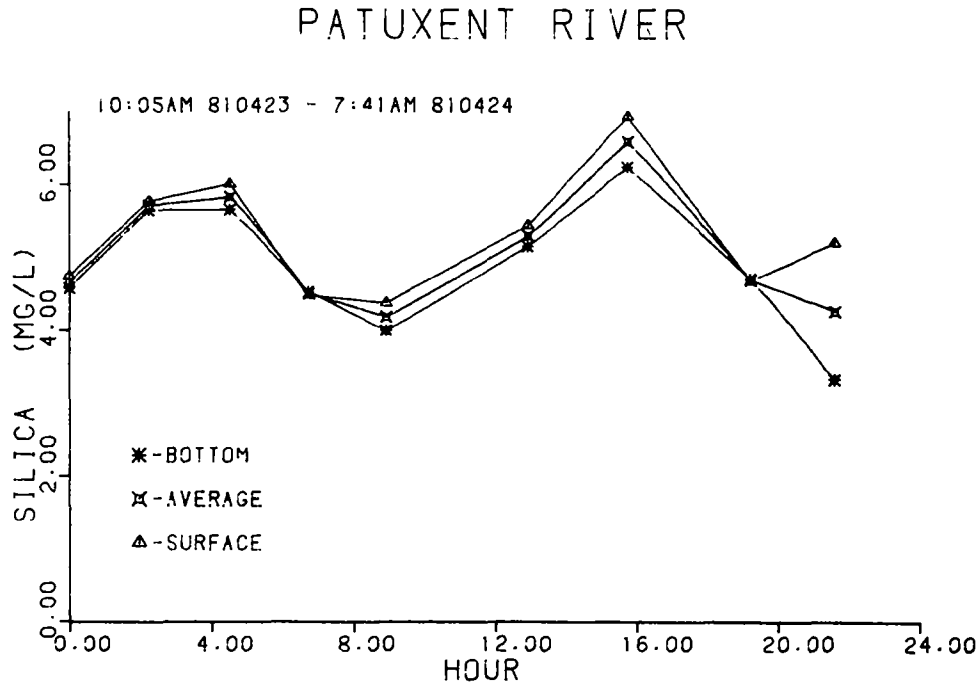
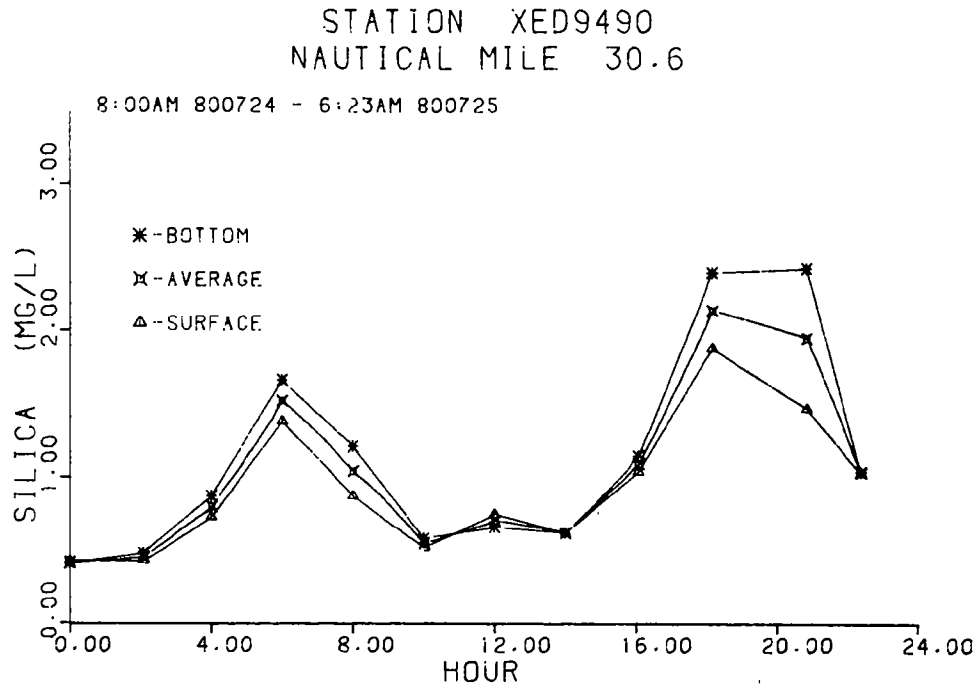


Figure 9-16 Intensive river survey plots of silica.



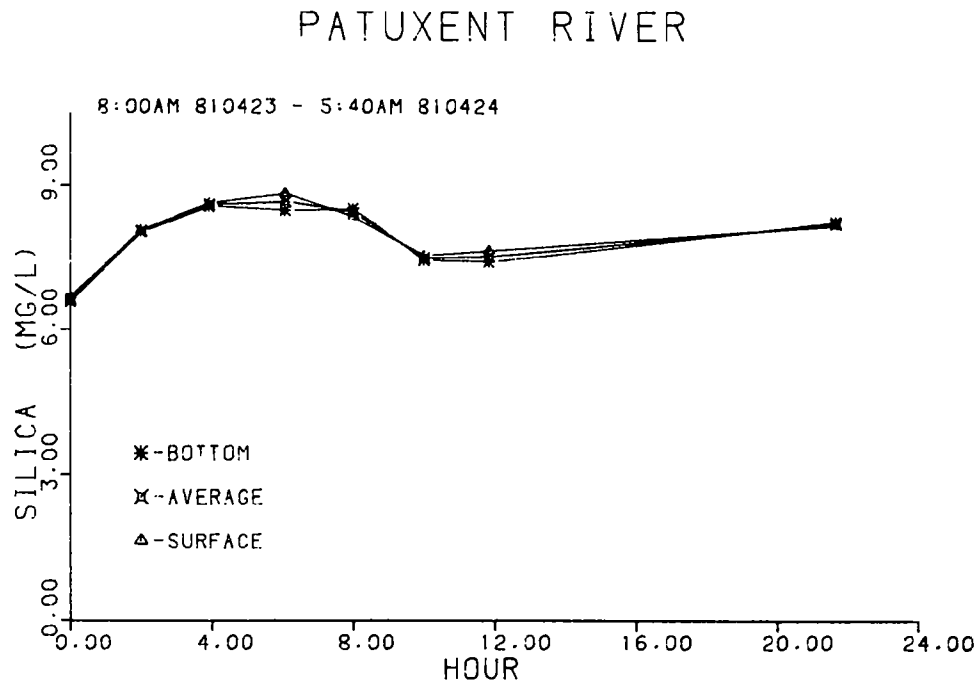
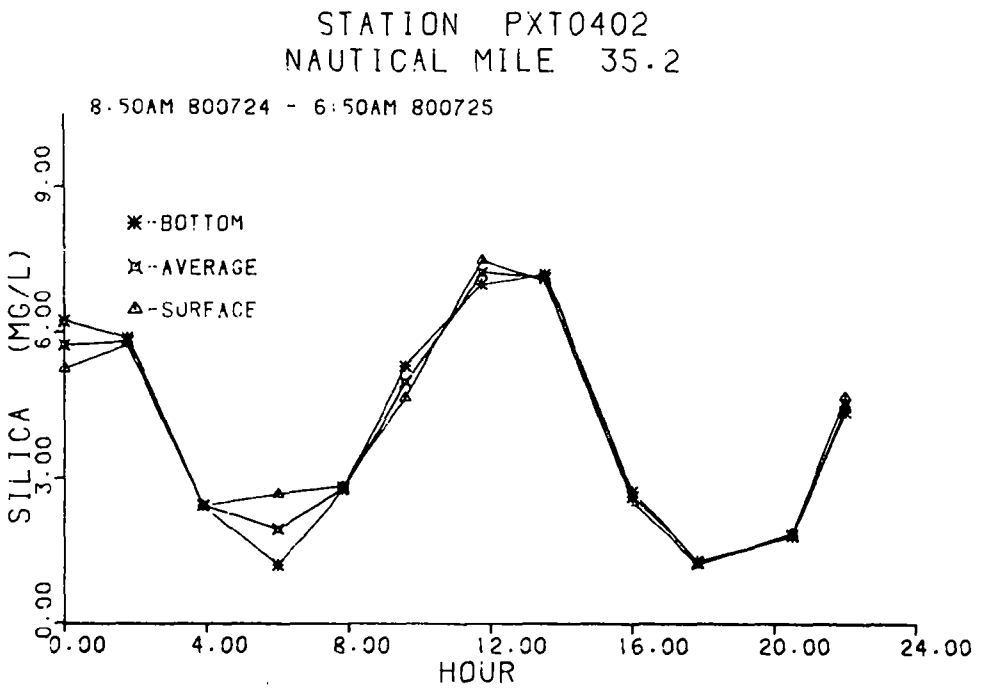


Figure 9-16 Intensive river survey plots of silica.



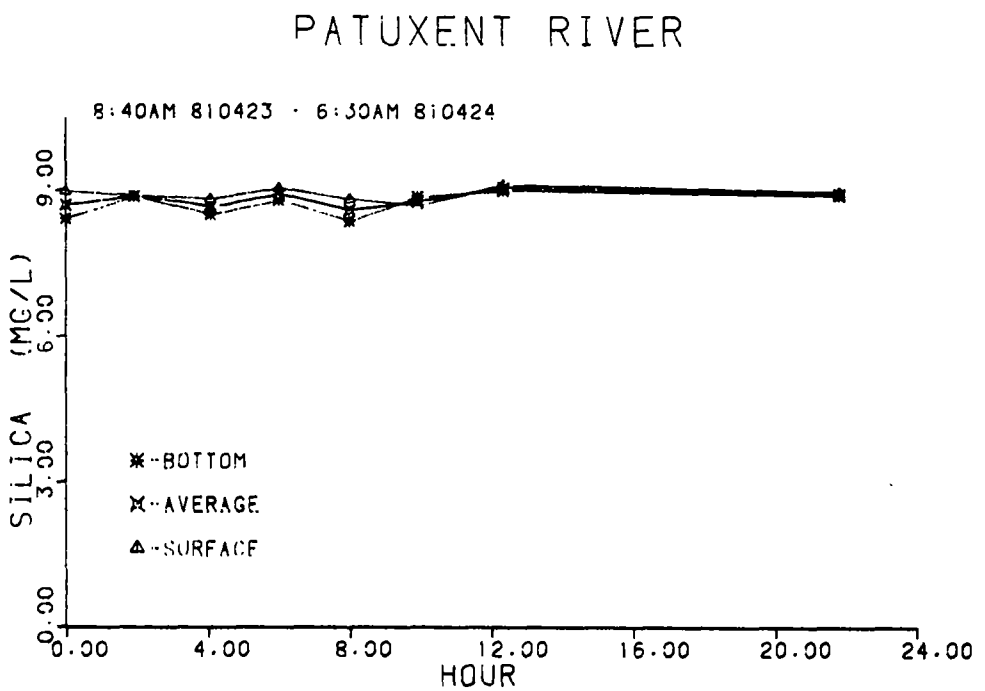
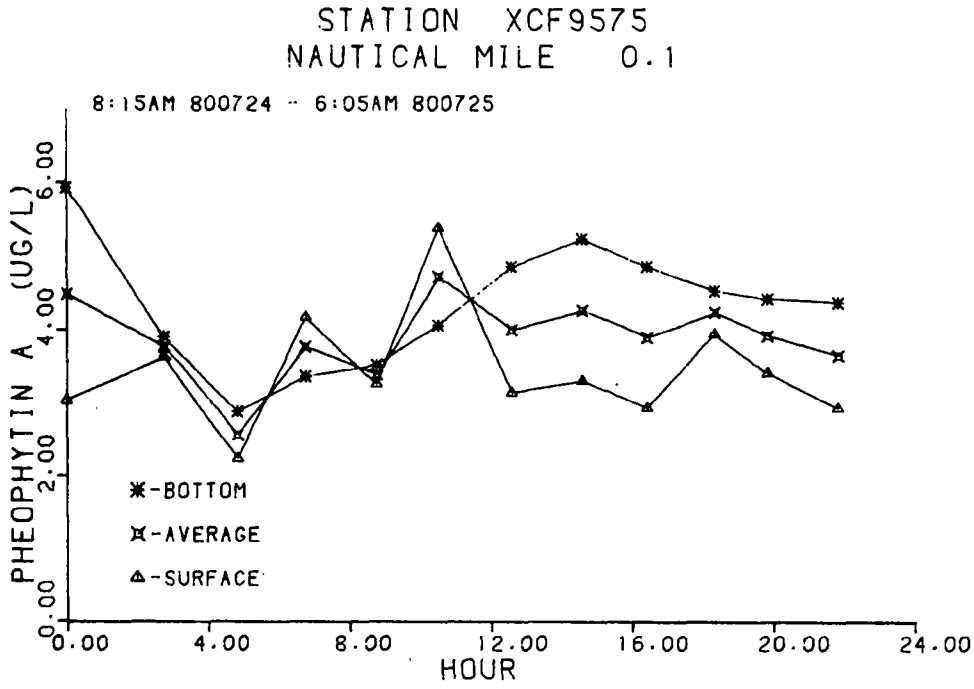


Figure 9-16 Intensive river survey plots of silica.



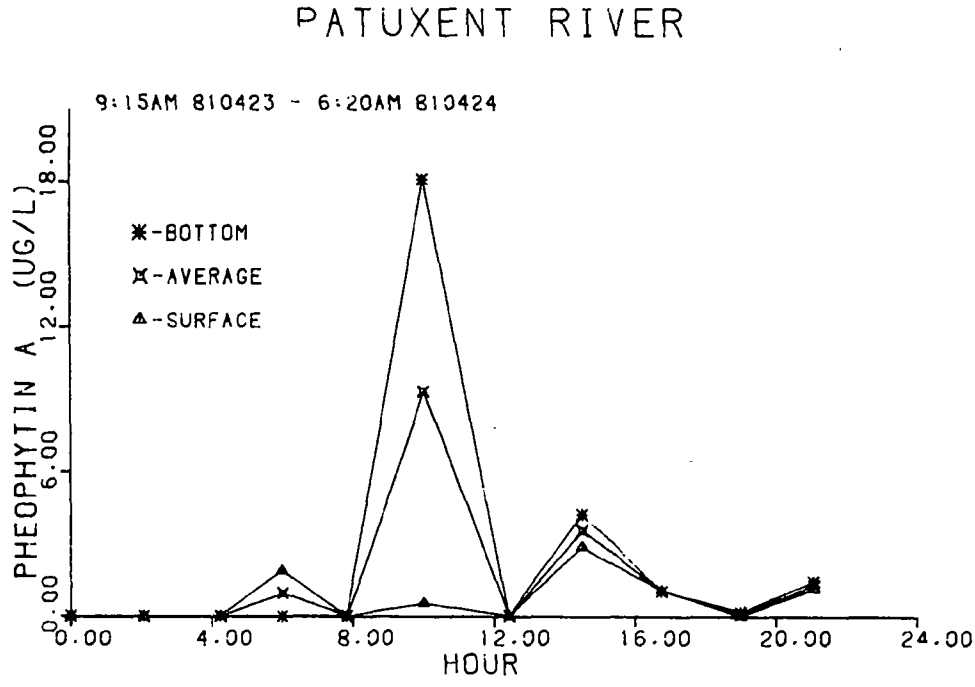
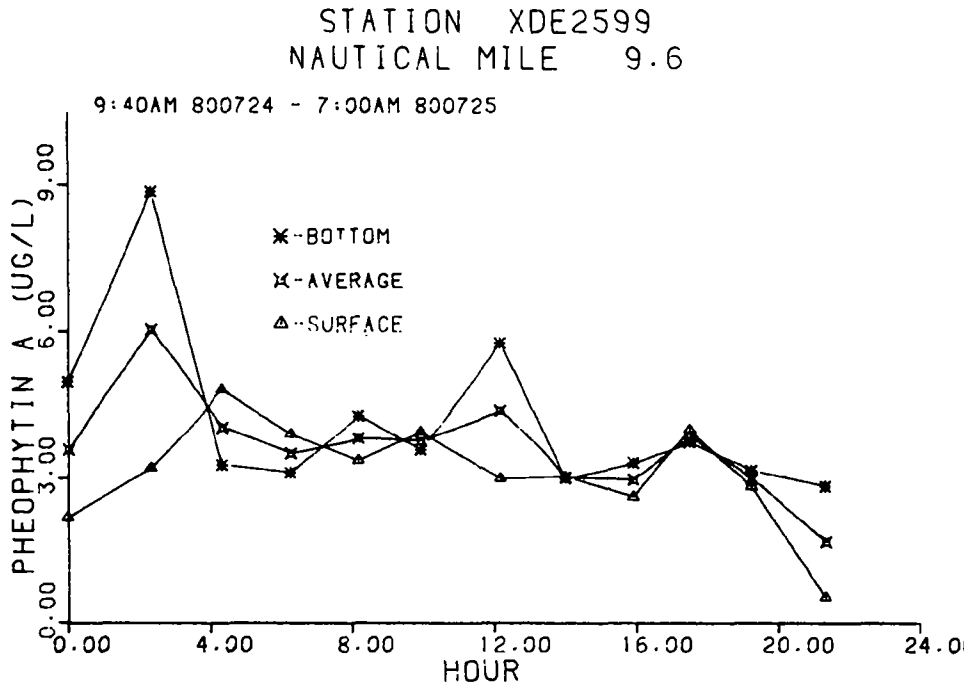


Figure 9-17Intensive survey plots of pheophytin-a.



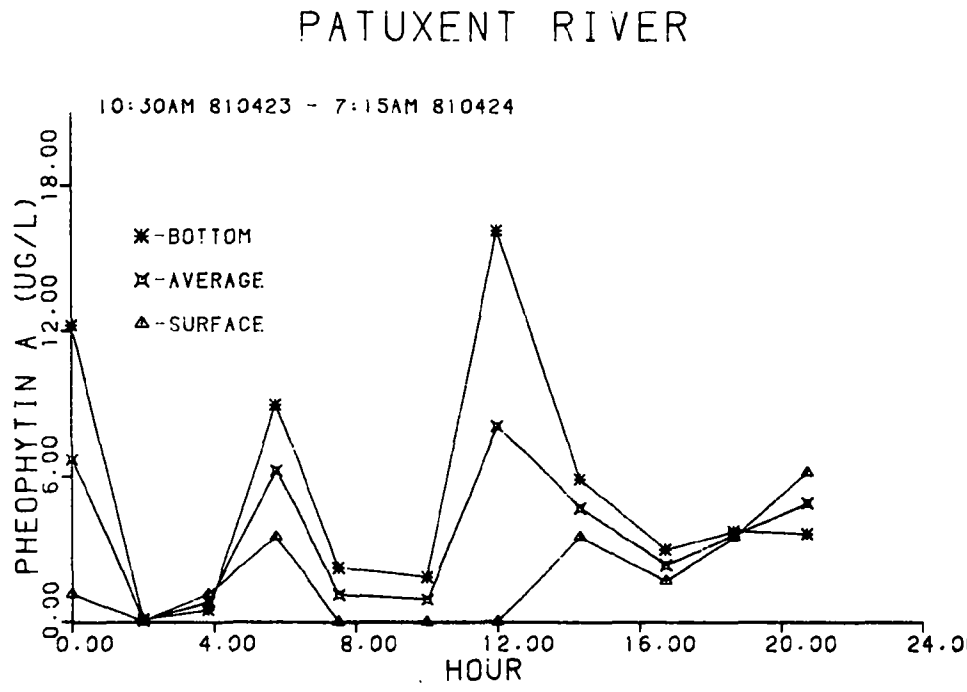
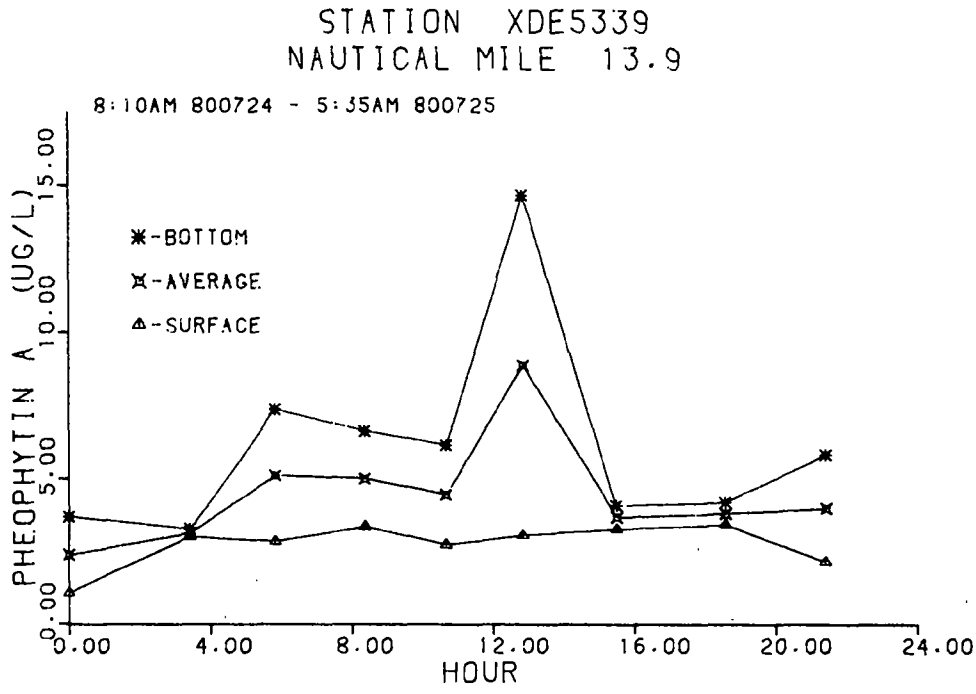


Figure 9-17 Intensive survey plots of pheophytin-a.



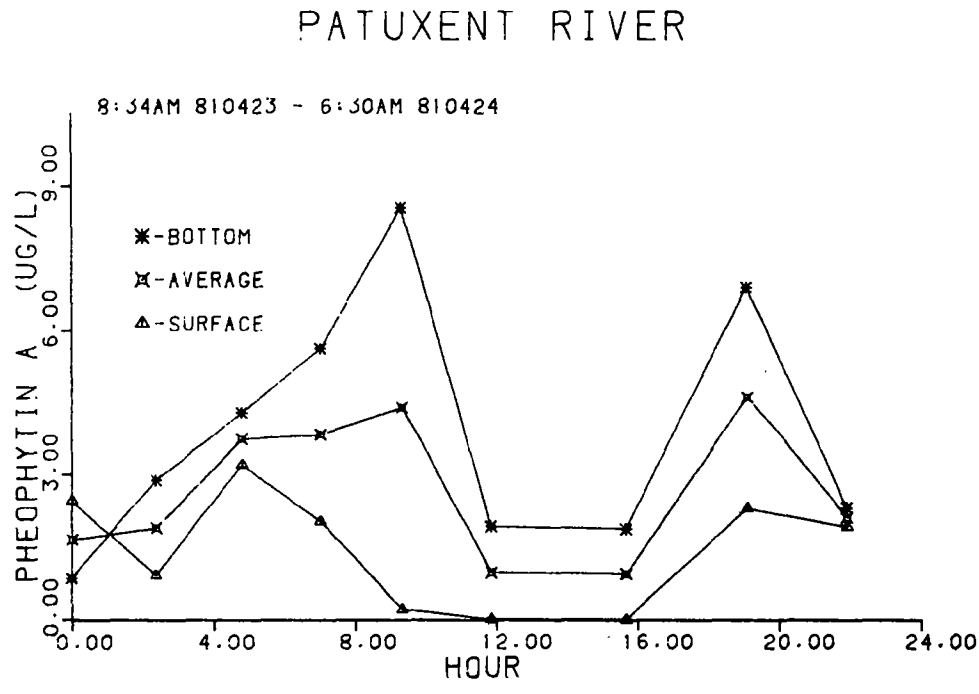
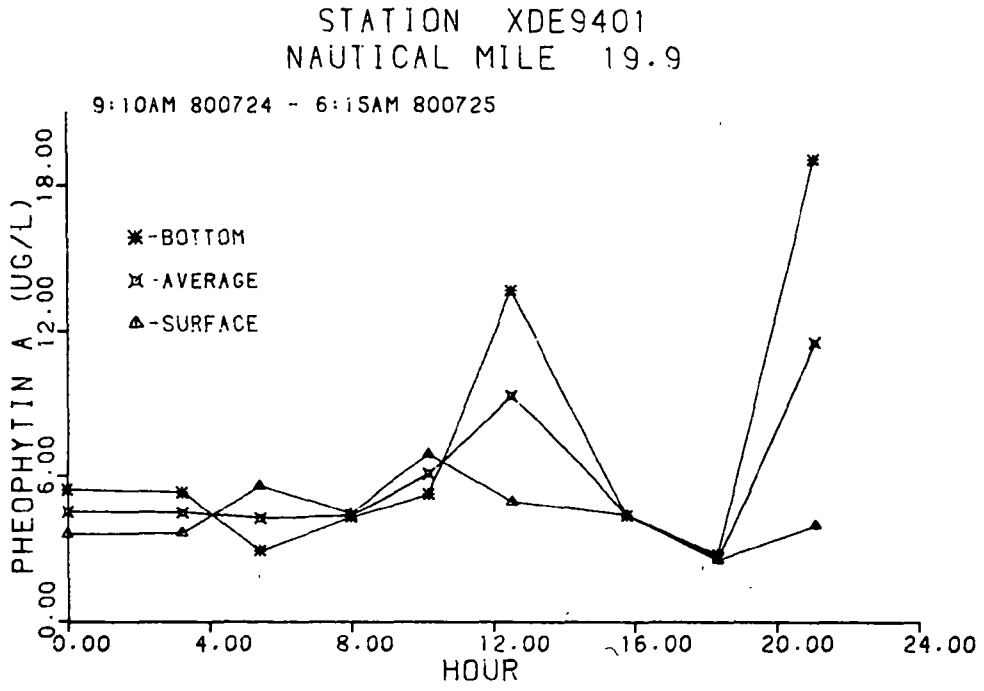


Figure 9-17 Intensive survey plots of pheophytin-a.



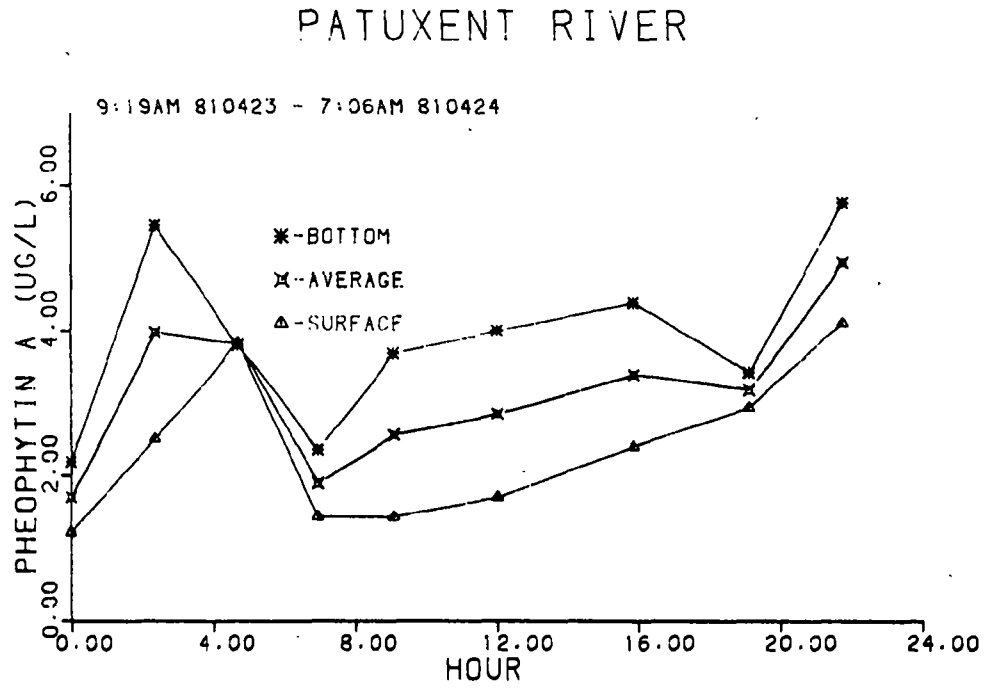
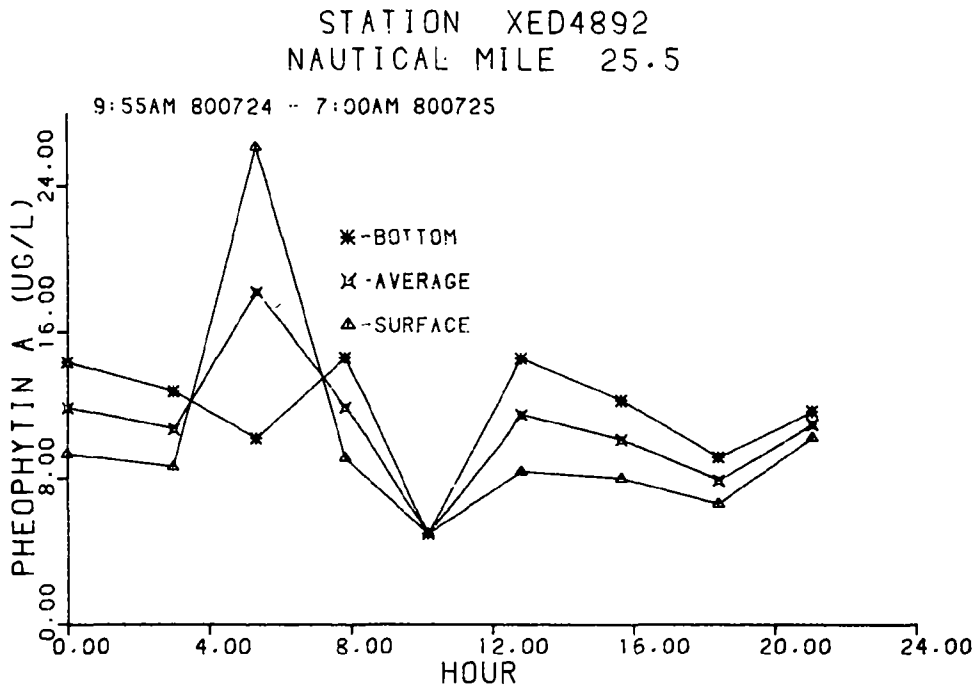


Figure 9-17 Intensive survey plots of pheophytin-a.



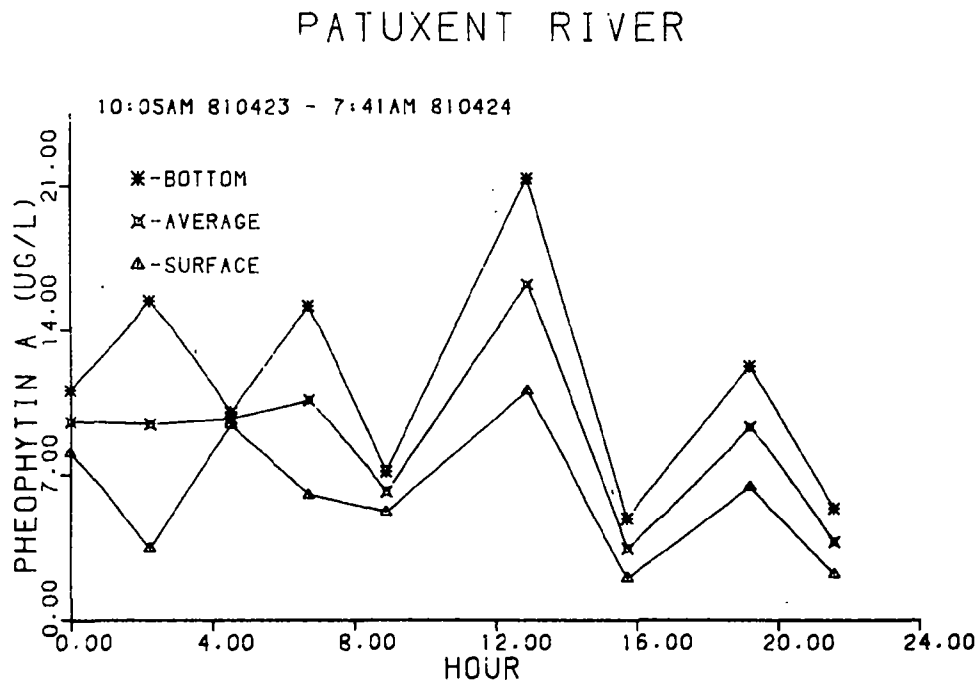
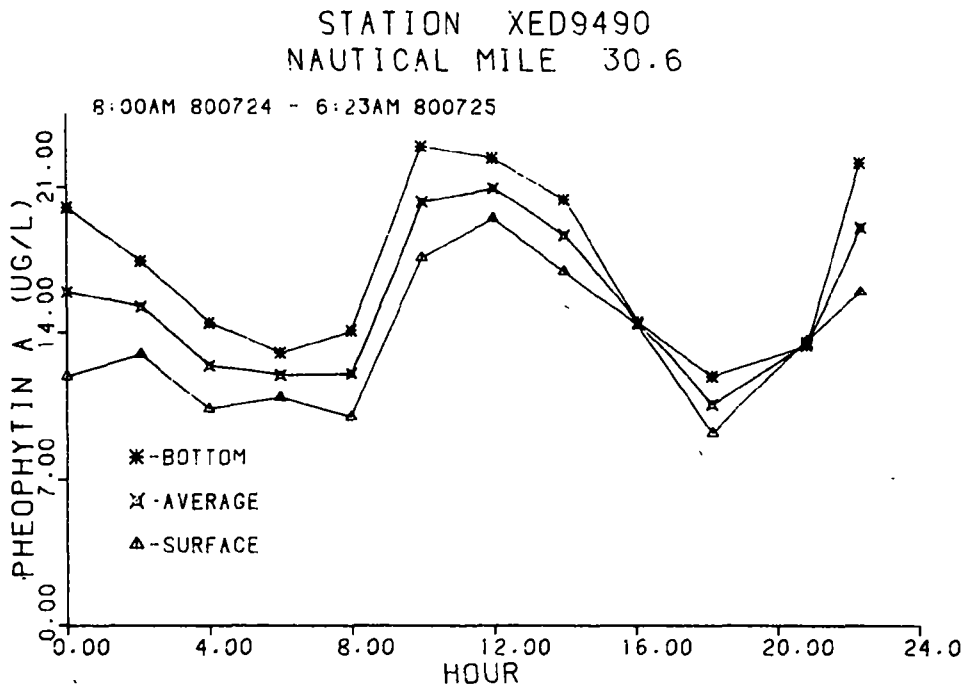


Figure 9-17Intensive survey plots of pheophytin-a.



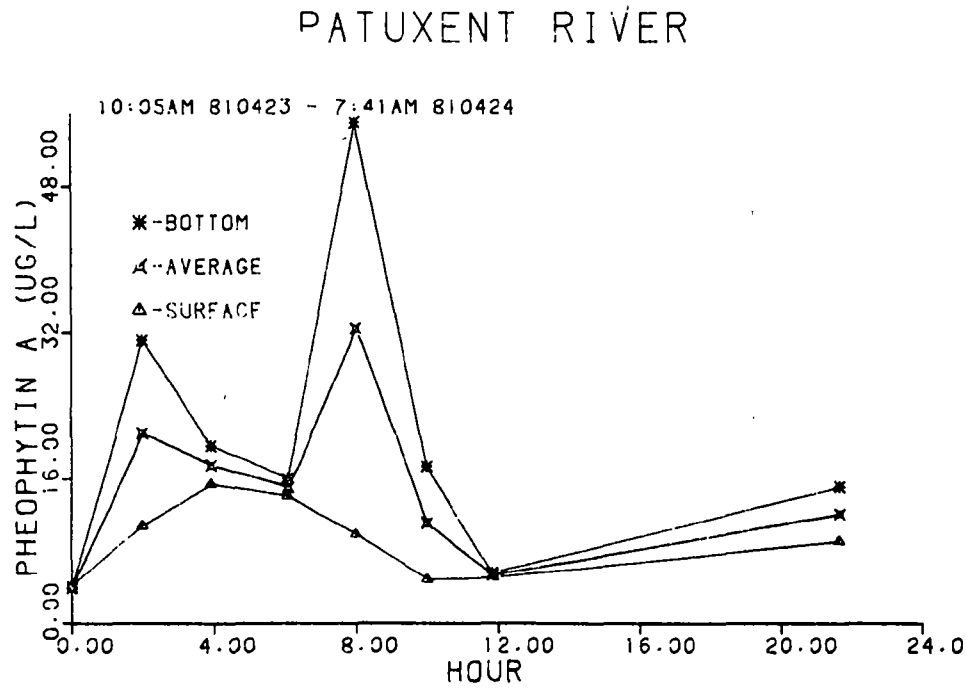
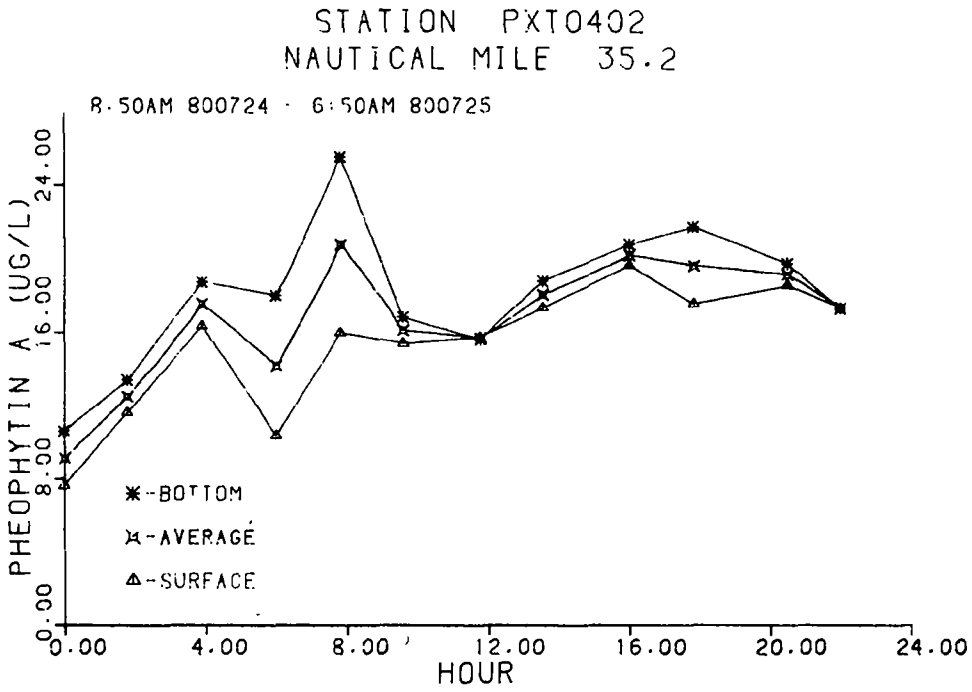


Figure 9-17 Intensive survey plots of pheophytin-a.



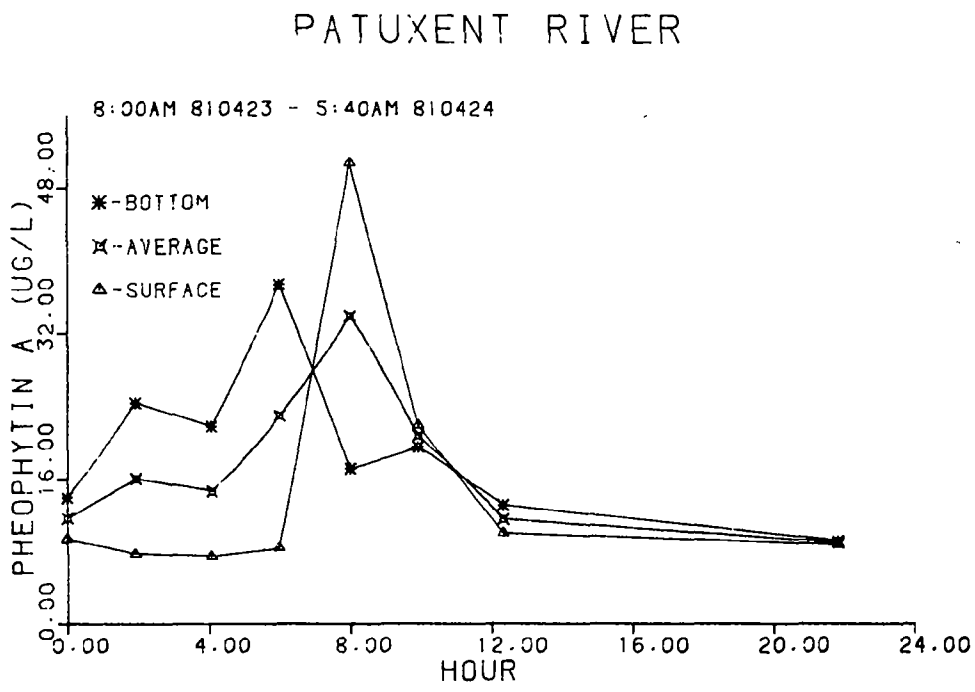
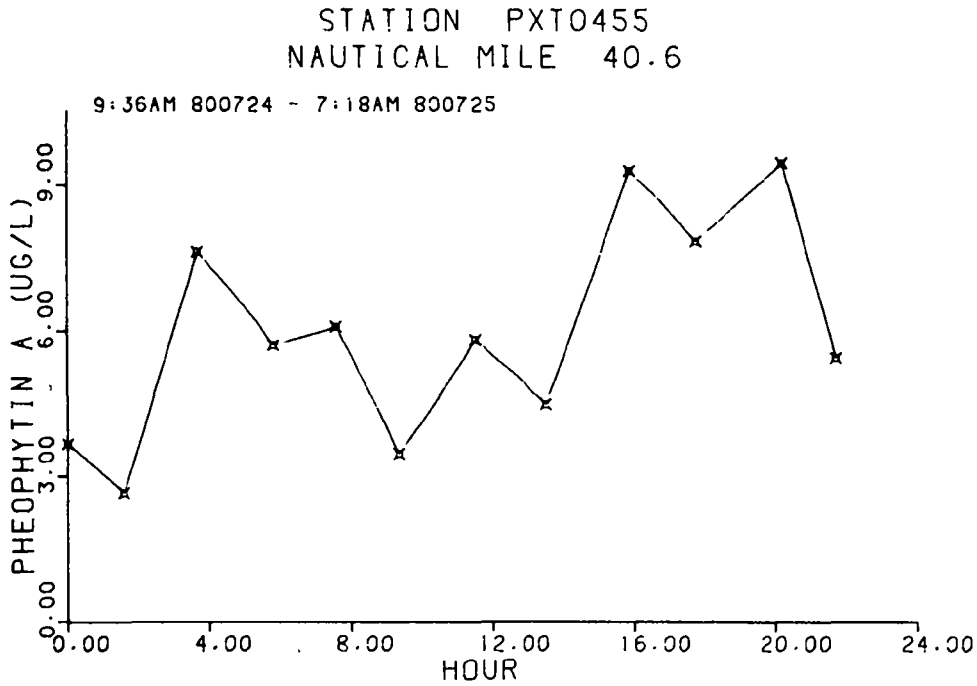


Figure 9-17 Intensive survey plots of pheophytin-a.



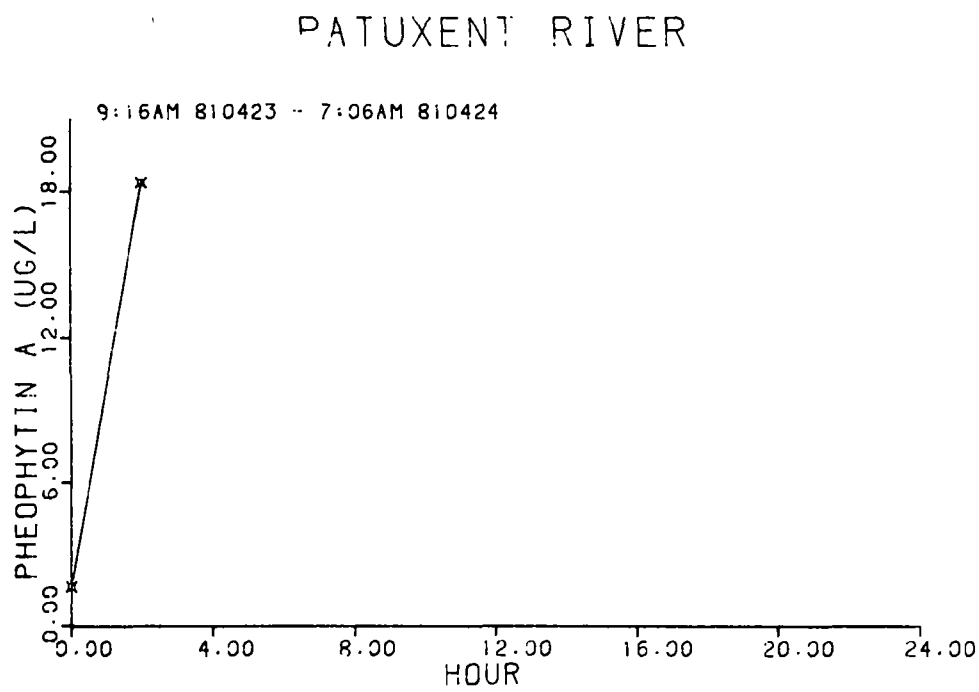
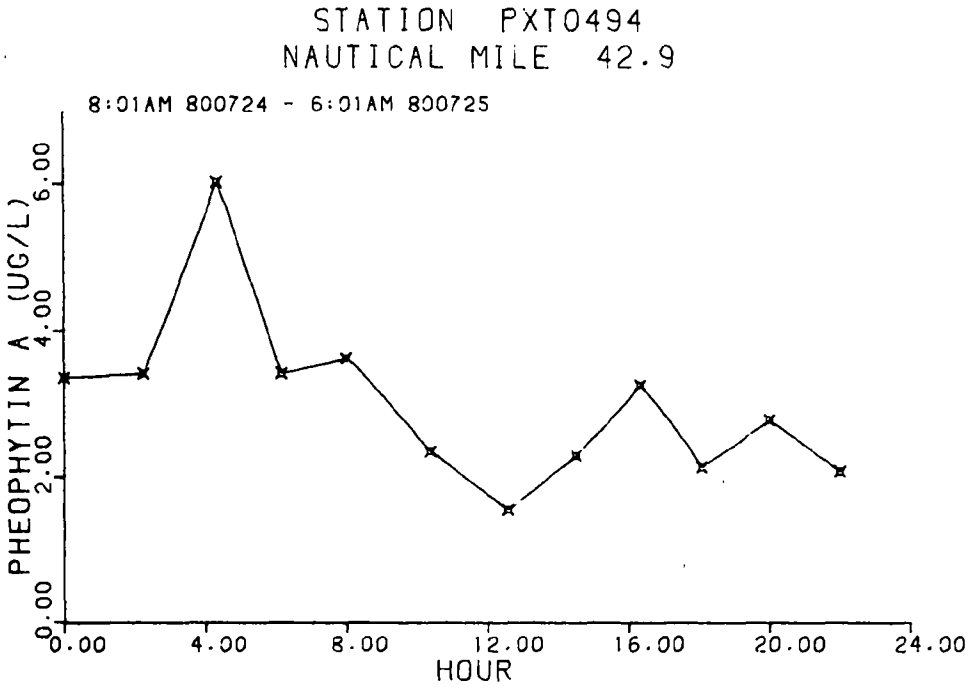


Figure 9-17 Intensive survey plots of pheophytin-a.



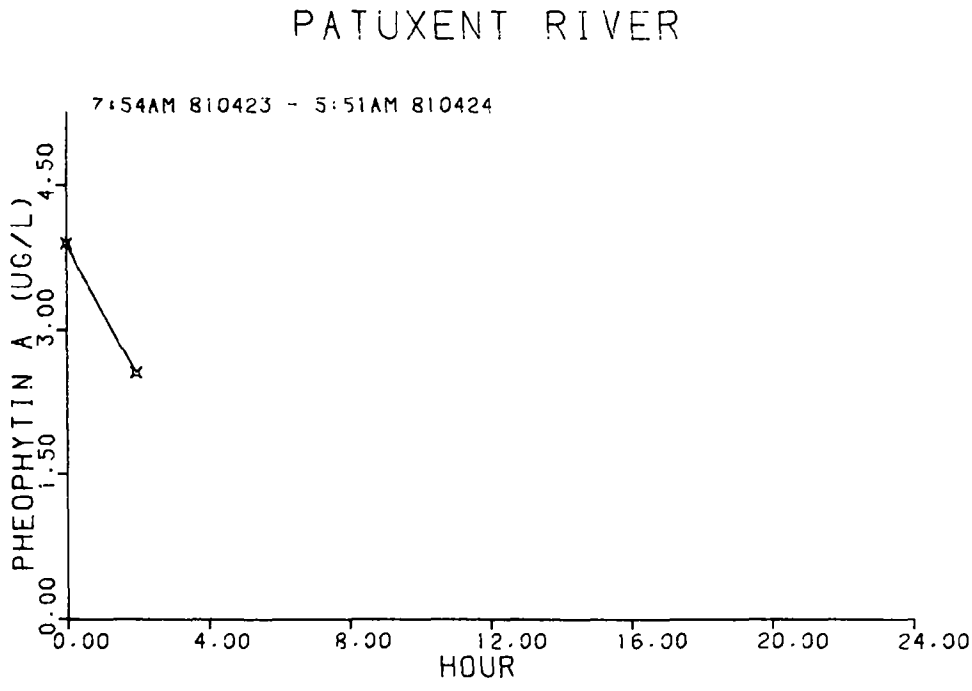
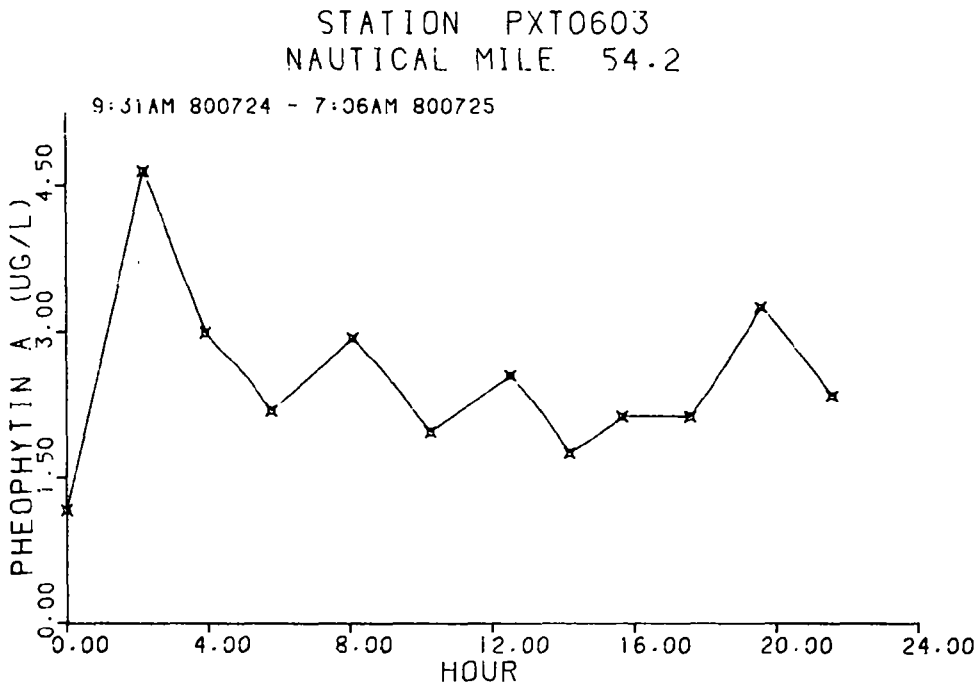


Figure 9-17 Intensive survey plots of pheophytin-a.



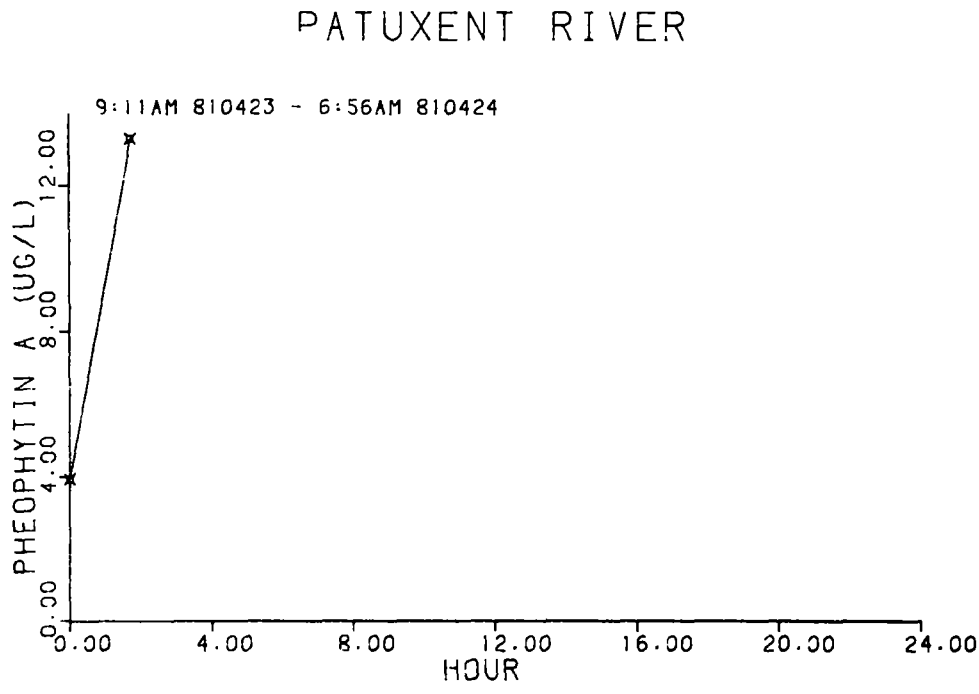
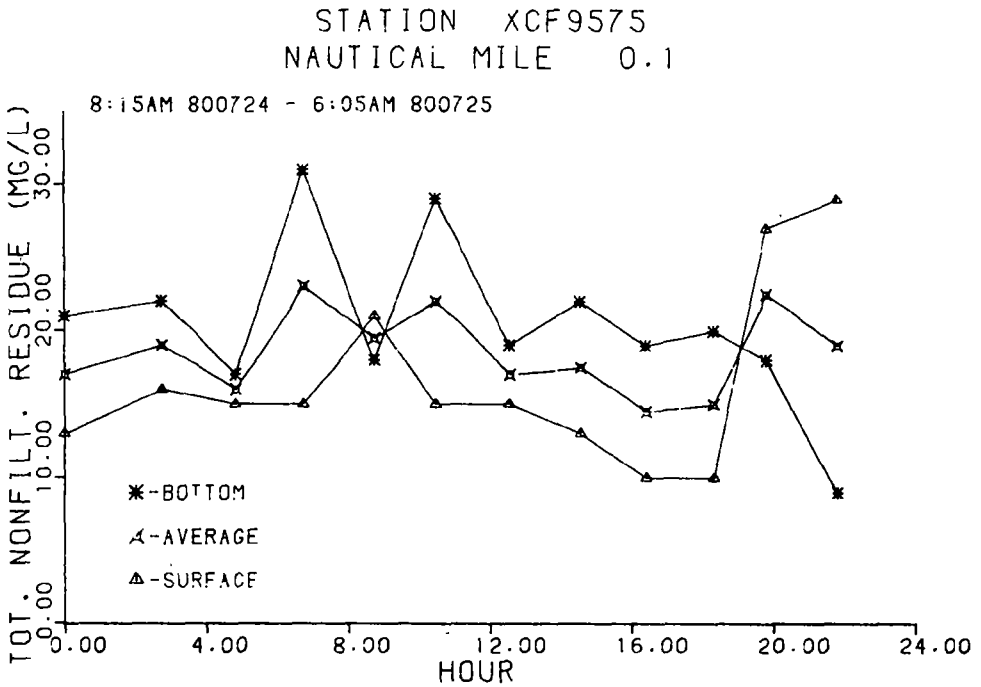


Figure 9-17 Intensive survey plots of pheophytin-a.



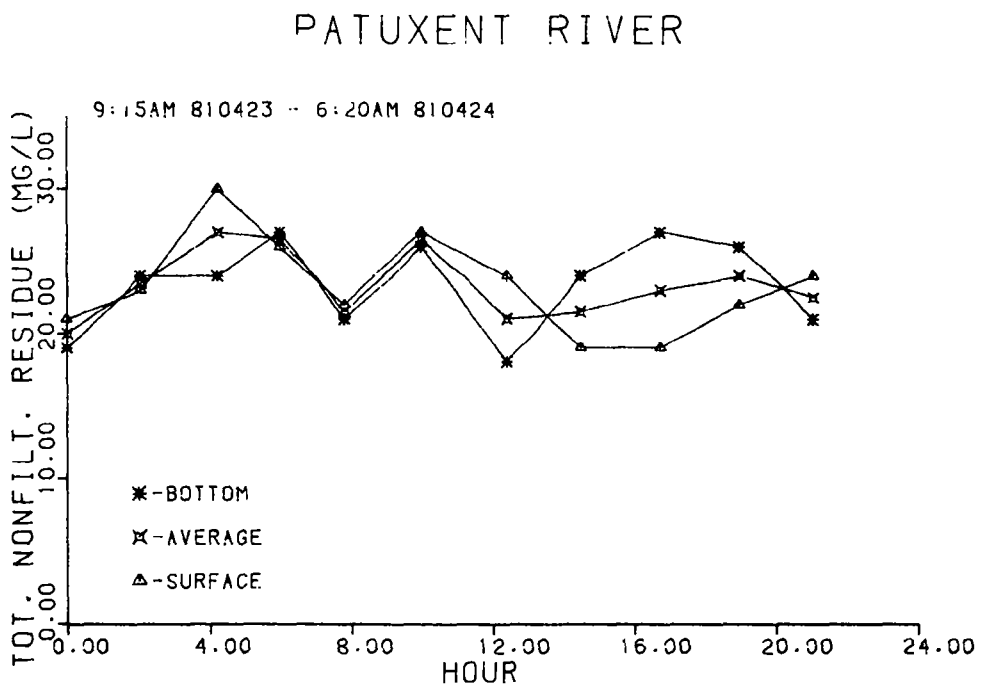
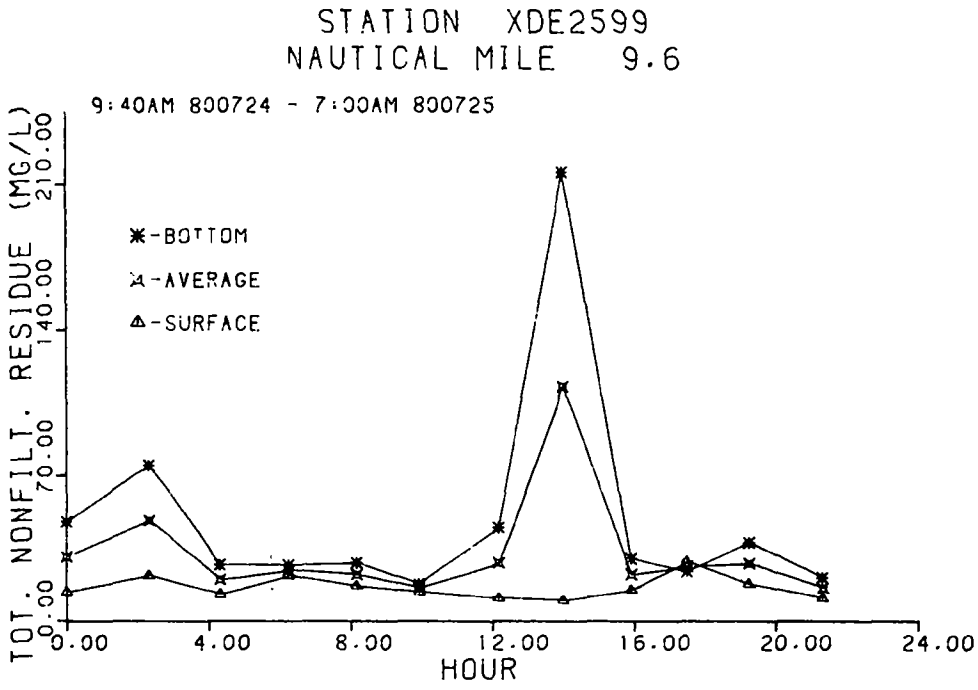


Figure 9-18Intensive river survey plots of total nonfilterable residue.



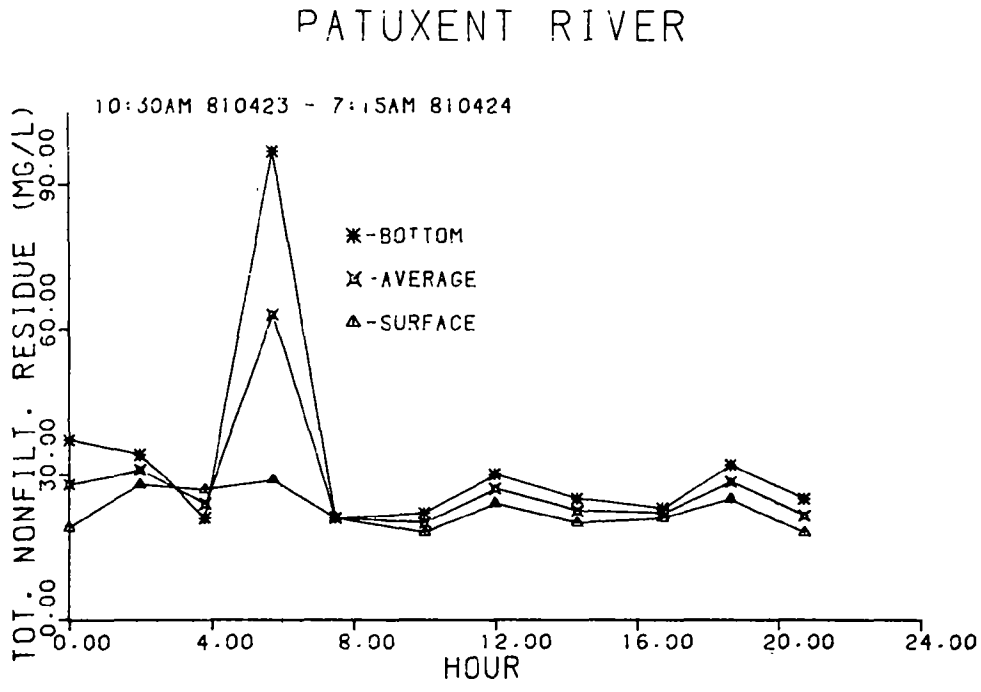
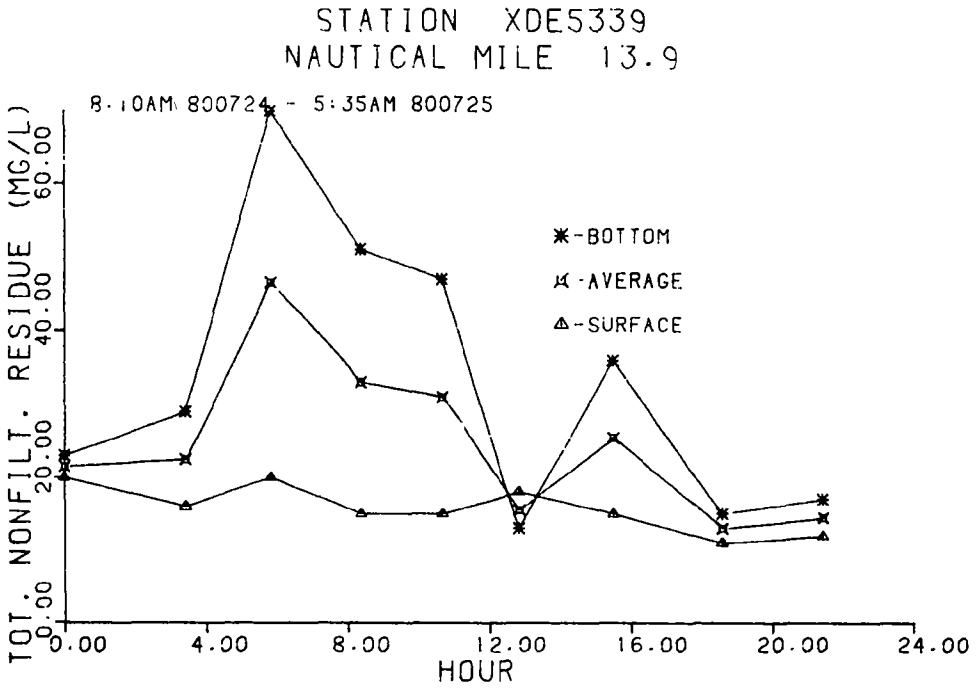


Figure9-18 Intensive river survey plots of total nonfilterable residue.



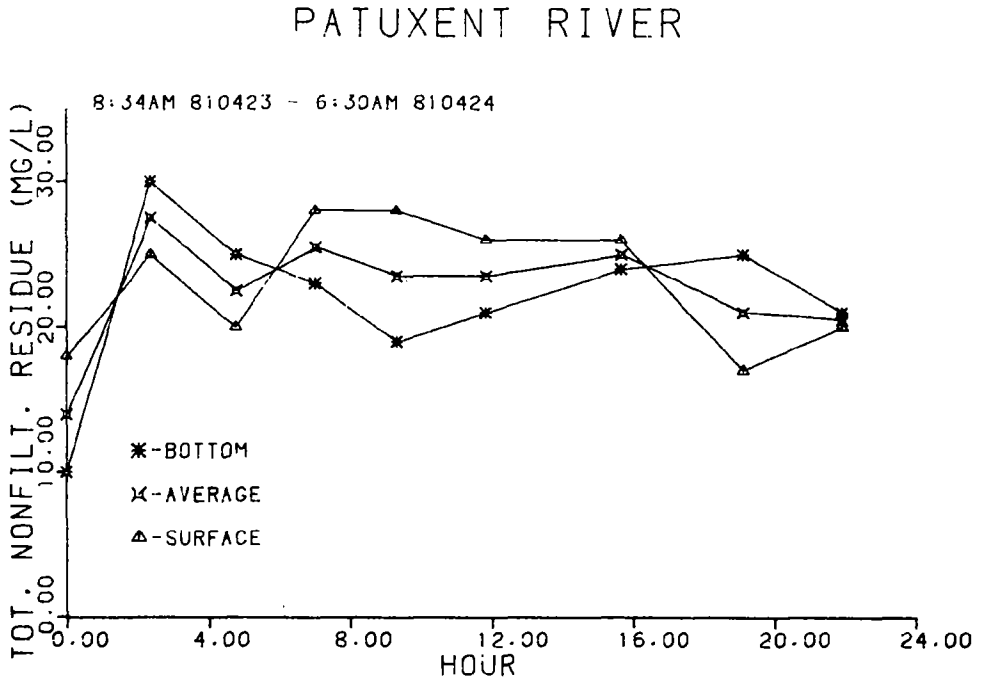
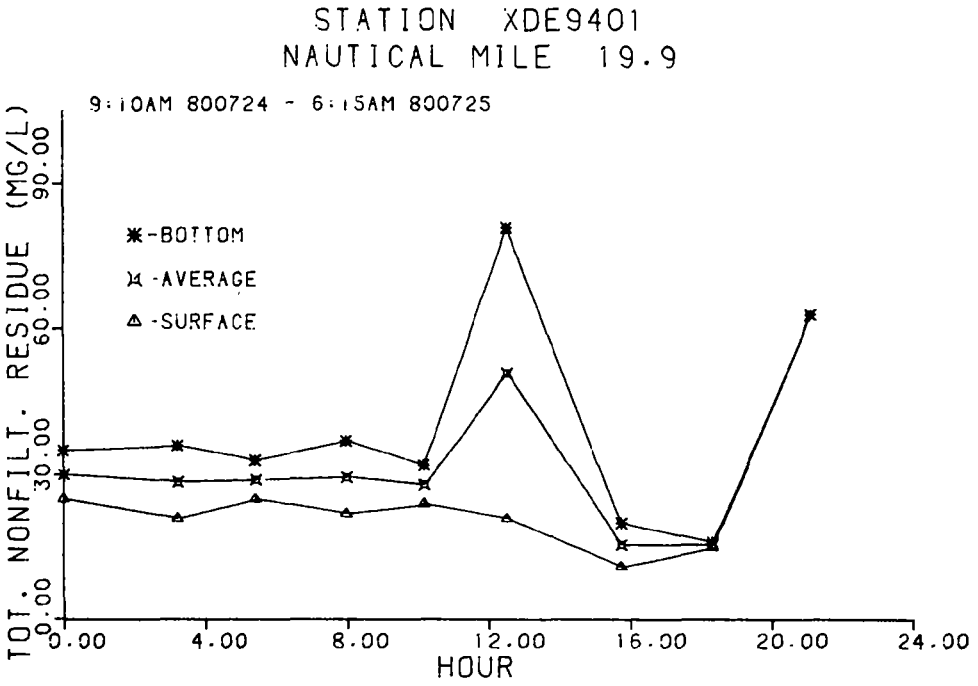


Figure 9-18 Intensive river survey plots of total nonfilterable residue. residue



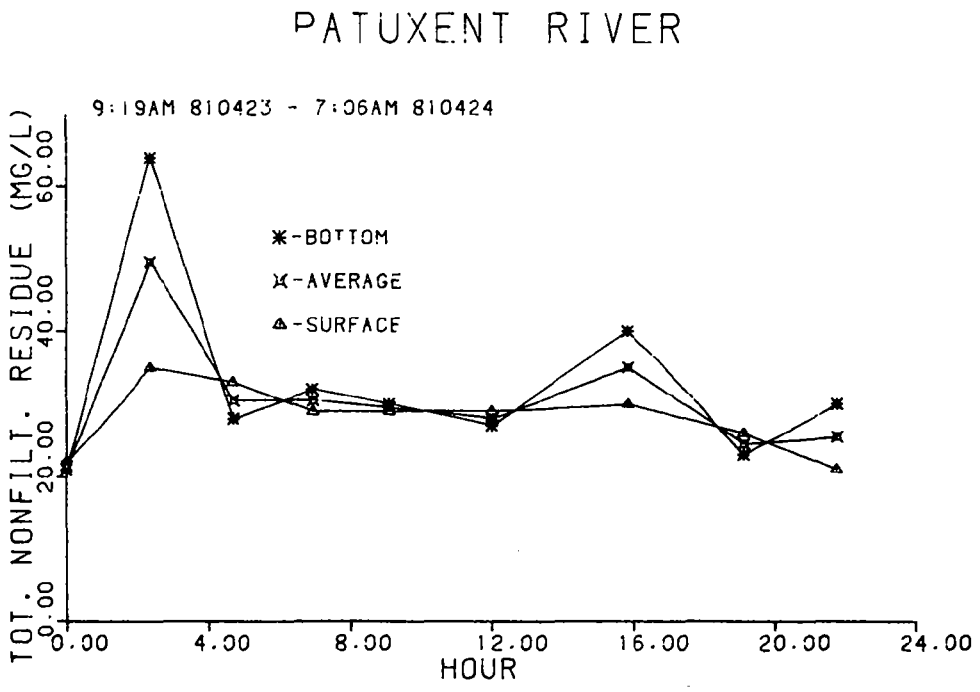
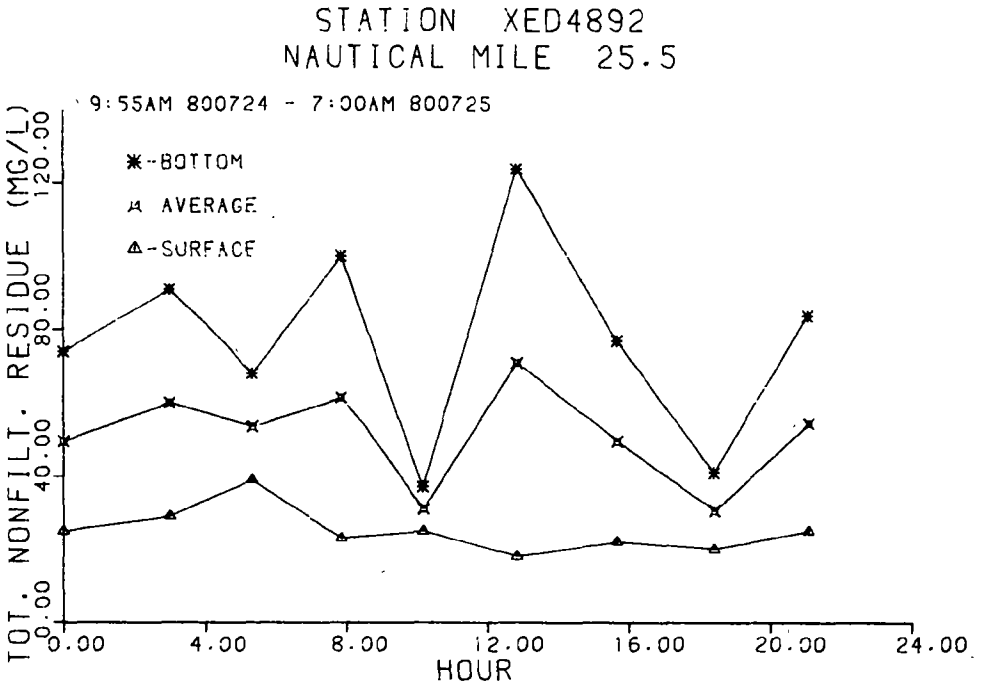


Figure 9-18 Intensive river survey plots of total nonfilterable residue.



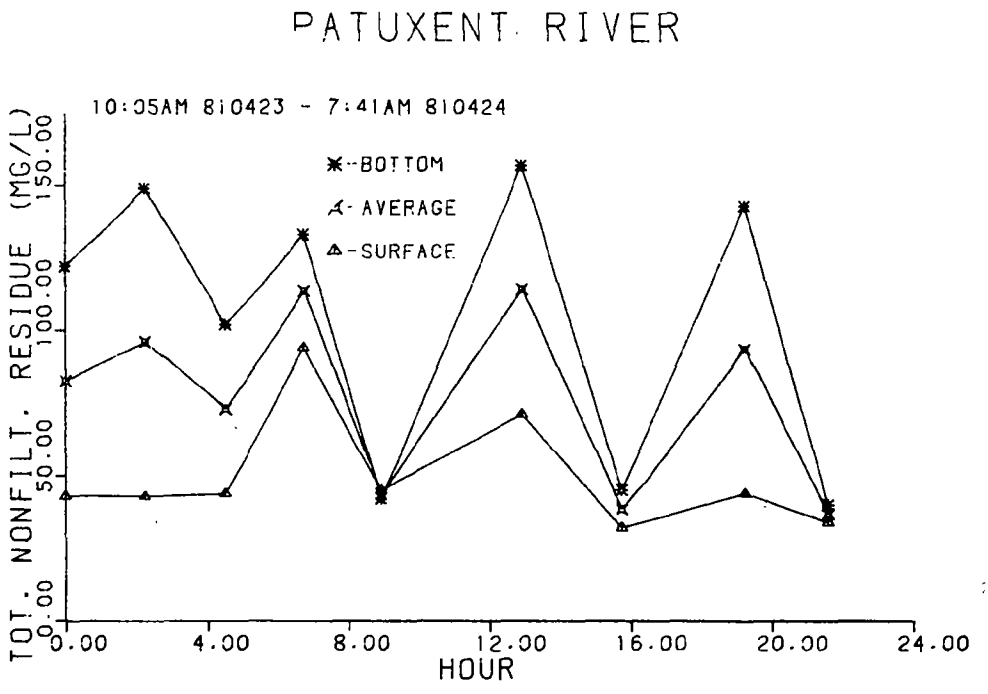
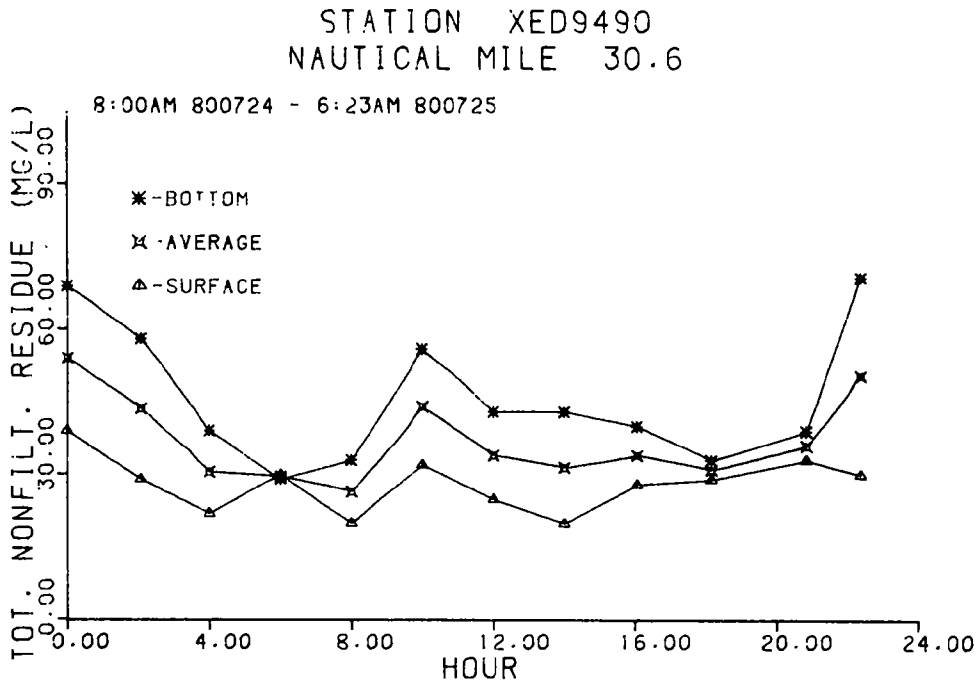


Figure 9-18Intensive river survey plots of total nonfilterable residue.



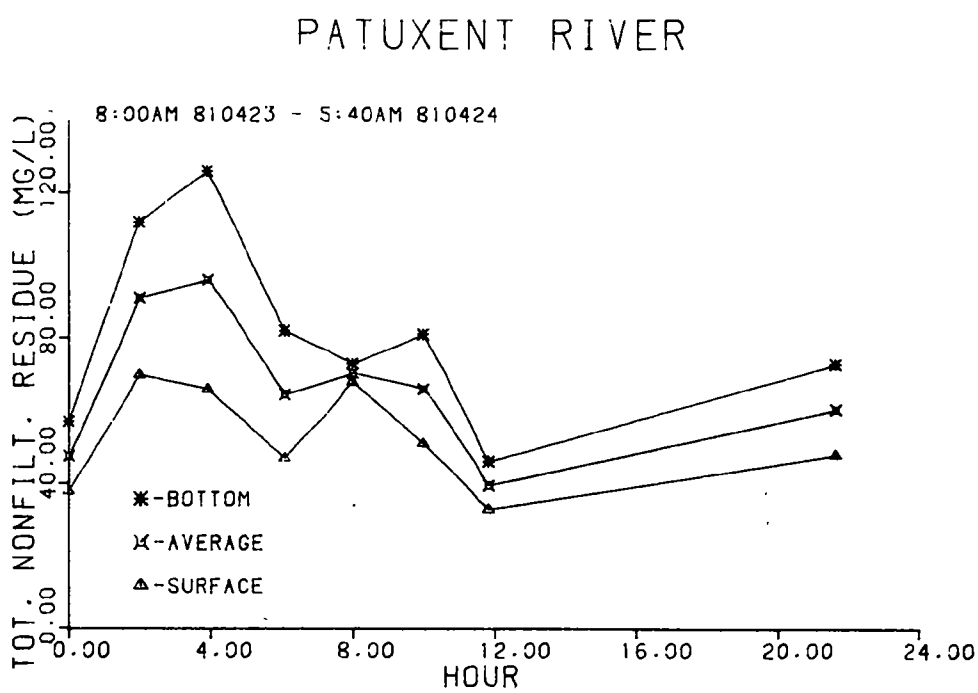
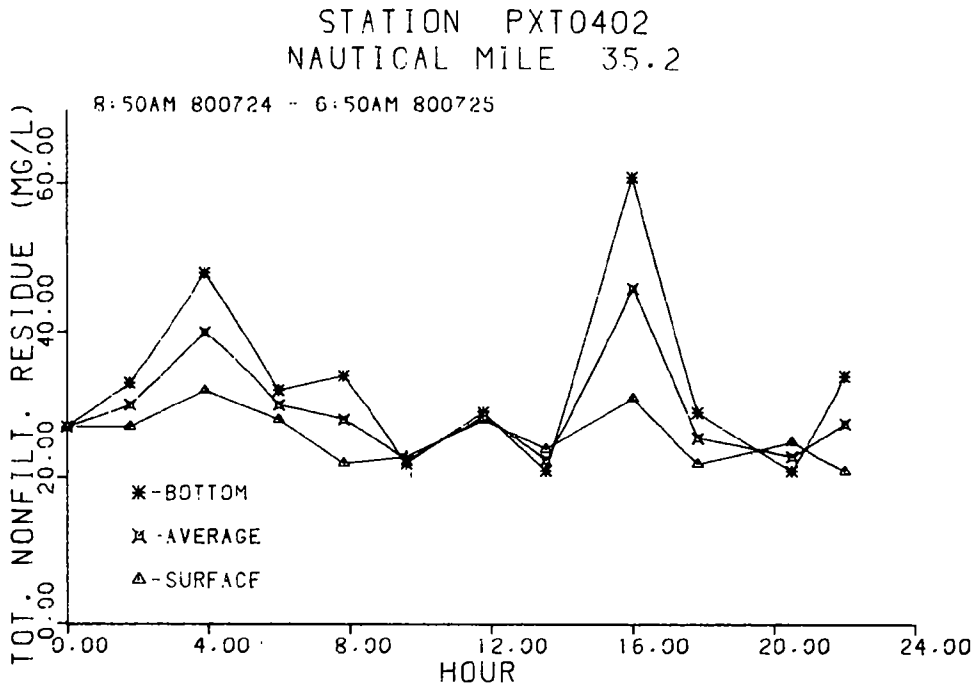


Figure 9-18 Intensive river survey plots of total nonfilterable residue.



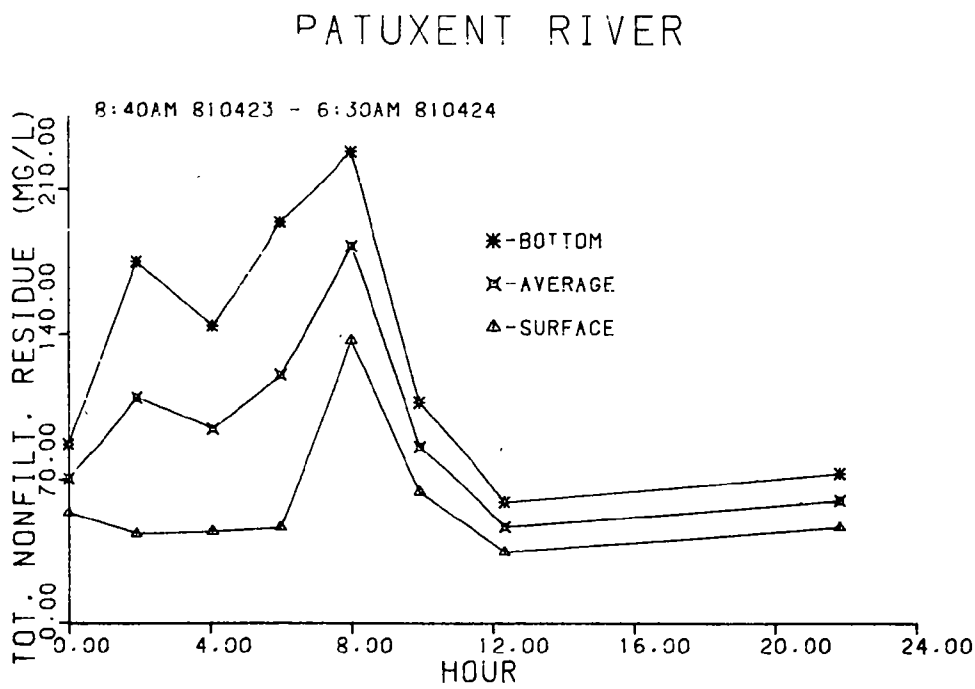
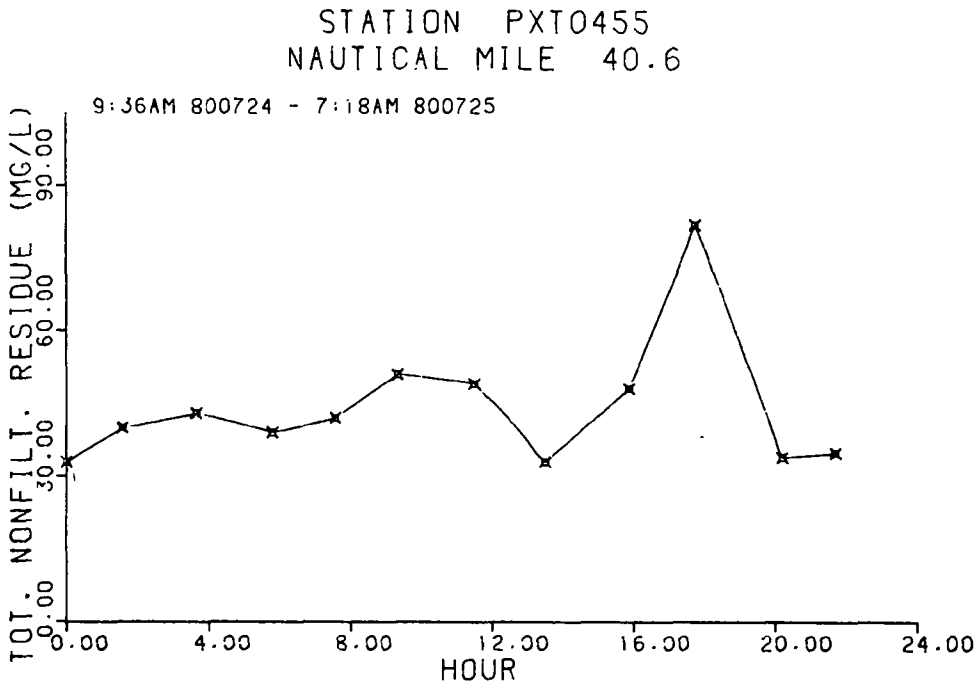


Figure 9-18Intensive river survey plots of total nonfilterable residue.



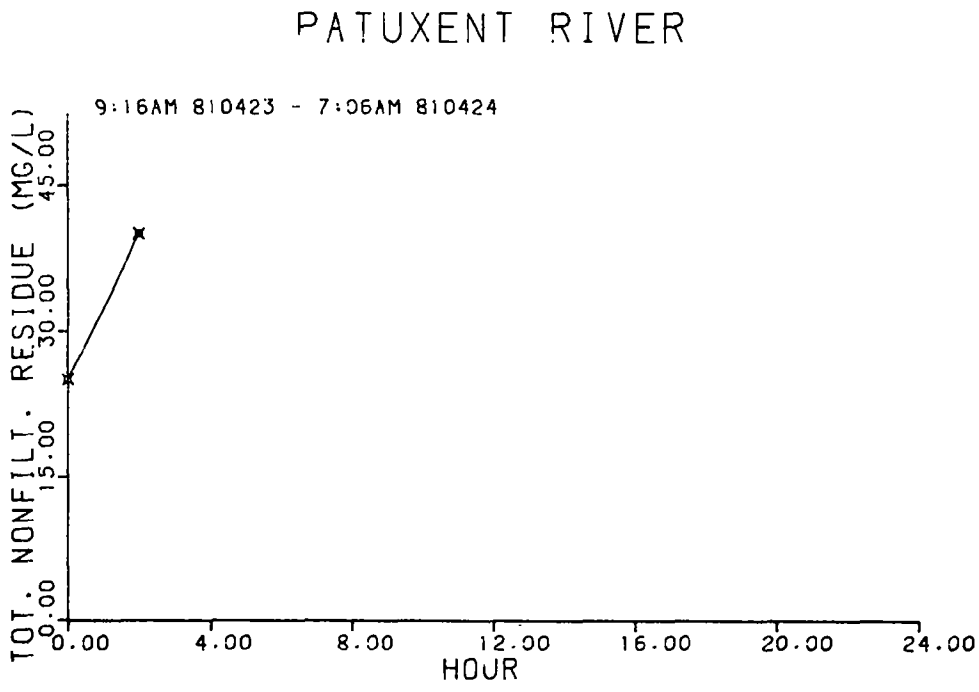
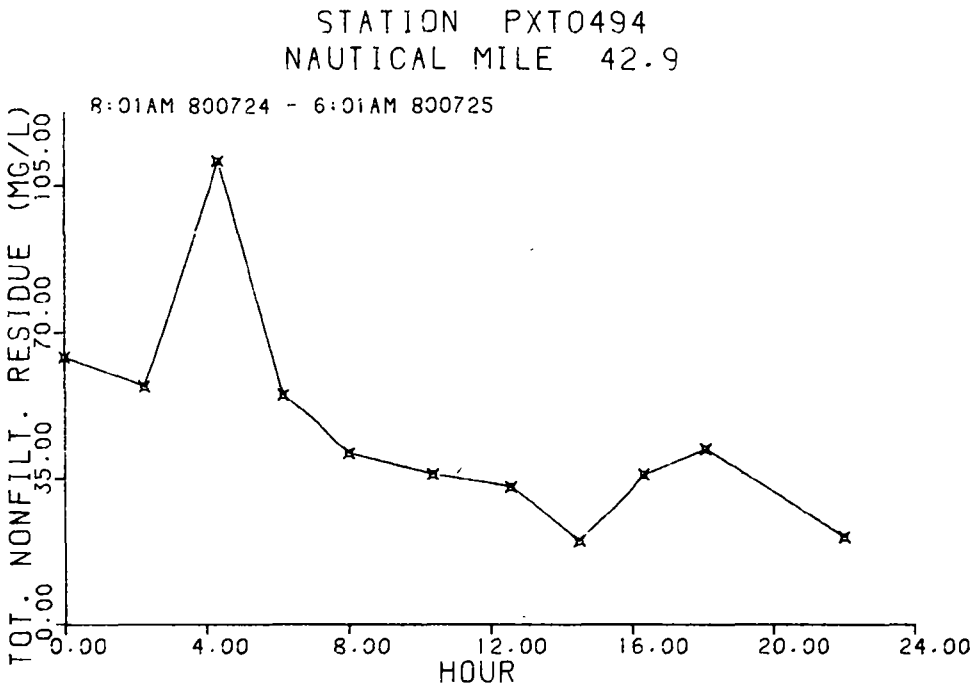


Figure 9-18Intensive river survey plots of total nonfilterable residue.



PATUXENT RIVER

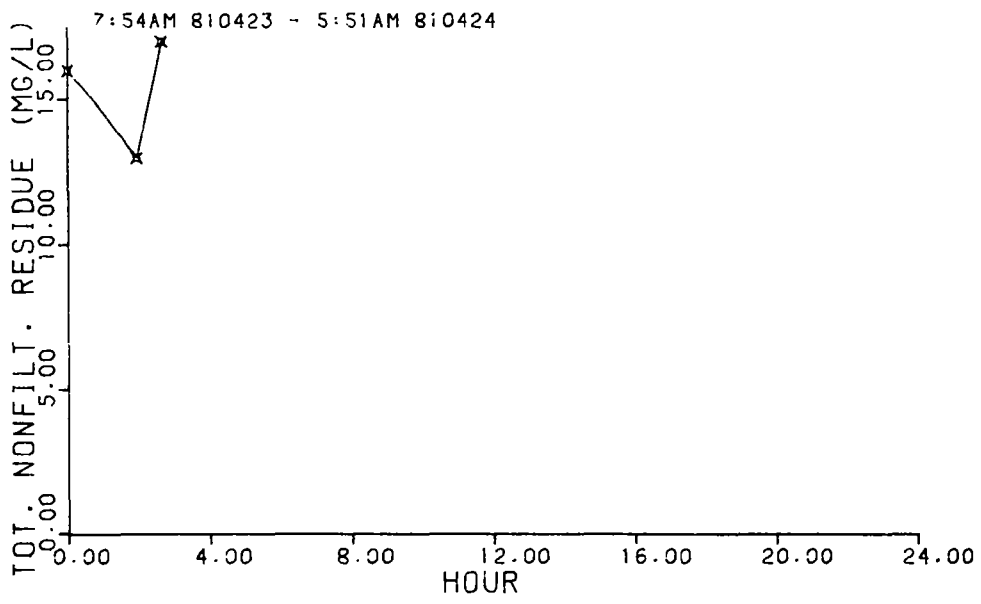
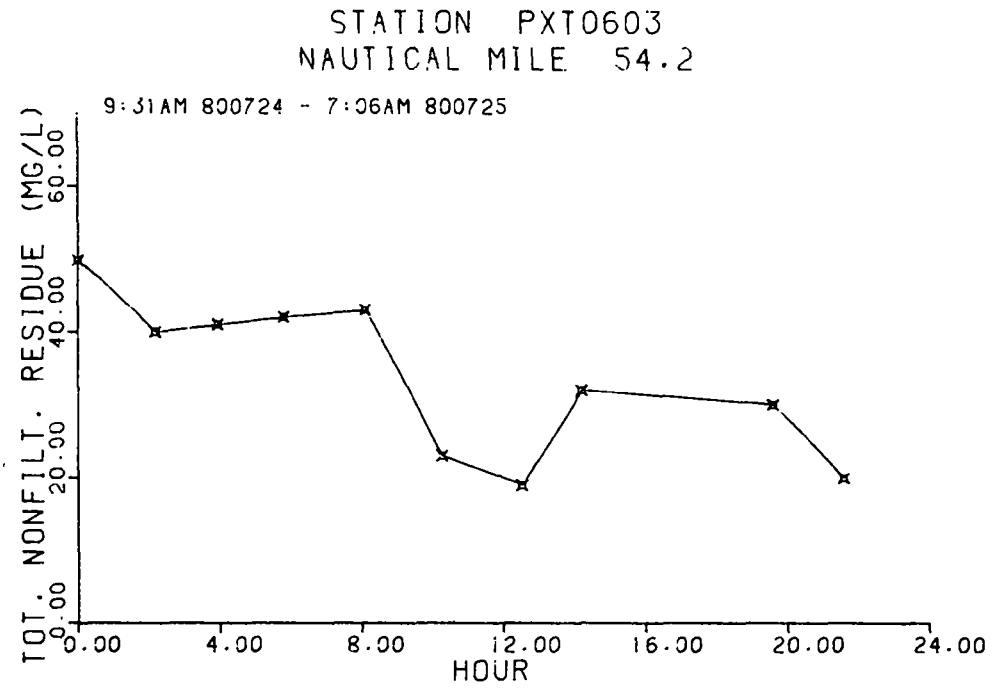


Figure 9-18 Intensive river survey plots of total nonfilterable residue.



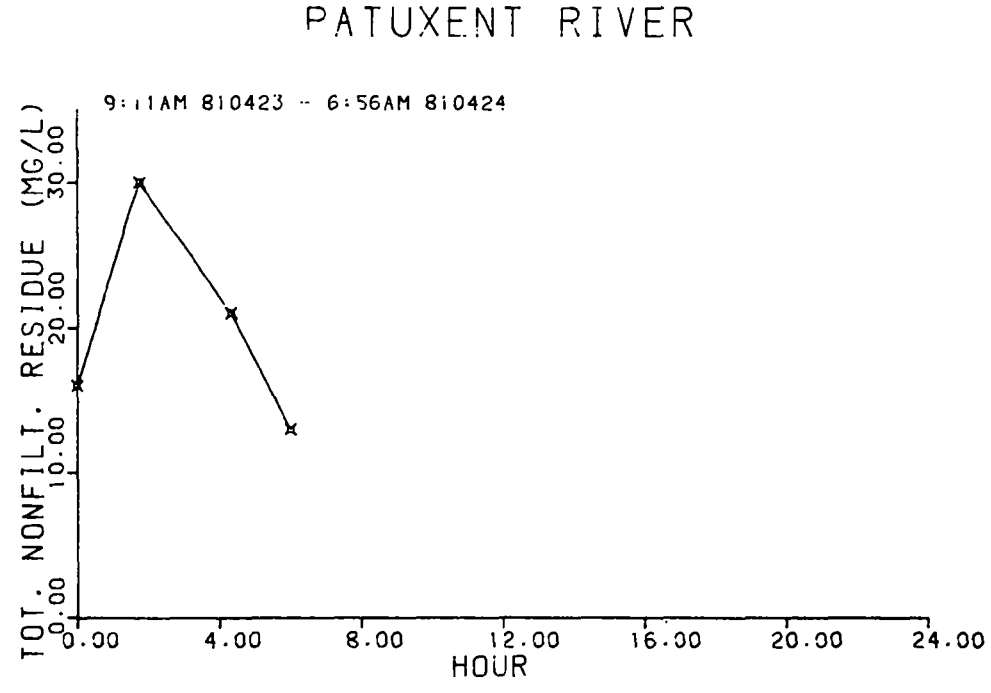
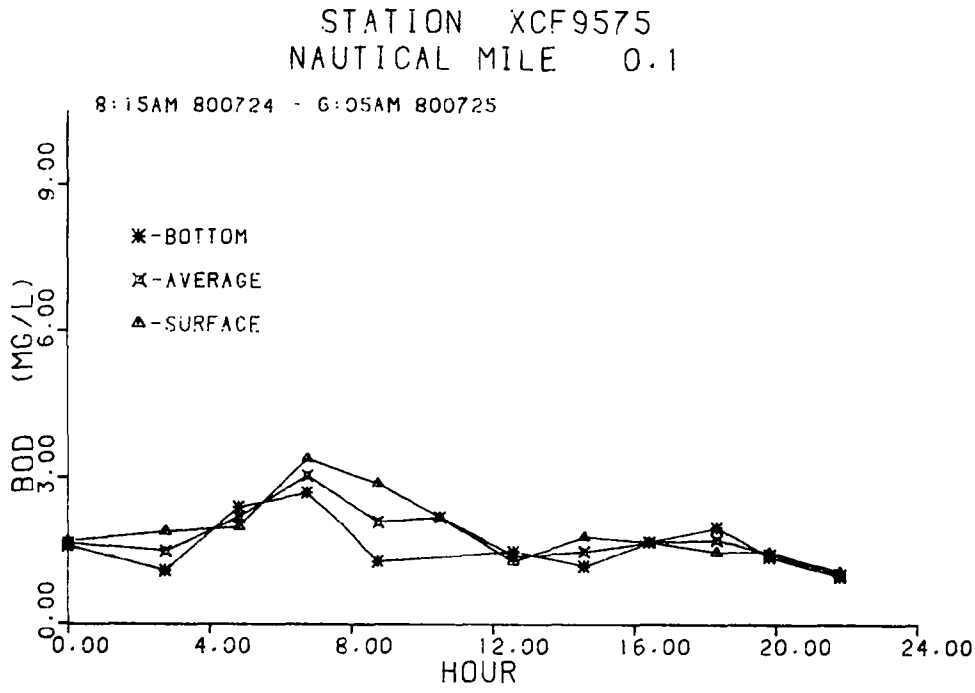


Figure 9-18Intensive river survey plots of total nonfilterable residue.



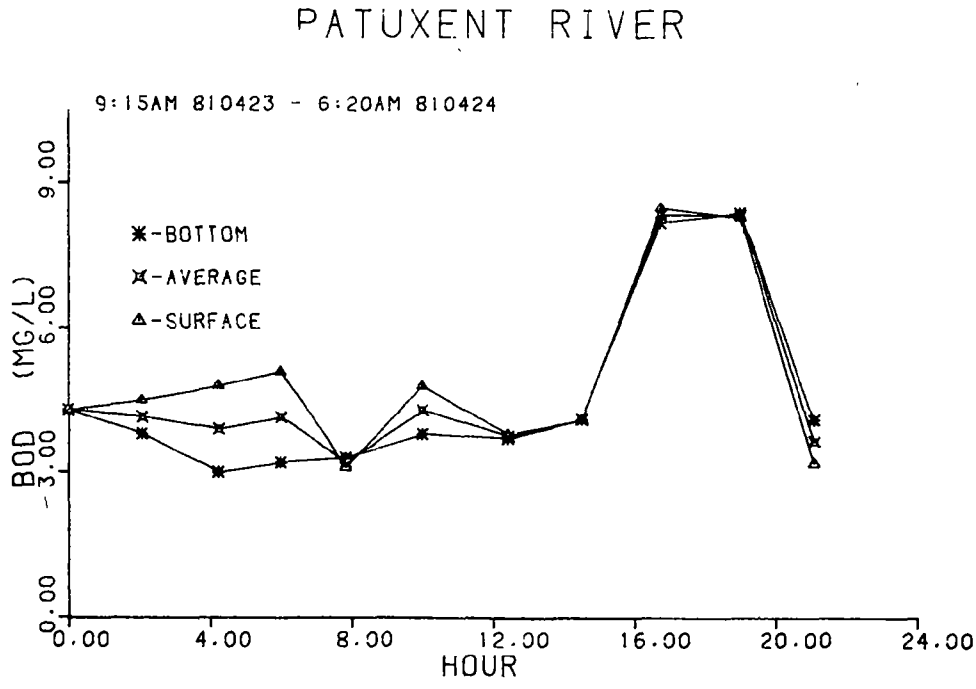
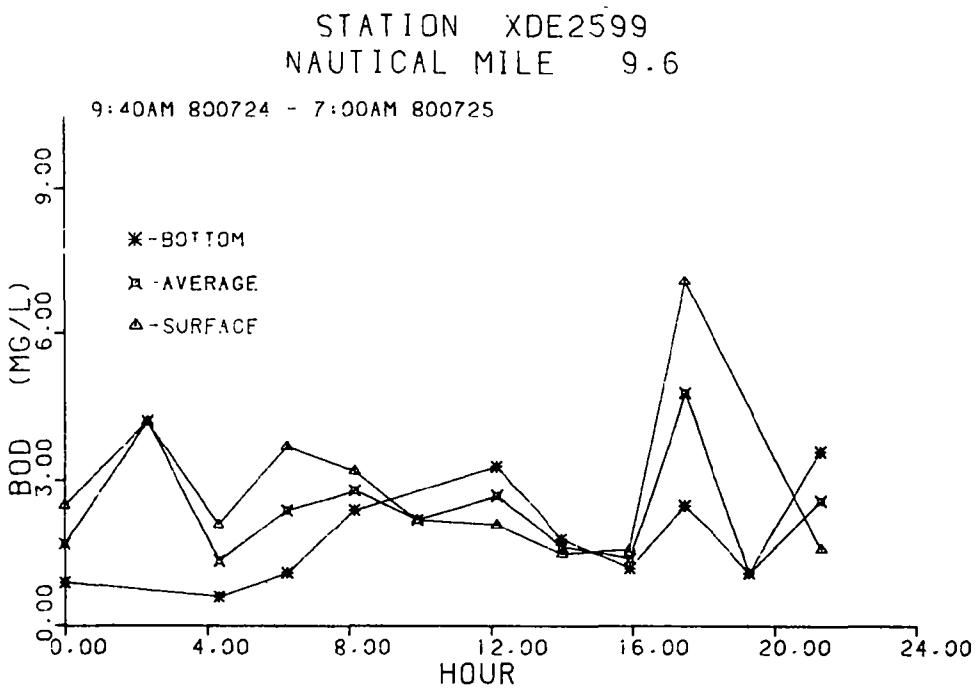


Figure 9-19 Intensive river survey plots of BOD_5.



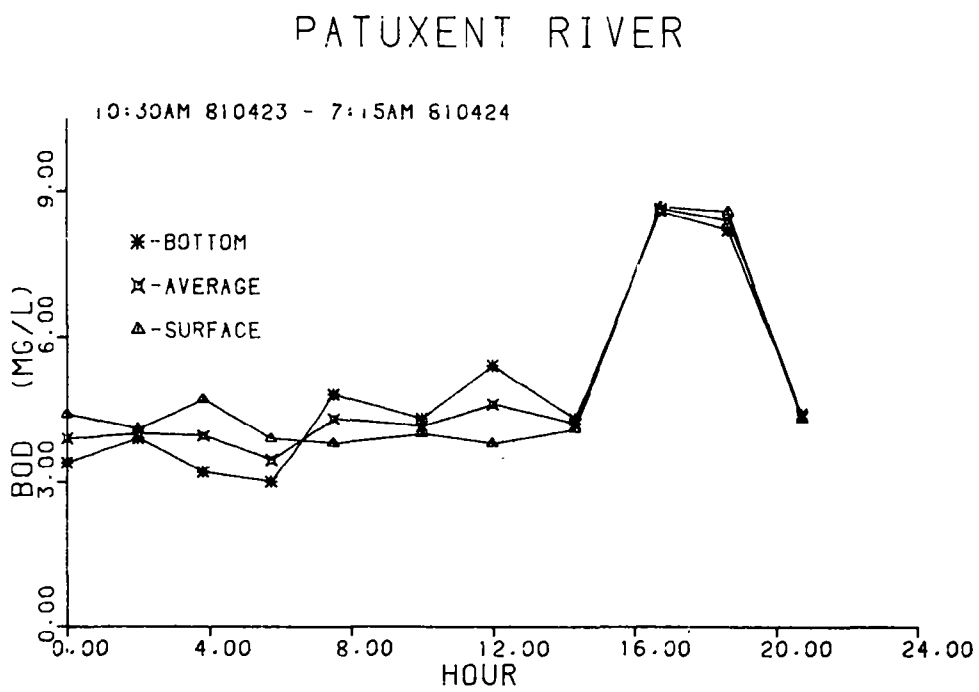
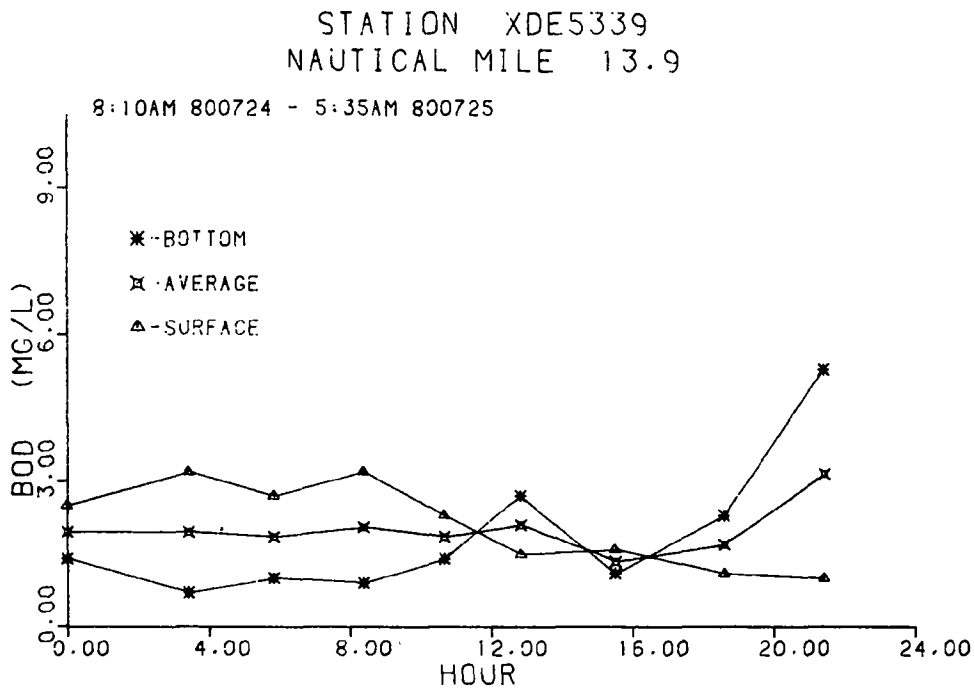


Figure 9-19 Intensive river survey plots of BOD_5.



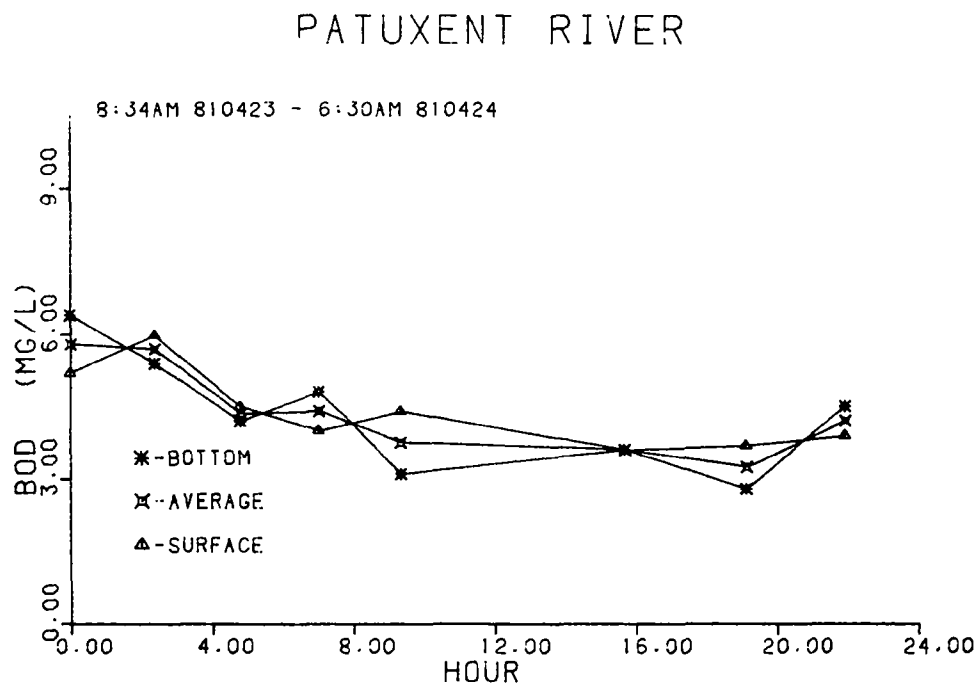
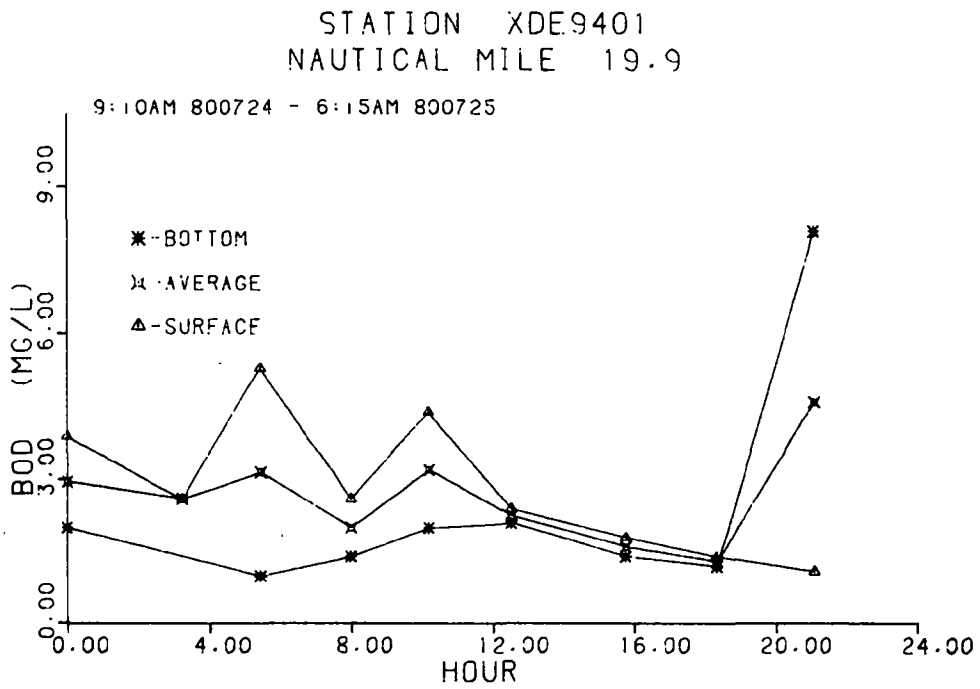


Figure 9-19 Intensive river survey plots of BOD_5.



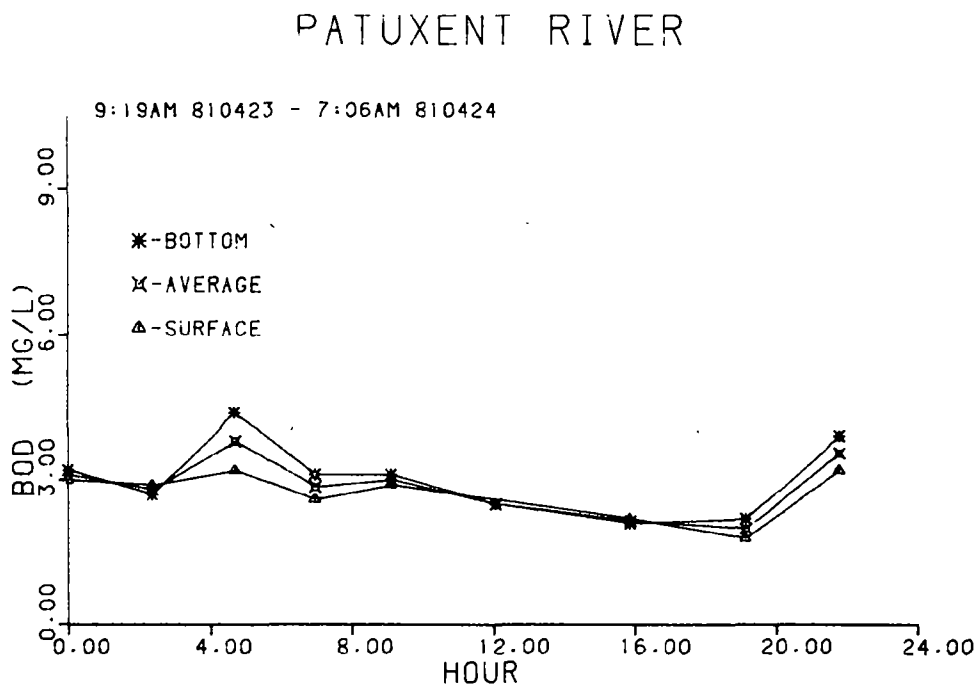
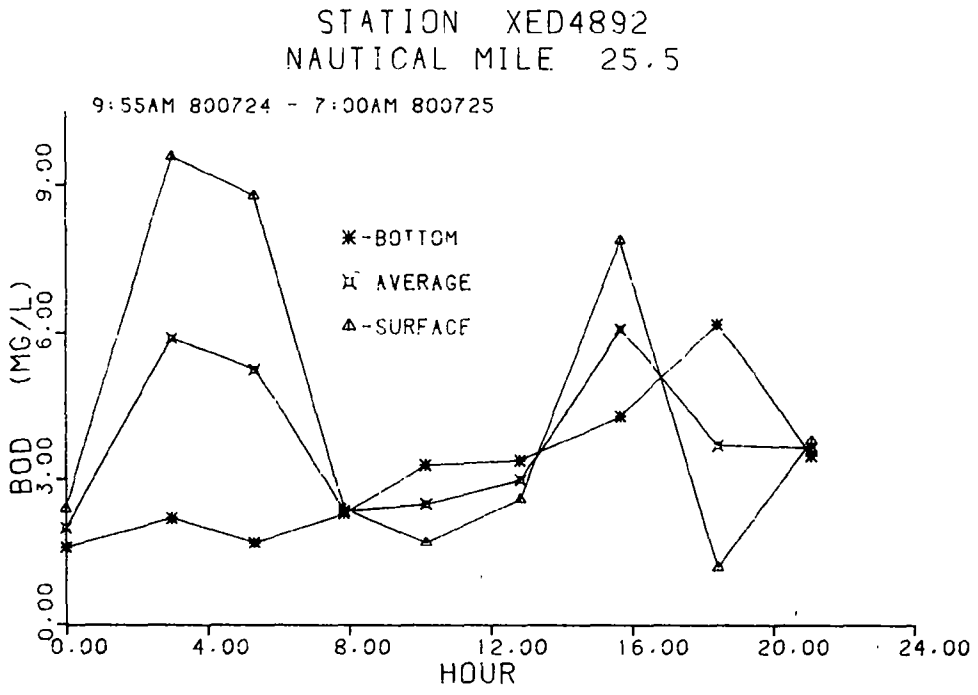


Figure 9-19 Intensive river survey plots of BOD_5.



