HYDROBIOLOGICAL MONITORING PROGRAM

SUMMARY REPORT FOR THE LOWER PEACE RIVER AND CHARLOTTE HARBOR

PHYTOPLANKTON
PRODUCTION AND STRUCTURE 1983 - 1991
TAXONOMY 1989-1991

ZOOPLANKTON
STRUCTURE AND TAXONOMY 1989-1991

as per

SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
CONSUMPTIVE USE PERMIT 2010420

for the

PEACE RIVER REGIONAL WATER SUPPLY FACILITY

REPORT FOR

PEACE RIVER / MANASOTA REGIONAL WATER SUPPLY AUTHORITY

by

ENVIRONMENTAL QUALITY LABORATORY, INC.

December, 1992

TABLE OF CONTENTS

VOLUME I

	EXECTIVE SUMMARY	i
1.0	PROJECT SUMMARY	1-1
2.0	INTRODUCTION	2-1
	Figure 2.1 Charlotte Harbor Study Area	2-2
3.0	REVIEW OF THE PRODUCTION AND STRUCTURE OF PHYTOPLANKTON COMMUNITIES WITHIN THE LOWER PEACE RIVER/UPPER CHARLOTTE HARBOR ESTUARINE SYSTEM - BETWEEN 1983 AND 1991	
	3.1 Introduction	3-1
	3.1.1 Importance of Phytoplankton Production and Structure	3-2
	3.1.2 Current Long-Term Studies of Primary Production	3-5
	3.2 Primary Productivity Methods	
	3.2.1 In Situ Measurements of Physical Parameters	3-7
	3.2.2 Light Profile	3-8
	3.2.3 Primary Productivity Measurements	3-8
	3.2.4 Determinations of Rates of C-14 Uptake	3-10
	3.2.5 Chlorophyll a	3-11
	3.2.6 Water Chemistry	3-11
	3.2.7 Population Structure	3-11
	Figure 3.1 In Situ Incubation Racks	3-9
	Table 3.1 Water Chemistry Methods	3-12
	3.3 Results 1983-1991	
	3.3.1 Physical/Chemical Parameters	3-14
	3.3.2 Phytoplankton Production and Biomass	3-72
	3.3.3 Size Fraction Determinations	3-114
	3.3.4 Summary Statistics	3-148
	3.3.5 Descriptive and Predictive Analysis	3-148
	3.3.6 Principal Component Analysis	3-198
	3.3.7 Summary of Monthly Means vs Temperature and Nutrients	3-202
	3.3.8 Relationships between Carbon Uptake and Chlorophyll a	3-202
	3.3.9 Multiple Regression Models	3-224
	3.3.10 Long-Term Trend Analysis	3-227
	Table 3.2 Physical/Chemical/Production Codes	3-15

TABLE OF CONTENTS (cont.)

Table 3.3	Physical and Chemical Parameters	3-18
Table 3.4	Physical Parameters - Light	3-29
Table 3.5	Physical Parameters - Flow	3-40
Table 3.6	Measured Rates of Primary Production	3-76
Table 3.7	Determination of Carbon Uptake by Size Fraction	3-82
Table 3.8	Determination of Chlorophyll a by Size Fraction	3-93
Table 3.9	Means and Ranges Physical Parameter	3-149
Table 3.10	Means and Ranges Water Column	3-157
Table 3.11	Means and Ranges Nutrients	3-161
Table 3.12	Means and Ranges Phytoplankton Production	3-165
Table 3.13	Means and Ranges Size Fractions	3-169
Table 3.14	Added Chemical Parameters	3-174
Table 3.15	Means and Ranges Added Parameters	3-177
Table 3.16	General Linear Models Carbon Uptake	3-226
Table 3.17	General Linear Models Chlorophyll a	3-228
Table 3.18	Trend Analysis - Light and Flow	3-229
Table 3.19	Trend Analysis - Color, Nutrients, Carbon Uptake, Chlorophyll a 0 o/oo	3-230
Table 3.20	Trend Analysis - Color, Nutrients, Carbon Uptake, Chlorophyll a 6 o/oo	3-231
Table 3.21	Trend Analysis - Color, Nutrients, Carbon Uptake, Chlorophyll a 12 o/oo	3-232
Table 3.22	Trend Analysis - Color, Nutrients, Carbon Uptake, Chlorophyll a 20 o/oo	3-233
Figure 3.2	Temperature vs Light	3- 50
Figure 3.3	Peace River Flow	3- 51
Figure 3.4	Distance from Sta. #20	3- 54
Figure 3.5	Monthly Means of Distance	3- 55
Figure 3.6	Color	3- 57
Figure 3.7	Monthly Means of Color	3- 60
Figure 3.8	Extinction Coefficient	3 -61
Figure 3.9	Monthly Means of Extinction	3 -63
Figure 3.10	Nitrate/Nitrite	3 -65
Figure 3.11	Monthly Means of Nitrogen	3 -67
Figure 3.12	Ortho-Phosphorus	3- 69
Figure 3.13	Monthly Means of Ortho-Phosphorus	3- 71
Figure 3.14	Silica	3- 73
Figure 3.15	Monthly Means of Silica	3 -75
Figure 3.16	Primary Production/hr	3- 104
Figure 3.17	Monthly Means of P.P./hr	3-106
Figure 3.18	Primary Production/Ein	3-107
Figure 3.19	Monthly Means of P.P/Ein	3-109
Figure 3.20	Chlorophyll a	3-111
Figure 3.21	Monthly Means of Chlorophyll a	3-113

1984

Figure 3.22	Carbon Uptake (mgC/m3/Einstein)	3-116

TABLE OF CONTENTS (cont.)

Figure 3.23	Percent Carbon Uptake Among Size Fractions	3-117
Figure 3.24	Chlorophyll a (mg/m3)	3-118
Figure 3.25	Percent Chlorophyll a Among Size Fractions	3-119
	1985	
Figure 3.26	Carbon Uptake (mgC/m3/Einstein)	3-120
Figure 3.27	Percent Carbon Uptake Among Size Fractions	3-121
Figure 3.28	Chlorophyll a (mg/m3)	3-122
Figure 3.29	Percent Chlorophyll a Among Size Fractions	3-123
	1986	
Figure 3.30	Carbon Uptake (mgC/m3/Einstein)	3-124
Figure 3.31	Percent Carbon Uptake Among Size Fractions	3-125
Figure 3.32	Chlorophyll a (mg/m3)	3-126
Figure 3.33	Percent Chlorophyll a Among Size Fractions	3-127
	1987	
Figure 3.34	Carbon Uptake (mgC/m3/Einstein)	3-128
Figure 3.35	Percent Carbon Uptake Among Size Fractions	3-129
Figure 3.36	Chlorophyll a (mg/m3)	3-130
Figure 3.37	Percent Chlorophyll a Among Size Fractions	3-131
	1988	
Figure 3.38	Carbon Uptake (mgC/m3/Einstein)	3-132
Figure 3.39	Percent Carbon Uptake Among Size Fractions	3-133
Figure 3.40	Chlorophyll a (mg/m3)	3-134
Figure 3.41	Percent Chlorophyll a Among Size Fractions	3-135
	1989	
Figure 3.42	Carbon Uptake (mgC/m3/Einstein)	3-136
Figure 3.43	Percent Carbon Uptake Among Size Fractions	3-137
Figure 3.44	Chlorophyll a (mg/m3)	3-138
Figure 3.45	Percent Chlorophyll a Among Size Fractions	3-139

TABLE OF CONTENTS (cont.)

1990

Figure 3.46	Carbon Uptake (mgC/m3/Einstein)	3-140
Figure 3.47	Percent Carbon Uptake Among Size Fractions	3-141
Figure 3.48	Chlorophyll a (mg/m3)	3-142
Figure 3.49	Percent Chlorophyll a Among Size Fractions	3-143

1991

Figure 3.50	Carbon Uptake (mgC/m3/Einstein)	3-144
Figure 3.51	Percent Carbon Uptake Among Size Fractions	3-145
Figure 3.52	Chlorophyll a (mg/m3)	3-146
Figure 3.53	Percent Chlorophyll a Among Size Fractions	3-147
Figure 3.54	Carbon Uptake (mgC/m3/Einstein) vs nitrogen and temperature 0 o/oo	3-180
Figure 3.55	Carbon Uptake (mgC/m3/Einstein) vs nitrogen and temperature 6 o/oo	3-181
Figure 3.56	Carbon Uptake (mgC/m3/Einstein) vs nitrogen and temperature 12 o/oo	3-182
Figure 3.57	Carbon Uptake (mgC/m3/Einstein) vs nitrogen and temperature 20 o/oo	3-183
Figure 3.58	Chlorophyll a (mg/m3) vs nitrogen and temperature 0 o/oo	3-184
Figure 3.59	Chlorophyll a (mg/m3) vs nitrogen and temperature 6 o/oo	3-185
Figure 3.60	Chlorophyll a (mg/m3) vs nitrogen and temperature 12 o/oo	3-186
Figure 3.61	Chlorophyll a (mg/m3) vs nitrogen and temperature 20 o/oo	3-187
Figure 3.62	Carbon Uptake (mgC/m3/Einstein) vs color and temperature 0 o/oo	3-189
Figure 3.63	Carbon Uptake (mgC/m3/Einstein) vs color and temperature 6 o/oo	3-190
Figure 3.64	Carbon Uptake (mgC/m3/Einstein) vs color and temperature 12 o/oo	3-191
Figure 3.65	Carbon Uptake (mgC/m3/Einstein) vs color and temperature 20 o/oo	3-192
Figure 3.66	Chlorophyll a (mg/m3) vs color and temperature 0 o/oo	3-193
Figure 3.67	Chlorophyll a (mg/m3) vs color and temperature 6 o/oo	3-194
Figure 3.68	Chlorophyll a (mg/m3) vs color and temperature 12 o/oo	3-195
Figure 3.69	Chlorophyll a (mg/m3) vs color and temperature 20 o/oo	3-196

TABLE OF CONTENTS (cont.)

Figure 3.70	Carbon Uptake (mgC/m3/Einstein) vs nitrogen and temperature	3-203
Figure 3.71	Carbon Uptake (mgC/m3/Einstein) vs color and temperature	3-204
Figure 3.72	Carbon Uptake (mgC/m3/Einstein) vs color and temperature	3-205
Figure 3.73	Chlorophyll a (mg/m3) vs color and temperature	3-206
Figure 3.74	Regression of Chlorophyll a vs Carbon Uptake 0 o/oo	3-208
Figure 3.75	Regression of Chlorophyll a vs Carbon Uptake % > 20um 0 o/oo	3-209
Figure 3.76	Regression of Chlorophyll a vs Carbon Uptake % <20um & >u um 0 o/oo	3-210
Figure 3.77	Regression of Chlorophyll a vs Carbon Uptake % <5um 0 o/oo	3-211
Figure 3.78	Regression of Chlorophyll a vs Carbon Uptake 6 o/oo	3-212
Figure 3.79	Regression of Chlorophyll a vs Carbon Uptake % > 20um 6 o/oo	3-213
Figure 3.80	Regression of Chlorophyll a vs Carbon Uptake % <20um & >u um 6 o/oo	3-214
Figure 3.81	Regression of Chlorophyll a vs Carbon Uptake % <5um 6 o/oo	3-215
Figure 3.82	Regression of Chlorophyll a vs Carbon Uptake 12 o/oo	3-216
Figure 3.83	Regression of Chlorophyll a vs Carbon Uptake % > 20um 12 o/oo	3-217
Figure 3.84	Regression of Chlorophyll a vs Carbon Uptake % <20um & >u um 12 o/oo	3-218
Figure 3.85	Regression of Chlorophyll a vs Carbon Uptake % <5um 12 o/oo	3-219
Figure 3.86	Regression of Chlorophyll a vs Carbon Uptake 20 o/oo	3-220
Figure 3.87	Regression of Chlorophyll a vs Carbon Uptake % > 20um 20 o/oo	3-221
Figure 3.88	Regression of Chlorophyll a vs Carbon Uptake % <20um & >u um 20 o/oo	3-222
Figure 3.89	Regression of Chlorophyll a vs Carbon Uptake % <5um 20 o/oo	3-223

3.4 Taxonomic Determinations of Phytoplankton Community Structure

3.4.1	Phytoplankton Density	3-235
3.4.2	Taxonomic Structure	3-237
3.4.3	Analysis of Community Structure	3-254
3.4.4	Analysis of Community Similarity	3-258

Table 3.23	Species Counts 1989-1991 0 o/oo	3-238
Table 3.24	Species Counts 1989-1991 6 o/oo	3-239
Table 3.25	Species Counts 1989-1991 12 o/oo	3-240
Table 3.26	Species Counts 1989-1991 20 o/oo	3-241
Table 3.27	Percent Major Taxonomic Groups	3-242

TABLE OF CONTENTS (cont.)

Table 3.28 Calculation of Community Indices 3-256
Table 3.29 Diversity, Evenness and Similarity 3-259
Table 3.30 Similarity Matrix 0 o/oo 3-274
Table 3.31 Similarity Matrix 6 o/oo 3-275
Table 3.32 Similarity Matrix 12 o/oo 3-276
Table 3.33 Similarity Matrix 20 o/oo 3-277
Figure 3.90 Phytoplankton Density 3-236
Figure 3.91 Percent Major Taxonomic Groups 1989 - 1991 0 o/oo 3-246
Figure 3.92 Percent Major Taxonomic Groups Monthly Means 1989 - 1991 0 o/oo 3-247
Figure 3.93 Percent Major Taxonomic Groups 1989 - 1991 6 o/oo 3-248
Figure 3.94 Percent Major Taxonomic Groups Monthly Means 1989 - 1991 6 o/oo 3-249
Figure 3.95 Percent Major Taxonomic Groups 1989 - 1991 12 o/oo 3-250
Figure 3.96 Percent Major Taxonomic Groups Monthly Means 1989 - 1991 12 o/oo 3-251
Figure 3.97 Percent Major Taxonomic Groups 1989 - 1991 20 o/oo 3-252
Figure 3.98 Percent Major Taxonomic Groups Monthly Means 1989 - 1991 20 o/oo 3-253
Figure 3.99 Number of Taxa by Station 1989-1991 3-263
Figure 3.100 Species Diversity by Station 1989-1991 3-265
Figure 3.101 Species Evenness by Station 1989-1991 3-267
Figure 3.102 Species Diversity and Evenness 1989 - 1991 0 o/oo 3-269
Figure 3.103 Species Diversity and Evenness 1989 - 1991 6 o/oo 3-270
Figure 3.104 Species Diversity and Evenness 1989 - 1991 12 o/oo 3-271
Figure 3.105 Species Diversity and Evenness 1989 - 1991 20 o/oo 3-272

3.5 Summary 3-273

4.0 ZOOPLANKTON STUDIES

4.1 Introduction 4- 1

4.2 Methods
4.2.1 Monthly Zooplankton Collection 4- 2
4.2.2 Diel Zooplankton Study 4- 3
4.2.3 Zooplankton Grazing Studies 4- 4

TABLE OF CONTENTS (cont.)

4.3 Results and Discussion
4.3.1 General Trends 4- 5
4.3.2 Influence of Physical/Chemical Factor, Phytoplankton Distributions, and Productivity on Zooplankton Taxa 4- 49
4.3.3 Results of Diel Zooplankton Collections 4-100
4.3.4 Zooplankton Grazing Studies 4-139

Table 4.1 Taxonomic and Lifestage List 4- 6
Table 4.2 Canonical Variate Analysis 4- 46
Table 4.3 Correlations of Zooplankton with constructed Canonical Variates 4- 47
Table 4.4 Physical/Chemical Parameters used for Principal Component Analysis 4- 51
Table 4.5 Principal Component Analysis - 0 o/oo Salinity 4- 52
Table 4.6 Principal Component Analysis - 6 o/oo Salinity 4- 65
Table 4.7 Principal Component Analysis - 12 o/oo Salinity 4- 78
Table 4.8 Principal Component Analysis - 20 o/oo Salinity 4- 92
Table 4.9 Results of Zooplankton Grazing Study 4-140

Figure 4.1 Total Number of Zooplankton Collected at 0 o/oo Salinity 4- 10
Figure 4.2 Total Density of Zooplankton Collected at 0 o/oo Salinity 4- 11
Figure 4.3 Diversity and Evenness of Zooplankton Collected at 0 o/oo Salinity 4- 12
Figure 4.4 Total Number of Zooplankton Collected at 6 o/oo Salinity 4- 14
Figure 4.5 Total Density of Zooplankton Collected at 6 o/oo Salinity 4- 15
Figure 4.6 Diversity and Evenness of Zooplankton Collected at 6 o/oo Salinity 4- 16
Figure 4.7 Total Number of Zooplankton Collected at 12 o/oo Salinity 4- 18
Figure 4.8 Total Density of Zooplankton Collected at 12 o/oo Salinity 4- 19
Figure 4.9 Diversity and Evenness of Zooplankton Collected at 12 o/oo Salinity 4- 20
Figure 4.10 Total Number of Zooplankton Collected at 20 o/oo Salinity 4- 22
Figure 4.11 Total Density of Zooplankton Collected at 20 o/oo Salinity 4- 23
Figure 4.12 Diversity and Evenness of Zooplankton Collected at 20 o/oo Salinity 4- 24
Figure 4.13 Total Number of Zooplankton Taxa 4- 26
Figure 4.14 Species Diversity 4- 27
Figure 4.15 Zooplankton Density 4- 28
Figure 4.16 Total Density - Rotifera 4- 29

TABLE OF CONTENTS (cont.)

Figure 4.17	Total Density - Copepoda	4- 31
Figure 4.18	Total Density - Acartia	4- 32
Figure 4.19	Total Density - Oithonia	4- 33
Figure 4.20	Total Density - Clausocalanus	4- 34
Figure 4.21	Total Density - Paracalanus	4- 35
Figure 4.22	Total Density - Saphirella	4- 36
Figure 4.23	Total Density - Cumacea	4- 37
Figure 4.24	Total Density - Branchipoda	4- 38
Figure 4.25	Total Density - Cirripeda	4- 40
Figure 4.26	Total Density - Polychaeta	4- 41
Figure 4.27	Total Density - Gastropod	4- 42
Figure 4.28	Total Density - Tubellaria	4- 43
Figure 4.29	Total Density - Sipunculida	4- 44
Figure 4.30	Station Means for Canonical Variate analysis of Zooplankton Denisty	4- 48
Figure 4.31	Gastropods vs. Factor I at 0 o/oo	4- 55
Figure 4.32	Cumacean Crustaceans vs. Factor I at 0 o/oo	4- 56
Figure 4.33	Clausocalanus vs. Factor I at 0 o/oo	4- 57
Figure 4.34	Total Zooplankton vs. Factor II at 0 o/oo	4- 58
Figure 4.35	Rotifers vs. Factor II at 0 o/oo	4- 59
Figure 4.36	Fish Larvae vs. Factor II at 0 o/oo	4- 60
Figure 4.37	Sipunculids vs. Factor II at 0 o/oo	4- 61
Figure 4.38	Branchipod vs. Factor II at 0 o/oo	4- 62
Figure 4.39	Zooplankton Diversity vs. Factor II at 0 o/oo	4- 63
Figure 4.40	Planktonic Annelids vs. Factor I at 6 o/oo	4- 68
Figure 4.41	Clausocalanus vs. Factor I at 6 o/oo	4- 69
Figure 4.42	Oithona vs. Factor I at 6 o/oo	4- 70
Figure 4.43	Paracalanus vs. Factor I at 6 o/oo	4- 71
Figure 4.44	Ostracoda vs. Factor I at 6 o/oo	4- 72
Figure 4.45	Tubellaria Factor I at 6 o/oo	4- 73
Figure 4.46	Branchipod vs. Factor I at 6 o/oo	4- 74
Figure 4.47	Barnacle Nauplii vs. Factor II at 6 o/oo	4- 75
Figure 4.48	Cumacean vs. Factor II at 6 o/oo	4- 76
Figure 4.49	Hemichordata vs. Factor II at 6 o/oo	4- 77
Figure 4.50	Total Number ofZooplankton vs. Factor I at 12 o/oo	4- 81
Figure 4.51	Oithona vs. Factor I at 12 o/oo	4- 82
Figure 4.52	Copepod vs. Factor I at 12 o/oo	4- 83
Figure 4.53	Ascidiacea vs. Factor I at 12 o/oo	4- 84
Figure 4.54	Scaphopoda vs. Factor I at 12 o/oo	4- 85
Figure 4.55	Gastropod vs. Factor I at 12 o/oo	4- 86
Figure 4.56	Rotifera vs. Factor I at 12 o/oo	4- 87
Figure 4.57	Barnacle Nauplii vs. Factor II at 12 o/oo	4- 88
Figure 4.58	Gastropod vs. Factor II at 12 o/oo	4- 89
Figure 4.59	Harpactacoid Copepods vs. Factor II at 12 o/oo	4- 90

TABLE OF CONTENTS (cont.)

Figure 4.60 Oithona vs. Factor I at 20 o/oo 4- 94
Figure 4.61 Copepod vs. Factor I at 20 o/oo 4- 95
Figure 4.62 Gastropod vs. Factor I at 20 o/oo 4- 96
Figure 4.63 Polychaete vs. Factor I at 20 o/oo 4- 97
Figure 4.64 Cumacean vs. Factor I at 20 o/oo 4- 98
Figure 4.65 Species Richness vs. Factor II at 20 o/oo 4- 99
Figure 4.66 Total Number of Taxa Collected over Diel at 12 o/oo during March 1990 4-102
Figure 4.67 Total Number of Taxa Collected over Diel at 12 o/oo during March 1991 4-103
Figure 4.68 Total Density of Zooplankton Collected over Diel at 12 o/oo during March 1990 4-105
Figure 4.69 Total Density of Zooplankton Collected over Diel at 12 o/oo during March 1991 4-106
Figure 4.70 Total Number of Zooplankton Taxa Collected over Diel during June 1990 4-107
Figure 4.71 Total Number of Zooplankton Taxa Collected over Diel during June 1991 4-108
Figure 4.72 Total Density of Zooplankton Collected over Diel at 12 o/oo during June 1990 4-110
Figure 4.73 Total Density of Zooplankton Collected over Diel at 12 o/oo during June 1991 4-111
Figure 4.74 Total Number of Zooplankton Taxa Collected over Diel at o/oo during September 1990 4-112
Figure 4.75 Total Number of Zooplankton Taxa Collected over Diel at o/oo during September 1991 4-113
Figure 4.76 Total Density of Zooplankton Collected over Diel at 12 o/oo during September 1990 4-114
Figure 4.77 Total Density of Zooplankton Collected over Diel at 12 o/oo during September 1991 4-115
Figure 4.78 Total Number of Zooplankton Taxa Collected over Diel at 12 o/oo during December 1990 4-117
Figure 4.79 Total Number of Zooplankton Taxa Collected over Diel at 12 o/oo during December 1991 4-118
Figure 4.80 Total Density of Zooplankton Collected over Diel at 12 o/oo during December 1990 4-119
Figure 4.81 Total Density of Zooplankton Collected over Diel at 12 o/oo during December 1991 4-120
Figure 4.82 Total Number of Zooplankton Taxa Collected over Diel at 20 o/oo during March 1990 4-121
Figure 4.83 Total Number of Zooplankton Taxa Collected over Diel at 20 o/oo during March 1991 4-122
Figure 4.84 Total Density of Zooplankton Collected over Diel at 20 o/oo during March 1990 4-123
Figure 4.85 Total Density of Zooplankton Collected over Diel at 20 o/oo during March 1991 4-124
Figure 4.86 Total Number of Zooplankton Taxa Collected over Diel at 20 o/oo during June 1990 4-126
Figure 4.87 Total Number of Zooplankton Taxa Collected over Diel at 20 o/oo during June 1991 4-127

TABLE OF CONTENTS (cont.)

Figure 4.88 Total Density of Zooplankton Collected over Diel at 20 o/oo during June 1990 4-128
Figure 4.89 Total Density of Zooplankton Collected over Diel at 20 o/oo during June 1991 4-129
Figure 4.90 Total Number of Zooplankton Taxa Collected over Diel at 20 o/oo during September 1990 4-130
Figure 4.91 Total Number of Zooplankton Taxa Collected over Diel at 20 o/oo during September 1991 4-131
Figure 4.92 Total Density of Zooplankton Collected over Diel at 20 o/oo during September 1990 4-133
Figure 4.93 Total Density of Zooplankton Collected over Diel at 20 o/oo during September 1991 4-134
Figure 4.94 Total Number of Zooplankton Taxa Collected over Diel at 20 o/oo during December 1990 4-135
Figure 4.95 Total Density of Zooplankton Collected over Diel at 20 o/oo during December 1990 4-136
Figure 4.96 Total Number of Zooplankton Taxa Collected over Diel at 20 o/oo during December 1991 4-137
Figure 4.97 Total Density of Zooplankton Collected over Diel at 20 o/oo during December 1991 4-138

5.0 Bibliography

Phytoplankton Literature 5- 1
Zooplankton Literature 5- 48

VOLUME II

APPENDIX A Phytoplankton Species Composition Diversity and Evenness

APPENDIX B Zooplankton Species Composition Diversity and Evenness

APPENDIX C Zooplankton Species Composition Diel and Grazing Experiments

EXECUTIVE SUMMARY

Specific conditions of the Southwest Florida Water Management District's consumptive use permit (#2010420) sets forth the requirement that the Regional Authority conduct a comprehensive hydrobiological monitoring program designed to assess the response of various physical, chemical and biological characteristics of the Charlotte Harbor estuary to changes in Peace River flow.

The following summary report analyzes the findings of the required monitoring of phytoplankton primary production and community structure at four salinity zones within the Lower Peace River and Upper Charlotte Harbor between 1983 and 1991. Further, previously unreported data regarding phytoplankton and zooplankton taxonomic structure for samples collected in conjunction with the monthly primary production investigations between 1989 and 1991 are presented and analyzed.

Based on the findings of this and previous reports the following are apparent:

- To date, no observed short-term seasonal or long-term trends in any of the physical/chemical or biological parameters measured in this extensive investigation of the Upper Charlotte Harbor estuary have shown any influence by current water withdrawals by the Peace River Regional Supply Facility.

- During the period 1983-1991, average 7-day Peace River flow prior to the monthly monitoring ranged from a low of 44 cfs (29 mgd) to a high of 8997 cfs (5,830 mgd). Mean 7-day average flow over the period was 702 cfs (455 mgd) with a standard deviation of 1074 cfs (696 mgd). Corresponding freshwater withdrawals ranged from 0 to 28.9 cfs (18.7 mgd), with a mean of 6.9 (4.5 mgd) and a standard deviation of 6.7 cfs (4.3 mgd).

- It is not therefor surprising that neither parametric nor non-parametric statistical procedures have been able to detect any affects of freshwater withdrawal with consumptive use being only a small fraction of the natural "noise" within the system.

- Analysis of long-term seasonal patterns in primary production, however, do indicate that the potential for impacts associated with freshwater withdrawals may be the greatest in the late-Spring / early-Summer. Specifically with the first short bursts of increasing river flow after the typical long-period of low river flow (nutrient inputs) characteristic of Winter/Spring dry-season.

- The results of the long-term monitoring program strongly indicate that primary production within the estuarine system to be fairly insensitive to freshwater withdrawals during higher periods of river flow characteristic of the mid-Summer / early-Fall wet-season. This suggested the potential to revise the current withdrawal schedule to provide for a sliding scale at higher flows.

- Measurements of primary production utilizing carbon uptake and other measurements of phytoplankton community structure, emphasizing the base of the food-chain, have proven to be the most effective method yet employed of estimating potential impacts of changes in nutrient loads affected by freshwater withdrawals. Measurement of associated zooplankton community structure have been shown to be less directly sensitive to changes in flow.

- It is suggested that any future monitoring programs continue to emphasize production estimates as related to changes in Peace River flow, and avoid the increasing modeling problems associated with corresponding natural noise and loss of statistical information with each higher level in the food-chain.

1.0 PROJECT SUMMARY

Specific conditions of the Southwest Florida Water Management District's (SWFWMD) original and subsequent consumptive use permits for the Peace River Regional Water Supply Facility set forth the requirement that the Utility conduct a comprehensive hydrobiological monitoring program. The District's expressed purpose in mandating this requirement has been to develop a significant data base to establish and assess the responses of various physical, chemical and biological characteristics of the Charlotte Harbor estuary to changes in Peace River flow. The program was designed to evaluate the consequences and significance of natural salinity changes associated with variations in freshwater input with regards to the overall health of aquatic fauna and flora communities in the lower Peace River and upper Charlotte Harbor. Once having established the influences of natural variations, the program's goal was to determine if freshwater withdrawals by the Peace River Water Supply Facility can be shown to alter these patterns.

A series of thirteen previous reports have been filed documenting the results of the hydrobiological monitoring program during the period from January 1976 through December 1991. These reports include summarizations of data collected during the first four years of baseline monitoring, prior to the start of freshwater withdrawals, as well as comparisons of these data to the results obtained from the hydrobiological monitoring programs during subsequent years of water treatment plant operation. As required under the most recent Peace River Water Supply Facility CUP Permit (#2010420), this document summarizes and extends the findings reported previously regarding phytoplankton primary production and community structure at four salinity zones within the Lower Peace River and Upper Charlotte Harbor between 1983 and 1991. In addition, previously unreported data regarding phytoplankton and zooplankton taxonomic structure for samples collected in conjunction with the monthly salinity based primary production investigations between 1988 and 1991 are presented and analyzed.

Natural seasonal variations in freshwater inflow into estuarine systems have been shown, in both temperate and tropical systems, to influence resident biological communities primarily through four major mechanisms: 1) moderate changes in flow can rapidly and significantly affect the relative physical positions of salinity zones within an estuary; 2) variations in freshwater input result in alterations of both the ambient concentrations and loadings of the major macro-nutrients typically associated with phytoplankton growth (nitrogen and phosphorus), as well as silica, iron and trace micronutrient which can further affect phytoplankton community structure; 3) decreases in water clarity (turbidity and color) associated with increased flows can alter the penetration of light within the water column affecting both phytoplankton as well as seagrass communities; and 4) high freshwater inputs can create strong salinity stratification resulting seasonally in zones within the estuary characterized by anoxic bottom waters which may limit the distribution of many species.

PRIMARY PRODUCTIVITY

Changes in freshwater inflow into the Charlotte Harbor estuarine system potentially influence measurements of phytoplankton primary production (carbon uptake and chlorophyll a biomass) and community structure primarily through: 1) affecting the ambient concentrations and loadings of macro- and micro-nutrients; and 2) affecting water color and the subsequent amount of light within the water column. This changes not only the size of the photic zone, but can lead to the selective advantage of those phytoplankton taxa able to maintain themselves in the upper portions of the water column.

The analysis and conclusions regarding phytoplankton production presented in this report are in part provisional representing an evaluation of the first eight years, of the ten years of data collection required under the current CUP agreement. The observations in this document will be extended and analyzed over a full ten year period in the 1994 summary report strengthening the accuracy of the interpretations relating patterns of phytoplankton production, biomass and community structure with seasonal variations in Peace River flow.

Physical/Chemical Parameters - In order to develop a thorough understanding of the dynamics of phytoplankton production within the Lower Peace River/Upper Charlotte Harbor estuarine system, it is important to comprehend both short- and long-term variations of those physical and nutrient parameters normally associated with influencing phytoplankton growth. Long-term and seasonal monthly averages for both a number of physical and nutrient parameters, as well as phytoplankton production and biomass, were plotted for measurements taken at four salinity based stations between June 1983 and May 1991. Visual analysis of these figures suggested the existence of close relationships between changes of various estimated parameters and associated phytoplankton production and biomass.

Descriptive Analysis - Primary production and biomass patterns were summarized by comparative graphical analyses of the relationships between phytoplankton responses and the combined influences of seasonal and flow related parameters. Temperature was selected to serve as an extremely stable proxy for seasonal variation, representing both increasing/decreasing ambient light and metabolic activity. Ambient water color was chosen to represent the combined competing influences associated with higher freshwater inputs: the stimulation of increasing nutrient loadings, and the negative effects of decreasing light penetration of the water column. The following patterns were apparent:

1) Both phytoplankton production and biomass were found to be low, irregardless of temperature, during periods of low water color.

2) As color increased to intermediate levels, both phytolankton production and biomass showed significant positive responses. The magnitudes of these responses were observed to be highly temperature dependent.

3) Past a point, however, further increases in color overwhelmed the initial stimulation of increasing nutrients associated with flow, and both production and biomass declined rapidly.

Principal Component analysis - was used to evaluate the combined and relative influence on phytoplankton responses of the 25 physical and chemical parameters measured during the study.

This analysis indicated that:

1) The highest measured production rates and chlorophyll a levels occurred at 6 and 12 o/oo during periods of relatively low freshwater inputs, coincident with high seasonal temperature and light.

2) Increasing nutrients, independent of flow, resulted in stimulation of phytoplankton production and biomass. Such phytoplankton responses also increased under similar flow conditions with increasing nutrient levels.

3) Strong interactions between light, temperature and nutrient levels were

apparent. At relatively low temperature/light levels, increasing nutrients did little to increase productivity, while increasing temperature/light at constant nutrient levels resulted in dramatic increases in phytoplankton production.

Multiple Regression Models - were developed to provide statistically predictive estimates of phytoplankton production and biomass from the measured physical and nutrient parameters. The resultant predictive models accounted for 44% of the observed variability in carbon uptake and 37% in ambient chlorophyll a levels.

Relationships between Carbon uptake and chlorophyll a - Chlorophyll a as an estimate of biomass can be influenced by both ambient light levels as well as the nutritional state of the cells. Chlorophyll a, thus, often represents an integration of the phytoplankton community's response to longer-term influences. Carbon uptake rates reflect the cumulative effects of current conditions, and reflect ambient growth potential. Although analysis indicated that the two measurements of phytoplankton production: 1) instantaneous growth rates as measured by carbon uptake, and 2) integrated growth as measured by chlorophyll a biomass, generally followed similar seasonal trends at each of the four salinity zones there was only weak direct correlations among these two measurements of phytoplankton production.

Long-Term Trend Analysis - the physical/chemical/primary production data set has extended over a sufficient period to allow for the use of modeling techniques which test for the presence of long-term trends with regard to time. The SEASKEN procedure for testing for monotonic trends in time using modified forms of the Kendall's Tau and Seasonal Kendall tests was used to analyze for the presence of long-term trends in the various chemical, physical and biological data collected at the four salinity zones between 1983 and 1991. Water withdrawal showed a distinct increase over the eight-year period.

An average decrease in measure solar radiation occurred over the same period. Significant long-term declines in both carbon uptake and chlorophyll a were observed at the 0 o/oo salinity zone. Significant long-term increases were apparent at the highest salinity zone for nitrogen, chlorophyll a, and the extinction of light within the water column. It is suggested that the observed declines in carbon uptake and chlorophyll a at 0 o/oo salinity may in fact result in part from a change in the seasonal pattern of early Spring rainfall. The resulting decline is of particular interest, since it emphasizes the dependence of phytoplankton production at the lower salinities upon river flow during the Spring when flows are often very low. The observed long-term increase in chlorophyll a at 20 o/oo, and the corresponding increase in the extinction coefficient of light within the water column, is also of interest, particularly since it seems to be independent of any corresponding change in river flow. If such trends continue, they may well be indicative of increased nitrogen loading of the higher salinity reaches of the Harbor by non-point source discharges into the estuarine system.

Taxonomic Determinations of Phytoplankton Community Structure - In 1988 the collection of monthly samples for the analysis of phytoplankton community structure was begun in conjunction with the long-term study of physical/chemical water quality and primary production at the four monitored salinity zones. Phytoplankton community structure has long been used in other studies as a tool in assessing both temporal and long-term changes in water quality in estuarine system. Distinct differences among the major taxonomic groups were observed with regards to the four salinity zones, both with consideration to species composition and seasonal patterns.

1) 0 o/oo Salinity - Blue-green algae are a very important part of the phytoplankton during the period from February through April. Green algae

are typically dominant or show major increases in May during periods characterized by low Peace River flow. Flagellates, by comparison, show a strong increase in their importance within the phytoplankton community related to increasing Summer river flows. Diatoms are less frequent in the phytoplankton during such periods of high river flow, and are important or show major peaks during the late fall and winter months, as flow and water temperature decline. Dinoflagellates are not an important component of the phytoplankton community at this salinity.

2) 6 o/oo Salinity - the taxonomic structure at this salinity zone shows a dramatic decline in the importance of both green and blue-green taxa within the phytoplankton community. This salinity zone is characterized by alternating blooms of diatoms and flagellates, with dinoflagellates also showing periodic blooms.

3) 12 o/oo Salinity - this zone is characterized by seasonal blooms of flagellates, diatoms and dinoflagellates. Flagellates typically dominate through the cooler months and well into beginning of Summer wet-season. As river flow and temperature increase diatoms begin to become more important. Green algae comprise only a small part of the phytoplankton community.

4) 20 o/oo Salinity - the seasonal patterns of the major taxonomic groups at this salinity zone follow patterns generally similar to those observed at 12 o/oo. Diatoms and dinoflagellates, however, show a marked increased in their relative importance within the phytoplankton community.

ZOOPLANKTON STUDIES

Zooplankton represent an important link between the phytoplankton community and higher levels in the estuarine food chain. Many groups of organisms are represented in the zooplankton either as larvae or adults, encompassing a wide variety of sizes and motile capabilities and are typically dispersed in estuaries in patchy aggregates. Various physical and chemical parameters have been shown to influence zooplankton distributions and abundances in estuaries. Such parameters include, salinity, river flows, nutrient concentrations by influencing phytoplankton dynamics, temperature, and predatory densities.

The zooplankton community of Charlotte Harbor was examined from 1989 through 1991 for three purposes:

1. Document and catalog existing zooplankton communities in the Upper Charlotte Harbor estuary. Little is known of the zooplankton community in the area of the estuary. This study identified taxonomic composition at four salinity based stations in the Harbor and the Peace River and examined diel trends in zooplankton distributions at two of these salinity stations.

2. Examine the interrelationships between the phytoplankton community which represents a major component of primary productivity in the estuary and the zooplankton community. Zooplankton provide the primary pathway in the estuary for transfer of energy from primary production to secondary production and higher trophic levels. Understanding the relationships between the phytoplankton and zooplankton community will aid in the understanding of factors that influence primary production.

3. Examine how the zooplankton community and individual zooplankton taxa respond to changes in physical and chemical characteristics of the estuary such as: freshwater inflow, water temperature, and nutrient availability. Since these factors also influence the phytoplankton community and measures of primary production, it is of interest to examine how changes in Peace River physiochemistry influence zooplankton as mediated by changes in the phytoplankton community.

To examine the zooplankton community of Peace River/Charlotte Harbor, zooplankton were collected monthly from four stations in the Charlotte Harbor estuary. These collections were done concurrent with, and at the same salinity-based station locations as the primary producitivity/phytoplankton study. Samples were collected from the water surface by filtering 75 liters of water through a 50 um mesh net at each station and collecting an oblique tow using a 1.0 m, 50 um mesh net raised at a constant rate from bottom to the surface of the water column at each station. Select physical and chemical parameters from the estuary for each zooplankton sample were measured in conjuction with each sampling for later correlation with the observed zooplankton community patterns.

Since many taxa of zooplankton exhibit some degree of diurnal movement, a sampling regime was undertaken to examine diel periodicity of zooplankton communities at two of the salinity based stations, 12 and 20 o/oo. Seasonal diel differences were investigated through collections in March, June, September and December of 1990 and 1991. Zooplankton communities were sampled quarterly at three discreet depths, within 12 inches of the surface, midwater, and within 12 inches of the bottom. All samples for both the monthly collections and the diel collections were field preserved with 5 % formalin and returned to the laboratory for enumeration and identification.

To examine the direct relationships between the phytoplankton community and the zooplankton community a grazing study was conducted under both low nutrient influx (low river flow) and high nutrient influx (high river flow) conditions in 1990 and 1991. Twice each year, once at low flow and once under high flow conditions, estuary water, collected at 12 o/oo salinity, was filtered to produce a concentrated zooplankton sample. Filtered esturaine water samples were then inoculated with the concentrate and chlorphyll a measured over time to assess the impacts of zooplankton grazing on primary productivity.

A total of 656 distinct zooplankton collections were made in Charlotte Harbor from March, 1989 through December, 1991. Taxonomic identifications and enumeration of specimens resulted in identification of 77 species or taxonomic groups of zooplankton (Table 4.1). These taxa represented all lifestages from eggs for some invertebrates and vertebrates to larval forms and fully reproductive adults. In general, from all stations, the dominant taxa were rotifers (ROTOTARIA), crustacean copepods and nauplii, barnacle nauplii (CIRRIPEDIA), larvae of MOLLUSCA, PLATYHELMINTHES, and ANNELIDA and various HYDROZOA.

Total zooplankton density from any collection location or depth was typically about 1 million zooplankters per cubic meter of water. Densities were as high as 5.8 million and as low as 10,000 individuals per cubic meter.

The zooplankton community at 0 ppt was dominated by filter feeding rotifers and copepod nauplii, although low densities of adult copepods were observed. Seasonally high densities of ctenophores, sipunculids, larvaceans, gastropods and gastropod larvae, and hydrozoa medusae were also observed. Peaks in these seasonally abundant organisms generally corresponded to the periods of highest zooplankton densities and diversity.

The zooplankton community at 6 ppt was composed primarily of copepod nauplii, filter feeding rotifers, and the grazing calanoid copepod *Acartia tonsa*. Higher densities of copepods were observed at 6 ppt than 0 ppt, primarily cyclopoid *Oithona* species. Seasonally high densities of hemicordates, sipunculids, cirripedian nauplii, gastropod larvae, and pelecypod larvae were also observed corresponding to peaks in zooplankton densities and diversity at this station.

At 12 ppt the zooplankton community was also predominately copepod nauplii and *Acartia tonsa*, with increases in the number of polychaete larvae, an increased number and type of calanoid and cyclopoid copepod including: *Oithona* species, *Saphirella sp.* and *Paracalanus crassirostris*. Seasonally high densities of harpactacoid copepods principally *Euterpina acutifrons*, sipunculids, cirripedian nauplii, gastropod larvae, and turbellaria were also observed.

The zooplankton community at 20 ppt was dominated by copepod nauplii *Acartia* *tonsa*, pelecyopod larvae, medusal forms of Hydrozoa and Schyphozoa, *Acartia tonsa*, and increased numbers of *Oithona nana*. Seasonally high densities of fish eggs and larvae (Pisces), Cirripedia nauplii, Hemicordates, Ascideaceans, Turbellaria, and Sipunculids were also observed. Peaks in these seasonally abundant organisms generally corresponded to the periods of highest zooplankton densities and diversity at this station.

Multivariate analyses of taxonomic distributions between stations using Canonical Variate Analyses (CVA) indicated distinct taxa patterns within stations that discriminated between the stations in terms of both taxonomic composition and abundances of the dominate zooplankton taxa. Differences between stations were attributable primarily to varying densities of *Oithona sp., Acartia tonsa,* rotifers, and ctenophores.

Many estuarine and riverine factors may interact to affect zooplankton community structure and dynamics as well as individual species responses to their environment. These factors include such basic parameters as river flow, nutrient availability, water temperature, and season, to complex factors such as primary productivity levels, phytoplankton community composition, and chlorophyll a concentrations. It is difficult to determine and describe causative relationships between these factors and zooplankton communities since zooplankton community and populations are dependent upon the cumulative responses to interactions of both the basic physical and chemical parameters as well as the complex factors influencing phytoplankton communities and productivity.

To examine the interelations Pricipal Component Analysis (PCA) 29 physical/chemical, phytoplankton, and productivity measures were analyzed for the four salinity stations resulting in three composite variables for each analysis accounting for about 60 % of the variance at each station. These composite factors were then regressed against zooplankton taxa densities and zooplankton community metrics at each station. This resulted in the identification of individual zooplankton taxa at each station that responded to changes in a wide variety of variables and conditions.

From the diel sampling a total of 77 taxonomic groups or species were collected. These species or taxa collected were similar to those collected from the monthly samples. Densities from the diel collections were similar to those observed from the monthly collections and were typically about 1 million plankters per m^3. For both salinities sampled species richness was usually between 20 to 35 taxa for all depths, times, and dates sampled.

Zooplankton grazing studies were conducted twice during the dry season and twice during the wet season to attempt to directly assess the impacts of zooplankton grazing on the phytoplankton community and how these effects may have been mediated by river flow. These studies were conducted in September, 1990 (wet), January, 1991 (dry), August, 1991 (wet), and finally again in December, 1991 (dry). Results of these samplings indicated a tremendous amount of variation between samples within treatments and times making comparisons difficult and measuring the effects of zooplankton on phytoplankton by this method not practical.

DISCUSSION OF PRIMARY PRODUCTIVITY RESULTS

The hydrobiological monitoring program was designed to describe and evaluate the response of various physical, chemical and biological characteristics of the Charlotte Harbor estuarine system to changes in Peace River flow. Individual aspects of the program such as the monitoring of estuarine primary productivity have been designed not only to quantify the seasonal and long-term patterns of key estuarine communities, but to specifically determine if freshwater withdrawals by the Regional Water Treatment Plant Facility could be shown to alter these patterns.

Over the past eight years, estuarine phytoplankton productivity has been investigated as a potentially effective method of evaluating possible impacts associated with freshwater withdrawals. During the course of these investigations, the influences of seasonal variations in river flow as related to changes in estuarine macro-nutrient concentrations have been quantified. Specifically, the monitoring efforts have demonstrated direct effects of seasonal changes in Peace River flow on rates of primary production and the structure of phytoplankton communities within the upper Charlotte Harbor estuarine system. These results have led to the development of preliminary predictive models of the response of phytoplankton production to changes in flow, as integrated with seasonal changes in other physical/chemical parameters. As the study continues over the remaining two years of the existing consumptive use permit, further natural variations in flow and phytoplankton production will be added to the existing data base. This will result in an increase in the predictive accuracy of the models presented in the current document.

CONTINUING HYDROBIOLOGICAL MONITORING

The initial hydrobiological monitoring program was designed to provide answers to specific questions raised by SWFWMD staff during the original permit process dealing with possible salinity changes in Charlotte Harbor. Analysis of data from pre and post water treatment plant operation presented in the August 1982 report indicated the need to revise the monitoring program in order to better evaluate possible changes in the Charlotte Harbor system as related to flow. Further modifications of the hydrobiological monitoring program were again made both in 1985 and in conjunction with the most recent renewal of the consumptive use permit in November 1988.

The design of the monitoring program under the existing consumptive use permit (CUP) is based on the results of analysis from more than 10 years of sampling in compliance with previous SWFWMD programs. The development of a comprehensive understanding of primary production and the related structure of the phytoplankton communities within the Charlotte Harbor system is fundamental to the development of knowledge of other interrelated systems and processes, such as secondary production and nutrient cycling. A thorough understanding of the processes controlling phytoplankton primary production in Charlotte Harbor is necessary to quantify the estuary's immediate and long-term responses to external inputs. Studying the portion of the Harbor's production attributable to the phytoplankton (meets the previous cited criteria) provides both a quickly responding barometer of external change, as well as insight into a basic process affecting water quality with widespread interrelations and effects upon other system components. Phytoplankton production generally represents an immediately available food resource unlike seagrasses, mangroves and saltmarsh production, where much of the resource becomes available through secondary processes. Of the various inputs into Charlotte Harbor estuarine system, phytoplankton production represents both the largest single component of primary production and a food source directly accessible to many filter and detrital feeding organisms. Phytoplankton production and composition, due to the short generation times involved, have also been shown to be effective in demonstrating ephemeral, seasonal and long-term changes in water quality. Phytoplankton production represents a highly integrated estuarine component and can be used to provide information on both direct and predictive secondary impacts of external influences.

Beyond the importance of phytoplankton as a major component of the estuary's food web, there are four principal reasons that information on rates of primary production within the Charlotte Harbor system are important:

1) It may be possible that production rates can be modeled and incorporated into generalized circulation and water quality models used to predict the effects of flow related changes in circulation and water quality within the Charlotte Harbor system. The applications of such information and models may be of wide application and interest to various governmental and regulatory agencies.

2) Excessive phytoplankton production may reduce light penetration of the water column by increasing turbidity and absorbance. High levels of phytoplankton production may further affect factors which in turn can influence the dominance of estuarine species. An example would be potential extreme diurnal oscillations in dissolved oxygen levels in the water column caused by high phytoplankton densities.

3) Trend analysis of inorganic nutrient inputs and their respective ratios, from freshwater sources such as the Peace, Myakka and Caloosahatchee Rivers, may also be interpreted more accurately once the factors influencing phytoplankton production in specific areas of the Charlotte Harbor system are understood.

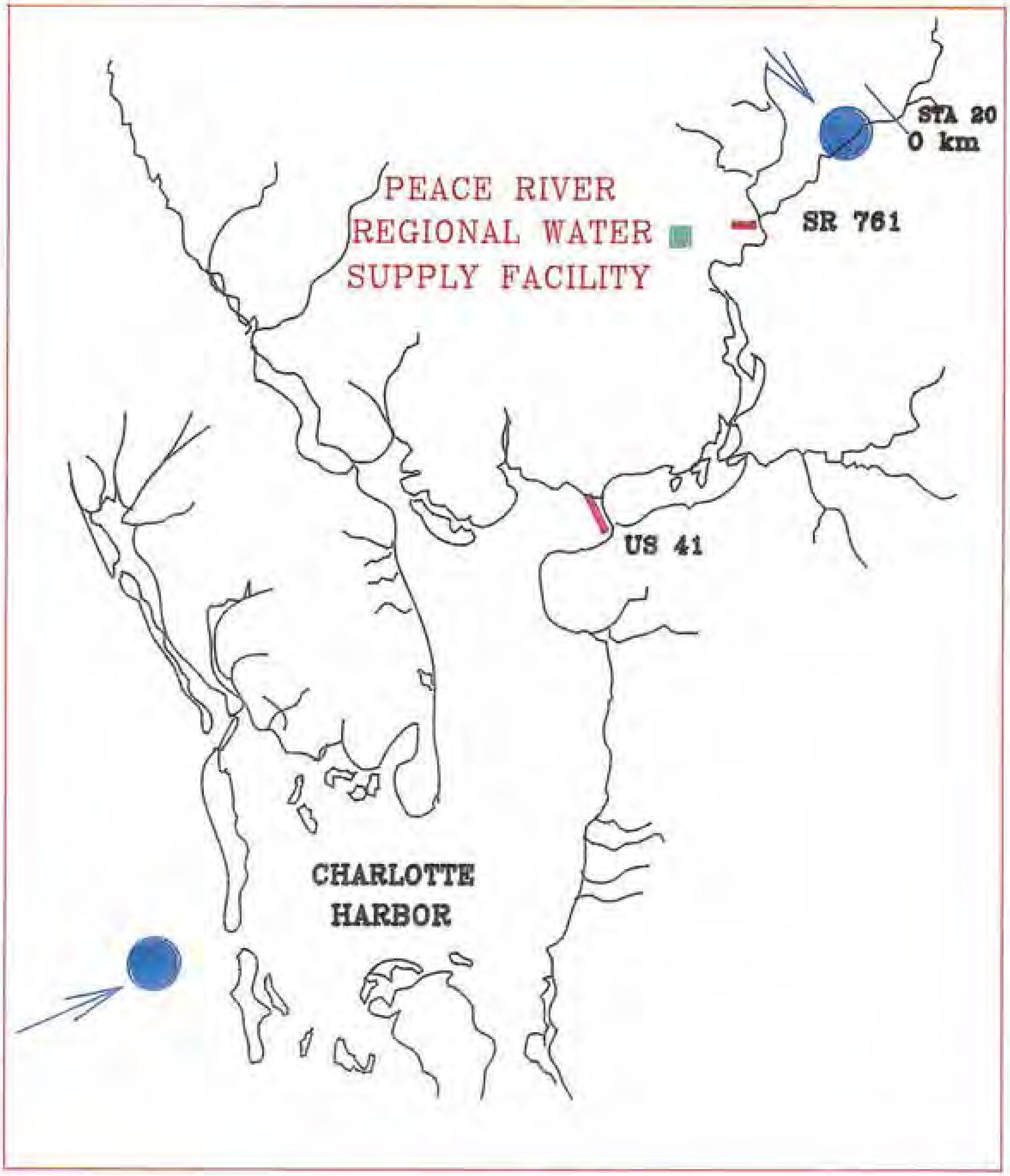
4) Significant long-term reductions in flow and related nutrient loadings into the estuary could potentially effect overall rates of primary production and or phytoplankton species distributions within the estuary. Such changes could have corresponding influences within the associated zooplankton communities resulting in further magnified changes on up the food chain, potentially affecting both recreational and commercial fishes within the Harbor.

2.0 INTRODUCTION

On December 10, 1975 the consumptive use permit #7500016 for the Peace River Regional Water Supply Facility was signed between General Development Utilities, Inc. and the Southwest Florida Water Management District (SWFWMD). In conjunction with this agreement, a comprehensive hydrobiological monitoring program, was set forth to assess the responses of various physical, chemical and biological characteristics of the Charlotte Harbor estuary to changes in Peace River flow. The program was designed to evaluate the impacts and significance of natural salinity changes on the aquatic fauna and flora in upper Charlotte Harbor, and to determine if freshwater withdrawals by the Peace River Water Supply Facility could be shown to alter these patterns. The area of study is shown in Figure 2.1.

A series of thirteen previous reports have been filed (February 1979, December 1980, July 1981, August 1982, September 1983, August 1984, July 1985, August 1986, August 1987, September 1989, December 1990, August 1991, and August 1992) with the SWFWMD, documenting the results of the hydrobiological monitoring program during the period from January 1976 through December 1991. These reports include summarizations of data collected during the first four years of baseline monitoring, prior to the start of freshwater withdrawals, as well as comparisons of these data to the results obtained from the hydrobiological monitoring programs during subsequent years of water treatment plant operation. As required under the most recent Peace River Water Supply

FIGURE 2.1
CHARLOTTE HARBOR STUDY AREA



3.0 REVIEW OF THE PRODUCTION AND STRUCTURE OF PHYTOPLANKTON COMMUNITIES WITHIN THE LOWER PEACE RIVER / UPPER CHARLOTTE HARBOR ESTUARINE SYSTEM - BETWEEN 1983 AND 1991

3.1 INTRODUCTION

The normal functioning of an estuarine system is dependent upon the complex interrelations of various components, including the relationships and dynamics of both organic and inorganic nutrient cycles. Total production and the maintenance of estuarine populations are dependent upon the interrelations of these processes mediated through a number of external physical forces, including the seasonal cycles of light, temperature and precipitation.

The development of an environmentally effective managerial perspective regarding estuarine freshwater inputs, requires the application of an assessment strategy focusing primarily upon those components of the various dynamic processes which exhibit the greatest sensitivity to disturbance. In choosing key dynamic processes on which to focus monitoring efforts, designed to assess the estuarine system's current status and potential susceptibility to induced impacts, consideration should be given to those elements capable of providing maximum information within reasonable limitations. In general this can most reasonably be accomplished by focusing on those system components which act both as barometers of environmental events, quickly responding to external changes, and those that contribute towards the greatest integrated understanding of the overall functioning of the estuarine system. It may be possible to develop generalized predictive estimates of potential long-term trends within the Charlotte Harbor system by concentrating monitoring efforts primarily upon the measurement of selected dynamic processes crucial to the overall functioning of the entire system, such as:

1) trends in nutrient inputs,
2) estimates of primary and secondary production rates, and
3) the population dynamics of key components in the baseline components of the estuarine food-web

3.1.1 Importance of Phytoplankton Production and Structure

The development of a comprehensive understanding of primary production as measured by carbon uptake and the related structure of the phytoplankton communities within the Charlotte Harbor system is fundamental to the development of knowledge of other interrelated systems and processes, such as secondary production and nutrient cycling. A thorough understanding of the processes controlling phytoplankton primary production in Charlotte Harbor is necessary to quantify the estuary's immediate and long-term responses to external inputs. Studying the portion of the Harbor's production attributable to the phytoplankton (meets the previous cited criteria) provides both a quickly responding barometer of external change, as well as insight into a basic process affecting water quality with widespread interrelations and effects upon other system components.

The 1983 DNR report "Assessment of Fisheries Habitat: Charlotte Harbor and Lake Worth, Florida" estimated the Charlotte Harbor estuarine system included approximately 488 square miles of open water, 91 square miles of seagrass, 5.5 square miles of saltmarsh and 88 square miles of mangrove forest. Estimated relative primary production rates taken from other studies for phytoplankton, seagrass, saltmarsh and mangrove forest environments, when combined with such areal habitat estimates for the Charlotte Harbor system suggested the relative importance of the primary production of each of these components.

Estimated Tons Carbon Fixed / Day

Phytoplankton	**1770**
Seagrass	**360 - 1460**
Mangrove Forest	1800 (**638** net export)
Saltmarsh	**9**

Study of phytoplankton related production within the Charlotte Harbor estuary confers a number of distinct advantages over investigations of other components contributing to the system's overall primary production. The basic processes involved in phytoplankton production are reasonably well understood, and the potential sources for error and variability are generally known. By comparison:

1) In a color induced, light limited estuary such as Charlotte Harbor, significant production by sea grasses and benthic algae are limited to either narrow fringing bands in shallow waters along shorelines, or areas of the lower harbor where water clarity is characterized by more marine influences (such as the Pine Island Sound area).

2) Methodologies for the quantification of production and inputs by both mangrove and salt marsh estuarine components are both difficult and extremely labor intensive. Seasonal and locality factors influencing such production are often highly complex and generally not well understood.

3) Bacterial production associated with the metabolism of dissolved

organics contained within freshwater inputs, although undoubtedly significant in estuarine systems, has only recently come under quantitative scientific investigation. Standard methodologies have yet to become widely accepted and sources of error and variability have not yet been well quantified.

Phytoplankton production generally represents an immediately available food resource unlike seagrasses, mangroves and saltmarsh production, where much of the resource becomes available through secondary processes. Of the various inputs into Charlotte Harbor estuarine system, phytoplankton production represents both the largest single component of primary production and a food source directly accessible to many filter and detrital feeding organisms. Phytoplankton production and composition, due to the short generation times involved, have also been shown to be effective in demonstrating ephemeral, seasonal and long-term changes in water quality. Phytoplankton production represents a highly integrated estuarine component and can be used to provide information on both direct and predictive secondary impacts of external influences.

Beyond the importance of phytoplankton as a major component of the estuary's food web, there are four principal reasons that information on rates of primary production within the Charlotte Harbor system are important:

1) It may be possible that production rates can be modeled and incorporated into generalized circulation and water quality models used to predict the effects of flow related changes in circulation and water quality within the Charlotte Harbor system. The applications of such information and models may be of wide application and interest to various governmental and regulatory agencies.

2) Excessive phytoplankton production may reduce light penetration of the water column by increasing turbidity and absorbance. High levels of phytoplankton production may further affect factors which in turn can influence the dominance of estuarine species. An example would be

potential extreme diurnal oscillations in dissolved oxygen levels in the water column caused by high phytoplankton densities.

3) Trend analysis of inorganic nutrient inputs and their respective ratios, from freshwater sources such as the Peace, Myakka and Caloosahatchee Rivers, may also be interpreted more accurately once the factors influencing phytoplankton production in specific areas of the Charlotte Harbor system are understood.

4) Significant long-term reductions in flow and related nutrient loadings into the estuary could potentially effect overall rates of primary production and or phytoplankton species distributions within the estuary. Such changes could have corresponding influences within the associated zooplankton communities resulting in further magnified changes on up the food chain, potentially affecting both recreational and commercial fishes within the Harbor.

3.1.2 Current Long-Term Studies of Primary Production

The current studies of primary production in the Lower Peace River/Upper Charlotte Harbor being conducted as part of the Peace River Regional Water Supply Facility's ongoing SWFWMD hydrobiological monitoring program are designed to develop the needed long-term base of data necessary to evaluate both short and long-term cycles in phytoplankton production in the upper estuarine system. Statistically comparable levels of phytoplankton production as measured using C-14 fixation rates have been determined monthly at four salinity based stations since June 1983. These investigations have included determinations of phytoplankton population structure, related physical parameters, water column light profiles and analysis of the major chemical constituents associated with phytoplankton growth. The four sampling locations in this study represent non-fixed surface salinity zones, such that the monthly location of each station is dependent upon the preceding amount of freshwater inflow from the Peace River. The four sampling zones are:

Station 101 = 0 o/oo Station 102 = 5-7 o/oo Station 103 = 11-13 o/oo Station 104 = 20-22 o/oo

To date, the furthest upstream sampling occurrence of the station at 0 o/oo has been approximately one half mile below Horse Creek (March, 1985), and the furthest occurrence of the downstream sampling of the 20-22 o/oo station has been in the Gulf just off Boca Grande (April, 1987), see arrows, Fig. 2.1.

This report presents data collected between 1983 and 1991 as part of this unique long-term study of the relationships between phytoplankton productivity and Peace River flow into Upper Charlotte Harbor. Under the newest SWFWMD withdrawal permit, phytoplankton studies will continue for at least another two years (through 1993), in order to develop a data base sufficiently large that statistical evaluation of trends and predictive models can be enhanced. In addition, this report includes a thorough taxonomic evaluation of the seasonal abundance and dominance of phytoplankton species, and their specific responses to variations in the periodicity of freshwater inflow from 1988 through 1991. This taxonomic portion of the study is also scheduled to continue through 1993.

3.2 PRIMARY PRODUCTIVITY METHODS

The methodologies used to measure and evaluate the physical, chemical and biological parameters encompassed within this investigation are outlined and described within the following sections.

3.2.1 In Situ Measurements of Physical Parameters

Depth, temperature, dissolved oxygen, conductivity pH, and oxidation-reduction potential were measured in situ with a Hydrolab TM Model 8000 system or Surveyor Model II system. Profiles were made from the surface to the bottom in 0.5m increments at each sampling station location. Depth measurements were determined on the basis of pre-measured marks on the unit's cable and/or pressure sensors within the sonde unit.

Pre-sampling instrument calibrations were conducted within 24 hours prior to use. Temperature was measured with a linear resistance thermistor, factory calibrated and accurate to within +/-0.2 oC. Dissolved oxygen (D.O.) was measured with a temperature-compensated, passive, polarographic cell, which measures the partial pressure of oxygen as parts per million (ppm or mg/l) of oxygen, +/-0.2 ppm. The probe was calibrated using the oxygen tension of water-saturated air (temperature corrected) as a standard.

The conductivity probes are six electrode cells and were calibrated against a KCl solution of known conductivity. Probe response was then tested with a solution of known, low conductivity to ensure that the reading is +/-1.0% of the range selected. The probes are automatically temperature compensated to provide conductivity at 25°C.

The Hydrolab™ pH probes are glass, KCl filled with silver/silver chloride reference electrodes and refillable junctions. They are automatically temperature compensated. Two buffer solutions of 7.0 and 10.0 pH (+/- 0.1) were used to calibrate the accuracy of the probe.

Oxidation-reduction potential (ORP) was measured using a platinum-tipped glass ORP probe and standard pH/ORP silver/silver chloride reference probe. Conversion of these ORP values to those of a standard hydrogen electrode can be approximated by adding 300 mV to the results from the silver/silver chloride electrode.

3.2.2 Light Profile

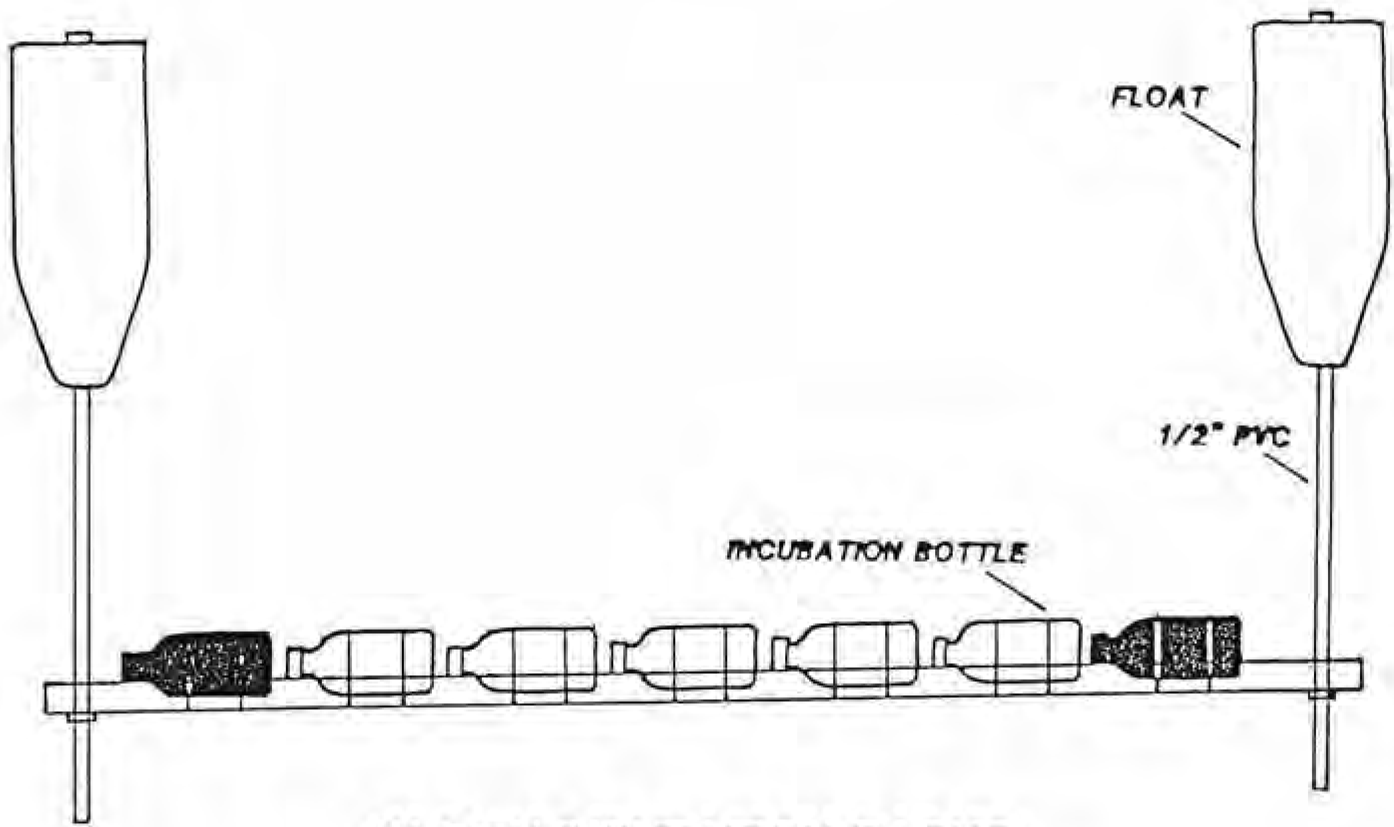
Light intensity profiles utilized both to determine the 50% light depth and calculate the water column extinction coefficient were conducted at each station. A LI-COR (model LI-185B) quantum/radiometer/photometer equipped with an underwater LI-1925B quantum sensor was used to measure photosynthetically active radiation (400-700 nanometers). Light intensities (microeinsteins/m_2/sec) were measured in the air just above the water surface, again just below the surface, and at six selected depths (20, 40, 60, 80, and 100 cm).

3.2.3 Primary Productivity Measurements

Five subsurface water samples were collected at each of the salinity based station locations. These were randomly collected to account for phytoplankton patchiness. The subsurface samples were placed in five replicate "light" and two (black plastic dipped) "dark" acid-rinsed, 450ml glass incubation bottles. Each bottle was then inoculated with 10 microcuries of trace metal-free ^{14}C (to obtain counts of approximately ten thousand counts per minute or CPM, depending on phytoplankton levels). The bottles were quickly placed on an adjustable rack (Figure 3.1) and incubated in situ at the depth where, during the light profile determination, 50% of incident surface radiation was found to remain.

All incubations were conducted within two hours of apparent noon to standardize for known patterns of diurnal periodicity in phytoplankton production. Cumulative light levels during the incubation periods were recorded using a LI-COR integrating quantum

FIGURE 3.1



IN SITU INCUBATION RACKS

photometer. After incubation all samples were placed in the dark, in cool ice chests and quickly returned to the laboratory and prepared for scintillation counting.

3.2.4 Determinations of Rates of C-14 Uptake

The following procedures were undertaken to determine both the overall rates of ^{14}C fixation, as well as those proportions attributable to the net- (> 20 microns), nano- (< 20 and > 5 microns) and pico- (< 5 microns) size fractions. Three separate subsamples were taken from each of the "light" sample bottles and processed as follows:

1) 50 ml was filtered through a 2.4 cm Whatman GF/C glass fiber filter using low vacuum (less than 2 PSI). The wet fiber filter was then placed in a scintillation vial and frozen until ready for analysis.

2) A second subsample was prepared in the same manner as the first, except prior to filtering, the 50 ml subsample was passed through 20 micron Nitex screening.

3) The third subsample was prepared in a likewise manner, but passed through 5 micron Nitex screening prior to filtering.

4) 50 ml sub-samples from each of the two dark bottles incubated at each station were filtered as in (1) above. Three corresponding filter blanks for each station were prepared by adding ten microcuries to a 450 ml ice stored water sample taken at the same station, and then immediately taking three 50 ml subsamples. These were also filtered as in (1) above.

5) To begin analysis 0.5 ml of 0.1 N HC1 was added to each vial and the vials were then allowed to stand for 3 hours before the addition of 10.0 ml of scintillation fluor. The vials were then placed in the liquid scintillation counter and allowed to dark adapt for at least 24 hours before being counted.

6) Background and known ^{14}C standards were run to check and validate the performance of the laboratory's Packard liquid scintillation system. Verification of the activity of the ^{14}C inoculation solution was also conducted monthly.

7) Each sample vial was counted for 30 minutes, or until the CPM in spectral region A had a standard deviation of less than 0.2%. Counts per minute were then converted to disintegrations per minute using the filter standardization channels ratio method.

3.2.5 Chlorophyll a

Ambient chlorophyll a levels are widely used to estimate phytoplankton biomass. For these investigations, chlorophyll a concentrations were determined fluorimetrically for the: 1) greater than 20 micron, 2) 5 to 20 micron, and 3) less than 5 micron size fractions, from samples collected simultaneously with those for primary productivity estimates. Chlorophyll a levels were determined for each of the three size fractions, both uncorrected and corrected for pheophytin, using the same filtering procedures as described above for the determination of carbon-14 incorporation. Comparable estimates were thus made for comparison of both phytoplankton biomass and productivity rates for each of three measured phytoplankton size fractions.

3.2.6 Water Chemistry

Surface water samples were collected for analysis at each salinity based station in pre-labeled, polyethylene containers. The containers were rinsed with sample water, filled and immediately placed in the dark on ice until returned to the laboratory following standard chain of custody and quality assurance procedures. Specific methods of analyses are listed in Table 3.1.

3.2.7 Population Structure

Surface water samples have been collected since 1988 for taxonomic analysis at each salinity based station in conjunction with primary productivity measurements. Samples for microscopic investigation are placed in one-liter polyethylene containers and immediately fixed with 4 ml of Lugol's solution, the preferred solution for preservation of samples which may include flagellates. The samples are placed on ice in the dark for transportation back to the lab, where they are held in a refrigerator at 4 °C until prepared

TABLE 3.1

WATER CHEMISTRY METHODS

Parameter	APHA*
Color	2120 C. pg 2-5
Chloride	4500 Cl B. pg 4-68
Turbidity	2130 B. pg 2-13
Alkalinity	2320 B. pg 2-35
NO_2+NO_3-N	4500 NO_3 F. pg 4-137
NH_3+NH_4-N	4500-NH_3 pg 4-126
Total Kjeldahl Nitrogen	4500 N_{org} pg 4-147
Ortho-phosphorus	4500-P pg 4-177 (non-digested)
Total Phosphorus	4500-P pg 4-177 (digested)
Silica	4500-Si E. 4-188
Inorganic Carbon	5310 B. pg 5-18
Total Organic Carbon	5310 B. pg 5-18
Dissolved Organic Carbon	5310 B. pg 5-18
Iron	3500-Fe B. pg 3-102

*Reference:
APHA - Standard Methods for the Examination of Water and Wastewater, 1989.

for counting. Extensive work has been completed in preparing a thorough photographic taxonomic inventory of the phytoplankton taxa seasonally present at the four salinity zones. To date over 500 taxa have been identified from samples collected. Samples are prepared for observation using a Zeiss inverted microscope utilizing the following settling procedures:

- Samples are removed from the refrigerator and gently shaken to assure resuspension of all material.

- Randomly selected subsamples totaling 5-200 ml (depending on the concentration of the material in the samples) is withdrawn and placed in 50 ml conical glass centrifuge tubes.

- The tubes are then spun at approximately 50 x gravity for 45 minutes. Three to four drops of iodine solution are then added at the top of the tubes, which are then allowed to stand for at least 24 hrs.

- At the end of the first settling period, the settled material in the bottom 2.5 ml and any cells adhering to the surface tension of each centrifuge tube is drawn off and placed in a 10 ml Zeiss inverted microscope settling chamber.

- Two drops of iodine solution is again added to promote settling, and the composite samples are again allowed to stand undisturbed for 24 hrs.

Once the samples have been prepared, the counting chambers are placed on a Zeiss inverted microscope for phytoplankton identification. Taxonomic determinations to the lowest practical taxonomy level are conducted from random fields using a modified strip method. To determine community structure, a standardized number of cells are identified (500). The majority of the taxonomic work is conducted using a 100X objective and 16X wide field oculars. As each observation is made, assigned genus and species codes are recorded. After having recorded the taxonomic determinations of 500 cells, additional notes on each sample are compiled using a combination of low and high power objectives. Determinations of the number of cells per unit volume are conducted or the same samples using a 10x ocular grid and 100x objective. The total number of cells in randomly selected fields, taken in a modified strip method are recorded on a data sheet and appropriate dilution calculations made.

3.3 RESULTS 1983-1991

Table 3.2 summarizes and describes the physical, chemical and biological parameters which were measured in conjunction with the current phytoplankton productivity study. Included are the codes for the variable names used both in the Tables in the results section of this document and in the Physical/Chemical/Production SAS data set which was file with both SWFWMD and the Water Authority with this document.

3.3.1 Physical/Chemical Parameters

In order to develop a thorough understanding of the dynamics of phytoplankton production within the Lower Peace River/Upper Charlotte Harbor estuarine system, it is first important to evaluate both the shorter and longer-term variabilities of those key physical and chemical (nutrients) factors normally associated with influencing phytoplankton growth. Resultant measurements of such key parameters, by date and salinity zone, for the period from 1983 through 1991, are present in the following tables:

TABLE 3.3 Physical and Chemical Parameters

TABLE 3.4 Physical Parameters - Measurements of Ambient Solar Radiation and Water Column Extinction

TABLE 3.2

PHYSICAL DATA

STATION	-	1 = 0 o/oo salinity, 2 = 6 o/oo salinity 3 = 12 o/oo salinity, 4 = 20 o/oo salinity
DATE	-	Day, Month, Year
TEMP	-	Temperature in degree centigrade
COLOR	-	Color in cobalt/platinum units (APHA)
EXC	-	Extinction Coefficient - calculated from light profile measurements at each station
OPD50	-	Depth (in meters) to the theoretical depth where 50% of the measured illumination just above the surface of the waters was still available.
OPD01	-	Depth (in meters) to the theoretical depth where 1% of surface light was still available. This is often taken as the compensation depth where net algal photosynthesis = net algal respiration.
MICROE	-	Total light (measured in Einsteins) available at the surface during the period of time the samples were incubated at each station
LIGHT	-	Total Einsteins available at the surface on the day of sampling
LT7A	-	Average daily total available light during the seven day period prior to each sampling date
EM	-	Total Einsteins during calender month
DIS	-	Monthly distance in kilometers downstream form Station #20 (see Figure 3.1) of each salinity based sampling location
PRFLOW	-	Peace River flow (in cubic ft/sec) on each sampling date
DAF7	-	Average daily Peace River flow over the seven day period prior to each sampling date
DAF14	-	Average daily Peace River flow over the fourteen day period prior to each sampling date
WINDSD	-	Average wind speed on the sampling date
WINDP3DA	-	Average daily wind speed over the three day period prior to the sampling date

CHEMICAL DATA

NH4	-	Ammonia nitrogen mg/l
N23	-	Nitrate + Nitrite Nitrogen mg/l
TOTN	-	Total Kjeldahl nitrogen mg/l
ONIT	-	Total Organic Nitrogen mg/l (= TOTN-NH4)
OP	-	Ortho-phosphate mg/l
TOTP	-	Total phosphorus mg/l
NPA	-	Atomic ratio of available nitrogen to phosphorus
SI	-	Silica mg/l
IOC	-	Available inorganic carbon mg/l

TABLE 3.2 (continued)

PRIMARY PRODUCTION (all values are means of five replicates at each station

P2	-	mg Carbon fixed per cubic meter per hour
P9	-	P2/ mg Chlorophyll _a_ per cubic meter
P3	-	mg Carbon fixed per cubic meter per Einstein per square meter at the surface
P10	-	P3/ mg Chlorophyll _a_ per cubic meter
P4	-	estimated mg Carbon fixed per cubic meter per day calculated from P3 and total Einsteins for the day
P5	-	estimated mg Carbon fixed per cubic meter per month calculated from P3 and total Einsteins for the month
P6	-	estimated mg Carbon fixed per square meter per day calculated from P3, the total Einsteins for the day and the calculated depth to the 1% light level
P7	-	estimated mg Carbon fixed per square meter per month calculated from P3, the total Einsteins for the month and the calculated depth to the 1% light level
F1	-	Fraction of P3 fixed by phytoplankton in the sample greater than 20 microns in size
F2	-	Fraction of P3 fixed by phytoplankton less than 20 and greater than 5 microns in size
F3	-	Fraction of P3 fixed by phytoplankton less than 5 microns in size
F4	-	F1 expressed as a percent
F5	-	F2 expressed as a percent
F6	-	F3 expressed as a percent

Chlorophyll _a_ (single values per station)

CHLA	-	total chlorophyll **a** of all size fractions in sample mg/m3
CF1	-	fraction of chlorophyll _a_ contained in phytoplankton in the sample greater than 20 microns in size
CF2	-	fraction of chlorophyll _a_ contained in the phytoplankton less than 20 and greater than 5 microns in size
CF3	-	fraction of chlorophyll _a_ contained in the phytoplankton less than 5 microns in size
CF4	-	CF1 expressed as a percent
CF5	-	CF2 expressed as a percent
CF6	-	CF3 expressed as a percent

TABLE 3.5 Physical Parameters - Peace River Flow and Relative Station location

Physical Parameters

Two of the critical key physical factors influencing phytoplankton productivity are: light, which provides the needed quanta for photosynthetic activity; and temperature, which influences the rates of various cellular metabolic processes. In Figure 3.2 both surface water temperature and average photosynthetically active solar radiation (measured in Einsteins) over the preceding seven-day period to each sampling event are plotted by sampling date between June 1983 and June 1991 (**it should be noted that on the time axis dates are designated for June of each year**). Seasonal variability and the interrelation between these two parameters are depicted. It is apparent that both the seasonal patterns of light levels between and within years are far more variable than those of surface water temperatures. Water temperature (with a defined lag) clearly follows the seasonal increases and decrease in light levels. This figure indicates that the highest average daily light levels generally occur in the late spring dry-season (April through May) prior to the beginning of the wet-season (June through September) afternoon rains.

Average 7- and 28-day Peace River flow, prior to each sampling date, are plotted in Figure 3.3 over the 8 year period of the study. Although the above described general descriptions of wet- and dry- seasons are apparent, there have been significant differences in the seasonal periodicity, duration and magnitude of Peace River flow over the study period. Specifically of note was the interval of very low Peace River flow which existed from late 1988 through approximately May of 1991. The influences of such

TABLE 3.3

PHISICAL AND CHEMICAL PARAMETERS

DATE			STATION	PHYSICAL COLOR	PHYSICAL TEMP	NUTRIENTS in mg/l NH4	N23	OP	SI	Atomic Ratio Nit/Phos NPA
JUN	16	83	0 o/oo	125	29.1	0.081	0.478	1.010	2.88	1.2
JUN	16	83	6 o/oo	88	28.9	0.026	0.047	0.849	1.58	0.1
JUN	16	83	12 o/oo	60	28.3	0.020	0.100	0.700	1.24	0.3
JUN	16	83	20 o/oo	27	28.7	0.031	0.008	0.234	0.60	0.3
JUL	22	83	0 o/oo	160	31.0	0.096	0.213	1.180	3.51	0.5
JUL	22	83	6 o/oo	125	30.7	0.027	0.037	0.680	2.87	0.2
JUL	22	83	12 o/oo	90	30.4	0.006	0.005	0.576	2.60	0.0
JUL	22	83	20 o/oo	40	30.8	0.001	0.003	0.297	1.79	0.0
AUG	19	83	0 o/oo	240	30.5	0.065	0.175	0.588	2.93	0.9
AUG	19	83	6 o/oo	192	31.4	0.085	0.096	0.515	2.97	0.8
AUG	19	83	12 o/oo	102	31.1	0.022	0.042	0.457	2.61	0.3
AUG	19	83	20 o/oo	41	31.0	0.001	0.002	0.237	1.83	0.0
SEPT	28	83	0 o/oo	250	26.1	0.069	0.155	0.569	2.63	0.8
SEPT	28	83	6 o/oo	180	26.3	0.038	0.116	0.381	2.54	0.9
SEPT	28	83	12 o/oo	120	25.9	0.041	0.072	0.299	2.25	0.8
SEPT	28	83	20 o/oo	55	26.0	0.006	0.004	0.162	1.09	0.1
OCT	20	83	0 o/oo	164	27.0	0.080	0.423	0.758	3.41	1.5
OCT	20	83	6 o/oo	122	27.4	0.077	0.257	0.546	2.53	1.3
OCT	20	83	12 o/oo	100	27.4	0.116	0.162	0.387	2.07	1.6
OCT	20	83	20 o/oo	54	26.5	0.033	0.038	0.207	1.38	0.7
NOV	22	83	0 o/oo	96	21.0	0.023	0.676	1.070	4.02	1.4
NOV	22	83	6 o/oo	90	21.5	0.023	0.277	0.642	2.64	1.0
NOV	22	83	12 o/oo	71	22.5	0.001	0.092	0.473	1.85	0.4
NOV	22	83	20 o/oo	39	21.5	0.001	0.005	0.212	1.24	0.0
DEC	28	83	0 o/oo	190	15.1	0.144	0.590	0.928	3.39	1.8
DEC	28	83	6 o/oo	160	15.1	0.073	0.454	0.664	2.84	1.8
DEC	28	83	12 o/oo	110	15.7	0.022	0.321	0.504	2.32	1.5
DEC	28	83	20 o/oo	31	15.1	0.002	0.084	0.192	1.36	1.0
JAN	18	84	0 o/oo	121	18.8	0.082	0.698	0.874	2.62	2.0
JAN	18	84	6 o/oo	105	19.5	0.076	0.442	0.607	2.07	1.9
JAN	18	84	12 o/oo	74	19.4	0.018	0.200	0.400	1.44	1.2
JAN	18	84	20 o/oo	45	19.4	0.004	0.038	0.221	1.04	0.4
FEB	15	84	0 o/oo	91	20.2	0.100	1.040	1.510	2.95	1.7
FEB	15	84	6 o/oo	78	19.9	0.014	0.423	0.778	1.62	1.2
FEB	15	84	12 o/oo	70	20.1	0.001	0.200	0.596	1.09	0.7
FEB	15	84	20 o/oo	41	19.4	0.001	0.006	0.220	0.36	0.0

TABLE 3.3 (Cont.)

PHISICAL AND CHEMICAL PARAMETERS

DATE			STATION	PHYSICAL COLOR	PHYSICAL TEMP	NUTRIENTS in mg/l NH4	N23	OP	SI	Atomic Ratio Nit/Phos NPA
MAR	9	84	0 o/oo	174	19.7	0.056	0.267	0.856	2.13	0.8
MAR	9	84	6 o/oo	136	19.6	0.063	0.144	0.540	1.17	0.8
MAR	9	84	12 o/oo	108	18.5	0.017	0.102	0.441	0.85	0.6
MAR	9	84	20 o/oo	52	18.7	0.001	0.002	0.247	0.23	0.0
APR	19	84	0 o/oo	108	23.7	0.062	0.016	0.872	2.71	0.2
APR	19	84	6 o/oo	94	23.7	0.021	0.002	0.411	0.85	0.1
APR	19	84	12 o/oo	60	23.6	0.008	0.001	0.287	0.14	0.0
APR	19	84	20 o/oo	35	22.8	0.031	0.001	0.163	0.33	0.4
MAY	7	84	0 o/oo	81	28.5	0.003	0.001	1.120	3.14	0.0
MAY	7	84	6 o/oo	83	28.5	0.027	0.046	0.542	1.76	0.3
MAY	7	84	12 o/oo	64	29.3	0.001	0.001	0.410	1.31	0.0
MAY	7	84	20 o/oo	44	28.8	0.001	0.001	0.219	1.08	0.0
JUN	7	84	0 o/oo	140	28.1	0.123	0.501	0.896	2.73	1.5
JUN	7	84	6 o/oo	80	27.5	0.030	0.224	0.672	1.48	0.8
JUN	7	84	12 o/oo	50	27.7	0.035	0.001	0.474	0.47	0.1
JUN	7	84	20 o/oo	34	26.9	0.005	0.001	0.261	0.05	0.0
JUL	9	84	0 o/oo	130	29.9	0.033	0.273	0.580	2.69	1.2
JUL	9	84	6 o/oo	103	30.1	0.006	0.204	0.486	2.10	0.9
JUL	9	84	12 o/oo	74	29.7	0.048	0.120	0.433	1.48	0.8
JUL	9	84	20 o/oo	35	29.4	0.001	0.003	0.277	0.45	0.0
AUG	16	84	0 o/oo	228	30.8	0.042	0.462	0.936	3.75	1.2
AUG	16	84	6 o/oo	156	32.3	0.039	0.198	0.504	2.61	1.0
AUG	16	84	12 o/oo	98	31.4	0.015	0.004	0.318	1.04	0.1
AUG	16	84	20 o/oo	42	31.1	0.007	0.001	0.157	0.14	0.1
SEPT	13	84	0 o/oo	142	29.0	0.082	0.538	0.980	3.94	1.4
SEPT	13	84	6 o/oo	110	30.4	0.021	0.146	0.513	2.87	0.7
SEPT	13	84	12 o/oo	78	29.8	0.044	0.057	0.390	1.92	0.5
SEPT	13	84	20 o/oo	38	28.6	0.001	0.004	0.194	0.44	0.0
OCT	4	84	0 o/oo	87	25.5	0.005	0.518	1.240	3.26	0.9
OCT	4	84	6 o/oo	103	24.9	0.001	0.280	0.704	2.80	0.9
OCT	4	84	12 o/oo	109	24.3	0.001	0.138	0.522	1.98	0.6
OCT	4	84	20 o/oo	33	24.0	0.001	0.001	0.155	0.65	0.0
NOV	15	84	0 o/oo	38	19.8	0.066	0.554	1.190	1.22	1.1
NOV	15	84	6 o/oo	48	20.0	0.024	0.221	0.850	1.31	0.6
NOV	15	84	12 o/oo	44	19.8	0.014	0.011	0.549	0.58	0.1
NOV	15	84	20 o/oo	30	18.1	0.003	0.014	0.279	0.39	0.1
DEC	13	84	0 o/oo	41	17.8	0.109	0.645	1.010	1.60	1.7
DEC	13	84	6 o/oo	45	18.5	0.097	0.332	0.737	1.48	1.3
DEC	13	84	12 o/oo	38	19.2	0.030	0.032	0.519	0.20	0.2
DEC	13	84	20 o/oo	29	18.7	0.003	0.007	0.290	0.04	0.0

TABLE 3.3 (Cont.)

PHISICAL AND CHEMICAL PARAMETERS

DATE			STATION	PHYSICAL COLOR	PHYSICAL TEMP	NUTRIENTS in mg/l NH4	NUTRIENTS in mg/l N23	NUTRIENTS in mg/l OP	NUTRIENTS in mg/l SI	Atomic Ratio Nit/Phos NPA
JAN	8	85	0 o/oo	37	17.5	0.043	0.713	1.040	1.03	1.6
JAN	8	85	6 o/oo	45	17.6	0.119	0.328	0.799	1.32	1.2
JAN	8	85	12 o/oo	37	17.4	0.124	0.187	0.567	1.15	1.2
JAN	8	85	20 o/oo	28	16.8	0.009	0.029	0.336	0.60	0.2
FEB	19	85	0 o/oo	36	17.8	0.086	0.628	0.843	0.65	1.9
FEB	19	85	6 o/oo	39	18.4	0.051	0.328	0.740	0.77	1.1
FEB	19	85	12 o/oo	37	17.9	0.065	0.177	0.593	0.71	0.9
FEB	19	85	20 o/oo	27	17.7	0.034	0.020	0.334	0.51	0.3
MAR	13	85	0 o/oo	35	26.4	0.024	0.198	1.110	0.14	0.4
MAR	13	85	6 o/oo	44	25.9	0.006	0.139	0.770	0.65	0.4
MAR	13	85	12 o/oo	41	25.5	0.006	0.110	0.639	0.62	0.4
MAR	13	85	20 o/oo	29	25.0	0.001	0.003	0.345	0.24	0.0
APR	17	85	0 o/oo	33	25.0	0.072	0.260	1.030	0.60	0.7
APR	17	85	6 o/oo	43	25.0	0.049	0.149	0.853	1.07	0.5
APR	17	85	12 o/oo	48	24.6	0.001	0.029	0.646	0.88	0.1
APR	17	85	20 o/oo	36	24.6	0.001	0.003	0.439	0.57	0.0
MAY	13	85	0 o/oo	37	29.9	0.038	0.110	1.010	1.29	0.3
MAY	13	85	6 o/oo	44	29.7	0.041	0.070	0.932	1.33	0.2
MAY	13	85	12 o/oo	44	29.2	0.001	0.003	0.739	1.05	0.0
MAY	13	85	20 o/oo	32	29.1	0.001	0.001	0.449	0.44	0.0
JUN	18	85	0 o/oo	42	30.6	0.014	0.528	0.906	1.64	1.3
JUN	18	85	6 o/oo	49	30.2	0.024	0.152	0.987	2.05	0.4
JUN	18	85	12 o/oo	46	30.6	0.087	0.005	0.736	2.05	0.2
JUN	18	85	20 o/oo	36	29.5	0.045	0.001	0.448	1.00	0.2
JUL	11	85	0 o/oo	62	32.0	0.041	0.352	0.856	2.39	1.0
JUL	11	85	6 o/oo	77	31.9	0.046	0.225	0.826	2.76	0.7
JUL	11	85	12 o/oo	60	30.9	0.022	0.010	0.559	1.58	0.1
JUL	11	85	20 o/oo	35	30.0	0.001	0.006	0.313	0.69	0.0
AUG	7	85	0 o/oo	170	29.4	0.081	0.372	0.825	2.79	1.2
AUG	7	85	6 o/oo	90	30.0	0.091	0.225	0.650	2.61	1.1
AUG	7	85	12 o/oo	100	30.5	0.004	0.087	0.408	1.74	0.5
AUG	7	85	20 o/oo	50	30.6	0.001	0.010	0.263	0.49	0.0
SEPT	9	85	0 o/oo	320	29.3	0.070	0.227	0.860	3.20	0.7
SEPT	9	85	6 o/oo	240	30.1	0.188	0.160	0.578	3.14	1.3
SEPT	9	85	12 o/oo	145	29.2	0.188	0.111	0.478	2.85	1.4
SEPT	9	85	20 o/oo	85	29.2	0.001	0.013	0.226	0.52	0.1
OCT	9	85	0 o/oo	170	26.5	0.081	0.372	0.825	2.79	1.2
OCT	9	85	6 o/oo	90	26.9	0.091	0.225	0.650	2.61	1.1
OCT	9	85	12 o/oo	100	27.5	0.004	0.087	0.408	1.74	0.5
OCT	9	85	20 o/oo	50	27.6	0.001	0.010	0.263	0.49	0.0

TABLE 3.3 (Cont.)

PHISICAL AND CHEMICAL PARAMETERS

DATE			STATION	PHYSICAL COLOR	TEMP	NUTRIENTS in mg/l NH4	N23	OP	SI	Atomic Ratio Nit/Phos NPA
NOV	26	85	0 o/oo	111	24.6	0.001	0.390	0.910	3.07	0.9
NOV	26	85	6 o/oo	111	24.7	0.012	0.300	0.657	2.75	1.0
NOV	26	85	12 o/oo	71	24.2	0.025	0.194	0.480	2.07	1.0
NOV	26	85	20 o/oo	52	24.0	0.039	0.081	0.332	1.21	0.8
DEC	20	85	0 o/oo	58	16.4	0.046	0.626	0.997	1.41	1.5
DEC	20	85	6 o/oo	62	16.2	0.031	0.162	0.579	1.66	0.7
DEC	20	85	12 o/oo	58	15.8	0.029	0.095	0.450	1.44	0.6
DEC	20	85	20 o/oo	38	15.5	0.026	0.037	0.242	0.99	0.5
JAN	14	86	0 o/oo	52	16.7	0.019	0.788	0.878	1.24	2.1
JAN	14	86	6 o/oo	46	17.1	0.024	0.229	0.630	1.05	0.9
JAN	14	86	12 o/oo	44	16.1	0.012	0.108	0.456	0.97	0.6
JAN	14	86	20 o/oo	34	15.0	0.001	0.035	0.281	0.91	0.2
FEB	14	86	0 o/oo	53	17.2	0.141	1.240	0.774	1.78	4.0
FEB	14	86	6 o/oo	52	16.2	0.028	0.139	0.537	1.29	0.7
FEB	14	86	12 o/oo	38	14.6	0.001	0.026	0.374	0.61	0.1
FEB	14	86	20 o/oo	27	15.7	0.001	0.001	0.234	0.14	0.0
MAR	12	86	0 o/oo	60	21.7	0.065	0.462	0.864	0.92	1.3
MAR	12	86	6 o/oo	52	22.0	0.139	0.291	0.650	1.22	1.5
MAR	12	86	12 o/oo	43	21.9	0.078	0.133	0.452	0.69	1.0
MAR	12	86	20 o/oo	25	21.1	0.001	0.019	0.253	0.29	0.1
APR	14	86	0 o/oo	111	24.3	0.001	0.039	0.932	2.75	0.0
APR	14	86	6 o/oo	114	24.2	0.001	0.183	0.700	2.02	0.6
APR	14	86	12 o/oo	81	23.7	0.001	0.004	0.454	0.89	0.0
APR	14	86	20 o/oo	46	23.4	0.001	0.001	0.287	0.01	0.0
MAY	13	86	0 o/oo	37	26.4	0.098	0.062	1.170	0.72	0.3
MAY	13	86	6 o/oo	60	26.6	0.007	0.020	0.751	1.53	0.0
MAY	13	86	12 o/oo	51	25.7	0.015	0.008	0.468	1.53	0.1
MAY	13	86	20 o/oo	37	24.7	0.035	0.001	0.312	0.87	0.2
JUN	17	86	0 o/oo	140	28.8	0.086	0.355	0.726	2.01	1.3
JUN	17	86	6 o/oo	92	28.3	0.001	0.097	0.678	1.80	0.3
JUN	17	86	12 o/oo	55	29.3	0.001	0.008	0.503	1.49	0.0
JUN	17	86	20 o/oo	29	28.5	0.026	0.001	0.322	0.56	0.1
JUL	11	86	0 o/oo	310	31.2	0.030	0.381	0.676	3.26	1.3
JUL	11	86	6 o/oo	260	32.0	0.010	0.185	0.460	3.36	0.9
JUL	11	86	12 o/oo	155	32.5	0.007	0.073	0.365	3.28	0.5
JUL	11	86	20 o/oo	70	30.5	0.001	0.002	0.221	1.64	0.0
AUG	7	86	0 o/oo	325	29.6	0.046	0.280	0.736	3.27	1.0
AUG	7	86	6 o/oo	190	30.5	0.166	0.206	0.466	3.48	1.8
AUG	7	86	12 o/oo	130	30.0	0.250	0.140	0.406	3.40	2.1
AUG	7	86	20 o/oo	50	29.3	0.001	0.001	0.179	1.01	0.0

TABLE 3.3 (Cont.)

PHISICAL AND CHEMICAL PARAMETERS

			PHYSICAL		NUTRIENTS in mg/l				Atomic Ratio Nit/Phos
DATE		STATION	COLOR	TEMP	NH4	N23	OP	SI	NPA
SEPT 14	86	0 o/oo	280	30.0	0.034	0.291	0.812	3.29	0.9
SEPT 14	86	6 o/oo	203	32.6	0.131	0.242	0.553	3.38	1.5
SEPT 14	86	12 o/oo	80	33.3	0.081	0.071	0.302	2.32	1.1
SEPT 14	86	20 o/oo	60	31.8	0.034	0.001	0.185	0.81	0.4
OCT 8	86	0 o/oo	160	29.0	0.071	0.487	0.786	3.44	1.6
OCT 8	86	6 o/oo	137	29.8	0.038	0.207	0.586	2.81	0.9
OCT 8	86	12 o/oo	98	29.6	0.112	0.111	0.415	1.94	1.2
OCT 8	86	20 o/oo	52	29.6	0.064	0.011	0.198	0.85	0.8
NOV 17	86	0 o/oo	150	25.8	0.089	0.586	0.864	4.26	1.7
NOV 17	86	6 o/oo	140	26.1	0.068	0.337	0.525	3.91	1.7
NOV 17	86	12 o/oo	102	26.2	0.086	0.242	0.396	2.11	1.8
NOV 17	86	20 o/oo	50	25.7	0.135	0.087	0.223	0.94	2.2
DEC 18	86	0 o/oo	43	22.5	0.027	0.652	0.901	1.06	1.7
DEC 18	86	6 o/oo	52	22.8	0.001	0.317	0.667	2.13	1.0
DEC 18	86	12 o/oo	46	23.0	0.001	0.060	0.409	1.70	0.3
DEC 18	86	20 o/oo	28	15.4	0.001	0.004	0.237	0.93	0.0
JAN 9	87	0 o/oo	215	13.4	0.061	0.395	0.424	2.48	2.4
JAN 9	87	6 o/oo	185	17.4	0.061	0.361	0.363	2.34	2.6
JAN 9	87	12 o/oo	102	15.5	0.074	0.212	0.238	1.78	2.7
JAN 9	87	20 o/oo	40	15.5	0.058	0.096	0.137	1.34	2.5
FEB 11	87	0 o/oo	112	16.9	0.059	0.667	0.718	3.04	2.3
FEB 11	87	6 o/oo	100	16.8	0.009	0.401	0.464	2.55	2.0
FEB 11	87	12 o/oo	73	16.0	0.001	0.169	0.293	1.65	1.3
FEB 11	87	20 o/oo	49	15.5	0.001	0.027	0.173	1.39	0.3
MAR 10	87	0 o/oo	102	20.8	0.049	0.485	0.650	2.27	1.8
MAR 10	87	6 o/oo	70	20.6	0.018	0.259	0.503	1.76	1.2
MAR 10	87	12 o/oo	60	20.0	0.015	0.177	0.354	1.41	1.2
MAR 10	87	20 o/oo	32	20.4	0.001	0.039	0.158	1.14	0.5
APR 20	87	0 o/oo	185	23.5	0.029	0.204	0.826	2.41	0.6
APR 20	87	6 o/oo	145	23.0	0.023	0.131	0.519	2.05	0.6
APR 20	87	12 o/oo	90	23.5	0.015	0.020	0.224	1.31	0.3
APR 20	87	20 o/oo	60	24.2	0.001	0.001	0.107	0.60	0.0
MAY 19	87	0 o/oo	200	26.0	0.058	0.336	0.536	1.22	1.6
MAY 19	87	6 o/oo	105	27.5	0.023	0.128	0.562	0.90	0.6
MAY 19	87	12 o/oo	80	27.5	0.001	0.003	0.421	0.56	0.0
MAY 19	87	20 o/oo	43	27.8	0.009	0.001	0.162	0.26	0.1
JUN 8	87	0 o/oo	75	28.5	0.001	0.001	1.060	3.35	0.0
JUN 8	87	6 o/oo	85	28.8	0.017	0.001	0.654	2.00	0.0
JUN 8	87	12 o/oo	64	27.5	0.001	0.001	0.471	1.04	0.0
JUN 8	87	20 o/oo	34	27.3	0.001	0.001	0.226	0.44	0.0

TABLE 3.3 (Cont.)

PHISICAL AND CHEMICAL PARAMETERS

DATE			STATION	PHYSICAL COLOR	PHYSICAL TEMP	NUTRIENTS in mg/l NH4	N23	OP	SI	Atomic Ratio Nit/Phos NPA
JUL	17	87	0 o/oo	160	29.8	0.030	0.547	0.592	2.74	2.2
JUL	17	87	6 o/oo	100	31.6	0.017	0.227	0.501	2.08	1.1
JUL	17	87	12 o/oo	75	31.0	0.033	0.054	0.411	1.50	0.4
JUL	17	87	20 o/oo	30	30.1	0.048	0.001	0.182	0.33	0.6
AUG	4	87	0 o/oo	220	30.7	0.060	0.242	0.630	3.18	1.0
AUG	4	87	6 o/oo	150	31.7	0.004	0.011	0.459	2.01	0.0
AUG	4	87	12 o/oo	85	31.7	0.001	0.005	0.372	2.14	0.0
AUG	4	87	20 o/oo	30	30.9	0.001	0.001	0.160	0.91	0.0
SEPT	25	87	0 o/oo	160	28.5	0.042	0.279	0.730	3.94	1.0
SEPT	25	87	6 o/oo	110	29.7	0.366	0.533	0.493	3.14	4.1
SEPT	25	87	12 o/oo	70	29.5	0.318	0.467	0.401	2.67	4.4
SEPT	25	87	20 o/oo	41	28.9	0.197	0.231	0.222	1.89	4.4
OCT	20	87	0 o/oo	180	25.0	0.074	0.169	0.129	2.61	4.3
OCT	20	87	6 o/oo	135	25.0	0.095	0.331	0.408	1.95	2.3
OCT	20	87	12 o/oo	80	24.5	0.056	0.225	0.297	1.19	2.1
OCT	20	87	20 o/oo	44	24.1	0.014	0.065	0.175	0.28	1.0
NOV	13	87	0 o/oo	150	19.7	0.106	0.572	1.040	3.09	1.4
NOV	13	87	6 o/oo	110	19.8	0.133	0.382	0.658	2.42	1.7
NOV	13	87	12 o/oo	70	21.6	0.132	0.229	0.429	1.74	1.9
NOV	13	87	20 o/oo	45	19.6	0.130	0.113	0.239	1.20	2.3
DEC	10	87	0 o/oo	200	18.7	0.038	0.391	0.622	3.26	1.5
DEC	10	87	6 o/oo	150	19.8	0.099	0.241	0.461	2.43	1.6
DEC	10	87	12 o/oo	100	20.3	0.138	0.160	0.336	1.88	2.0
DEC	10	87	20 o/oo	46	20.7	0.178	0.075	0.145	1.15	3.9
JAN	18	88	0 o/oo	95	16.0	0.046	0.628	0.564	3.46	2.7
JAN	18	88	6 o/oo	71	17.1	0.044	0.488	0.495	1.84	2.4
JAN	18	88	12 o/oo	48	17.2	0.046	0.249	0.337	0.87	2.0
JAN	18	88	20 o/oo	37	16.7	0.046	0.061	0.218	0.10	1.1
FEB	10	88	0 o/oo	115	16.0	0.086	0.627	0.572	2.65	2.8
FEB	10	88	6 o/oo	105	15.9	0.060	0.434	0.426	1.86	2.6
FEB	10	88	12 o/oo	68	15.6	0.012	0.208	0.271	0.99	1.8
FEB	10	88	20 o/oo	41	15.4	0.012	0.033	0.143	0.27	0.7
MAR	11	88	0 o/oo	195	19.9	0.427	0.422	0.638	3.69	3.0
MAR	11	88	6 o/oo	105	19.7	0.064	0.309	0.408	1.22	2.0
MAR	11	88	12 o/oo	80	20.1	0.010	0.195	0.307	0.91	1.5
MAR	11	88	20 o/oo	28	20.3	0.010	0.008	0.128	0.12	0.3
APR	13	88	0 o/oo	120	20.8	0.116	0.303	0.687	3.10	1.3
APR	13	88	6 o/oo	110	21.0	0.053	0.071	0.421	0.96	0.6
APR	13	88	12 o/oo	90	21.4	0.033	0.003	0.306	0.13	0.2
APR	13	88	20 o/oo	53	20.9	0.033	0.003	0.173	0.04	0.4

TABLE 3.3 (Cont.)

PHISICAL AND CHEMICAL PARAMETERS

DATE			STATION	PHYSICAL		NUTRIENTS in mg/l				Atomic Ratio Nit/Phos
				COLOR	TEMP	NH4	N23	OP	SI	NPA
MAY	16	88	0 o/oo	36	26.8	0.032	0.051	0.723	0.72	0.2
MAY	16	88	6 o/oo	52	26.9	0.048	0.021	0.463	0.60	0.3
MAY	16	88	12 o/oo	46	27.2	0.019	0.002	0.361	0.69	0.1
MAY	16	88	20 o/oo	36	28.1	0.019	0.002	0.272	0.69	0.1
JUN	13	88	0 o/oo	60	27.3	0.062	0.000	0.580	2.31	0.2
JUN	13	88	6 o/oo	50	26.8	0.022	0.009	0.521	1.60	0.1
JUN	13	88	12 o/oo	44	26.5	0.019	0.007	0.426	1.19	0.1
JUN	13	88	20 o/oo	24	27.0	0.019	0.008	0.255	0.83	0.2
JUL	12	88	0 o/oo	37	29.9	0.029	0.113	0.855	0.29	0.3
JUL	12	88	6 o/oo	54	30.0	0.016	0.001	0.638	0.37	0.0
JUL	12	88	12 o/oo	53	30.8	0.008	0.001	0.462	1.87	0.0
JUL	12	88	20 o/oo	33	30.8	0.007	0.001	0.291	0.13	0.0
AUG	8	88	0 o/oo	320	31.3	0.179	0.230	0.700	3.30	1.3
AUG	8	88	6 o/oo	240	31.3	0.156	0.129	0.522	3.12	1.2
AUG	8	88	12 o/oo	160	30.1	0.101	0.099	0.409	2.84	1.1
AUG	8	88	20 o/oo	52	30.0	0.085	0.016	0.183	1.65	1.2
SEPT	19	88	6 o/oo	180	29.3	0.139	0.083	0.431	2.76	1.1
SEPT	19	88	12 o/oo	170	30.8	0.001	0.011	0.284	1.61	0.0
SEPT	19	88	20 o/oo	98	29.6	0.001	0.009	0.140	0.75	0.1
SEPT	19	88	0 o/oo	275	29.8	0.088	0.114	0.680	3.66	0.6
OCT	11	88	0 o/oo	125	25.5	0.043	0.516	0.696	2.78	1.8
OCT	11	88	6 o/oo	105	25.1	0.019	0.199	0.444	2.49	1.1
OCT	11	88	12 o/oo	85	23.8	0.036	0.119	0.358	2.13	0.9
OCT	11	88	20 o/oo	52	24.4	0.014	0.006	0.193	1.39	0.2
NOV	10	88	0 o/oo	64	21.0	0.079	1.033	0.616	3.44	4.1
NOV	10	88	6 o/oo	57	21.4	0.066	0.428	0.440	3.03	2.5
NOV	10	88	12 o/oo	47	24.1	0.047	0.262	0.351	2.33	2.0
NOV	10	88	20 o/oo	34	24.1	0.034	0.060	0.206	1.82	1.0
DEC	8	88	0 o/oo	96	19.4	0.043	0.001	0.520	4.65	0.1
DEC	8	88	6 o/oo	82	20.5	0.015	0.050	0.429	3.61	0.3
DEC	8	88	12 o/oo	76	20.7	0.015	0.050	0.307	2.06	0.4
DEC	8	88	20 o/oo	46	20.1	0.015	0.044	0.195	1.36	0.6
JAN	25	89	0 o/oo	61	19.4	0.137	1.245	0.574	2.04	5.5
JAN	25	89	6 o/oo	44	19.8	0.050	0.483	0.443	1.25	2.7
JAN	25	89	12 o/oo	42	19.7	0.021	0.341	0.365	0.87	2.2
JAN	25	89	20 o/oo	26	19.7	0.008	0.094	0.197	0.50	1.1
FEB	13	89	0 o/oo	57	20.2	0.001	0.001	0.177	0.50	0.0
FEB	13	89	6 o/oo	48	19.7	0.039	0.311	0.489	2.04	1.6
FEB	13	89	12 o/oo	40	19.6	0.017	0.082	0.338	1.36	0.6
FEB	13	89	20 o/oo	23	19.1	0.048	0.626	0.760	2.56	2.0

TABLE 3.3 (Cont.)

PHISICAL AND CHEMICAL PARAMETERS

			PHYSICAL		NUTRIENTS in mg/l				Atomic Ratio Nit/Phos
DATE		STATION	COLOR	TEMP	NH4	N23	OP	SI	NPA
MAR 15	89	0 o/oo	86	22.4	0.047	1.079	0.665	2.33	3.8
MAR 15	89	6 o/oo	62	21.9	0.006	0.595	0.454	1.56	3.0
MAR 15	89	12 o/oo	46	22.6	0.006	0.197	0.296	0.44	1.5
MAR 15	89	20 o/oo	36	21.9	0.006	0.001	0.165	0.05	0.0
APR 20	89	0 o/oo	39	27.1	0.051	0.462	0.807	0.64	1.4
APR 20	89	6 o/oo	39	27.1	0.018	0.224	0.604	1.10	0.9
APR 20	89	12 o/oo	45	26.6	0.026	0.107	0.372	1.06	0.8
APR 20	89	20 o/oo	25	26.4	0.002	0.024	0.225	0.67	0.2
MAY 9	89	0 o/oo	49	26.8	0.039	0.520	0.770	1.07	1.6
MAY 9	89	6 o/oo	68	26.5	0.029	0.182	0.630	1.67	0.7
MAY 9	89	12 o/oo	54	25.3	0.032	0.074	0.486	1.55	0.4
MAY 9	89	20 o/oo	32	25.2	0.011	0.008	0.278	0.54	0.1
JUN 14	89	0 o/oo	34	30.8	0.004	0.034	0.868	1.12	0.1
JUN 14	89	6 o/oo	52	30.7	0.006	0.023	0.749	1.19	0.0
JUN 14	89	12 o/oo	49	31.4	0.001	0.001	0.615	0.74	0.0
JUN 14	89	20 o/oo	48	29.7	0.001	0.001	0.454	0.33	0.0
JUL 25	89	0 o/oo	220	27.3	0.136	0.542	0.682	3.75	2.2
JUL 25	89	6 o/oo	150	29.3	0.098	0.218	0.624	3.10	1.1
JUL 25	89	12 o/oo	80	28.9	0.036	0.045	0.434	1.53	0.4
JUL 25	89	20 o/oo	40	28.6	0.021	0.001	0.285	0.50	0.1
AUG 16	89	0 o/oo	223	29.5	0.088	0.403	0.609	3.25	1.8
AUG 16	89	6 o/oo	140	30.9	0.002	0.002	0.322	2.15	0.0
AUG 16	89	12 o/oo	108	30.3	0.001	0.001	0.313	1.88	0.0
AUG 16	89	20 o/oo	55	30.4	0.011	0.001	0.194	0.70	0.1
SEPT 13	89	0 o/oo	290	29.5	0.013	0.053	0.721	3.74	0.2
SEPT 13	89	6 o/oo	190	29.7	0.049	0.271	0.494	3.48	1.4
SEPT 13	89	12 o/oo	119	31.0	0.001	0.088	0.328	2.98	0.6
SEPT 13	89	20 o/oo	48	29.6	0.001	0.003	0.218	2.12	0.0
OCT 10	89	0 o/oo	195	28.0	.	0.070	0.921	4.70	0.1
OCT 10	89	6 o/oo	165	28.3	.	0.032	0.546	3.50	0.1
OCT 10	89	12 o/oo	125	29.4	.	0.063	0.352	2.88	0.4
OCT 10	89	20 o/oo	102	28.4	.	0.072	0.323	1.80	0.5
NOV 15	89	0 o/oo	118	16.6	0.013	0.684	0.790	3.25	2.0
NOV 15	89	6 o/oo	118	17.1	0.025	0.194	0.537	3.39	0.9
NOV 15	89	12 o/oo	95	24.1	0.017	0.082	0.338	2.89	0.6
NOV 15	89	20 o/oo	57	23.4	0.088	0.027	0.227	2.46	1.1
DEC 14	89	0 o/oo	63	16.6	0.039	1.181	1.143	1.72	2.4
DEC 14	89	6 o/oo	55	17.1	0.001	0.005	0.658	1.32	0.0
DEC 14	89	12 o/oo	50	16.2	0.001	0.001	0.554	1.34	0.0
DEC 14	89	20 o/oo	32	16.2	0.001	0.001	0.284	0.50	0.0

TABLE 3.3 (Cont.)

PHISICAL AND CHEMICAL PARAMETERS

DATE			STATION	PHYSICAL COLOR	PHYSICAL TEMP	NUTRIENTS in mg/l NH4	N23	OP	SI	Atomic Ratio Nit/Phos NPA
JAN	18	90	0 o/oo	77	19.1	0.008	1.209	0.878	1.95	3.1
JAN	18	90	6 o/oo	68	19.4	0.066	0.861	0.635	2.22	3.3
JAN	18	90	12 o/oo	48	19.8	0.061	0.501	0.375	1.88	3.4
JAN	18	90	20 o/oo	32	19.2	0.033	0.286	0.233	1.49	3.1
FEB	14	90	0 o/oo	52	21.4	0.069	0.806	1.039	1.06	1.9
FEB	14	90	6 o/oo	51	21.2	0.093	0.580	0.726	1.22	2.1
FEB	14	90	12 o/oo	51	20.9	0.104	0.425	0.590	1.05	2.0
FEB	14	90	20 o/oo	43	20.4	0.080	0.143	0.215	0.57	2.3
MAR	14	90	0 o/oo	105	23.3	0.022	0.514	0.872	1.66	1.4
MAR	14	90	6 o/oo	83	23.5	0.014	0.410	0.580	1.53	1.6
MAR	14	90	12 o/oo	69	23.1	0.003	0.389	0.472	1.41	1.8
MAR	14	90	20 o/oo	42	22.7	0.004	0.197	0.267	0.95	1.7
APR	12	90	0 o/oo	55	24.2	0.052	1.201	0.829	0.86	3.4
APR	12	90	6 o/oo	57	23.7	0.008	0.404	0.638	1.33	1.4
APR	12	90	12 o/oo	45	23.9	0.008	0.031	0.433	1.09	0.2
APR	12	90	20 o/oo	29	24.3	0.022	0.140	0.245	0.64	1.5
MAY	8	90	0 o/oo	34	27.2	0.022	0.286	1.154	0.63	0.6
MAY	8	90	6 o/oo	52	26.4	0.006	0.066	0.742	1.19	0.2
MAY	8	90	12 o/oo	48	25.9	0.001	0.001	0.483	1.20	0.0
MAY	8	90	20 o/oo	32	24.9	0.002	0.004	0.298	0.87	0.0
JUN	20	90	0 o/oo	115	28.9	0.114	1.839	0.316	3.01	14.1
JUN	20	90	6 o/oo	61	29.6	0.001	0.323	0.550	2.46	1.3
JUN	20	90	12 o/oo	49	29.9	0.001	0.175	0.448	2.32	0.8
JUN	20	90	20 o/oo	38	29.6	0.001	0.034	0.301	2.11	0.2
JUL	11	90	0 o/oo	115	29.6	0.001	0.446	0.864	2.61	1.1
JUL	11	90	6 o/oo	79	29.8	0.004	0.265	0.575	2.49	1.0
JUL	11	90	12 o/oo	62	29.3	0.046	0.139	0.441	2.11	0.9
JUL	11	90	20 o/oo	41	29.2	0.010	0.024	0.299	1.14	0.2
AUG	16	90	0 o/oo	342	29.7	0.020	0.441	0.725	3.58	1.4
AUG	16	90	6 o/oo	150	30.5	0.098	0.232	0.470	3.39	1.6
AUG	16	90	12 o/oo	93	30.9	0.001	0.066	0.306	2.11	0.5
AUG	16	90	20 o/oo	108	29.2	0.001	0.022	0.224	1.42	0.2
SEPT	16	90	0 o/oo	432	28.1	0.065	0.251	0.124	3.73	5.8
SEPT	16	90	6 o/oo	359	29.6	0.078	0.267	0.345	4.01	2.2
SEPT	16	90	12 o/oo	249	29.7	0.178	0.164	0.186	3.51	4.2
SEPT	16	90	20 o/oo	174	29.2	0.988	0.247	0.185	2.01	15.2
OCT	12	90	6 o/oo	320	27.4	0.078	0.099	0.444	2.18	0.9
OCT	12	90	12 o/oo	85	28.1	0.079	0.039	0.336	1.81	0.8
OCT	12	90	20 o/oo	60	27.7	0.023	0.009	0.215	1.35	0.3
OCT	12	90	0 o/oo	336	27.3	0.072	0.519	0.717	3.95	1.8

TABLE 3.3 (Cont.)

PHISICAL AND CHEMICAL PARAMETERS

DATE			STATION	PHYSICAL COLOR	PHYSICAL TEMP	NUTRIENTS in mg/l NH4	N23	OP	SI	Atomic Ratio Nit/Phos NPA
NOV	16	90	0 o/oo	120	24.4	0.008	0.695	0.786	.	2.0
NOV	16	90	6 o/oo	130	24.2	0.007	0.295	0.576	.	1.1
NOV	16	90	12 o/oo	95	25.1	0.023	0.206	0.414	.	1.2
NOV	16	90	20 o/oo	60	24.0	0.073	0.113	0.301	.	1.4
DEC	16	90	0 o/oo	39	22.4	0.070	0.663	0.982	0.81	1.7
DEC	16	90	6 o/oo	50	22.9	0.070	0.272	0.710	1.39	1.1
DEC	16	90	12 o/oo	48	22.8	0.070	0.142	0.525	1.46	0.9
DEC	16	90	20 o/oo	45	23.0	0.070	0.043	0.329	1.79	0.7
JAN	17	91	0 o/oo	70	19.6	0.020	0.753	0.709	1.81	2.4
JAN	17	91	6 o/oo	55	20.0	0.020	0.228	0.652	1.60	0.8
JAN	17	91	12 o/oo	47	19.7	0.020	0.135	0.466	1.55	0.7
JAN	17	91	20 o/oo	30	19.6	0.020	0.054	0.322	0.82	0.5
FEB	13	91	0 o/oo	60	19.6	0.069	0.504	0.834	1.22	1.5
FEB	13	91	6 o/oo	65	19.4	0.040	0.444	0.547	1.92	2.0
FEB	13	91	12 o/oo	55	19.1	0.024	0.240	0.348	1.70	1.7
FEB	13	91	20 o/oo	42	18.6	0.030	0.046	0.218	1.16	0.7
MAR	5	91	0 o/oo	100	21.4	0.020	1.220	0.572	1.99	4.9
MAR	5	91	6 o/oo	65	20.4	0.032	0.201	0.332	1.87	1.6
MAR	5	91	12 o/oo	50	20.2	0.061	0.159	0.313	1.59	1.6
MAR	5	91	20 o/oo	35	19.1	0.061	0.106	0.238	1.49	1.6
APR	10	91	0 o/oo	77	26.4	0.043	0.306	0.824	1.42	0.9
APR	10	91	6 o/oo	90	26.7	0.056	0.031	0.492	2.16	0.4
APR	10	91	12 o/oo	61	26.3	0.028	0.065	0.304	1.92	0.6
APR	10	91	20 o/oo	36	26.5	0.037	0.018	0.183	0.92	0.6
MAY	7	91	0 o/oo	125	29.3	0.025	0.358	0.948	2.65	0.9
MAY	7	91	6 o/oo	90	28.8	0.017	0.060	0.530	2.11	0.3
MAY	7	91	12 o/oo	65	28.7	0.010	0.028	0.447	2.27	0.1
MAY	7	91	20 o/oo	38	28.4	0.010	0.001	0.245	2.49	0.1
JUN	13	91	0 o/oo	210	28.0	0.082	0.620	0.667	3.01	2.4
JUN	13	91	6 o/oo	130	28.7	0.020	0.307	0.445	2.91	1.6
JUN	13	91	12 o/oo	115	28.8	0.010	0.192	0.366	2.79	1.2
JUN	13	91	20 o/oo	65	28.3	1.618	0.247	0.248	2.28	17.1
JUL	10	91	0 o/oo	292	30.0	0.039	0.361	0.756	3.18	1.2
JUL	10	91	6 o/oo	170	31.6	0.154	0.154	0.427	2.90	1.6
JUL	10	91	12 o/oo	160	31.3	0.091	0.041	0.319	2.39	0.9
JUL	10	91	20 o/oo	65	31.1	0.043	0.007	0.123	1.40	0.9
AUG	7	91	0 o/oo	312	29.2	0.002	0.275	0.699	3.38	0.9
AUG	7	91	6 o/oo	200	30.2	0.122	0.164	0.508	3.09	1.2
AUG	7	91	12 o/oo	160	30.4	0.002	0.001	0.262	1.97	0.0
AUG	7	91	20 o/oo	85	31.1	0.002	0.001	0.148	1.39	0.0

TABLE 3.3 (Cont.)

PHISICAL AND CHEMICAL PARAMETERS

		PHYSICAL		NUTRIENTS in mg/l				Atomic Ratio Nit/Phos
DATE	STATION	COLOR	TEMP	NH4	N23	OP	SI	NPA
SEPT 16 91	0 o/oo	162	29.5	0.034	0.422	0.719	3.95	1.4
SEPT 16 91	6 o/oo	150	30.3	0.028	0.179	0.707	3.07	0.6
SEPT 16 91	12 o/oo	106	29.7	0.019	0.047	0.380	2.83	0.3
SEPT 16 91	20 o/oo	61	29.8	0.010	0.009	0.226	1.86	0.1
OCT 8 91	0 o/oo	167	25.2	0.032	0.662	0.706	3.95	2.2
OCT 8 91	6 o/oo	100	25.2	0.066	0.189	0.497	2.51	1.1
OCT 8 91	12 o/oo	75	25.1	0.044	0.062	0.415	1.83	0.5
OCT 8 91	20 o/oo	68	25.9	0.005	0.004	0.248	0.05	0.0
NOV 12 91	0 o/oo	82	18.8	0.028	0.698	0.957	4.00	1.7
NOV 12 91	6 o/oo	78	19.6	0.012	0.105	0.554	2.54	0.4
NOV 12 91	12 o/oo	61	19.1	0.014	0.050	0.361	1.38	0.4
NOV 12 91	20 o/oo	40	18.5	0.004	0.017	0.201	0.44	0.2
DEC 16 91	0 o/oo	51	19.8	0.061	0.677	0.929	1.12	1.8
DEC 16 91	6 o/oo	50	20.0	0.063	0.391	0.705	1.08	1.4
DEC 16 91	12 o/oo	44	18.8	0.047	0.139	0.400	0.94	1.0
DEC 16 91	20 o/oo	32	18.6	0.003	0.035	0.308	0.19	0.2

TABLE 3.4

PHYSICAL PARAMETERS
MEASUREMENTS OF AMBIENT SOLAR RADIATION AND WATER COLUMN EXTINCTION

				Light Levels in Einsteins				Depth in Meters Remaining Surface Light		
			Incubation Period	Day	7-Day Avg	Month	Extinction Coefficient	50%	1 %
DATE			STATION	MICROE	LIGHT	LT7A	EM	EXC	OPD50	OPD01
JUN	16	83	0 o/oo	12.6	48.4	47.2	1408.9	2.90	0.24	1.6
JUN	16	83	6 o/oo	12.3	48.4	47.2	1408.9	2.59	0.27	1.8
JUN	16	83	12 o/oo	12.4	48.4	47.2	1408.9	1.59	0.43	2.9
JUN	16	83	20 o/oo	12.8	48.4	47.2	1408.9	1.50	0.46	3.1
JUL	22	83	0 o/oo	12.4	49.9	47.1	1442.8	4.35	0.16	1.1
JUL	22	83	6 o/oo	11.5	49.9	47.1	1442.8	3.49	0.20	1.3
JUL	22	83	12 o/oo	8.8	49.9	47.1	1442.8	2.61	0.27	1.8
JUL	22	83	20 o/oo	9.9	49.9	47.1	1442.8	1.13	0.62	4.1
AUG	19	83	0 o/oo	8.0	40.9	47.6	1287.5	4.36	0.16	1.1
AUG	19	83	6 o/oo	10.1	40.9	47.6	1287.5	3.37	0.21	1.4
AUG	19	83	12 o/oo	10.6	40.9	47.6	1287.5	1.81	0.38	2.5
AUG	19	83	20 o/oo	11.3	40.9	47.6	1287.5	1.22	0.57	3.8
SEPT	28	83	0 o/oo	10.6	40.3	40.6	1028.9	4.97	0.14	0.9
SEPT	28	83	6 o/oo	10.5	40.3	40.6	1028.9	3.61	0.19	1.3
SEPT	28	83	12 o/oo	11.6	40.3	40.6	1028.9	2.49	0.28	1.8
SEPT	28	83	20 o/oo	12.1	40.3	40.6	1028.9	1.42	0.49	3.3
OCT	20	83	0 o/oo	9.9	48.0	27.8	1049.6	4.34	0.16	1.1
OCT	20	83	6 o/oo	10.3	48.0	27.8	1049.6	3.41	0.20	1.4
OCT	20	83	12 o/oo	10.5	48.0	27.8	1049.6	2.34	0.30	2.0
OCT	20	83	20 o/oo	10.1	48.0	27.8	1049.6	1.52	0.46	3.0
NOV	22	83	0 o/oo	8.6	32.8	31.6	808.5	.	0.00	0.0
NOV	22	83	6 o/oo	9.6	32.8	31.6	808.5	.	0.00	0.0
NOV	22	83	12 o/oo	10.0	32.8	31.6	808.5	.	0.00	0.0
NOV	22	83	20 o/oo	10.2	32.8	31.6	808.5	.	0.00	0.0
DEC	28	83	0 o/oo	7.6	27.3	21.0	691.1	4.08	0.17	1.1
DEC	28	83	6 o/oo	8.9	27.3	21.0	691.1	4.45	0.16	1.0
DEC	28	83	12 o/oo	9.0	27.3	21.0	691.1	3.04	0.23	1.5
DEC	28	83	20 o/oo	9.3	27.3	21.0	691.1	1.42	0.49	3.2
JAN	18	84	0 o/oo	8.6	27.3	21.0	770.9	3.49	0.20	1.3
JAN	18	84	6 o/oo	8.7	27.3	21.0	770.9	3.15	0.22	1.5
JAN	18	84	12 o/oo	9.1	27.3	21.0	770.9	2.32	0.30	2.0
JAN	18	84	20 o/oo	9.1	27.3	21.0	770.9	1.55	0.45	3.0
FEB	15	84	0 o/oo	11.1	36.6	27.5	874.1	2.36	0.29	2.0
FEB	15	84	6 o/oo	11.2	36.6	27.5	874.1	2.17	0.32	2.1
FEB	15	84	12 o/oo	11.2	36.6	27.5	874.1	1.93	0.36	2.4
FEB	15	84	20 o/oo	11.1	36.6	27.5	874.1	1.06	0.65	4.3

TABLE 3.4 (Cont.)

PHYSICAL PARAMETERS
MEASUREMENTS OF AMBIENT SOLAR RADIATION AND WATER COLUMN EXTINCTION

				Light Levels in Einsteins				Depth in Meters Remaining Surface Light		
			Incubation Period	Day	7-Day Avg	Month	Extinction Coefficient	50%	1 %
DATE			STATION	MICROE	LIGHT	LT7A	EM	EXC	OPD50	OPD01
MAR	9	84	0 o/oo	12.9	47.8	40.9	1248.4	4.36	0.16	1.1
MAR	9	84	6 o/oo	12.9	47.8	40.9	1248.4	3.22	0.22	1.4
MAR	9	84	12 o/oo	12.7	47.8	40.9	1248.4	2.28	0.30	2.0
MAR	9	84	20 o/oo	12.2	47.8	40.9	1248.4	1.27	0.55	3.6
APR	19	84	0 o/oo	10.1	48.3	41.1	1352.0	2.76	0.25	1.7
APR	19	84	6 o/oo	10.0	48.3	41.1	1352.0	2.68	0.26	1.7
APR	19	84	12 o/oo	21.7	48.3	41.1	1352.0	1.63	0.43	2.8
APR	19	84	20 o/oo	29.3	48.3	41.1	1352.0	1.03	0.68	4.5
MAY	7	84	0 o/oo	12.5	54.0	52.1	1452.0	3.66	0.19	1.3
MAY	7	84	6 o/oo	12.5	54.0	52.1	1452.0	2.86	0.24	1.6
MAY	7	84	12 o/oo	12.6	54.0	52.1	1452.0	2.42	0.29	1.9
MAY	7	84	20 o/oo	13.3	54.0	52.1	1452.0	1.48	0.47	3.1
JUN	7	84	0 o/oo	12.5	45.3	57.5	1403.3	3.49	0.20	1.3
JUN	7	84	6 o/oo	13.5	45.3	57.5	1403.3	2.20	0.32	2.1
JUN	7	84	12 o/oo	13.8	45.3	57.5	1403.3	1.71	0.41	2.7
JUN	7	84	20 o/oo	12.6	45.3	57.5	1403.3	1.14	0.61	4.0
JUL	9	84	0 o/oo	9.4	37.2	44.1	1300.1	3.37	0.21	1.4
JUL	9	84	6 o/oo	9.8	37.2	44.1	1300.1	2.04	0.34	2.3
JUL	9	84	12 o/oo	9.8	37.2	44.1	1300.1	1.68	0.41	2.7
JUL	9	84	20 o/oo	9.0	37.2	44.1	1300.1	1.09	0.64	4.2
AUG	16	84	0 o/oo	13.9	49.6	42.6	1380.9	4.81	0.14	1.0
AUG	16	84	6 o/oo	13.5	49.6	42.6	1380.9	3.69	0.19	1.2
AUG	16	84	12 o/oo	13.0	49.6	42.6	1380.9	2.08	0.33	2.2
AUG	16	84	20 o/oo	12.7	49.6	42.6	1380.9	1.19	0.58	3.9
SEPT	13	84	0 o/oo	11.7	43.8	41.4	1151.7	4.14	0.17	1.1
SEPT	13	84	6 o/oo	13.0	43.8	41.4	1151.7	3.87	0.18	1.2
SEPT	13	84	12 o/oo	13.4	43.8	41.4	1151.7	1.84	0.38	2.5
SEPT	13	84	20 o/oo	12.7	43.8	41.4	1151.7	1.03	0.67	4.5
OCT	4	84	0 o/oo	7.9	38.5	34.3	1127.7	2.45	0.28	1.9
OCT	4	84	6 o/oo	8.3	38.5	34.3	1127.7	2.98	0.23	1.5
OCT	4	84	12 o/oo	10.0	38.5	34.3	1127.7	4.08	0.17	1.1
OCT	4	84	20 o/oo	12.5	38.5	34.3	1127.7	1.10	0.63	4.2
NOV	15	84	0 o/oo	7.7	27.0	31.2	817.5	1.73	0.40	2.7
NOV	15	84	6 o/oo	8.2	27.0	31.2	817.5	1.84	0.38	2.5
NOV	15	84	12 o/oo	10.0	27.0	31.2	817.5	1.45	0.48	3.2
NOV	15	84	20 o/oo	9.0	27.0	31.2	817.5	0.91	0.76	5.0
DEC	13	84	0 o/oo	9.2	28.3	27.0	780.9	2.34	0.30	2.0
DEC	13	84	6 o/oo	9.2	28.3	27.0	780.9	1.96	0.35	2.3
DEC	13	84	12 o/oo	9.1	28.3	27.0	780.9	2.88	0.24	1.6
DEC	13	84	20 o/oo	8.7	28.3	27.0	780.9	1.90	0.37	2.4

TABLE 3.4 (Cont.)

PHYSICAL PARAMETERS
MEASUREMENTS OF AMBIENT SOLAR RADIATION AND WATER COLUMN EXTINCTION

		Light Levels in Einsteins				Depth in Meters Remaining Surface Light		
		Incubation Period	Day	7-Day Avg	Month	Extinction Coefficient	50%	1 %
DATE	STATION	MICROE	LIGHT	LT7A	EM	EXC	OPD50	OPD01
JAN 8 85	0 o/oo	10.4	30.3	21.5	817.7	1.66	0.42	2.8
JAN 8 85	6 o/oo	10.3	30.3	21.5	817.7	1.97	0.35	2.3
JAN 8 85	12 o/oo	10.0	30.3	21.5	817.7	2.26	0.31	2.0
JAN 8 85	20 o/oo	9.7	30.3	21.5	817.7	2.80	0.25	1.6
FEB 19 85	0 o/oo	10.8	35.5	30.0	894.4	1.36	0.51	3.4
FEB 19 85	6 o/oo	11.0	35.5	30.0	894.4	1.50	0.46	3.1
FEB 19 85	12 o/oo	11.3	35.5	30.0	89.4	1.40	0.50	3.3
FEB 19 85	20 o/oo	10.9	35.5	30.0	894.4	1.30	0.53	3.5
MAR 13 85	0 o/oo	12.7	42.5	38.2	1218.5	1.75	0.40	2.6
MAR 13 85	6 o/oo	12.7	42.5	38.2	1218.5	1.76	0.39	2.6
MAR 13 85	12 o/oo	12.5	42.5	38.2	1218.5	1.70	0.41	2.7
MAR 13 85	20 o/oo	12.1	42.5	38.2	1218.5	1.08	0.64	4.3
APR 17 85	0 o/oo	13.8	53.8	34.9	1296.9	1.41	0.49	3.3
APR 17 85	6 o/oo	13.6	53.8	34.9	1296.9	1.86	0.37	2.5
APR 17 85	12 o/oo	13.4	53.8	34.9	1296.9	2.22	0.31	2.1
APR 17 85	20 o/oo	13.2	53.8	34.9	1296.9	1.69	0.41	2.7
MAY 13 85	0 o/oo	9.4	49.6	45.2	1478.1	1.40	0.50	3.3
MAY 13 85	6 o/oo	9.8	49.6	45.2	1478.1	1.51	0.46	3.0
MAY 13 85	12 o/oo	10.6	49.6	45.2	1478.1	1.87	0.37	2.5
MAY 13 85	20 o/oo	12.5	49.6	45.2	1478.1	1.34	0.52	3.4
JUN 18 85	0 o/oo	13.3	55.3	37.7	1372.1	1.23	0.56	3.8
JUN 18 85	6 o/oo	13.5	55.3	37.7	1372.1	1.69	0.41	2.7
JUN 18 85	12 o/oo	13.6	55.3	37.7	1372.1	3.09	0.22	1.5
JUN 18 85	20 o/oo	14.4	55.3	37.7	1372.1	1.69	0.41	2.7
JUL 11 85	0 o/oo	13.7	47.1	47.7	1297.8	1.61	0.43	2.9
JUL 11 85	6 o/oo	13.6	47.1	47.7	1297.8	1.73	0.40	2.7
JUL 11 85	12 o/oo	12.8	47.1	47.7	1297.8	1.65	0.42	2.8
JUL 11 85	20 o/oo	11.5	47.1	47.7	1297.8	1.40	0.49	3.3
AUG 7 85	0 o/oo	6.2	25.7	43.7	1277.5	3.52	0.20	1.3
AUG 7 85	6 o/oo	4.1	25.7	43.7	1277.5	3.50	0.20	1.3
AUG 7 85	12 o/oo	3.7	25.7	43.7	1277.5	2.37	0.29	1.9
AUG 7 85	20 o/oo	4.7	25.7	43.7	1277.5	1.52	0.46	3.0
SEPT 9 85	0 o/oo	13.2	44.8	39.5	1263.0	4.71	0.15	1.0
SEPT 9 85	6 o/oo	13.2	44.8	39.5	1263.0	3.83	0.18	1.2
SEPT 9 85	12 o/oo	12.9	44.8	39.5	1263.0	3.00	0.23	1.5
SEPT 9 85	20 o/oo	12.6	44.8	39.5	1263.0	1.88	0.37	2.5
OCT 9 85	0 o/oo	8.4	45.4	39.5	1050.0	4.15	0.17	1.1
OCT 9 85	6 o/oo	9.0	45.4	39.5	1050.0	3.68	0.19	1.3
OCT 9 85	12 o/oo	10.0	45.4	39.5	1050.0	2.96	0.23	1.6
OCT 9 85	20 o/oo	9.0	45.4	39.5	1050.0	1.94	0.36	2.4

TABLE 3.4 (Cont.)

PHYSICAL PARAMETERS
MEASUREMENTS OF AMBIENT SOLAR RADIATION AND WATER COLUMN EXTINCTION

				Light Levels in Einsteins				Depth in Meters Remaining Surface Light		
			Incubation Period	Day	7-Day Avg	Month	Extinction Coefficient	50%	1 %
DATE			STATION	MICROE	LIGHT	LT7A	EM	EXC	OPD50	OPD01
NOV	26	85	0 o/oo	8.9	.	.	825.0	2.83	0.24	1.6
NOV	26	85	6 o/oo	8.7	.	.	825.0	2.95	0.23	1.6
NOV	26	85	12 o/oo	8.5	.	.	825.0	2.86	0.24	1.6
NOV	26	85	20 o/oo	8.0	.	.	825.0	2.27	0.31	2.0
DEC	20	85	0 o/oo	8.8	27.4	20.3	724.8	1.65	0.42	2.8
DEC	20	85	6 o/oo	8.9	27.4	20.3	724.8	1.62	0.43	2.8
DEC	20	85	12 o/oo	8.8	27.4	20.3	724.8	1.82	0.38	2.5
DEC	20	85	20 o/oo	8.6	27.4	20.3	724.8	1.45	0.48	3.2
JAN	14	86	0 o/oo	9.4	30.5	21.2	775.9	1.75	0.40	2.6
JAN	14	86	6 o/oo	9.3	30.5	21.2	775.9	1.92	0.36	2.4
JAN	14	86	12 o/oo	9.1	30.5	21.2	775.9	1.83	0.38	2.5
JAN	14	86	20 o/oo	8.8	30.5	21.2	775.9	1.42	0.49	3.2
FEB	14	86	0 o/oo	11.3	38.4	26.6	898.7	2.23	0.31	2.1
FEB	14	86	6 o/oo	11.3	38.4	26.6	898.7	1.91	0.36	2.4
FEB	14	86	12 o/oo	11.2	38.4	26.6	898.7	2.00	0.35	2.3
FEB	14	86	20 o/oo	10.9	38.4	26.6	898.7	1.41	0.49	3.3
MAR	12	86	0 o/oo	12.2	41.6	33.7	1171.0	2.03	0.34	2.3
MAR	12	86	6 o/oo	11.3	41.6	33.7	1171.0	2.05	0.34	2.2
MAR	12	86	12 o/oo	10.9	41.6	33.7	1171.0	1.74	0.40	2.6
MAR	12	86	20 o/oo	10.2	41.6	33.7	1171.0	1.36	0.51	3.4
APR	14	86	0 o/oo	13.8	49.5	45.3	1448.7	3.01	0.23	1.5
APR	14	86	6 o/oo	13.8	49.5	45.3	1448.7	3.31	0.21	1.4
APR	14	86	12 o/oo	13.7	49.5	45.3	1448.7	2.22	0.31	2.1
APR	14	86	20 o/oo	13.2	49.5	45.3	1448.7	1.73	0.40	2.7
MAY	13	86	0 o/oo	10.2	42.5	44.6	1444.3	1.32	0.52	3.5
MAY	13	86	6 o/oo	8.9	42.5	44.6	1444.3	1.79	0.39	2.6
MAY	13	86	12 o/oo	10.0	42.5	44.6	1444.3	1.54	0.45	3.0
MAY	13	86	20 o/oo	11.7	42.5	44.6	1444.3	1.41	0.49	3.3
JUN	17	86	0 o/oo	13.8	47.1	38.1	1274.5	3.02	0.23	1.5
JUN	17	86	6 o/oo	13.1	47.1	38.1	1274.5	2.21	0.31	2.1
JUN	17	86	12 o/oo	12.3	47.1	38.1	1274.5	1.54	0.45	3.0
JUN	17	86	20 o/oo	11.8	47.1	38.1	1274.5	1.09	0.64	4.2
JUL	11	86	0 o/oo	11.4	55.3	43.2	1272.8	4.92	0.14	0.9
JUL	11	86	6 o/oo	10.2	55.3	43.2	1272.8	3.17	0.22	1.5
JUL	11	86	12 o/oo	9.2	55.3	43.2	1272.8	2.52	0.28	1.8
JUL	11	86	20 o/oo	10.6	55.3	43.2	1272.8	1.44	0.48	3.2
AUG	7	86	0 o/oo	12.7	38.6	40.8	1205.6	5.11	0.14	0.9
AUG	7	86	6 o/oo	12.0	38.6	40.8	1205.6	3.48	0.20	1.3
AUG	7	86	12 o/oo	11.2	38.6	40.8	1205.6	2.36	0.29	2.0
AUG	7	86	20 o/oo	10.5	38.6	40.8	1205.6	1.45	0.48	3.2

TABLE 3.4 (Cont.)

PHYSICAL PARAMETERS
MEASUREMENTS OF AMBIENT SOLAR RADIATION AND WATER COLUMN EXTINCTION

			Light Levels in Einsteins				Depth in Meters Remaining Surface Light		
			Incubation Period	Day	7-Day Avg	Month	Extinction Coefficient	50%	1 %
DATE		STATION	MICROE	LIGHT	LT7A	EM	EXC	OPD50	OPD01
SEPT	14 86	0 o/oo	10.5	43.9	37.8	1102.7	4.80	0.14	1.0
SEPT	14 86	6 o/oo	10.7	43.9	37.8	1102.7	3.70	0.19	1.2
SEPT	14 86	12 o/oo	8.4	43.9	37.8	1102.7	2.07	0.34	2.2
SEPT	14 86	20 o/oo	9.2	43.9	37.8	1102.7	1.33	0.52	3.5
OCT	8 86	0 o/oo	10.8	34.6	34.4	943.9	3.43	0.20	1.3
OCT	8 86	6 o/oo	10.4	34.6	34.4	943.9	3.32	0.21	1.4
OCT	8 86	12 o/oo	10.1	34.6	34.4	943.9	2.43	0.28	1.9
OCT	8 86	20 o/oo	9.4	34.6	34.4	943.9	1.56	0.44	2.9
NOV	17 86	0 o/oo	2.6	21.1	25.0	727.4	3.69	0.19	1.2
NOV	17 86	6 o/oo	3.2	21.1	25.0	727.4	3.48	0.20	1.3
NOV	17 86	12 o/oo	2.6	21.1	25.0	727.4	2.76	0.25	1.7
NOV	17 86	20 o/oo	3.2	21.1	25.0	727.4	2.02	0.34	2.3
DEC	18 86	0 o/oo	5.6	18.6	20.5	566.2	1.64	0.42	2.8
DEC	18 86	6 o/oo	5.1	18.6	20.5	566.2	2.83	0.25	1.6
DEC	18 86	12 o/oo	5.7	18.6	20.5	566.2	1.80	0.38	2.6
DEC	18 86	20 o/oo	5.1	18.6	20.5	566.2	1.42	0.49	3.2
JAN	9 87	0 o/oo	7.9	23.8	20.3	715.5	4.46	0.16	1.0
JAN	9 87	6 o/oo	7.1	23.8	20.3	715.5	3.72	0.19	1.2
JAN	9 87	12 o/oo	7.1	23.8	20.3	715.5	2.37	0.29	1.9
JAN	9 87	20 o/oo	6.2	23.8	20.3	715.5	1.61	0.43	2.9
FEB	11 87	0 o/oo	7.4	38.6	24.2	751.8	2.53	0.27	1.8
FEB	11 87	6 o/oo	8.6	38.6	24.2	751.8	2.91	0.24	1.6
FEB	11 87	12 o/oo	8.0	38.6	24.2	751.8	2.41	0.29	1.9
FEB	11 87	20 o/oo	7.2	38.6	24.2	751.8	1.61	0.43	2.9
MAR	10 87	0 o/oo	10.6	40.5	25.3	878.8	2.53	0.27	1.8
MAR	10 87	6 o/oo	11.0	40.5	25.3	878.8	2.27	0.31	2.0
MAR	10 87	12 o/oo	10.9	40.5	25.3	878.8	1.73	0.40	2.7
MAR	10 87	20 o/oo	10.8	40.5	25.3	878.8	1.54	0.45	3.0
APR	20 87	0 o/oo	10.9	41.1	41.9	1304.2	3.87	0.18	1.2
APR	20 87	6 o/oo	12.0	41.1	41.9	1304.2	4.23	0.16	1.1
APR	20 87	12 o/oo	11.6	41.1	41.9	1304.2	2.21	0.31	2.1
APR	20 87	20 o/oo	8.5	41.1	41.9	1304.2	1.23	0.56	3.7
MAY	19 87	0 o/oo	9.6	39.2	40.7	1389.8	3.64	0.19	1.3
MAY	19 87	6 o/oo	11.3	39.2	40.7	1389.8	2.56	0.27	1.8
MAY	19 87	12 o/oo	11.1	39.2	40.7	1389.8	1.79	0.39	2.6
MAY	19 87	20 o/oo	11.2	39.2	40.7	1389.8	1.79	0.39	2.6
JUN	8 87	0 o/oo	11.7	44.9	37.9	1294.1	4.03	0.17	1.1
JUN	8 87	6 o/oo	11.1	44.9	37.9	1294.1	2.66	0.26	1.7
JUN	8 87	12 o/oo	16.3	44.9	37.9	1294.1	2.06	0.34	2.2
JUN	8 87	20 o/oo	11.8	44.9	37.9	1294.1	1.15	0.60	4.0

TABLE 3.4 (Cont.)

PHYSICAL PARAMETERS
MEASUREMENTS OF AMBIENT SOLAR RADIATION AND WATER COLUMN EXTINCTION

			Light Levels in Einsteins				Depth in Meters Remaining Surface Light		
			Incubation Period	Day	7-Day Avg	Month	Extinction Coefficient	50%	1 %
DATE		STATION	MICROE	LIGHT	LT7A	EM	EXC	OPD50	OPD01
JUL	17 87	0 o/oo	9.9	43.8	33.5	1209.5	3.56	0.19	1.3
JUL	17 87	6 o/oo	8.5	43.8	33.5	1209.5	3.11	0.22	1.5
JUL	17 87	12 o/oo	9.9	43.8	33.5	1209.5	1.79	0.39	2.6
JUL	17 87	20 o/oo	8.6	43.8	33.5	1209.5	0.96	0.72	4.8
AUG	4 87	0 o/oo	8.8	39.5	37.6	1207.9	4.68	0.15	1.0
AUG	4 87	6 o/oo	7.3	39.5	37.6	1207.9	2.98	0.23	1.5
AUG	4 87	12 o/oo	5.7	39.5	37.6	1207.9	2.46	0.28	1.9
AUG	4 87	20 o/oo	8.8	39.5	37.6	1207.9	0.78	0.89	5.9
SEPT	25 87	0 o/oo	8.2	38.2	37.3	1009.4	3.66	0.19	1.3
SEPT	25 87	6 o/oo	8.4	38.2	37.3	1009.4	3.47	0.20	1.3
SEPT	25 87	12 o/oo	8.4	38.2	37.3	1009.4	3.07	0.23	1.5
SEPT	25 87	20 o/oo	8.2	38.2	37.3	1009.4	1.99	0.35	2.3
OCT	20 87	0 o/oo	7.7	33.5	33.8	918.7	4.13	0.17	1.1
OCT	20 87	6 o/oo	8.6	33.5	33.8	918.7	3.47	0.20	1.3
OCT	20 87	12 o/oo	6.5	33.5	33.8	918.7	2.25	0.31	2.0
OCT	20 87	20 o/oo	8.0	33.5	33.8	918.7	1.98	0.35	2.3
NOV	13 87	0 o/oo	6.7	23.4	23.7	596.0	3.28	0.21	1.4
NOV	13 87	6 o/oo	6.7	23.4	23.7	596.0	2.84	0.24	1.6
NOV	13 87	12 o/oo	6.7	23.4	23.7	596.0	2.32	0.30	2.0
NOV	13 87	20 o/oo	6.5	23.4	23.7	596.0	1.58	0.44	2.9
DEC	10 87	0 o/oo	6.3	20.3	19.4	616.3	3.95	0.18	1.2
DEC	10 87	6 o/oo	6.0	20.3	19.4	616.3	3.42	0.20	1.3
DEC	10 87	12 o/oo	6.3	20.3	19.4	616.3	2.84	0.24	1.6
DEC	10 87	20 o/oo	6.5	20.3	19.4	616.3	1.39	0.50	3.3
JAN	18 88	0 o/oo	8.6	31.7	19.2	620.4	2.77	0.25	1.7
JAN	18 88	6 o/oo	9.2	31.7	19.2	620.4	2.06	0.34	2.2
JAN	18 88	12 o/oo	9.2	31.7	19.2	620.4	1.70	0.41	2.7
JAN	18 88	20 o/oo	9.2	31.7	19.2	620.4	1.38	0.50	3.3
FEB	10 88	0 o/oo	8.2	25.8	19.1	809.6	3.09	0.22	1.5
FEB	10 88	6 o/oo	8.5	25.8	19.1	809.6	2.66	0.26	1.7
FEB	10 88	12 o/oo	8.5	25.8	19.1	809.6	2.01	0.34	2.3
FEB	10 88	20 o/oo	7.8	25.8	19.1	809.6	1.95	0.35	2.4
MAR	11 88	0 o/oo	10.1	43.1	25.9	1089.4	4.03	0.17	1.1
MAR	11 88	6 o/oo	10.8	43.1	25.9	1089.4	2.79	0.25	1.7
MAR	11 88	12 o/oo	11.2	43.1	25.9	1089.4	2.06	0.34	2.2
MAR	11 88	20 o/oo	11.5	43.1	25.9	1089.4	1.30	0.53	3.6
APR	13 88	0 o/oo	11.1	37.1	38.4	1173.7	3.00	0.23	1.5
APR	13 88	6 o/oo	11.6	37.1	38.4	1173.7	3.50	0.20	1.3
APR	13 88	12 o/oo	11.9	37.1	38.4	1173.7	2.98	0.23	1.5
APR	13 88	20 o/oo	12.3	37.1	38.4	1173.7	2.15	0.32	2.1

TABLE 3.4 (Cont.)

PHYSICAL PARAMETERS
MEASUREMENTS OF AMBIENT SOLAR RADIATION AND WATER COLUMN EXTINCTION

				Light Levels in Einsteins				Depth in Meters Remaining Surface Light		
			Incubation Period	Day	7-Day Avg	Month	Extinction Coefficient	50%	1 %
DATE			STATION	MICROE	LIGHT	LT7A	EM	EXC	OPD50	OPD01
MAY	16	88	0 o/oo	11.6	37.3	43.3	1350.7	1.48	0.47	3.1
MAY	16	88	6 o/oo	12.1	37.3	43.3	1350.7	2.04	0.34	2.3
MAY	16	88	12 o/oo	13.3	37.3	43.3	1350.7	1.77	0.39	2.6
MAY	16	88	20 o/oo	13.5	37.3	43.3	1350.7	1.26	0.55	3.6
JUN	13	88	0 o/oo	8.5	35.6	32.8	1116.8	2.33	0.30	2.0
JUN	13	88	6 o/oo	7.6	35.6	32.8	1116.8	2.28	0.30	2.0
JUN	13	88	12 o/oo	7.3	35.6	32.8	1116.8	1.54	0.45	3.0
JUN	13	88	20 o/oo	7.5	35.6	32.8	1116.8	1.17	0.59	3.9
JUL	12	88	0 o/oo	11.0	39.7	41.2	1215.6	1.60	0.43	2.9
JUL	12	88	6 o/oo	10.8	39.7	41.2	1215.6	2.13	0.33	2.2
JUL	12	88	12 o/oo	10.5	39.7	41.2	1215.6	1.99	0.35	2.3
JUL	12	88	20 o/oo	10.3	39.7	41.2	1215.6	1.45	0.48	3.2
AUG	8	88	0 o/oo	10.1	38.2	34.7	1060.7	5.81	0.12	0.8
AUG	8	88	6 o/oo	11.5	38.2	34.7	1060.7	4.66	0.15	1.0
AUG	8	88	12 o/oo	10.7	38.2	34.7	1060.7	3.67	0.19	1.3
AUG	8	88	20 o/oo	10.2	38.2	34.7	1060.7	1.69	0.41	2.7
SEPT	19	88	6 o/oo	9.2	34.2	34.0	943.9	3.17	0.22	1.5
SEPT	19	88	12 o/oo	9.7	34.2	34.0	943.9	3.78	0.18	1.2
SEPT	19	88	20 o/oo	9.4	34.2	34.0	943.9	2.42	0.29	1.9
SEPT	19	88	0 o/oo	9.2	34.2	34.0	943.9	5.13	0.14	0.9
OCT	11	88	0 o/oo	9.6	35.0	29.7	951.9	3.56	0.19	1.3
OCT	11	88	6 o/oo	9.2	35.0	29.7	951.9	2.85	0.24	1.6
OCT	11	88	12 o/oo	9.6	35.0	29.7	951.9	2.79	0.25	1.6
OCT	11	88	20 o/oo	9.2	35.0	29.7	951.9	1.99	0.35	2.3
NOV	10	88	0 o/oo	8.9	29.4	23.7	679.4	2.87	0.24	1.6
NOV	10	88	6 o/oo	8.9	29.4	23.7	679.4	2.00	0.35	2.3
NOV	10	88	12 o/oo	8.8	29.4	23.7	679.4	1.31	0.53	3.5
NOV	10	88	20 o/oo	8.8	29.4	23.7	679.4	1.22	0.57	3.8
DEC	8	88	0 o/oo	7.7	23.1	23.2	691.0	5.33	0.13	0.9
DEC	8	88	6 o/oo	7.7	23.1	23.2	691.0	2.43	0.28	1.9
DEC	8	88	12 o/oo	7.4	23.1	23.2	691.0	1.93	0.36	2.4
DEC	8	88	20 o/oo	7.2	23.1	23.2	691.0	1.29	0.54	3.6
JAN	25	89	0 o/oo	7.6	26.0	19.4	710.6	3.16	0.22	1.5
JAN	25	89	6 o/oo	8.2	26.0	19.4	710.6	2.17	0.32	2.1
JAN	25	89	12 o/oo	8.5	26.0	19.4	710.6	2.07	0.34	2.2
JAN	25	89	20 o/oo	7.9	26.0	19.4	710.6	1.48	0.47	3.1
FEB	13	89	0 o/oo	6.0	28.5	29.6	812.5	2.62	0.26	1.8
FEB	13	89	6 o/oo	7.1	28.5	29.6	812.5	2.05	0.34	2.2
FEB	13	89	12 o/oo	8.2	28.5	29.6	812.5	1.59	0.44	2.9
FEB	13	89	20 o/oo	9.1	28.5	29.6	812.5	1.46	0.48	3.2

TABLE 3.4 (Cont.)

PHYSICAL PARAMETERS
MEASUREMENTS OF AMBIENT SOLAR RADIATION AND WATER COLUMN EXTINCTION

				Light Levels in Einsteins				Depth in Meters Remaining Surface Light		
			Incubation Period	Day	7-Day Avg	Month	Extinction Coefficient	50%	1 %
DATE		STATION	MICROE	LIGHT	LT7A	EM	EXC	OPD50	OPD01
MAR	15 89	0 o/oo	11.0	39.9	33.6	1001.8	2.50	0.28	1.8
MAR	15 89	6 o/oo	11.0	39.9	33.6	1001.8	2.00	0.35	2.3
MAR	15 89	12 o/oo	10.9	39.9	33.6	1001.8	1.74	0.40	2.6
MAR	15 89	20 o/oo	10.3	39.9	33.6	1001.8	1.22	0.57	3.8
APR	20 89	0 o/oo	6.7	30.7	32.7	1127.0	1.44	0.48	3.2
APR	20 89	6 o/oo	7.1	30.7	32.7	1127.0	1.69	0.41	2.7
APR	20 89	12 o/oo	7.4	30.7	32.7	1127.0	1.25	0.56	3.7
APR	20 89	20 o/oo	8.3	30.7	32.7	1127.0	1.38	0.50	3.3
MAY	9 89	0 o/oo	11.7	48.8	45.2	1346.8	2.52	0.27	1.8
MAY	9 89	6 o/oo	12.1	48.8	45.2	1346.8	1.77	0.39	2.6
MAY	9 89	12 o/oo	11.8	48.8	45.2	1346.8	1.67	0.41	2.8
MAY	9 89	20 o/oo	11.6	48.8	45.2	1346.8	2.02	0.34	2.3
JUN	14 89	0 o/oo	12.2	50.5	45.9	1198.4	1.44	0.48	3.2
JUN	14 89	6 o/oo	12.3	50.5	45.9	1198.4	1.48	0.47	3.1
JUN	14 89	12 o/oo	11.7	50.5	45.9	1198.4	1.36	0.51	3.4
JUN	14 89	20 o/oo	10.8	50.5	45.9	1198.4	1.23	0.56	3.7
JUL	25 89	0 o/oo	8.6	33.9	32.0	1075.0	3.99	0.17	1.2
JUL	25 89	6 o/oo	9.8	33.9	32.0	1075.0	2.85	0.24	1.6
JUL	25 89	12 o/oo	9.8	33.9	32.0	1075.0	2.77	0.25	1.7
JUL	25 89	20 o/oo	8.6	33.9	32.0	1075.0	1.51	0.46	3.0
AUG	16 89	0 o/oo	10.5	34.0	34.0	1054.0	3.42	0.20	1.3
AUG	16 89	6 o/oo	11.6	34.0	34.0	1054.0	3.34	0.21	1.4
AUG	16 89	12 o/oo	9.6	34.0	34.0	1054.0	2.04	0.34	2.3
AUG	16 89	20 o/oo	8.7	34.0	34.0	1054.0	1.38	0.50	3.3
SEPT	13 89	0 o/oo	10.1	41.5	32.6	899.1	5.37	0.13	0.9
SEPT	13 89	6 o/oo	10.4	41.5	32.6	899.1	4.26	0.16	1.1
SEPT	13 89	12 o/oo	9.9	41.5	32.6	899.1	2.30	0.30	2.0
SEPT	13 89	20 o/oo	10.0	41.5	32.6	899.1	1.49	0.47	3.1
OCT	10 89	0 o/oo	9.2	18.5	28.9	844.6	3.84	0.18	1.2
OCT	10 89	6 o/oo	8.9	18.5	28.9	844.6	3.71	0.19	1.2
OCT	10 89	12 o/oo	9.0	18.5	28.9	844.6	3.31	0.21	1.4
OCT	10 89	20 o/oo	8.4	18.5	28.9	844.6	2.05	0.34	2.2
NOV	15 89	0 o/oo	7.7	25.2	22.7	681.4	1.67	0.41	2.8
NOV	15 89	6 o/oo	7.1	25.2	22.7	681.4	3.25	0.21	1.4
NOV	15 89	12 o/oo	7.7	25.2	22.7	681.4	2.07	0.33	2.2
NOV	15 89	20 o/oo	5.8	25.2	22.7	681.4	2.09	0.33	2.2
DEC	14 89	0 o/oo	7.4	23.8	17.3	560.5	1.67	0.41	2.8
DEC	14 89	6 o/oo	6.7	23.8	17.3	560.5	3.25	0.21	1.4
DEC	14 89	12 o/oo	7.3	23.8	17.3	560.5	2.99	0.23	1.5
DEC	14 89	20 o/oo	6.7	23.8	17.3	560.5	2.26	0.31	2.0

TABLE 3.4 (Cont.)

PHYSICAL PARAMETERS
MEASUREMENTS OF AMBIENT SOLAR RADIATION AND WATER COLUMN EXTINCTION

				Light Levels in Einsteins				Depth in Meters Remaining Surface Light		
			Incubation Period	Day	7-Day Avg	Month	Extinction Coefficient	50%	1 %
DATE			STATION	MICROE	LIGHT	LT7A	EM	EXC	OPD50	OPD01
JAN	18	90	0 o/oo	7.8	23.1	23.2	667.6	1.72	0.40	2.7
JAN	18	90	6 o/oo	6.9	23.1	23.2	667.6	2.23	0.31	2.1
JAN	18	90	12 o/oo	7.5	23.1	23.2	667.6	1.91	0.36	2.4
JAN	18	90	20 o/oo	7.2	23.1	23.2	667.6	1.45	0.48	3.2
FEB	14	90	0 o/oo	8.7	30.5	25.7	725.7	2.47	0.28	1.9
FEB	14	90	6 o/oo	8.3	30.5	25.7	725.7	1.50	0.46	3.1
FEB	14	90	12 o/oo	8.7	30.5	25.7	725.7	1.77	0.39	2.6
FEB	14	90	20 o/oo	8.1	30.5	25.7	725.7	1.18	0.59	3.9
MAR	14	90	0 o/oo	7.2	22.8	32.5	1014.8	3.30	0.21	1.4
MAR	14	90	6 o/oo	7.4	22.8	32.5	1014.8	2.63	0.26	1.8
MAR	14	90	12 o/oo	7.8	22.8	32.5	1014.8	1.67	0.42	2.8
MAR	14	90	20 o/oo	7.0	22.8	32.5	1014.8	1.53	0.45	3.0
APR	12	90	0 o/oo	11.3	44.4	36.0	1118.1	1.47	0.47	3.1
APR	12	90	6 o/oo	10.4	44.4	36.0	1118.1	1.88	0.37	2.4
APR	12	90	12 o/oo	11.6	44.4	36.0	1118.1	1.46	0.47	3.1
APR	12	90	20 o/oo	11.4	44.4	36.0	1118.1	1.20	0.58	3.8
MAY	8	90	0 o/oo	8.7	35.4	41.0	1148.7	1.19	0.58	3.9
MAY	8	90	6 o/oo	6.2	35.4	41.0	1148.7	2.03	0.34	2.3
MAY	8	90	12 o/oo	8.2	35.4	41.0	1148.7	1.87	0.37	2.5
MAY	8	90	20 o/oo	6.2	35.4	41.0	1148.7	1.42	0.49	3.2
JUN	20	90	0 o/oo	6.3	45.2	39.7	1108.8	1.84	0.38	2.5
JUN	20	90	6 o/oo	7.0	45.2	39.7	1108.8	2.45	0.28	1.9
JUN	20	90	12 o/oo	6.7	45.2	39.7	1108.8	1.59	0.44	2.9
JUN	20	90	20 o/oo	6.2	45.2	39.7	1108.8	1.45	0.48	3.2
JUL	11	90	0 o/oo	6.6	24.8	35.2	1013.6	2.00	0.35	2.3
JUL	11	90	6 o/oo	7.5	24.8	35.2	1013.6	1.99	0.35	2.3
JUL	11	90	12 o/oo	8.5	24.8	35.2	1013.6	1.96	0.35	2.4
JUL	11	90	20 o/oo	6.6	24.8	35.2	1013.6	1.48	0.47	3.1
AUG	16	90	0 o/oo	8.6	45.7	30.4	943.0	4.23	0.16	1.1
AUG	16	90	6 o/oo	8.9	45.7	30.4	943.0	2.94	0.24	1.6
AUG	16	90	12 o/oo	8.8	45.7	30.4	943.0	2.19	0.32	2.1
AUG	16	90	20 o/oo	8.1	45.7	30.4	943.0	1.89	0.37	2.4
SEPT	16	90	0 o/oo	8.7	27.5	30.3	870.9	5.34	0.13	0.9
SEPT	16	90	6 o/oo	9.3	27.5	30.3	870.9	4.44	0.16	1.0
SEPT	16	90	12 o/oo	8.7	27.5	30.3	870.9	3.08	0.23	1.5
SEPT	16	90	20 o/oo	9.3	27.5	30.3	870.9	2.15	0.32	2.1
OCT	12	90	6 o/oo	7.0	31.0	24.9	812.6	4.73	0.15	1.0
OCT	12	90	12 o/oo	6.5	31.0	24.9	812.6	3.43	0.20	1.3
OCT	12	90	20 o/oo	7.0	31.0	24.9	812.6	2.03	0.34	2.3
OCT	12	90	0 o/oo	6.6	31.0	24.9	812.6	4.15	0.17	1.1

TABLE 3.4 (Cont.)

PHYSICAL PARAMETERS
MEASUREMENTS OF AMBIENT SOLAR RADIATION AND WATER COLUMN EXTINCTION

			Light Levels in Einsteins				Depth in Meters Remaining Surface Light		
			Incubation Period	Day	7-Day Avg	Month	Extinction Coefficient	50%	1 %
DATE		STATION	MICROE	LIGHT	LT7A	EM	EXC	OPD50	OPD01
NOV	16 90	0 o/oo	8.5	22.3	21.7	686.9	2.80	0.25	1.6
NOV	16 90	6 o/oo	7.4	22.3	21.7	686.9	3.27	0.21	1.4
NOV	16 90	12 o/oo	8.2	22.3	21.7	686.9	3.22	0.21	1.4
NOV	16 90	20 o/oo	7.0	22.3	21.7	686.9	3.08	0.23	1.5
DEC	16 90	0 o/oo	5.2	19.8	21.4	565.6	1.18	0.59	3.9
DEC	16 90	6 o/oo	5.5	19.8	21.4	565.6	1.88	0.37	2.5
DEC	16 90	12 o/oo	6.4	19.8	21.4	565.6	1.82	0.38	2.5
DEC	16 90	20 o/oo	6.4	19.8	21.4	565.6	1.90	0.37	2.4
JAN	17 91	0 o/oo	7.3	27.1	16.2	610.5	2.21	0.31	2.1
JAN	17 91	6 o/oo	7.1	27.1	16.2	610.5	1.91	0.36	2.4
JAN	17 91	12 o/oo	6.9	27.1	16.2	610.5	2.17	0.32	2.1
JAN	17 91	20 o/oo	6.3	27.1	16.2	610.5	2.38	0.29	1.9
FEB	13 91	0 o/oo	7.4	26.3	26.6	671.8	1.44	0.48	3.2
FEB	13 91	6 o/oo	7.2	26.3	26.6	671.8	1.69	0.41	2.7
FEB	13 91	12 o/oo	7.2	26.3	26.6	671.8	1.47	0.47	3.1
FEB	13 91	20 o/oo	6.2	26.3	26.6	671.8	1.35	0.51	3.4
MAR	5 91	0 o/oo	9.3	34.1	20.6	852.9	2.02	0.34	2.3
MAR	5 91	6 o/oo	8.5	34.1	20.6	852.9	2.06	0.34	2.2
MAR	5 91	12 o/oo	8.1	34.1	20.6	852.9	1.58	0.44	2.9
MAR	5 91	20 o/oo	7.8	34.1	20.6	852.9	1.41	0.49	3.3
APR	10 91	0 o/oo	5.5	29.7	31.6	1053.6	1.75	0.40	2.6
APR	10 91	6 o/oo	6.4	29.7	31.6	1053.6	2.05	0.34	2.2
APR	10 91	12 o/oo	6.8	29.7	31.6	1053.6	1.43	0.48	3.2
APR	10 91	20 o/oo	7.4	29.7	31.6	1053.6	1.51	0.46	3.0
MAY	7 91	0 o/oo	10.5	31.1	39.3	1005.0	2.40	0.29	1.9
MAY	7 91	6 o/oo	9.7	31.1	39.3	1005.0	2.16	0.32	2.1
MAY	7 91	12 o/oo	8.6	31.1	39.3	1005.0	1.84	0.38	2.5
MAY	7 91	20 o/oo	8.1	31.1	39.3	1005.0	1.49	0.47	3.1
JUN	13 91	0 o/oo	7.5	30.3	34.2	1025.0	4.20	0.17	1.1
JUN	13 91	6 o/oo	7.7	30.3	34.2	1025.0	3.00	0.23	1.5
JUN	13 91	12 o/oo	8.4	30.3	34.2	1025.0	2.30	0.30	2.0
JUN	13 91	20 o/oo	7.7	30.3	34.2	1025.0	1.72	0.40	2.7
JUL	10 91	0 o/oo	8.5	26.0	39.0	932.5	5.29	0.13	0.9
JUL	10 91	6 o/oo	8.5	26.0	39.0	932.5	3.74	0.19	1.2
JUL	10 91	12 o/oo	8.5	26.0	39.0	932.5	2.24	0.31	2.1
JUL	10 91	20 o/oo	8.5	26.0	39.0	932.5	1.89	0.37	2.4
AUG	7 91	0 o/oo	9.0	24.9	30.7	962.6	4.79	0.14	1.0
AUG	7 91	6 o/oo	7.9	24.9	30.7	962.6	3.91	0.18	1.2
AUG	7 91	12 o/oo	8.4	24.9	30.7	962.6	2.86	0.24	1.6
AUG	7 91	20 o/oo	8.1	24.9	30.7	962.6	1.83	0.38	2.5

TABLE 3.4 (Cont.)

PHYSICAL PARAMETERS
MEASUREMENTS OF AMBIENT SOLAR RADIATION AND WATER COLUMN EXTINCTION

			Light Levels in Einsteins				Depth in Meters Remaining Surface Light		
			Incubation Period	Day	7-Day Avg	Month	Extinction Coefficient	50%	1 %
DATE		STATION	MICROE	LIGHT	LT7A	EM	EXC	OPD50	OPD01
SEPT	16 91	0 o/oo	8.6	31.0	29.2	881.7	3.66	0.19	1.3
SEPT	16 91	6 o/oo	8.6	31.0	29.2	881.7	3.01	0.23	1.5
SEPT	16 91	12 o/oo	8.2	31.0	29.2	881.7	2.44	0.28	1.9
SEPT	16 91	20 o/oo	7.8	31.0	29.2	881.7	1.50	0.46	3.1
OCT	8 91	0 o/oo	5.9	19.7	26.0	773.8	3.42	0.20	1.3
OCT	8 91	6 o/oo	5.6	19.7	26.0	773.8	2.64	0.26	1.7
OCT	8 91	12 o/oo	6.0	19.7	26.0	773.8	3.36	0.21	1.4
OCT	8 91	20 o/oo	6.2	19.7	26.0	773.8	1.77	0.39	2.6
NOV	12 91	0 o/oo	7.5	20.9	20.3	606.0	2.95	0.24	1.6
NOV	12 91	6 o/oo	7.2	20.9	20.3	606.0	2.43	0.29	1.9
NOV	12 91	12 o/oo	6.2	20.9	20.3	606.0	1.75	0.40	2.6
NOV	12 91	20 o/oo	5.7	20.9	20.3	606.0	1.33	0.52	3.5
DEC	16 91	0 o/oo	6.6	22.7	19.6	571.0	1.89	0.37	2.4
DEC	16 91	6 o/oo	5.9	22.7	19.6	571.0	2.30	0.30	2.0
DEC	16 91	12 o/oo	5.3	22.7	19.6	571.0	2.15	0.32	2.1
DEC	16 91	20 o/oo	4.5	22.7	19.6	571.0	2.34	0.30	2.0

TABLE 3.5

PHYSICAL PARAMETERS - PEACE RIVER FLOW

				Distance in km	River Flow (cubic ft/sec) Same Day	7-Day Avg	14-Day Avg
DATE			STATION	DIS	PRFLOW	DAF7	DAF14
JUN	16	83	0 o/oo	14.7	470	811	538
JUN	16	83	6 o/oo	20.3	470	811	538
JUN	16	83	12 o/oo	25.6	470	811	538
JUN	16	83	20 o/oo	40.8	470	811	538
JUL	22	83	0 o/oo	11.4	521	773	1123
JUL	22	83	6 o/oo	18.9	521	773	1123
JUL	22	83	12 o/oo	24.2	521	773	1123
JUL	22	83	20 o/oo	38.9	521	773	1123
AUG	19	83	0 o/oo	19.8	2020	1950	1622
AUG	19	83	6 o/oo	24.8	2020	1950	1622
AUG	19	83	12 o/oo	29.7	2020	1950	1622
AUG	19	83	20 o/oo	52.0	2020	1950	1622
SEPT	28	83	0 o/oo	21.7	3610	3577	2687
SEPT	28	83	6 o/oo	32.3	3610	3577	2687
SEPT	28	83	12 o/oo	36.4	3610	3577	2687
SEPT	28	83	20 o/oo	51.2	3610	3577	2687
OCT	20	83	0 o/oo	17.4	850	665	653
OCT	20	83	6 o/oo	21.7	850	665	653
OCT	20	83	12 o/oo	24.6	850	665	653
OCT	20	83	20 o/oo	33.2	850	665	653
NOV	22	83	0 o/oo	14.3	369	296	340
NOV	22	83	6 o/oo	22.3	369	296	340
NOV	22	83	12 o/oo	25.6	369	296	340
NOV	22	83	20 o/oo	34.5	369	296	340
DEC	28	83	0 o/oo	13.0	1110	1281	1273
DEC	28	83	6 o/oo	17.0	1110	1281	1273
DEC	28	83	12 o/oo	20.8	1110	1281	1273
DEC	28	83	20 o/oo	30.4	1110	1281	1273
JAN	18	84	0 o/oo	15.7	1030	1144	1305
JAN	18	84	6 o/oo	22.1	1030	1144	1305
JAN	18	84	12 o/oo	26.4	1030	1144	1305
JAN	18	84	20 o/oo	32.4	1030	1144	1305
FEB	15	84	0 o/oo	17.0	503	349	396
FEB	15	84	6 o/oo	21.7	503	349	396
FEB	15	84	12 o/oo	24.8	503	349	396
FEB	15	84	20 o/oo	30.4	503	349	396
MAR	9	84	0 o/oo	19.7	761	1085	1274
MAR	9	84	6 o/oo	23.9	761	1085	1274
MAR	9	84	12 o/oo	25.6	761	1085	1274
MAR	9	84	20 o/oo	30.4	761	1085	1274
APR	19	84	0 o/oo	15.1	345	341	361
APR	19	84	6 o/oo	23.9	345	341	361
APR	19	84	12 o/oo	27.7	345	341	361
APR	19	84	20 o/oo	45.2	345	341	361

TABLE 3.5 (Cont.)

PHYSICAL PARAMETERS - PEACE RIVER FLOW

				Distance in km	River Flow (cubic ft/sec) Same Day	7-Day Avg	14-Day Avg
DATE			STATION	DIS	PRFLOW	DAF7	DAF14
MAY	7	84	0 o/oo	6.8	82	125	203
MAY	7	84	6 o/oo	19.4	82	125	203
MAY	7	84	12 o/oo	21.7	82	125	203
MAY	7	84	20 o/oo	33.2	82	125	203
JUN	7	84	0 o/oo	8.6	297	400	367
JUN	7	84	6 o/oo	15.9	297	400	367
JUN	7	84	12 o/oo	19.6	297	400	367
JUN	7	84	20 o/oo	26.6	297	400	367
JUL	9	84	0 o/oo	15.9	559	484	388
JUL	9	84	6 o/oo	22.9	559	484	388
JUL	9	84	12 o/oo	25.1	559	484	388
JUL	9	84	20 o/oo	31.5	559	484	388
AUG	16	84	0 o/oo	19.9	940	1354	1500
AUG	16	84	6 o/oo	27.8	940	1354	1500
AUG	16	84	12 o/oo	33.2	940	1354	1500
AUG	16	84	20 o/oo	49.6	940	1354	1500
SEPT	13	84	0 o/oo	15.7	355	488	512
SEPT	13	84	6 o/oo	23.9	355	488	512
SEPT	13	84	12 o/oo	26.4	355	488	512
SEPT	13	84	20 o/oo	36.4	355	488	512
OCT	4	84	0 o/oo	8.5	222	210	198
OCT	4	84	6 o/oo	16.1	222	210	198
OCT	4	84	12 o/oo	19.8	222	210	198
OCT	4	84	20 o/oo	30.4	222	210	198
NOV	15	84	0 o/oo	5.2	62	84	88
NOV	15	84	6 o/oo	11.7	62	84	88
NOV	15	84	12 o/oo	16.5	62	84	88
NOV	15	84	20 o/oo	24.2	62	84	88
DEC	13	84	0 o/oo	5.9	94	100	111
DEC	13	84	6 o/oo	11.8	94	100	111
DEC	13	84	12 o/oo	16.1	94	100	111
DEC	13	84	20 o/oo	23.0	94	100	111
JAN	8	85	0 o/oo	4.5	74	80	77
JAN	8	85	6 o/oo	11.9	74	80	77
JAN	8	85	12 o/oo	16.1	74	80	77
JAN	8	85	20 o/oo	23.0	74	80	77
FEB	19	85	0 o/oo	7.4	91	93	91
FEB	19	85	6 o/oo	11.9	91	93	91
FEB	19	85	12 o/oo	15.9	91	93	91
FEB	19	85	20 o/oo	23.2	91	93	91
MAR	13	85	0 o/oo	2.4	55	61	70
MAR	13	85	6 o/oo	9.8	55	61	70
MAR	13	85	12 o/oo	13.9	55	61	70
MAR	13	85	20 o/oo	20.2	55	61	70

TABLE 3.5 (Cont.)

PHYSICAL PARAMETERS - PEACE RIVER FLOW

DATE			STATION	Distance in km DIS	River Flow (cubic ft/sec) Same Day PRFLOW	7-Day Avg DAF7	14-Day Avg DAF14
APR	17	85	0 o/oo	7.4	175	100	98
APR	17	85	6 o/oo	13.0	175	100	98
APR	17	85	12 o/oo	16.6	175	100	98
APR	17	85	20 o/oo	22.8	175	100	98
MAY	13	85	0 o/oo	2.6	60	44	40
MAY	13	85	6 o/oo	8.6	60	44	40
MAY	13	85	12 o/oo	12.1	60	44	40
MAY	13	85	20 o/oo	19.9	60	44	40
JUN	18	85	0 o/oo	3.0	157	121	83
JUN	18	85	6 o/oo	10.6	157	121	83
JUN	18	85	12 o/oo	14.7	157	121	83
JUN	18	85	20 o/oo	20.1	157	121	83
JUL	11	85	0 o/oo	4.5	114	104	114
JUL	11	85	6 o/oo	11.1	114	104	114
JUL	11	85	12 o/oo	17.4	114	104	114
JUL	11	85	20 o/oo	21.0	114	104	114
AUG	7	85	0 o/oo	15.8	995	624	523
AUG	7	85	6 o/oo	20.8	995	624	523
AUG	7	85	12 o/oo	25.6	995	624	523
AUG	7	85	20 o/oo	28.3	995	624	523
SEPT	9	85	0 o/oo	17.4	3310	2005	1394
SEPT	9	85	6 o/oo	21.7	3310	2005	1394
SEPT	9	85	12 o/oo	25.7	3310	2005	1394
SEPT	9	85	20 o/oo	49.6	3310	2005	1394
OCT	9	85	0 o/oo	14.3	859	1110	1069
OCT	9	85	6 o/oo	20.4	859	1110	1069
OCT	9	85	12 o/oo	23.3	859	1110	1069
OCT	9	85	20 o/oo	33.2	859	1110	1069
NOV	26	85	0 o/oo	13.0	169	213	230
NOV	26	85	6 o/oo	18.6	169	213	230
NOV	26	85	12 o/oo	22.3	169	213	230
NOV	26	85	20 o/oo	26.3	169	213	230
DEC	20	85	0 o/oo	7.4	147	143	133
DEC	20	85	6 o/oo	17.0	147	143	133
DEC	20	85	12 o/oo	20.3	147	143	133
DEC	20	85	20 o/oo	25.3	147	143	133
JAN	14	86	0 o/oo	10.2	261	239	202
JAN	14	86	6 o/oo	19.6	261	239	202
JAN	14	86	12 o/oo	23.2	261	239	202
JAN	14	86	20 o/oo	25.7	261	239	202
FEB	14	86	0 o/oo	11.3	345	267	251
FEB	14	86	6 o/oo	19.8	345	267	251
FEB	14	86	12 o/oo	23.3	345	267	251
FEB	14	86	20 o/oo	26.9	345	267	251

TABLE 3.5 (Cont.)

PHYSICAL PARAMETERS - PEACE RIVER FLOW

				Distance in km	River Flow (cubic ft/sec) Same Day	7-Day Avg	14-Day Avg
DATE			STATION	DIS	PRFLOW	DAF7	DAF14
MAR	12	86	0 o/oo	13.4	339	213	216
MAR	12	86	6 o/oo	20.5	339	213	216
MAR	12	86	12 o/oo	23.4	339	213	216
MAR	12	86	20 o/oo	26.6	339	213	216
APR	14	86	0 o/oo	8.7	200	192	269
APR	14	86	6 o/oo	15.9	200	192	269
APR	14	86	12 o/oo	20.3	200	192	269
APR	14	86	20 o/oo	25.1	200	192	269
MAY	13	86	0 o/oo	4.5	77	88	88
MAY	13	86	6 o/oo	12.1	77	88	88
MAY	13	86	12 o/oo	17.2	77	88	88
MAY	13	86	20 o/oo	22.2	77	88	88
JUN	17	86	0 o/oo	9.4	372	184	118
JUN	17	86	6 o/oo	17.2	372	184	118
JUN	17	86	12 o/oo	22.6	372	184	118
JUN	17	86	20 o/oo	25.6	372	184	118
JUL	11	86	0 o/oo	20.3	831	1114	1012
JUL	11	86	6 o/oo	29.1	831	1114	1012
JUL	11	86	12 o/oo	30.4	831	1114	1012
JUL	11	86	20 o/oo	42.4	831	1114	1012
AUG	7	86	0 o/oo	21.2	2120	1202	886
AUG	7	86	6 o/oo	27.4	2120	1202	886
AUG	7	86	12 o/oo	30.7	2120	1202	886
AUG	7	86	20 o/oo	49.6	2120	1202	886
SEPT	14	86	0 o/oo	19.8	1510	1467	1144
SEPT	14	86	6 o/oo	24.3	1510	1467	1144
SEPT	14	86	12 o/oo	30.4	1510	1467	1144
SEPT	14	86	20 o/oo	49.6	1510	1467	1144
OCT	8	86	0 o/oo	11.1	394	358	512
OCT	8	86	6 o/oo	17.4	394	358	512
OCT	8	86	12 o/oo	20.8	394	358	512
OCT	8	86	20 o/oo	27.6	394	358	512
NOV	17	86	0 o/oo	10.2	246	337	573
NOV	17	86	6 o/oo	21.2	246	337	573
NOV	17	86	12 o/oo	23.4	246	337	573
NOV	17	86	20 o/oo	27.5	246	337	573
DEC	18	86	0 o/oo	7.4	167	185	172
DEC	18	86	6 o/oo	15.8	167	185	172
DEC	18	86	12 o/oo	23.6	167	185	172
DEC	18	86	20 o/oo	27.5	167	185	172
JAN	9	87	0 o/oo	19.9	1990	2651	2113
JAN	9	87	6 o/oo	22.8	1990	2651	2113
JAN	9	87	12 o/oo	27.6	1990	2651	2113
JAN	9	87	20 o/oo	30.5	1990	2651	2113

TABLE 3.5 (Cont.)

PHYSICAL PARAMETERS - PEACE RIVER FLOW

DATE			STATION	Distance in km DIS	River Flow (cubic ft/sec) Same Day PRFLOW	7-Day Avg DAF7	14-Day Avg DAF14
FEB	11	87	0 o/oo	17.4	285	312	364
FEB	11	87	6 o/oo	21.3	285	312	364
FEB	11	87	12 o/oo	26.9	285	312	364
FEB	11	87	20 o/oo	30.0	285	312	364
MAR	10	87	0 o/oo	17.0	694	384	344
MAR	10	87	6 o/oo	20.5	694	384	344
MAR	10	87	12 o/oo	23.6	694	384	344
MAR	10	87	20 o/oo	29.7	694	384	344
APR	20	87	0 o/oo	15.8	734	1098	1777
APR	20	87	6 o/oo	24.6	734	1098	1777
APR	20	87	12 o/oo	31.9	734	1098	1777
APR	20	87	20 o/oo	51.6	734	1098	1777
MAY	19	87	0 o/oo	8.0	958	1174	744
MAY	19	87	6 o/oo	20.9	958	1174	744
MAY	19	87	12 o/oo	27.5	958	1174	744
MAY	19	87	20 o/oo	33.4	958	1174	744
JUN	8	87	0 o/oo	4.5	208	196	271
JUN	8	87	6 o/oo	11.3	208	196	271
JUN	8	87	12 o/oo	18.3	208	196	271
JUN	8	87	20 o/oo	21.0	208	196	271
JUL	17	87	0 o/oo	14.3	889	695	870
JUL	17	87	6 o/oo	21.0	889	695	870
JUL	17	87	12 o/oo	24.3	889	695	870
JUL	17	87	20 o/oo	35.1	889	695	870
AUG	4	87	0 o/oo	15.8	1060	787	1085
AUG	4	87	6 o/oo	25.3	1060	787	1085
AUG	4	87	12 o/oo	29.7	1060	787	1085
AUG	4	87	20 o/oo	35.7	1060	787	1085
SEPT	25	87	0 o/oo	15.7	293	417	611
SEPT	25	87	6 o/oo	23.4	293	417	611
SEPT	25	87	12 o/oo	25.6	293	417	611
SEPT	25	87	20 o/oo	32.9	293	417	611
OCT	20	87	0 o/oo	16.8	912	1133	698
OCT	20	87	6 o/oo	21.1	912	1133	698
OCT	20	87	12 o/oo	25.6	912	1133	698
OCT	20	87	20 o/oo	31.6	912	1133	698
NOV	13	87	0 o/oo	14.3	604	836	633
NOV	13	87	6 o/oo	17.3	604	836	633
NOV	13	87	12 o/oo	25.1	604	836	633
NOV	13	87	20 o/oo	28.1	604	836	633
DEC	10	87	0 o/oo	14.5	761	960	1303
DEC	10	87	6 o/oo	21.7	761	960	1303
DEC	10	87	12 o/oo	26.5	761	960	1303
DEC	10	87	20 o/oo	33.2	761	960	1303

TABLE 3.5 (Cont.)

PHYSICAL PARAMETERS - PEACE RIVER FLOW

DATE			STATION	DIS (Distance in km)	PRFLOW (River Flow (cubic ft/sec) Same Day)	DAF7 (7-Day Avg)	DAF14 (14-Day Avg)
JAN	18	88	0 o/oo	8.6	371	413	359
JAN	18	88	6 o/oo	19.6	371	413	359
JAN	18	88	12 o/oo	22.9	371	413	359
JAN	18	88	20 o/oo	25.6	371	413	359
FEB	10	88	0 o/oo	14.6	1170	631	758
FEB	10	88	6 o/oo	24.9	1170	631	758
FEB	10	88	12 o/oo	25.4	1170	631	758
FEB	10	88	20 o/oo	34.5	1170	631	758
MAR	11	88	0 o/oo	17.0	1600	1140	894
MAR	11	88	6 o/oo	26.9	1600	1140	894
MAR	11	88	12 o/oo	30.8	1600	1140	894
MAR	11	88	20 o/oo	33.2	1600	1140	894
APR	13	88	0 o/oo	16.8	318	393	596
APR	13	88	6 o/oo	22.3	318	393	596
APR	13	88	12 o/oo	26.4	318	393	596
APR	13	88	20 o/oo	32.1	318	393	596
MAY	16	88	0 o/oo	6.3	138	151	191
MAY	16	88	6 o/oo	15.4	138	151	191
MAY	16	88	12 o/oo	20.2	138	151	191
MAY	16	88	20 o/oo	23.7	138	151	191
JUN	13	88	0 o/oo	11.3	159	167	132
JUN	13	88	6 o/oo	17.8	159	167	132
JUN	13	88	12 o/oo	19.2	159	167	132
JUN	13	88	20 o/oo	23.9	159	167	132
JUL	12	88	0 o/oo	5.2	230	219	248
JUL	12	88	6 o/oo	14.4	230	219	248
JUL	12	88	12 o/oo	18.3	230	219	248
JUL	12	88	20 o/oo	21.1	230	219	248
AUG	8	88	0 o/oo	17.1	1710	2170	2135
AUG	8	88	6 o/oo	24.3	1710	2170	2135
AUG	8	88	12 o/oo	28.8	1710	2170	2135
AUG	8	88	20 o/oo	34.9	1710	2170	2135
SEPT	19	88	6 o/oo	31.6	4900	8997	7820
SEPT	19	88	12 o/oo	61.0	4900	8997	7820
SEPT	19	88	20 o/oo	67.5	4900	8997	7820
SEPT	19	88	0 o/oo	24.5	4900	8997	7820
OCT	11	88	0 o/oo	17.4	547	1168	1253
OCT	11	88	6 o/oo	24.1	547	1168	1253
OCT	11	88	12 o/oo	26.5	547	1168	1253
OCT	11	88	20 o/oo	33.2	547	1168	1253
NOV	10	88	0 o/oo	15.8	529	555	396
NOV	10	88	6 o/oo	23.5	529	555	396
NOV	10	88	12 o/oo	25.5	529	555	396
NOV	10	88	20 o/oo	29.2	529	555	396

TABLE 3.5 (Cont.)

PHYSICAL PARAMETERS - PEACE RIVER FLOW

DATE			STATION	Distance in km DIS	River Flow (cubic ft/sec) Same Day PRFLOW	7-Day Avg DAF7	14-Day Avg DAF14
DEC	8	88	0 o/oo	12.3	483	626	659
DEC	8	88	6 o/oo	19.1	483	626	659
DEC	8	88	12 o/oo	23.5	483	626	659
DEC	8	88	20 o/oo	27.5	483	626	659
JAN	25	89	0 o/oo	17.4	752	406	295
JAN	25	89	6 o/oo	23.4	752	406	295
JAN	25	89	12 o/oo	24.7	752	406	295
JAN	25	89	20 o/oo	27.3	752	406	295
FEB	13	89	0 o/oo	12.6	294	297	392
FEB	13	89	6 o/oo	17.4	294	297	392
FEB	13	89	12 o/oo	20.9	294	297	392
FEB	13	89	20 o/oo	25.6	294	297	392
MAR	15	89	0 o/oo	13.7	277	422	446
MAR	15	89	6 o/oo	17.4	277	422	446
MAR	15	89	12 o/oo	21.3	277	422	446
MAR	15	89	20 o/oo	27.2	277	422	446
APR	20	89	0 o/oo	8.6	289	197	160
APR	20	89	6 o/oo	15.8	289	197	160
APR	20	89	12 o/oo	20.8	289	197	160
APR	20	89	20 o/oo	25.6	289	197	160
MAY	9	89	0 o/oo	3.5	78	132	130
MAY	9	89	6 o/oo	13.7	78	132	130
MAY	9	89	12 o/oo	17.4	78	132	130
MAY	9	89	20 o/oo	23.7	78	132	130
JUN	14	89	0 o/oo	0.4	45	45	45
JUN	14	89	6 o/oo	7.0	45	45	45
JUN	14	89	12 o/oo	11.6	45	45	45
JUN	14	89	20 o/oo	18.9	45	45	45
JUL	25	89	0 o/oo	16.4	524	395	448
JUL	25	89	6 o/oo	19.7	524	395	448
JUL	25	89	12 o/oo	23.0	524	395	448
JUL	25	89	20 o/oo	30.0	524	395	448
AUG	16	89	0 o/oo	14.1	548	374	429
AUG	16	89	6 o/oo	20.6	548	374	429
AUG	16	89	12 o/oo	21.7	548	374	429
AUG	16	89	20 o/oo	25.9	548	374	429
SEPT	13	89	0 o/oo	14.7	515	892	809
SEPT	13	89	6 o/oo	19.0	515	892	809
SEPT	13	89	12 o/oo	21.7	515	892	809
SEPT	13	89	20 o/oo	29.4	515	892	809
OCT	10	89	0 o/oo	6.7	788	718	954
OCT	10	89	6 o/oo	14.6	788	718	954
OCT	10	89	12 o/oo	21.7	788	718	954
OCT	10	89	20 o/oo	32.3	788	718	954

TABLE 3.5 (Cont.)

PHYSICAL PARAMETERS - PEACE RIVER FLOW

DATE			STATION	Distance in km DIS	River Flow (cubic ft/sec) Same Day PRFLOW	7-Day Avg DAF7	14-Day Avg DAF14
NOV	15	89	0 o/oo	6.7	146	156	175
NOV	15	89	6 o/oo	14.5	146	156	175
NOV	15	89	12 o/oo	20.2	146	156	175
NOV	15	89	20 o/oo	25.2	146	156	175
DEC	14	89	0 o/oo	9.8	240	205	185
DEC	14	89	6 o/oo	20.8	240	205	185
DEC	14	89	12 o/oo	23.7	240	205	185
DEC	14	89	20 o/oo	28.6	240	205	185
JAN	18	90	0 o/oo	11.4	287	354	384
JAN	18	90	6 o/oo	17.4	287	354	384
JAN	18	90	12 o/oo	22.8	287	354	384
JAN	18	90	20 o/oo	26.0	287	354	384
FEB	14	90	0 o/oo	11.0	236	192	210
FEB	14	90	6 o/oo	18.6	236	192	210
FEB	14	90	12 o/oo	22.1	236	192	210
FEB	14	90	20 o/oo	25.6	236	192	210
MAR	14	90	0 o/oo	11.0	220	336	523
MAR	14	90	6 o/oo	17.4	220	336	523
MAR	14	90	12 o/oo	20.7	220	336	523
MAR	14	90	20 o/oo	25.4	220	336	523
APR	12	90	0 o/oo	7.4	136	150	182
APR	12	90	6 o/oo	20.4	136	150	182
APR	12	90	12 o/oo	21.7	136	150	182
APR	12	90	20 o/oo	25.5	136	150	182
MAY	8	90	0 o/oo	5.1	57	75	75
MAY	8	90	6 o/oo	10.9	57	75	75
MAY	8	90	12 o/oo	16.7	57	75	75
MAY	8	90	20 o/oo	22.6	57	75	75
JUN	20	90	0 o/oo	7.9	109	260	345
JUN	20	90	6 o/oo	21.9	109	260	345
JUN	20	90	12 o/oo	25.4	109	260	345
JUN	20	90	20 o/oo	28.0	109	260	345
JUL	11	90	0 o/oo	4.9	261	292	360
JUL	11	90	6 o/oo	19.2	261	292	360
JUL	11	90	12 o/oo	21.7	261	292	360
JUL	11	90	20 o/oo	25.4	261	292	360
AUG	16	90	0 o/oo	13.0	1505	908	937
AUG	16	90	6 o/oo	21.7	1505	908	937
AUG	16	90	12 o/oo	25.6	1505	908	937
AUG	16	90	20 o/oo	32.4	1505	908	937
SEPT	16	90	0 o/oo	8.9	320	398	669
SEPT	16	90	6 o/oo	23.7	320	398	669
SEPT	16	90	12 o/oo	28.8	320	398	669
SEPT	16	90	20 o/oo	30.3	320	398	669

TABLE 3.5 (Cont.)

