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EISENHUT,D.G. Division of Licensing

SUBJECT: Forwards repts in response to FSAR & environ rept - OL stage acceptance review questions per NRC request for addl info to 830419 submittal re OL application. List of repts submitted encl.

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NIAGARA MOHAWK

NIAGARA MOHAWK POWER CORPORATION/300 ERIE BOULEVARD WEST, SYRACUSE, N.Y. 13202/TELEPHONE (315) 474-1511

May 13, 1983
(6628)

Mr. Darrell G. Eisenhut, Director
Division of Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Eisenhut:

Subject: Nine Mile Point Unit 2
Operating License Application
Docket No. 50-410
Responses to Acceptance Review Questions

On April 19, 1983, one (1) copy of the reports listed on Attachment 1 of this letter was submitted to you. In response to the NRC Project Manager's oral request, attached are five (5) additional copies of these reports.

Very truly yours,

CVMangan

C. V. Mangan
Vice President
Nuclear Engineering & Licensing

CVM/JAM:ja
Attachments

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Attachment 1

List of Reports Submitted
in Response to NRC Acceptance Review
Information Requests E291.2, E291.10
and E291.11(a)

1.* 316(a) Demonstration Submission: NPDES Permit NY0001015: Nine Mile Point Unit 1. Prepared for Niagara Mohawk Power Corporation by Lawler, Matusky and Skelly Engineers, 1975. 8305230585

2. Evaluation of the Angled Screen Fish Diversion System at Oswego Steam Station Unit 6, Interim Report. Prepared for Niagara Mohawk Power Corporation by Lawler, Matusky and Skelly Engineers, 1982. 8305230587

3. James A. Fitzpatrick Nuclear Power Plant 316(a) Demonstration Submission: Permit NY0020109. Prepared for Power Authority of the State of New York, 1977. 8305230592

4. James A. Fitzpatrick Nuclear Power Plant 316(b) Demonstration Submission: Permit NY0020109. Prepared for Power Authority of the State of New York by Lawler, Matusky and Skelly Engineers, 1977. 8305230599

5. Lake Ontario Fish Tag Report Summary 1972-1976. Prepared for Niagara Mohawk Power Corporation by J. F. Storr, 1977. 8305230603

6. 1973 Nine Mile Point Aquatic Ecology Studies - Nine Mile Point Generating Station, Volume I, Volume II and Volume III Parts 1-4. Prepared for Niagara Mohawk Power Corporation and Power Authority of the State of New York by Quirk, Lawler and Matusky Engineers, 1974. 8305230607 628 622 599

7. 1974 Nine Mile Point Aquatic Ecology Studies. Two volumes. Prepared for Niagara Mohawk Power Corporation and Power Authority of the State of New York by Lawler, Matusky and Skelly Engineers, 1975. Vol. 1 8305230650 Vol. 2: 8305230656

8. 1975 Nine Mile Point Aquatic Ecology Studies. Prepared for Niagara Mohawk Power Corporation and Power Authority of the State of New York by Lawler, Matusky and Skelly Engineers, 1976. 8305230661

9. 1976 Nine Mile Point Aquatic Ecology Studies. Two volumes. Prepared for Niagara Mohawk Power Corporation and Power Authority of the State of New York by Lawler, Matusky and Skelly Engineers, 1977.

10. Nine Mile Point Aquatic Ecology Studies 1977 Annual Report. Prepared for Niagara Mohawk Power Corporation and Power Authority of the State of New York by Texas Instruments, Inc. 1978.

11. Nine Mile Point Aquatic Ecology Studies 1978 Annual Report. Prepared for Niagara Mohawk Power Corporation and Power Authority of the State of New York by Texas Instruments, Inc. 1979. See 50-220 #7905060211

* Niagara Mohawk was not required to prepare a 316(b) demonstration for Nine Mile Point Unit 1.

List of Reports Submitted
in Response to NRC Acceptance Review
Information Requests E291.2, E291.10
and E291.11(a)
(Continued)

12. Oswego Unit 5 316(a) Demonstration Submission: Permit NY003212. Prepared for Niagara Mohawk Power Corporation by Lawler, Matusky and Skelly Engineers, 1975. 83

13. Oswego Unit 5 Intake Considerations: Permit NY003212. Prepared for Niagara Mohawk Power Corporation by Lawler, Matusky and Skelly Engineers, 1975. 83

14. Oswego Unit 6 316(a) Demonstration Submission: Permit NY0003221. Prepared for Niagara Mohawk Power Corporation by Lawler, Matusky and Skelly Engineers, 1975. 8305230687

15. Oswego Unit 6 Intake Considerations: Permit NY0003221. Prepared for Niagara Mohawk Power Corporation by Lawler, Matusky and Skelly Engineers, 1975. 8305230691

16. Oswego Steam Station Units 1-4, 316(a) Demonstration Submission: Permit NY0002186. Prepared for Niagara Mohawk Power Corporation by Lawler, Matusky and Skelly Engineers, 1976. 8305230696

17. Oswego Steam Station Units 1-4 Intake Considerations: Permit NY002186. Prepared for Niagara Mohawk Power Corporation by Lawler, Matusky and Skelly Engineers, 1976. 8305230699

18. Studies to Alleviate Potential Fish Entrapment at Unit No. 6 - Oswego Steam Station. Prepared for Niagara Mohawk Power Corporation by Stone & Webster Engineering Corporation, 1977. 8305230701

Quirk, Lawler & Matusky Engineers
Environmental Science & Engineering Consultants

415 ROUTE 303, TAPPAN, NEW YORK 10983
(914) 359-2100

THOMAS P. QUIRK, P.E.
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MICHAEL J. SKELLY, P.E.

ROBERT A. NORRIS, DIR,
COMPUTER APPLICATIONS

September 9, 1974
File: 191-14,15,17

Mr. P.D. Raymond
Vice President - Engineering
Niagara Mohawk Power Corporation
300 Erie Boulevard West
Syracuse, New York 13202

Mr. George T. Berry
General Manager & Chief Engineer
Power Authority of the
State of New York
10 Columbus Circle
New York, New York 10019

Dear Messrs. Raymond and Berry:

In accordance with Niagara Mohawk Power Corporation's and the Power Authority of the State of New York's authorization, we submit herein the results of the ecological investigations conducted at the Nine Mile site during 1973.

Very truly yours,

Michael J. Skelly

Michael J. Skelly, Ph.D
Partner

MJS:wh

Docket #:
Control #: 8305230574

TABLE OF CONTENTS

	Page
Letter of Transmittal	
LIST OF FIGURES	viii
LIST OF TABLES	xxi
SUMMARY	S-1
A. INTRODUCTION	S-1
1. Time Coverage	S-3
2. Space Coverage	S-4
a. Nine Mile Point	S-4
b. The Great Lakes Basin	S-6
3. System Parameters and Analyses	S-6
a. Delineation of System Parameters	S-6
b. Integrative Procedures	S-13
B. ASSESSMENT	S-16
1. The Lake Ontario Situation	S-16
2. The Biota of Lake Ontario	S-19
3. Assessment	S-19
a. Lake Function	S-20
b. Phytoplankton	S-21
c. Zooplankton	S-28
d. Benthos	S-31
e. Fish	S-36
I. PLANKTON	
A. GENERAL INTRODUCTION	1
1. Light	2
2. Temperature	3
3. Nutrients, Mixing and Currents	4
B. PHYTOPLANKTON	8
1. Introduction	8
2. Results	10
a. Species Inventory	10
b. Patterns of Abundance	10
c. Comparison of Abundance of Net Phytoplankton and Whole Water Phytoplankton	15
d. Windrow Phytoplankton	15
e. Seasonal Succession	16
f. Chlorophyll a Concentrations	16

TABLE OF CONTENTS (Cont'd)

		Page
B.	PHYTOPLANKTON Cont'd	
	3. Discussion of Results	18
	4. Conclusions	23
C.	MICROZOOPLANKTON	24
	1. Introduction	24
	a. Previous Work in Lake Ontario	24
	b. Trophic Considerations	27
	2. Results	30
	a. Replicate Samples	30
	b. Species Inventory	30
	c. Distribution and Abundance	30
	d. Statistical Analysis	41
	e. Seasonal Abundance of Cladocerans and Phaeopigments	42
	3. Discussion of Results	42
	a. Patterns of Abundance	42
	b. Rotifers as Indicators	47
	4. Conclusions	47
D.	MACROZOOPLANKTON AND ICHTHYOPLANKTON	49
	1. Introduction	49
	2. Macrozooplankton Results	51
	a. Species Inventory	51
	b. Seasonal Patterns of Abundance	51
	c. Diurnal Variations in Abundance	54
	d. Variations in Abundance Among Stations at a Transect	55
	e. Variations in Abundance Among Stations Along a Depth Contour	56
	3. Discussion of Macrozooplankton Results	57
	a. Seasonal Patterns of Abundance	57
	b. Diurnal Variations	58
	c. Variations Between Stations	59
	d. Variations Between Dates	59

TABLE OF CONTENTS Cont'd

Page

D. MACROZOOPLANKTON AND ICHTHYOPLANKTON Cont'd

4. Macrozooplankton Conclusions........................ 59
5. Ichthyoplankton Results............................. 61

a. Species Inventory.............................. 61
b. Abundance...................................... 61
c. Diurnal Migration.............................. 65
d. Species Other than Alewives.................... 66
e. Length-frequency............................... 66

6. Discussion of Ichthyoplankton Results.............. 69

a. General.. 69
b. Trophic Interactions........................... 70

7. Ichthyoplankton Conclusions........................ 72

E. ENTRAINED PLANKTON.................................... 73

1. Introduction....................................... 73
2. Results.. 76

a. Entrained Phytoplankton........................ 76
b. Entrained Microzooplankton..................... 77
c. Entrained Macrozooplankton..................... 79
d. Entrained Ichthyoplankton...................... 81

3. Discussion of Results 82

a. Summary and Interpretation of Results.......... 82
b. Sampling Entrained Plankton.................... 84

II. BENTHOS

A. INTRODUCTION.. 86
B. STATION LOCATION AND SUBSTRATE CHARACTERISTICS........ 88
C. RESULTS AND DISCUSSION................................ 89

1. Identification..................................... 89

a. General Systematic Survey...................... 89
b. Taxonomic Considerations....................... 90

2. Distribution and Abundance......................... 91

a. Major Taxonomic Level.......................... 91
b. Seasonal Abundance............................. 110
c. Percent Composition............................ 113

TABLE OF CONTENTS Cont'd

	Page
C. RESULTS AND DISCUSSION Cont'd	
3. Community Structure	117
a. Affinity Index	117
b. Species Diversity	121
c. Fish Support Potential	126
d. Analysis of Variance (ANOVA)	130
D. PERIPHYTON	138
1. Introduction	138
2. Results and Discussion	139
a. Species Composition and Abundance	139
b. Production Rates	145
3. Conclusions	147
III. FISH	
A. INTRODUCTION	149
1. Background of Lake Ontario Fisheries	151
2. Present Study Objectives	153
B. RESULTS AND DISCUSSION	154
1. Seines	161
a. Distribution and Abundance	161
b. Community Structure	164
2. Trawls	166
a. Distribution and Abundance	166
b. Community Structure	178
3. Gill Nets	186
a. Distribution and Abundance	186
b. Community Structure	193
c. Surface Gill Net Diversity	194
d. Bottom Gill Net Diversity	195

TABLE OF CONTENTS Cont'd

	Page
B. RESULTS AND DISCUSSION Cont'd	
4. Stomach Content Analysis	198
a. Smallmouth Bass (*Micropterus dolomieui*	199
b. White Perch (*Morone americana*)	201
c. Yellow Perch (*Perca flavescens*)	204
d. Summary	210
5. Age and Growth	212
a. Introduction	212
b. Results and Discussion	215
6. Reproduction	230
a. Introduction	230
b. Results and Discussion	234
7. Fish Communities and Nine Mile Point Unit 1 Operation	245
a. Historical Perspective	245
b. Fish Communities Prior to Plant Operation	246
c. Fish Communities After Plant Operation Began	248
IV. FISH IMPINGEMENT	
A. INTRODUCTION	262
B. RESULTS AND DISCUSSION	265
1. Day-Night Comparisons of Fish Impingement Rates	265
2. Species Composition	266
a. Species Listed by Collection	266
b. Seasonal Cycles	267
3. Lake and Plant Comparisons	269
a. Relative Abundance	269
b. Relative Condition Factors	272
c. Species Diversity	274
4. Physical Conditions	278
C. IMPLICATIONS OF FISH IMPINGEMENT	281
1. Alewife (*Alosa pseudoharengus*)	282

TABLE OF CONTENTS Cont'd

	Page
C. IMPLICATIONS OF FISH IMPINGEMENT Cont'd	
2. Rainbow Smelt (*Osmerus mordax*)	291
V. WATER QUALITY	
A. INTRODUCTION	296
1. General	296
2. Previous Water Quality Studies	299
B. 1973 Water Quality Investigations	302
1. Sampling Stations and Frequency	302
2. Collection Procedures	303
a. Weekly Field Measurements	303
b. Bi-Monthly Collections	303
c. Monthly Collections	303
d. Dissolved Oxygen Loss	304
e. Bottom Sediments	304
f. Effluent Analysis	305
3. Laboratory Analyses	305
a. Bi-Monthly Collections	305
b. Monthly Collections	305
c. Bottom Sediments	306
d. Effluent Analyses	306
4. Laboratory Analytical Procedures	306
C. RESULTS AND DISCUSSION	307
1. Weekly Water Quality Results	307
2. Analysis of Thermal Data	307
a. General	307
b. Discussion of Thermal Data	308
c. Principles of Lake Stratification	309
d. New York State Thermal Criteria	312
e. Determination of Stratification	313
f. Comparison Between Nine Mile Point and Oswego Thermal Profile Stations	317
3. Bi-Monthly and Monthly Surveys	318
a. Selected Data Presentation	319
b. Metals Results	323
c. Simple Statistics and Correlations	324

TABLE OF CONTENTS Cont'd

	Page
C. RESULTS AND DISCUSSION Cont'd	
4. Dissolved Oxygen Loss	331
5. Effluent Survey	331
6. Bottom Sediment Characteristics	332
D. SUMMARY AND CONCLUSIONS	333
1. Water Quality	334
2. Temperature	337
3. Dissolved Oxygen Loss	338
4. Effluent Survey	338
5. Sediment Characteristics	338
REFERENCES	339

VOLUME III Bound Separately - Appendices I - VII

LIST OF FIGURES

Figure No.	Title	Following Page
I-1	Location of Microzooplankton and Phytoplankton Stations in the Nine Mile Point Area.	10
I-2	Total Net Phytoplankton Abundance on the 10' Contour Depth.	11
I-3	Total Net Phytoplankton Abundance on the 20' Contour Depth.	11
I-4	Total Net Phytoplankton Abundance on the 40' Contour Depth.	11
I-5	Total Net Phytoplankton Abundance on the 60' Contour Depth.	11
I-6	Total Whole Water Phytoplankton Abundance on the 10' Contour Depth.	11
I-7	Total Whole Water Phytoplankton Abundance on the 20' Contour Depth.	11
I-8	Total Whole Water Phytoplankton Abundance on the 40' Contour Depth.	11
I-9	Total Whole Water Phytoplankton Abundance on the 60' Contour Depth.	11
I-10	Net Phytoplankton Abundance on the 10' Contour Depth.	11
I-11	Net Phytoplankton Abundance on the 20' Contour Depth.	11
I-12	Net Phytoplankton Abundance on the 40' Contour Depth.	11

LIST OF FIGURES (Continued)

Figure No.	Title	Following Page
I-13	Net Phytoplankton Abundance on the 60' Contour Depth.	11
I-14	Percent Composition of Net Phytoplankton on the 10' Contour Depth.	11
I-15	Percent Composition of Net Phytoplankton on the 20' Contour Depth.	11
I-16	Percent Composition of Net Phytoplankton on the 40' Contour Depth.	11
I-17	Percent Composition of Net Phytoplankton on the 60' Contour Depth.	11
I-18	Whole Water Phytoplankton Abundance on the 10' Contour Depth.	11
I-19	Whole Water Phytoplankton Abundance on the 20' Contour Depth.	11
I-20	Whole Water Phytoplankton Abundance on the 40' Contour Depth.	11
I-21	Whole Water Phytoplankton Abundance on the 60' Contour Depth.	11
I-22	Percent Composition of Whole Water Phytoplankton on the 10' Contour Depth.	11
I-23	Percent Composition of Whole Water Phytoplankton on the 20' Contour Depth.	11
I-24	Percent Composition of Whole Water Phytoplankton on the 40' Contour Depth.	11
I-25	Percent Composition of Whole Water Phytoplankton on the 60' Contour Depth.	11
I-26	Chlorophyll a Distribution At All Four Transects.	16

LIST OF FIGURES (Continued)

Figure No.		Following Page
I-27	Pheo-Pigment Distribution At all Four Transects.	17
I-28	Trophic Intrarelationships of the Micro-plankton at Nine Mile Point.	28
I-29	Total Microzooplankton.	30
I-30	Microzooplankton Abundance at NMPW.	31
I-31	Microzooplankton Abundance at NMPP.	32
I-32	Microzooplankton Abundance at FITZ.	32
I-33	Microzooplankton Abundance at NMPE	33
I-34	Nine Mile Point Area 1973 Macrozooplankton and Ichthyoplankton Sampling Stations.	51
I-35	Seasonal Abundance of Leptodora at Nine Mile Point 1973.	51
I-36	Seasonal Abundance of Cladocerans at Nine Mile Point 1973.	52
I-37	Seasonal Abundance of Copepods at Nine Mile Point 1973.	53
I-38	Seasonal Abundance of Amphipods at Nine Mile Point 1973.	53
I-39	Seasonal Abundance of Total Macrozooplankton at Nine Mile Point 1973.	54
I-40	Larvae Concentrations for 1973 NMPW-1/2 Mile.	61
I-41	Larvae Concentrations for 1973 NMPW-1 Mile.	61
I-42	Larvae Concentrations for 1973 NMPW-3 Miles.	61
I-43	Larvae Concentrations for 1973 NMPP.	61

LIST OF FIGURES (Continued)

Figure No.	Title	Following Page
I-44	Larvae Concentrations for 1973 NMPE-½ Mile.	61
I-45	Larvae Concentrations for 1973 NMPE-1 Mile.	61
I-46	Larvae Concentrations for 1973 NMPE-3 Miles.	61
I-47	Alewife Larvae Length-Frequency at NMPW Transects.	67
I-48	Alewife Larvae Length-Frequency at NMPP Transects.	67
I-49	Alewife Larvae Length-Frequency at NMPE Transects.	67
I-50	Phytoplankton Chlorophyll a in Intake and Discharge Samples At Nine Mile Point Nuclear Station.	76
I-51	Total Microzooplankton Abundance.	77
I-52	Entrained Microzooplankton.	77
I-53	Viability of Entrained Microzooplankton.	77
I-54	Entrained Macrozooplankton.	79
I-55	Total Macrozooplankton.	81
I-56	Abundance of Fish Eggs and Larvae in Intake and Discharge Waters At Nine Mile Point Nuclear Station.	82
II-1	Benthic Sampling Stations in the Nine Mile Point Area of Lake Ontario.	88
II-2	Nine Mile Point Ecological Survey Benthos: Percent of Total Number At Each Transect By Date June, 1973.	114

LIST OF FIGURES (Continued)

Figure No.	Title	Following Page
II-3	Nine Mile Point Ecological Survey Benthos: Percent of Total Number At Each Transect By Date August, 1973.	113
II-4	Nine Mile Point Ecological Survey Benthos: Percent of Total Number At Each Transect By Date October, 1973	113
II-5	Nine Mile Point Ecological Survey Benthos: Percent Composition of Total Biomass At Each Transect By Date June, 1973.	113
II-6	Nine Mile Point Ecological Survey Benthos: Percent Composition of Total Biomass At Each Transect By Date August, 1973.	113
II-7	Nine Mile Point Ecological Survey Benthos: Percent Composition of Total Biomass at Each Transect By Date October, 1973.	113
II-8	Nine Mile Point Ecological Survey Affinity Index 30 June - 2 July.	118
II-9	Nine Mile Point Ecological Survey Affinity Index 30 August 1973.	118
II-10	Nine Mile Point Ecological Survey Affinity Index 23-24 October 1973.	118
II-11	Nine Mile Point Ecological Survey Species Diversity and Evenness 30 June 1973.	122
II-12	Nine Mile Point Ecological Survey Species Diversity and Evenness 31 August 1973.	122
II-13	Nine Mile Point Ecological Survey Species Diversity and Evenness 24 October 1973.	122
II-14	Nine Mile Point Ecological Survey Biomass Diversity 30 June 1973.	125

LIST OF FIGURES (Continued)

Figure No.	Title	Following Page
II-15	Nine Mile Point Ecological Survey Biomass Diversity 31 August 1973.	125
II-16	Nine Mile Point Ecological Survey Biomass Diversity 24 October 1973.	125
II-17	Bottom Periphyton - Glass Substrates Cells/dm^2 x 10.	140
II-18	Bottom Periphyton - Glass Substrates Cells/dm^2 x 10^3.	140
II-19	Nine Mile Point - Bottom Periphyton Affinity Index 29 June 1973.	141
II-20	Nine Mile Point - Bottom Periphyton Affinity Index 30-31 August 1973.	141
II-21	Buoy Periphyton - Glass Substrates Cells/dm^2 x 10^3.	142
II-22	Bottom Periphyton - Glass Substrates Cells/dm^2 x 10^3.	143
II-23	Nine Mile Point - Buoy Periphyton Affinity Index 29 August 1973.	143
II-24	Nine Mile Point - Buoy Periphyton Affinity Index 11 October 1973.	143
III-1	Fish Sampling Locations in the Nine Mile Point Area of Lake Ontario.	144
III-2	Total Fish Collected Monthly By Seine in the Nine Mile Point Area.	161
III-3	Total Fish Biomass Collected Monthly By Seine in the Nine Mile Point Area.	161

LIST OF FIGURES (Continued)

Figure No.	Title	Following Page
III-4	Monthly Seine Collections at Transect Nine Mile Point West.	162
III-5	Monthly Seine Collections at Transect Nine Mile Point Plant.	162
III-6	Monthly Seine Collections at Transect FitzPatrick.	162
III-7	Monthly Seine Collections at Transect Nine Mile Point East.	162
III-8	Total Numbers of Fishes Collected by Date During Seine Collection at Nine Mile Point Areas.	162
III-9	Total Fish Biomass Collected by Date During Seine Collections at Nine Mile Point.	162
III-10	Species Diversity (H), Evenness (J), and Species Richness (S-1) of Nine Mile Point Area Collections Calculated Values Are Based on Numerical Abundance.	165
III-11	Monthly Trawl Catch Per Unit Effort for Each Transect.	166
III-12	Monthly Trawl Biomass Per Unit Effort for Each Transect.	168
III-13	Mean Catch Per Unit Effort for Day and Night Surface Trawls.	168
III-14	Mean Catch Per Unit Effort for Day and Night Bottom Trawls.	168
III-15	Mean Monthly Catch Per Unit Effort for Surface and Bottom Trawl Collections.	171
III-16	Mean Monthly Biomass Per Unit Effort for Surface and Bottom Trawl Collections.	171

LIST OF FIGURES (Continued)

Figure No.	Title	Following Page
III-17	Mean Catch Per Unit Effort for Each Day-time Trawl Collection.	171
III-18	Mean Catch Per Unit Effort for Each Night-time Trawl Collection.	172
III-19	Mean Biomass Per Unit Effort for Day Surface and Bottom Trawls By Date.	173
III-20	Mean Biomass Per Unit Effort for Night Surface and Bottom Trawls By Date.	173
III-21	Monthly Catch Per Unit Effort for Surface Trawl Collections at NMPW.	173
III-22	Monthly Catch Per Unit Effort for Surface Trawl Collections at NMPE.	173
III-23	Monthly Catch Per Unit Effort for Surface Trawl Collections at NMPP.	173
III-24	Monthly Catch Per Unit Effort for Bottom Trawl Collections at NMPW.	174
III-25	Monthly Catch Per Unit Effort for Bottom Trawl Collections at NMPP.	174
III-26	Monthly Catch Per Unit Effort for Bottom Trawl Collections at NMPE.	174
III-27	Mean Catch Per Unit Effort for Day Bottom Trawl Collections Above the 20, 40, and 60 Foot Contours.	175
III-28	Mean Catch Per Unit Effort for Night Bottom Trawl Collections, 20', 40', 60' Contours.	175
III-29	Mean Catch Per Unit Effort for Day and Night Bottom Trawl Collections, 20' Contour.	175

LIST OF FIGURES (Continued)

Figure No.	Title	Following Page
III-30	Mean Catch Per Unit Effort for Day and Night Bottom Trawl Collections Along the 40' Contour.	175
III-31	Mean Catch Per Unit Effort for Day and Night Bottom Trawl Collections Along the 60' Contour.	175
III-32	Total Catch Per Unit Effort for Surface and Bottom Gill Net Collections at Nine Mile Point East Transect.	176
III-33	Total Catch Per Unit Effort for Surface and Bottom Gill Net Collections at Nine Mile Point West Transect.	186
III-34	Total Catch Per Unit Effort for Surface and Bottom Gill Net Collections at Nine Mile Point Plant Transect.	186
III-35	Total Catch Per Unit Effort for Surface and Bottom Gill Net Collections at FitzPatrick Transect.	186
III-36	Length-Frequency of Lake Catch.	197
III-37	Alewife Length-Frequency	227
III-38	Rainbow Smelt Length-Frequency	229
III-39	Yellow Perch Reproductive Cycle at Nine Mile Point During the 1973 Spawning Season.	235
III-40	White Perch Reproductive Cycle at Nine Mile Point During the 1973 Spawning Season.	235
III-41	White Perch Reproductive Cycle at Bowline During 1971 and 1972 Spawning Seasons.	236

LIST OF FIGURES (Continued)

Figure No.	Title	Following Page
III-42	Relationship Between Log Numbers of Eggs vs. Body Weight, Body Length and Ovary Weight for 32 White Perch.	239
III-43	Alewife Reproductive Cycle at Nine Mile Point During the 1973 Spawning Season.	240
III-44	Rainbow Smelt Reproductive Cycle at Nine Mile Point During the 1973 Spawning Season.	241
III-45	Smallmouth Bass Reproductive Cycle at Nine Mile Point During the 1973 Spawning Season.	243
III-46	Relationship Between Log Numbers of Eggs vs. Body Weight, Body Length, and Ovary Weight for 21 Smallmouth Bass.	244
III-47	Fish Monitoring Sites in the Nine Mile Point Plant Area From 1969 to 1973.	246
IV-1	Monthly Impingement and Average Number Per Hour of All Species Except Alewife and Rainbow Smelt.	268
IV-2	Nine Mile Point Alewife.	270
IV-3	Nine Mile Point Rainbow Smelt.	270
IV-4	Nine Mile Point Impingement Survey.	275
IV-5	Nine Mile Point Impingement Survey, Fish Impingement Rate Based on Cooling Water Flow and Hours Sampled.	279
IV-6	Temperature (^{o}F and Δt) at Nine Mile Point Intake Forebay and Discharge.	279

LIST OF FIGURES (Continued)

Figure No.	Title	Following Page
V-1	Location Map	296
V-2	Location of QL&M & Non-QL&M Quality Stations	301
V-3	Average Surface Temperature vs Time 20 ft & 100 ft Stations	308
V-4	Surface Temperature vs Time 50 ft Stations NMP-W Transect	309
V-5	Monthly Mean Surface Temperature for Lake Ontario	309
V-6	Average Surface Temperature vs Time 100 ft Stations - Five Transects	309
V-7	Monthly Mean Surface Temperature at 100 ft. Stations During 1973 Survey	309
V-8	Spatial Distribution of Thermal Stratification - 50 ft. Stations Oswego-Nine Mile Point	313
V-9	Spatial Distribution of Thermal Stratification - June 25, 1973 Oswego-Nine Mile Point	315
V-10	Spatial Distribution of Thermal Stratification - September 28, 1973 Oswego-Nine Mile Point	316
V-11	Plot of Mid Depth (8M) Temperature (°C) at Plant Transects in 50' of Water at Nine Mile vs Oswego	317
V-12	Plot of Depth of Stratification at Nine Mile Point vs Oswego in 50' of Water at Plant Transects	317
V-13	Water Quality Parameter vs Time. Values are Averages of Nine Mile East, West & Center Transects in 20 & 60 Feet of Water (DO mg/1)	319

LIST OF FIGURES (Continued)

Figure No.	Title	Following Page
V-14	Water Quality Parameter vs Time. Values are Averages of Nine Mile East, West & Center Transects in 20 & 60 Feet of Water (Temperature °F)	319
V-15	Water Quality Parameter vs Time. Values are Averages of Nine Mile East, West & Center Transects in 20 & 60 Feet of Water (Chl a μg/l)	319
V-16	Water Quality Parameter vs Time. Values are Averages of Nine Mile East, West & Center Transects in 20 & 60 Feet of Water (TKN mg/l)	319
V-17	Water Quality Parameter vs Time. Values are Averages of Nine Mile East, West & Center Transects in 20 & 60 Feet of Water (NO_3N mg/l)	319
V-18	Water Quality Parameter vs Time. Values are Averages of Nine Mile East, West & Center Transects in 20 & 60 Feet of Water (Total Phosphorus-P mg/l)	319
V-19	Water Quality Parameter vs Time. Values are Averages of Nine Mile East, West & Center Transects in 20 & 60 Feet of Water (Ortho PO_4-P mg/l)	319
V-20	Water Quality Parameter vs Time. Values are Averages of Nine Mile East, West & Center Transects in 20 & 60 Feet of Water (Silicon mg/l)	319
V-21	Water Quality Parameter vs Time. Values are Averages of Nine Mile East, West & Center Transects in 20 & 60 Feet of Water (CO_2 mg/l)	319
V-22	Water Quality Parameter vs Time. Values are Averages of Nine Mile East, West & Center Transects in 20 & 60 Feet of Water (pH)	319

LIST OF FIGURES (Continued)

Figure No.	Title	Following Page
V-23	Water Quality Parameter vs Time. Values are Averages of Nine Mile East, West & Center Transects in 20 & 60 Feet of Water (TDS mg/l)	319
V-24	Water Quality Parameter vs Time at the Nine Mile East Transect in 20' of Water	326
V-25	Water Quality Parameter vs Time at the Nine Mile East Transect in 60' of Water	326
V-26	Water Quality Parameter vs Time at the Nine Mile West Transect in 20' of Water	326
V-27	Water Quality Parameter vs Time at the Nine Mile West Transect in 60' of Water	326
V-28	Water Quality Parameter vs Time at the Nine Mile Plant Transect in 45' of Water	326
V-29	Water Quality Parameter vs Time at the Nine Mile Plant Transect in 60' of Water	326

LIST OF TABLES

Table No.	Title	Following Page
S-1	Operating Characteristics, Nine Mile Point Nuclear Generation Units	S-5
S-2	Intake Characteristics	S-5
I-1	Species of Phytoplankton Collected in Whole Water and Net Samples in the Vicinity of Nine Mile Point During 1973.	10
I-2	Maximum and Minimum Abundance Within Transects and Along Contours for Net Phytoplankton Samples.	11
I-3	Maximum and Minimum Total Abundance Within Transects and Along Contours for Whole Water Phytoplankton Samples.	11
I-4	Net Phytoplankton Samples Algal Groups.	16
I-5	Paired-t Test Between Microzooplankton Samples and Replicate.	30
I-6	Rotifer Inventory Nine Mile Point - 1973.	30
I-7	Abundance of Total Microzooplankton at Nine Mile Point - 1973.	34
I-8	Patterns of Abundance at a Depth Contour: Total Microzooplankton.	35
I-9	Abundance of Rotifers at Nine Mile Point - 1973	36
I-10	Patterns of Abundance at a Depth Contour: Rotifers.	37
I-11	Abundance of Cladocerans at Nine Mile Point - 1973.	37
I-12	Patterns of Abundance at a Depth Contour: Cladocerans.	37

LIST OF TABLES (Continued)

Table No.	Title	Following Page
I-13	Abundance of Copepod Adults at Nine Mile Point - 1973.	38
I-14	Patterns of Abundance at a Depth Contour: Copepod Adults.	38
I-15	Abundance of Copepod Nauplii at Nine Mile Point - 1973.	39
I-16	Patterns of Abundance at a Depth Contour: Copepod Nauplii	40
I-17	Nine Mile Point Macrozooplankton Major Taxonomic Groups Identified From 1973 Collections.	51
I-18	Bartlett's Test for Significant Differences Between Day and Night Macrozooplankton Abundance in Surface Samples.	55
I-19	Statistical Tests for Significant Differences Between Day and Night Macrozooplankton Abundance in Mid-Water and Bottom Samples.	55
I-20	Summary of Results of Two-way ANOVA for Macrozooplankton Populations.	56
I-21	Larval Fish Found in Nine Mile Point Area	61
I-22	Statistical Analyses of Day-Night Abundance for Alewife and Total Fish Larvae.	65
I-23	Larvae Species Occurrence.	66
I-24	Nine Mile Point Totals By Length Interval (mm)	67
I-25	Chlorophyll <u>a</u> at Nine Mile Point, 1973 Plant Site.	76

LIST OF TABLES (Continued)

Table No.	Title	Following Page
I-26	Plankton Physiological Condition.	77
I-27	Analysis of Variance for Entrained Micro-zooplankton Nine Mile Point 1973.	79
I-28	Test of the Equality of % Live Microzoo-plankton Between Intake and Discharge Samples at Nine Mile Point, 1973.	79
I-29	Analysis of Variance for Entrained Macrozoo-plankton Nine Mile Point 1973.	81
I-30	Fish Larvae Viability.	82
I-31	Analysis of Variance for Entrained Fish Larvae Nine Mile Point, 1973.	82
II-1	Nine Mile Point Ecological Survey Benthic Station Substrate Composition.	89
II-2	Taxonomic Testing of Benthic Organisms.	89
II-3	Percentage of Amphipoda.	92
II-4	Transect Abundance of Tricladida.	94
II-5	Depth Distribution of Tricladida.	94
II-6	Transect Abundance of Nematoda.	95
II-7	Depth Distribution of Nematoda.	96
II-8	Transect Abundance of Pelecypoda.	100
II-9	Transect Abundance of Postocopa.	100
II-10	Depth Distribution of Ostracoda.	101
II-11	Transect Abundance of Gastropoda.	102
II-12	Depth Distribution of Gastropoda.	103

LIST OF TABLES (Continued)

Table No.	Title	Following Page
II-13	Transect Abundance of Oligochaetea.	104
II-14	Depth Distribution of Oligochaeta.	105
II-15	Transect Abundance of Diptera.	107
II-16	Depth Distribution of Diptera.	107
II-17	Seasonal Abundance Transect.	109
II-18	Seasonal Biomass By Transect.	110
II-19	Seasonal Abundance By Station.	111
II-20	Seasonal Biomass By Station.	112
II-21	Nine Mile Point Ecological Survey - Lake Temperature Values Corresponding to Benthic Collections.	119
II-22	Nine Mile Point Ecological Survey - Total Benthic Biomass in Grams for Each Transect and Station by Date.	129
II-23	Nine Mile Point Ecological Survey - Fish Support Potential at Each Station and Location by Transect.	129
II-24	Correlation Coefficient from a Regression (Y = A+Bx) of Faunal Biomass on Chlorophyll a Values, Bottom Periphyton: Nine Mile Point 1973.	140
II-25	Correlation Coefficients From a Regression (Y = A+Bx) of Biomass on Chlorophyll a Values Buoy Periphyton: Nine Mile Point 1973.	143
II-26	Bottom Periphyton - 2 Week Exposure Production Rate in $mg/dm^2/day$.	145

LIST OF TABLES (Continued)

Table No.	Title	Following Page
II-27	Bottom Periphyton Average Production Rates at a Transect ($mg/dm^2/day$).	146
II-28	Production Rates ($mg/dm^2/day$) for Buoy Periphyton, 14 August 1973 (2 Weeks) Exposure Period.	146
III-1	Total Fish Collected by Gill Net, Surface Trawl, Bottom Trawl and Seine in the Vicinity of Nine Mile Point Generating Station - 1973.	154
III-2	Total Fish Collected by Gear in the Nine Mile Point Area - 1973.	155
III-3	Inventory of Fishes Collected at Nine Mile Point Area.	156
III-4	Catch and Percent Composition of Seine Collections in the Nine Mile Point Area.	161
III-5	Biomass and Percent Composition of Seine Collections in the Nine Mile Point Area.	161
III-6	Two-way Analysis of Variance of Monthly Seine Collection Data.	163
III-7	Two-way Analysis of Variance of Monthly Seine Biomass Data.	163
III-8	Day-Night Comparisons of Catch Per Unit Effort for Surface and Bottom Trawls.	169
III-9	Day-Night Comparisons of Biomass Per Unit Effort for Surface and Bottom Trawls.	169
III-10	Comparison of Surface and Bottom Catch Per Unit Effort for Day and Night Collections.	172
III-11	Comparison of Surface and Bottom Trawl Biomass Per Unit Effort for Day and Night Collections.	173

LIST OF TABLES (Continued)

Table No.	Title	Following Page
III-12	Three Way Analysis of Variance of Day Surface Trawl Catch Per Unit Effort.	177
III-13	Three Way Analysis of Variance of Day Bottom Trawl Catch Per Unit Effort.	177
III-14	Three Way Analysis of Variance of Night Surface Trawl Catch Per Unit Effort.	177
III-15	Three Way Analysis of Variance of Night Bottom Trawl Catch Per Unit Effort.	177
III-16	Three Way Analysis of Variance of Day Surface Trawl Biomass Per Unit Effort.	177
III-17	Three Way Analysis of Variance of Day Bottom Trawl Biomass Per Unit Effort.	177
III-18	Three Way Analysis of Variance of Night Surface Trawl Biomass Per Unit Effort.	177
III-19	Three Way Analysis of Variance of Night Bottom Trawl Biomass Per Unit Effort.	177
III-20	Monthly Catch Per Unit Effort and Percent Composition of Surface Trawl Collections in the Nine Mile Point Area.	178
III-21	Monthly Catch Per Unit Effort and Percent Composition of Bottom Trawl Collections in the Nine Mile Point Area.	179
III-22	Monthly Biomass Per Unit Effort and Percent Composition of Surface Trawl Collections in the Nine Mile Point Area.	181
III-23	Monthly Biomass Per Unit Effort and Percent Composition of Bottom Trawl Collections in the Nine Mile Point Area.	181

LIST OF TABLES (Continued)

Table No.	Title	Following Page
III-24	Three Way Analysis of Variance of Surface Gill Net Catch Per Unit Effort.	191
III-25	Three Way Analysis of Variance of Bottom Gill Net Catch Per Unit Effort.	191
III-26	Comparison of Surface and Bottom Gill Net Catch Per Unit Effort at the 30, 40 and 60 Foot Depth Contours.	192
III-27	Comparison of Surface and Bottom Gill Net Catch Per Unit Effort at the 30, 40 and 60 Foot Depth Contours of Each Transect.	193
III-27(a)	Size Categories.	199
III-28	Calculated Growth of Male and Female Yellow Perch.	216
III-29	Mean Calculated Total Lengths at Annulus Formation for Yellow Perch.	217
III-30	Calculated Growth of Male and Female White Perch - Nine Mile Point 1973.	219
III-31	Mean Calculated Standard Lengths at Annulus Formation for White Perch Based On Several Studies.	220
III-32	Calculated Growth of Male and Female Smallmouth Bass.	224
III-33	Mean Lengths at Various Ages of Smallmouth Bass Based Upon Several Studies.	224
III-34	Calculated Growth of Male and Female Alewife.	226
III-35	Mean Calculated Total Lengths at Annulus Formation for Alewife.	226
III-36	Calculated Growth of Male and Female Rainbow Smelt.	228

LIST OF TABLES (Continued)

Table No.	Title	Following Page
III-37	Mean Lengths at Various Ages of Rainbow Smelt.	229
III-38	Coefficient of Maturity Values, Sample Size and Collection Dates for Yellow Perch.	235
III-39	Coefficient of Maturity Values, Sample Size and Collection Dates for White Perch.	236
III-40	Summary of Fecundity Data for 32 White Perch Collected at Nine Mile Point June 1973.	237
III-41	Coefficient of Maturity Values, Sample Size and Collection Dates for Rainbow Smelt.	240
III-42	Coefficient of Maturity Values, Sample Size and Collection Dates for Alewives.	241
III-43	Comparison of Sex Ratios for Alewives Collected by Gill Nets and Trawls vs. Impingement.	241
III-44	Summary of Fecundity Data for 11 Alewives Collected from Lake Ontario.	242
III-45	Coefficient of Maturity Values, Sample Size and Collection Dates for Smallmouth Bass.	243
III-46	Summary of Fecundity Data for 21 Smallmouth Bass.	244
III-47	Numbers of Species, Fishes, Species Diversity, Evenness, and Species Richness of Gill Net Collections, August and October 1969.	247
III-48	Numbers of Species, Fishes, Species Diversity, Evenness, and Species Richness of Gill Net Collections, May and July 1970.	249
III-49	Numbers of Species, Fishes, Species Diversity, Evenness, and Species Richness of Gill Net Collections, August and October 1970.	250

LIST OF TABLES (Continued)

Table No.	Title	Following Page
III-50	Numbers of Species, Fishes, Species Diversity, Evenness, and Species Richness of Gill Net Collections, 1 June 1971.	252
III-51	Numbers of Species, Fishes, Species Diversity, Evenness, and Species Richness of Gill Net Collections, 29 June-2 July 1971.	253
III-52	Numbers of Species, Fishes, Species Diversity, Evenness, and Species Richness of Gill Net Collections, August 1971.	253
III-53	Numbers of Species, Fishes, Species Diversity, Evenness, and Species Richness of Gill Net Collections, November 1971.	255
III-54	Numbers of Species, Fishes, Species Diversity, Evenness, and Species Richness of Gill Net Collections Offshore from James A. Fitz-Patrick Nuclear Power Plant.	260
IV-1	Hourly Alewife Impingement Rates at Nine Mile Point Nuclear Power Station and Summary of Rank Sum Test for Large Samples for Day-Night Comparisons.	265
IV-2	Hourly Rainbow Smelt Impingement Rates at Nine Mile Point Nuclear Power Station and Summary of Student's t-test for Day-Night Comparisons.	265
IV-3	Total Fish Impingement Catch - Nine Mile Point.	265
IV-4	Fish Impingement Collections at Nine Mile Point, 1973 by Sampling Date and by Species.	267

LIST OF TABLES (Continued)

Table No.	Title	Following Page
IV-5	Species List and Total Numbers of Fish Per Month During Nine Mile Point Impingement.	267
IV-6	Baseline Length-Weight Equation for River and Relative Condition Factors for Impinged Alewives at Nine Mile Point on 13 June 1973 on Lake Ontario.	273
IV-7	Baseline Length-Weight Equation for River and Relative Condition Factors for Impinged Rainbow Smelt at Nine Mile Point on 28 December 1973 on Lake Ontario.	273
IV-8	Commercial Catch of Alewives in Lake Michigan 1957 to 1972.	274
IV-9	Alewives Available to Bottom Trawls in Lake Michigan, 1963 to 1972 (After Brown, 1972).	285
IV-10	Relative Abundance of Alewives in Lake Onrario at All Stations, by Month, 1972.	286
IV-11	Alewife Stock Estimates for Mean, Minimum, and Maximum Abundance Values for All Stations, 1972.	286
IV-12	Ratios of Annual Impingement of Alewives at Nine Mile Point Unit One to Lake Ontario Alewife Stock Estimates.	287
IV-13	Relative Abundance of Alewives in Lake Ontario at Oswego (Nine Mile Point), by Month, 1972.	289
IV-14	Commercial Landings of Smelt in the Great Lakes, 1971.	292
IV-15	Commercial Landings of Smelt-Lake Michigan, 1945-1971.	292

LIST OF TABLES (Continued)

Table No.	Title	Following Page
IV-16	Commercial Landings of Smelt - Lake Ontario, 1952-1971.	292
IV-17	Smelt Abundance in Lake Ontario.	292
IV-18	Smelt Abundance, Oswego Transect.	292
IV-19	Smelt Stock Estimates for Lake Ontario.	292
IV-20	Smelt Stock Estimates for Lake Ontario from Mean Catch Rates Oswego (Nine Mile Point) Transect Only.	292
IV-21	Stock Estimates of Smelt in the Vicinity of Oswego (Nine Mile Point), by Month, 1972.	292
IV-22	Ratios of Annual Impingement of Smelt at Nine Mile Point Unit One to Lake Ontario Smelt Stock Estimates for the Entire Lake.	293
IV-23	Ratios of Annual Impingement of Smelt at Nine Mile Point Unit One to Smelt Stock Estimates for Lake Ontario Near Oswego.	293
IV-24	Ratios of Annual Impingement of Smelt at Nine Mile Point Unit One to Oswego "Vicinity" Smelt Stock Estimates.	293
IV-25	Ratios of Annual Impingement of Smelt at Nine Mile Point Unit One to Commercial Smelt Catches in Lake Ontario.	294
V-1	Water Quality Surveys on Lake Ontario Undertaken by Various Agencies	299
V-2	Values Characteristic of Lake Ontario, Off Shore, Mixed	300

LIST OF TABLES (Continued)

Table No.	Title	Following Page
V-3	Water Quality Surveys on Lake Ontario Undertaken by QL&M	301
V-4	Comparison of Water Quality Parameters at Stations in the Oswego Region of Lake Ontario, Including the Oswego River	301
V-5	Comparison of Water Quality Parameters at Stations in the Nine Mile Region of Lake Ontario	301
V-6	Summary of Bathythermograph & Martek Readings During 1973 at Oswego and Nine Mile Point	307
V-7	Depths of Stratification, Oswego-Nine Mile Point, May-December 1973	313
V-8	Water Quality Parameters Over All Stations at NMP, All Time, Over All Depths (S&B)	322
V-9	Trace and/or Heavy Metals - 1973 Nine Mile Point Water Quality Investigations	324
V-10	Computer Retrieval Categories	324
V-11	Similarities in Correlation Coefficients Within NMP Bimonthly Computer Retrieval Categories for Selected Parameter Pairs	326
V-12	Analysis of Variance - 1973 Nine Mile Point Water Quality Investigations	327
V-13	Anova Set 1, 3-Way Anova, NMP-1 through NMP-6	328
V-14	Anova Set 2, 2-Way Anova, NMP-1 through NMP-6	328

LIST OF TABLES (Continued)

Table No.	Title	Following Page
V-15	Anova Set 3, 3-Way Anova NMP-7 and NMP-8	328
V-16	Anova Set 4, 2-Way Anova NMP-7 through NMP-12	328
V-17	Anova Set 1, Homogeneous Subsets	328
V-18	Anova Set 2, Homogeneous Subsets	328
V-19	Summary of Intake and Discharge at Nine Mile Point Power Plant	331
V-20	Nine Mile Point Effluent Analysis - Daily Average at Discharge Channel, and Storm Drain	331
V-21	Analysis of Influent & Effluent at Power Plant Oxidation Pond - 24 Hour Composites	331
V-22	Nine Mile Point Sediment Characteristics	332

SUMMARY

A. INTRODUCTION

The 1973 Ecological Report is organized into three volumes: two volumes contain descriptive report material and one volume contains the year's data summarized in tabular form and a documentation of field, laboratory and statistical methods.

Volumes I and II provide the results and interpretation of data from each portion of the project. Chapter format is as follows:

Chapter	Title	Topics Covered
I	Plankton	Phytoplankton, zooplankton, fish eggs and larvae, entrainment primary productivity, and plankton overview.
II	Benthos	Benthic invertebrates, periphyton, benthic fish support potential, benthos overview.
III	Fish	Studies of fish in the vicinity of Nine Mile Point - overview of fish stocks.
IV	Fish Impingement	Fish impingement studies, overview of impingement and effects on populations in Lake Ontario
V	Water Quality	Water quality, chemistry, hydrology, meteorology, overview.

Volume III consists of appendices which present the supporting data for each of the technical Chapters. Appendices documenting all techniques and procedures employed in the field and in the laboratory are included. A special appendix is provided which documents the statistical tests and mathematical procedures used in formulating the conclusions arrived at in the body of this report.

Niagara Mohawk Power Corporation (NMPC) and the Power Authority of the State of New York (PASNY) have funded jointly a study to determine the effect on the aquatic ecosystem of existing and future generating stations at the Nine Mile Point site. These studies involve a comprehensive documentation of the chemical, physical and biological characteristics of Lake Ontario in the vicinity of Nine Mile Point. This report represents the results of studies conducted during 1973. It serves to document the condition of the aquatic ecosystem at Nine Mile Point four years after operation of Nine Mile Point Unit 1. Further, this report serves as a documentation of baseline pre-operational data relevant to the future operation of the James A. FitzPatrick Nuclear Power Plant and Nine Mile Point Unit 2.

The purpose of this report is to provide an in-depth description of the aquatic ecology in the vicinity of Nine Mile Point and the status of the biota and water quality in relation to pre-operational conditions. However, other than for sites located on virgin waters, there exists no real possibility of conducting, in the strict sense, a "pre-op/post-op" ecological comparison. Due to impacts from a variety of activities, any system, including Lake Ontario, is likely always to be in the process of alteration, response, or tending toward a new equilibrium from natural and man-induced environmental alterations.

Impacts upon a natural system may derive from activities, such as power plants, domestic waste disposal, domestic water supply intakes, industrial operations, flood control and irrigation, land-based construction, port construction, commerical fisheries, sports fisheries, boating and others.

Each activity imposes its own unique stress or alteration upon the system. It should be pointed out; however, that each alteration of an aquatic system

need not, in fact very rarely will, lead to irreparable harm. In many instances engineering activities, such as construction, land development, etc., will have a measurable effect on a system, but only on a short-term basis.

The inherent plasticity of biological systems almost invariably generates a homeostatic ecological response pattern when ecological impact occurs. It is in this context that an environmental assessment of the Nine Mile Point site must be made.

The data constitute an extension of ecological observations based on a scope of work initiated in 1971 (Storr, 1973), and expanded through 1972 (Storr, 1973; QL&M 1973a). Collections of fishes, phytoplankton, zooplankton, benthos, water chemistry and water quality are natural history data. However, in the treatment and organization of these data, the objective has been to establish for Nine Mile Point the basic interrelationships between organisms and their environment. The community approach to ecosystems utilized herein affords an opportunity to assess the conditions of the system as a whole, as well as from the perspective of a single species. Nutrient cycling, seasonal stability, energy flow and communities in development may be perceived using the tools of observation, natural history, population biology and the integrative techniques of community analysis presented in this report.

1. TIME COVERAGE

The Nine Mile Point site has been the focus of pre-operational ecological studies since 1963, at which time Dr. John F. Storr began accumulating data relevant to the basic current flow patterns, plankton, benthos and fish populations of Lake Ontario prior to and during Nine Mile Point Unit 1 reactor and generator construction.

Pre-operational assessment of Lake conditions, biotic components and ecological relationships (Storr, 1973) were utilized wherever possible in formulating the conclusions of the present report regarding the assessment of the effect of plant operation on aquatic ecology at Nine Mile Point. Post-op evaluation of the ecological effects of steam electric generating stations must span a lengthy time-course. While evaluation of effects relies upon pre-op/post-op data comparisons, sufficient data must be gathered in the post-operational phase to identify not only measurable differences in populations or communities, but also to identify whether the changes documented constitute part of natural biological variation, or serve as tangible evidence of trends, showing that the the system has, in fact, been affected and is seeking a new equilibrium.

The lake-wide approach to Ontario ecological studies will, in this report, be confined primarily to fishes, fisheries and the relatively few other communities which have received intensive study in recent years.

2. SPACE COVERAGE

a. Nine Mile Point

There are two nuclear electric generating stations located on the Nine Mile Point promotory on the south shore of Lake Ontario, one of which has been operating since December 1969; the other is scheduled to go into operation during August 1974. A third nuclear station is proposed for this site (Nine Mile Point Unit 2) and is scheduled for operation in 1979.

The operating station, Nine Mile Point Unit 1, and the proposed station, Nine Mile Point Unit 2, are owned and operated by Niagara Mohawk Power Corporation.

Both stations will occupy the same 900 acre site in the Town of Scriba, Oswego County, New York. Immediately adjacent to this site is the 702 acre site owned by the Power Authority of the State of New York. This is the site of the James A. FitzPatrick Nuclear Power Plant presently completing pre-operational testing. Operating characteristics and intake characteristics of the generating units at Nine Mile Point are presented in Tables S-1 and S-2.

Ecological studies at Nine Mile Point have been designed to document and evaluate the condition of the aquatic biota in the vicinity of Nine Mile Point. For the purpose of this study the "vicinity" of Nine Mile Point is defined as the area within a three-mile radius of the generating station. Samples were collected within this area to describe adequately the chemical, physical and biological parameters of the Lake ecosystem and to allow an evaluation of ecosystem function under the influence of the generating stations.

The biota of the Nine Mile Point vicinity demonstrate no ecological relationships any more unique than the Lake Ontario system itself. The Lake supports a minimum of four species of fish as landlocked populations whose original habitat was estuarine or marine: lamprey eel, alewife, smelt, and white perch. Of these, the presence in the Lake of three (alewife, smelt and perch) may be traced to introduction by man. Fisheries managers are in the process of introducing other species, the coho and chinook salmon, to the Lake Ontario system in hopes that these anadromous fish will establish a breeding population in the Lake and replace the formerly abundant lake trout as a desirable sport and commercial fish.

TABLE S-1

OPERATING CHARACTERISTICS, NINE MILE POINT NUCLEAR GENERATION UNITS

	NMP UNIT 1 (operational)	NMP UNIT 2 (in construction)	J. A. FITZPATRICK (August 1974 start
Generating capacity (MW_e)	610	1100	821
Cooling water flow (GPM)			
condenser	250,000	503,000	352,300
service water	18,000	32,000	17,900
Heat rejection (BTU/hr)	4.0×10^9	8.1×10^9	5.7×10^9
Cooling water temp. rise (OF)	31.2	32.2	31.5

TABLE 3-2

INTAKE CHARACTERISTICS

	FITZPATRICK	UNIT 1	UNIT 2
Length of main tunnel from existing NMP shoreline	900 ft.	850 ft.	1300 ft.
Number of openings	4	6	6
Size of opening	8 ft. high x 17.7 ft. wide	5.5 ft. high x 10.3 ft. wide	75 ft. high x 27 ft. wide
Other dimensions	3 ft. sill 2 ft. roof	3 ft. sill 6 in. roof	3 ft. sill 2 ft. roof
Maximum velocity through intake	1.4 fps	1.8 fps	1 fps
Tunnel cross-section	117 sq.ft.	78 sq.ft.	238 sq.ft.
Water velocity at screens	1.4 fps	0.85 fps	1 fps
Water depth at intake location	24 ft. (LWD)	24.5 ft. (LWD)	24.5 ft. (LWD)
Water depth to top of structure	10 ft. (LWD)	15.5 ft. (LWD)	12.0 ft. (LWD)
TOTAL FLOW	370,200 (gpm) (825 cfs)	268,000 gpm (597 cfs)	535,000 gpm (1188 cfs)

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TABLE S-2
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OUTFALL STRUCTURE CHARACTERISTICS

	FITZPATRICK	UNITS 1 & 2
Length of main tunnel from existing Nine Mile Point Shoreline	1,200 ft.	1,500 ft.
Tunnel velocity	4.7 fps	5 fps
Length of diffuser	775 ft.	510 ft.
Number of diffuser ports	12	20
Number of diffuser ports per riser	2	2
Inside diameter of diffuser ports	2.5 ft.	2.5 ft.
Port spacing	150 ft.	45 ft.
Initial jet velocity	14 fps	81.2 fps
Angle between ports	42°	20°
Total diffuser flow	825 cfs	1788 cfs
Average depth of port centerline below mean low water	24.5 ft.	40 ft.
Average depth to Lake bottom below mean low water	30.5 ft.	45 ft.
Port temperature rise above Lake ambient	31.5°F	30.9°F

The Great Lakes Basin

An important aspect of any power plant study is the geographic range covered by populations which utilize the plant site during any phase of their life history. This defines the extent to which the harmful or beneficial effects of power plant operation may range. Some species present in great abundance as eggs, larvae or juveniles in the Lake at Nine Mile Point may range over a broad expanse of Lake Ontario and into the Atlantic Ocean. In the case of the Americal eel, an abundant catadromous fish in Lake Ontario waters, spawning migrations may carry adults from freshwater ponds and streams in the Ontario drainage to the depths of the Sargasso Sea.

3. SYSTEM PARAMETERS AND ANALYSIS

Delineation of System Parameters

(i) Plankton

The plankton may be differentiated into phytoplankton and zooplankton. Several categories exist within each of these groups, serving to characterize the plankton by size, function and origin.

The classical description of the plankton as immobile creatures at the mercy of the currents is, to a certain extent, erroneous. Most planktonic organisms, phytoplankers included, are capable of either maintaining their vertical position in the water column or undertaking substantial vertical migrations. The zooplankters of Lake Ontario are capable of vertical migrations of many meters, spanning distinct current and flow regimes in the process.

Phytoplankton in Lake Ontario provide a major portion of the basic energy requirements of the system. In most lakes and in coastal and offshore marine

environments the phytoplankton, fixed algae and encrusting algae are the major source of energy-rich organic molecules upon which the system thrives. In estuaries, swiftly flowing rivers and streams, and some lakes, allochthonous material (substances in the aquatic system derived from external sources) in the form of detritus may form an important part of the energy base. Detritus input may be derived from a variety of sources, including decomposition products from vegetation in the watershed, feedlot drainage, and domestic waste disposal.

Phytoplankton are representatives of several plant classes: the blue-green algae (Cyanophyceae), the green algae (Chlorophyceae), the diatoms (Bacillariophyceae), the golden brown algae (Chrysophyceae), the dinoflagellates (Dinophyceae), the cryptomonads (Chryptophyceae), the euglenoids (Euglenophyceae) and the yellow-green algae (Xanthophyceae). The most numerous and most ecologically important forms are blue-green algae, diatoms, green algae and cryptomonads. Various blue-greens, greens and diatoms are important in their contribution to noxious blooms in enriched water. For the most part, diatoms are desirable forms, and diverse diatom communities are considered indicative of good water quality.

The phytoplankton studies included in the present report are primarily species inventories, representing in-depth inventory studies necessary to make a full evaluation of baseline conditions in the Lake Ontario phytoplankton community. For the purposes of establishing the biological correlate of Lake Ontario water quality, particular attention has been paid to the potential nuisance algae, primarily the blue-green algae. The present studies encompass evaluations of algal standing crop, productivity, and definition of the phytoplankton community structure.

The zooplankton have been divided into several groups based upon size of the organism, and the source or origin of the planktonic form. Zooplankton are composed of the holoplankton (organisms which spend their entire life history in the plankton) and the meroplankton (organisms representing life history stages of organisms which are not planktonic as adults). The true zooplankters are forms such as copepods, cladocerans, rotifers, and protozoans. Meroplankton are fauna whose adult stages may be benthic, pelagic, or terrestrial, such as the eggs and larvae of clams, mussels, crabs, snails and fishes. For the purpose of the present study, the zooplankton have been differentiated into the ichthyoplankton (meroplanktonic fish eggs and larvae), the microzooplankton (primarily holoplankters too small to be retained by a 571μ mesh net), and the macrozooplankton (planktonic and meroplanktonic forms other than fish eggs and larvae which are retained by the 571μ mesh net).

The zooplankton represent an important component of the ecological system, including primary and secondary consumers. They convert very fine particulates of high organic content (e.g. algae, bacteria and detritus) into animal protein suitable for consumption by organisms at high trophic levels. Food consumption and assimilation, reproduction and turnover rate for the true zooplankton are rapid, providing a vital, renewable nutrient resource for filter feeding adult fishes, larval fishes and many other life forms.

As vital links in the food web and as forms incapable of extended horizontal movement, the populations of zooplankton in a lake such as Ontario, require careful evaluation in relation to the possible effects of power plant operation. The lower level secondary producers (zooplankton) have been studied primarily

to establish a species inventory for the Lake and to describe, in relative terms, seasonal and spatial patterns of distribution and abundance. The studies include assessment of community structure, rates and mechanisms of secondary production, and definition of standing crop estimates in Lake Ontario waters at Nine Mile Point.

(ii) Benthos

The benthos represent an ideal indicator community for field studies of environmental impact for a variety of reasons:

1. they are easily sampled,
2. they are "fixed" or relatively immobile and as such cannot help but respond to impacts directed upon them, and
3. their importance to other communities is readily established.

The benthos may be subdivided according to functional or structural characteristics. Benthic communities are composed of benthic infauna (those organisms which live in the sediments) and epifauna (those organisms which live at the sediment-water interface, but whose major activities are performed on the surface of the sediments rather than in the sediments themselves). Many of the benthic eipfauna undergo daily vertical migrations into the water column and as a result appear in macrozooplankton samples. Forms common to Lake Ontario which show this behavior are the amphipods (or scuds), opossum shrimps (Mysis), certain cladocerans (e.g. Leptodora) and some insect larvae (e.g. Chaoborus)

The benthos perform a variety of essential ecological functions which range from direct effects on the sediment and its chemical make-up to conversion of detritus to animal biomass and assisting in recirculation of nutrients trapped in the sediments.

eding strategies among the benthos range from primary consumers (e.g., snails feeding on encrusting diatom growths) to detritus feeders (e.g., insects feeding upon decayed carcasses of other organisms).

(iii) Fish Eggs and Larvae

The primary objective of fish egg and larval studies is to define the patterns of distribution and abundance of the major groups of ichthyoplankton in Lake Ontario at Nine Mile Point.

Fish eggs and larvae (ichthyoplankton) are meroplanktonic, representing the early, juvenile stages of some of the fish species which spawn in the Lake and its tributaries. The abundance of ichthyoplankton on an annual basis is dependent only upon the intensity of a given year's spawning activity, and those factors in the environment which determine rates of mortality in the larval population. Since fish larvae of a single fish species do not reproduce, ichthyoplankton biomass represents a non-renewable source pertinent to the nutrition of other organisms and recruitment of the adult fish population. In the system-overview, fish eggs and larvae serve as a continuous food source to other organisms due to the sequential spawning of several species of fish in the Lake and, therefore, represent a seasonally variable, renewable resource. As a resource of recruitment to the adult population, the annual spawning activity for a species limits the number of potential adults to be derived from that spawning. Regulation of adult abundance for a given species, however, depends not only upon the numerical abundance of juveniles spawned in a given year, but also upon a complex interaction of natural mortality, predation, abundance, distribution and development. This injects a density-dependent compensation factor into the equation from which one may try to calculate recruitment from spawning intensity.

The length of time fish eggs and larvae remain planktonic depends upon the species. The eggs of some species of fish (e.g., white perch) which spawn in Lake Ontario do not become planktonic because they adhere to vegetation or stones or because the eggs are laid in nests (e.g., sunfishes, sticklebacks).

The larvae of some species spawning in Lake Ontario are absent from ichthyoplankton samples, or they are present in numbers far fewer than one would expect based upon the numbers of adults and juveniles resident in the Lake. Sunfish are a good example. For several days after hatching, juvenile sunfish are guarded by the adult male. Parental behavior includes herding the larvae in a tight school and preventing their dispersal until they have reached the age where they can protect themselves in the dense vegetation of backwater areas. The larvae of several of the more important sport and commercial fishes (white perch, yellow perch and smelt) are subject to wide dispersal by currents.

The assessment of the effects of power plant operation on the ichthyoplankton included studies of larval abundance in the power plant cooling water flow, determination of the survival potential of larvae after passage through the plant, and estimation of the short-term and long-term effects of power plants on ichthyoplankton populations in the Lake.

(iv) Fish

This report presents studies of fishes in Lake Ontario from three points of view:

1. inventories reflective of the fish species composition in the Lake today;
2. population characteristics of abundant species; and
3. the fish community in the Lake at Nine Mile Point as demonstrative of the stability and diversity of the fish fauna in Lake Ontario.

(v) Hydrodynamic Characteristics

The existence of the flora and fauna of any lake system depends upon a variety of ongoing physical processes to provide suitable habitat, nutrients, routes of dispersal, transport and, in some cases, partners for breeding. Therefore, the eventual understanding of an ecosystem is dependent upon being able to relate biological events with the physical determinants of the system. An understanding of hydrodynamics provides a valuable data base against which one can compare biological data and attempt to define which physical parameters limit and control the ecosystem.

(vi) Water Quality

In order for an aquatic organism to survive, grow and reproduce in a chosen or preferred habitat, a variety of physical, chemical and biological criteria must be met. The chemical requirements for survival, growth and reproduction constitute what is generally referred to as water quality criteria.

Pre-operational studies in the vicinity of Nine Mile Point have employed extensive surveys of water quality and water chemistry at sites coincident with biological sampling stations. The chemical observations to date serve to identify one chemical environment within which the observed complexity of plankton, benthos and fish may successfully survive for the duration of their life history, grow to sexual maturity and reproduce.

The interaction of chemical factors in the environment with the biota may be perceived at two levels: the chemical, wherein the level of concentration of a chemical entity affects an organism directly; and the physiological, wherein the organism has the capacity to regulate the effect of the chemical on its system by adapting in the context of survival, growth and reproduction.

The assessment of power plant impact on water quality parameters serves a dual purpose. First, the direct measurement of water quality parameters will serve to quantify changes in water quality which may occur as the result of plant operation. Second, the values and changes in values for various parameters can be related to the biology of the Nine Mile Point area.

With these data, an attempt shall be made to define the relationship between water quality parameters and the biota, resulting in an expression of the overall "health" of the aquatic system.

(vii) Natural and Man-made Parameters

Many events in areas near Nine Mile Point may well have induced homeostatic responses in the aquatic communities at Nine Mile Point; the final state of these responses may not have been achieved at this time. The imposition of the power plant construction and operation may influence the first response additively, geometrically, or not at all. In any case, the present evaluation of plant effects must occur within the context of the aquatic community in its present state of response or stability. Final decision concerning the real impact of any activity imposing stress upon an aquatic system should be deferred until consistent, trend-setting data are available. The present report is intended as an interpretive contribution to the initial stages of trend definition as the Lake Ontario aquatic system responds to the presence of power stations at the Nine Mile Point site.

b. Integrative Procedures

As defined previously, the pre-operational methodology instituted for the Nine Mile Point site study consisted of an ecological survey to describe the biotic

and abiotic environment within the vicinity of Nine Mile Point, including the incorporation of available Lake-wide or global data into a system description.

The present report is descriptive of post-operational conditions, showing a dynamic aquatic system composed of interacting biotic communities. The data accumulated in the course of study have been treated, therefore, as component bits of information relating to the overall functions of a naturally integrated system, rather than as isolated observations related to, e.g., fish, fish larvae, or phytoplankton.

Several approaches to data integration have been used: modelling of biological/physical interactions; reductional analysis of community structure; and interrelationships between populations which perform discrete functions in the ecosystem.

The integrative procedures used in the report are primarily a variety of community and statistical analyses applicable to any trophic level or population of entities (e.g., a chemical "species") sampled.

Numerous techniques are available by which community structure may be analyzed. Although the various techniques are often referred to by the generic term "diversity index," each technique for expression of community structure has distinct advantages over other techniques and weaknesses for which other techniques compensate.

The reduction techniques applied to the data in this report were carefully chosen to represent adequately community structure in terms of:

- the numbers of species (inventory) represented in collections,
- the distribution of individuals among species in communities,
- the expected upper limit of species diversity within a community, and
- the evenness of the community.

Four indices have been used. The first, species richness, is an expression which describes communities primarily according to the number of different species present in the community. A major strength of the species richness expression is that, by weighting heavily the numbers of species represented in the community, the index recognizes the potential for community stability based upon potential complexity and the number of intrarelationships possible between members of the community. The major weakness of the species richness index is its failure to account for distribution of individuals among the species represented in the community.

A second index, the information theory diversity index, accounts for the distribution of individuals among species by weighting the numbers per species. Consider two communities of 100 individuals representing five species; one with individuals distributed among species in the ratio of 96:1:1:1:1, the other with individuals distributed in the ratio of 20:20:20:20:20. Species richness values for the two communities would be similar in recognition of the same potential for complexity and stability in the two communities. However, information theory diversity would show a high value for the community having a maximum distribution of individuals among species (20:20:20:20:20), and a low value for the community having the majority of individuals in a single species.

Two additional values may be derived from the data used to estimate species diversity. These are the calculations of "theoretical maximum diversity,"

derived from information theory diversity, and "evenness," derived from the relationship between calculated information theory diversity and theoretical maximum diversity.

The presentation of Lake Ontario ecological data in the context of communities affords an added dimension to our knowledge of the ecological system at Nine Mile Point. That is, with community analyses, significant environmental or biological impact in post-operational studies are detected more easily. The latter point is an important new tool, since by examination of community structure the factors of natural, homeostatic response due to natural and man-induced stresses may be assessed, in context, over a much shorter time period.

B. ASSESSMENT

In this section of the report an interpretive overview of data from Nine Mile Point studies and information existing in the literature on Lake Ontario are provided. The objectives are to describe the ecology of Nine Mile Point and to assess the ecology of Nine Mile Point in the context of Lake-wide data and pre-operational ecological data.

Alternative conclusions will be discussed to provide points of view against which the value of the present assessment may be weighed. The ecological programs and entrainment/impingement programs conducted at the Nine Mile Point site indicate that the operation of the existing station has not and will not have any measurable detrimental effect on the aquatic ecology of Lake Ontario.

1. THE LAKE ONTARIO SITUATION

Historically, the Laurentian Great Lakes were included within a massive inland sea, Lake Algonquin, whose shorelines had been altered significantly by the

Pleistocene glaciers to form a series of distinct lakes. In point of fact, it is presumed that the present Great Lakes, formed along the ancient course of the St. Lawrence River, altered their drainage from the Mississippi and Ohio Rivers to the St. Lawrence as the land rebounded from the weight of glacial ice (Coleman, 1922). The existence of discrete bodies of water in the vicinity of the Great Lakes region for several thousand years is attested to by the many unique varieties and subspecies of fish found endemic to certain of the basins prior to the extensive canal construction of the 19th and 20th Centuries. At their inception, the Great Lakes were oligotrophic.

In modern times the hydrologic relationship of Lakes Erie and Ontario have produced a most interesting limnological situation. Considering the Great Lakes as a river system, the last in line, Ontario, derives a substantial proportion of its flow from Lake Erie. Given the trophic status of the two lakes and the low trophic potential of Ontario (i.e., few urban and industrial areas, deep basin, few major tributaries), it may be seen that a major factor in the aquatic ecology of Lake Ontario is Lake Erie. Despite the natural rate of eutrophication in Lake Ontario, cultural impact is likely speeding up eutrophication in Lake Erie and having significant impact on the Ontario basin (Beeton, 1969; Ogawa, 1969).

Beeton (1965) classified Lake Ontario as mesotrophic*, showing the flora and fauna of an oligotrophic system and the physico-chemical characteristics of an eutrophic system. Ogawa (1969) showed that the phytoplankton of Lake Ontario

* Mesotrophy denotes a system intermediate to oligotrophy and eutrophy, approaching, but not having the characteristics of a classically eutrophic system.

qualitatively resembled that of Lake Erie (i.e., eutrophy), but quantitatively resembled oligotrophic Lake Michigan.

Lake Ontario fish fauna tend to confirm the classification of Lake Ontario as mesotrophic. Christie (1973) provided a detailed description of the past and present fish fauna of Lake Ontario in the context of "indicator" species. His summary statements concerning the populations of fish in Lake Ontario were directed primarily toward analysis of events which caused observed changes in the fish stocks, but are suggestive of the rather recent and abrupt changes in trophic status of the Lake. However, within the fish community the connotations of "trophic status" may take on quite a different meaning that trophy as related to the nutrient characteristics of surface waters.

Beyond concentrations of nutrients in water, trophy and trophic relationships assume a more dynamic aspect than simple availability of nutrients. Once minerals are incorporated into energy-rich molecules during photosynthesis, two simultaneous processes occur: one is cyclic; the other is unidirectional. These are, respectively, mineral cycling and energy flow (Odum, 1971). Despite the classification of a lake as oligotrphic or eutrophic, the system may be balanced or unbalanced trophically. In Lake Ontario, for example, a very great proportion of energy is transferred into alewife biomass, for which there are few, if any, predators. Thus, even in an oligotrophic system there may exist a trophic or energetic imbalance.

This phenomenon, however, has been in progress since the mid-1800's (Smith, 1972; Christie, 1973; O'Connor, 1973) and bespeaks more the activities of commercial fisherman than a changing character of Lake Ontario's waters. A wealth of arguments derived from the theories of niche diversification, eco-catastrophe

and niche utilization (Hutchinson, 1967; Slobodkin, 1961) could be advanced to defend the classification of Lake Ontario as oligotrophic, despite a distinct lack of the cold-water fish fauna that are found in the other Great Lakes. Such arguments would be moot, however, for Lake Ontario is and will remain difficult to categorize by a single term or concept (Ogawa, 1969).

2. THE BIOTA OF LAKE ONTARIO

The majority of biological data for Lake Ontario consist of inventory and survey reports documenting the presence or absence of a variety of plankton, benthos and fishes at various points in time during the past century. The seasonal distribution of organisms has been documented at various sites in the Lake for several years during the past decade (see Beeton, 1965, 1969; Davis, 1966; Sweeney, 1969; Christie, 1971). By virtue of the economic importance of fishes to the human population of New York State and the provin[ce] of Ontario, much more attention has been paid the fishes and fisheries of Lake Ontario than any other community (see bibliography by Downing et al., 1972; Christie, 1973).

Much effort has been directed toward a categorization of environmental changes in the Laurentian Great Lakes, including Lake Ontario. Beeton (1965) and Christie (1973) pay particular attention to changes in Lake Ontario fish stocks and fisheries, whereas the historical benthos, plankton and chemical characteristics of the Lake are widely distributed among several reports (see Beeton, 1969; literature summaries in the Plankton and Benthos sections of this report.

3. ASSESSMENT

Previous sections have introduced the context in which the present post-operat

assessment of the Nine Mile Point and James A. FitzPatrick Nuclear Stations must be made. It is inevitable that some ecological differences be found between the present data and that reported in the literature, for no biological population, however well-balanced within its environment, is static. All are dynamic, generally showing evidence of variance about a mean from generation to generation.

It is likewise inevitable that the data presented in the body of this report show differences between the vicinity of Nine Mile Point and other sectors of Lake Ontario. Indeed, any study should show differences in areal and spatial distribution of biota, for no environment is homeogeneous to the extent that populations dispersed in a Lake of 7340 square miles could be the same.

Further, it is inevitable that differences in data will occur between control transect stations and stations near and in the heated water effluent. It is our charge to take these data, provide interpretation in a system overview, and evaluate the impact (whether observed or projected) on the Lake Ontario ecosystem within the confines of natural eutrophication phenomena.

a. Lake Function

Lake Ontario biological studies over the years provided extensive data which, when perceived in overview, define distinct functions for the Lake at each stage of its "aging" in geologic time (see summaries by Beeton, 1969; Christie, 1973; bibliography by Downing et al., 1973; RG&E, 1974). The several functions of the Lake derive energy from a common source (photosynthesis and allochthonous detritus input) yet allocate the energy toward distinctly different end products.

Lake Ontario may be perceived as an extraordinarily wide and deep portion of the St. Lawrence River in which the chemical and biological environment are

distinct from the river. The functions of Lake Ontario include:

1. the support of resident populations of plankton, benthos and fish;

2. the provision of energy resources to ecosystems external to the Lake, e.g., St. Lawrence River;

3. the accumulation of nutrients as a natural process, i.e., to become eutrophic; and

4. the regulation of nutrient cycling and energy flow within all communities in the system.

The ecological assessment of the Nine Mile Point area is being executed in terms of the defined functions of the Lake, treating first the primary producers; second the primary consumers (zooplankton); third, the benthos; and fourth, the fishes. The chemical environment of the Lake in terms of historical changes and present-day concentrations constitutes an integral part of the overview in each section.

b. Phytoplankton

Data from 1973 studies at Nine Mile Point demonstrate that operation of Nine Mile Point Unit 1 had no measurable impact, positive or negative, upon the phytoplanktonic community. The taxonomy, distribution and abundance of phytoplankers at the site are essentially the same as has been determined for the Lake as a whole. The potential effects of the Nine Mile Point Station on primary production cannot be evaluated from the data available in the literature. Programs ongoing in 1974 will provide an assessment on the localized effects of the power plant on photosynthesis.

(i) Taxonomy

Records documenting phytoplanktonic species in Lake Ontario waters date back

to at least 1924 (Davis, 1969). In his report on changes in the biota of Lake Erie and Ontario (Sweeney, 1969), Davis presented in tabular form a record of species dominating the vernal diatom pulse at Toronto on Lake Ontario. These records showed clearly a change in species composition of Asterionalla, Melosira and Cyclotella between 1925 and 1954. Several authors (Beeton, 1965, 1969; and others) have noted that the phytoplankton species observed in the Great Lakes in recent times would, under normal circumstances, be regarded as firm indicators of eutrophy. However, Melosira, Tabellaria and Cyclotella occur even in the most oligotrophic of the Great Lakes. On the other hand, the fact of environmental changes occurring in Lake Ontario and, just as importantly, in Lake Erie, cannot be denied. Lake Erie has been classified as eutrophic, and properly so, particularly in the shoal western basin (Beeton, 1965, 1969). Since this Lake contributes 83% of the inflow to Lake Ontario, it is understandable that Ontario, particularly the western end, would be affected by the chemical characterisitcs of eutrophic Lake Erie water.

The phytoplankton species in the vicinity of the Nine Mile Point generating station conform closely to inventories of species recorded for shoal waters in Lake Ontario and are composed partially of species characteristic of the open Lake (see: Schenck and Thompson, 1965; Davis, 1966, 1969; Nalewajko, 1966, 1967; Ogawa, 1969; Munawar and Nauwerck, 1971; Phytoplankton, Chapter I of this report). No significant change has occurred in the species of phytoplankton present in the waters of Lake Ontario in the past decade. The taxonomy of the Nine Mile Point phytoplankton reflects the same species shifts observed in other parts of the Lake over the past 50 years (Chapter I, this report).

Nine Mile Point Unit 1 has been in commercial operation for more than four years. There was no difference observed between the major species of phytoplankton found at Nine Mile Point in 1973 and species inventories for other areas of the Lake since about 1947. Within the context of natural and cultural eutrophication ongoing in Lake Ontario, it is concluded that the operation of Nine Mile Point Unit 1 had no effect on the components of the phytoplankton community.

(ii) Abundance and Distribution

Since many algae respond to toxins, stress or inhibitors with a reduction in growth (i.e., division) or encapsulation into spores, impact on the phytoplankton may be evaluated by an examination of the abundance and distribution patterns of phytoplankton populations in the vicinity of the plant in relation to the abundance and distribution of the same species in the Lake as a whole.

As of the year 1966 no studies had been conducted which examined in detail the distribution and abundance of Lake Ontario phytoplankton. Several reports provided quantitative information of phytoplankton populations, but the work was restricted in either time or space (see review in Davis, 1966).

Schenk and Thompson (1965) studied the abundance of phytoplankton in the intake of the Toronto filtration plant and showed that the mean annual quantity of phytoplankton nearly doubled between 1923 and 1954, with an increase of 5.0 areal standard units per ml per year. Despite the trend detected at the Ontario filtration plant (Schenk and Thompson, 1965), Lake-wide studies undertaken in 1964 (Ogawa, 1969) showed that no appreciable increase in phytoplankton abundance had occurred in the vicinity of Nine Mile Point between 1964 and 1973

(10^4 - 10^6 cells/l at Nine Mile Point 1973 (Chapter I this report) versus 5.0 x 10^5 cells/l at Ogawa's station 71, Nine Mile Point, 1964).

Nalewajko (1966, 1967) stressed the difference in abundance of phytoplankton, particularly diatoms, between inshore and open-lake waters of Lake Ontario. The conclusion derived from these data was that Lake Ontario may be divided into two zones: the open Lake, characterized by phytoplankton associations and abundance indicative of oligotrophic conditions; and inshore region characterized by associations and abundance similar to those of a eutrophic lake.

The 1973 studies at Nine Mile Point examined the distribution and abundance of phytoplankton along a gradient from east to west and along transects from 10 to 60 ft. depths.

Net phytoplankton abundance varied throughout the sampling period, as would be expected in a natural system. All transects showed a peak in abundance during the month of July, 1973. The magnitude of algal abundance was quite similar across the east to west horizontal gradient at any given depth. The data showed no trends suggestive of an effect from Nine Mile Unit 1.

Critical in the analysis of power plant effects is the potential stimulating effect of the heated water discharge on phytoplankton abundance, either at the discharge or slightly downstream from the discharge. The sampling stations established at Nine Mile Point were of considerable value in estimating this effect, since regular sampling schedules provide algal abundance both upstream and downstream of the present discharge, as well as at the point of discharge.

At all transects and at all depths the pattern of net phytoplankton abundance was similar. In no instance was there evidence of a plant-stimulated increase in abundance.

The same conclusion may be drawn by comparing upstream-downstream values. In some instances downstream values exceeded upstream values. In some cases, the reverse was true. No single trend of effect was evident.

Almost the same conclusions may be drawn from the whole water phytoplankton data; no single identifiable trend, with either season or transect can be derived from the data. A trend was identified, however, wherein the abundance of phytoplankton decreased with distance from shore, or, more properly, with increased depth contour.

Nalewajko (1966, 1967) and Ogawa (1969) in reporting work performed well before the construction of Nine Mile Point Unit 1 (1964) noted a similar phenomenon, however. In general, the quantities of phytoplankton decreased as one moved Lake-ward from shore; in fact, species composition changed as well.

In light of the prior demonstration of an inshore-offshore gradient in algal cell abundance (Nalewajko, 1966, 1967; Beeton, 1969) and since the trend at Nine Mile Point involves changes of less than an order of magnitude, the only interpretation of the data is that, at Nine Mile Point, the abundance of phytoplankters conforms to a general pattern previously established for the Lake.

The composition of the phytoplankton community likewise changed significantly between depths at any given transect. However, species composition for given depths at all transects remained similar. Since the data confirm previous reports for Lake Ontario phytoplankton species composition (Nalewajko, 1966, 1967), the changes observed cannot be attributed to the four-year operation of the station.

(iii) Standing Crop and Productivity

Standing crop of phytoplankton, estimated by chlorophyll a determination, showed approximately the same trends which were observed for phytoplankton distribution and abundance.

The range of chlorophyll a concentration at Nine Mile Point was from 0 to 38μg/l, similar to the ranges determined for the Lake as a whole (Nicholson, 1970).

Phaeopigments, the degradation products of the chlorophylls, may be an appropriate parameter for discussion when evaluating the effects of a power station using once-through cooling.

They may bespeak an effect of the station on phytoplankton: however, the supporting data do not show this. For example, during the time phaeopigments were measured, chlorophyll values were also determined. If the phytoplankters were being damaged but not destroyed by the plant discharge, one would expect that abundance data would remain the same (which it does) but that the relationship between chlorophyll a and phaeopigments would be inverse (which it is not).