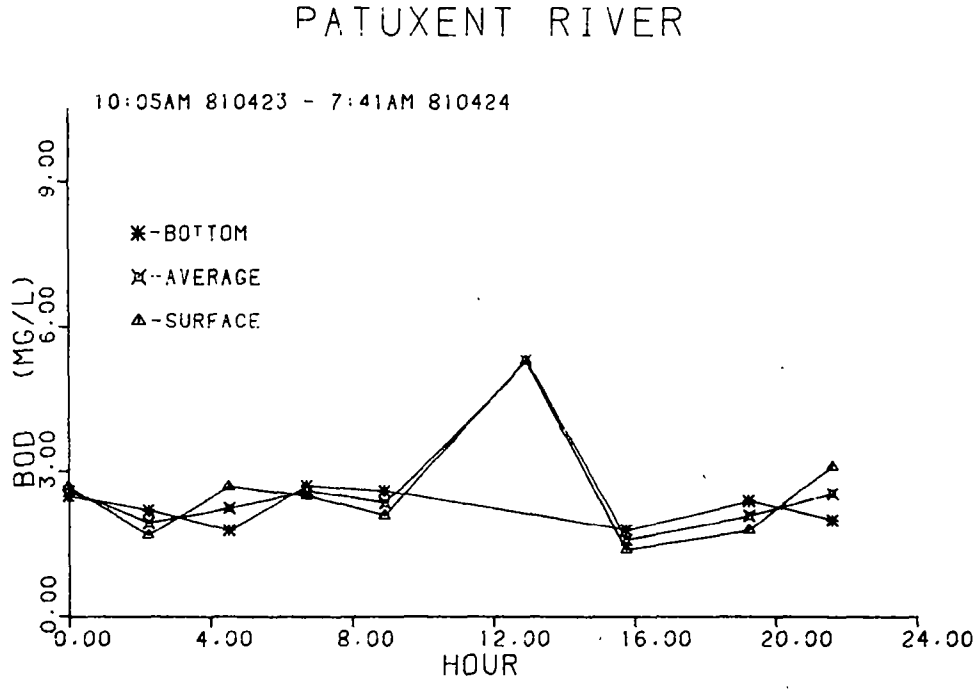
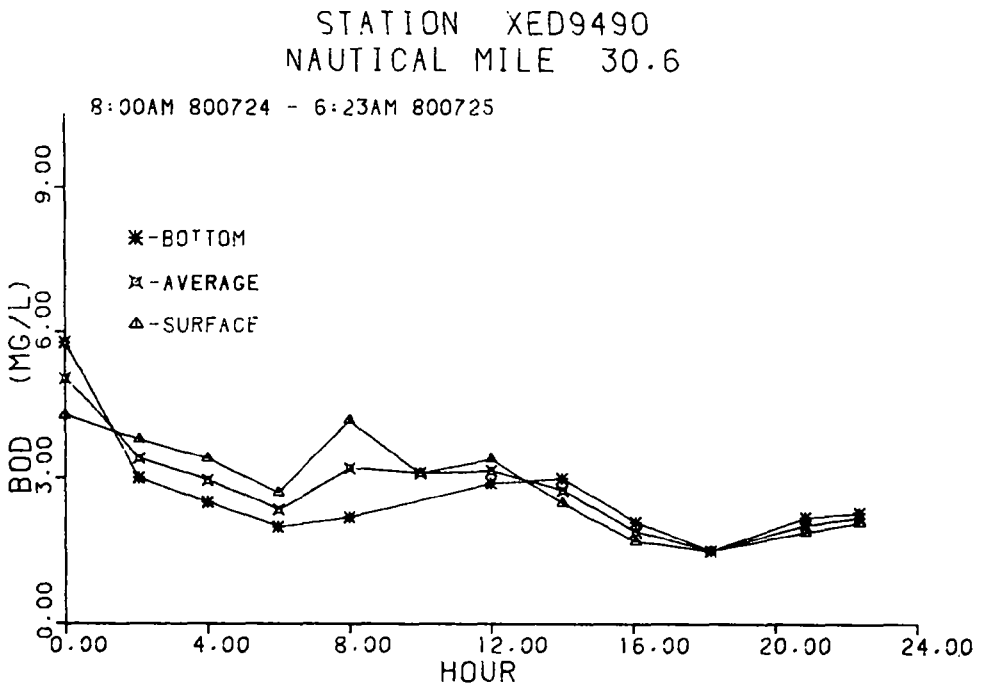


Figure 9-19 Intensive river survey plots of BOD_5.



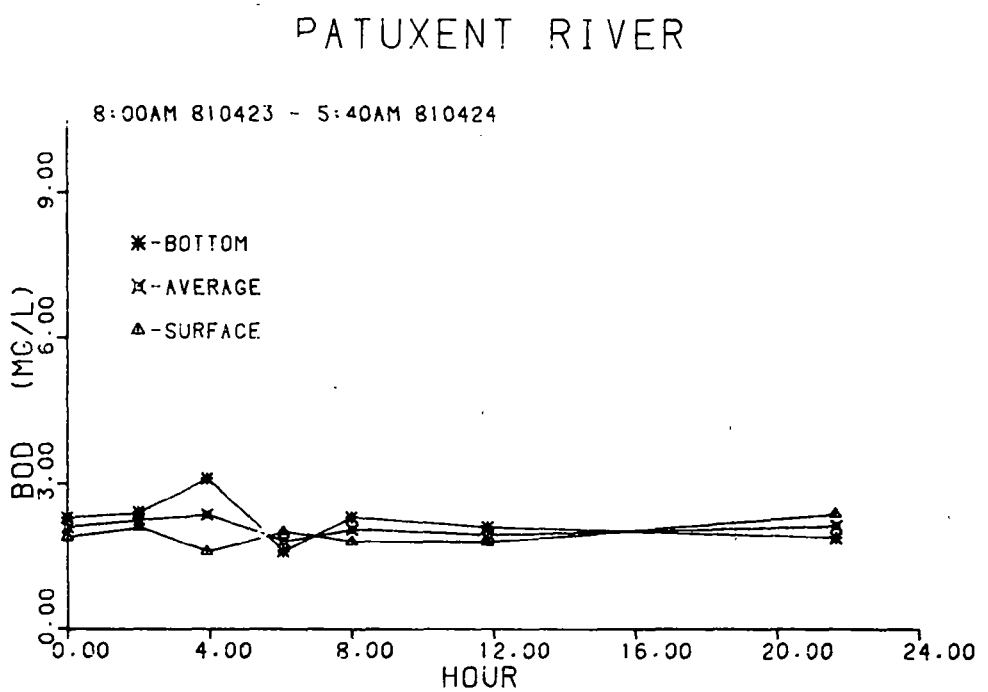
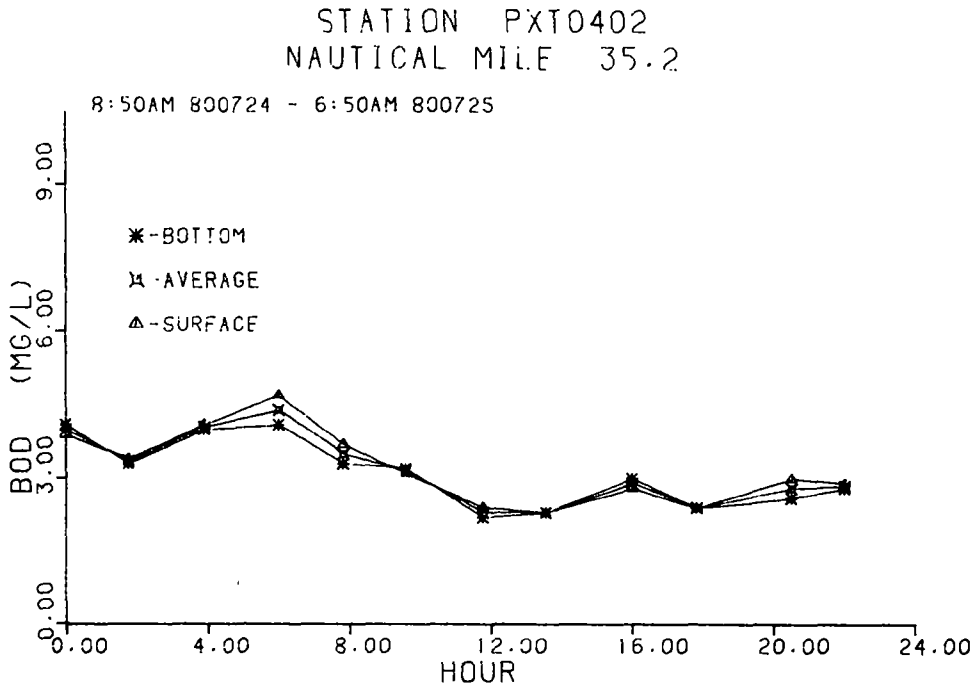


Figure 9-19 Intensive river survey plots of BOD_5.



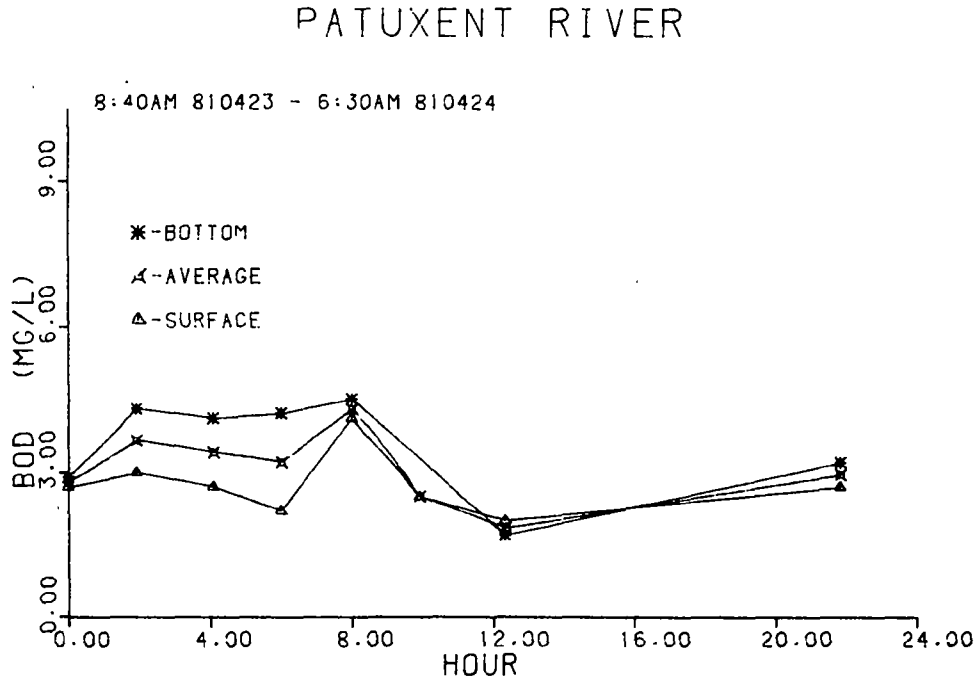
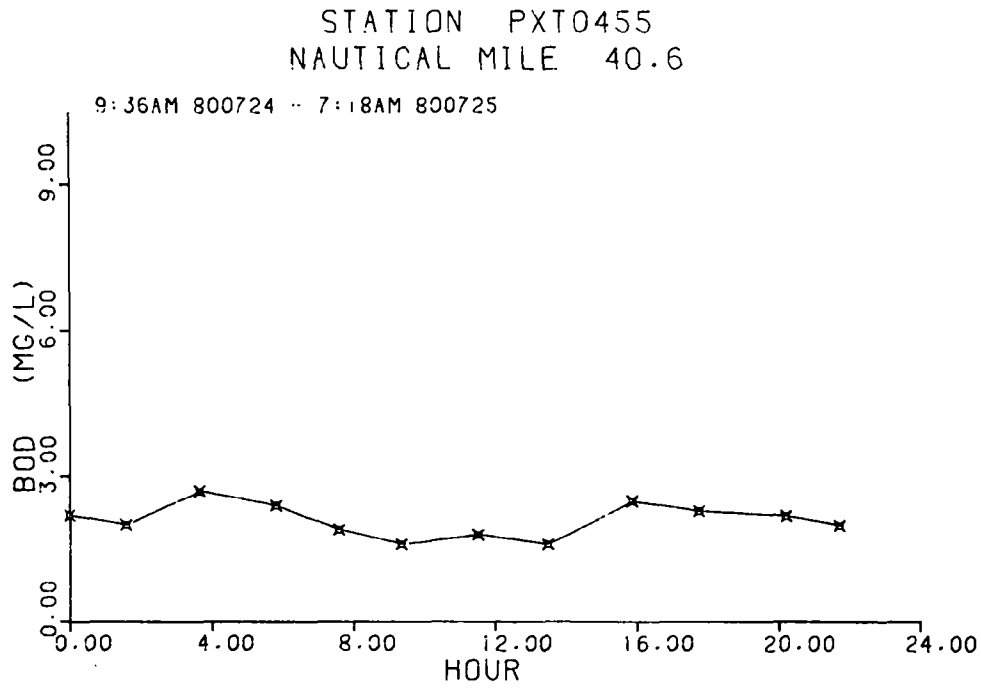


Figure 9-19 Intensive river survey plots of BOD_5.



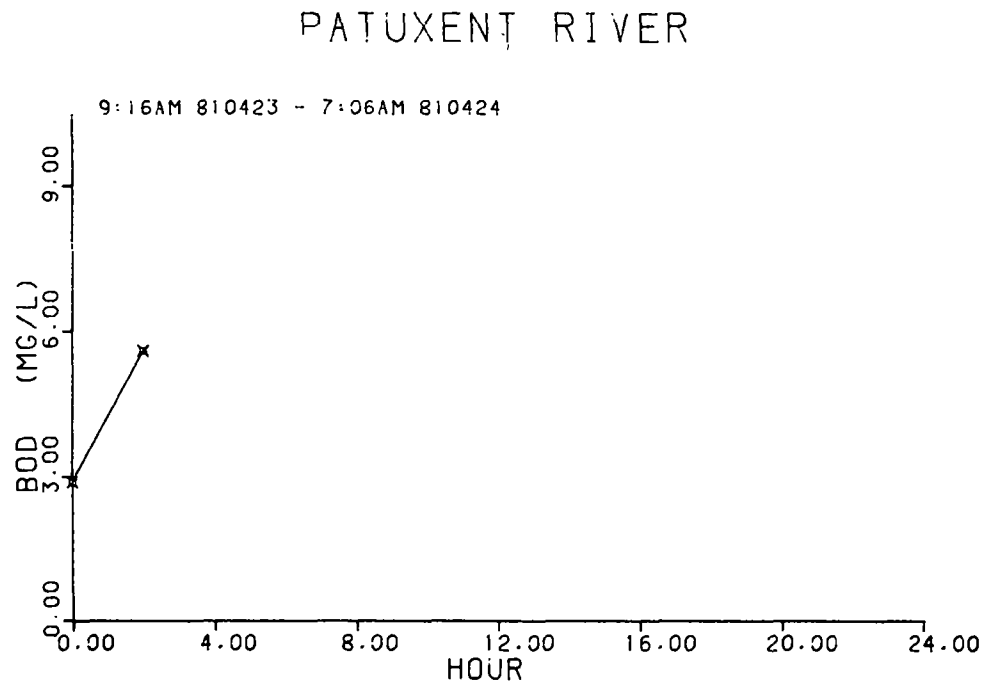
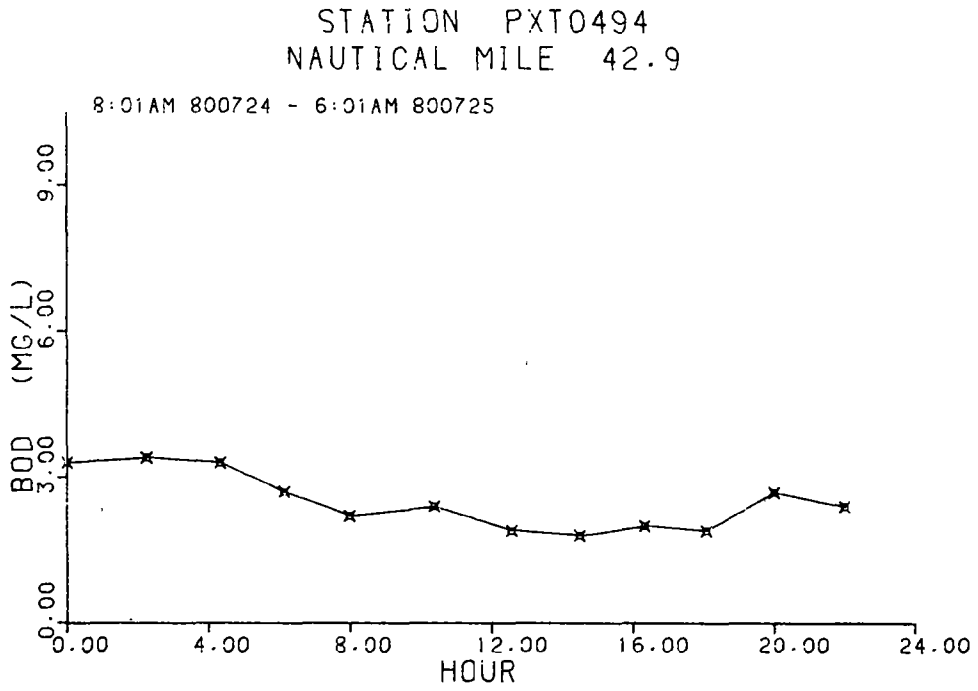


Figure 9-19 Intensive river survey plots of BOD_5.



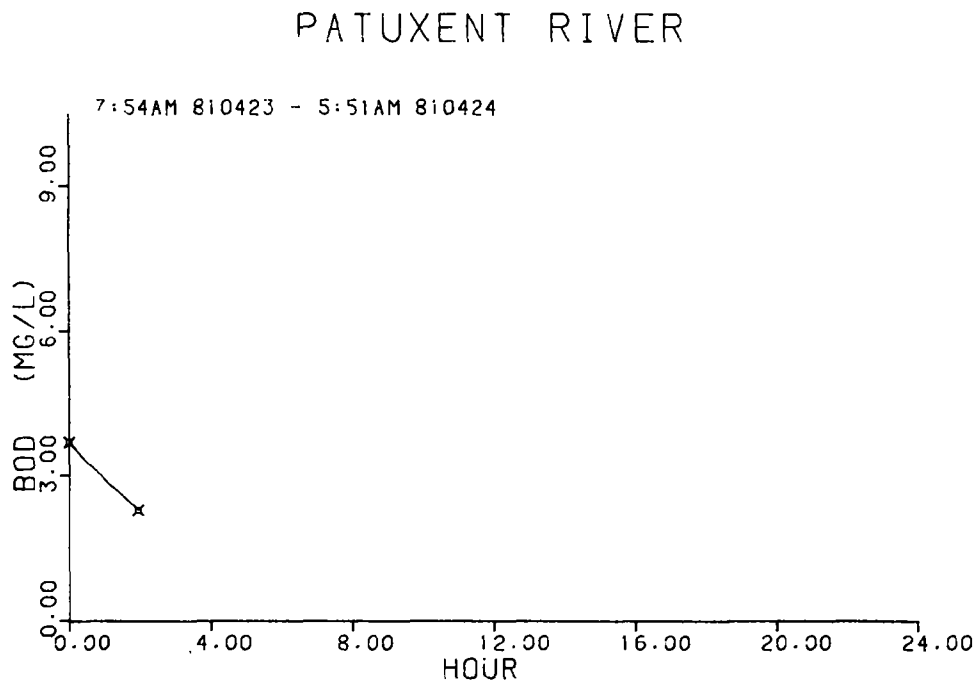
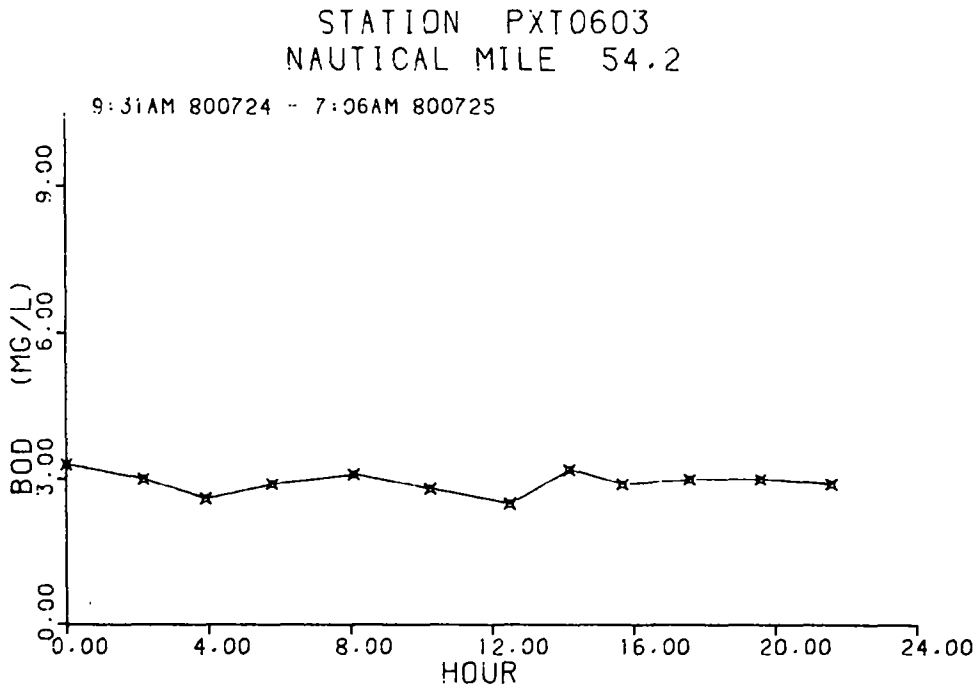


Figure 9-19 Intensive river survey plots of BOD_5.



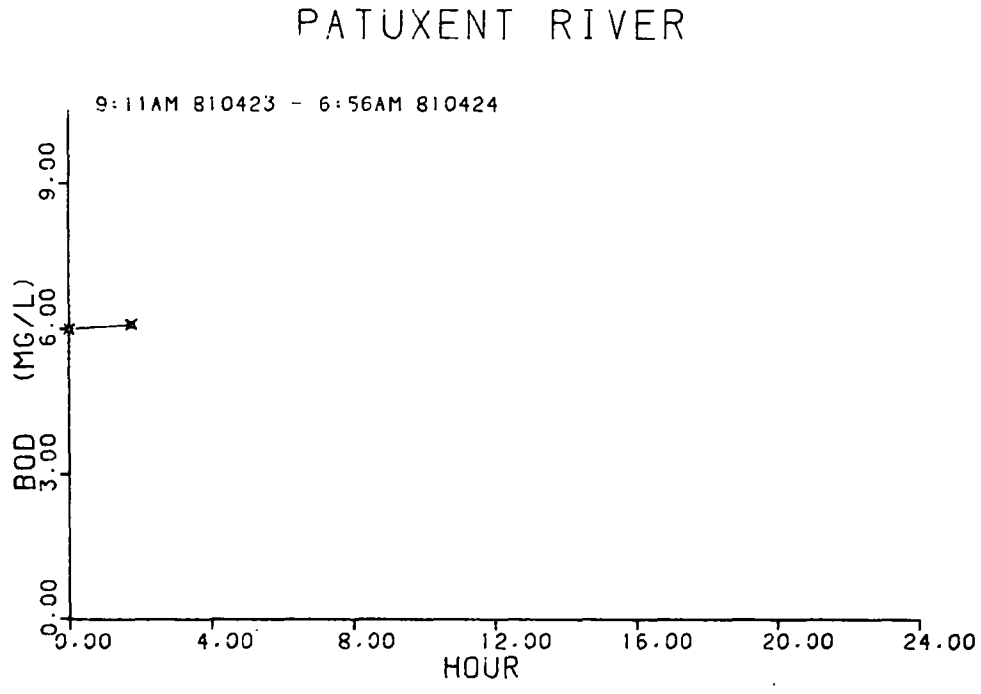


Figure 9-19 Intensive river survey plots of BOD_5.

Table 9-1
Statistical Summary of Patuxent River Intensive Survey Data for 1980-1981

Variable	Year	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
Temp	80	198	26.58	1.77	0.13	6.65
	81	173	15.91	1.38	0.10	8.64
DO	80	197	5.44	1.60	0.11	29.47
	81	173	8.45	1.34	0.10	15.89
DOSAT	80	197	69.63	21.21	1.51	30.45
	81	173	90.11	14.73	1.12	16.35
BOD5	80	190	2.55	1.39	0.10	54.32
	81	171	3.69	1.64	0.13	44.34
PH	80	198	7.13	0.39	0.03	5.46
	81	173	7.78	0.70	0.05	8.99
TALK	80	198	49.6	16.36	1.16	32.97
	81	174	54.88	14.09	1.07	25.67
SALIN	80	152	8.09	5.97	0.48	73.72
	81	128	11.75	6.19	0.55	52.71
RESIDUE	80	194	32.90	23.30	1.67	70.82
	81	174	40.14	37.34	2.83	93.03
TOTN	80	194	1.21	0.76	0.05	62.70
	81	174	1.44	1.13	0.09	78.65
DISSNIT	80	143	0.83	0.55	0.05	66.51
	81	174	1.21	1.12	0.08	92.15
FAMMON	80	194	0.13	0.11	0.01	84.30
	81	174	0.28	0.34	0.03	118.36
FNITRITE	80	194	0.06	0.09	0.01	149.72
	81	174	0.04	0.06	0.0	126.36
FNITRATE	80	190	0.43	0.55	0.04	129.04
	81	174	0.67	0.82	0.06	122.39
TPHOS	80	193	0.18	0.16	0.01	93.12
	81	174	0.15	0.16	0.01	105.30
FPHOS	80	195	0.08	0.09	0.01	114.36
	81	174	0.06	0.08	0.01	128.78
FOPHOS	80	195	0.06	0.09	0.01	145.62
	81	174	0.05	0.09	0.01	187.81
TOC	80	195	8.44	4.06	0.29	48.14
	81	0	--	--	--	---
DOC	80	0	--	--	--	---
	81	174	4.13	1.60	0.12	38.72
CHLORIDE	80	197	3027.7	2949.9	210.17	97.43
	81	0	--	--	--	---
SILICA	80	196	4.99	2.87	0.20	57.50
	81	174	4.22	3.42	0.26	81.02
CHLORA	80	197	14.57	19.94	1.42	136.83
	81	174	23.72	12.08	0.92	50.94
CHLORAC	80	0	--	--	--	---
	81	156	14.95	10.60	0.85	70.94
PHEOP	80	197	7.54	6.12	0.44	81.18
	81	174	7.08	8.67	0.66	122.51

Table 9-2 Statistical Summary of Patuxent River Intensive Survey Data for 1980-1981, Surface, Bottom, and Mid Depths.

Variable	Depth	Year	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
TEMP	S	80	75	27.56	1.00	0.12	3.62
	S	81	65	15.78	1.37	0.17	8.710
	M	80	36	24.72	1.70	0.28	6.89
	M	81	32	16.37	0.83	0.15	5.07
	B	80	87	26.51	1.68	0.18	6.34
	B	81	76	15.83	1.53	0.17	9.63
DO	S	80	74	6.11	1.39	0.16	22.70
	S	81	65	8.88	0.97	0.12	10.90
	M	80	36	4.85	0.71	0.12	14.73
	M	81	32	7.30	1.43	0.25	19.54
	B	80	87	5.10	1.83	0.20	35.90
	B	81	76	8.57	1.33	0.15	15.48
DOSAT	S	80	74	80.09	18.35	2.13	22.91
	S	81	65	95.91	10.02	1.24	10.44
	M	80	36	58.36	7.95	1.32	13.62
	M	81	32	74.45	15.12	2.67	20.32
	B	80	87	65.41	23.41	2.51	35.79
	B	81	76	91.73	13.46	1.54	14.67
BOD5	S	80	74	2.88	1.65	0.19	57.36
	S	81	62	3.66	1.69	0.21	46.52
	M	80	36	2.51	0.53	0.09	21.07
	M	81	34	4.24	1.45	0.25	34.18
	B	80	80	2.27	1.33	0.15	58.66
	B	81	75	3.50	1.64	0.19	46.90
pH	S	80	75	7.18	0.42	0.05	5.83
	S	81	65	8.00	0.72	0.09	8.98
	M	80	36	7.02	0.20	0.03	2.83
	M	81	32	7.14	0.23	0.04	3.28
	B	80	87	7.13	0.41	0.04	5.82
	B	81	76	7.86	0.66	0.08	8.39
TALK	S	80	75	54.20	13.48	1.56	24.86
	S	81	65	59.30	12.24	1.52	20.64
	M	80	36	29.82	2.33	0.39	7.83
	M	81	32	36.79	1.51	0.27	4.11
	B	80	87	53.83	15.94	1.71	29.61
	B	81	77	58.66	12.47	1.42	21.26
SALIN	S	80	74	8.04	5.85	0.68	72.85
	S	81	64	11.69	6.10	0.76	52.13
	M	80	3	0.17	0.12	0.07	69.28
	M	81	1	0.30	--	--	--
	B	80	75	8.46	6.01	0.69	71.00
	B	81	63	12.0	6.22	0.78	51.84

* Surface, Mid, and Bottom.

Table 9-2 (continued)
Statistical Summary of Patuxent River Intensive Survey
Data for 1980-1981, Surface, Bottom, and Mid Depths.

Variable	Depth	Year	N	Mean	Standard Deviation	Mean Error	Coefficient of Variation
RESIDUE	S	80	74	21.27	6.99	0.81	32.86
	S	81	65	35.58	20.35	2.52	57.20
	M	80	33	41.98	18.08	3.15	43.08
	M	81	32	19.78	6.96	1.23	35.21
	B	80	87	39.34	29.41	3.15	74.749
	B	81	77	52.44	49.60	5.65	94.58
TOTN	S	80	74	0.97	0.66	0.08	67.53
	S	81	65	1.01	0.67	0.08	66.75
	M	80	35	2.37	0.40	0.07	16.90
	M	81	32	3.38	0.54	0.10	16.09
	B	80	85	0.94	0.45	0.05	47.6
	B	81	77	0.99	0.68	0.08	68.44
DISSNIT	S	80	73	0.67	0.42	0.05	62.42
	S	81	65	0.82	0.70	0.09	85.84
	M	80	12	2.08	0.17	0.05	8.08
	M	81	32	3.11	0.50	0.09	16.17
	B	80	58	0.77	0.40	0.05	52.58
	B	81	77	0.75	0.66	0.08	88.66
FAMMON	S	80	73	0.06	0.04	0.01	66.81
	S	81	65	0.20	0.24	0.03	124.14
	M	80	36	0.29	0.14	0.02	47.91
	M	81	32	0.71	0.33	0.06	45.86
	B	80	85	0.13	0.07	0.01	51.88
	B	81	77	0.18	0.26	0.03	144.86
FINITRITE	S	80	74	0.03	0.03	0.0	120.61
	S	81	65	0.02	0.03	0.0	126.10
	M	80	34	0.23	0.10	0.02	42.53
	M	81	32	0.14	0.04	0.01	29.18
	B	80	86	0.03	0.03	0.0	109.95
	B	81	77	0.02	0.03	0.0	149.48
FINITRATE	S	80	73	0.23	0.37	0.04	162.75
	S	81	65	0.36	0.47	0.06	130.45
	M	80	34	1.36	0.22	0.04	16.35
	M	81	32	2.13	0.30	0.05	14.11
	B	80	83	0.22	0.34	0.04	156.55
	B	81	77	0.32	0.44	0.05	137.09
TPHOS	S	80	73	0.10	0.08	0.01	77.72
	S	81	65	0.08	0.06	0.01	78.25
	M	80	34	0.47	0.15	0.03	32.50
	M	81	32	0.40	0.17	0.03	43.15
	B	80	86	0.12	0.07	0.01	59.16
	B	81	77	0.11	0.10	0.01	92.09

* Surface, Mid, and Bottom.

Table 9-2 (continued)
Statistical Summary of Patuxent River Intensive Survey
Data for 1980-1981, Surface, Bottom, and Mid depths.

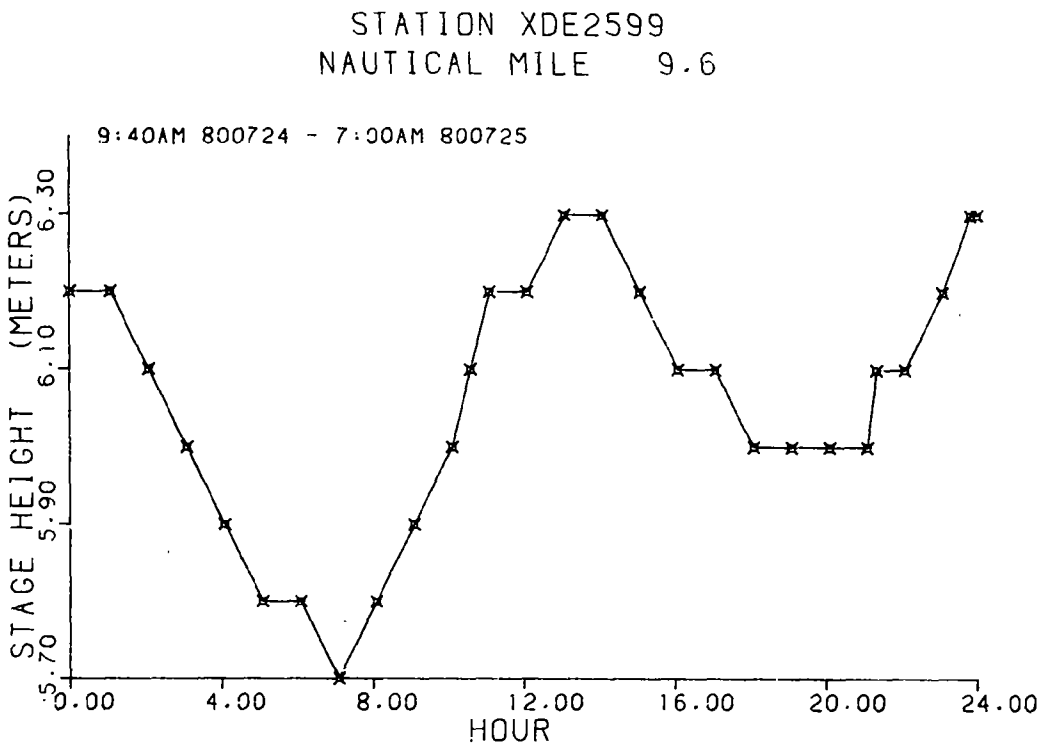
Variable	Depth	Year	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
FPHOS	S	80	74	0.05	0.03	0.0	59.54
	S	81	65	0.03	0.01	0.0	15.43
	M	80	36	0.22	0.13	0.02	59.96
	M	81	32	0.21	0.12	0.0	56.73
	B	80	85	0.05	0.03	0.0	59.93
	B	81	77	0.03	0.01	0.0	20.96
FOPHOS	S	80	74	0.03	0.02	0.0	82.90
	S	81	65	0.01	0.02	0.0	115.39
	M	80	36	0.21	0.13	0.02	61.86
	M	81	32	0.21	0.13	0.02	61.18
	B	80	85	0.03	0.02	0.0	60.09
	B	81	77	0.01	0.02	0.0	114.24
TOC	S	80	73	7.94	4.10	0.48	51.70
	S	81	0	--	--	--	--
	M	80	36	9.01	3.63	0.61	40.32
	M	81	0	--	--	--	--
	B	80	86	8.63	4.20	0.45	48.60
	B	81	0	--	--	--	--
DOC	S	80	0	--	--	--	--
	S	81	65	3.69	1.55	0.19	42.03
	M	80	0	--	--	--	--
	M	81	32	4.95	1.30	0.23	26.31
	B	80	0	--	--	--	--
	B	81	77	4.16	1.63	0.19	39.13
CHLORIDE	S	80	75	3805.8	2653.3	306.38	69.72
	S	81	0	--	--	--	--
	M	80	36	21.67	4.04	0.67	18.66
	M	81	0	--	--	--	--
	B	80	86	3607.4	3039.0	327.71	84.24
	B	81	0	--	--	--	--
SILICA	S	80	74	3.73	1.88	0.22	50.44
	S	81	65	3.42	3.34	0.41	97.91
	M	80	36	8.78	0.86	0.14	9.85
	M	81	32	8.11	0.65	0.12	8.04
	B	80	86	4.49	2.80	0.30	62.26
	B	81	77	3.29	3.04	0.35	92.49
CHLORA	S	80	75	23.29	24.12	2.79	103.55
	S	81	65	24.67	8.33	1.03	33.78
	M	80	36	3.88	3.47	0.21	89.21
	M	81	32	12.88	9.42	1.67	73.16
	B	80	86	11.44	16.73	1.80	146.24
	B	81	77	27.42	13.17	1.50	48.05

* Surface, Mid, and Bottom.

Table 9-2 (continued)
Statistical Summary of Patuxent River Intensive Survey
Data for 1980-1981, Surface, Bottom, and Mid depths.

Variable	Depth	Year	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
CHLORAC	S	80	0	--	--	--	--
	S	81	53	17.40	8.29	1.14	47.65
	M	80	0	--	--	--	--
	M	81	32	6.28	6.21	1.10	98.96
	B	80	0	--	--	--	--
	B	81	71	17.03	11.73	1.39	68.88
PHEOP	S	80	75	7.77	5.88	0.68	75.68
	S	81	65	4.85	7.26	0.90	149.66
	M	80	36	3.83	2.15	0.36	55.97
	M	81	32	7.43	6.93	1.22	93.17
	B	80	86	8.90	6.84	0.74	76.83
	B	81	77	8.80	9.99	1.14	113.45

* Surface, Mid, and Bottom.



PATUXENT RIVER

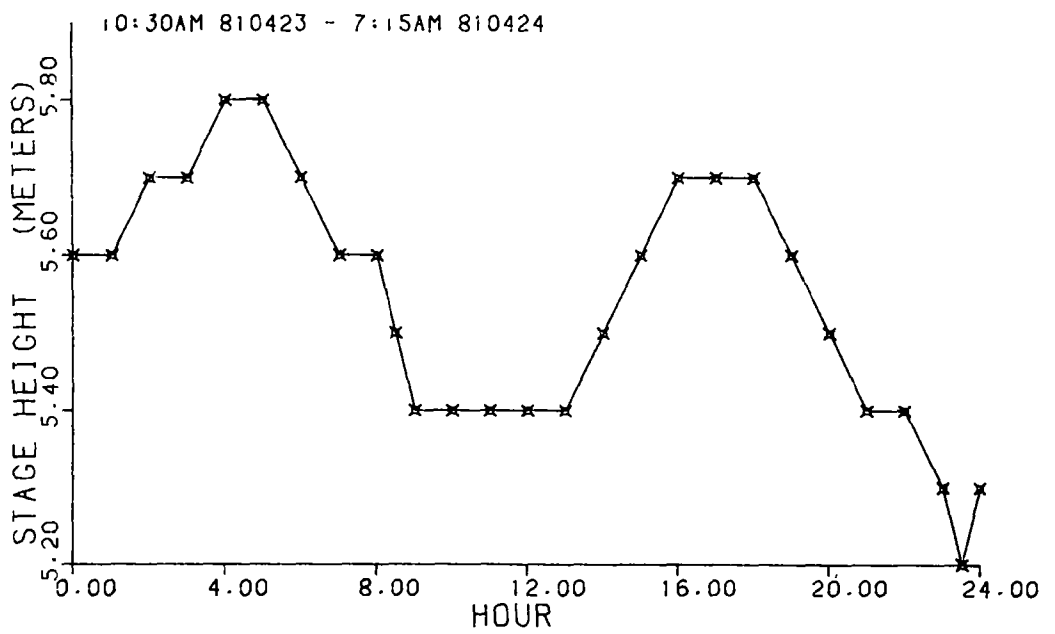


Figure 9-20 Patuxent River stage height observed during the July, 1980 and April, 1981 intensive water quality survey.

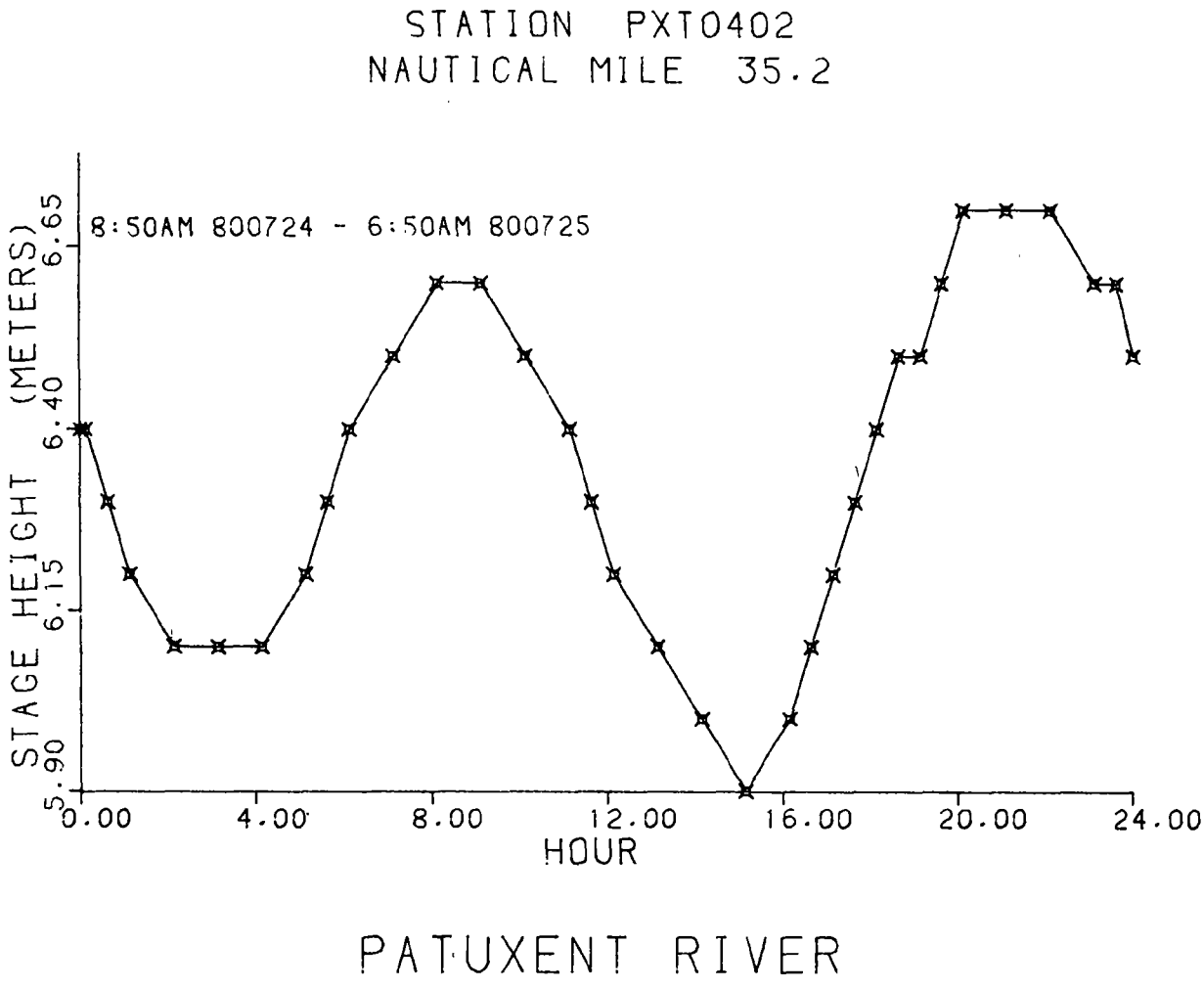


Figure 9-20 Lower Patuxent River stage height observed at station PXT0402 during the July, 1980 intensive river water quality survey.

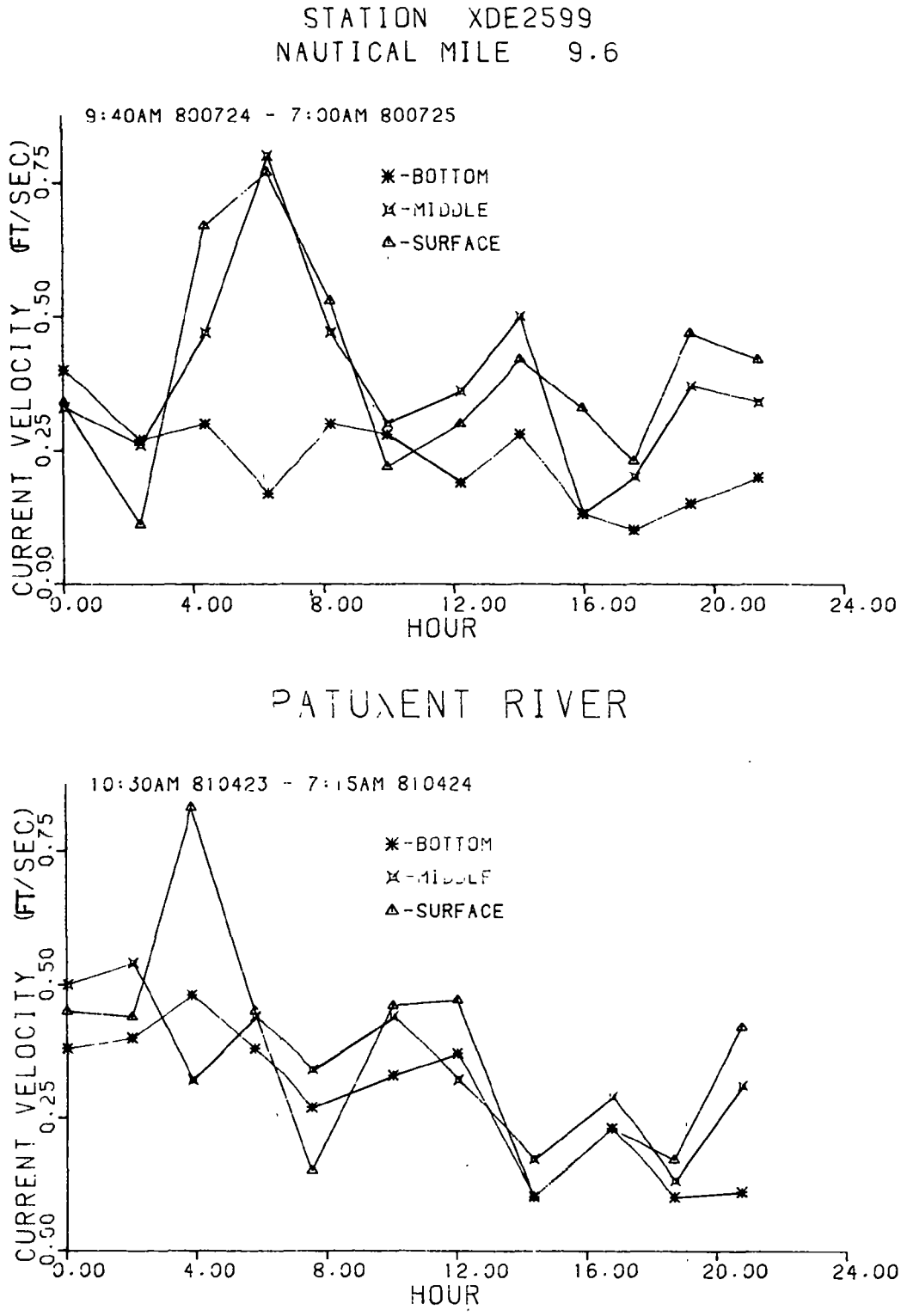
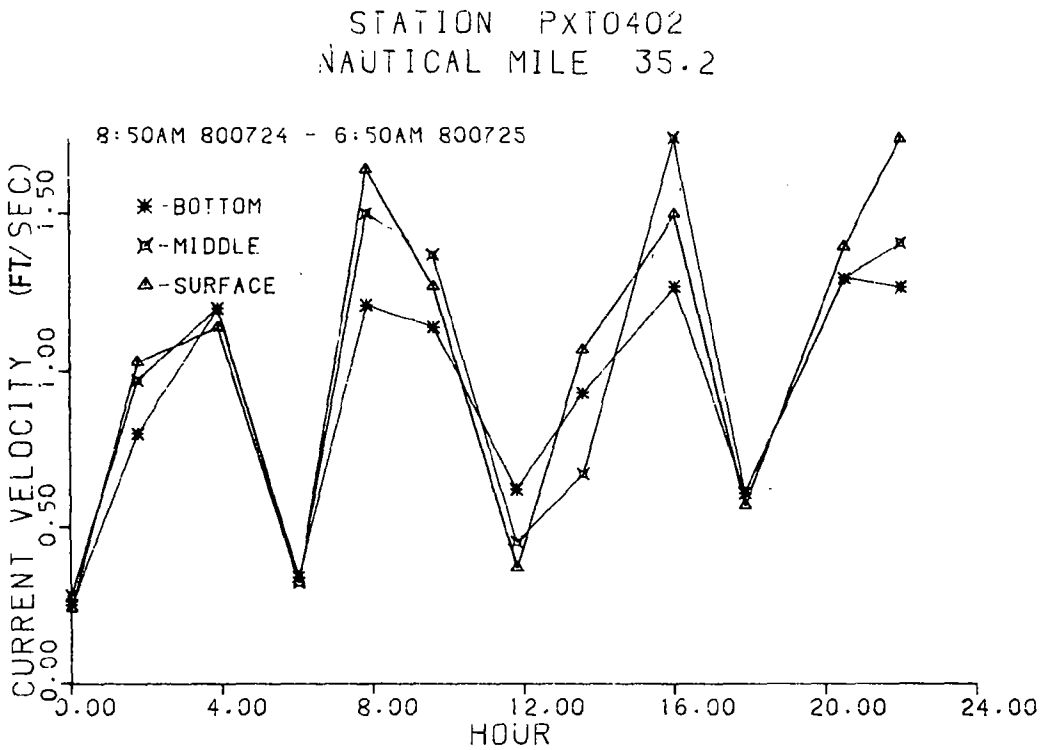


Figure 9-21 Patuxent River current velocity measured during the July and April intensive water quality surveys.



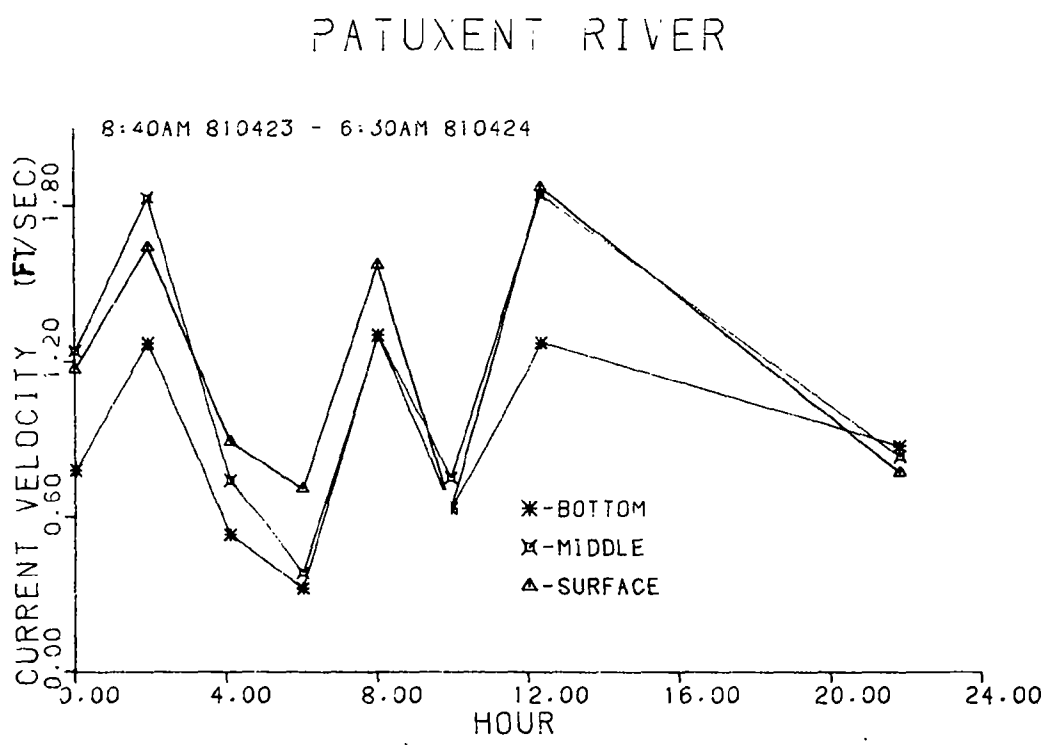


Figure 9-21 Patuxent River current velocity measured during the July and April intensive water quality surveys.

APPENDIX I

FIGURES AND TABLES OF DISSOLVED OXYGEN CHARACTERISTICS

SECTION 10

Table 10-1
Patuxent River Dissolved Oxygen For Years 1936-1981

Years	Mean	Standard Deviation	N	Correlation* Coefficient
1936	6.84	1.99	130	-.286
1937	6.28	2.12	191	-.269
1938	8.42	2.39	49	.440
1939	7.59	2.81	192	-.645
1940	11.16	3.48	11	-.643
1949	6.56	1.25	44	.435
1950	9.09	2.37	37	-.745
1951	10.19	.714	8	-.012
1952	4.45	2.05	2	--
1957	4.66	1.54	18	-.273
1958	6.1	3.69	37	-.432
1959	8.61	2.96	107	-.2
1960	6.76	3.37	75	-.542
1961	3.44	3.19	34	-.572
1962	7.02	1.67	67	.436
1963	6.88	2.34	709	-.153
1964	9.47	2.97	169	-.306
1965	8.27	1.32	102	.386
1966	9.41	3.05	26	.523
1967	8.39	2.13	61	-.046
1968	9.48	1.63	40	-.138
1969	9.07	2.89	173	.154
1970	9.16	2.31	81	-.017
1971	11.23	1.16	12	.551
1974	8.10	2.28	44	.396
1975	8.93	1.89	33	.108
1976	7.77	2.85	14	.446
1977	9.28	2.06	239	.167
1978	5.47	2.77	604	-.415
1980	6.27	2.33	247	-.109
1981	7.92	2.10	245	-.010

*From regression of DO vs Salinity.

Table10-2Patuxent River Dissolved Oxygen Upper River (.2-10.0 ppt) Salinity For Years 1936-1981

Year	Mean	Standard Deviation	N	Correlation* Coefficient
1936	7.58	1.24	36	.062
1937	7.15	1.64	28	.296
1939	10.66	1.87	51	.011
1940	17.4	--	1	--
1952	5.9	--	1	--
1957	5.27	.32	3	--
1958	7.17	3.0	31	.086
1959	9.85	1.58	15	.108
1960	8.91	1.70	46	.379
1961	5.65	2.85	11	-.117
1962	6.56	1.63	44	.152
1963	7.56	1.97	130	-.110
1964	9.97	2.54	114	-.205
1965	7.80	1.47	55	.280
1966	6.85	3.53	6	.715
1967	8.66	2.06	45	.042
1968	9.75	1.79	22	-.012
1969	9.15	2.96	132	.298
1970	9.10	2.30	67	-.075
1971	11.23	1.16	12	.551
1974	7.74	2.36	34	.274
1975	8.93	1.89	33	.108
1976	7.77	2.85	14	.446
1977	9.11	1.94	103	.455
1978	6.63	2.23	310	-.251
1979	12.4	--	1	--
1980	6.75	1.94	99	-.076
1981	7.93	2.07	83	-.267

*From regression of DO vs Salinity (Salinity = .2-10.0 ppt)

Table 10-3 Patuxent River Dissolved Oxygen Lower River (10.01-24.0 ppt) Salinity For Years 1936-1981

Year	Mean	Standard Deviation	N	Correlation* Coefficient
1936	6.56	2.15	94	-.255
1937	6.13	2.17	163	-.301
1938	8.42	2.39	49	.440
1939	6.48	2.20	141	-.4
1940	10.54	2.96	10	-.39
1949	6.57	1.25	44	.435
1950	9.09	2.37	37	-.745
1951	10.19	.714	8	-.012
1952	3.00	--	1	--
1957	4.53	1.61	15	-.302
1958	.58	.85	6	-.748
1959	8.40	3.09	92	-.138
1960	3.35	2.41	29	-.357
1961	2.39	2.82	23	-.456
1962	7.90	1.38	23	.504
1963	6.72	2.39	579	-.059
1964	8.44	3.53	55	-.193
1965	8.82	.83	47	-.109
1966	10.18	2.51	20	-.060
1967	7.63	2.22	16	.701
1968	9.14	1.38	18	.174
1969	8.8	2.65	41	-.010
1970	9.44	2.41	14	-.056
1974	9.33	1.55	10	.487
1977	9.41	2.15	136	-.172
1978	4.23	2.75	294	.042
1980	5.95	2.51	148	.249
1981	7.92	2.12	162	.163

*From regression of DO vs Salinity (Salinity = 10.01-24.0 ppt)

Table10-4 Patuxent River August Dissolved Oxygen For Years 1936-1981

Years	Mean	Standard Deviation	N	Correlation* Coefficient
1936	5.42	1.69	33	-.491
1937	6.04	1.03	80	-.305
1938	5.83	1.40	14	-.318
1939	5.09	1.91	46	-.391
1949	5.99	1.05	16	-.216
1958	2.89	2.43	18	-.788
1962	7.62	.87	33	.377
1963	6.12	1.12	477	-.192
1964	7.20	.84	22	.616
1965	7.12	1.11	30	.591
1966	6.46	1.33	5	.781
1967	7.27	1.05	34	-.218
1969	5.62	1.59	9	.626
1970	7.62	1.31	10	-.005
1976	7.50	--	1	--
1977	6.33	1.52	3	-.731
1978	5.46	2.20	95	-.599
1980	6.00	1.24	14	-.399
1981	4.90	1.24	14	-.235

*From regression of DO vs Salinity.

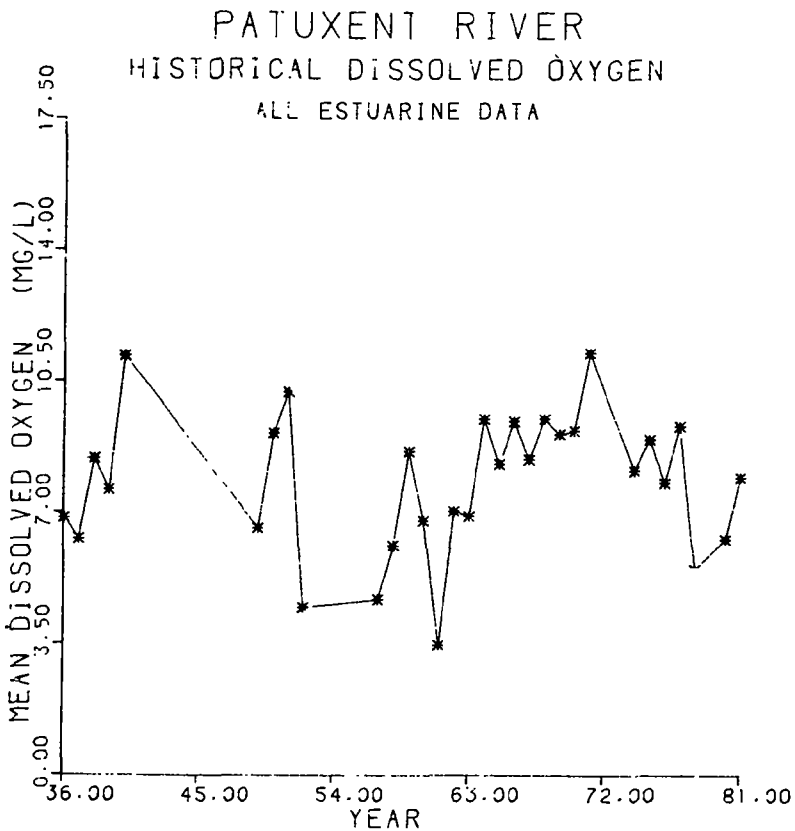


Figure 10-1 Historical yearly mean dissolved oxygen in the Patuxent Estuary.

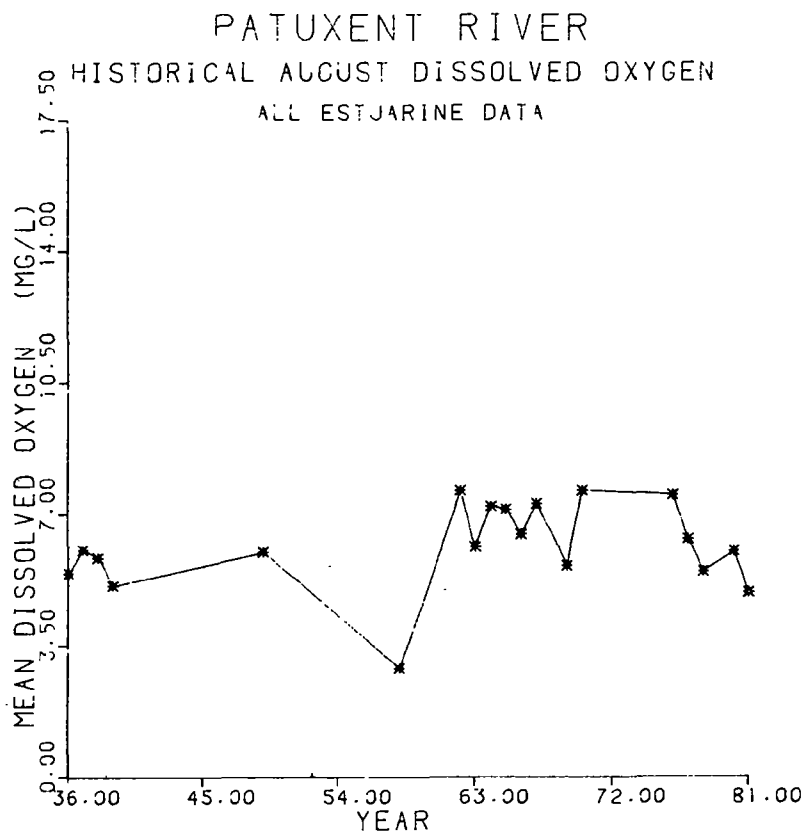


Figure 10-4 Historical yearly mean dissolved oxygen for the month of August in the Patuxent estuary.

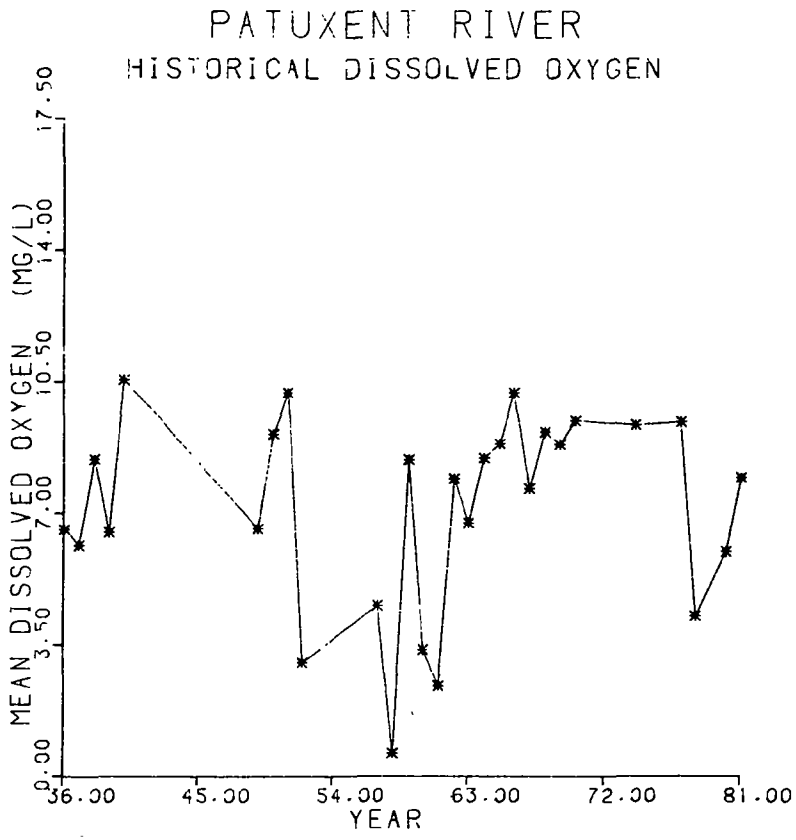


Figure 10-3 Historical yearly mean dissolved oxygen in the lower Patuxent Estuary.

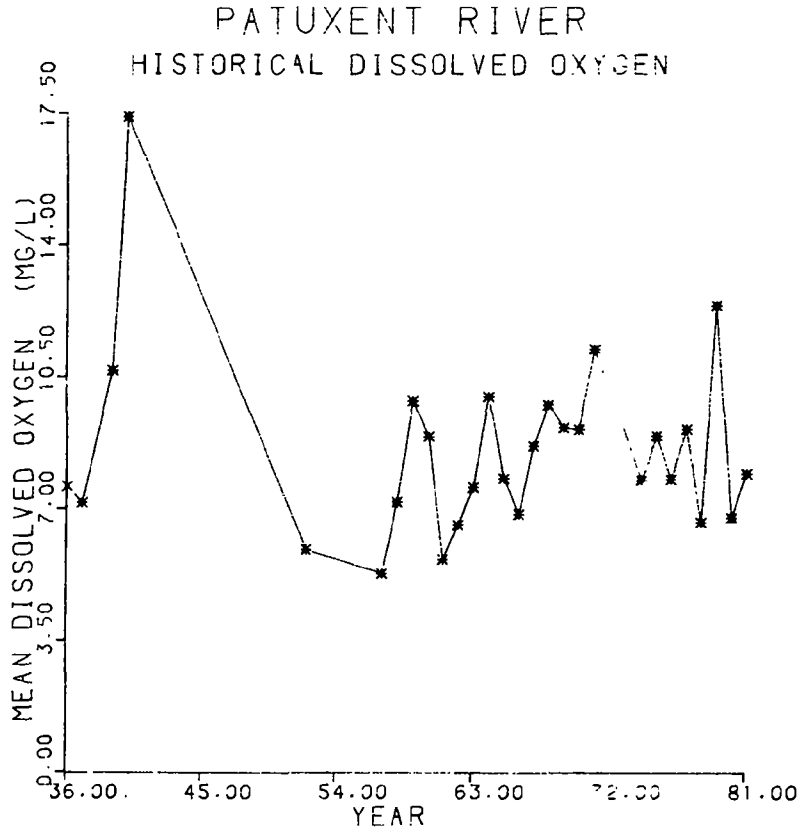


Figure 10-2 Historical yearly mean dissolved oxygen in the upper Patuxent Estuary.

Table10- 5Patuxent River August Dissolved Oxygen Upper River (.2-10.0 ppt) Salinity For Years 1936-1981

Years	Mean	Standard Deviation	N	Correlation* Coefficient
1936	6.47	.21	3	--
1937	6.57	.91	11	-.201
1939	6.63	1.86	3	--
1958	4.04	2.12	12	-.527
1962	7.56	1.18	11	.501
1963	6.38	.87	64	.325
1964	6.86	.71	11	.66
1965	6.97	.93	28	.55
1966	4.60	--	1	--
1967	7.73	.96	23	.424
1969	5.7	1.68	8	.892
1970	7.62	1.31	10	-.005
1976	7.50	--	1	--
1978	6.13	1.60	67	-.636
1980	5.96	1.49	5	-.897
1981	5.46	.86	5	-.619

*From regression of DO vs Salinity.

Table10- 6 Patuxent River August Dissolved Oxygen
Lower River (10.01-24.0 ppt) Salinity For Years 1936-1981

Years	Mean	Standard Deviation	N	Correlation* Coefficient
1936	5.32	1.74	30	-.494
1937	5.95	1.03	69	-.356
1938	5.83	1.40	14	-.318
1939	4.98	1.88	43	-.358
1949	5.99	1.05	16	-.216
1958	.58	.85	6	-.748
1962	7.65	.69	22	.365
1963	6.08	1.15	413	-.452
1964	7.54	.85	11	.511
1965	9.20	1.84	2	--
1966	6.93	.95	4	.190
1967	6.31	.34	11	-.456
1969	5.00	--	1	--
1977	6.33	1.52	3	--
1978	3.86	2.61	28	.071
1980	6.02	1.17	9	-.954
1981	4.59	1.35	9	.083

*From regression of DO vs Salinity (Salinity = 10.01-24.0 ppt)

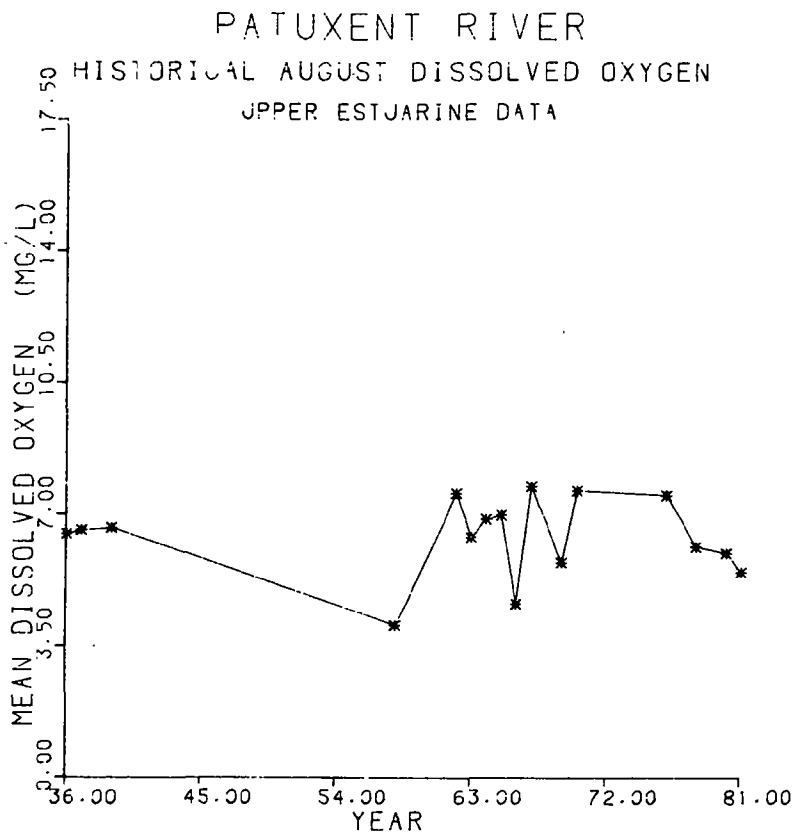


Figure 10-5 Historical yearly mean dissolved oxygen in the upper Patuxent Estuary for the month of August.

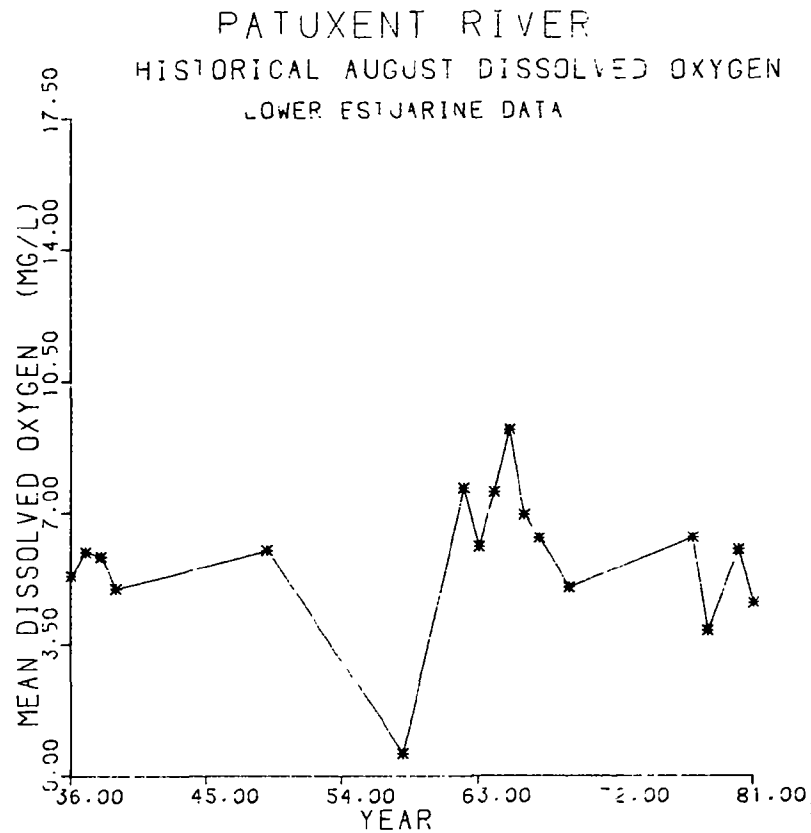


Figure 10-6 Historical yearly mean dissolved oxygen in the lower Patuxent Estuary for the month of August.

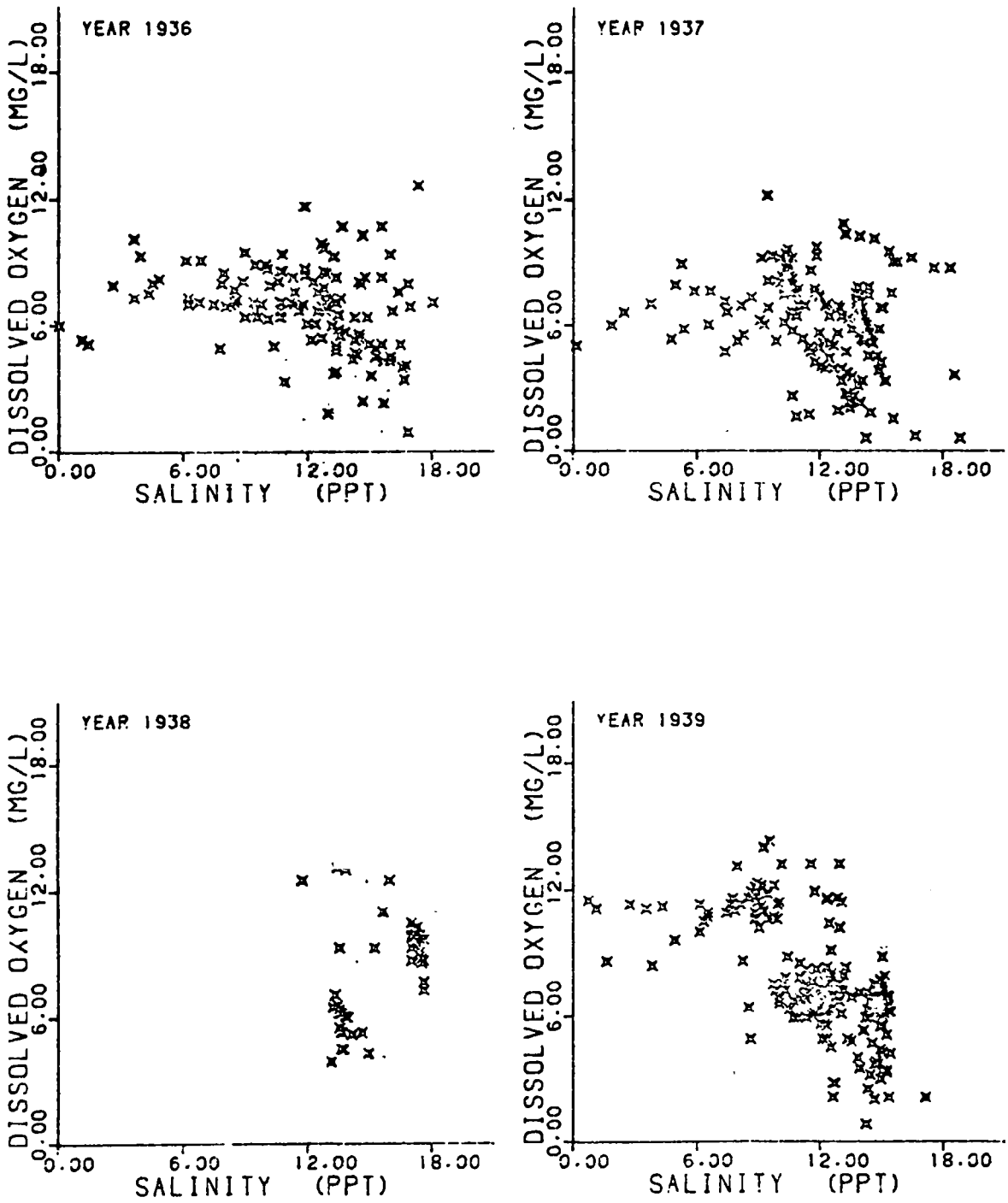


Figure 10-7 Patuxent River plots of historical dissolved oxygen versus salinity

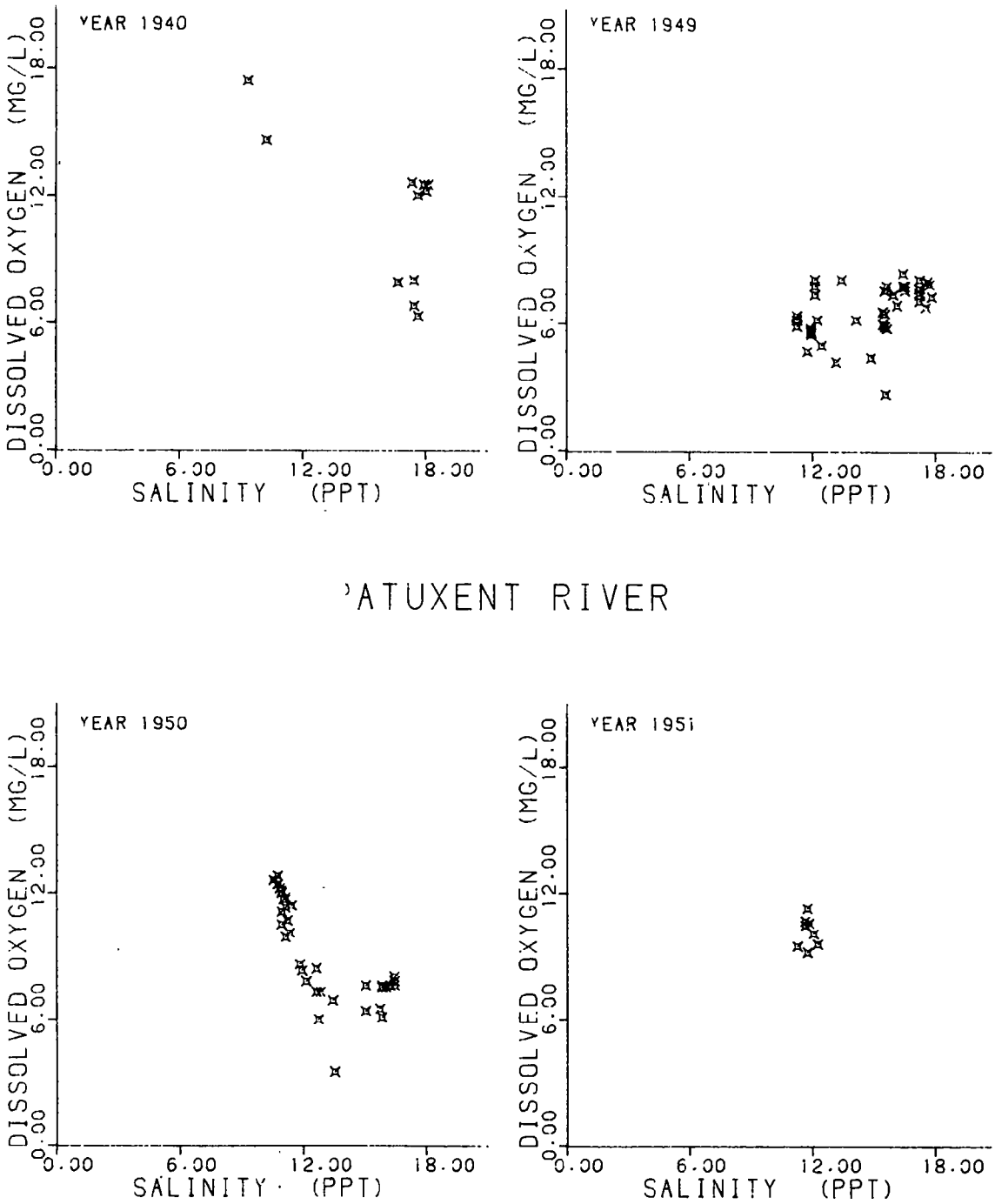


Figure 10-7 Patuxent River Plots of historical dissolved oxygen versus salinity.

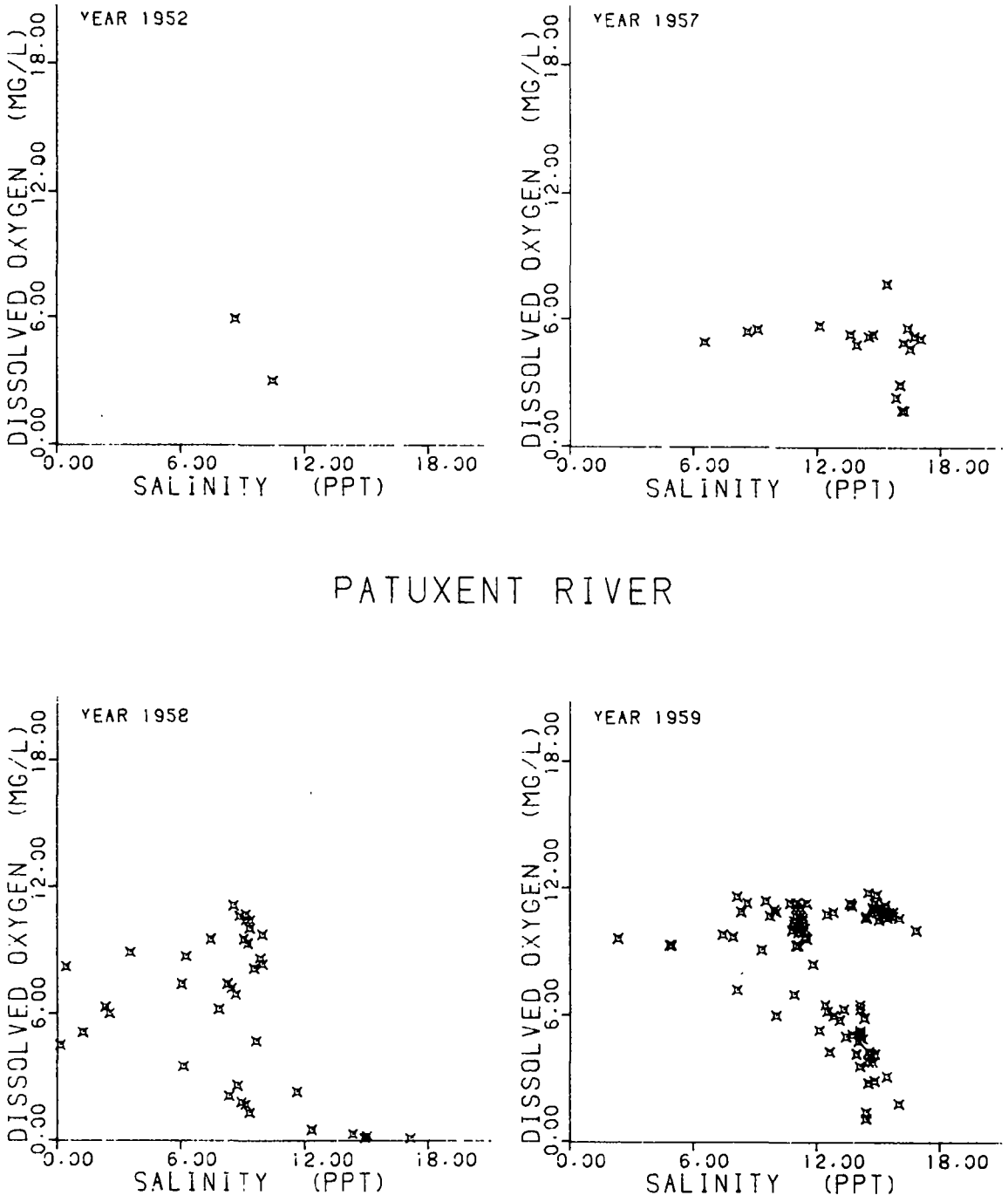


Figure 10-7 Patuxent River Plots of historical dissolved oxygen versus salinity.

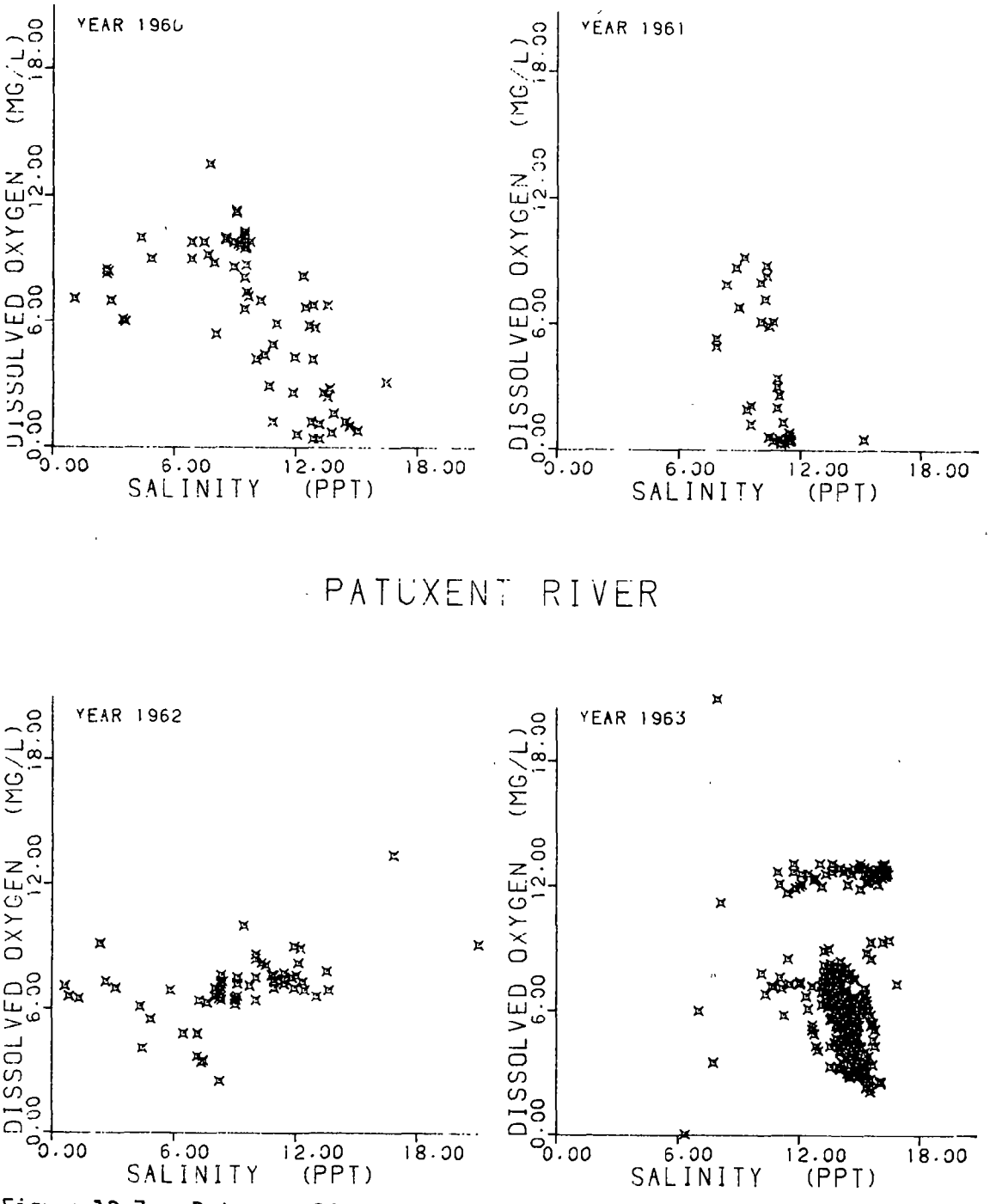


Figure 10-7 Patuxent River Plots of historical dissolved oxygen versus salinity.

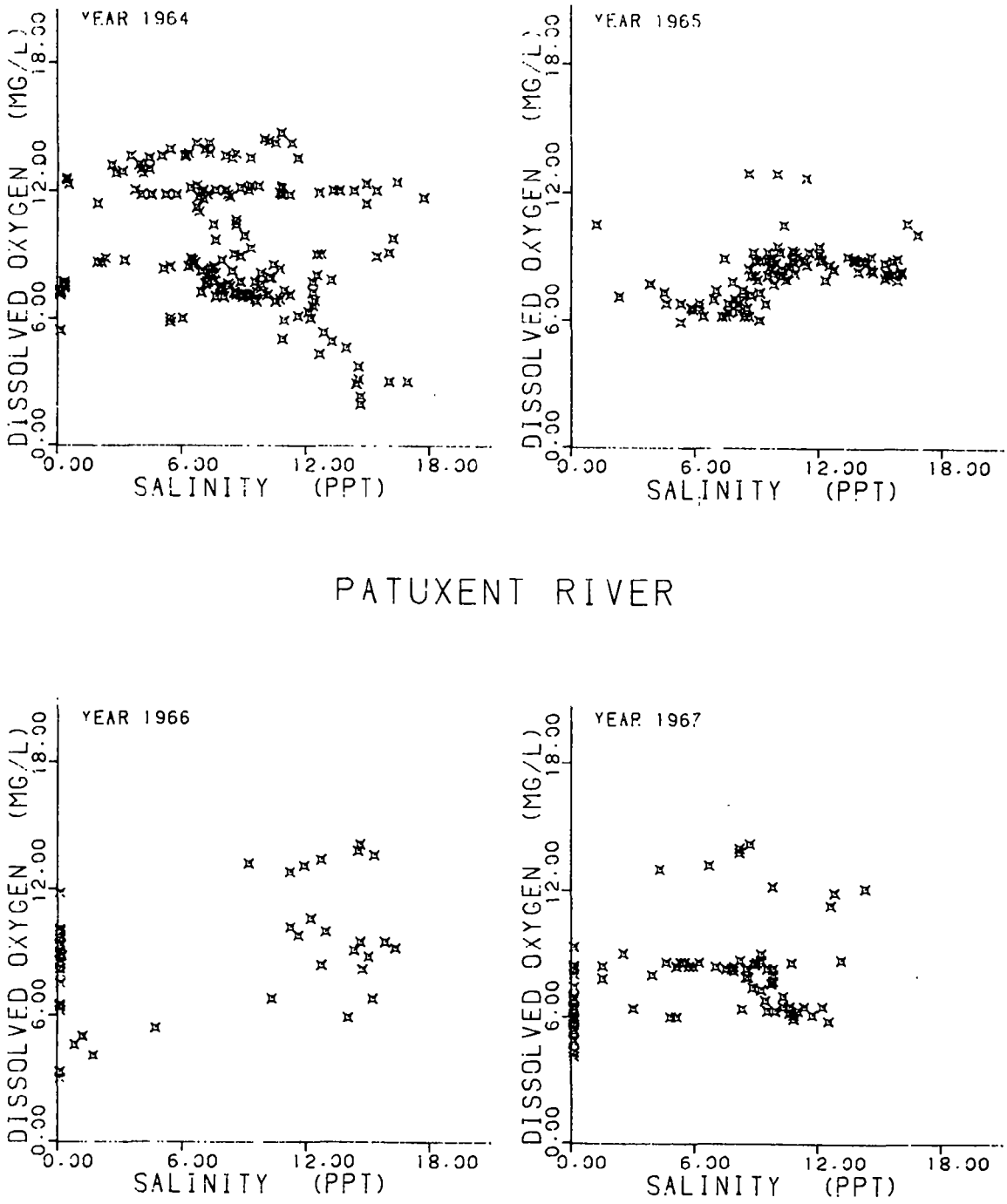


Figure 10-7 Patuxent River Plots of historical dissolved oxygen versus salinity.

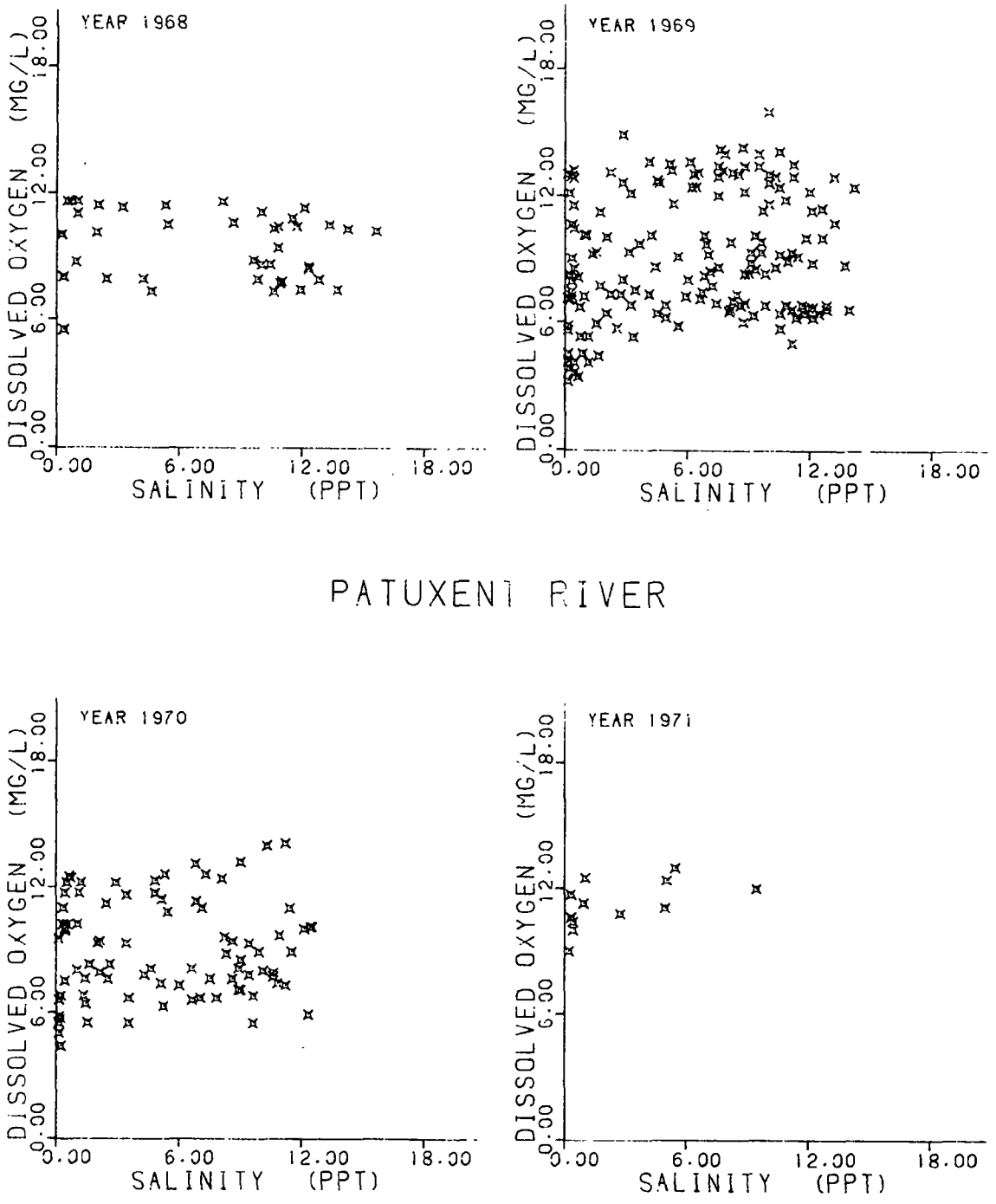


Figure 10-7 Patuxent River Plots of historical dissolved oxygen versus salinity.

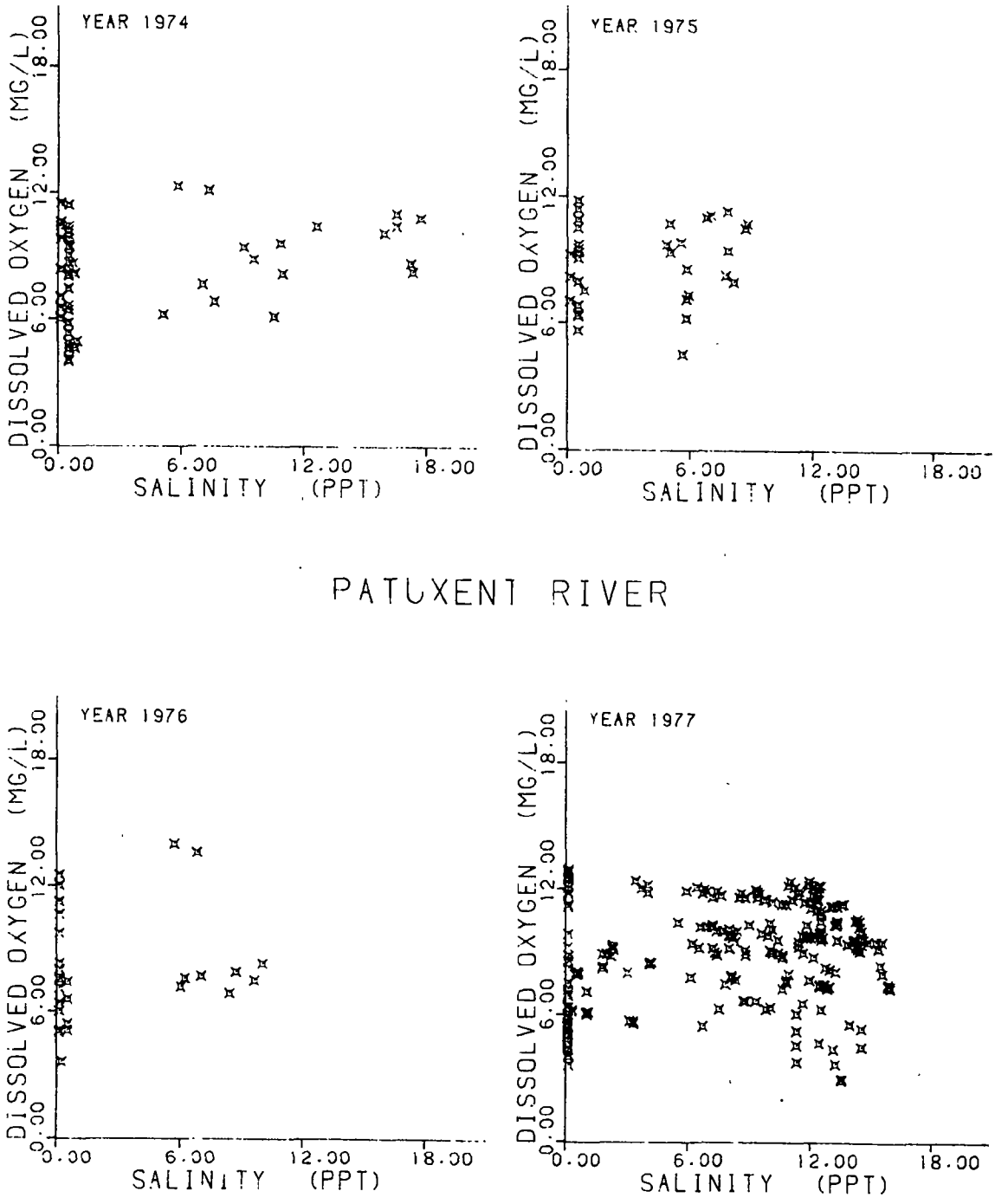
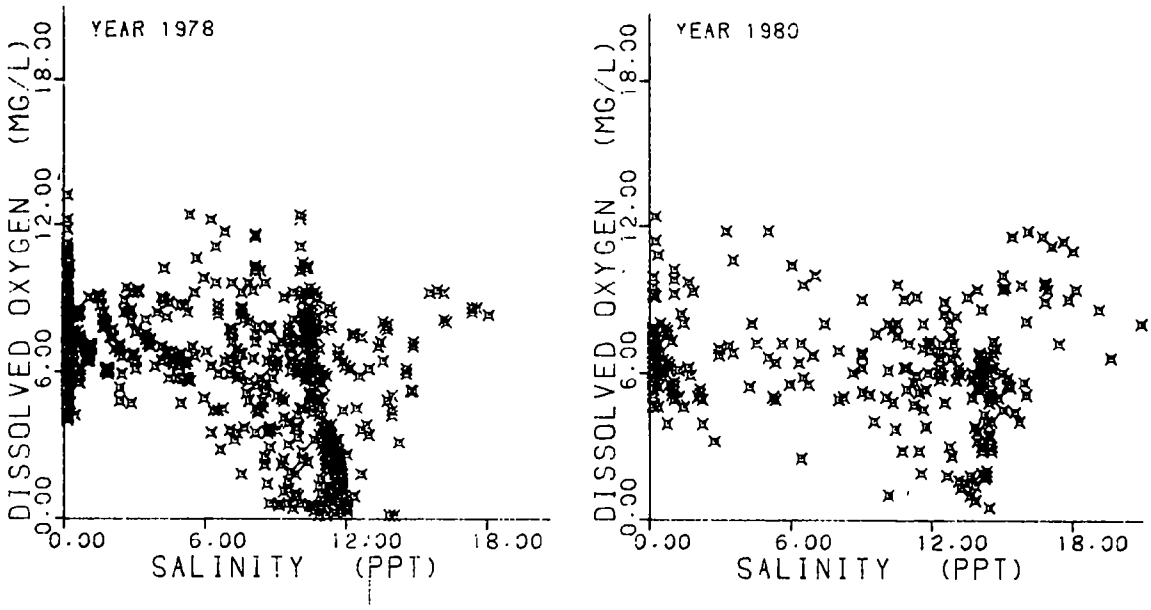


Figure 10-7 Patuxent River Plots of historical dissolved oxygen versus salinity.



PATUXENT RIVER

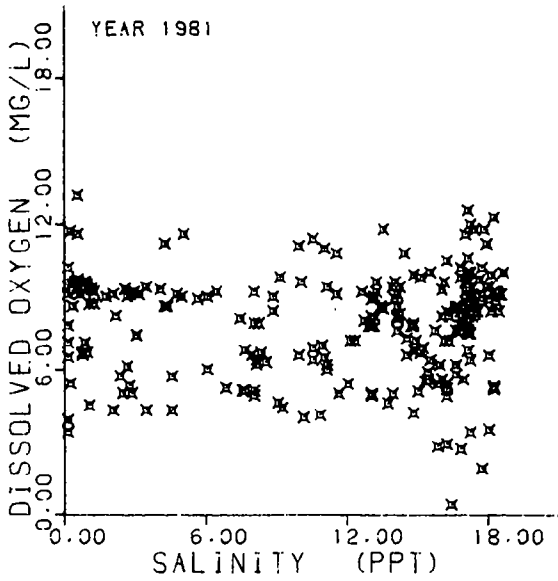


Figure 10-7 Patuxent River Plots of historical dissolved oxygen versus salinity.

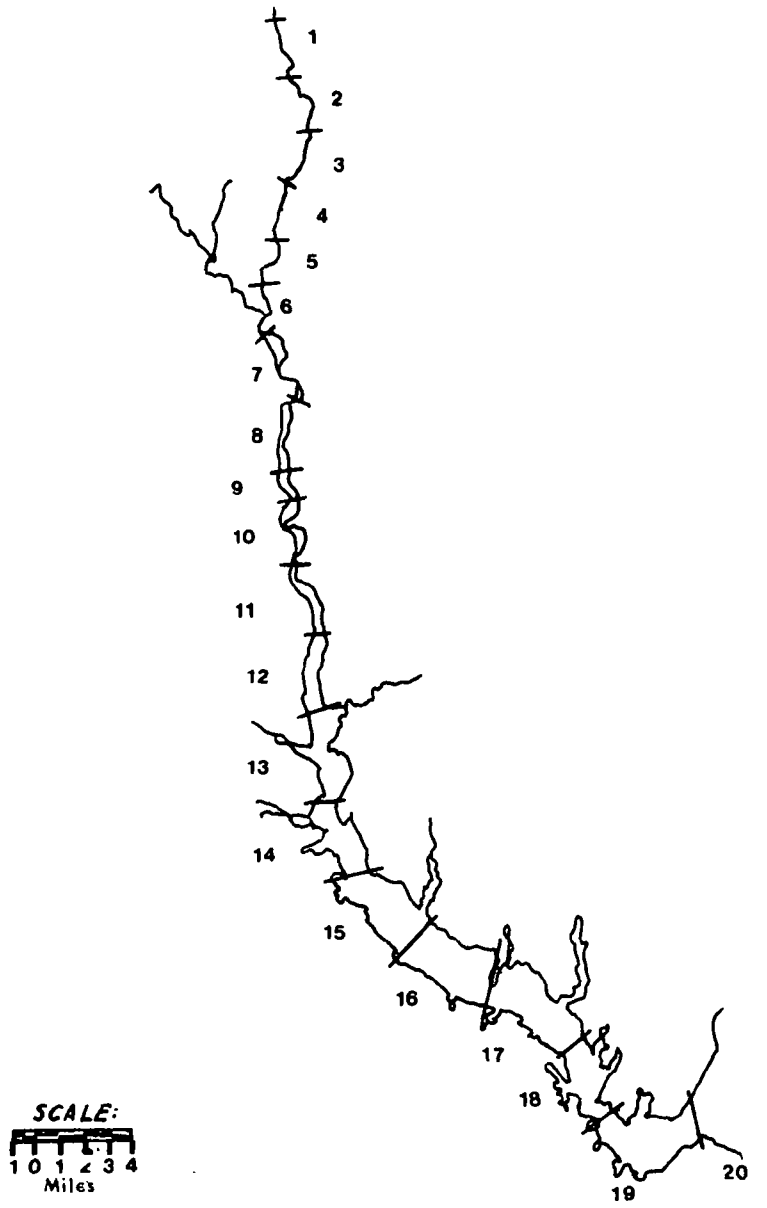


Figure 10-8 Patuxent River Segments for historical dissolved oxygen seasonal trend analysis.

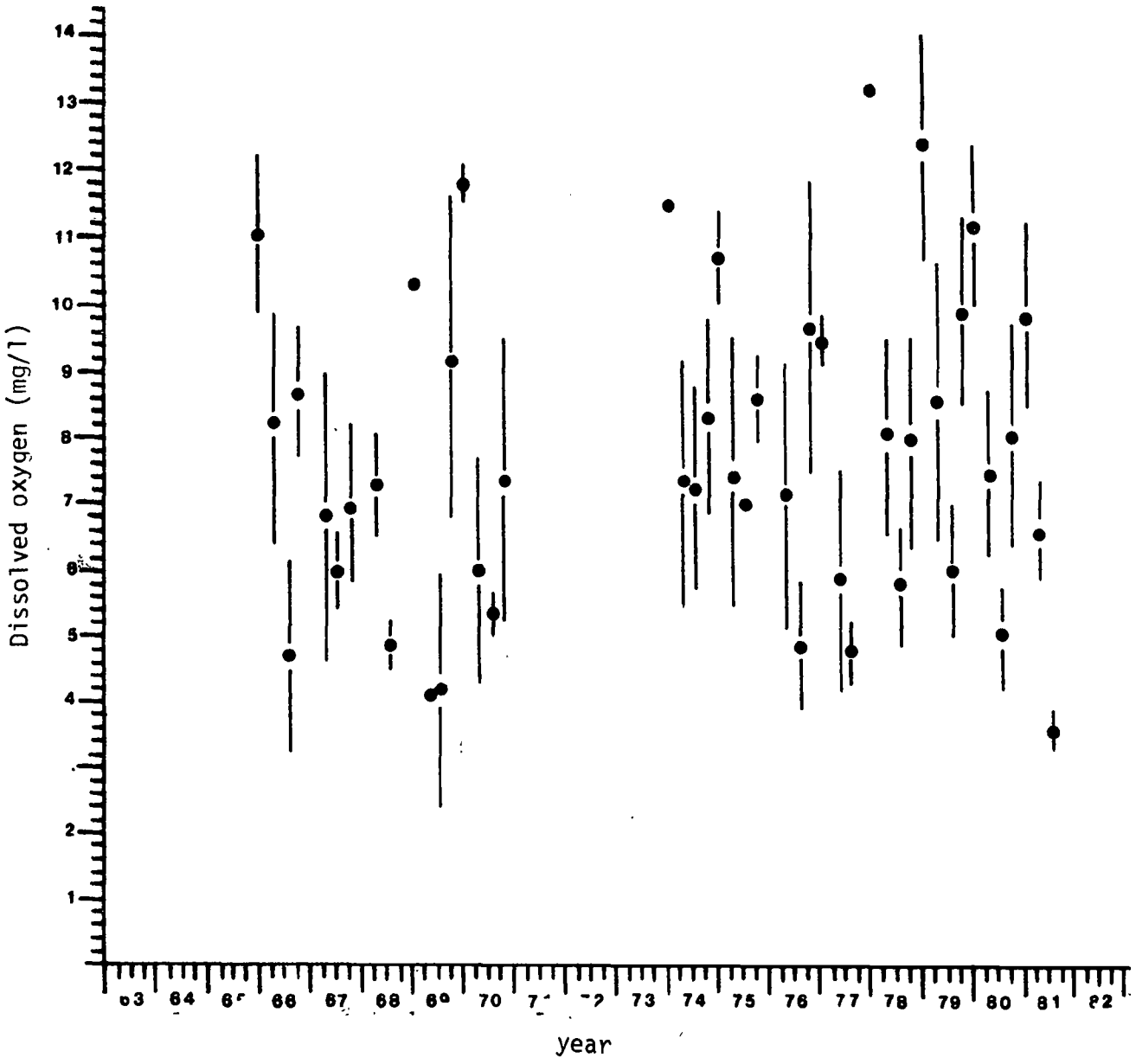


Figure 10-9 Patuxent River plot of historical seasonal dissolved oxygen - segment one.

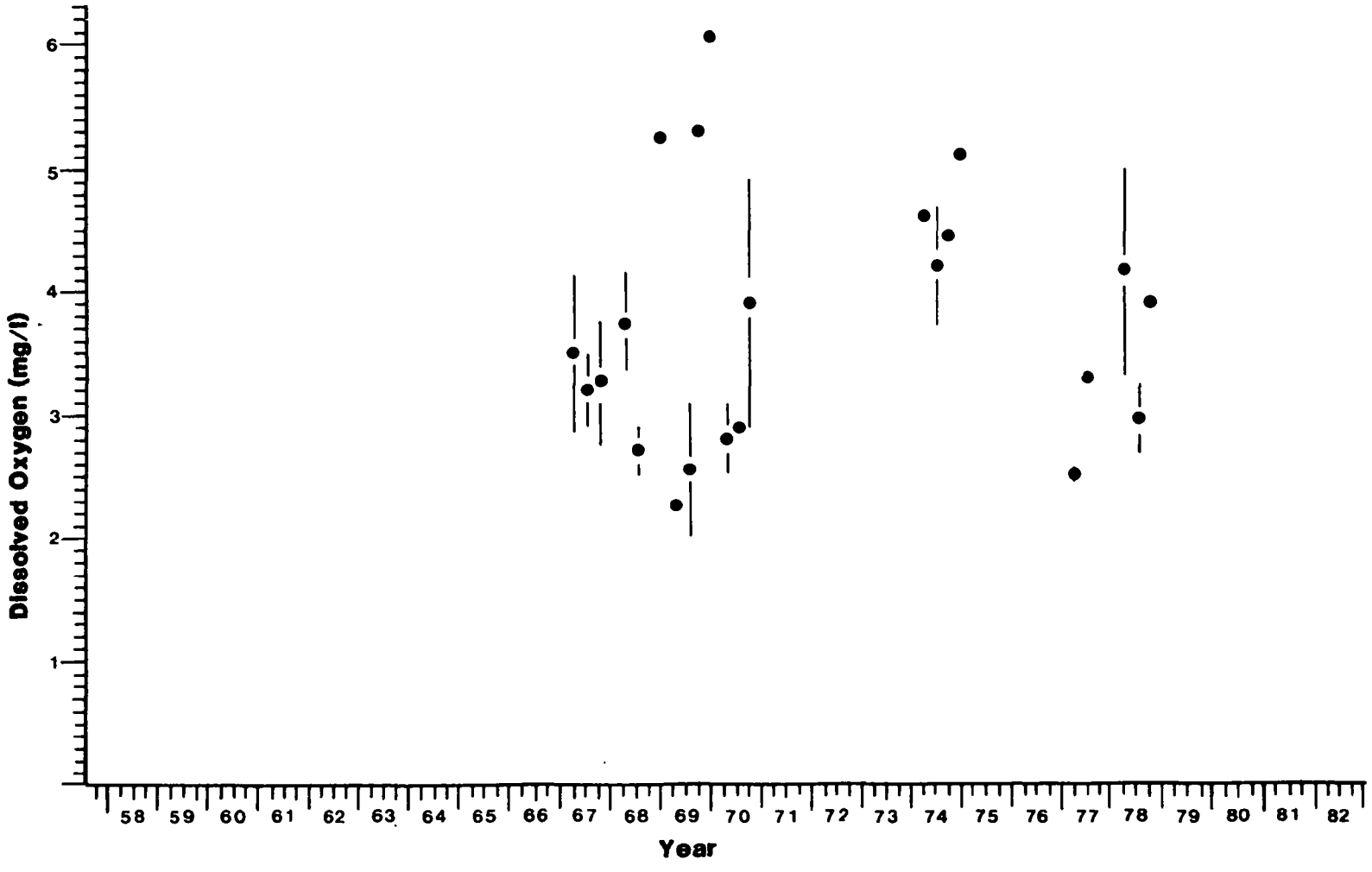


Figure 10-10 Patuxent River historical dissolved oxygen, segment two.