PHYSICAL PARAMETERS - PEACE RIVER FLOW

				Distance in km	River Flow (cubic ft/sec) Same Day	7-Day Avg	14-Day Avg
DATE			STATION	DIS	PRFLOW	DAF7	DAF14
OCT	12	90	6 o/oo	20.9	554	492	537
OCT	12	90	12 o/oo	25.4	554	492	537
OCT	12	90	20 o/oo	28.1	554	492	537
OCT	12	90	0 o/oo	13.0	554	492	537
NOV	16	90	0 o/oo	3.6	77	96	98
NOV	16	90	6 o/oo	10.1	77	96	98
NOV	16	90	12 o/oo	19.3	77	96	98
NOV	16	90	20 o/oo	23.5	77	96	98
DEC	16	90	0 o/oo	4.9	70	80	64
DEC	16	90	6 o/oo	12.5	70	80	64
DEC	16	90	12 o/oo	19.1	70	80	64
DEC	16	90	20 o/oo	21.7	70	80	64
JAN	17	91	0 o/oo	9.0	287	90	67
JAN	17	91	6 o/oo	17.0	287	90	67
JAN	17	91	12 o/oo	23.7	287	90	67
JAN	17	91	20 o/oo	28.8	287	90	67
FEB	13	91	0 o/oo	9.8	100	112	127
FEB	13	91	6 o/oo	17.4	100	112	127
FEB	13	91	12 o/oo	23.9	100	112	127
FEB	13	91	20 o/oo	25.6	100	112	127
MAR	5	91	0 o/oo	7.4	403	244	174
MAR	5	91	6 o/oo	20.8	403	244	174
MAR	5	91	12 o/oo	24.0	403	244	174
MAR	5	91	20 o/oo	27.8	403	244	174
APR	10	91	0 o/oo	8.6	419	298	273
APR	10	91	6 o/oo	17.4	419	298	273
APR	10	91	12 o/oo	21.0	419	298	273
APR	10	91	20 o/oo	24.5	419	298	273
MAY	7	91	0 o/oo	8.5	280	461	621
MAY	7	91	6 o/oo	17.4	280	461	621
MAY	7	91	12 o/oo	20.1	280	461	621
MAY	7	91	20 o/oo	25.4	280	461	621
JUN	13	91	0 o/oo	15.6	755	1295	1109
JUN	13	91	6 o/oo	22.9	755	1295	1109
JUN	13	91	12 o/oo	26.6	755	1295	1109
JUN	13	91	20 o/oo	30.5	755	1295	1109
JUL	10	91	0 o/oo	15.4	2973	3363	2869
JUL	10	91	6 o/oo	27.7	2973	3363	2869
JUL	10	91	12 o/oo	52.1	2973	3363	2869
JUL	10	91	20 o/oo	56.1	2973	3363	2869
AUG	7	91	0 o/oo	19.7	2751	3088	2728
AUG	7	91	6 o/oo	28.8	2751	3088	2728
AUG	7	91	12 o/oo	49.6	2751	3088	2728
AUG	7	91	20 o/oo	55.3	2751	3088	2728

TABLE 3.5 (Cont.)

PHYSICAL PARAMETERS - PEACE RIVER FLOW

				Distance in km	River Flow (cubic ft/sec) Same Day	7-Day Avg	14-Day Avg
DATE			STATION	DIS	PRFLOW	DAF7	DAF14
SEPT	16	91	0 o/oo	14.2	1112	1363	1493
SEPT	16	91	6 o/oo	23.3	1112	1363	1493
SEPT	16	91	12 o/oo	26.3	1112	1363	1493
SEPT	16	91	20 o/oo	34.8	1112	1363	1493
OCT	8	91	0 o/oo	17.4	731	510	526
OCT	8	91	6 o/oo	25.4	731	510	526
OCT	8	91	12 o/oo	31.9	731	510	526
OCT	8	91	20 o/oo	34.9	731	510	526
NOV	12	91	0 o/oo	9.8	150	182	235
NOV	12	91	6 o/oo	15.8	150	182	235
NOV	12	91	12 o/oo	21.7	150	182	235
NOV	12	91	20 o/oo	21.7	150	182	235
DEC	16	91	0 o/oo	12.6	65	99	110
DEC	16	91	6 o/oo	17.4	65	99	110
DEC	16	91	12 o/oo	21.5	65	99	110
DEC	16	91	20 o/oo	27.0	65	99	110

FIGURE 3.2

CHARLOTTE HARBOR 1989 – 1991

Temperature vs 7-day Light

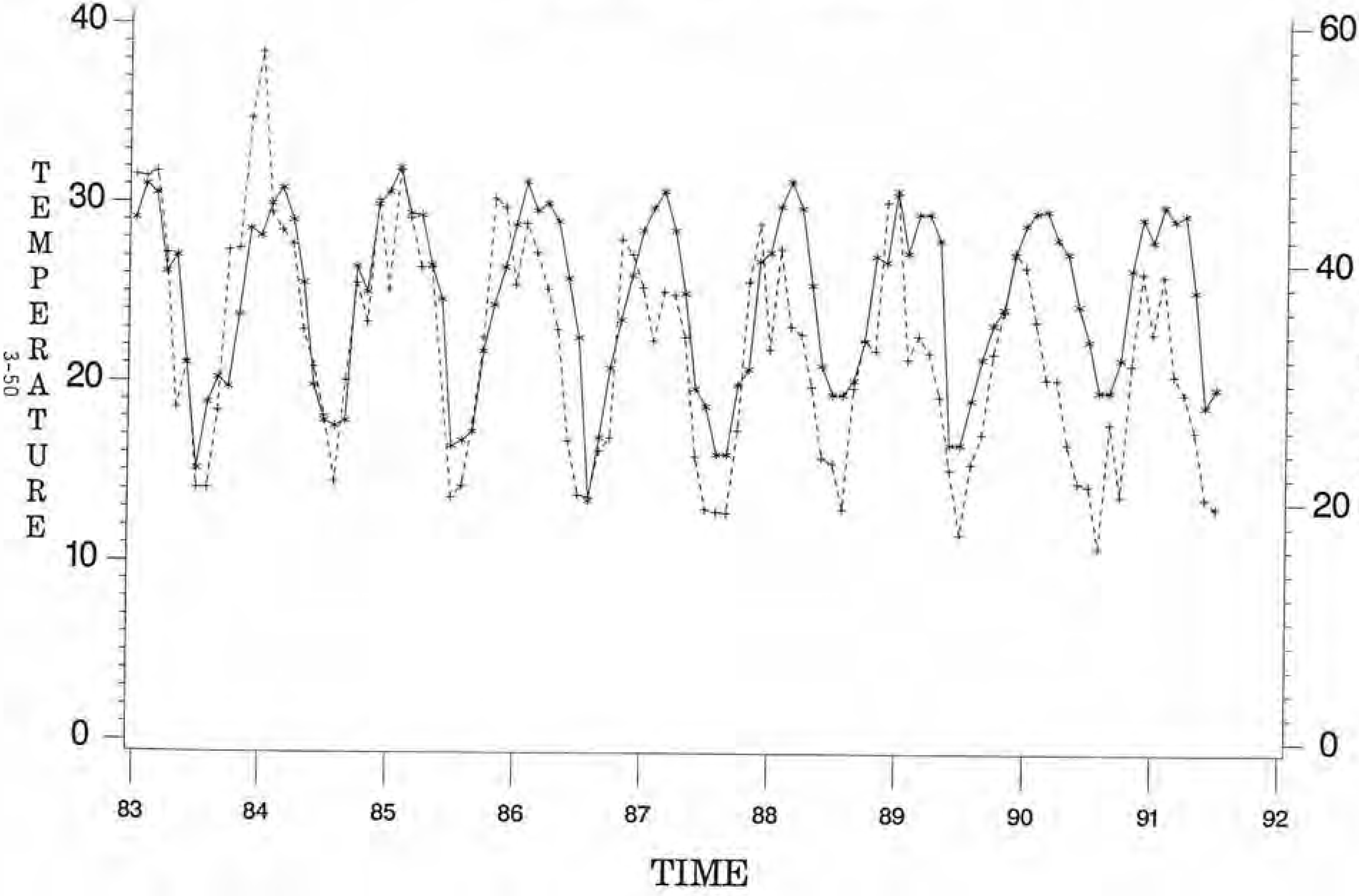
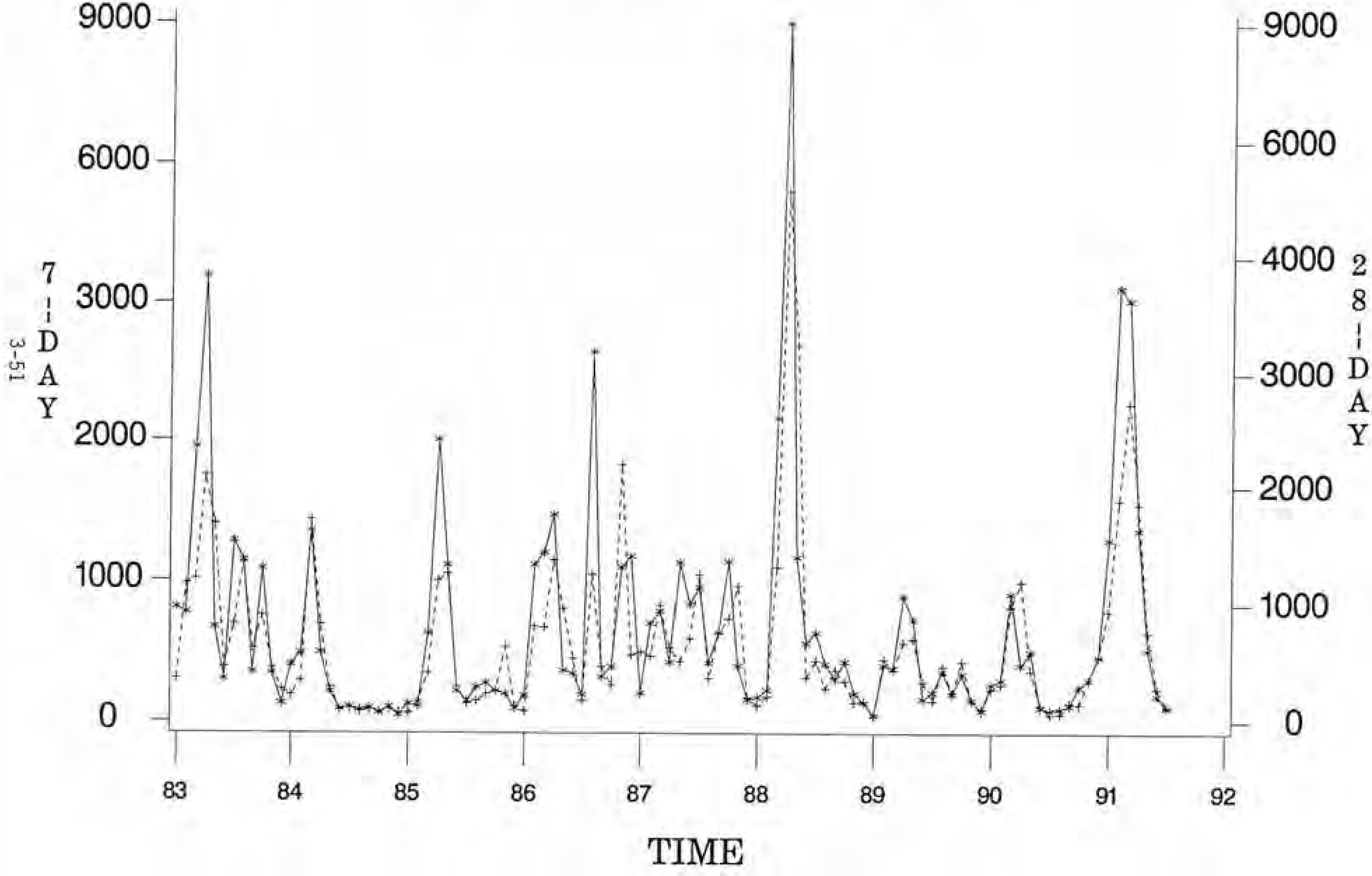


FIGURE 3.3

CHARLOTTE HARBOR 1989 – 1991

Average 7 and 28 Day Peace River Flow



variability on the relative location of the salinity zone based stations are indicated in Figures 3.4 (a) and (b), and Figure 3.5. The monthly locations, relative to a fixed point up the Peace River (see Figure 2.1 - Station #20), are depicted for each salinity based station. As shown in Figures 3.4, the variability of the relative position within the estuary of the lower two salinity zones is far less than that of the two higher salinity monitoring locations. Both the relative position within the harbor of the two highest salinity zones, as well as the relative distance between the 12 and 20 o/oo salinities, is shown to increase dramatically during periods of high river inflow. These patterns, and the seasonal influences of river flow, are further emphasized in Figure 3.5, which depicts the monthly average position over the eight-year period of each of the four salinity zones. As indicated, while there are marked differences seasonally with regard to the relative location of each salinity zone, the difference in distance between zones is far more constant.

Dilution associated with freshwater river inflow, as indicated, is the dominant force in determining the relative location and extent of the salinity zones within the harbor. The primary influences of river inflow on phytoplankton production and biomass within these salinity zones, however, are specifically dependent upon secondary parameters associated with Peace River freshwater inputs. These influences are dominated by two components of freshwater inflow having diametrically opposing affects of phytoplankton production: 1) increasing color, and 2) increasing macro-nutrient loadings.

In the Peace River basin, rainfall resulting in increased surface flow is associated with dramatic elevations in the concentrations of highly colored "humic" compounds derived from decaying vegetation. Figures 3.6(a) and (b) depict the long-term seasonal

FIGURE 3.4(A)

CHARLOTTE HARBOR 1983 – 1991

Distance from Station #20

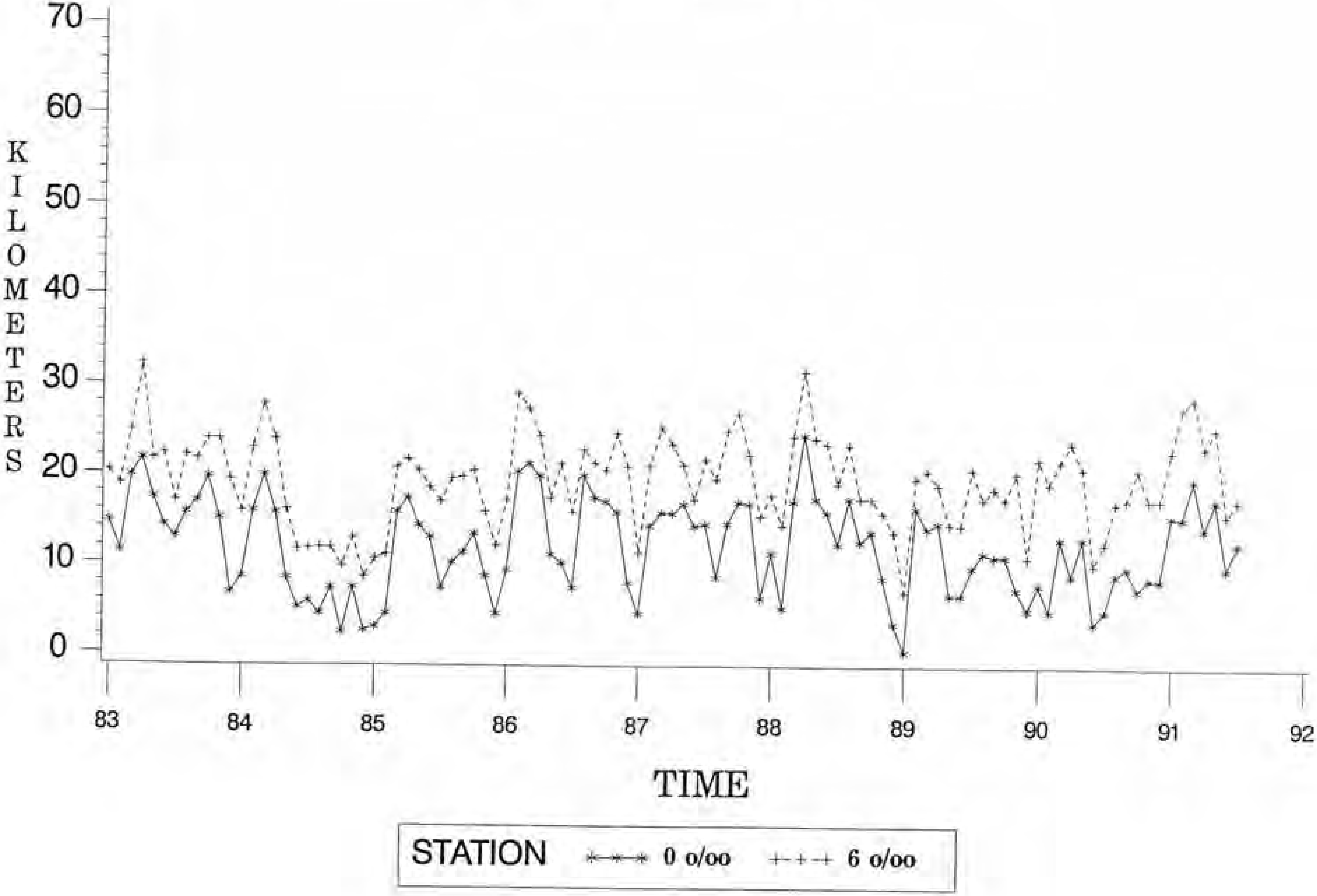


FIGURE 3.4(b)

CHARLOTTE HARBOR 1983 – 1991

Distance from Station #20

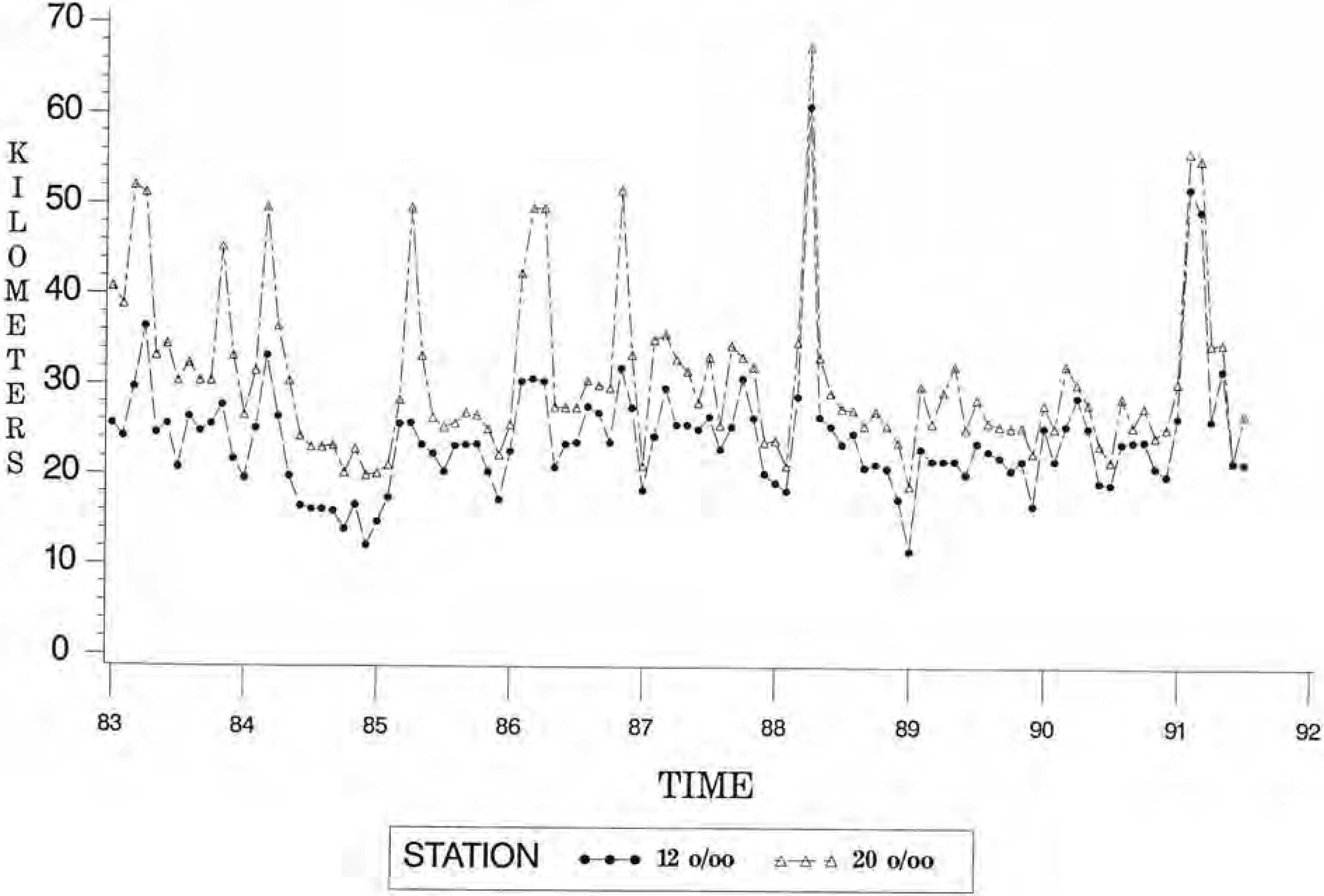
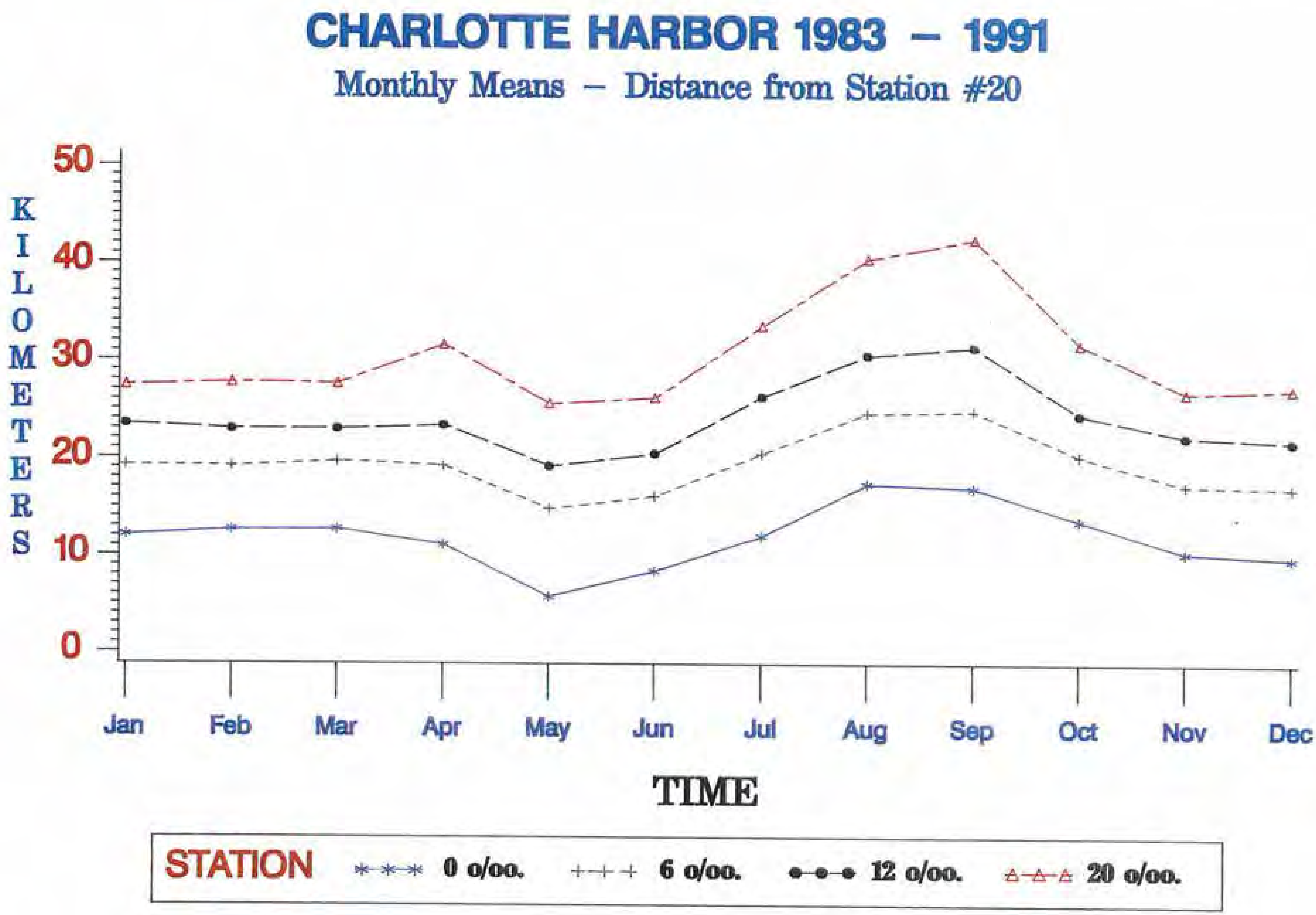


FIGURE 3.5



CHARLOTTE HARBOR 1983 – 1991
Monthly Means – Distance from Station #20
KILOMETERS
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
TIME
STATION
0 o/oo.
6 o/oo.
12 o/oo.
20 o/oo.

difference in distance between zones is far more constant.

Dilution associated with freshwater river inflow, as indicated, is the dominant force in determining the relative location and extent of the salinity zones within the harbor. The primary influences of river inflow on phytoplankton production and biomass within these salinity zones, however, are specifically dependent upon secondary parameters associated with Peace River freshwater inputs. These influences are dominated by two components of freshwater inflow having diametrically opposing affects of phytoplankton production: 1) increasing color, and 2) increasing macro-nutrient loadings.

In the Peace River basin, rainfall resulting in increased surface flow is associated with dramatic elevations in the concentrations of highly colored "humic" compounds derived from decaying vegetation. Figures 3.6(a) and (b) depict the long-term seasonal patterns of water color at each of the four salinity zones. Color at the lowest two salinities was extremely variable, reaching very high levels during periods of increased river flow. Color at the highest salinity zone (20 o/oo), by comparison, was relatively stable, increasing only during the highest periods of river inflow. It is interesting to note that water color at 6 o/oo was often higher than at 0 o/oo during periods of low river flow, suggesting localized influences. Monthly mean water color by station, Figure 3.7, shows the relative influences of both the summer wet-season and early spring cold-front derived rains. Again, the dramatic increases in color at the lower salinity zones during the summer wet-season are apparent.

The major biological influence of water color on phytoplankton production and biomass is associated with its effect on the penetration of light through the water

FIGURE 3.6(A)

CHARLOTTE HARBOR 1983 – 1991

Color

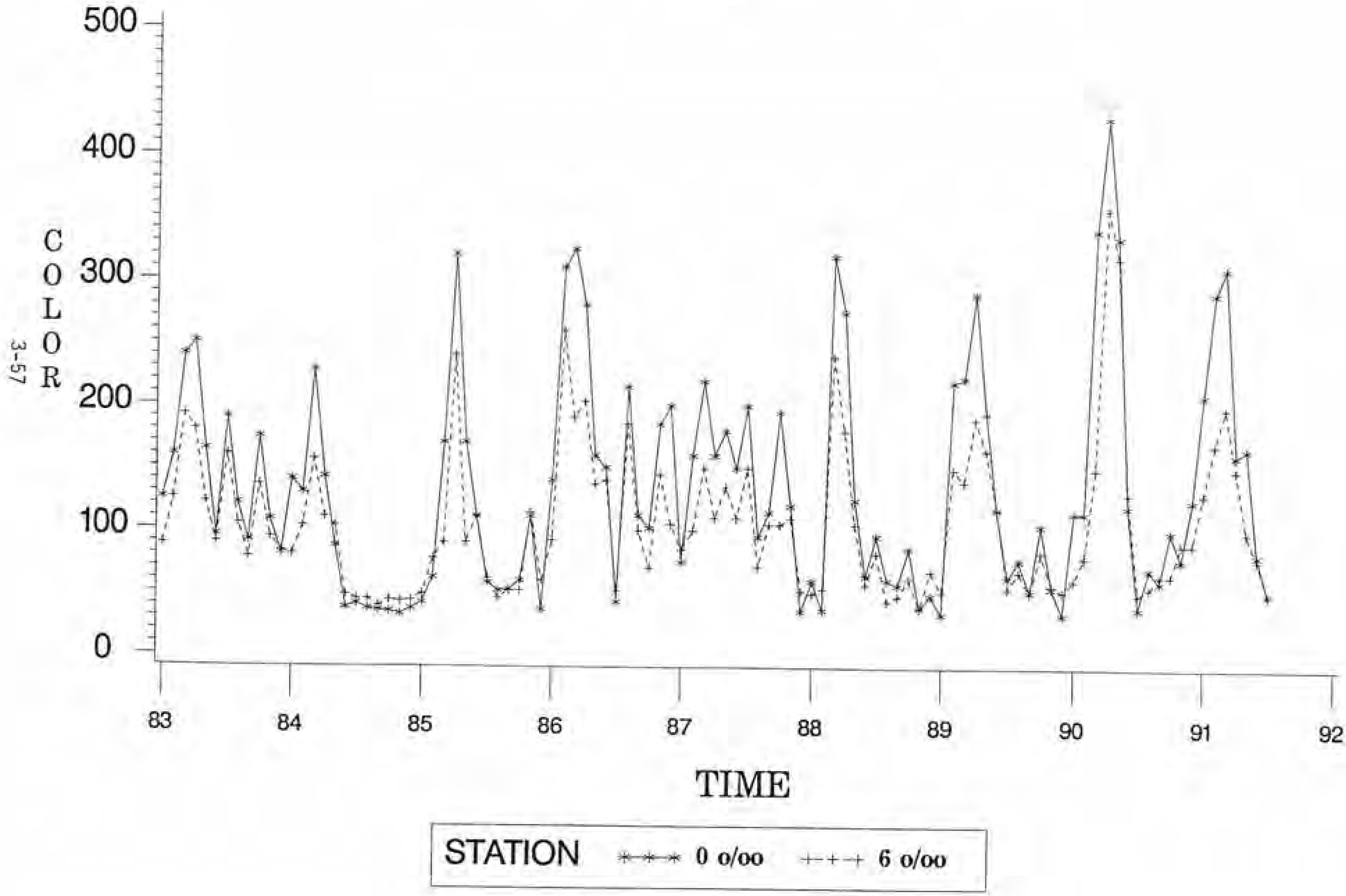
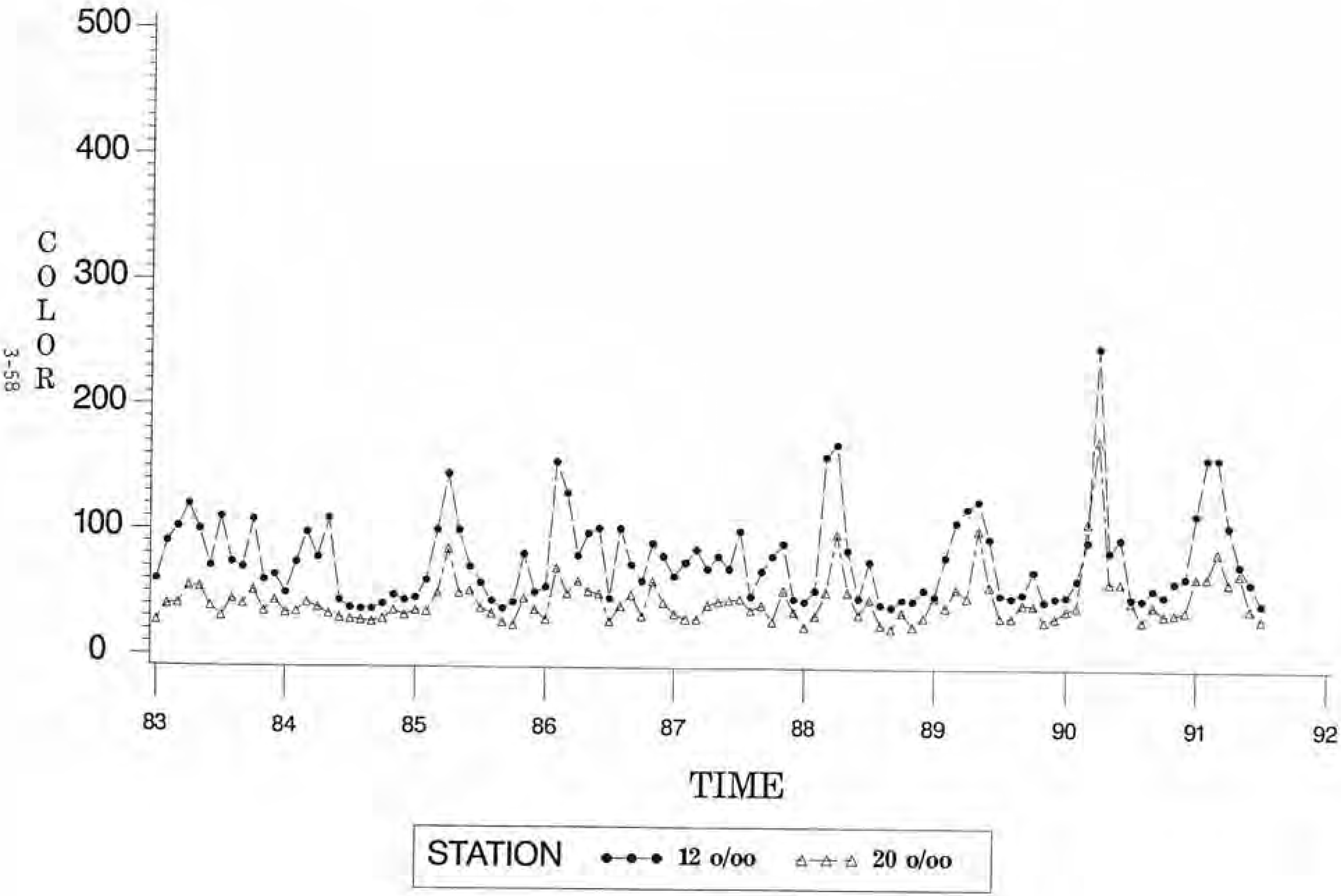


FIGURE 3.6(B)

CHARLOTTE HARBOR 1983 – 1991

Color



patterns of water color at each of the four salinity zones. Color at the lowest two salinities was extremely variable, reaching very high levels during periods of increased river flow. Color at the highest salinity zone (20 o/oo), by comparison, was relatively stable, increasing only during the highest periods of river inflow. It is interesting to note that water color at 6 o/oo was often higher than at 0 o/oo during periods of low river flow, suggesting localized influences. Monthly mean water color by station, Figure 3.7, shows the relative influences of both the summer wet-season and early spring cold-front derived rains. Again, the dramatic increases in color at the lower salinity zones during the summer wet-season are apparent.

The major biological influence of water color on phytoplankton production and biomass is associated with its effect on the penetration of light through the water column. The compensation depth, that point where photosynthetic phytoplankton carbon fixation equals metabolic respiration, usually occurs at approximately 1% of surface illumination. As water color increases, the zone within the water column capable of supporting net-photosynthesis declines. The most common measurement of relative light penetration is to measure the water column extinction coefficient (see Methods 3.2.2), which is influenced by both absorbance (color and chlorophyll a levels) and scattering (particulate and turbidity). Figures 3.8(a) and (b), and 3.9 indicate both the relative long-term and seasonal patterns of light extinction at and among the four measured salinity zones. (An extinction coefficient of 4.8 equals a 1% depth of approximately 1.0 meter - see Table 3.4).

FIGURE 3.7
CHARLOTTE HARBOR 1983 – 1991
Monthly Means – Color

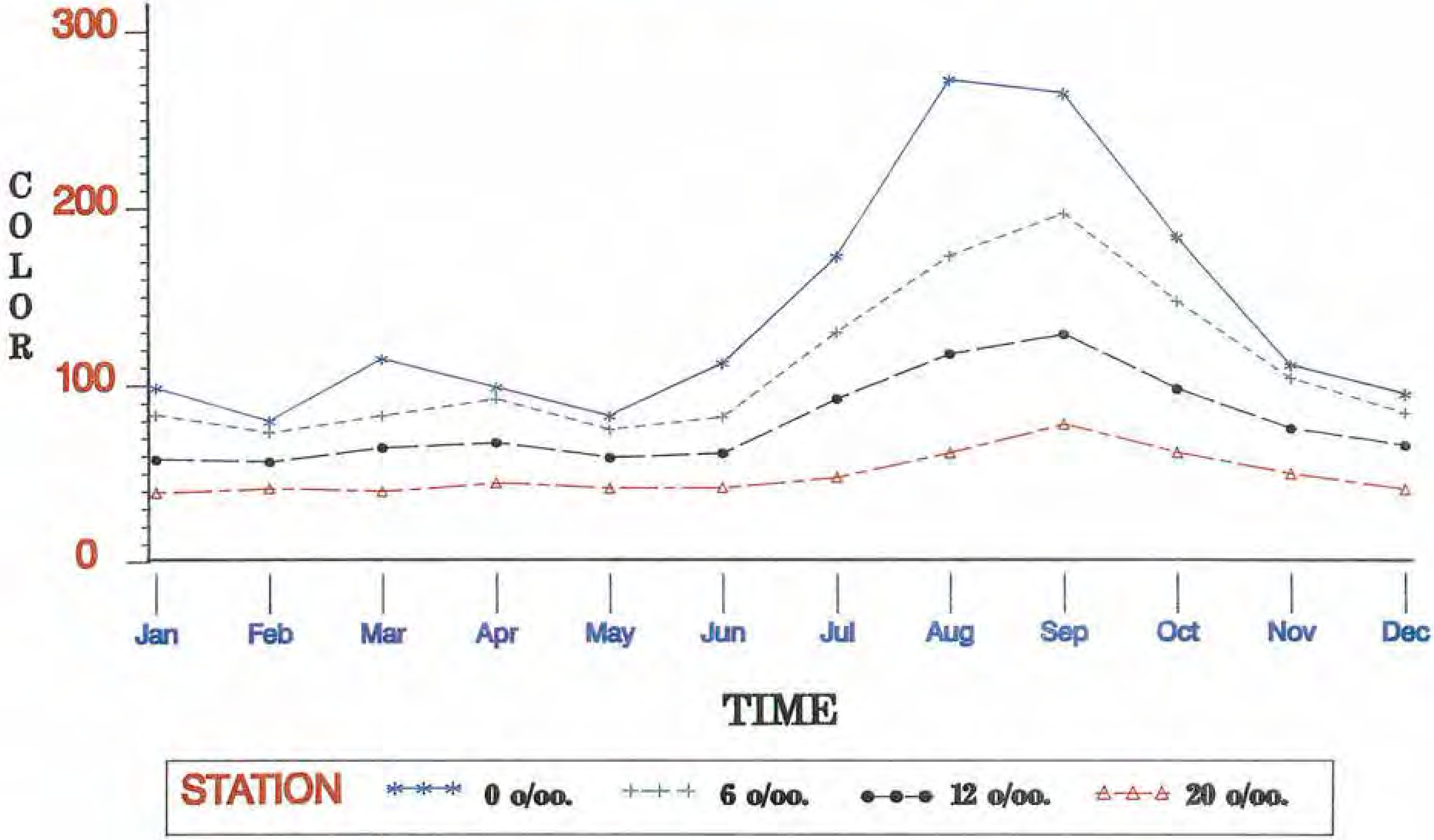


FIGURE 3.8(A)

CHARLOTTE HARBOR 1983 – 1991

Extinction Coefficent

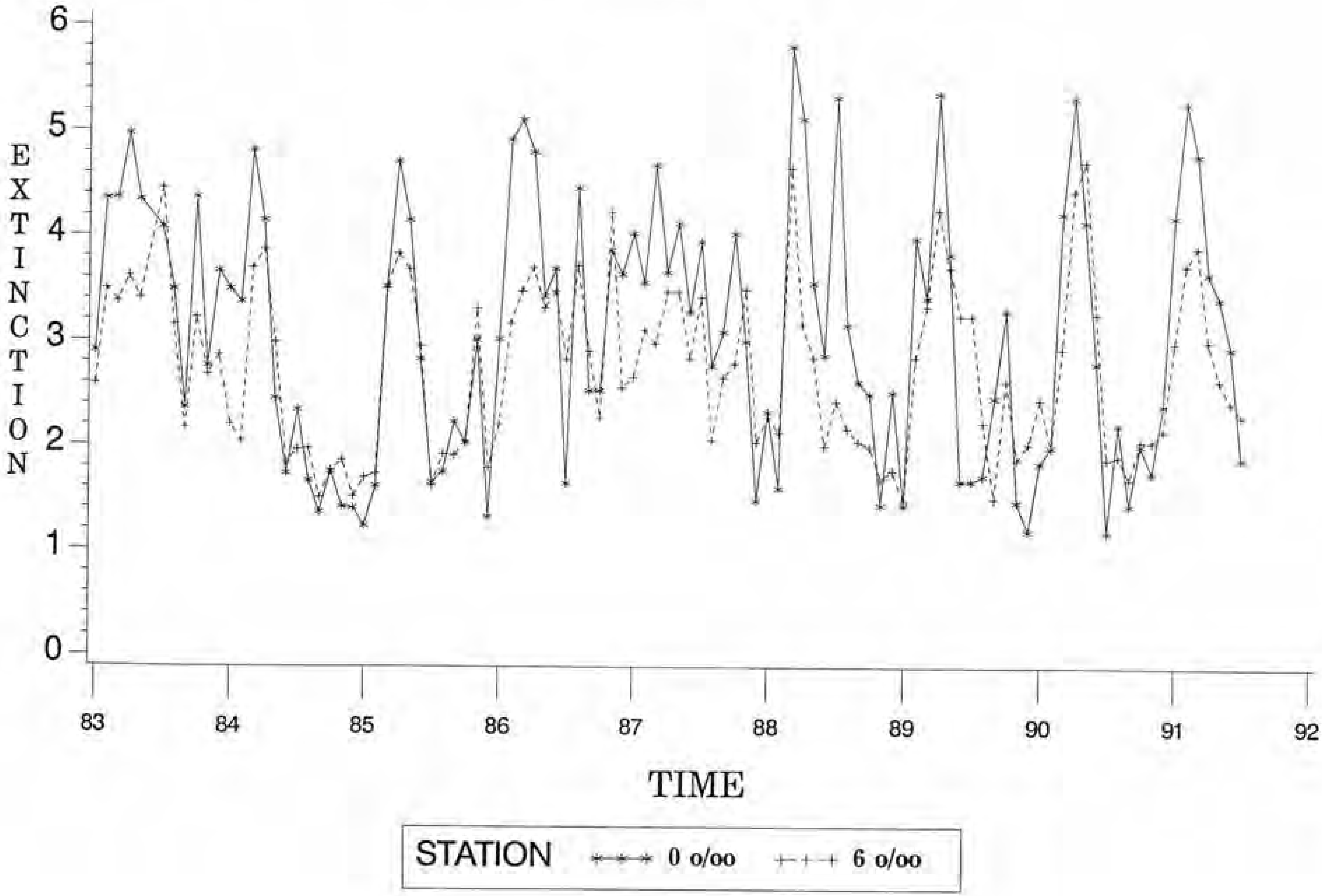


FIGURE 3.8(B)

CHARLOTTE HARBOR 1983 – 1991

Extinction Coefficent

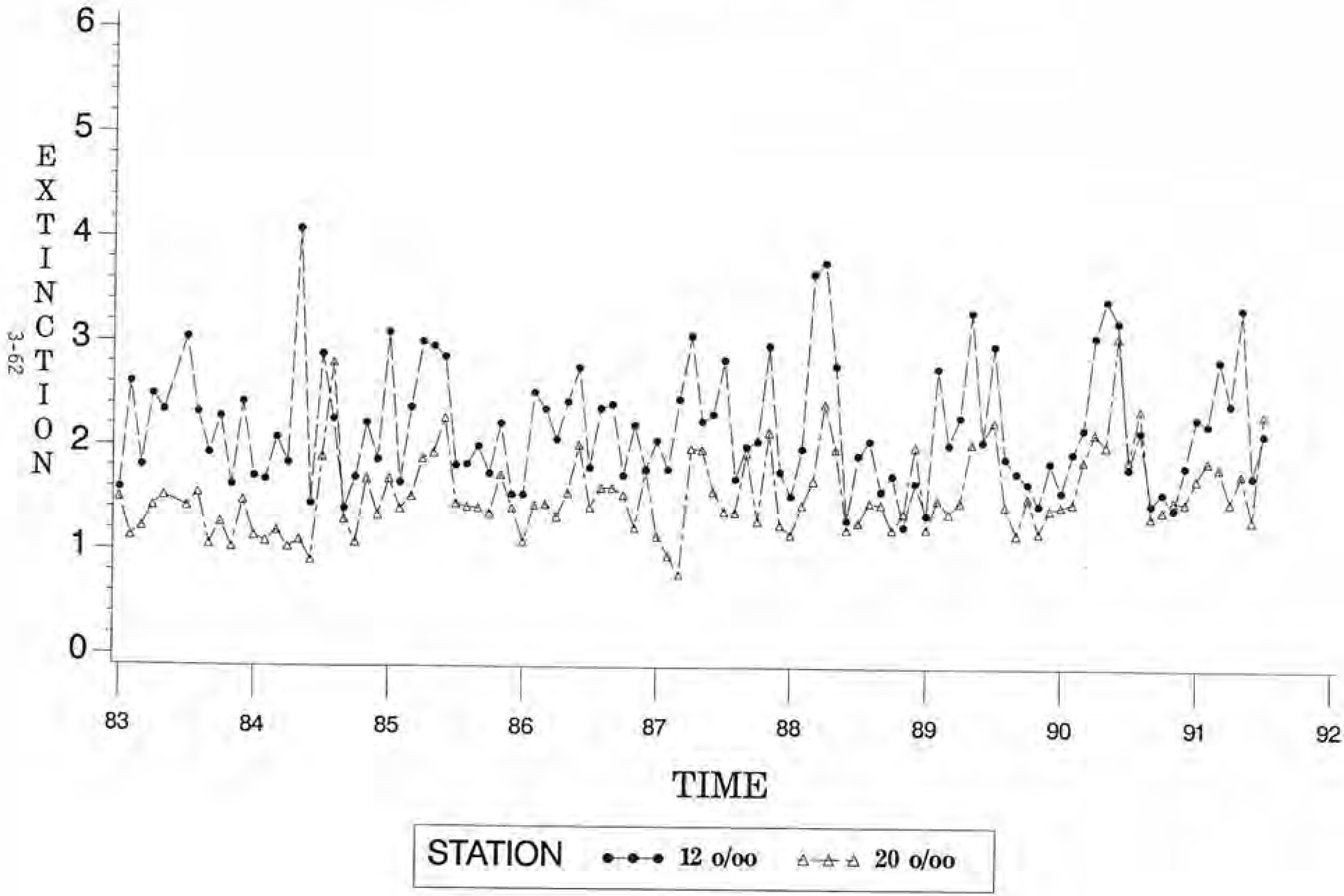
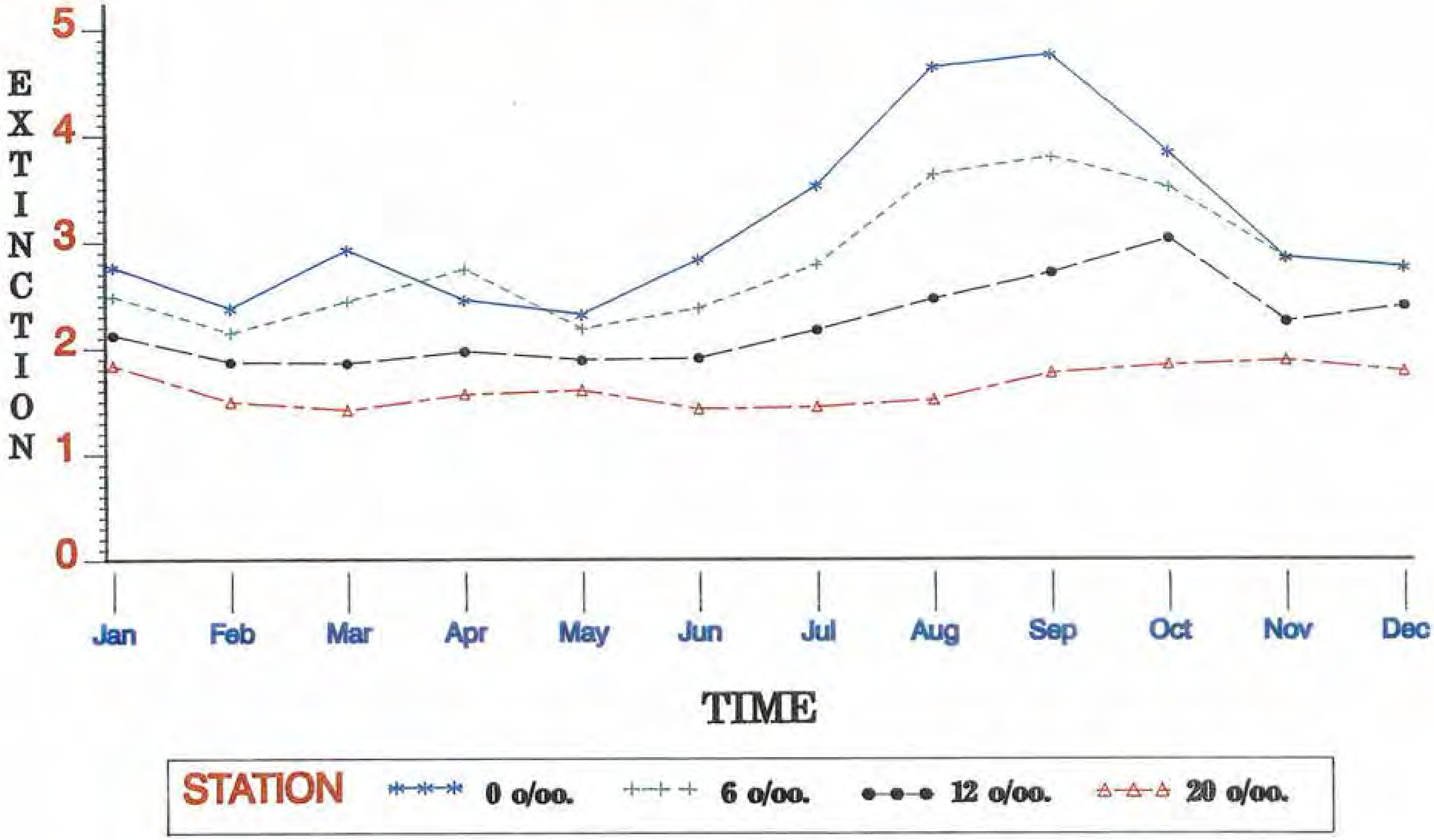


FIGURE 3.9

CHARLOTTE HARBOR 1983 – 1991

Monthly Means – Extinction Coefficent



Chemical Parameters (Nutrients)

River flow not only influences the physical location and characteristics of the salinity zones within the upper Charlotte Harbor estuarine system, it also dominates the loadings and influences ambient concentrations of the major macro-nutrients required for algal growth within these zones. It should be noted that phytoplankton biomass often represents a better long-term integration of loading, while productivity measurements are usually indicative of short-term uptake rates based on nutrient 'availability'. Availability, in this sense, is more than simple measured ambient concentrations, and further encompasses both the combined influences of turnover rates and competition factors. Patterns in ambient nutrient concentrations, therefore, are the resultant blending of riverine input, saltwater dilution, recycling/regeneration, and biological demand.

The availability of three major macro-nutrients: 1) nitrogen, 2) phosphorus, and 3) silica; are thought to have the potential of limiting phytoplankton growth and production in estuarine and coastal marine waters. Long-term, and monthly mean, patterns for each of these three macro-nutrients are depicted over the eight-year study period in Figures 3.10 through 3.15.

NITROGEN - Both the long-term and seasonal variability of ambient nitrate/nitrite (N2/3) concentrations showed marked increases with riverine influence (Figures 3.10 (a),(b) and 3.11). Ambient nitrogen concentrations, at all salinities, consistently attain their highest levels during the cold water/low light winter period (January-February) and then decline sharply through the spring as phytoplankton production increased. Nitrate/nitrite concentrations generally rose again during the wet-season, as river inflow

FIGURE 3.10(A)

CHARLOTTE HARBOR 1983 – 1991

Nitrate\Nitrite

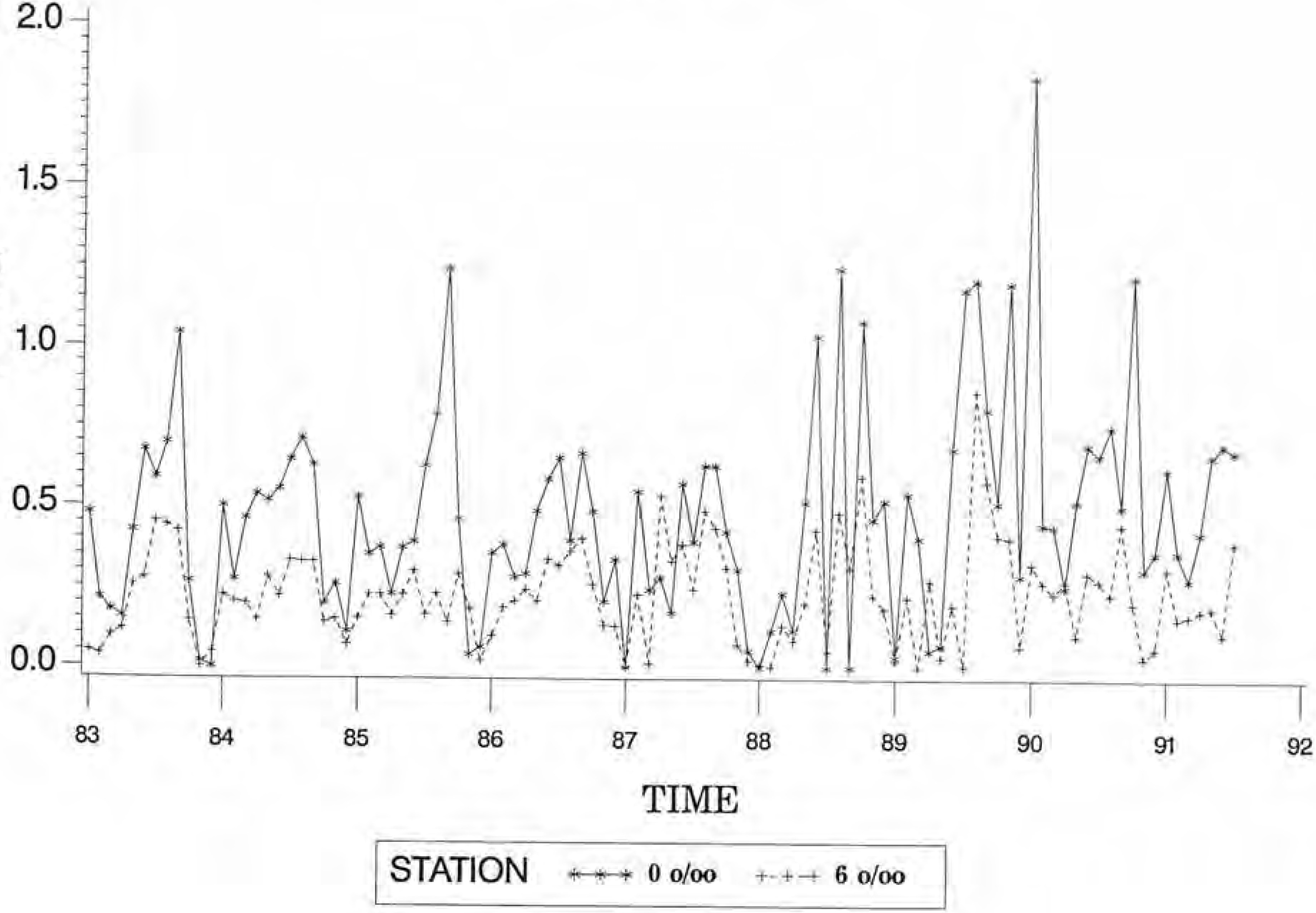


FIGURE 3.10(B)

CHARLOTTE HARBOR 1983 – 1991

Nitrate\Nitrite

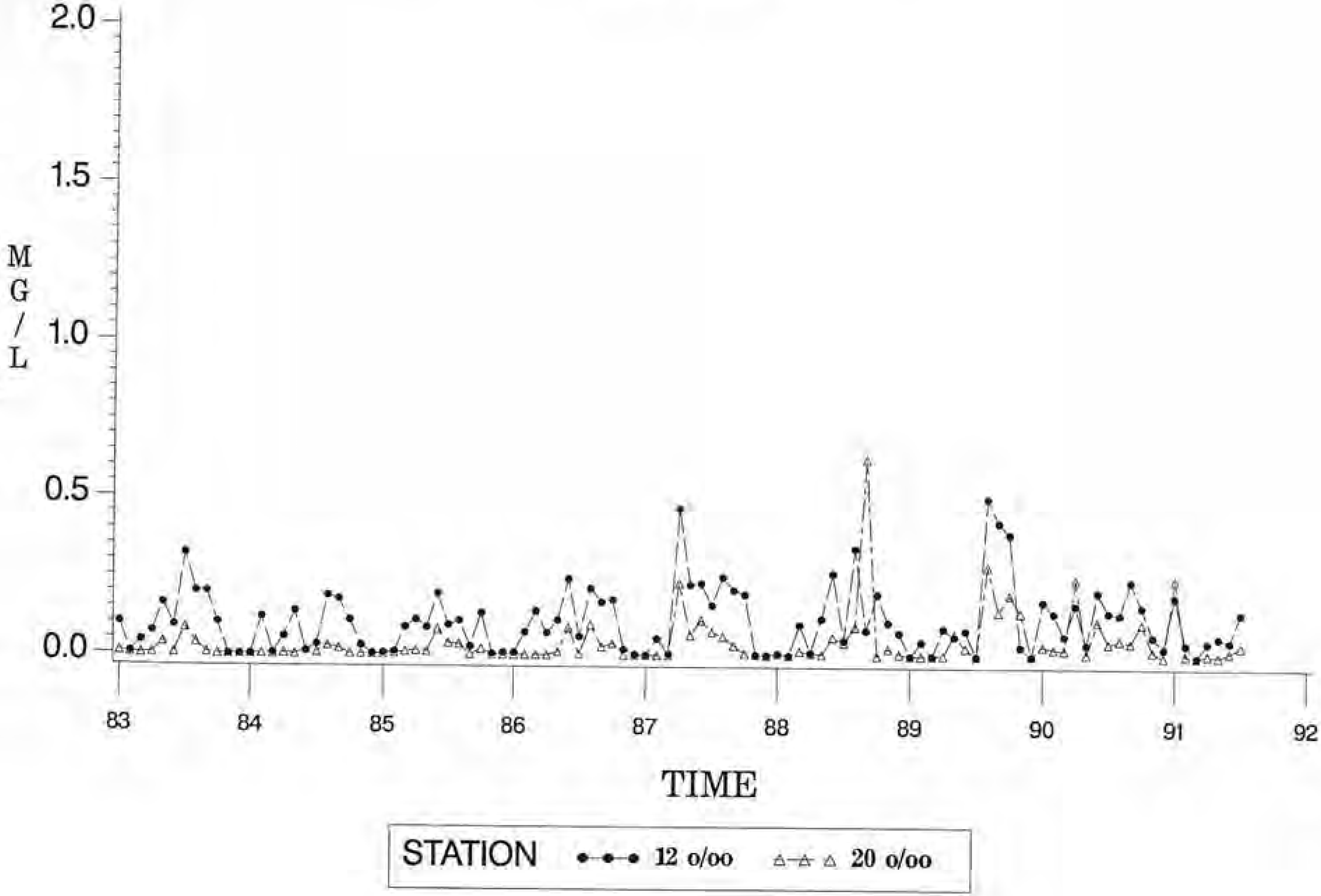
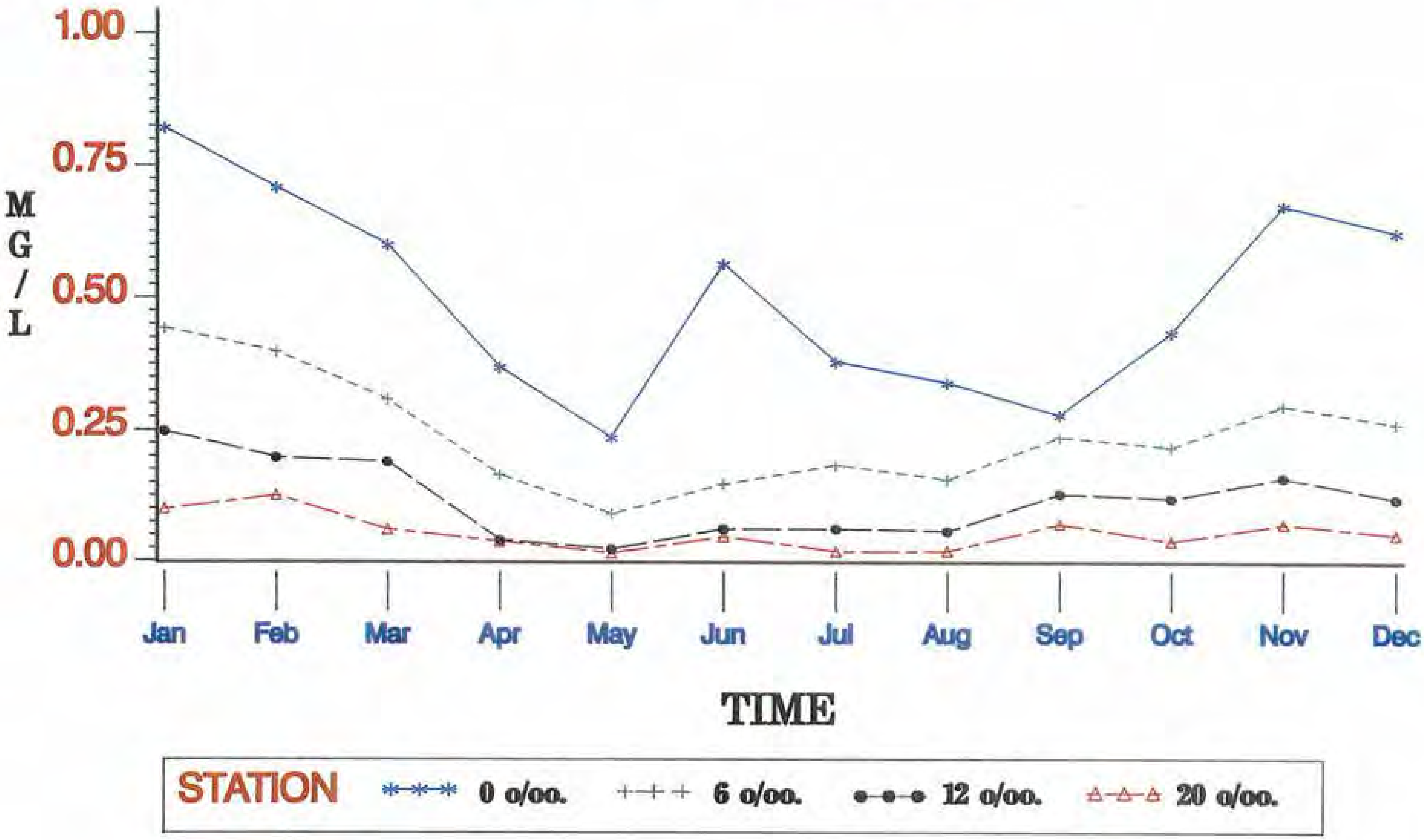


FIGURE 3.11

CHARLOTTE HARBOR 1983 – 1991

Monthly Means – Nitrate\Nitrite



increased loading and higher water color decreased the depth of the photic zone. However, at the highest salinity zone (20 o/oo), N2/3 concentrations remained near detection limits throughout all but the winter months.

PHOSPHORUS - The Peace River and its tributaries run through a large number of natural phosphate deposits. As a result, ambient ortho-phosphorus (PO4-P) concentrations within the upper Charlotte Harbor estuarine system are unusually high when compared to most other temperate and semi-tropical estuaries. Unlike nitrogen and silica, othro-phosphorus levels at all salinities within the estuary show little if any response to biological demand. PO4-P concentrations seldom fell below 0.2 mg/l at any of the stations. Concentrations did decline somewhat through the summer as wet-season dilution decreased PO4-P levels in river inflow. However, there were never any indications that ambient ortho-phosphorus levels might limit phytoplankton production or growth within the Charlotte Harbor estuarine system. The ratio of Nitrogen/Phosphorus (N/P), commonly used as an indicator of the relative potential for nutrient limitation between the two major macro-nutrients never exceeded 20 (which is often taken as beginning to suggest the possible potential of phosphorus limitation. Over the eight years, the Harbor wide N/P ratio had a mean of 1.1 and a standard deviation of 1.6 (see Table 3.11).

SILICA - Silica as a macro-nutrient may not limit phytoplankton production per se in estuarine systems. However, seasonally low availability may influence the relative competitive ability of specific taxonomic groups, such

FIGURE 3.L(A)

CHARLOTTE HARBOR 1983 – 1991

Ortho – Phosphorus

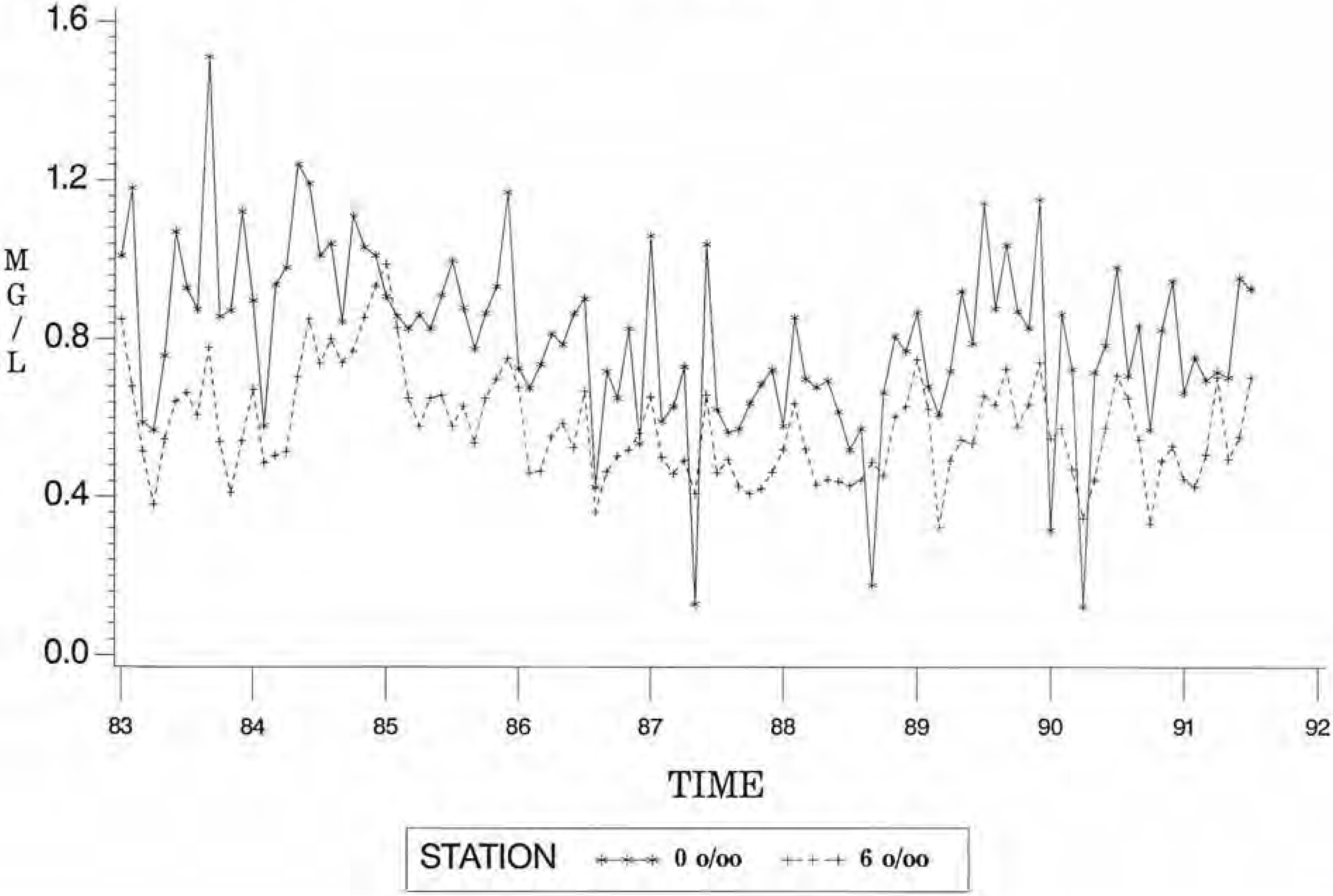


FIGURE 3.__(B)

CHARLOTTE HARBOR 1983 – 1991

Ortho – Phosphorus

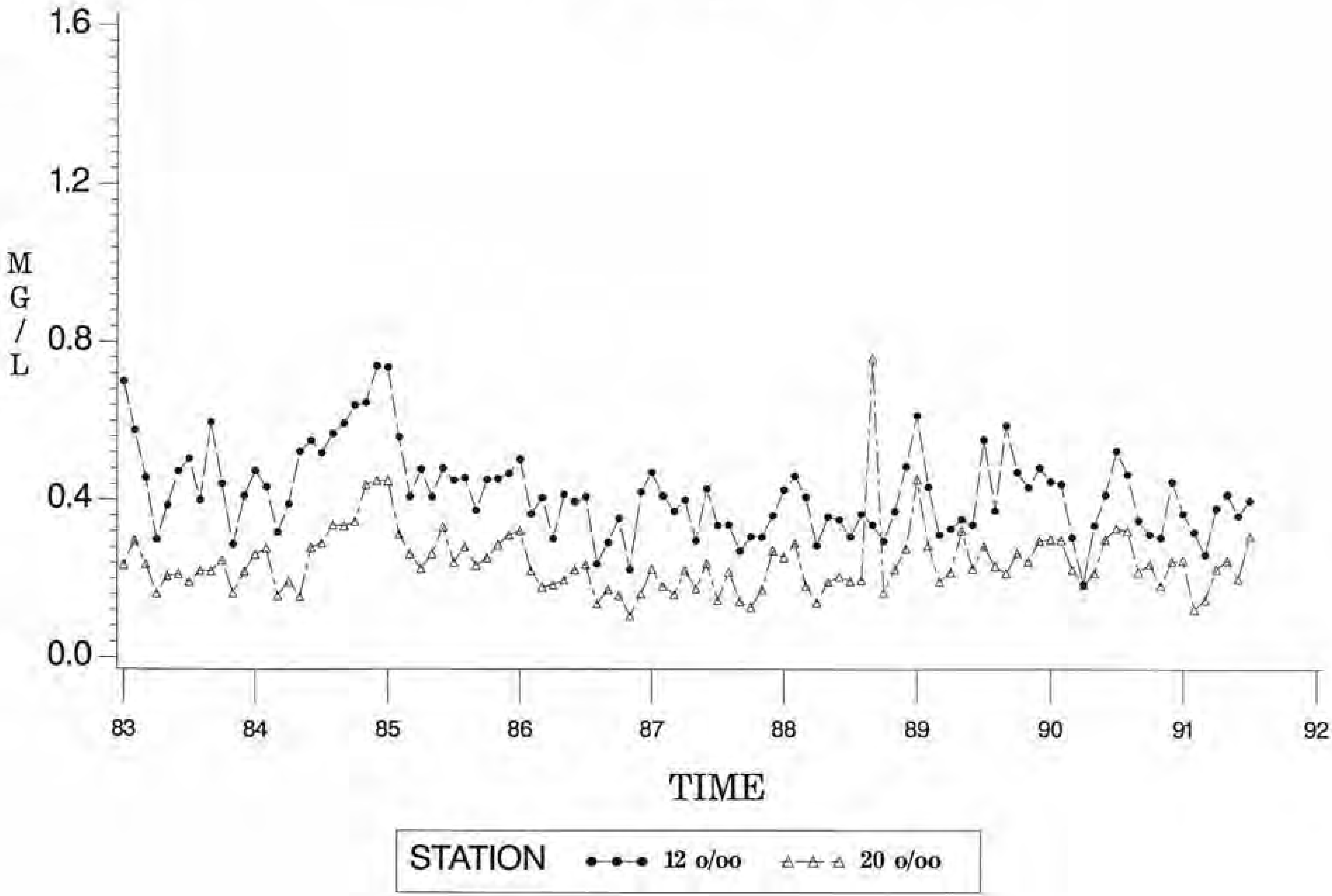
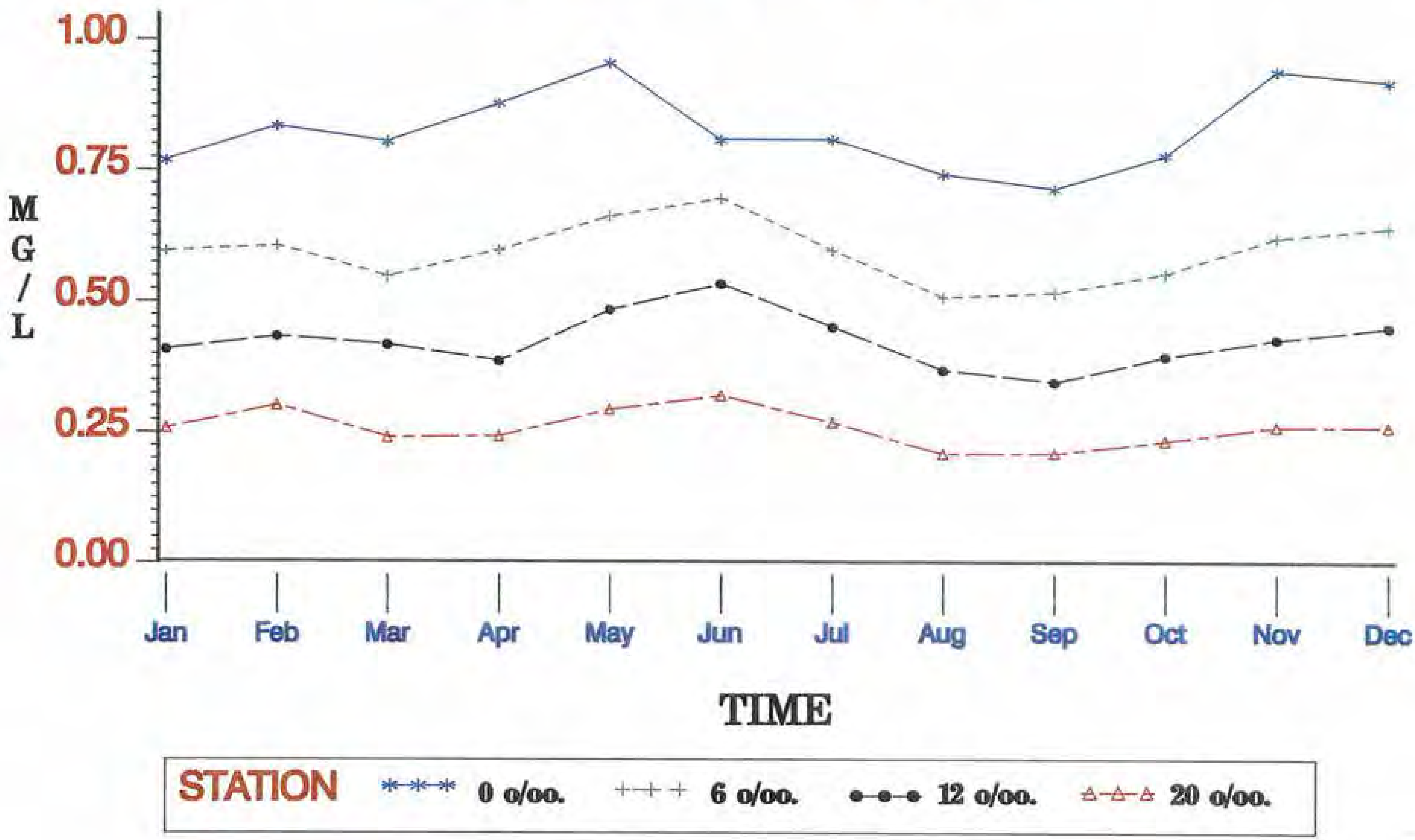


FIGURE 3.13

CHARLOTTE HARBOR 1983 – 1991

Monthly Means – Ortho – Phosphorus



as diatoms, which require silica for growth and reproduction. As indicated in Figures 3.14(a),(b) and 3.15, the patterns of ambient silica concentrations follow a complex relationship, increasing generally with freshwater inflow and temperature. However selectively, marked decreases in ambient concentrations are indicated during specific periods of high phytoplankton productivity at all salinities.

3.3.2 Phytoplankton Production and Biomass

Measured and estimated rates of primary production, as well as carbon uptake and chlorophyll **a** within specific size fractions, by date and salinity zone, are presented in the following tables:

TABLE 3.6 Measured Rates of Primary Production

TABLE 3.7 Determination of Carbon Uptake by Size Fraction

TABLE 3.8 Determination of Chlorophyll a Levels by Size Fraction

Overall rates of primary production at each of the four salinity zones during the period 1983-1991 are graphically summarized as mg carbon fixed per cubic meter per hour in Figures 3.16(a), (b) and 3.17, and as mg carbon fixed per cubic meter per Einstein available light per square meter at the surface in Figures 3.18(a), (b) and 3.19. In the first instance, productivity is standardized simply per unit time, while in the second measurement, components of time, and monthly and seasonal differences in ambient light levels are all standardized. Both methods of measurement, however, indicated the same general trends.

FIGURE 3.14(A)

CHARLOTTE HARBOR 1983 – 1991

Silica

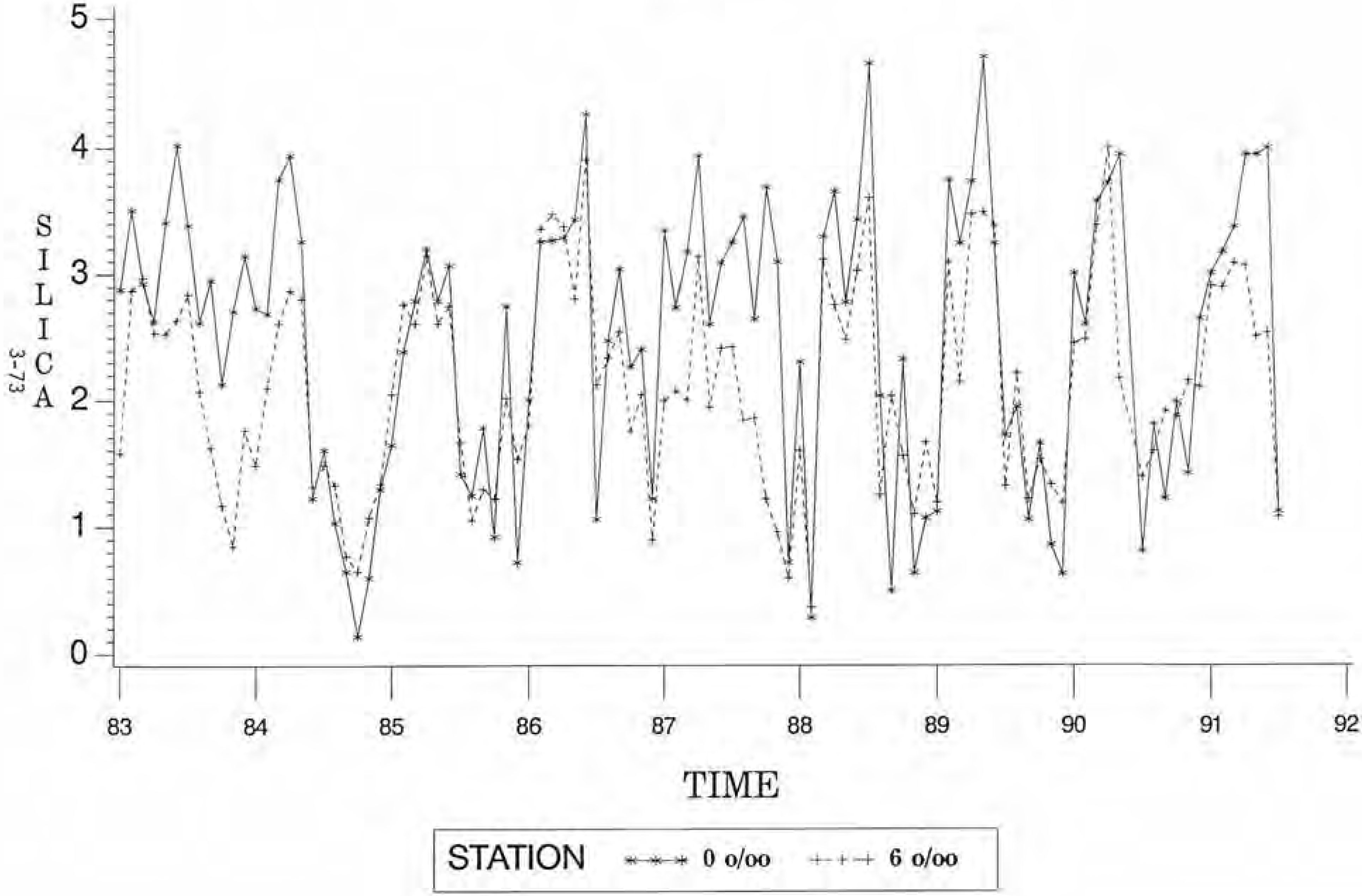


FIGURE 3.14(E)

CHARLOTTE HARBOR 1983 – 1991

Silica

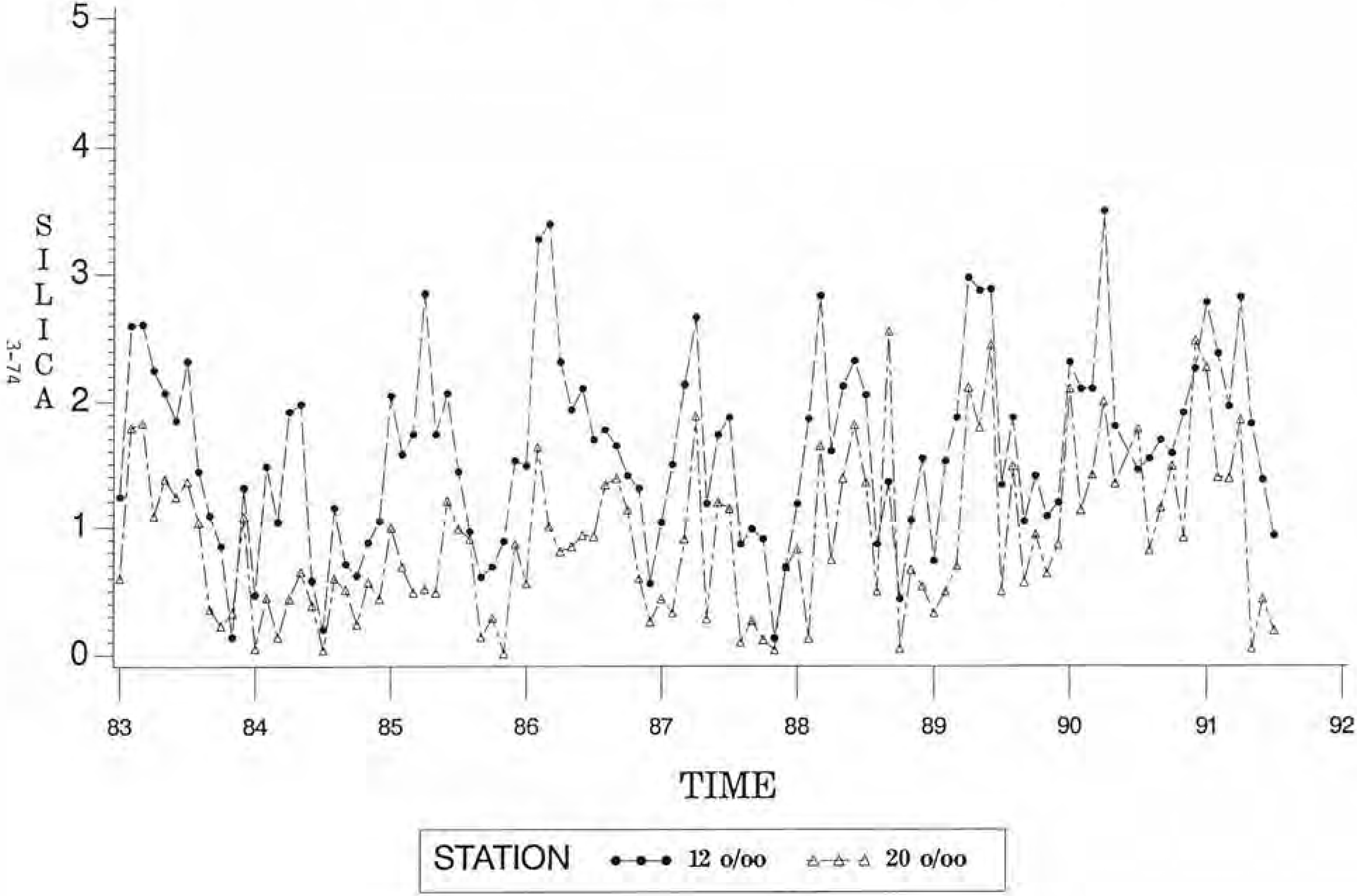


FIGURE 3.15

CHARLOTTE HARBOR 1983 – 1991

Monthly Means – Silica

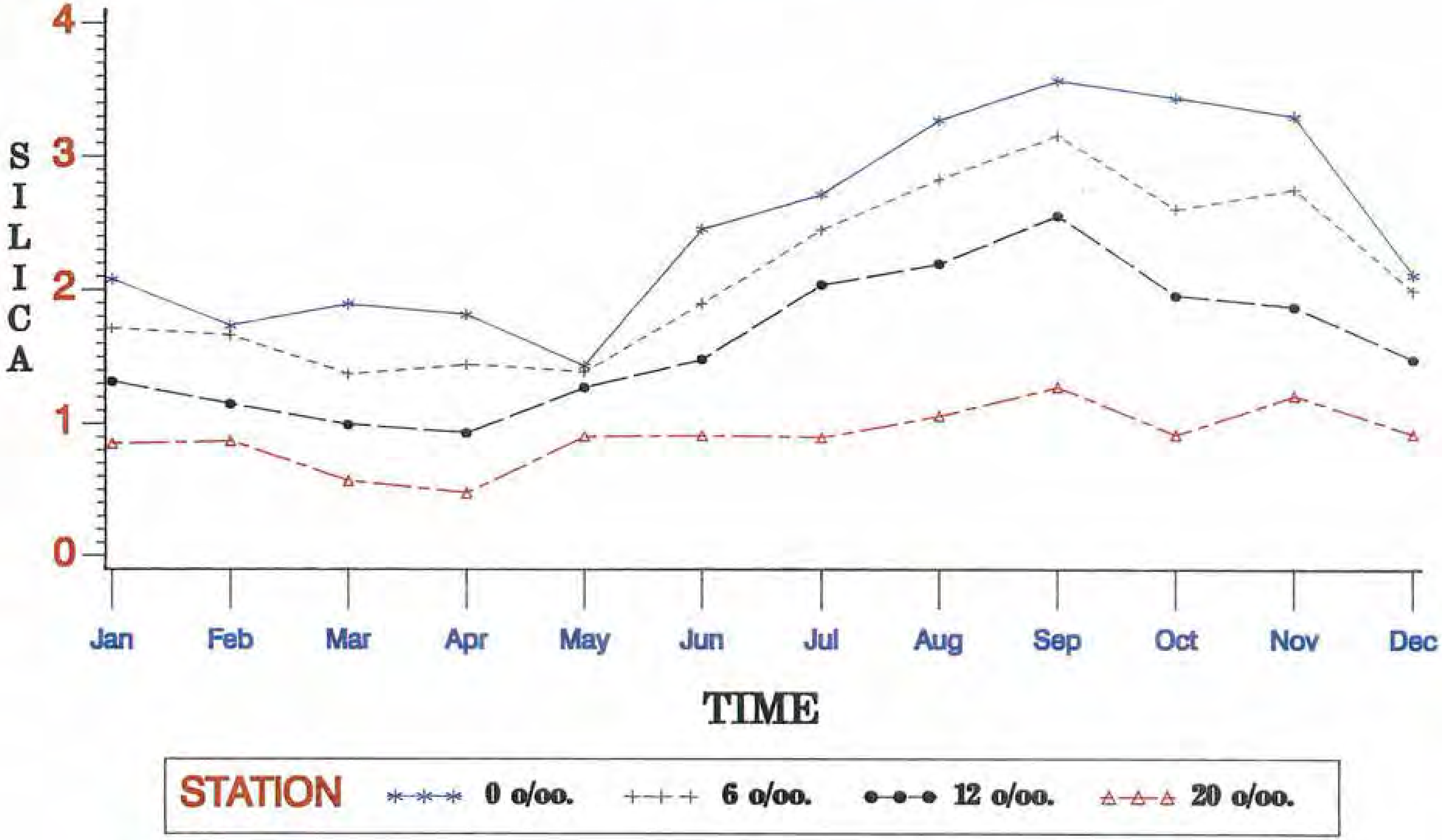


TABLE 3.6

MEASURED RATES OF PRIMARY PRODUCTION
(based on mean values of five replicates)

				mg Carbon/m3		mg Carbon/m3		gram Carbon fixed			
				/hr	/hr/chla	/E	/E/chla	/m3/day	/m3/mon	/m2/day	/2/mon
			STATION	P2	P9	P3	P10	P4	P5	P6	P7
JUN	16	83	0 o/oo	68.3	4.5	10.7	0.7	.52	15.18	.83	24.15
JUN	16	83	6 o/oo	379.5	6.2	61.3	1.0	2.96	86.38	5.27	153.55
JUN	16	83	12 o/oo	110.4	6.8	17.7	1.4	.85	24.97	2.48	72.16
JUN	16	83	20 o/oo	63.0	7.8	9.7	1.2	.47	13.78	1.45	42.40
JUL	22	83	0 o/oo	98.2	2.4	15.8	0.4	.78	22.81	.83	24.13
JUL	22	83	6 o/oo	180.8	2.5	31.3	0.4	1.56	45.26	2.06	59.66
JUL	22	83	12 o/oo	96.2	3.6	21.6	0.8	1.08	31.23	1.90	55.16
JUL	22	83	20 o/oo	28.5	9.1	5.7	1.8	.28	8.22	1.16	33.66
AUG	19	83	0 o/oo	65.5	3.5	16.2	0.8	.66	20.91	.70	22.06
AUG	19	83	6 o/oo	127.1	2.4	24.9	0.4	1.02	32.15	1.02	32.15
AUG	19	83	12 o/oo	154.2	6.8	28.8	1.2	1.18	37.14	3.00	94.37
AUG	19	83	20 o/oo	81.1	7.8	14.3	1.3	.58	18.45	2.22	69.79
SEPT	28	83	0 o/oo	10.7	4.6	2.0	0.8	.08	2.08	.07	1.93
SEPT	28	83	6 o/oo	48.3	4.1	9.1	0.7	.37	9.45	.47	12.07
SEPT	28	83	12 o/oo	66.1	10.8	11.3	1.8	.45	11.66	.84	21.56
SEPT	28	83	20 o/oo	66.6	10.0	11.0	1.6	.44	11.32	1.44	36.83
OCT	20	83	0 o/oo	30.2	2.3	6.0	0.4	.29	6.36	.30	6.75
OCT	20	83	6 o/oo	96.1	3.3	18.6	0.6	.89	19.56	1.20	26.41
OCT	20	83	12 o/oo	96.7	3.0	18.3	0.5	.88	19.27	1.73	37.90
OCT	20	83	20 o/oo	80.8	4.2	15.9	0.8	.76	16.76	2.32	50.94
NOV	22	83	0 o/oo	34.3	11.4	7.9	2.6	.26	6.45	.	.
NOV	22	83	6 o/oo	111.4	14.1	23.1	2.9	.76	16.74	.	.
NOV	22	83	12 o/oo	156.0	16.4	31.0	3.2	1.01	25.07	.	.
NOV	22	83	20 o/oo	69.9	18.4	13.6	3.5	.44	11.02	.	.
DEC	28	83	0 o/oo	12.5	2.2	3.2	0.5	.08	2.26	.10	2.54
DEC	28	83	6 o/oo	19.3	2.9	4.3	0.6	.11	2.98	.12	3.08
DEC	28	83	12 o/oo	48.2	2.1	10.6	0.4	.29	7.35	.44	11.15
DEC	28	83	20 o/oo	19.2	4.4	4.1	0.9	.11	2.84	.36	9.20
JAN	18	84	0 o/oo	32.9	3.7	7.6	0.8	.20	5.89	.27	7.77
JAN	18	84	6 o/oo	65.0	2.1	14.8	0.5	.40	11.44	.59	16.70
JAN	18	84	12 o/oo	150.8	3.1	32.9	0.6	.90	25.43	1.35	38.14
JAN	18	84	20 o/oo	157.0	5.8	34.4	1.2	.93	26.53	2.78	78.67
FEB	15	84	0 o/oo	25.8	3.5	4.6	0.6	.16	4.03	.33	7.88
FEB	15	84	6 o/oo	93.6	3.0	16.5	0.5	.60	14.49	1.28	30.73
FEB	15	84	12 o/oo	151.6	3.8	26.8	0.6	.98	23.48	2.34	56.04
FEB	15	84	20 o/oo	48.7	4.7	8.7	0.8	.31	7.62	1.39	33.18
MAR	9	84	0 o/oo	110.4	3.7	17.0	0.5	.81	21.25	.85	22.43
MAR	9	84	6 o/oo	120.8	1.7	18.6	0.2	.89	23.28	1.27	33.31
MAR	9	84	12 o/oo	71.5	4.7	11.2	0.7	.53	14.01	1.08	28.30
MAR	9	84	20 o/oo	38.3	4.7	6.2	0.7	.30	7.84	1.09	28.51
APR	19	84	0 o/oo	75.2	2.5	14.8	0.5	.71	20.08	1.19	33.49
APR	19	84	6 o/oo	114.6	2.3	22.7	0.4	1.09	30.75	1.89	52.90
APR	19	84	12 o/oo	123.9	4.2	21.8	0.7	1.05	29.49	1.58	44.24
APR	19	84	20 o/oo	50.2	4.7	9.1	0.8	.44	12.32	1.32	36.98
MAY	7	84	0 o/oo	142.4	5.3	22.7	0.8	1.16	33.01	1.46	41.50
MAY	7	84	6 o/oo	193.2	6.1	30.7	0.9	1.58	44.68	2.54	71.92
MAY	7	84	12 o/oo	164.5	7.8	25.9	1.2	1.33	37.74	2.53	71.80
MAY	7	84	20 o/oo	81.3	10.0	12.1	1.5	.62	17.69	1.94	55.08
JUN	7	84	0 o/oo	189.9	6.4	30.3	1.0	1.37	42.56	1.81	56.14
JUN	7	84	6 o/oo	148.8	6.6	21.9	0.9	.99	30.78	1.49	46.17
JUN	7	84	12 o/oo	165.0	8.4	23.8	1.2	1.08	33.50	2.92	90.39
JUN	7	84	20 o/oo	59.9	7.0	9.4	1.1	.42	13.27	1.72	53.45
JUL	9	84	0 o/oo	122.9	5.2	25.9	1.1	.96	33.76	1.32	46.10
JUL	9	84	6 o/oo	51.9	4.2	10.5	0.8	.39	13.71	.39	13.71
JUL	9	84	12 o/oo	69.4	5.1	14.1	1.0	.52	18.40	.26	9.20
JUL	9	84	20 o/oo	82.5	5.2	18.2	1.1	.67	23.69	2.87	100.33

TABLE 3.6 (Cont.)

MEASURED RATES OF PRIMARY PRODUCTION
(based on mean values of five replicates)

				mg Carbon/m3		mg Carbon/m3		gram Carbon fixed			
				/hr	/hr/chla	/E	/E/chla	/m3/day	/m3/mon	/m2/day	/2/mon
			STATION	P2	P9	P3	P10	P4	P5	P6	P7
AUG	16	84	0 o/oo	56.6	6.8	8.1	0.9	.40	11.20	.38	10.72
AUG	16	84	6 o/oo	47.6	7.6	7.0	1.1	.34	9.68	.17	4.84
AUG	16	84	12 o/oo	113.2	2.6	17.3	0.4	.86	24.01	1.91	53.25
AUG	16	84	20 o/oo	64.3	15.3	10.0	2.4	.50	13.92	1.94	53.99
SEPT	13	84	0 o/oo	55.8	5.0	9.5	0.8	.41	10.96	.46	12.18
SEPT	13	84	6 o/oo	542.6	3.5	83.1	0.5	3.64	95.78	4.34	114.08
SEPT	13	84	12 o/oo	73.6	2.9	10.9	0.4	.48	12.62	1.19	31.53
SEPT	13	84	20 o/oo	42.3	5.6	6.6	0.8	.29	7.64	1.30	34.18
OCT	4	84	0 o/oo	59.7	3.1	15.0	0.7	.58	16.96	1.09	31.90
OCT	4	84	6 o/oo	421.0	7.1	100.7	1.7	3.88	113.63	5.83	170.45
OCT	4	84	12 o/oo	220.3	2.0	47.4	0.4	1.82	53.48	2.06	60.37
OCT	4	84	20 o/oo	75.9	6.8	15.1	1.3	.58	17.04	2.44	71.61
NOV	15	84	0 o/oo	40.6	2.7	10.4	0.7	.28	8.52	.74	22.64
NOV	15	84	6 o/oo	41.0	4.8	9.9	1.1	.26	8.14	.67	20.42
NOV	15	84	12 o/oo	75.4	4.3	17.5	1.0	.47	14.34	1.50	45.55
NOV	15	84	20 o/oo	45.1	7.7	9.9	1.7	.26	8.16	1.35	41.10
DEC	13	84	0 o/oo	14.8	5.5	3.2	1.1	.09	2.50	.17	4.93
DEC	13	84	6 o/oo	49.7	11.5	10.7	2.5	.30	8.38	.71	19.67
DEC	13	84	12 o/oo	194.1	12.9	42.4	2.8	1.20	33.17	1.91	52.97
DEC	13	84	20 o/oo	84.8	12.6	19.4	2.9	.55	15.21	1.33	36.95
JAN	8	85	0 o/oo	22.4	7.0	4.3	1.3	.13	3.51	.36	9.75
JAN	8	85	6 o/oo	26.9	9.9	5.2	1.9	.16	4.27	.37	9.98
JAN	8	85	12 o/oo	43.4	9.0	8.6	1.8	.26	7.05	.53	14.37
JAN	8	85	20 o/oo	129.6	13.3	26.5	2.7	.81	21.73	1.34	35.80
FEB	19	85	0 o/oo	19.4	4.5	3.5	0.8	.12	3.20	.43	10.87
FEB	19	85	6 o/oo	51.5	8.3	9.3	1.5	.33	8.32	1.01	25.52
FEB	19	85	12 o/oo	49.0	8.7	8.6	1.5	.30	.76	1.00	2.53
FEB	19	85	20 o/oo	34.7	6.8	6.3	1.2	.22	5.68	.79	20.09
MAR	13	85	0 o/oo	90.0	4.3	14.1	0.6	.66	17.26	1.74	45.44
MAR	13	85	6 o/oo	77.3	2.3	12.1	0.3	.56	14.81	.85	22.22
MAR	13	85	12 o/oo	110.2	8.8	17.5	1.4	.82	21.38	.82	21.38
MAR	13	85	20 o/oo	68.8	27.5	11.3	4.5	.53	13.85	.79	20.78
APR	17	85	0 o/oo	38.3	3.8	5.5	0.5	.29	7.21	.98	23.62
APR	17	85	6 o/oo	92.0	7.5	13.4	1.1	.72	17.48	1.79	43.29
APR	17	85	12 o/oo	379.4	6.0	56.5	0.9	3.04	73.38	6.32	152.15
APR	17	85	20 o/oo	145.1	8.9	21.8	1.3	1.17	28.39	3.21	77.37
MAY	13	85	0 o/oo	70.7	6.8	14.9	1.4	.74	22.09	2.44	72.92
MAY	13	85	6 o/oo	80.9	7.5	16.3	1.5	.81	24.22	1.22	36.34
MAY	13	85	12 o/oo	93.6	7.6	17.5	1.4	.86	25.87	1.30	38.81
MAY	13	85	20 o/oo	62.8	7.8	10.8	1.3	.53	16.04	1.07	32.09
JUN	18	85	0 o/oo	36.8	7.3	5.5	1.1	.30	7.58	1.14	28.44
JUN	18	85	6 o/oo	72.0	5.1	10.6	0.7	.58	14.61	.29	7.30
JUN	18	85	12 o/oo	236.6	3.4	34.7	0.5	1.92	47.62	2.85	70.87
JUN	18	85	20 o/oo	87.6	4.8	13.0	0.7	.72	17.96	1.97	48.92
JUL	11	85	0 o/oo	52.8	5.9	7.7	0.8	.36	9.99	1.03	28.51
JUL	11	85	6 o/oo	75.4	4.6	11.1	0.6	.52	14.40	1.39	38.38
JUL	11	85	12 o/oo	113.9	5.9	17.6	0.9	.83	22.93	.83	22.93
JUL	11	85	20 o/oo	49.1	4.7	8.4	0.8	.39	10.98	1.31	36.13
AUG	7	85	0 o/oo	17.4	3.9	5.5	1.2	.14	7.13	.18	9.33
AUG	7	85	6 o/oo	53.0	4.2	25.2	2.0	.65	32.26	.65	32.26
AUG	7	85	12 o/oo	91.6	5.3	48.8	2.8	1.25	62.34	1.25	62.34
AUG	7	85	20 o/oo	75.2	6.5	31.9	2.7	.82	40.79	1.23	61.18
SEPT	9	85	0 o/oo	10.8	3.5	1.6	0.5	.07	2.06	.07	2.01
SEPT	9	85	6 o/oo	45.4	6.2	6.8	0.9	.30	8.66	.30	8.66
SEPT	9	85	12 o/oo	66.3	6.2	10.2	0.9	.45	12.91	.45	12.91
SEPT	9	85	20 o/oo	106.8	4.9	16.8	0.7	.75	21.30	1.51	42.60

TABLE 3.6 (Cont.)

MEASURED RATES OF PRIMARY PRODUCTION
(based on mean values of five replicates)

				mg Carbon/m3		mg Carbon/m3		gram Carbon fixed			
				/hr	/hr/chla	/E	/E/chla	/m3/day	/m3/mon	/m2/day	/2/mon
			STATION	P2	P9	P3	P10	P4	P5	P6	P7
OCT	9	85	0 o/oo	6.7	2.6	1.6	0.6	.07	1.69	.08	1.87
OCT	9	85	6 o/oo	49.9	5.3	11.0	1.1	.50	11.59	.62	14.52
OCT	9	85	12 o/oo	34.4	5.2	6.8	1.0	.31	7.21	.48	11.22
OCT	9	85	20 o/oo	59.8	5.2	13.2	1.1	.60	13.89	1.42	32.93
NOV	26	85	0 o/oo	39.1	4.5	8.7	1.0	.23	7.21	.38	11.73
NOV	26	85	6 o/oo	44.6	4.9	10.1	1.1	.27	8.38	.27	8.38
NOV	26	85	12 o/oo	46.1	4.9	10.7	1.1	.29	8.87	.46	14.26
NOV	26	85	20 o/oo	109.3	6.2	27.0	1.5	.72	22.28	1.09	33.43
DEC	20	85	0 o/oo	6.5	2.2	1.4	0.5	.04	1.06	.11	2.98
DEC	20	85	6 o/oo	43.8	4.2	9.7	0.9	.26	7.09	.76	20.14
DEC	20	85	12 o/oo	30.0	4.3	6.7	0.9	.18	4.92	.27	7.38
DEC	20	85	20 o/oo	29.8	5.1	6.9	1.1	.18	4.99	.18	4.99
JAN	14	86	0 o/oo	5.0	2.5	1.0	0.5	.03	.82	.08	2.16
JAN	14	86	6 o/oo	25.2	5.4	5.3	1.1	.16	4.16	.32	8.32
JAN	14	86	12 o/oo	21.0	5.1	4.5	1.1	.13	3.55	.20	5.33
JAN	14	86	20 o/oo	19.0	4.1	4.2	0.9	.13	3.32	.19	4.98
FEB	14	86	0 o/oo	164.9	4.1	29.0	0.7	1.11	26.07	2.30	53.85
FEB	14	86	6 o/oo	66.3	2.9	11.7	0.5	.44	10.52	.67	15.78
FEB	14	86	12 o/oo	55.6	3.1	9.9	0.5	.38	8.92	.38	8.92
FEB	14	86	20 o/oo	56.3	4.0	10.2	0.7	.39	9.24	.59	13.86
MAR	12	86	0 o/oo	22.1	3.9	3.6	0.6	.15	4.23	.34	9.58
MAR	12	86	6 o/oo	33.1	3.2	5.8	0.5	.24	6.85	.54	15.39
MAR	12	86	12 o/oo	91.2	7.9	16.6	1.4	.69	19.45	.69	19.45
MAR	12	86	20 o/oo	39.7	3.9	7.7	0.7	.32	9.05	.32	9.05
APR	14	86	0 o/oo	210.0	6.2	30.4	0.9	1.66	44.09	2.55	67.40
APR	14	86	6 o/oo	318.8	4.1	46.0	0.6	2.52	66.67	3.51	92.84
APR	14	86	12 o/oo	115.5	5.2	16.8	0.7	.92	24.38	1.91	50.60
APR	14	86	20 o/oo	127.0	7.7	19.2	1.1	1.05	27.84	2.81	74.30
MAY	13	86	0 o/oo	63.5	4.7	12.4	0.9	.52	17.96	1.84	62.66
MAY	13	86	6 o/oo	34.5	6.3	7.7	1.4	.32	11.11	.84	28.55
MAY	13	86	12 o/oo	35.2	7.5	7.0	1.4	.29	10.11	.88	30.20
MAY	13	86	20 o/oo	55.5	12.9	9.4	2.2	.40	13.68	1.31	44.71
JUN	17	86	0 o/oo	26.2	9.0	3.7	1.3	.17	4.83	.27	7.36
JUN	17	86	6 o/oo	254.4	10.1	38.8	1.5	1.83	49.48	3.80	102.93
JUN	17	86	12 o/oo	81.9	13.2	13.3	2.1	.62	16.97	.31	8.48
JUN	17	86	20 o/oo	139.9	18.4	23.6	3.1	1.11	30.09	1.66	45.14
JUL	11	86	0 o/oo	25.6	1.3	4.5	0.2	.24	5.72	.23	5.36
JUL	11	86	6 o/oo	68.4	3.2	13.4	0.6	.74	17.07	.37	8.53
JUL	11	86	12 o/oo	93.7	12.5	21.6	2.9	1.20	27.77	.60	13.88
JUL	11	86	20 o/oo	62.5	17.3	13.7	3.8	.75	17.45	1.13	26.18
AUG	7	86	0 o/oo	32.8	3.3	5.1	0.5	.20	6.23	.18	5.62
AUG	7	86	6 o/oo	45.8	7.1	7.6	1.1	.29	9.18	.14	4.59
AUG	7	86	12 o/oo	72.2	10.1	12.8	1.8	.49	15.52	.24	7.76
AUG	7	86	20 o/oo	54.7	7.4	10.3	1.4	.40	12.47	.80	24.95
SEPT	14	86	0 o/oo	26.9	7.2	5.1	1.3	.19	5.65	.18	5.42
SEPT	14	86	6 o/oo	41.6	8.8	7.7	1.6	.29	8.51	.14	4.25
SEPT	14	86	12 o/oo	139.9	8.1	32.9	1.9	1.25	36.36	1.87	54.54
SEPT	14	86	20 o/oo	67.2	7.2	14.6	1.5	.55	16.10	1.92	55.79
OCT	8	86	0 o/oo	40.2	3.8	7.4	0.7	.22	7.00	.30	9.41
OCT	8	86	6 o/oo	87.2	5.4	16.6	1.0	.50	15.73	.70	21.82
OCT	8	86	12 o/oo	70.9	7.0	14.0	1.4	.42	13.25	.80	25.06
OCT	8	86	20 o/oo	83.8	5.5	17.8	1.1	.54	16.83	1.60	49.58
NOV	17	86	0 o/oo	66.4	8.5	49.4	6.3	1.04	35.97	1.30	44.95
NOV	17	86	6 o/oo	28.3	1.8	17.1	1.1	.36	12.50	.48	16.55
NOV	17	86	12 o/oo	66.4	7.5	49.4	5.6	1.04	35.98	1.74	59.97
NOV	17	86	20 o/oo	77.5	6.7	47.0	4.0	.99	34.23	1.99	68.47

TABLE 3.6 (Cont.)

MEASURED RATES OF PRIMARY PRODUCTION
(based on mean values of five replicates)

				mg Carbon/m3 /hr	mg Carbon/m3 /hr/chla	mg Carbon/m3 /E	mg Carbon/m3 /E/chla	/m3/day	gram Carbon fixed /m3/mon	gram Carbon fixed /m2/day	gram Carbon fixed /2/mon
			STATION	P2	P9	P3	P10	P4	P5	P6	P7
DEC	18	86	0 o/oo	10.8	2.3	3.8	0.8	.07	2.15	.19	6.05
DEC	18	86	6 o/oo	50.7	2.9	19.6	1.1	.36	11.15	.59	18.15
DEC	18	86	12 o/oo	63.4	5.6	22.2	1.9	.41	12.59	.82	25.18
DEC	18	86	20 o/oo	97.9	8.5	38.2	3.3	.71	21.64	2.30	70.23
JAN	9	87	0 o/oo	5.4	0.0	1.3	0.0	.03	.98	.03	1.02
JAN	9	87	6 o/oo	10.9	0.0	3.0	0.0	.07	2.17	.03	1.08
JAN	9	87	12 o/oo	14.7	0.0	4.0	0.0	.09	2.92	.09	2.92
JAN	9	87	20 o/oo	9.3	0.0	2.9	0.0	.07	2.12	.10	3.18
FEB	11	87	0 o/oo	15.0	3.4	4.0	0.9	.15	3.04	.28	5.54
FEB	11	87	6 o/oo	74.3	6.4	17.2	1.5	.66	12.96	1.05	20.54
FEB	11	87	12 o/oo	86.1	10.6	21.2	2.6	.82	16.00	1.57	30.62
FEB	11	87	20 o/oo	60.6	8.4	16.8	2.3	.64	12.64	1.85	36.21
MAR	10	87	0 o/oo	56.6	5.5	10.6	1.0	.43	9.33	.78	16.97
MAR	10	87	6 o/oo	93.2	6.7	16.9	1.2	.68	14.87	1.39	30.18
MAR	10	87	12 o/oo	160.0	10.1	29.1	1.8	1.18	25.62	2.95	64.05
MAR	10	87	20 o/oo	114.8	9.3	21.0	1.7	.85	18.52	2.55	55.48
APR	20	87	0 o/oo	277.5	12.5	50.6	2.2	2.08	66.11	2.48	78.76
APR	20	87	6 o/oo	176.3	12.2	29.1	2.0	1.19	38.03	1.19	38.03
APR	20	87	12 o/oo	337.8	20.1	57.9	3.4	2.38	75.57	2.38	75.57
APR	20	87	20 o/oo	152.9	13.6	35.8	3.2	1.47	46.69	5.51	175.08
MAY	19	87	0 o/oo	6.0	2.5	1.2	0.5	.04	1.75	.06	2.22
MAY	19	87	6 o/oo	136.6	6.4	24.1	1.1	.94	33.50	1.41	50.26
MAY	19	87	12 o/oo	127.5	6.2	22.9	1.1	.89	31.83	1.34	47.75
MAY	19	87	20 o/oo	46.7	4.6	9.6	0.9	.37	13.44	.97	34.63
JUN	8	87	0 o/oo	204.3	4.0	34.9	0.7	1.68	45.17	1.93	51.67
JUN	8	87	6 o/oo	187.2	7.4	33.6	1.3	1.62	43.58	2.82	75.57
JUN	8	87	12 o/oo	251.7	8.6	46.3	1.5	2.23	59.91	4.99	133.74
JUN	8	87	20 o/oo	103.7	7.2	17.4	1.2	.84	22.62	3.37	90.28
JUL	17	87	0 o/oo	73.8	5.0	14.8	1.0	.57	18.01	.74	23.30
JUL	17	87	6 o/oo	248.6	1.9	58.2	0.4	2.24	70.41	1.12	35.20
JUL	17	87	12 o/oo	141.4	5.1	28.5	1.0	1.10	34.49	.55	17.24
JUL	17	87	20 o/oo	35.7	4.3	8.2	0.9	.31	9.95	1.11	34.83
AUG	4	87	0 o/oo	46.5	2.4	10.5	0.5	.41	12.74	.40	12.53
AUG	4	87	6 o/oo	46.2	1.6	12.5	0.4	.49	15.12	.24	7.56
AUG	4	87	12 o/oo	51.6	1.7	17.9	0.6	.71	21.73	1.33	40.74
AUG	4	87	20 o/oo	23.3	3.1	5.2	0.7	.20	6.39	1.23	37.70
SEPT	25	87	0 o/oo	8.5	0.6	2.0	0.1	.07	2.07	.09	2.61
SEPT	25	87	6 o/oo	28.9	2.7	6.9	0.6	.26	6.96	.35	9.23
SEPT	25	87	12 o/oo	92.9	1.8	22.1	0.4	.84	22.34	.84	22.34
SEPT	25	87	20 o/oo	45.0	1.6	10.9	0.4	.41	11.01	.62	16.52
OCT	20	87	0 o/oo	13.4	9.6	3.4	2.4	.11	3.19	.13	3.56
OCT	20	87	6 o/oo	25.5	4.9	5.9	1.1	.19	5.45	.26	7.23
OCT	20	87	12 o/oo	51.4	7.6	15.8	2.3	.53	14.51	1.08	29.73
OCT	20	87	20 o/oo	86.2	9.0	21.3	2.2	.71	19.63	1.67	45.73
NOV	13	87	0 o/oo	4.0	0.8	1.2	0.2	.02	.72	.03	1.01
NOV	13	87	6 o/oo	15.5	0.4	4.6	0.1	.10	2.74	.10	2.74
NOV	13	87	12 o/oo	32.0	2.3	9.4	0.6	.22	5.64	.33	8.46
NOV	13	87	20 o/oo	36.5	3.3	11.2	1.0	.26	6.68	.52	13.36
DEC	10	87	0 o/oo	1.9	0.0	0.6	0.0	.01	.37	.01	.43
DEC	10	87	6 o/oo	10.4	2.1	3.4	0.7	.06	2.10	.09	2.82
DEC	10	87	12 o/oo	19.3	3.4	6.1	1.0	.12	3.77	.18	5.66
DEC	10	87	20 o/oo	32.1	3.4	9.8	1.0	.20	6.09	.66	20.21
JAN	18	88	0 o/oo	13.4	1.2	3.0	0.3	.09	1.91	.16	3.17
JAN	18	88	6 o/oo	26.6	2.8	5.7	0.6	.18	3.58	.41	8.01
JAN	18	88	12 o/oo	39.1	3.1	8.4	0.6	.26	5.23	.72	14.15
JAN	18	88	20 o/oo	65.1	3.0	14.1	0.6	.44	8.76	1.50	29.31

TABLE 3.6 (Cont.)

MEASURED RATES OF PRIMARY PRODUCTION
(based on mean values of five replicates)

				mg Carbon/m3 /hr	/hr/chla	mg Carbon/m3 /E	/E/chla	/m3/day	gram Carbon fixed /m3/mon	/m2/day	/2/mon
			STATION	P2	P9	P3	P10	P4	P5	P6	P7
FEB	10	88	0 o/oo	2.3	1.2	0.5	0.3	.01	.45	.02	.67
FEB	10	88	6 o/oo	12.5	1.9	2.9	0.4	.07	2.35	.07	2.35
FEB	10	88	12 o/oo	35.9	3.3	8.4	0.7	.21	6.84	.21	6.84
FEB	10	88	20 o/oo	50.6	4.0	12.9	1.0	.33	10.47	.67	20.95
MAR	11	88	0 o/oo	10.1	3.6	1.9	0.7	.08	2.16	.09	2.47
MAR	11	88	6 o/oo	70.7	6.5	13.0	1.2	.56	14.17	.28	7.08
MAR	11	88	12 o/oo	82.1	9.3	14.6	1.6	.63	15.95	.63	15.95
MAR	11	88	20 o/oo	113.9	9.8	19.7	1.7	.85	21.47	2.97	75.16
APR	13	88	0 o/oo	20.5	3.0	3.6	0.5	.13	4.31	.20	6.61
APR	13	88	6 o/oo	66.0	2.9	11.3	0.5	.42	13.34	.55	17.56
APR	13	88	12 o/oo	113.2	5.9	18.8	1.0	.70	22.15	.70	22.15
APR	13	88	20 o/oo	63.4	4.6	10.2	0.7	.38	12.06	.81	25.80
MAY	16	88	0 o/oo	44.1	6.2	7.5	1.0	.28	10.24	.87	31.78
MAY	16	88	6 o/oo	73.3	7.3	12.0	1.2	.45	16.29	.67	24.43
MAY	16	88	12 o/oo	71.1	6.9	10.6	1.0	.39	14.38	.39	14.38
MAY	16	88	20 o/oo	66.4	6.2	9.8	0.9	.36	13.24	.36	13.24
JUN	13	88	0 o/oo	44.1	5.7	10.2	1.3	.36	11.47	.72	22.71
JUN	13	88	6 o/oo	110.9	7.1	29.1	1.8	1.03	32.56	.51	16.28
JUN	13	88	12 o/oo	58.2	6.4	15.9	1.7	.56	17.77	.84	26.65
JUN	13	88	20 o/oo	48.1	4.3	12.7	1.1	.45	14.26	1.79	56.19
JUL	12	88	0 o/oo	46.0	5.6	8.3	1.0	.33	10.10	.95	29.13
JUL	12	88	6 o/oo	123.2	15.0	22.7	2.7	.90	27.61	.90	27.61
JUL	12	88	12 o/oo	76.2	6.0	14.4	1.1	.57	17.55	.57	17.55
JUL	12	88	20 o/oo	86.0	10.4	16.6	2.0	.66	20.28	.66	20.28
AUG	8	88	0 o/oo	30.7	2.8	6.0	0.5	.23	6.45	.18	5.11
AUG	8	88	6 o/oo	128.4	1.6	22.1	0.2	.84	23.49	.83	23.19
AUG	8	88	12 o/oo	211.9	4.9	39.3	0.9	1.50	41.75	1.50	41.75
AUG	8	88	20 o/oo	37.4	4.3	7.3	0.8	.28	7.77	.76	21.15
SEPT	19	88	6 o/oo	110.7	11.3	23.8	2.4	.81	22.48	.40	11.24
SEPT	19	88	12 o/oo	229.4	5.2	47.2	1.0	1.62	44.61	.81	22.30
SEPT	19	88	20 o/oo	174.7	5.5	37.0	1.1	1.27	34.97	1.90	52.46
SEPT	19	88	0 o/oo	17.2	3.6	3.7	0.8	.12	3.52	.11	3.16
OCT	11	88	0 o/oo	86.7	13.3	18.0	2.7	.63	17.19	.81	22.25
OCT	11	88	6 o/oo	254.8	18.8	54.9	4.0	1.92	52.32	.96	26.16
OCT	11	88	12 o/oo	214.9	12.5	44.7	2.6	1.56	42.60	.78	21.30
OCT	11	88	20 o/oo	264.0	15.7	56.9	3.3	1.99	54.21	4.61	125.52
NOV	10	88	0 o/oo	23.5	5.4	5.2	1.2	.15	3.58	.24	5.75
NOV	10	88	6 o/oo	22.9	14.3	5.1	3.1	.14	3.46	.14	3.46
NOV	10	88	12 o/oo	16.3	10.2	3.6	2.3	.10	2.49	.10	2.49
NOV	10	88	20 o/oo	42.2	9.6	9.5	2.1	.28	6.48	.42	9.72
DEC	8	88	0 o/oo	428.5	5.6	110.8	1.4	2.56	76.58	2.21	66.12
DEC	8	88	6 o/oo	84.8	4.1	21.7	1.0	.50	15.04	.75	22.56
DEC	8	88	12 o/oo	56.8	9.1	15.1	2.4	.35	10.48	.83	25.05
DEC	8	88	20 o/oo	19.7	6.7	5.4	1.8	.12	3.73	.18	5.60
JAN	25	89	0 o/oo	15.2	2.2	3.4	0.6	.09	2.47	.09	2.47
JAN	25	89	6 o/oo	36.6	3.4	8.8	0.8	.22	6.27	.22	6.27
JAN	25	89	12 o/oo	29.2	4.9	6.8	1.1	.17	4.86	.17	4.86
JAN	25	89	20 o/oo	39.7	7.7	9.9	1.9	.25	7.06	.38	10.60
FEB	13	89	0 o/oo	114.0	6.0	37.8	2.0	1.08	30.74	1.89	53.97
FEB	13	89	6 o/oo	45.9	2.6	12.7	0.7	.36	10.37	.82	23.34
FEB	13	89	12 o/oo	39.1	3.3	9.4	0.8	.26	7.67	.78	22.24
FEB	13	89	20 o/oo	22.2	2.0	5.2	0.4	.14	4.24	.47	13.42
MAR	15	89	0 o/oo	21.5	7.1	3.9	1.3	.15	3.91	.28	7.19
MAR	15	89	6 o/oo	185.5	8.2	33.6	1.5	1.34	33.74	3.10	77.73
MAR	15	89	12 o/oo	150.8	11.4	27.6	2.0	1.10	27.69	1.10	27.69
MAR	15	89	20 o/oo	91.6	12.7	17.7	2.4	.70	17.73	.70	17.73

TABLE 3.6 (Cont.)

MEASURED RATES OF PRIMARY PRODUCTION
(based on mean values of five replicates)

				mg Carbon/m3		mg Carbon/m3		gram Carbon fixed			
				/hr	/hr/chla	/E	/E/chla	/m3/day	/m3/mon	/m2/day	/2/mon
			STATION	P2	P9	P3	P10	P4	P5	P6	P7
APR	20	89	0 o/oo	25.6	3.8	7.5	1.1	.23	8.51	.74	27.19
APR	20	89	6 o/oo	136.6	11.3	38.2	3.1	1.17	43.10	3.20	117.66
APR	20	89	12 o/oo	77.4	5.7	20.7	1.5	.63	23.34	.63	23.34
APR	20	89	20 o/oo	98.9	10.4	23.6	2.4	.72	26.62	.72	26.62
MAY	9	89	0 o/oo	28.4	8.1	4.8	1.3	.23	6.53	.43	11.91
MAY	9	89	6 o/oo	34.9	5.6	5.7	0.9	.28	7.72	.73	20.12
MAY	9	89	12 o/oo	29.4	7.3	4.9	1.2	.24	6.67	.66	18.38
MAY	9	89	20 o/oo	63.7	6.1	10.9	1.0	.53	14.67	1.21	33.51
JUN	14	89	0 o/oo	61.0	8.7	9.9	1.4	.50	11.97	1.61	38.21
JUN	14	89	6 o/oo	78.2	9.0	12.6	1.4	.63	15.14	1.99	47.23
JUN	14	89	12 o/oo	58.5	6.9	9.9	1.1	.50	11.95	1.71	40.60
JUN	14	89	20 o/oo	103.9	10.5	19.1	1.9	.96	22.88	3.59	85.41
JUL	25	89	0 o/oo	32.2	6.2	7.4	1.4	.25	8.03	.29	9.27
JUL	25	89	6 o/oo	77.7	6.2	15.7	1.2	.53	16.93	.26	8.46
JUL	25	89	12 o/oo	297.5	6.9	60.2	1.4	2.04	64.81	2.04	64.81
JUL	25	89	20 o/oo	124.9	3.6	28.9	0.8	.98	31.14	.98	31.14
AUG	16	89	0 o/oo	16.5	6.6	3.1	1.2	.10	3.30	.14	4.45
AUG	16	89	6 o/oo	223.0	3.9	38.2	0.6	1.30	40.31	1.30	40.31
AUG	16	89	12 o/oo	63.8	2.1	13.2	0.4	.44	13.92	.44	13.92
AUG	16	89	20 o/oo	60.0	10.9	13.6	2.4	.46	14.39	.69	21.58
SEPT	13	89	0 o/oo	21.3	5.6	4.2	1.1	.17	3.78	.14	3.24
SEPT	13	89	6 o/oo	167.0	5.4	32.0	1.0	1.32	28.81	1.43	31.17
SEPT	13	89	12 o/oo	358.3	1.0	71.8	0.2	2.98	64.63	4.47	96.95
SEPT	13	89	20 o/oo	84.9	1.6	16.9	0.3	.70	15.23	2.10	45.69
OCT	10	89	0 o/oo	29.1	4.8	6.2	1.0	.11	5.29	.13	6.34
OCT	10	89	6 o/oo	84.7	2.0	18.9	0.4	.35	15.99	.35	15.99
OCT	10	89	12 o/oo	48.2	1.2	10.6	0.2	.19	8.97	.19	8.97
OCT	10	89	20 o/oo	161.6	0.6	38.3	0.1	.70	32.38	1.59	72.79
NOV	15	89	0 o/oo	17.6	7.0	4.5	1.8	.10	3.11	.28	8.57
NOV	15	89	6 o/oo	31.4	1.0	8.7	0.2	.19	5.97	.28	8.46
NOV	15	89	12 o/oo	43.9	1.5	11.4	0.4	.25	7.77	.57	17.27
NOV	15	89	20 o/oo	9.0	1.5	3.0	0.5	.06	2.09	.15	4.63
DEC	14	89	0 o/oo	4.2	1.2	1.1	0.3	.02	.64	.07	1.77
DEC	14	89	6 o/oo	454.3	5.0	134.7	1.5	3.20	75.55	4.54	107.03
DEC	14	89	12 o/oo	27.7	0.5	7.5	0.1	.18	4.24	.27	6.52
DEC	14	89	20 o/oo	179.0	16.5	53.1	4.9	1.26	29.77	2.57	60.68
JAN	18	90	0 o/oo	9.0	1.2	2.3	0.3	.05	1.54	.14	4.13
JAN	18	90	6 o/oo	30.4	4.9	8.7	1.4	.20	5.85	.10	2.92
JAN	18	90	12 o/oo	38.4	6.1	10.1	1.6	.24	6.78	.12	3.39
JAN	18	90	20 o/oo	28.4	7.3	7.8	2.0	.18	5.22	.59	16.62
FEB	14	90	0 o/oo	12.2	3.2	2.8	0.7	.08	2.03	.15	3.79
FEB	14	90	6 o/oo	12.5	2.4	2.9	0.5	.09	2.16	.27	6.64
FEB	14	90	12 o/oo	24.1	4.5	5.5	1.0	.16	4.02	.43	10.43
FEB	14	90	20 o/oo	38.1	4.3	9.3	1.0	.28	6.77	.28	6.77
MAR	14	90	0 o/oo	201.3	2.7	55.5	0.7	1.26	56.38	1.76	78.62
MAR	14	90	6 o/oo	101.0	3.1	27.0	0.8	.61	27.49	.92	41.23
MAR	14	90	12 o/oo	59.8	3.9	15.2	1.0	.34	15.48	.96	42.80
MAR	14	90	20 o/oo	47.8	3.9	13.6	1.1	.31	13.86	.93	41.73
APR	12	90	0 o/oo	6.5	2.0	1.1	0.3	.05	1.29	.16	4.06
APR	12	90	6 o/oo	41.2	2.5	7.8	0.4	.34	8.80	.85	21.55
APR	12	90	12 o/oo	23.9	3.0	4.1	0.5	.18	4.62	.57	14.55
APR	12	90	20 o/oo	18.0	2.9	3.1	0.5	.13	3.51	.53	13.50
MAY	8	90	0 o/oo	7.5	1.9	1.7	0.4	.06	1.98	.23	7.67
MAY	8	90	6 o/oo	24.9	3.2	7.9	1.0	.28	9.13	.63	20.69
MAY	8	90	12 o/oo	24.9	2.8	6.0	0.6	.21	6.91	.52	17.05
MAY	8	90	20 o/oo	21.0	5.0	6.7	1.6	.24	7.71	.78	24.97

TABLE 3.6 (Cont.)

MEASURED RATES OF PRIMARY PRODUCTION
(based on mean values of five replicates)

				mg Carbon/m3		mg Carbon/m3		gram Carbon fixed			
				/hr	/hr/chla	/E	/E/chla	/m3/day	/m3/mon	/m2/day	/2/mon
			STATION	P2	P9	P3	P10	P4	P5	P6	P7
JUN	20	90	0 o/oo	1.2	0.4	0.3	0.1	.00	.42	.02	1.05
JUN	20	90	6 o/oo	25.4	3.3	7.1	0.9	.18	7.96	.09	3.98
JUN	20	90	12 o/oo	32.9	3.1	9.7	0.9	.24	10.76	.12	5.38
JUN	20	90	20 o/oo	39.8	3.9	12.7	1.2	.32	14.15	.32	14.15
JUL	11	90	0 o/oo	7.9	3.3	2.3	1.0	.05	2.42	.13	5.58
JUL	11	90	6 o/oo	40.5	6.0	10.6	1.6	.26	10.83	.26	10.83
JUL	11	90	12 o/oo	18.2	1.9	4.2	0.4	.10	4.32	.21	8.64
JUL	11	90	20 o/oo	28.0	2.3	8.4	0.7	.20	8.52	.10	4.26
AUG	16	90	0 o/oo	5.5	1.6	1.2	0.3	.05	1.20	.06	1.31
AUG	16	90	6 o/oo	35.1	14.6	7.9	3.2	.36	7.45	.18	3.72
AUG	16	90	12 o/oo	132.4	7.5	30.0	1.7	1.37	28.29	.68	14.14
AUG	16	90	20 o/oo	84.5	4.8	20.7	1.2	.95	19.60	.47	9.80
SEPT	16	90	0 o/oo	11.1	1.6	2.5	0.3	.09	2.21	.08	1.91
SEPT	16	90	6 o/oo	8.0	2.1	1.7	0.4	.06	1.49	.06	1.55
SEPT	16	90	12 o/oo	60.2	9.8	13.8	2.2	.52	12.02	.26	6.01
SEPT	16	90	20 o/oo	241.1	10.3	51.6	2.2	1.94	44.95	4.17	96.37
OCT	12	90	6 o/oo	93.5	2.2	26.3	0.6	.71	21.43	.35	10.71
OCT	12	90	12 o/oo	191.6	3.0	58.3	0.9	1.57	47.40	1.57	47.40
OCT	12	90	20 o/oo	75.8	2.7	21.3	0.7	.57	17.38	1.31	39.44
OCT	12	90	0 o/oo	9.2	1.7	2.7	0.5	.07	2.25	.08	2.50
NOV	16	90	0 o/oo	0.8	0.5	0.2	0.1	.00	.13	.00	.22
NOV	16	90	6 o/oo	7.4	1.8	1.9	0.4	.04	1.35	.06	1.91
NOV	16	90	12 o/oo	43.9	5.5	10.6	1.3	.25	7.29	.36	10.41
NOV	16	90	20 o/oo	16.5	2.9	4.6	0.8	.11	3.22	.17	4.82
DEC	16	90	0 o/oo	1.6	0.9	0.6	0.3	.01	.35	.04	1.39
DEC	16	90	6 o/oo	6.6	1.4	2.3	0.5	.04	1.34	.10	3.30
DEC	16	90	12 o/oo	20.5	4.5	6.4	1.4	.12	3.62	.30	9.14
DEC	16	90	20 o/oo	17.9	3.2	5.5	1.0	.10	3.15	.25	7.66
JAN	17	91	0 o/oo	2.2	0.9	0.6	0.2	.01	.37	.03	.77
JAN	17	91	6 o/oo	15.2	3.7	4.3	1.0	.11	2.62	.28	6.33
JAN	17	91	12 o/oo	12.0	2.5	3.4	0.7	.09	2.10	.19	4.44
JAN	17	91	20 o/oo	7.5	1.0	2.4	0.3	.06	1.46	.12	2.83
FEB	13	91	0 o/oo	0.8	0.8	0.2	0.2	.00	.15	.01	.50
FEB	13	91	6 o/oo	11.1	2.4	3.0	0.6	.08	2.04	.21	5.57
FEB	13	91	12 o/oo	24.4	3.7	6.7	1.0	.17	4.50	.55	14.13
FEB	13	91	20 o/oo	26.5	3.5	8.4	1.1	.22	5.67	.75	19.35
MAR	5	91	0 o/oo	5.9	5.9	1.2	1.2	.04	1.08	.09	2.48
MAR	5	91	6 o/oo	59.6	13.5	13.9	3.1	.47	11.91	1.06	26.63
MAR	5	91	12 o/oo	87.5	32.4	21.5	7.9	.73	18.34	.36	9.17
MAR	5	91	20 o/oo	71.6	26.5	18.3	6.7	.62	15.61	.31	7.80
APR	10	91	0 o/oo	14.5	6.3	5.2	2.2	.15	5.49	.40	14.49
APR	10	91	6 o/oo	87.6	5.7	27.1	1.7	.80	28.55	1.81	64.12
APR	10	91	12 o/oo	107.9	16.3	31.7	4.8	.94	33.42	3.03	107.37
APR	10	91	20 o/oo	100.1	6.8	27.0	1.8	.80	28.48	2.45	86.65
MAY	7	91	0 o/oo	17.0	3.0	3.2	0.5	.10	3.25	.19	6.25
MAY	7	91	6 o/oo	37.7	4.9	7.7	1.0	.24	7.78	.51	16.62
MAY	7	91	12 o/oo	33.5	5.2	7.8	1.2	.24	7.83	.60	19.56
MAY	7	91	20 o/oo	24.2	3.2	5.9	0.8	.18	6.01	.57	18.61
JUN	13	91	0 o/oo	46.0	4.0	12.1	1.0	.38	12.44	.40	13.64
JUN	13	91	6 o/oo	90.9	7.5	23.4	1.9	.71	24.06	.35	12.03
JUN	13	91	12 o/oo	137.3	10.4	32.6	2.4	.98	33.41	.49	16.70
JUN	13	91	20 o/oo	99.4	9.3	25.6	2.4	.77	26.31	2.09	70.63
JUL	10	91	0 o/oo	8.0	1.4	1.9	0.3	.04	1.77	.04	1.54
JUL	10	91	6 o/oo	285.5	9.3	67.1	2.1	1.75	62.64	1.75	62.64
JUL	10	91	12 o/oo	284.6	4.4	67.0	1.0	1.74	62.50	.87	31.25
JUL	10	91	20 o/oo	87.4	4.2	20.5	1.0	.53	19.18	1.30	46.85

TABLE 3.6 (Cont.)

MEASURED RATES OF PRIMARY PRODUCTION
(based on mean values of five replicates)

				mg Carbon/m3		mg Carbon/m3		gram Carbon fixed			
				/hr	/hr/chla	/E	/E/chla	/m3/day	/m3/mon	/m2/day	/2/mon
			STATION	P2	P9	P3	P10	P4	P5	P6	P7
AUG	7	91	0 o/oo	15.1	2.6	3.3	0.6	.13	3.22	.12	3.10
AUG	7	91	6 o/oo	224.3	13.1	56.2	3.2	2.24	54.18	2.64	63.75
AUG	7	91	12 o/oo	126.4	3.2	29.7	0.7	1.18	28.66	.59	14.33
AUG	7	91	20 o/oo	149.6	8.7	36.8	2.1	1.47	35.42	.73	17.71
SEPT	16	91	0 o/oo	25.0	8.3	5.7	1.9	.17	5.08	.08	2.54
SEPT	16	91	6 o/oo	53.9	8.3	12.4	1.9	.36	10.95	.38	10.95
SEPT	16	91	12 o/oo	87.4	2.1	21.3	0.5	.66	18.77	.99	28.16
SEPT	16	91	20 o/oo	64.3	3.7	16.3	0.9	.50	14.44	1.56	44.32
OCT	8	91	0 o/oo	14.0	4.0	4.7	1.3	.09	3.65	.12	4.92
OCT	8	91	6 o/oo	39.5	3.8	14.0	1.3	.27	10.89	.48	19.02
OCT	8	91	12 o/oo	55.8	1.1	18.3	0.3	.36	14.22	.49	19.51
OCT	8	91	20 o/oo	35.7	1.2	11.4	0.4	.22	8.89	.59	23.15
NOV	12	91	0 o/oo	48.3	2.5	12.7	0.6	.26	7.72	.41	12.06
NOV	12	91	6 o/oo	280.7	13.6	77.0	3.7	1.61	46.65	3.05	88.48
NOV	12	91	12 o/oo	156.5	8.1	49.7	2.6	1.04	30.12	2.73	79.16
NOV	12	91	20 o/oo	90.7	7.3	31.3	2.5	.65	18.99	2.27	65.71
DEC	16	91	0 o/oo	37.6	4.6	11.3	1.4	.25	6.48	.62	15.80
DEC	16	91	6 o/oo	109.8	11.3	36.7	3.7	.83	20.96	1.67	41.97
DEC	16	91	12 o/oo	48.6	6.7	18.2	2.5	.41	10.42	.89	22.36
DEC	16	91	20 o/oo	45.9	1.7	20.3	0.7	.46	11.58	.90	22.80

TABLE 3.7

DETERMINATION OF CARBON UPTAKE BY SIZE FRACTION

		mg Carbon fixed /m3/Einstein			percent in each size fraction		
		>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE	STATION	F1	F2	F3	F4	F5	F6
JUN 16 83	0 o/oo	0.43	0.96	9.39	4.0	8.9	87.1
JUN 16 83	6 o/oo	1.32	10.10	49.89	2.2	16.5	81.4
JUN 16 83	12 o/oo	0.60	0.80	16.32	3.4	4.5	92.1
JUN 16 83	20 o/oo	3.36	0.54	5.89	34.3	5.5	60.1
JUL 22 83	0 o/oo	3.83	1.62	10.37	24.2	10.2	65.6
JUL 22 83	6 o/oo	0.65	0.85	29.87	2.1	2.7	95.2
JUL 22 83	12 o/oo	2.36	0.00	21.13	10.9	0.0	97.6
JUL 22 83	20 o/oo	0.21	0.00	5.83	3.7	0.0	100.0
AUG 19 83	0 o/oo	1.29	3.15	11.80	8.0	19.4	72.6
AUG 19 83	6 o/oo	1.02	1.21	22.74	4.1	4.8	91.1
AUG 19 83	12 o/oo	1.17	0.14	27.54	4.1	0.5	95.4
AUG 19 83	20 o/oo	0.58	0.43	13.32	4.1	3.0	92.9
SEPT 28 83	0 o/oo	0.38	0.55	1.10	18.7	27.2	54.1
SEPT 28 83	6 o/oo	2.36	1.04	5.80	25.6	11.3	63.1
SEPT 28 83	12 o/oo	2.71	1.66	6.97	23.9	14.6	61.4
SEPT 28 83	20 o/oo	1.23	2.15	7.63	11.2	19.5	69.3
OCT 20 83	0 o/oo	1.53	0.78	3.75	25.3	12.8	61.9
OCT 20 83	6 o/oo	3.77	1.85	13.01	20.3	9.9	69.8
OCT 20 83	12 o/oo	2.62	0.85	14.90	14.2	4.6	81.1
OCT 20 83	20 o/oo	0.84	0.74	14.39	5.3	4.6	90.1
NOV 22 83	0 o/oo	1.19	1.61	5.19	14.9	20.2	64.9
NOV 22 83	6 o/oo	4.83	4.83	13.52	20.9	20.8	58.3
NOV 22 83	12 o/oo	4.62	4.37	22.03	14.9	14.1	71.0
NOV 22 83	20 o/oo	0.54	0.48	12.62	3.9	3.5	92.6
DEC 28 83	0 o/oo	0.72	0.40	2.15	22.1	12.1	65.8
DEC 28 83	6 o/oo	1.07	0.71	2.53	24.8	16.6	58.6
DEC 28 83	12 o/oo	5.59	0.59	4.45	52.6	5.6	41.9
DEC 28 83	20 o/oo	0.70	0.49	2.92	17.1	11.8	71.1
JAN 18 84	0 o/oo	1.21	1.38	5.06	15.8	18.1	66.1
JAN 18 84	6 o/oo	5.48	1.22	8.14	36.9	8.2	54.9
JAN 18 84	12 o/oo	13.90	2.51	16.58	42.1	7.6	50.3
JAN 18 84	20 o/oo	0.73	1.14	32.54	2.1	3.3	94.6
FEB 15 84	0 o/oo	0.29	1.34	2.99	6.3	29.1	64.7
FEB 15 84	6 o/oo	3.12	3.25	10.21	18.8	19.6	61.6
FEB 15 84	12 o/oo	7.72	6.14	13.01	28.7	22.8	48.4
FEB 15 84	20 o/oo	1.78	2.65	4.30	20.4	30.4	49.3
MAR 9 84	0 o/oo	7.19	3.25	6.58	42.2	19.1	38.7
MAR 9 84	6 o/oo	9.53	1.58	7.53	51.1	8.5	40.4
MAR 9 84	12 o/oo	2.57	1.46	7.20	22.9	13.0	64.1
MAR 9 84	20 o/oo	0.90	1.12	4.26	14.4	17.8	67.8

TABLE 3.7 (Cont.)

DETERMINATION OF CARBON UPTAKE BY SIZE FRACTION

				mg Carbon fixed /m3/Einstein			percent in each size fraction		
				>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE			STATION	F1	F2	F3	F4	F5	F6
APR	19	84	0 o/oo	2.21	2.09	10.55	14.8	14.1	71.0
APR	19	84	6 o/oo	6.08	10.02	6.65	26.7	44.0	29.2
APR	19	84	12 o/oo	4.00	10.29	7.52	18.4	47.2	34.5
APR	19	84	20 o/oo	1.53	2.52	5.06	16.8	27.6	55.5
MAY	7	84	0 o/oo	4.70	7.88	10.16	20.7	34.7	44.7
MAY	7	84	6 o/oo	9.43	5.40	15.95	30.6	17.5	51.8
MAY	7	84	12 o/oo	4.87	2.74	18.39	18.7	10.5	70.7
MAY	7	84	20 o/oo	2.73	1.28	8.18	22.4	10.5	67.1
JUN	7	84	0 o/oo	1.92	8.38	20.03	6.3	27.6	66.0
JUN	7	84	6 o/oo	6.18	3.66	12.09	28.2	16.7	55.1
JUN	7	84	12 o/oo	13.48	2.72	7.68	56.5	11.4	32.2
JUN	7	84	20 o/oo	5.05	0.32	4.09	53.4	3.4	43.2
JUL	9	84	0 o/oo	4.24	7.90	13.83	16.3	30.4	53.2
JUL	9	84	6 o/oo	2.50	1.93	6.12	23.7	18.2	58.0
JUL	9	84	12 o/oo	8.64	0.78	4.73	61.0	5.5	33.4
JUL	9	84	20 o/oo	7.97	0.94	9.32	43.7	5.1	51.1
AUG	16	84	0 o/oo	1.33	0.67	6.11	16.4	8.3	75.3
AUG	16	84	6 o/oo	1.69	0.56	4.76	24.1	8.0	67.9
AUG	16	84	12 o/oo	10.32	1.02	6.05	59.4	5.8	34.8
AUG	16	84	20 o/oo	3.78	2.92	3.38	37.5	28.9	33.5
SEPT	13	84	0 o/oo	0.94	1.75	6.83	9.9	18.3	71.7
SEPT	13	84	6 o/oo	10.13	10.97	62.07	12.2	13.2	74.6
SEPT	13	84	12 o/oo	3.81	0.95	6.20	34.8	8.7	56.6
SEPT	13	84	20 o/oo	1.27	0.51	4.85	19.1	7.8	73.2
OCT	4	84	0 o/oo	1.43	2.12	11.50	9.5	14.1	76.4
OCT	4	84	6 o/oo	53.60	18.41	28.76	53.2	18.3	28.5
OCT	4	84	12 o/oo	15.89	12.78	18.76	33.5	26.9	39.5
OCT	4	84	20 o/oo	8.14	2.25	4.73	53.8	14.9	31.3
NOV	15	84	0 o/oo	1.02	3.75	5.66	9.7	36.0	54.3
NOV	15	84	6 o/oo	1.37	0.64	7.96	13.7	6.4	79.8
NOV	15	84	12 o/oo	9.50	1.45	6.60	54.1	8.2	37.6
NOV	15	84	20 o/oo	3.61	0.55	5.82	36.2	5.5	58.3
DEC	13	84	0 o/oo	0.16	0.63	2.41	5.0	19.8	75.2
DEC	13	84	6 o/oo	3.81	1.67	5.25	35.5	15.5	48.9
DEC	13	84	12 o/oo	26.90	11.50	4.08	63.3	27.1	9.6
DEC	13	84	20 o/oo	10.40	6.27	2.81	53.4	32.2	14.4
JAN	8	85	0 o/oo	0.94	0.89	2.47	22.0	20.6	57.4
JAN	8	85	6 o/oo	0.54	0.58	4.10	10.3	11.2	78.5
JAN	8	85	12 o/oo	1.72	1.74	5.16	20.0	20.2	59.8
JAN	8	85	20 o/oo	12.56	7.33	6.70	47.2	27.6	25.2

TABLE 3.7 (Cont.)

DETERMINATION OF CARBON UPTAKE BY SIZE FRACTION

			mg Carbon fixed /m3/Einstein			percent in each size fraction		
			>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE		STATION	F1	F2	F3	F4	F5	F6
FEB	19 85	0 o/oo	0.40	0.30	2.89	11.1	8.2	80.6
FEB	19 85	6 o/oo	0.32	0.33	8.66	3.5	3.5	93.0
FEB	19 85	12 o/oo	0.94	0.77	6.90	11.0	9.0	80.1
FEB	19 85	20 o/oo	2.07	0.89	3.39	32.6	14.0	53.4
MAR	13 85	0 o/oo	6.68	0.47	7.02	47.2	3.3	49.5
MAR	13 85	6 o/oo	1.60	0.85	9.72	13.1	7.0	79.9
MAR	13 85	12 o/oo	3.33	2.24	11.98	19.0	12.8	68.3
MAR	13 85	20 o/oo	6.06	0.76	4.55	53.3	6.7	40.0
APR	17 85	0 o/oo	0.53	0.31	4.72	9.6	5.5	84.9
APR	17 85	6 o/oo	0.82	0.88	11.79	6.1	6.5	87.4
APR	17 85	12 o/oo	14.89	12.61	29.08	26.3	22.3	51.4
APR	17 85	20 o/oo	6.89	4.73	10.28	31.5	21.6	46.9
MAY	13 85	0 o/oo	0.68	0.58	13.69	4.5	3.9	91.6
MAY	13 85	6 o/oo	0.47	1.16	14.76	2.9	7.1	90.1
MAY	13 85	12 o/oo	6.05	0.51	10.94	34.6	2.9	62.5
MAY	13 85	20 o/oo	4.42	0.00	6.47	40.7	0.0	59.6
JUN	18 85	0 o/oo	0.11	0.41	5.01	1.9	7.5	90.6
JUN	18 85	6 o/oo	0.85	0.40	9.40	8.0	3.8	88.2
JUN	18 85	12 o/oo	14.91	7.38	12.42	43.0	21.3	35.8
JUN	18 85	20 o/oo	1.15	2.82	9.12	8.8	21.5	69.7
JUL	11 85	0 o/oo	0.37	0.00	7.38	4.8	0.0	95.9
JUL	11 85	6 o/oo	1.48	2.50	7.11	13.4	22.5	64.1
JUL	11 85	12 o/oo	7.38	0.69	9.60	41.7	3.9	54.3
JUL	11 85	20 o/oo	0.95	0.28	7.24	11.2	3.4	85.5
AUG	7 85	0 o/oo	0.34	1.22	4.03	6.0	21.9	72.1
AUG	7 85	6 o/oo	3.02	3.65	18.58	12.0	14.5	73.6
AUG	7 85	12 o/oo	5.90	5.01	37.89	12.1	10.3	77.6
AUG	7 85	20 o/oo	7.07	3.16	21.70	22.1	9.9	68.0
SEPT	9 85	0 o/oo	0.06	0.22	1.35	3.5	13.6	82.8
SEPT	9 85	6 o/oo	0.24	0.55	6.07	3.5	8.0	88.5
SEPT	9 85	12 o/oo	1.09	0.63	8.51	10.6	6.2	83.2
SEPT	9 85	20 o/oo	8.29	0.78	7.80	49.1	4.6	46.2
OCT	9 85	0 o/oo	0.33	0.30	0.98	20.6	18.8	60.6
OCT	9 85	6 o/oo	4.30	1.19	5.55	39.0	10.8	50.3
OCT	9 85	12 o/oo	1.66	0.60	4.61	24.1	8.8	67.1
OCT	9 85	20 o/oo	5.53	3.53	4.18	41.7	26.7	31.6
NOV	26 85	0 o/oo	0.54	0.80	7.41	6.1	9.1	84.7
NOV	26 85	6 o/oo	0.80	1.31	8.06	7.9	12.9	79.2
NOV	26 85	12 o/oo	2.78	1.11	6.87	25.8	10.3	63.9
NOV	26 85	20 o/oo	17.59	1.90	7.54	65.1	7.0	27.9

TABLE 3.7 (Cont.)

DETERMINATION OF CARBON UPTAKE BY SIZE FRACTION

				mg Carbon fixed /m3/Einstein			percent in each size fraction		
				>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE			STATION	F1	F2	F3	F4	F5	F6
DEC	20	85	0 o/oo	0.15	0.29	1.03	10.0	19.8	70.2
DEC	20	85	6 o/oo	0.17	0.20	9.42	1.7	2.0	96.2
DEC	20	85	12 o/oo	0.49	0.38	5.92	7.2	5.6	87.2
DEC	20	85	20 o/oo	1.59	0.74	4.57	23.0	10.7	66.3
JAN	14	86	0 o/oo	0.11	0.07	0.88	10.4	6.6	83.0
JAN	14	86	6 o/oo	0.30	0.19	4.87	5.6	3.6	90.8
JAN	14	86	12 o/oo	0.39	0.62	3.57	8.6	13.5	77.9
JAN	14	86	20 o/oo	1.34	0.25	2.70	31.2	5.9	62.9
FEB	14	86	0 o/oo	10.20	9.25	9.56	35.2	31.9	33.0
FEB	14	86	6 o/oo	6.45	1.37	3.89	55.1	11.7	33.2
FEB	14	86	12 o/oo	3.88	3.41	2.64	39.0	34.4	26.6
FEB	14	86	20 o/oo	5.08	2.33	2.88	49.4	22.7	28.0
MAR	12	86	0 o/oo	0.20	0.81	2.61	5.5	22.3	72.2
MAR	12	86	6 o/oo	2.22	0.32	3.30	38.0	5.5	56.5
MAR	12	86	12 o/oo	4.19	2.28	10.14	25.2	13.7	61.0
MAR	12	86	20 o/oo	2.06	1.56	4.12	26.6	20.1	53.3
APR	14	86	0 o/oo	3.41	9.96	17.07	11.2	32.7	56.1
APR	14	86	6 o/oo	5.50	16.85	23.67	12.0	36.6	51.4
APR	14	86	12 o/oo	6.40	4.44	5.99	38.0	26.4	35.6
APR	14	86	20 o/oo	8.37	4.28	6.56	43.6	22.3	34.2
MAY	13	86	0 o/oo	0.10	1.34	11.00	0.8	10.8	88.4
MAY	13	86	6 o/oo	0.43	0.50	6.77	5.5	6.4	88.0
MAY	13	86	12 o/oo	1.90	1.28	3.82	27.2	18.3	54.5
MAY	13	86	20 o/oo	0.23	2.89	6.35	2.4	30.5	67.1
JUN	17	86	0 o/oo	0.02	0.22	3.55	0.4	5.9	93.7
JUN	17	86	6 o/oo	11.63	7.08	20.11	30.0	18.2	51.8
JUN	17	86	12 o/oo	2.08	1.55	9.69	15.6	11.6	72.8
JUN	17	86	20 o/oo	9.75	0.16	13.71	41.3	0.7	58.1
JUL	11	86	0 o/oo	0.14	1.09	3.27	3.0	24.3	72.7
JUL	11	86	6 o/oo	2.49	0.83	10.10	18.5	6.2	75.3
JUL	11	86	12 o/oo	3.20	2.43	16.19	14.7	11.2	74.2
JUL	11	86	20 o/oo	0.13	0.56	13.02	1.0	4.1	94.9
AUG	7	86	0 o/oo	0.89	0.63	3.66	17.2	12.1	70.7
AUG	7	86	6 o/oo	2.73	0.23	4.65	35.9	3.1	61.1
AUG	7	86	12 o/oo	4.99	0.47	7.42	38.7	3.6	57.6
AUG	7	86	20 o/oo	3.56	0.06	6.74	34.4	0.6	65.1
SEPT	14	86	0 o/oo	0.55	0.49	4.10	10.7	9.5	79.8
SEPT	14	86	6 o/oo	1.17	0.68	5.87	15.2	8.8	76.0
SEPT	14	86	12 o/oo	2.27	1.59	29.12	6.9	4.8	88.3
SEPT	14	86	20 o/oo	4.08	0.35	10.17	28.0	2.4	69.6

TABLE 3.7 (Cont.)

DETERMINATION OF CARBON UPTAKE BY SIZE FRACTION

				mg Carbon fixed /m3/Einstein			percent in each size fraction		
				>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE			STATION	F1	F2	F3	F4	F5	F6
OCT	8	86	0 o/oo	0.93	1.63	4.87	12.5	21.9	65.5
OCT	8	86	6 o/oo	3.35	0.57	12.75	20.1	3.4	76.5
OCT	8	86	12 o/oo	2.32	0.67	11.05	16.5	4.8	78.7
OCT	8	86	20 o/oo	3.26	1.15	13.42	18.3	6.5	75.3
NOV	17	86	0 o/oo	10.00	8.38	31.08	20.2	16.9	62.8
NOV	17	86	6 o/oo	1.53	3.38	12.28	8.9	19.6	71.4
NOV	17	86	12 o/oo	7.88	7.77	33.82	15.9	15.7	68.4
NOV	17	86	20 o/oo	19.73	0.00	29.56	41.9	0.0	62.8
DEC	18	86	0 o/oo	0.31	0.70	2.80	8.2	18.3	73.5
DEC	18	86	6 o/oo	5.23	2.49	11.97	26.6	12.6	60.8
DEC	18	86	12 o/oo	5.59	4.10	12.55	25.1	18.4	56.4
DEC	18	86	20 o/oo	16.39	13.34	8.50	42.9	34.9	22.2
JAN	9	87	0 o/oo	0.22	0.10	1.05	16.3	7.6	76.1
JAN	9	87	6 o/oo	0.21	0.21	2.62	6.8	6.9	86.2
JAN	9	87	12 o/oo	0.33	0.03	3.74	8.0	0.6	91.3
JAN	9	87	20 o/oo	0.69	0.41	1.87	23.2	13.8	63.0
FEB	11	87	0 o/oo	0.25	0.23	3.57	6.2	5.7	88.1
FEB	11	87	6 o/oo	0.23	1.98	15.04	1.3	11.5	87.2
FEB	11	87	12 o/oo	2.01	2.28	16.99	9.5	10.7	79.8
FEB	11	87	20 o/oo	2.56	3.81	10.45	15.2	22.6	62.1
MAR	10	87	0 o/oo	0.44	0.55	9.63	4.1	5.1	90.7
MAR	10	87	6 o/oo	0.64	0.96	15.33	3.8	5.7	90.5
MAR	10	87	12 o/oo	0.68	0.71	27.76	2.3	2.4	95.2
MAR	10	87	20 o/oo	1.63	0.54	18.91	7.7	2.6	89.7
APR	20	87	0 o/oo	2.45	11.95	36.30	4.8	23.6	71.6
APR	20	87	6 o/oo	-0.17	1.22	28.12	-0.6	4.2	96.4
APR	20	87	12 o/oo	3.91	2.62	51.42	6.7	4.5	88.7
APR	20	87	20 o/oo	3.24	12.13	20.44	9.0	33.9	57.1
MAY	19	87	0 o/oo	0.04	0.18	1.05	3.0	14.4	82.7
MAY	19	87	6 o/oo	0.18	4.00	19.94	0.7	16.6	82.7
MAY	19	87	12 o/oo	1.08	4.64	17.19	4.7	20.3	75.0
MAY	19	87	20 o/oo	2.77	1.28	5.63	28.7	13.2	58.1
JUN	8	87	0 o/oo	4.59	5.88	24.44	13.1	16.8	70.0
JUN	8	87	6 o/oo	1.46	3.67	28.55	4.3	10.9	84.8
JUN	8	87	12 o/oo	3.44	13.90	28.96	7.4	30.0	62.6
JUN	8	87	20 o/oo	4.77	0.59	12.13	27.3	3.4	69.4
JUL	17	87	0 o/oo	1.28	2.48	11.12	8.6	16.7	74.7
JUL	17	87	6 o/oo	7.97	4.30	45.94	13.7	7.4	78.9
JUL	17	87	12 o/oo	4.65	2.97	20.90	16.3	10.4	73.3
JUL	17	87	20 o/oo	1.86	0.59	5.78	22.6	7.1	70.2

TABLE 3.7 (Cont.)

DETERMINATION OF CARBON UPTAKE BY SIZE FRACTION

		mg Carbon fixed /m3/Einstein			percent in each size fraction		
		>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE	STATION	F1	F2	F3	F4	F5	F6
AUG 4 87	0 o/oo	0.60	1.29	8.66	5.7	12.2	82.1
AUG 4 87	6 o/oo	0.80	0.98	10.75	6.4	7.8	85.8
AUG 4 87	12 o/oo	4.04	1.52	12.43	22.5	8.4	69.1
AUG 4 87	20 o/oo	0.25	0.13	4.91	4.7	2.4	92.9
SEPT 25 87	0 o/oo	0.32	0.41	1.32	15.6	20.1	64.3
SEPT 25 87	6 o/oo	2.68	0.60	3.62	38.8	8.7	52.5
SEPT 25 87	12 o/oo	17.19	1.05	3.89	77.6	4.8	17.6
SEPT 25 87	20 o/oo	1.98	1.36	7.58	18.1	12.4	69.5
OCT 20 87	0 o/oo	0.30	0.88	2.30	8.7	25.3	66.0
OCT 20 87	6 o/oo	1.40	1.30	3.23	23.6	22.0	54.4
OCT 20 87	12 o/oo	1.62	5.08	9.10	10.3	32.1	57.6
OCT 20 87	20 o/oo	8.01	8.65	4.71	37.5	40.5	22.1
NOV 13 87	0 o/oo	0.15	0.31	0.75	12.8	25.2	62.0
NOV 13 87	6 o/oo	0.88	1.55	2.17	19.1	33.7	47.2
NOV 13 87	12 o/oo	2.29	3.39	3.79	24.2	35.8	40.0
NOV 13 87	20 o/oo	3.41	3.27	4.53	30.5	29.1	40.4
DEC 10 87	0 o/oo	0.06	0.13	0.41	10.2	21.8	68.0
DEC 10 87	6 o/oo	0.51	1.00	1.90	14.8	29.4	55.7
DEC 10 87	12 o/oo	0.72	2.04	3.37	11.7	33.3	55.0
DEC 10 87	20 o/oo	1.14	1.97	6.79	11.5	19.9	68.6
JAN 18 88	0 o/oo	0.30	1.07	1.72	9.6	34.8	55.6
JAN 18 88	6 o/oo	0.82	1.44	3.52	14.2	24.9	60.9
JAN 18 88	12 o/oo	1.19	3.98	3.27	14.1	47.1	38.7
JAN 18 88	20 o/oo	2.34	7.80	3.99	16.6	55.2	28.2
FEB 10 88	0 o/oo	0.05	0.13	0.38	8.6	24.0	67.5
FEB 10 88	6 o/oo	0.12	0.67	2.12	4.2	23.0	72.8
FEB 10 88	12 o/oo	0.61	3.74	4.10	7.2	44.2	48.5
FEB 10 88	20 o/oo	1.88	8.21	2.85	14.5	63.4	22.0
MAR 11 88	0 o/oo	0.12	0.65	1.21	6.0	32.9	61.1
MAR 11 88	6 o/oo	0.91	5.38	6.72	7.0	41.3	51.6
MAR 11 88	12 o/oo	3.03	6.66	4.96	20.7	45.4	33.9
MAR 11 88	20 o/oo	4.67	11.69	3.35	23.7	59.3	17.0
APR 13 88	0 o/oo	0.13	0.92	2.63	3.5	25.0	71.5
APR 13 88	6 o/oo	0.21	3.50	7.65	1.9	30.8	67.3
APR 13 88	12 o/oo	-0.60	4.75	14.73	-3.2	25.2	78.0
APR 13 88	20 o/oo	1.18	2.97	6.13	11.5	28.9	59.6
MAY 16 88	0 o/oo	0.39	2.14	5.05	5.2	28.2	66.6
MAY 16 88	6 o/oo	1.45	2.62	7.99	12.0	21.7	66.3
MAY 16 88	12 o/oo	0.16	2.54	7.96	1.5	23.8	74.7
MAY 16 88	20 o/oo	0.88	4.04	4.88	8.9	41.2	49.8

TABLE 3.7 (Cont.)

DETERMINATION OF CARBON UPTAKE BY SIZE FRACTION

DATE			STATION	mg Carbon fixed /m3/Einstein			percent in each size fraction		
				>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
				F1	F2	F3	F4	F5	F6
JUN	13	88	0 o/oo	0.19	2.87	7.22	1.8	27.9	70.2
JUN	13	88	6 o/oo	4.82	10.74	13.60	16.5	36.8	46.6
JUN	13	88	12 o/oo	0.60	3.94	11.37	3.8	24.8	71.5
JUN	13	88	20 o/oo	3.35	5.13	4.28	26.2	40.2	33.5
JUL	12	88	0 o/oo	0.42	1.51	6.38	5.1	18.2	76.7
JUL	12	88	6 o/oo	5.31	6.98	10.42	23.4	30.7	45.9
JUL	12	88	12 o/oo	1.88	4.92	7.64	13.0	34.0	52.9
JUL	12	88	20 o/oo	6.39	5.77	4.52	38.3	34.6	27.1
AUG	8	88	0 o/oo	0.16	1.52	4.41	2.6	24.9	72.5
AUG	8	88	6 o/oo	1.75	1.29	19.12	7.9	5.8	86.3
AUG	8	88	12 o/oo	1.71	2.58	35.08	4.4	6.5	89.1
AUG	8	88	20 o/oo	0.01	0.67	6.89	0.1	8.9	91.0
SEPT	19	88	6 o/oo	11.05	8.71	4.05	46.4	36.6	17.0
SEPT	19	88	12 o/oo	24.08	14.84	8.36	50.9	31.4	17.7
SEPT	19	88	20 o/oo	21.79	11.71	3.55	58.8	31.6	9.6
SEPT	19	88	0 o/oo	0.69	0.95	2.11	18.4	25.3	56.3
OCT	11	88	0 o/oo	2.07	3.84	12.15	11.4	21.3	67.3
OCT	11	88	6 o/oo	6.82	28.84	19.30	12.4	52.5	35.1
OCT	11	88	12 o/oo	16.99	18.38	9.38	38.0	41.1	21.0
OCT	11	88	20 o/oo	9.83	38.42	8.70	17.3	67.5	15.3
NOV	10	88	0 o/oo	0.09	1.21	3.98	1.7	22.9	75.4
NOV	10	88	6 o/oo	0.65	0.31	4.13	12.8	6.1	81.1
NOV	10	88	12 o/oo	0.20	0.40	3.09	5.3	10.8	83.9
NOV	10	88	20 o/oo	1.16	4.40	3.99	12.1	46.1	41.8
DEC	8	88	0 o/oo	4.46	54.81	51.56	4.0	49.5	46.5
DEC	8	88	6 o/oo	2.38	11.38	8.01	10.9	52.3	36.8
DEC	8	88	12 o/oo	3.02	6.06	6.09	19.9	40.0	40.1
DEC	8	88	20 o/oo	2.10	0.48	2.83	38.9	8.9	52.2
JAN	25	89	0 o/oo	0.41	1.67	1.40	11.8	48.0	40.2
JAN	25	89	6 o/oo	2.82	1.06	4.95	32.0	12.0	56.0
JAN	25	89	12 o/oo	1.74	0.37	4.74	25.4	5.4	69.2
JAN	25	89	20 o/oo	2.59	0.91	6.45	26.0	9.1	64.9
FEB	13	89	0 o/oo	-0.34	8.79	29.40	-0.9	23.2	77.7
FEB	13	89	6 o/oo	2.41	0.56	9.81	18.8	4.4	76.8
FEB	13	89	12 o/oo	1.38	1.26	6.80	14.6	13.4	72.0
FEB	13	89	20 o/oo	2.02	1.82	1.38	38.7	34.8	26.5
MAR	15	89	0 o/oo	0.11	0.82	2.97	2.8	21.1	76.1
MAR	15	89	6 o/oo	1.82	2.38	29.48	5.4	7.1	87.5
MAR	15	89	12 o/oo	8.80	9.10	9.74	31.8	32.9	35.2
MAR	15	89	20 o/oo	6.23	7.97	3.50	35.2	45.0	19.8

TABLE 3.7 (Cont.)

DETERMINATION OF CARBON UPTAKE BY SIZE FRACTION

DATE			STATION	mg Carbon fixed /m3/Einstein			percent in each size fraction		
				>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
				F1	F2	F3	F4	F5	F6
APR	20	89	0 o/oo	0.17	1.59	5.80	2.2	21.0	76.8
APR	20	89	6 o/oo	10.04	4.72	23.48	26.2	12.3	61.4
APR	20	89	12 o/oo	2.83	1.50	16.39	13.7	7.2	79.1
APR	20	89	20 o/oo	6.72	6.59	10.32	28.4	27.9	43.7
MAY	9	89	0 o/oo	0.13	0.08	4.64	2.7	1.7	95.6
MAY	9	89	6 o/oo	0.15	0.10	5.48	2.7	1.7	95.6
MAY	9	89	12 o/oo	0.33	0.96	3.67	6.6	19.3	74.1
MAY	9	89	20 o/oo	2.13	5.68	3.09	19.5	52.1	28.4
JUN	14	89	0 o/oo	0.77	0.90	8.32	7.7	9.0	83.3
JUN	14	89	6 o/oo	4.92	0.92	6.79	39.0	7.3	53.7
JUN	14	89	12 o/oo	3.23	0.05	6.70	32.4	0.5	67.1
JUN	14	89	20 o/oo	4.72	0.59	13.78	24.7	3.1	72.2
JUL	25	89	0 o/oo	0.31	1.19	5.97	4.2	16.0	79.9
JUL	25	89	6 o/oo	6.65	2.57	6.53	42.2	16.3	41.4
JUL	25	89	12 o/oo	46.01	6.71	7.57	76.3	11.1	12.6
JUL	25	89	20 o/oo	21.86	4.45	2.66	75.5	15.4	9.2
AUG	16	89	0 o/oo	0.18	0.56	2.40	5.7	17.8	76.4
AUG	16	89	6 o/oo	6.34	22.38	9.53	16.6	58.5	24.9
AUG	16	89	12 o/oo	-0.09	5.57	7.73	-0.7	42.2	58.5
AUG	16	89	20 o/oo	5.85	4.37	3.44	42.8	32.0	25.2
SEPT	13	89	0 o/oo	0.60	1.11	2.50	14.3	26.3	59.4
SEPT	13	89	6 o/oo	14.32	4.44	13.28	44.7	13.9	41.4
SEPT	13	89	12 o/oo	45.37	3.32	23.20	63.1	4.6	32.3
SEPT	13	89	20 o/oo	11.22	2.48	3.23	66.3	14.7	19.1
OCT	10	89	0 o/oo	0.55	1.92	3.80	8.8	30.6	60.6
OCT	10	89	6 o/oo	1.49	2.19	15.26	7.9	11.6	80.6
OCT	10	89	12 o/oo	2.11	2.00	6.52	19.8	18.8	61.3
OCT	10	89	20 o/oo	29.30	2.23	6.80	76.4	5.8	17.7
NOV	15	89	0 o/oo	0.17	0.03	4.38	3.6	0.6	95.7
NOV	15	89	6 o/oo	2.92	0.58	5.27	33.3	6.6	60.1
NOV	15	89	12 o/oo	5.57	0.69	5.14	48.9	6.1	45.1
NOV	15	89	20 o/oo	0.18	0.03	2.86	6.0	1.0	93.0
DEC	14	89	0 o/oo	0.05	0.00	1.13	4.0	0.0	97.9
DEC	14	89	6 o/oo	123.17	0.00	11.78	91.4	0.0	8.7
DEC	14	89	12 o/oo	4.43	0.02	3.11	58.6	0.3	41.2
DEC	14	89	20 o/oo	47.42	0.24	5.46	89.3	0.4	10.3
JAN	18	90	0 o/oo	0.09	0.00	2.24	3.7	0.0	96.9
JAN	18	90	6 o/oo	3.31	0.04	5.41	37.8	0.5	61.8
JAN	18	90	12 o/oo	2.25	0.94	6.98	22.1	9.2	68.7
JAN	18	90	20 o/oo	0.71	1.54	5.58	9.1	19.7	71.2

TABLE 3.7 (Cont.)

DETERMINATION OF CARBON UPTAKE BY SIZE FRACTION

DATE			STATION	mg Carbon fixed /m3/Einstein			percent in each size fraction		
				>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
				F1	F2	F3	F4	F5	F6
FEB	14	90	0 o/oo	0.19	0.69	1.92	6.8	24.7	68.5
FEB	14	90	6 o/oo	0.61	0.37	2.00	20.5	12.5	67.0
FEB	14	90	12 o/oo	0.44	0.60	4.51	7.9	10.8	81.4
FEB	14	90	20 o/oo	1.87	0.86	6.61	20.0	9.3	70.7
MAR	14	90	0 o/oo	5.59	30.71	19.27	10.1	55.3	34.7
MAR	14	90	6 o/oo	10.54	6.52	10.02	38.9	24.1	37.0
MAR	14	90	12 o/oo	3.41	2.82	9.03	22.4	18.5	59.2
MAR	14	90	20 o/oo	1.59	2.12	9.95	11.7	15.5	72.8
APR	12	90	0 o/oo	0.02	0.28	0.86	1.5	24.0	74.5
APR	12	90	6 o/oo	2.66	0.70	4.51	33.8	8.9	57.3
APR	12	90	12 o/oo	0.06	0.42	3.66	1.4	10.2	88.4
APR	12	90	20 o/oo	0.33	0.28	2.54	10.6	8.8	80.6
MAY	8	90	0 o/oo	0.06	0.09	1.58	3.5	5.1	91.4
MAY	8	90	6 o/oo	0.12	0.50	7.34	1.5	6.3	92.3
MAY	8	90	12 o/oo	0.68	1.20	4.14	11.3	19.9	68.8
MAY	8	90	20 o/oo	0.43	1.52	4.76	6.5	22.6	70.9
JUN	20	90	0 o/oo	0.00	0.08	0.30	0.4	20.3	79.3
JUN	20	90	6 o/oo	0.40	0.79	5.99	5.6	11.0	83.4
JUN	20	90	12 o/oo	0.56	0.30	8.84	5.8	3.1	91.1
JUN	20	90	20 o/oo	0.32	2.39	10.06	2.5	18.7	78.8
JUL	11	90	0 o/oo	0.21	0.44	1.74	8.8	18.3	72.9
JUL	11	90	6 o/oo	0.21	2.25	8.23	2.0	21.1	77.0
JUL	11	90	12 o/oo	0.10	0.48	3.68	2.4	11.2	86.4
JUL	11	90	20 o/oo	5.39	0.55	2.47	64.1	6.5	29.4
AUG	16	90	0 o/oo	0.02	0.34	0.92	1.6	26.8	71.5
AUG	16	90	6 o/oo	2.33	1.29	4.28	29.5	16.3	54.2
AUG	16	90	12 o/oo	17.03	5.02	7.95	56.7	16.7	26.5
AUG	16	90	20 o/oo	14.46	1.83	4.50	69.6	8.8	21.6
SEPT	16	90	0 o/oo	0.30	0.18	2.07	11.7	7.1	81.2
SEPT	16	90	6 o/oo	0.11	0.47	1.13	6.5	27.6	65.9
SEPT	16	90	12 o/oo	3.58	4.05	6.18	25.9	29.3	44.8
SEPT	16	90	20 o/oo	22.17	20.42	9.04	42.9	39.6	17.5
OCT	12	90	6 o/oo	4.28	17.81	4.30	16.2	67.5	16.3
OCT	12	90	12 o/oo	29.01	17.24	12.10	49.7	29.5	20.7
OCT	12	90	20 o/oo	6.01	10.36	5.01	28.1	48.5	23.4
OCT	12	90	0 o/oo	0.18	0.69	1.91	6.3	24.8	68.8
NOV	16	90	0 o/oo	0.00	0.03	0.17	1.0	15.7	83.3
NOV	16	90	6 o/oo	0.14	0.59	1.24	7.1	30.0	62.9
NOV	16	90	12 o/oo	0.27	1.61	8.74	2.5	15.2	82.3
NOV	16	90	20 o/oo	0.88	1.12	2.70	18.7	23.8	57.4

TABLE 3.7 (Cont.)

DETERMINATION OF CARBON UPTAKE BY SIZE FRACTION

		mg Carbon fixed /m3/Einstein			percent in each size fraction		
		>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE	STATION	F1	F2	F3	F4	F5	F6
DEC 16 90	0 o/oo	0.06	0.17	0.40	9.9	27.4	62.7
DEC 16 90	6 o/oo	0.02	0.64	1.72	0.9	26.9	72.2
DEC 16 90	12 o/oo	0.01	1.72	4.68	0.2	26.8	73.1
DEC 16 90	20 o/oo	0.16	0.69	4.74	2.8	12.4	84.8
JAN 17 91	0 o/oo	0.05	0.04	0.52	7.8	6.5	85.7
JAN 17 91	6 o/oo	1.13	0.12	3.04	26.3	2.8	70.8
JAN 17 91	12 o/oo	0.14	0.38	2.93	4.0	10.9	85.0
JAN 17 91	20 o/oo	0.46	0.45	1.49	19.3	18.7	62.0
FEB 13 91	0 o/oo	-0.02	0.03	0.22	-7.6	13.4	94.3
FEB 13 91	6 o/oo	0.84	0.25	1.97	27.4	8.1	64.5
FEB 13 91	12 o/oo	0.47	0.15	6.09	6.9	2.2	90.8
FEB 13 91	20 o/oo	1.40	0.69	6.35	16.6	8.2	75.2
MAR 5 91	0 o/oo	0.26	0.03	0.98	20.7	2.2	77.1
MAR 5 91	6 o/oo	2.02	1.28	10.68	14.5	9.1	76.4
MAR 5 91	12 o/oo	2.80	4.51	14.20	13.0	20.9	66.0
MAR 5 91	20 o/oo	6.55	4.95	6.80	35.8	27.1	37.2
APR 10 91	0 o/oo	0.28	0.07	4.86	5.4	1.4	93.1
APR 10 91	6 o/oo	4.33	1.08	21.69	16.0	4.0	80.0
APR 10 91	12 o/oo	5.27	6.78	19.67	16.6	21.4	62.0
APR 10 91	20 o/oo	7.16	0.12	19.76	26.5	0.5	73.1
MAY 7 91	0 o/oo	-0.02	0.19	3.07	-0.6	5.8	94.9
MAY 7 91	6 o/oo	0.26	0.37	7.12	3.3	4.8	91.9
MAY 7 91	12 o/oo	-0.09	0.53	7.36	-1.1	6.7	94.4
MAY 7 91	20 o/oo	0.09	0.36	5.54	1.4	6.0	92.6
JUN 13 91	0 o/oo	0.97	0.32	10.85	8.0	2.6	89.4
JUN 13 91	6 o/oo	2.21	1.54	19.73	9.4	6.6	84.0
JUN 13 91	12 o/oo	6.60	7.21	18.79	20.2	22.1	57.6
JUN 13 91	20 o/oo	6.99	2.35	16.33	27.2	9.1	63.6
JUL 10 91	0 o/oo	0.55	0.51	0.84	28.9	26.8	44.3
JUL 10 91	6 o/oo	2.98	16.75	47.45	4.4	24.9	70.6
JUL 10 91	12 o/oo	7.12	5.22	54.68	10.6	7.8	81.6
JUL 10 91	20 o/oo	3.71	3.74	13.13	18.0	18.2	63.8
AUG 7 91	0 o/oo	0.28	1.37	1.70	8.5	40.9	50.7
AUG 7 91	6 o/oo	8.14	9.14	39.02	14.5	16.2	69.3
AUG 7 91	12 o/oo	4.95	2.37	22.46	16.6	8.0	75.4
AUG 7 91	20 o/oo	5.04	5.01	26.75	13.7	13.6	72.7
SEPT 16 91	0 o/oo	0.84	1.31	3.62	14.6	22.6	62.8
SEPT 16 91	6 o/oo	0.19	0.37	11.87	1.5	2.9	95.6
SEPT 16 91	12 o/oo	9.76	1.18	10.35	45.8	5.6	48.6
SEPT 16 91	20 o/oo	9.01	1.87	5.50	55.0	11.4	33.6

TABLE 3.7 (Cont.)

DETERMINATION OF CARBON UPTAKE BY SIZE FRACTION

DATE			STATION	mg Carbon fixed /m3/Einstein >20 um F1	20><5 um F2	5> um F3	percent in each size fraction >20 um F4	20><5 um F5	5> um F6
OCT	8	91	0 o/oo	0.91	0.27	3.53	19.4	5.8	74.8
OCT	8	91	6 o/oo	1.94	3.95	8.19	13.8	28.0	58.2
OCT	8	91	12 o/oo	3.29	3.25	11.86	17.9	17.6	64.5
OCT	8	91	20 o/oo	2.93	1.04	7.53	25.5	9.0	65.5
NOV	12	91	0 o/oo	0.78	1.35	10.61	6.1	10.6	83.3
NOV	12	91	6 o/oo	9.64	23.30	44.06	12.5	30.3	57.2
NOV	12	91	12 o/oo	5.51	13.31	30.89	11.1	26.8	62.1
NOV	12	91	20 o/oo	17.52	4.50	9.33	55.9	14.4	29.8
DEC	16	91	0 o/oo	1.90	0.49	8.97	16.7	4.3	79.0
DEC	16	91	6 o/oo	9.80	2.23	24.69	26.7	6.1	67.2
DEC	16	91	12 o/oo	0.69	3.73	13.84	3.8	20.4	75.8
DEC	16	91	20 o/oo	11.16	3.44	5.70	55.0	17.0	28.1

TABLE 3.8

DETERMINATION OF CHLOROPHYLL a LEVELS BY SIZE FRACTION

				micro-grams/cubic meter			percent in each size fraction		
				>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE			STATION	CF1	CF2	CF3	CF4	CF5	CF6
JUN	16	83	0 o/oo	0.1	2.0	13.0	0.7	13.2	86.1
JUN	16	83	6 o/oo	4.5	3.2	52.7	7.5	5.3	87.3
JUN	16	83	12 o/oo	0.0	0.9	11.6	0.0	7.2	92.8
JUN	16	83	20 o/oo	3.0	1.1	3.9	37.5	13.7	48.7
JUL	22	83	0 o/oo	6.6	6.6	26.4	16.7	16.7	66.7
JUL	22	83	6 o/oo	12.9	0.8	58.7	17.8	1.1	81.1
JUL	22	83	12 o/oo	0.0	0.7	26.0	0.0	2.6	97.4
JUL	22	83	20 o/oo	0.2	0.0	2.9	6.5	0.0	93.5
AUG	19	83	0 o/oo	5.6	1.5	11.2	30.6	8.2	61.2
AUG	19	83	6 o/oo	14.6	1.2	36.9	27.7	2.3	70.0
AUG	19	83	12 o/oo	3.1	2.0	17.3	13.8	8.9	77.2
AUG	19	83	20 o/oo	0.1	0.0	10.3	1.0	0.0	99.0
SEPT	28	83	0 o/oo	0.8	0.0	1.5	34.8	0.0	65.2
SEPT	28	83	6 o/oo	1.7	1.0	8.9	14.7	8.6	76.7
SEPT	28	83	12 o/oo	0.8	1.0	4.3	13.1	16.4	70.5
SEPT	28	83	20 o/oo	0.9	1.0	4.7	13.6	15.2	71.2
OCT	20	83	0 o/oo	4.5	2.0	6.2	35.4	15.7	48.8
OCT	20	83	6 o/oo	7.8	0.4	20.6	27.1	1.4	71.5
OCT	20	83	12 o/oo	8.4	5.5	18.1	26.2	17.2	56.6
OCT	20	83	20 o/oo	0.0	3.8	16.0	0.0	19.8	83.3
NOV	22	83	0 o/oo	0.5	0.5	2.0	16.7	16.7	66.7
NOV	22	83	6 o/oo	2.1	1.1	4.7	26.6	13.9	59.5
NOV	22	83	12 o/oo	1.6	0.7	7.2	16.8	7.4	75.8
NOV	22	83	20 o/oo	0.2	0.2	3.4	5.3	5.3	89.5
DEC	28	83	0 o/oo	0.6	0.4	4.7	10.5	7.0	82.5
DEC	28	83	6 o/oo	1.2	1.1	4.2	18.5	16.9	64.6
DEC	28	83	12 o/oo	12.7	0.0	10.2	55.5	0.0	44.5
DEC	28	83	20 o/oo	0.5	0.7	3.1	11.6	16.3	72.1
JAN	18	84	0 o/oo	0.4	0.4	7.9	4.6	4.6	90.8
JAN	18	84	6 o/oo	15.2	0.8	13.7	51.2	2.7	46.1
JAN	18	84	12 o/oo	19.4	6.9	22.1	40.1	14.3	45.7
JAN	18	84	20 o/oo	4.6	2.5	19.6	17.2	9.4	73.4
FEB	15	84	0 o/oo	0.8	1.5	4.9	11.1	20.8	68.1
FEB	15	84	6 o/oo	8.3	0.0	22.9	27.2	0.0	75.1
FEB	15	84	12 o/oo	14.0	1.3	24.1	35.5	3.3	61.2
FEB	15	84	20 o/oo	2.7	1.2	6.3	26.5	11.8	61.8
MAR	9	84	0 o/oo	6.5	6.1	16.8	22.1	20.7	57.1
MAR	9	84	6 o/oo	31.1	18.7	18.7	45.4	27.3	27.3
MAR	9	84	12 o/oo	4.8	0.0	11.4	31.6	0.0	75.0
MAR	9	84	20 o/oo	1.4	0.3	6.4	17.3	3.7	79.0

TABLE 3.8 (Cont.)

DETERMINATION OF CHLOROPHYLL a LEVELS BY SIZE FRACTION

			micro-grams/cubic meter			percent in each size fraction		
			>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE		STATION	CF1	CF2	CF3	CF4	CF5	CF6
APR	19 84	0 o/oo	2.9	10.2	16.4	9.8	34.6	55.6
APR	19 84	6 o/oo	21.0	11.5	17.1	42.3	23.2	34.5
APR	19 84	12 o/oo	1.6	17.1	10.2	5.5	59.2	35.3
APR	19 84	20 o/oo	1.3	2.3	7.0	12.3	21.7	66.0
MAY	7 84	0 o/oo	4.4	9.9	12.3	16.5	37.2	46.2
MAY	7 84	6 o/oo	11.4	1.1	19.1	36.1	3.5	60.4
MAY	7 84	12 o/oo	3.5	2.6	14.9	16.7	12.4	71.0
MAY	7 84	20 o/oo	1.0	1.4	5.7	12.3	17.3	70.4
JUN	7 84	0 o/oo	3.1	4.4	21.9	10.5	15.0	74.5
JUN	7 84	6 o/oo	5.1	1.0	16.3	22.8	4.5	72.8
JUN	7 84	12 o/oo	7.9	4.1	7.6	40.3	20.9	38.8
JUN	7 84	20 o/oo	5.1	0.1	3.3	60.0	1.2	38.8
JUL	9 84	0 o/oo	4.5	6.9	12.2	19.1	29.2	51.7
JUL	9 84	6 o/oo	5.6	0.0	7.0	46.3	0.0	57.9
JUL	9 84	12 o/oo	7.9	1.3	4.3	58.5	9.6	31.9
JUL	9 84	20 o/oo	12.2	0.3	3.3	77.2	1.9	20.9
AUG	16 84	0 o/oo	0.8	1.1	6.4	9.6	13.3	77.1
AUG	16 84	6 o/oo	1.6	0.8	3.8	25.8	12.9	61.3
AUG	16 84	12 o/oo	3.2	20.9	19.1	7.4	48.4	44.2
AUG	16 84	20 o/oo	1.9	0.6	1.7	45.2	14.3	40.5
SEPT	13 84	0 o/oo	1.3	3.5	6.3	11.7	31.5	56.8
SEPT	13 84	6 o/oo	9.0	13.3	128.8	6.0	8.8	85.2
SEPT	13 84	12 o/oo	6.3	4.1	15.0	24.8	16.1	59.1
SEPT	13 84	20 o/oo	2.7	0.0	4.8	36.0	0.0	64.0
OCT	4 84	0 o/oo	0.0	5.9	13.2	0.0	30.9	69.1
OCT	4 84	6 o/oo	36.9	4.0	18.2	62.4	6.8	30.8
OCT	4 84	12 o/oo	44.6	0.0	67.7	41.5	0.0	63.0
OCT	4 84	20 o/oo	5.8	1.4	3.9	52.3	12.6	35.1
NOV	15 84	0 o/oo	2.6	2.2	9.9	17.7	15.0	67.3
NOV	15 84	6 o/oo	1.5	1.4	5.5	17.9	16.7	65.5
NOV	15 84	12 o/oo	8.4	1.8	7.1	48.6	10.4	41.0
NOV	15 84	20 o/oo	1.3	0.4	4.1	22.4	6.9	70.7
DEC	13 84	0 o/oo	0.0	0.3	2.4	0.0	11.1	88.9
DEC	13 84	6 o/oo	1.2	0.6	2.5	27.9	14.0	58.1
DEC	13 84	12 o/oo	9.5	2.7	2.8	63.3	18.0	18.7
DEC	13 84	20 o/oo	1.7	3.1	1.9	25.4	46.3	28.4
JAN	8 85	0 o/oo	0.4	0.5	2.3	12.5	15.6	71.9
JAN	8 85	6 o/oo	0.2	0.5	2.0	7.4	18.5	74.1
JAN	8 85	12 o/oo	0.4	1.7	2.7	8.3	35.4	56.2
JAN	8 85	20 o/oo	3.5	3.3	2.9	36.1	34.0	29.9

TABLE 3.8 (Cont.)

DETERMINATION OF CHLOROPHYLL a LEVELS BY SIZE FRACTION

			micro-grams/cubic meter			percent in each size fraction		
			>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE			STATION	CF1	CF2	CF3	CF4	CF5	CF6

DATE			STATION	CF1	CF2	CF3	CF4	CF5	CF6
FEB	19	85	0 o/oo	0.7	0.7	2.9	16.3	16.3	67.4
FEB	19	85	6 o/oo	0.0	1.4	5.0	0.0	22.6	80.6
FEB	19	85	12 o/oo	0.3	0.9	4.4	5.4	16.1	78.6
FEB	19	85	20 o/oo	2.2	0.0	3.0	43.1	0.0	58.8
MAR	13	85	0 o/oo	13.0	0.0	7.9	62.5	0.0	38.0
MAR	13	85	6 o/oo	9.5	3.4	20.6	28.4	10.1	61.5
MAR	13	85	12 o/oo	2.6	2.5	7.4	20.8	20.0	59.2
MAR	13	85	20 o/oo	1.5	0.0	1.0	60.0	0.0	40.0
APR	17	85	0 o/oo	3.5	0.2	6.2	35.4	2.0	62.6
APR	17	85	6 o/oo	1.9	3.8	6.5	15.6	31.1	53.3
APR	17	85	12 o/oo	12.1	14.6	36.2	19.2	23.2	57.6
APR	17	85	20 o/oo	3.3	4.9	8.1	20.2	30.1	49.7
MAY	13	85	0 o/oo	0.6	0.8	8.9	5.8	7.8	86.4
MAY	13	85	6 o/oo	0.8	0.2	9.7	7.5	1.9	90.7
MAY	13	85	12 o/oo	2.3	0.9	9.0	18.9	7.4	73.8
MAY	13	85	20 o/oo	2.9	0.3	4.8	36.2	3.7	60.0
JUN	18	85	0 o/oo	0.6	1.0	3.4	12.0	20.0	68.0
JUN	18	85	6 o/oo	0.8	2.0	11.2	5.7	14.3	80.0
JUN	18	85	12 o/oo	37.8	6.3	25.2	54.5	9.1	36.4
JUN	18	85	20 o/oo	4.1	4.1	10.6	21.8	21.8	56.4
JUL	11	85	0 o/oo	1.7	0.1	7.1	19.1	1.1	79.8
JUL	11	85	6 o/oo	2.4	3.3	10.5	14.8	20.4	64.8
JUL	11	85	12 o/oo	6.2	0.8	12.1	32.5	4.2	63.4
JUL	11	85	20 o/oo	1.0	0.0	9.3	9.7	0.0	90.3
AUG	7	85	0 o/oo	1.1	0.0	4.2	25.0	0.0	95.5
AUG	7	85	6 o/oo	1.1	1.2	10.3	8.7	9.5	81.7
AUG	7	85	12 o/oo	2.1	2.7	12.3	12.3	15.8	71.9
AUG	7	85	20 o/oo	2.4	1.1	8.0	20.9	9.6	69.6
SEPT	9	85	0 o/oo	0.5	0.1	2.5	16.1	3.2	80.6
SEPT	9	85	6 o/oo	0.8	0.4	6.1	11.0	5.5	83.6
SEPT	9	85	12 o/oo	1.4	0.9	8.4	13.1	8.4	78.5
SEPT	9	85	20 o/oo	12.1	2.0	7.4	56.3	9.3	34.4
OCT	9	85	0 o/oo	0.5	0.6	1.5	19.2	23.1	57.7
OCT	9	85	6 o/oo	3.4	0.8	5.1	36.6	8.6	54.8
OCT	9	85	12 o/oo	1.6	0.9	4.1	24.2	13.6	62.1
OCT	9	85	20 o/oo	4.5	1.8	5.1	39.5	15.8	44.7
NOV	26	85	0 o/oo	0.7	0.9	7.0	8.1	10.5	81.4
NOV	26	85	6 o/oo	0.5	1.3	7.2	5.6	14.4	80.0
NOV	26	85	12 o/oo	1.8	1.4	6.2	19.1	14.9	66.0
NOV	26	85	20 o/oo	9.9	3.3	4.4	56.3	18.7	25.0

TABLE 3.8 (Cont.)

DETERMINATION OF CHLOROPHYLL a LEVELS BY SIZE FRACTION

			micro-grams/cubic meter			percent in each size fraction		
			>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE			STATION	CF1	CF2	CF3	CF4	CF5	CF6

DATE			STATION	CF1	CF2	CF3	CF4	CF5	CF6
DEC	20	85	0 o/oo	0.5	0.5	1.9	17.2	17.2	65.5
DEC	20	85	6 o/oo	1.0	0.4	8.9	9.7	3.9	86.4
DEC	20	85	12 o/oo	0.4	0.5	6.1	5.7	7.1	87.1
DEC	20	85	20 o/oo	0.7	0.7	4.4	12.1	12.1	75.9
JAN	14	86	0 o/oo	0.1	0.3	1.6	5.0	15.0	80.0
JAN	14	86	6 o/oo	0.5	0.3	3.8	10.9	6.5	82.6
JAN	14	86	12 o/oo	1.7	0.1	2.3	41.5	2.4	56.1
JAN	14	86	20 o/oo	0.8	0.5	3.3	17.4	10.9	71.7
FEB	14	86	0 o/oo	10.2	16.0	13.2	25.9	40.6	33.5
FEB	14	86	6 o/oo	11.7	4.5	6.4	51.8	19.9	28.3
FEB	14	86	12 o/oo	8.2	3.2	6.5	45.8	17.9	36.3
FEB	14	86	20 o/oo	4.4	4.8	4.6	31.9	34.8	33.3
MAR	12	86	0 o/oo	1.4	0.0	4.6	25.0	0.0	82.1
MAR	12	86	6 o/oo	3.2	0.1	6.9	31.4	1.0	67.6
MAR	12	86	12 o/oo	2.1	2.3	7.1	18.3	20.0	61.7
MAR	12	86	20 o/oo	3.4	1.8	4.8	34.0	18.0	48.0
APR	14	86	0 o/oo	4.0	8.6	21.3	11.8	25.4	62.8
APR	14	86	6 o/oo	7.9	4.7	64.6	10.2	6.1	83.7
APR	14	86	12 o/oo	6.5	1.5	14.1	29.4	6.8	63.8
APR	14	86	20 o/oo	3.6	5.5	7.4	21.8	33.3	44.8
MAY	13	86	0 o/oo	0.8	1.6	11.1	5.9	11.9	82.2
MAY	13	86	6 o/oo	0.0	0.8	4.6	0.0	14.8	85.2
MAY	13	86	12 o/oo	1.3	0.6	2.8	27.7	12.8	59.6
MAY	13	86	20 o/oo	0.3	1.1	2.9	7.0	25.6	67.4
JUN	17	86	0 o/oo	0.1	0.2	2.6	3.4	6.9	89.7
JUN	17	86	6 o/oo	0.4	9.0	15.7	1.6	35.9	62.5
JUN	17	86	12 o/oo	0.6	1.0	4.6	9.7	16.1	74.2
JUN	17	86	20 o/oo	2.3	0.0	5.4	30.3	0.0	71.1
JUL	11	86	0 o/oo	1.5	1.3	17.0	7.6	6.6	85.9
JUL	11	86	6 o/oo	2.3	3.5	15.0	11.1	16.8	72.1
JUL	11	86	12 o/oo	1.9	0.4	5.2	25.3	5.3	69.3
JUL	11	86	20 o/oo	0.3	0.7	2.6	8.3	19.4	72.2
AUG	7	86	0 o/oo	2.6	1.9	5.3	26.5	19.4	54.1
AUG	7	86	6 o/oo	2.2	0.1	4.1	34.4	1.6	64.1
AUG	7	86	12 o/oo	2.5	0.0	4.6	35.2	0.0	64.8
AUG	7	86	20 o/oo	3.8	0.0	3.8	51.4	0.0	51.4
SEPT	14	86	0 o/oo	0.1	1.1	2.5	2.7	29.7	67.6
SEPT	14	86	6 o/oo	0.5	0.8	3.4	10.6	17.0	72.3
SEPT	14	86	12 o/oo	3.0	0.0	14.2	17.4	0.0	82.6
SEPT	14	86	20 o/oo	4.0	0.0	5.3	43.0	0.0	57.0

TABLE 3.8 (Cont.)