Given this lack of correspondence in pigment data, one must determine the source of input to the system of the phaeopigments. Since abundance remained the same and no agreement existed between chlorophyll a and phaeopigments, it is likely that the source of phaeopigment is not from the power station but external to the sampling area.

No data were obtained relevant to the calculation of rates of primary productivity of the plankton during 1973. Programs in progress (1974) incorporate the ^{14}C

method of primary productivity determination and will enable a comparison of 1974 post-op conditions with pre-op conditions (Fenlon et al., 1971).

Fenlon et al. (1971) determined that primary productivity at Nine Mile Point during July and August 1970, was less upstream and downstream of the heated effluent from Nine Mile Point Unit 1. The differences shown, however, were not significant at the 90% level of confidence and, hence, are more demonstrative of variability in results than of station-to-station differences in production. Likewise, Fenlon et al. (1971) had no comparable data for primary production at the site during August of 1969. Given the obviously high variance in production estimates and no comparable data for pre-op conditions, no conclusions regarding the effects of the plant on primary production can be drawn at this time.

Harris (1973) determined photosynthetic rates for Lake Ontario phytoplankton and found an inverse relationship between photosynthesis and temperature which may provide insight for studies of productivity in progress at Nine Mile Point.

Some disagreement exists as to the potential effect of thermal stress on primary productivity. Morgan and Stross (1969) determined that production was decreased in water passing through a power plant when ambient temperatures exceed 20°C. However, production was stimulated by plant passage at temperatures below 20°C. Lauer et al. (1972) determined essentially no change in production (^{14}C method) in Hudson River estuarine plankton passing through the Indian Point Nuclear Station during the spring and fall months. During the summer, however, a temperature change of slightly more than 5°C (when ambient was ~24°C) stimulated production.

It is of interest to note briefly that the minimal effect periods for productivity changes noted by Morgan and Stross (1969) and Lauer *et al*. (1972) include periods when the respective source bodies of water would be expected to be dominated by diatoms. In neither case, however, was there an effort to differentiate production due to net plankton and that due to nanoplankton. Decreases or increases in production associated with temperature changes and related phenomena may be due primarily to effects upon the nanoplankton, as the nanoplankton are generally assumed to carry out as much as 75 to 90% of the production in the phytoplankton community (Kalff, 1967).

c. Zooplankton

The zooplankton populations of Lake Ontario consist of a wide variety of forms including a holoplanktonic community dominated by rotifers, cyclopoid copepods and cladocerans, and a meroplanktonic fauna dominated almost exclusively by the phantom midge (*Chaoborus*) and larvae of the alewife, *Alosa pseudoharengus*. The data from 1973 studies demonstrate that the operation of Nine Mile Unit 1 had no measurable impact upon the holoplanktonic or meroplanktonic components of the zooplankton community.

(i) Taxonomy

Taxonomically the zooplankton of Lake Ontario, especially in the vicinity of Nine Mile Point, are indistinct from those identified prior to the beginning of operations of Nine Mile Point Unit 1 in 1969. Patalas (1969) examined the crustacean plankton of the Lake during 1967 and showed that the taxonomy of the community was similar throughout the Lake, although significant differences in abundance existed between the western and eastern ends. Storr's (1964) data agreed well with that of Patalas (1969) and provided additional data regarding

the rotiferan component of the zooplankton, identifying *Asplanchna*, *Keratella* and *Brachionus* as the dominant genera.

Studies undertaken since the beginning of plant operations in December, 1969, showed that the crustacean and rotiferan zooplankters present in the community are similar to those described previously (Fenlon et al., 1971; RG&E, 1974). Most studies referred to (see Chapter I, this report) cite the same groups of organisms as dominant at any given time of year, but frequently show rank-order of dominance as highly variable from year to year (see, e.g., Patalas, 1969; Quirk, Lawler & Matusky Engineers, 1974a; Chapter I, this report). Attempts to identify variance in species dominance patterns as trends in overall species dominance on a year-to-year basis have proven unreliable at best. From the data available, the taxonomic composition of the zooplankton has not been influenced at all during the four years of operation of Nine Mile Point Unit 1.

(ii) Abundance

As shown (Chapter I, this report), few data relevant to zooplankton abundance are available for comparison with 1973 zooplankton abundance data. Storr (1964) provided primarily semi-quantitative taxonomic data. Patalas (1969) detailed patterns of distribution throughout the Lake more than absolute abundance. Quantities of zooplankton collected at Nine Mile Point in 1973 were comparable with data from the vicinity of Sterling, New York (RG&E, 1974) suggesting that, at least in the geographic area surrounding the City of Oswego, zooplankton populations are similar. Among the holoplanktonic zooplankters the daily and seasonal patterns of abundance may be more relevant to the potential effects of an electric generating station that the absolute abundance of a population or community at a single point in time. Some data suggestive of a power plant

effect on the cladoceran populations in the vicinity of Nine Mile Point were published by Fenlon et al. (1971). It was stated in that report that the enormous increases observed in Bosmina populations in 1970 (with no concomitant increase in the primary production) were due to heat stimulation by the Nine Mile Point Station.

Based upon analysis of the data of Fenlon et al. (1971), 1973 data (this report) and the work of others (Storr, 1964; RG&E, 1974), we offer an alternative conclusion to that put forth by Fenlon et al. (1971). That conclusion is that Bosmina populations sampled in 1969 and 1970 differed significantly due not to the effects of the Nine Mile Point Power Station, but to the timing of sampling in relation to normal, seasonal pulses within the population. Seasonal pulses have been observed in Lake Ontario Cladocera (Patalas, 1969) which in 1973 studies provided for differences in standing crop of up to five orders of magnitude. The 1969 data for Bosmina suggest that sampling was initiated during the declining phase of a pulse (see Chapter I, this report for similar pulses and declines) which has been observed to occur during July and August in the Lake as a whole.

Comparison of one year's data with another is, at best, tenuous statistically. Fenlon et al. (1971) initiated sampling in late July of 1970, whereas 1969 sampling was initiated in early July. The vagaries of year-to-year inconsistency in population growth as a function of environmental parameters may have shifted abundance patterns sufficiently to yield vastly different numbers of organisms in one year as opposed to the same "season" of another year. 1973 data (Chapter I, this report) showed that populations of cladocerans at Nine Mile Point remained about 100,000 individuals/m^3 for more than two weeks, and declined to zero in the following weeks. A similar phenomenon was observed among cladocerans at

all transects. Unless one can guarantee the relationship of a sampling program to seasonal pulses and blooms of a highly variable population, year-to-year variations in abundance cannot be considered adequate data for impact assessment. An inclusive sampling program, such as that concluded in 1973 and proposed for 1974 may, however, provide sufficient data upon which to evaluate the impact hypothesis proposed by Fenlon et al. (1971).

d. Benthos

The benthos of the Nine Mile Point area are similar to populations and associations found in Lake Ontario in general (Brinkhurst et al., 1968; Johnson and Matheson, 1968; Brinkhurst, 1969; QL&M, 1973a; Storr, 1972, 1973; RG&E, 1974). The major groups of organisms present at Nine Mile Point in 1973 (Chapter II, this report) were oligochaete worms (e.g., Tubifex, Limnodrilus) amphipods or "scuds" (e.g., Pontoporeia, Gammarus) and pelecypod molluscs (e.g., the families Sphaeriidae and Unionidae). As noted by several investigators, the distribution and abundance of the benthos at any site present a complex picture, generally the result of rather strict habitat requirements and substrate preferences among the benthos (Pennak, 1953; Johnson and Matheson, 1968; QL&M, 1973a). Present data on the abundance and productivity of benthos agree with the historical data on benthos in the vicinity of Nine Mile Point, which show that benthic communities to the east of the Point differed markedly from the west, prior to the construction and operation of Nine Mile Point Unit 1. The NMPP transect differed from others in having a disrupted gradient of community transition between littoral and profundal sampling stations. Abundance and diversity at the Station closest to the cooling water intake were lower than at the same depths on a similar transect (NMPW).

Samples from the vicinity of the heated water discharge were indistinguishable from samples taken at the same depth on transect NMPW.

Throughout the study period there appeared a generalized horizontal gradient in benthic diversity and abundance associated with transects. There was observed an increase diversity and abundance of organisms as one proceeded from NMPW to NMPE (Figure II-1). The trend applied to most stations, including the littoral zone community and the profundal community.

Several hypothesis may be proposed to explain these data. Paramount in each hypothesis is the effect of the predominantly west-to-east longshore current in Lake Ontario in the vicinity of Nine Mile Point (see Chapter V, this report).

The first hypothesis would state that the benthos increase in abundance and diversity along a west to east gradient due to stimulated growth and reproduction as the direct result of thermal loading from Nine Mile Point Unit 1.

The hypothesis may be supported by the data demonstrating that, in the context of prevailing current patterns, upstream stations (i.e., western transects) show lower values of abundance that do stations on transects downstream of the present heated-water discharge. Abundance values generally increased at the FitzPatrick transect, less than one mile downstream from the NMPP (i.e., effluent) transect. Further, abundance of some groups at some seasons was decidedly less at NMPP than upstream or downstream of the plant.

Examination of the data shows that a shift in species composition occurred concomitant with the observed upstream-downstream changes in abundance and diversity of the benthos. The shift in species composition was not one of the addition of species or groups, but one indicative of different benthic habitats.

Many authors have noted that in benthic communities the single most important factor in determining the species represented at a site is the nature and the texture of the substrate (see Sanders, 1960, Carricker, 1967; QL&M, 1973a, 1974a, 1974b; RG&E, 1974; Storr, 1972; Matousek, 1974). Further, the relative abundance and standing crop of benthos may be affected markedly by the organic content of the substrate and the differentiation of "niches" within a small area (see Pennak, 1953; Johnson and Matheson, 19681 Gannon and Beeton, 1969; Thut, 1969; bibliography of Sherk and Cronin, 1970).

In evaluating the above hypothesis, therefore, attention should be paid the bottom sediments to determine if, in fact, evidence regarding substrate complexity and habitat differentiation might also explain the gradients observed.

The available evidence (Benthos; Chapter II, this report) shows sufficient substrate change between transects to support the argument that the observed gradient of diversity and abundance is, in fact, due to animal-sediment relationships rather than to an effect of the generating station. Storr (1973) found a similar gradient among the benthos in the vicinity of Nine Mile Point prior to the generating station going on-line.

Another hypothesis may contend that the electric generating station causes stimulation of primary and secondary productivity among planktonic forms, and that this increased biomass, being available to suspension and deposit feeder, has resulted in the increased diversity and abundance of benthos downstream of the plant.

Few data can be cited in support of this hypothesis. Fenlon et al. (1971) showed that in 1970 the population of Bosmina apparently increased downstream

of the Nine Mile Point Station. They also showed that at one point in time primary productivity was decreased at the thermal effluent in relation to stations upstream and downstream. Their data do not show any comparison between pre-operational and post-operational primary productivity.

Periphyton samples taken by Jackson (1967) prior to plant operation examined in comparison to 1973 data show approximately the same standing crop at the Nine Mile Point Station. Likewise, historical phytoplankton data agree well with data presented herin, to suggest that primary productivity prior to and four years after plant operation is approximately the same.

For the benthos to have increased due to the power plant at Nine Mile Point stimulating production, there would have to be a source of organic input to the system stimulated by heat, but undetectable in the monitoring program. The possibility of detritus input or input from organic load is slight.

The final hypothesis to be presented has been discussed in part previously: there exists a gradient in substrate and sediment habitat differentiation which affords the benthos an organically richer and more varied habitat as one moves west to east along the Nine Mile Point promotory.

As shown (Chapter II, this report), substrate differences between tran-sects are significant, changing from "scoured" bedrock at NMPW to having a high proportion of silt and fine sand at NMPE. Such a change is generally found to result in a more diverse and more productive benthos (Pennak, 1953; Matousek, 1974) provided the finely divided solids (silt, sand, clay) contain an adequate percentage of organic matter.

In support of this hypothesis are data associated with current patterns in the

vicinity of Nine Mile Point. Scott and Landsberg (1969) and Scott et al. (1971) demonstrated the presence of a predominantly west to east longshore bottom current on the southern shore of Lake Ontario, presumably wind driven, but also associated with internal waves and "tide."

One result of the longshore current is to generate a gyre or eddy in Mexico Bay in which water movement is slowed and sedimentation may occur. Being a relatively shallow bay, Mexico Bay also is likely to have relatively more abundant phyto- and zooplankton population, also resulting in a higher rate of sedimentation.

Quite different benthic communities may be found as the depth of the substrate sampled increases. Generally, the differentiation of benthic populations or communities with depth is associated closely with rates of sedimentation and the extent to which bottom sediments are disturbed, either by currents, wind or wave action, or by other factors such as, shipping, recreation and commercial fishing (QL&M, 1974a).

The benthos in the vicinity of Nine Mile Point were characteristic of previously described animal-depth relationships in Lake Ontario (Johnson and Matheson, 1968) and in similar, freshwater environments (see Thut, 1969).

Among all transects at Nine Mile Point, the benthos changed from a sparse, littoral fauna characterized by organisms adapted to frequent disturbance by waves and wind, to a profundal community characterized by fauna preferring cold water and stable substrates.

The differences in the benthic populations near the cooling water intake may be attributed to the operation of the plant. In an area of bedrock covered wit

little or no silt and sand, the benthic community would be expected to be sparse and limited to a relatively few species. This is true for the NMPW transect which has a substrate quite similar to NMPP over most of the distance from the 10 ft. contour to the 60 ft. contour. However, at the site of the cooling water intake, some 24 ft. deep, the substrate appears to be almost exclusively bedrock and bedrock rubble, with no silt covering. The most likely explanation of this difference is that the movement of large quantities of water toward the intake structure occurs with a velocity sufficient, when added to the velocity of the prevailing currents, to scour the finer sediments from the bottom. By removing the finer sediments, a control has been imposed upon the population of this site by certain benthic groups.

e. Fish

An exhaustive discussion of fish populations in Lake Ontario, their changes and the casual factors of these changes is not warranted at this point in the report. The value of the Lake's fishes and fisheries has resulted in intensive study, survey, summary and philosophizing on the fishes of Lake Ontario as stocks, species and resources. The reader is referred to the exhaustive treatment of the subject by Beeton (1961, 1965, 1969) and especially by Christie (1971, 1973).

The trends perceived by Beeton (1969) and Christie (1973) regarding decreases and sometimes extinction of important stocks of salmon, lake trout and whitefish in Lake Ontario have been borne out by investigations at Nine Mile Point (Storr, 1973; QL&M, 1973a; this report).

In this report, data on fish distribution and abundance at Nine Mile Point from 1969 through 1973 are compared. Analyses of species and of the fish community as a whole demonstrate that the operation of Nine Mile Point Unit 1 has had no measurable impact on the fishes in the area or on Lake populations.

(i) Taxonomy

The species inventory for fishes common at Nine Mile has not changed to any great extent since pre-operational studies by Storr (1973). Many more species occur in species lists from 1972 (GLFL Cruise Reports, 1972 a-e; BSFW and NYDEC, 1973; QL&M, 1973a) and from 1973 (this report) primarily due to increased sampling efforts (see QL&M, 1973a; Material and Methods, this report) and a greater variety of gear-types utilized in IFYGL studies (GLFL Cruise Reports, 1972 a-e) and post-operational surveys at Nine Mile Point (QL&M, 1973a; this report).

The 1973 sampling yielded no specimens of fishes categorized by Christie (1973) as "greatly reduced." The fish community was dominated throughout the year by introduced fishes, primarily the alewife and the rainbow smelt. The only species of "uncertain status" (Christie, 1973) collected in 1973 studies was the Chinook salmon.

(ii) Abundance

Fish abundance in the vicinity of Nine Mile Point has been variable from 1969 through 1973. Some trends in patterns of abundance have been noted (QL&M, 1973b; this report) suggesting an overall increase in alewives and smelt population, a small increase in populations of white perch, and relatively stable populations of yellow perch and smallmouth bass since 1969.

Analyses of growth data for the species mentioned above suggests growth rates of selected fishes in Lake Ontario are lower than in similar bodies of water. Length frequency analysis of alewife populations indicate a growth rate much slower than in some other landlocked alewife populations. Slower growth rates in combination with the massive projected size of the Lake Ontario alewife population (O'Connor, 1973) show that the Lake Ontario alewife population is overcrowded, probably having reached the carrying capacity of the Lake for that species.

Of particular interest in the comparison of fish abundance was the maintenance of the smallmouth bass and yellow perch populations at levels approximately equal to those of 1969. Most documents related to the impact of electric generating stations in cold water habitats presume a decline in sport and commercial fisheries based upon the stringent thermal requirements of fishes like perch and bass (see Edsall and Yocum, 1972). However, investigations at Nine Mile Point (Storr, 1973; QL&M, 1973*a*; this report) demonstrate that the thermal requirements of these species can be met while operating a generating station.

(iii) Community Structure

The fish community at Nine Mile Point was variable, changing with season from a simple system in winter/spring to a highly complex community in late summer or early fall.

The fish community in Lake Ontario at Nine Mile Point is not diverse; for most of each year (Storr, 1973; GLFL Cruise Reports, 1973*a*-*e*; QL&M, 1973*b*) it is dominated by one or two species and a very small number of species present in low and intermediate numbers. Diversity peaked in late summer and fall (GLFL

Cruise Reports 1973a-e; this report) and never reaches values much above 2.0. Such a situation denotes a system relying upon the maintenance of energy flow through one or a few pathways. This is generally associated with instability (McErlean *et al.*, 1973).

The Lake Ontario ecosystem is dependent upon the persistence of smelt and alewives for stability. The alewife is an overcrowded, unfished population having reached or exceeded the carrying capacity of its environment. In a very real sense the cropping of alewives by power stations and other utilities on the Lake exerts a stabilizing influence on the alewife population. Successful establishment of coho and/or Chinook salmon in the Lake may further impact the alewife population and make ecological space available for greater numbers of other species.

I. PLANKTON

A. GENERAL INTRODUCTION

Lake Ontario ecosystems have not been examined as closely as those of its westerly neighbor, Lake Erie. Early studies of both lakes were primarily taxonomic surveys; quantitative investigations were limited in both geographic and scientific scope. Although there is a general lack of quantitative biological data and trophodynamic studies, changes in Great Lakes' biota, which were roughly correlated with increasing human use of drainage basin resources, have been documented (Sweeney, 1969).

The studies of the environmental impact of power generating stations in the Nine Mile Point area is one of the first integrated programs designed to assess the natural biological systems in Lake Ontario. However, due to the previous paucity of integrated biological, chemical, and physical data concerning the seasonal and annual variations of the biota, the present studies in the Nine Mile Point area have been directed toward establishing baseline data.

In addition, information has been obtained on the immediate effects of power plant operation on biotic communities including the effects of impingement, entrainment, and thermal discharges.

The plankton, by definition those organisms which are non-motile or feebly swimming, are dependent on the water quality characteristics of the Lake. Because of trophodynamic interactions, such as grazing, nutrient recycling,

and temporary recruitment of fish and benthic larvae, the quality and quantity of plankton populations will directly or indirectly affect the structure of the entire aquatic food web.

The response of planktonic organisms to the physical and chemical parameters of their environment is diverse and complex, but a number of phenomena are common to most phytoplankton and zooplankton populations. The effects of light, temperature, nutrients, mixing and currents and trophodynamics on the plankton communities are described in the following sections. The total effect of these phenomena on the plankton community is, of course, an integrated effect.

1. LIGHT

Primary productivity is the conversion of inorganic nutrients to organic material. The bulk of primary production results from the conversion of the energy in sunlight by photosynthesis into high energy organic chemical bonds in green plants. The amount of primary production determines the potential production of all consumer trophic levels; the depth to which sunlight penetrates the water column, therefore, has a significant influence on primary production. Since respirational losses of energy equal photosynthetic increases in energy at about the 1% incident light level for most phytoplankton populations, the bulk of primary production occurs above this light level in the water column (the photic zone). If temperature and nutrient conditions are optimal, the amount of primary production is a function of the depth of the photic zone (Sverdrup,

1953; Ryther, 1954).

In most estuaries and in many eutrophic lakes, the water is quite turbid due to suspended particulate material (Westlake, 1966); primary production, therefore, may be lower in such water bodies than would be predicted from nutrient availability (Riley, 1967). In some water bodies, the abundance of phytoplankton is so great that self-shading may limit primary production (Talling, 1960).

Zooplankters are affected by light in a number of ways; diel migration is perhaps the most commonly known example (Swain et al., 1970). Many crustacean larvae and some crustacean adults are positively phototrophic (Moore, 1958) and, therefore, are most abundant in surface waters. The vertical migration of zooplankton in Lake Michigan is presumeably governed by light intensity and has been found to be the major mechanism of niche separation of omnivores and herbivores (Lane and McNaught, 1970).

In the Nine Mile Point area the average depth of 1% incident light level is approximately 50 feet (Beeton, 1965). This depth is reduced markedly after vertical mixing. In general, however, the light penetration in Lake Ontario in the Nine Mile Point area is sufficient to support a healthy and diverse phytoplankton population.

2. TEMPERATURE

Temperature controls many of the physiological processes of phytoplankton and zooplankton (Kinne, 1964; Raymont, 1963). The effects of changing

temperatures are evident in changing feeding, growth, reproduction, photosynthetic and mortality rates. Temperature and light interactions are the major variables in the mechanism of spring "blooms" of phytoplankton (Sverdrup, 1953). Turnover of the water column and nutrient replenishment of the photic zone is a function of fall or winter cooling (Smith, 1973).

The vertical and horizontal distribution of many phytoplankters and the horizontal distribution of some zooplankters in Lake Ontario appears to be closely related to the temperature structure of the Lake (Nalewajko, 1966 and 1967; Patalas, 1969). Of special importance to the Lake Ontario nearshore biota is the occurrence in the spring of a "thermal bar" (a vertical density barrier) between nearshore waters and deep offshore waters (Rodgers, 1971). Munawar and Nauwerck (1971) recorded a second spring bloom in nearshore waters (but not in offshore waters in 1970) during the time of early thermal bar formation. The two events are probably related.

3. NUTRIENTS, MIXING AND CURRENTS

It is known that biological production is closely linked to the availability of raw materials in the form of nutrients. Since phytoplankters are the base of many aquatic food webs, overall biological production is ultimately dependent on phytoplankton nutrients, including nitrates, nitrites, ammonia, dissolved organic nitrogen (Lui and Roels, 1969) orthophosphorus, silicates, and trace metals (Odum, 1971).

Shiomi and Chawla (1970) collected and analyzed samples for nutrient concentration at 60 stations in Lake Ontario. Their results showed that in surface waters the concentration of dissolved inorganic nitrogen, silicon dioxide, and phosphorus were high during the winter and decreased during the spring; concentrations of these nutrients are very low during the summer. Enrichment of surface waters occurred following the fall turn-over, and maximum nutrient levels were found just prior to the "spring" bloom in February. Nutrient concentrations in bottom waters followed some of the seasonal trends of surface waters, especially in the spring, but, in general, they were more constant over time than in surface waters. The authors speculated that nutrient concentrations may have limited phytoplankton growth in the summer and that low silicate concentrations may have limited diatom production.

The results of studies on the annual cycle of phytoplankton production in Lake Ontario (Munawar and Nauwerck, 1971) tend to support the speculation of Shiomi and Chawla, with the exception of the occurrence of late summer blooms of blue-green and green algae. It can be inferred that such late blooms may be related to concentrations of humic substances (Lange, 1970), release of phosphorus from sediments or biological populations (Shelske and Callender, 1970; Gumerman, 1970), or complex interactions between phytoplankton populations and zooplanktonic feeding and reproduction (Stross, 1973). Since total phosphate concentrations in the Oswego area are generally higher than average Lake values throughout the year (Shiomi and Chawla, 1970), the late summer bloom could be highly significant in the trophodynamic structure of the Nine Mile Point area (see Water Quality chapter).

The circulation of water in Lake Ontario and especially in the Nine Mile Point area has been studied in detail, and the conclusions are of great importance to ecological investigations. Although the general south shore current is wind driven from west to east (Gunwaldsen et al., 1970), the eastward transport is several times greater than the flow of Niagara River water through the Lake, and as a result, a coastal counter current is to be expected (Scott et al., 1971). Both the eastern current (about 10km from shore) and a westward counter current out of Mexico Bay have been documented (Landsbert et al., 1970), but they were variable in direction, velocity, and distance from shore. The western counter-current was frequently masked by the easterly flow, and both upwelling and down-welling occurred. It is significant that water passing from west to east was concentrated at times in the Mexico Bay area (Landsberg et al., 1970) and that a study of thermal plumes in the winter found a pocket of warmer water contiguous with the Nine Mile Point area in Mexico Bay (Chermack, 1970). It is, therefore, concluded that plankton populations in the Nine Mile Point area will be subject to transport by water masses and that nutrient concentrations will fluctuate not only with seasonal patterns, but also with upwelling and downwelling patterns.

4. TROPHODYNAMICS

Since ecosystem stability is a function of system interaction (Pomeroy et al., 1972), studies of trophic interrelationships can lead to a better understanding of population fluctuations. The first step in mass and

energy transfer is the conversion of dissolved nutrients by photosynthesis into plant material. If their standing stocks were not decreased through the grazing of zooplankters, the composition of the phytoplankton populations would be determined by specific requirements of each algal species for light intensity, temperature and nutrient concentration; their resulting populations would reflect their growth rates for a given set of environmental parameters (Dugdale, 1967; Caperon and Meyer, 1972).

Grazing by herbivorous zooplankters is, however, a basic feature of aquatic ecosystems; and this effect may considerably alter the abundance and composition of phytoplankton populations. Due to size specific grazing, i.e., "selection" of small phytoplankton cells by small herbivores and medium-sized cells by medium-sized herbivores (Jørgensen, 1966), a phytoplankton population composed primarily of diatoms, such as found during spring blooms in Lake Ontario, may be expected to aid the development of small zooplankters. The somewhat larger green and blue-green algal cells found in the summer can be expected to aid the development of larger herbivores.

Herbivorous zooplankters are a source of nutrition for omnivorous and carnivorous zooplankters, which include not only crustaceans, but also insect and fish larvae. These third and fourth trophic levels may, in turn, serve as food for the smaller fishes, such as the alewife (Warshaw, 1972). More specific examples of trophodynamic relationships between plankton populations of Lake Ontario are discussed later in this section.

B. PHYTOPLANKTON

1. INTRODUCTION

Phytoplankton comprise the principal component of the primary producers in most aquatic ecosystems. This assemblage of organisms is responsible for energy input resulting from photosynthesis in those organisms containing chlorophyll. The total primary production, depends upon intrinsic factors, such as the nutritional status of the algae, and extrinsic parameters, including the past and current environmental conditions, especially light, temperature and nutrients (Flemer, 1969; Odum, 1971). Although some of the energy is utilized by the phytoplankton for their own metabolic requirements, the remaining energy is available to other levels through grazing or secondary production (Odum, 1971).

Variations in the trophodynamic relationships in any aquatic ecosystem tend to indicate fluctuations in water quality (Pomeroy et al., 1972). Since many algae are adversely affected by pollutants in aquatic habitats, variations in the composition and abundance of the algae may indicate changes in water quality (Palmer, 1966, 1967; Mackenthun, 1969; anonymous, 1971; Villegas and de Giner, 1973). The presence of large numbers of Euglena or Trachelomonas in fresh water systems for example, may indicate increasing amounts of organic pollution, whereas the later occurrence of Cryptomonas and Chrysococcus tends to indicate that self-purification of the water body has begun. In a diatom community, high species diversity with relatively small species numbers indicates stability,

whereas in polluted regions a few diatom species in large numbers tend to dominate the community (Patrick and Reimer, 1966; Patrick 1967). In addition to organic or industrial pollutants, it is known that algal succession is normally affected by temperature (Patten et al., 1963, Lauer et al., 1972; Fogg et al., 1973; QL&M Engineers, 1974).

Changes in the amount of primary productivity in any aquatic ecosystem is another indication of changes in water quality (see General Plankton Introduction). Earlier investigations indicated that an 8°C rise in temperature enhanced primary production in waters below 16°C, but primary production was inhibited at temperatures above 20°C (Morgan and Stross, 1969). Fenlon et al. (1971) reported that primary productivity in the vicinity of Nine Mile Point in Lake Ontario was not significantly affected by the increased temperature of the outfall waters.

The concept of algal assemblages as biological indicators of water quality has been presented by a number of authors. Phytoplankton composition in the Great Lakes as compared to other lakes throughout the world was reported by Davis (1966). His paper included a synopsis of Schenkx and Thompson's (1965) investigations of the dominant diatom pulses at the Toronto Island Filtration Plant from 1923-54. Their work is in agreement with the investigation of Munawar and Nauwerck (1971), Nalewajko (1966), Reinwand (1969), and Ogawa (1969) all of whom indicated that inshore phytoplankton populations were denser than offshore populations in Lake Ontario.

There is little information concerning concentrations of chlorophyll a in Lake Ontario pertinent to the Nine Mile Point area. Nicholson (1970) reported surface chlorophyll a distribution for the entire Lake. Chau et al. (1970) concluded that the highest concentrations (8 - 24 milligrams/m^3) of chlorophyll a exist along the western and southern shores of Lake Ontario. By including the degradation products of chlorophyll (phaeopigments) in the calculation of chlorophyll a concentrations, Glooschenko et al. (1972) found that the highest average chlorophyll a concentrations occurred along the southern shore between Rochester and Oswego, New York, and from Stony Point north to the St. Lawrence River.

2. RESULTS

a. Species Inventory

Approximately one-hundred twenty-five species of green algae, approximately thirty-five species of diatoms, and forty-five species of blue-green algae were identified from the 1973 Nine Mile Point phytoplankton collections (see Figure I-1). These species along with species of less abundant families of algae are listed in Table I-1 and Appendix III-A.

b. Patterns of Abundance

(i) Total Abundance

Net phytoplankton abundance (the abundance of algal cells retained by a 20µ plankton net) ranged between 2.3 x 10^4 algal cells/liter (cells/l) and 1.6 x 10^6 algal cells/l; whole water phytoplankton abundance (the

FIGURE I-1

LOCATION OF MICROZOOPLANKTON AND PHYTOPLANKTON STATIONS IN THE NINE MILE POINT AREA DURING THE 1973 STUDY

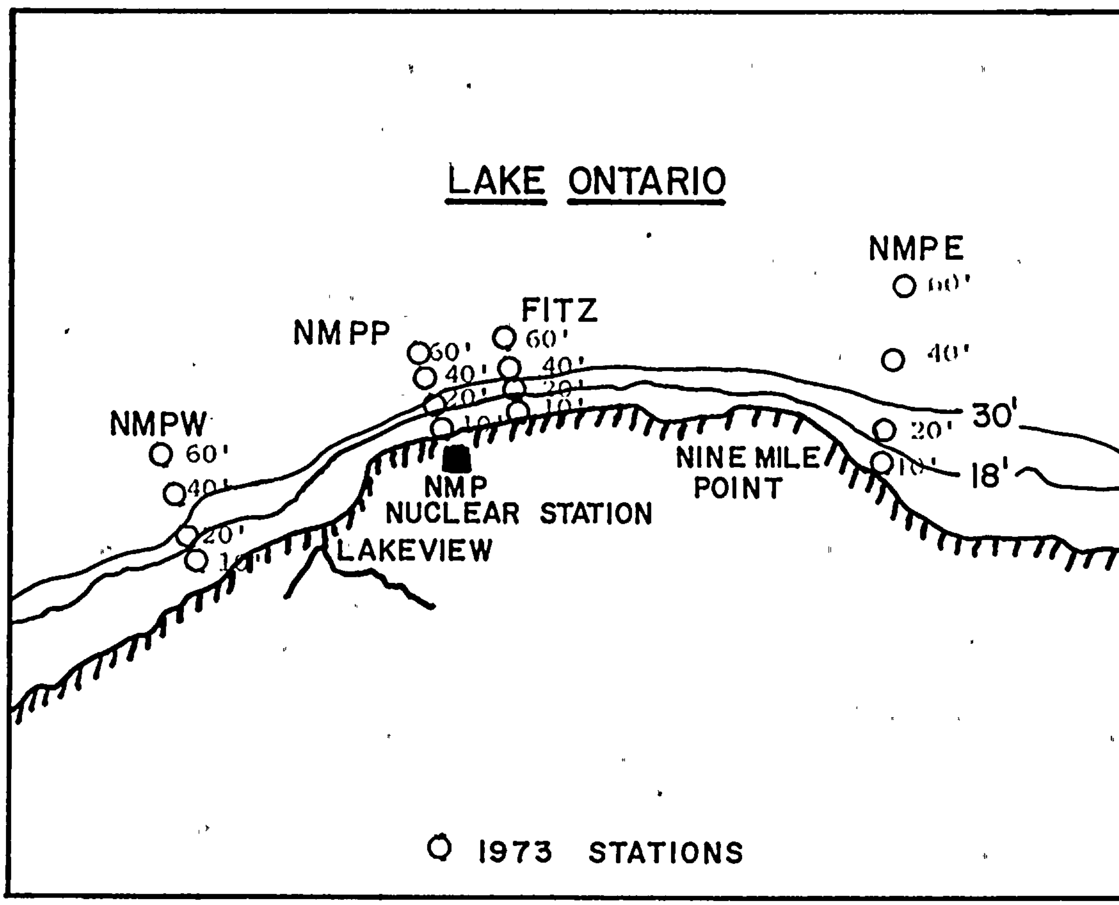

TABLE I-1

Species of Phytoplankton Collected in Whole Water
and Net Samples in the Vicinity of Nine Mile Point during 1973

GREEN ALGAE

Actinastrum sp.
A. gracillimum
A. hantzschii
Ankistrodesmus sp.
A. convolutus
A. falcatus
Arthrodesmus sp.
Botryococcus braunii
B. protuberans
B. sudeticus
Carteria cordiformis
Characium sp.
C. ornithocephalum
Chlamydomonas sp.
C. epiphytica
C. pseudopertyi
Chorella ellipsoidea
C. vulgaris
Chlorococcum sp.
Chodatella sp.
Cladophora filament
Closteriopsis longissima
Closterium sp.
Coelastrum sp.
C. cambricum
C. microporum
Cosmarium sp.
C. crenatum
C. depressum
C. formosulum
C. nitidulum
Crucigenia sp.
C. lauterbornii
C. quadrata
Dactylococcus infusionum
Dictyosphaerium sp.
D. ehrenbergianum
D. pulchellum
Dimorphococcus lunatus
Echinosphaerella limnetica
Errerella borhemiensis
Eudorina elegans
Franceia sp.
F. Droescheri
F. ovalis
Gleocystis sp.
G. ampla
G. gigas
G. planctonica
G. vesticulosa
Golenkinia paucispina
G. radiata
Gonium sp.
G. sociale
Hyalotheca sp.
H. dissiliens
Kirchneriella lunaris
K. obesa
K. subsolitaria
Lagerheimia ciliata
L. longiseta
L. subsalsa
L. quadriseta
Micractinium sp.
M. pusillum
Microspora sp.
Mougeotia sp.
Nephrocytium Agardhianum
N. limneticum
N. lunatum
N. obesum
Oedogonium sp.
Oocystis sp.
O. Borgei
O. parva
O. solitaria
Pandorina morum
Pediastrum sp.
P. biradiatum
P. Boryanum
P. duplex
P. simplex
P. tetras
Planktosphaeria sp.

TABLE I-1 (con't)

Pleodorina californica
Polyedriopsis quadrispina
Quadrigula Chodatii
Q. lacustris
Scenedesmus sp.
S. abundans
S. acuminatus
S. bijuga
S. biradiatum
S. Brasiliensis
S. denticulatus
S. dimorphus
S. longus
S. obliquus
S. quadricauda
Schizochlamys gelatinosa
Schroederia sp.
S. setigera
Selenastrum minutum
S. Westii
Sphaerocystis sp.
S. Schroteri
Spondylosium sp.
Staurastrum sp.
S. cuspidatum
S. gracile
Stigeoclonium tenue
Tetradesmus sp.
T. staurogeniaeforme
Tetraedron caudatum
T. minimum
T. muticum
T. peutaedricum
T. regulare
Tetraspora sp.
T. lacustris
T. lamellosa
Treubaria sp.
T. setigerum
T. triappendiculata
Ulothrix sp.
U. subconstricta
U. subtilissima
U. zonata
Uronema sp.
Volvox sp.
V. aureus
Zygnema sp.

UID biflagellate
UID cresent-shaped cell
UID colony
UID 3-celled colony
UID 4-celled colony
UID 8-celled colony
UID desmid
UID flagellate
UID filamentous
UID green
UID quadriflagellate
UID unicellular
UID zygospore

EUGLENOIDS -

Euglena sp.
Phacus sp.

DIATOMS -

Achnanthes sp.
Asterionella formosa
Cocconeis sp.
Coscinodiscus sp.
C. subtilis
Cyclotella sp.
C. bodanica
C. comta
C. meneghiniana
Cymbella sp.
Diatoma sp.
D. elongatum
Fragilaria sp.
F. capucina
F. crotonensis
Gomphonema sp.
Gyrosigma sp.
Melosira sp.
M. binderana
Meridion sp.
Navicula sp.
N. confervacea
N. tripunctata

TABLE I-1 (con't)

DIATOMS (con't)

Nitzschia sp.
N. acicularis
N. sigma
Rhoicosphenia sp.
Stephanodiscus sp.
S. astraea
S. hantzschii
S. niagarae
Surirella sp.
Synedra sp.
Tabellaria sp.
T. fenestrata
T. flocculosa
UID pennate

GOLDEN-BROWN ALGAE -

Dinobryon sp.
D. bavaricum
D. cylindricum
D. divergens
D. sertularia
D. sociale
Mallamonas sp.
Synura sp.

BLUE-GREEN ALGAE -

Agmenellum punctata
A. quadriduplicatum
Anabaena sp.
A. circinalis
A. flos-aquae
A. spiroides
Anacystis sp.
A. cyanea
A. dispersus
A. limneticus
A. minimus
A. minor
A. Prescotti
Aphanocapsa sp.
A. endophytica
A. rivularis
Aphanizomenon sp.
A. flos-aquae
Aphanothece sp.
Chroococcus sp.
C. limneticus
C. minutus
Coelosphaerium Kuetzingianum
C. Naegelianum
Gloeocapsa sp.
G. aerogenosa
G. punctata
Gloeothece sp.
G. linearis
G. rupestris
Gomphosphaeria sp.
G. aponina
G. lacustris
Lyngbya sp.
L. aerugineo-coerulea
L. Birgei
L. Diguetii
L. limnetica
Merismopedia tenussima
Microcystis aeruginosa
M. incerta
Nostoc sp.
Oscillatoria sp.
O. limnetica
O. subbrevis
Phormidium mucicola
Stigonema sp.
UID cresent-shaped
UID filamentous

DINOFLAGELLATES -

Ceratium hirundinella
Glenodinium sp.
G. palustre
G. pulvisculus
G. quadridens
Gymnodinium sp.
Periodinium cinctum
P. inconspicuum
P. wisconsinensis
UID dinoflagellate

abundance of algal cells in an unfiltered water sample) ranged between 2.1×10^4 algal cells/l and 7.1×10^6 algal cells/l. The ranges of whole water phytoplankton and net phytoplankton population numbers found at each sampling station (see Figures I-2 and I-9) during the 1973 sampling period are presented in Tables I-2 and I-3.

The abundance of total net phytoplankton fluctuated throughout the sampling period, exhibiting either bi-, tri- or quadrimodal* pulses of abundance. The fluctuations in abundance of total net phytoplankton along contours were similar to the fluctuations noted for transects. The whole water phytoplankton exhibited bimodal patterns of total abundance along all contours and all transects.

Division of total abundance into group abundances and percentages per date indicated a seasonal trend of diatoms: greens: blue-greens: diatoms in net samples (Figures I-10 - I-17) and whole water phytoplankton samples (Figures I-18 - I-25). Diatom assemblages usually peaked before June and pulsed again around September and October. A reduced pulse of diatoms was occasionally observed during July or August. Green algae filled in a temporal gap by becoming more abundant during July and August. Blue-green algae generally followed the green algal pulses by a few weeks, reaching maximum abundance during July, late August, and October.

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* bi-, tri-, or quadrimodal: two, three or four points on a frequency curve where the frequency of occurrence is notably greater than it is on either side of the point.

FIGURE I-2

TOTAL NET. PHYTOPLANKTON ABUNDANCE ON THE 10' CONTOUR DEPTH

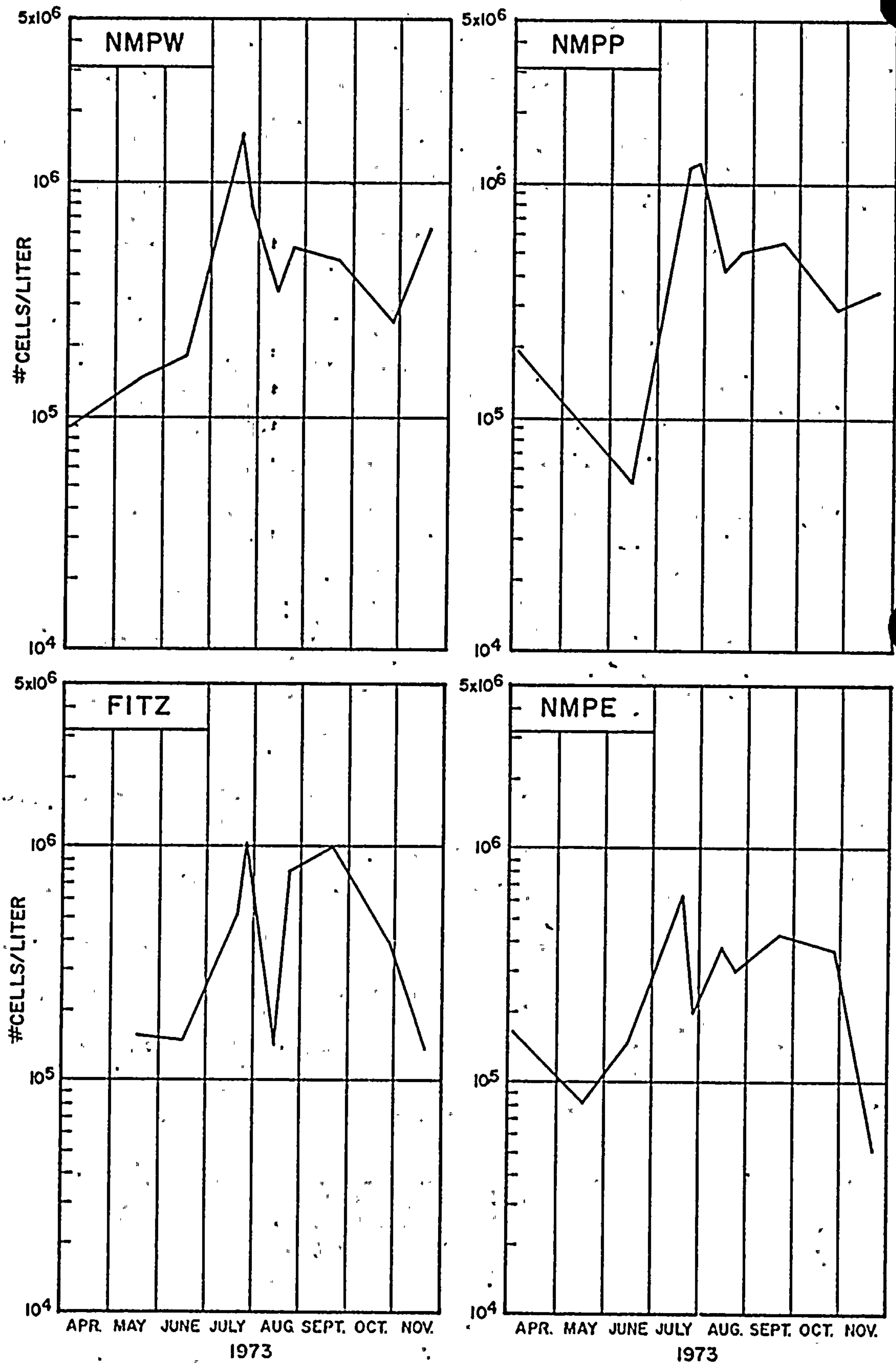


FIGURE I-3

TOTAL NET PHYTOPLANKTON ABUNDANCE
ON THE 20' CONTOUR DEPTH

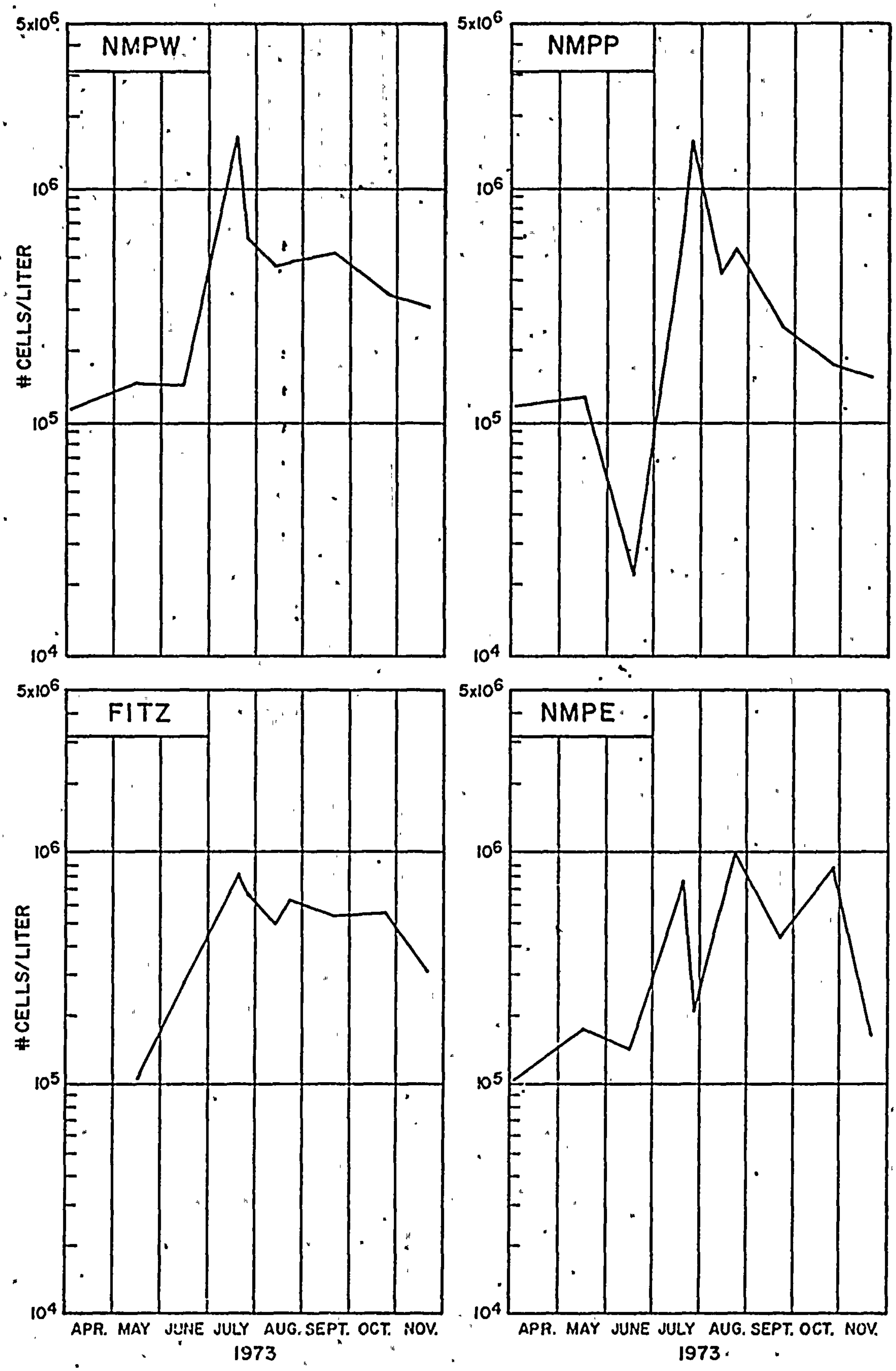


FIGURE I-4

TOTAL NET PHYTOPLANKTON ABUNDANCE
ON THE 40' CONTOUR DEPTH

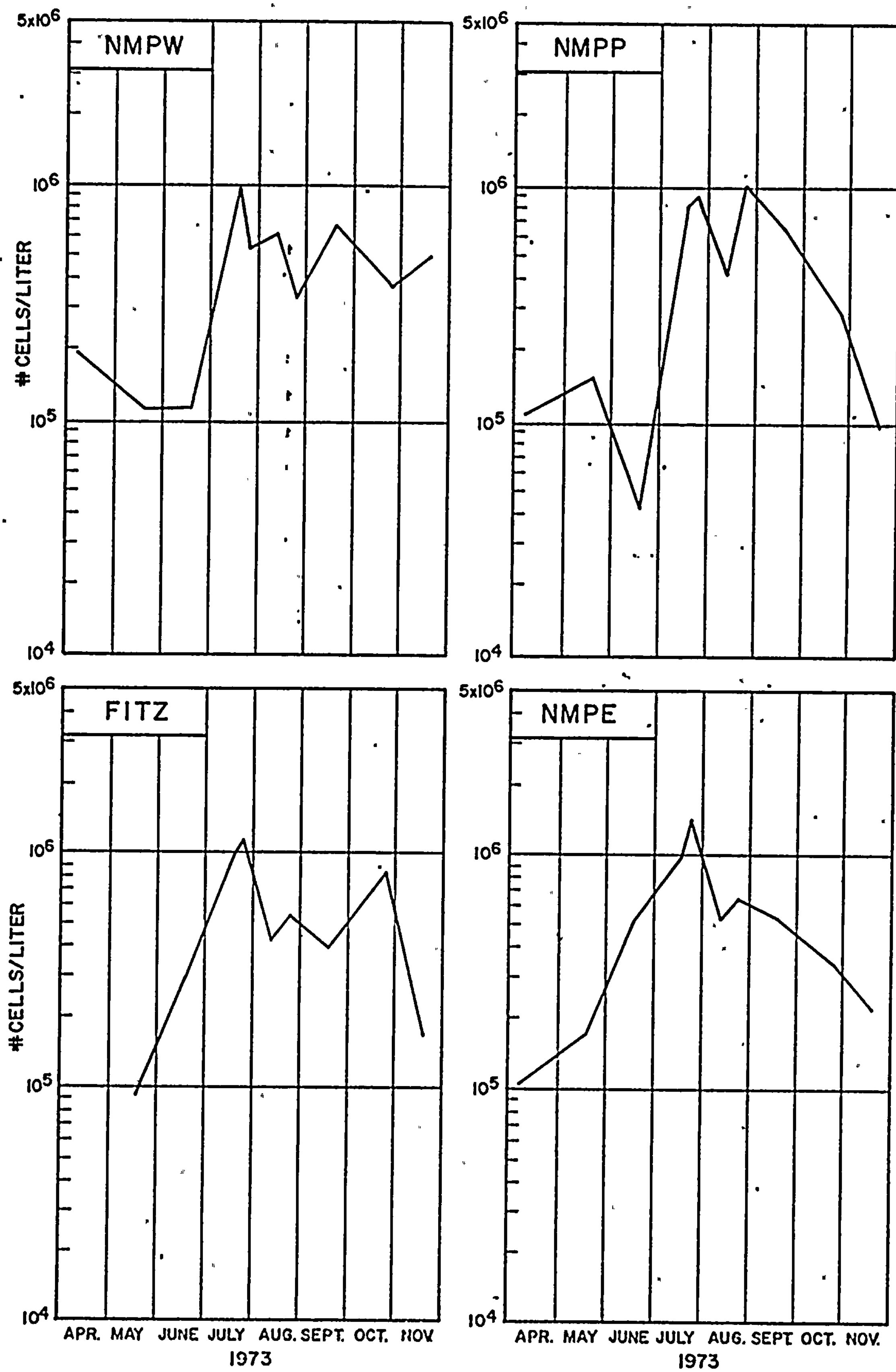


FIGURE I-5
TOTAL NET PHYTOPLANKTON ABUNDANCE
ON THE 60' CONTOUR DEPTH

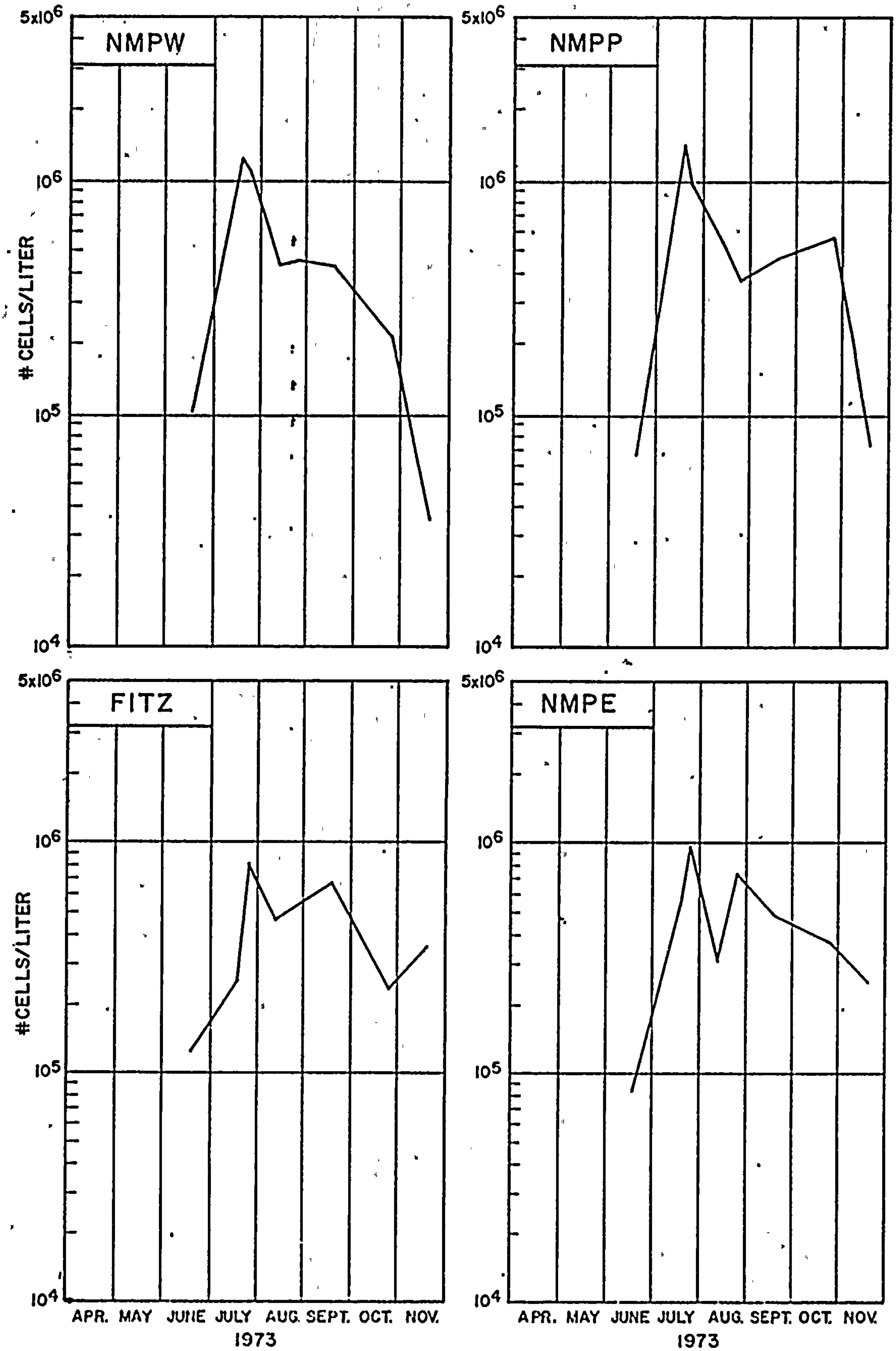


FIGURE I-6.

TOTAL WHOLE WATER PHYTOPLANKTON ABUNDANCE ON THE 10' CONTOUR DEPTH

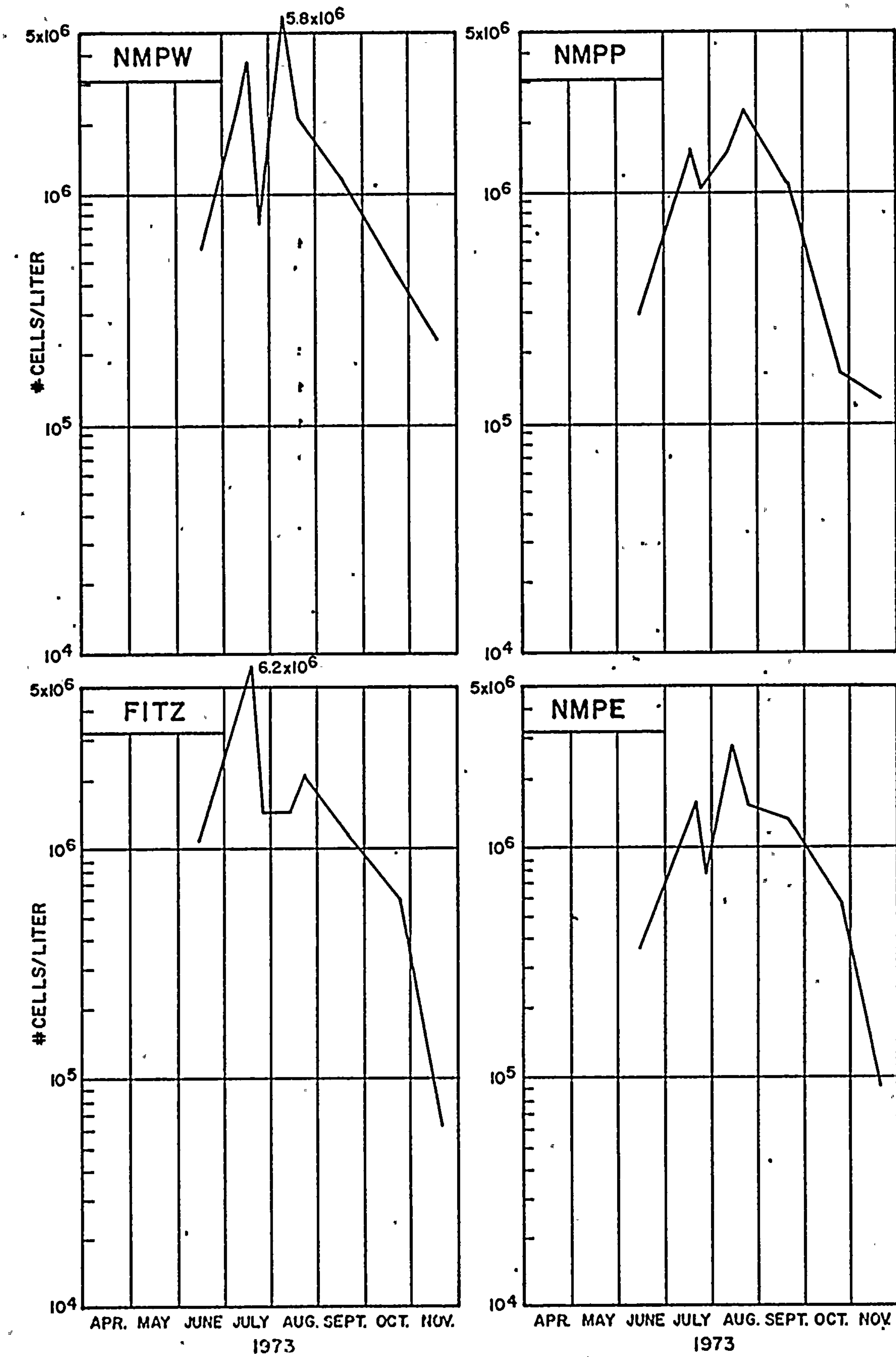


FIGURE I-7

TOTAL WHOLE WATER PHYTOPLANKTON ABUNDANCE ON THE 20' CONTOUR DEPTH

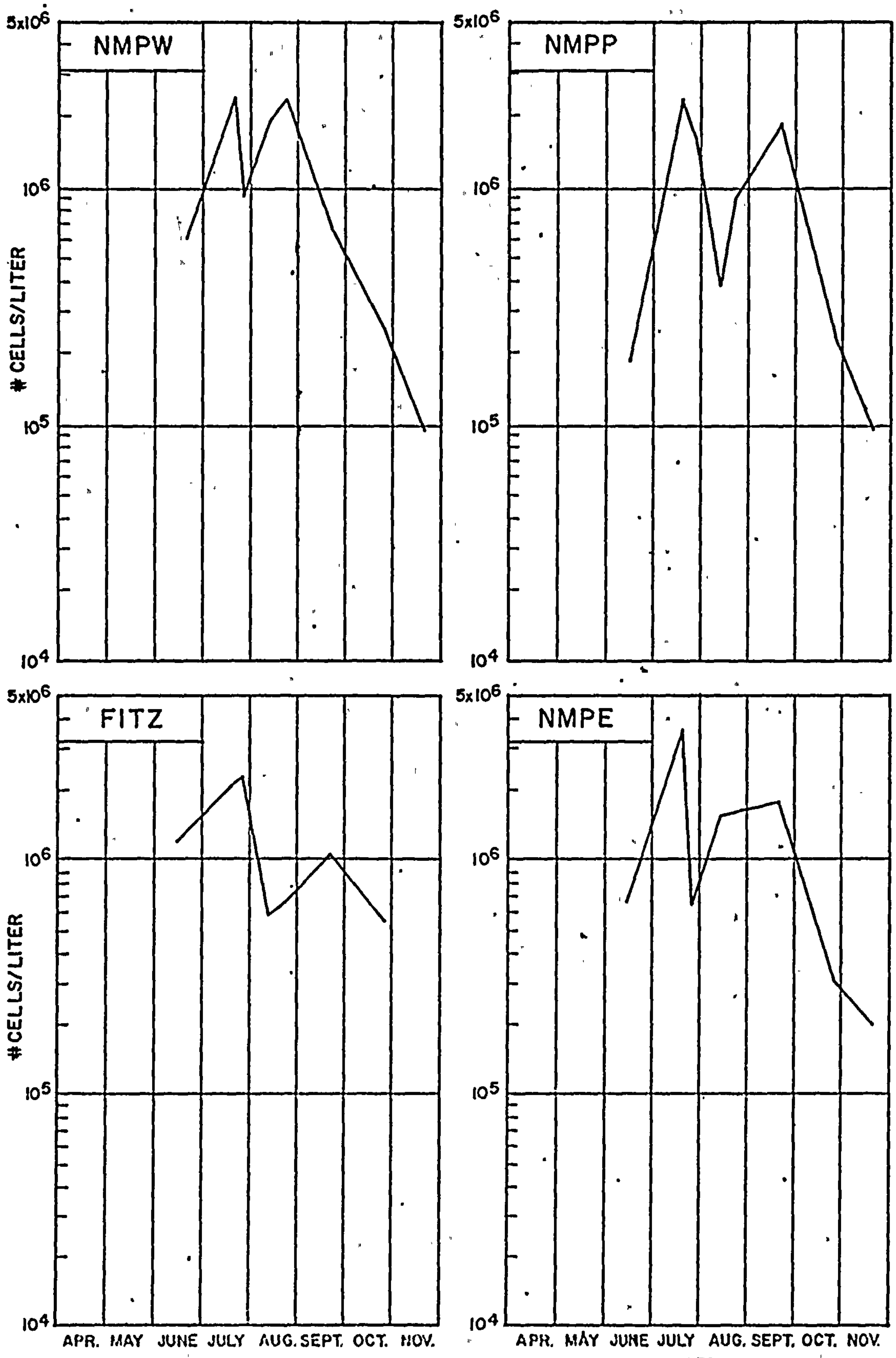


FIGURE I-8
TOTAL WHOLE WATER PHYTOPLANKTON ABUNDANCE
ON THE 40' CONTOUR DEPTH

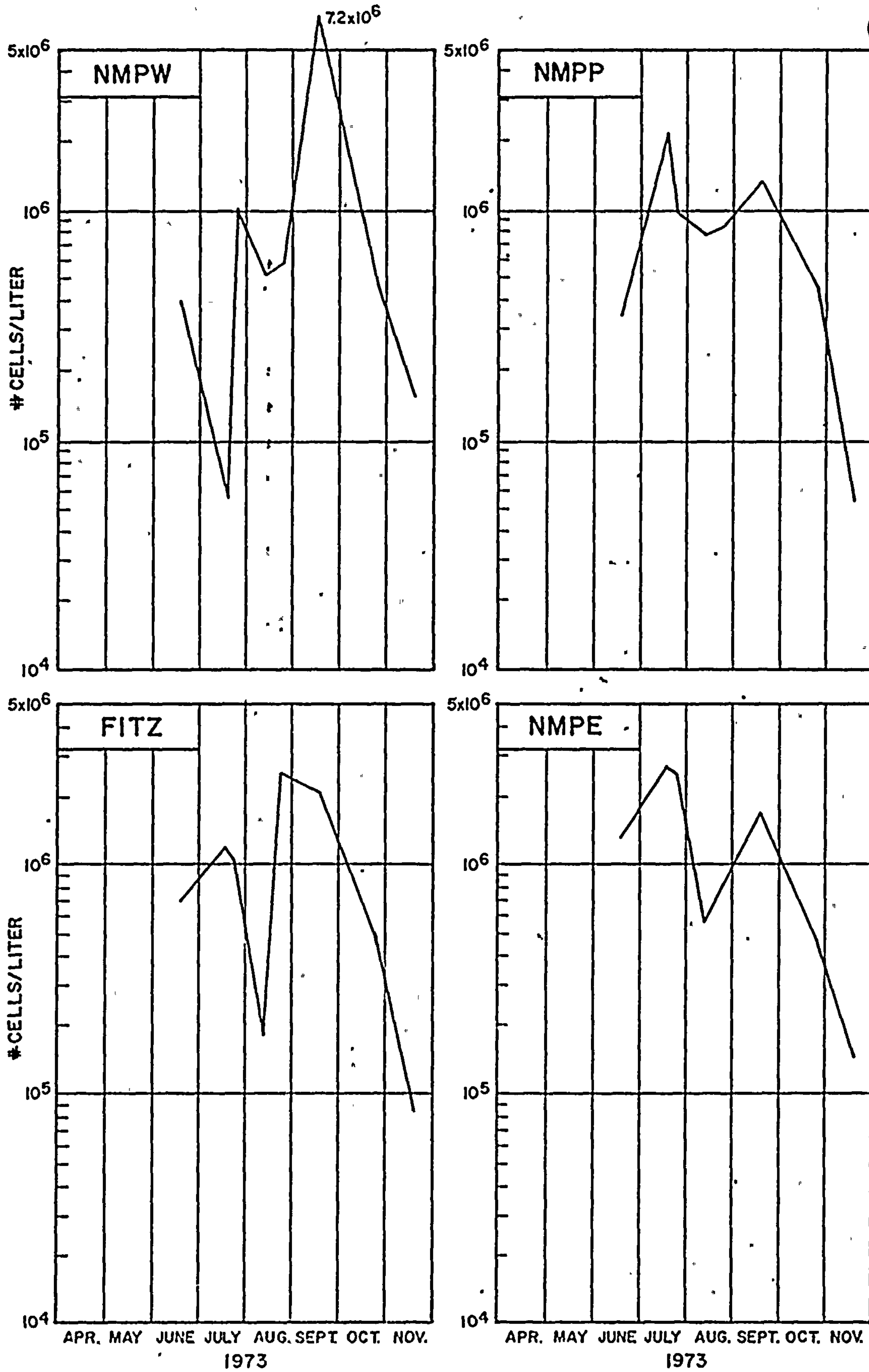


FIGURE I-9

TOTAL WHOLE WATER PHYTOPLANKTON ABUNDANCE ON THE 60' CONTOUR DEPTH

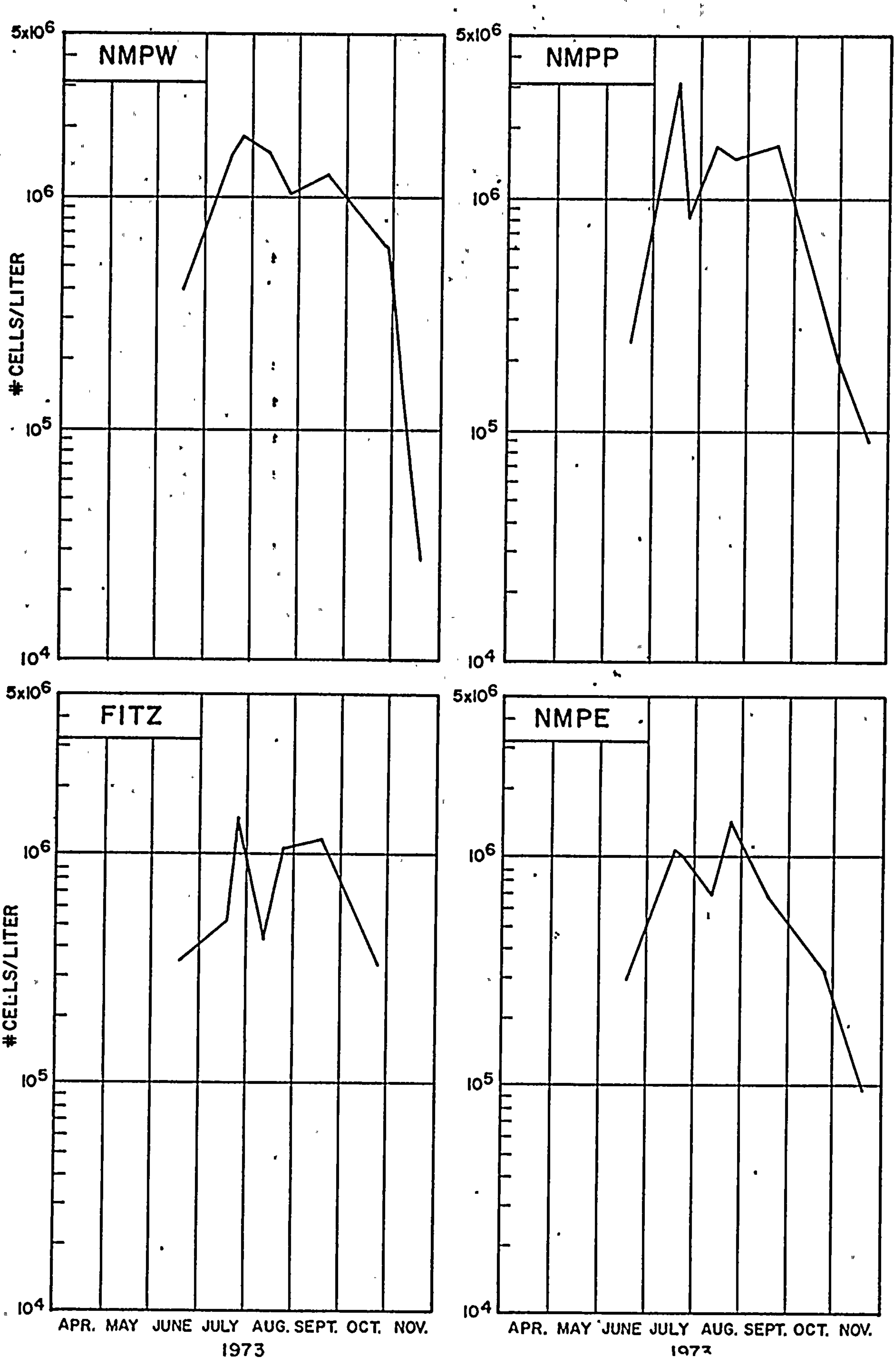


TABLE I-2

Maximum and mininum abundance within transects and along contours for net phytoplankton samples.

Transect	Contour Depth	cells/Liter
NMPW	60 ft.	3.5×10^4
	20 ft.	1.6×10^6
NMPP	20 ft.	2.2×10^4
	60 ft.	1.4×10^6
FITZ	60 ft.	9.0×10^4
	40 ft.	1.1×10^6
NMPE	60 ft.	4.7×10^4
	40 ft.	1.4×10^6

Contour Depth	Transect	cells/Liter
10 ft.	NMPE	5.1×10^4
	NMPW	1.6×10^6
20 ft.	NMPP	2.3×10^4
	NMPW	1.6×10^6
40 ft.	NMPW	7.9×10^4
	NMPE	1.4×10^6
60 ft.	NMPW	3.5×10^4
	NMPP	1.4×10^6

TABLE I-3

Maximum and minimum total abundance within transects and along contours for whole water phytoplankton samples.