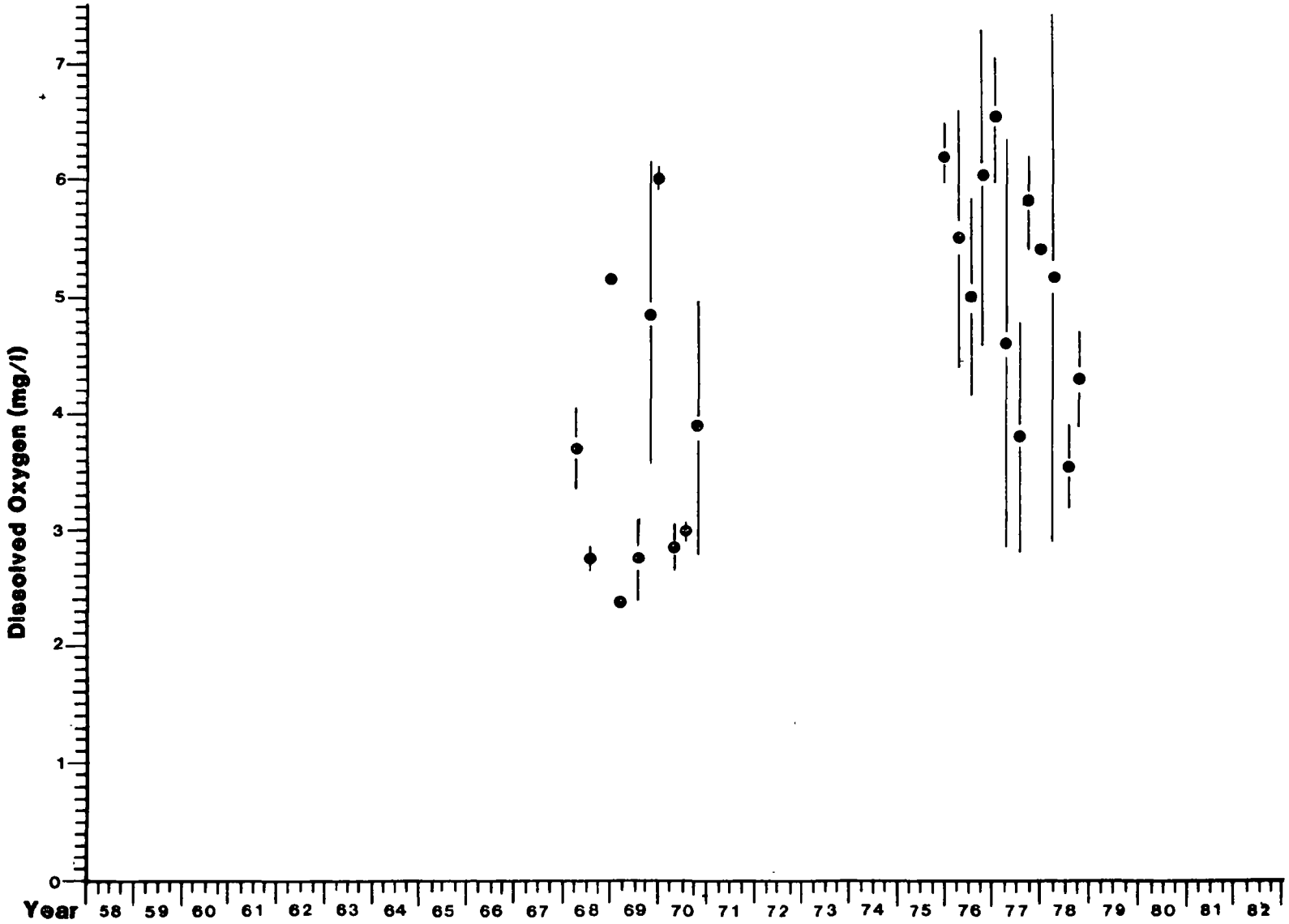


Figure10-11Patuxent River historical dissolved oxygen, segment three.

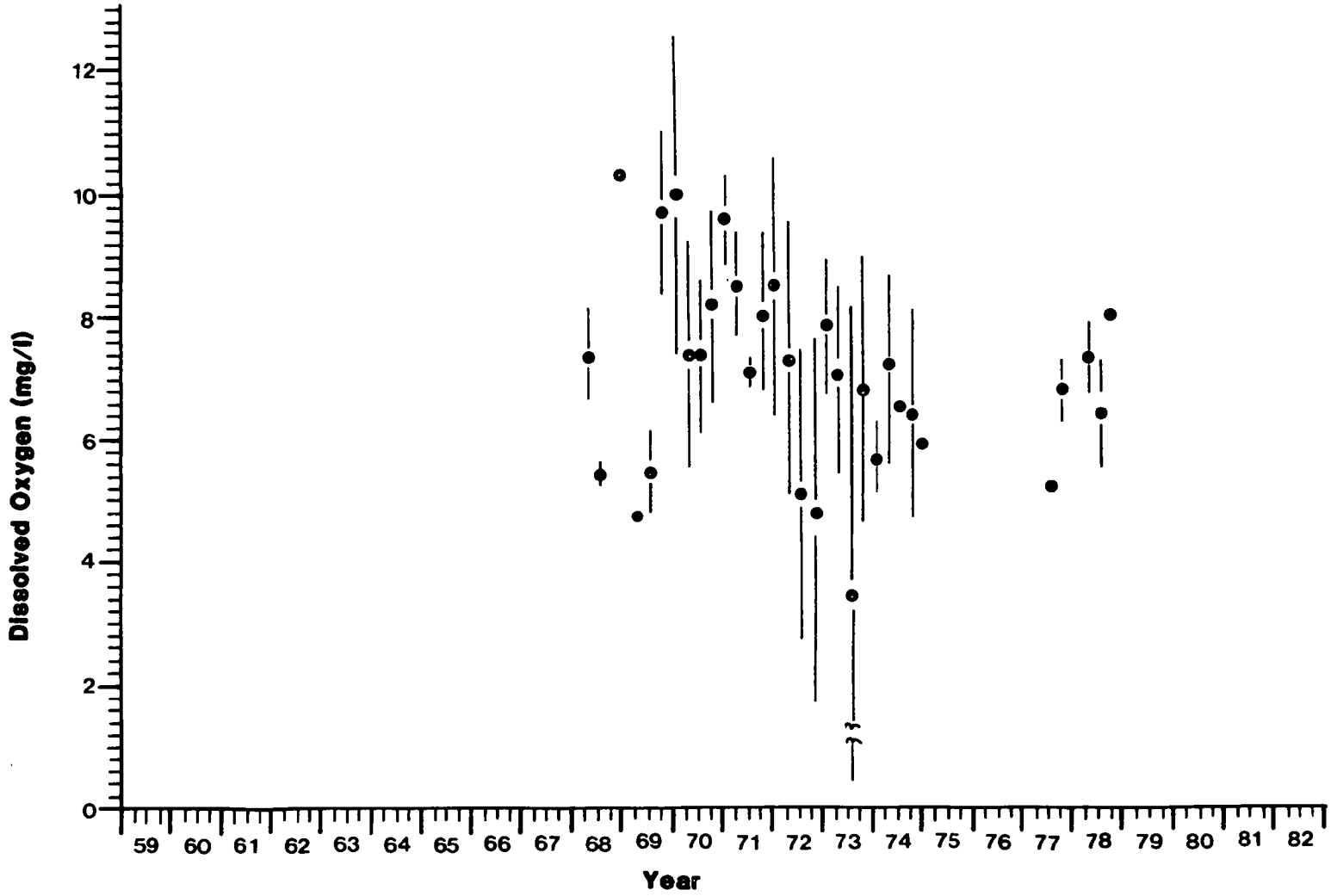


Figure10-12Patuxent River historical dissolved oxygen, segment four.

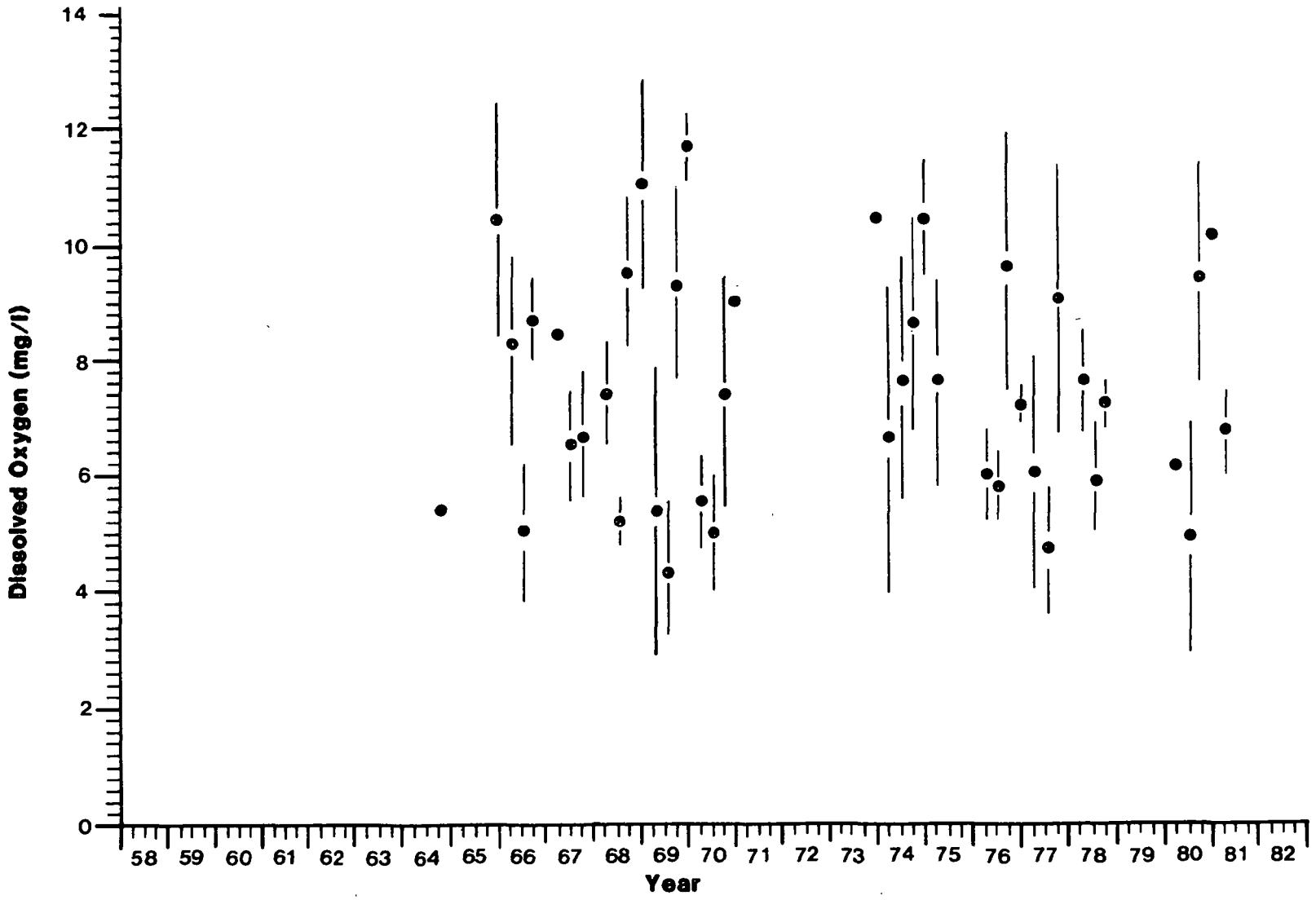


Figure10-13Patuxent River historical dissolved oxygen, segment five.

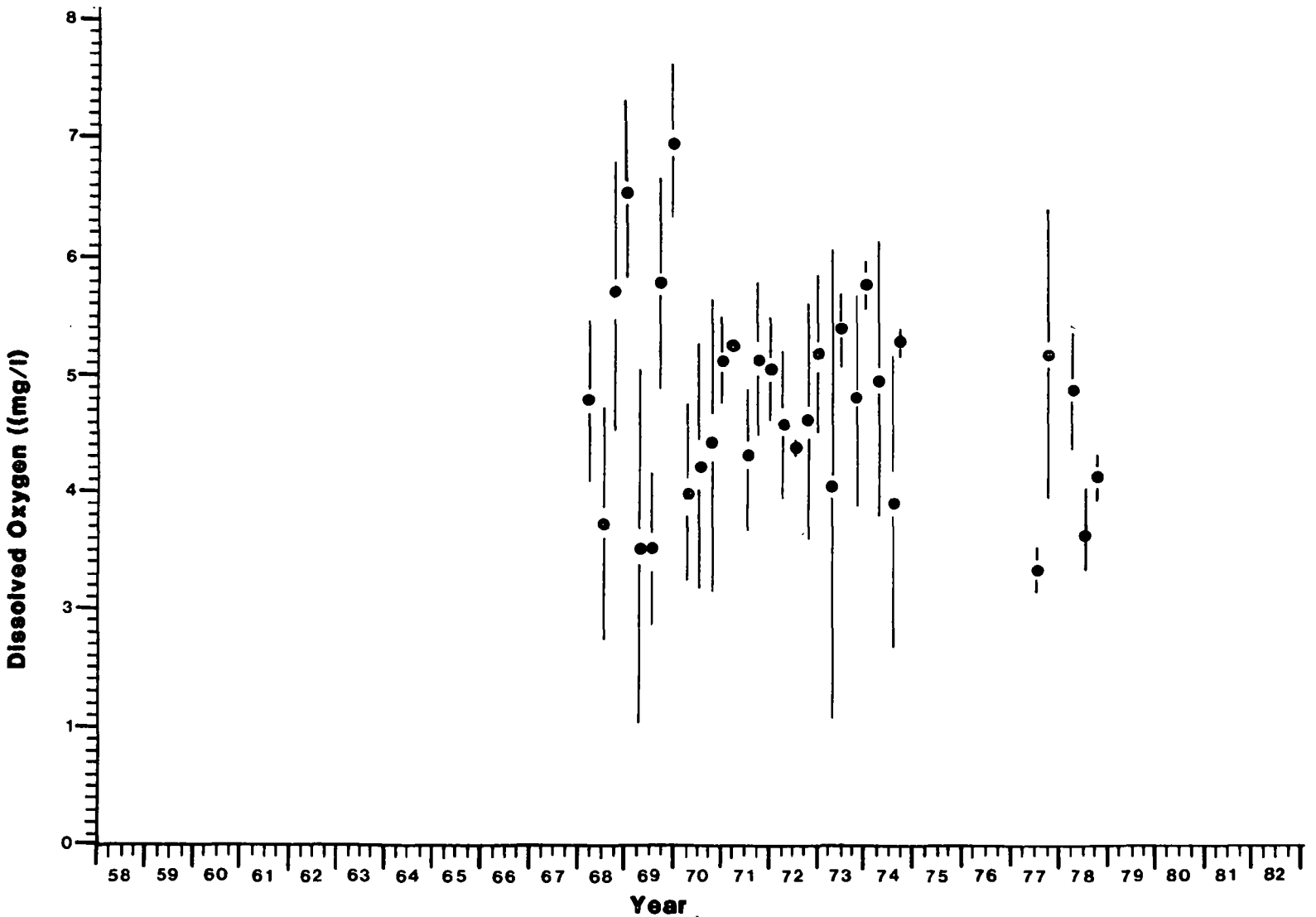


Figure 10-14 Patuxent River historical dissolved oxygen, segment six.

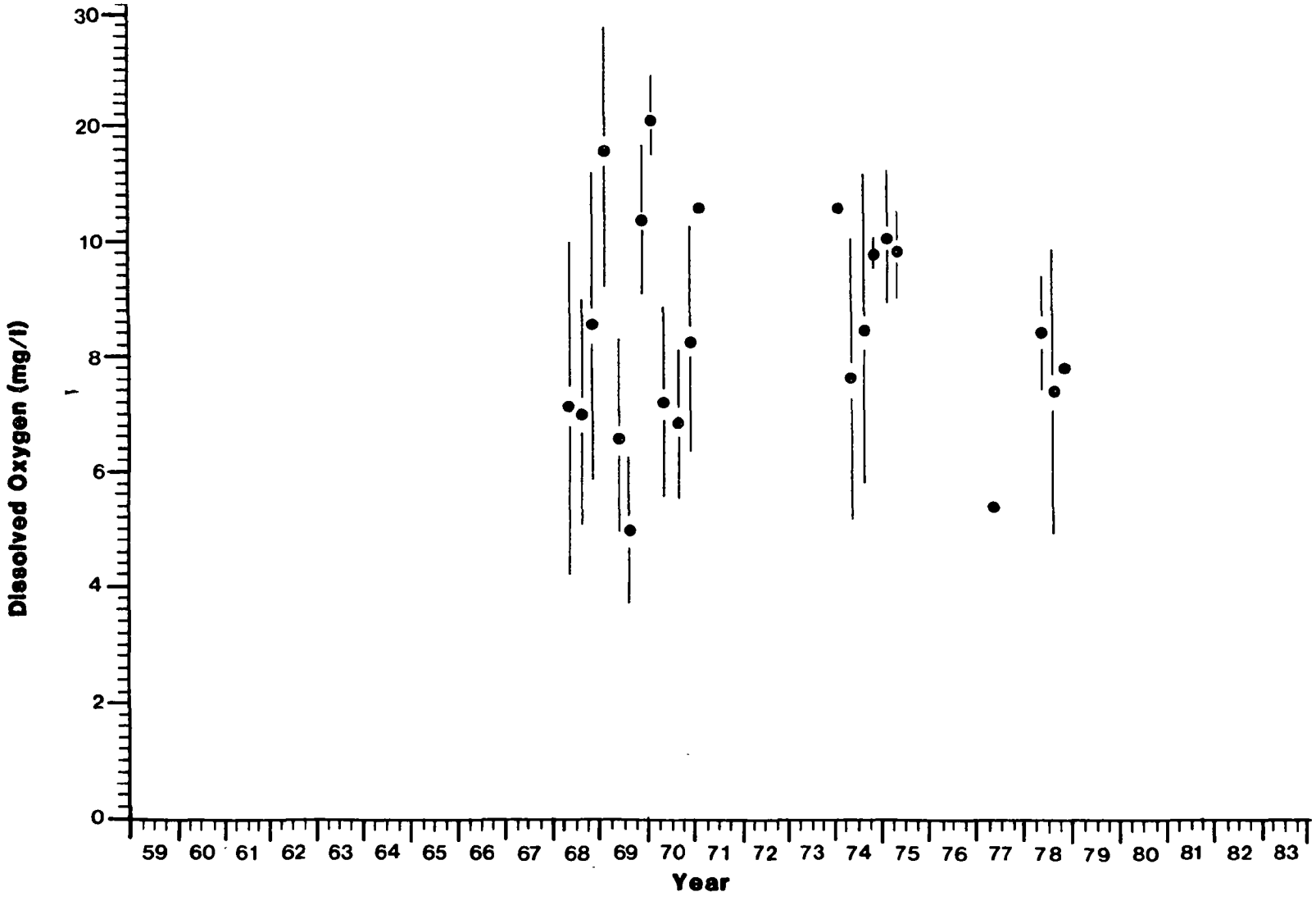


Figure 10-15 Patuxent River historical dissolved oxygen, segment seven.

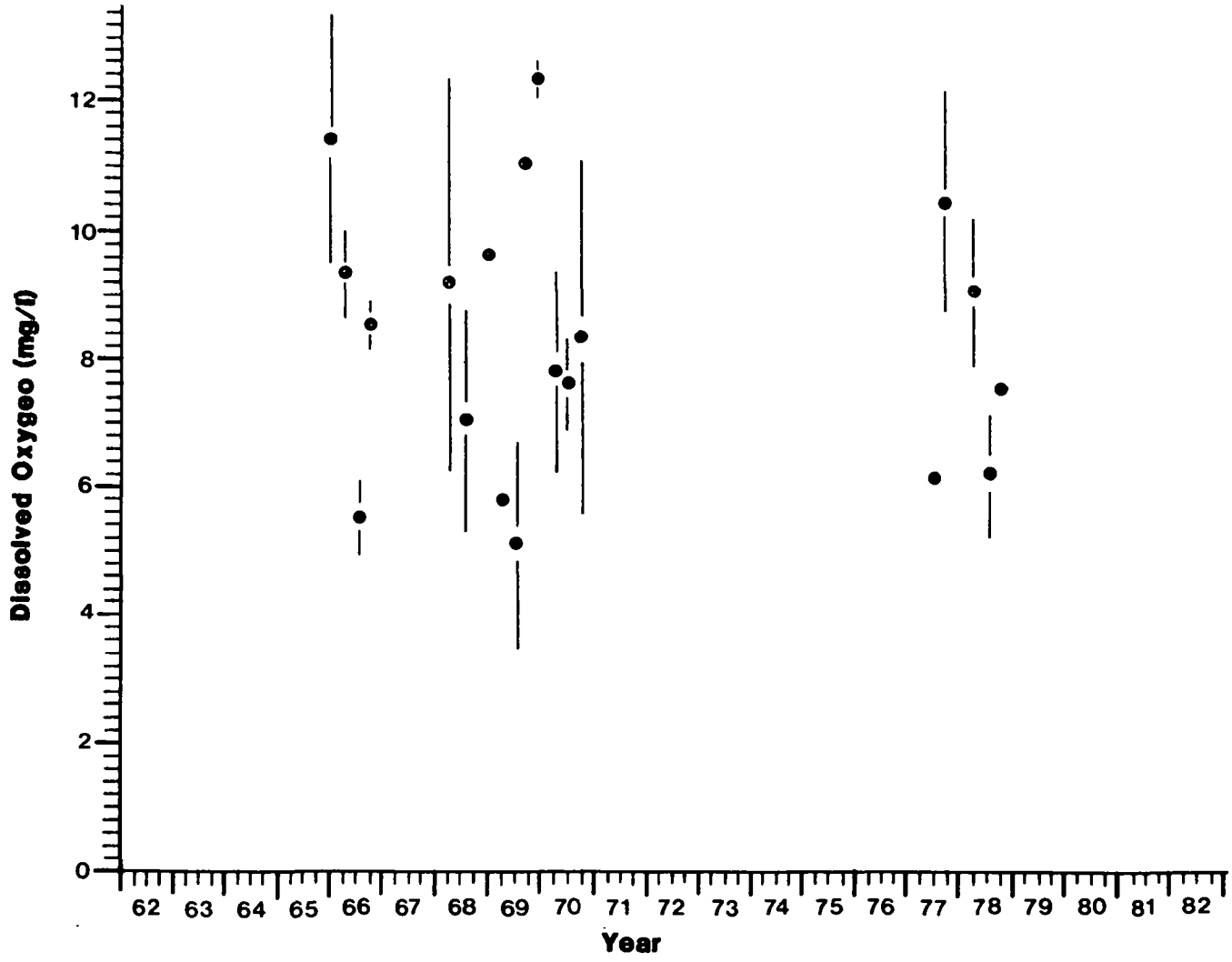


Figure10-16Patuxent River historical dissolved oxygen, segment eight.

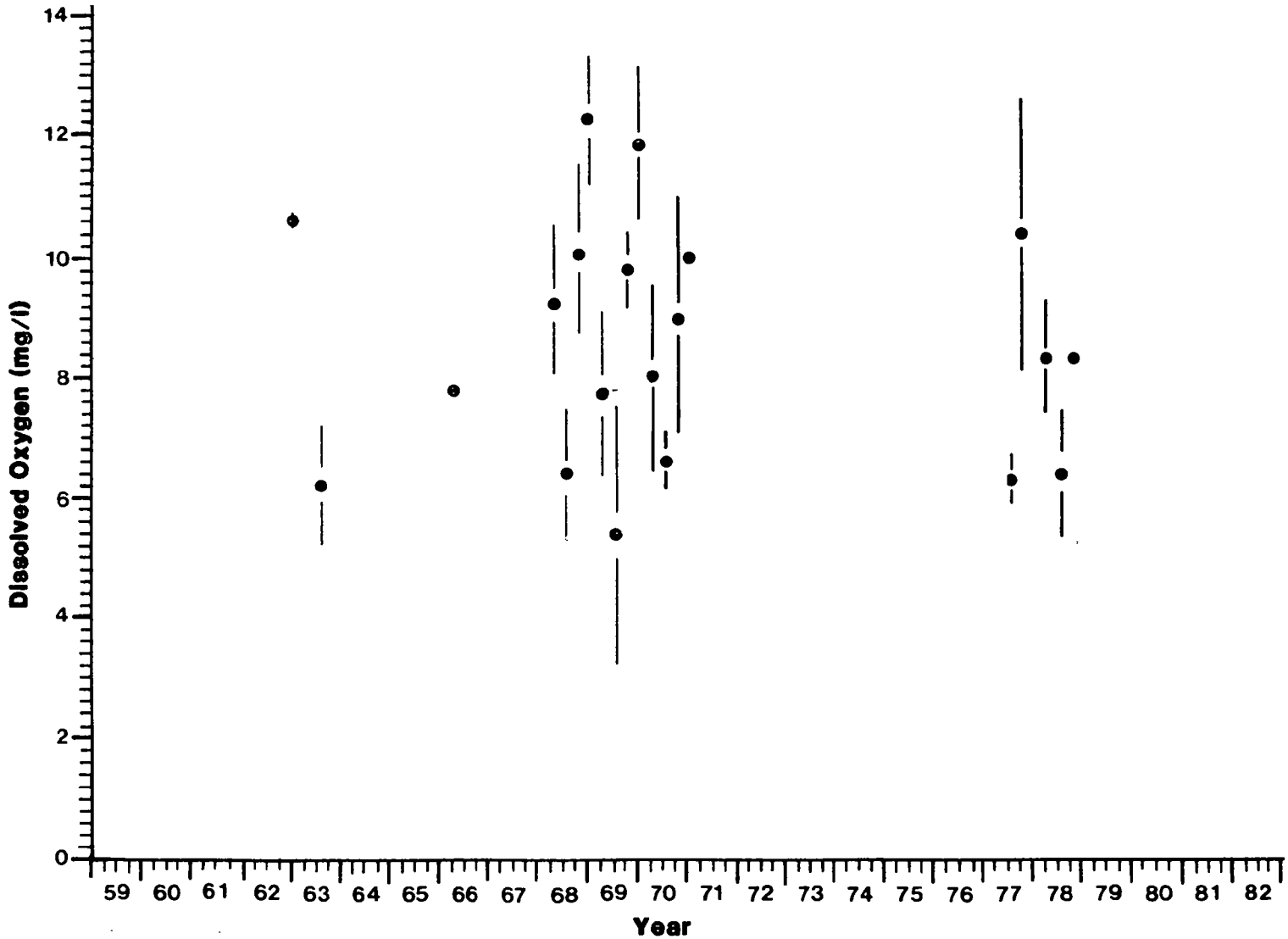


Figure10-17Patuxent River historical dissolved oxygen, segment nine.

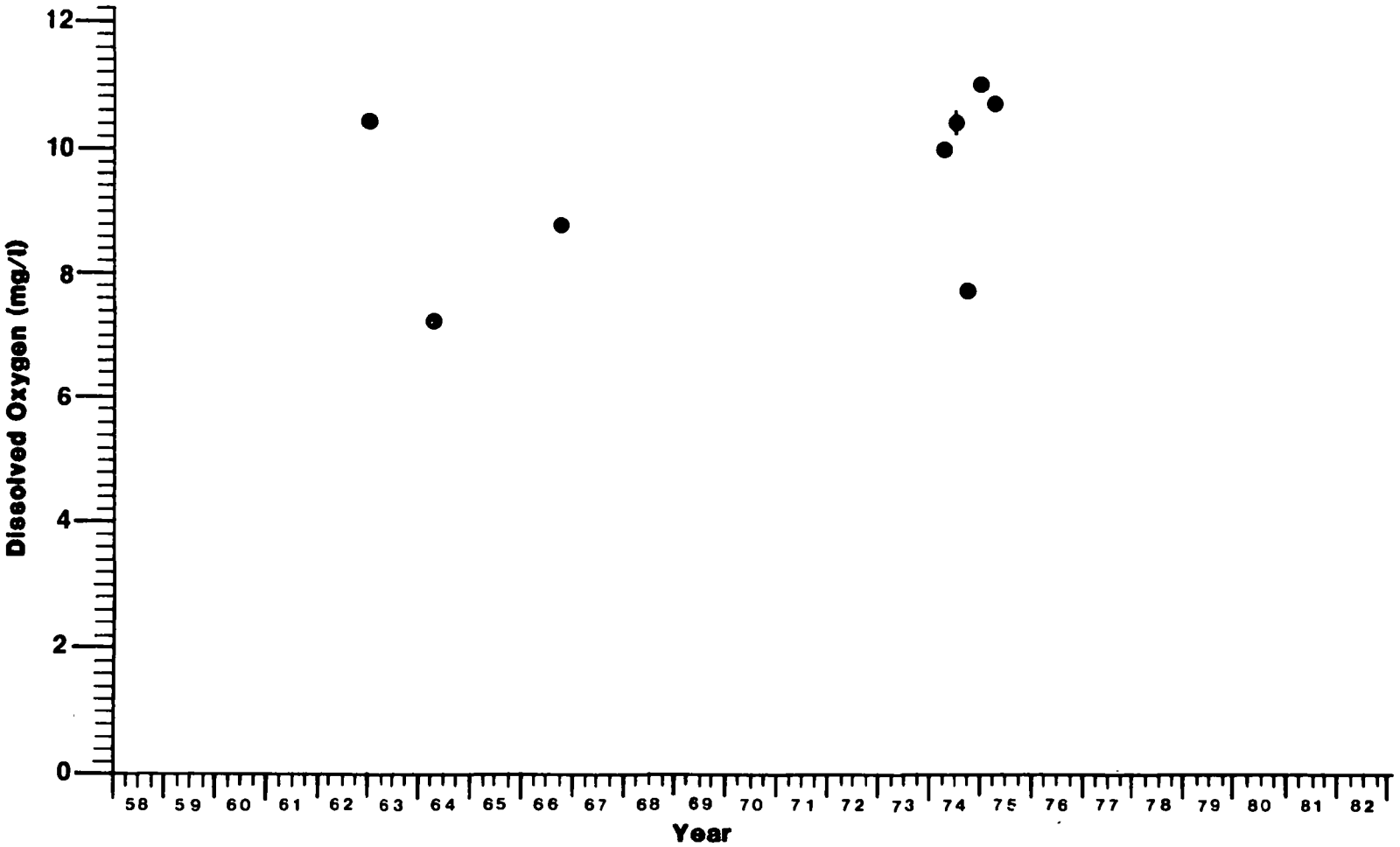


Figure10-18 Patuxent River historical dissolved oxygen, segment ten.

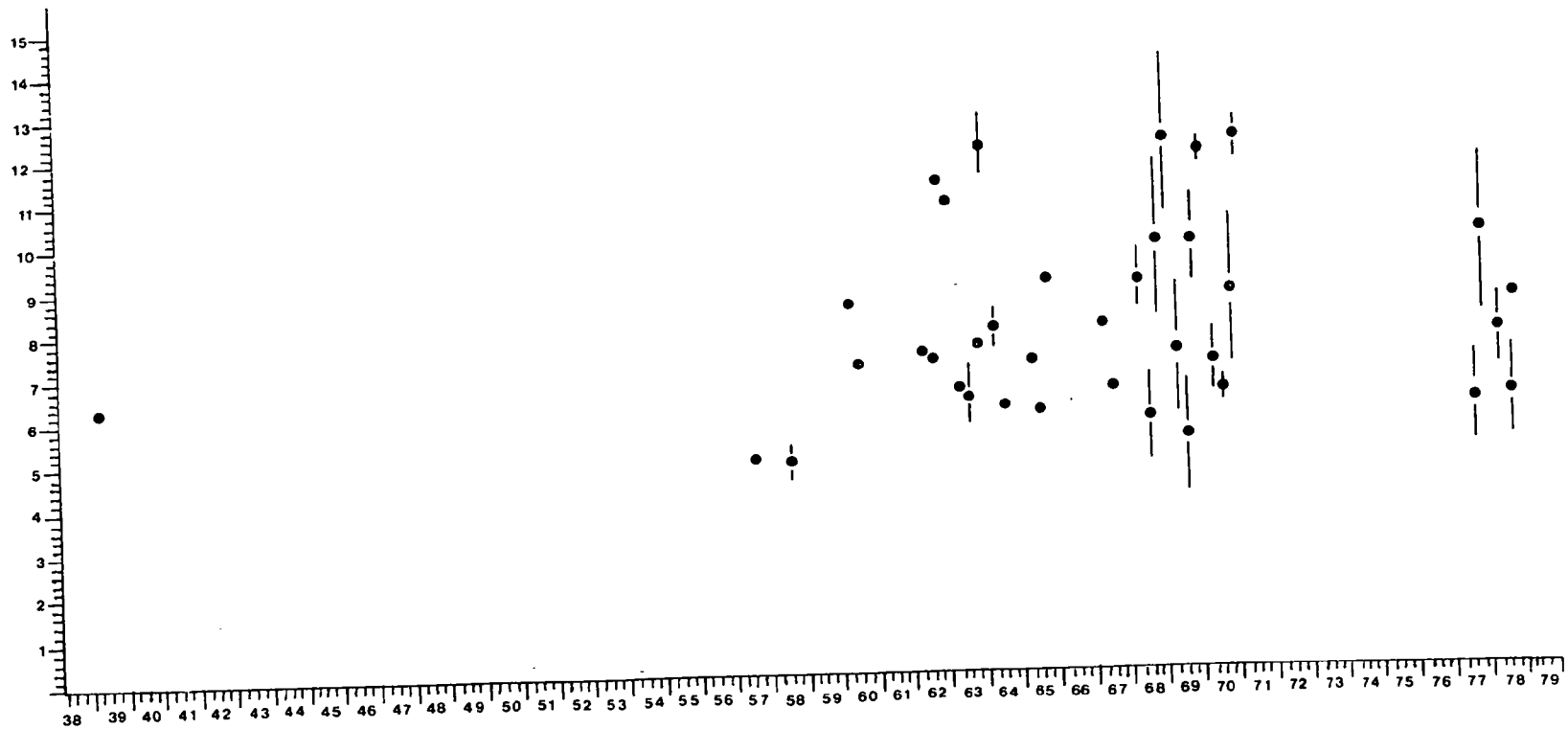


Figure 10-19 Patuxent River historical dissolved oxygen, segment eleven.

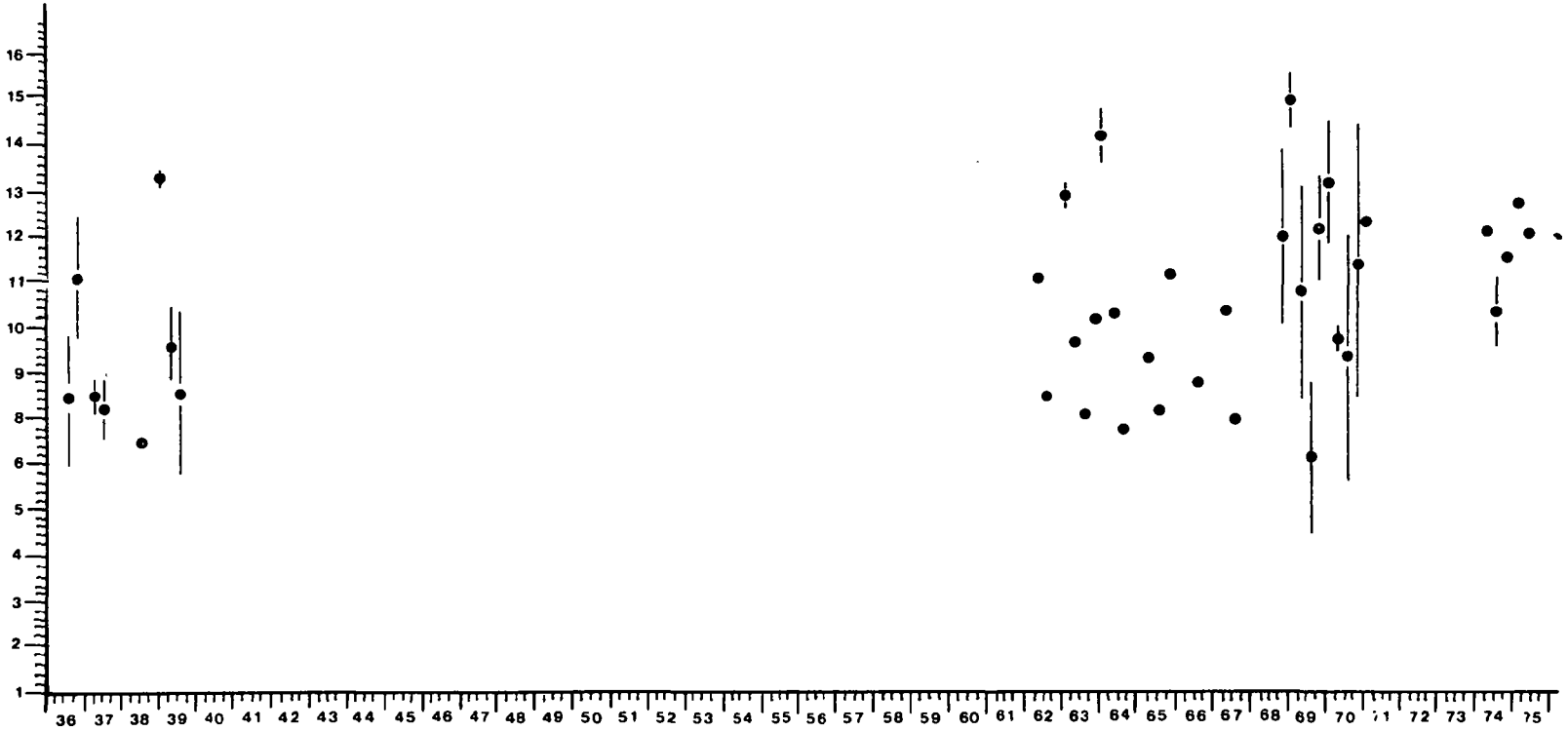


Figure 10-20 Patuxent River Historical dissolved oxygen, segment twelve.

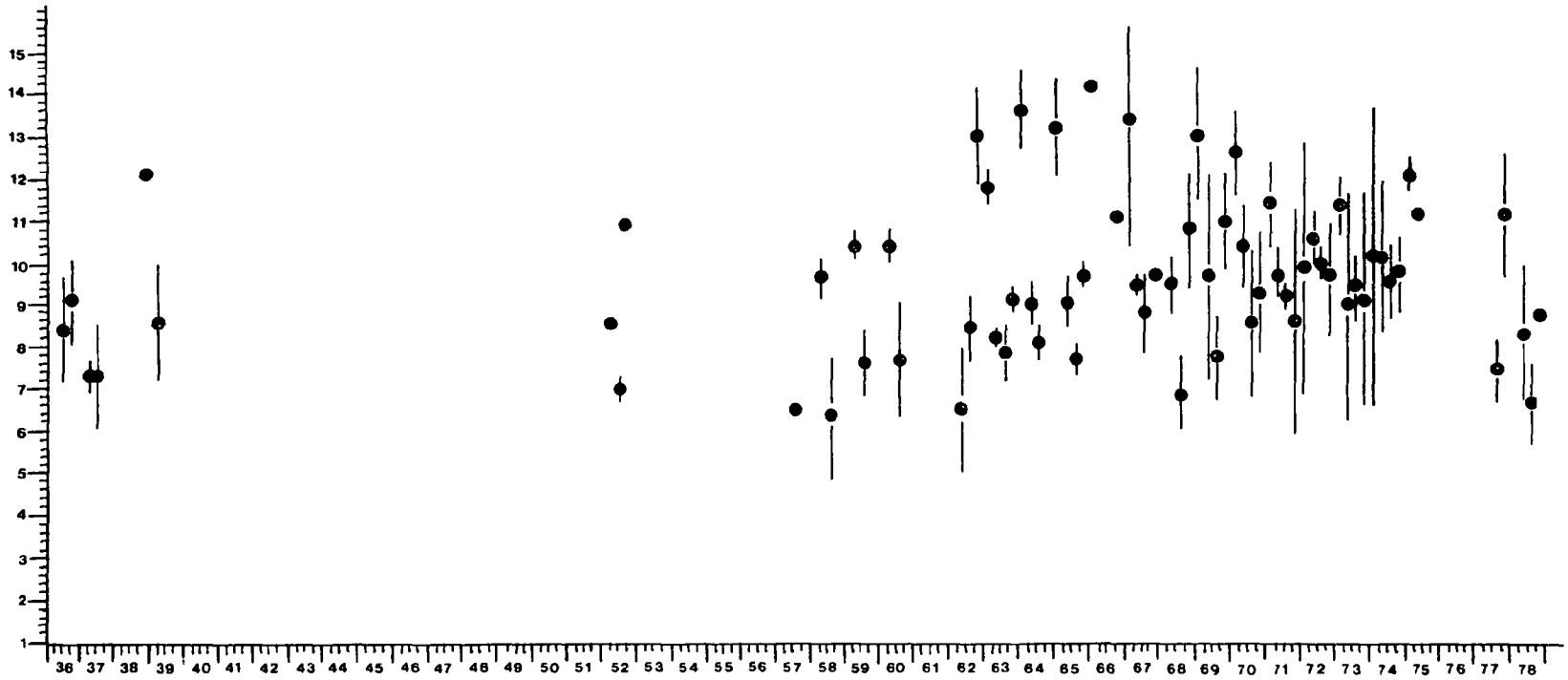


Figure 10-21 Patuxent River historical dissolved oxygen, segment thirteen.

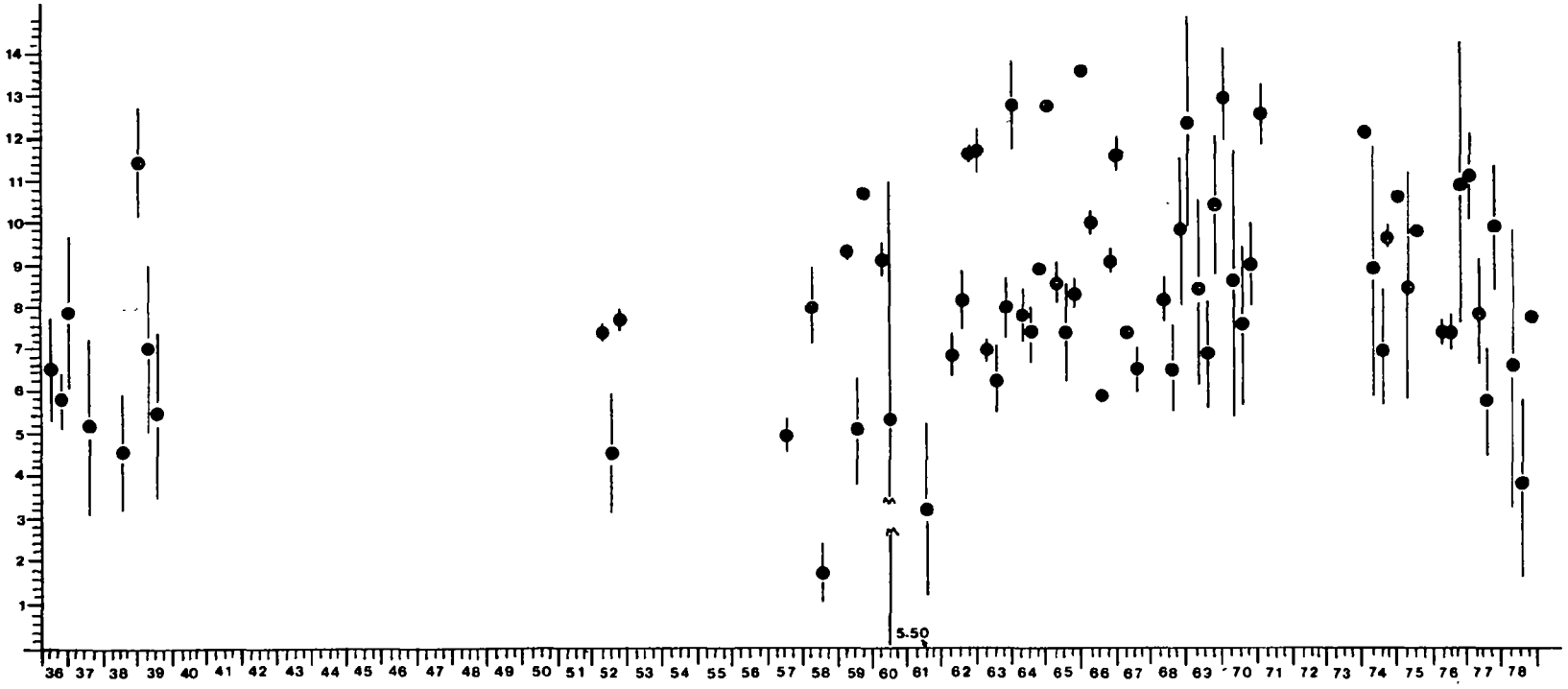


Figure 10-22 Patuxent River historical dissolved oxygen, segment fourteen.

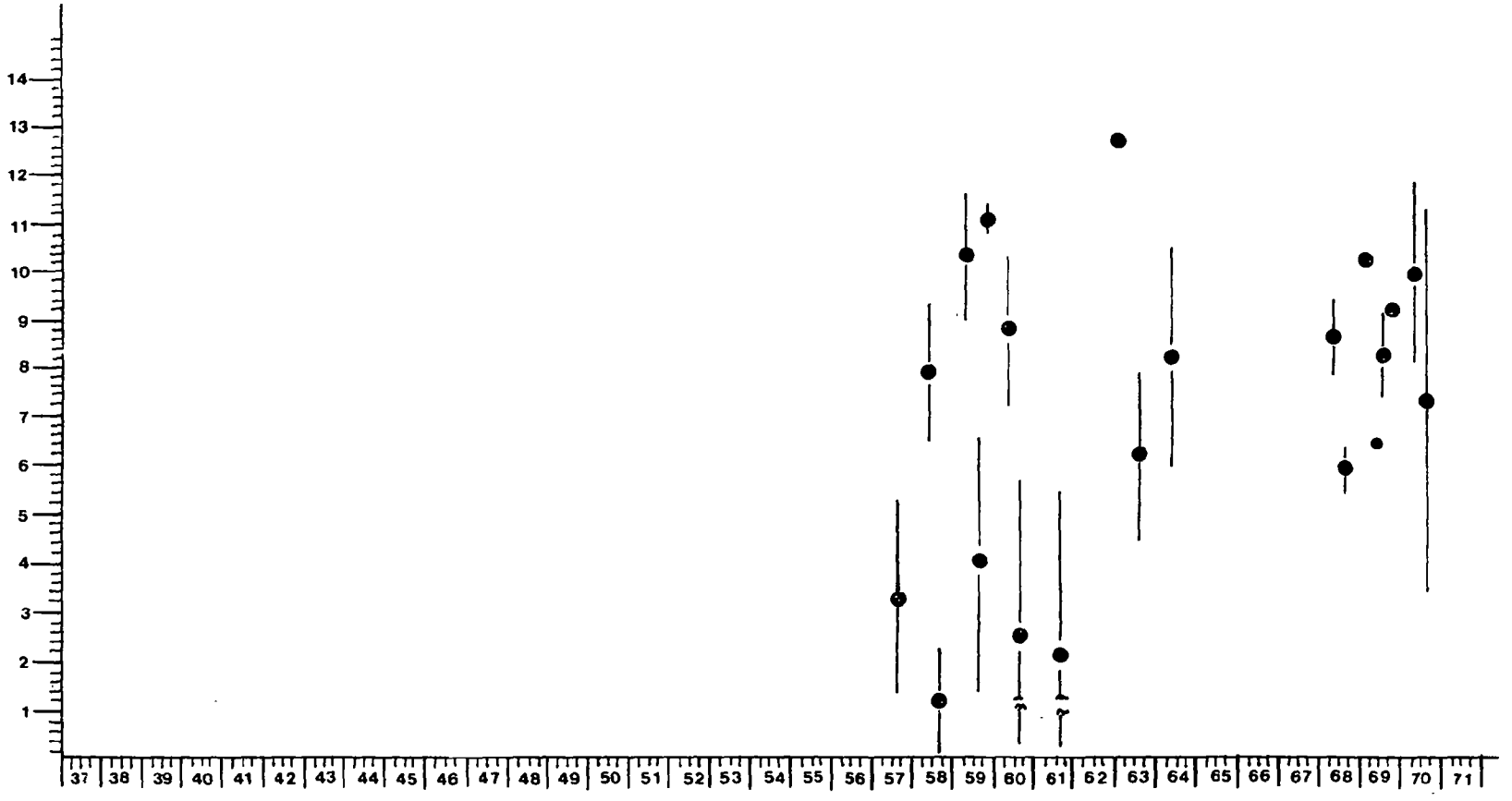


Figure10-23 Patuxent River historical dissolved oxygen, segment fifteen.

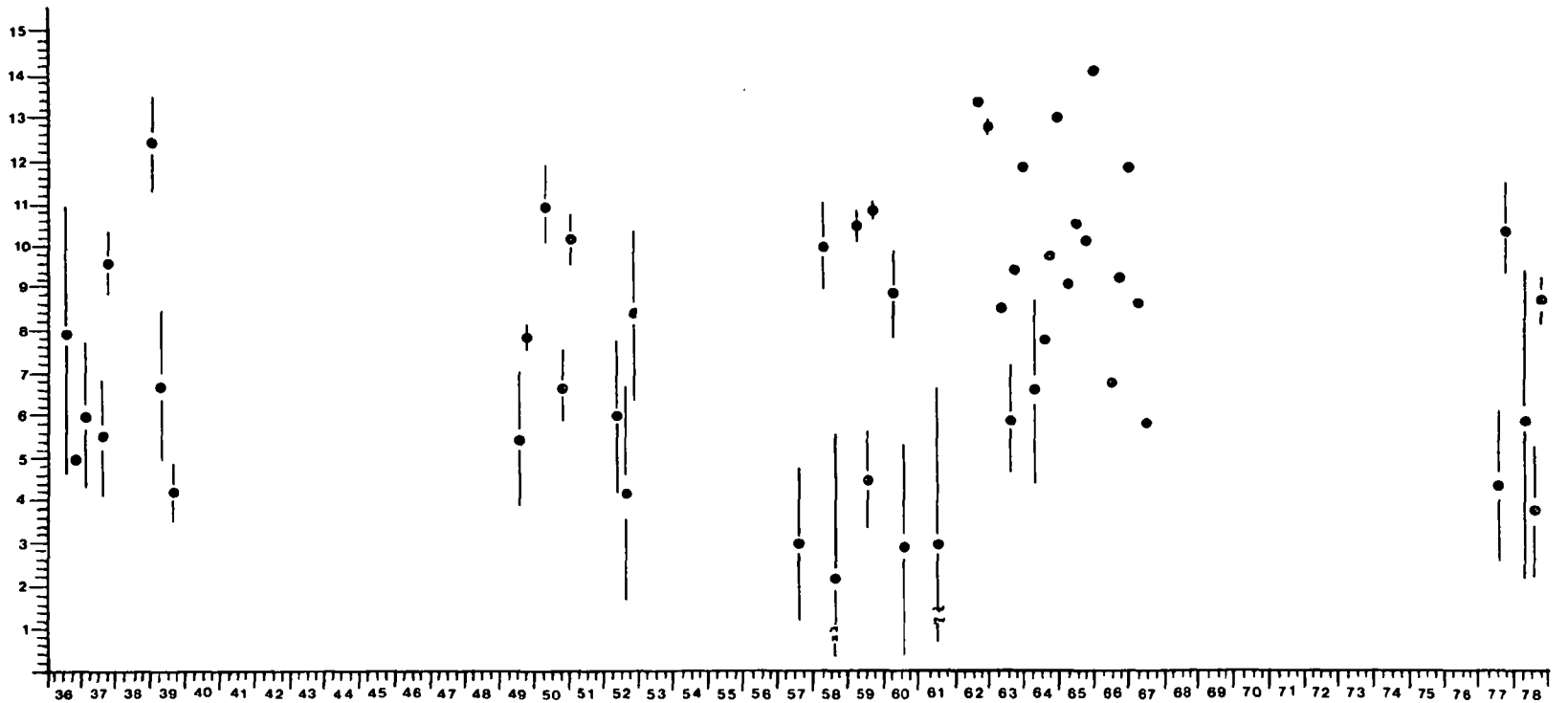


Figure 10-24 Patuxent River historical dissolved oxygen, segment sixteen.

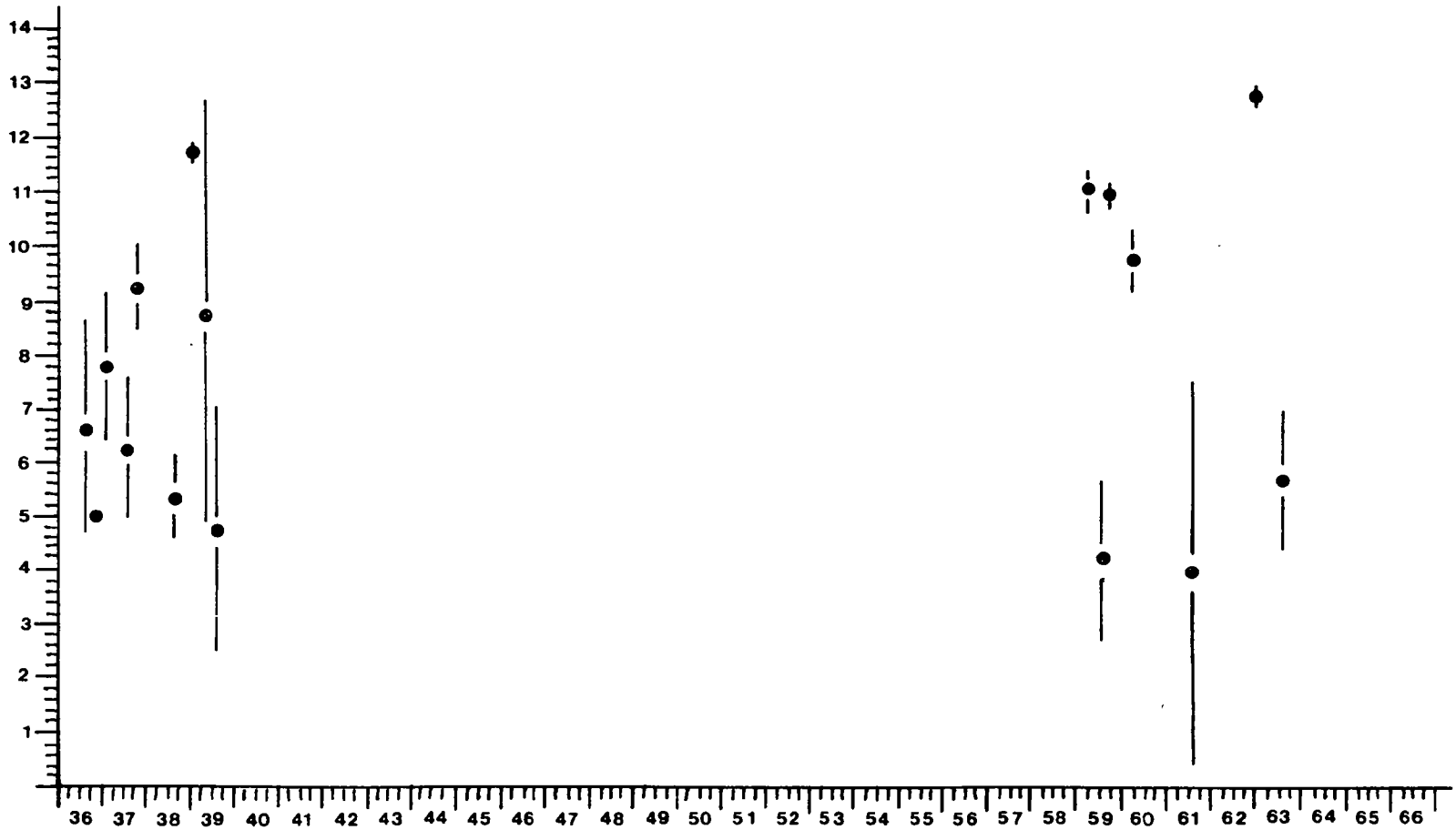


Figure 10-25 Patuxent River historical dissolved oxygen, segment seventeen.

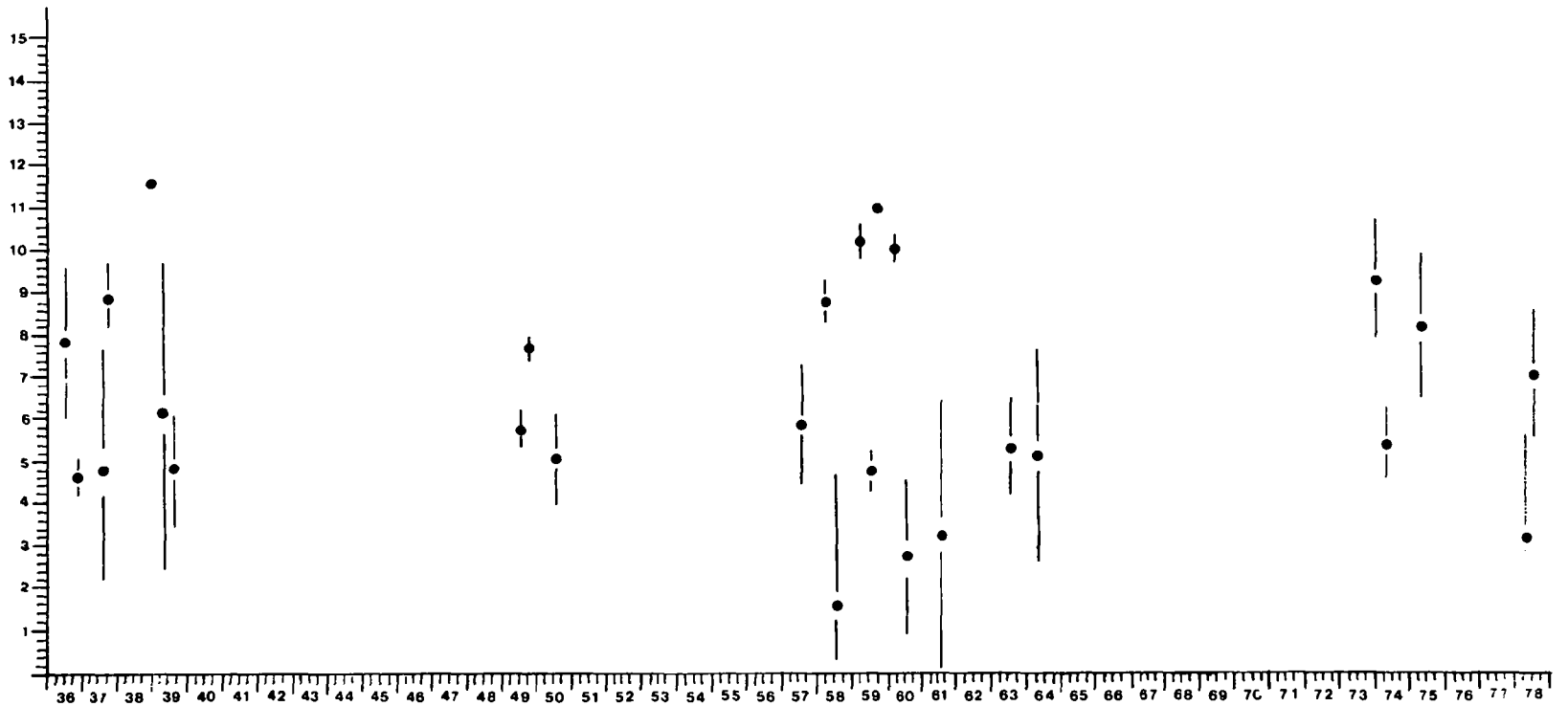


Figure 10-26 Patuxent River historical dissolved oxygen, segment eighteen.

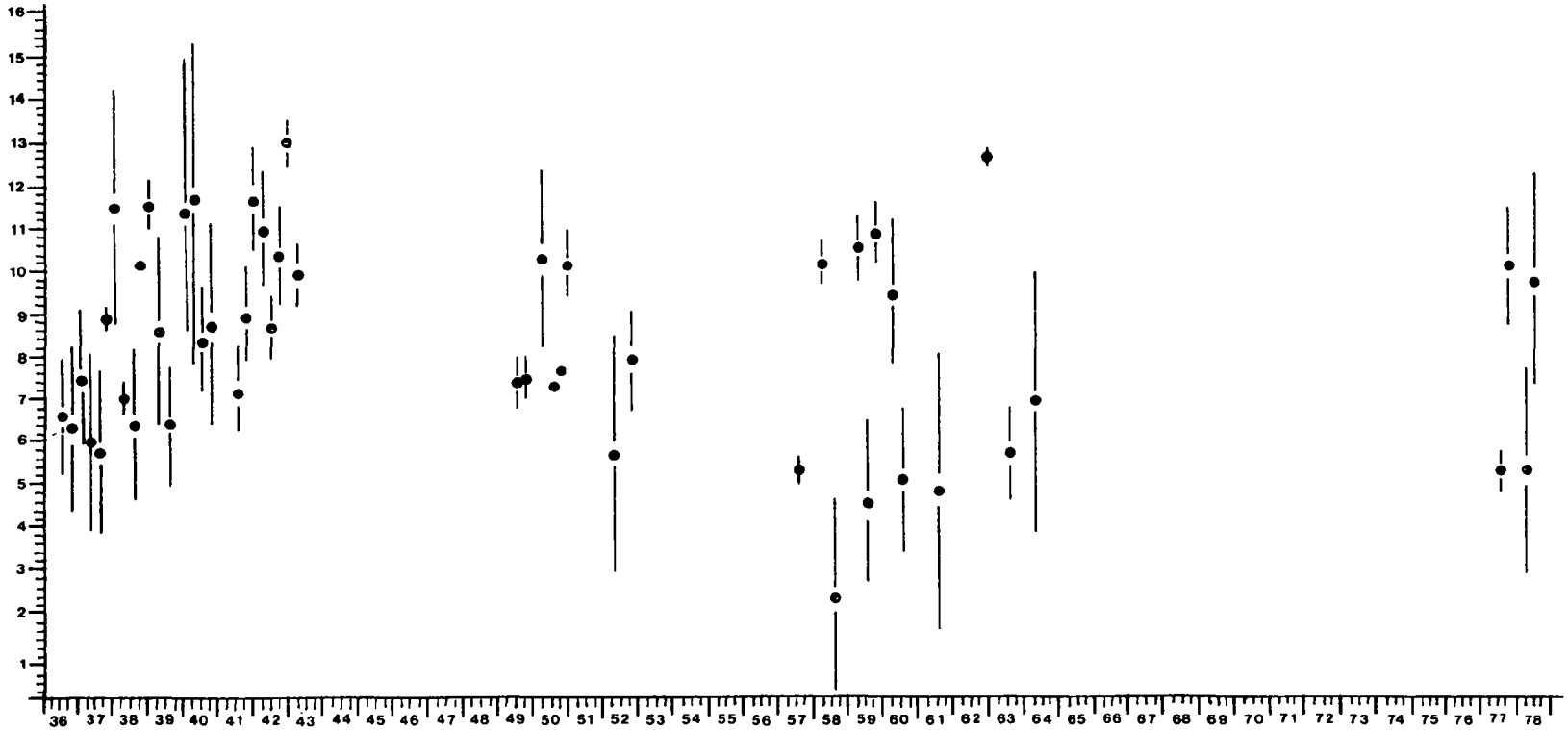


Figure 10-27 Patuxent River historical dissolved oxygen, segment nineteen.

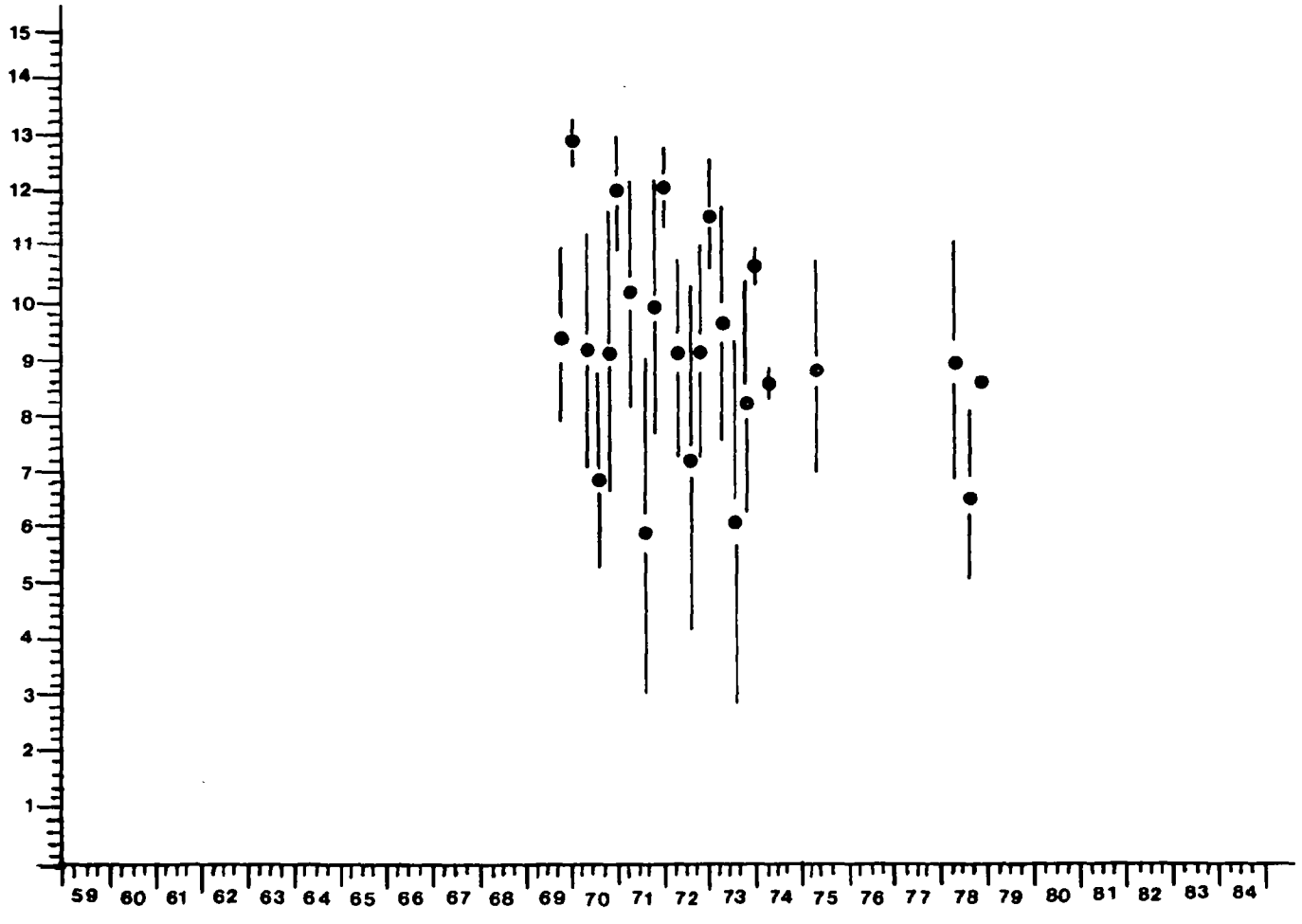


Figure 10-28 Patuxent River historical dissolved oxygen, segment 20.

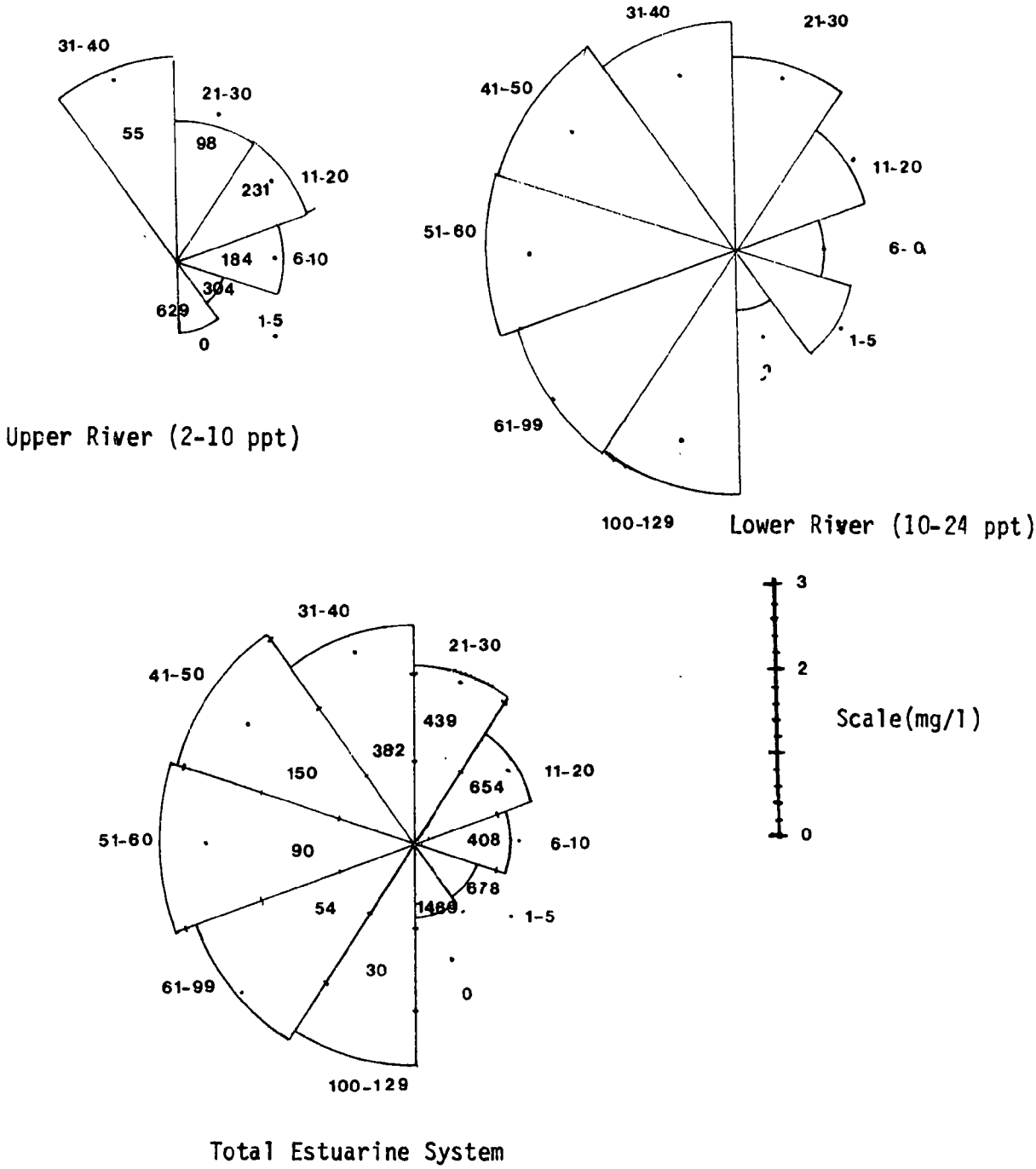


Figure10-29Patuxent River dissolved oxygen deficits. Each section represents a depth range in feet, 0-129 feet. Value inside the section is the number of observations. The dot represents the standard deviation in mg/l of the dissolved oxygen deficit at the given depth range.

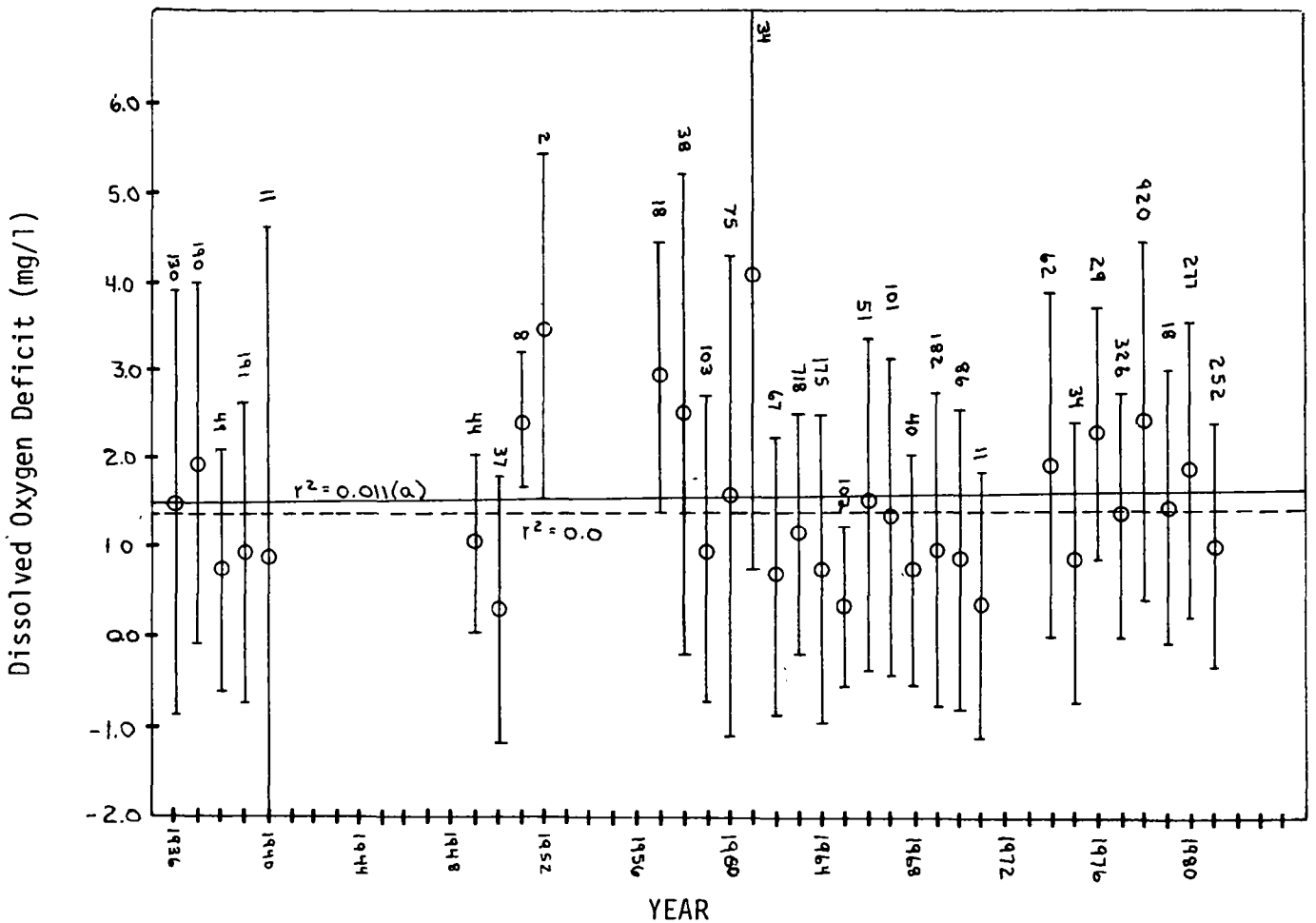


Figure 10-30 Patuxent Estuary Dissolved Oxygen Deficits (0.0 to 21 ppt). Regression line (b) obtained from regression of all values against time. Regression line (b) obtained from regression of yearly mean DOS against time.

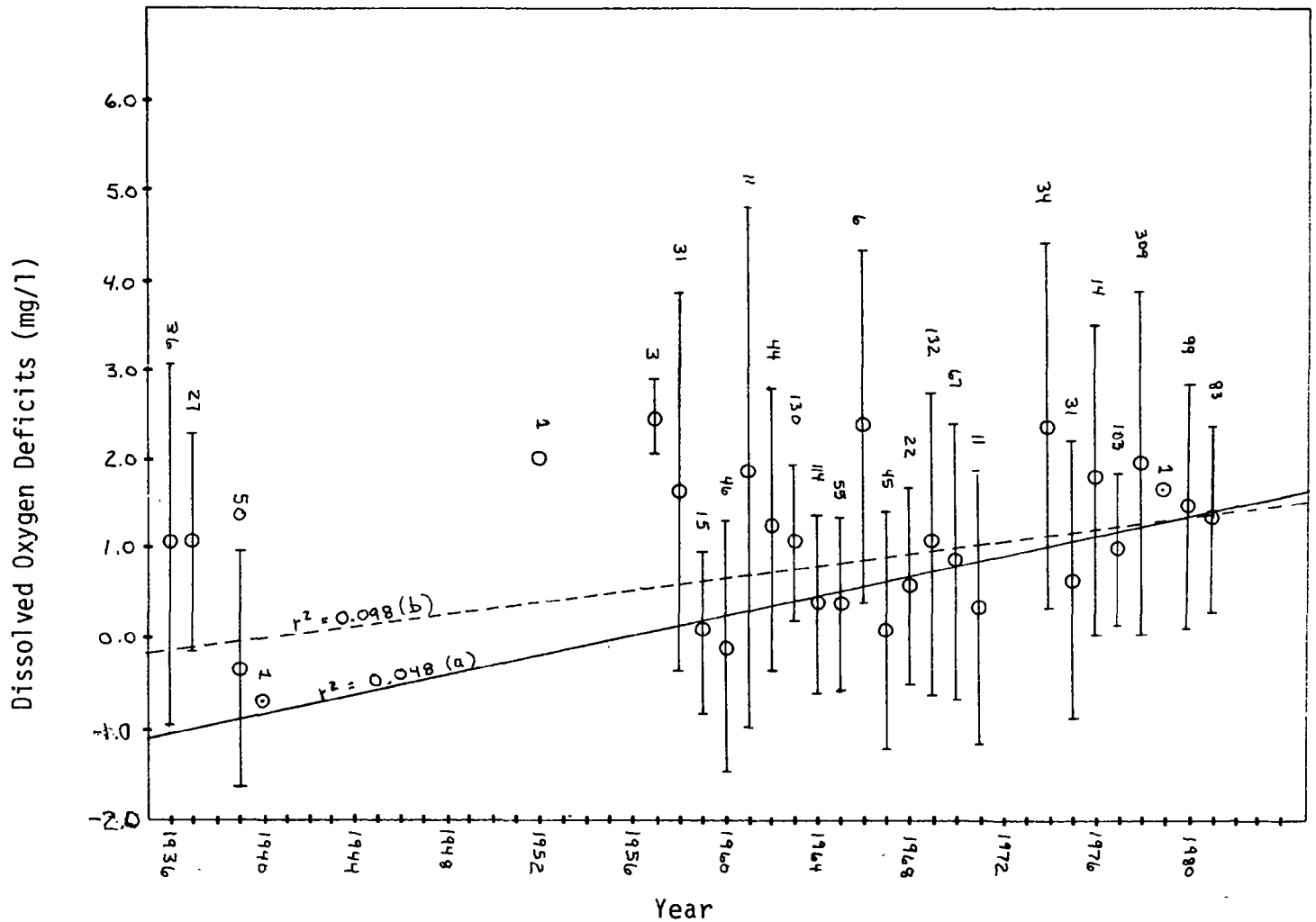


Figure10-31 Patuxent River Dissolved Oxygen Deficits (2.0 to 10.0 ppt) Regression line (a) obtained from regression of all dissolved oxygen deficits against time. Regression line (b) obtained from regressing yearly mean dissolved oxygen deficits against time.

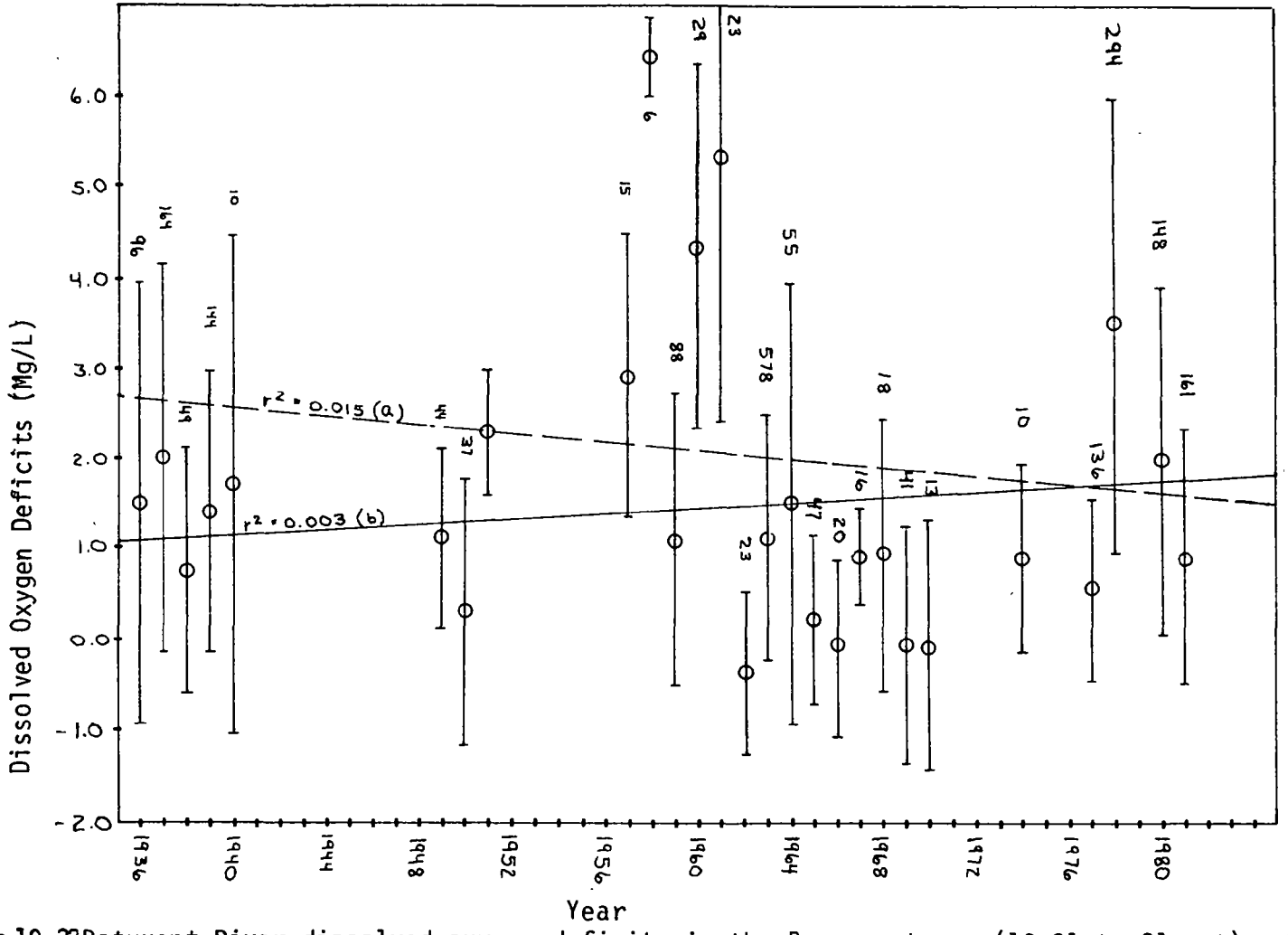


Figure 10-32 Patuxent River dissolved oxygen deficits in the Power estuary (10.01 to 21 ppt). Mean values and standard deviations. Regression line (a) is regression yearly mean values versus time, regression line (b) was obtained from regression of all values versus time.

Table 10-7
Dissolved Oxygen Deficits in Lower
Patuxent Estuary (Sal=10.01-24.0 ppt) for Years 36-81

Year	Average DOD	Standard Deviation	N	Correlation* Coefficient
1936	1.5703	2.5708	96	.339
1937	2.0640	2.2192	164	.182
1938	0.7520	1.3995	49	-.115
1939	1.3742	1.6335	144	.347
1940	1.6840	2.8510	10	.528
1941	--	--	--	--
1942	--	--	--	--
1943	--	--	--	--
1944	--	--	--	--
1945	--	--	--	--
1946	--	--	--	--
1947	--	--	--	--
1948	--	--	--	--

Table 10-7 (continued)
Dissolved Oxygen Deficits in Lower
Patuxent Estuary (Sal=10.01-24.0 ppt) for Years 36-81

Year	Average DOD	Standard Deviation	N	Correlation* Coefficient
1949	1.1189	1.0464	44	-.159
1950	0.28243	1.5403	37	.643
1951	2.2950	0.7099	8	-.024
1952	4.8200	0.0	1	0.0
1953	--	--	--	--
1954	--	--	--	--
1955	--	--	--	--
1956	--	--	--	--
1957	2.9240	1.6858	15	.284
1958	6.8933	0.8017	6	.768
1959	1.1080	1.7635	88	.279
1960	4.3245	2.1808	29	.398
1961	5.2970	2.9376	23	.458

Table 10-7 (continued)
Dissolved Oxygen Deficits in Lower
Patuxent Estuary (Sal=10.01-24.0 ppt) for Years 36-81

Year	Average DOD	Standard Deviation	N	Correlation* Coefficient
1962	-0.3544	0.9148	23	-.600
1963	1.1828	1.4032	578	.221
1964	1.5089	2.5761	55	.357
1965	0.2259	0.9100	47	.535
1966	-0.0880	1.0020	20	.113
1967	0.9431	0.5340	16	-.569
1968	0.9250	1.5271	18	.041
1969	-0.10390	1.3819	41	-.099
1970	-0.13769	1.3829	13	.123
1971	--	--	--	--
1972	--	--	--	--
1973	--	--	--	--
1974	0.8970	1.1386	10	-.038

Table 10-7 (continued)
Dissolved Oxygen Deficits in Lower
Patuxent Estuary (Sal=10.01-24.0 ppt) for Years 36-81

Year	Average DOD	Standard Deviation	N	Correlation* Coefficient
1975	--	--	--	--
1976	--	--	--	--
1977	0.5541	1.0754	136	-.189
1978	3.4982	2.6057	294	.011
1979	--	--	--	--
1980	1.9694	1.9793	148	-.119
1981	0.8158	1.4693	161	-.169

* From Regression of DOD vs Salinity (Sal=10.01 to 24.0 ppt)

Table 10-8
Dissolved Oxygen Deficits in Upper
Patuxent Estuary (Sal=.2 to 10.0 ppt) for Years 36-81

Year	Average DOD	Standard Deviation	N	Correlation* Coefficient
1936	1.1692	2.1420	36	-.143
1937	1.1430	1.2577	27	-.033
1938	--	--	--	--
1939	-0.3278	1.3016	50	-.278
1940	-7.3500	0.0	1	0.0
1941	--	--	--	--
1942	--	--	--	--
1943	--	--	--	--
1944	--	--	--	--
1945	--	--	--	--
1946	--	--	--	--
1947	--	--	--	--
1948	--	--	--	--

Table 10-8 (continued)
Dissolved Oxygen Deficits in Upper
Patuxent Estuary (Sal=.2 to 10.0 ppt) for Years 36-81

Year	Average DOD	Standard Deviation	N	Correlation* Coefficient
1949	--	--	--	--
1950	--	--	--	--
1951	--	--	--	--
1952	2.0500	0	1	0
1953	--	--	--	--
1954	--	--	--	--
1955	--	--	--	--
1956	--	--	--	--
1957	2.4633	0.4165	3	-.999
1958	1.6574	2.1932	31	-.008
1959	0.10067	0.91362	15	-.402
1960	-0.10043	1.4574	46	-.231
1961	1.8609	2.9403	11	.120

Table 10-8 (continued)
Dissolved Oxygen Deficits in Upper
Patuxent Estuary (Sal=.2 to 10.0 ppt) for Years 36-81

Year	Average DOD	Standard Deviation	N	Correlation* Coefficient
1962	1.2552	1.6137	44	-.166
1963	1.1335	0.8016	130	-.348
1964	0.32728	1.0429	114	-.063
1965	0.3338	0.9868	55	-.669
1966	2.3367	2.0790	6	-.601
1967	0.14867	1.3142	45	-.343
1968	0.6005	1.1842	22	-.590
1969	1.1309	1.7335	132	-.605
1970	0.8257	1.6848	67	-.382
1971	0.2927	1.5944	11	-.728
1972	--	--	--	--
1973	--	--	--	--
1974	2.3185	2.1965	34	-.432

Table (continued)

Table 10-8 (continued)
Dissolved Oxygen Deficits in Upper
Patuxent Estuary (Sal=.2 to 10.0 ppt) for Years 36-81

Year	Average DOD	Standard Deviation	N	Correlation* Coefficient
1975	0.6887	1.6017	31	-.556
1976	1.7643	1.7452	14	-.701
1977	1.0817	0.8585	103	-.553
1978	1.9187	1.9139	309	.166
1979	1.6700	0.0	1	0.0
1980	1.4598	2.4054	99	-.081
1981	1.3054	1.1896	83	.178

* From Regression of DOD vs Salinity (Sal= .2 to 10.0 ppt)

Table 10-9
Dissolved Oxygen Deficits
In Patuxent Estuary for Years 36-81

Year	Average DOD	Standard Deviation	Standard Error of Mean	N	Correlation* Coefficient
1936	1.4835	2.4675	0.2164	130	.174
1937	1.9512	2.1324	0.1547	190	.187
1938	0.7520	1.3995	0.1999	49	.115
1939	0.9349	1.7347	0.1255	191	.432
1940	0.8627	3.8386	1.1574	11	.766
1941	--	--	--	--	--
1942	--	--	--	--	--
1943	--	--	--	--	--
1944	--	--	--	--	--
1945	--	--	--	--	--
1946	--	--	--	--	--
1947	--	--	--	--	--
1948	--	--	--	--	--

Table 10-9
Dissolved Oxygen Deficits
In Patuxent Estuary for Years 36-81

Year	Average DOD	Standard Deviation	Standard Error of Mean	N	Correlation* Coefficient
1949	1.1189	1.0464	0.1578	44	-.159
1950	0.2824	1.5403	0.2533	37	.643
1951	2.2950	0.7099	0.2509	8	-.024
1952	3.4350	1.9587	1.3850	2	1.00
1953	--	--	--	--	--
1954	--	--	--	--	--
1955	--	--	--	--	--
1956	--	--	--	--	--
1957	2.8472	1.5466	0.3645	18	.202
1958	2.5271	2.7800	0.4510	38	.443
1959	0.9613	1.7014	0.1676	103	.288
1960	1.6105	2.7924	0.3224	75	.562
1961	4.1853	3.3219	0.5697	34	.578

Table 10-9
Dissolved Oxygen Deficits
In Patuxent Estuary for Years 36-81

Year	Average DOD	Standard Deviation	Standard Error of Mean	N	Correlation* Coefficient
1962	0.7027	1.6026	0.1958	67	-.493
1963	1.1824	1.3061	0.0487	718	.027
1964	0.7558	1.7793	0.1345	175	.234
1965	0.2841	0.9491	0.0939	102	-.118
1966	1.5331	1.8833	0.2637	51	-.708
1967	1.3663	1.7767	1.7767	101	-.632
1968	0.7465	1.3410	0.2120	40	-.105
1969	0.9569	1.7896	0.1327	182	-.621
1970	0.8331	1.7363	0.1872	86	-.470
1971	0.2927	1.5944	0.4807	11	-.728
1972	--	--	--	--	--
1973	--	--	--	--	--
1974	1.9633	2.0096	0.2787	52	.373

Table 10-9
Dissolved Oxygen Deficits
In Patuxent Estuary for Years 36-81

Year	Average DOD	Standard Deviation	Standard Error of Mean	N	Correlation* Coefficient
1975	0.8609	1.6358	0.2805	34	-.604
1976	2.2648	1.4307	0.2657	29	-.657
1977	1.3584	1.4131	0.0783	326	-.669
1978	2.4322	2.1486	0.0708	920	.308
1979	1.7350	1.6092	0.3793	18	-.010
1980	1.7996	1.7298	0.1039	277	.046
1981	1.0545	1.4450	0.0910	252	-.237

* From Regression of DOD vs Salinity

Table 10-10 Dissolved Oxygen Deficits In Upper Patuxent Estuary (Sal=.2-10.0 ppt)

Years	Average DOD	Standard Deviation	N	Correlation* Coefficient
1936 - 40	.43	1.90	114	-.208
1941 - 50	--	--	--	--
1951 - 60	.60	1.85	96	-.111
1961 - 70	.83	1.43	626	-.392
1971 - 81	1.57	1.69	685	-.014

*From regression of DOD vs. Salinity (Sal=.2-10.0 ppt)

Table 10-11 Dissolved Oxygen Deficits In Lower Patuxent Estuary (Sal=10.01-24.0 ppt)

Years	Average DOD	Standard Deviation	N	Correlation* Coefficient
1936 - 40	1.61	2.12	456	.153
1941 - 50	.74	1.35	81	.351
1951 - 60	2.25	2.39	147	.160
1961 - 70	1.10	1.74	834	.137
1971 - 81	2.05	2.39	749	-.313

*From regression of DOD vs. Salinity (Sal=10.01-24.0 ppt)

Table 10-12 Dissolved Oxygen Deficits In Patuxent Estuary

Years	Average DOD	Standard Deviation	N	Correlation* Coefficient
1936 - 40	1.38	2.13	571	.208
1941 - 50	.74	1.35	81	.351
1951 - 60	1.61	2.33	244	.287
1961 - 70	1.09	1.65	1556	-.126
1971 - 81	1.92	1.95	1902	-.046

*From regression of DOD vs. Salinity

Table 10-13
Dissolved Oxygen Deficits Lower Patuxent Estuary (10-24 ppt salinity)

Depth (feet)	Year 1936	1937	1938	1939	1940
0	--*	--	--	--	--
1-5	1.4/2.3/0.60/41**	0.7/1.4/0.0/78	0.7/1.3/-0.2/47	0.8/1.3/0.4/103	1.7/2.9/0.5/10
6-10	--	--	--	--	--
11-20	2.1/1.5/0.15/9	1.1/1.5/-/2	--	2.9/1.2/0.5/7	--
21-30	2.2/0.8/0.13/7	3.8/1.5/-0.1/7	--	2.8/1.8/0.6/14	--
31-40	2.4/2.3/0.11/12	3.1/1.8/-0.3/58	--	1.2/1.9/0.3/5	--
41-50	0.7/2.9/0.43/5	4.8/2.9/-0.9/5	--	3.9/1.9/0.9/4	--
51-60	3.0/3.6/0.61/8	4.5/2.5/0.1/8	1.7/3.5/-/2	2.7/3.8/-/2	--
61-99	-0.3/3.5/-0.06/9	--	--	1.7/2.0/.9/3	--
100-129	2.0/4.6/0.85/3	4.7/2.4/0.7/4	--	2.0/1.9/0.8/3	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-13
Patuxent River Dissolved Oxygen Deficits Lower Estuary (10-24 ppt)

Depth (feet)	Year 1949	1950	1951	1957	1958
0	0.4/0.9/009/9**	-0.4/1.4/0.9/6	--*	--	--
1-5	--	--	--	--	--
6-10	--	-1.1/1.2/0.9/4	--	1.7/1.0/-0.3/6	--
11-20	0.7/0.8/0.3/8	-0.1/1.4/.8/8	2.1/1.3/-/2	4.5/-/-/1	--
21-30	1.2/1.1/0.0/6	0.1/1.6/0.9/4	--	3.4/1.6/-/3	6.4/1.0/-/3
31-40	0.9/0.5/-/3	0.9/1.2/0.6/7	2.6/0.8/-/2	3.5/1.9/-/3	--
41-50	--	--	--	--	7.3/0.1/-/2
51-60	1.2/0.6/-0.8/4	0.8/1.3/0.7/4	1.9/0.0/-/2	--	--
61-99	1.7/0.4/-0.8/5	--	--	--	7.3/-/-/1
100-129	1.9/1.1/-/3	2.1/1.5/-.8/4	2.6/0.3/-/2	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/ number of observations

Table 10-13
(continued) Patuxent River Dissolved Oxygen Deficits Lower Estuary (10-24 ppt) salinity

Depth (feet)	Year 1959	1960	1961	1962
0	0.4/1.0/-0.0/13**	0.9/0.6/-/3	-1.4/-/-/1	-.4/.9/-.6/23
1-5	--*	--	--	--
6-10	0.6/1.2/0.1/16	2.6/0.7/-0.6/4	-.3/.8/-/2	--
11-20	0.8/1.5/0.3/16	4.1/2.3/-0.5/5	4.4/2.8/-.01/5	--
21-30	1.5/2.2/0.3/12	5.0/2.4/-0.3/4	6.4/1.2/.5/5	--
31-40	1.7/2.3/0.4/14	5.3/1.8/-0.0/6	6.6/1.1/.687/4	--
41-50	--	--	--	--
51-60	1.1/1.8/0.1/8	5.6/1.3/-/3	7.3/.1/-/3	--
61-99	1.3/1.8/-/3	4.9/1.9/-/2	--	--
100-129	1.7/1.8/0.5/5	6.5/0.1/-/2	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity) /number of observations

Table 10-13
(continued) Patuxent River Dissolved Oxygen Deficits Lower Estuary (10-24 ppt) salinity

Depth (feet)	Year 1963	1964	1965	1966
0	.4/.8/-.1/147**	-.1/.9/.2/36	.2/.9/.5/47	-.1/1.0/-113/20
1-5	.3/.8/.0/79	--	--	--
6-10	.9/.9/-.3/125	1.1/-/-/1	--	--
11-20	--*	2.5/.7/.3/4	--	--
21-30	1.5/1.2/-.3/59	3.6/.6/-.4/4	--	--
31-40	2.0/1.4/-.4/88	4.7/.3/-/3	--	--
41-50	2.6/1.4/-.2/26	6.0/.5/-/2	--	--
51-60	2.9/1.5/-.0/33	6.4/.21/-/2	--	--
61-98	3.3/1.4/.8/20	7.0/.6/-/3	--	--
100-129	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity) /number of observations

Table 10-13
(continued) Patuxent River Dissolved Oxygen Deficits Lower Estuary (10-24 ppt) salinity

Depth (feet)	1967	1968	1969	1970	1974
0	.9/.5/-.6/16**	--	.6/1.0/-.8/6	-2.6/-/-/1	1.0/1.1/.07/5
1-5	--*	.8/1.8/.3/8	-.3/1.4/.0/33	-.1/1.2/.2/11	--
6-10	--	--	--	--	--
11-20	--	1.1/1.4/-.2/6	--	--	--
21-30	--	--	--	--	-.01/.45/-/2
31-40	--	--	--	--	--
41-50	--	.9/1.4/-.1/4	1.6/1.1/-/2	--	.81/1.6/-/2
51-60	--	--	--	--	--
61-98	--	--	--	--	2.4/-/-/1
100-129	--	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity) /number of observations

Table 10-13
(continued) Patuxent River Dissolved Oxygen Deficits Lower Estuary (10-24 ppt) salinity

Depth (feet)	Year 1977	1978	1980	1981
0	.34/1.0/-.2/20**	.02/1.5/.29/43	1.2/1.5/.09/72	.37/1.1/-.42/79
1-5	--*	--	--	--
6-10	.2/.84/-.64/14	.82/.84/.69/17	2.4/-/-/1	1.8/1.6/-.78/6
11-20	.5/.88/-.28/35	3.4/1.8/-.2/89	1.7/.76/.27/7	.73/1.0/-.6/4
21-30	.65/.98/-.24/33	3.8/2.1/-.44/56	2.8/2.1/-.3/46	.97/1.4/-.17/32
31-40	.98/1.5/-.17/14	5.6/1.4/-.7/43	2.6/2.5/-.65/12	1.4/2.0/.2/31
41-50	.65/1.3/-.23/20	5.5/1.8/-.23/37	3.4/2.2/.02/10	1.5/1.3/-.07/9
51-60	--	5.4/3.7/-.34/7	--	--
61-98	--	8.4/.06/-/2	--	--
100-129	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity) /number of observations

Table 10-14 Dissolved Oxygen Deficits Upper Patuxent Estuary (.2-10 ppt salinity)

Depth (feet)	Year 1936	1937	1938	1939	1940
0	--*	--	--	--	--
1-5	0.9/2.3/-0.1/21**	0.8/1.2/0.0/20	--	-0.7/1.2/-0.3/41	-7.4/-/-/1
6-10	1.3/1.1/0.7/4	2.1/0.3/0.9/3	--	--	--
11-20	1.7/2.2/-0.2/11	2.5/0.3/0.0/3	--	0.9/0.3/-.2/4	--
21-30	--	1.9/-/-/1	--	1.6/0.7/0.2/4	--
31-40	--	--	--	0.8/-/-/1	--
41-50	--	--	--	--	--
51-60	--	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/ number of observations

Table 10-14 (continued)
Patuxent River Dissolved Oxygen Deficit Upper Estuary (2-10 ppt)

Depth (feet)	Year 1957	1958	1959	1960
0	--*	--	-0.2/0.8/-0.6/8	-1.0/1.7/-0.4/14
1-5	--	--	--	--
6-10	--	1.4/2.2/-0.0/14	0.3/1.2/-.2/4	0.1/1.5/-.3/11
11-20	2.2/-/-/1**	3.2/2.0/0.8/6	0.6/0.7/-/3	0.5/1.0/-0.5/9
21-30	--	1.1/2.9/0.1/5	--	0.2/1.2/-/2
31-40	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-14 (continued)
Patuxent River Dissolved Oxygen Deficits
Upper Estuary (.2-10 ppt) Salinity

Depth (Feet)	Years 1961	1962	1963	1964
0	-.3/1.7/-.6/5	1.3/1.6/-.2/44	.9/.7/-.2/72	--
1-5	--	--	--	--
6-10	2.5/2.1/.2/4	--	1.0/.9/-.1/19	-.2/1.0/-.8/6
11-20	5.7/-/-/1	--	1.6/.7/-.3/28	.5/.9/.0/8
21-30	--	--	1.8/1.0/-.6/5	.8/.4/-/2
31-40	6.4/-/-/1	--	2.1/.7/-.7/5	.6/-/-/1

Table 10-14 (continued)
Patuxent River Dissolved Oxygen Deficits
Upper Estuary (.2-10. ppt)

Depth (Feet)	Year 1965	1966	1967	1968
0	.3/1.0/-.7/55	2.3/2.1/-.6/6	.1/1.3/-.3/45	--
1-5	--	--	--	.6/1.2/-.6/22
6-10	--	--	--	--
11-20	--	--	--	--
21-30	--	--	--	--
31-40	--	--	--	--

Table 10-14 (continued)
Patuxent River Dissolved Oxygen Deficits
Upper Estuary (.2-10. ppt)

Depth (Feet)	Year 1969	1970	1971	1974
0	2.6/1.7/-.7/16	-.8/1.1/-/2	--	2.2/2.2/-.44/30
1-5	.9/1.7/-.6/114	.9/1.7/-.5/63	.4/1.6/-.83/10	--
6-10	--	--	--	--
11-20	.2/1.3/-/2	1.0/1.1/-/2	--	--
21-30	--	--	--	1.5/-/-/1
31-40	--	--	--	--

Table 10-14 (continued)
Patuxent River Dissolved Oxygen Deficits
Upper Estuary (.2-10 ppt) Salinity

Depth (Feet)	Year 1975	1976	1977	1978	1980	1981
0	.69/1.7/-.59/26	2.3/1.6/-.8/10	.88/.75/-.38/29	.89/1.5/-.33/75	1.3/1.5/-.1/49	1.3/1.1/.03/44
1-5	--	.44/1.4/.88/4	-.59/1.4/-.29/4	--	3.6/-/-/1	--
6-10	--	--	1.2/.76/-.54/32	1.6/.98/-.19/65	1.6/1.0/.4/14	2.0/1.4/-.76/7
11-20	.29/1.3/-/3	--	1.4/.69/-.6/26	2.1/1.8/.23/90	1.8/1.4/-.38/19	1.7/1.5/-.01/14
21-30	--	--	1.3/.85/-.74/10	2.5/2.1/.3/45	1.1/1.6/.6/4	.69/.54/.48/14
31-40	--	--	1.1/1.4/-/2	3.2/2.8/.41/27	1.6/1.2/-.03/10	1.2/1.6/-/3

Table 10-15
Dissolved Oxygen Deficits
In Patuxent Estuary At Various
Depth Ranges

Depth Range (ft.)	Average DOD	Standard Deviation	Correlation* Coefficient	N
0	.96922	1.5191	-.472	1469
1-5	.83102	1.7399	-.209	678
6-10	1.2144	1.3609	-.451	408
11-20	1.7701	1.6857	-.120	654
21-30	2.1285	2.0336	.040	439
31-40	2.6496	2.2304	.006	382
41-50	3.1099	2.5432	-.137	150
51-60	3.1480	2.6192	-.022	90
61-98	2.8917	2.8664	-.177	54
100-129	2.7297	2.4884	.208	30

*from regression of DOD vs salinity

Table 10-16
Dissolved Oxygen Deficits In
Lower Patuxent Estuary (salinity=
10.01 to 24.0 ppt.) at Various Depth Ranges

Depth Range (ft.)	Average DOD	Standard Deviation	Correlation* Coefficient	N
0	.36464	1.1253	.044	547
1-5	.75598	1.6282	.256	331
6-10	.55527	1.0852	-.107	150
11-20	1.7124	1.8210	-.417	333
21-30	2.3156	2.1421	-.375	298
31-40	2.7530	2.358	-.429	305
41-50	3.1983	2.5472	-.331	138
51-60	3.1949	2.5972	-.075	86
61-98	2.8959	2.9203	-.114	51
100-129	2.8786	2.4979	.093	28

*from regression of DOD vs salinity (10.01 to 24.0 ppt.)

Table 10-17
Dissolved Oxygen Deficits In
Upper Patuxent Estuary (salinity=
.2 to 10.0 ppt.) at Various Depth Ranges

Depth Range (ft.)	Average DOD	Standard Deviation	Correlation* Coefficient	N
0	.85285	1.4818	-.380	629
1-5	.60878	1.7318	-.487	304
6-10	1.3170	1.2606	-.168	184
11-20	1.7381	1.5698	.010	231
21-30	1.7154	1.8145	.182	98
31-40	2.4687	2.3503	.335	55
41-50	2.1400	2.4704	.185	11
51-60	2.1400	3.3151	.543	4
61-98	2.8200	2.1264	-.988	3
100-129	.64500	1.3364	1.0	2

*from regression of DOD vs salinity (.2 to 10.0 ppt.)

Table 10-18 Patuxent River Dissolved Oxygen Difficits Upper River (.2 to 10.0 ppt) Salinity

Month	YEARS 1936	1937	1939	1957	1958	1959
January	--	2.4/.3/-2	--	--	--	--
February	--	--	--	--	--	--
March	--	1.0/2.1/-/2	.28/.88/-.49/19	--	--	--
April	--	--	-1.2/1.1/.195/14	--	.48/1.2/-.21/19	-.06/.84/-.65/13
May	--	--	-1.1/1.2/-.93/10	--	--	--
June	--	--	--	--	--	--
July	-.09/1.1/.01/22	.7/1.4/-.23/12	.89/.5/.97/4	--	--	--
August	1.0/.22/-/3	1.3/.87/-.06/10	.84/1.9/-/3	--	3.5/2.1/.5/12	--
September	2.1/1.3/-.99/4	--	--	2.5/.42/-/3	--	--
October	--	--	--	--	--	--
November	--	--	--	--	--	--
December	4.6/1.1/.29/7	--	--	--	--	--

Table 10-18 Patuxent River Dissolved Oxygen Deficits Upper River (.2 to 10.0 ppt) Salinity

Month	YEARS 1960	1961	1962	1963	1964	1965
January	--	--	--	--	1.2/.51/-.81/22	--
February	--	--	--	1.1/.42/-.71/28	-.8/.89/-.83/27	.3/1.9/-/3
March	--	--	--	1.1/.42/-.71/28	-.8/.89/-.83/27	--
April	-.25/.96/-.25/35	--	--	--	--	--
May	--	--	1.7/1.5/.02/33	--	.07/.97/-.45/24	-.2/.76/-.82/22
June	--	--	--	.8/.26/.62/19	.75/.56/.7/30	--
July	--	1.9/2.9/.12/11	--	.64/1.0/.055/17	--	--
August	--	--	.05/1.3/-.61/11	1.4/.88/-.4/64	.74/.8/-.68/11	.71/.91/-.56/28
September	.36/2.5/-.11/11	--	--	--	--	--
October	--	--	--	1.3/.77/-/2	--	--
November	--	--	--	--	--	.92/.47/-/2
December	--	--	--	--	--	--

Table 10-18 Patuxent River Dissolved Oxygen Deficits Upper River (.2 to 10.0 ppt) Salinity

	YEARS					
Month	1966	1967	1968	1969	1970	1971
January	--	--	--	-.62/1.0/-.64/15	--	--
February	.-96/-/-/1	-.04/2.6/-.1/7	--	2.1/1.5/-.32/19	.67/.84/-.99/9	--
March	--	--	--	.17/.91/-.74/10	1.2/1.4/-.96/8	.29/1.6/-.73/11
April	--	--	--	1.1/1.97/-.65/11	1.7/.72/-.36/9	--
May	--	.64/.67/-.14/15	--	-1.9/.64/-.85/7	-2.1/2.9/-.98/5	--
June	--	--	--	2.0/2.04/-.79/20	--	--
July	2.8/-/-/1	--	--	.99/1.4/-.69/16	1.2/.74/-.98/7	--
August	3.6/-/-/1	-.12/1.0/-.5/23	--	1.8/1.9/-.92/8	-.21/1.4/-.14/10	--
September	3.9/1.2/-2	--	-.47/1.0/-.84/4	.66/.5/.8/8	.73/1.9/-.27/6	--
October	.76/-/-/1	--	1.7/1.5/-.53/5	.42/1.2/-.63/6	2.2/1.3/-.74/7	--
November	--	--	.29/.48/-.64/8	2.2/1.9/-.95/6	--	--
December	--	--	.84/1.0/-.99/5	2.1/.94/-.92/6	1.5/.59/.05/6	--

Table 10-18 Patuxent River Dissolved Oxygen Deficits Upper River (.2 to 10.0 ppt) Salinity

Month	YEARS 1974	1975	1976	1977	1978	1980	1981
January	--	.31/.4/-/3	--	--	--	--	--
February	--	1.8/.88/-.77/5	--	--	--	--	--
March	.47/-/1/1	.71/1.01/-/2	--	.1.4/1.8/-/2	--	--	.62/.6/.12/5
April	-3.4/-/1/1	.15/.95/-.76/5	--	.22/.47/-/2	.79/1.0/-.69/23	--	.69/.77/.37/49
May	2.7/1.9/-.51/10	-.54/1.7/-.53/5	2.6/.6/-/3	--	1.2/1.8/-.01/37	--	2.0/.91/.75/4
June	31./2.0/-.88/4	1.4/1.9/-.52/10	1.7/1.8/-/2	.85/.49/-/3	2.5/2.0/.38/55	.82/2.6/.83/7	3.11/.71/-.67/7
July	-3.61/-/-/1	--	3.2/2.5/-/3	1.5/.741/-.37/19	2.4/2.9/-.01/57	1.7/1.1/-.29/69	2.1/.88/.72/11
August	--	--	.78/-1/-/1	--	1.6/1.5/.58/66	1.9/1.3/.85/5	2.2/.96/-.71/5
September	4.3/.66/-/3	--	1.3/-/-/1	--	1.9/.71/.6/48	.12/1.2/.67/6	--
October	2.1/1.6/-.42/6	--	1.6/.5/-/2	.92/.97/-.83/36	3.7/0/-/1	-.11/.58/-.74/4	--
November	2.5/1.7/0.0/5	--	--	1.6/.46/-.96/12	2.5/.7/-.59/21	.99/2.5/-.67/4	--
December	2.7/.76/-/3	--	-.73/.33/-/2	1.1/.45/-.36/29	2.6/-/-/1	2.1/.5/-/2	--

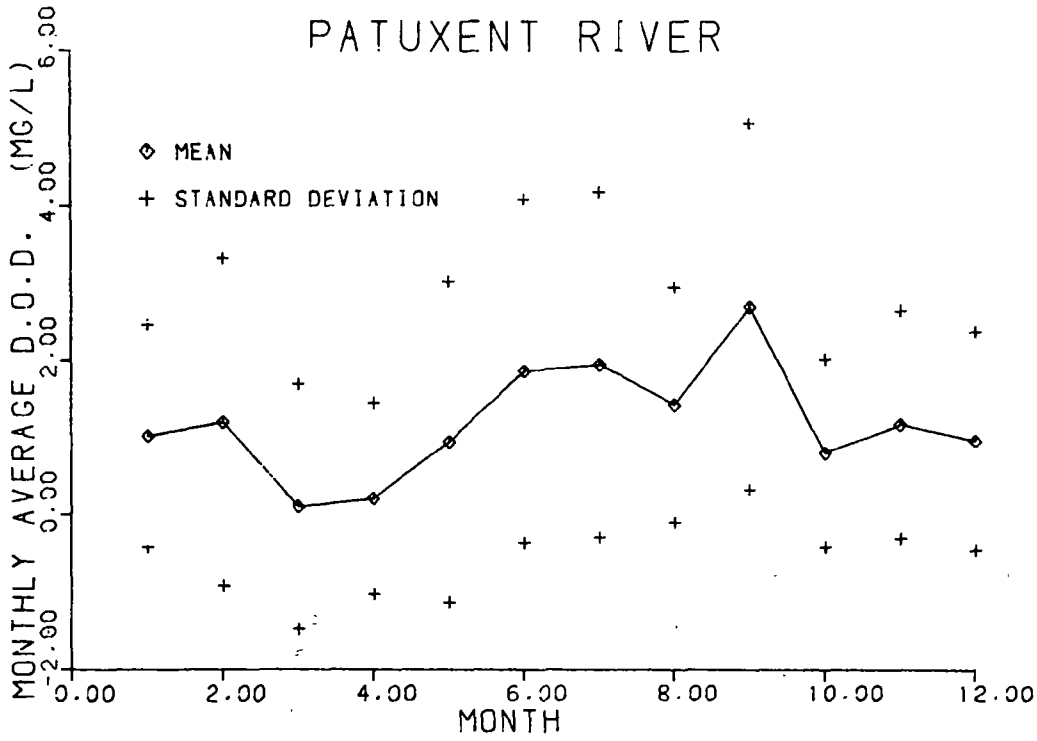


Figure 10-33 Patuxent River monthly average and standard deviations of historical dissolved oxygen deficits for saline waters (0.1 to 20 ppt).