DETERMINATION OF CHLOROPHYLL a LEVELS BY SIZE FRACTION

		micro-grams/cubic meter			percent in each size fraction		
		>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE	STATION	CF1	CF2	CF3	CF4	CF5	CF6
OCT 8 86	0 o/oo	2.1	0.0	8.5	19.8	0.0	80.2
OCT 8 86	6 o/oo	2.8	0.5	12.6	17.6	3.1	79.2
OCT 8 86	12 o/oo	1.9	0.6	7.5	19.0	6.0	75.0
OCT 8 86	20 o/oo	5.3	1.2	8.5	35.3	8.0	56.7
NOV 17 86	0 o/oo	3.1	0.0	4.7	39.7	0.0	60.3
NOV 17 86	6 o/oo	2.4	0.0	13.2	15.4	0.0	84.6
NOV 17 86	12 o/oo	2.0	0.3	6.5	22.7	3.4	73.9
NOV 17 86	20 o/oo	5.0	0.2	6.3	43.5	1.7	54.8
DEC 18 86	0 o/oo	0.6	1.0	3.0	13.0	21.7	65.2
DEC 18 86	6 o/oo	5.5	7.1	4.7	31.8	41.0	27.2
DEC 18 86	12 o/oo	4.3	2.8	4.1	38.4	25.0	36.6
DEC 18 86	20 o/oo	3.6	4.1	3.8	31.3	35.7	33.0
JAN 9 87	0 o/oo	0.0	0.0	0.0	0.0	0.0	0.0
JAN 9 87	6 o/oo	0.0	0.0	0.0	0.0	0.0	0.0
JAN 9 87	12 o/oo	0.0	0.0	0.0	0.0	0.0	0.0
JAN 9 87	20 o/oo	0.0	0.0	0.0	0.0	0.0	0.0
FEB 11 87	0 o/oo	0.0	0.4	4.1	0.0	9.1	93.2
FEB 11 87	6 o/oo	0.0	1.5	10.3	0.0	13.0	89.6
FEB 11 87	12 o/oo	0.9	1.7	5.5	11.1	21.0	67.9
FEB 11 87	20 o/oo	1.7	1.3	4.2	23.6	18.1	58.3
MAR 10 87	0 o/oo	0.5	0.0	9.7	4.9	0.0	95.1
MAR 10 87	6 o/oo	0.3	0.0	13.5	2.2	0.0	97.8
MAR 10 87	12 o/oo	0.0	0.2	15.6	0.0	1.3	98.7
MAR 10 87	20 o/oo	0.0	0.2	12.1	0.0	1.6	98.4
APR 20 87	0 o/oo	1.6	20.5	0.0	7.2	92.8	0.0
APR 20 87	6 o/oo	0.0	1.3	13.1	0.0	9.0	91.0
APR 20 87	12 o/oo	0.0	2.0	14.8	0.0	11.9	88.1
APR 20 87	20 o/oo	0.3	2.4	8.5	2.7	21.4	75.9
MAY 19 87	0 o/oo	0.1	0.2	2.1	4.2	8.3	87.5
MAY 19 87	6 o/oo	0.8	1.6	18.9	3.8	7.5	88.7
MAY 19 87	12 o/oo	1.2	4.3	15.0	5.9	21.0	73.2
MAY 19 87	20 o/oo	4.1	0.6	5.3	41.0	6.0	53.0
JUN 8 87	0 o/oo	7.4	5.8	36.8	14.8	11.6	73.6
JUN 8 87	6 o/oo	3.5	5.2	16.5	13.9	20.6	65.5
JUN 8 87	12 o/oo	7.5	0.0	21.7	25.7	0.0	74.3
JUN 8 87	20 o/oo	2.6	0.3	11.5	18.1	2.1	79.9
JUL 17 87	0 o/oo	1.2	1.7	11.8	8.2	11.6	80.3
JUL 17 87	6 o/oo	21.7	0.0	116.3	17.2	0.0	92.2
JUL 17 87	12 o/oo	5.5	4.8	17.3	19.9	17.4	62.7
JUL 17 87	20 o/oo	0.0	3.0	5.3	0.0	36.1	63.9

TABLE 3.8 (Cont.)

DETERMINATION OF CHLOROPHYLL a LEVELS BY SIZE FRACTION

				micro-grams/cubic meter			percent in each size fraction		
				>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE			STATION	CF1	CF2	CF3	CF4	CF5	CF6
AUG	4	87	0 o/oo	0.0	3.2	16.2	0.0	16.5	83.5
AUG	4	87	6 o/oo	4.0	2.3	21.3	14.5	8.3	77.2
AUG	4	87	12 o/oo	3.1	3.2	23.6	10.4	10.7	78.9
AUG	4	87	20 o/oo	0.6	0.3	6.6	8.0	4.0	88.0
SEPT	25	87	0 o/oo	3.2	0.0	11.8	23.7	0.0	87.4
SEPT	25	87	6 o/oo	1.0	1.1	8.5	9.4	10.4	80.2
SEPT	25	87	12 o/oo	36.3	0.0	16.0	70.3	0.0	31.0
SEPT	25	87	20 o/oo	4.7	0.0	23.8	17.2	0.0	87.2
OCT	20	87	0 o/oo	0.0	1.0	0.5	0.0	71.4	35.7
OCT	20	87	6 o/oo	0.9	1.4	2.9	17.3	26.9	55.8
OCT	20	87	12 o/oo	0.1	2.4	4.2	1.5	35.8	62.7
OCT	20	87	20 o/oo	5.1	0.0	4.4	53.7	0.0	46.3
NOV	13	87	0 o/oo	0.6	1.9	2.6	11.8	37.3	51.0
NOV	13	87	6 o/oo	24.1	8.3	4.6	65.1	22.4	12.4
NOV	13	87	12 o/oo	0.3	3.7	9.8	2.2	26.8	71.0
NOV	13	87	20 o/oo	3.5	3.5	3.9	32.1	32.1	35.8
DEC	10	87	0 o/oo	15.1	4.5	9.6	51.7	15.4	32.9
DEC	10	87	6 o/oo	1.2	0.0	4.2	24.5	0.0	85.7
DEC	10	87	12 o/oo	3.4	0.0	2.8	59.6	0.0	49.1
DEC	10	87	20 o/oo	3.8	0.0	7.2	40.9	0.0	77.4
JAN	18	88	0 o/oo	1.1	3.3	6.0	10.6	31.7	57.7
JAN	18	88	6 o/oo	0.8	3.5	5.1	8.5	37.2	54.3
JAN	18	88	12 o/oo	2.8	5.5	4.2	22.4	44.0	33.6
JAN	18	88	20 o/oo	3.3	12.0	6.0	15.5	56.3	28.2
FEB	10	88	0 o/oo	0.4	0.3	1.1	22.2	16.7	61.1
FEB	10	88	6 o/oo	0.3	1.6	4.5	4.7	25.0	70.3
FEB	10	88	12 o/oo	2.8	4.6	3.4	25.9	42.6	31.5
FEB	10	88	20 o/oo	0.6	8.7	3.3	4.8	69.0	26.2
MAR	11	88	0 o/oo	0.2	0.7	1.9	7.1	25.0	67.9
MAR	11	88	6 o/oo	0.0	5.9	4.9	0.0	54.6	45.4
MAR	11	88	12 o/oo	1.1	3.4	4.3	12.5	38.6	48.9
MAR	11	88	20 o/oo	0.2	2.4	9.0	1.7	20.7	77.6
APR	13	88	0 o/oo	0.0	3.5	3.7	0.0	52.2	55.2
APR	13	88	6 o/oo	6.7	4.0	11.8	29.8	17.8	52.4
APR	13	88	12 o/oo	0.0	5.9	13.8	0.0	31.2	73.0
APR	13	88	20 o/oo	1.7	4.7	7.4	12.3	34.1	53.6
MAY	16	88	0 o/oo	0.4	1.1	5.6	5.6	15.5	78.9
MAY	16	88	6 o/oo	0.7	1.9	7.4	7.0	19.0	74.0
MAY	16	88	12 o/oo	0.3	2.6	7.4	2.9	25.2	71.8
MAY	16	88	20 o/oo	1.1	3.1	6.5	10.3	29.0	60.7

TABLE 3.8 (Cont.)

DETERMINATION OF CHLOROPHYLL a LEVELS BY SIZE FRACTION

				micro-grams/cubic meter			percent in each size fraction		
				>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE			STATION	CF1	CF2	CF3	CF4	CF5	CF6
JUN	13	88	0 o/oo	0.3	1.9	5.5	3.9	24.7	71.4
JUN	13	88	6 o/oo	1.8	5.0	8.8	11.5	32.1	56.4
JUN	13	88	12 o/oo	0.0	2.8	6.7	0.0	30.8	73.6
JUN	13	88	20 o/oo	1.3	5.4	4.3	11.8	49.1	39.1
JUL	12	88	0 o/oo	0.2	1.8	6.2	2.4	22.0	75.6
JUL	12	88	6 o/oo	2.5	0.1	5.6	30.5	1.2	68.3
JUL	12	88	12 o/oo	0.0	3.9	10.9	0.0	31.0	86.5
JUL	12	88	20 o/oo	2.6	2.7	2.9	31.7	32.9	35.4
AUG	8	88	0 o/oo	3.1	1.7	6.0	28.7	15.7	55.6
AUG	8	88	6 o/oo	13.4	0.0	69.7	16.9	0.0	88.0
AUG	8	88	12 o/oo	0.0	3.5	39.8	0.0	8.2	92.8
AUG	8	88	20 o/oo	0.9	1.3	6.4	10.5	15.1	74.4
SEPT	19	88	6 o/oo	0.7	6.0	3.1	7.1	61.2	31.6
SEPT	19	88	12 o/oo	31.1	7.1	5.9	70.5	16.1	13.4
SEPT	19	88	20 o/oo	5.5	15.0	11.0	17.5	47.6	34.9
SEPT	19	88	0 o/oo	1.6	1.2	1.9	34.0	25.5	40.4
OCT	11	88	0 o/oo	0.0	1.1	5.6	0.0	16.9	86.2
OCT	11	88	6 o/oo	0.9	5.3	7.3	6.7	39.3	54.1
OCT	11	88	12 o/oo	2.9	7.3	6.9	17.0	42.7	40.4
OCT	11	88	20 o/oo	9.6	3.1	4.1	57.1	18.5	24.4
NOV	10	88	0 o/oo	0.5	1.8	2.0	11.6	41.9	46.5
NOV	10	88	6 o/oo	0.0	0.2	1.5	0.0	12.5	93.7
NOV	10	88	12 o/oo	0.0	0.3	1.3	0.0	18.8	81.2
NOV	10	88	20 o/oo	0.3	2.1	2.0	6.8	47.7	45.5
DEC	8	88	0 o/oo	7.9	32.1	36.4	10.3	42.0	47.6
DEC	8	88	6 o/oo	3.8	9.4	7.4	18.4	45.6	35.9
DEC	8	88	12 o/oo	1.8	1.2	3.2	29.0	19.4	51.6
DEC	8	88	20 o/oo	0.7	0.4	1.8	24.1	13.8	62.1
JAN	25	89	0 o/oo	0.0	2.4	3.6	0.0	41.4	62.1
JAN	25	89	6 o/oo	0.0	5.1	6.4	0.0	47.7	59.8
JAN	25	89	12 o/oo	1.5	0.0	4.6	25.4	0.0	78.0
JAN	25	89	20 o/oo	0.9	0.4	3.8	17.6	7.8	74.5
FEB	13	89	0 o/oo	3.1	3.2	12.5	16.5	17.0	66.5
FEB	13	89	6 o/oo	0.9	3.4	12.8	5.3	19.9	74.9
FEB	13	89	12 o/oo	1.6	0.9	9.1	13.8	7.8	78.4
FEB	13	89	20 o/oo	1.1	3.9	5.9	10.1	35.8	54.1
MAR	15	89	0 o/oo	0.0	1.2	2.6	0.0	40.0	86.7
MAR	15	89	6 o/oo	3.5	1.8	17.2	15.6	8.0	76.4
MAR	15	89	12 o/oo	4.7	5.3	3.2	35.6	40.2	24.2
MAR	15	89	20 o/oo	0.7	3.8	2.7	9.7	52.8	37.5

TABLE 3.8 (Cont.)

DETERMINATION OF CHLOROPHYLL a LEVELS BY SIZE FRACTION

DATE			STATION	micro-grams/cubic meter >20 um CF1	20><5 um CF2	5> um CF3	percent in each size fraction >20 um CF4	20><5 um CF5	5> um CF6
APR	20	89	0 o/oo	0.1	1.7	4.8	1.5	25.8	72.7
APR	20	89	6 o/oo	1.5	1.5	9.1	12.4	12.4	75.2
APR	20	89	12 o/oo	0.3	1.1	12.1	2.2	8.1	89.6
APR	20	89	20 o/oo	2.1	2.2	5.2	22.1	23.2	54.7
MAY	9	89	0 o/oo	0.0	0.5	3.1	0.0	14.3	88.6
MAY	9	89	6 o/oo	0.1	1.0	5.1	1.6	16.1	82.3
MAY	9	89	12 o/oo	0.0	0.3	3.9	0.0	7.5	97.5
MAY	9	89	20 o/oo	0.2	5.9	4.3	1.9	56.7	41.3
JUN	14	89	0 o/oo	0.0	0.6	6.4	0.0	8.6	91.4
JUN	14	89	6 o/oo	1.2	1.2	6.3	13.8	13.8	72.4
JUN	14	89	12 o/oo	1.4	1.5	5.5	16.7	17.9	65.5
JUN	14	89	20 o/oo	1.5	1.4	7.0	15.2	14.1	70.7
JUL	25	89	0 o/oo	1.0	0.4	3.8	19.2	7.7	73.1
JUL	25	89	6 o/oo	0.0	6.0	6.4	0.0	48.4	51.6
JUL	25	89	12 o/oo	33.9	3.2	5.5	79.6	7.5	12.9
JUL	25	89	20 o/oo	26.8	3.9	3.2	79.1	11.5	9.4
AUG	16	89	0 o/oo	0.2	0.3	2.0	8.0	12.0	80.0
AUG	16	89	6 o/oo	3.1	11.0	42.6	5.5	19.4	75.1
AUG	16	89	12 o/oo	13.4	4.7	11.8	44.8	15.7	39.5
AUG	16	89	20 o/oo	2.7	1.0	1.8	49.1	18.2	32.7
SEPT	13	89	0 o/oo	0.3	1.0	2.5	7.9	26.3	65.8
SEPT	13	89	6 o/oo	10.2	0.0	20.5	33.2	0.0	66.8
SEPT	13	89	12 o/oo	37.8	0.0	302.6	11.1	0.0	88.9
SEPT	13	89	20 o/oo	38.6	4.7	9.5	73.1	8.9	18.0
OCT	10	89	0 o/oo	0.0	1.2	4.8	0.0	20.0	80.0
OCT	10	89	6 o/oo	34.6	0.0	6.4	84.4	0.0	15.6
OCT	10	89	12 o/oo	28.3	1.6	7.9	74.9	4.2	20.9
OCT	10	89	20 o/oo	182.8	42.6	25.2	72.9	17.0	10.1
NOV	15	89	0 o/oo	0.2	0.1	2.2	8.0	4.0	88.0
NOV	15	89	6 o/oo	22.8	0.4	8.3	72.4	1.3	26.3
NOV	15	89	12 o/oo	20.3	0.0	7.3	73.6	0.0	26.4
NOV	15	89	20 o/oo	0.6	0.3	4.8	10.5	5.3	84.2
DEC	14	89	0 o/oo	1.9	1.4	0.2	54.3	40.0	5.7
DEC	14	89	6 o/oo	70.9	0.0	18.9	79.0	0.0	21.0
DEC	14	89	12 o/oo	39.4	0.0	12.6	75.8	0.0	24.2
DEC	14	89	20 o/oo	5.6	0.2	5.0	51.9	1.9	46.3
JAN	18	90	0 o/oo	0.1	1.6	5.3	1.4	22.9	75.7
JAN	18	90	6 o/oo	0.0	1.9	4.3	0.0	30.6	69.4
JAN	18	90	12 o/oo	0.0	0.5	5.8	0.0	7.9	92.1
JAN	18	90	20 o/oo	0.4	0.0	3.5	10.3	0.0	89.7

TABLE 3.8 (Cont.)

DETERMINATION OF CHLOROPHYLL a LEVELS BY SIZE FRACTION

DATE			STATION	micro-grams/cubic meter >20 um CF1	20><5 um CF2	5> um CF3	percent in each size fraction >20 um CF4	20><5 um CF5	5> um CF6
FEB	14	90	0 o/oo	1.5	0.1	2.2	39.5	2.6	57.9
FEB	14	90	6 o/oo	1.4	0.2	3.6	26.9	3.8	69.2
FEB	14	90	12 o/oo	0.5	0.9	3.9	9.4	17.0	73.6
FEB	14	90	20 o/oo	1.2	0.9	6.7	13.6	10.2	76.1
MAR	14	90	0 o/oo	4.8	40.9	28.4	6.5	55.2	38.3
MAR	14	90	6 o/oo	10.2	7.9	14.2	31.6	24.5	44.0
MAR	14	90	12 o/oo	1.8	2.0	11.5	11.8	13.1	75.2
MAR	14	90	20 o/oo	0.9	1.5	9.7	7.4	12.4	80.2
APR	12	90	0 o/oo	0.0	0.6	2.6	0.0	18.8	81.2
APR	12	90	6 o/oo	2.4	2.9	10.9	14.8	17.9	67.3
APR	12	90	12 o/oo	1.4	0.7	5.8	17.7	8.9	73.4
APR	12	90	20 o/oo	1.9	0.5	3.8	30.6	8.1	61.3
MAY	8	90	0 o/oo	0.4	0.8	2.7	10.3	20.5	69.2
MAY	8	90	6 o/oo	0.5	0.7	6.4	6.6	9.2	84.2
MAY	8	90	12 o/oo	2.1	0.0	6.7	23.9	0.0	76.1
MAY	8	90	20 o/oo	1.5	0.7	2.0	35.7	16.7	47.6
JUN	20	90	0 o/oo	0.0	0.7	1.9	0.0	26.9	73.1
JUN	20	90	6 o/oo	1.0	0.5	6.2	13.0	6.5	80.5
JUN	20	90	12 o/oo	1.5	0.6	8.3	14.4	5.8	79.8
JUN	20	90	20 o/oo	1.6	1.7	6.7	16.0	17.0	67.0
JUL	11	90	0 o/oo	0.0	0.4	2.0	0.0	16.7	83.3
JUL	11	90	6 o/oo	0.0	0.9	5.8	0.0	13.4	86.6
JUL	11	90	12 o/oo	2.4	0.7	6.2	25.8	7.5	66.7
JUL	11	90	20 o/oo	7.7	0.0	4.4	63.6	0.0	36.4
AUG	16	90	0 o/oo	0.1	0.6	2.7	2.9	17.6	79.4
AUG	16	90	6 o/oo	0.0	0.1	2.3	0.0	4.2	95.8
AUG	16	90	12 o/oo	8.6	2.0	7.0	48.9	11.4	39.8
AUG	16	90	20 o/oo	9.9	4.0	3.4	57.2	23.1	19.7
SEPT	16	90	0 o/oo	0.5	3.3	2.8	7.6	50.0	42.4
SEPT	16	90	6 o/oo	0.1	0.5	3.1	2.7	13.5	83.8
SEPT	16	90	12 o/oo	1.7	0.7	3.7	27.9	11.5	60.7
SEPT	16	90	20 o/oo	9.2	7.7	6.4	39.5	33.0	27.5
OCT	12	90	6 o/oo	8.7	18.1	14.2	21.2	44.1	34.6
OCT	12	90	12 o/oo	38.7	7.8	15.8	62.1	12.5	25.4
OCT	12	90	20 o/oo	5.5	5.6	16.5	19.9	20.3	59.8
OCT	12	90	0 o/oo	0.6	0.5	4.1	11.5	9.6	78.8
NOV	16	90	0 o/oo	0.1	0.9	0.6	6.3	56.2	37.5
NOV	16	90	6 o/oo	0.6	0.3	3.1	15.0	7.5	77.5
NOV	16	90	12 o/oo	1.4	0.1	6.4	17.7	1.3	81.0
NOV	16	90	20 o/oo	0.8	0.9	3.9	14.3	16.1	69.6

TABLE 3.8 (Cont.)

DETERMINATION OF CHLOROPHYLL a LEVELS BY SIZE FRACTION

				micro-grams/cubic meter			percent in each size fraction		
				>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE			STATION	CF1	CF2	CF3	CF4	CF5	CF6
DEC	16	90	0 o/oo	0.0	0.8	0.9	0.0	47.1	52.9
DEC	16	90	6 o/oo	0.3	1.6	2.6	6.7	35.6	57.8
DEC	16	90	12 o/oo	0.0	0.9	3.6	0.0	20.0	80.0
DEC	16	90	20 o/oo	0.0	0.0	5.5	0.0	0.0	100.0
JAN	17	91	0 o/oo	0.0	0.8	1.5	0.0	34.8	65.2
JAN	17	91	6 o/oo	0.3	0.0	3.8	7.3	0.0	92.7
JAN	17	91	12 o/oo	0.7	1.0	3.1	14.6	20.8	64.6
JAN	17	91	20 o/oo	1.2	2.2	4.2	15.8	28.9	55.3
FEB	13	91	0 o/oo	0.0	0.1	0.9	0.0	10.0	90.0
FEB	13	91	6 o/oo	0.2	0.1	4.3	4.3	2.2	93.5
FEB	13	91	12 o/oo	0.0	0.2	6.4	0.0	3.0	97.0
FEB	13	91	20 o/oo	0.7	0.1	6.6	9.5	1.4	89.2
MAR	5	91	0 o/oo	0.2	0.2	0.6	20.0	20.0	60.0
MAR	5	91	6 o/oo	0.5	0.5	3.4	11.4	11.4	77.3
MAR	5	91	12 o/oo	0.2	0.0	2.5	7.4	0.0	92.6
MAR	5	91	20 o/oo	0.0	0.3	2.4	0.0	11.1	88.9
APR	10	91	0 o/oo	0.0	0.5	1.8	0.0	21.7	78.3
APR	10	91	6 o/oo	2.4	2.9	10.0	15.7	19.0	65.4
APR	10	91	12 o/oo	0.5	0.6	5.5	7.6	9.1	83.3
APR	10	91	20 o/oo	4.4	1.5	8.8	29.9	10.2	59.9
MAY	7	91	0 o/oo	0.1	0.0	5.5	1.8	0.0	98.2
MAY	7	91	6 o/oo	0.0	1.4	6.2	0.0	18.4	81.6
MAY	7	91	12 o/oo	0.7	0.0	5.7	10.9	0.0	89.1
MAY	7	91	20 o/oo	1.0	0.3	6.1	13.5	4.1	82.4
JUN	13	91	0 o/oo	0.6	3.0	7.9	5.2	26.1	68.7
JUN	13	91	6 o/oo	0.9	0.9	10.3	7.4	7.4	85.1
JUN	13	91	12 o/oo	0.0	0.9	12.3	0.0	6.8	93.2
JUN	13	91	20 o/oo	0.3	0.0	10.3	2.8	0.0	97.2
JUL	10	91	0 o/oo	0.0	3.1	2.7	0.0	53.4	46.6
JUL	10	91	6 o/oo	0.0	5.5	25.2	0.0	17.9	82.1
JUL	10	91	12 o/oo	0.0	11.0	53.6	0.0	17.0	83.0
JUL	10	91	20 o/oo	1.5	4.1	15.0	7.3	19.9	72.8
AUG	7	91	0 o/oo	0.1	1.8	3.4	1.9	34.0	64.2
AUG	7	91	6 o/oo	0.0	3.0	14.1	0.0	17.5	82.5
AUG	7	91	12 o/oo	3.9	7.1	28.4	9.9	18.0	72.1
AUG	7	91	20 o/oo	1.2	3.0	12.9	7.0	17.5	75.4
SEPT	16	91	0 o/oo	0.2	0.4	2.4	6.7	13.3	80.0
SEPT	16	91	6 o/oo	0.0	0.0	6.5	0.0	0.0	100.0
SEPT	16	91	12 o/oo	30.0	0.7	9.5	74.6	1.7	23.6
SEPT	16	91	20 o/oo	8.5	2.6	6.2	49.1	15.0	35.8

TABLE 3.8 (Cont.)

DETERMINATION OF CHLOROPHYLL a LEVELS BY SIZE FRACTION

			micro-grams/cubic meter			percent in each size fraction		
			>20 um	20><5 um	5> um	>20 um	20><5 um	5> um
DATE		STATION	CF1	CF2	CF3	CF4	CF5	CF6
OCT	8 91	0 o/oo	0.8	2.1	0.6	22.9	60.0	17.1
OCT	8 91	6 o/oo	2.0	2.9	5.5	19.2	27.9	52.9
OCT	8 91	12 o/oo	22.1	3.1	22.1	46.7	6.6	46.7
OCT	8 91	20 o/oo	2.4	9.5	16.5	8.5	33.5	58.1
NOV	12 91	0 o/oo	0.0	5.3	13.8	0.0	27.7	72.3
NOV	12 91	6 o/oo	7.4	0.9	12.3	35.9	4.4	59.7
NOV	12 91	12 o/oo	5.6	3.5	10.0	29.3	18.3	52.4
NOV	12 91	20 o/oo	6.1	1.5	4.7	49.6	12.2	38.2
DEC	16 91	0 o/oo	0.5	0.9	6.7	6.2	11.1	82.7
DEC	16 91	6 o/oo	1.8	2.7	5.2	18.6	27.8	53.6
DEC	16 91	12 o/oo	0.8	0.7	5.7	11.1	9.7	79.2
DEC	16 91	20 o/oo	14.2	4.7	7.9	53.0	17.5	29.5

FIGURE 3.1?(A)

CHARLOTTE HARBOR 1983 – 1991

Primary Production

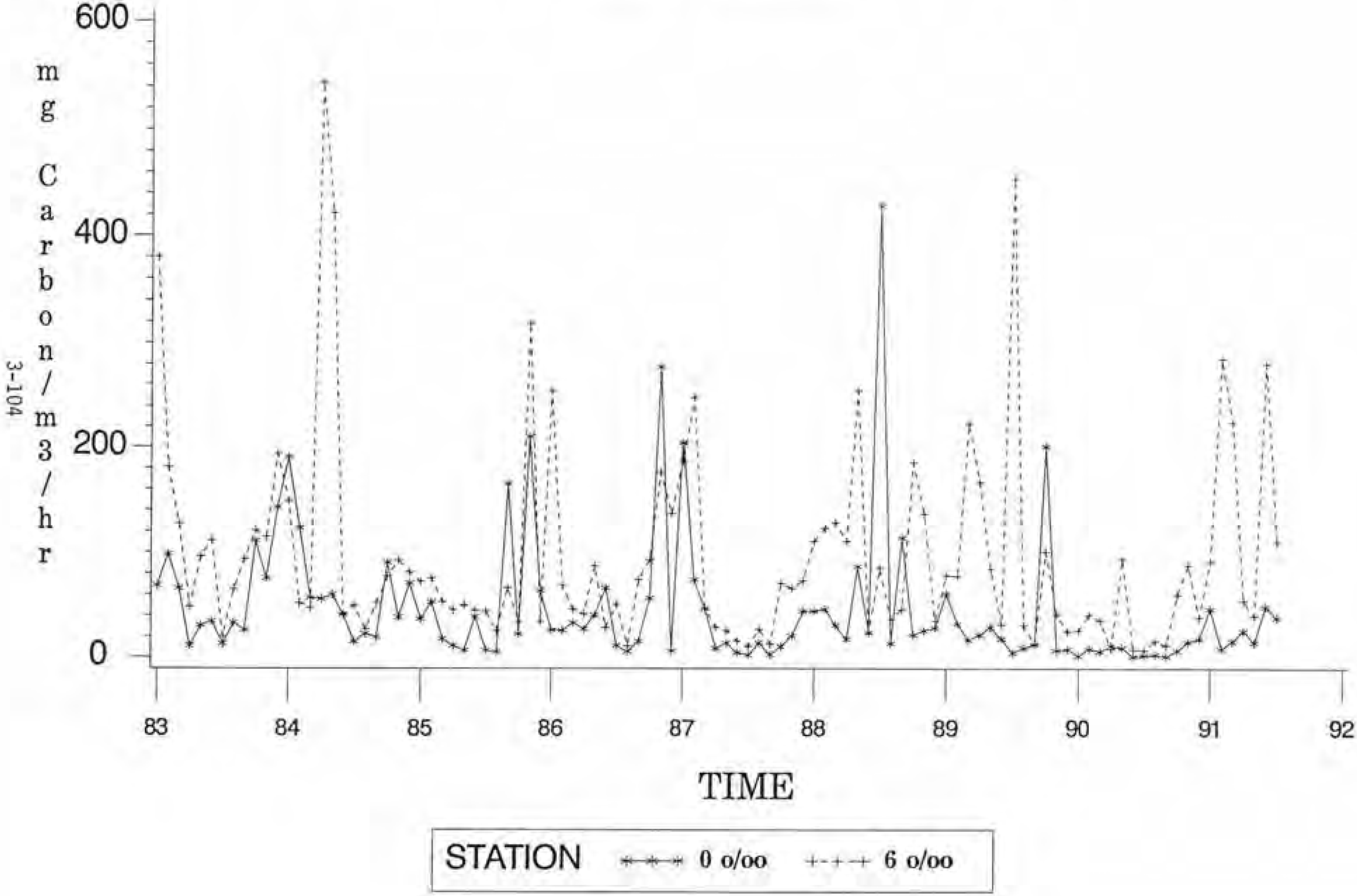


FIGURE 3.10(B)

CHARLOTTE HARBOR 1983 – 1991

Primary Production

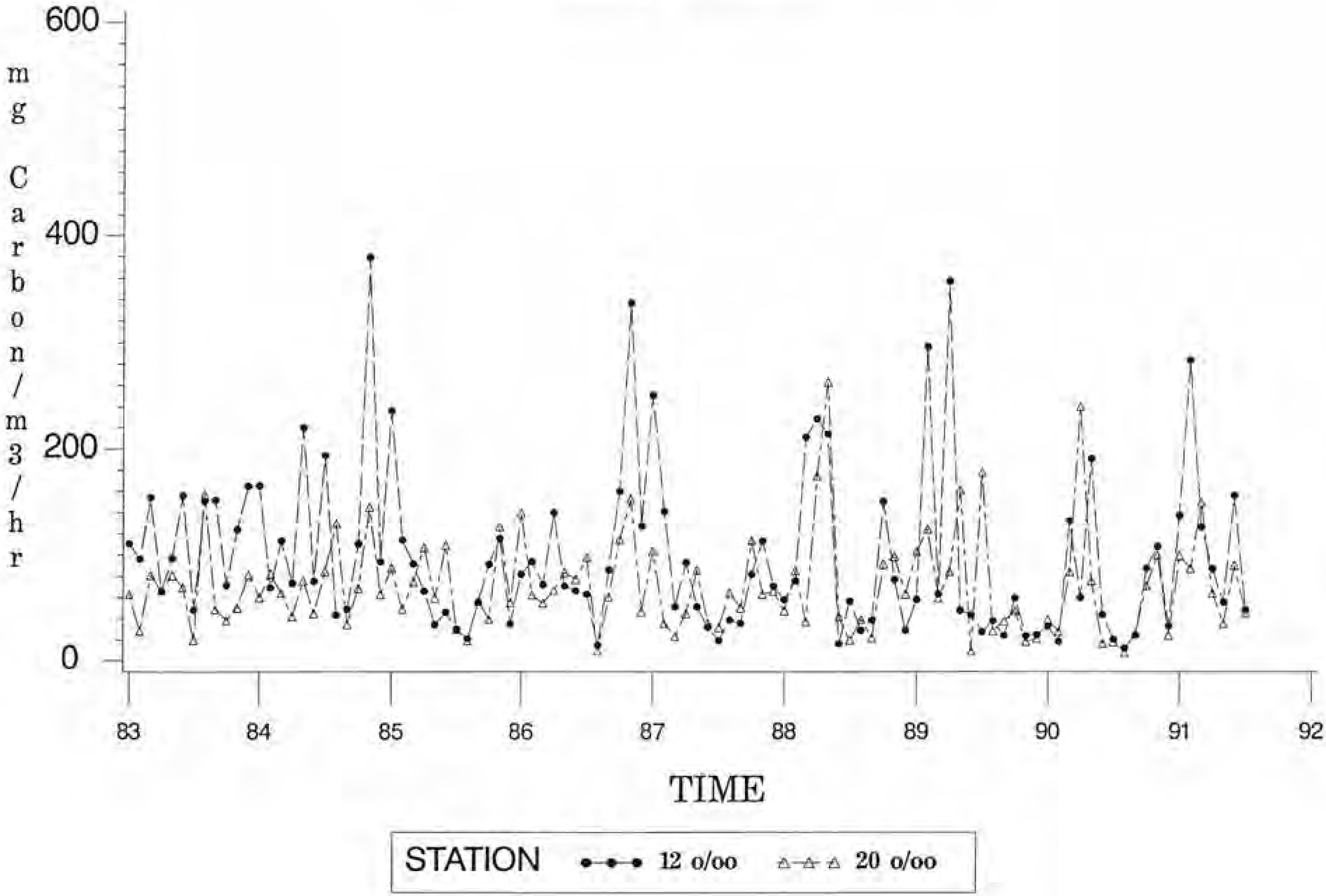


FIGURE 3.17

CHARLOTTE HARBOR 1983 – 1991

Monthly Means – Primary Production

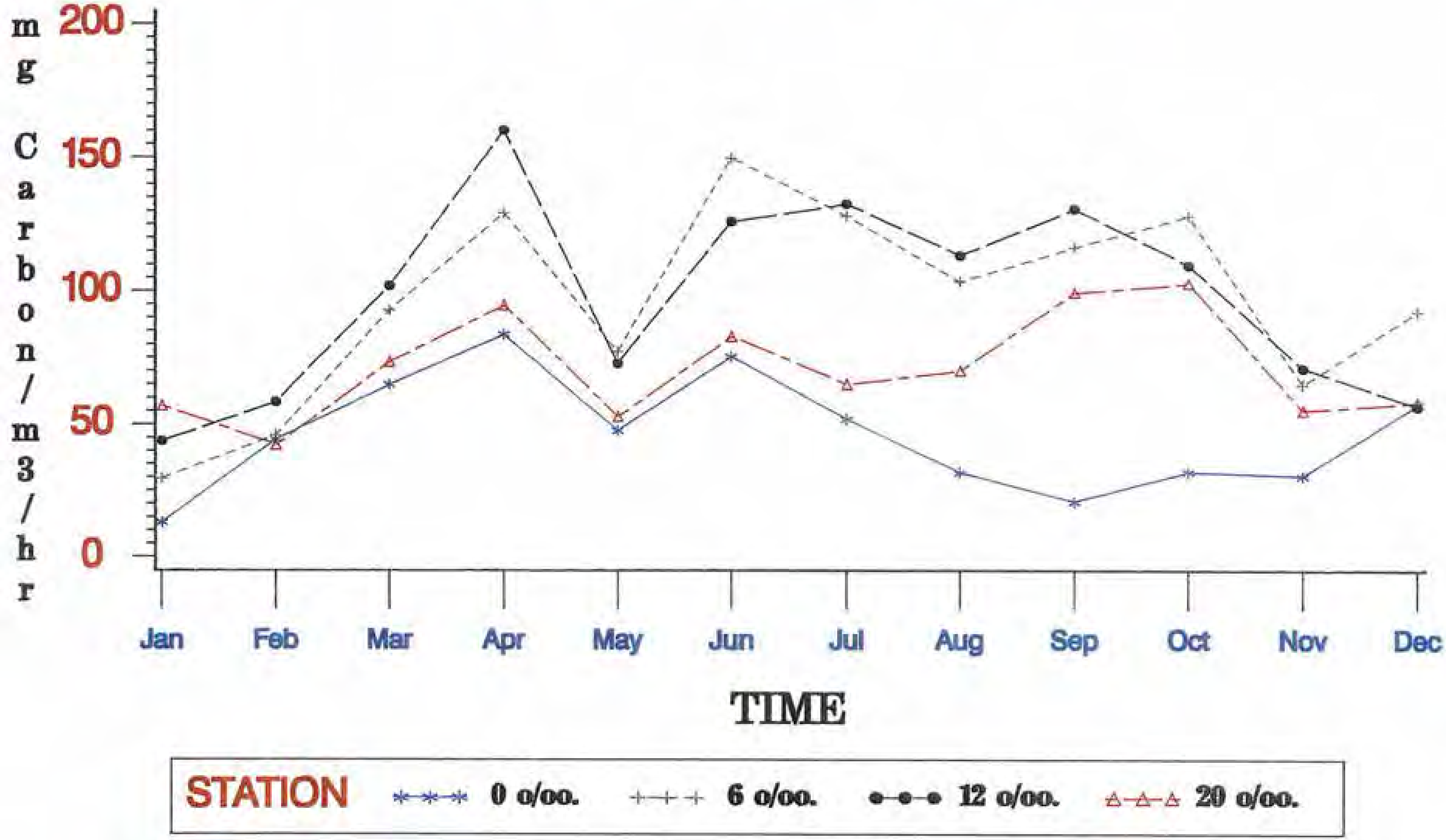


FIGURE 3.10(A)

CHARLOTTE HARBOR 1983 – 1991

Primary Production

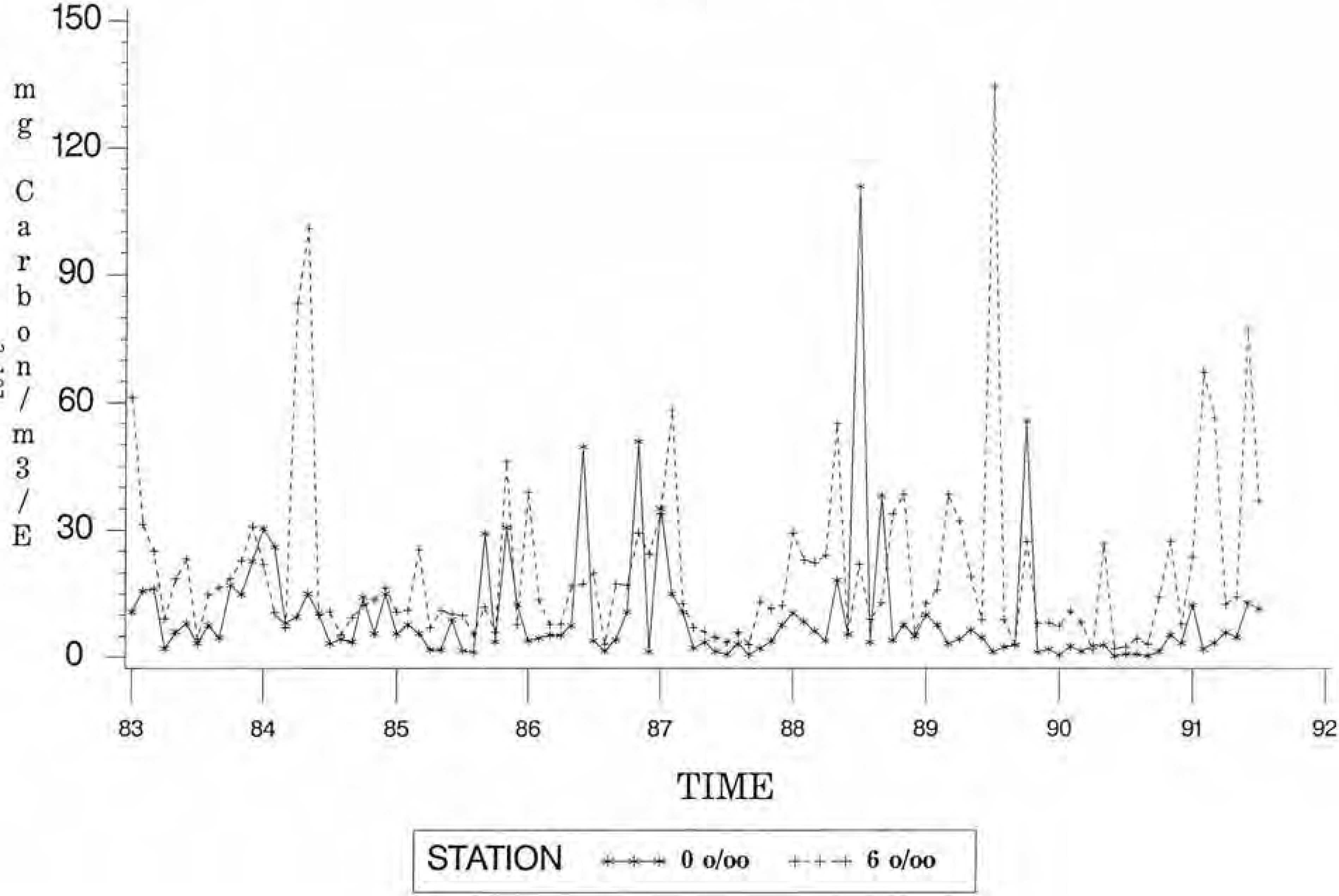


FIGURE 3.18(b)

CHARLOTTE HARBOR 1983 – 1991

Primary Production

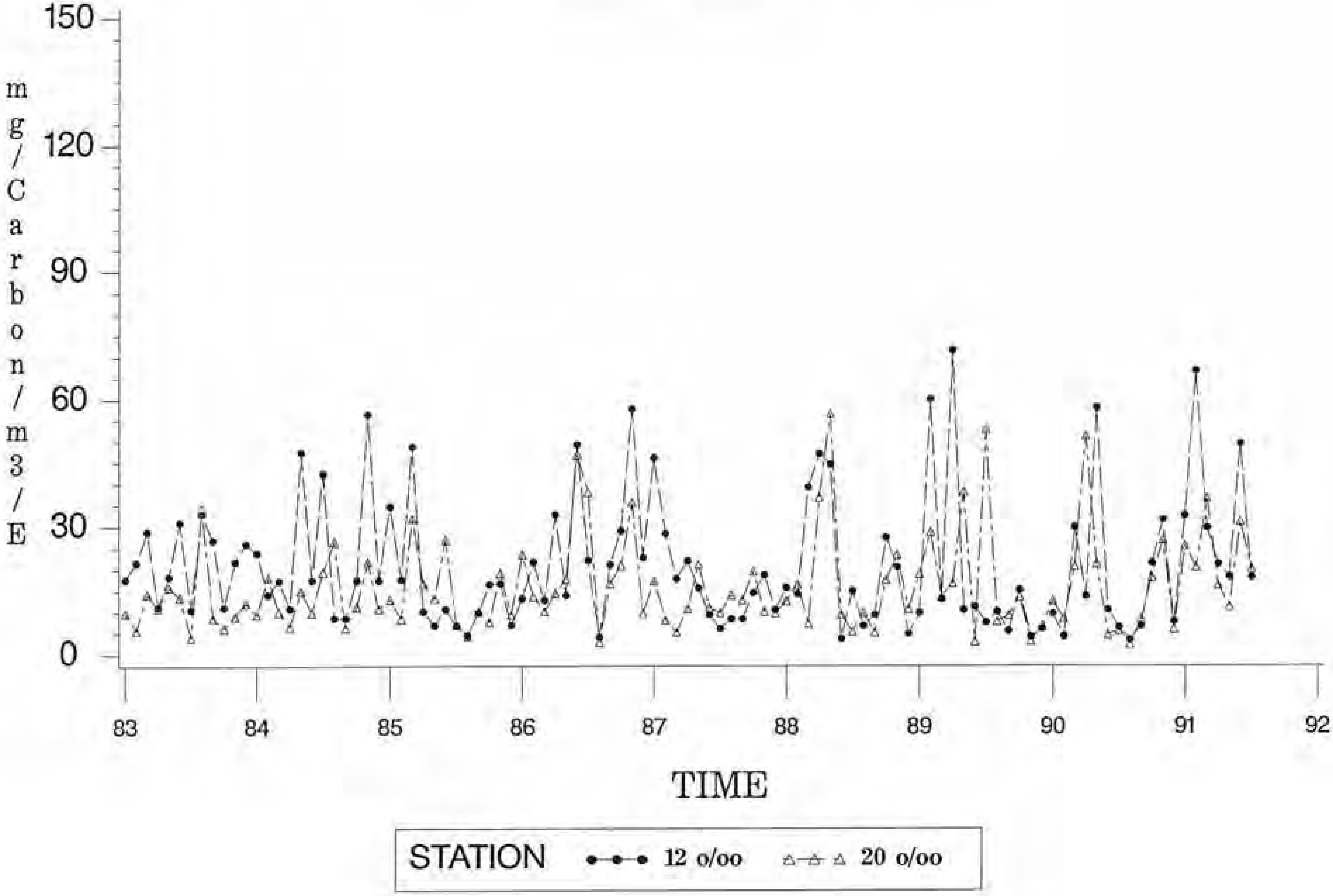
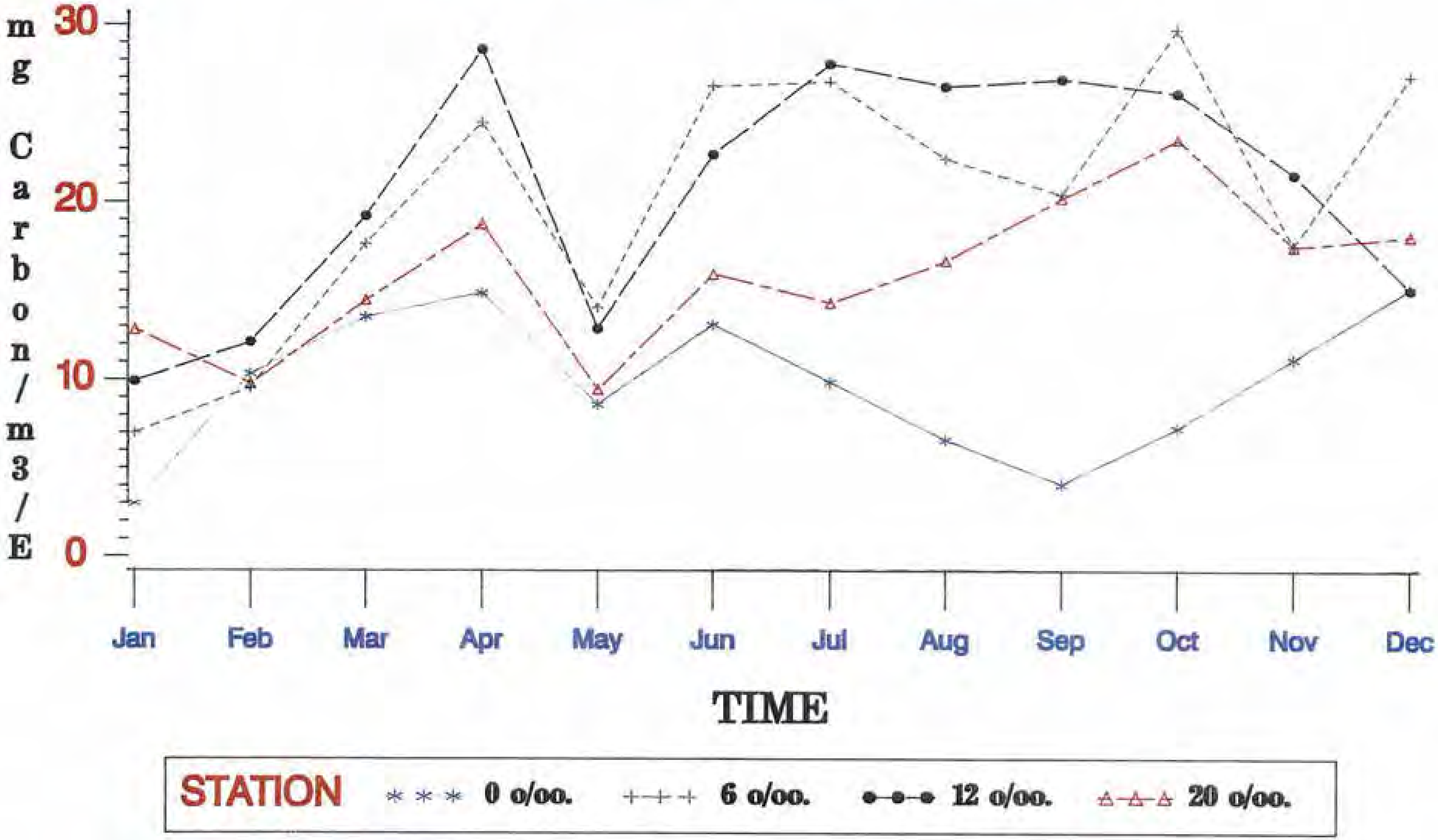


FIGURE 3.19

CHARLOTTE HARBOR 1983 – 1991

Monthly Means – Primary Production



1) Carbon uptake at each of the four salinity zones increased with rising water temperatures through the spring months (February-April), and then declined just prior to the beginning of the wet-season. Declining productivity was coincident with periods of sharp declines in ambient nitrogen levels.

2) Phytoplankton production then increased, most sharply at the intermediate salinities (6 and 12 o/oo), with the initial beginning of the wet-season rains. Further increases in wet-season (June-September) river flow, resulting in elevated water color, resulted in decreasing primary production at the three most highly riverine influenced salinities.

3) Carbon uptake often then increased slightly again at the end of the wet-season, during periods when water color was declining and nutrients were available. Primary production rates from this point slowly declined with seasonally cooler water temperatures.

4) Overall, primary production rates were generally the lowest in the freshwater zone (0 o/oo), and highest at the two intermediate salinities. Both long-term and seasonally, carbon uptake at the highest salinity zone (20 o/oo) displayed relatively little of the variability apparent at the three more riverine influenced zones.

Estimates of phytoplankton biomass, measured as chlorophyll a, both long-term and seasonally at each of the four salinity zones, are presented in Figures 3.20(a), (b) and 3.21. Phytoplankton biomass often serves as a better integration of long-term growth potential when compared to productivity measurements, which are more indicative of short-term interactions of nutrient 'availability' and the ephemeral influences of physical and biological factors. Nevertheless, chlorophyll a levels measured during the eight years of study generally have been observed to respond to Peace River flow and followed the same seasonal trends previously described for carbon uptake. Of note, however, were the unusually very high levels of chlorophyll a observed first at 12 o/oo and then the following month at 20 o/oo in the fall of 1989, which were not as dramatically apparent in corresponding measurements of phytoplankton carbon uptake. This observation both

FIGURE 3.2?(A)

CHARLOTTE HARBOR 1983 – 1991

Chlorophyll a

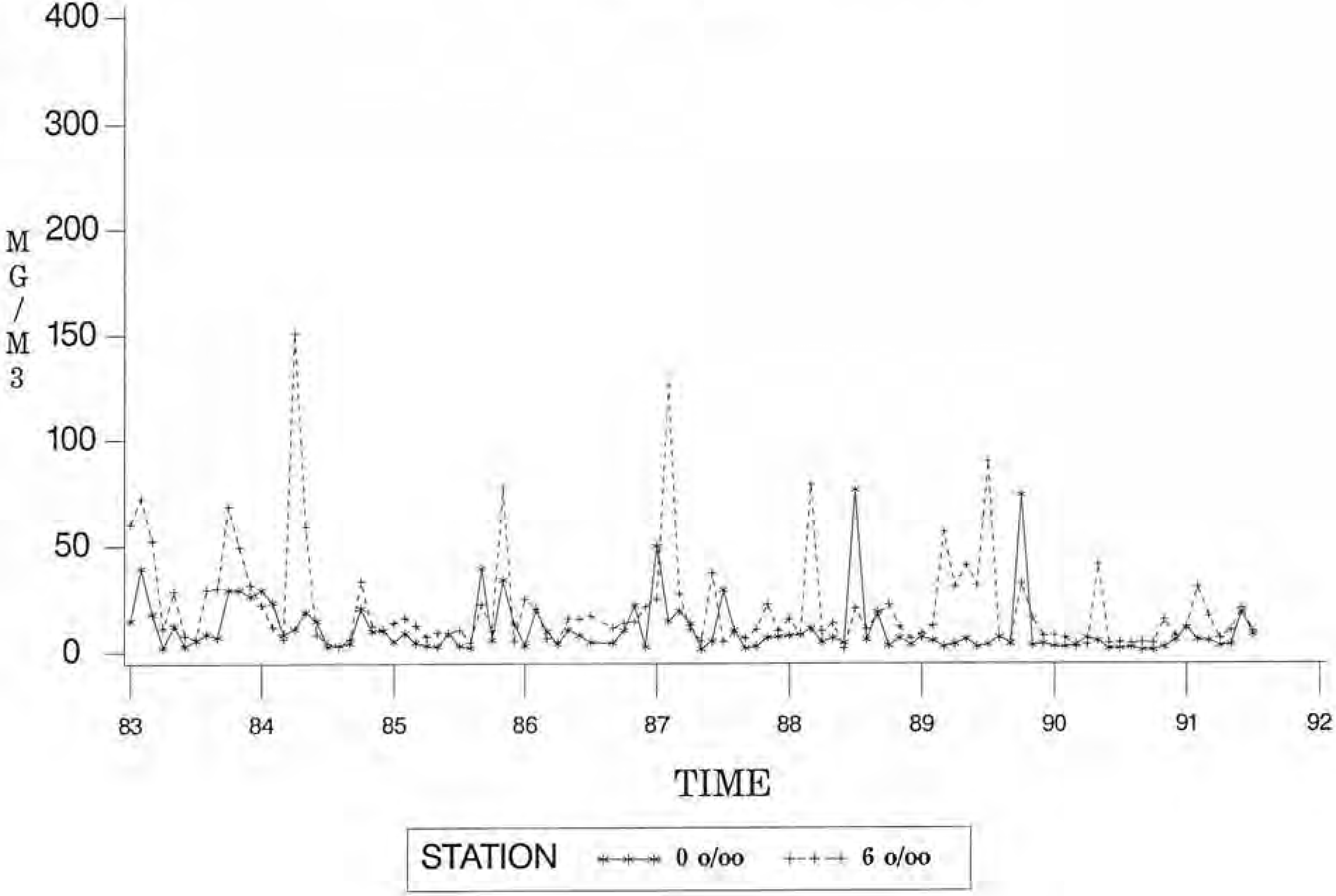


FIGURE 3.20(b)

CHARLOTTE HARBOR 1983 – 1991

Chlorophyll a

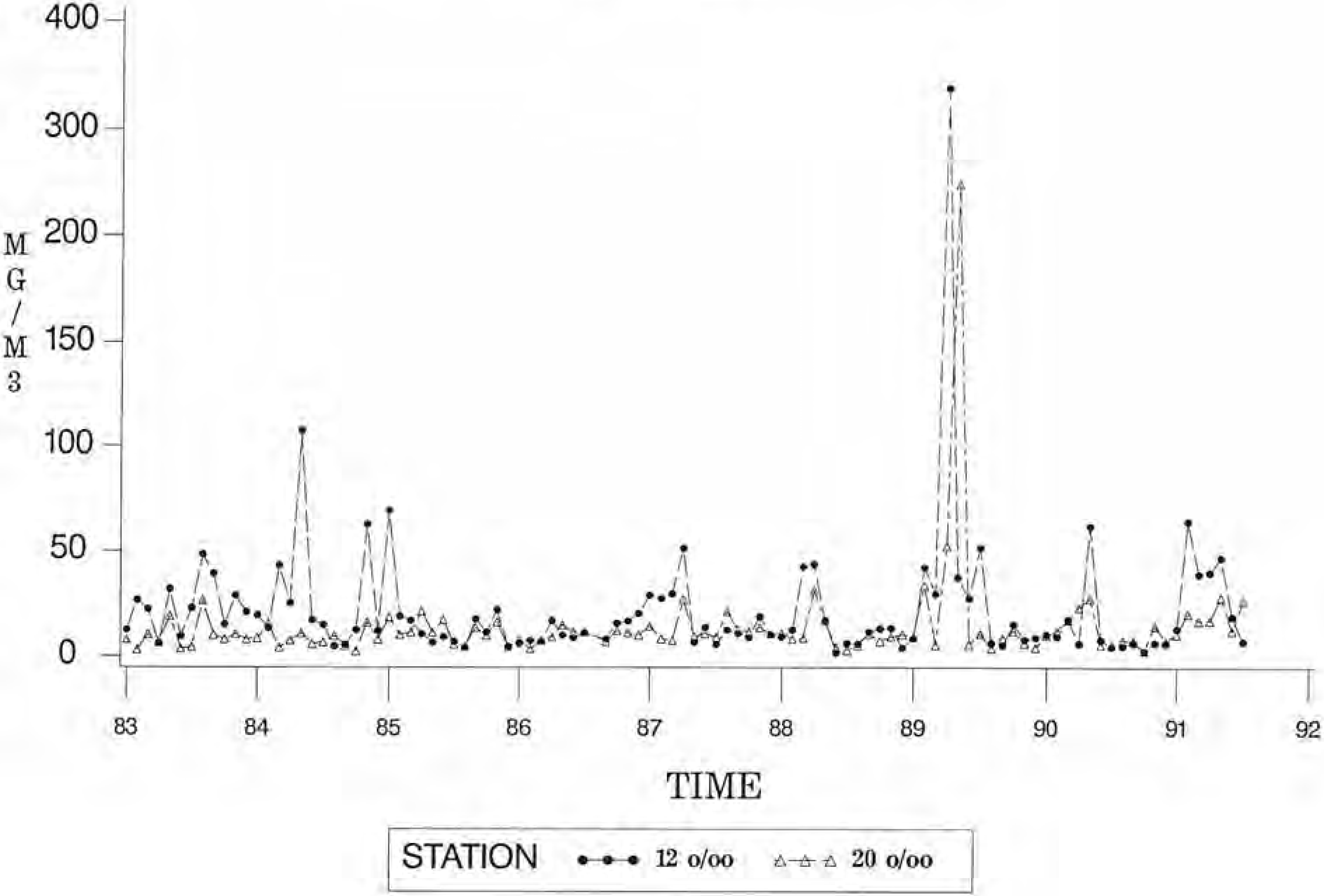
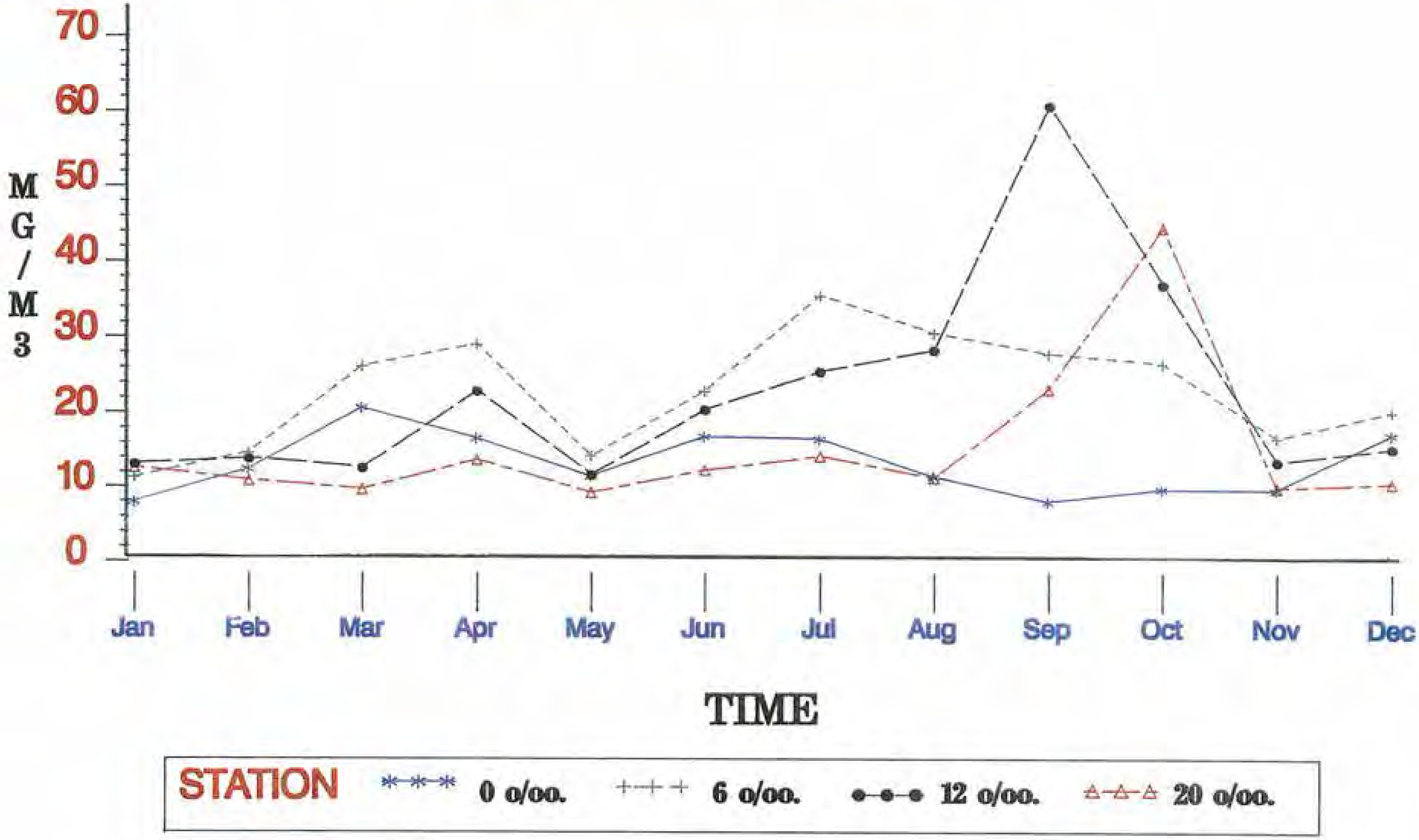


FIGURE 3.21

CHARLOTTE HARBOR 1983 – 1991

Monthly Means – Chlorophyll a



demonstrates the progressive movement of a phytoplankton bloom between salinity zones within the estuary, and sometimes weak relationship between phytoplankton biomass and production.

3.3.3 Size Fraction Determinations

In both areal and seasonal studies of phytoplankton primary productivity, knowledge of the relative distribution of production within phytoplankton size fractions provides important information to both phytoplankton community structure as well as potential patterns of energy flow to primary consumers, such as zooplankton and filter feeders. The importance of segmenting measured phytoplankton production and biomass estimates by relative size fractions has been emphasized in a number of other estuarine studies, primarily in temperate systems. While the terminologies and size ranges applied have varied, with regard to the use of such terms such as ultra-, nano-, micro- and net-, the value of partitioning phytoplankton assemblages into functional groups based on size has been shown both in assessing food-chain value and determining phytoplankton community responses to environmental variables. One premise for the division of phytoplankton assemblages into size based functional groupings is the supposition that smaller cell with their intrinsically higher surface to volume ratios should also have higher rates of photosynthesis and nutrient uptake under limiting conditions. Overall rates of primary production (as mg Carbon Uptake/m3/Einstein) and chlorophyll a (mg/m3), indicating the relative contributions of phytoplankton within each of three measured size ranges:

1) the fraction >20 um

2) the fraction <20 um and >5 um

3) the fraction >5 um,

are depicted by salinity zone and month for the years 1984 through 1991 in Figures 3.22 through 3.53. Four figures are presented for each year:

1) Carbon Uptake - comparable total amounts for each station and month are depicted by the height of the bar with the measured value being given beneath. The relative contributions are shown by the patterns for each size fraction.

2) Percent Carbon Uptake - in each instance the height of the bar equals 100%, with the patterns depicting the relative percent of the total contributed by each size fraction.

3) Chlorophyll a - comparable total amounts for each station and month are depicted by the height of the bar with the measured value being given beneath. The relative contributions are shown by the patterns for each size fraction.

4) Percent Chlorophyll a - in each instance the height of the bar equals 100%, with the patterns depicting the relative percent of the total contributed by each size fraction.

These figures of the distribution of phytoplankton production and biomass among the size fractions measured exhibit the following patterns:

1) At each of the salinity zones, both production and biomass measurements were generally dominated by the smallest size fraction (<5 um).

2) In spite of the above generalization, in many instances larger phytoplankton either comprised a significant portion or dominated the community structure. Qualitative microscopic investigations indicated that at the two intermediate salinity zones dinoflagellate blooms were often associated with such conditions. At the highest salinity zones, increased production and biomass in the largest size fraction was usually indicative of large numbers of diatoms, with specific taxonomic groups being seasonally important.

3) Although the relative distributions of both carbon uptake and chlorophyll

FIGURE 3.22
CARBON UPTAKE (mgC/m3/Einstein), BY DATE AND STATION
1984

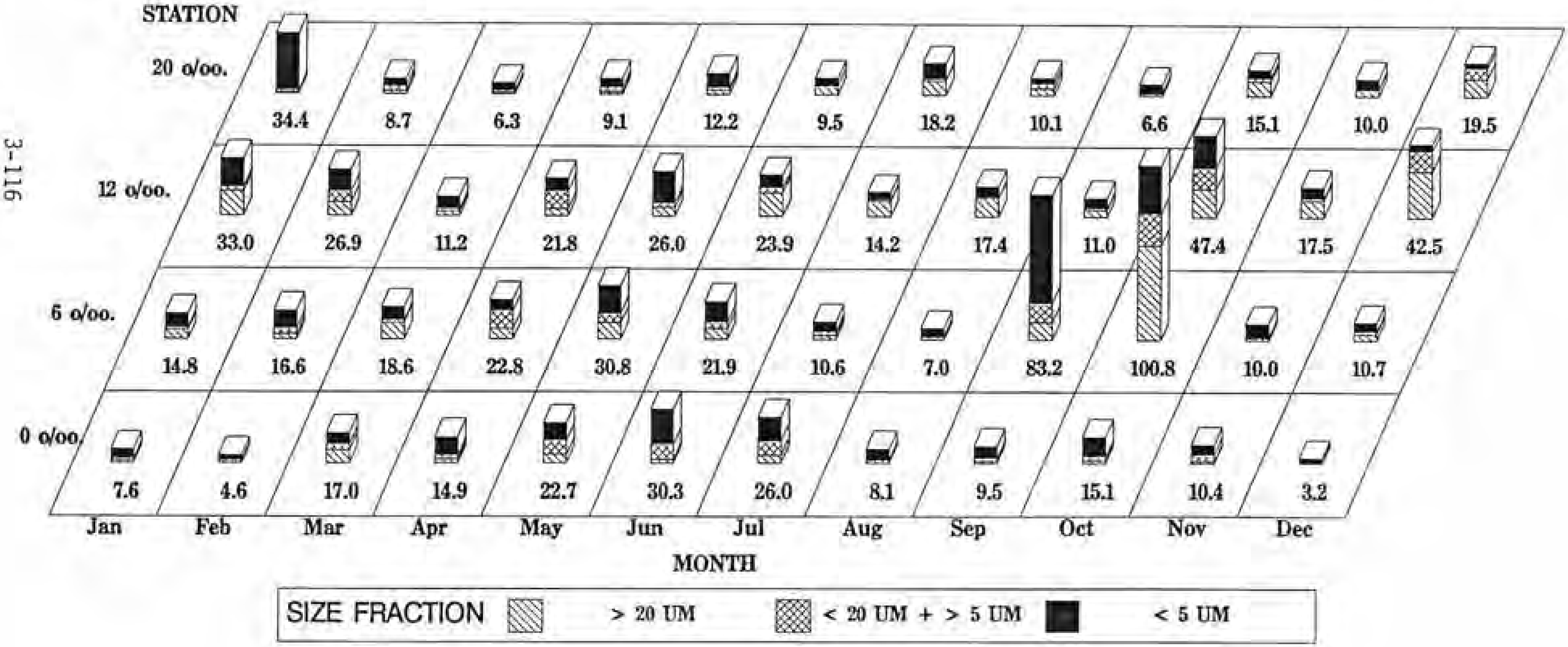


FIGURE 3.23

PERCENT CARBON UPTAKE AMONG SIZE FRACTIONS, BY DATE AND STATION

1984

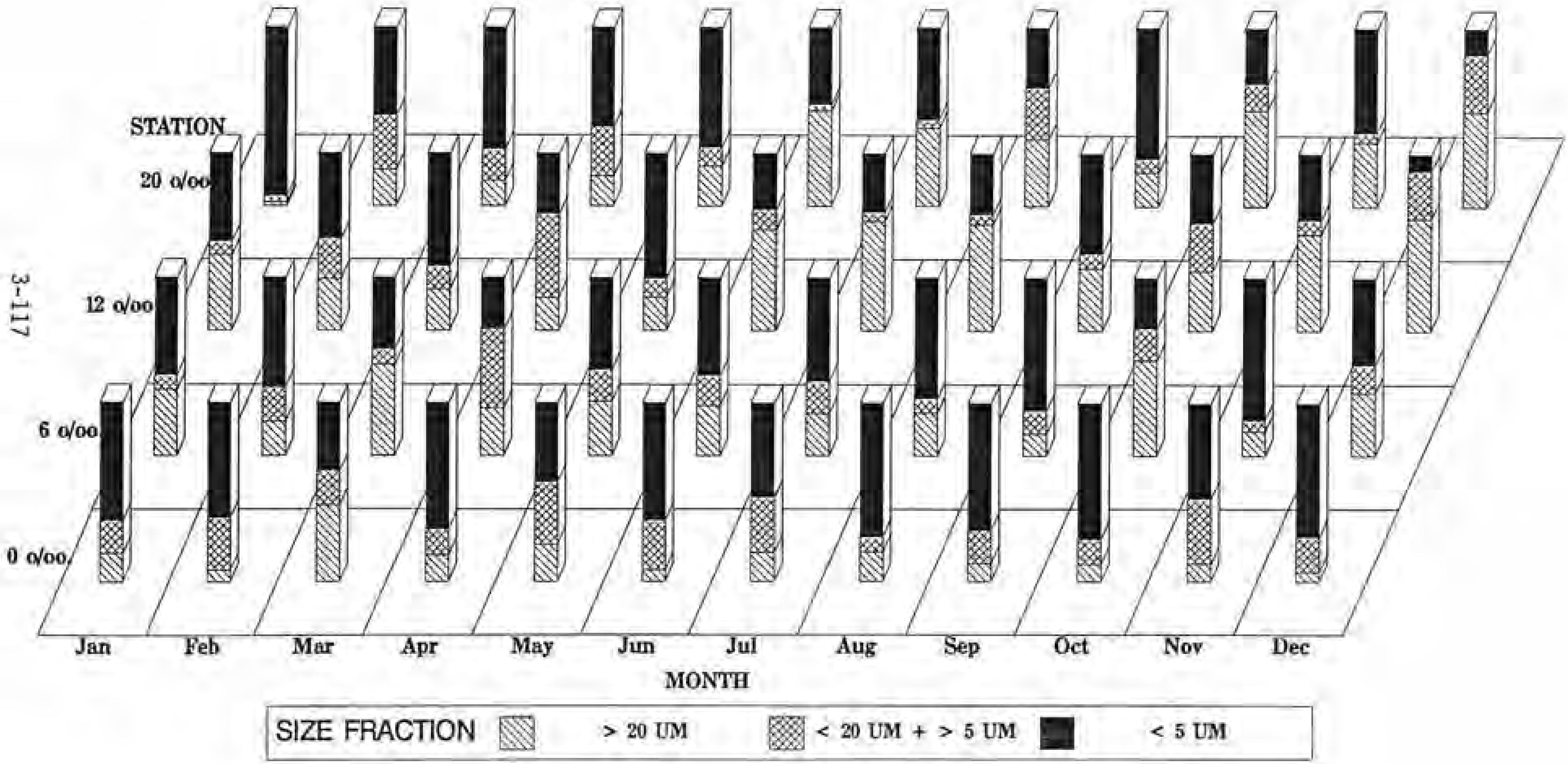


FIGURE 3.24
CHLOROPHYLL a (MG/M3), BY MONTH AND STATION
1984

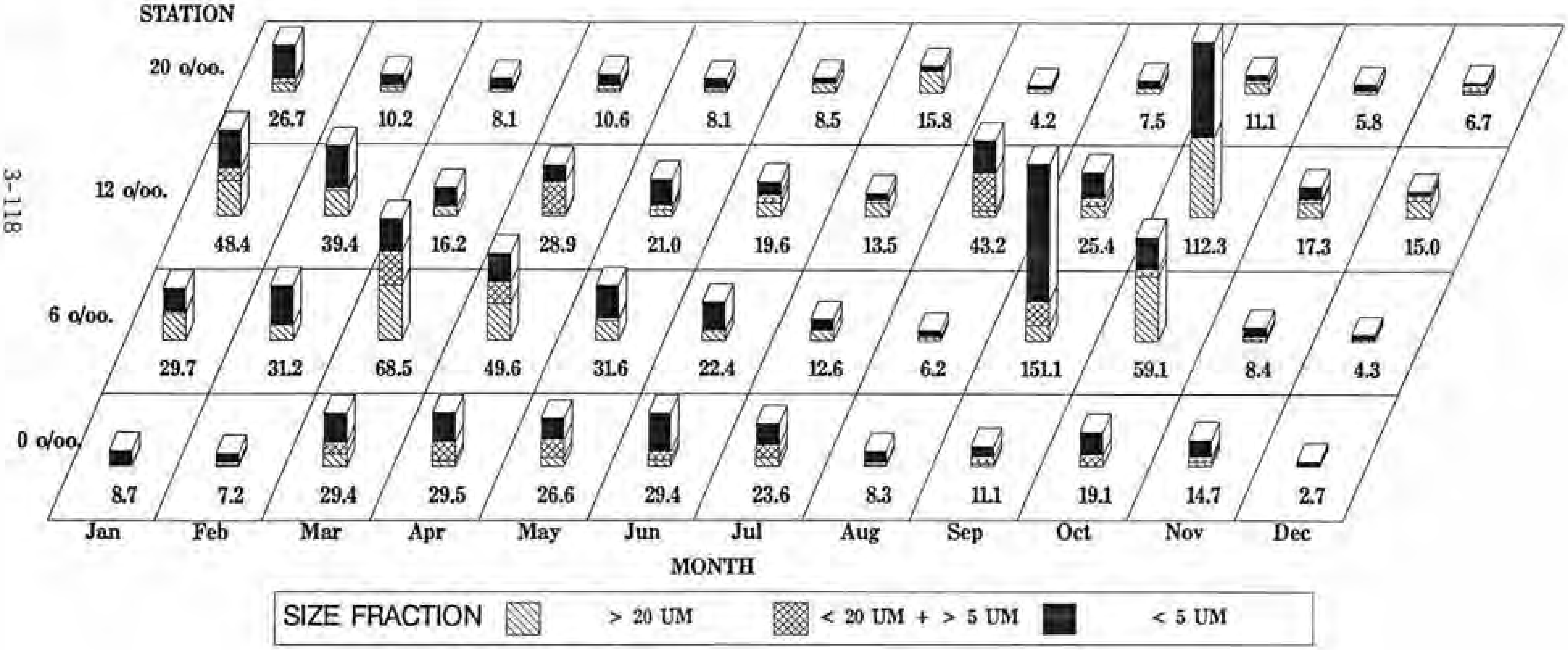


FIGURE 3.25
PERCENT CHLOROPHYLL a AMONG SIZE FRACTIONS, BY MONTH AND STATION
1984

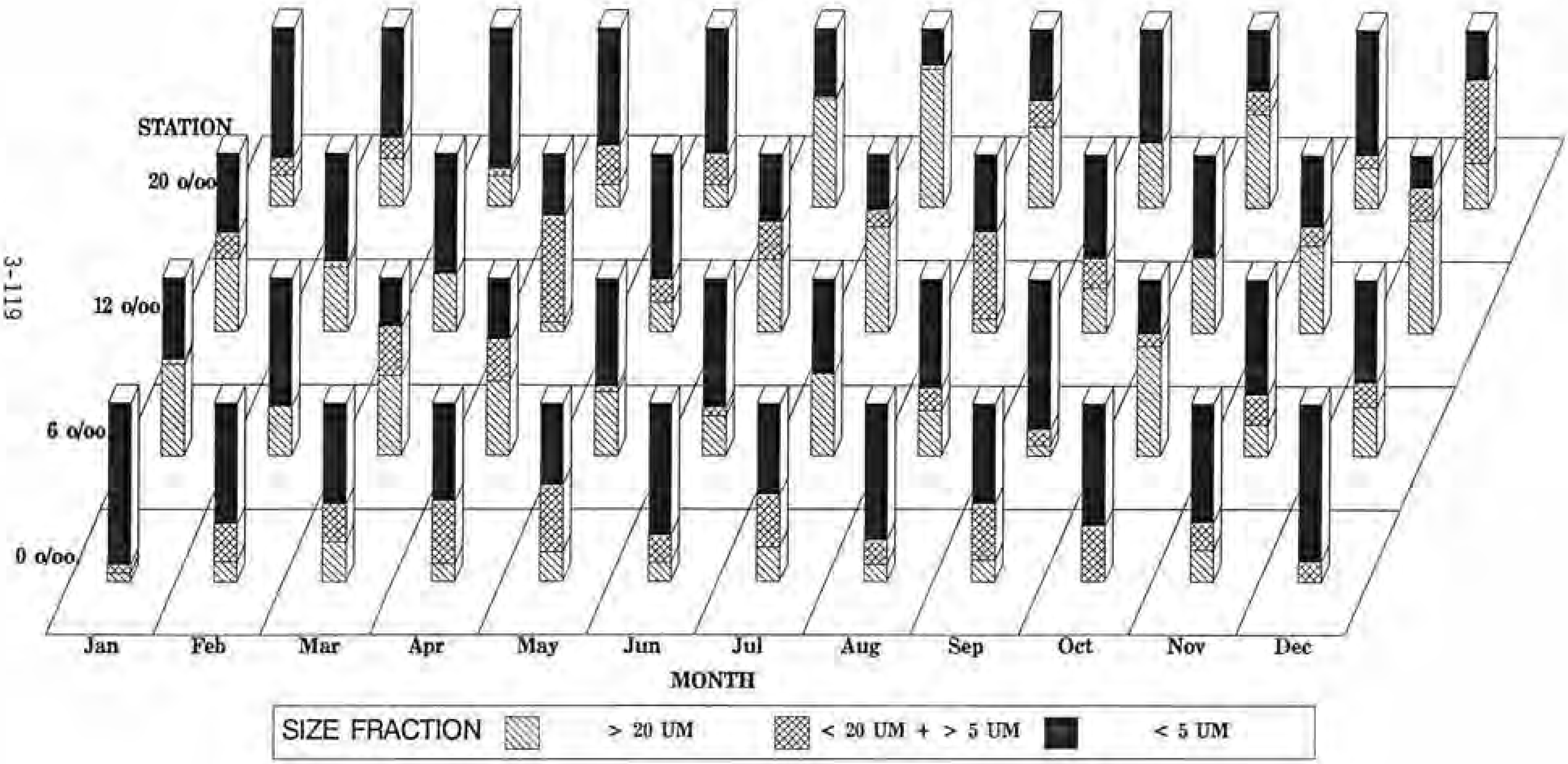


FIGURE 3.26
CARBON UPTAKE (mgC/m3/Einstein), BY DATE AND STATION
1985

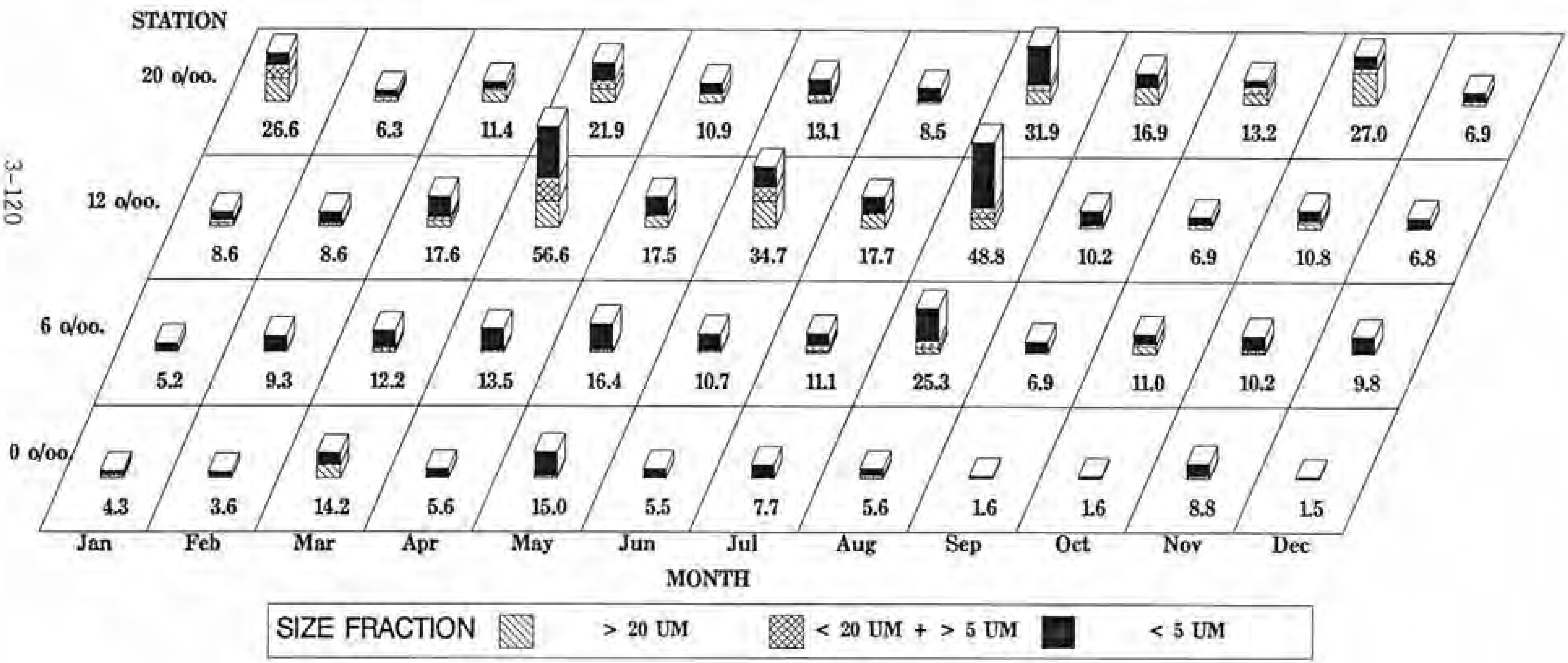


FIGURE 3.27
PERCENT CARBON UPTAKE AMONG SIZE FRACTIONS, BY DATE AND STATION
1985

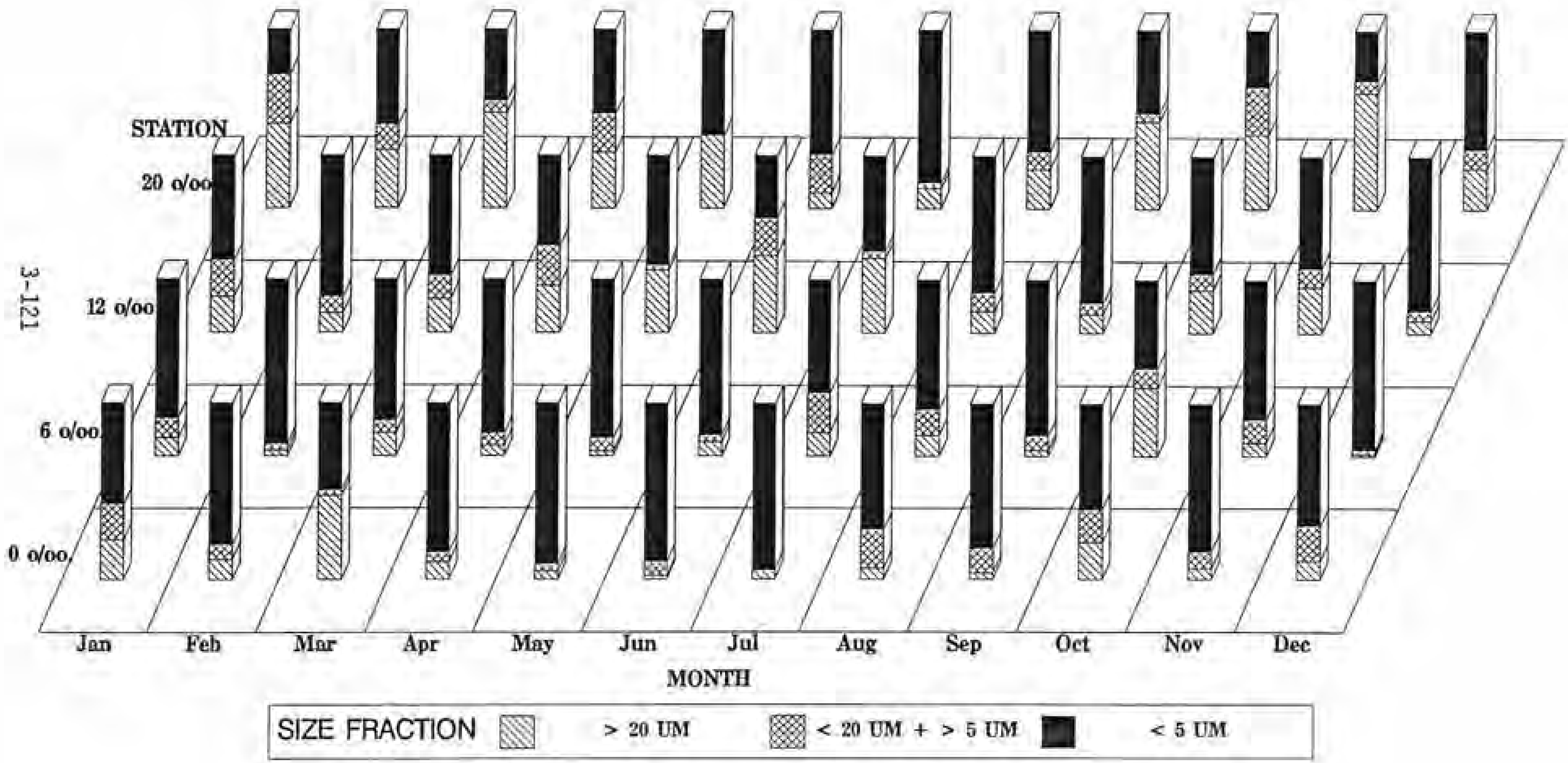


FIGURE 3.28

CHLOROPHYLL a (MG/M3), BY MONTH AND STATION

1985

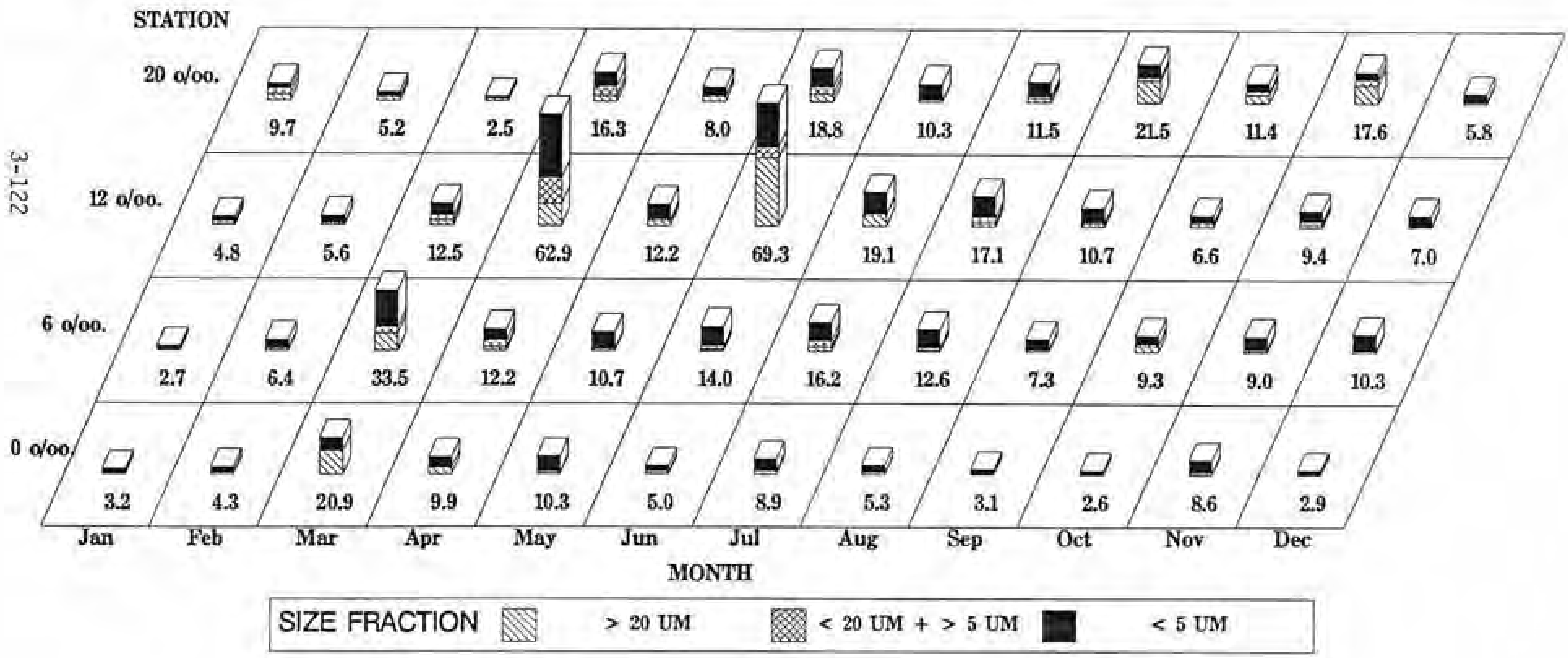


FIGURE 3.29
PERCENT CHLOROPHYLL a AMONG SIZE FRACTIONS, BY MONTH AND STATION
1985

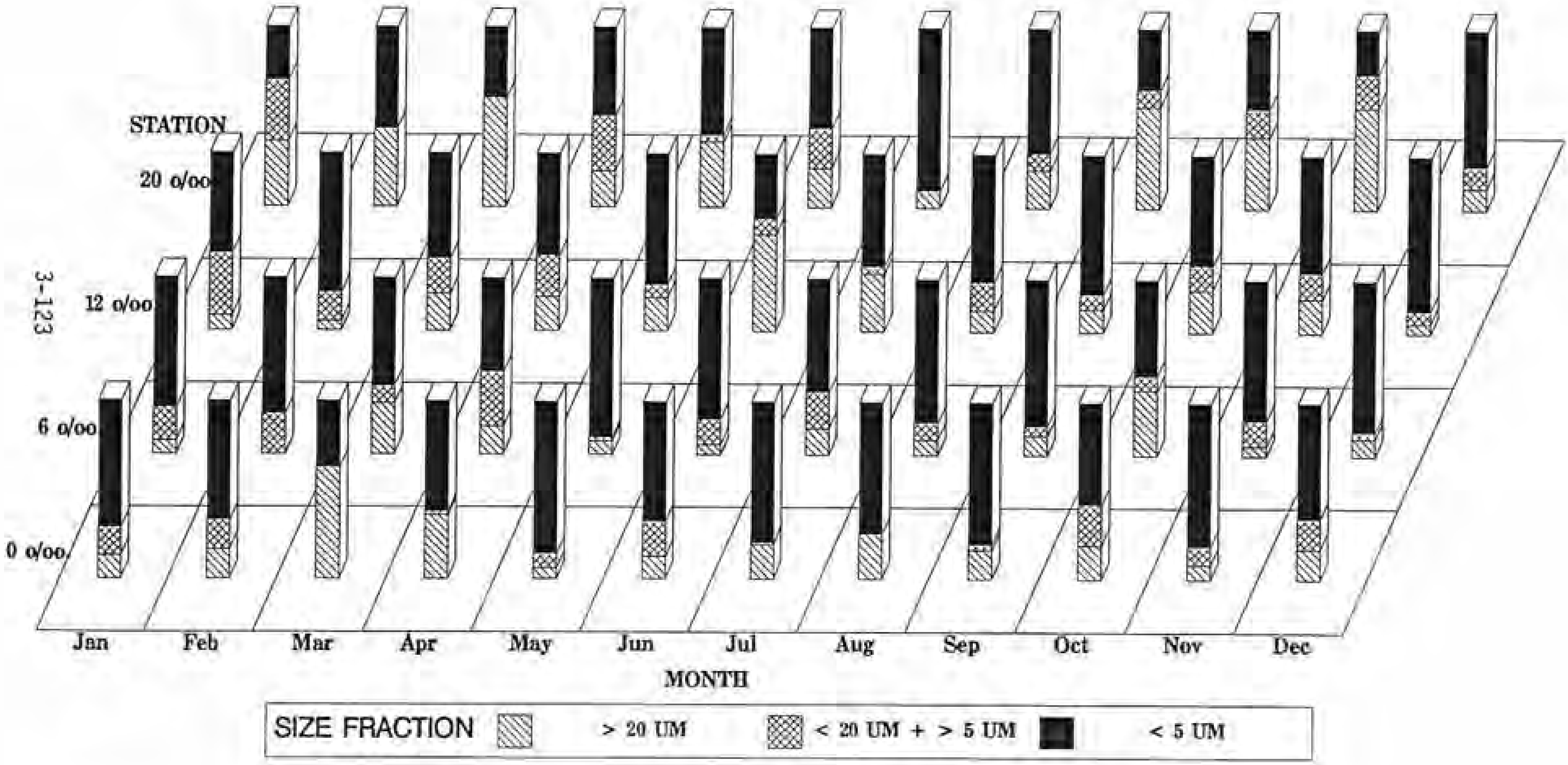


FIGURE 3.30

CARBON UPTAKE (mgC/m3/Einstein), BY DATE AND STATION

1986

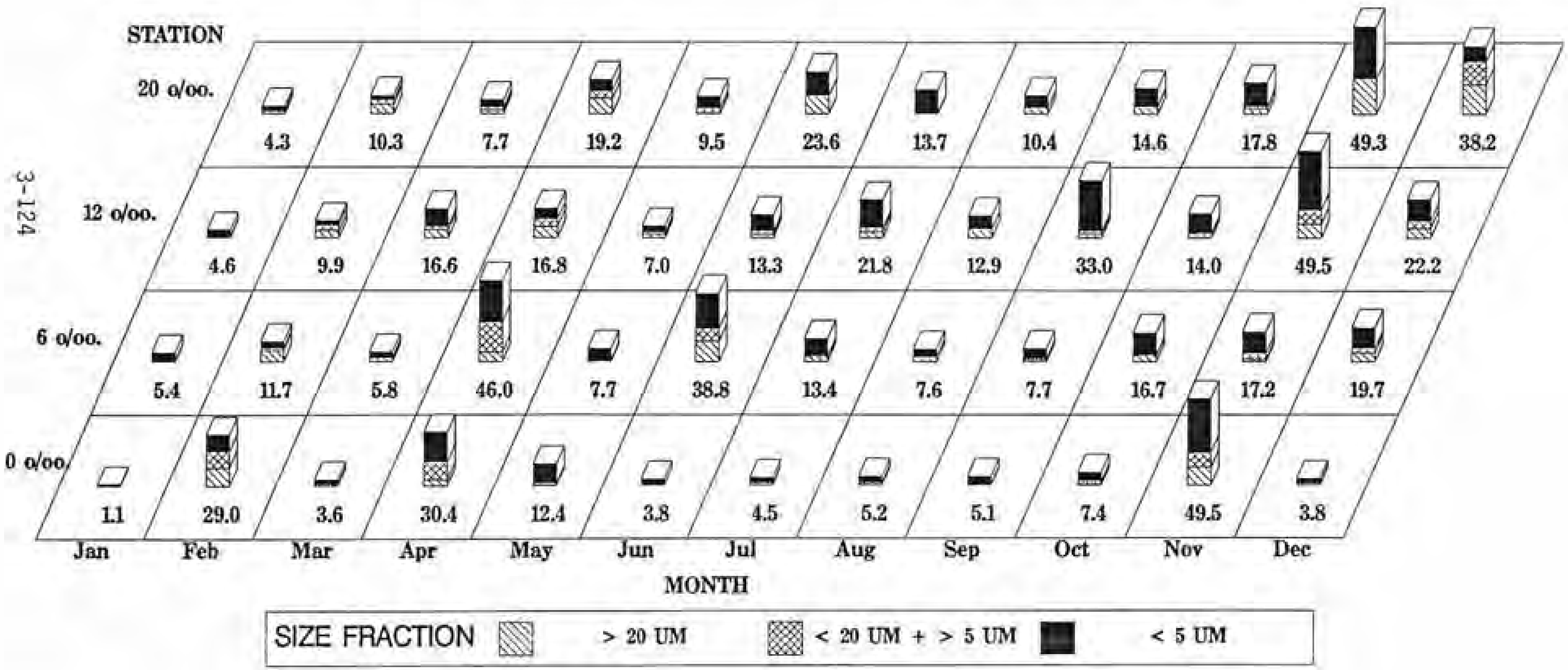


FIGURE 3.31
PERCENT CARBON UPTAKE AMONG SIZE FRACTIONS, BY DATE AND STATION
1986

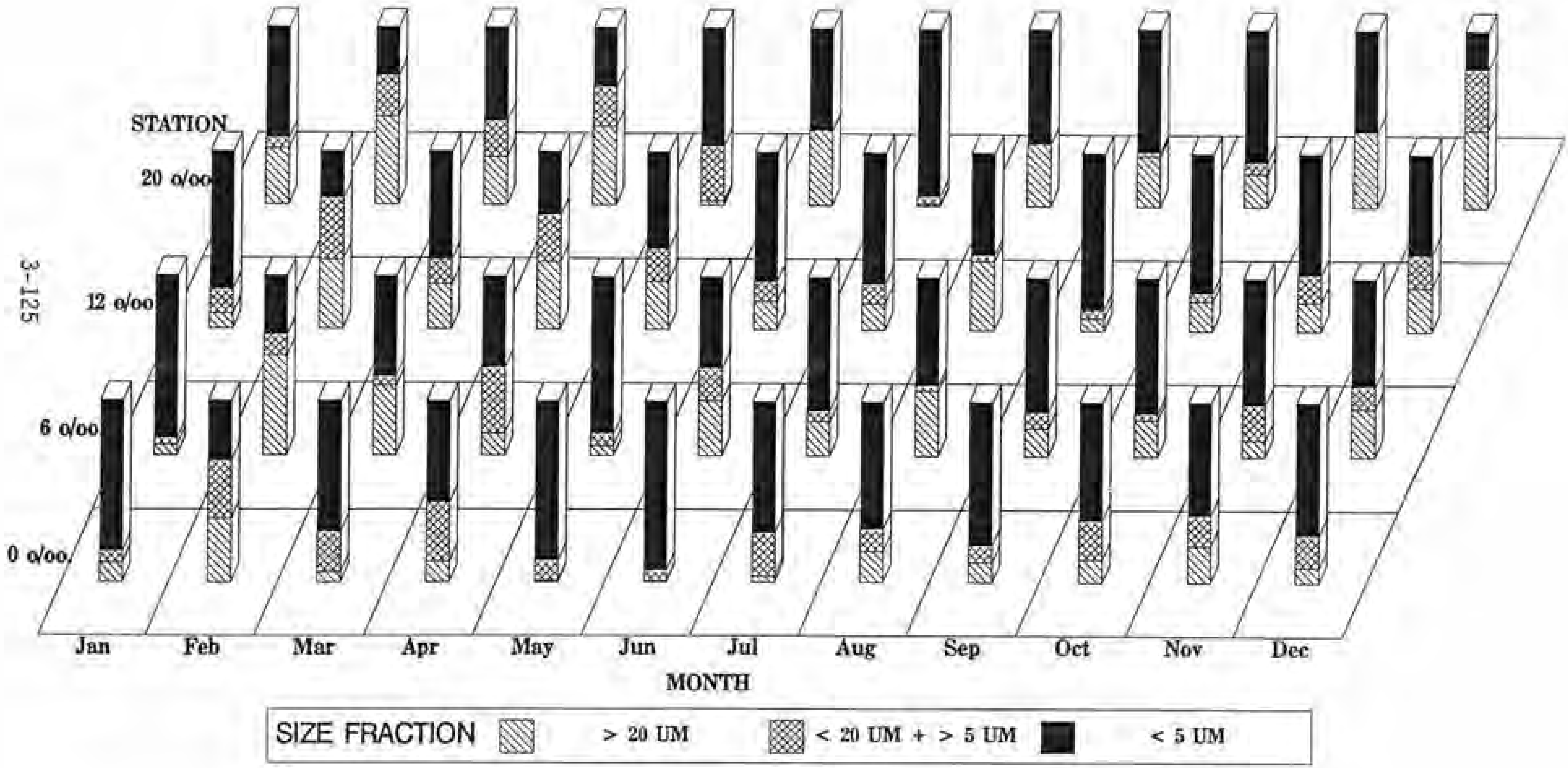


FIGURE 3.32
CHLOROPHYLL a (MG/M3), BY MONTH AND STATION
1986

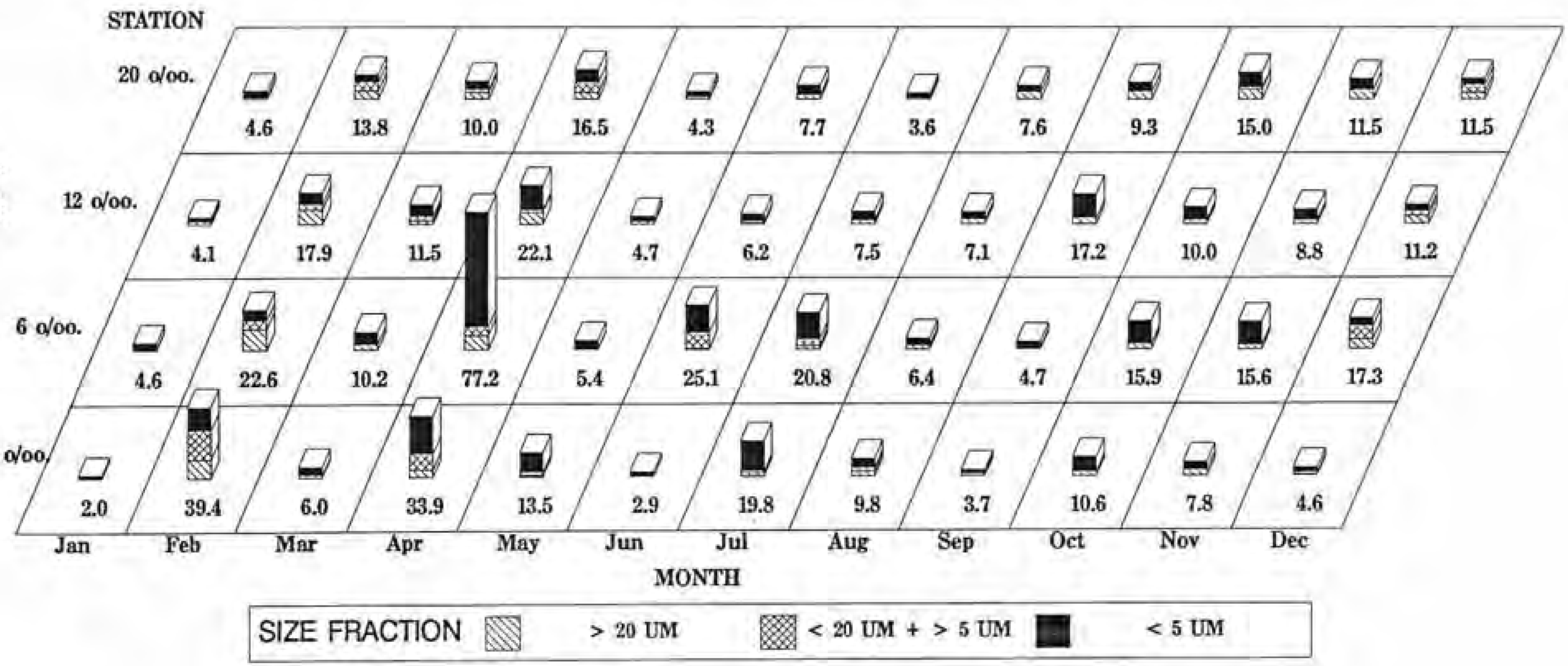


FIGURE 3.33

PERCENT CHLOROPHYLL a AMONG SIZE FRACTIONS, BY MONTH AND STATION

1986

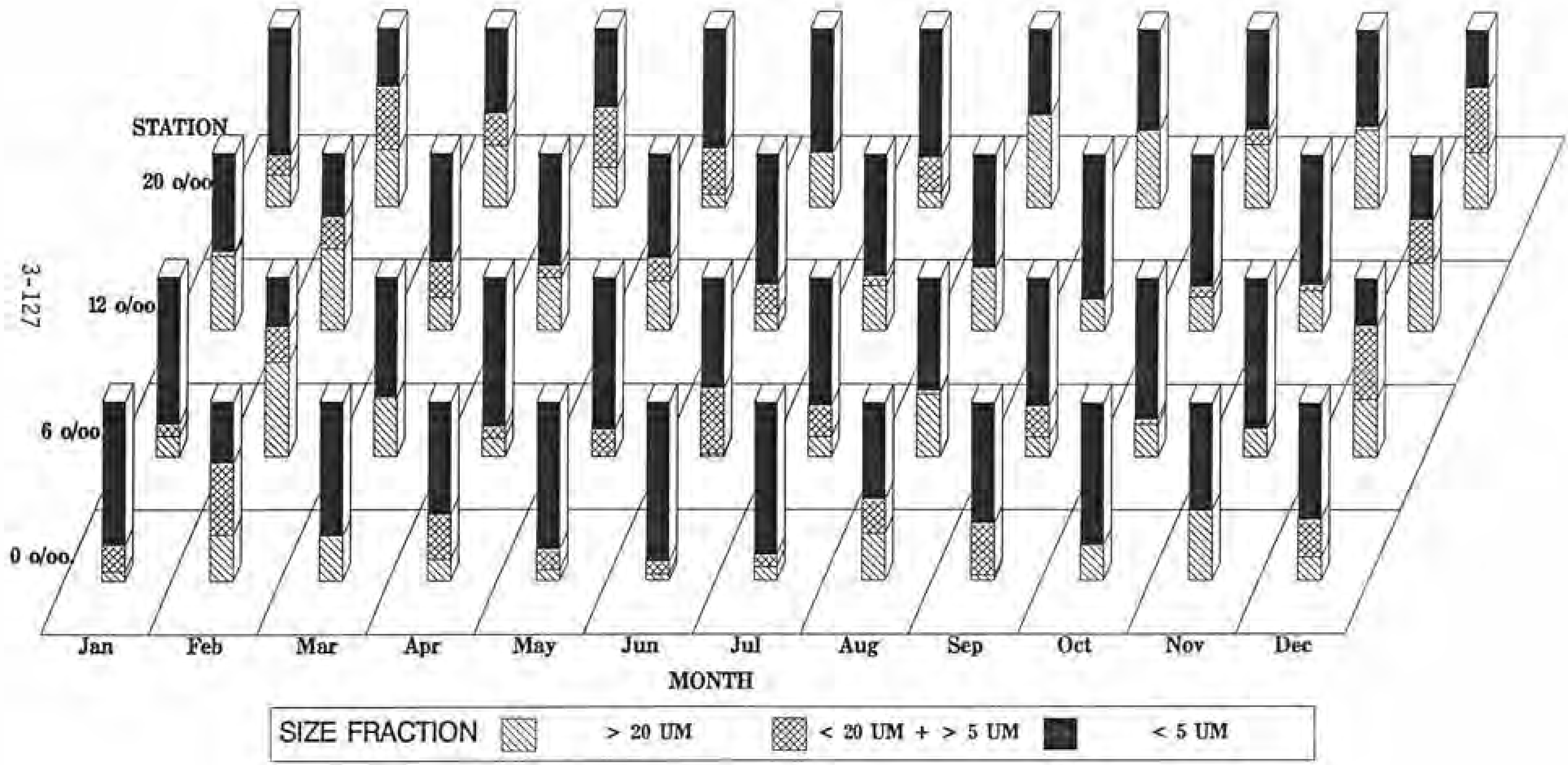


FIGURE 3.34

CARBON UPTAKE (mgC/m3/Einstein), BY DATE AND STATION

1987

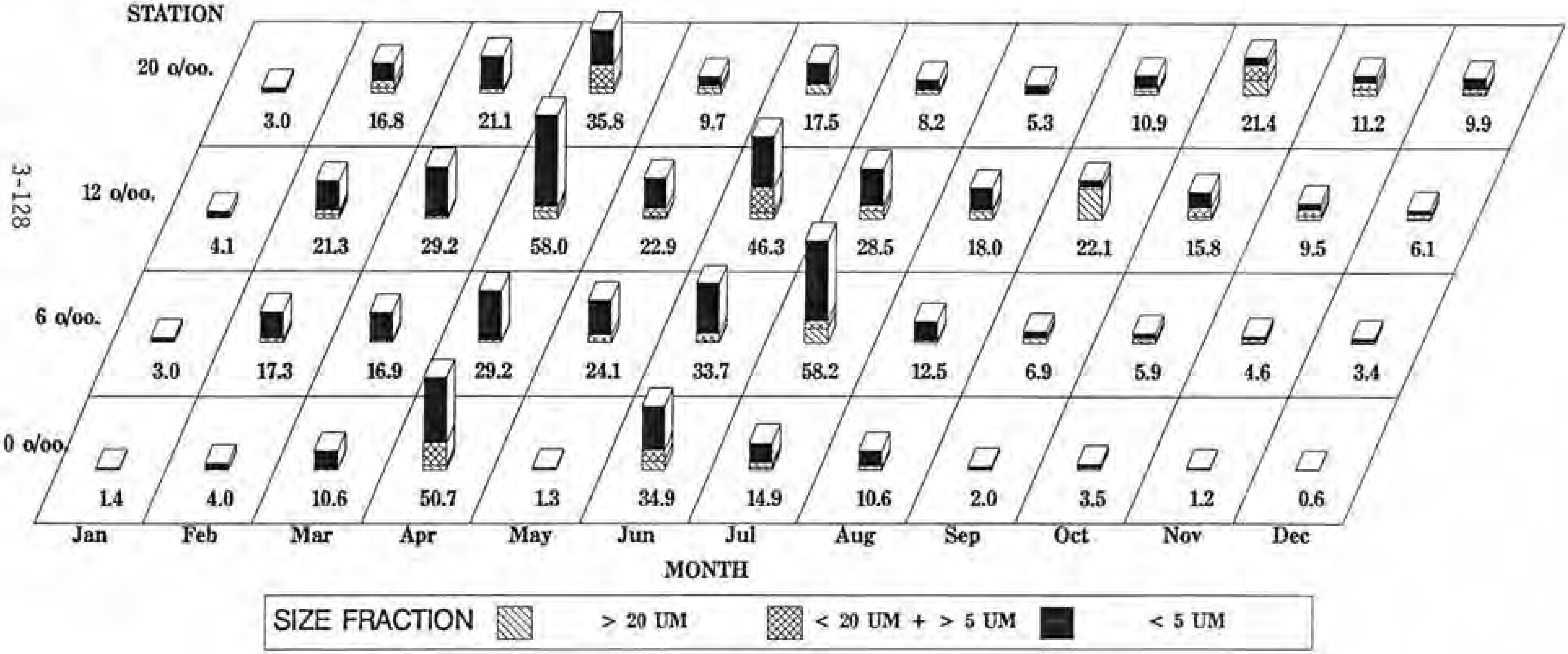


FIGURE 3.35
PERCENT CARBON UPTAKE AMONG SIZE FRACTIONS, BY DATE AND STATION
1987

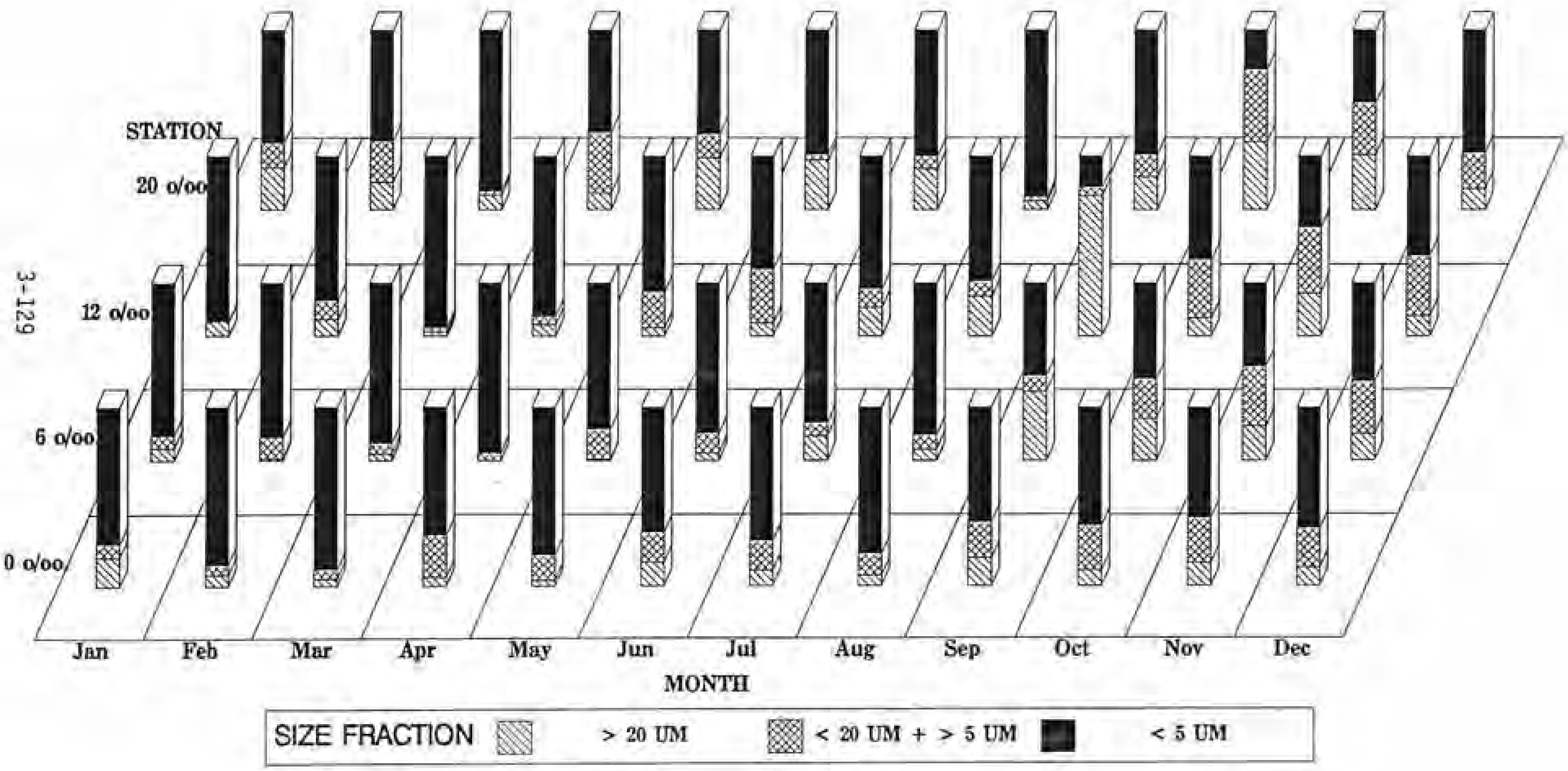


FIGURE 3.36
CHLOROPHYLL a (MG/M3), BY MONTH AND STATION
1987

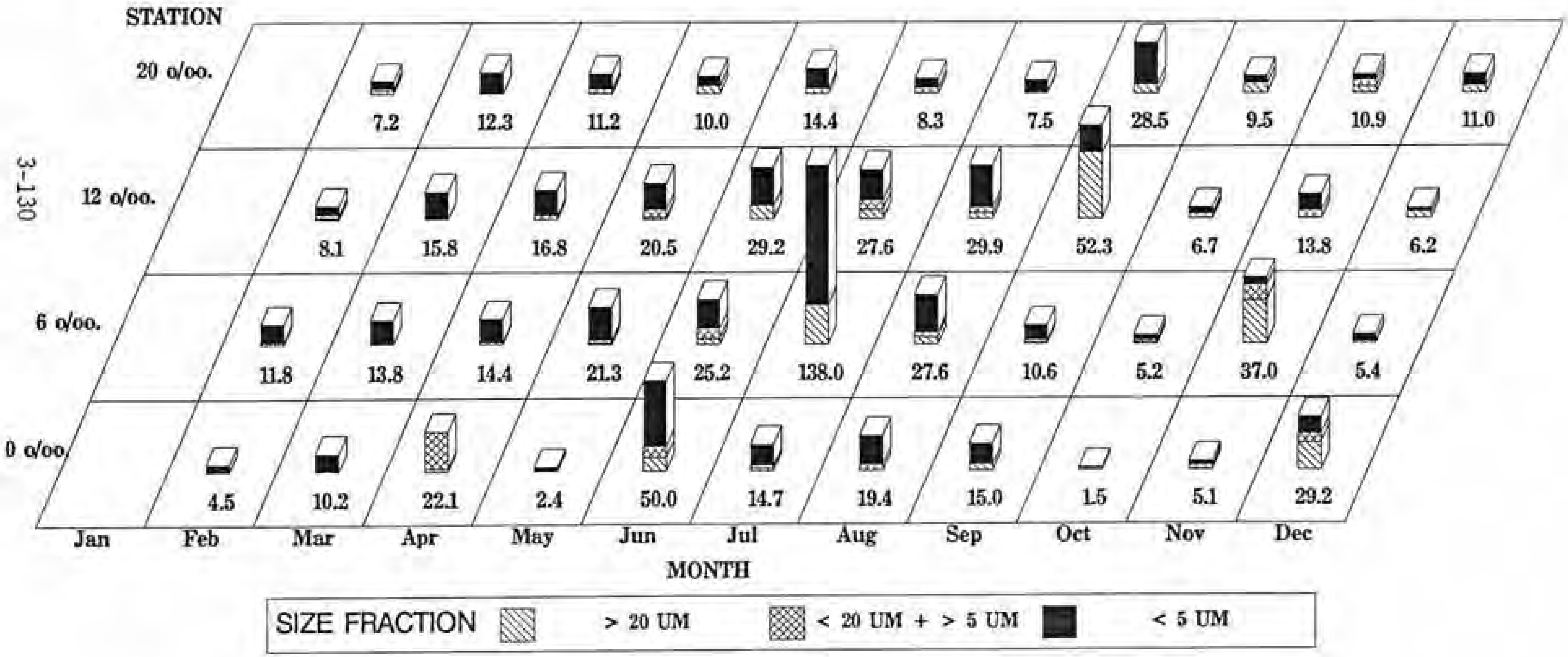


FIGURE 3.37
PERCENT CHLOROPHYLL a AMONG SIZE FRACTIONS, BY MONTH AND STATION
1987

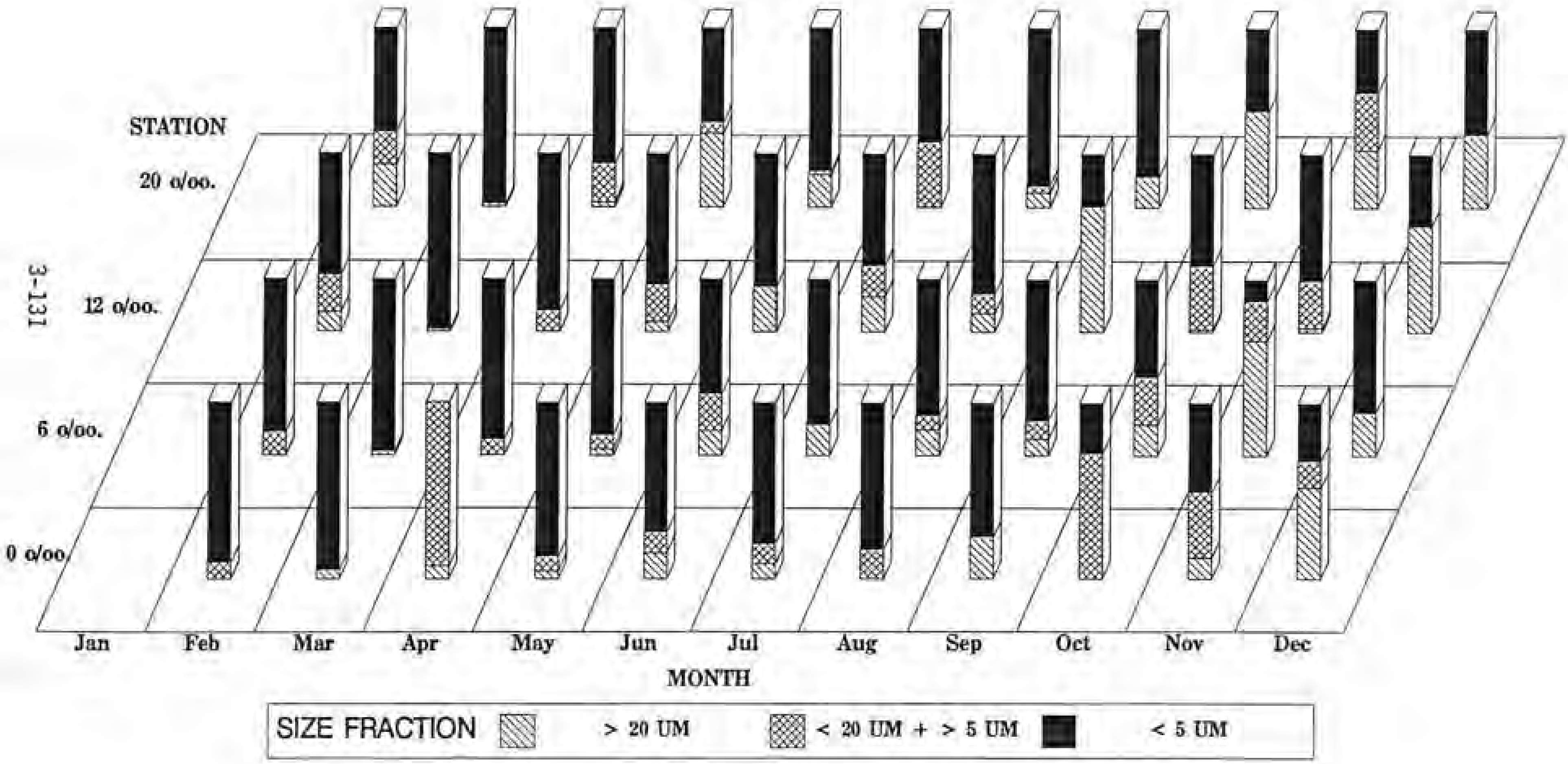


FIGURE 3.3[illegible]

CARBON UPTAKE (mgC/m3/Einstein), BY DATE AND STATION

1988

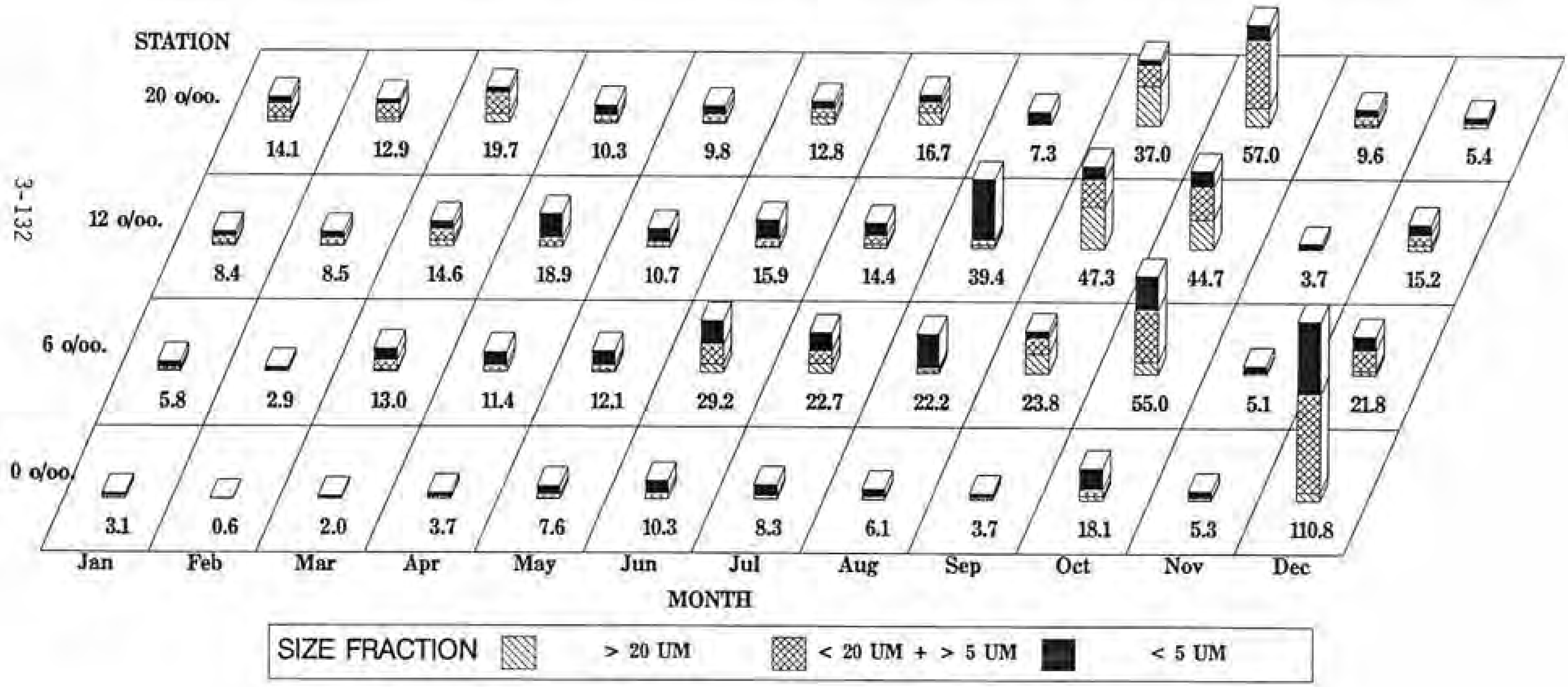


FIGURE 3.39

PERCENT CARBON UPTAKE AMONG SIZE FRACTIONS, BY DATE AND STATION

1988

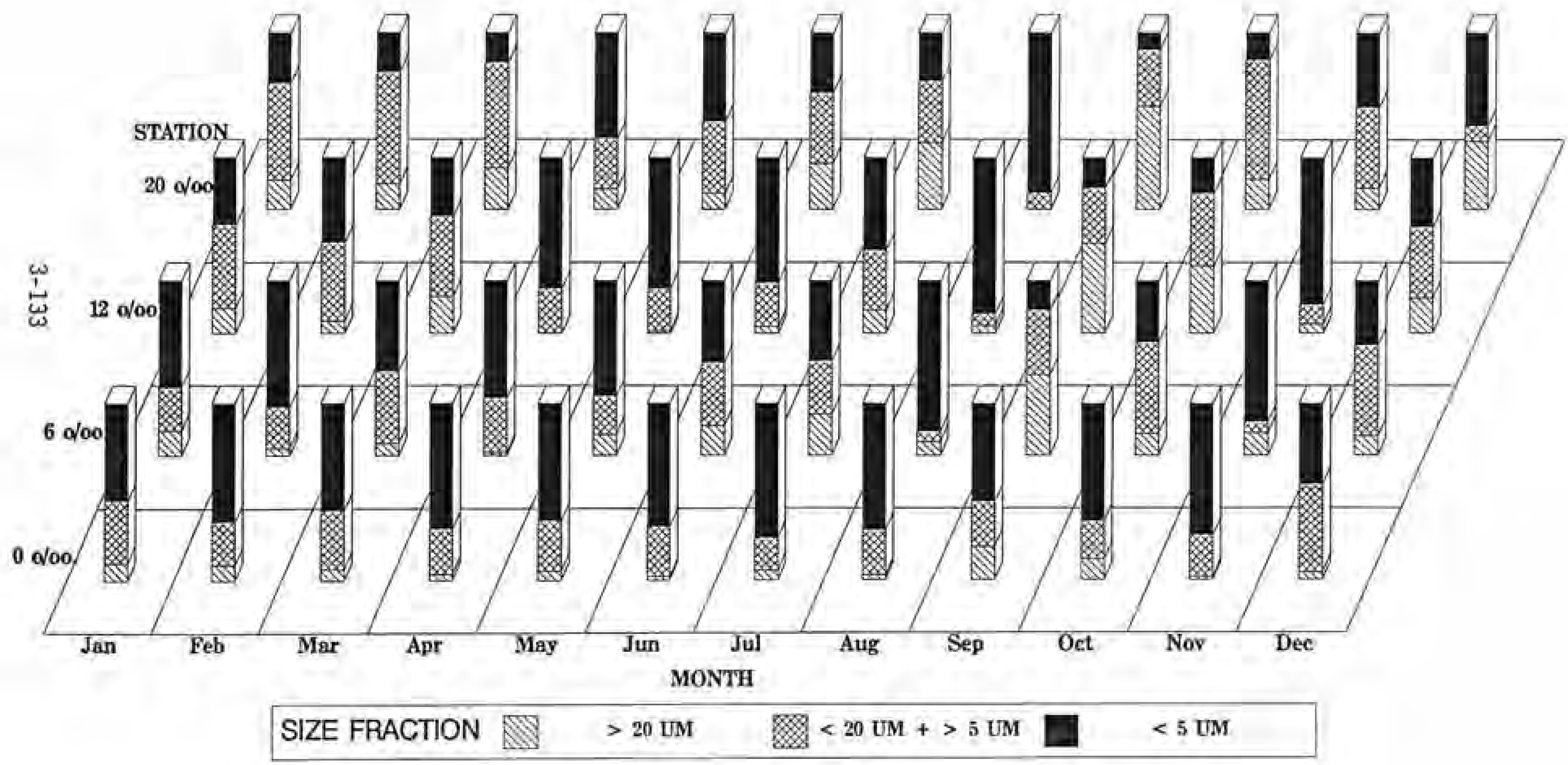


FIGURE 3.40
CHLOROPHYLL a (MG/M3), BY MONTH AND STATION
1988

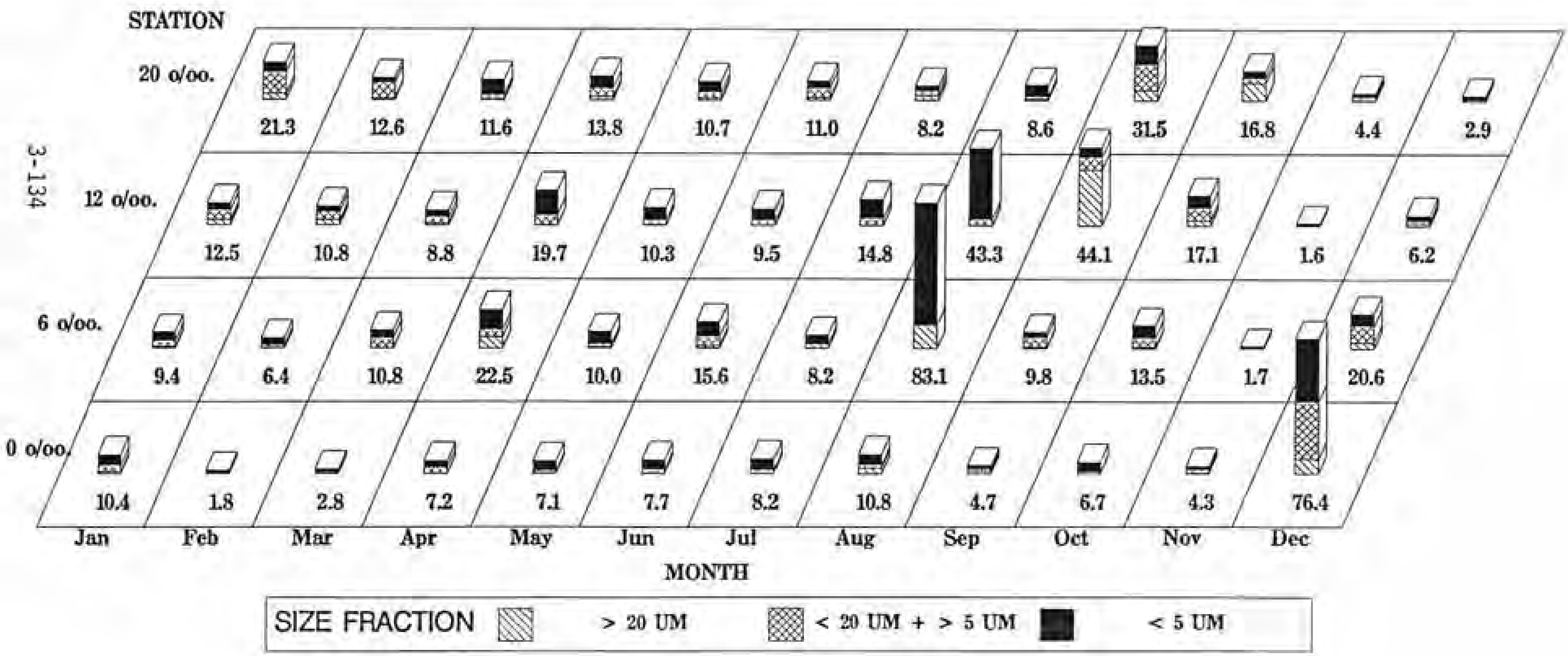


FIGURE 3.41

PERCENT CHLOROPHYLL a AMONG SIZE FRACTIONS, BY MONTH AND STATION

1988

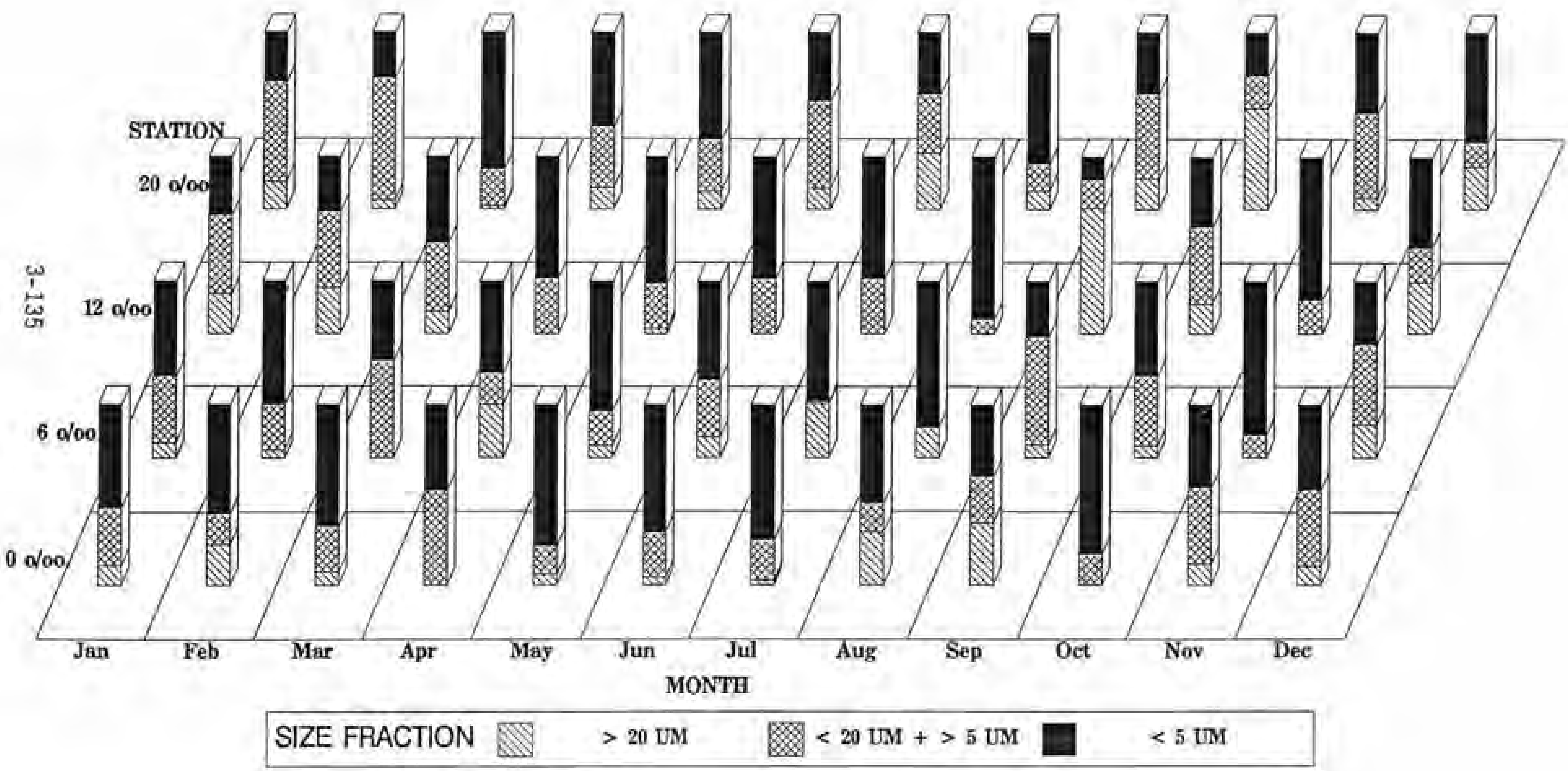


FIGURE 3.42
CARBON UPTAKE (mgC/m3/Einstein), BY DATE AND STATION
1989

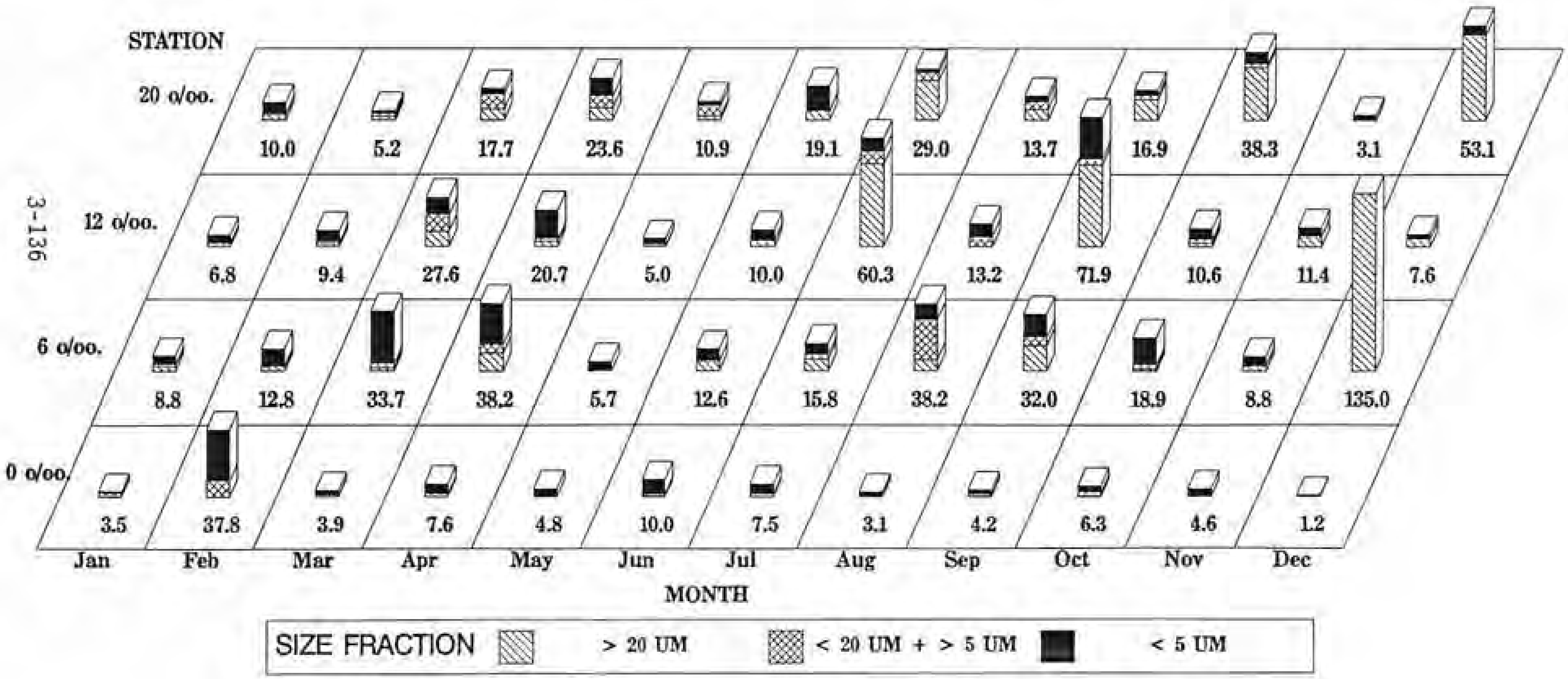


FIGURE 3.43

PERCENT CARBON UPTAKE AMONG SIZE FRACTIONS, BY DATE AND STATION

1989

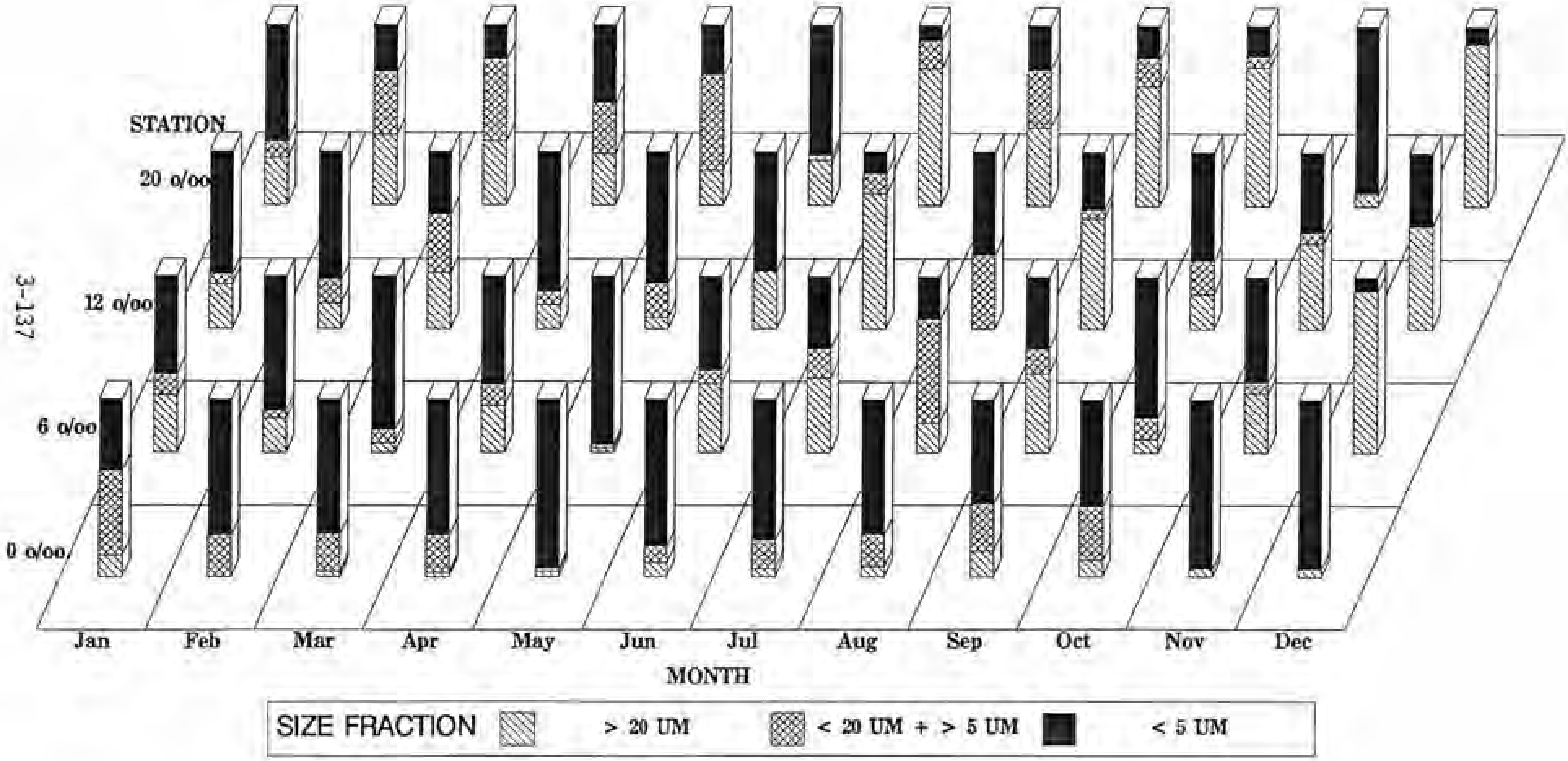


FIGURE 3.4.

CHLOROPHYLL a (MG/M3), BY MONTH AND STATION

1989

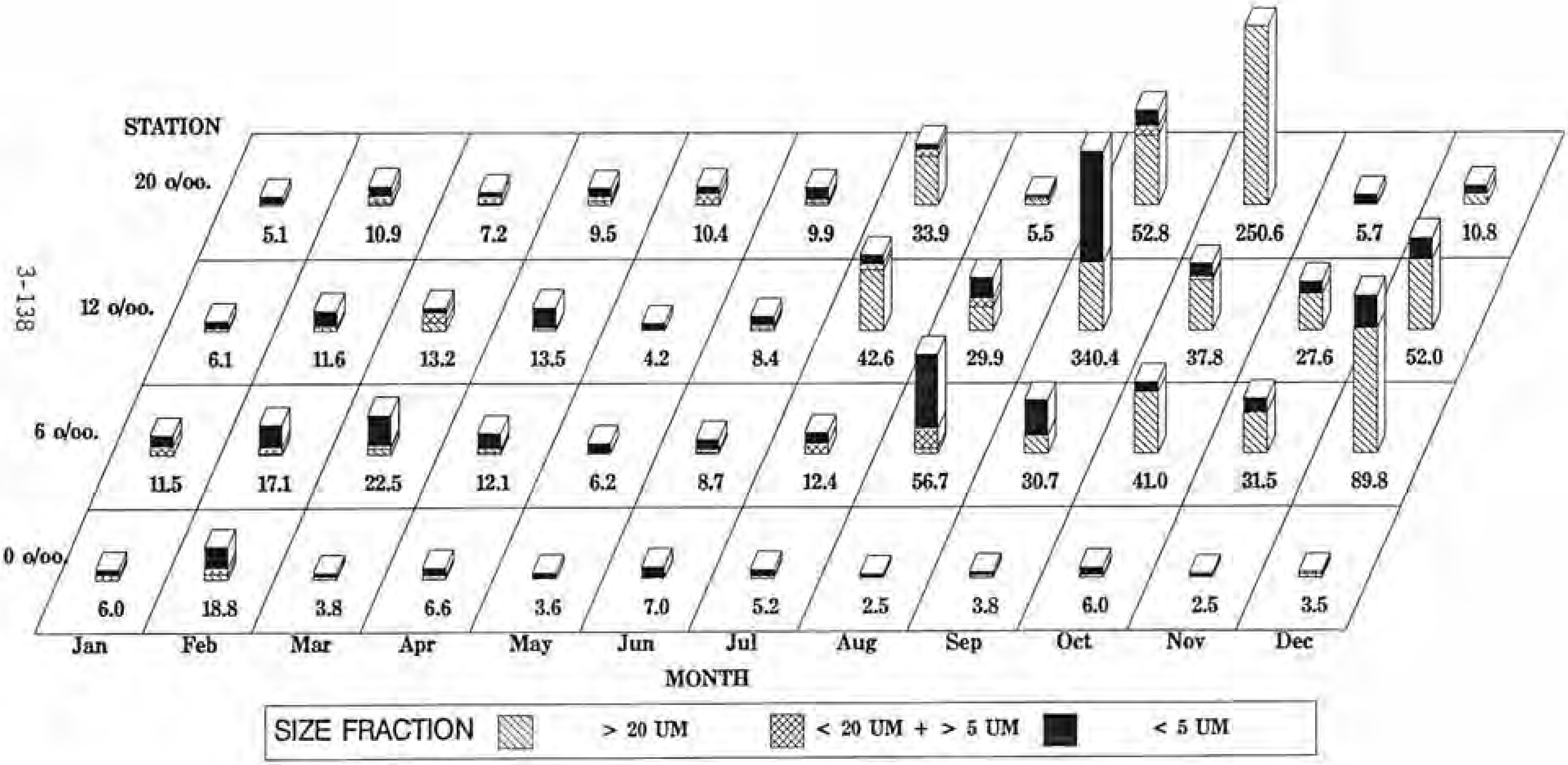


FIGURE 3.45
PERCENT CHLOROPHYLL a AMONG SIZE FRACTIONS, BY MONTH AND STATION
1989

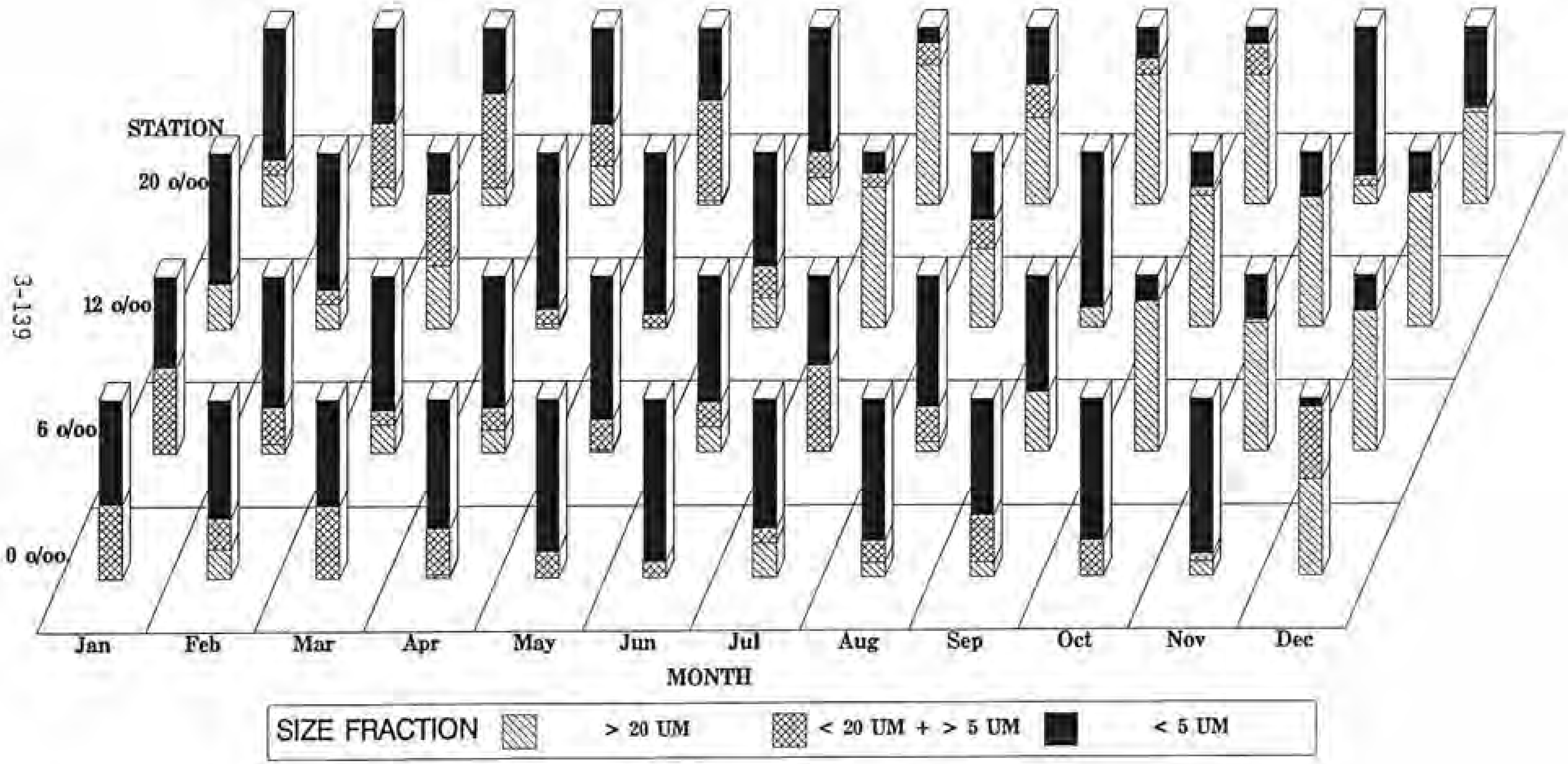


FIGURE 3.46
CARBON UPTAKE (mgC/m3/Einstein), BY DATE AND STATION
1990

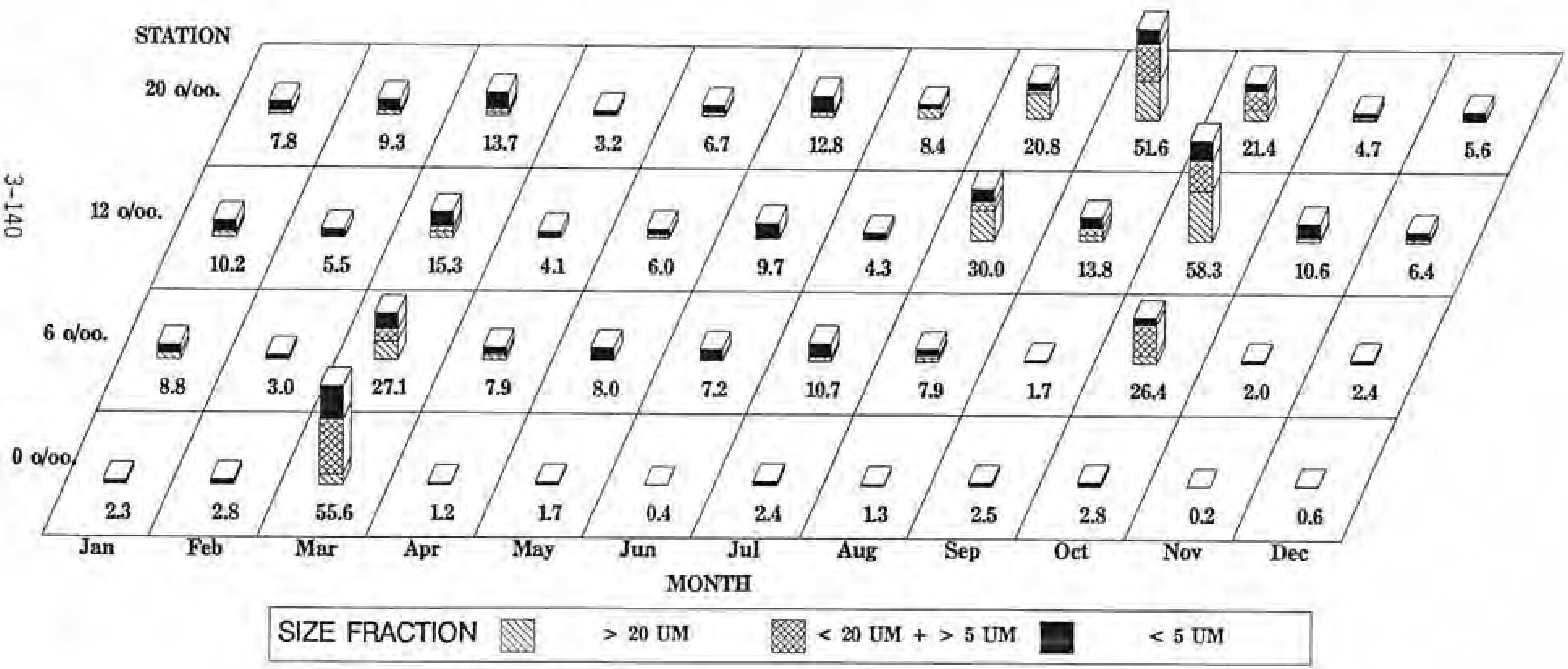


FIGURE 3.47

PERCENT CARBON UPTAKE AMONG SIZE FRACTIONS, BY DATE AND STATION

1990

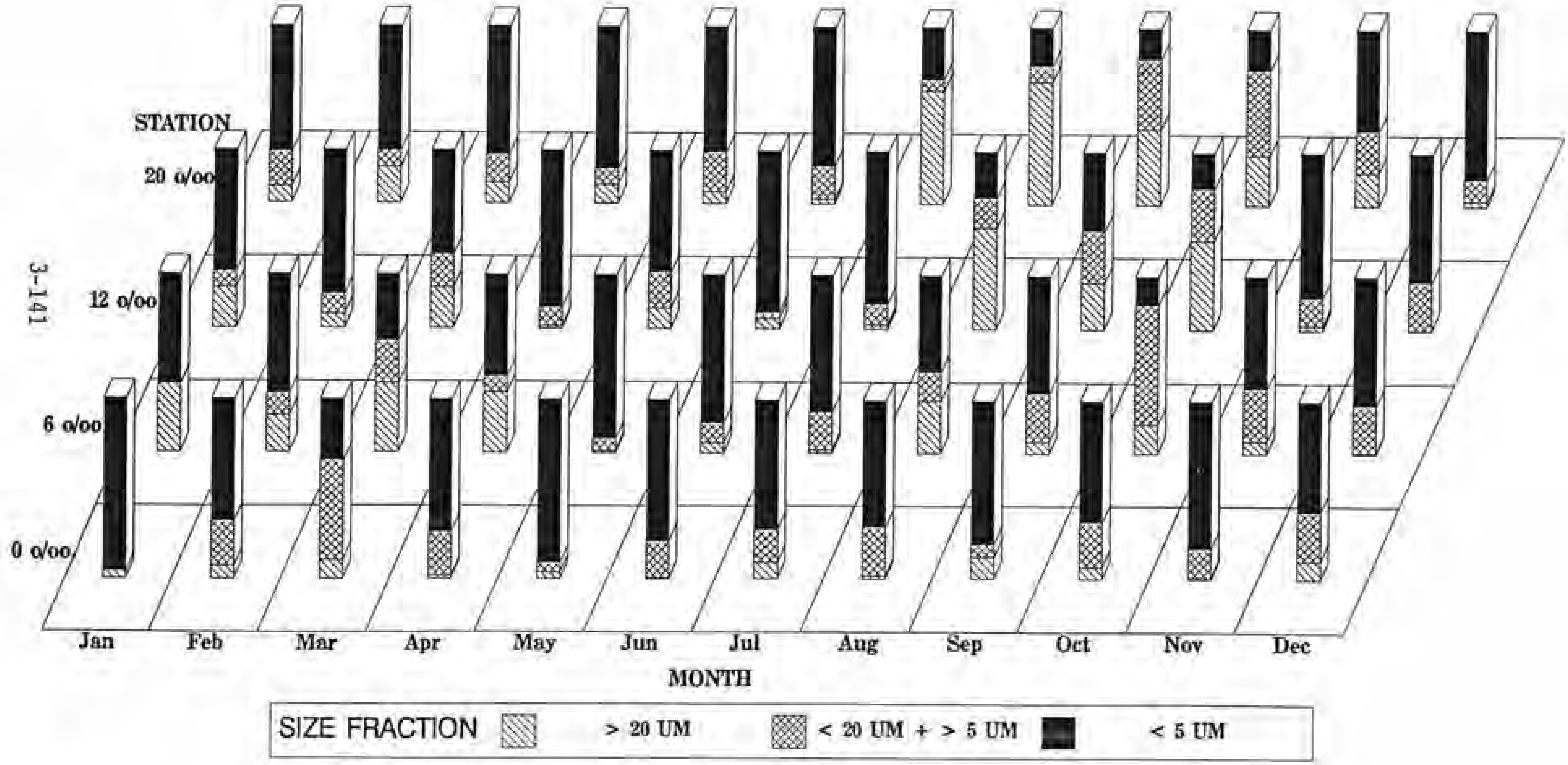


FIGURE 3.48

CHLOROPHYLL a (MG/M3), BY MONTH AND STATION

1990

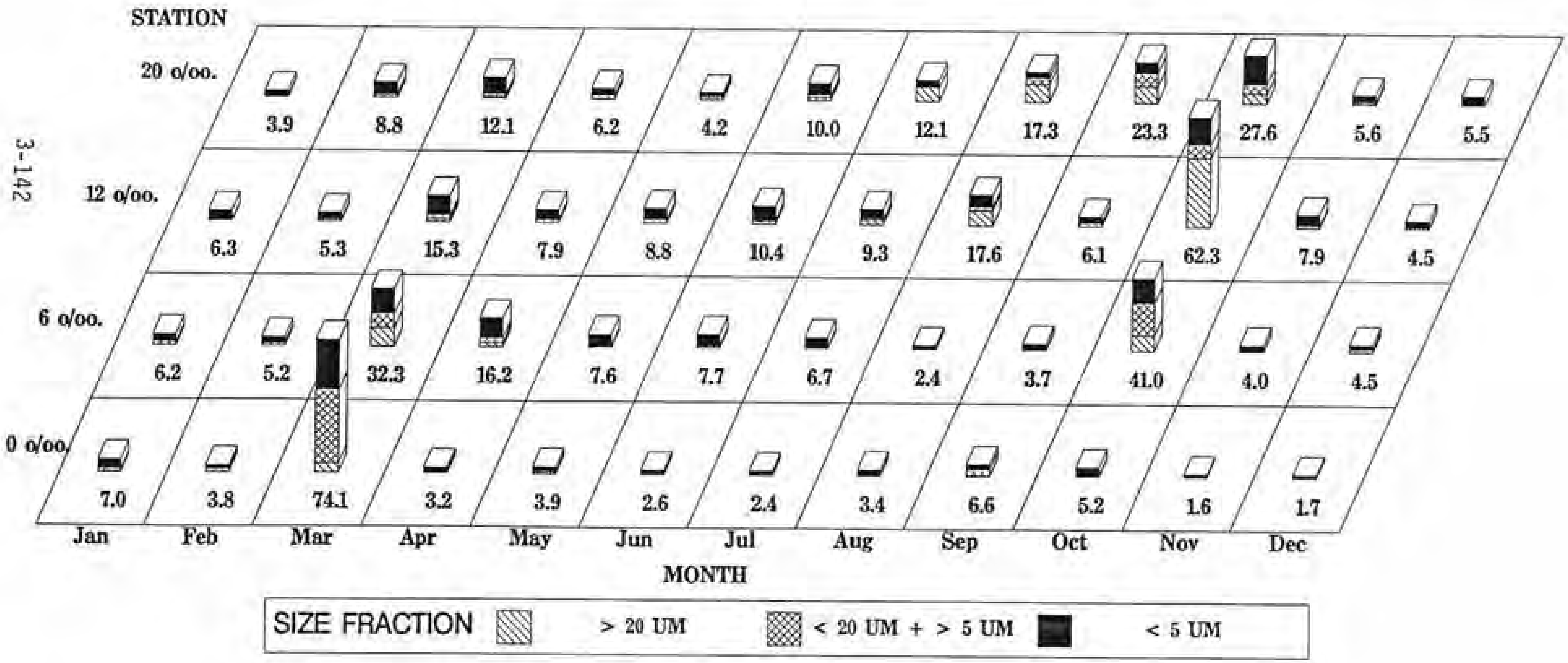


FIGURE 3.49
PERCENT CHLOROPHYLL a AMONG SIZE FRACTIONS, BY MONTH AND STATION
1990

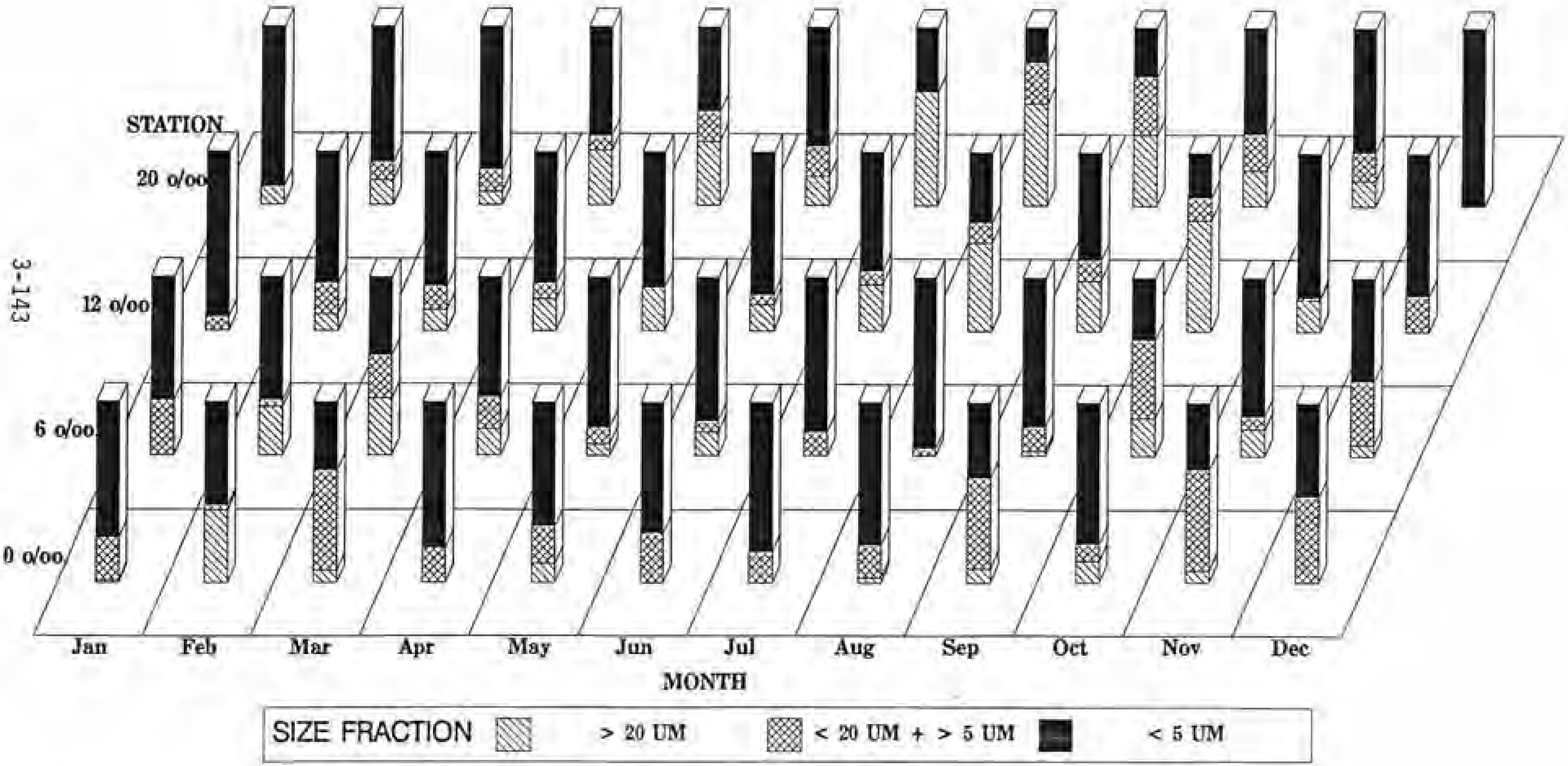


FIGURE 3.50
CARBON UPTAKE (mgC/m3/Einstein), BY DATE AND STATION
1991

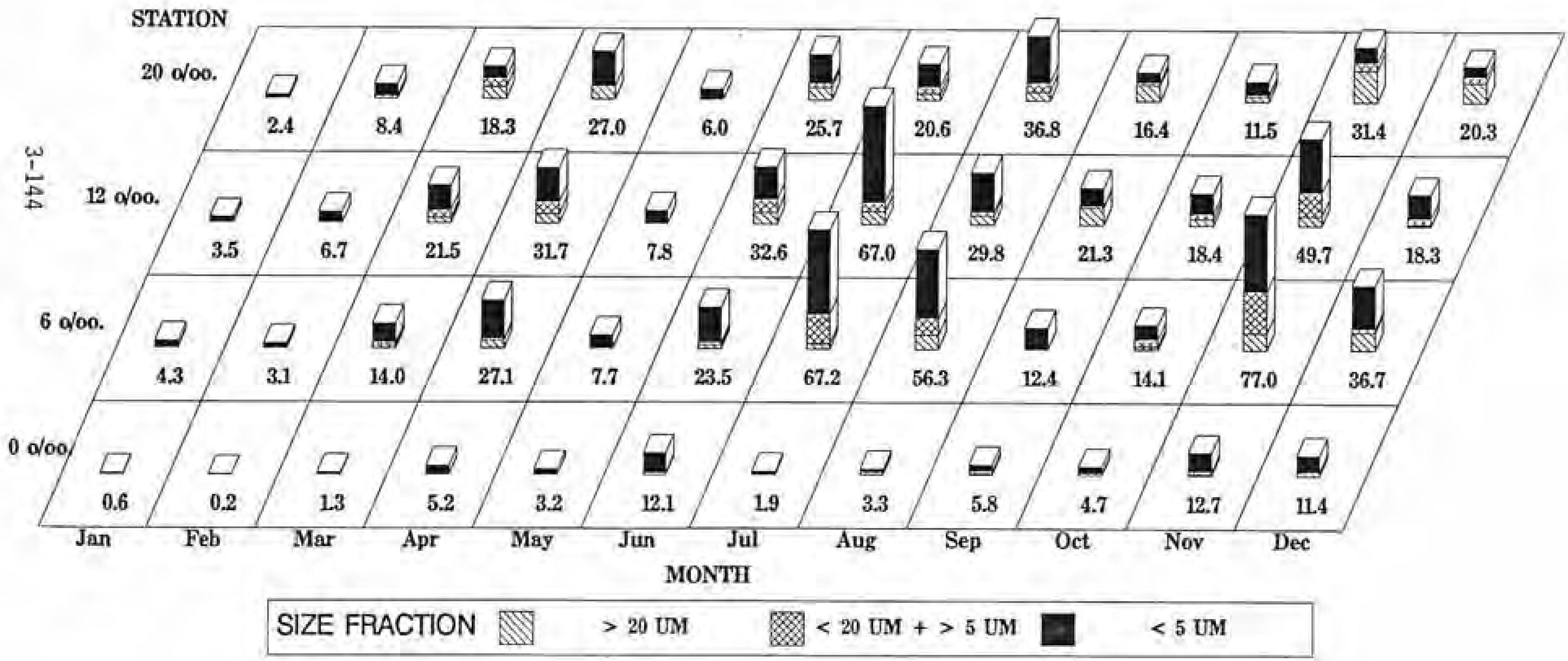


FIGURE 3.51

PERCENT CARBON UPTAKE AMONG SIZE FRACTIONS, BY DATE AND STATION

1991

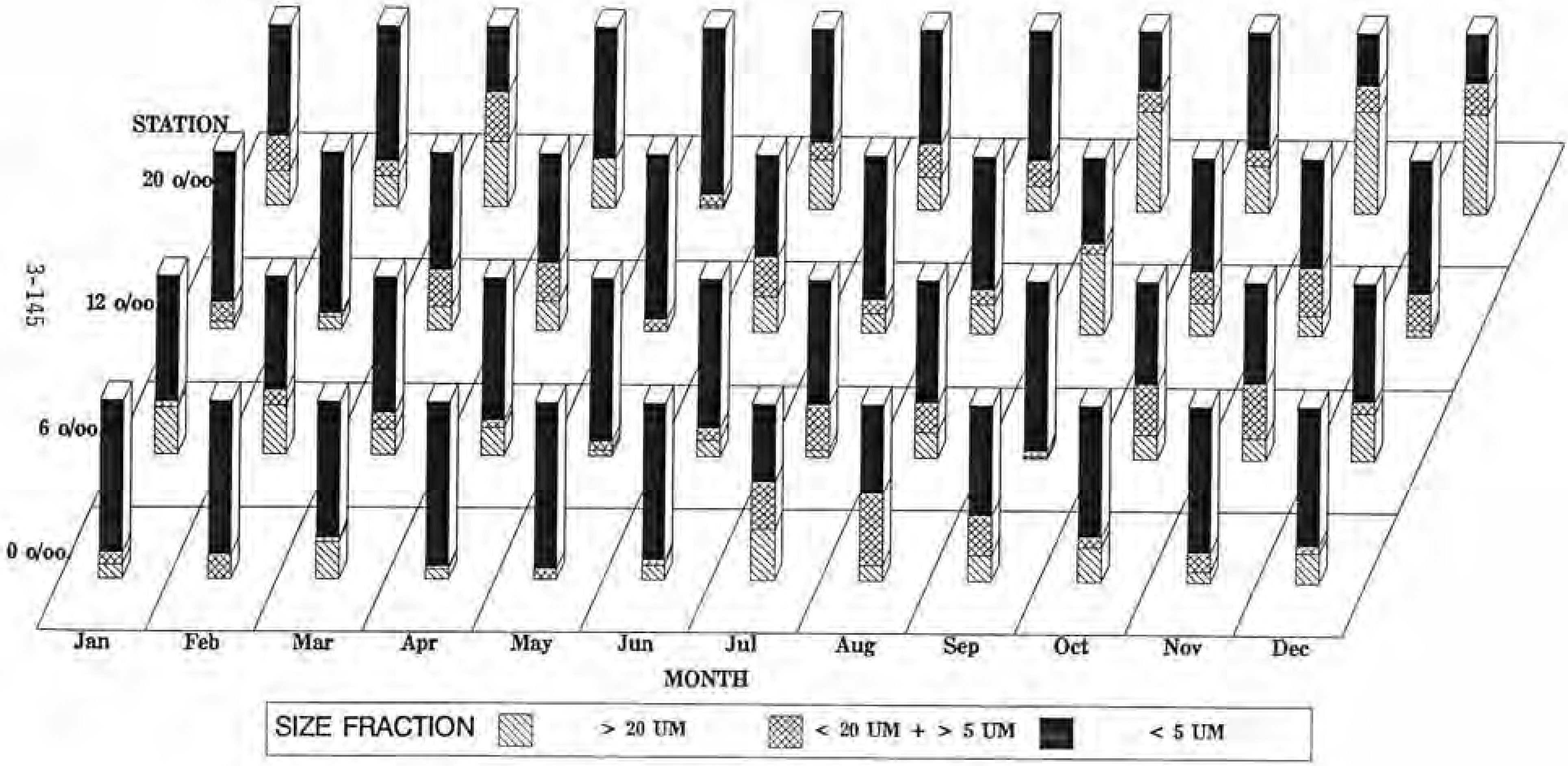


FIGURE 3.52
CHLOROPHYLL a (MG/M3), BY MONTH AND STATION
1991

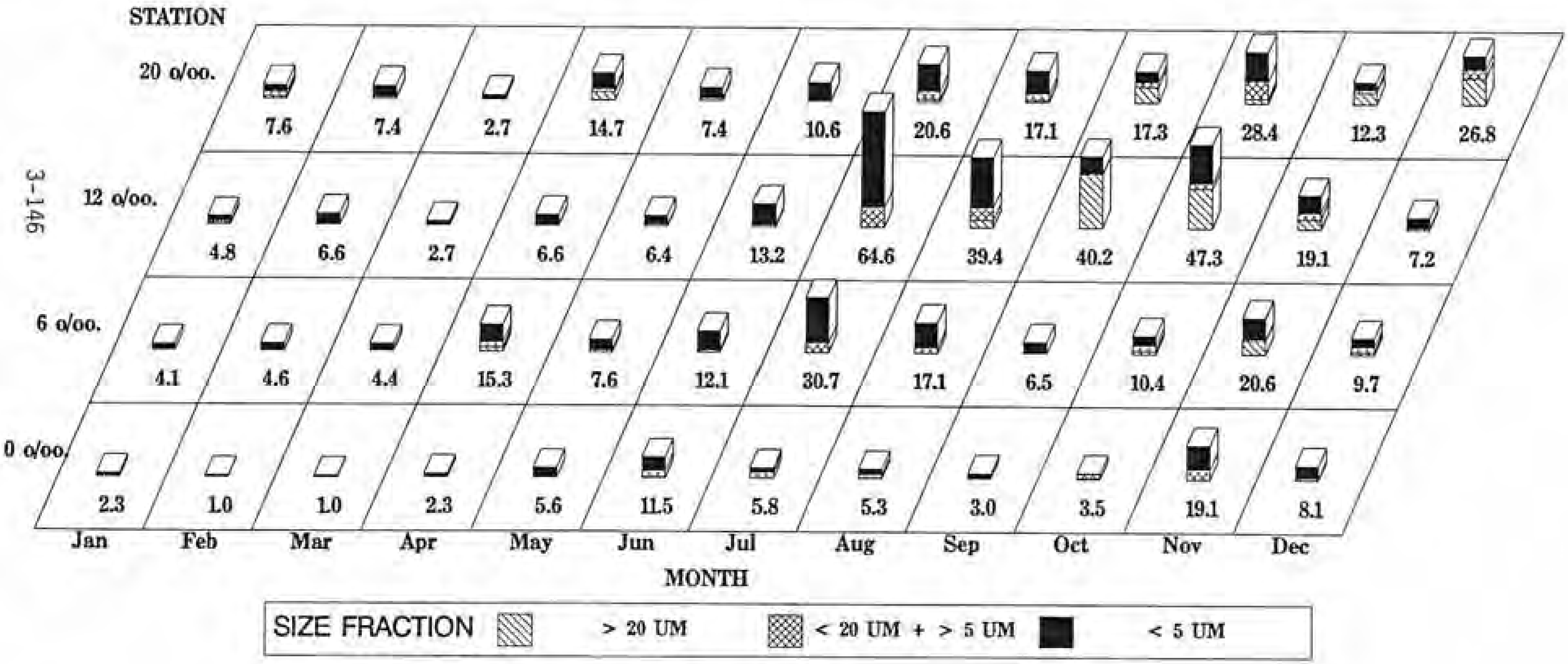
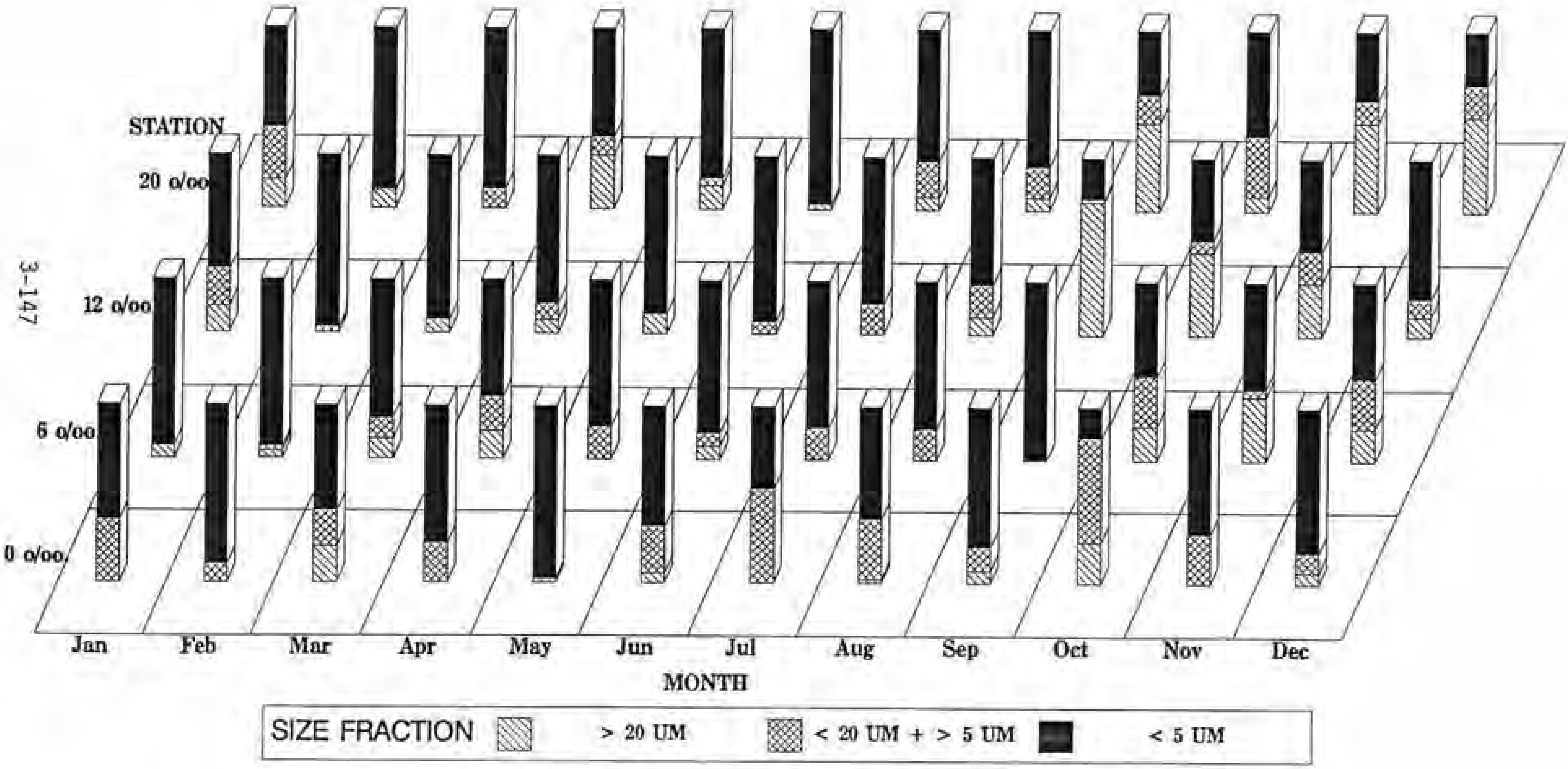


FIGURE 3.53
PERCENT CHLOROPHYLL a AMONG SIZE FRACTIONS, BY MONTH AND STATION
1991



a among size fractions for a specific station on a specific date usually followed the same patterns, exceptions did exist. In most of these instance, chlorophyll a within the larger size fractions indicated significant biomass, while carbon uptake was dominated by the smallest size fraction.

3.3.4 Summary Statistics

Summary statistics for many of the preceding measurements of Physical, Chemical Parameters and estimates of Phytoplankton Primary Production are presented in Tables 3.9 through 3.15. Each summary table lists the: 1) variable name as given in Table 3.2 (see page), 2) both the maximum and minimum values for each measurement over a period or for a salinity zone, and 3) the corresponding mean and standard deviations for each parameter.

SUMMARY TABLES

Table 3.9 - physical measurements relating to light and Peace River flow, summarized by year and month
Table 3.10 - measurements of water color and extinction by year and salinity zone
Table 3.11 - major nutrients by year and salinity zone
Table 3.12 - phytoplankton production and biomass estimates by year and salinity zone
Table 3.13 - phytoplankton production and biomass percentages within each measured size fraction by year and salinity zone
Table 3.14 - parameters added to program in 1990 by date and salinity
Table 3.15 - variables in Table 3.14 summarized by year and salinity zone

3.3.5 Descriptive and Predictive Analysis

The primary production and corresponding physical/chemical data sets collected between 1983 and 1991 were further summarized by comparative graphical analyses of the relationships of phytoplankton responses to the combined influences of seasonal and

TABLE 3.9

RANGES AND MEANS BY YEAR AND MONTH

OVERALL 1983-1991

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	412	13.4	33.3	24.8	5.0
LIGHT	408	18.5	55.4	35.6	9.6
EM	412	89.4	1478.1	1000.5	261.3
DIS	412	0.4	67.5	21.6	9.6
PRFLOW	412	45.0	4900.0	652.1	806.5
DAF7	412	44.6	8997.1	702.4	1073.9
DAF14	412	40.8	7820.7	677.5	927.7

BY YEAR

YEAR=83

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	28	15.1	31.4	25.8	5.3
LIGHT	28	27.3	49.9	41.1	8.0
EM	28	691.1	1442.8	1102.5	274.3
DIS	28	11.4	52.0	26.3	10.6
PRFLOW	28	369.0	3610.0	1278.6	1105.7
DAF7	28	296.9	3577.1	1336.6	1055.7
DAF14	28	340.8	2687.9	1177.2	757.5

YEAR=84

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	48	17.8	32.3	24.3	4.8
LIGHT	48	27.0	54.1	40.3	9.0
EM	48	770.9	1452.0	1138.3	252.2
DIS	48	5.2	49.6	22.3	9.3
PRFLOW	48	62.0	1030.0	437.5	318.8
DAF7	48	84.6	1354.6	514.0	422.8
DAF14	48	88.9	1500.9	559.0	485.2

TABLE 3.9 (Cont.)

RANGES AND MEANS BY YEAR AND MONTH

YEAR=85

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	48	15.5	32.0	25.3	5.3
LIGHT	44	25.8	55.4	41.6	10.0
EM	48	89.4	1478.1	1109.5	284.6
DIS	48	2.4	49.6	16.9	8.7
PRFLOW	48	55.0	3310.0	517.2	904.5
DAF7	48	44.6	2005.7	391.9	578.0
DAF14	48	40.8	1394.0	327.4	432.4

YEAR=86

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	48	14.6	33.3	25.2	5.5
LIGHT	48	18.6	55.4	38.5	10.6
EM	48	566.2	1448.7	1069.3	276.6
DIS	48	4.5	49.6	21.9	9.4
PRFLOW	48	77.0	2120.0	571.8	602.9
DAF7	48	88.9	1467.4	487.6	463.0
DAF14	48	88.0	1144.1	453.8	358.9

YEAR=87

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	48	13.4	31.7	23.9	5.3
LIGHT	48	20.4	45.0	35.6	8.1
EM	48	596.0	1389.8	991.0	275.4
DIS	48	4.5	51.6	23.6	8.2
PRFLOW	48	208.0	1990.0	782.3	457.0
DAF7	48	196.0	2651.4	887.3	628.1
DAF14	48	271.6	2113.6	901.6	557.4

TABLE 3.9 (Cont.)

RANGES AND MEANS BY YEAR AND MONTH

YEAR=88

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	48	15.4	31.3	23.8	5.1
LIGHT	48	23.1	43.2	34.2	5.6
EM	48	620.4	1350.7	975.3	226.3
DIS	48	5.2	67.5	23.9	11.1
PRFLOW	48	138.0	4900.0	1012.9	1294.8
DAF7	48	151.7	8997.1	1386.1	2384.2
DAF14	48	132.3	7820.7	1287.2	2062.4

YEAR=89

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	48	16.2	31.4	24.9	4.9
LIGHT	48	18.5	50.5	33.5	9.7
EM	48	560.5	1346.8	942.6	224.6
DIS	48	0.4	32.3	18.7	7.2
PRFLOW	48	45.0	788.0	374.7	239.8
DAF7	48	45.0	892.1	353.5	237.9
DAF14	48	45.0	954.1	372.6	266.5

YEAR=90

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	48	19.1	30.9	25.6	3.5
LIGHT	48	19.8	45.7	31.1	9.2
EM	48	565.6	1148.7	889.7	191.3
DIS	48	3.6	32.4	18.8	7.5
PRFLOW	48	57.0	1505.0	319.3	385.9
DAF7	48	75.9	908.7	303.3	225.4
DAF14	48	64.1	937.6	365.7	257.5

TABLE 3.9 (Cont.)

RANGES AND MEANS BY YEAR AND MONTH

YEAR=91

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	48	18.5	31.6	24.8	4.8
LIGHT	48	19.8	34.1	27.0	4.3
EM	48	571.0	1053.6	828.9	171.0
DIS	48	7.4	56.1	23.6	11.3
PRFLOW	48	65.2	2973.0	835.7	963.3
DAF7	48	90.2	3363.7	925.8	1121.8
DAF14	48	67.4	2869.4	861.4	971.6

BY MONTH

MONTH=JAN

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	32	13.4	20.0	18.0	1.8
LIGHT	32	23.1	31.8	27.5	3.0
EM	32	610.5	817.7	711.1	71.3
DIS	32	4.5	32.4	20.5	6.9
PRFLOW	32	74.0	1990.0	631.5	598.1
DAF7	32	80.3	2651.4	672.3	823.5
DAF14	32	67.4	2113.6	600.5	691.0

MONTH=FEB

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	32	14.6	21.4	18.2	2.0
LIGHT	32	25.9	38.6	32.6	5.1
EM	32	89.4	898.7	779.7	147.8
DIS	32	7.4	34.5	20.6	6.6
PRFLOW	32	91.0	1170.0	378.0	329.1
DAF7	32	93.7	631.9	282.1	160.8
DAF14	32	91.6	758.4	323.9	200.3

TABLE 3.9 (Cont.)

RANGES AND MEANS BY YEAR AND MONTH

MONTH=MAR

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	32	18.5	26.4	21.6	2.1
LIGHT	32	22.8	47.8	39.1	7.2
EM	32	852.9	1248.4	1059.5	141.4
DIS	32	2.4	33.2	20.7	7.2
PRFLOW	32	55.0	1600.0	543.7	463.1
DAF7	32	61.4	1140.0	485.8	383.0
DAF14	32	70.9	1274.0	493.0	385.6

MONTH=APR

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	32	20.8	27.1	24.3	1.8
LIGHT	32	29.8	53.9	41.9	8.4
EM	32	1053.6	1448.7	1234.3	129.5
DIS	32	7.4	51.6	21.3	9.8
PRFLOW	32	136.0	734.0	327.0	180.2
DAF7	32	100.3	1098.4	346.5	303.7
DAF14	32	98.7	1777.1	464.9	524.4

MONTH=MAY

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	32	24.7	29.9	27.4	1.5
LIGHT	32	31.2	54.1	42.3	7.5
EM	32	1005.0	1478.1	1326.9	157.6
DIS	32	2.6	33.4	16.3	8.3
PRFLOW	32	57.0	958.0	216.3	293.3
DAF7	32	44.6	1174.7	281.8	364.4
DAF14	32	40.8	744.5	262.0	254.5

TABLE 3.9 (Cont.)

RANGES AND MEANS BY YEAR AND MONTH

MONTH=JUN

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	36	26.5	31.4	28.8	1.2
LIGHT	36	30.3	55.4	44.8	7.2
EM	36	1025.0	1408.9	1244.7	133.9
DIS	36	0.4	40.8	17.8	8.5
PRFLOW	36	45.0	755.3	285.8	211.1
DAF7	36	45.0	1295.8	387.0	390.7
DAF14	36	45.0	1109.0	334.6	317.4

MONTH=JUL

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	36	27.3	32.5	30.4	1.1
LIGHT	36	24.8	55.4	39.8	10.0
EM	36	932.5	1442.8	1195.5	153.4
DIS	36	4.5	56.1	23.1	11.5
PRFLOW	36	114.0	2973.0	766.9	829.4
DAF7	36	104.1	3363.7	827.0	957.4
DAF14	36	114.1	2869.4	826.1	806.5

MONTH=AUG

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	36	29.2	32.3	30.5	0.8
LIGHT	36	25.0	49.6	37.5	7.8
EM	36	943.0	1380.9	1153.3	147.4
DIS	36	13.0	55.3	28.2	11.0
PRFLOW	36	548.0	2751.0	1516.6	670.2
DAF7	36	374.4	3088.0	1384.4	831.8
DAF14	36	429.9	2728.7	1316.6	724.1

TABLE 3.9 (Cont.)

RANGES AND MEANS BY YEAR AND MONTH

MONTH=SEPT

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	36	25.9	33.3	29.4	1.6
LIGHT	36	27.6	44.9	38.4	5.9
EM	36	870.9	1263.0	1016.8	128.8
DIS	36	8.9	67.5	28.9	13.0
PRFLOW	36	293.0	4900.0	1769.4	1653.3
DAF7	36	398.6	8997.1	2178.6	2628.0
DAF14	36	512.4	7820.7	1904.8	2215.7

MONTH=OCT

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	36	23.8	29.8	26.6	1.8
LIGHT	36	18.5	48.0	33.8	9.6
EM	36	773.8	1127.7	941.4	113.6
DIS	36	6.7	34.9	22.5	7.4
PRFLOW	36	222.0	912.0	650.8	225.9
DAF7	36	210.6	1168.1	707.5	340.0
DAF14	36	198.3	1253.9	711.6	312.1

MONTH=NOV

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	36	16.6	26.2	22.0	2.7
LIGHT	32	21.0	32.9	25.3	4.0
EM	36	596.0	825.0	714.2	83.3
DIS	36	3.6	34.5	19.1	7.3
PRFLOW	36	62.0	604.0	261.4	187.8
DAF7	36	84.6	836.4	306.6	235.1
DAF14	36	88.9	633.1	308.1	186.9

TABLE 3.9 (Cont.)

RANGES AND MEANS BY YEAR AND MONTH

MONTH=DEC

Variable	N	Minimum	Maximum	Mean	Std Dev
TEMP	36	15.1	23.0	18.8	2.7
LIGHT	36	18.6	28.3	23.5	3.4
EM	36	560.5	780.9	640.8	79.2
DIS	36	4.9	33.2	18.9	7.2
PRFLOW	36	65.2	1110.0	348.6	350.7
DAF7	36	80.3	1281.4	409.2	424.1
DAF14	36	64.1	1303.9	445.9	487.3

TABLE 3.10

RANGES AND MEANS BY YEAR AND LOCATION

OVERALL 1983-1991

Variable	N	Minimum	Maximum	Mean	Std Dev
COLOR	412	23.00	432.00	90.69	66.50
EXC	408	0.78	5.81	2.39	1.00
OPD50	408	0.12	0.89	0.34	0.13
OPD01	408	0.80	5.90	2.25	0.87

BY YEAR

YEAR=83

Variable	N	Minimum	Maximum	Mean	Std Dev
COLOR	28	27.00	250.00	111.50	61.68
EXC	24	1.13	4.97	2.83	1.21
OPD50	24	0.14	0.62	0.30	0.15
OPD01	24	0.90	4.10	2.00	0.97

YEAR=84

Variable	N	Minimum	Maximum	Mean	Std Dev
COLOR	48	29.00	228.00	80.15	43.47
EXC	48	0.91	4.81	2.35	1.01
OPD50	48	0.14	0.76	0.36	0.16
OPD01	48	1.00	5.00	2.38	1.08

YEAR=85

Variable	N	Minimum	Maximum	Mean	Std Dev
COLOR	48	27.00	320.00	69.37	56.82
EXC	48	1.08	4.71	2.13	0.86
OPD50	48	0.15	0.64	0.37	0.12
OPD01	48	1.00	4.30	2.45	0.79

TABLE 3.10 (Cont.)

RANGES AND MEANS BY YEAR AND LOCATION

YEAR=86

Variable	N	Minimum	Maximum	Mean	Std Dev
COLOR	48	25.00	325.00	94.79	75.85
EXC	48	1.09	5.11	2.35	1.00
OPD50	48	0.14	0.64	0.34	0.12
OPD01	48	0.90	4.20	2.27	0.81

YEAR=87

Variable	N	Minimum	Maximum	Mean	Std Dev
COLOR	48	30.00	220.00	100.98	54.20
EXC	48	0.78	4.68	2.64	0.99
OPD50	48	0.15	0.89	0.31	0.15
OPD01	48	1.00	5.90	2.06	1.01

YEAR=88

Variable	N	Minimum	Maximum	Mean	Std Dev
COLOR	48	24.00	320.00	88.54	64.54
EXC	48	1.17	5.81	2.51	1.12
OPD50	48	0.12	0.59	0.33	0.13
OPD01	48	0.80	3.90	2.17	0.84

YEAR=89

Variable	N	Minimum	Maximum	Mean	Std Dev
COLOR	48	23.00	290.00	82.15	60.71
EXC	48	1.22	5.37	2.30	0.94
OPD50	48	0.13	0.57	0.35	0.12
OPD01	48	0.90	3.80	2.30	0.80

TABLE 3.10 (Cont.)