Transect	Contour Depth	cells/Liter
NMPW	60 ft.	2.1×10^4
	40 ft.	7.1×10^6
NMPP	40 ft.	5.7×10^4
	60 ft.	3.1×10^6
FITZ	10 ft.	6.5×10^4
	10 ft.	6.2×10^6
NMPE	10 ft.	9.3×10^4
	20 ft.	3.5×10^6

Contour Depth	Transect	cells/Liter
10 ft.	NMPE	9.3×10^4
	FITZ	6.2×10^6
20 ft.	NMPW	9.6×10^4
	NMPE	3.5×10^6
40 ft.	NMPP	5.7×10^4
	NMPW	7.1×10^6
60 ft.	NMPW	2.1×10^4
	NMPP	3.1×10^6

FIGURE I-10

NET PHYTOPLANKTON ABUNDANCE ON THE 10' CONTOUR DEPTH

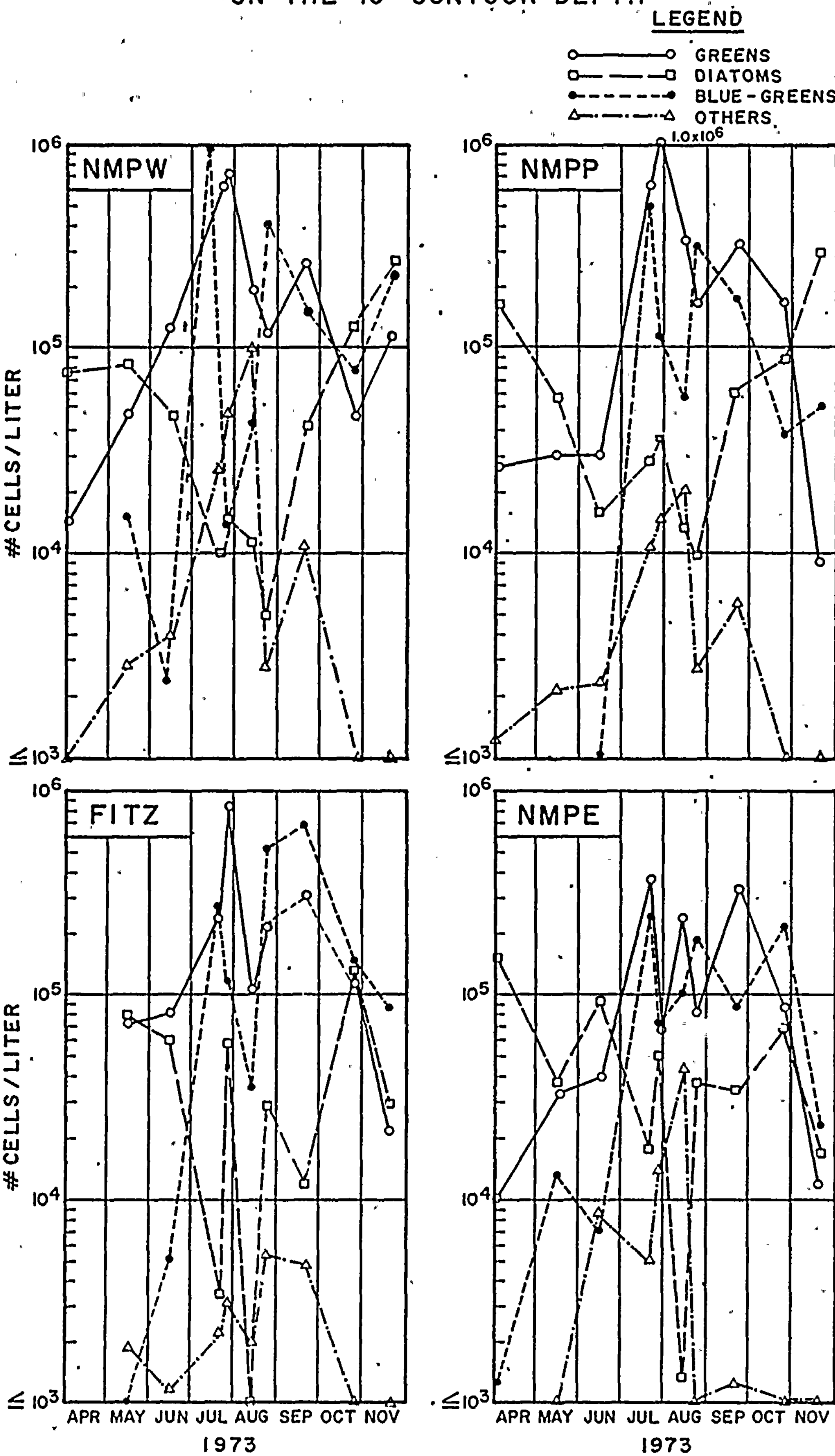


FIGURE I-11
NET PHYTOPLANKTON ABUNDANCE
ON THE 20' CONTOUR DEPTH

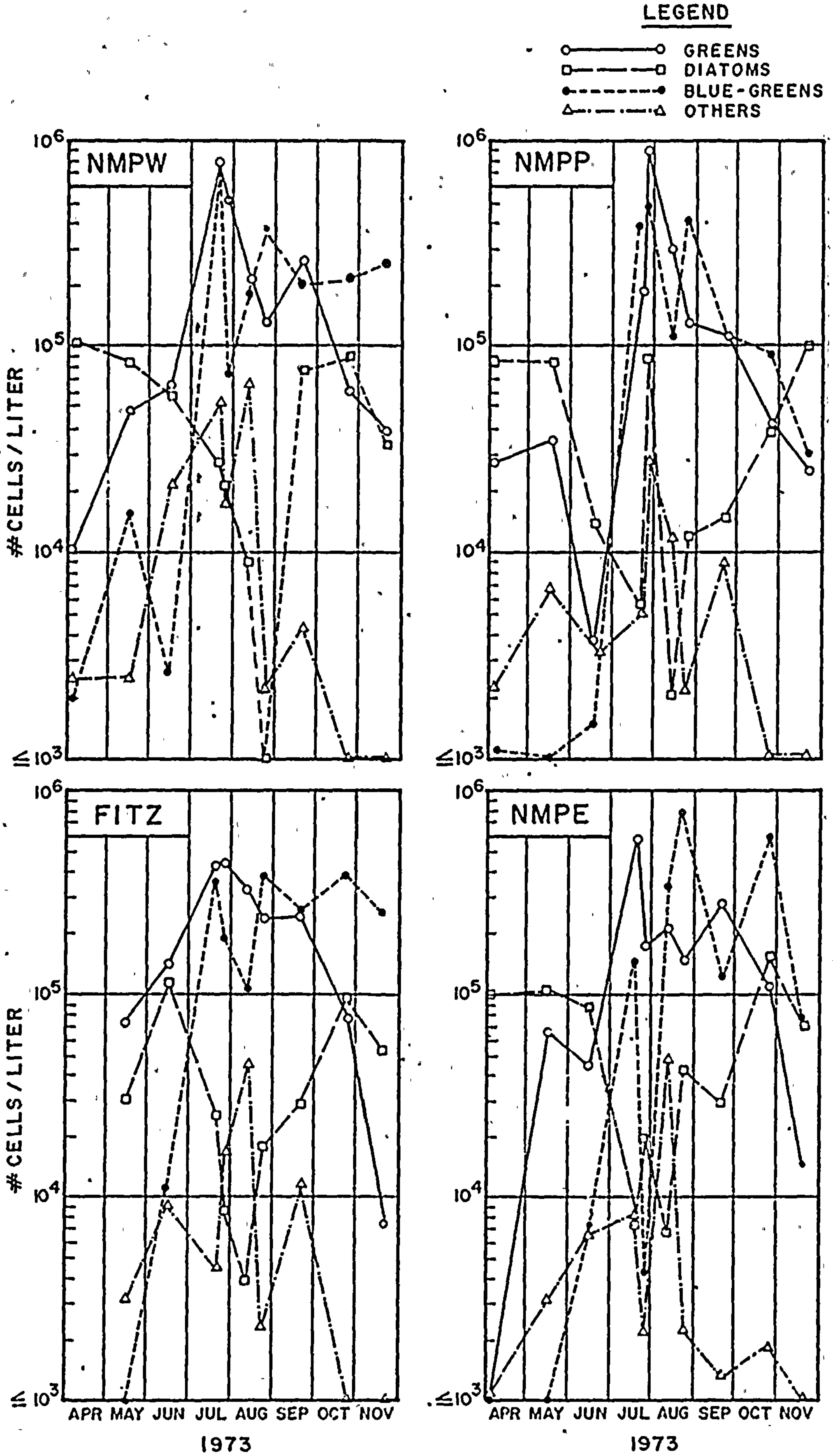


FIGURE I-12

NET PHYTOPLANKTON ABUNDANCE
ON THE 40' CONTOUR DEPTH

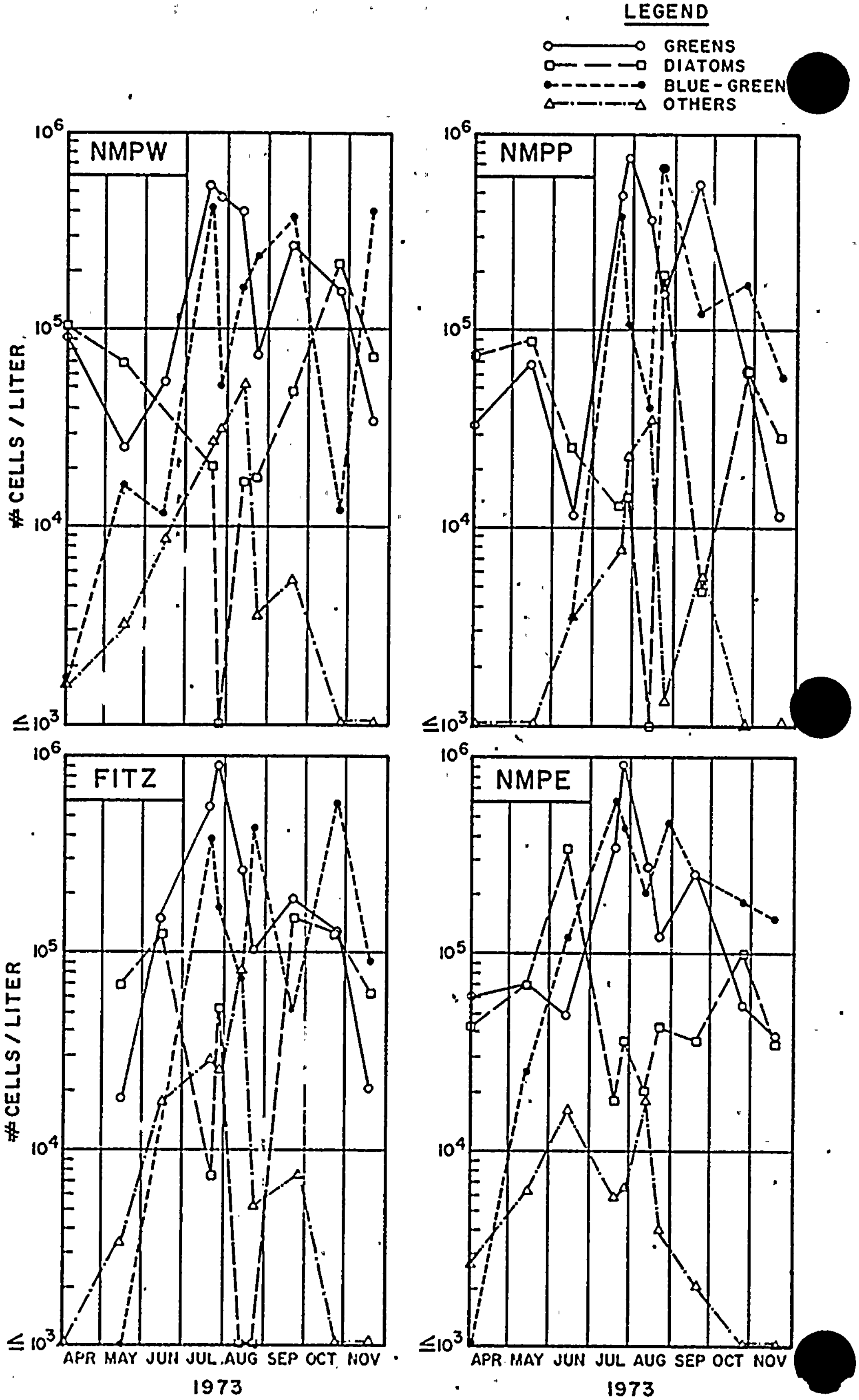


FIGURE I-13

NET PHYTOPLANKTON ABUNDANCE ON THE 60' CONTOUR DEPTH

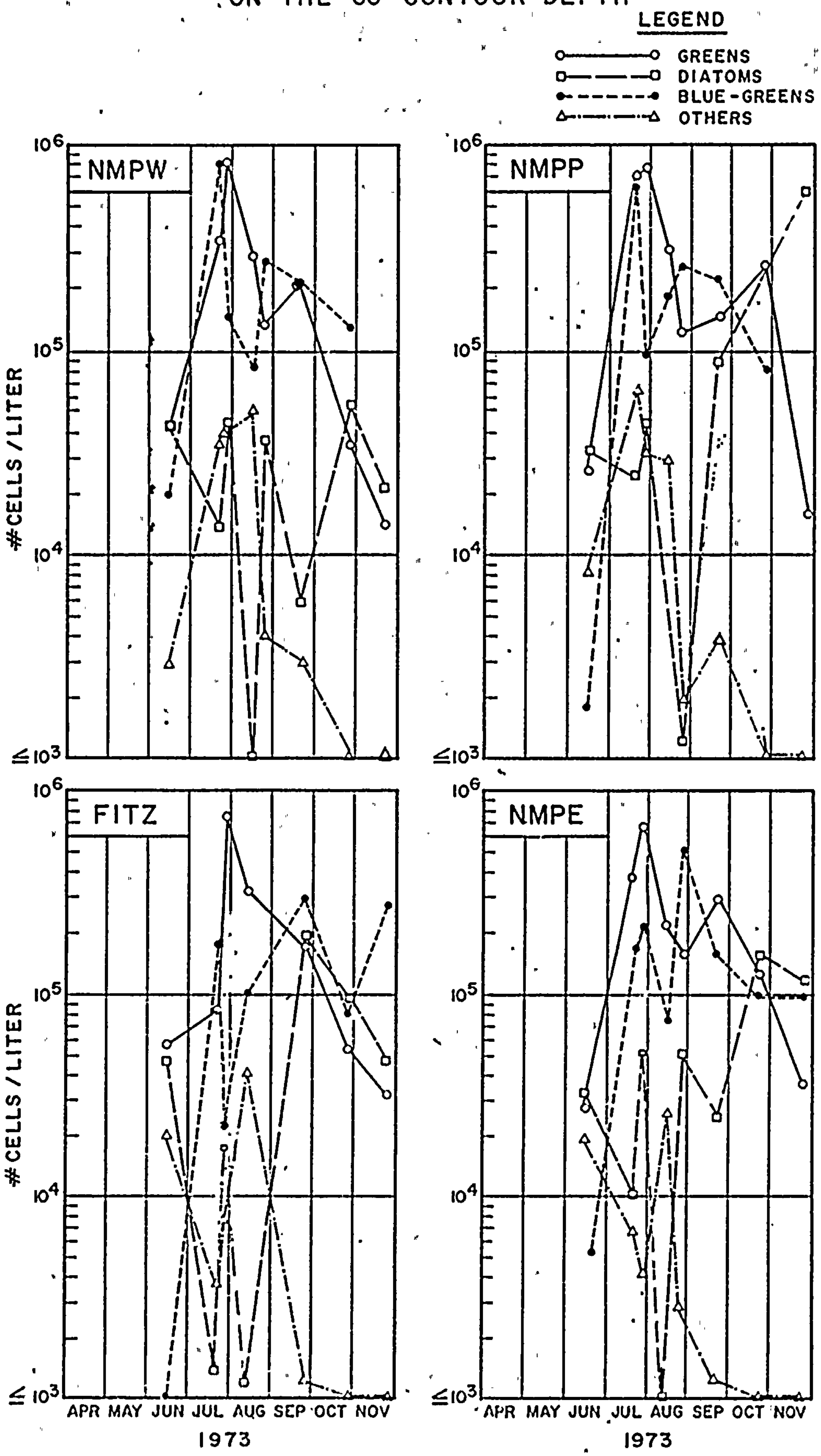


FIGURE I-14

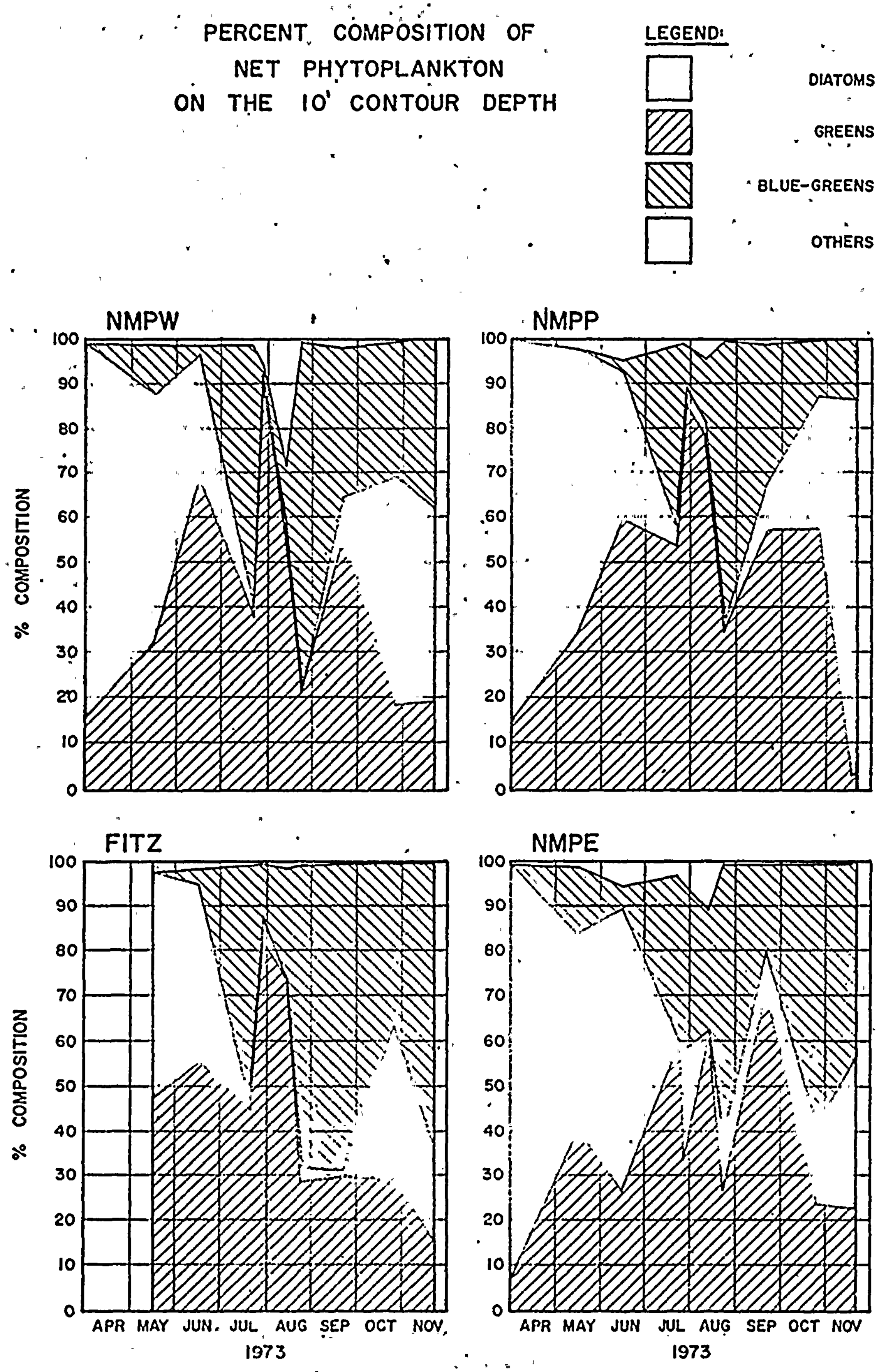

PERCENT COMPOSITION OF
NET PHYTOPLANKTON
ON THE 10' CONTOUR DEPTH
LEGEND:
DIATOMS
GREENS
BLUE-GREENS
OTHERS
NMPW
NMPP
FITZ
NMPE
% COMPOSITION
0
10
20
30
40
50
60
70
80
90
100
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
1973

FIGURE I-15
PERCENT COMPOSITION OF
NET PHYTOPLANKTON
ON THE 20' CONTOUR DEPTH

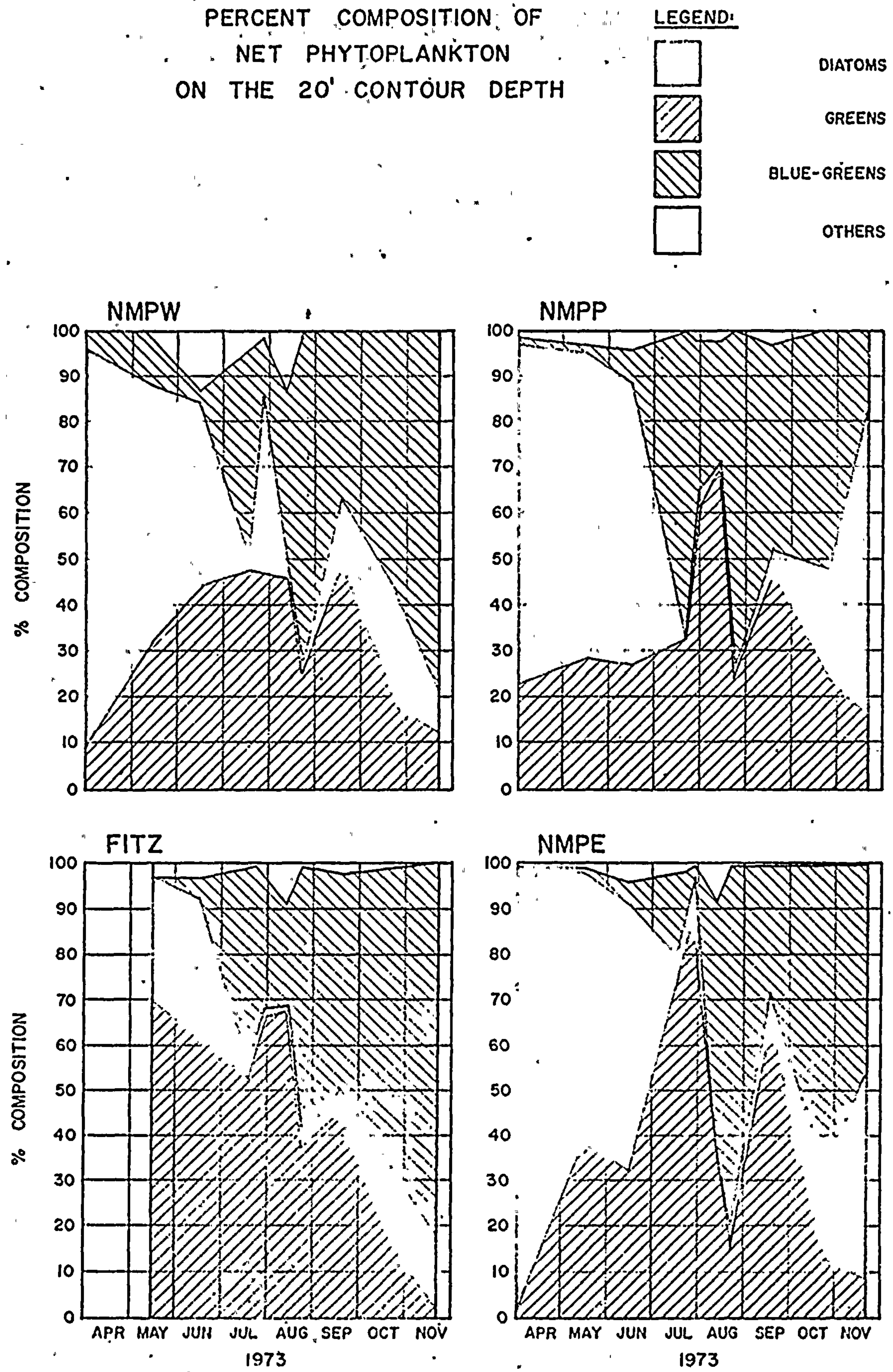


FIGURE I-16
PERCENT COMPOSITION OF
NET PHYTOPLANKTON
ON THE 40' CONTOUR DEPTH

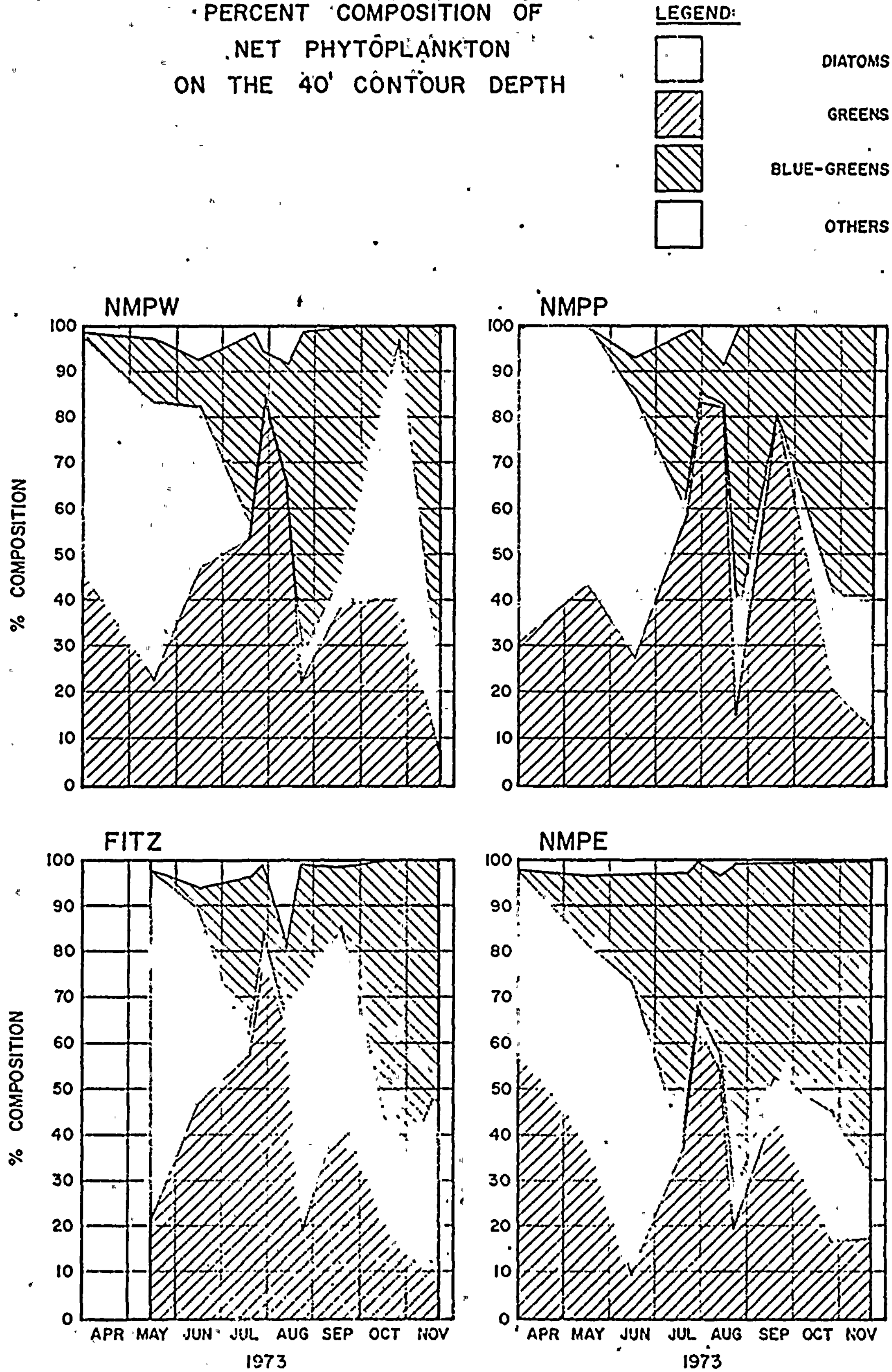


FIGURE I-17

PERCENT COMPOSITION OF
NET PHYTOPLANKTON
ON THE 60' CONTOUR DEPTH

LEGEND:
DIATOMS
GREENS
BLUE-GREENS
OTHERS

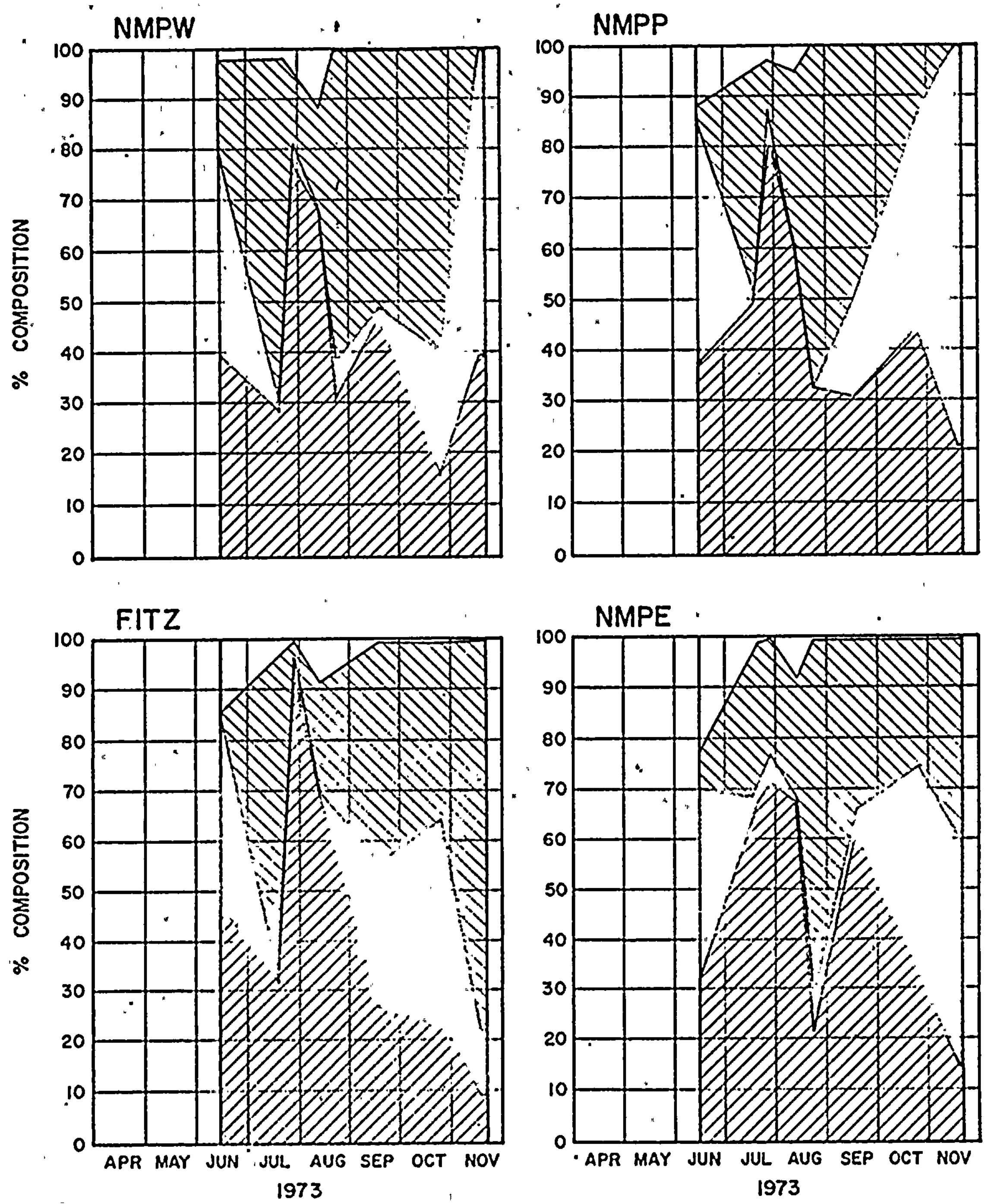


FIGURE I-18

WHOLE WATER PHYTOPLANKTON ABUNDANCE ON THE 10' CONTOUR DEPTH

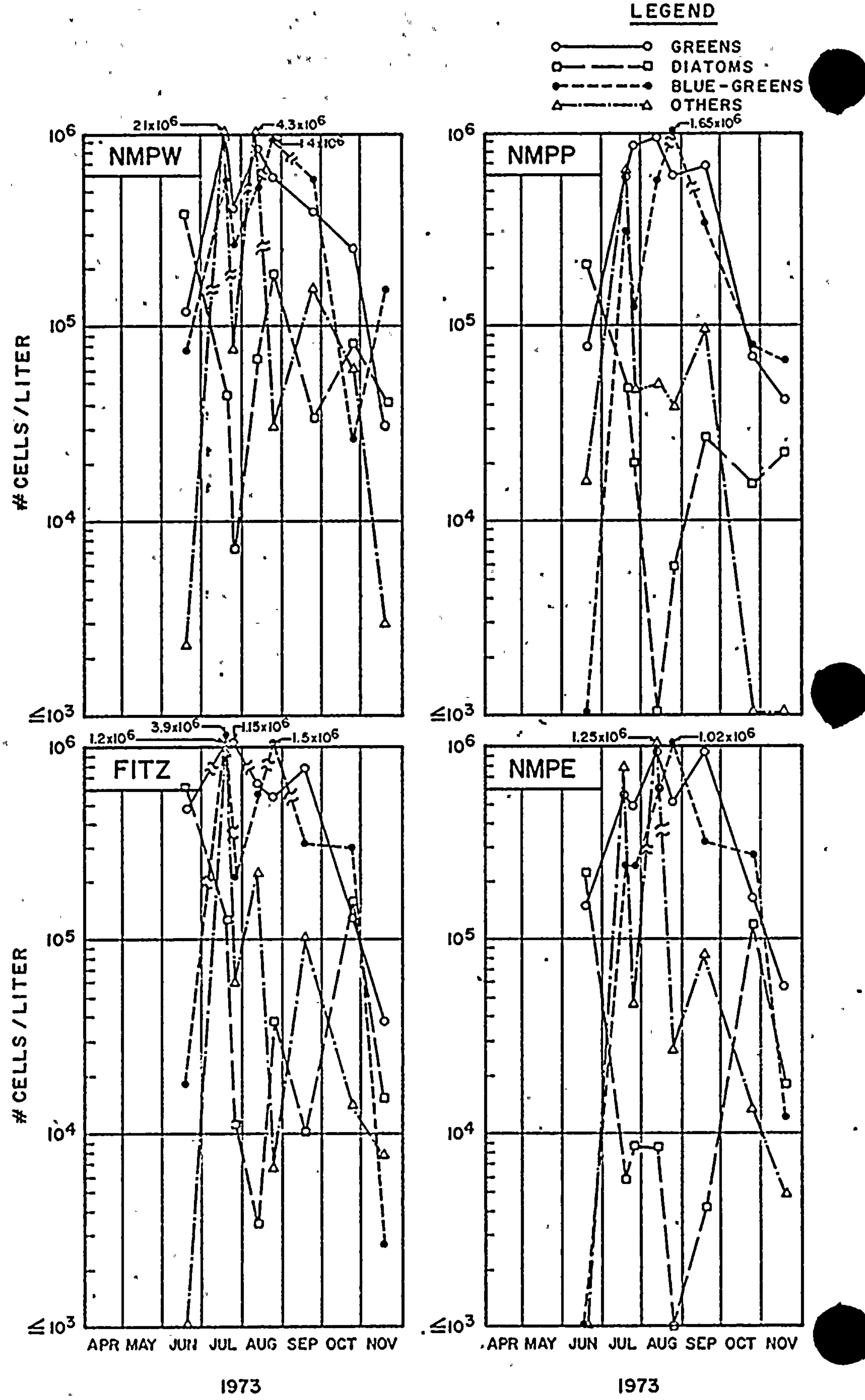


FIGURE I-19

WHOLE WATER PHYTOPLANKTON ABUNDANCE
ON THE 20' CONTOUR DEPTH

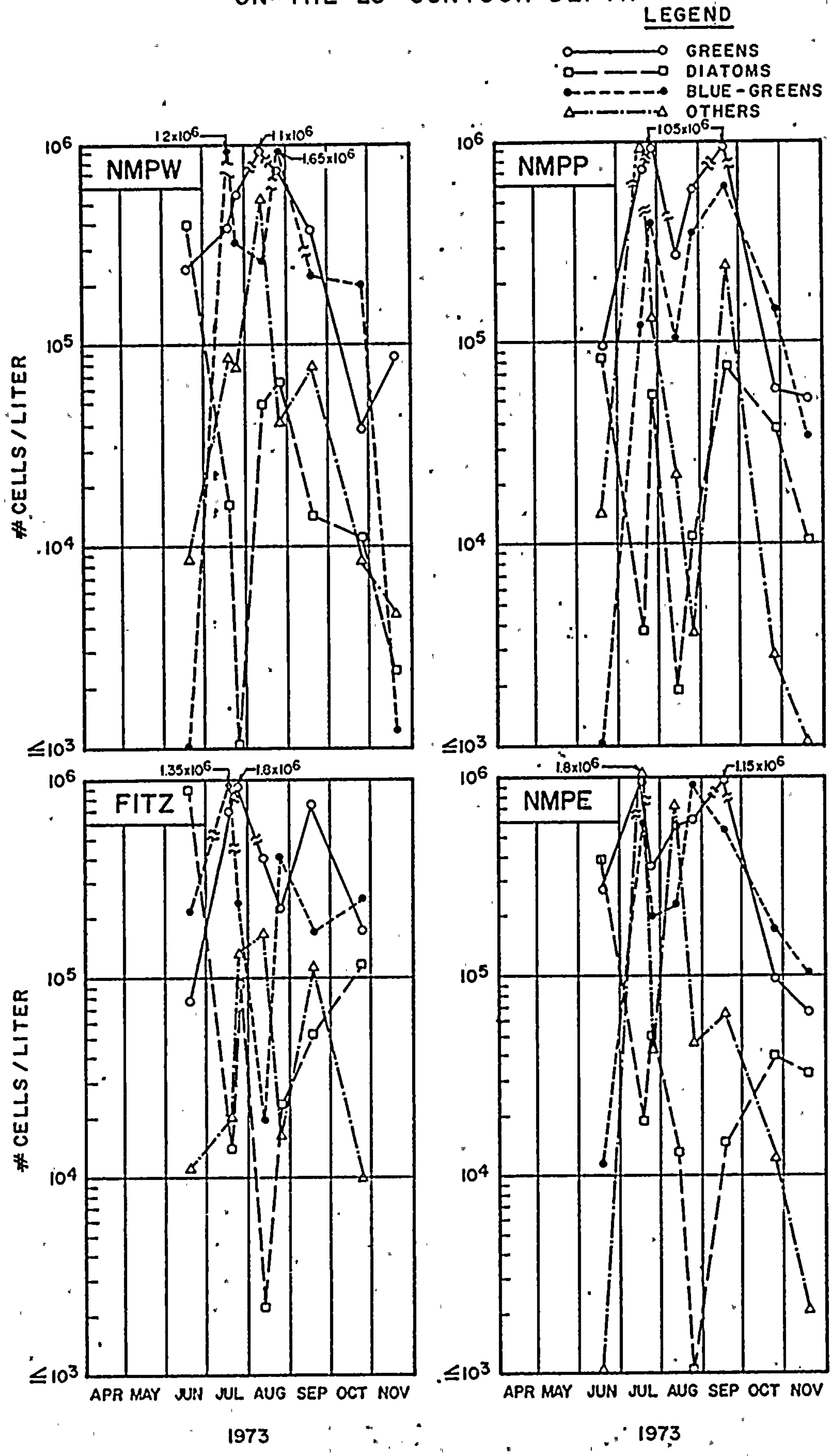


FIGURE I-20

WHOLE WATER PHYTOPLANKTON ABUNDANCE ON THE 40' CONTOUR DEPTH

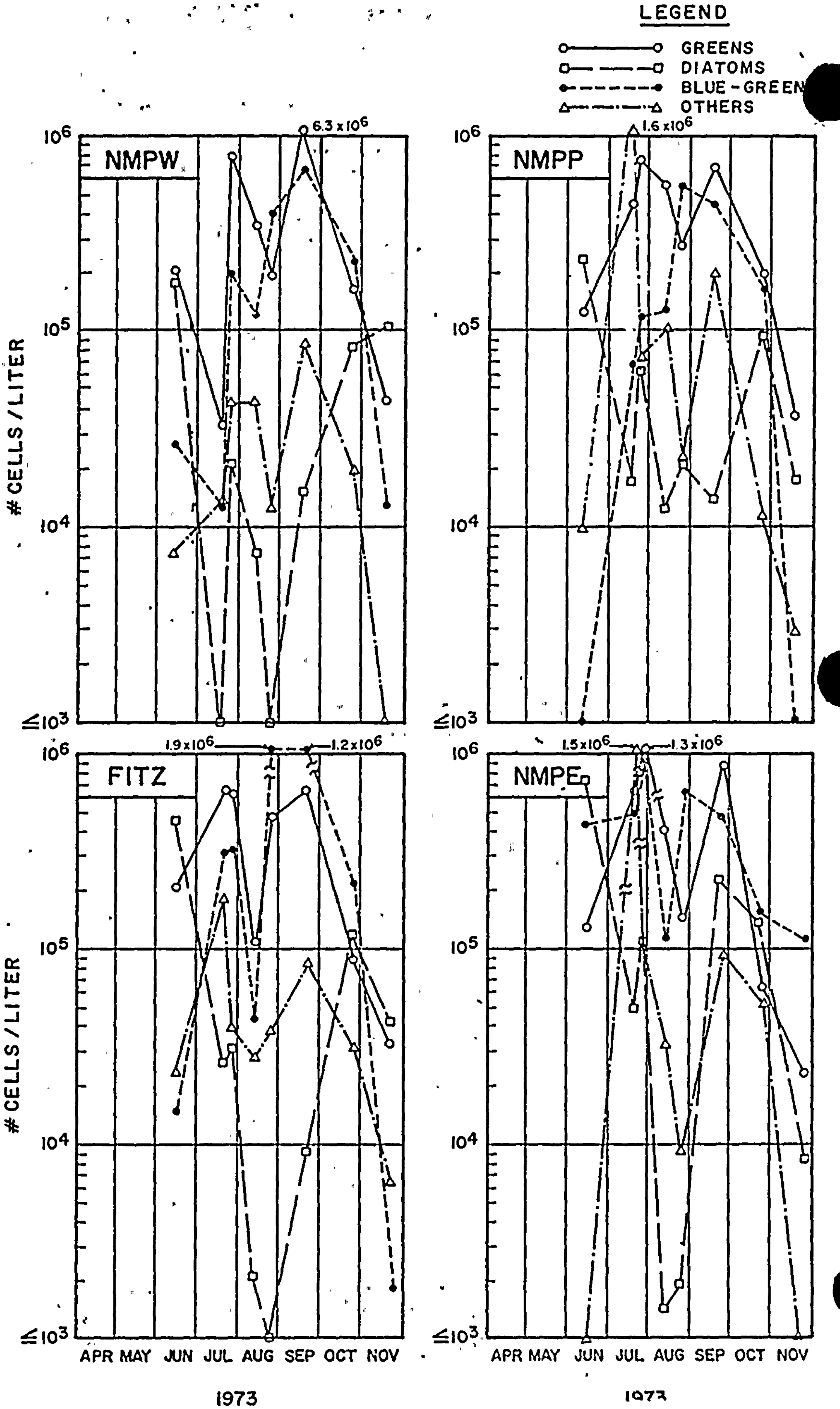


FIGURE I-21

WHOLE WATER PHYTOPLANKTON ABUNDANCE ON THE 60' CONTOUR DEPTH

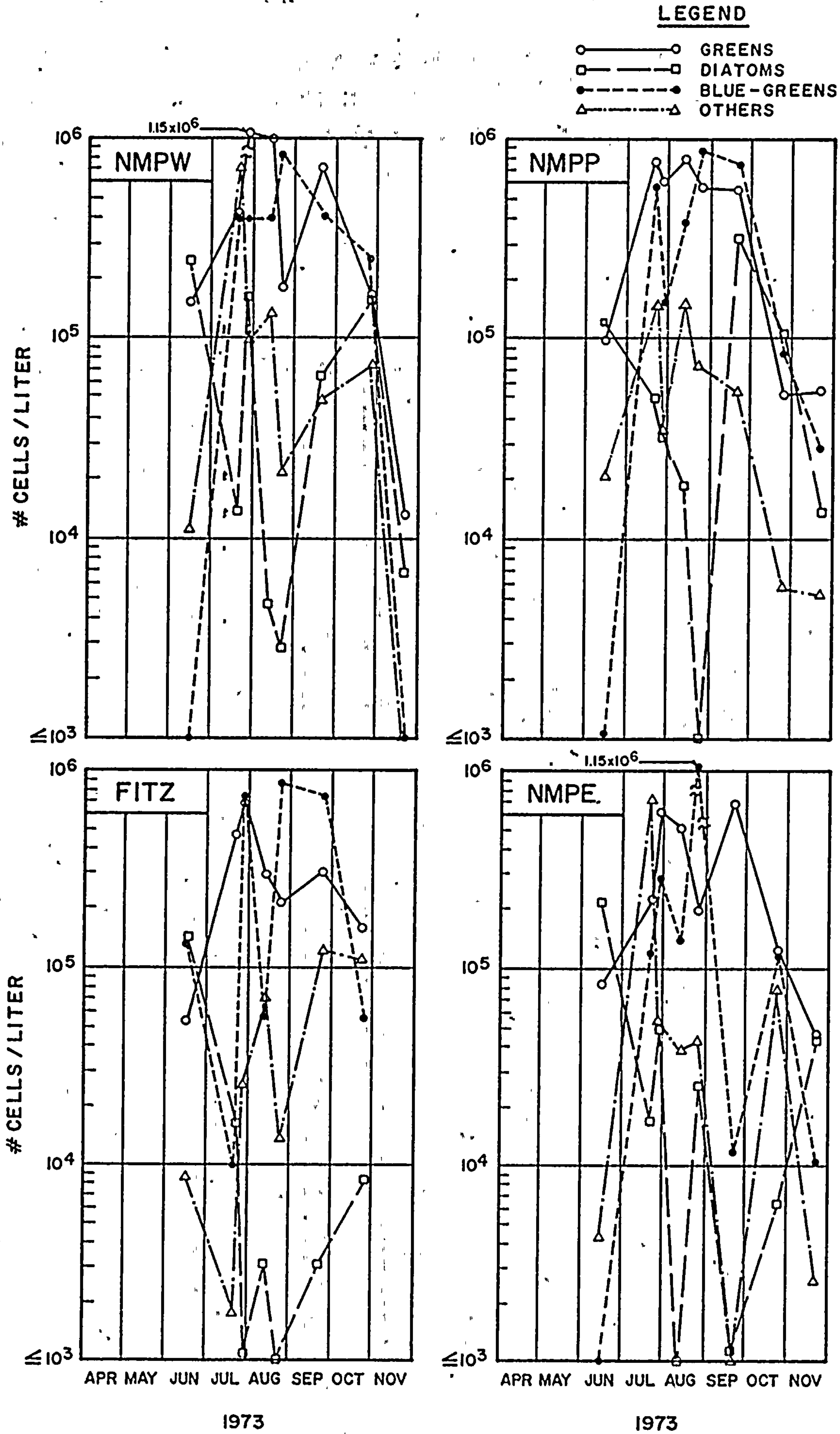


FIGURE I-22

PERCENT COMPOSITION OF WHOLE WATER PHYTOPLANKTON ON THE 10' CONTOUR DEPTH

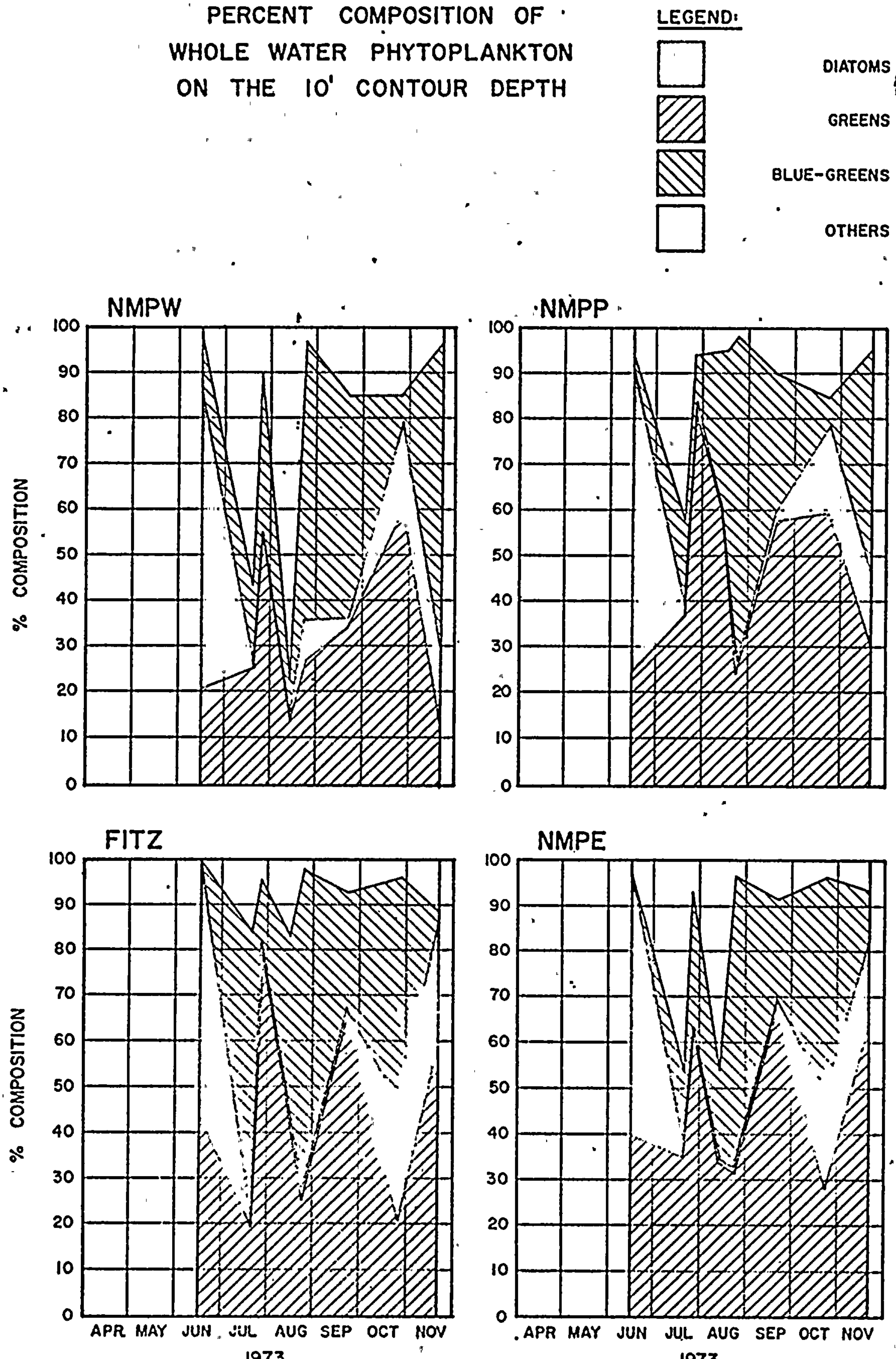


FIGURE I-23

PERCENT COMPOSITION OF
WHOLE WATER PHYTOPLANKTON
ON THE 20' CONTOUR DEPTH

LEGEND:

DIATOMS

GREENS

BLUE-GREENS

OTHERS

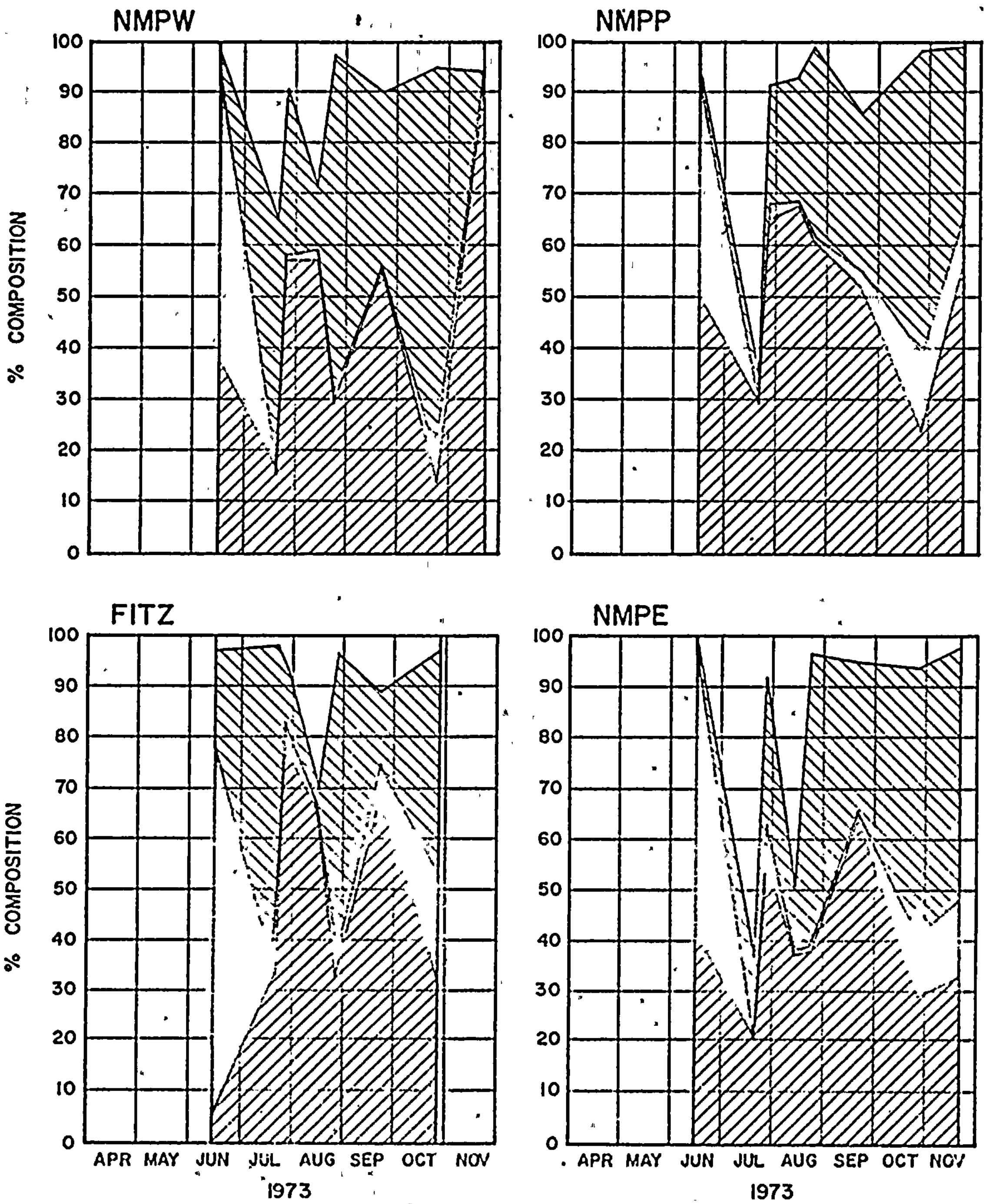


FIGURE I-24

PERCENT COMPOSITION OF WHOLE WATER PHYTOPLANKTON ON THE 40' CONTOUR DEPTH

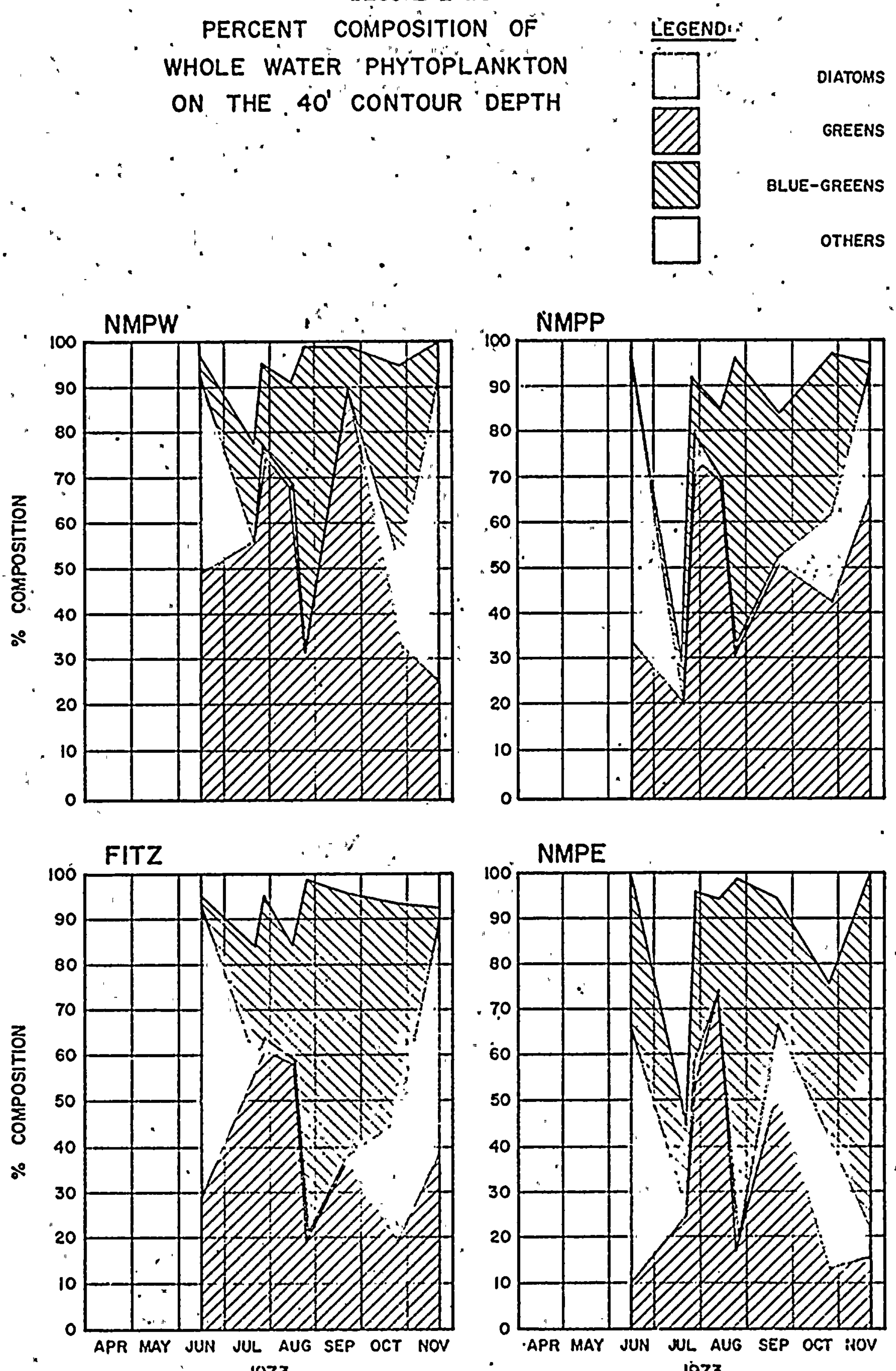
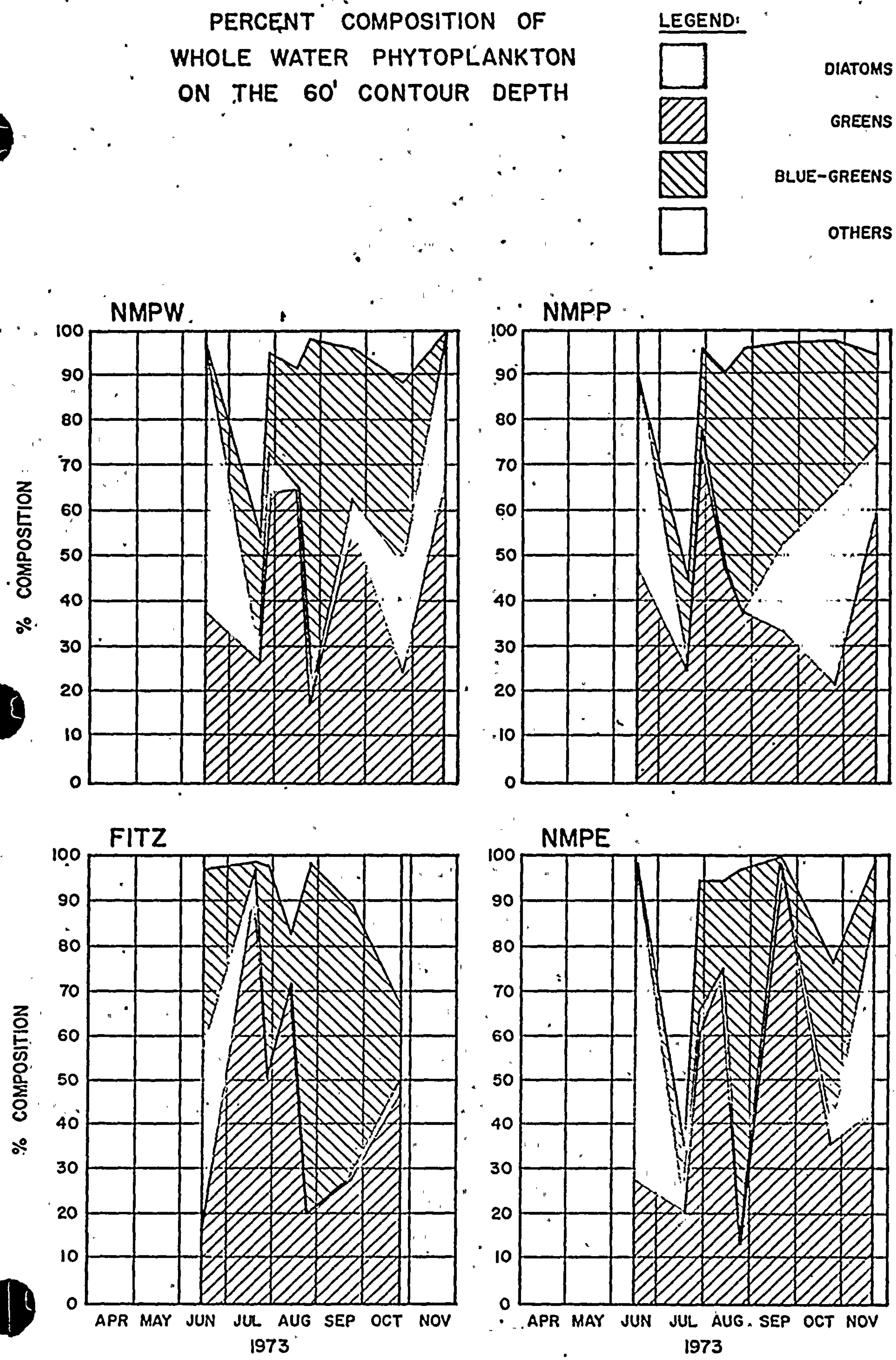


FIGURE I-25

PERCENT COMPOSITION OF WHOLE WATER PHYTOPLANKTON ON THE 60' CONTOUR DEPTH



To determine possible significant differences in total phytoplankton collected between each contour of each transect over the sampling period, statistical analyses were conducted on both net and whole water phytoplankton total abundances. The results of a two-way analysis of variance (ANOVA) for total net phytoplankton collected at each contour showed no significant differences between transects over the collection period (see Appendix III-B); there were no significant differences in abundance between contours for a given transect (see Appendix III-B).

Identical two-way ANOVAs were conducted on the total abundance of whole water phytoplankton: the abundance at contours showed no significant differences between transects over the collection period (Appendix III-B); and with the exception of the FITZ transect, there were no significant differences in abundance between contours for a given transect (Appendix III-B). The result of a Student-Newman-Kuels test showed that abundance of whole water phytoplankton at the 60 ft. depth contour of FITZ transect was least similar to the abundance at the 10 ft. depth contour (Appendix III-C). The effect due to dates (season) showed significant differences at contours and transects for both net phytoplankton (Appendix III-B) and whole water phytoplankton (Appendix III-B). Student-Newman-Keuls tests were then conducted on each significant difference found in the ANOVA tests to indicate on which collecting dates the abundance of net or whole water algae were most similar or most dissimilar (Appendix III-C). The general trend

for net and whole water phytoplankton abundance for contours and transects over time showed that spring and fall abundance were more similar one to another than they were to summer abundances of phytoplankton.

(ii) Diatoms

The abundance of each of the four major groups of phytoplankton is shown by contour depth for each transect for net phytoplankton (Figures I-10 - I-13) and for whole water phytoplankton (Figure I-18 - I-21). The percent composition of each group is shown in Figures I-14 - I-17 and Figures I-22 - I-25, respectively.

Diatoms were most abundant in the spring and fall months at all stations in net and whole water phytoplankton samples. The range of percent of total abundance was from over 90% of the total phytoplankton during the spring to <0.1% of the phytoplankton at several stations during the summer months. The numerical abundance of diatoms never exceeded 5×10^5 cells/liter in net samples, whereas diatom abundance approximated 10^6 cells/l in whole water samples on several occasions.

(iii) Green Algae

The abundance of green algae from net samples over the sampling period exhibited both bi- and trimodal peaks of abundance with some intermediate fluctuation and composed as much as 61% of the total phytoplankton during late August. Green algae were most prevalent during the mid-summer; abundances approaching 10^6 cells/l were not uncommon

in net samples; slightly higher abundances were found in whole water samples. Ninety-eight percent of the total whole water phytoplankton at NMPE-60 ft. station during late September were green algae. Generally, higher percentages of green algae occurred at the 40 and 50 ft. contours in April than at the corresponding inshore contours (Figure I-16; Appendix III-A).

(iv) Blue-Green Algae

Blue-green algae tended toward dominance in the late summer and fall months. Bi-,tri and quadrimodal pulses were determined in the seasonal distribution of blue-green algae from both net and whole water samples in an apparently random occurrence among stations and contours. Blue-green algae were most abundant in whole water samples during July at FITZ-10 ft. station (3.9×10^6 blue-green algae/l), although they accounted for approximately 50% of the phytoplankton population at that time. The blue-green algae abundance in net samples never exceeded 10^6 cells/l.

(v) "Other" Algae

Euglenoids, golden-brown algae and dinoflagellates composed all "other" phytoplankton. Although their abundance in net samples was low and usually amounted to less than 10% of the total phytoplankton collected in net samples, their abundance in whole water samples quite often exceeded 10% of total phytoplankton numbers. During July, for example, "other" algae accounted for just over 60% of all phytoplankton in whole water samples collected at the NMPP-20 ft.

station and approximately 70% of those collected at NMPP-40 ft. station; the bulk of "other" algae at those two stations were euglenoids.

c. Comparison of Abundance of Net Phytoplankton and Whole Water Phytoplankton

To determine which collection technique yielded greater numbers of algae, the abundance of green algae, dinoflagellates, blue-green algae, euglenoids, diatoms and total algae in net samples and whole water samples was compared using a paired t-test or a Wilcoxon Signed Rank Test (for larger samples). Because of their infrequent occurrence, golden-brown algae were not tested. The results are presented in Appendix III-B.

For diatoms there was no significant difference between abundance in net and whole water samples. However, for green algae, dinoflagellates, blue-green algae, euglenoids and total algae, the abundance in whole water samples was significantly greater than the abundance in net samples.

d. Windrow Phytoplankton

Windrow phytoplankton samples were collected on five dates between June and September in the manner described in Appendix I-A; the resultant data are compiled in Appendix III- D. The windrow phytoplankton populations exhibited the general seasonal trends followed by the populations sampled at the sixteen stations off Nine Mile Point, i.e., relatively high abundance during the late spring months followed by a mid-summer decrease in abundance and, subsequently, a significant increase in abundance during the fall.

The main purpose of the windrow collections was to take advantage of this natural concentrating mechanism to obtain samples of the rarer phytoplankton species. Although fewer species of green algae, golden-brown algae and blue-green algae were collected from windrows than were found at the sixteen standard stations, three species, *Asterococcus sp.*, *Elekuthrix sp.*, and *Peridinium aciculiferium*, were found only on windrows.

e. Seasonal Succession

The seasonal succession of algal genera by month is summarized in Table I-4. The diatom succession centered upon variations primarily among the genera *Asterionella*, *Fragilaria*, and *Cyclotella*; *Pediastrum* remained the dominant green alga over the course of most of the sampling program; the blue-green succession involved ten genera; and the dinoflagellates *Ceratium*, *Peridinium*, and *Glenodinium* dominated the successional patterns of "other" algae.

f. Chlorophyll *a* Concentrations

Phytoplankton biomass data based on chlorophyll *a* concentrations were obtained as described in Appendix I-A. These data are tabulated in Appendix III-E and shown in Figure I-26.

Chlorophyll *a* concentrations showed bimodal or trimodal seasonal trends; concentration values ranged from 0.0 to 38.0μg/l over the course of the 1973 sampling program. Although chlorophyll *a* values paralleled trends in numerical abundance during the late spring and early summer, the late summer

TABLE I-4

RANKING OF
NET PHYTOPLANKTON BY ALGAL GROUP*

Date 1973	Green Algae	Diatoms	Blue-Green Algae	Others
2 April	Hyalotheca Golenkinia Mougeotia	Asterionella Melosira Fragilaria	Chroococcus - -	Glenodinium (D) Dynobrion (GB) -
16 May	Hyalotheca Golenkinia Mougeotia	Asterionella Stephanodiscus Melosira	Chroococcus Oscillatoria -	Glenodinium (D) Dynobrion (GB) Euglena (E)
15 June	Scenedesmus Pediastrum Micractinsium	Asterionella Cyclotella Stephanodiscus	Anabaena Chroococcus Oscillatoria	Dynobrion (GB) Synura (GB) Glenodinium (D)
20 July	Pediastrum Gleocystis Coelastrum	Cyclotella Fragilaria Melosira	Microcystis Phormidium Gomphosphaeria	Ceratium (D) Glenodinium (D) Peridinium (D)
27 July	Pediastrum Eudorina Coelastrum	Cyclotella Fragilaria Coscinodiscus	Coelosphaera Microcystis Aphanocapsa	Glenodinium (D) Peridinium (D) Ceratium (D)
13 August	Pediastrum Gleocystis Coelastrum	Coscinodiscus Fragilaria Cyclotella	Microcystis Coelosphaerium Gomphosphaeria	Peridinium (D) Glenodinium (D) Ceratium (D)

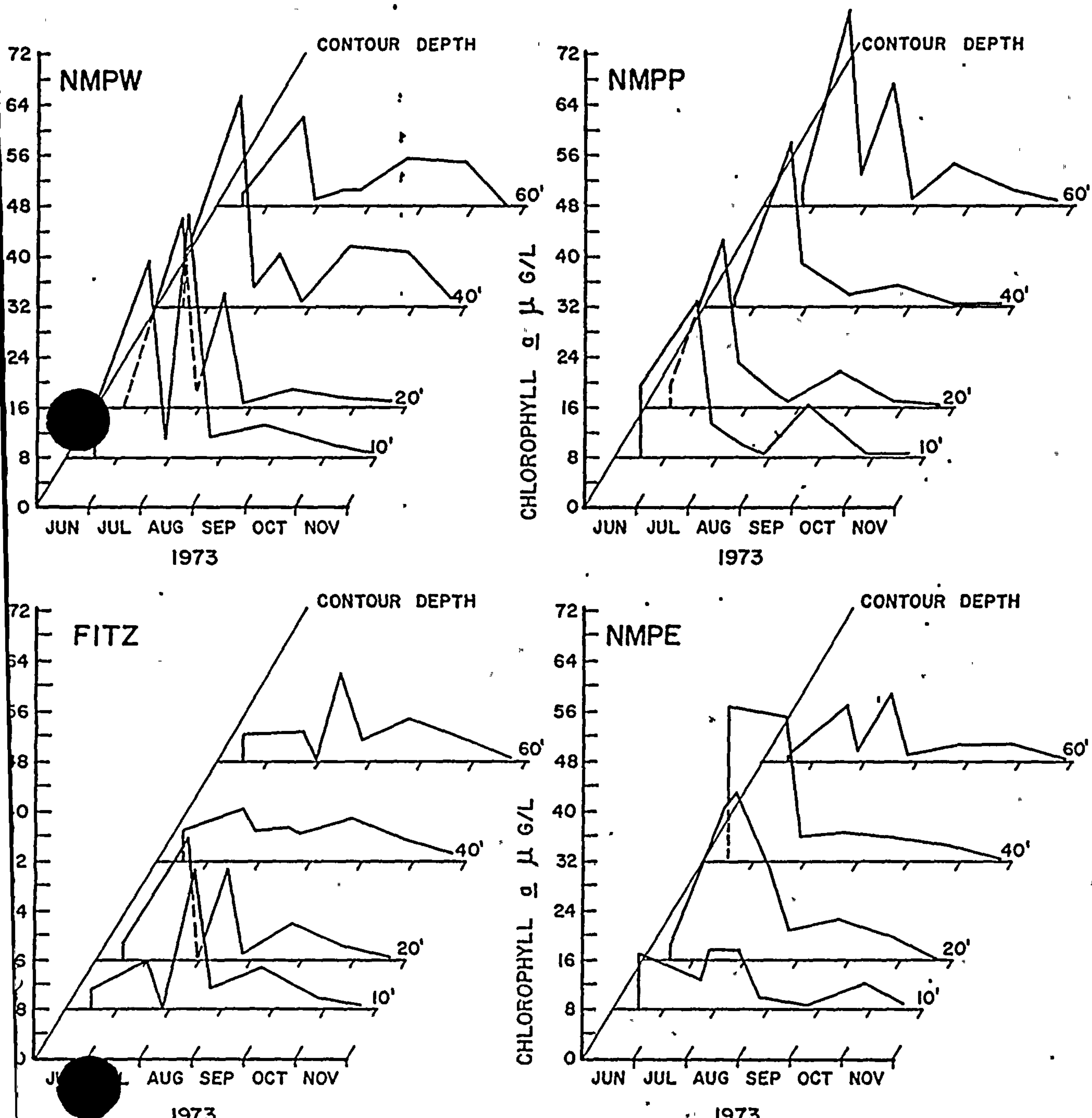
TABLE I-4 (cont'd)

Date 1973	Green Algae	Diatoms	Blue-Green Algae	Others
23 August	Pediastrum Gleocystis Dictyosphaerium	Fragilaria Melosira Cyclotella	Coelosphaerium Microcystis Anabaena	Ceratium (D) Peridinium (D) Glenodinium (D)
21 September	Pediastrum Dictyosphaerium Coelastrum	Fragilaria Stephanodiscus Coscinodiscus	Coelosphaerium Microcystis Anabaena	Glenodinium (D) Peridinium (D) Ceratium (D)
25 October	Pediastrum Ulothrix Planktosphaeria	Fragilaria Tabellaria Astrionella	Gomphosphaeria Anacystis Anabaena	Ceratium (D) Glenodinium (D) Mallamonas (GB)
20 November	Pediastrum Staurastrum Closteriopsis	Fragilaria Tabellaria Astrionella	Gomphosphaeria Anacystis Oscillatoria	Glenodinium (D) – –

* = Genus only
– = no representative
D = dinoflagellate
E = euglenoid
GB = golden-brown algae

FIGURE I-26

CHLOROPHYLL a DISTRIBUTION
AT
ALL FOUR TRANSECTS



and fall increase in algal abundance was not as readily apparent in the chlorophyll a measurements. Regression equations, as described by Sokal and Rohlf (1969), applied to chlorophyll a concentrations and net and whole water phytoplankton abundance confirmed the link between these two indicators of standing stock. The following equalities were found*:

for whole water phytoplankton	714.8 = 64.4 chlor. a where r = 0.46
for net phytoplankton	413.3 = 16.6 chlor. a where r = 0.39

Figure I-27 shows the seasonal patterns of phaeopigment concentrations (the degradation products of chlorophylls) at the sixteen plankton stations off Nine Mile Point. The correlation coefficient between phaeopigment and chlorophyll a concentrations (-0.05) was found to be negative, but not significant at $\alpha = 0.05$. This result indicates that phaeopigment values were inversely proportional to chlorophyll a values, a finding which will be utilized in the microzooplankton section.

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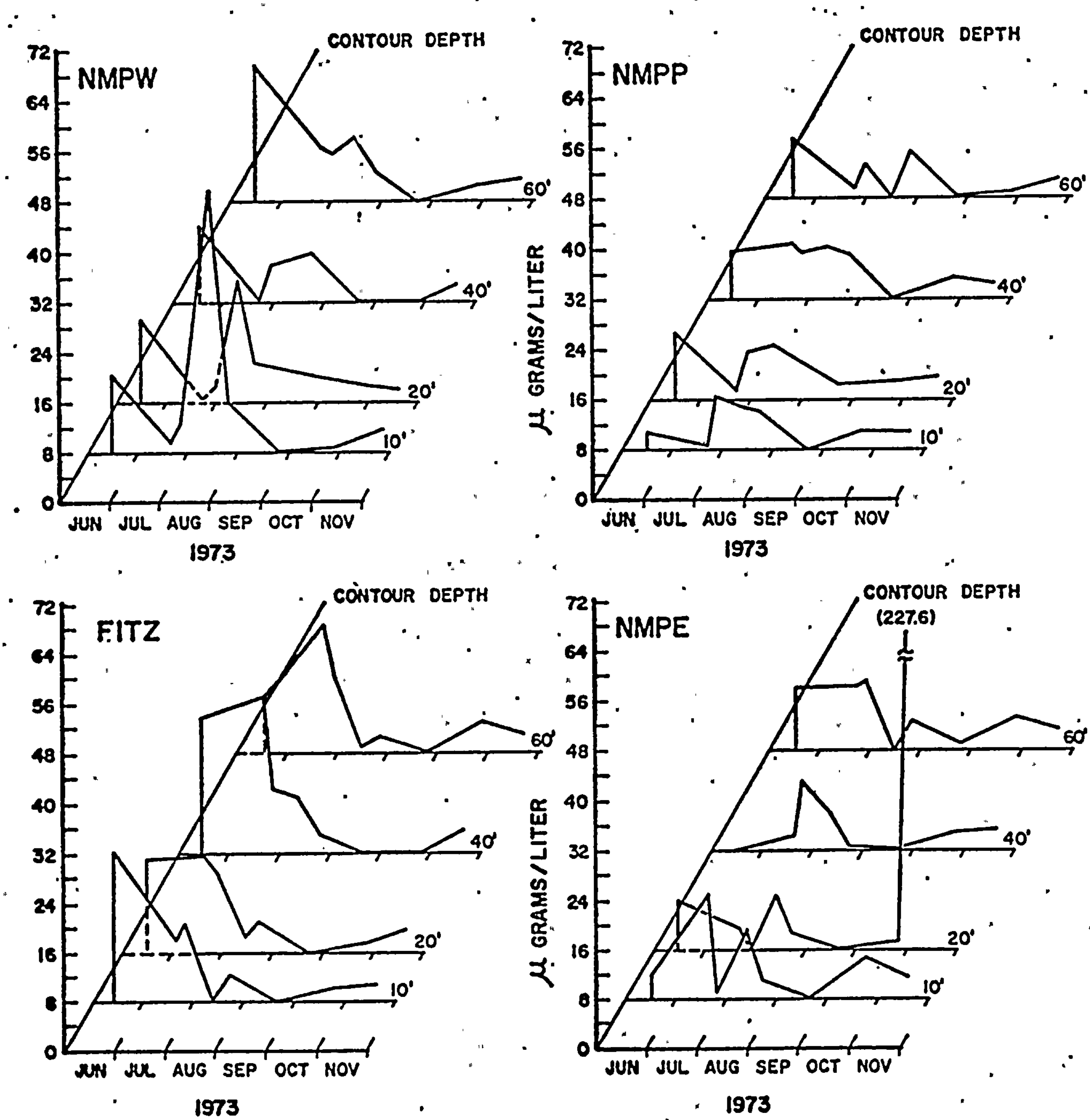
* All statistical analyses are defined and described in Appendix II.

FIGURE I-27

PHEO-PIGMENT DISTRIBUTION
AT
ALL FOUR TRANSECTS



3. DISCUSSION OF RESULTS

The 1973 phytoplankton abundance in the Nine Mile Point vicinity ranged from 10^4 to $>10^6$ cells/l. In a 1964 study of Lake Ontario, Ogawa (1969) reported 2.6×10^5 to 1.8×10^6 cells/l in the Lake surface waters for total phytoplankton, with approximately 5×10^5 cells/l in the Nine Mile Point region. Therefore, minimal density changes have occurred in nearly a decade.

Several authors found higher phytoplankton abundance in in shore waters than offshore waters in Lake Ontario (Nalewajko, 1966; Ogawa, 1969; Munawar and Nauwerck, 1971). The investigations in the Nine Mile Point vicinity tended to reflect a general inshore-offshore trend. However, the only statistically significant difference confirming this trend occurred at the FITZ transect when whole water phytoplankton abundances were compared.

The seasonal patterns observed in the Nine Mile Point vicinity reflected successional patterns previously found in Lake Ontario. The diatom community was composed of Asterionella, Fragilaria, Cyclotella, Melosira, Tabellaria and Stephanodiscus. Reinwand (1969) noted that Asterionella, Fragilaria and Tabellaria comprised the major species in surface waters in Lake Ontario. During the spring months, the more shallow waters became warmer; later in the year the thermal bar moved offshore. Melosira binderana and Stephanodiscus tenuis were associated with the development of the thermal bar (Nalewajko, 1966, 1967; Munawar and Nauwerck, 1971; Lorefice, 1972). Green algae tend to be the dominant component of the phytoplankton in Lake Ontario in the late summer (Ogawa, 1969; Munawar and Nauwerck, 1971). In the Nine Mile Point area, the green algae increased rapidly in abundance during July with about fifteen species regularly occurring. Among these

species were Scenedesmus, Oocystis and Coelastrum, which Ogawa (1969) reported to exist throughout the Lake.

Blue-green algae followed the dominance of green algae. Munawar and Nauwerck(1971) found that during the summer and fall maxima, green algae comprised the dominant group with smaller populations of blue-green algae and cryptomonads, respectively. Further, Davis (1966) noted that green algae and blue-green algae were dominant in shallower waters, while the diatoms seemed to be of greater importance in the open Lake.

Various parameters might influence the successional trends found in the Nine Mile Point vicinity. Diatoms followed by the green algae was the basic pattern early in 1973. Diatom growth was favored by nutrient availability and temperature (Patrick, 1966). The warmer temperatures of the summer induced the green algal pulses (Smith, 1950). Blue-green algae, generally considered nuisance algae because of their rapid growth in warm and nutrient-rich circumstances, were extant in August. Since the temperatures at NMPP and FITZ (28.2 - 29.1°C) were higher than the two control transects (25.5-26.8°C) (Appendix III-C), increased growth of blue-green algae would be expected and were reflected in the whole water phytoplankton on the 10 ft. contour and in the net phytoplankton on the 20 ft. contour. (Figures I-18 and I-11). Also contributing to the increased abundance of blue-green algae were lower concentrations of dissolved oxygen, nitrate and total phosphorus (See Water Quality Section; Shapiro, 1973; Fogg et al., 1973)

Algal populations may become a nuisance or even harmful when a large magnitude of algae per unit area, i.e., a bloom, exists. Bloom proportions of algae may

impart odors and foul tastes to water supplies, deplete the oxygen supply through decomposition of algae cells, cause skin rashes or illness in man, and ruin the asthetic and recreational resources of the aquatic facilities. Whether or not an algal bloom is harmful depends upon the composition and abundance of the algae in the vicinity (Mackenthun, 1969).

Two criteria have been employed to recognize the presence of blooms. Whipple et (1948) suggested that individual cell counts of algae exceeding 5 x 10^5 cells/l constituted a potentially harmful concentration, while densities greater than 3 x 10^6 cells/l indicated the existence of a troublesome concentration. A second criterion which may be used is the rapid growth of algae over a short duration of time (Odum, 1971). Utilizing Whipple's density definition, it is noted that the concentrations of Microcystis reached 5 x 10^5 cells/l on several occasions, thus constituting bloom proportions. However, rapid growth of this blue-green alga did not occur. The possibility of other blue-green algae exceeding Whipple's density specifications existed, since Oscillatoria, Phoridinium, Lyngbya and Aphanizomenon were counted as filaments and not enumerated as cells. Green algae, a dinoflagellate, and a euglenoid, in addition to blue-green algae, exceeded 5 x 10^5 cells/l during the sampling period. On 21 September in whole water phytoplankton samples collected at the NMPW transect at the 40 ft. contour, Dictyosphaeruim pulchellum and Botryococcus sudeticus reached concentrations of 3.0 x 10^6 cells/l and 2.5 x 10^6 cells/l, respectively. During July collections, net phytoplankton analysis showed that Volvox aureus, a colonial green, had a density of 5.9 x 10^5 cells/l at the NMPE transect on 10 ft. contour depth. The dinoflagellate Glenodinuim paluste reached a concentration of 1.2 x 10^6 cells/l on 13 August 1973. Euglena sp. exceeded concentrations of 5 x 10^5 cells/l at several sites during July whole water phytoplankton sampling.

The isolated nature of high numbers of certain species also reflects the patchiness of phytoplankton in Lake Ontario. As pointed out by Parsons and Takahashi (1973) planktonic populations generally tend to be clumped or aggregated, rather than distributed randomly. Nutrient availability, temperature, light, wind, algal reproduction rates, grazing pressure and sampling techniques individually or in combination will influence the location of an algal patch (Parson and Takahashi, 1973). Further indication of patchiness in Lake Ontario is reflected in the presence of the planktonic patchiness due to wind conditions which result in windrows. The presence of windrows is usually related to Langmuir circulation patterns where water masses move in vortices, producing microzones of downwelling and upwelling water. Phytoplankton and detrital material in a windrow may be randomly distributed through dispersal in areas of upwelling or aggregation in areas of downwelling. Fluctuations in chlorophyll a may also be indicative of phytoplankton patchiness in the surface waters in the Nine Mile Point area.

As noted in the result section, the seasonal pattern of abundance in the vicinity of the Nine Mile Point area was either bi-or tri modal. Glooschenko et al. (1972) observed three cycles of abundance in Lake Ontario: 1) a unimodal pattern of abundance is characteristic of deep waters which are the last to warm; 2) a bimodal pattern of abundance, with vernal and autumnal pulses usually occurring in the central reaches of the Lake and along the southern and northern shores; and 3) a trimodel trend of abundance in nutrient-rich regions and in the eastern third of the Lake. The yearly patterns tended to be influenced by the thermal bar, as well as by nutrient concentrations.

The results reported herein showed that between 0-38 μg/liter of chlorophyll a occurred in the Nine Mile Point vicinity. During 1967, the distribution of chlorophyll a in the Oswego-Nine Mile Point area was 3-31 $\mu g/m^3$ (Nicholson, 1970). Further, Glooschenko et al. (1972) found yearly average concentrations of 4-5 μg/l along the southeastern shore of Lake Ontario.

Chlorophyll a concentrations indicate the general pattern of primary production. Odum (1971) pointed out that chlorophyll is related to the photosynthetic rate by an assimilation ratio or "rate of production per gm of chlorophyll." If the assimilation ratio and available light intensity were known, primary productivity could be calculated by using an equation of Ryther and Yentsch (1957). Flemer (1969) reported that the basic relationships between pigments and phytosynthesis were influenced by intrinsic factors, such as nutritional status of the alga, and extrinsic parameters, especially temperature, light and nutrient availability. The pheopigment analysis was indicative of chlorophyll degradation because of the negative correlation between pheophytins and chlorophyll. The possible correlation with zooplankton will be presented in the zooplankton section.

4. CONCLUSIONS

a. A phytoplankton succession pattern of diatoms: green algae: blue-green algae was confirmed for the vicinity of Nine Mile Point. The green algae dominance shifted to a green algae: blue-green algae codominance during the late summer and early fall months. "Other" algae were of minor importance.

b. The successional pattern of the algae was controlled mainly by the annual cycle of temperature change.

c. No single species of algae were present in bloom proportions at a single sampling site for more than the duration of one sampling period.

d. There were statistically significant differences in the concentration of algae between the various depth contours and transects on each sampling date.

C. MICROZOOPLANKTON

1. INTRODUCTION

a. Previous Work in Lake Ontario

There are five recent papers relevant to the present microzooplankton populations in the Nine Mile Point area. Robertson (1966) reviewed and synthesized the available information on the distribution of calanoid copepods in the Great Lakes. Ten species of calanoids, including six diaptomid species, Senecella calanoides, Limnocalonus macrurus, Epichura lacustris, and Eurytemora affinis, were found in Lake Ontario. Of particular interest was the occurrence of the brackish-water genus Eurytemora, which was first documented in Lake Ontario in 1959.

An extensive survey of the distribution of crustacean plankton in Lake Ontario was made in 1967 (Patalas, 1969); eleven species of copepods and eleven species of cladocerans were found. Cyclops bicuspidatus thomasi and Tropocyclops prasinus mexicanus were the most abundant copepods; Bosmina longirostris, Daphnia retrocurva, Bosmina coregoni coregoni, and Ceriodaphnia lacustris were the most abundant cladocerans. An average of almost twice as many organisms per square centimeter (cm^2) of Lake area were found in the eastern portion of the Lake than were found in the western portion. Crustacean populations increased first in the eastern end of the Lake in June-July; the pattern of increasing abundance then moved westward. Since a positive correlation between the heat content of the water column at 0-25 meters (m) and zooplankton abundance was reveal

Patalas concluded that temperature and the depth of the epilimnion (zone above the thermocline) were the major variables controlling the annual cycle of zooplankton abundance and distribution.

Storr (1970) studied the zooplankton populations in the Nine Mile Point area from July to October, 1964. Cyclops bicuspidatus thomasi and Diaptomus pygeatus were the most abundant copepods; Daphnia dubia, Daphnia galeata, Ceriodaphnia reticulata, Bosmina longirostris, and Polyphemus pediculus were the most abundant cladocerans; and Asplanchna sp., Keratella sp. and Brachionus sp. were the most abundant rotifers. The total zooplankton population (only the most abundant organisms) peaked in mid-July, and declined thereafter to early September. The population increased in September and remained about the same on the two dates sampled in October. The mid-summer populations were composed primarily of Keratella sp.; during the late summer decline and the September increase, populations were composed primarily of cladocerans and cyclopoid copepods.

Storr's calculations of abundance were based on numbers of organisms in the sample concentrations; they are qualitative and, as such, are comparable only to the qualitative data presented in this report.

The effects of Nine Mile Point Unit I on aquatic production was studied by comparing standing stocks and instantaneous measurements of primary and secondary production made in 1969 prior to plant operation and during limited plant operation in 1970 (Fenlon et al., 1971). Although primary production figures were available only for the 1970 sampling program,

Fenlon, McNaught and Schroeder felt that the data collected at a control transect west of the plant, at the plant discharge, and at a transect east of the plant were sufficient to delineate trends.

The results of these studies indicated that primary production was not significantly affected by power plant operation; it was, however, lower at the discharge and higher at a nearshore station east of the plant than at a nearshore station in the west control transect. Populations of the two dominant cladocerans (Bosmina sp. and Daphnia retrocurva) increased significantly in the overall study area after the start of plant operation. Even greater increases in the standing stock of these two cladocerans were found in the vicinity of the discharge.

The effects of entrainment on plankton at Nine Mile Point were studied by Storr (1971 a, 1971 b, 1972) from mid-June to early November 1971. Although the results of this study were semi-quantitative, he concluded that: 1) zooplankters were probably killed both by mechanical damage and temperature shock by passage through the condensers; 2) more of some groups of zooplankters, such as Daphnia and protozoans, were killed than were other zooplankters, such as rotifers and copepods; 3) the latent effects of condenser passage could include either decreases or increases of reproductive rates and increases in mortality depending on the physiological state of the populations prior to entrainment; and 4) that 100% mortality occurred when discharge temperatures were greater than 105°F.

b. Trophic Considerations

Most studies of zooplankton have been confined to consideration of holoplankters; few data exist on the role of meroplankters (temporary plankton) in the total zooplankton population. The information available indicates that meroplankters sometimes form a significant fraction of the zooplankton standing stock and probably have a highly significant role in the trophodynamics of aquatic communities. Since trophodynamic studies are based on matter and energy transfer, information on the feeding modes of zooplankters common to Lake Ontario is necessary to the description of transfer pathways.

The dominant copepods in Lake Ontario are *Cyclops bicuspidatus thomasi*, *Tropocyclops prasinus*, and *Diaptomus pygmeatus*. All free-living (as opposed to parasitic) cyclopoid copepods are raptorial; both plant or animal material may be seized and ingested. The majority of cyclopoids probably obtain most of their nutritional needs from animal foods, even though plants may be ingested (Hutchinson, 1967). McQueen (1969) found that late copepodite and adult *Cyclops bicuspidatus thomasi* would not feed on seven species of algae offered, but they ate their own nauplii and early copepodite stages, diaptomid nauplii, and rotifers. He estimated that *C. bicuspidatus* consumed approximately 30% of its own naupliar standing stock and approximately 30% of the standing stock of diaptomid nauplii in Marion Lake during the summer of 1967.