Table 10-19 Patuxent River Dissolved Oxygen Deficits Lower River (10.01 to 24.0 ppt) Salinity

Month	Years 1936	1937	1938	1939	1940	1949	1950
January	--	3.5/1.6/.71/6	1.7/3.4/-/2	--	.39/.46/-.9/4	--	--
February	--	4.6/1.5/-.13/6	-.93/.18/-/2	--	2.9/4.3/-/2	--	--
March	--	5.4/1.6/.37/7	--	-.17/1.1/.59/10	4.3/.52/-/3	--	--
April	--	--	--	--	--	--	-.89/1.2/.85/17
May	--	.83/.63/-/2	--	--	--	--	1.4/1.2/.95/5
June	--	3.3/3.8/-/3	--	.45/.86/-.05/16	--	--	--
July	-.57/1.9/-.4/33	2.4/2.8/.7/58	1.6/.42/.88/4	.98/1.0/-.32/34	--	--	1.6/1.8/.93/4
August	2.1/1.8/.47/30	1.4/1.0/.33/69	1.5/1.4/.28/14	2.4/1.9/.35/43	--	1.3/1.1/.2/16	--
September	1.4/.59/.41/6	--	-3.0/2.1/-/2	1.4/1.5/-.07/38	--	1.2/1.4/.11/15	--
October	2.3/1.7/.08/10	.06/.25/-/2	--	--	--	.76/.41/.29/13	1.1/.55/-/33/11
November	4.6/1.9/-.6/10	-.02/.56/.85/8	.63/.46/-.21/12	--	--	--	--
December	5.6/1.7/.84/5	--	.46/.26/.06/13	--	--	--	--

Table 10-19 Patuxent River Dissolved Oxygen Deficits
Lower River (10.01 to 24.0 ppt) Salinity

Month	Years 1951	1957	1958	1959	1960
January	2.3/.71/-.02/8	--	--	--	--
February	--	--	--	--	--
March	--	--	--	--	--
April	--	--	--	-.1/.76/.42/23	2.8/1.1/-2
May	--	--	--	--	--
June	--	--	--	--	--
July	--	--	--	2.9/1.5/.65/34	--
August	--	--	6.9/.8/.77/6	--	--
September	--	2.9/1.7/.28/15	--	--	4.4/2.2/.4/27
October	--	--	--	--	--
November	--	--	--	--	--
December	--	--	--	0.0/.28/-.04/31	--

Table 10-19 Patuxent River Dissolved Oxygen Deficits Lower River (10.01-24.0 ppt) Salinity

Month	Years						
	1961	1962	1963	1964	1965	1966	1967
January	--	--	--	.45/.3/-.06/12	--	--	--
February	--	--	--	--	-.39/.3/-.06/12	-.94/.56/-.97/6	.23/.39/-/3
March	--	--	.86/.41/-.1/60	-1.2/1.3/.56/7	--	--	--
April	--	--	--	--	--	--	--
May	--	--	--	4.5/1.9/.87/19	.58/.48/-.61/12	-.98/.37/-/3	.45/-/-/1
June	--	--	.4/.52/.35/8	.08/.32/-/3	--	--	--
July	5.3/2.9/.46/23	--	2.7/1.5/.71/65	--	--	--	--
August	--	-.24/.75/-.5/22	1.3/1.1/.4/412	-.05/.87/-.54/11	-1.8/1.4/-/2	.54/.97/-.19/4	1.2/.32/.18/11
September	--	--	--	--	--	--	--
October	--	--	.47/.64/-.38/33	--	--	--	--
November	--	--	--	.12/.48/-/3	.67/.59/.08/32	.67/.61/-.4/7	--
December	--	--	--	--	--	--	--

Table 10-19 Patuxent River Dissolved Oxygen Deficits Lower River (10.1-24.0 ppt) Salinity

	Years						
Month	1968	1969	1970	1974	1977	1978	1980
January	--	--	--	--	--	--	--
February	--	-.6/-/-/1	-1.9/-/-/1	--	--	--	--
March	--	--	-2.5/-/-/1	--	--	.57/-/-/1	--
April	--	-1.7/1.7/.27/6	.52/-/-/1	--	--	.57/-/-/1	--
May	--	-.67/-/-/1	--	--	--	5.7/3.1/.77/18	
June	--	-.6/.9/.7/6	--	--	--	5.7/3.1/.77/18	2.5/1.8/-.31/7
July	--	.64/.93/-.85/13	--	-.81/-/-/1	2.4/1.4/.31/14	2.6/3.5/-.08/12	2.4/2.1/.23/95
August	--	2.4/-/-/-	--	--	1.0/1.6/-/3	3.6/2.6/-.09/28	1.3/1.1/.95/9
September	.48/1.3/-/3	1.3/.75/-/2	-.13/1.6/-.06/5	2.1/-/-/1	1.6/-/-/1	3.6/2.4/.35/215	1.9/.51/-.25/8
October	2.6/.46/.25/7	-1.2/.3/-.89/4	.54/.59/-/3	--	.08/.98/-.35/37	--	.12/.9/.38/10
November	.3/.3/-/2	-1.2/.52/-.99/4	--	1.8/-/-/1	.64/.6/-.71/20	.9/.68/-.77/17	.54/.63/-.74/9
December	-.17/.36/.54/6	-.07/.16/-/3	.56/.89/-/2	1.4/-/-/1	.34/.58/-.04/61	--	.91/1.5/-.73/10

Table 10-19 Patuxent River Dissolved Oxygen Deficits Lower River (10.1-24.0 ppt) Salinity

	Years
Month	1981
January	--
February	--
March	-.24/.7/-.47/9
April	.34/1.0/-.24/102
May	2.0/1.0/-.49/8
June	1.5/2.2/.3/16
July	2.1/1.4/-.07/17
August	2.6/1.4/-.14/9
September	--
October	--
November	--
December	--

Table 10-20

Patuxent River Dissolved Oxygen Deficits
Upper River (0.2-10 ppt) Salinity August Data

Year	Depth (Feet) 0	1-5	6-10	11-20	21-30	31-40
1936	--	1.0/0.28/-/2	--	--	--	--
1937	--	0.77/0.75/-0.7/6	1.9/0.3/-/2	--	--	--
1958	--	--	2.9/2.0/.27/7	4.0/2.13/1.0/4	--	--
1962	0.48/1.29/-0.6/11	--	--	--	--	--
1963	0.97/0.7/0.0/21	--	1.1/1.0/-0.22/13	1.7/0.7/-0.48/22	2.0/0.95/-0.8/4	2.3/0.69/-0.79/4
1964	0.74/0.8/-0.69/11	--	--	--	--	--
1965	0.7/0.9/-0.56/28	--	--	--	--	--
1966	3.6/-/-/1	--	--	--	--	--
1967	-0.12/1.03/-0.5/23	--	--	--	--	--
1969	--	2.2/1.67/-0.9/7	--	--	--	--
1970	--	-0.52/1.3/-0.42/8	--	1.0/1.12/-/2	--	--
1976	0.79/-/-/1	--	--	--	--	--
1977	--	--	--	--	--	--
1978	0.83/1.15/0.26/5	--	1.46/0.85/0.27/17	1.9/1.6/0.86/21	2.01/1.9/0.9/8	2.8/2.7/0.86/5
1980	0.63/0.43/-/2	--	--	--	--	--
1981	1.6/0.7/-/3	--	--	--	--	--

Table 10-21 Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity, August Data

Depth (feet)	Years 1936	1937	1938	1939	1949
0	--	--	--	--	.58/1.2/-/3
1-5	.75/.99/.31/12	.78/.62/.38/36	1.5/1.4/.28/14	1.1/1.2/.34/23	--
6-10	--	--	--	--	--
11-20	1.6/1.0/-/3	--	--	3.0/1.2/.53/7	.82/1.2/-/3
21-30	2.2/.96/.63/5	2.3/.78/-/2	--	4.4/1.5/-.27/6	.95/.91/-/3
31-40	3.6/.84/-/3	2.0/.9/.08/28	--	--	--
41-50	--	--	--	4.7/.92/-/3	1.8/.76/3
51-60	4.4/2.0/.97/4	--	--	--	--
61-98	3.9/1.6/-/2	--	--	--	2.0/.43/-/2
100-129	--	2.8/1.7/-/2	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table10-21(continued)
Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity, August Data

Depth (feet)	Years 1958	1962	1963	1964
0	--*	-.24/.75/-.5/22	.47/.66/-.1/84	-.05/.87/-.54/11
1-5	--	--	--	--
6-10	--	--	--	--
11-20	--	--	.99/.58/.18/97	--
21-30	6.5/1.0/-/3**	--	1.6/.75/.14/45	--
31-40	--	--	2.1/.9/.21/64	--
41-50	7.3/.12/-/2	--	2.5/.9/.57/19	--
51-60	--	--	2.9/1.1/.6/26	--
61-98	--	--	2.7/1.2/.79/15	--
100-129	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity) /number of observations

Table10-21 (continued)
Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity, August Data

Depth (feet)	Years 1965	1966	1967	1977
0	-1.8/1.4/-/2**	.54/.97/-.19/4	1.2/.32/.18/11	1.0/1.6/-/3
1-5	--*	--	--	--
6-10	--	--	--	--
11-20	--	--	--	--
21-30	--	--	--	--
31-40	--	--	--	--
41-50	--	--	--	--
51-60	--	--	--	--
61-98	--	--	--	--
100-129	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity) /number of observations

Table10-21(continued)
Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity, August Data

Depth (feet)	Year 1978	1980	1981
0	.73/.85/-.84/4	1.0/1.1/.96/5	1.8/.98/-.67/4
1-5	--	--	--
6-10	--*	--	--
11-20	--	--	--
21-30	4.0/2.2/-.4/10	2.1/.76/-/3	3.7/1.5/-/3
31-40	6.4/1.3/.3/6**	--	--
41-50	5.6/2.4/-/2	--	--
51-60	--	--	--
61-98	--	--	--
100-129	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD cs salinity)/number of observations

Table 10-22

Patuxent River August
Dissolved Oxygen Deficits (3-8 A.M.)

	Depth (ft.)			
Years	0	1-15	16-40	41-129
1936-40	--	1.7/1.3/.48/27	2.1/1.0/.64/11	3.7/1.3/.96/5
1941-50	--	--	--	--
1951-60	--	--	--	--
1961-70	1.0/.38/.32/11	.96/1.3/-.15/37	1.4/.52/.53/38	1.9/.49/.14/21
1971-81	1.8/1.2/-.32/7	2.2/1.5/-.85/7	3.2/1.2/-.38/8	--

Table 10-22

Patuxent River August
Dissolved Oxygen Deficits (9-10 A.M.)

	Depth (ft.)			
Years	0	1-15	16-40	41-129
1936-40	--	1.1/.98/.18/35	2.2/.93/.13/6	4.5/.91/--/2
1941-50	--	--	--	2.1/ .6/.99/5
1951-60	--	--	--	7.3/.08/--/2
1961-70	.65/.91/-.58/26	.82/1.2/-.38/66	1.5/.73/-.36/60	2.5/.81/.4/23
1971-81	1.2/.92/.61/9	1.7/1.2/.69/10	3.2/2.5/.53/15	--

Table 10-22

Patuxent River August
Dissolved Oxygen Deficits (11 A.M. - 6 P.M.)

	Depth (ft.)			
Years	0	1-15	16-40	41-129
1936-40	--	.88/1.2/-.06/52	2.9/1.4/.04/25	4.2/1.5/.47/9
1941-50	--	--	--	--
1951-60	--	4.1/2.0/.71/7	4.4/2.6/.97/4	--
1961-70	.35/.94/-.33/192	.63/1.1/-.41/85	1.9/1.1/.19/78	3.8/.7/.62/20
1971-81	.7/.92/-.02/21	1.7/1.3/.5/21	3.1/2.4/.63/25	--

Table 10-22

Patuxent River August
Dissolved Oxygen Deficits (7 P.M.-1 A.M.)

	Depth (ft.)			
Years	0	1-15	16-40	41-129
1936-40	--	.78/1.2/.61/12	1.8/.83/.99/6	--
1941-50	--	--	--	--
1951-60	--	--	--	--
1961-70	--	.73/2.0/-.66/16	.52/1.8/-/2	--
1971-81	--	--	--	--

Table 10-23 Patuxent River August Dissolved Oxygen Deficits Upper River (.2-10.0 ppt) Salinity (3-8 A.M.)

	Depth (ft.)		
Years	0	1-15	16-40
1936-40	--	--	--
1941-50	--	--	--
1951-60	--	--	--
1961-70	--	.73/2.0/-.66/16	.52/1.8/--/2
1971-81	2.7/1.1/--/2	3.2/.46/.86/4	3.8/.01/--/2

Table 10-23 Patuxent River August Dissolved Oxygen Deficits Upper River (.2-10.0 ppt) Salinity (9-10 A.M.)

	Depth (ft.)		
Years	0	1-15	16-40
1936-40		1.1/.86/.44/8	1.9/--/--/1
1941-50			
1951-60			
1961-70	1.4/1.3/-.76/6	1.0/1.7/-.64/26	2.1/1.4/-.66/7
1971-81	.79/.57/.61/6	1.8/1.3/.83/9	.66/.12/-.73/5

Table 10-23 Patuxent River August Dissolved Oxygen Deficits Upper River (.2-10.0 ppt) Salinity (11 A.M. - 6 P.M.)

	Depth (ft.)		
Years	0	1-15	16-40
1936-40	--	.87/1.1/-.45/6	2.6/--/--/1
1941-50	--	--	--
1951-60	--	4.1/1.9/.71/7	3.5/2.4/.94/3
1961-70	.47/1.0/-.42/89	.97/1.5/-.47/33	1.6/.81/-.43/13
1971-81	.72/1.0/-.27/13	1.7/1.4/.57/19	2.3/1.9/.97/17

Table 10-23 Patuxent River August Dissolved Oxygen Deficits Upper River (.2-10.0 ppt) Salinity (7 P.M. - 1 A.M.)

	Depth (ft.)		
Years	0	1-15	16-40
1936-40	--	--	--
1941-50	--	--	--
1951-60	--	--	--
1961-70	--	.73/2.0/-.66/16	.52/1.8/--/2
1971-81	--		--

Table 10-24 Patuxent River August Dissolved Oxygen Deficits Lower River (10.01-24.0 ppt) Salinity (3-8 A.M.)

	Depth (ft.)			
Years	0	1-15	16-40	41-129
1936-40	--	1.7/1.3/.48/27	2.1/1.0/.04/11	--
1941-50	--	--	--	--
1951-60	--	--	--	--
1961-70	1.0/.38/.32/11	1.1/.35/.42/21	1.5/.38/.11/36	--
1971-81	1.4/1.2/-.02/5	.95/1.6/-/3	3.0/1.4/-.22/6	--

Table 10-24 Patuxent River August Dissolved Oxygen Deficits Lower River (10.01-24.0 ppt) Salinity (9-10 A.M.)

	Depth (ft.)			
Years	0	1-15	16-40	41-129
1936-40	--	1.1/1.0/.46/27	2.3/1.0/-.21/5	4.5/.91/-/2
1941-50	--	--	--	2.1/.60/.99/5
1951-60	--	--	--	7.3/.08/-/2
1961-70	.42/.66/.23/20	.69/.63/.04/40	1.5/.57/.21/53	2.5./.81/.4/23
1971-81	1.9/1.2/-/3	1.4/-/-/1	4.5/2.1/-.65/10	--

Table 10-24 Patuxent River August Dissolved Oxygen Deficits Lower River (10.01-24.0 ppt) Salinity (11 A.M.-6 P.M.)

	Depth (ft.)			
Years	0	1-15	16-40	41-129
1936-40	--	.88/1.2/-.01/46	2.9/1.4/.01/24	4.2/1.5/.47/9
1941-50	--	--	--	--
1951-60	--	--	2.0/-/-/1	--
1961-70	.25/.85/-.31/103	.4/.7/-.18/52	2.0/1.1/.47/65	3.8/.7/.62/20
1971-80	.67/.85/.78/8	2.2/1.6/-/2	4.8/1.5/-.41/8	--

Table 10-24 Patuxent River August Dissolved Oxygen Deficits Lower River (10.01-24.0 ppt) Salinity (7 P.M.-1 A.M.)

	Depth (ft.)			
Years	0	1-15	16-40	41-129
1936-40	--	.78/1.2/.61/12	1.8/.83/.99/6	--
1941-50	--	--	--	--
1951-60	--	--	--	--
1961-70	--	--	--	--
1971-81	--	--	--	--

Table 10-25 Patuxent River July and August Dissolved Oxygen Deficits (3-8 A.M.)

Years	Depths (ft.) 0-15	16-40	41-129
1936-40	1.5/1.3/.54/37	2.5/1.4/-.17/17	3.4/1.5/.78/7
1941-50	1.0/.14/-/2	--	--
1951-60	1.9/.63/-.21/9	3.8/1.5/-.06/13	4.3/1.6/.93/6
1961-70	1.1/1.1/-.19/84	1.8/.94/.41/53	2.9/1.4/.4/34
1971-81	1.6/1.1/-.33/43	2.6/1.6/.19/30	3.8/2.1/.86/5

(-) indicates no data

Table 10-25 Patuxent River July And August Dissolved Oxygen Deficits (9-10 A.M.)

Years	Depths (ft.) 0-15	16-40	41-129
1936-40	.97/1.0/.16/63	1.9/1.2/.01/15	3.5/3.9/.26/6
1941-50	1.7/.15/-/2	--	2.1/.6/.996/5
1951-60	1.1/.86/.77/5	5.3/2.7/-/2	7.3/.08/-/2
1961-70	.83/1.2/-.4/141	2.4/1.9/-.31/78	3.0/1.5/-.45/27
1971-81	1.8/1.4/-.16/79	3.7/2.2/.36/43	2.8/2.1/.42/9

(-) indicates no data

Table10-25 Patuxent River July And August Dissolved Oxygen Deficits (11 A.M.-6 P.M.)

Years	Depths (ft.) 0-15	16-40	41-129
1936-40	.42/1.2/.23/102	2.7/1.9/.37/53	2.4/3.7/.17/18
1941-50	.13/1.1/.92/4	.12/.3/-/2	2.7/2.1/-/2
1951-60	3.4/2.1/-.18/9	3.8/2.1/.32/7	--
1961-70	.48/1.0/-.37/322	2.1/1.3/.18/91	4.4/1.5/-.44/24
1971-81	1.1/1.8/.026/110	3.0/2.3/.32/74	2.5/2.8/.16/11

(-) indicates no data

Table 10-25 Patuxent River July And August Dissolved Oxygen Deficits (7 P.M.- 1 A.M.)

Years	Depths (ft.) 0-15	16-40	41-219
1936-40	.31/1.2/.63/25	2.9/1.9/.07/14	-2.1/.63/.16/4
1941-50	--	--	--
1951-60	--	--	--
1961-70	.94/1.5/-.54/38	.52/1.8/-/2	--
1971-81	.79/1.4/.16/19	2.7/2.0/.57/14	3.0/1.6/.9/4

(-) indicates no data

Table 10-26 Patuxent River July And August Dissolved Oxygen Deficits Upper River (.2-10.0 ppt) Salinity (3 - 8 A.M.)

	Depth (ft.)		
Years	0-15	16-40	41-129
1936-40	--	--	--
1941-50	--	--	--
1951-60	2.9/-/-/1	--	--
1961-70	.98/1.6/-.67/35	.52/1.8/-/2	--
1971-81	2.2/.94/.07/18	2.2/1.1/.05/10	.84/-/-/1

(-) indicates no data

Table 10-26 Patuxent River July And August Dissolved Oxygen Deficits Upper River (.2-10.0 ppt) Salinity (9-10 A.M.)

	Depths (ft.)		
Years	0-15	16-40	41-129
1936-40	1.0/1.2/.4/13	2.1/.29/-/2	--
1941-50	--	--	--
1951-60	.85/.77/-/3	--	--
1961-70	1.1/1.6/-.54/62	3.0/2.2/.23/9	--
1971-81	2.0/1.4/.03/59	2.7/.92/15	.83/.01/-/2

Table 10-26 Patuxent River July and August Dissolved Oxygen Deficits Upper River (.2-10.0 ppt) Salinity (11 A.M.-6 P.M.)

	Depths (ft.)		
Years	0-15	16-40	41-129
1936-40	.16/1.2/-.026/30	.9/.82/.31/8	--
1941-50	--	--	--
1951-60	4.1/2.0/.71/7	3.5/2.4/-/3	--
1961-70	.64/1.2/-.48/153	1.5/.77/-.23/17	--
1971-81	.99/1.8/-.26/76	2.7/2.1/.57/45	3.7/3.0/.53/5

(-) indicates no data

Table10-26 Patuxent River July And August Dissolved Oxygen Deficits Upper River (.2-10.0 ppt) Salinity (7 P.M.-1 A.M.)

	Depths (ft.)		
Years	0-15	16-40	41-129
1936-40	-1.2/-/-/1	--	--
1941-50	--	--	--
1951-60	--	--	--
1961-70	.94/1.7/-.67/33	.52/1.8/-/2	--
1971-81	.42/1.1/-.7/8	1.3/1.1/.14/5	.84/-/-/1

(-) indicates no data

Table 10-27 Patuxent River July and August Dissolved Oxygen Deficits Lower River (10.01-24.0 ppt) Salinity (3-8 A.M.)

Years	Depths (ft.) 0-15	16-40	41-129
1936-40	1.5/1.3/.54/37	2.5/1.6/-.172/17	3.4/1.5/.78/7
1941-50	1.0/.14/-/2	--	--
1951-60	1.8/.54/.87/8	3.8/1.5/-.06/13	4.3/1.6/.93/6
1961-70	12./.45/.17/49	1.9/.88/.38/51	2.9/1.4/.4/34
1971-81	1.1/1.1/.11/25	2.8/1.7/.13/21	4.6/1.4/.6/4

(-) indicates no data

Table 10-27 Patuxent River July and August Dissolved Oxygen Deficits Lower River (10.01-24.0 ppt) Salinity (9-10 A.M.)

Years	Depths (ft.) 0-15	16-40	41-129
1936-40	.96/.96/.44/50	1.9/1.3/.19/13	3.5/3.9/.26/6
1941-50	1.7/.15/-/2	--	2.1/.6/.996/5
1951-60	1.5/1.1/-/2	5.2/2.7/-/2	7.3/.08/-/2
1961-70	.62/.69/-.12/79	2.4/1.9/-.75/69	3.0/1.5/-.45/27
1971-81	1.2/1.4/.2/20	4.2/2.0/-.57/28	3.4/2.0/-.05/7

(-) indicates no data

Table 10-27 Patuxent River July and August Dissolved Oxygen Deficits Lower River (10.01-24.0 ppt) Salinity (11 A.M.-6 P.M.)

Years	Depths (ft.) 0-15	16-40	41-129
1936-40	.53/1.3/.36/72	3.0/1.9/.11/45	2.4/3.7/.17/18
1941-50	.13/1.1/.92/4	.12/.3/-/2	2.7/2.1/-/2
1951-60	1.1/.14/-/2	4.1/2.2/-.63/4	--
1961-70	.32/.82/-.22/169	2.2/1.3/-.08/74	4.4/1.5/-.44/24
1971-81	1.5/1.6/.49/34	3.4/2.5/-.12/29	1.6/2.6/.62/6

(-) indicates no data

Table10-27Patuxent River July and August Dissolved Oxygen Deficits Lower River (10.01-24.0 ppt) Salinity (7 P.M.-1 A.M.)

	Depths (ft.)		
Years	0-15	16-40	41-129
1936-40	.37/1.2/.6/24	2.9/1.9/.07/14	-2.1/.63/.16/4
1941-50	--	--	--
1951-60	--	--	--
1961-70	.99/.23/-.37/5	--	--
1971-81	1.1/1.6/.48/11	3.5/2.0/.31/9	3.8/.86/-/3

(-) indicates no data

Table 10-28
Patuxent River Dissolved Oxygen Deficits
Upper River (0.2-10 ppt salinity), January Data

Depth (feet)	Year 1937	1964	1969	1975
0	--*	1.2/0.5/-0.8/22	--	0.3/0.4/-/3
1-5	2.4/0.1/-/2**		-0.6/1.1/-0.6/15	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-29 Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24.0 ppt) Salinity January Data

Depth	Years 1937	1940	1951	1964
0	--	--	--	.45/.3/-.06/12
1-5	1.8/.04/-/2	.39/.46/-.9/2	--	--
6-10	--	--	--	--
11-20	--	--	2.1/1.3/-/2	--
21-30	--	--	--	--
31-40	4.4/1.5/-/3	--	2.6/.85/-/2	--
41-50	--	--	--	--
51-60	--	--	1.9/.01/-/2	--
61-98	--	--	--	--
100-129	--	--	2.6/.34/-/2	--

Table 10-30
Patuxent River Dissolved Oxygen Deficits
Upper River (0.2-10 ppt) Salinity February Data

Depth (Feet)	Year 1965	1966	1967	1969	1970	1975
0	0.3/1.9/-/3	-0.96/-/-/1	-0.04/2.6/-0.1/7	3.2/0.3/-.99/6	--	1.8/0.87/-.77/5
1-5	--	--	--	1.6/1.6/-.33/13	0.67/0.84/-.99/9	--

Table 10-31 Patuxent River Dissolved Oxygen Deficits Lower River (10.01-24.0 ppt) Salinity February Data

Depth (feet)	Year 1937	1940	1965	1966	1969	1970
0	--*	--	-.39/-/-/1	-.94/.56/-.97/6	-.6/-/-/1	-1.9/-/-/1
1-5	4.7/1.4/-/3**	2.9/4.3/-/2	--	--	--	--
6-10	--	--	--	--	--	--
11-20	--	--	--	--	--	--
21-30	--	--	--	--	--	--
31-40	--	--	--	--	--	--
41-50	--	--	--	--	--	--
51-60	--	--	--	--	--	--
61-98	--	--	--	--	--	--
100-129	--	--	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-32 Patuxent River Dissolved Oxygen Deficits Upper River (0.2-10 ppt) Salinity, March Data

Depth (feet)	Year 1937	1939	1963
0	--*	--	1.1/0.4/-.68/26
1-5	0.1/2.1/+2**	0.1/0.89/-.37/15	--
6-10	--	--	0.5/0.22/-/2
11-20	--	--	--
21-30	--	0.86/.27/-/3	--

Depth (feet)	Year 1971	1974	1975
0	--	0.47/-/-/1	0.71/1.02/-/2
1-5	0.4/1.6/-0.8/10	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-32 Patuxent River Dissolved Oxygen Deficits Upper River (0.2-10 ppt) Salinity, March Data (cont.)

Depth (feet)	Year 1964	1969	1970
0	-0.8/0.9/-0.8/27	--*	--
1-5	--	0.26/0.9/-.75/9**	1.2/1.4/-.96/8
6-10	--	--	--
11-20	--	--	--
21-30	--	--	--

Depth (feet)	Year 1977	1981
0	--	0.97/0.32/-/3
1-5	-1.4/1/8/-/2	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-33 Patuxent River Dissolved Oxygen Deficits Lower River (10.01-24.0 ppt) Salinity March Data

Depth (feet)	Year 1937	1939	1940	1963	1964	1974
0	--*	--	--	-.85/.5/-.19/14	-1.2/1.3/.56/7	.66/-/-/1
1-5	4.6/1.4/-/3**	-.9/.84/.86/4	4.6/.5/-/3	--	--	--
6-10	--	--	--	-.94/.5/-.38/10	--	--
11-20	--	--	--	-.9/.4/-.33/14	--	--
21-30	--	--	--	-.86/.42/.05/7	--	-.01/.45/-/2
31-40	--	-.02/2.1/-/2	--	-.77/.34/.05/11	--	--
41-50	--	--	--	-.83/.16/-/2	--	.8/1.6/-/2
51-60	--	--	--	-.94/.2/-/2	--	--
61-98	--	--	--	--	--	--
100-129	--	--	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Continued Patuxent River Dissolved Oxygen Deficits Lower River (10.01-24.0 ppt) Salinity March Data

Depth (feet)	Year 1981
0	-.37/.62/-.95/4
1-5	--
6-10	--
11-20	--
21-30	.89/-/-/1
31-40	-.87/.62/-/2
41-50	--
51-60	--
61-98	--
100-129	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-34 Patuxent River Dissolved Oxygen Deficits Upper River (0.2-10 ppt) Salinity, April Data

Year	Depth (feet) 0	1-5	6-10
1939	--*	-1.2/1.1/.2/14**	--
1958	--	--	-.14/1.27/-/7
1959	-0.3/.75/-.75/7	--	-0.1/1.0/-/3
1960	-0.82/0.69/-.77/9	--	-0.52/0.84/-0.8/8
1969	--	1.13/1.97/-0.6/11	--
1970	1.7/.72/-.36/9	--	--
1974	-3.4/-/-/1	--	--
1975	0.15/0.95/-.76/5	--	--
1977	0.22/0.47/-/2	--	--
1978	0.63/1.24/-.66/6	--	1.5/0.5/-.9/4
1981	0.61/0.67/0.38/24	--	1.6/1.6/-.9/5

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-34 Patuxent River Dissolved Oxygen Deficits Upper River (0.2-10 ppt) Salinity, Ap... Data(cont.)

Year	Depth (feet) 11-20	21-30	31-40
1939	--*	--	--
1958	1.8/.66/-/2**	0.15/0.7/-/4	--
1959	0.6/.75/-/3	--	--
1960	--	--	--
1969	-.05/.75/-.6/6	0.20/1.27/-.09/6	--
1970	--	--	--
1974	--	--	--
1975	--	--	--
1977	--	--	--
1978	--	--	--
1981	1.0/1.3/-.7/7	0.0/0.7/-/3	0.46/0.26/-/3
	0.47/.27/.26/8	0.6/.55/.62/11	

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity/number of observations

Table 10-35

Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24.0 ppt) Salinity April Data

Depth	Years 1950	1959	1960	1969	1970	1978	1981
0	-1.6/.67/-/3	-1.3/-/-/1	--	--	--	--	.05/.97/-.43/51
1-5	--	--	--	-1.7/1.7/.27/6	.52/-/-/1	--	--
6-10	-1.6/.66/-/3	-.3/.76/.1/4	--	--	--	--	.99/1.2/-.5/4
11-20	-1.7/.34/-/3	-.46/.83/-.4/5	--	--	--	--	.88/1.2/-/3
21-30	-.65/.85/-/3	-.35/.69/-/3	--	--	--	.57/-/-/1	.46/.73/-.27/23
31-40	.0/.88/-/3	.32/.83/.75/5	2./-/-/1	--	--	--	.66/1.2/.18/20
41-50	--	--	--	--	--	--	--
51-60	--	.19/.15/-/2	--	--	--	--	--
61-98	--	--	--	--	--	--	--
100-129	--	--	--	--	--	--	--

Table 10-36

Patuxent River Dissolved Oxygen Deficits
Upper River (0.2-10 ppt) Salinity May Data

	Depth (Feet)					
Year	0	1-5	6-10	11-20	21-30	31-40
1939	--	-1.1/1.2/-0.9/10	--	--	--	--
1962	1.7/1.5/.02/33	--	--	--	--	--
1964	-0.44/1.0/-.74/7	--	-0.22/0.98/-0.8/6	0.49/0.89/-0.02/8	0.79/0.36/-/2	--
1965	-0.20/0.76/-0.8/22	--	--	--	--	--
1967	0.64/0.67/-0.14/15	--	--	--	--	--
1969	--	-0.19/0.64/-.85/7	--	--	--	--
1970	--	-2.1/2.9/-0.98/5	--	--	--	--
1974	2.4/1.8/-0.7/6	--	--	--	--	--
1975	-1.6/2.2/-/2	--	--	-0.02/1.6/-/2	--	--
1976	2.6/0.60/-/3	--	--	--	--	--
1978	-0.07/1.4/-0.7/10	--	1.3/0.56/-0.52/6	0.73/1.40/-0.7/9	1.6/1.7/-0.38/6	2.97/1.8/0.7/4
1981	1.68/0.23/-/2	--	--	--	--	--

Table 10-37
Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity May Data

Depth (feet)	Years 1964	1965	1966	1967
0	--*	-.58/.48/-.6/12	-.98/.37/-/3	.45/-/-/1
1-5	--	--	--	--
6-10	1.1/-/-/1**	--	--	--
11-20	2.5/.7/.33/4	--	--	--
21-30	3.6/.6/-.39/4	--	--	--
31-40	4.7/.29/-/3	--	--	--
41-50	6.0/.47/-/2	--	--	--
51-60	6.4/.18/-/2	--	--	--
61-98	7.0/.58/-/3	--	--	--
100-129	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-37 (continued)
Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity May Data

Depth (feet)	Years 1969	1978	1981
0	--*	--	1.3/.95/-.9/4
1-5	-.67/-/-/1**	--	--
6-10	--	--	--
11-20	--	--	--
21-30	--	1.4/.13/-/2	--
31-40	--	--	--
41-50	--	--	3.0/.45/-/3
51-60	--	--	--
61-98	--	--	--
100-129	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation ˆficient (DOD vs salinity)/number of observations

Table 10-38 Patuxent River Dissolved Oxygen Deficits Upper River (0.2-10 ppt) Salinity June Data

	Depth (feet)					
Year	0	1-5	6-10	11-20	21-30	31-40
1963	0.8/0.26/0.62/19**	--*	--	--	--	--
1964	0.75/0.56/0.7/30	--	--	--	--	--
1969	3.1/1.76/-0.85/7	1.4/2.0/-0.8/13	--	--	--	--
1974	3.08/2.0/-0.9/4	--	--	--	--	--
1975	1.4/2.1/-0.59/8	--	--	--	--	--
1976	1.7/1.85/-/2	--	--	--	--	--
1977	0.85/0.49/-/3	--	--	--	--	--
1978	1.02/0.67/0.1/14	--	1.39/0.52/0.2/10	2.87/2.02/0.24/17	3.4/1.9/-0.3/8	5.56/2.3/-0.0/5
1980	1.28/3.4/0.8/4	--	--	--	--	--
1981	2.97/0.86/-.78/4	--	--	3.28/0.84/-/2	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-39
Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity June Data

Depth (feet)	Years 1937	1939	1963	1964
0	--*	--	.4/.52/-.35/8	.08/.32/-/3
1-5	-.96/-/-/1**	.45/.86/-.05/16	--	--
6-10	--	--	--	--
11-20	--	--	--	--
21-30	--	--	--	--
31-40	--	--	--	--
41-50	--	--	--	--
51-60	5.5/1.0/-/2	--	--	--
61-98	--	--	--	--
100-129	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-39 (continued)
Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity, June Data

Depth (feet)	Years 1969	1978	1980	1981
0	.9/.08/-/2**	.23/-/-/1	.96/.75/-/3	.78/.92/-.36/8
1-5	.46/1.2/.76/4	--	--	--
6-10	--*	--	--	--
11-20	--	.74/-/-/1	--	--
21-30	--	2.0/.14/-/3	4.7/.5/-/2	.87/2.3/-/3
31-40	--	8.3/-/-/1	--	4.9/2.2/-/3
41-50	--	6.6/2.2/.76/5	--	.13/.28/-/2
51-60	--	7.4/1.2/-.08/5	--	--
61-98	--	8.4/.06/-/2	--	--
100-129	--	--	--	--

* (-) indicates no data

** values represent-average/standard diviation/correlation coefficinet (DOD vs salinity)/number of observations

Table 10-40
Patuxent River Dissolved Oxygen Deficits
(Upper River) Salinity, July Data

	Depth (feet)		
Year	11-20	21-30	31-40
1936	0.49/1.3/0.43/7	--	--
1937	2.6/0.38/-/2	--	--
1961	--*	--	--
1963	1.15/0.6/0.7/6**	--	--
1966	--	--	--
1969	--	--	--
1974	--	--	--
1976	--	--	--
1977	1.84/0.41/-.76/6	--	--
1978	2.87/2.4/-0.98/17	4.27/2.94/-0.19/8	4.15/4.39/-0.2/5
1980	2.35/1.06/0.62/14	1.38/0.14/-/2	2.04/0.8/0.6/7
1981	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinitu)/number of observations

Table 10-40
Patuxent River Dissolved Oxygen Deficits
(Upper River) Salinity, July Data

Year	Depth (feet) 0	1-5	6-10
1936	--*	-0.52/0.91/-0.26/13	0.65/0.02/-/2
1937	--	0.1/0.97/-0.1/9	--
1961	-0.31/1.7/-0.65/5**	--	2.6/2.1/0.16/4
1963	-0.53/1.3/-0.2/4	--	1.0/0.65/0.57/4
1966	2.8/-/-/1	--	--
1969	0.36/0.22/-/2	1.08/1.5/-0.7/14	1.2/0.7/-0.9/7
1974	-3.5/-/-/1	--	--
1976	3.2/2.5/-/3	--	--
1977	0.57/0.84/-0.38/5	--	1.72/0.4/-0.6/6
1978	0.04.2.09/-0.71/13	--	1.53/1.8/-0.86/10
1980	1.4/2/0/-0.4/32	--	1.5/1.0/0.36/11
1981	2.0/0.83/0.9/6	--	3.14/0.37/-/2

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-41. Patuxent River Dissolved Oxygen Deficits Lower River (10.01-24 ppt) Salinity July Data

Depth (feet)	Year 1936	1937	1938	1939	1950	1959
0	--*	--	--	--	.93/.93/-/2	--
1-5	-.19/.85/.38/14**	-.22/.7/.4/26	1.6/.42/.9/4	.7/1.1/-.2/22	--	--
6-10	--	--	--	--	--	1.9/.55/.04/6
11-20	--	2.2/-/-/1	--	--	--	2.5/.54/-.72/6
21-30	--	4.5/1.6/-/2	--	1.6/.8/-.2/8	--	3.8/1.4/.24/5
31-40	1.1/2.7/-.08/5	4.3/1.7/.5/23	--	1.3/1.0/-/2	--	4.4/1.4/.27/5
41-50	-1.4/.77/-/3	--	--	--	--	--
51-60	-2.4/1.6/-.74/6	5.8/1.7/-/3	--	--	--	4.0/1.1/-/2
61-98	--	--	--	--	--	--
100-129	--	6.6/.7/-/2	--	--	--	3.6/.2/-/2

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-41 Patuxent River Dissolved Oxygen Deficits Lower River (10.01-24 ppt) Salinity July Data

Depth (feet)	Year 1961	1963	1969	1974	1977	1978
0	-1.4/-/-/1**	.8/.74/.77/8	.42/1.2/-.95/4	-.81/-/-/1	.61/1.0/-/3	-1.3/-/-/1
1-5	--*	--	.73/.83/.78/9	--	--	--
6-10	-.27/.82/-/2	.99/.66/.64/8	--	--	--	--
11-20	4.4/2.8/-.01/5	--	--	--	--	--
21-30	6.4/1.2/.53/5	3.0/.9/-.14/7	--	--	2.6/.96/-/3	2.0/3.1/-/3
31-40	6.6/1.1/.69/4	3.5/.69/.2/13	--	--	3.4/.89/-/3	6.6/.84/-.99/4
41-50	7.3/.12/-/3	4.1/.77/.85/5	--	--	4.1/.64/-/2	-.55/-/-/1
51-60	--	4.5/.32/.92/5	--	--	--	.3/1.9/-/2
61-98	--	4.9/.29/.79/5	--	--	--	--
100-129	--	--	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-41 Patuxent River Dissolved Oxygen Deficits Lower River (10.01-24 ppt) Salinity July Data

Depth (feet)	Year 1980	1981
0	1.5/1.6/.55/46	1.2/1.2/-.6/8
1-5	--*	--
6-10	--	--
11-20	1.5/.16/-/3**	--
21-30	3.1/2.2/.33/33	3.7/1.1/.12/4
31-40	4.3/2.4/-.4/6	2.2 / .48/-/2
41-50	4.3/1.7/.66/7	1.87/.08/-/2
51-60	--	--
61-98	--	--
100-129	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-42 Patuxent River Dissolved Oxygen Deficits Upper River (0.2-10 ppt) Salinity September, Data

Year	Depth (feet) 0	1.5	6-10
1936	--*	2.1/1.5/-/2	--
1960	-1.2/2.9/-0.5/5**	--	1.86/1-4/-/3
1966	3.9/1.2-/2	--	--
1968	--	-0.47/1.04/-0.84/4	--
1969	--	0.59/0.5/0.78/7	--
1970	-0.83/1.9/-/2	1.5/1.7/-0.85/4	--
1974	4.34/0.66/-/3	--	--
1976	1.25/-/-/1	--	--
1978	1.9/0.75/0.21/11	--	1.93/0.85/-0.12/13
1980	-0.04/1.5/-/3	--	

(-) indicates no data

* values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-42 Patuxent River Dissolved Oxygen Deficits Upper River (0.2-10 ppt) Salinity September, Data (cont.)

Year	Depth (feet) 11-20	21-30	31-40
1936	--*	--	--
1960	1.5/0.76/-/3**	--	--
1966	--	--	--
1968	--	--	--
1969	--	--	--
1970	--	--	--
1974	--	--	--
1976	--	--	--
1978	2.0/0.69/0.55/13	1.82/0.58/0.09/8	1.56/0.66/-/3
1980	--	--	--

* (-) indicates no data

** value represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-43
Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity, September Data

Depth (feet)	Year 1936	1938	1939	1949
0	--*	--	--	0.0/.7/-/3
1-5	.94/.2/-/3**	-3.0/2.1/-/2	1.4/1.5/-.07/38	--
6-10	--	--	--	--
11-20	1.4/-/-/1	--	--	.62/.88/-/3
21-30	--	--	--	1.6/2.1/-/2
31-40	--	--	--	--
41-50	--	--	--	2.6/2.9/-/2
51-60	--	--	--	--
61-98	--	--	--	1.6/.01/-/2
100-129	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-43 (continued)
Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity, September Data

Depth (feet)	Years 1957	1960	1968	1970
0	--	.9/.56/-/3	--	-2.6/-/-/1
1-5	--	--	-1.9/-/-/1	.09/.29/-/3
6-10	1.7/.97/-.3/6	2.6/.7/-.64/4	--	--
11-20	4.6/-/-/1	4.1/2.3/-.5/5	--	--
21-30	3.4/1.6/-/3	5.0/2.4/-.29/4	--	--
31-40	3.5/1.9/-/3	5.9/1.0/-.41/5	--	--
41-50	--	--	--	--
51-60	--	5.6/1.3/-/3	--	--
61-98	--	--	--	--
100-129	--	6.5/.13/-/2	--	--

* (-) indicates no data

** values represent-average/standard devistion/correlation coefficient (DOD vs salinity)/number of observations

Table10-43(continued)
Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity,September Data

Depth (feet)	Years 1974	1977	1978	1980
0	2.1/-/-/1	1.6/-/-/1	-.13/1.6/.42/33	1.6/.43/.06/4
1-5	--	--	--	--
6-10	--	--	.77/.84/.66/16	--
11-20	--	--	3.8/1.6/.07/75	--
21-30	--	--	4.8/1.5/-.9/33	2.0/.26/-/3
31-40	--	--	5.5/.82/-.51/30	--
41-50	--	--	5.7/.94/-.5/28	--
51-60	--	--	--	--
61-98	--	--	--	--
100-129	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-44

Patuxent River Dissolved Oxygen Deficits
Upper River (0.2 to 10 ppt) Salinity October Data

	Depth (Feet)					
Year	0	1-5	6-10	11-20	21-30	31-40
1963	1.2/0.77/-/2	--	--	--	--	--
1966	0.76/-/-/1	--	--	--	--	--
1968	--	1.71/1.47/-0.53/5	--	--	--	--
1969	--	0.42/1.16/-0.6/6	--	--	--	--
1970	--	2.2/1.34/-0.74/7	--	--	--	--
1974	2.1/1.6/-0.4/6	--	--	--	--	--
1977	0.68/1.1/-0.75/8	--	0.7/1.0/-0.64/10	1.11/0.8/-0.94/10	1.2/1.1/-0.99/6	1.1/1.5/-/2
1978	3.7/-/-/1	--	--	--	--	--
1980	-0.4/0.7/-/2	--	--	--	--	--

Table 10-45 Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity October Data

Depth (ft.)	1936	1949	1950	1963	1968
0	--	.66/.8/-/3	--	.47/.64/-.38/33	--
1-5	2.0/1.8/.12/5	--	--	--	2.5/.41/.46/4
6-10	--	--	--	--	--
11-20	--	.56/.12/-/2	.95/.05/-/3	--	--
21-30	--	--	--	--	--
31-40	2.3/2.4/-/2	.62/.35/-/2	1.2/.68/-/3	--	--
41-50	--	--	--	--	--
51-60	--	.68/.01/-/2	1.3/.96/-/3	--	--
61-98	--	--	--	--	--
100-129	--	--	.91/.08/-/2	--	--

Table 10-45 (continued)
Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity October Data

Depth (ft.)	1969	1970	1977	1980
0	--	--	.04/1.4/-.79/5	-.59/.35/.27/5
1-5	-1.2/.31/-.89/4	.54/.59/-/3	--	--
6-10	--	--	.02/1.4/-.81/5	--
11-20	--	--	.02/1.0/-.38/10	--
21-30	--	--	.19/1.0/-.24/8	--
31-40	--	--	-.04/.73/-/3	--
41-50	--	--	.18/.5/.92/6	--
51-60	--	--	--	--
61-98	--	--	--	--
100-129	--	--	--	--

Table 10-46

Patuxent River Dissolved Oxygen Deficits
Upper River (0.2-10 ppt) Salinity November Data

	Depths (Feet)					
Year	0	1-5	6-10	11-20	21-30	31-40
1965	0.92/0.47/-/2	--	--	--	--	--
1968	--	0.29/0.48/-0.64/8	--	--	--	--
1969	--	2.2/1.86/-0.95/6	--	--	--	--
1974	2.48/1.73/-/5	--	--	--	--	--
1977	1.41/0.5/-0.99/4	--	1.5/0.4/-0.95/5	1.9/0.46/-/3	--	--
1978	2.37/0.78/-0.72/4	--	2.37/0.71/-0.68/5	2.54/0.75/-0.73/6	2.83/0.7/-0.97/4	2.8/0.89/-/2
1980	1.58/2.65/-/3	--	--	--	--	--

Table 10-47
Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity November Data

Depth (feet)	Years 1936	1937	1938	1964	1965
0	--*	--	--	.12/.48/-/3	.67/.59/.08/32
1-5	4.8/2.2/-.71/5**	-.5/.24/.69/4	.63/.46/-.21/12	--	--
6-10	--	--	--	--	--
11-20	--	--	--	--	--
21-30	--	--	--	--	--
31-40	--	.63/.04/-/2	--	--	--
41-50	--	--	--	--	--
51-60	--	--	--	--	--
61-98	--	--	--	--	--
100-129	--	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-47
Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity November Data

Depth (feet)	Years 1966	1974	1977	1978	1980
0	.67/.61/-.41/7	1.8/-/-/1**	.24/.35/-/2	.79/.76/-.84/4	.24/.17/-.32/4
1-5	--*	--	--	--	--
6-10	--	--	.29/.28/-/2	1.6/-/-/1	--
11-20	--	--	.63/.52/-.98/6	1.0/.82/-.84/5	2.0/-/-1
21-30	--	--	.82/.65/-.86/6	.57/.67/-.66/4	.18/.45/-/2
31-40	--	--	.74/1.0/-/2	1.3/.41/-/2	.75/.26/-/2
41-50	--	--	.76/1.1/-/2	--	--
51-60	--	--	--	--	--
61-98	--	--	--	--	--
100-129	--	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-48 Patuxent River Dissolved Oxygen Deficits
Upper River (0.2-10ppt) Salinity December Data

	Depth (Feet)				
Year	0	1-5	6-10	11-20	21-30
1936	--	4.77/1.05/0.97/4	--	5.23/0.47/-/2	--
1968	--	0.84/1.02/-.99/5	--	--	--
1969	--	2.14/0.95/-0.92/6	--	--	--
1970	--	1.53/0.59/0.05/6	--	--	--
1974	2.7/0.76/-/3	--	--	--	--
1977	1.0/0.43/-0.33/9	--	1.09/0.53/-0.60/11	1.10/0.45/-0.53/7	1.29/0.13/-/2
1978	2.6/-/-/1	--	--	--	--
1980	2.46/-/-/1	--	--	--	--

Table 10-49
Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity December Data

Depth (feet)	Year 1936	1938	1959	1968	1969
0	--*	--	--	--	--
1-5	6.4/.89/-/2	.46/.26//06/13	--	-.45/.26/-/3	-.07/.16/-/3
6-10	--	--	-.12/.39/-.54/6	--	--
11-20	3.9/.01/-/2**	--	.03/.14/-.43/5	--	--
21-30	--	--	.12/.14/-.78/4	--	--
31-40	--	--	.15/.19/-.8/4	--	--
41-50	--	--	--	--	--
51-60	--	--	.11/.24/.89/4	--	--
61-98	--	--	--	--	--
100-129	--	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

Table 10-49 (continued)
Patuxent River Dissolved Oxygen Deficits
Lower River (10.01-24 ppt) Salinity December Data

Depth (feet)	Years 1970	1974	1977	1980
0	--	1.4/-/-/1	-.05/.52/.33/6	.77/1.7/-.92/5
1-5	.56/.89/-/2**	--	.31/.52/-.31/7	--
6-10	--*	--	--	--
11-20	--	--	.45/.54/-.07/16	3.1/-/-/1
21-30	--	--	.45/.56/-.11/16	--
31-40	--	--	.37/.71/.14/6	-.18/.13/-/2
41-50	--	--	.23/.67/.1/10	--
51-60	--	--	--	--
61-98	--	--	--	--
100-129	--	--	--	--

* (-) indicates no data

** values represent-average/standard deviation/correlation coefficient (DOD vs salinity)/number of observations

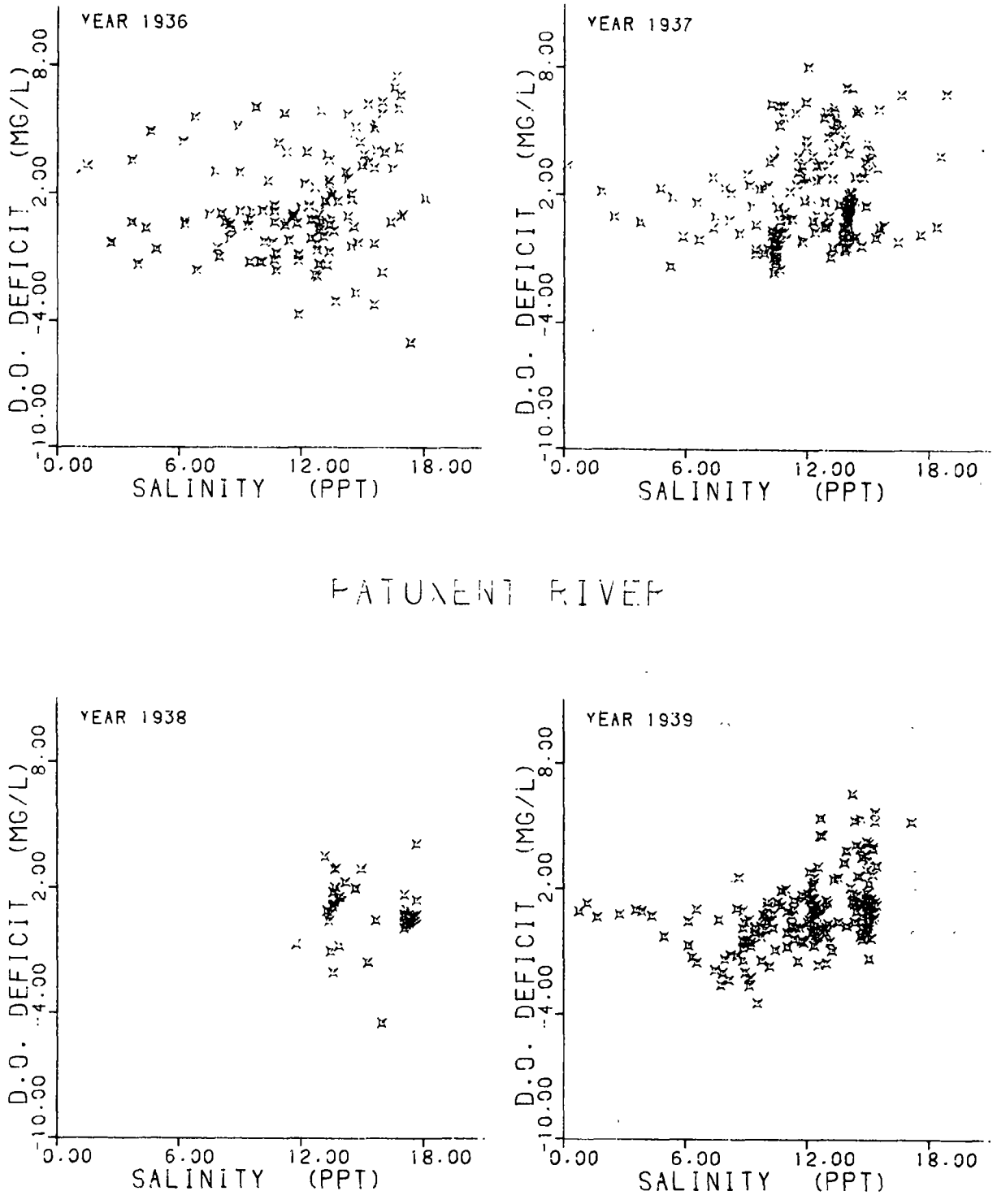
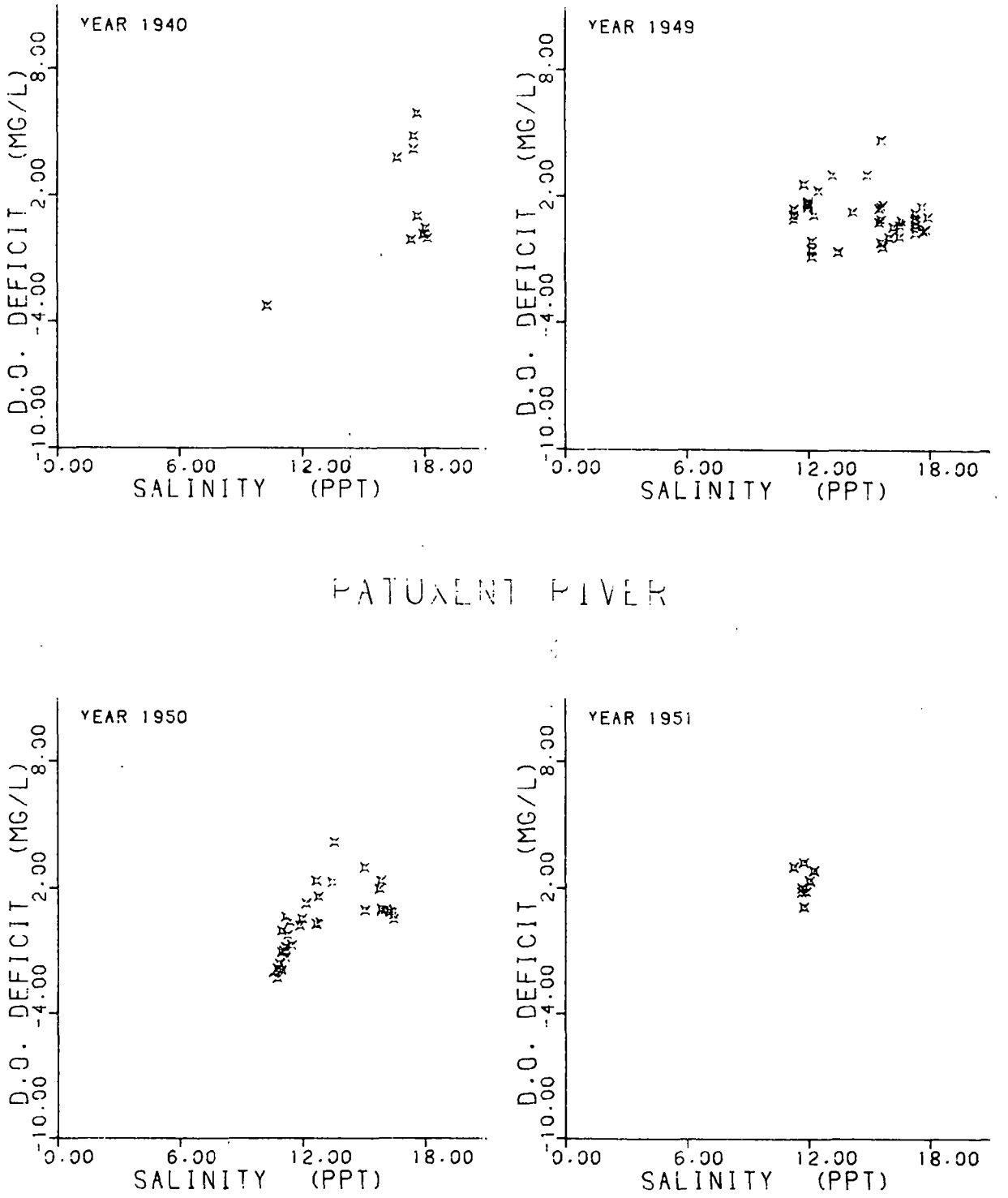
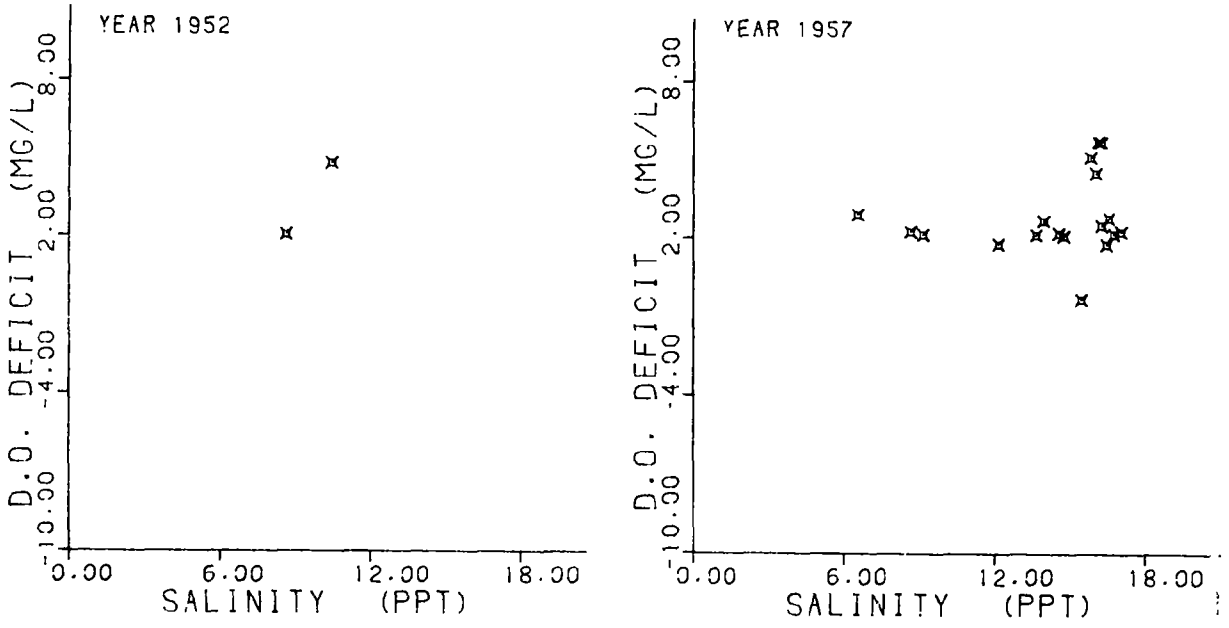


Figure 10-34 Patuxent River plots of historical dissolved oxygen deficits versus salinity.



PATUXENT RIVER

Figure 10-34 (continued) Patuxent River plots of historical dissolved oxygen deficits versus salinity.



PATUXENT RIVER

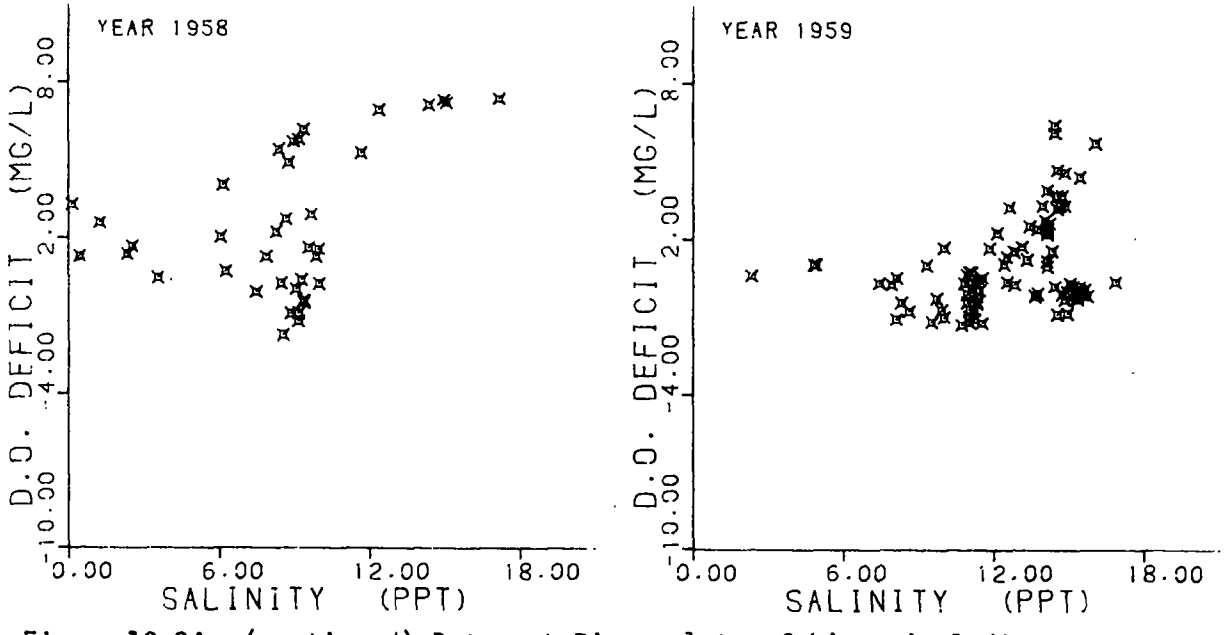
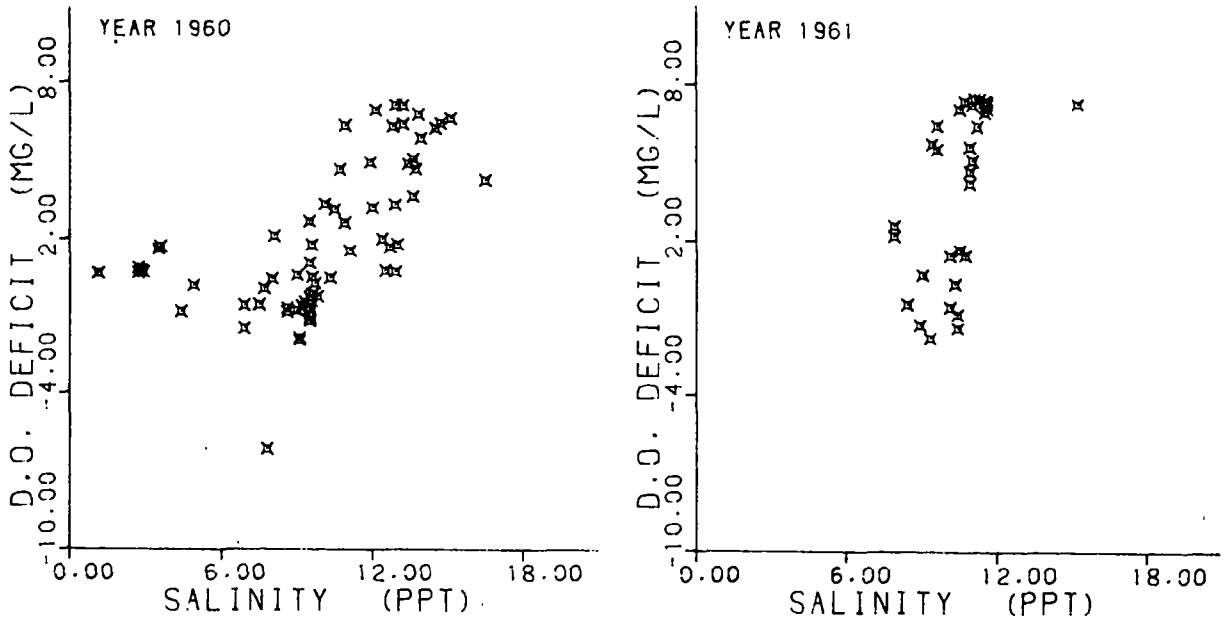


Figure 10-34 (continued) Patuxent River plots of historical dissolved oxygen deficits versus salinity.



PATUXENT RIVER

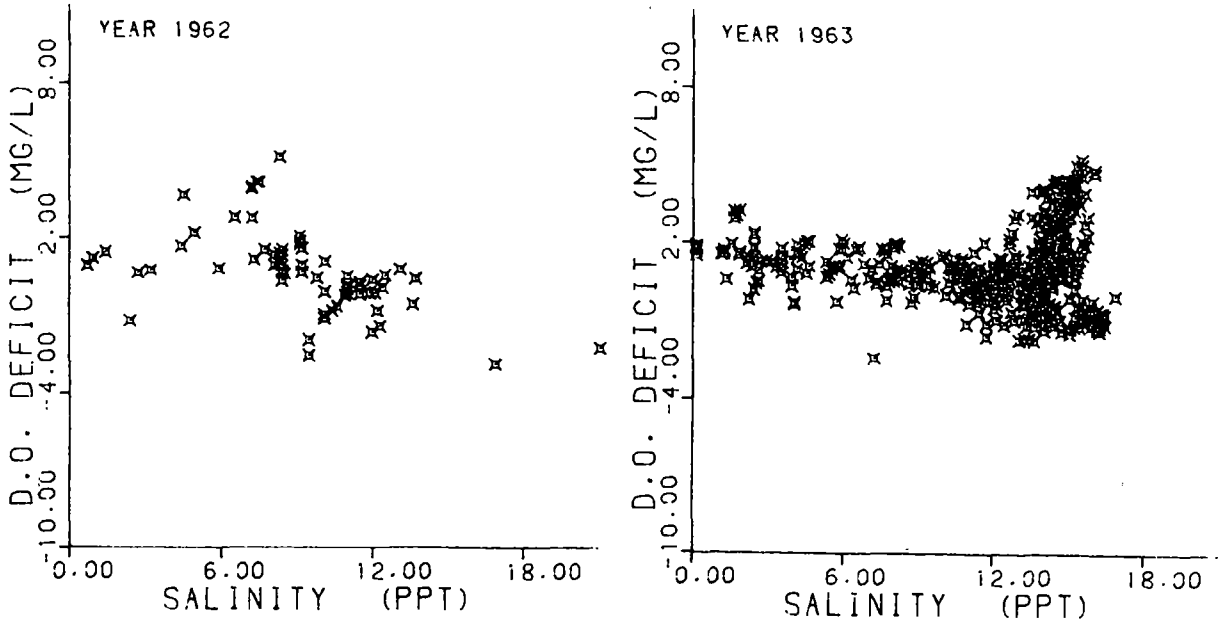
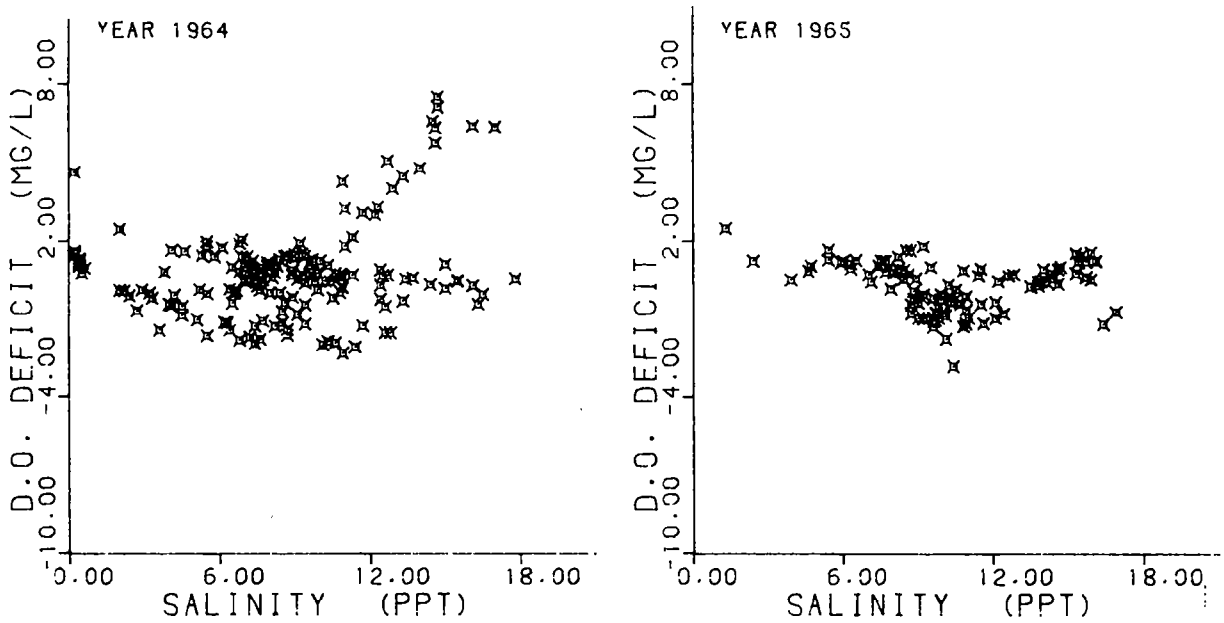


Figure 10-34 (continued) Patuxent River plots of historical dissolved oxygen deficits versus salinity.



PATUXENT RIVER

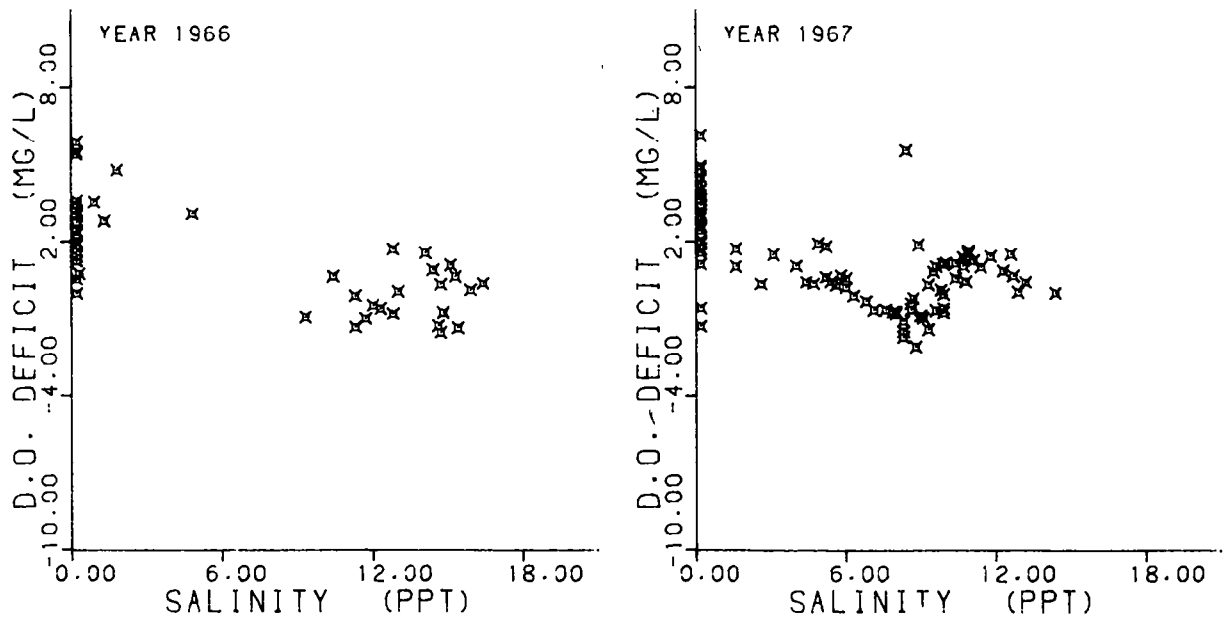
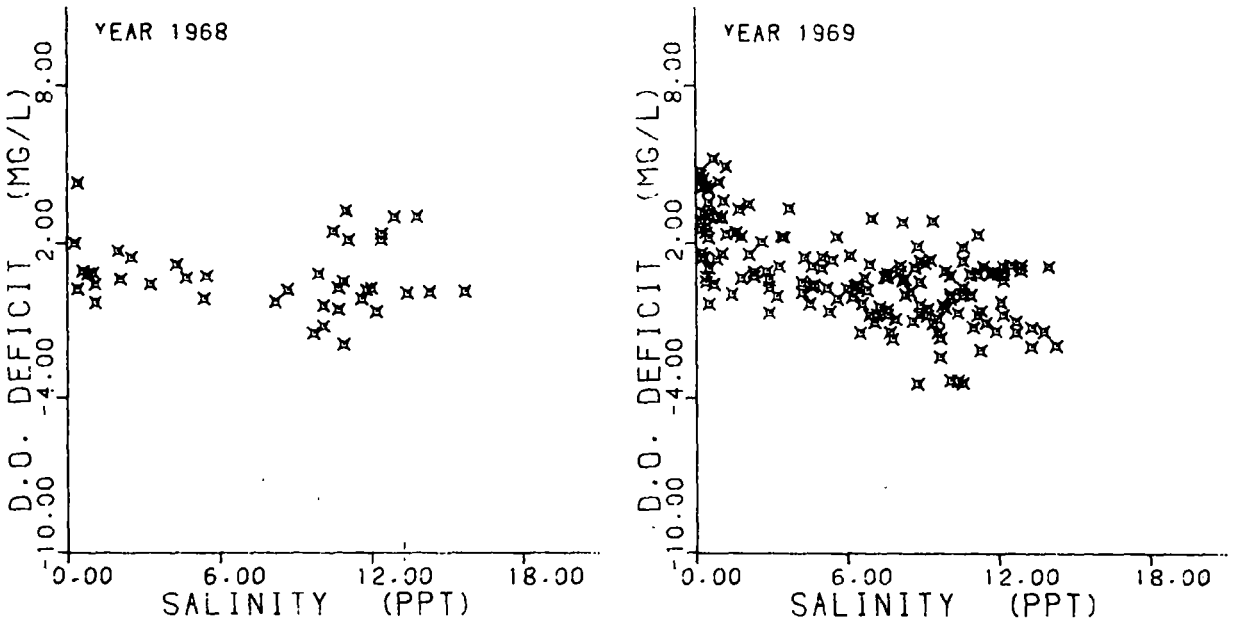


Figure 10-34 (continued) Patuxent River plots of historical dissolved oxygen deficits versus salinity.



PATUXENT RIVER

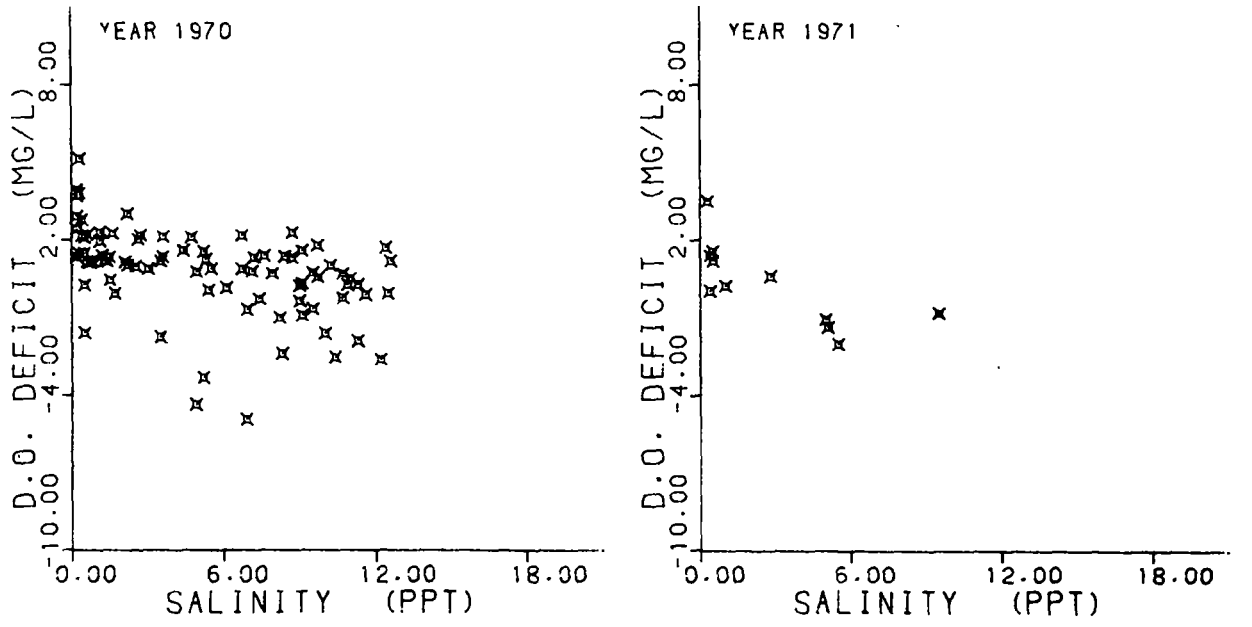
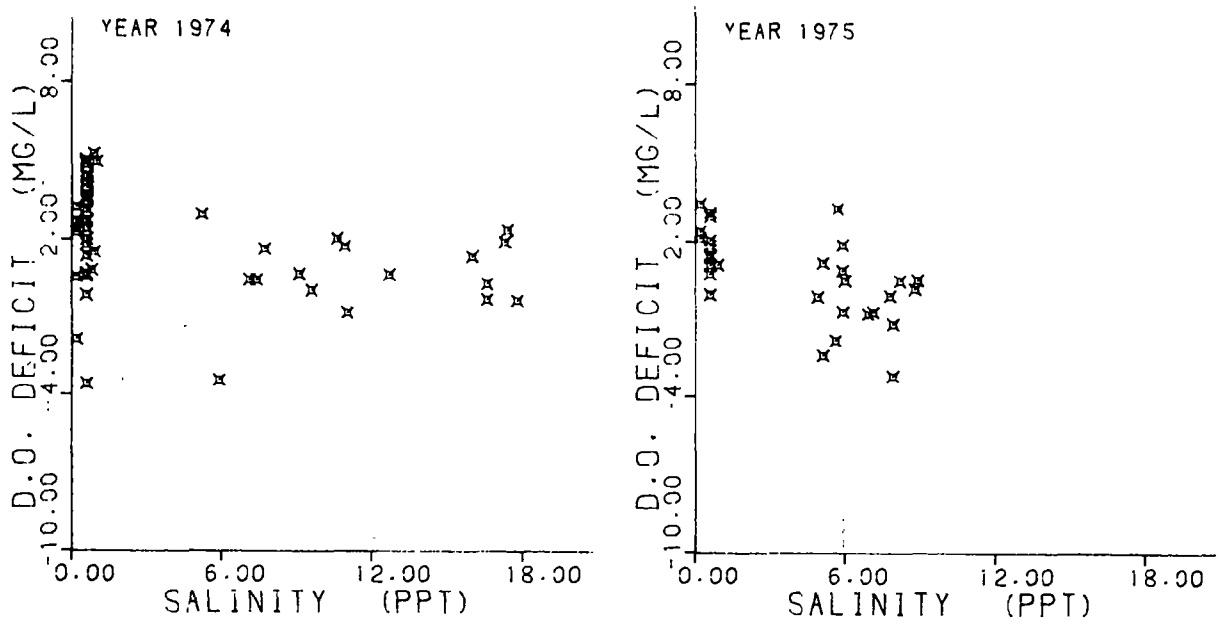


Figure 10-34 (continued) Patuxent River plots of historical dissolved oxygen deficits versus salinity.



PATUXENT RIVER

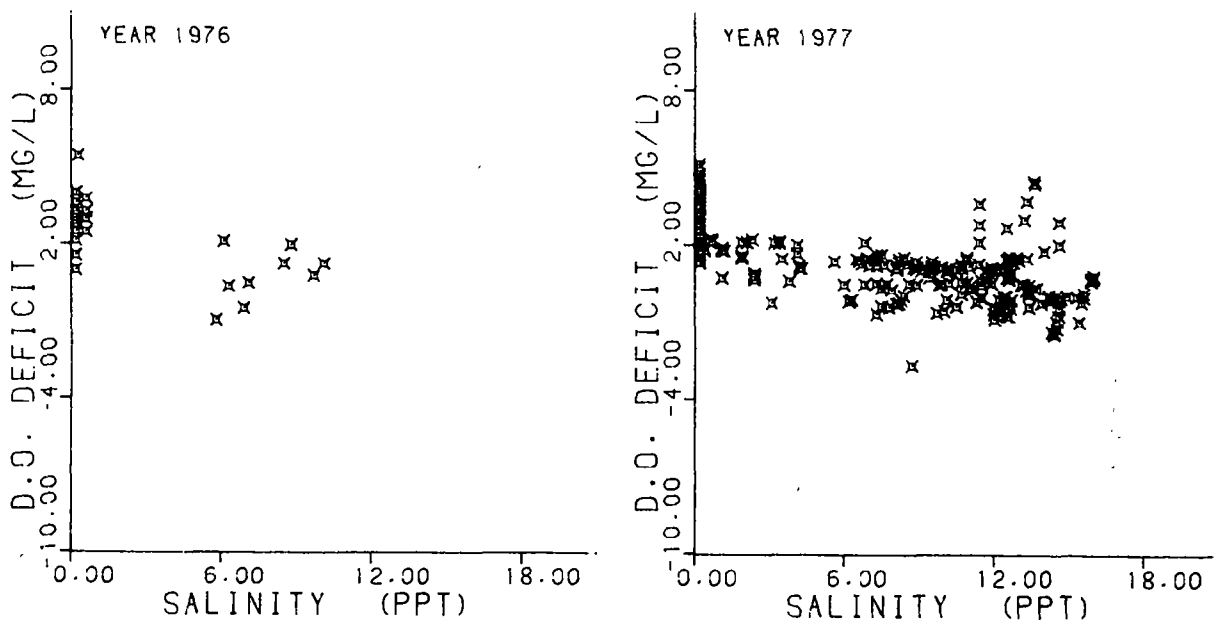
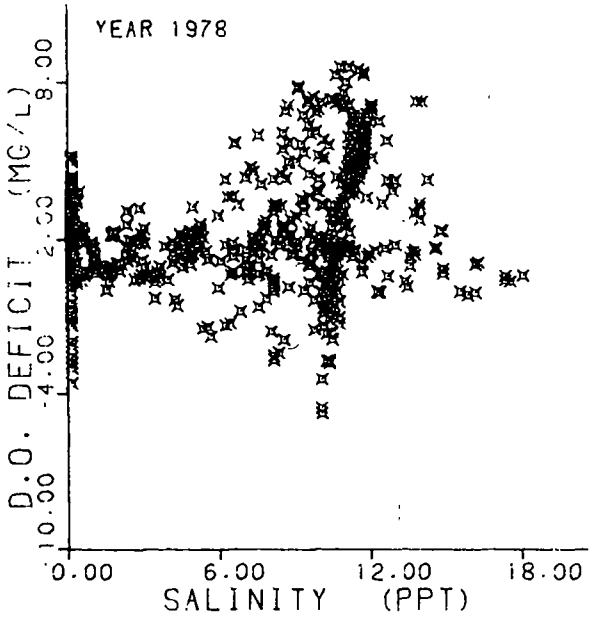
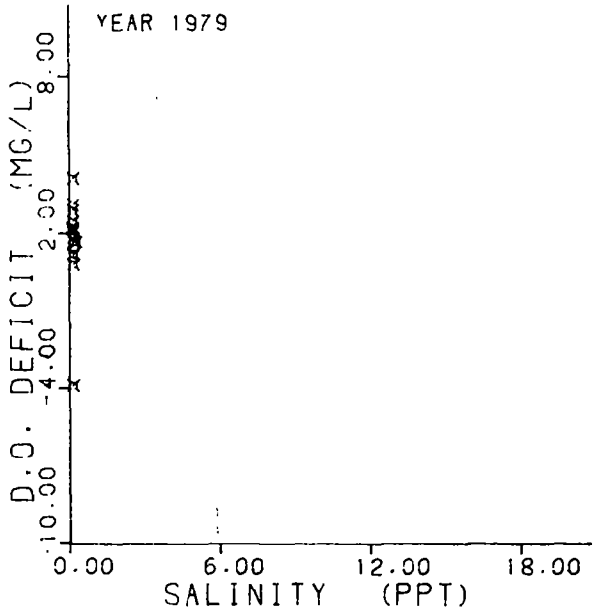
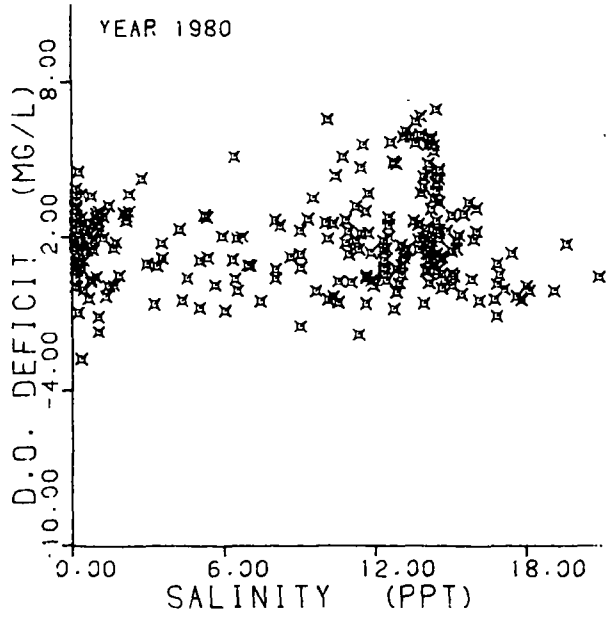


Figure 10-34 (continued) Patuxent River plots of historical dissolved oxygen deficits versus salinity.





PATUXENT RIVER



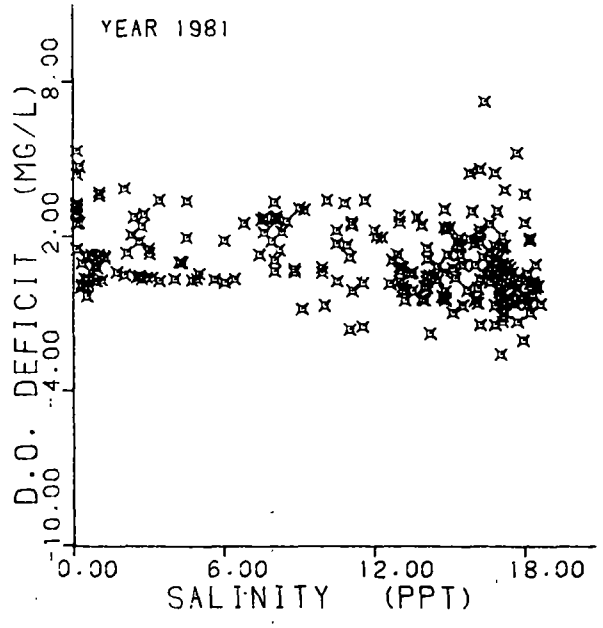


Figure 10-34 (continued) Patuxent River plots of historical dissolved oxygen deficits versus salinity.

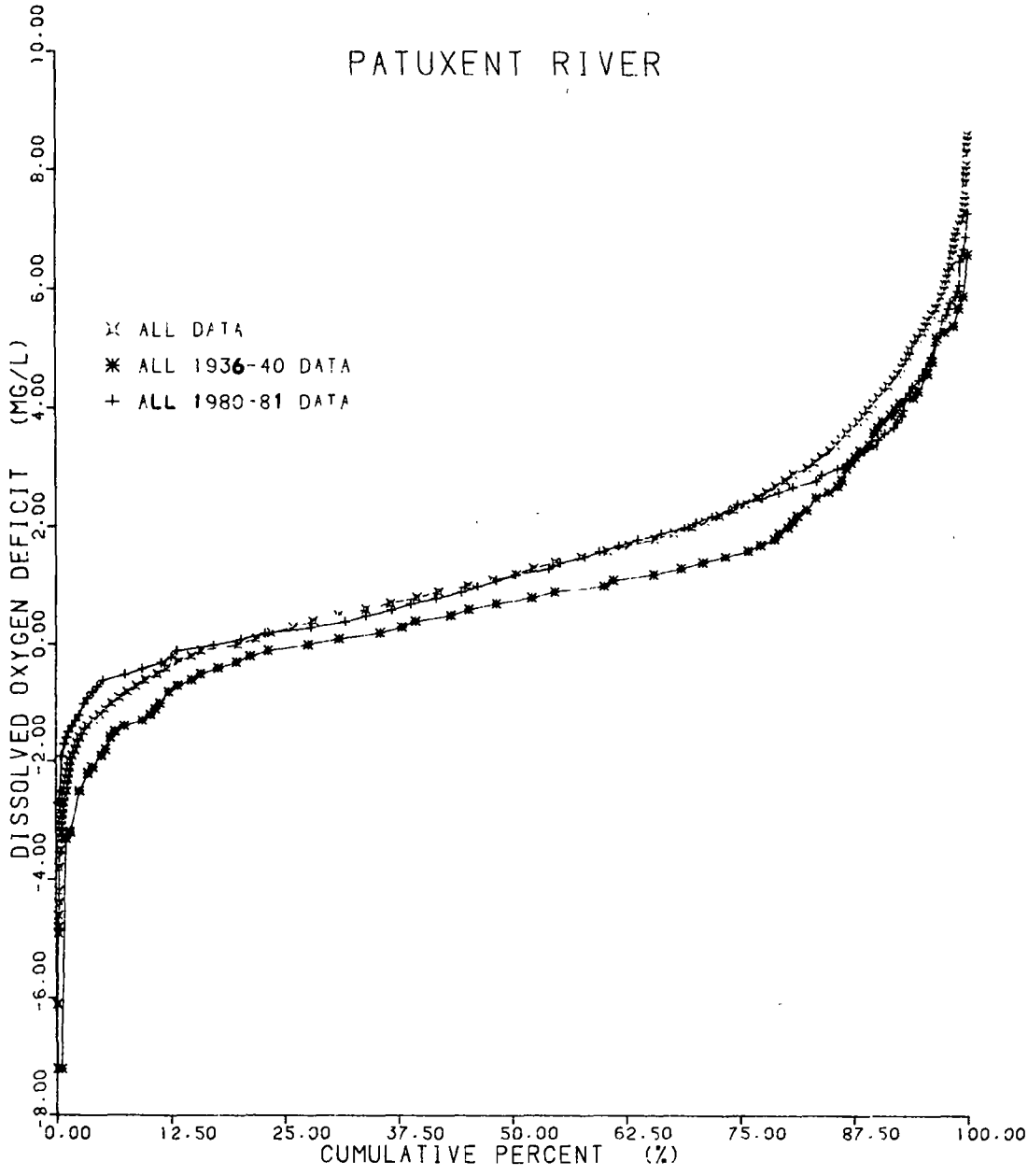


Figure 10-35 Patuxent River cumulative frequency distributions of dissolved oxygen deficits for all historical data, historical data from 1936-1940, and 1980-1981.

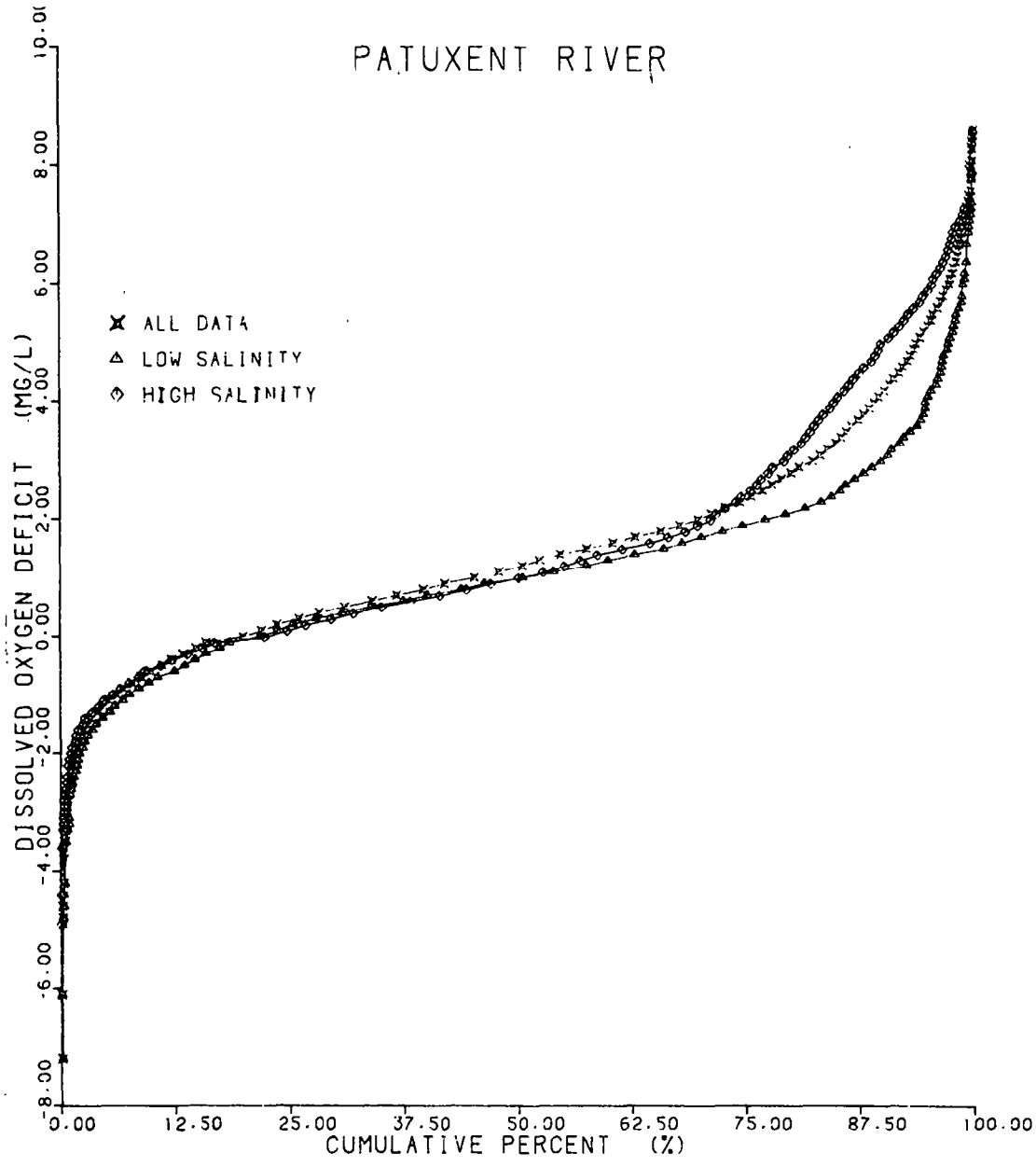


Figure 10-36 Cumulative frequency distributions of dissolved oxygen deficits in the upper and lower Patuxent River and all historical data (>0.1 ppt salinity).

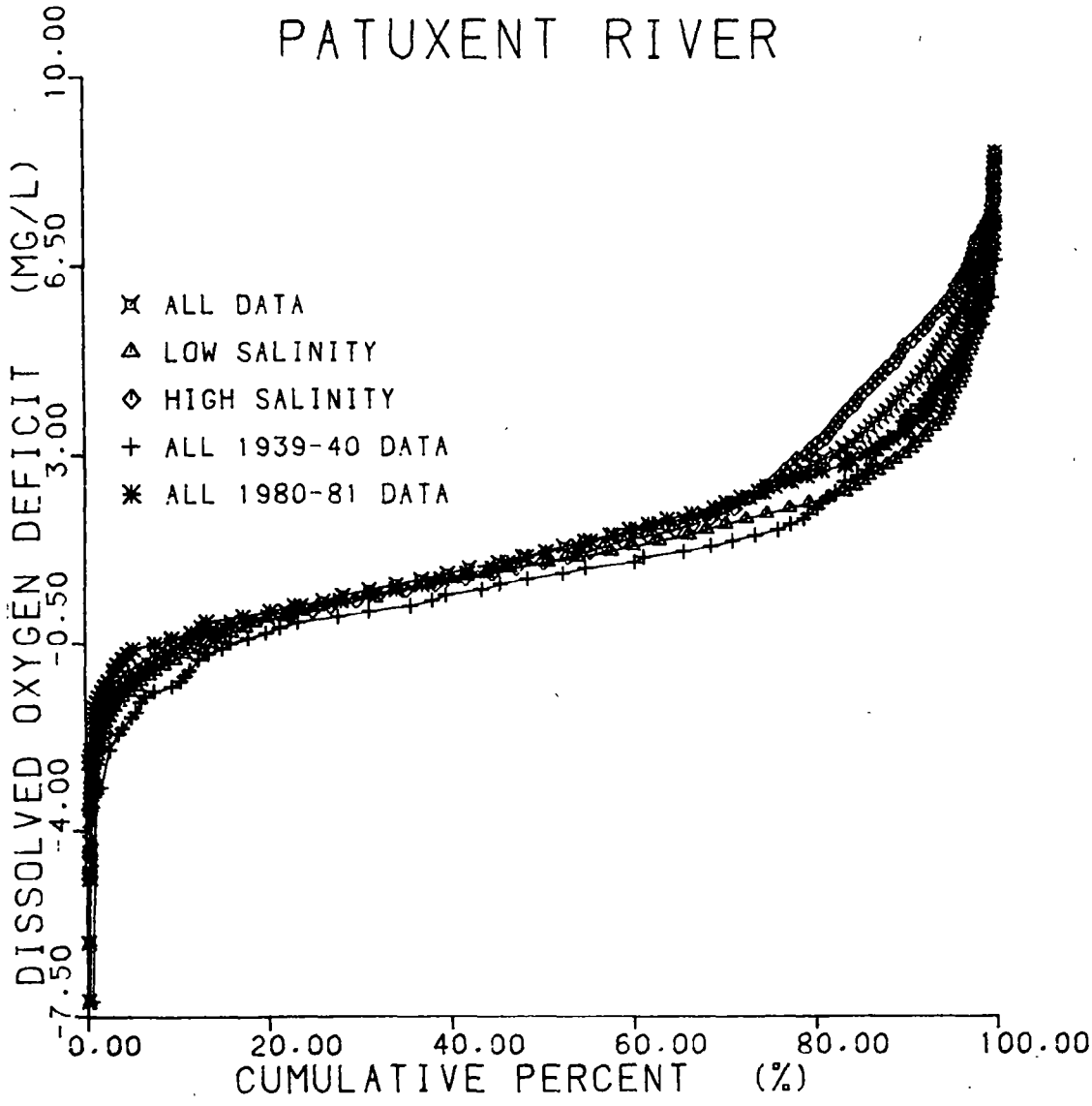


Figure 10-37 Cumulative frequency distribution of Patuxent River dissolved oxygen deficits which compare historical data, current study data, and salinity regime (0.2-10ppt and 10.01 ppt salinity).

APPENDIX J

FIGURES AND TABLES FOR SECTION 11

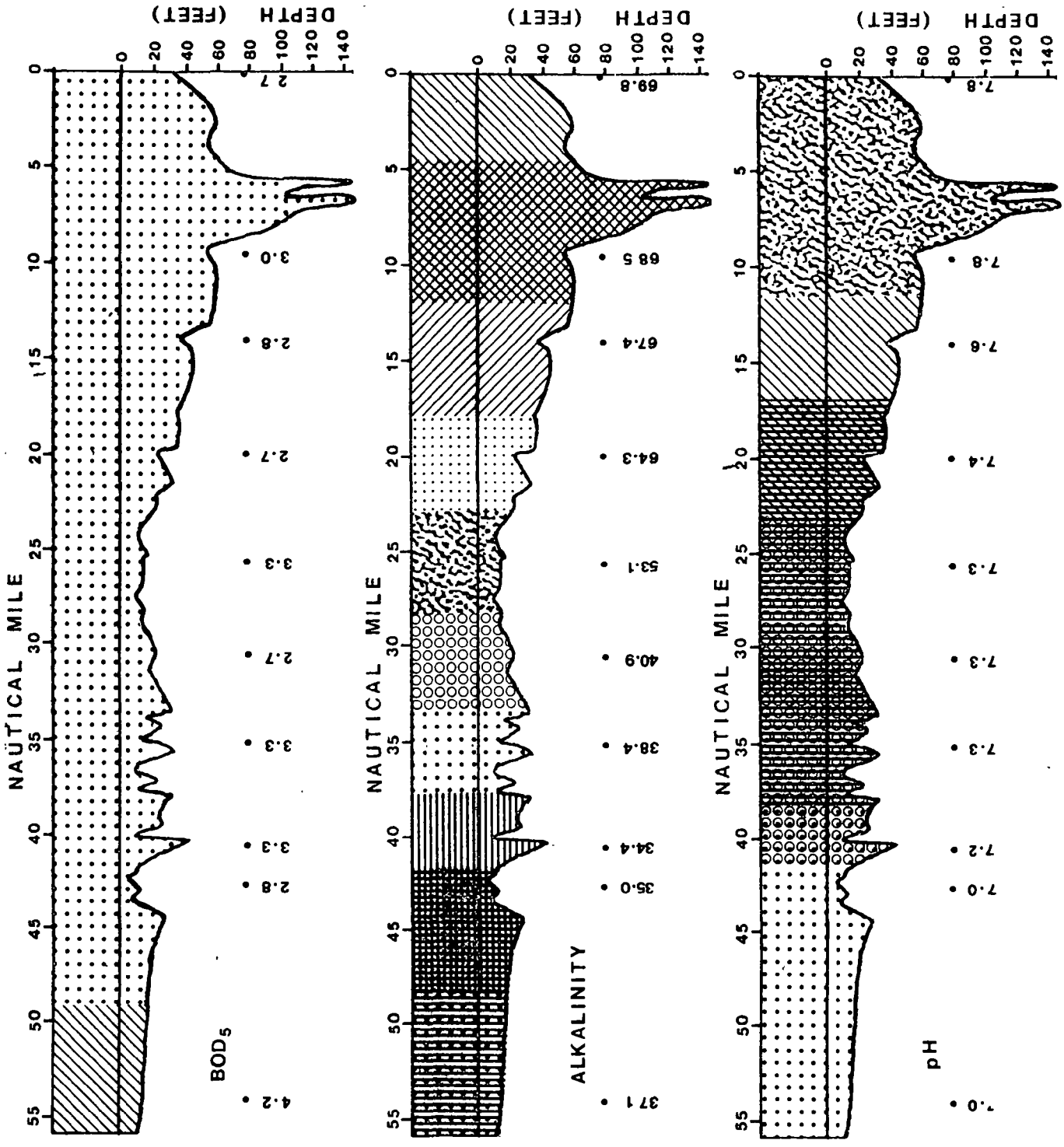


Figure 11-1 Patuxent River longitudinal characterization of 1980-1981 data for BOD_5 (mg/l), alkalinity (mg/l), and pH, all slack survey data.

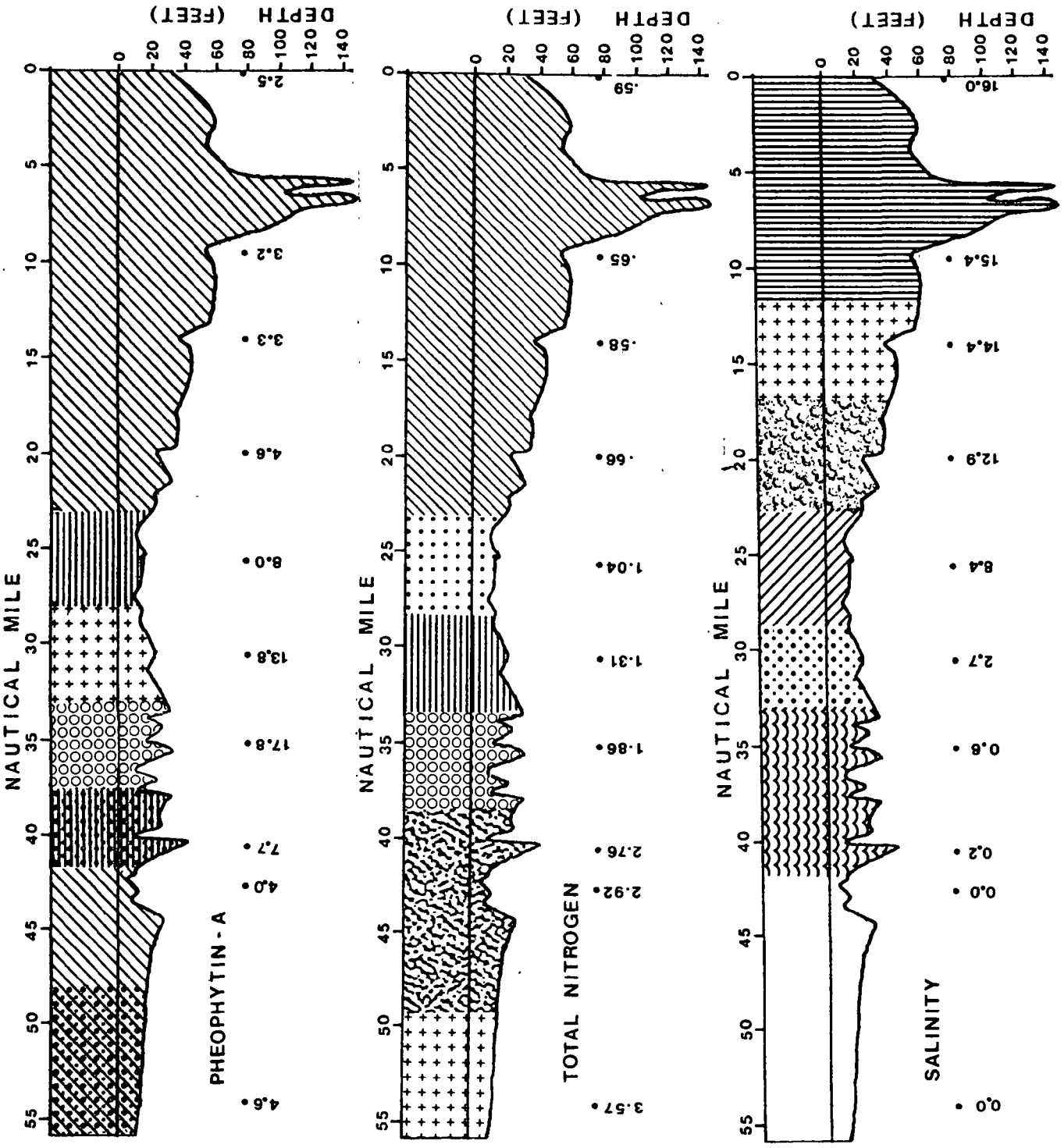


Figure 11-2 Patuxent River longitudinal characterization of 1980-1981 data for pheophylin-a (ug/l), total nitrogen (mg/l) and salinity (ppt), all slack survey data.

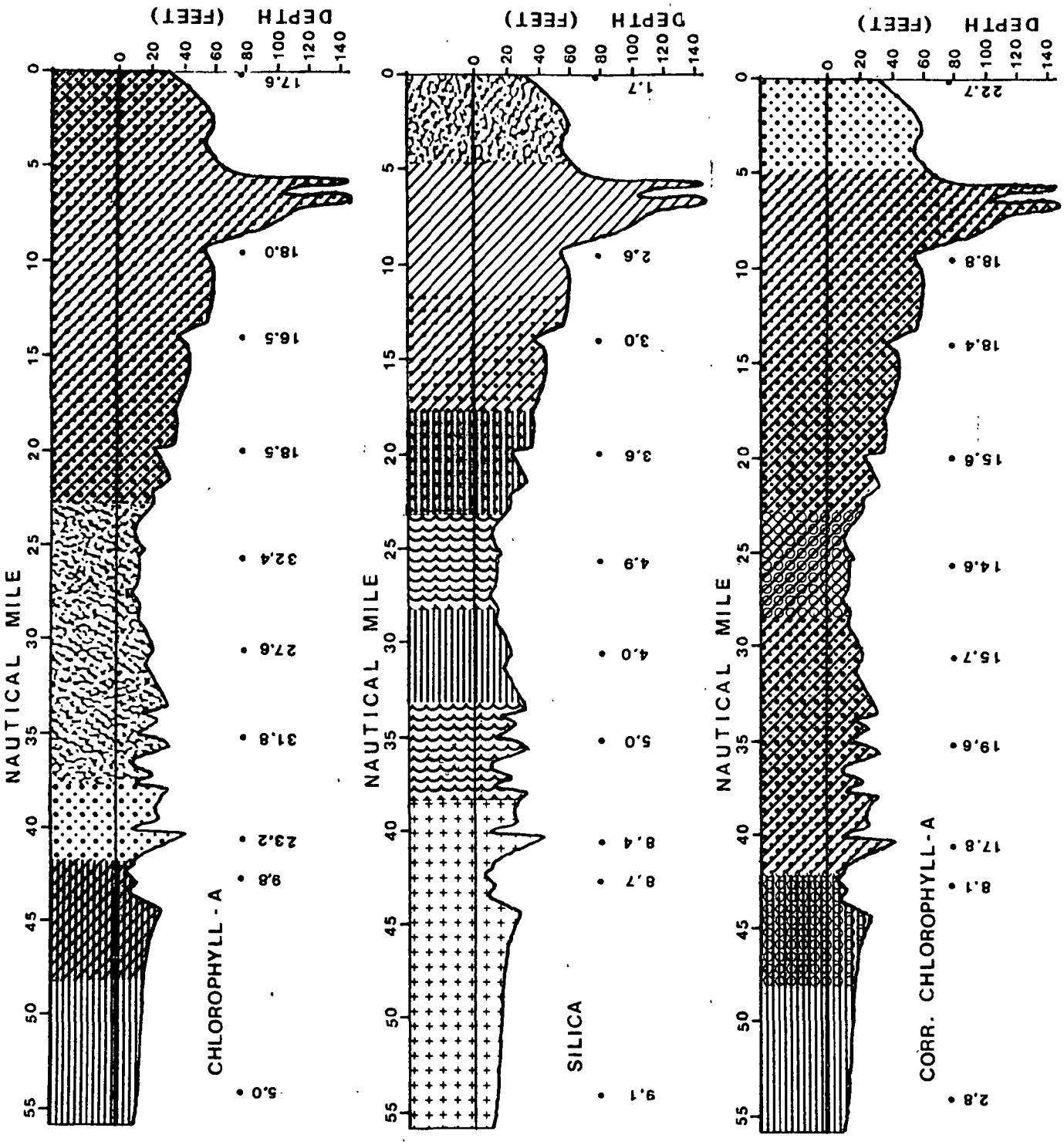


Figure 11-3 Patuxent River longitudinal characterization of 1980-1981 data for chlorophyll-a (µg/l), dissolved reactive silica (mg/l) and corrected chlorophyll-a (µg/l), all slack survey data.

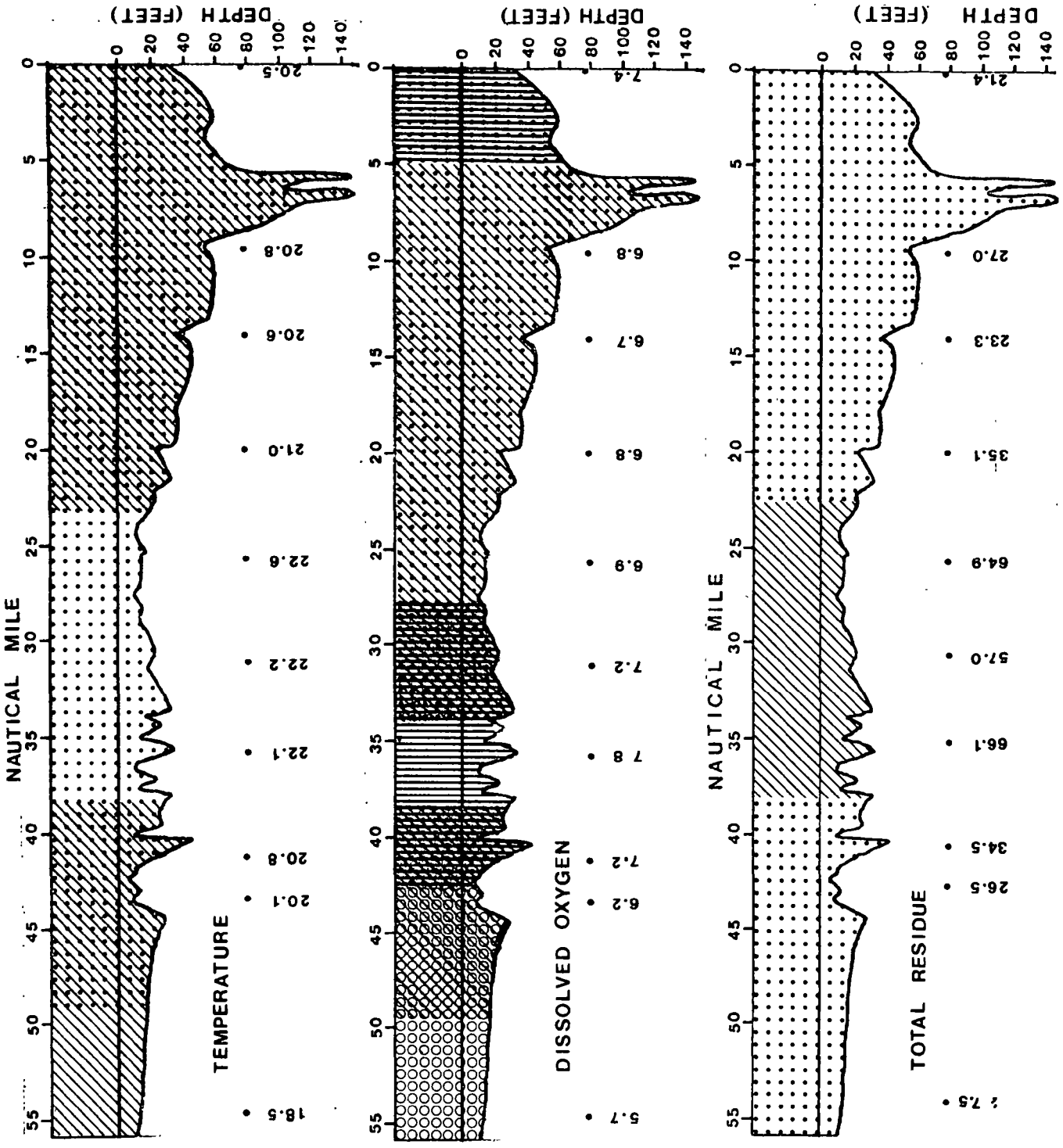


Figure 11-4 Patuxent River longitudinal characterization of 1980-1981 data for temperature (°C), dissolved oxygen (mg/l) and total nonfilterable residue (mg/l), all slack survey data.

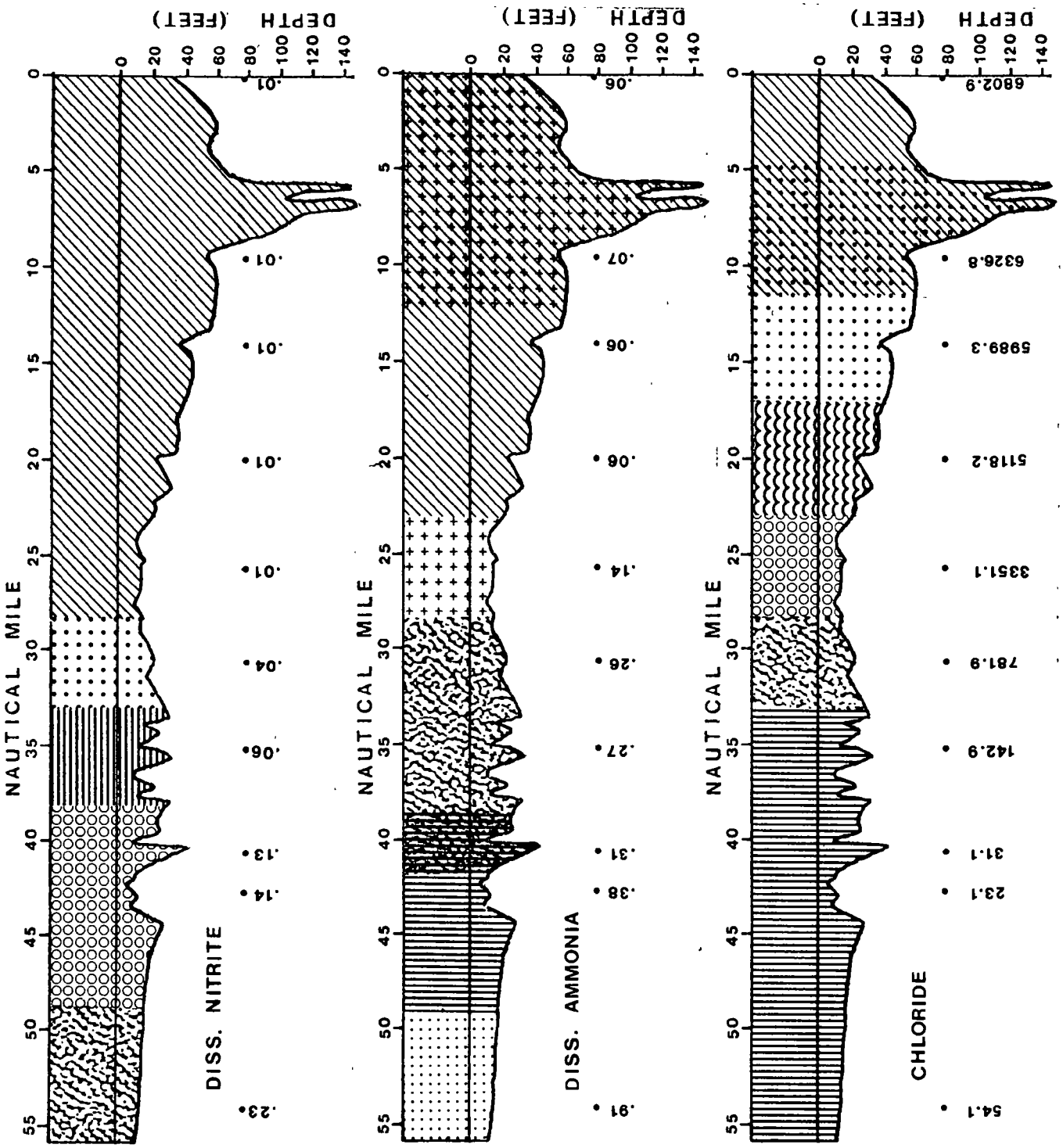


Figure 11-5 Patuxent River longitudinal characterization of 1980-1981 data for dissolved nitrite (mg/l), dissolved ammonia (mg/l) and chlorides (mg/l), all slack survey data.