RANGES AND MEANS BY YEAR AND LOCATION

YEAR=90

Variable	N	Minimum	Maximum	Mean	Std Dev
COLOR	48	29.00	432.00	102.67	97.87
EXC	48	1.18	5.34	2.30	1.00
OPD50	48	0.13	0.59	0.35	0.12
OPD01	48	0.90	3.90	2.32	0.81

YEAR=91

Variable	N	Minimum	Maximum	Mean	Std Dev
COLOR	48	30.00	312.00	94.73	63.57
EXC	48	1.33	5.29	2.35	0.92
OPD50	48	0.13	0.52	0.33	0.10
OPD01	48	0.90	3.50	2.19	0.69

BY LOCATION

STATION=0 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
COLOR	103	33.00	432.00	134.95	89.15
EXC	102	1.18	5.81	3.09	1.23
OPD50	102	0.12	0.59	0.27	0.12
OPD01	102	0.80	3.90	1.80	0.82

STATION=6 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
COLOR	103	39.00	359.00	106.02	60.27
EXC	102	1.48	4.73	2.74	0.81
OPD50	102	0.15	0.47	0.28	0.08
OPD01	102	1.00	3.10	1.83	0.55

TABLE 3.10 (Cont.)

RANGES AND MEANS BY YEAR AND LOCATION

STATION=12 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
COLOR	103	37.00	249.00	77.09	35.72
EXC	102	1.25	4.08	2.19	0.60
OPD50	102	0.17	0.56	0.34	0.09
OPD01	102	1.10	3.70	2.24	0.56

STATION=20 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
COLOR	103	23.00	174.00	44.70	20.58
EXC	102	0.78	3.08	1.56	0.40
OPD50	102	0.23	0.89	0.47	0.11
OPD01	102	1.50	5.90	3.14	0.76

TABLE 3.11

RANGES AND MEANS BY YEAR AND LOCATION

OVERALL 1983-1991

Variable	N	Minimum	Maximum	Mean	Std Dev
NH4	408	0.001	1.618	0.049	0.104
N23	412	0.001	1.839	0.212	0.255
OP	412	0.107	1.510	0.510	0.253
SI	408	0.010	4.700	1.791	1.032
NPA	412	0.004	17.189	1.152	1.577

BY YEAR

YEAR=83

Variable	N	Minimum	Maximum	Mean	Std Dev
NH4	28	0.001	0.144	0.043	0.039
N23	28	0.002	0.676	0.176	0.191
OP	28	0.162	1.180	0.547	0.281
SI	28	0.600	4.020	2.320	0.833
NPA	28	0.029	1.814	0.809	0.585

YEAR=84

Variable	N	Minimum	Maximum	Mean	Std Dev
NH4	48	0.001	0.123	0.031	0.033
N23	48	0.001	1.040	0.190	0.237
OP	48	0.155	1.510	0.571	0.321
SI	48	0.040	3.940	1.512	1.060
NPA	48	0.008	2.040	0.673	0.592

YEAR=85

Variable	N	Minimum	Maximum	Mean	Std Dev
NH4	48	0.001	0.188	0.043	0.045
N23	48	0.001	0.713	0.178	0.180
OP	48	0.226	1.110	0.644	0.249
SI	48	0.140	3.200	1.445	0.892
NPA	48	0.010	1.936	0.701	0.513

TABLE 3.11 (Cont.)

RANGES AND MEANS BY YEAR AND LOCATION

YEAR=86

Variable	N	Minimum	Maximum	Mean	Std Dev
NH4	48	0.001	0.250	0.047	0.056
N23	48	0.001	1.240	0.192	0.243
OP	48	0.179	1.170	0.526	0.240
SI	48	0.010	4.260	1.789	1.116
NPA	48	0.016	4.078	0.918	0.833

YEAR=87

Variable	N	Minimum	Maximum	Mean	Std Dev
NH4	48	0.001	0.366	0.060	0.077
N23	48	0.001	0.667	0.201	0.183
OP	48	0.107	1.060	0.424	0.228
SI	48	0.260	3.940	1.855	0.898
NPA	48	0.004	4.475	1.502	1.281

YEAR=88

Variable	N	Minimum	Maximum	Mean	Std Dev
NH4	48	0.001	0.427	0.054	0.068
N23	48	0.001	1.033	0.161	0.219
OP	48	0.128	0.855	0.418	0.180
SI	48	0.040	4.650	1.756	1.205
NPA	48	0.045	4.126	1.065	0.990

YEAR=89

Variable	N	Minimum	Maximum	Mean	Std Dev
NH4	44	0.001	0.137	0.028	0.034
N23	48	0.001	1.245	0.224	0.315
OP	48	0.165	1.143	0.493	0.225
SI	48	0.050	4.700	1.794	1.133
NPA	48	0.007	5.503	1.005	1.157

TABLE 3.11 (Cont.)

RANGES AND MEANS BY YEAR AND LOCATION

YEAR=90

Variable	N	Minimum	Maximum	Mean	Std Dev
NH4	48	0.001	0.988	0.061	0.142
N23	48	0.001	1.839	0.343	0.361
OP	48	0.124	1.154	0.508	0.252
SI	44	0.570	4.010	1.853	0.936
NPA	48	0.009	15.259	2.117	2.896

YEAR=91

Variable	N	Minimum	Maximum	Mean	Std Dev
NH4	48	0.002	1.618	0.069	0.230
N23	48	0.001	1.220	0.229	0.256
OP	48	0.123	0.957	0.475	0.226
SI	48	0.050	4.000	2.023	0.938
NPA	48	0.026	17.189	1.431	2.479

BY LOCATION

STATION= 0 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
NH4	102	0.001	0.427	0.059	0.052
N23	103	0.000	1.839	0.475	0.331
OP	103	0.124	1.510	0.802	0.223
SI	102	0.140	4.700	2.508	1.110
NPA	103	0.004	14.127	1.715	1.667

STATION= 6 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
NH4	102	0.001	0.366	0.051	0.053
N23	103	0.001	0.861	0.225	0.154
OP	103	0.322	0.987	0.577	0.134
SI	102	0.370	4.010	2.125	0.822
NPA	103	0.021	4.168	1.150	0.786

TABLE 3.11 (Cont.)

RANGES AND MEANS BY YEAR AND LOCATION

STATION= 12 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
NH4	102	0.001	0.318	0.038	0.053
N23	103	0.001	0.501	0.109	0.106
OP	103	0.186	0.739	0.418	0.108
SI	102	0.130	3.510	1.621	0.737
NPA	103	0.007	4.475	0.870	0.863

STATION= 20 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
NH4	102	0.001	1.618	0.048	0.187
N23	103	0.001	0.626	0.040	0.082
OP	103	0.107	0.760	0.243	0.086
SI	102	0.010	2.560	0.910	0.627
NPA	103	0.010	17.189	0.871	2.323

TABLE 3.12

RANGES AND MEANS BY YEAR AND LOCATION

OVERALL 1983-1991

Variable	N	Minimum	Maximum	Mean	Std Dev
P2	412	0.9	542.7	78.3	77.1
P9	408	0.1	32.4	5.9	4.1
P3	412	0.2	134.8	16.9	16.7
P10	408	0.0	8.0	1.3	1.0
CHLA	408	1.0	340.4	17.4	26.5

BY YEAR

YEAR=83

Variable	N	Minimum	Maximum	Mean	Std Dev
P2	28	10.8	379.5	86.4	72.6
P9	28	2.1	18.4	6.5	4.5
P3	28	2.0	61.3	16.0	12.1
P10	28	0.4	3.6	1.2	0.9
CHLA	28	2.3	72.4	18.7	18.2

YEAR=84

Variable	N	Minimum	Maximum	Mean	Std Dev
P2	48	14.8	542.7	108.8	94.6
P9	48	1.8	15.3	5.6	3.0
P3	48	3.2	100.8	20.2	18.0
P10	48	0.3	2.9	1.0	0.6
CHLA	48	2.7	151.1	25.0	26.9

YEAR=85

Variable	N	Minimum	Maximum	Mean	Std Dev
P2	48	6.5	379.5	70.4	61.4
P9	48	2.2	27.5	6.4	3.8
P3	48	1.5	56.6	13.7	11.2
P10	48	0.4	4.5	1.3	0.7
CHLA	48	2.5	69.3	12.6	12.8

TABLE 3.12 (Cont.)

RANGES AND MEANS BY YEAR AND LOCATION

YEAR=86

Variable	N	Minimum	Maximum	Mean	Std Dev
P2	48	5.0	318.9	73.7	61.2
P9	48	1.3	18.4	6.6	3.7
P3	48	1.1	49.5	16.5	13.1
P10	48	0.2	6.3	1.6	1.3
CHLA	48	2.0	77.2	13.0	12.3

YEAR=87

Variable	N	Minimum	Maximum	Mean	Std Dev
P2	48	1.9	337.8	80.9	81.3
P9	44	0.1	20.1	5.6	4.2
P3	48	0.6	58.2	16.7	14.8
P10	44	0.0	3.5	1.2	0.8
CHLA	44	1.4	126.1	18.7	20.1

YEAR=88

Variable	N	Minimum	Maximum	Mean	Std Dev
P2	48	2.3	428.5	85.2	82.7
P9	48	1.3	18.9	6.7	4.1
P3	48	0.6	110.8	17.9	19.3
P10	48	0.3	4.1	1.4	0.9
CHLA	48	1.6	79.2	14.7	16.0

YEAR=89

Variable	N	Minimum	Maximum	Mean	Std Dev
P2	48	4.3	454.4	87.6	91.9
P9	48	0.5	16.6	5.6	3.6
P3	48	1.1	134.8	19.8	23.1
P10	48	0.1	4.9	1.2	0.9
CHLA	48	2.5	340.4	29.3	59.6

TABLE 3.12 (Cont.)

RANGES AND MEANS BY YEAR AND LOCATION

YEAR=90

Variable	N	Minimum	Maximum	Mean	Std Dev
P2	48	0.9	241.2	42.3	52.4
P9	48	0.5	14.7	3.7	2.6
P3	48	0.2	58.3	11.0	13.6
P10	48	0.1	3.3	1.0	0.6
CHLA	48	1.6	74.1	11.5	14.4

YEAR=91

Variable	N	Minimum	Maximum	Mean	Std Dev
P2	48	0.9	285.5	72.9	72.7
P9	48	0.9	32.4	6.6	6.1
P3	48	0.2	77.0	19.6	18.5
P10	48	0.2	8.0	1.8	1.6
CHLA	48	1.0	64.6	13.4	13.1

BY LOCATION

STATION=0 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
P2	103	0.9	428.5	45.9	63.7
P9	102	0.1	13.4	4.3	2.6
P3	103	0.2	110.8	9.8	14.7
P10	102	0.0	6.3	1.0	0.8
CHLA	102	1.0	76.4	10.9	13.2

STATION=6 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
P2	103	6.6	542.7	97.5	99.3
P9	102	0.4	18.9	5.7	3.7
P3	103	1.7	134.8	20.6	21.4
P10	102	0.1	4.1	1.3	0.9
CHLA	102	1.6	151.1	21.7	24.9

TABLE 3.12 (Cont.)

RANGES AND MEANS BY YEAR AND LOCATION

STATION=12 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
P2	103	12.0	379.5	98.4	77.4
P9	102	0.5	32.4	6.4	4.4
P3	103	3.4	71.9	21.0	15.6
P10	102	0.1	8.0	1.4	1.1
CHLA	102	1.6	340.4	22.7	36.4

STATION=20 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
P2	103	7.6	264.1	71.5	46.4
P9	102	0.6	27.5	7.1	4.8
P3	103	2.4	57.0	16.1	11.2
P10	102	0.1	6.8	1.6	1.1
CHLA	102	2.5	250.6	14.1	24.9

TABLE 3.13

RANGES AND MEANS BY YEAR AND LOCATION

OVERALL 1983-1991

Variable	N	Minimum	Maximum	Mean	Std Dev
% uptake	412	0.0	91.4	19.7	17.4
>20 u	412	0.0	67.5	16.9	13.0
>5&<20 u	412	8.7	100.0	63.5	21.2
<5 u					
% Chla					
>20 u	412	0.0	84.4	19.7	19.0
>5&<20 u	412	0.0	92.8	16.4	14.8
<5 u	412	0.0	100.0	63.5	21.7

BY YEAR

YEAR=83

Variable	N	Minimum	Maximum	Mean	Std Dev
% uptake					
>20 u	28	2.1	52.6	15.0	11.8
>5&<20 u	28	0.0	27.2	10.2	7.3
<5 u	28	41.9	100.0	75.2	15.8
% Chla					
>20 u	28	0.0	55.5	17.4	13.6
>5&<20 u	28	0.0	19.8	9.2	6.6
<5 u	28	44.5	99.0	73.6	14.7

YEAR=84

Variable	N	Minimum	Maximum	Mean	Std Dev
% uptake					
>20 u	48	2.1	63.3	29.0	17.2
>5&<20 u	48	3.3	47.2	17.6	10.8
<5 u	48	9.6	94.6	53.3	17.9
% Chla					
>20 u	48	0.0	77.2	28.4	18.8
>5&<20 u	48	0.0	59.2	15.5	13.5
<5 u	48	18.7	90.8	56.5	18.2

TABLE 3.13 (cont.)

RANGES AND MEANS BY YEAR AND LOCATION

YEAR=85

Variable	N	Minimum	Maximum	Mean	Std Dev
% uptake					
>20 u	48	1.7	65.1	20.2	16.4
>5&<20 u	48	0.0	27.6	11.0	7.4
<5 u	48	25.2	96.2	68.8	18.8
% Chla					
>20 u	48	0.0	62.5	21.8	16.1
>5&<20 u	48	0.0	35.4	12.7	9.3
<5 u	48	25.0	95.5	66.1	17.0

YEAR=86

Variable	N	Minimum	Maximum	Mean	Std Dev
% uptake					
>20 u	48	0.4	55.1	21.6	14.5
>5&<20 u	48	0.0	36.6	14.1	10.2
<5 u	48	22.2	94.9	64.4	18.0
% Chla					
C >20 u	48	0.0	51.8	22.9	13.9
C20><5 u	48	0.0	41.0	13.4	12.3
C <5 u	48	27.2	89.7	63.9	16.9

YEAR=87

Variable	N	Minimum	Maximum	Mean	Std Dev
% uptake					
>20 u	48	0.0	77.6	14.1	13.3
>5&<20 u	48	0.6	40.5	15.7	10.7
<5 u	48	17.6	96.4	70.1	17.9
% Chla					
>20 u	48	0.0	70.3	15.4	18.8
>5&<20 u	48	0.0	92.8	13.7	18.3
<5 u	48	0.0	98.7	64.1	29.7

TABLE 3.13 (cont.)

RANGES AND MEANS BY YEAR AND LOCATION

YEAR=88

Variable	N	Minimum	Maximum	Mean	Std Dev
% uptake					
>20 u	48	0.0	58.8	14.3	13.9
>5&<20 u	48	5.8	67.5	32.5	14.9
<5 u	48	9.6	93.9	53.2	22.3
% Chla					
>20 u	48	0.0	70.5	13.8	14.6
>5&<20 u	48	0.0	69.0	30.4	15.6
<5 u	48	13.4	93.7	56.9	19.9

YEAR=89

Variable	N	Minimum	Maximum	Mean	Std Dev
% uptake					
>20 u	48	0.0	91.4	28.0	25.3
>5&<20 u	48	0.0	58.5	16.0	14.9
<5 u	48	8.7	97.9	55.9	26.5
% Chla					
>20 u	48	0.0	84.4	27.2	29.0
>5&<20 u	48	0.0	56.7	16.8	15.5
<5 u	48	5.7	97.5	57.0	27.1

YEAR=90

Variable	N	Minimum	Maximum	Mean	Std Dev
% uptake					
>20 u	48	0.2	69.6	15.8	17.6
>5&<20 u	48	0.0	67.5	19.5	13.3
<5 u	48	16.3	96.9	64.7	22.0
% Chla					
>20 u	48	0.0	63.6	16.5	16.9
>5&<20 u	48	0.0	56.2	17.3	14.3
<5 u	48	19.7	100.0	66.2	19.7

TABLE 3.13 (cont.)

RANGES AND MEANS BY YEAR AND LOCATION

YEAR=91

Variable	N	Minimum	Maximum	Mean	Std Dev
% uptake					
>20 u	48	0.0	55.9	16.9	14.2
>5&<20 u	48	0.5	40.9	12.7	9.3
<5 u	48	28.1	95.6	70.3	17.5
% Chla					
>20 u	48	0.0	74.6	13.4	16.9
>5&<20 u	48	0.0	60.0	15.6	13.2
<5 u	48	17.1	100.0	71.0	20.6

BY LOCATION

STATION= 0 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
% uptake					
>20 u	103	0.0	47.2	9.9	8.6
>5&<20 u	103	0.0	55.3	18.1	11.1
<5 u	103	33.0	97.9	72.0	14.4
% Chla					
>20 u	103	0.0	62.5	12.1	12.8
>5&<20 u	103	0.0	92.8	20.9	16.8
<5 u	103	0.0	98.2	67.0	19.9

STATION= 6 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
% uptake					
>20 u	103	0.0	91.4	18.3	15.4
>5&<20 u	103	0.0	67.5	15.5	13.0
<5 u	103	8.7	96.4	66.2	19.7
% Chla					
>20 u	103	0.0	84.4	17.7	17.8
>5&<20 u	103	0.0	61.2	14.7	13.6
<5 u	103	0.0	100.0	67.2	20.7

TABLE 3.13 (cont.)

RANGES AND MEANS BY YEAR AND LOCATION

STATION= 12 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
% uptake					
>20 u	103	0.0	77.6	22.4	18.6
>5&<20 u	103	0.0	47.2	16.0	11.9
<5 u	103	9.6	97.6	61.7	21.3
% Chl a					
>20 u	103	0.0	79.6	23.5	21.3
>5&<20 u	103	0.0	59.2	13.5	12.2
<5 u	103	0.0	98.7	62.6	22.3

STATION= 20 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
% uptake					
>20 u	103	0.0	89.3	28.2	19.5
>5&<20 u	103	0.0	67.5	18.0	15.4
<5 u	103	9.2	100.0	53.9	24.2
% Chl a					
>20 u	103	0.0	79.1	25.8	20.1
>5&<20 u	103	0.0	69.0	16.5	15.1
<5 u	103	0.0	100.0	57.1	22.6

TABLE 3.14

ADDED CHEMICAL PARAMETERS

DATE			STATION	TURB	TOC	DOC	IRON
JAN	18	90	0 o/oo	2.10	21.00	15.00	0.16
JAN	18	90	6 o/oo	3.40	20.00	14.00	0.09
JAN	18	90	12 o/oo	3.80	15.00	13.00	0.17
JAN	18	90	20 o/oo	2.70	8.10	6.50	0.07
FEB	14	90	0 o/oo	1.98	13.00	12.00	0.20
FEB	14	90	6 o/oo	2.20	14.00	12.00	0.12
FEB	14	90	12 o/oo	2.40	12.00	12.00	0.10
FEB	14	90	20 o/oo	2.50	11.00	7.40	0.05
MAR	14	90	0 o/oo	6.00	.	25.00	0.18
MAR	14	90	6 o/oo	5.70	.	24.00	0.13
MAR	14	90	12 o/oo	4.50	.	9.60	0.14
MAR	14	90	20 o/oo	3.30	.	15.00	0.07
APR	12	90	0 o/oo	2.40	13.88	8.87	0.19
APR	12	90	6 o/oo	5.00	17.33	11.03	0.09
APR	12	90	12 o/oo	2.80	16.08	14.38	0.03
APR	12	90	20 o/oo	3.00	14.66	15.14	0.15
MAY	8	90	0 o/oo	1.45	15.25	8.26	0.13
MAY	8	90	6 o/oo	2.10	16.43	8.31	0.11
MAY	8	90	12 o/oo	2.60	24.38	12.72	0.06
MAY	8	90	20 o/oo	2.90	23.10	16.64	0.10
JUN	20	90	0 o/oo	2.00	25.03	4.27	0.20
JUN	20	90	6 o/oo	3.20	20.87	10.56	0.08
JUN	20	90	12 o/oo	2.30	18.41	13.92	0.04
JUN	20	90	20 o/oo	2.10	19.22	15.93	0.04
JUL	11	90	0 o/oo	2.80	15.51	7.48	0.22
JUL	11	90	6 o/oo	2.70	5.13	7.52	0.07
JUL	11	90	12 o/oo	2.00	11.30	11.15	0.07
JUL	11	90	20 o/oo	2.20	7.08	12.76	0.14
AUG	16	90	0 o/oo	2.20	40.26	4.35	0.38
AUG	16	90	6 o/oo	1.89	41.37	8.50	0.21
AUG	16	90	12 o/oo	2.30	28.95	11.00	0.07
AUG	16	90	20 o/oo	2.10	28.69	12.01	0.02
SEPT	16	90	0 o/oo	3.80	37.56	0.21	0.47
SEPT	16	90	6 o/oo	3.30	31.12	6.06	0.26
SEPT	16	90	12 o/oo	2.70	27.13	9.24	0.18
SEPT	16	90	20 o/oo	2.90	22.24	12.36	0.13
OCT	12	90	6 o/oo	7.40	33.08	9.26	0.22
OCT	12	90	12 o/oo	8.80	29.71	12.99	0.17
OCT	12	90	20 o/oo	4.60	28.03	19.28	0.13
OCT	12	90	0 o/oo	4.20	35.06	3.79	0.40
NOV	16	90	0 o/oo	1.94	26.00	14.00	0.15
NOV	16	90	6 o/oo	4.70	26.00	15.00	0.28
NOV	16	90	12 o/oo	4.80	22.00	18.00	0.22
NOV	16	90	20 o/oo	6.20	21.00	22.00	0.20

TABLE 3.14 (cont.)

ADDED CHEMICAL PARAMETERS

DATE			STATION	TURB	TOC	DOC	IRON
DEC	16	90	0 o/oo	0.89	23.00	15.00	0.06
DEC	16	90	6 o/oo	2.50	19.00	15.00	0.10
DEC	16	90	12 o/oo	2.80	16.00	19.00	0.26
DEC	16	90	20 o/oo	4.60	17.00	20.00	0.86
JAN	17	91	0 o/oo	3.40	29.00	12.00	0.14
JAN	17	91	6 o/oo	3.90	27.00	16.00	0.12
JAN	17	91	12 o/oo	6.00	19.00	17.00	0.21
JAN	17	91	20 o/oo	8.21	16.00	20.00	0.26
FEB	13	91	0 o/oo	1.78	32.00	8.00	0.07
FEB	13	91	6 o/oo	3.30	37.00	10.00	0.07
FEB	13	91	12 o/oo	3.40	33.00	13.00	0.04
FEB	13	91	20 o/oo	2.50	28.00	13.00	0.05
MAR	5	91	0 o/oo	1.95	15.00	10.00	0.21
MAR	5	91	6 o/oo	3.00	12.00	19.00	0.09
MAR	5	91	12 o/oo	3.20	11.00	19.00	0.06
MAR	5	91	20 o/oo	3.30	8.00	20.00	0.12
APR	10	91	0 o/oo	1.67	27.00	13.00	0.17
APR	10	91	6 o/oo	3.00	28.00	16.00	0.11
APR	10	91	12 o/oo	1.82	23.00	21.00	0.08
APR	10	91	20 o/oo	1.93	23.00	26.00	0.21
MAY	7	91	0 o/oo	2.10	21.00	15.00	0.19
MAY	7	91	6 o/oo	3.85	17.00	20.00	0.11
MAY	7	91	12 o/oo	3.10	16.00	22.00	0.16
MAY	7	91	20 o/oo	4.20	13.00	25.00	0.06
JUN	13	91	0 o/oo	3.55	37.50	36.70	0.31
JUN	13	91	6 o/oo	3.90	31.10	31.10	0.17
JUN	13	91	12 o/oo	3.60	30.10	30.10	0.13
JUN	13	91	20 o/oo	3.00	29.40	29.40	0.09
JUL	10	91	0 o/oo	3.45	41.00	40.7	0.67
JUL	10	91	6 o/oo	2.90	33.90	32.4	0.36
JUL	10	91	12 o/oo	3.60	26.10	23.5	0.25
JUL	10	91	20 o/oo	5.00	15.80	15.7	0.19
AUG	7	91	0 o/oo	3.00	94.60	69.0	0.60
AUG	7	91	6 o/oo	2.40	55.90	48.2	0.32
AUG	7	91	12 o/oo	3.70	106.60	79.1	0.10
AUG	7	91	20 o/oo	2.05	46.30	39.8	0.01
SEPT	16	91	0 o/oo	3.75	45.00	44.3	0.42
SEPT	16	91	6 o/oo	3.70	.	.	0.28
SEPT	16	91	12 o/oo	4.20	27.82	27.3	0.13
SEPT	16	91	20 o/oo	2.40	21.76	19.6	0.18
OCT	8	91	0 o/oo	4.30	37.30	36.7	0.29
OCT	8	91	6 o/oo	3.80	33.50	32.4	0.19
OCT	8	91	12 o/oo	10.50	28.10	26.5	0.15
OCT	8	91	20 o/oo	10.40	88.94	87.2	0.03

TABLE 3.14 (cont.)

ADDED CHEMICAL PARAMETERS

NOV	12	91	0 o/oo	3.50	63.50	73.8	0.18
NOV	12	91	6 o/oo	3.40	33.20	32.6	0.14
NOV	12	91	12 o/oo	2.30	35.30	34.6	0.15
NOV	12	91	20 o/oo	1.64	26.40	25.9	0.10
DEC	16	91	0 o/oo	6.10	22.00	21.5	0.12
DEC	16	91	6 o/oo	6.70	25.90	22.4	0.20
DEC	16	91	12 o/oo	5.30	26.70	26.1	0.06
DEC	16	91	20 o/oo	4.20	22.20	20.9	0.06

TABLE 3.15

RANGES AND MEANS BY YEAR AND LOCATION

OVERALL 1990-1991

Variable	N	Minimum	Maximum	Mean	Std Dev
TURB	96	0.89	10.50	3.53	1.77
TOC	91	5.13	106.60	26.94	16.65
DOC	95	0.21	87.20	20.36	15.31
IRON	96	0.01	0.86	0.17	0.14

BY YEAR

YEAR=90

Variable	N	Minimum	Maximum	Mean	Std Dev
TURB	48	0.89	8.80	3.27	1.58
TOC	44	5.13	41.37	21.16	8.60
DOC	48	0.21	25.00	12.32	5.16
IRON	48	0.02	0.86	0.17	0.14

YEAR=91

Variable	N	Minimum	Maximum	Mean	Std Dev
TURB	48	1.64	10.50	3.79	1.93
TOC	47	8.00	106.60	32.36	20.28
DOC	47	8.00	87.20	28.56	17.76
IRON	48	0.01	0.67	0.18	0.13

TABLE 3.15 (cont.)

RANGES AND MEANS BY YEAR AND LOCATION

BY LOCATION

STATION= 0 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
TURB	24	0.89	6.10	2.93	1.33
TOC	23	13.00	94.60	31.76	18.34
DOC	24	0.21	73.80	20.79	19.76
IRON	24	0.06	0.67	0.25	0.16

STATION= 6 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
TURB	24	1.89	7.40	3.66	1.38
TOC	22	5.13	55.90	26.31	11.26
DOC	23	6.06	48.20	18.32	10.72
IRON	24	0.07	0.36	0.16	0.08

STATION= 12 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
TURB	24	1.82	10.50	3.85	2.09
TOC	23	11.00	106.60	26.25	18.91
DOC	24	9.24	79.10	20.68	14.26
IRON	24	0.03	0.26	0.13	0.07

STATION= 20 o/oo

Variable	N	Minimum	Maximum	Mean	Std Dev
TURB	24	1.64	10.40	3.66	2.09
TOC	23	7.08	88.94	23.43	16.78
DOC	24	6.50	87.20	21.56	15.74
IRON	24	0.01	0.86	0.14	0.17

flow related parameters. As indicated in Figure 3.2 it was found that temperature, rather than light, can be used to serve as an extremely stable proxy for seasonal variation. As previously indicated, the two flow related parameters which dominate the response of phytoplankton in the upper Charlotte Harbor estuarine system are nitrogen and color. Three dimensional plots, Figures 3.54 through 3.69, were developed using the SAS statistical procedure G3GRID using the observed ranges over all four salinity zones. This procedure takes the observed data and uses it to develop predicted response surfaces employing functions which both interpolate and smooth the predicted values. In interpreting these representations two important factors must be realized: 1) ambient nutrient levels per se are often difficult to directly correlate with either carbon fixation or chlorophyll a, and 2) the surfaces resulting from such 3-dimensional plots represent values "predicted" from the observed data set, **not observed values**, and are thus highly influenced by both the size and range of observations within the original data set.

The difficulty in developing predictive responses using ambient nitrogen levels are apparent in Figures 3.54 through 3.61. Although a number of very interesting patterns are apparent, the interpretation of these response surfaces are somewhat confounded by the observations that: 1) high levels of primary production can be sustained by rapid rates of nutrient recycling during periods when ambient concentrations remain low, and 2) high ambient nitrogen levels occur both during the winter when production is restricted by light and temperature, and during the summer when increasing nitrogen is also associated with increasing color.

Nevertheless, when phytoplankton responses as measured by carbon uptake and chlorophyll a were integrated over the observed ranges of temperature and nitrogen

FIGURE 3.54

STATION 0 o/oo

Carbon Uptake (mg/m3/E)
vs Nitrate/Nitrite (mg/l) and Temperaturue (C)

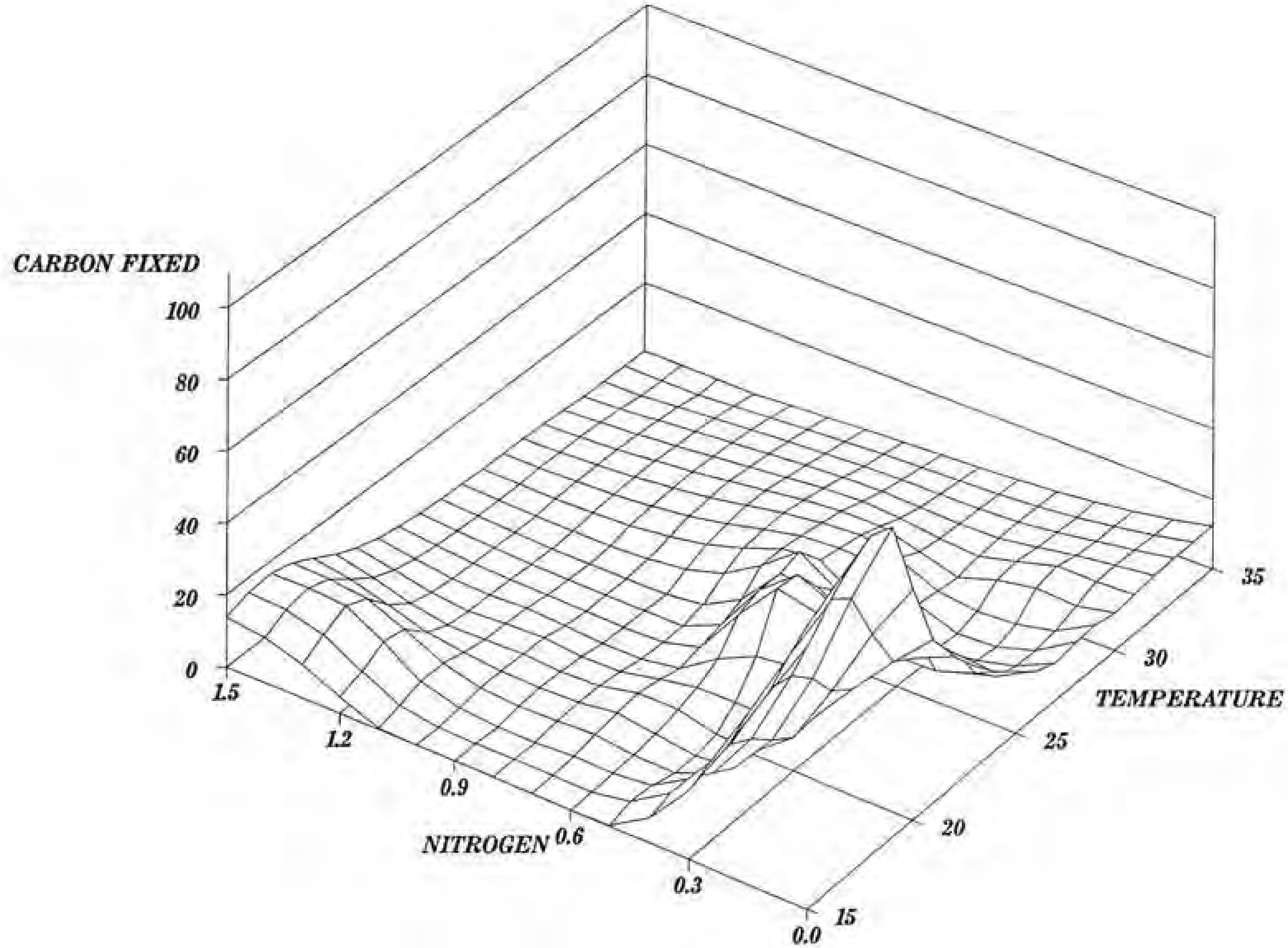


FIGURE 3.[illegible]5

STATION 6 o/oo

Carbon Uptake (mg/m3/E)
vs Nitrate/Nitrite (mg/l) and Temperaturue (C)

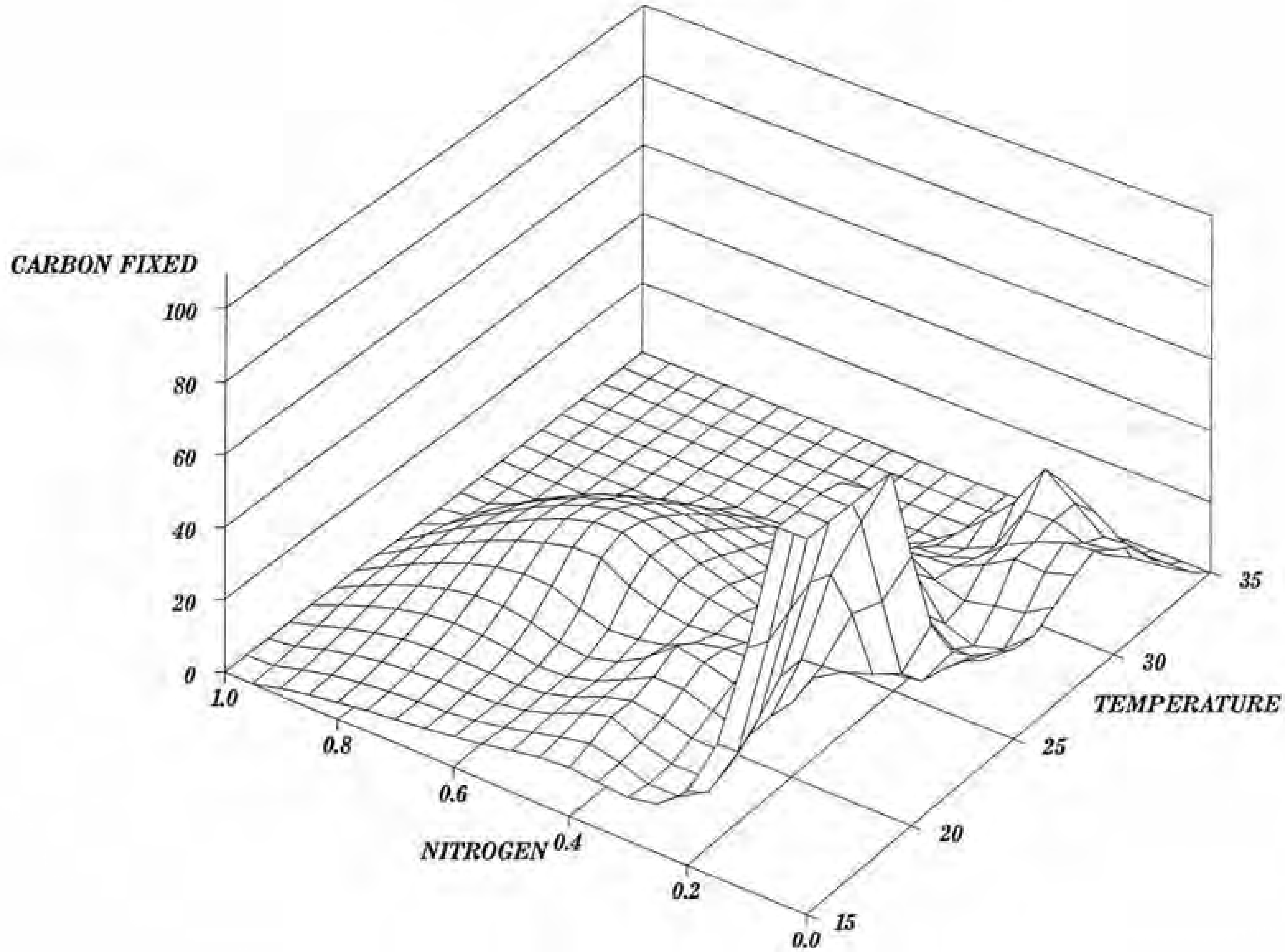


FIGURE 3.5[illegible]

STATION 12 o/oo

Carbon Uptake (mg/m3/E)
vs Nitrate/Nitrite (mg/l) and Temperaturue (C)

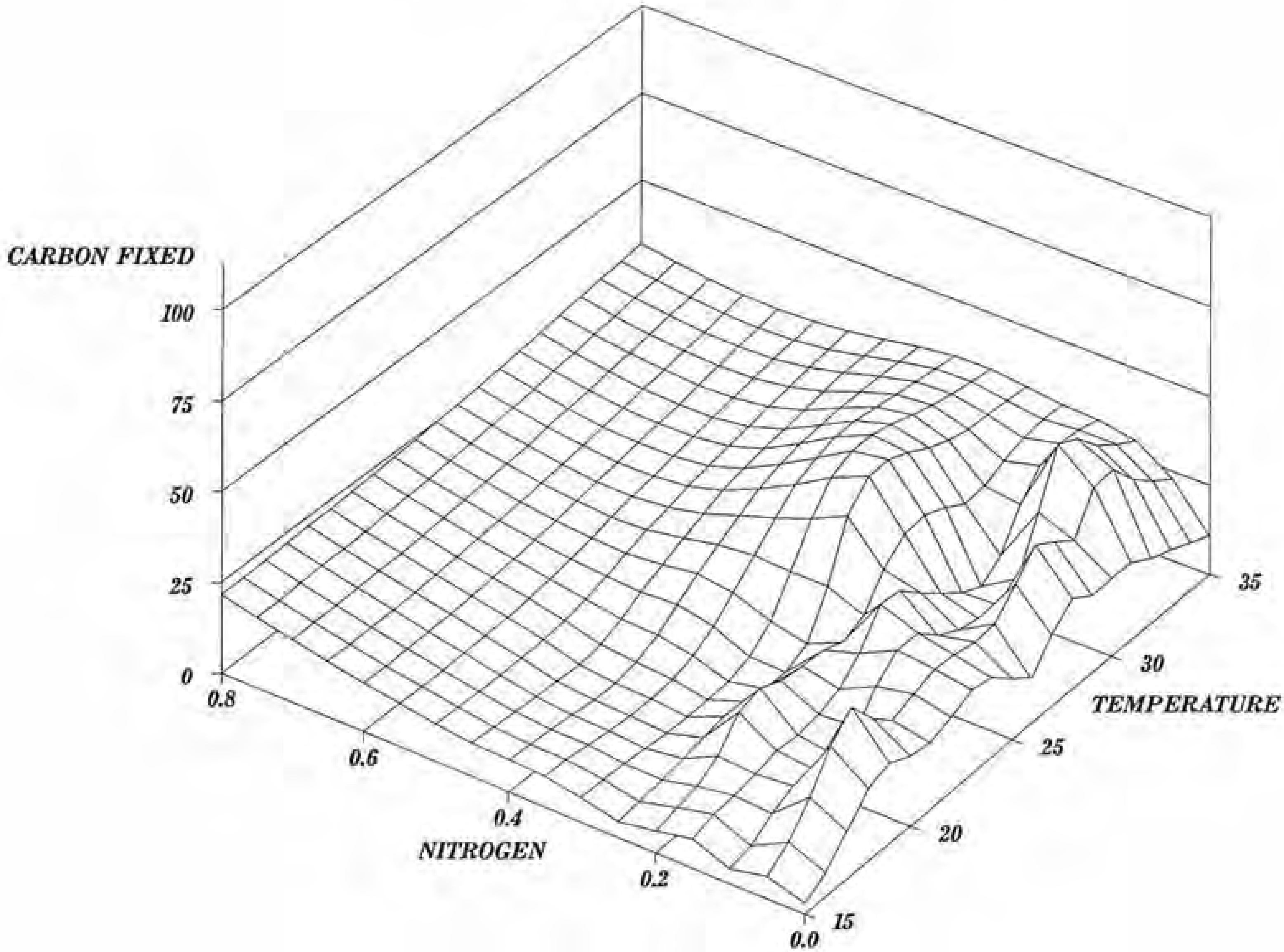


FIGURE 3.57

STATION 20 o/oo

Carbon Uptake (mg/m3/E)
vs Nitrate/Nitrite (mg/l) and Temperaturue (C)

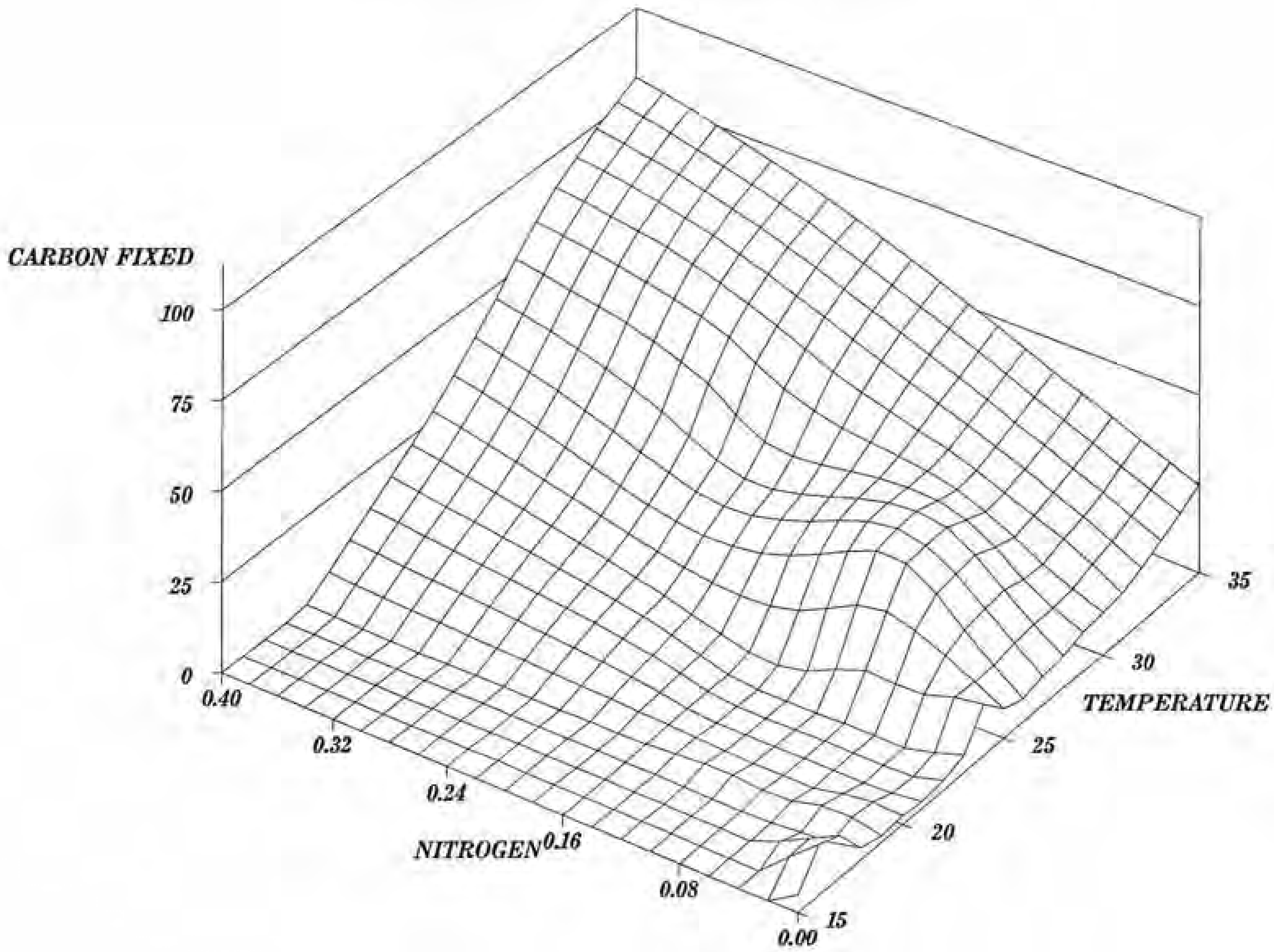


FIGURE 3.58

STATION 0 o/oo

Chlorophyll a (mg/m3)
vs Nitrate/Nitrite (mg/l) and Temperaturue (C)

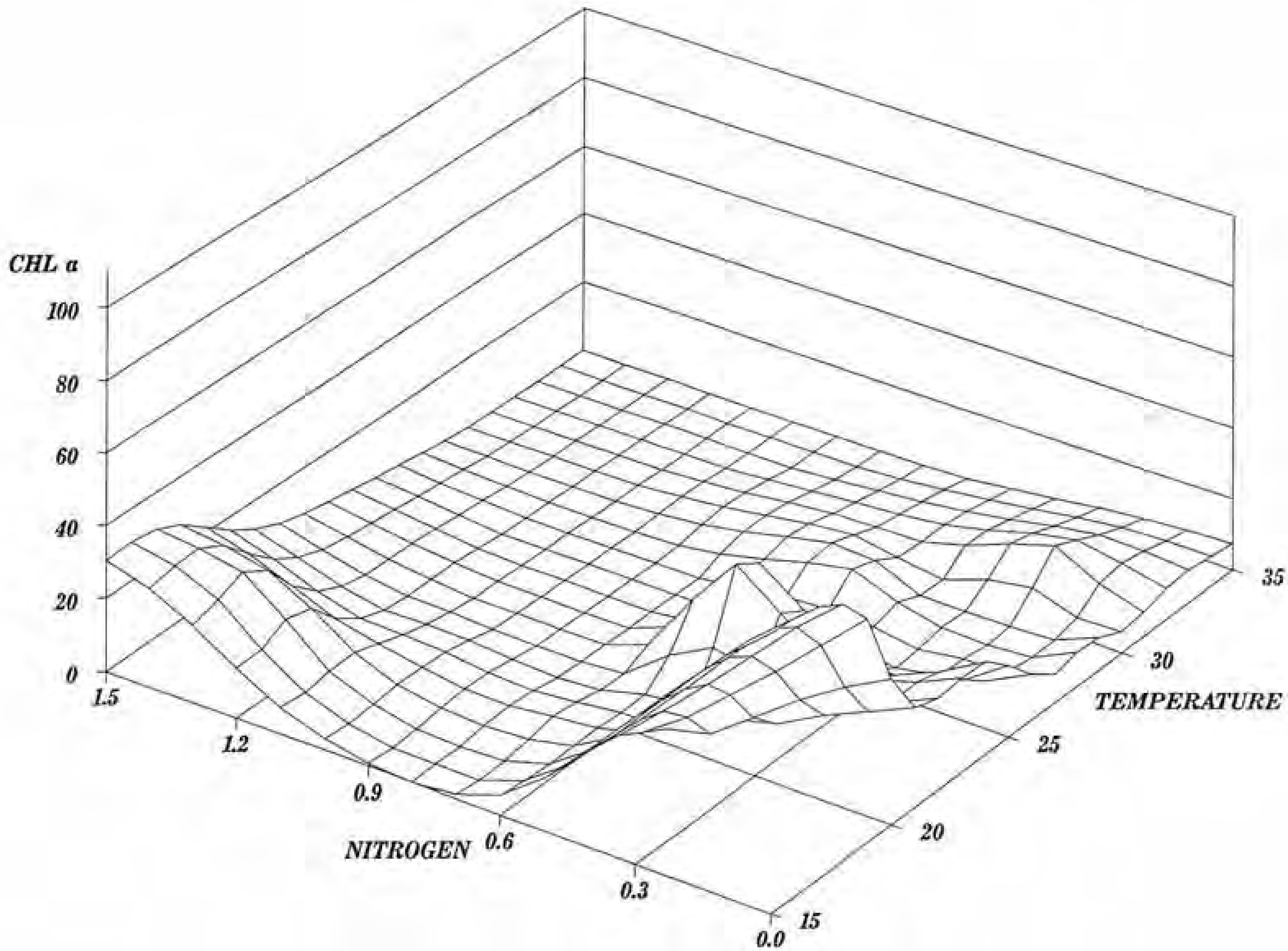


FIGURE 3.59

STATION 6 o/oo

Chlorophyll a (mg/m3)
vs Nitrate/Nitrite (mg/l) and Temperaturue (C)

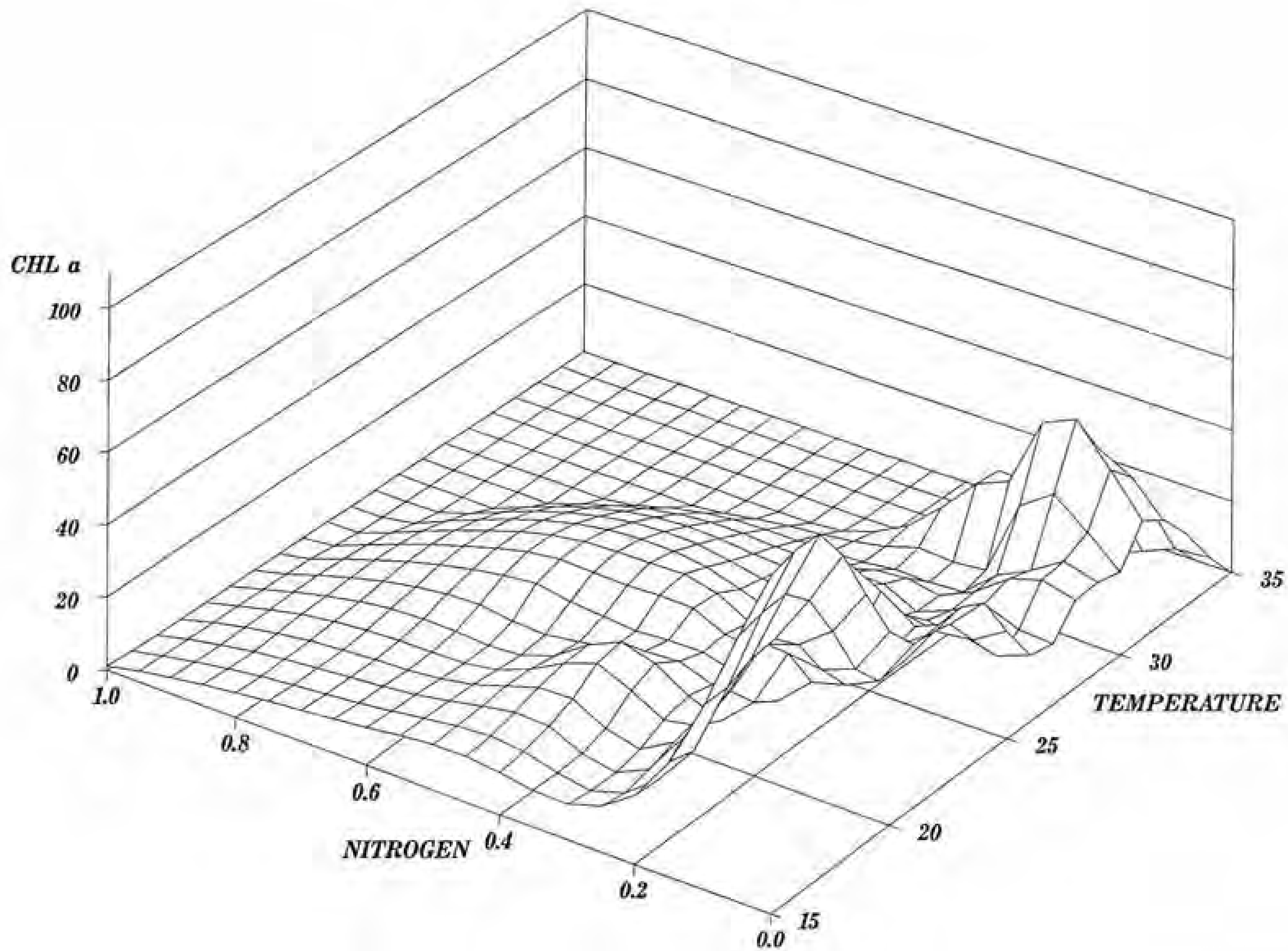


FIGURE 3.60

STATION 12 o/oo

Chlorophyll a (mg/m3)
vs Nitrate/Nitrite (mg/l) and Temperaturue (C)

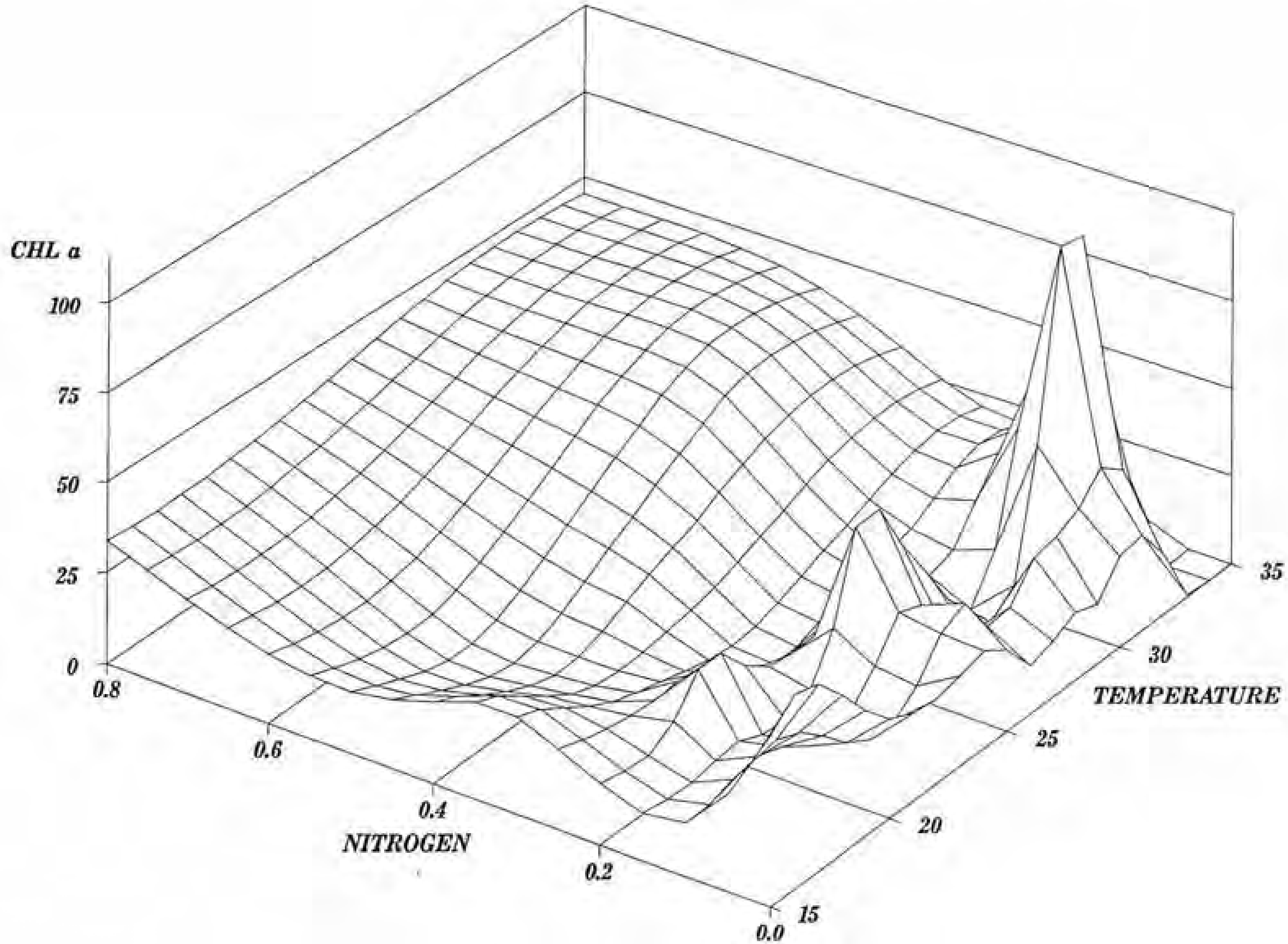
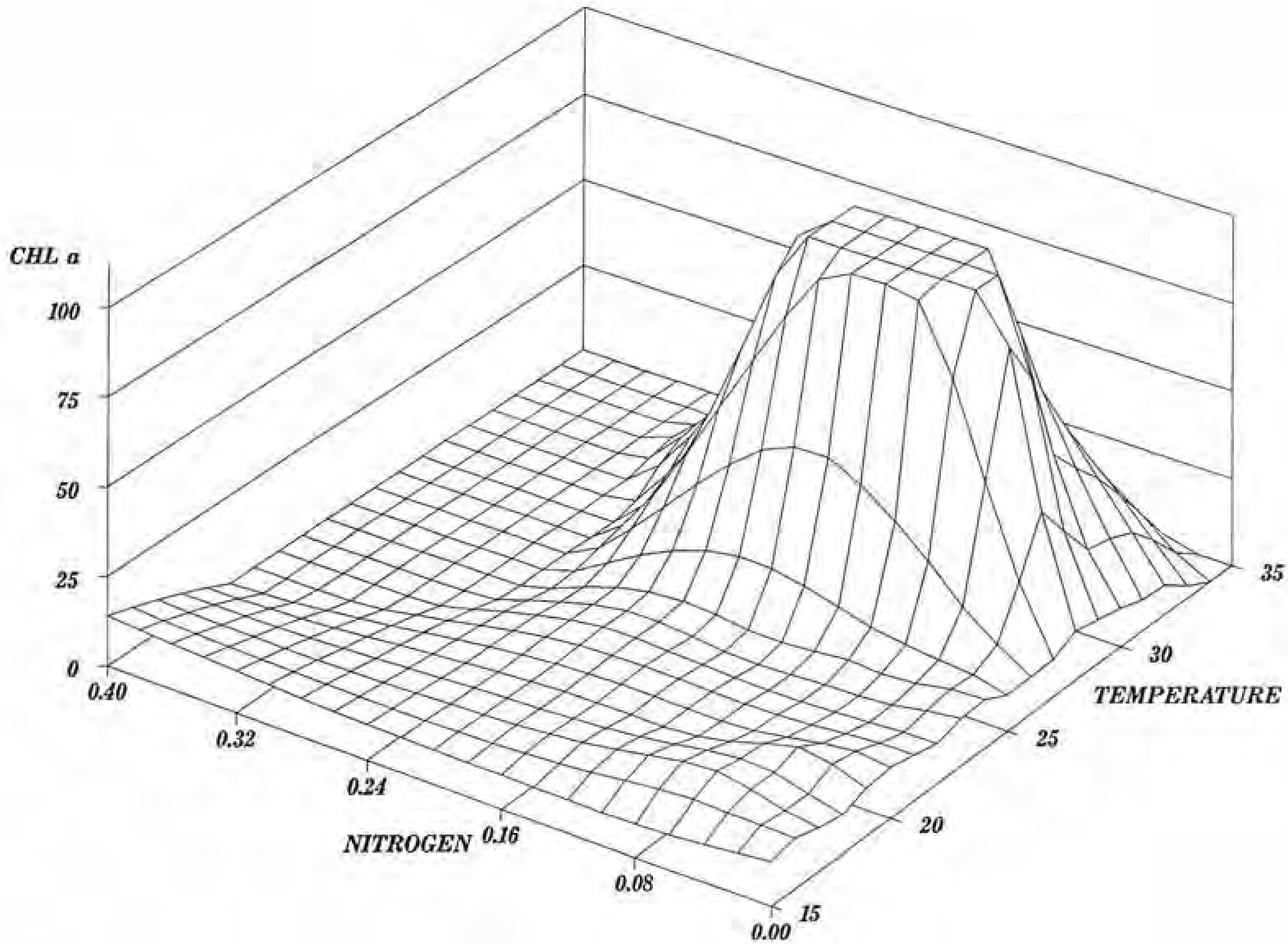


FIGURE 3.51

STATION 20 o/oo

Chlorophyll a (mg/m3)
vs Nitrate/Nitrite (mg/l) and Temperaturue (C)



3) 12 o/oo Salinity - carbon uptake and chlorophyll a show somewhat different predicted response patterns. While carbon uptake indicates steady increasing rates with higher temperatures at moderate nitrogen levels, the pattern for chlorophyll a is typified by discreet increasing peaks with rising temperatures.

4) 20 o/oo Salinity - of particular note in these figures is the reduced ambient range of observed nitrogen levels, when compared to the other three salinity zones. At this salinity, at water temperatures above 20 °C, there is an almost linear response of carbon uptake to both temperature and nitrogen. Chlorophyll a, on the other hand, indicates extremely high predicted levels at high temperatures and intermediate nitrogen levels.

The advantages of using color as a proxy for flow, combining the competing influences of increasing nutrient loadings and decreasing light penetration of the water column, are apparent in the predictive models shown in Figures 3.62 through 3.69. These figures indicate:

1) 0 o/oo Salinity - peaks in carbon uptake are predicted at intermediate temperatures and levels of water color. Chlorophyll a, is indicated to be somewhat more temperature dependent.

2) 6 0/00 Salinity - both measurement of phytoplankton production and biomass indicate predictive peaks at intermediate levels of color, and stronger seasonal variation than at the lower salinity.

3) 12 0/00 Salinity - carbon uptake indicates a progress predicted response to the combined influences of increasing temperature and water color (nutrient loading). Chlorophyll a, by comparison, indicates the highest predicted levels at Summer temperatures and intermediate ranges of water color.

4) 20 o/oo Salinity - at this salinity the predicted responses of the two measurements of phytoplankton production, carbon uptake and chlorophyll a biomass, show marked differences. Much like at 12 o/oo, carbon uptake indicates a progress predicted response to the combined influences of increasing temperature and water color over the observed ambient ranges. Chlorophyll a, by contrast, indicates very high predicted levels at intermediate temperatures and high water color (nutrients).

FIGURE 3.[illegible]2

STATION 0 o/oo

Carbon Uptake (mg/m3/E)
vs Color and Temperaturue (C)

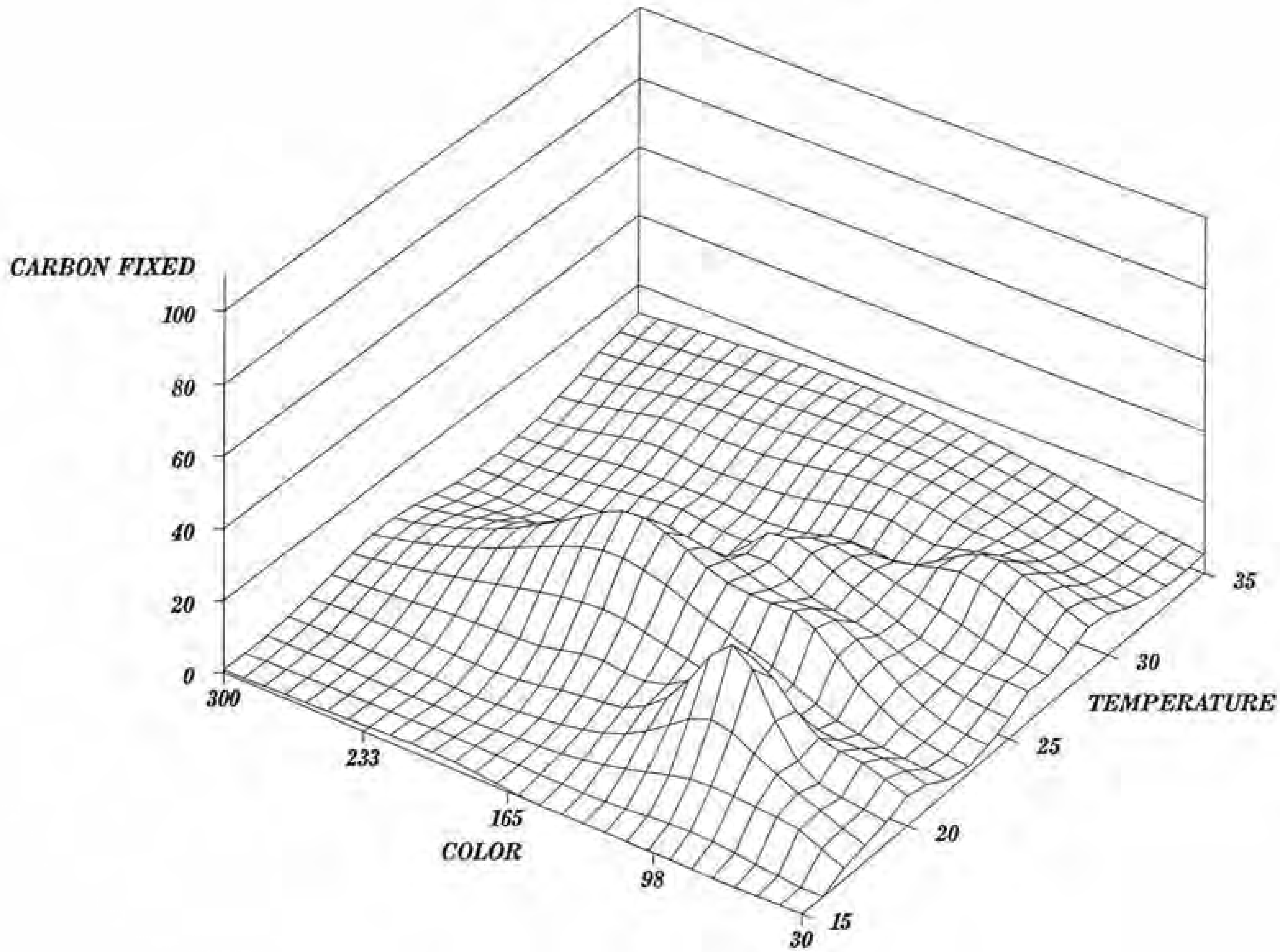


FIGURE 3.63

STATION 6 o/oo

Carbon Uptake (mg/m3/E)
vs Color and Temperaturue (C)

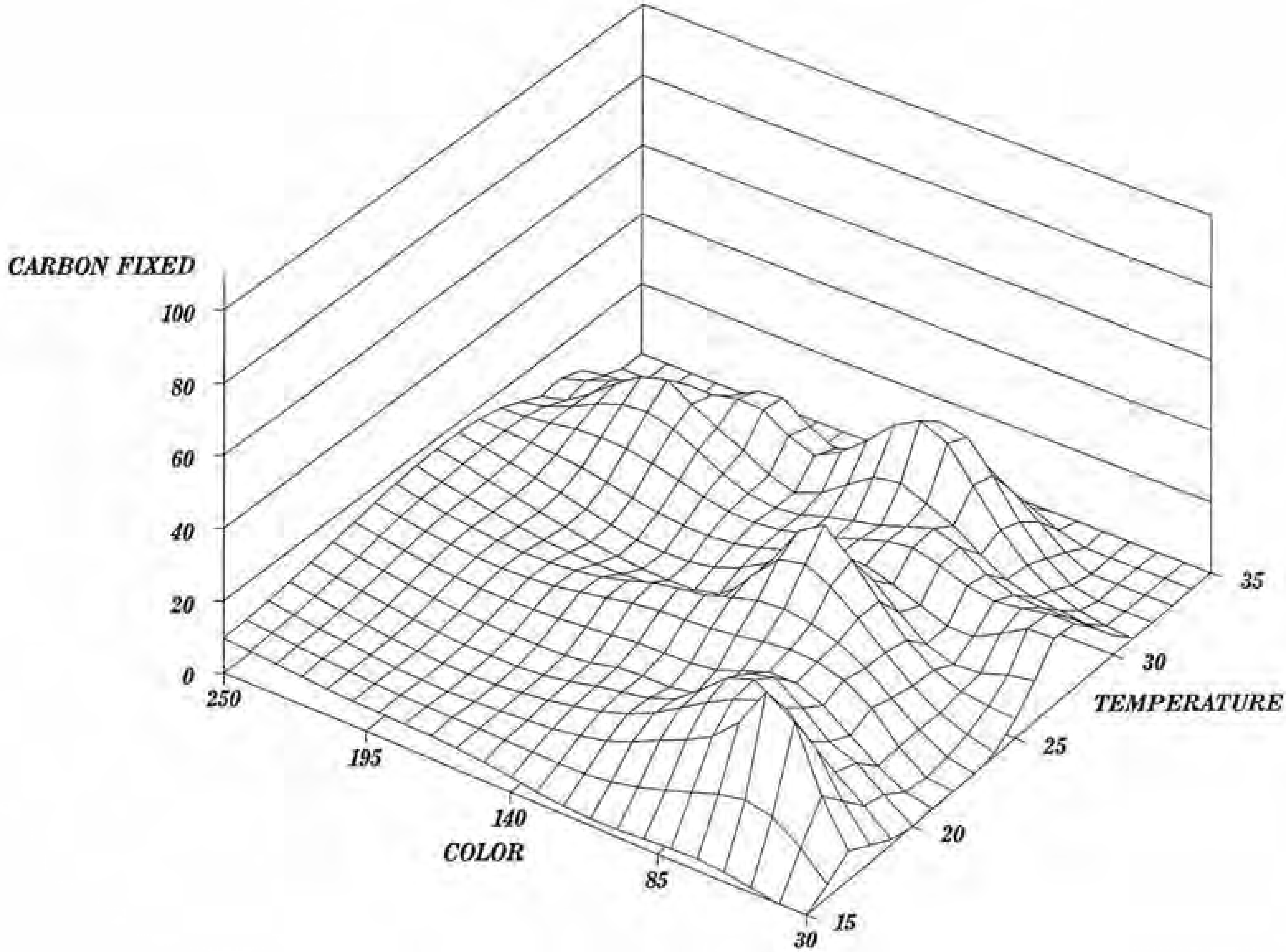


FIGURE 3.[illegible]4

STATION 12 o/oo

Carbon Uptake (mg/m3/E)
vs Color and Temperaturue (C)

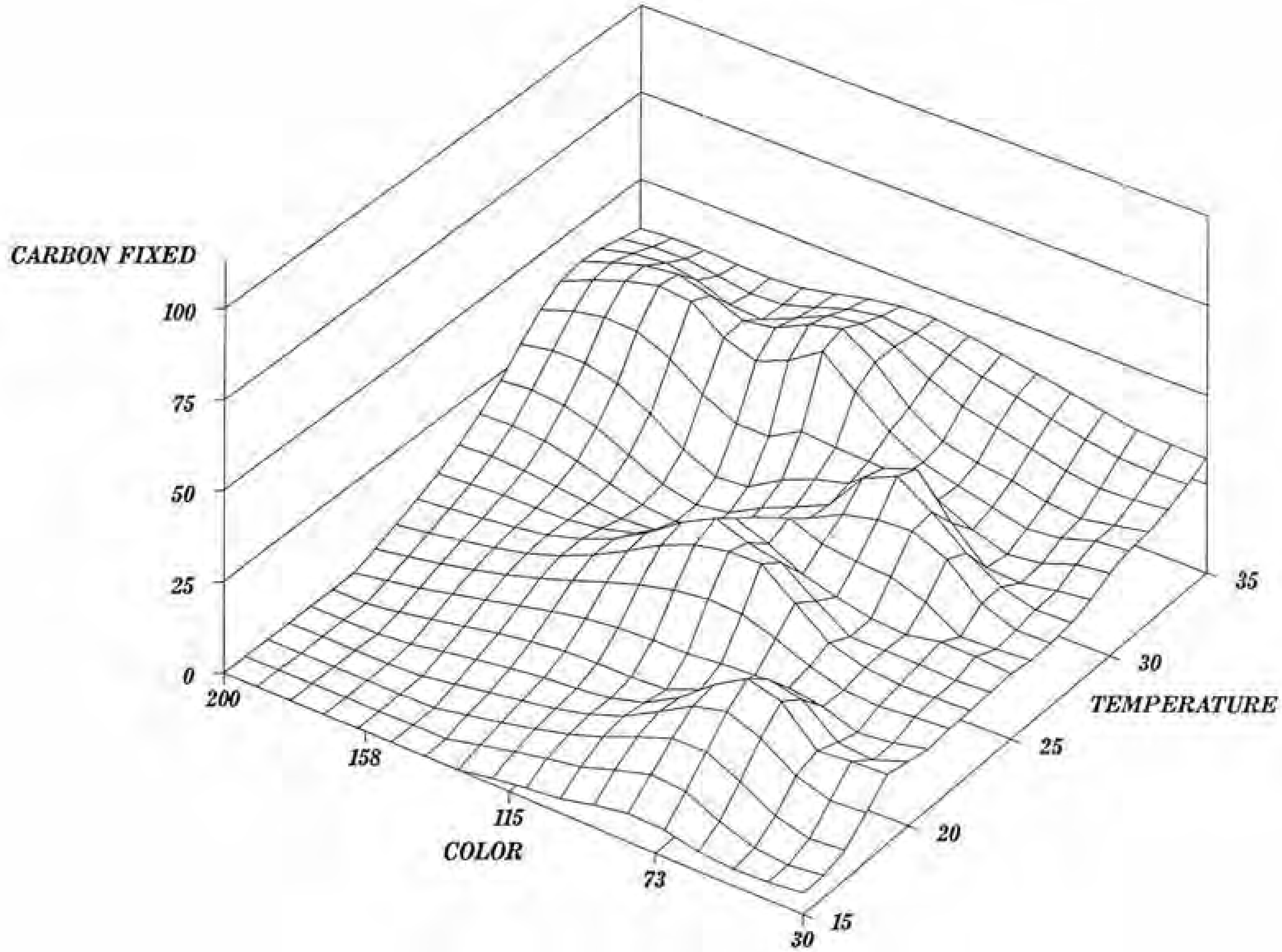


FIGURE 3.65

STATION 20 o/oo

Carbon Uptake (mg/m3/E)
vs Color and Temperaturue (C)

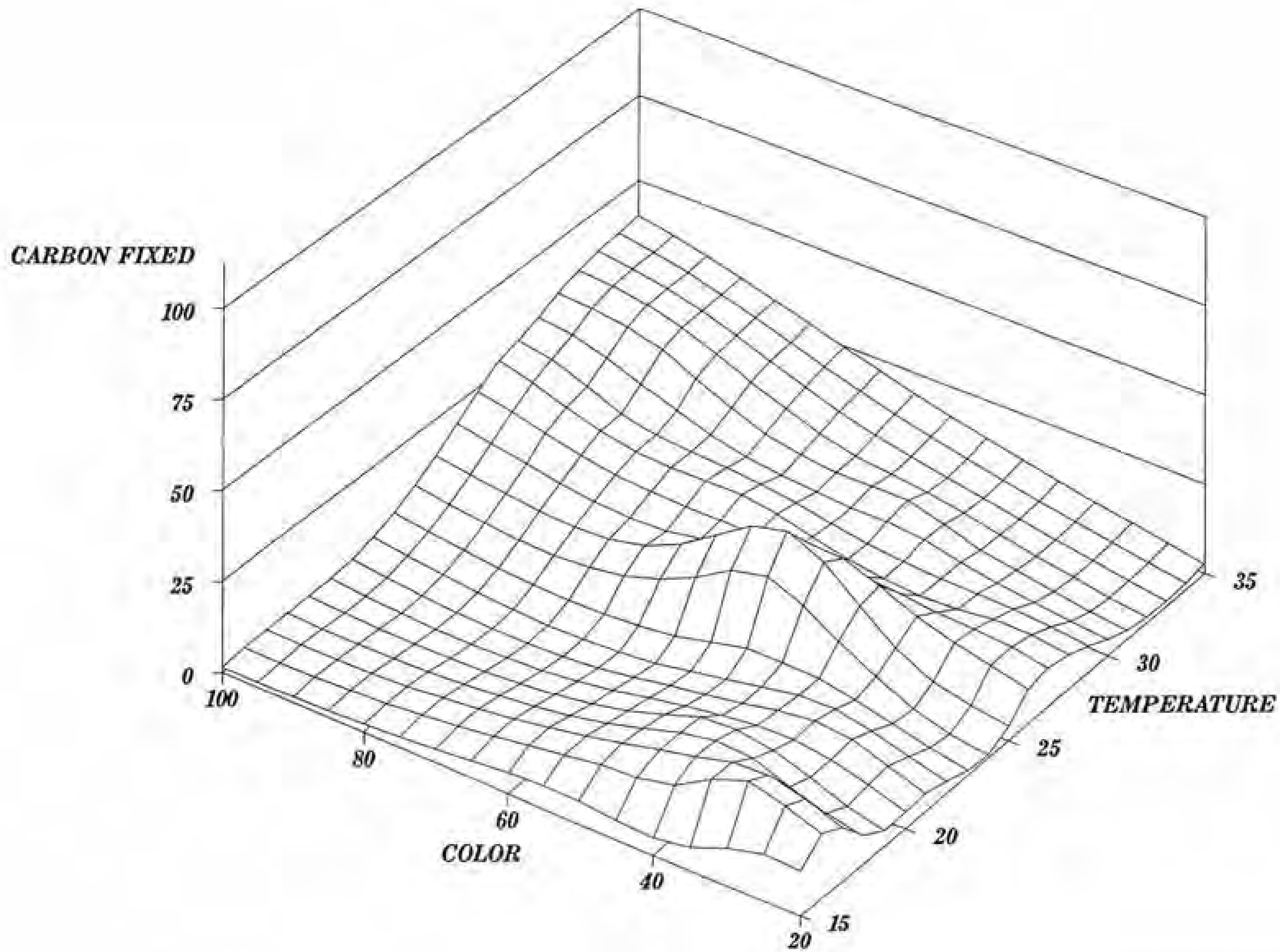


FIGURE 3-56

STATION 0 o/oo

Chlorophyll a (mg/m3)
vs Color and Temperaturue (C)

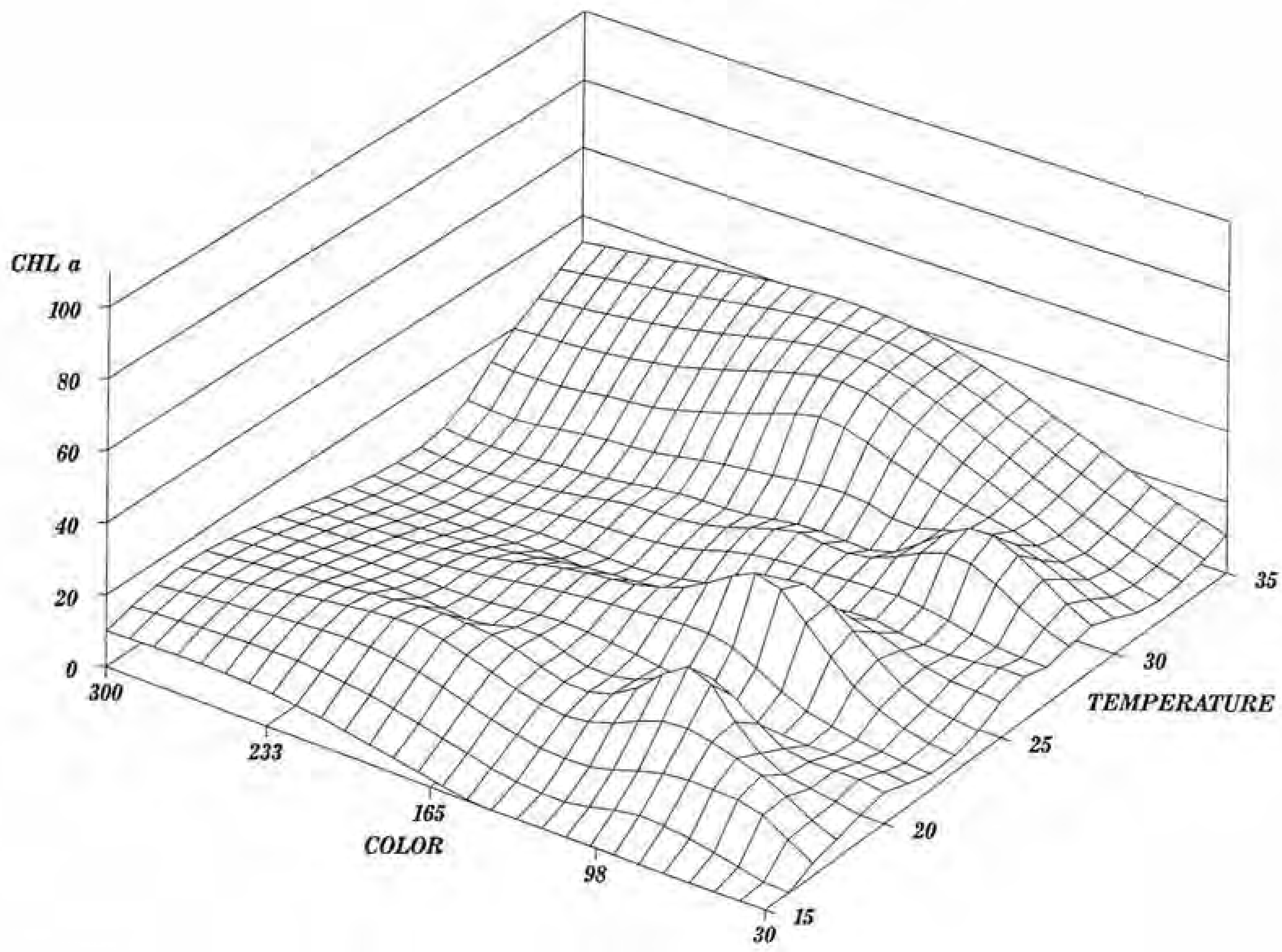


FIGURE 3.37

STATION 6 o/oo

Chlorophyll a (mg/m3)
vs Color and Temperaturue (C)

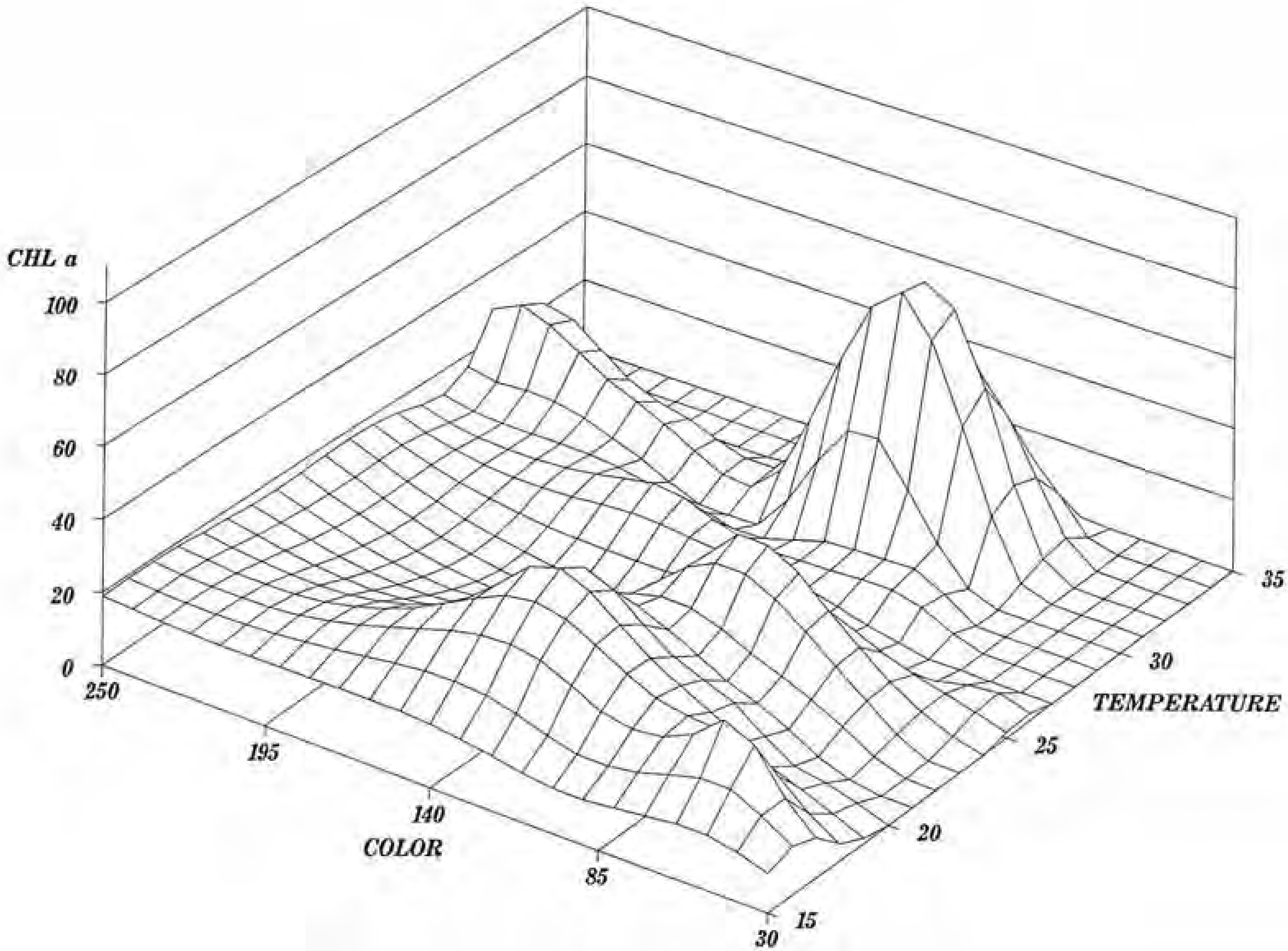


FIGURE 3 -8

STATION 12 o/oo

Chlorophyll a (mg/m3)
vs Color and Temperaturue (C)

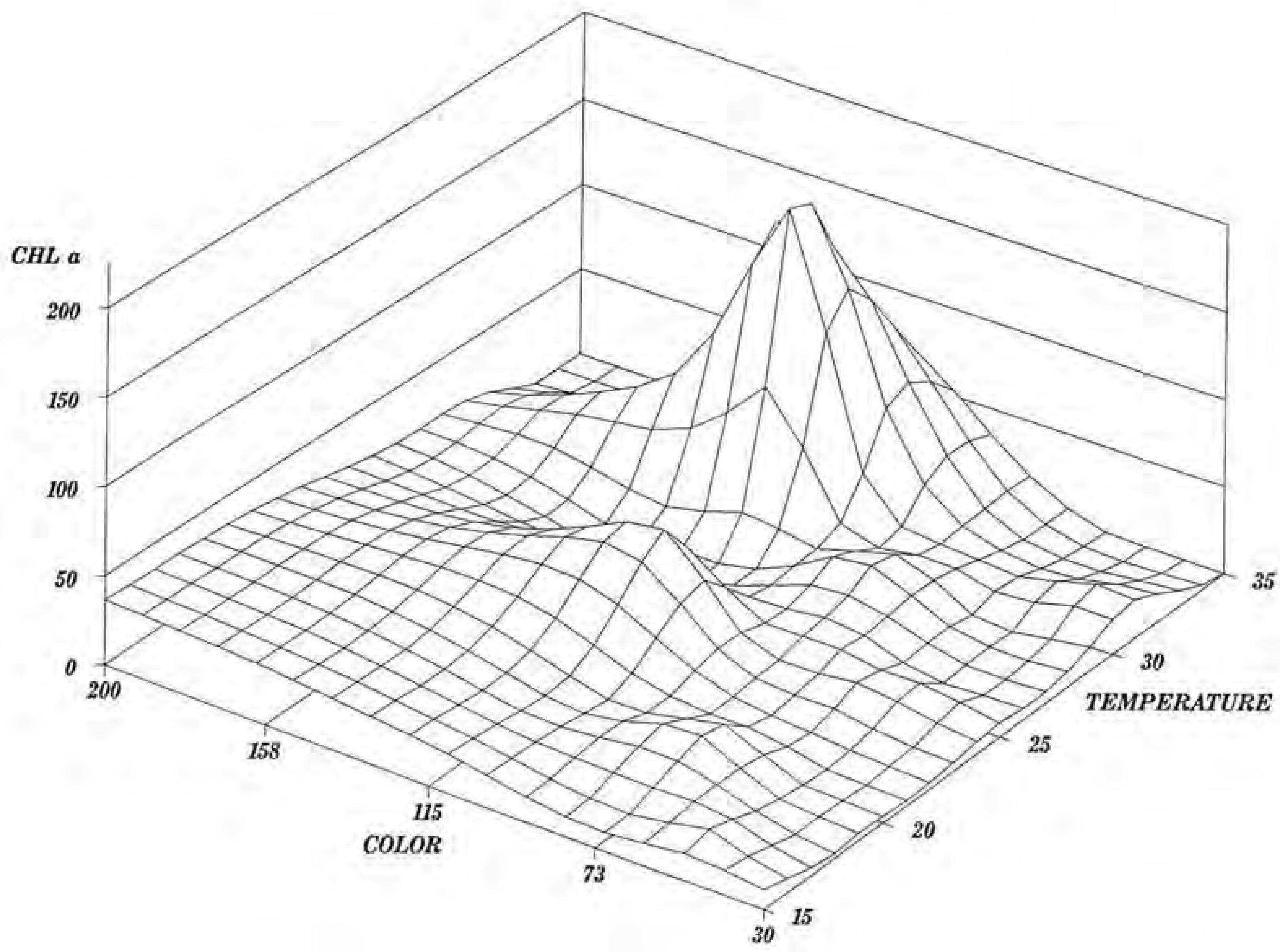
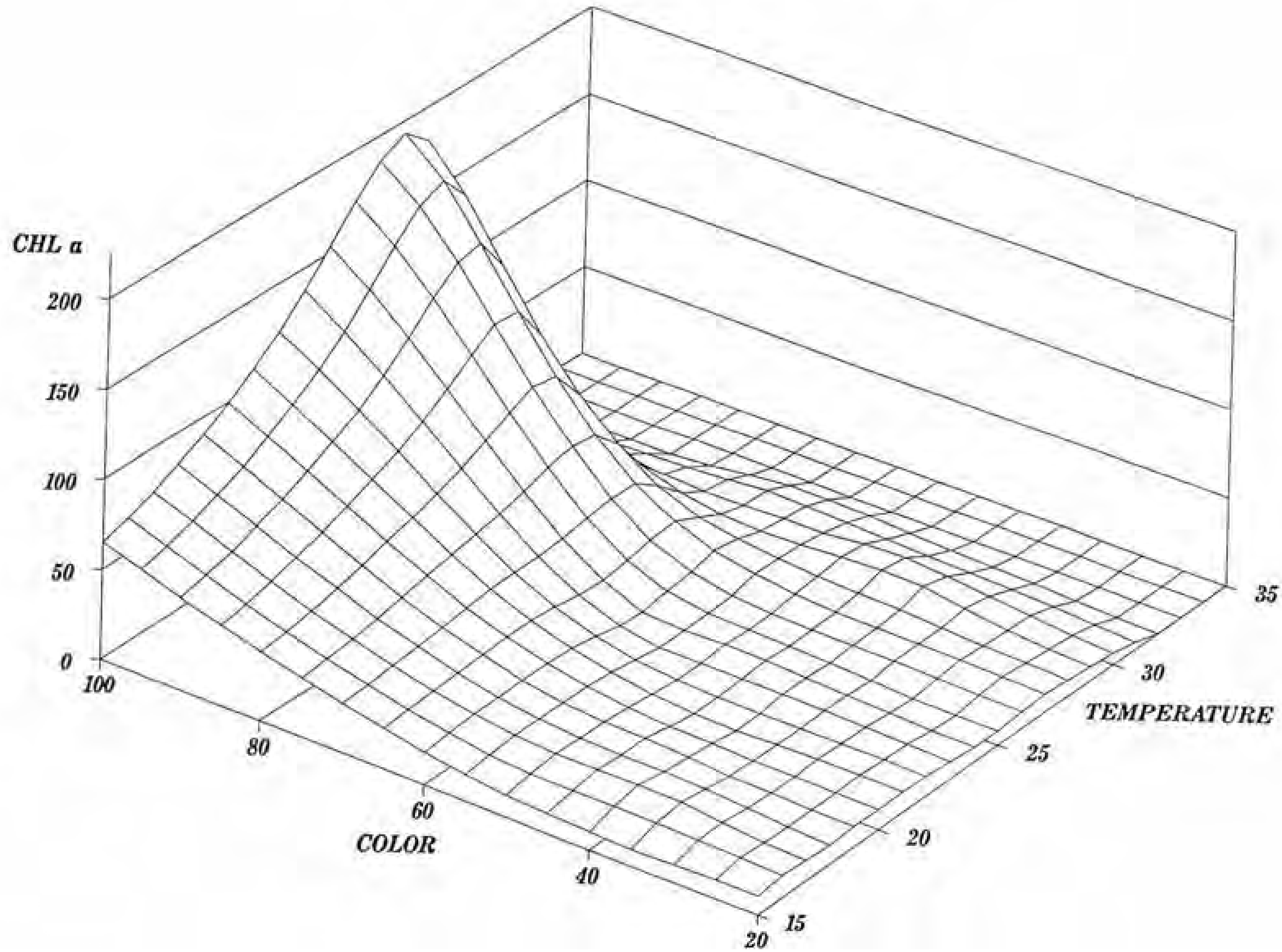


FIGURE 3.69

STATION 20 o/oo

Chlorophyll a (mg/m3)
vs Color and Temperaturue (C)



(N2/3) characteristically seasonally observed at each salinity zone, the following generalized patterns were apparent:

1) 0 o/oo Salinity - both carbon uptake and chlorophyll a show very similar predictive responses. Maximum production measurements are expected at temperatures ranging between 20 and 25 °C and ambient nitrogen levels up to 0.6 mg/l. These are conditions typical of both Spring and Fall. Although a predicted secondary peak is apparent at high nitrogen levels at low temperatures, very little production is predicted during periods of high temperature and high nitrogen. This result corresponds, as shown below, to the negative effects of high water color on phytoplankton production.

2) 6 o/oo Salinity - two peaks in phytoplankton production are apparent, one at lower and a second at the highest Summer temperatures. A much diminished broader response is apparent over intermediate observed temperature and nitrogen levels.

3) 12 o/oo Salinity - carbon uptake and chlorophyll a show somewhat different predicted response patterns. While carbon uptake indicates steady increasing rates with higher temperatures at moderate nitrogen levels, the pattern for chlorophyll a is typified by discreet increasing peaks with rising temperatures.

4) 20 o/oo Salinity - of particular note in these figures is the reduced ambient range of observed nitrogen levels, when compared to the other three salinity zones. At this salinity, at water temperatures above 20 °C, there is an almost linear response of carbon uptake to both temperature and nitrogen. Chlorophyll a, on the other hand, indicates extremely high predicted levels at high temperatures and intermediate nitrogen levels.

The advantages of using color as a proxy for flow, combining the competing influences of increasing nutrient loadings and decreasing light penetration of the water column, are apparent in the predictive models shown in Figures 3.62 through 3.69. These figures indicate:

1) 0 o/oo Salinity - peaks in carbon uptake are predicted at intermediate temperatures and levels of water color. Chlorophyll a, is indicated to be somewhat more temperature dependent.

2) 6 0/00 Salinity - both measurement of phytoplankton production and

biomass indicate predictive peaks at intermediate levels of color, and stronger seasonal variation than at the lower salinity.

3) 12 0/00 Salinity - carbon uptake indicates a progress predicted response to the combined influences of increasing temperature and water color (nutrient loading). Chlorophyll a, by comparison, indicates the highest predicted levels at Summer temperatures and intermediate ranges of water color.

4) 20 o/oo Salinity - at this salinity the predicted responses of the two measurements of phytoplankton production, carbon uptake and chlorophyll a biomass, show marked differences. Much like at 12 o/oo, carbon uptake indicates a progress predicted response to the combined influences of increasing temperature and water color over the observed ambient ranges. Chlorophyll a, by contrast, indicates very high predicted levels at intermediate temperatures and high water color (nutrients).

Based on the preceding observed patterns the following generalization may be made regarding phytoplankton production in the lower Peace River/upper Charlotte Harbor estuarine system:

1) Both phytoplankton production and biomass are indicated to be low, at all salinities, irregardless of temperature, during periods of low water color.

2) As color increases to intermediate levels, both phytoplankton production and biomass are predicted to show significant responses. The magnitudes of these responses are indicated as being highly temperature dependent.

3) Past a point at lower salinities, however, further increases in color overwhelm the initial stimulation of increasing nutrients associated with flow, and both production and biomass are predicted to decline rapidly.

4) The strongest indications of nutrient limiting conditions are apparent at 20 o/oo salinity, which shows the strongest seasonal responses to increasing loadings.

3.3.6 Principal Component Analysis

The limitations of the preceding methods in attempting to determine and describe the causative physical and chemical factors controlling the response of phytoplankton populations to freshwater inflows are apparent. Such methods allow for the simultaneous analysis of the responses and interactions of only one or two factors at a time. Phytoplankton production and growth are dependent, however, upon the cumulative responses to interactions of both gross and subtle factors. One widely used method for testing and describing such cumulative interactions is Principal Component Analysis. This technique, a subset of Factor Analysis, produces new synthetic variables (Factors) that are composites of the original independent variables. Each new Factor (or composite variable) created by this method is independent (uncorrelated) from every other new Factor. The ecological interpretation of these "new synthetic variables", as a result, is dependent only on their correlation (loadings) with the original measured variables. Each original sample observation can then be scored on the new synthetic composite Factors. Such scores are dependent both on the values for each of the original variables, and the correlations of these original parameters with the new synthetic factors. In essence, each sample can thus be described with respect to a small number of new independent composite variables (Factors) rather than the large number of physical and chemical parameters originally measured, while still preserving most of the ecologically relevant information contained within the original data set.

Principal component analysis was conducted using 25 physical and chemical parameters originally measured during the primary production study. Three of the new synthetic composite variables (Factors 1 through 3), developed from the original 25 variables, were retained for further analysis. Each of these new Factors was selected on the basis of its accounting for at least 10% of the total variation within the original data set.

The first of the new synthetic variables, Factor I, included high positive loadings with the measured flow variables, water color and the extinction coefficient of light, while at the same time having a high negative loading for the 1% light depth. Observations with high positive scores on Factor I, therefore, are characteristic of waters influenced by high flow and color, and rapid extinction through the water column of light. A sample with a low Factor I score would distinguish waters during low flow and having high clarity.

Factor II had high positive loadings with temperature and light, and negative loadings for nitrate-nitrite (NO3+NO2-N). Thus, samples with high positive scores on Factor II are characteristic of warmer water temperatures, high ambient light conditions, low nitrate/nitrate concentrations, (Summer conditions). A sample with a low Factor II score, by comparison, would represent conditions of relatively cooler water temperatures, and higher ambient nitrogen levels.

Factor III was positively correlated with nutrient variables (nitrate/nitrite, silica, ortho-phosphorus), and negatively correlated with both the relative distance down the harbor of the station location and the 1% light depth. An observation with a high positive score on Factor III, therefore, would be characteristic of increased nutrient concentrations, a relative riverine location, and low water clarity. Observations with a negative score on Factor III, by comparison, would be indicative of the upper harbor, low nutrients, and increased water clarity.

In essence, Factor I may be visualized, with its high loadings for flow, color and extinction coefficient, as summarizing freshwater inputs into the estuary. Factor II, by comparison, with its high correlation with water temperature, light, and wind is descriptive of seasonal variation over the study period. The final new synthetic variable, Factor III, summarizes station location in the study area, independent of flow and season.

The distributions of station "scores" on Factors I, II and III indicated significant differences existed in the physical and chemical characteristics of the salinity zone based stations with regards to Factor I (the freshwater input component). Mean station scores for Factor I were inversely related to salinity. There were also marked differences between stations with regard to Factor II, a proxy for seasonal changes. Analysis indicated t 0 and 6 o/oo were significantly different from 20 o/oo, while the 12 o/oo station relation to Factor II was intermediate. Differences existed between all stations with respect to Factor III. This indicated both, that independent of flow or season differences still existed between the nutrient characteristic of the four salinity zones, and that there was a strong locational component to the salinity based stations.

Correlations of carbon uptake rates (mg Carbon/m3/Einsteins) and chlorophyll a (mg/m3) with Factors I, II and III indicated that phytoplankton productivity and biomass were significantly correlated with all three Factors (alpha=0.05). Carbon uptake versus Factors I and II demonstrated that the highest measured production rates occurred at 6 o/oo and 12 o/oo during periods of relatively low freshwater inputs, coincident with periods of high temperature and light. The 20 o/oo station indicated the least variability with respect to Factors I and II, whereas carbon uptake at the 0 o/oo station was the most influenced. A similar plot of chlorophyll a versus Factors I and II showed similar trends. The response of chlorophyll a to the composite factors, however, appeared to be more of a threshold effect, rather than the gradual monotonic response observed for carbon uptake.

3.3.7 Summary of Monthly Means vs Temperature and Nutrients

Many of the observed patterns present in the preceding sections of this document can be observed in the summary patterns presented in Figures 3.70 through 3.73. In these figures monthly means for carbon uptake and chlorophyll a at each salinity zone over the eight years of study are depicted versus corresponding monthly means of nitrogen vs. temperature, and color vs. temperature. Seasonal difference at each salinity zone correspond to relative position of monthly means within the X-Y plain of the figures, while differences in carbon uptake and chlorophyll a are depicted both by the vertical height and the size of the symbol along the Z-axis.

These figures emphasize the following previously observed patterns:

1) There are marked differences among the salinity based stations with regard to mean monthly water color and nitrogen levels, and these patterns show strong seasonal patterns.

2) Carbon uptake and chlorophyll a both exhibit strong seasonal patterns among stations, with the intermediate two salinities having the highest phytoplankton production levels.

3) Carbon uptake and chlorophyll a differ in there response to the combined influences of nutrient (nitrogen/water color) loadings and season (temperature).

3.3.8 Relationships between Carbon Uptake and Chlorophyll a

In these investigations the responses of estuarine phytoplankton to changes in the physical and chemical environments were evaluated by the simultaneous measurements of both growth rates as measured by carbon uptake and standing biomass as determined by chlorophyll a levels. It should be noted that chlorophyll a as an estimate of biomass can be influenced by both ambient light levels as well as the nutritional state of the cells. Chlorophyll a, thus, often represents an integration of the phytoplankton community's

FIGURE 3.70

Carbon Uptake (mg/m3/E)
vs Nitrate/Nitrite (mg/l) and Temperaturue (C)

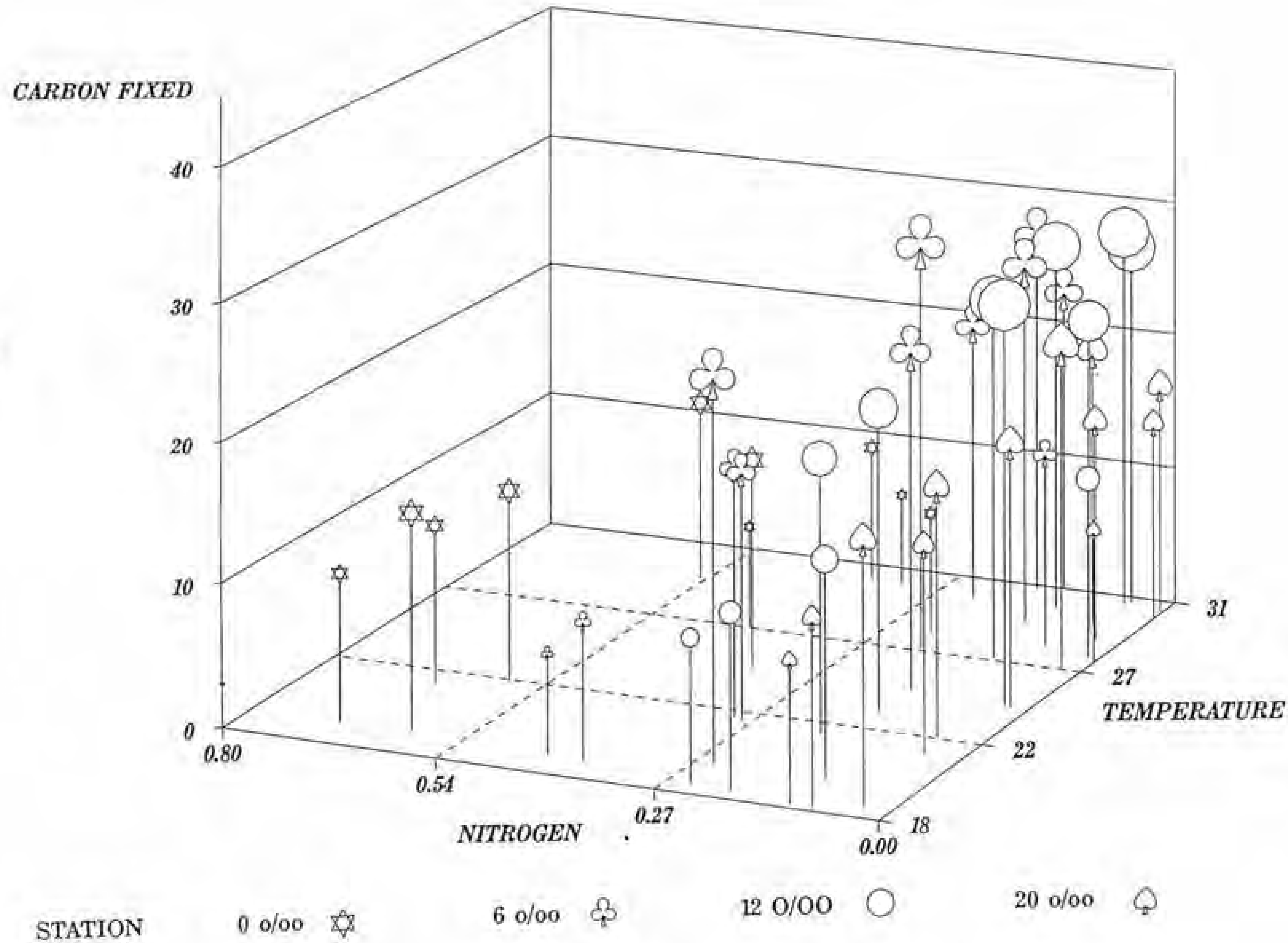


FIGURE 3.71

Carbon Uptake (mg/m3/E)
vs Color and Temperaturue (C)

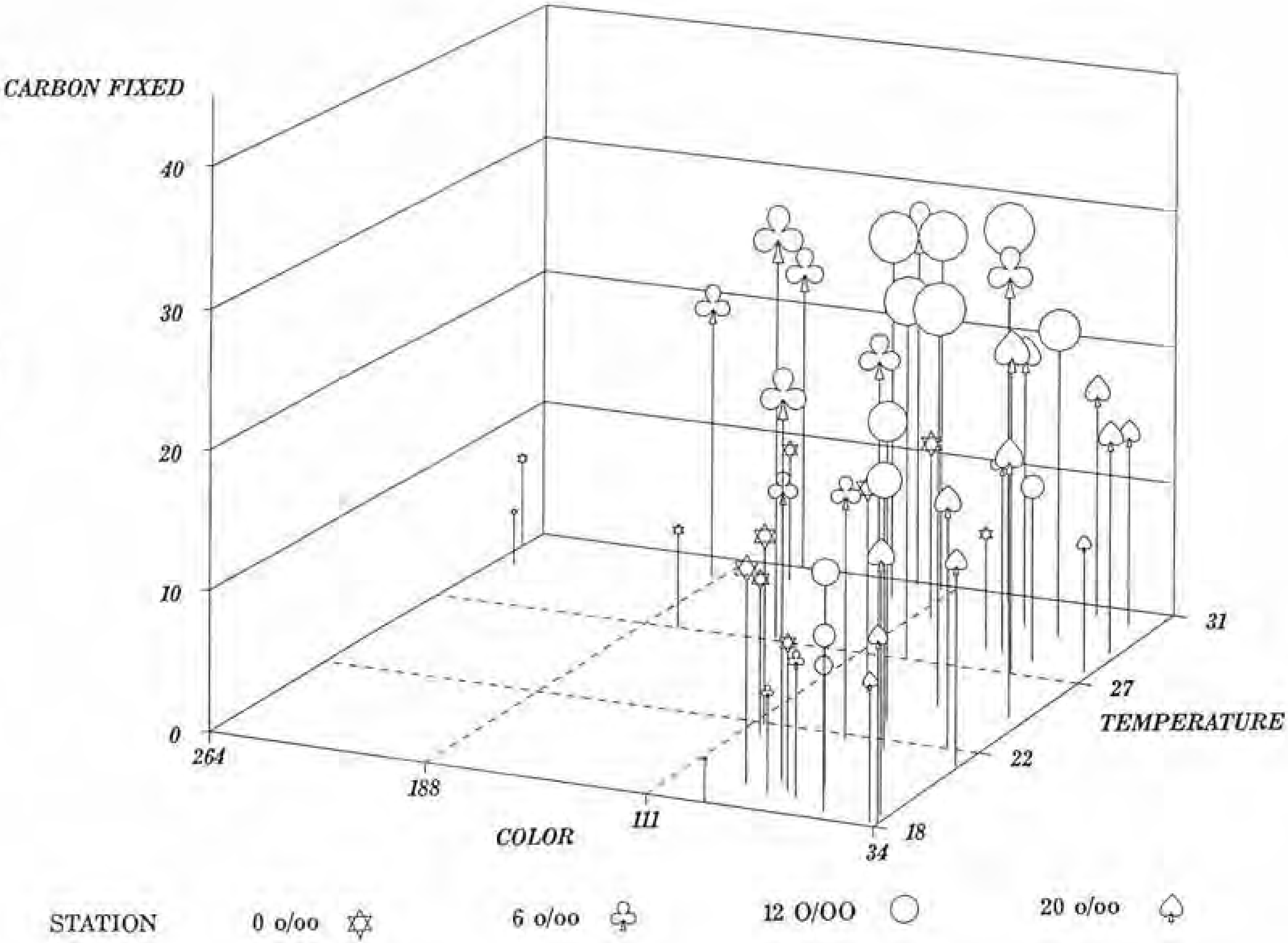


FIGURE 3.72

Chlorophyll a (mg/m3)
vs Nitrate/Nitrite (mg/l) and Temperaturue (C)

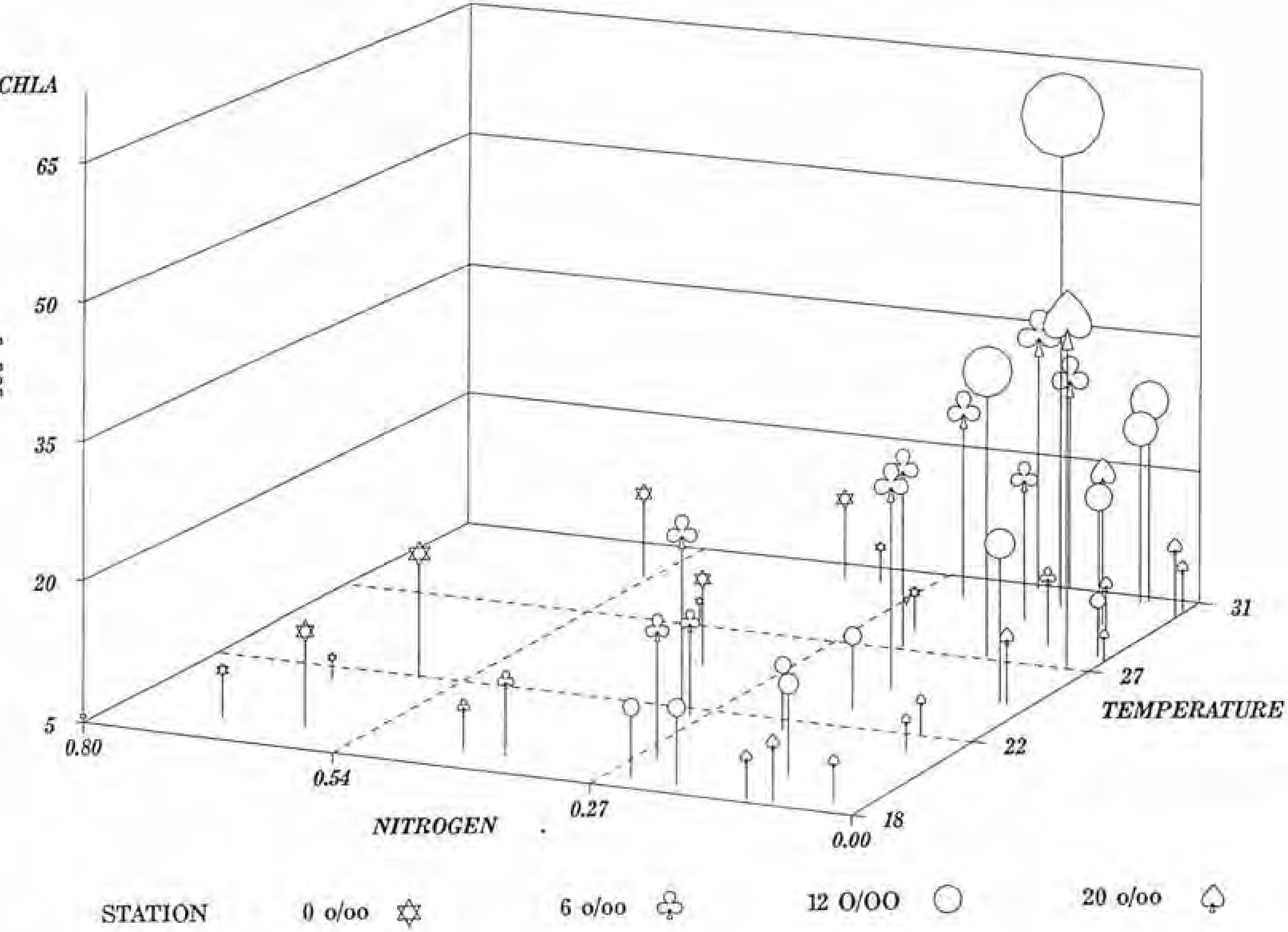
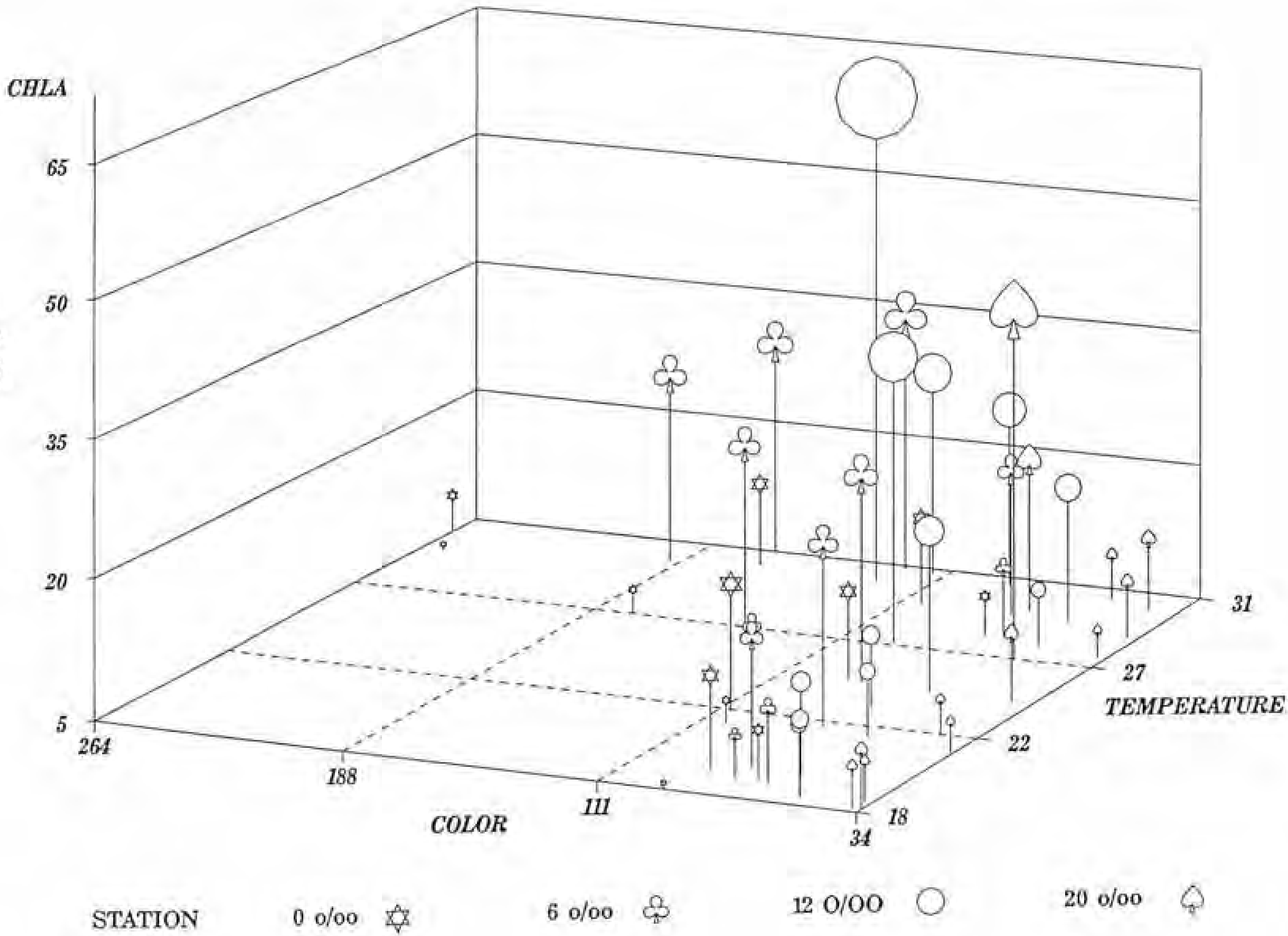


FIGURE 3.73

Chlorophyll a (mg/m3)
vs Color and Temperaturue (C)



response to longer-term influences, whereas, carbon uptake rates reflect the cumulative effects of current conditions.

The observed relationships between carbon uptake (mg Carbon/m3/Einstein) and chlorophyll a (mg/m3), as well as the relative percentages within each of the three measured size fractions, are presented by salinity zones:

1) 0 o/oo Salinity - there was a moderate level of correlation between total carbon uptake and chlorophyll a, as indicated in Figure 3.74, which shows the observed values, the predicted regression line and the corresponding 95% confidence interval. As indicated in Figures 3.75 through 3.77, there were no real correlations between the percentages of carbon uptake and chlorophyll a within each of the measured fractions during each sampling event.

2) 6 o/oo Salinity - carbon uptake explained less than 50% of the variability in chlorophyll a both overall and among the relative percentages within each size fraction (Figures 3.78 through 3.81).

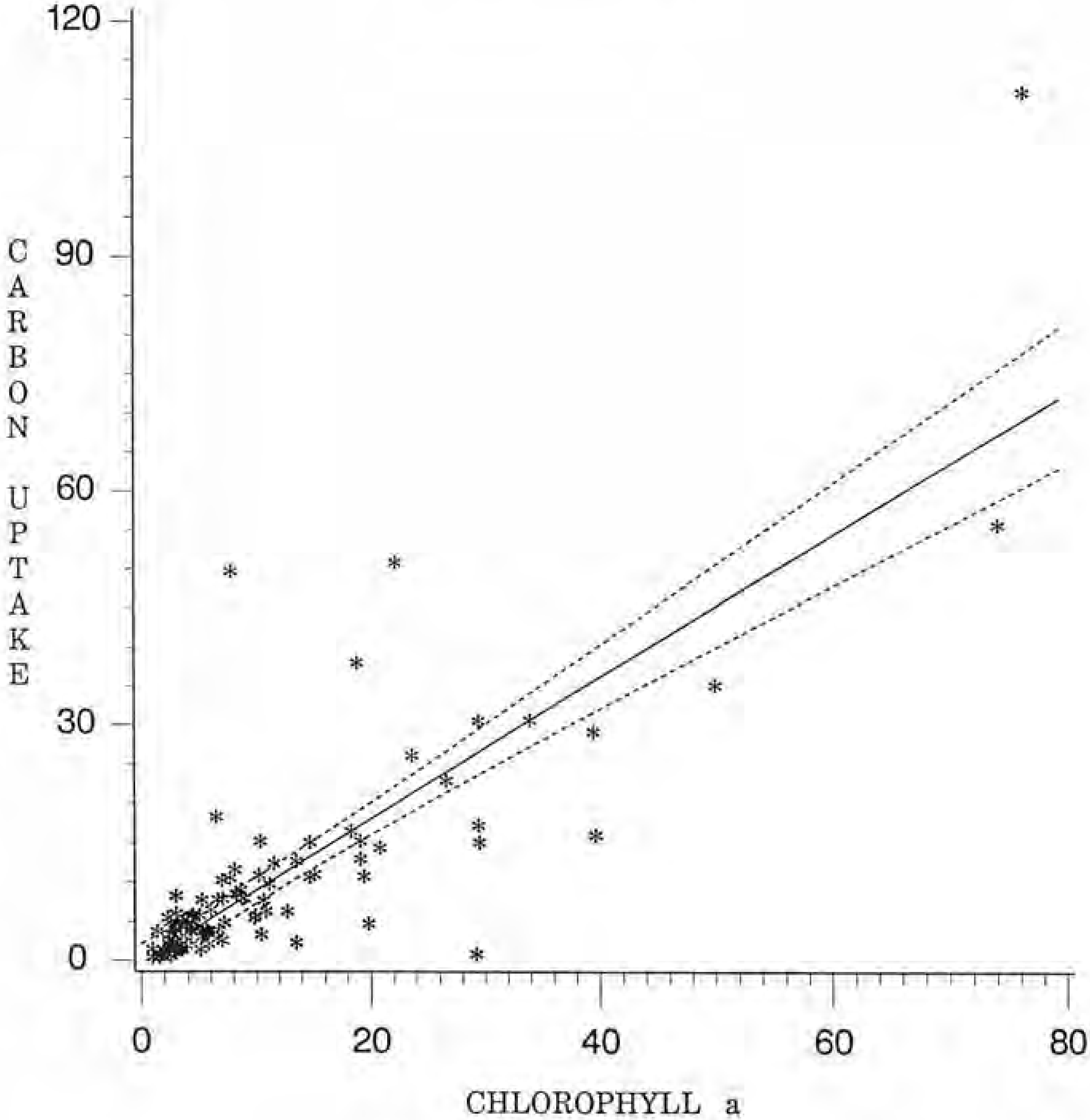
3) 12 o/oo Salinity - carbon uptake and chlorophyll a were only weakly correlated with regard to the relative contribution of the smallest size fraction (Figure 3.85).

4) 20 o/oo Salinity - overall there was no correlation between the amount of observed rates of carbon uptake and measured chlorophyll a levels at this salinity zone. However, there were weak correlations between the relative percents measured within the three size fractions of the two measured phytoplankton estimates (Figures 3.86 through 3.89).

These figures indicate that although the two measurements of phytoplankton production: 1) instantaneous growth rates as measured by carbon uptake, and 2) integrated growth as measured by chlorophyll a biomass, generally followed similar seasonal trends, as observed in preceding sections of this document, there was only weak (if any) direct correlations among these two measurements.

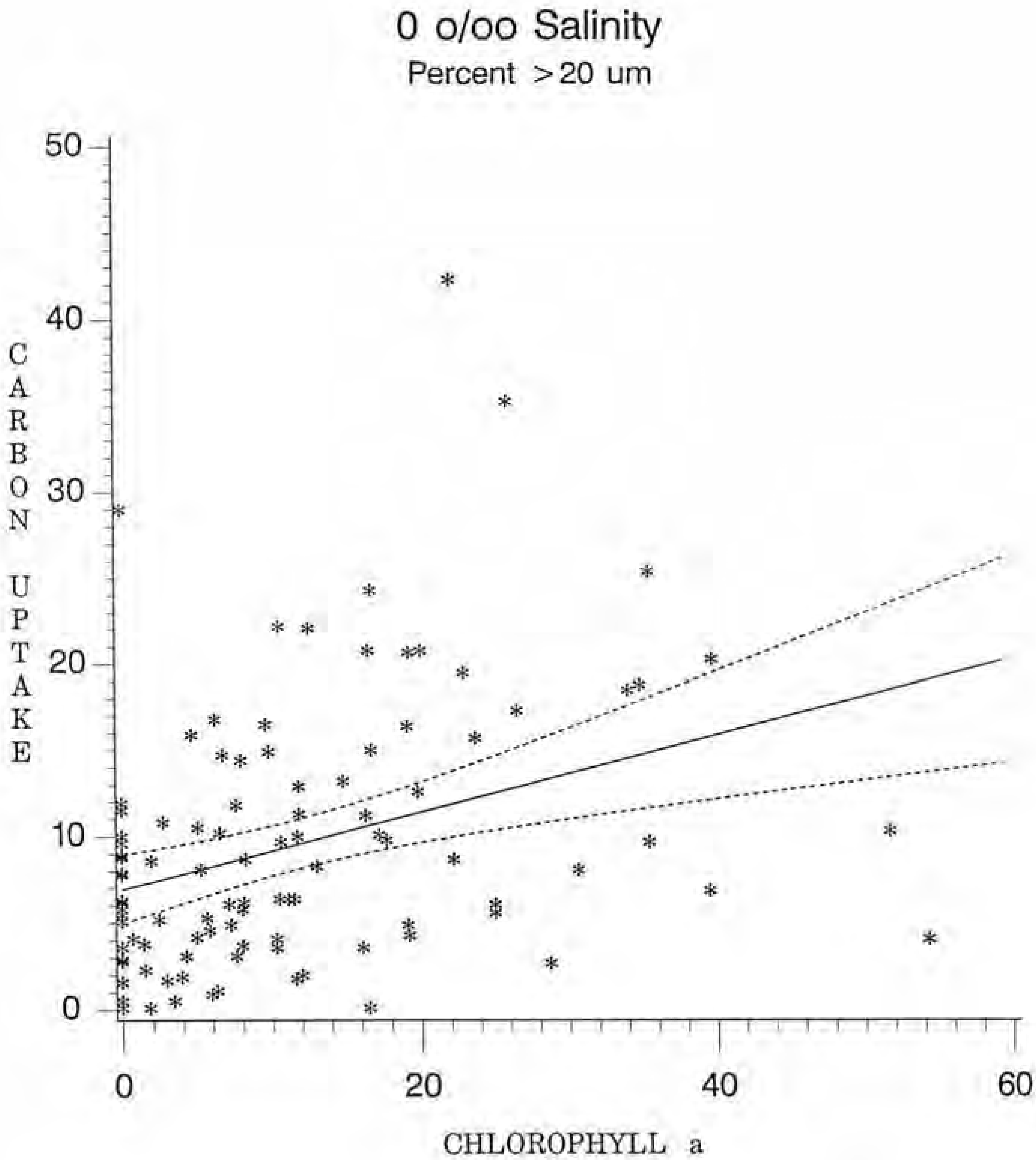
FIGURE 3.74

0 o/oo Salinity



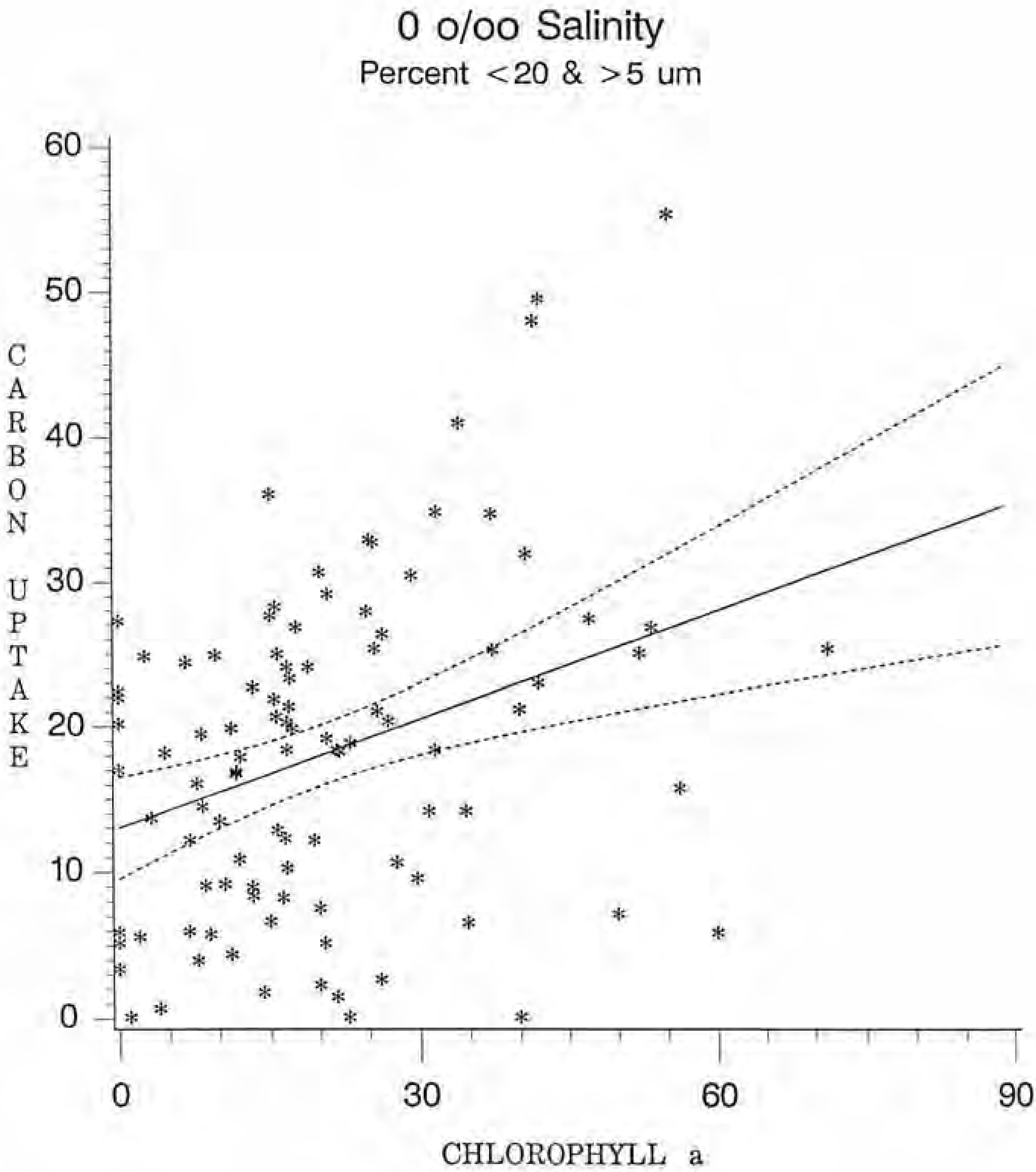
Carbon Uptake = −0.07 + 0.91(Chlorophyll a)   R square = 0.65

FIGURE 3.75



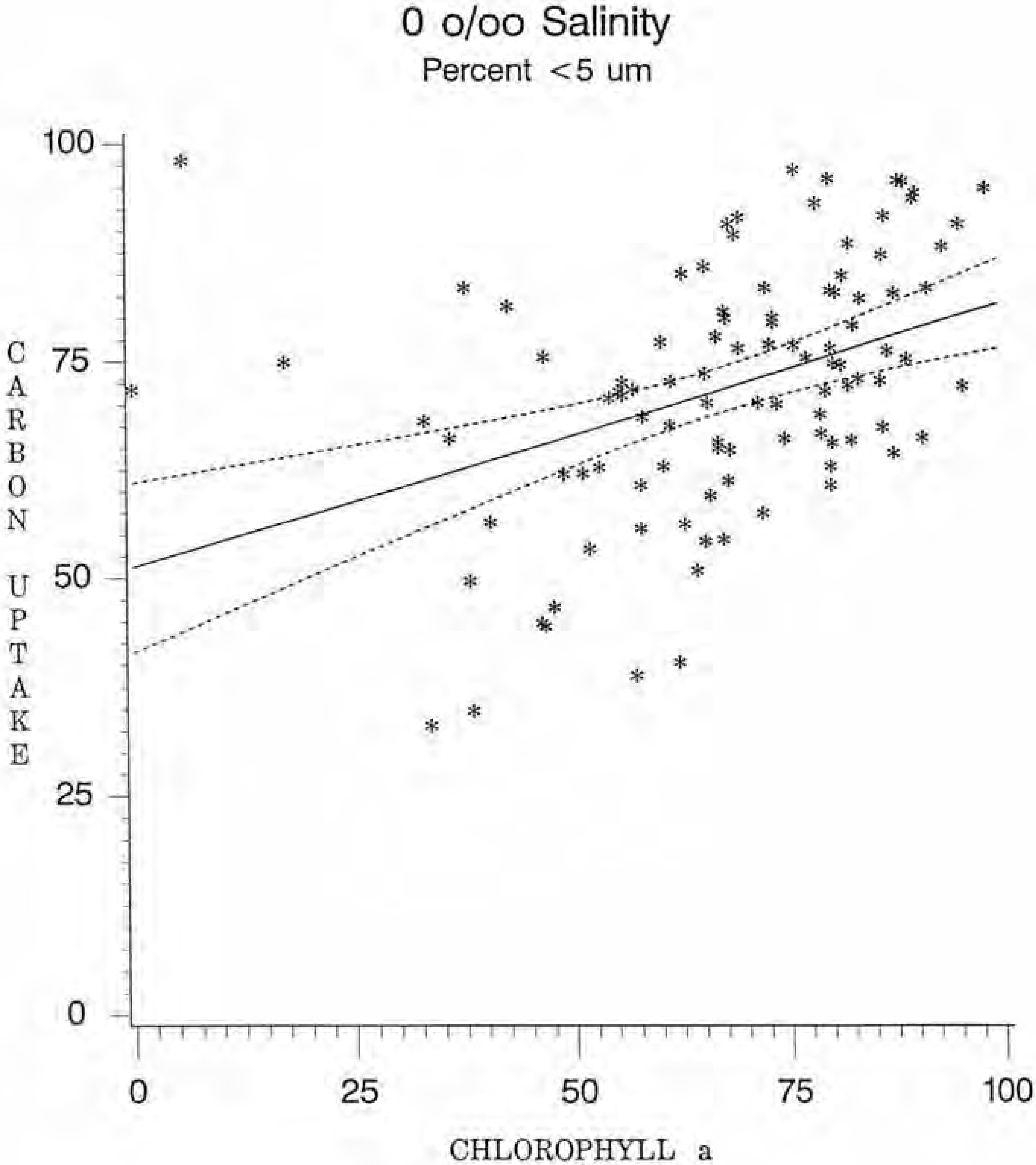
Carbon Uptake = 6.23 + 0.30(Chlorophyll a)   R square = 0.21

FIGURE 3.76



Carbon Uptake = 13.58 + 0.22(Chlorophyll a)   R square = 0.11

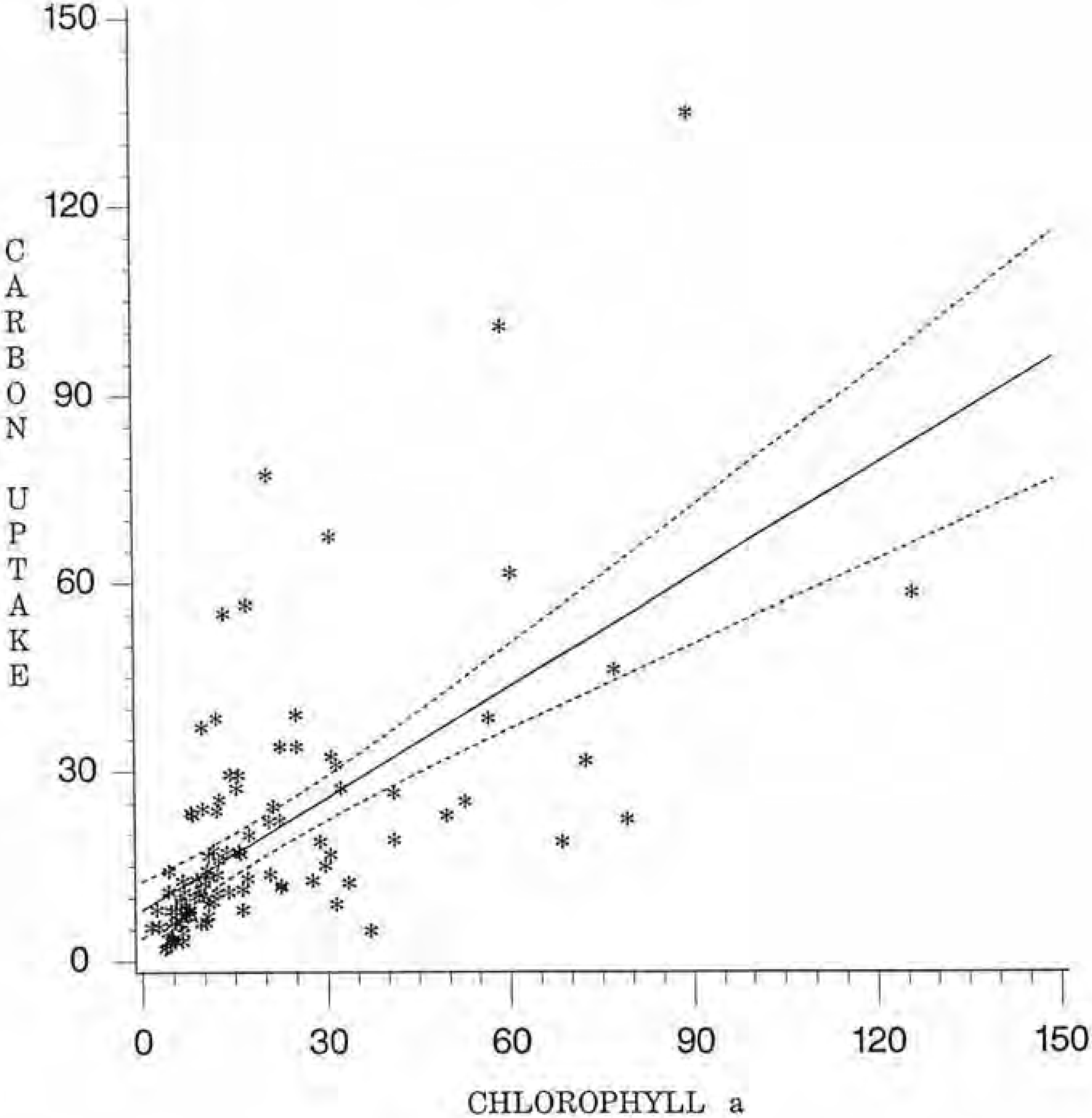
FIGURE 3.77



Carbon Uptake = 51.24 + 0.31(Chlorophyll a)   R square = 0.16

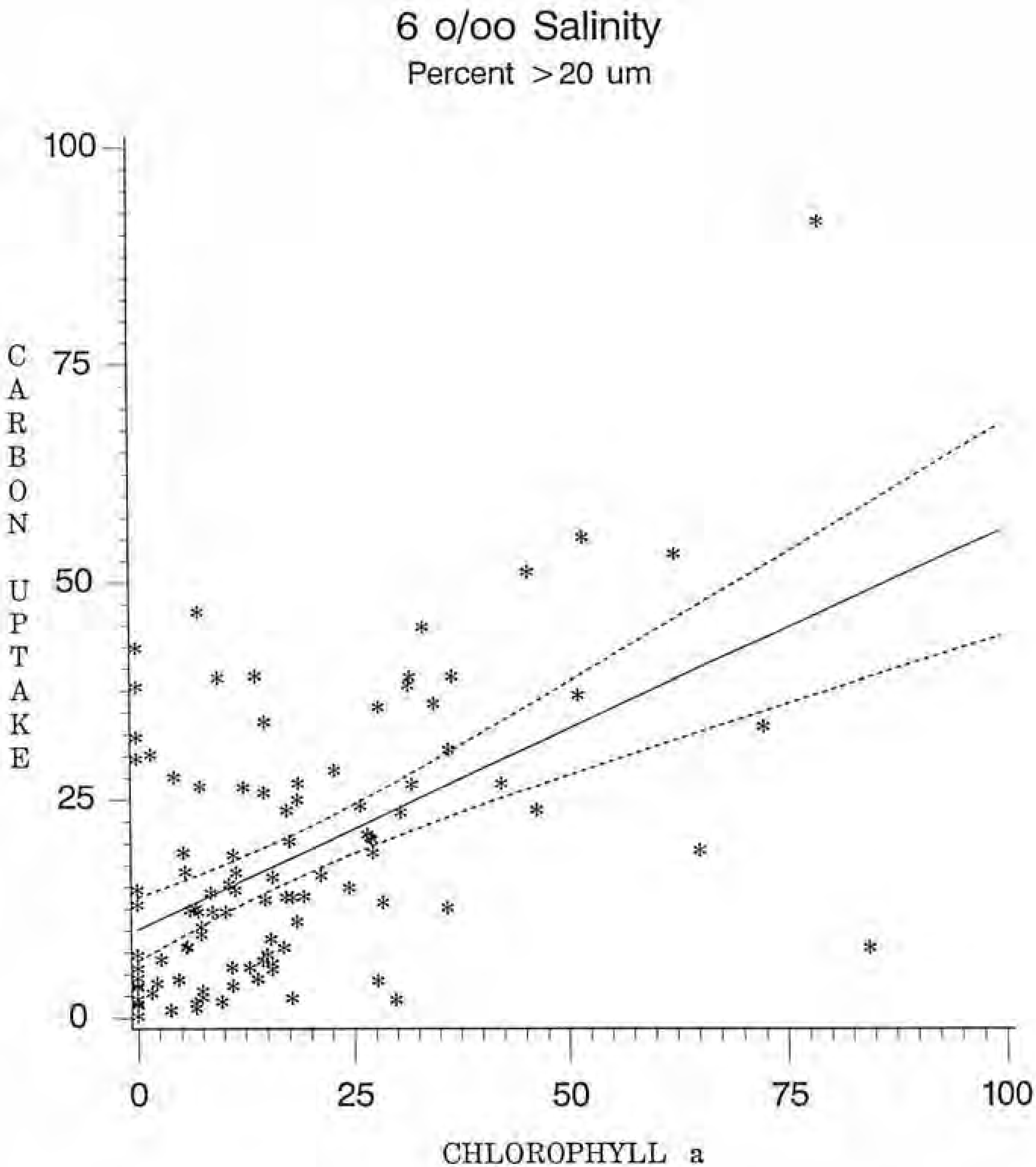
FIGURE 3.78

6 o/oo Salinity



Carbon Uptake = 8.58 + 0.56(Chlorophyll a)   R square = 0.43

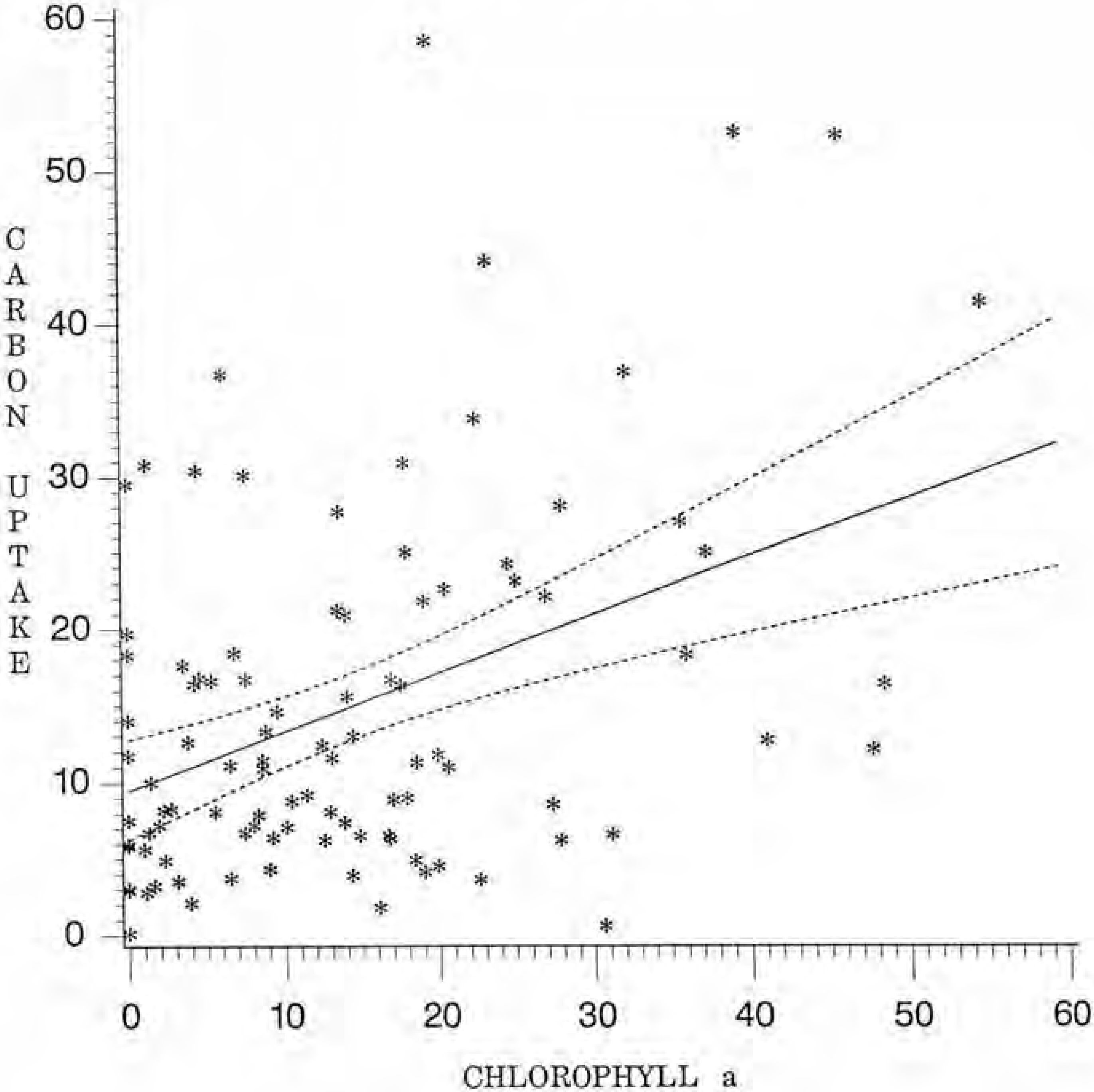
FIGURE 3.79



Carbon Uptake = 10.15 + 0.46(Chlorophyll a) R square = 0.28

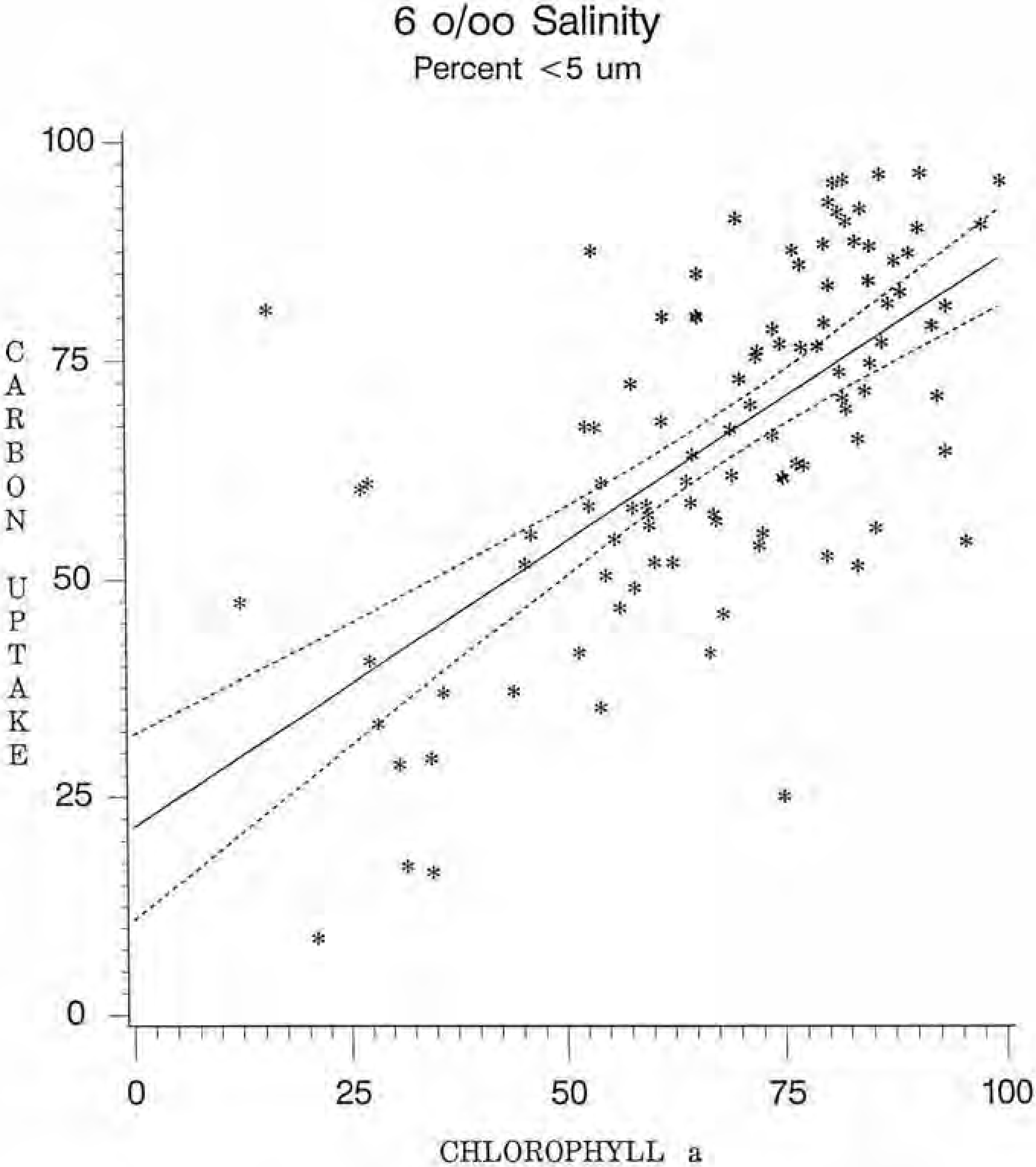
FIGURE 3.80

6 o/oo Salinity
Percent <20 & >5 um



Carbon Uptake = 8.84 + 0.46(Chlorophyll a)   R square = 0.23

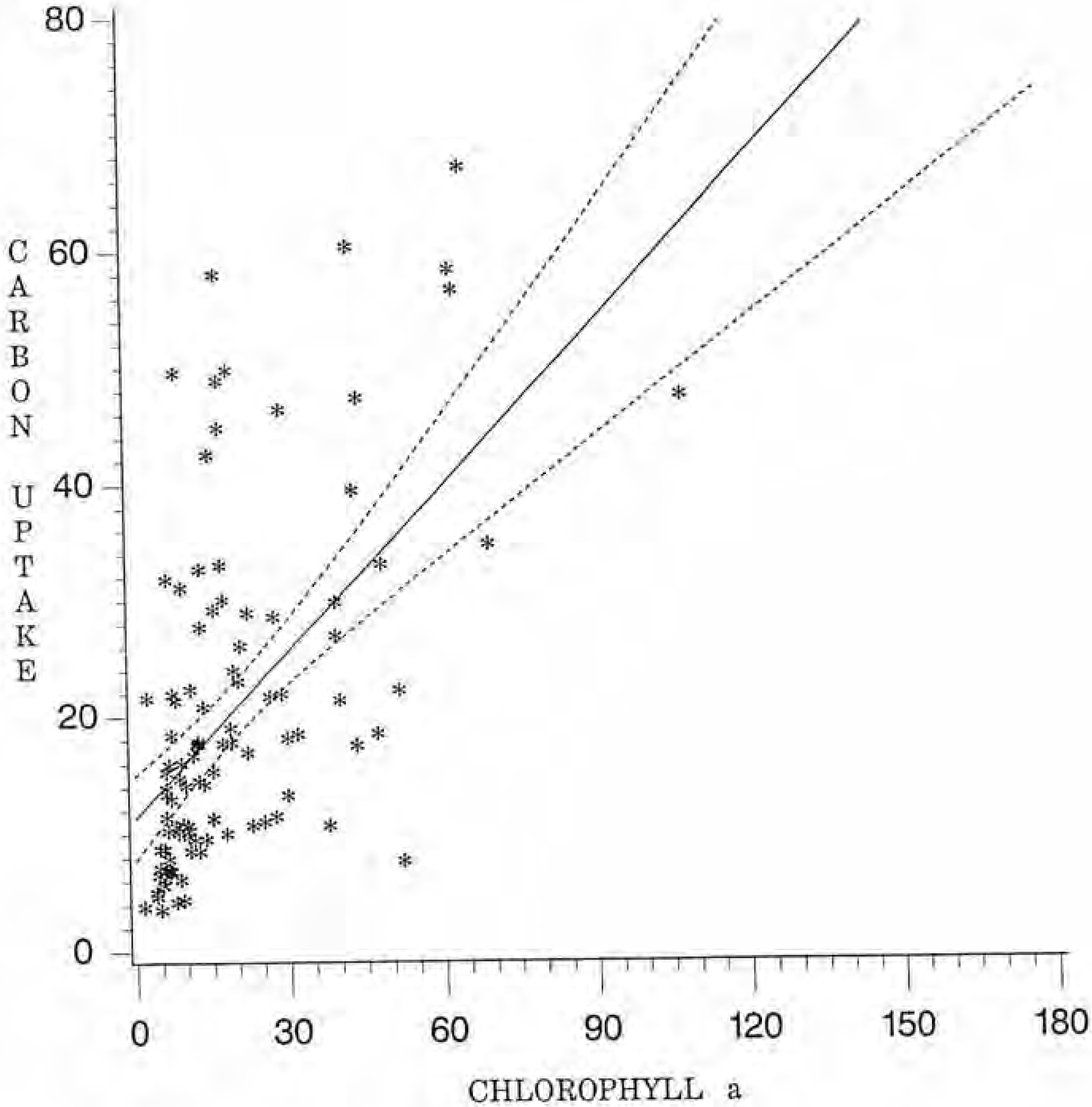
FIGURE 3.81



Carbon Uptake = 21.56 + 0.66(Chlorophyll a)   R square = 0.43

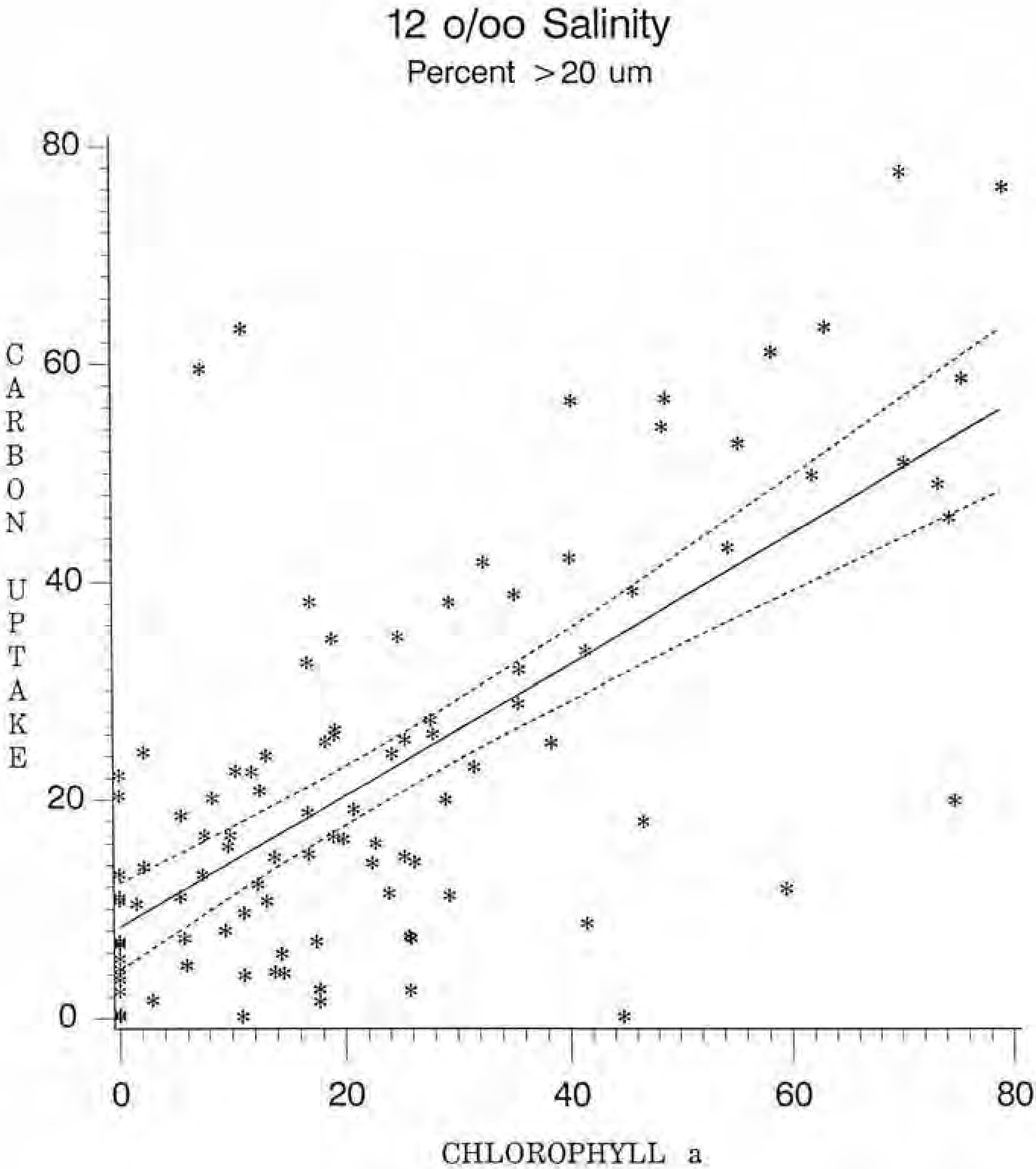
FIGURE 3.82

6 o/oo Salinity



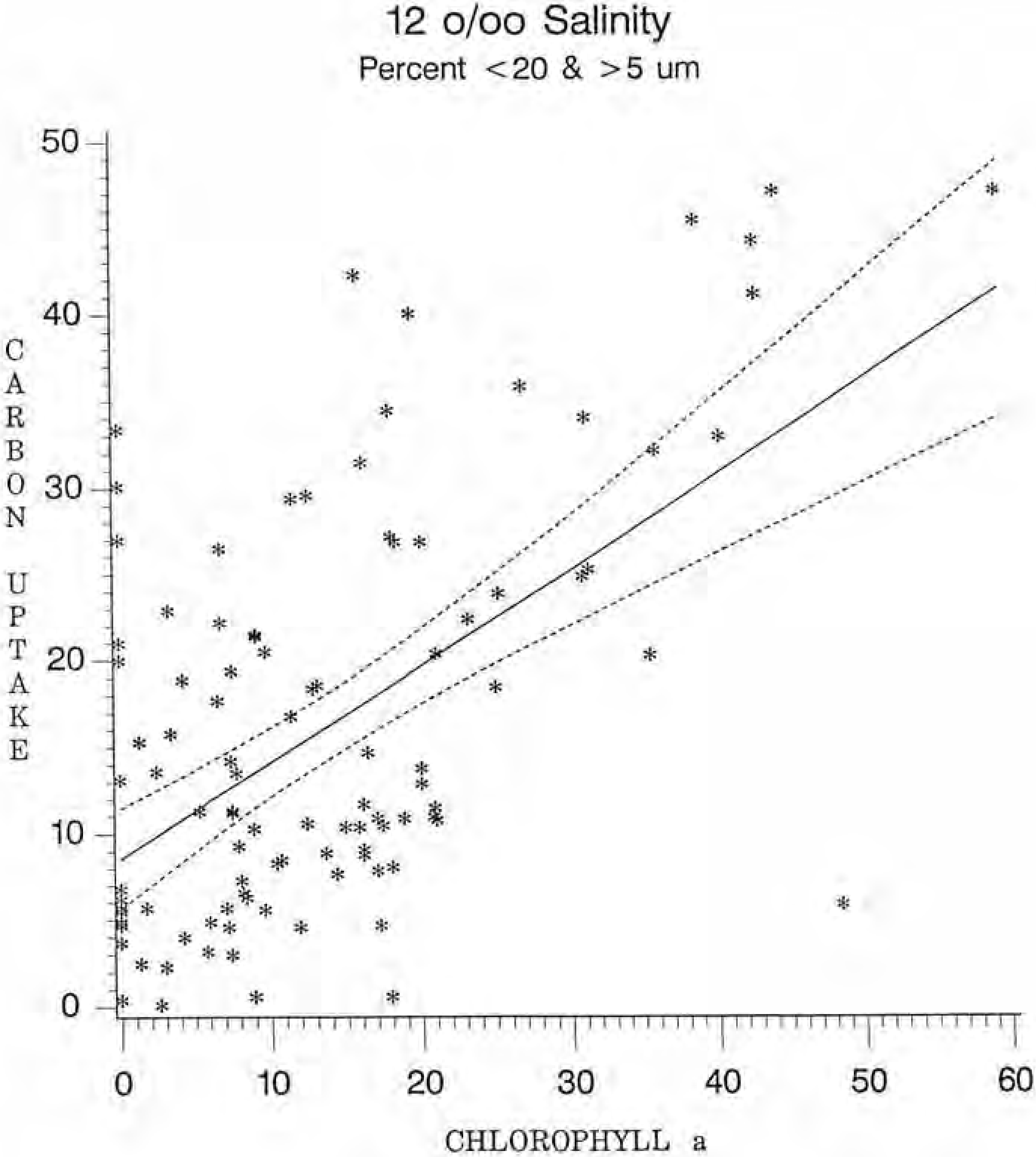
Carbon Uptake = 15.81 + 0.23(Chlorophyll a)   R square = 0.30

FIGURE 3.83



Carbon Uptake = 8.36 + 0.60(Chlorophyll a)   R square = 0.47

FIGURE 3.84

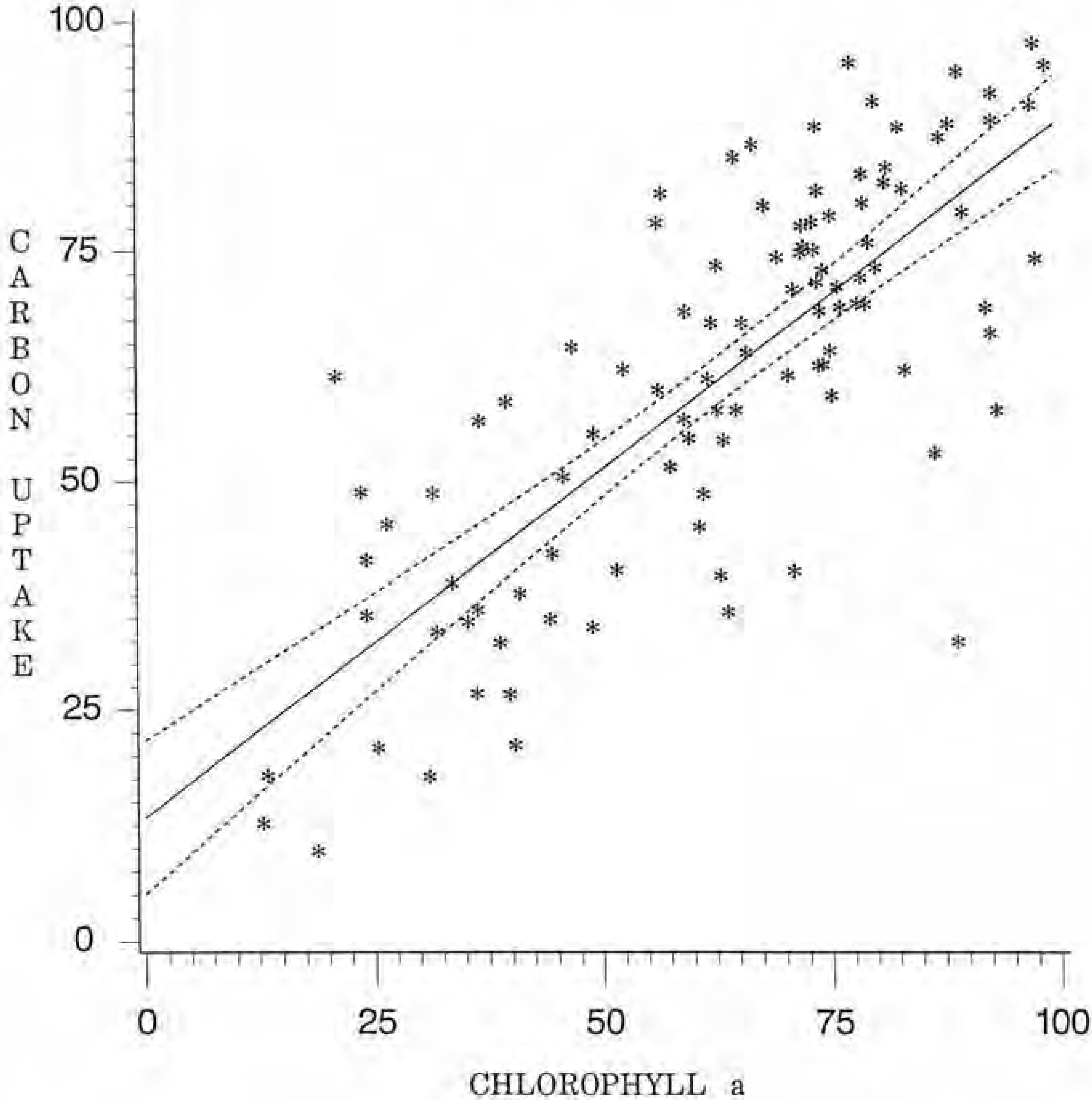


Carbon Uptake = 8.55 + 0.56(Chlorophyll a)   R square = 0.32

FIGURE 3.85

12 o/oo Salinity

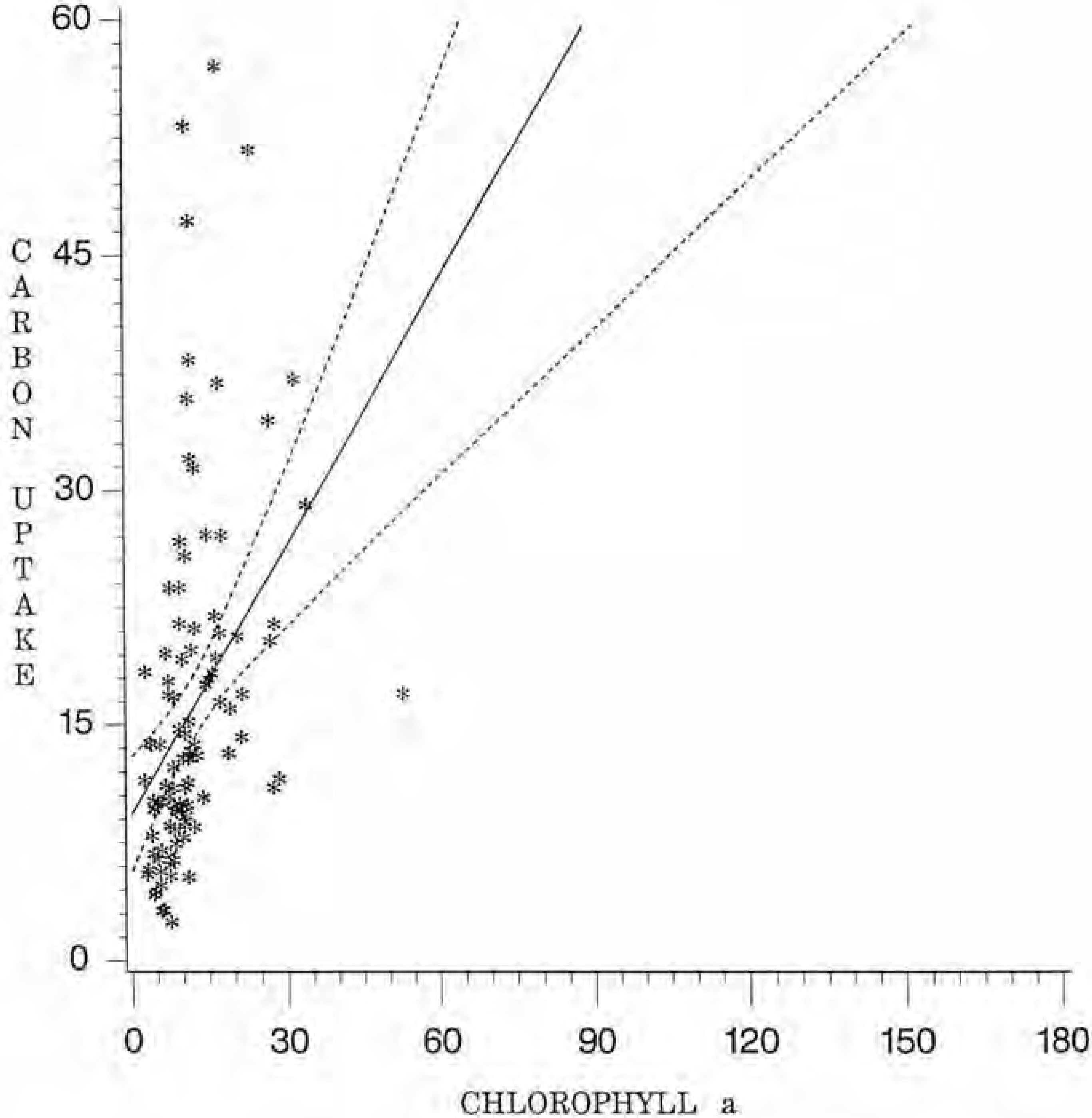
Percent <5 um



Carbon Uptake = 13.38 + 0.76(Chlorophyll a)   R square = 0.60

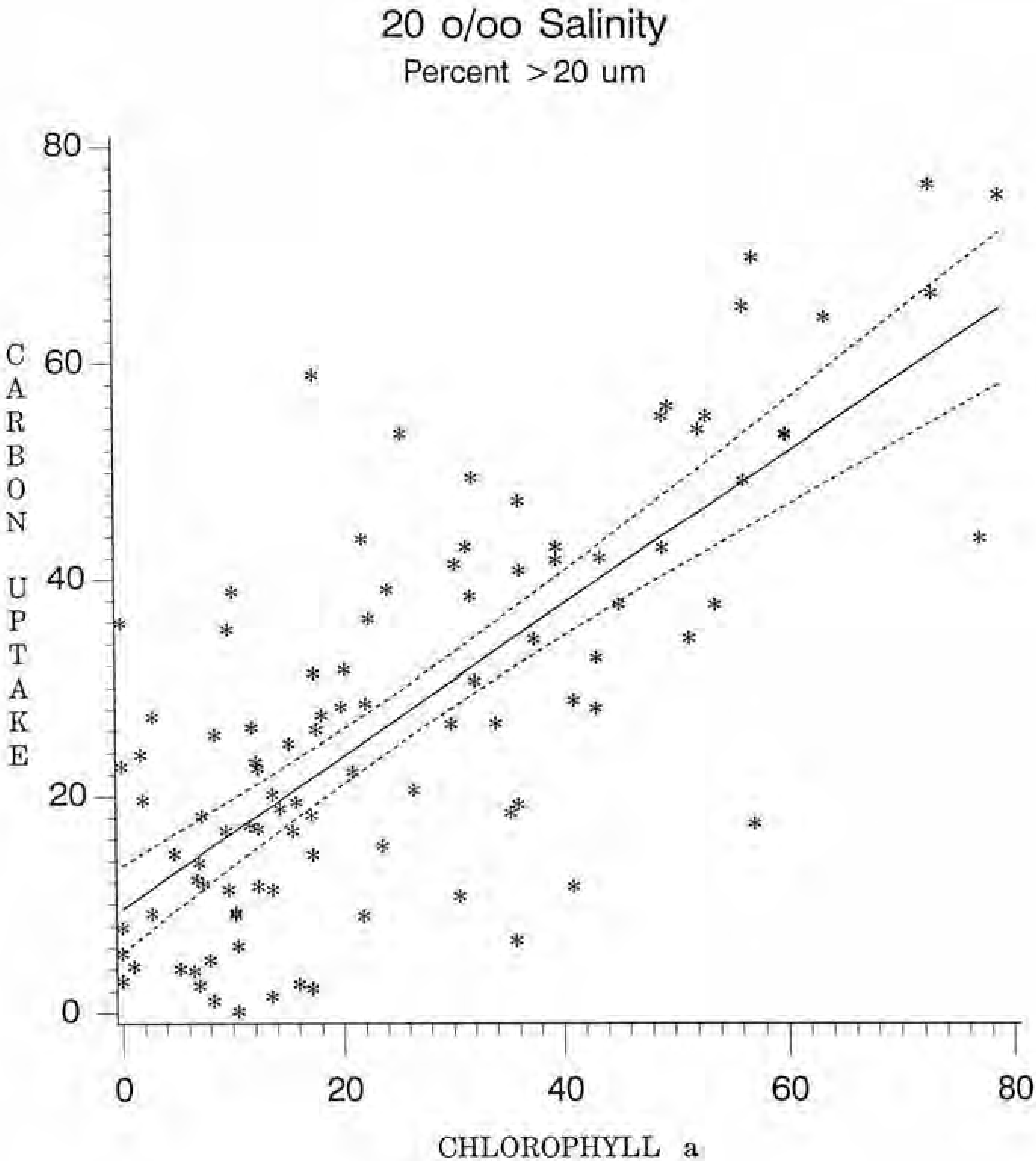
FIGURE 3.86

20 o/oo Salinity



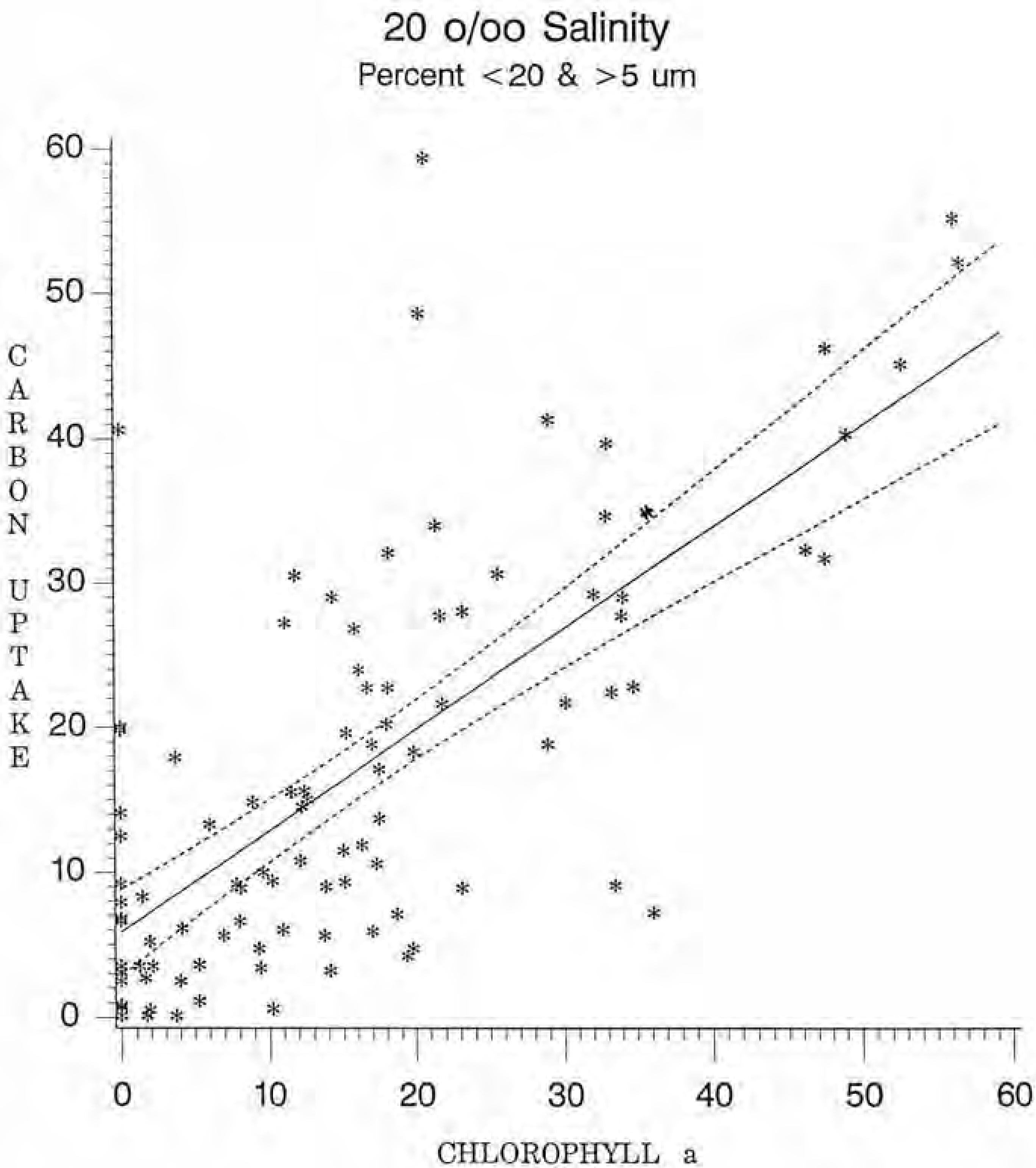
Carbon Uptake = 14.28 + 0.14(Chlorophyll a)   R square = 0.10

FIGURE 3.87



Carbon Uptake = 9.26 + 0.73(Chlorophyll a)   R square = 0.56

FIGURE 3.88

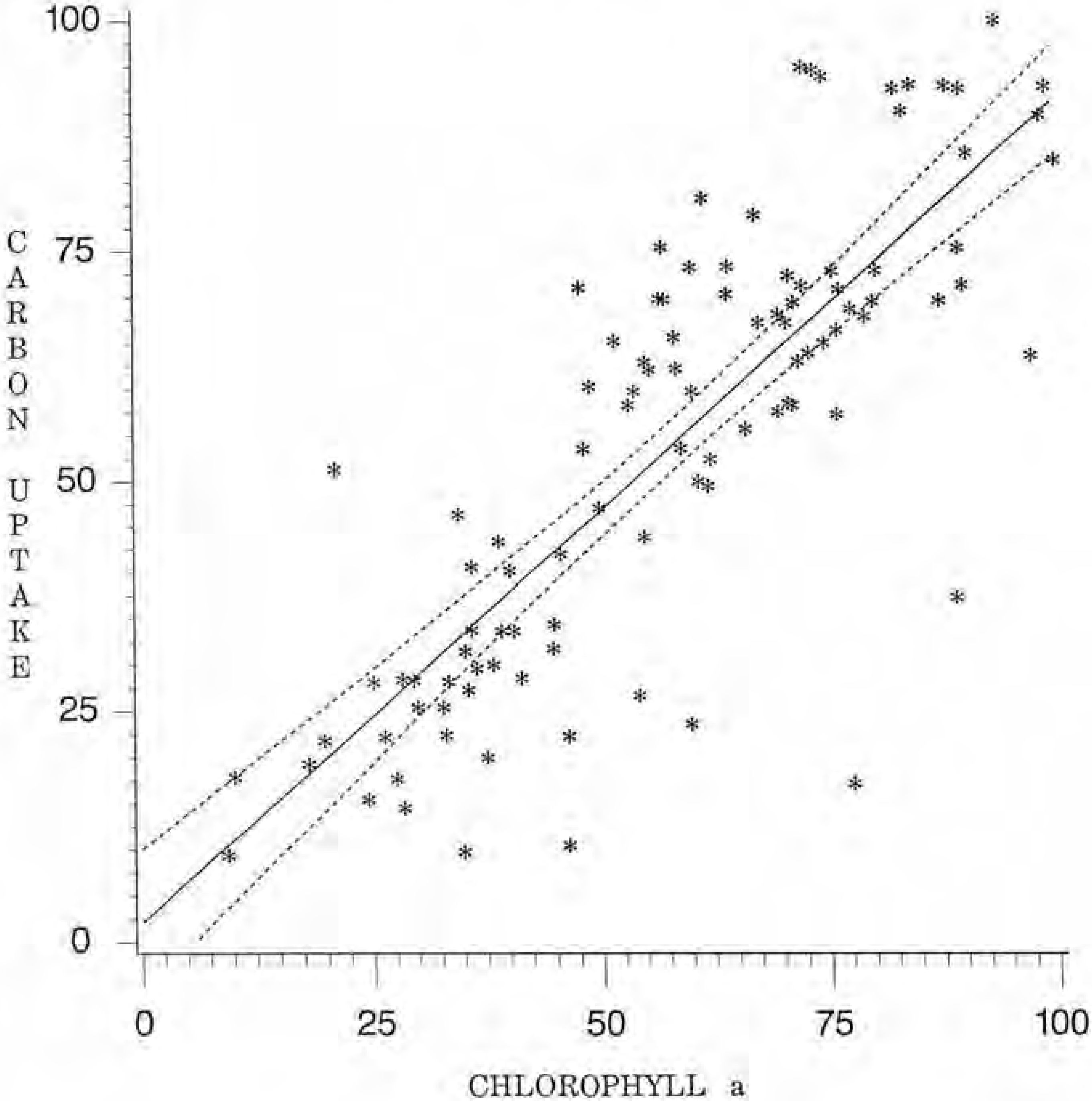


Carbon Uptake = 6.01 + 0.72(Chlorophyll a) R square = 0.50

FIGURE 3.89

20 o/oo Salinity

Percent <5 um



Carbon Uptake = 2.15 + 0.90(Chlorophyll a) R square = 0.66

3.3.9 Multiple Regression Models

In PCA analyses (see Section 3.3.8) many intercorrelated physical-chemical variables were used to describe and explain patterns of variation in observed phytoplankton production and biomass. Consistent patterns of variation were utilized to create new composite variables (Factors) that were then employed to examine the relationships among stations and associations of composite variables with regards to the estuarine phytoplankton community.

Another method of analyzing the relationships between measured physical/chemical parameters and phytoplankton production is through the use of statistical models. This differs from the PCA approach in that PCA only describes patterns and measures associations with no attempt to ascribe causality. Statistical models are more inferential in nature and ascribing relative causal relations.

One such method of analysis is to employ models developed utilizing multiple regression procedures. In multiple regression numerous measured independent physical and chemical variables (i.e. flow, salinity, temperature, and light), as well as interactions among these variables, can be used to directly explain observed variation in dependent variables (i.e. carbon uptake or chlorophyll a). The goal of multiple regression is to arrive at the fewest number of independent variables that significantly explain the greatest variation in the dependent variable. This is accomplished by interactively using independent variables that provide the closest possible agreements between estimates of the dependent variable's predicted and actual observed values. The resultant model is computed by minimizing the sum of the squared deviations between predicted value and actual observed dependent values.

Construction of such multiple regression models is a dynamic process, with independent variables statistically added and deleted until a balance is reached between adding more variables and maximizing the correlation between the predicted and actual value of the dependent variable. In the actual physical and chemical data set, many of the independent variables are intercorrelated. Such intercorrelations, while not a problem in PCA, have the potential of causing difficulty with multicollinearity in a multiple regression model. To avoid such problems with multicollinearity, the single variable with the highest correlation (largest factor loading) from the preceding PCA analysis, was selected from each of the first five Principal Components initially constructed in the multiple regression model. Since it is known that not all processes in nature are linear, quadratic (squared) terms for the independent variables were also tested in the model. Finally, interactions between independent variables (i.e color and salinity may act together to influence productivity) were also tested to determine if such interactions might further increase the predictive ability of the model.

Models were thus developed using the smallest number of parameters that independently, significantly accounted for the observed variability of dependent measurements of phytoplankton production and biomass. The resultant model of overall measured primary production at all stations, standardized by ambient light, is presented in Table 3.16 (variable names follow those presented in Table 3.2; most are preceded by an L to denote the values having been log transformed in order to meet the criteria of normal distribution required). Seven variables, of the original 25 measured physical/chemical parameters use in the Principal Component Analysis, combined with selective interactions among these variables, could be used to explain 44% of the

TABLE 3.16

General Linear Models Procedure

Number of observations in data set = 403

Dependent Variable: Carbon Uptake (mg Carbon/m3/Einstein)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	129.18239508	11.74385410	27.82	0.0001
Error	391	165.04009488	0.42209743		
Corrected Total	402	294.22248995			

R-Square	C.V.	Root MSE	LP3 Mean
0.439064	25.65688	0.64969026	2.53222598

Source	Estimate	Mean Square	F Value	Pr > F
INTERCEPT	-15.29451			
LDAF14	0.13992	5.23261577	12.40	0.0005
LLT14	1.29322	17.90148905	42.41	0.0001
LTEMP	2.27238	0.57302741	1.36	0.2447
SAL	0.05933	27.39925009	64.91	0.0001
SAL*SAL	-0.00213	27.01638581	64.01	0.0001
LN23	-1.54909	12.73002881	30.16	0.0001
LCOLOR	1.80281	1.45978662	3.46	0.0637
LCOLOR*LCOLOR	-0.10666	12.16151730	28.81	0.0001
LEXC	6.40726	18.92358516	44.83	0.0001
LCOLOR*LEXC	-1.14256	3.00427834	7.12	0.0080
LTEMP*LLT7	-0.31708	2.78043071	6.59	0.0106

observed variability in measured primary production. Table 3.17 presents the results of the best analogous model developed to predict ambient phytoplankton chlorophyll a levels.

3.3.10 Long-Term Trend Analysis

Since the physical/chemical/primary production data set has collected data monthly over an eight-year period, the data set is of sufficient size to allow for the use of modeling techniques which test for the presence of long-term trends with regard to time. Since chemical and biological data seldom meet the criteria of normal distribution required of parametric models, nonparametric procedures, which do not require extensive data transformations offer distinct advantages. One of the most commonly used procedures used by the U.S. Geological Service (USGS) and others to test for trends in water quality data is the SEASKEN tests for monotonic trends in time by modified forms of the Kendall's Tau and Seasonal Kendall tests.

Using FORTRAN programs obtain from the USGS, and the DECTIME program under SAS for data sets with missing values, SEASKEN tests for the presence of long-term trends were run for the various chemical, physical and biological data collected at the four salinity zones between 1983 and 1991. Parameter codes used in Tables 3.18 through 3.22 match those previously used throughout this report and are summarized in Table 3.2 (see page).

1) Table 3.18 - lags for daily average flow, average withdrawal, light levels prior to sampling dates, and water temperature at the highest and lowest salinity zones were tested for long-term trend. As indicated, water withdrawal has shown a distinct increase over the eight-year period, while an average decrease in measure solar radiation has occurred over the same period.

TABLE 3.17

General Linear Models Procedure

Number of observations in data set = 399

Dependent Variable: log Chlorophyll a (ug/m3)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	99.50187597	9.95018760	22.91	0.0001
Error	388	168.51571694	0.43431886		
Corrected Total	398	268.01759291			

R-Square	C.V.	Root MSE	LCHLA Mean
0.371251	26.20743	0.65902872	2.51466327

Source	Estimate	Mean Square	F Value	Pr > F
INTERCEPT	-12.4043			
SAL	0.0813	3.62114329	8.34	0.0041
SAL*SAL	-0.0018	21.34585546	49.15	0.0001
LCOLOR	4.2267	10.43030451	24.02	0.0001
LCOLOR*LCOLOR	-0.5152	9.21494736	21.22	0.0001
LTEMP	-0.0206	4.65059379	10.71	0.0012
LDAF28	0.1244	2.39726853	5.52	0.0193
LLT14	0.4739	7.71366931	17.76	0.0001
LN23	-1.1560	12.02518995	27.69	0.0001
LOP	1.3039	7.47348787	17.21	0.0001
LEXC	1.7503	20.62941591	47.50	0.0001

TABLE 3.18

TREND ANALYSIS - SEASONAL KENDAL

PARAMETER	TAU VALUE	SIGNIFICANCE LEVEL		MEDIAN VALUE	EQUATION DESCRIBING ESTIMATED TREND
		Unadjusted	Adjusted for Serial Correlation		
DAF 7	-0.12	0.164	0.533	356.1	
DAF 28	-0.12	0.164	0.528	428.1	
AW 7	0.32	0.000	0.011	3.73	= 0.767+ (0.741 * time)
AW 28	0.28	0.001	0.007	4.98	= 2.785+ (0.548 * time)
LT 7	-0.55	0.000	0.001	229.9	= 272.3+ (-8.489 * time)
LT 28	-0.69	0.000	0.001	913.4	= 1108+ (-38.95 * time)
Temp at 0 0/00	0.06	0.474	0.542	25.9	
Temp at 20 0/00	0.11	0.185	0.180	24.8	

TABLE 3.19

TREND ANALYSIS - SEASONAL KENDAL

0 ‰

PARAMETER	TAU VALUE	SIGNIFICANCE LEVEL		MEDIAN VALUE	EQUATION DESCRIBING ESTIMATED TREND
		Unadjusted	Adjusted for Serial Correlation		
COLOR	0.08	.334	.613	113.5	
Ext. Coefficient	-0.01	0.923	0.952	3.01	
NO2/3	0.21	0.011	0.078	.444	
OP	-0.29	0.001	.116	.825	
Si	0.04	0.630	0.764	2.73	
Carbon Uptake (mg/C/m³/E)	-0.37	0.000	0.034	4.99	= 8.57 + (-0.894 * time)
% > 20	-0.40	0.000	0.014	7.90	= 12.87 + (-1.24 * time)
% > 5 + < 20	0.07	0.391	0.430	18.6	
% < 5	0.19	0.022	0.648	72.4	= 68.16 + (1.05 * time)
Chlorophyll a (mg/m³)	-0.32	0.001	0.014	6.00	= 11.47 (-1.094 * time)
% > 20	-0.31	0.001	0.034	9.7	= 15.67 + (-1.43 * time)
% > 5 + < 20	0.17	0.045	0.114	16.7	
% < 5	0.01	0.972	0.959	68.6	

TABLE 3.20

TREND ANALYSIS - SEASONAL KENDAL

6 ‰

PARAMETER	TAU VALUE	SIGNIFICANCE LEVEL		MEDIAN VALUE	EQUATION DESCRIBING ESTIMATED TREND
		Unadjusted	Adjusted for Serial Correlation		
COLOR	0.02	0.802	0.903	90.0	
Ext. Coefficient	-0.01	0.949	0.968	2.66	
NO2/3	0.09	0.300	0.100	0.222	
OP	-0.25	0.003	0.154	0.552	
Si	0.13	0.101	0.194	2.07	
Carbon Uptake (mg/C/m^3/E)	-0.14	0.108	0.326	12.6	
% > 20	0.02	0.830	0.865	14.65	
% > 5 + < 20	0.07	0.453	0.529	11.4	
% < 5	-0.08	0.335	0.400	66.7	
Chlorophyll a (mg/m^3)	-0.17	0.031	0.056	12.1	= 17.1 + (-1.000 * time)
% > 20	-0.27	0.008	0.034	13.8	= 21.66+ (-1.572 * time)
% > 5 + < 20	0.09	0.274	0.383	0.424	
% < 5	0.06	0.460	0.554	72.1	

TABLE 3.21

TREND ANALYSIS - SEASONAL KENDAL

12 ‰

PARAMETER	TAU VALUE	SIGNIFICANCE LEVEL		MEDIAN VALUE	EQUATION DESCRIBING ESTIMATED TREND
		Unadjusted	Adjusted for Serial Correlation		
COLOR	-0.02	0.858	0.920	69.5	
Ext. Coefficient	0.00	1.00	1.00	2.07	
NO2/3	0.17	0.045	0.080	0.088	
OP	-0.27	0.001	0.09	0.411	
Si	0.18	0.027	0.117		
Carbon Uptake ($mg/C/m^3/E$)	-0.16	0.058	0.080	15.5	
% > 20	-0.18	0.029	0.184	17.5	
% > 5 + < 20	0.14	0.100	0.306	11.5	
% < 5	0.06	0.460	0.554	72.1	
Chlorophyll a (mg/m^3)	-0.11	0.177	0.327	13.2	
% > 20	-0.09	0.273	0.424	17.7	
% > 5 + < 20	-0.02	0.872	0.908	10.7	
% < 5	0.13	0.116	0.180	66.7	

TABLE 3.22

TREND ANALYSIS - SEASONAL KENDAL
20 ‰

PARAMETER	TAU VALUE	SIGNIFICANCE LEVEL		MEDIAN VALUE	EQUATION DESCRIBING ESTIMATED TREND
		Unadjusted	Adjusted for Serial Correlation		
COLOR	0.18	0.028	0.203	39.5	
Ext. Coefficient	0.32	0.0001	0.014	1.45	= 1.217+ 0.0467 * time
NO2/3	0.27	0.001	0.023	0.009	= .0005+ .002 * time
OP	0.04	0.668	0.845	0.227	
Si	0.17	0.031	0.193	0.820	
Carbon Uptake ($mg/C/m^3/E$)	0.05	0.592	0.564	12.5	
% > 20	-0.04	0.642	0.774	24.2	
% > 5 + < 20	0.13	0.116	0.333	13.9	
% < 5	-0.07	0.453	0.610	58.2	
Chlorophyll a (mg/m^3)	0.15	0.058	0.040	10.0	= 7.892+ 0.42 * time
% > 20	-0.01	0.923	0.945	19.9	
% > 5 + < 20	0.11	0.155	0.307	14.1	
% < 5	-0.03	0.773	0.858	58.3	

2) Table 3.19 - tests were run to analyze for the presence of long-term changes in water color, macronutrients, carbon uptake, chlorophyll a and phytoplankton production within size fractions at 0 o/oo salinity. Significant long-term declines in both carbon uptake and chlorophyll a were observed at this salinity zone. Carbon uptake also indicates a long-term decline in the percent of production attributable to the largest phytoplankton size fraction with a corresponding increase in the smallest.

3) Table 3.20 - tests were run to analyze for the presence of long-term changes in water color, macronutrients, carbon uptake, chlorophyll a and phytoplankton production within size fractions at 6 o/oo salinity. As at the preceding salinity zone, long-term declines in chlorophyll a level and the percent within the largest size fraction were indicated.

4) Table 3.21 - tests were run to analyze for the presence of long-term changes in water color, macronutrients, carbon uptake, chlorophyll a and phytoplankton production within size fractions at 12 o/oo salinity. No long-term trends were found for any of the tested parameters.

5) Table 3.22 - tests were run to analyze for the presence of long-term changes in water color, macronutrients, carbon uptake, chlorophyll a and phytoplankton production within size fractions at 20 o/oo salinity. Significant long-term increases were apparent at the highest salinity zone for nitrogen, chlorophyll a, and the extinction of light within the water column.