Most of the freshwater genera of calanoid copepods, such as *Diaptomus*

pygmeatus, are filter feeders; selection of particle size depends on the filtering appendages (Hutchinson, 1967). Lane and McNaught (1970) considered Diaptomus spp. to be omnivorous, feeding on course plant or animal material.

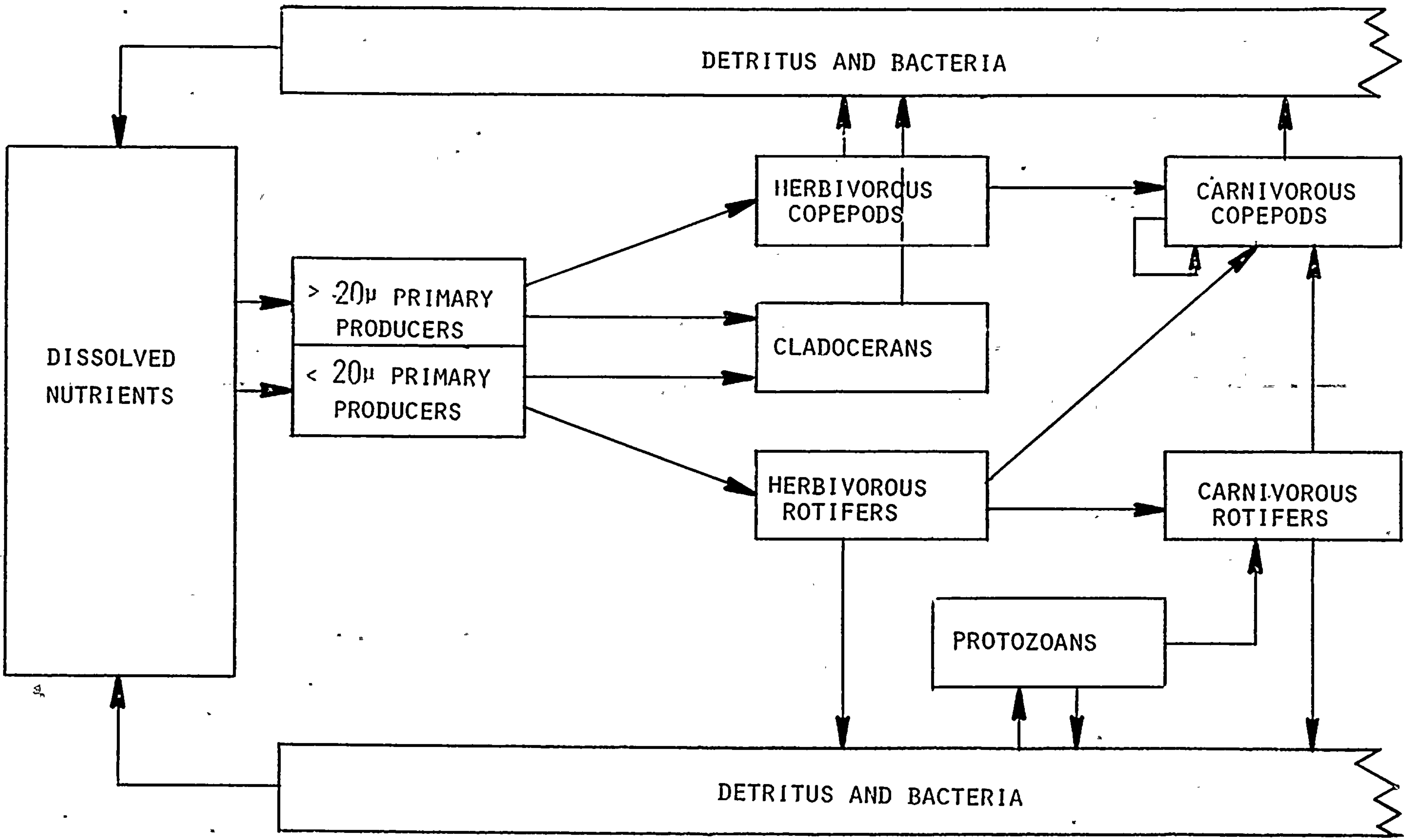
The most abundant cladocerans in the Nine Mile Point area, including Bosmina spp. and Ceriodaphnia spp., are filter feeders. The feeding habits of filter-feeding cladocerans has been studied extensively (see Hutchinson, 1967); it is known that these zooplankters consume primarily smaller particles including bacteria, detritus, and nanoplankton. Filtering rates apparently increase as the size of organism increases but are depressed by high concentrations of suspended material (Crowley, 1973).

Most of the rotifers of the Nine Mile Point area are probably herbivores feeding on nanoplankters less than 20μ diameter, but members of the family Asplanchnidae are raptorial (Hutchinson, 1967), eating other rotifers and protozoans.

Figure I-28 is based on information from the literature and illustrates the trophic intrarelationships of the microzooplankton population which could be expected to exist in the Nine Mile Point area. Only primary matter and energy transfer pathways are shown; no attempt has been made to quantify either rates or standing stocks, since both are variable. The figure has been included herein as a simplified way of bringing order to information on feeding and is not intended to represent quantitative values.

TROPHIC INTERRELATIONSHIPS OF THE MICROZOOPLANKTON

AT NINE MILE POINT



Recent investigations have suggested that trophic interrelationships may be considerably simplified by the vertical distribution of plankton. The work of Lane and McNaught (1970) indicates that competition for food between species is reduced by the vertical distribution of zooplankton; i.e. species A at 20 ft. consumes phytoplankter X, and species B at 40 ft. might consume phytoplankter Y. Thus, due to niche separation, the trophodynamics of species A may be quite independent from the trophodynamics of species B.

McNaught (1968), using accoustical methods of determining zooplankton distribution in Gull Lake, Michigan, found that diurnal migration has a considerable influence on trophic interactions. The importance to trophic structure of a meroplankter (Chaoborus), which migrated from the benthos to the epilimnion at night, and of a planktivorous fish (Osmerus mordox), which moved offshore at night to feed on Chaoborus, was clarified by his study.

One of the explanations proposed by Stross (1973) for the rapid disappearance of cladocerans followed by a bloom of blue-green algae in Lake Saratoga depended on Chaoborus grazing on the cladocerans. Although the same set of circumstances might not be found in Lake Ontario, the mechanisms proposed by Stross and others may be applicable to Lake Ontario plankton interactions (see Discussion).

2. RESULTS

a. Replicate Samples

On 16 May and on 15 June a single sample was taken at each station (Figure I-1). Two samples were taken at each station beginning on 20 July 1973 and on all sampling dates thereafter. The results of a paired-t test (all statistical tests are defined and described in Appendix II) showed that the replicate samples were significantly different only on 20 July 1973 (Table I-5); the results presented in this section are, therefore, the data of a single sample at each station.

b. Species Inventory

Five cladoceran genera (Bosmina, Ceriodaphnia, Daphnia, Diaphanosoma, and Leptodora) and twelve genera of rotifers were identified (Table I-6); two species of the rotifer genus Keratella were identified and one abundant, but unidentified rotifer was found. The most common protozoan genera were Epistylis, Vorticella, Codonella, and Strombidium.

c. Distribution and Abundance

(i) Seasonal Abundance by Transect

The information presented in this section is based on the data compiled in Appendix III-F, which is composed of tables of microzooplankton abundance at each station on each sampling date.

NMPW:

Figure I-29 shows that the total microzooplankton population ranged

TABLE I-5 PAIRED-t TEST BETWEEN MICROZOOPLANKTON SAMPLES AND REPLICATES.

DATE	t-VALUE	df	p-VALUE
20 July	-3.283	14	p<.01*
26 July	0.405	14	p>.5
13 Aug	0.499	15	p>.5
23 Aug	0.383	14	p>.5
20 Sept	0.586	15	p>.5
25 Oct	-0.404	15	p>.5
20 Nov	-0.907	15	p>.6

*Significant difference between a sample and its replicate.

TABLE I- 6

ROTIFER INVENTORY

NINE MILE POINT - 1973

Ascomorpha sp.

Asplanchna sp.

Brachionus sp.

Chromogaster sp.

Collotheca

Conochilus sp.

Filinia sp.

Kellekotia sp.

Keratella cochlearis

K. quadrata Notholca Lecane Lepadella

Polyarthra

Ploesoma sp.

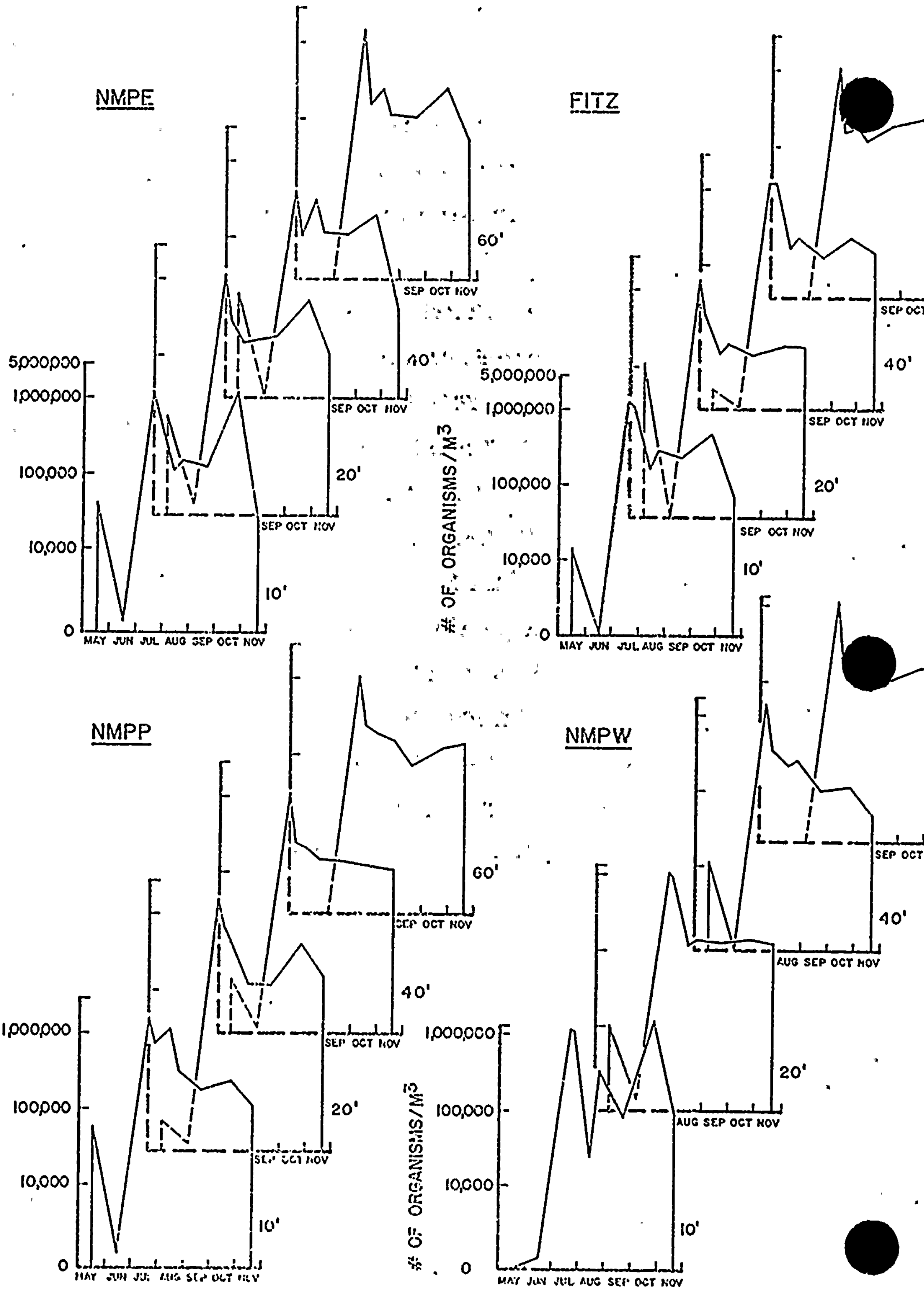
Synchaeta sp.

Trichocerca sp.

Unidentified (UID) Rotifer

FIGURE I-29

Abundance of Total Microzooplankton at Nine Mile Point - 1973

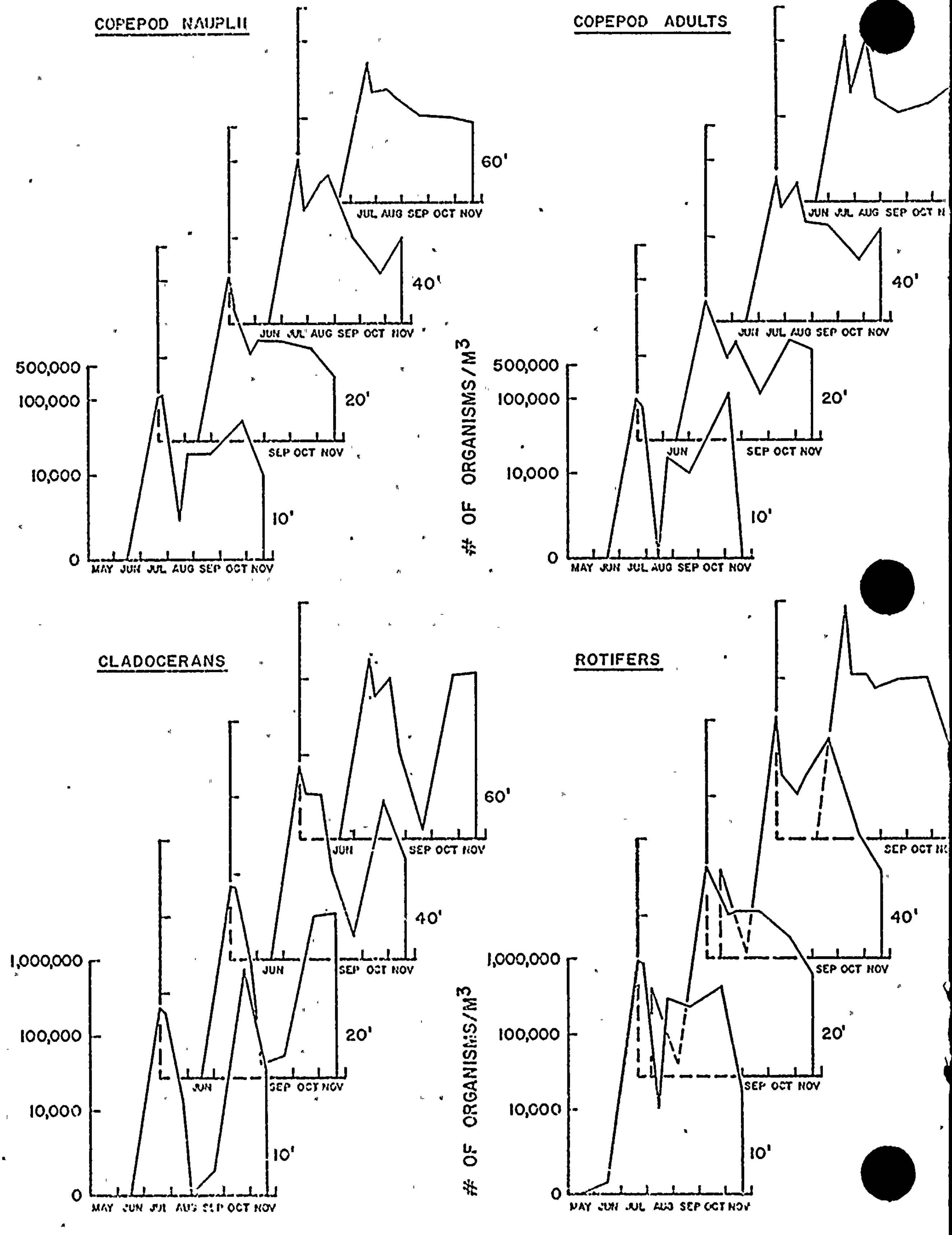


from 0 to over 2×10^6 organisms/m^3 during the course of the 1973 sampling program. Peak seasonal levels were reached on 20 July at the three stations in deeper water and on 20 October at the 10 ft. stations. Rapid declines in abundance from late July through early August were common to all four stations on the NMPW transect. Microzooplankton abundance was approximately an order of magnitude higher at the end of the sampling program in late November than at the beginning of the sampling program in early May.

Since rotifers composed the largest percentage of the total microzooplankton on most sampling dates (see Appendix III-F), seasonal changes in the total microzooplankton populations at NMPW were primarily reflections of changes in the rotifer population. Figure I-30 shows that seasonal trends in rotifer abundance paralleled trends in total microzooplankton over most of the sampling period.

Cladocerans formed the second highest percentage of the total microzooplankton population at most times and occasionally the highest percentage of the total (see Appendix III-F). Figure I-30 shows that two peaks of cladoceran abundance occurred at all four stations; the first peak on 20 July was followed by a steep decline in numbers in August and a second peak in October or November. Maximum seasonal abundance, approximately $3\text{-}4 \times 10^5$ organisms/m^3, occurred at three of the four stations on the NMPW transect during July; abundance was several times less during the fall pulse of cladoceran abundance.

FIGURE I-30
Microzooplankton Abundance at NMPW - 1973



The combination of copepod adults and nauplii formed the smallest percentage (10-20% on most sampling dates) of the total microzooplankton population (see Appendix III-F). There were three peaks of abundance in the adult copepod populations at all four stations (see Figure I-30). The peaks were found during July, August, and November at the 60 ft. and 40 ft. stations, and during July, August and October at the 20 ft. and 10 ft. stations. On most collection dates, there were between 10^4 and 10^5 copepods/m^3.

Copepod nauplii appeared in a trimodal pattern of seasonal abundance only at the 40 ft. station (see Figure I-30); a late July peak followed by a general decrease in abundance (a second pulse in abundance occurred at the 10 ft. station during October) was more common.

NMPP:

The abundance and distribution of microzooplankters at the NMPP transect were similar to those noted at the NMPW transect, some differences, however, can be seen on Figure I-31.

FITZ:

The abundance and distribution of microzooplankters at this transect were also similar to the patterns discussed in relation to the NMPW transect. The FITZ patterns are illustrated on Figure I-32.

NMPE:

The seasonal pattern of total microzooplankton abundance at the NMPE transect was considerably different from that at the NMPW transect; a tri modal seasonal pattern was noted at the 20 ft. and 60 ft. stations

FIGURE I-31

Microzooplankton Abundance at NMPP - 1973

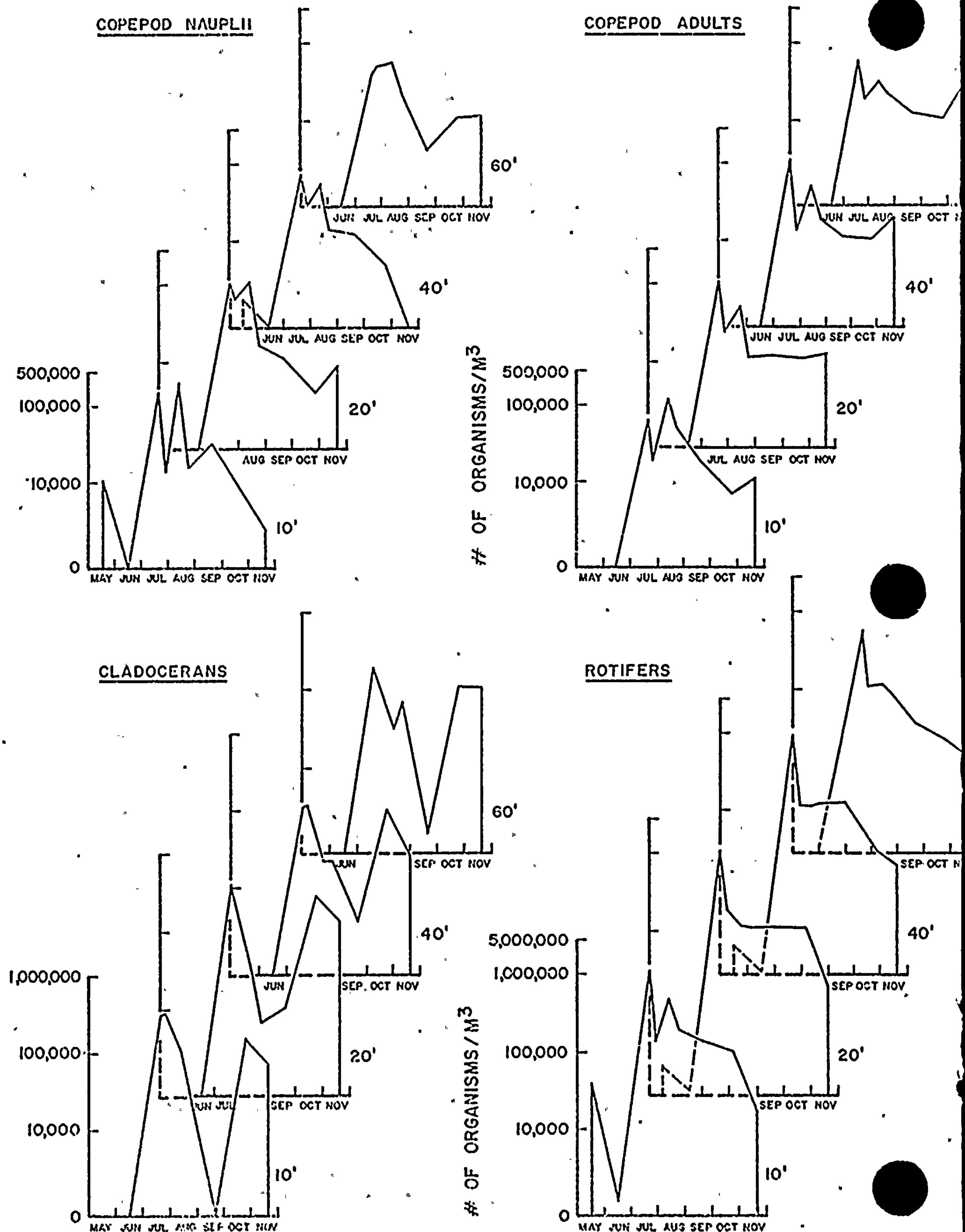
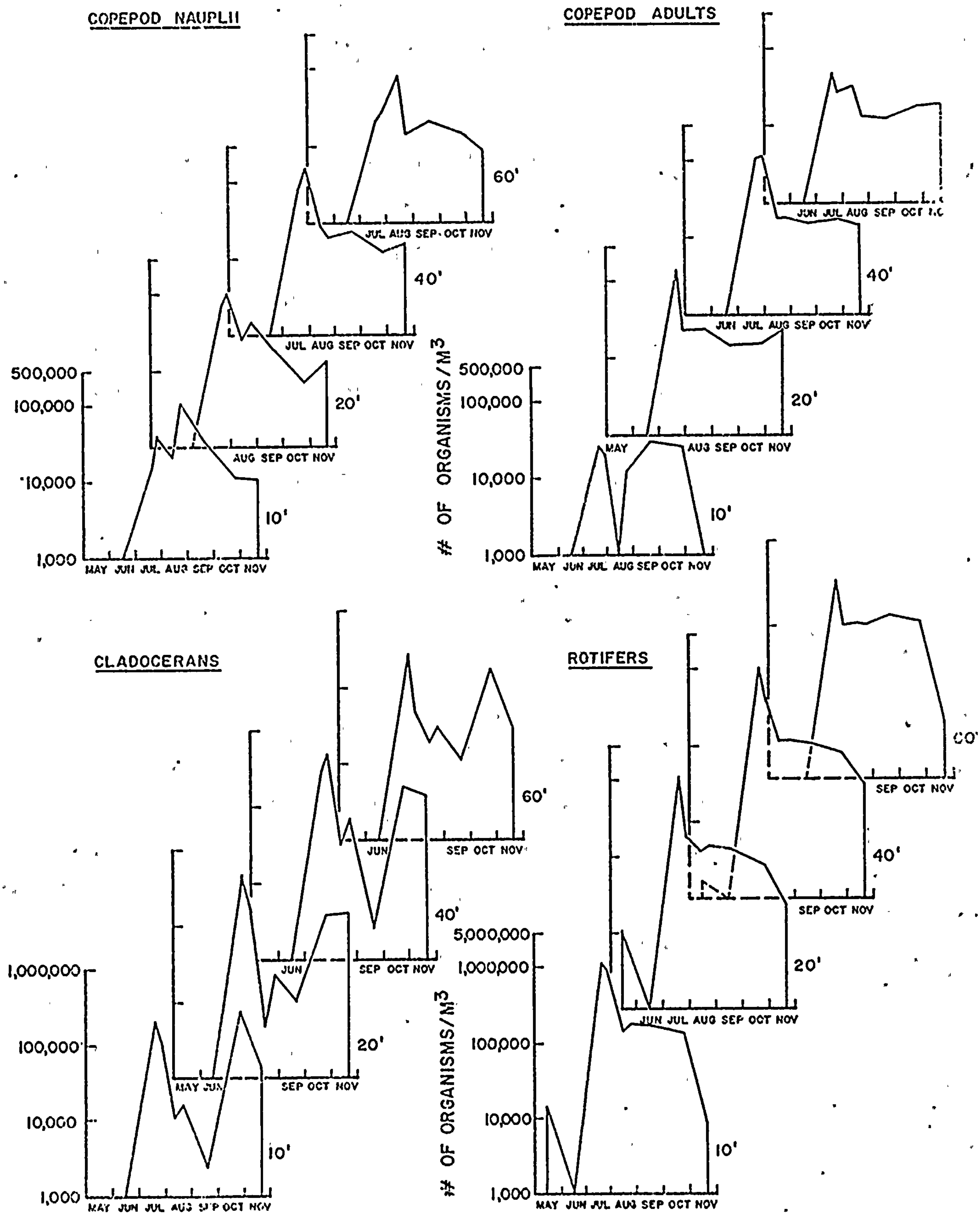


FIGURE I-32

Microzooplankton Abundance at FITZ - 1973



and a quadrimodal pattern was found at the 10 ft. and 40 ft. stations (Figure I-29).

At the transects discussed previously, rotifers formed the majority of total microzooplankton numbers, and the seasonal patterns of rotifers abundance at NMPE (see Figure I-33) were roughly parallel to the seasonal abundance patterns of total microzooplankton. The major differences in seasonal abundance patterns appeared to be the magnitude of the last (25 October) peak for the rotifers; this peak was about the same magnitude as the August peak, while for the total microzooplankton population, the last peak in abundance was greater than the August peak at three of the four stations.

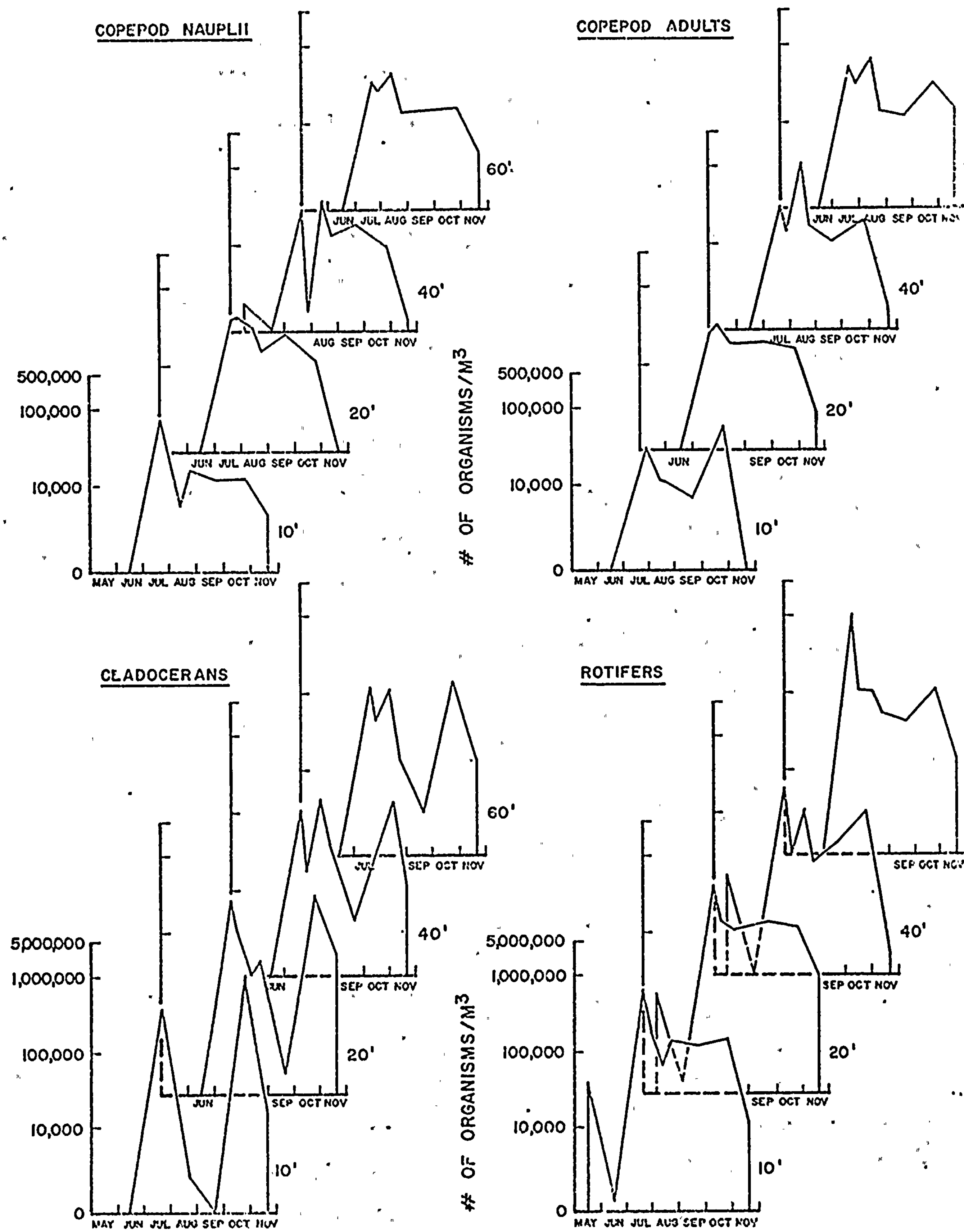
Rotifer abundance at NMPE ranged between 3.9×10^5 and 1.1×10^6 organisms/m^3 on 20 July; the lower and higher limits of this range were found at the 40 and 60 ft. stations, respectively (see Appendix III-F).

The cladocerans at NMPE (see Figure I-33) occurred in both bimodal or trimodal patterns of seasonal abundance. Levels of cladoceran abundance were somewhat higher during the fall peaks than during the earlier peaks of abundance.

Figure I-33 shows that the seasonal pattern of adult copepod abundance was either bimodal (as at the 10 and 20 ft. stations) or trimodal (as at the 40 and 60 ft. stations), and for cladocerans, the trimodal patterns could be interpreted as being bimodal.

FIGURE I-33

Microzooplankton Abundance at NMPE- 1973



The seasonal patterns of naupliar copepod abundance were quite irregular among the four stations at NMPE (see Figure I-33).

In general, the organisms followed a unimodal pattern of seasonal abundance with maximum abundance during July. Mid-summer depressions in abundance of varying magnitude were common.

In summary, the seasonal patterns of abundance by transect was characterized by a major peak in the numbers of all taxonomic groups on 20 July or 26 July. Subsequent peaks in abundance were of a smaller magnitude than the first peak except at the 10 ft. stations. Sharp declines in numbers occurred on 15 June and 13 August; these declines were more noticeable at the stations in shallower water.

Only rotifer abundance was clearly affected by the depth of water; numbers/m^3 increased as depth decreased. The data suggest that both adult and naupliar copepod abundance were influenced by the depth of water, but the relationship was variable.

(ii) Seasonal Abundance by Depth Contour

Total Microzooplankton

Table I-7 shows that considerable variation in the seasonal patterns of total microzooplankton abundance occurred among transects at the 10 ft. depth contour (the significance of statistical differences in the seasonal patterns of abundance is discussed in section 3a of this chapter). With the exception of 16 May, NMPW and NMPE appear to be most similar with three peaks of abundance; the time of occurrence of the three peaks was the same at both stations and the numbers of

TABLE I- 7 ABUNDANCE OF TOTAL MICROZOOPLANKTON AT NINE MILE POINT - 1973.
(organisms/m^3)

	MAY 16	JUN 15	JUL 20	JUL 26	AUG 13	AUG 23	SEP 20	OCT 25	NOV 20	
NMPW	0	1,472	1,639,310	1,562,710	45,665	585,857	93,751	1,791,192	94,697	
NMPP	78,600	1,851	2,474,688	863,637	1,418,981	550,926	323,862	409,510	141,414	10'
FITZ	24,734	1,389	1,986,112	1,142,255	303,030	505,683	419,822	704,665	86,911	
NMPE	64,196	1,263	1,559,846	757,576	122,895	265,152	197,812	1,534,090	43,518	
NMPW	12,843	1,369	1,345,388	989,256	178,172	220,920	194,694	224,476	179,328	
NMPP	3,400	631	2,133,425	826,029	435,063	189,853	185,222	644,332	275,938	20'
FITZ	13,080	1,052	2,433,002	722,368	279,306	363,235	253,575	341,820	330,033	
NMPE	29,350	1,473	1,288,306	508,939	265,522	282,045	309,563	749,574	116,185	
NMPW	15,136	631	2,253,363	596,897	397,818	470,003	116,289	166,278	72,457	
NMPP	6,400	106	1,430,462	418,434	354,291	279,256	235,001	181,316	118,703	40'
FITZ	3,165	631	1,717,059	1,750,023	301,092	309,406	189,379	412,159	237,316	
NMPE	31,261	294	670,852	104,188	559,509	160,038	115,377	369,737	15,898	
NMPW	-	322	1,515132	299,302	404,332	185,143	127,691	268,150	231,107	
NMPP	-	329	1,285,150	423,908	341,418	266,049	89,805	196,011	210,480	60'
FITZ	-	449	1,113,650	275,447	310,810	197,853	338,136	412,910	92,961	
NMPE	-	326	2,543,979	293,910	441,935	155,335	115,763	455,760	74,087	

organisms found at each station were the same within half an order of magnitude.

10 ft contour?

On four of the nine sampling dates, microzooplankton abundance was generally greater at NMPP than at NMPW, less at FITZ than at NMPP, and less at NMPE than at FITZ. On one sampling date, abundance decreased from west to east; on three of the remaining sampling dates, microzooplankton abundance was generally greater at FITZ than at NMPP. These patterns are summarized in Table I-8.

The most common pattern of total microzooplankton abundance at the 10 ft. depth contour occurred on only one date among the stations on the 20 ft. depth contour. The most common pattern at the 20 ft. contour was a decrease between NMPW and NMPP followed by successive increases at F[illegible] and NMPE (see Table I-7 and Table I-8). The second most common west to east abundance pattern was an increase between NMPW and NMPP followed by an increase at FITZ and a decrease at NMPE.

At the 40 ft. contour (see Table I-8), the seasonal patterns of total microzooplankton abundance were, with the exception of NMPE, remarkably similar. Using concentrations of organisms per cubic meter at NMPW as a baseline, a decrease in abundance between NMPW and NMPP, followed by an increase at FITZ and a subsequent decrease at NMPE was noted on four sampling dates. Two other patterns occurred on each of two sampling dates (Table I-8).

Only one abundance pattern occurred on more than one sampling date at

TABLE I-8 PATTERNS OF ABUNDANCE AT A DEPTH CONTOUR: TOTAL MICROZOOPLANKTON

	Patterns				Number of Occurrences of each pattern				
	NMPW	NMPP	FITZ	NMPE	10'	20'	40'	60'	T
1.	X	+	−	−	4	1	1	1	7
2.	X	+	+	−	1	2	2	1	6
3.	X	+	+	+	0	0	0	0	0
4.	X	−	−	−	1	1	0	1	3
5.	X	−	+	+	1	3	0	1	5
6.	X	−	−	+	0	0	2	2	4
7.	X	−	+	−	1	1	4	1	7
8.	X	+	−	+	1	1	0	1	3

the 60 ft. contour: a decrease in microzooplankton abundance between NMPW and NMPP followed by a decrease at FITZ and an increase at NMPE (Table I- 8).

The patterns of total microzooplankton abundance between the four transects are summarized in Table I- 8, which shows the number of occurrences of each pattern at each contour and the total number of occurrences of each pattern. Patterns number one, number two, and number seven occurred most frequently. These three patterns have one relationship in common: a decrease in abundance between FITZ and NMPE; an increase between NMPP and FITZ was common to pattern number two and pattern number seven. NMPP < FITZ > NMPE

Rotifers

Table I- 9 shows that seasonal patterns of rotifer abundance differed considerably among the 10 ft. stations; the rotifers at NMPW fluctuated more in numbers than the rotifers at the other three stations (see Statistical Analysis section).

The most common west to east abundance pattern at the 10 ft. contour was an increase between NMPW and NMPP followed by a decrease at FITZ and subsequently, a decrease at NMPE; this pattern occurred on four collecting dates (see Table I- 9). This pattern of abundance also occurred among the stations on the 20 ft. depth contour on 20 July and 13 August. The most common pattern on the 20 ft. contour was a decrease in abundance between NMPW and NMPP followed by successive increases at

TABLE I-19 ABUNDANCE OF ROTIFERS AT NINE MILE POINT - 1973 (organisms/m^3)

	MAY 16	JUN 15	JUL 20	JUL 26	AUG 13	AUG 23	SEP 20	OCT 25	NOV 20	
NMPW	0	1,472	983,587	939,605	14,520	518,728	42,614	670,927	31,566	
NMPP	65,500	1,851	1,574,803	227,905	711,701	393,518	232,953	103,114	33,880	10'
FITZ	24,734	1,389	1,629,268	956,017	262,626	329,547	313,762	210,242	12,416	
NMPE	64,196	1,263	812,793	436,659	85,647	218,856	172,559	250,000	12,037	
NMPW	12,843	1,369	669,116	426,222	108,924	162,238	157,860	73,878	30,309	
NMPP	3,400	631	1,272,983	351,185	189,222	133,760	138,917	119,079	33,887	20'
FITZ	13,080	1,052	1,594,741	331,717	193,221	220,425	189,379	90.928	40,412	
NMPE	29,350	1,473	667,137	238,052	123,448	147,337	223,108	151,862	48,410	
NMPW	15,136	631	1,603,355	366,450	134,244	342,663	77,982	56,170	19,889	
NMPP	3,200	106	1,078,162	165,016	162,070	180,066	196,509	53,686	34,616	40'
FITZ	3,165	631	1,092163	751,343	169,700	165,017	117,158	105,911	56,093	
NMPE	28,135	294	391,282	50,936	145,232	43,222	63,355	106,347	1,953	
NMPW	-	322	953,377	142,074	141,197	88,603	98,049	102,398	20,837	
NMPP	-	329	787,838	147,969	150,283	96,997	61,741	41,553	22,802	60'
FITZ	-	428	615,233	103,977	140,461	110,468	221,004	143,969	7,436	
NMPE	-	326	1,028,826	130,584	128,813	77,667	67,352	150,423	20,205	

FITZ and NMPE; this pattern was found on three collecting dates (Table I-10).

The most frequently occurring pattern on the 40 ft. contour, a decrease in abundance between NMPW and NMPP followed by an increase at FITZ and a subsequent decrease at NMPE, was found on the three early summer collecting dates (Table I-10). An increase in abundance followed by a second increase and a subsequent decrease occurred on two sampling dates among the stations on the 60 ft. depth contour. An increase between NMPW and NMPP followed by a decrease at FITZ and a subsequent increase at NMPE was also found on two sampling dates on this depth contour (Table I-10). The most frequently occurring patterns for rotifers generally followed the total microzooplankton patterns (see Table I-8 .), since rotifers composed the largest percentage of total microzooplankton.

Cladocerans

The most frequently occurring west to east abundance pattern at the 10 ft. depth contour, an increase between NMPW and NMPP, a decrease at FITZ, and an increase at NMPE occurred on three dates (Table I-11). No single abundance pattern occurred more frequently then any other along the 20 ft. contour (Table I-12). However, an increase in cladoceran abundance between NMPW and NMPP followed by a second increase at FITZ and a decrease at NMPE, and an increase between NMPW and NMPP

TABLE I-10 PATTERNS OF ABUNDANCE AT A DEPTH CONTOUR; ROTIFERS

	Patterns				Number of Occurrences				
	NMPW	NMPP	FITZ	NMPE	10'	20'	40'	60'	T
1.	X	+	-	-	4	0	1	1	6
2.	X	+	+	-	2	2	2	2	8
3.	X	+	+	+	0	1	0	0	1
4.	X	-	-	-	1	1	1	0	3
5.	X	-	+	+	1	3	1	1	6
6.	X	-	-	+	0	0	1	1	2
7.	X	-	+	-	0	1	3	1	5
8.	X	+	-	+	1	1	0	2	4

TABLE I-11 ABUNDANCE OF CLADOCERANS AT NINE MILE POINT - 1973
(organisms/m^3)

	MAY 16	JUN 15	JUL 20	JUL 26	AUG 13	AUG 23	SEP 20	OCT 25	NOV 20	
NMPW	0	0	440,025	385,732	26,305	0	2,841	886,363	52,609	
NMPP	0	0	532,827	575,757	139,520	55,556	0	288,720	88,384	
FITZ	0	0	293,201	99,327	0	28,409	4,419	439,920	62,079	10
NMPE	0	0	627,525	210,438	13,889	4,209	0	1,189,39	325,000	
NMPW	0	0	461,583	436,746	42,622	1,726	2,631	102,293	123,762	
NMPP	0	0	642,385	341,294	53,357	8,630	11,576	504,047	213,005	
FITZ	0	0	640,622	231,949	7,366	40,359	12,839	225,635	235,738	20
NMPE	0	511,551	145,020	50,094	69,459	2,789	552,932	62,934		
NMPW	0	0	467,043	143,557	118,658	16,207	2,736	97,321	24,153	
NMPP	0	0	136,668	179,750	41,202	41,202	6,078	110,410	46,990	
FITZ	0	0	410,968	616,008	49,936	77,351	4,815	256,483	129,445	40
NMPE	0	0	175,961	30,099	250,103	64,249	6,348	215,163	10,[illegible]	
NMPW	-	0	337,053	79,561	112,115	31,677	1,140	129,655	157,229	
NMPP	-	0	358,584	169,962	55,764	85,912	2,245	130,445	119,272	
FITZ	-	0	389,388	74,790	23,714	42,868	15,470	208,954	42,763	60
NMPE	-	0	179,862	69,837	161,576	28,766	5,262	225,635	20,206	

TABLE I-12 PATTERNS OF ABUNDANCE AT A DEPTH CONTOUR: CLADOCERANS

	Patterns				Number of Occurrences				
	NMPW	NMPP	FITZ	NMPE	10'	20'	40'	60'	T
1.	X	+	-	-	2	1	0	2	5
2.	X	+	+	-	0	2	4	2	8
3.	X	+	+	+	0	1	0	1	2
4.	X	-	-	-	0	1	0	1	2
5.	X	-	+	+	1	0	1	0	2
6.	X	-	-	+	0	0	0	1	1
7.	X	-	+	-	1	0	1	0	2
8.	X	+	-	+	3	2	1	0	6

followed by a decrease at FITZ and an increase at NMPE were patterns that occurred on each of two date pairs. The former abundance pattern, two increases followed by a decrease, occurred on four sampling dates along the 40 ft. contour: 26 July, 23 August, 25 October, and 20 November (Table I-12). The same abundance pattern occurred among the stations on the 60 ft. contour (Table I-12) on two sampling dates; a second abundance pattern, an increase between NMPW and NMPP followed by sequential decreases in abundance at FITZ and NMPE, occurred with equal frequency. Generally patterns number one, number two, and number eight occurred most frequently among all four depth contours (Table I-12). An increase between NMPW and NMPP was common to all three of the abundance patterns and decreases at FITZ and NMPE were common to two of the patterns (Table I-12).

NMPW < NMPP (
+ sometimes NMPP > FITZ + NMPE

Copepod Adults

Table I-13 indicates that the stations along the 10 ft. contour were quite different from one to another on the same dates: the differences on 13 August were especially notable (see Statistical Analysis section). The only pattern of abundance (proceeding from west to east) which occurred more than once was an increase between NMPW and NMPP followed by sequential decreases at FITZ and NMPE on two sampling dates (Table I-14).

The seasonal abundance of adult copepods among the stations on the 20 ft. contour appeared to be quite similar between with the possible

TABLE I-13. ABUNDANCE OF COPEPOD ADULTS AT NINE MILE POINT - 1973. (organisms/m^3)

	MAY 16	JUN 15	JUL 20	JUL 26	AUG 13	AUG 23	SEP 20	OCT 25	NOV 20	
NMPW	0	0	103,535	89,015	0	30,513	11,364	160,038	0	
NMPP	0	0	82,884	35,985	191,919	74,074	34,091	8,838	14,731	10'
FITZ	0	0	38,186	24,832	0	17,045	44,192	38,931	0	
NMPE	0	0	29,882	52,609	15,573	12,626	8,418	75,758	0	
NMPW	0	0	75,141	57,882	9,682	25,889	5,262	28,415	17,680	
NMPP	0	0	106,082	49,463	75,036	17,259	18,522	14,681	19,364	
FITZ	0	0	115,857	30,520	32,203	34,150	16,049	16,838	33,677	20'
NMPE	0	0	47,148	57,461	36,308	35,782	36,255	29,204	4,841	
NMPW	0	0	77,038	45,334	72,458	27,783	21,890	7,104	18,470	
NMPP	0	0	127,557	23,574	73,668	35,098	14,181	10,129	37,097	40'
FITZ	0	0	123,853	140,002	33,940	33,519	27,283	31,901	25,889	
NMPE	0	0	53,830	20,838	103,135	31,151	11,787	38,334	2,510	
NMPW	-	0	147,661	37,886	106,819	31,677	14,821	25,047	43,569	
NMPP	-	0	79,509	33,993	57,251	41,570	19.084	12,331	54,374	
FITZ	-	0	70,090	49,252	55,567	21,434	64,091	32,993	33,466	60'
NMPE	-	0	74,061	44,587	83,350	24,451	17,891	50,515	26,941	

TABLE I-14. PATTERNS OF ABUNDANCE AT A DEPTH CONTOUR: COPEPOD ADULTS

	Patterns				Number of Occurrences				
	NMPW	NMPP	FITZ	NMPE	10'	20'	40'	60'	T
1.	X	+	-	-	2	0	3	1	6
2.	X	+	+	-	1	2	0	1	4
3.	X	+	+	+	0	0	1	0	1
4.	X	-	-	-	1	0	0	0	1
5.	X	-	+	+	1	2	2	1	6
6.	X	-	-	+	1	1	0	2	4
7.	X	-	+	-	1	0	1	1	3
8.	X	+	-	+	0	2	0	1	3

exceptions of 13 August and 20 September (Table I-13). Three west to east patterns of abundance occurred more than once (Table I-14). The first pattern, which was found on two dates, was an increase at NMPP, a second increase at FITZ, and a subsequent decrease in adult copepod abundance at NMPE; the second pattern (also found on two dates) was a decrease and two sequential increases; and the third pattern (found on two dates) was an increase followed by a decrease and a subsequent increase.

Two common patterns of adult copepod abundance were found among the stations on the 40 ft. contour: the first was an increase followed by sequential decreases, and a decrease followed by sequential increases (Table I-14). Only one pattern of west to east abundance of adult copepods occurred on more than one sampling date along the 60 ft. contour: an increase followed by a decrease and a subsequent increase (Table I-14).

It should be noted that patterns number one and pattern number five (see Table I-14) which occurred most frequently among all contours, are reciprocals; the same relationship occurs for all other patterns, indicating that no single pattern of abundance from west to east was representative of adult copepods.

Copepod Nauplii

Table I-15 shows that differences in the abundance of copepod nauplii occurred among stations on the 10 ft. depth contour; these differences

TABLE I-15. ABUNDANCE OF COPEPOD NAUPLII AT NINE MILE POINT - 1973.

	MAY 16	JUN 15	JUL 20	JUL 26	AUG 13	AUG 23	SEP 20	OCT 25	NOV 20	
NMPW	0	0	112,163	148,358	4,840	36,616	36,937	73,864	10,522	
NMPP	13,100	0	284,174	23,990	375,851	27,778	56,818	8,838	4,419	
FITZ	0	0	25,457	62,079	40,404	130,682	57,449	15,572	12,416	1
NMPE	0	0	89,646	57,870	7,786	29,461	16,835	18,939	6,481	
NMPW	0	0	139,548	68,406	16,944	31,067	28,941	19,890	7,577	
NMPP	0	0	111,975	84,087	117,448	30,204	16,207	6,525	9,682	
FITZ	0	0	81,782	128,182	46,516	68,301	35,308	8,419	20,206	2
NMPE	0	0	62,470	68,406	55,672	29,467	47,411	15,576	0	
NMPW	0	0	105,927	41,556	12,458	83,350	13,681	5,683	9,945	
NMPP	3,200	0	88,075	50,094	77,351	22.890	18,233	7,091	0	
FITZ	0	0	90,075	242,670	47,516	33,519	40,123	17,864	25,889	4
NMPE	3,126	0	49,779	2,315	61,039	21,416	33,887	9,893	1[illegible]	
NMPW	-	0	77,041	39,781	44,201	33,186	13,681	11,050	9,472	
NMPP	-	0	62,818	71,984	78,720	41,570	6,735	11,682	14,032	
FITZ	-	21	38,939	47,428	91,068	23,083	37,571	26,994	9,296	6
NMPE	-	0	59,468	48,902	68,196	24,451	25,258	29,187	6,735	

are probably not significant, since on the dates when they were found, they occurred at only one of the three stations (see Statistical Analysis section). The most frequently occurring west to east pattern of abundance, a decrease between NMPW and NMPP succeeded by an increase at FITZ and a subsequent decrease at NMPE, was found on three collecting dates (Table I-16).

Differences in the seasonal patterns of abundance of nauplii among the stations on the 20 ft. contour are probably not significant for the reason explained previously. Two common patterns of west to east naupliar abundance were noted at the 20 ft. contour (Table I-16): two sequential increases followed by a decrease, and a decrease followed by two sequential increases.

Significant differences in the seasonal pattern of abundance among the stations at the 40 ft. contour are possible for 16 May, 13 August, and 20 November (Table I-15). There were two common west to east patterns of abundance among the stations on the 40 ft. depth contour: two sequential increases followed by a decrease, and a decrease followed by an increase and a subsequent decrease (Table I-16).

Only one west to east naupliar abundance pattern was observed on more than one date among the stations on the 60 ft. contour; this pattern which occurred on two dates was an increase between NMPW and NMPP followed by a decrease at FITZ and a subsequent increase at NMPE Table I-16).

TABLE I-16. PATTERNS OF ABUNDANCE AT A DEPTH CONTOUR: COPEPOD NAUPLII

	Patterns				Number of Occurrences				
	NMPW	NMPP	FITZ	NMPE	10'	20'	40'	60'	T
1.	X	+	-	-	1	0	0	1	2
2.	X	+	+	-	1	2	3	1	7
3.	X	+	+	+	0	0	0	1	1
4.	X	-	-	-	0	1	0	0	1
5.	X	-	+	+	1	2	0	0	1
6.	X	-	-	+	0	0	0	1	3
7.	X	-	+	-	3	1	3	1	8
8.	X	+	-	+	1	1	2	2	6

Table I-16, summarizing the number of occurrences of each pattern, shows that patterns number two, number seven, and number eight occurred most frequently. Two of these patterns show an increase between NMPW and NMPP and between NMPP and FITZ; two patterns show a decrease between FITZ and NMPE. The most common pattern of overall abundance would, therefore, be number two.

NMPP < FITZ > NMPE

d. Statistical Analysis

A three-way analysis of variance (ANOVA) (Appendix II) including variance due to date, depth contour, and transect, was conducted for each of the following groups: rotifers, cladocerans, copepod adults and copepod nauplii.

The results showed that for rotifers, abundance among dates differed significantly, abundance among transects differed significantly, and abundance among depth contours differed significantly (see Appendix III-G). A Student-Newman-Keuls test showed that the 40 and 60 ft. depths were most similar and that the 10 and 20 ft. depths were most similar; the FITZ transect was least similar to the NMPE transect, while the NMPW and NMPP transects were most similar.

The only significant difference in cladoceran and naupliar copepod abundance was among dates (see Appendix III-G; Discussion of Results).

Significant differences were found for adult copepod abundance among dates, and among date/depth interaction and date/transect interaction (Appendix

III-G). The interactions will be described in Discussion of Results.

e. Seasonal Abundance of Cladocerans and Phaeopigments

The grazing rate of herbivorous zooplankters and its relationship to the zooplankton biomass/phaeopigment concentration ratio (see Lorenzen, 1967) was explored by Glooshenko et al. (1972), who studied the zooplankton biomass and phaeopigment concentrations in Lake Ontario. A striking agreement between the seasonal trends of zooplankton biomass and of phaeopigment concentrations were found.

The phaeopigment data collected by QL&M off Nine Mile Point in 1973 corresponded in sampling locations to microzooplankton sampling locations, and comparison between the seasonal patterns of microzooplankton abundance and phaeopigment concentrations is, therefore, valid. The seasonal trends in phaeopigment concentrations (see Phytoplankton Results section) and the seasonal trends in cladoceran abundance (see preceding Microzooplankton Results section) were similar. It is possible that a combination of adult copepod abundance and cladoceran abundance patterns would match phaeopigment concentration patterns more closely than cladoceran abundance patterns alone (see Discussion of Microzooplankton Results).

3. DISCUSSION OF RESULTS

a. Patterns of Abundance

(i) Seasonal

The seasonal patterns of rotifer and copepod abundance were characterized by maxima in the early summer followed by a sharp mid-summer decrease and then gradual declines in abundance to early winter (a fall peak in abundance occurred at the 10 ft. stations). This seasonal pattern is essentially the same as that reported by Patalas (1969) for the crustacean populations of the eastern portion of Lake Ontario. There were some differences, however; the data herein indicate that an early spring increase in rotifers and copepod nauplii occurred, only the last part of which was within the sampling period. The presence of nauplii in May might have been a reflection of the growth of the *Cyclops bicuspidatus* population, a winter and early spring form in Lake Erie (Beeton and Chandler, 1963).

Alternatively, the organisms found in the spring may have been the survivors of overwintering populations. Although the microzooplankton populations were decreasing in abundance at most sampling stations in November, the magnitude of overwintering populations (resting larval stages, eggs, or adults which form the reproductive stock for the following season) could not be predicted from these data.

There were sufficient rations for herbivores (at least 2×10^4 algal cells/liter) throughout the sampling period (see Phytoplankton Results section). The time of maximum microzooplankton abundance corresponded

to the first peak in phytoplankton abundance in late July; during the time of the second peak in phytoplankton abundance (late August or September) minor increases in naupliar abundance were found at some stations. The second maximum of cladoceran abundance followed the second peak in phytoplankton abundance; the decrease of the latter population may have been closely related to the grazing by cladoceran population. The increase of phaeopigment concentrations (chlorophyll degradation products associated with grazing rates) during the second cladoceran maximum supports the grazing hypothesis (see Results section).

The late mid-summer declines in microzooplankton abundance may have been due to a lack of algal rations caused by heavy grazing in July. High phaeopigment concentrations in August indicate that over-grazing may well have been an indirect contributing factor to the microzooplankton decline. However, the water temperature data indicate that advection of cooler water occurred in late July and late August (see report of Water Quality). Advection may have introduced new microzooplankton (and phytoplankton) populations at lower abundance levels; indigenous populations if not replaced, may have been adversely affected by the temperature changes.

Maximum summer temperatures (approximately 80°F at surface) were recorded in early September. Although cladoceran abundance was depressed at that time, possibly as a result of the high temperature, the abundance of the

other taxonomic groups did not appear to be significantly affected.

(ii) Among Transects

Since the abundance of rotifers was significantly different between transects, this group could serve as a useful indicator of the effects of power plant operation if the differences were directly related to some aspect of plant operation. Qualitative analysis of west to east patterns of rotifer abundance revealed that the most frequently occurring pattern was two sequential increases followed by a decrease (x++-; see Results section). This pattern (or any geographic pattern of abundance) could be caused mechanically through hydrodynamic processes or naturally through biological processes. West to east patterns of abundance will be discussed further in the final section of this report.

Significant differences in adult copepod abundance were found among transects on some dates. While Student-Newman-Kuels tests cannot be applied where interactions occur, an examination of the trends in abundance (Table I-13) shows that 13 August and 20 November were most likely the dates when significant differences occurred.

However, since no single west to east abundance pattern occurred more frequently than any other over the entire sampling period, it may be argued that differences in abundance among transects reflected random patchiness or the absence of any consistent, localized population effects.

Although there were no significant differences in cladoceran abundance among transects, the same west to east abundance pattern most common to rotifers (x++-) was the most frequently occurring pattern for cladoceran populations. The "mean" pattern was an increase followed by either a decrease or an increase and a decrease (x+[+ or -]-). The most common west to east abundance pattern for copepod nauplii was a decrease followed by an increase and a subsequent decrease (x-+-); the "mean" pattern was the same as that for rotifers and cladocerans (x++-).

It was probably not coincidence that the "mean" west to east abundance pattern for rotifers, cladocerans, and copepod nauplii were essentially the same. A similar pattern was found by Fenlon *et al*. (1971) for cladocerans in the Nine Mile Point area (see Microzooplankton Introduction); these workers related increased abundance to enhanced reproduction in the warm waters discharged by the power plant.

The effect of these patterns, though they could be considered local acceleration of eutrophication, may be to provide increased rations for planktivorous larval and adult fishes as well as for carnivorous zooplankters.

(iii) Among Depths

Differences in the abundance of rotifers between depths were significant; there were more rotifers at the two nearshore stations than at the two offshore stations (see Results section).

Since nearshore-offshore temperature patterns were not consistent, it

is unlikely that the rotifer abundance pattern was due to the effects of temperature. Phytoplankton abundance was higher in nearshore waters than in offshore waters, but significantly only at FITZ. Even so, it is possible that the relationship of rotifer abundance to depth was partially a response to the availability of algal rations.

b. Rotifers as Indicators

The results of the data obtained on rotifers suggest that this taxonomic group may be a useful general indicator of the influence of power plant operation. Since rotifer population numbers form the largest portion of total microzooplankton population numbers and since the rotifer population contained both herbivorous and carnivorous genera, its value as an indicator is clear. Significant changes in rotifer abundance and generic structure may reflect changes in the rate and amount of energy and matter transfer through the food web. Changes in the food web (trophic structure) may presage biological changes with a wider geographic impact.

4. CONCLUSIONS

a. The seasonal abundance patterns of the taxonomic groups composing the microzooplankton population were related primarily to changes in temperature and the availability of food.

b. Rotifer standing stocks were the most reliable indicator of environmental changes; fluctuations in copepod and cladoceran standing stocks were not always as clearly related to a change in a measured environmental variable.

c. Microzooplankton production was enhanced in the near vicinity of Nine Mile Point Nuclear Station.

d. It is suggested that, over time, nektonic production may increase due to localized increases in secondary production off Nine Mile Point.

D. MACROZOOPLANKTON AND ICHTHYOPLANKTON

1. INTRODUCTION

Classifications according to size are widely used for distinguishing smaller and larger numbers of the plankton community. For the purposes of the 1973 survey in the Nine Mile Point vicinity, the term "macrozooplankton" was defined as those invertebrate zooplankters retained in a 571μ mesh plankton net; "ichthyoplankton" was defined as the vertebrate zooplankters (fish larvae) retained in a 571μ plankton net. This somewhat arbitrary definition (but see Fraser, 1968, and Ahlstrom, 1969) was based primarily on requirements for obtaining larval fish samples for which a 571μ mesh net was deemed suitable (Appendix I-C, Methods and Materials for macrozooplankton and ichthyoplankton studies).

There have been no previous studies of the macrozooplankton *per se* in Lake Ontario. Since the information obtained by Quirk, Lawler and Matusky in 1973 forms the basis of knowledge concerning the abundance and distribution of macrozooplankton in Lake Ontario, no other studies can be presented as background information. However, invertebrate crustaceans of the same species may be found in both the macrozooplankton and microzooplankton due to the wide range of size encompassed by the developmental stages of these organisms. The introductory material for copepods and cladocerans presented earlier in the macrozooplankton section may thus be generally applicable to representatives of these two taxa in the macrozooplankton.

There are few published data on the distribution and abundance of fish larvae in the Nine Mile Point area; some information is available (although not specifically related to the Nine Mile Point vicinity) concerning the feeding habits of larval fish populations. Since alewives are by far the most abundant fish in the study area (Storr, 1973), the larvae of this fish can be expected to be the dominant ichthyoplankter. Although Lake Michigan populations may differ from Lake Ontario populations, Norden's study of alewife larvae in Lake Michigan (1968) will serve to provide background information. Norden found that alewives spawned from June through August and that larvae greater than 5mm in length were most abundant during August, September and October. Stomach contents analyses revealed that alewife larvae fed predominantly on copepods and cladocerans 200 to 300μ in cross-section.

Information concerning Lake Ontario macrozooplankton and ichthyoplankton populations is scanty. The intent of the following subsections of this report is to provide as much baseline information as possible concerning species inventories, seasonal trends of abundance, diurnal migration patterns and trophic interactions.

2. MACROZOOPLANKTON RESULTS

a. Species Inventory

Twelve major taxonomic groups were identified from the macrozooplankton populations (see Table I-17). Other macrozooplanktonic organisms, including Mysis relicta (the opossum shrimp) and several families of insect larvae and pupae, were present in small numbers; these were combined under the heading "Other Macrozooplankters." The results presented herein are based on the abundance of total macrozooplankton and the abundance of the four groups found in the greatest numbers: cladocerans other than Leptodora, copepods, amphipods, and Leptodora. (See Appendix III-H for data tables, station locations, and collection dates. Station locations are also presented in Figure I-34).

Although the majority of the four major groups identified are meroplanktonic*, the most abundant groups, copepods and cladocerans, are holoplanktonic**. The importance of meroplankters in the macrozooplankton population is discussed in a later section of this report (also see Introduction to Microzooplankton).

b. Seasonal Patterns of Abundance

(i) Leptodora

Leptodora were found in small numbers (generally between 10 and 1000 organisms/1000m^3) during the spring (see Figure I-35). An order of magnitude decrease in Leptodora abundance was noted at most stations

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* Spending only a portion of a life cycle as plankters.

** Spending the entire life cycle as plankters.

TABLE I-17

NINE MILE POINT MACROZOOPLANKTON MAJOR GROUPS IDENTIFIED FROM 1973 COLLECTIONS

Amphipods

Cladocerans (other than *Leptodora*)

Copepods

Dipteran Larvae

Dipteran Pupae

Hydracarina

Hydroids

Isopods

Leptodora kindtii

Oligochaetes

Ostracods

Pelecypods

FIGURE I-34

NINE MILE POINT AREA

1973 MACROZOOPLANKTON AND ICHTHYOPLANKTON SAMPLING STATIONS

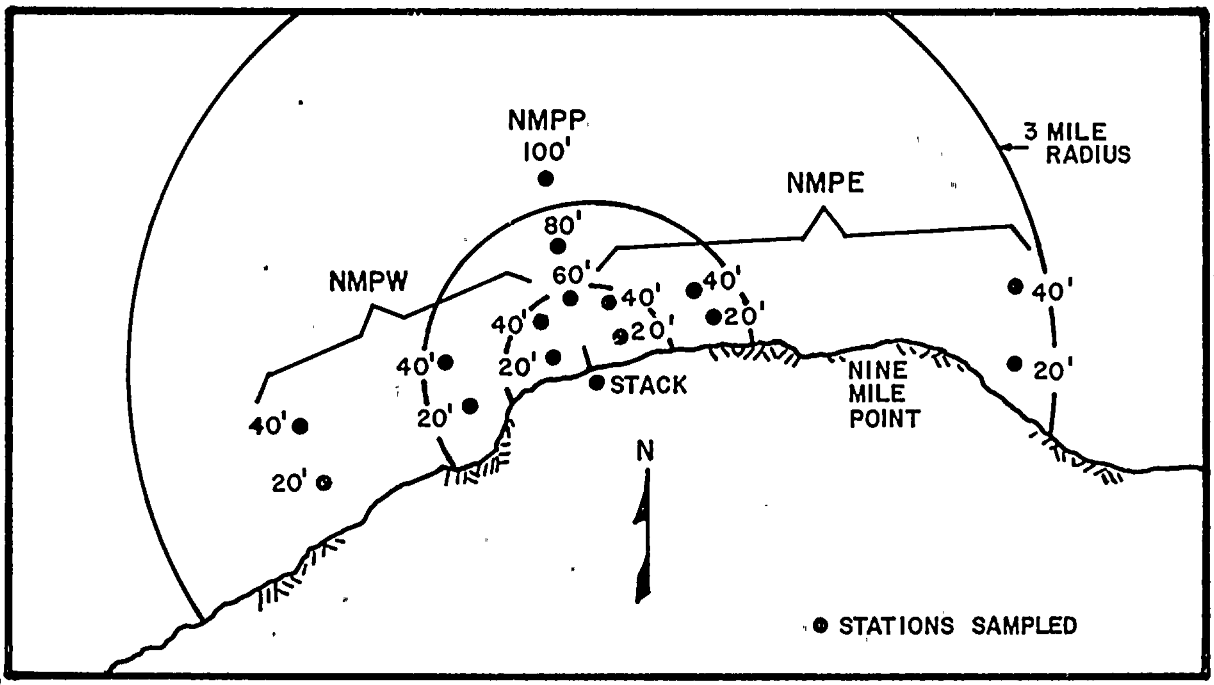


FIGURE I-35
SEASONAL ABUNDANCE OF LEPTODORA AT NINE MILE POINT - 1973

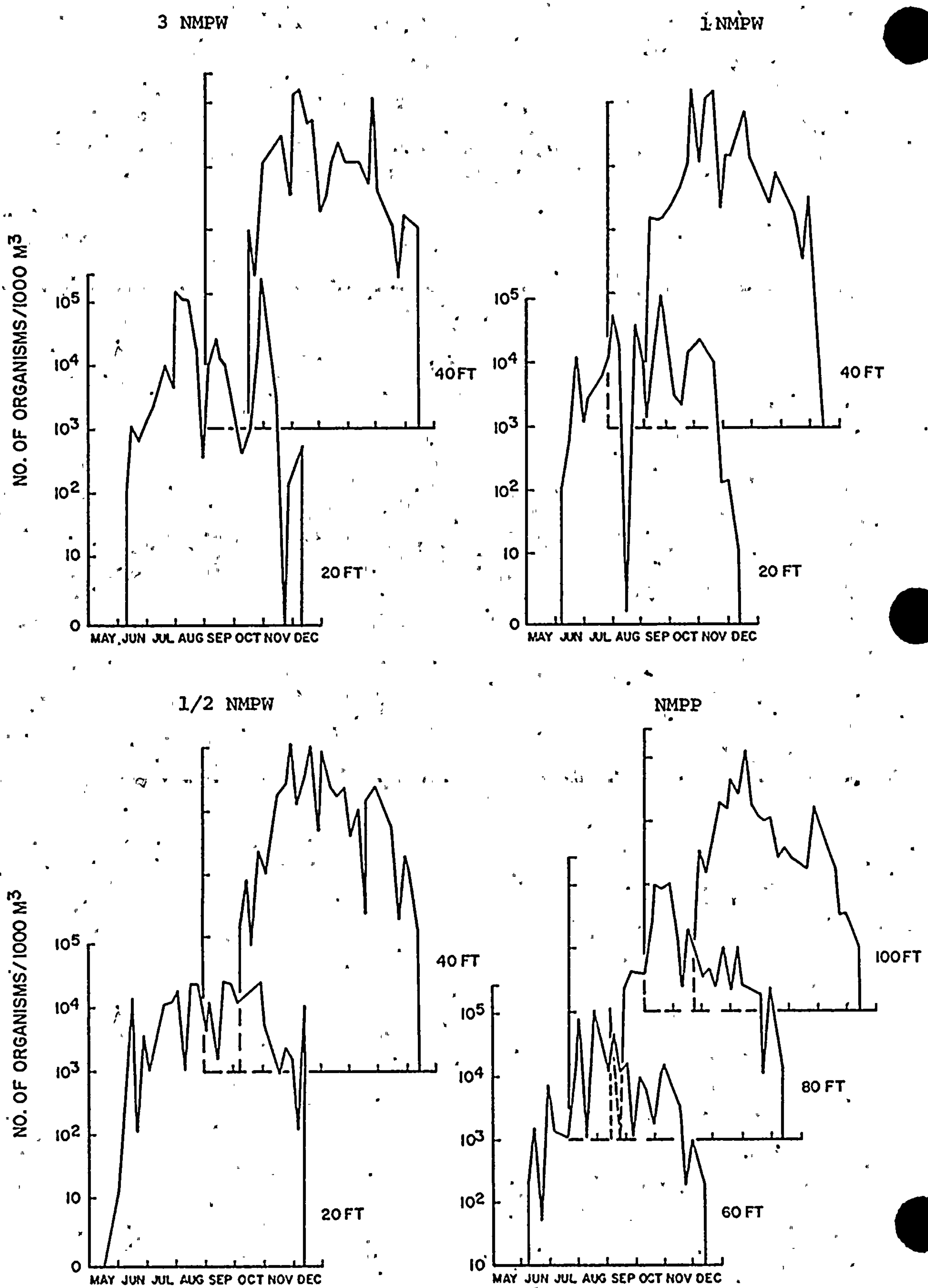
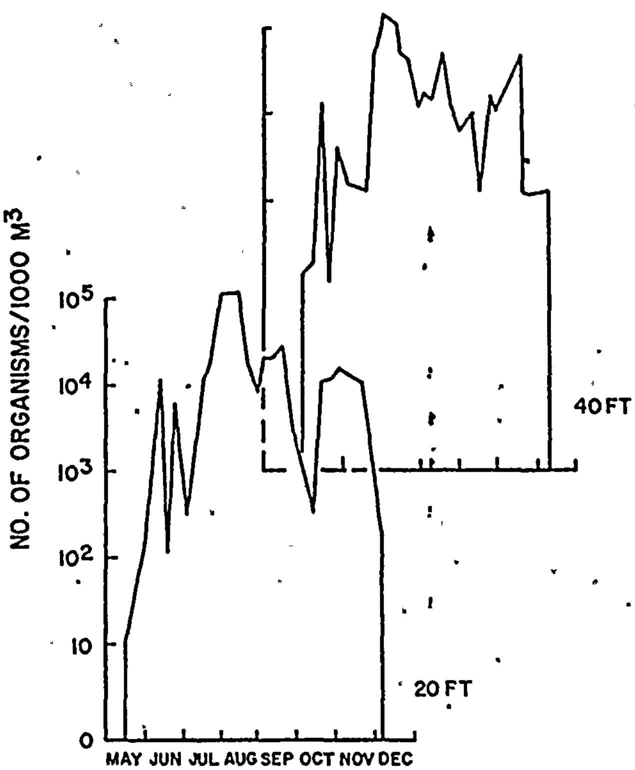


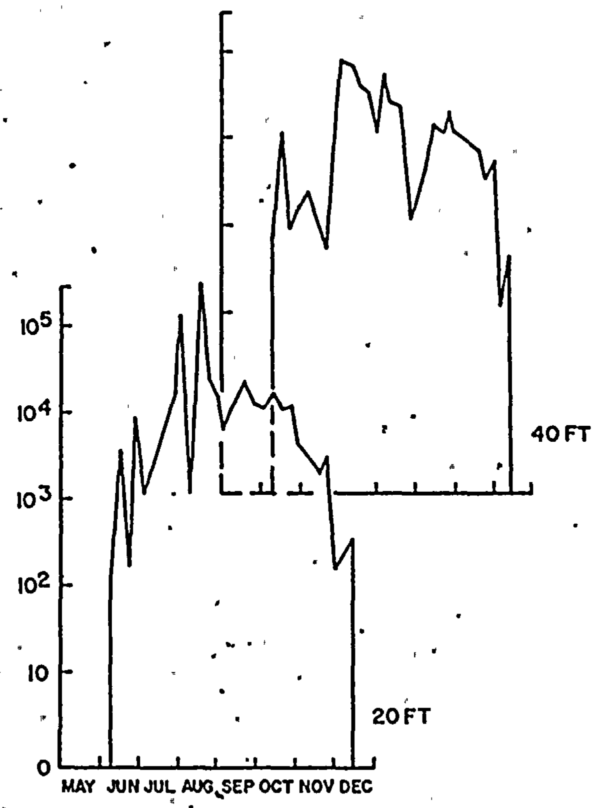
FIGURE I-35 (cont.)

SEASONAL ABUNDANCE OF LEPTODORA AT NINE MILE POINT - 1973

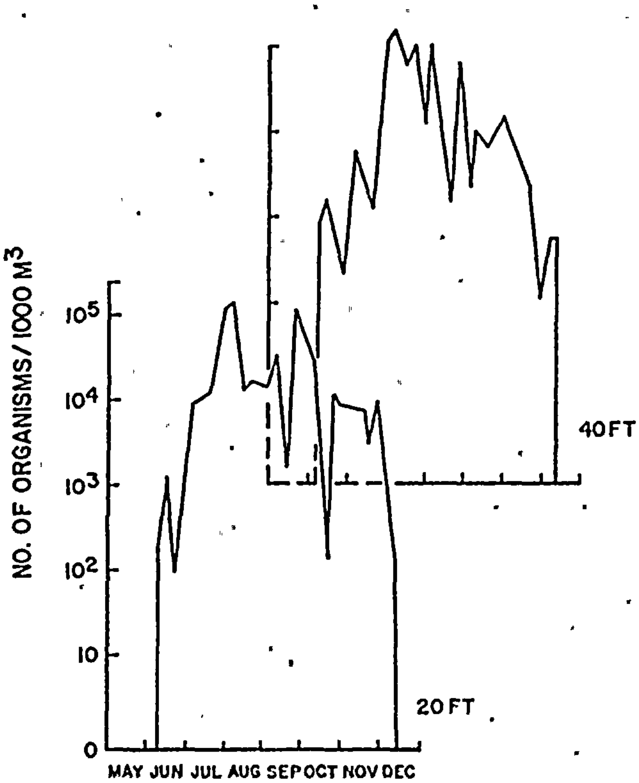
1/2 NMPE



1 NMPE



3 NMPE



during late June, followed by an increase of greater magnitude through July to approximately 2 x 10^5 organisms/$1000m^3$ during late July or early August. There was a general decreasing trend in the abundance of *Leptodora* after August, although at some stations peaks of abundance were found in September, October, and November. There was no apparent pattern to the occurrence of these fall peaks of abundance. In early December the numbers of *Leptodora* in the water column were of the same order of magnitude as populations in early June (see Figure I-35).

(ii) Other Cladocerans

Cladocerans other than *Leptodora* occurred in a bimodal seasonal pattern of abundance; the two peaks of abundance were evident at about one-third of the stations and masked by fluctuations in abundance at two-thirds of the stations (see Figure I-36). Cladocerans were present at all stations by mid-June; cladoceran abundance ranged between approximately 10 and 1000 organisms/$1000m^3$ during June.

As shown in Figure I-36, the first peak in the biomodal abundance pattern was found during late July or August at those stations where the general increase was not masked by rapid population fluctuations. The standing stock of cladocerans decreased between the occurrence of the first peak and early October, when abundance again increased. The second of the two seasonal peaks of abundance occurred between mid-October and mid-November; standing stocks were an average of five-fold higher at most stations during

FIGURE I-36
SEASONAL ABUNDANCE OF CLADOCERANS AT NINE MILE POINT 1973

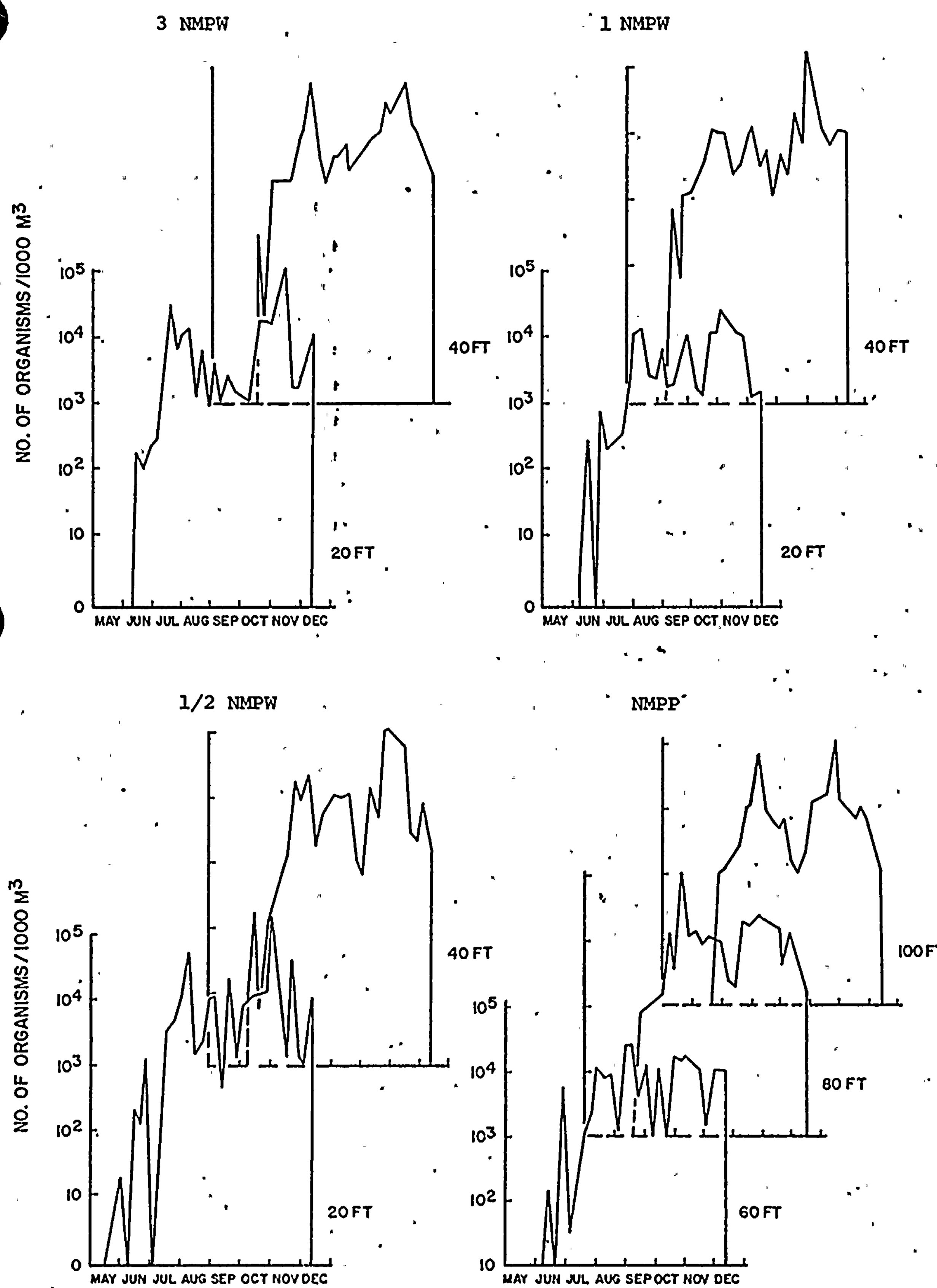
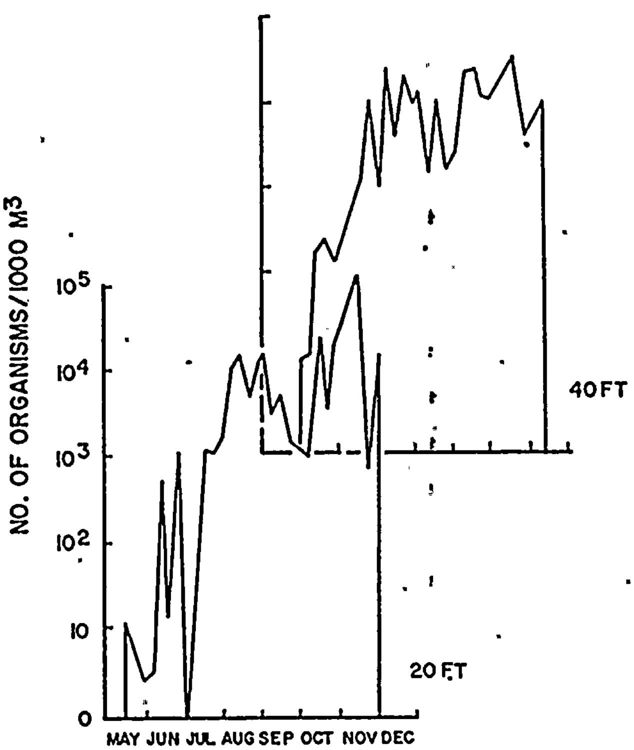
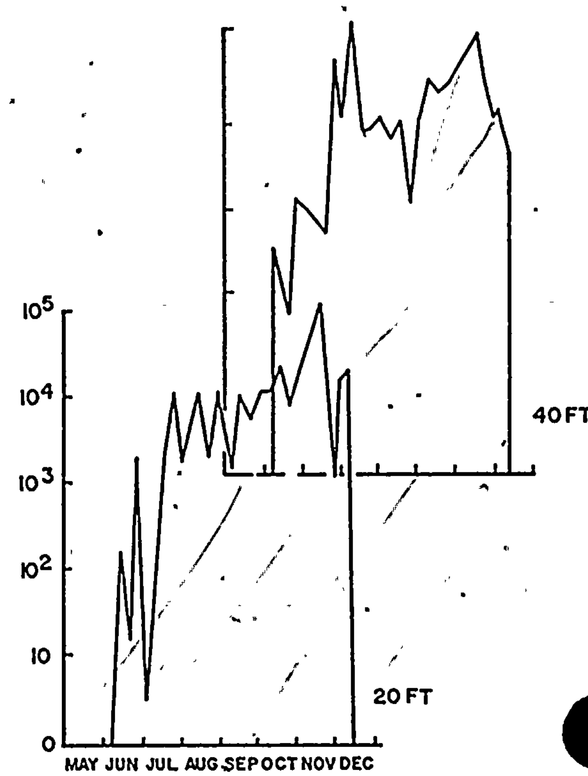


FIGURE I-36 (cont.)
SEASONAL ABUNDANCE OF CLADOCERANS AT NING MILE POINT 1973

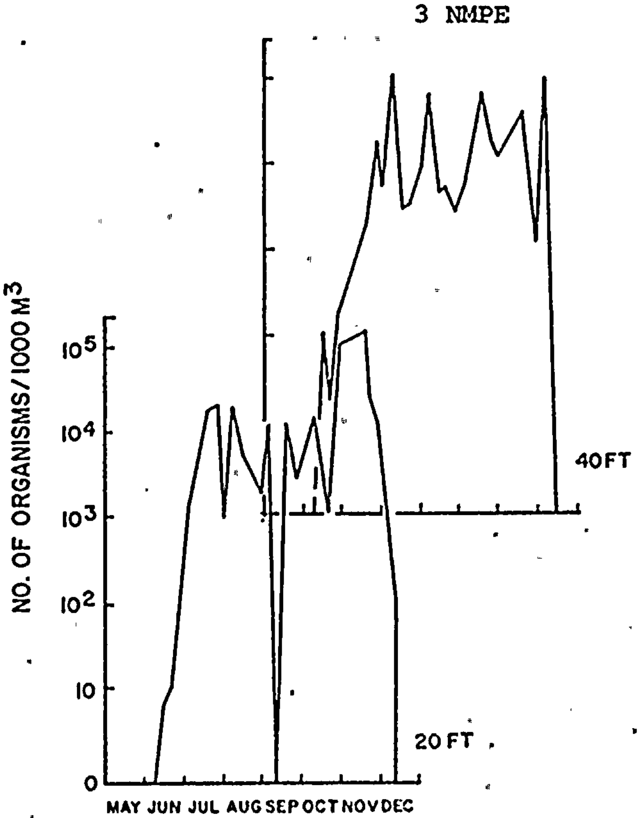
1/2 NMPE



1 NMPE



3 NMPE



the fall pulse than during the spring pulse. After mid-November, cladoceran numbers decreased at all stations to approximately the levels of abundance found during the June-July sampling period (between 10^3 and 10^4 organisms/1000m^3).