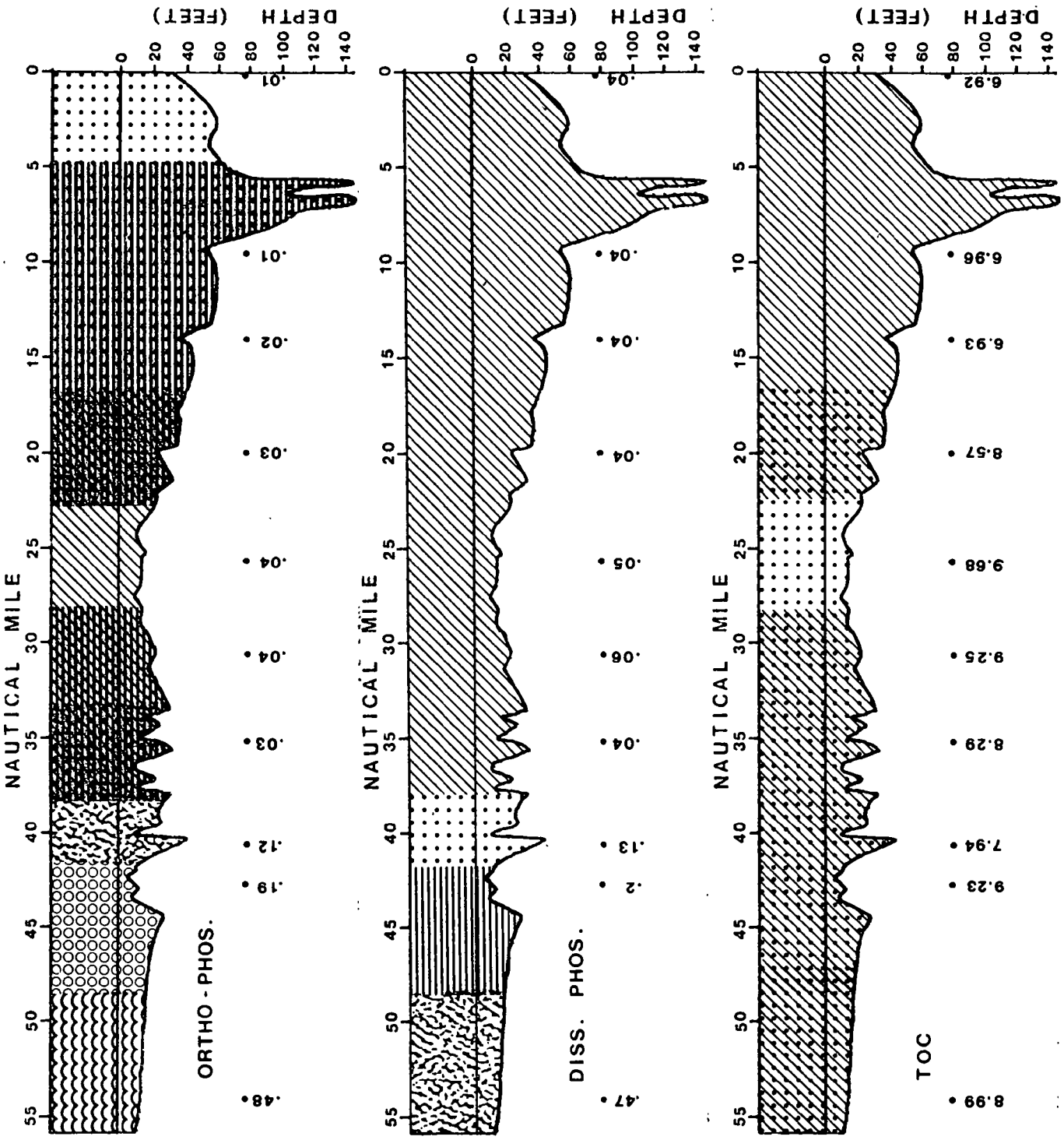


Figure 11-6 Patuxent River longitudinal characterization of 1980-1981 data for dissolved ortho-phosphorus (mg/l), dissolved phosphorus (mg/l) and total organic carbon (mg/l), all slack survey data.

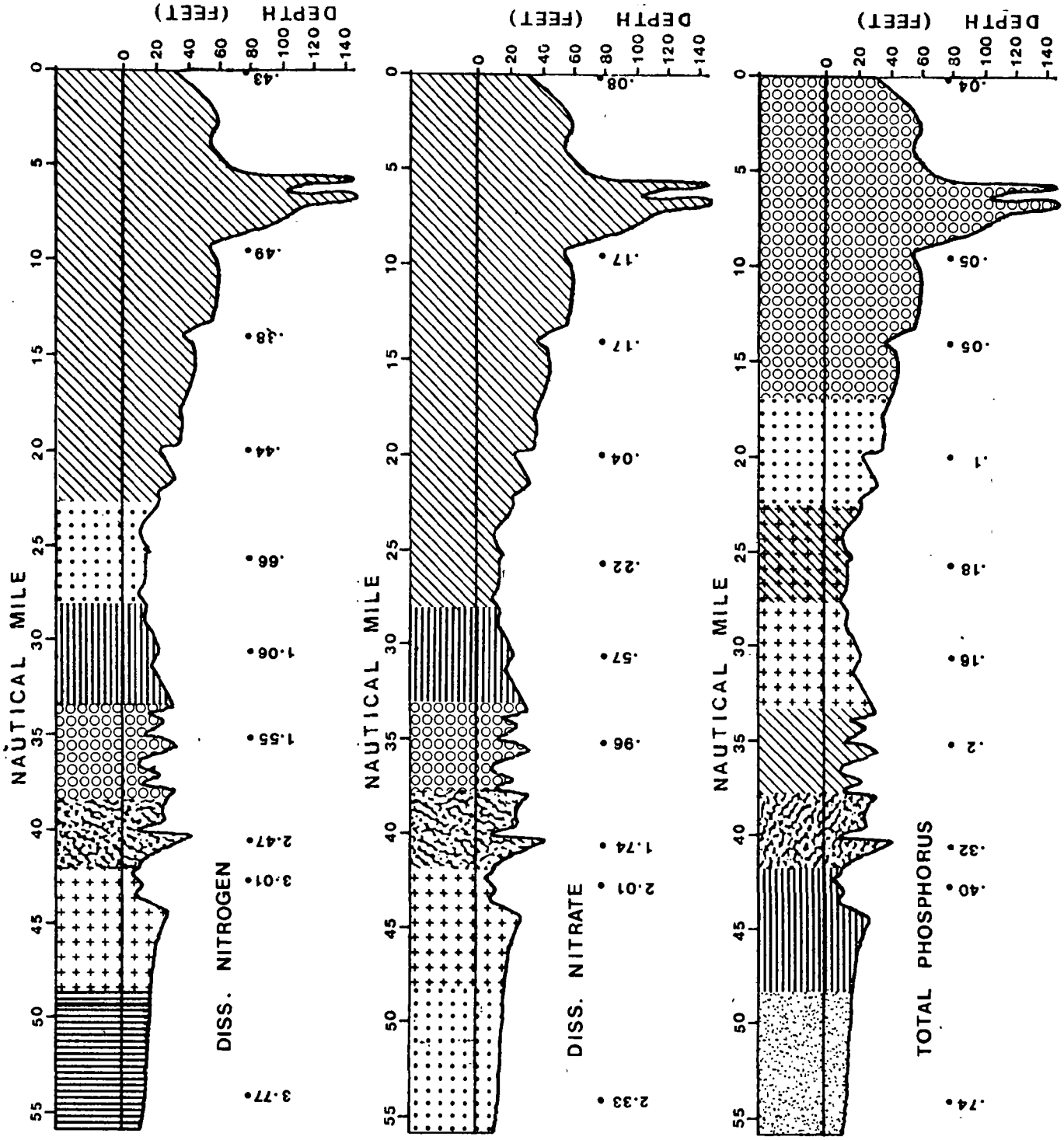


Figure 11-7 Patuxent River longitudinal characterization of 1980-1981 data for total phosphorus (mg/l), dissolved nitrate (mg/l) and total dissolved nitrogen (mg/l), all slack survey data.

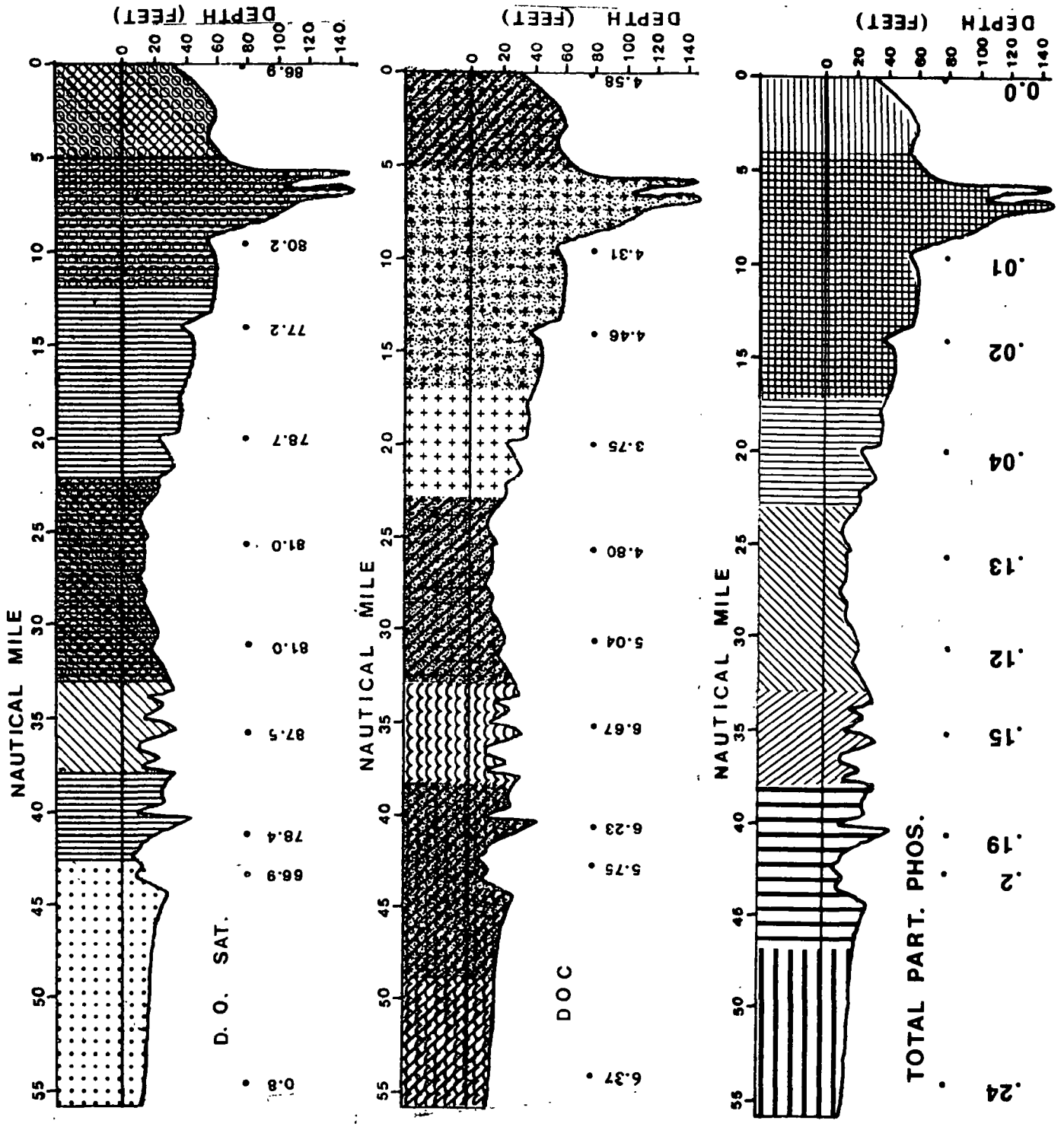
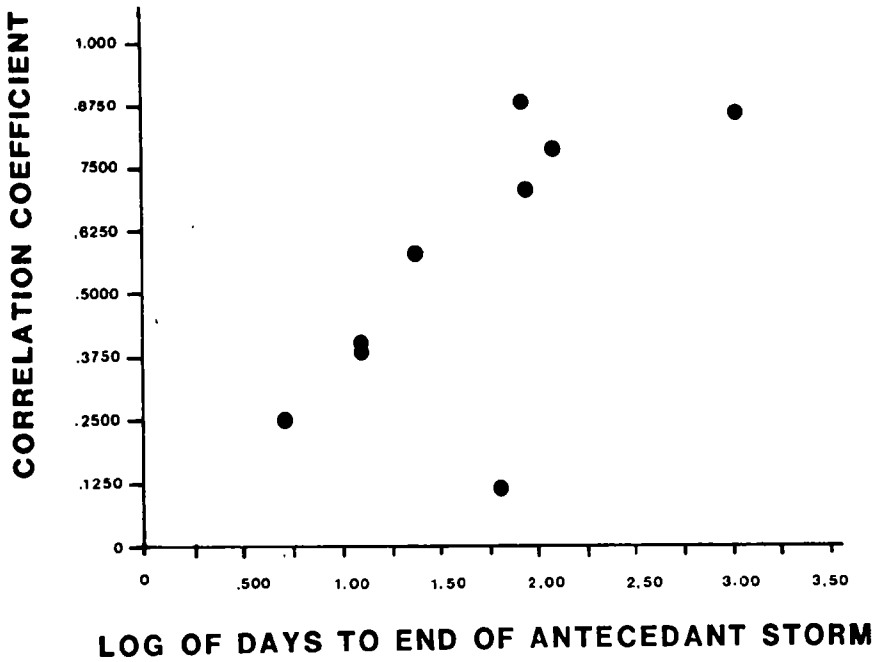


Figure 11-8 Patuxent River longitudinal characterization of 1980-1981 data for dissolved oxygen saturation (%), dissolved organic carbon (mg/l) and total particulate phosphorus (mg/l), all slack survey data.



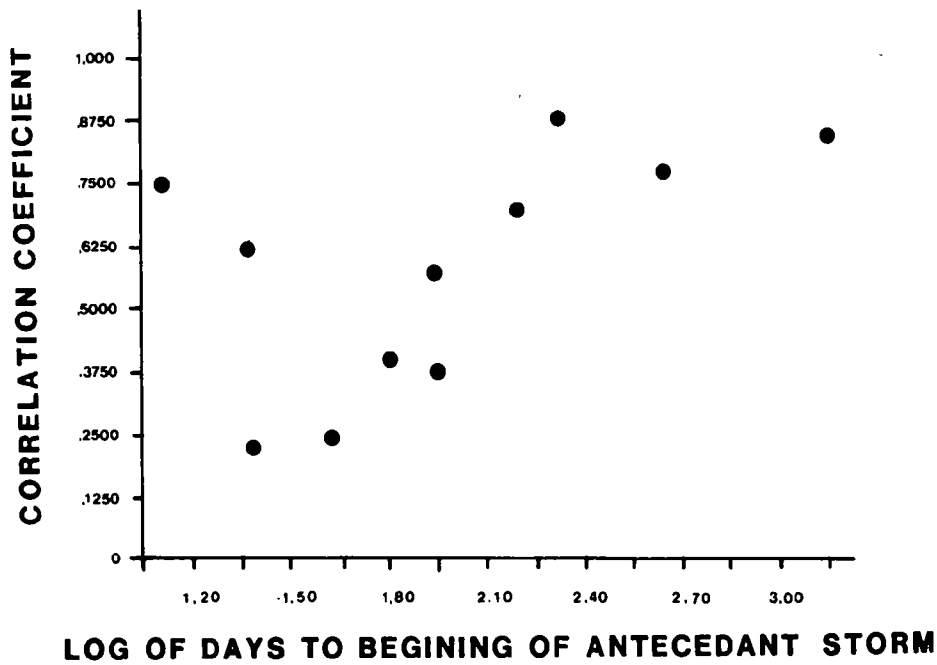


Figure 11-9 Correlation coefficient (log total N/P ratio versus nautical mile) plotted against log of antecedant storm days for Patuxent Estuary.

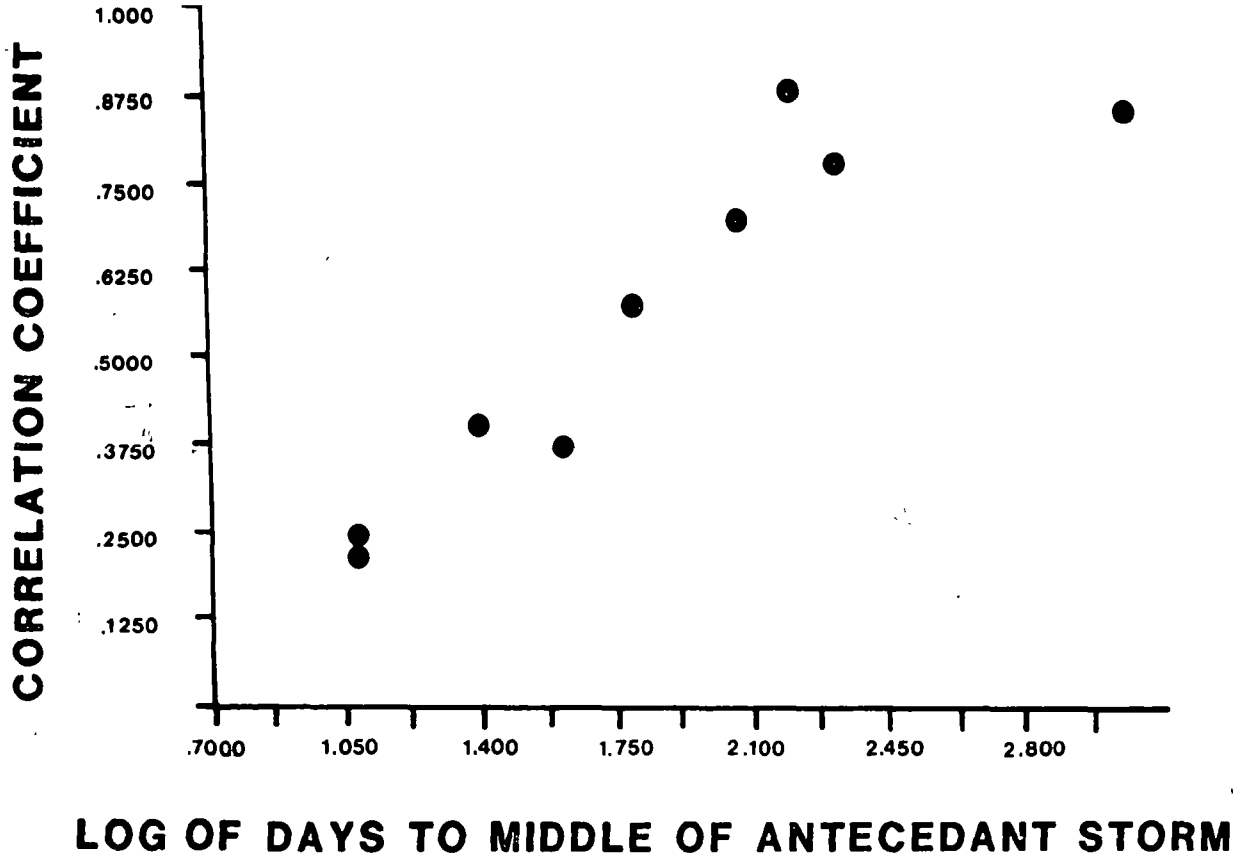


Figure 11-10 This figure shows that a strong relation exists between total N:P ratios and rainfall events in the Patuxent Estuary. A high correlation coefficient indicates the longitudinal river profile of N:P fits an exponential curve. The log of days to antecedant storm is the log of the number of days from a slack survey to the previous major storm event. These plots show a nonlinear relation between the N:P ratio and runoff events, and that the ratios are dependent upon the time period between the slack water survey and the rainfall/runoff event.

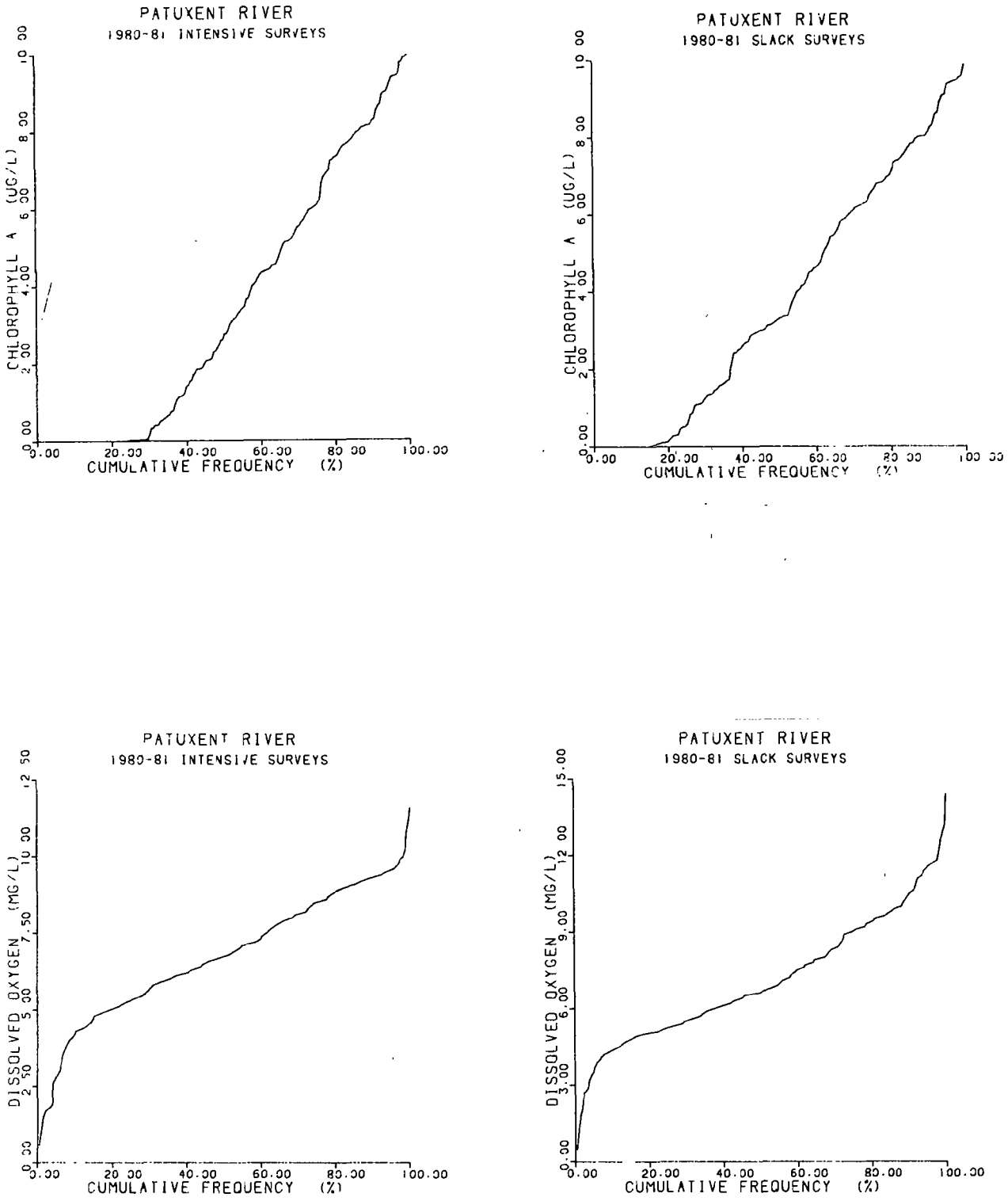


Figure11-11Cumulative frequency distributions of water quality variables collected during 1980-1981 slack water surveys and intensive river surveys.

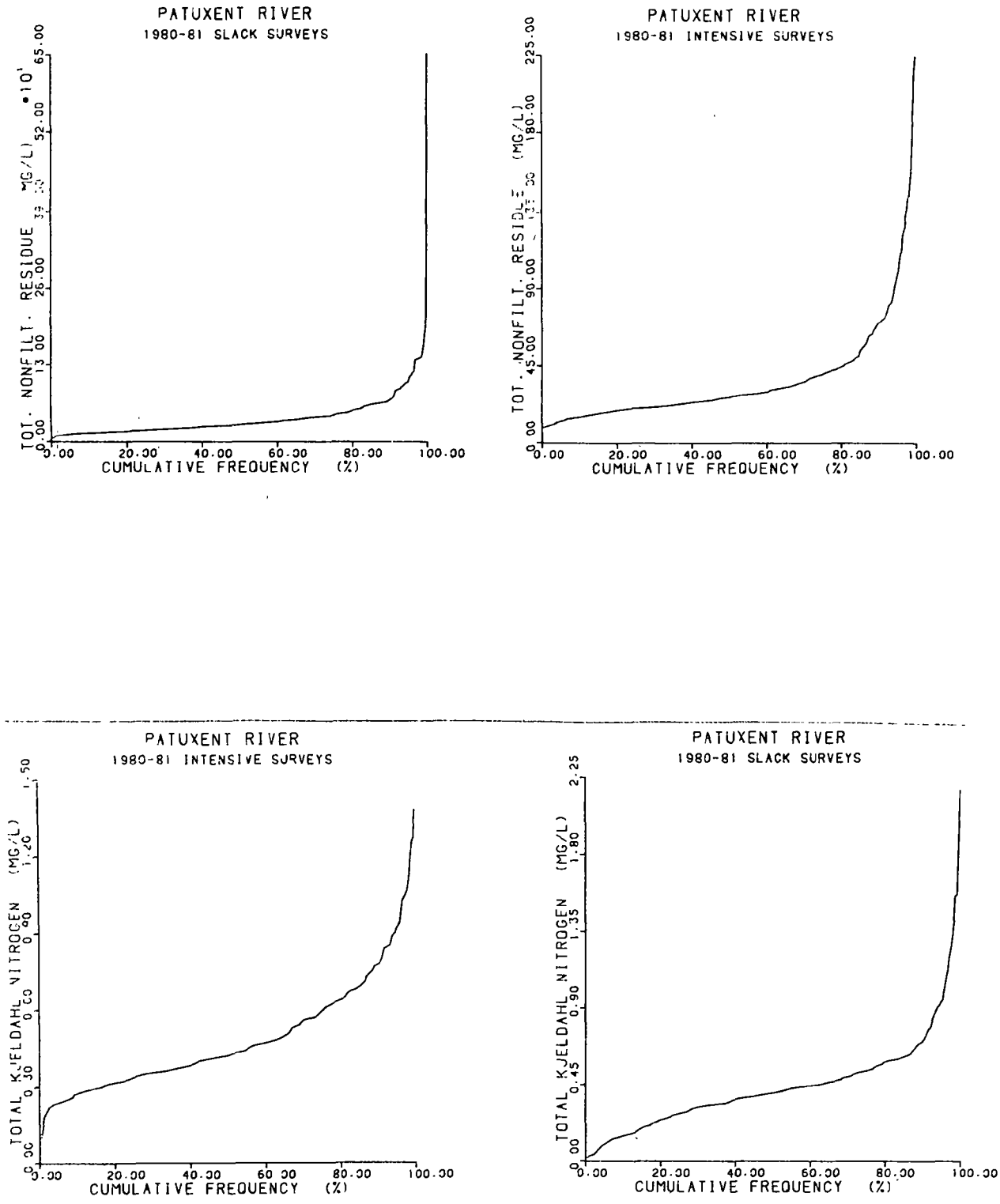


Figure 11-12 Cumulative frequency distributions of water quality variables collected during 1980-1981 slack water surveys and intensive river surveys.

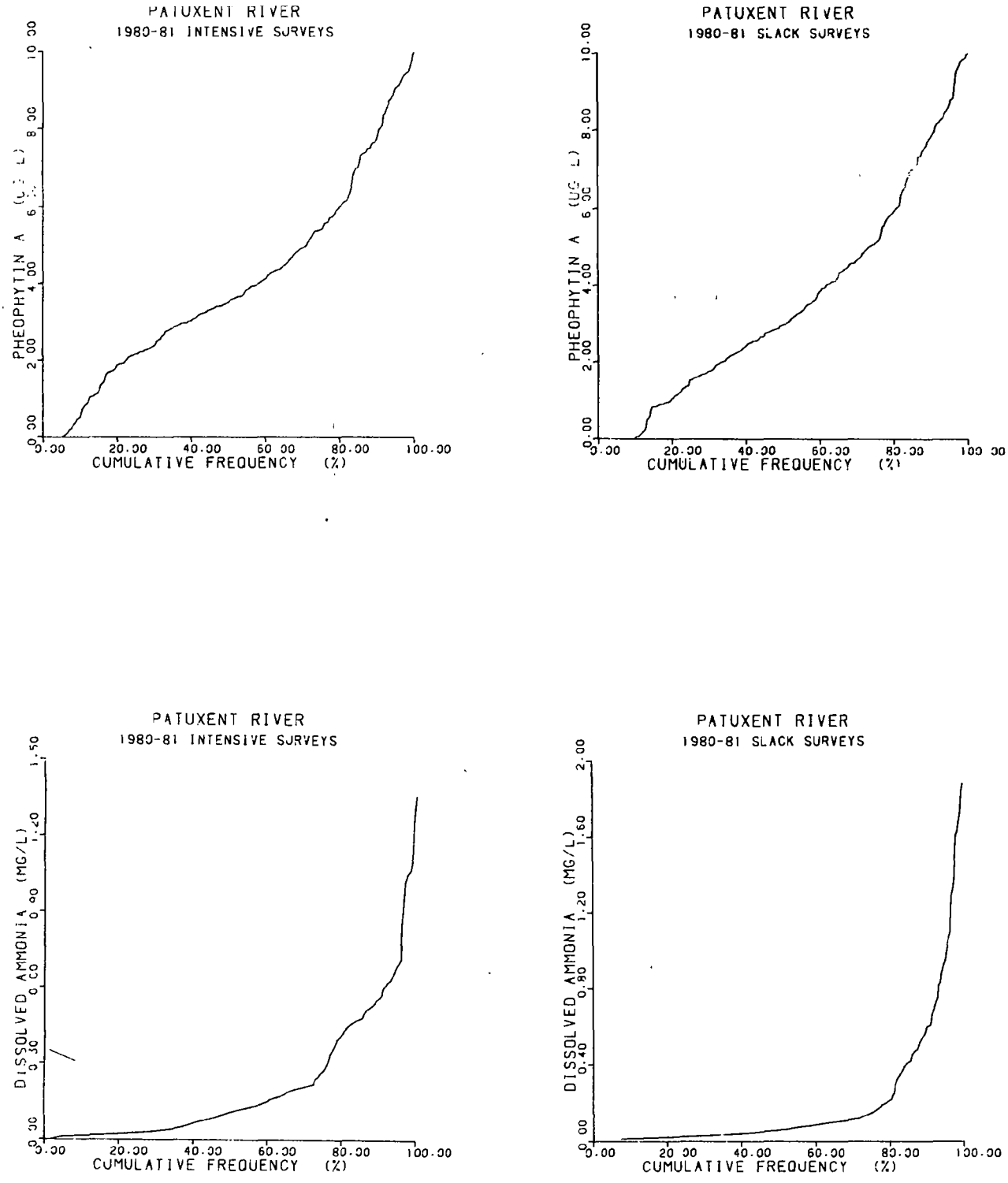


Figure11-13Cumulative frequency distributions of water quality variables collected during 1980-1981 slack water surveys and intensive river surveys.

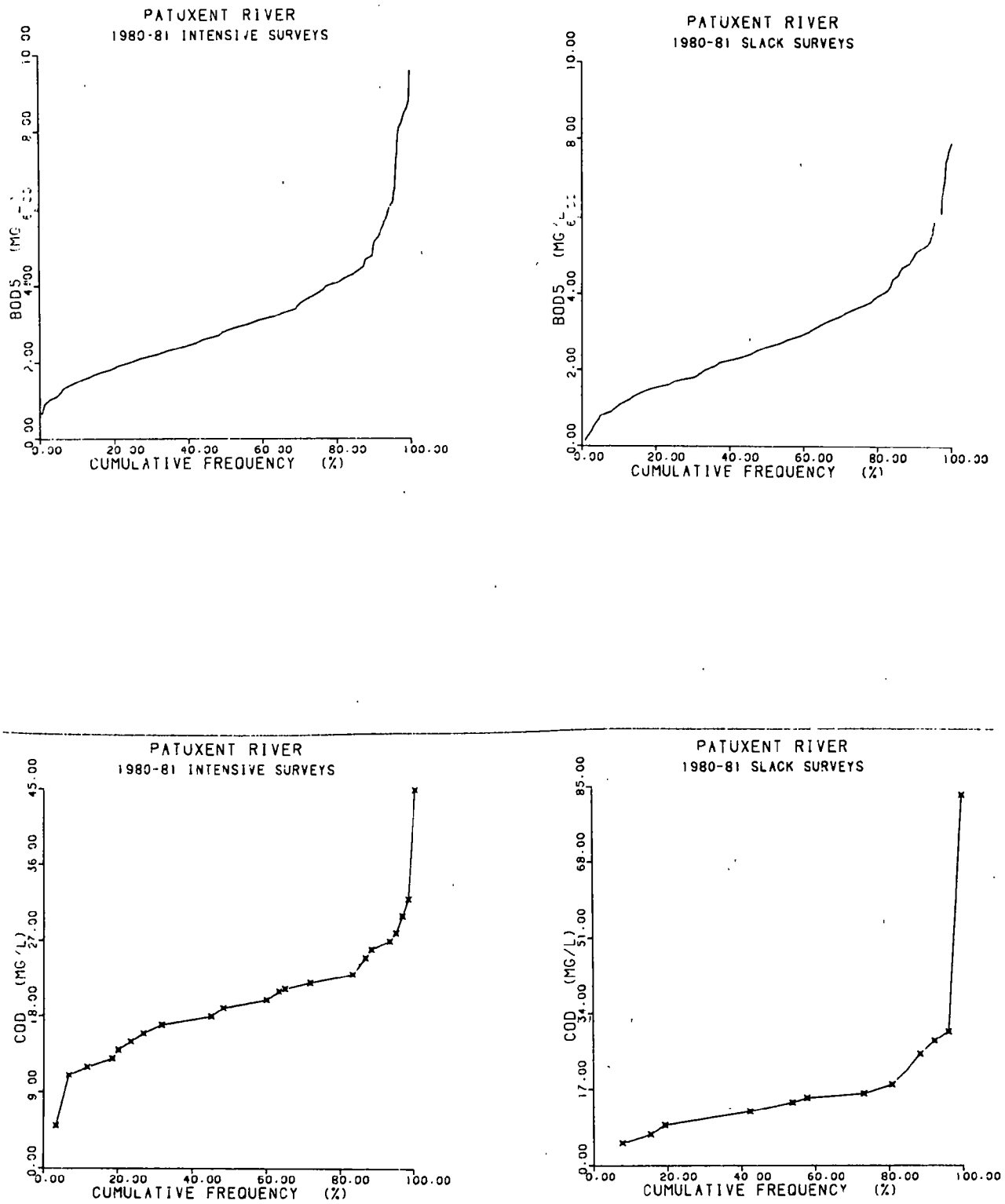


Figure11-14Cumulative frequency distributions of water quality variables collected during 1980-1981 slack water surveys and intensive river surveys.

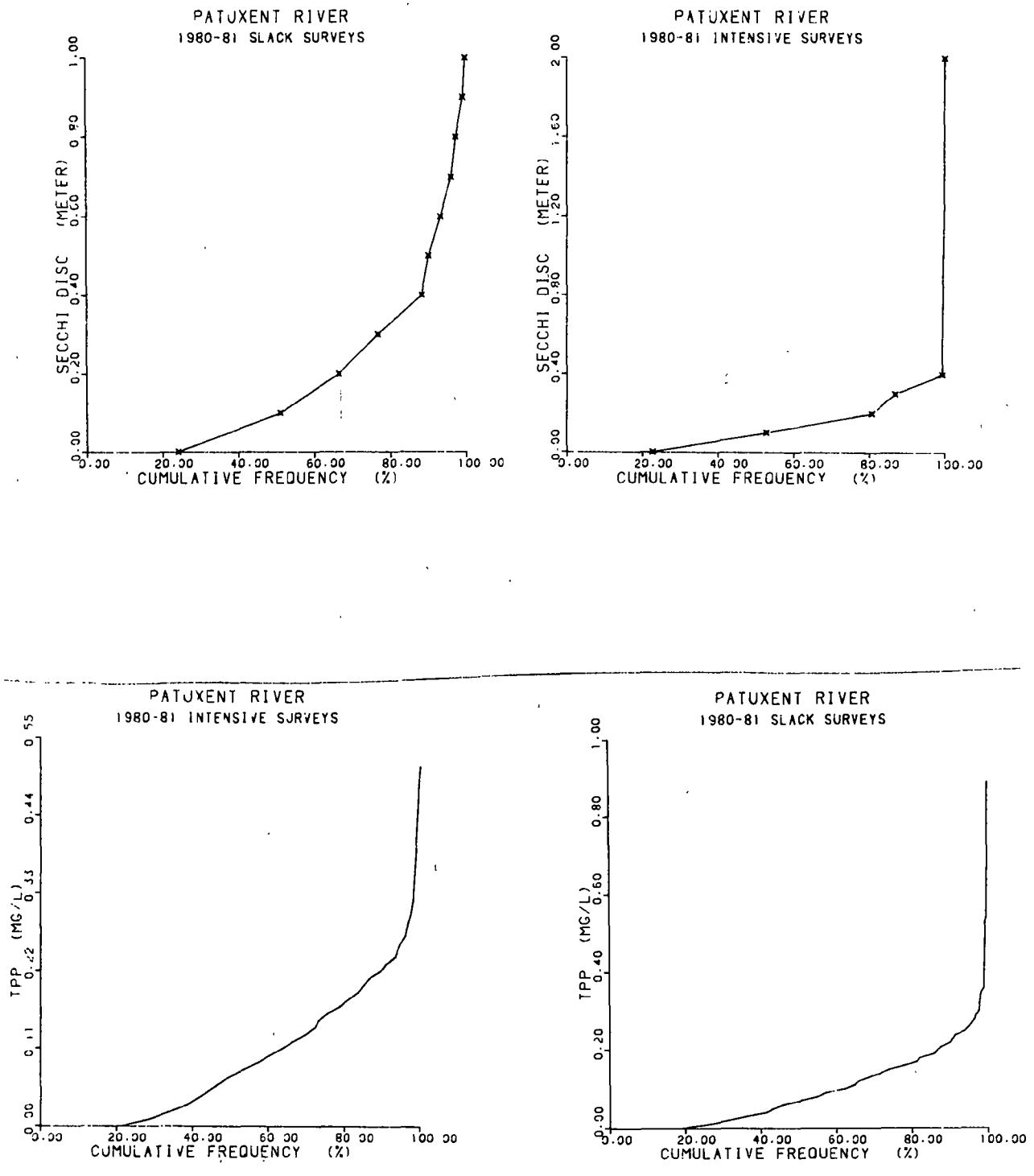
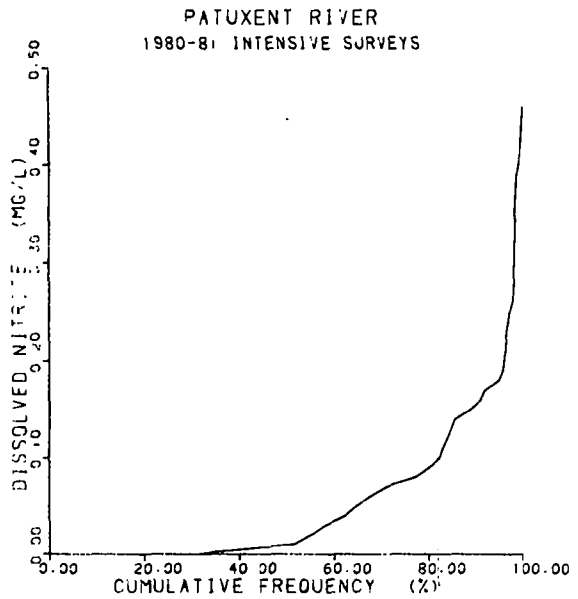
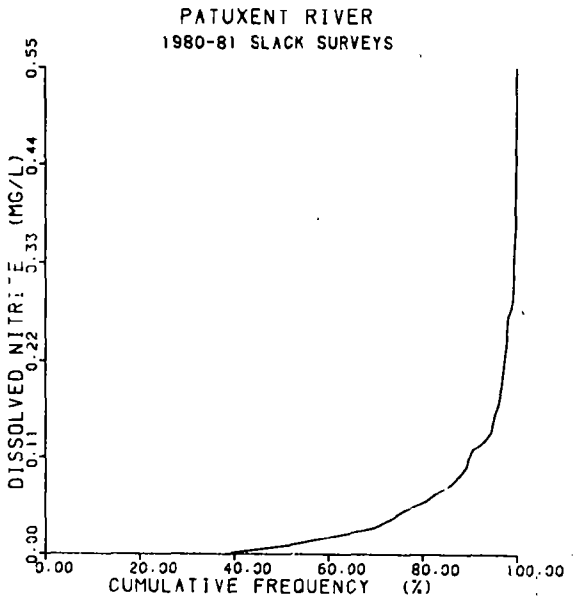
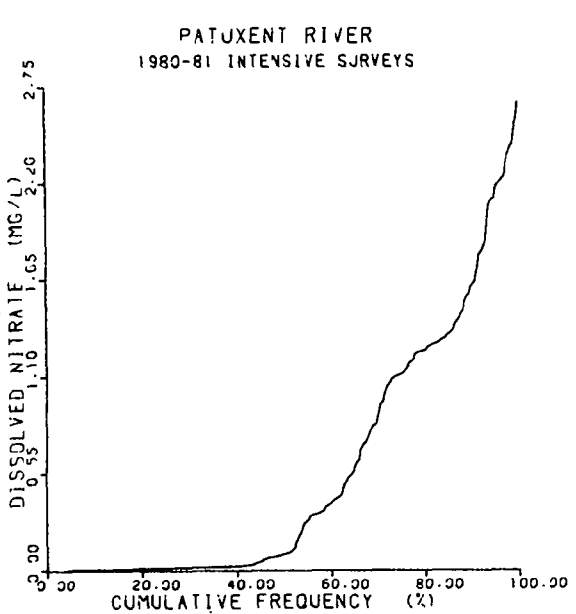


Figure11-15Cumulative frequency distributions of water quality variables collected during 1980-1981 slack water surveys and intensive river surveys.







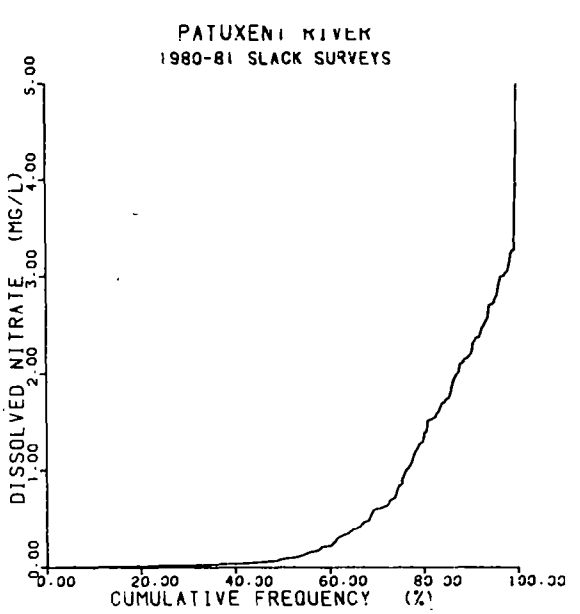


Figure11-16 Cumulative frequency distributions of water quality variables collected during 1980-1981 slack water surveys and intensive river surveys.

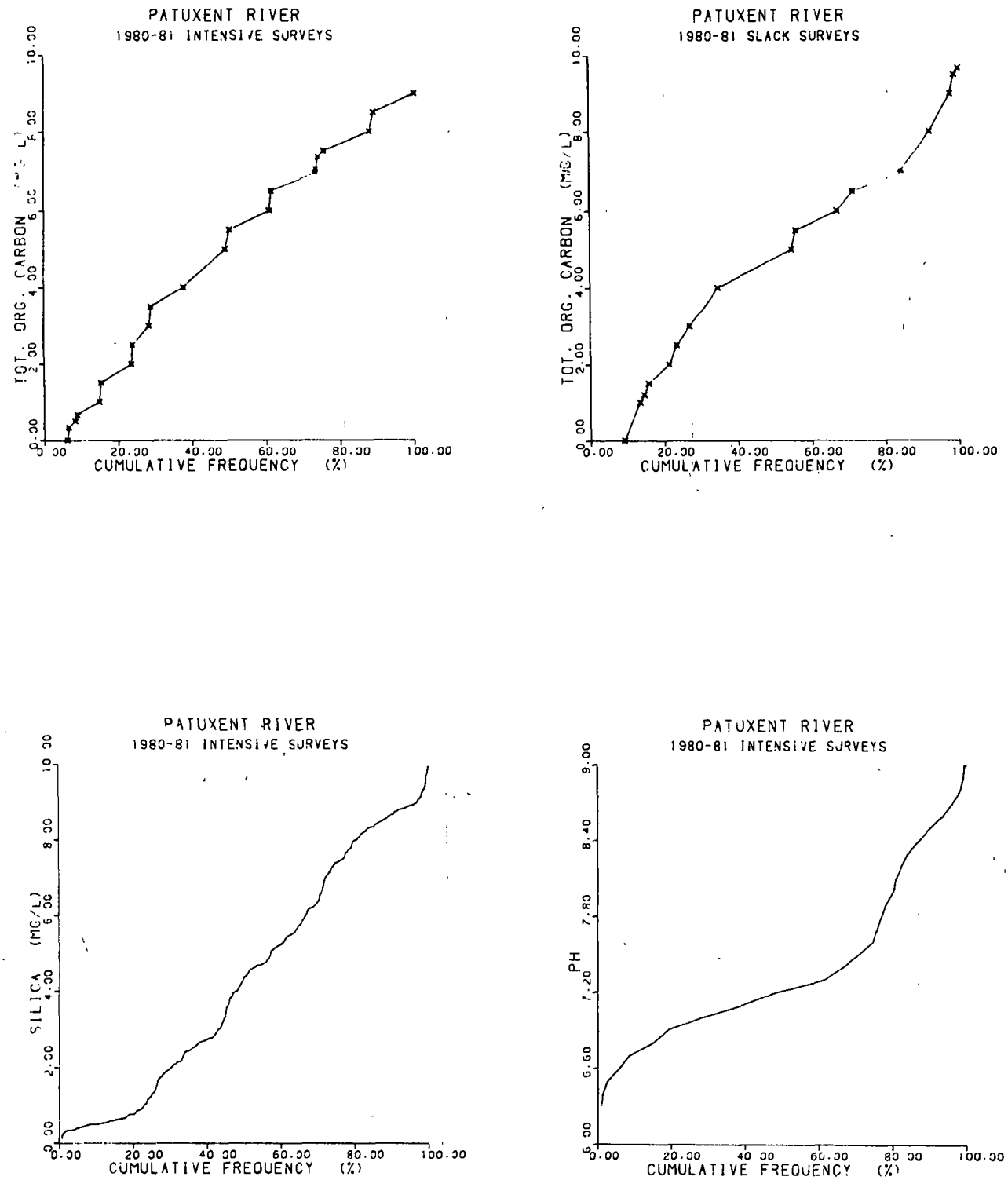


Figure 11-17 Cumulative frequency distributions of water quality variables collected during 1980-1981 slack water surveys and intensive river surveys.

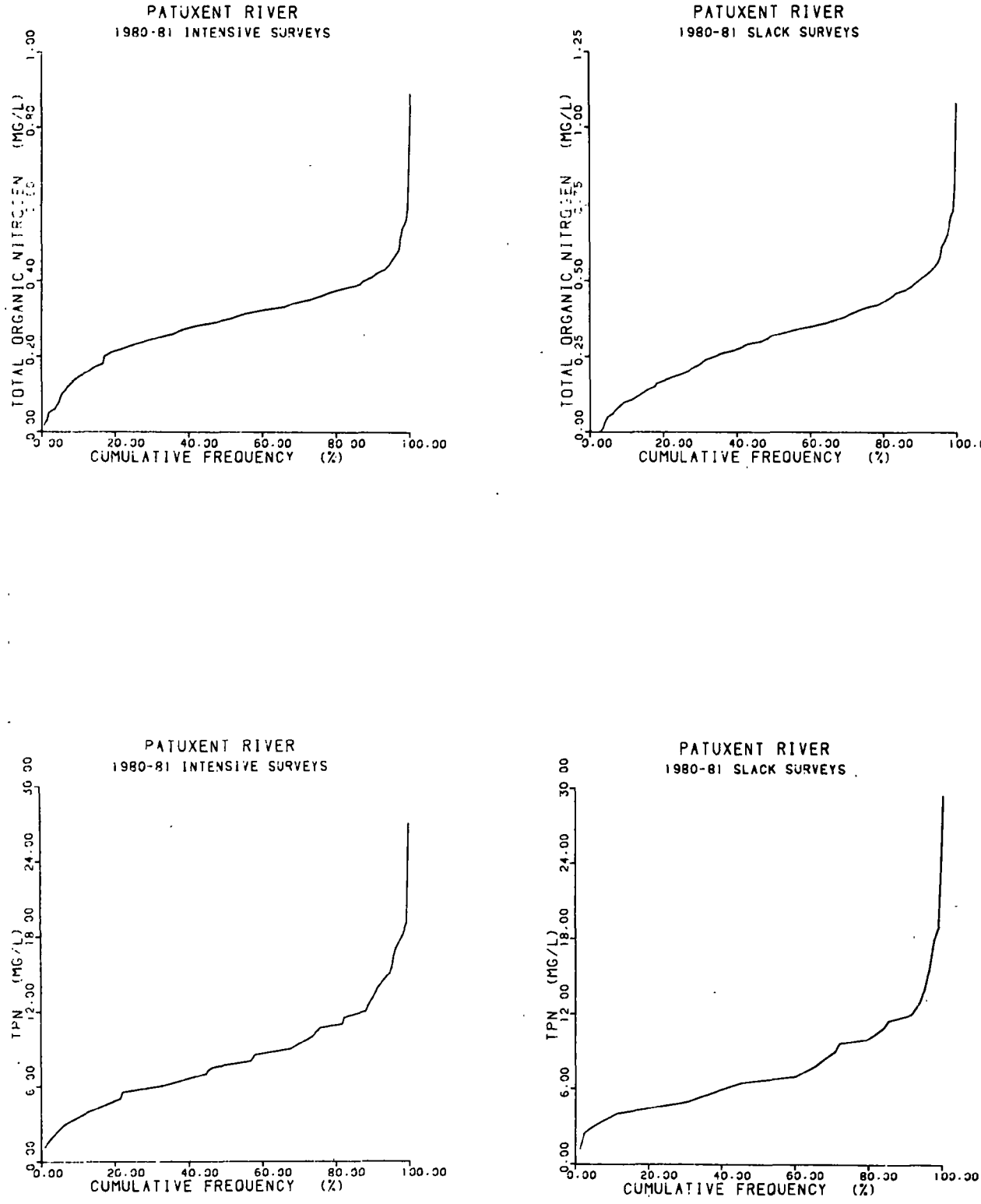


Figure 11-18 Cumulative frequency distributions of water quality variables collected during 1980-1981 slack water surveys and intensive river surveys.

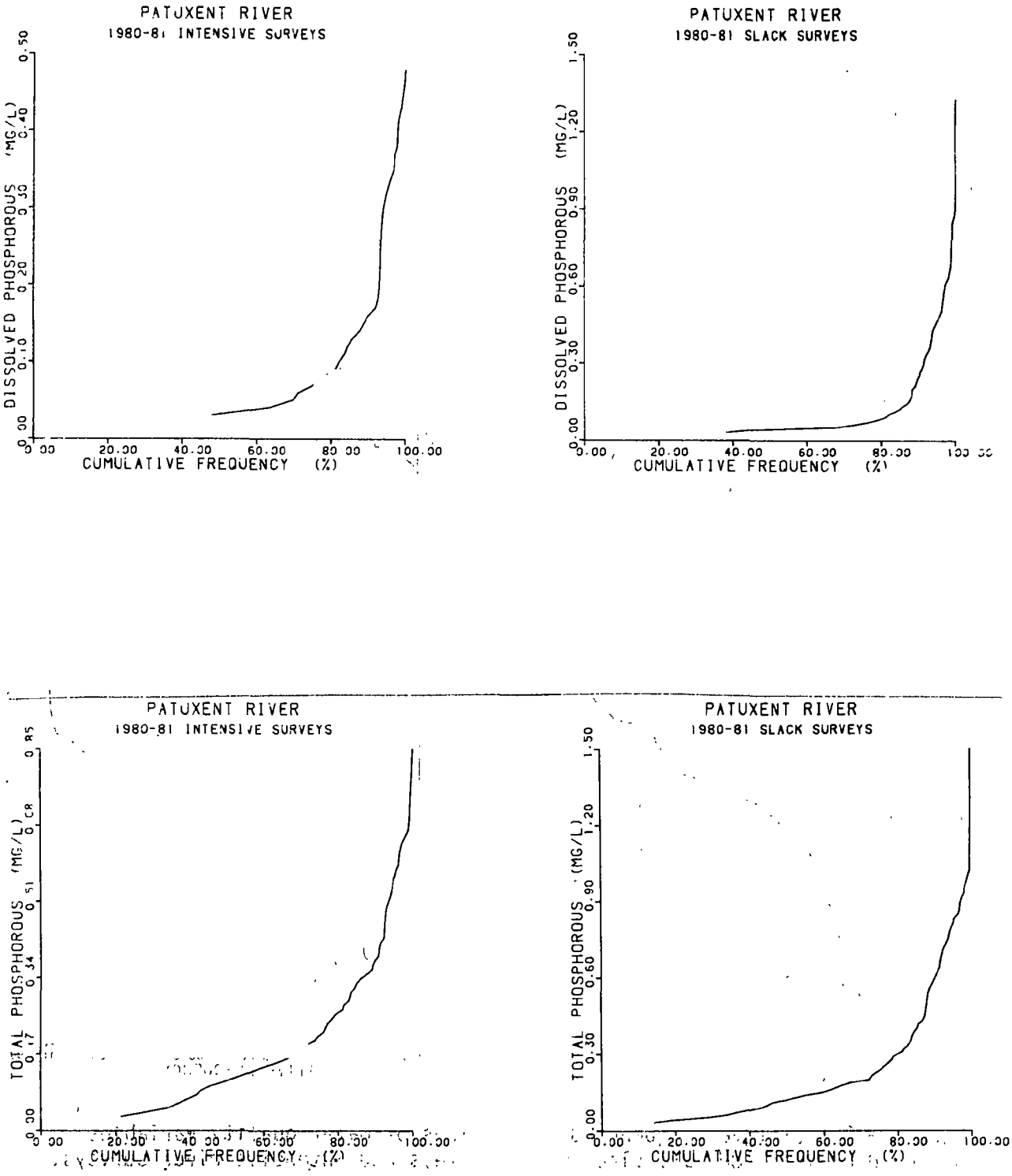


Figure 11-19 Cumulative frequency distributions of water quality variables collected during 1980-1981 slack water surveys and intensive river surveys.

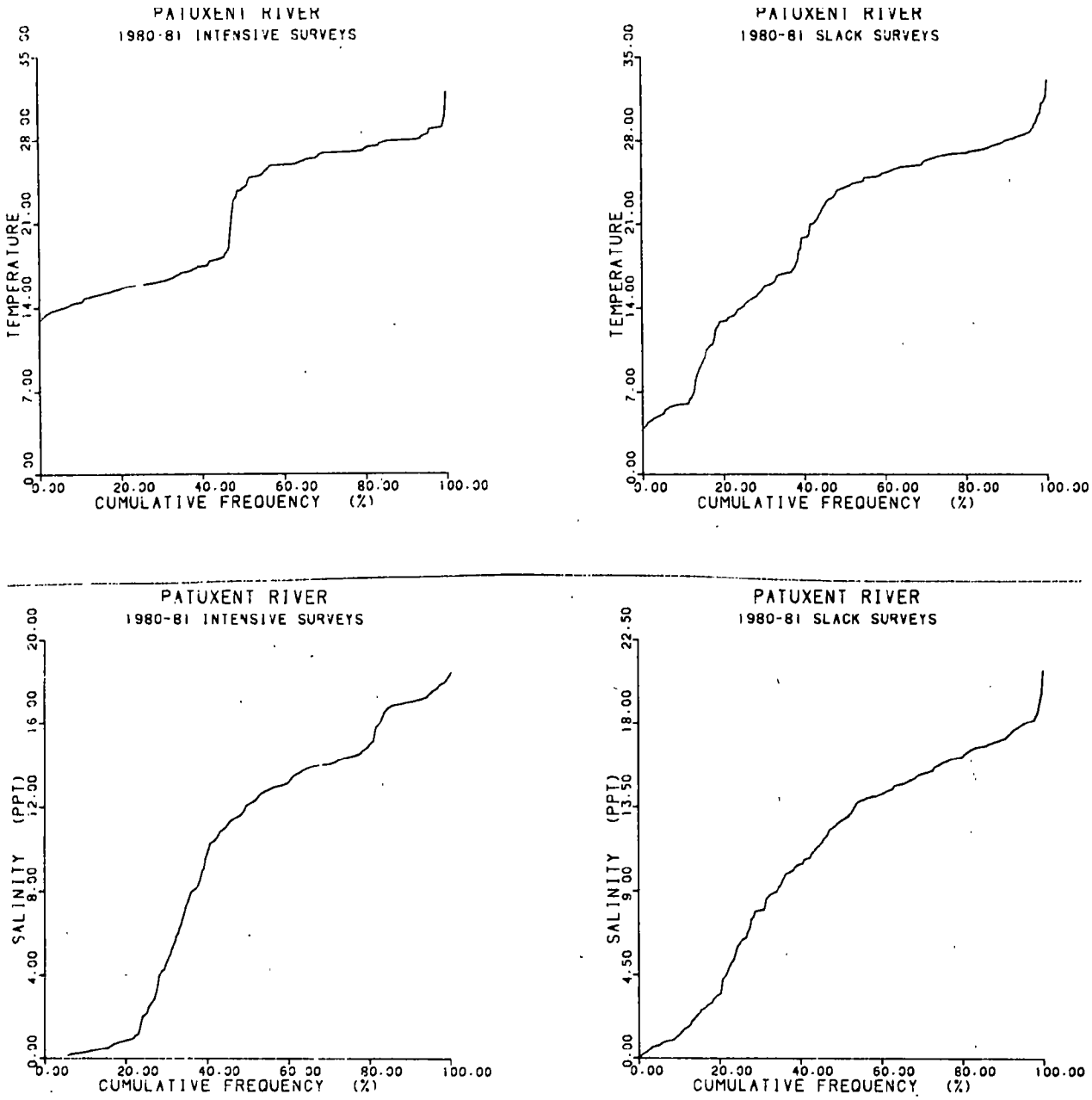


Figure11-20Cumulative frequency distributions of water quality variables collected during 1980-1981 slack water surveys and intensive river surveys.

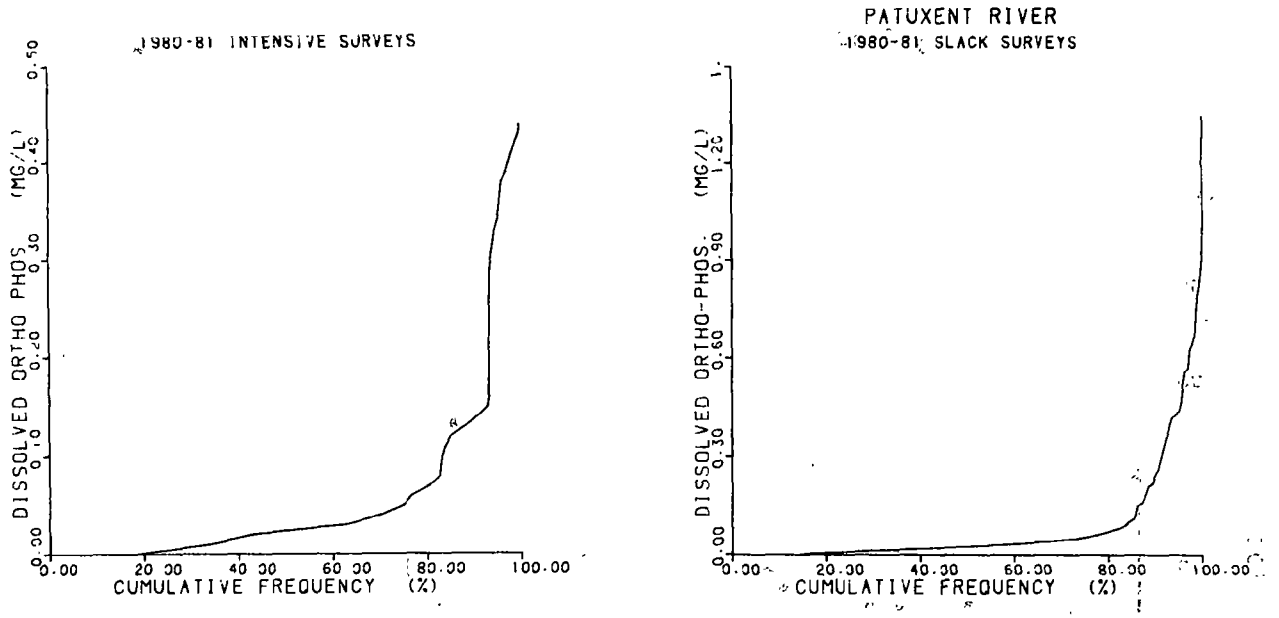


Figure 11-21Cumulative frequency distributions of water quality variables collected during 1980-1981 slack water surveys and intensive river surveys.

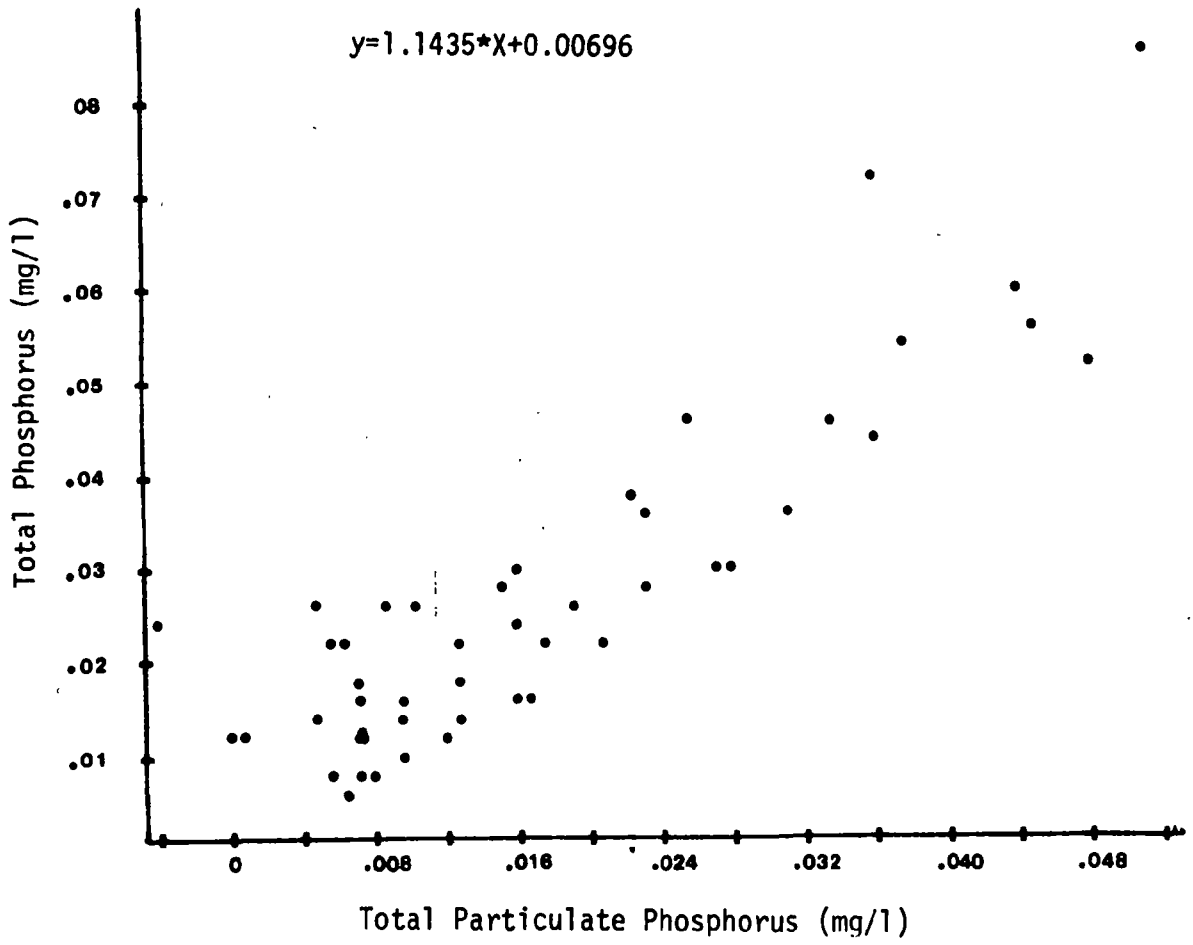


Figure 11-22 Patuxent River data plot of total phosphorus versus total particulate phosphorus in the lower Patuxent Estuary, 1980-1981 (48 observations, r=0.88).

Table 11-1
Water Quality Linear Relationships
In The Patuxent Estuary

Dependent Variable	Independant Variable	N	Regression Equation	Correlation Coefficient (r)
DIP	TOP	47	Y=0.75361*X+.00035	0.93
DIP	TP	47	Y=0.32166*X-.00006	0.73
Chlor-a	TP	38	Y=321.55*X+1.6679	0.65
Chlor-a	TPP	38	Y=505.04*X+2.0969	0.76
TP	TPP	48	Y=1.1435*X+0.00696	0.88
SESTON	TPP	47	Y=911.03*X+35.914	0.54
NO2+NO3	Ln(ORTHO-P)	202	Y=.54637*X+2.6603	0.76
NO2+NO3+NH3	Ln(ORTHO-p)	202	Y=.71821*X+3.5078	0.78
NH_4	NO_2	48	Y=12.557*X-0.02396	0.76
NO_3	TDN	44	Y=0.41010*X-0.25134	0.81
NH_4	TDN	48	Y=0.40827*X-0.19162	0.86
DO	NO_3	18	Y=6.8504*X+7.1326	0.50
DO	PC:PN Ratio	19	Y=1.6832*X-2.1631	0.62
Chlor-a	PC	38	Y=7.2065*X-1.3438	0.81

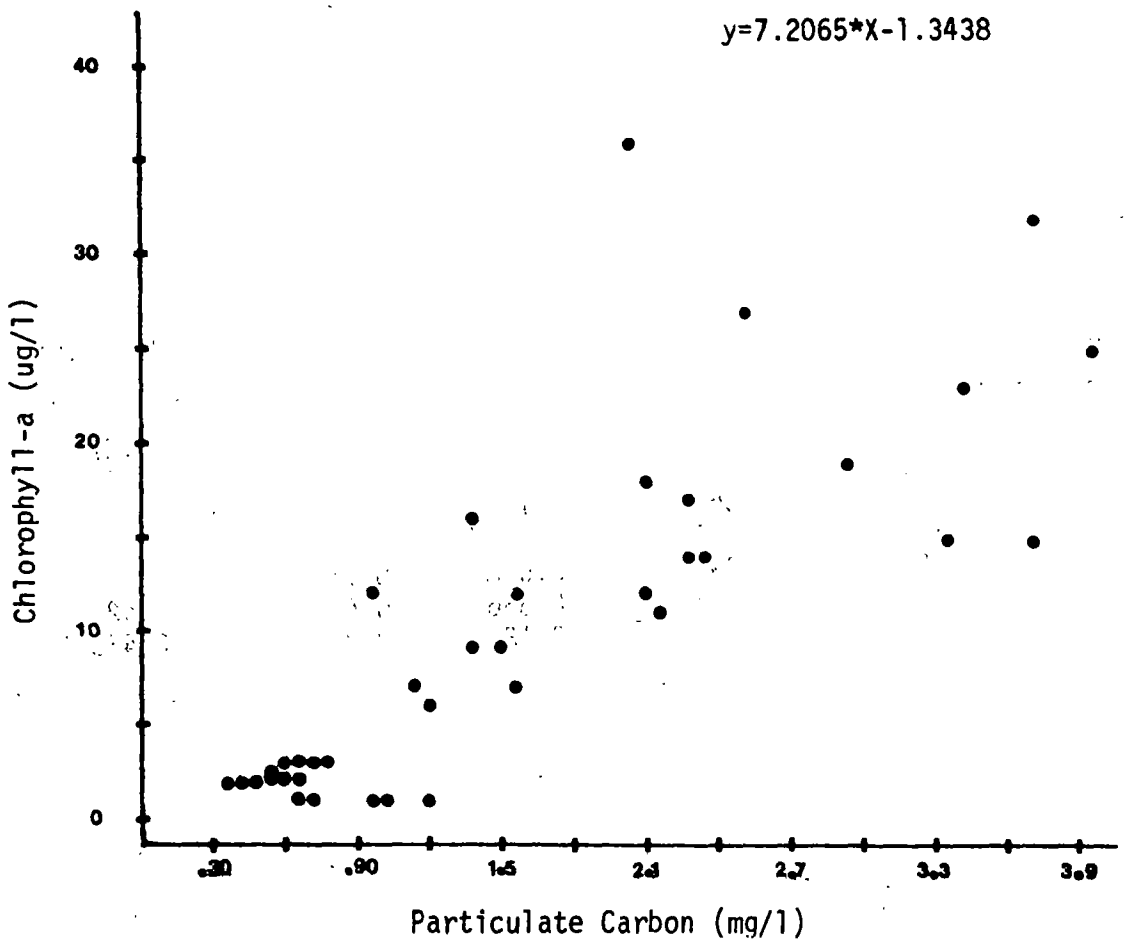


Figure 11-23 Plot of particulate carbon versus chlorophyll-a in the lower Patuxent estuary, 1980-1981, 38 observations, r=0.81.

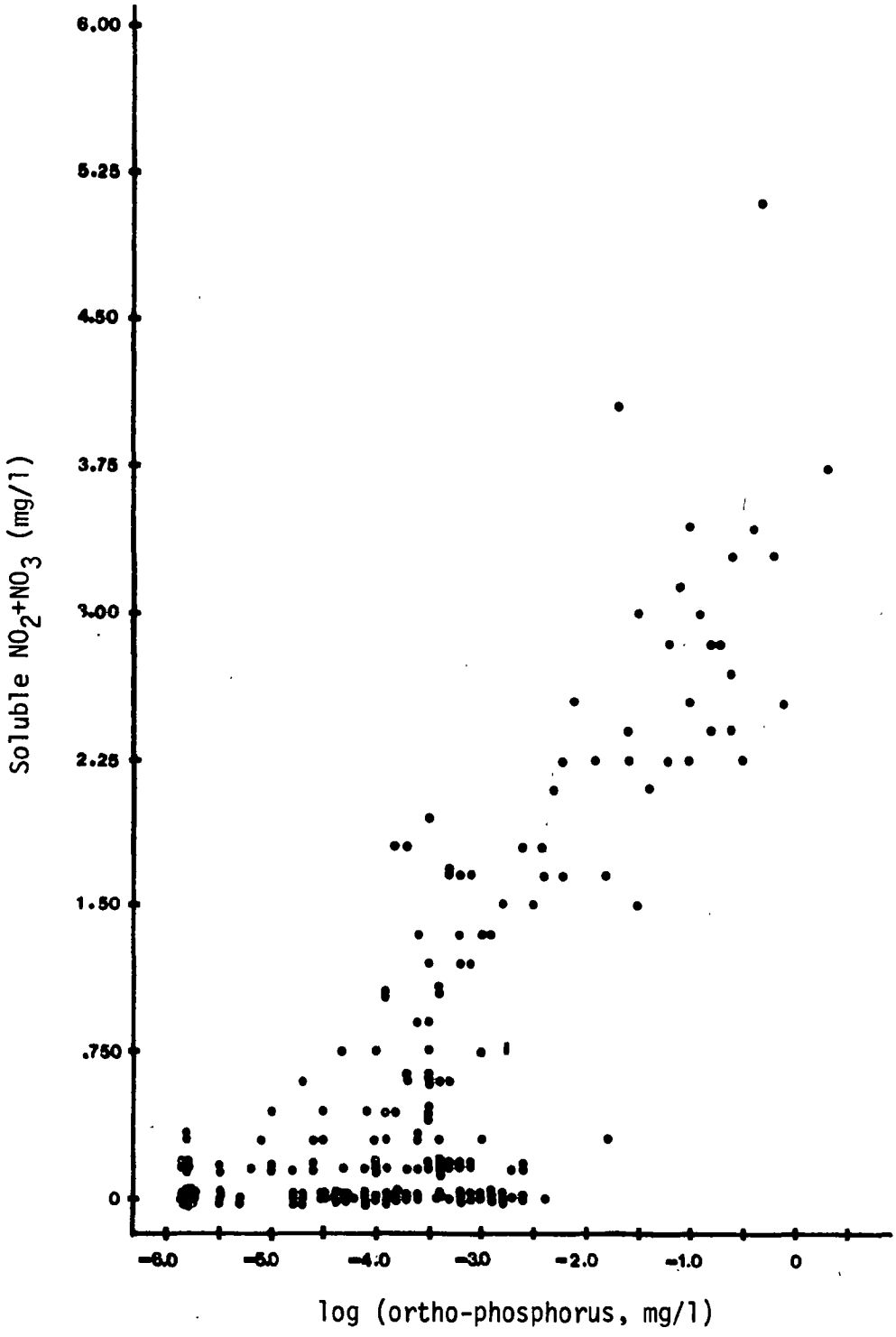


Figure 11-24 Plot of slack water survey data, log ortho-phosphorus versus soluble NO_2+NO_3 for the Patuxent River, 1980, 1981, 202 observations, correlation coefficient - 0.76.

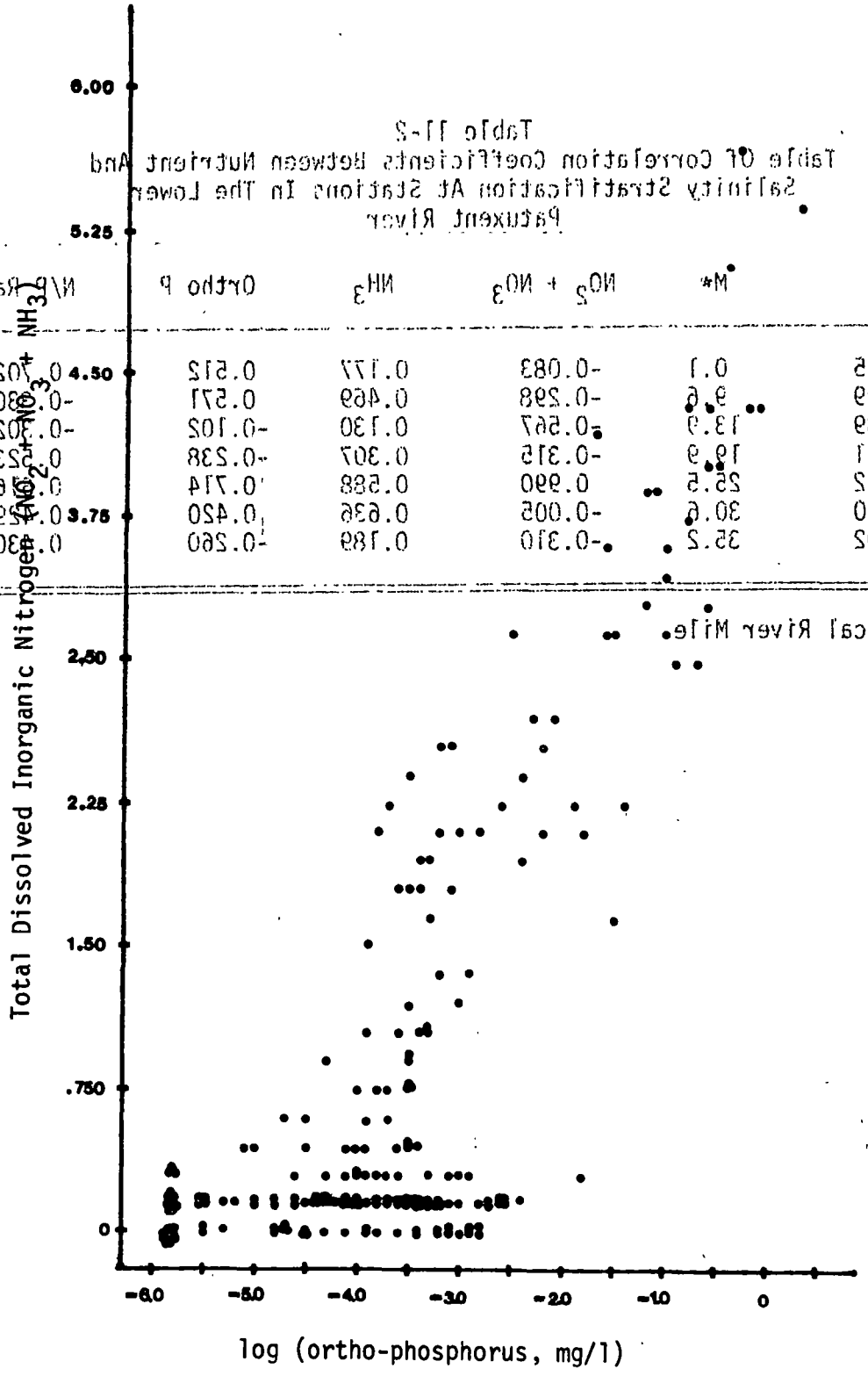
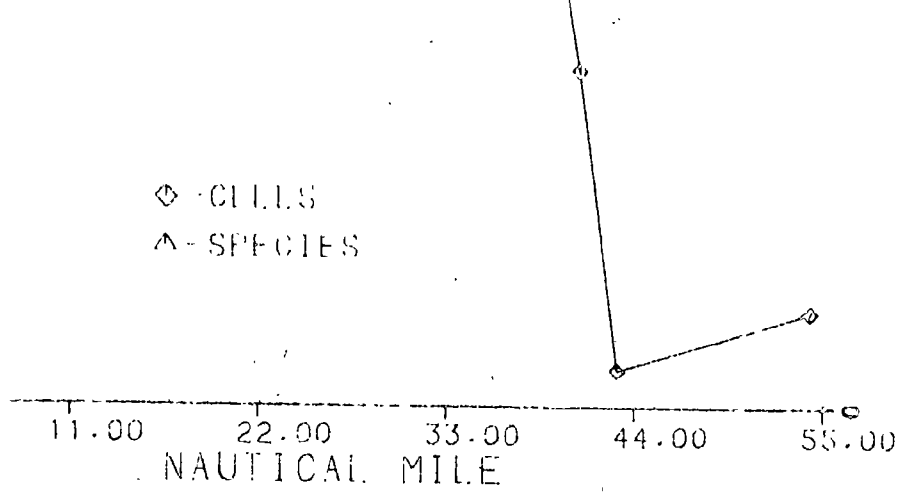


Figure 11-25 Plot of slack water ortho-phosphorus and total dissolved inorganic nitrogen in Patuxent River for 1980-1981 data, 202 observations.

Table 11-2
Table Of Correlation Coefficients Between Nutrient And Salinity Stratification At Stations In The Lower Patuxent River

Station	M*	$NO_2 + NO_3$	NH_3	Ortho P	N/P Ratio
XCF 9575	0.1	-0.083	0.177	0.512	0.702
XDE 2599	9.6	-0.298	0.469	0.571	-0.330
XDE 5339	13.9	-0.567	0.130	-0.102	-0.302
XDE 9401	19.9	-0.315	0.307	-0.238	0.523
XED 4892	25.5	0.990	0.588	0.714	0.616
XED 9490	30.6	-0.005	0.636	0.420	0.429
PXT 0402	35.2	-0.310	0.189	-0.260	0.430

* Nautical River Mile



11-26 Number of species and phytoplankton cells observed along uxent estuary and lower river during July 1980 survey.

Table 11-3

Table of Correlation Coefficients Between Transformed Values of Nutrient and Salinity Stratification at Stations in the Lower Patuxent River

STATION	R.M.	NO_2+NO_3	NH_3	ORTHO-P	N/P RATIO
XCF 9575	0.1	0.014(C)	0.009(C)	0.574(D)	0.731(E)
XDE 2599	9.6	-0.336(E)	0.624(D)	0.598(E)	-0.440(D)
XDE 5339	13.9	-0.637(F)	0.235(E)	0.478(D)	-0.737(F)
XDE 9401	19.9	-0.278(B)	0.307(A)	-0.439(C)	0.641(D)
XED 4892	25.6	0.315(D)	0.745(G)	0.733(E)	0.627(E)
XED 9490	30.6	0.210(D)	0.636(A)	0.536(G)	0.758(D)
PXT 0402	35.2	-0.310(A)	0.836(G)	-0.822(C)	0.430(A)

(A) Regression of Nutrient vs Salinity Absolute Surface to Bottom Differences
(B) Regression of Log (Nurtrient) vs Salinity Absolute Surface to Bottom Differences
(C) Regression of Nutrient vs Log (Salinity) Absolute Surface to Bottom Differences
(D) Regression of Log (Nutrient) vs Salinity/AVG.Q. Absolute Surface to Bottom Differences
(E) Regression of Nutrient vs Salinity *AVG. Q. Absolute Surface to Bottom Differences

(F) Regression of Nutrient vs Log (Salinity/AVG.Q.) Absolute Surface to Bottom Differences
(G) Regression of Log (Nutrient) vs Log (Salinity/AVG.Q.) Absolute Surface to Bottom Differences

*AVG.Q. = Avg. daily mean cfs for twenty day period prior to survey date.

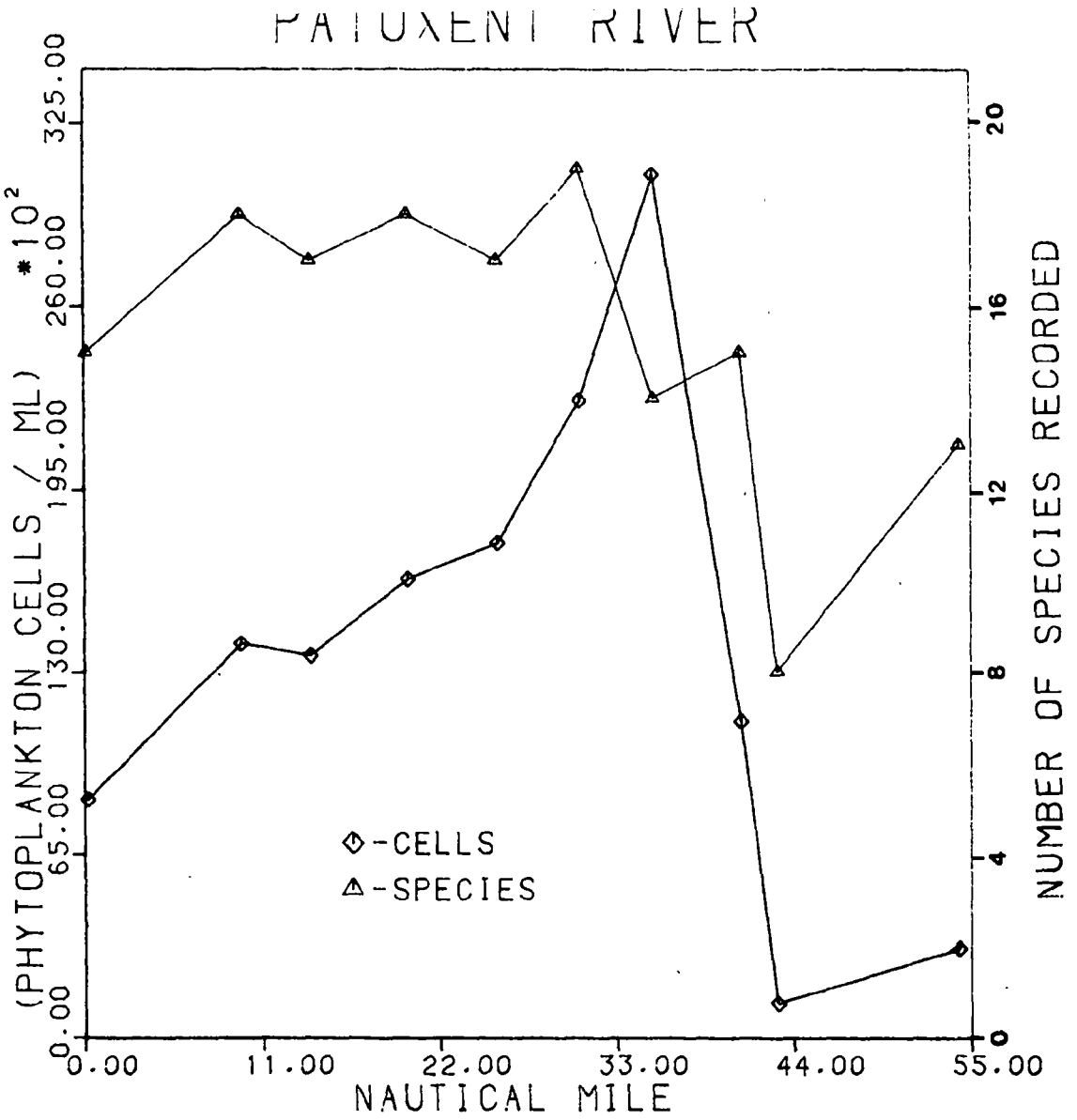


Figure 11-26 Number of species and phytoplankton cells observed along the Patuxent estuary and lower river during July 1980 survey.

Table 11- 4 Patuxent River Longitudinal Phytoplankton Results For July 1980*

Station Designation	XCF 9575	XDE 2599	XDE 5339[b]	XDE 9401	XED 4892	XED 9490	PXT 0402	PXT 0455	PXT 0494	WXT 0045	PXT 0503
Total Cells · ml^{-1}[a]	8450	14012	13584 12354	16311	17595	22676	30644	11231	1177	535	3155
No. Species Recorded	15	18	17 17	18	17	19	14	15	8	5	13
Total Diatoms	1604	3744	3530 4065	2193	1177	8450	21713	3102	428	321	106
Total Dinoflagellates	160	1391	963 856	2193	2086	214	267	0	0	0	0
Total Green Algae	107	53	53 160	53	106	1016	106	1604	428	0	1497
Total Cryptophytes and Crysophytes	1765	2834	3369 2621	4439	6097	5348	4011	5669	214	53	53
Total Blue Greens	0	0	0 0	0	214	267	2567	481	0	106	1284
Unident. 1.5-2 um Coccoid	3744	4385	5508 4653	7434	7862	7273	2086	535	-	-	-
Inorganic Detritus Load	VERY CLEAN	VERY SLIGHT	LOW LOAD	SLIGHTLY TURBID	MOD-ERATE	MOD-ERATE	MUCH REDUCED	REDUCED	VERY HVY.	VERY HVY.	VERY HVY.

* Data collected by Biospheries, 1981, for this study.

[a]Several observed organisms could not be assigned to division by microscopic character. The total subsequent figures, therefore, do not necessarily equal total cells.

[b]Two figures in column represent Q.A. replicate assessments.

Note: (All densities are expressed as cells per ml of original pooled five subsamples)

Table 11-5 Patuxent River Longitudinal Phytoplankton Results For April 1981*

Station Designation	XCF 9575	XDE 2599[b]	XDE 5339	XDE 9401	XED 4892	XED 9490	PXT 0402	PXT 0455	PXT 0494	WXT 0045	PXT 0603
Total Cells · ml-1[a]	17381	19520 17916	16204	17488	25563	13958	10963	7380	2727	8985	4708
No. Species Recorded	12	16 13	13	15	14	15	11	19	16	13	14
Total Diatoms	14600	14815 12033	11917	5936	2621	642	1177	1392	855	1230	1073
Total Dinotlagellates	375	855 375	428	3583	5403	536	0	0	54	0	0
Total Green Algae	108	162 269	214	322	215	161	749	1445	642	1872	856
Total Cryptophytes and Crysophutes	2300	3477 3262	3263	856	2353	4064	1498	375	750	1818	642
Total Blue Greens	0	214 0	0	214	0	0	54	374	0	588	321
Tentatively identified as Nannochloris (a green) algae)	0	0 1979	588	1979	14974	8557	7487	3744	374	3423	1818
Detritus Load					Substantial inorganic Detritus	Increased inorganic + organic Detritus	Extremely dense inorganic, organic Detritus	Clean Sample			Large grain inorganic Detritus

* Data collected by Biospheries Inc., for this study. (All densities are expressed as cells per ml of original pooled five subsamples).

[a]Several observed organisms could not be assigned to division by microscopic character. The total subsequent figures, therefore, do not necessarily equal total cells.

[b]Two figures in column represent Q.A. replicate assessments.

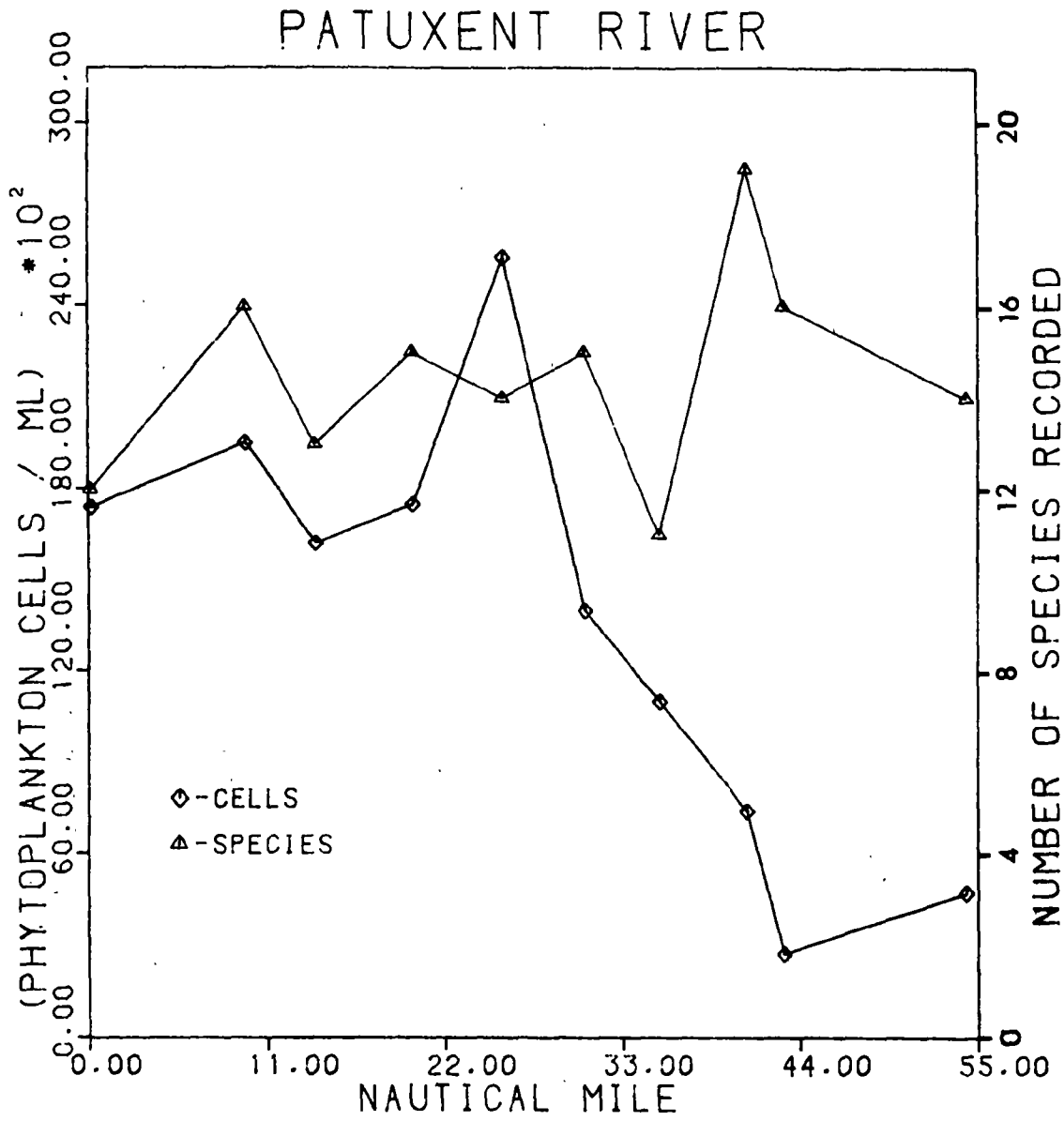


Figure 11-27 Estimated phytoplankton cells and number of species in the Patuxent River versus nautical mile for the April, 1981 survey.

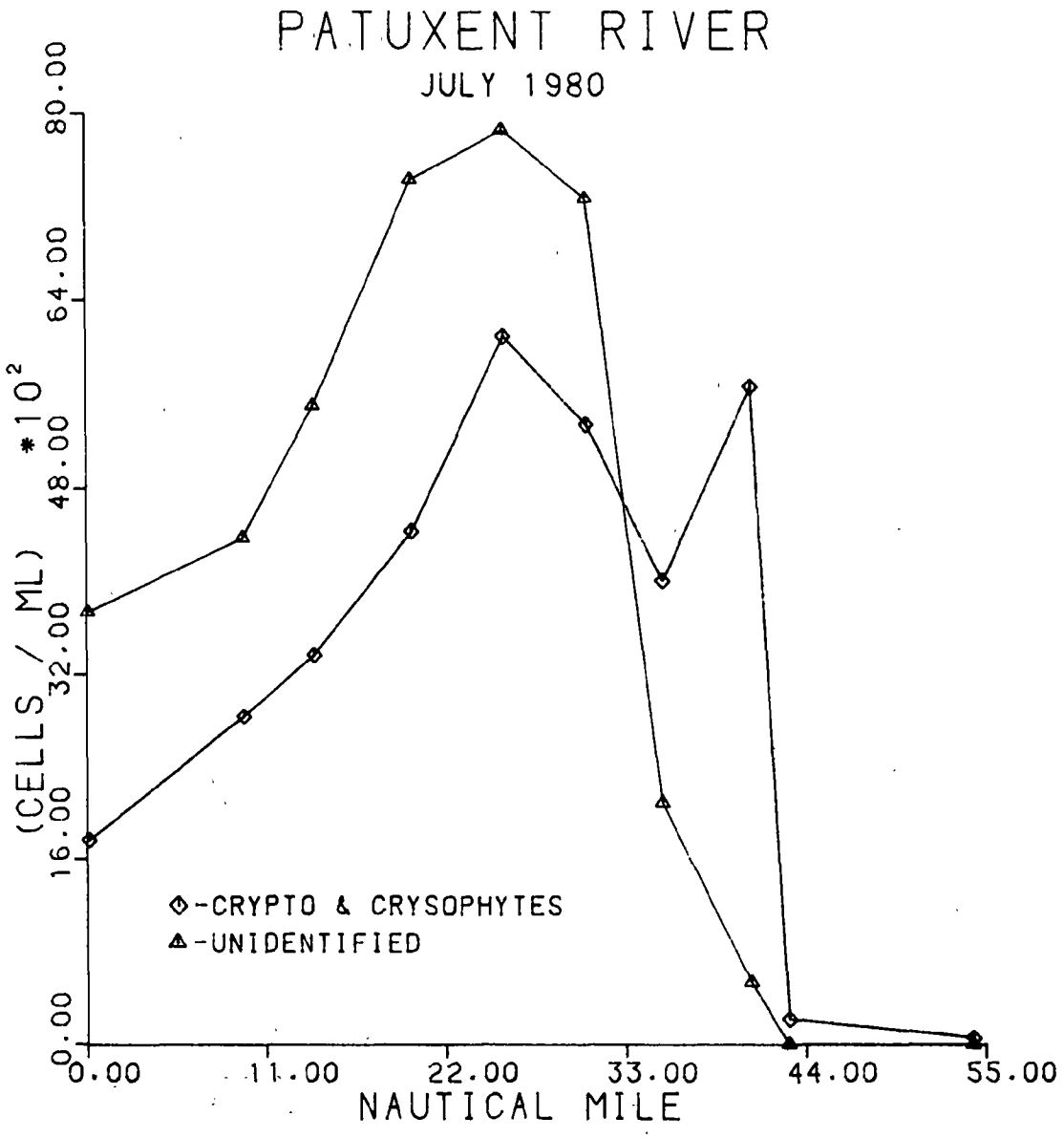


Figure 11-28 Estimated cells of phytoplankton during the July longitudinal phytoplankton survey.

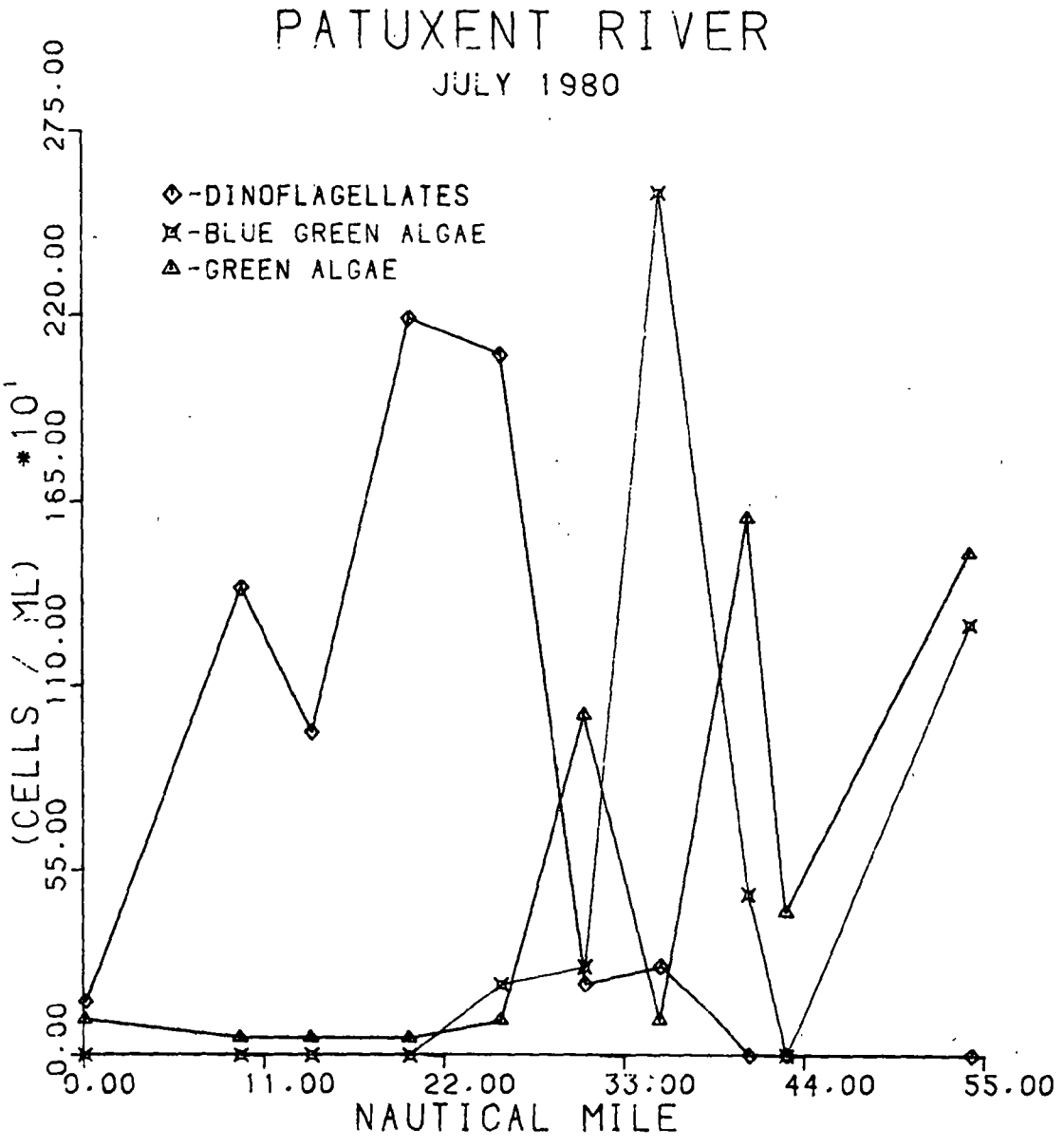


Figure 11-29 Dominant classes of phytoplankton observed during the July 1980 longitudinal survey.

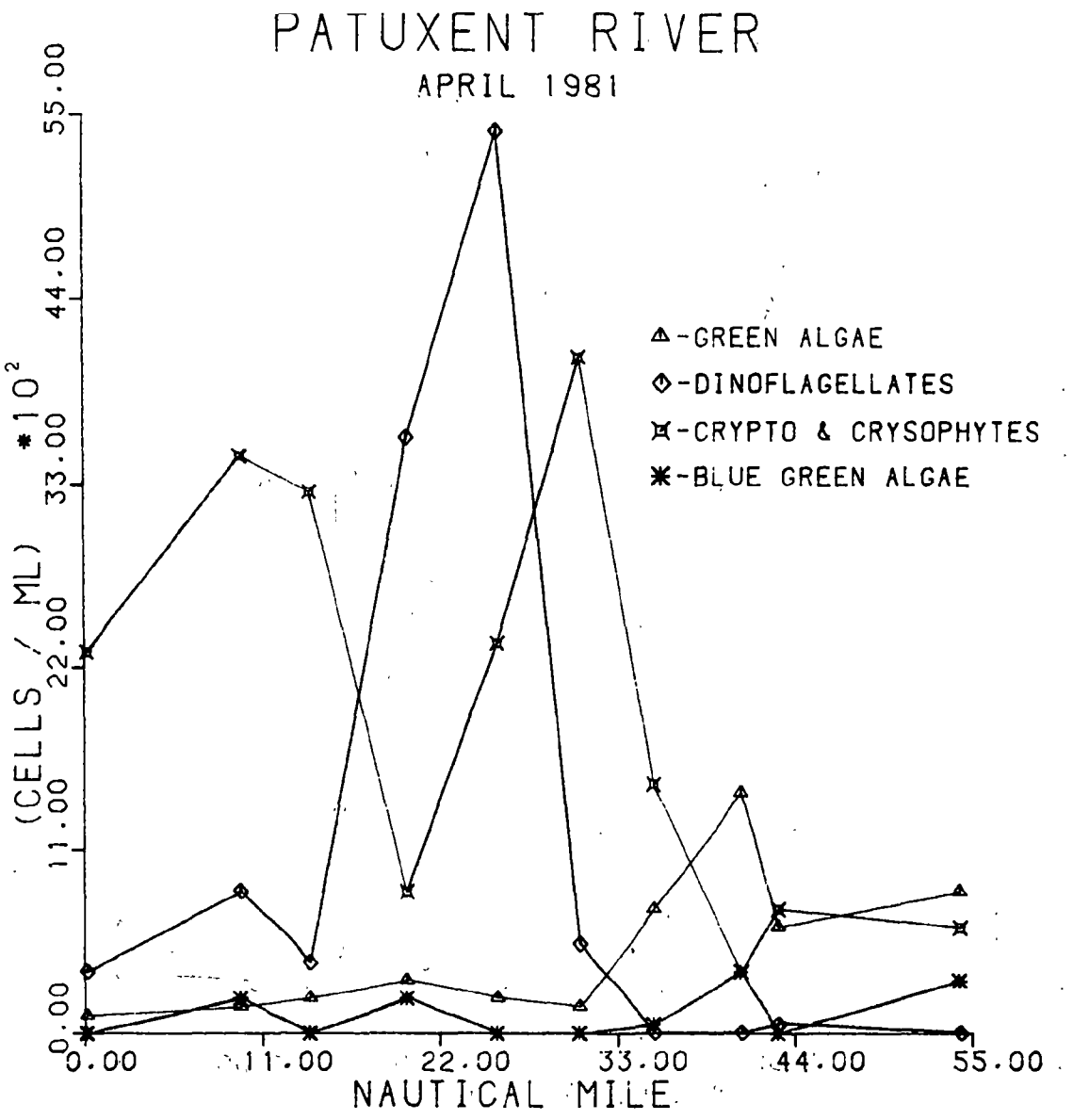


Figure 11-30 Estimated longitudinal profile of phytoplankton in the Patuxent River.

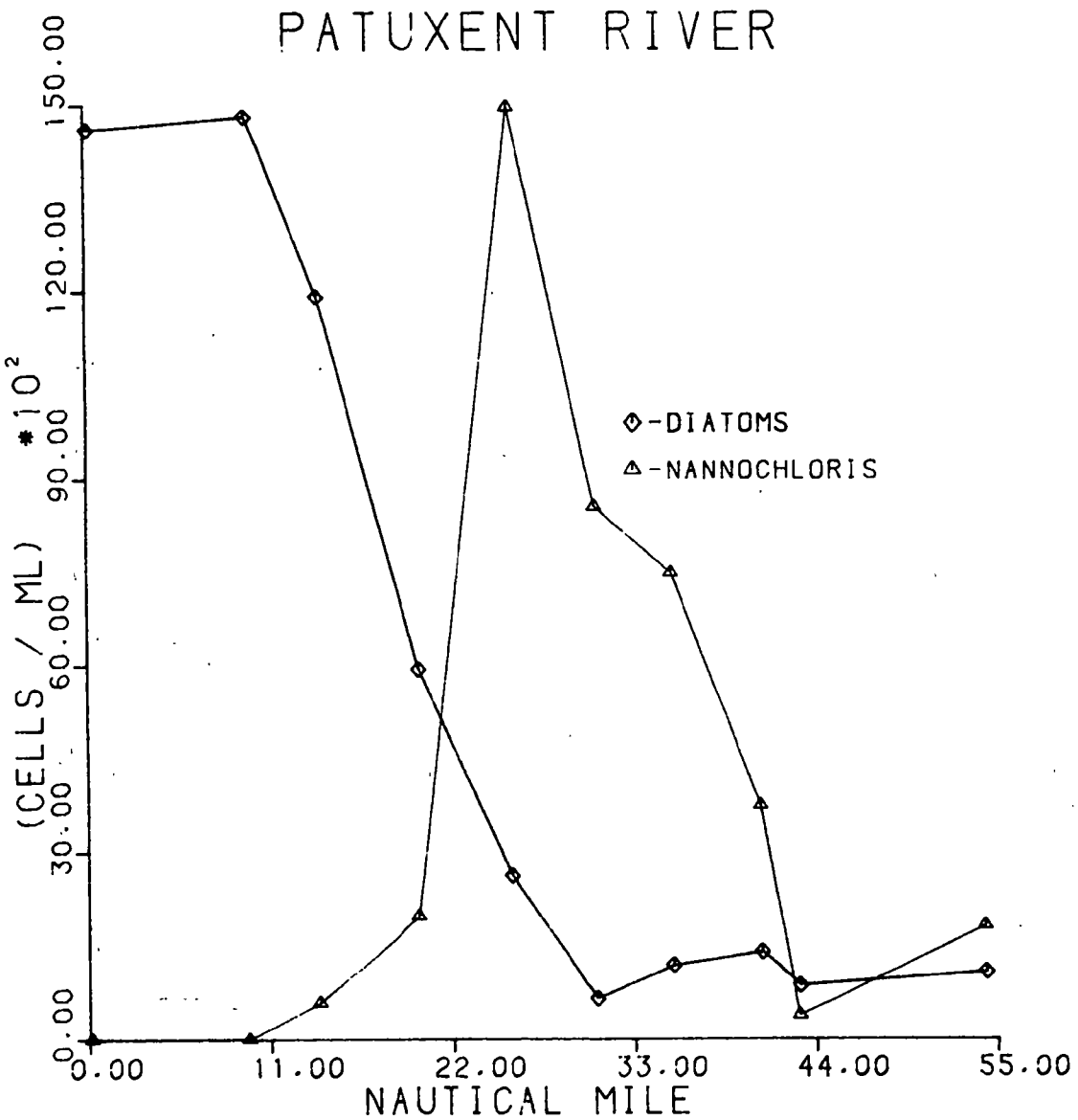


Figure 11-31 Estimated longitudinal profile of diatoms and the green algae (tentatively identified as Nannochloris in the Patuxent River April, 1981) survey.

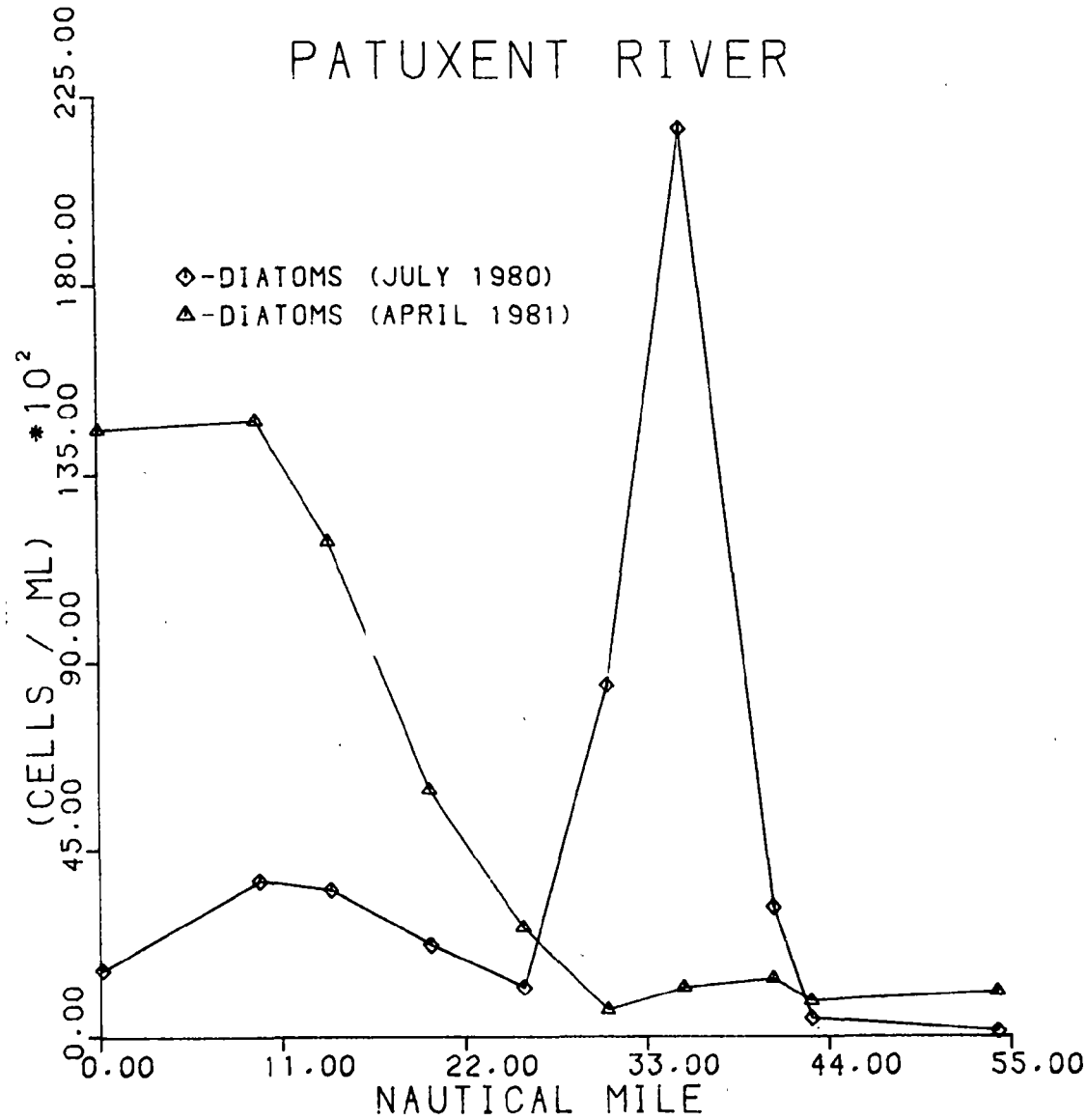


Figure 11-32 Comparison of diatom cell dominance in the Patuxent River for the July 1980 and April 1981 longitudinal surveys.

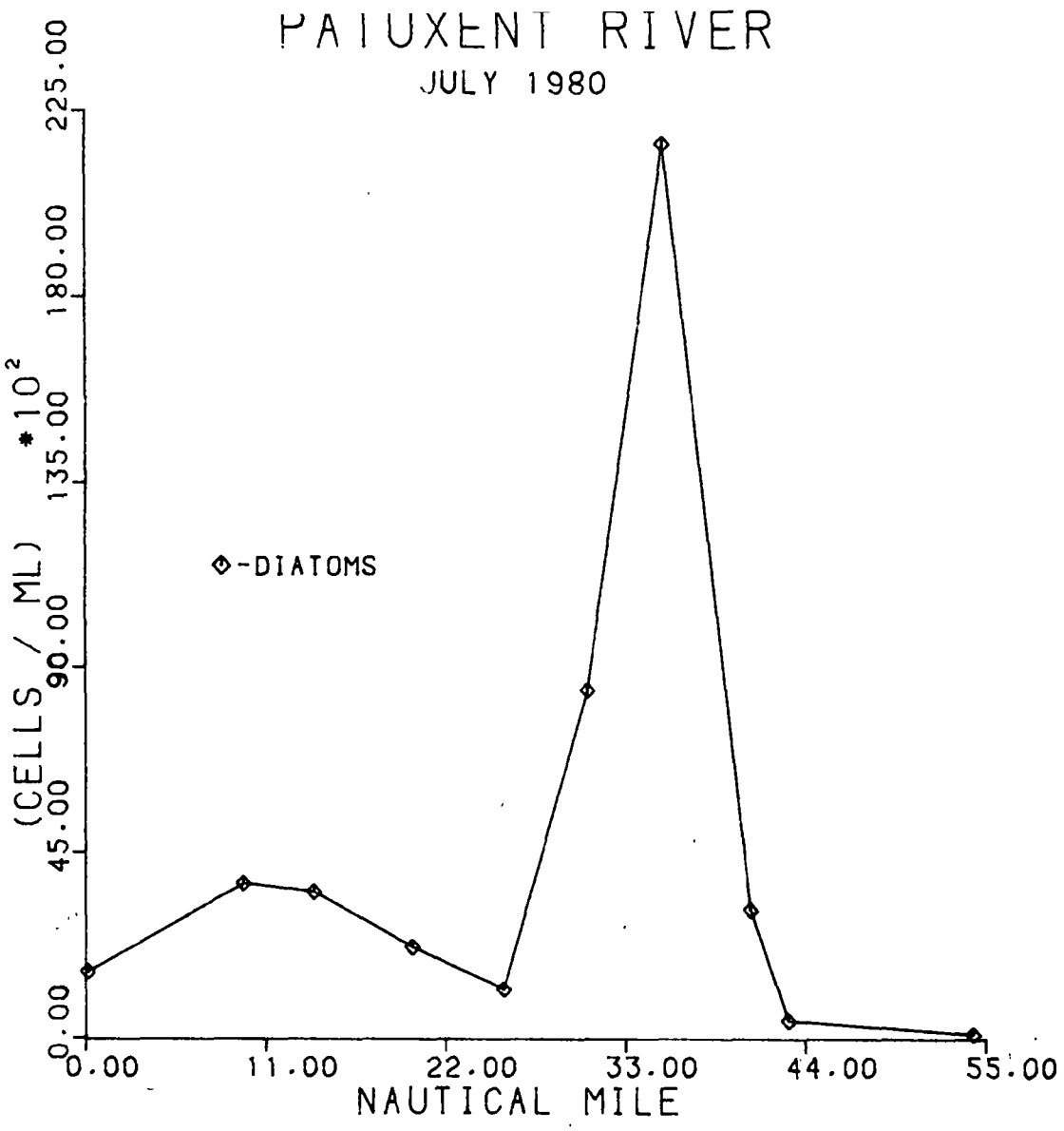


Figure 11-33 Estimated number of diatoms observed during the July 1980 Patuxent River longitudinal survey.