The results of the preceding analysis yielded two long-term patterns which were of particular interest. Those were the decline in both carbon uptake and chlorophyll a apparent at the lowest salinity, and the increase in nitrogen and chlorophyll a at the highest salinity zone. These observations are especially of interest since they are apparently independent of any long-term changes in river flow.

Analysis of the plots and models presented earlier in this document strongly suggest that the observed declines in carbon uptake and chlorophyll a at 0 o/oo salinity may in fact result in a change between the earlier years of the study and the later, in the seasonal pattern of rainfall. Short periods of seasonal rains earlier in the Spring, resulting in high phytoplankton production at the lower salinities, have been absent during the last few years. The resulting decline is of particular interest, since it emphasizes the dependence of phytoplankton production at the lower salinities upon river flow during the Spring when flows are often very low. The observed long-term increase in chlorophyll a at 20 o/oo, and the corresponding increase in the extinction coefficient of light within the water column, is also of interest, particularly since it seems to be independent of any corresponding change in river flow. If such trends continue, they may well be indicative of increased nitrogen loading of the higher salinity reaches of the Harbor by non-point source discharges into the estuarine system.

3.4 Taxonomic Determinations of Phytoplankton Community Structure

In 1988 the collection of monthly samples for the analysis of phytoplankton community structure was begun in conjunction with the long-term study of physical/chemical water quality and primary production at the four monitored salinity zones. Phytoplankton community structure has long been used in other studies as a tool in assessing both temporal and long-term changes in water quality in estuarine system.

A complete presentation of all the phytoplankton taxonomic data collected between 1988 and 1991, listing: 1) the taxonomic structure, 2) percent composition of the major taxonomic groups, and 3) species diversity and evenness indices, are presented by salinity zone, month and year in Appendix A.

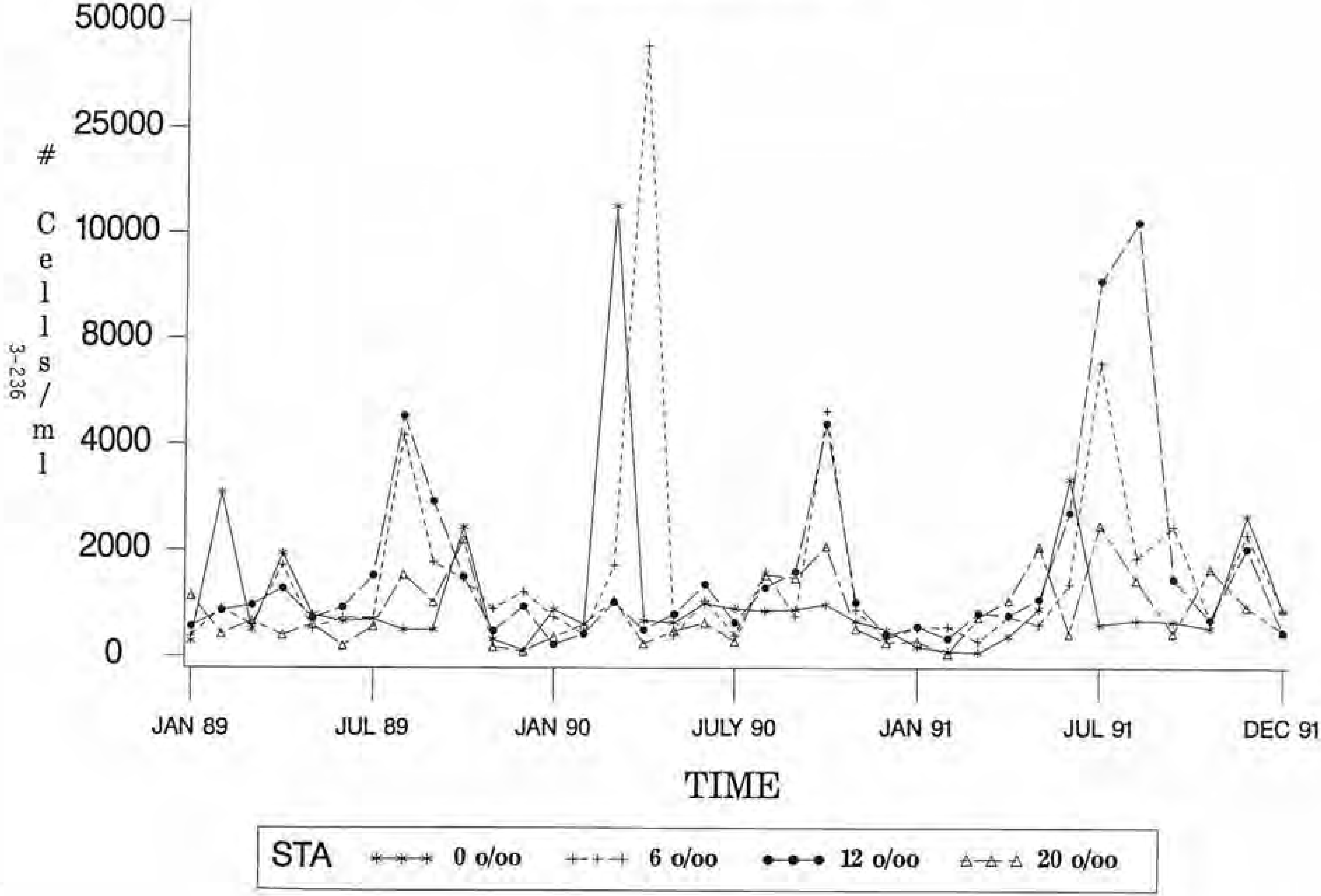
3.4.1 Phytoplankton Density

The densities of phytoplankton at each salinity zone are plotted over the three-year period in Figure 3.90 Of note are: 1) the repeating pattern, associated with river flow, of

FIGURE 3.90

CHARLOTTE HARBOR 1989 – 1991

Phytoplankton Density



high phytoplankton densities between July and September at the two intermediate salinities, and 2) the very high peaks in March at 0 o/oo and April at 6 o/oo of 1990 which occurred after a brief rainfall event.

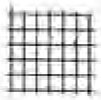
3.4.2 Taxonomic Structure

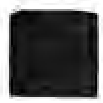
Complete summaries of the taxonomic counts for the monthly samples over the three-year period are presented in Tables 3.23 through 3.26 by salinity zone.

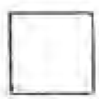
These are divided into five major functional taxonomic groups:

1) Green Algae (Chlorophyta) 

2) Flagellates (Euglenophyta and Pyrophyta) 

3) Dinoflagellates 

4) Diatoms (Bacillariophyceae) 

5) Blue-Green Algae (Cyanophyta) 

and summarized in Table 3.27. Plots of these groupings are presented over time, and by monthly means, at each of the four sampled salinity zones in Figures 3.91 through 3.98 using the above pattern codes for each functional taxonomic group. The following patterns of occurrence are apparent in these figures:

1) 0 o/oo Salinity - Blue-green algae are a very important part of the phytoplankton during the period from February through April. Green algae are typically dominant or show major increases in May during periods characterized by low Peace River flow. Flagellates, by comparison, show a strong increase in their importance within the phytoplankton community

TABLE 3.23 Species Counts 1988-1991 at 0 o/oo

	JAN 89	FEB 89	MAR 89	APR 89	MAY 89	JUN 89	JUL 89	AUG 89	SEP 89	OCT 89	NOV 89	DEC 89	JAN 90	FEB 90	MAR 90	APR 90	MAY 90	JUN 90	JUL 90	AUG 90	SEP 90	OCT 90	NOV 90	DEC 90	JAN 91	FEB 91	MAR 91	APR 91	MAY 91	JUN 91	JUL 91	AUG 91	SEP 91	OCT 91	NOV 91	DEC 91	TOTAL
CHLOROPHYTA																																					
Actinastrum gracilimum	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Ankistrodesmus sp.	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Chaetosphaeridium sp.	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	4	0	0	0	27
Chlymentomonas sp.	17	1	15	0	0	0	12	6	16	1	3	7	0	0	0	1	0	3	1	16	4	0	1	7	8	0	0	0	0	11	20	0	4	0	1	33	188
Chlamydomonas sphagnicola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Chlamydomonas sp.	2	21	13	0	0	1	0	5	6	0	7	0	37	24	0	0	1	0	0	5	4	0	2	3	9	12	4	0	1	0	0	0	18	18	1	1	195
Crucigenia fenestrata	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
Crucigenia tetrapedia	0	19	4	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35
Oocystis sp.	0	0	0	0	0	0	0	8	0	12	0	0	0	0	15	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	49
Pediastrum boryanum	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	7	1	0	21
Pediastrum duplex v. reticulum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Protococcus viridis	0	0	0	0	0	0	0	0	0	0	2	0	0	0	3	0	0	6	0	0	0	0	13	0	0	0	0	0	0	4	0	0	0	0	299	0	327
Selanastrum sp.	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Scenedesmus abundans v. brevicauda	0	0	0	0	0	0	0	0	4	68	0	0	0	0	0	7	0	8	0	0	24	0	0	4	0	0	0	0	0	0	4	0	40	14	10	0	183
Scenedesmus acuminatus	0	0	0	0	0	0	0	0	0	12	0	0	0	0	8	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29
Scenedesmus bicaudata	0	0	0	0	0	0	0	0	0	4	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	16
Scenedesmus bijuga	4	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	6	10	0	0	0	0	0	0	2	0	0	6	7	0	0	39
Scenedesmus bijuga v. alternans	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Scenedesmus quadricauda v. Westii	47	15	8	0	0	3	0	0	0	20	2	0	25	2	19	0	7	1	0	0	93	6	4	4	2	0	2	6	4	0	0	0	38	12	8	0	328
Spermatozoopsis exultans	4	17	28	67	305	145	65	83	43	7	14	62	9	52	10	85	275	271	20	41	6	51	23	131	72	65	66	39	162	21	17	28	8	36	10	72	2410
Tetraedron sp.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Green colonial #1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	4
EUGLENOPHYTA																																					
Euglena acus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	168	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	169
Euglena sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	349	0	0	0	0	350
Eutreptilla gymnastica	5	0	0	0	0	0	2	3	16	1	4	5	0	0	0	2	1	4	0	1	1	5	0	1	0	0	1	9	2	0	40	0	0	3	1	31	138
Phacus pleuronectes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Trachelomonas sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PYROPHYTA																																					
Cryptomonas curvata	0	0	2	0	0	0	0	1	4	0	1	1	4	2	0	1	0	0	1	0	0	1	0	0	0	2	0	0	0	1	3	0	0	0	0	0	24
Cryptomonas erosa	1	20	6	3	1	2	120	29	94	5	10	2	0	9	3	4	1	9	1	16	0	40	1	3	3	1	4	22	13	12	34	2	5	40	1	7	524
Cryptomonas ovata	8	138	95	6	1	6	27	1	38	5	18	14	162	7	0	2	0	1	0	5	0	27	7	2	11	7	2	27	12	1	0	0	1	15	0	25	671
Cryptomonas sp.# 1	5	3	49	13	7	3	31	86	119	10	19	12	38	10	5	31	18	17	1	122	1	42	21	8	9	3	24	90	34	200	37	14	15	40	4	63	1204
Cryptomonas sp.# 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Unidentified flagellate #1	0	0	6	0	28	180	72	59	10	1	5	18	32	5	0	30	24	25	3	47	0	3	45	4	272	9	75	1	97	5	35	10	5	5	0	5	1116
DINOPHYCEAE																																					
Gonyalux palustre	10	8	1	5	3	0	13	9	44	0	12	1	10	0	1	0	0	8	2	3	0	5	1	1	3	1	2	5	1	3	90	27	4	28	2	1	304
CHRYSOPHYTA																																					
Calycomonas ovalis	0	4	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Mallomonas acaroides	0	0	1	0	0	0	2	6	1	0	0	0	3	3	0	0	1	0	0	12	0	4	0	0	0	0	0	1	0	1	1	4	0	0	0	0	40
BACILLARIOPHYCEAE																																					
Amphora sp. #1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Amphora sp. #2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cyclotella sp.	46	9	25	7	4	26	34	54	31	22	25	17	0	16	113	37	19	32	3	52	8	245	10	13	0	2	3	39	63	112	16	15	22	10	14	84	1228
Cymbella sp.	0	1	1	0	0	0	0	1	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Entomoneis alata	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Gyrosigma/Pleurosigma	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	6
Melosira granulata	40	15	46	14	21	0	0	5	3	4	1	53	92	343	39	72	81	42	5	3	0	8	11	173	47	31	0	83	2	0	6	3	1	8	9	68	1329
Navicula spp.	16	0	6	0	2	1	0	4	3	1	315	79	0	4	0	2	1	0	0	0	2	1	2	82	1	3	11	3	1	0	0	0	1	4	1	18	564
Nitzschia closterium	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Nitzschia palea	3	2	1	2	0	0	0	1	9	2	0	6	2	1	2	2	0	1	0	3	5	18	0	4	0	2	0	1	1	34	0	0	3	7	2	30	144
Nitzschia reversa	1	0	2	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	2	1	0	0	1	0	1	0	0	0	1	0	1	14
Nitzschia sigma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Nitzschia tryblionella	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	3
Nitzschia spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	4
Skeletonema costatum	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	2	22
Stephanodiscus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
CYANOPHYTA																																					
Anabaenopsis elenkinii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	82
Aphanizomenon sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	2	0	0	0	0	0	0	0	0	0	0	13
Aphanocapsa sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24
Chroococcus dispersus v. minor	0	37	0	0	0	0	0	0	0	8	0	3	0	0	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	16	133
Chroococcus limneticus v. subsalsu	0	115	17	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	0	0	0	223
Chroococcus minutus	66	35	112	379	120	128	80	96	41	78	29	189	63	8	11	197	66	46	429	148	69	19	330	50	44	322	281	159	61	31	134	42	38	82	0	0	3983
Coelosphaerium sp.	53	4	14	0	0	0	0	9	11	106	19	0	0	10	25	0	0	10	2	0	0	0	0	0	0	0	0	11	38	0	0	6	61	73	33	4	489
Lyngbya contorta trichome	21	1	0	0	0	0	0	0	2	7	2	5	0	3	0	0	0	0	0	1	75	1	2	0	5	0	0	0	0	1	1	0	2	1	12	2	144
Merismopedia glauca	0	29	32	0	0	0	36	18	0	0	0	0	0	0	45	15	0	12	16	0	6	0	16	0	0	0	0	0	4	0	8	0	93	0	0	16	346
Merismopedia sp.	38	0	0	4	0	0	0	0	0	85	0	6	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	34	86	72	0	333
Oscillatoria rubescens trichome	103	0	16	0	0	0	0	0	0	1	0	1	0	0	0	11	0	0	0	0	8	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	144
Phormidium fragile	5	0	0	0	8	2	0	15	0	15	0	3	0	0	51	0	4	0	0	0	5	1	0	4	0	36	20	2	2	60	36	0	11	2	3	16	301
Spirulina sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	18000

TABLE 3.24 Species Counts 1988-1991 at 6 o/oo

	JAN 89	FEB 89	MAR 89	APR 89	MAY 89	JUN 89	JUL 89	AUG 89	SEP 89	OCT 89	NOV 89	DEC 89	JAN 90	FEB 90	MAR 90	APR 90	MAY 90	JUN 90	JUL 90	AUG 90	SEP 90	OCT 90	NOV 90	DEC 90	JAN 91	FEB 91	MAR 91	APR 91	MAY 91	JUN 91	JUL 91	AUG 91	SEP 91	OCT 91	NOV 91	DEC 91	TOTAL
CHLOROPHYTA																																					
Actinastrum gracilimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	56
Ankistrodesmus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3
Chlymentomnonas sp.	15	7	3	0	0	37	5	0	12	1	12	0	0	14	0	10	68	0	30	0	11	3	9	1	23	42	10	40	2	41	2	0	2	2	0	15	417
Chlamydomonas sphagnicola	0	3	1	0	0	0	0	8	0	0	0	0	1	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Chlamydomonas sp.	23	1	20	0	8	5	0	0	0	5	1	0	0	11	0	23	0	0	26	0	0	0	3	1	0	16	0	0	30	0	1	0	0	0	0	0	174
Oocystis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	8
Pediastrum duplex v. reticulum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Pediastrum simplex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16
Protococcus viridis	3	12	7	0	0	3	48	0	2	0	8	0	0	0	27	0	22	143	10	0	28	0	16	0	0	0	29	0	0	98	0	0	22	0	12	0	492
Scenedesmus abundans v. brevicauda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	8
Scenedesmus acuminatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Scenedesmus bijuga	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4
Scenedesmus quadricauda v. Westii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	4	4	0	0	2	0	0	0	0	12	0	4	0	32
Spermatozoopsis exultans	8	0	7	0	4	1	24	0	5	0	0	0	3	4	8	0	1	6	0	5	5	0	3	5	0	0	3	1	0	4	0	8	29	11	3	6	154
EUGLENOPHYTA																																					
Euglena acus	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	16	0	0	0	0	0	0	5	0	0	0	0	2	0	0	0	0	0	0	3	27
Euglena sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Eutreptilla gymnastica	0	0	2	0	14	3	6	7	11	8	5	0	0	4	2	32	0	55	18	8	26	3	5	1	3	27	0	113	10	8	17	0	2	5	1	30	426
PYROPHYTA																																					
Cryptomonas curvata	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Cryptomonas erosa	0	43	0	0	2	0	7	0	0	0	2	0	1	9	0	0	2	2	6	6	9	0	4	2	0	1	2	1	0	0	0	1	1	1	0	0	102
Cryptomonas ovata	35	277	0	38	14	148	14	48	5	25	4	0	10	40	16	5	24	2	24	60	5	1	8	18	8	32	6	22	0	0	26	2	7	7	1	11	943
Cryptomonas sp.# 1	116	136	124	362	64	109	108	23	351	141	229	16	406	341	85	107	261	113	141	225	161	13	208	152	403	180	173	63	36	95	10	10	44	106	20	212	5344
Unidentified flagellate #1	9	0	2	0	0	18	55	0	1	4	4	1	1	10	0	17	0	16	0	0	7	0	23	37	0	4	5	7	0	30	1	6	0	15	2	7	282
Unidentified flagellate #2	5	0	6	1	0	0	0	0	0	0	1	0	11	0	0	8	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	36
DINOPHYCEAE																																					
Ceratium hircus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Gonyalux palustre	0	4	3	1	2	0	1	0	0	0	2	0	0	0	14	3	2	0	18	0	1	0	3	0	1	0	1	68	0	5	1	0	33	0	0	2	165
Gonyalux polygramma	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29
Gonyalux scriopsae	0	1	0	2	0	0	0	0	0	0	0	0	12	12	5	0	0	135	0	0	0	0	0	26	1	7	1	2	0	0	0	0	0	0	0	2	206
Gymnodinium splendens	61	8	5	3	4	0	0	25	16	1	0	2	21	8	14	24	28	0	0	0	1	0	1	0	0	0	8	1	0	0	1	1	0	2	0	1	236
Peridinium cerasus	0	0	0	0	0	24	0	0	0	37	121	474	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	1	666
Prorocentrum micans	0	0	0	0	0	0	1	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
CHRYSOPHYTA																																					
Calycomonas ovalis	3	0	0	0	0	0	0	14	5	28	12	0	2	0	0	7	0	1	2	1	2	1	3	5	1	0	1	0	0	0	0	0	0	2	2	1	93
Mallomonas acaroides	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
BACILLARIOPHYCEAE																																					
Actinoptychus undulatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	54	0	0	54
Amphora sp. #2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Bacillaria paradoxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	15
Biddulphia sinensis	0	0	0	0	0	0	29	5	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37
Coscinodiscus eccentris	0	0	2	0	0	0	1	0	0	1	0	1	15	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	26
Chaetocerus subtile	0	0	6	28	256	34	2	0	2	2	0	0	0	20	3	32	10	0	78	0	0	0	18	0	0	2	20	66	11	37	25	0	0	0	13	17	682
Cyclotella undulata	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cyclotella sp.	14	5	14	13	20	23	7	18	9	29	5	1	5	3	131	29	18	19	48	0	6	5	48	5	15	64	18	41	383	26	33	7	20	101	3	43	1229
Entomoneis alata	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
Gyrosigma/Pleurosigma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	1	0	3	0	0	0	0	0	0	0	3	22
Melosira granulata	7	0	6	1	0	23	8	4	2	0	6	0	2	0	14	0	0	0	2	0	0	0	1	0	0	1	0	0	0	8	0	0	14	0	0	3	102
Melosira sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Navicula spp.	140	2	17	0	0	1	3	0	7	0	17	2	0	1	1	66	0	4	0	0	1	0	5	3	31	19	120	0	0	1	0	1	1	0	1	6	450
Nitzschia closterium	6	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3	7	1	1	0	0	0	0	0	0	0	0	22
Nitzschia palea	3	0	1	0	0	1	0	0	2	2	7	1	0	1	9	1	0	0	0	0	6	0	0	5	0	4	0	2	0	2	0	0	0	0	0	4	51
Nitzschia reversa	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	1	8
Nitzschia sigma	4	0	0	0	0	0	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Nitzschia spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	3	6	0	0	0	0	0	1	0	0	0	0	13
Rhizosolenia styliformis	1	0	6	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	11
Skeletonema costatum	2	0	169	45	4	2	129	339	21	125	18	0	4	17	18	0	30	0	0	15	137	462	106	0	0	23	0	33	0	0	373	235	4	55	374	110	2850
Stephanodiscus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Surirell sp.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
CYANOPHYTA																																					
Anabaenopsis elenkinii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Chroococcus dispersus v. minor	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Chroococcus limneticus v. subsalsu	0	0	77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77
Chroococcus minutus	32	0	12	2	108	67	46	8	47	77	44	1	6	0	0	104	6	0	88	175	74	12	34	198	3	0	96	34	24	143	10	228	301	110	15	21	2126
Coelosphaerium sp.	5	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	8	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	26	0	65
Lyngbya contorta trichome	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	5
Merismopedia glauca	0	0	8	4	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	40
Oscillatoria rubescens trichome	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	64	1	0	2	0	0	0	0	0	1	0	83
Phormidium fragile	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	29
TOTAL	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	18000

TABLE 3.25 Species Counts 1988-1991 at 12 o/oo

	JAN 89	FEB 89	MAR 89	APR 89	MAY 89	JUN 89	JUL 89	AUG 89	SEP 89	OCT 89	NOV 89	DEC 89	JAN 90	FEB 90	MAR 90	APR 90	MAY 90	JUN 90	JUL 90	AUG 90	SEP 90	OCT 90	NOV 90	DEC 90	JAN 91	FEB 91	MAR 91	APR 91	MAY 91	JUN 91	JUL 91	AUG 91	SEP 91	OCT 91	NOV 91	DEC 91	TOTAL
CHLOROPHYTA																																					
Actinastrum gracilimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Chlymentomonas sp.	5	0	0	4	14	0	0	0	0	7	0	0	5	0	0	0	0	12	0	0	0	0	8	8	0	4	0	10	3	5	6	0	0	0	0	19	110
Chlamydomonas sphagnicola	0	1	0	0	0	0	6	9	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
Chlamydomonas sp.	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0	0	0	0	37
Crucigenia tetrapedia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4
Protococcus viridis	0	2	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	7	0	0	0	0	0	28
Scenedesmus bijuga	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Scenedesmus quadricauda v. Westii	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	8
Spermatozoopsis exultans	0	1	1	0	0	1	0	0	0	1	1	0	1	0	4	2	0	0	2	0	1	0	0	0	0	0	0	1	0	5	2	0	6	0	0	0	29
EUGLENOPHYTA																																					
Euglena acus	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Eutreptilla gymnastica	2	2	0	2	7	2	1	0	1	2	4	0	1	3	7	6	0	1	0	3	11	0	0	2	0	64	0	4	0	5	10	0	3	0	0	12	155
PYROPHYTA																																					
Cryptomonas erosa	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	2	0	0	2	0	0	0	1	0	0	0	0	0	12
Cryptomonas ovata	4	98	0	27	0	2	0	0	0	0	0	3	4	63	1	0	10	0	8	0	0	0	3	8	1	72	2	1	0	22	2	0	0	0	0	2	333
Cryptomonas sp.# 1	270	246	43	421	347	48	138	20	55	53	186	62	328	356	363	248	152	279	111	77	12	20	268	294	292	236	391	140	119	225	63	2	61	50	72	296	6344
Unidentified flagellate #1	21	0	0	16	15	53	2	2	0	4	4	1	9	0	5	24	33	13	67	27	0	0	4	46	23	10	0	97	59	12	6	3	15	0	0	5	576
Unidentified flagellate #2	3	0	0	0	0	0	0	0	0	0	35	0	0	1	10	2	0	0	0	0	1	0	0	12	23	4	2	0	0	0	0	0	0	0	0	0	93
DINOPHYCEAE																																					
Ceratium fusus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Ceratium hircus	2	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	3	2	0	0	15
Dinophysus caudata facutiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	4
Gonyalux palustre	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	6	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Gonyalux scrippsae	0	3	0	12	0	0	0	0	0	0	0	0	1	4	7	0	0	0	4	0	0	0	0	0	17	5	0	0	0	0	0	0	1	0	0	1	55
Gymnodinium simplex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Gymnodinium splendens	57	54	14	0	0	0	7	5	397	0	1	0	7	1	0	2	65	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	3	636
Peridinium cerasus	0	0	0	0	0	0	1	0	9	77	100	421	0	0	0	0	0	0	0	0	0	27	0	0	3	0	0	0	0	0	28	0	132	51	0	0	849
Polykrikos swartzii	0	9	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Prorocentrum micans	5	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	12
Protoperidinium conicum	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
CHRYSOPHYTA																																					
Calycomonas ovalis	2	0	0	0	0	0	1	12	0	24	0	2	8	1	0	0	20	1	3	0	1	1	4	24	0	1	0	0	2	0	0	0	2	1	2	5	117
Mallomonas acaroides	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	5
BACILLARIOPHYCEAE																																					
Actinoptychus undulatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5
Asterionella gracile	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Bacillaria paradoxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Biddulphia sinensis	0	0	0	0	0	0	41	3	0	3	0	0	1	0	0	0	0	0	0	35	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	86
Coscinodiscus eccentris	2	0	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	2	13
Chaetocerus compressa	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Chaetocerus dicipens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Chaetocerus subtile	1	0	0	4	34	4	0	0	0	0	7	0	1	0	8	3	0	3	19	5	0	0	3	8	19	0	0	3	1	31	0	0	2	0	11	0	167
Cyclotella undulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
Cyclotella sp.	8	0	0	3	2	3	4	0	0	5	10	0	5	1	8	3	1	1	3	16	2	0	15	6	0	2	2	2	12	34	30	0	4	211	2	8	403
Entomoneis alata	0	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Gomphonema spp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Gyrosigma/Pleurosigma	0	0	0	0	0	0	2	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	1	20
Hemialux sinensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Melosira granulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Navicula spp.	30	3	0	0	0	0	1	0	1	0	11	2	3	3	1	2	0	0	0	0	0	0	3	12	0	26	0	3	1	3	0	0	0	10	0	5	120
Nitzschia closterium	1	1	0	0	2	0	0	0	0	0	1	0	1	4	1	0	1	0	0	0	1	0	1	20	0	1	0	3	0	0	0	0	0	2	1	14	55
Nitzschia fruticosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	19
Nitzschia palea	0	0	0	0	0	0	2	2	0	0	19	1	27	3	1	2	0	0	0	2	0	0	1	2	0	1	0	0	1	0	2	0	0	0	0	17	83
Nitzschia reversa	2	0	0	0	4	1	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	12
Nitzschia tryblionella	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	16
Nitzschia spp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Rhizosolenia setigera	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Rhizosolenia stolterfothii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	8	15
Rhizosolenia styliformis	24	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	10	8	81
Skeletonema costatum	0	48	402	0	0	0	198	319	4	219	6	0	7	0	60	7	2	0	0	8	395	439	149	22	37	25	2	26	0	21	267	433	148	40	336	53	3673
Surirell sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
CYANOPHYTA																																					
Anabaenopsis elenkinii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
Aphanizomenon sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	24
Chroococcus limneticus v. subsalsu	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Chroococcus minutus	45	20	0	10	76	382	85	128	29	104	110	7	82	46	8	180	191	189	283	325	55	8	41	20	79	42	98	208	272	133	75	61	116	111	27	21	3666
Coelosphaerium sp.	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Merismopedia glauca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Oscillatoria rubescens trichome	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	13
TOTAL	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	18000

TABLE 3.26 Species Counts 1988-1991 at 20 o/oo

	JAN 89	FEB 89	MAR 89	APR 89	MAY 89	JUN 89	JUL 89	AUG 89	SEP 89	OCT 89	NOV 89	DEC 89	JAN 90	FEB 90	MAR 90	APR 90	MAY 90	JUN 90	JUL 90	AUG 90	SEP 90	OCT 90	NOV 90	DEC 90	JAN 91	FEB 91	MAR 91	APR 91	MAY 91	JUN 91	JUL 91	AUG 91	SEP 91	OCT 91	NOV 91	DEC 91	TOTAL
CHLOROPHYTA																																					
Chlymentomonas sp.	0	1	4	1	10	0	0	0	0	0	0	0	0	16	8	0	1	0	24	0	0	0	0	0	0	1	22	11	4	0	0	0	0	0	0	0	103
Chlamydomonas sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Scenedesmus quadricauda v. Westii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Spermatozoopsis exultans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	5
EUGLENOPHYTA																																					
Eutreptilla gymnastica	0	1	0	0	0	0	2	1	0	3	1	0	0	11	0	6	1	11	2	0	15	1	2	3	3	104	3	4	2	2	2	1	5	1	0	0	187
PYROPHYTA																																					
Cryptomonas ovata	0	2	5	5	1	4	0	0	0	1	0	0	1	1	1	0	0	0	6	1	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	31
Cryptomonas sp.# 1	362	37	118	321	359	254	94	52	6	42	266	76	311	365	381	356	210	221	393	27	145	5	92	257	426	251	384	404	137	182	10	13	9	48	52	8	6674
Unidentified flagellate #1	0	4	0	0	0	2	0	0	0	0	0	0	3	2	1	1	0	0	0	0	0	0	0	0	0	7	0	23	0	0	0	0	0	0	0	0	43
Unidentified flagellate #2	5	0	0	1	0	0	0	0	0	0	0	0	30	5	0	3	1	9	0	0	0	0	0	0	1	4	11	0	0	1	0	0	0	0	0	0	71
DINOPHYCEAE																																					
Amphidinium crassum	0	3	0	0	1	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	14
Ceratium fusus	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Ceratium hircus	6	2	0	1	0	0	0	41	88	437	23	1	0	0	0	0	0	0	0	2	3	30	39	0	0	0	0	2	0	0	0	0	327	2	14	0	1018
Dinophysus caudata facutiformis	1	0	0	0	0	0	0	0	1	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	9
Gonyalux palustre	0	0	0	0	1	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Gonyalux scrippsae	0	1	0	0	2	0	0	0	0	0	0	10	0	0	6	0	0	0	0	0	1	0	0	3	0	0	0	2	0	0	0	0	2	0	0	0	27
Gymnodinium simplex	62	0	14	7	3	4	0	0	3	0	1	0	6	7	0	3	7	2	8	1	5	0	2	6	1	36	7	0	4	0	1	1	0	0	4	0	195
Gymnodinium splendens	1	173	2	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	181
Peridinium cerasus	0	0	0	4	0	0	0	0	269	0	4	53	0	0	0	0	0	0	0	0	1	1	8	0	0	0	0	2	0	0	0	0	65	0	0	0	407
Polykrikos swartzii	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Prorocentrum micans	3	2	1	0	3	0	0	5	79	11	1	0	0	1	0	0	0	0	1	0	1	0	13	0	1	2	38	0	0	0	0	0	0	0	2	0	164
Protoperidinium depressum	0	1	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
CHRYSOPHYTA																																					
Calycomonas ovalis	10	1	6	4	9	0	0	1	0	0	3	0	5	3	3	8	8	0	5	1	0	0	2	1	21	2	23	0	1	1	0	0	0	0	1	0	119
Calycomonas wulfie	0	0	0	2	7	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	25
Centritractus aff. belonophorus	0	0	0	20	2	0	0	0	0	0	0	0	0	0	0	0	1	1	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40
Mallomonas acaroides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	5
BACILLARIOPHYCEAE																																					
Actinoptychus undulatus	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	30	24	0	0	66
Bacillaria paradoxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5
Biddulphia sinensis	0	0	1	1	0	2	198	36	4	1	4	141	0	0	0	0	0	0	24	18	0	0	2	0	8	1	1	20	0	0	0	0	0	0	22	0	484
Biddulphia rhombus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Coscinodiscus eccentris	0	0	0	0	0	14	0	0	0	0	0	4	1	5	0	24	0	0	0	0	0	0	0	0	1	0	0	2	0	1	0	0	3	6	0	0	61
Chaetocerus compressa	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	11
Chaetocerus subtile	0	0	0	0	0	0	0	0	0	0	0	0	30	0	10	3	1	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	3	0	50
Cyclotella sp.	1	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3	0	0	0	0	0	2	0	0	0	0	8	0	0	0	0	0	0	17
Entomoneis alata	0	0	0	0	0	0	0	0	0	0	75	8	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85
Gyrosigma/Pleurosigma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	5
Hemialux sinensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Navicula spp.	1	7	0	0	0	1	0	0	0	0	0	0	0	0	0	1	2	7	3	0	0	0	0	6	3	1	0	0	0	0	0	1	0	2	0	0	35
Nitzschia closterium	2	8	7	0	0	2	0	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	4	0	36
Nitzschia palea	0	0	2	0	2	0	0	0	0	0	47	22	0	1	0	4	0	1	2	0	0	2	21	10	5	0	0	2	0	0	0	0	0	0	0	3	124
Nitzschia reversa	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Nitzschia tryblionella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
Nitzschia spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	1	0	0	52
Paralia (Melosira) sulcata	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	16	30
Rhizosolenia setigera	0	0	0	0	0	0	0	12	0	0	0	23	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	59	5	0	0	10	0	111
Rhizosolenia stolterfothii	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98	0	100
Rhizosolenia styliformis	2	0	29	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	472	564
Skeletonema costatum	12	257	243	121	74	0	202	334	44	0	16	0	87	6	17	10	0	7	3	3	310	450	295	26	0	29	2	0	0	10	424	437	9	0	212	0	3640
CYANOPHYTA																																					
Anabaena spiroides v. crassa trichome	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Anabaenopsis elenkinii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	30
Chroococcus minutus	32	0	68	9	25	217	2	7	0	0	46	150	20	75	65	77	256	240	0	445	18	11	20	184	24	59	0	24	352	287	3	33	0	386	8	0	3143
Merismopedia glauca	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Spirulina sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
TOTAL	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	18000

TABLE 3.27
CHARLOTTE HARBOR 1989 - 1991
Percent Major Taxonomic Groups

MONTH	YEAR	STATION	GREEN ALGAE	FLAGELLATES	DINO-FLAGELLATES	DIATOMS	BLUE-GREEN ALGAE
1	89	0 o/oo	15.6	4.0	2.0	21.2	57.2
2	89	0 o/oo	15.8	32.2	1.6	5.4	44.2
3	89	0 o/oo	13.6	31.6	0.2	16.2	38.2
4	89	0 o/oo	13.4	4.4	1.0	4.6	76.6
5	89	0 o/oo	61.0	7.4	0.6	5.4	25.6
6	89	0 o/oo	30.4	38.2	0.0	5.4	26.0
7	89	0 o/oo	16.6	50.4	2.6	6.8	23.2
8	89	0 o/oo	20.4	35.8	1.8	13.2	27.6
9	89	0 o/oo	13.8	56.4	8.8	9.8	10.8
10	89	0 o/oo	29.8	4.4	0.0	5.8	60.0
11	89	0 o/oo	6.4	11.4	2.4	69.8	10.0
12	89	0 o/oo	15.4	10.4	0.2	32.6	41.4
1	89	6 o/oo	9.8	33.0	12.2	35.4	9.0
2	89	6 o/oo	4.6	91.4	2.6	1.4	0.0
3	89	6 o/oo	7.6	26.8	1.6	44.6	19.4
4	89	6 o/oo	0.0	80.2	1.2	17.4	1.2
5	89	6 o/oo	2.4	18.8	1.2	56.0	21.6
6	89	6 o/oo	9.2	55.6	4.8	17.0	13.4
7	89	6 o/oo	15.4	38.2	0.4	36.8	9.2
8	89	6 o/oo	1.6	15.6	5.0	73.4	1.6
9	89	6 o/oo	3.8	73.6	3.2	9.0	9.4
10	89	6 o/oo	1.2	35.8	10.0	32.0	15.4
11	89	6 o/oo	4.2	49.0	24.6	10.8	8.8
12	89	6 o/oo	0.0	3.4	95.2	1.2	0.2
1	89	12 o/oo	1.6	60.0	12.8	14.4	10.8
2	89	12 o/oo	1.6	69.2	13.2	10.4	5.6
3	89	12 o/oo	0.2	8.8	2.8	88.2	0.0
4	89	12 o/oo	0.8	93.4	2.4	1.4	2.0
5	89	12 o/oo	2.8	73.8	0.0	8.4	15.0
6	89	12 o/oo	0.2	21.0	0.0	2.4	76.4
7	89	12 o/oo	1.2	28.8	2.4	50.2	17.0
8	89	12 o/oo	1.8	4.4	1.0	64.8	25.6
9	89	12 o/oo	0.2	11.2	81.8	1.0	5.8
10	89	12 o/oo	1.6	11.8	15.6	45.4	20.8
11	89	12 o/oo	0.2	45.8	20.2	11.8	22.0
12	89	12 o/oo	0.0	13.2	84.2	0.8	1.4
1	89	20 o/oo	0.0	73.4	14.6	3.6	6.4
2	89	20 o/oo	0.2	8.8	36.4	54.4	0.0
3	89	20 o/oo	0.8	24.6	3.4	56.4	13.6
4	89	20 o/oo	0.2	65.4	2.4	24.8	2.0
5	89	20 o/oo	2.0	72.0	2.0	15.4	5.0
6	89	20 o/oo	0.0	52.0	0.8	3.8	43.4

TABLE 3.27 (cont.)
CHARLOTTE HARBOR 1989 - 1991
Percent Major Taxonomic Groups

MONTH	YEAR	STATION	GREEN ALGAE	FLAGELLATES	DINO-FLAGELLATES	DIATOMS	BLUE-GREEN ALGAE
7	89	20 o/oo	0.0	19.2	0.4	80.0	0.4
8	89	20 o/oo	0.0	10.6	9.2	78.6	1.4
9	89	20 o/oo	0.0	1.2	89.2	9.6	0.0
10	89	20 o/oo	0.0	9.2	90.6	0.2	0.0
11	89	20 o/oo	0.0	53.4	6.6	30.2	9.2
12	89	20 o/oo	0.0	15.2	12.8	42.0	30.0
1	90	0 o/oo	14.2	47.2	2.0	19.0	16.4
2	90	0 o/oo	15.6	6.6	0.0	73.0	4.2
3	90	0 o/oo	13.8	1.6	0.2	31.0	53.4
4	90	0 o/oo	18.6	14.0	0.0	22.8	44.6
5	90	0 o/oo	56.6	8.8	0.0	20.4	14.0
6	90	0 o/oo	58.6	11.2	1.6	15.0	13.6
7	90	0 o/oo	4.2	1.2	0.4	1.6	92.6
8	90	0 o/oo	14.0	38.2	0.6	11.6	33.0
9	90	0 o/oo	29.8	34.4	0.0	3.0	32.8
10	90	0 o/oo	12.6	23.6	1.0	57.8	4.2
11	90	0 o/oo	10.6	14.8	0.2	4.6	69.6
12	90	0 o/oo	29.8	3.6	0.2	54.8	11.6
1	90	6 o/oo	0.8	85.8	6.6	5.2	1.2
2	90	6 o/oo	5.8	80.8	4.0	9.2	0.0
3	90	6 o/oo	23.4	20.6	6.6	35.4	14.0
4	90	6 o/oo	6.6	35.0	10.4	25.8	20.8
5	90	6 o/oo	18.2	60.6	6.4	11.6	3.2
6	90	6 o/oo	30.2	37.6	27.0	5.0	0.0
7	90	6 o/oo	13.2	38.2	3.8	26.4	18.0
8	90	6 o/oo	1.4	59.8	0.0	3.6	35.0
9	90	6 o/oo	10.4	41.8	0.4	30.2	16.8
10	90	6 o/oo	0.6	3.4	0.0	93.4	2.4
11	90	6 o/oo	6.6	49.6	0.8	35.6	6.8
12	90	6 o/oo	2.2	43.2	5.2	8.8	39.6
1	90	12 o/oo	1.8	68.4	1.8	10.0	16.4
2	90	12 o/oo	2.6	84.6	1.2	2.2	9.2
3	90	12 o/oo	1.4	77.2	1.4	15.8	4.2
4	90	12 o/oo	0.4	57.0	1.6	5.0	36.0
5	90	12 o/oo	1.0	39.0	17.0	0.8	38.2
6	90	12 o/oo	2.4	58.6	0.0	1.0	37.8
7	90	12 o/oo	0.4	37.2	0.8	4.4	56.6
8	90	12 o/oo	0.0	21.4	0.4	13.2	65.0
9	90	12 o/oo	0.2	5.0	1.6	82.0	11.0
10	90	12 o/oo	0.0	4.0	6.4	87.8	1.6
11	90	12 o/oo	1.6	55.0	0.0	34.4	8.2
12	90	12 o/oo	1.6	72.8	0.0	16.8	4.0

TABLE 3.27 (cont.)
CHARLOTTE HARBOR 1989 - 1991
Percent Major Taxonomic Groups

MONTH	YEAR	STATION	GREEN ALGAE	FLAGELLATES	DINO-FLAGELLATES	DIATOMS	BLUE-GREEN ALGAE
1	90	20 o/oo	0.0	69.0	1.8	24.2	4.0
2	90	20 o/oo	3.2	76.8	2.0	2.4	15.0
3	90	20 o/oo	1.6	76.6	2.2	5.8	13.2
4	90	20 o/oo	0.0	73.2	0.8	9.0	15.4
5	90	20 o/oo	0.6	42.4	1.6	0.6	51.2
6	90	20 o/oo	0.0	48.2	0.4	3.2	48.0
7	90	20 o/oo	5.2	80.2	1.8	7.2	0.6
8	90	20 o/oo	0.0	5.6	0.6	4.6	89.0
9	90	20 o/oo	0.0	32.0	2.2	62.2	3.6
10	90	20 o/oo	0.0	1.2	6.2	90.4	2.2
11	90	20 o/oo	0.0	18.8	12.4	64.4	4.0
12	90	20 o/oo	0.0	52.0	1.8	9.2	36.8
1	91	0 o/oo	18.2	59.0	0.6	10.2	12.0
2	91	0 o/oo	15.6	4.4	0.2	7.8	72.0
3	91	0 o/oo	14.4	21.2	0.4	3.8	60.2
4	91	0 o/oo	9.0	29.8	1.0	25.6	34.4
5	91	0 o/oo	33.4	31.6	0.2	13.8	21.0
6	91	0 o/oo	7.6	43.8	0.6	29.4	18.4
7	91	0 o/oo	11.6	30.0	18.0	4.4	35.8
8	91	0 o/oo	5.6	75.0	5.4	3.6	9.6
9	91	0 o/oo	26.4	5.2	0.8	5.4	62.2
10	91	0 o/oo	18.8	20.8	5.6	6.0	48.8
11	91	0 o/oo	66.0	1.2	0.4	5.2	27.2
12	91	0 o/oo	22.2	26.2	0.2	40.6	10.8
1	91	6 o/oo	5.4	82.8	0.4	10.6	0.6
2	91	6 o/oo	11.6	48.8	1.4	25.4	12.8
3	91	6 o/oo	8.4	37.2	2.0	32.6	19.6
4	91	6 o/oo	8.6	41.2	14.2	29.2	6.8
5	91	6 o/oo	6.4	9.6	0.0	78.8	5.2
6	91	6 o/oo	29.0	26.6	1.0	14.8	28.6
7	91	6 o/oo	0.6	10.8	0.4	86.2	2.0
8	91	6 o/oo	1.6	3.8	0.2	48.8	45.6
9	91	6 o/oo	14.6	10.8	6.6	7.8	60.2
10	91	6 o/oo	6.4	26.8	1.8	42.6	22.0
11	91	6 o/oo	3.8	4.8	0.0	78.4	12.6
12	91	6 o/oo	4.2	52.8	1.2	37.4	4.2
1	91	12 o/oo	0.0	67.8	4.4	12.0	15.8
2	91	12 o/oo	2.0	77.2	1.2	11.0	8.4
3	91	12 o/oo	0.0	79.4	0.0	0.8	19.8
4	91	12 o/oo	2.2	48.4	0.0	7.8	41.6
5	91	12 o/oo	6.4	35.6	0.0	3.2	54.4
6	91	12 o/oo	2.8	52.8	0.0	17.8	26.6

TABLE 3.27 (cont.)
CHARLOTTE HARBOR 1989 - 1991
Percent Major Taxonomic Groups

MONTH	YEAR	STATION	GREEN ALGAE	FLAGELLATES	DINO-FLAGELLATES	DIATOMS	BLUE-GREEN ALGAE
7	91	12 o/oo	3.0	16.4	5.6	59.8	15.2
8	91	12 o/oo	0.0	1.0	0.0	86.8	12.2
9	91	12 o/oo	2.0	15.8	27.4	31.2	23.2
10	91	12 o/oo	0.0	10.0	10.6	57.0	22.2
11	91	12 o/oo	0.0	14.4	0.4	74.4	10.4
12	91	12 o/oo	3.8	63.0	1.0	26.2	4.2
1	91	20 o/oo	0.0	86.0	0.4	4.6	4.8
2	91	20 o/oo	0.6	73.4	7.6	6.2	11.8
3	91	20 o/oo	4.4	79.6	9.2	0.6	0.0
4	91	20 o/oo	2.6	86.6	1.2	4.8	4.8
5	91	20 o/oo	0.8	27.8	0.8	0.0	70.4
6	91	20 o/oo	0.0	37.0	1.4	4.0	57.4
7	91	20 o/oo	0.0	2.4	0.2	96.8	0.6
8	91	20 o/oo	0.0	2.8	0.2	90.4	6.6
9	91	20 o/oo	0.0	2.8	79.0	18.2	0.0
10	91	20 o/oo	0.0	9.8	0.4	6.6	83.2
11	91	20 o/oo	0.0	10.4	4.0	83.8	1.6
12	91	20 o/oo	0.0	1.6	0.2	98.2	0.0

FIGURE 3.91

CHARLOTTE HARBOR 1989 – 1991

Percent Major Taxonomic Groups

STATION=0 o/oo

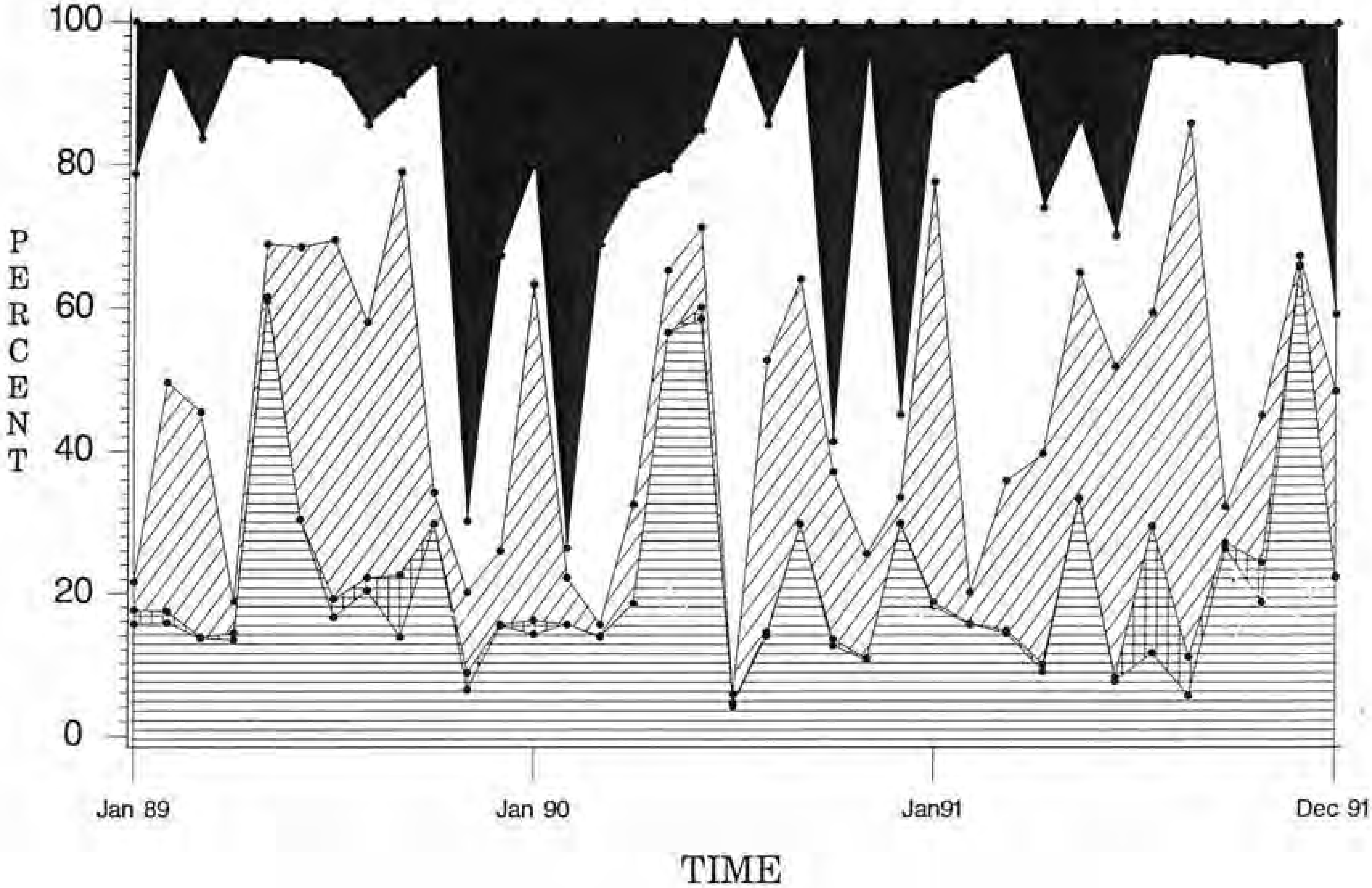


FIGURE 3.92

CHARLOTTE HARBOR 1989 – 1991

Percent Major Taxonomic Groups

STATION=0 o/oo

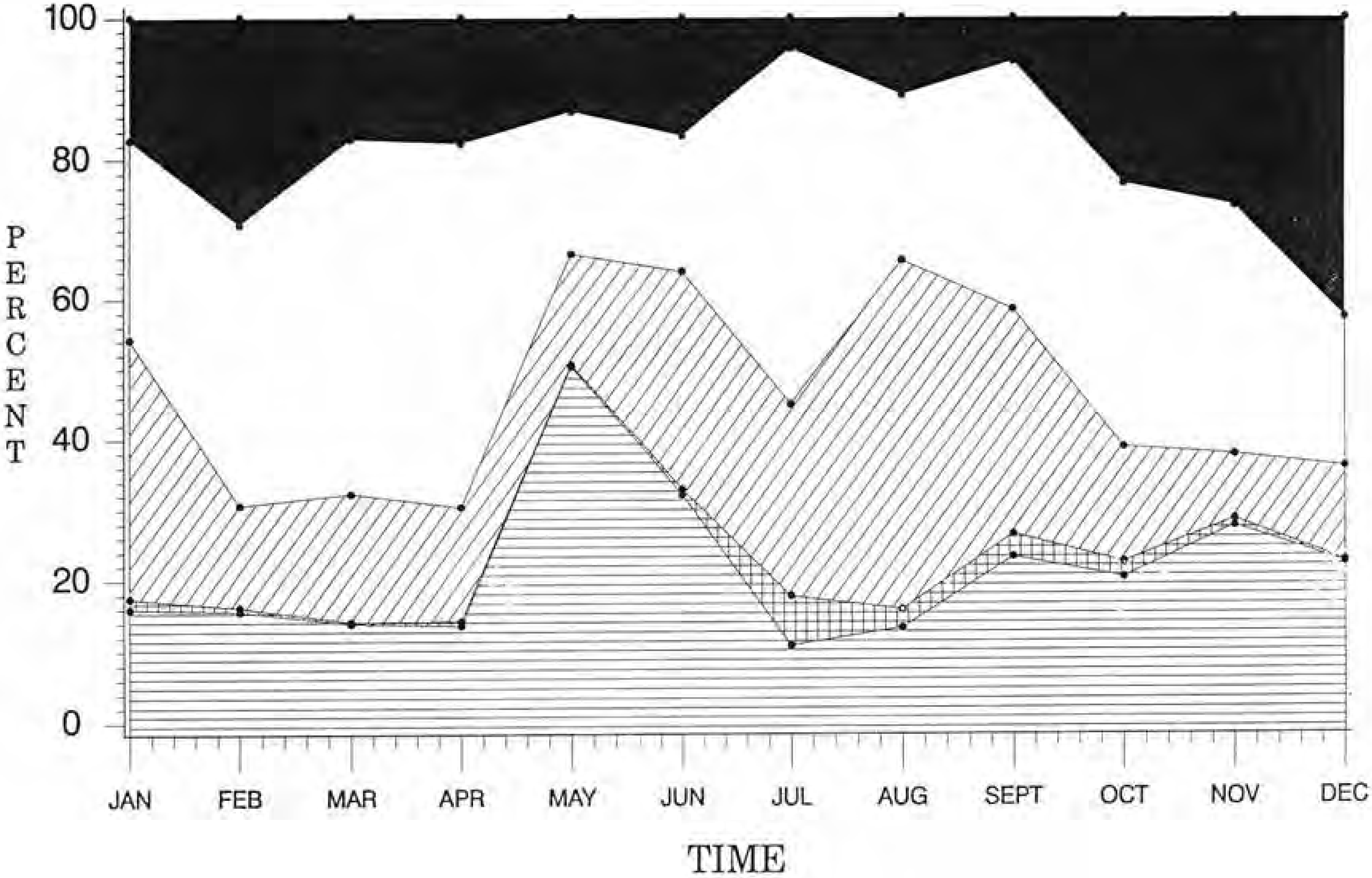


FIGURE 3.93

CHARLOTTE HARBOR 1989 – 1991

Percent Major Taxonomic Groups

STATION=6 o/oo

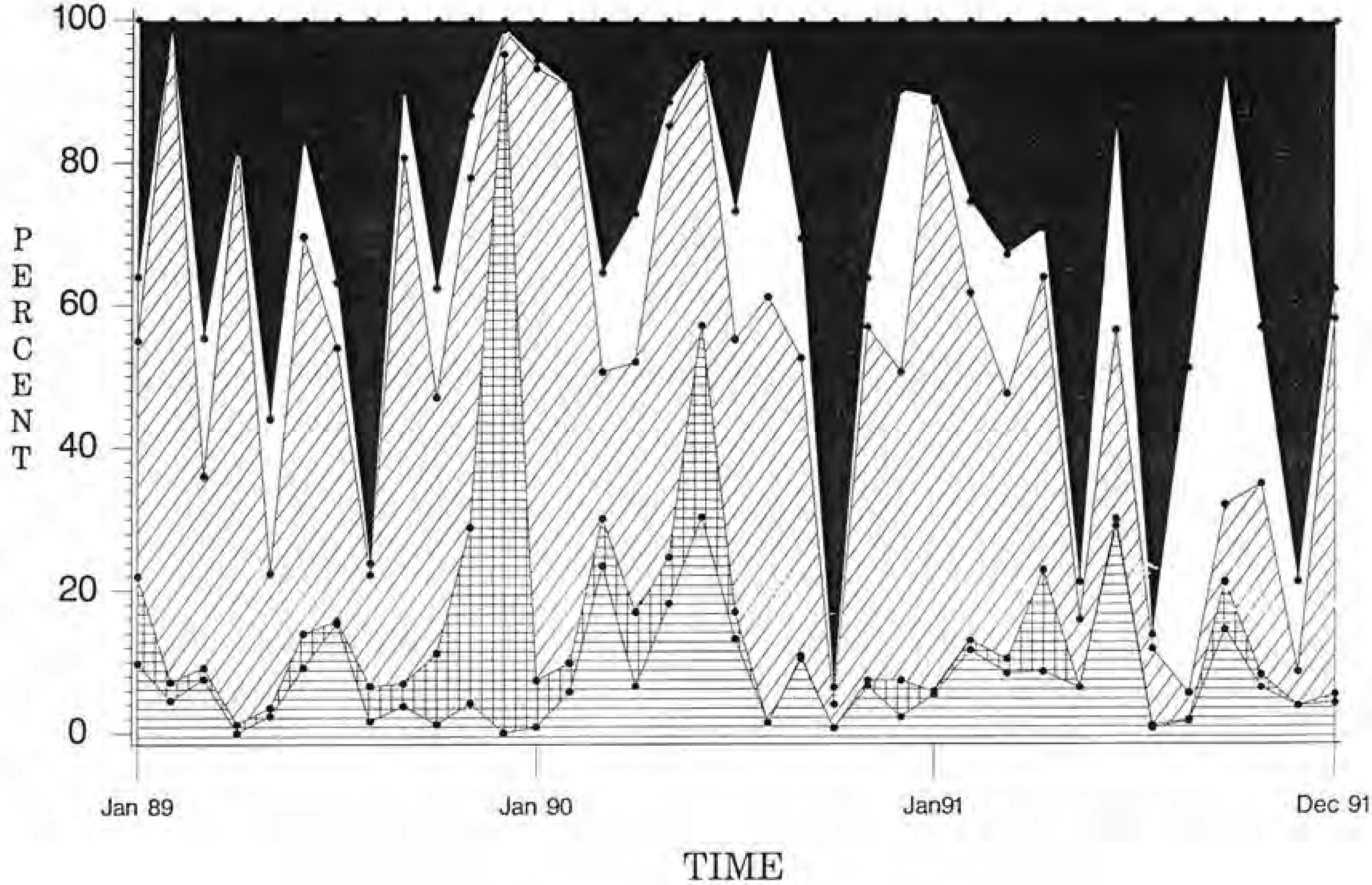


FIGURE 3.94

CHARLOTTE HARBOR 1989 – 1991

Percent Major Taxonomic Groups

STATION=6 o/oo

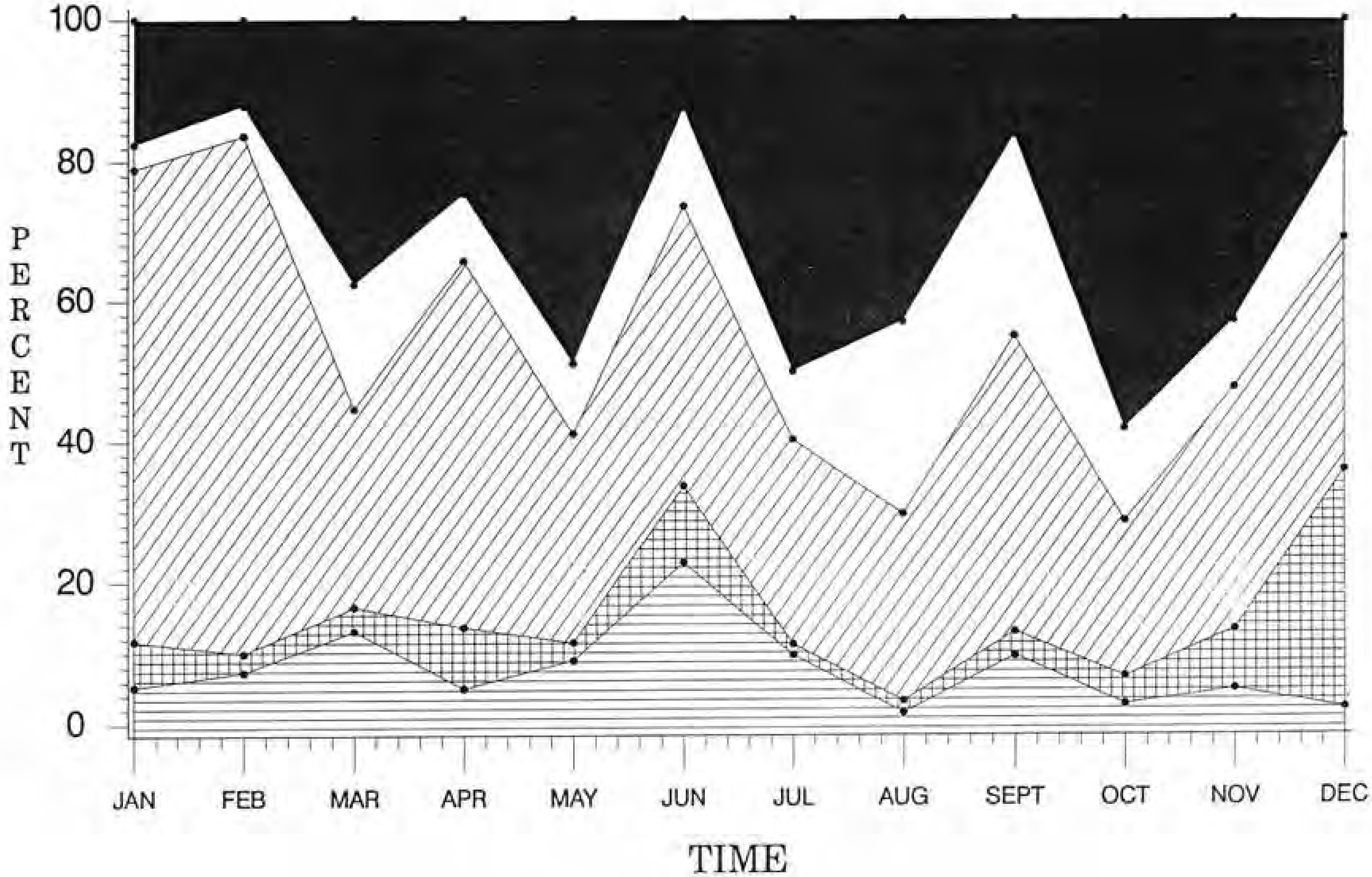


FIGURE 3.95

CHARLOTTE HARBOR 1989 – 1991

Percent Major Taxonomic Groups

STATION=12 o/oo

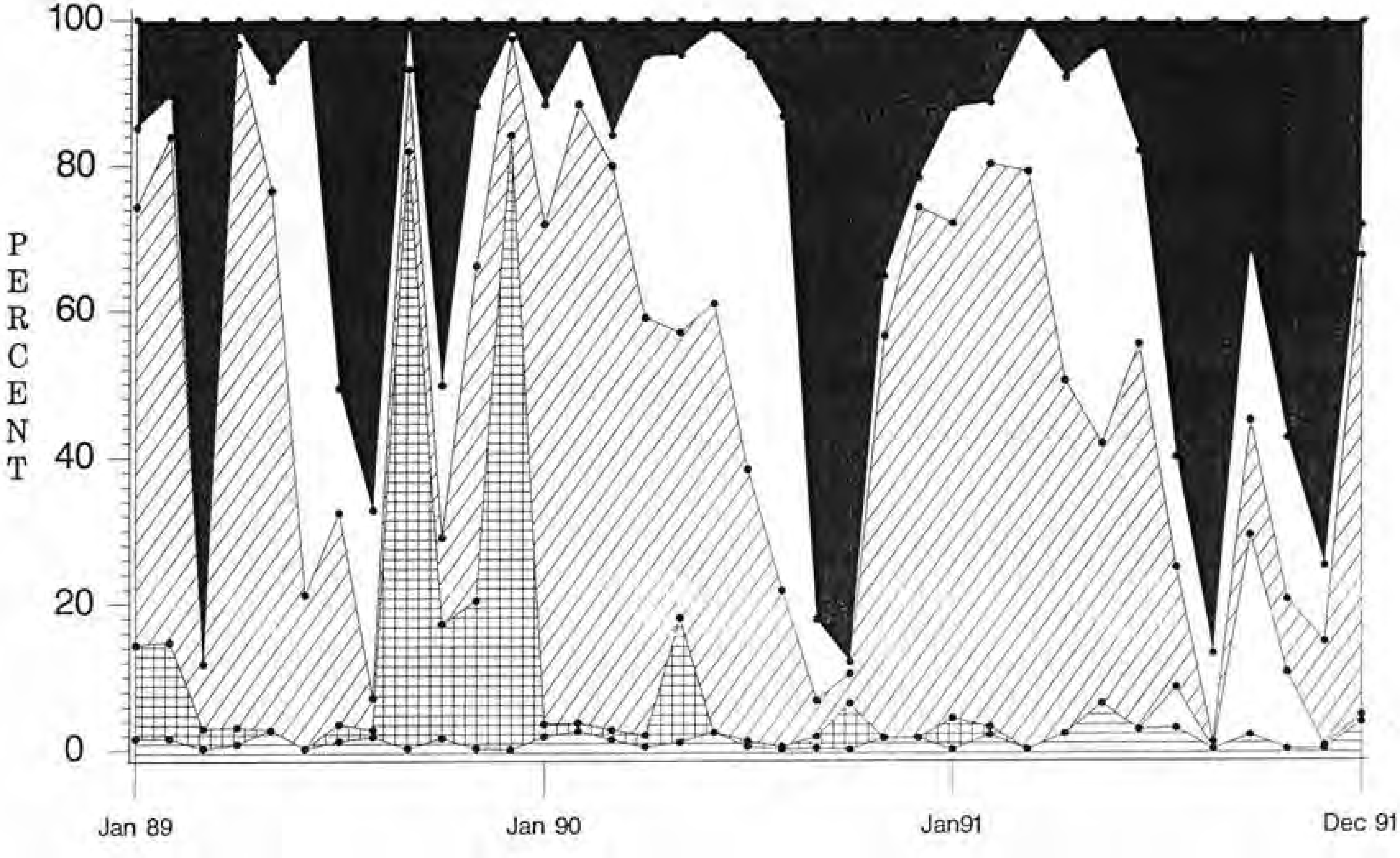


FIGURE 3.96

CHARLOTTE HARBOR 1989 – 1991

Percent Major Taxonomic Groups

STATION=12 o/oo

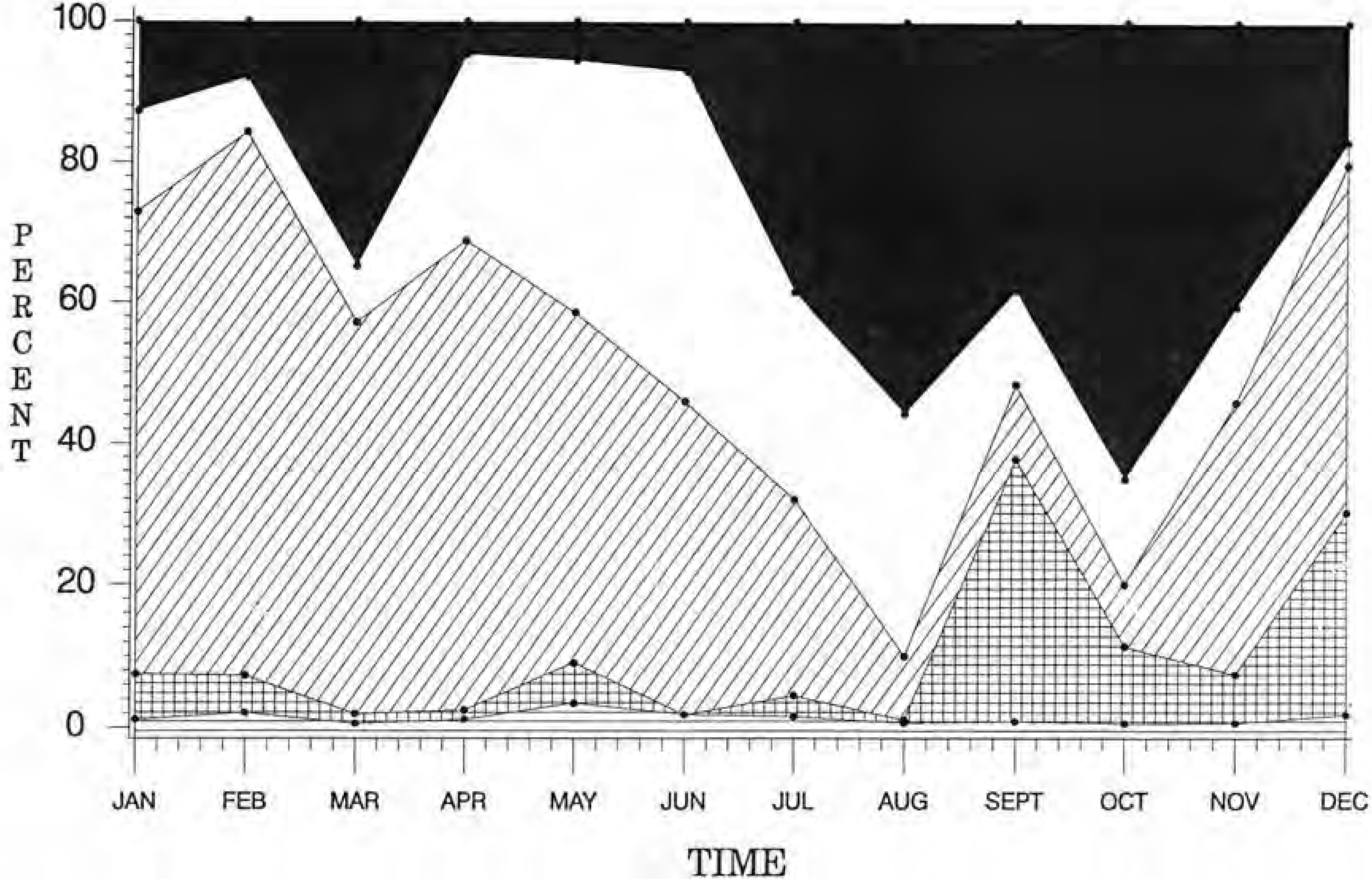


FIGURE 3.97

CHARLOTTE HARBOR 1989 – 1991

Percent Major Taxonomic Groups

STATION=20 o/oo

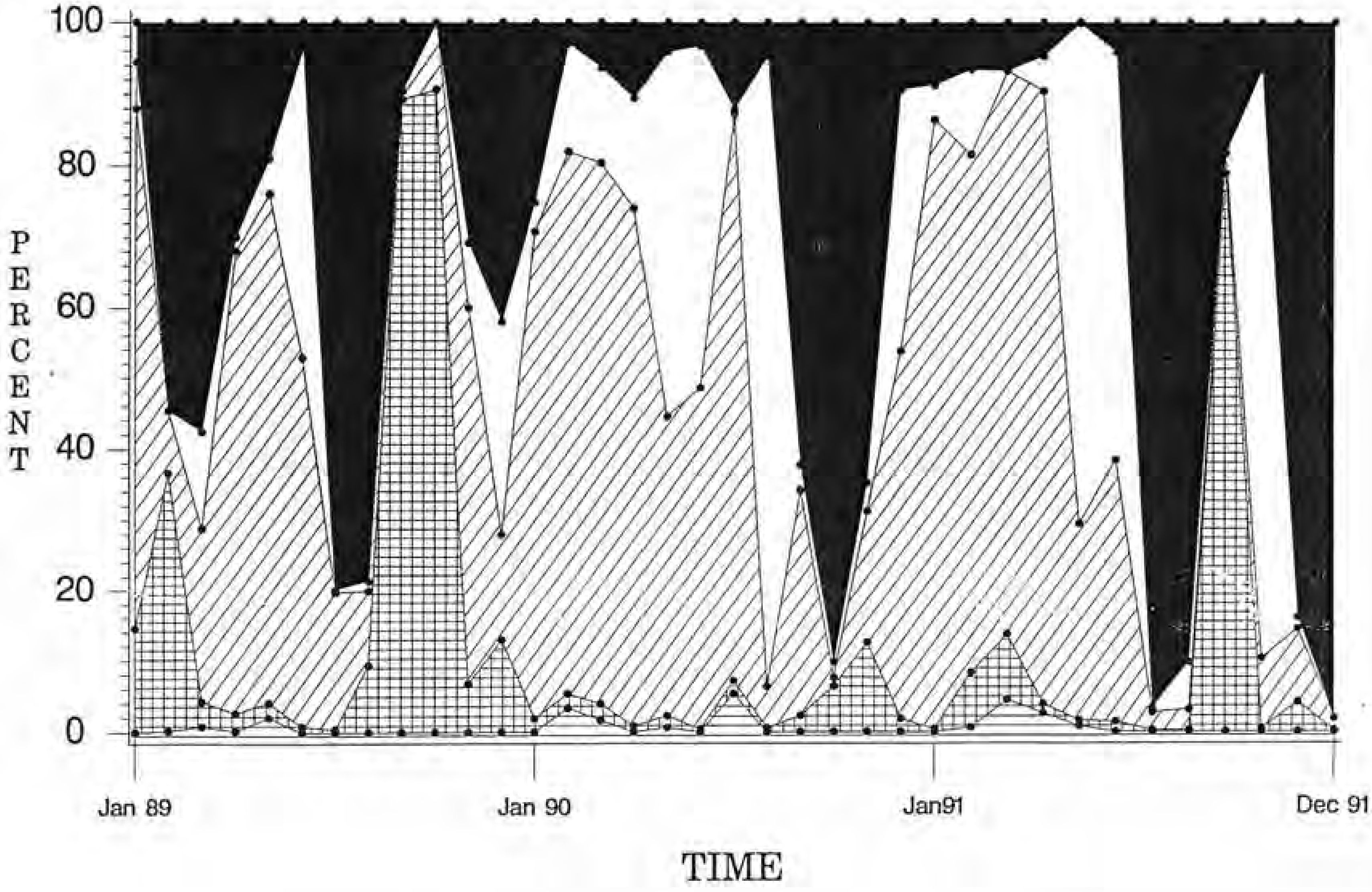
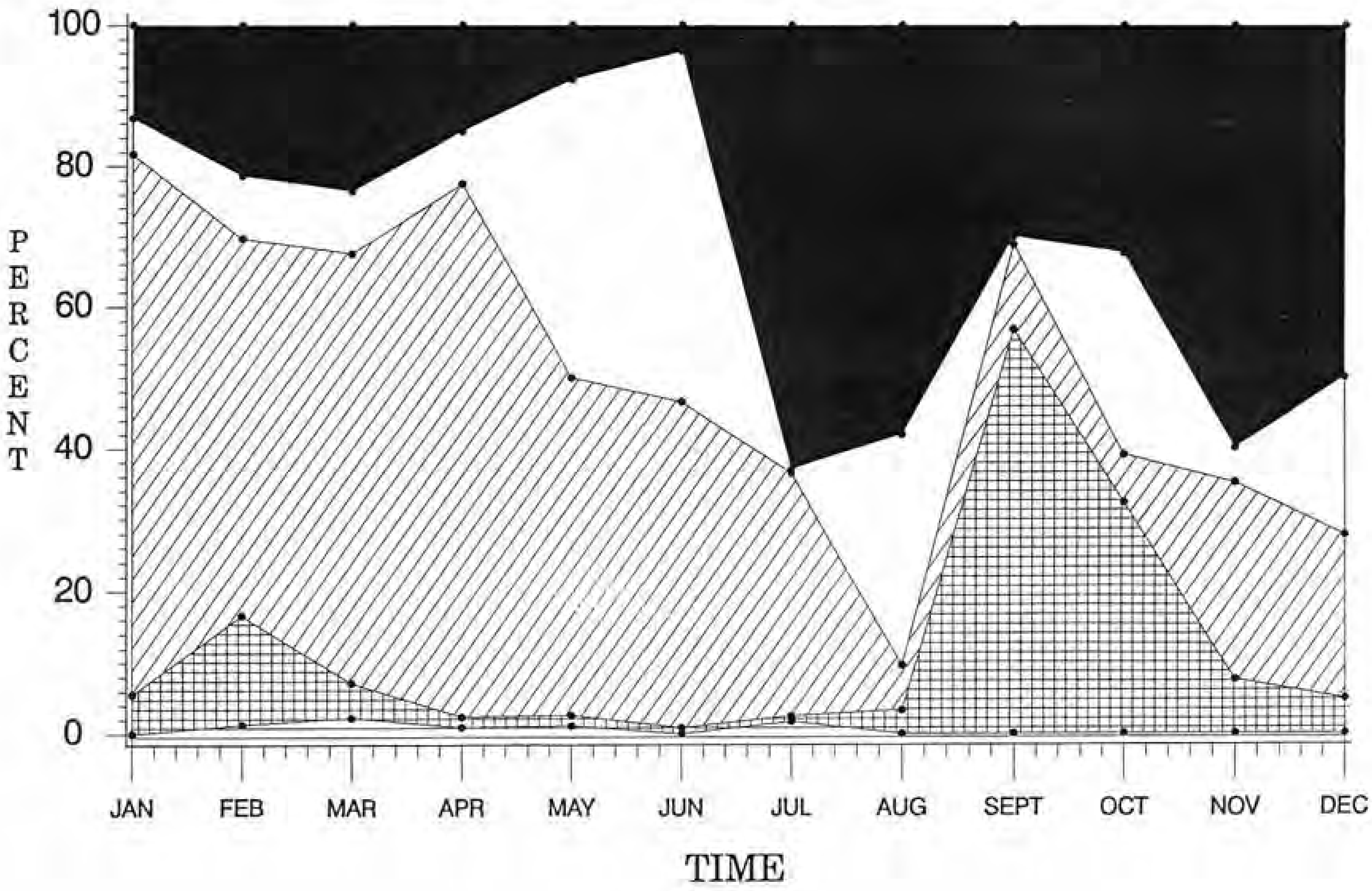


FIGURE 3.98

CHARLOTTE HARBOR 1989 – 1991

Percent Major Taxonomic Groups

STATION=20 o/oo



related to increasing Summer river flows. Diatoms make up their smallest part of the phytoplankton during such periods of high river flow, and are important or show major peaks during the late fall and winter months, as flow and water temperature decline. Dinoflagellates are not an important component of the phytoplankton community at this salinity.

2) 6 o/oo Salinity - the taxonomic structure at this salinity zone shows a dramatic decline in the importance of both green and blue-green taxa within the phytoplankton community. This salinity zones is characterized by alternating blooms of diatoms and flagellates, with dinoflagellates also showing periodic blooms.

3) 12 o/oo Salinity - this zones is characterized by seasonal blooms of flagellates, diatoms and dinoflagellates. Flagellates typically dominate through the cooler months and well into beginning of Summer wet-season. As river flow and temperature increase diatoms begin to become more important. Green algae are no longer an important part of the phytoplankton community.

4) 20 o/oo Salinity - the seasonal patterns of the major taxonomic groups at this salinity zone follow patterns generally similar to those observed at 12 o/oo. Diatoms and dinoflagellates, however, show a marked increased in their relative importance within the phytoplankton community.

3.4.3 Analysis of Community Structure

Diversity and similarity indices have been widely utilized in analyzing community structure. Such indices allow large amounts of information relevant to the richness and equitablility of species within a community to be organized and reduced into a single quantitative expression. Two properties should characterize a diversity index to accomplish this accurately; 1) the index should attain its maximum value when all species are equally distributed; and 2) if all species within two samples are equally distributed , the value of the index should be greater for the sample with the largest number of species. A second measure of community structure often used in conjunction with species diversity is species evenness. Evenness can most easily be thought of as an expression or comparison of the observed species diversity within a community sample with some theoretical maximum diversity for a sample of the same size and containing the same number of taxa. A number of widely used measurements of species diversity and evenness are presented in Table 3.28. These are present for each phytoplankton sample in Appendix A.

One diversity index commonly used in biological studies is the Shannon-Weiner index (also known as Pielou base e). This measure of diversity was originally derived from information theory and is used to predict the relative amount of information in a sample as the uncertainty of predicting species identities of individuals selected at random. The Shannon-Weiner index and it's corresponding measurement of evenness are calculated as:

Diversity (H') = $-1 \text{ Sum } [P_i(\ln P_i)]$

Evenness (J') = $(-1 \text{ Sum } [P_i(\ln P_i)]) / \log_e S$

where:

P_i = percent ith taxa represents of the total sample n_i/N
n_i = number of individuals of the ith taxa in the sample
N = total number of individual in the sample
S = total number of taxa in sample

The "biological validity" of diversity indices can readily be criticized if attempts are made to extend the mathematical characteristics of information theory contained in the index to the structure of natural communities . However, if these indices are viewed as convenient methods of condensing data and describing the distributions of taxa within sampled communities, then their application becomes much more clear.

Shannon-Weiner indices of diversity and evenness were used to compare

TABLE 3.28

Measurements of Species Diversity, Evenness and Similarity

DIVERSITY AND EVENNESS

Pielou Base e diversity (H') =

$$-1. \Sigma P_i \log_e P_i$$

Pielou Base e evenness (J') =

$$(-1. \Sigma P_i \log_e P_i) / \log_e S$$

Margalev diversity =

$$(S - 1) / \log_e N$$

Pielou Base 10 diversity =

$$-1. \Sigma P_i \log_{10} P_i$$

Pielou Base 10 evenness =

$$(-1. \Sigma P_i \log_{10} P_i) / \log_{10} S$$

Simpson Diversity = $1. / \Sigma P_i^2$

Simpson Evenness = $(1. - \Sigma P_i^2) / (1. - (1./S))$

TABLE 3.28 (cont.)

Measurements of Species Diversity, Evenness and Similarity

DIVERSITY AND EVENNESS

McIntosh Diversity = $(N - (\Sigma n_i^2)^{½}) / (N - (N)^{½})$

McIntosh Evenness = $(N - (\Sigma n_i^2)^{½}) / (N - (N/S^{½}))$

Sheldon Evenness = $e^{H'} / S$

Heip Evenness = $(e^{H'} - 1.) / (S - 1.)$

SIMILARITY

Simplified Morisita = $(2.\Sigma P_{1i} \times P_{2i}) / (\Sigma P_{1i}^2 + \Sigma P_{2i}^2)$

n_{1i} = number of individuals in sample 1 of i^{th} taxa

N_1 = total number of individuals in sample 1

S_{12} = total number of taxa in both samples 1 and 2

S_1 = number of taxa in sample 1

P_i = percent i^{th} taxa represents of the total sample (n_i/N)

phytoplankton species diversity between sampling months at each salinity zone. Table 3.29 lists the number of taxa observed within the monthly taxonomic counts of 500 cells/sample at each of the four salinity zones, and the resultant calculated diversity and evenness indices. These phytoplankton community indices are plotted by versus sampling dates in Figures 3.99 thought 3.101. The following patterns were observed:

1) At each of the salinity zones, all three measurements of phytoplankton community structure showed a very wide range of variation with very little in any way of discernable patterns within a salinity zone.

2) One trend was apparent in all three of these measurements of community structure; all showed a progressive overall decline with increasing salinity.

3) The strong relationships between diversity and evenness is indicated in Figures 3.102 through 3.105, in which both indices are plotted with time at each salinity zone.

3.4.4 Analysis of Community Similarity

A second common measure of community structure often used is comparing the taxonomic structure among samples is similarity. Similarity measures indicate the amount of information of one sample or population that is contained or is "similar" to the information of another sample or population. In this study the C lambda, or Morisita-Ona index (Table 3.28) was used to measure the taxonomic similarity of the phytoplankton communities within a salinity zone among sampling dates.

This index is widely used as a measurement of similarity weighing both the presence of species and the relative abundance distribution of each species between samples. This similarity index is conceptually unambiguous in that, analogous to a probability or correlation coefficient, its values vary from 0.0 to 1.0. Zero represents total dissimilarity between samples, 0.0 to 0.4 generally denote samples from highly different

TABLE 3.29

CHARLOTTE HARBOR 1989 - 1991
Diversity (H') and Evenness (J') Indices

MONTH	YEAR	STATION	NUMBER TAXA	DIVERSITY H'	EVENNESS J'
1	89	0 o/oo	23	2.52	0.803
2	89	0 o/oo	21	2.31	0.758
3	89	0 o/oo	23	2.47	0.787
4	89	0 o/oo	10	0.92	0.402
5	89	0 o/oo	11	1.18	0.492
6	89	0 o/oo	12	1.44	0.581
7	89	0 o/oo	13	2.16	0.844
8	89	0 o/oo	22	2.34	0.757
9	89	0 o/oo	24	2.40	0.754
10	89	0 o/oo	26	2.45	0.751
11	89	0 o/oo	21	1.62	0.533
12	89	0 o/oo	25	2.12	0.659
1	89	6 o/oo	21	2.24	0.734
2	89	6 o/oo	13	1.28	0.500
3	89	6 o/oo	24	2.06	0.647
4	89	6 o/oo	12	1.05	0.424
5	89	6 o/oo	12	1.49	0.600
6	89	6 o/oo	17	2.07	0.729
7	89	6 o/oo	20	2.21	0.738
8	89	6 o/oo	12	1.29	0.519
9	89	6 o/oo	18	1.28	0.444
10	89	6 o/oo	19	2.02	0.687
11	89	6 o/oo	20	1.77	0.591
12	89	6 o/oo	10	0.28	0.121
1	89	12 o/oo	23	1.76	0.561
2	89	12 o/oo	15	1.58	0.584
3	89	12 o/oo	7	0.72	0.370
4	89	12 o/oo	10	0.72	0.314
5	89	12 o/oo	9	1.07	0.486
6	89	12 o/oo	10	0.85	0.367
7	89	12 o/oo	21	1.62	0.532
8	89	12 o/oo	9	1.05	0.477
9	89	12 o/oo	9	0.77	0.350
10	89	12 o/oo	12	1.58	0.637
11	89	12 o/oo	17	1.78	0.628
12	89	12 o/oo	9	0.58	0.262
1	89	20 o/oo	14	1.06	0.402
2	89	20 o/oo	15	1.23	0.453
3	89	20 o/oo	13	1.49	0.583
4	89	20 o/oo	16	1.12	0.404
5	89	20 o/oo	15	1.06	0.391
6	89	20 o/oo	9	0.96	0.438

TABLE 3.29 (cont.)

CHARLOTTE HARBOR 1989 - 1991
Diversity (H') and Evenness (J') Indices

MONTH	YEAR	STATION	NUMBER TAXA	DIVERSITY H'	EVENNESS J'
7	89	20 o/oo	6	1.11	0.621
8	89	20 o/oo	11	1.21	0.506
9	89	20 o/oo	10	1.34	0.581
10	89	20 o/oo	8	0.52	0.249
11	89	20 o/oo	15	1.58	0.582
12	89	20 o/oo	12	1.81	0.730
1	90	0 o/oo	15	2.06	0.761
2	90	0 o/oo	17	1.32	0.466
3	90	0 o/oo	20	2.39	0.799
4	90	0 o/oo	17	1.89	0.669
5	90	0 o/oo	14	1.45	0.551
6	90	0 o/oo	18	1.77	0.613
7	90	0 o/oo	13	0.68	0.266
8	90	0 o/oo	20	2.11	0.704
9	90	0 o/oo	21	2.03	0.667
10	90	0 o/oo	20	1.90	0.634
11	90	0 o/oo	18	1.43	0.493
12	90	0 o/oo	19	1.83	0.621
1	90	6 o/oo	15	0.91	0.336
2	90	6 o/oo	20	1.39	0.465
3	90	6 o/oo	24	2.55	0.803
4	90	6 o/oo	18	2.35	0.814
5	90	6 o/oo	16	1.75	0.632
6	90	6 o/oo	14	1.72	0.652
7	90	6 o/oo	19	2.16	0.735
8	90	6 o/oo	10	1.32	0.572
9	90	6 o/oo	21	1.97	0.647
10	90	6 o/oo	8	0.39	0.187
11	90	6 o/oo	18	1.90	0.657
12	90	6 o/oo	20	1.79	0.597
1	90	12 o/oo	22	1.32	0.428
2	90	12 o/oo	14	1.05	0.397
3	90	12 o/oo	17	1.15	0.406
4	90	12 o/oo	17	1.33	0.468
5	90	12 o/oo	10	1.51	0.656
6	90	12 o/oo	9	0.96	0.436
7	90	12 o/oo	9	1.24	0.563
8	90	12 o/oo	10	1.21	0.525
9	90	12 o/oo	17	0.89	0.315
10	90	12 o/oo	6	0.53	0.293
11	90	12 o/oo	12	1.27	0.509
12	90	12 o/oo	16	1.67	0.602

TABLE 3.29 (cont.)

CHARLOTTE HARBOR 1989 - 1991
Diversity (H') and Evenness (J') Indices

MONTH	YEAR	STATION	NUMBER TAXA	DIVERSITY H'	EVENNESS J'
1	90	20 o/oo	12	1.28	0.516
2	90	20 o/oo	15	1.03	0.380
3	90	20 o/oo	12	0.92	0.371
4	90	20 o/oo	15	1.08	0.397
5	90	20 o/oo	13	1.02	0.399
6	90	20 o/oo	10	1.05	0.455
7	90	20 o/oo	18	1.01	0.350
8	90	20 o/oo	9	0.49	0.224
9	90	20 o/oo	10	1.01	0.437
10	90	20 o/oo	7	0.44	0.226
11	90	20 o/oo	14	1.38	0.523
12	90	20 o/oo	12	1.17	0.470
1	91	0 o/oo	17	1.60	0.566
2	91	0 o/oo	17	1.33	0.470
3	91	0 o/oo	15	1.47	0.544
4	91	0 o/oo	18	2.03	0.704
5	91	0 o/oo	18	1.98	0.685
6	91	0 o/oo	17	1.82	0.641
7	91	0 o/oo	18	2.31	0.799
8	91	0 o/oo	11	1.21	0.503
9	91	0 o/oo	25	2.61	0.809
10	91	0 o/oo	23	2.55	0.813
11	91	0 o/oo	20	1.55	0.517
12	91	0 o/oo	22	2.51	0.812
1	91	6 o/oo	14	0.87	0.330
2	91	6 o/oo	18	2.12	0.734
3	91	6 o/oo	20	1.85	0.619
4	91	6 o/oo	18	2.25	0.778
5	91	6 o/oo	9	0.94	0.426
6	91	6 o/oo	14	1.99	0.753
7	91	6 o/oo	12	1.04	0.420
8	91	6 o/oo	11	1.04	0.435
9	91	6 o/oo	15	1.55	0.574
10	91	6 o/oo	20	2.10	0.703
11	91	6 o/oo	18	1.15	0.396
12	91	6 o/oo	22	1.92	0.620
1	91	12 o/oo	12	1.43	0.575
2	91	12 o/oo	16	1.73	0.626
3	91	12 o/oo	8	0.63	0.305
4	91	12 o/oo	13	1.47	0.574
5	91	12 o/oo	11	1.28	0.535
6	91	12 o/oo	12	1.63	0.658

TABLE 3.29 (cont.)
CHARLOTTE HARBOR 1989 - 1991
Diversity (H') and Evenness (J') Indices

MONTH	YEAR	STATION	NUMBER TAXA	DIVERSITY H'	EVENNESS J'
7	91	12 o/oo	14	1.55	0.586
8	91	12 o/oo	5	0.45	0.277
9	91	12 o/oo	15	1.70	0.626
10	91	12 o/oo	12	1.66	0.667
11	91	12 o/oo	13	1.21	0.471
12	91	12 o/oo	21	1.70	0.559
1	91	20 o/oo	15	0.71	0.261
2	91	20 o/oo	14	1.49	0.566
3	91	20 o/oo	12	0.97	0.391
4	91	20 o/oo	13	0.87	0.337
5	91	20 o/oo	6	0.71	0.398
6	91	20 o/oo	10	0.96	0.418
7	91	20 o/oo	7	0.55	0.282
8	91	20 o/oo	8	0.55	0.263
9	91	20 o/oo	10	1.20	0.519
10	91	20 o/oo	9	0.86	0.392
11	91	20 o/oo	16	1.80	0.648
12	91	20 o/oo	5	0.27	0.170

FIGURE 3.99 (A)

CHARLOTTE HARBOR 1989 – 1991

Number of Taxa by Station

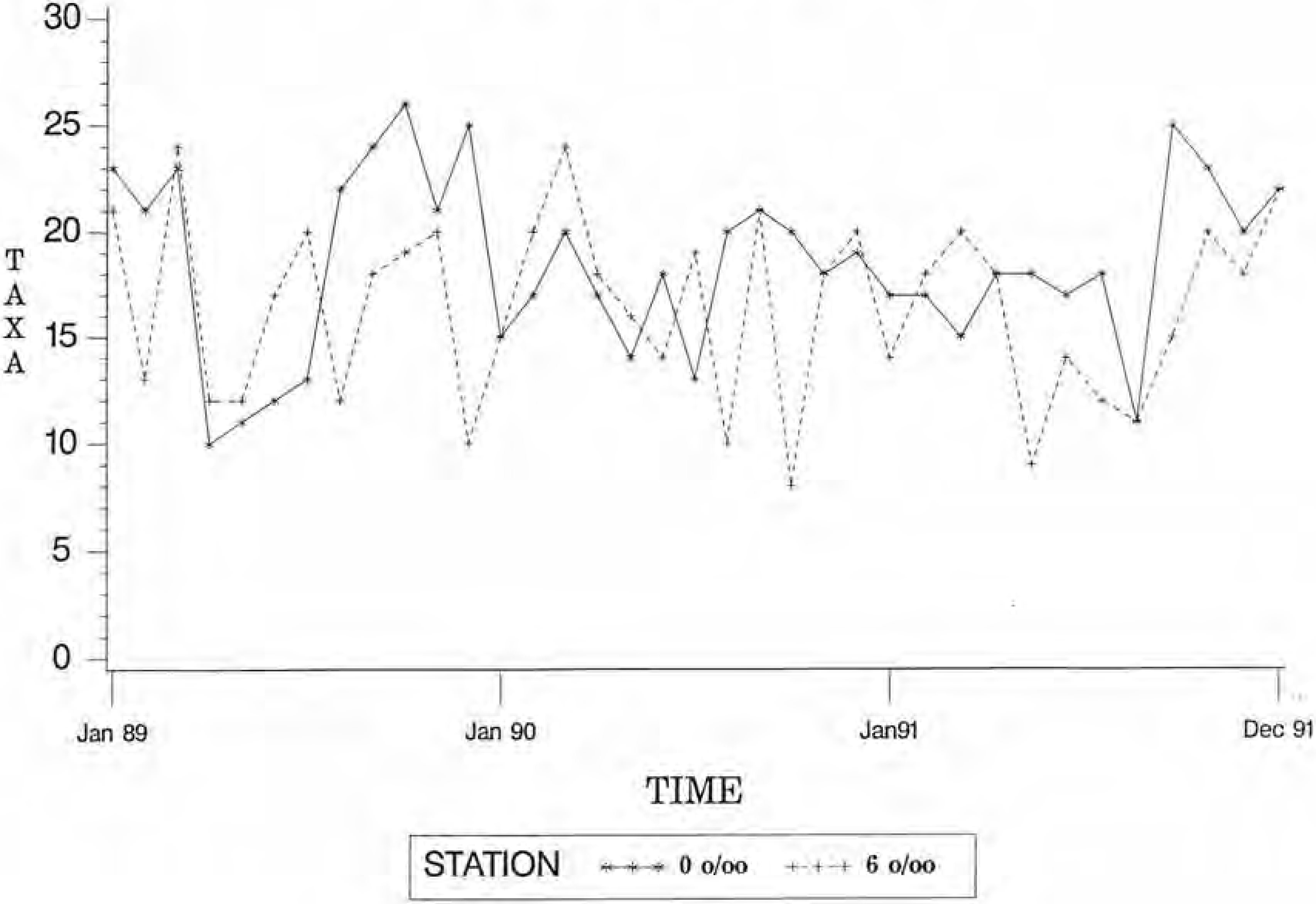


FIGURE 3.99 (B)
CHARLOTTE HARBOR 1989 – 1991
Number of Taxa by Station

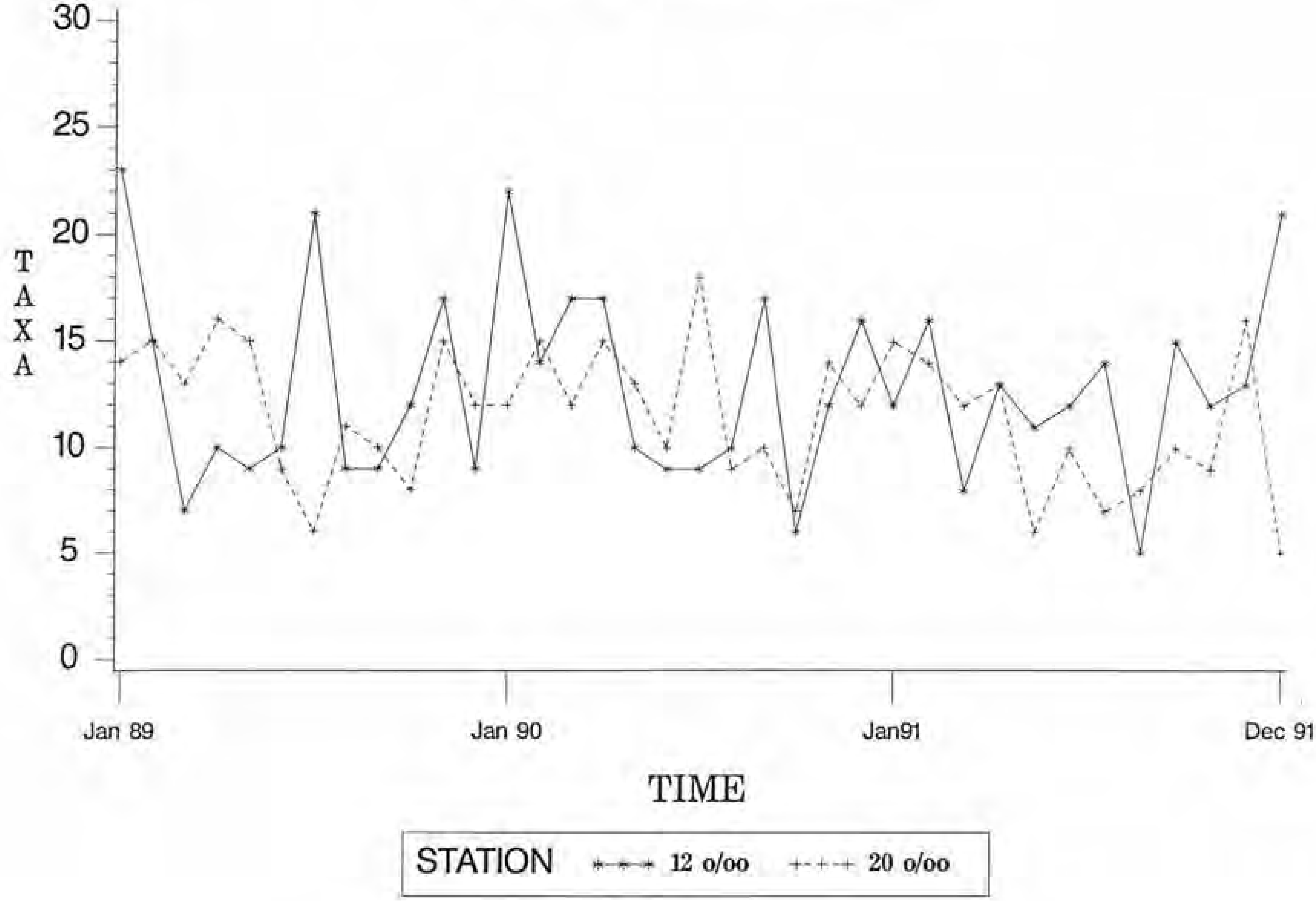


FIGURE 3.100 (A)
CHARLOTTE HARBOR 1989 – 1991
Species Diversity by Station

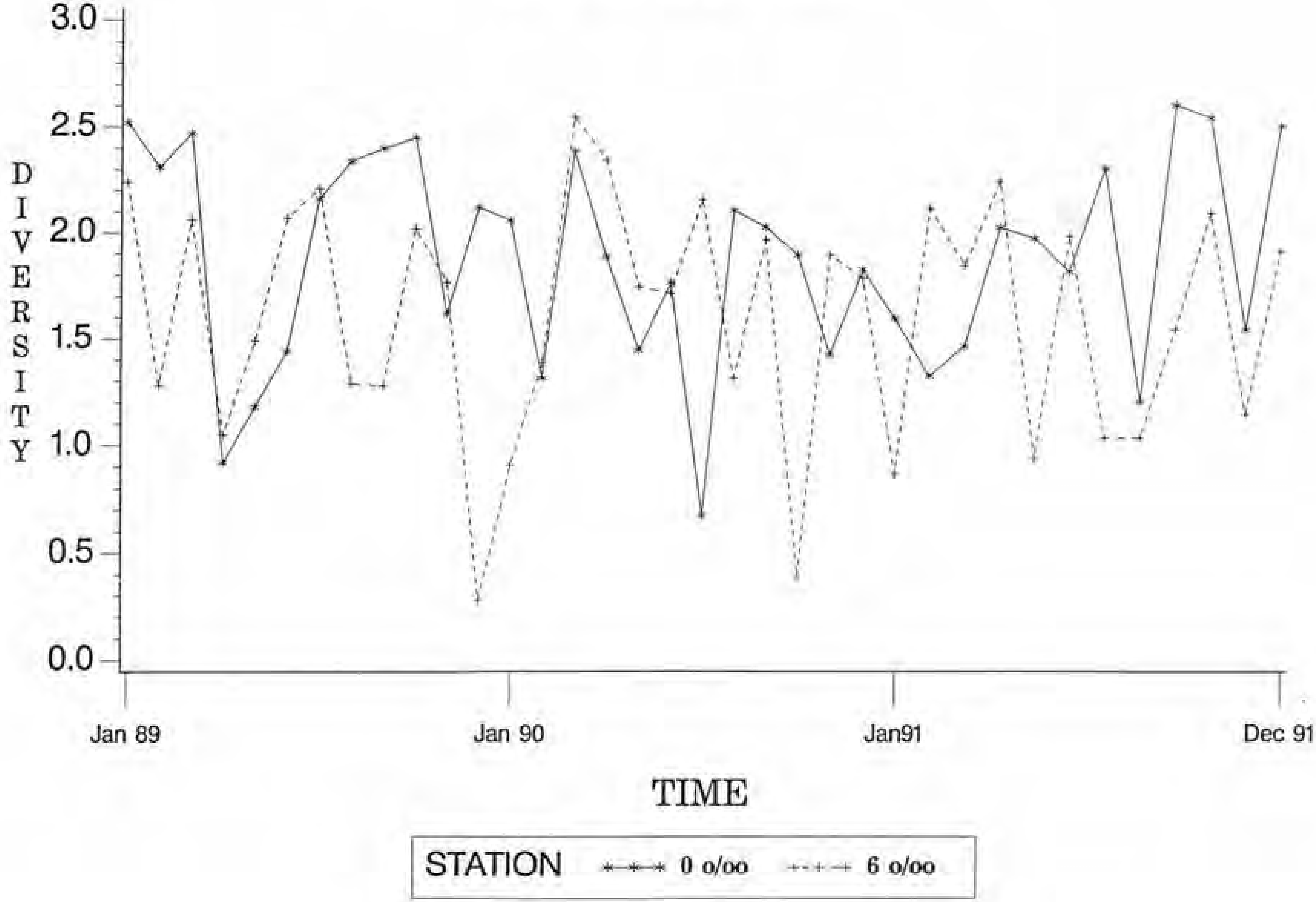


FIGURE 3.100 (B)

CHARLOTTE HARBOR 1989 – 1991

Species Diversity by Station

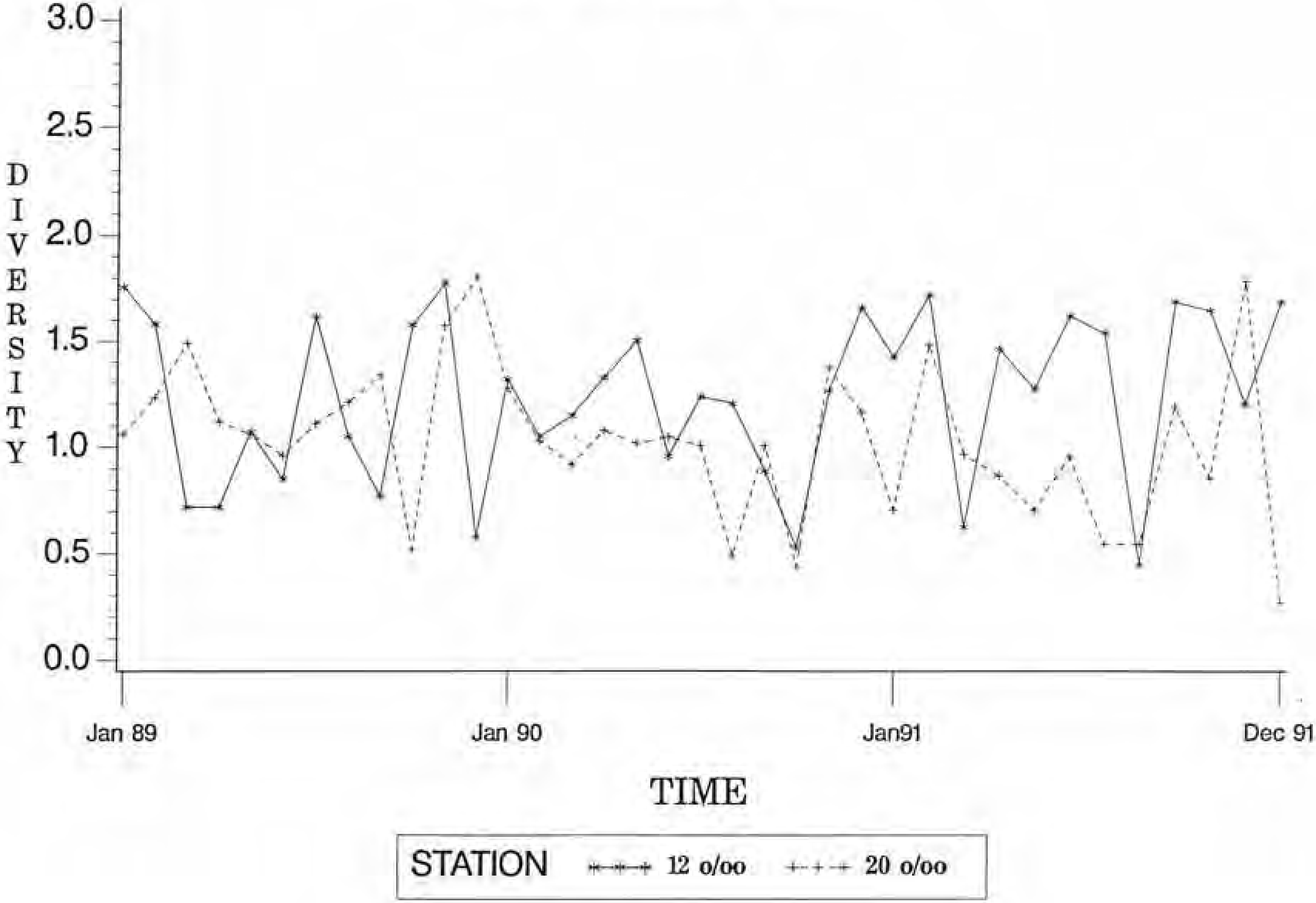


FIGURE 3.101 (A)
CHARLOTTE HARBOR 1989 – 1991
Species Evenness by Station

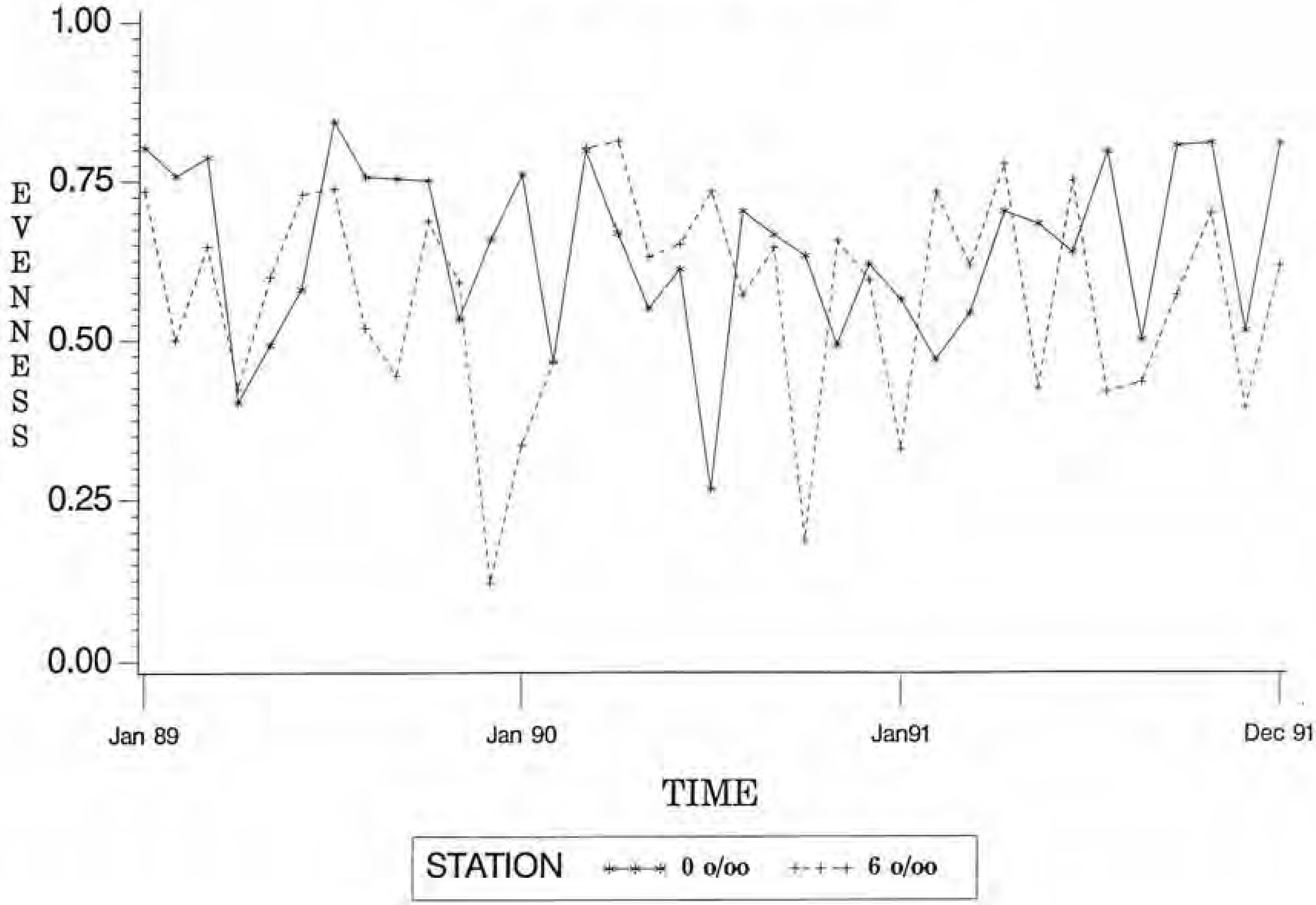


FIGURE 3.101 (B)
CHARLOTTE HARBOR 1989 – 1991
Species Evenness by Station

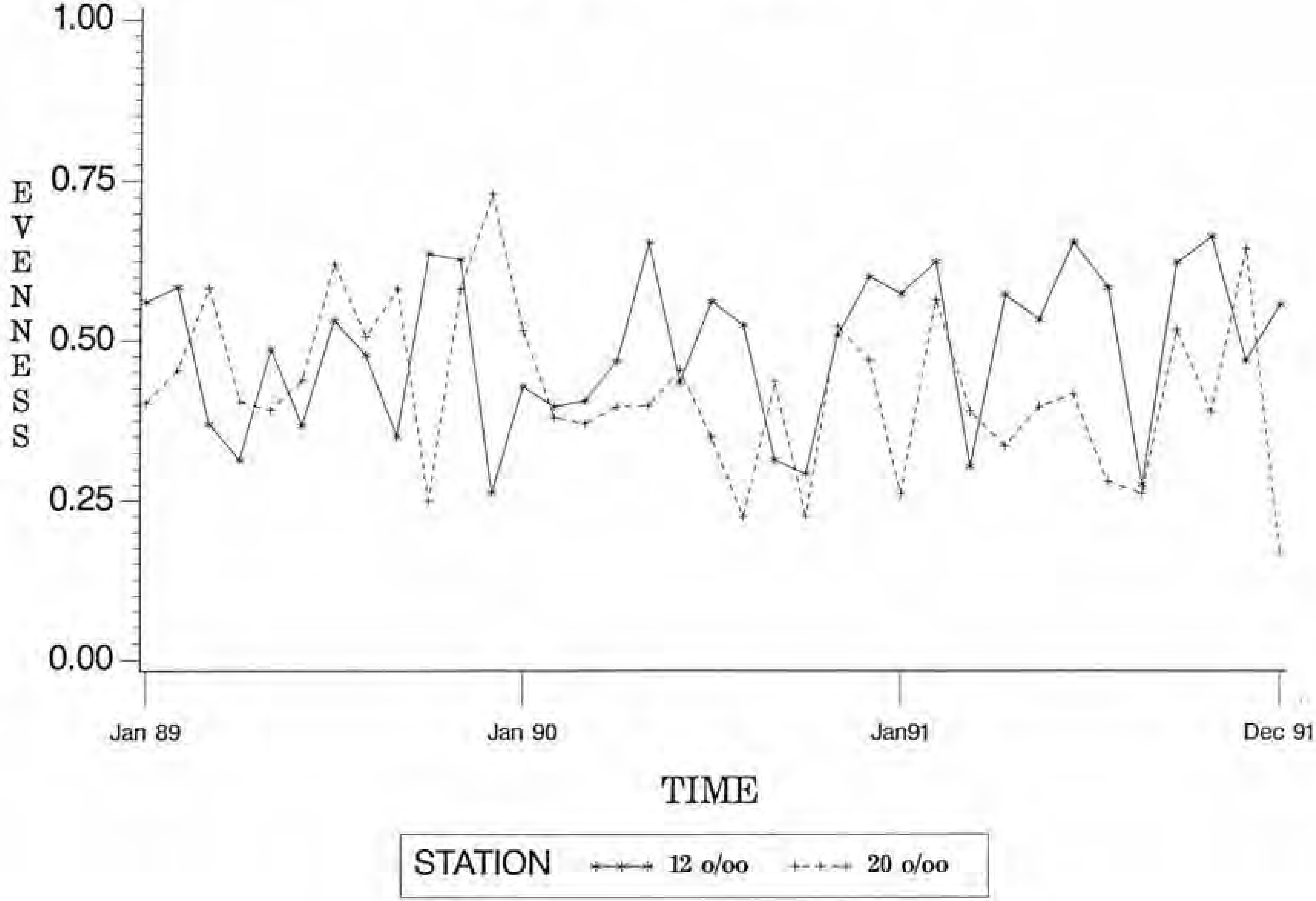


FIGURE 3.102

CHARLOTTE HARBOR 1989 — 1991

Species Diversity and Evenness

STATION=0 o/oo

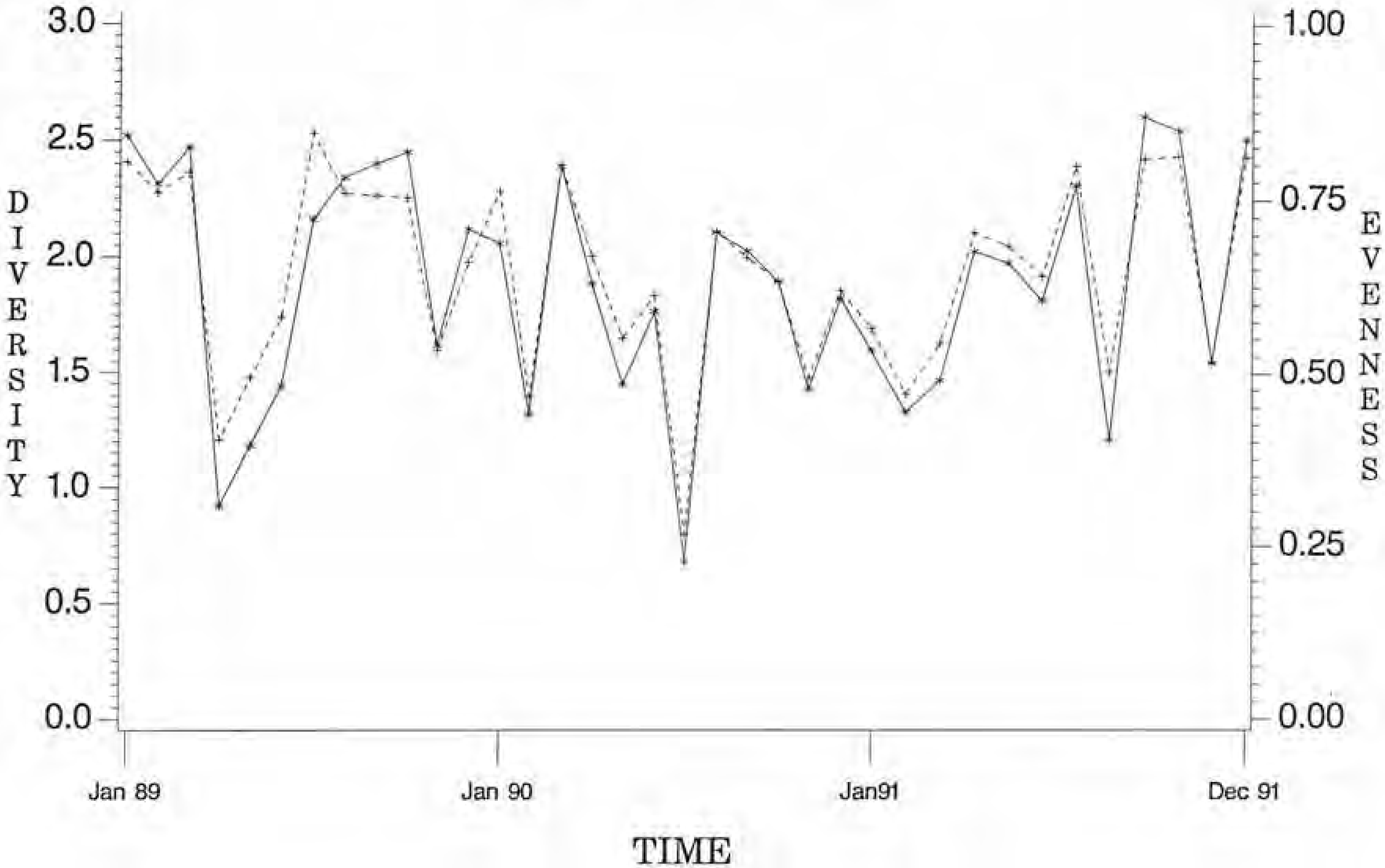


FIGURE 3.103
CHARLOTTE HARBOR 1989 – 1991
Species Diversity and Evenness
STATION=6 o/oo

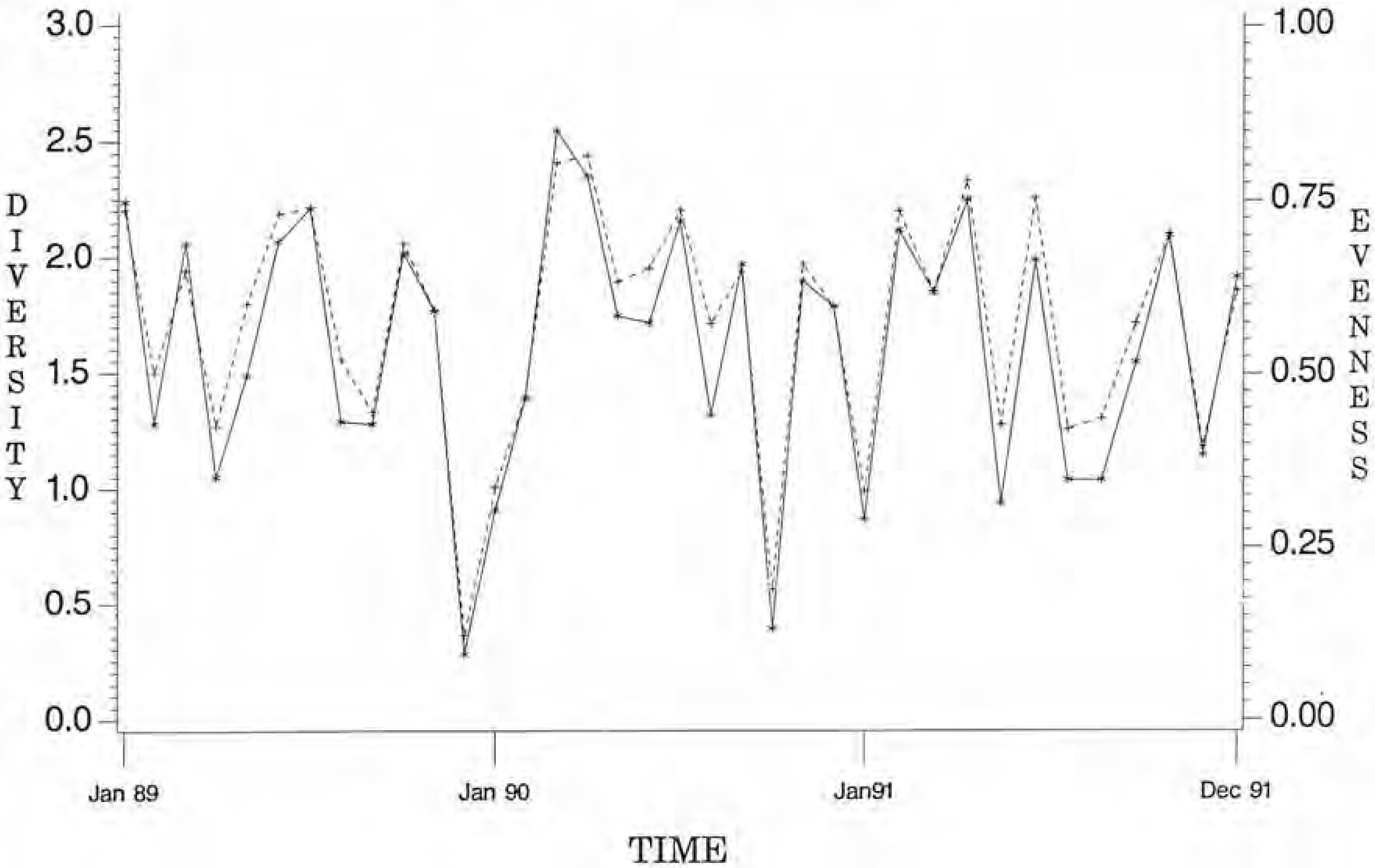


FIGURE 3.104
CHARLOTTE HARBOR 1989 – 1991
Species Diversity and Evenness

STATION=12 o/oo

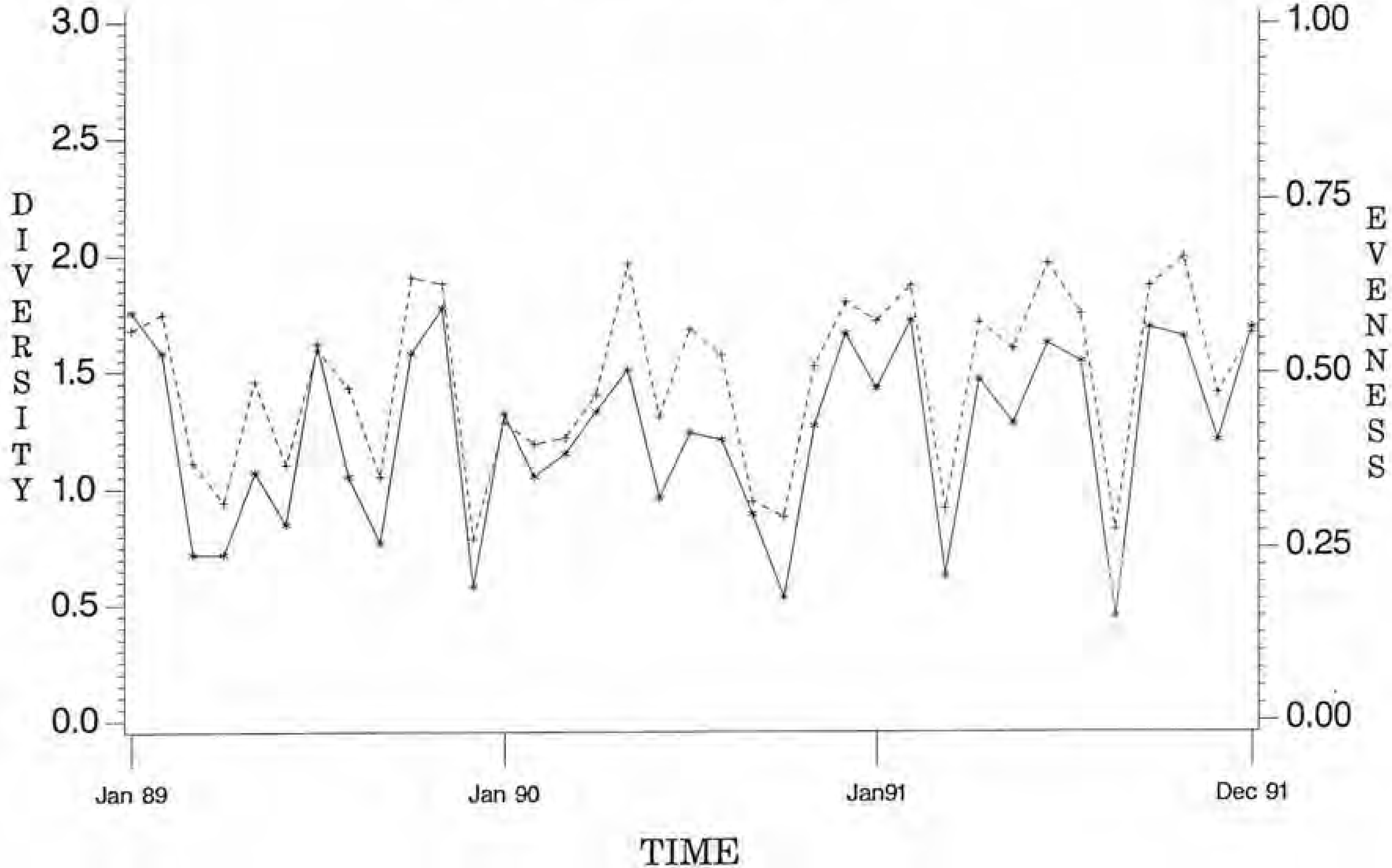
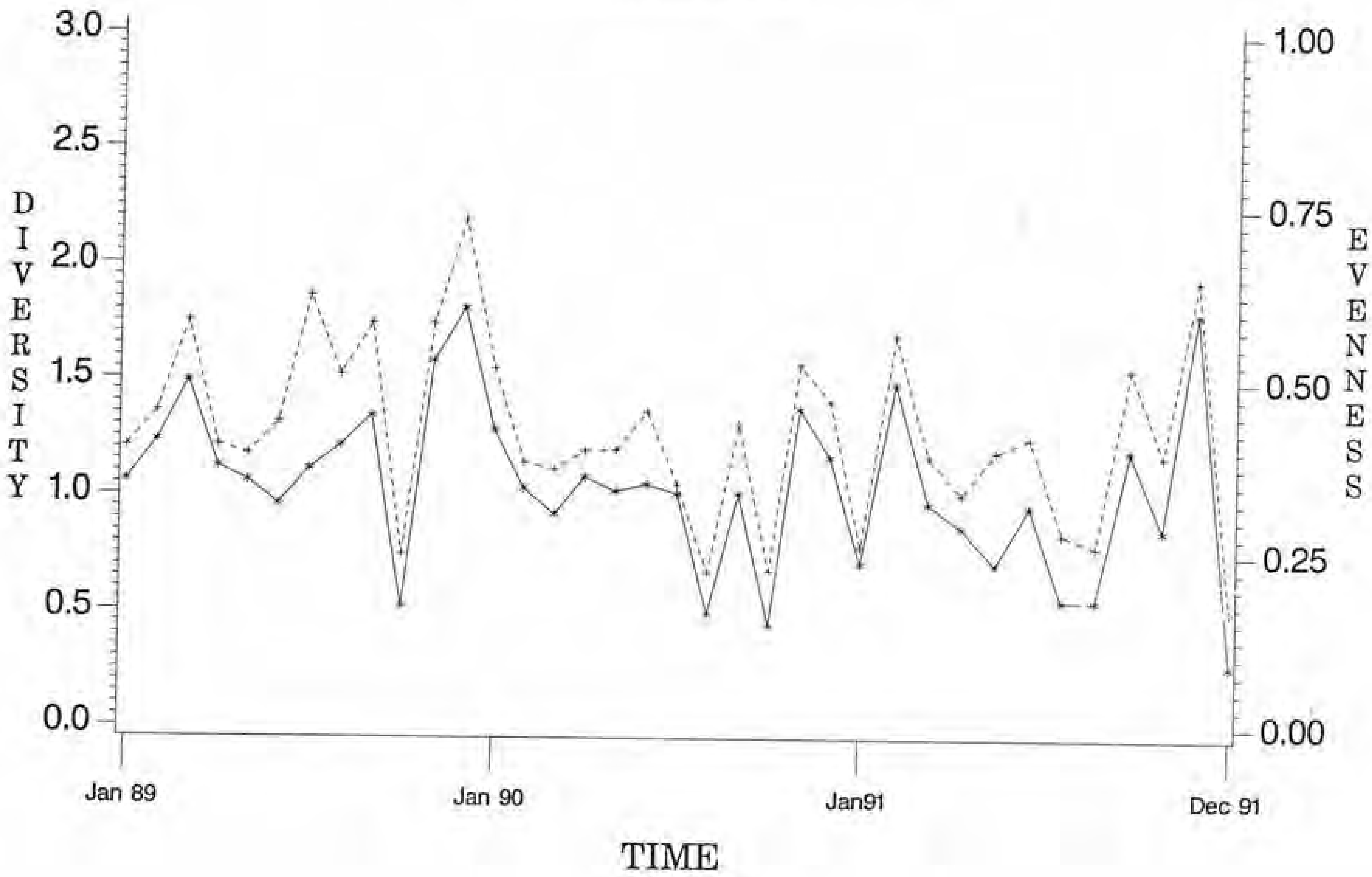


FIGURE 3.105

CHARLOTTE HARBOR 1989 – 1991

Species Diversity and Evenness

STATION=20 o/oo



communities, 0.4 to 0.6 results are seen when comparing the distributions of taxa from collections of intermediate likeness, and value 0.6 to 1.0 characterize samples taken from increasingly similar or identical communities. Un-order matrices of such a similarity measure, though useful, may often be confusing. Therefore, unordered matrices were reordered by the following criteria. The phytoplankton sample with the lowest affinity (similarity value) to all other sampling dates was placed at the top of the Y axis. Below this was positioned the sample with the highest affinity to the first sample. Ranked in the third position was the sampling date with the greatest similarity to the second sample, not already listed. This procedure was followed until all sampling dates had been listed in a comparative ordination along the Y axis. Each matrix was then completed by reversing the ranked order of the sampling dates along the X axis. By this method each table constructed in such a manner that the affinity values generally increase both from the top to bottom and from left to right. This results in the clustering of areas of high similarity separated by areas of low similarity along the diagonal margin.

The resultant similarity matrices for the phytoplankton samples collected between 1988 and 1991 at each salinity zone are presented in Tables 3.30 through 3.33. Not surprisingly, as apparent in these tables, the taxonomic similarity of the samples within the four zones increased with increasing salinity.

3.5 SUMMARY

Physical/Chemical Parameters - In order to develop a thorough understanding of the dynamics of phytoplankton production within the Lower Peace River/Upper Charlotte Harbor estuarine system, it is important to comprehend both short- and long-

TABLE 3.30 Similarity Matrix - 0 o/oo

	AUG 91	NOV 89	SEP 90	MAY 89	JUN 90	MAY 90	FEB 90	DEC 90	JAN 89	JUL 91	MAR 89	JAN 90	FEB 89	SEP 91	MAR 90	OCT 90	DEC 91	JUN 91	SEP 89	JUL 89	JAN 91	JUN 89	MAY 91	AUG 89	AUG 90	JUL 90	APR 89	FEB 91	NOV 90	MAR 91	DEC 89	APR 90	APR 91	OCT 91	OCT 89
NOV 91	0.01	0.02	0.03	0.03	0.07	0.04	0.04	0.04	0.10	0.02	0.03	0.02	0.02	0.09	0.08	0.05	0.06	0.05	0.03	0.02	0.01	0.02	0.06	0.04	0.03	0.00	0.01	0.01	0.04	0.01	0.03	0.03	0.04	0.16	0.17
OCT 89	0.06	0.08	0.25	0.17	0.15	0.14	0.05	0.15	0.58	0.38	0.40	0.19	0.14	0.60	0.27	0.17	0.15	0.18	0.24	0.26	0.08	0.23	0.31	0.37	0.40	0.31	0.34	0.37	0.37	0.38	0.41	0.42	0.43	0.84	
OCT 91	0.09	0.12	0.21	0.32	0.31	0.30	0.10	0.28	0.57	0.59	0.57	0.33	0.24	0.53	0.19	0.21	0.31	0.32	0.58	0.54	0.16	0.36	0.47	0.60	0.59	0.34	0.40	0.43	0.43	0.47	0.53	0.54	0.61		
APR 91	0.12	0.13	0.26	0.44	0.39	0.46	0.41	0.57	0.49	0.71	0.83	0.59	0.30	0.28	0.29	0.37	0.53	0.55	0.63	0.58	0.24	0.48	0.50	0.78	0.87	0.61	0.68	0.73	0.72	0.74	0.83	0.90			
APR 90	0.13	0.12	0.29	0.64	0.56	0.62	0.36	0.62	0.47	0.71	0.74	0.45	0.23	0.29	0.26	0.32	0.42	0.33	0.41	0.60	0.38	0.70	0.64	0.77	0.81	0.73	0.81	0.87	0.84	0.88	0.92				
DEC 89	0.12	0.43	0.29	0.55	0.45	0.51	0.28	0.63	0.46	0.68	0.71	0.44	0.25	0.24	0.18	0.22	0.34	0.22	0.34	0.52	0.31	0.62	0.52	0.66	0.73	0.70	0.78	0.84	0.81	0.86					
MAR 91	0.14	0.14	0.29	0.57	0.39	0.44	0.06	0.33	0.33	0.70	0.59	0.33	0.18	0.22	0.09	0.14	0.13	0.23	0.31	0.54	0.43	0.74	0.53	0.65	0.76	0.89	0.93	0.96	0.97						
NOV 90	0.13	0.11	0.29	0.44	0.25	0.31	0.07	0.26	0.33	0.65	0.57	0.33	0.18	0.22	0.09	0.13	0.08	0.19	0.25	0.45	0.30	0.59	0.37	0.54	0.70	0.96	0.97	0.97							
FEB 91	0.13	0.11	0.29	0.54	0.36	0.42	0.15	0.37	0.34	0.64	0.58	0.33	0.19	0.20	0.11	0.12	0.12	0.17	0.24	0.43	0.24	0.58	0.40	0.53	0.66	0.95	0.98								
APR 89	0.13	0.10	0.27	0.52	0.32	0.38	0.09	0.30	0.30	0.58	0.52	0.28	0.17	0.18	0.07	0.12	0.09	0.16	0.23	0.39	0.19	0.53	0.36	0.48	0.63	0.98									
JUL 90	0.12	0.09	0.26	0.39	0.19	0.25	0.04	0.21	0.27	0.53	0.46	0.24	0.14	0.17	0.06	0.08	0.02	0.12	0.17	0.33	0.16	0.46	0.26	0.40	0.57										
AUG 90	0.12	0.12	0.24	0.43	0.37	0.39	0.08	0.30	0.39	0.73	0.71	0.39	0.19	0.28	0.24	0.42	0.47	0.70	0.70	0.65	0.37	0.61	0.62	0.91											
AUG 89	0.12	0.14	0.20	0.56	0.58	0.56	0.12	0.42	0.37	0.70	0.66	0.34	0.20	0.35	0.34	0.49	0.62	0.65	0.74	0.79	0.48	0.72	0.83												
MAY 91	0.11	0.11	0.13	0.77	0.83	0.79	0.14	0.51	0.28	0.43	0.45	0.27	0.19	0.25	0.29	0.48	0.57	0.38	0.48	0.68	0.64	0.87													
JUN 89	0.12	0.09	0.17	0.72	0.67	0.67	0.10	0.42	0.22	0.51	0.42	0.29	0.15	0.16	0.12	0.25	0.29	0.18	0.29	0.65	0.84														
JAN 91	0.07	0.05	0.06	0.37	0.37	0.39	0.21	0.30	0.10	0.30	0.22	0.30	0.09	0.08	0.05	0.09	0.20	0.09	0.17	0.49															
JUL 89	0.09	0.10	0.16	0.45	0.46	0.43	0.08	0.31	0.26	0.64	0.56	0.35	0.32	0.31	0.23	0.40	0.41	0.34	0.74																
SEP 89	0.09	0.12	0.10	0.28	0.33	0.30	0.09	0.24	0.24	0.60	0.56	0.40	0.30	0.22	0.18	0.42	0.58	0.69																	
JUN 91	0.07	0.10	0.07	0.15	0.21	0.19	0.06	0.14	0.21	0.36	0.38	0.20	0.07	0.18	0.39	0.61	0.61																		
DEC 91	0.06	0.17	0.05	0.36	0.51	0.50	0.40	0.60	0.34	0.28	0.50	0.39	0.25	0.23	0.56	0.62																			
OCT 90	0.07	0.11	0.07	0.22	0.33	0.28	0.11	0.21	0.30	0.22	0.31	0.16	0.16	0.17	0.60																				
MAR 90	0.04	0.06	0.10	0.09	0.17	0.16	0.21	0.24	0.36	0.19	0.28	0.14	0.18	0.37																					
SEP 91	0.04	0.06	0.23	0.11	0.14	0.11	0.04	0.10	0.40	0.28	0.43	0.19	0.45																						
FEB 89	0.03	0.07	0.10	0.14	0.14	0.14	0.10	0.15	0.17	0.19	0.65	0.73																							
JAN 90	0.05	0.09	0.15	0.18	0.18	0.24	0.43	0.42	0.31	0.32	0.82																								
MAR 89	0.09	0.14	0.24	0.34	0.31	0.35	0.27	0.44	0.52	0.60																									
JUL 91	0.12	0.10	0.25	0.33	0.25	0.26	0.07	0.25	0.39																										
JAN 89	0.06	0.15	0.32	0.15	0.15	0.18	0.22	0.32																											
DEC 90	0.07	0.38	0.10	0.60	0.67	0.75	0.75																												
FEB 90	0.03	0.03	0.02	0.21	0.30	0.41																													
MAY 90	0.11	0.07	0.10	0.96	0.98																														
JUN 90	0.11	0.08	0.09	0.95																															
MAY 89	0.12	0.08	0.13																																
SEP 90	0.04	0.04																																	
NOV 89	0.02																																		

TABLE 3.31 Similarity Matrix - 6 o/oo

	MAY 91	MAY 89	APR 91	JUN 90	JAN 89	FEB 89	JUN 89	FEB 91	MAR 90	OCT 91	JUN 91	JUL 90	APR 90	MAR 91	AUG 90	DEC 90	SEP 91	AUG 91	OCT 91	NOV 91	JUL 91	AUG 89	MAR 89	JUL 89	OCT 89	SEP 90	NOV 90	DEC 91	MAY 90	JAN 91	JAN 90	APR 89	FEB 90	SEP 89	NOV 89
DEC 89	0.01	0.01	0.01	0.01	0.02	0.01	0.10	0.02	0.01	0.04	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.15	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.41
NOV 89	0.10	0.26	0.35	0.44	0.56	0.39	0.57	0.75	0.42	0.57	0.52	0.68	0.60	0.74	0.77	0.65	0.29	0.19	0.08	0.11	0.09	0.13	0.54	0.56	0.75	0.71	0.80	0.80	0.85	0.80	0.79	0.82	0.83	0.85	
SEP 89	0.13	0.27	0.34	0.45	0.54	0.44	0.51	0.76	0.41	0.54	0.48	0.66	0.56	0.73	0.83	0.66	0.27	0.16	0.09	0.12	0.09	0.13	0.54	0.53	0.66	0.71	0.83	0.84	0.93	0.98	0.98	0.98	0.98		
FEB 90	0.10	0.28	0.34	0.47	0.53	0.54	0.55	0.78	0.41	0.48	0.42	0.65	0.51	0.69	0.78	0.58	0.14	0.07	0.07	0.10	0.09	0.13	0.54	0.52	0.63	0.68	0.83	0.84	0.94	0.97	0.98	0.99			
APR 89	0.13	0.29	0.33	0.44	0.50	0.51	0.52	0.76	0.41	0.49	0.40	0.63	0.48	0.67	0.77	0.56	0.15	0.12	0.15	0.18	0.16	0.20	0.57	0.53	0.64	0.69	0.84	0.85	0.92	0.98	0.98				
JAN 90	0.11	0.22	0.27	0.43	0.48	0.44	0.44	0.70	0.36	0.43	0.38	0.57	0.45	0.64	0.74	0.55	0.15	0.05	0.04	0.06	0.04	0.08	0.47	0.44	0.56	0.61	0.76	0.77	0.88	0.99					
JAN 91	0.13	0.22	0.28	0.42	0.51	0.44	0.45	0.72	0.37	0.44	0.39	0.58	0.47	0.68	0.74	0.54	0.15	0.04	0.03	0.05	0.03	0.07	0.47	0.44	0.55	0.61	0.76	0.77	0.89						
MAY 90	0.15	0.26	0.42	0.50	0.59	0.50	0.60	0.86	0.50	0.55	0.52	0.73	0.57	0.73	0.76	0.59	0.17	0.12	0.12	0.16	0.14	0.19	0.60	0.60	0.70	0.75	0.88	0.89							
DEC 91	0.24	0.31	0.54	0.46	0.55	0.41	0.55	0.85	0.57	0.70	0.50	0.73	0.61	0.70	0.74	0.59	0.22	0.39	0.39	0.45	0.45	0.49	0.82	0.80	0.89	0.92	0.99								
NOV 90	0.26	0.33	0.49	0.48	0.55	0.40	0.57	0.84	0.59	0.74	0.57	0.75	0.63	0.73	0.76	0.64	0.28	0.42	0.38	0.45	0.44	0.47	0.82	0.84	0.90	0.93									
SEP 90	0.10	0.29	0.50	0.45	0.48	0.32	0.51	0.70	0.44	0.73	0.62	0.68	0.63	0.67	0.75	0.68	0.42	0.64	0.50	0.58	0.56	0.60	0.86	0.91	0.95										
OCT 89	0.19	0.31	0.48	0.34	0.48	0.37	0.60	0.69	0.49	0.79	0.57	0.69	0.65	0.65	0.75	0.68	0.43	0.64	0.47	0.54	0.54	0.59	0.83	0.86											
JUL 89	0.08	0.22	0.42	0.44	0.42	0.29	0.47	0.58	0.42	0.66	0.59	0.55	0.52	0.55	0.58	0.54	0.32	0.59	0.49	0.56	0.56	0.61	0.82												
MAR 89	0.11	0.18	0.37	0.29	0.41	0.23	0.33	0.58	0.39	0.55	0.32	0.45	0.41	0.48	0.48	0.37	0.14	0.55	0.60	0.69	0.67	0.71													
AUG 89	0.06	0.05	0.21	0.04	0.09	0.15	0.14	0.18	0.16	0.30	0.05	0.08	0.07	0.06	0.14	0.07	0.05	0.72	0.94	0.98	0.99														
JUL 91	0.09	0.10	0.22	0.03	0.04	0.07	0.09	0.15	0.14	0.29	0.05	0.08	0.05	0.04	0.10	0.04	0.05	0.72	0.97	0.99															
NOV 91	0.02	0.07	0.18	0.04	0.04	0.03	0.05	0.13	0.11	0.27	0.06	0.06	0.05	0.06	0.11	0.06	0.06	0.73	0.97																
OCT 90	0.01	0.03	0.14	0.01	0.02	0.01	0.03	0.10	0.08	0.23	0.03	0.03	0.02	0.03	0.08	0.03	0.04	0.69																	
AUG 91	0.07	0.28	0.24	0.02	0.13	0.02	0.23	0.10	0.09	0.54	0.45	0.30	0.36	0.29	0.48	0.54	0.69																		
SEP 91	0.13	0.40	0.26	0.12	0.23	0.09	0.39	0.14	0.13	0.59	0.72	0.52	0.58	0.50	0.70	0.83																			
DEC 90	0.11	0.43	0.36	0.36	0.48	0.32	0.62	0.52	0.29	0.74	0.81	0.76	0.78	0.76	0.93																				
AUG 90	0.11	0.41	0.39	0.37	0.54	0.52	0.71	0.66	0.35	0.71	0.72	0.79	0.73	0.80																					
MAR 91	0.15	0.39	0.39	0.45	0.86	0.34	0.57	0.70	0.43	0.65	0.70	0.76	0.87																						
APR 90	0.21	0.49	0.57	0.34	0.77	0.26	0.59	0.63	0.44	0.73	0.75	0.84																							
JUL 90	0.29	0.67	0.68	0.41	0.55	0.39	0.73	0.75	0.56	0.75	0.79																								
JU 91	0.18	0.50	0.46	0.53	0.41	0.21	0.56	0.47	0.39	0.69																									
OCT 91	0.48	0.35	0.48	0.30	0.45	0.25	0.55	0.64	0.68																										
MAR 90	0.59	0.16	0.42	0.39	0.38	0.27	0.41	0.68																											
FEB 26	0.33	0.23	0.53	0.48	0.62	0.48	0.63																												
JUN 89	0.16	0.41	0.47	0.28	0.52	0.80																													
FEB 89	0.06	0.14	0.24	0.24	0.38																														
JAN 89	0.12	0.20	0.29	0.31																															
JUN 90	0.12	0.12	0.33																																
APR 91	0.23	0.48																																	
MAY 89	0.14																																		

TABLE 3.32 Similarity Matrix - 12 o/oo

	DEC 89	NOV 89	OCT 91	NOV 91	MAR 89	OCT 90	AUG 91	SEP 90	AUG 89	SEP 91	OCT 89	JUL 91	JUL 89	NOV 90	FEB 91	FEB 89	JAN 89	DEC 90	DEC 91	MAR 90	APR 89	FEB 90	MAR 91	MAY 89	JAN 90	JAN 91	JUN 91	JUN 90	APR 90	JUN 89	AUG 90	JUL 90	MAY 91	APR 91	MAY 90
SEP 89	0.04	0.13	0.06	0.04	0.06	0.02	0.02	0.02	0.06	0.08	0.07	0.06	0.12	0.13	0.13	0.30	0.32	0.13	0.14	0.14	0.14	0.14	0.15	0.15	0.17	0.15	0.14	0.15	0.15	0.09	0.10	0.11	0.11	0.12	0.41
MAY 90	0.09	0.78	0.44	0.18	0.07	0.04	0.10	0.12	0.31	0.52	0.42	0.33	0.56	0.60	0.66	0.65	0.74	0.63	0.62	0.56	0.54	0.63	0.68	0.69	0.73	0.74	0.86	0.87	0.90	0.75	0.82	0.88	0.90	0.91	
APR 91	0.08	0.75	0.46	0.25	0.14	0.12	0.19	0.20	0.40	0.58	0.50	0.41	0.60	0.60	0.62	0.54	0.64	0.62	0.58	0.52	0.50	0.58	0.64	0.66	0.68	0.72	0.85	0.85	0.89	0.81	0.87	0.95	0.95		
MAY 91	0.07	0.69	0.49	0.15	0.04	0.03	0.12	0.13	0.35	0.53	0.43	0.33	0.50	0.46	0.50	0.41	0.53	0.47	0.45	0.40	0.40	0.49	0.57	0.57	0.60	0.62	0.78	0.83	0.85	0.93	0.96	0.99			
JUL 90	0.06	0.67	0.47	0.15	0.04	0.03	0.12	0.13	0.36	0.53	0.43	0.32	0.48	0.43	0.48	0.39	0.50	0.44	0.41	0.37	0.37	0.46	0.55	0.55	0.57	0.59	0.76	0.81	0.83	0.94	0.97				
AUG 90	0.05	0.59	0.49	0.15	0.05	0.05	0.15	0.16	0.39	0.52	0.44	0.33	0.46	0.34	0.36	0.27	0.37	0.30	0.29	0.25	0.25	0.34	0.45	0.43	0.46	0.47	0.67	0.73	0.75	0.98					
JUN 89	0.03	0.49	0.42	0.10	0.01	0.02	0.14	0.14	0.37	0.46	0.39	0.27	0.36	0.23	0.26	0.17	0.27	0.20	0.19	0.15	0.15	0.24	0.36	0.33	0.36	0.37	0.56	0.65	0.67						
APR 90	0.12	0.86	0.42	0.23	0.10	0.07	0.10	0.12	0.28	0.49	0.41	0.35	0.63	0.79	0.82	0.76	0.87	0.84	0.83	0.80	0.78	0.85	0.89	0.90	0.92	0.93	0.97	0.99							
JUN 90	0.13	0.84	0.40	0.22	0.09	0.05	0.08	0.10	0.26	0.46	0.38	0.32	0.60	0.79	0.81	0.76	0.87	0.84	0.84	0.82	0.82	0.87	0.92	0.92	0.94	0.93	0.95								
JUN 91	0.12	0.88	0.50	0.28	0.15	0.11	0.13	0.16	0.30	0.51	0.44	0.40	0.67	0.83	0.88	0.83	0.89	0.87	0.87	0.82	0.78	0.86	0.86	0.90	0.91	0.94									
JAN 91	0.14	0.84	0.32	0.33	0.21	0.16	0.15	0.18	0.26	0.44	0.39	0.39	0.67	0.91	0.90	0.88	0.95	0.97	0.96	0.95	0.91	0.95	0.95	0.97	0.98										
JAN 90	0.14	0.81	0.30	0.24	0.12	0.07	0.06	0.08	0.17	0.36	0.30	0.29	0.59	0.88	0.89	0.87	0.95	0.96	0.96	0.96	0.95	0.97	0.98	0.99											
MAY 89	0.14	0.79	0.27	0.22	0.10	0.05	0.03	0.06	0.13	0.33	0.27	0.26	0.56	0.86	0.87	0.85	0.94	0.96	0.95	0.96	0.96	0.97	0.99												
MAR 91	0.15	0.76	0.27	0.22	0.11	0.05	0.04	0.07	0.15	0.32	0.27	0.27	0.55	0.84	0.84	0.83	0.91	0.92	0.93	0.96	0.97	0.97													
FEB 90	0.14	0.75	0.24	0.21	0.10	0.05	0.02	0.05	0.10	0.29	0.24	0.24	0.53	0.85	0.90	0.91	0.92	0.95	0.95	0.96	0.98														
APR 89	0.15	0.67	0.19	0.21	0.11	0.05	0.01	0.03	0.07	0.23	0.19	0.21	0.48	0.83	0.83	0.84	0.89	0.93	0.92	0.97															
MAR 90	0.14	0.71	0.23	0.36	0.26	0.20	0.17	0.19	0.22	0.33	0.33	0.36	0.62	0.92	0.86	0.87	0.91	0.96	0.97																
DEC 91	0.14	0.77	0.27	0.38	0.27	0.21	0.18	0.21	0.24	0.38	0.37	0.40	0.67	0.94	0.91	0.91	0.95	0.98																	
DEC 90	0.14	0.77	0.25	0.28	0.17	0.11	0.08	0.11	0.15	0.33	0.29	0.30	0.59	0.89	0.91	0.89	0.95																		
JAN 89	0.13	0.80	0.28	0.21	0.11	0.04	0.02	0.05	0.12	0.32	0.26	0.26	0.56	0.85	0.90	0.91																			
FEB 89	0.12	0.72	0.24	0.35	0.25	0.19	0.17	0.20	0.24	0.37	0.36	0.38	0.64	0.86	0.94																				
FEB 91	0.12	0.78	0.27	0.28	0.17	0.12	0.11	0.14	0.19	0.37	0.33	0.34	0.61	0.84																					
NOV 90	0.12	0.72	0.34	0.65	0.55	0.49	0.47	0.50	0.54	0.57	0.63	0.67	0.86																						
JUL 89	0.08	0.58	0.38	0.84	0.74	0.69	0.71	0.75	0.83	0.77	0.88	0.91																							
JUL 91	0.12	0.35	0.41	0.95	0.89	0.87	0.88	0.91	0.95	0.80	0.95																								
OC 89	0.29	0.48	0.42	0.85	0.77	0.76	0.78	0.82	0.90	0.93																									
SEP 91	0.51	0.66	0.49	0.65	0.56	0.56	0.58	0.61	0.72																										
AUG 89	0.01	0.22	0.31	0.94	0.91	0.90	0.94	0.96																											
SEP 90	0.01	0.10	0.21	0.97	0.98	0.99	0.99																												
AUG 91	0.00	0.08	0.19	0.95	0.98	0.99																													
OCT 90	0.07	0.08	0.16	0.95	0.99																														
MAR 89	0.02	0.09	0.16	0.97																															
NOV 91	0.03	0.21	0.22																																
OCT 91	0.21	0.47																																	
NOV 89	0.45																																		

TABLE 3.33 Similarity Matrix - 20 o/oo

	OCT 89	SEP 91	SEP 89	DEC 89	AUG 90	OCT 91	MAY 91	JUN 91	MAY 90	JUN 90	JUN 89	DEC 90	FEB 91	NOV 89	JAN 89	MAR 91	JUL 90	JAN 91
DEC 91	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
NOV 91	0.07	0.08	0.15	0.15	0.05	0.05	0.10	0.16	0.15	0.18	0.17	0.25	0.28	0.25	0.22	0.19	0.20	0.18
MAR 89	0.04	0.03	0.14	0.30	0.25	0.28	0.36	0.45	0.45	0.48	0.47	0.55	0.52	0.48	0.45	0.40	0.40	0.40
SEP 90	0.05	0.04	0.15	0.16	0.08	0.10	0.20	0.30	0.31	0.34	0.36	0.45	0.49	0.45	0.45	0.42	0.42	0.41
NOV 90	0.14	0.16	0.22	0.15	0.08	0.10	0.16	0.24	0.24	0.27	0.26	0.35	0.37	0.36	0.32	0.29	0.29	0.28
AUG 89	0.13	0.15	0.19	0.12	0.04	0.04	0.07	0.13	0.11	0.14	0.13	0.21	0.24	0.21	0.18	0.16	0.16	0.15
JUL 91	0.00	0.03	0.14	0.02	0.02	0.01	0.01	0.05	0.02	0.04	0.02	0.10	0.12	0.07	0.06	0.03	0.03	0.02
AUG 91	0.00	0.03	0.14	0.05	0.08	0.08	0.08	0.11	0.07	0.09	0.07	0.14	0.13	0.09	0.07	0.03	0.04	0.03
OCT 90	0.07	0.09	0.16	0.02	0.03	0.03	0.03	0.05	0.02	0.04	0.02	0.10	0.11	0.07	0.05	0.02	0.02	0.01
FEB 89	0.02	0.03	0.13	0.04	0.01	0.01	0.04	0.09	0.08	0.10	0.09	0.16	0.19	0.16	0.14	0.12	0.12	0.11
JUL 89	0.03	0.03	0.12	0.50	0.05	0.04	0.12	0.19	0.20	0.23	0.25	0.31	0.36	0.34	0.32	0.31	0.35	0.31
APR 89	0.09	0.04	0.08	0.31	0.08	0.14	0.36	0.53	0.61	0.66	0.73	0.80	0.86	0.88	0.93	0.92	0.93	0.91
JAN 90	0.09	0.03	0.06	0.34	0.11	0.17	0.40	0.57	0.65	0.70	0.76	0.83	0.88	0.90	0.95	0.94	0.93	0.92
MAY 89	0.09	0.03	0.05	0.33	0.13	0.19	0.42	0.58	0.67	0.71	0.78	0.84	0.87	0.90	0.97	0.97	0.97	0.97
MAR 90	0.09	0.03	0.03	0.38	0.23	0.29	0.51	0.66	0.74	0.78	0.85	0.88	0.87	0.90	0.98	0.98	0.98	0.99
FEB 90	0.09	0.03	0.02	0.41	0.26	0.32	0.54	0.69	0.77	0.80	0.87	0.90	0.89	0.91	0.98	0.97	0.97	0.98
APR 90	0.09	0.03	0.02	0.42	0.26	0.33	0.55	0.70	0.78	0.81	0.88	0.91	0.89	0.92	0.98	0.97	0.97	0.97
APR 91	0.10	0.03	0.03	0.34	0.12	0.18	0.42	0.57	0.66	0.70	0.78	0.82	0.85	0.88	0.98	0.99	0.99	0.99
JAN 91	0.10	0.03	0.02	0.32	0.12	0.18	0.41	0.57	0.66	0.69	0.77	0.80	0.83	0.87	0.97	0.99	0.99	
JUL 90	0.09	0.03	0.02	0.32	0.06	0.12	0.36	0.53	0.62	0.66	0.75	0.79	0.84	0.88	0.98	0.99		
MAR 91	0.10	0.03	0.05	0.29	0.06	0.12	0.36	0.53	0.62	0.66	0.74	0.79	0.85	0.88	0.98			
JAN 89	0.11	0.04	0.03	0.34	0.14	0.21	0.44	0.60	0.69	0.72	0.80	0.84	0.88	0.90				
NOV 89	0.15	0.11	0.06	0.44	0.20	0.26	0.47	0.63	0.71	0.74	0.80	0.85	0.87					
FEB 91	0.08	0.03	0.04	0.43	0.24	0.30	0.50	0.65	0.72	0.76	0.80	0.85						
DEC 90	0.07	0.02	0.03	0.62	0.59	0.66	0.82	0.92	0.96	0.98	0.99							
JUN 89	0.07	0.02	0.02	0.64	0.67	0.73	0.87	0.95	0.98	0.99								
JUN 90	0.06	0.02	0.02	0.66	0.74	0.80	0.92	0.98	1.00									
MAY 90	0.06	0.02	0.01	0.67	0.77	0.83	0.94	0.99										
JUN 91	0.05	0.02	0.02	0.68	0.84	0.89	0.97											
MAY 91	0.03	0.01	0.01	0.65	0.94	0.96												
OCT 91	0.02	0.01	0.00	0.60	0.98													
AUG 90	0.01	0.01	0.00	0.57														
DEC 89	0.03	0.05	0.22															
SEP 89	0.28	0.46																
SEP 91	0.93																	

	APR 91	APR 91	FEB 90	MAR 90	MAY 89	JAN 90	APR 89	JUL 89	FEB 89	OCT 90	AUG 91	JUL 91	AUG 89	NOV 90	SEP 90	MAR 89	NOV 91
DEC 91	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.10	0.20
NOV 91	0.19	0.22	0.21	0.23	0.35	0.41	0.47	0.69	0.71	0.72	0.74	0.74	0.84	0.85	0.82	0.85	
MAR 89	0.41	0.47	0.46	0.47	0.58	0.64	0.69	0.72	0.76	0.78	0.81	0.80	0.90	0.95	0.95		
SEP 90	0.42	0.45	0.44	0.46	0.60	0.65	0.71	0.74	0.79	0.87	0.89	0.88	0.95	0.98			
NOV 90	0.29	0.32	0.31	0.33	0.48	0.53	0.61	0.73	0.81	0.89	0.90	0.90	0.98				
AUG 89	0.16	0.18	0.17	0.19	0.34	0.40	0.49	0.77	0.82	0.95	0.95	0.95					
JUL 91	0.02	0.05	0.04	0.07	0.22	0.28	0.36	0.64	0.78	0.99	0.99						
AUG 91	0.03	0.07	0.06	0.08	0.23	0.29	0.37	0.64	0.78	1.00							
OCT 90	0.01	0.04	0.03	0.06	0.21	0.26	0.35	0.63	0.77								
FEB 89	0.11	0.14	0.13	0.16	0.28	0.33	0.40	0.59									
JUL 89	0.33	0.32	0.31	0.33	0.44	0.48	0.53										
APR 89	0.92	0.92	0.92	0.93	0.98	0.98											
JAN 90	0.93	0.94	0.94	0.95	0.98												
MAY 89	0.97	0.97	0.97	0.98													
MAR 90	0.99	0.99	1.00														
FEB 90	0.98	1.00															
APR 90	0.98																

term variations of those physical and nutrient parameters normally associated with influencing phytoplankton growth. Long-term and seasonal monthly averages for both a number of physical and nutrient parameters, as well as phytoplankton production and biomass, were plotted for measurements taken at four salinity based stations between June 1983 and May 1991. Visual analysis of these figures suggested the existence of close relationships between changes of various estimated parameters and associated phytoplankton production and biomass.

Descriptive Analysis - Primary production and biomass patterns were summarized by comparative graphical analyses of the relationships between phytoplankton responses and the combined influences of seasonal and flow related parameters. Temperature was selected to serve as an extremely stable proxy for seasonal variation, representing both increasing/decreasing ambient light and metabolic activity. Ambient water color was chosen to represent the combined competing influences associated with higher freshwater inputs: the stimulation of increasing nutrient loadings, and the negative effects of decreasing light penetration of the water column. The following patterns were apparent:

1) Both phytoplankton production and biomass were found to be low, irregardless of temperature, during periods of low water color.

2) As color increased to intermediate levels, both phytoplankton production and biomass showed significant positive responses. The magnitudes of these responses were observed to be highly temperature dependent.

3) Past a point, however, further increases in color overwhelmed the initial stimulation of increasing nutrients associated with flow, and both production and biomass declined rapidly.

Principal Component analysis - was used to evaluate the combined and relative influence on phytoplankton responses of the 25 physical and chemical parameters measured during the study.

This analysis indicated that:

> 1) The highest measured production rates and chlorophyll a levels occurred at 6 and 12 o/oo during periods of relatively low freshwater inputs, coincident with high seasonal temperature and light.
>
> 2) Increasing nutrients, independent of flow, resulted in stimulation of phytoplankton production and biomass. Such phytoplankton responses also increased under similar flow conditions with increasing nutrient levels.
>
> 3) Strong interactions between light, temperature and nutrient levels were apparent. At relatively low temperature/light levels, increasing nutrients did little to increase productivity, while increasing temperature/light at constant nutrient levels resulted in dramatic increases in phytoplankton production.

Multiple Regression Models - were developed to provide statistically predictive estimates of phytoplankton production and biomass from the measured physical and nutrient parameters. The resultant predictive models accounted for 44% of the observed variability in carbon uptake and 37% in ambient chlorophyll a levels.

Relationships between Carbon uptake and chlorophyll a - Chlorophyll a as an estimate of biomass can be influenced by both ambient light levels as well as the nutritional state of the cells. Chlorophyll a, thus, often represents an integration of the phytoplankton community's response to longer-term influences. Carbon uptake rates reflect the cumulative effects of current conditions, and reflect ambient growth potential. Although analysis indicated that the two measurements of phytoplankton production:

1) instantaneous growth rates as measured by carbon uptake, and

2) integrated growth as measured by chlorophyll a biomass,

generally followed similar seasonal trends at each of the four salinity zones; there were only weak direct correlations between these two measurements of phytoplankton production.

Long-Term Trend Analysis - the physical/chemical/primary production data set has extended over a sufficient period to allow for the use of modeling techniques which test for the presence of long-term trends with regard to time. The SEASKEN procedure for testing for monotonic trends in time using modified forms of the Kendall's Tau and Seasonal Kendall tests was used to analyze for the presence of long-term trends in the various chemical, physical and biological data collected at the four salinity zones between 1983 and 1991. Water withdrawal has shown a distinct increase over the eight-year period. An average decrease in measure solar radiation occurred over the same period. Significant long-term declines in both carbon uptake and chlorophyll a were observed at the 0 o/oo salinity zone. Significant long-term increases were apparent at the highest salinity zone for nitrogen, chlorophyll a, and the extinction of light within the water column. It is suggested that the observed declines in carbon uptake and chlorophyll a at 0 o/oo salinity may in fact result in part from a change in the seasonal pattern of early Spring rainfall. The resulting decline is of particular interest, since it emphasizes the dependence of phytoplankton production at the lower salinities upon river flow during the Spring when flows are often very low. The observed long-term increase in chlorophyll a at 20 o/oo, and the corresponding increase in the extinction coefficient of light within the water column, is also of interest, particularly since it seems to be independent of any corresponding change in river flow. If such trends continue, they may well be indicative of increased nitrogen loading of the higher salinity reaches of the Harbor by non-point source discharges into the estuarine system.

Taxonomic Determinations of Phytoplankton Community Structure - In 1988 the collection of monthly samples for the analysis of phytoplankton community structure was begun in conjunction with the long-term study of physical/chemical water quality and primary production at the four monitored salinity zones. Phytoplankton community structure has long been used in other studies as a tool in assessing both temporal and long-term changes in water quality in estuarine system. Distinct differences among the major taxonomic groups were observed with regards to the four salinity zones, both with consideration to species composition and seasonal patterns.

1) 0 o/oo Salinity - Blue-green algae are a very important part of the phytoplankton during the period from February through April. Green algae are typically dominant or show major increases in May during periods characterized by low Peace River flow. Flagellates, by comparison, show a strong increase in their importance within the phytoplankton community related to increasing Summer river flows. Diatoms are less frequent in the phytoplankton during such periods of high river flow, and are important or show major peaks during the late fall and winter months, as flow and water temperature decline. Dinoflagellates are not an important component of the phytoplankton community at this salinity.

2) 6 o/oo Salinity - the taxonomic structure at this salinity zone shows a dramatic decline in the importance of both green and blue-green taxa within the phytoplankton community. This salinity zone is characterized by alternating blooms of diatoms and flagellates, with dinoflagellates also showing periodic blooms.

3) 12 o/oo Salinity - this zone is characterized by seasonal blooms of flagellates, diatoms and dinoflagellates. Flagellates typically dominate through the cooler months and well into beginning of Summer wet-season. As river flow and temperature increase diatoms begin to become more important. Green algae comprise only a small part of the phytoplankton community.

4) 20 o/oo Salinity - the seasonal patterns of the major taxonomic groups at this salinity zone follow patterns generally similar to those observed at 12

o/oo. Diatoms and dinoflagellates, however, show a marked increased in their relative importance within the phytoplankton community.

4.0 ZOOPLANKTON STUDIES

4.1 INTRODUCTION

Zooplankton represent an important link between the phytoplankton community and higher levels in the estuarine food chain. Many groups of organisms are represented in the zooplankton either as larvae or adults, encompassing a wide variety of sizes and motile capabilities and are typically dispersed in estuaries in patchy aggregates dependent on river flow, wind direction and phytoplankton distributions.

The function of the zooplankton community in the estuarine ecosystem is twofold. First, the role of the estuaries as nursery and spawning areas for many organisms is well established. Since many species of zooplankton are herbivorous, feeding on productive free floating phytoplankton, zooplankton convert phytoplankton biomass into concentrated, usable energy for higher level predators including ichthyoplankton. A second function of zooplankton in the estuarine ecosystem is that of nutrient recyclers. Zooplankton graze heavily on the phytoplankton community and it has been shown that through the excretion of vital nutrients, primary production of phytoplankton may be stimulated, thus enhancing estuarine productivity.

Various physical and chemical parameters have been shown to influence zooplankton distributions and abundances in estuaries. Such parameters include, salinity, river flows, nutrient concentrations by influencing phytoplankton dynamics, temperature, and predatory densities. Little is known of the zooplankton assemblages of the lower Peace River and Charlotte Harbor.

This program was designed to study flow-related population responses of zooplankton communities in upper Charlotte Harbor to phytoplankton levels. By investigation of the role of zooplankton in the Charlotte Harbor estuary, insight may be gained into the relative effects of freshwater withdrawal on this important constituent of the estuarine system. Zooplankton were sampled in conjunction with phytoplankton at the same four estuarine station locations.

4.2 METHODS

4.2.1 Monthly Zooplankton Collections

Field Methods

Zooplankton were collected monthly from four stations in the Charlotte Harbor estuary. These collections were done concurrent with, and at the same salinity-based station locations as the phytoplankton study. Samples were collected from the water surface by filtering 75 liter of water through a 50 um mesh net at each station and collecting an oblique tow using a 1.0 m, 50 um mesh net raised at a constant rate from bottom to top at each station. Samples are preserved immediately in 5% unbuffered salinity appropriate formalin.

Laboratory Methods

Sample analyses were conducted using a 10-100X dissection microscope. Each sample is thoroughly mixed and aliquoted. Aliquot size (1-5 ml) depended on sample densities with counts conducted in a zooplankton counting wheel. Aliquots were counted until three successive counts yield no new taxa. A minimum of 500 plankters were counted for every sample. Zooplankton taxa were enumerated to the lowest taxonomic unit possible. Physical and chemical parameters for each zooplankton sample were measured as described in the Phytoplankton Methods Section for later correlation with the observed community patterns.

4.2.2 Diel Zooplankton Study

Field Methods

Since many taxa of zooplankton exhibit some degree of diurnal movement, a sampling regime was undertaken to examine diel periodicity of zooplankton communities at two of the salinity based stations. Seasonal diel differences were investigated through collections in March, June, September and December of 1990 and 1991. Zooplankton communities were sampled at three discreet depths, within 12 inches of the surface, midwater, and within 12 inches of the bottom, quarterly. Sampling was accomplished using a peristaltic pump with 50 l of water filtered through a 50 um mesh net for each depth.

The two salinity based sampling stations were selected for the diel study, 12 o/oo and 20 o/oo. Each salinity station was located using a refractometer or hydrolab, and marked with a drogue to track movements of the salinity zone through time. Zooplankton were sampled at four hour intervals over a 24 h period at each station.

In addition, diel chlorophyll a concentrations and in-situ hydrolab measurements were conducted concurrent with the zooplankton collections. Water chemistry parameters were measured at midday and late evening. Laboratory methods for identification and enumeration of zooplankton communities follow those used for monthly zooplankton collections.

4.2.3 Zooplankton Grazing Studies

Zooplankton may influence phytoplankton communities in several ways. Two possible modes of influences are:

(1). direct herbivory of phytoplankton cells by zooplankters,

(2). stimulation of phytoplankton communities via nutrient recycling and stimulation.

This portion of zooplankton study was designed to examine these two modes under both low nutrient influx (low river flow) and high nutrient influx (high river flow) conditions.

Twice each year, once at low flow and once under high flow conditions, estuary water, collected at 12 o/oo salinity, was filtered to produce a concentrated zooplankton sample. One-liter of this concentrate, mixed with three liters of estuary water was placed in a four-liter transparent container and suspended in-situ just below the surface of the water. Twenty-five replicate containers were prepared in this manner and allowed to incubate in-situ a maximum of 20 hours. At four hour intervals five replicate containers were removed and transported back to the laboratory for nutrient and chlorophyll a analyses.

Twenty-five replicate control containers were also placed in-situ concurrent with those described above. The control containers were prepared similar to the experimental containers except all water in these containers was filtered through 50 um mesh to remove most of the zooplankton. Five control containers were removed every five hours in conjunction with the unfiltered containers described above with chlorophyll a and nutrient concentrations measured from each container.

In the laboratory three subsamples were removed from each replicate filtered and unfiltered container. Fifty ml of each subsample was size-fractioned by filtration through 50, 20, and 5 um filters. Chlorophyll a concentrations were measured for each size fraction using the methods described in Section 2.2 of this report. Nutrient concentrations from each container were also measured.

4.3 RESULTS AND DISCUSSION

4.3.1 General Trends

A total of 656 distinct zooplankton collections were made in Charlotte Harbor from March, 1989 through December, 1991. Taxonomic identifications and enumeration of specimens resulted in identification of 77 species or taxonomic groups of zooplankton (Table 4.1). These taxa represented all lifestages from eggs for some invertebrates and vertebrates to larval forms and fully reproductive adults. In general, from all stations, the dominant taxa were rotifers (ROTOTARIA), crustacean copepods and nauplii, barnacle nauplii (CIRRIPEDIA), larvae of MOLLUSCA, PLATYHELMINTHES, and ANNELIDA and various HYDROZOA.

Total zooplankton density from any collection location or depth was typically about 1 million zooplankters per cubic meter of water. Densities were as high as 5.8 million and

TABLE 4.1
TAXONOMIC and LIFESTAGE LIST OF ZOOPLANKTONIC ORGANISMS COLLECTED FROM CHARLOTTE HARBOR, 1989-1991, ALL COLLECTIONS.

Taxonomic Classification

- **COELENTERATA (CNIDARIA)**
  - HYDROZOA
    - Siphonophora
    - Nectophora
    - Hydromedusae
    - Schyphomedusae
- **CTENOPHORA**
  - Cydippida
  - Cestida
- **ROTOTARIA**
- **GASTROTRICHIA**
- **PLATYHELMINTHES**
  - Turbellaria
  - Mueller's Larvae
- **NEMATODA**
- **NEMERTEA**
  - Pilidium (larvae)
- **ANNELIDA**
  - POLYCHAETA
    - (Trochophore, Larvae, Adult, Egg)
  - OLIGOCHAETA
- **MOLLUSCA**
  - GASTROPODA
    - (Trochopore, Veliger, Adult)
  - PELECYOPODA (Bivalvia)
    - (Trochophore, Veliger, Adult)
    - *Amygdalum papyrium*
  - SCAPHOPODA
  - CEPPHALOPODA
- **ARTHROPODA**
  - CRUSTACEA
    - BRANCHIPODA
      - CLADOCERA
    - OSTRACODA

COPEPODA (Nauplii)
- CALANOIDA
  - PSEUDODIAPTOMIDAE
    - *Pseudodiaptomus coronatus*
  - ACARTIDIIDAE
    - *Acartia tonsa*
  - CENTROPOGIDAE
    - *Centropages hamatus*
  - PONTELLIDAE
    - *Labidocera aestiva*
  - PARACALANIDAE
    - *Paracalanus crassirostris*
    - *Paracalanus parvus*
    - *Acrocalanus longicornis*
  - PSEUDOCALANIDAE
    - *Clausocalanus arcuicornis*
  - TEMORIDAE
    - *Temora turbinata*
- HARPACTACOIDA
  - EUTERPINATIDAE
    - *Euterpina acutifrons*
  - CLYTEMNESTRIDAE
    - *Clytemnestra sp.*
  - AEGISTHIDAE
    - *Aegisthus sp.*
- CYCLOPOIDA
  - CLAUSIDIIDAE
    - *Saphirella sp.*
    - Saphirella tropica
  - OITHONIDAE
    - *Oithona nana*
    - *Oithona brevicornis*
    - *Oithona simplex*
    - *Oithona colcarva*
  - CORYCAEIDAE
    - *Corycaeus americanus*
    - *Farranulla carinata*
  - ONCAEIDAE
    - *Oncaea venusta*
  - SAPPHIRINIDAE
    - *Sapphrina sp.*
    - *Copilia sp.*

CIRRIPEDIA (Nauplii)
Cypris Larvae
CUMACEA
AMPHIPODA
ISOPODA
Agathoa oculata
MYSIDACEA
DECAPODA
(Zoea and Pre-Zoea)
Porcellanid
Hippidean
Brachyuran
Nantantia
Paguridae
Euphausid
MEROSTOMATA
Limulus polyphemus (Larvae)
ARACHINIDA
HALACARIDAE
INSECTA
CHIRONOMIDAE
CHAOBORIDAE

CHAETOGNATHA
(Larvae and Adults)
ECHINODERMATA
Bipinnaria Larvae
Pleuteus Larvae
Holothuroidea Larvae

SIPUNCULIDA
PHORONIDAE
(Actinotrocha larvae)
BRACHIOPODA
BRYOZOA
HEMICORDATA
CORDATA
UROCHORDATA
ASCIDIACEA
TUNICATA
THALIACEA
LARVACEA
PISCES

as low as 10,000 individuals per cubic meter. A taxonomic list and taxa densities for each zooplankton collection are listed by station, month, and collection in Appendix B for monthly collections and Appendix C for diel samplings.

Monthly Samples

The results of monthly zooplankton collections concurrent with phytoplankton and productivity studies (Section 4) indicated that species richness (number of taxa per sampling) ranged from 6 to 47 taxa in any one collection. This includes both surface and oblique samples with surface samples generally having higher species number and densities. Comparisons within stations between years and between stations indicate little trend in zooplankton community density or diversity with variation between years being almost as great as the variation between stations.

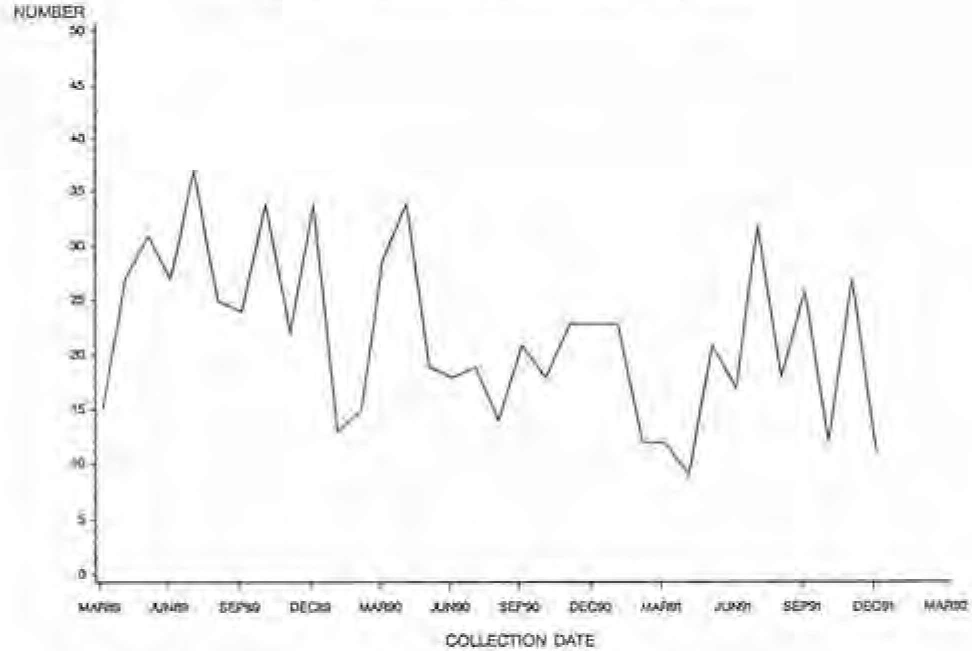
At 0 ppt salinity (station 101), surface sample species richness ranged from 10 to 38 with the peak number of species present in May and June (Figure 4.1). The oblique samples had fewer taxa collected with a maximum species richness of 28 (Figure 4.1).

The highest densities of zooplankton were observed in late spring (April-June) with secondary peaks in density occurring in late fall through early winter (Nov-Jan) (Figure 4.2). Peak densities exceeded 1 million individuals per m^3 with densities as low as 20,000 individuals. Average zooplankton density at 0 ppt was approximately 200,000 per m^3. Total zooplankton density was usually four to five times greater in the surface than in the oblique collections.

Pielou Base e species diversity metrics ranged from approximately 0.25 to 2.75 with an average of approximately 1.75 for surface samples (Figure 4.3). Peaks in diversity occurred in late fall (Nov-Jan) with lowest species diversity found in June, 91. High

FIGURE 4.1

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
AT STATION 101, 0 PPT SALINITY, SURFACE SAMPLE



TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
AT STATION 101, 0 PPT SALINITY, OBLIQUE SAMPLE

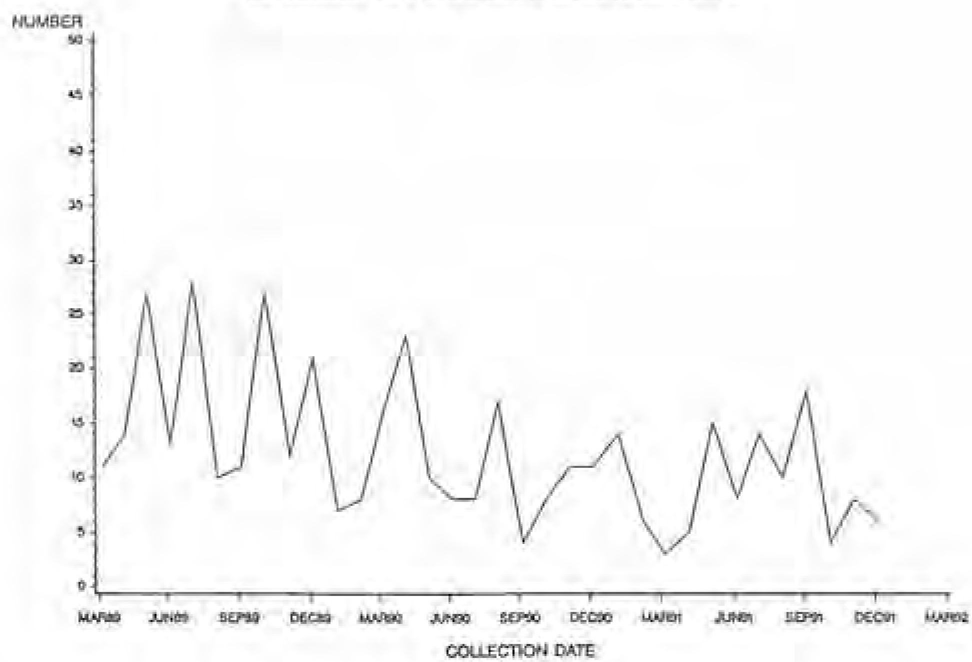
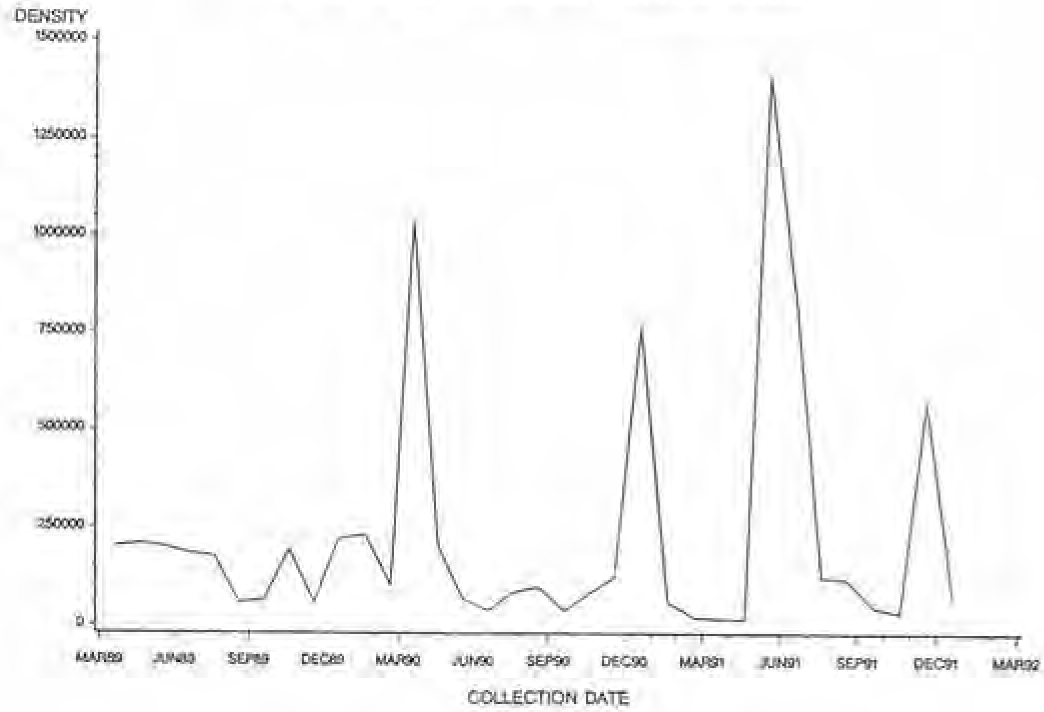


FIGURE 4.2

TOTAL ZOOPLANKTON DENSITY PER CUBIC METER
AT STATION 101, 0 PPT SALINITY, SURFACE WATER



TOTAL ZOOPLANKTON DENSITY PER CUBIC METER
AT STATION 101, 0 PPT SALINITY, OBLIQUE SAMPLE

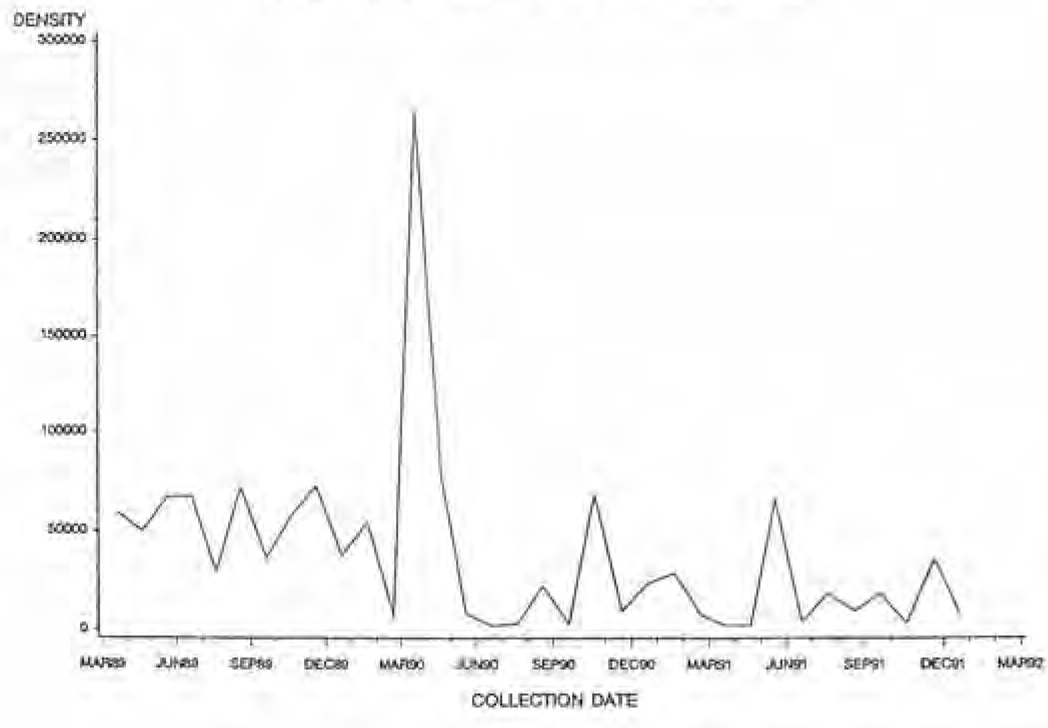
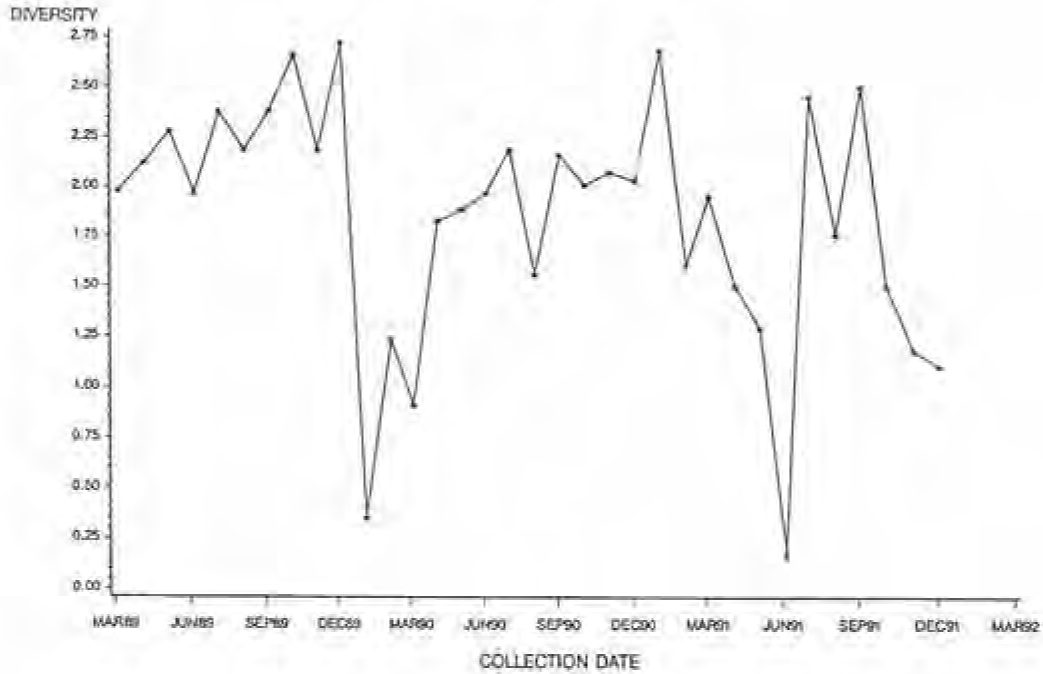
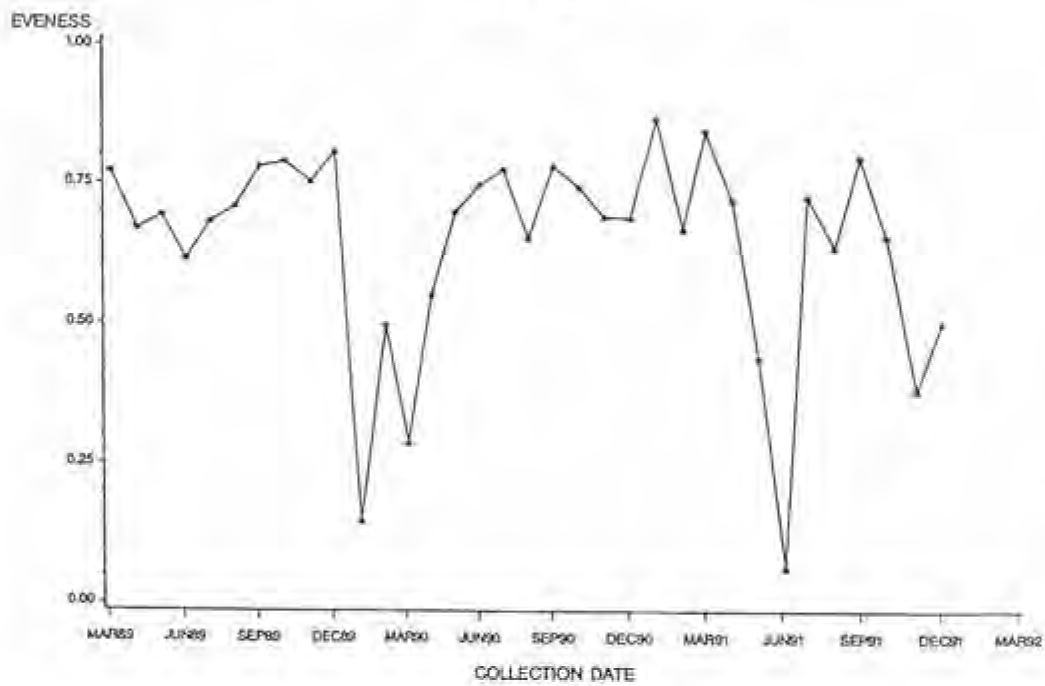


FIGURE 4.3

Pielou Base e Species Diversity From
All Stations, Surface Sample
Station=0 ppt



Species Diversity Eveness Measurements From
All Stations, Surface Sample
Station=0 ppt



species diversity however, was observed in May-June, 1989 and 1990. Evenness measures followed the trend in diversity.

The zooplankton community at 0 ppt was dominated by filter feeding rotifers and copepod nauplii, although low densities of adult copepods was observed. Seasonally high densities of ctenophores, sipunculids, larvaceans, gastropods and gastropod larvae, and hydrozoa medusae were also observed. Peaks in these seasonally abundant organisms generally corresponded to the periods of highest zooplankton densities and diversity.

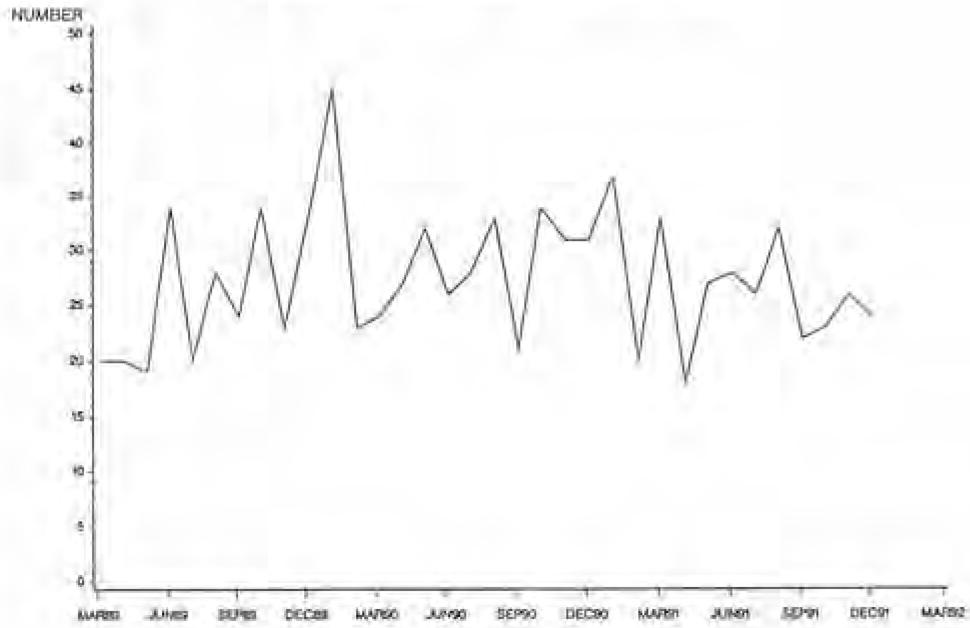
At 6 ppt salinity (station 102), surface sample species richness ranged from 17 to 46 with peak number of species present in June-July, October-November, and February (Figure 4.4). The oblique samples had fewer taxa collected with a maximum species richness of 25 (Figure 4.4).

The highest densities of zooplankton were observed in spring (April-June) with secondary peaks in density occurring in late fall (October-Nov) (Figure 4.5). Densities ranged from 10,000 to 3.5 million individuals per m^3 with an average density of approximately 750,000 plankters. Total zooplankton density was usually ten times greater in the surface than in the oblique collections.

Pielou Base e species diversity metrics ranged from approximately 0.25 to 2.00 with an average of approximately 1.25 for surface samples (Figure 4.6). Peaks in diversity occurred in early summer (May-July) with lowest species diversity found in September. However, high species diversity was observed in September, 1991. Evenness measures generally followed the trend in diversity.