(iii) Copepods

The copepod populations varied as much as four orders of magnitude among sampling dates, averaging about half an order of magnitude from date to date over the course of the sampling period (Figure I-37). Seasonal trends were, therefore, not clearly distinguishable. It appeared that copepod abundance patterns were similar to cladoceran abundance patterns; both followed a bimodal seasonal pattern (see Figure I-36 for the clearest patterns).

The abundance patterns of the June through August collections marked the first of the two increases in copepod standing stock; the second increase extended from September through the end of the sampling period (early December).

(iv) Amphipods

The seasonal distribution of planktonic amphipods in the Nine Mile Point area cannot be established because of the large variation in population densities among sampling dates (see Figure I-38 and the following two subsections). Amphipods first appeared in June samples; although they were frequently absent from the samples, they were present at the end of the

FIGURE I-37

SEASONAL ABUNDANCE OF COPEPODS AT NINE MILE POINT 1973

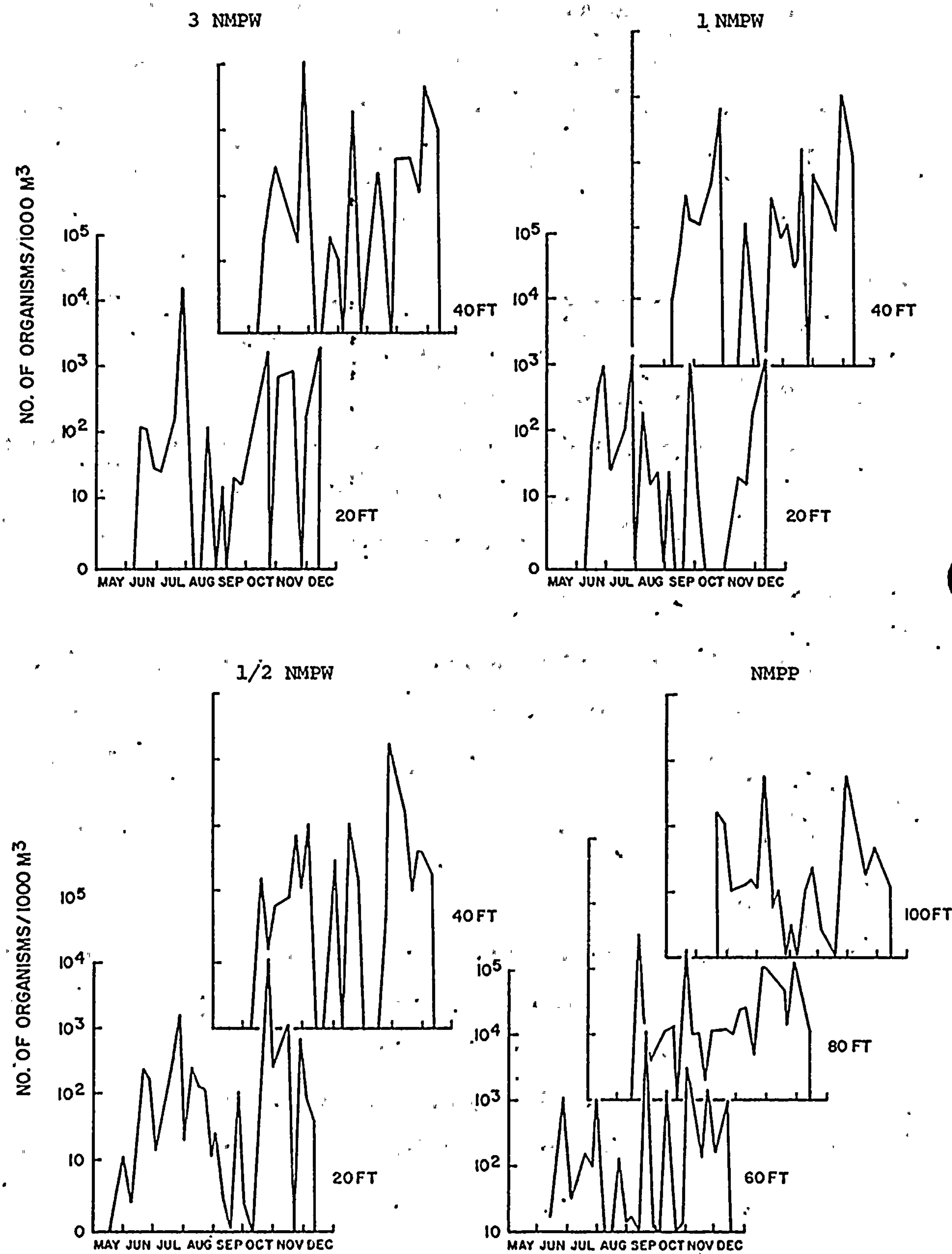


FIGURE I-37 (cont.)

SEASONAL ABUNDANCE OF COPEPODS AT NINE MILE POINT 1973

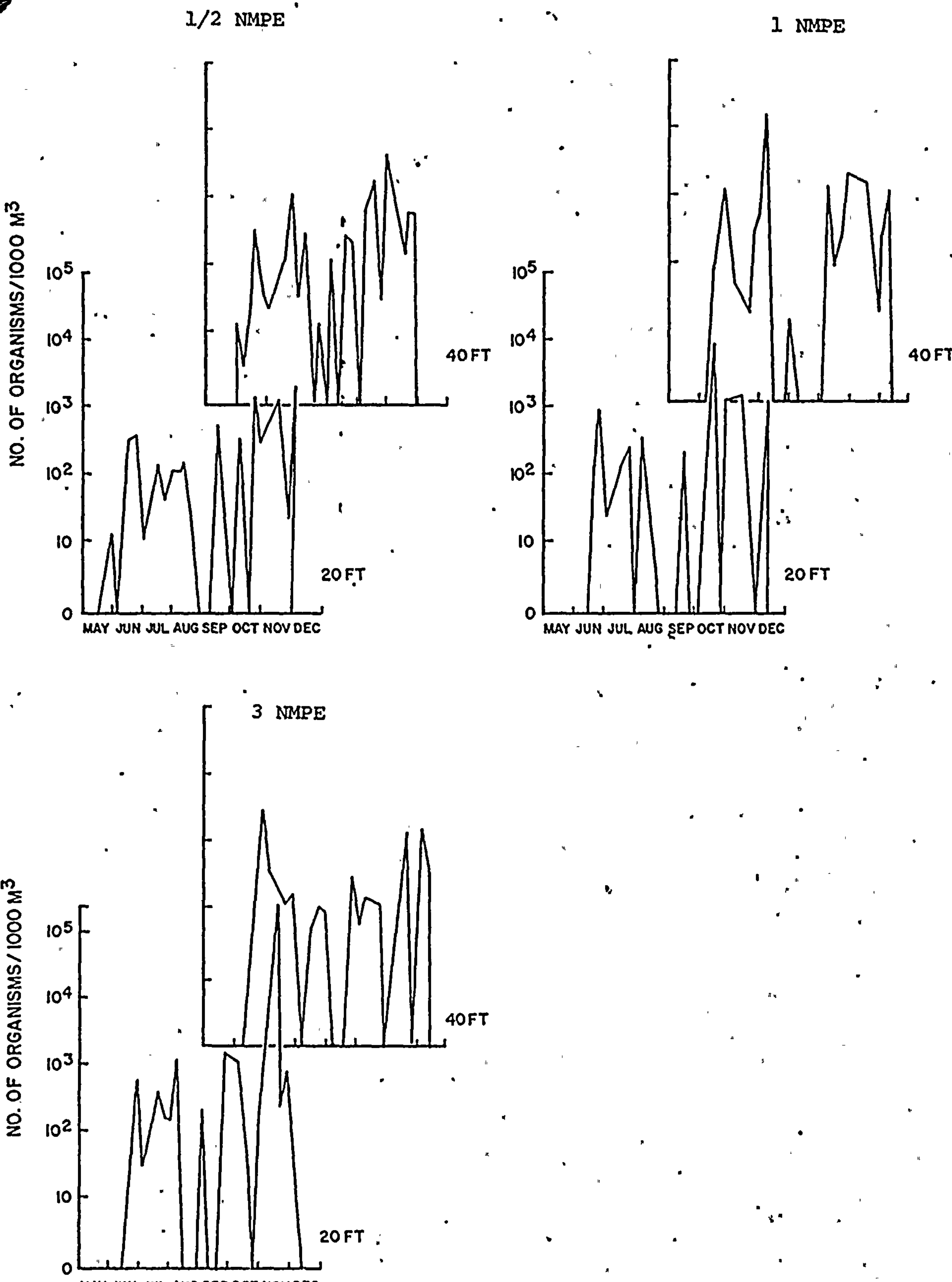


FIGURE I-38

SEASONAL ABUNDANCE OF AMPHIPODS AT NINE MILE POINT 1973

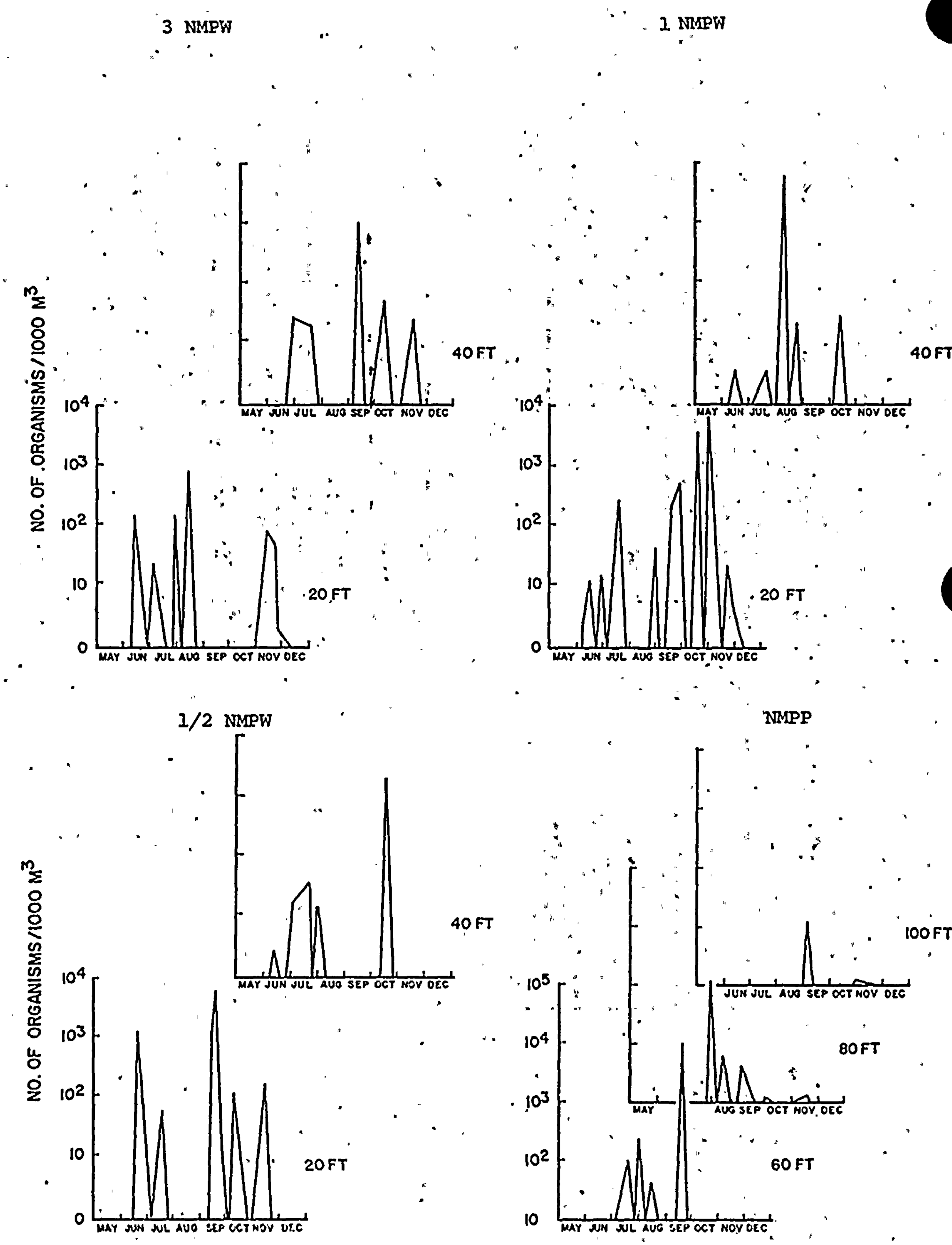
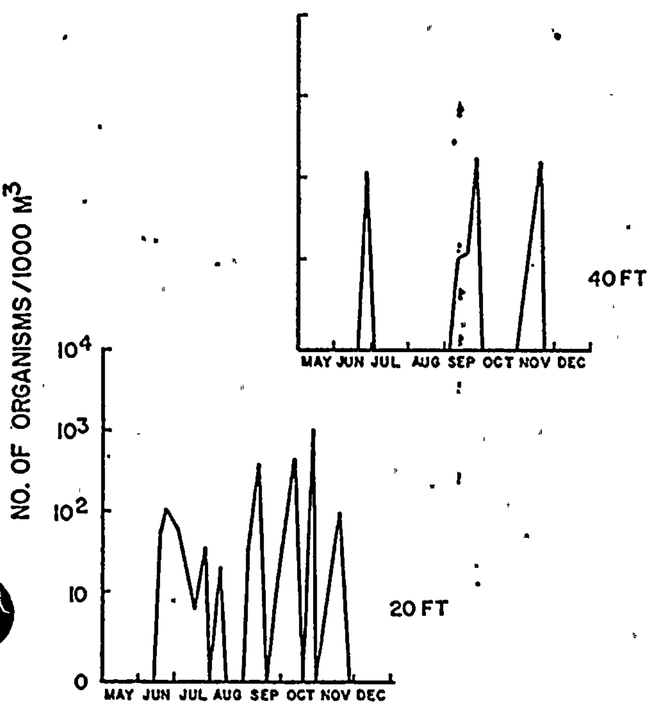


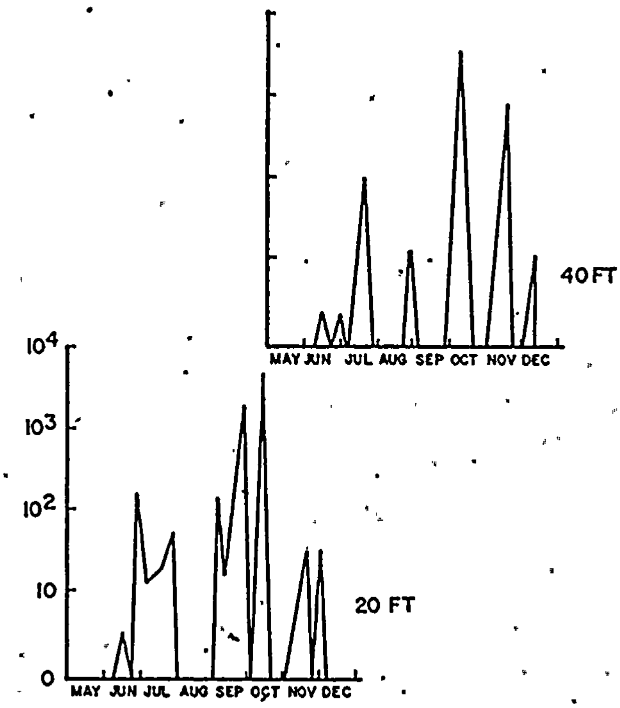
FIGURE I-38 (cont.)

SEASONAL ABUNDANCE OF AMPHIPODS AT NINE MILE POINT 1973

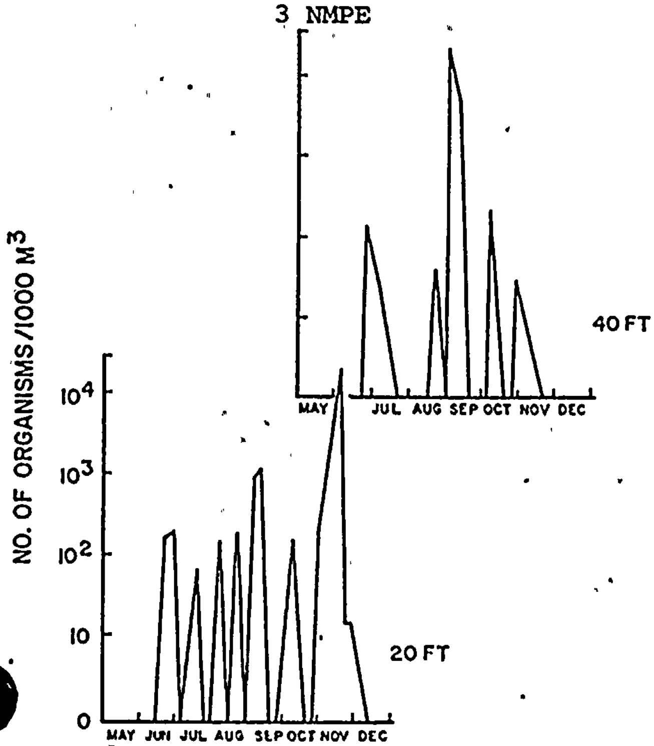
1/2 NMPE



1 NMPE



3 NMPE



sampling period during early December collections. The greatest numbers collected were over 3×10^4 amphipods/$1000m^3$.

(v) Total Macrozooplankton

Since the bulk of the total macrozooplankton was composed of the most abundant taxonomic groups discussed in preceding subsections, it was expected that the seasonal abundance pattern of total macrozooplankton would reflect the biomodal patterns of cladocerans and copepods with some mid-season masking effects due to the unimodal pattern of Leptodora occurrence.

Figure I-39 shows that such was the case. The total macrozooplankton population increased logarithmically during May and June, reaching the first peak of abundance at all stations during July and early August. Abundance decreased slightly during late August and early September and rose again to a fall peak of abundance. The first of the two pulses in the macrozooplankton standing stock was slightly greater in magnitude than the second pulse.

c. Diurnal Variations in Abundance

Since many zooplankters exhibit diurnal migration patterns, which are important in the trophic mechanisms of energy transfer (Lane and McNaught, 1970), Bartlett's test for homogeneity of variance (see Appendix II) was applied to surface day and night macrozooplankton samples to determine whether

FIGURE I-39

SEASONAL ABUNDANCE OF TOTAL MACROZOOPLANKTON AT NINE MILE POINT 1973

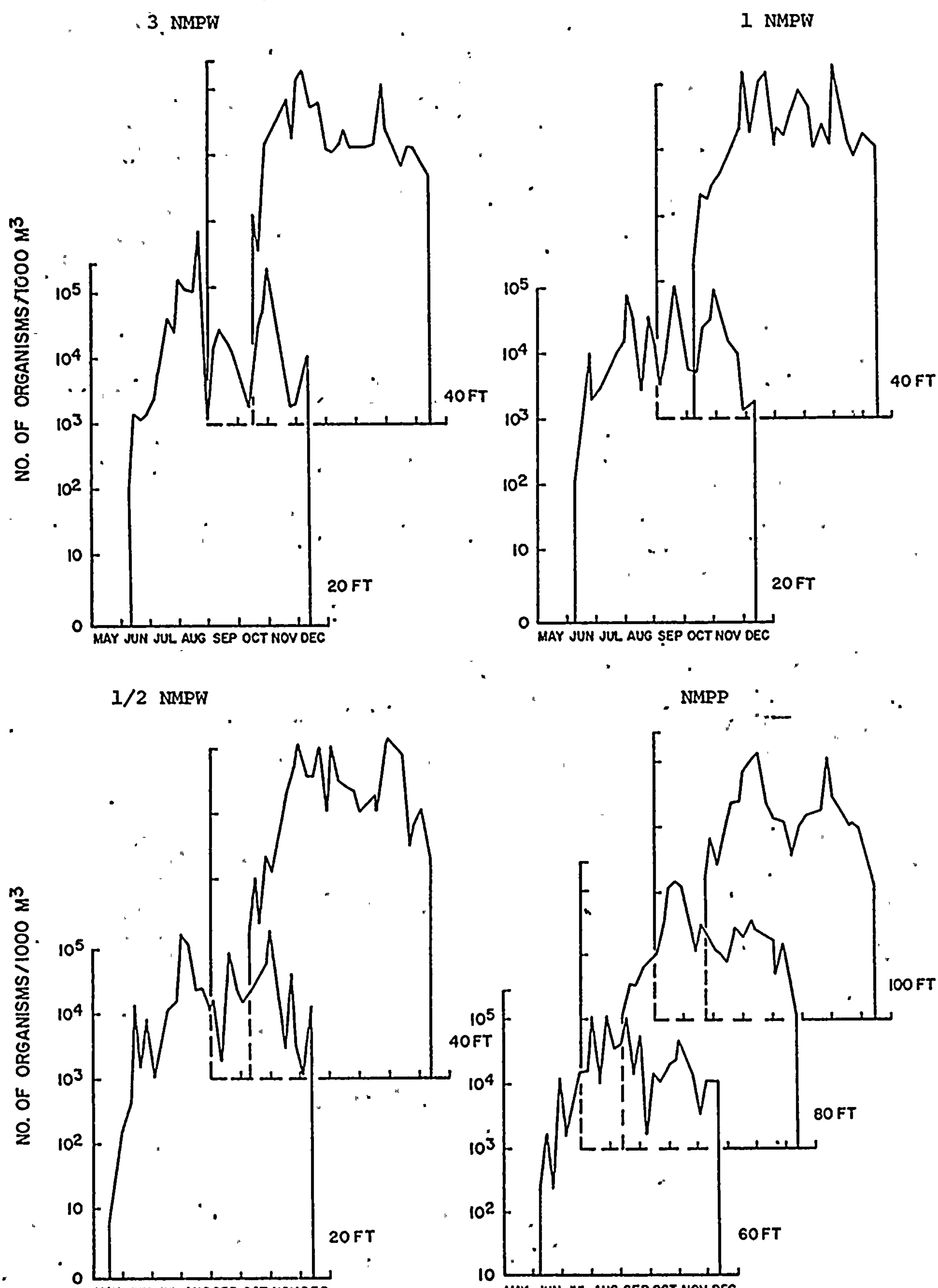
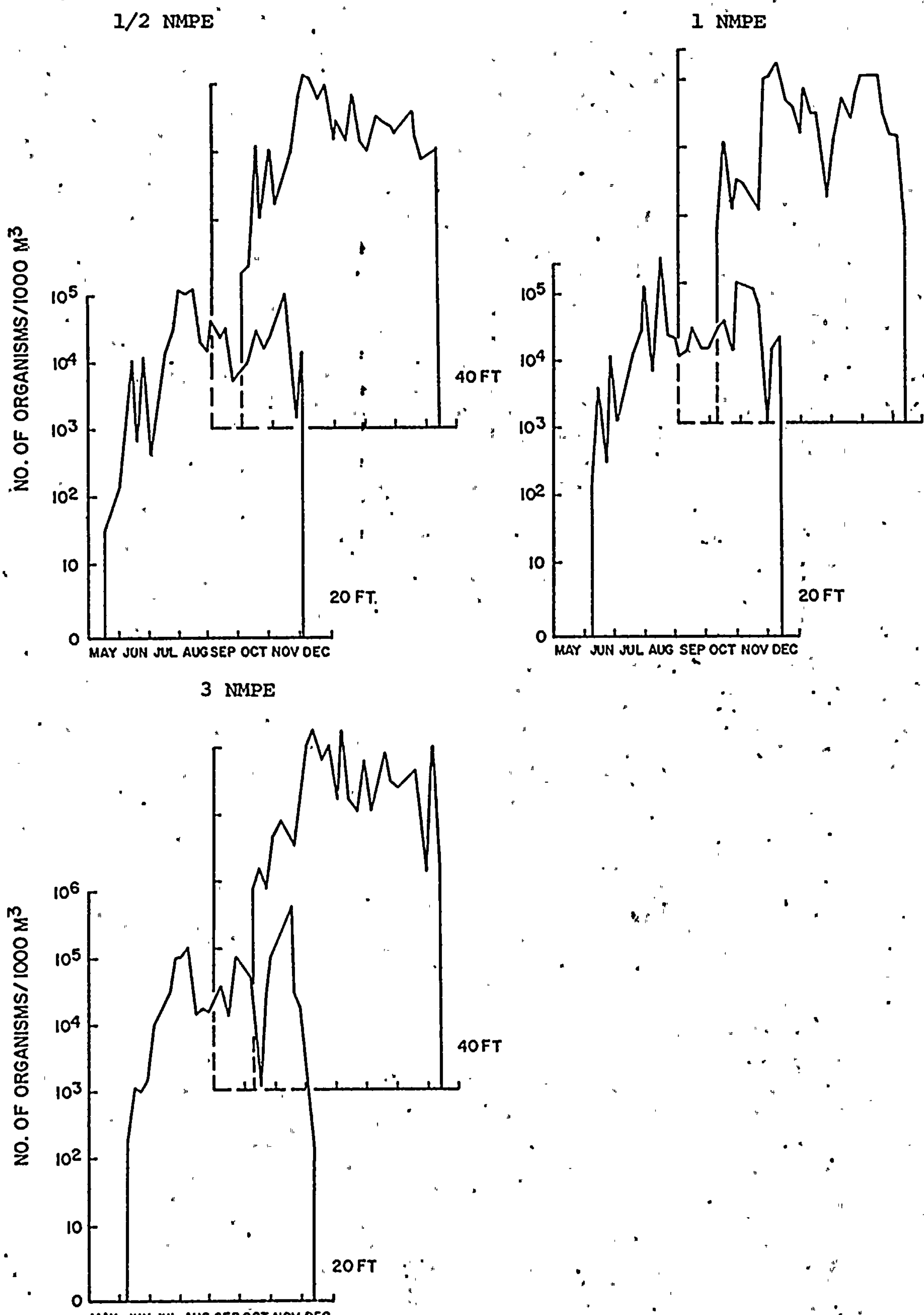


FIGURE I-39 (cont.)

SEASONAL ABUNDANCE OF TOTAL MACROZOOPLANKTON AT NINE MILE POINT 1973



there were significant differences in abundance between these two time periods. The results show that there was a significant difference between the day and night abundance of the total macrozooplankton population and of the four taxonomic groups composing the bulk of macrozooplankton numbers (see Table I-18). Night abundance was greater than day abundance for the five taxonomic groups tested.

Two tests were employed, a paired-t and a Wilcoxon Signed-Rank test (see Appendix II), to determine the extent of diurnal variations in abundance through the water column at the deepest station: 3-NMPP-100 ft. The results of these tests show that amphipods were significantly more abundant in both the bottom and the mid-water portion of the water column at night; there were no significant differences between day and night abundance of the other taxonomic groups tested (see Table I-19).

d. Variations in Abundance Among Stations at a Transect

Two-way ANOVA (all statistical analyses are defined and described in Appendix II) were conducted for the four major macrozooplankton groups and for total macrozooplankton to determine if there were significant differences between abundance values within a transect and abundance values among dates. The results are presented in full in Appendix III-J; a summary of these results is presented in Table I-19. The summary table shows that there were no significant differences in Leptodora abundance, copepod abundance, or total macrozooplankton abundance among stations along a transect. Significant differences

TABLE I-18

BARTLETT'S TEST FOR SIGNIFICANT DIFFERENCES BETWEEN DAY AND NIGHT MACROZOOPLANKTON ABUNDANCE IN SURFACE SAMPLES

Taxonomic Group	Calculated z-value
Total Macrozooplankton	z = 8.725*
Leptodora	z = 5.158*
Cladocerans	z = 8.992*
Copepods	z = 9.198*
Amphipods	z = -9.138*

Critical z-value - 1.960

*Significant difference at $\alpha = 0.05$.

TABLE I-19

STATISTICAL TESTS FOR SIGNIFICANT DIFFERENCES BETWEEN DAY AND NIGHT MACROZOOPLANKTON ABUNDANCE IN MID-WATER AND BOTTOM SAMPLES

Paired-t Test

Taxonomic Group	Depth	d.f.	t-value	p-value
Total Macrozooplankton	mid-water	8	-2.142	$0.050 \leq p \leq 0.100$
Leptodora	mid-water	8	-1.837	$0.100 \leq p \leq 0.200$
Cladocerans	mid-water	8	-0.434	$p > 0.500$
Total Macrozooplankton	bottom	7	-1.861	$0.100 \leq p \leq 0.200$
Leptodora	bottom	6	-1.944	$0.050 \leq p \leq 0.100$
Cladocerans	bottom	6	-1.127	$0.200 \leq p \leq 0.400$
Copepods	bottom	7	-1.195	$0.200 \leq p \leq 0.400$

no significant differences at = 0.05

Wilcoxon Test

Taxonomic Group	Depth	d.f.	T-	T+	T		
Copepods	mid-water	9	37	8	8	$6 \leq T \leq 39$	$\alpha = .027$
*Amphipods	mid-water	8	36	0	0	$4 \leq T \leq 32$	$\alpha = .027$
*Amphipods	bottom	7	28	0	0	$2 \leq T \leq 26$	$\alpha = .023$

*Significant difference

between stations were found at 1-NMPW and 1/2-NMPE for cladocerans and amphipods, respectively. Since significant differences in abundance among sampling dates were expected, the lack of such differences at one or more transects for the four major macrozooplankton taxonomic groups was unusual. The lack of significant differences among dates for copepods and amphipods may have been due partially to the fluctuations of abundance between sampling dates.

e. Variations in Abundance Among Stations Along a Depth Contour

Two-way ANOVA's were also conducted to determine if there was significant differences among stations at the 20 ft. depth contour and at the 40 ft. depth contour (see Appendix III-J). Table I-20 shows that there were no significant differences among stations at either of the two contours for all four taxonomic groups and for total macrozooplankton. There were significant differences among dates for all macrozooplankton groups, except amphipods, and for total macrozooplankton abundance.

These results indicate that the previously reported phenomenon of "no significant differences" among dates at a transect for Leptodora, copepods, and cladocerans (see section on Variations in Abundance at a Transect) was not evident over all stations.

TABLE I-20

SUMMARY OF RESULTS OF TWO-WAY ANOVA
FOR MACROZOOPLANKTON POPULATIONS

	Leptodora		Cladocerans		Copepods		Amphipods		Total Macrozoo.	
TEST	S	D	S	D	S	D	S	D	S	D
Transect #1		*		*		*				*
Transect #2			*	*		*				*
Transect #3		*		*						*
Transect #4		*		*		*		*		*
Transect #5		*		*		*	(*)			*
Transect #6		*		*		*				*
Transect #7		*						*		*
20' depth contour		*		*		*				*
40' depth contour		*		*		*				*

<u>Key</u>: *Significant difference at $\alpha = 0.05$
Transect #1 = 3-NMPW; 20 ft., 40 ft.
Transect #2 = 1-NMPW; 20 ft., 40 ft.
Transect #3 = 1/2-NMPW; 20 ft., 40 ft.
Transect #4 = NMPP; 60 ft., 80 ft., 100 ft.
Transect #5 = 1/2-NMPE; 20 ft., 40 ft.
Transect #6 = 1-NMPE; 20 ft., 40 ft.
Transect #7 = 3-NMPE; 20 ft., 40 ft.
S = Stations
D = Dates

3. DISCUSSION OF MACROZOOPLANKTON RESULTS

a. Seasonal Patterns of Abundance

Since the bimodal abundance pattern of the macrozooplankton population was primarily a reflection of the seasonal abundance patterns of cladocerns, Leptodora, and copepods, the environmental factors which affected these three taxonomic groups largely determined the structure and stability of the macrozooplankton populations as a whole.

The determination of the direct effects of physical environmental parameters on a single population is a difficult problem when field collections are the only available sources of information. However, comparison of trends in environmental parameters with trends in the population under consideration w[illegible] many times help to elucidate broad concepts of environmental and biolgical interactions.

For example, the seasonal abundance pattern of Leptodora was shown to be unimodal with the greatest numbers of this genus present during August. Since Leptodora is a raptorial feeder, its prey may have decreased in abundance as Leptodora reached peak numbers. It is noteworthy, therefore, that the herbivorous zooplankters (cladocerans and copepods) in both the macrozooplankton and microzooplankton fractions of the planktonic community showed depressed population numbers during August and September.

The late summer depression in herbivorous zooplankters may also have been influenced by a decrease in populations of their food, the algae (see Phytoplankton section) during late July, as well as by Leptodora predation. Maximum summer water temperature also occurred during late August and the depression in herbivore abundance might also be attributable to the influence of temperature.

This set of population and environmental trends is quite similar to the interactions described by Stross (1973) for Lake Saratoga, and it is expected that the trophic mechanisms proposed by Stross are equally valid for Lake Ontario, with the exception that the predator in Lake Ontario was Leptodora rather than Chaoborus. This trophic scheme and its application to Lake Ontario is discussed in more detail in this report, Section I-A4.

b. Diurnal Variations

The results of statistical analyses showed that there were significant differences between day and night abundance of the four major macrozooplankton taxonomic groups in surface waters. Since there were no significant differences in the day and night abundance of amphipods in mid-water and bottom collections, it is concluded that benthic populations of this taxonomic group were planktonic during the night. Storr (1970) indicated that the benthic amphipod Gammarus feeds in the periphytic Cladophora of the Nine Mile Point area; Hutchinson (1967) reported that planktonic Gammarus feeds on smaller cladocerans and copepods. It is suggested, therefore, that the amphipods in the

Nine Mile Point area serve a double trophic function: benthic amphipod populations as important source of food for adult fishes during the day (Storr, 1973), and planktonic amphipod populations as predators of herbivores.

c. Variations Between Stations

There were not enough significant differences among stations, either at a transect or at a depth contour, to develop an interstation abundance pattern. Patterns of abundance may have existed; if so, they could have been masked by patchiness or they may have been so slightly developed as to fall below the limit of sampling precision.

d. Variations Between Dates

The lack of significant differences in the abundance of amphipods among dates indicates two major possibilities: 1) the total populations of these organisms were not significantly affected by seasonal changes or, 2) that they were a refractory element of the macrozooplankton which should be considered as a benthic population.

4. MACROZOOPLANKTON CONCLUSIONS

a. The data compiled by QL&M in the Nine Mile Point area during 1973 represent the first study of the macrozooplankton fraction *per se* in Lake Ontario. Although patchiness of macrozooplankton numbers may have

accounted for some interstation variations, the seasonal trends of the most abundant organisms were distinguishable: Leptodora standing stocks were characterized by a unimodal seasonal pattern of abundance, whereas cladocerans and copepods were characterized by bimodal seasonal patterns of abundance.

b. Temperature and the availability of food appeared to be major factors controlling seasonal patterns.

c. Meroplankters composed a small and refractory portion of the total macrozooplankton population.

5. ICHTHYOPLANKTON RESULTS

a. Species Inventory

The larvae of 18 species of fish were identified in samples collected during the 1973 sampling period at the seven Nine Mile Point sampling stations (Figure I-34). These larvae are listed in Table I-21 according to common and scientific name in order of decreasing abundance. The sampling stations are described and the collecting dates are listed in Appendix III-K.

b. Abundance

(i) General Abundance

The data showing total larval abundance are presented in Appendix III-K. The date, time, transect, and contour is listed for each collecting effort. Although all samples were analyzed for total number of fish larvae of each species, only selected samples were chosen for length-frequency analysis (see Appendix III-M). The larvae (expressed as larvae/ $1000m^3$ of water) of each species found in the samples selected for complete analysis are listed under the abbreviation for each column name shown in Table I-21.

Using the data tabulated in Appendix III-L, graphs were generated to show larval alewife abundance and total fish larvae abundance (Figures I-40 through I-46).

TABLE: I-21

LARVAL FISH FOUND IN NINE MILE POINT AREA

Common Name	Scientific Name	Abbreviation
Alewife	Alosa pseudoharengus	AW
Johnny Darter	Etheostoma nigrum	JD
Carp	Cyprinus carpio	CP
Mottled Sculpin	Cottus bairdi	MTSC
White Perch	Morone americana	WP
Rainbow Smelt	Osmerus mordax	RSM
Yellow Perch	Perca flavescens	YP
White Bass	Morone chrysops	WB
White Sucker	Catostomus commersoni	WS
Spottail Shiner	Notropis hudsonius	STSH
Common Shiner	Notropis cornutus	CSH
Goldfish	Carassius auratus	GF
Emerald Shiner	Notropis atherinoides	EMSH
Unidentified Shiner	Notropis sp.	NOSP
[illegible] Perch	Percina caprodes	LP
[illegible]kin Seed	Lepomis gibbosus	PS
Unidentified Sunfish	Lepomis sp.	LESP
Three-spined Stickleback	Gasterosteus aculeatus	TSB

FIGURE I-40

LARVAE CONCENTRATION FOR 1973
NMPW-½ MILE

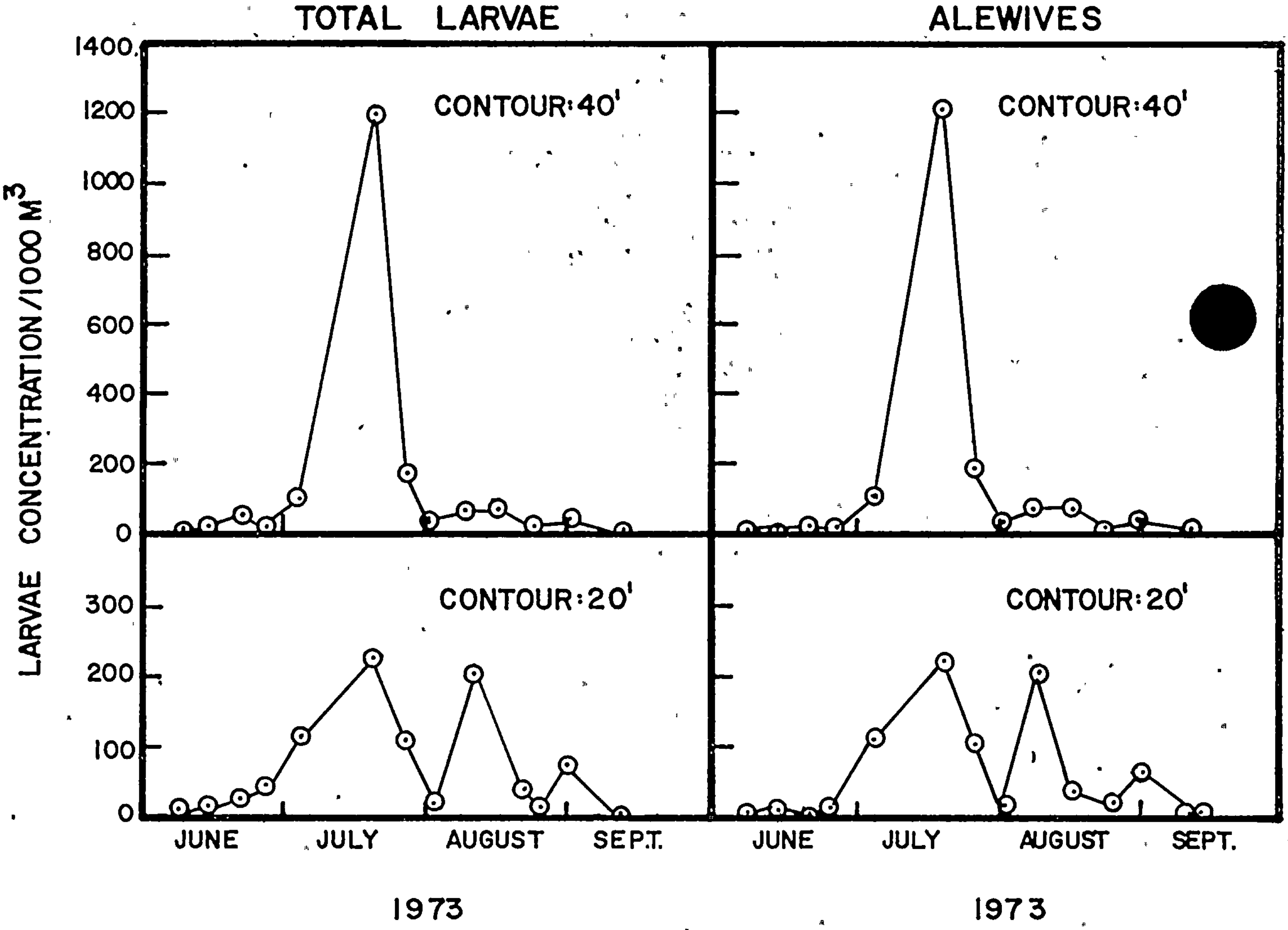


FIGURE I-41

LARVAE CONCENTRATION FOR 1973
NMPW-1 MILE

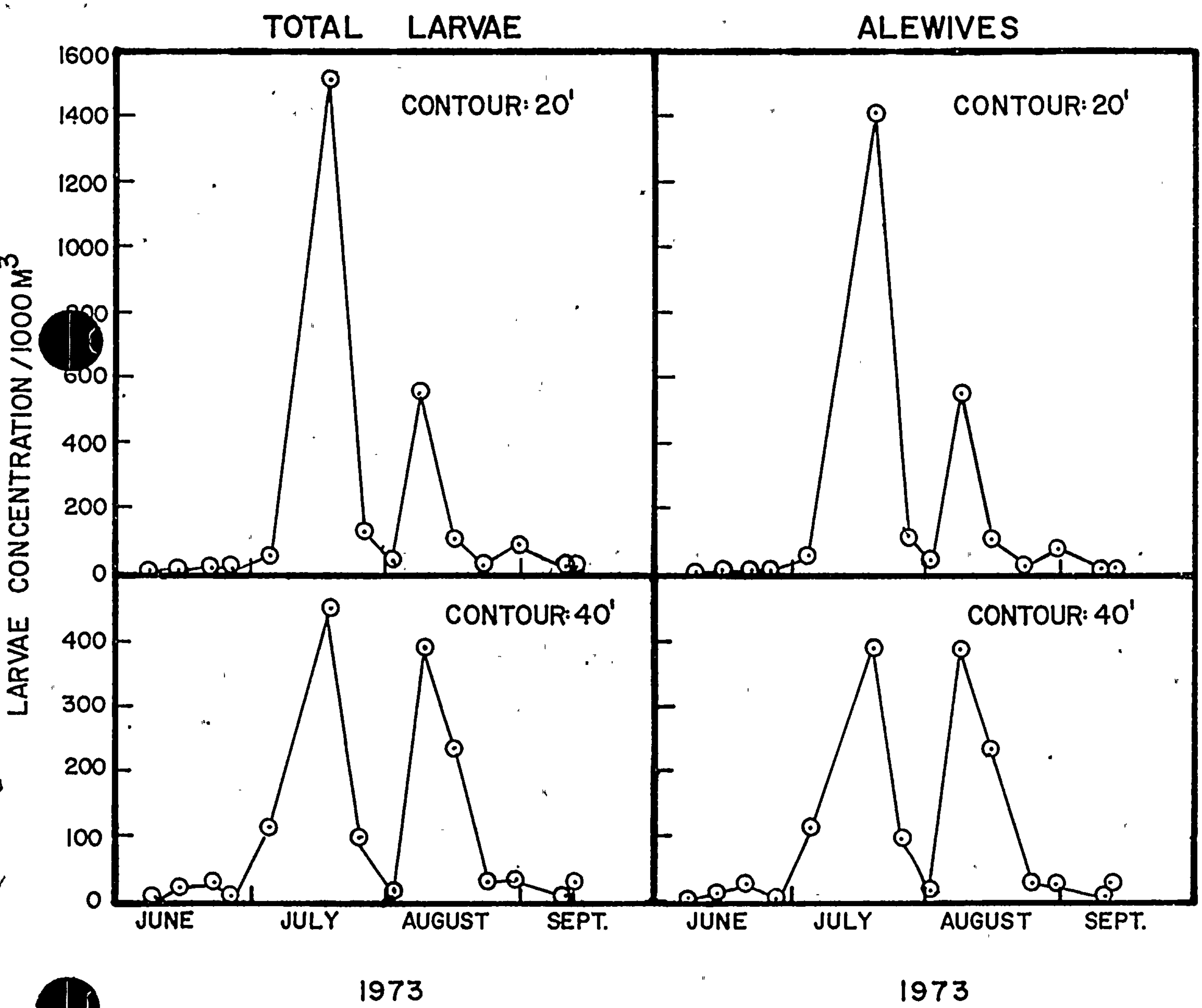


FIGURE I-42

LARVAE CONCENTRATION FOR 1973

NMPE—3 MILES

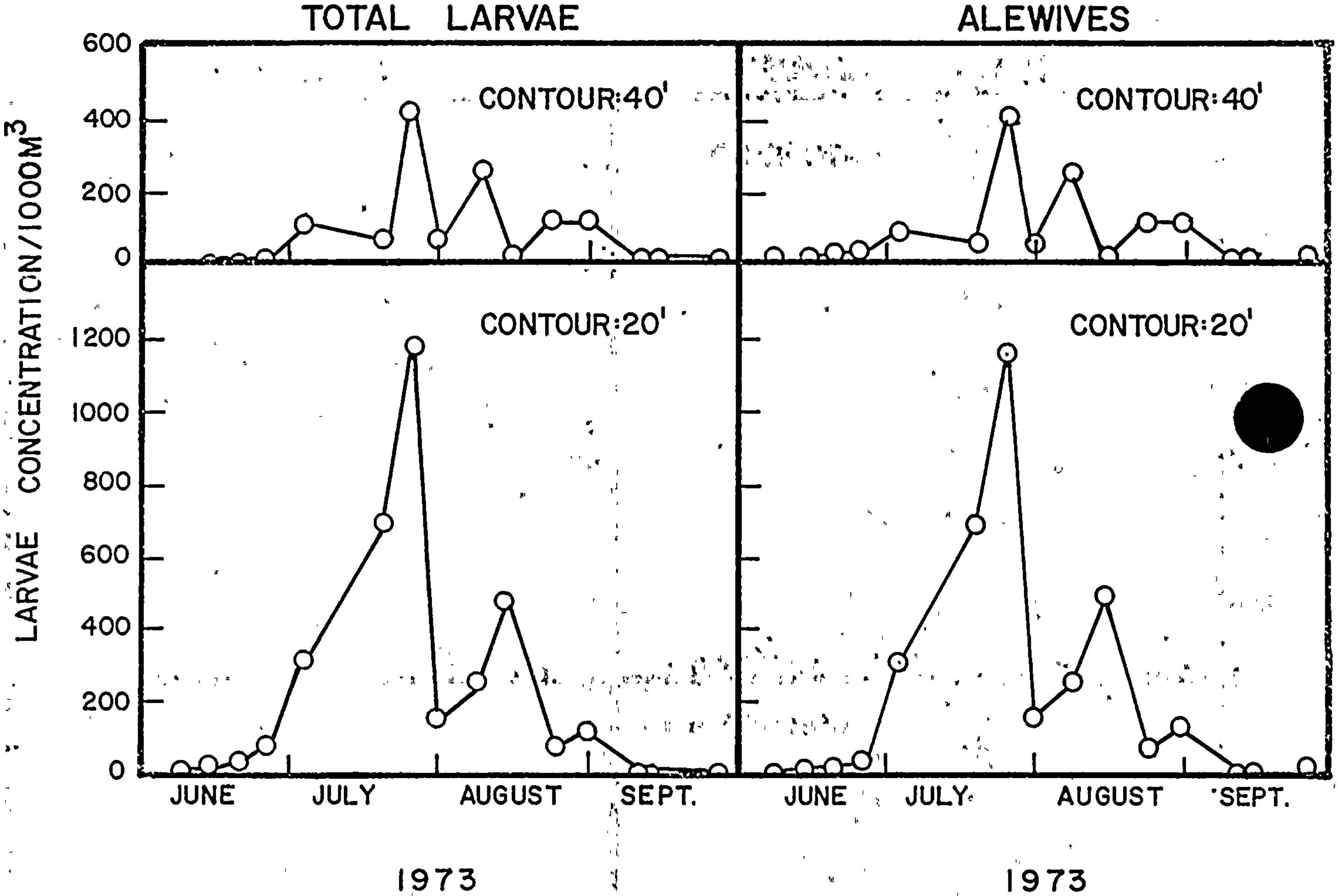


FIGURE I-43

LARVAE CONCENTRATION FOR 1973
NMPP

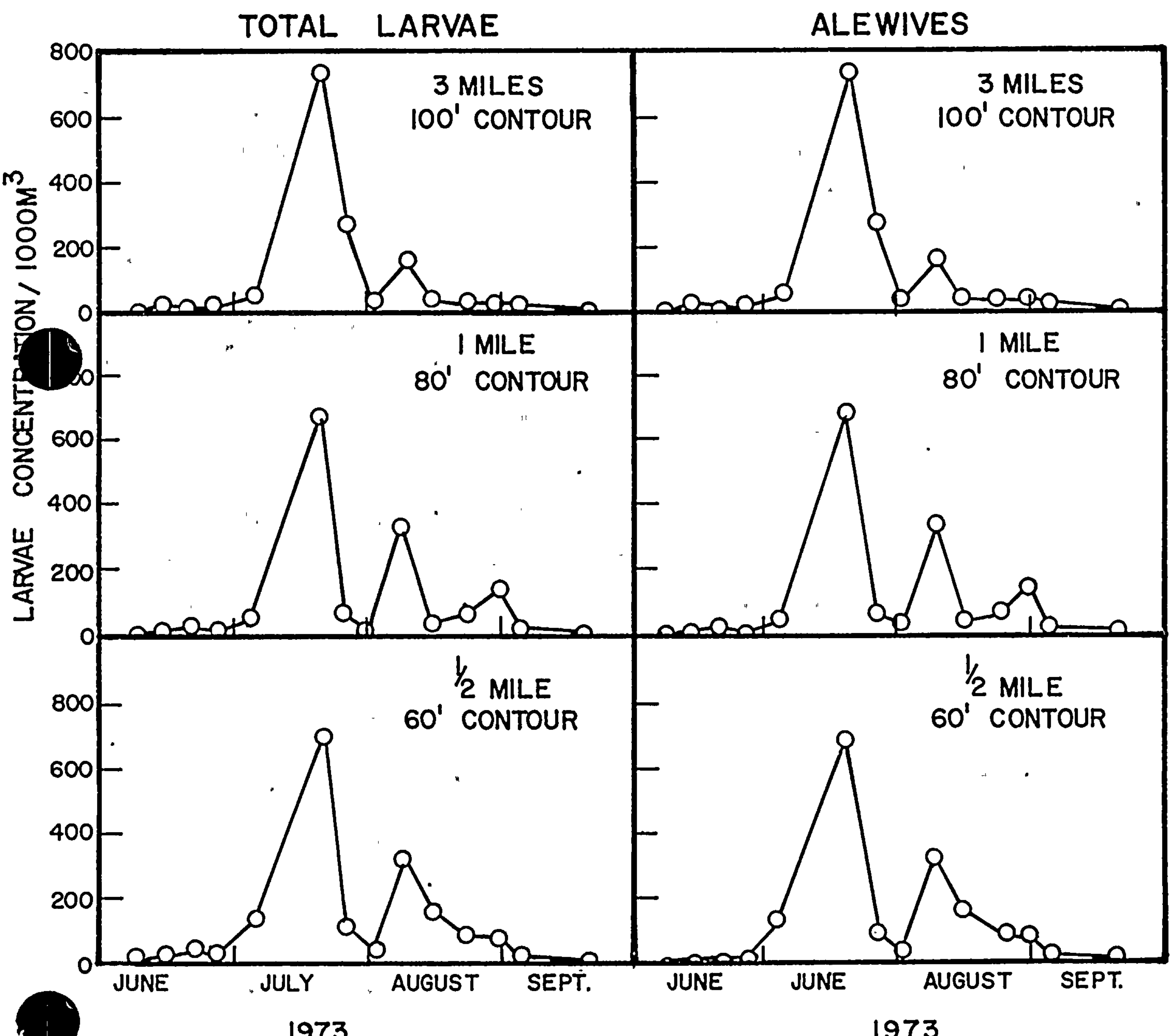


FIGURE I-44

LARVAE CONCENTRATION FOR 1973
NMPE-½ MILE

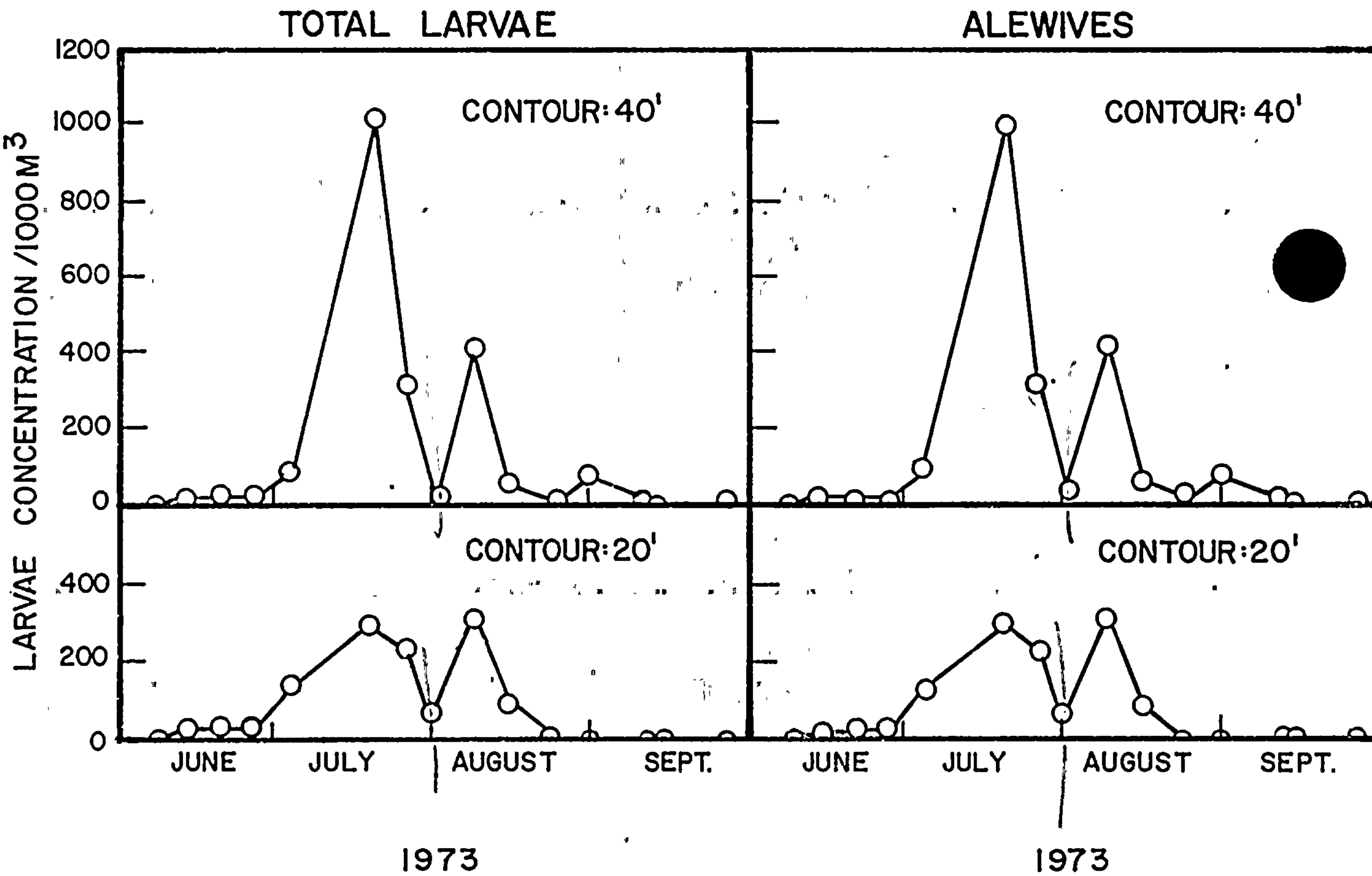


FIGURE I-45

LARVAE CONCENTRATION FOR 1973

NMPE-1 MILE

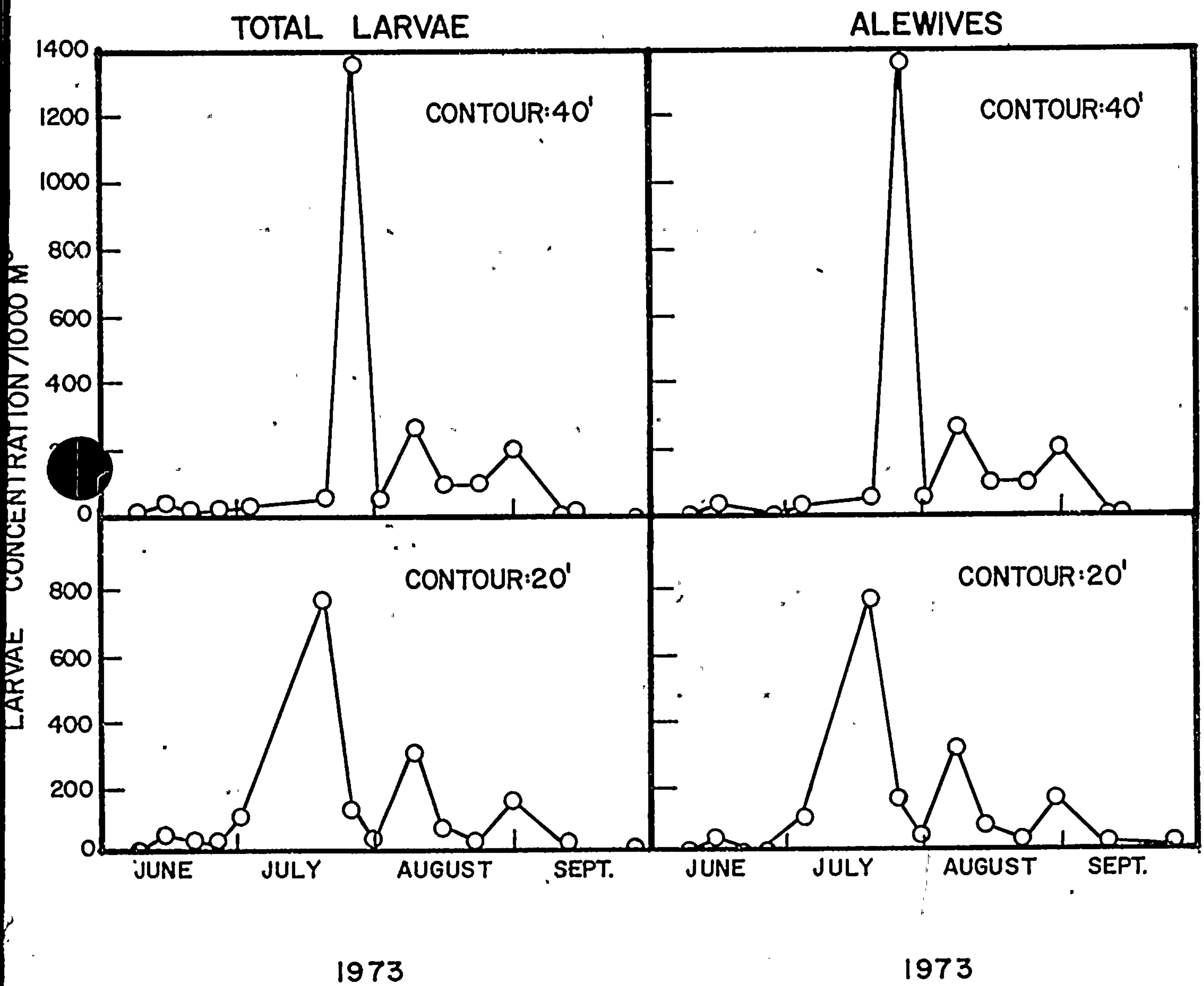
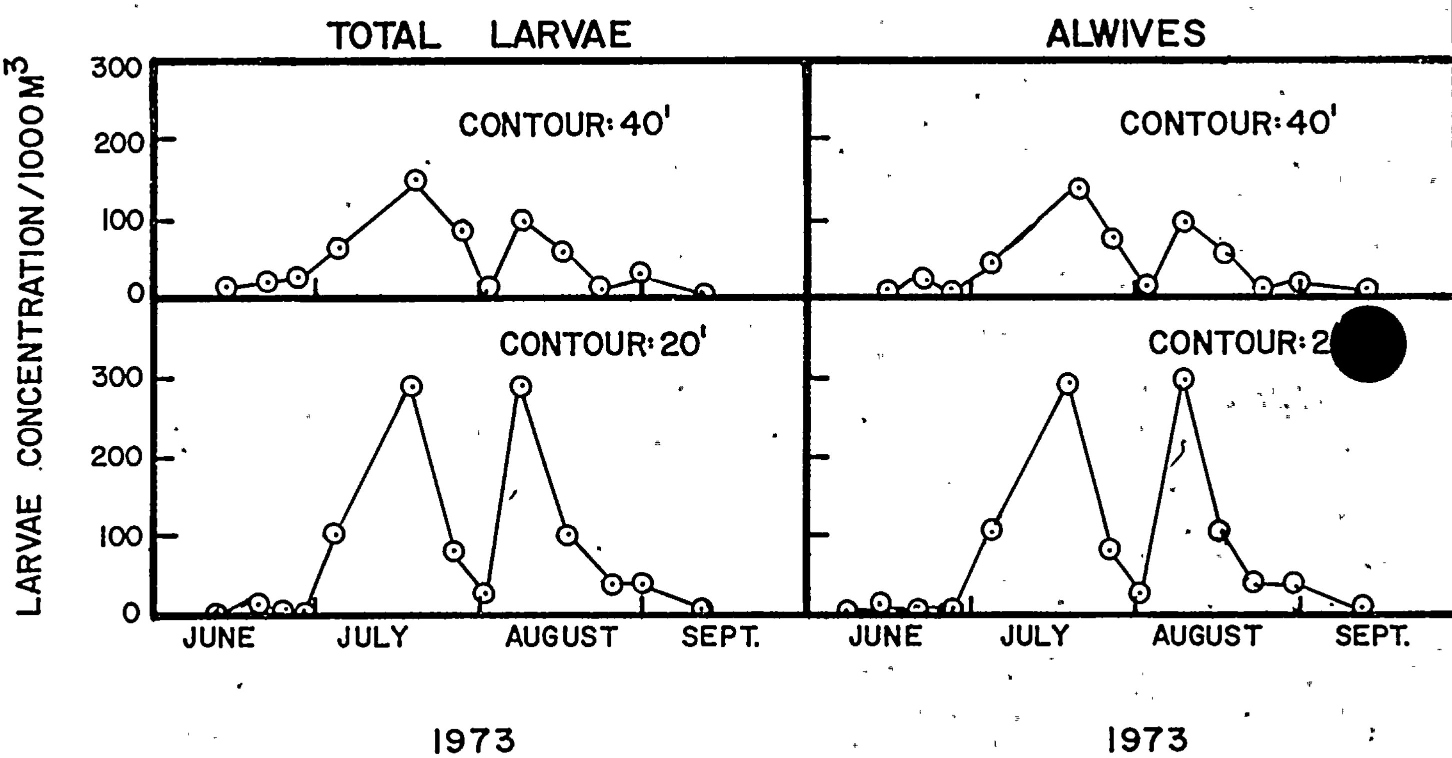


FIGURE I-46

LARVAE CONCENTRATION FOR 1973
NMPW-3 MILES



Alewife larvae were the most abundant of all fish larvae occurring in the Nine Mile Point vicinity during 1973 (see Figures I-40 through I-46). The general scheme of total larval occurrence at all stations shows low abundance of fish larvae during June, and slightly increased abundance during the first week in July. The largest concentrations of fish larvae occurred during the third week of July at all stations. Collections during the first week of August showed very low concentrations of larvae, while the next sampling date (second week of August) resulted in highly varied concentrations, ranging from low concentrations reflective of early July catches to higher concentrations equalling the peak concentrations found during the third week of July. Total larval concentrations collected thereafter were always less than 100 larvae/1000m^3 at all stations. Very few larvae were collected during September.

(ii) Abundance by Depth Contour

The results of a two-way ANOVA for the abundance of alewfie larvae among dates and stations for the west and east 20 ft. contour depths are presented in Appendix III-M (procedures for data analyses are presented in the Statistics section: Appendix II). There were no significant differences between abundance at 20 ft. depths when west and east transects were compared. Highly significant differences were shown for total abundance of alewife larvae over time. When total larval abundance

at the 20 ft. depths were compared in an identical two-way ANOVA, the results were identical to the results obtained for alewife larvae (see Appendix III-M).

Two-way analysis of variance (ANOVA) to test for significant differences in the abundance of larvae between dates and stations for the west and east 40 ft. contour depth were conducted for both alewife and total fish larvae (Appendix III-M). For both alewife larvae and total fish larvae, there were no significant differences between 40 ft. sampling sites; there were highly significant differences among dates. Although no statistically significant differences were found among the 20 ft. contour depths at the three radii for west and east stations, the numbers of larvae found at each contour during mid-July and mid-August peaks abundance vary widely (see Figures III-40 through III-46 and Appendix III-M)

Abundance of alewife larvae at the 40 ft. contour depths differed from abundances found at 20 ft. contours, although the abundance of total fish larvae always reflected alewife concentration. The total number of larvae captured during the second pulse of concentration (second week of August) was usually smaller than the abundance found in mid-July.

(iii) Abundance at Each Transect Between Contours

Further two-way ANOVA were conducted to determine possible differences in abundance between dates and contours at all six 20/40 ft. contour pairs at NMPW and at NMPE and for the three NMPP radii at the 60, 80,

and 100 ft. contours. The results for abundance of alewife larvae are presented in west to east transect configuration in Appendix III-M. The results of identical ANOVA tests using the abundance of total larvae are presented in Appendix III-M.

For both alewife larvae and total fish larvae there was no significant differences between the various contour stations analyzed. There were significant differences, however, among dates at all contour stations analyzed, except at the 1 mile NMPW transect between 20 and 40 ft. contours, where no statistically significant differences over time were detected for total fish larvae or for alewife larvae.

The range of alewife larvae at the three transects varied widely. At the NMPW 1/2 mile transect, there were approximately 1000 more total larvae/1000m^3 of water collected at the 40 ft. contour than were collected at the 20 ft. contour during July (Figure I-40). The converse of this pattern was noted for mid-July collections at the NMPW 1 mile contour. At the NMPW 3 mile contour peak concentrations of less than 300 total fish larvae/1000m^3 of water were noted throughout the sampling period at both contours.

Larvae concentrations for NMPP at the 60, 80, and 100 ft. contours varied synchronously at the three contours for both alewife larvae and total fish larvae (Figure I-43).

the NMPE 1/2 mile transect collections contained approximately 700 more total larvae/1000m^3 of water at the 40 ft. contour than at the 20 ft. contour, a condition in basic agreement with the results of the NMPW 1/2 mile transect collections during mid-July (Figure I-42 and I-44). At the 40 ft. contour of NMPE 1 mile transect, the pattern continued with approximately 600 more larvae/1000m^3 found than were collected during mid-July at the 20 ft. contours. The reverse pattern was noted at the NMPE 3 mile contour, a peak of approximately 1200 total larvae/1000m^3 of water at the 20 ft. contour being noted, with a peak of 400 larvae/1000m^3 of water at the 40 ft. contour.

c. Diurnal Migration

Further statistical analyses were conducted to detect any differences the day and night distribution patterns of alewife larvae and total fish larvae (see the statistics section for methods of analysis; Appendix II).

Homogeniety of variance was proven for the day/night pairs of data by using Bartlett's test; a paired t-test was then conducted. For both alewife and total larvae, there were significantly greater larvae concentrations in the surface night samples than in the surface samples collected during the day (Table I-22). For both mid-depth tows and bottom tows, the abundance of alewife larvae and total fish larvae was significantly greater in night samples than in day samples (Table I-22).

TABLE I-22

STATISTICAL ANALYSES OF DAY-NIGHT
ABUNDANCE FOR ALEWIFE AND TOTAL FISH LARVAE

A. SURFACE SAMPLES

all stations

GROUP	t-VALUE	DF
Alewife Larvae	-8.692	137
Total Larvae	-9.740	137

B. MID-DEPTH AND BOTTOM SAMPLE

selected stations

3-NMPP-100

GROUP	DEPTH	t-VALUE	DF	P-VALUE
Total Larvae	Bottom	-3.417	7	$.010 \leq p \leq .025$
Total Larvae	Mid-depth	-2.408	8	$.025 \leq p \leq .05$
Alewife Larvae	Bottom	-3.421	7	$.010 \leq p \leq .025$
Alewife Larvae	Mid-depth	-2.406	8	$.025 \leq p \leq .05$

For both mid-depth tows and bottom tows, the abundance of alewife larvae and total fish larvae was significantly greater in night samples than in day samples (Table I-22).

d. Species Other Than Alewives

Although the alewife (Alosa pseudoharengus) represented the preponderance of ichthyoplankton larvae collected in the Nine Mile Point vicinity during 1973, thirteen other genera representing seventeen species of ichthyoplankters were collected. These organisms are listed in Table I-21. Their infrequent occurrence in the samples collected precluded the application of statistical analysis techniques.

The occurrence of all species is listed in qualitative fashion in Table I-23. Larval johnny darter occurred in various samples collected from 20 June - 30 August. The pattern of johnny darter occurrence was approximated by that of carp, mottled sculpin and white perch larvae. Rainbow smelt occurred earlier in the sampling period than any other species (7 May) and larvae were collected during all the remaining months of the year. All other species of larval fish occurred during only one or two collecting dates, with the exception of pumpkinseed larvae which were collected between 4 July and 8 August.

e. Length-Frequency

The results of all length-frequency measurements made on selected species are presented in Appendix III-L. These results include length-frequency data on

TABLE I-23

NINE MILE POINT

LARVAE SPECIES OCCURRENCE

1973

DATE	AW	JD	CP	MTSC	WP	RSM	YP	WB	WS	STSH	CSH	GF	EMSH	NOSP	LP	PS	LESP	TSB
3-9																		
4-26																		
5-7						X												
5-16						X	X											
6-1						X												
6-8						X		(X)	(X)									
6-14	X			X	X	X	X	(X)	(X)									
6-20/21	X	X	X	X	X	X				(X)	X	X	(X)	X	(X)			
6-26	X	X	X	X	X	X												
7-4	X	X	X	X	X						X					X		
7-18	X	X	X	X	X													
7-25	X	X	X	X	X	X										X		
8-1	X		X		X											X	X	
8-8	X					X										X		
8-15	X	X		X	X	X												
8-22	X				X	X												
8-30	X	X		X		X				(X)								
9-5	X																	
9-12	X			X														
9-19	X					X												
9-26						X												
10-3	X		X															
10-10						X												
10-19																		(X)
10-26	X																	
10-31																		
11-15																		
11-18													(X)					(X)
11-21																		
11-28						X												
12-5						X												
12-12	X					X												

the larvae of alewives, johnny darters, carp, mottled sculpins, white perch, rainbow smelt, white bass, and common shiners (see Table I-24). Although larvae larger than 14mm in total length were noted in the data records, only records of alewife larvae in the 2-14mm size range were used for graphing (Figures I-47, I-48, and I-49). Because of the paucity of larvae of other species of fish in the samples, length-frequency data are presented only for alewives. Since vertical distribution of fish larvae was not of immediate concern in length-frequency graphs, total numbers of larvae found at all collections for each radius from each data were grouped to provide a larger sample size for each sampling date.

(i) NMPW

Although small numbers (maximum = 11) of alewife larvae occurred in samples used for length-frequency measurements during June at the ½, 1, and 3 mile radii, it was not until July that any of the samples examined contained over 100 alewife larvae (refer to Figures I-47 through I-49). At each radius on the 4 July sampling date, the larvae analyzed were generally in the 3-5mm category. On 18-19 July, the vast majority of the larvae were grouped into the 2-3mm category, a general decrease in the larger sizes being found for the 5-14mm category. On 25-26 July, the majority of larvae collected at the three radii were in the 5-9mm range; the majority of alewife larvae were in

TABLE I-24

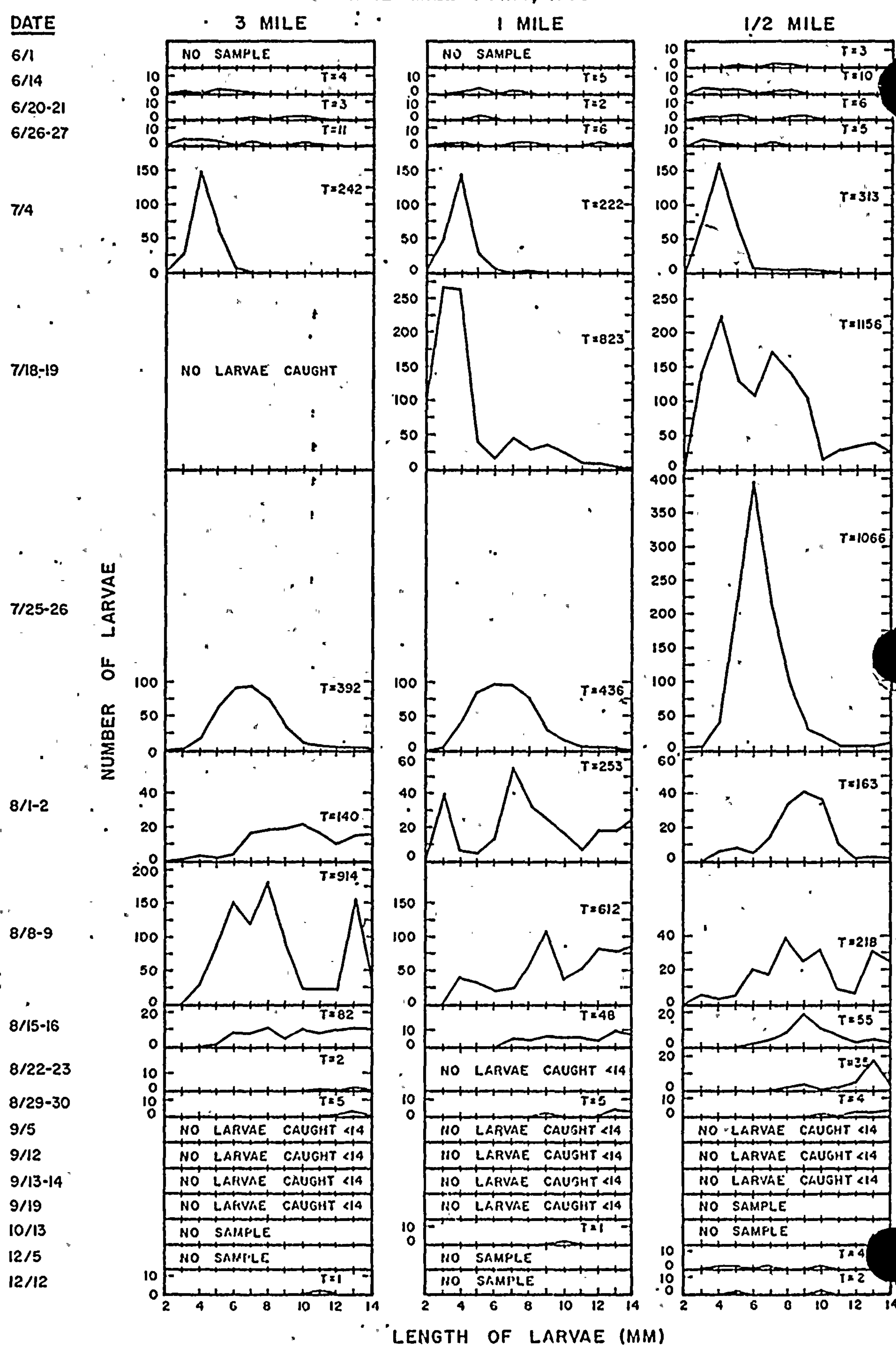
NINE MILE POINT LARVAE TOTALS BY LENGTH INTERVAL (mm)

DATE	2	3	4	5	6	7	8	9	10	11	12	13	14	other	total
5/7	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
5/16	0	0	2	7	1	1	0	0	0	0	0	0	0	0	11
6/1	0	0	0	2	1	2	1	0	0	0	0	0	0	0	6
6/8	0	0	3	2	4	2	0	0	0	0	0	0	0	0	11
6/14	1	34	20	13	7	6	6	0	0	0	0	0	0	0	87
6/20&21	0	10	18	68	8	7	24	28	23	5	1	0	1	3	196
6/26&27	86	43	27	72	31	13	10	1	12	6	19	8	1	19	348
7/4	6	353	880	411	68	116	101	41	30	50	43	11	17	82	2209
7/18&19	100	640	5358	1025	709	908	777	862	531	272	284	137	97	1223	12923
7/25&26	1	98	643	2189	2305	1339	824	522	355	198	128	102	94	375	9173
8/1&2	3	64	97	55	96	214	199	274	197	69	92	107	98	1878	3443
8/8&9	0	9	107	165	327	447	669	565	272	281	254	587	363	3103	7149
8/15&16	0	0	0	2	16	33	45	80	63	43	53	45	38	883	1301
8/22&23	0	0	0	0	0	1	4	10	21	21	26	94	72	590	839
8/29&30	0	0	0	0	0	0	0	1	2	1	12	32	16	935	999
9/5	0	0	0	0	0	0	0	0	0	0	0	0	0	9	9
9/12,13 &14	0	0	0	0	0	0	0	0	0	0	0	0	0	57	57
9/19	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7
9/26	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
10/3	0	0	0	0	1	0	0	0	1	0	0	0	0	0	2
10/10	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
10/26	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
11/28	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
12/5	0	0	1	1	1	1	0	0	1	0	0	0	0	4	9
12/12	0	0	2	1	0	0	0	0	1	1	0	0	0	2	7

Figure I-47

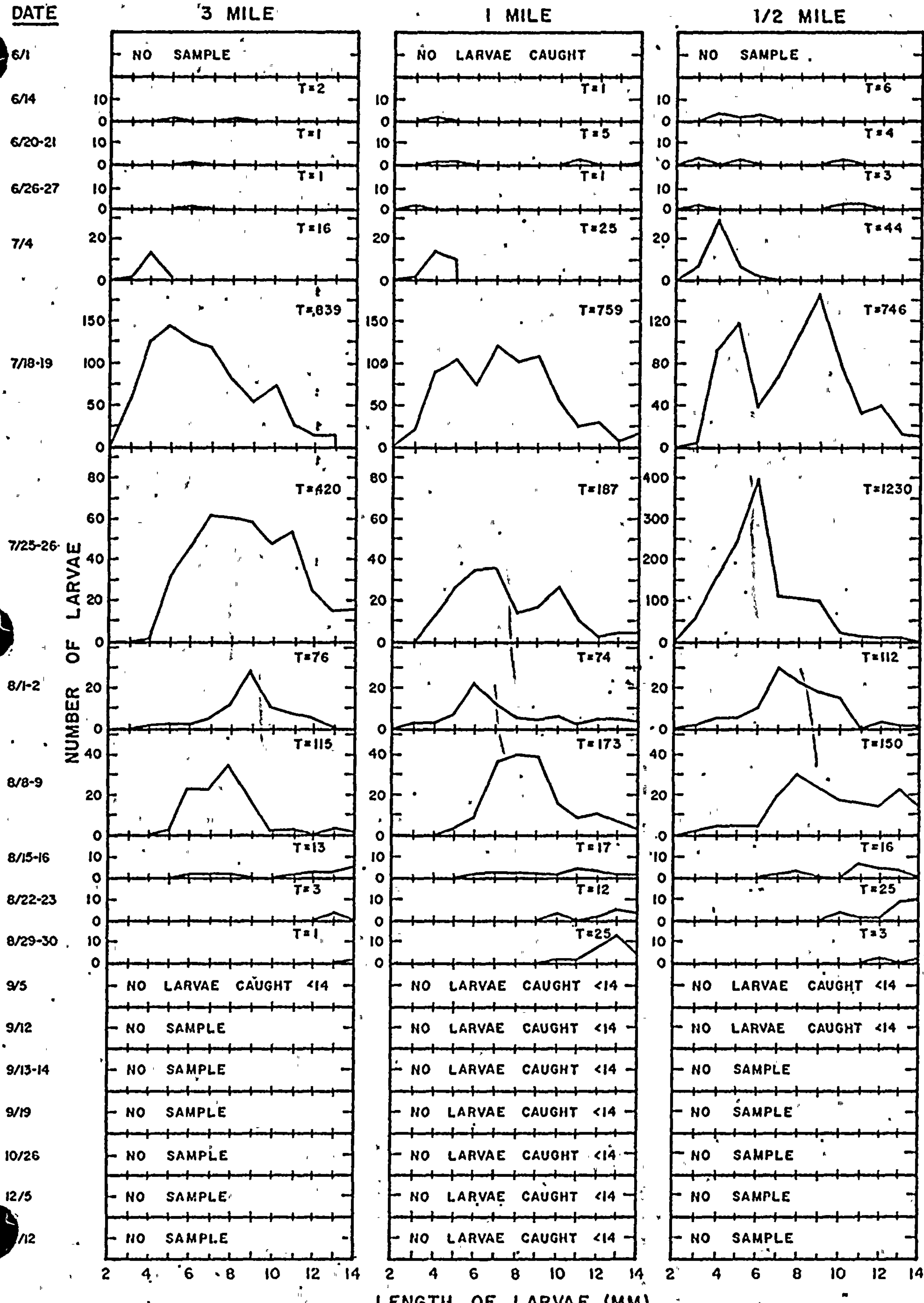
ALEWIFE LARVAE LENGTH-FREQUENCY AT NMPW TRANSECTS

NINE MILE POINT, 1973

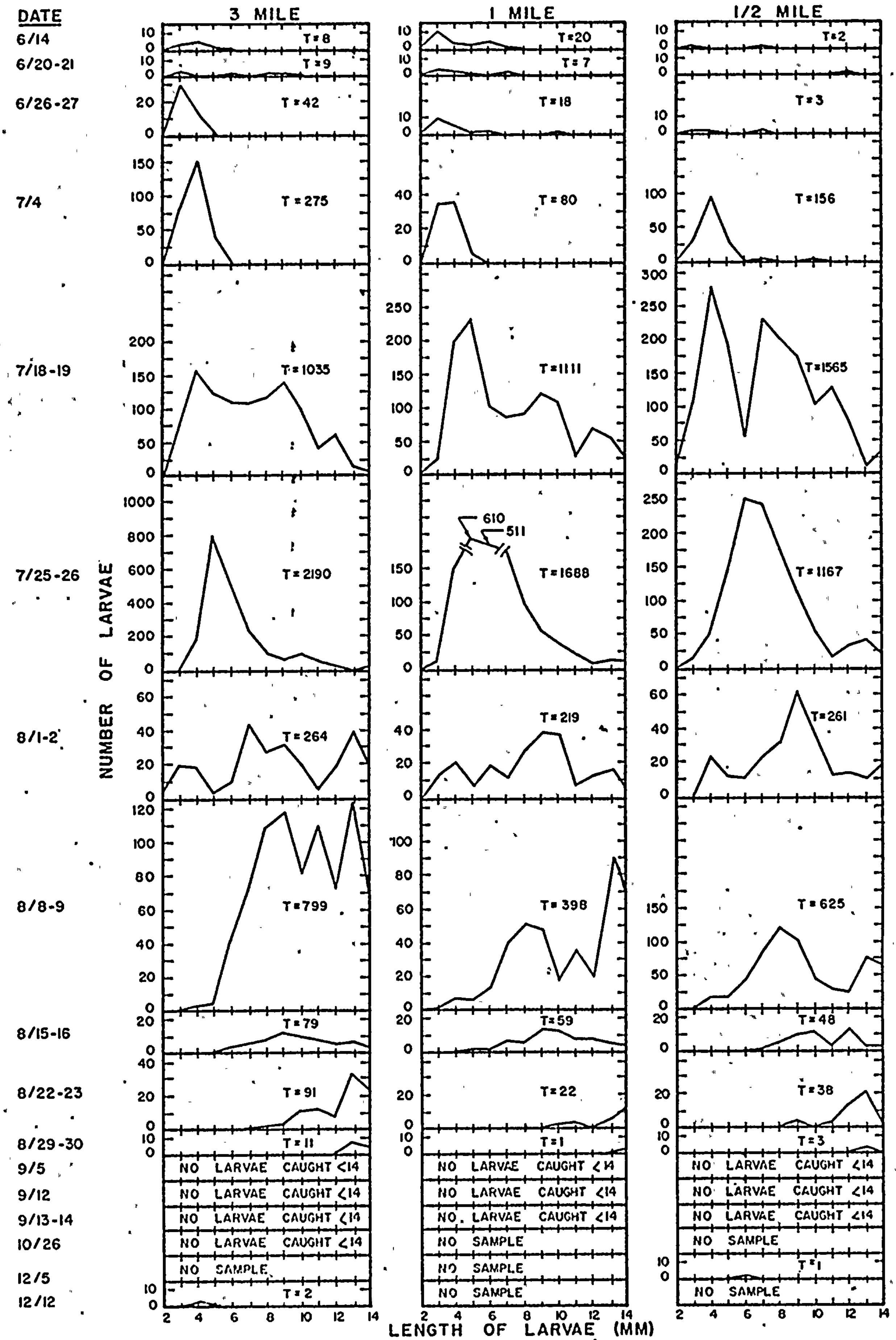


ALEWIFE LARVAE LENGTH-FREQUENCY AT NMPP TRANSECTS

NINE MILE POINT, 1973



ALEWIFE LARVAE LENGTH-FREQUENCY AT NMPE TRANSECTS
NINE MILE POINT, 1973



the 5-11mm size range on 1-2 August.