Table 11-6 Patuxent River Surface Chlorophyll-a And Pheophytin-a Data*

Date	Station	Chlorophyll-a ($mg \cdot m^{-3}$)	Pheophytin-a ($mg \cdot m^{-3}$)
7/23/80[a]	XCF 9575	23.8	-18.0[b]
	XDE 2599	28.3	11.9
	XDE 5339	21.2	-9.5[b]
	XED 9401	42.0	-11.7[b]
	XED 4892	35.1	40.0
	XED 9490	41.5	14.3
	PXT 0402	79.4	-46.0[b]
	PXT 0455	36.3	12.1
	PXT 0494	27.5	-45.3[b]
	WXT 0045	15.2	6.4
7/24/80[a]	PXT 0603	56.5	-33.0[b]
4/20-21/81[f,g]	XCF 9575	13.0	15.0
	XDE 2599	3.4[c]	18.8[c]
	XDE 5339	2.7[d]	17.6[d]
	XDE 9401	10.8[c]	5.2[d]
	XDE 4892	3.0[c]	20.8[c]
	XDE 9490	4.8	4.8
	PXT 0402	5.1[c]	7.9
	PXT 0455	4.9[c]	4.3[c]
	PXT 0494	2.4[e]	4.7
	WXT 0045	6.0[d]	9.8[d]
	PXT 0603	5.0	0.9

* Data collected by Biospherics Inc., 1981 for this study.

[a]Chlorophyll values were calculated using the equation of R.A. Vollenweider (A Manual on Methods for Measuring Primary Production in Aquatic Environments, IPB Handbook No. 12, Blackwell Scientific Publications, London, p. 39, 1974.) due to sample turbidity and possible spectrophotometer error.
[b]The pheophytin-a values for these samples are also suspect of the above reason.
[c]Sample of 4
[d]Sample of 3
[e]Sample of 2
[f]Remaining values are means of 5 samplings on the 4/20-21, 1981, cruise. Remaining cruise values are means of 3 samples.
[g]Chlorophyll were calculated using the equation Strickland and Parsons (A Practical Handbook of Seawater Analysis, Bulletin 167, Fisheries Research Board of Canada, p. 194, 1968).

Table 11-7 Patuxent River Longitudinal Water And Sediment Bacteria Measurements For July 23-24, 1980.[b]

Water Samples
(CFU/ml water)[a]

Station	Nitrosomonas sp.	Nitrobacter sp.
XCF 9575	3.2×10	5.1×10^3
XDE 2599	3.3×10^2	4.0×10^4
XDE 5339	1.5×10^2	1.7×10^4
XDE 9401	1.7×10^2	1.5×10^3
XED 4892	6.1×10^0	1.9×10^3
XED 9490	8.0×10^0	8.0×10^2
PXT 0402	1.0×10^3	3.3×10^4
PXT 0455	3.2×10	6.9×10^3
WWTP	2.2×10^3	7.7×10^4
PXT 0494	6.3×10^2	3.9×10^4
WXT 0045	4.6×10^2	5.0×10^4
PXT 0603	1.9×10^2	9.6×10^3

Sediment Samples
(CFU/gram wet sediment)[a]

Station	Nitrosomonas sp.	Nitrobacter sp.
XCF 9575	2.0×10^4	2.7×10^4
XDE 2599	2.7×10^4	6.8×10^3
XDE 5339	4.3×10^4	2.7×10^4
XDE 9401	4.9×10^3	3.5×10^4
XED 4892	1.0×10^4	1.0×10^4
XED 9490	1.4×10^3	4.9×10^4
PXT 0402	3.0×10^4	3.5×10^5
PXT 0455	2.7×10^3	7.2×10^4
WWTP	8.9×10^3	5.9×10^4
PXT 0494	2.2×10^4	6.8×10^4
WXT 0045	2.0×10^4	1.9×10^5
PXT 0603	3.2×10^4	2.9×10^5

[a]Colony Forming Unit (CFU)

[b]Data collected by Biosperics, Inc., 1981 for this study.

Table 11-8 Patuxent River Longitudinal Water And Sediment Bacteria Measurements For August 21, 1980.[b]

Water Samples
(CFU/ml water)[a]

Station	Nitrosomonas sp.	Nitrobacter sp.
XCF 9575	3.3×10^3	1.3×10^4
XDE 2599	2.7×10^3	3.0×10^3
XDE 5339	2.0×10^3	1.6×10^4
XDE 9401	1.6×10^3	3.0×10^3
XED 4892	4.8×10^2	1.9×10^4
XED 9490	1.2×10^3	2.9×10^4
PXT 0402	4.3×10^3	1.5×10^4
PXT 0455	3.4×10^3	4.9×10^3
WWTP	1.1×10^3	4.3×10^2
PXT 0494	2.4×10^3	3.5×10^3
WXT 0045	7.0×10^2	1.5×10^4
PXT 0603	8.6×10^2	1.5×10^5

Sediment Samples
(CFU/gram wet sediment)[a]

Station	Nitrosomonas sp.	Nitrobacter sp.
XCF 9575	9.8×10^5	3.5×10^4
XDE 2599	1.1×10^6	1.6×10^3
XDE 5339	2.5×10^6	3.7×10^4
XDE 9401	6.9×10^5	1.2×10^4
XED 4892	7.3×10^4	2.0×10^4
XED 9490	7.6×10^5	1.2×10^6
PXT 0402	3.6×10^5	7.7×10^3
PXT 0455	4.5×10^5	1.8×10^5
WWTP	6.1×10^5	1.5×10^5
PXT 0494	4.1×10^4	4.7×10^5
WXT 0045	5.9×10^5	2.6×10^5
PXT 0603	1.6×10^6	4.7×10^4

[a]Colony Forming Unit (CFU)

[b]Data collected by Biospherics Inc., 1981 for this study.

Table 11-9 Patuxent River Longitudinal Water And Sediment Bacteria Measurements For April 20-21, 1981.[b]

Water Samples
(CFU/m) water)[a]

Station	Nitrosomonas sp.	Nitrobacter sp.
XCF 9575	3.0×10	<10
XDE 2599	3.7×10^2	1.2×10
XDE 5339	8.5×10^2	1.7×10
XDE 9401	3.0×10	2.5×10^0
XED 4892	3.5×10	2.0×10^2
XED 9490	6.0×10	7.6×10^2
PXT 0402	< 10	7.7×10^2
PXT 0455	3.0×10	1.9×10^2
WWTP	2.0×10	2.6×10^3
PXT 0494	< 10	8.3×10^2
WXT 0045	4.0×10	4.2×10^3
PXT 0603	< 10	3.3×10^3

Sediment Samples
(CFU/gram wet sediment)[a]

Station	Nitrosomonas sp.	Nitrobacter sp.
XCF 9575	$< 10^2$	3.1×10^3
XDE 2599	2.4×10^5	1.4×10^3
XDE 5339	4.5×10^3	8.2×10^3
XDE 9401	2.4×10^3	6.9×10^3
XED 4892	9.2×10^3	1.0×10^4
XED 9490	1.0×10^3	3.8×10^3
PXT 0402	1.6×10^3	5.2×10^3
PXT 0455	4.4×10^2	5.8×10^3
WWTP	5.1×10^3	4.3×10^3
PXT 0494	1.4×10^2	1.0×10^4
WXT 0045	1.0×10^2	2.3×10^3
PXT 0603	4.0×10^2	8.2×10^3

[a]Colony Forming Unit (CFU)

[b]Data collected by Biospherics Inc. for this study.

Table 11-10 Photosynthetic And Related Measurements In The Patuxent River*

STATION	TIDE STAGE	DEPTH (ft.)	TEMP (°C)	SAL (0/00)	D.O. (mg/l)	SECCHI (ft.)	LIGHT PENETRATION (uE/m²/sec)	GROSS PHOTOSYNTHESIS (mg-at $O_2/m^3/hr$)	NET PHOTOSYNTHESIS (mg-at $O_2/m^3/hr$)	RESPIRATION (mg-at $O_2/m^3/hr$)	TOTAL CHLORO-PHYLL-a ug/l
							AIR=524				
SOTTERLY	E	0	24.0	11.5	7.4	4.6	482	16.5	11.8	4.6	9.8
POINT		1.7	23.8	11.9	7.0		221	15.3	8.8	6.5	10.37
6/24/80		3.3	23.8	11.9	7.0		127	7.8	4.4	34	9.78
1030 HRS		6.6	23.8	12.0	6.8		54	3.1	0.5	2.6	12.01
		9.9	23.8	12.0	6.6		24				
		13.2	23.6	12.1	6.4		11				
		16.5	23.4	12.1	4.4		5	- 1.9	- 1.1	0.9	9.75
		19.8	23.2	12.1	4.1						
							AIR=800				
JACKS	E	0	25.0	10.5	7.6	4.3	442	167.8	159.9	8.0	
BAY		1.7	24.5	10.5	7.0		225	7.4	- 1.8	9.1	29.64
6/24/80		3.3	24.5	10.5	7.3		67	21.2	8.6	12.6	31.20
0930 HRS		6.6	24.5	10.5	6.8		31	4.5	1.5	3.0	8.42
		9.9	24.0	10.6	6.3		9.4				
		13.2	24.0	10.8	5.0		2.3				
		16.5	23.5	11.0	3.2		0.7				
		19.8	23.0	10.5	2.0		0	7.9	0.0	7.9	15.91
							AIR=760				
SELBY	E	0	24.0	0.1	8.3	1.0	576	126.9	107.6	19.3	75.59
LANDING		1.7	24.2	0.1	8.2		101	22.2	9.5	12.7	47.06
6/24/80		3.3	24.0	0.1	7.7		14	17.2	- 3.3	20.5	52.52
0940 HRS		6.6	24.0	0.1	7.7		0.7	2.7	- 9.1	11.9	53.77
		9.9	23.8	0.1	7.6		0	7.7	- 2.8	10.5	61.98

H - high slack tide
L - low slack tide
E - ebb tide
F - flood tide

*data collected by Biospherics Inc., 1981, for this study.

Table 11-10 (continued) Photosynthetic And Related Measurements In The Patuxent River

STATION	TIDE STAGE	DEPTH (ft.)	TEMP (°C)	SAL (0/00)	D.O. (mg/l)	SECCHI (ft.)	LIGHT PENETRATION uE/m²/sec)	GROSS PHOTOSYNTHESIS (mg-at $O_2/m^3/hr$)	NET PHOTOSYNTHESIS (mg-at $O_2/m^3/hr$)	RESPIRATION (mg-at $O_2/m^3/hr$)	TOTAL CHLORO-PHYLL-a ug/l
							AIR=1500				
SOTTERLY	E	0	26.5	13.1	4.9	3.0	1050	40.0	22.8	17.3	3.36
POINT		1.7	26.3	13.2	4.8		875	13.7	- 2.7	16.5	
7/18/80		3.3	26.8	13.3	4.3		210	17.4	-11.0	28.5	
0945 HRS		6.6	26.5	13.3	4.2		20	3.8	-19.5	23.6	2.59
		9.9	26.2	13.3	4.2		7				
		13.2	26.0	13.3	4.2		0.7	1.0	-10.6	11.6	3.2
		16.5	26.0	13.8	3.2		0.3				
		19.8	25.1	13.8	1.6		0.2				
							AIR=2200				
JACKS	E	0	29.5	13.0	8.0	3.3	930	73.0	93.2	-20.5	4.74
BAY		1.7	29.5	13.0	7.9		560	17.3	31.0	-13.7	
7/18/80		3.3	28.0	13.5	8.0		93	7.6	15.9	- 8.3	
1521 HRS		6.6	28.0	13.5	5.1		55	1.0	5.1	- 4.1	3.37
		9.9	27.5	14.0	4.7		6.3				
		13.2	27.0	14.5	3.0		0.4				
		16.5	27.0	14.5	1.8			11.7	- 4.6	16.4	3.81
							AIR=645				
SELBY	F	0	28.1	0.1	8.3	1.0	400	77.5	96.8	-19.3	4.79
LANDING		1.7	28.2	0.1	6.3		62	32.0	-28.9	60.9	
7/18/80		3.3	28.2	0.1	6.2		10.2	28.8	29.7	- 1.0	
0755 HRS		6.6	28.2	0.1	6.2		0.6	4.8	10.4	- 5.6	2.43
		9.9	28.2	0.1	6.1		0	2.0	7.1	- 5.1	2.44

Table 11-10 (continued) Photosynthetic And Related Measurements In The Patuxent River

STATION	TIDE STAGE	DEPTH (ft.)	TEMP (°C)	SAL (0/00)	D.O. (mg/l)	SECCHI (ft.)	LIGHT PENETRATION ($uE/m^2/sec$)	GROSS PHOTOSYNTHESIS (mg-at $O_2/m^3/hr$)	NET PHOTOSYNTHESIS (mg-at $O_2/m^3/hr$)	RESPIRATION (mg-at $O_2/m^3/hr$)	BOD (mg/l)
							AIR=381				
SOTTERLY	H	0	26.9	14.3	5.0	3.6	150	12.1	8.6	3.5	0.41
POINT		1.7	26.1	14.3	4.8		66	6.4	5.9	0.5	
8/19/80		3.3	26.1	14.3	4.8		35	3.3	2.1	1.3	
0840 HRS		6.6	26.0	14.4	4.8		14	2.0	-0.2	2.2	1.06
		9.9	26.0	14.4	4.8		2.8				
		13.2	26.0	14.4	4.8		1.0		-1.4	0.7	1.13
		16.5	26.0	14.4	4.8		0.4	-0.7			
							AIR=650				
JACKS	E	0	27.0	12.3	7.6	4.3	400	112.7	68.8	43.9	9.6
BAY		1.7	27.0	11.6	6.3		430	31.8	15.9	15.9	
8/19/80		3.3	27.0	11.2	6.4		60	20.8	0.0	20.7	
1030 HRS		6.6	27.0	11.6	6.0		15	12.8	-6.5	19.2	0.68
		9.9	27.0	11.7	5.4		0.9				
		13.2	26.0	10.0	5.1		0.1	19.4	20.1	-0.7	0.73
							AIR=457				
SELBY	F	0	24.8	0.1	5.8	1.3	292	62.4	56.3	6.1	1.22
LANDING		1.7	24.9	0.1	5.9		35	22.0	19.4	2.6	
8/19/80		3.3	24.8	0.1	6.1		5.0	3.1	-3.2	5.7	
0936 HRS		6.6	24.9	0.1	6.2		0.3	-7.6*	-2.0*	-5.6*	1.29
		9.9	24.9	0.1	6.0		0				
		13.2	24.9	0.1	5.8		0				
		16.5	24.9	0.1	5.7		0	2.3	-0.9	3.0	3.72

Table 11-10 (continued) Photosynthetic And Related Measurements In The Patuxent River

STATION	TIDE	DEPTH (ft.)	TEMP (°C)	SAL (0/000)	D.O. (mg/l)	SECCHI (ft.)	LIGHT PENETRATION ($uE/m^2/sec$)	GROSS PHOTOSYNTHESIS ($mg\text{-}at\ O_2/m^3/hr$)	NET PHOTOSYNTHESIS ($mg\text{-}at\ O_2/m^3/hr$)	RESPIRATION ($mg\text{-}at\ O_2/m^3/hr$)
							AIR=1100			
SOTTERLY		0	23.8	13.9	7.9	8.9	850	29.2	10.0	4.5
POINT		1.7	24.1	13.8	7.6		540	4.0	0.3	3.7
5/6/81		3.3	23.5	13.9	7.4		260	7.0	2.1	4.9
0845 HRS		6.6	23.1	13.8	7.5		180	3.6	1.0	4.7
		9.9	23.0	13.9	7.6		80			
		13.2	23.0	14.2	7.6		26	2.2	1.1	1.1
		16.5	23.0	14.6	7.6		15			
JACKS		0	14.0	15.5	8.7	8.3	BROKEN			
BAY		1.7	14.0	15.3	9.0		METER			
5/6/81		3.3	13.8	15.8	8.8					
p830 HRS		6.6	13.8	16.0	8.6			survey cancelled		
		9.9	13.8	16.3	8.3					
							AIR=1050			
SELBY		0	18.0	0.1	9.2	1.3	1000			
LANDING		1.7	17.5	0.1	9.5		150			
4/28/81		3.3	17.5	0.1	9.4		30	survey cancelled		
1100 HRS		6.6	17.2	0.1	9.2		0.9			
		9.9	17.0	0.1	9.0		0.1			

Table 11-10 (continued) Photosynthetic And Related Measurements In The Patuxent River

STATION	TIDE STATE	DEPTH (ft.)	TEMP (°C)	SAL (0/00)	D.O. (mg/l)	SECCHI (ft.)	LIGHT PENETRATION (uE/m²/sec)	GROSS PHOTOSYNTHESIS (mg-at $O_2/m^3/hr$)	NET PHOTOSYNTHESIS (mg-at $O_2/m^3/hr$)	RESPIRATION (mg-at $O_2/m^3/hr$)	BOD (mg/l)
							AIR=326				
SOTTERLY	F	0	21.5	14.2	7.9	9.2	220	7.8	0.9	7.0	3.1
POINT		1.7	20.9	13.1	7.6		86	3.8	1.3	2.5	
5/29/81		3.3	20.8	14.6	7.4		75	4.0	1.6	2.5	
0820 HRS		6.6	21.0	15.0	7.5		40	2.5	1.7	0.9	2.88
		9.9	18.4	16.1	7.6		26				
		13.2	21.0	15.0	7.6		16	1.1	1.1	0.0	3.04
		16.5	19.8	15.4	7.6		9.1				
							AIR=1960				
JACKS	E	0	23.0	12.9	7.1	8.3	1720	0.6	33.2	31.2	3.04
BAY		1.7	21.5	12.9	7.2		600	4.1	3.5	0.7	
5/29/81		3.3	21.6	12.9	7.2		67	7.5	5.1	2.4	
1220 HRS		6.6	21.4	12.9	6.8		35	8.9	9.2	0.2	3.14
		9.9	21.5	13.0	6.8		27				
		13.2	22.0	13.0	6.8		15		4.6	-1.3	2.53
		16.5	22.0	13.0	6.7			3.3			
							AIR=160				
SELBY	E	0	20.3	0.1	4.8	1.3	110	23.9	10.3	13.5	6.18
LANDING		1.7	20.2	0.1	4.7		21	12.5	6.7	5.7	
6/3/81		3.3	20.1	0.1	4.8		1.9	4.2	1.3	3.0	
0835 HRS		6.6	20.0	0.1	4.9		.5	6.3	5.1	3.1	6.62
		9.9	20.0	0.1	4.9						
		13.2		0.1				2.2	1.1	3.3	3.23

Table 11-10 (continued) Photosynthetic And Related Measurements In The Patuxent River

STATION	TIDE STATE	DEPTH (ft.)	TEMP (°C)	SAL (0/00)	D.O. (mg/l)	SECCHI (ft.)	LIGHT PENETRATION (uE/m²/sec)	GROSS PHOTOSYNTHESIS (mg-at $O_2/m^3/hr$)	NET PHOTOSYNTHESIS (mg-at $O_2/m^3/hr$)	RESPIRATION (mg-at $O_2/m^3/hr$)	BOD (mg/l)
							AIR=650				
SOTTERLY	F	0	25.2	15.0	9.3	3.0	100	16.1	6.6	9.4	7.23
POINT		1.7	25.0	15.4	9.3		70	15.1	5.1	7.3	
6/30/81		3.3	25.0	15.8	9.4		20	10.1	2.7	7.3	
0920 HRS		6.6	25.0	15.8	8.9		2.5	4.0	0.0	4.1	4.9
		9.9	25.0	15.8	7.9			2.7	-2.4	5.2	5.6
							AIR=1000				
JACKS	E	0	25.5	14.3	7.0	3.3	750	5.5	1.6	3.9	3.04
BAY		1.7	24.8	14.3	6.9		87	4.8	1.2	3.6	
6/30/81		3.3	24.8	14.3	6.9		75	5.4	3.0	5.0	
0730 HRS		6.6	24.8	14.7	6.9		1	0.9	2.5	5.3	3.36
		9.9	24.8	14.2	7.1						
		13.2	24.6	14.7	5.5						
		16.5	24.6	14.9	4.5			0.0	1.8	1.2	0.86
		19.8	24.4	14.8	4.7						
							AIR=1790				
SELBY	F	0	26.0	0.1	5.8	1.2	1200	69.3	61.6	7.7	4.83
LANDING		1.7	26.0	0.1	5.6		210	18.4	9.5	9.0	
6/26/81		3.3	26.0	0.1	5.6		23	9.5	3.7	5.9	
0745 HRS		6.6	25.9	0.1	5.5		0.8	6.2	2.4	6.4	5.5
		9.9	25.9	0.1	5.5		0				
		13.2	25.9	0.1	5.4			2.7	-3.7	6.37	5.34

Table 11-10 (continued) Photosynthetic And Related Measurements In The Patuxent River

STATION	TIDE STATE	DEPTH (ft.)	TEMP (°C)	SAL (0/000)	D.O. (mg/l)	SECCHI (ft.)	LIGHT PENETRATION ($uE/m^2/sec$)	GROSS PHOTOSYNTHESIS (mg-at $O_2/m^3/hr$)	NET PHOTOSYNTHESIS (mg-at $O_2/m^3/hr$)	RESPIRATION (mg-at $O_2/m^3/hr$)	BOD (mg/l)
							AIR=430				
SOTTERLY	F	0	26.0	18.3	8.5	2.3	240	36.8	32.1	4.8	5.38
		1.7	26.0	16.5	8.3		51	19.9	16.1	3.8	
		3.3	26.0	18.5	8.3		19.5	10.7	6.2	4.4	
		6.6	26.0	18.5	8.0		2.1	7.0	2.0	5.0	2.14
		9.9	26.0	18.3	8.1		0.1	3.0	4.3	7.2	3.46
							AIR=660				
JACKS BAY 7/24/81 1045 HRS	E	0	26.0	16.0	8.5	2.3	435	74.7	61.1	13.6	6.24
		1.7	26.0	16.0	8.4		180	28.7	23.5	7.0	
		3.3	26.0	16.0	8.5		57.0	17.7	9.5	8.1	
		6.6									
		9.9	26.0	16.0	8.6		3.5	4.5	1.2	3.3	3.97
		13.2						5.4			
		16.5	26.0	14.0	6.9		0.1		7.7	6.8	3.46
							AIR=240				
SELBY LANDING	F	0	26.0	0.1	8.3	1.0	230	123.3	100.7	21.6	
		1.7	25.0	0.1	8.0		150	12.3	168.7	11.7	
		3.3	24.5	0.1	7.6		18.0	13.7	4.6	18.1	
		6.6	24.5	0.1	6.9		0.6	16.0	2.5	17.8	9.28
		9.9		0.1							
		13.2	24.0	0.1	6.1			9.6	6.0	15.6	9.18[a]

[a] Sample set of 1

Table 11-10 (continued) Photosynthetic And Related Measurements In The Patuxent River

STATION	TIDE STAGE	DEPTH (ft.)	TEMP (°C)	SAL (0/00)	S.O. (mg/l)	SECCHI (ft.)	LIGHT PENETRATION (uE/m²/sec)	GROSS PHOTOSYNTHESIS (mg-at $O_2/m^3/hr$)	NET PHOTOSYNTHESIS (mg-at $O_2/m^3/hr$)	RESPIRATION (mg-at $O_2/m^3/hr$)	BOD (mg/l)
							AIR=1950				
SOTTERLY	E	0	25.0	17.3	7.8	1.7	520	49.6	42.9	6.7	6.11
POINT		1.7	25.0	17.2	7.3		200	27.3	13.1	14.1	4.7
8/19/81		3.3	25.0	17.4	7.0		180	8.0	6.0	1.9	
1251 HRS		6.6	24.6	17.3	6.9		18	2.8	1.7	3.3	
		9.9						2.7	-2.4	5.2	
		13.2									
		16.5	24.6	17.2	6.9		0.1	2.5	2.6	4.0	2.66
							AIR=1800				
JACKS	H	0	28.0	17.0	6.0	1.0	1500	47.7	50.9	9.9	6.56
BAY		1.7	26.0	16.0	6.2		580	24.2	14.2	11.6	
8/7/81		3.3	25.0	15.0	5.7		150	24.7	19.6	10.5	6.3
1345 HRS		6.6	25.0	15.0	4.3		20	12.5	4.6	7.9	
		9.9	25.0	15.0	3.7		1.5				
		13.2									
		16.5	25.0	15.0	3.7			8.7	3.3	5.8	2.21
							AIR=5700				
SELBY	H	0	27.0	1.0	8.0	0.7	3000	142.9	134.5	131.5	3.78
landing		1.7	27.0	1.0	7.9		170	45.5	33.7	11.7	
8/5/81		3.3	27.0	1.2	7.9		14	17.1	6.6	10.5	
1145 HRS		6.6	27.0	1.3	7.8		4.8	24.0	6.6	17.3	5.76
		9.9									
		13.2	27.0	1.2	7.6		0.1	10.1	5.6	4.5	3.58

Table 11-11 Summary Of Lower Patuxent Estuary Plankton Productivity (P_A) And Night Time Respiration (R_N) During The October 1980 - August 1981.*

Station	Date	P_A, $gO_2\ m^{-2}\ d^{-1}$			$\bar{X}$ + S.D.	R_N, $gO_2\ m^{-2}\ d^{-1}$			$\bar{X}$ + S.D.
Marsh Point	10/80	2.06	1.80	1.87	1.91 ± .13	-	-	-	-
	4/81	11.48	11.80	11.56	11.61 ± .17	10.63	10.34	11.50	10.82 ± .60
	8/81	5.05	6.50	7.00	6.75 ± .35	5.85	5.98	5.72	5.85 ± .13
Broomes Island	10/80	4.30	4.24	4.56	4.37 ± .17	-	-	-	-
	4/81	8.48	8.48	8.28	8.41 ± .12	8.58	8.58	8.58	8.58 ± 0
	8/81	7.15	5.25	5.03	5.81 ± 1.17	5.16	5.16	5.58	5.30 ± .24
St. Leonard Creek	10/80	6.48	6.25	6.60	6.44 ± .18	-	-	-	-
	4/81	6.26	6.30	6.82	6.46 ± .31	7.00	5.25	5.25	5.83 ± 1.01
	8/81	8.75	8.25	7.85	8.28 ± .45	5.67	5.88	7.56	6.37 ± 1.04

* Data collected by D'Elia, et. al., 1981 for this study.

Table 11-12 Comparison Of Phytoplankton Demand And Benthic Remineralization Of Nitrogen And Phosphorus In The Lower Patuxent Estuary, 1980-81.*

Station	Date	g-at $m^{-2}d^{-1}$ Phytoplankton Demand N	Phytoplankton Demand P	Benthic Recycling N	Benthic Recycling P	Percent of Total Nutrient Demand Derived From Benthos N	Percent of Total Nutrient Demand Derived From Benthos P
Marsh Pt.	10/80	.0081	.0005	.0035	0	43.0	0
	4/81	.0495	.0031	.0015	0	3.1	0
	8/81	.0288	.0018	.0086	.0011	30.0	61.3
Broome Is.	10/80	.0186	.0012	.0005	0	2.4	0
	4/81	.0359	.0022	.0007	0	1.9	0
	8/81	.0248	.0015	.0075	.0007	30.3	49.6
St. Leonard Creek	10/81	.0225	.0017	.0032	0	11.7	0
	4/81	.0276	.0017	-.0006	0	--	0
	8/81	.0353	.0022	.0070	.0007	19.7	33.8

* Data collected by D'Elia, et. al., 1981 for this study.

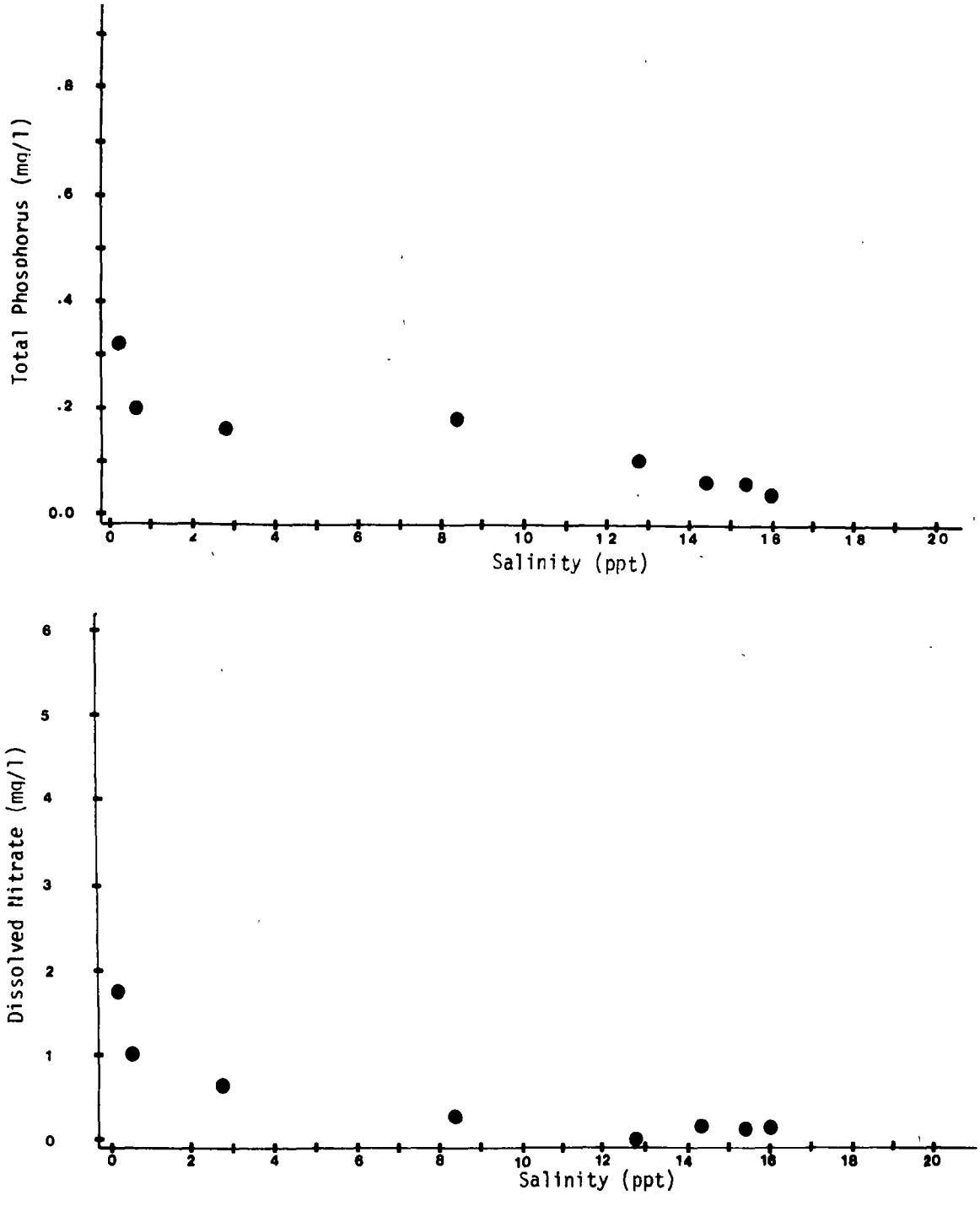


Figure 11-34 Average total phosphorus and dissolved nitrate versus average salinity plots for the Patuxent River 1980-1981.

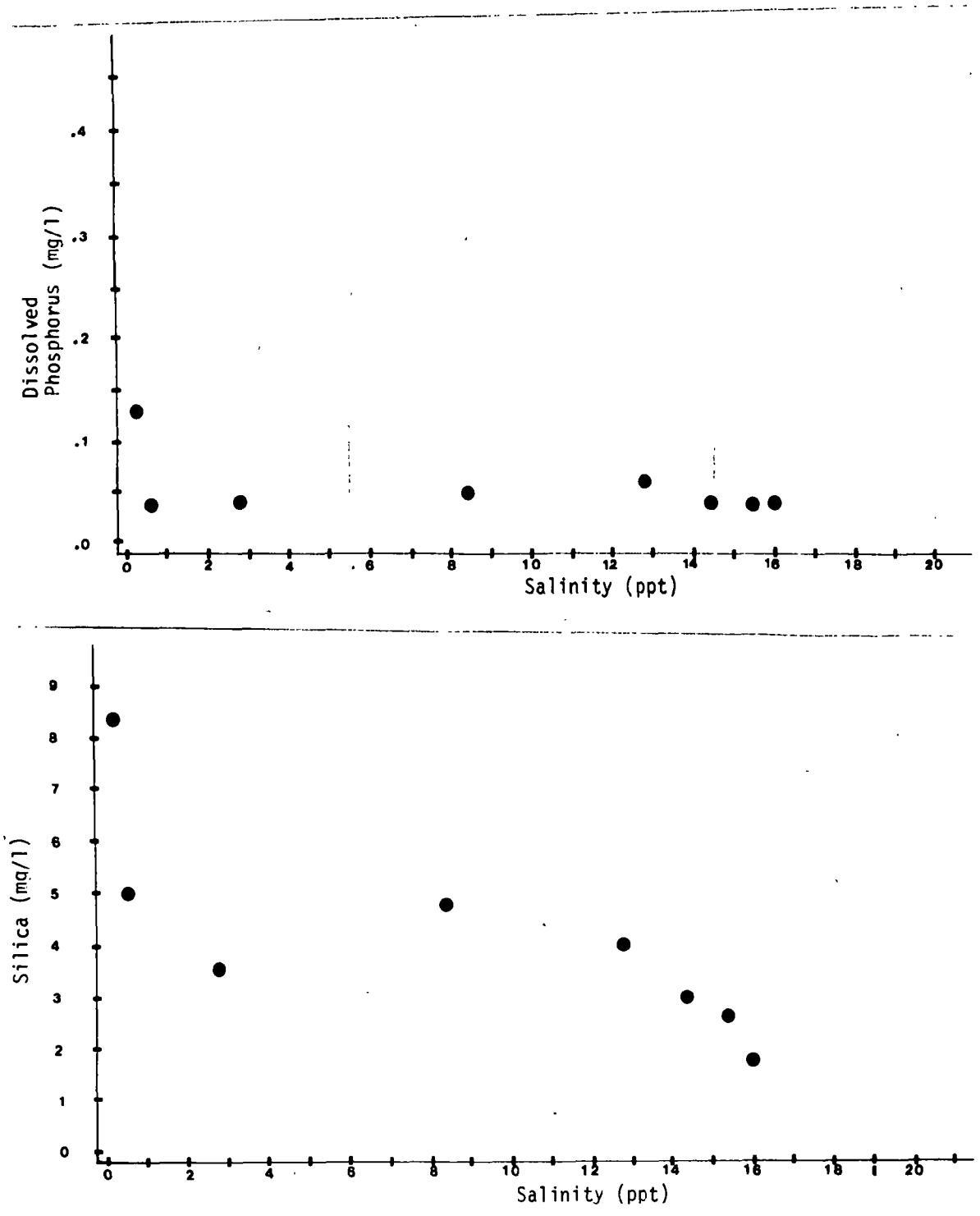
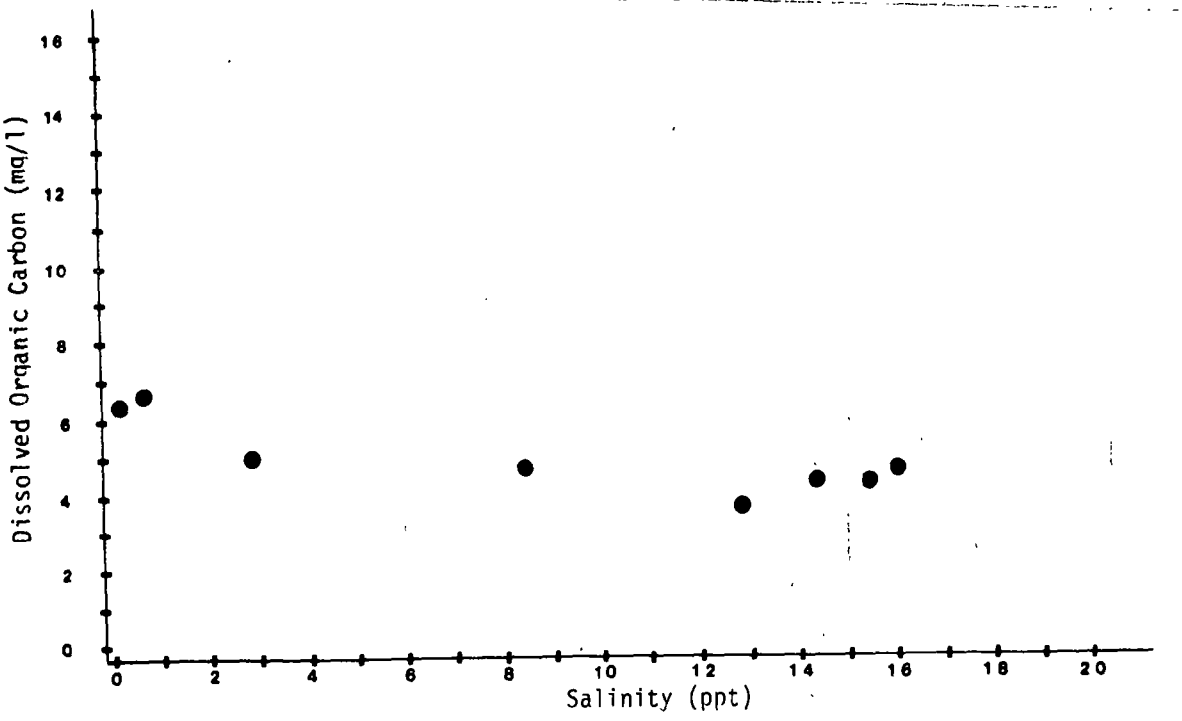


Figure 11-35 Relationship between mean dissolved phosphorus, mean silica and mean salinity at mainstem Patuxent Estuary stations, 1980-1981.



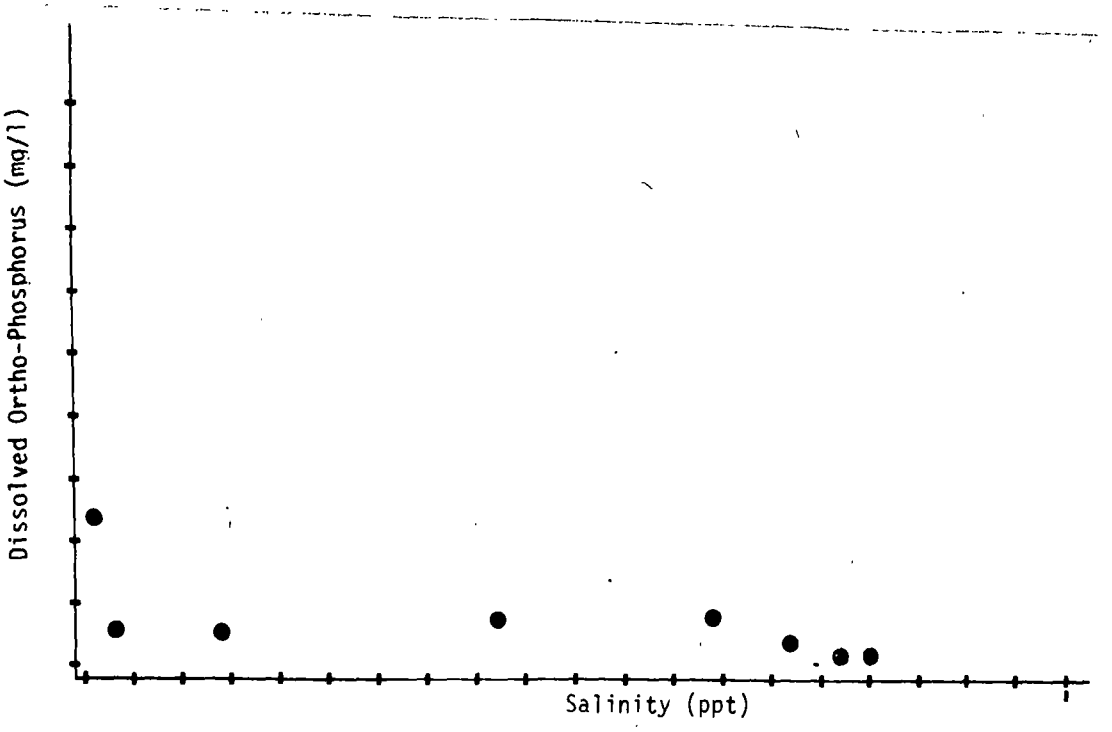
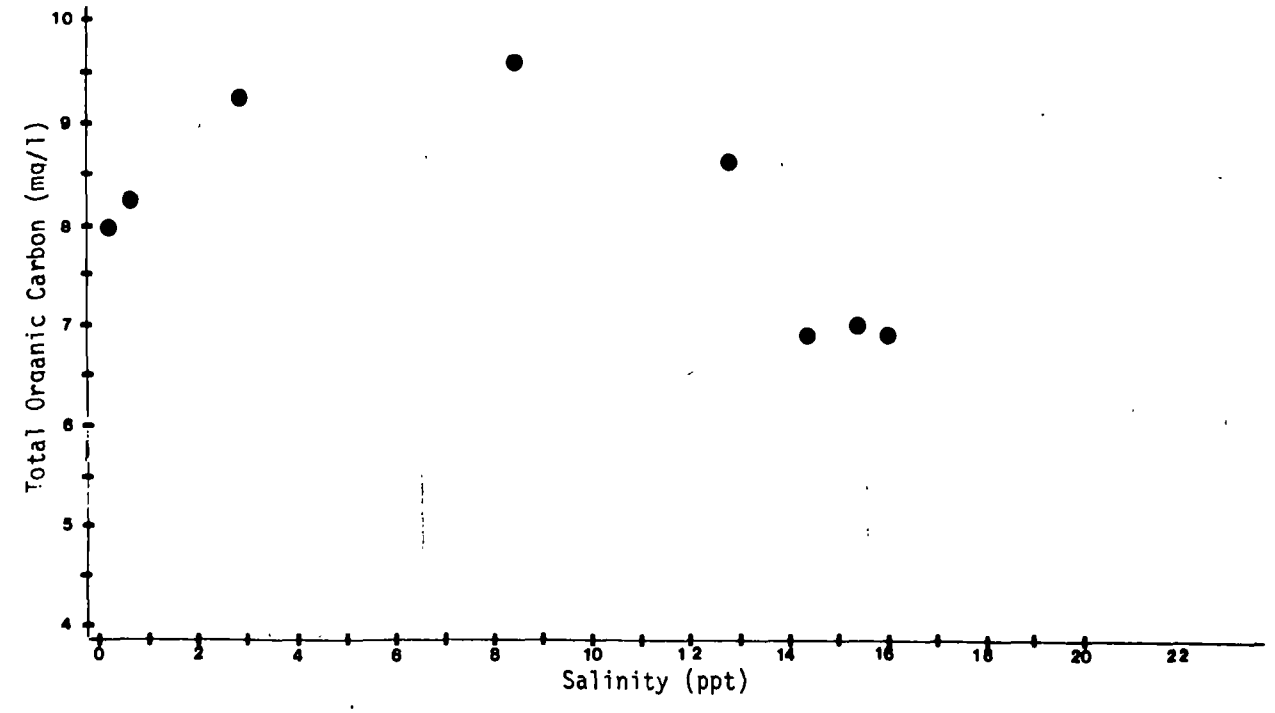


Figure 11-36 Relationship between mean dissolved organic carbon, mean dissolved ortho-phosphorus and mean salinity at mainstem Patuxent Estuary stations, 1980-1981.



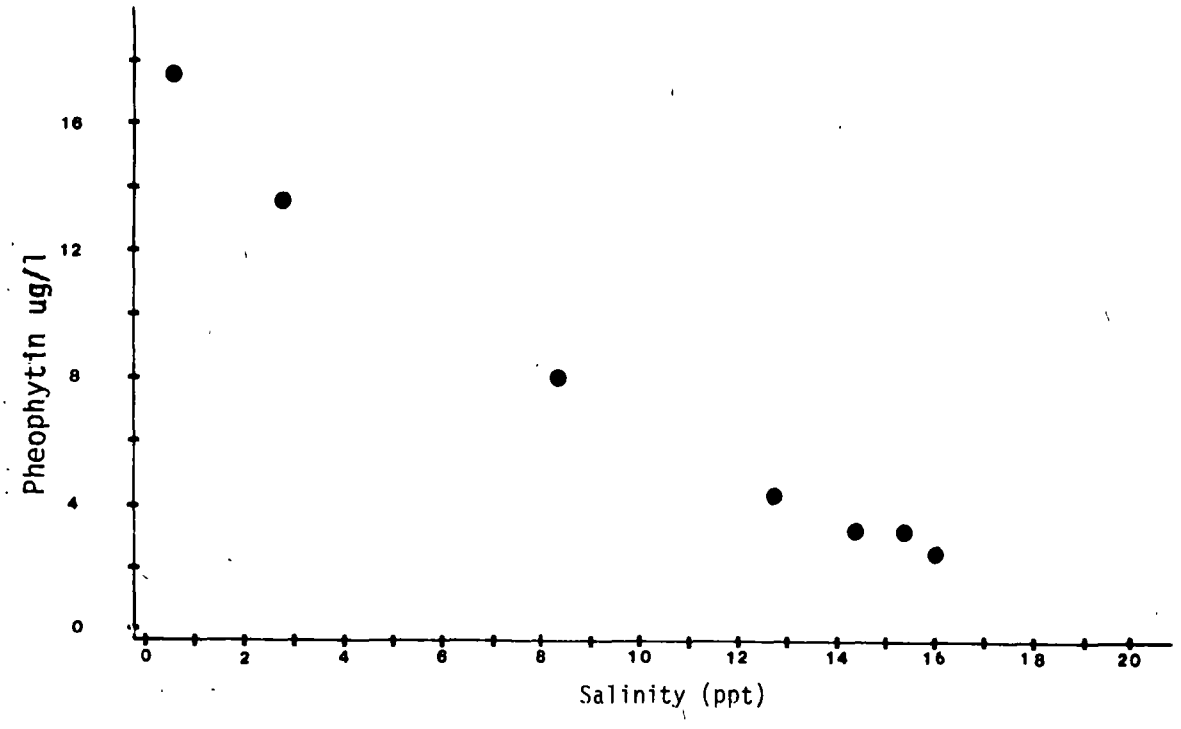
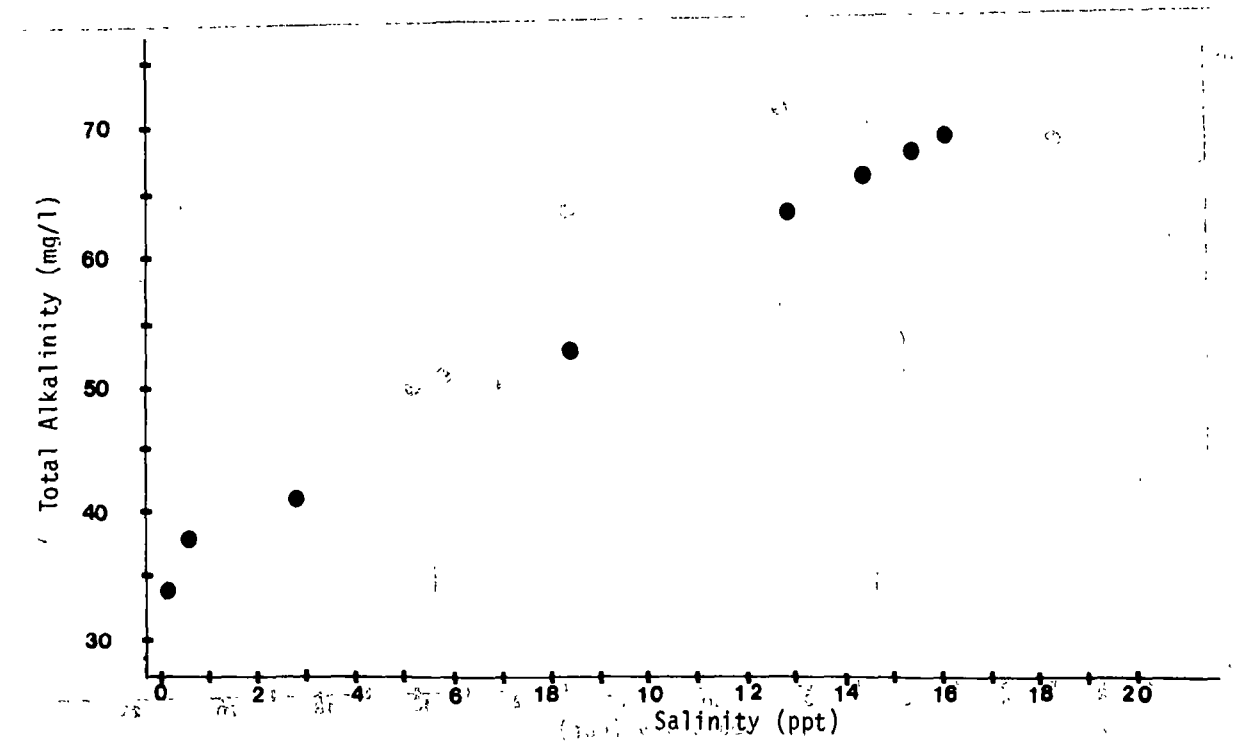


Figure 11-37 Relationship between mean total organic carbon, mean pheophytin-a, and mean salinity at mainstem Patuxent Estuary stations, 1980-1981.



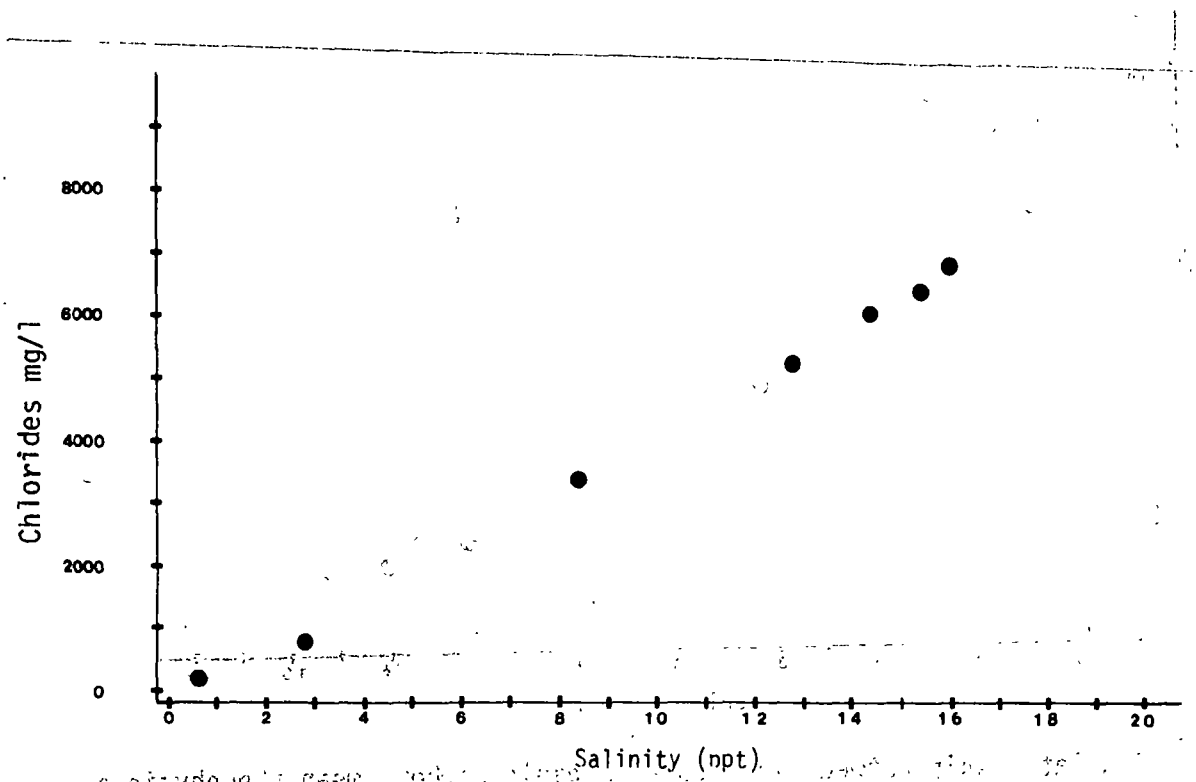
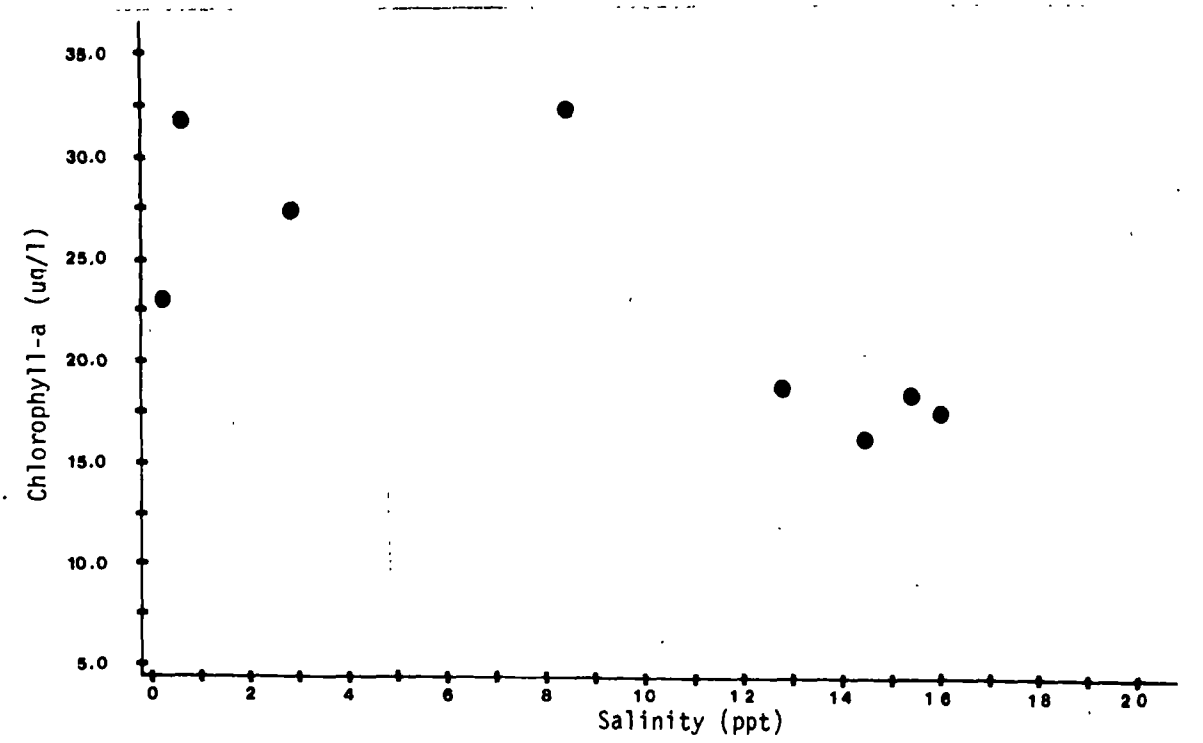


Figure 11-38 Relationship between mean total alkalinity, mean chlorides and mean salinity at mainstem Patuxent Estuary stations, 1980-1981.



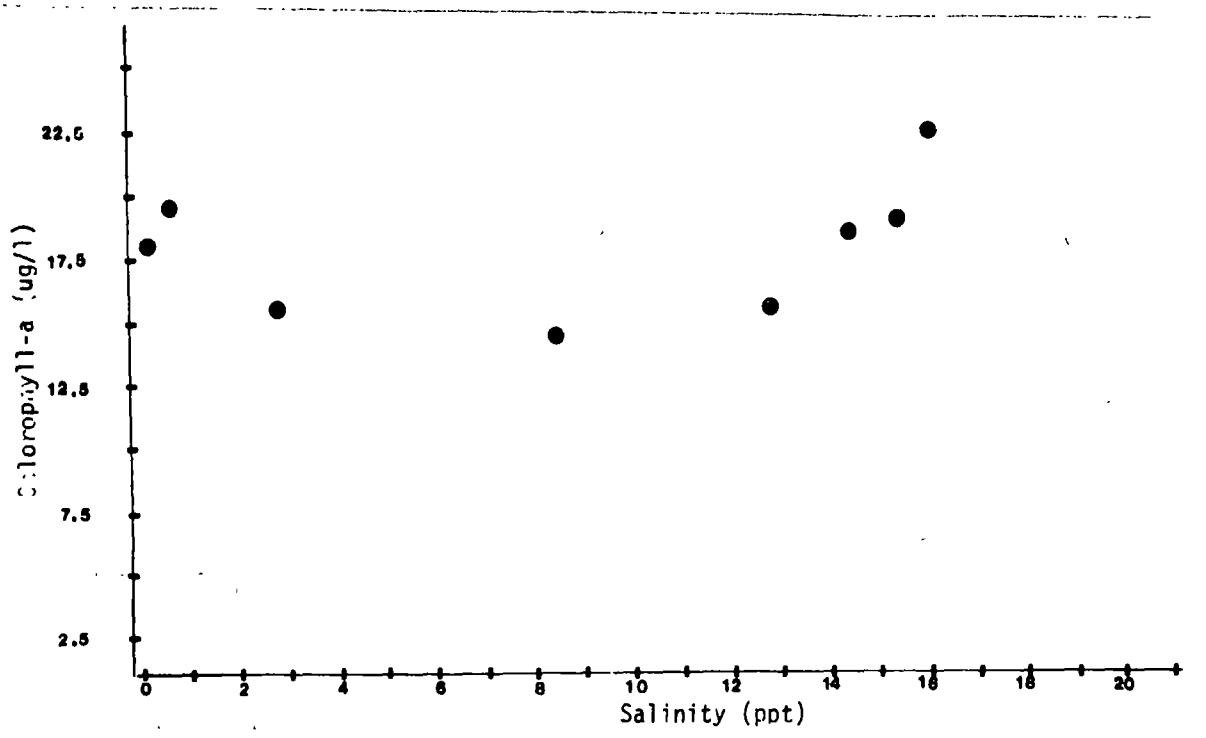
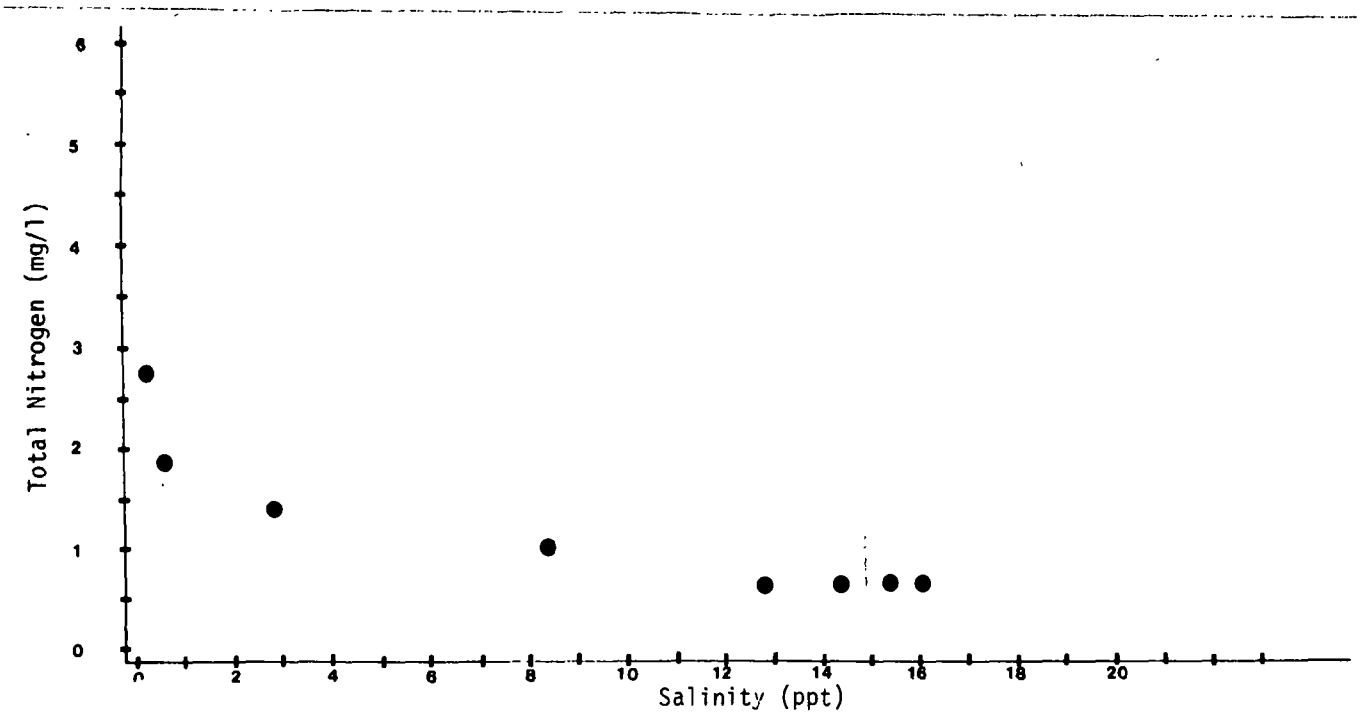


Figure 11-39 Relationship between mean chlorophyll-a and mean corrected chlorophyll-a versus mean salinity at mainstem Patuxent Estuary stations, 1980-1981.



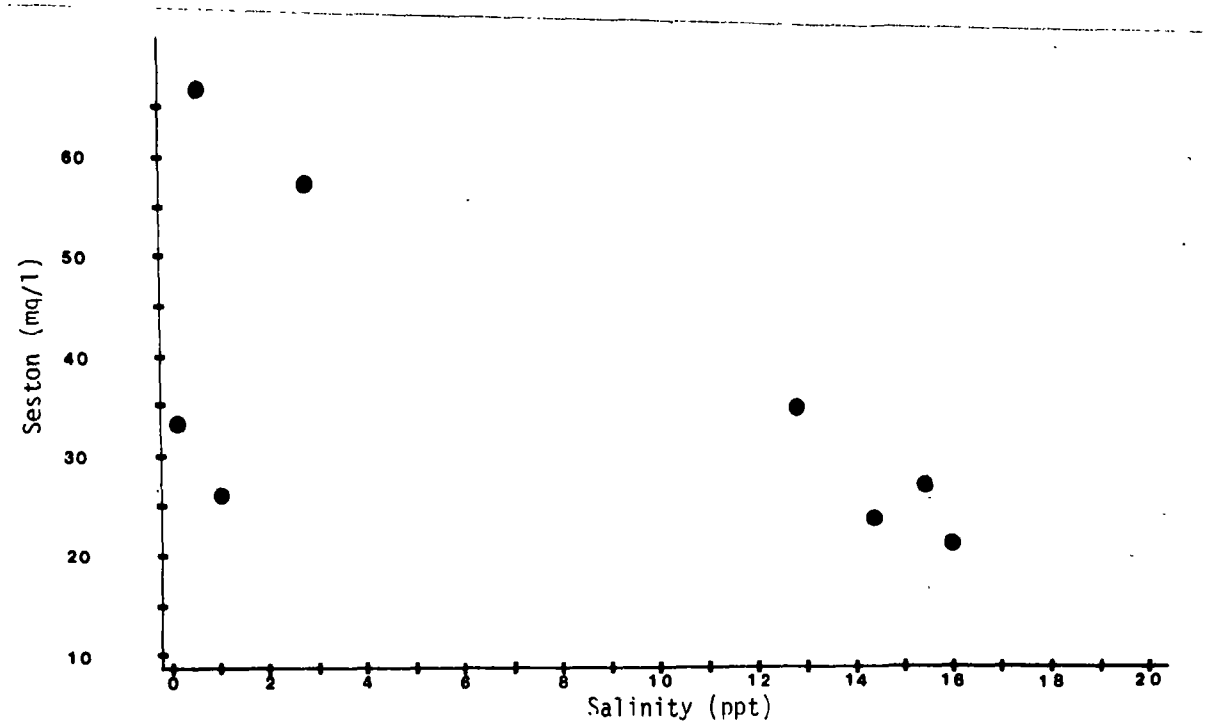
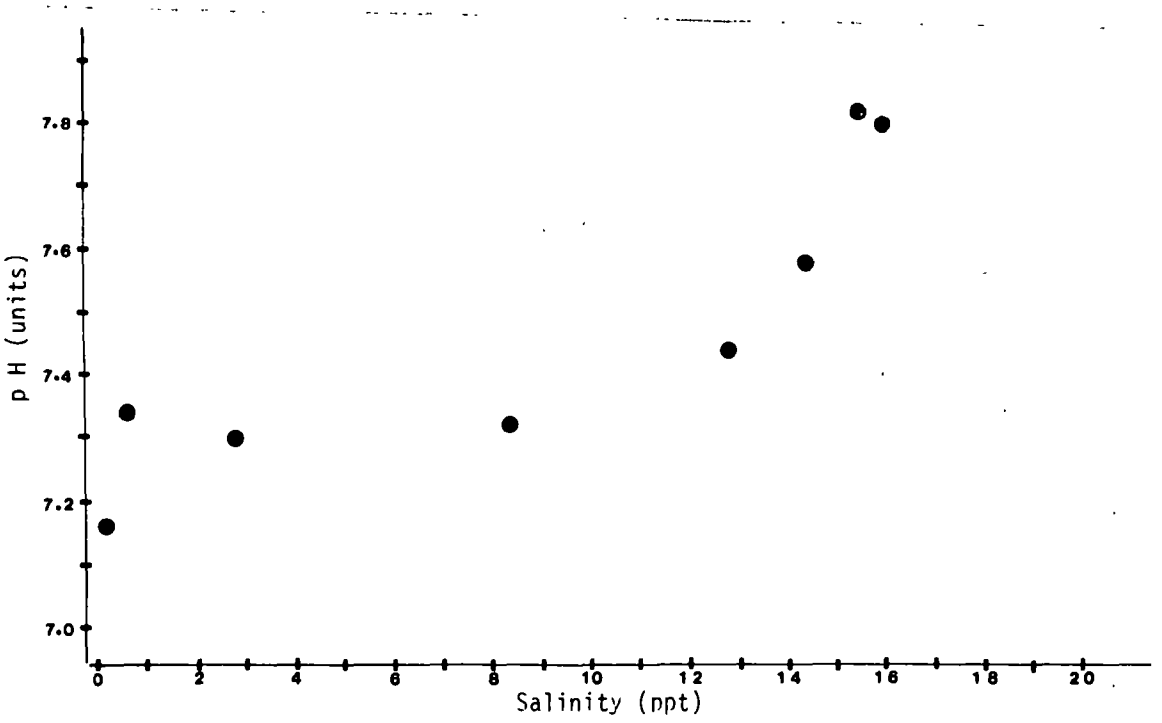


Figure 11-40 Relationship between mean total nitrogen, mean total unfilterable residue and mean salinity at mainstem Patuxent Estuary stations, 1980-1981.



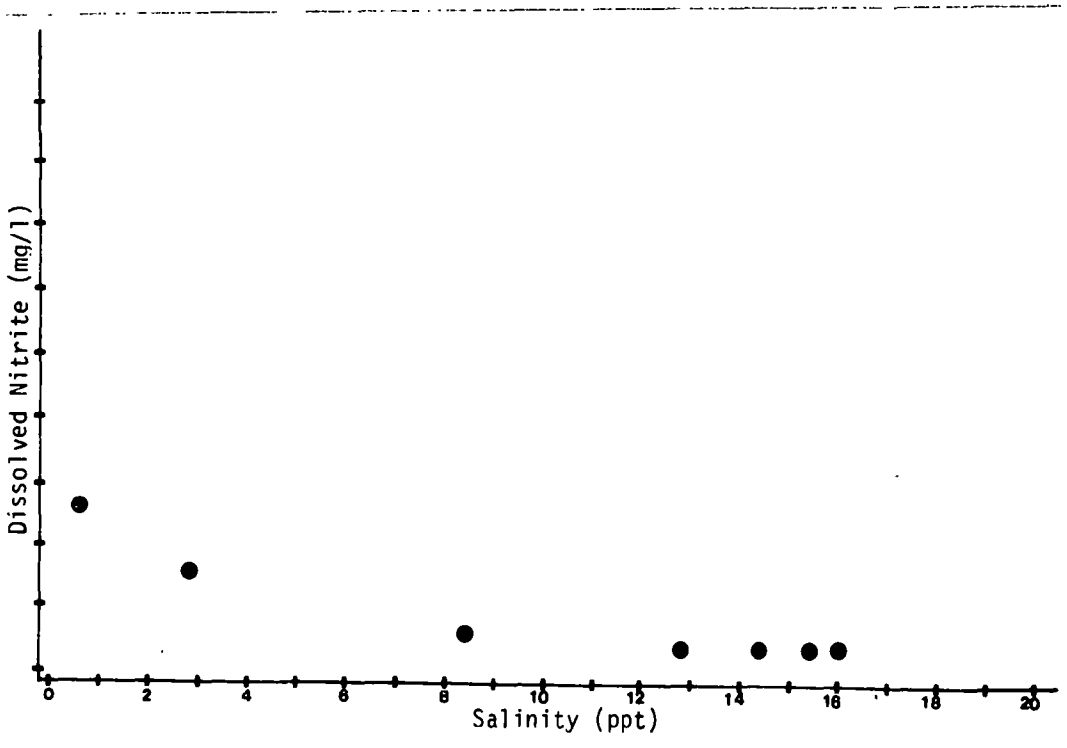


Figure 11-41 Relationship between mean pH, mean dissolved nitrite and mean salinity at mainstem Patuxent Estuary stations, 1980-1981.

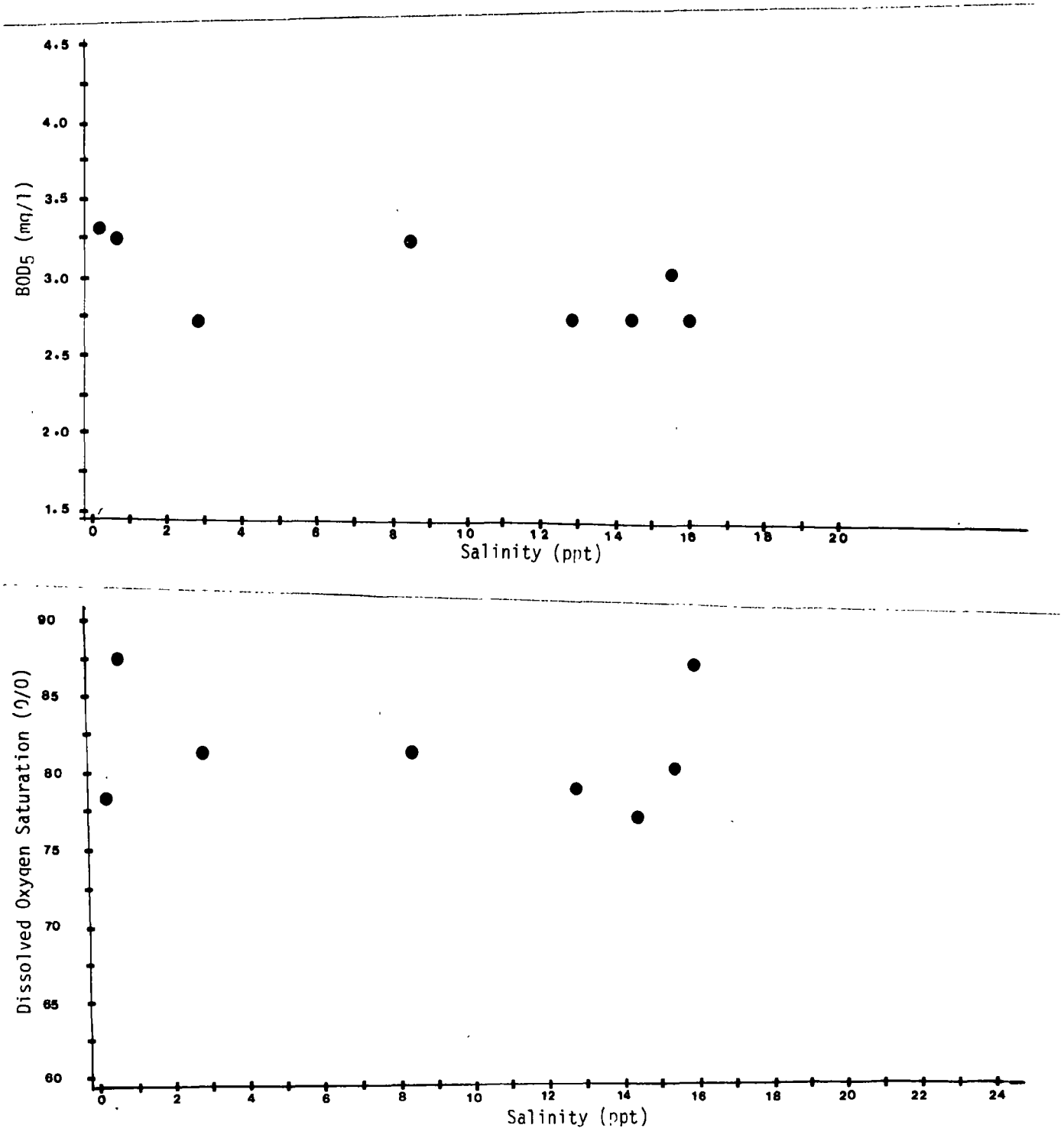
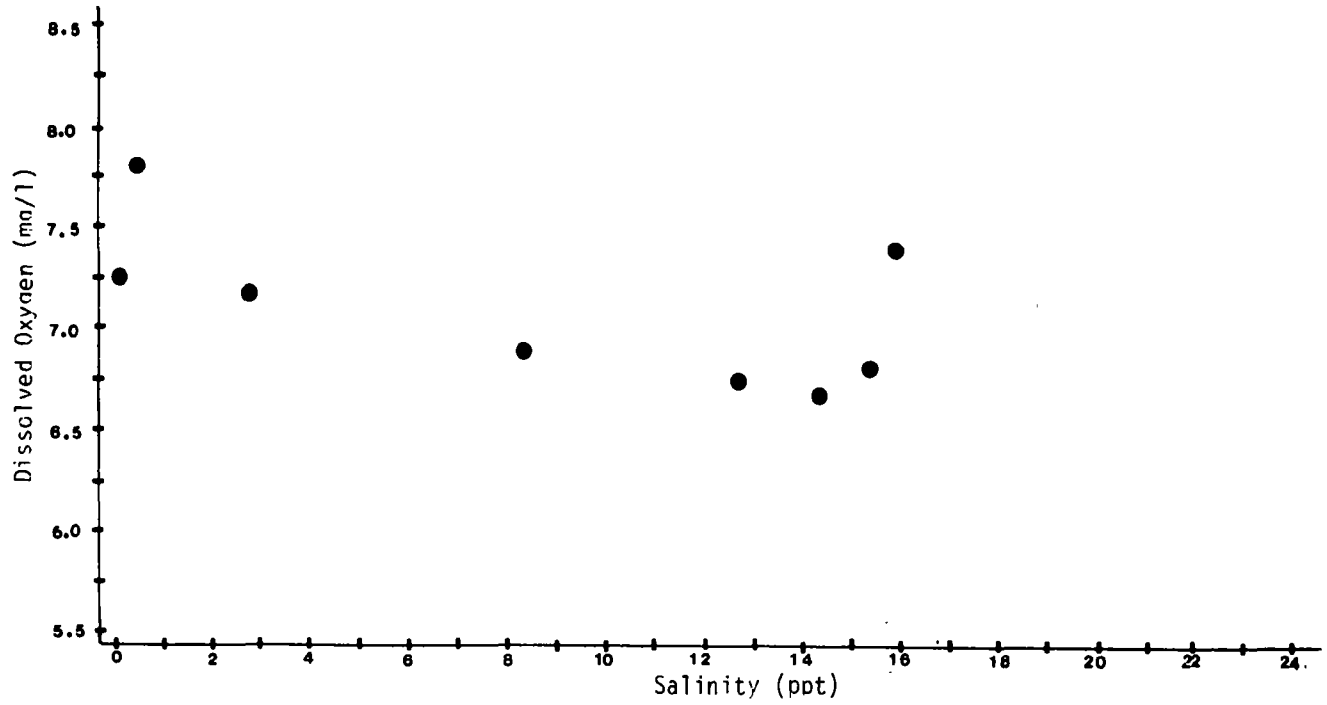


Figure 11-42 Relationship between mean BOD_5, mean dissolved oxygen saturation and mean salinity at mainstem Patuxent Estuary stations, 1980-1981.



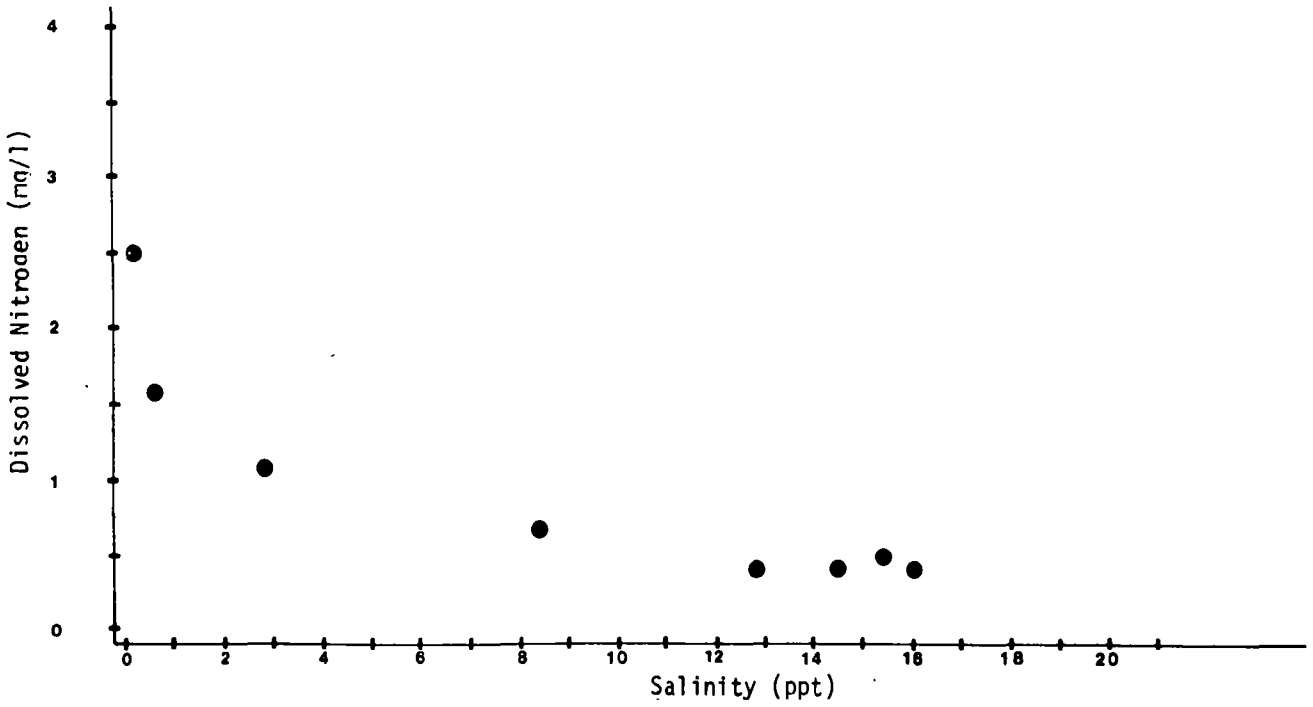


Figure 11-43 Relationship between mean dissolved nitrogen, mean dissolved oxygen and mean salinity at mainstem Patuxent Estuary stations, 1980-1981.

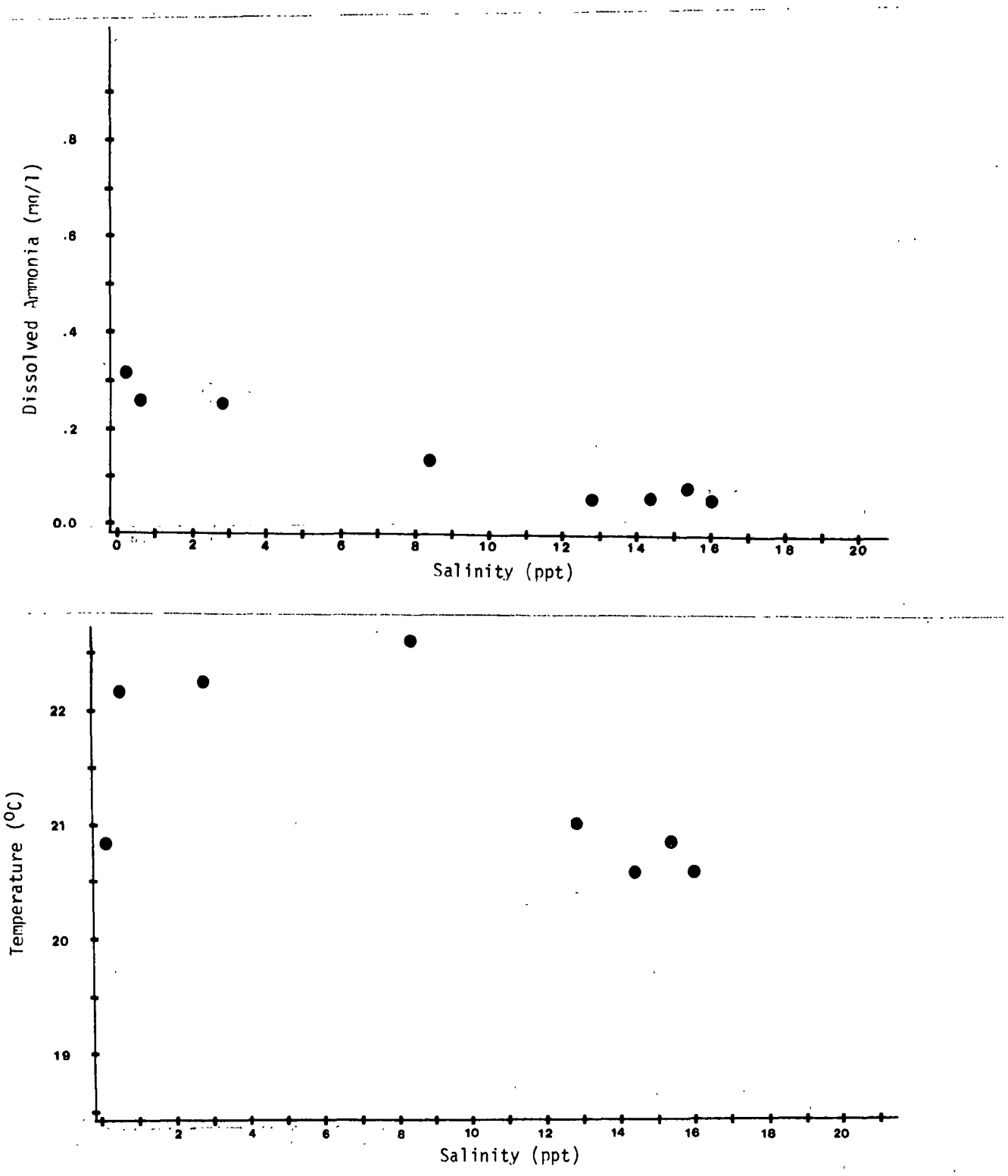
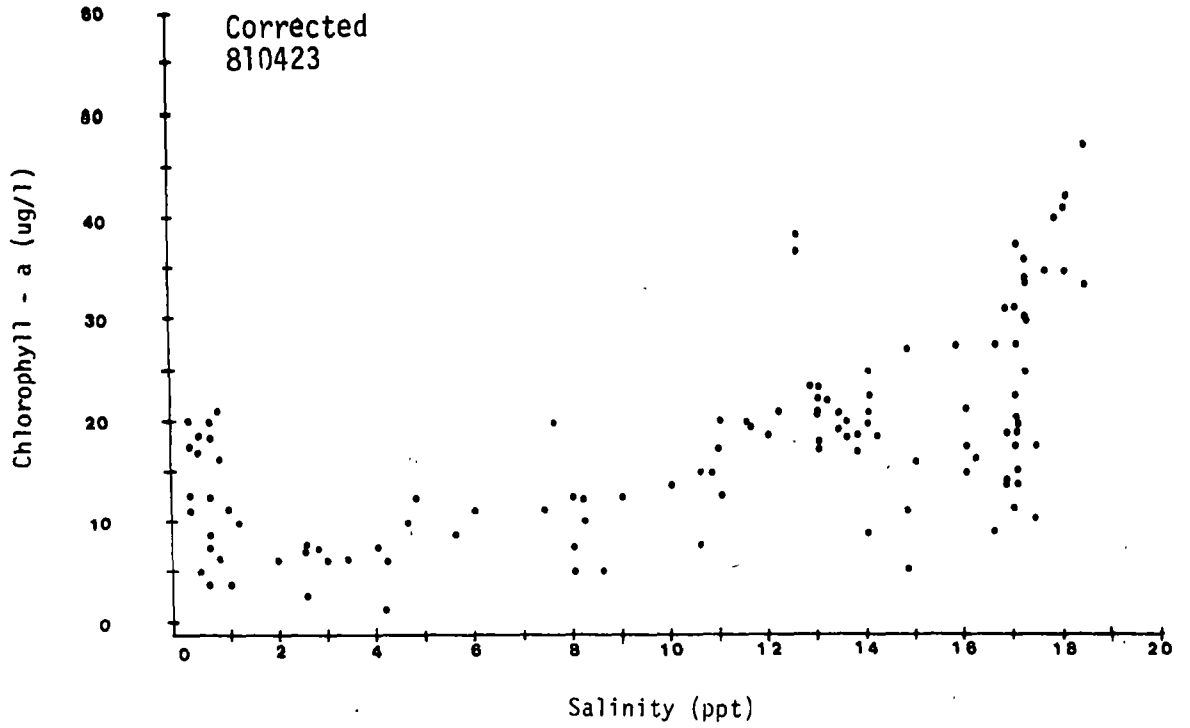


Figure 11-44 Relationship between mean dissolved ammonia, mean temperature and mean salinity at mainstem Patuxent Estuary stations, 1980-1981.



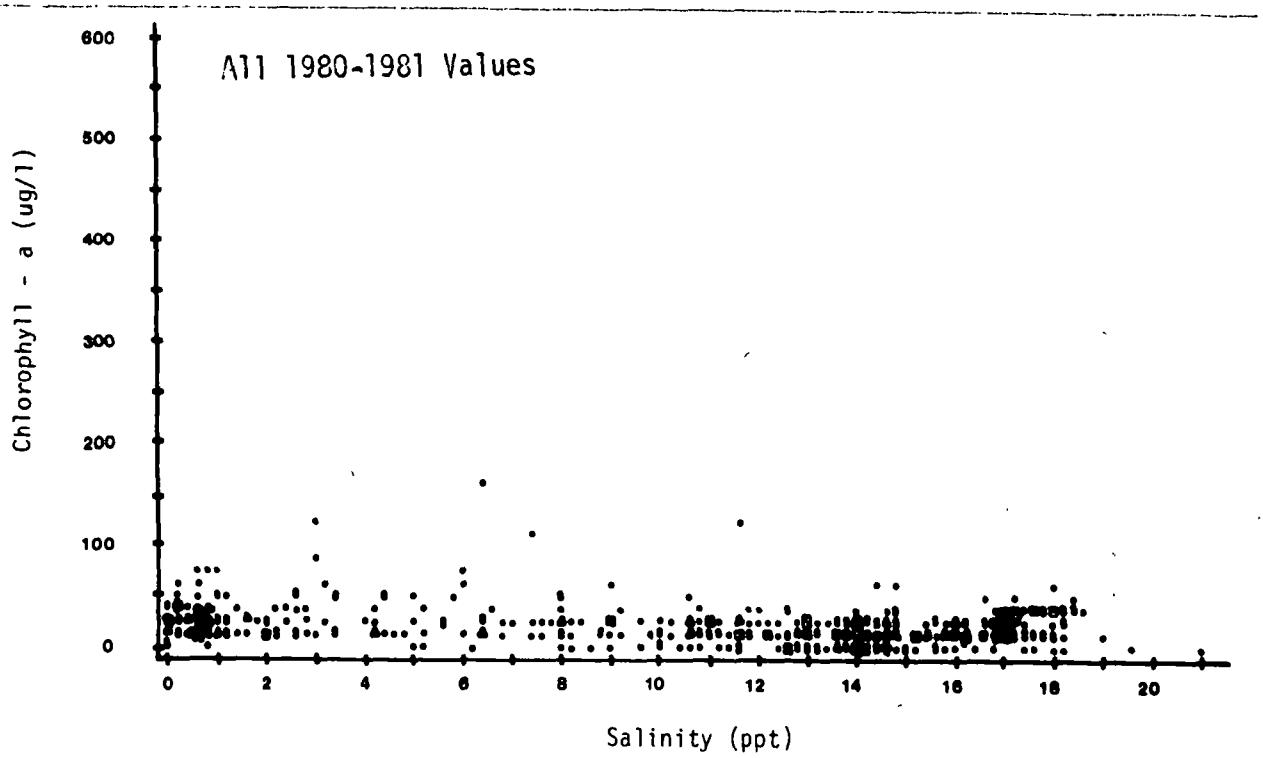
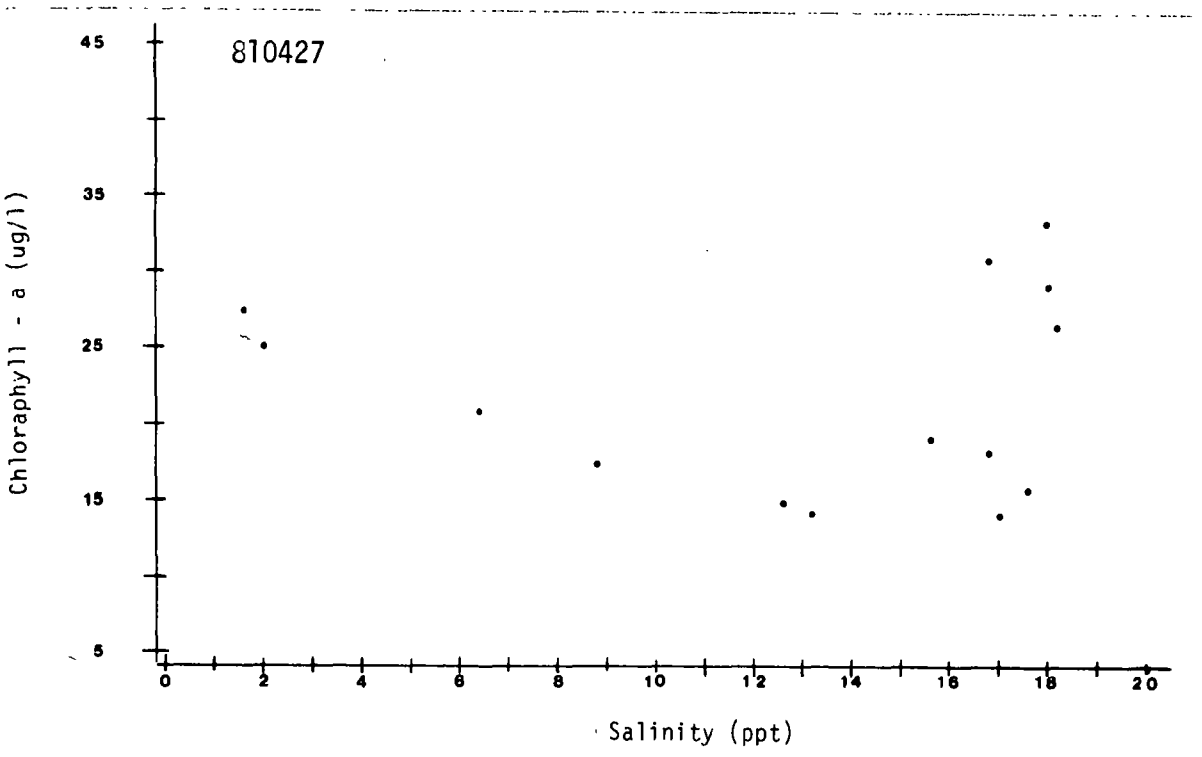


Figure 11-45 Relationship between corrected chlorophyll-a and salinity in the Patuxent Estuary for intensive survey data taken April 23, 1981, and chlorophyll-a and salinity for all 1980-1981 slack and intensive survey data. (surface and bottom concentrations)



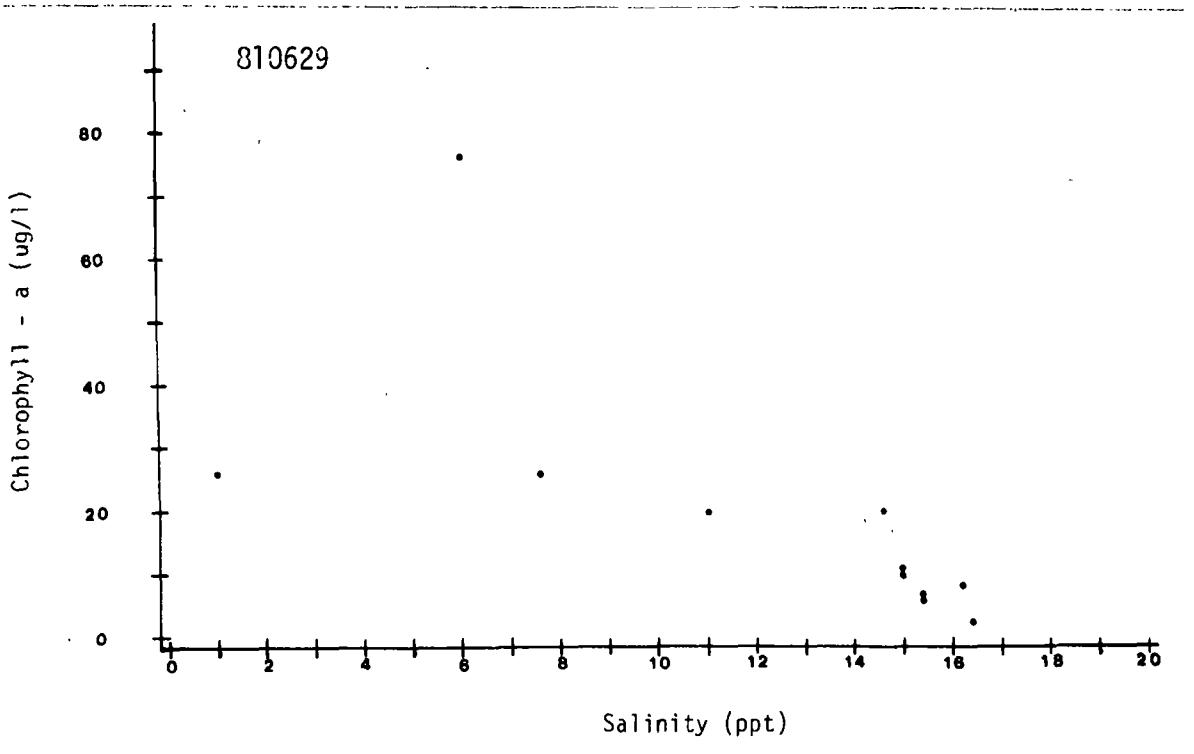
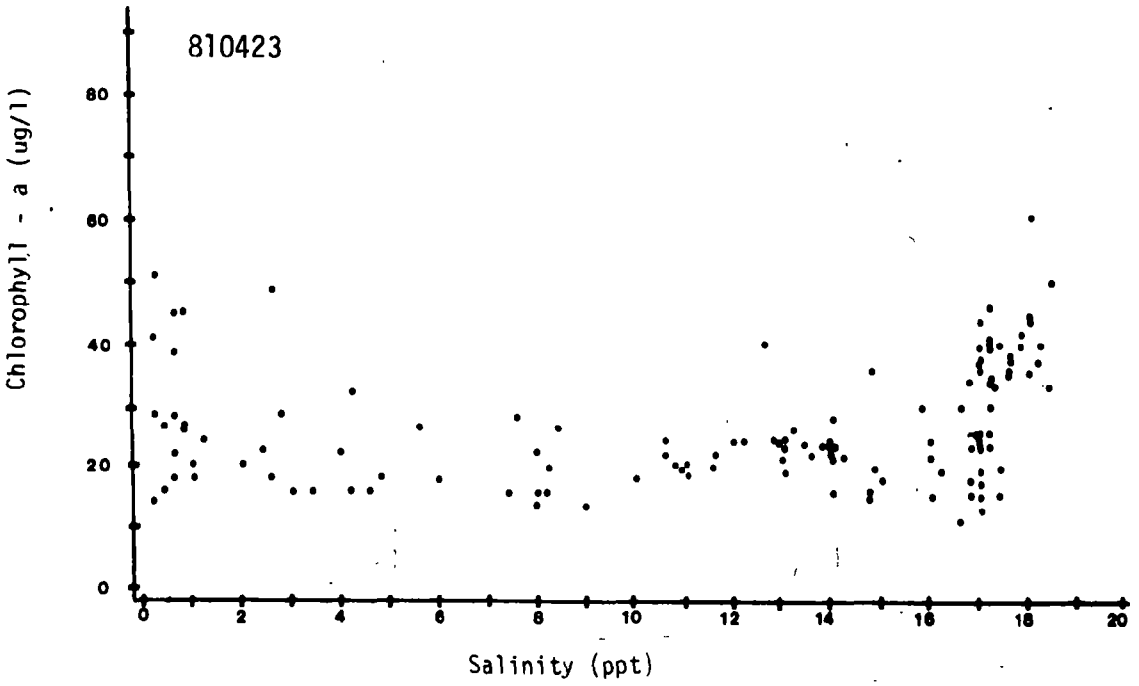


Figure 11-46 Relationship between chlorophyll-a and salinity in the Patuxent Estuary for slack tide survey data taken April 27, 1981 and June 29, 1981. (surface and bottom concentrations)



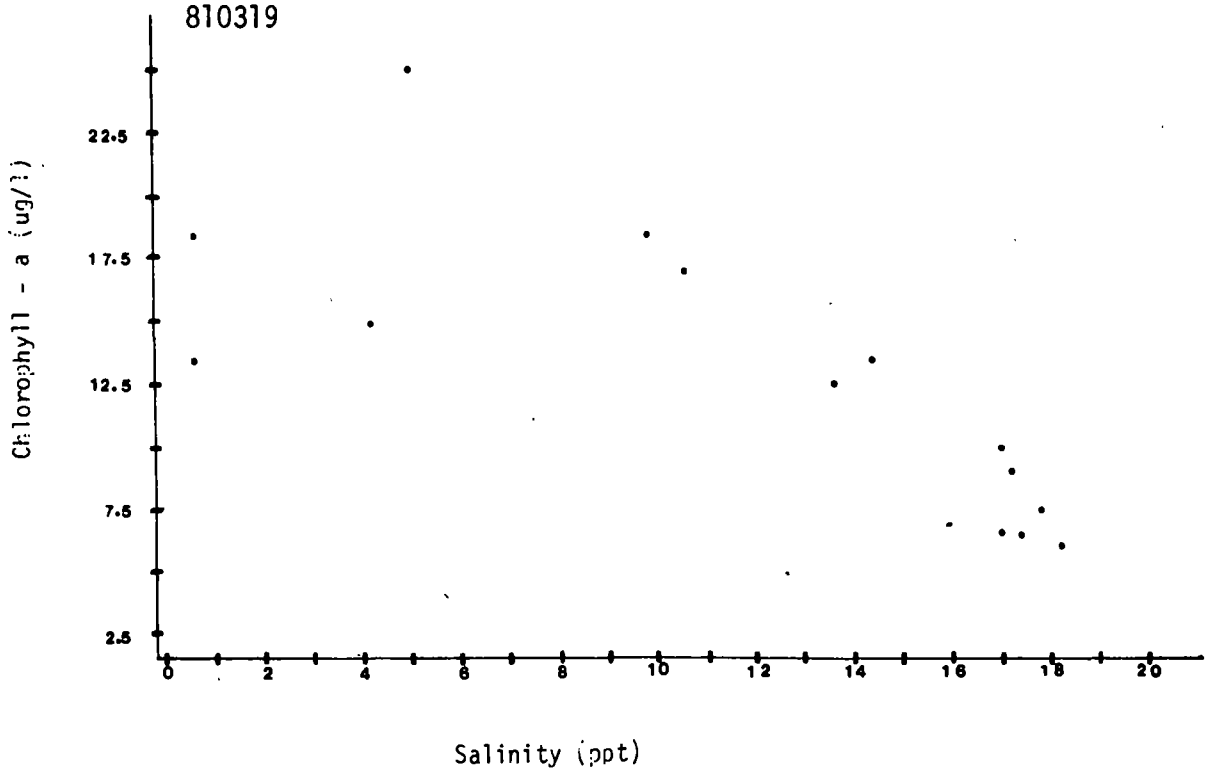
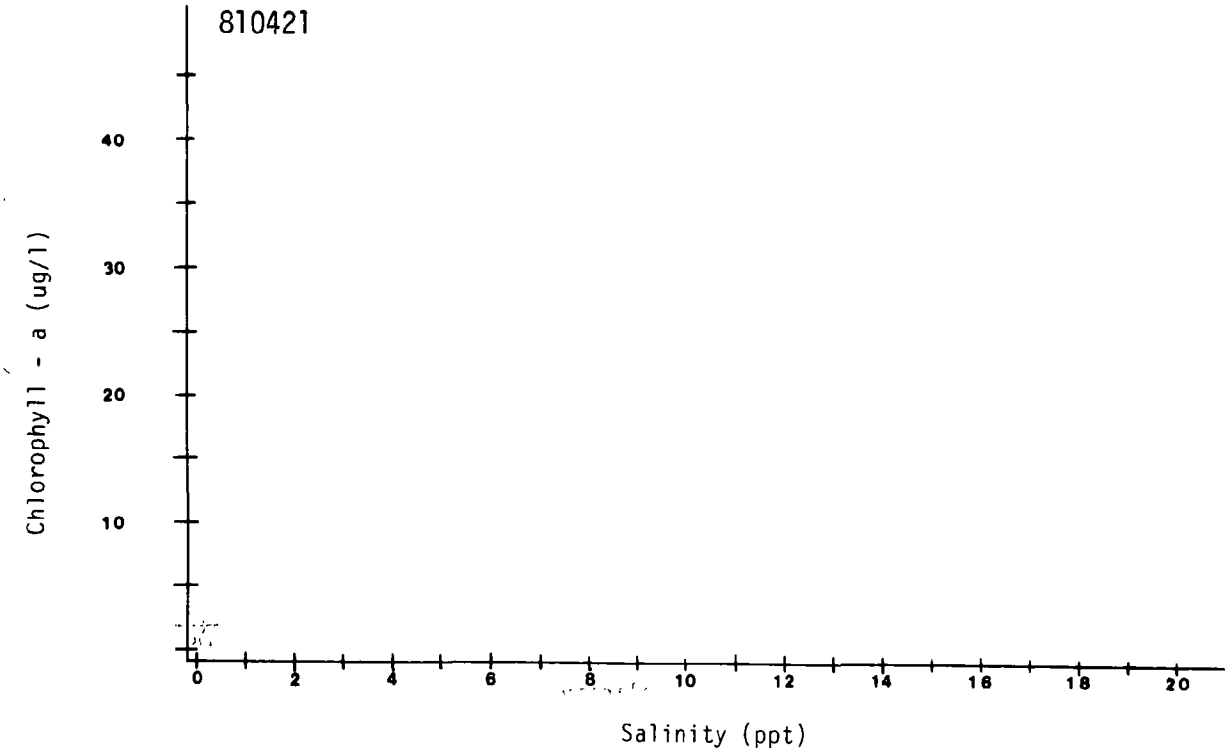


Figure 11-47 Relationship between Chlorophyll-a and salinity in the Patuxent Estuary for intensive survey data on April 23, 1981 and for slack tide survey data on March 19, 1981. (surface and bottom concentrations)



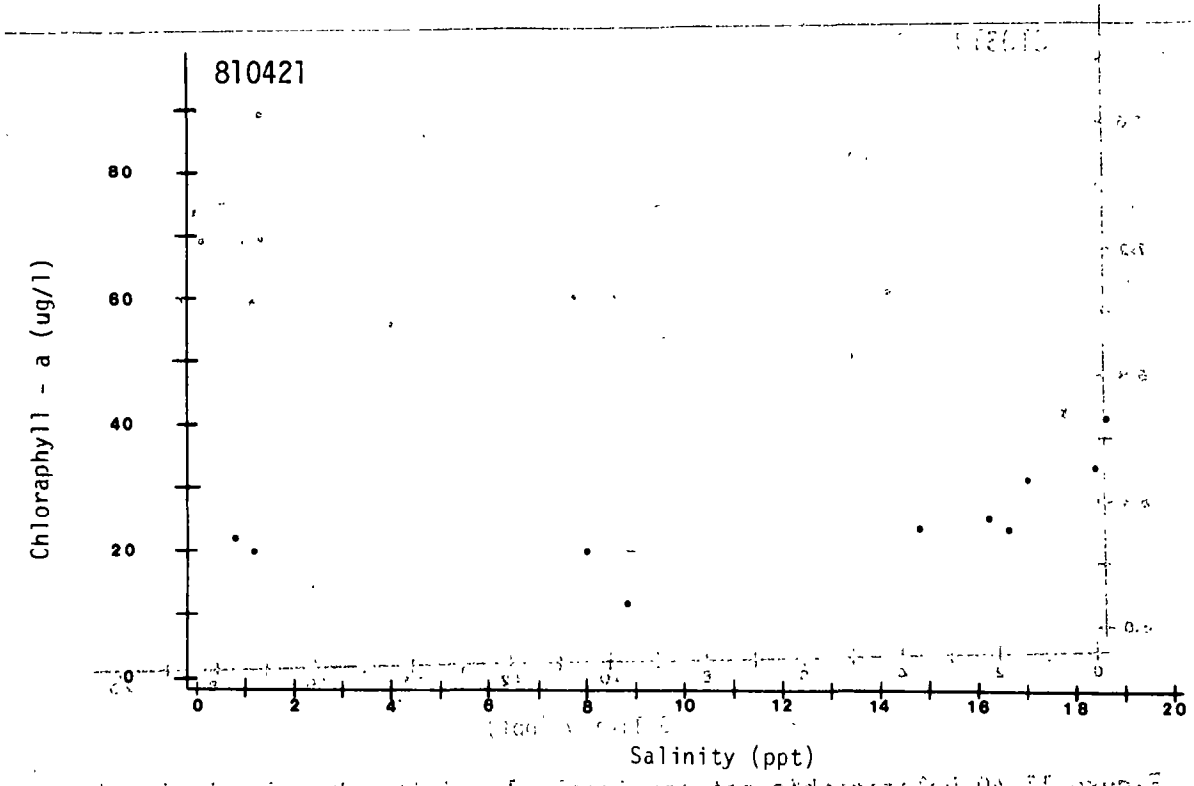
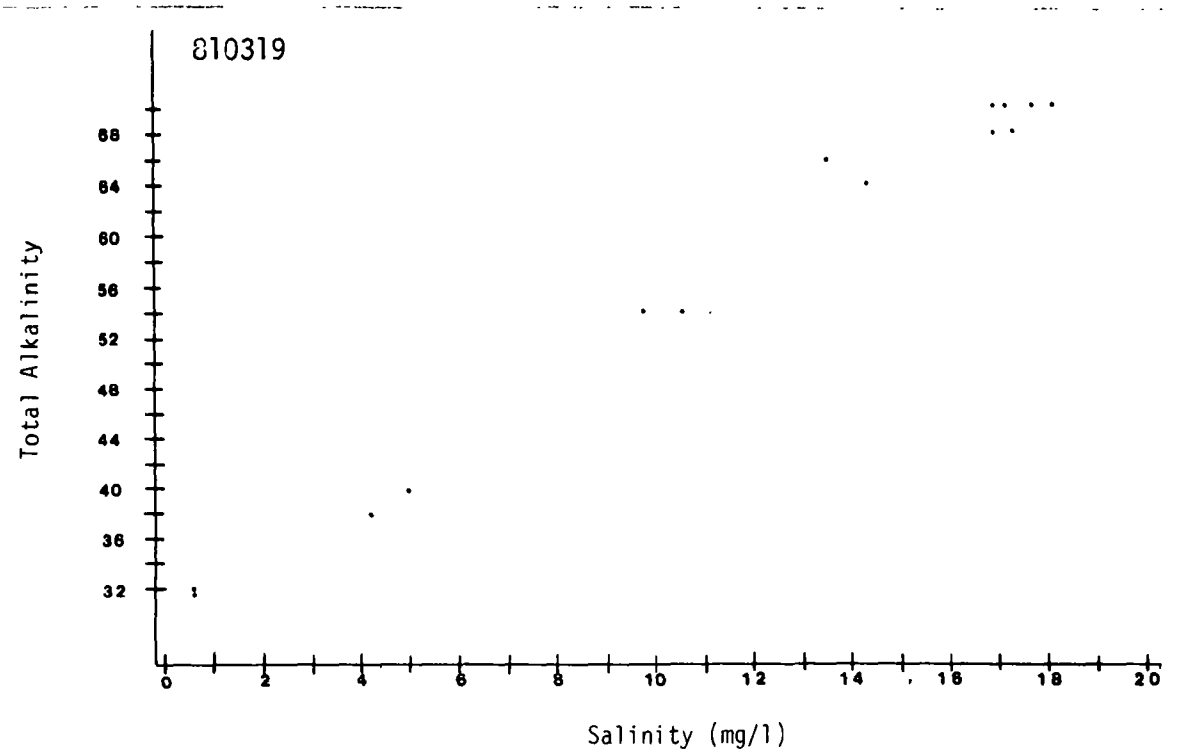


Figure 11-48 Relationship between corrected chlorophyll-a, chlorophyll-a, and salinity in the Patuxent Estuary for slack tide survey data taken April 21, 1981. (surface and bottom concentrations)



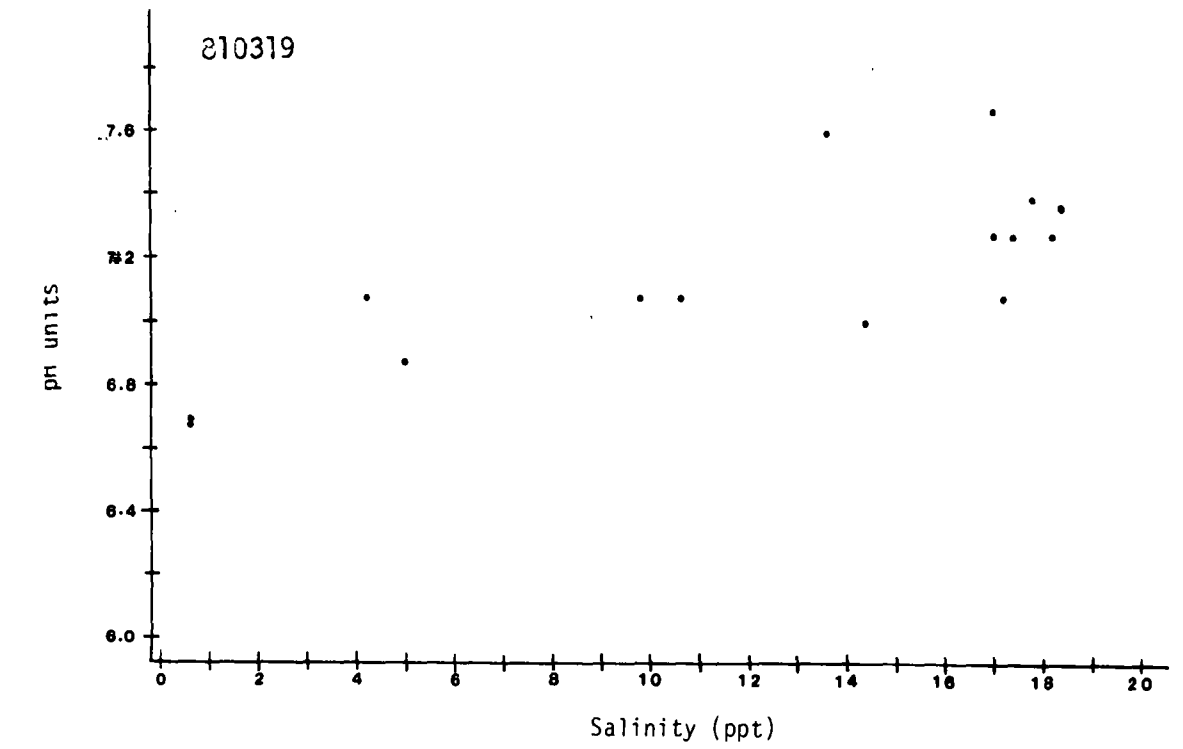
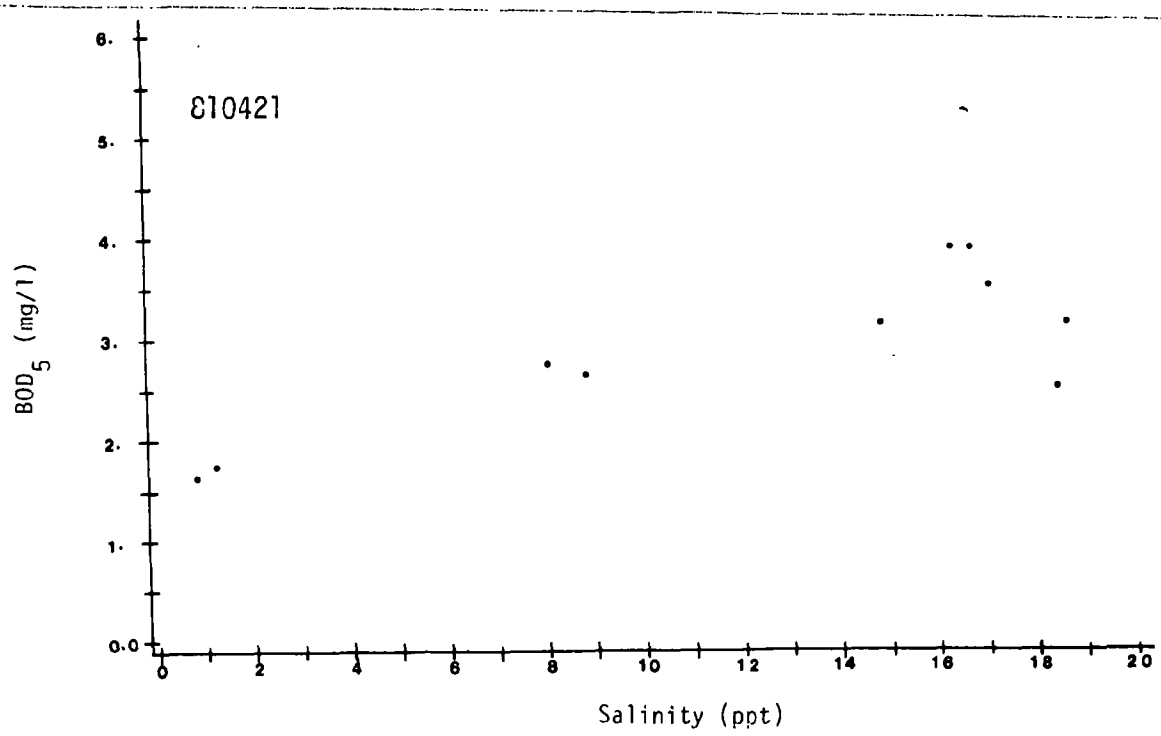