FIGURE 4.4

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
AT STATION 102, 6 PPT SALINITY, SURFACE SAMPLE



TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
AT STATION 102, 6 PPT SALINITY, OBLIQUE SAMPLE

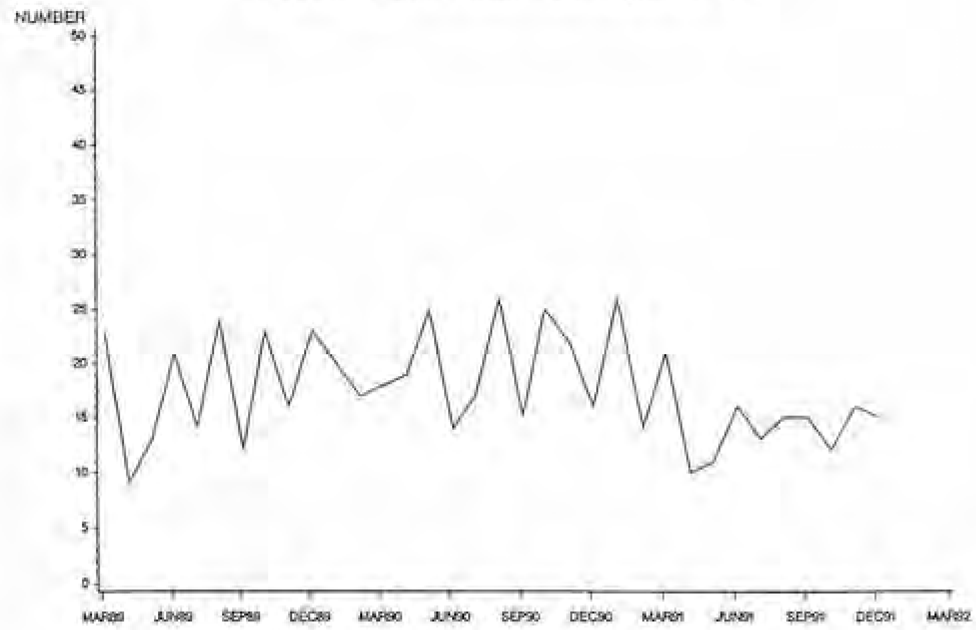
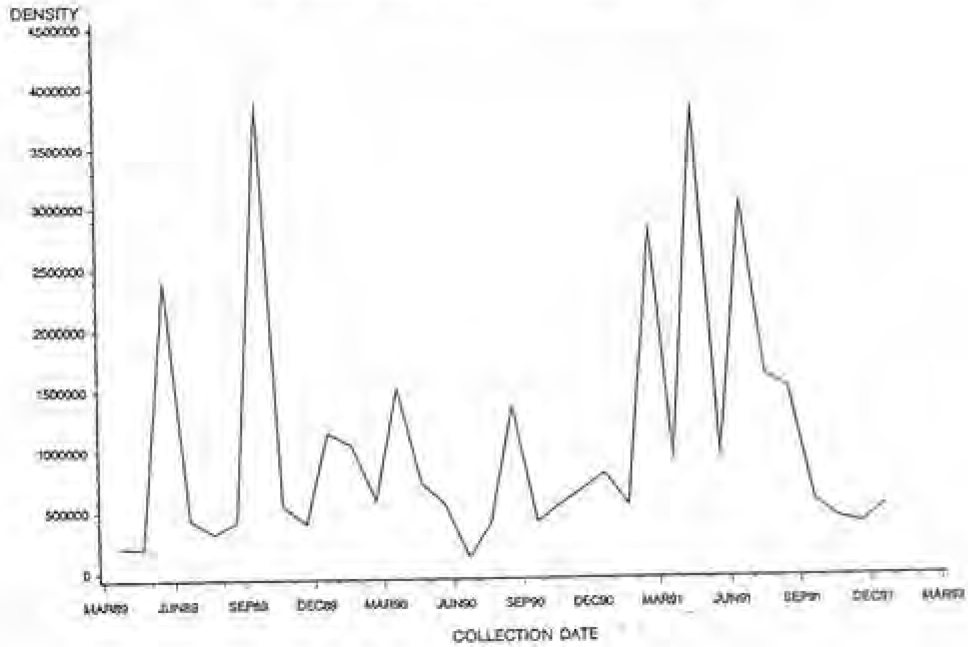


FIGURE 4.5

TOTAL ZOOPLANKTON DENSITY PER CUBIC METER
AT STATION 102, 6 PPT SALINITY, SURFACE WATER



TOTAL ZOOPLANKTON DENSITY PER CUBIC METER
AT STATION 102, 6 PPT SALINITY, OBLIQUE SAMPLE

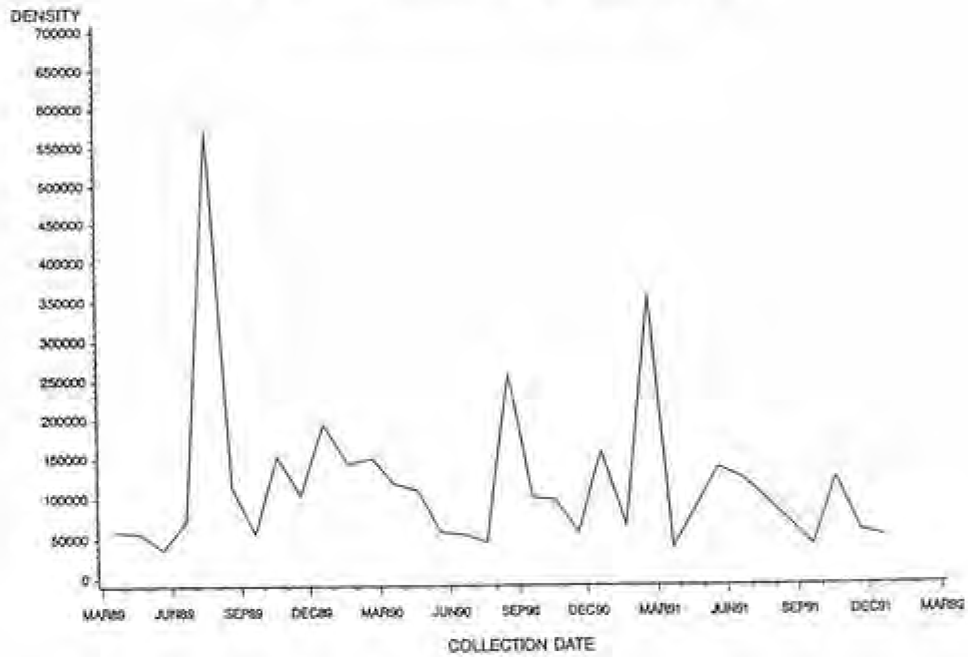
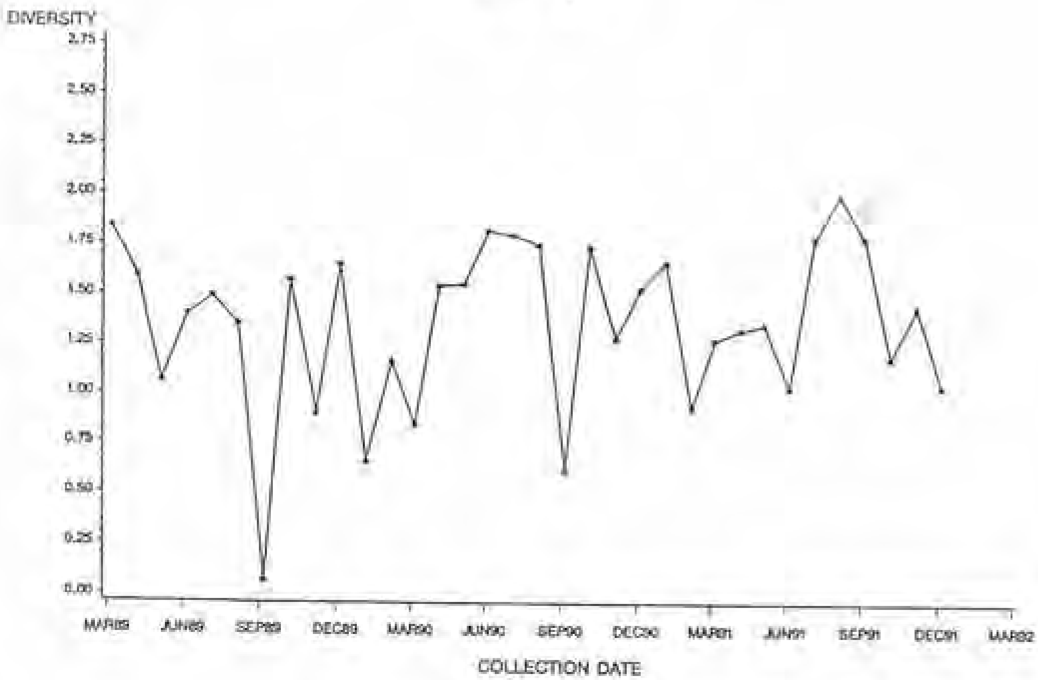
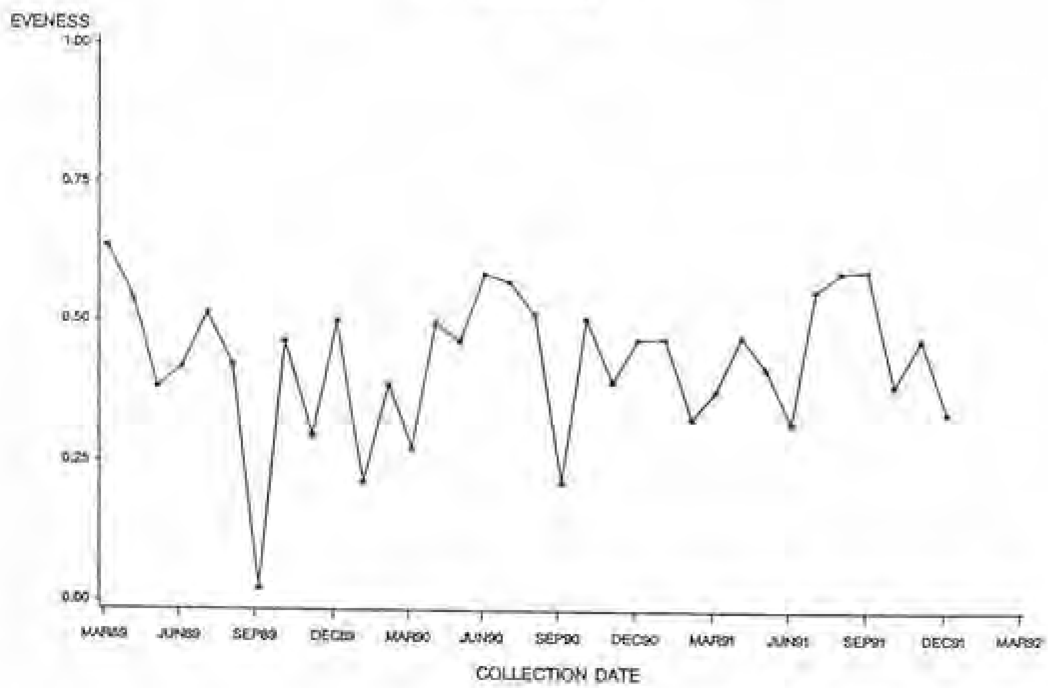


FIGURE 4.6

Pielou Base e Species Diversity From
All Stations, Surface Sample
Station = 6ppt



_ Species Diversity Eveness Measurements From
All Stations, Surface Sample
Station = 6ppt



The zooplankton community at 6 ppt was dominated by copepod nauplii, filter feeding rotifers, and the grazing calanoid copepod *Acartia tonsa*. Higher densities of copepods were observed at 6 ppt than 0 ppt, primarily cyclopoid *Oithona* species. Seasonally high densities of hemicordates, sipunculids, cirripedian nauplii, gastropod larvae, and pelecypod larvae were also observed. Peaks in these seasonally abundant organisms generally corresponded to the periods of highest zooplankton densities and diversity.

At 12 ppt salinity (station 103), surface sample species richness ranged from 13 to 49 with peak number of species present in June-July, October-November, and February (Figure 4.7). The oblique samples had fewer taxa collected with a maximum species richness of 38 (Figure 4.7).

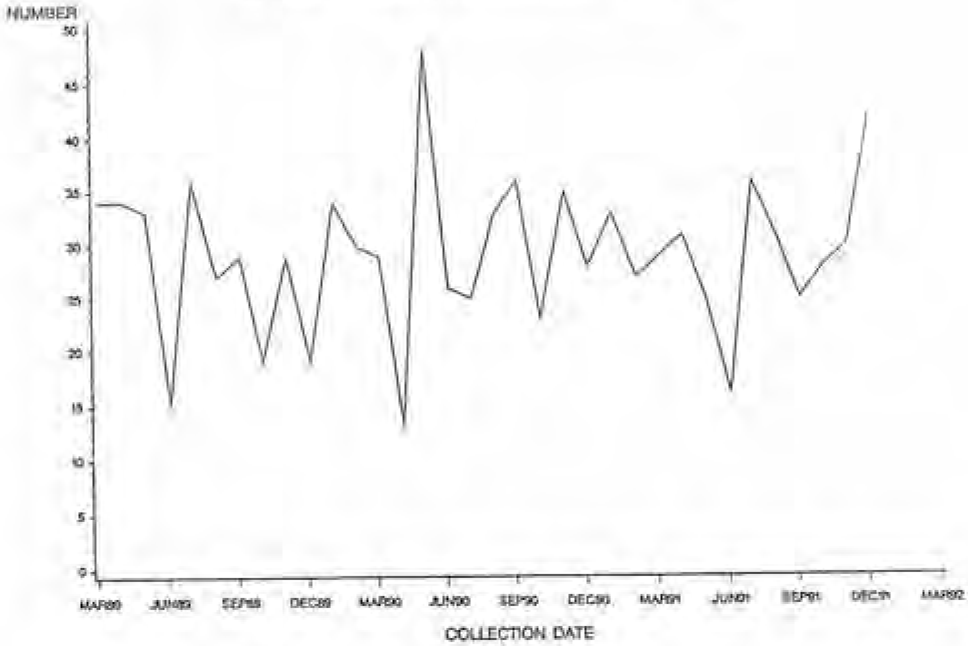
The highest densities of zooplankton were observed in late summer (August-October) (Figure 4.8). Total density ranged from 20,000 per m^3 to peaks in excess of 4.5 million. Average zooplankton density from surface samples was approximately 1 million plankters per m^3. Total zooplankton density was usually five to 10 times greater in the surface than in the oblique collections.

Pielou Base e species diversity metrics ranged from approximately 0.75 to 2.50 with an average of approximately 1.60 for surface samples (Figure 4.9). Peaks in diversity occurred in late summer (August-October) and spring (March-May). Lowest species diversity found in the summer months. Evenness measures generally followed the trend in diversity.

The zooplankton community at 12 ppt was dominated by copepod nauplii, *Acartia tonsa*, polychaete larvae, an increased number and type of calanoid and cyclopoid

FIGURE 4.7

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
AT STATION 103, 12 PPT SALINITY, SURFACE SAMPLE



TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
AT STATION 103, 12 PPT SALINITY, OBLIQUE SAMPLE

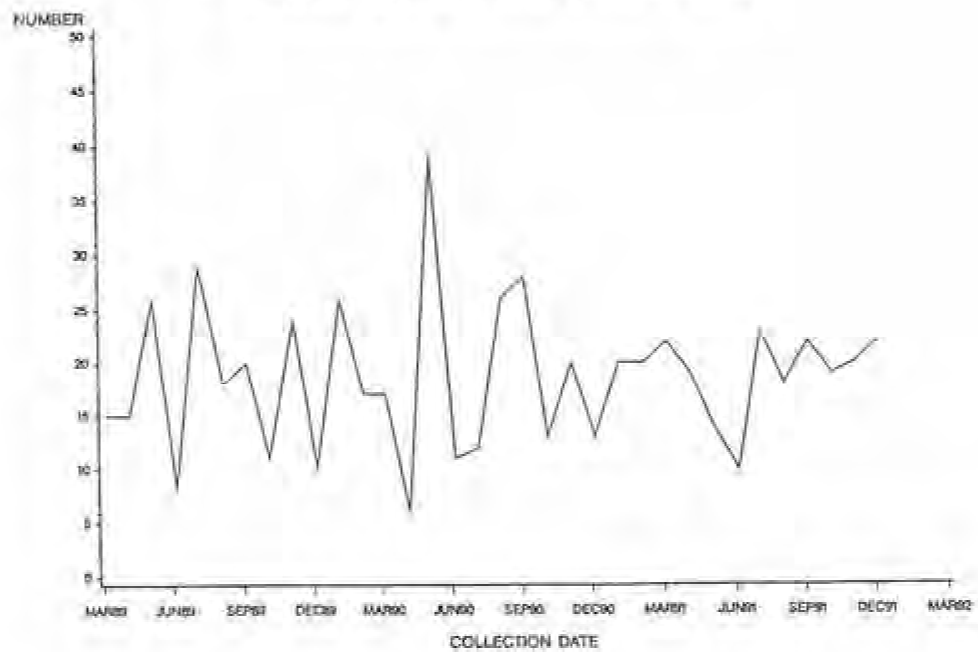
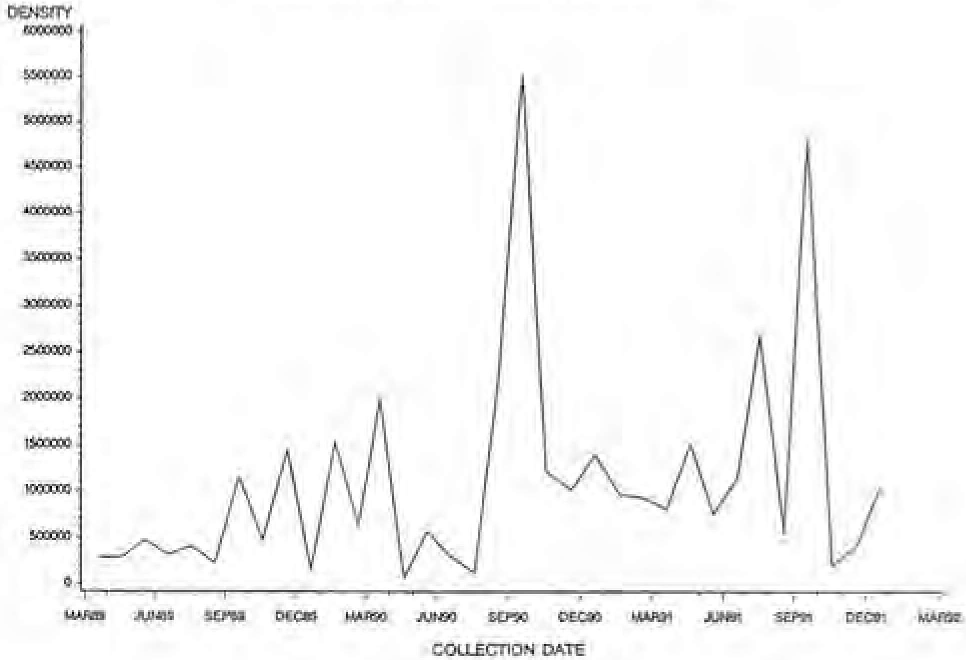


FIGURE 4.8

TOTAL ZOOPLANKTON DENSITY PER CUBIC METER
AT STATION 103, 12 PPT SALINITY, SURFACE WATER



TOTAL ZOOPLANKTON DENSITY PER CUBIC METER
AT STATION 103, 12 PPT SALINITY, OBLIQUE SAMPLE

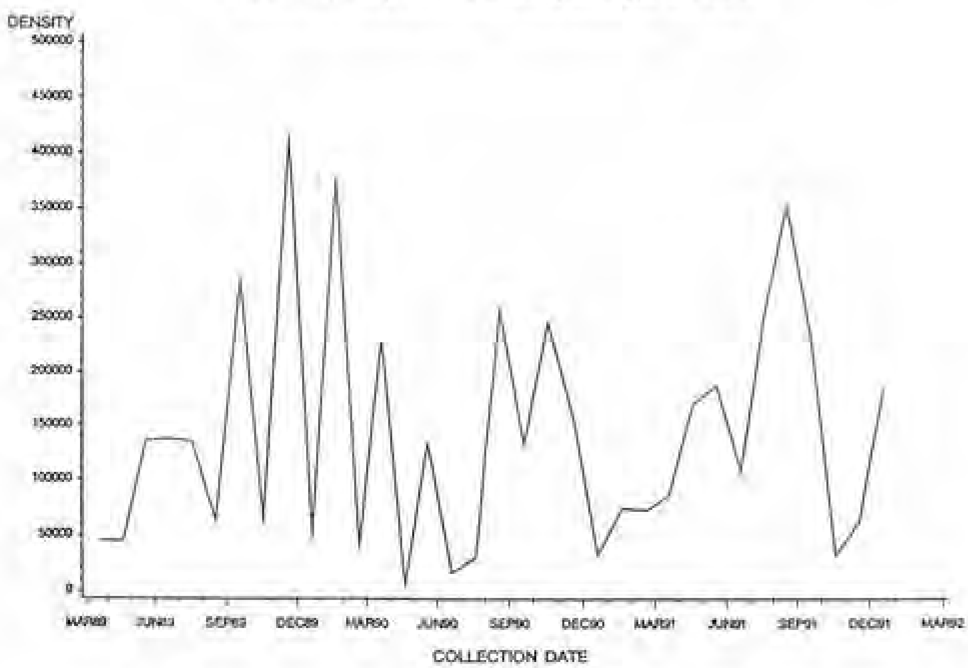
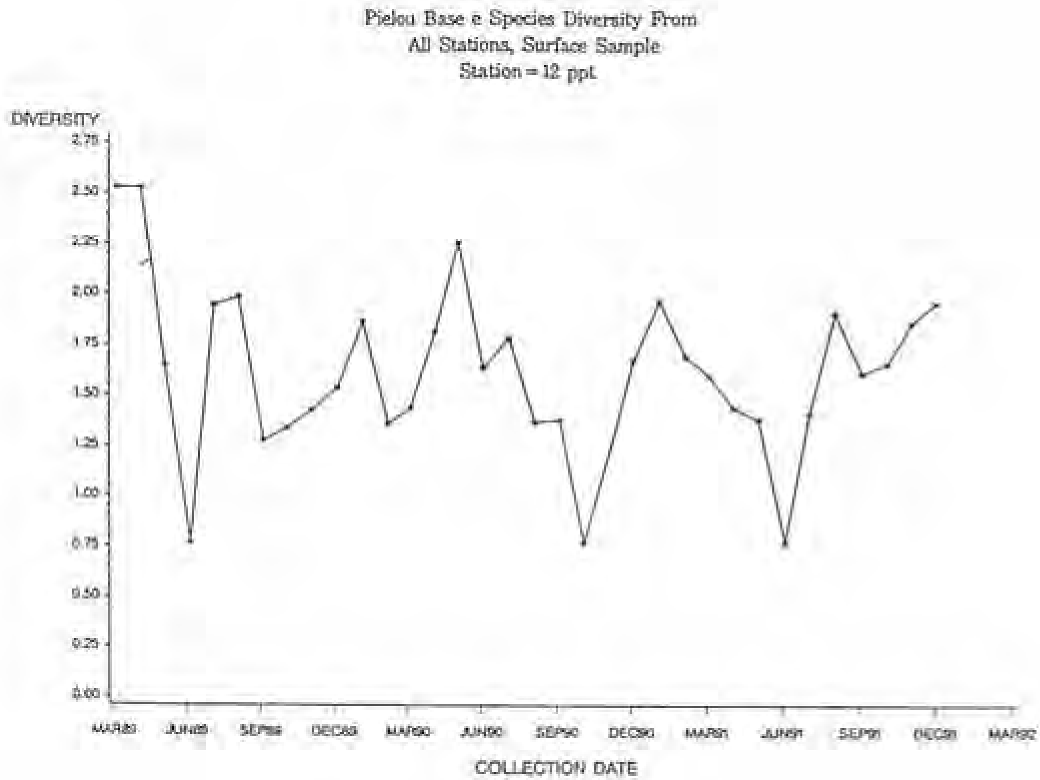
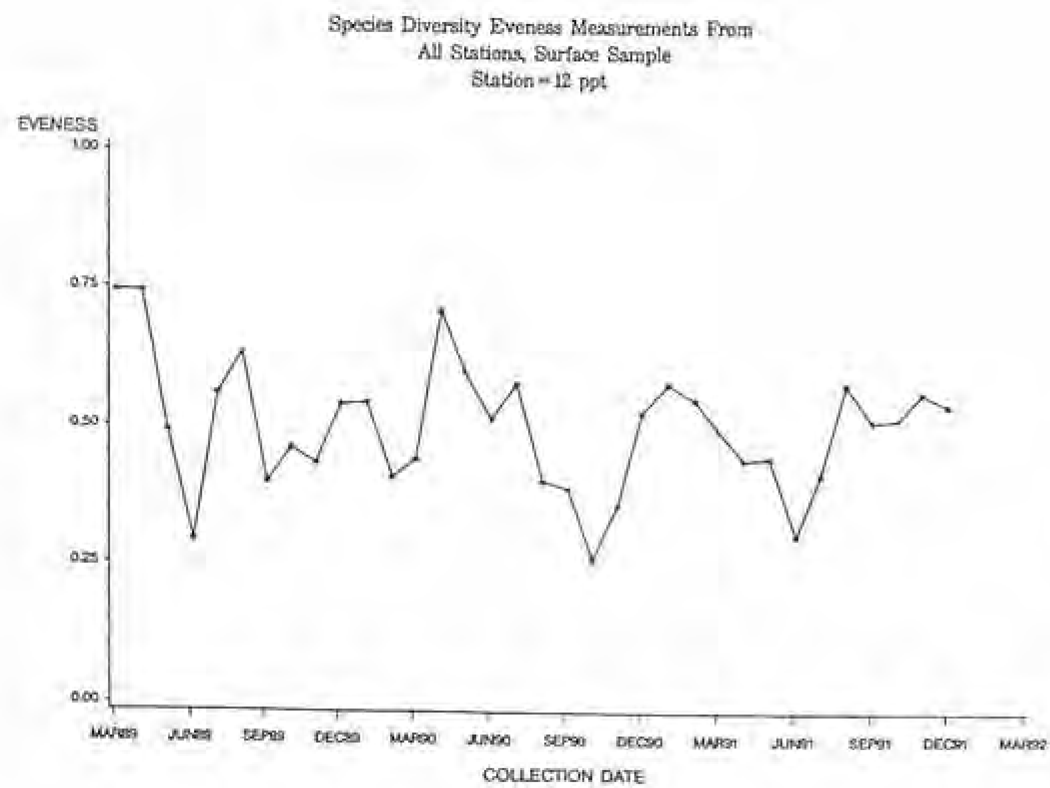


FIGURE 4.9


Pielou Base e Species Diversity From
All Stations, Surface Sample
Station = 12 ppt
DIVERSITY
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
MAR89
JUN89
SEP89
DEC89
MAR90
JUN90
SEP90
DEC90
MAR91
JUN91
SEP91
DEC91
MAR92
COLLECTION DATE


Species Diversity Eveness Measurements From
All Stations, Surface Sample
Station = 12 ppt
EVENESS
1.00
0.75
0.50
0.25
0.00
MAR89
JUN89
SEP89
DEC89
MAR90
JUN90
SEP90
DEC90
MAR91
JUN91
SEP91
DEC91
MAR92
COLLECTION DATE

copepod including: *Oithona* species, *Saphirella sp.* and *Paracalanus crassirostris.* Seasonally high densities of harpactacoid copepods principally *Euterpina acutifrons*, sipunculids, cirripedian nauplii, gastropod larvae, and turbellaria were also observed. Peaks in these seasonally abundant organisms generally corresponded to the periods of highest zooplankton densities and diversity.

At 20 ppt salinity (station 104), surface sample species richness ranged from 17 to 42 with peak number of species present in June-July and January-February (Figure 4.10). Low species richness was observed in November of each year. The oblique samples had fewer taxa collected with a maximum species richness of 38 (Figure 4.10).

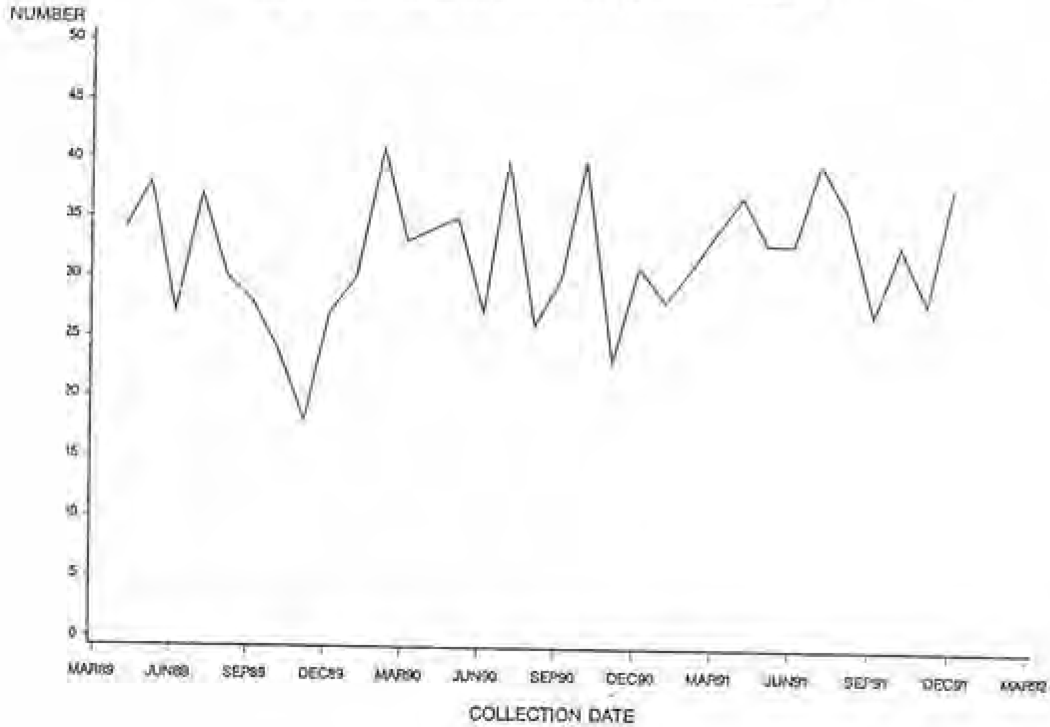
Densities of zooplankton were cyclical with high densities in one month usually followed by low densities the succeeding month (Figure 4.11). Total density ranged from 100,000 per m^3 to peaks in excess of 6 million. Average zooplankton density from surface samples was approximately 1.5 million plankters per m^3. Total zooplankton density was usually five to 10 times greater in the surface than in the oblique collections.

Pielou Base e species diversity metrics ranged from approximately 0.75 to 2.50 with an average of approximately 1.75 for surface samples (Figure 4.9). Well defined peaks and valleys in the diversity measure were not as readily observed at 20 ppt as at the other stations with diversity more constant (Figure 4.12). This consistency was also seen in the species richness (Figure 4.10). Evenness measures generally followed the trend in diversity.

The zooplankton community at 20 ppt was dominated by copepod nauplii *Acartia tonsa*, pelecyopod larvae, medusal forms of Hydrozoa and Schyphozoa, *Acartia tonsa*,

FIGURE 4.10

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
AT STATION 104, 20 PPT SALINITY, SURFACE SAMPLE



TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
AT STATION 104, 20 PPT SALINITY, OBLIQUE SAMPLE

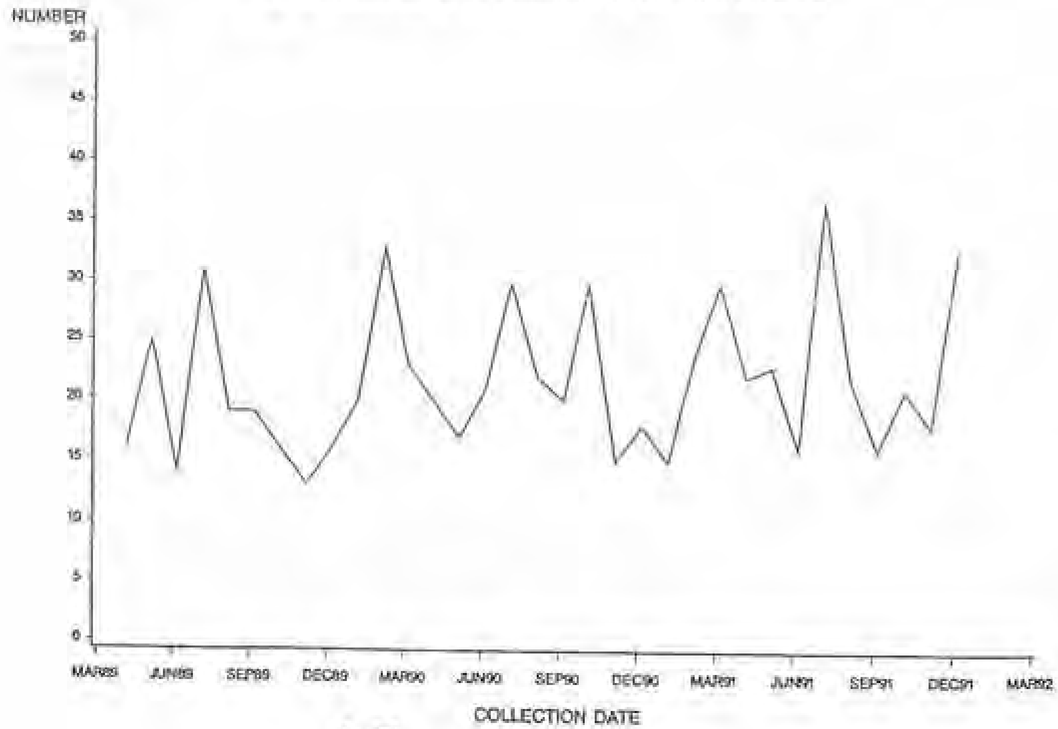
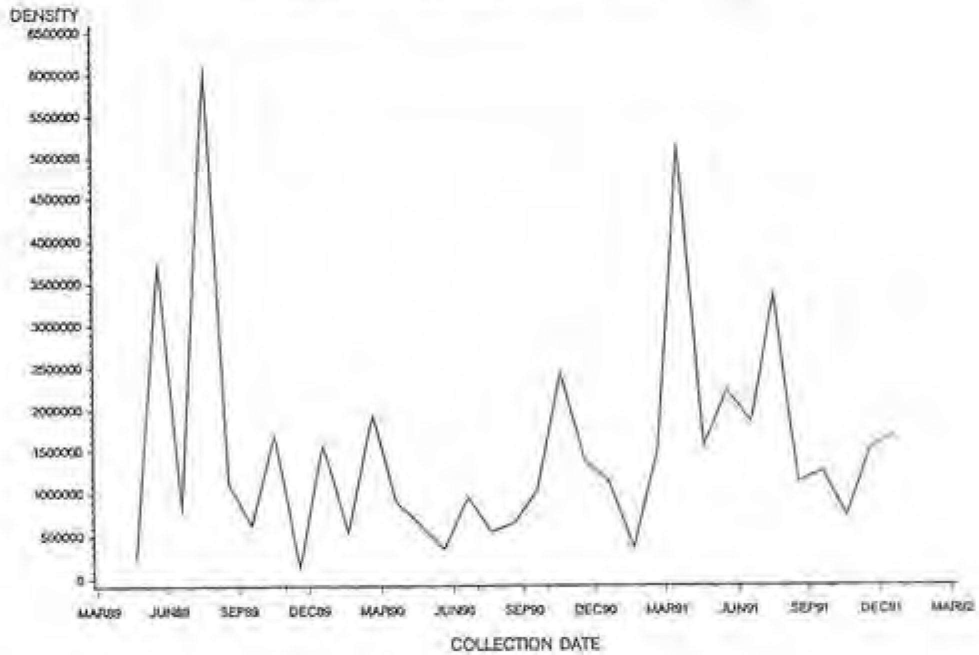


FIGURE 4.11

TOTAL ZOOPLANKTON DENSITY PER CUBIC METER
AT STATION 104, 20 PPT SALINITY, SURFACE WATER



TOTAL ZOOPLANKTON DENSITY PER CUBIC METER
AT STATION 104, 20 PPT SALINITY, OBLIQUE SAMPLE

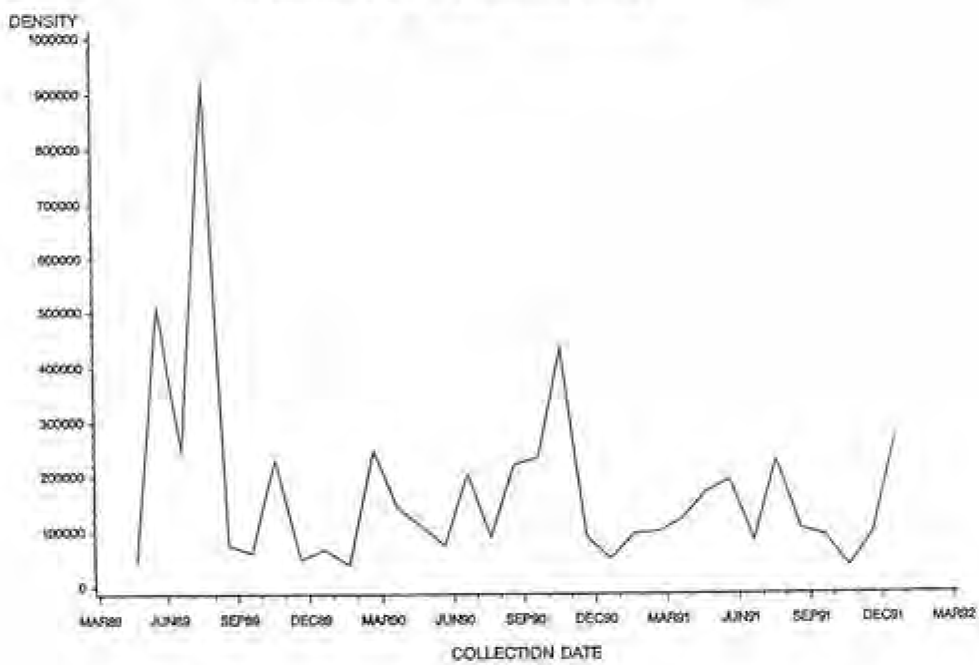
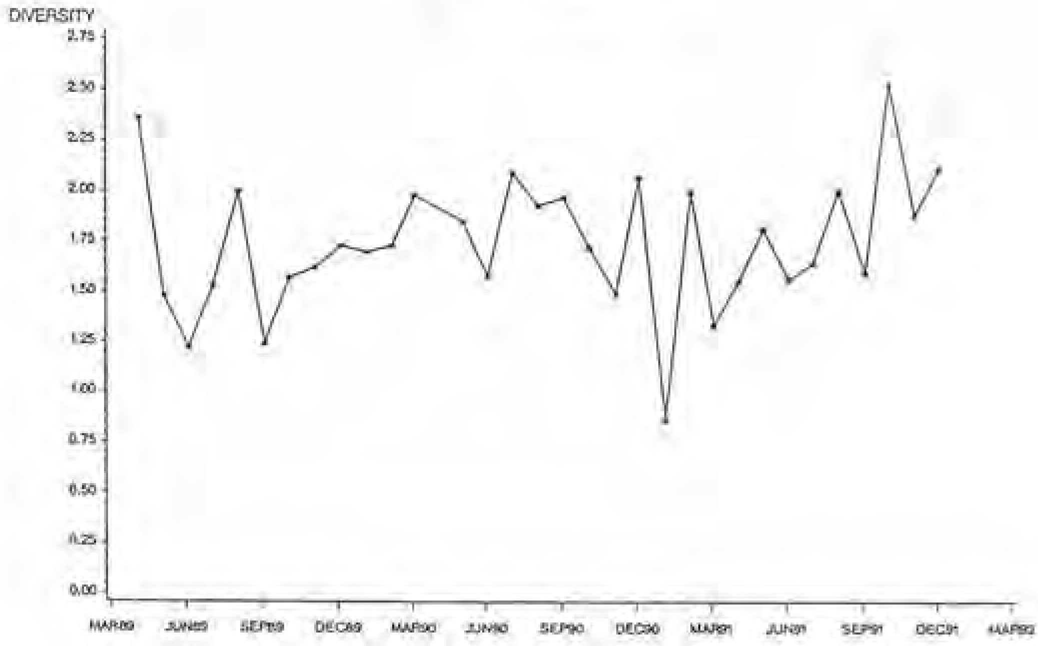
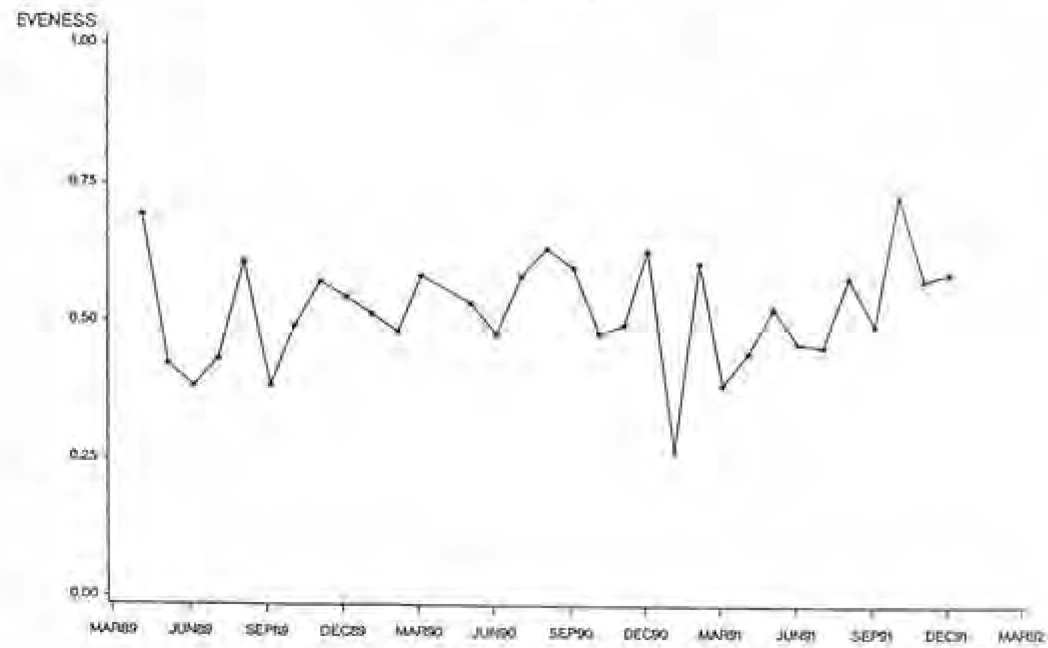


FIGURE 4.12

Pielou Base e Species Diversity From
All Stations, Surface Sample
Station = 20 ppt



Species Diversity Eveness Measurements From
All Stations, Surface Sample
Station = 20 ppt



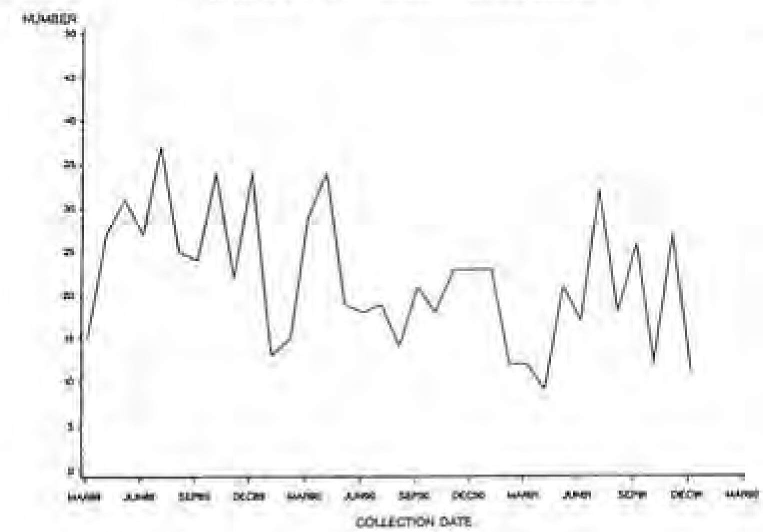
and increased numbers of *Oithona nana*. Seasonally high densities of fish eggs and larvae (Pisces), Cirripedia nauplii, Hemicordates, Ascideaceans, Turbellaria, and Sipunculids were also observed. Peaks in these seasonally abundant organisms generally corresponded to the periods of highest zooplankton densities and diversity.

Comparisons between stations in community measures such as diversity and evenness, and species richness indicated that 0 ppt salinity, although having the high species diversity, was more variable in richness and diversity than the other stations. Station 20 was least variable in diversity and richness measures with 6 and 12 ppt intermediate (Figures 4.13 and 4.14). This is due to the riverine nature of 0 ppt waters which were usually well upstream in the Peace River. Rivers generally have much lower zooplankton diversity and densities than do lakes or estuaries. Total density estimates from all stations showed seasonal peaks in zooplankton abundance followed by crashes in zooplankton number. Zero ppt salinity generally had the lowest density of zooplankton with density increasing across stations with increasing salinity (Figure 4.15).

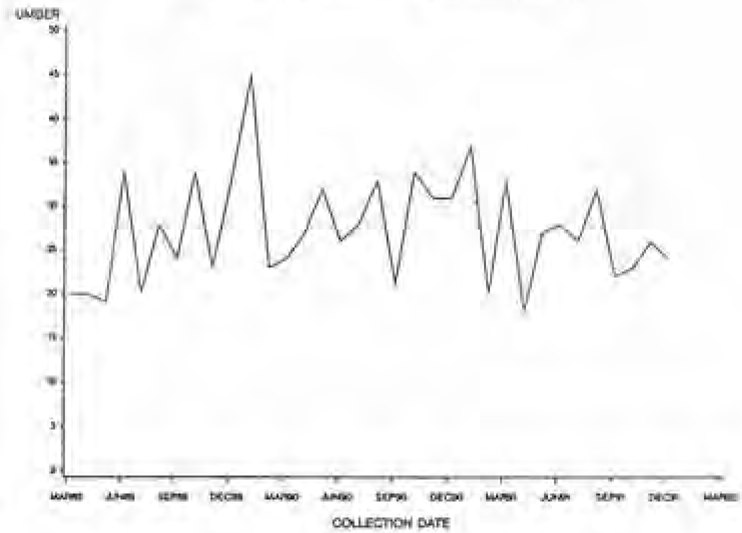
Individual species responses across stations by collection date indicated salinity specific responses of many taxonomic groups with season. Zero ppt salinity had a diverse zooplankton community with densities much lower than the other three salinities. The zooplankton community of 0 ppt was dominated by rotifers with densities as high as 100,000 rotifers per m^3 (Figure 4.16). Station 6 ppt salinity had higher rotifer densities than did 0 o/oo but due to higher overall densities rotifers accounted for a lower proportion of the total zooplankton community than in 0 ppt water. Rotifer densities decreased at the higher salinity stations of 12 an 20 ppt salinity.

FIGURE 4.13

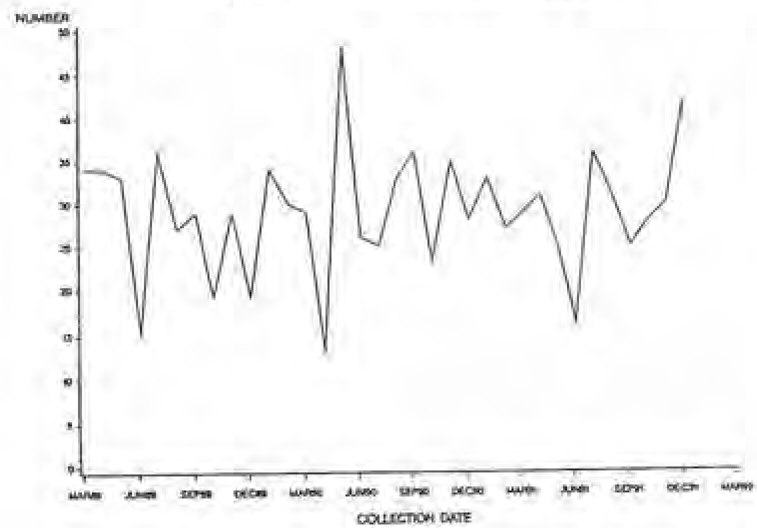
TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
AT STATION 101, 0 PPT SALINITY, SURFACE SAMPLE



TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
AT STATION 102, 6 PPT SALINITY, SURFACE SAMPLE



TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
AT STATION 103, 12 PPT SALINITY, SURFACE SAMPLE



TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
AT STATION 104, 20 PPT SALINITY, SURFACE SAMPLE

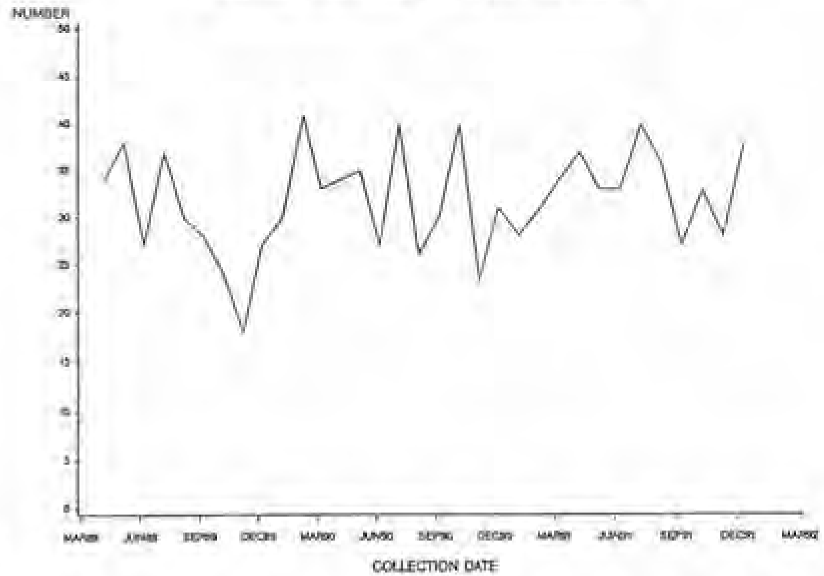


FIGURE 4.14

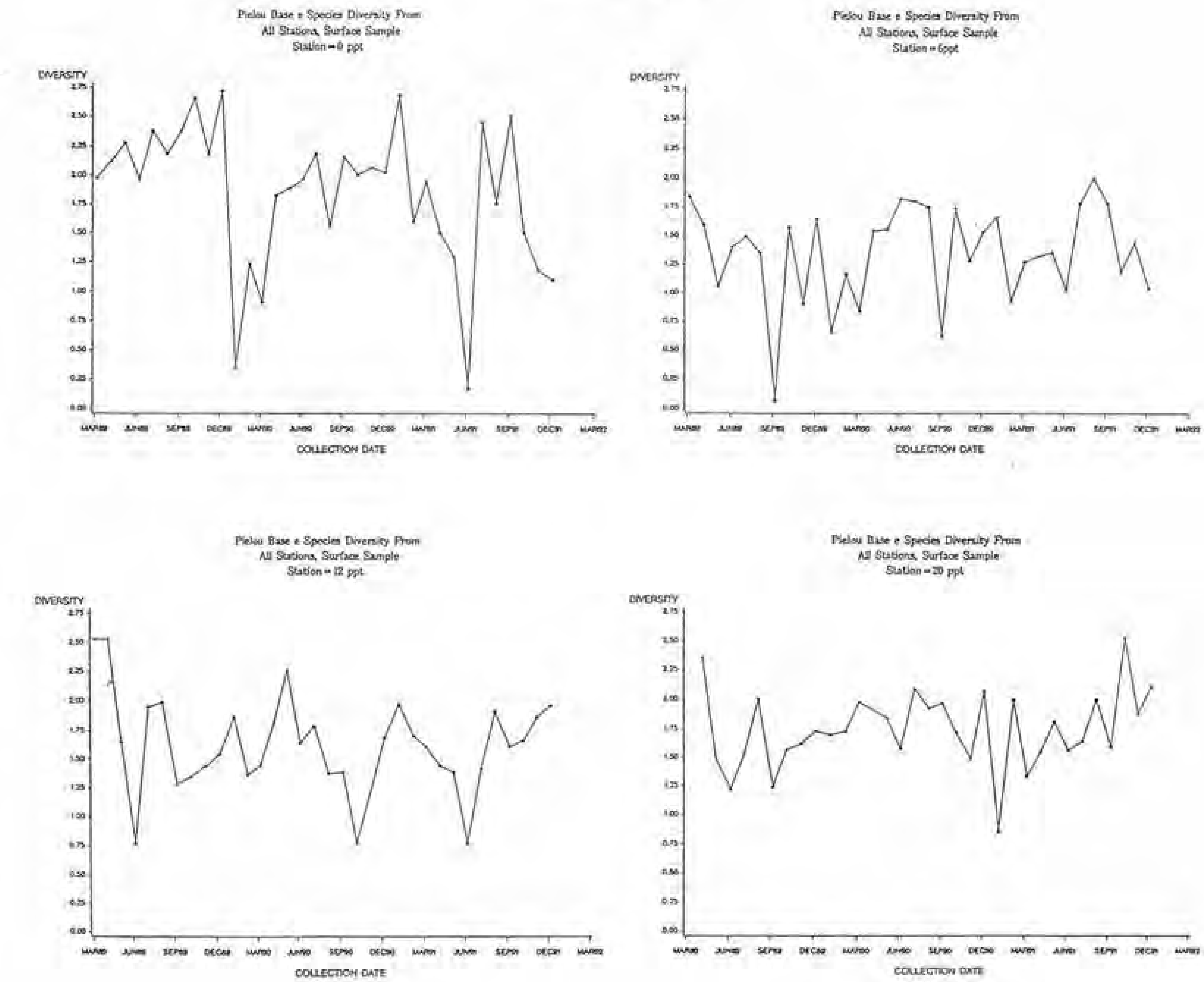
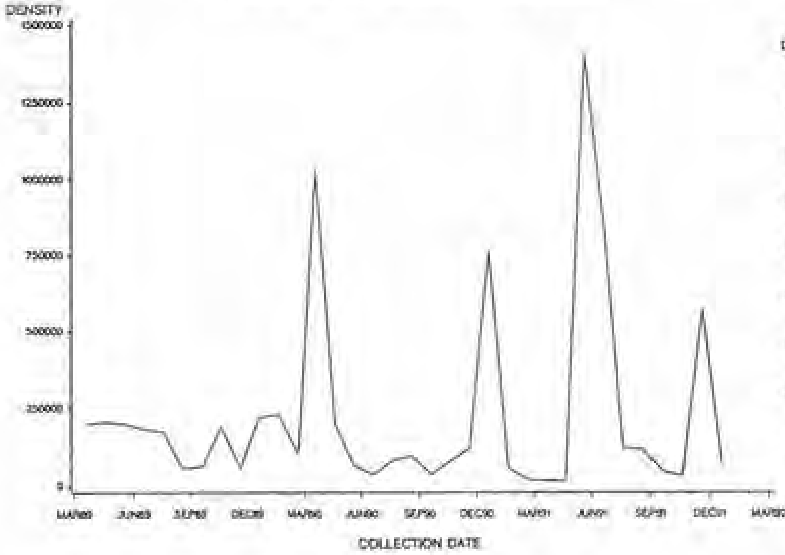
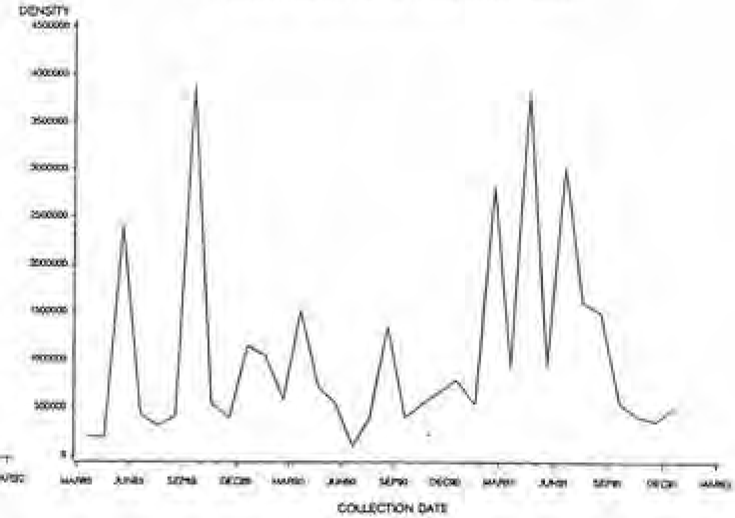

Pielou Base e Species Diversity From
All Stations, Surface Sample
Station = 0 ppt
DIVERSITY
COLLECTION DATE
Pielou Base e Species Diversity From
All Stations, Surface Sample
Station = 6ppt
DIVERSITY
COLLECTION DATE
Pielou Base e Species Diversity From
All Stations, Surface Sample
Station = 12 ppt
DIVERSITY
COLLECTION DATE
Pielou Base e Species Diversity From
All Stations, Surface Sample
Station = 20 ppt
DIVERSITY
COLLECTION DATE

FIGURE 4.15

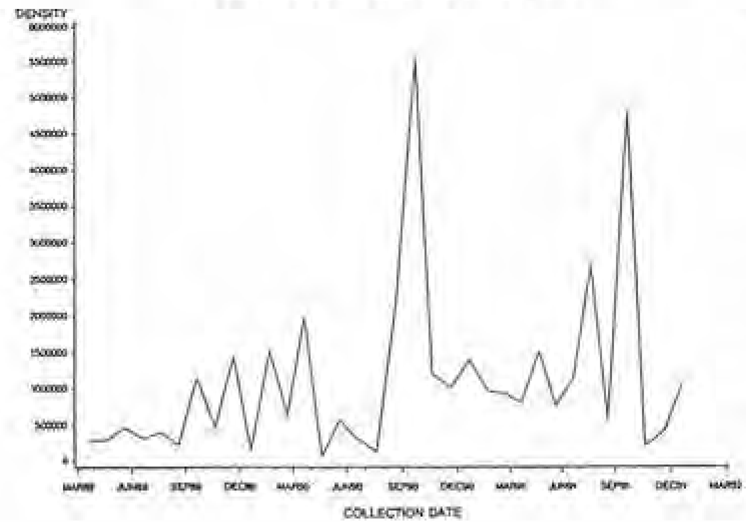
TOTAL ZOOPLANKTON DENSITY PER CUBIC METER
AT STATION 101, 0 PPT SALINITY, SURFACE WATER



TOTAL ZOOPLANKTON DENSITY PER CUBIC METER
AT STATION 102, 6 PPT SALINITY, SURFACE WATER



TOTAL ZOOPLANKTON DENSITY PER CUBIC METER
AT STATION 103, 12 PPT SALINITY, SURFACE WATER



TOTAL ZOOPLANKTON DENSITY PER CUBIC METER
AT STATION 104, 20 PPT SALINITY, SURFACE WATER

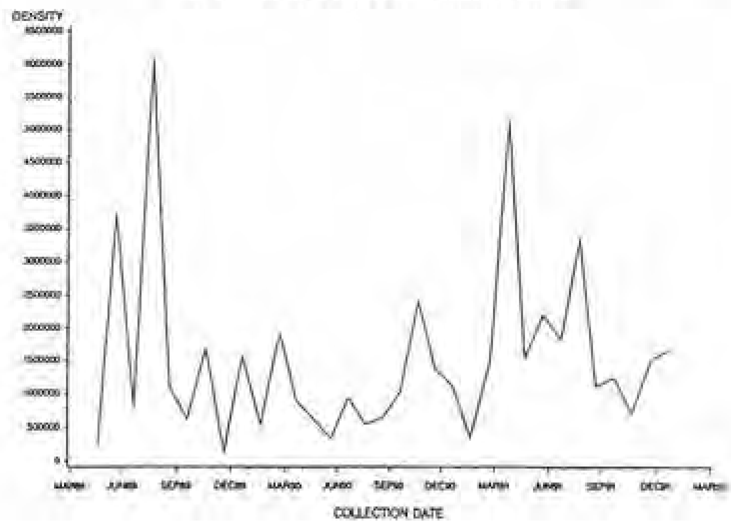
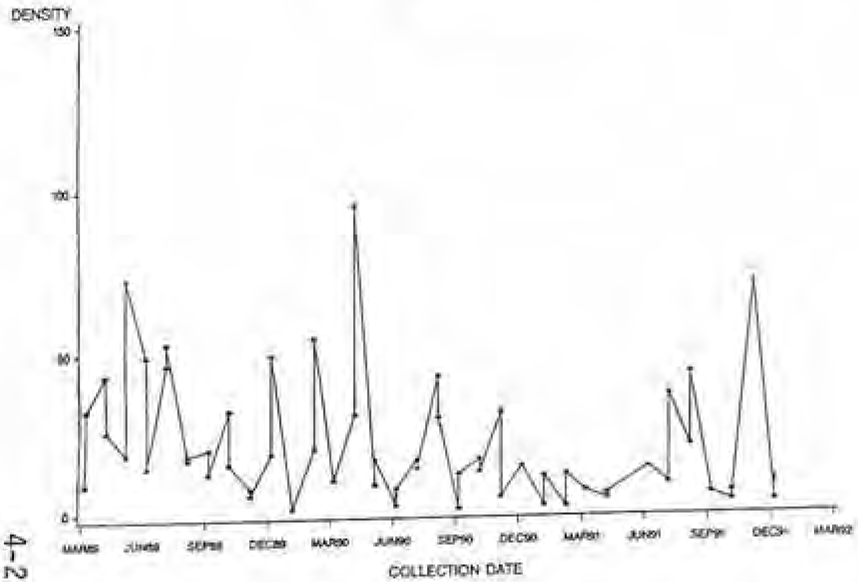
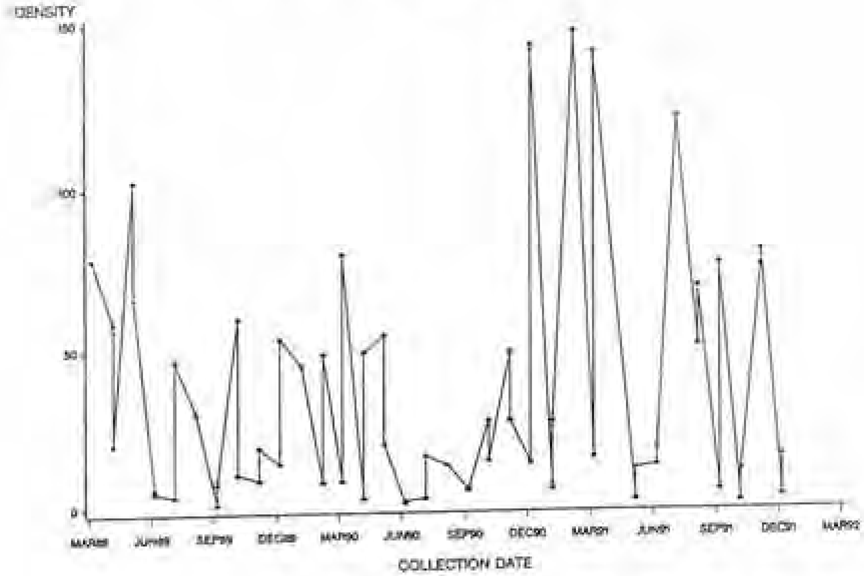


FIGURE 4.16

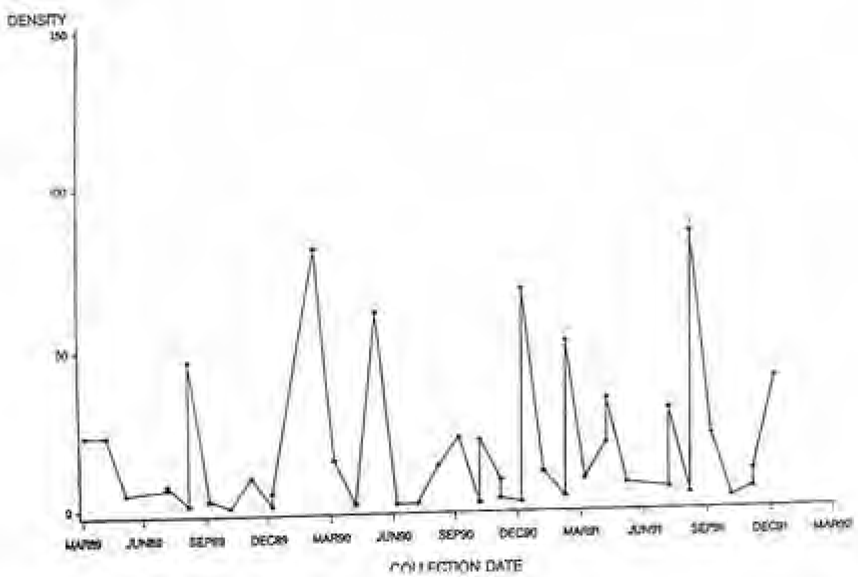
Total Density (#/m3 x 1000) of Rotifera Collected
At All Stations, Surface Sample
Station = 0 ppt



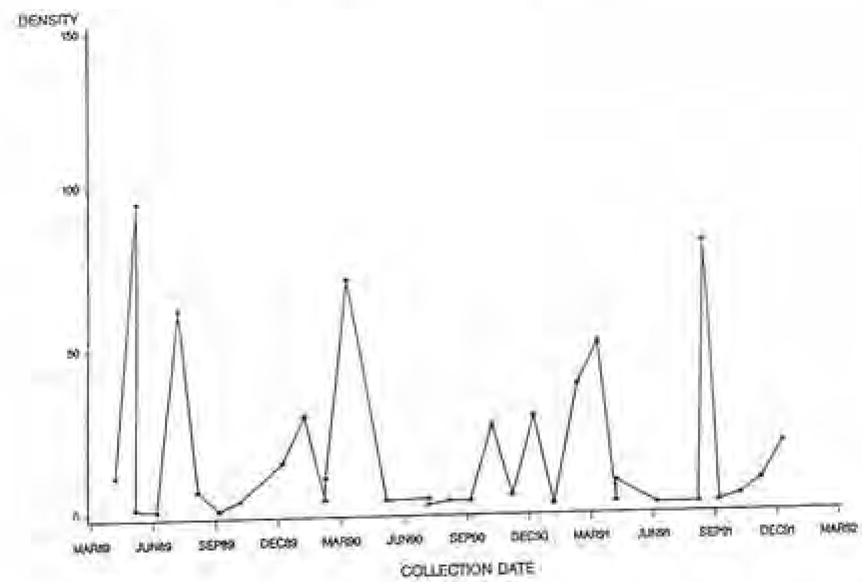
Total Density (#/m3 x 1000) of Rotifera Collected
At All Stations, Surface Sample
Station = 6 ppt



Total Density (#/m3 x 1000) of Rotifera Collected
At All Stations, Surface Sample
Station = 12 ppt



Total Density (#/m3 x 1000) of Rotifera Collected
At All Stations, Surface Sample
Station = 20 ppt



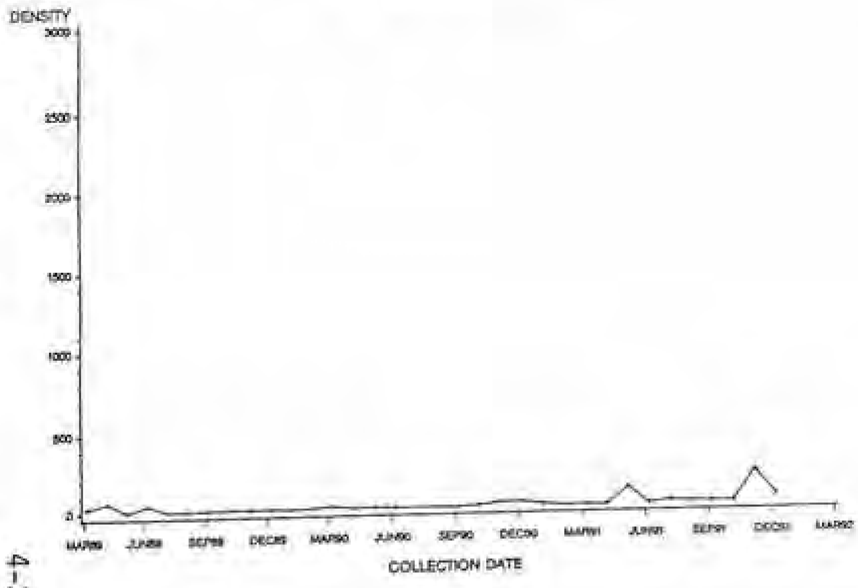
Copepod nauplii were the dominant plankter over all stations with densities as high as 2.6 million nauplii per m^3 (Figure 4.17). Peaks in zooplankton nauplii occurred in different stations at different seasons. This may indicate that different copepod species were reproducing at different stations. This may also indicate a differential response to salinity or other estuarine factors associated with salinity of reproductive timing by widely distributed copepod species (e.g. *Acartia tonsa*). Peak abundances of nauplii did roughly correspond at times, specifically late spring at all stations with secondary peaks generally in the fall. Copepod nauplii were approximately similar in the proportion of the zooplankton community found at 6, 12, and 20 ppt.

The calanoid copepod *Acartia tonsa* was by far the dominant copepod species found at any salinity zone with high densities occurring at 6 and 12 ppt salinities with reported densities as high as 1 million per m^3 (Figure 4.18). Other species of copepod crustaceans were generally absent from the 0 ppt salinity waters. Species of the genus, *Oithona*, were most abundant at the 20 ppt salinity waters, less abundant at 12 and 6 ppt, and occurring infrequently at 0 ppt (Figure 4.19). Other species of the dominant crustaceans (copepod genera *Clausocalanus arcuicornis, Paracalanus crassirostris, and Saphirella* sp. and Branchiopod and Cumacean crustaceans) followed similar trends to *Oithona*, but occurred at much lower densities than did either *Acartia tonsa* or *Oithona* species (Figures 4.20 through 4.24).

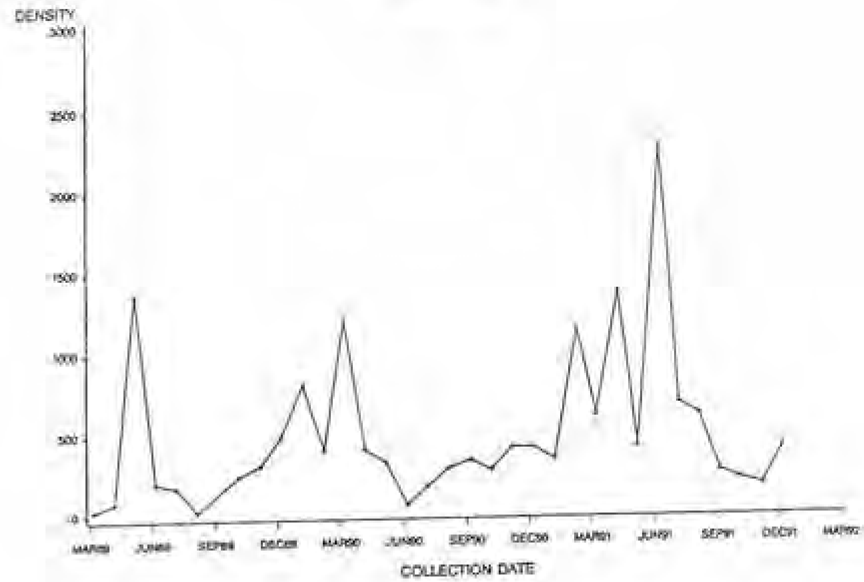
Zooplankton collections from the four salinity stations of Charlotte Harbor also showed periodic high densities of larval forms of various invertebrates and fish. Zero ppt salinity had episodic high densities of larval fish and fish eggs as did 20 ppt salinity waters. All salinities sampled frequently had large numbers of invertebrate larvae such

FIGURE 4.17

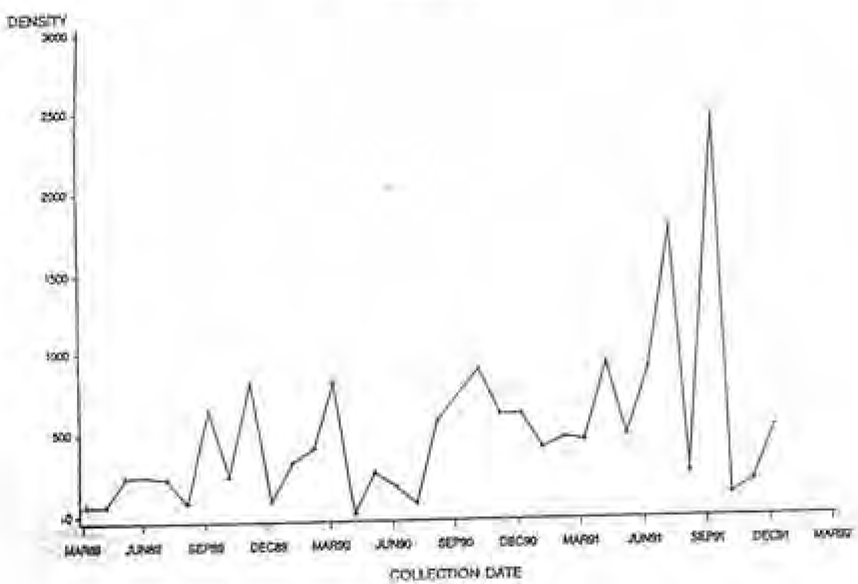
Total Density (#/m3 x 1000) of Copepoda Nauplii Collected
At All Stations, Surface Sample
Station=0 ppt



Total Density (#/m3 x 1000) of Copepoda Nauplii Collected
At All Stations, Surface Sample
Station=6 ppt



Total Density (#/m3 x 1000) of Copepoda Nauplii Collected
At All Stations, Surface Sample
Station=12 ppt



Total Density (#/m3 x 1000) of Copepoda Nauplii Collected
At All Stations, Surface Sample
Station=20 ppt

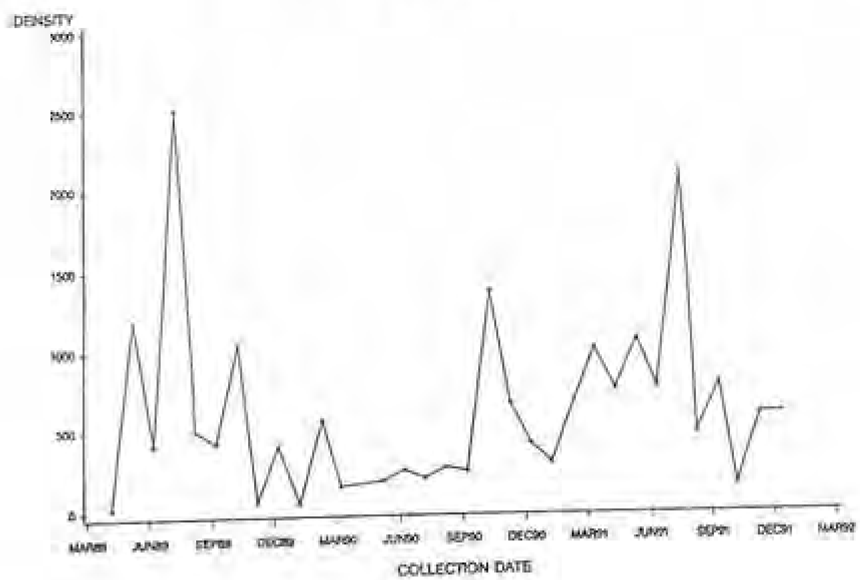
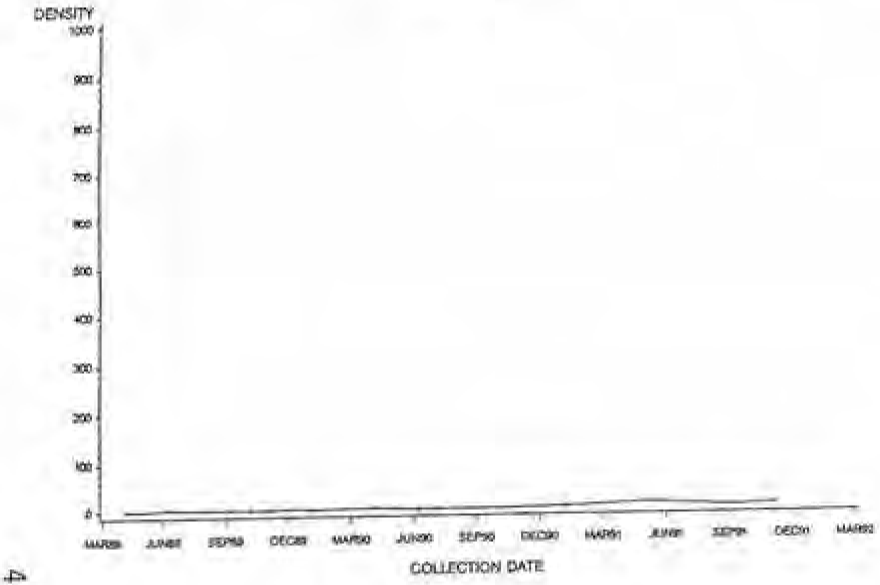
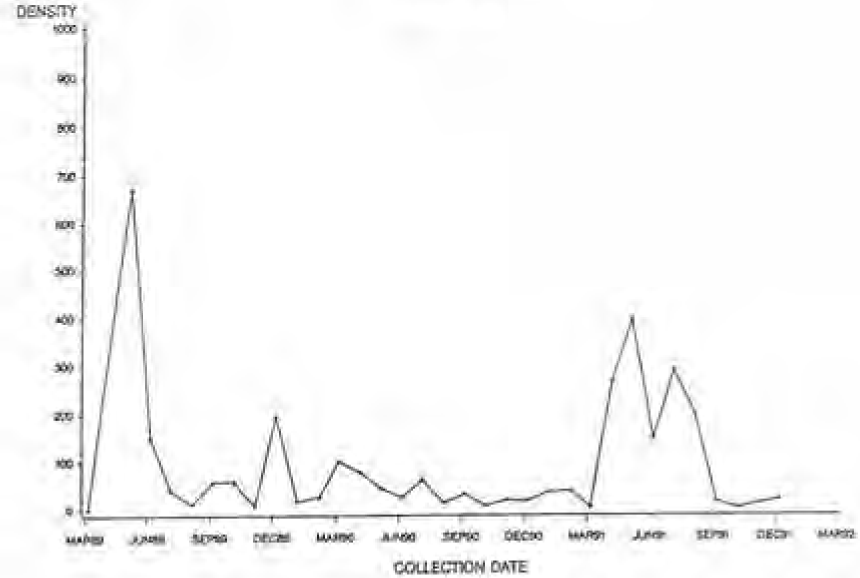


FIGURE 4.18

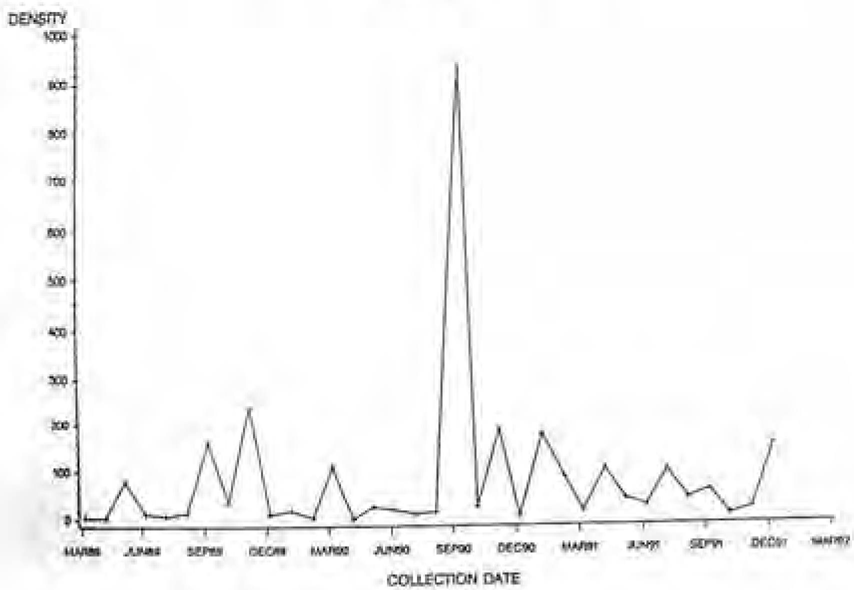
Total Density (#/m3 x 1000) of Acartia tonsa Collected
At All Stations, Surface Sample
Station = 0 ppt



Total Density (#/m3 x 1000) of Acartia tonsa Collected
At All Stations, Surface Sample
Station = 6 ppt



Total Density (#/m3 x 1000) of Acartia tonsa Collected
At All Stations, Surface Sample
Station = 12 ppt



Total Density (#/m3 x 1000) of Acartia tonsa Collected
At All Stations, Surface Sample
Station = 20 ppt

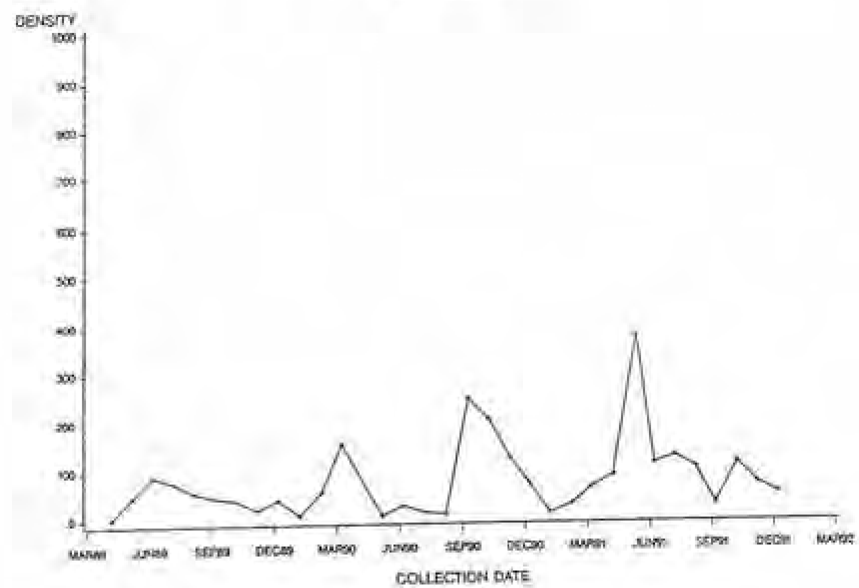
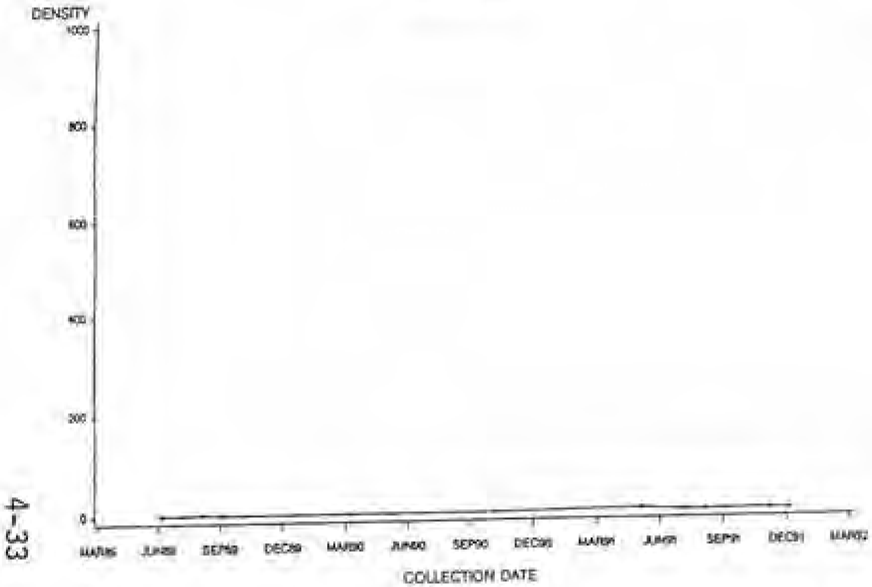
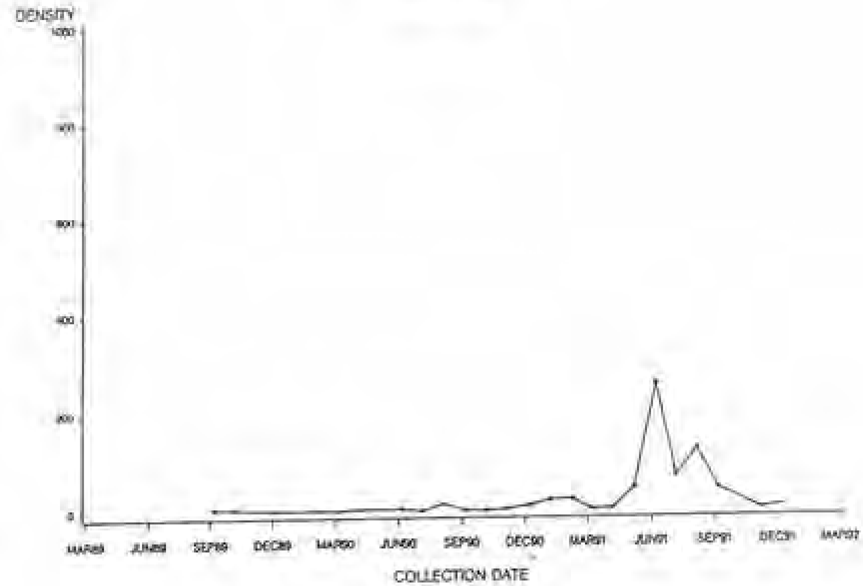


FIGURE 4.19

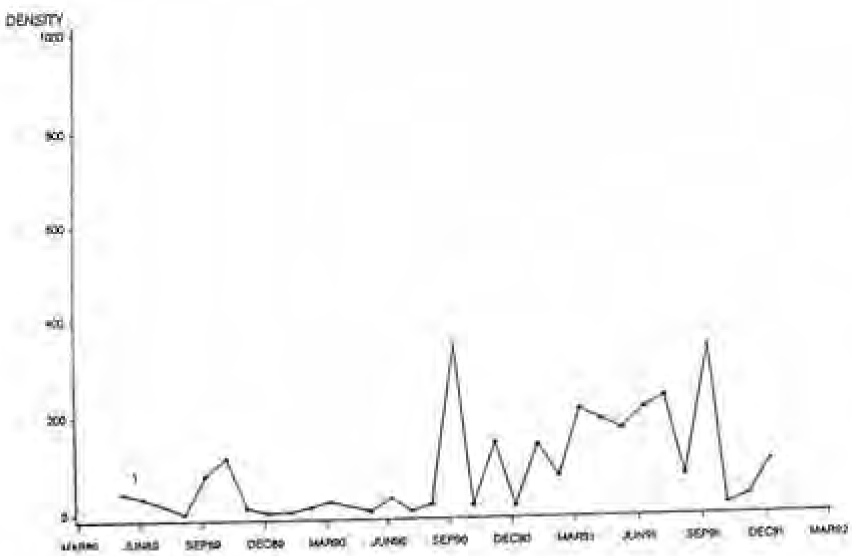
Total Density (#/m3 x 1000) of Oithona sp.
At All Stations, Surface Sample
Station = 0 ppt



Total Density (#/m3 x 1000) of Oithona sp.
At All Stations, Surface Sample
Station = 6 ppt



Total Density (#/m3 x 1000) of Oithona sp.
At All Stations, Surface Sample
Station = 12 ppt



Total Density (#/m3 x 1000) of Oithona sp.
At All Stations, Surface Sample
Station = 20 ppt

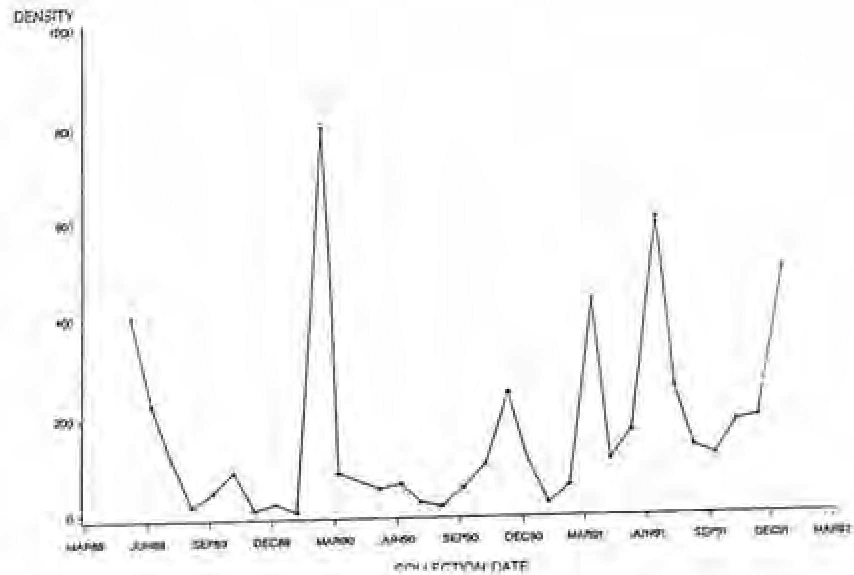


FIGURE 4.20

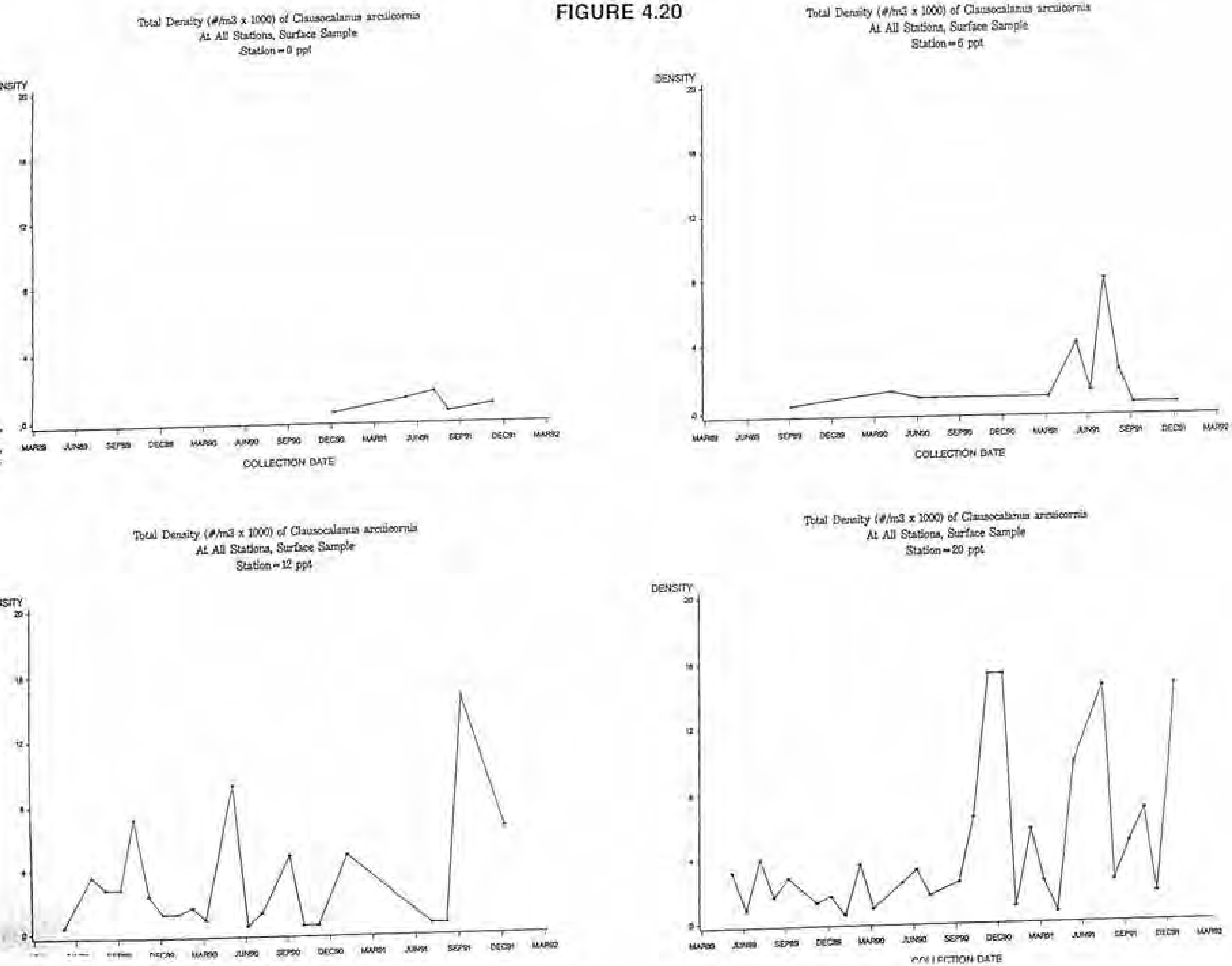

Total Density (#/m3 x 1000) of Clausocalanus arcuicornis
At All Stations, Surface Sample
Station = 0 ppt
DENSITY
COLLECTION DATE
MAR89 JUN89 SEP89 DEC89 MAR90 JUN90 SEP90 DEC90 MAR91 JUN91 SEP91 DEC91 MAR92
Total Density (#/m3 x 1000) of Clausocalanus arcuicornis
At All Stations, Surface Sample
Station = 6 ppt
DENSITY
COLLECTION DATE
Total Density (#/m3 x 1000) of Clausocalanus arcuicornis
At All Stations, Surface Sample
Station = 12 ppt
DENSITY
Total Density (#/m3 x 1000) of Clausocalanus arcuicornis
At All Stations, Surface Sample
Station = 20 ppt
DENSITY

FIGURE 4.21

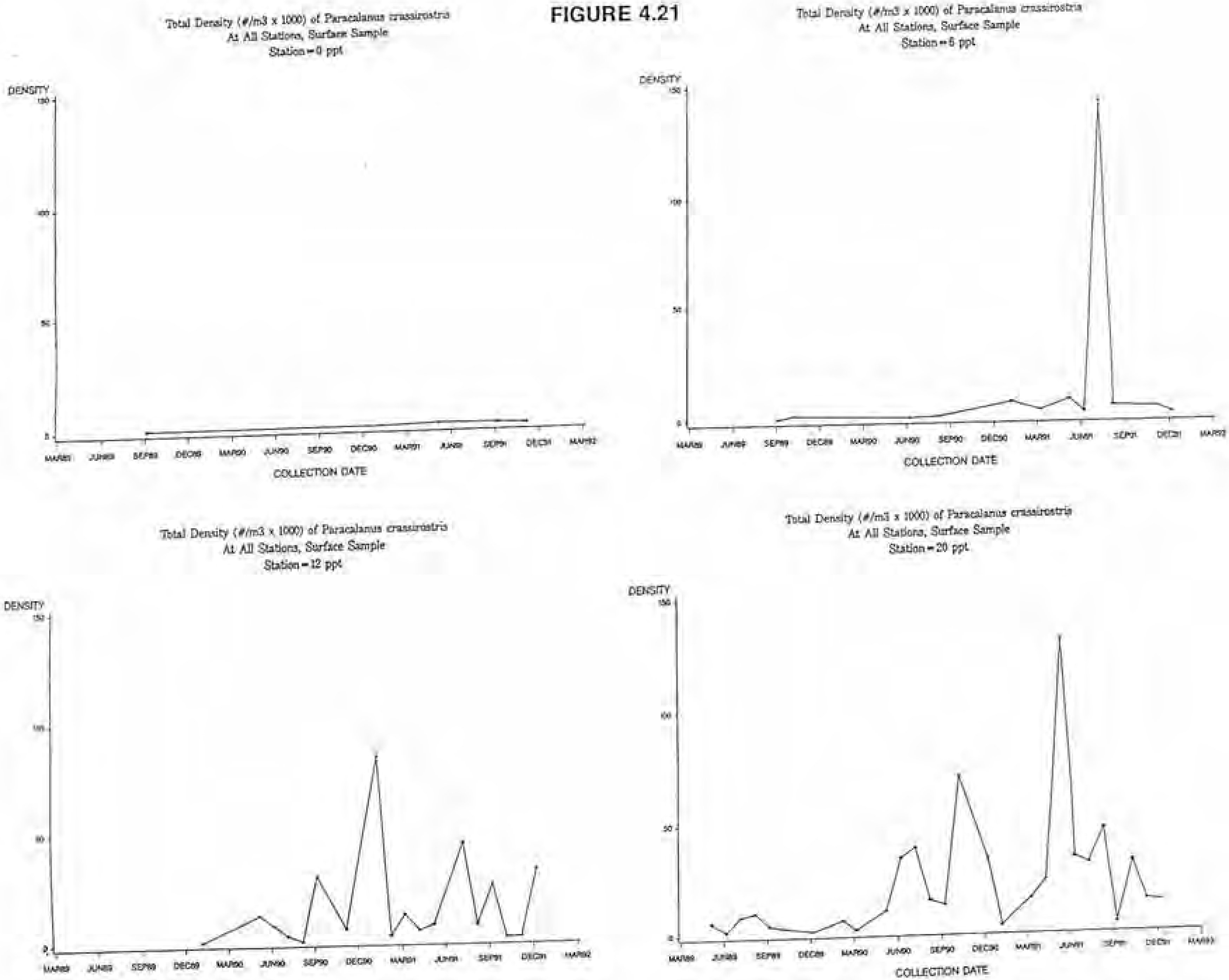
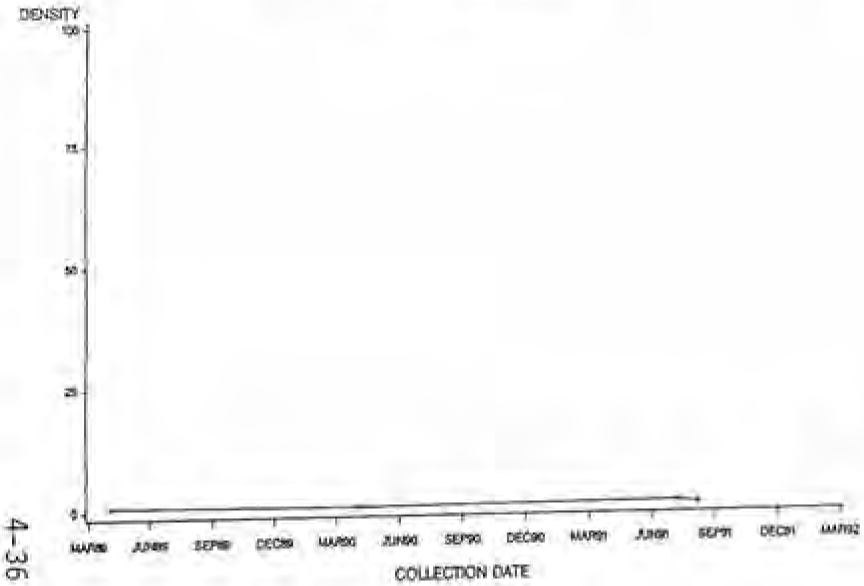
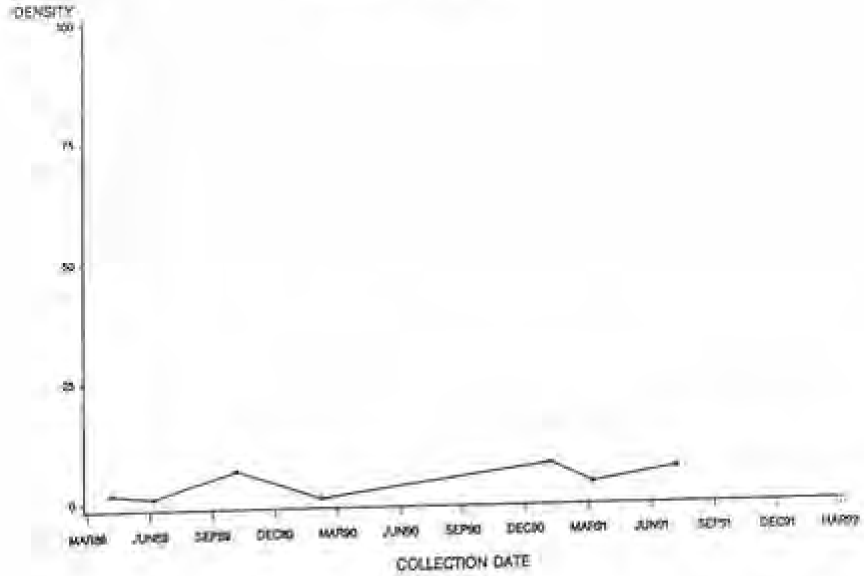

Total Density (#/m3 x 1000) of Paracalanus crassirostris
At All Stations, Surface Sample
Station=0 ppt
DENSITY
COLLECTION DATE
Total Density (#/m3 x 1000) of Paracalanus crassirostris
At All Stations, Surface Sample
Station=6 ppt
DENSITY
COLLECTION DATE
Total Density (#/m3 x 1000) of Paracalanus crassirostris
At All Stations, Surface Sample
Station=12 ppt
DENSITY
COLLECTION DATE
Total Density (#/m3 x 1000) of Paracalanus crassirostris
At All Stations, Surface Sample
Station=20 ppt
DENSITY
COLLECTION DATE

FIGURE 4.22

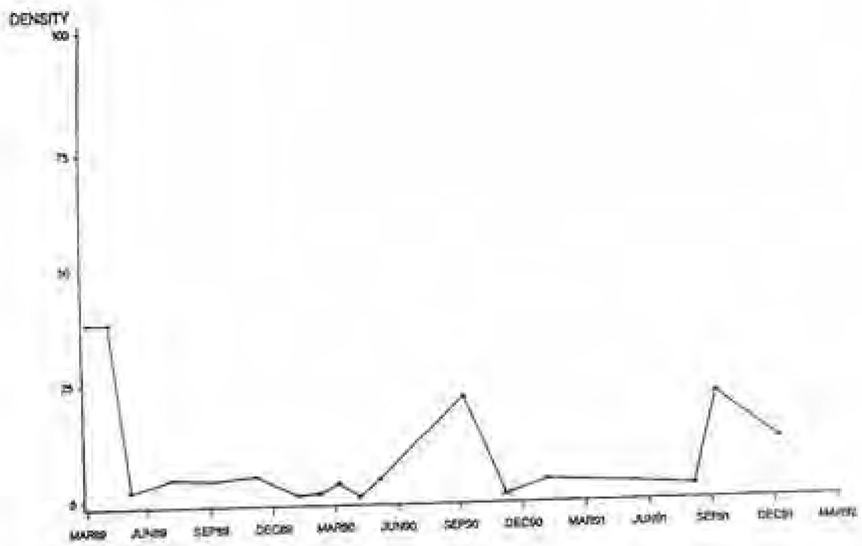
Total Density (#/m3 x 1000) of Saphirella Collected
At All Stations, Surface Sample
Station = 0 ppt



Total Density (#/m3 x 1000) of Saphirella Collected
At All Stations, Surface Sample
Station = 6 ppt



Total Density (#/m3 x 1000) of Saphirella Collected
At All Stations, Surface Sample
Station = 12 ppt



Total Density (#/m3 x 1000) of Saphirella Collected
At All Stations, Surface Sample
Station = 20 ppt

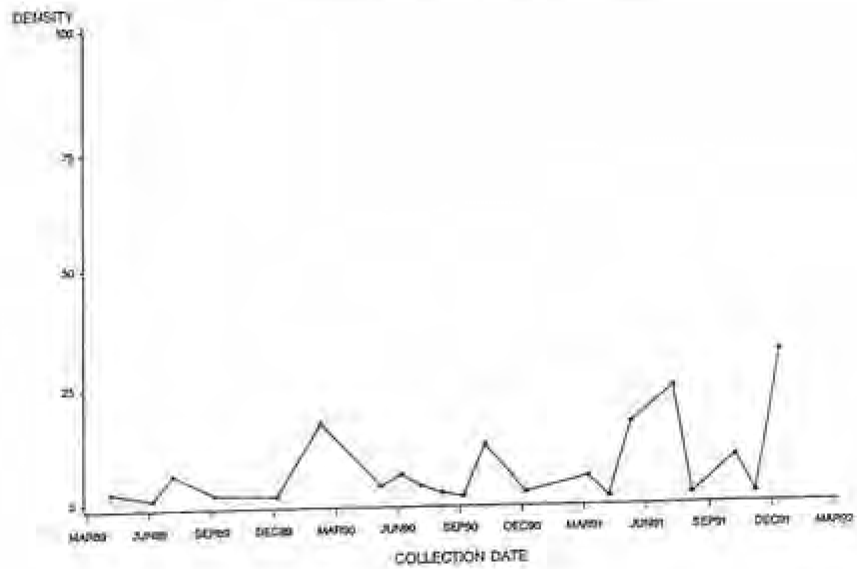
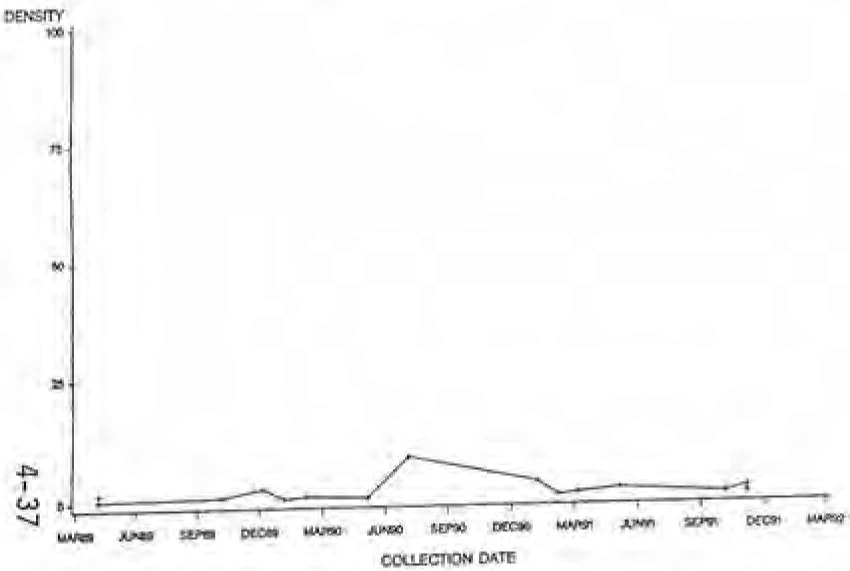
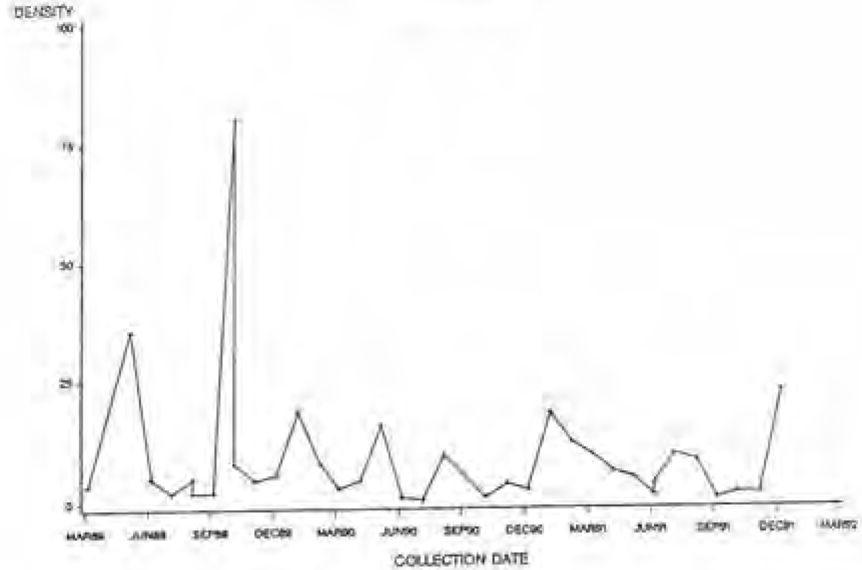


FIGURE 4.23

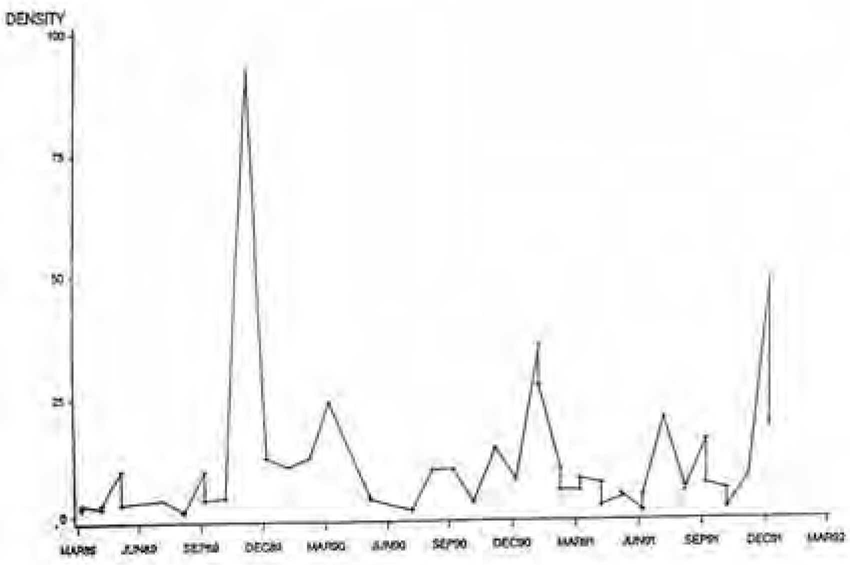
Total Density (#/m3 x 1000) of Cumacea Collected
At All Stations, Surface Sample
Station = 0 ppt



Total Density (#/m3 x 1000) of Cumacea Collected
At All Stations, Surface Sample
Station = 6 ppt



Total Density (#/m3 x 1000) of Cumacea Collected
At All Stations, Surface Sample
Station = 12 ppt



Total Density (#/m3 x 1000) of Cumacea Collected
At All Stations, Surface Sample
Station = 20 ppt

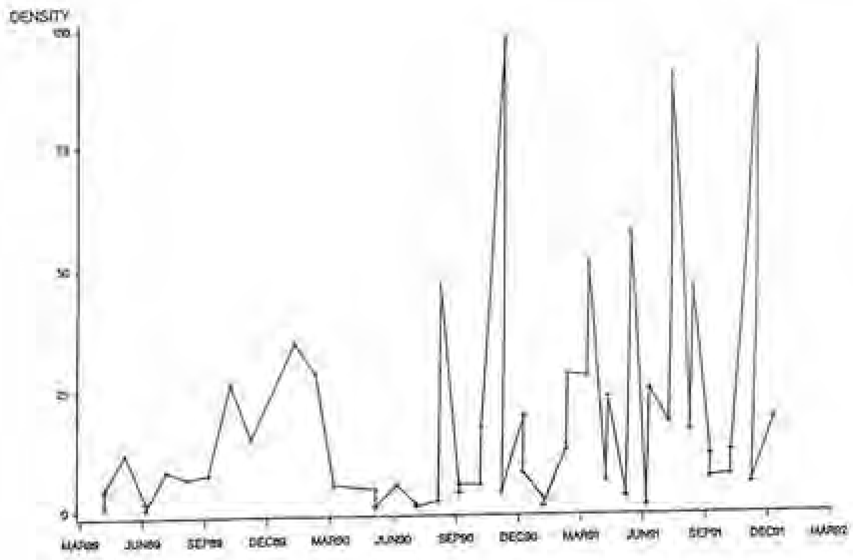
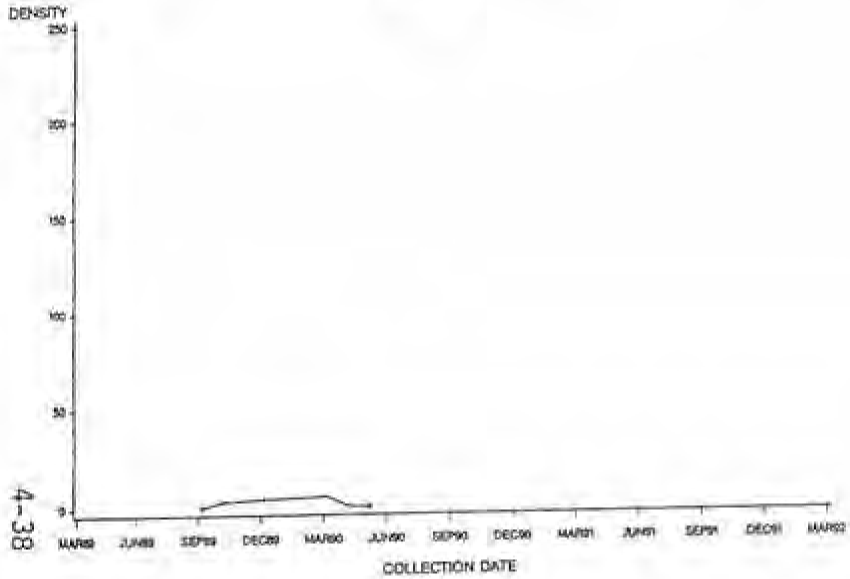
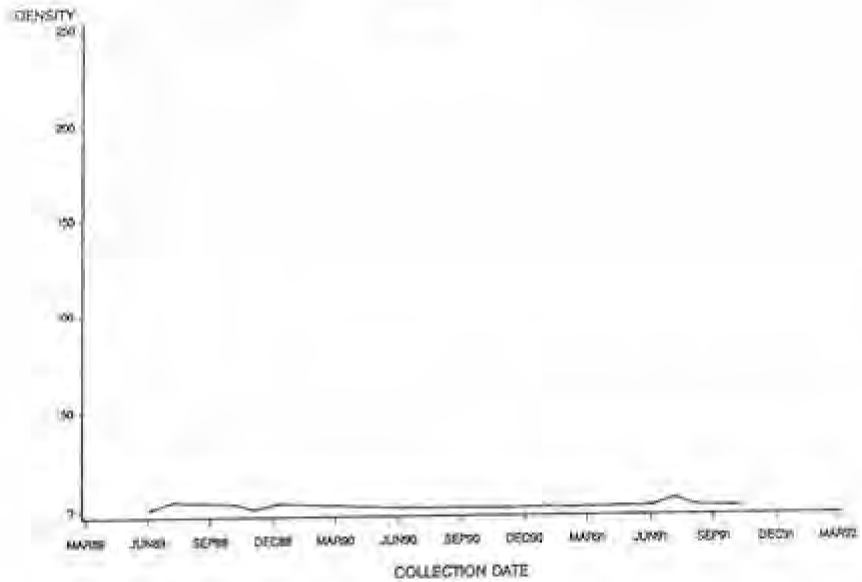


FIGURE 4.24

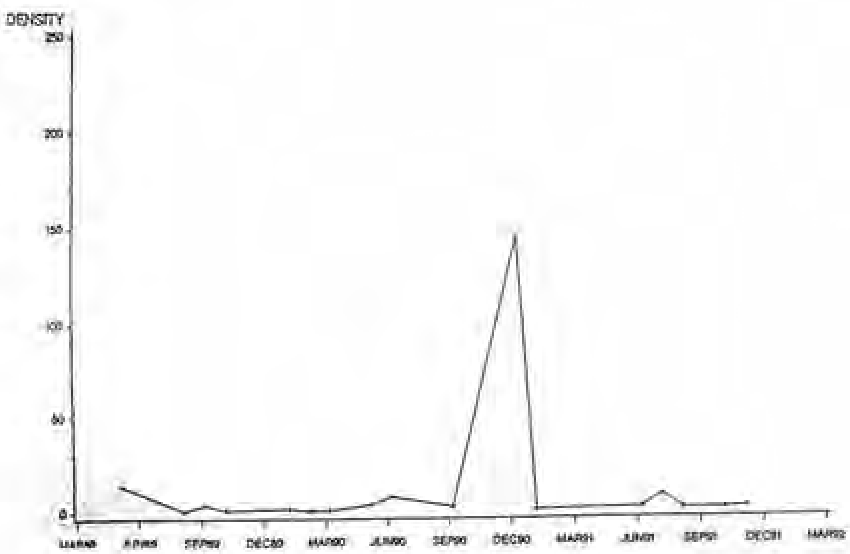
Total Density (#/m3 x 1000) of Branchipoda Cladocerans Collected
At All Stations, Surface Sample
Station = 0 ppt



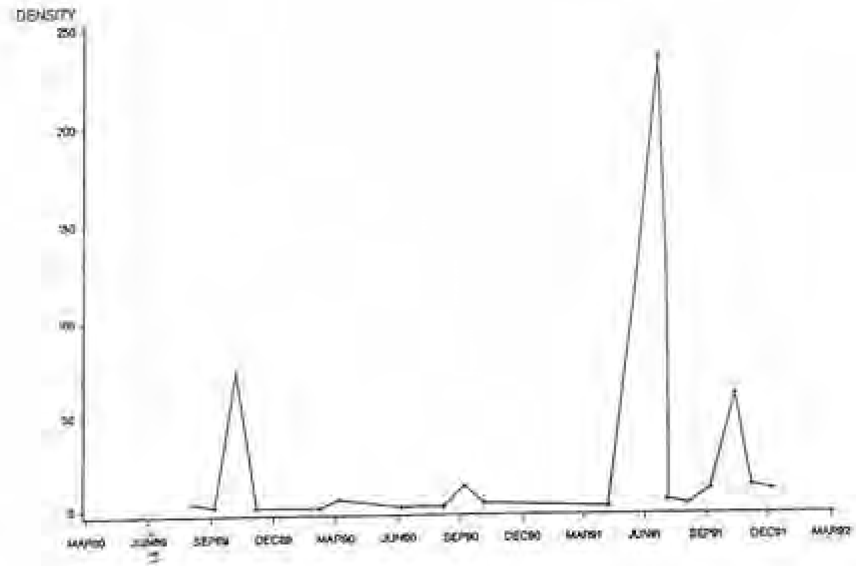
Total Density (#/m3 x 1000) of Branchipoda Cladocerans Collected
At All Stations, Surface Sample
Station = 6 ppt



Total Density (#/m3 x 1000) of Branchipoda Cladocerans Collected
At All Stations, Surface Sample
Station = 12 ppt



Total Density (#/m3 x 1000) of Branchipoda Cladocerans Collected
At All Stations, Surface Sample
Station = 20 ppt



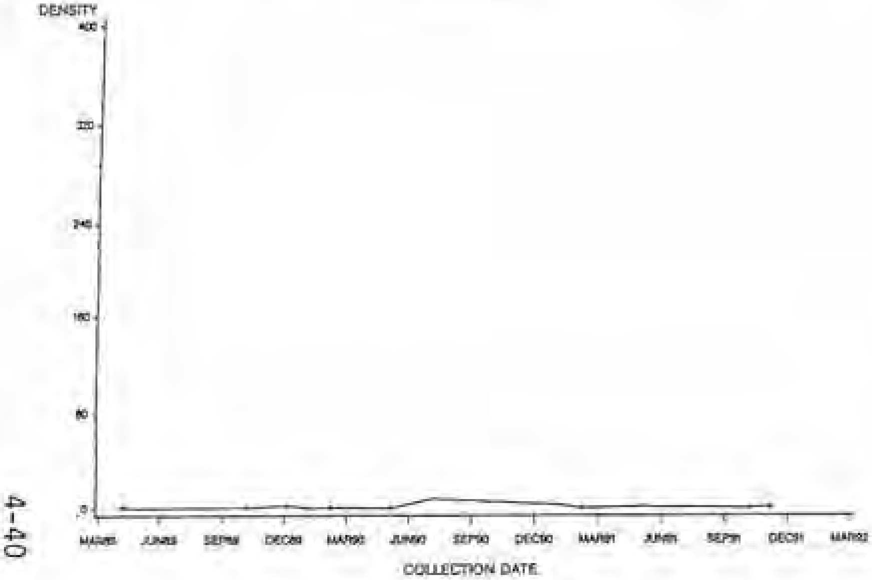
as Echinoderms, Gastropods, and Polychaetes as well as crustacean Cirripedia nauplii. Stations 6, 12, and 20 generally had the highest densities of these larval forms, although high densities of gastropods were reported from 0 ppt waters (Figure 4.25 through 4.27).

Other zooplankton groups frequently occurred in high densities at the higher salinity stations. These include invertebrates such as: Turbellaria (Figure 4.28), Hydroza (both meduase and sessile forms), and Schyphazoa as well as chordate taxa such as: Hemichordates, Urochordates, and Larvaceans. Other taxa such as Ctenophores and Sipunculids (Figure 4.29), and Annelid worms were more abundant at the lower salinity stations of 6 ppt and frequently occurred at 0 ppt.

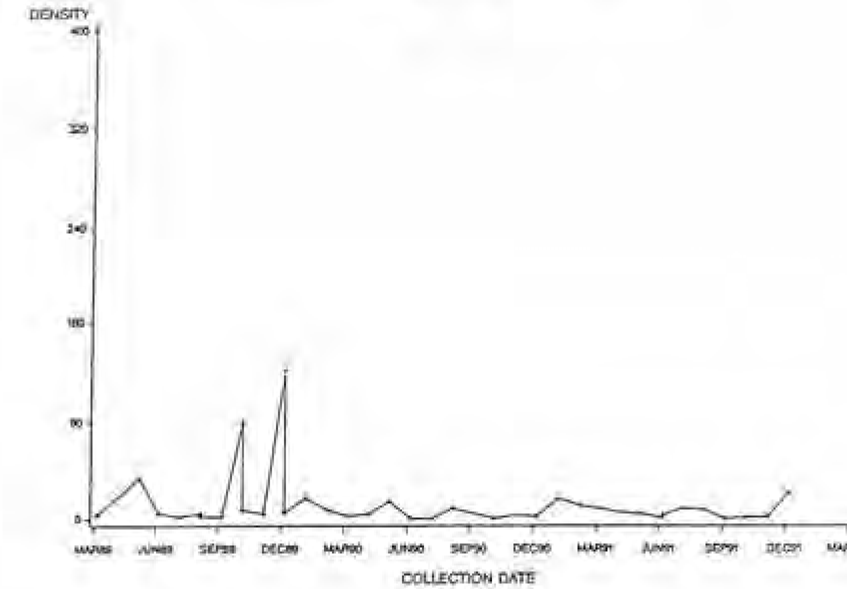
Multivariate analyses of taxonomic distributions between stations using Canonical Variate Analyses (CVA) indicated distinct taxa patterns within stations that discriminated between the stations in terms of both taxonomic composition and abundances. In this analyses, taxa that accounted for more than five percent of the overall density across stations were used to try to discriminate between salinity zones. Each individual taxa represents a dimension in multi-dimensional space that represents overall zooplankton distributions among all salinities sampled. CVA constructs the axis from all the species that best separates or discriminates between the salinities. CVA then constructs the next best axis with the proviso that the second axis be independent or orthoganal to previously constructed axes. This is repeated until the number of axis constructed is one less than the number of groups being discriminated, in this case four salinity zones yields three possible independent axes or Canonical Variates (CV's). These axes or CV's are composite variables made up of the original species or taxa used in the analyses. This in effect, reduces dimensionality of zooplankton from the number of original taxa to just

FIGURE 4.25

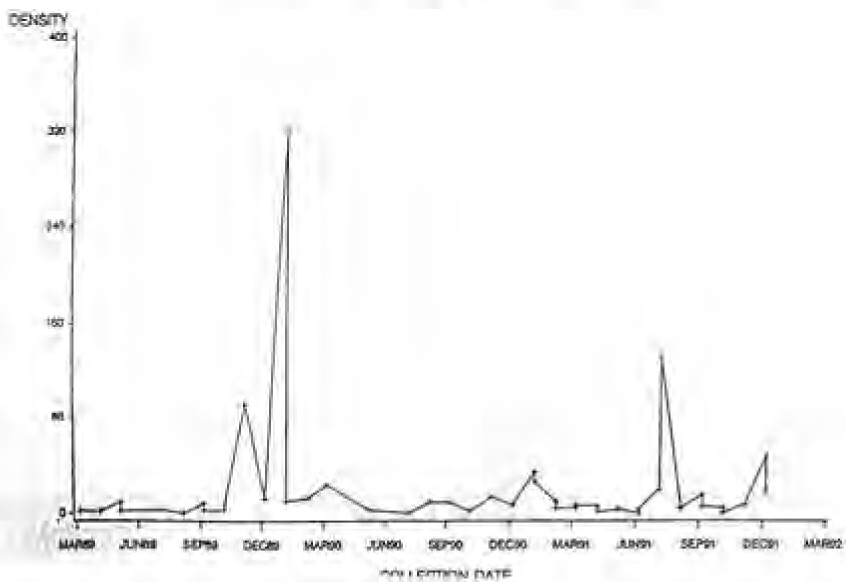
Total Density (#/m3 x 1000) of Cirripeda Nauplii Collected
At All Stations, Surface Sample
Station = 0 ppt



Total Density (#/m3 x 1000) of Cirripeda Nauplii Collected
At All Stations, Surface Sample
Station = 6 ppt



Total Density (#/m3 x 1000) of Cirripeda Nauplii Collected
At All Stations, Surface Sample
Station = 12 ppt



Total Density (#/m3 x 1000) of Cirripeda Nauplii Collected
At All Stations, Surface Sample
Station = 20 ppt

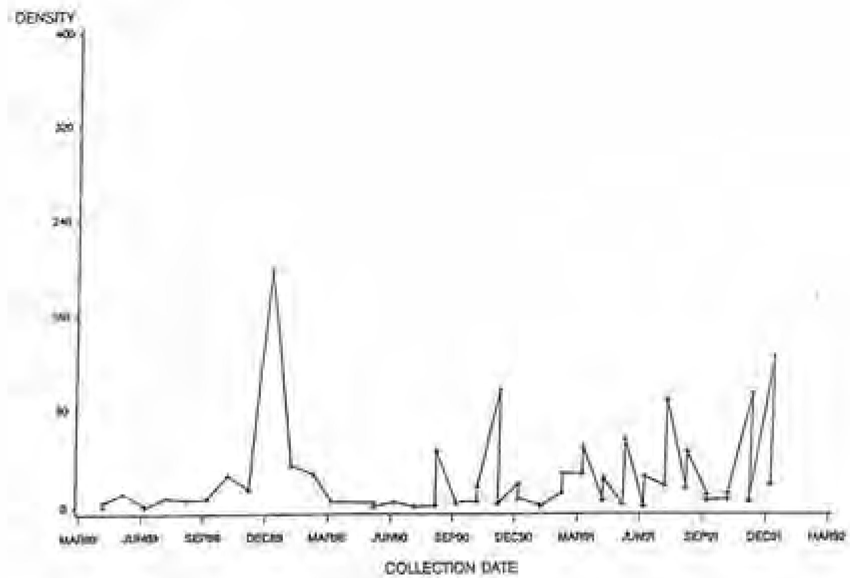
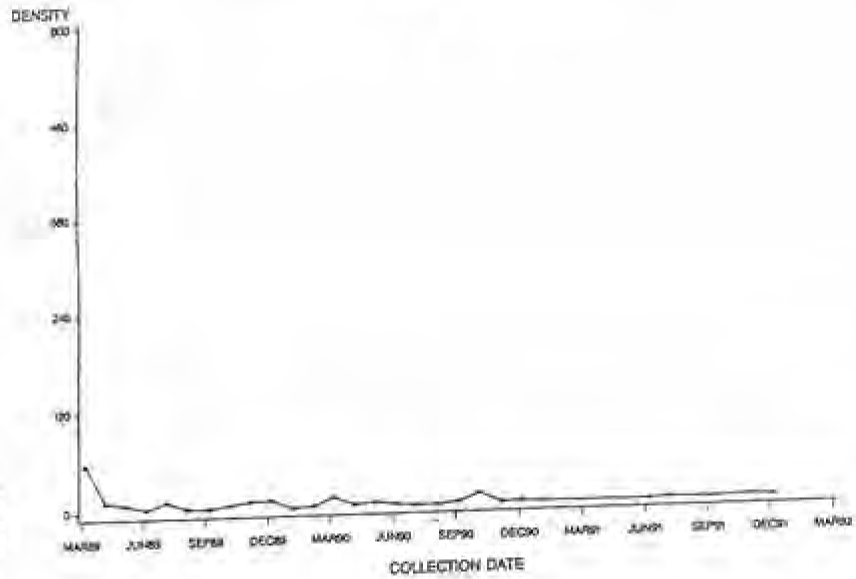
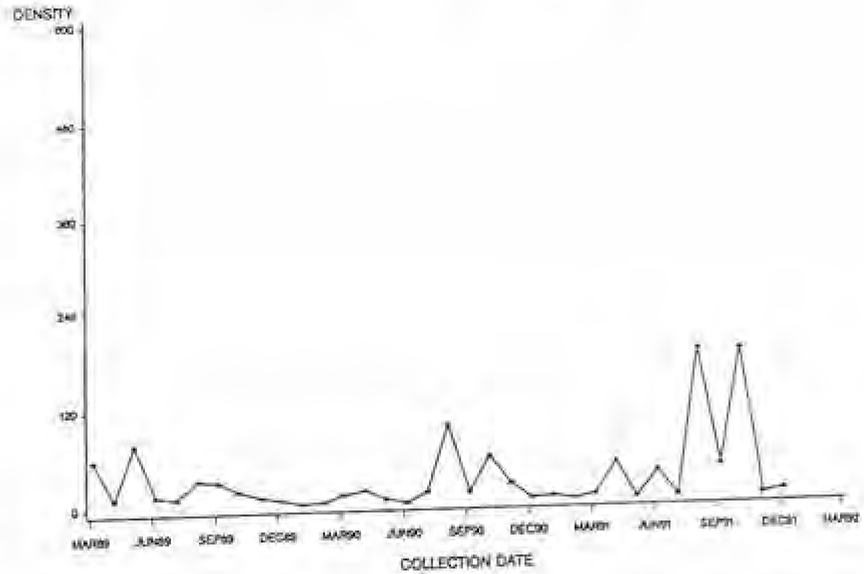


FIGURE 4.26

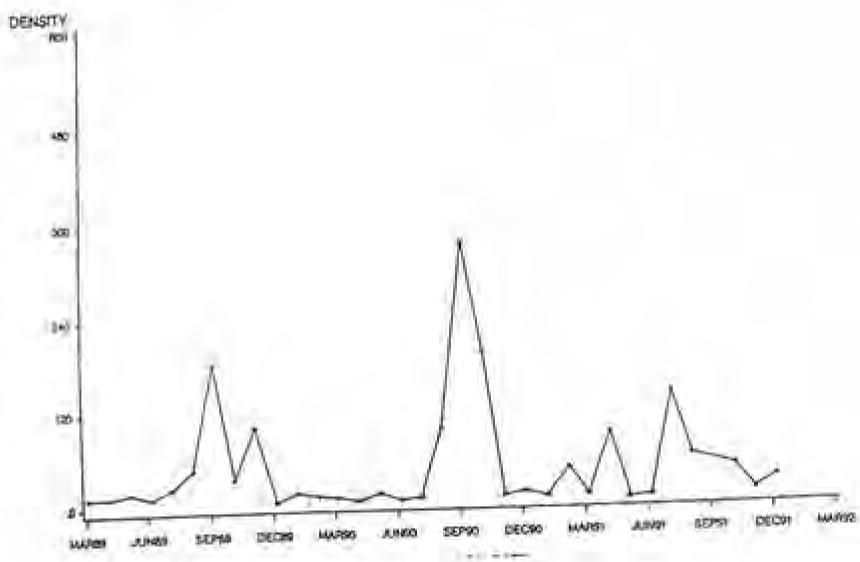
Total Density (#/m3 x 1000) of Polychaeta Collected
At All Stations, Surface Sample
Station = 0 ppt



Total Density (#/m3 x 1000) of Polychaeta Collected
At All Stations, Surface Sample
Station = 6 ppt



Total Density (#/m3 x 1000) of Polychaeta Collected
At All Stations, Surface Sample
Station = 12 ppt



Total Density (#/m3 x 1000) of Polychaeta Collected
At All Stations, Surface Sample
Station = 20 ppt

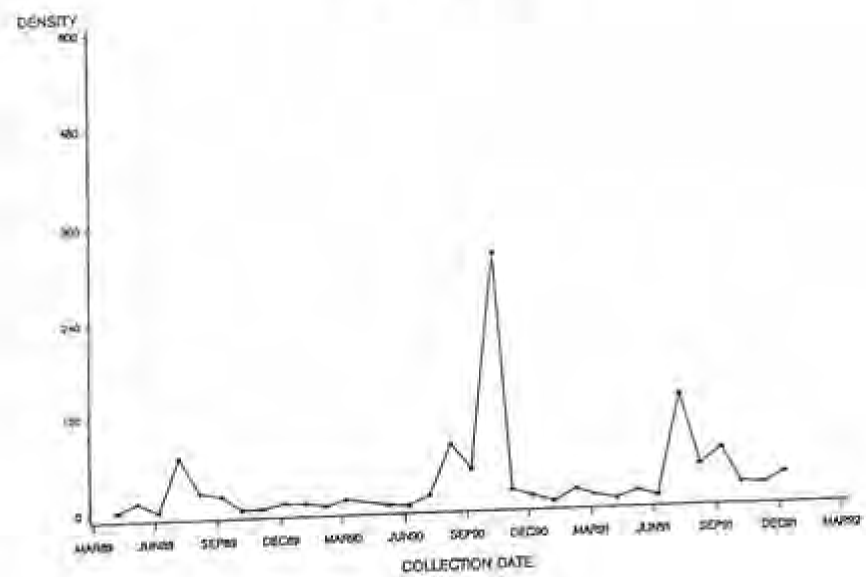
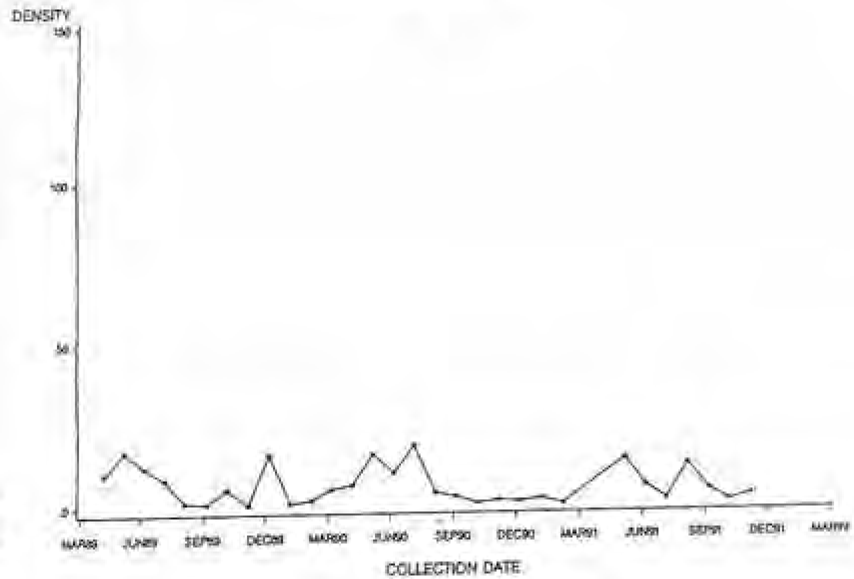
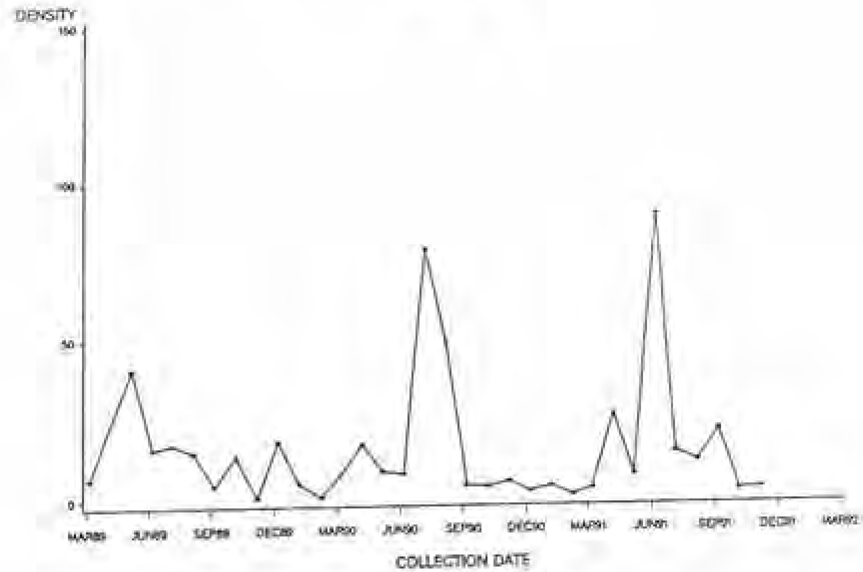


FIGURE 4.27

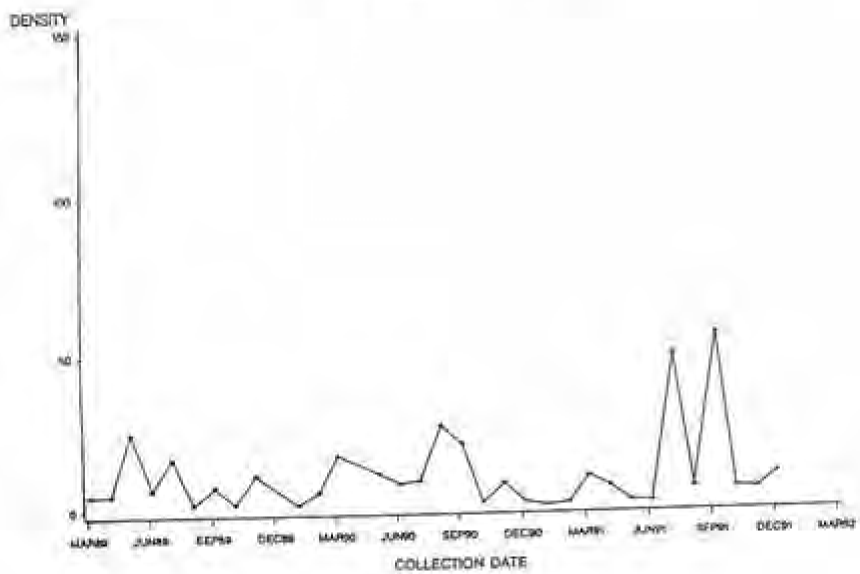
Total Density (#/m3 x 1000) of Gastropod Larvae
At All Stations, Surface Sample
Station = 0 ppt



Total Density (#/m3 x 1000) of Gastropod Larvae
At All Stations, Surface Sample
Station = 6 ppt



Total Density (#/m3 x 1000) of Gastropod Larvae
At All Stations, Surface Sample
Station = 12 ppt



Total Density (#/m3 x 1000) of Gastropod Larvae
At All Stations, Surface Sample
Station = 20 ppt

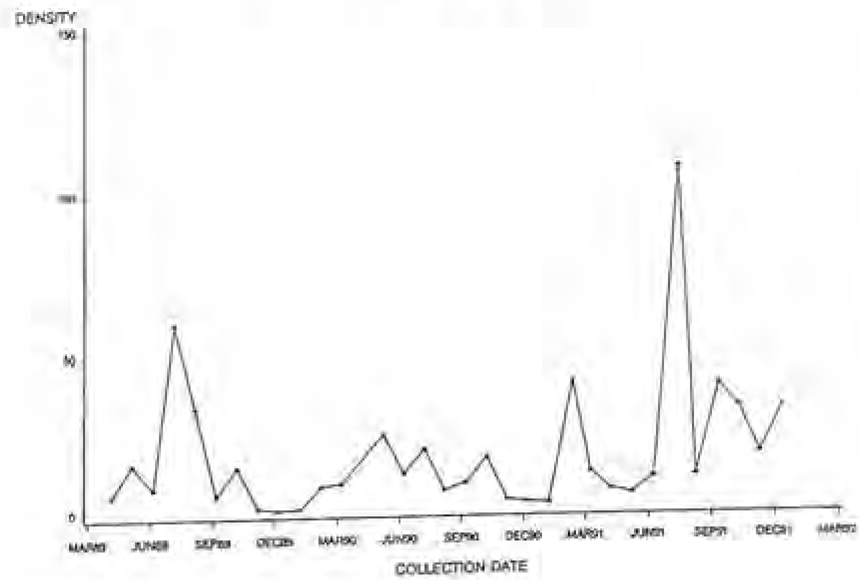
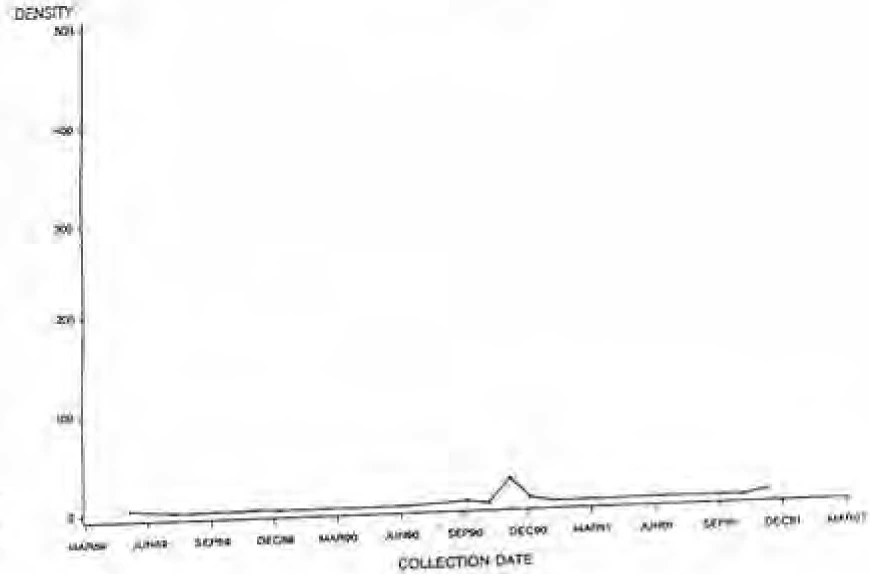
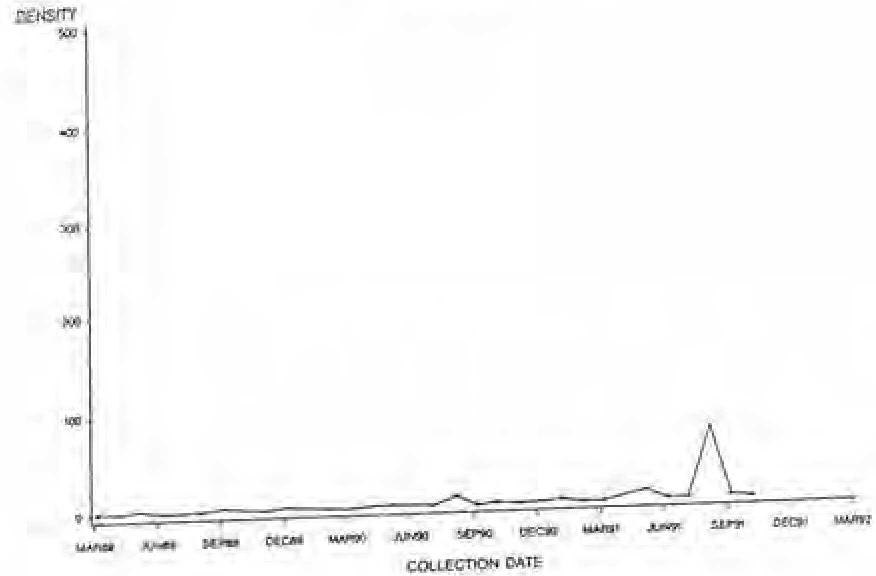


FIGURE 4.28

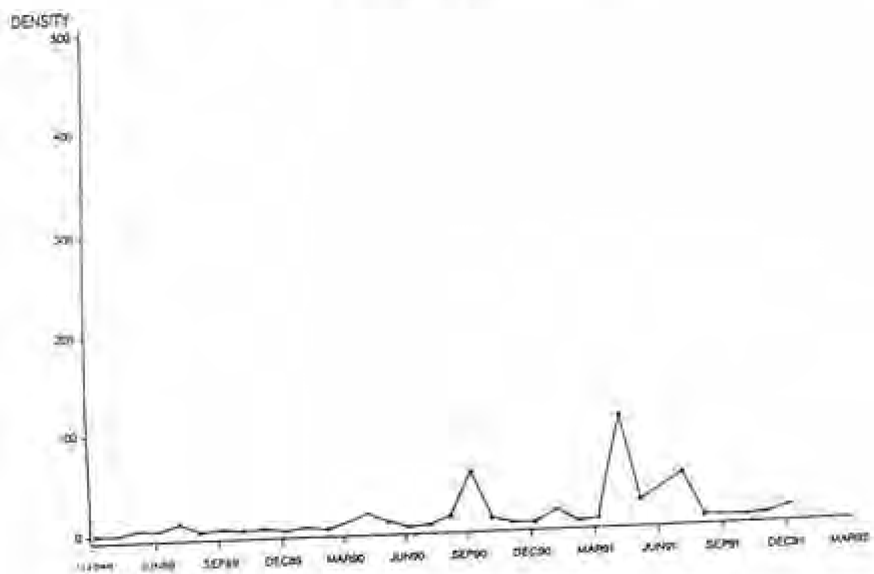
Total Density (#/m3 x 1000) of Turbellaria
At All Stations, Surface Sample
Station = 0 ppt



Total Density (#/m3 x 1000) of Turbellaria
At All Stations, Surface Sample
Station = 5 ppt



Total Density (#/m3 x 1000) of Turbellaria
At All Stations, Surface Sample
Station = 12 ppt



Total Density (#/m3 x 1000) of Turbellaria
At All Stations, Surface Sample
Station = 20 ppt

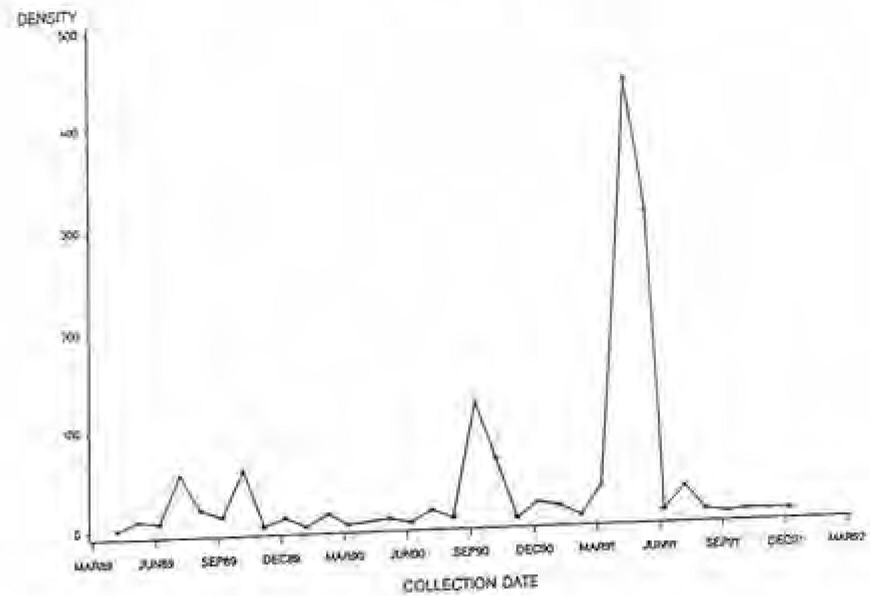
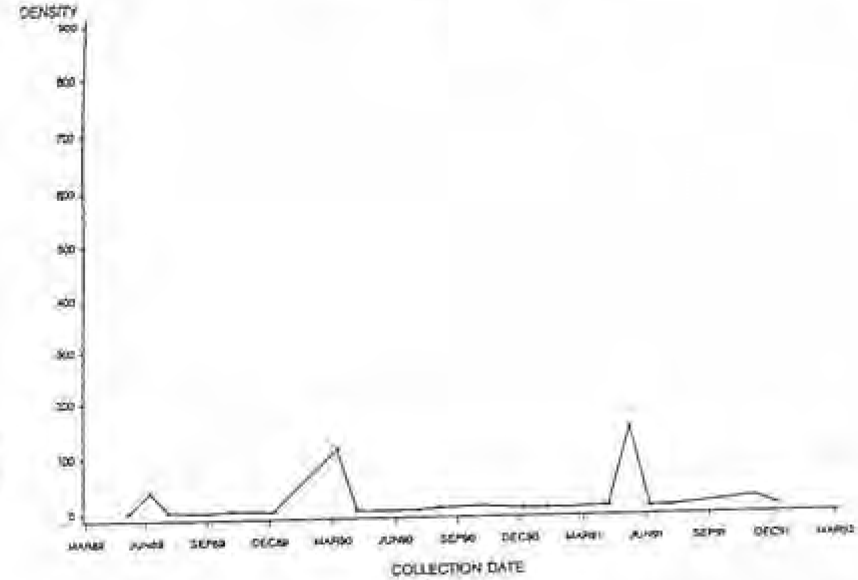
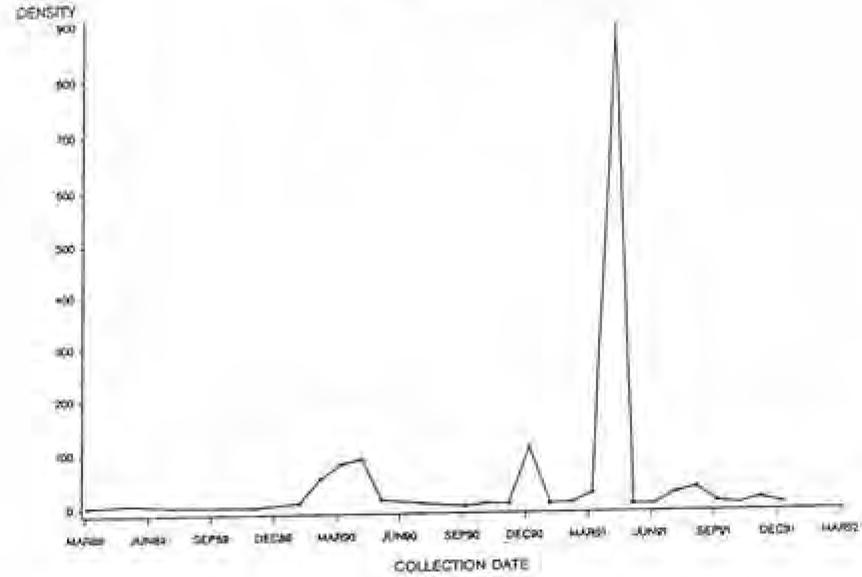


FIGURE 4.29

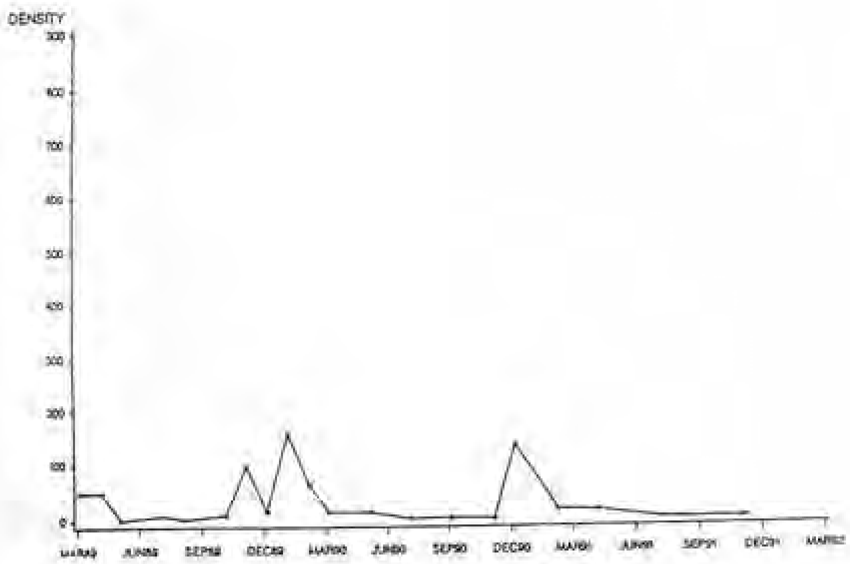
Total Density (#/m3 x 1000) of Sipunculida
At All Stations, Surface Sample
Station = 0 ppt



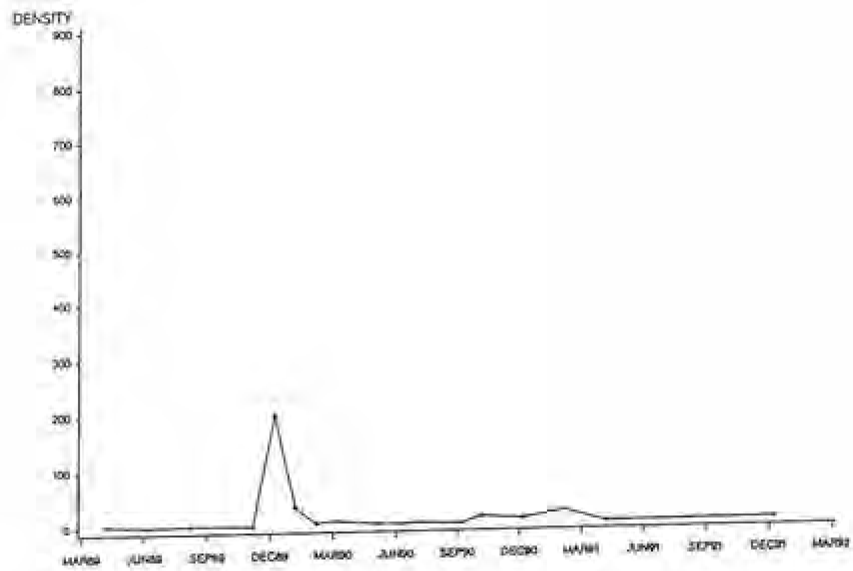
Total Density (#/m3 x 1000) of Sipunculida
At All Stations, Surface Sample
Station = 6 ppt



Total Density (#/m3 x 1000) of Sipunculida
At All Stations, Surface Sample
Station = 12 ppt



Total Density (#/m3 x 1000) of Sipunculida
At All Stations, Surface Sample
Station = 20 ppt



a fewer composite variables or axis that describe the zooplankton community. Each original taxa has a correlation with each CV axis. A high correlation with the axis indicates that original taxa was useful in discriminating between the stations and contributed significantly towards separating the salinities based upon taxonomic abundances. In addition, all original observations can be transformed or "scored" into canonical variate space and represented as such.

The results of the canonical variate analysis are summarized in Table 4.2. From this analysis, two of the possible three canonical axes were significant. Correlations of the original taxa with the two significant canonical variates show that CV-I is positively correlated with increasing numbers of *Oithona* species, *Paracalanus crassirostris*, Ascidiancea, Cirripedia nauplii, and Turbellaria while being negatively correlated with Rotifer abundance (Table 4.3). A scoring of the original observations on CV-I would indicate that observations with positive scores had high abundances of Oithona species, *Paracalanus crassirostris*, Ascidiancea, Cirripedia nauplii, and Turbellaria and low numbers of rotifers. A negative score on CV-I indicated a high density of rotifers and low densities of Oithona, *Paracalanus crassirostris*, Ascidiancea, Cirripedia nauplii, and Turbellarians. A similar scoring procedure for the second axis indicated that a positive score on CV-II was high in Ctenophores and low in copepod nauplii, polychaete larvae and *Acartia tonsa* while negative scores indicated the opposite.

A plot of the original observations in the above described canonical variate space shows the discrimination between the stations with the means scores of each salinity plotted with 95 % confidence ellipses (Figure 4.30). Clear discrimination between stations is shown based upon taxonomic abundances with each station associated with a distinct

TABLE 4.2
RESULTS OF CANONICAL VARIATE ANALYSIS OF ZOOPLANKTON TAXA WITH SALINITY STATIONS.

Canonical Variate	Canonical Correlation	Eigenvalue	% Var Explained.	Cumulative. Var.
I	0.7352	1.177	0.712	0.712
II	0.5192	0.396	0.223	0.935
III	0.3132	0.109	0.065	1.000

Statistical Tests of Canonical Correlations for Significance

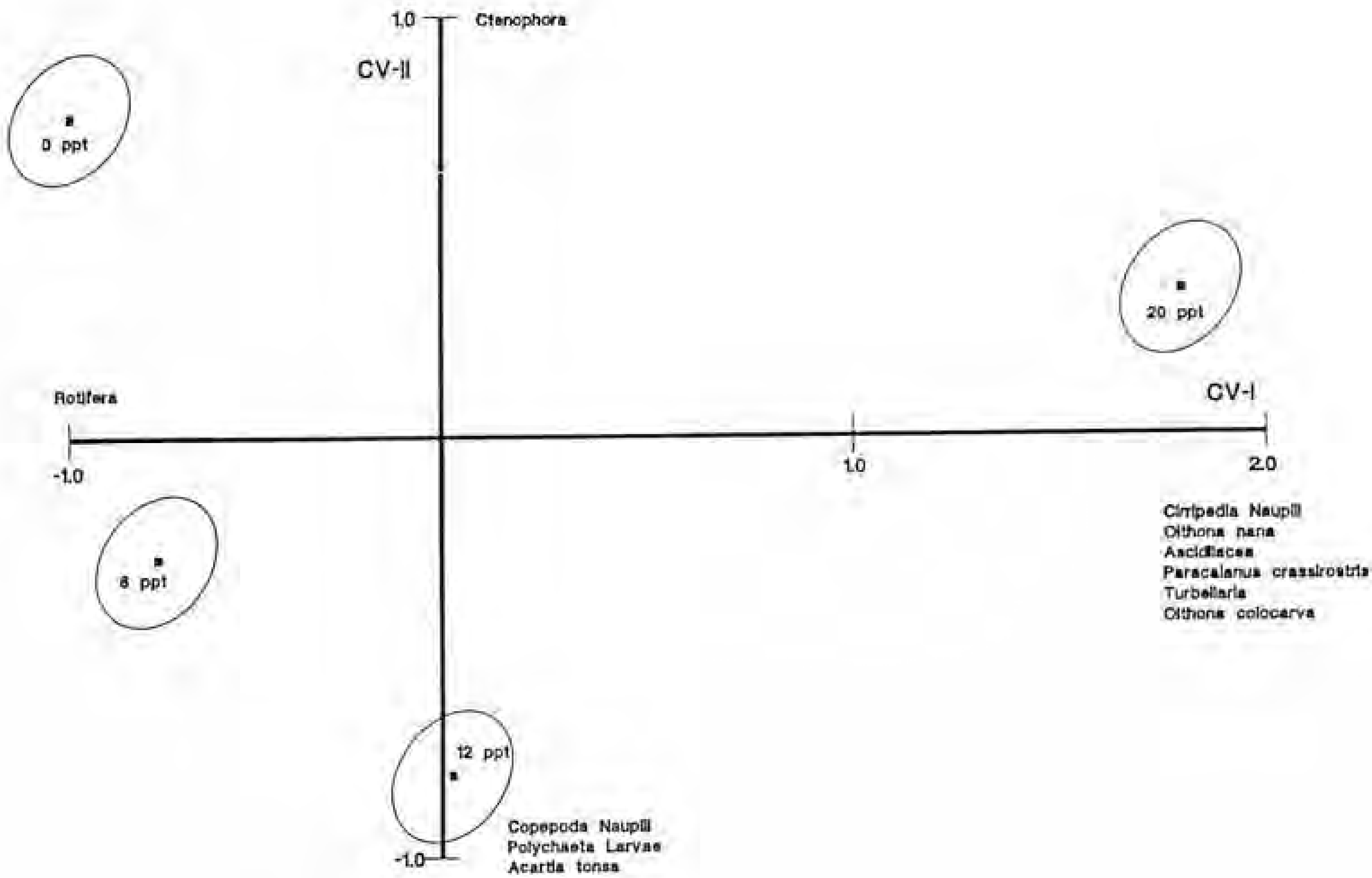
Canonical Variate	Approx. F	Num Df	Den Df	Prob > F.
I	3.295	51	340.20	0.0001
II	1.668	32	230.00	0.0176
III	0.841	15	116.00	0.6304

Table 4.3
Correlations of the Original Zooplankton Taxa With the Constructed Canonical Variates.

Zooplankton Taxa	Correlations CV-I	CV-II
Copepod Nauplii	0.132	-0.435*
Cumacea	-0.224	0.312
Polychaete Larvae	0.093	-0.453*
Rotifera	-0.538*	0.175
Sipunculids	0.089	-0.163
Acartia tonsa	0.176	-0.494*
Cirripedia Nauplii	0.481*	-0.235
Hemicordates	0.130	-0.285
Oithona sp.	0.402*	-0.089
Oithona nana	0.492*	-0.009
Oithona colocarva	0.401*	0.101
Pelecypod Larvae	0.282	-0.007
Annelids	0.088	-0.284
Hydrozoa medusae	0.388	0.169
Gastropod Larvae	-0.379	-0.311
Ascidiacea	0.611*	-0.181
Paracalanus crassirostris	0.427*	-0.084
Clausocalanus arcuicornis	0.558*	0.195
Turbellaria	0.414	0.099
Ctenophora	-0.006	0.441*
Polychaete Larvae	0.126	0.223

FIGURE 4.30

STATION MEANS WITH 95 % CONFIDENCE ELIPSES FOR CANONICAL VARIATE ANALYSES OF ZOOPLANKTON SPECIES DENSITY. AXES ARE LABELED WITH MAJOR TAXA ASSOCIATED WITH EACH CANONICAL VARIATE.



pattern of zooplankton distribution. This also shows the gradation in zooplankton communities with salinity from freshwater riverine conditions to more marine oriented species at station 20 ppt salinity.

4.3.2 Influence of Physical/Chemical Factors, Phytoplankton Distributions, and Productivity on Zooplankton Taxa.

Many estuarine and riverine factors may interact to affect zooplankton community structure and dynamics as well as individual species responses to their environment. These factors include such basic parameters as river flow, nutrient availability, water temperature, and season, to complex factors such as primary productivity levels, phytoplankton community composition, and chlorophyll a concentrations (sections 3 and 4 this report). It is difficult to even attempt to determine and describe causative relationships between these factors and zooplankton communities since zooplankton community and populations are dependent upon the cumulative responses to interactions of both the basic physical and chemical parameters as well as the complex factors influencing phytoplankton communities and productivity.

One widely used method for testing and describing such cumulative interactions is Principal Component Analysis. This technique, a subset of Factor Analysis, produces new synthetic variables (Factors) that are composites of the original independent variables. Each new Factor (or composite variable) created by this method is independent (uncorrelated) from every other new Factor. The ecological interpretation of these "new synthetic variables", as a result, is dependent only on their correlation (loadings) with the original measured variables. Each original sample observation can then be scored on the new synthetic composite Factors. Such scores are dependent both on the values for each of the original variables, and the correlations of these original parameters with the new synthetic factors. In essence, each sample can thus be described with respect to a small number of new independent composite variables (Factors) rather than the large number of physical and chemical parameters originally measured, while still preserving most of the ecologically relevant information contained within the original data set.

Principal component analysis was conducted using 29 physical, chemical, productivity, and phytoplankton community parameters originally measured during the primary production and phytoplankton community study (Sections 3 and 4) (Table 4.4). Analysis of the original variables indicated that 686 of the possible 812 intercorrelations of these physical and chemical parameters were statistically significant. All original observations were standardized or transformed to mean =0 and standard deviation=1 to adjust for differences in measurement scale and its potential effects on correlations of the original variables with the new composite factors. Since it was previously shown that zooplankton species and community responses were salinity specific, PCA and subsequent discussion of the results are done by salinity.

Zero o/oo Salinity

Three of the new synthetic composite variables (Factors 1 through 3), developed from the original 29 variables, were retained for further analysis. Each of these new Factors was selected on the basis of its accounting for at least 10% of the total variation within the original data set (Table 5a). Together these three new synthetic composite Factors accounted for 62 % of the statistical variance expressed in the original 29 variables.

TABLE 4.4.
THE ORIGINAL PHYSICAL/CHEMICAL, PRODUCTIVITY, and PHYTOPLANKTON VARIABLES USED FOR PRINCIPAL COMPONENT ANALYSIS.

ORIGINAL VARIABLE
Phytoplankton Species Richness
Phytoplankton Species Diversity
Abundance of Green Algae
Abundance of Flagellate Algae
Abundance of Dinoflagellate
Abundance of Diatoms
Abundance of Blue-Green Algae
Total Carbon Uptake (Productivity)
Productivity (Carbon Uptake) > 20 um
Productivity (Carbon Uptake) <20 and >5 um
Productivity (Carbon Uptake) < 5 um
Total Peace River Flow (Daily)
Total Peace River Flow (7 Day)
Total Peace River Flow (14 Day)
Total Peace River Flow (28 Day)
Color
Total Chlorophyll a
Chlorophyll > 20 um
Chlorophyll < 20 and > 5 um.
Chlorophyll < 5 um.
Nitrate+Nitrite (NO_2+NO_3-N)
Silica
Total Nitrogen
Total Phosphorous
Nitrogen/Phosphorous Ratio
Daily Freshwater Withdrawal
Average Daily Withdrawal (7 Days)
Average Daily Withdrawal (14 Days)

*** Note four flow variables deleted as redundant.**

TABLE 4.5a.
RESULTS OF PRINCIPAL COMPONENT ANALYSES, SALINITY 0 o/oo, MONTHLY PYSICAL/CHEMICAL PARAMETERS AND PRODUCTIVITY MEASURES.

FACTOR	EIGENVALUE	% VARIANCE EXPLAINED	CUMULATIVE %
I	8.757	28.25	28.25
II	7.142	23.04	51.29
III	3.227	10.41	61.70
IV	1.869	6.03	67.73

TABLE 4.5b.
CORRELATIONS OF THE ORIGINAL VARIABLES WITH THE COMPOSITE PRINCIPAL COMPONENT AXES (factor loadings) FOR 0 o/oo SALINITY.

ORIGINAL VARIABLE	CORRELATION COEFFICIENT		
	Factor I	Factor II	Factor III
Phytoplankton Species Richness	0.062	0.131	0.474**
Phytoplankton Species Diversity	0.210	0.291	0.347*
Abundance of Green Algae	-0.288	-0.133	0.080
Abundance of Flagellate Algae	0.587**	-0.062	-0.191
Abundance of Dinoflagellate	0.705**	0.067	-0.183
Abundance of Diatoms	-0.304	0.010	0.055
Abundance of Blue-Green Algae	-0.087	0.127	0.089
Total Carbon Uptake (Productivity)	-0.202	0.943**	0.039
Productivity (Carbon Uptake) > 20 um	-0.077	0.854**	0.199
Productivity (Carbon Uptake) >20<5 um	-0.159	0.944**	0.142
Productivity (Carbon Uptake) < 5 um	-0.216	0.745**	-0.089
Total Peace River Flow (Daily)	0.939**	0.135	-0.126
Total Peace River Flow (7 Day)	0.950**	0.178	-0.052
Total Peace River Flow (14 Day)	0.962**	0.169	0.022
Total Peace River Flow (28 Day)	0.935**	0.087	-0.119
Color	0.747**	0.017	0.254
Total Chlorophyll a	-0.150	0.948**	0.169
Chlorophyll > 20 um	-0.202	0.831**	0.039
Chlorophyll < 20 and > 5 um.	-0.119	0.905**	0.221
Chlorophyll < 5 um.	-0.181	0.915**	0.098
Nitrate+Nitrite	-0.285	-0.304	0.469*
Silica	0.615*	-0.072	0.536*
Total Nitrogen	0.404*	0.130	0.422*
Total Phosphorous	-0.145	0.004	-0.204
Nitrogen/Phosphorous Ratio	-0.109	-0.286	0.574*
Daily Freshwater Withdrawal	0.051	-0.354	0.553*
Average Daily Withdrawal (7 Days)	0.068	-0.366	0.720**
Average Daily Withdrawal (14 Days)	0.135	-0.240	0.787**

*** and ** indicate significant correlation coefficents**

The first of the new synthetic variables, Factor I, included high positive loadings or correlations with the measured flow variables, water color and flagellate and dinoflagellate abundances (Table 5b). Observations with high positive scores on Factor I, therefore, are characteristic of waters influenced by high flow and color, and high numbers of dinoflagellates and flagellate phytoplankton. A sample with a low Factor I score would distinguish waters during low flow and having high clarity and lower numbers of dinoflagellates and flagellates.

Factor II had high positive loadings with all measures of primary productivity and chlorophyll a (Table 5b). Thus, samples with high positive scores on Factor II are characteristic of waters with high primary productivity and high concentrations of chlorophyll a while a sample with a low Factor II score, by comparison, would represent conditions of relatively low productivity and chlorophyll.

Factor III was positively correlated with withdrawal measurements, nitrogen to phosphorous ratios resulting from increased nitrogen concentrations, and phytoplankton species diversity (Table 5b). An observation with a high positive score on Factor III, therefore, would be characteristic of increased nutrient nitrogen to phosphorous ratios, increased phytoplankton diversity, and high periods of higher freshwater withdrawals. Observations with a negative score on Factor III, by comparison, would be indicative lower phytoplankton diversity, lower nitrogen leading to lower nitrogen to phosphorous ratios and lower freshwater withdrawal. In essence, Factor I may be visualized, with its high loadings for flow, as summarizing freshwater inputs into the estuary. Factor II, by comparison, with its high correlation with productivity measures is descriptive of primary productivity at 0 ppt salinity. The final new synthetic variable, Factor III, summarized freshwater withdrawal, nitrogen availability, and phytoplankton diversity independent of river flow and productivity.

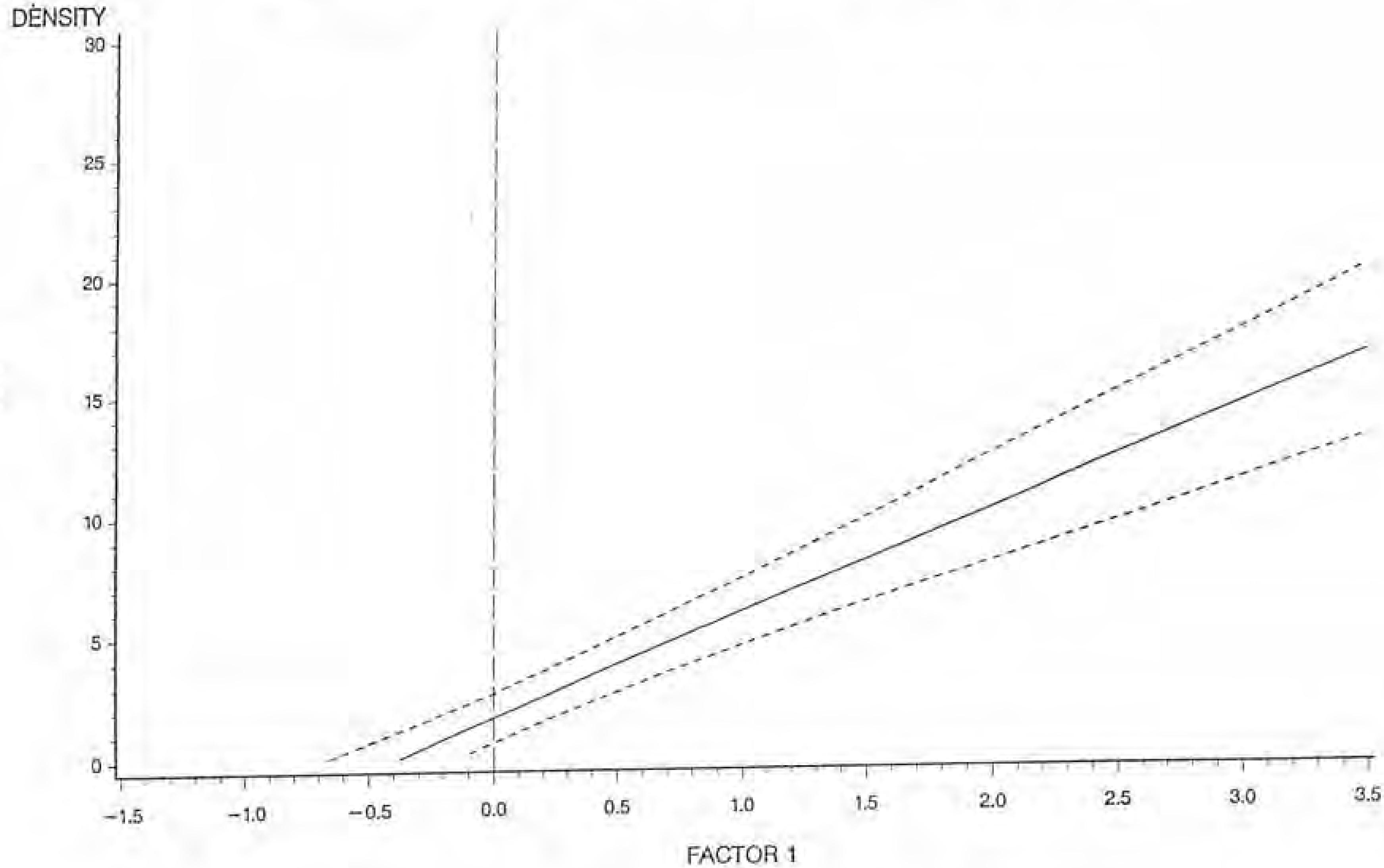
To examine the interaction of zooplankton taxa with the new composite variables the density of each zooplankton taxa, zooplankton species diversity, species richness, and total density for each collection were regressed against the scores of the original observations for each of the factors. Since repetitive analyses were conducted using similar data, the probability for tests of the null hypothesis (i.e. no relationship between dependent (zooplankton metric) and independent (Factor Scores)) was reduced from 0.05 to 0.005. This reduction was done to control overall experiment-wise error rates at 0.05 and to reduce the probability of committing a Type II statistical error when evaluating the null hypothesis.

Results of significant relationships of zooplankton taxa or community measures with the factors are shown with 95 % confidence intervals in Figures 4.31 through 4.39. Few zooplankton metrics or taxa responded to Factor I, the flow factor. Of those that did, gastropod larvae cumacean crustaceans, and the copepod *Clausocalanus arcuicornis*, all increased in density with increasing flow and increasing densities of flagellates and dinoflagellates (Figures 4.31 through 4.33).

Many more taxa significantly responded to Factor II, the productivity factor with total zooplankton density increasing with increases in Factor II scores (productivity and chlorophyll a) (Figure 4.34). This increase in density was the result of increases in rotifers, fish larvae, sipunculids, and branchiopod crustaceans (Figures 4.34 through 4.38 respectively). Overall zooplankton species diversity decreased with increasing productivity and decreasing phytoplankton species diversity (Figure 4.39). No measures of

FIGURE 4.31

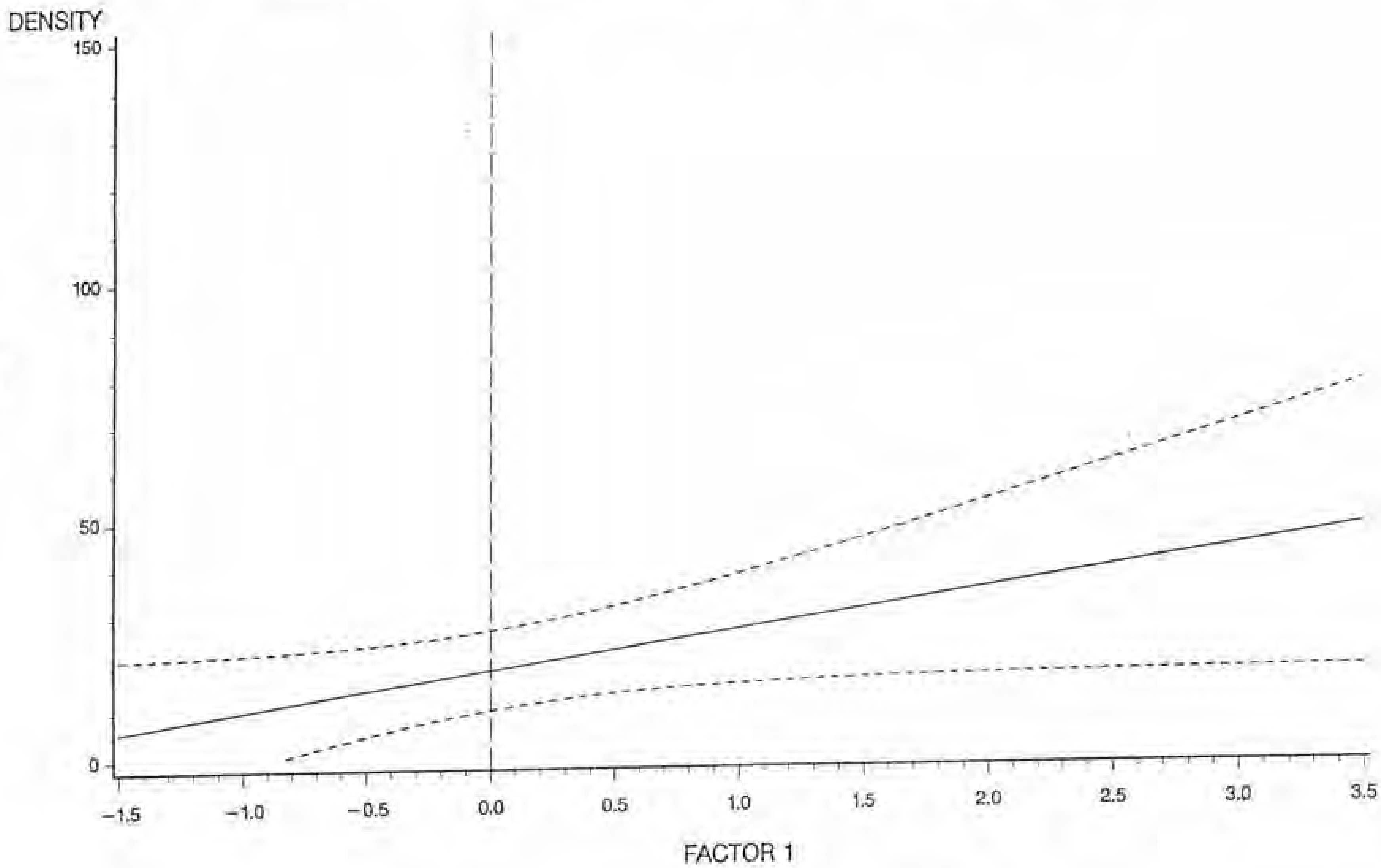
Plot Of Average Response Of Planktonic Gastropods Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 0 ppt Salinity.



Positive Scores Indicate Increasing River Flows and Dinoflagellate/Flagellate Abundance
Negative Scores Indicate Lower Flows With Fewer Dinoflagellates/Flagellates

FIGURE 4.32

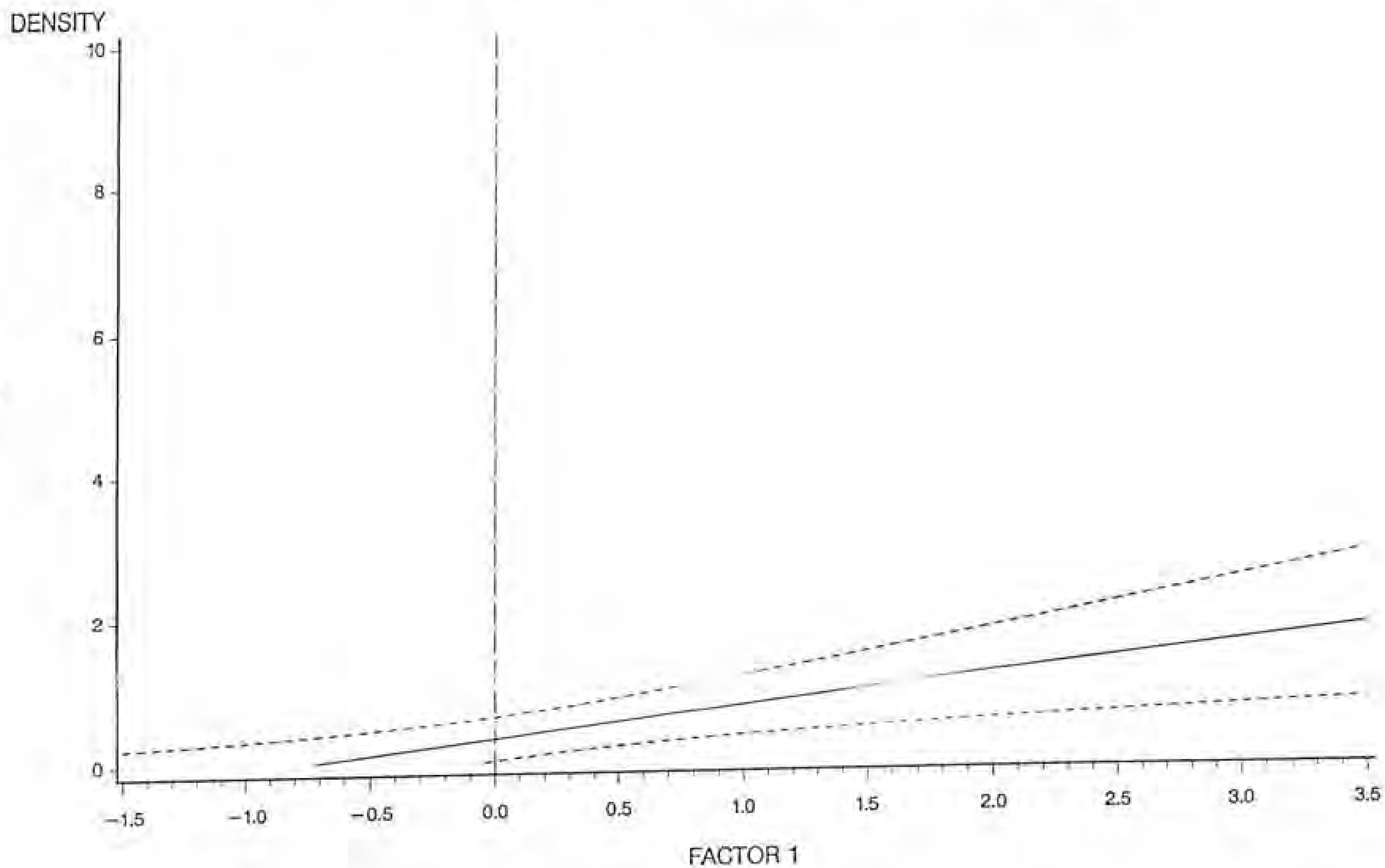
Plot Of Average Response Of Cumacean Crustaceans Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 0 ppt Salinity.



Positive Scores Indicate Increasing River Flows and Dinoflagellate/Flagellate Abundance
Negative Scores Indicate Lower Flows With Fewer Dinoflagellates/Flagellates

FIGURE 4.33

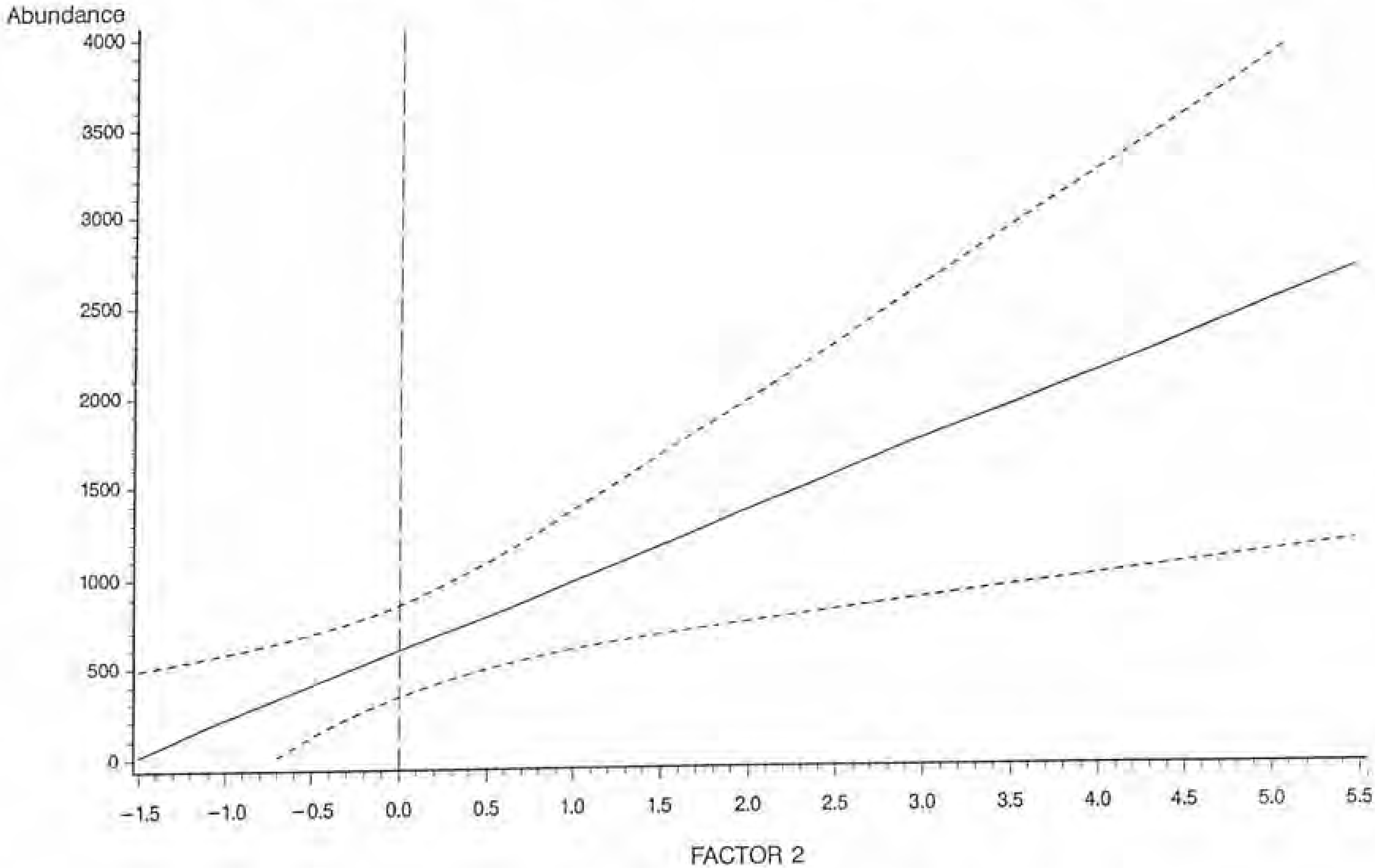
Plot Of Average Response Of Clausocalanus arcuicornis Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 0 ppt Salinity.



Positive Scores Indicate Increasing River Flows and Dinoflagellate/Flagellate Abundance
Negative Scores Indicate Lower Flows With Fewer Dinoflagellates/Flagellates

FIGURE 4.34

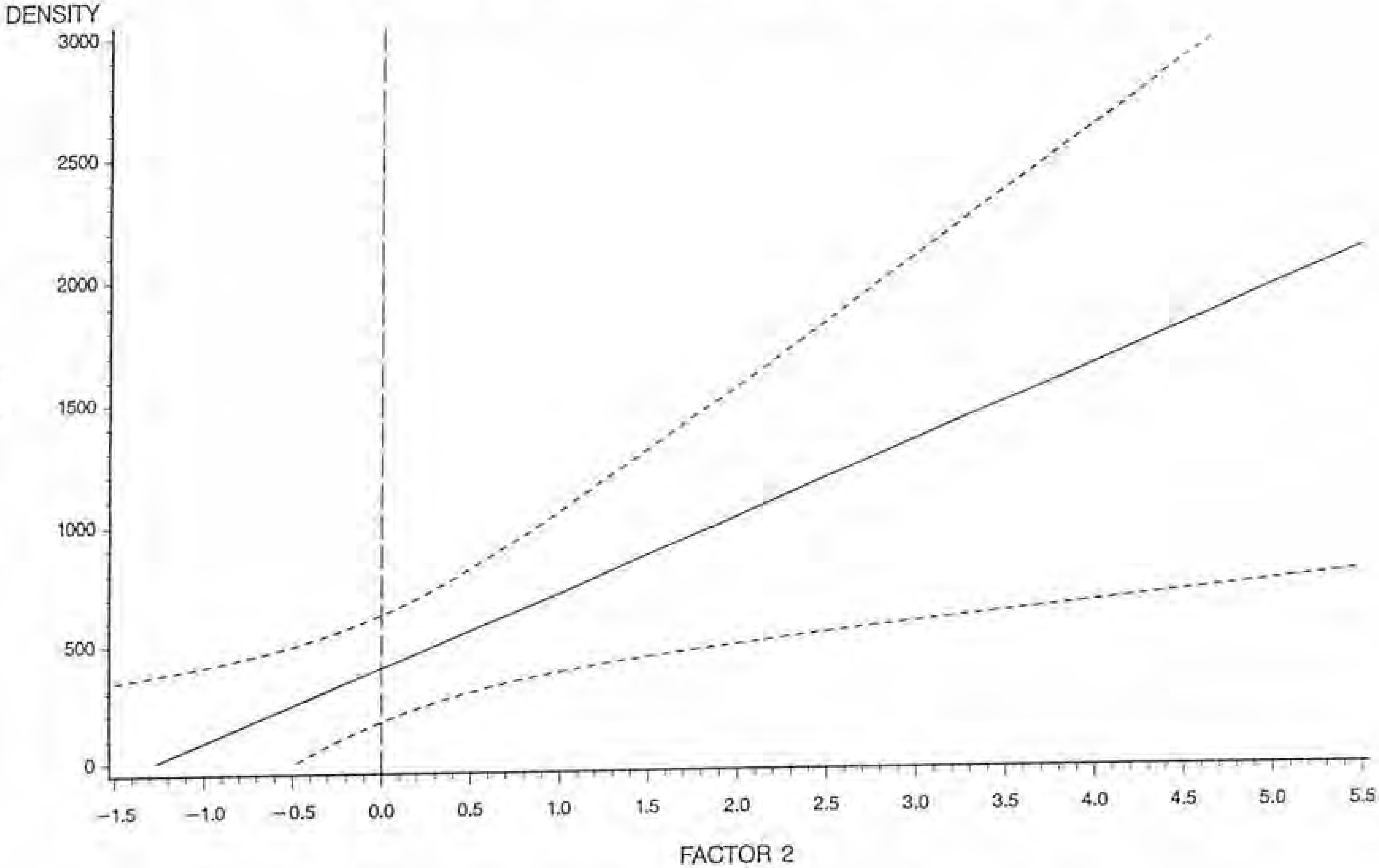
Plot Of Average Response Of Total Zooplankton Abundance Versus Principal Component Factor 2 Scores With 95 % Confidence Intervals At Station 0 ppt Salinity.



Positive Scores Indicate Increasing Productivity and Chlorophyll a
Negative Scores Indicate Lower Productivity and Chlorophyll a

FIGURE 4.35

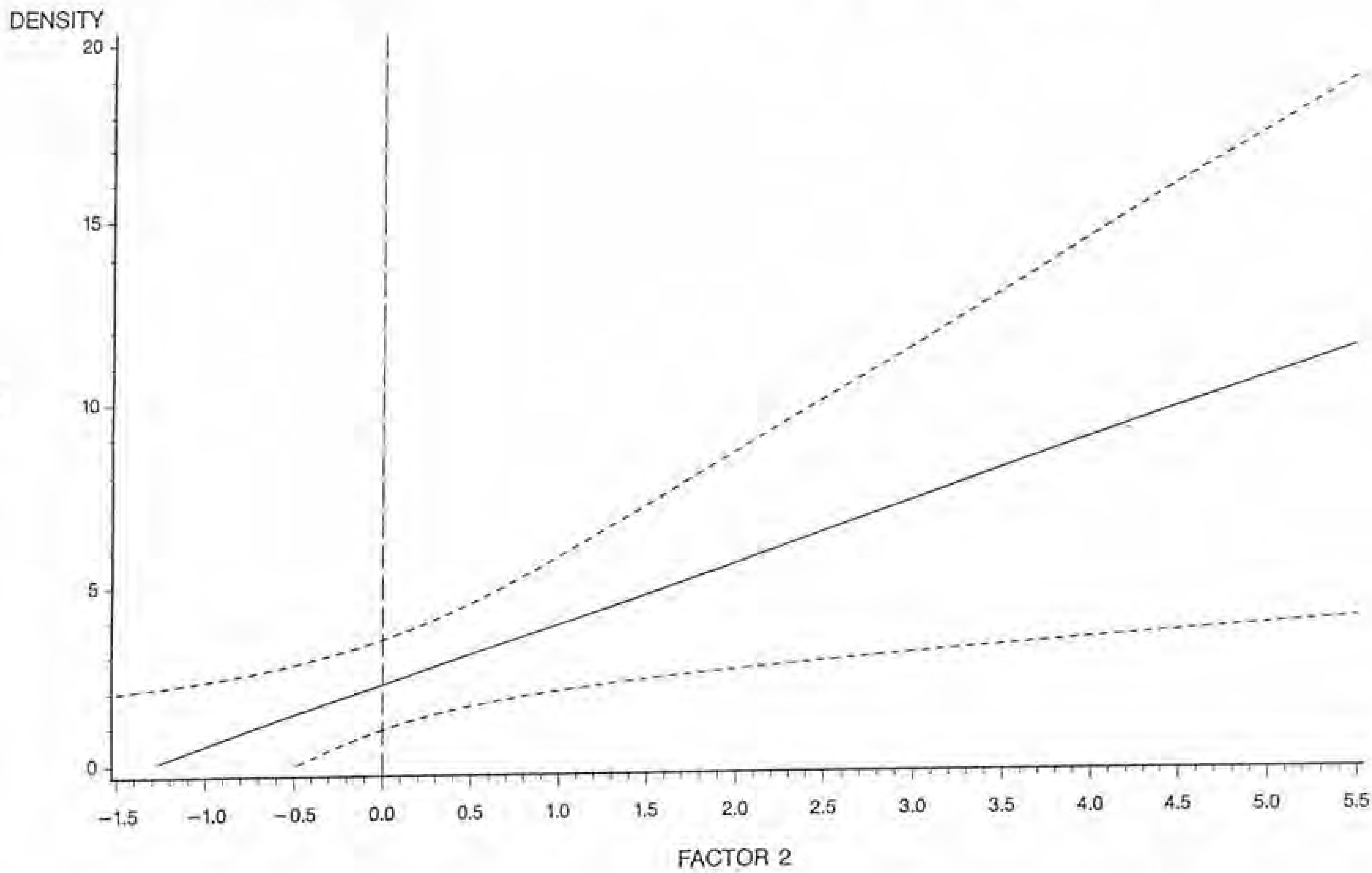
Plot Of Average Response Of Rotifers Versus Principal Component
Factor 2 Scores With 95 % Confidence Intervals At Station 0 ppt Salinity.