Although alewife larvae sizes ranged from 2-14mm on the 8-9 August sampling date, only 5mm or larger larvae were collected on 15-16 August. Only larvae of the 8mm size or larger were collected at the three radii on 22-23 August or thereafter; several alewife larvae were collected at the ½ mile radius during December. They ranged in length from 4-10mm.

(ii) NMPP

Length-frequency data for alewife larvae from the three radii at Nine Mile Point sampling stations generally reflect the season distribution of the west transect. Although few alewife larvae occurred before July, their lengths ranged from 2-14mm.

(iii) NMPE

The length-frequency trends found at the NMPW and NMPP radii were also found at the NMPE transect.

6. DISCUSSION OF ICHTHYOPLANKTON RESULTS

a. General

The data presented in Figure I-40 reflect a spawning season for fish in the vicinity of Nine Mile Point which lasts from approximately May through August. The collections which yielded the most species of fish larvae were made between 14 June and 25 July, inclusive. The preponderance of larvae collected were alewife larvae, and their comparatively large numbers effectively masked the importance to the ecosystem of other species of ichthyoplankters. The length-frequency data (Appendix III-M) for alewife larvae show a prolonged spawning period from mid-June through approximately the middle of July. It is possible that alewives belonging to different subpopulations within the Lake would have slightly different periods of intense spawning effecting a seemingly prolonged spawning period for the entire population. The bimodal distributions of lengths of larvae noted especially in the 1-2 August collections is a reflection of this possibility. Furthermore, although a general trend of larval development can be deduced from the length-frequency data, prolonged juvescence of some of the larvae, especially in the absence of large numbers of predators, would tend to indicate a longer spawning period than actually existed.

The non-homogeneous distribution of plankton populations (patchiness) has long been a problem when standing stock measurements are being investigated. It is

important that in the range of comparisons of abundance between contours and transects there were no statistically significant differences in the numbers of fish larvae collected on a particular date. The statistically significant differences found were due to dates of collection and were to be expected because of the large variations in numbers of larvae between sampling dates. Therefore, the patchiness of larval distribution seems of less importance, because of the results of statistical comparisons conducted between contours and transects. It may be inferred that the baseline data concerning ichthyoplankters in the vicinity of Nine Mile Point will be highly suitable for comparison with the data being collected during 1974.

The diurnal differences in larval distribution were not unexpected. A number of authors, such as Croker (1965), have demonstrated the general preference of ichthyoplankters for bottom waters during the day and surface waters during the night. The most common explanation of this phenomenon involves the higher numbers of food organisms (microzooplankton and macrozooplankton) in the upper reaches of the water column at night (see Macrozooplankton Section) and the need of protection through lower visibility in the bottom waters during the day.

b. Trophic Interactions

The trends of the trophodynamic structure within the plankton population of the Nine Mile Point area are complex and cannot be defined by reliance on

baseline data collected for one year. The general trends have been approximated, however, and are shown in graphic form in Figure I-47.

(i) The rise in temperature during the spring and early summer stimulated phytoplankton growth; secondary production through the rapid rate of cladoceran and copepod population was evident.

(ii) Herbivore production was paralleled by the increase in the carnivorous Leptodora and copepod populations.

(iii) When the production of phytoplankton was limited by dissolved inorganic nutrients during mid-summer, secondary production of herbivores was reduced concomitantly through predation by Leptodora, fish larvae, and carnivorous copepods.

(iv) The late summer - early fall phytoplankton bloom was made possible by the beginning of the fall turnover which provided dissolved inorganic nitrogen (see Water Quality chapter) and by temporarily decreased grazing pressure from the smaller herbivorous zooplankters.

(v) Both primary and secondary production increased during the fall from summer minima.

7. ICHTHYOPLANKTON CONCLUSIONS

The data revealed that the ichthyoplankton population collected during the 1973 sampling program was always dominated by alewives. Baseline conditions for the alewife population in terms of concentration per unit volume of water and length-frequency were presented. The effects of the Nine Mile Point Unit 1 on the ichthyoplankton community cannot be determined at this time.

E. ENTRAINED PLANKTON

1. INTRODUCTION

Aquatic organisms unable to swim out of intake water flow and small enough to pass through travelling screen mesh are liable to entrainment through power plants. In general, any organism smaller than approximately 25mm in two dimensions may be entrained; phytoplankton, microzooplankton, macrozooplankton, and ichthyoplankton, will be susceptible to the effects of passage through a power plant.

The possible effects associated with passage include:

1. no discernable effect,
2. short-term stimulation of metabolic rates,
3. short-term physiological or morphological damage,
4. long-term physiological or morphological damage, or
5. death.

A number of recent studies have established the type and extent of some entrainment effects on various numbers of the plankton community. Storr (1972) studied the possible effects of entrainment on phytoplankton by comparing the mortality of flagellated forms, while Morgan and Stross (1969) and Lauer et al. (1972) studied these effects through a comparison of primary productivity measurements in power plant intake and discharge waters. Four basic effects due to entrainment were noted:

1. Mortality approaching one-third of the entrained population numbers,
2. Short-term stimulation of primary production,
3. Short-term inhibition of primary production, and
4. No discernable effects.

Although the negative effects usually occurred when temperatures were at the summer maximum, the information available in the literature is not sufficient to predict the effects on the phytoplankton population at any given power plant.

Through a combination of laboratory and field studies, Cairns (1969) found that protozoan standing stocks were reduced by severe temperature changes ($\Delta T = 15 - 30^{\circ}C$) experienced over a period of 10 minutes. Due to rapid reproductive rates, protozoan numbers recovered to pre-thermal shock levels of abundance within a few days.

Studies of the thermal tolerance of the copepods *Acartia tonsa* and *Eurytemora affinis* (Heinle, 1969) indicated that a direct relationship may exist between mortality and entrainment temperature shock; regardless of the baseline temperature, mortality occurred when the organism was subjected to temperatures above its optimum for 15 minutes (Heinle, 1969). In another study, Lauer *et al.* (1972) suggested that a temperature increase (ΔT) of $15^{\circ}F$ during entrainment could cause heavy mortality of calanoid copepods when the ambient temperature was near $80^{\circ}F$. Storr (1973) found greater mortality in entrained populations of protozoans than in populations of copepods and cladocerans during the summer in Lake Ontario.

There are few data concerning the effects of entrainment on macrozooplankters. Lauer et al. (1972) reported that median lethal tolerance limits of selected macrozooplankters (*Gammarus sp.*, *Neomysis american*, and *Monoculoides edwardsi*) ranged between 34° and 39°C with a five minute exposure time. Lauer's study also indicated that the early stages of fish larvae (yolk sac larvae) were more susceptible to entrainment mortality than were the later stages; no data concerning alewife larvae, which are the most abundant ichthyoplankters in Lake Ontario, were reported.

These summaries indicate that a major cause of death due to entrainment was elevated temperature. Almost no quantitative information is available concerning the effects of the mechanical forces of entrainment on plankton population. Difficulties in obtaining comparable, undamaged samples of intake and discharge abundance during field studies have precluded the possibility of making conclusions. Other investigative difficulties have included determination of live, dead, and stunned organisms in entrainment samples and, in studies of the long-term effects of entrainment, assurance that the populations collected are representative of natural post-entrainment populations. Methods and materials used during the 1973 study by QL&M at Nine Mile Point are included in Appendix I-H.

2. RESULTS

a. Entrained Phytoplankton

(i) Biomass

Chlorophyll *a* concentrations at the power plant intake were of the same magnitude as chlorophyll *a* concentrations in the Lake during the same time period (see Table I-25; Figure I-50; Figure I-26, Phytoplankton Results Section). The trend of chlorophyll *a* concentration over time at the plant intake was similar to trends at the NMPP transect. The differences noted between the Lake and intake chlorophyll *a* concentrations may have been due to differences in the depth from which the samples were taken (Lake = surface samples; intake = mid-water samples) as well as to patchiness (see also Phytoplankton Discussion).

A comparison of intake and discharge concentrations (see Figure I-50 and Table I-25) shows that the concentration of chlorophyll *a* in the discharge was greater than or equal to the concentration in intake waters on five of the seven dates used for comparison.

(ii) Physiological Condition

Primary production as estimated by oxygen evolution was used as an indicator of the physiological state of entrained phytoplankton populations on three sampling dates. Net primary productivity and gross

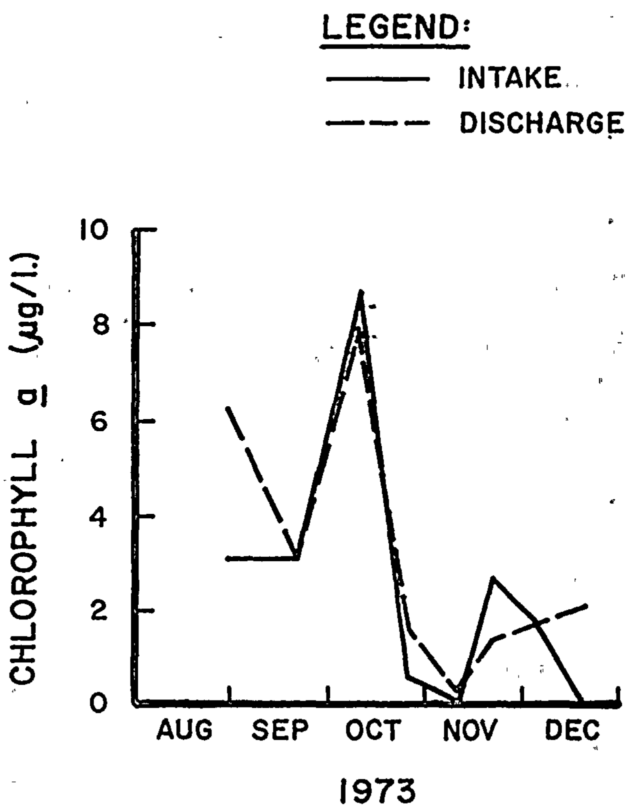
TABLE I-25

CHLOROPHYLL a at NINE MILE POINT, 1973

Plant Site

Date	Chlorophyll a (mg/liter) Intake	Discharge
31 AUG	3.1	6.2
20 SEP	3.1	3.1
10 OCT	8.7	8.2
25 OCT	0.6	1.6
7 NOV	0	0.3
21 NOV	2.7	1.4
5 DEC	1.7	---
19 Dec	0	2.1

PHYTOPLANKTON CHLOROPHYLL a IN INTAKE & DISCHARGE SAMPLES AT NINE MILE POINT NUCLEAR STATION



primary productivity in discharge samples were approximately 50% of productivity levels in intake samples on all collection dates; community respiration was higher in discharge collections than in intake collections on two of the three collection dates (see Table I-26)

Net primary production ranged between 16.9 and 184.6mgC/m^3/6 hrs.; the decreasing trend of primary productivity from September through October paralleled a decrease in surface phytoplankton populations (see Phytoplankton Results section).

b. Entrained Microzooplankton

(i) Abundance

The complete results of the numbers of entrained microzooplankters are included as Appendix III-N; the data for the most abundant microzooplankters (rotifers, cladocerans, copepod adults, and copepod nauplii) and for total microzooplankton are presented in Figures I-51 to I-53.

The greatest numbers of entrained microzooplankters (between 5×10^5 and 1×10^6 organisms/m^3) were found during the month of September (Figure I-51). Populations increased from less than 6×10^4 organisms/m^3 in early July to the September maximum and decreased from September to December. Abundance in December was of the same magnitude as July. The seasonal trend in microzooplankton abundance

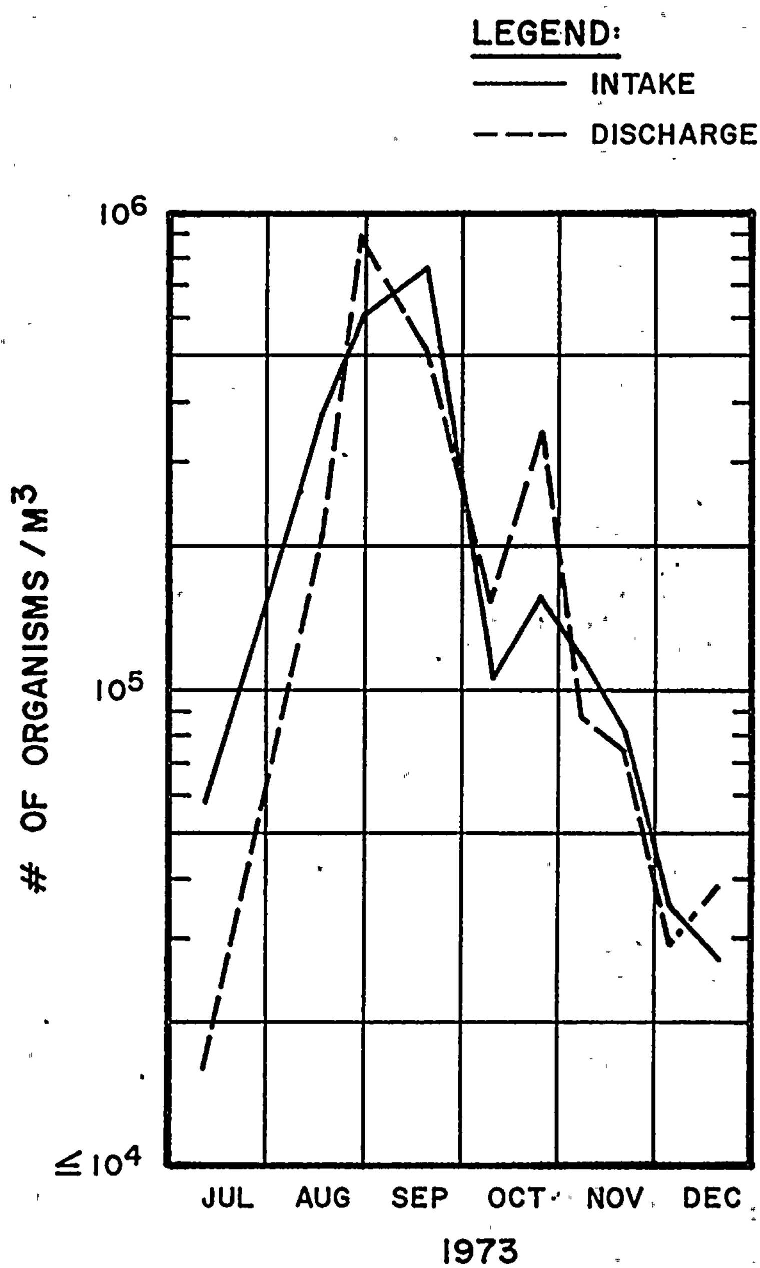
TABLE 26

PHYTOPLANKTON PHYSIOLOGICAL CONDITION

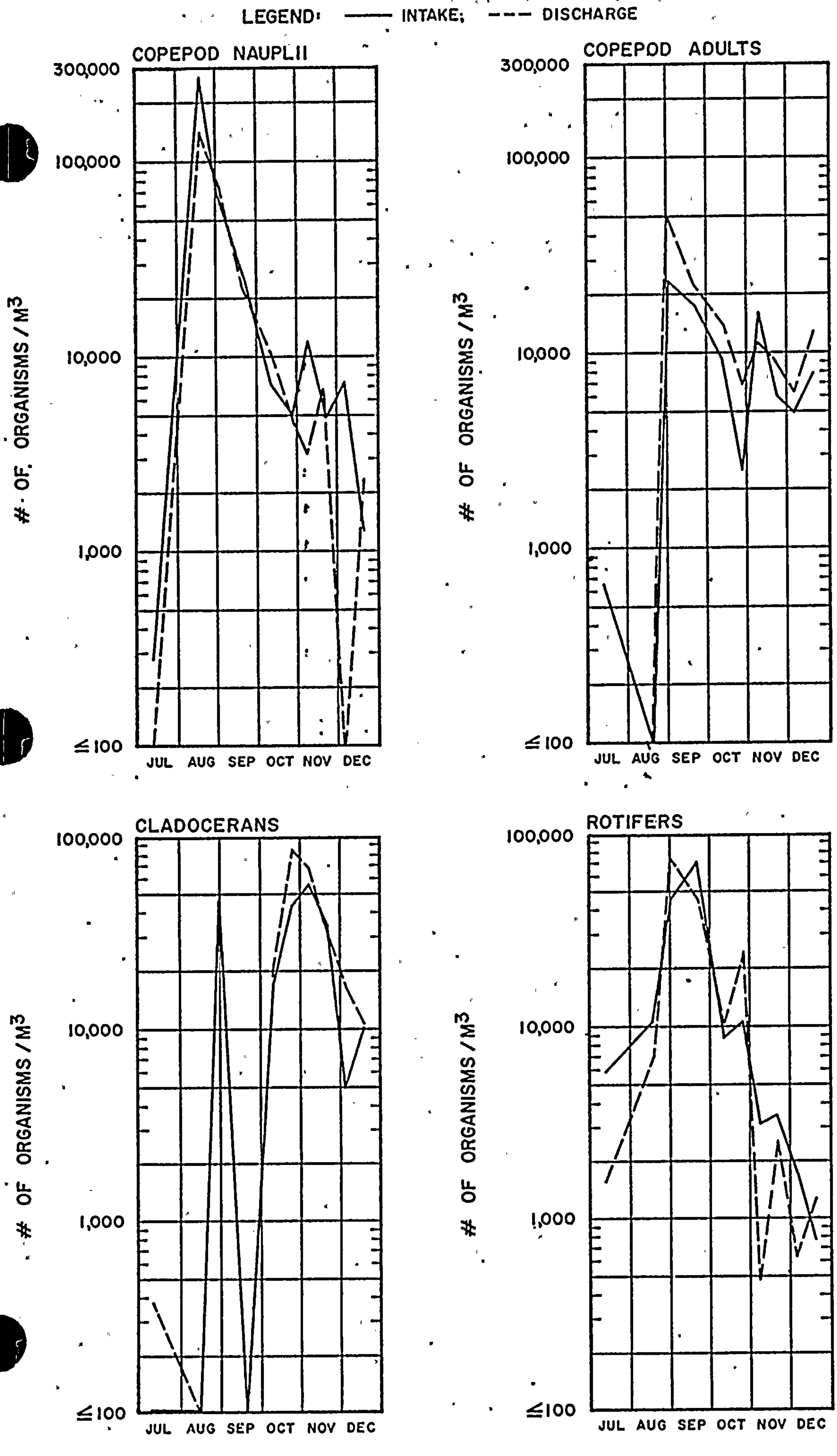
Date	Location	Community Respiration ($mgC/m^3/6$ hrs.)	mean	Gross Primary Productivity ($mgC/m^3/6$ hrs.)	mean	Net Primary Productivity ($mgC/m^3/6$ hrs.)	mean
9-20-73	Intake	48.8	48.8	237.7	233.0	188.9	184.2
	Intake R	48.8		228.3		179.5	
	Discharge	75.1	50.7	156.4	136.1	81.3	85.4
	Discharge R	26.3		115.7		89.4	
10-10-73	Intake	15.0	18.8	178.3	203.3	163.3	184.6
	Intake R	22.5		228.3		205.8	
	Discharge	-11.3	-13.2	93.8	98.5	105.1	111.7
	Discharge R	-15.0		103.2		118.2	
10-25-73	Intake	52.6	45.1	84.5	84.5	31.9	39.5
	Intake R	37.5		84.5		47.0	
	Discharge	48.8	60.1	53.2	47.0	4.4	16.9
	Discharge R	11.3		40.7		29.4	

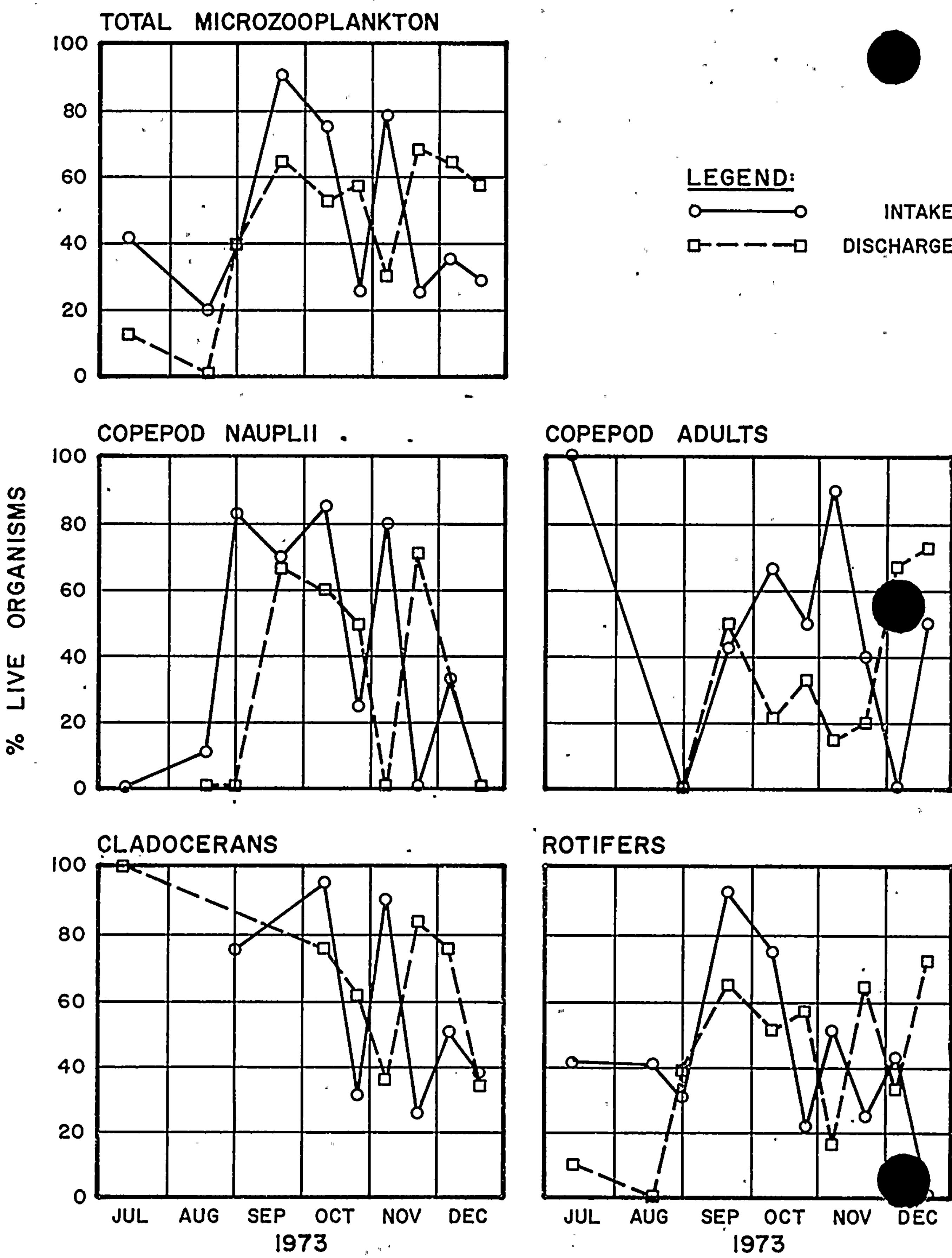
FIGURE I-51

TOTAL MACROZOOPLANKTON ABUNDANCE



ENTRAINED MICROZOOPLANKTON




TOTAL MICROZOOPLANKTON
COPEPOD NAUPLII
COPEPOD ADULTS
CLADOCERANS
ROTIFERS
% LIVE ORGANISMS
100
80
60
40
20
0
LEGEND:
INTAKE
DISCHARGE
JUL AUG SEP OCT NOV DEC
1973

reflects seasonal trends in abundance of rotifers and copepod nauplii (Figure I-52). The seasonal trends in abundance for copepod adults and cladocerans (Figure I-52) were somewhat different from the trends observed for rotifers and copepod nauplii; a depression of the number of cladocerans and adult copepods was noted during mid-August. A second depression of cladoceran numbers was noted during late September.

Microzooplankton abundance in discharge waters was higher than macrozooplankton abundance in intake waters on at least four of the ten sampling dates (Figure I-52). Within the total microzooplankton population, there were fewer organisms per unit of discharge water than per unit of intake water on six of the ten sampling dates; the same trend was found for rotifer and the naupliar stages of copepods. The abundance of cladocerans per unit volume of intake water was higher than their abundance per unit of discharge water on four of the ten sampling dates, whereas copepod adults were more abundant in intake water on only two of the ten sampling dates.

(ii) Viability

Figure I-53 shows the percentage of rotifers, cladocerans, copepod adults, copepod nauplii and total microzooplankton found alive in intake and in discharge waters. There were lower percentages of living microzooplankters in discharge waters than in intake waters during the summer and fall; the reverse was true during early winter. This seasonal pattern was similar for the four most abundant taxonomic groups within the microzooplankton population.

(iii) Statistical Analyses

Comparisons of microzooplankton abundance between intake and discharge waters showed that there were no significant differences for rotifers, claodcerans, copepod adults, copepod nauplii, and total microzooplankton. There were significant differences in the numbers of entrained microzooplankters between dates (Table I-27).

With the exception of the 19 December collection of copepod nauplii the percentage of live microzooplankters in intake waters and discharge waters on each collection date showed significant differences on all dates for the four most abundant groups and the total microzooplankton (Table I-28). Live organisms were more abundant in the intake than in the discharge throughout the summer and early fall. Tests confirmed that the percentage of living microzooplankters in discharge waters was higher in the fall and early winter than in the summer.

c. Entrained Macrozooplankton

(i) Abundance

The data presented herein are based on the most abundant taxonomic groups in day samples; the data for all organisms in both day and night samples are presented in Appendix III-O.

The abundance of Leptodora in intake and discharge waters (Figure I-54) showed that the general trend of this group over time was similar to

TABLE I-27

Analysis of Variance for Entrained Microzooplankton

Nine Mile Point, 1973

Group	Source	d.f.	ss	ms	F-ratio
Rotifers	Intake/Discharge	1	0.107	0.107	1.486
	Dates	9	8.043	0.894	12.417*
	Error	9	0.648	0.072	
	Total	19	8.797		
Cladocerans	Intake/Discharge	1	0.064	0.064	0.040
	Dates	9	67.457	7.495	4.702*
	Error	9	14.343	1.594	
	Total	19	81.864		
Copepod Adults	Intake/Discharge	1	0.100	0.100	0.219
	Dates	9	38.648	4.294	9.396*
	Error	9	4.110	0.457	
	Total	19	42.858		
Copepod Nauplii	Intake/Discharge	1	2.286	2.286	2.422
	Dates	9	27.480	3.053	3.234*
	Error	9	8.497	0.944	
	Total	19	38.264		
Total Microzooplankton	Intake/Discharge	1	0.009	0.009	0.265
	Date	9	4.741	0.527	15.500*
	Error	9	0.309	0.034	
	Total	19	5.059		

*Significant difference among source of variance.

Critical F-values: $F_{1,9} = 5.12$; $F_{9,9} = 3.18$

TABLE I-28

Test of the Equality of Percentage of Live Microzooplankters

between Intake and Discharge Samples

at Nine Mile Point, 1973

Dates	Rotifers ts	Cladocerans ts	Copepod Adults ts	Copepod Nauplii ts	Total Microzoo. ts
11 JUL 1973	83.36	--	--	--	77.63
17 AUG 1973	287.03	--	--	207.41	336.38
31 AUG 1973	-84.15	--	0	438.95	11.01
20 SEP 1973	387.47	--	-14.12	7.50	371.78
10 OCT 1973	111.559	54.40	71.67	38.86	121.57
25 OCT 1973	-201.33	-103.09	14.68	-25.85	-221.33
7 NOV 1973	48.68	218.63	139.82	111.31	229.39
21 NOV 1973	-98.22	-164.49	26.75	-105.90	-177.92
5 DEC 1973	13.48	-32.50	-100.92	--	-73.33
19 DEC 1973	-141.12	6.36	-32.87	0	-74.43

-- = no paired data available

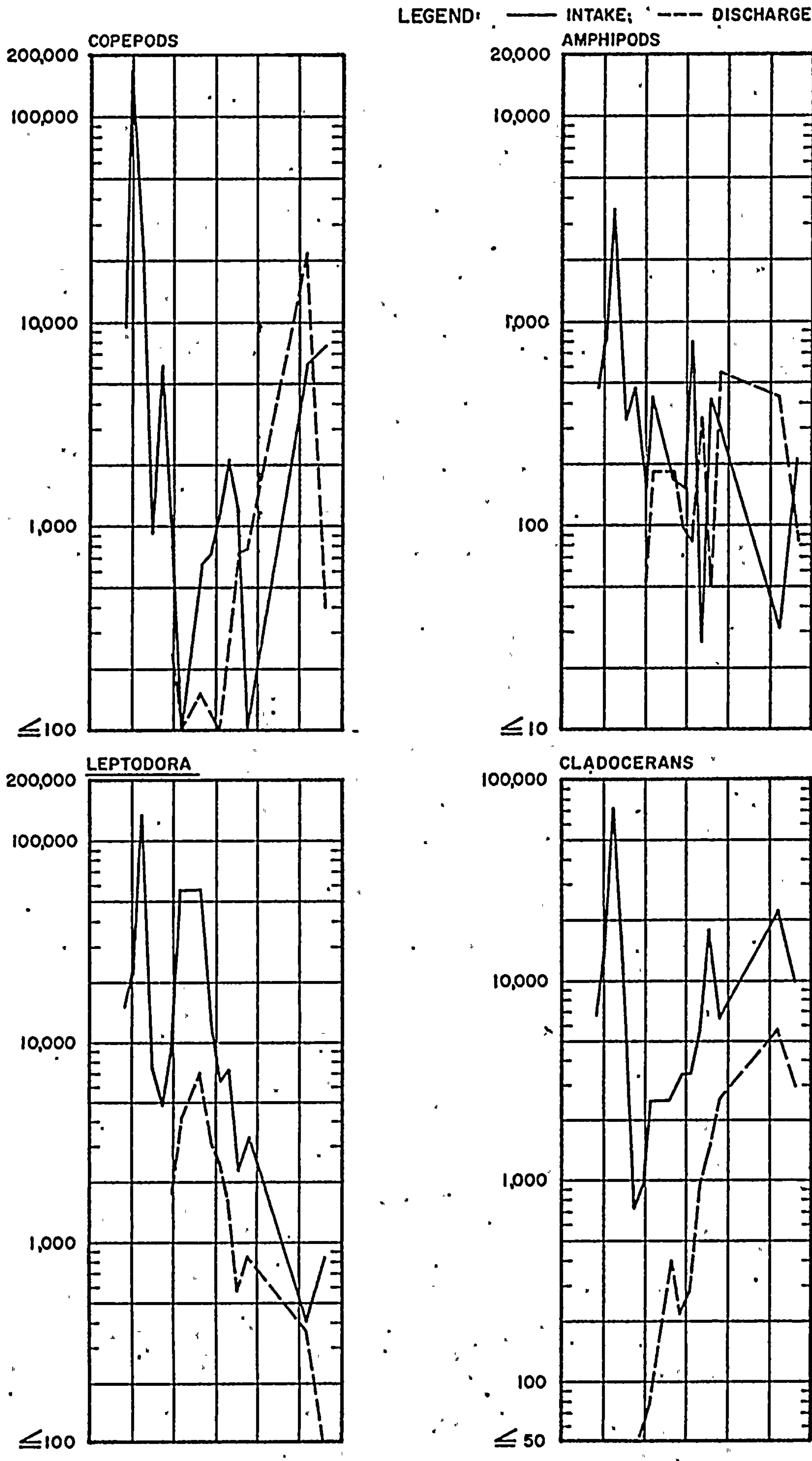
Critical t = 1.96

Positive ts = intake higher than discharge

Negative ts = discharge higher than intake

Figure I-54

ENTRAINED MACROZOOPLANKTON



the seasonal trend of the Lake population showing maximum abundance in late summer followed by a decrease to December (see Macrozooplankton Results section).

Leptodora abundance in discharge waters was always lower than its abundance in intake waters; the differences between intake and discharge abundance were random.

Cladoceran populations (exclusive of Leptodora) in the intake and discharge also reflected trends in abundance of Lake populations (see Figure I-54). The differences in cladoceran abundance between intake and discharge waters, however, followed a seasonal trend of decreasing disparity in numbers/1000m^3. Discharge abundance was approximately 1% of intake abundance in late August, and approximately 30% of intake abundance in mid-December.

The high magnitude oscillations in abundance noted in Lake populations of copepods (see Macrozooplankton Results section) were also apparent in entrained copepod abundance were most similar to the trends in copepod abundance at 1/2 - NMPW - 20 ft. Copepod abundance in discharge samples was higher than abundance in intake samples on two of the ten sampling dates; no pattern was discernible in the differences between intake and discharge abundance.

The same trend was evident for entrained amphipods (see Figure I-54), but amphipod abundance in discharge samples was higher than abundance in intake samples on four of the ten sampling dates.

The total macrozooplankton populations reflected the combined entrainment patterns of the four major taxonomic groups, and, since Leptodora and cladocerans were by far the most abundant groups, the abundance of total macrozooplankton in discharge samples was less than that in intake samples (Figure I-55). As with entrained Leptodora and copepods, there seemed to be no discernible pattern to the differences between intake and discharge abundance.

(ii) Statistical Analysis

Analysis of macrozooplankton abundance showed significant differences in abundance between intake and discharge for Leptodora, cladocerans, and total macrozooplankton. In all cases abundance was greater in intake samples than in discharge samples. Significant differences in abundance between stations were found for Leptodora, cladocerans, and total macrozooplankton. Significant differences between dates were found for Leptodora, cladocerans, and copepods (Table I-29).

d. Entrained Ichthyoplankton

(i) Abundance

The data in this section cover only the time periods when fish larvae and fish eggs were abundant in entrainment samples. The data for the entire sampling program is presented in Appendix III-P.

Fish larvae, primarily alewives, occurred in entrainment samples from late August to early September. The abundance of larvae in discharge

TOTAL MACROZOOPLANKTON (DAY)

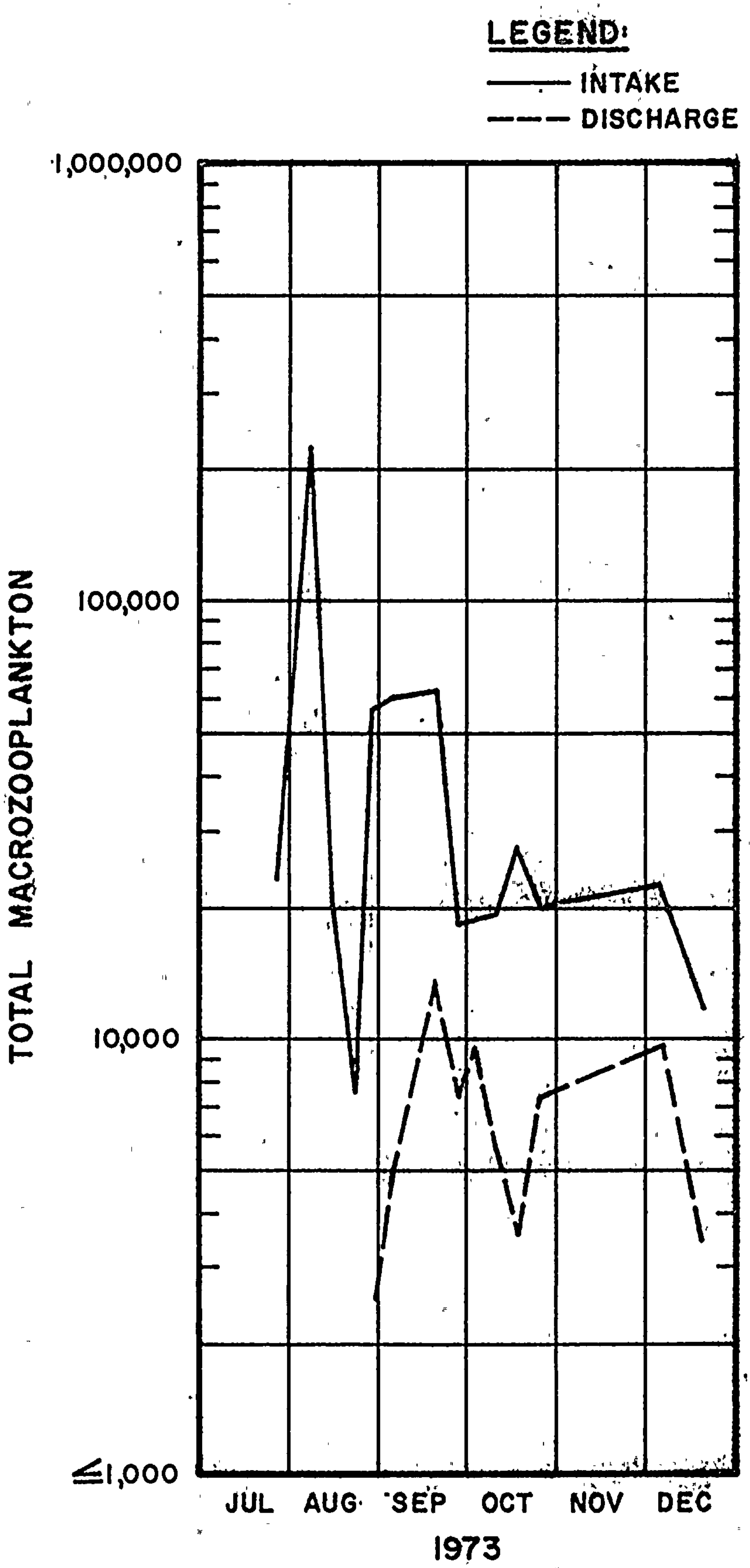


TABLE I- 29

Analysis of Variance for Entrained Macrozooplankton

Nine Mile Point, 1973

Group	Source	d.f.	ss	ms	F-ratio
Leptodora	Intake/Discharge	1	2.293	2.293	143.313*
	Date	11	6.490	0.590	36.875*
	Error	11	0.171	0.016	
	Total	23	8.953		
Cladocerans	Intake/Discharge	1	2.831	2.831	37.25*
	Date	11	7.482	0.680	8.947*
	Error	11	0.834	0.076	
	Total	23	11.147		
Copepods	Intake/Discharge	1	0.840	0.840	2.064
	Date	11	15.709	1.428	3.509*
	Error	11	4.479	0.407	
	Total	23	21.029		
Amphipods	Intake/Discharge	1	0.012	0.012	0.059
	Date	11	2.038	0.185	0.916
	Error	11	2.222	0.202	
	Total	23	4.271		
Total Macrozoo.	Intake/Discharge	1	1.458	1.458	31.021*
	Date	11	0.621	0.056	1.191
	Error	11	0.512	0.047	
	Total	23	2.592		

*Significant difference within source of variance at $\alpha = 0.05$

Critical F - values: $F_{1, 11} = 4.84$; $F_{11, 11} = 2.82$

waters was greater than in intake waters on three of the five sampling dates (Figure I-56).

Entrained fish eggs were found earlier in the study than were fish larvae (Figure I-56). Too few eggs occurred in the samples to characterize any difference in abundance of fish eggs between intake and discharge waters.

(ii) Ichthyoplankton Viability

Except during the month of December there were no living fish larvae in discharge collections (Table I-30). There were almost always living larvae in intake samples.

(iii) Statistical Analysis

Analysis showed that the numbers of fish larvae collected in entrainment samples differed between sampling dates (Table I-31).

3. <u>DISCUSSION OF RESULTS</u>

a. Summary and Interpretation of Results

(i) Phytoplankton

(a) Lake populations of phytoplankton were non-selectively entrained.

(b) The chlorophyll <u>a</u> concentration in discharge waters was greater than or equal to that of the intake on 5 of the 7 collection dates. The higher discharge values were probably a reflection of sampling bias (see Introduction to Entrained Plankton and the following subsection).

(c) Net and gross primary productivity decreased and the community

ABUNDANCE OF FISH EGGS AND LARVAE IN INTAKE AND DISCHARGE WATERS AT NINE MILE POINT NUCLEAR STATION

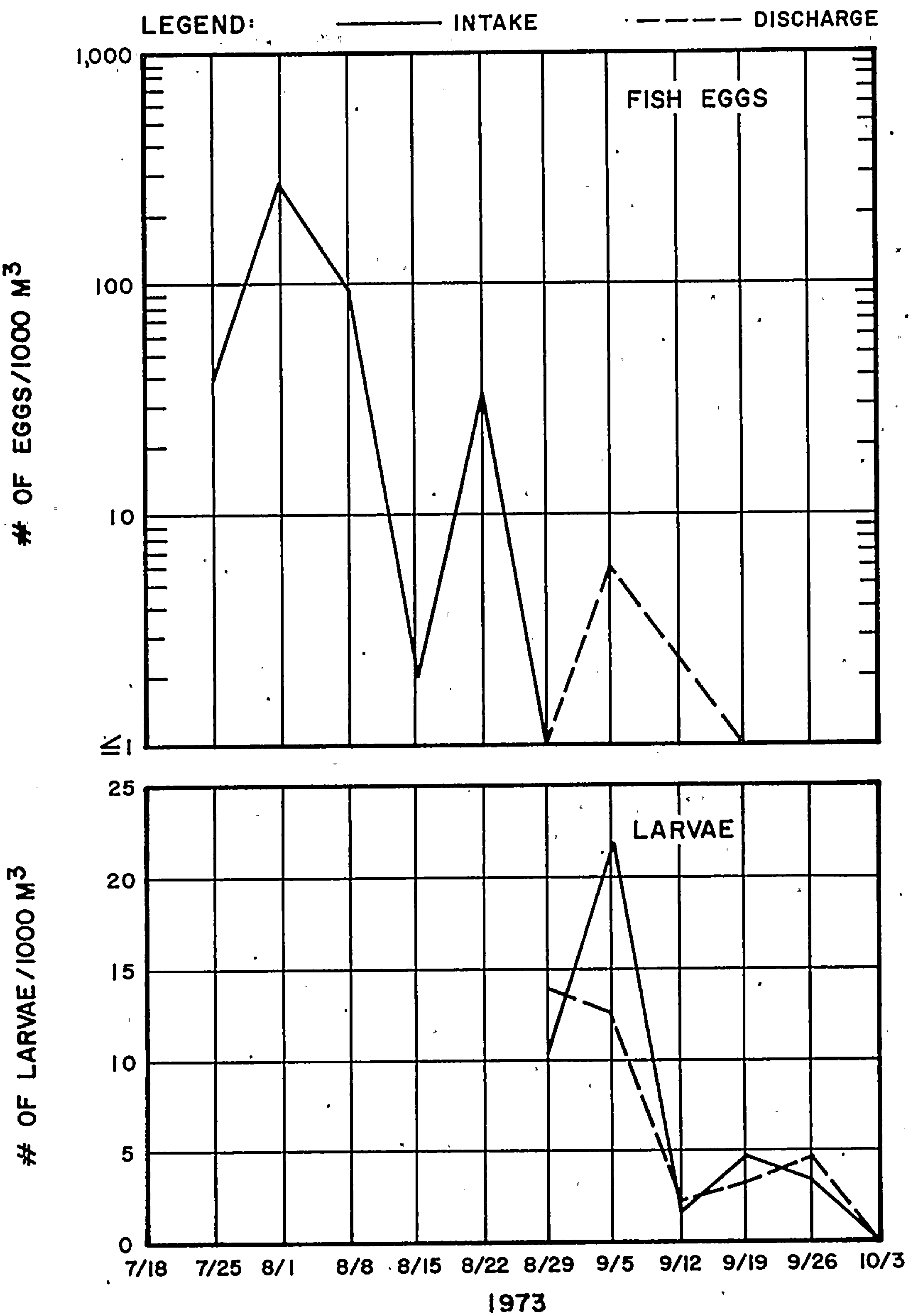


TABLE I-30

FISH LARVAE VIABILITY

	Intake (no./1000m^3)		Discharge (no./1000m^3)		
Date	Live	Dead	Live	Dead	Date
7/25/73	27	53	0	31	7/25/73
7/25	51	0	0	680	7/25
7/25	45	45	0	75	7/25
8/1	26	121	0	20	7/25
8/1	35	210	0	1134	8/15
8/15	567	1134	0	369	8/29
8/15	208	1134	0	64	8/29
8/15	56	0	0	56	8/29
8/15	227	0	0	100	8/29
8/22	4	49	0	141	8/29
8/22	115	18	0	185	8/29
8/22	0	113	0	14	9/5
8/22	0	7	0	81	9/5
8/22	0	19	0	147	9/5
8/29	309	92	0	156	9/5
8/29	2165	92	0	205	9/5
8/29	126	0	0	156	9/5
8/29	61	121	0	13	9/19
8/29	71	0	0	8	9/19
9/5	0	17	0	27	9/19
9/5	132	94	0	56	9/19
9/5	19	197	0	36	9/19
9/5	140	193	0	4	9/19
9/5	52	91	0	61	9/26
9/19	33	17	0	25	9/26
9/19	262	30	0	40	9/26
9/19	30	0	0	1134	9/26
9/19	42	34	0	38	9/26
9/19	49	16	0	9	10/10
9/19	52	0	0	5	10/10
9/26	3	0	0	7	10/17
9/26	60	0	16	11	12/5
9/26	10	0	0	29	12/5
9/26	75	0	0	30	12/5
9/26	45	0	10	5	12/5
12/5	17	0	5	36	12/5
12/5	1458	1458	6	11	12/5
12/5	21	0	32	21	12/5
12/5	138	0	0	23	12/5
12/5	85	0	0	22	12/5
12/5	23	0	7	7	12/19
12/5	7	0	12	2	12/19
12/5	5	10			
12/5	28	0			
12/19	24	125			
12/19	14	0			

TABLE I-31

Analysis of Variance for Entrained Fish Larvae

Nine Mile Point, 1973

	Source	d.f.	ss	ms	F-ratio
Total Fish Larvae	Intake/Discharge	1	0.0007	0.0007	0.021
	Date	11	4.3214	0.3929	11.799*
	Error	11	0.3666		
	Total	23	4.6887		

*Significant difference within source of variance at $\alpha = 0.05$

Critical F-values: $F_{1, 11} = 4.84$; $F_{11, 11,} = 2.82$

respiration increased between intake and discharge.

(ii) Microzooplankton

(a) The seasonal trends in the abundance of entrained microzooplankers did not reflect seasonal changes in Lake populations of microzooplankton. This result may have been related to differences in the populations sampled. Lake population abundance represented mid-water populations. The differences observed between Lake and entrained microzooplankton populations reflect selective entrainment by the power station.

(b) Comparisons of microzooplankton abundance in intake waters and in discharge waters indicated the existence of a sampling problem (see Introduction to Entrained Plankton and following subsection). The general trends of the most abundant organisms (rodifers and copepod nauplii) were toward reduced abundance in discharge waters.

(c) The percentage of living microzooplankters in discharge waters was the lowest during the summer months and the highest during the fall and early winter. The percentage of living microzooplankters was greater in intake waters than in discharge waters during the summer; the opposite relationship was found during the fall and early winter. These results indicate that, during the summer, some portion of living microzooplankters were killed through entrainment, whereas during the fall and early winter, previously dead microzooplankters may have disintegrated during entrainment.

(iii) Macrozooplankton

(a) Lake populations of macrozooplankton were non-selectively entrained.

(b) Considerable numbers of Leptodora and cladocerans disintegrated during entrainment; the greatest differences between intake and discharge abundance occurred during the summer months. The same trends were noted for copepod and amphipod populations, but higher numbers of these organisms were found in discharge samples than were found in intake samples on some collection dates (see subsection 2.c.).

(iv) Ichthyoplankton

(a) The period of fish larvae entrainment was within the period of larval occurrence in the Lake.

(b) Since a greater number of larvae were found in discharge waters than in intake waters on 3 of the 5 collection dates, when larvae were prevalent, it was concluded that these results evidence a sampling problem (see Introduction to Entrained Plankton and the following subsection).

b. Sampling Entrained Plankton

The results of entrainment samples for some groups of organisms (Leptodora and cladocerans, for example) showed that representative samples were taken consistantly. Some zooplankters however, were not sampled representatively, since concentrations in intake samples were significantly

lower than in discharge samples. The source of the sampling problem may be found in collection procedures, e.g. net placement, net design, and subsampling techniques.

Any plankton collecting device must sample a certain volume of water to overcome the effects of population patchiness; the volume required to adequately sample the rarer organisms is greater than that required for the most abundant organisms (Cassie, 1968). It is felt that the problems encountered in sampling microzooplankton and phytoplankton were related primarily to population patchiness rather than small numbers of organisms. The macrozooplankton and ichthyoplankton sampling difficulties were, however, most related to small population numbers.

II. BENTHOS

A. INTRODUCTION

Benthos are defined as those organisms attached to or resting on the bottom or living in the sediment of a body of water (Odum, 1971). Numerous studies have determined that the benthos are an important link in the transfer of energy between the lower and higher trophic (feeding) levels (Odum, 1971; Cairns and Dickson, 1971).

The community structure of benthic invertebrates has been shown to reflect changes in environmental conditions (Johnson and Matheson, 1968; Cairns and Dickson, 1971; Goodnight, 1973); benthic surveys have been very successful in evaluating changes in the aquatic ecosystem as a result of industrial and domestic waste discharges (Wilhm and Dorris, 1966; Bechtel and Copeland, 1970).

Benthic fauna represent an ideal community for evaluation of the effects of environmental alteration because: (1) the non-motile benthic populations cannot avoid impact, and (2) their position in the trophic structure is at the base of the ecosystem. Very few comprehensive studies have been published which relate the potential effects of power plant operation (chemical and thermal) to the benthic community.

In an extensive survey of the benthic organisms of Lake Ontario, Brinkhurst et al. (1968) found several organisms which exhibited distinct distribution patterns. The oligochaetes *Stylodrilus heriangianus*, *Tubifex tubifex* and *Limnodrilus hoffmeisteri* were found to be common in all areas of the Lake, but the latter two were especially abundant in areas of high organic content.

Other oligochaete worms, including Ilyodrilus templetoni, Limnodrilus cervix, L. claparedionus, L. udekemeanus and Peloseolex multisetosus, were also abundant in areas of high organic content. The nearshore area had more associated species (such as the oligochaetes Peloscolex ferox, Aulodrilus spp. and Potamothrix spp., and dipteran Procladius denticulatus) than were found in deep water areas. Pelecypoda (clams and mussels), mainly from the family Sphaeriidae, were seldom collected from water deeper than 100 feet and dipteran larvae were found mostly nearshore, except for Heterotrisocladius subspilosus which was in deeper water.

Work conducted on a surface level discharge in Lake Erie found fewer benthic species in the warmer water area (Havens and Emerson, Consulting Engineers, 1968). However, greater abundance of the species was found than on a similar substrate out of the thermal influence. The primary thermal plume organisms were oligochaetes, leeches and some dipteran larvae. Sphaeriidae were abundant in the boundary zone.

Historically, benthic studies in Lake Ontario have concentrated upon the more industrialized western portion of the Lake (Johnson and Matheson, 1968; Johnson and Brinkhurst, 1971 a and b). Some surveys have been conducted in the vicinity of Nine Mile Point by Judd and Gemmel (1971), Storr (1972), and QL&M Engineers (1973). The studies point principally to the influence of Cladophora on the abundance of organisms in the littoral zone of the Lake, Judd and Gemmel (1971) observed few organisms in the shore zone, possibly due to wave action. The fauna increased in abundance and diversity related to depth in the littoral and sub-littoral zone. Storr (see QL&M Engineers,

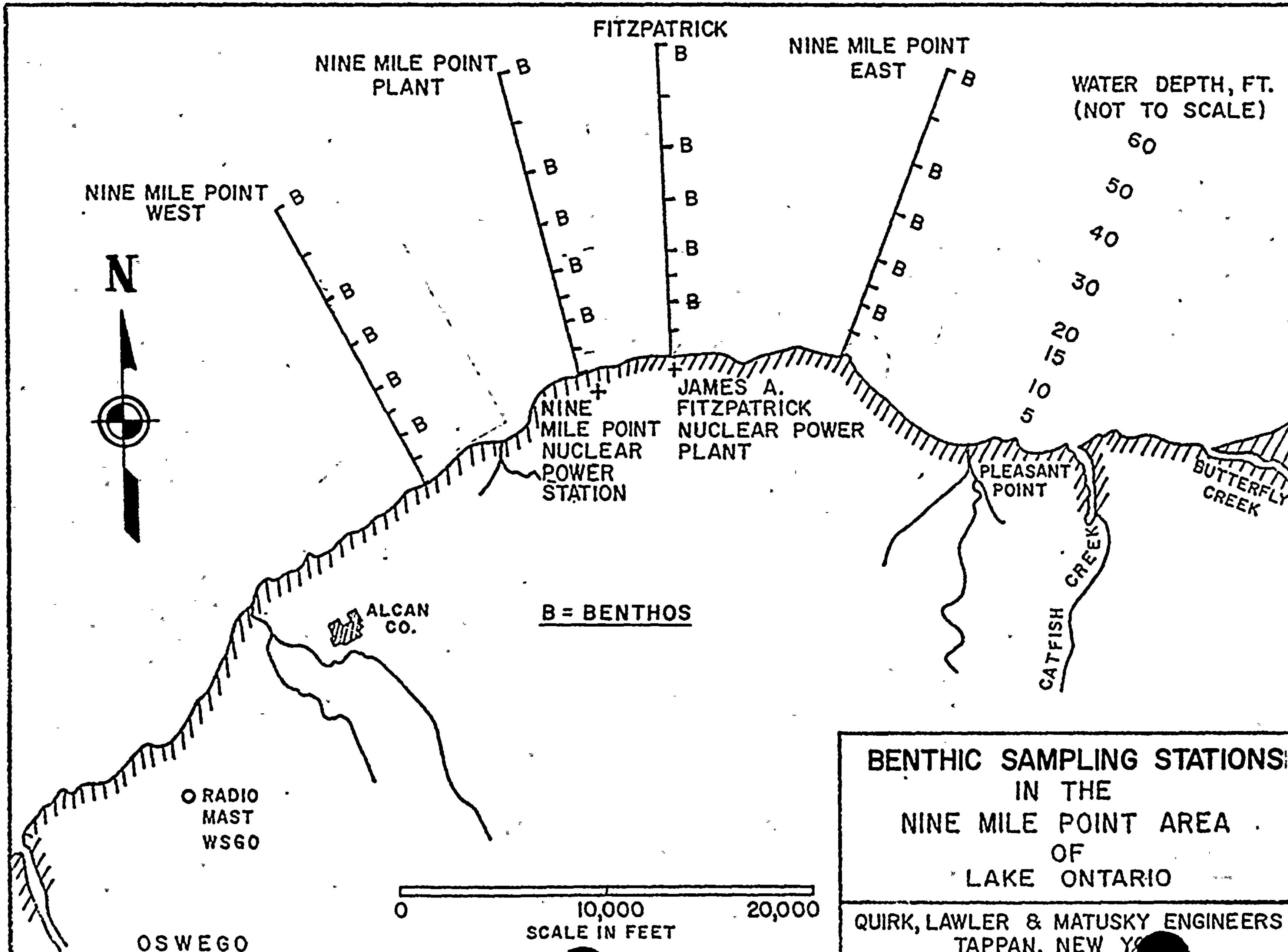
1973) found an increase in numbers of benthos over a three year study but this increase was not the result of thermal discharge from Nine Mile Point Unit 1.

Limited historical information was available on the benthic community in the immediate vicinity of Nine Mile Point. A primary objective of the 1973 program was to obtain information on the benthic community and determine the seasonal fluctuations of the related invertebrate populations. The study was also designed to evaluate the effect of operation of Nine Mile Point Nuclear Station Unit 1 on the benthic community.

B. STATION LOCATION AND SUBSTRATE CHARACTERISTICS

Four transects each composed of five stations were sampled in the 1973 benthic survey (Figure II-1). The transect designations were Nine Mile Point West (NMPW), Nine Mile Point Plant (NMPP), FitzPatrick (FITZ) and Nine Mile Point East (NMPE). The NMPW transect was approximately 8000 ft. west of the Nine Mile Point Nuclear Power Station and NMPE was approximately 8000 ft. east of the J. A. FitzPatrick Nuclear Power Station (under construction). The NMPP and FITZ transects were directly lakeward from each Power Station centerline. Depths sampled on each transect were 10, 20, 30, 40 and 60 ft. The nature of the transects and depths along each transect enabled comparison of benthic populations from each to west and evaluation of the benthic community in relation to depth at each transect.

Substrate type is important in understanding the distribution patterns of



BENTHIC SAMPLING STATIONS IN THE NINE MILE POINT AREA OF LAKE ONTARIO

QUIRK, LAWLER & MATUSKY ENGINEERS
TAPPAN, NEW Y

FIGURE II-1

many aquatic invertebrates. Several investigators have evaluated benthic communities and found a strong correlation between benthic community structure and sediment type (Sanders, 1960; Johnson and Matheson, 1968; Johnson and Brinkhurst, 1971a).

Substrate types at each station were recorded at the time of each collection. These are presented in Table II-1. NMPW transect was predominately bedrock covered by a shallow layer of sand and silt. At the NMPP transect the bedrock was covered by rubble (2 to 64mm in diameter rocks) and sand-silt. The 10, 20 and 30 ft. stations along the FITZ transect were similar to the substrates found at NMPP; however, the 40 and 60 ft. stations were, for the most part, sand and silt. All but the 10 ft. station at NMPE were sand and silt. Wave action and shore currents maintained a rubble-boulder (greater than 256mm in diameter) substrate at the 10 ft. depth.

C. RESULTS AND DISCUSSION

1. IDENTIFICATION

a. General Systematic Survey

The organisms making up the benthic taxonomic hierarchy (Table II-2) are diverse in morphology and ecology. Five phyla were represented; a total of 81 genera were identified. The organisms identified were associated primarily with the surface of the substrate, i.e., epi-benthic, such as

TABLE II-1

NINE MILE POINT ECOLOGICAL SURVEY
BENTHIC STATION SUBSTRATE COMPOSITION

NMPE	FITZ	NMPP	NMPW	DEPTH
85% Sm. Boulder and Rubble 15% Sand and Silt	90% Bedrock and Rubble 10% Sand and Silt	85% Bedrock 15% Sand and Silt	90% Bedrock 10% Sand and Silt	10'
100% Sand and Silt	90% Bedrock and Rubble 10% Sand and Silt	95% Bedrock and Rubble 5% Sand and Silt	95% Bedrock 5% Sand and Silt	20'
100% Sand and Silt	95% Bedrock and Rubble 5% Sand and Silt	95% Bedrock and Rubble 5% Sand and Silt	95% Bedrock 5% Sand and Silt	30'
100% Sand and Silt	100% Sand and Silt	95% Bedrock and Rubble 5% Sand and Silt	90% Bedrock 10% Sand and Silt	40'
100% Sand and Silt	100% Sand and Silt	90% Bedrock and Rubble 10% Sand and Silt	80% Bedrock 20% Sand and Silt	60'

TABLE II-2

TAXONOMIC LISTING
OF BENTHIC ORGANISMS

PHYLUM
  CLASS
    ORDER
      FAMILY
        GENUS SPECIES

Platyhelminthes

  Turbellaria
    Tricladida
      Planariidae
        Dugesia sp.

Aschelminthes

  Nemata

Mollusca

  Gastropoda
    Pulmonata
      Ancylidae
        Ferrissia parallela
      Lymnaeidae
        Lymnaea catacapium
      Physidae
        Physa integra
        Physa sayii
      Planorbidae
        Gyraulus parvus
        Helisoma anceps
        Helisoma trivalvis
    Mesogastropoda
      Amnicolidae
        Amnicola integra
        Amnicola limosa
        Amnicola lustrica
        Amnicola walkerii
      Pleuroceridae
        Goniobasis livescens
      Valvatidae
        Valvata sincera

  Pelecypoda
    Heterodonta
      Sphaeriidae
        Musculium sp.
        Pisidium sp.
        Sphaerium sp.
    Eulamellibranchia
      Unionidae
        Lampsilis sp.

Annelida

  Polychaeta
    Sabelliformia
      Sabellidae
        Manayunkia speciosa
  Clitellata
    Hirudinea
      Glossiphoniidae
        Helobdella stagnalis
    Oligochaeta
      Enchythraeidae
      Lumbriculidae
        Stylodrilus heriangianus
      Naididae
        Arcteonais lomondi
        Nais pseudobtusa
        Nais variabilis
        Ophidonais serpentina
        Piquetiella michiganensis
        Specaria josinae
        Uncinais uncinata
        Vejdovskyella intermedias
      Tubificidae
        Aulodrilus limnobius
        Aulodrilus piqueti
        Aulodrilus pluriseta
        Ilyodrilus templantaii
        Limnodrilus claparedianus
        Limnodrilus hoffmeisteri
        Limnodrilus profundicola
        Limnodrilus udekemianus
        Peloscolex ferox
        Peloscolex freyi
        Peloscolex multisetosus

TABLE II-2 (continued)

Potamothrix moldaveiensis
Potamothrix vejdovskyi
Tubifex tubifex

Arthropoda

- Pychnogonida
  - Acarina
    - Hygrobatidae
      - Hygrobates sp.
    - Lebertiidae
      - Lebertia sp.
    - Pionidae
      - Forelia sp.
      - Piona sp.
    - Unionicolidae
      - Unionicola sp.
- Crustacea
  - Amphipods
    - Gammaridae
      - Gammarus fasciatus
    - Haustoriidae
      - Pontoporeia affinis
  - Ostracoda (Podocopa)
  - Isopoda
    - Asellidae
      - Asellus racovitzai
  - Decapoda
    - Astacidae
      - Cambarus bartonii
      - Orconectes propinquus
- Insecta
  - Ephemeroptera
    - Heptageniidae
      - Stenonema sp.
  - Trichoptera
    - Hydroptilidae
    - Leptoceridae
      - Athripsodes sp.
      - Oecetis sp.
  - Diptera
    - Tendipedidae
      - Calopsectra (Tanytarsus) sp.
      - Cricotopus sp.
      - Cryptochironomus sp.
      - Dicrotendipes sp.
      - Eukiefferella sp.
      - Heterotrissocladius sp.
      - Hydrobaenus (Orthocladius) sp.
      - Kiefferules sp.
      - Micropsectra sp.
      - Microtendipes sp.
      - Paracladopelma sp.
      - Paratendipes (Parachironomus) sp.
      - Pentaneura sp.
      - Phaenopsectra (Tanytarsus, P[illegible]edi[illegible]
      - Polypedilum sp.
      - Procladius sp.
      - Psectrocladius sp.
      - Pseudochironomus sp.
      - Stictochironomus sp.
      - Tendipes (Chironomus) sp.
      - Xenochironomus sp.

amphipods. However, several infaunal forms* including oligochaetes were also collected.

b. Taxonomic Considerations

Accurate determination of specimens is a pre requisite to an ecological investigation which is primarily concerned with determining the community structure. Problems associated with the nomenclature of the invertebrate fauna complicate interpretation of the data. The nomenclature employed in this report is that accepted by the International Committee on Zoological Nomenclature (1800). Problems related to taxonomy usually have minor impact on an ecological survey. The majority of the major taxa have well-ordered keys based on morphological characteristics. In cases such as the Tendepedidea, keys like James (1959) present both names if synonomy exists. This also permits comparison of data from one study to another if different nomenclature is reported.

Certain taxonomic groups are difficult to classify due to their small size, lack of easily recognizable external anatomical features, or the necessity of in vivo observations for accurate identification. Identification of the Tricladida (flat worm) to the species level, for example, requires serial sectioning for internal anatomical differences. These types of taxonomic problems are usually beyond the scope and requirements of general benthic surveys. In this report, identification proceeded to the lowest possible realistic taxonomic level.

*Those living in the sediment.

2. DISTRIBUTION AND ABUNDANCE

a. Major Taxonomic Level

(i) Polychaeta

Members of the Class Polychaeta are almost exclusively marine; however, a few freshwater forms exist. In the Great Lakes region of the United States the only polychaete described is Manayunkia speciosa. The ecology of this small worm (average length 2.5 to 5.0 mm) has only recently been investigated. M. speciosa is usually found in small colonies associated with sand or muddy bottoms. They construct tubes of mud or detritus, relying on cilia on the barbules or tentacles to obtain food items (Pettibone, 1953; Hartman, 1959).

A total of 3293 individual M. speciosa were collected at Nine Mile Point during 1973. June and August collections had approximately the same numerical abundances with 520 collected during June (16%) and 419 collected during August (13%). The greatest abundance was found during October: the 2355 organisms collected per square meter amounted to 71% of the total yearly collection. This species reproduces sexually (Pettibone, 1953), and the greater abundance during October could represent the seasonal young.

Most polychaetes were found at NMPW and NMPE with very few occurring at the plant transects. Thirty-two percent (1090) of the organisms were collected along the west transect and 53% (1795) along the east transect.

Since there is a marked difference in substrate type between NMPW and NMPE (Table II-1), substrate preference does not appear to be the limiting factor for Manayunkia distribution. A total of 87 percent of the polychaetes were collected in the littoral zone (20 feet). Only 2 percent were found deeper than 30 feet. The same depth preference was found for all three collections indicating active selection of shallow water habitat.

(ii) Amphipoda

The amphipod population was composed of two species, Pontoporeia affinis and Gammarus fasciatus. Amphipods are usually found in shallow water, under rocks and are considered to be omnivorous.

Based on 178,086 amphipods per square meter recorded for the three sampling collections, Gammarus was the most abundant (78% of the total). The greatest abundance was found during June for both species. This was followed by a steady decline through August and October. The same trend was found by Thut (1969) for peak abundance of Pontoporeia in Lake Washington. He attributed the variable abundance to reproduction from March through July.

Of the four transects sampled, more amphipods were recorded at NMPE and FITZ than at NMPW and NMPP during the spring and summer collections. All transects exhibited equal abundance during the fall collection. The two east transects had a more extensive algal growth in June possibly contributing to the spring peak of Pontoporeia abundance; abundance from the summer collection could be due to the spring brood and relative stability of the population in a favorable area (available food and acceptable substrate).

An abundance pattern associated with depth was found for the two species, Gammarus preferring the littoral zone and Pontoporeia the deeper water stations. Table II-3 lists the total percentage of each collected by depth and the presence of each species:

TABLE II-3
AMPHIPODA PERCENTAGES

Depth (ft.)	Percent Total Population	%of Amphipods Gammarus fasciatus	Pontoporeia affinis
10	53.6	100	0
20	14.1	96.7	3.3
30	16.9	87.7	12.3
40	4.1	67.1	32.9
60	10.9	41.8	58.2

Johnson and Matheson (1968) and Thut (1969) recorded a similar pattern of distribution for Pontoporeia in the Hamilton Bay area of Lake Ontario and Lake Washington. Apparently, warmer littoral water temperatures and the presence during June of Cladophora (which serves as refuge and an area rich in food) in part contribute to the abundance of Gammarus. Stenothermal* conditions in the deeper water zone and possible food preference (Johnson and Matheson, 1968) are more favorable for Pontoporeia.

(iii) Isopoda

Asellus recovitzai was the only isopod collected in the Nine Mile Point

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*An organism only slightly resistant to changes in temperature

area. Like most isopods, Asellus is primarily a scavenger having secretive habits. Its food consists of both animal and plant material.

Seventy-six percent (167) of the specimens were collected at the 60 ft. depth. Of the remaining 24%, 12 % were collected during June from Cladophora. The deeper depth preference is probably a result of lower competition for food and lower predation.

On all collection dates the greatest number were collected on the NMPW transect. This transect is mainly bedrock (Table II-1) in contrast to other transects with rubble and sand and silt. A fine silt is reported to have covered the bedrock; this species appears to have a preference for this substrate.

(iv) Tricladida

Triclads were abundant during the June collection with 81% of the 2898 specimens, or 2295, collected at this time. The fewest were collected in August (3%) with a slight increase in October (16%). Pennak (1953) reports the members of this order to be more active under colder water conditions which would account for the June abundance and increase during October after the warmer conditions of August.

The transect and depth distribution by collection and total are given in Tables II-4 and Table II-5.

TABLE II-4

TRANSECT ABUNDANCE OF TRICLADIDA

TRANSECT	JUNE		AUGUST		OCTOBER		TOTAL	
	#/m²	%	#/m²	%	#/m²	%	#/m²	%
NMPW	134	6	-	-	83	18	217	8
NMPP	804	35	59	78	42	9	905	32
FITZ	661	29	17	22	309	66	987	35
NMPE	696	30	-	-	34	7	730	26
TOTAL	2295		76		468		2839	

TABLE II-5

DEPTH DISTRIBUTION OF TRICLADIDA

DEPTH FT.	JUNE		AUGUST		OCTOBER		TOTAL	
	#/m²	%	#/m²	%	#/m²	%	#/m²	%
10C*	1139	48	-	-	-	-	1139	3[illegible]
10NC**	268	11	-	-	23	5	291	10
20C	-	-	-	-	-	-	-	-
20NC	59	3	59	78	100	22	218	8
30	561	24	-	-	285	62	846	29
40	118	5	17	22	-	-	135	5
60	209	9	-	-	50	11	259	9
TOTAL	2354		76		458		2888	

A difference was noted between the three eastern transects and the western transect. Since NMPW has a bedrock substrate, as opposed to rubble and sand and silt at the other transects, a substrate preference by Dugesia sp. could limit the number at NMPW. Ball (1969) and Pennak (1953) report that

* Cladophora

** Non-Cladophora

Dugesia lugubris in Lake Ontario has a strong photonegative behavior which would favor substrates in which the organism could burrow or hide.

(v) Nemata (Nematoda)

The class Nemata exhibits a definite distribution pattern based on substrate characteristics. Pennak (1953) reported that aquatic nematodes show a specific habitat preference, invariably associated with bottom muds and organic debris.

Table II-6 below gives transect abundance by month for the 1973 collections:

TABLE II-6

TRANSECT ABUNDANCE OF NEMATODA

TRANSECT	JUNE		AUGUST		OCTOBER		TOTAL	
	#/m^2	%	#/m^2	%	#/m^2	%	#/m^2	%
NMPW	8	<1	0	-	17	<1	25	<1
NMPP	84	3	8	<1	0	-	92	1
FITZ	552	20	235	10	34	3	821	13
NMPE	2169	77	2119	90	1298	96	5586	86
TOTAL	2813		2362		1349		6524	

Greater numbers during all seasons were collected at NMPE. A seasonal comparison of the stations shows the greater concentrations at the deeper water stations from 30 ft. to 60 ft. (Table II-7).

TABLE II-7

DEPTH DISTRIBUTION OF NEMATODA

STATION	NMPW #/m^2	NMPW %	NMPP #/m^2	NMPP %	FITZ #/m^2	FITZ %	NMPE #/m^2	NMPE %	TOTAL #/m^2	TOTAL %
10C*	-	-	-	-	-	-	34	-	34	1
10NC*	-	-	-	-	67	8	84	1.5	151	2
20C*	-	-	84	91	-	-	-	-	84	1
20NC*	25	100	8	9	-	-	360	5.5	393	6
30	-	-	-	-	25	3	2365	42	2390	37
40	-	-	-	-	197	24	1977	35	2174	33
60	-	-	-	-	536	65	770	14	1306	20
TOTAL	25		92		825		5590		6532	

* refer to Methods and Materials, Appendix I

Stations which had the highest abundance of nematodes were those listed Table II-1 (substrate type) as being predominantly silt and sand. The stations composed mainly of bedrock and rubble had fewer numbers of organisms.

The greatest number of nematodes was found during the June sampling: 45% of the total benthic organisms. A slight decline was noted during August followed by a fairly sharp decline during October. Nematodes have a very rapid reproductive rate (Chitwood and Allen, 1959); during the spring, increased abundance could be the result of the reproductive cycle initiated by the warming water. Normal attrition and burrowing into the substrate for feeding and protection account for the summer-fall decline.

(vi) Decapoda

Two species of decapods (crayfish) were collected and identified during the 1973 sampling program. The two species, members of the family Astacidae, were *Orconectes propinquus* and *Cambarus bartonii*.

Crayfish are omnivorous, nocturnal scavengers with a preference for vegetative material (Pennak, 1953). The general distribution pattern is restricted to the temperate zones with the northern range extending to southern Canada (Hobbs, 1959). *Cambarus bartonii* has been reported as far north as New Brunswick and *Orconectes propinquus* as far north as Maine. Both species are usually found in shallow water to a depth of six to eight feet (primarily the depth distribution of benthic plant material).

A total of 10 specimens were collected, with only one specimen of *C. bartonii*. *O. propinquus* was collected at varying depths and from different transects intermittently throughout the study. The small number of organisms collected precluded any statement concerning habitat preference; however, the importance of this group in the diet of smallmouth bass and other important fish species in this section of Lake Ontario (Williams and Miller, 1973) points to the need of further work on decapod distribution.

(vii) Acari (Hydracarina)

Little information is available describing the ecology of many species of aquatic mites. This is partially due to taxonomic difficulties and limited

investigative interest in free-living water mites by researchers (Mullin, Personnel Communication). Distribution patterns can be defined, but the ecological significance of the group in the Nine Mile Point area is not known.

The greatest number of water mites were collected during August, representing a gradual increase from June abundance (see Appendix IV-A). A sharp decline in numbers was noted from the October collection. Pennak (1953) reports the same general trend. The organisms are normally associated with aquatic plant material which occurs in the greatest abundance during the late summer and declines during the fall and winter. Abundance was highest at NMPW (44% of total Acari) with the lowest number recorded at FITZ (14 percent of those organisms collected). NMPP and NMPW were similar with 22 and 20 percent, respectively. Generally, Lebertia sp. appeared to be the only shallow water group, with 95% of the 1265 specimens collected in 30 ft. of water or less. Hygrobates sp., Forelia sp., and Unionicola sp. were recorded at deeper water stations. Limnesia sp. did not show a depth distribution pattern being found at all depths. Piona sp. was collected only during the June collection. There is some evidence that Acari have seasonal movement pattersn going to shallow water areas in the spring-summer period moving back to deeper water during the fall (Pennak, 1953). This was not confirmed; however, the greater abundance at the 20 and 30 ft. stations in August compared to abundance at deeper stations in June and October indicates this type of pattern (Appendix IV-A).

(viii) Pelecypoda

The pelecypods were represented by two families during 1973: Sphariidae and Unionidae. Only one genus was found from the family Unionidae, Lampsilis. Three genera, Sphaerium, Pisidium and Musculium, represented the family Sphaeriidae.

Greater than 99% of the pelecypods collected were Pisidium and Sphaerium; Pisidium were dominant, composing 78% of the collection (Appendix IV-A). These small clams are important fish food items, especially for benthic feeding fish (Pennak, 1953).

The greatest concentration of Sphaeriidae was at NMPE (Table II-8). Sixty percent of the Pisidium (10,000) and 99% of the Sphaerium (4983) were collected along the transect. Sphaerium was found only along one other transect: NMPW. NMPP had the fewest Pisidium with 20 percent (257), NMPW had 15 percent (2571), and FITZ had 23 percent (3904). The greater number at NMPE is attributable to the silt-sand substrate. At NMPW, the silt-covered bedrock could be used to great advantage by the small clams.

Sphaeriidae are noted for their preference for greater depths, generally being among the deepest living freshwater pelecypods (Pennak, 1953; Johnson and Matheson, 1968). For Sphaerium, 94% were collected at the 30 and 40 ft. stations with 58 percent being found at 30 ft. (see Appendix IV-A). Pisidium concentrations increased with depth; 50% of those collected were found at 60 ft. The sampling program may not

TABLE II-8

TRANSECT ABUNDANCE OF PELECYPODA

STATION	JUNE #/m²	JUNE %	AUGUST #/m²	AUGUST %	OCTOBER #/m²	OCTOBER %	TOTAL #/m²	TOTAL %
NMPE	2,412	81.38	11,874	84.17	11,265	59.28	25,551	70.83
FITZ	416	15.55	1,799	12.75	4,557	23.98	6,817	18.90
NMPP	91	3.07	300	2.13	49	0.26	440	1.22
NMPW	0	0	134	0.95	3,131	16.48	3,265	[illegible]05
TOTAL	2,964		14,107		19,002		36,073	

encompass the greatest concentration of Pisidium, which may be in the profundal water areas, well outside the 60 ft. contour depth. The numbers of clams collected increased with time during the three collection periods. The reproductive cycle begins in early spring with the growth period for the young from April to September. The increased number could be due to the growth of the young of the year.

(ix) Ostracoda (Podocopa)

Ostracods composed 13% of the total number of organisms collected. They are important in the trophic structure of the ecosystem, since they are omnivorous scavengers feeding on molds, algae, bacteria and fine detritus.

Identification problems have made work on the ecology of the ostracods difficult. Some distributional patterns were identified. Table II-9 presents the transect distribution by collection date for 1973.

TABLE II-9

TRANSECT ABUNDANCE OF OSTRACODA

STATION	JUNE #/m^2	%	AUGUST #/m^2	%	OCTOBER #/m^2	%	TOTAL #/m^2	%
NMPW	2890	10	294	3	2279	49	5363	13
NMPP	12278	43	1232	15	42	1	13552	52
FITZ	4397	15	1291	15	552	12	6240	15
NMPE	9287	32	5603	67	1741	38	16631	40
TOTAL	28852		8420		4614		41886	

The greatest numbers were found during June; the abundance then declined through the next two samplings. The spring peak of abundance represents newly hatched organisms. Attrition and migration account for the summer-fall decline. Transect abundance was highly variable throughout the study. Other investigators have reported no discernable requirements affecting distribution (Pennak, 1953), since the ostracods are found inhabiting all substrate types.

The distribution by depth is presented in Table II-10.

TABLE II-10

DEPTH DISTRIBUTION OF OSTRACODA

	JUNE		AUGUST		OCTOBER		TOTAL	
	#/m^2	%	#/m^2	%	#m^2	%	#/m^2	%
10C*	3283	11	-	-	-	-	3283	8
10NC**	1006	3	2128	25	58	1	3192	8
20C	318	1	0	-	-	-	318	<1
20NC	1290	4	3427	41	17	0.5	4734	11
30	3367	12	1408	17	728	16	5503	13
40	15803	55	921	11	712	15.5	17436	42
60	3785	13	536	6	3099	67	7420	18
TOTAL	28852		8420		4614		41886	

* Cladophora sample

**Non-Cladophora sample

There appears to be a depth preference for the deeper stations with the highest percentage, on an overall basis, living found at 40 ft.

(x) Gastropoda

Fourteen species of gastropods representing two orders (Mesogastropoda

Pulmonata) were collected in the benthic samples during 1973. Samples collected during June (Table II-11) showed the lowest number of total gastropods, 6468 specimens per square meter (20%). The spring low was followed by an increase during August to 13567 organisms (42%) and a subsequent reduction by October to 12403 organisms (38%). The increase in Valvata sincera, Goniobasis livescens and Amnicola limosa accounted for the summer-fall increase in abundance.

TABLE II-11

TRANSECT ABUNDANCE OF GASTROPODA

	JUNE				AUGUST				OCTOBER			
	Mesogastropoda		Pulmonata		Mesogastropoda		Pulmonata		Mesogastropoda		Pulmonata	
	$\#/m^2$	%	$\#/m^2$	%	$\#/m^2$	%	$\#/m^2$	%	$\#/m^2$	%	$\#/m^2$	%
NMPW	16	<1	76	1	526	4	243	2	2764	22	845	7
NMPP	336	5	477	7	268	2	327	2	99	1	295	2
FITZ	218	3	2429	38	1340	10	167	1	479	4	594	5
NMPE	1886	29	1030	16	10277	76	419	3	7143	58	184	1
TOTAL	2456	38	4012	62	12411	92	1156	8	10485	85	1918	15

For all collections, the greatest numbers were collected at the NMPE; this is correlated with substrate preference. The interesting aspect of the transect abundance is the increase over time for both orders at NMPW. This increase was due to the occurrence of Goniobasis livescens in August and Amnicola limosa, Gyraulus parvus and Physa integra in October. Except for Gyraulus parvus, all of these species appear to undergo a seasonal increase from east-to-west. Gyraulus, which has a later growth and developmental period than the other species, reaches peak abundance during the fall.