Figure 11-49 Relationship between total alkalinity, pH and salinity in the Patuxent Estuary for slack tide survey data on March 19, 1981. (surface and bottom concentrations)



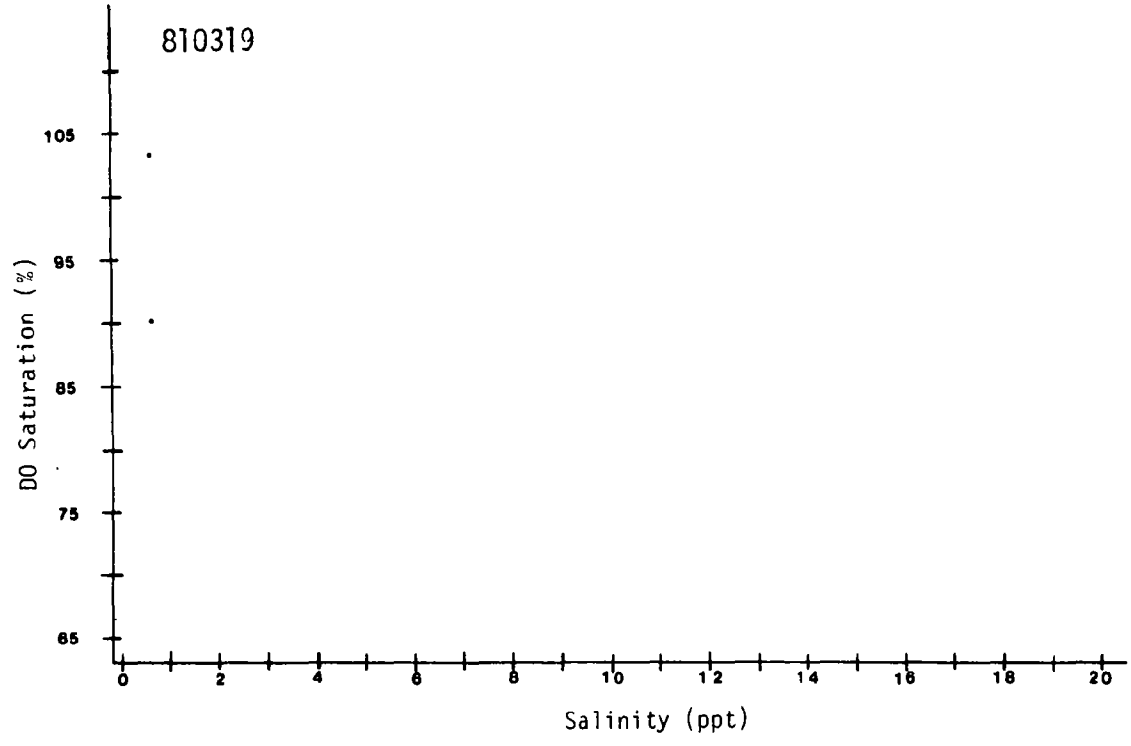
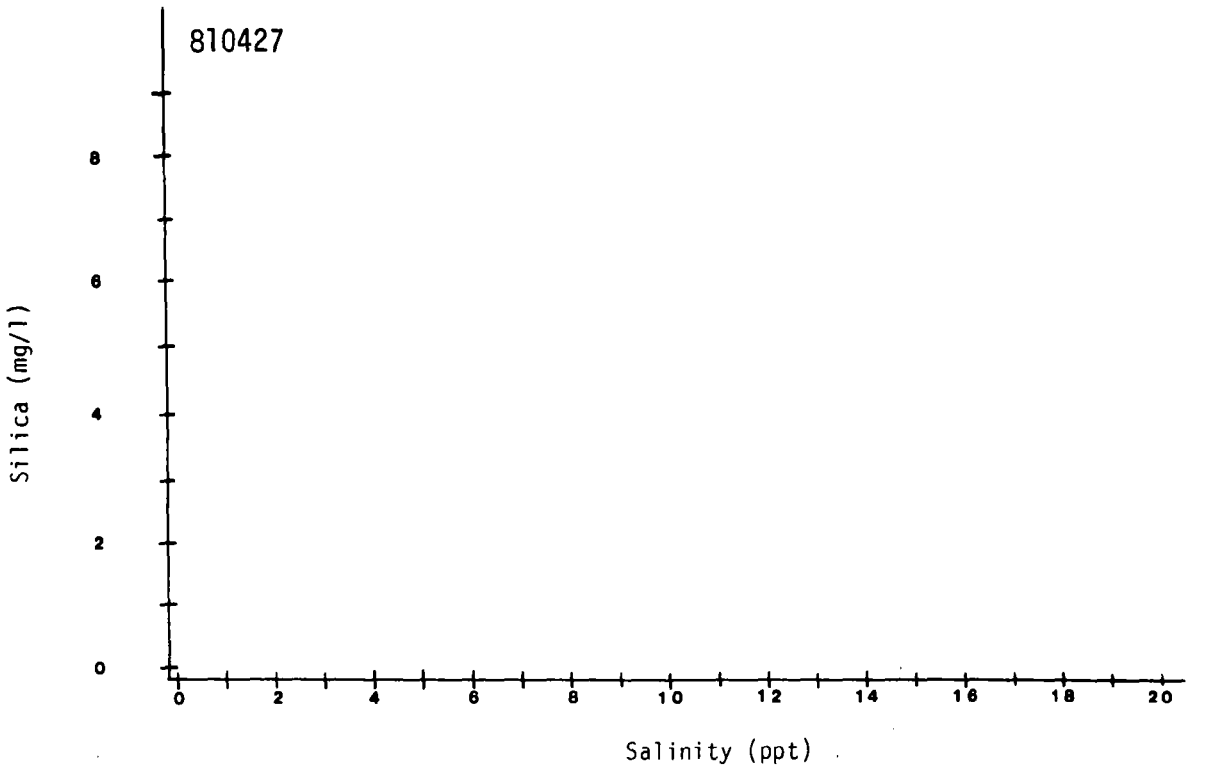


Figure 11-50 Relationship between BOD_5, dissolved oxygen saturation and salinity in the Patuxent Estuary for slack tide survey data taken April 21, 1981 and March 19, 1981. (surface and bottom concentration)



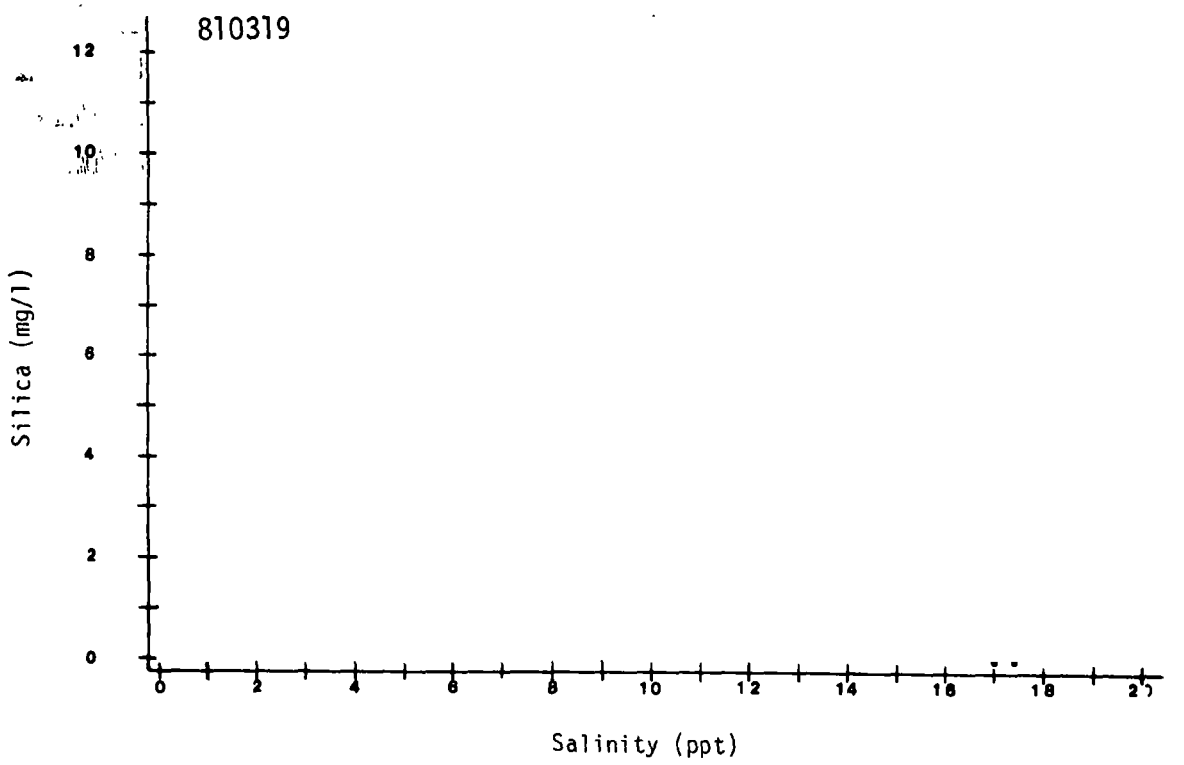
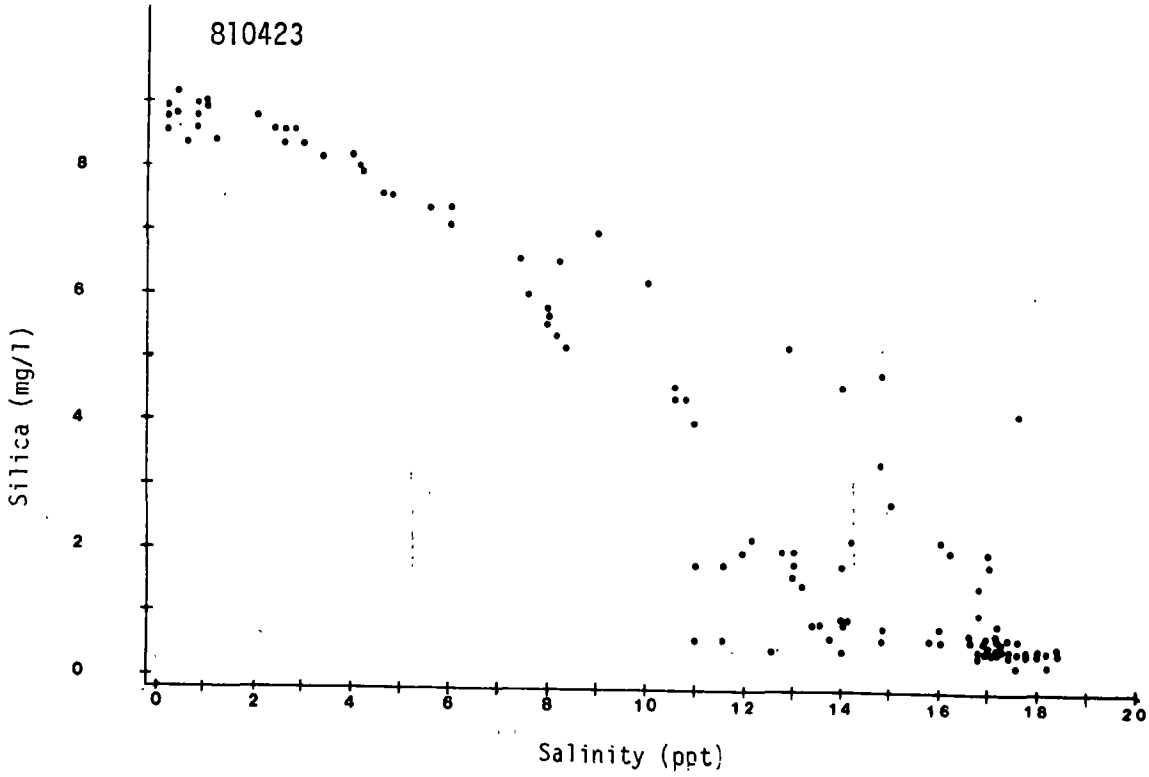


Figure 11-51 Relationship between silica and salinity in the Patuxent Estuary for slack tide survey data on April 27, 1981 and March 19, 1981. (surface and bottom concentrations)



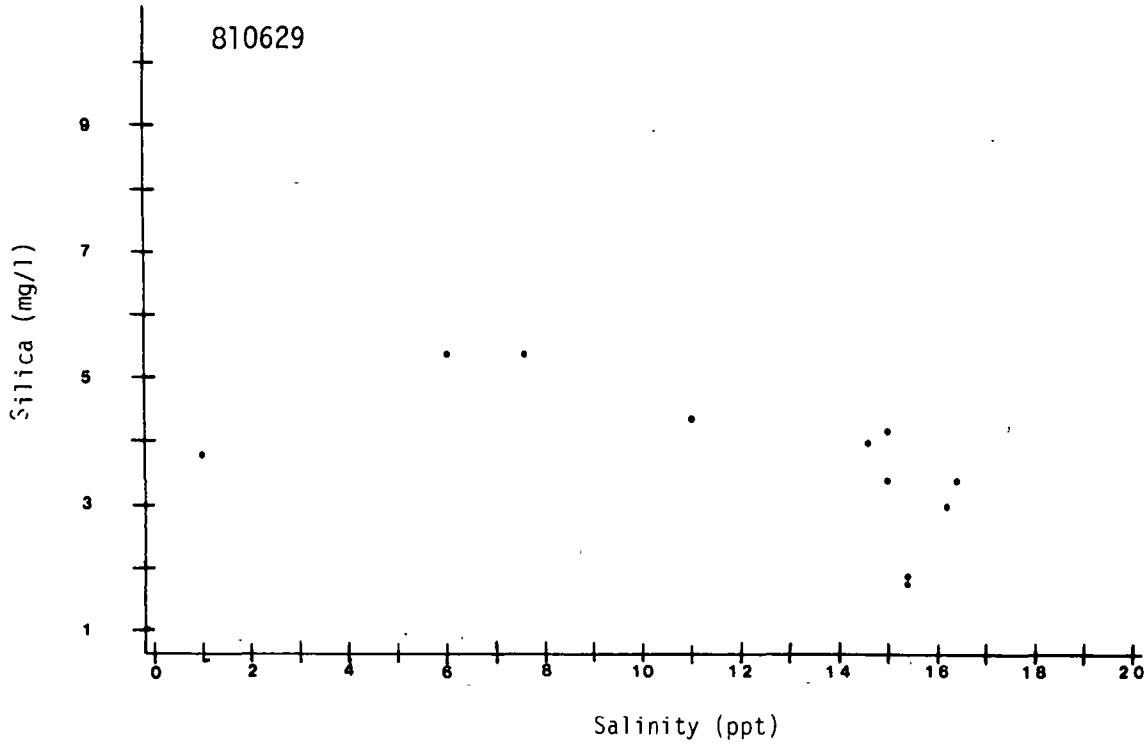
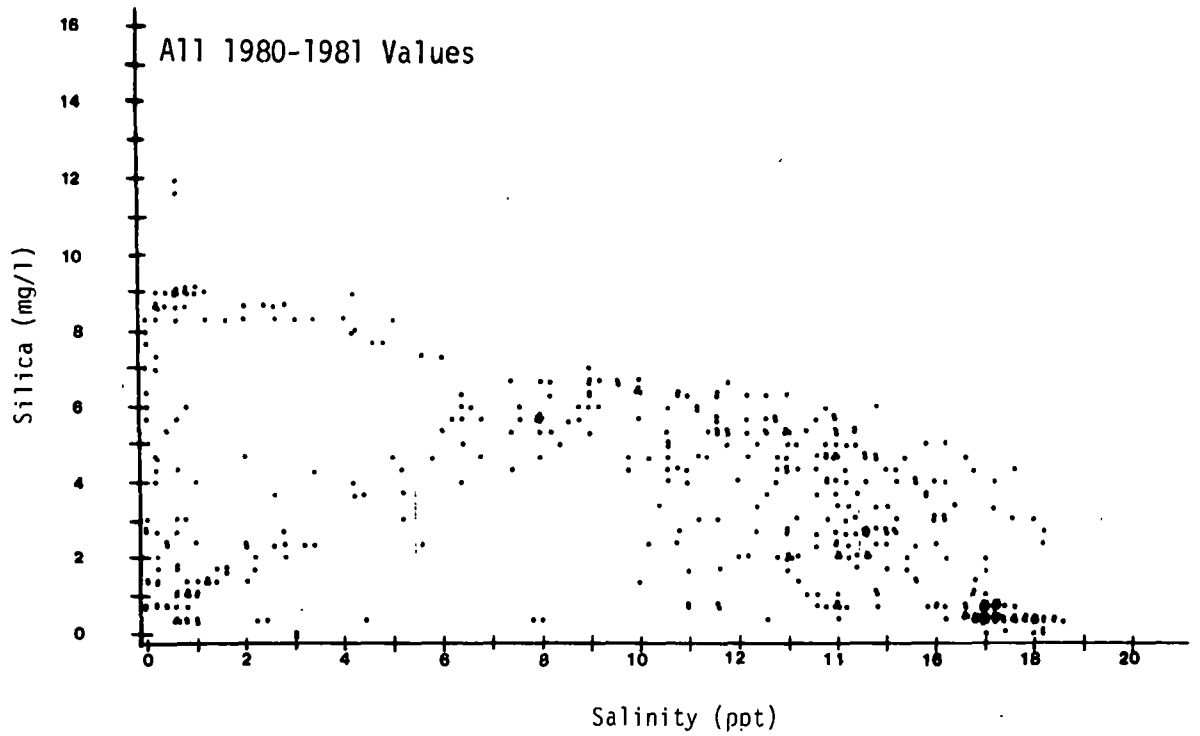


Figure 11-52 Relationship between silica and salinity in the Patuxent River for intensive survey data on April 23, 1981 and for slack tide survey data on June 29, 1981. (surface and bottom concentrations)



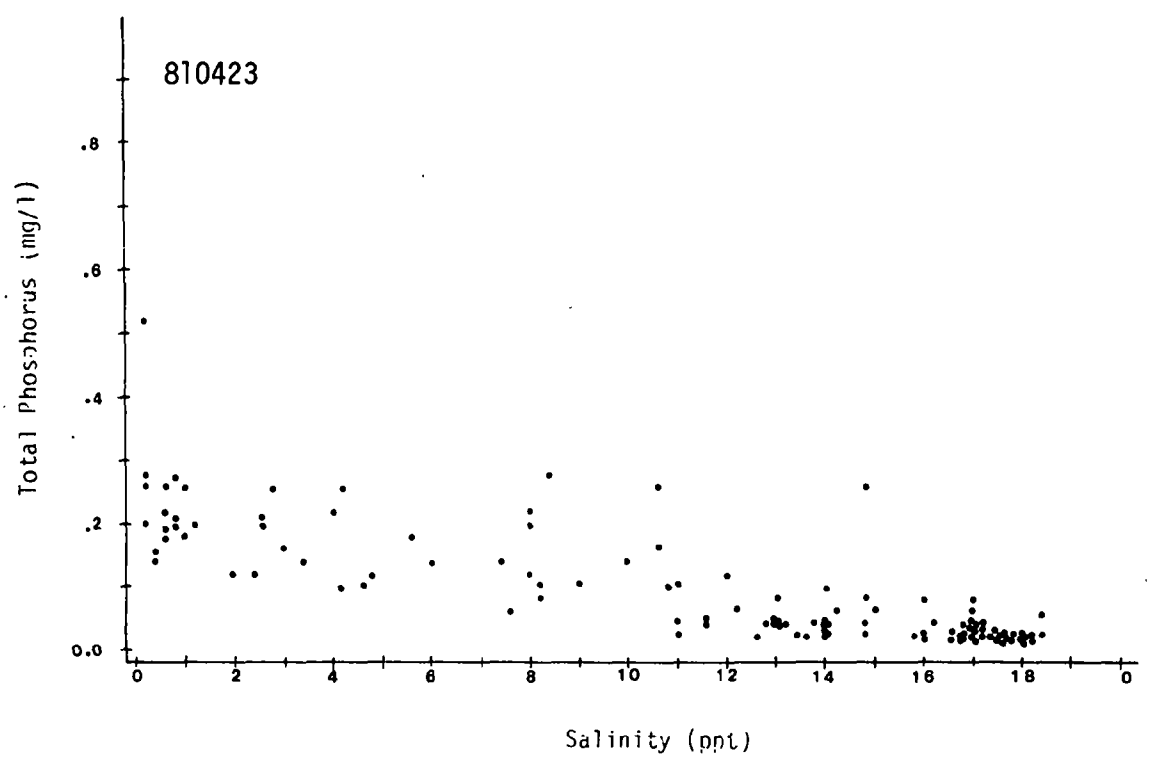
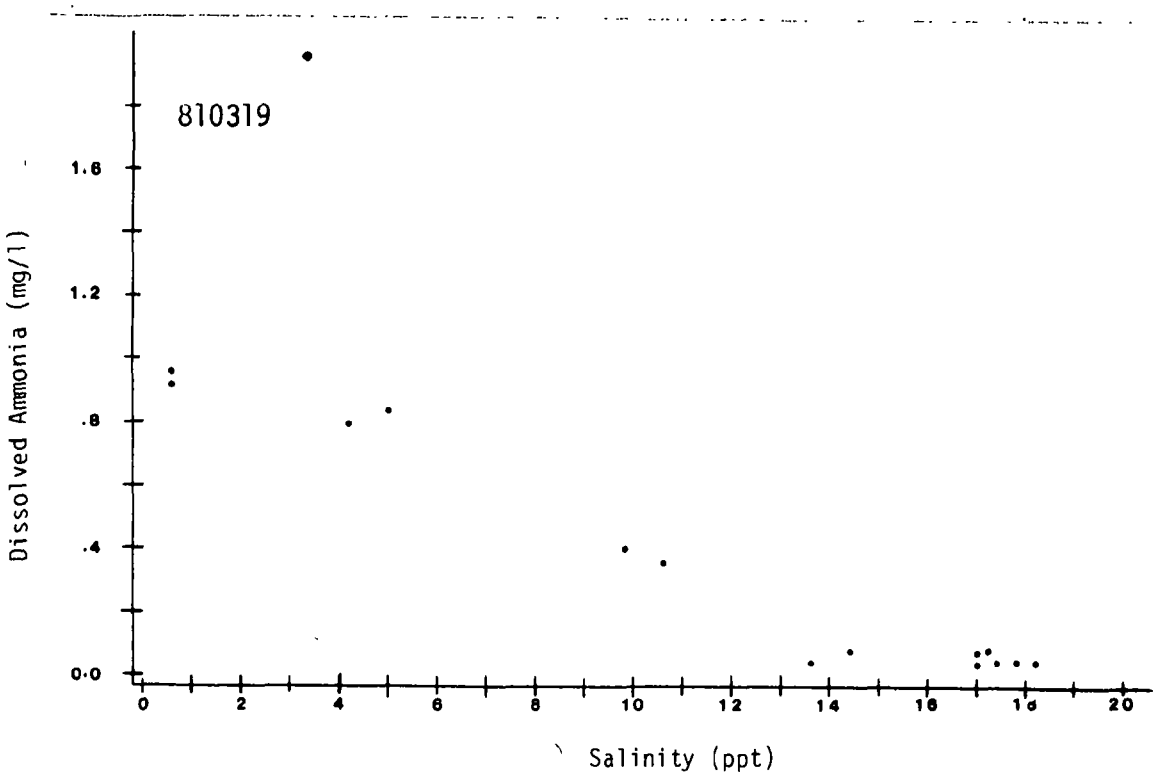


Figure 11-53 Relationship between silica and salinity in the Patuxent Estuary for all 1980-1980 slack tide and intensive survey data and between total phosphorus and salinity for intensive survey data on April 23, 1981. (surface and bottom concentrations)



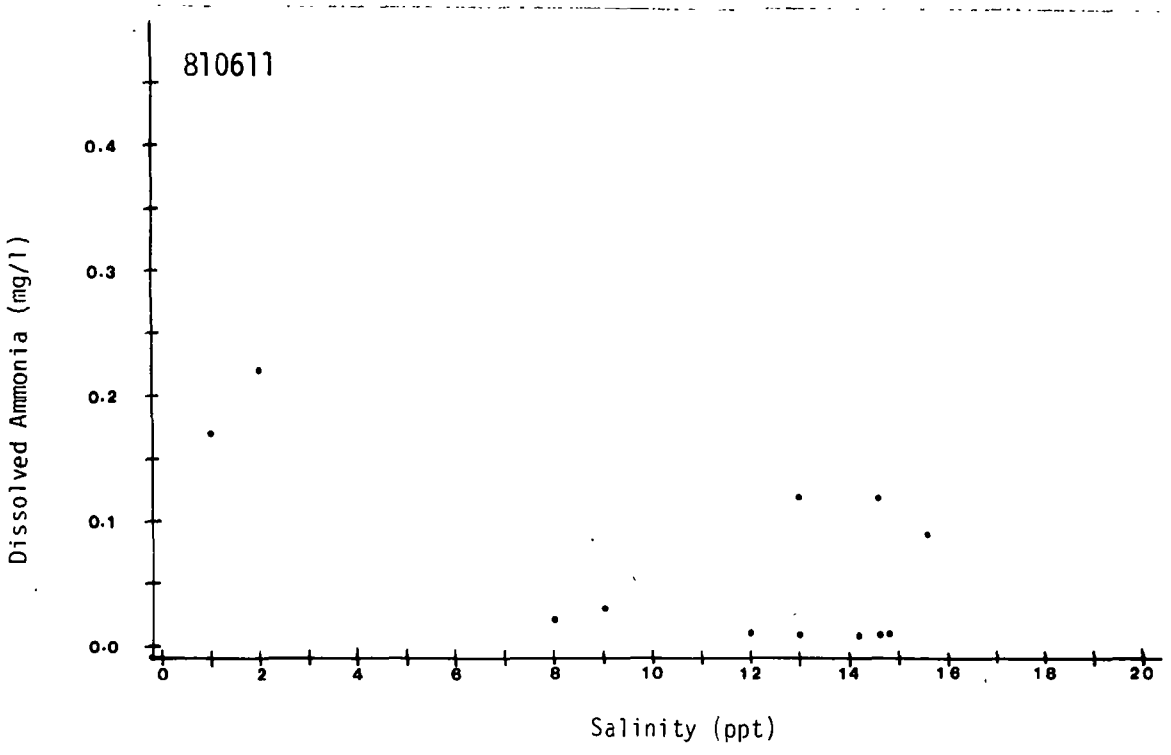
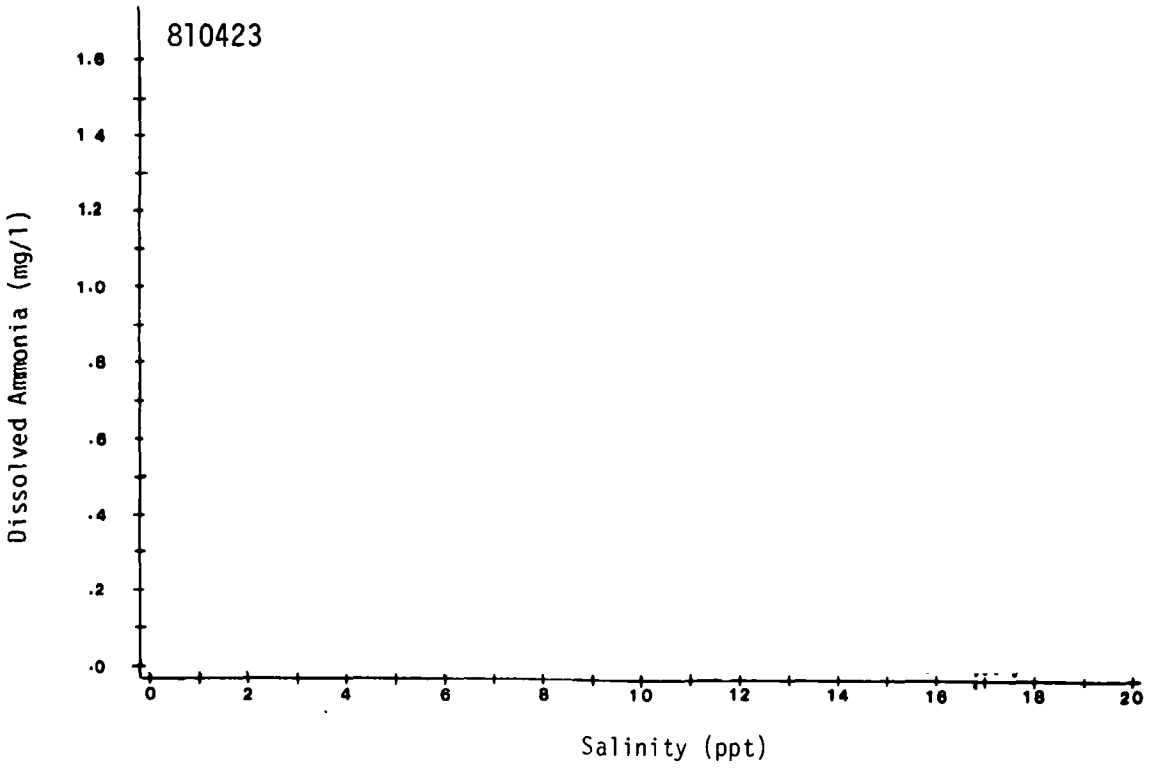


Figure 11-54 Relationship between dissolved ammonia and salinity in the Patuxent Estuary for slack tide survey data on March 19, 1981 and June 11, 1981. (surface and bottom concentrations)



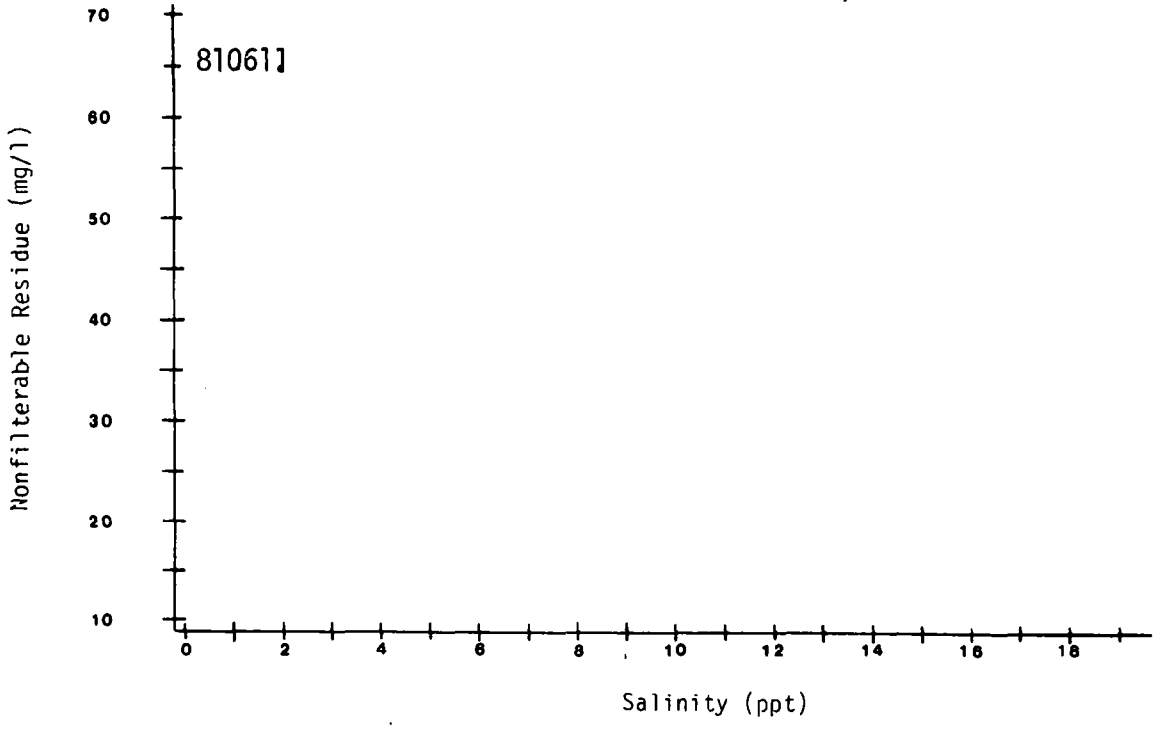
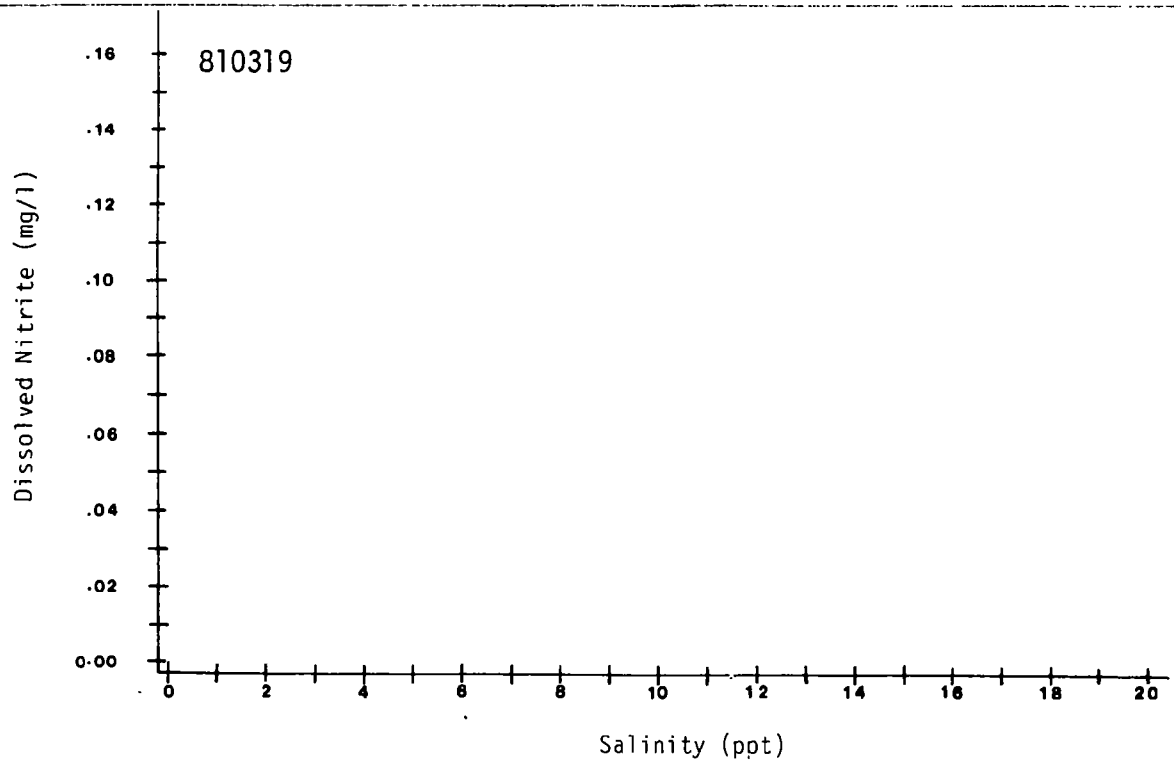


Figure 11-55 Relationship between dissolved ammonia and salinity in the Patuxent Estuary for intensive survey data on April 23, 1981 and total nonfilterable residue and salinity for slack tide survey data on June 11, 1981. (surface and bottom concentrations)



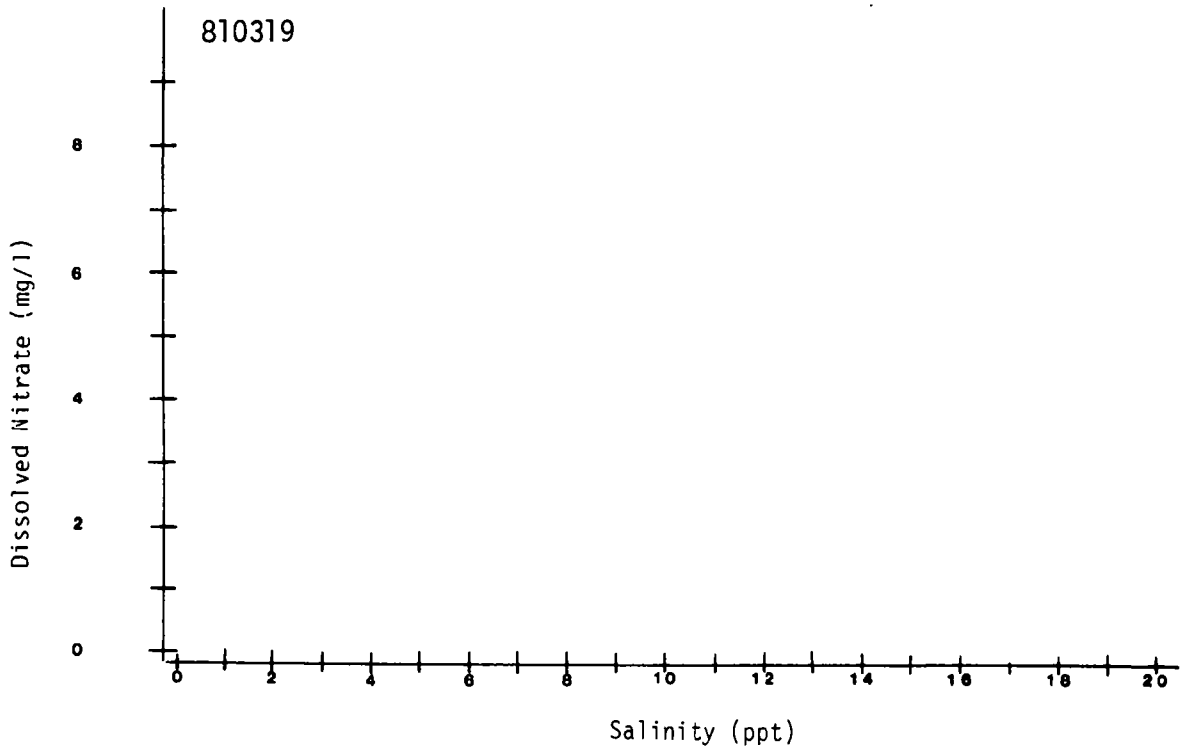
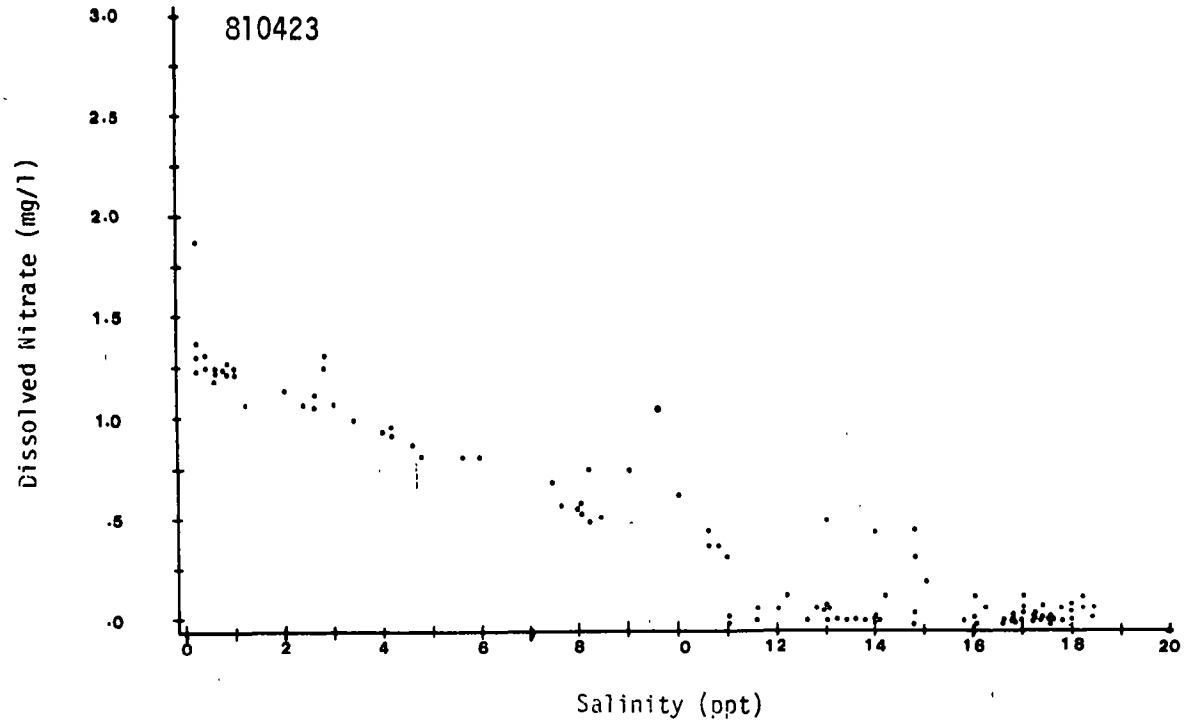


Figure 11-56 Relationship between dissolved nitrite, dissolved nitrate and salinity in Patuxent Estuary for slack tide survey data on March 19, 1981. (surface and bottom concentrations)



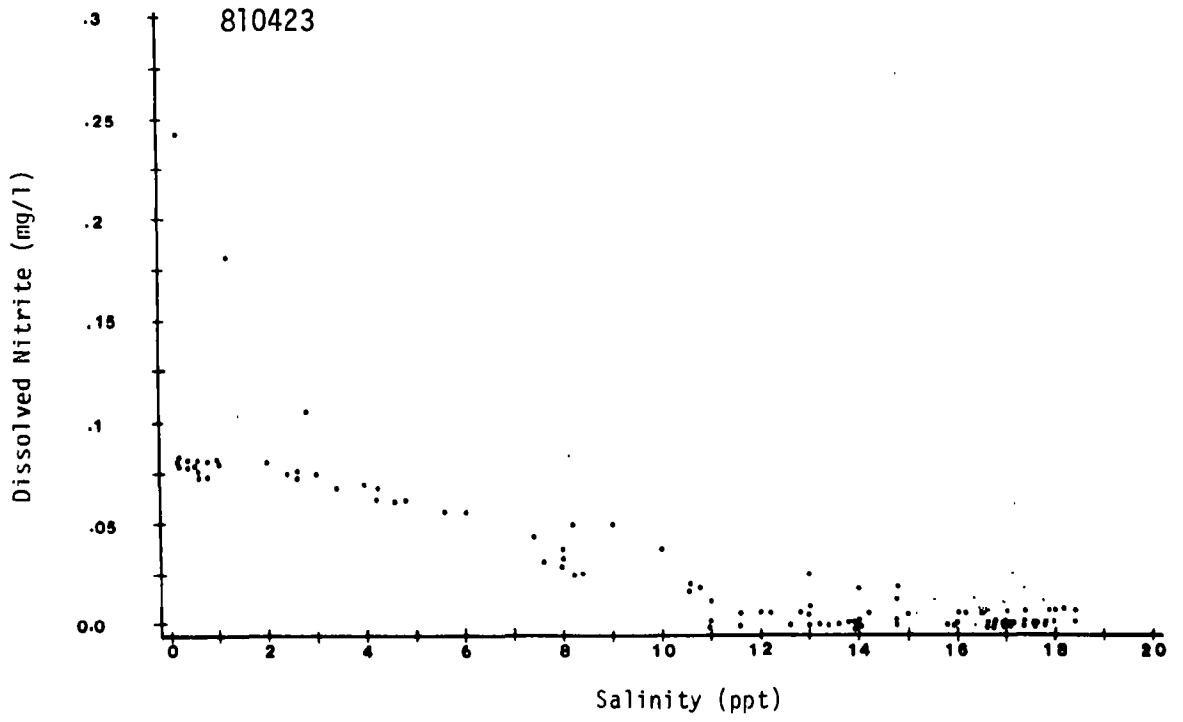
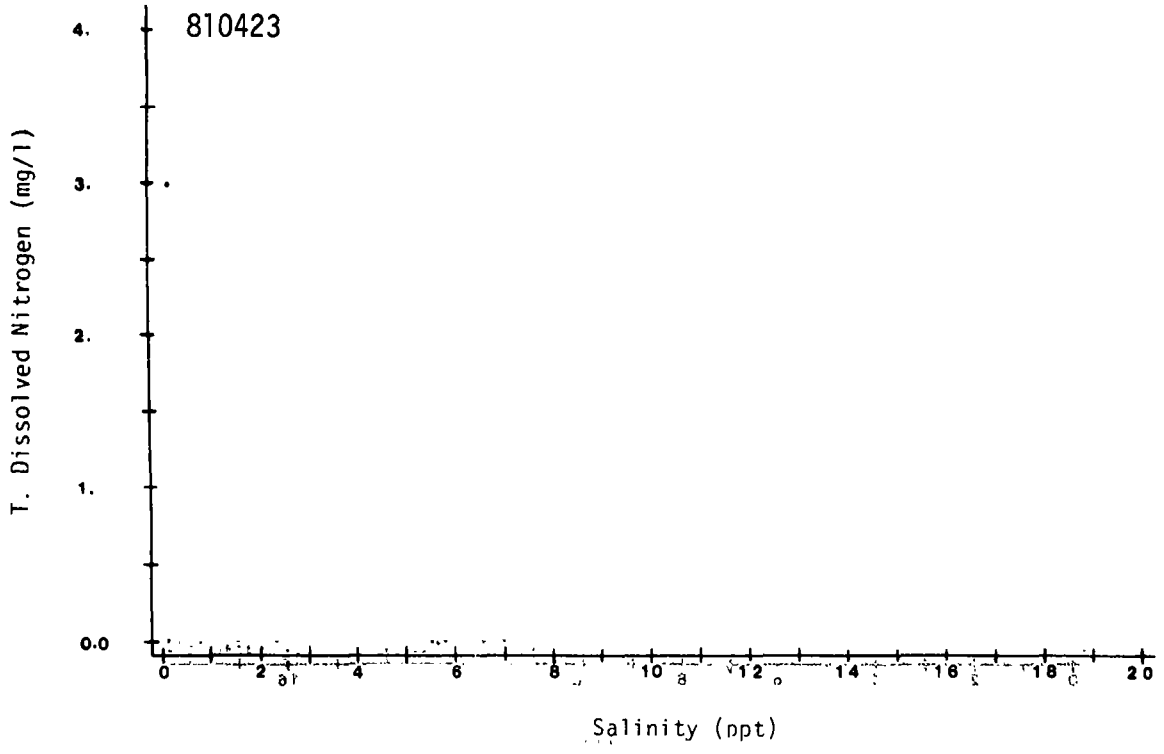


Figure 11-57 Relationship between dissolved nitrate, dissolved nitrite and salinity in the Patuxent Estuary for intensive river survey data on April 23, 1981. (surface and bottom concentrations)



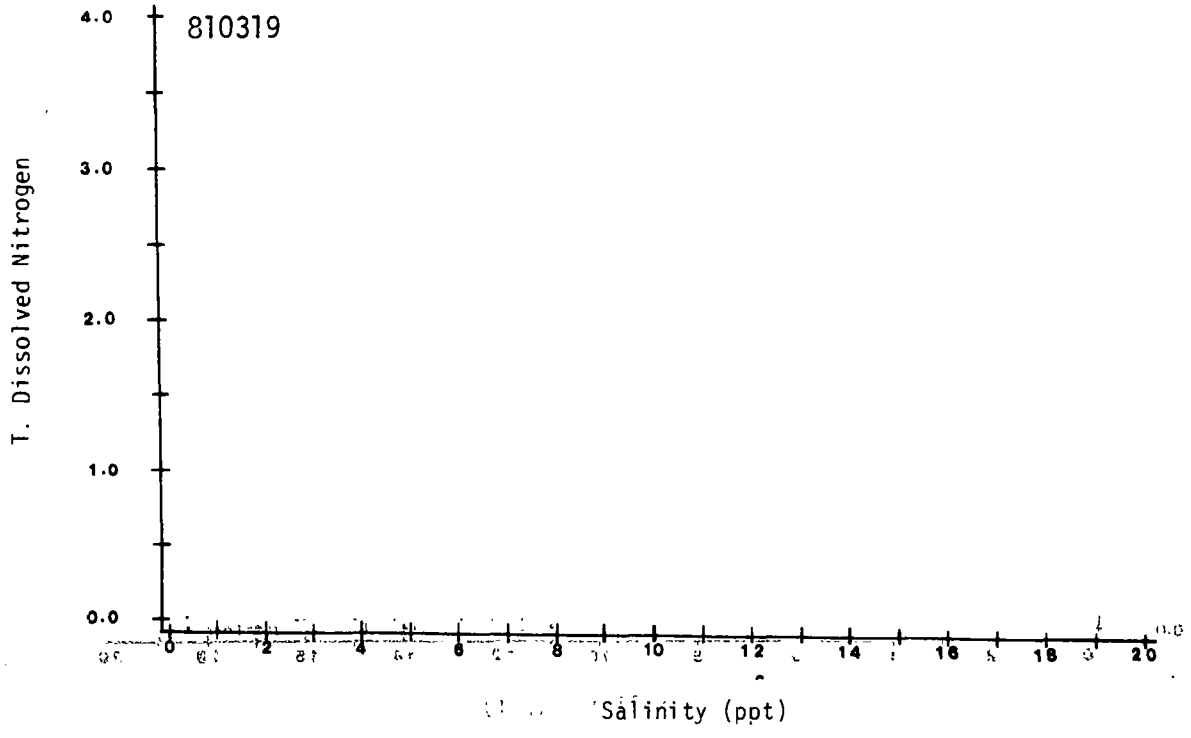


Figure 11-58 Relationship between total dissolved nitrogen and salinity in the Patuxent Estuary for slack tide survey on March 19, 1981 and intensive river survey data on April 23, 1981. (surface and bottom concentrations)

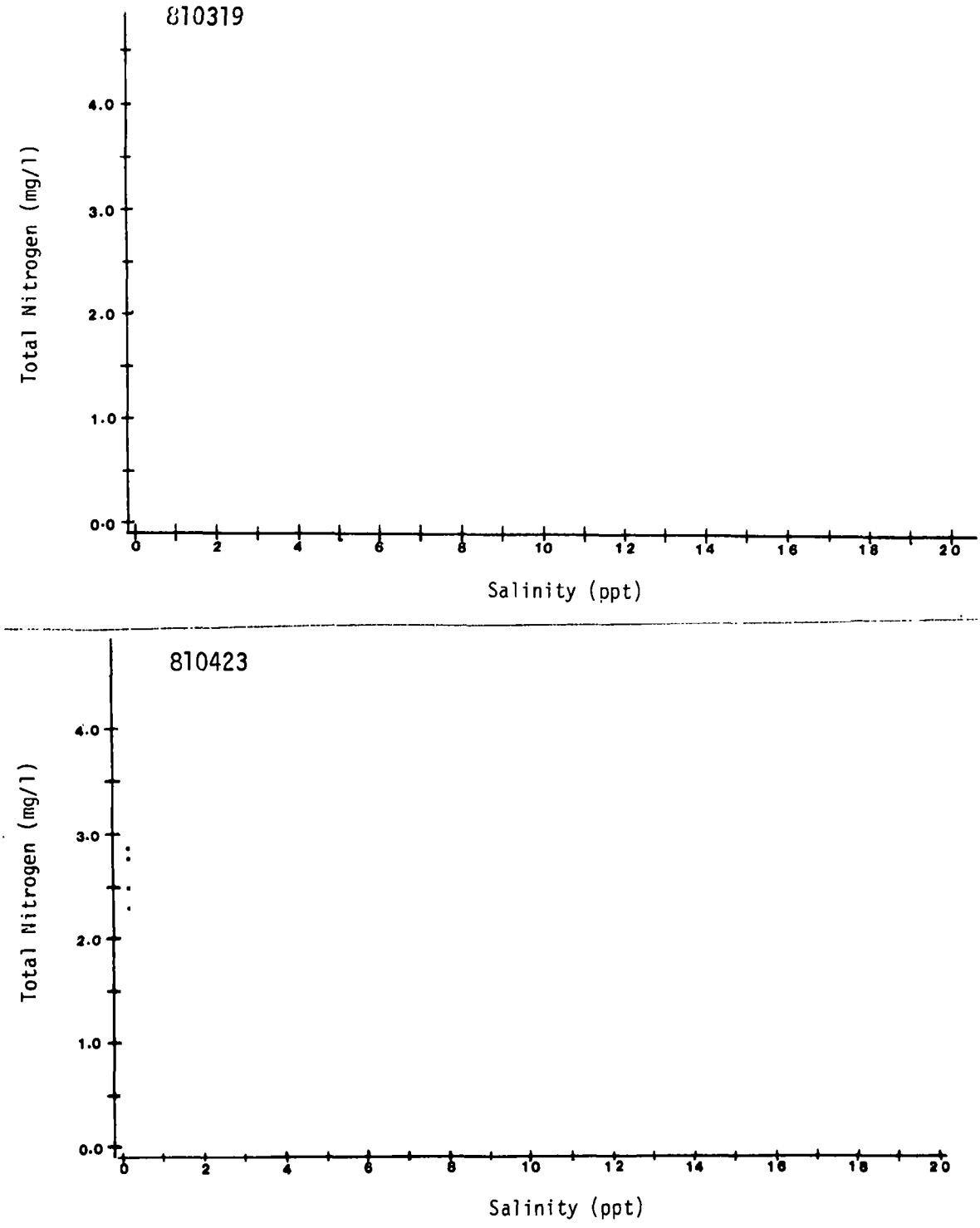


Figure 11-59 Relationship between total nitrogen and salinity in the Patuxent Estuary for slack tide survey data on March 19, 1981 and for intensive survey data on April 23, 1981. (surface and bottom concentrations)

Table 11-13
Linear Relationships Between Mean Dissolved Silica and Station Means of Variables at Patuxent River Stations in this Study, 1980-1981.

Variable	r^2*	depth***
Temperature	0.86	S
Dissolved oxygen	0.83	S
Dissolved oxygen saturation	0.80	S
pH	0.78	A
Alkalinity	0.61	B
	0.73	A
Chlorides	0.56	S
	0.62	B
	0.70	A
Dissolved nitrogen	0.63	A
Nitrite	0.60	A
Total-phosphorus	0.62	A
Chlorophyll-a (corrected)	0.52	S
	0.56	B
	0.61	A
Salinity	0.52	S
	0.60	B
	0.61	A

*Only r^2's greater than 0.5 are shown.
**S = surface means, B = bottom means, A = all depths station means.

Table 11-14
Linear Relationship Between Mean Salinity (ppt) and Station Means of Quality Variables at Patuxent River Stations in this Study, 1980-1981.

Variable	r^2*	Depth**	Variable	r^2*	Depth**
Temperature	0.69	S			
	0.74	B	Nitrate	0.78	S
				0.83	B
BOD_5	0.57	B		0.71	A
pH	0.80	S	Total P	0.85	S
	0.56	B		0.84	B
	0.77	A		0.82	A
Alkalinity	0.995	S	Dissolved organic		
	0.993	B	carbon*	0.73	S
	0.995	A		0.50	B
				0.73	A
Residue	0.811	S			
	0.82	B	Chlorides	0.992	S
				0.996	B
Dissolved Nitrogen	0.87	S		0.998	A
	0.89	B			
	0.76	A	Silica	0.52	S
				0.58	B
Dissolved Ammonia*	0.94	S		0.61	A
	0.95	B			
	0.96	A	Chlorophyll-a	0.86	B
				0.6	A
Total Nitrogen	0.89	S			
	0.95	B	Chlorophyll-a		
	0.80	A	(corrected)	0.56	A
Nitrite	0.87	S	Pheophytin-a	0.96	S
	0.67	B		0.99	B
	0.67	A		0.73	A

*Only r^2's greater than 0.5 are shown.

**S = surface means, B = bottom means, A = all depths station means.

Table 11-15 Statistical Summary of Patuxent River Intensive and Slack Survey Data for 1980 Through 1981

Variable	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
TEMP	683	20.98	6.75	0.26	32.18
DO	673	7.04	2.32	0.09	32.93
DOSAT	675	79.94	20.79	0.80	26.00
BOD5	686	2.97	1.59	0.06	53.62
PH	681	7.42	0.56	0.02	7.55
TALK	655	53.53	14.87	0.58	27.79
SALIN	503	10.32	6.14	0.23	59.50
RESIDUE	661	37.90	39.23	1.53	103.51
TOTN	707	1.30	1.18	0.04	90.69
DISSNIT	640	1.00	0.98	0.04	98.57
FAMMON	706	0.19	0.29	0.01	149.65
FNITRITE	707	0.05	0.07	0.0	158.37
FNITRATE	703	0.61	1.04	0.04	171.50
TPHOS	714	0.18	0.20	0.01	112.79
FPHOS	707	0.08	0.12	0.0	151.59
FOPHOS	708	0.07	0.13	0.0	195.83
TOC	310	8.09	3.96	0.23	48.97
DOC	402	5.08	3.34	0.17	65.76
CHLORIDE	260	3121.5	2986.1	185.2	95.66
SILICA	655	4.65	3.23	0.13	69.55
CHLORA	706	20.29	25.21	0.95	124.22
CHLORAC	308	15.63	12.84	0.73	82.20
PHEOP	707	6.77	8.34	0.31	123.34

Table 11-16 Statistical Summary of Patuxent River Intensive and Slack Survey Data for 1980-1981

Variable	Year	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
TEMP	80	346	23.95	6.47	0.35	27.00
	81	337	17.92	5.57	0.30	31.10
DO	80	340	6.30	2.32	0.13	36.75
	81	333	7.80	2.07	0.11	26.52
DOSAT	80	342	75.24	22.12	1.20	29.39
	81	333	84.77	18.13	0.99	21.39
BOD5	80	343	2.62	1.56	0.08	59.61
	81	343	3.33	1.55	0.08	46.56
PH	80	346	7.26	0.45	0.02	6.15
	81	335	7.59	0.62	0.03	8.11
TALK	80	309	52.03	15.76	0.90	30.28
	81	346	54.87	13.93	0.75	25.38
SALIN	80	260	9.01	5.95	0.37	66.03
	81	243	11.72	6.04	0.39	51.55
RESIDUE	80	309	32.65	24.02	1.37	73.55
	81	352	42.51	48.40	2.58	113.85
TOTN	80	359	1.26	1.23	0.07	98.12
	81	348	1.34	1.11	0.06	83.27
DISSNIT	80	292	0.85	0.79	0.05	93.32
	81	348	1.12	1.11	0.06	98.49
FAMMON	80	358	0.15	0.24	0.01	164.52
	81	348	0.24	0.32	0.02	134.87
FNITRITE	80	358	0.05	0.08	0.0	166.62
	81	349	0.04	0.06	0.0	143.15
FNITRATE	80	354	0.49	0.78	0.04	158.97
	81	349	0.73	1.24	0.07	171.22
TPHOS	80	362	0.18	0.21	0.01	114.83
	81	352	0.17	0.19	0.01	110.16
FPHOS	80	359	0.09	0.14	0.0	158.12
	81	348	0.08	0.11	0.0	141.04
FOPHOS	80	360	0.08	0.15	0.0	193.92
	81	348	0.06	0.11	0.01	190.13
TOC	80	308	8.12	3.96	0.23	48.82
	81	2	4.50	2.83	2.00	62.85
DOC	80	54	11.11	4.58	0.62	41.26
	81	348	4.15	1.79	0.10	43.02
CHLORIDE	80	260	3121.5	2986.1	185.19	95.66
	81	0	--	--	--	---
SILICA	80	307	5.10	2.93	0.17	57.37
	81	348	4.26	3.44	0.18	80.85
CHLORA	80	360	17.01	31.36	1.65	184.40
	81	346	23.71	15.88	0.85	66.96
CHLORAC	80	0	--	--	--	---
	81	308	15.63	12.84	0.73	82.20
PHEOP	80	361	6.32	5.70	0.30	90.25
	81	346	7.23	10.40	0.56	143.76

Table 11-17
Statistical Summary of Patuxent River Intensive and Slack Survey Data For 1980 Through 1981, Surface, Bottom, and Mid Depths

Variable	Depth	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
TEMP	S*	259	21.56	7.03	0.44	32.60
	M*	127	19.71	6.01	0.53	30.47
	B*	297	21.01	6.75	0.39	32.13
DO	S	258	7.56	2.04	0.13	26.94
	M	118	6.36	1.85	0.17	29.13
	B	297	6.87	2.61	0.15	37.98
DOSAT	S	258	87.81	16.86	1.05	19.21
	M	120	68.14	14.21	1.30	20.85
	B	297	77.87	23.26	1.35	29.87
BOD5	S	270	3.23	1.64	0.10	50.80
	M	118	3.43	1.43	0.13	41.74
	B	298	2.55	1.51	0.09	59.17
PH	S	259	7.57	0.59	0.04	7.75
	M	127	7.06	0.30	0.03	4.29
	B	295	7.44	0.55	0.03	7.45
TALK	S	255	57.09	12.96	0.81	22.71
	M	110	35.54	6.18	0.59	17.38
	B	290	57.23	13.8	0.81	24.12
SALIN	S	250	10.14	6.04	0.38	59.58
	M	4	0.20	0.12	0.06	57.74
	B	249	10.66	6.15	0.39	57.71
RESIDUE	S	255	29.54	16.4	1.03	55.52
	M	116	29.16	16.55	1.54	56.78
	B	290	48.76	54.40	3.19	11.57
TOTN	S	276	0.94	0.63	0.04	67.76
	M	118	3.10	0.81	0.07	26.15
	B	313	0.93	1.03	0.06	109.86
DISSNIT	S	274	0.70	0.59	0.04	83.37
	M	86	3.02	0.75	0.08	24.98
	B	280	0.67	0.51	0.03	76.30
FAMMON	S	275	0.11	0.17	0.01	158.56
	M	119	0.54	0.44	0.04	80.83
	B	312	0.14	0.19	0.01	138.52
FNITRITE	S	276	0.02	0.03	0.0	125.84
	M	117	0.17	0.10	0.01	56.93
	B	314	0.02	0.03	0.0	132.70
FINITRATE	S	275	0.32	0.60	0.04	189.15
	M	117	2.04	0.67	0.06	32.85
	B	311	0.33	1.03	0.06	313.08

* S, M, B = Surface, Mid, and Bottom Depths

Table 11-17 (continued)
Statistical Summary of Patuxent River Intensive and Slack Survey Data for 1980 Through 1981, Surface, Bottom, and Mid Depths

Variable	Depth	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
TPHOS	S	275	0.10	0.08	0.0	81.61
	M	126	0.51	0.24	0.02	46.64
	B	313	0.12	0.1	0.01	87.68
FPHOS	S	276	0.05	0.06	0.0	120.08
	M	119	0.27	0.20	0.02	75.77
	B	312	0.04	0.02	0.0	49.67
FOPHOS	S	276	0.02	0.02	0.0	94.67
	M	121	0.27	0.21	0.02	78.15
	B	311	0.02	0.02	0.0	87.89
TOC	S	117	7.96	4.21	0.39	52.92
	M	58	8.78	3.85	0.51	43.87
	B	135	7.91	3.78	0.33	47.79
DOC	S	156	4.59	3.23	0.26	70.32
	M	68	6.11	2.81	0.34	45.94
	B	178	5.12	3.55	0.27	69.27
CHLORIDE	S	101	3883.0	2724.9	271.1	70.18
	M	45	37.47	51.59	7.69	137.69
	B	114	3664.1	3043.3	285.0	83.06
SILICA	S	256	3.63	2.63	0.16	72.41
	M	110	8.78	1.28	0.12	14.53
	B	289	3.98	3.02	0.18	75.93
CHLORA	S	276	26.20	33.50	2.02	127.90
	M	119	12.33	14.50	1.33	117.59
	B	311	18.10	17.59	1.00	97.16
CHLORAC	S	114	19.02	12.48	1.17	65.62
	M	56	8.72	11.48	1.53	131.72
	B	138	15.63	12.62	1.07	80.74
PHEOP	S	276	5.72	6.51	0.39	113.86
	M	119	5.36	5.08	0.47	94.63
	B	312	8.23	10.34	0.59	125.69

Table 11-18
Statistical Summary of Patuxent River Intensive and Slack Survey
Data for 1980-1981, Surface, Bottom, and Mid Depths

Variable	Depth	Year	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
DO	S*	80	130	6.90	2.05	0.18	29.7
	S	81	128	8.22	1.80	0.16	21.89
	M*	80	59	5.76	1.97	0.26	34.23
	M	81	59	6.95	1.52	0.20	21.84
	B*	80	151	6.00	2.55	0.21	42.45
	B	81	146	7.77	2.36	0.20	30.405
DOSAT	S	80	130	84.6	18.9	1.66	22.38
	S	81	128	91.0	13.8	1.22	15.16
	M	80	61	64.2	13.1	1.68	20.47
	M	81	59	72.2	14.2	1.85	19.69
	B	80	151	71.6	24.4	1.99	34.06
	B	81	146	84.3	20.2	1.67	23.9
BOD5	S	80	137	3.08	1.76	0.15	57.27
	S	81	133	3.39	1.5	0.13	44.17
	M	80	57	2.82	1.09	0.14	38.5
	M	81	61	4.01	1.49	0.19	37.12
	B	80	149	2.11	1.36	0.11	64.27
	B	81	149	2.99	1.53	0.13	51.13
PH	S	80	131	7.36	0.46	0.04	6.24
	S	81	128	7.79	0.63	0.06	8.03
	M	80	64	7.05	0.33	0.04	4.64
	M	81	63	7.06	0.28	0.04	3.95
	B	80	151	7.25	0.45	0.04	6.20
	B	81	144	7.64	0.58	0.05	7.64
TALK	S	80	121	56.09	13.35	1.21	23.80
	S	81	134	58.0	12.59	1.09	21.7
	M	80	51	32.48	5.29	0.74	16.3
	M	81	59	38.18	5.67	0.74	14.85
	B	80	137	55.72	14.93	1.28	26.79
	B	81	153	58.57	12.60	1.01	21.52
RESIDUE	S	80	119	23.42	9.63	0.88	41.10
	S	81	136	34.90	19.06	1.63	54.61
	M	80	53	34.74	18.37	2.52	52.88
	M	81	63	24.46	13.28	1.67	54.29
	B	80	137	39.87	31.12	2.66	78.05
	B	81	153	56.71	68.0	5.50	119.9
TOTN	S	80	140	0.94	0.66	0.06	70.10
	S	81	136	0.93	0.61	0.05	65.44
	M	80	59	2.82	0.86	0.11	30.33
	M	81	59	3.37	0.66	0.08	19.61
	B	80	160	0.96	1.30	0.1	135.98
	B	81	153	0.91	0.63	0.05	68.64

* Surface, Mid, and Bottom.

Table 11-18 (continued)
Statistical Summary of Patuxent River Intensive and Slack Survey
Data for 1980-1981, Surface, Bottom, and Mid Depth

Variable	Depth	Year	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
TOC	S*	80	117	7.96	4.21	0.39	52.92
	S	81	0	--	--	--	---
	M*	80	56	8.93	3.81	0.51	42.69
	M	81	2	4.50	2.83	2.00	62.85
	B*	80	135	7.91	3.78	0.33	47.60
	B	81	0	--	--	--	---
DOC	S	80	20	10.53	4.96	1.11	70.18
	S	81	136	3.72	1.60	0.14	42.86
	M	80	9	11.78	3.54	1.18	30.03
	M	81	59	5.25	1.28	0.17	24.40
	B	80	25	11.33	4.71	0.94	41.60
	B	81	153	4.11	1.94	0.16	47.21
SILICA	S	80	120	3.94	2.00	0.18	50.61
	S	81	136	3.36	3.07	0.26	91.26
	M	80	51	9.17	1.28	0.18	13.93
	M	81	59	8.44	1.19	0.15	14.04
	B	80	136	4.59	2.76	0.24	59.97
	B	81	153	3.43	3.15	0.25	91.74
CHLORA	S	80	141	26.87	45.01	3.79	167.54
	S	81	135	25.50	13.64	1.17	53.5
	M	80	60	8.26	12.64	1.63	152.99
	M	81	59	16.47	15.19	1.98	92.23
	B	80	159	11.57	15.32	1.21	132.43
	B	81	152	24.94	17.25	1.40	69.16
CHLORAC	S	80	0	--	--	--	---
	S	81	114	19.02	12.48	1.17	65.62
	M	80	0	--	--	--	---
	M	81	56	8.72	11.48	1.53	131.72
	B	80	0	--	--	--	---
	B	81	138	15.63	12.62	1.07	80.74
PHEOP	S	80	141	6.06	5.48	0.46	90.33
	S	81	135	5.35	7.44	0.64	138.95
	M	80	60	4.19	2.96	0.38	70.64
	M	81	59	6.56	6.37	0.83	97.21
	B	80	160	7.34	6.41	0.51	87.39
	B	81	152	9.17	13.24	1.07	144.43

* Surface, Mid, and Bottom.

Table 11-18 (continued)
Statistical Summary of Patuxent River Intensive and Slack Survey
Data for 1980-1981, Surface, Bottom, and Mid Depths

Variable	Depth	Year	N	Mean	Standard Deviation	Standard Mean Error	Coefficient of Variation
DISSNIT	S*	80	138	0.65	0.45	0.04	69.75
	S	81	136	0.76	0.69	0.06	91.39
	M*	80	27	2.79	0.91	0.18	32.65
	M	81	59	3.12	0.65	0.08	20.91
	B*	80	127	0.66	0.42	0.04	63.17
	B	81	153	0.68	0.58	0.05	85.47
	S	80	139	0.06	0.07	0.01	108.87
	S	81	136	0.15	0.23	0.02	146.76
	M	80	60	0.43	0.44	0.06	103.47
	M	81	59	0.66	0.40	0.05	61.52
	B	80	159	0.12	0.14	0.01	121.50
	B	81	153	0.16	0.22	0.02	144.30
FNITRITE	S	80	140	0.02	0.03	0.0	124.30
	S	81	136	0.02	0.03	0.0	127.88
	M	80	58	0.19	0.12	0.02	61.13
	M	81	59	0.15	0.06	0.01	41.93
	B	80	160	0.02	0.03	0.0	119.09
	B	81	154	0.02	0.03	0.0	148.18
FNITRATE	S	80	139	0.22	0.38	0.03	172.54
	S	81	136	0.42	0.75	0.06	179.86
	M	80	58	1.89	0.84	0.11	44.46
	M	81	59	2.18	0.40	0.05	18.32
	B	80	157	0.22	0.36	0.03	166.10
	B	81	154	0.44	1.41	0.11	318.60
TPHOS	S	80	139	0.10	0.09	0.01	88.65
	S	81	136	0.09	0.07	0.01	70.96
	M	80	63	0.55	0.25	0.03	44.72
	M	81	63	0.47	0.22	0.03	47.51
	B	80	160	0.11	0.08	0.01	73.13
	B	81	153	0.12	0.12	0.01	98.81
FPHOS	S	80	140	0.05	0.03	0.0	64.13
	S	81	136	0.05	0.07	0.01	159.90
	M	80	60	0.30	0.24	0.03	81.76
	M	81	59	0.24	0.15	0.02	62.85
	B	80	159	0.04	0.03	0.0	58.37
	B	81	153	0.04	0.01	0.0	33.74
FOPHOS	S	80	140	0.03	0.02	0.0	81.23
	S	81	136	0.05	0.07	0.01	159.90
	M	80	62	0.31	0.26	0.03	82.99
	M	81	59	0.24	0.15	0.02	64.59
	B	80	158	0.03	0.02	0.0	72.41
	B	81	153	0.04	0.01	0.0	33.74

* Surface, Mid, and Bottom.

Table 11-19 Statistical Summary of Patuxent River Water Quality Variable, 1980-1981 with salinity regimes (a) 0-3 ppt, (b) 3.1-10 ppt, and (c) greater than 10 ppt.

variable	regime	N	mean	standard deviation	standard error of mean	coefficient of variation
Temp	a	295	21.21	6.37	0.37	30.02
	b	78	22.38	7.08	0.80	31.665
	c	310	20.4	6.97	0.39	34.16
DO	a	286	7.07	2.16	0.13	30.50
	b	77	7.22	2.09	0.24	28.98
	c	310	6.98	2.09	0.24	28.98
DOSAT	a	288	77.92	18.33	1.08	23.52
	b	77	83.26	16.39	1.87	19.70
	c	310	80.99	23.60	1.34	29.13
BOD_5	a	315	3.07	1.45	0.08	47.04
	b	73	3.31	1.87	0.22	56.34
	c	298	2.78	1.65	0.10	59.34
pH	a	293	7.2	0.37	0.02	5.15
	b	78	7.3	0.43	0.05	5.91
	c	310	7.7	0.64	0.04	8.39
TALK	a	303	41.40	10.93	0.63	26.41
	b	71	51.12	6.32	0.75	12.36
	c	281	67.22	5.38	0.32	8.008
Residue	a	309	40.37	47.54	2.70	117.75
	b	72	63.94	39.1	4.6	61.15
	c	280	28.48	22.05	1.32	77.43
TOTN	a	324	1.95	1.42	0.08	72.65
	b	78	1.13	0.45	0.05	39.88
	c	305	0.64	0.37	0.02	57.46
DISSNIT	a	273	1.63	1.17	0.07	71.93
	b	73	0.83	0.52	0.06	61.91
	c	294	0.45	0.29	0.02	65.06
FAMMON	a	320	0.31	0.37	0.02	120.24
	b	78	0.22	0.24	0.03	113.131
	c	308	0.07	0.07	0.004	98.23
FNITRITE	a	320	0.08	0.09	0.005	106.123
	b	78	0.02	0.02	0.002	94.76
	c	309	0.01	0.16	0.001	162.24

Table 11-19 (continued) Statistical Summary of Patuxent River Water Quality Variables, 1980-1981 within salinity regimes (a) 0-3 ppt, (b) 3.1-10 ppt and (c) greater than 10 ppt.

variable	regime	N	mean	standard deviation	standard error of mean	coefficient of variation
NITRATE	a	318	1.14	1.22	0.068	107.0
	b	78	0.33	0.36	0.04	108.65
	c	307	0.13	0.62	0.04	480.61
TPHOS	a	328	0.29	0.24	0.01	84.93
	b	78	0.17	0.17	0.009	44.47
	c	308	0.07	0.07	0.004	104.78
FPHOS	a	321	0.12	0.17	0.009	132.55
	b	78	0.05	0.02	0.002	41.38
	c	308	0.04	0.05	0.003	121.812
FOPHOS	a	321	0.12	0.18	0.01	149.40
	b	78	0.04	0.02	0.002	42.23
	c	309	0.02	0.02	0.001	127.90
TOC	a	161	8.36	3.64	0.29	43.60
	b	33	9.13	3.07	0.53	33.57
	c	116	7.43	4.50	0.42	60.58
DOC	a	167	5.9	3.32	0.257	56.33
	b	45	4.84	3.33	0.50	68.83
	c	190	4.42	3.22	0.23	72.85
Chloride	a	121	286.19	702.49	63.86	245.47
	b	30	3280.00	1206.4	220.3	36.78
	c	109	6225.2	1307.0	125.2	21.0
SILICA	a	302	6.19	3.55	0.20	57.25
	b	72	5.50	1.90	0.22	34.79
	c	281	2.79	1.94	0.12	69.92
CHLORA	a	321	19.60	18.15	1.01	92.62
	b	77	27.80	25.04	2.85	90.06
	c	308	19.14	30.74	1.75	160.59
CHLORAC	a	142	13.69	13.54	1.14	98.88
	b	36	15.00	14.29	2.38	95.24
	c	130	17.91	11.28	0.99	63.01
PHEOP	a	321	9.39	10.71	0.60	114.04
	b	77	8.87	6.85	0.78	77.255
	c	309	3.51	3.16	0.18	89.96

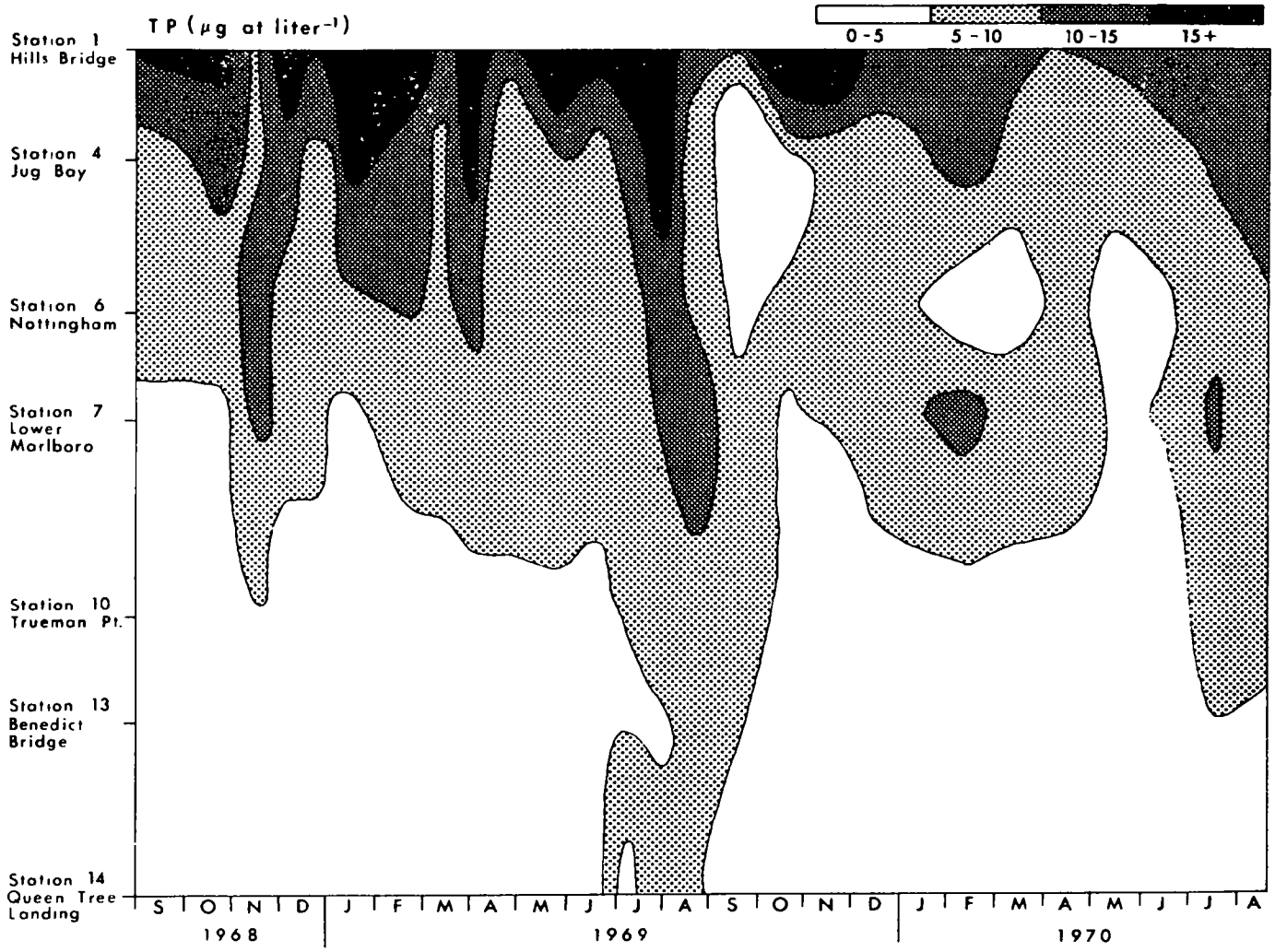


Figure11-60Space-time domain plot of total phosphorus Patuxent Estuary, from Flemer, et. al., 1970, surface waters.(30)

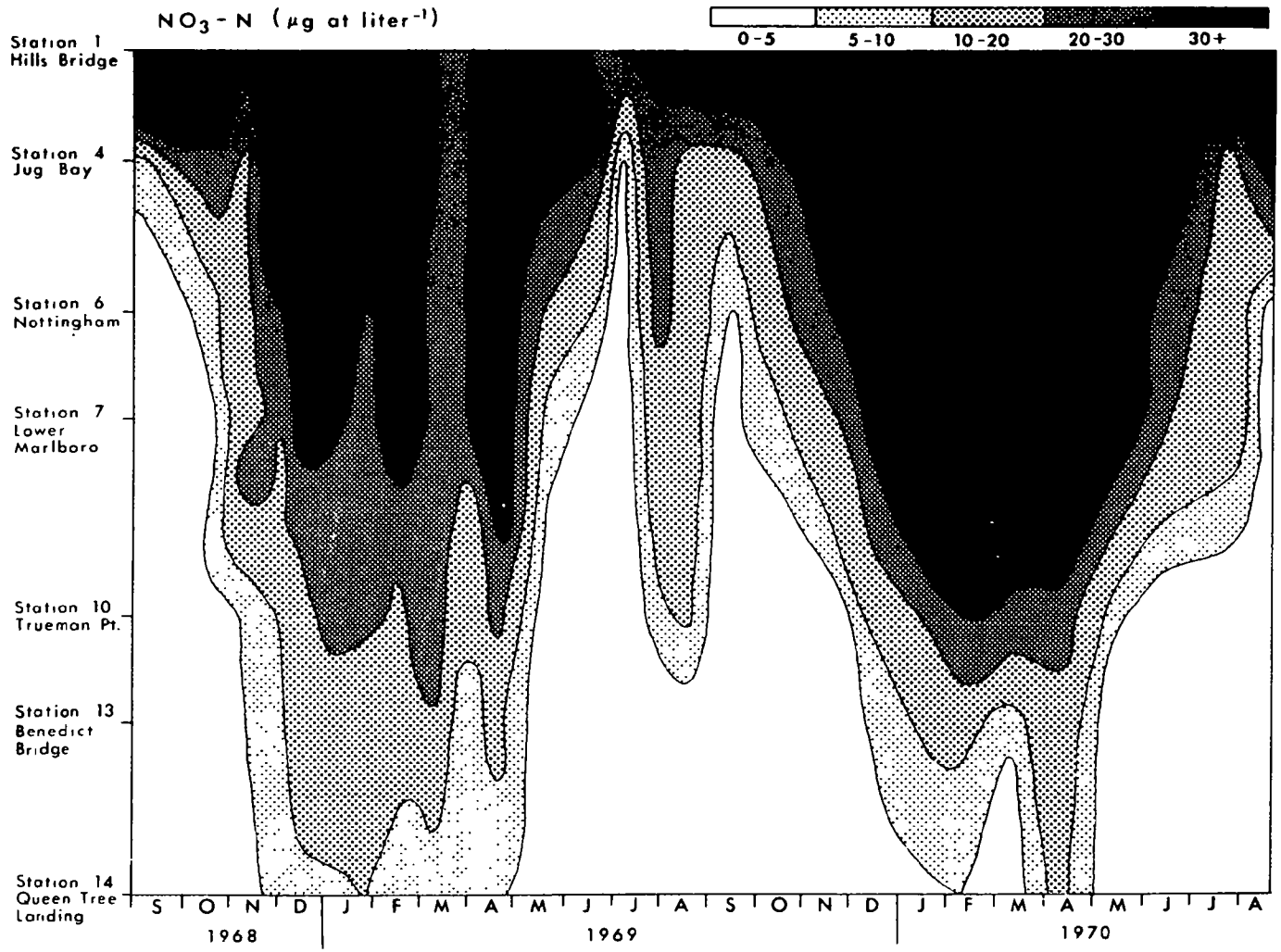


Figure 11-61 Space-time domain plot of NO_3 for the Patuxent estuary, from Flemer et. al., 1970, surface waters. (30)

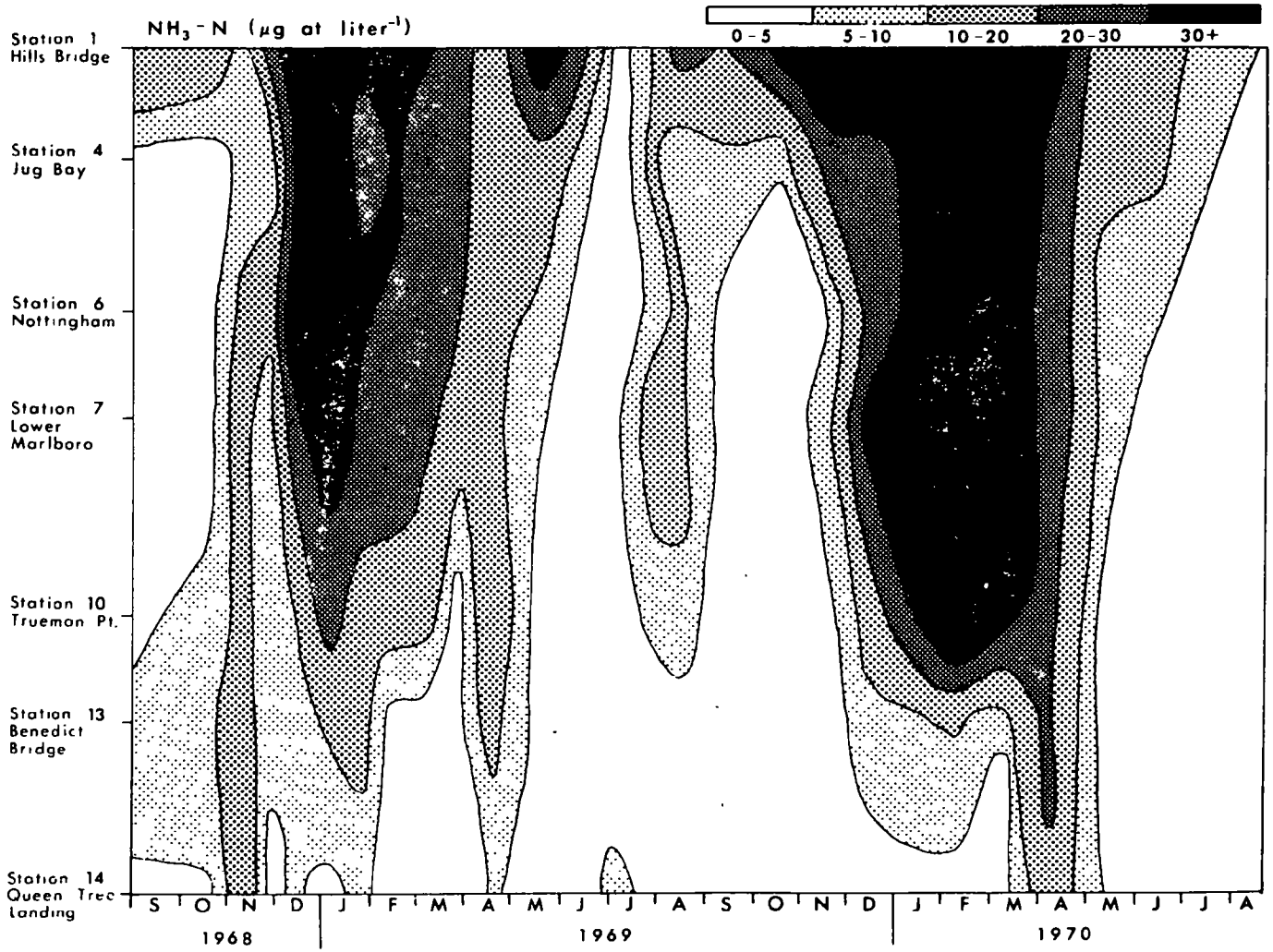


Figure II-62 Space-time domain plot of NH_3 for the Patuxent Estuary, from Flemen, et. al., 1970, surface waters. (30)

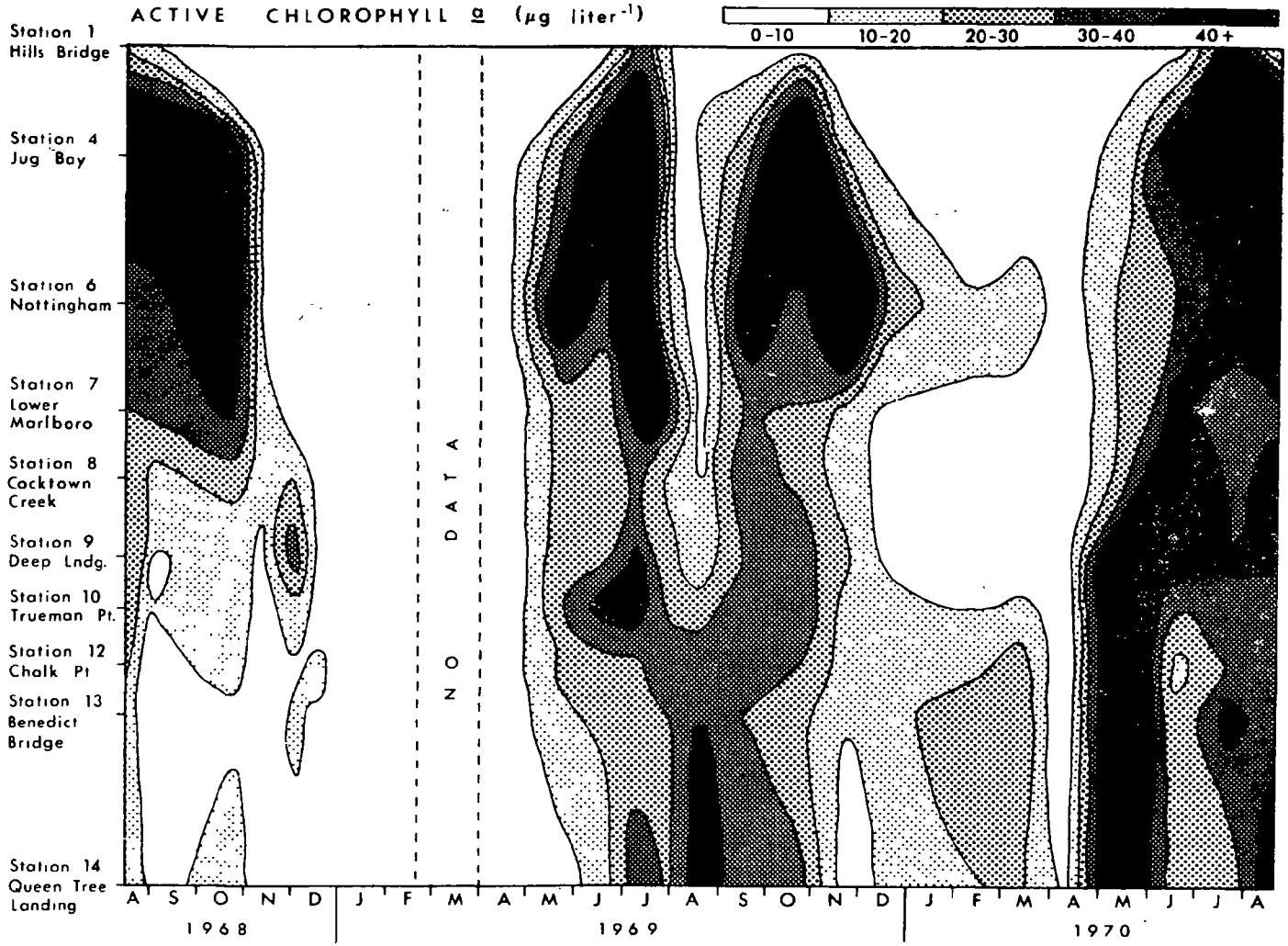
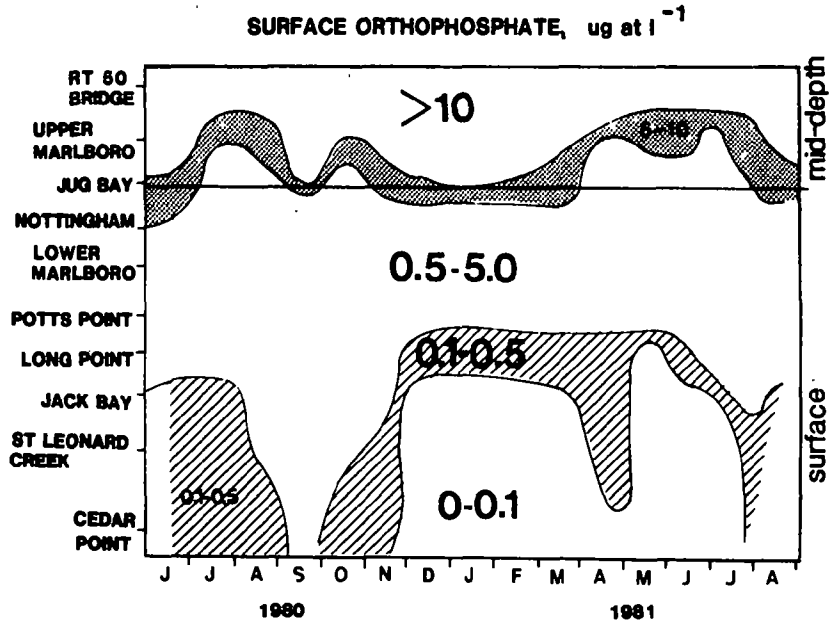


Figure 11-63 Space-time domain plot of chlorophyll-a in the Patuxent estuary, surface waters, from Flemer, et. al., 1970.(30)



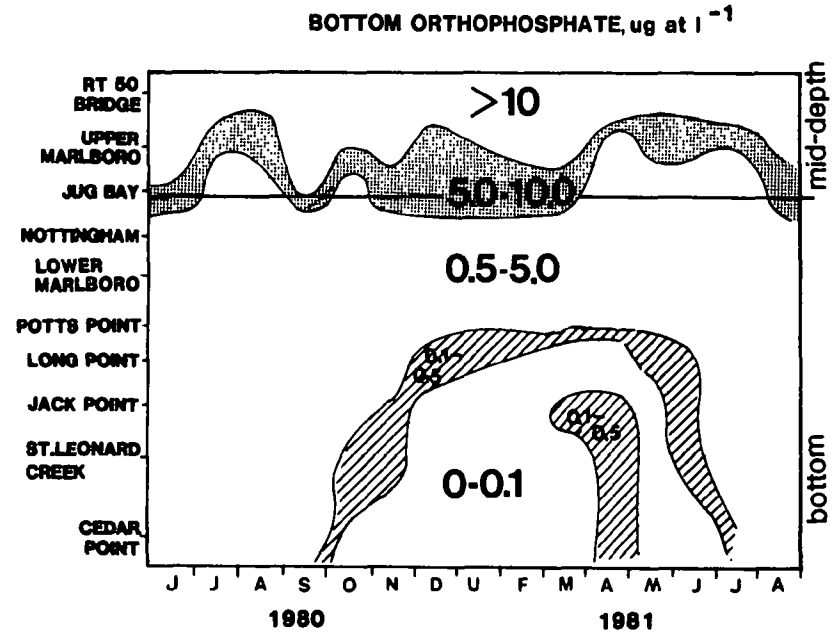


Figure 11-64 Patuxent River space-time domain plot of orthophosphate plotted by D'Elia, et., al., 1981. Upper three stations are mid-depth samples.(16)

Table 11-20 Sediment Oxygen Demand And Net Nutrient Fluxes Occurring In The Lower Patuxent River, October 1980 - August 1981**

Station	Date	Oxygen flux, g O_2 m^{-2} h^{-1} $\bar{X} \pm$ S.D.	Benthic Nutrient Fluxes, mg-at m^{-2} h^{-1} $\bar{X} \pm$ S.D. NH_4^+	NO_2^-	NO_3^-	DIP
Marsh Point	10/80	*-0.099 ± 0.022	0.170 ± 0.012	0	-0.025 ± 0.015	0
	4/81	-0.100 ± 0.007	0.064 ± 0.002	0	0	0
	8/81	-0.404 ± 0.015	0.360 ± 0.152	0	0	0.046 ± 0.012
Broomes Island	10/80	-0.105 ± 0.007	0	0	0.019 ± 0.007	0
	4/81	-0.066 ± 0.004	0.028 ± 0.032	0	0	
	8/81	-0.061 ± 0.012	0.300 ± 0.080	0.006 ± 0.001	0.007 ± 0.004	0.031 ± 0.021
St. Leonard Creek	10/80	-0.066 ± 0.032	0.113 ± 0.043	0	0.021 ± 0.007	0
	4/81	-0.084 ± 0.006	-0.026 ± 0.012	0	0	0
	8/81	0.079 ± 0.012	0.285 ± 0.128	0.005 ± 0.001	0	0.031 ± 0.022

* Negative signs denote net benthic uptake and no sign denotes net benthic release.

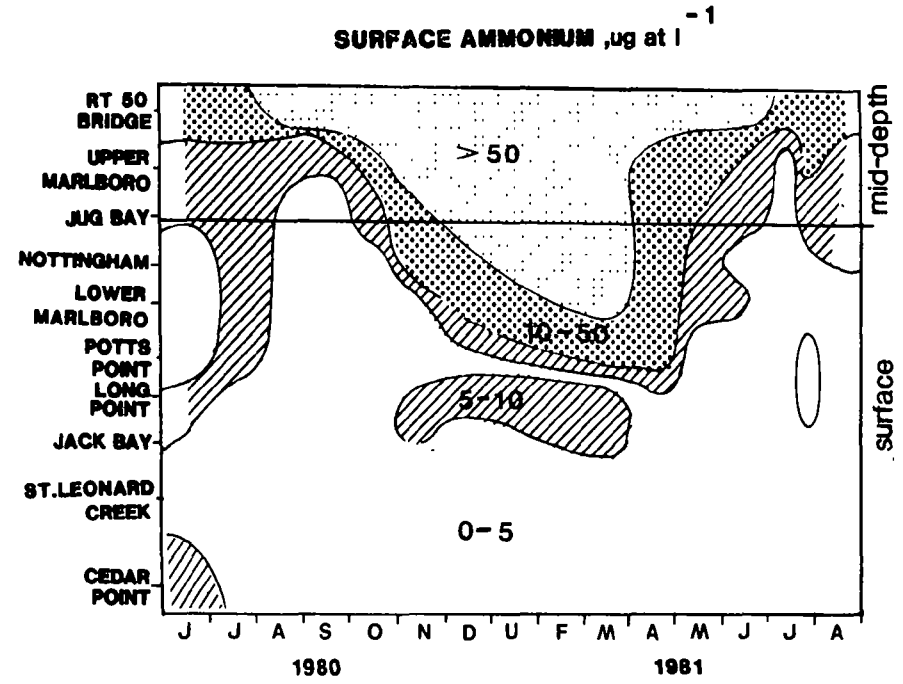
** Data collected by D'Elia, et. al., 1981 for this study.

Table 11-21 Summary Of Upper Patuxent Estuary Sediment Nutrient Fluxes, 1979-1980.**

* Station Date	Incubation Period (min) $\bar{X}$ S.D.	ug -at-m^2/hr, $\bar{X}$ + S.D. NO_3	NO_2	NH_4	DON	DIP	DOP
JP 7/27/79	198 ± 9	-145 ± 4	0.0 ± 0	637 ± 104	-255 ± 306	-8.2 ± 2.3	0.0 ± 0
PP 7/29/79	219 ± 10	8.2 ± 4.4	0.0 ± 0	693 ± 35	-284 ± 23	73.5 + 5.4	0.0 ± 0
BV 7/26/79	224 ± 10	18.8 ± 10.7	4.6 ± 8.0	297 ± 127	0.0 ± 0	25.2 ± 6.1	0.0 ± 0
MP 7/26/79	207 ± 10	42.5	5.6 ± 9.8	267 ± 35	--	15.8 ± 4.5	0.0 ± 0
JP 9/5/79	151 ± 5	-182.7 ± 25.6	3.6 ± 6.2	740 ± 120	--	-1.9 + 2.2	0.0 ± 0
PP 9/5/79	101 ± 16	-55.0 ± 42.3	-16.1 ± 3.5	730 ± 137	-327.9 + 222.1	65.1 ± 10.2	0.0 ± 0
BV 9/4/79	153 ± 4	21.5 ± 9.7	-69.5 ± 73.6	640 ± 211	-740 ± 81	38.1 ± 7.3	0.0 ± 0
MP 9/4/79	199 ± 5	0.0 ± 0	3.2 ± 4.6	333 ± 15	273 ± 107	62.1 ± 14.9	0.0 ± 0
JP 10/31/79	165 ± 32	-52.6 ± 37.6	0.0 ± 0	36 ± 7	145.7 ± 129.1	-1.8 ± 2.5	0.0 ± 0
PP 10/31/79	203 ± 8	-79.0 ± 28.7	0.0 ± 0	211 ± 83	-102.2 ± 14.4	4.8 ± 5.1	0.0 ± 0
BV 10/30/79	210 ± 7	-33.6	-10.8 ± 3.7	98 ± 12	0.0 ± 0	11.8 ± 12.7	0.0 ± 0
MP 10/30/79	209 ± 6	-33.6	-18.5 ± 3.4	56 ± 34	206.9 ± 181.3	6.3 ± 5.4	0.0 ± 0
JP 12/12/79	214 ± 6	254.9 ± 42.1	0.0 ± 0	60.8 ± 36.3	0.0 ± 0	-33.5 ± 53.5	0.0 ± 0
PP 12/12/79	257 ± 2	-149.8 ± 124.3	0.0 ± 0	128 ± 55	0.0 ± 0	7.2 ± 1.0	0.0 ± 0
BV 12/11/79	260 ± 6	-228.1 ± 52.7	-7.4 ± 0.4	21 ± 8	36.2 ± 131.5	-68.3 ± 4.2	0.0 ± 0
MP 12/11/79	201 ± 2	-26.8 ± 19.3	0.0 ± 0	53 ± 21	63.3 ± 109.6	-63.3 ± 5.7	0.0 ± 0
JP 3/5/80	191 ± 81	-491.9	-2.4 ± 4.2	10 ± 18	-1780.4 ± 1700.7	1.9 ± 10.5	0.0 ± 0
PP 2/29/80	292 ± 63	-26.0 ± 23.4	0.0 ± 0	103 ± 21	-93 ± 162	4.8 ± 4.2	0.0 ± 0
BV 2/28/80	241 ± 4	0.0 ± 0	0.0 ± 0	215 ± 61	--	0.0 ± 0	0.0 ± 0
MP 2/28/80	200 ± 9	0.0 ± 0	0.0 ± 0	53 ± 15	0.0 ± 0	0.0 ± 0	0.0 ± 0
JP 5/23/80	196 ± 1	--	3.4 ± 5.8	253 ± 211	0.0 ± 0	--	0.0 ± 0
PP 5/23/80	214 ± 1	-127.9 ± 14.9	0.0 ± 0	225 ± 88	-75.5 ± 130.8	16.2 ± 4.2	0.0 ± 0
BV 5/22/80	228 ± 3	-16.2 ± 3.4	0.0 ± 0	275 ± 61	-236.1 ± 284.6	12.1 ± 0.8	0.0 ± 0
MP 5/22/80	253 ± 3	0.0 ± 0	0.0	78 ± 16	-244.5 ± 345.8	0.0 ± 0	0.0 ± 0

* JP = Jones Point; PP = Potts Point; BR = Buena Vista; MP = Marsh Point

**by Boynton, et. al., 1981, reported in D'Elia et. al., 1981 for this study



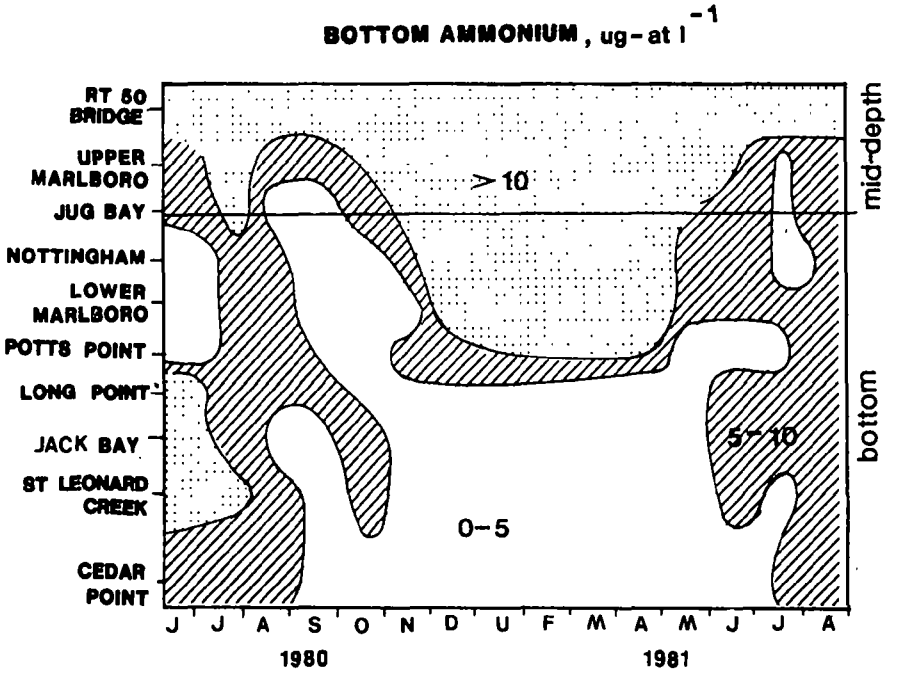
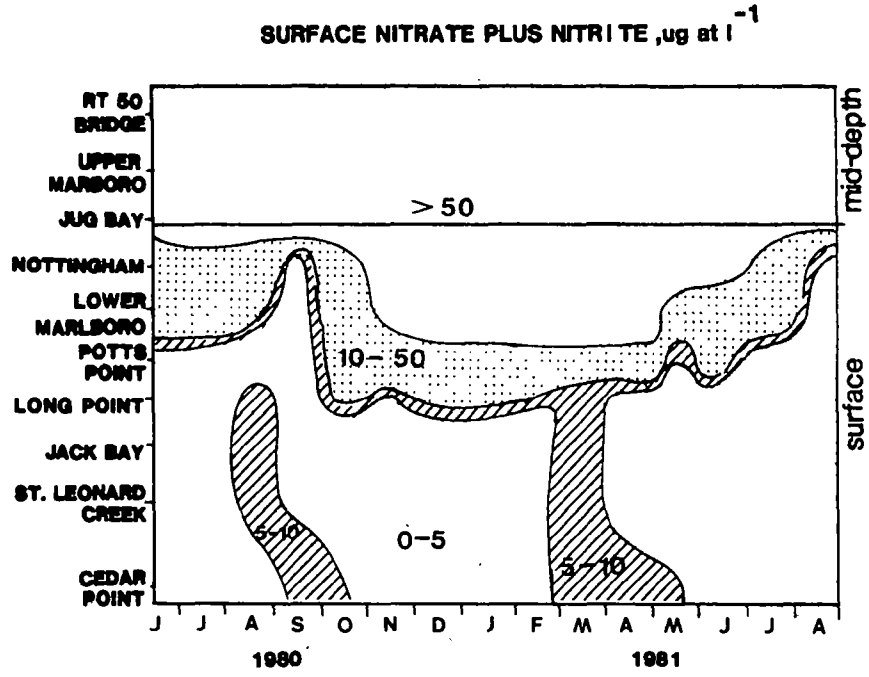


Figure 11-65 Space-time domain plot of surface and bottom ammonium in Patuxent River, 1980-1981.



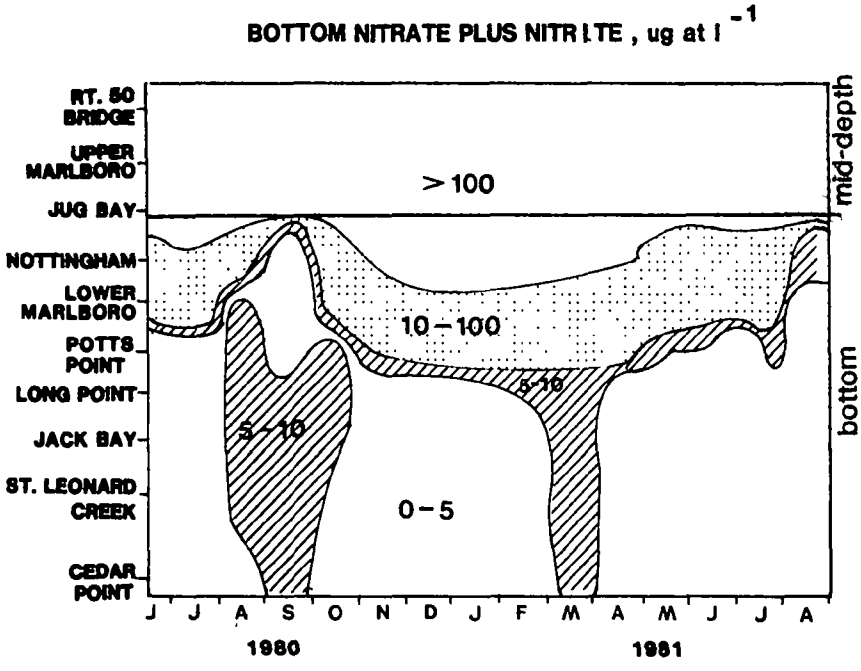


Figure 11-66 Space-time domain plot of surface and bottom nitrate in Patuxent River 1980-1981.(16)

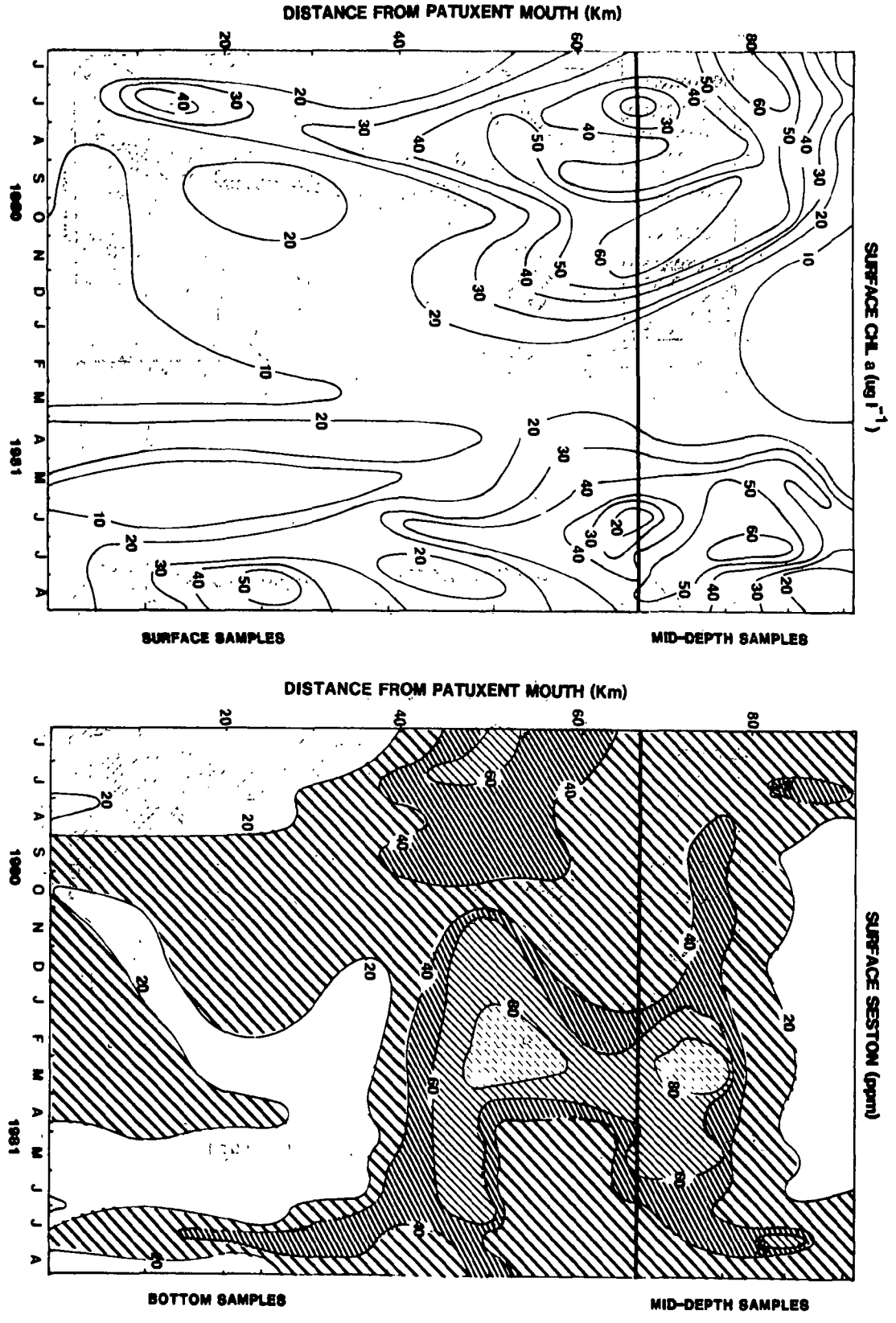


Figure 11-67 Space time domain plot of surface chlorophyll-a and seston in Patuxent River, 1980-1981.

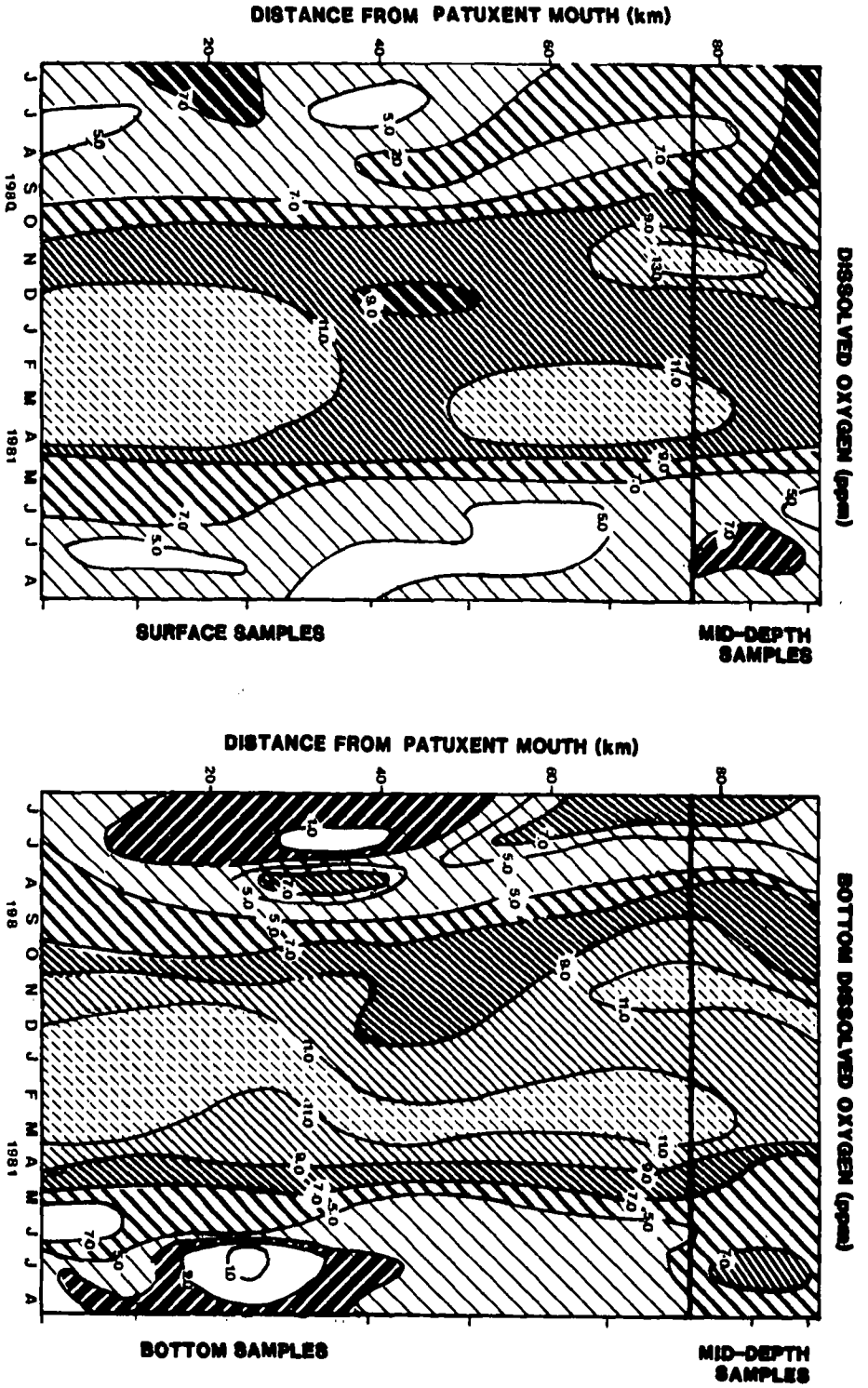


Figure 11-68 Space-time domain plot of surface and bottom dissolved oxygen in Patuxent River, 1980-1981.