Positive Scores Indicate Increasing Productivity and Chlorophyll a
Negative Scores Indicate Lower Productivity and Chlorophyll a

FIGURE 4.36

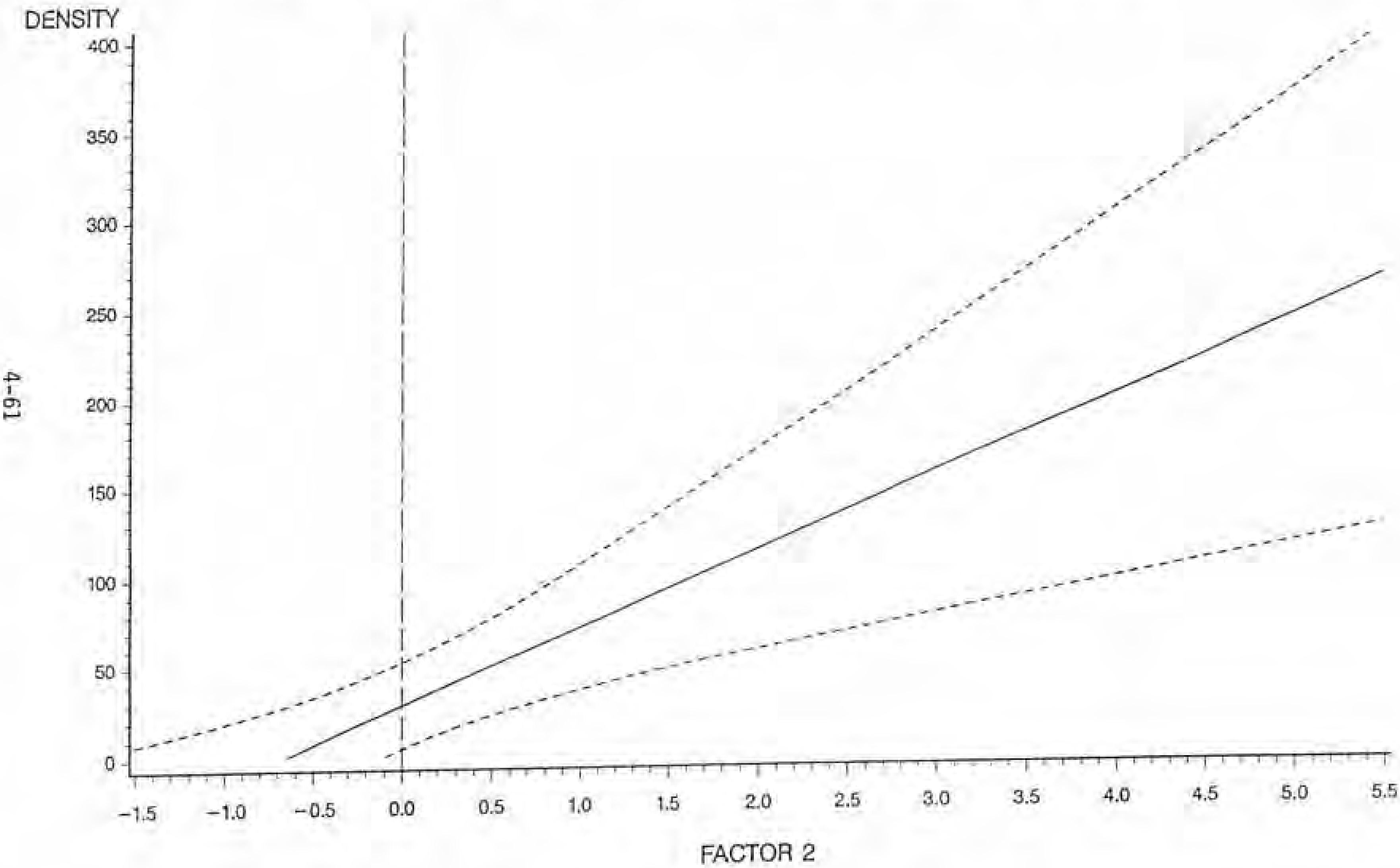
Plot Of Average Response Of Fish Larvae Versus Principal Component Factor 2 Scores With 95 % Confidence Intervals At Station 0 ppt Salinity.



Positive Scores Indicate Increasing Productivity and Chlorophyll a
Negative Scores Indicate Lower Productivity and Chlorophyll a

FIGURE 4.37

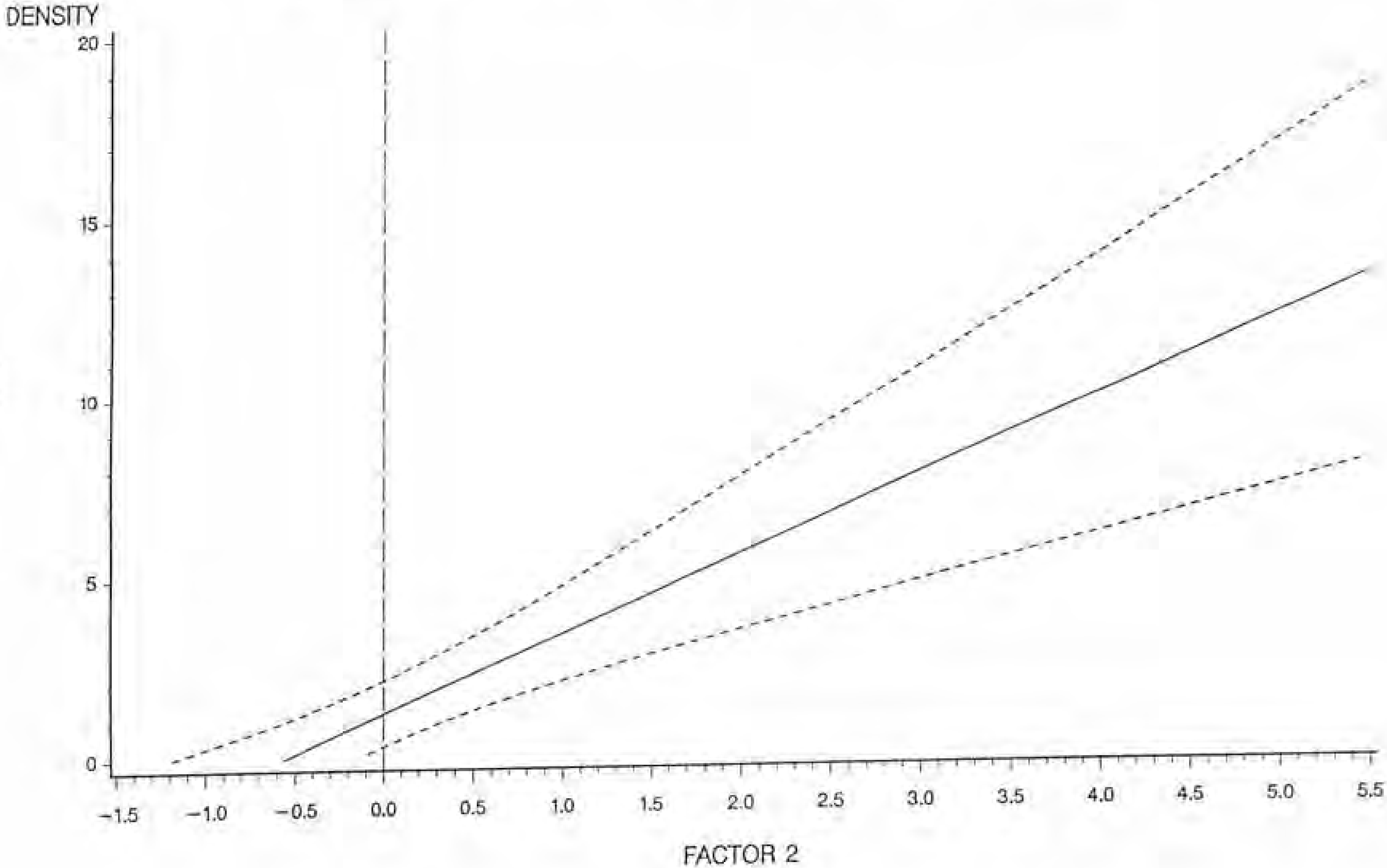
Plot Of Average Response Of Sipunculids Versus Principal Component Factor 2 Scores With 95 % Confidence Intervals At Station 0 ppt Salinity.



Positive Scores Indicate Increasing Productivity and Chlorophyll a
Negative Scores Indicate Lower Productivity and Chlorophyll a

FIGURE 4.38

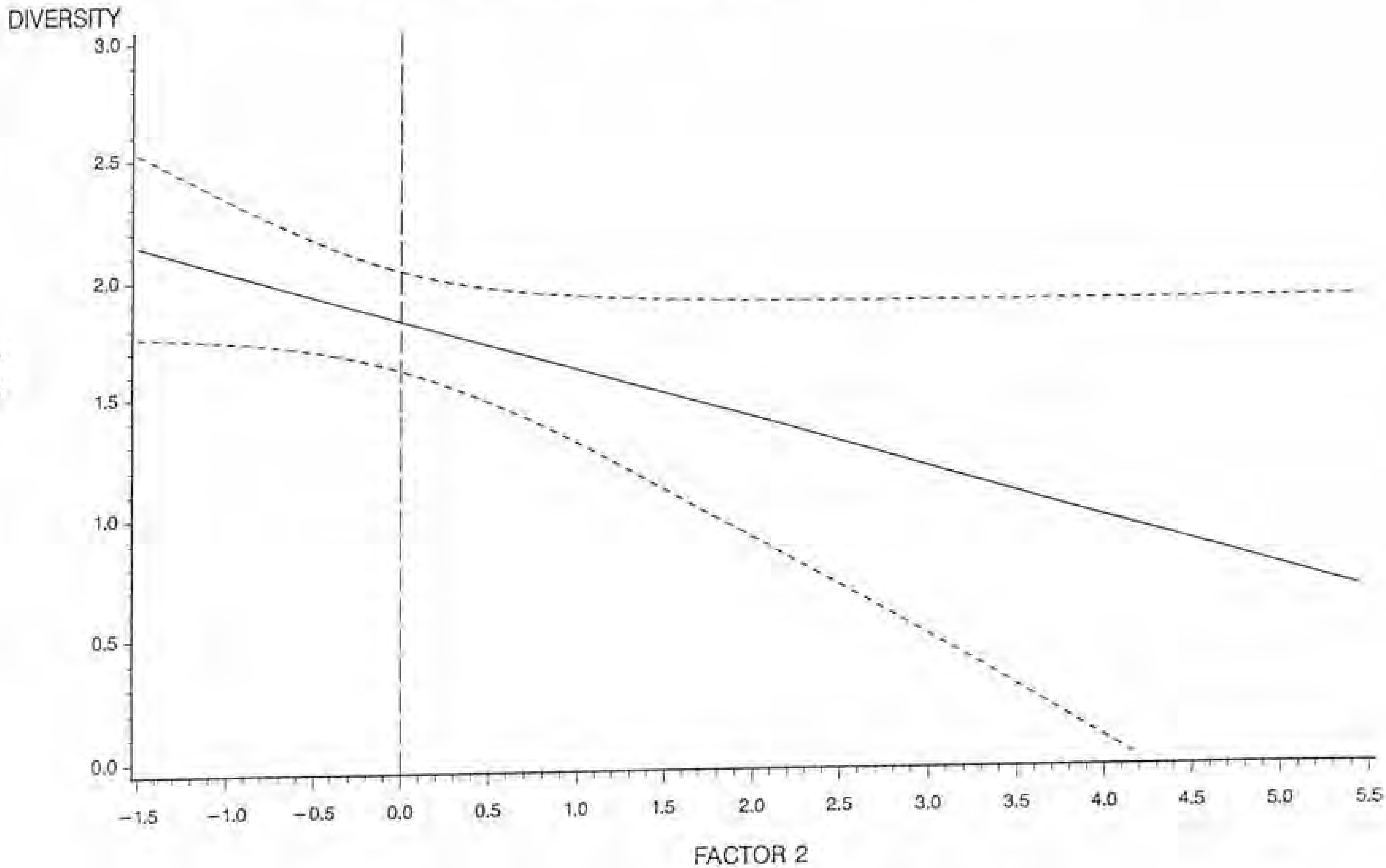
Plot Of Average Response Of Branchipod Cladocera Versus Principal Component Factor 2 Scores With 95 % Confidence Intervals At Station 0 ppt Salinity.



Positive Scores Indicate Increasing Productivity and Chlorophyll a
Negative Scores Indicate Lower Productivity and Chlorophyll a

FIGURE 4.39

Plot Of Average Response Of Zooplankton Species Diversity Versus Principal Component Factor 2 Scores With 95 % Confidence Intervals At Station 0 ppt Salinity.



Positive Scores Indicate Increasing Productivity and Chlorophyll a
Negative Scores Indicate Lower Productivity and Chlorophyll a

zooplankton community composition or individual taxa were significantly related to Factor III, the withdrawal component.

Six o/oo Salinity

Three of the new synthetic composite variables (Factors 1 through 3), developed from the original 29 variables, were retained for further analysis. Each of these new Factors was selected on the basis of its accounting for at least 10% of the total variation within the original data set (Table 6a). Together these three new synthetic composite Factors accounted for 59 % of the statistical variance expressed in the original 29 variables.

The first of the new synthetic variables, Factor I, included high positive loadings or correlations with the measured flow variables, water color, primary productivity in the small size fraction, diatom abundance, and phytoplankton species richness (Table 6b). A negative correlation or loading of flagellates with Factor I was also observed. Observations with high positive scores on Factor I, therefore, are characteristic of waters influenced by high flow and color, high numbers of diatoms, high phytoplankton species richness, and high productivity in the smaller size fractions. A sample with a negative Factor I score would distinguish waters during low flow and having high clarity and lower numbers of diatoms, lower small size fraction productivity, and high numbers of flagellates.

Factor II had high positive loadings with primary productivity and chlorophyll a in the large size fractions, number of dinoflagellates and freshwater withdrawal. Negative correlations of phytoplankton species diversity, nitrogen concentrations, and

TABLE 4.6a.
RESULTS OF PRINCIPAL COMPONENT ANALYSES, SALINITY 6 o/oo, MONTHLY PYSICAL/CHEMICAL PARAMETERS AND PRODUCTIVITY MEASURES.

FACTOR	EIGENVALUE	% VARIANCE EXPLAINED	CUMULATIVE %
I	9.514	30.70	30.70
II	5.718	18.45	49.14
III	2.957	9.54	58.68
IV	2.871	9.26	67.94

TABLE 4.6b.
CORRELATIONS OF THE ORIGINAL VARIABLES WITH THE COMPOSITE PRINCIPAL COMPONENT AXES (factor loadings) FOR 6 o/oo SALINITY.

ORIGINAL VARIABLE	CORRELATION COEFFICIENT		
	Factor I	Factor II	Factor III
Phytoplankton Species Richness	-0.401*	-0.299	0.132
Phytoplankton Species Diversity	-0.332	-0.468*	0.119
Abundance of Green Algae	-0.192	-0.304	0.218
Abundance of Flagellate Algae	-0.594**	-0.319	0.037
Abundance of Dinoflagellate	-0.065	0.793**	0.478*
Abundance of Diatoms	0.512	0.121	-0.633*
Abundance of Blue-Green Algae	0.323	-0.414*	0.402*
Total Carbon Uptake (Productivity)	0.465*	0.740**	0.079
Productivity (Carbon Uptake) > 20 um	0.062	0.845**	0.357
Productivity (Carbon Uptake) <20>5 um	0.559*	0.247	-0.661**
Productivity (Carbon Uptake) < 5 um	-0.638**	0.070	-0.086
Total Peace River Flow (Daily)	0.899**	-0.221	0.079
Total Peace River Flow (7 Day)	0.916**	-0.240	0.106
Total Peace River Flow (14 Day)	0.930**	-0.255	0.133
Total Peace River Flow (28 Day)	0.880**	-0.317	0.252
Color	0.590*	-0.095	-0.043
Total Chlorophyll a	0.319	0.840**	-0.050
Chlorophyll > 20 um	0.056	0.833**	0.387
Chlorophyll < 20 and > 5 um.	0.289	0.158	-0.720**
Chlorophyll < 5 um.	0.494*	0.424*	-0.438*
Nitrate+Nitrite	-0.325	-0.464*	0.083
Silica	0.550*	-0.244	0.303
Total Nitrogen	0.472*	0.322	0.151
Total Phosphorous	-0.534*	0.229	0.182
Nitrogen/Phosphorous Ratio	-0.077	-0.535*	0.096
Daily Freshwater Withdrawal	0.103	0.423*	0.353
Average Daily Withdrawal (7 Days)	0.145	0.227	0.274
Average Daily Withdrawal (14 Days)	0.176	0.075	0.287

*** and ** indicate significant correlation coefficents**

nitrogen/phosphorous rations with Factor II scores were also observed. Thus, samples with high positive scores on Factor II are characteristic of waters with high primary productivity and high concentrations of chlorophyll a in the larger (< 20 um) size fraction, a large number of dinoflagellates, low phytoplankton species diversity, and low nitrogen concentrations. A sample with a low Factor II score, by comparison, would represent conditions of relatively low productivity and chlorophyll a, fewer dinoflagellates, high phytoplankton diversity, and more ambient nitrogen.

Factor III was positively correlated with blue-green and dinoflagellate algal densities, independent of Factor II and negatively correlated with small size fraction chlorophyll a concentrations. An observation with a high positive score on Factor III, therefore, would be characteristic of increased blue-green algal densities and dinoflagellate densities and low small size fraction chlorophyll a. Observations with a negative score on Factor III, by comparison, would be indicative lower blue-green algae and dinoflagellate density and higher chlorophyll a in the small size fraction.

In essence, Factor I may be visualized, with its high loadings for flow, as summarizing freshwater inputs at 6 ppt salinity and high diatom productivity. Factor II, by comparison, with its high correlation with large size fraction productivity and dinoflagellate abundance measures is primary productivity in the larger size fraction and freshwater withdrawal. The final new synthetic variable, Factor III, summarized blue-green algae, abundances.

To examine the interaction of zooplankton taxa with the new composite variables the density of each zooplankton taxa, zooplankton species diversity, species richness, and total density for each collection were regressed against the scores of the original observations for each of the factors. Significance levels of the regressions were changed to 0.005 as was previously done in the 0 ppt salinity analyses.

Results of significant relationships of zooplankton taxa or community measures with the factors for 6 ppt salinity observations are shown with 95 % confidence intervals in Figures 4.40 through 4.49. Many zooplankton taxa responded to Factor I, the flow and diatom factor. Of those that did, planktonic annelids, the copepods *Clausocalanus arcuicornis, Oithona sp., Paracalanus crassirostris, ostracods, turbellarians, branchiopod cladocera all* increased in density with increasing flow and increasing densities of diatoms (Figures 4.40 through 4.46 respectively).

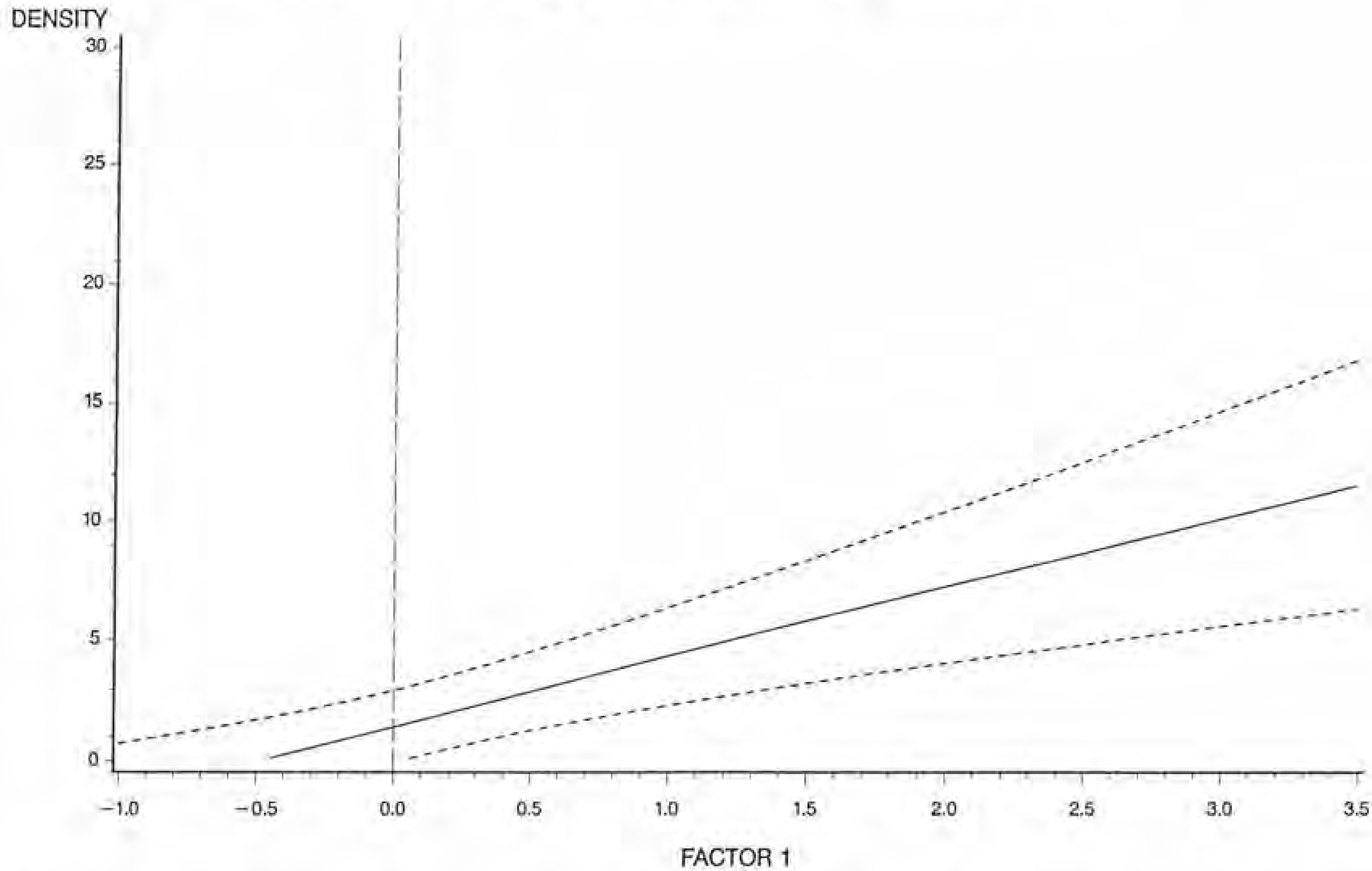
Only three taxa significantly responded to Factor II, the dinoflagellate productivity factor with increases in the densities of Cirripedia nauplii, cumacean crustacean, and hemicordates all observed with increasing Factor II scores. No measures of zooplankton community composition or individual taxa were significantly related to Factor III, the withdrawal component.

12 o/oo Salinity

Three of the new synthetic composite variables (Factors 1 through 3), developed from the original 29 variables, were retained for further analysis. Each of these new Factors was selected on the basis of its accounting for at least 10% of the total variation within the original data set (Table 7a). Together these three new synthetic composite Factors accounted for 58 % of the statistical variance expressed in the original 29 variables.

FIGURE 4.40

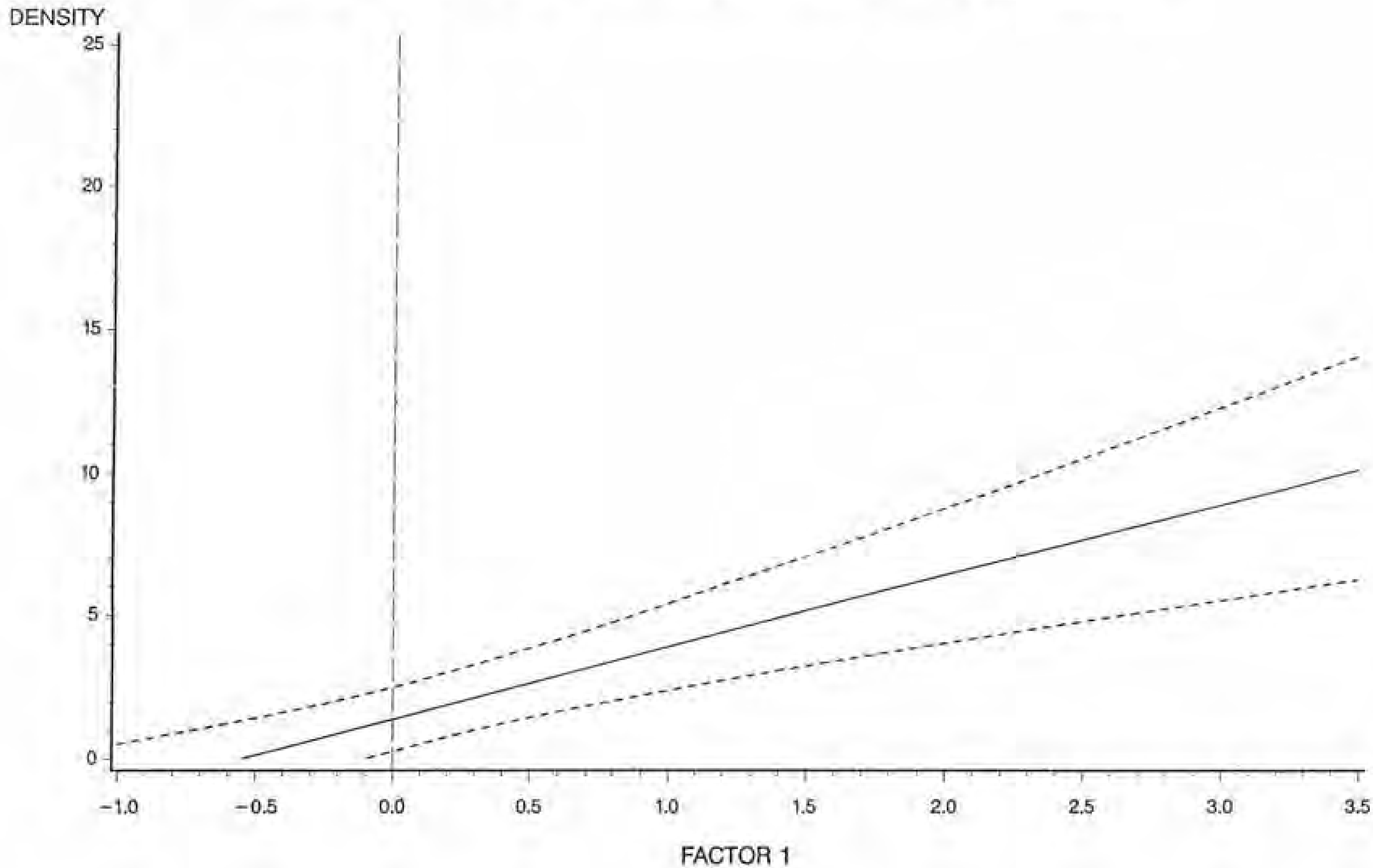
Plot Of Average Response Of Planktonic Annelids Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 6 ppt Salinity.



Positive Scores Indicate Increasing River Flow
Negative Scores Indicate Lower Flows

FIGURE 4.41

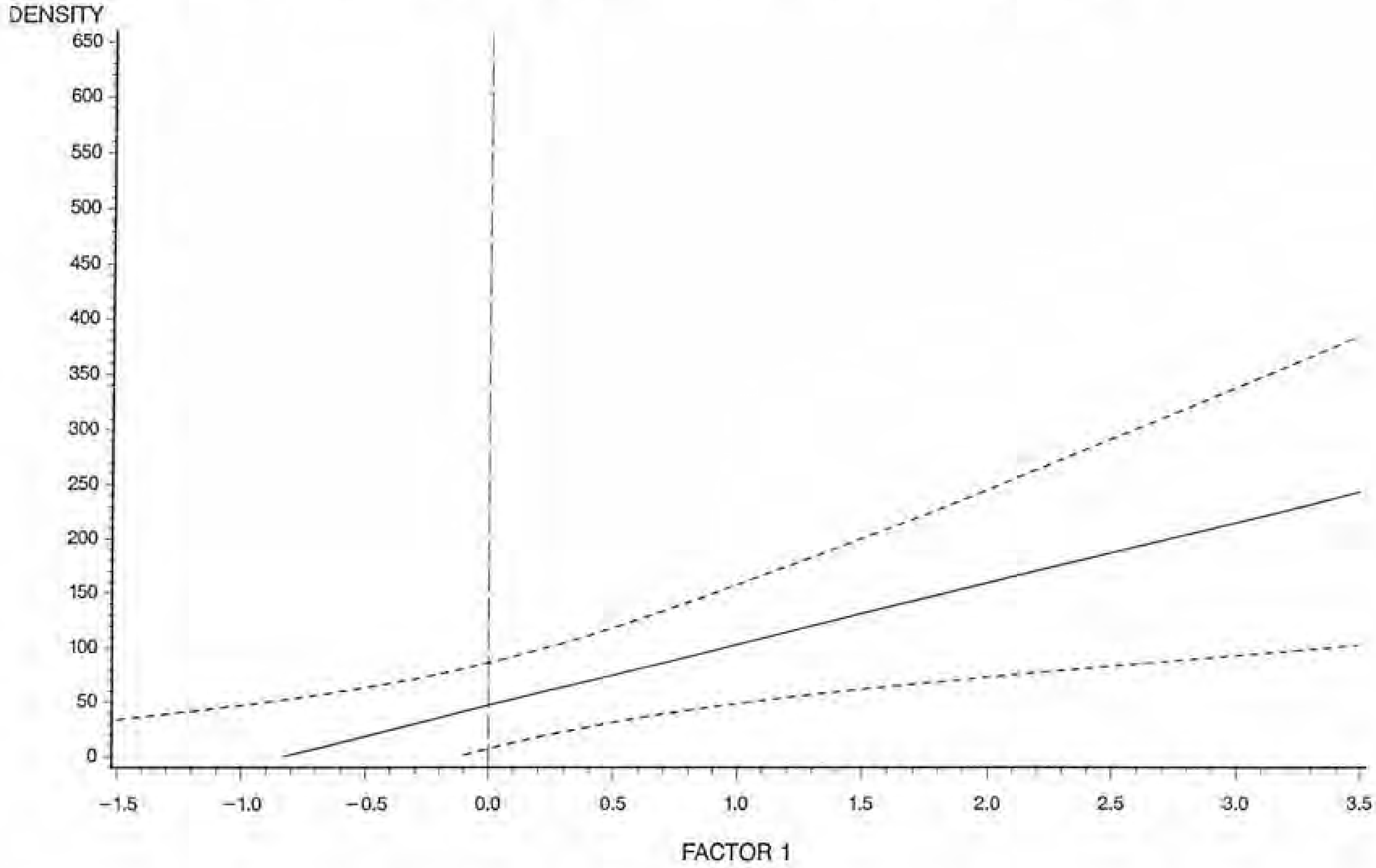
Plot Of Average Response Of Clausocalanus arcuicornis Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 6 ppt Salinity.



Positive Scores Indicate Increasing River Flow
Negative Scores Indicate Lower Flows

FIGURE 4.42

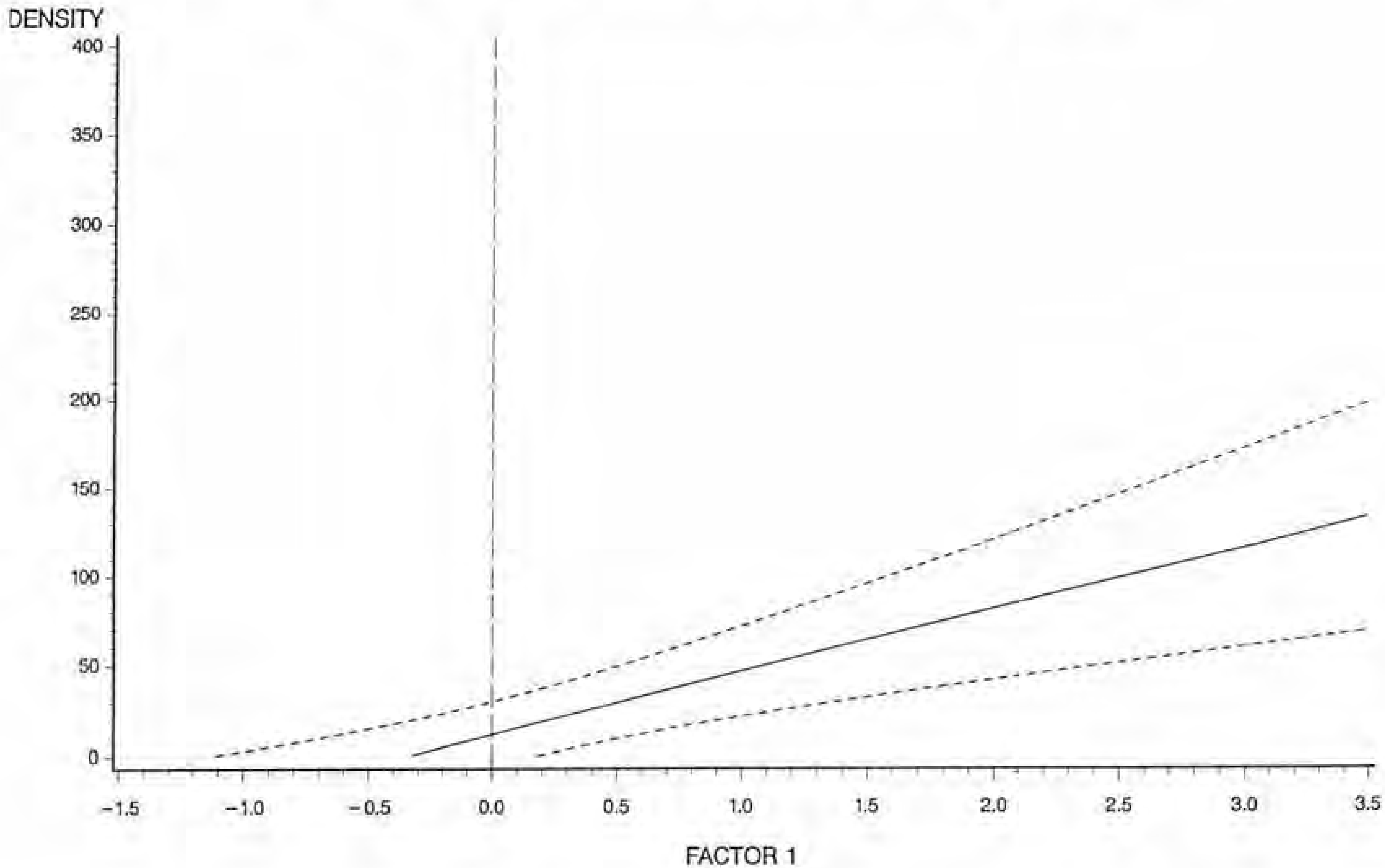
Plot Of Average Response Of Oithona sp. Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 6 ppt Salinity.



Positive Scores Indicate Increasing River Flow
Negative Scores Indicate Lower Flows

FIGURE 4.43

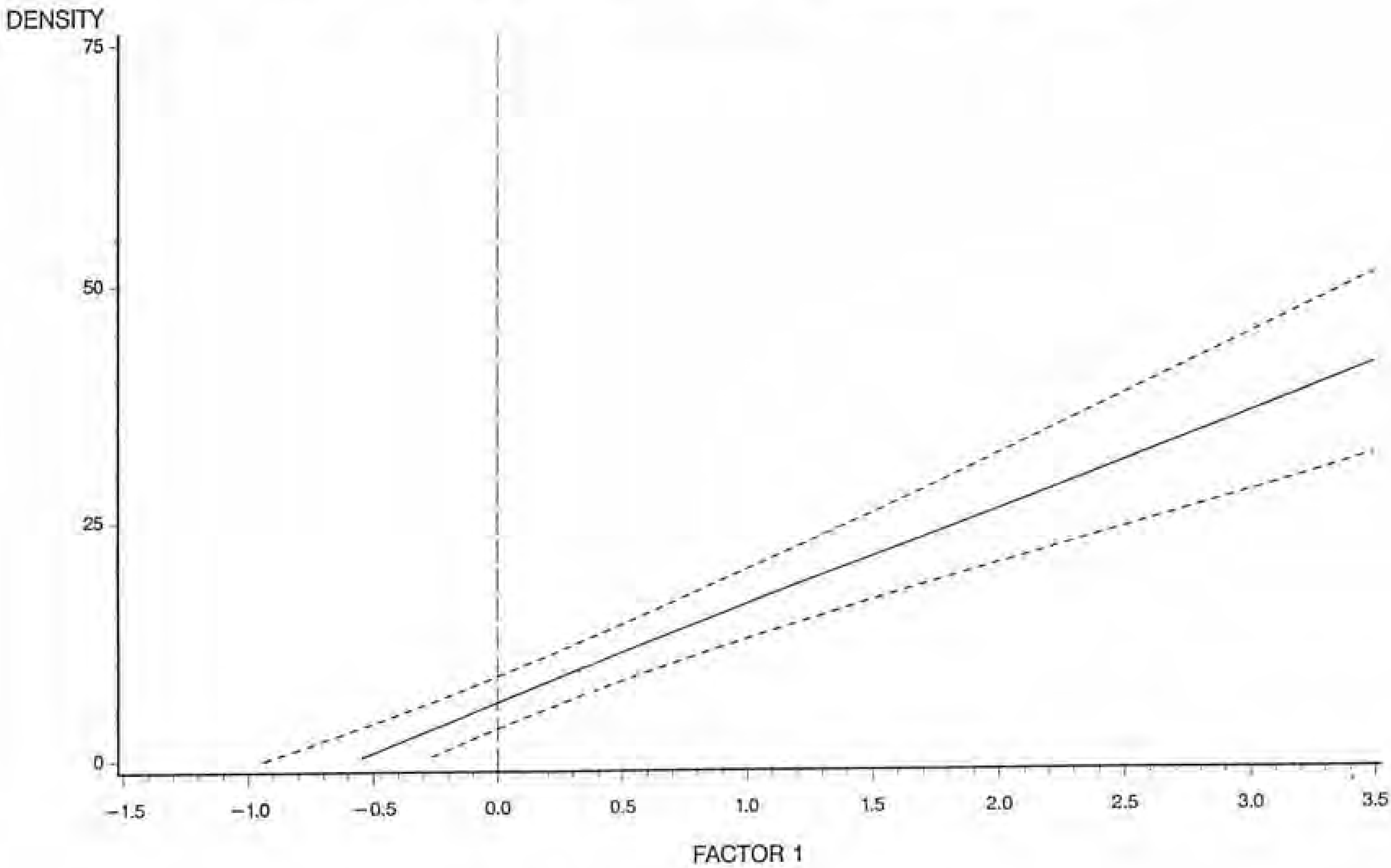
Plot Of Average Response Of Paracalanus crassirostris Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 6 ppt Salinity.



Positive Scores Indicate Increasing River Flow
Negative Scores Indicate Lower Flows

FIGURE 4.44

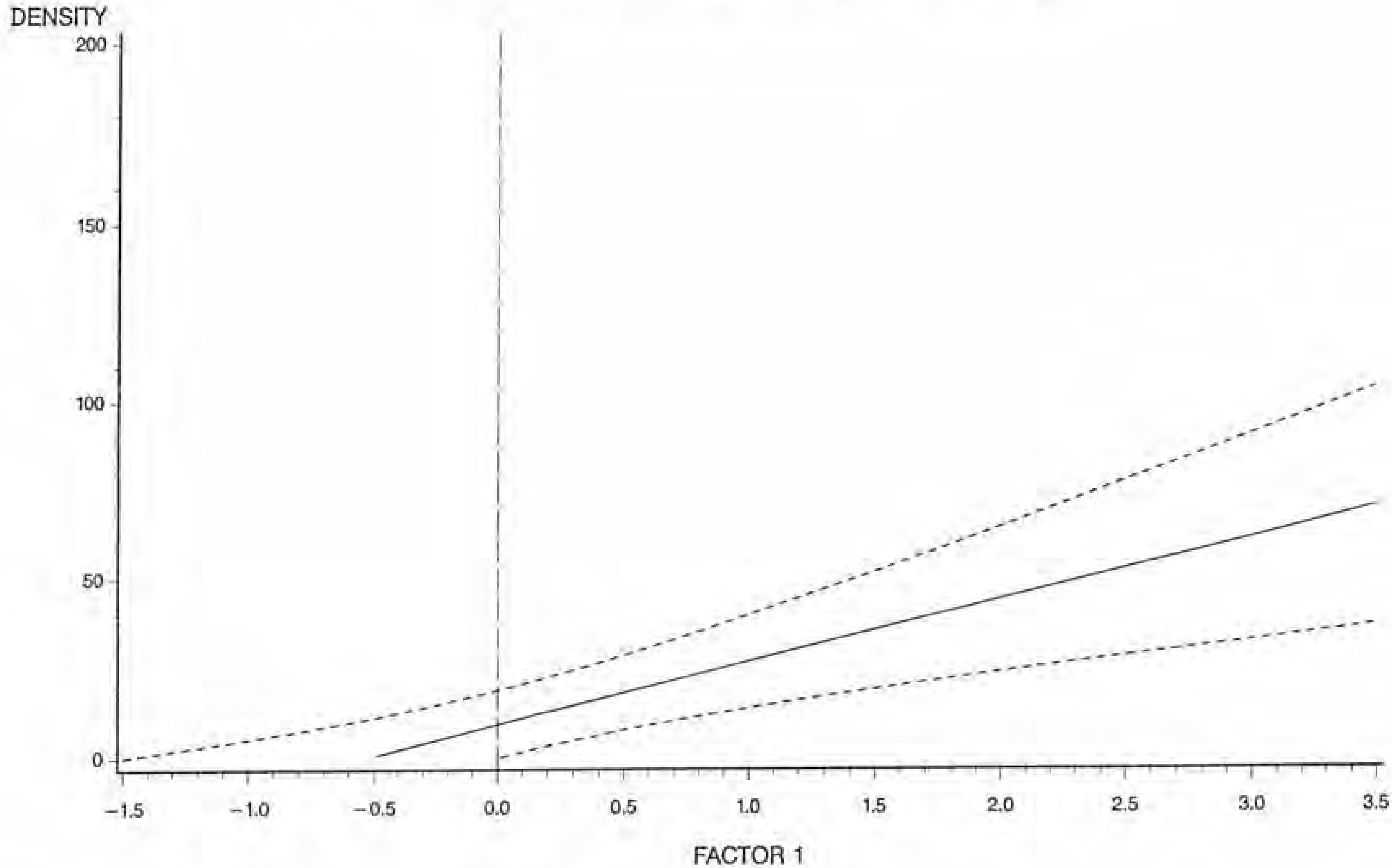
Plot Of Average Response Of Ostracoda sp. Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 6 ppt Salinity.



Positive Scores Indicate Increasing River Flow
Negative Scores Indicate Lower Flows

FIGURE 4.45

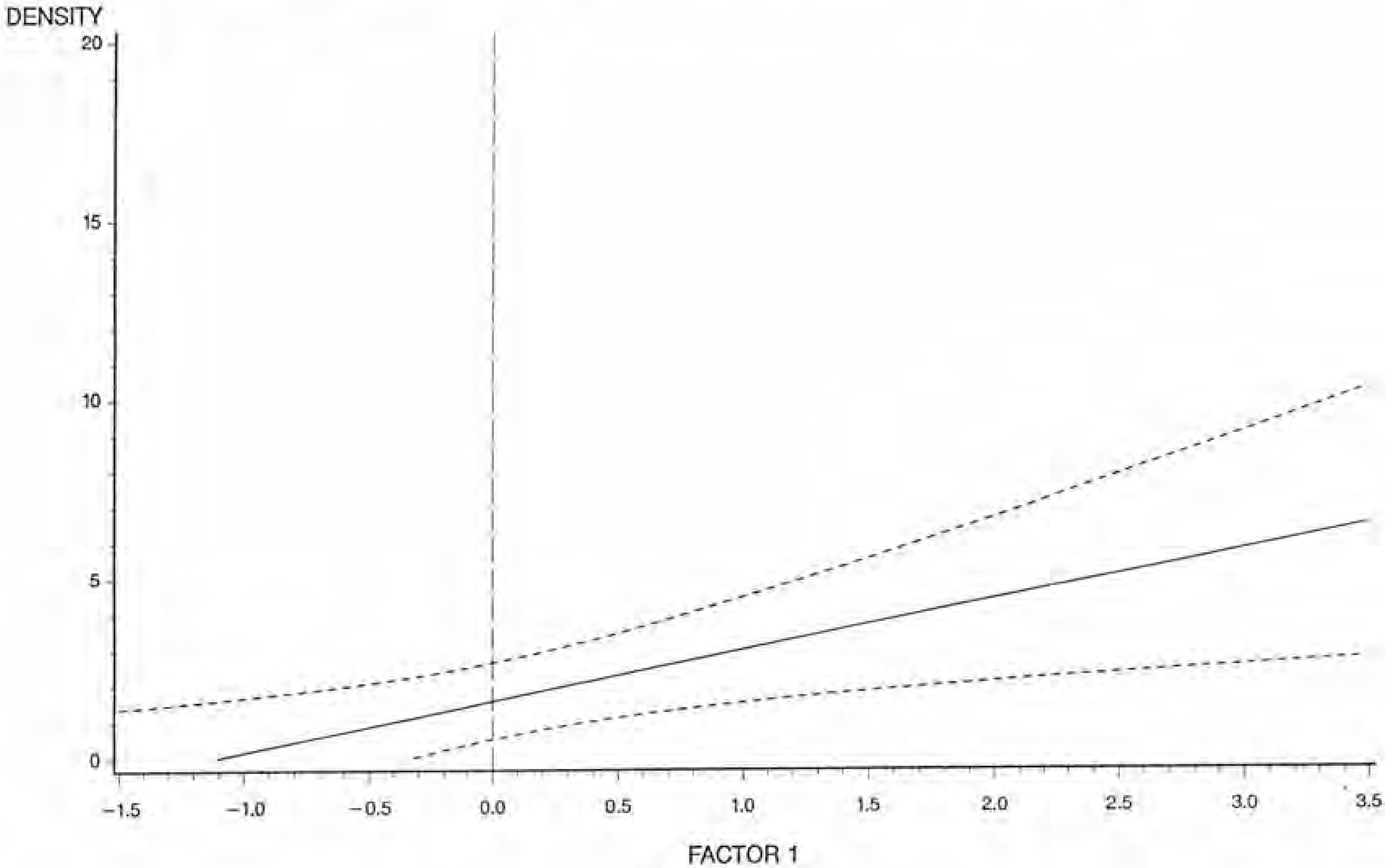
Plot Of Average Response Of Turbellaria Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 6 ppt Salinity.



Positive Scores Indicate Increasing River Flow
Negative Scores Indicate Lower Flows

FIGURE 4.46

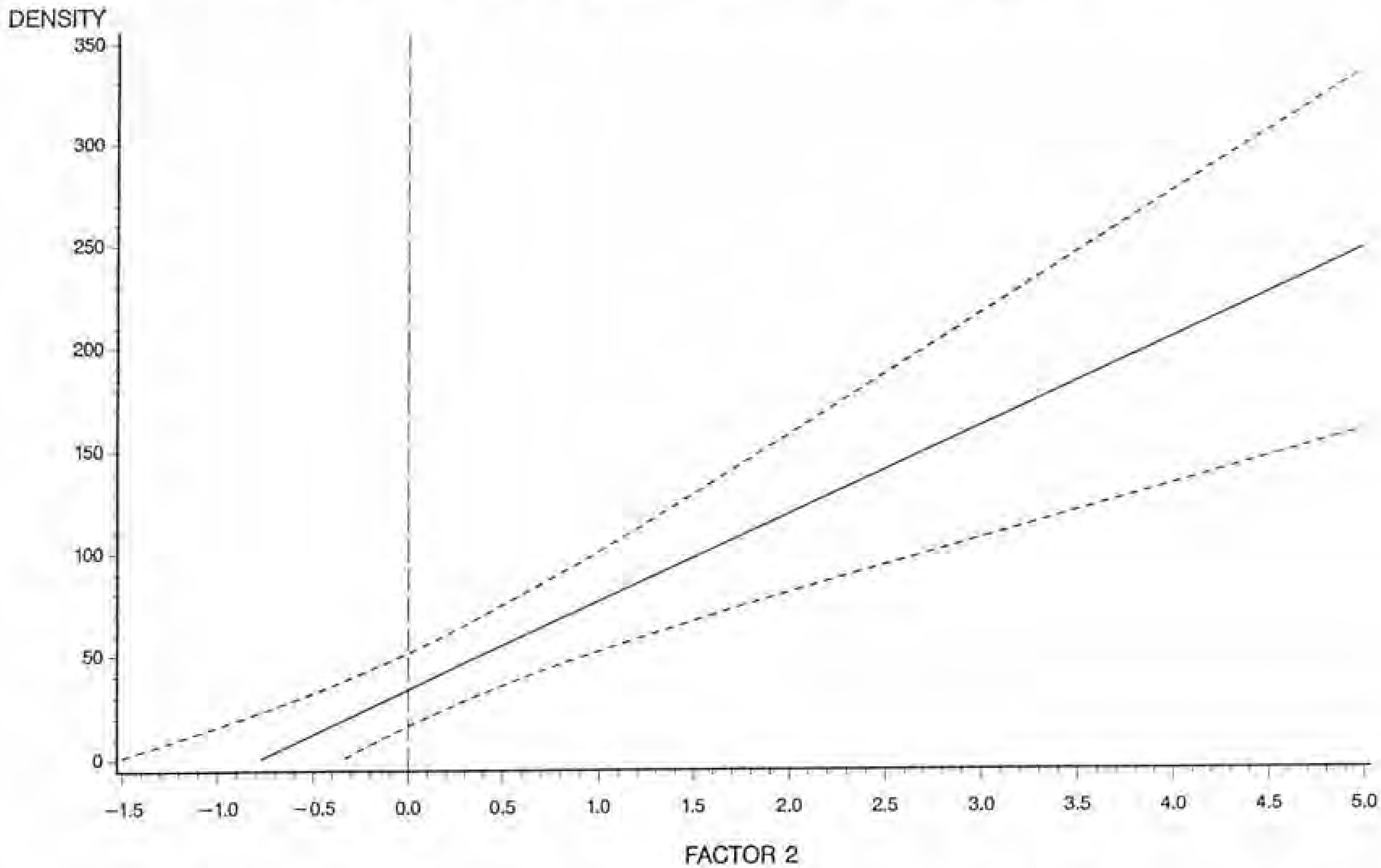
Plot Of Average Response Of Branchipod Cladocera Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 6 ppt Salinity.



Positive Scores Indicate Increasing River Flow
Negative Scores Indicate Lower Flows

FIGURE 4.47

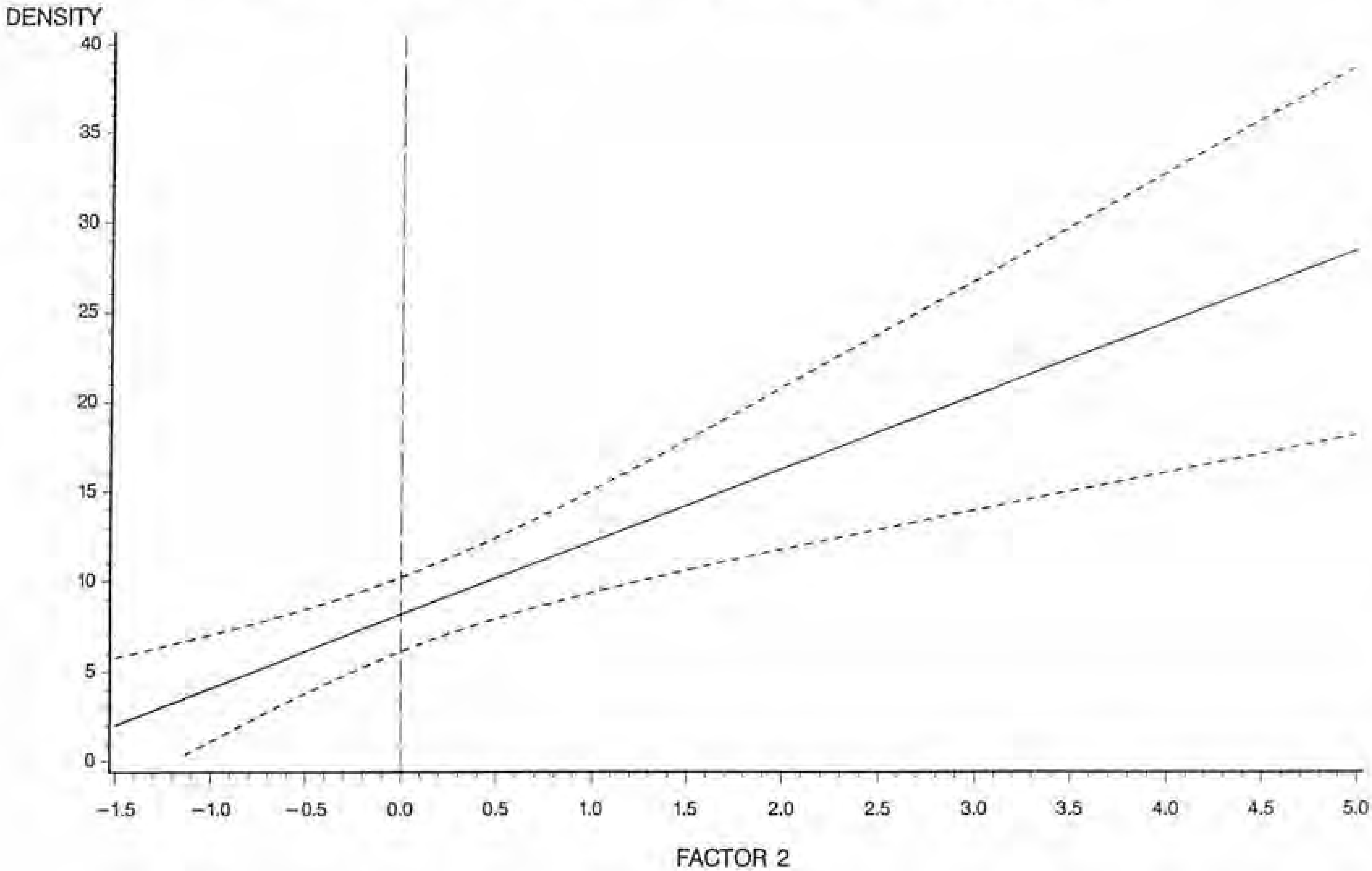
Plot Of Average Response Of Barnacle Nauplii (Cirripedia) Versus Principal Component Factor 2 Scores With 95 % Confidence Intervals At Station 6 ppt Salinity.



Positive Scores Indicate Increasing Productivity/Chlorphyll a,
Negative Scores Indicate Lower Productivity and Higher Phytoplankton Diversity

FIGURE 4.48

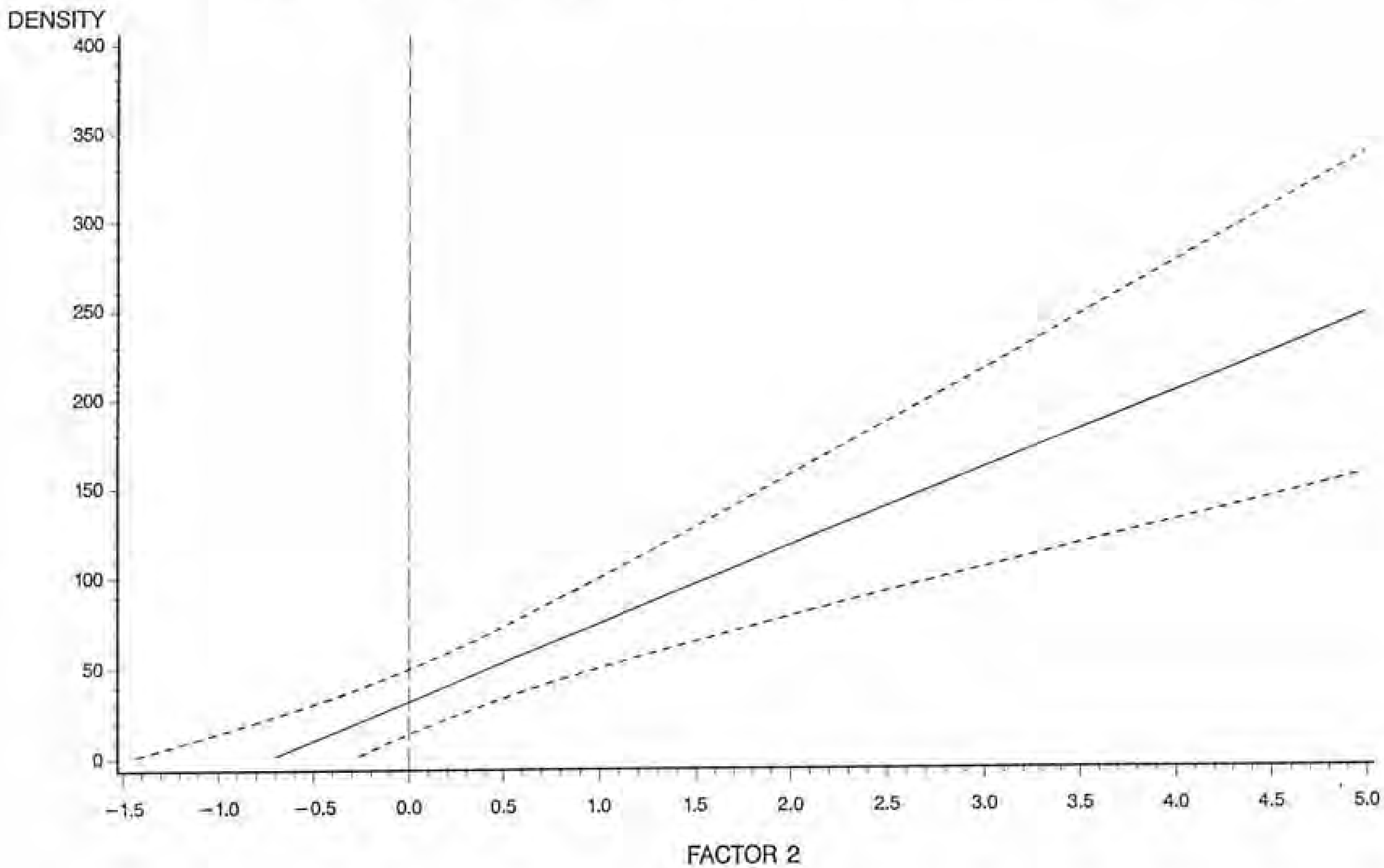
Plot Of Average Response Of Cumacean Cladocera Versus Principal Component Factor 2 Scores With 95 % Confidence Intervals At Station 6 ppt Salinity.



Positive Scores Indicate Increasing Productivity/Chlorphyll a,
Negative Scores Indicate Lower Productivity and Higher Phytoplankton Diversity

FIGURE 4.49

Plot Of Average Response Of Hemichordata (Tornaria Larvae) Versus Principal Component Factor 2 Scores With 95 % Confidence Intervals At Station 6 ppt Salinity.



Positive Scores Indicate Increasing Productivity/Chlorphyll a,
Negative Scores Indicate Lower Productivity and Higher Phytoplankton Diversity

TABLE 4.7a.
RESULTS OF PRINCIPAL COMPONENT ANALYSES, SALINITY 12 o/oo, MONTHLY PYSICAL/CHEMICAL PARAMETERS AND PRODUCTIVITY MEASURES.

FACTOR	EIGENVALUE	% VARIANCE EXPLAINED	CUMULATIVE %
I	10.420	33.62	33.62
II	4.448	14.35	47.97
III	3.185	10.28	58.24
IV	2.518	8.12	66.37

TABLE 4.7b.
CORRELATIONS OF THE ORIGINAL VARIABLES WITH THE COMPOSITE PRINCIPAL COMPONENT AXES (factor loadings) FOR 12 o/oo SALINITY.

ORIGINAL VARIABLE	CORRELATION COEFFICIENT		
	Factor I	Factor II	Factor III
Phytoplankton Species Richness	-0.287	-0.410*	0.308
Phytoplankton Species Diversity	-0.191	-0.450*	0.279
Abundance of Green Algae	-0.093	-0.452*	0.117
Abundance of Flagellate Algae	-0.684**	-0.369	0.195
Abundance of Dinoflagellate	0.135	0.627**	0.522*
Abundance of Diatoms	0.640**	0.041	-0.462*
Abundance of Blue-Green Algae	-0.094	-0.116	-0.127
Total Carbon Uptake (Productivity)	0.696**	0.387	0.116
Productivity (Carbon Uptake) > 20 um	0.402	0.624**	0.272
Productivity (Carbon Uptake) <20>5 um	0.400	0.349	-0.446*
Productivity (Carbon Uptake) < 5 um	0.713**	-0.100	0.087
Total Peace River Flow (Daily)	0.878**	-0.229	0.072
Total Peace River Flow (7 Day)	0.906**	-0.324	0.137
Total Peace River Flow (14 Day)	0.923**	-0.318	0.105
Total Peace River Flow (28 Day)	0.886**	-0.299	0.044
Color	0.736**	-0.070	-0.012
Total Chlorophyll a	0.415	0.625**	0.602
Chlorophyll > 20 um	0.334	0.704**	0.135
Chlorophyll < 20 and > 5 um.	0.744**	-0.099	-0.249
Chlorophyll < 5 um.	0.345	0.529	0.660**
Nitrate+Nitrite	-0.357	-0.340	0.118
Silica	0.496*	0.054	0.125
Total Nitrogen	0.460*	-0.246	-0.330
Total Phosphorous	-0.444*	0.056	0.201
Nitrogen/Phosphorous Ratio	-0.142	-0.288	-0.043
Daily Freshwater Withdrawal	0.100	0.460*	-0.506*
Average Daily Withdrawal (7 Days)	0.159	0.443	-0.681**
Average Daily Withdrawal (14 Days)	0.204	0.311	-0.557*

*** and ** indicate significant correlation coefficents used in interpretation**

The first of the new synthetic variables, Factor I, included high positive loadings or correlations with the measured flow variables, water color, primary productivity in the small size fraction, and diatom abundance (Table 7b). Negative correlations or loading of flagellates with Factor I was also observed. Observations with high positive scores on Factor I, therefore, are characteristic of waters influenced by high flow and color, high numbers of diatoms, and high productivity in the smaller size fractions. A sample with a negative Factor I score would distinguish waters during low flow and having high clarity and lower numbers of diatoms, lower small size fraction productivity, and high numbers of flagellates.

Factor II had high positive loadings with primary productivity and chlorophyll a in the large size fractions and number of dinoflagellates. Negative correlations of phytoplankton species diversity and species richness with Factor II scores were also observed. Thus, samples with high positive scores on Factor II are characteristic of waters with high primary productivity and high concentrations of chlorophyll a in the larger (< 20 um) size fraction, a large number of dinoflagellates, low phytoplankton species diversity. A sample with a low Factor II score, by comparison, would represent conditions of relatively low productivity and chlorophyll a, fewer dinoflagellates and high phytoplankton diversity.

Factor III was positively correlated with dinoflagellate density, and overall chlorophyll a independent of Factor I and II and negatively correlated with freshwater withdrawals. An observation with a high positive score on Factor III, therefore, would be characteristic of increased dinoflagellate density, and lower freshwater withdrawals.

Observations with a negative score on Factor III, by comparison, would be indicative higher withdrawals and lower dinoflagellate density.

In essence, Factor I may be visualized, with its high loadings for flow, as summarizing freshwater inputs at 12 ppt salinity and high diatom productivity. Factor II, by comparison, with its high correlation with large size fraction productivity and dinoflagellate abundance measured primary productivity in the larger size fraction and lower phytoplankton diversity. The final new synthetic variable, Factor III, summarized freshwater withdrawal.

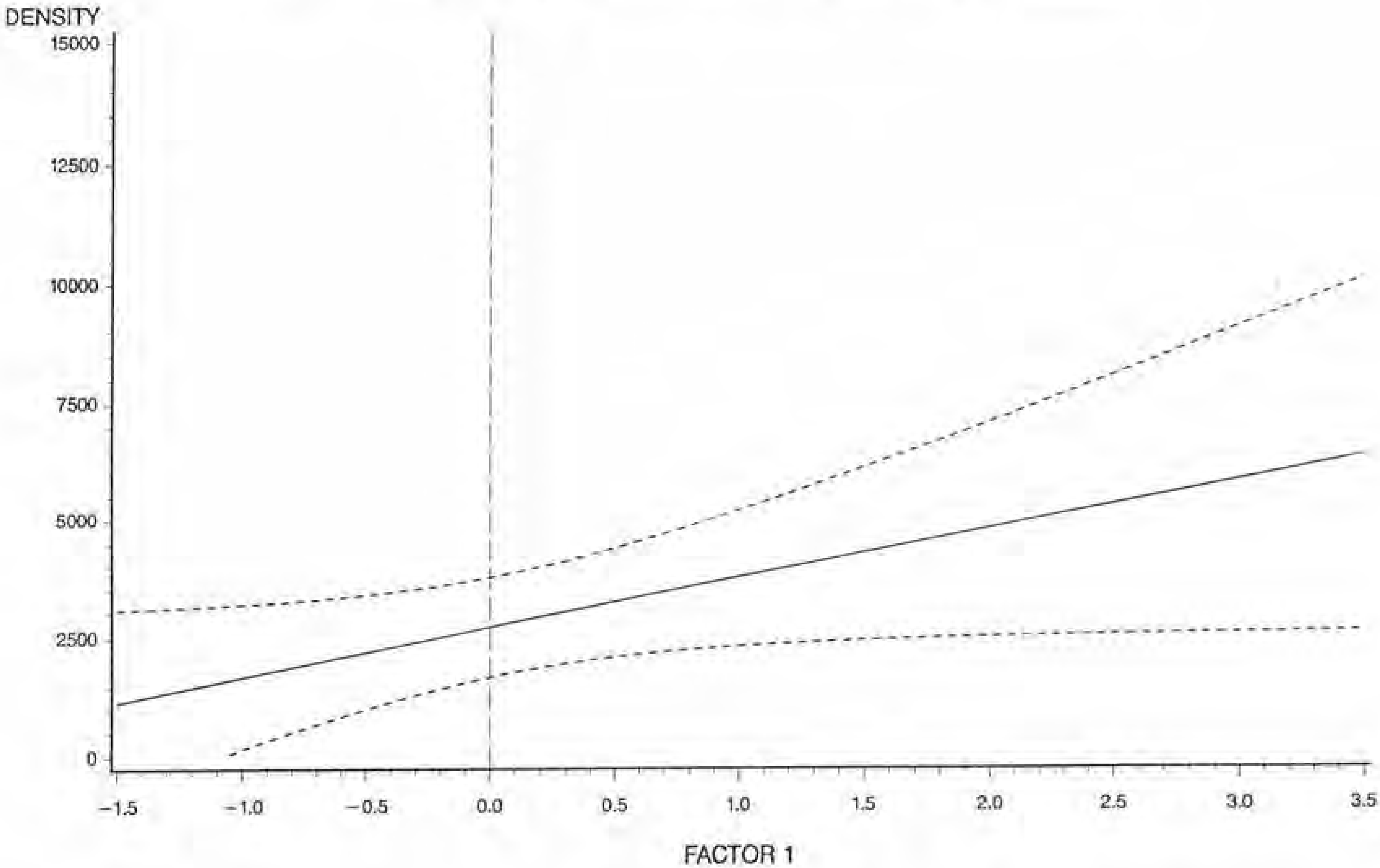
To examine the interaction of zooplankton taxa with the new composite variables the density of each zooplankton taxa, zooplankton species diversity, species richness, and total density for each collection were regressed against the scores of the original observations for each of the factors. Significance levels of the regressions were changed to 0.005 as was previously done in the 0 and 6 ppt salinity analyses.

Results of significant relationships of zooplankton taxa or community measures with the factors for 12 ppt salinity observations are shown with 95 % confidence intervals in Figures 4.50 through 4.59. Many zooplankton measures responded to Factor I, the flow and diatom factor. Total zooplankton density increased with increasing Factor I scores (flow and diatom productivity) (Figure 4.50). This increase in density was the result of increases in *Oithona nana*, copepod nauplii, ascidiacians, scaphapod larvae, gastropod larvae, and rotifers with increasing flow and increasing densities of diatoms (Figures 4.51 through 4.56 respectively).

Only three taxa significantly responded to Factor II, the dinoflagellate productivity factor with decreases in the densities of Cirripedia nauplii, gastropod larvae, and

FIGURE 4.50

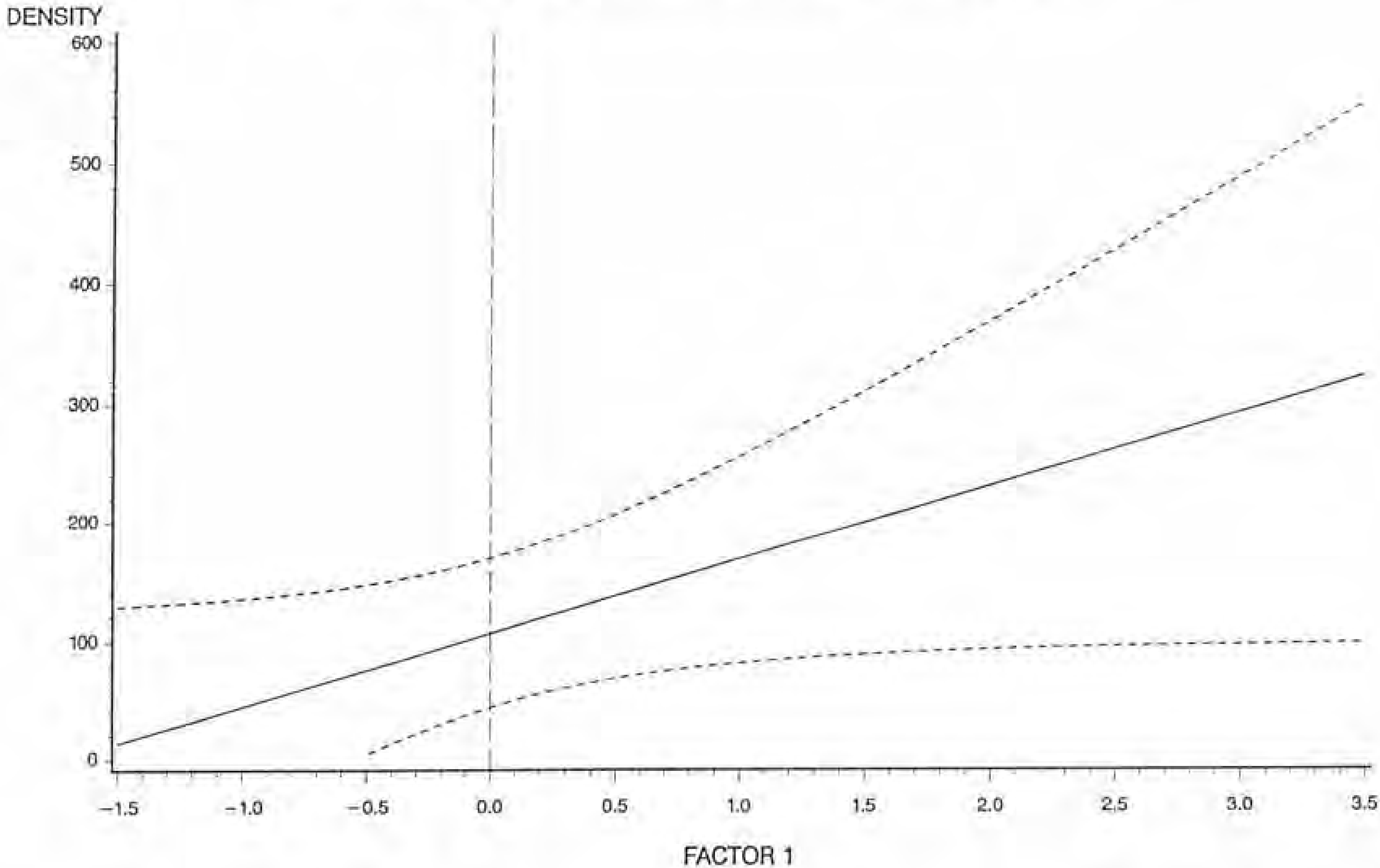
Plot Of Average Response Of Total Number of Zooplankton Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 12 ppt Salinity.



Positive Scores Indicate Increasing River Flow and Nutrients
Negative Scores Indicate Lower Flows and Nutrients

FIGURE 4.51

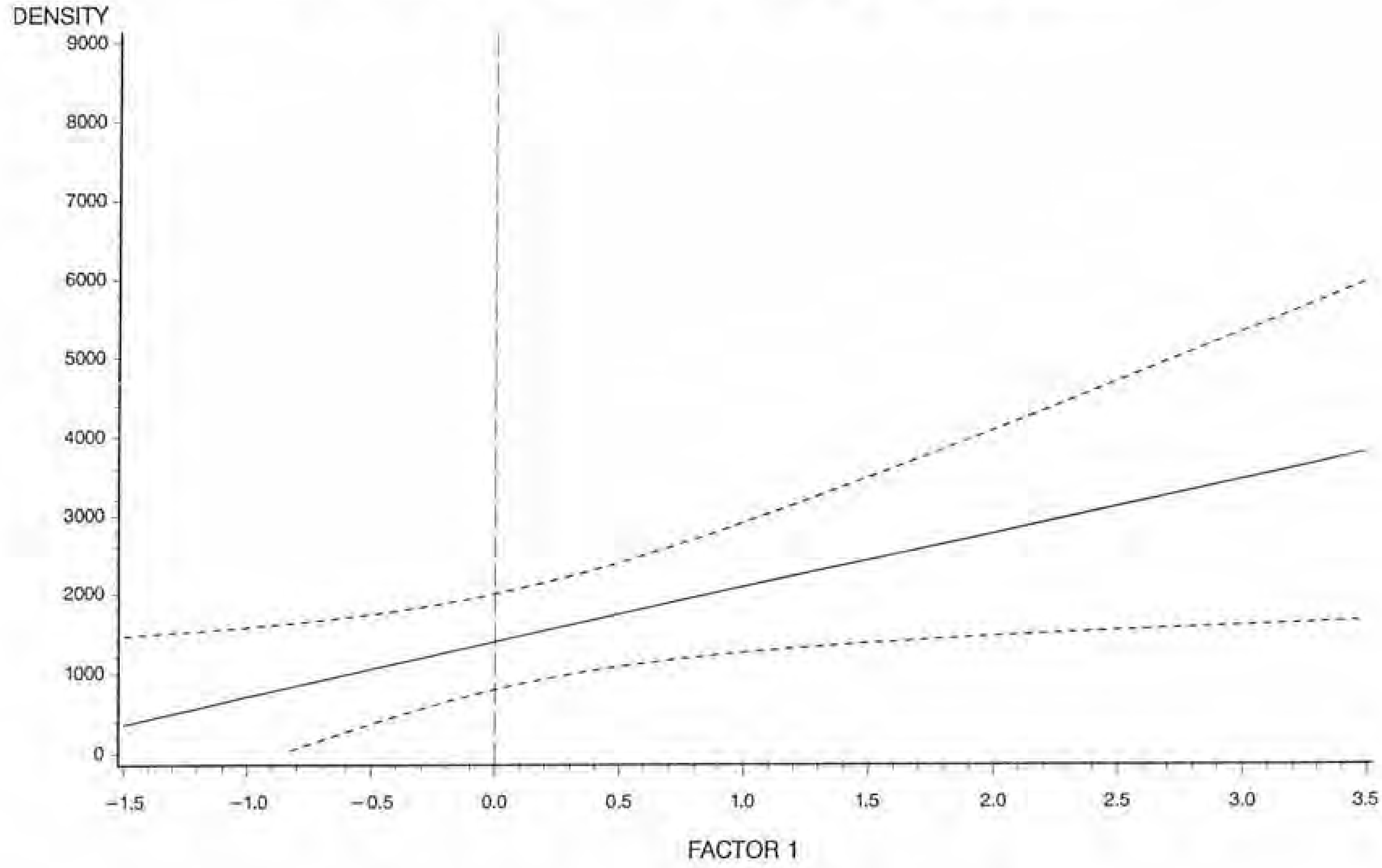
Plot Of Average Response Of Oithona nana Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 12 ppt Salinity.



Positive Scores Indicate Increasing River Flow and Nutrients
Negative Scores Indicate Lower Flows and Nutrients

FIGURE 4.52

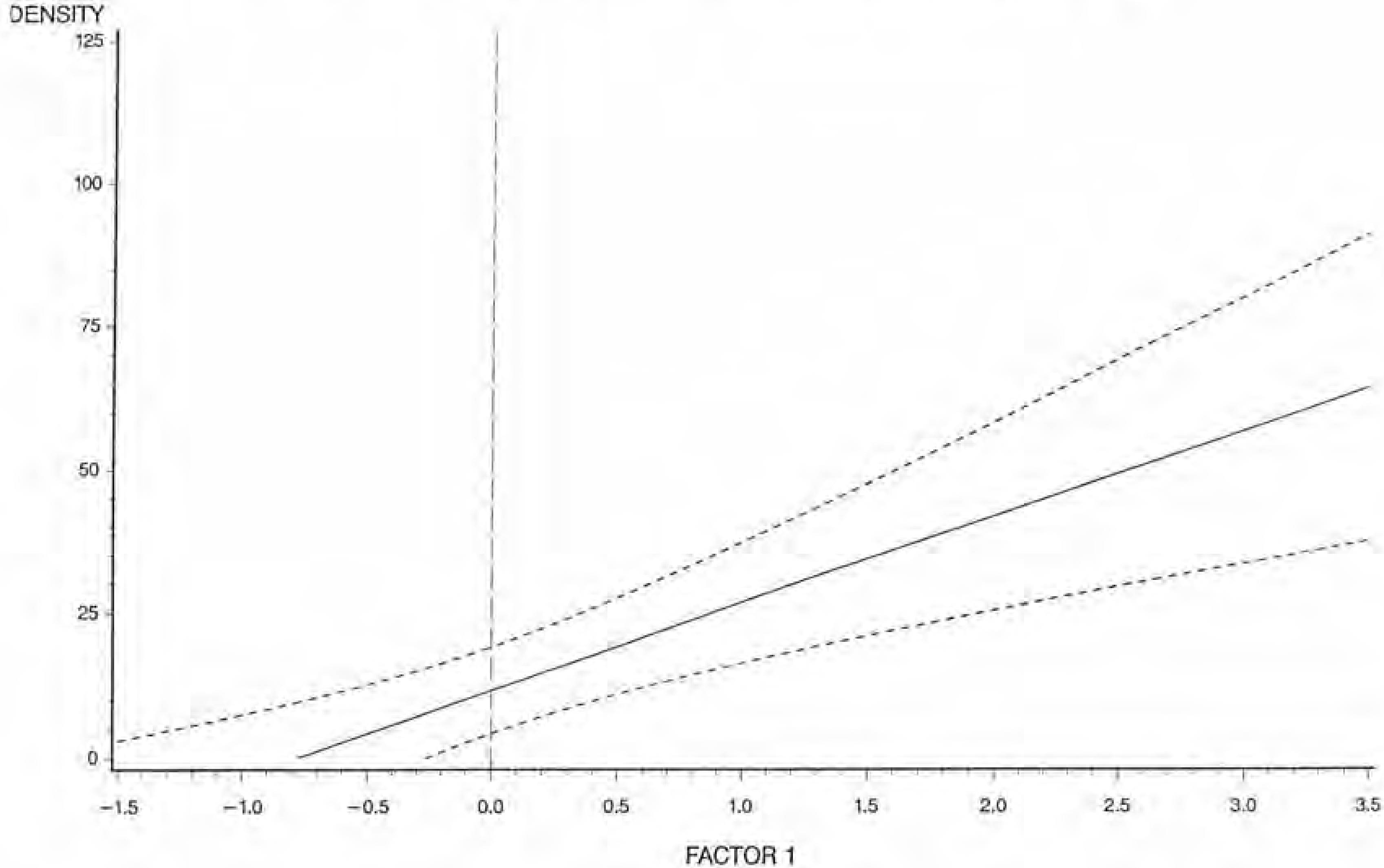
Plot Of Average Response Of Copepod Nauplii Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 12 ppt Salinity.



Positive Scores Indicate Increasing River Flow and Nutrients
Negative Scores Indicate Lower Flows and Nutrients

FIGURE 4.53

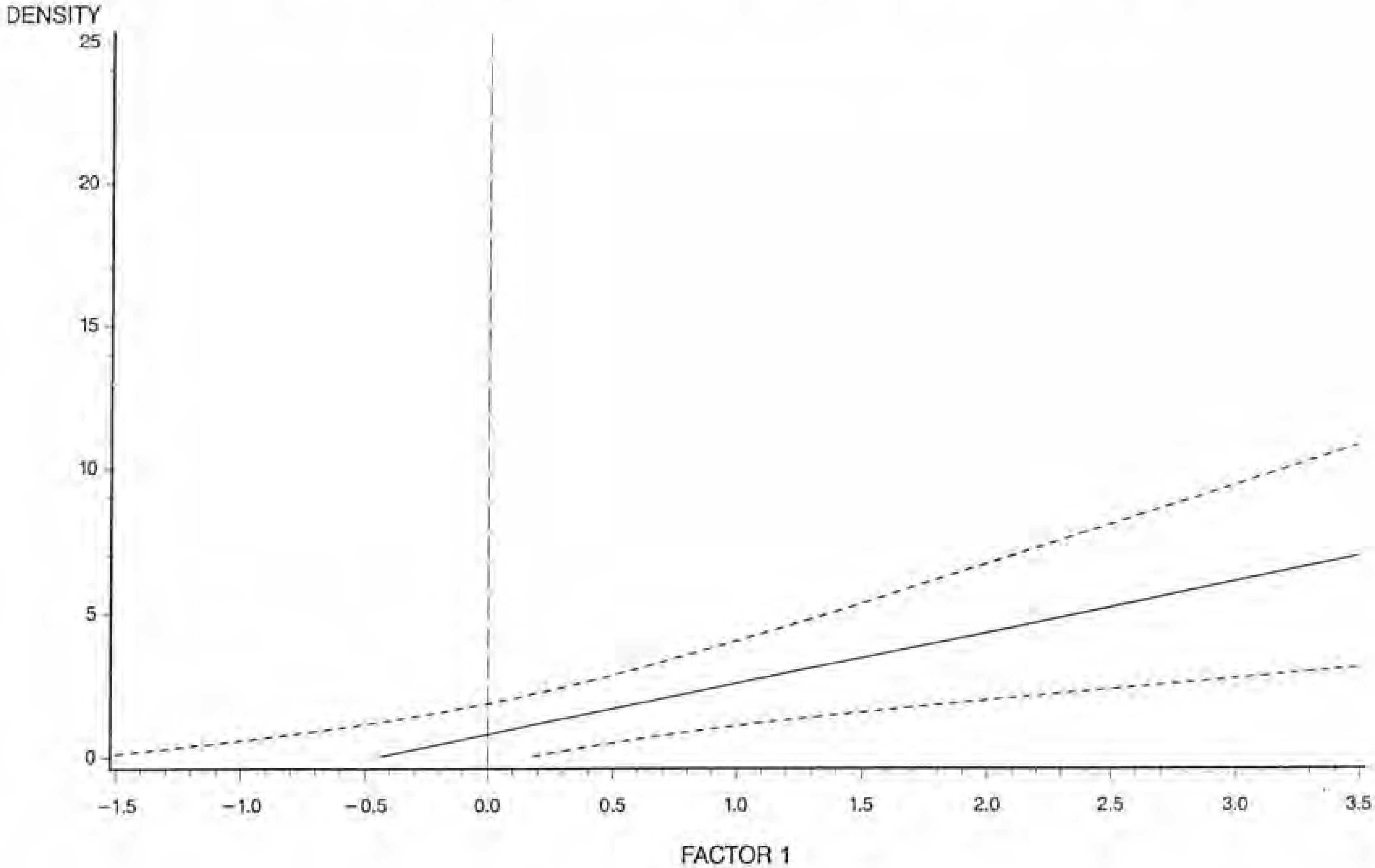
Plot Of Average Response Of Ascidiacea Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 12 ppt Salinity.



Positive Scores Indicate Increasing River Flow and Nutrients
Negative Scores Indicate Lower Flows and Nutrients

FIGURE 4.54

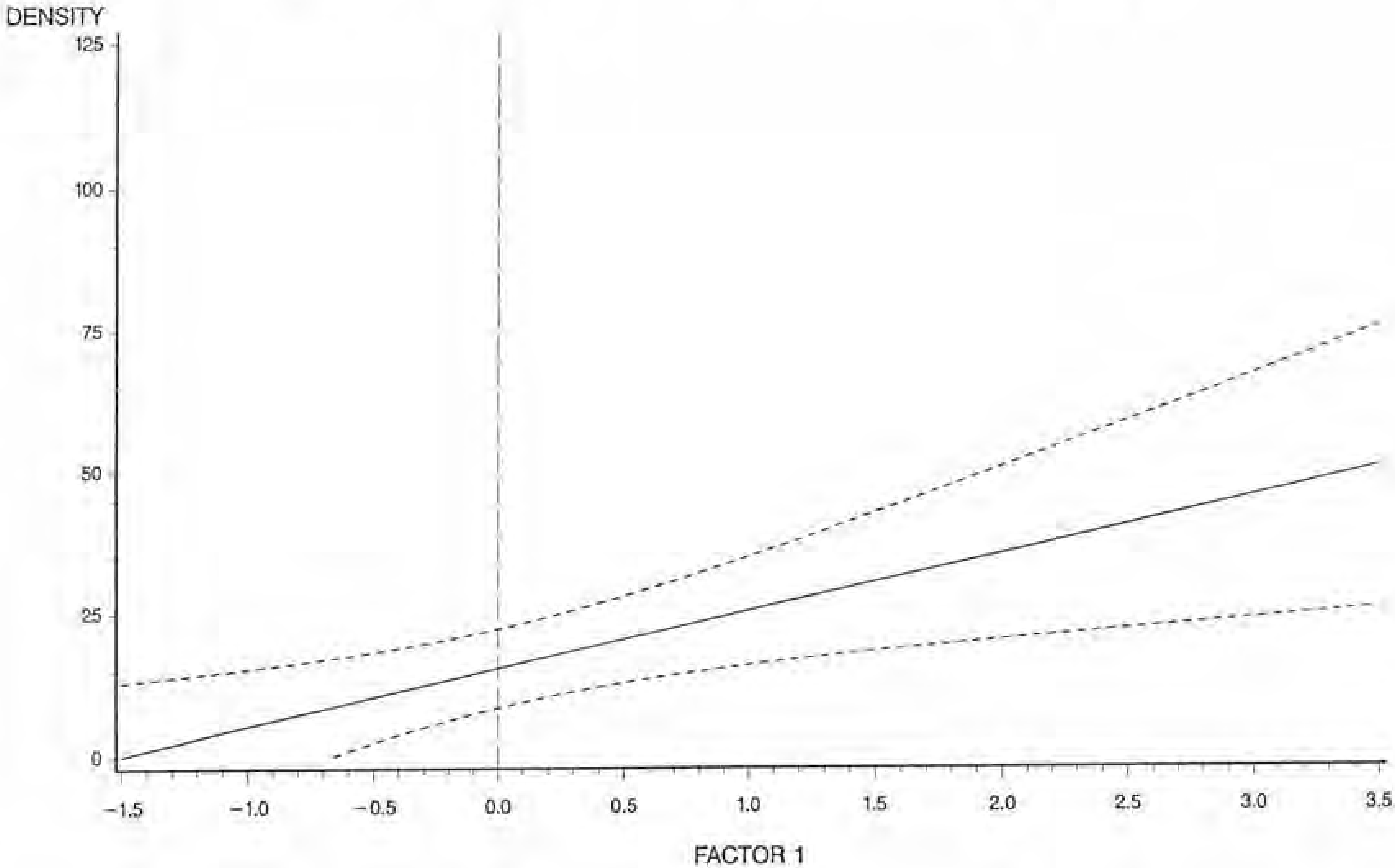
Plot Of Average Response Of Scaphapoda Larvae Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 12 ppt Salinity.



Positive Scores Indicate Increasing River Flow and Nutrients
Negative Scores Indicate Lower Flows and Nutrients

FIGURE 4.55

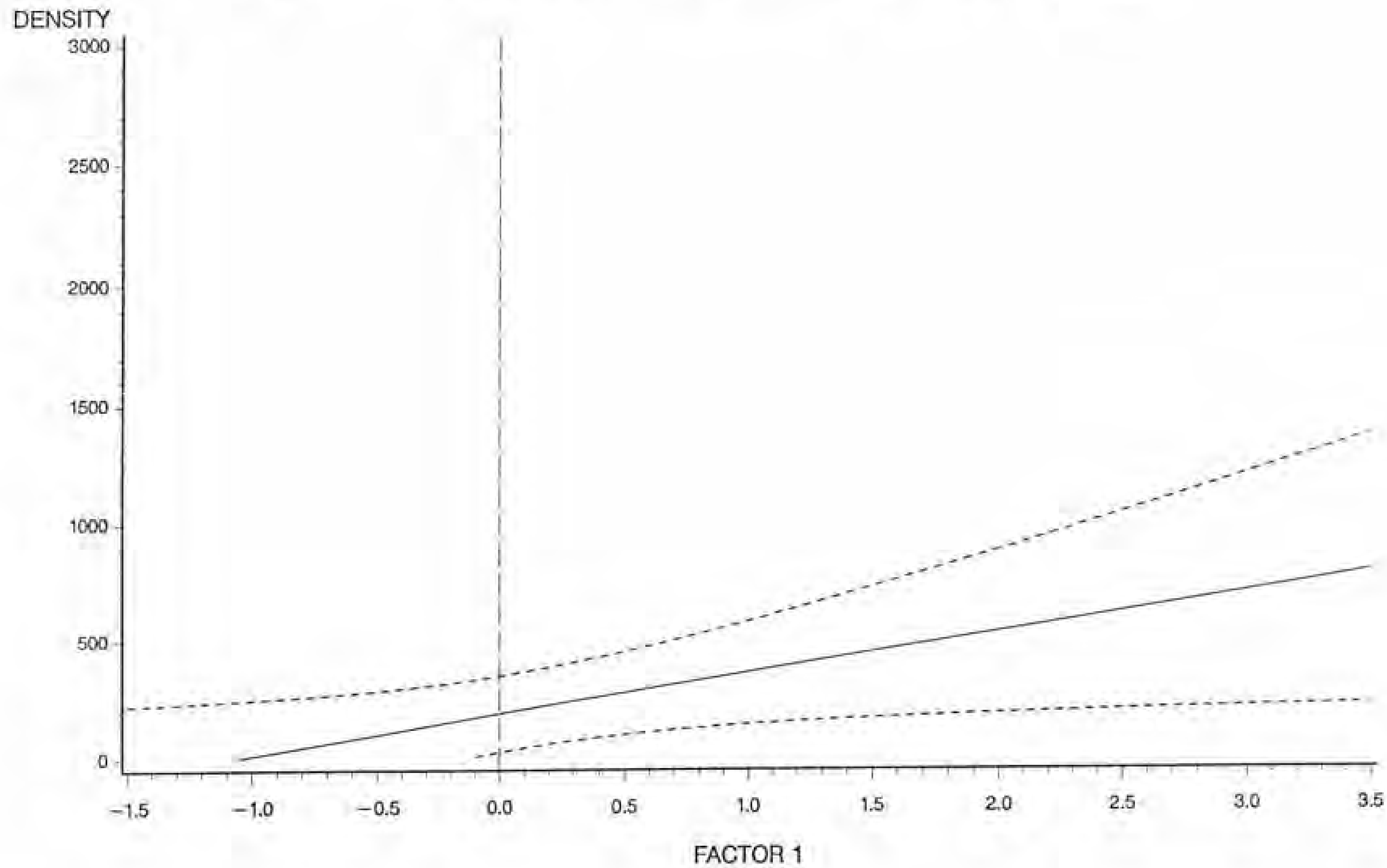
Plot Of Average Response Of Gastropod Larvae Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 12 ppt Salinity.



Positive Scores Indicate Increasing River Flow and Nutrients
Negative Scores Indicate Lower Flows and Nutrients

FIGURE 4.56

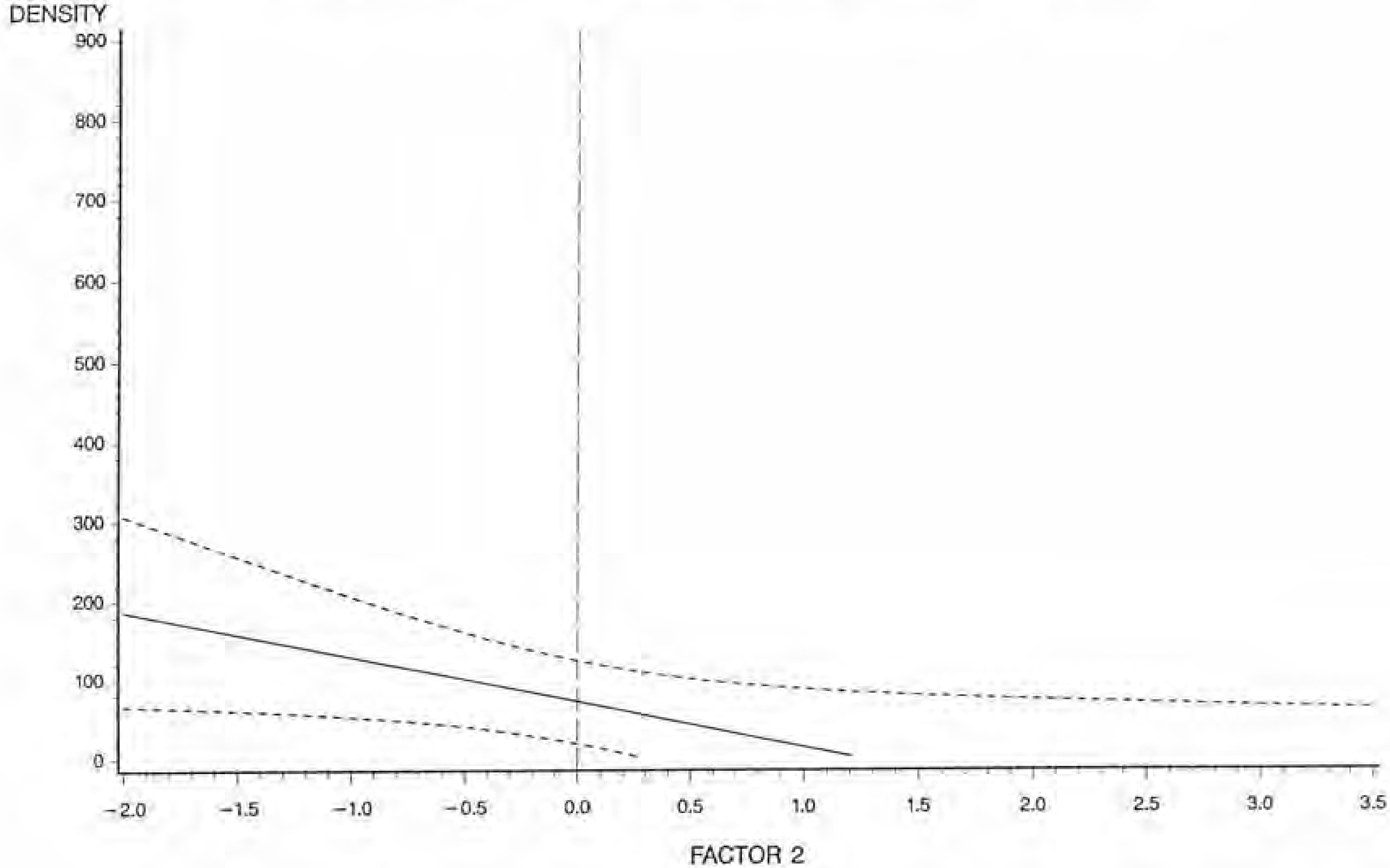
Plot Of Average Response Of Rotifera Versus Principal Component
Factor 1 Scores With 95 % Confidence Intervals At Station 12 ppt Salinity.



Positive Scores Indicate Increasing River Flow and Nutrients
Negative Scores Indicate Lower Flows and Nutrients

FIGURE 4.57

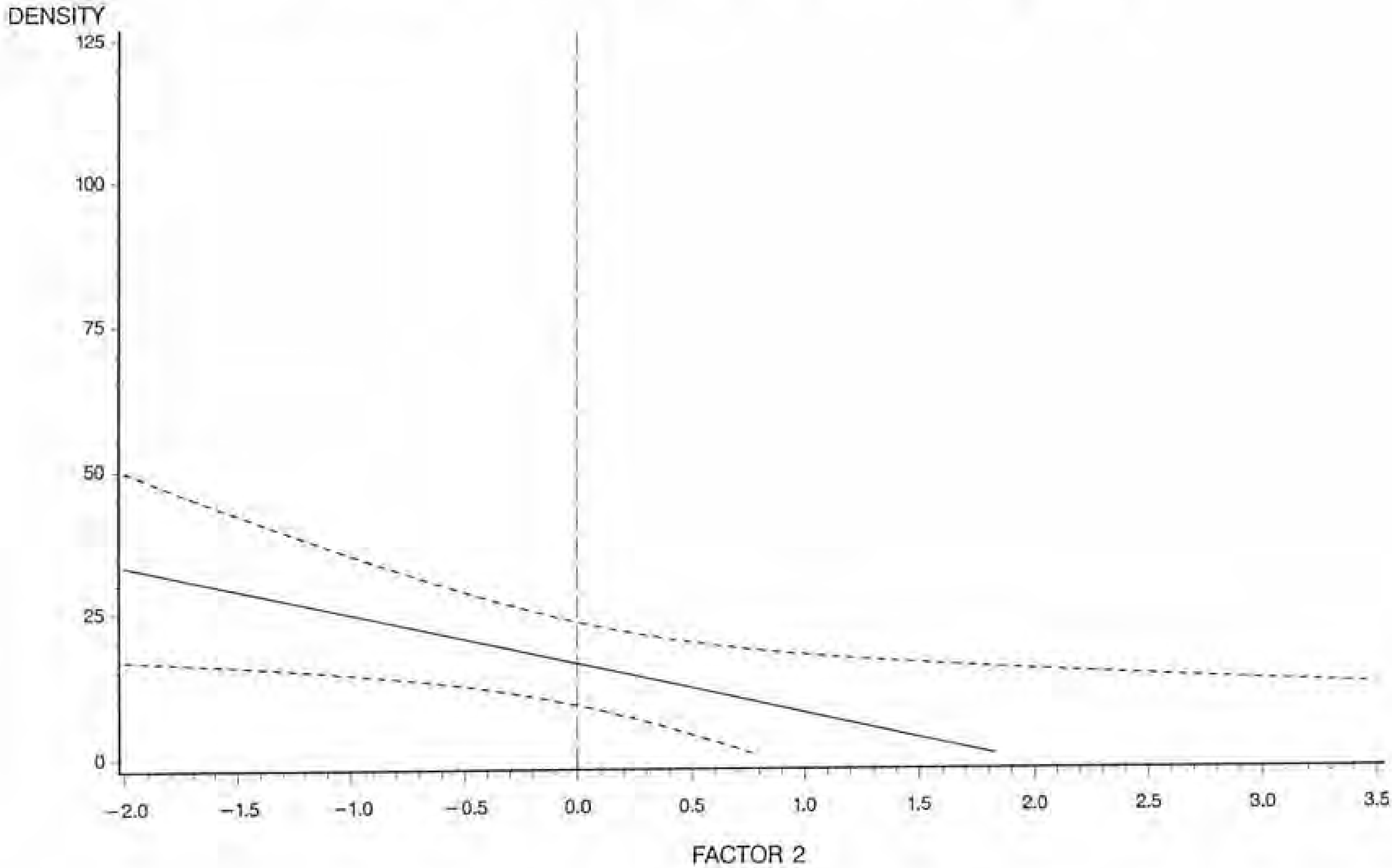
Plot Of Average Response Of Barnacle Nauplii (Cirripedia) Versus Principal Component Factor 2 Scores With 95 % Confidence Intervals At Station 12 ppt Salinity.



Positive Scores Indicate Increasing Phytoplankton Productivity and Dinoflagellates
Negative Scores Indicate Lower Productivity and Higher Phytoplankton Diversity

FIGURE 4.58

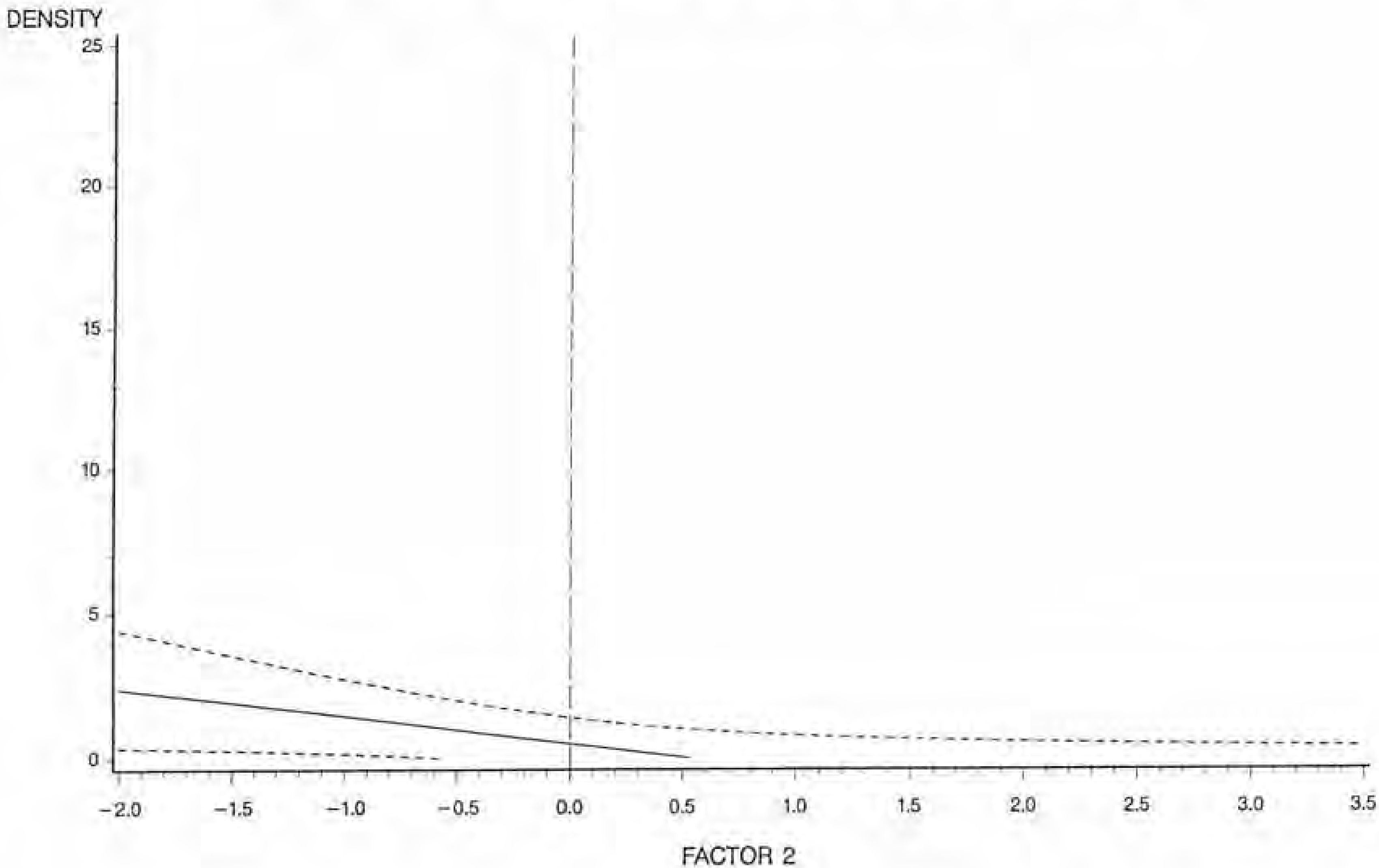
Plot Of Average Response Of Gastropod Larvae Versus Principal Component Factor 2 Scores With 95 % Confidence Intervals At Station 12 ppt Salinity.



Positive Scores Indicate Increasing Phytoplankton Productivity and Dinoflagellates
Negative Scores Indicate Lower Productivity and Higher Phytoplankton Diversity

FIGURE 4.59

Plot Of Average Response Of Harpactacoid Copepods Versus Principal Component Factor 2 Scores With 95 % Confidence Intervals At Station 12 ppt Salinity.



Positive Scores Indicate Increasing Phytoplankton Productivity and Dinoflagellates
Negative Scores Indicate Lower Productivity and Higher Phytoplankton Diversity

harpactacoid copepods all observed with increasing Factor II scores. No measures of zooplankton community composition or individual taxa were significantly related to Factor III, the withdrawal component.

20 o/oo Salinity

Three of the new synthetic composite variables (Factors 1 through 3), developed from the original 29 variables, were retained for further analysis. Each of these new Factors was selected on the basis of its accounting for at least 10% of the total variation within the original data set (Table 8a). Together these three new synthetic composite Factors accounted for 58 % of the statistical variance expressed in the original 29 variables.

The first of the new synthetic variables, Factor I, included high positive loadings or correlations with the measured flow variables, water color, primary productivity in the small size fraction, and diatom abundance (Table 8b). Negative correlations or loading of flagellates and phytoplankton species diversity with Factor I were also observed. Observations with high positive scores on Factor I, therefore, are characteristic of waters influenced by high flow and color, high numbers of diatoms, and high productivity in the smaller size fractions. A sample with a negative Factor I score would distinguish waters during low flow and having high clarity and lower numbers of diatoms, lower small size fraction productivity, and high numbers of flagellates.

Factor II had high positive loadings with primary productivity and chlorophyll a in the large size fractions and number of dinoflagellates. Thus, samples with high positive scores on Factor II are characteristic of waters with high primary productivity and high

TABLE 4.8a.
RESULTS OF PRINCIPAL COMPONENT ANALYSES, SALINITY 20 o/oo, MONTHLY PYSICAL/CHEMICAL PARAMETERS AND PRODUCTIVITY MEASURES.

FACTOR	EIGENVALUE	% VARIANCE EXPLAINED	CUMULATIVE %
I	9.501	30.65	30.65
II	4.806	15.51	46.15
III	3.406	10.99	57.14
IV	2.363	7.62	64.77

TABLE 4.8b.
CORRELATIONS OF THE ORIGINAL VARIABLES WITH THE COMPOSITE PRINCIPAL COMPONENT AXES (factor loadings) FOR 20 o/oo SALINITY.

ORIGINAL VARIABLE	CORRELATION COEFFICIENT		
	Factor I	Factor II	Factor III
Phytoplankton Species Richness	-0.627**	-0.102	0.064
Phytoplankton Species Diversity	-0.451*	-0.035	0.329
Abundance of Green Algae	-0.316	-0.046	0.184
Abundance of Flagellate Algae	-0.647**	-0.126	-0.005
Abundance of Dinoflagellate	0.313	0.544*	-0.260
Abundance of Diatoms	0.424*	-0.205	0.199
Abundance of Blue-Green Algae	-0.034	-0.084	-0.025
Total Carbon Uptake (Productivity)	0.544*	0.298	0.534*
Productivity (Carbon Uptake) > 20 um	0.293	0.536*	0.426
Productivity (Carbon Uptake) <20>5 um	0.300	0.039	0.502*
Productivity (Carbon Uptake) < 5 um	0.531*	-0.308	0.118
Total Peace River Flow (Daily)	0.857**	-0.365	-0.106
Total Peace River Flow (7 Day)	0.876**	-0.399	-0.112
Total Peace River Flow (14 Day)	0.917**	-0.322	-0.099
Total Peace River Flow (28 Day)	0.897**	-0.319	-0.008
Color	0.636**	0.213	0.221
Total Chlorophyll a	0.447	0.843**	-0.177
Chlorophyll > 20 um	0.383	0.862**	-0.167
Chlorophyll < 20 and > 5 um.	0.456	0.824**	-0.144
Chlorophyll < 5 um.	0.663**	0.420	-0.218
Nitrate+Nitrite	-0.114	0.006	-0.344
Silica	0.276	0.053	-0.222
Total Nitrogen	0.420	0.703**	-0.056
Total Phosphorous	-0.235	0.376	-0.550*
Nitrogen/Phosphorous Ratio	0.175	-0.046	0.193
Daily Freshwater Withdrawal	0.048	0.229	0.668**
Average Daily Withdrawal (7 Days)	0.080	0.185	0.826**
Average Daily Withdrawal (14 Days)	0.124	0.077	0.736**

*** and ** indicate significant correlation coefficents used in interpretation**

concentrations of chlorophyll a in the larger (< 20 um) size fraction, a large number of dinoflagellates. A sample with a low Factor II score, by comparison, would represent conditions of relatively low productivity and chlorophyll a, and fewer dinoflagellates.

Factor III was positively correlated freshwater withdrawal and negatively correlated with phosphate concentrations. An observation with a high positive score on Factor III, therefore, would be characteristic of higher freshwater withdrawals. Observations with a negative score on Factor III, by comparison, would be indicative lower withdrawals and higher phosphate concentrations.

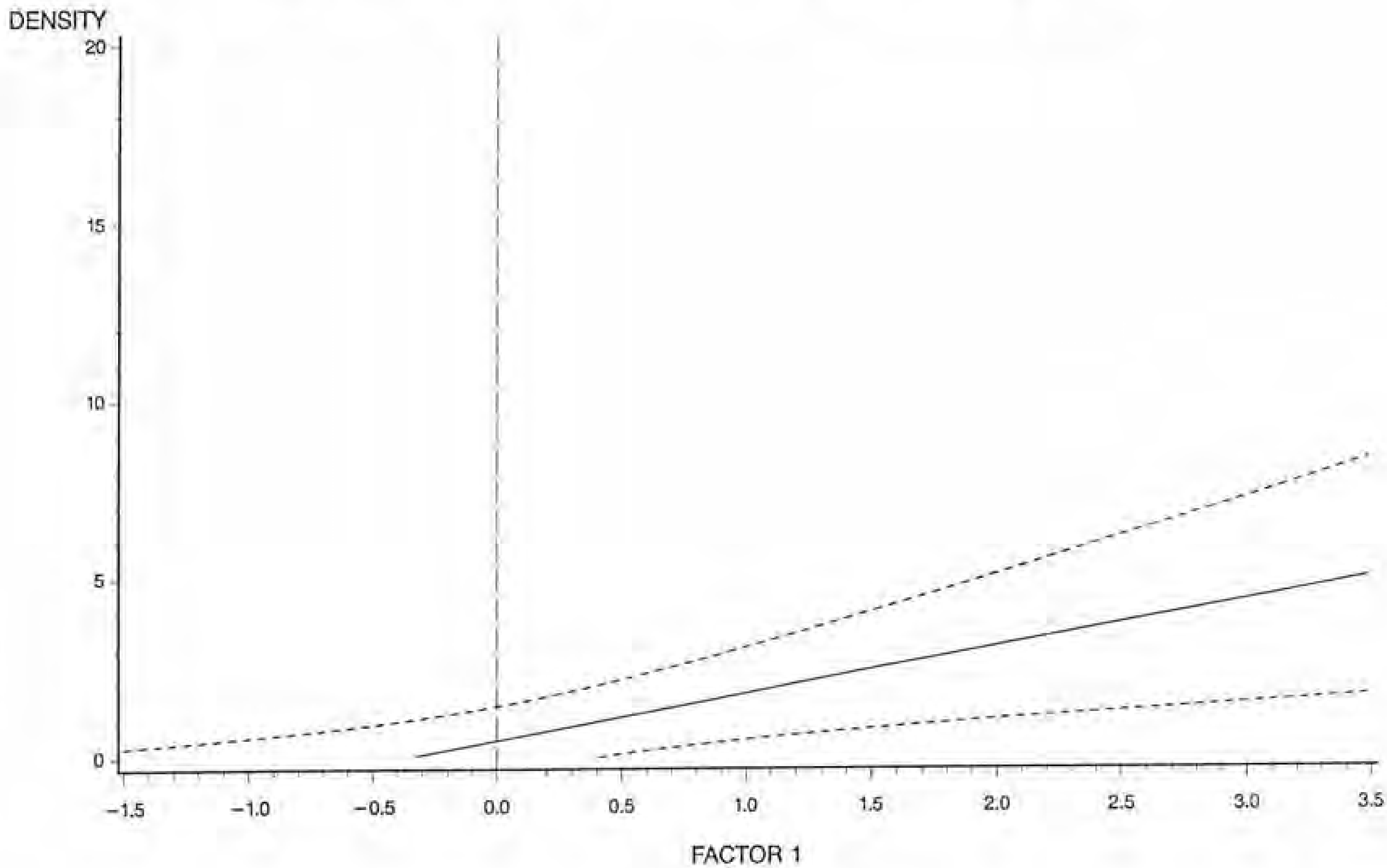
In essence, Factor I may be visualized, with its high loadings for flow, as summarizing freshwater inputs at 12 ppt salinity and high diatom productivity. Factor II, by comparison, with its high correlation with large size fraction productivity and dinoflagellate abundance is primary productivity in the larger size fraction. The final new synthetic variable, Factor III, summarized freshwater withdrawal.

To examine the interaction of zooplankton taxa with the new composite variables the density of each zooplankton taxa, zooplankton species diversity, species richness, and total density for each collection were regressed against the scores of the original observations for each of the factors. Significance levels of the regressions were changed to 0.005 as was previously done in the 0, 6, and 12 ppt salinity analyses.

Results of significant relationships of zooplankton taxa or community measures with the factors for 20 ppt salinity observations are shown with 95 % confidence intervals in Figures 4.60 through 4.65. Many zooplankton measures responded to Factor I, the flow and diatom factor. Increases in the densities of *Oithona colocarva,* copepod nauplii, planktonic gastropods, polychaete larvae and cumacean crustaceans were all observed

FIGURE 4.60

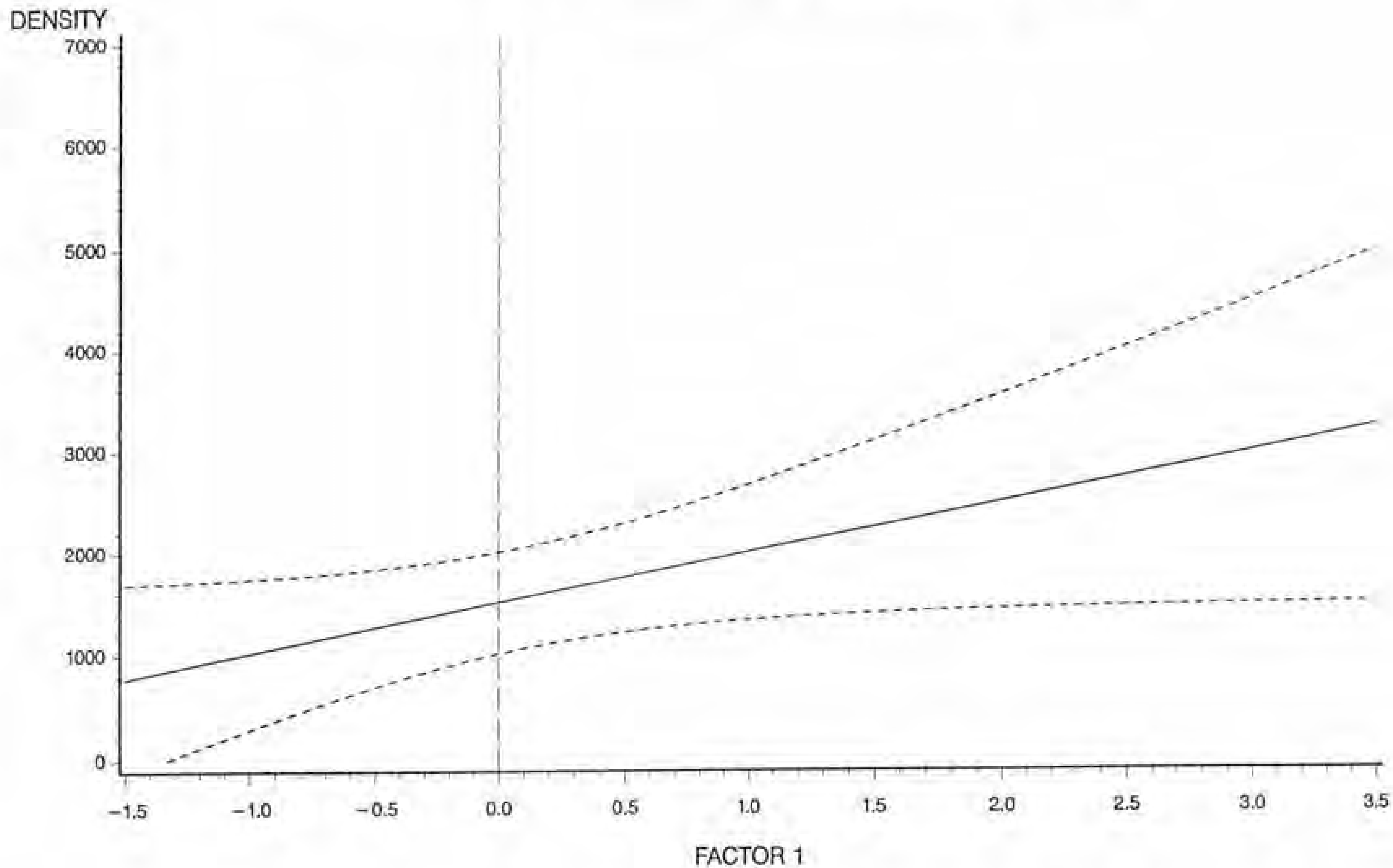
Plot Of Average Response Of Oithona colcarva Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 20 ppt Salinity.



Positive Scores Indicate Increasing River Flow and Diatoms/Chlorphyll a
Negative Scores Indicate Lower River Flows

FIGURE 4.61

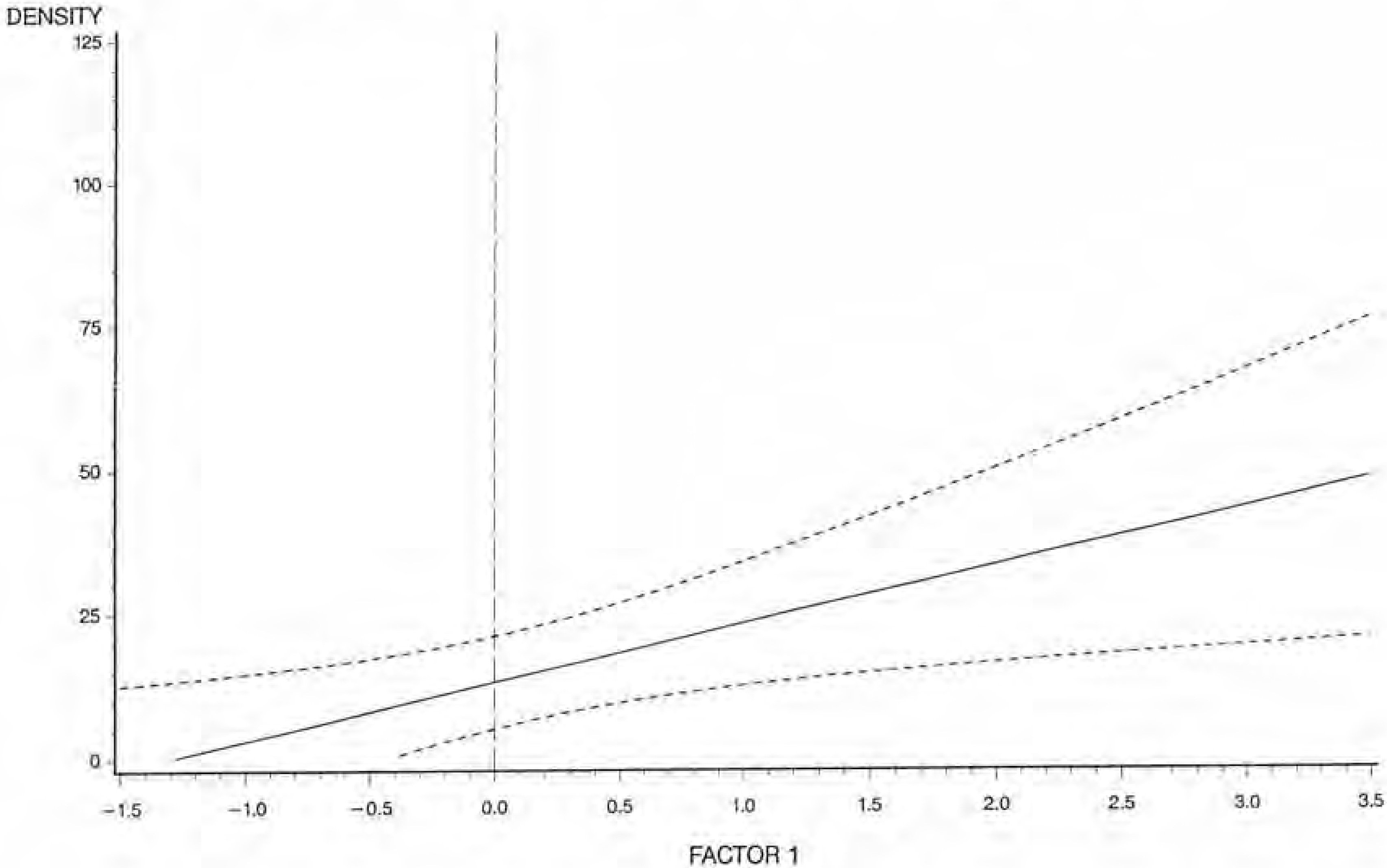
Plot Of Average Response Of Copepod Nauplii Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 20 ppt Salinity.



Positive Scores Indicate Increasing River Flow and Diatoms/Chlorphyll a
Negative Scores Indicate Lower River Flows

FIGURE 4.62

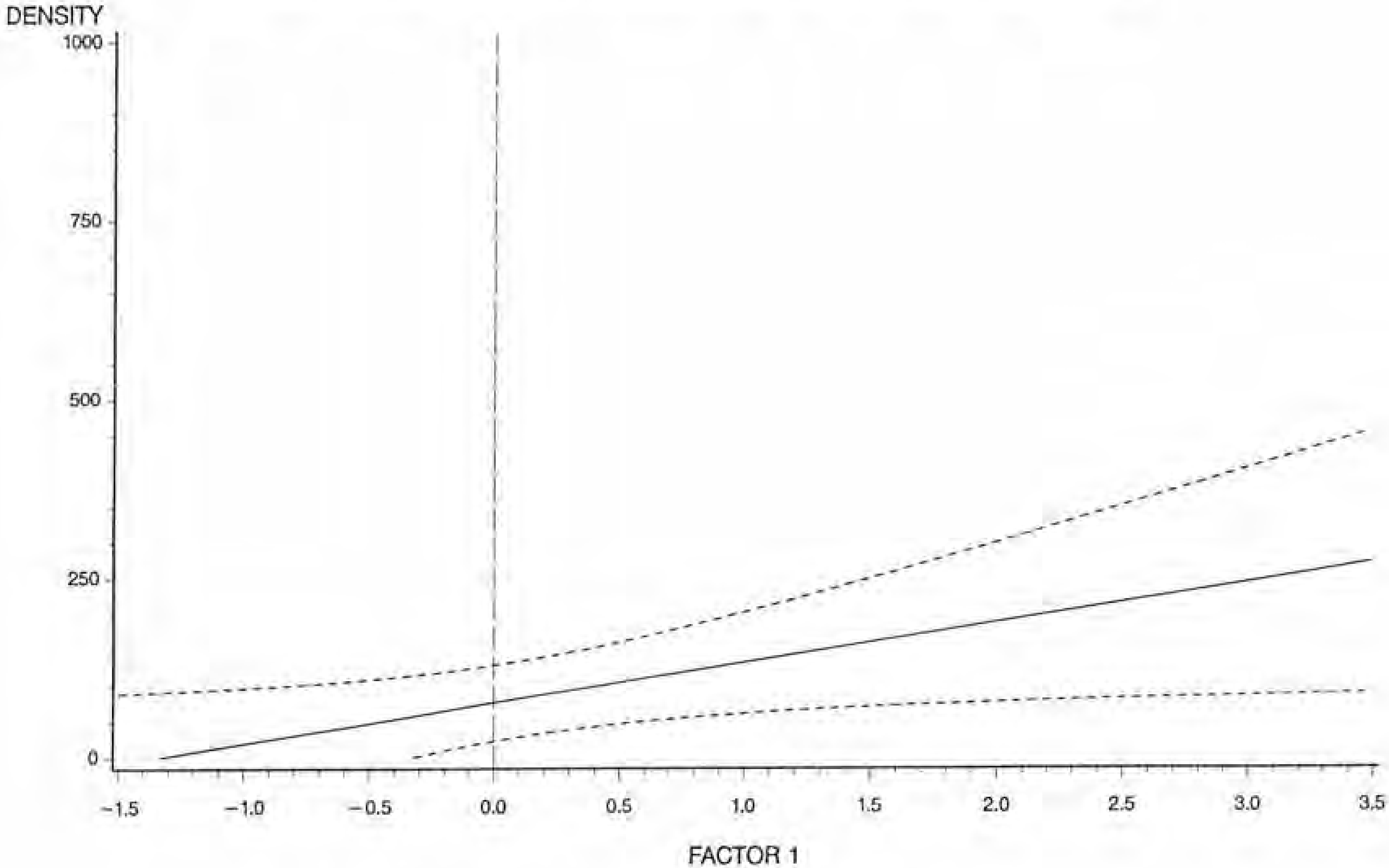
Plot Of Average Response Of Planktonic Gastropods Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 20 ppt Salinity.



Positive Scores Indicate Increasing River Flow and Diatoms/Chlorphyll a
Negative Scores Indicate Lower River Flows

FIGURE 4.63

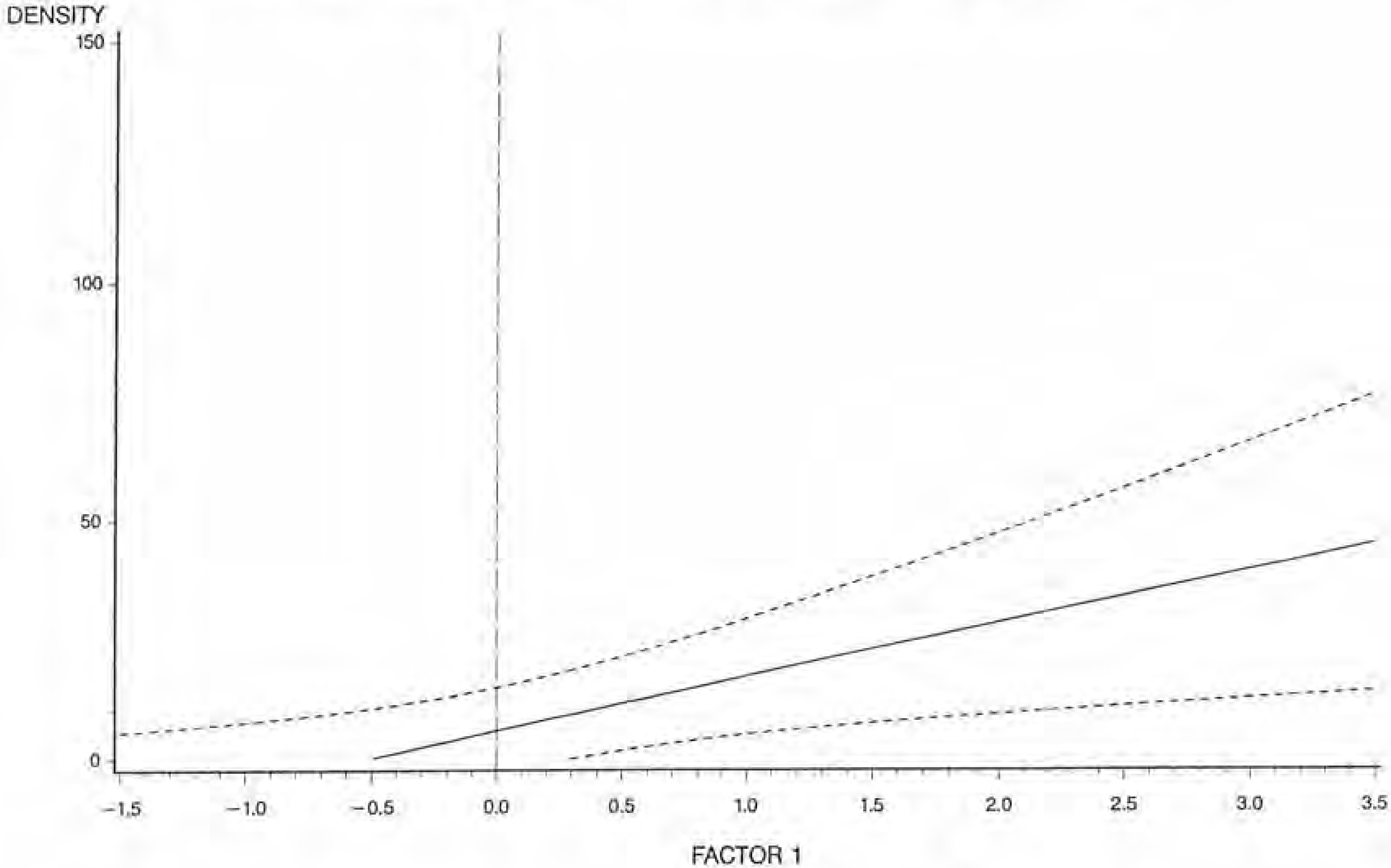
Plot Of Average Response Of Polychaete Larvae Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 20 ppt Salinity.



Positive Scores Indicate Increasing River Flow and Diatoms/Chlorphyll a
Negative Scores Indicate Lower River Flows

FIGURE 4.64

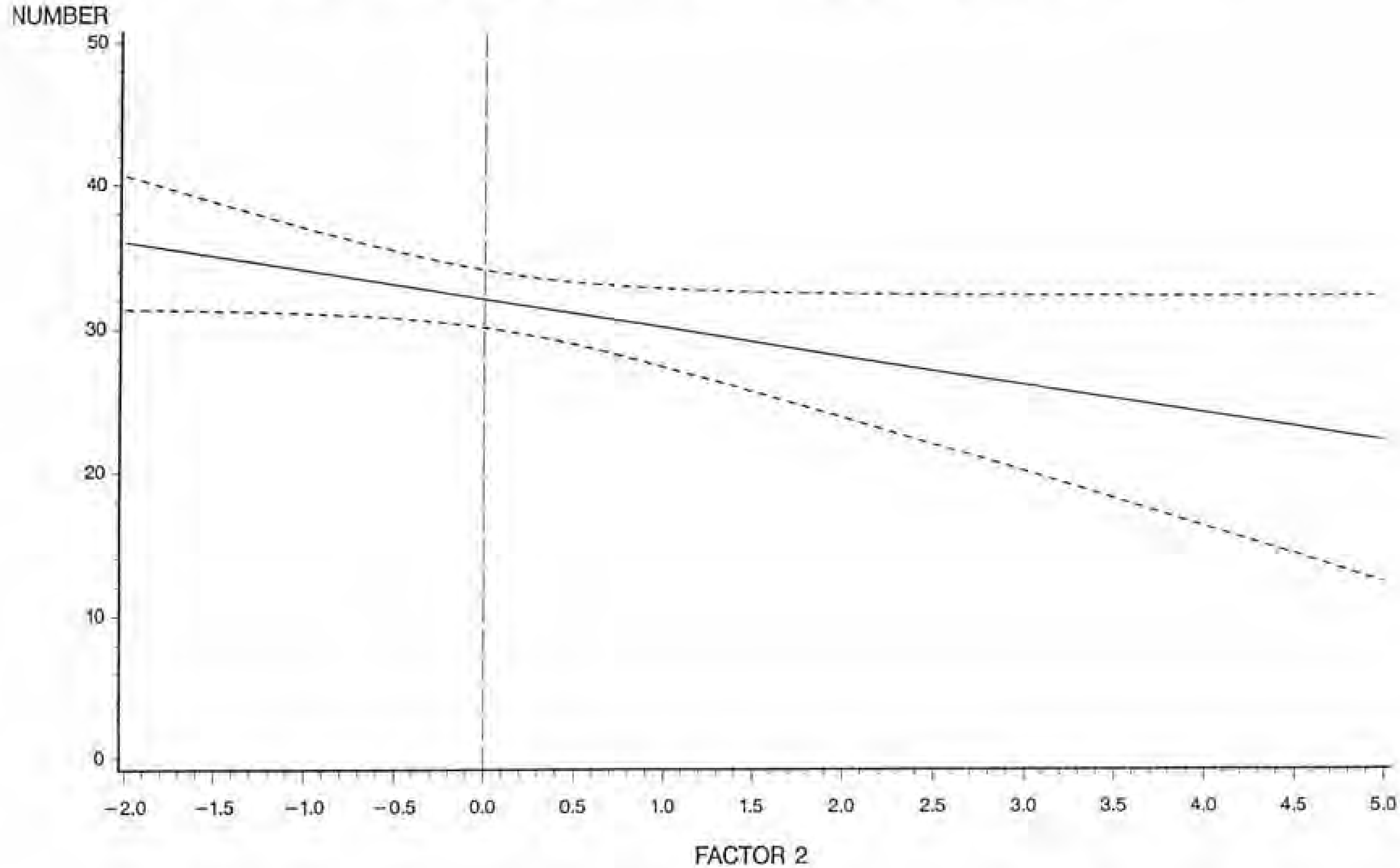
Plot Of Average Response Of Cumacean Crustaceans Versus Principal Component Factor 1 Scores With 95 % Confidence Intervals At Station 20 ppt Salinity.



Positive Scores Indicate Increasing River Flow and Diatoms/Chlorphyll a
Negative Scores Indicate Lower River Flows

FIGURE 4.65

Plot Of Average Response Of Zooplankton Species Richness Versus Principal Component Factor 2 Scores With 95 % Confidence Intervals At Station 20 ppt Salinity.



Positive Scores Indicate Increasing Dinoflagellates/Chlorphyll a
Negative Scores Indicate Fewer Dinoflagellates Increasing Phytoplankton Diversity

with increasing flow and increasing densities of diatoms (Figures 4.60 through 4.64 respectively).

Only the species richness of zooplankton responded to Factor II score, the dinoflagellate productivity factor with decreases in zooplankton species richness observed with increasing Factor II scores. No measures of zooplankton community composition or individual taxa were significantly related to Factor III, the withdrawal component.

4.3.3 Results of Diel Zooplankton Collections

Many species of zooplankton exhibit some degree of diurnal or diel periodicity in abundance. Many species seek refuge of predation in the sediments during the day when they are most vulnerable to sight feeding planktivores, rise to the surface during the twilight hours to feed, and return to the sediments during daylight. The monthly zooplankton study reported above was conducted at apparent high noon, concurrent with primary productivity and phytoplankton studies. To examine how the zooplankton community changed with changes in time of day a diel study of the zooplankton community was conducted.

The results of each zooplankton sampling from the diel study are presented in Appendix C. From the diel sampling a total of 77 taxonomic groups or species were collected. These species or taxa collected were similar to those collected from the monthly samples. Densities from the diel collections were similar to those observed from the monthly collections and were typically about 1 million plankters per m^3. For both salinities sampled species richness was usually between 20 to 35 taxa for all depths, times, and dates sampled.

12 o/oo Salinity Diel Studies

Diels conducted in March of 1990 and 1991 showed similar across years in terms of species richness (Figures 4.66 and 4.67). At both times, species richness was between 20 to 35 species or taxa of plankton. In each sampling date species richness for both surface and bottom waters, peaked during the afternoon (1500-1600 hrs), declined at twilight (1800-1900 hrs), again peaked in the early evening (2100-2200 hrs), declined around midnight, and finally increased again prior to sunrise.

Total density of zooplankton during March, 1990 and 1991 ranged from a daytime low of about 150,000 plankton per m^3 to an evening high of 1.75 million per m^3 (Figures 4.68 and 4.69). The patterns of plankton density shifts during the diel period were consistent with those observed for species richness. The highest observations for total zooplankton density were observed during the afternoon, early evening, and just prior to sunrise with declines observed between peaks. These observed shifts in density corresponded with shifts in species richness. This correspondence between species richness and total density probably indicates additional species migrating into the zooplankton from the sediments. This would increase the number of taxa as well as increase overall density.

Diels conducted during June of 1990 and 1991 were slightly different in their patterns of species richness (Figures 4.70 and 4.71). In 1990, well defined peaks were observed at 1200, 1800, and 2400 hours. It should be noted that these peaks correspond to lows in species richness during March diels. In 1991, two peaks in richness were observed, one at 1200-1500 hrs and a second at 0300 hours. In the bottom samples during 1991 species richness was usually lowest whereas in 1990 bottom

FIGURE 4.66

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
DURING 24 HOUR DIEL, 12 PPT SALINITY.
DATE=MAR90

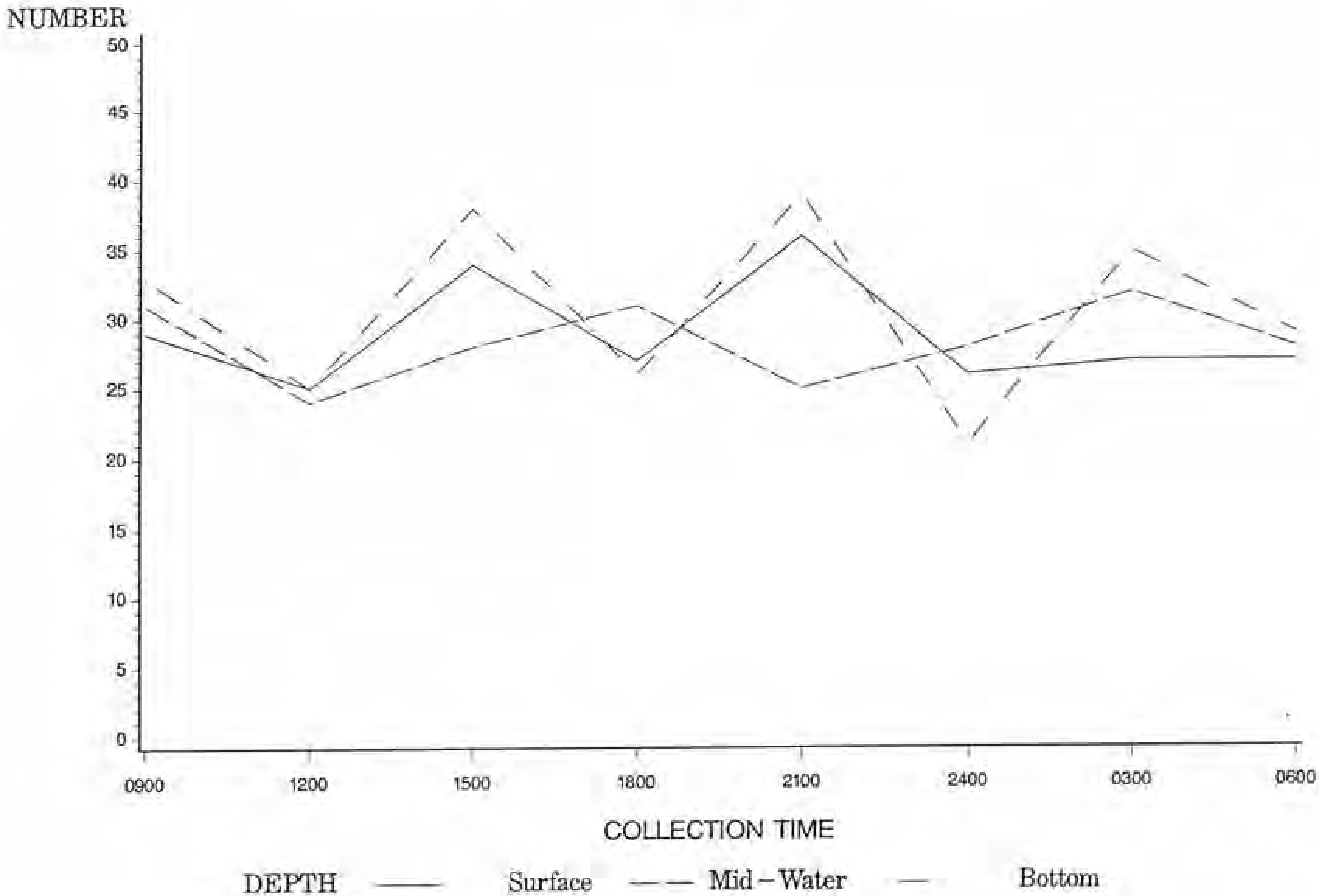
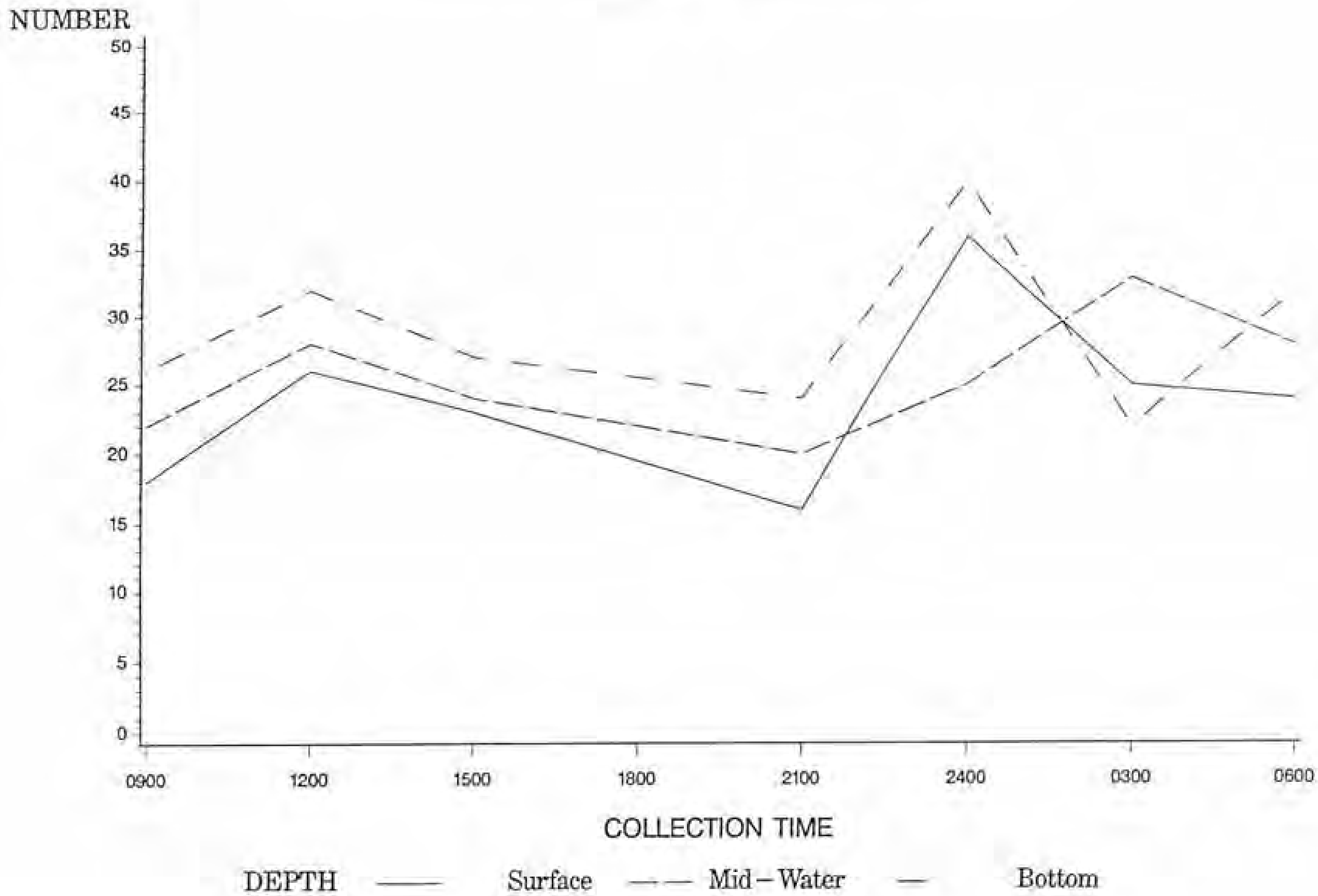


FIGURE 4.67

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
DURING 24 HOUR DIEL, 12 PPT SALINITY.
DATE=MAR91



richness for both surface and bottom waters, peaked during the afternoon (1500-1600 hrs), declined at twilight (1800-1900 hrs), again peaked in the early evening (2100-2200 hrs), declined around midnight, and finally increased again prior to sunrise.

Total density of zooplankton during March, 1990 and 1991 ranged from a daytime low of about 150,000 plankton per m^3 to an evening high of 1.75 million per m^3 (Figures 4.68 and 4.69). The patterns of plankton density shifts during the diel period were consistent with those observed for species richness. The highest observations for total zooplankton density were observed during the afternoon, early evening, and just prior to sunrise with declines observed between peaks. These observed shifts in density corresponded with shifts in species richness. This correspondence between species richness and total density probably indicates additional species migrating into the zooplankton from the sediments. This would increase the number of taxa as well as increase overall density.

Diels conducted during June of 1990 and 1991 were slightly different in their patterns of species richness (Figures 4.70 and 4.71). In 1990, well defined peaks were observed at 1200, 1800, and 2400 hours. It should be noted that these peaks correspond to lows in species richness during March diels. In 1991, two peaks in richness were observed, one at 1200-1500 hrs and a second at 0300 hours. In the bottom samples during 1991 species richness was usually lowest where as in 1990 bottom species richness was usually equal or exceeded surface and midwater species richness. At both times, species richness was between 15 to 25 species or taxa of

FIGURE 4.68

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 12 PPT SALINITY.
DATE=MAR90

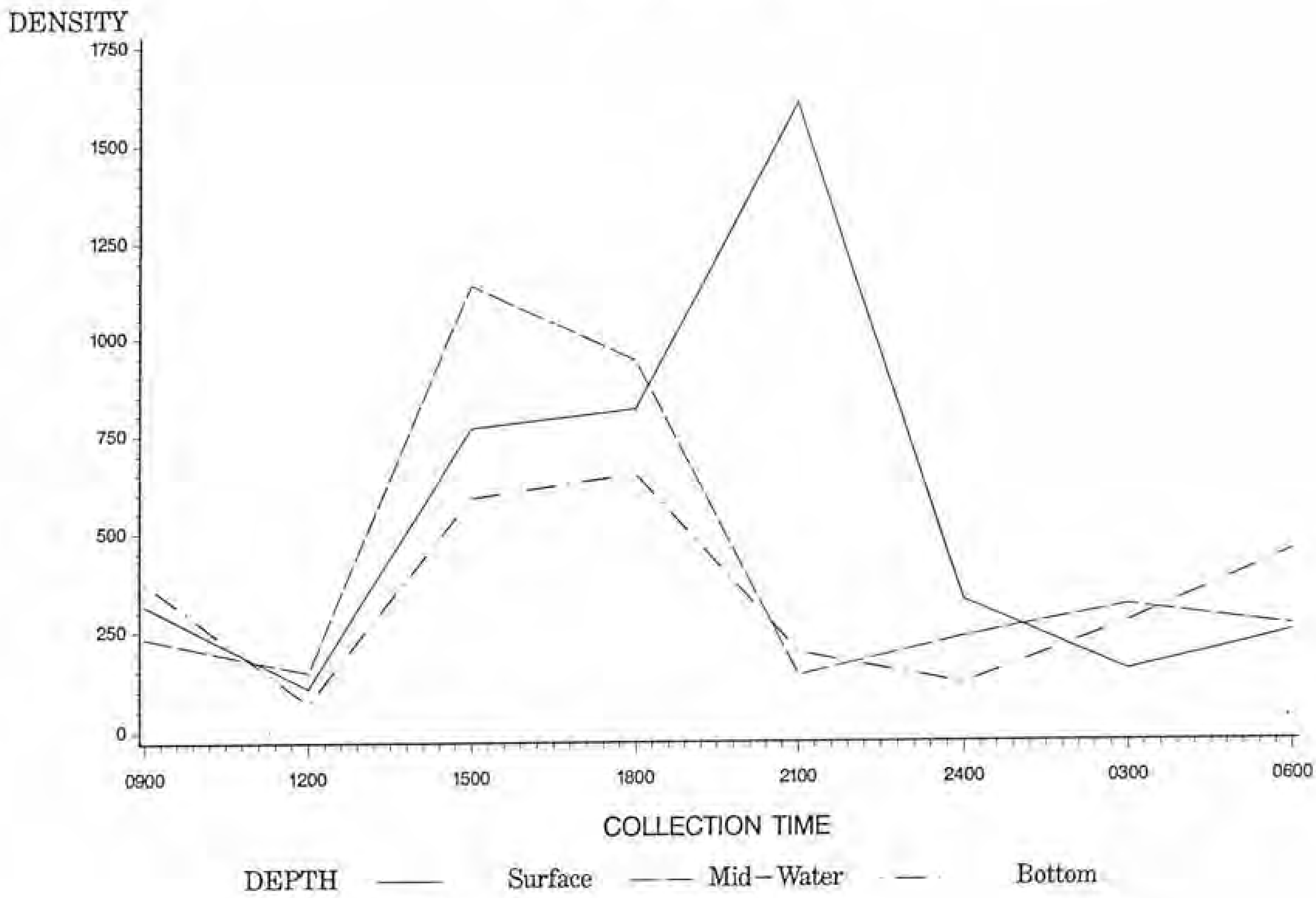


FIGURE 4.69

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 12 PPT SALINITY.
DATE=MAR91

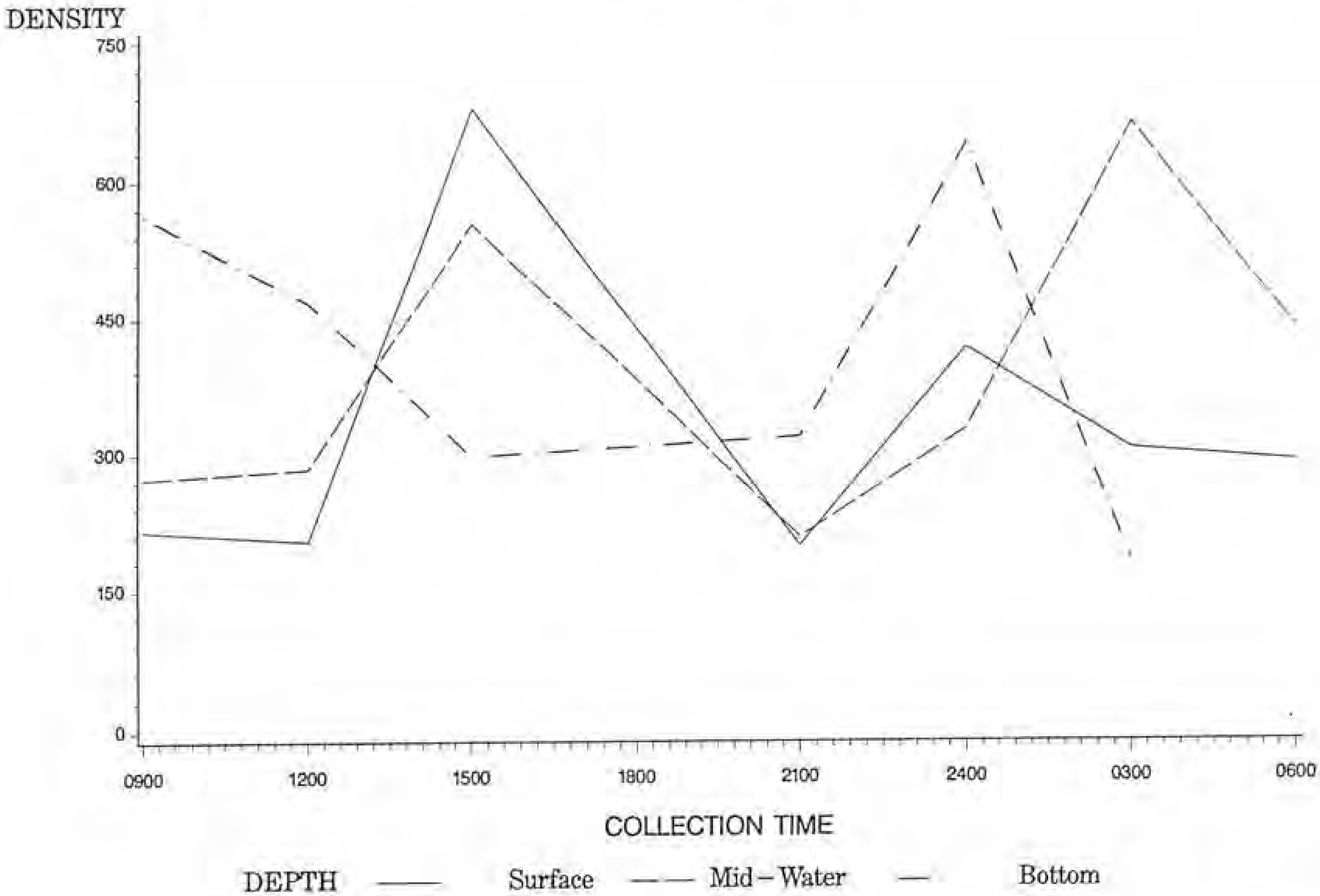


FIGURE 4.70

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
DURING 24 HOUR DIEL, 12 PPT SALINITY.
DATE=JUN90

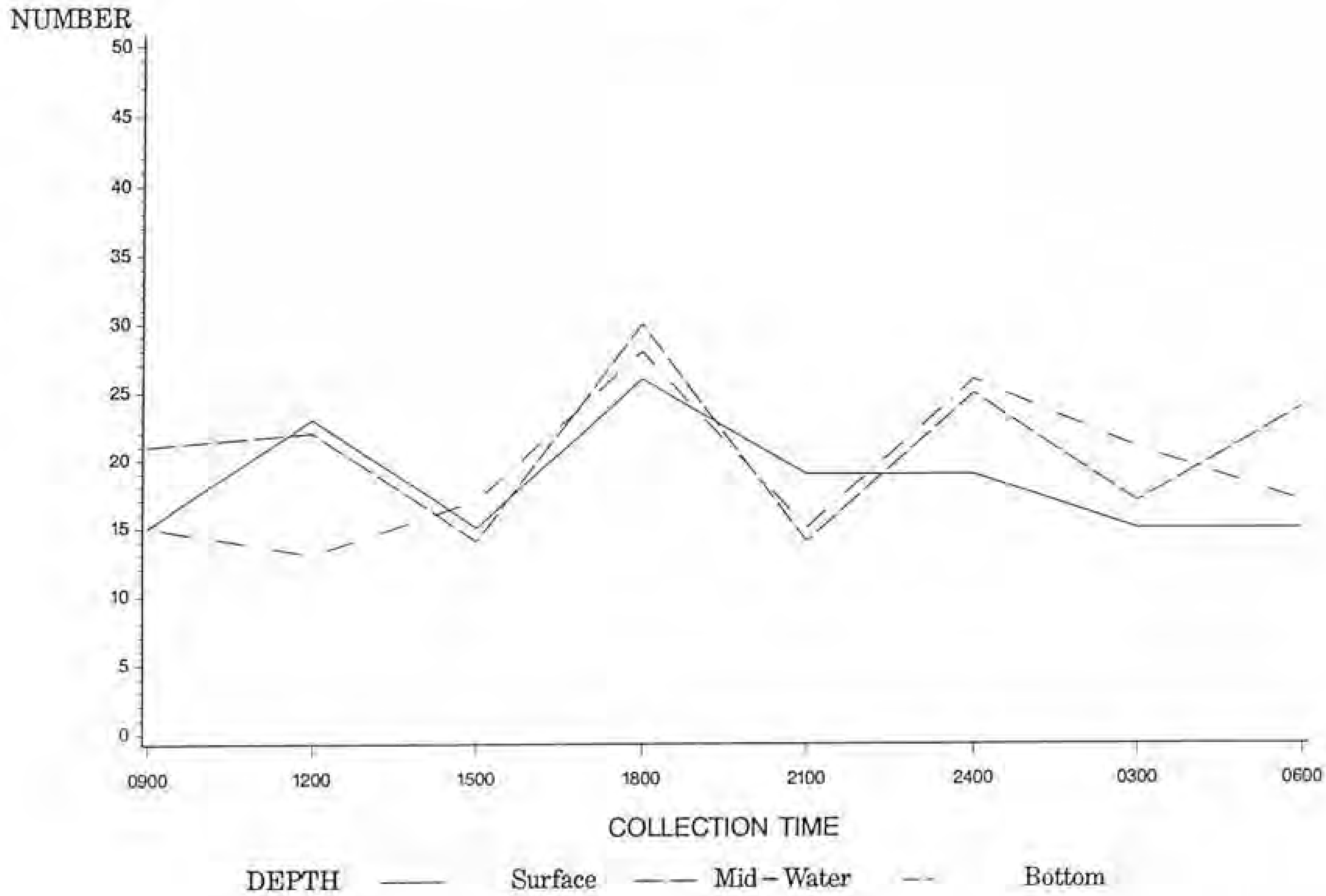
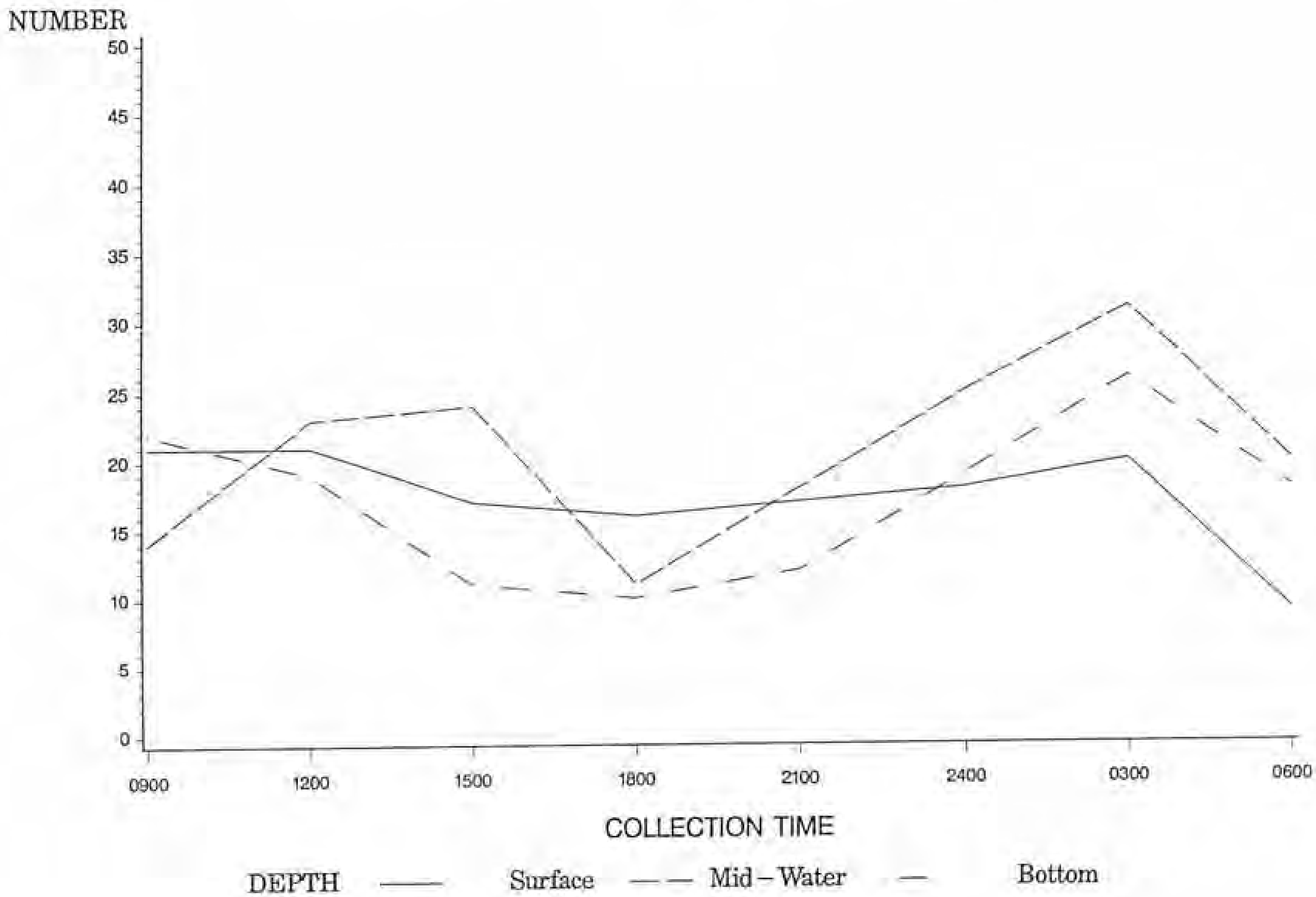


FIGURE 4.71

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
DURING 24 HOUR DIEL, 12 PPT SALINITY.
DATE=JUN91



species richness was usually equal or exceeded surface and midwater species richness. At both times, species richness was between 15 to 25 species or taxa of plankton. This is about half of the observed number of species during the March diels.

Total density of zooplankton during June, 1990 and 1991 ranged from a evening lows of only 50,000 plankton per m^3 in 1990 to an daytime high of 550,000 per m^3 (Figures 4.72 and 4.73). During 1990, no observed pattern in planktonic densities was observed with densities remaining low during the study duration (50,000 to 300,000). The patterns of plankton density shifts during the 1991 diel period were consistent with those observed for 1991 species richness data with highest densities observed during periods of highest species richness.

Diels conducted during September of 1990 and 1991 were slightly different in their patterns of species richness (Figures 4.74 and 4.75). In 1990, peaks were observed at 1200 and 2100 hours. In 1991, two peaks in richness were observed, one at 1200-and a second at 1800 hours. A sharp decline in richness was observed from 1200 to 1500 hours with a subsequent peak at 1800 hrs. After 1800 hours species richness gradually declined in the surface and midwater samples. In the bottom samples during 1991, species richness increased steadily throughout the day, peaking at 2400 hours. During both sampling events, 1990 and 1991, species richness was between 10 to 30 species or taxa of plankton. This is about half of the observed number of species during the March diels and comparable to the June diels. Total density of zooplankton during September, 1990 and 1991 ranged from night-time lows of only 50,000 plankton per m^3 in 1990 and 1991 to daytime highs of over 600,000 per m^3 (Figures 4.76 and 4.77). During 1990, only one well-defined peak in zooplankton density at 1200 hours was

FIGURE 4.72

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 12 PPT SALINITY.
DATE = JUN90

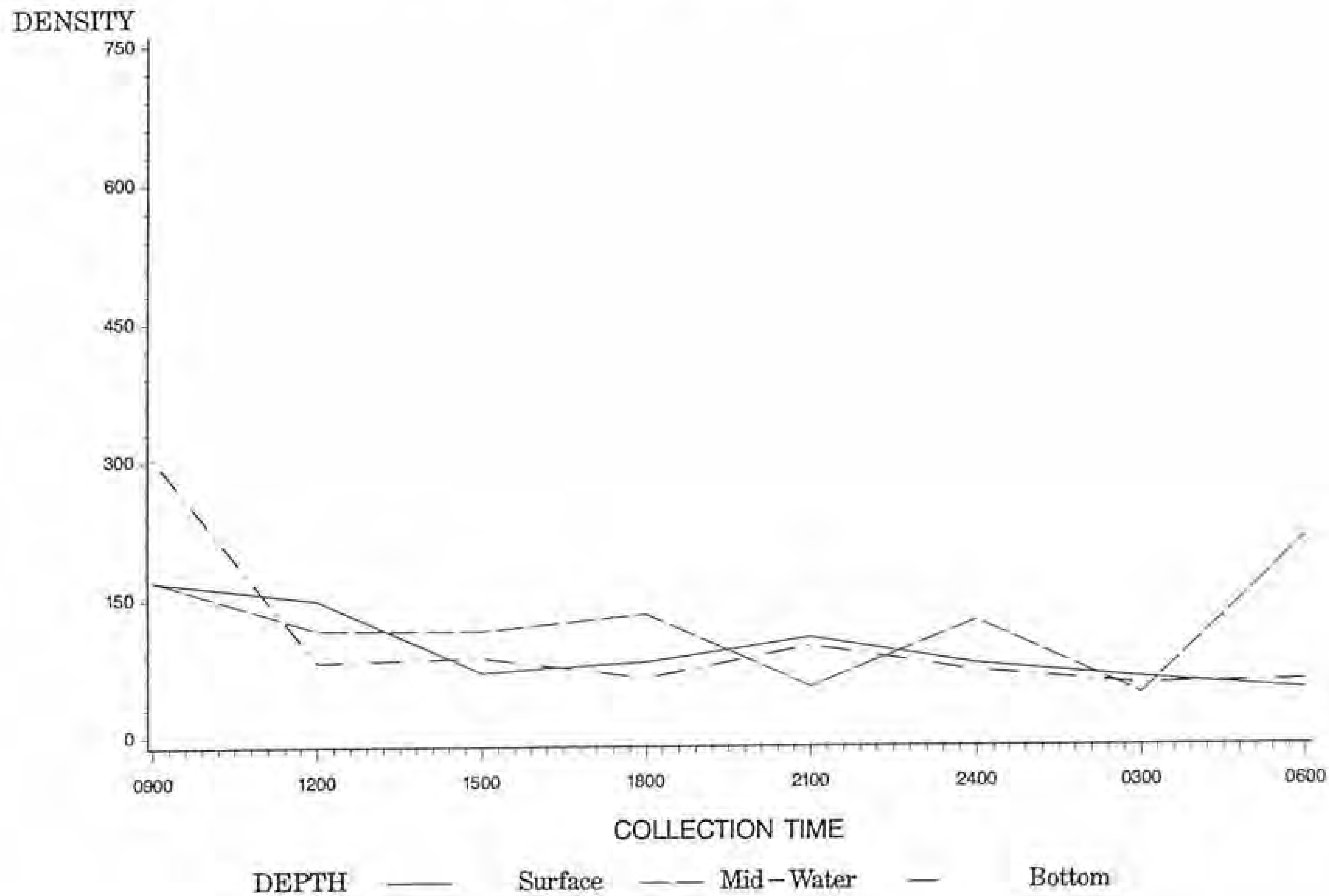


FIGURE 4.73

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 12 PPT SALINITY.
DATE=JUN91

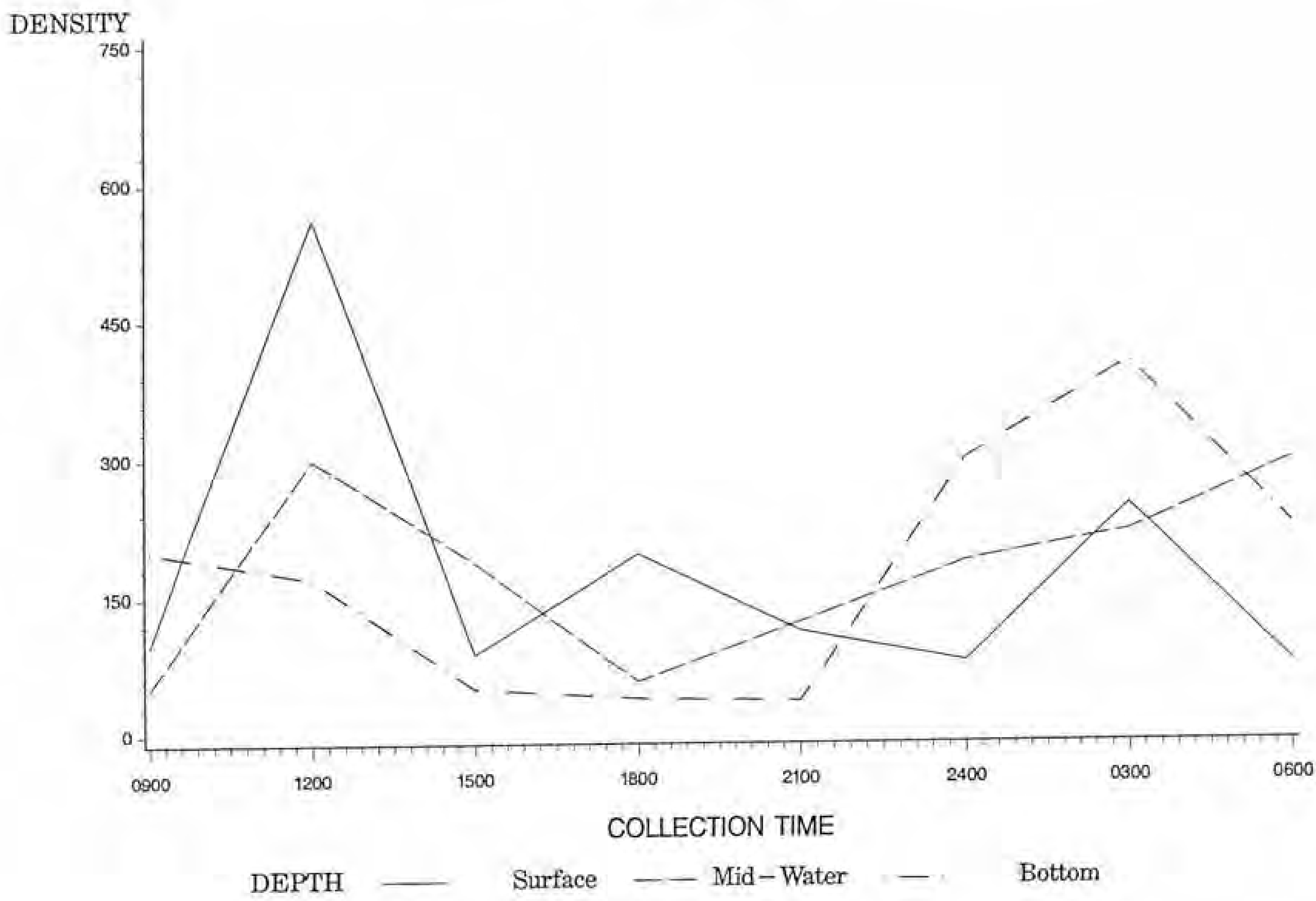


FIGURE 4.74

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
DURING 24 HOUR DIEL, 12 PPT SALINITY.
DATE=SEP90

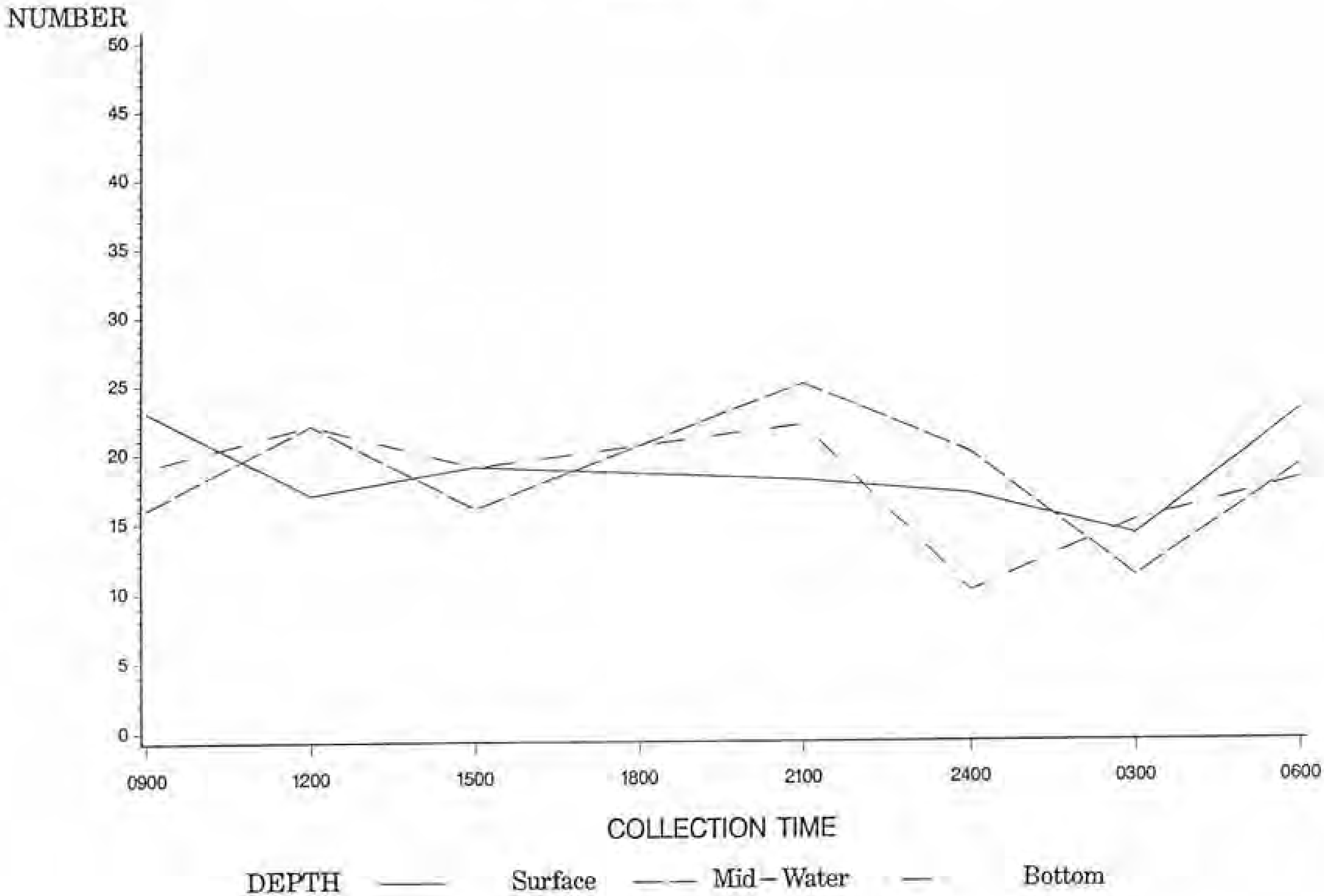


FIGURE 4.75

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED DURING 24 HOUR DIEL, 12 PPT SALINITY. DATE=SEP91

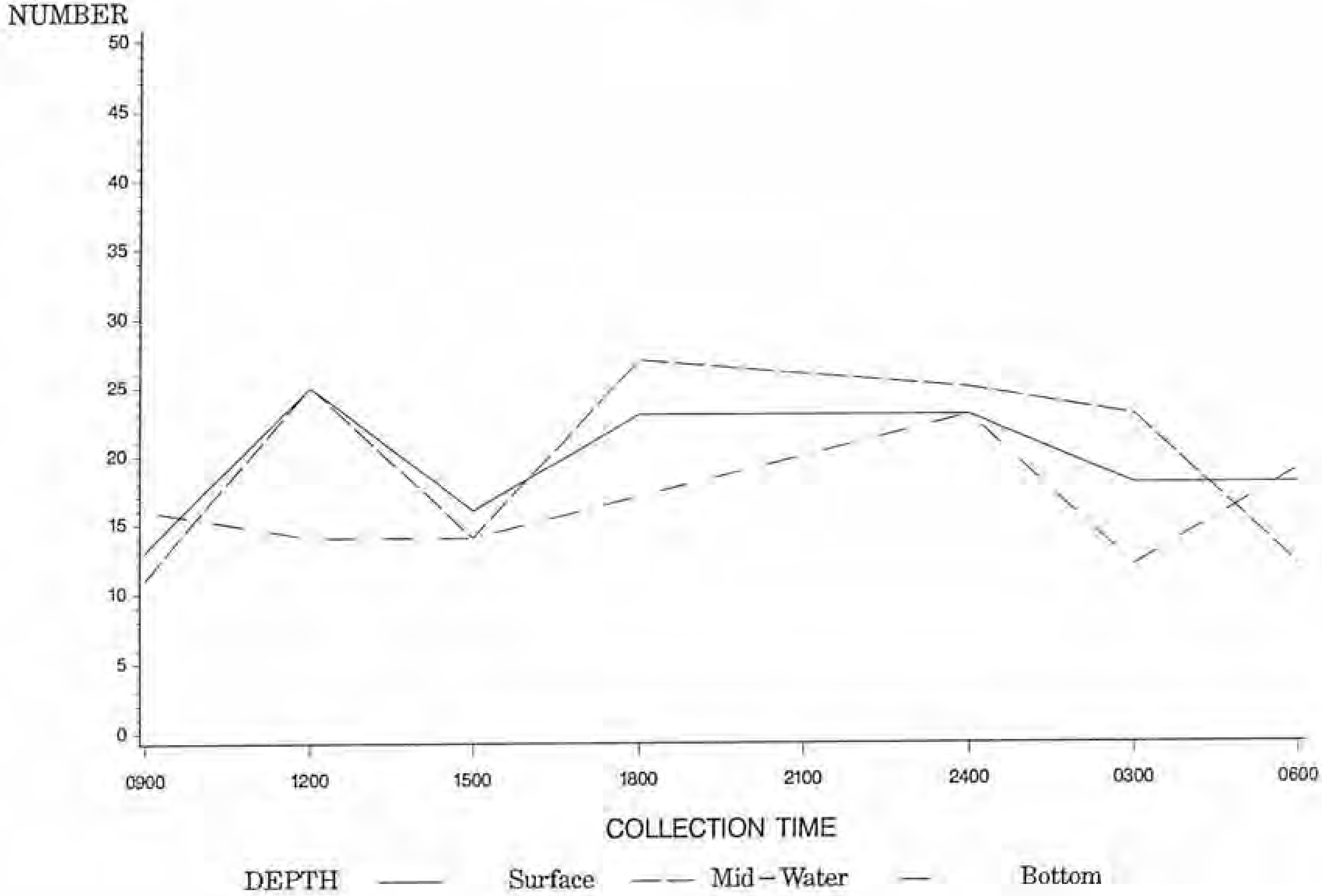


FIGURE 4.76

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 12 PPT SALINITY.
DATE=SEP90

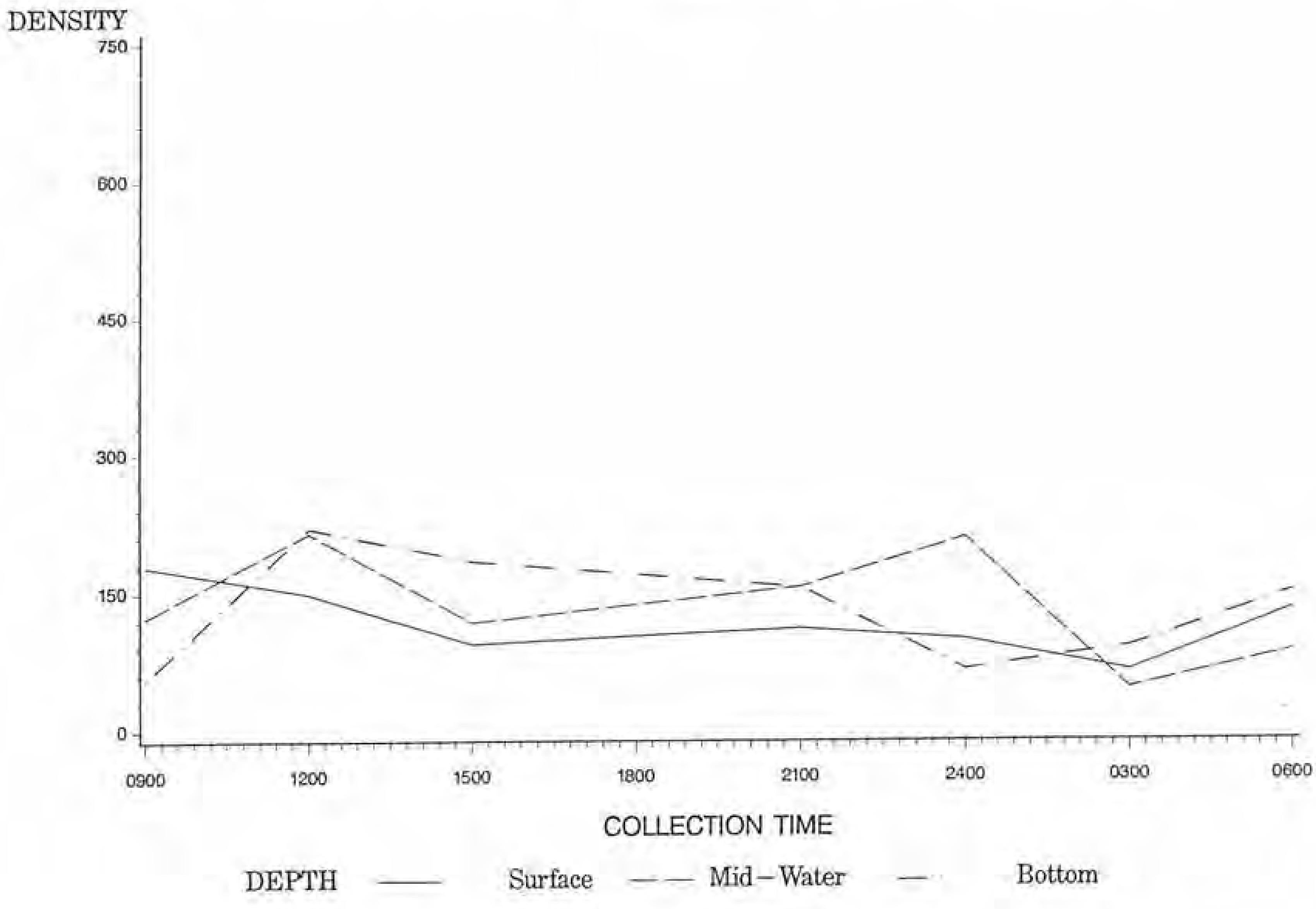
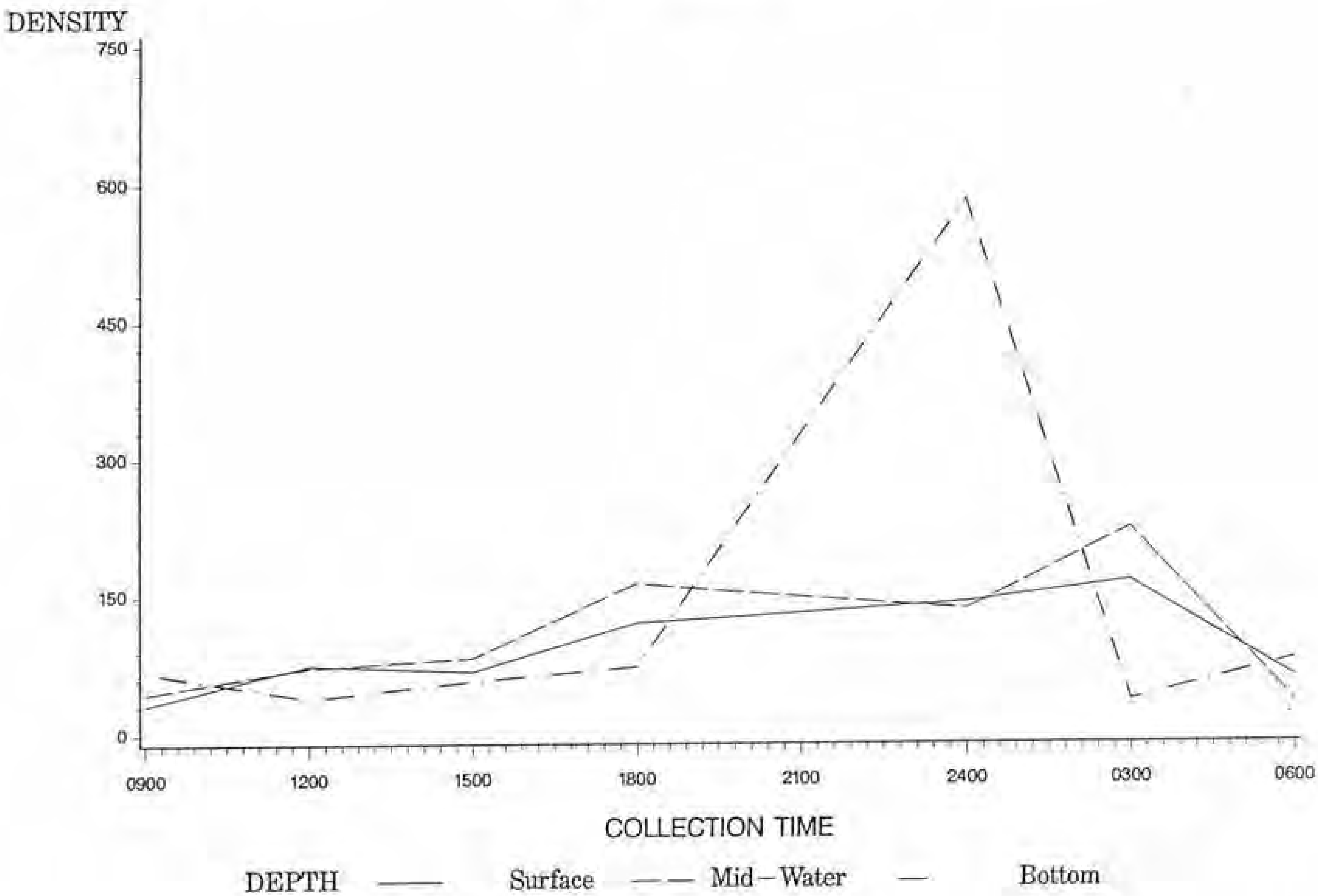


FIGURE 4.77

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 12 PPT SALINITY.
DATE=SEP91



observed with densities remaining low throughout the duration of the study period. In 1991, zooplankton densities were also generally low during the study period. The patterns of plankton density shifts during the 1991 diel period were, however, consistent with those observed for 1991 species richness data with highest densities observed during periods of highest species richness. This was especially pronounced for the bottom samples which had a small peak in species richness at 0300 with peak densities of over 600,000 individuals.

Diels conducted during December of 1990 and 1991 showed defined peaks in species richness and density (Figures 4.78 and 4.79). In 1990, a peak was observed at 1500 hrs in the bottom and midwater samples and again at 2400-0300 hours. The surface samples had species richness peaks during bottom and midwater declines at 1800 hrs. In 1991, species richness peaks were well-defined and congruent between sampling depths. Three peaks in richness were observed, at 1500, 2100, and at 0300 hours. A sharp decline in richness was observed from 1800, 2400, and 0600 hours. During the daylight hours species richness was generally highest on the surface and lowest at midwater while species richness at night was highest in the bottom samples. During both sampling events, 1990 and 1991, species richness was between 10 to 35 species or taxa of plankton.

Total density of zooplankton during December, 1990 and 1991 ranged from daytime lows of only 50,000 plankton per m^3 in 1990 and 1991 to daytime and nighttime highs of 600,000 per m^3 in 1990 (Figures 4.80 and 4.81). During 1990, two well-defined peaks in zooplankton density at 1500 hours for bottom samples and again at 2400-0300

FIGURE 4.78

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
DURING 24 HOUR DIEL, 12 PPT SALINITY.
DATE=DEC90

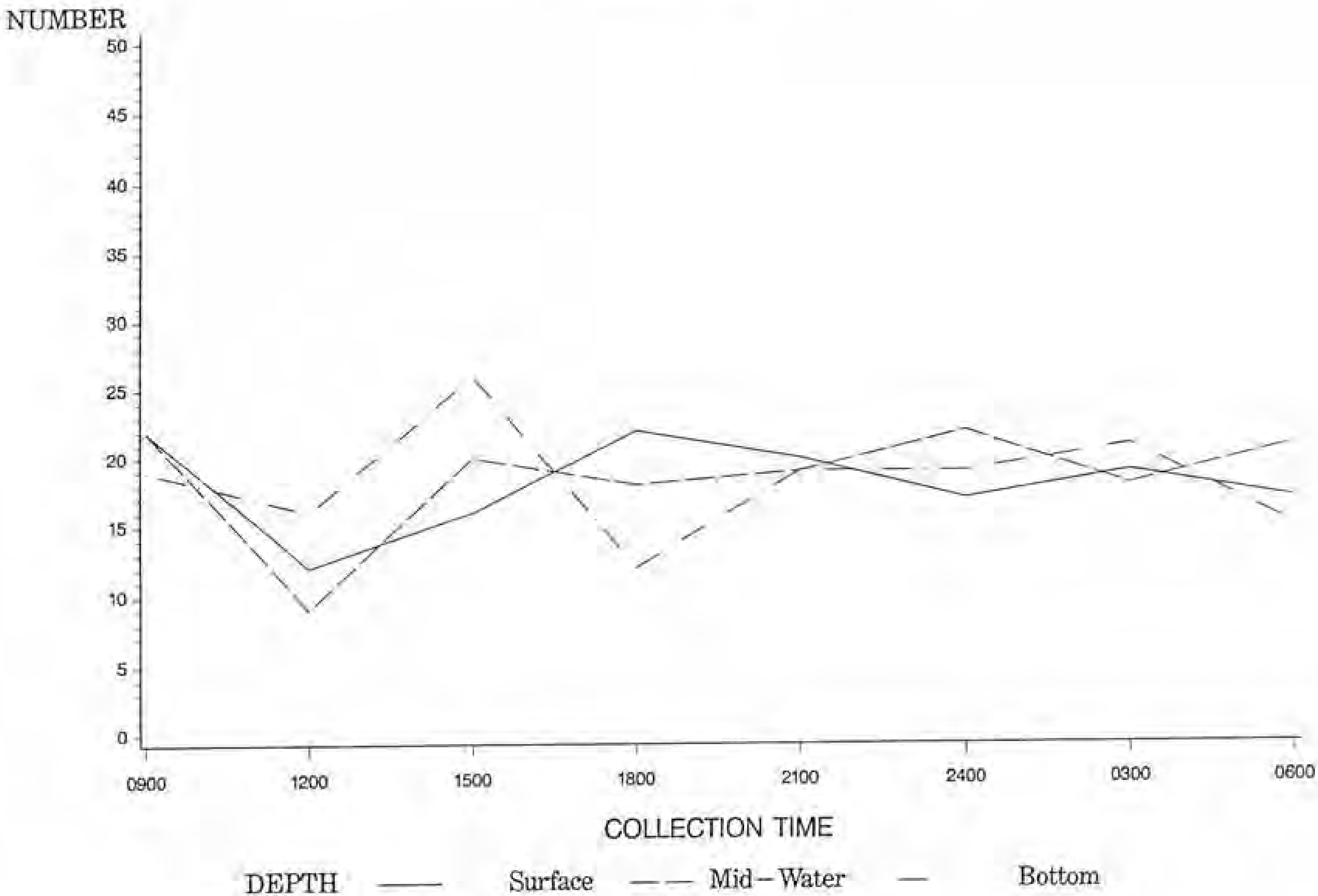


FIGURE 4.79

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
DURING 24 HOUR DIEL, 12 PPT SALINITY.
DATE=DEC91

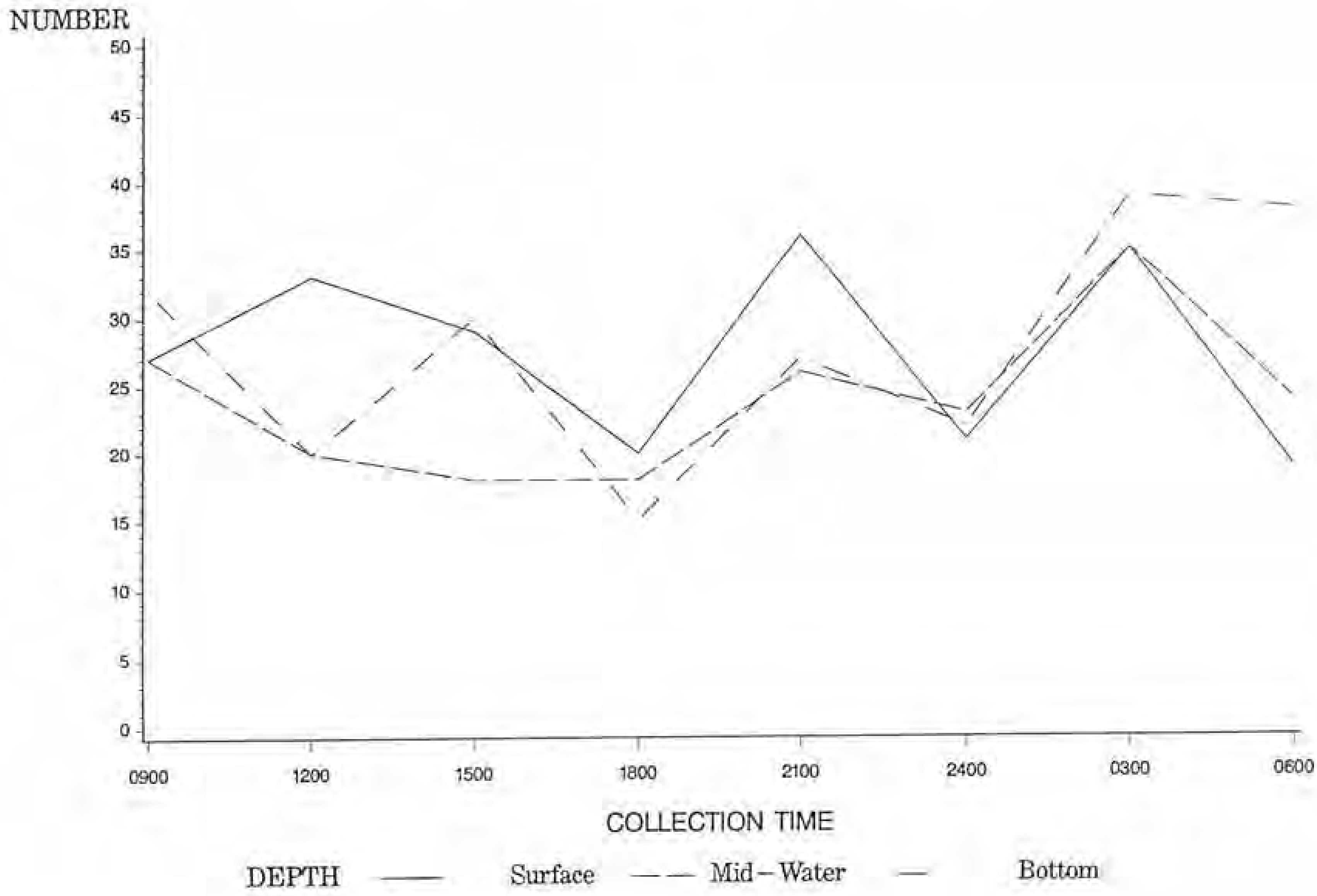


FIGURE 4.80

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 12 PPT SALINITY.
DATE=DEC90

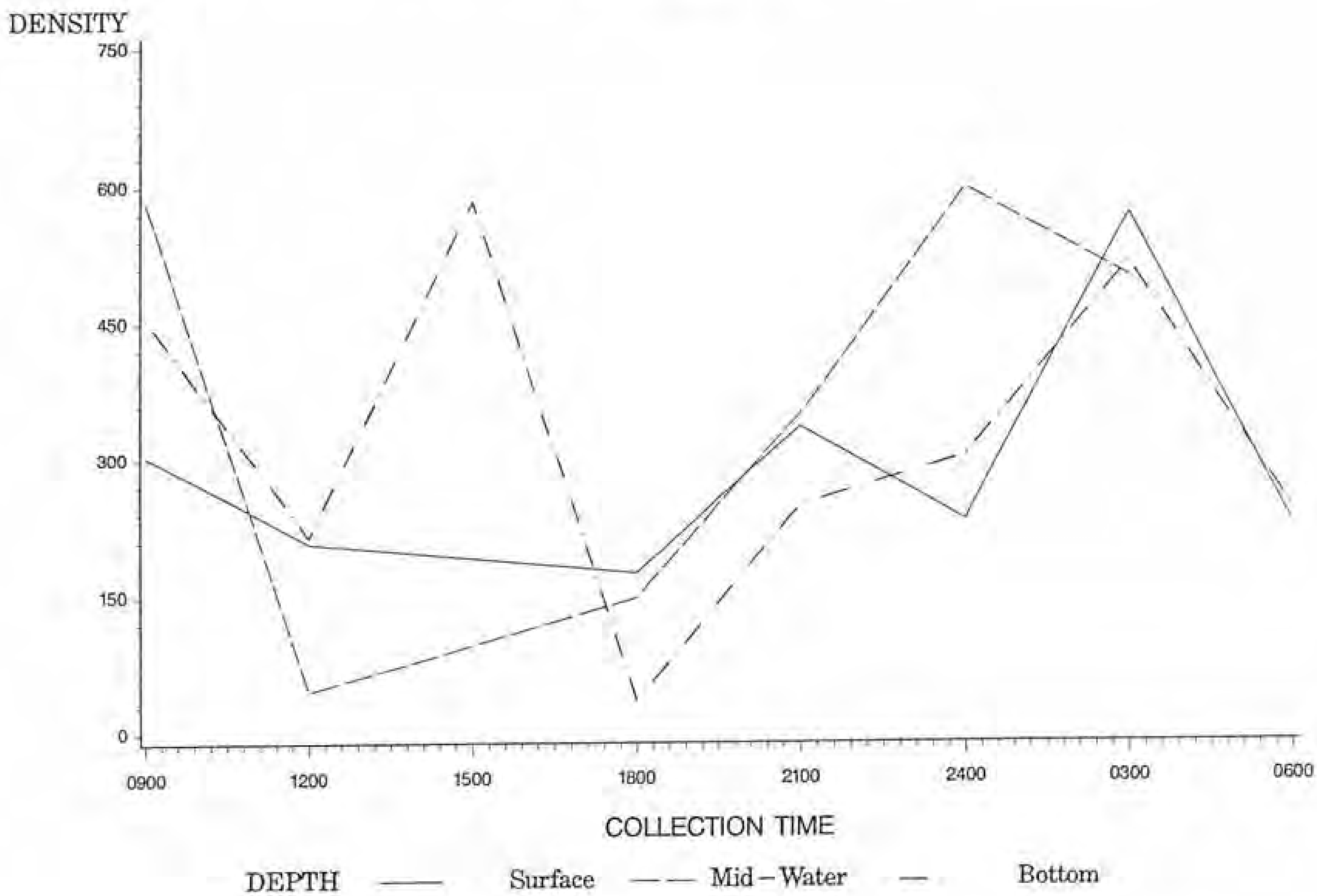
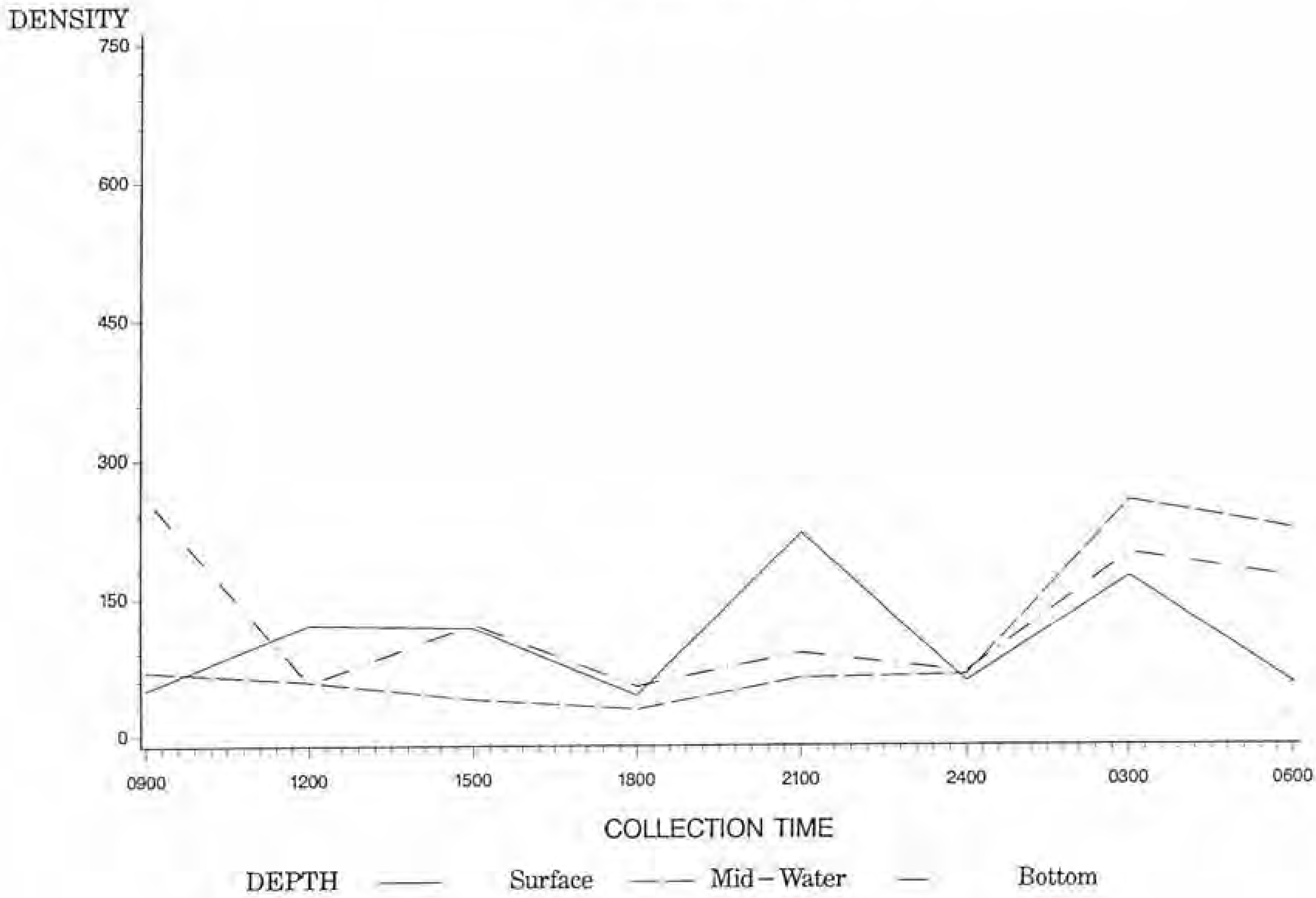


FIGURE 4.81

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 12 PPT SALINITY.
DATE = DEC91



In 1991, zooplankton densities were generally low during the study period. Peaks in density did occur at 2100 and 0300 hours. The patterns of plankton density shifts during the 1991 diel period were consistent with those observed for 1991 species richness data with highest densities observed during periods of highest species richness.