Generally, gastropods are vegetarians feeding on algae, however; some gastropods are omnivores (Pennak, 1953). Some species have been shown to have a specific substrate preference as well as a vegetational habitat preference (Reid, 1961; Thut, 1969).

Morphological differences in the two orders collected result in differences in distribution patterns. Mesogastropods possess a gill for underwater respiration. The Pulmonata do not have gills. Instead, they have a pulmonary cavity which functions as a lung (Clench, 1959). The lung cavity does not require that the Pulmonata obtain air, since some gas exchange is possible through the body surface.

The air breathing habit does restrict the pulmonates to a nearshore, shallow-water habitat. Table II-12 gives the depth distribution by collection for the two orders. The percentage of the total collection is listed for each order at each station.

TABLE II-12

DEPTH DISTRIBUTION OF GASTROPODA

	JUNE				AUGUST				OCTOBER			
	Mesogastropoda		Pulmonata		Mesogastropoda		Pulmonata		Mesogastropods		Pulmonata	
	$\#/m^2$	%	$\#/m^2$	%	$\#/m^2$	%	$\#/m^2$	%	$\#/m^2$	%	$\#/m^2$	%
10C*	75	1	3887	60	-	-	-	-	-	-	-	-
10NC**	26	-	42	1	1157	9	486	4	1314	11	1333	11
20C.	-	-	8	-	-	-	-	-	-	-	0	-
20NC	67	1	-	-	1079	8	134	<1	1105	9	192	2
30	653	10	34	1	4790	35	151	1	4396	35	246	2
40	579	9	8	-	3467	26	159	1	2187	18	44	-
60	1056	16	33	1	1918	14	226	2	1483	12	91	1
TOTAL	2456	38	4012	62	12411	92	1156	9	10485	85	1906	15

* Cladophora samples
** Non-Cladophora samples

On all collection dates the greater percentages of Mesogastropoda were found in deeper water with the greatest concentration at 30 ft. For Pulmonata the greatest numbers were at the shallower depths with the greatest concentration at 10 ft.

During June, the Pulmonata, due to a large number of Physa integra associated with Cladophora growth, composed 62% of the total collection. The percentage of pulmonates dropped to 9% during August with a slight increase to 15% in October. Members of this order which live in lakes are known to migrate on a seasonal basis in correlation with water temperature; this in conjunction with the Cladophora association could account for the decrease in numerical abundance.

(xi) Oligochaeta

Four families of Oligochaetes represented by twenty-two identifiable species were collected. These worms are important to the trophic structure of the community since they are primarily detritovores living in the bottom sediments. The families Tubificidae, Naididae, and Lumbriculidae are strictly aquatic, while Enchythraeidae are semi-aquatic with species usually found in debris at the water's edge (Pennak, 1953).

TABLE II-13

TRANSECT ABUNDANCE OF OLIGOCHAETA

	JUNE				AUGUST				OCTOBER			
	#/m^2	%	BIOMASS*	%	#/m^2	%	BIOMASS	%	#/m^2	%	BIOMASS	%
NMPW	544	5	0.25	6	16	2	0.03	6	569	9	0.38	8
NMPP	1674	17	0.52	12	536	55	0.20	42	0	-	0	0
FITZ	4330	43	2.09	50	93	9	0.11	23	3953	61	2.32	50
NMPE	3511	35	1.35	32	336	34	0.14	29	2009	31	1.95	42
TOTAL	10059		4.21		981		0.48		6531		4.65	

* in gms/m^2.

The FITZ transect showed greatest abundance during June and October (Table II-13); NMPP had the highest value in August. The August maximum at NMPP was due primarily to a large proportion (50%) of immature Tubificidae, reflected by the biomass values. NMPE exhibited a consistently high percentage of total biomass, averaging 33% for all three dates. The smallest percentage abundance was always found at NMPW. The eastern transects have more stations with a sand-silt substrate that would be more favorable to the infaunal Oligochaeta, resulting in the greater numbers at these two transects.

The depth distribution pattern (Table II-14) indicates a preference by this group for the deeper water stations.

TABLE II-14

DEPTH DISTRIBUTION OF OLIGOCHAETA

	JUNE				AUGUST				OCTOBER			
	#/m^2	%	BIOMASS*	%	#/m^2	%	BIOMASS	%	#/m^2	%	BIOMASS	%
10C	1608	16	0.46	11	-	-	-	-	-	-	-	-
10NC	418	4	0.11	3	0	0	0	0	50	1	1.04	22
20C	342	3	0.12	3	-	-	-	-	-	-	-	-
20NC	93	1	0.05	1	553	54	0.61	62	41	1	0.21	5
30	1366	14	0.66	16	143	14	0.07	7	1474	23	0.77	17
40	2672	27	0.97	23	101	10	0.22	22	2244	34	1.17	25
60	3528	35	1.84	44	218	21	0.08	8	2722	42	1.46	31
TOTAL	10027		4.21		1015		0.98		6531		4.65	

* in gms/m^2

Johnson and Matheson (1968) found a greater abundance of Oligochaetes with depth in Lake Ontario around Hamilton Bay. Thut (1969) found that both mean numbers and mean biomass of oligochaetes increased with depth in

Lake Washington. The greater number of worms at the 20 ft. station during August was due to the presence of immature worms which are normally found in shallower water (Johnson and Matheson, 1968).

Temperature is usually not a limiting factor; however, during adverse conditions, protective cocoons may be formed or the worms may burrow deeper into the substrate (Pennak, 1953). Large numbers of the cocoons are normally found in late summer to early autumn, which could explain the decrease in numbers during August and the increase during October.

(xii) Diptera

Tendipedid larvae, which composed the dipteran collection, are immature midges that can develop dense populations on a seasonal basis. The importance of this group is its value as a fish food, being a major item in many fish diets (Reid, 1961). The larvae are chiefly herbivorous, feeding on algae, aquatic plants, and some detritus (Pennak, 1953).

An important aspect concerning the ecology of the tendipedids and other aquatic insects is their two phase life cycle (Reid, 1961; Ross, 1965; Thut, 1969). The larval-pupal forms are aquatic, while the adults are terrestrial, usually found flying around the water's edge. Mating occurs near the shoreline, and eggs are deposited in shallow water. The tendipedids proceed through larval development, pupate, and emerge together (Neess and Dugdale, 1959), however, some species have a life cycle which lasts for more than one year (Pennak, 1953).

The transect distribution(Table II-15) indicated a greater concentration

of dipterans in terms of both abundance and biomass at the eastern transects. Several tendipedid species, including Cryptochironomus sp., burrow into the substrate; the sand-silt bottom at FITZ and NMPE accounts for the greater abundance at these two transects.

TABLE II-15

TRANSECT ABUNDANCE OF DIPTERA

	JUNE				AUGUST				OCTOBER			
	#/m^2	%	BIO*	%	#/m^2	%	BIO	%	#/m^2	%	BIO	%
NMPW	1123	5	4.16	6	379	4	0.92	6	1943	35	5.52	35.6
NMPP	3322	14	12.50	18	1523	14	2.93	20	41	<1	0.12	1.1
FITZ.	12553	53	30.31	42	1457	14	2.17	15	2571	46	7.31	47.1
NMPE	6508	28	24.74	34	7245	68	8.38	58	971	18	2.58	16.6
TOTAL	23506		71.71		10604		14.40		5526		15.53	

* gms/m^2.

During June, 91.6% of the dipteran population was found at the 10 and 20 ft. stations (Table II-16); seventy-one percent of these populations were associated with the Cladophora. Abundance and biomass both decreased with depth.

TABLE II-16

DEPTH DISTRIBUTION OF DIPTERA

	JUNE				AUGUST				OCTOBER			
	#/m^2	%	BIO***	%	#/m^2	%	BIO.	%	#m/^{2}	%	BIO.	%
10C*	18115	77.1	51.39	71.7	-	-	-	-	-	-	-	-
10NC**	452	1.9	1.71	2.4	4514	42.6	4.45	30.9	335	6.1	0.706	4
20C	84	0.4	0.32	0.4	-	-	-	-	-	-	-	-
20NC	2864	12.2	10.78	15.0	1364	12.9	2.78	19.3	59	1.1	0.15	1.
30	1174	5.0	4.56	6.4	1298	12.2	1.60	11.1	242	4.4	0.69	4.
40	650	2.7	2.41	3.4	1977	18.6	3.18	22.1	243	4.4	0.69	4
60	167	0.7	0.62	0.9	1448	13.7	2.40	16.7	4647	84.1	13.29	85.
TOTAL	23506		71.71		10601		14.40		5526		15.53	

* Cladophora
** non-Cladophora
***gms/m^2.

Between June and August, a decrease in abundance was noted, the greater abundance and biomass again occurring at the shallow water stations. There was a marked increase in the abundance at stations deeper than 20 ft. The slower warming of the water at these deeper stations retarded the hatching or development of the larvae; movement from the shallower to deeper water by some species added to the numerical increase found during August.

During October, very few specimens were found at the shallower depths due to emergence and migration. Also, in each previous collection approximately 7% of the collections had been pupae; during October only larval forms were found. This suggests that the organisms represent species that either overwinter as larvae and emerge during the spring or spend more than one year in the aquatic environment. Ninety-one percent of the dipterans collected at 60 ft. (4212 specimens) were Chironomus sp. This same genus was found by Thut (1969) to be located at deeper depths (40-55m) in Lake Washington.

A much larger population of dipterans was found associated with Cladophora during the spring. The population declined as the abundance of Cladophora declined, suggesting that several species have life cycles coinciding with the growth of this filamentous alga.

(xiii) Others

Organisms such as Trichoptera, Ephemeroptera and Hirudinea were found in such low concentrations that their distributional patterns could not be described.

Of the Hirudinea collected, Helobdella stagnalis, was found only during June. The common name for this organism is "snail leech," since it is parasitic on gastropods.

b. Seasonal Abundance

Seasonal trends in organism abundance, biomass and comparisons of seasonal totals enables broad generalizations about the benthic community. The total number of specimens for the three collection dates is given in Table II-17.

TABLE II-17

SEASONAL ABUNDANCE BY TRANSECT

	JUNE		AUGUST		OCTOBER		TOTAL	
	$\#/m^2$	%	$\#/m^2$	%	$\#/m^2$	%	$\#/m^2$	%
NMPW	7463	5	11949	11	21924	28	41336	12
NMPP	35063	22	10009	9	7665	10	52737	15
FITZ	68680	43	32386	29	20495	26	121561	35
NMPE	48473	30	55823	51	28349	36	132645	38
TOTAL	159673		110167		78433		348279	

The greatest overall concentration was found at FITZ and NMPE. The substrate at these two transects is sand-silt, which offers a wide variety of benthic ecological niches. The plant transect, NMPP, had an abundant faunal assemblage in the spring, but was the lowest

during the summer and fall. The warmer water from the NMP discharge could accelerate growth during the early months following the cold winter period (Markowski, 1960). The low summer and low fall abundance could possibly be due to avoidance of the warmer water area by summer organisms normally found during the warmer summer period in temperate lakes.

There appears to be a seasonal shift in abundance from NMPE and FITZ to the NMPW transect. This shift in numbers could be due to different communities at the two locations, the eastern transects having a community with a similar substrate preference and a spring-summer development and maturation cycle. The west transect would have a fauna preferring more bedrock and rubble, reaching greatest abundance during the fall.

The total transect biomass (Table II-18) followed the same pattern as numerical abundance.

TABLE II-18

SEASONAL BIOMASS BY TRANSECT

	JUNE		AUGUST		OCTOBER		TOTAL	
	Biomass*	%	Biomass*	%	Biomass*	%	Biomass*	%
NMPW	26.69	9	15.80	7	76.57	33	119.06	16
NMPP	69.33	23	31.49	15	20.93	9	121.75	17
FITZ	115.39	38	71.54	34	60.86	26	247.79	33
NMPE	91.51	30	90.97	44	70.66	31	253.14	34
TOTAL	302.92		209.80		229.02		741.74	

* Biomass in grams/m^2.

Cladophora samples from 10 ft. during June (Table II-19) were the highest in percent of total organisms collected. Stations at 30 ft. were next in abundance on a total survey basis. Except for Cladophora samples, the deeper stations (30, 40, 60 ft.) had more organisms than the more shallow, littoral stations. The abundance percentage at the deeper stations increased throughout the study, pointing to the migration of organisms from the littoral to the sub-littoral and profundal waters in preparation for the winter period, as well as emergence of some organisms normally found in the littoral zone (Neess and Dugdale, 1959; Ross, 1965).

TABLE II-19

SEASONAL ABUNDANCE BY STATION

	JUNE		AUGUST		OCTOBER		TOTAL	
	$\#/m^2$	%	$\#/m^2$	%	$\#/m^2$	%	$\#/m^2$	%
10C*	96682	60.3	-	-	-	-	96682	27.7
10NC**	3527	2.2	30973	27.9	20052	25.6	54552	15.6
20C	1657	1.0	-	-	-	-	1657	0.5
20NC	6853	4.3	19506	17.6	9713	12.4	36072	10.3
30	10480	6.5	35260	31.8	12953	16.5	58693	16.8
40	25231	15.7	14073	12.7	10078	12.9	49382	14.1
60	15896	9.9	11204	10.1	25525	32.6	52625	15.1
TOTAL	160326		111016		78321		349663	

* C = Cladophora sample
** NC = Non-Cladophora sample

More organisms were collected during June, mainly due to the large numbers found associated with Cladophora. Dipterans and amphipods dominated the June samples. The decline during August, although not great, was probably due to emergence of midge larvae and avoidance of warmer water by such

groups as Tricladida. The decline in abundance during the fall was due to emergence, migration and normal seasonal cycles for many organisms at the beginning of the quiescent (overwintering) period.

Biomass data by depth (Table II-20) suggests that the 10 ft. station with and without Cladophora had the greatest biomass. Twenty ft. stations had the least biomass with the sub-littoral stations showing an increase. Again the 30 ft. station had a high value compared to the other depths.

TABLE II-20

SEASONAL BIOMASS BY STATION

	JUNE		AUGUST		OCTOBER		TOTAL	
	BIOMASS*	%	BIOMASS*	%	BIOMASS*	%	BIOMASS*	%
10C	168.33	55.7	-	-	-	-	168.33	22.7
10NC	17.97	5.9	46.85	22.3	97.703	42.7	162.53	21.9
20C	1.88	0.4	-	-	-	-	1.88	0.2
20NC	13.26	4.4	27.36	13.0	24.759	10.8	65.39	8.8
30	39.62	13.1	58.99	28.1	34.972	15.3	133.59	18.0
40	22.66	7.5	38.94	18.6	22.148	9.7	83.759	11.3
60	39.04	12.9	37.64	17.9	49.440	21.6	126.13	17.0
TOTAL	302.75		209.78		229.022		741.609	

* in gms/m^2.

This is a further indication that optimum conditions for the growth and development of a large percentage of organisms collected are found at 30 ft.

c. Percent Composition

The organisms collected during 1973 benthic sampling at Nine Mile Point were divided into five taxonomic categories, and the percent composition

of the total each category comprised was calculated. The calculations were completed for each station by transect and date for both abundance and biomass. The five categories were Arthropoda, Annelida, Insecta, Mollusca and Others. Composition of the categories was:

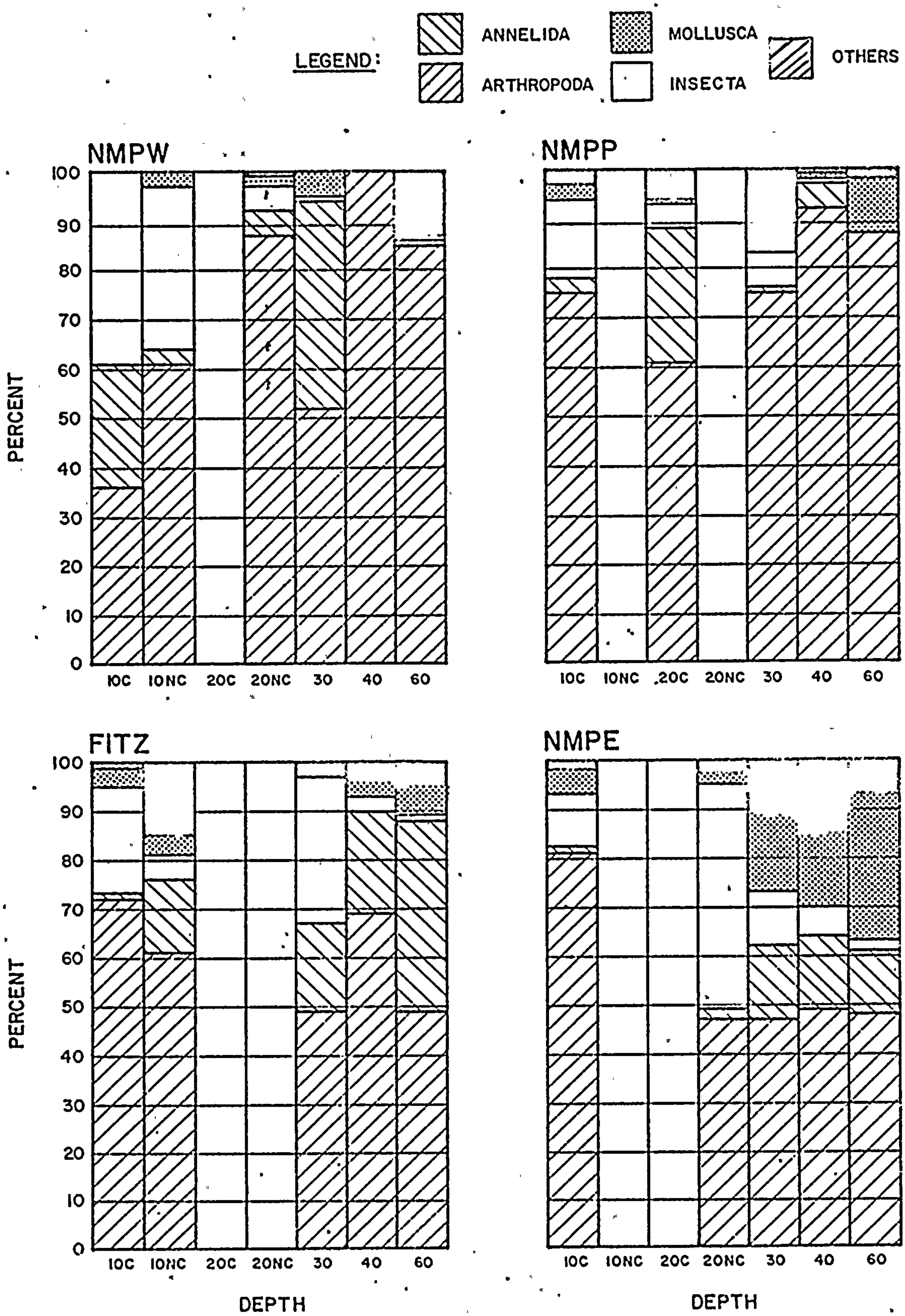
1. Arthropoda: Amphipoda, Podocopa, Acarina, Isopoda, Decapoda
2. Annelida: Oligochaetea, Polychaeta, Hirudinea
3. Insecta: Diptera, Ephemeroptera, Trichoptera
4. Mollusca: Gastropoda, Pelecypoda
5. Others: Nemata, Turbellaria

The categories were not phylogenetically selected: for example, Insecta is a class within the Phylum Arthropoda. The Arthropoda are primarily crustaceans, except for the aquatic mites of the Order Acari. They do, however, reflect taxonomic groups that have a major influence on the total abundance and biomass.

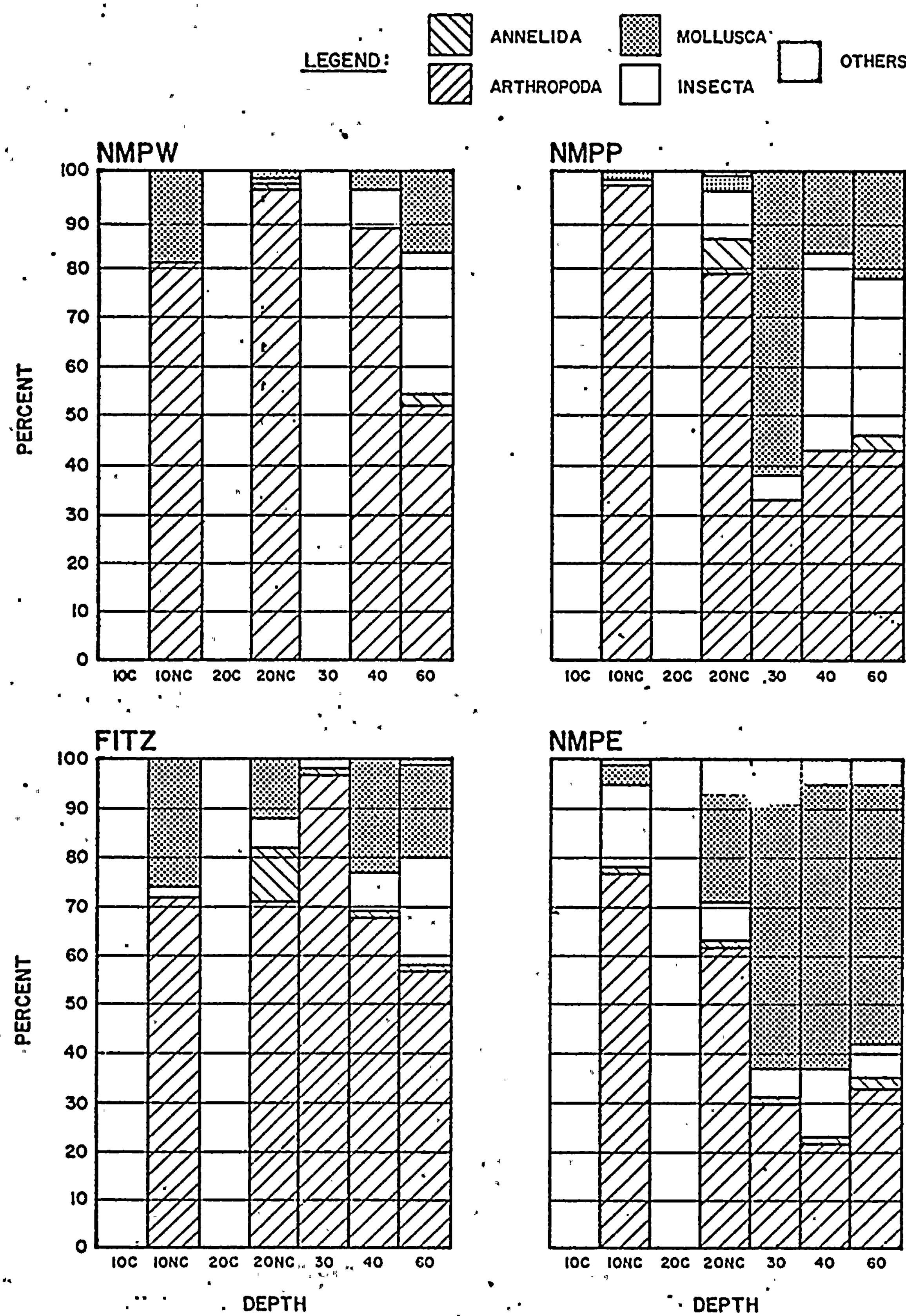
Percent composition for total numbers collected is presented graphically in Figures II-2, II-3 and II-4. Total biomass percent composition are presented in Figures II-5, II-6 and II-7.

Samples collected during June were dominated by the Arthropoda. Within this category the important fish food items, amphipods, composed 73% of the group. At NMPW and NMPP the arthropods were found in great abundance at all stations. The shallow water stations at NMPE and FITZ were high in arthropods; however abundance declined with depth. This

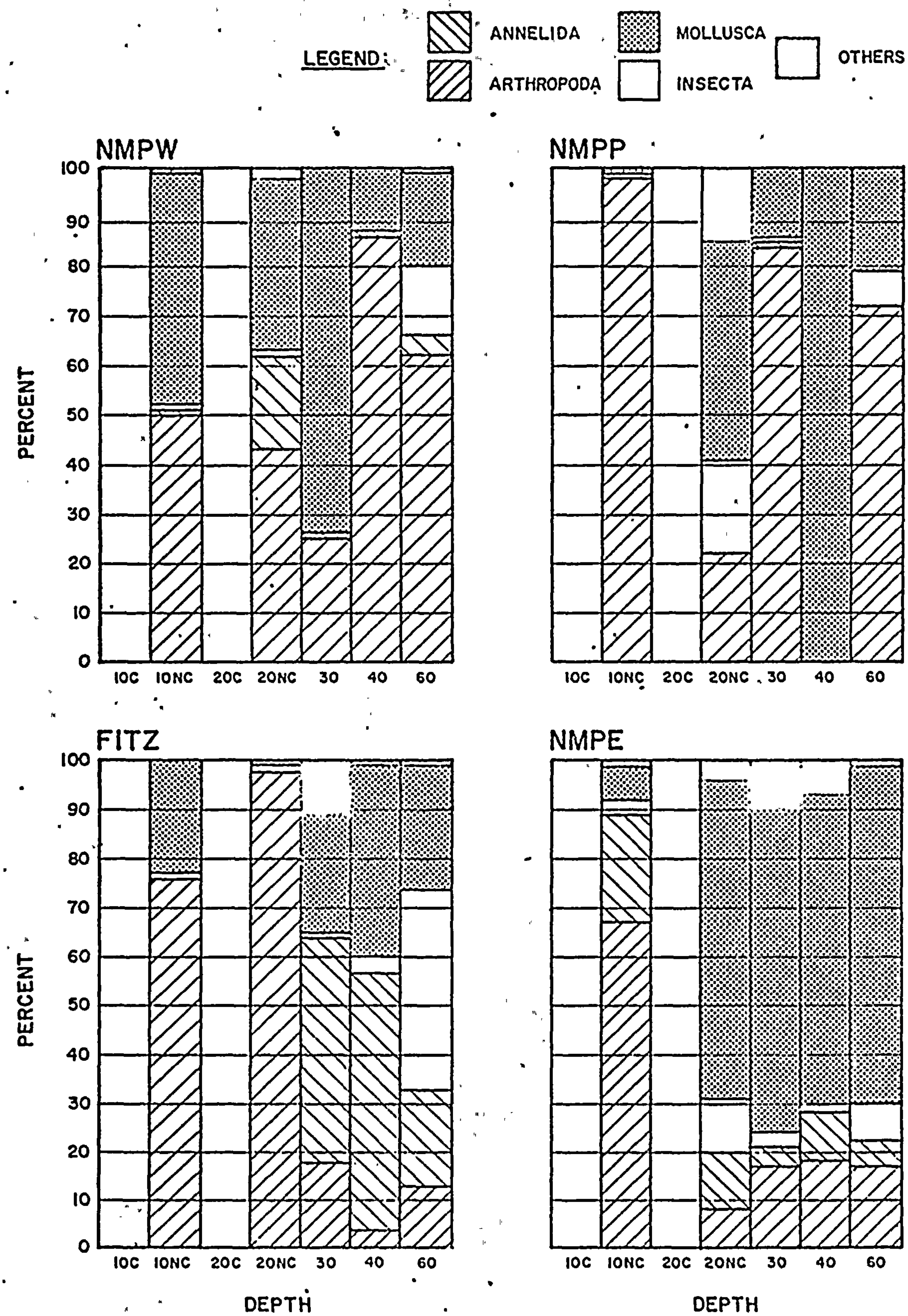
NINE MILE POINT ECOLOGICAL SURVEY
BENTHOS: PERCENT OF TOTAL NUMBER AT EACH TRANSECT BY DATE
JUNE, 1973



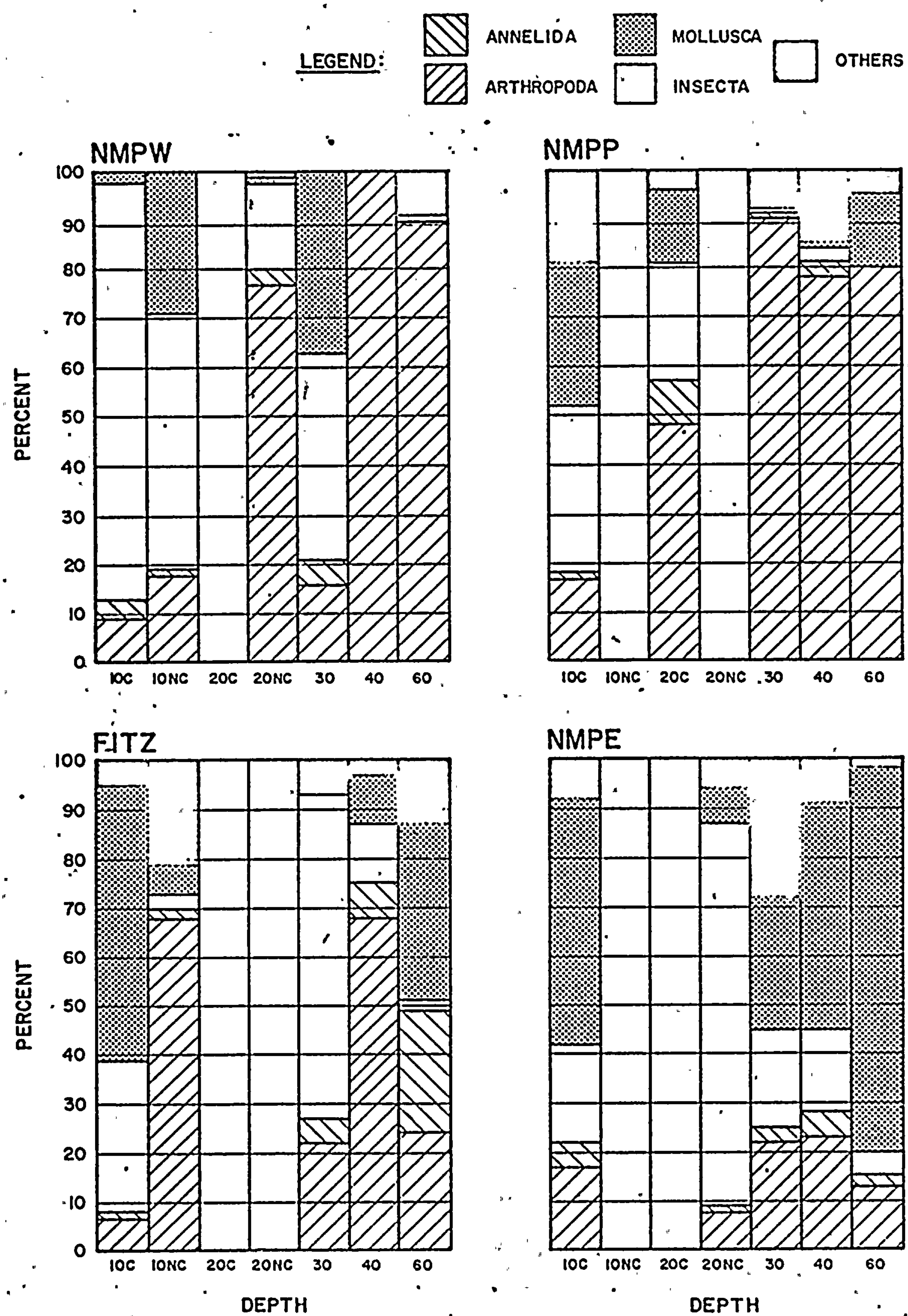
NINE MILE POINT ECOLOGICAL SURVEY
BENTHOS: PERCENT OF TOTAL NUMBER AT EACH TRANSECT BY DATE
AUGUST, 1973



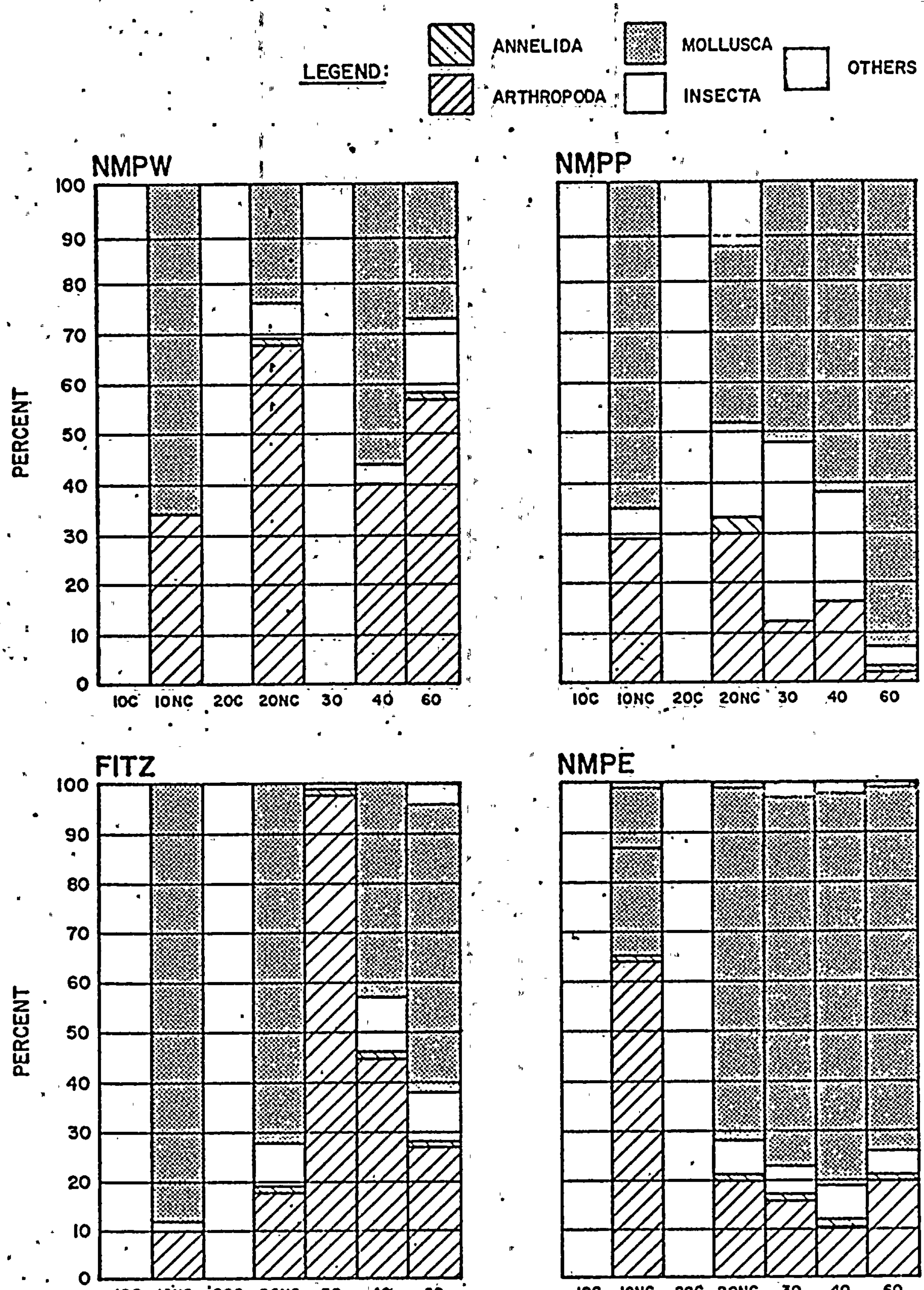
NINE MILE POINT ECOLOGICAL SURVEY
BENTHOS : PERCENT OF TOTAL NUMBER AT
EACH TRANSECT BY DATE
OCTOBER, 1973



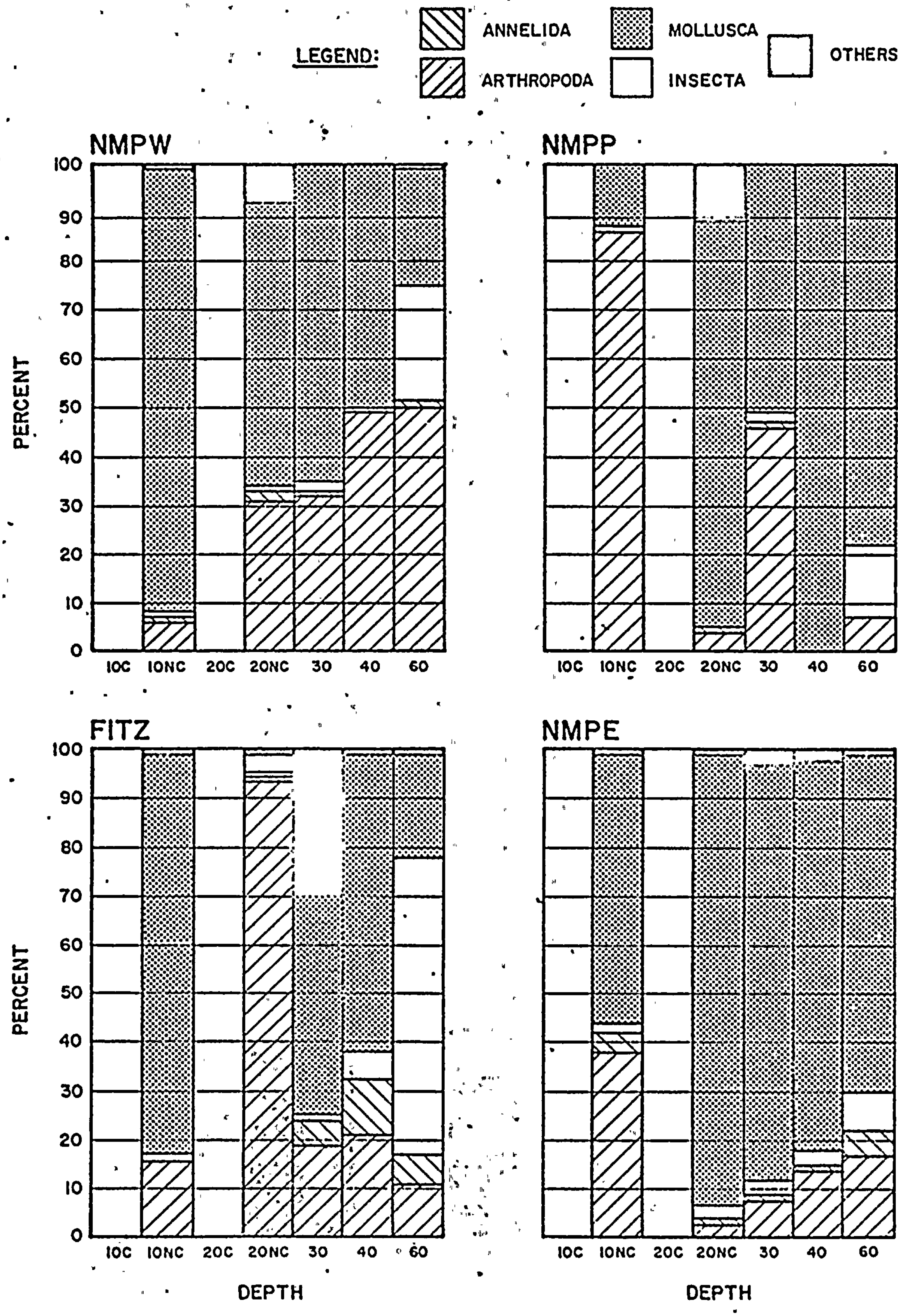
NINE MILE POINT ECOLOGICAL SURVEY
BENTHOS: PERCENT COMPOSITION OF TOTAL BIOMASS AT EACH TRANSECT BY DATE
JUNE, 1973



NINE MILE POINT ECOLOGICAL SURVEY
BENTHOS: PERCENT COMPOSITION OF TOTAL BIOMASS AT EACH TRANSECT BY DATE
AUGUST, 1973



NINE MILE POINT ECOLOGICAL SURVEY
BENTHOS: PERCENT COMPOSITION OF TOTAL BIOMASS AT EACH TRANSECT BY DATE
OCTOBER, 1973



and arthopod biomass is much less than the numerical percentage (this is especially true for the arthropods), indicating that organisms of small individual weight, such as the Ostracoda, contribute heavily to the numerical abundance of this group.

During August, Arthropoda percentage composition was again dominant (Figure II-6), except at the sub-littoral stations at NMPE where molluscs were the major constituent. Percentage composition of dipterans was fairly constant at all stations with a slightly higher value at the 10 ft. station. NMPE was the only transect having a contribution from the "other" category; Nemata were found in small concentrations. The percentage composition of the Mollusca was much less at NMPW, NMPP and FITZ; however, there was a marked increase in numbers during August. This increase is consistent with a reproductive cycle initiated by warmer spring water temperatures. Dipteran population in comparison to the total collection declined at the shallow water stations, increasing at stations greater than 30 ft. The decline at the shallow stations is probably due to emergence of species during the spring and the concentration at deeper stations due to growth and development of summer-fall emerging species.

The difference between population abundance and population biomass to the trophic structure is further emphasized by the biomass percentage composition for August (Figure II-6). The major contributing group to the August biomass was Mollusca, especially at the deeper stations. Dipteran biomass was evident at all transects; however, the mid-depth stations at NMPP were

especially rich in this group. The higher biomass values at these stations is due in part to a high number of pupal forms, especially at the 20 ft. station. The biomass of annelids and members of the "other" category was negligible during August.

The percentage composition of the molluscs increased at all transects during October, becoming the dominant category at many stations. The highest percentage composition was found at NMPE; molluscs decreased in importance from east to west. Dipteran abundance became very patchy during October with the greatest percentage of dipterans found at the deepest stations. There was a sharp increase in the number of annelids (Oligochaeta) composing the community from August to October, especially at the sub-littoral stations of FITZ. This increase was due to a large number of immature Tubificidae. Depth differences were noted in the dominance of Arthropoda at NMPW, but only the shallow stations of NMPP, FITZ and NMPE were affected by changing concentrations of arthropods. With the decreased water temperature during October there was a subsequent increase in activity of Tricladida (Pennak, 1953); this is reflected in the number of "others" in the percentage composition.

Mollusca were the dominant group by weight during October (Figure II-7) at all transects and at all but four stations. The arthropod value was highest at the sub-littoral stations of NMPW, the 10 ft. station of NMPP, and the 20 ft. station of FITZ. Insecta were found in higher abundances only at the deepest water stations; they were the major biomass contributor at FITZ 60 ft. contour (Table II-16).

Observations based on abundance and biomass percentage composition suggest several distributional trends at Nine Mile Point. The spring abundance was dominated by Arthropoda, primarily amphipods; the dominance of arthropods declined during August and by October Mullusca are the dominant group. The Mollusca were increasingly abundant from east to west and from the deeper water stations to the shallow ones. Biomass percent composition followed the abundance patterns, arthropods being the main contributor to biomass during the spring and the Mollusca becoming the main group in the fall. The other groups showed seasonal abundance and growth; and this reflected in the respective percentage composition values for abundance and biomass.

3. COMMUNITY STRUCTURE

The interrelationship of biotic and abiotic factors determines, to a great extent, the assemblage of organisms in a given area or habitat (Ruttner, 1963; Odum, 1971). As environmental influences change there is usually a resultant change in the community structure (Cairns and Dickson, 1971; Fretwell, 1972). Determination of community structure and community changes in time and space may be used to evaluate environmental influences. As pointed out by Macan (1974), the community structure of aquatic ecosystems is not assessed easily. It requires extensive investigation to obtain adequate species inventories, not to mention a representative sampling of all species present at all locations.

a. Affinity Index

While discussing the dynamics of animal populations, Nicholson (1954) noted

that the mathematical method was not an alternative to observation and experimentation but was a supplemental tool to be used inferentially. One method of mathematically comparing animal communities is the affinity index based on a method proposed by Renkonken (see Kontkanen, 1957). This index expresses the "dominance affinity" of the species content in two samples as the sum of the lowest dominance values (percent) of every species common to both. The major drawback to this index is that a species in great abundance and possibly of less diagnostic significance has an exaggerated influence, making comparison of index values in some cases less significant.

The affinity index values from Nine Mile Point studies were arranged in a trellis diagram (see Figures II-8 to II-10) by transect from west to east. The trellis diagram arrangement was suggested by MacFayden (1963) as a meaningful way of displaying affinity data. In addition, for ease in interpreting the index values, the numbers were grouped into four categories and cross-hatching used to indicate groups of similar value.

An example of the affinity index calculation would be:

PERCENT COMPOSITION

Species	Sample A	Sample B	Dominance Value
Amphipoda	29	44	29
Gastropoda	3	5	3
Diptera	68	51	51

INDEX VALUE 83

NINE MILE POINT ECOLOGICAL SURVEY
AFFINITY INDEX
30 JUNE-2 JULY

	NMPW 10c	NMPW 10	NMPW 20	NMPW 30	NMPW 40	NMPW 60	NMPP 10c	NMPP 20c	NMPP 30	NMPP 40	NMPP 60	FITZ 10c	FITZ 10	FITZ 30	FITZ 40	FITZ 60	NMPE 10c	NMPE 20	NMPE 30	NMPE 40	NMPE 60
NMPW 10c																					
NMPW 10	55.7																				
NMPW 20	39.0	52.7																			
NMPW 30	28.0	22.5	47.6																		
NMPW 40	19.4	39.1	41.4	11.1																	
NMPW 60	24.5	36.5	41.9	28.2	35.7																
NMPP 10c	34.5	28.9	36.6	36.3	9.4	17.4															
NMPP 20c	38.9	37.1	54.1	44.0	24.8	31.2	45.4														
NMPP 30	27.9	16.6	36.6	33.9	12.8	30.3	71.3	45.1													
NMPP 40	22.1	44.5	44.7	15.5	89.8	38.1	13.3	29.1	13.9												
NMPP 60	17.1	51.7	48.3	23.2	73.9	49.6	8.8	26.0	11.9	77.1											
FITZ 10c	57.4	33.2	33.2	33.2	7.6	13.6	86.5	41.7	67.4	8.7	6.0										
FITZ 10	39.6	41.8	57.3	36.5	32.2	48.9	48.1	68.5	53.0	39.6	33.1	41.0									
FITZ 30	34.7	70.1	50.9	27.6	34.0	41.6	25.1	56.7	24.7	41.9	34.1	21.5	60.8								
FITZ 40	32.4	52.7	64.1	22.9	48.8	40.8	21.7	53.9	21.0	55.4	17.4	17.7	59.9	66.2							
FITZ 60	20.6	27.0	32.0	13.8	17.1	17.9	11.4	37.1	12.1	21.1	19.7	7.1	23.6	37.1	52.1						
NMPE 10c	35.2	26.1	38.1	37.3	11.7	18.2	83.9	45.6	72.1	13.7	11.0	29.9	45.6	25.4	22.3	12.4					
NMPE 20	43.7	59.0	53.5	38.4	22.4	31.2	39.0	51.7	35.0	27.6	25.0	36.0	49.5	70.8	39.0	24.5	40.3				
NMPE 30	27.2	56.6	48.9	12.6	41.4	37.2	14.3	44.6	14.3	46.5	47.3	8.7	49.8	54.6	71.0	44.1	14.3	39.9			
NMPE 40	20.4	55.9	51.7	11.1	35.5	31.3	9.4	43.6	8.4	39.7	39.5	5.6	43.1	48.8	69.7	51.5	10.1	29.5	78.1		
NMPE 60	21.8	36.2	40.6	13.1	24.6	24.6	10.5	39.7	10.2	22.1	34.3	6.3	39.4	42.4	68.5	62.4	11.1	28.4	60.4	67.0	

5.6 - 21.1 (blank) 21.2 - 42.3 (hatched \\) 42.4- 63.5 (hatched //) 63.6 - 89.9 (cross-hatched)

NINE MILE POINT ECOLOGICAL SURVEY
AFFINITY INDEX
30 AUGUST 1973

	NMPW 10	NMPW 20	NMPW 30	NMPW 40	NMPW 60	NMPP 10	NMPP 20	NMPP 30	NMPP 40	NMPP 60	FITZ 10	FITZ 20	FITZ 30	FITZ 40	FITZ 60	NMPE 10	NMPE 20	NMPE 30	NMPE 40
NMPW 10																			
NMPW 20	82.3																		
NMPW 30	6.9	1.7																	
NMPW 40	25.1	21.8	11.5																
NMPW 60	19.9	17.9	5.7	40.9															
NMPP 10	74.8	74.9	2.1	24.7	33.3														
NMPP 20	57.7	57.4	6.0	40.9	44.0	65.7													
NMPP 30	33.1	29.4	39.2	46.4	39.1	33.1	53.4												
NMPP 40	15.7	9.8	13.8	38.6	50.2	33.3	40.5	15.3											
NMPP 60	17.2	12.8	11.4	35.2	45.5	35.2	12.1	10.9	53.8										
FITZ 10	84.9	70.1	9.1	29.5	21.5	70.7	57.3	38.7	20.7	18.0									
FITZ 20	43.3	37.2	12.1	39.0	41.1	38.1	55.1	58.2	38.7	18.1	15.4								
FITZ 30	81.8	93.7	1.2	21.7	19.7	75.4	58.1	30.0	10.8	13.7	70.8	39.3							
FITZ 40	37.2	33.0	4.8	35.8	42.3	40.1	60.7	18.5	32.9	37.0	38.8	53.8	41.0						
FITZ 60	9.6	9.4	5.8	26.0	40.2	14.2	32.2	29.7	35.7	35.1	11.3	30.5	12.9	62.1					
NMPE 10	70.0	69.9	5.8	31.2	29.7	69.7	68.3	41.2	21.4	22.8	73.5	49.2	68.8	47.3	19.9				
NMPE 20	14.3	11.8	17.5	25.0	37.5	11.1	30.2	38.5	38.2	30.5	15.3	51.5	13.3	40.3	16.7	24.4			
NMPE 30	13.1	12.9	18.5	26.2	35.6	17.6	29.8	44.7	18.9	52.2	14.6	29.1	16.7	48.8	48.3	23.3	49.2		
NMPE 40	12.1	11.8	22.0	15.8	24.9	13.2	17.4	35.7	18.1	21.3	14.4	20.5	14.6	47.3	44.9	16.7	38.8	79.6	
NMPE 60	10.2	9.7	7.8	17.3	26.4	15.7	21.8	23.3	24.9	25.7	11.6	16.6	12.3	52.6	69.0	12.9	37.0	57.1	59.2

1.2 - 23.1   23.2 - 46.2   46.3 - 79.3   79.4 - 93 .7

NINE MILE POINT ECOLOGICAL SURVEY
AFFINITY INDEX
23-24 OCTOBER 1973

	NMPW 10	NMPW 20	NMPW 30	NMPW 40	NMPW 60	NMPP 10	NMPP 20	NMPP 30	NMPP 40	NMPP 60	FITZ 10	FITZ 20	FITZ 30	FITZ 40	FITZ 60	NMPE 10	NMPE 20	NMPE 30	NMPE 40	NMPE 60
NMPW 10																				
NMPW 20	44.7																			
NMPW 30	18.0	62.9																		
NMPW 40	69.6	57.7	30.1																	
NMPW 60	32.6	35.7	16.4	36.4																
NMPP 10	69.5	41.9	14.5	80.2	32.4															
NMPP 20	75.2	44.9	17.9	80.7	32.5	91.2														
NMPP 30	75.0	47.6	20.0	83.8	33.1	90.9	94.2													
NMPP 40	28.8	32.5	36.7	29.3	21.2	22.1	29.5	25.5												
NMPP 60	17.1	8.5	20.6	13.8	38.5	7.0	13.3	13.3	45.7											
FITZ 10	77.7	13.4	17.0	81.8	32.1	86.6	93.7	92.8	28.7	16.3										
FITZ 20	69.6	42.3	15.2	80.5	32.3	97.9	90.8	87.7	21.0	7.0	87.1									
FITZ 30	38.6	45.9	30.0	41.3	45.8	32.5	39.3	41.0	44.0	20.2	38.5	32.5								
FITZ 40	5.1	7.5	5.5	6.5	29.1	5.1	4.9	5.1	5.1	5.2	4.9	5.1	30.1							
FITZ 60	1.7	4.8	3.0	5.9	46.6	1.7	1.6	1.9	1.8	17.3	1.4	1.5	26.7	56.8						
NMPE 10	62.9	60.1	37.3	59.6	38.3	57.7	60.5	60.1	25.4	10.5	62.0	58.0	41.8	12.0	7.7					
NMPE 20	29.9	38.1	22.0	39.1	45.7	38.9	28.3	31.7	28.5	9.7	28.1	28.5	53.0	25.9	26.8	36.1				
NMPE 30	5.9	26.2	24.0	20.9	28.4	6.0	5.9	8.5	13.0	11.0	6.0	5.9	23.8	26.4	25.5	13.7	32.5			
NMPE 40	4.9	7.9	5.9	8.8	42.4	4.6	4.8	5.1	6.5	18.5	4.4	4.5	27.6	39.7	45.7	11.4	40.2	63.1		
NMPE 60	11.1	19.2	17.0	19.8	49.8	10.9	11.2	14.4	16.8	17.3	11.0	10.8	33.5	50.4	50.6	18.3	42.4	49.3	51.8	

1.5 - 24.1 (blank) 24.2 - 48.2 (hatched \\\) 48.3 - 72.3 (hatched ///) 72.4 - 97.9 (cross-hatched)

If values ranged form 23 to 98 and four categories were used in the cross hatching, this value would be in the highest affinity group indicating two samples that are very similar. Three diagrams representing the 30 June - 2 July, 29-31 August and 23-24 October collections are presented in Figures II-8, II-9 and II-10, respectively.

The spring collection (30 June - 2 July, Figure II-8) encompassed the growth period of Cladophora in the littoral zone. Plant and algal growth of the type found during this sampling have been reported to affect abundance and growth of certain animal populations (Nicholson, 1954; Markowski, 1960; Storr, 1972). Substrate type and algal growth permitted comparative samples of Cladophora and non-Cladophora benthic areas to be collected at the 10 ft. stations at the NMPW and FITZ transects. It was found that the algal mat community and the normal substrate community at each comparative station were not similar. All Cladophora samples, except those at NMPW from the 10 ft. station were similar showing that the alga has its own associated populations different from the underlying substrate

In general, during the spring, sub-littoral stations at 40 and 60 ft. had similar communities which were different from the littoral stations which had similar communities. The littoral area is defined as that portion of the shoreward profile inhabited by autotrophic plants. The sub-littoral area is an area below the littoral zone and not having autotrophic plants (Ruttner, 1963). In general, the littoral area for this report would have Cladophora growth during June and the sub-littoral area would not have this growth. Table II-21 gives the surface and bottom temperature at the

TABLE II-21

NINE MILE POINT ECOLOGICAL SURVEY

Lake Temperature Values (^{o}C)
Corresponding to Benthic Collections

2 July 1973

Transect	West	Plant	East
Station Depth			
20S	21.8	22.8	20.0
25B	16.0	18.2	16.8
40S	21.5	22.9	20.0
45B	8.5	9.2	9.0
50S	21.8	23.9	20.7
50B	7.4	8.1	7.9
100S	21.5	21.1	21.1
100B	5.2	5.2	5.0

27 August 1973

Transect	West	Plant	East
Station Depth			
20S	28.5	26.5	23.1
20B	23.4	23.4	22.8
40S	23.1	-	-
40B	19.0	-	-
50S	23.0	25.5	23.0
50B	17.5	17.9	16.0
100S	23.0	23.0	23.0
100B	12.8	12.2	13.0

22 October 1973

Transect	West	Plant	East
Station Depth			
20S	11.9	11.5	11.3
20B	11.2	11.4	11.2
40S	12.0	11.7	11.6
40B	11.6	11.5	11.4
50S	12.0	11.8	11.6
50B	11.7	11.5	11.4
100S	12.0	11.9	11.7
100B	11.8	11.8	11.0

S = Surface

B = Bottom

collection times. During the period of spring sampling, a much lower temperature was noted at the bottom between the littoral and sub-littoral stations. This thermal bar could explain the community difference between the shallower and deeper stations.

In August the affinity values showed the populations to be more diverse in composition. Littoral - sub-littoral differences in community structure existed, but were not as pronounced as in the June collections. During this time of year in temperate areas, seasonal reproduction, growth and migration from deeper waters to the shore areas (Ruttner, 1963) results in this diverse community structure. Transitory substrates, such as emergent plants, decreased light penetration due to algae and/or turbidity are environmental influences affecting the community during this time. Temperature (Table II-21) at the study depths is not felt to be a limiting factor during this period, since it is within the general range acceptable for most aquatic organisms (Pennak, 1953; Odum, 1971; Macan, 1974). Another factor contributing to the greater affinity index value for the littoral stations is an increase in fauna, including the mayflies and caddisflies which have one form adapted for aquatic life and a second stage which is terrestrial (Macan, 1974).

The greatest affinity occurred during the spring and summer values in the littoral zone and along the eastern transects. During October, the littoral zone again showed high affinity values; however, the transect affinity was greatest for NMPW, NMPP, and FITZ transects to a depth of 60 ft. Communities at the sub-littoral stations did not have high affinity values, probably

because of their transient community structure. The temperature at all stations at this time show homothermy, which would not affect differences in community structure.

b. Species Diversity

Community structure analysis is one of the most reliable, available biological methods for documenting environmental change. This is primarily because it necessitates few assumptions (McErlean *et al.*, 1972). Indices of diversity reduce the number of parameters that determine community structure to a common scale (Sager and Hasler, 1969). This common scale can then be used to compare areas where differences are not obvious. The diversity index used to compare the community structure was the Shannon-Weaver formula based on the information theory approach of Margalef (Pielou, 1966; Wilhm and Dorris, 1966; Harkins and Austin, 1973). The formula for this analysis is:

$$H' = -\Sigma p_i \log p_i,$$

where p_i is estimated from n_i/N and the log of p_i is to $base_2$. The ratio n_i/N is the number of specimens in a population (n_i) to the number of species (N) in the community.

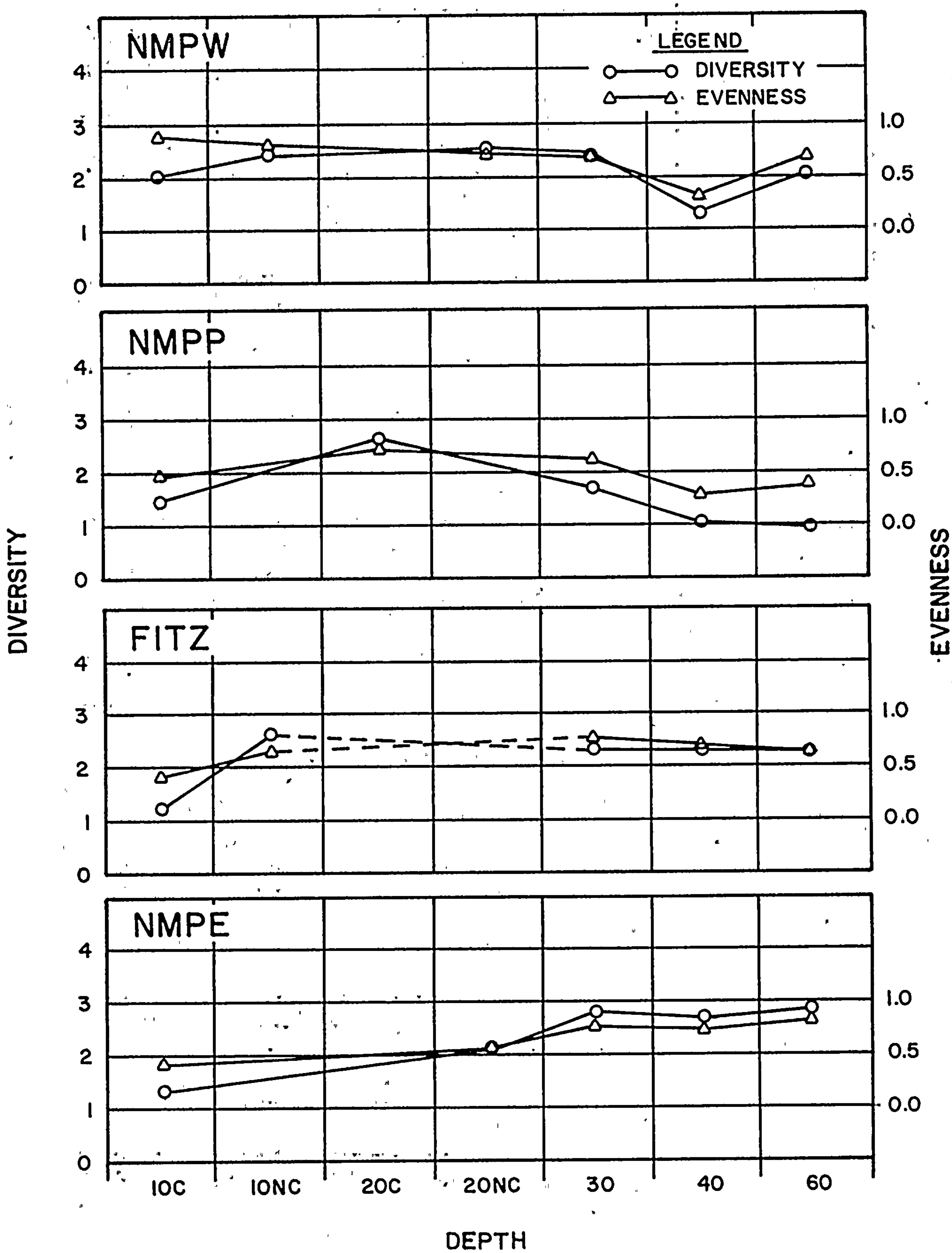
A second comparison used in conjunction with diversity was a measure of evenness which is a comparison of diversity as measured by total species and by diversity measured by some other statistic (Dahlberg and Odum, 1970; Hill, 1973). The other is H_{max} in which diversity is calculated based on

even distribution of the individuals within the available species. The diversity index was calculated for both abundance of specimens and biomass. Wilhm (1968) reported a more realistic index based on weight, because biomass units are more closely associated with ecological energetics.

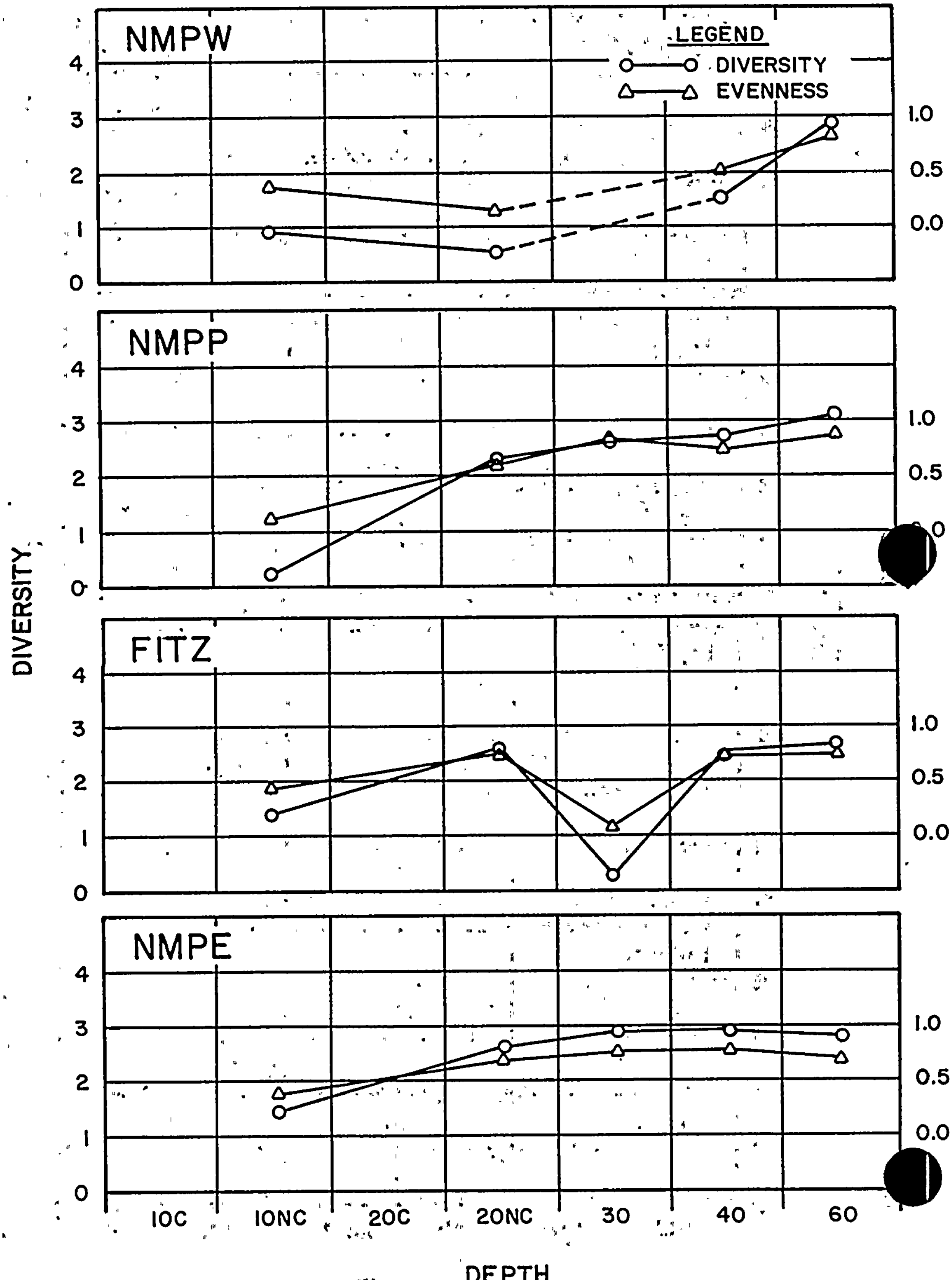
Figures II-11, II-12, and II-13 give the diversity and evenness values based on abundance for the four transects by date. A value of one on the evenness scale indicates that the individuals are evenly distributed through the species collected, whereas lower evenness values represent dominance of the collection by one or more species. Diversity index values range from 0 to reported highs of greater than 10 (Wilhm, 1970). A diverse population usually indicates that all or most of the available niches are occupied. If more niches are occupied, a more efficient flow of the available energy and a more stable environment usually results (Odum, 1971).

During June, two comparable samples from 10 ft. stations at NMPW and EITZ (a Cladophora and a non-Cladophora sample) showed that the non-Cladophora sample in each case had a higher diversity, indicating a more restricted assemblage of organisms associated with the Cladophora. Since Cladophora is a transitory substrate, the associated organisms must of necessity be adapted to a restricted growth cycle. Evenness values indicate that the few niches available in this substrate are filled. The numerical dominance found for amphipods apparently does not limit the growth of several other species. The NMPP 20 ft. sample was a Cladophora sample;

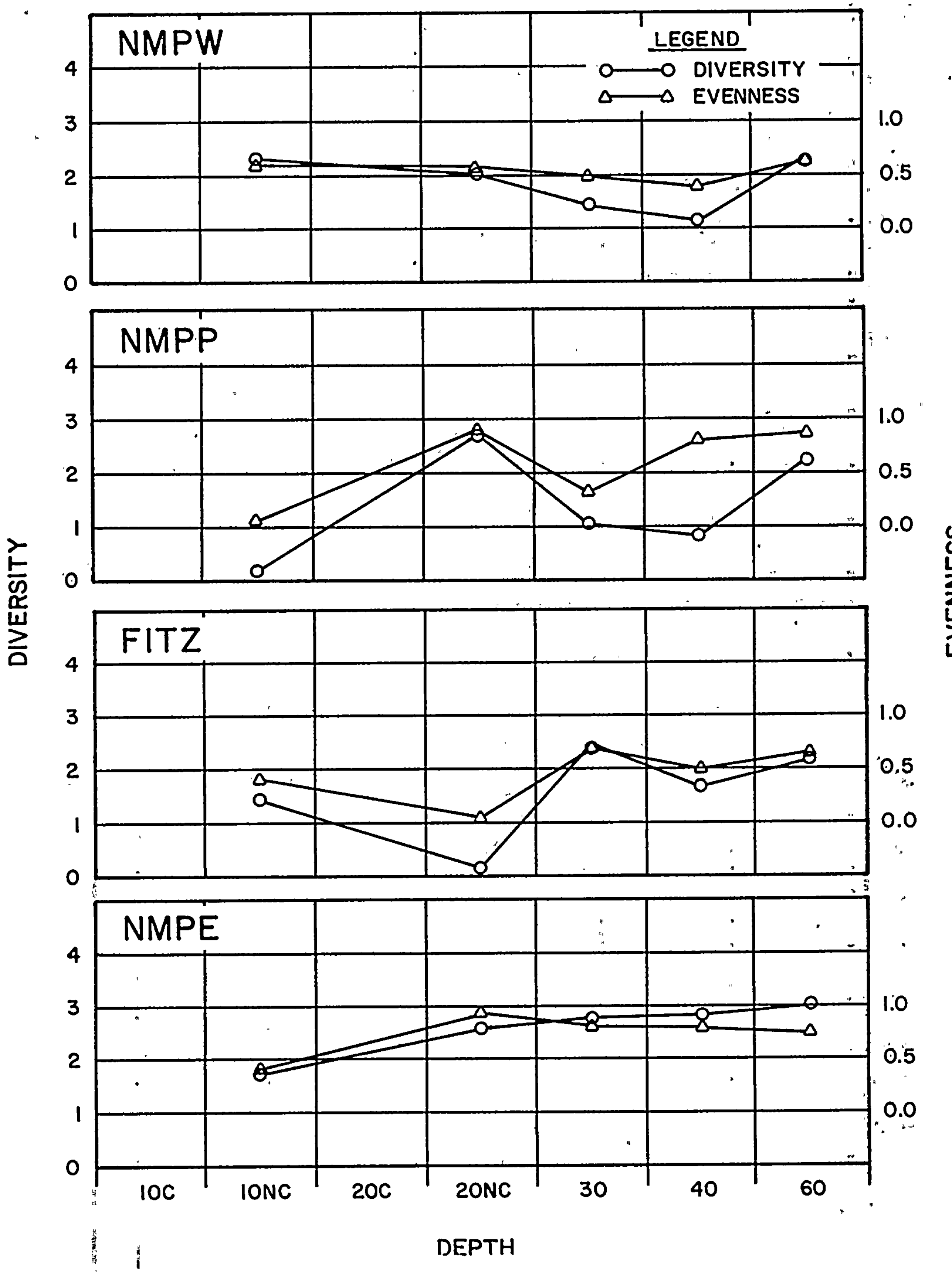
NINE MILE POINT ECOLOGICAL SURVEY
SPECIES DIVERSITY AND EVENNESS
30 JUNE, 1973



NINE MILE POINT ECOLOGICAL SURVEY
SPECIES DIVERSITY AND EVENNESS
31 AUGUST, 1973



NINE MILE POINT ECOLOGICAL SURVEY
SPECIES DIVERSITY AND EVENNESS
24 OCTOBER, 1973



there were no other comparable samples collected. The Cladophora samp at this depth appeared to be more diverse than non-Cladophora samples, which is the inverse of the condition found at the 10 ft. stations.

Except for NMPP, diversity values for June were lower at the shore stations and increased with depth to 30 ft. The values remained fairly constant at 40 and 60 ft. for the two eastern transects, while declining at the two western transects. The spring population represented by the June 1973 collection is usually composed of a few species undergoing rapid growth (Ruttner, 1963). The shore area undergoes rapid temperature changes; because it is shallower it warms faster. This permits the nearshore community to grow rapidly in comparison to deeper water areas. Since this shallow area usually has a smaller species representation due to wave action, water level fluctuations and rapid temperature changes (Judd an Gemmel, 1971) diversity is low; an increase in diversity with depth was expected. Evenness values showed that the shore zone (except at NMPW) has a fauna dominated by a few species. The population distribution increased with depth forming a very stable community for NMPE and FITZ, and less stable communities at the two western transects. This is probably substrate associated, since the sand-silt of the two eastern transects would permit a stable infauna community.

Diversity values during August (Figure II-12) showed a wide range of values. The NMPE transect had a low diversity value with slight dominance at 10 ft. which generally became more diverse (diversity at the sub-littoral stations decreased slightly at 60 ft.). The same general trend was noted for

NMPP; however, the most diverse community at this transect was found at 60 ft. The general trend of increasing diversity with depth indicated more stable ecological conditions at the deeper stations.

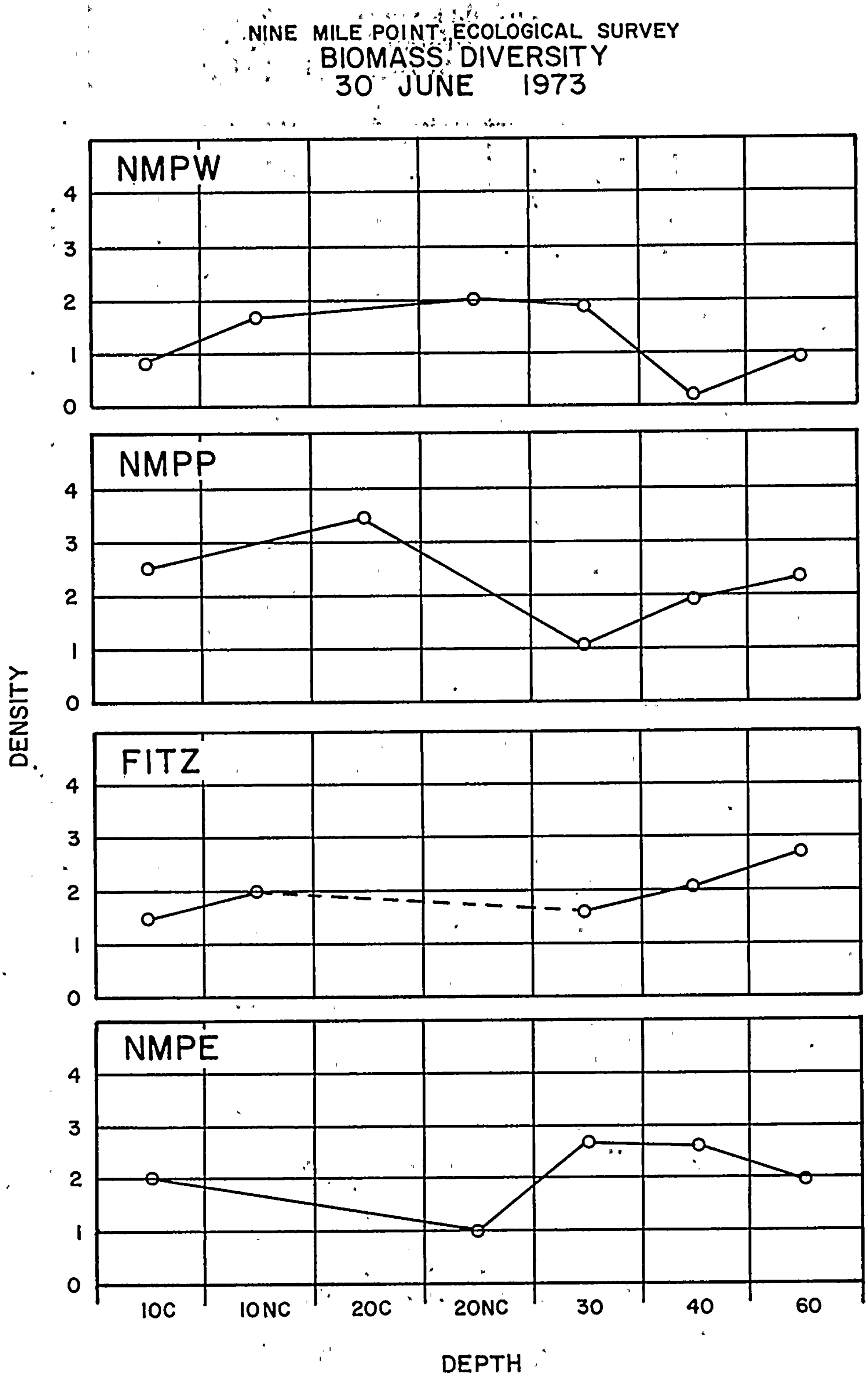
NMPE transect had the same diversity pattern during October and August. FITZ-20 ft. showed a decline in diversity, while the 30 ft. station became more diverse than during August. This was due to a decrease in annelids and gastropods at 20 ft. and subsequent increase of the two at 30 ft. Both organisms are known to migrate to deeper waters during the colder months (Pennak, 1953; Johnson and Matheson, 1969) which could account for the changes at the 20 ft. station. The NMPP transect had a very low diversity at 10 ft. possibly due to avoidance of the warmer water in this area by the majority of species, since evenness was also very low. The reduction of the number of molluscs and insects from the 30 ft. station, accounted for the change in diversity during this time, possibly due to migration and to emergence.

The diversity pattern based on abundance suggests a benthic community changing with time and depth. During June the community structure was diverse at all stations, showing a slight increase in depth at NMPE and FITZ and a decrease at NMPP and NMPW. The shore area was dominated by a thick growth of Cladophora which resulted in high abundance of organisms with cyclic species composition. August diversity showed a general increase with depth; the shallow 10 ft. stations were the least diverse, except for FITZ-30 ft. which was dominated by Gammarus fasciatus. During October, flucuations in diversity and evenness suggested a community under-

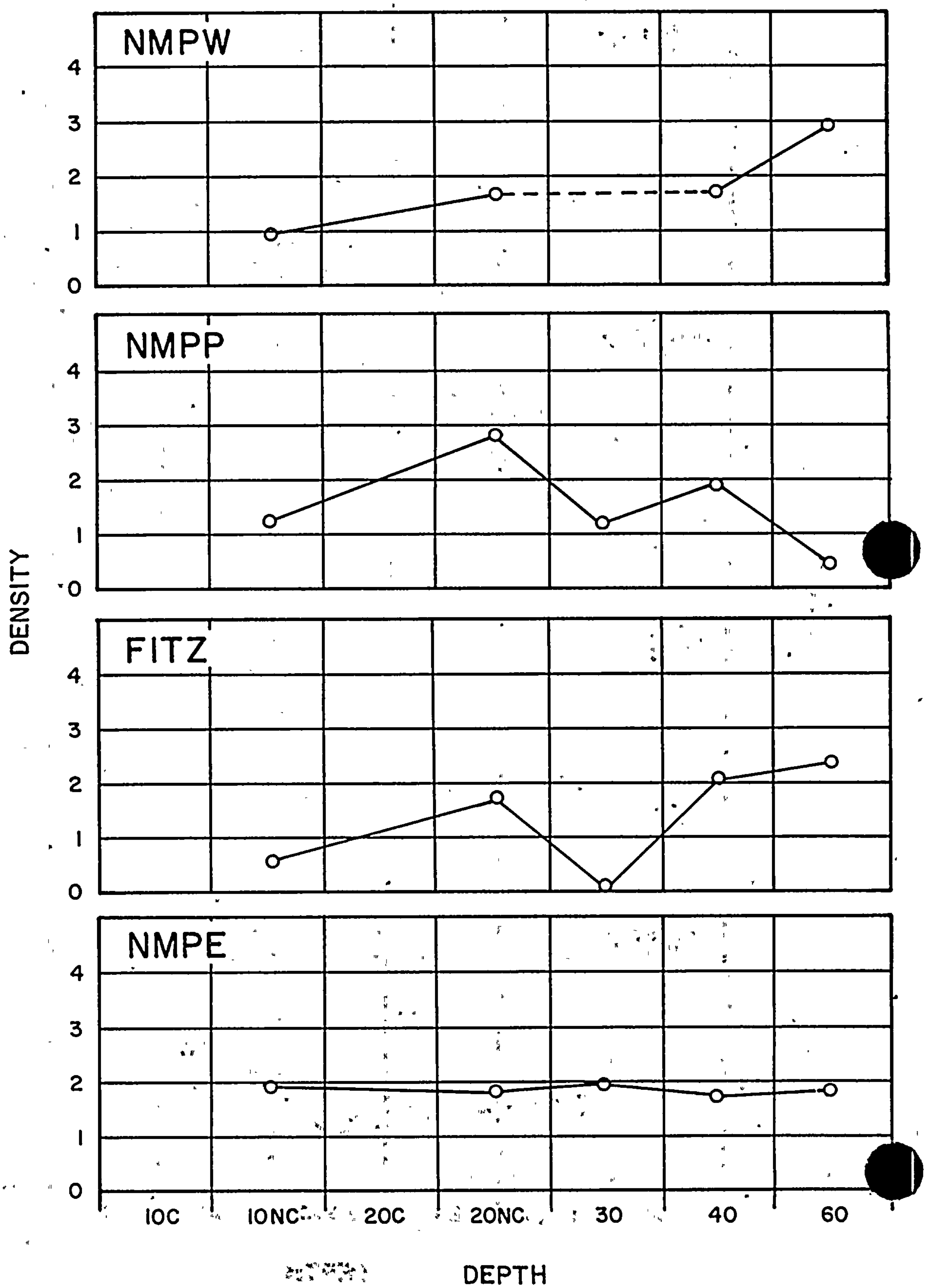
going change, probably associated with changes in temperature. The greatest diversity was found at NMPP-20 ft., possibly due to the warmer discharge water. The population became more even with depth, but the diversity value indicated fewer species composing the faunal assemblages.

Diversity based on benthic biomass is presented in Figures II-14, II-15 and II-16. Biomass diversity during June shows a higher biomass associated with the non-Cladophora sample at 10 ft., but a possibly greater association at 20 ft. For the two western transects the biomass diversity increased with depth beyond 20 ft. with a slight drop at 60 ft. on NMPE transect. NMPP transect had lower biomass diversity at 30 ft.; NMPW had a lower biomass diversity at 40 ft.. At NMPP 40 ft., ostracods were the dominant forms, occupying most of the available niches and decreasing the diversity. NMPP 20 ft. was more diverse and was dominated by amphipods.