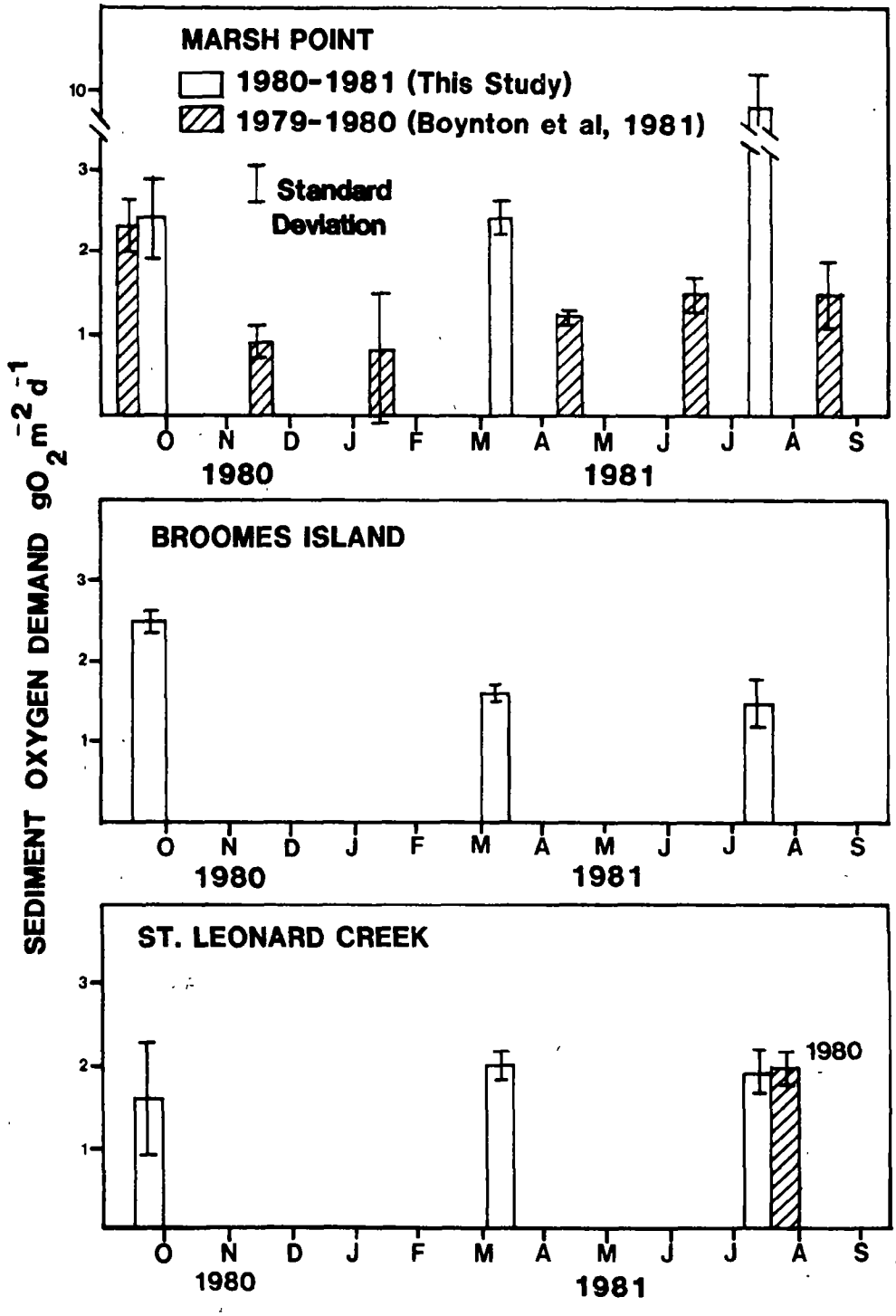
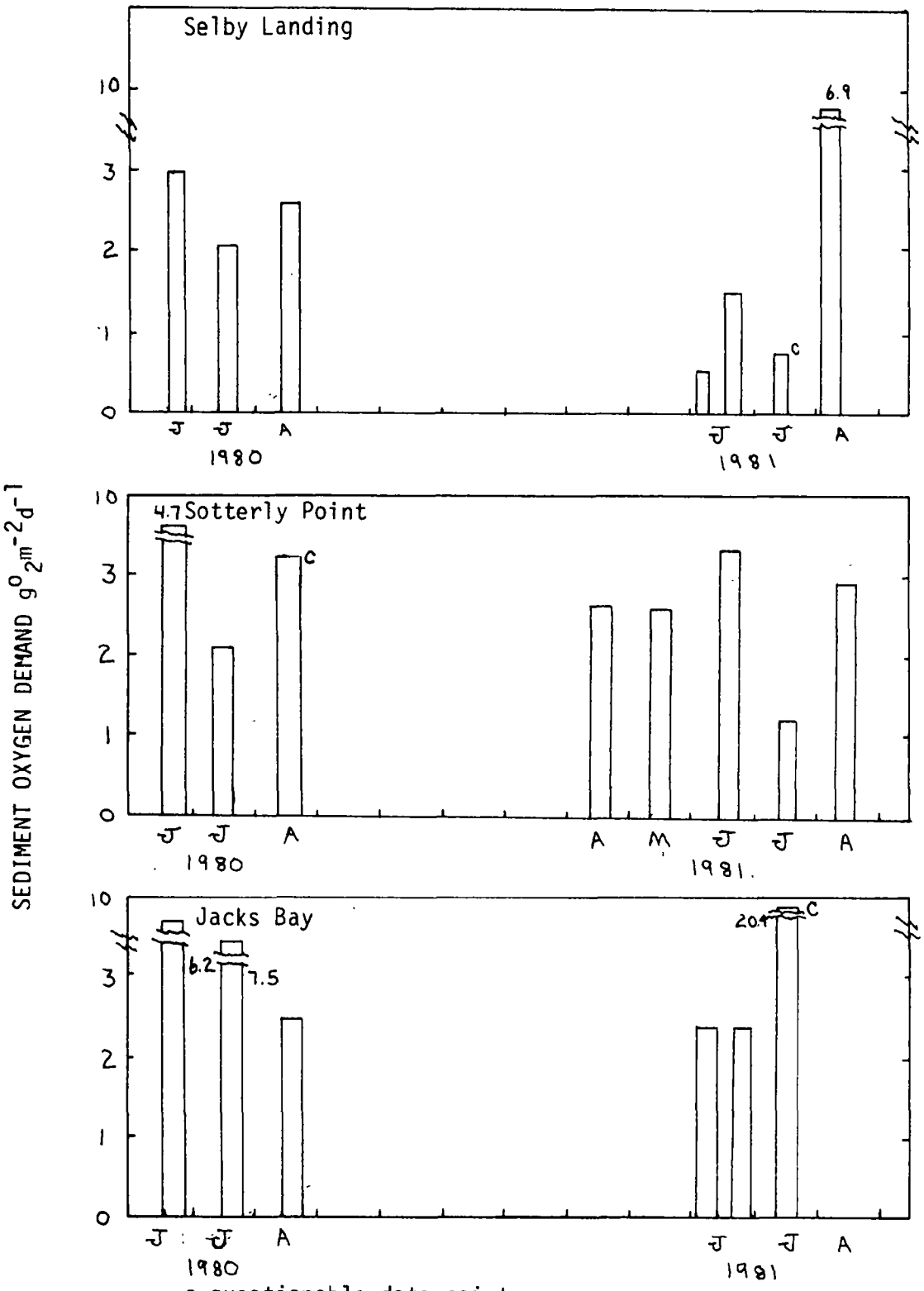


Figure 11-69 Sediment oxygen demand in the Patuxent Estuary, data collected by D'Elia, et. al., 1981.(16)



c-questionable data points

Figure 11-70 Sediment oxygen demand in the Patuxent estuary during 1980-1981 at Jacks Bay, Sotterly Point and Selby Landing, data collected by Biospherics, Inc., 1981.

Table 11-22 Benthic Respiration in The Patuxent River 1980-1981

Date	STATION						
	Selby Landing (b)	Marsh Point (d)	Jacks Bay (b)	Broomes Island (d)	St. Leonards Creek (d)	Sotterly Point (b)	Avg.
6/24/80	0.123	--	0.257	--	--	0.197	0.192 ± 0.055
7/18/80	0.089	--	0.314	--	--	0.084	0.162 ± 0.107
8/19/80	0.110	--	0.107	--	--	0.136 (c)	0.118 ± 0.013
10/-/80	--	0.099 ± 0.022	--	0.105 ± 0.007 (a)	0.061 ± 0.012	--	0.088 ± 0.019
4/-/81	--	0.100 ± 0.007	--	0.066 ± 0.004	0.084 ± 0.006	--	0.083 ± 0.006
4/28/81	--	--	--	--	--	0.110	0.110
5/29/81	--	--	--	--	--	0.110	0.110
6/03/81	0.020	--	0.100	--	--	--	0.06 ± 0.04
6/26/81	0.064	--	--	--	--	--	0.064
6/30/81	--	--	0.100	--	--	0.140	0.12 ± 0.02

Table 11-22 (Continued) Benthic Respiration In The Patuxent River 1980-1981

Date	STATION						
	Selby Landing (b)	Marsh Point (d)	Jacks Bay (b)	Broomes Island (d)	St. Leonards Creek (d)	Sotterly Point (b)	Avg.
7/17/81	.028 (c)	--	--	--	--	--	0.028
7/24/81	--	--	0.850 (c)	--	--	0.042	0.446 ± 0.404
8/05/81	.289	--	--	--	--	--	0.289
8/07/81	--	0.065	--	--	--	--	0.065
8/19/81	--	--	--	--	--	0.120	0.120
8/--/81	--	0.404 ± 0.015	--	0.061 ± 0.012	-0.079 ± 0.012	--	0.129 ± 0.013

c - questionable data points reported

a - represents average observed at the station

b - Biospherics data

d - University of Maryland data

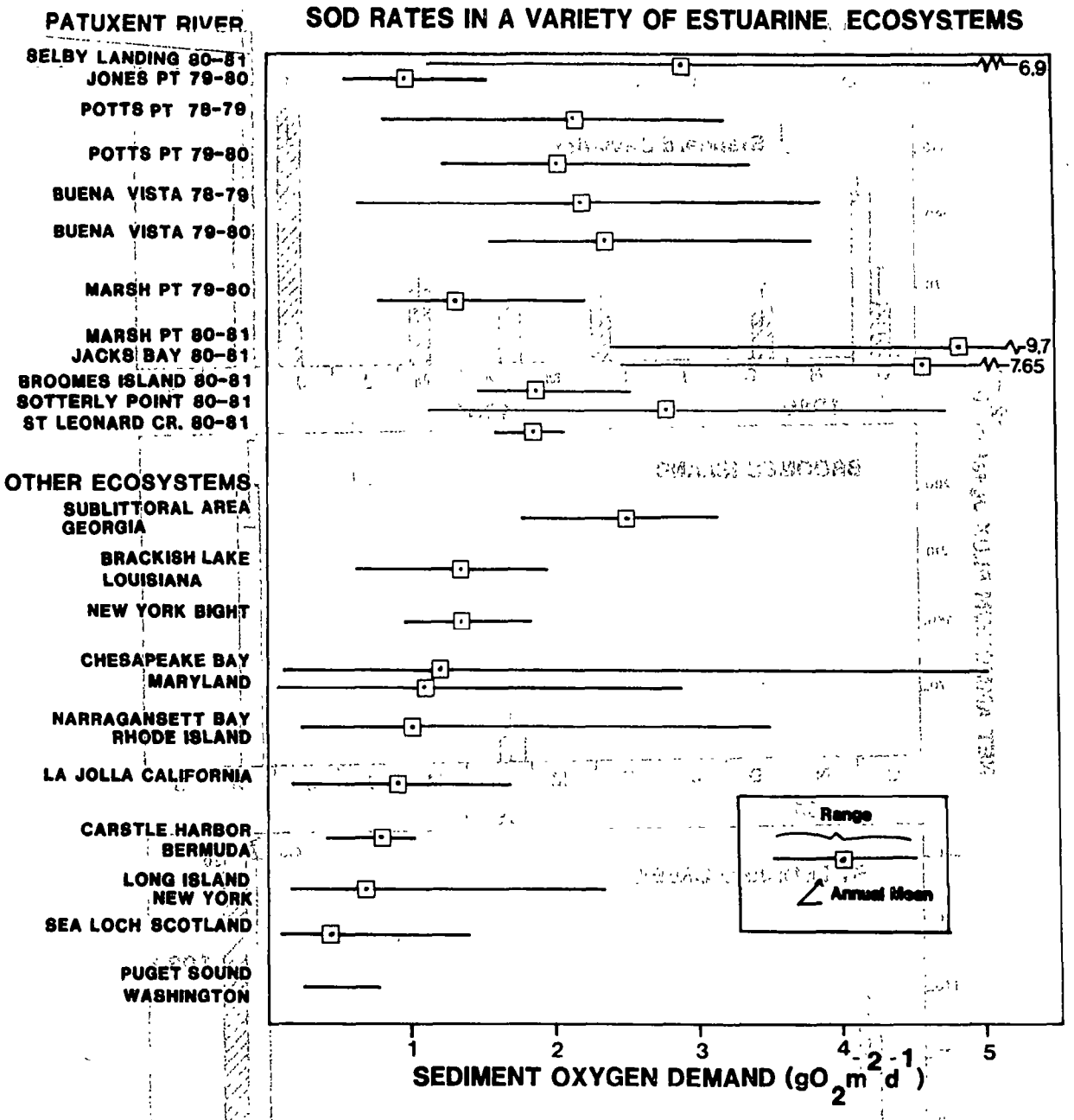


Figure11-71 Sediment Oxygen Demand rates in estuarine ecosystems, compiled by D'Elia, et. al., 1981. (16)

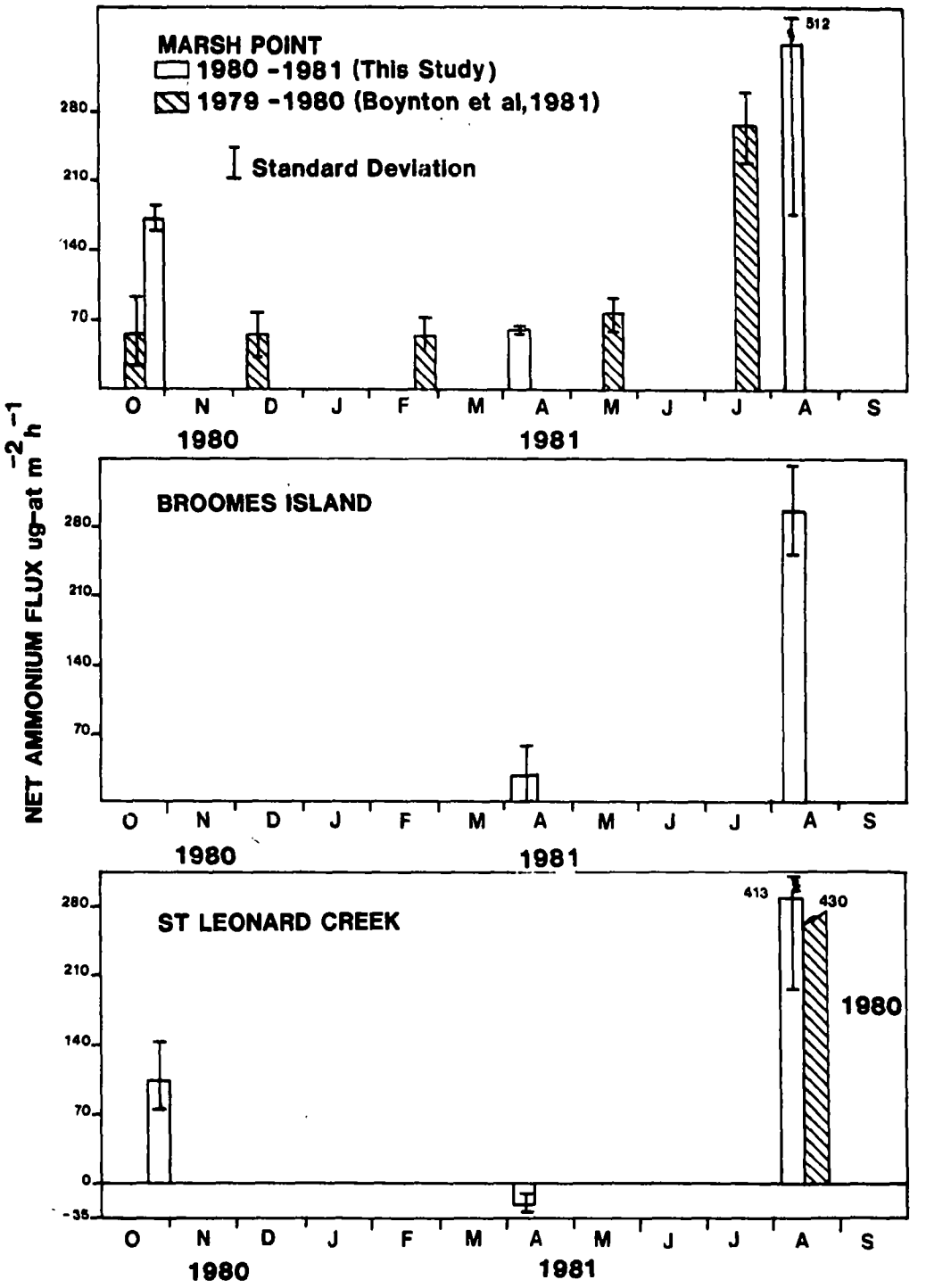


Figure11-72 Patuxent Estuary ammonium flux from bottom sediments. Data collected by D'Elia, et. al., 1981.(16)

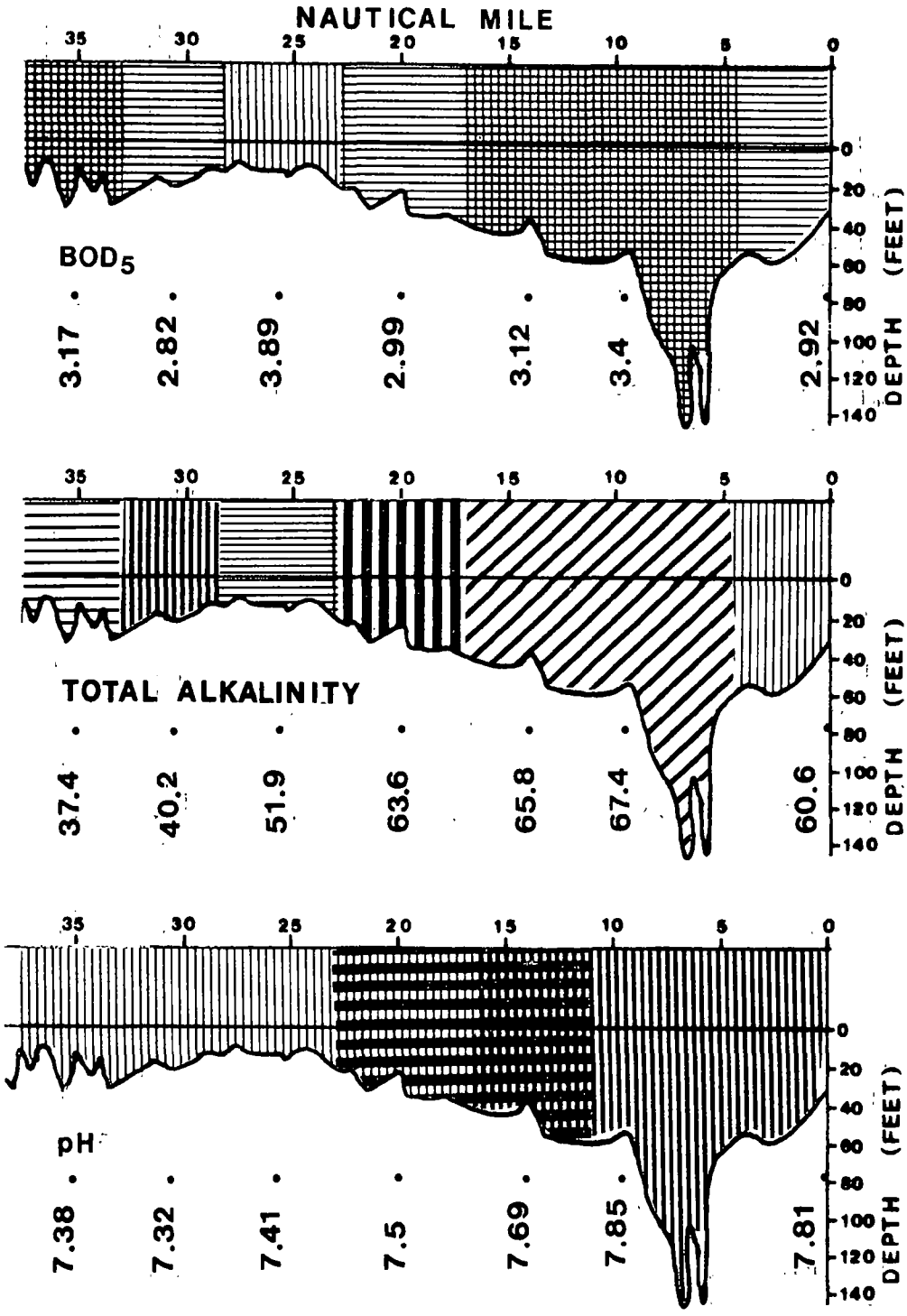


Figure 11-73 Patuxent River longitudinal characterization of 1980-1981 data for BOD5 (mg/l), alkalinity (mg/l), and pH, surface station data.

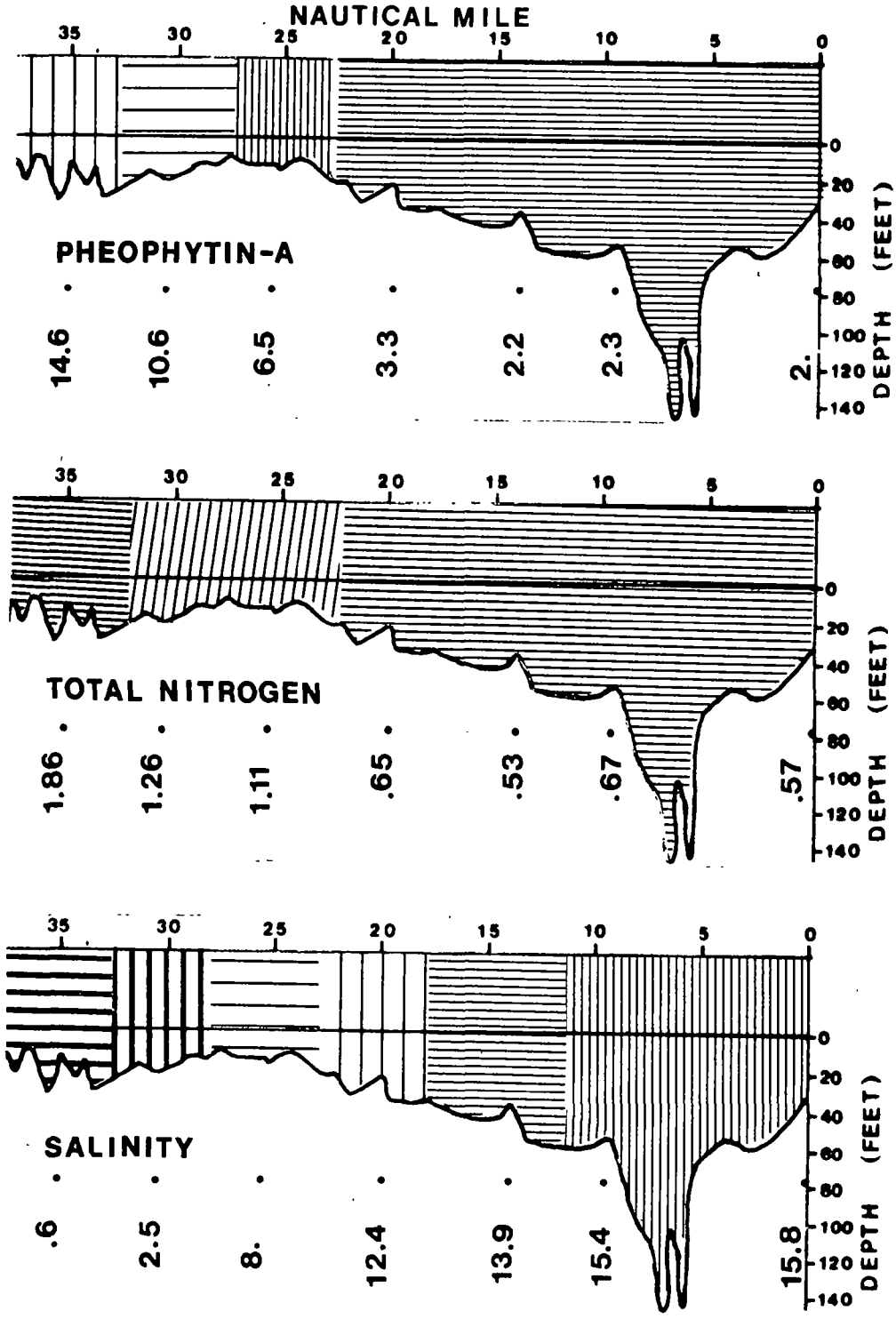


Figure 11-74 Patuxent River longitudinal characterization of 1980-1981 data for pheophytin-a (ug/l), total nitrogen (mg/l), and salinity (ppt), surface station data.

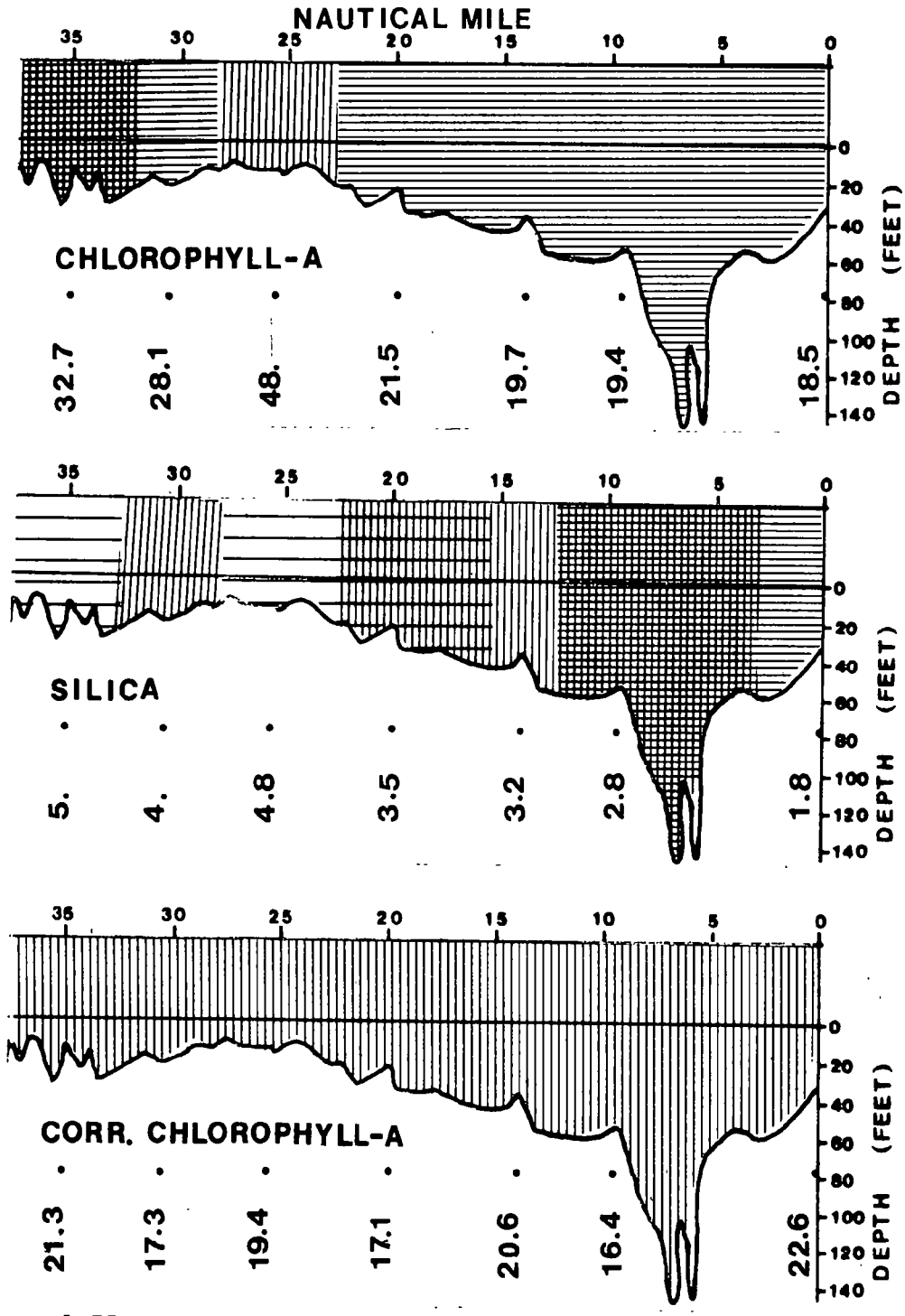


Figure 11-75 Patuxent River longitudinal characterization of 1980-1981 data for chlorophyll-a (ug/l), dissolved reactive silica (mg/l), and corrected chlorophyll-a (ug/l), surface station data.

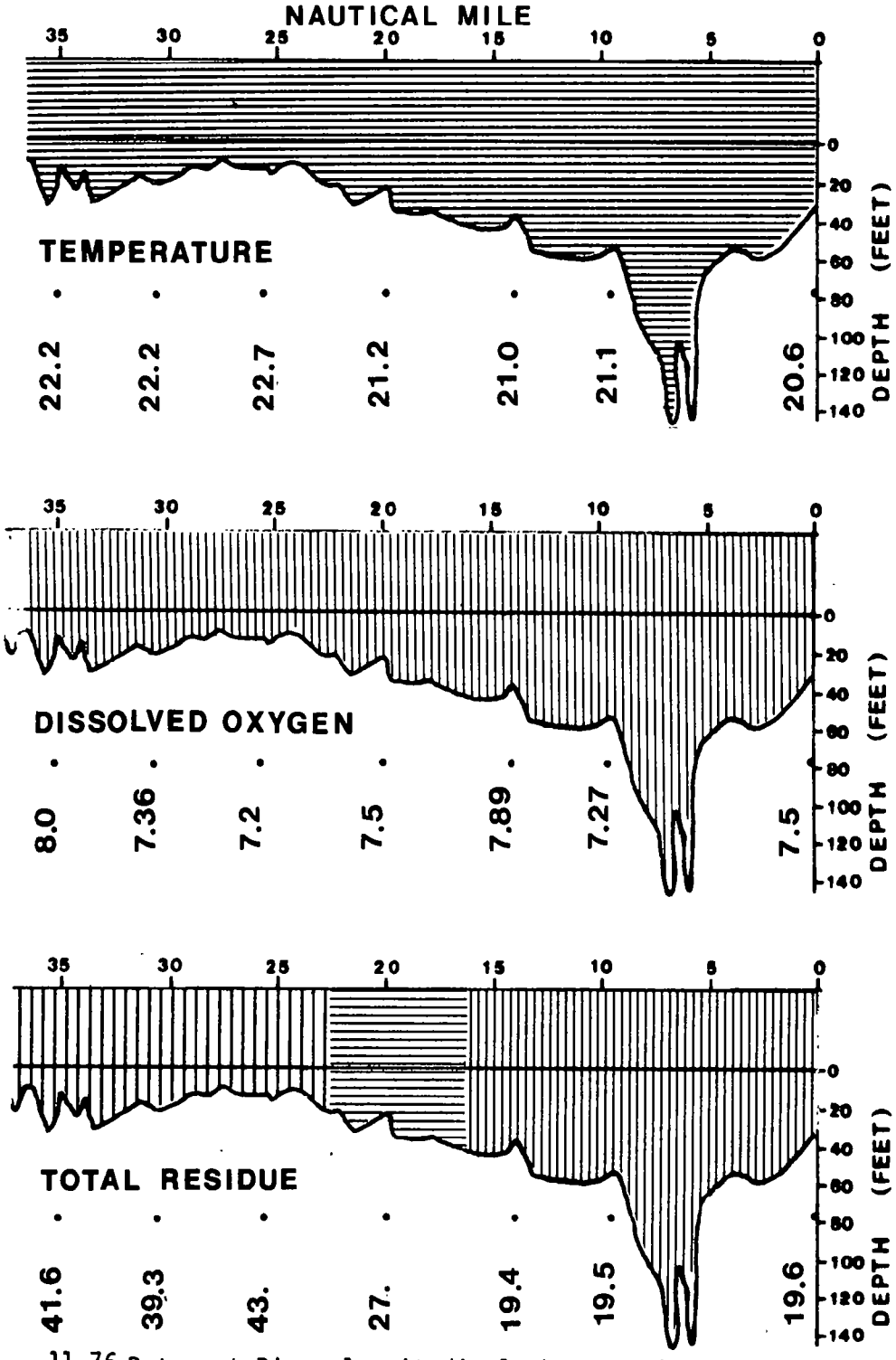


Figure 11-76 Patuxent River longitudinal characterization of 1980-1981 data for temperature (°C), dissolved oxygen (mg/l), and total nonfilterable residue (mg/l), surface station data.

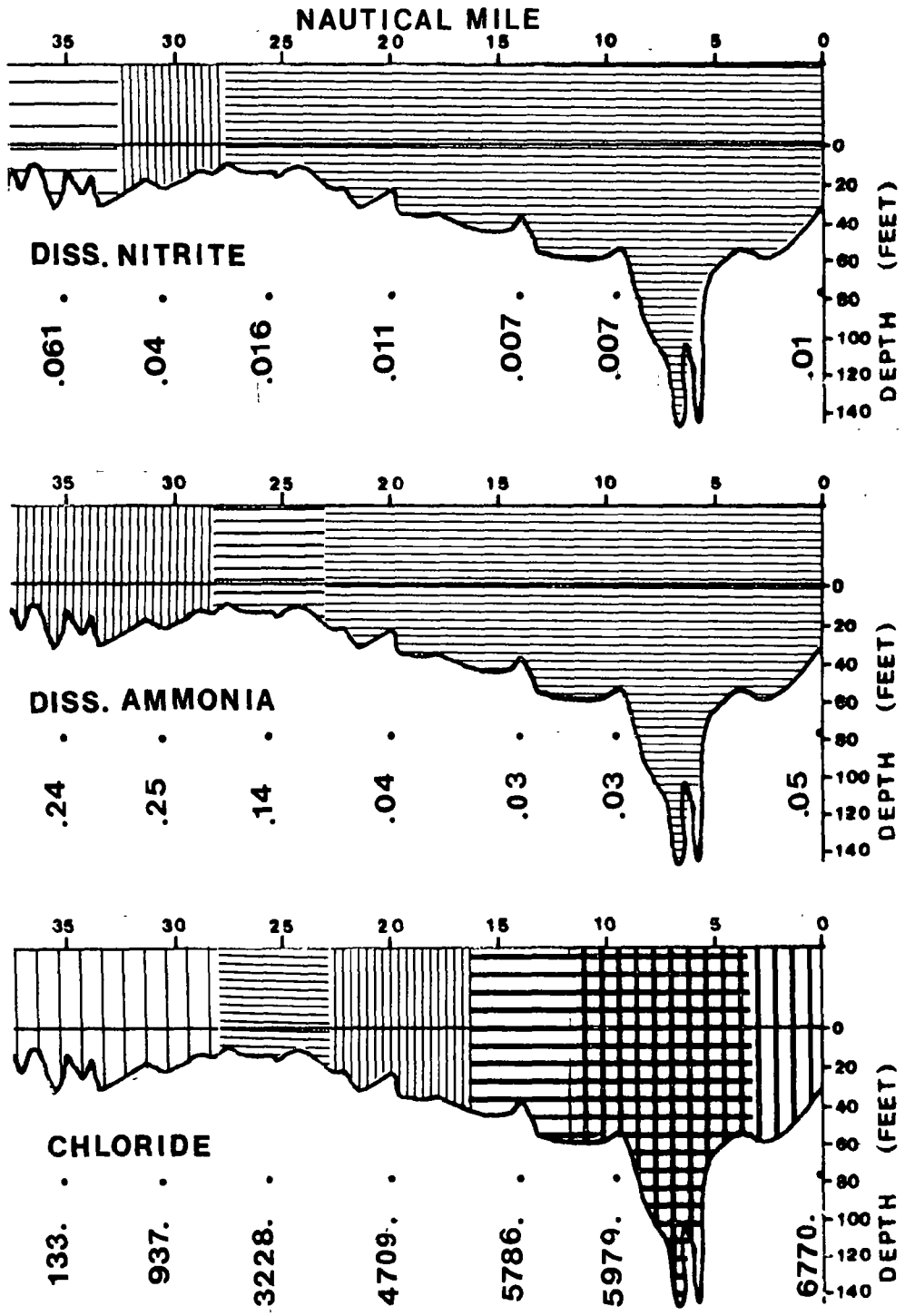


Figure 11-77 Patuxent River longitudinal characterization of 1980-1981 data for dissolved nitrite (mg/l), dissolved ammonia (mg/l), and chlorides (mg/l), surface station data.

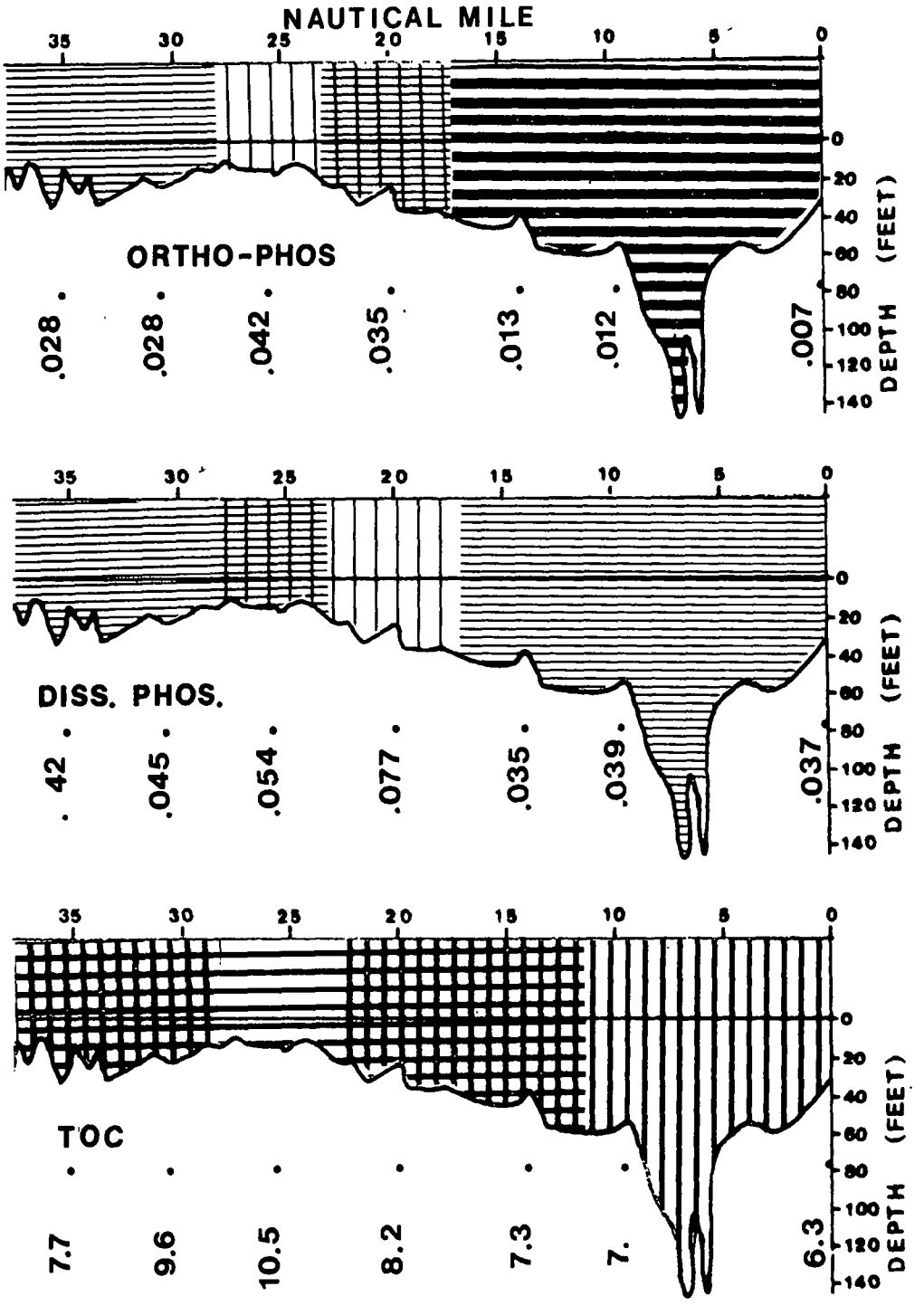


Figure 11-78 Patuxent River longitudinal characterization of 1980-1981 data for dissolved ortho-phosphorus (mg/l), dissolved phosphorus (mg/l), and total organic carbon (mg/l), surface station data.

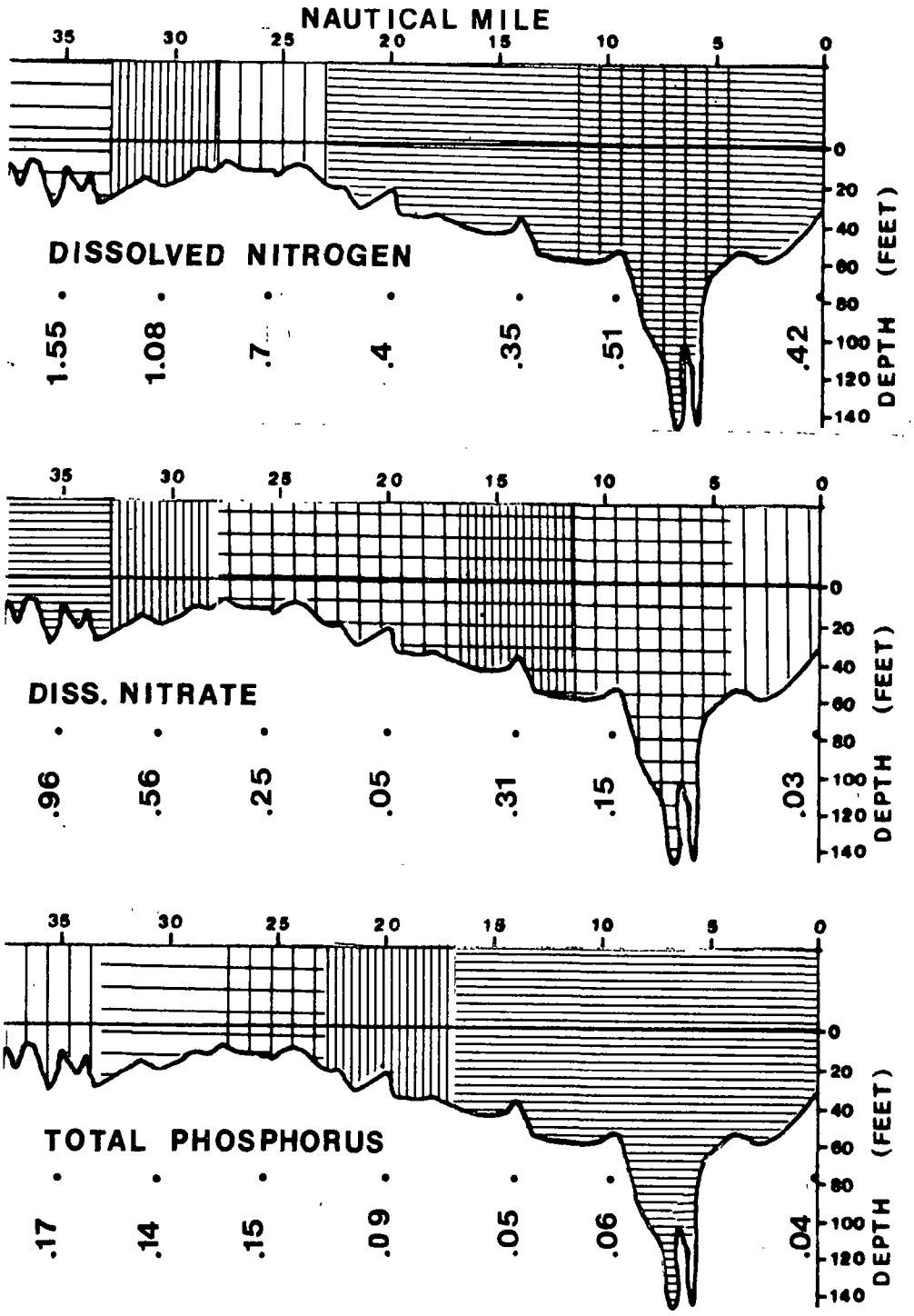


Figure 11-79 Patuxent River longitudinal characterization of 1980-1981 data for total dissolved nitrogen (mg/l), dissolved nitrate (mg/l), and phosphorus (mg/l), surface station data.

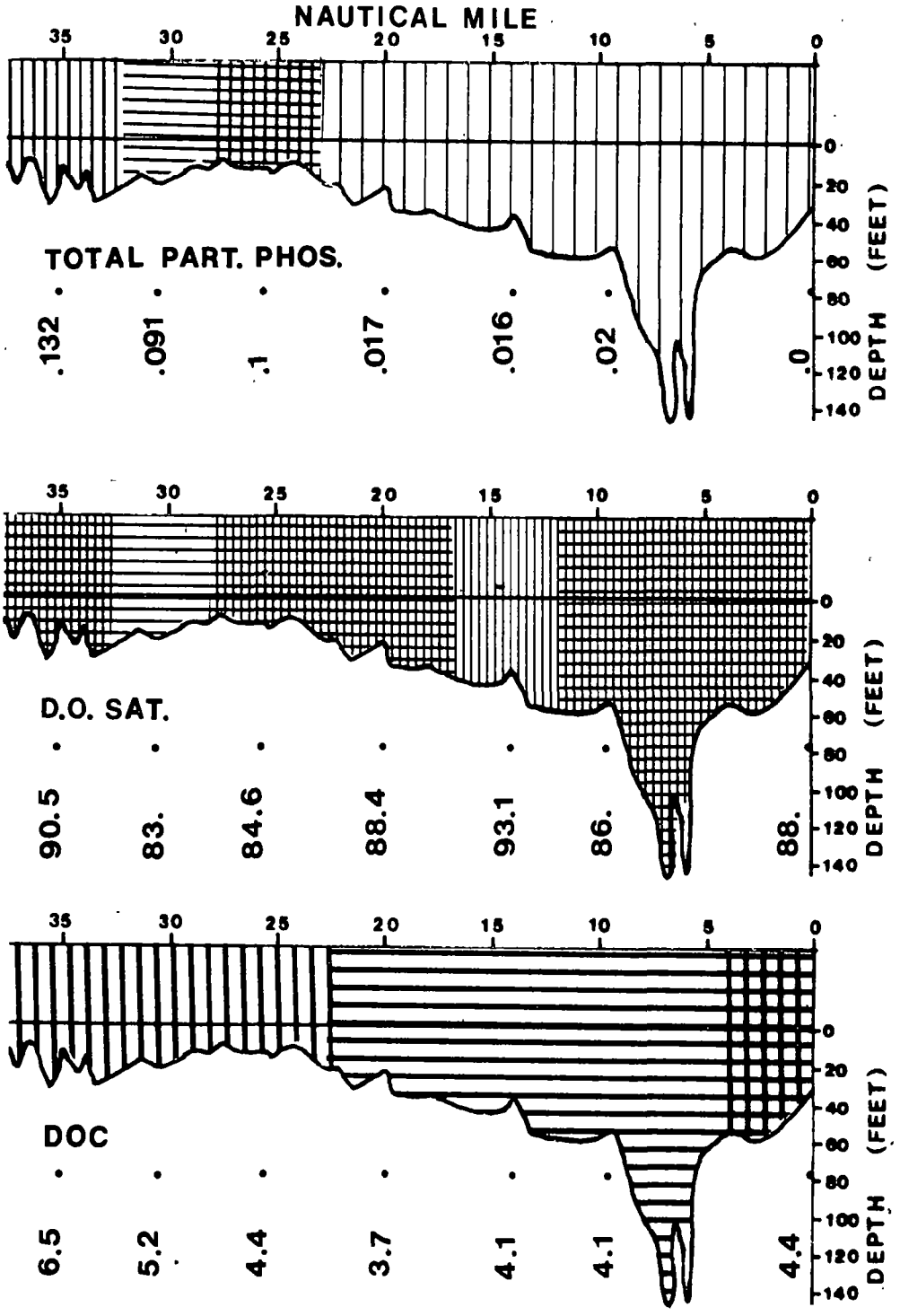


Figure 11-80 Patuxent River longitudinal characterization of 1980-1981 data for total particulate phosphorus (mg/l), dissolved oxygen saturation (%), and dissolved organic carbon (mg/l), surface station data.

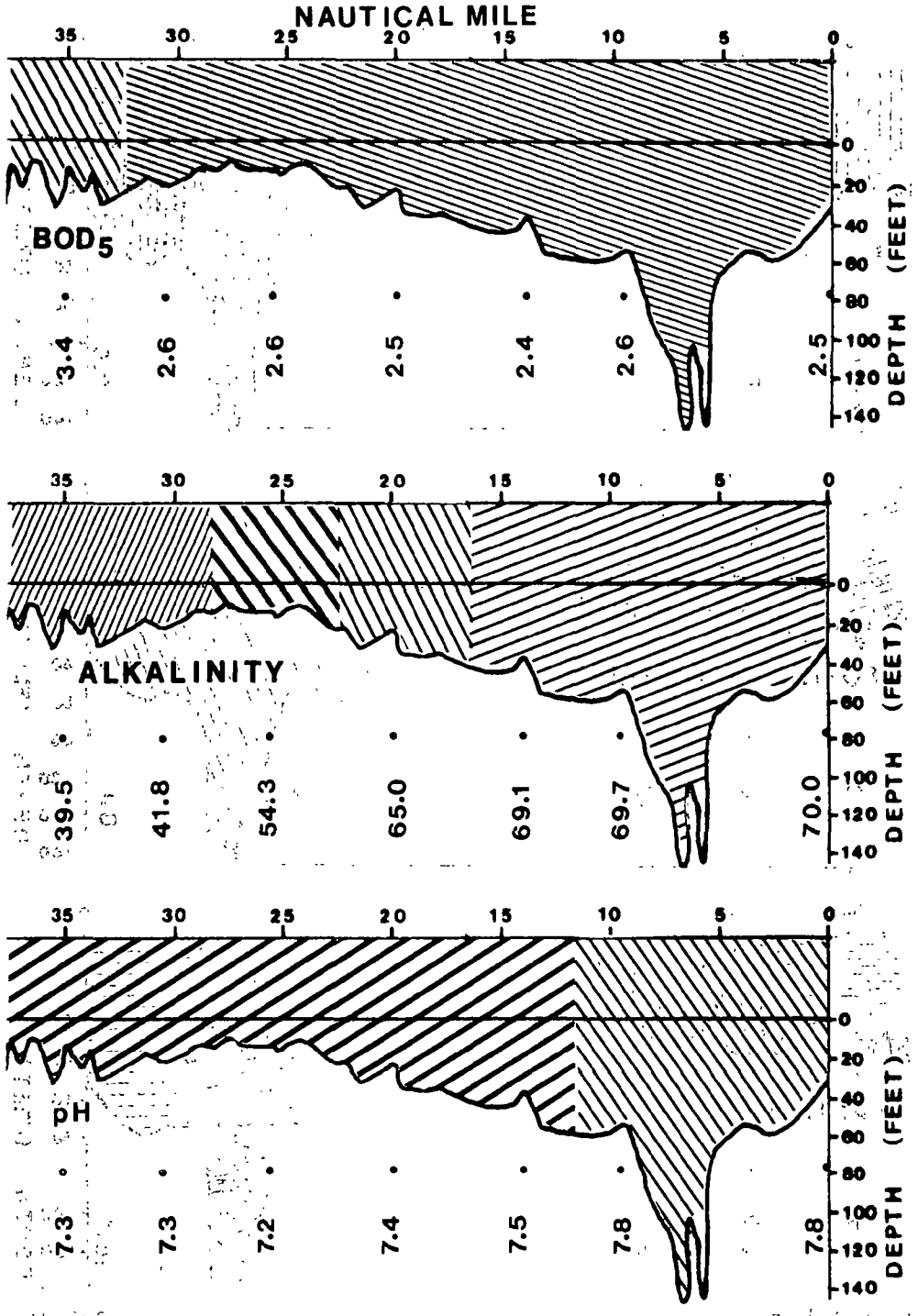


Figure 11-81 Patuxent River longitudinal characterization of 1980-1981 data for BOD5 (mg/l), alkalinity (mg/l), and pH, bottom depth station data.

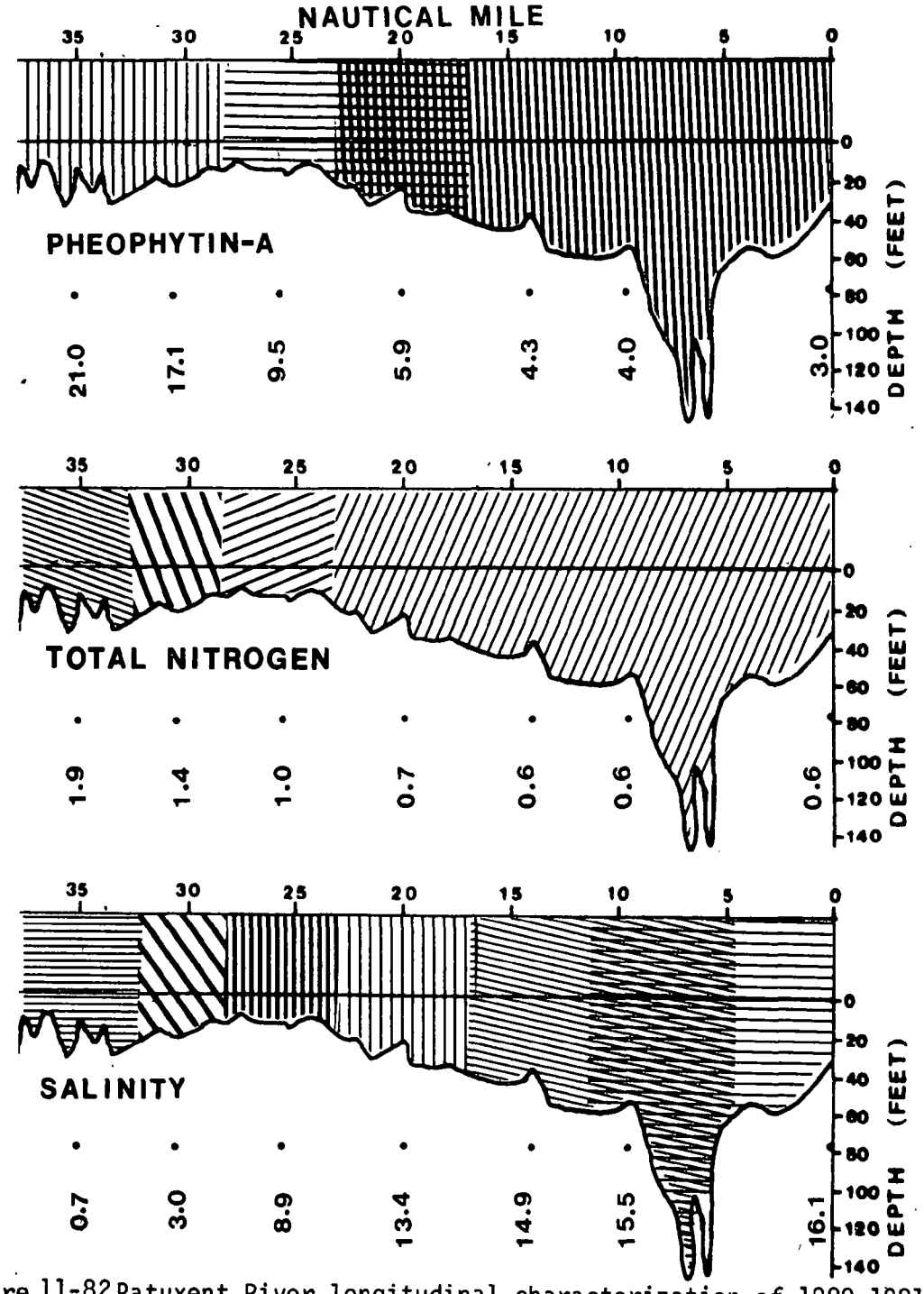


Figure 11-82 Patuxent River longitudinal characterization of 1980-1981 data for pheophytin-a (ug/l), total nitrogen (mg/l), and salinity (ppt), bottom depth station data.

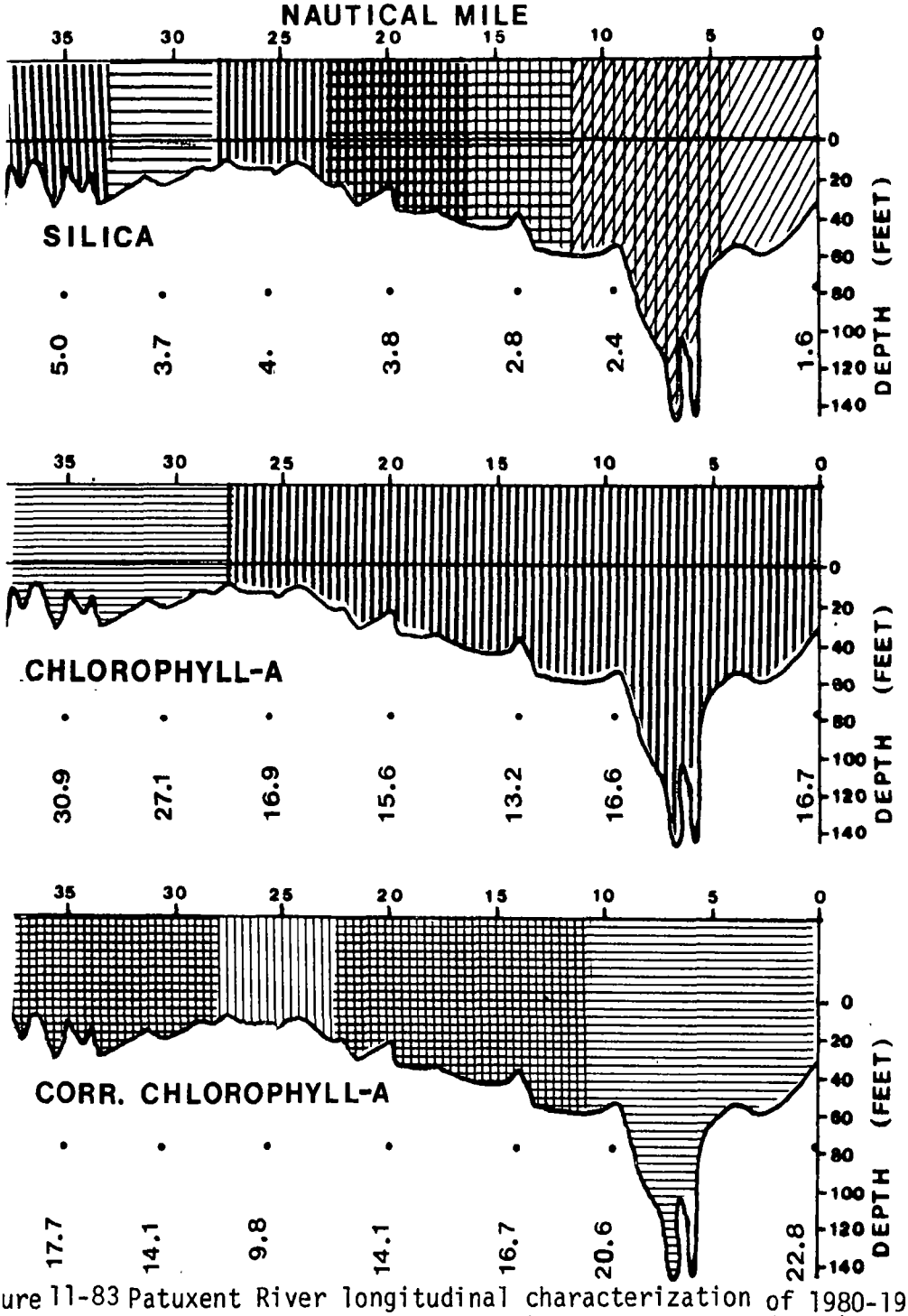


Figure 11-83 Patuxent River longitudinal characterization of 1980-1981 data for dissolved reactive silica (mg/l), chlorophyll-a (ug/l), and corrected chlorophyll-a (ug/l), bottom depth station data.

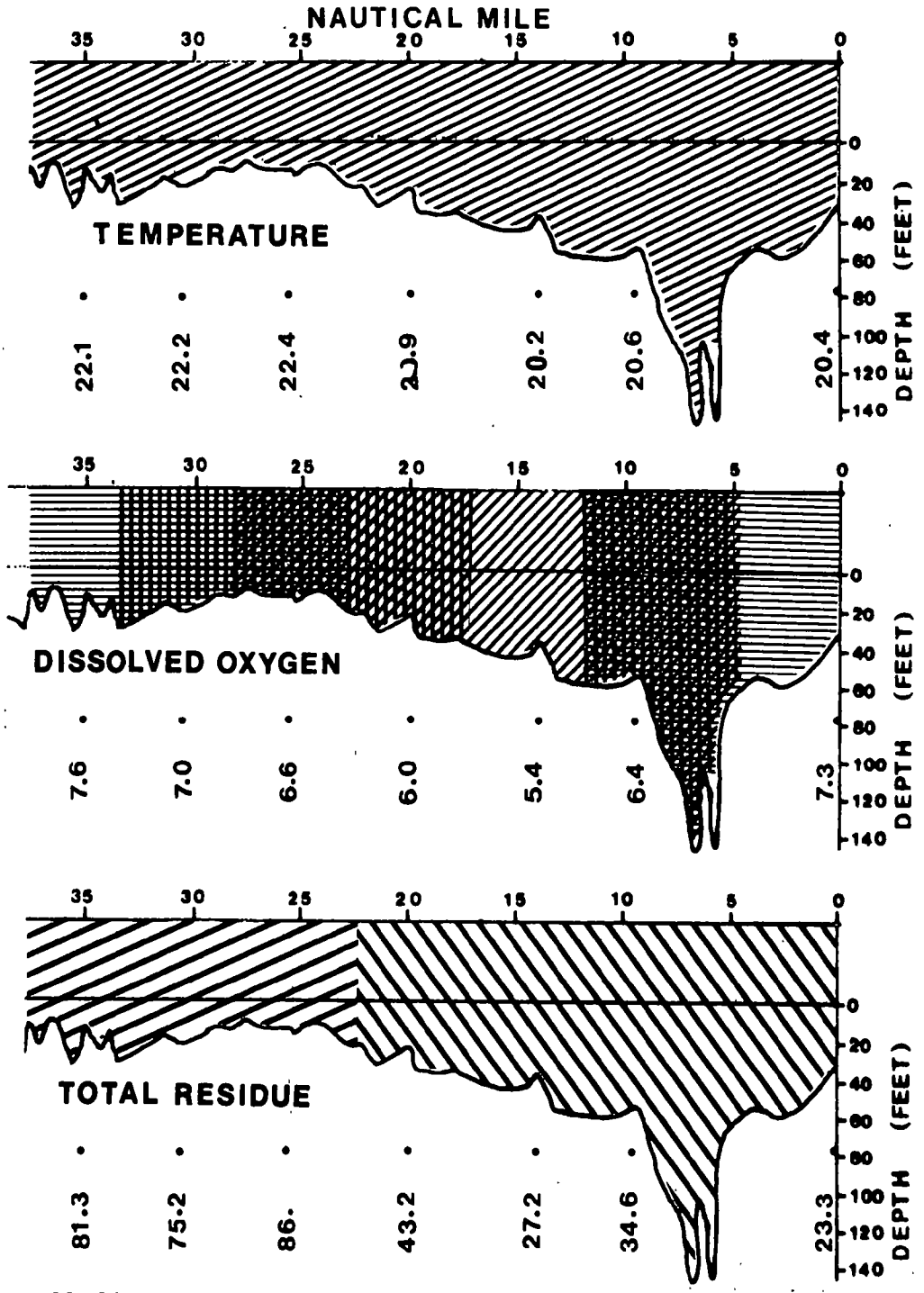


Figure 11-84 Patuxent River longitudinal characterization of 1980-1981 data for temperature (°C), dissolved oxygen (mg/l), and total nonfilterable residue (mg/l), bottom depth station data.

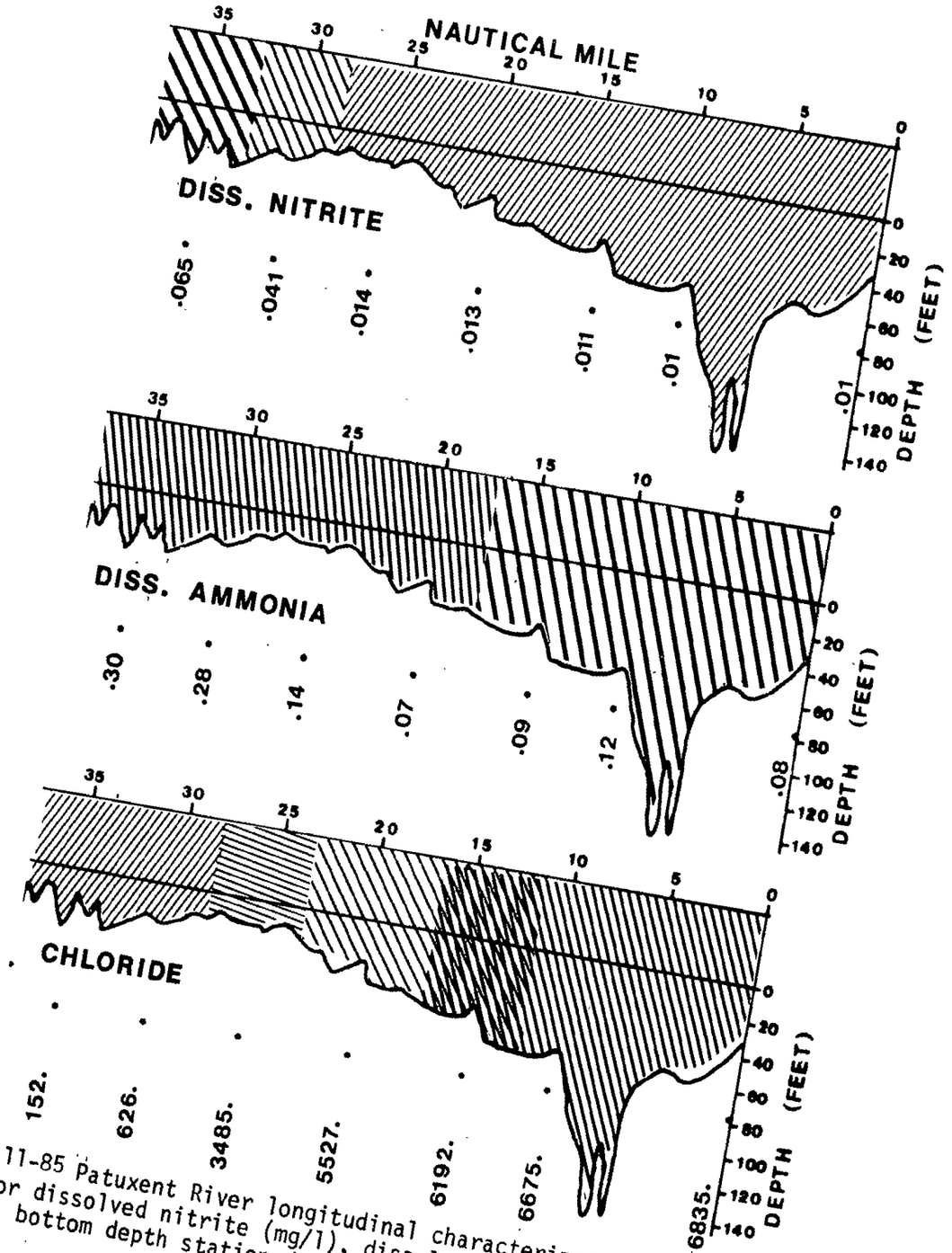


Figure 11-85 Patuxent River longitudinal characterization of 1980-1981 data for dissolved nitrite (mg/l), dissolved ammonia (mg/l), and chlorides (mg/l), bottom depth station data.

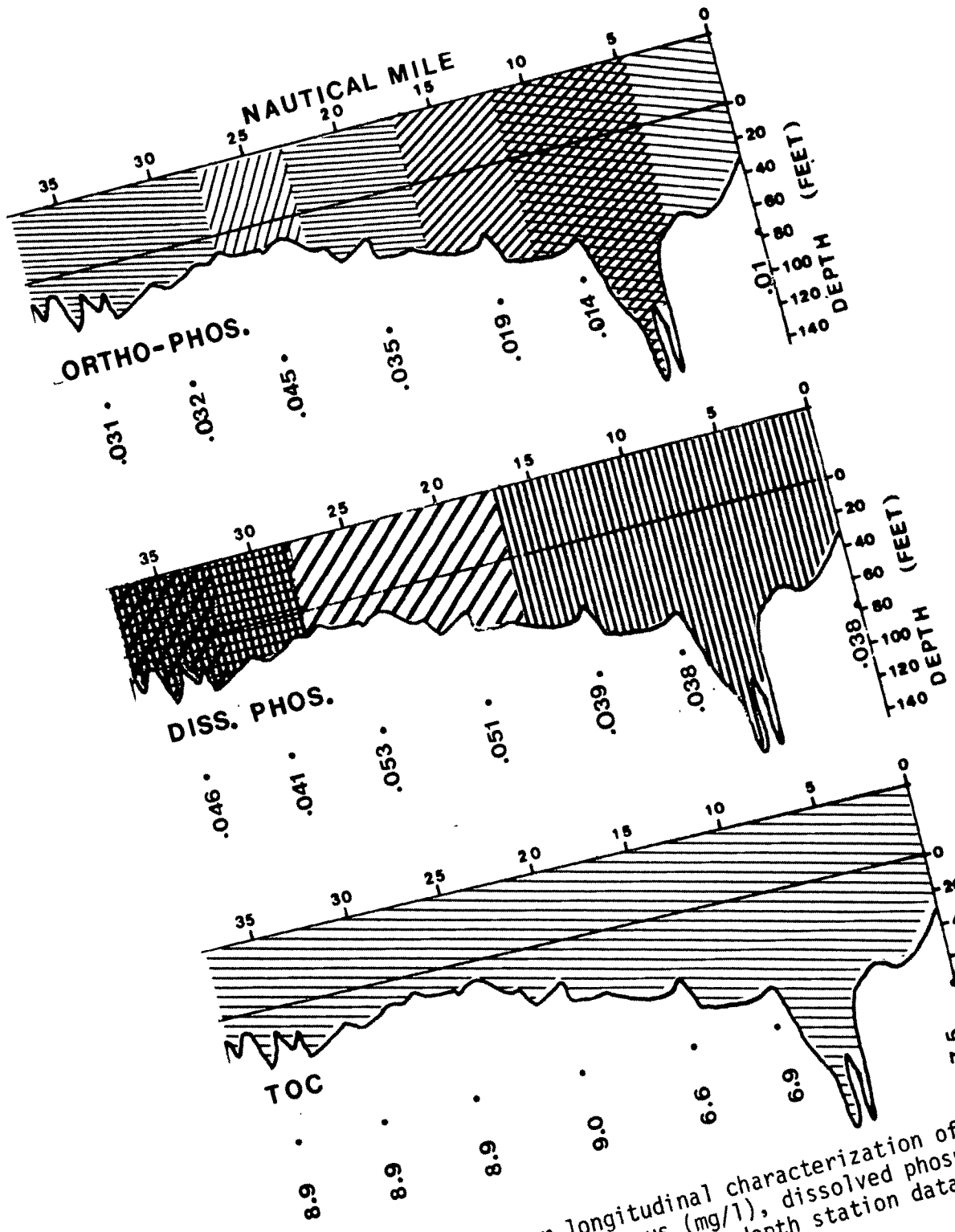


Figure 11-86 Patuxent River longitudinal characterization of 1980-1981 data for dissolved ortho-phosphorus (mg/l), dissolved phosphorus (mg/l), and total organic carbon (mg/l), bottom depth station data.

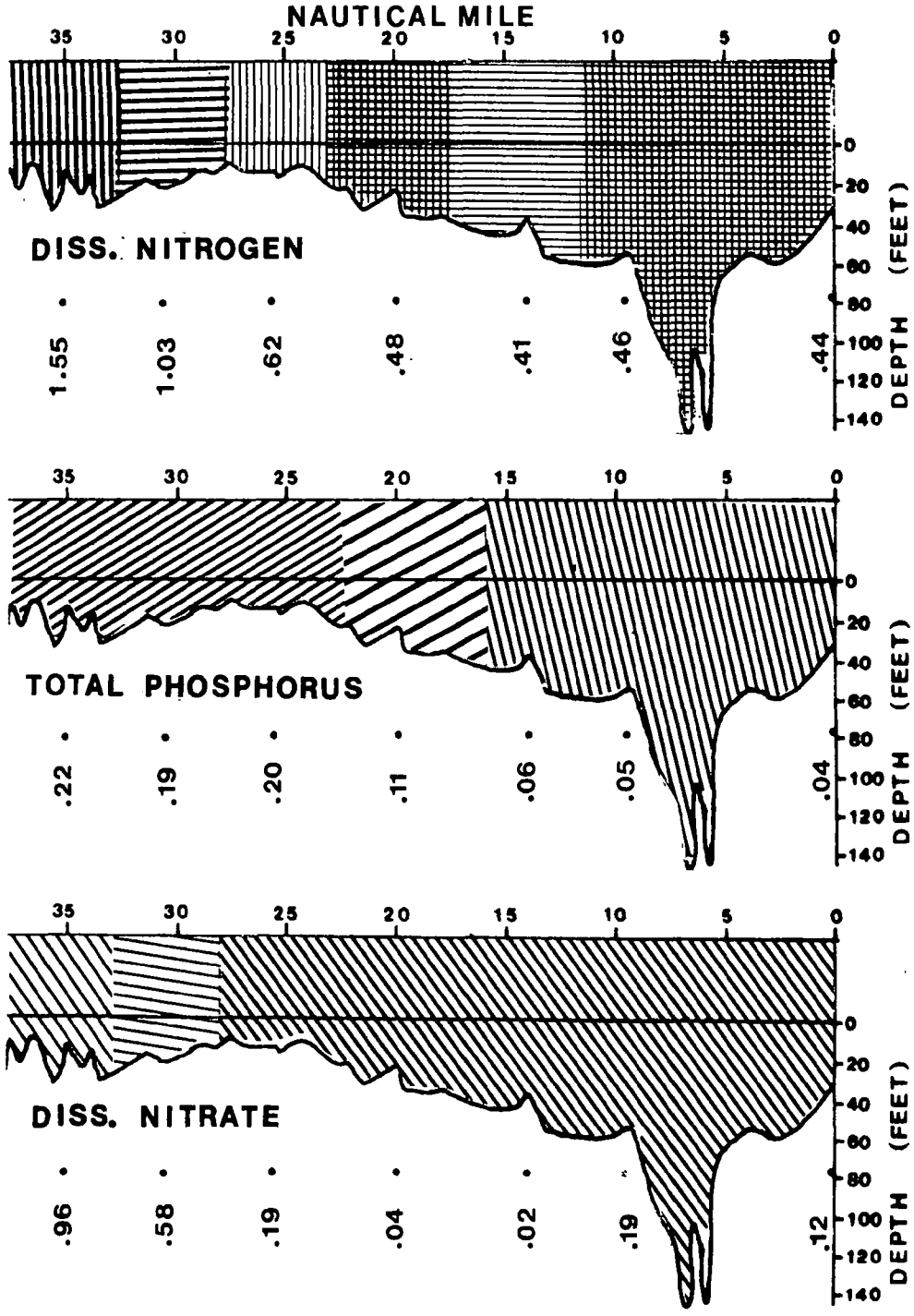


Figure 11-87 Patuxent River longitudinal characterization of 1980-1981 data for total dissolved nitrogen (mg/l), total phosphorus (mg/l) and dissolved nitrate (mg/l), bottom depth station data.

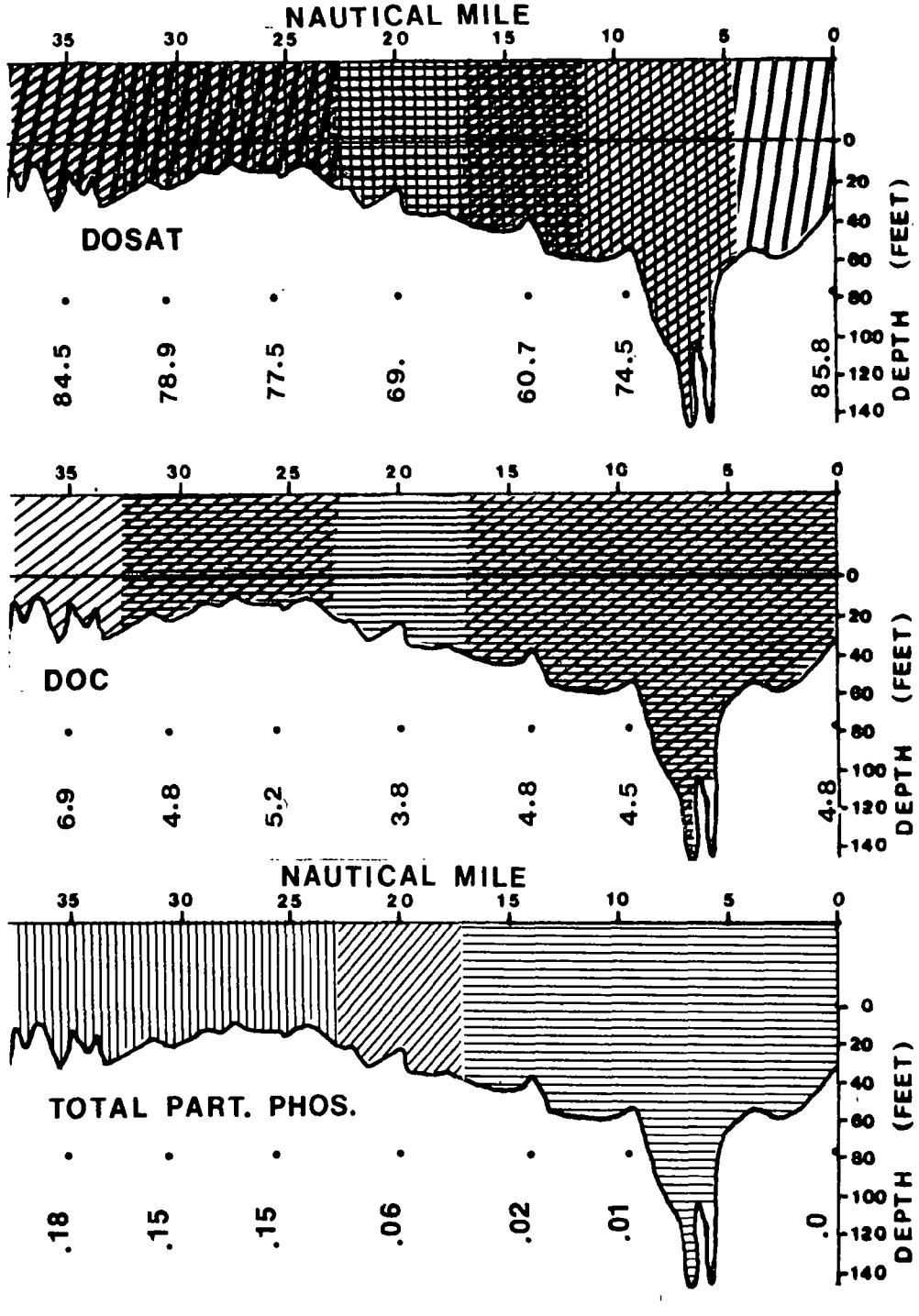


Figure 11-88 Patuxent River longitudinal characterization of 1980-1981 data for dissolved oxygen saturation (%), dissolved organic carbon (mg/l), and total particulate phosphorus (mg/l), bottom depth station data.

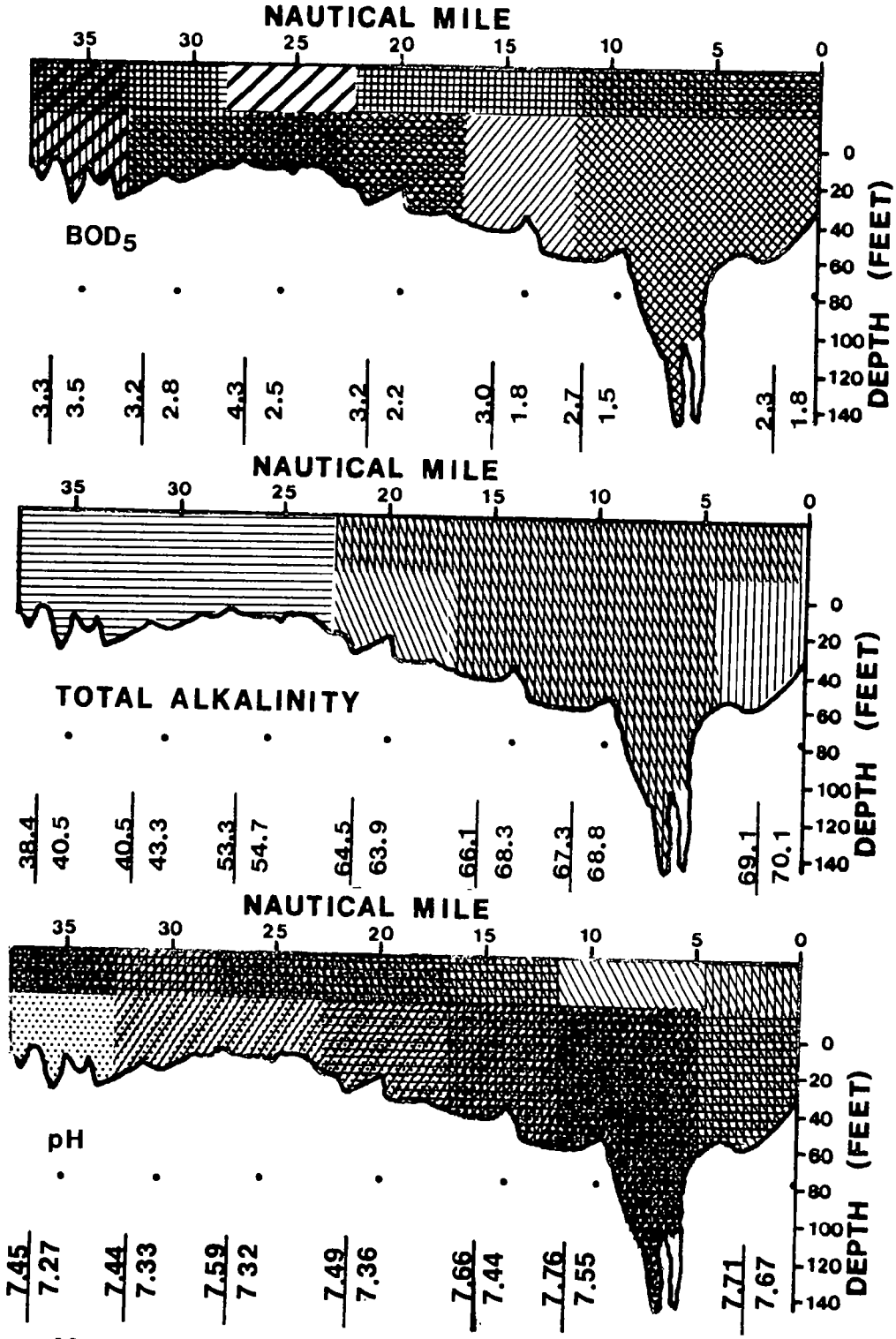


Figure 11-89 Patuxent River longitudinal characterization of 1980-1981 data for BOD5 (mg/l), alkalinity (mg/l), and pH, using surface and bottom depth station data.

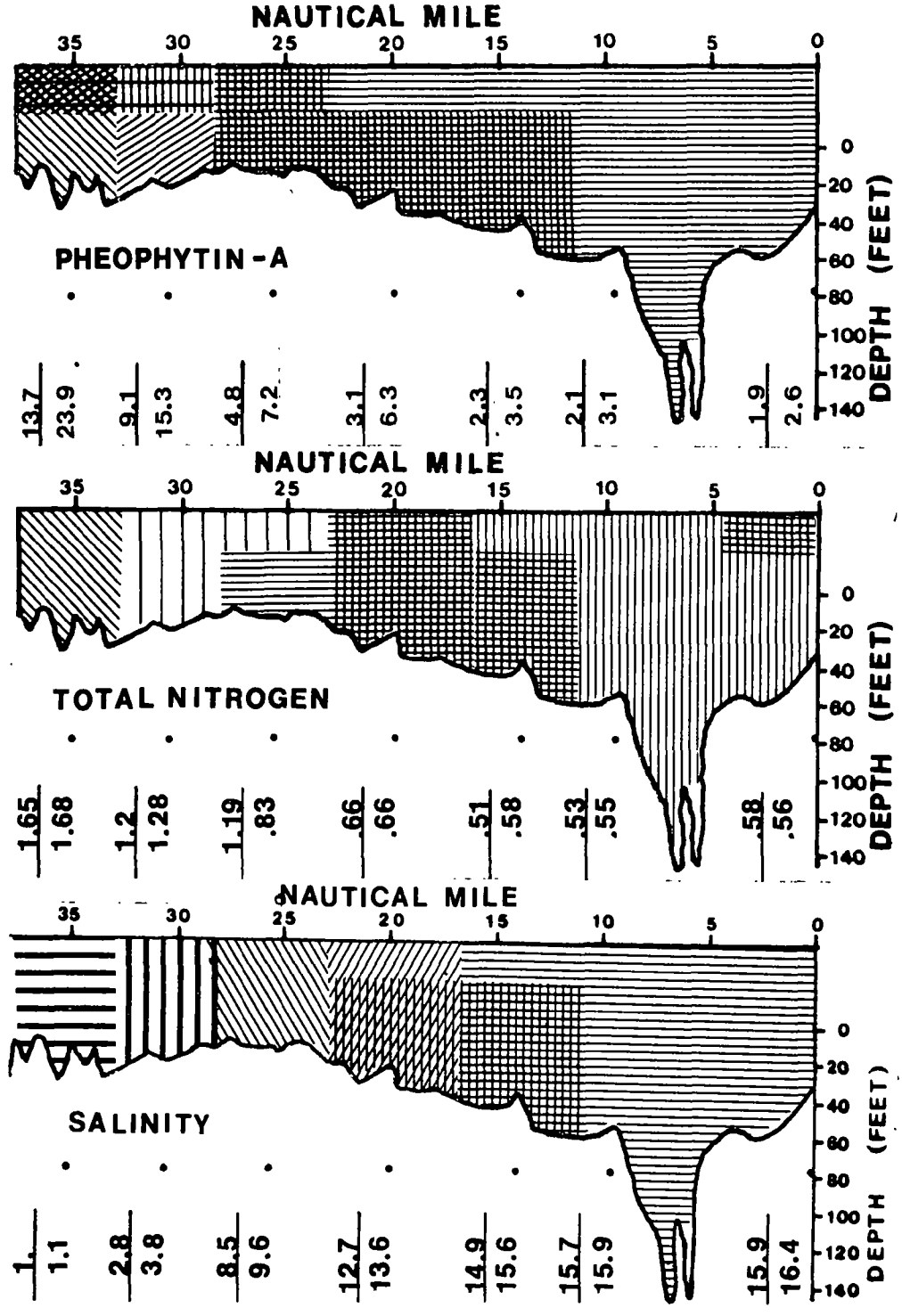


Figure 11-90 Patuxent River longitudinal characterization of 1980-1981 data for pheophytin-a (ug/l), total nitrogen (mg/l), and salinity (ppt), using surface and bottom depth station data.

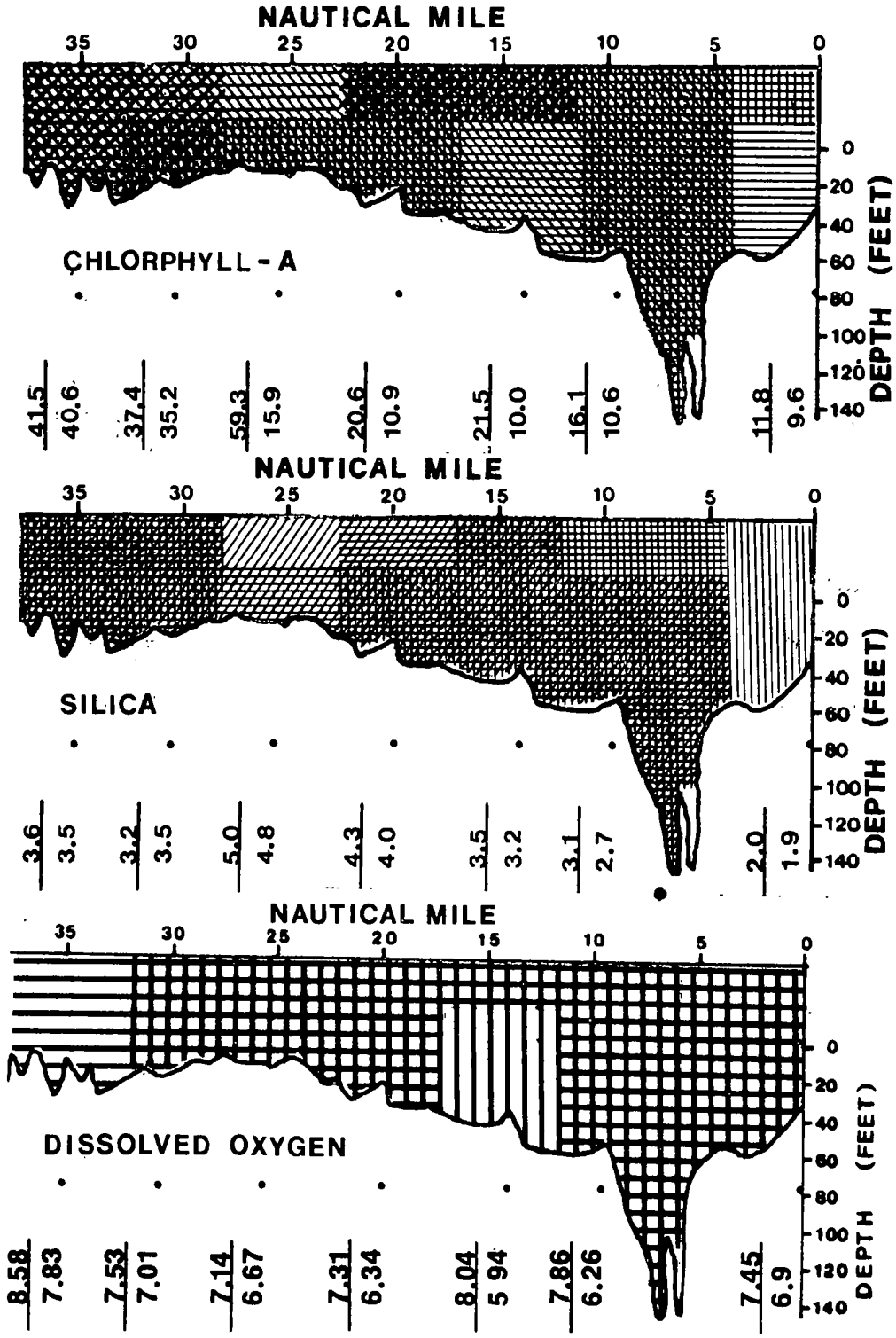


Figure 11-91 Patuxent River longitudinal characterization of 1980-1981 data for chlorophyll-a (ug/l), dissolved reactive silica (mg/l), and dissolved oxygen (mg/l), using surface and bottom depth station data.

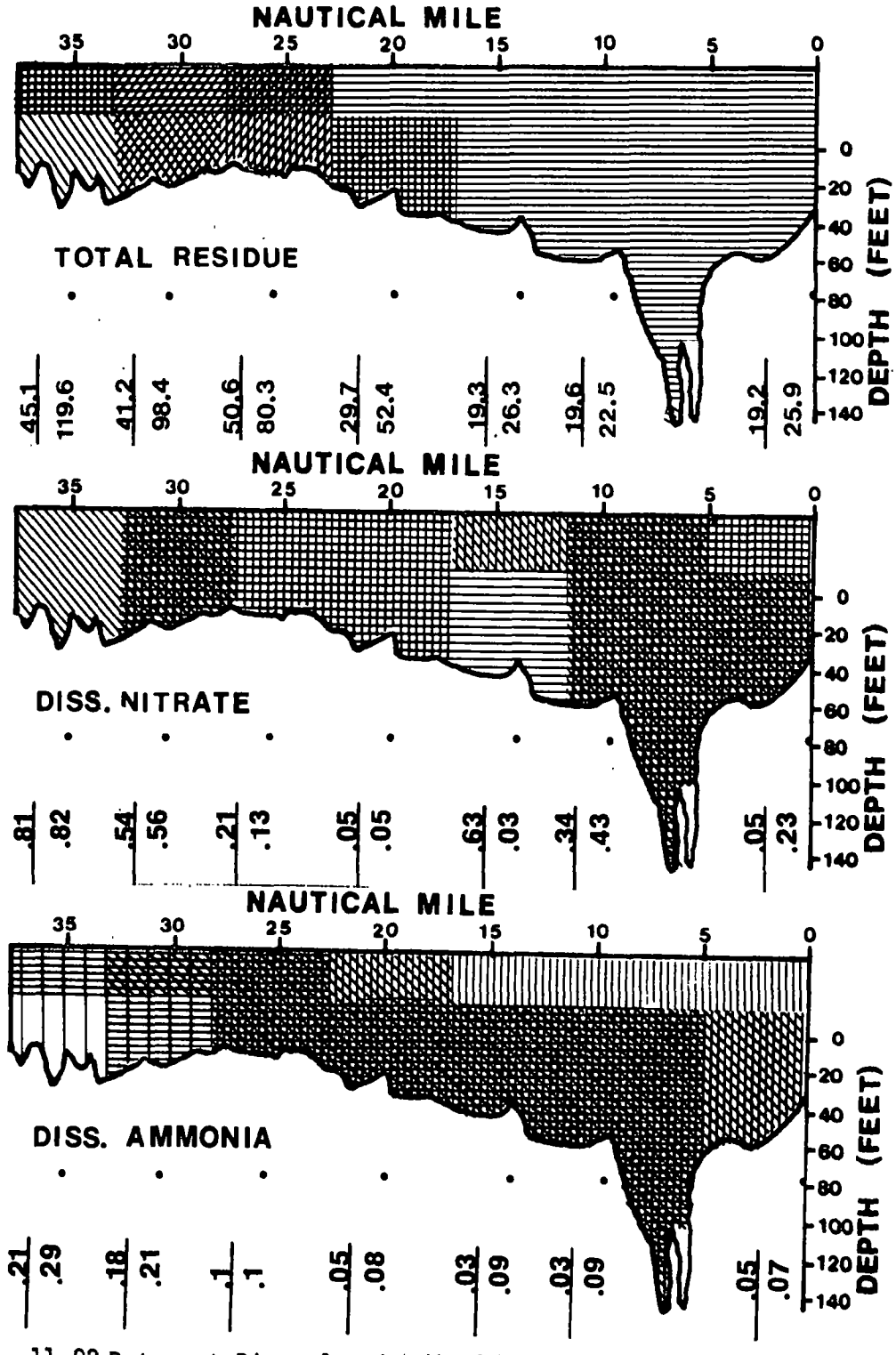


Figure 11-92 Patuxent River longitudinal characterization of 1980-1981 data for total nonfilterable residue (mg/l), dissolved nitrate (mg/l), and dissolved ammonia (mg/l), using surface and bottom depth station data.

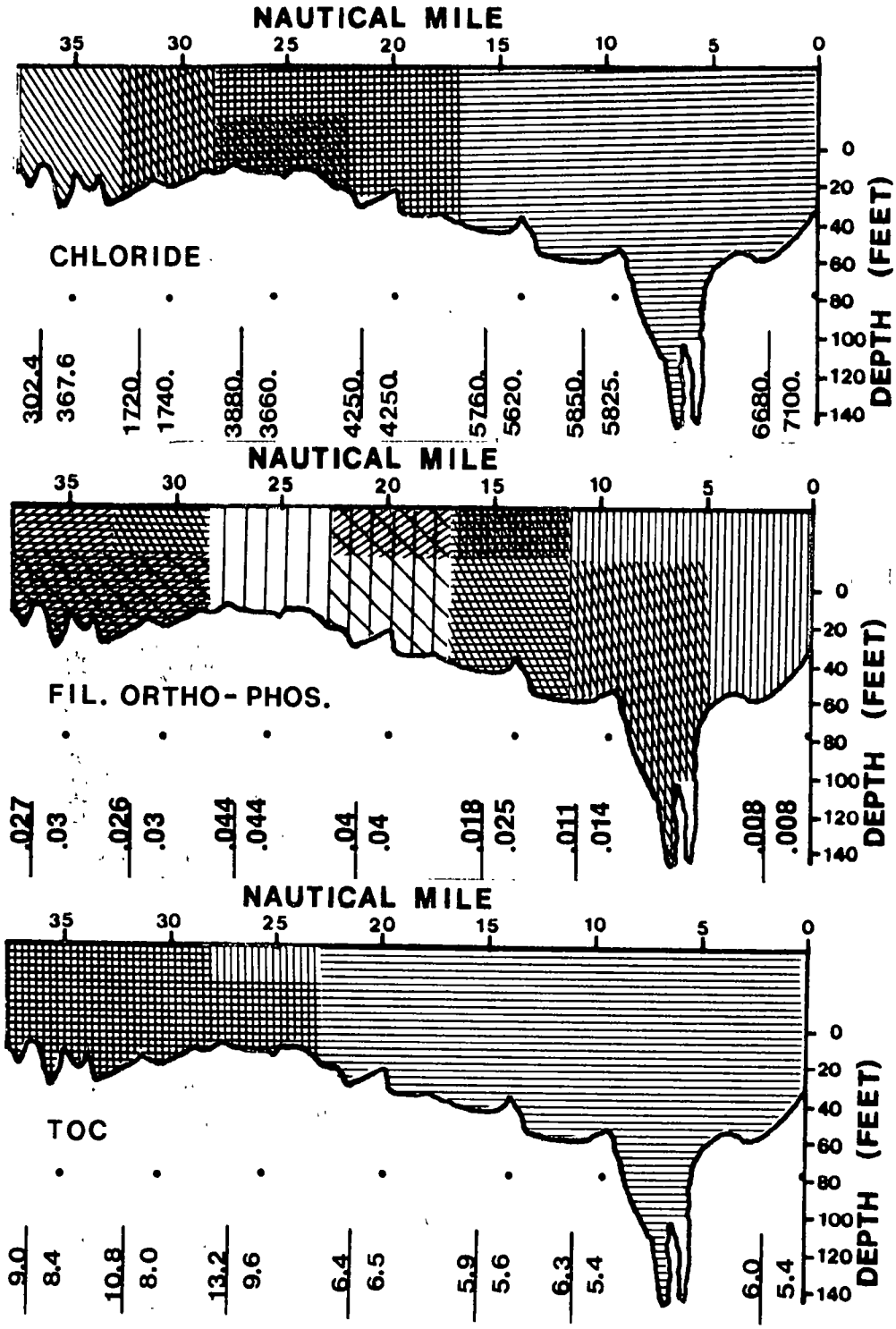


Figure 11-93 Patuxent River longitudinal characterization of 1980-1981 data for chlorides (mg/l), dissolved ortho-phosphorus (mg/l), and total organic carbon (mg/l), using surface and bottom depth station data.

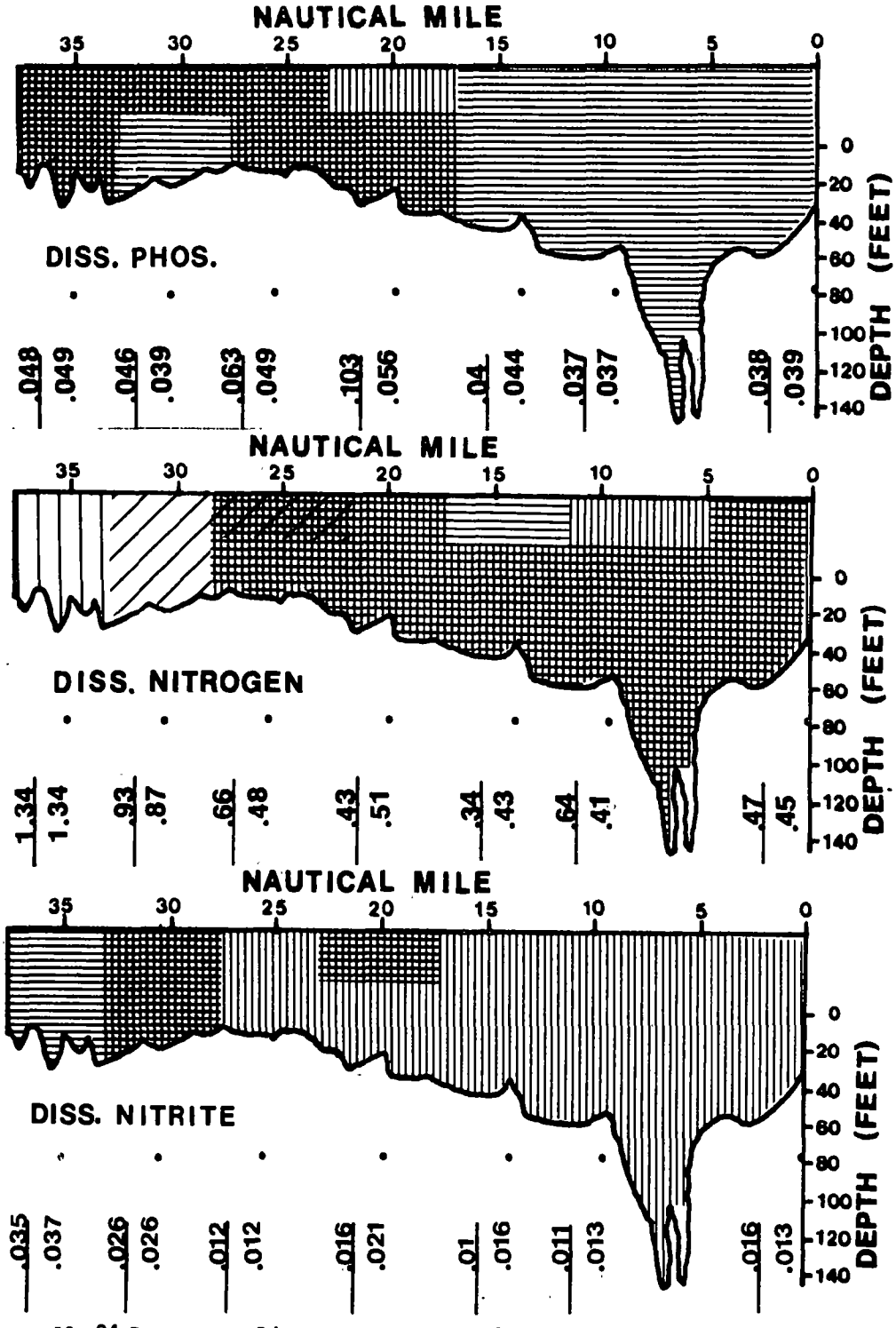


Figure 11-94 Patuxent River longitudinal characterization of 1980-1981 data for dissolved phosphorus (mg/l), total dissolved nitrogen (mg/l), and dissolved nitrite (mg/l), using surface and bottom depth station data.

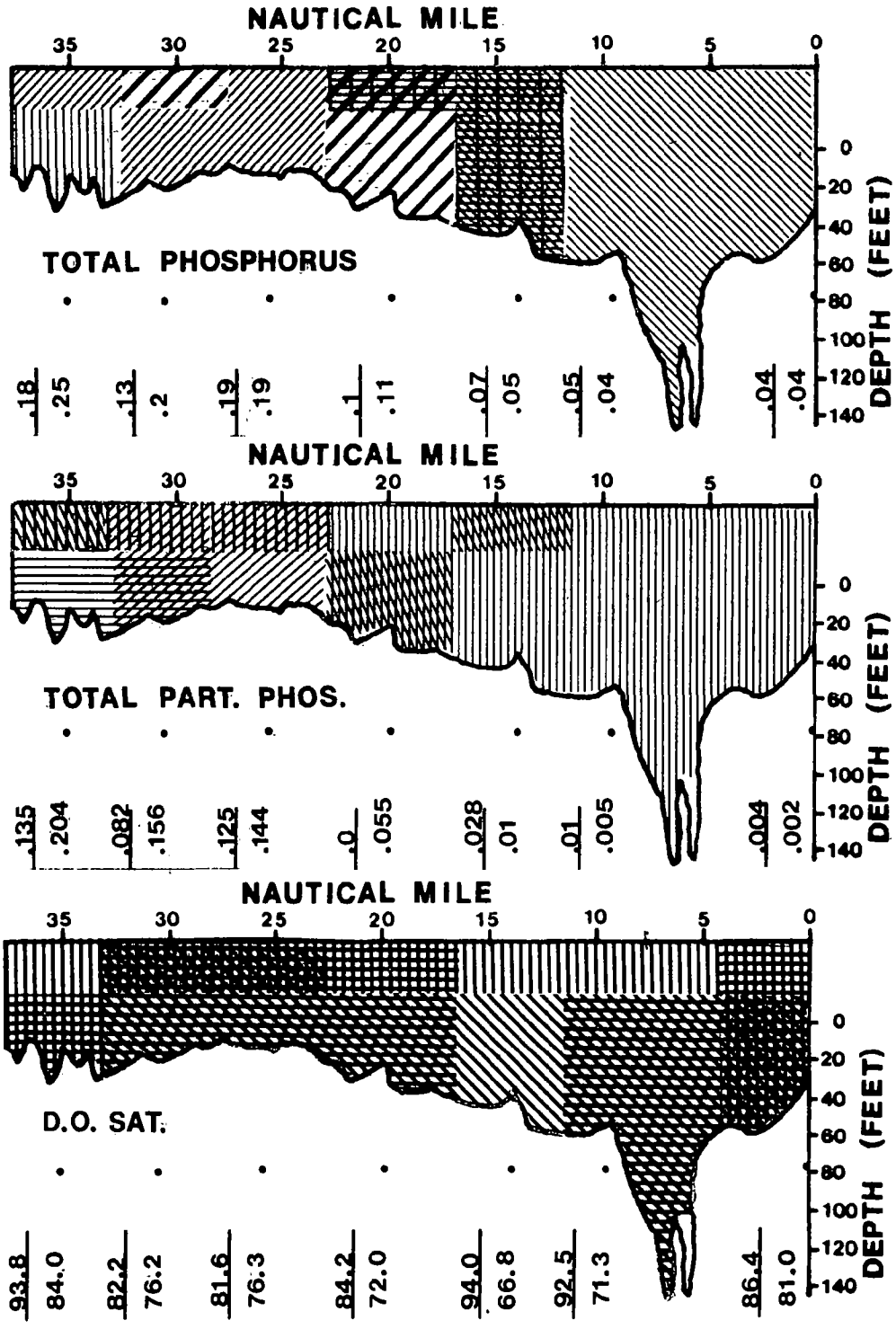


Figure 11-95 Patuxent River longitudinal characterization of 1980-1981 data for total phosphorus (mg/l), total particulate phosphorus (mg/l), and dissolved oxygen saturation (%), using surface and bottom depth station data.

Table 11-23 Patuxent River Lateral and Center Station Means

Station	Left Bank Mean	STD	Center Mean	STD	Right Bank Mean	STD
			Dissolved Nitrite (MG/L)			
XCF8763	0.005	0.001				
XCF9575			0.004	0.001		
XCF9958					0.003	0.000
XDE2586	0.003	0.000				
XDE2599			0.004	0.001		
XDE2898					0.003	0.001
XDE4543	0.004	0.001				
XDE5339			0.004	0.001		
XDE5352					0.006	0.003
XDD9699	0.006	0.004				
XDE9401			0.008	0.007		
XDE9603					0.007	0.005
XED4891	0.02	0.02				
XED4892			0.02	0.02		
XED4894					0.02	0.02
			Dissolved Ammonia (MG/L)			
XCF8763	0.09	0.06				
XCF9575			0.07	0.06		
XCF9958					0.03	0.01
XDE2586	0.04	0.02				
XDE2599			0.07	0.10		
XDE2898					0.07	0.09
XDE4543	0.03	0.02				
XDE5339			0.07	0.09		
XDE5352					0.04	0.04
XDD9699	0.06	0.02				
XDE9401			0.04	0.03		
XDE9603					0.05	0.01
XED4891	0.18	0.18				
XED4892			0.26	0.21		
XED4894					0.27	0.21

Table 11-23 Patuxent River Lateral and Center Station Means

Station	Left Bank Mean	STD	Center Mean	STD	Right Bank Mean	STD
			Total Nitrogen (MG/L)			
XCF8763	0.47	0.06				
XCF9575			0.46	0.05		
XCF9958					0.54	0.09
XDE2586	0.54	0.26				
XDE2599			0.45	0.26		
XDE2898					0.43	0.18
XDE4543	0.40	0.06				
XDE5339			0.43	0.08		
XDE5352					0.45	0.19
XDD9699	0.56	0.11				
XDE9401			0.44	0.11		
XDE9603					0.56	0.08
XED4891	0.89	0.40				
XED4892			1.52	0.66		
XED4894					1.58	0.77
			Dissolved Nitrate (MG/L)			
XCF8763	0.04	0.03				
XCF9575			0.02	0.00		
XCF9958					0.02	0.01
XDE2586	0.01	0.005				
XDE2599			0.02	0.00		
XDE2898					0.02	0.00
XDE4543	0.02	0.01				
XDE5339			0.04	0.04		
XDE5352					0.10	0.18
XDD9699	0.09	0.08				
XDE9401			0.05	0.07		
XDE9603					0.06	0.05
XED4891	0.23	0.28				
XED4892			0.34	0.37		
XED4894					0.35	0.37

Table 11-23 Patuxent River Lateral and Center Station Means

Station	Left Bank Mean	STD	Center Mean	STD	Right Bank Mean	STD
			Total Phosphorus (MG/L)			
XCF8763	0.03	0.00				
XCF9575			0.03	0.00		
XCF9958					0.03	0.00
XDE2586	0.05	0.02				
XDE2599			0.04	0.02		
XDE2898					0.06	0.01
XDE4543	0.05	0.02				
XDE5339			0.04	0.01		
XDE5352					0.05	0.01
XDD9699	0.08	0.03				
XDE9401			0.07	0.02		
XDE9603					0.06	0.03
XED4891	0.13	0.06				
XED4892			0.26	0.22		
XED4894					0.16	0.07
			Dissolved Orthophosphorus (MG/L)			
XCF8763	0.01	0.00				
XCF9575			0.01	0.00		
XCF9958					0.01	0.00
XDE2586	0.01	0.02				
XDE2599			0.02	0.01		
XDE2898					0.01	0.01
XDE4543	0.01	0.01				
XDE5339			0.01	0.01		
XDE5352					0.01	0.01
XDD9699	0.03	0.03				
XDE9401			0.03	0.02		
XDE9603					0.02	0.01
XED4891	0.04	0.02				
XED4892			0.06	0.01		
XED4894					0.07	0.03

Table 11-23 Patuxent River Lateral and Center Station Means

Station	Left Bank Mean	STD	Center Mean	STD	Right Bank Mean	STD
			BOD_5 (MG/L)			
XCF8763	1.70	0.71				
XCF9575			1.25	0.78		
XCF9958					3.05	1.77
XDE2586	4.00	3.00				
XDE2599			3.10	2.12		
XDE2898					3.05	1.95
XDE4543	3.00	1.05				
XDE5339			2.40	1.60		
XDE5352					3.77	1.96
XDD9699	3.15	0.91				
XDE9401			2.60	0.92		
XDE9603					2.32	1.67
XED4891	2.67	0.39				
XED4892			2.92	1.74		
XED4894					3.80	2.34
			Total Organic Carbon (MG/L)			
XCF8763	5.25	1.77				
XCF9575			3.50	0.71		
XCF9958					6.00	2.83
XDE2586	6.50	2.12				
XDE2599			6.50	0.71		
XDE2898					6.50	0.71
XDE4543	7.50	0.71				
XDE5339			6.75	0.35		
XDE5352					7.00	1.41
XDD9699	5.00	2.83				
XDE9401			4.50	0.71		
XDE9603					6.25	3.18
XED4891	4.00	0.00				
XED4892			10.50	2.12		
XED4894					9.50	3.54

Table 11-23 Patuxent River Lateral and Center Station Means

Station	Left Bank Mean	STD	Center Mean	STD	Right Bank Mean	STD
			Chlorophyll-A (UG/L)			
XCF8763	8.44	5.08				
XCF9575			6.21	3.85		
XCF9958					24.05	8.55
XDE2586	24.06	16.17				
XDE2599			24.18	16.36		
XDE2898					19.27	12.57
XDE4543	19.93	11.54				
XDE5339			32.33	8.75		
XDE5352					24.56	11.87
XDD9699	18.66	11.23				
XDE9401			18.44	12.79		
XDE9603					22.30	9.80
XED4891	13.36	9.27				
XED4892			20.07	18.10		
XED4894					16.32	8.02
			Pheophytin-A (UG/L)			
XCF8763	0.13	0.19				
XCF9575			0.00	0.00		
XCF9958					0.13	0.19
XDE2586	2.90	2.14				
XDE2599			0.81	1.46		
XDE2898					1.01	1.66
XDE4543	2.62	2.81				
XDE5339			0.28	0.32		
XDE5352					4.07	3.94
XDD9699	4.87	3.89				
XDE9401			2.03	1.80		
XDE9603					2.98	4.60
XED4891	5.81	4.94				
XED4892			4.04	1.34		
XED4894					8.46	9.69