20 o/oo Salinity Diel Studies

Diels conducted in March of 1990 and 1991 showed differing patterns of species richness across years (Figures 4.82 and 4.83). During 1990, species richness remained relatively constant over the diel period ranging from 27 to 37 species with no well-defined peaks in species number at any sampling depth. In 1991, species richness was generally lower than in 1990 with definite peaks in richness observed at different depths. Peaks in species richness were observed in surface and midwater samples at 1500 and 2100 hours while in bottom samples one peak was observed at 0300 hours.

Total density of zooplankton during March, 1990 and 1991 ranged from a evening and early morning low of about 50,000 plankton per m^3 to a morning high of 1.2 million per m^3 in 1990 (Figures 4.84 and 4.85) . The patterns of plankton density shifts during the diel period were consistent with those observed for species richness for surface samples but not for midwater or bottom samples. This was probably due to shifts in distribution of the existing zooplankton and not the addition of new taxa or individuals from the sediments. The highest observations for total zooplankton density were observed during the daylight hours.

for surface, midwater, and bottom samples. These peaks generally correlated with peaks in zooplankton species richness.

In 1991, zooplankton densities were generally low during the study period. Peaks in density did occur at 2100 and 0300 hours. The patterns of plankton density shifts during the 1991 diel period were consistent with those observed for 1991 species richness data with highest densities observed during periods of highest species richness.

20 o/oo Salinity Diel Studies

Diels conducted in March of 1990 and 1991 showed differing patterns of species richness across years (Figures 4.82 and 4.83). During 1990, species richness remained relatively constant over the diel period ranging from 27 to 37 species with no well-defined peaks in species number at any sampling depth. In 1991, species richness was generally lower than in 1990 with definite peaks in richness observed at different depths. Peaks in species richness were observed in surface and midwater samples at 1500 and 2100 hours while in bottom samples one peak was observed at 0300 hours.

Total density of zooplankton during March, 1990 and 1991 ranged from an evening and early morning low of about 50,000 plankton per m^3 to a morning high of 1.2 million per m^3 in 1990 (Figures 4.84 and 4.85) . The patterns of plankton density shifts during the diel period were consistent with those observed for species richness for surface samples but not for midwater or bottom samples. This was probably due to shifts in distribution of the existing zooplankton and not the addition of new taxa or individuals from the sediments. The highest observations for total zooplankton density were observed during the daylight hours.

FIGURE 4.82

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE = MAR90

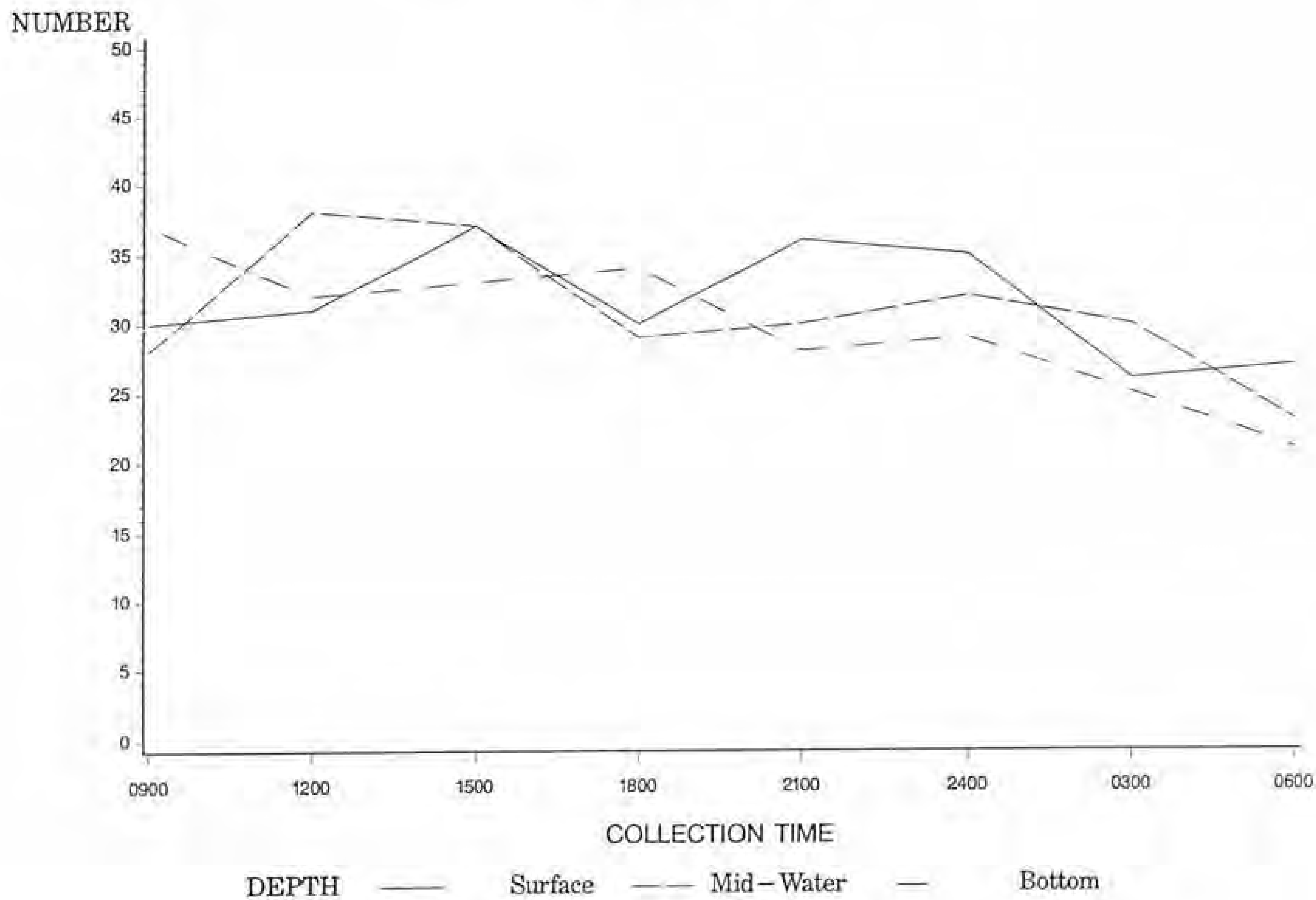


FIGURE 4.83

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE=MAR91

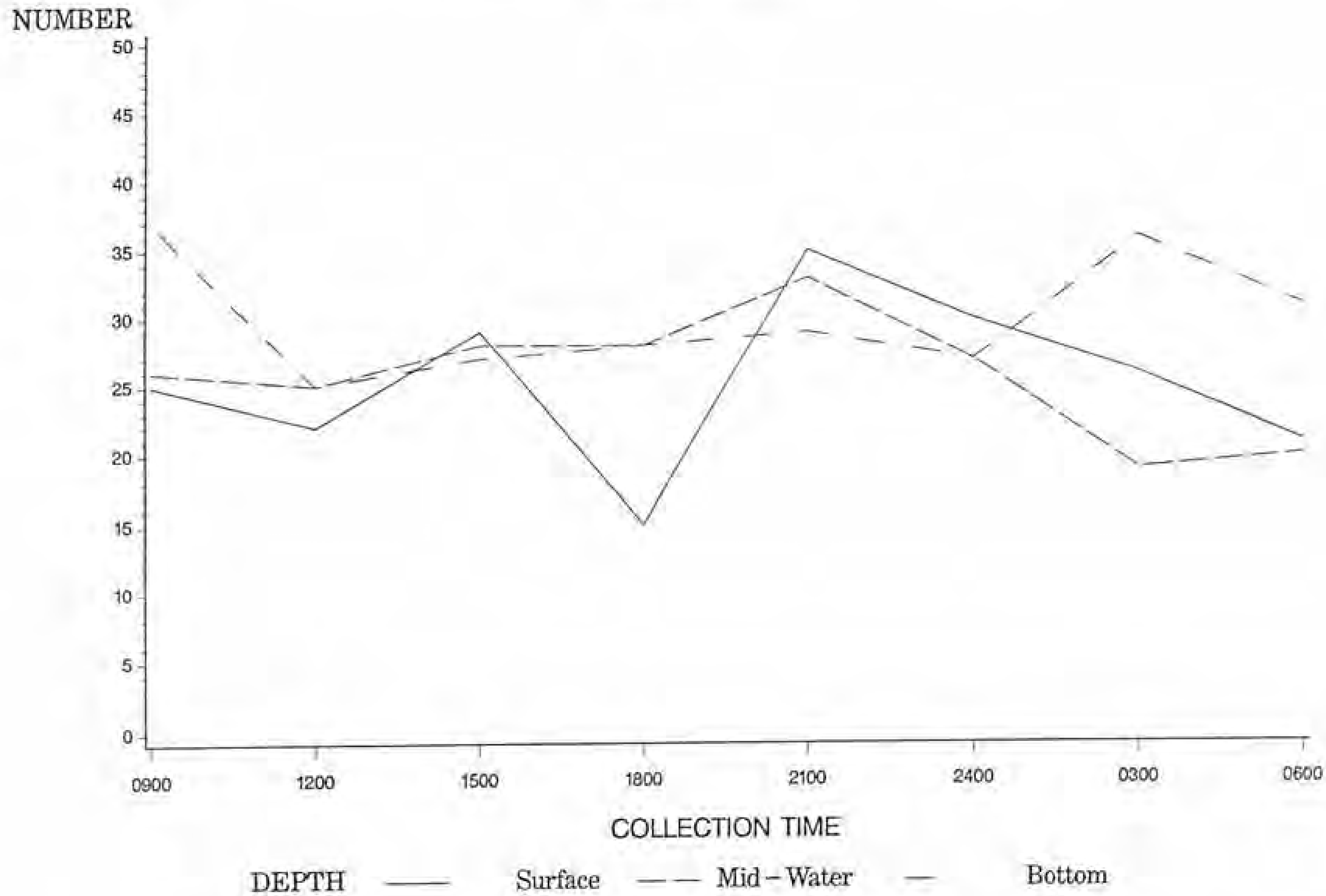


FIGURE 4.84

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE = MAR90

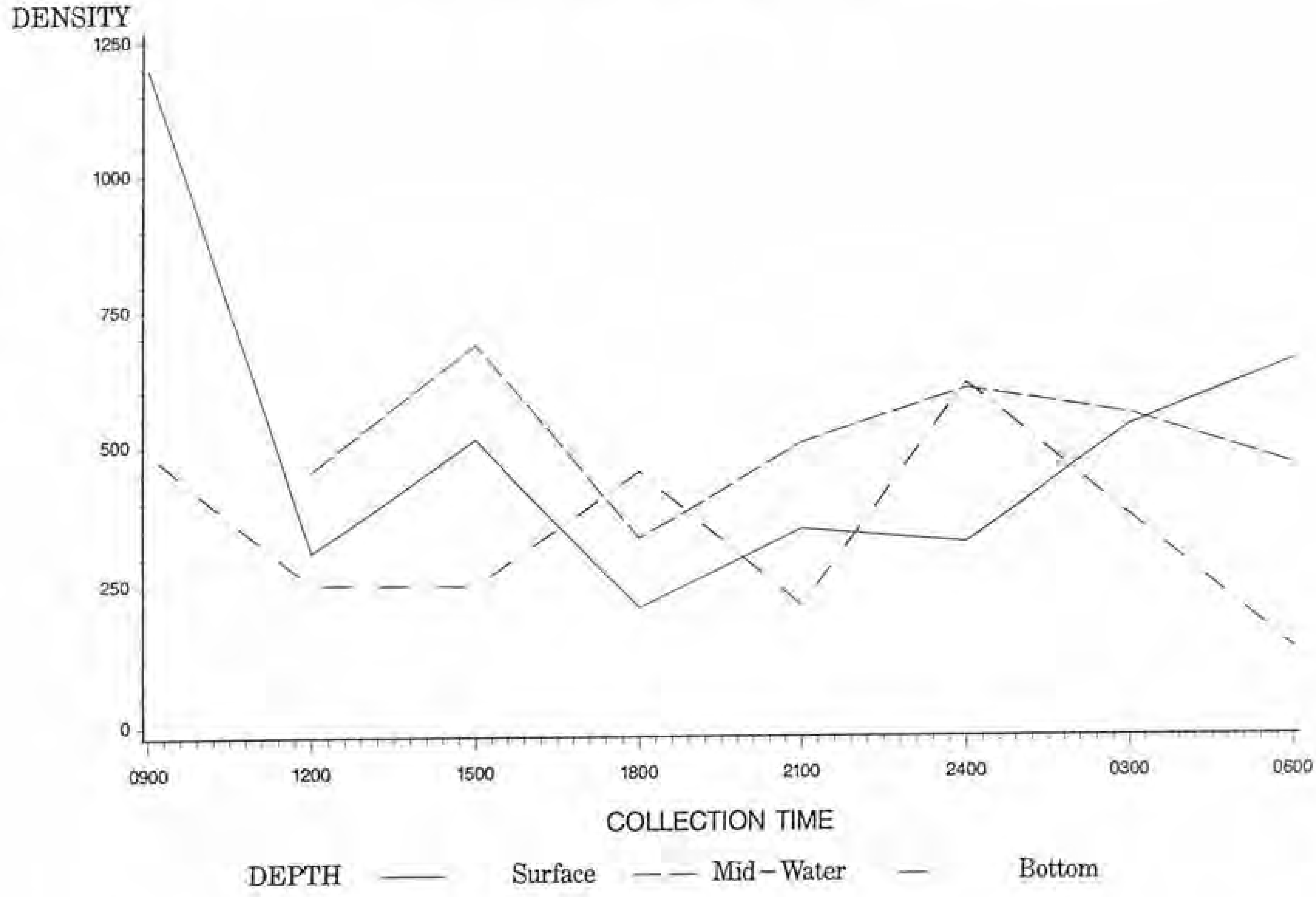
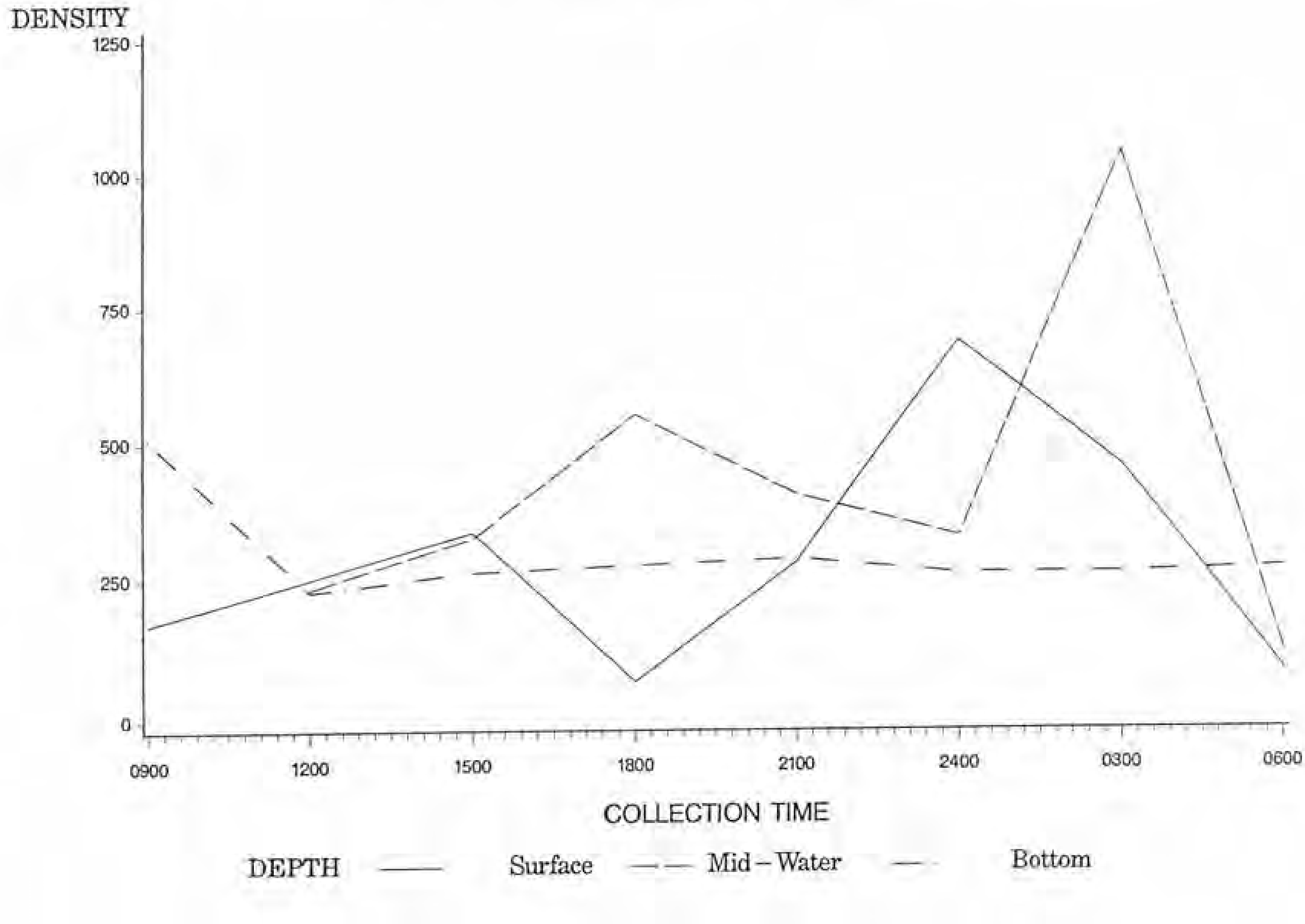


FIGURE 4.85

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE = MAR91



Diels conducted during June of 1990 and 1991 were slightly different in their patterns of species richness (Figures 4.86-4.87). In 1990, well defined peaks were observed at 1500 and 2400 hours for midwater and bottom samples. Surface samples had a peak species richness at 1800 hours and a second slight peak at 0300 hours. In 1991, two peaks in richness were observed in bottom samples, one at 1200 hrs and a second at 2100 hours. In the surface samples during 1991 species richness peaked three times during the 24-hour diel period, at 1200, 1800, and again at 2400 hrs. Midwater species richness remained relatively constant over the period. In 1990 species richness was between 17 to 45 species or taxa of plankton whereas 1991 had many fewer taxa with richness ranging from 7 to 31.

Total density of zooplankton during June, 1990 and 1991 ranged from a evening lows of only 50,000 plankton per m^3 to a daytime high of approximately 1.2 million per m^3 (Figures 4.88 and 4.89). During both years, well defined peaks in zooplankton abundances were observed. These peaks in abundance corresponded of peaks in species richness indicating that new species were being added to the community during the diel period thereby increasing densities.

Diels conducted during September of 1990 and 1991 were slightly different in their patterns of species richness (Figures 4.90 and 4.91). In 1990, a defined peak in surface species richness was observed at 1200 hours with a bottom peak at 2400 hrs. In 1991, peaks in richness at all depth were observed at 1500-1800 and also at 0300 hours. A sharp decline in richness was observed from 1200 to 1500 hours with a subsequent peak at 1800 hrs. After 1800 hours, species richness gradually declined in the surface and

FIGURE 4.86

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE=JUN90

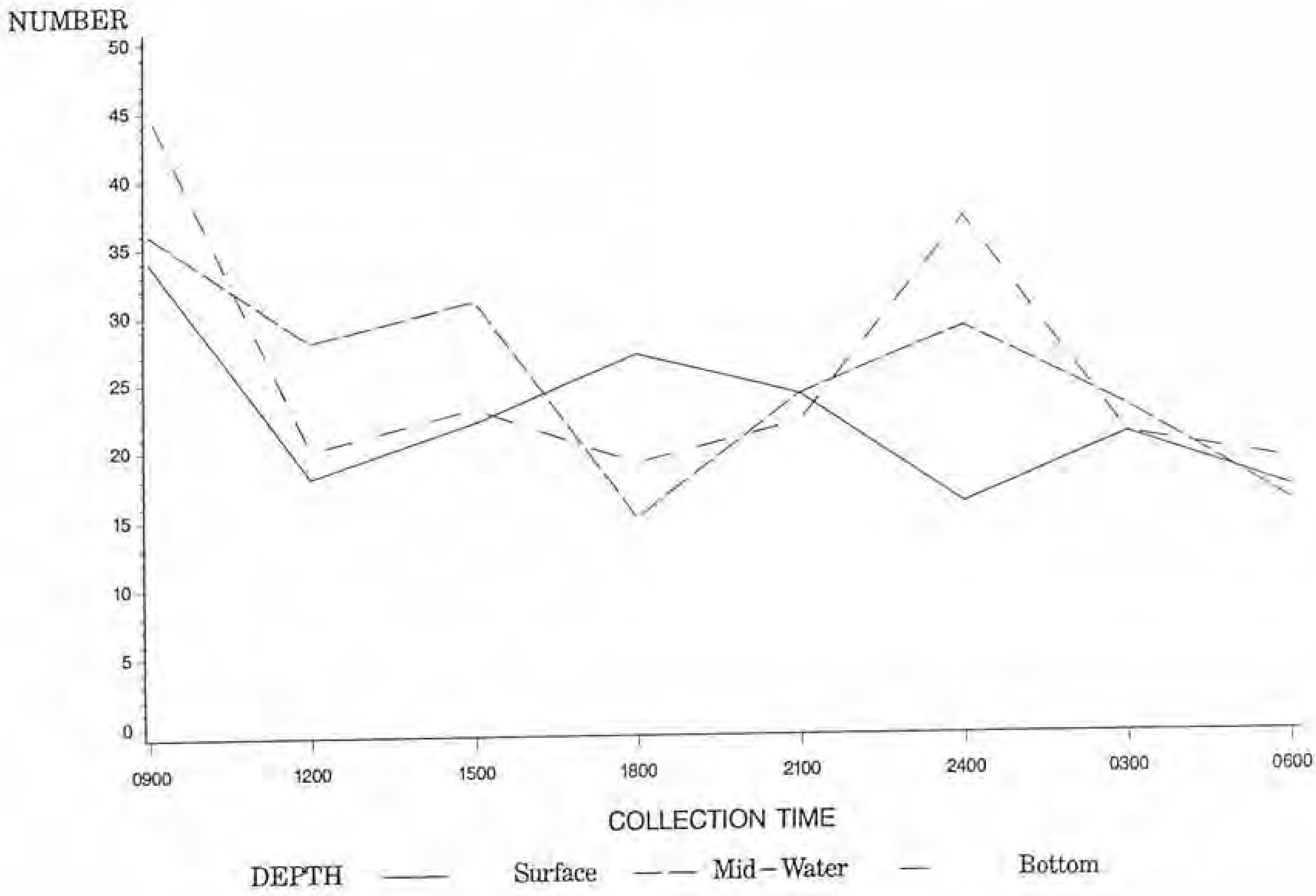


FIGURE 4.87

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE = JUN91

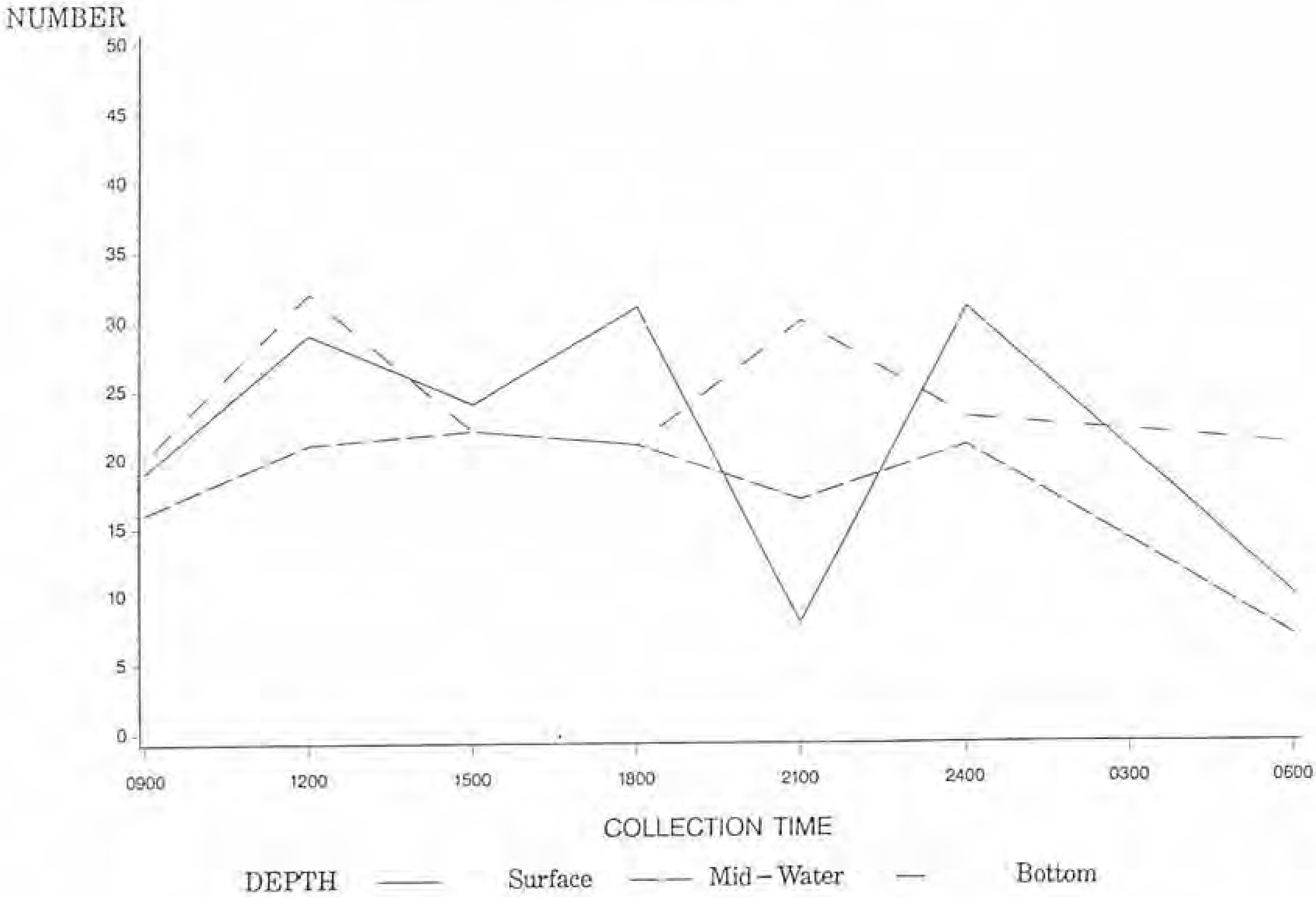


FIGURE 4.88

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE = JUN90

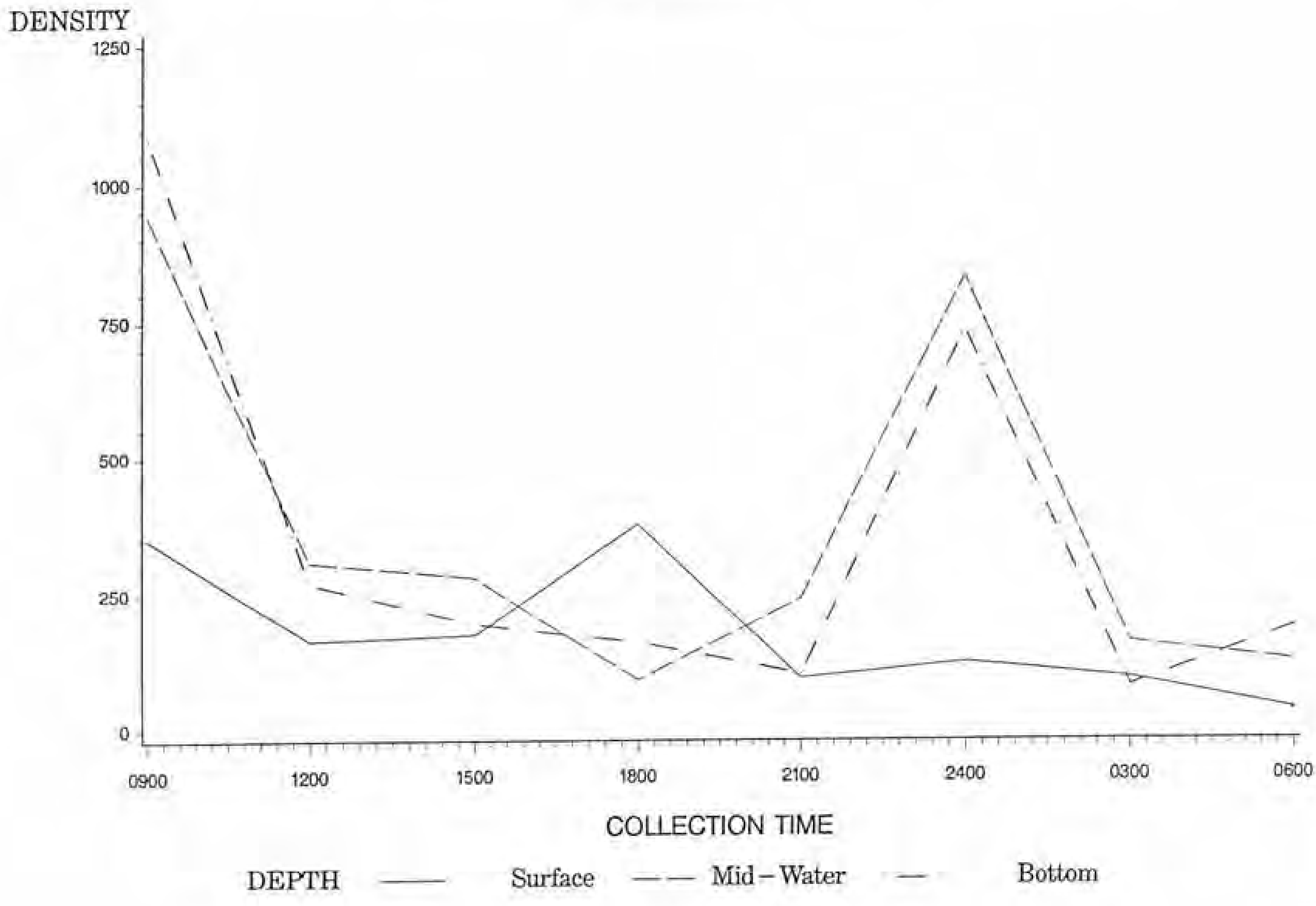


FIGURE 4.89

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE=JUN91

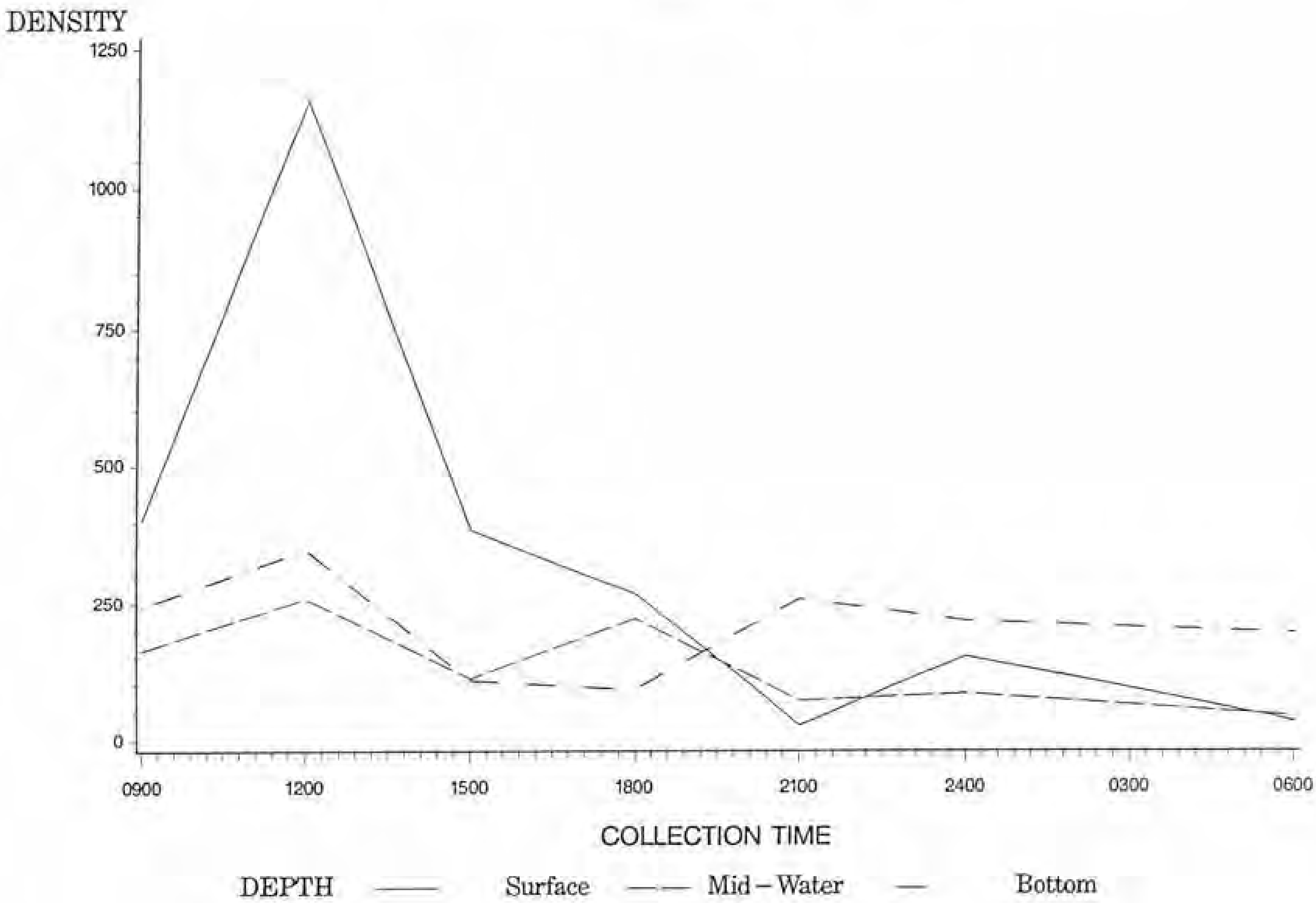


FIGURE 4.90

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE=SEP90

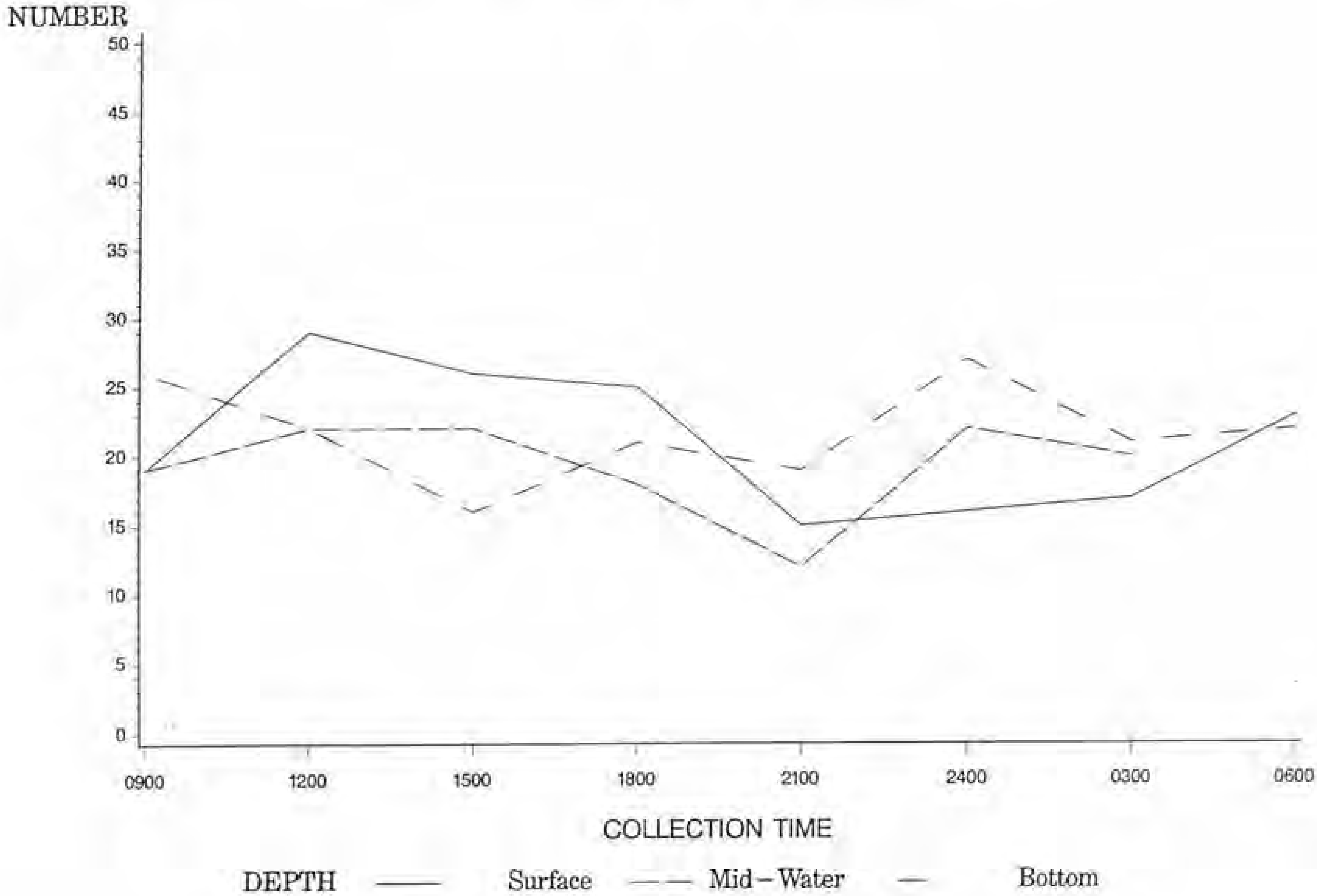
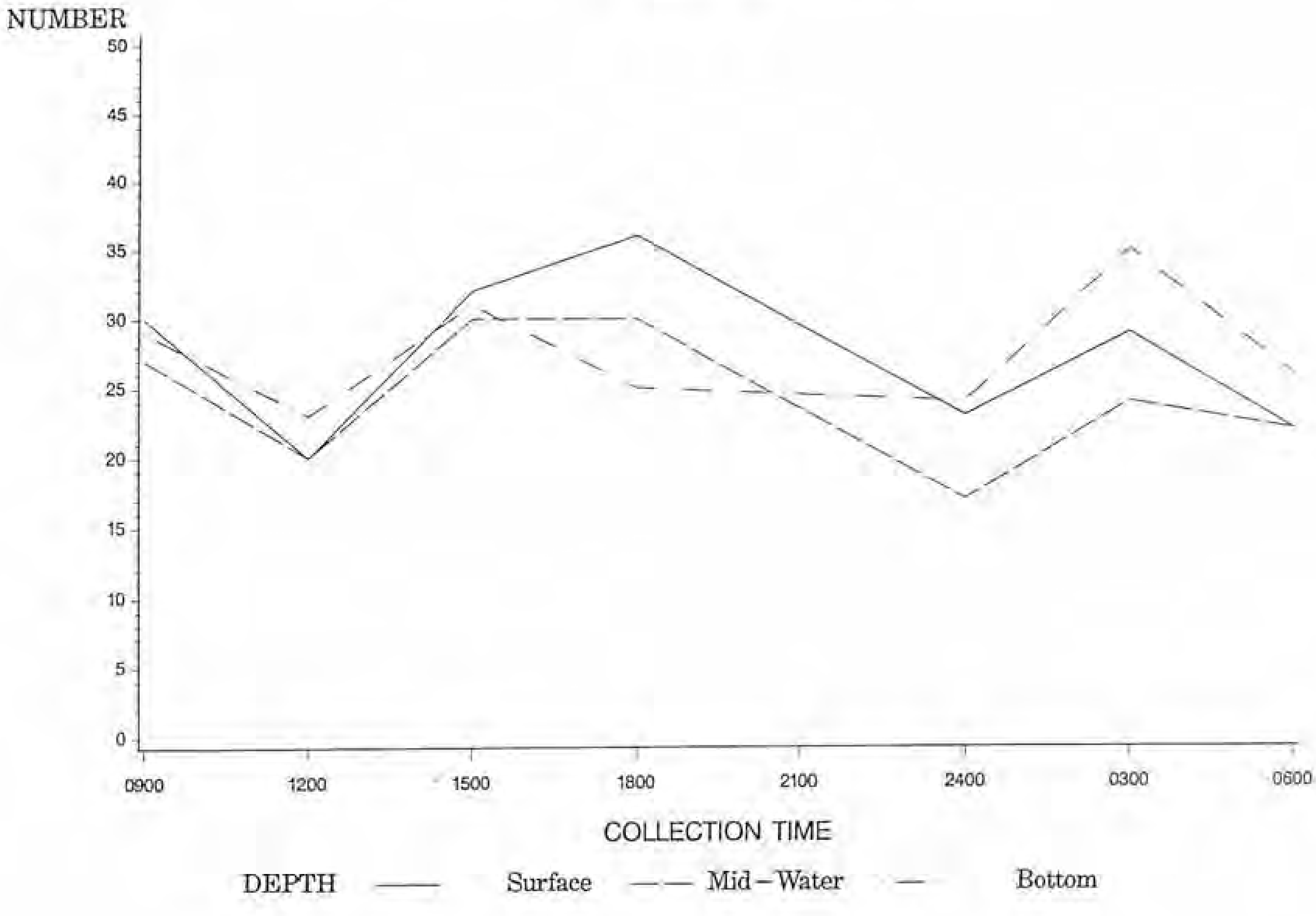


FIGURE 4.91

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE=SEP91



midwater samples while remaining relatively constant in the bottom samples. Species richness was slightly lower in 1990 than in 1991.

Total density of zooplankton during September, 1990 and 1991 ranged from 100,000 plankton per m^3 in 1990 and 1991 to daytime highs of over 600,000 per m^3 (Figures 4.92 and 4.93). During 1990, only one well-defined peak in zooplankton density at 1800 hours was observed in surface samples. A second peak in density was observed at 2400 hours in the bottom samples. In 1991, peaks in zooplankton densities occurred at all depths. The patterns of plankton density shifts during the 1991 diel period were very consistent with those observed for 1991 species richness data with highest densities observed during periods of highest species richness. This was especially pronounced for the bottom samples which had a small peak in species richness at 0300 with peak densities of over 600,000 individuals. This pattern is identical to that observed at the 12 ppt salinity zone.

Diels conducted during December of 1990 showed poorly defined peaks in species richness and density (Figures 4.94 and 4.95. In 1990, species richness remained relatively constant over the diel period at all depths ranging from a low of 17 to a high of 27 species. Densities during this time period also experienced small amount of variation with minimum densities of 40,000 per m^3 and maximum densities of 350,000 per m^3.

In 1991, peaks in both species richness and density were well-defined and congruent between times and sampling depths (Figures 4.96 and 4.97). Peaks in richness and density occurred between 2100 and 2400 hours with rises in zooplankton species richness corresponding to increasing density. Species richness varied from a low

FIGURE 4.92

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE=SEP90

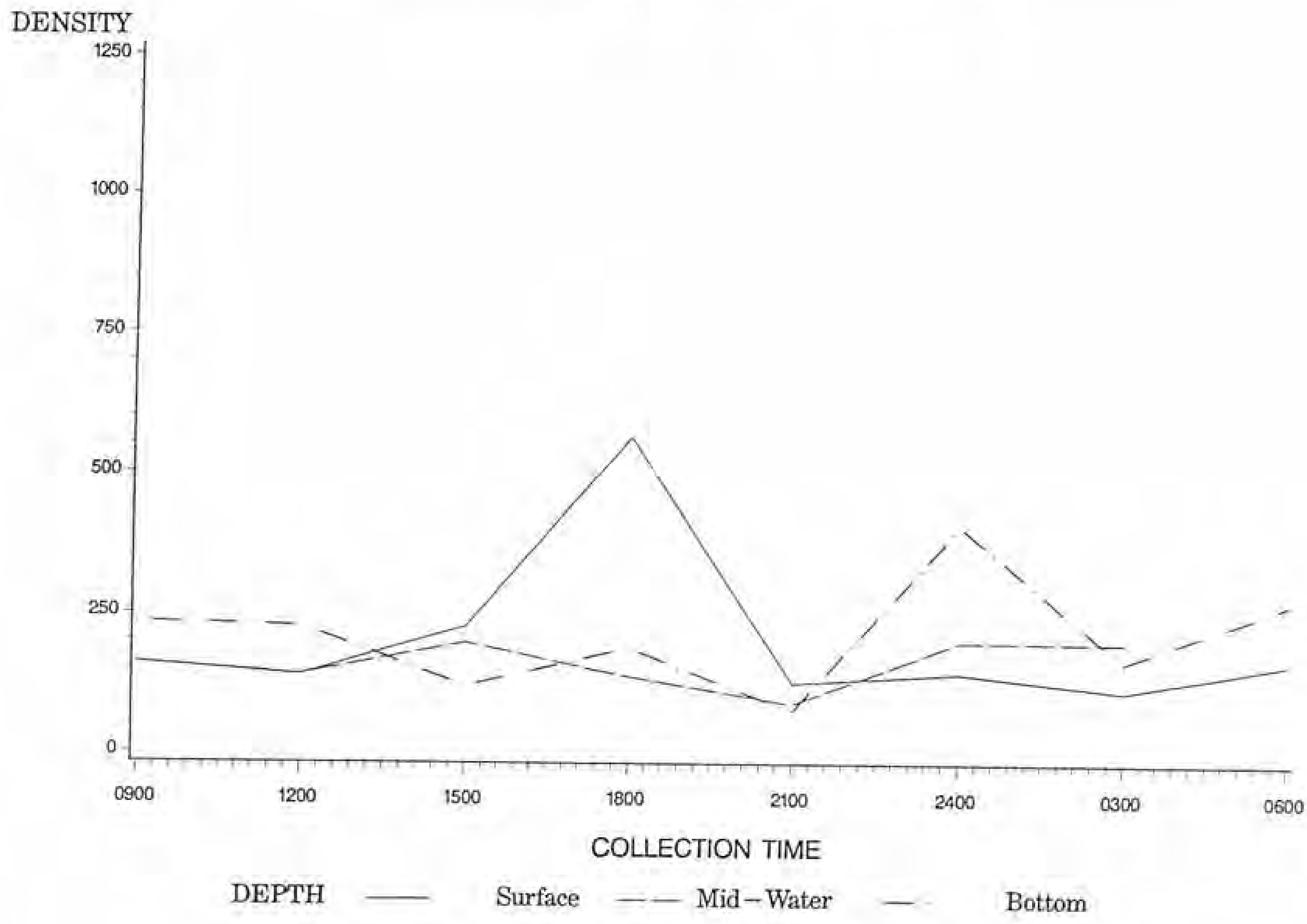


FIGURE 4.93

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE=SEP91

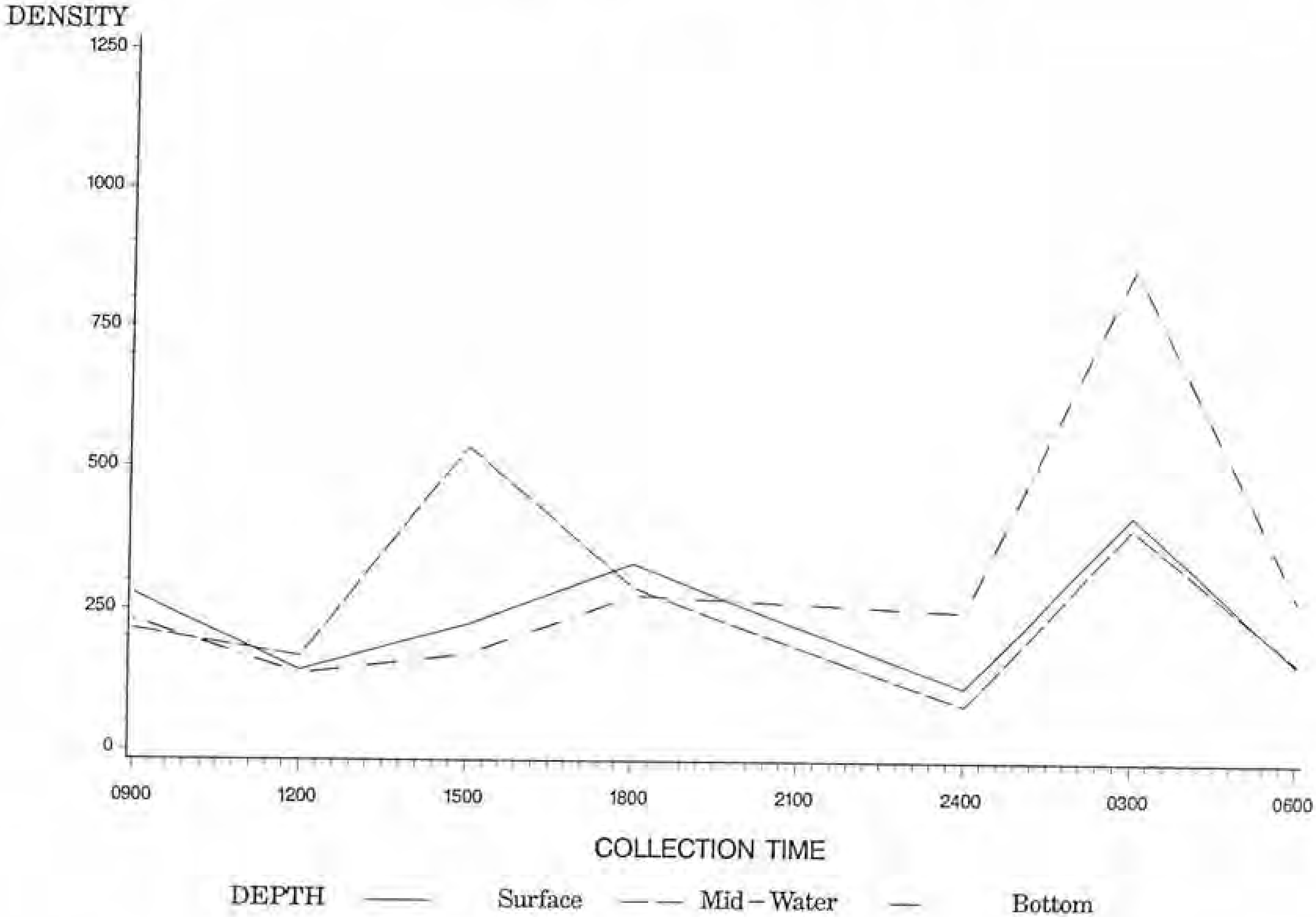


FIGURE 4.94

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE = DEC90

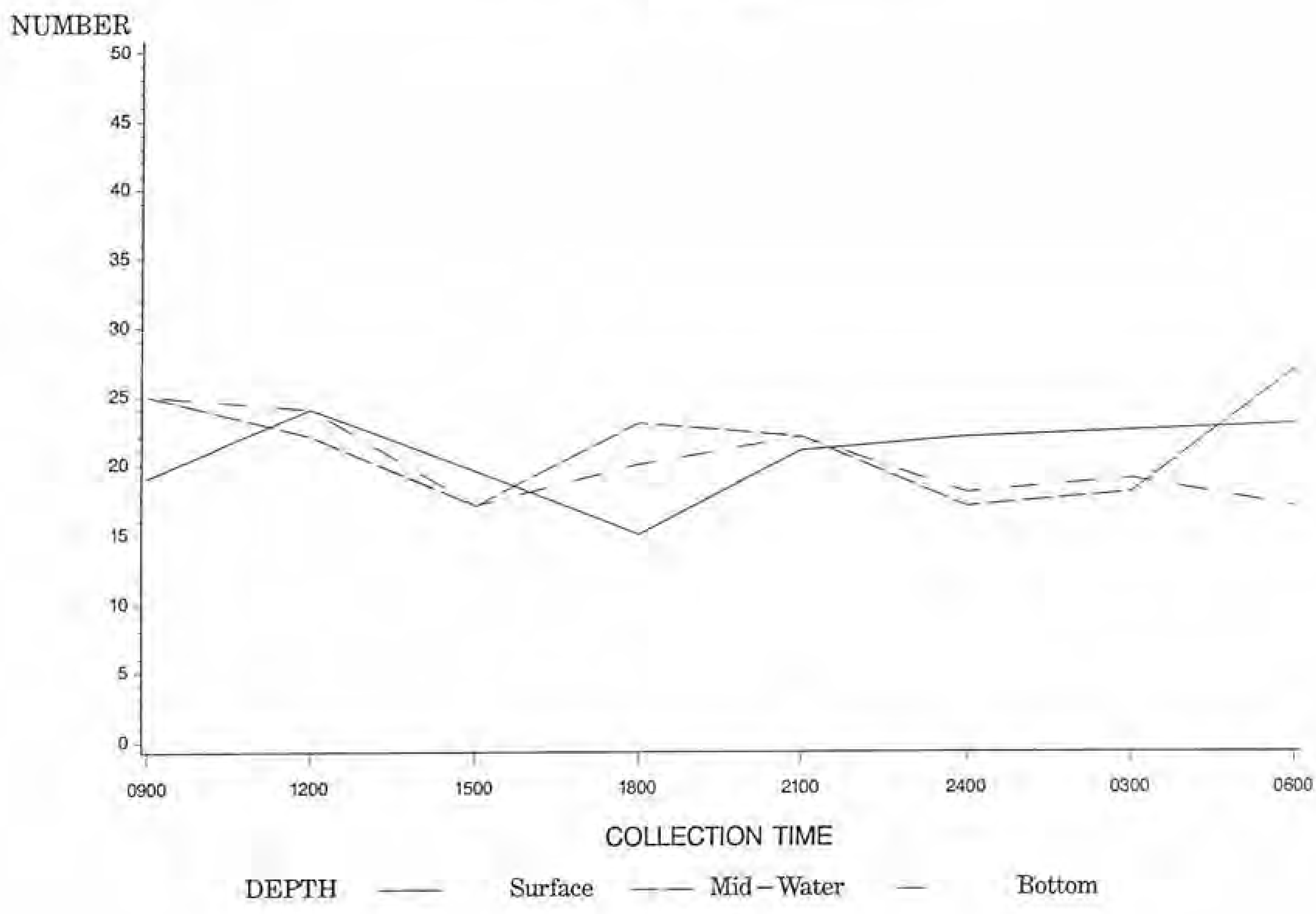


FIGURE 4.95

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE=DEC90

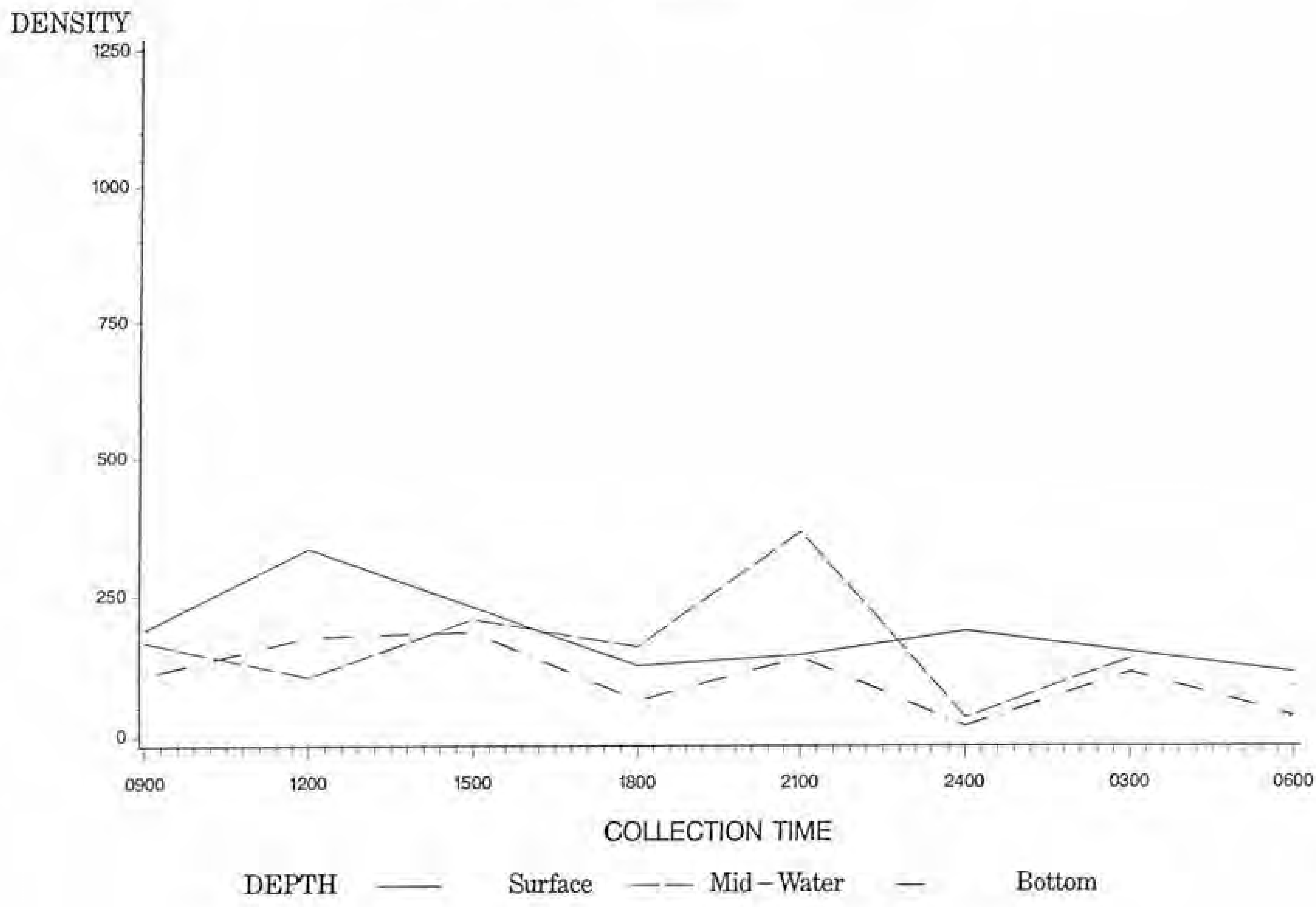


FIGURE 4.96

TOTAL NUMBER OF TAXA OF ZOOPLANKTON COLLECTED
DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE=DEC91

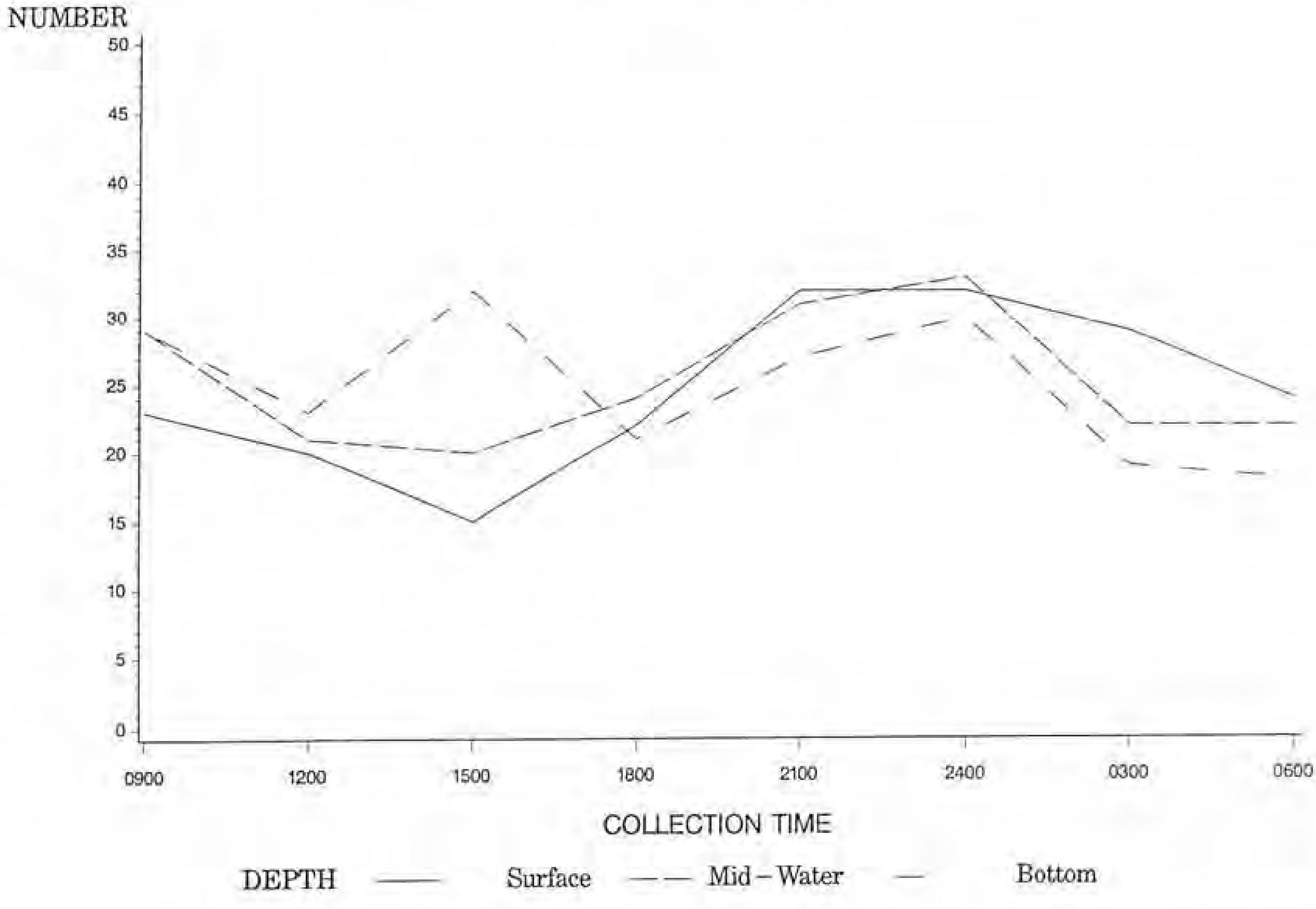
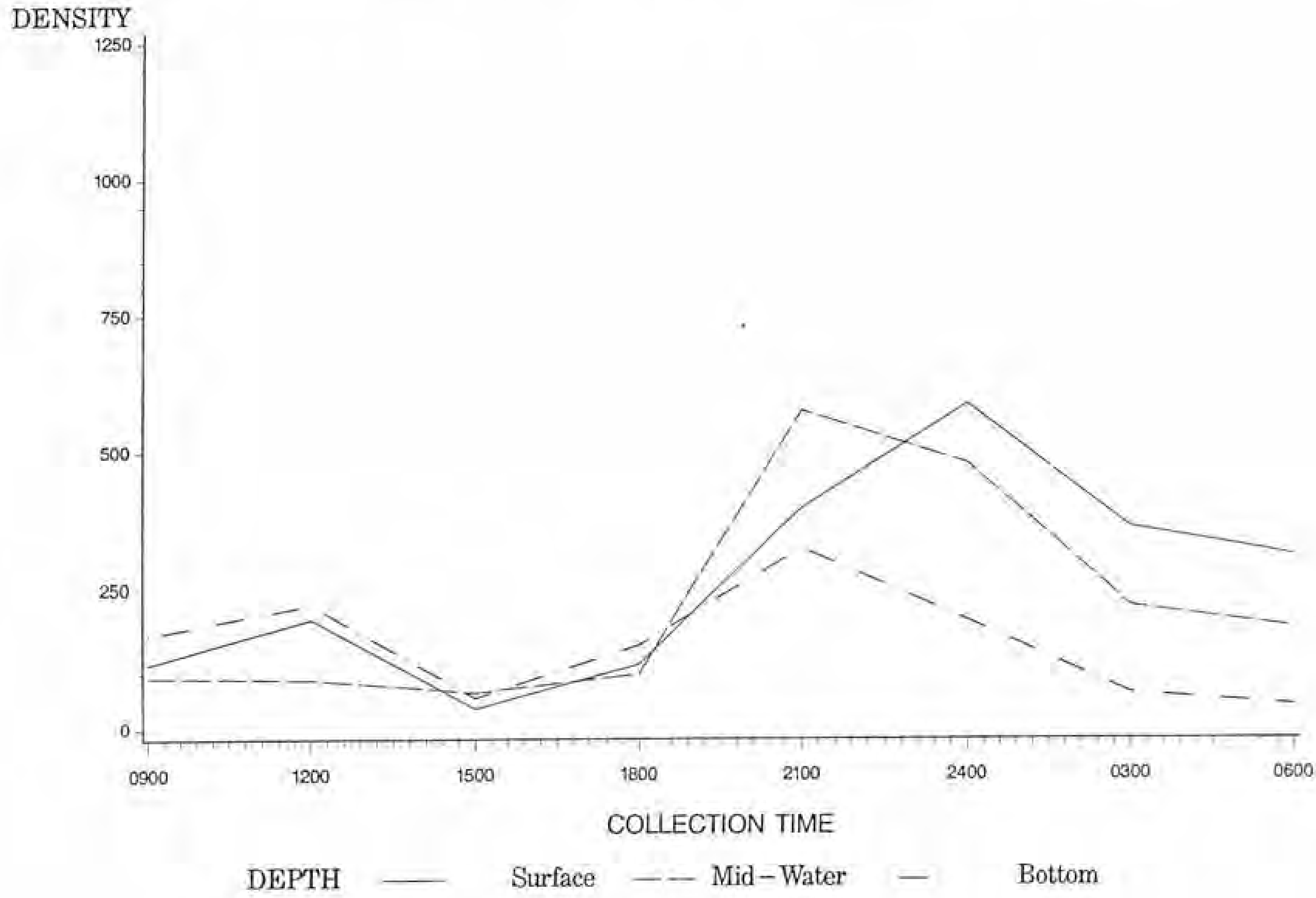


FIGURE 4.97

TOTAL DENSITY OF ZOOPLANKTON PER CUBIC METER (x 1000) COLLECTED DURING 24 HOUR DIEL, 20 PPT SALINITY.
DATE=DEC91



of 17 to a high of 34 species of plankton. Zooplankton densities ranged from approximately 50,000 plankters per m^3 to highs of 550,000 individuals.

4.3.4 Zooplankton Grazing Studies

Zooplankton grazing studies were conducted twice during the dry season and twice during the wet season to try to directly assess the impacts of zooplankton grazing on the phytoplankton community and how these effects may have been mediated by river flow. These studies were conducted in September, 1990 (wet), January, 1991 (dry), August, 1991 (wet), and finally again in December, 1991 (dry). Results of these samplings indicated a tremendous amount of variation between samples within treatments and times (Table 9). Due to this high variablilty within samples statistical conclusions of the effect of zooplankton on phytoplankton communities can not be made. Results of the experiments are presented in Table 9. Review of the data show no clear trends in zooplankton grazing as reflected in shifts in chlorophyll a concentrations between size fractions. If grazing were signigicantly impacting phytoplankton, it was expected that a shift in percent chlorphyll in the large size fraction (> 50 um) would occur. This was not observed from the data due to high within sample variance previously discussed.

Table 4.9

RESULTS OF ZOOPLANKTON GRAZING STUDY
DATA REPRESENTS CHLORYPHYLL a CONCENTRATIONS
FROM FRACTIONATED SAMPLES

------------------------------------ Coll. Date=SEPTEMBER, 1990 Container=Filtered ------------------------------------

TIME	Mean Total Chlorophyll a	Mean > 50 um	Mean < 50 > 20 um	Mean < 20 and < 5 um	Mean < 5 um	STD Whole	STD > 50	STD <50>20	STD <20>5	STD Lt 5	N Obs.
1100	13.6767	0.86600	0.95200	7.9733	3.88533	1.53379	0.97198	0.63441	0.85693	0.43372	15
1400	14.9720	1.49133	0.98933	10.0447	2.44667	2.14951	1.33597	0.81502	1.66317	0.46791	15
1700	11.9920	0.83467	1.43400	7.3167	2.40667	1.53510	0.89524	1.17411	1.53965	0.33833	15
2000	16.6373	2.11200	1.21333	10.2880	3.02400	1.86784	1.54797	0.78423	2.21413	1.63523	15

------------------------------------ Coll. Date=SEPTEMBER, 1990 Container=Unfiltered ------------------------------------

TIME	Mean Total Chlorophyll a	Mean > 50 um	Mean < 50 > 20 um	Mean < 20 and < 5 um	Mean < 5 um	STD Whole	STD > 50	STD <50>20	STD <20>5	STD Lt 5	N Obs.
1100	14.6967	1.87267	1.46400	8.2087	3.15133	1.84959	1.87670	0.63131	0.81333	0.43563	15
1400	13.9287	1.49733	0.78867	8.6680	2.97467	2.89764	1.12982	0.73614	2.22092	0.68304	15
1700	14.2400	1.50400	1.16933	8.9640	2.60267	2.75452	1.04410	0.81664	1.55361	0.49631	15
2000	19.0193	2.50267	1.54000	11.6887	3.28800	1.87032	1.27668	1.03871	2.53055	0.62792	15

RESULTS OF ZOOPLANKTON GRAZING STUDY
DATA REPRESENTS CHLORYPHYLL a CONCENTRATIONS
FROM FRACTIONATED SAMPLES

------------------------------ Coll. Date=JANUARY, 1991 Container=Filtered ------------------------------

TIME	Mean Total Chlorophyll a	Mean > 50 um	Mean < 50 > 20 um	Mean < 20 and < 5 um	Mean < 5 um	STD Whole	STD > 50	STD <50>20	STD <20>5	STD Lt 5	N Obs.
Initial	10.0267	0.37733	0.32733	0.22200	9.1000	3.19688	0.39759	0.22789	0.30098	3.02456	15
1100	14.8473	0.33333	0.23467	0.46133	13.8180	2.18870	0.30868	0.29916	0.45740	2.04634	15
1400	19.3613	0.60867	0.71733	0.72467	17.3107	2.85353	0.58097	0.56596	0.92089	3.19392	15
1700	20.6160	0.85467	0.56933	1.31467	17.8773	1.75305	0.63638	0.41671	1.83294	2.44671	15
2000	16.0600	0.71333	0.83333	0.85933	13.6540	1.86979	0.53274	0.91948	0.73880	2.23203	15
0000	16.6460	0.44400	2.19267	2.27933	11.7300	4.43873	2.89470	3.40433	2.76694	4.40432	15

------------------------------ Coll. Date=JANUARY, 1991 Container=Unfiltered ------------------------------

TIME	Mean Total Chlorophyll a	Mean > 50 um	Mean < 50 > 20 um	Mean < 20 and < 5 um	Mean < 5 um	STD Whole	STD > 50	STD <50>20	STD <20>5	STD Lt 5	N Obs.
Initial	35.6160	16.4987	0.84067	0.47200	17.8047	1.71542	1.77415	1.00899	0.57994	1.35823	15
1100	41.2633	17.8673	0.91333	1.68000	20.8027	6.33519	3.63298	0.78230	1.41387	3.66628	15
1400	34.9927	15.4960	1.07267	0.90333	17.5207	6.69965	3.43932	0.73146	1.19025	4.21458	15
1700	43.8617	23.5742	0.70667	0.69000	18.8908	2.33577	3.01491	0.60285	1.30387	1.59529	12
2000	41.9167	25.4633	0.90733	1.16933	14.3767	7.99892	7.71749	0.73020	0.88701	1.20569	15
0000	26.8087	11.3687	1.09267	1.44800	12.8993	9.30913	4.25935	0.96667	1.09883	5.05249	15

RESULTS OF ZOOPLANKTON GRAZING STUDY
DATA REPRESENTS CHLORYPHYLL a CONCENTRATIONS
FROM FRACTIONATED SAMPLES

------------------------------ Coll. Date=AUGUST, 1991 Container=Filtered ------------------------------

TIME	Mean Total Chlorophyll a	Mean > 50 um	Mean < 50 > 20 um	Mean < 20 and < 5 um	Mean < 5 um	STD Whole	STD > 50	STD <50>20	STD <20>5	STD Lt 5	N Obs.
Initial	25.2373	3.0953	10.2653	1.80800	10.0687	2.4475	4.03573	3.80472	1.07629	2.04327	15
1100	27.4780	4.2787	8.6980	2.91400	11.5873	8.3107	7.17713	2.85977	1.53316	2.82317	15
1400	32.9873	11.4127	5.9560	6.38400	9.2347	9.1043	7.95435	5.01444	4.22586	4.16032	15
1700	20.6420	6.3240	2.8640	2.06067	9.3933	6.5528	4.88308	2.85251	1.55043	1.78666	15
2000	23.0013	3.6547	5.7207	2.45000	11.1760	5.3131	4.34703	2.97868	1.41346	2.07926	15
0000	41.4527	4.2173	10.0100	5.07867	22.1467	12.3088	3.60314	5.31831	3.44917	8.69329	15

------------------------------ Coll. Date=AUGUST, 1991 Container=Unfiltered ------------------------------

TIME	Mean Total Chlorophyll a	Mean > 50 um	Mean < 50 > 20 um	Mean < 20 and < 5 um	Mean < 5 um	STD Whole	STD > 50	STD <50>20	STD <20>5	STD Lt 5	N Obs.
Initial	192.662	64.615	31.6780	26.4773	69.8913	18.9644	22.3226	22.2205	17.0327	13.7246	15
1100	244.750	148.238	20.3220	27.6227	48.5673	58.9894	63.2650	35.8913	17.2734	16.3782	15
1400	177.854	99.741	23.3993	24.7453	29.9680	56.2100	58.3659	30.4075	25.0021	15.1683	15
1700	167.051	53.983	32.3187	28.0100	52.7393	71.1485	43.9557	22.6372	19.3300	13.1513	15
2000	141.992	69.219	25.5693	15.0387	32.1653	57.8388	44.9832	24.3125	14.9350	17.1901	15
0000	188.715	45.829	44.4050	40.9608	57.5200	32.3228	35.1270	38.0453	33.2540	21.0016	12

RESULTS OF ZOOPLANKTON GRAZING STUDY
DATA REPRESENTS CHLORYPHYLL a CONCENTRATIONS
FROM FRACTIONATED SAMPLES

------------------------------ Coll. Date=DECEMBER, 1991 Container=Filtered ------------------------------

TIME	Mean Total Chlorophyll a	Mean > 50 um	Mean < 50 > 20 um	Mean < 20 and < 5 um	Mean < 5 um	STD Whole	STD > 50	STD <50>20	STD <20>5	STD Lt 5	N Obs.
Initial	3.8800	0.15333	0.12000	0.22000	3.38667	0.20071	0.14075	0.09411	0.20071	0.20307	15
1100	9.0640	1.07600	0.63400	0.42867	6.92533	5.87773	1.96383	0.50077	0.46710	4.83694	15
1400	10.4500	2.59167	2.75833	-0.60000	5.70000	6.62125	3.63530	4.14607	2.66390	1.46412	12
1700	5.9250	0.59167	0.50000	0.51667	4.31667	1.14028	0.76807	0.51874	0.57656	1.22685	12
2000	8.0600	1.02067	0.92667	0.77600	5.33667	6.89628	1.70721	1.27880	0.90268	3.72373	15
0000	3.9733	0.34000	0.26667	0.26000	3.10667	1.04161	0.96273	0.27946	0.41196	0.51474	15

------------------------------ Coll. Date=DECEMBER, 1991 Container=Unfiltered ------------------------------

TIME	Mean Total Chlorophyll a	Mean > 50 um	Mean < 50 > 20 um	Mean < 20 and < 5 um	Mean < 5 um	STD Whole	STD > 50	STD <50>20	STD <20>5	STD Lt 5	N Obs.
Initial	336.316	246.527	10.9373	16.0040	62.8480	80.2539	74.4672	10.6413	17.5809	18.7816	15
1100	371.617	314.747	9.5127	7.2620	40.0947	24.0293	17.7266	4.8119	5.4900	11.6564	15
1400	114.521	76.854	3.5917	2.4883	31.5867	46.4796	31.7574	2.8845	2.5680	15.0279	12
1700	249.914	187.521	10.2480	3.7820	48.3633	92.7772	78.5239	7.4777	4.6527	13.5544	15
2000	309.421	210.213	18.5993	6.8067	73.8027	56.7037	57.3219	29.7869	13.4347	15.3021	15
0000	287.459	186.932	14.2520	10.1773	76.0980	69.1700	57.2578	11.7129	8.2805	22.6589	15

BIBLIOGRAPHY

PHYTOPLANKTON LITERATURE

Abbott, M.R., T.M. Powell, and P.J. Richerson (1982) The relationship of environmental variability to the spatial patterns of phytoplankton biomass in lake Tahoe. Journal of Plankton Research 4: 927-941.

Abhele, L.G. (1976) Comparative species richness in fluctuating and constant environments: coral-associated decapod crustaceaus. Science 192: 461-463.

Admeral, W., J. Beukema, and F.B. vanEs (1985) Seasonal fluctuations in the biomass and metabolic activity of bacterioplankton and phytoplankton in a well-mixed estuary: The Ems-Dollard (Wadden Sea). Journal of Plankton Research 7: 877-890.

Admiraal, W., H. Peletier, and R.W.P.M. Laane (1986) Nitrogen metabolism of marine planktonic diatoms: excretion, assimilation and cellular pools of free amino acids in seven species with different cell size. Journal Experimental Marine Biology and Ecology 98: 241-263.

Admiraal, W., H. Peletier, and H. Zomer (1982) Observations and experiments on the population dynamics of epipelic diatoms from an estuarine mudflat. Estuarine, Coastal and Shelf Science 14: 471-487.

Admiraal, W., and D. Werner (1983) Utilization of limiting concentrations of ortho-phosphate and production of extracellular organic phosphates in cultures of marine diatoms. Journal of Plankton Research 5-4: 495-513.

Ahmed, A.M., M.H. Haikal, A.A. Mohammed, and M.A. Zidan (1986) Field and laboratory studies on Nile phytoplankton in Egypt. I. Some physical and chemical characteristics. Int Revue ges Hydrobiol 71: 127-138.

Ahmed, A.M., A.A. Mohammed, M.M. Heikal, and Z.i.d.a.n. MA (1986) Field and laboratory studies on Nile phytoplankton in Egypt. II. Phytoplankton. Int Revue ges Hydrobiol 71: 233-244.

Allen, T.F., and J.F. Koonce (1973) Multivariate approachestoalgal stratgems and tactics in systems analysis of phytoplankton. Ecology 54: 1234-1246.

Aloi, J.E., S.L. Loeb, and C.R. Goldman (1988) Temporal and spatial variability of the eulittoral epilithic periphyton, Lake Tahoe, California-Nevada. Jour. Freshwater Ecology 4: 401-408.

Amblard, C. (1981) Interets du dosage des adenosines 5'-phosphate pour l'etude de la dynamique despopulations phytoplanctoniques lacustres (le Pavin-France). Hydrobiologia 85: 257-270.

Amblard, C., and G. Bourdier (1988) Evidence for diel changes in adenine nucleotides, fatty acids contents and primary productivity in lacustrine phytoplankton. Arch. Hydrobiol. 113: 1-14.

Anderson, G.C., and K. Banse (1965) Chlorophylls in marine phytoplankton: correlation with carbon uptake. Deep-sea reasearch 12: 531-533.

Anderson, G.C. (1963) Hydrography and phytoplankton production. Cont. # 251, Dept. Oceanograpohy, Univ. Washington. :.

Anderson, G.F. (1986) Silica, diatoms and freshwater productivity maximum in Atlantic Coastal Plain estuaries, Chesapeake Bay. Estuarine, Coastal and Shelf Science 22: 183-197.

Anderson, J.T., J.C. Roff, and J. Gerrath (1981) The diatoms and dinoflagellates of Hudson Bay. Canadian Journal of Botany 59: 1793-1810.

Antia, A.N., E.J. Carpenter, and J. Chang (1990) Species-specific phytoplankton growth rates via diel DNA synthesis cycles. III.Accuracy of growth rate measurement in the dinoflagellate Prorocentrum minimum. Marine Ecology - Progress Series 63: 273-279.

Antoine, S.E., and K. Benson-Evans (1985) The epiplic algal flora of the river Wye system, Wales, U.K. I. Productivity and total biomass dynamics. Int Revue ges Hydrobiol 70: 575-589.

Arbelaez, J., B. Koopman, and E.P. Lincoln (1983) Effects of dissolved oxygen and mixing on algal autoflotation. J of Water Pollution Control August: 1075-1079.

Arfi, R., P. Dufour, and D. Mauren (1981) Phytoplankton and pollution: first studies in Bietri Bay (Ivory Coast). Mathematical data processing. Oceanologica Acta 4: 319-330.

Arnold, E.M., and D.A. Voss (1981) Numerical behavior of a zooplankton, phytoplankton and phosphorus system. Ecological Modeling 13: 183-193.

Arvola, L. (1980) On the species composition and biomass of the phytoplankton in the Lokka Reservior, nordthern Finland. Ann. Bot. Fenici. 17: 325-335.

Atchue, J. Day, and H.G. Marshall (1983) Algal dynamics and nitrogen and phosphorus cycling in a cypress stand in the seasonally flooded Great Dismal Swanp. Hydrobiologia 106: 115-122.

Axler, R.R., G.W. Redfield, and C.R. Goldman (1981) The importance of regenerated nitrogen to a subalpine lake. Ecology 62: 345-354.

Bailey-Watts, A.E., A. Kirka, L. May, and D.H. Jones (1990) Changes in phytoplankton over various time scales in a shallow, eutrophic lake: the Loch Leven experience with special reference to the influence of flushing rate. Freshwater Biology 23: 85-111.

Bainbridge, R. (1956) The size, shape and density of marine phytoplankton concentrations. In H.M. Fox (ed): Biological Reviews of the Cambridge Philosphical Society.

Baker, K.K., and A.L. Baker (1982) Seasonal succession of the phytoplankton in the upper Mississippi River. Hydrobiologia 83: 295-301.

Balch, W.M. (1987) Studies of nitrate transport by marine phytoplankton using 36Cl-ClO3 - as a transport analogue. I. Physiological findings. J. Phycol. 23: 107-118.

Balch, W.M., C. Garside, and E.H. Renger (1987) Studies of nitrate transport by marine phytoplankton using 36Cl-ClO3 as a transport analogue - II. Field observations. Deep-Sea Research 34: 221-236.

Banse, K. (1988) Estimates of average phytoplankton division rates in the open Arabian Sea. Indian Jour. Mar. Sci. 17: 31-36.

Bauerfeind, E., W. Hickel, U. Niermann, and H.V. Westernhagen (1990) Phytoplankton biomass and potential nutrient limitaition of phytoplankton development in the southeastern north sea in spring 1985 and 1986. Netherlands Jour. Sea Res. 25: 131-142.

Baybutt, R.I., and J.C. Makarewicz (1981) Multivariate analysis of the Lake Michigan phytoplankton community at Chicago. Bulletin Torrey Botanical Club 108: 255-267.

Bell, C.R., and L.J. Albright (1982) Bacteriological investigation of the neuston and plankton in the Fraser River Estuary, British Columbia. Estuarine, Coastal and Shelf Science 15: 385-394.

Benner, R., E.R. Peele, and R.E. Hodson (1986) Microbial utilization of dissolved organic matter from leaves of the red mangrove, Rhizophora mangle, in the Fresh Creek Estuary, Bahamas. Estuarine, Coastal and Shelf Science 23: 607-619.

Bergmann, M.A., and H.E. Welch (1990) Nitrogen fixation by epilithic periphyton in small arctic lakes in response to experimental nitrogen and phosphorus fertilization. Canadian Journal of Fisheries and Auqatic Science 47(8): 1545-1550.

Berman, T., Y. Azov, A. Schneller, P. Walline, and D.W. Townsend (1986) Extent, transparency, and phytoplankton distribution of the neritic waters overlying the Israeli coastal shelf. Oceanologica Acta 9/4: 439-447.

Bidigare, R.R., J. Marra, T.D. Dickey, R. Iturriaga, K.S. Baker, R.C. Smith, and H. Pak (1990) Evidence fro phytoplankton succession and chromatic adaptation in the Sargasso Sea during spring 1985. Marine Ecology - Progress Series 60: 113-122.

Bienfang, P.K., and J.P. Szypen (1981) Phytoplankton dynamics in the subtropical Pacific Ocean off Hawaii. Deep - Sea Research 28: 981-1000.

Biggs, R.B., T.B. DeMoss, M.M. Carter, and E.L. Beasley (1989) Susceptibility of U.S. estuaries to pollution. Aquatic Sciences 1: 189-207.

Bird, J.L. (1983) Relationships between particle - grazing zooplankton and vertical phytoplankton distributions on the Texas Continental Shelf. Estuarine, Coastal and Shelf Science 16: 131-144.

Blaauboer, M.C.I. (1982) The phytoplankton species composition and the seasonal periodicity in Lake Vechten from 1956 to 1979.

Blaseo, D., and H.L. Conway (1982) Effect of Ammonium on the regulation of nitrate assimilation in natural phytoplankton populations. Journal Experimental Marine Biology and Ecology 61: 157-168.

Boliln, R.L., and D.P. Abbott (1962) Studies on the marine climate and phytoplankton of the central coastal area of California. 1954-1960. Calif. Co-operative Oceanic Fisheries Investigations Reports 9: 23-45.

Bonin, D.J., M.R. Droop, S.Y. Maestrini, and M.C. Bonin (1986) Physiological features of six micro-algae to be used as indicators of seawater quality. Cryptogamie, Algologie 7(1): 23-83.

Booth, B.C. (1988) Size classes and major taxonomic groups of phytoplankton at two locations in the subarctic Pacific Ocean in May and August, 1984. Mar Biol 97: 275-286.

Booth, W.E. (1987) Cotribution by diatoms to marine algal host-epiphyto photosynthesis. Botanica Marina 30: 129-140.

Bopp, F., and R.B. Biggs (1981) Metals in estuarine sediments: Factor analysis and its environmental significance. Science 214: 441-443.

Borgmann, U., E.S. Millard, and C.C. Charlton (1988) Dynamics of a stable, large volume, laboratory ecosystem containing Daphnia and phytoplankton. Journal of Plankton Research 10: 691-713.

Borstad, G.A. (1982) The influence of the meandering Guiana Current on surface conditions near Barbados - temporal variations of Trichodesmium (Cyanophyta) and other plankton. Jour Mar Res 40: 435-452.

Bothwell, M.L. (1988a) Growth rate responses of lotic periphytic diatoms to experimental phosphorus enrichment: the influence of temperature and light. Canadian Journal of Fisheries and Auqatic Science 45: 261-270.

Bothwell, M.L. (1988b) Growth rate responses of lotic periphytic diatoms to experimental phosphorus enrichment: the influence of temperature and light. Canadian Journal of Fisheries and Auqatic Science 45: 261-270.

Boynton, W.R., W.M. Kemp, and C.W. Keefe. A comparative anslysis of nutrients and other factors influencing estuarine phytoplankton production. In (ed): Estuarine Comparisons. : Academic Press, pp. 69-90.

Braud, L.E. (1981) Genetic variabililty in reproduction rates in marine phytoplankton populations. 35: 1117-1127.

Braud, L.E. (1984) The salinity tolerance of forty-six marine phytoplankton isolates. Estuarine, Coastal and Shelf Science 18: 543-556.

Braud, L.E., and R.R.L. Guillard (1981) The effects of continuous light and light intensity on the reproduction rates of twenty-two species of marine phytoplankton. Journal Experimental Marine Biology and Ecology 50: 119-132.

Browder, J.A., and etal (1981) Perspective on the ecological causes and effects of the variable algal composition of southern Everglades periphyton. South Florida Research Center Report T-643 : 110 pp.

Brown, O.B., R.H. Evans, J.W. Brown, H.R. Gordon, R.C. Smith, and K.S. Baker (1985) Phytoplankton blooming off the U.S. East Coast: A satellite description. Science 229: 163-167.

Brown, P.C. (1982) Phytoplankton and nutrients in the southern Benguela region. Trans. Roy. Soc. S. Afr. 44: 347-355.

Bruno, S.F., R.D. Staker, G.M. Sharma, and J.T. Turner (1983b) Primary productivity and phytoplankton size fraction dominance in a temperate North Atlantic estuary. Estuaries 6: 200-211.

Brush, G.S. (1984) Stratigraphic evidence of eutrophication in an estuary. Water Resources Research 20: 531-541.

Brzezinski, M.A., and D.M. Nelson (1988) Interactions between pulsed nutrient supplies and a photocycle affect phytoplankton competition for limiting nutrients in long-term culture. Journal of Phycology 24: 346-356.

Burris, J.E. (1981) Effects of oxygen and inorganic carbon concentrations on the photosynthetic quotients of marine algae. Marine Biology 65: 215-219.

Cabecadas, G., M.J. Brogueira, and J. Windolf (1986) A phytoplankton bloom in Shallow Divor Reservoir (Portugal)- the importance of internal nutrient loading. Int Revue ges Hydrobiol 71: 795-806.

Cabrera, S., and V. Montecino (1990) Photosynthetic parameters of the entire eutrophic phytoplankton of the Bransfield Strait, summer 1985. Polar Biol 10: 507-513.

Caljon, A.G. (1987a) Phytoplankton of a recently landlocked brackish-water lagoon of Lake Tanganyika: a systematic account. Hydrobiologia 153: 31-54.

Caljon, A.G. (1987b) A recently landlocked brackish-water lagoon of Lake Tanganytika: physical and chemical characteristics, and spatio-temporal distribution of phytoplankton. Hydrobiologia 153: 55-70.

Callaway, R.J., and D.T. Specht (1982) Dissolved silicon in the Yaquira Estuary, Oregon. Estuarine, Coastal and Shelf Science 15: 561-567.

Callender, E., and D.E. Hammond (1982) Nutrient exchange across the sediment-water interface in the Potomac River Estuary. Estuarine, Coastal and Shelf Science 15: 395-413.

Campbell, D.E., and R.W. Spinrad (1987) The relationship between light attenuation and particle characteristics in a turbid esturay. Estuarine, Coastal and Shelf Science 25: 53-65.

Campbell, E.E., and G.C. Bate (1987) Factors influencing the magnitude of phytoplankton primary production in a high-energy surf zone. Estuarine, Coastal and Shelf Science 24: 741-750.

Campbell, E.E., D.R. du Preez, and G.C. Bate (1988) The light environment in a high energy surf-zone with high phytoplankton biomass. Botanic Marina 31: 329-335.

Canfield, D.E.J.r. (1983) Prediction of cholrophyll A concentrations in Florida lakes: the importance of phosphorus and nitrogen. Water Resource Bulletin 19(2): 255-262.

Caperon, J., and J. Myer (1972) Nitrogen - limited growth of marine phytoplankton. I. Changes in population characteristics with steady - state growth rate. Deep-Sea Research 19: 601-618.

Carlton, R.G., and R.G. Wetzel (1988) Phosphorus flux from lake sediments: effect of epipelic algal oxygen production. Limnology and Oceanography 33: 562-570.

Carney, G.C. (1981) The measurement of primary production in pond phytoplankton using the carbon-14 technique. Jour. Biol. Ed. 15: 31-34.

Carpenter, E.J., and J. Chang (1988) Species-specific phytoplankton growth rates via diel DNA synthesis cycles. I. Concept of the method. Marine Ecology - Progress Series 43: 105-111.

Carpenter, E.J., and S. Dunham (1985) Nitrogenous nutrient uptake, primary production, and species composition of phytopolankton in the Carmans River Estuary, Long Island, New York. Limnology and Oceanography 30: 513-526.

Carpenter, E.J., R.L. Iverson, and W.E. Esaias () Phytoplankton productivity measurement using carbon-14. paper : 1-27.

Carrick, H.J., and R.L. Lowe (1988) Response of Lake Michigan benthic algae to in situ enrichment with Si, N, and P. Canadian J. Fish and Aquat Sci 45(2): 271-279.

Castenholz, R.W. (1961) The effect of grazing on marine littoral diatom populations. Ecology 42: 783-794.

Chang, W.Y.B. (1981) Path analysis and factors affecting primary productivity. Jour. Freshwater Ecol. 1: 113-120.

Chervin, M.B., T.C. Malone, and P.J. Neale (1981) Interactions between suspended organic matter and copepod grazing in the plume of the Hudson River. Estuarine, Coastal and Shelf Science 13: 169-183.

Chessman, B.C. (1985) Artificial substratum periphyton and water quality in the lower La Trobe River, Victoria, Australia. Journal Marine and Freshwater Research 36: 855-871.

Childers, D.L., and J.W. Day (1988) A flow-through flume technique for quantifying nutrient and materials fluxes in microtidal estuaries. Estuarine, Coastal and Shelf Science 27: 483-494.

Chrost, R.H., and M.A. Faust (1983) Organic carbon release by phytoplankton: Its composition and utilization by bacterioplankton. Journal of Plankton Research 5: 477-493.

Chu, S.P. (1943) The influence of the mineral composition of the medium on the growth of planktonic algae. Part II. The influence of the concentration of nitrogen and phosphate phosphorus. Journal of Ecology 31: 8-148.

Citarella, G. (1982) Contribution a l etude des phytoplanctontes du detroit de Northumberland, Nouveau-Brunswic, Canada. Hydrobiologia 87: 113-120.

Ckhester, A.J., and J.D. Larrance (1981) Composition and vertical flux of organic matter in a large Alaskan estuary. Estuaries 4: 42-52.

Cloern, J.E. (1982) Does the benthos control phytoplankton biomass in South San Francisco Bay. Marine Ecology - Progress Series 9: 191-202.

Cloern, J.E., A.E. Alpine, B.E. Cole, R.L.J. Wong, J.F. Arthur, and M.D. Ball (1983) River discharge controls phytoplankton dynamics in the Northern San Francisco Bay estuary. ESCC 16: 415-429.

Cloern, J.E., and R.T. Cheug (1981) Simulation model of Skeletonema costatum pop[ulation dynamics in Northern San Francisco Bay, California. Estuarine, Coastal and Shelf Science 12: 83-100.

Cloern, J.E., B.E. Cole, R.L.J. Wong, and A.E. Alpine (1985) Temporal dynamics of estuarine phytoplankton: A case study of San Francisco Bay. Hydrobiologia 129: 153-176.

Coffin, R.B., B. Fry, B.J. Peterson, and R.T. Wright (1989) Carbon isotopic composition of estuarine bacteria. Limnology and Oceanography 34: 1305-1310.

Cohen, R.H., M.G. Kelley, and M.R. Church (1982) THe effect of CO2 on the relationship of photosynthetic rate to light intensity in laboratory phytoplankton cultures. Archiv Fur Hydrobiologia 94(3): 326-340.

Cole, B.E. (1989) Temporal and spatial patterns of phytoplankton production in Tomales Bay, California, U.S.A. Estuarine, Coastal and Shelf Science 28: 103-115.

Cole, B.E., and J.E. Cloern (1984) Significance of biomass and light availability to phytoplankton productivity in San Francisco Bay. Marine Ecology - Progress Series 17: 15-24.

Cole, B.E., and J.E. Cloern (1987) An empirical model for estimating phytoplankton productivity in estuaries. Marine Ecology - Progress Series 36: 299-305.

Cole, B.E., J.E. Cloern, and A.E. Alpine (1986) Biomass and productivity of three phytoplankton size classes in Francisco Bay. Estuaries 9 (2): 117-126.

Cole, J.J. (1982) Interactions between bacteria and algae in aquatic ecosystems. Ann. Rev. Ecol. Syst. 13: 291-314.

Colijn, F., L. Villerius, M. Rademaker, K.D. Hammer, and K. Eberlein (1990) Changes in spatial distribution of primary production, Photosynthetic pigments and phytoplankton species composition during two surveys in the German Bight. Netherlands Jour. Sea Res. 25: 155-164.

Conrad, H.M., and P. Saltman (1962) Growth substances. In R.A. Lewin (ed): Physiology and Biochem of Alage. :, pp. 663-671.

Cook, L.L., and S.A. Whipple (1982) The distribution of edaphic diatoms along environmental gradients of a Louisiana salt marsh. Journal of Phycology 18: 64-71.

Cosper, E. (1982) Influence of light intensity on diel variations in rates of growth, respiration and organic release of a marine diatom: comparison of diurnally constant and fluctuating light. Journal of Plankton Research 4: 705-723.

Cullen, J.J., F.M.H. Reid, and E. Stewart (1982) Phytoplankton in the surface and chlorophyll maximum off southern California in August, 1978. Journal of Plankton Research 4: 665-694.

Currie, D.J. (1986) Does orthophosphate uptake supply sufficient phosphorus to phytoplankton to sustain their growth?. Canadian Journal of Fisheries and Aquatic Science 43: 1482-1487.

D'Croz, L., J.D. Rosario, and R. Holness (1989) Degradation of red mangrove (Rhizophora mangle L.) leaves in the Bay of Panama. Rev. Biol. Trop. 37: 101-104.

D'Elia, C.F., J.G. Sanders, and W.R. Boynton (1986) Nutrient enrichment studies in a coastal plain estuary: phytoplankton growth in large-scale, continuous cultures. Canadian Journal of Fisheries and Auqatic Science 43: 397-406.

Davis, M.W., and C.D. McIntire (1983) Effects of physical gradients on the production dynamics of sediment - associated algae. Marine Ecology - Progress Series 13: 103-114.

Davoren, W.T. (1982) Tragedy of the San Francisco Bay commons. Coastal Zone Management Jour. 9: 111-153.

De La Cruz, A.A. (1982) Effects of oil on phytoplankton metabolism in natural and experimental estuarine ponds. Mar. Envir. Res. 7: 257-263.

deEmiliani, M.O.G., and P.J. Depetris (1982) A principal components analysis of the phytoplankton from a pond in the Parana River Valley, Argentina. Hydrobiologia 89: 117-122.

DeFelice, D. (1975) Model studies and epipelic diatoms of upper Florida Bay and associated sounds. Masters Thesis Duke Univeristy :.

deJorge, V.N. (1985) The occurrence of 'epipsammic' diatom populations: A result of interaction between physical sorting of sediment and certain properties of diatom species. Estuarine, Coastal and Shelf Science 21: 607-622.

Demers, S., J.C. Therriault, E. Bourget, and A. Bah (1987) Resuspension in the shallow sublittoral zone of a macrotidal estuarine environment: wind influence. Limnology and Oceanography 32-2: 327-339.

DeSeve, M.A., and M.E. Godstein (1981) The structure and composition of epilithic diatom communities of the St. Lawrence and Ottawa Rivers in the Moutrea area. Canadian Journal of Botany 59: 337-387.

Devassy, V.P., and J.I. Goes (1989) Seasonal patterns of phytoplankton biomass and productivity in a tropical estuarine complex (west coast of India). Proc. Indian Acad. Sci. 99: 485-501.

Dooley, M. (1973) Preliminary investigations of phytoplankton from the west coast of Ireland. British Phycological Journal 8: 79-94.

Dooris, P.M., G.M. Dooris, and D.F. Martin (1982) Phytoplankton responses to ground water in central Florida lakes. Water Resource Bulletin 18: 335-337.

Dortch, Q. (1982) Effect of growth conditions on accumulation of internal nitrate, ammonium, amino acids,and protein in three marine diatoms. Journal Experimental Marine Biology and Ecology : 243-264.

Dortch, Q. (1990) The interaction between ammonium and nitrate uptake in phytoplankton. Marine Ecology - Progress Series 61: 183-201.

Drenner, R.W., S.T. Threlkeld, J.D. Smith, J.R. Mummert, and P.A. Cantrell (1989) Interdependence of phosphorus, fish, and site effects on phytoplankton biomass and zooplankton. Limnology and Oceanography 34: 1315-1321.

Droop, M.R. (1957) Auxotrophy and organic compounds in the nutrition of marine phytoplankton. J. Gen. Microbiol. 16: 286-293.

Droop, M.R. (1962) Organic micronutrients. In R. Lewin (ed): Physiology and Biochemistry of Algae. :, pp. 141-158.

Dubinsky, Z., P.G. Falkowski, and K. Wyman (1986) Light harvesting and utilization by phytoplankton. Plant Cell Physiol. 27 (7): 1335-1349.

Duursma, E.K., and P. Ruardij (1989) Conservative mixing in estuaries as affected by sorption, complexing and turbidity maximum: a simple model example. Marine Chemistry 28: 251-258.

Edsbagge, H. (1965) Vertical distribution of diatoms. Sveusk Botanisk Tidskrift 59: 463-468.

El-Sayed, S.Z., and L.H. Weber (1982) Spatial and temporal variations in phytoplankton biomass and primary productivity in the southwest Atlantic and Scotia Sea. Polar biology 1: 83-90.

Elber, F., and F. Schanz (1990) Algae, other than diatoms, affecting the density, species richness and diversity of diatom communities in rivers. Archiv Fur Hydrobiologia 119(1): 1-14.

Elser, J.J., and B.L. Kimmel (1986) Alteration of phytoplankton phosphorus status during enrichment experiments: implications for interpreting nutrient enrichment bioassay results. Hydrobiologia 133: 217-222.

Epp, R.W., and W.M. Lewis (1981) Photosynthesis in copepods. Science 214: 1349-1350.

Eppley, R., and etal (1969) Half-saturation constants for uptake of nitrate and ammonium by marine phytoplankton. Limnology and Oceanography 14: 912-920.

Eppley, R.W. (1972) Temperature and phytoplankton growth in the sea. Fishery Bulletin 70: 1063-1085.

Eppley, R.W., and J.L. Coatsworth (1968) Uptake of nitrate and nitrite by Ditylum brightwellii - kinetics and mechanisms. Journal of Phycology 4: 151-156.

Eppley, R.W., R.W. Holmes, and J.D.H. Strickland (1967) Sinking rates of marine phytoplankton measured with a fluorometer. Journal Experimental Marine Biology and Ecology 1: 191-208.

Eppley, R.W., and W.H. Thomas (1969) Comparison of half-saturation constants for growth and nitrate uptake of marine phytoplankton. Journal of Phycology 5: 373-379.

Erga, S.R. (1989) Ecological studies on the phytoplankton of Boknafjorden, Western Norway. 1. The Effect of water exchange process and environmental factors on temporal and vertical variability of biomass. Sarsia 74: 161-176.

Erga, S.R., and H.R. Skjoldal (1990) Diel variations in photosynthetic activity of summer phytoplankton in Lindaspollene, western Norway. Marine Ecology - Progress Series 65: 73-85.

Everitt, D.A., S.W. Wright, J.K. Volman, D.P. Thomas, and E.J. Lindstrom (1990) Phytoplankton community compositions in the western equatorial Pacific determined form chlorphyll and carotenoid pigment distribuitions. Deep-Sea Research 37: 975-997.

Fabri, R., and L. Leclerq (1977) Les ruisseaux et rivieres de haute belgique chareteristiques physico - chimiques des eaux naturelles et polluees. Natura Mosana 30: 78-87.

Fairchild, G.W., and A.C. Everett (1988) Effects of nutrient (N,P,C) enrichment upon periphyton standing crop, species composition and primary production in an oligotrophic softwater lake. Freshwater Biol 19: 57-70.

Falkowski, P.G. (1983) Light-shade adaptation and vetical mixing of marine phytoplankton: A compariative field study. Jour Mar Res 41: 215-237.

Falkowski, P.G., C.N. Flagg, G.T. Rowe, S.L. Smith, T.E. Whitledge, and C.D. Wirick (1988) The fate of a spring phytoplankton bloom: export or ixidation?. Continental Shelf Res. 8: 457-484.

Faust, M.A., and R.J. Chrost (1981) Photosynthesis, extracellualar release, and heterotrophy of disolved organic matter in Rhode River estrarine plankton. In B.J. Neilson and L.E. Cronin (eds): Estuaries and Nutrients. :, pp. 465-479.

Fielding, P.J., K.S.t.J. Damstra, and G.M. Branch (1988) Benthic diatom biomass, Production and Sediment Chlorophyll in Lagebaan Lagoon, South Africa. Estuarine, Coastal and Shelf Science 27: 413-426.

Filardo, M.J., and W.M. Dunstan (1985b) Hydrodynamic control of phytoplankton in low salinity waters of the James River Estuary, Virginia, U.S.A. Estuarine, Coastal and Shelf Science 21: 653-667.

Findenegg, I. (1965) Relationship between standing crop and primary productivity. Proc. IBP symp. Primary Productivity in Aquatic Environments, Pallanza, Italy, April 1965. :.

Fisher, N.S. (1981) On the selection for heavy metal tolerance in diatoms from the Derwert Estuary, Tasmania. Aust. J. Mar. Freshwater Res. 32: 555-561.

Fisher, N.S., and J.G. Fabris (1982) Complexation of Cu, An and Cd by metabolites excreted from marine diatoms. Marine Chemistry 11: 245-255.

Fisher, N.S., and G.J. Jones (1981) Heavy metals and marine phytoplankton: correlation of toxicity and sulfhydryl-binding. Journal of Phycology 17: 108-111.

Fisher, T.R., W. Harding, D.W. Stanley, and L.G. Ward (1988) Phytoplankton, nutirents, and turbidity in the Chesapeake, Delaware, and Hudson Estuaries. Estuarine, Coastal and Shelf Science 27: 61-93.

Fitzgerald, G.P., and T.C. Nelson (1966) Extractive and enzymatic analyses for limiting on surplus phosphorus in algae. Journal of Phycology 2: 32-37.

Flint, R.W. (1984) Phytoplankton production in the Corpus Christi Bay estuary. Cont. Mar. Sci. 27: 65-83.

Flores-Verdugo, F., J.W. Day, L. Mee, and R. Briseno-Duenas (1988) Phytoplankton production and seasonal biomass variation of seagrass, Ruppia maritima L., in a tropical Mexican lagoon with an ephemeral inlet. Estuaries 11: 51-56.

Fournier, R.O. (1966) Some implications of nutrient enrichment on different temporal stages of a phytoplankton community. Chesapeake Science 7: 11-19.

Fraser, T.H., and W.H. Wilcox (1981) Enrichment of a subtropical estuary with nitrogen, phosphorus and silica. In B. Neilson and E. Cronin (eds): Estuaries and Nutrients. :.

Frechette, M., and L. Legendre (1982) Phytoplankton photosynthetic response to light in an internal tide. Estuaries 5: 287-293.

Froelich, P.N. (1988) Kinetic control of dissolved phosphate in natural rivers and estuaries: a primer on the phosphate buffer mechanism. Limnol Oceanogr 33(2): 649-668.

Froelich, P.N., L.W. Kaul, J.T. Byrd, M.O. Andreae, and K.K. Roe (1985) Arsenic, Barium, Germanium, Tin, Dimethylsulfide and nutrient biochemistry in Charlotte Harbor, Florida, a phosphorus-enriched estuary. Estuarine, Coastal and Shelf Science 20: 239-264.

Furnas, M.J. (1983a) Community structure, biomass and productivity of size fractionated summer phytoplankton populations in lower Narragansett Bay, Rhode Island. Journal of Plankton Research 5: 637-655.

Furnas, M.J. (1983b) Nitrogen dynamics in lower Narragnsett Bay, Rhode Island. I. Uptake by size-fractionated phytoplankton populations. Journal of Plankton Research 5: 657-676.

Furnas, M.J. (1987) Effects of prescreening on productivity of size-fractionated phytoplankton. Limnology and Oceanography 32: 483-491.

Furnas, M.J., and A.W. Mitchell (1986) Phytoplankton dynamics in the central Great Barrier Reef-I. Seasonal changes in biomass and community structure and their relation to intrusive activity. Continental Shelf Research 6: 363-384.

Furnas, M.J., T.J. Smayda, and E.A. Deason (1986) Nitrogen dynamics in lower Narragansett Bay, II. Phytoplankton uptake, depletion rates of nitrogenous nutrient pools, and estimates of ecosystem remineralization. Journal of Plankton Research 8-4: 755-769.

Gallegos, C.L. (1989) Microzooplankton grazing on phytoplankton in the Rhode River, Maryland: nonlinear feeding kinetics. Marine Ecology - Progress Series 57: 23-33.

Garnier, J., L.e.l.o.n.g. JF, and M. Meybeck (1987) Comparaison physico-chimique et biologique de sept bassins artificiels dans les alluvions de la region parisienne. Naturaliste Can. 114: 325-342.

Gaxiola-Castro, G., and S. Alvarez-Borrego (1986) Photosynthesis-irradiance relationship for winter phytoplankton in Pacific waters off Mexico. Oceanologica Acta 9/4: 497-501.

Geider, R.J. (1987) Light and temperature dependence of the carbon to cholorphyll a ration in microalgae and cyanobacteria: implications for physiology and growth of phytoplankton. New Phytol. 106: 1-34.

Geider, R.J. (1988) Estimating the growth and loss rates of phytoplankton from time-series observtions of 14-C-bicarbonate uptake. Marine Ecology - Progress Series 43: 125-138.

Gibson, C.E. () Silica budgets and the ecology of planktonic diatoms in an unstratified lake (Lough Neagh, N. Ireland). Int. Revue ges. Hydrobiol. 66: 641-664.

Gifford, D.J., R.N. Bohren, and C.M. Boyd (1981) Spines on diatoms: Do copepods care?. Limnology and Oceanography 26: 1057-1061.

Gilbert, P.M., J.C. Goldman, and E.J. Carpenter (1982) Seasonal variation in the utilization of ammonium and nitrate by phytoplankton in Vineyard Sound, Massachusetts, USA. Mar. Biol. 70: 237-249.

Gilstad, M., and E. Sakshaug (1990) Growth rates of ten diatom species from the Barents Sea at different irradiances and day lengths. Marine Ecology - Progress Series 64: 169-173.

Giovannoni, S.J., E.F. DeLong, T.M. Schmidt, and N.R. Pace (1990) Tangential flow filtration and preliminary phylogenetic analysis of marine picoplankton. Applied and Envrionmental Microbiology 56: 2572-2575.

Glibert, P.M., M.R. Dennett, and J.C. Goldman (1985) Inorganic carbon uptake by 7 phytoplankton in vineyard sound, Massachusetts. I. Measurements of the photosynthesis-Irradiance response of winter and early-spring assemblages. Journal Experimental Marine Biology and Ecology 85: 21-36.

Glover, H.E., M.D. Keller, and R.W. Spinrad (1987) The effects of light quality and intensity on photosynthesis and growth of marine eukaryotic and prokaryotic phytoplankton clones. Journal Experimental Marine Biology and Ecology 105: 137-159.

Goldman, J.C., and M.R. Dennett (1986) Dark CO2 uptake by the diatom Chaetoceros simplex in response to nitrogen pulsing. Marine Biology 90: 493-500.

Goldman, J.C., M.R. Dennett, and C.B. Riley (1981) Marine phytoplankton photosynthesis and transient ammonium availability. Marine Biology Letters 2: 323-331.

Goldman, J.G., D.A. Caron, and M.R. Dennett (1987) Nutrient cycling in a microflagellate food chain: IV. Phytoplankton-microflagellate interactions. Marine Ecology - Progress Series 38: 75-87.

Goldsborough, L.G., and G.G.C. Robinson (1985) Seasonal succession of diatom epiphyton on dense mats of Lemna minor. Canadian Journal of Botany 63: 2332-2339.

Gonzalez, J.M., E.B. Sherr, and B.F. Sherr (1990) Size-selective grazing on bacteria by natural assemblages of estuarien flagellates and ciliates. Applied and Environmental Microbiology 56: 583-589.

Gorsky, G., P. Guilbert, and E. Valenta (1989) The autonomous image analyzer - enumeration, measurement and identification of marine phytoplankton. Marine Ecology - Progress Series 58: 133-142.

Gotham, I.J., and G. Yull Rhee (1981) Comparative kinetic studies of phosphate-limited growth and phosphate uptake in phytoplankton in continuous culture. Journal of Phycology 17: 257-265.

Gould, R.W.J.r., E.R. Balmori, and G.A. Fryxell (1986) Multivariate statistics applied to phytoplankton data from two Gulf Stream warm core rings. Limnology and Oceanography 31(5): 951-968.

Gowen, R.J., P. Tett, and B.J.B. Wood (1983) Changes in the major dihydroporphyrin plankton pigments during the spring bloom of phytoplankton in two Scottish sea-lochs. J. Mar. Biol. Ass. U.K. 63: 27-36.

Graf, G., W. Bengtsson, U. Diesner, R. Schulz, and H. Theede (1982) Benthic response to sedimentation of a spring phytoplankton bloom: process and budget. Marine Biology 67: 201-208.

Graneli, E. (1987) Nutrient limitation of phytoplankton biomass in a brackish water bay highly influenced by river discharge. Estuarine, Coastal and Shelf Science 25: 555-565.

Graneli, E., W. Graneli, and L. Rydberg (1986) Nutrient limitation at the ecosystem and the phytoplankton community level in the Laholm Bay, South-East Kattegat. Ophelia 26: 181-194.

Grant, J., U.V. Bathmann, and E.L. Mills (1986) The interaction between benthic diatom films and sediment transport. Estuarine, Coastal and Shelf Science 23: 225-238.

Greeson, P.E. (1979) A supplement to - methods for collection and analysis of aquatic biological and microbiological samples. U.S. Geological Survey Techniques of water-Resources Investigations, Book 5, Chapter A4 :.

Grenney, W.J., D.A. Bella, and H.C. Curl (1973) A theoretical approach to interspecific competion in phytoplankton communities. The American Naturalist 107: 405-425.

Grobbelaar, J.U. (1985) Phytoplankton productivity in turbid waters. Journal of Plankton Research 7 (5): 653-663.

Grover, J.P. (1988) Dynamics on competition in a variable environment: experiments with two diatom species. Ecology 69(2): 408-417.

Guillard, R.R., T.A. Jackson, and P. Kilham (1973) Kinetics of silicon-limited growth in the marine diatom Thalassiosira pseudonana Hasle and Heimdal (Cyclotell nana Hustedt). Journal of Phycology 9: 233-237.

Guillard, R.R.L., and P.J. Wangersky (1958) The production of extracellular carbonydrates by some marine flagellates. Limnology and Oceanography 3: 449-454.

Haberstroh, P.R., and S.I. Ahmed (1986) Resolution by high pressure liquid chromatography of intracellular and extracellular free amino acids of a nitrogen deficient marine diatom, Skeletonema costatum (Grev.) Cleve, pulsed with nitrate or ammonium. Journal Experimental Marine Biology and Ecology 101: 101-117.

Hager, S.W., and D.D. Harmon (1984) Chemical determination of particulate nitrogen in San Francisco Bay. A comparison of two estimates. Estuarine, Coastal and Shelf Science 19: 181-191.

Hallegraeff, G.M. (1981) Seasonal study of phytoplankton pigments and species at a coastal station off Sydney: Importance of diatoms and nanoplankton. Marine Biology 61: 107-118.

Hallegraeff, G.M., and D.D. Reid (1986) Phytoplankton species successions and their hydrological environment at a coastal station off Sydney. Aust. J. Mar. Freshw. Res. 37: 361-377.

Hama, T., N. Handa, M. Takahashi, F. Whitney, and C.S. Wong (1988) Change in distribution patterns of photosynthetically incorporated C during phytoplankton bloom in controlled experimental ecosystem. J Exp Mar Biol Ecol 120: 39-56.

Hama, T., K. Matsunaga, N. Handa, and M. Takahashi (1988) Day-night changes in production of carbohydrate and protein by natural phytoplankton poplulations from Lake Biwa, Japan. J Plank Res 10(5): 941-955.

Hama, T., T. Miyazaki, Y. Ogawa, T. Iwakuma, M. Takahashi, A. Otsuki, and S. Ichimura (1983) Measurement of photosynthetic production of a marine phytoplankton population using a stable C13 isotope. Marine Biology 73: 31-36.

Hammer, K.D., U.H. Brockmann, and G. Kattner (1981) Release of dissolved free amino acids during a bloom of Tihalassiosira rotula. Kieler Meeresforsch 5: 101-109.

Hammer, K.D., and K. Eberlein (1981) Parallel experiments with Thalassiosira rotula in outdoor plastic tanks: development of dissolved free amino acids during algae bloom. Marine Chemistry 10: 533-544.

Handa, N., and K. Yanagi (1969) Studies on water-extractable carbohydrates of the particulate matter from the northwest Pacific Ocean. Marine Biology 4: 197-207.

Hansson, L.A. (1988) Effects of competitive interactions on the biomass development of planktonic and periphytic algae in lakes. Limnology and Oceanography 33: 121-128.

Harding, L.W., B.B. Prezelin, B.M. Sweeney, and J.L. Cox (1981) Diel oscillations in the photosynthesis-irradiance relationship of a planktonic marine diatom. Journal of Phycology 17: 389-394.

Harding, L.W.J.r., B.W. Meeson, and T.R.J.r. Fisher (1986) Phytoplankton production in two east coast estuaries: photosynthesis-light functions and patterns of carbon assimilation in Chesapeake and Delaware Bays. Estuarine, Coastal and Shelf Science 23: 773-806.

Hardy, J.T., and M. Valett (1981) Natural and microcosm phytoneuston communities of Sequim Bay, Washington. Estuarine, Coastal and Shelf Science 12: 3-13.

Hargrave, B.T., and G.H. Green (1970) Effects of copepod grazing on two natural phytoplankton populations. JFRBC 27: 1395-1403.

Hargraves, P.E., and R.M. Viquez (1985) Spatial and temporal distribution of phytoplankton in the Gulf of Nicoya, Costa Rica. Bulletin Marine Science 37: 557-585.

Harrison, G.H., and M.M. Morel (1986) Response of the marine diatom Thalassiosira weissflogii to iron stress. Limnology and Oceanography 31: 989-997.

Harrison, P.G., and C.D. Durance (1985) Reductions in photosynthetic carbon uptake in epiphytic diatoms by water-soluble extracts of leaves of Zostera marina. Marine Biology 90: 117-119.

Harrison, P.J., M.H. Hu, Y.P. Yang, and X. Lu (1990) Phosphate limitation in estuarine and coastal waters of China. J. Exp. Mar. Biol. Ecol. 140: 79-87.

Hart, T.J. (1963) Speciation in marine phytoplankton. Systematics Association Publication Number 5: Speciation in the Sea. : 145-155.

Hartman, R.T. (1960) Algae metabolites of natural waters. The pymatuning symposium in ecology, the ecology of algae. Sp. Pub. #2, Univ. Pittsburg : 38-55.

Hattori, A., and E. Wada (1972) Assimilation of inorganic nitrogen in the euphotic layer of the north Pacific Ocean. In Takenouti (ed): Bio. Ocean. of the N.N.P.O. :, pp. 279-287.

Haug, A., S. Myklestad, and E. Sakshaug (1973) Studies on the phytoplankton ecology of the Trondheimsfjord. I. the chemical composition of phytoplankton populations. Journal Experimental Marine Biology and Ecology 11: 15-26.

Heath, C.W., I.C. Smalls, and D. Cannon (1980) Some factors involved in the occurrence and limitation of algal blooms in an Australian estuary. Prog. Wat. Tech. 12: 421-443.

Hecky, R.E. (1988) Nutrient limitation of phytoplankton in freshwater and marine environments: A review of recent evidence on the effects of enrichment. Limnology and Oceanography 33: 796-822.

Heffernan, J.J., and R.A. Gibson (1983) Chlorophyll distrubution in continental shelf sediments off West Palm Beach, Florida and West End, Bahamas. Estuarine, Coastal and Shelf Science 17: 107-110.

Hegseth, E.N. (1982) Chemical and species composition of the phytoplankton during the first spring bloom in Thondheimsfjorden, 1975. Sarsia 67: 131-141.

Hellbust, J.A. (1965) Excretion of some organic compounds by marine phytoplankton. Limnology and Oceanography 10: 192-206.

Henning, M., and J.G. Kohl (1981) Toxic blue-green algae water blooms found in some lakes in the German Democratic Republic. Int Revue ges Hydrobiol 66: 553-561.

Herbland, A., and A.L. Bouteiller (1983) Dynamique du phytoplancton et matiere organique particulaire dans la zone euphotique de l'Atlantique equatorial. Mar. Biol. 72: 265-278.

Hewes, D.C., F.M.H. Reid, and O. Holm-Hansen (1984) The quantitiative analysis of nanoplankton: a study of methods. Journal of Plankton Research 6: 601-613.

Hinga, K.R. (1990) Alteration of phosphorus dynamics during experimental eutrophication of enclosed marine ecosystems. Marine Pollution Bulletin 21: 275-280.

Hitchcock, G.L. (1983) An examination of diatom area:volume ratios and their influence on estimates of plasma volume. Journal of Plankton Research 5: 311-324.

Hoagland, K.D., S.C. Roemer, and J.R. Rosowski (1982) Colonization and community structure of two periphyton assemblages, with emphasis on the diatoms (Bacillariophyceae). Amer. J. Bot. 69: 188-213.

Hobson, L.A. (1918) Seasonal variations in maximum photosynthetic rates of phytoplankton in Saanich Inlet, Vancouver Island, British Columbia. Journal Experimental Marine Biology and Ecology 52: 1-13.

Hobson, L.A., and C.J. Lorenzen (1972) Relationships of chlorophyll maxima to density structure in the Atlantic ocean and gulf of Mexico. Deep-Sea Research 19: 297-306.

Holms, N.T.H., and B.A. Whitton (1981) Phytoplankton of four rivers, the Tyne, Wean, Tees and Swale. Hydrobiologia 80: 111-127.

Hongue, D., O.K. Skogheim, A. Hindar, and H. Abrahamsen (1980) Effects of heavy metals in combination with NTA, humic acid, and suspended sediment on natural phytoplankton photosynthesis. Bull. Environ. Contam. Toxicol. 25: 594-600.

Hopkinson, C.S.J.r. (1987) Nutrient regeneration in shallow-water sediments of the estuarine plume region of the nearshore Georgia Bight, USA. Marine Biology 94: 127-142.

Horner, R.R., and E.B. Welch (1981) Stream periphyton development in relation to current velocity and nutrients. Canadian Journal of Fisheries and Auqatic Science 38(4): 449-457.

Horwood, J.W., J.H. Nichols, and R. Harrop (1982) Seasonal changes in net phytoplankton of the west-central North Sea. J. Mar. Biol. Ass. U.K. 62: 15-23.

Howarth, R.W., R. Marino, J. Lane, and J.J. Cole (1988) Nitrogen fixation in freshwater, estuarine, and marine ecosystems 1. rates and importance. Limnol Oceanogr 33(4): 669-687.

Huang, R. (1988) The influence of hydrography on the distribution of phytoplankton in the Southern Taiwan Strait. Estuarine, Coastal and Shelf Science 26: 643-656.

Hubener, T.H., V. Kell, D. Kolbow, B. Strehlow, and U. Lenschow (1989) Dynamik des Phytoplanktons de Oberwarnow 1984-1986. Acta hydrochim. hydrobiol. 17: 619-631.

Hulburt, E.M. (1966) The distribution of phytoplankton, and its relationship to hydrography, between southern New England and Venezuela. Jour Mar Res 24: 67-81.

Hulburt, E.M. (1982) The adaptation of marine phytoplankton species to nutrient and temperature. Ocean Science and Engineering 7: 187-228.

Hulburt, E.M. (1985a) Format for phytoplankton productivity in Casco Bay, Maine, and in the southern Sargasso Sea. Bulletin Marine Science 37 (3): 808-826.

Hulburt, E.M. (1985b) Use of logical equivalence in modeling ecological relations of oceanic phytoplankton. Ecol. Mod. 27: 25-43.

Hulburt, E.M. (1985c) Adaptation and niche breadth of phytoplankton species along a nutrient gradient in the ocean. Journal of Plankton Research 7: 581-594.

Hulburt, E.M., and N. Corwin (1981) An ecological context for classification of phytoplankton and environmental variables in New York waters. Ocean Science and Engineering 6: 195-222.

Humphrey, G.F. (1983) The effect of the spectral composition of light on the growth, pigments, and photosynthetic rate of unicellular marine algae. Journal Experimental Marine Biology and Ecology 66: 49-67.

Ignatiades, L., M. Karydis, and K. Pagou (1987) Patterns of dark 14CO2 incorporation by natural marine phytoplankton communities. Microb. Ecol. 13: 249-259.

Iverson, R.L., H.F. Bittaker, and V.B. Myers (1976) Loss of radiocarbon in direct use of Aquasol for liquid scintillation counting of solutions containing 14C-NaHCO3. Limnology and Oceanography : 756-758.

Iverson, R.L., T.E. Whitledge, and J.J. Goering (1979) Chlorophyll and nitrate fine structure in the Southeastern Bering Sea Shelf break front. Nature 281: 664-666.

Jalewajko, C. (1966) Photosynthesis and excreation in various planktonic algae. Limnology and Oceanography 11: 1-10.

Jeffrey, S.W., and G.M. Hallegraeff (1987) Chlorophyllase distribution in ten classes of phytoplankton: a problem for chlorophyll analysis. Marine Ecology - Progress Series 35: 293-304.

Jensen, A., and E. Sakshaug (1973) Studies on the phytoplankton ecology of the Trondheimsfjord. II. Chloroplast pigments in relation to abundance and physiological state of the phytoplankton. Journal Experimental Marine Biology and Ecology 11: 137-155.

Jensen, L.M. (1983) Phytoplankton release of extracellular organic carbon, molecular weight composition, and bacterial assimilation. Marine Ecology - Progress Series 11: 39-48.

Jensen, L.M., and M. Sondegarrd (1982) A biotic formation of particles from extracellular organic carbon released by phytoplankton. Microb. Ecol. 8: 47-54.

Jimenez, F., J. Rodriguez, B. Bautista, and V. Rodriguez (1987) Relations between chlorophyll, phytoplankton cell abundance and biovolume during a winter bloom in Mediterranean coastal waters. Journal Experimental Marine Biology and Ecology 105: 161-173.

Jitts (1964) Cell divison rates of phytoplankters. JFRBC 21: 143-157.

Jitts, H.R., C.D. McAllister, K. Stephene, and J.D.H. Strickland (1964) The cell division rates of some marine phytoplankters as a function of light and temperature. JFRBC 21: 139-157.

Joint, I.R., and A.J. Pomroy (1981) Primary production in a turbid estuary. Estuarine, Coastal and Shelf Science 13: 303-316.

Joint, I.R., A.J. Pomroy, and G.A. Robinson (1987) Morphological changes in Skeletonema costatum (Bacillariophyceae) during a spring bloom in a marine ecosystem enclosure. British Phycological Journal 22: 119-124.

Jones, R.C. (1981) Productivity of algal epiphytes in a Georgia salt marsh: Effect of inundation frequency and implications for total marsh productivity. Estuaries 3: 315-317.

Jones, R.C. (1990) The effect of submersed aquatic vegetation on phytoplankton and water quality in the tidal freshwaer Potamc River. Jour. Freshwater Ecol. 5: 279-288.

Jones, R.C., K. Walti, and M.S. Adams (1983) Phytoplankton as a factor in the decline of the submersed macrophyte Myriophyllum spicatum L. in lake Wiagra, Wisconsin, U.S.A. Hydrobiologia 107: 213-219.

Jorgensen, E.G. (1968) The adaptation of plankton algae II. Aspects of the temperature adaptation of Skeletonema costatum. Physiologia Plantarum 21: 423-427.

Kagawa, H., M. Togashi, and Z. Kawabata (1988) Comparison of P, Ca and Mg contents of phytoplankton between the heads of two river reservoirs with different phosphorus loading. Verh. Internat. Verein. Limnol. 23: 1022-1027.

Kaneta, P.J., M. Levandowsky, and W. Esaias (1985) Multivariate analysis of the phytoplankton community in the New York Bight. Marine Ecology - Progress Series 23: 231-239.

Karydis, M., and H. Coccossis (1990) Use of multiple criteria for eutrophication assessment of coastal waters. Environmental Monitoring and Assessment 14: 89-100.

Kat, M. (1982) Effects of fluctuating salinities on development of Thalassiosira anystii a diatom not observed before in the Dutch coastal area. Jour. Mar. Biol. Ass. U.K. 62: 483-484.

Keller, A.A. (1988) Estimating phytoplankton productivity from light availability and biomass in the MERL mesocosms and Narragansett Bay. Marine Ecology - Progress Series 45: 159-168.

Keller, A.A., and U. Riebesell (103) Phytoplankton carbon dynamics during a winter-spring diatom bloom in a enclosed marine ecosystem: primary production, biomass and loss rates. Mar. Biol. 103: 131-142.

Kilham, P., and R.E. Hecky (1988) Comparative ecology of marine and freshwater phytoplankton. Limnology and Oceanography 33: 776-795.

Kilham, S.S. (1986) Dynamics of Lake Michigan natural phytoplankton communities in continuous cultures along a Si:P loading gradient. 43: 351-360.

Kingston, J.C., R.L. Lowe, E.F. Stoermer, and T.B. Ladewski (1983) Spatial and temporal distribution of benthic diatoms in Norther Lake Michigan. Ecology 64: 1566-1580.

Kitting, C.L., B. Fry, and M.D. Morgan (1984) Detection of inconspicuous epiphytic algae supporting food webs in seagrass meadows. Oecologia 62: 145-149.

Kleppel, G.S. (1980) Nutrients and phytoplankton community composition in Southern California Coastal Waters. CALCOFI Reports 21: 191-196.

Klinkhammer, G.P., and M.L. Bender (1981) Trace metal distributions in the Hudson River Estuary. Estuarine, Coastal and Shelf Science 12: 629-643.

Kogure, K., U. Simidu, and N. Taga (1982) Bacterial attachment of phytoplankton in sea water. Journal Experimental Marine Biology and Ecology 56: 197-204.

Kreis, R.G., T.B. ladewski, and E.F. Stoermer (1983) Influence of the St. Marys river plume on northern Lake Huron phytoplankton assemblages. J. Great Lakes Res. 9: 40-51.

Krempin, D.W., S. McGrath, J.B. SooHoo, and C.W. Sullivan (1981) Orthophosphate uptake by phytoplankton and bacterio plankton from the Los Angeles Harbor and Southern California Coastal Waters. Marine Biology 64: 23-33.

Kuhn, D.L., J.L. Plafkin, J.J.r. Cairns, and R.L. Lowe (1981) Qualitative characterization of aquatic environments using diatom life-form strategies. Trans. Am. Microsc. Soc. 100/2: 165-182.

Kunishi, H.M. (1988) Sources of nitrogen and Phosphorus in an Estuary of the Chesapeake Bay. J. Environ. Qual. 17: 185-188.

Kuosa, H., and B. Marcussen (1988) Grazing of bacteria and phytoplankton by heterotrophic nanoflagellates in a Baltic Sea sample. Hydrobiolgia 161: 211-216.

Lacroix, G., P. Boet, J. Garnier, F. Lescher-Moutoue, R. Pourriot, and P. Testard (1989) Factors controlling the planktonic community in the shallow lake of Creteil, France. Int. Revue ges. Hydrobiol. 74: 353-370.

Lancelot, C. (1984) Extracellular release of small and large molecules by phytoplankton in the Southern Bight of the North Sea. Estuarine, Coastal and Shelf Science 18: 65-77.

Lancelot, C., and B. Billen (1984) Activity of heterotrophic bacteria and its coupling to primary production during the spring phytoplankton bloom in the southern bight of the North Sea. Limnology and Oceanography 29: 721-730.

Lane, J.L., and C.R. Goldman (1984) Size-fraction of natural phytoplankton communities in nutrient bioassay studies. Hydrobiologia 118: 219-223.

Lane, P., and R. Lane (1977) The dynamics of aquatic systems. 2. The effects of nutrient enrichment on model plankton communities. Limnology and Oceanography 22: 454.

Lange, K.B. (1985) Spatial and seasonal variations of diatom assemblages off the Argentinian coast (south western Atlantic). Oceanologica Acta 8: 361-369.

Laws, E.A. (1988) Phytoplankton population dynamics and the fate of production during the spring bloom in Auke, Bay, Alaska. Limnology and Oceanography 33: 57-65.

Lazerte, B.D., and S. Watson (1981) The prediction of lacustrine phytoplankton diversity. Canadian Journal of Fisheries and Auqatic Science 38: 524-534.

Le Bouteiller, A. (1986) Environmental control of nitrate and ammonium uptake by phytoplankton in the equatorial Atlantic Ocean. Marine Ecology - Progress Series 30: 167-179.

Lean, D.R.S., and e.t. al (1987) The effects of changes in both the abundance of nitrogen and phosphorus and their ratio on Lake Okaro phytoplankton, with comments on six other central volcanic plateau lakes. N.Zealand Jour. Mar. Freshwater Res. 21: 539-542.

Lederman, T.C., and P. Tett (1981) Problems in modeling the photosynthesis-light relationship for phytoplankton. Botanica Marina 24: 125-134.

Lehman, J.T., and D. Scavia (1982) Microscale patchiness of nutrients in plankton communities. Science 216: 729-730.

Levandowsky, M. (1972) Ecological niches of sympatric phytoplankton species. The American Naturalist 106: 71-77.

Levasseur, M., J.C. Therriault, and L. Legendre (1983) Tidal currents, winds and the morphology of phytoplankton spatial structures. J. Mar. Res. 41: 655-672.

Levasseur, M., J.C. Therriault, and L. Legendre (1984) Hierarchical control of phytoplankton succession by physical factors. Marine Ecology - Progress Series 19: 211-222.

Lewis, W.M. (1974) Primary production in the plankton community of a tropical lake. Ecological Monographs 44: 377-409.

Lewis, W.M. (1976) Surface/volume ratio: Implications for phytoplankton morphology. Science 192: 885-887.

Lewis, W.M., and W. Riehl (1982) Phytoplankton composition and morphology in Lake Valencia, Venezuela. Int Revue ges Hydrobiol 67: 297-322.

Li, W.K.W., and J.C. Goldman (1981) Problems in estimating growth rates of marine phytoplankton from short-term C14 assays. Microb. Ecology 7: 113-121.

Li, W.K.W., and W.G. Harrison (1982) Carbon flow into the end-products of photosynthesis in short and long incubtions of a natural phytoplankton population. Marine Biology 72: 175-182.

Li, W.K.W., and T. Platt (1982) Distribution of carbon among photosynthetic end-products in phytoplankton of the eastern Canadian Arctic. J. Phycol. 18: 466-471.

Litaker, W., C.S. Duke, B.E. Kenney, and J. Ramus (1987) Short-term environmental variability and phytoplankton abundance in a shallow tidal estuary. I. Winter and summer. Marine Biology 96: 115-121.

Lively, J.S., Z. Kaufman, and E.J. Carpenter (1983) Phytoplankton ecology of a barrier island estuary: Great South Bay, New York. Estuarine, Coastal and Shelf Science 16: 51-68.

Livingston, R.J. (1987) Field sampling in estuaries: the relationship of scale to variability. Estuaries 10: 194-207.

Lochte, K., and O. Pfannkuche (1987) Cyclonic cold-core eddy in the eastern North Atlantic. II. Nutrients, phytoplankton and bacterioplankton. Marine Ecology - Progress Series 39: 153-164.

Lovstad, O. (1986a) Biotests with phytoplankton assemblages. Growth limitation along temporal and spatial gradients. Hydrobiologia 134: 141-149.

Lovstad, O. (1986b) Transplant experiments. Growth-limiting factors for diatoms and bluegreen algae in Norwegian lakes. Hydrobiologia 134: 201-206.

Lukatelich, R.J., and A.J. McComb (1986) Nutrient levels and the development of diatom and blue-green algal blooms in a shallow Australian estuary. Journal of Plankton Research 8 (4): 597-618.

Lund, J.W.G. (1965) The ecology of the freshwater phytoplankton. Biological Review 40: 231-293.

Lung, W.S., and H.W. Paerl (1988) Modeling blue-green algal blooms in the lower Neuse river. Wate. Res. 22: 895-905.

Lutter, S., J.P. Taasen, C.C.E. Hopkins, and V. Smetacek (1989) Phytoplankton dynamics and sedimentation processes during spring and summer in Balsfjord, Northern Norway. Polar Biol. 10: 113-124.

Macko, S.A., and E.J. Green (1982) An investigation of the dissolved free amino acids and their relation to phytoplankton cell density in the Damariscotta River Estuary, Maine. Estuaries 5: 68-73.

Mahnken, R., and J. Wilhm (1982) Diel variation in species composition and diversity, density, and chlorophyll content of phytoplankton in an intermittent stream in Oklahoma. The Southwest Naturalist 27: 79-86.

Makarewicz, J.C., and R.I. Baybutt (1981) Long-term (1927-1978) changes in the phytoplankton community of Lake Michigan at Chicago. Bull. Torrey Bot. Soc. 108 (2): 240-254.

Malone, T.C. (1971) Diurnal rhythms in net plankton and nannoplankton assimilation ratios. Marine Biology 10: 285-289.

Malone, T.C., C. Garside, and P.J. Neale (1980) Effects of silicate depletion on photosynthesis by diatoms in the plume of the Hudson River. Marine Biology 58: 197-204.

Maloney, T.E., W.E. Miller, and T. Shiroyma (1972) Algal responses to nutrient additions in natural waters I Laboraatory assays. Nutrients and Eutrophication (special symposia) The Amer. Soc. L & O 1: 134-140.

Malthus, T.J., and S.F. Mitchell (1990) On the occurrence, causes and potential consequences of low zooplankton to phytoplankton ratios in New Zealand lakes. Freshwater Biology 22: 383-394.

Maples, R., R. Donahoe, and G.J. Fister (1983) Seasonal variability of chlorophyll a in the nearshore marine waters of southwestern Louisiana. Louisiana Academy Science 46: 53-56.

Maples, R.S. (1983) Community structure of diatoms epiphytic on pneumatophores of the black mangrove, Avicennia Germinans, in a Lousiana salt marsh. Gulf Res. Reports 7: 255-259.

Marchall, H.G. (1985) Phytoplankton assessment of the DupliwRiver, Georgia. Castanea 50: 187-194.

Margalef, R. (1966) Perspectives in ecological theory. : Univ. of Chicago Pres.

Margalef, R. (1967) Some concepts relative to the organization of plankton. Oceanogr. Mar. Biol. Ann. Rev. 5: 257-289.

Margalef, R., and M. Estrada (1971) Simple approaches to a pattern analysis of phytoplankton. Inv. Pesq. (French) 35(1): 269-297.

Marra, J., and K. Heinemann (1982) Photosynthesis response by phytoplankton to sunlight variability. Limnology and Oceanography 27: 1141-1153.

Marshall, H.G. (1966) The distribution of phytoplankton along a 140 mile transect in the Chesapeake Bay. 119 The Virginia Jour. Sci. 17: 105.

Marshall, H.G. (1980) Seasonal phytoplankton composition in the Lower Chesapeake Bay and Old Plantation Creek, Cape Charles, Virginia. Estuaries 3: 207-216.

Marshall, H.G. (1982a) The composition of phytoplankton within the Chesapeake Bay plume and adjacent waters off the Virginia Coast, USA. Estuarine, Coastal and Shelf Science 15: 29-43.

Marshall, H.G. (1982b) Phytoplankton distribution along the eastern coast of the USA IV. Shelf waters between Cape Lookout, N. Carolina, and Cape Canaveral, FL. Pro. Biol. Soc. Wash. 95: 99-113.

Marshall, H.G. (1982c) Mesoscale distribution patterns for diatoms over the Northeastern Continental Shelf of the US. Proc. 7th Diatom Symposium : 393-400.

Marshall, H.G. (1984) Diatom associations of the northeastern continental shelf and slope waters of the United States. Procedings of the 8th Diatom Symposium 8: 539-548.

Marshall, H.G., and M.S. Cohn (1983) Distribution and composition of phytoplankton in Northeastern coastal waters of the US. Estuarine, Coastal and Shelf Science 17: 119-131.

Marshall, H.G., and M.S. Cohn (1987) Phytoplankton distribution along the eastern coast of the USA. Part VI. Shelf waters between Cape Henry and Cape May. Journal of Plankton Research 9: 139-149.

Marshall, H.G., and R. Lacouture (1986) Seasonal patterns of growth and composition of phytoplankton in the lower Chesapeake Bay and vicinity. Estuarine, Coastal and Shelf Science 23: 115-130.

Marshall, H.G., K.K. Nesius, and S.J. Cibik (1981) Phytoplankton studies within the Virginia Barrier Islands II. Seasonal study of phytoplankton within the Barrier Island Channels. Castanea 46: 89-99.

Marshall, M. (1977) Phytoplankton and primary productivity studies in Lake Okeechobee during 1974. S. FL Water Management Dictrict 77-2:.

Massey, J.E. (1981) Physicochemical influences on phytoplankton production in a tropical alpine lake. Archiv Fur Hydrobiologia 91: 133-143.

McAllister, C.D., and e.t. al (1964) Marine phytoplankton photosynthesis as a function of light intensity: a comparison of methods. J. Fish. Rea. Board of Canada 21: 159-181.

McCauley, and J. Kalff (1981) Emperical relationship between phytoplankton and zooplankton biomass in lakes. Canadian Journal of Fisheries and Auqatic Science 38: 458-463.

McClatchie, S., S.K. Juniper, and G.A. Knox (1093) Structure of a mudflat diatom community in the Avon-Heathcote Estuary, New Zealand. New Zealand J. Mar. and Freshwater Research 16: 299-309.

McIntire, C.D., and W.S. Overton (1971) Distributional patterns in assemblages of attached diatoms from Yaquina Estuary, Oregon. Ecology 52(5): 758-777.

McPherson, B., and R. Miller (1990) Nutrient distribution and variability in the Charlotte Harbor estuarine system, Florida. Water Resources Bulletin 26: 67-80.

Meeter, D.A., and R.J. Livingston (1977) Statistical methods applied to a four-year study of a Florida estuarine system. In Dickson, Cairns, and Livingston (eds): Biological Data in Water Pollution Assesment: Quantitative and Statistical Analysis. ASTM Special Technical Pub. #652. :.

Millan-Nunez, R., S. Alvarez-Borrego, and D.M. Nelson (1982) Effects of physical phenomena on the distribution of nutrients and phytoplankton productivity in a coastal lagoon. Estuarine, Coastal and Shelf Science 15: 317-335.

Mitamura, O. (1986) Urea metabolism and its significance in the nitrogen cycle in the euphotic layer of Lake Biwa II. Half-saturation constant for nitrogen assimilation by fractionated phytoplankton in different trophic areas. Archiv Fur Hydrobiologia 107 (2): 167-182.

Mitchell, S.F., and C.W. Burns (1981) Phytoplankton photosynthesis and its relation to standing crop and nutrients in two warm-monomictic south island lakes. New Zealand Jour. of Marine and Freshwater Research 15: 51-67.

Mode, J.R., and H.L. Hoogveld (1982) The algal periodicity in Tjeukemeer during 1968-1978. Hydrobiologia 95: 223-234.

Mommaerts, J.P. (1973) The relative importance of nanoplankton in the North Sea primary production. British Phycological Journal 8: 13-20.

Montagna, P.A., B.C. Voull, T.L. Herring, and B.W. Dudley (1983) The relationship between abundances of meiofauna and their suspected microbial food (diatoms and bacteria). Estuarine, Coastal and Shelf Science 17: 381-394.

Morel, F.M.M. (1987) Kinetics of nutrient uptake and growth in phytoplankton. Journal of Phycology 23: 137-150.

Mukai, T. (1987) Effects of Micro-scale in situ environmental gradients concerning water qualities on the structure of the phytoplankton community in a coastal embayment. Estuarine, Coastal and Shelf Science 25: 447-458.

Mukai, T., and K. Takimoto (1985) Effects of environmental gradients concerning water qualities on the structure of the phytoplankton community in the coastal sea. Estuarine, Coastal and Shelf Science 20: 169-181.

Munawar, M., and I.F. Munawar (1988) Georgia Bay phytoplankton: Ecology and response to contaminants. Hydrobiologia 163: 95-117.

Munawar, M., I.F. Munawar, P.E. Ross, and A. Dagenais (1982) Microscopic evidence of phytoplankton passing through glass- fibre filters and its implications for chlorophyll analysis. Archiv Fur Hydrobiologia 94: 520-528.

Nakanishi, M., and M. Morsi (1965) Effect of variation in salinity on photosynthesis of phytoplankton growing in estuaries. J. Faculty of Sci., Univ. Tokyo 9: 19-42.

Nalewajko, C., and C. Garside (1983) Methodological problems in the simultaneous assessment of photosynthesis and nutrient uptake in phytoplankton as functions of light intensity and cell size. Limnology and Oceanography 28-3: 591-597.

Nalewajko, C., and K. Lee (1983) Light stimulation of phosphate uptake in marine phytoplankton. Marine Biology 74: 9-15.

Navarro, J.N., C. Perez, N. Arce, and B. Arroyo (1989) Benthic marine diatoms of Caja de Muertos Island, Puerto Rico. Nova Hedwigia 49: 333-367.

Newell, R.C., M.I. Lucas, and E.A.S. Linley (1981) Rate of degradation and effeciency of conversion of phytoplankton debris by marine micro-organisms. Marine Ecology - Progress Series 6: 123-136.

Nicholls, K.H., G.W. Robinson, R. Taylor, and E.C. Carney (1988) Phytoplankton and phosphorus in southern Georgian Bay, 1973-1982, and implications for phosphorus loading controls. Hydrobiologia 163: 85-93.

Nichols, F.H. (1985) Increased benthic grazing: an alternative explanation for low phytolankton biomass in northern San Francisco Bay during the 1976-1977 drought. Estuarine, Coastal and Shelf Science 21: 379-388.

Nielsen, E.S., and E.G. Jorgensen (1968) The adaptation of plankton Algae. I. General Part. Physiologia Plantarum 21: 401-413.

Nielsen, E.S., and T.S. Park (1964) On the time course in adapting to low light intensities in marine phytoplankton. Du Journal du Conseil Int. Pour L'Exploration de la Mer 29: 19-24.

Noges, T. (1989) ATP as an index of phytoplankton productivity. The Chl a/ATP quotient. Int Revue ges Hydrobiol 74: 121-133.

O'Brien, J.J., and J.S. Wroblewski (1972) A simulation of the mesoscale distribution of the lower marine trophic level off West Florida. Contributions to geophysical fluid dynamics institute, FSU : 1-64.

Officer, C.B., R.B. Biggs, J.L. Taft, L.E. Cronin, M.A. Tyler, and W.R. Boynton (1983) Chesapeake Bay Anoxia: origin, Development, and significance. Science 223: 22-27.

Ogura, N. (1972) Decomposition of dissolved organic matter derived from dead phytoplankton. In Takenouti and etal (eds): Biol. Ocean. of the N.N.P.O., pp. 507-515.

Olive, J.H., D.M. Benton, and J. Kishler (1969) Distribution of c-14 in products of photosynthesis and its relationship to phytoplankton composition and rate of photosynthesis. Ecology 50: 380-386.

Olrik, K. (1981) Succession of phytoplankton in response to environmental factors in Lake Arreso, North Zealand, Denmark. Schweiz. Z. Hydrol. 43: 6-20.

Olrik, K., S. Lundoer, and K. Rasmussen (1984) Interactions between phytoplankton, zooplankton, and fish in the nutrient rich shallow lake Hjarback Fjord Denmark. Int. Revue ges. Hydrobiol. 69: 389-405.

Oviatt, C., B. Buckley, and S. Nixon (1981) Annual phytoplankton metabolism in Narragansett Bay calculated from survey field measurements and microcosm observations. Estuaries 4: 167-175.

Oviatt, C., P. Lane, F. French, and P. Donaghay (1989) Phytoplankton species and abundance in response to eutrophication in coastal mesocosms. Jour. Plank. Res. 11/6: 1223-1244.

Oviatt, C.A., A.A. Keller, P.A. Sampoul, and L.L. Beattyl (1986) Patterns of productivity during eutrophication: a mesocosm experiment. Marine Ecology - Progress Series 28: 69-80.

Paasche, E. (1973) Silicon and the ecology of marine plankton diatoms. II. Silicate-uptake kinetics in five diatom species. Marine Biology 19: 262-269.

Paasche, E., I. Bryceson, and K. Tangen (1984) Interspecific variation in dark nitrogen uptake by dinoflagellates. Journal of Phycology 20: 394-401.

Padisak, J. (1980) Short-term studies on the phytoplankton of Lake Balaton in the summers of 1976, 1977 and 1978. Acta Botanica Academiae Scentiarium Hungaricae 26: 397-416.

Paerl, H.W. (1983) Environmental regulation of H2 utilization (3H2 exchange) amoung natural and laboratory populations of N2 and non-N2 fixing phytoplankton. Microb. Ecol. 9: 79-97.

Paerl, H.W. (1988) Nuisance phytoplankton blooms in coastal, estuarine, and inland waters. Limnology and Oceanography 33: 823-847.

Palenik, B., and F.M.M. Morel (1990) Amino acid utilization by marine phytoplankton: a novel mechanism. Limnology and Oceanography 35(2): 260-269.

Palumbo, A.V., P.J. Mulholland, and J.W. Elwood (1987) Extraction with DSMO to simultaneously measure periphyton photosynthesis, chlorophyll, and ATP. Limnology and Oceanography 32: 464-471.

Parslow, J.S., P.J. Harrison, and P.A. Thompson (1984) Saturated uptake kinetics: transient response of the marina diatom Thalassiosira pseudonana to ammonium, nitrate, silicate or phosphate starvation. Marine Biology 83: 51-59.

Parsons, T.R., R.J. LeBrasseur, and J.D. Fulton (1967) Some observations on the dependence of zooplankton grazing on the cell size and concentration of phytoplankton blooms. Jour. Oceanogr. Soc. Japan 23: 10-17.

Parsons, T.R., K. Stephens, and R.J. LeBrasseur (1969) Production studies in the stratit of Georgia. Part I. Primary production under the Fraser River plume, Febuary to May, 1967. Journal Experimental Marine Biology and Ecology 3: 27-38.

Parsons, T.R., and M. Takahashi (1973) Environmental control of phytoplankton cell size. Limnology and Oceanography 18: 511-515.

Patrick, R. (1967) The effect of invasion rate, species pool and size of area on the structure of the diatom community. Proc. Nat. Acad. Sci. Phil. 58: 1335-1342.

Patrick, R. (1968) The sturcture of diatom communities in similar ecological conditions. The American Naturalist 102: 173-183.

Patten, B. (1968) Mathematical models of plankton production. Int Revue ges Hydrobiol 53: 357-408.

Paulson, A.J., H. Curl, and R.A. Feely (1989) Estimates of trace metal inputs from non-point sources discharged into estuaries. Marine Pollution Bulletin 20: 549-555.

Pennock, J.R. (1985) Chlorophyll distributions in the Delaware Estuary: Regulation by Light-Limitation. Estuarine, Coastal and Shelf Science 21: 711-725.

Pennock, J.R. (1987) Temporal and spatial variability in phytoplankton ammonium and nitrate uptake in the Delaware estuary. Estuarine, Coastal and Shelf Science 24: 841-857.

Pennock, J.R., and J.H. Sharp (1986) Phytoplankton production in the Delaware Estuary: temporal and spatial variability. Marine Ecology - Progress Series 34: 143-155.

Perez, L., and J.C. canteras (1990) Spatial heterogeneity of phytoplankton in an estuary of Cantabria, Northern Spain. Jour. Coastal Res. 6: 157-168.

Perrin, C.J., M.L. Bothwell, and P.A. Slaney (1987) Experimental enrichment of a coastal stream in British Columbia: Effects of organic and inorganic additions on autotrophic periphyton production. Can. J. Fish. Aquat. Sci. 44: 1247-1256.

Perry, M.J., M.C. Talbot, and R.S. Alberte (1981) Photoadaptation in marine phytoplankton: Response of photosynthetic unit. Marine Biology 62: 91-101.

Peterson, B.J., R.W. Howarthard, and R.H. Garritt (1985) Multiple stable isotopes used to trace the flow of organic matter in estuarine food webs. Science 227: 1361-1363.

Peterson, C.G., and R.J. Stevenson (1989) Seasonality in river phytoplankton: multivariate analyses of data from the Ohio River and six Kentucky tributaries. Seasonality in river phytoplankton: multivariate analyses of data from the Ohio River and six Kentucky tributaries. 182: 99-114.

Peterson, D.H., and J.F. Festa (1984) Numerical simulation of phytoplankton productivity in patially mixed estuaries. Estuarine, Coastal and Shelf Science 19: 563-589.

Peterson, D.H., M.J. Perry, K.E. Bencala, and M.C. Talbot (1987) Phytoplankton productivity in relation to light intensity: A simple equasion. Estuarine, Coastal and Shelf Science 24: 813-832.

Pierce, J.W., D.L. Correll, B. Goldberg, M.A. Faust, and W.H. Klein (1986) Response of underwater light transmittance in the Rhode River estuary to changes in water-quality parameters. Estuaries 9/3: 169-178.

Plat, T., C.L. Gallegos, and W.G. Harrison (1980) Photoinhibition of photosynthesis in natural assemblages of marine phytoplankton. MR 34: 687-701.

Pollingher, U., and T. Berman (1982) Relative contributions of net and nannoplankton to primary production in Lake Kinneret (Israel). Arch. Hydrobiol. 96: 33-46.

Pollingher, U., T. Berman, B. Kaplan, and D. Scharf (1988) Lake Kinneret phytoplankton: response to N and P enrichments in experiments and in nature. Hydrobiologia 166: 65-75.

Porter, K.G. (1976) Enhancement of algal growth and productivity by grazing zooplankton. Science 192: 1332-1333.

Porter, K.G. (1977) The plant-animal interface in freshwater ecosystems. American Scientist 65: 159-170.

Potter, I.C., N.R. Loneragan, R.C. Lenanton, and P.J. Chrystal (1983) Blue-green algae and fish population changes in a eutrophic estuary. Mar. Pollution Bulletin 6: 228-233.

Poulet, S.A., V. Martin-Jezequel, and D. Delmas (1985) Gradient of dissolved free amino acids and phytoplankton in a shallow bay. Hydrobiologia 121: 11-17.

Powell, T.M., J.E. Cloern, and L.M. Huzzey (1989) Spatial and temporal variability in South San Franscisco Bay (USA). I. Horizontal distributions of salinity, suspended sediments, and phytoplankton biomass and productivity. Estuarine, Coastal and Shelf Science 28: 583-597.

Pratt, D.M. (1957) The phytoplankton of Narragansett Bay. Limnology and Oceanography 2: 425-440.

Priscu, J.C. (1987) Time-course of inorganic nitrogen uptake and incorporation by natural populations of freshwater phytoplankton. Freshwater Biology 17: 331-339.

Provasoli, L. (1963) Organic regulation of phytoplankton fertility. In M.N. Hill (ed.): The Sea Vol. II. :, pp. 165-219.

Puddu, A., and R. Arfi (1984) Phytoplankton distribution in the coastal area subject to the impact with the Tiber River outfall. Int Revue ges Hydrobiol 69: 541-552.

Qlueguiner, B., M. Hafsaoui, and P. Treguer (1986) Simultaneous uptake of ammonium and nitrate by phytoplankton in coastal ecosystems. Estuarine, Coastal and Shelf Science 23: 751-757.

Queguiner, B., and L. Legendre (1986) Phytoplankton photosynthetic adaptation to high frequency light fluctuations simulating those induced by sea surface waves. Marine Biology 90: 483-491.

Rai, H. (1982) Primary production of various size fractions of natural phytoplankton communities in a north German lake. Arch. Hydrobiol. 95: 395-412.

Rai, H., and T.R. Jacobsen (1990) Phosphate (32P)-uptake capabilities of natural picoplankton and ultraplankton communities in lakes of differing degrees of eutrophication. Arch. Hydrobiol. 118: 421-435.

Raimbault, P., and V. Gentilhomme (1990) Short- and long-term responses of the marine diatom Phaeodactylum tricornutum to spike additions of nitrate at nanomolar levels. Journal Experimental Marine Biology and Ecology 135: 161-176.

Raimbault, P., M. Rodier, and I. Taupier-Letage (1988) Size fraction of phytoplankton in the Ligurian Sea and the Algerian Basin (Mediterranean): size distribution versus total concentration. Marine Micobial Food Webs 3: 1-7.

Rainer, S.F., and R.C. Fitzhardinge (1981) Benthic communities in an estuary with periodic deoxygenation. Aust. J. Mr. Freshwater Res. 32: 227-243.

Ram, N.M., and S. Plotkin (1983) Assessing aquatic productivity in the Housatonic River using the algal assay: bottle test. Water Research 17/9: 1095-1106.

Rao, D.V.S. (1981) Growth response of marine phytoplankton to selected concentrations of trace metals. 24: 369-379.

Rau, G.H., J.-L. Teyssie, F. Rassaulzadegan, and S.W. Fowler (1990) 13C/12C and 15N/14/N variations among size-fractionated marine particles: implications for their origin and trophic relationships. Marine Ecology - Progress Series 59: 33-38.

Redalje, D.G. (1983) Phytoplankton carbon biomass and specific growth rates determined with the labeled chlorophyll a technique. Marine Ecology - Progress Series 11: 217-225.

Reid, F.M.H. (1983) Biomass estimation of components of the marine nanoplankton and picoplankton by the Utermohl settling technique. Journal of Plankton Research 5(2): 235-252.

Reish, D.J., T.J. Dauwling, and A.J. Mearns (1976) Marine and estuarine pollution. Jour. WPCF 48: 1439-1459.

Reish, D.J., G.G. Geesey, P.S. Oshida, F.G. Wilkes, A.J. Mearns, S.S. Rossi, and T.C. Ginn (1981) Marine and estuarine pollution. Jour. WPCF 53: 925-949.

Relexans, J.C., M. Meybeck, G. Billen, M. Brugeaille, H. Etcheber, and M. Somville (1988) Algal and Microbial Processes involved in particulate organic matter dynamics in the Loire Estuary. Estuarine, Coastal and Shelf Science 27: 625-644.

Schiewer, U., H.A. Al-Saadi, and H.A. Hameed (1982) On the diel rhythm of phytoplankton productivity in Shatt al-Arab at Basrah, Iraq. Arch. Hydrobiol. 93: 158-172.

Schoenberg, S.A., and J.D. Oliver (1988) Temporal dynamics and spatial variation of algae in relation to hydrology and sediment characteristics in the Okefenokee Swamp, Georgia. Hydrobiologia 162: 123-133.

Seitzinger, S.P. (1988) Denitrification in freshwater and coastal marine ecosystems: ecological and geochemical significance. Limnol Oceanogr 33(4): 702-724.

Sellner, K.G. (1983) Plankton productivity and biomass in a tributary of the upper Chesapeake Bay. I. Importance of size-fractioned phytoplankton productivity, biomass and species composition in carbon export. Estuarine, Coastal and Shelf Science 17: 197-206.

Sewell, P.L. (1982) Urban groundwater as a possible nutrient source for an estuarine benthic algal bloom. Estuarine, Coastal and Shelf Science 15: 569-576.

Sherr, E.B., B.F. Sherr, T. Berman, and J.J. McCarthy (1982) Differences in nitrate and ammonia uptake among components of a phytoplankton population. Journal of Plankton Research 4(4): 961-965.

Sieburth, J.M.N. (1967) Seasonal selection of estuarine bacteria by water termperature. Journal Experimental Marine Biology and Ecology 1: 98-121.

Sieburth, J.M.N. (1976) Dissolved organic matter and heterotrophic microneuston in the surface microlayers of the North Atlantic. Science 194: 1415-1418.

Simmons, E.G., and W.H. Thomas (1962) Phytoplankton of the Eastern Mississippi Delta. Pub. Inst. Mar. Sci. (Texas) 8: 269-298.

Simon, J.L. (1974) Tampa Bay estuarine system - A synopsis. Florida Scientist 37: 217-244.

Sincair, M., D.V. Subba Rao, and R. Couture (1981) Phytoplankton temporal distrubutions in estuaries. Oceanologica Acta 4: 239-246.

Sindermann, C.J. (1988) Biological indicators and biological effects of estuarine/coastal pollution. Water Resources Bulletin 24: 931-939.

Sklar, F.H., and R.E. Turner (1981) Characteristics of phytoplankton production off Barataria Bay in an area influenced by the Mississippi River. Cont. Mar. Sci. 24: 93-106.

Small, L.F., and W.A. Glooschenko (1972) Estimates of primary production off Oregon using an improved chlorophyll-light technique. JFRBC 29: 1261-1267.

Smayda, T.J. (1973) A survey of phytoplankton dynamics in the coastal waters from Cape Hatteras to Nantucket. Marine Publication Series, University of Rhode Island 2: 3-1 to 3-100.

Smith, C.J., R.D. Delanne, and W.H. Patrick (1985) Fate of riverine nitrate entering an estuary: I. Denitrification and nitrogen burial. Estuaries 8: 15-21.

Smith, V.H. (1983) Low nitrogen to phosphorus ratios favor dominance by blue-green algae in lake phytoplankton. Science 221: 669-670.

Soeder, C.J. (1965) Some aspects of phytoplankton growth and activity. Mem. Ist. Ital. Idrobiol. 18: 47-59.

Sommer, U. (1981) The role of r- and k- selection in the succession of phytoplankton in Lake Constance. Acta Oecologica 2: 327-342.

Sommer, U. (1983) Light, stratification and zooplankton as controlling factors for the spring development of phytoplankton in Lake Constance. Schweiz. Z. Hydrol. 45: 394-404.

Sommer, U. (1985a) Seasonal succession of phytoplankton in Lake Constance. Bioscience 35: 351-357.

Sommer, U. (1985b) Comparison between steady state and non-steady state competition: experiments with natural phytoplankton. Limnology and Oceanography 30: 335-346.

Sommer, U. (1986) Phytoplankton competition along a gradient of dilution rates. Oecologia 68: 503-506.

Speis, A., E.D. Nutbrown, and T.R. Parsons (1983) An experimental approach to estuarine microplankton ecology. Estuarine, Coastal and Shelf Science 17: 97-105.

Squires, A.P. (1984) The distribution and ecology of zooplankton in Charlotte Harbor, Florida. Thesis, Univ. S. Florida :.

Starr, M., J.H. Himmelman, and J.C. Therriault (1990) Direct coupling of marine invertebrate spawning with phytoplankton blooms. Science 247: 1071-1074.

Stearns, D.E., W. Litaker, and G. Rosenberg (1987) Impacts of zooplankton grazing and excretion on short-interval fluctuations chlorophyll a and nitrogen concentrations in w well-mixed estuary. Estuarine, Coastal and Shelf Science 24: 305-325.

Steidinger, K.A. (1973) Phytoplankton Ecology: A conceptual review based on Eastern Gulf of Mexico research. CRC Critical Reviews in Microbiology 3: 49-68.

Stephens, F.C., and R.A. Gibson (1976) Studies of epiphytic diatoms in the Indian River, Florida. In (ed.): Indian River Coastal Zone Study 1975-1976, Annual Report Chapter 5. :.

Stoermer, E.F. (1978) Phytoplankton assemblages as indicators of water quality in the laurentian Great Lakes. Trans. Amer. Micro. Soc. 97: 2-16.

Stoker, Y.E. (1987) Phytoplankton composition and abundance and relation to environmental parameters in the Charlotte Harbor estuarine system, Southwest Florida, USA. draft paper, prepared for BM : 1-39.

Strickland, J.D. (1972) Research on the marine planktonic food web at the institute of marine resources: A review of the past seven years of work. Oceanogr. Mar. Biol. Ann. Rev. 10: 349-414.

Stross, R.G., and R.C. Sokol (1989) Runoff and flocculation modify underwater light environment of the Hudson River Estuary. Estuarine, Coastal and Shelf Science 29: 305-316.

Sullivan, M.J. (1978) Diatom community structure: taxonomic and statistical analyses of a Missisippi salt marsh. Journal of Phycology 14: 468-475.

Sullivan, M.J. (1982) Distribution of edaphic diatoms in a Mississippi salt marsh: A cononical correlation analysis. Journal of Phycology 18: 130-133.

Sullivan, M.J., and C.A. Moncreiff (1990) Edaphic algae are an important component of salt marsh food-webs: evidence from multiple stable isotope analyses. Marine Ecology - Progress Series 62: 149-159.

Sullivan, P.F., and S.R. Carpenter (1982) Evaluation of fourteen trophic state indices for phytoplankton of Indiana lakes and reservoirs. Environmental Pollution 27: 143-153.

Swift, D.R. (1981) Preliminary investigations of periphyton and water quality relationships in the everglades water conservation areas. South Florida Water Management District Technical Publication 81-5 : 83 pp.

Taft, J.L., E.O. Hartwig, and R. Loftus (1981) Seasonal oxgen depletion in Chesapeake Bay. Estuaries 3: 242-247.

Takahashi, M., and N. Fukazawa (1982) A mechanism of "red-tide" formation. II. Effect of selective nutrient stimulaio on the growth of different phytoplankton species in natural water. Mar. Biol. 70: 267-273.

Takahashi, M., and Y. Saijo (1988) Nitrogen metabolism in Lake Kizaki, Japan V. the role of nitrogen fixation in nitrogen requirement of phytoplankton. Arch. Hydrobiol. 112(1): 43-54.

Tamminen, T. (1982) Effects of ammonium effluents on planktonic primary production and in a coastal brackish water environment. I. Nutrient balance of the water body and effluent tests. Netherlands Jour. Sea Res. 16: 455-464.

Tett, P. (1973) The use of log-normal statistics to describe phytoplankton populations from the Firth of Lorne area. Journal Experimental Marine Biology and Ecology 11: 121-136.

Theriot, E., and G. Fryxell (1985) Multivariate statistical analysis of net diatom species distributions in the Southwestern Atlantic and Indian Ocean. Polar Biol 5: 23-30.

Therriault, J.C., D. Booth, L. Legendre, and S. Demers (1990) Phytoplankton photoadaptation to vertical excursions as estimated by an in vivo fluorescence ratio. Marine Ecology - Progress Series 60: 97-111.

Therriault, J.C., and T. Platt (1981) Environmental control of phytoplankton patchiness. JFAS 38: 638-641.

Thompson, A.R., R.B. Frydenborag, C.A. Biedermann, C.W. Dye, and L.T. Ross (1982) Phytoplankton and periphyton community dynamics in deterntion/retention wetlands, Kissimmee River Basin, Florida. Florida Department Regulation Report : 51 pp.

Thompson, P.A. (1989) Light-limited growth on ammonium vs. nitrate: What is the advantage for marine phytoplankton?. Limnology and Oceanography 34: 1014-1024.

Tilman, D., R. Kiesling, R. Sterner, S.S. Kilham, and F.A. Johnson (1986) Green, bluegreen and diatom algae: taxonomic differences in competitive ability for phosphorus, silicon and nitrogen. Archiv Fur Hydrobiologia 106 (4): 473-485.

Tilman, D., and R.L. Kiesling (1984) Freshwater algal ecology: taxonomic trade-offs in the temperature dependence of nutrient competitive abilities. In C. A. Reddy and M.J. Klug (eds): Current Perspectives in microbial ecology. Washington, DC: Amer. Soc. of Microbiology, pp. 314-319.

Tilman, D., S.S. Kilham, and P. Kilham (1982) Phytoplankton community ecology: the role of limiting nutrients. Ann. Rev. Ecol. Syst. 13: 349-372.

Tilzer, M.M. (1988) Secchi-disc - chlorophyll relationships in a lake with highly variable phytoplankton biomass. Hydrobiologia 162: 163-171.

Toetz, D.W. (1981a) Effects of ph, phosphate and ammonia on the rate of uptake of nitrate and ammonia by freshwater phytoplankton. Hydrobiologia 76: 23-26.

Toro, J.E. (1985) Annual cycle and composition of the phytoplankton in the Quempillen River Estuary, Southern Chile. Estuarine, Coastal and Shelf Science 21: 461-469.

Torpey, J., and R.M. Ingle (1966) The red tide. Fla. Board Cons. Educat. Ser. No. 1 : 27pp.

van der Veer, J. (1982) Simple and reliable methods for the fixation, mounting and staining of small and delicate marine plankton for light microscopic identification. Marine Biology 66: 9-14.

Varis, O. (1989) Development of phytoplankton community in a restored eutrophic lake - A multivariate analysis. Verh. Int. Verein. Limnol. : 1-7.

Varis, O., and J. Kettunen (1989) Multivariate analysis of lake phytoplankton and environmental fractors. Arch. Hydrobiol. 117: 163-175.

Vassiliou, A., L. Ignatiades, and M. Karydis (1989) Clustering of transect phytoplankton collections with a quick randomization algorithm. Journal Experimental Marine Biology and Ecology 130: 135-145.

Videau, C. (1987) Primary production and physiological state of phytoplankton at the Ushant tidal front (west coast of Brittany, France). Marine Ecology - Progress Series 35: 141-151.

Vieira, A.A.H., and C. Teizeira (1982) Excretion of dissolved organic matter by natural populations of marine phytoplankton at different time lengths during the photoperiod. Rev. Microbiol., Sao Paulo 13(3): 206-210.

Vincent, W.F. (1980) Mechanisms of rapid photosynthetic adaptation in natural phytoplankton communities: II. Changes in photochemical capacity as measured by DCMU-induced chlorophyll fluorescence. Journal of Phycology 16: 568-577.

Viner, A.B. (1984) Laboratory experiments on the effects of light and temperature on the uptake of nutrients by Lake Rotongaio phytoplankton. New Zealand Jour. Mar. and Freshwater Res. 18: 323-340.

Wah, T.T., and Y.C. Wee (1988) Diatoms from Mangrove environments of Singapore and southern peninsular Malaysia. Bot. Mar. 31: 317-327.

Walker, K.F., and T.J. Hillman (1982) Phosphorus and nitrogen loads in waters associated with the River Murray near Albury-Wodonga, and their effects on phytoplankton populations. Aust. J. Mar. Freshwater Res. 33: 223-243.

Walker, L.M. (1984) Life histories, dispersal, and survival in marine, planktonic dinoflagellates. In K.A. Steidinger and L.M. Walked (eds): Marine Plankton Life Cycle Strategies. : CRC Press, pp. 19-32.

Walker, L.M., and etal (1979) Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. VI. Plankton Dynamics VII. Phytoplankton VIII. Zooplankton IX. Diel Plankton X. Benthic Algae Species List. Florida Department Natural Resources .

Wambeke, F.V., and M.A. Bianch (1985) Dynamics of bacterial communities and qualitative evolution of heterotrophic bacteria during the growth and decomposition processes of phytoplankton in an experimental marine ecosystem. Journal Experimental Marine Biology and Ecology 86: 119-137.

Wangersky, P.J., and C.P. Wangersky (1980) The manna effect: A model of phytoplankton patchiness in a regenerative system. Inst. Revue ges. Hydrobiol. 65: 681-690.

Ward, B.B., M.C. Talbot, and M.J. Perry (1984) Contributions of phytoplankton and nitrifying bacteria to ammonium and nitrite dynamics in coastal waters. Cont. Shelf Res. 3: 383-398.

Ward, R.W., V. Vreeland, C.H. Southwick, and A.J. Reading (1965) Ecological studies related to plankton productivity in two Chesapeake Bay estuaries. Chesapeake Science 6: 214-225.

Watt, W.D. (1966) Release of dissolved organic material from the cells of phytoplankton populations. Proceedings Royal Soc. London (Botany) 164: 521-550.

Weber, C.I. (1968) The preservation of phytoplankton grab samples. Trans. Amer. Micro. Soc. 87: 70-81.

Wehrtmann, I.S., and A.I. Dittel (1990) Utilization of floating mangrove leaves as a transport mechanism of estuarine organisms, with emphasis on decapod Crustacea. Marine Ecology - Progress Series 60: 67-73.

White, E., G. Payne, S. Pickmere, and P. Woods (1986a) Nutrient demand and availability related to growth among natural assemblages of phytoplankton. New Zealand J. Marine and Freshwater Research 20: 199-208.

Whitton, B.A. (1965) Extracellular products of blue-green algae. J. Gen. Microbiol. 40: 1-11.

Williams, W.T., J.S. Bunt, R.D. John, and D.J. Abel (1981) The conmmunity concept and the phytoplankton. Marine Ecology - Progress Series 6: 115-121.

Wirick, C.D. (1989) Herbivores and the spatial distributions of the phytoplankton. II. Estimating grazing in planktonic environments. Int. Revue ges. Hydrobiol. 74: 249-259.

Wofsy, S.C. (1983) A simple model to predict extinction coefficients and phytoplankton biomass in eutrophic waters. Limnology and Oceanography 28: 1144-1155.

Wolfe, D.A., M.A. Champ, D.A. Flemer, and A.J. Mearns (1987) Long-term biological data sets: their role in research, monitoring, and management of estuarine and coastal systems. Estuaries 10: 181-193.

Wolter, K. (1982) Bacterial incorporation of organic substances released by natural phytoplankton populations. Marine Ecology - Progress Series 7: 287-295.

Wood, E.J.F., and E.F. Corcoran (1966) Diurnal variation in phytoplankton. Science 16: 383-403.

Wu, J.T., and W.C. Suen (1985) Changes of algal associations in relation to water pollution. Bot. Bull. Academia Sinica 26: 203-212.

Wynne, D., and G.-Y. Rhee (1986) Effects of light intensity and quality on the relative N and P requirement (the optimum N:P ratio) of marine planktonic algae. Journal of Plankton Research 8 (1): 91-103.

Yamada, M., A. Tsuruta, and Y. Yoshida (1980a) A list of phyotplankton as eutrophic level indicator. Bulletin of the Japanese Society of Scientific Fisheries 46: 1435-1438.

Yamada, M., A. Tsuruta, and Y. Yoshida (1980b) Classification of eutrophic level in several marine regions. Bulletin of the Japanese Society of Scientific Fisheries 46: 1439-1444.

Yentsch, C.S., and R.W. Lee (1966) A study of photosynthetic light reactions an a new interpretation of sun and shade phytoplankton. J. Mar. Res. 24: 319-337.

Yoder, J.A., and S.S. Bishop (1985) Effects of mixing-induced irradiance fluctuations on photosynthesis of natural assemblages of coastal phytoplankton. Marine Biology 90: 87-93.

Yoshida, Y. (1972) Effects of zooplankton on the changes in concentration of inorganic nitrogen compounds and phytoplankton number in natural sea water. In Takenouti and etal (eds): Biol. Ocean. of the N.N.P.O. :, pp. 535-540.

Zeeman, S.I. (1985) The effects of tropical storm Dennis on coastal phytoplankton. Estuarine, Coastal and Shelf Science 20: 403-418.

BIBLIOGRAPHY

ZOOPLANKTON LITERATURE

Ackefors, H. (1969) Ecological zooplankton investigations in the Baltic Proper 1963-1965. Institute of Marine Research, Lysekil. Series Biolgy. 18: 139.

Amren, H. (1964a) Studies on the ecology and taxonomy of zooplankton especially the rotifers from Spitsbergen. Abstracts of Uppsala Dilssertations in Science 42: 10p.

Amren, H. (1964b) Ecological and taxonomical studies on zooplankton from Spitsbergen. Aoologiska Bildrag Fran Uppsala 36: 210-280.

Amren, H. (1964c) Temporal variation of the rotifer Keratella quadrata (Mull.) in some ponds on Spits Bergen. Zoologiska Bidrag Fan Uppsala 36: 193-208.

Amren, H. (1964d) Ecological studies of zooplankton populations in some ponds on spitsbergen. Zoologiska Bidrag Fran Uppsala 36: 161-191.

Anderson, G.C. (1972) On the verticle distribution of zooplankton in relation to chlorophyll concentration. In Takenout and e.t. al (eds): Bio. ocean. of the NNPO. :, pp. 342-345.

Anraku, M. (1964) Some technical problems encountered in quantitative studies of grazing and predation by marine planktonic copepods. The Journal of the Oceanographical Society of Japan. 20-5: 19-29.

Arnold, E.M., and D.A. Voss (1981) Numerical behavior of a zooplankton, phytoplankton and phosphorus system. Ecological Modeling 13: 183-193.

Bernard, C., and F. Rassoulzadegan (1990) Bacteria of microflagellates as a major food source for marine ciliates: possible implications for the microzooplankton. Marine Ecology - Progress Series 64: 147-155.

Bird, J.L. (1983) Relationships between particle-grazing zooplankton and vertical phytoplankton distributions on the Texas continental shelf. Estuarine, Coastal and Shelf Science 16: 131-144.

Brawley, S.H., and W.H. Adey (1981) The effect of micrograzers on algal community structure in a coral reef microcosum. Marine Biology 61: 167-177.

Brown, R.G.B., and D.E. Gaskin (1989) Summer zooplankton distributions at the surface of the outer Bay of Fundy, eastern Canada. Can. J. Zool. 67: 2725-2730.

Burns, C.W., and Z. Xu (1990) Calanoid copepods feeding on algae and filamentous cyanobacteria: rates of ingestion, defaecation and effects on trichome length. Journal of Plankton Research 12: 201-213.

Canter, H.M., S.I. Heaney, and J.W.G. Lund (1990) The ecological significance of grazing on planktonic opoulations of cyanobacteria by the ciliate Nassula. New Phytol. 114: 247-263.

Checkley, D.M., and C.A. Miller (1989) Nitrogen isotope fractionation by oceanic zooplankton. Deep-Sea Research 36: 1449-1456.

Chervin, M.B., T.C. Malone, and P.J. Neale (1981) Interactions between suspended organic matter and copepod grazing in the plume of the Hudson Rive. Estuarine, Coastal and Shelf Science 13: 169-183.

Ckhester, A.J., and J.D. Larrance (1981) Composition and vertical flux of organic matter in a large Alaskan estuary. Estuaries 4: 42-52.

Cushing, D.H. (1968) Grazing by herbivorous copepods in the sea. In Juillet (ed): J. Cons. Perm. int. Explor. Mer. Copenhague:, pp. 70-82.

Drenner, R.W., S.T. Threlkeld, J.D. Smith, J.R. Mummert, and P.A. Cantrell (1989) Interdependence of phosphorus, fish, and site effects on phytoplankton biomass and zooplankton. Limnology and Oceanography 34: 1315-1321.

Elser, J.J., M.M. Elser, and S.R. Carpenter (1986) Size fractionation of algal chlorophyll, carbon fixation and phosphatase activity: relationships with species-specific size distributions and zooplankton community structure. Journal of Plankton Research 8(2): 365-383.

Esaias, W.E., and H.C. Curl (1972) Effect of dinoflagellate bioluminescence on copepod ingestion rates. Limnology and Oceanography 17: 901-906.

Ferguson, A.J.D., J.M. Thompson, and C.S. Reynolds (1982) Structure and dynamics of zooplankton communities maintained in closed systems, with special reference to the algal food suply. Journal of Plankton Research 4: 523-543.

Folt, C., and C.R. Goldman (1981) Allelopathy between zooplankton: A mechanism for interference competition. Science 213: 1133-1135.

Forsyth, D.J., and M.R. James (1984) Zooplankton grazing on lake bacterioplankton and phytoplankton. Journal of Plankton Research 6: 803-810.

Frost, B.W. (1972) Effects of size and concentration of food particles on the feeding behavior of the marine planktonic copepod Calanus pacificus. Limnology and Oceanography 17: 905-815.

Fukuchi, M., and H. Sasaki (1981) Phytoplankton and zooplankton standing stocks and downward flux of particulate material around fast ice edge of Lutzow-Holm Bay, Antarctica. Memoirs of National Institute of Polar Research 34: 13-36.

Fukuchi, M., and A. Tanimura (1981) A preliminary note on the occurrence of copepods under sea ice near Syowa station, Antarctica. Memoirs of National Institute of Polar Research 34: 37-43.

Fukuchi, M., A. Tanimura, and H. Ohtsuka (1985) Marine biological oceanographical investigations in Lutzow-Holm, Bay, Antarctica. In W.R. Siegfried, P.R. Condy, and R.M. Laws (eds): Antarctic Nutrient Cycles of Food Webs. :, pp. 52-59.

Fukuchii, M., A. Tanimura, and H. Ohtsuka (1985) Zooplankton community conditions under sea ice near Syowa Station, Antarctica. Bull. Mar. Sci. 37: 518-528.

Fulton, R.S. (1985) Predator-prey relationships in an estuarine littoral copepod community. Ecology 21: 21-29.

Furnas, M.J., T.J. Smayda, and E.A. Deason (1986) Nitrogen dynamics in lower Narragansett Bay. II. Phytoplankton uptake, depletion rates of nitrogenous nutrient pools, and estimates of ecosystem remineralization. Journal of Plankton Research 8-4: 755-769.

Gallegos, C.L. (1989) Microzooplankton grazing on phytoplankton in the Rhode River, Maryland: nonlinear feeding kinetics. Marine Ecology - Progress Series 57: 23-33.

Gifford, D.J., R.N. Bohren, and C.M. Boyd (1981) Spines on diatoms: Do copepods care?. Limnology and Oceanography 26: 1057-1061.

Grice, G.E., and A.D. Hart (1962) The abundance, seasonal occurance and distribution of the epizooplankton between New York and Bermuda. Ecological Monographs 32: 287-308.

Hargrave, B.T., and G.H. Green (1970) Effects of copepod grazing on two natural phytoplankton populations. JFRBC 27: 1395-1403.

Hendrickson, W.H., S.B.R. Karri, and A.O. Shar (1985) Simulations in a plankton model. Int Revue ges Hydrobiol 70: 547-559.

Hobson, L.A., and C.J. Lorenzen (1972) Reltionships of chlorophyll maxima to density structure in the Atlantic ocean and gulf of Mexico. Deep-Sea Research 19: 297-306.

Kamykowski, D., and J.L. Bind (1981) Phytoplankton associations with the variable nepheloid layer on the Texas continental shelf. Estuarine, Coastal and Shelf Science 13: 317-326.

Larson, R.J. (1987) In situ feeding rates of the Ctenophore Mnemiopsis mccradyi. Estuaries 10-2: 87-91.

Malthus, T.J., and S.F. Mitchell (1990) On the occurrence, causes and potential consequences of low zooplankton to phytoplankton ratios in New Zealand lakes. Freshwater Biology 22: 383-394.

Marshall, S.M., and A.P. Orr (1955) Experimental feeding of the copepod Calanus finmarchicus (gunner) on phytoplankton cultures labled with radioactive carbon (C14). Deep-Sea Research 3(sup): 110-114.

Mazumder, A., D.J. McQueen, W.D. Taylor, D.R.S. Lean, and M.D. Dickman (1990) Micro- and mesozooplankton grazing on natural pico- and nanoplankton in contrasting plankton communities produced by planktivore manipulation and fertilization. Archiv Fur Hydrobiologia 118(3): 257-282.

McAllister, C.D. (1972) Estimates of the transfer of primary production to secondary production of ocean station. In Takenoute (ed): Biol. Ocean. of the NNPO. :, pp. 541-557.

McCauley, and J. Kalff (1981) Emperical relationship between phytoplankton and zooplankton biomass in lakes. Canadian Journal of Fisheries and Auqatic Science 38: 458-463.

Minoda, T. (1972) Characteristics of the vertical distribution of copepods in the Bering Sea and south of the Aleutian chain, May-June, 1962. In Takenout and etal (eds): Bio. Ocean. of the N.N.P.O. :, pp. 324-331.

Morris, M.J., G. Gust, and J.J. Torres (1985) Propulsion efficiency and cost of transport for copepods: a hydromechanical model of crustacean swimming. Marine Biology 86: 283-295.

Morris, M.J., and T.L. Hopkins (1983) Biochemical composition of crustacean zooplankton from the eastern Gulf of Mexico. Journal Experimental Marine Biology and Ecology 69: 1-19.

Mourelatos, S. (1989) Broutage du zooplancton in situ: revue ctitique des methodes courantes. Acta OEcologica 10: 257-271.

Mullin, M.M., and E.R. Brooks (1972) The vertical distribution of juvenile calanus (copepoda) and phytoplankton within the upper 50m of water off La Jolla, California. In Takenouti and etal (eds): Biol. Ocean. of the N.N. P.O. :, pp. 347-353.

O'Brien, J.J., and J.S. Wroblewski (1972) A simulation of the mesoscale distribution of the lower marine trophic level off West Florida. Contributions to geophysical fluid dynamics institute, FSU : 1-64.

Olrik, K., S. Lundoer, and K. Rasmussen (1984) Interactions between phytoplankton, zooplankton, and fish in the nutrient rich shallow lake Hjarback Fjord Denmark. Int. Revue ges. Hydrobiol. 69: 389-405.

Paffenhoffer, G.A., and J.H. Strickland (1970) A note on the feeding of Calanus helgolandicus on detritus. Marine Biology 5: 97-99.

Parsons, T.R., and detal (1969) Production studies in the strait of Georgia. II. Secondary production under the Fraser River plume, February to May, 1967. Journal Experimental Marine Biology and Ecology 3: 39-50.

Parsons, T.R., R.J. LeBrasseur, and J.D. Fulton (1967) Some observations on the dependence of zooplankton grazing on the cell size and concentration of phytoplankton blooms. Jour. Oceanogr. Soc. Japan 23: 10-17.

Porter, K.G. (1972) A method for the in situ study of zooplankton grazing effects of zooplankton grazing effects on algal species composition and standing crop. Limnology and Oceanography 17: 913-917.

Porter, K.G. (1976) Enhancement of algal growth and productivity by grazing zooplankton. Science 192: 1332-1333.

Porter, K.G. (1977) The plant-animal interface in freshwater ecosystems. American Scientist 65: 159-170.

Putt, M., and D.K. Stoecker (1989) An experimentally determined carbon: volume ratio for marine "oligotrichous" ciliates from estuarine and coastal waters. Limnology and Oceanography 34: 1097-1103.

Riemann, B., M. Sondergaard, H.H. Schierup, S. Bosselmann, G. Christensen, J. Hasen, and B. Nielsen (1982) Carbon metabolism during a spring diatom bloom in the eutrophic Lake Mosso. Int. Revue ges Hydrobiol. 67: 145-185.

Rocha, O., and A. Duncan (1985) The relationship between cell carbon and cell volume in freshwater algal species used in zooplanktonic studies. Journal of Plankton Research 7: 279-294.

Roman, M.R., M.R. Reeve, and J.L. Froggatt (1983) Carbon production and export from Biscayne Bay, Florida. I. Temporal patterns in primary production, seston and zooplankton. Estuarine, Coastal and Shelf Science 17: 45-59.

Roman, M.R., C.S. Yentsch, A.L. Gauzens, and D.A. Phinney (1986) Grazer control of the fine-scale distribution of phytoplankton in warm-core Gulf Stream rings. Jour Mar Res 44: 795-813.

Rose, K.A., and G.L. Swartzman (42) Stepwise iterative calibration of a multi-species phytoplankton-zooplankton simulation model using laboratory data. Ecological Modelling 42: 1-32.

Sanders, J.G., R.W. Osman, and G.F. Riedel (1989) Pathways of arsenic uptake and incorporation in estuarine phytoplankton and the filter-feeding invertebrates Eurytomora affinis, Balanus improvisus and Crassostrea virginica. Mar. Biology 103: 319-325.

Schoenberg, S. (1990) Short-term productivity responses of algae and bacteria to zooplankton grazing in two freshwater lakes. Freshwater Biology 23: 395-410.

Schoenberg, S.A. (1989) Effects of algal concentration, bacterial size and water chemistry on the ingestion of natural bacteria by cladocerans. Journal of Plankton Research 11: 1273-1295.

Squires, A.P. (1984) The distribution and ecology of zooplankton in Charlotte Harbor, Florida. Thesis, Univ. S. Florida :.

Stearns, D.E., W. Litaker, and G. Rosenberg (1987) Impacts pf zooplankton grazing and excretion on short-interval fluctuations in chlorophyll a and nitrogen concentrations in a well-mixed estuary. Estuarine, Coastal and Shelf Science 24: 305-325.

Strickland, J.D. (1972) Research on the marine planktonic food web at the institute of marine resources: A review of the past seven years of work. Oceanogr. Mar. Biol. Ann. Rev. 10: 349-414.

Taniguchi, A., and T. Kawamura (1972) Primary production in the Oyashio Region with special reference to the subsurface cchlorophyll maximum layer and phytoplankton-zooplankton relationships. In Takenouti and etal (eds):. :, pp. 232-243.

Teixeira, C., J. Tundisi, and M.B. Kutner (1965) Plankton studies in a mangrove environment. II. The standing stock and some ecological factors. do Inst. Ocean. da USP 208: 13-41.

Thompson, J.M., A.J.D. Ferguson, and C.S. Reynolds (1982) Natural filtration rates of zooplankton in a closed system: the derivation of a community grazing index. Journal of Plankton Research 4: 545-560.

Timonin, A.G. (1971) The structure of plankton communities of the Indian Ocean. Marine Biology 9: 281-289.

Urabe, J. (1989) Relative importance of temporal and spatial heterogeneity in the zooplankton community of an artificial reservoir. Hydrobiologia 184: 1-6.

Walker, L.M., and etal (1979) Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. VI. Plankton Dynamics VII. Phytoplankton VIII. Zooplankton IX. Diel Plankton X. Benthic Algae Species List. Florida Department Natural Resources :.

Williamson, C.E., and M.E. Stoeckel (1990) Estimating predation risk in zooplankton communities: the importance of vertical overlap. Hydrobiologia 198: 125-131.

Wirick, C.D. (1989) Herbivores and the spatial distributions of the phytoplankton. II. Estimating grazing in planktonic environments. Int. Revue ges. Hydrobiol. 74: 249-259.

Witek, Z., and A. Krajewska-Soltys (1989) Some examples of the epipelagic plankton size structure in high latitude oceans. Journal of Plankton Research 11: 1143-1155.

Yoshida, Y. (1972) Effects of zooplankton on the changes in concentration of inorganic nitrogen compounds and phytoplankton number in natural sea water. In Takenouti and etal (eds): Biol. Ocean. of the N.N.P.O. :, pp. 535-540.