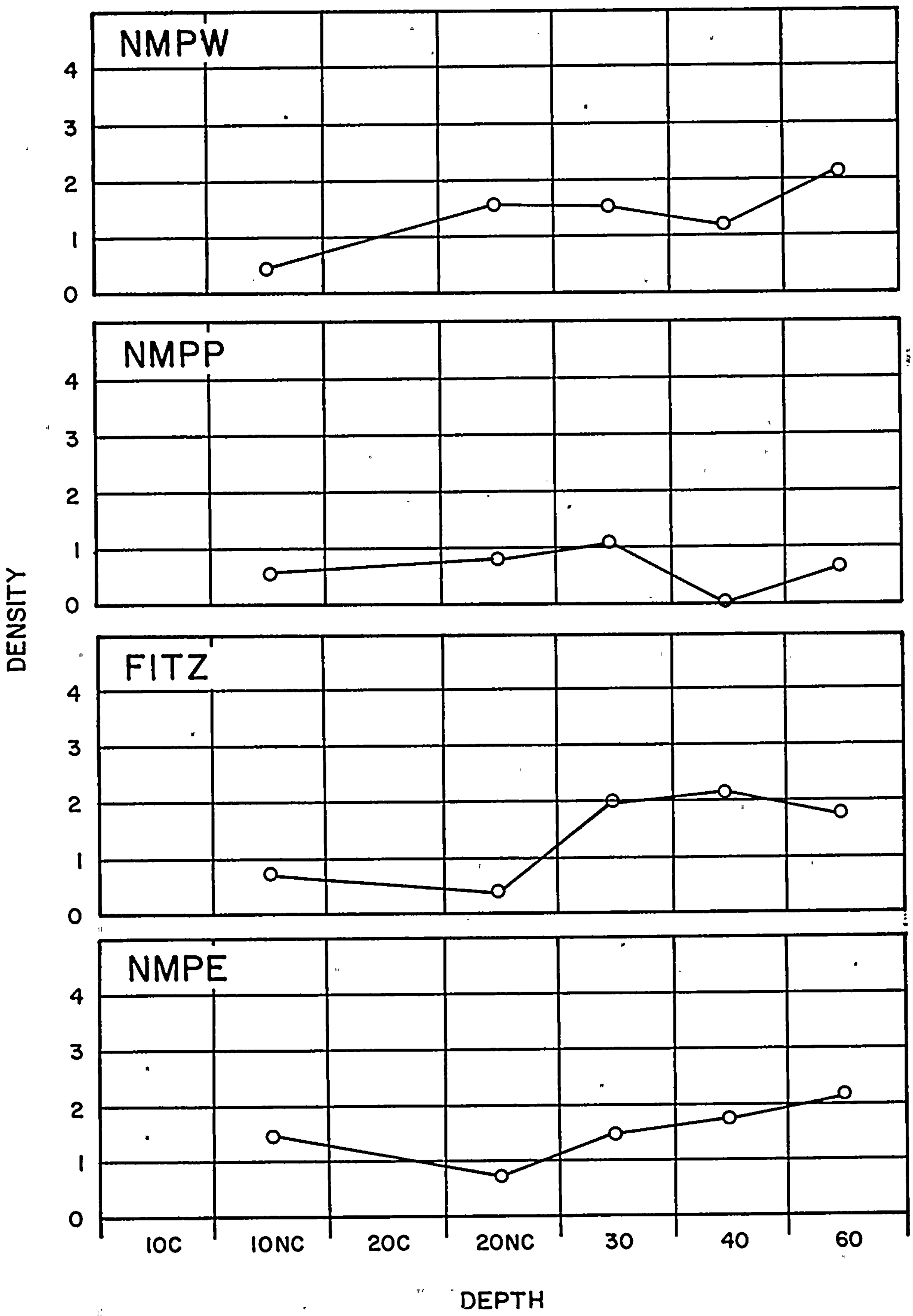
Biomass diversity during October was approximately constant at all stations; since the substrate was similar at all stations along the NMPE transect, a single community was probably represented with equal energy relations throughout the transect. Twenty ft. stations at the other three transects indicated an increase from the 10 ft. stations; there was a decline at 30 ft. stations. The low value at the 30 ft. station was due to dominance by molluscs at NMPP and NMPE and amphipods at FITZ. Since amphipods are a preferred food item, the FITZ area should be preferred by a greater number of fish. Greater biomass diversity was found at the 60 ft. depths for NMPW and FITZ; biomass diversity declined at NMPP 60 ft. The low NMPP index value was due to dominance by gastropods.


NINE MILE POINT ECOLOGICAL SURVEY
BIOMASS DIVERSITY
30 JUNE 1973
NMPW
NMPP
FITZ
NMPE
DENSITY
0
1
2
3
4
10C
10NC
20C
20NC
30
40
60
DEPTH

NINE MILE POINT ECOLOGICAL SURVEY
BIOMASS DIVERSITY
31 AUGUST 1973



NINE MILE POINT ECOLOGICAL SURVEY
BIOMASS DIVERSITY
24 OCTOBER 1973



In general, the biomass diversity values were lower during October due to the dominance of a few species (mainly Mollusca) in the study area. The most efficient energy conversion and diverse biomass availability was found at the deeper stations, especially along NMPW and NMPE. In both areas the presence of amphipods and tendipeds helped balance the gastropod dominance by offering more food choices to the fish population and more pathways for energy transfer throughout the system.

c. Fish Support Potential

Communities of organisms are in a constant state of flux. Natality, mortality, immigration and emigration influence community abundance, biomass, diversity and stability (Odum, 1971). Periodic sampling of a community provides information about the instantaneous standing crop; however, it does not necessarily give an indication of the total amount of material produced or the rate of production (Phillipson, 1966).

Productivity is a measure of the amount of organic matter produced within a community per unit time and is usually derived from biomass data (Russell-Hunter, 1970). Estimates of productivity are useful in assessing energy flow through biological systems (Hayne and Ball, 1956.) Knowledge of the mechanics of energy transfer between trophic levels provides improved understanding of the total ecosystem.

Gerking (1962) reviewed a number of estimations of benthic productivity in

freshwater environments. Estimates based on direct measurements of productivity ranged from slightly more than 1.0 to 7.4 times the standing crop biomass. The different methods reported were greatly influenced by the production rates of certain organisms, including Tanypus and Chironomus, which were generally greater than the community rate. A study conducted by Hayne and Ball (1956) found the annual freshwater benthic productivity averaged 17 times more than the average summer standing crop biomass.

Except for periods of natality, when larval forms are dispersed, movement of most benthos is limited (Scheltema, 1974). Fluctuations in benthic community composition are largely due to mortality, which is related to natural death, interspecific competition or predation (Odum, 1971). Natural death no doubt occurs; however, a number of investigators (Hayne and Ball, 1959; Gerking, 1962) have suggested that the percentage of the community lost by this cause is negligible. Most losses are attributed to predation by bottom feeding organisms.

Predation on the benthos by fish has considerable influence on benthic productivity. The productivity rate of 17 times the standing crop found by Hayne and Ball (1956) was calculated on a system with fish present. When fish were removed, the production rate was reduced but the standing crop increased. Allen (1950) found that trout in a New Zealand stream consumed 100 times the average benthic standing crop. Benthos increased in a Michigan lake upon removal of fish with a two to three fold increase in standing crop over comparable periods before fish removal (Ball and Hayne cited in Gerking, 1962). These findings indicate that maintenance of the

benthic community by predation at a level which utilizes the available energy more efficiently increases the productivity.

Based on the interaction of fish, a primary predator on benthos, theoretical considerations of energy flow from benthos to fish can be made. The following equation from information presented by Hayne and Ball (1956) and Gerking (1962) was used to estimate the quality of biomass (energy) transferred from the benthos to the fish:

$$B_F = \frac{F_p}{B_p} (P_B) (B_B), \qquad (1)$$

where B_F (Fish Support Potential) is the theoretical biomass of fish produced by consumption of benthos; F_p and B_p are calculated fish and benthic production, respectively; the rate of benthic productivity is P_B, and B_B is the observed benthic standing crop.

Hayne and Ball (1956) calculated F_p as 181 pounds and B_p as 811 pounds, yielding a conversion of benthic biomass to fish biomass of 0.223 or 22.3%. The study conducted by Allen on a trout stream in New Zealand (see MacFayden, 1963) gives an F_p value of 2280 kilograms and a B_p value of 14620 kilograms for a 15.6% conversion. The mean of the two conversion efficiency factors was 19% which was used in the formula:

$$B_F = 0.19 (F_p) (B_B) \qquad (2)$$

As productivity rates varied between one and 10 times, the standing crop in the reported studies a factor of 5 was used in the calculation of the Fish

Support Potential. The formula thus used for the calculation was:

$$B_F = 0.95 \ (B_B)$$

The biomass by station and transect for each collection date is presented in Table II-22, and the calculated fish support potential is presented in Table II-23.

The greatest fish support potential was found in June, declining in August and increasing slightly in October. The June maximum is due, in part, to a larger number of organisms associated with the Cladophora at FITZ.

The highest support potential values were found at the deeper water stations during all seasons sampled. There was an observed increase in standing crop and, therefore, support potential at the shallow 10 ft. stations with respect to time. This potential food availability could be important to the trophic structure as studies indicate an increase in the shore area fish population as a result of spawning.

The presentation of theoretical data such as the calculated fish support potential necessitates the discussion of certain ecological principles. The benthic community is a dynamic community with representatives from several different trophic levels. This suggests that not all benthic production is available to higher trophic levels, including fish, since some of that productivity may be utilized by other benthic populations. Gross ecological efficiency (the ratio of the amount of food available to the food consumed) is reported by Phillipson (1966) in laboratory

TABLE II-22

NINE MILE POINT ECOLOGICAL SURVEY

Total Benthic Biomass in Grams for
Each Transect and Station by Date

June, 1973

TRANSECT

STATION	NMPW	NMPP	FITZ	NMPE
10C	3.275	33.903	88.606	42.633
10NC	2.409	-	15.599	-
20C	-	1.334	-	-
20NC	0.488	-	-	12.777
30	1.869	19.999	1.725	15.940
40	1.044	8.770	3.165	10.521
60	17.597	5.325	6.482	9.635
TOTAL	26.682	69.331	115.577	91.506

August, 1973

STATION	NMPW	NMPP	FITZ	NMPE
10NC	5.805	6.230	17.515	17.352
20NC	4.540	5.704	7.2	9.912
30	0	2.228	34.429	22.334
40	1.791	3.889	6.229	23.329
60	3.189	12.437	5.118	17.049
TOTAL	15.325	30.488	70.486	89.976

October, 1973

STATION	NMPW	NMPP	FITZ	NMPE
10NC	41.906	10.454	22.795	22.556
20NC	7.188	4.178	11.263	2.130
30	1.466	3.604	10.472	19.42
40	3.138	1.336	4.747	12.927
60	22.784	1.355	11.079	13.622
TOTAL	76.482	20.927	60.356	70.655

TABLE II-23

NINE MILE POINT ECOLOGICAL SURVEY

FISH SUPPORT POTENTIAL OF BENTHOS AT EACH STATION AND LOCATION BY TRANSECT

June, 1973

STATION	NMPW	NMPP	FITZ	NMPE
10C	3.113	32.2079	84.1757	40.5014
10NC	2.289	-	14.8191	-
20C	-	1.2673	-	-
20NC	0.4636	-	-	12.1382
30	1.7756	18.9991	1.6388	15.1430
40	0.9918	8.3315	3.0068	9.9950
60	16.7172	5.0588	6.1579	9.1533

August, 1973

STATION	NMPW	NMPP	FITZ	NMPE
10	5.5148	5.9185	16.6393	16.4844
20	4.3130	5.4188	6.8400	9.4164
30	0	2.1166	32.7076	21.2173
40	1.7015	3.6946	5.9176	22.1626
60	3.0296	11.8152	4.8574	16.1966

October, 1973

STATION	NMPW	NMPP	FITZ	NMPE
10	39.8107	9.9313	21.6553	21.4282
20	6.8286	3.9691	10.6999	2.0235
30	1.3927	3.4238	9.9484	18.4490
40	2.9811	1.2692	4.5097	12.2807
60	21.6448	1.2873	10.5251	12.9409

experiments as approximately 13% between trophic levels. Slobodkin (see Phillipson, 1966) in another laboratory experiment found a gross ecological efficiency of 7%. He suggests that the most probably value for natural ecosystems is approximately 10%. The value used in the formula was 19%, which could be unrealistic.

d. Analysis of Variance (ANOVA)

The effects of time (season), depth (station) and transect (location) on the major benthic taxa collected were evaluated using a three-way analysis of variance (Simpson et al., 1960; Elliot, 1971). This statistical test, conducted for both abundance and biomass, enables the determination of the effects of three main variables on the benthic community. The interaction effects are of interest since the main effects may not have a significant effect on the community structures, but could have an effect in combination with another primary variable.

The analysis of variance requires that samples be collected on an equal basis, i. e., at the same levels for each factor, and that there be homogeneity of variance between the samples. Since replicate samples were not collected during June, only one set of samples each from August and October was used in the analysis.

The primary variables and first order interaction effects were tested by means of an F-ratio between their respective mean squares and the deviation mean squares. The log means of the primary parameters were ranked if the F-ratio indicated a significant effect existed; and the means were tested using a Student-Newman-Kuels analysis. This analysis indicated the le

of significance for each variable. The test tables for the analysis and primary parameter ranking are given in Appendix IV-B.

For total organisms there was a significant difference by transect for abundance and biomass and by depth for biomass alone. NMPE had significantly more organisms and greater biomass than the other three transects (Appendix IV-B). (FITZ and NMPW had similar abundances; and NMPP and NMPW were similar). Fewest organisms were collected at NMPP. Biomass was found to be slightly different from abundance with the least weight collected at NMPW; and all three western transects were significantly less than NMPE. There was a general decline from east to west in numbers and biomass. The biomass was greatest at 10 ft., but the 10 ft. station was significantly different from the 40 ft. station. It is interesting to note that the stations having the greatest biomass were the 10 and 60 ft. stations (see Appendix IV-B), indicating that available food (energy) exists for the higher trophic levels for both shore and deeper water species.

Triclads were found to be significantly different by season for both abundance and biomass with the greater number and weight collected during June. August and October were similar with the smallest abundance found during August. The results correspond to the cold water temperature activity pattern for this order as reported by Pennak (1953).

A significantly greater abundance and biomass were collected at NMPE. The next transect west, FITZ, was next in significance for both values,

lowest values were found at NMPW. No nemetodes were collected at NMPP. The difference found by transect was reflected in the abundance and biomass of nematodes collected by depth and (for abundance) by season. These first order interactions point to the influence that one variable has on community structure in association with another.

The Mollusca (Gastropoda, Pelecypoda) form an important component of the community structure due to their high percentage of the total collection. A significantly greater abundance and biomass of gastropods was found by date and transect; biomass was found to be significantly greater for depth. A significantly greater number and biomass of gastropods was found at NMPE: the other three transects having comparable values. In both cases, the lowest values were recorded at FITZ. August and October collections were similar in their abundance and weight, both being significantly greater than those of June. This is probably a result of reproduction during the early summer months. Depth was found significant for biomass, with the littoral 10 ft. station significantly higher than the similar sub-littoral stations at 30, 40 and 60 feet. The depth preference and abundance of the pulmonates are the prime factor for the significance of the 10 ft. stations. In addition, for abundance a significant interaction difference was found for depth by transect, indicating that the stations were different depending on the location. This is directly attributable to the substrate preference of the group.

Abundance and biomass of Pelecypoda were significantly different by transect and for depth by transect. The sand-silt substrate which would offer the preferred habitat was observed only at the more easterly transects (FITZ and NMPE). Testing of the ranked transects found NMPE to be significantly greater than FITZ; both were significantly greater than NMPP and NMPW. There was also a depth-transect interaction, suggesting a depth difference for numbers and biomass depending on the transect. This is sediment-related, since the station composition of soft bottom material differs along the transect.

Among the annelids, only the Oligochaeta were found to vary due to environmental influences. Insufficient numbers of Hirudinea were available for testing. Non-interactions or main effects (transect, depth, or station differences) were found for the Polychaeta.

Oligochaete abundance was significantly affected by depth, season and transect. A significantly greater number were collected at NMPE and FITZ than at NMPW and NMPP. Abundance was significantly greater during June and October than during August. Oligochaete abundance increased with depth. The mid-depth stations were similar in total numbers. Comparing the increase in number to the collection date (Appendix IV-B), there was an increase with depth of immature worms lacking capilliform chaetae. These are members of the Family Tubificidae. As shown by Johnson and Mathieson (1968), members of this family are usually found in the

deeper water areas. Of the three main effects, only depth had no significant effect on the biomass of oligochaetes. The greater biomass was found during June and October; both were significantly greater than August values. The two eastern transects were significantly higher in biomass than the two western transects; however, ranking within the two transect groupings was reversed for abundance, with FITZ the greatest and NMPW the least.

The largest contributors to the benthic community were the Arthropods, with a total of three classes and eight orders. The order Acarina was not significantly influenced by the three main effects or any combination of those variables.

Based on stomach analysis of fish, members of the order Amphipoda were the most important fish food items; therefore, their abundance and distribution is important to the energetics of the ecosystem. The greatest number and weight of amphipods was found at NMPE. These values declined toward the west, with the lowest values found at the NMPW transect. NMPE and FITZ were similar. FITZ was also found to be similar to NMPP and NMPW. This pattern would indicate a transition at the FITZ transect which is probably related to substrate. NMPE transect is primarily sand and silt; while the two western transects are bedrock and larger stones. FITZ is a composite with both types of substrate composing its stations. A significantly greater number and biomass was

found at the 10 ft. station. The 60 ft. station ranked second in abundance, but third in biomass. This is attributed to the smaller Pontoporeia affinis being the dominant amphipod at the deeper water stations. The 40 ft. station had the smallest number and biomass of the stations tested. Only biomass was affected by season, with August and October collections being similar; but were significantly different from June collections, which had the smallest biomass. Thut (1969) reported for P. affinis in early June peak in abundance due to reproduction and a fall increase in animal size due to growth and maturation. The 1973 sampling may have begun too late to document the spring increase, but it reflected the fall growth period.

The order Decapoda was present in the collections from June and August; but the order was not represented during October. Although the number of decapods collected was small, enough individuals were collected for statistical analysis. Abundance during June and August were similar; however, the larger numbers were collected during June. The crayfish collected during June were larger than those collected later in the year; the biomass was significantly greater during the spring than during the summer.

The range of abundance of Asellus racovitzai, the only isopod collected in the study area, was significantly different due to the first order interaction of depth and transect. This indicates that depth had a

different effect on abundance and biomass and was dependent upon transect. Substrate preference varies with depth at each transect and could be the factor contributing to differences of this type.

The numbers of ostracods collected were found to be significantly different for each season sampled. More were collected during June; the fewest were collected during October; biomass was highest in June; August and October biomass values were similar. This shows that the organisms underwent a period of rapid growth and development in the spring followed by a decline in inumbers and biomass through the summer and fall. First order interactions were also found that indicate that the seasonal effect differs depending on transect and depth. As several genera were collected, this difference is probably associated with species preference for general habitat.

Insecta, the third arthropod class represented in the Nine Mile Point benthos collections, is an important member of the benthic community. Members of the three arthropod orders collected, beside being important food items in the diet of fish, occupy all trophic levels (herbivores, carnivores and omnivores).

Members of the order Diptera were dominant in the study area. Species abundance was affected significantly by transect, with NMPE significantly greater than FITZ, which in turn, was significantly greater than NMPP and NMPW. The general trend was toward an increase in dipteran abundance from west to east. A significant depth by date interaction for abundance

occurred which would be attributable to the larvae moving to deeper water to overwinter under the more stable conditions. All first order interactions were found to be significant for dipteran biomass. On a temporal basis biomass may differ due to emergence and migration to deeper waters with subsequent growth of newly hatched larvae and maturation of older forms. Transect differences would also be a result of emergence and migration from or to the deeper water stations.

D. PERIPHYTON

1. INTRODUCTION

The periphyton studies are included in the benthos section to underscore the similarities between these communities; both are either sessile or partially sessile and both depend upon a solid substrate for growth.

Sladeckova (1962) defined periphyton as the community of aquatic organisms growing attached to any kind of substrate. Welch (1948) defined the substrate as the surfaces of water plants, wood, stones, or other objects immersed in water. Since colonization by periphyton is rapid on any non-toxic surface, this unique community may be studied qualitatively and quantitatively by placing non-toxic artifical substrates of known surface area, texture or composition in the water column. The relative permanance of the periphyton community, its rapid growth and response to environmental factors make periphyton an ideal subject for natural experiments.

The periphyton community is composed of sessile plants and animals, which adhere to the substrate by means of rhizoids, gelatinous stalks or secretions, and of organisms which are epiphytic on the algal colonizing the substrate. The photosynthetic component of periphytic growth consists mainly of algal species from the epilithic[1] and epiphytic[2] benthic communities. Species from the epipelic[3] benthic community and planktonic

---

[1] those organisms growing upon rock surfaces.

[2] those organisms growing upon the surfaces of plants.

[3] those organisms growing upon the surface of the sediments.

community are also found, because they can become trapped once the initial growth has been established (Round, 1974). The non-photosynthetic component of any periphyton community consists almost entirely of stalked protozoans (e.g. rotifers).

Previous studies of periphyton growth using artificial substrates in the Nine Mile Point vicinity of Lake Ontario are limited to the work of Jackson (1967) who conducted biomass determinations for eight depths between 10 and 360 cm on 4 buoyed collection stations traversing Mexico Bay (immediately east of Nine Mile Point). During this study, the relative growth rates of the algae Cladophora glomerata on substrates at varying depths were also determined. Jackson determined that the average periphyton biomass produced in a 3.6m column of water in Mexico Bay was 78.3mg per square decimeter (dm). The values recorded by Jackson are comparable to other oligotrophic, temperate lakes.

Since periphyton may contribute a large portion of the primary and secondary production in shallow waters, the purpose of this investigation was to ascertain the possible effects of treated effluent from nuclear power generating plants on the periphyton organism in terms of changes in species composition, biomass and chlorophyll a concentrations. The study consisted of harvesting microscope slides and styrofoam substrates at approximately two week intervals and on a cumulative basis from bottom and buoy structures.

2. RESULTS AND DISCUSSION

a. Species Composition and Abundance

(i) Bottom Periphyton

(a) Abundance and composition

The abundance data of the three major groups of periphytic algae (green alga, diamtoms, and blue-green algae) and the fauna collected on artificial substrates were expressed as a percentage of the total number of organisms/dm^2. Major group composition for each of the four transects by depth are shown for the two week collection intervals in Figure II-17 and for the cumulative exposures from 29 June through 14 September (Figure II-18).

These diagrams show that with increasing depth the protozoans constituted a larger percentage of the total number of periphytic organisms. Over longer exposure periods the percent composition of protozoans generally decreased in shallow water (to 30 ft.) but increased at the 40 ft. depth. Increases in the algae relative to the protozoan components of the shallow-water periphyton appeared to be the result of the accumulated growth of the algal community. The linear regressions for biomass on chlorophyll a for over-all exposure periods show higher correlations at the 10, 20, and 30 ft. depths for the cumulative exposure period (see Table II-24), indicating that the protozoans constituted a smaller portion of the total biomass with longer exposure periods.

From their investigations concerning the periphyton in the Sedlice Reservoir, Czechoslovakia, Sladecek and Sladeckova (1964) concluded that the protozoans were the dominant life form at a depth of 6 mete (22 ft.). These observations are similar to those made during the

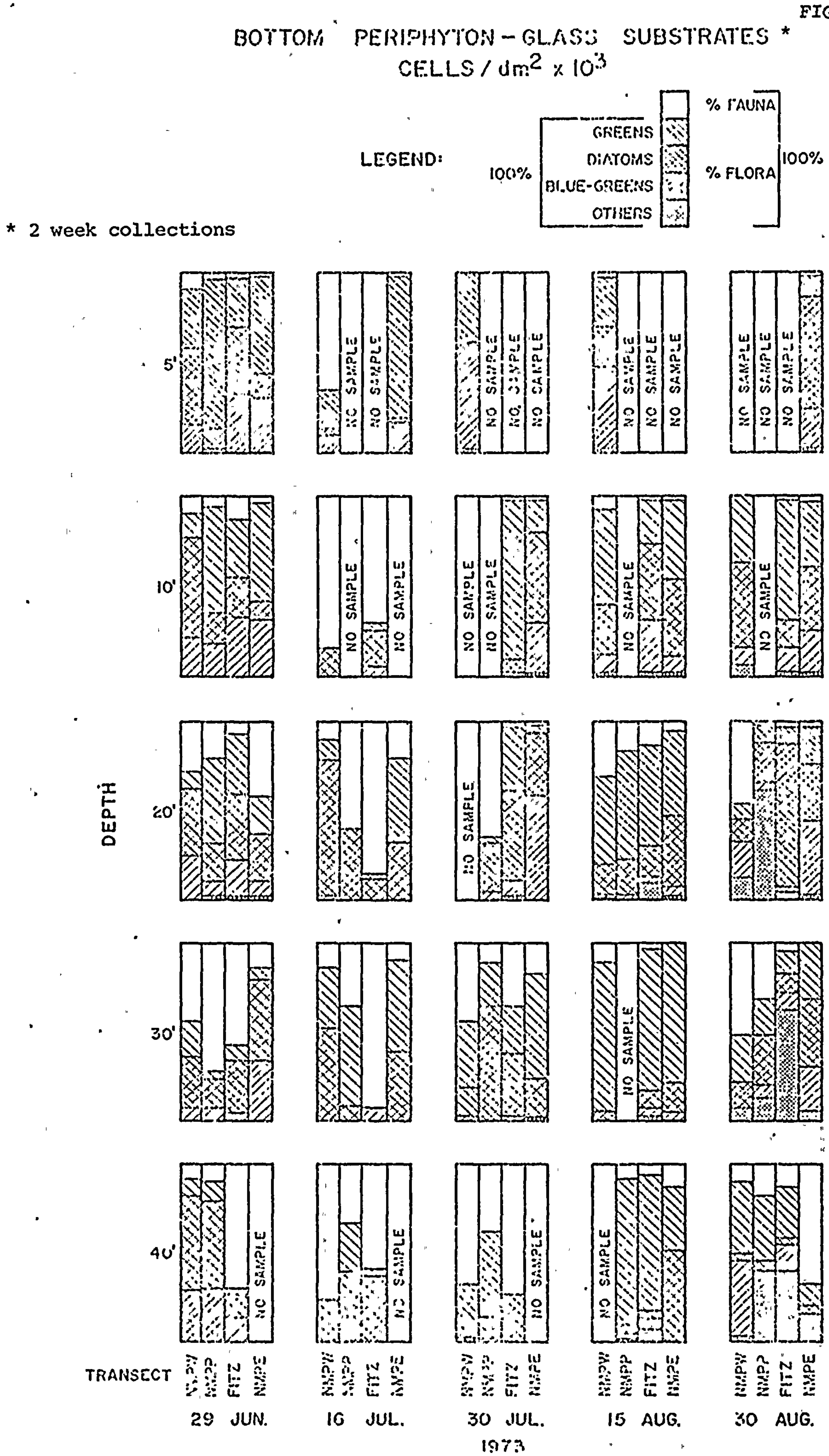

BOTTOM PERIPHYTON - GLASS SUBSTRATES *
CELLS / dm² x 10³
LEGEND:
100%
GREENS
DIATOMS
BLUE-GREENS
OTHERS
% FAUNA
% FLORA
100%
* 2 week collections
DEPTH
5'
10'
20'
30'
40'
NO SAMPLE
TRANSECT
NMPW
NMPP
FITZ
NMPE
29 JUN.
16 JUL.
30 JUL.
15 AUG.
30 AUG.
1973

FIGURE II

BOTTOM PERIPHYTON - GLASS SUBSTRATES * CELLS / dm^2 x 10^3

* cumulative collections

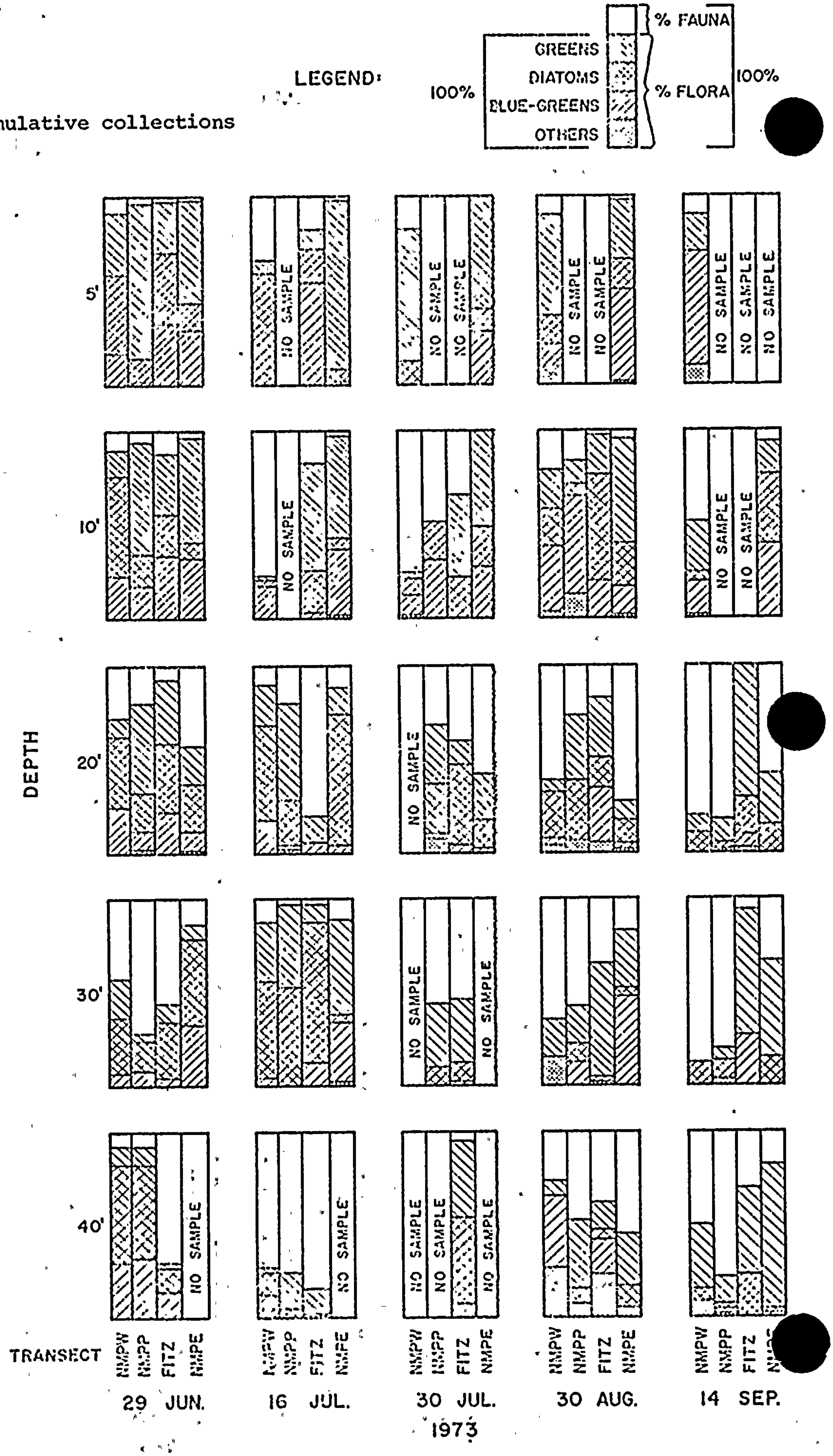


Table II-24 Correlation Coefficients from a Regression (Y=A+Bx) of Faunal Biomass On Chlorophyll a Values, Bottom Periphyton: Nine Mile Point, 1973.

	2 Week Exposure	Over 2 Week Exposure
5'	.865	.602
10'	.750	.882
20'	.470	.546
30'	.057	.337
40'	.170	-0.026

present study (Figures II-17 and II-18).

The periphytic protozoan community in the Nine Mile Point vicinity was based primarily on ciliated protozoans, consisting mainly of members of the family Vorticellidae and suctorial protozoans of the family Acinetidae. Relative to the Vorticellids, suctorial protozoans were found in increasing abundance with increasing depth, a result which may be explained through the feeding behaviors of both types of organisms. The Vorticellidae feed on small particles, including algal cells, whereas, the acinetids are carnivorous, feeding on smaller protozoans (Pennak, 1953). These findings suggest a maturation of the community on the artificial substrate; community maturation proceeds according to the following sequence. Initially, substrates are colonized by primary consumers which need only a surface for attachment to survive. Later, increasing numbers of carnivores, which probably derive their food from the first protozoa attracted to the artificial substrate, became abundant.

(b) Affinity indices

The species composition of the algae and protozoans were analyzed using the Affinity Index method of Sanders (1960); affinity indices were calculated by depth and by transect. Data for affinity determination were selected from the early summer (29 June) and for late summer (30 August) time periods (Figures II-19 and II-20). Few substrate locations were found in either period with similarities in the 0-25% range. For the 29 June collection 39 pairs of stations out of a possible 171 pairs were found to have affinity indices in the 75-10

NINE MILE POINT-BOTTOM PERIPHYTON
AFFINITY INDEX
29 JUNE 1973

Exposure Time
2.0 Weeks

	NMPW 5	NMPW 10	NMPW 20	NMPW 30	NMPW 40	NMPP 5	NMPP 10	NMPP 20	NMPP 30	NMPP 40	FITZ 5	FITZ 10	FITZ 20	FITZ 30	FITZ 40	NMPE 5	NMPE 10	NMPE 20	NMPE 30	NMPE 40
NMPW 5		80.5	70.8	66.4	75.1	19.4	70.8	82.6	35.9	76.8	86.4	79.5	92.2	51.8	37.8	63.0	60.5	65.5	73.5	-
NMPW 10			77.8	59.2	91.7	29.9	53.8	53.8	36.6	90.2	76.3	67.0	80.0	52.5	38.5	19.8	17.3	59.7	83.8	-
NMPW 20				73.0	79.5	24.8	48.7	59.6	55.5	79.8	74.4	67.9	75.7	70.6	57.4	18.0	15.5	73.5	84.0	-
NMPW 30					53.1	37.8	50.8	68.7	68.9	54.8	60.4	62.9	64.9	84.8	64.7	13.0	10.5	96.1	57.0	-
NMPW 40						25.4	49.3	47.7	35.0	96.8	80.1	69.2	76.3	50.7	36.9	53.2	51.1	53.6	90.5	-
NMPP 5							76.1	63.6	19.4	26.8	42.3	50.1	48.4	25.6	18.6	69.4	69.4	36.4	22.9	-
NMPP 10								80.5	32.5	50.7	64.6	74.0	72.3	35.5	34.4	88.3	86.0	52.4	46.8	-
NMPP 20									47.5	49.4	60.5	76.7	70.7	53.4	46.5	72.7	70.2	71.2	51.9	-
NMPP 30										35.3	29.9	39.3	34.4	80.3	93.9	25.3	22.8	69.5	41.4	-
NMPP 40											83.0	72.4	77.7	51.2	37.2	54.6	54.0	55.3	92.3	-
FITZ 5												83.8	89.7	45.8	31.8	71.1	70.4	59.5	79.6	-
FITZ 10													84.1	47.6	41.2	77.9	77.6	64.5	72.8	-
FITZ 20														50.3	36.3	69.1	66.6	64.6	74.1	-
FITZ 30															76.1	27.7	25.2	82.2	54.6	-
FITZ 40																30.0	28.1	67.6	43.3	-
NMPE 5																	95.2	44.6	50.7	-
NMPE 10																		42.1	50.5	-
NMPE 20																			57.8	-
NMPE 30																				-
NMPE 40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

0-25%   25.1-50%   50.1-75%   75.1-100%

NINE MILE POINT-BOTTOM PERIPHYTON AFFINITY INDEX 30-31 AUGUST 1973

Exposure Time 2.1 Weeks

	NMPW 5	NMPW 10	NMPW 20	NMPW 30	NMPW 40	NMPP 5	NMPP 10	NMPP 20	NMPP 30	NMPP 40	FITZ 5	FITZ 10	FITZ 20	FITZ 30	FITZ 40	NMPE 5	NMPE 10	NMPE 20	NMPE 30	NMPE 40
NMPW 5		60.9	37.4	38.9	39.1	-	49.1	66.8	52.8	62.1	-	48.9	74.2	67.9	50.7	59.7	85.3	36.6	56.7	34.6
NMPW 10			52.9	43.0	66.6	-	72.1	65.1	63.0	46.6	-	62.3	86.7	44.7	62.1	75.2	62.6	46.6	77.0	55.7
NMPW 20				70.3	38.6	-	34.3	62.5	78.2	59.4	-	36.2	45.4	45.2	54.7	28.1	36.9	83.1	29.9	76.1
NMPW 30					48.8	-	40.6	53.1	76.6	76.0	-	20.2	43.2	57.0	67.1	21.2	24.2	78.1	37.3	81.2
NMPW 40						-	75.9	41.4	46.5	44.8	-	28.9	61.2	35.9	77.0	49.0	29.2	38.6	65.1	40.4
NMPP 5	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-
NMPP 10						-		40.9	46.0	38.1	-	38.9	69.7	31.1	64.1	69.0	39.2	36.2	78.9	39.9
NMPP 20						-			57.7	68.4	-	54.2	70.7	64.8	53.4	50.9	62.8	50.7	52.4	71.0
NMPP 30						-				69.5	-	43.1	60.0	57.3	69.5	44.0	46.1	81.7	51.7	86.2
NMPP 40						-					-	24.6	56.9	79.0	63.1	35.4	48.2	62.1	[illegible]	[illegible]
FITZ 5	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-
FITZ 10				-		-				-	-		58.4	24.5	39.3	60.1	62.2	25.2	45.8	33.7
FITZ 20						-					-			51.8	62.3	78.0	68.0	43.6	81.3	61.6
FITZ 30						-					-	-			54.5	35.3	62.2	49.5	51.1	66.7
FITZ 40						-					-					40.3	40.8	56.6	54.9	63.4
NMPE 5				-		-					-						67.2	26.2	83.8	40.1
NMPE 10				-		-					-							29.2	54.6	43.1
NMPE 20						-					-								33.4	78.8
NMPE 30						-					-									48.3
NMPE 40						-					-									

0-25% 25.1-50% 50.1-75% 75.1-100%

range. On 30 August, 17 pairs of stations were in this range. Intermediate indices of affinity (25-50% and 50-75%) occurred most frequently.

The species association that became predominant on the substrates after approximately one month in shallow depths was that composed primarily of Navicula sp. and Lyngbya diguetii. Stigeoclonium tenue, which has been reported as an indicator of eutrophic situations (Hynes, 1972), appeared sporadically but never became established. Many planktonic species were also recorded, notably Scenedesmus and Tetraedron; these planktonic forms may have adhered to the gelatinous sheath of the filamentous Lyngbya and the secretions of Navicula.

(ii) Buoy Periphyton

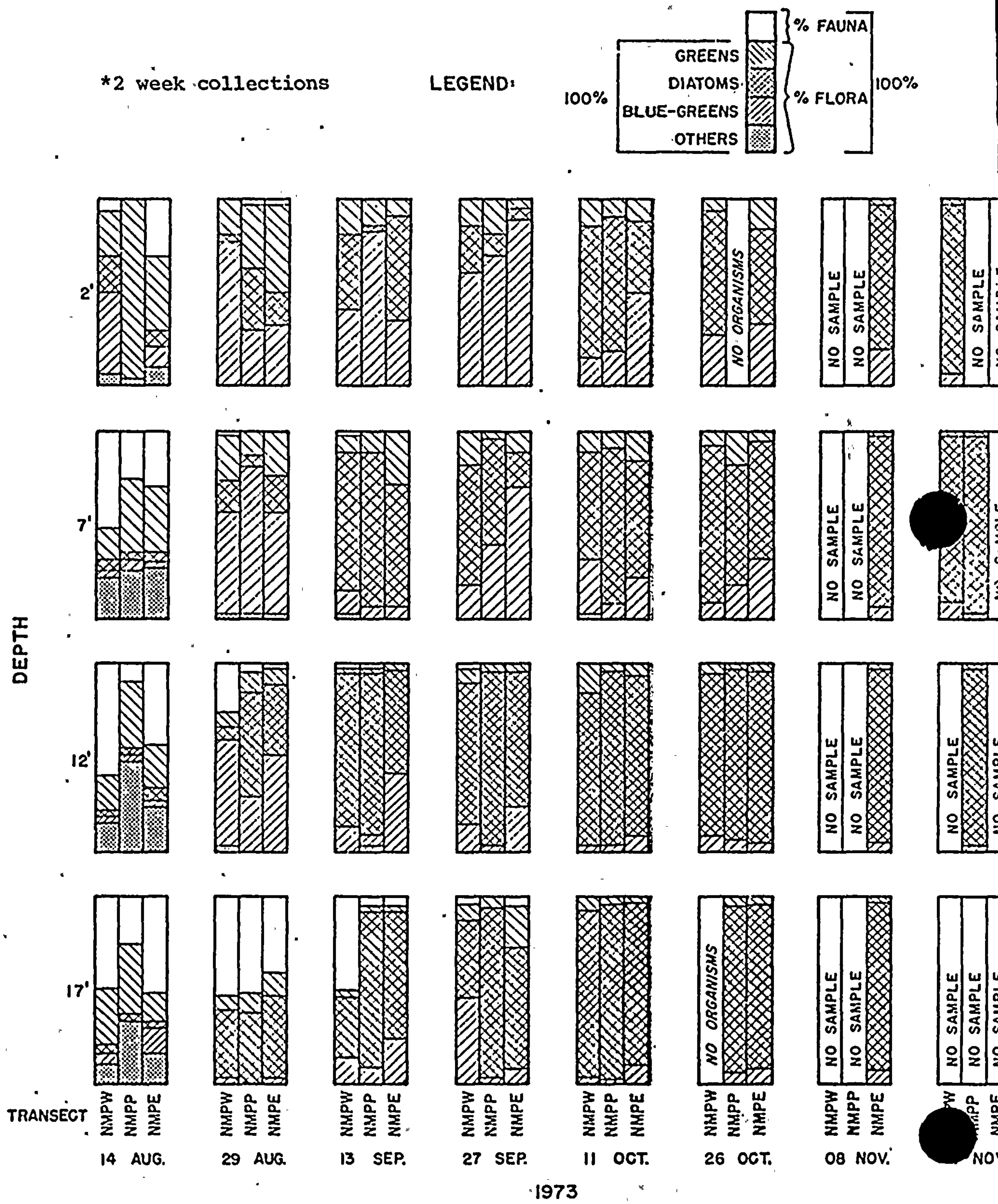
(a) Abundance and composition

Glass substrates were retrieved from buoys on a cumulative basis. Periphytic communities similar to those observed between the 5 and 20 ft. depths on bottom substrates developed on the buoys (Figure II-21). Although a Navicula-Lyngbya association similar to that on benthic substrates developed over time on buoy substrates, the densities on the suspended buoy substrates were substantially greater than on bottom substrates (see Appendices IV-C and IV-D). For example, after a 10 week growth period, the densities of Navicula on the buoy substrates at the 7 ft. depth on the NMPW transect were approximately 10^9 cells/dm^2; densities of approximately 10^6 cells/dm^2 were found on substrates left for a comparable time interval at the 10 ft. depth on the NMPW bottom transect.

FIGURE II

BUOY PERIPHYTON - GLASS SUBSTRATES*
CELLS / dm^2 x 10^3

*2 week collections



The percent composition of protozoans on substrates at the buoy stations was lower than that observed on bottom samples; however, densities of protozoans (organisms/dm^2) were usually greater at the buoy stations than on bottom substrates.

Another indication of the extent of the protozan component of the periphytic community on the buoy substrates was derived by comparing biomass and chlorophyll a values over all exposure periods. Linear regressions of biomass on chlorophyll a for buoy periphyton (Table II-25; Figure II-21) showed slightly lower correlation coefficients than those for the cumulative exposure periods on bottom substrates (Table II-24; Figure II-22). These results indicate that a higher proportion of the biomass on many buoy substrates (compared to bottom substrates) was not actively photosynthesizing at the time of collection.

(b) Affinity indices

Affinity indices between buoy substrate depths were calculated for 29 August (exposure time 4.6 weeks) and 11 October (exposure time 10.7 weeks) (Figures II-23 and II-24). On 29 August, 12 depth comparisons out of a possible 66 combinations showed affinity indices in the 75-100% range. These similarities occurred mainly at the 7 and 17 ft. depths for all three transects. After an additional 6 weeks of periphytic growth, a total of 44 depth comparisons out of 66 possible combinations showed affinities in the 75-100% range. Similarities occurred between similar depths on each of the three buoy stations (Figure II-24). The extent of similarity, based upon species composition, indicates a possible uniformity in the periphytic community

BOTTOM PERIPHYTON - GLASS SUBSTRATES *
CELLS / $dm^2 \times 10^3$

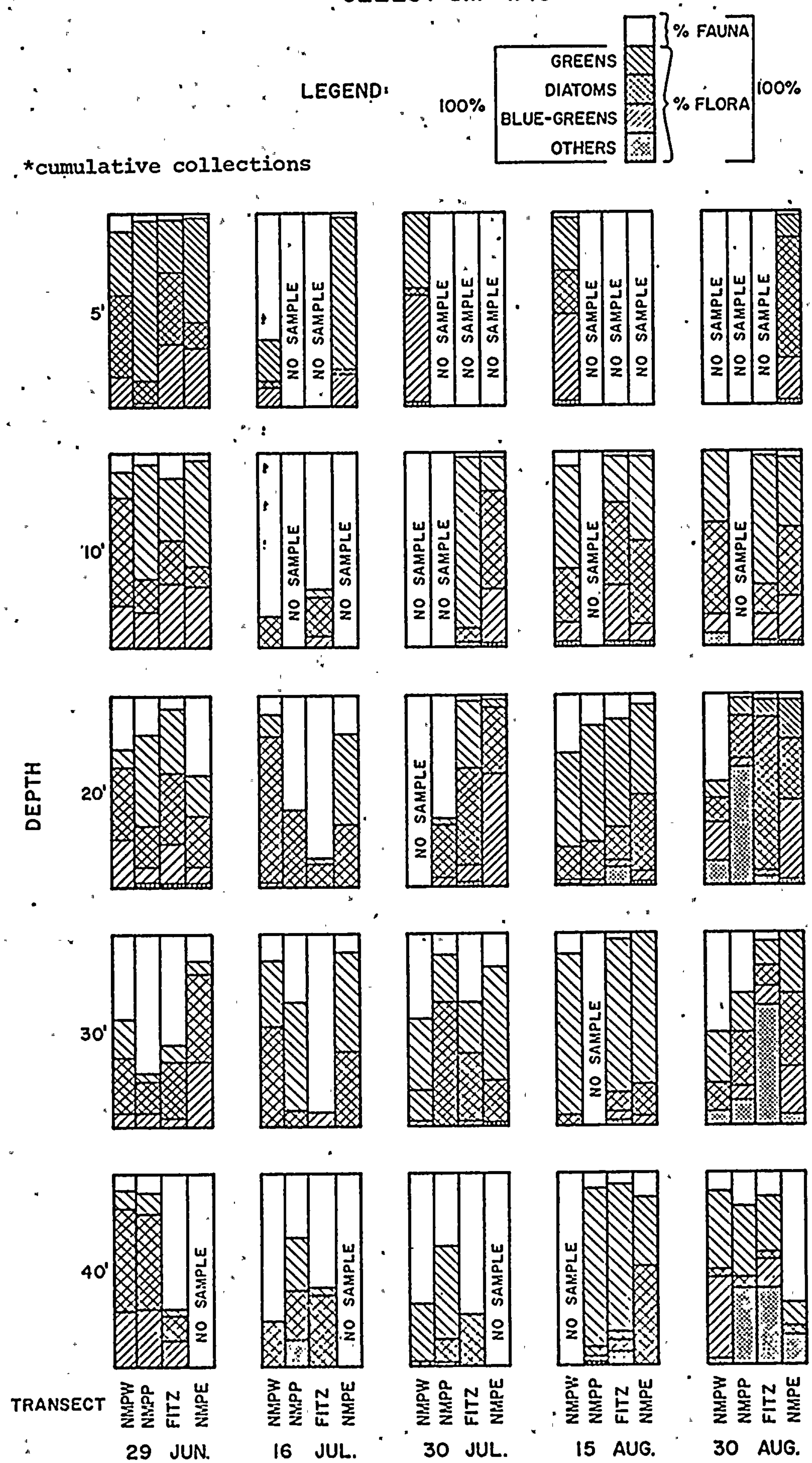


FIGURE II-23

NINE MILE POINT-BUOY PERIPHYTON
AFFINITY INDEX
29 AUGUST 1973

Exposure Time 4.6 Weeks	NMPW 2	NMPW 7	NMPW 12	NMPW 17	NMPP 2	NMPP 7	NMPP 12	NMPP 17	NMPE 2	NMPE 7	NMPE 12	NMPE 17
NMPW 2		80.8	68.8	12.0	53.3	91.7	42.0	12.2	55.5	79.7	63.5	18.6
NMPW 7			72.9	29.4	75.2	76.1	59.5	29.7	74.4	97.9	80.0	36.0
NMPW 12				41.3	45.8	72.4	45.4	38.9	49.3	70.8	66.0	42.3
NMPW 17					43.4	15.5	50.4	96.4	30.9	30.3	47.5	87.2
NMPP 2						48.6	73.4	43.6	86.0	73.6	72.2	49.9
NMPP 7							45.6	15.8	50.8	74.9	67.0	21.4
NMPP 12								52.1	60.9	60.4	76.6	61.5
NMPP 17									31.1	30.6	48.0	88.9
NMPE 2										73.6	60.5	37.4
NMPE 7											60.4	36.9
NMPE 12												51.4
NMPE 17												

0-25% 25.1-50% 50.1-75% 75.1-100%

NINE MILE POINT-BUOY PERIPHYTON
AFFINITY INDEX
11 OCTOBER 1973

Exposure Time 10.7 Weeks	NMPW 2	NMPW 7	NMPW 12	NMPW 17	NMPP 2	NMPP 7	NMPP 12	NMPP 17	NMPE 2	NMPE 7	NMPE 12	NMPE 17
NMPW 2	X	83.3	87.1	79.7	96.1	86.0	75.1	76.5	65.8	89.2	84.6	83.4
NMPW 7		X	70.4	67.4	86.8	73.7	62.9	64.3	79.9	90.4	72.5	71.3
NMPW 12			X	90.6	83.6	92.3	86.8	88.0	53.0	77.6	90.2	86.9
NMPW 17				X	79.7	93.7	95.4	96.8	47.4	69.0	94.7	92.6
NMPP 2					X	86.0	75.3	76.6	67.7	89.1	84.8	83.7
NMPP 7						X	89.1	90.5	53.7	75.3	97.9	94.6
NMPP 12							X	98.6	43.0	64.4	90.5	90.8
NMPP 17								X	44.3	65.6	91.8	92.0
NMPE 2									X	73.0	52.5	51.3
NMPE 7										X	74.0	73.0
NMPE 12											X	96.7
NMPE 17												X

0-25%   25.1-50%   50.1-75%   75.1-100%

TABLE II-25

CORRELATION COEFFICIENTS FROM A REGRESSION (Y = A & BX) OF BIOMASS ON CHLOROPHYLL a VALUES, BUOY PERIPHYTON: NINE MILE POINT, 1973

2'	.668
7'	.752
12'	.142
17'	.404

not only between similar depths but also between different depths after long exposure periods. It appears that by 11 October a stable community composed primarily of Navicula, Lyngbya and attached protozoans had developed. In comparison, only 4.7 weeks earlier on 29 August the species composition of the periphyton community was less uniform (Figure II-23).

(c) Styrofoam substrates

The periphyton communities on styrofoam substrates differed qualitatively and quantitatively from periphyton communities on glass substrates. For example, after two weeks of exposure, the abundance of Navicula spp. collected on 14 August from styrofoam substrates at the 2 ft. depth of the NMPW buoy was almost an order of magnitude greater than abundance on glass slides collected at the same time and location. This grea abundance on stryoforam substrates than on glass substrates was common throughout the study period at all buoy stations for the two dominant algal forms, Navicula spp. and Lyngbya diguetti, and for Cladophora sp. (Appendix I-E and IV-E). Castenholz (1960) found that glass provided a poor attachment surface for periphyton. Stryofoam offers a greater and coarser surface area which apparently results in greater algal abundance by providing a better substrate for periphytic attaching mechanisms.

Although styrofoam appears to support greater densities of organisms and a greater number of species, its use presents difficulties in quantification of the samples. Detaching the growing material from the substrate by mechanical operation in a blender (see Methods and Mater

results in some loss of organic material due to rupturing of cells even at low blender speeds. For this reason, obtaining accurate and reproducable biomass data from a styrofoam substrate is difficult.

Cladophora abundance ranged from 0.056 to 1457 x 10^3 algal cells/dm^2 on styrofoam substrates and averaged approximately two orders of magnitude less on glass substrates; Cladophora composed less than 1 percent of the total algal population at all stations and all depths. Few Cladophora were found growing in water equal to or greater than 17 feet in depth; similar findings were reported by Neil and Owen (1964), who recorded reduced Cladophora growth at depths greater than 12 ft. in the Toronto-Hamilton vicinity of Lake Ontario.

A three-way analysis of variance (Appendix II) was conducted to determine whether there were differences in Cladophora abundance between transects, sampling depths, and collecting dates. The results (Appendix IV-F) show that there was one significant difference within the three variables and within interactions among variables at $\alpha = 0.05$: the effect due to dates (time) was significant.

b. Production Rates

(i) Bottom periphyton

Net production rates, measured as the increase in ash-free dry weight (mg/dm^2/day), were calculated for periphyton communities on glass slides exposed at five depths on each of the four bottom transects for four sampling dates during July and August (Table II-26). Average net production for a station ranged from 0.05 mg/dm^2/day on 15 August at the

TABLE II-26

BOTTOM PERIPHYTON-2 WEEK EXPOSURES

PRODUCTION RATE IN mg/dm^2/day

	NMPW	NMPP	FITZ	NMPE
7-16-73				
5'	0.33	-	-	0.82
10'	0.14	-	0.87	0.45
20'	0.32	0.50	0.13	0.33
30'	0.54	0.86	0.95	0.77
40'	0.34	0.14	0.28	-
7-30-73				
5'	0.49	-	-	3.59
10'	0.45	-	0.09	3.24
20'	-	0.39	0.19	0.33
30'	-	0.44	0.07	1.84
40'	0.13	-	0.14	-
8-15-73				
5'	0.24	-	-	2.65
10'	1.68	0.62	1.61	1.04
20'	0.20	0.21	0.62	0.27
30'	0.41	0.38	0.58	1.10
40'	0.23	0.05	0.63	0.50
8-30-73				
5'	0.37	-	-	2.76
10'	0.74	0.50	0.97	1.31
20'	0.48	0.59	0.64	0.38
30'	0.54	0.77	0.74	0.46
40'	0.36	0.50	0.75	0.25

NMPP transect to 3.59 mg/dm^2/day on 30 July at the NMPE transect (Table II-27).

Production rates were analyzed statistically to ascertain whether there were significant differences between transects, between depths and between dates (Appendix II). The results of the analysis revealed that significant differences occurred among transects (Appendix IV-F). A Least Significant Difference test (Appendix II) showed that NMPW and NMPE were most similar and that NMPP and FITZ were least similar in terms of production rates (Appendix IV-F); the highest rates were found at FITZ and the lowest were found at NMPP.

(ii) Buoy periphyton

Since the buoy periphyton substrates were harvested on a cumulative basis, only the first collection made on 14 August, 1973 represented a two week exposure period suitable for analysis of production rates. The production values for 14 August are listed in Table II-28. The data were tested to determine wheter there were significant differences between transects and depths (Appendix II). Significant differences were found both between transects and between depths (Appendix IV-F). A Student-Newman-Keuls ranking test revealed that production at the 2 ft. depth was significantly greater than at the other depths (Appendix IV-G). A similar ranking test of the transects showed that production at the NMPE and NMPP transects was significantly greater than at the other transects (Appendix IV-G).

The 29 August, 1973 buoy collection, which represented a 1 month exposure time, can be compared to the data of Jackson (1967), who also

TABLE II-27

BOTTOM PERIPHYTON
AVERAGE PRODUCTION RATES AT A TRANSECT ($mg/dm^2/day$)

	NMPW	NMPP	FITZ	NMPE
7-16	0.33	0.5	0.56	0.59
7-30	0.36	0.42	0.12	2.25
8-15	0.55	0.32	0.86	1.11
8-30	0.50	0.59	0.78	1.03

TABLE II-28

PRODUCTION RATES (mg/dm^2/day) for BUOY PERIPHYTON
AUGUST 14, 1973 (2 WEEKS)
EXPOSURE PERIOD

	NMPW	NMPP	NMPE
2'	1.6	2.1	2.3
7'	0.1	1.1	0.4
12'	0.2	1.2	1.0
17'	0.4	1.6	0.8

used 1 month exposure times. Averaging the total biomass for 60 cm, 210 cm, and 360 cm depths in August, 1966, as reported by Jackson (1967), yields the following values for his 4 buoy stations in Mexico Bay: 81.6, 98.3, 72.3 and 46.6 mg/dm^2. Monthly biomass data collected by QL&M during August, 1973 at the three buoy locations, and averaged for 2, 7, and 12 ft. depths, yielded the following values from west to east: 50.5, 109.5 and 57.6 mg/dm^2. Assuming that no differences exist in substrate selectivity between plexiglass, as used by Jackson, and glass, used in the QL&M study, it is apparent that similar ranges of monthly increases in biomass exists between both studies.

3. CONCLUSIONS

a. The rates of animal to plant periphyton increased from nearshore to offshore waters in the bottom samples and from shallow to deeper depths in the buoy samples after two weeks of exposure.

b. The ratio of animal to plant periphyton decreased as the periphyton community matured.

c. The plant portion of the periphyton was composed primarily of Navicula spp. and Lyngbya diguetti; the animal portion of the periphyton was composed primarily of rotifers.

d. Cladophora was more abundant on styrofoam substrates than on glass substrates. This alga composed less than 1 percent of the total plant periphyton. There were no significant differences in the abundance of Cladophora between dates, transects, or depths, even though a direct relationship w

found between abundance and increasing depth.

e. Net production rates ranged from 0.05 mg ash-free dry wt./dm^2/day to 3.59 mg ash-free dry wt./dm^2/day; the greatest increase in production occurred between the NMPP transect and the FITZ transect.

f. The major factors influencing periphyton growth in the Nine Mile Point vicinity appear to be temperature and light intensity. The results indicated that below a water depth of 17 ft. growth is retarded; the warm temperatures of the discharge plume appeared to retard net production. Production was enhanced immediately to the east of the discharge plume; this effect was limited to one transect.

g. Periphyton communities account for a significant portion of benthic primary and secondary production in the Nine Mile Point vicinity; Cladophora contributes an insignificant fraction to periphyton production.

III. FISH

A. INTRODUCTION

Fishes are a conspicuous component of any freshwater environment whether it be a eutrophic lake dominated by carp and catfish or an oligotrophic lake inhabited by trout and salmon (Benñet, 1971). In addition to being conspicuous inhabitants of the ecosystem, fishes contribute to energy flow through the system. Different species or different life history stages of species may function as primary, secondary or higher level consumers or as detrital feeders (Lagler, Bardach, and Miller, 1962). Fishes derive energy from the various organisms which are used as food sources and, in turn, provide energy for predators, including birds and mammals, or for decomposers. Loss or addition of fishes to an aquatic system may influence the stability of the system by altering patterns of energy flow.

Recognition of the importance of fishes in freshwater systems is due primarily to the development of commercial and recreational fisheries. Extensive exploitation of freshwater fish stocks in the United States has centered in the Great Lakes region. Early commercial fishing in these lakes originated in colonial or post-colonial periods and expanded as population demands increased. The Great Lakes Fishery Commission (1962) has reviewed commercial fish production in these lakes from 1867-1960. Commercial fishing in Lake Erie was reviewed by Applegate and Van Meter

(1970), and Christie (1973) has reviewed the Lake Ontario fishery. Historically, fishing efforts have been so intense in Lake Ontario that overfishing is partially responsible for destabilizing the fish stocks (Christie, 1973).

Efforts to describe the fisheries component of an aquatic system generally require characterization of the spatial and temporal distribution of fishes within the system (see Odum, 1971). This approach utilizes data on numerical and biomass abundance and addresses itself to fluctuations in either of these values; the fluctuations may be attributable to such variables as time (day, month, season), depth or location. Further reduction of these data into diversity indices(mathematical values which describe the community in terms of the relative abundance of each species) provide a more complete assessment of community structure and distribution. Changes in community abundance or diversity distribution may reflect alterations in the environment which have resulted in stress to and destabilization of the fish community.

A second approach to describing the fishes in an aquatic system is through consideration of the population dynamics of selected species. In this sense, population dynamics refers to age distribution, growth rate, age at maturity, relative condition, and feeding preferences. Fish populations are characterized by well-defined age distributions, rates of growth, maturation ages, condition, and feeding preferences (see Lagler, Bardach,

and Miller, 1962; Cushing, 1968). Changes in environmental conditions may influence these parameters and may ultimately affect the success of the population.

1. BACKGROUND OF LAKE ONTARIO FISHERIES

Lake Ontario fisheries resources have long been commercially exploited. Early fishing efforts were quite intense, especially in shallow water and spawning area (Christie, 1973). Construction of dams and millraces on tributary systems reduced accessibility of spawning areas. These two factors and others resulting from man's influence on the Lake region are generally held responsible for the decline of Lake Ontario fisheries (Christie, 1973). Atlantic salmon stocks collapsed during the early to mid-1800's and lake trout, burbot, herring, and deepwater ciscoe fisheries collapsed during the 1940's (Christie, 1973). Alewives were introduced into Lake Ontario during the late 1800's, and the sea lamprey was indentified as a problem at about the same time (Smith, 1973). Rainbow smelt became predominant during the 1920's and 1930's (Christie, 1973). Coincident with these major changes in fish populations were extreme fluctuations in the abundance of many other species occurring in the Lake (see Christie, 1973). Periodic attempts to stock the Lake with trout, salmon, and other species have met with little or no success in establishing reproducing populations(Hubbs and Lagler, 1958; Christie, 1973).

The net result of the changes in Lake Ontario fish stocks has been an almost complete loss of piscivorous fishes and an extreme predominance of forage fishes (U.S. Bureau of Sport Fisheries and Wildlife and N.Y. Department of Environmental Conservation, 1973). Absence of forage fishes from deepwater areas of the Lake has virtually eliminated stocks of predators (BSFW and NYSDEC, 1973) to such an extent that these areas are relatively uninhabited (see Christie, 1973).

In 1972 a cooperative fishery survey of Lake Ontario was conducted under the auspices of the International Field Year for the Great Lakes to determine the composition and distribution of the fish fauna and to estimate the abundance of major fish stocks (BSFW and NYSDEC, 1973). To achieve these objectives, periodic sampling of fish populations were conducted at seven locations on the Lake perimeter from May to October 1972. Fishes were collected by trawl, experimental gill net, and beach seine. Of particular interest is a transect which was established in Mexico Bay just east of Nine Mile Point. Greatest catches of alewives were recorded at this transect.

Early in the design-construction phase of Nine Mile Point Nuclear Station Unit 1, Niagara Mohawk Power Corporation contracted Dr. John F. Storr, an oceanographic and limnological consultant, to assess Lake Ontario fish populations near the Nine Mile Point area. Abundance and

distribution of fish stocks were determined by fathometric surveys and by gill net collections (Storr: 1969 a and b; 1970 a, b, e, f, and g; 1971 a, c, e-g; 1972 a, b, and c; and Undated). Additional studies were conducted to determine the food preferences of yellow perch (Storr, 1970 c and d) and other fishes (Storr: 1970 h and i; 1971 b and d, and 1972 c and d). Storr's work provides a description of the fish communities prior to full scale operation of the power station.

Quirk, Lawler and Matusky Engineers (1973) conducted additional studies on the distribution and abundance of fishes in the Nine Mile Point area during 1972. Fish populations were sampled periodically by surface and bottom trawling, surface, bottom, and mid-depth gill netting, and beach seining. Anatomical and meristic data from these fish were used to determine population characteristics, i.e., length-weight relationships, condition factors, length-frequency distributions, coefficients of maturity and sex ratios for selected species (QL&M, 1973). Similar work has been conducted near the Oswego Steam Station (QL&M, 1972).

2. PRESENT STUDY OBJECTIVES

This report is intended to describe Lake Ontario fish communities in the Nine Mile Point area. These data are considered to provide post-operational assessment of these communities with respect to the Nine Mile Point Nuclear Power Station Unit 1 and pre-operational assessment with respect to the

James A. FitzPatrick Plant and Nine Mile Point Unit 2. Communities were evaluated to determine:

a. natural variation in species, species abundance, and diversity over time;

b. variation in community structure as defined by habitat, depth, and location;

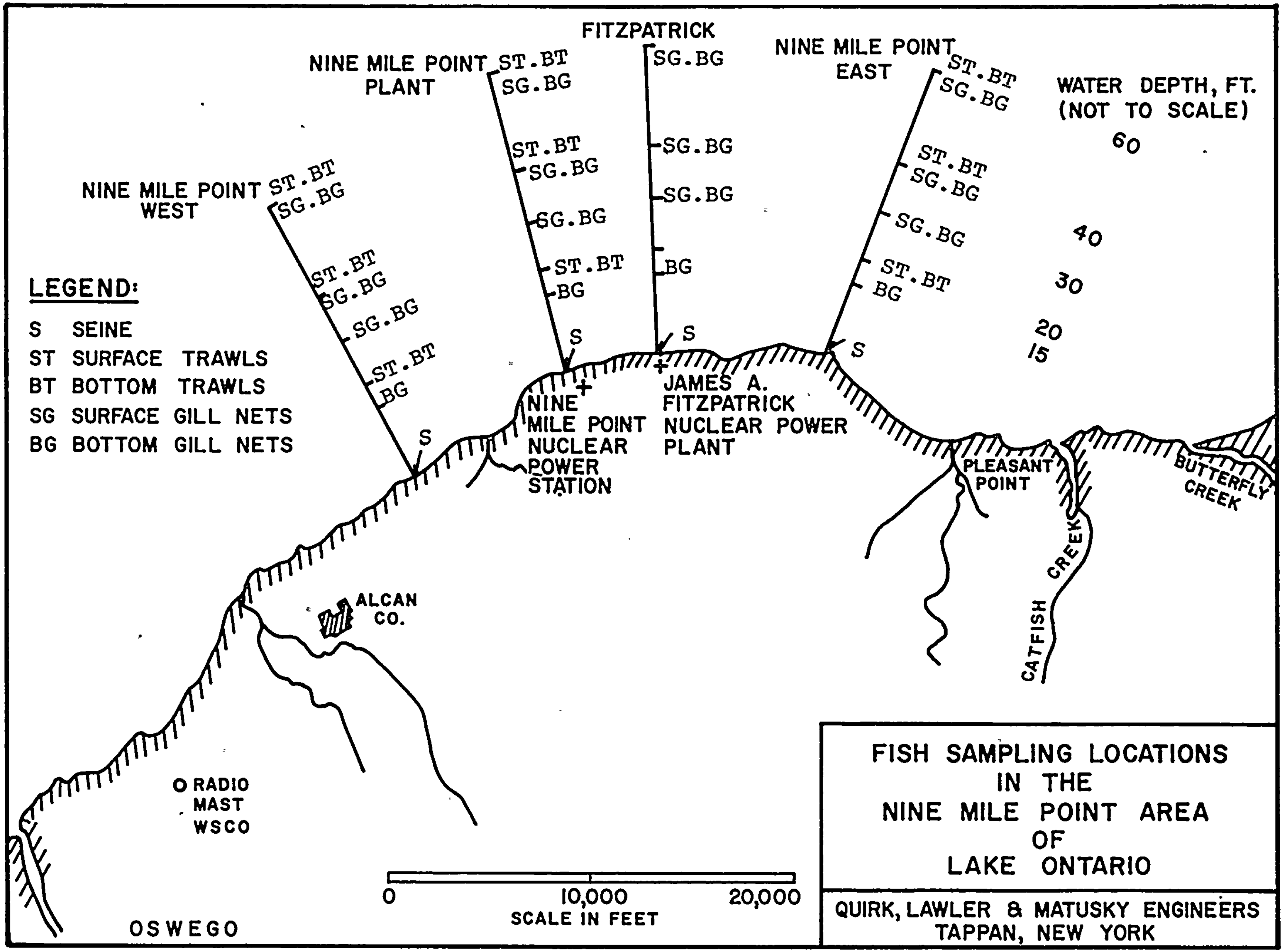
c. population dynamics of selected species; and

d. trophic relationships between fishes and other components of the biotic community.

B. RESULTS AND DISCUSSION

Fish communities in the Nine Mile Point area were sampled from March through December, 1973. Fishes were collected periodically by seine, trawl, and gill net. Seining and gill netting were conducted at four transects: Nine Mile Point West (NMPW), Nine Mile Point Plant (NMPP), FitzPatrick (FITZ) and Nine Mile Point East (NMPE). Trawls initiated at NMPP crossed the FITZ transect, eliminating the need for discrete trawls at each of those transects. Sampling locations are illustrated in Figure III-1.

A total of 59,672 fishes were collected by all three gears over the ten months sampling period (Table III-1). Of this total, 75% were alewives, 7% were white perch, 5% were spottail shiner, 4% were yellow perch and 2%



FISH SAMPLING LOCATIONS
IN THE
NINE MILE POINT AREA
OF
LAKE ONTARIO

QUIRK, LAWLER & MATUSKY ENGINEERS
TAPPAN, NEW YORK

FIGURE III-1

TABLE III-1

TOTAL FISH COLLECTED BY GILL NET, SURFACE TRAWL, BOTTOM TRAWL AND SEINE IN THE VICINITY OF NINE MILE POINT GENERATING STATION 1973 BY DATE AND SPECIES

	Total 1973		March		April		May		June		July		August		September		October		November		December	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Alewife	45043	75	2220	98	1204	84	418	72	6278	78	18373	78	9472	69	3085	68	2205	75	457	65	1331	74
American Eel	5	0									4	0	1	0								
Banded Killfish	3	0									1	0	1	0	1	0						
Black Bullhead	5	0							2	0	2	0							1	0		
Black Crappie	1	0											1	0								
Bluegill	9	0											9	0								
Brown Bullhead	260	0							1	0	12	0	244	2	3	0			1	0		
Brown Trout	31	0							2	0	2	0					1	0	6	1	20	1
Burbot	1	0																			1	0
Carp	34	0							5	0	3	0	6	0	18	0	1	0			1	0
Chinook Salmon	5	0											3	0	2	0						
Emerald Shiner	79	0					9	2	23	0			22	0	2	0	9	0	14	2		
Freshwater Drum	1	0											1	0								
Gar	2	0									1	0	1	0								
Gizzard Shad	386	1					2	0			17	0	139	1	47	1	115	4	27	4	39	2
Golden Shiner	4	0									2	0	2	0								
Johnny Darter	103	0			9	1	7	1	70	1			2	0	3	0	12	0				
Lake Chub	54	0			1	0			13	0	10	0	2	0	3	0	11	0	2	0	12	1
Lake Herring	3	0							2	0			1	0								
Lamprey Eel	1	0																			1	0
Long Nose Dace	1	0											1	0								
Mottled Sculpin	56	0	3	0	7	1	3	1	35	0	1	0	5	0					1	0	1	0
Northern Pike	9	0									1	0			5	0	2	0			1	0
Pumpkinseed	11	0									3	0	7	0			1	0				
Rainbow Smelt	1301	2	41	2	86	6	79	14	357	4	121	1	54	0	218	5	157	5	109	15	79	4
Rock Bass	256	0							3	0	54	0	114	1	70	2	15	0				
Smallmouth Bass	828	1							45	1	181	1	416	3	141	3	40	1			2	0
Spottail Shiner	3117	5	2	0	54	4	8	1	308	4	1573	7	609	4	184	4	116	4	65	9	198	11
Stone Cat	2	0											1	0	1	0						
Threespine Stickleback	78	0					54	9	23	0			1	0								
Trout Perch	293	1			53	4	1	0	81	1	105	1	19	0	26	0	5	0	1	0	2	0
Walleye	7	0									1	0					6	0				
White Bass	23	0									1	0	2	0	7	0	6	0	1	0	6	0
White Perch	4372	7			7	1	2	0	220	3	1723	7	2028	15	300	7	87	3	3	0	2	0
White Sucker	561	1			6	0			85	1	198	1	87	1	45	0	62	2	7	1	71	4
Yellow Bass	31	0									11	0	5	0	6	0	8	0			1	0
Yellow Perch	2264	4			8	1			531	7	1137	5	491	4	368	8	78	3	9	1	42	2
Unidentified	34	0							2	0	30	0	1	0			1	0				
Total	59672	97	2266	100	1435	102	583	100	8086	100	23567	101	13748	99	4535	98	2938	97	704	98	1810	99

were rainbow smelt. Thirty-three different species were represented in the remaining 7%.

Relatively few large piscivores were caught. These consisted of one burbot, three lake herring, five chinook salmon, seven walleyes, nine northern pike, and thirty-one brown trout.

The number of species collected each month increased from March through August then generally declined (Table III-1; see Appendix V-A). The small number of species collected in March, April and May was due to the fact that only trawl collections were conducted during those months. From June through September, when all gear were used, the number of species collected increased from 20 during June to 32 during August, decreased to 15 during November, and increased slightly, to 18 during December.

Gill nets were the most productive of the three types of gear used to sample the fishes (Table III-2; see Appendix V-A), the total gill net catch being approximately four times greater than trawl collections and seven times greater than seine collections. Bottom gill net and bottom trawl collections caught more fishes than surface gill net and surface trawl collections. Of the 43,948 fishes collected by gill nets, over half(29,952) were collected by bottom gill nets. Surface trawls caught 3,372 fishes and bottom trawls 6,342. A total of 6,010 fishes were collected by seine over the sampling period. Gill nets and trawls sampled similar offshore fish communities, while seines sampled from nearshore areas. Gill nets were the most effective of the offshore gear.

TABLE III-2

Total Fish Collected by Gear in the Nine Mile Point Area - 1973

	SEINES	SURFACE TRAWL		BOTTOM TRAWL		TRAWL TOTAL		SURFACE GILL NET		BOTTOM GILL NET		TOTAL GILL NET		TOTAL
	#	#	Mean #/ Unit eff.	#	Mean #/ Unit eff.	#	Mean #/ Unit eff.	#	Mean #/ Unit eff.	#	Mean #/ Unit eff	#	Mean#/ Uniteff	#
Alewife	5178	3166	9.94	5406	14.67	8572	12.18	11,540	26.718	19,753	32.817	31,293	30.269	[illegible]
Rainbow Smelt	9	101	0.35	497	1.46	598	0.87	226	0.523	468	0.778	694	0.671	[illegible]
Spottail Shiner	470	5	0.009	99	0.34	104	0.16	180	0.417	2363	3.926	2543	2.460	3117
Emerald Shiner	49	27	0.06	2	0.004	29	0.03	1	0.002			1	0.001	79
Mottled Sculpin		4	0.01	50	0.13	54	0.07	0		2	0.003	2	0.002	56
Three Spine Stickleback	23	50	0.19	5	0.02	55	0.11							78
Trout perch		2	0.003	119	0.36	121	0.17	24	0.056	148	0.246	172	0.166	293
Yellow Perch	9			12	0.04	12	0.02	486	1.125	2157	3.584	2643	2.556	2664
White Perch	219	1	0.001	27	0.07	28	0.04	1084	2.510	3041	5.052	4125	3.990	4372
White Sucker	2			10	0.03	10	0.02	105	0.243	444	0.738	549	0.531	561
White Bass		1	0.004	1	0.002	2	0.003	2	0.005	19	0.032	21	0.020	23
Rock Bass		2	0.003	4	0.007	6	0.005	71	0.164	179	0.297	250	0.242	256
Smallmouth Bass	14			4	0.009	4	0.004	182	0.421	628	1.043	810	0.784	828
Gizzard Shad	4	13	0.03	10	0.02	23	0.02	35	0.081	321	0.533	356	0.344	383
Johnny darter				91	0.23	91	0.11			13	0.022	13	0.013	104
Brown bullhead				1	0.002	1	0.001	9	0.021	251	0.417	260	0.252	261
Lake Chub				1	0.004	1	0.002	13	0.030	39	0.065	52	0.050	53
American Eel				3	0.008	3	0.004	2	0.005			2	0.002	5
Sea Lamprey								1	0.002			1	0.001	1
Pumpkinseed	15							1	0.002	9	0.015	10	0.010	25
Carp	2							3	0.007	15	0.025	18	0.174	20
Black Crappie	2													[illegible]
Banded Killifish	2													[illegible]
Bluegill sunfish	9													9
Longnose Dace	1													1
Unidentified	2							2	0.005	30		32	0.031	34
Brown trout								21	0.049	10	0.017	31	0.030	31
Stone cat										2	0.003	2	0.002	2
Lake herring										3	0.005	3	0.003	3
Chinook salmon								1	0.002	4	0.007	5	0.005	5
Yellow bass								6	0.014	25	0.042	31	0.030	31
Gold shiner								1	0.002	3	0.005	4	0.004	4
Gar										2	0.003	2	0.002	2
FWD										1	0.002	1	0.001	1
Northpike										9	0.015	9	0.009	9
Burbot										1	0.002	1	0.001	1
Walleye										7	0.012	7	0.007	7
Black bullhead										5	0.008	5	0.005	5
TOTAL	6012	3372		6342		9714		13996		29952		43948		59672

Seventeen species were collected by seine, 18 by trawl, and 33 by gill net. Alewives formed the greatest portion of the catch by each gear. Spottail shiners were the second most abundant species collected by seine. Rainbow smelt ranked second for trawls, and white perch were second for gill nets. The few burbot, lake herring, chinook salmon, walleyes, northern pike, and brown trout that were taken were all collected by gill netting. With the exception of a single chinook salmon, all were taken by bottom gill nets.

Based upon numerical abundance, the major fish species collected at the Nine Mile Point area are as follows: alewife, white perch, spottail shiner, yellow perch, and rainbow smelt (Table III-3). Characterizations of each species follow:

Alewife (*Alosa pseudoharengus*)

The alewife is an anadromous fish of the herring family common to the coast of North America from Nova Scotia to North Carolina (Bigelow and Schroeder, 1953). The alewife also occurs as a landlocked species in certain lakes of New York State, including the Finger Lakes and Laurentian Great Lakes (Scott, 1961; Smith, 1973). Despite long-standing access to the Great Lakes through natural waterways, alewives are not native to the Great Lakes and were apparently introduced to Lake Ontario sometime during the 1860's (Christie, 1973). Establishment of the alewife during the 1860's

TABLE III - 3

INVENTORY OF FISHES
COLLECTED AT NINE MILE POINT AREA

Scientific Name*	Common Name
Family Petromyzontidae	
Petromyzon marinus	Sea lamprey
Family Lepisosteidae	
Lepisosteus osseus	Longnose gar
Family Anguillidae	
Anguilla rostrata	American eel
Family Clupeidae	
Alosa pseudoharengus	Alewife
Dorosoma cepedianum	Gizzard shad
Family Salmonidae	
Salmo trutta	Brown trout
Oncorhynchus tshawutscha	Chinook salmon
Coregonus artedii	Cisco or Lake herring
Family Osmeridae	
Osmerus mordax	Rainbow smelt
Family Esocidae	
Esox lucius	Northern pike
Family Cyprinidae	
Cyprinus carpio	Carp
Notemigonus crysoleucas	Golden shiner
Rhinichthys cataractae	Longnose dace
Notropis cornutus	Common shiner
Notropis hudsonius	Spottail shiner
Notropis atherinoides	Emerald shiner
Couesius plumbeus	Lake chub
Family Catostomidae	
Catostomus commersoni	White sucker
Family Ictaluridae	
Ictalurus nebulosus	Brown bullhead
Ictalurus melas	Black bullhead
Noturus flavus	Stonecat
Family percopsidae	
Percopsis omiscomaycus	Trout perch
Family Gadidae	
Lota lota	Burbot

TABLE III-3 Cont'd)

Scientific Name*	Common Name
Family Cyprinodontidae	
Fundulus diaphanus	Banded Killifish
Family Gasterosteidae	
Gasterosteus aculeatus	Threespined stickleback
Family Cottidae	
Cottus bairdi	Mottled sculpin
Family Percichthyidae	
Morone americana	White perch
Morone chrysops	White bass
Morone mississippiensis	Yellow bass
Family Centrarchidae	
Ambloplites rupestris	Rock bass
Lepomis macrochirus	Bluegill
Lepomis gibbosus	Pumpkinseed
Micropterus dolomieui	Smallmouth bass
Pomoxis nigromaculatus	Black crappie
Family Percidae	
Etheostoma nigrum	Johnny darter
Perca flavescens	Yellow perch
Stizostedion vitreum	Walleye
Family Sciaenidae	
Aplodinotus grunniens	Freshwater drum

*According to a list of common and scientific names of fishes from the United Staes and Canada. Amer. Fish Soc. Spec. Publ. No. 6 3rd ed.

coincided with a sharp decline in abundance of salmon and lake trout (Smith, 1973).

The annual inshore-offshore migration of alewives has been viewed as detrimental to a variety of desirable forage fish, namely slimy sculpins and emerald shiners (Smith, 1973). In addition, the filter-feeder ability of the alewife resulted in zooplankton depletion and subsequent loss of food for other desirable species (Brown, 1972). Abundance of alewives has been of great nuisance value in several respects, namely, clogging of municipal water supply stations, interruption of industrial operations and fouling of beaches during the "annual die-off."

Alewives are an important commercial species in the Great Lakes. The amplitude of year-to-year population variations is large. Alewives spawn in the littoral zone in June and early July and the juveniles spend some time there. In late summer, they are common at depths down to 20 fathoms (Christie, 1973). The fish move into deeper waters during the winter.

In the Nine Mile Point area during 1973, alewives provided 75% of the total commercial fish catch by gill nets, trawls, and seines. According to monthly catch per unit effort data, greatest numbers of alewives were caught during April and July. In Lake Ontario, particularly along the southern shore, large numbers die during the spring. The causes for this mortality are presently unknown.

Rainbow Smelt (Osmerus mordax)

The rainbow smelt is an anadromous fish of the Atlantic Coast of North America which ranges from Labrador to Virginia (Bigelow and Schroeder, 1953). Landlocked populations of smelt occur in fresh water throughout the Great Lakes region, New York State and the Province of Ontario (Scott, 1961). Introduction of smelt into the Laurentian Great Lakes probably occurred as the result of the introductions which began in Crystal Lake, Michigan in 1912 (Scott, 1961). Some of these fish eventually escaped into Lake Erie where the species was reported in 1932. Smelt were not present in sufficient numbers to support a commercial fishery in Lake Erie until the 1950's. A commercial fishery for smelt has existed in Lake Ontario since 1952, in Lake Michigan since 1931 and, intermittently in Lakes Huron and Superior since the late 1930's. Current commercial production of smelt from the Great Lakes is substantial, totalling 17,131,000 lbs. in 1971; 76% of this production originated in Lake Erie.

According to Wells (1968), the smelt lives in the thermocline during the summer. In Lake Michigan, the smelt does not inhabit deep waters in the winter. Smelt are considered a threat to stocks of some of the more important commercial and game species (e.g. Lake trout} Gordon, 1961). However, the threat appears to be restricted to competition with other species for similar foods. The adult smelt is know to prey upon the eggs and larvae of valuable forage fish, such as the emerald shiner, common shiner and possibly upon the juvenile

forms of the lake trout and Atlantic salmon. The smelt attains a size of approximately fourteen inches and a weight of approximately one-half pound. Smelt are also figured prominently into the diet of yellow perch, walleye, lake trout and smallmouth bass.

At Nine Mile Point in 1973, the rainbow smelt provided 2% (1301) of the total fish catch from seines, trawls, and gill nets. Based upon monthly catch per unit effort, greatest numbers of smelt were caught during June and September.

White Perch (Morone americana)

White perch occur along the Atlantic Coast of North America from New Brunswick, Prince Edward Island, and Nova Scotia to South Carolina and have been introduced into various waters of New England, New York and Quebec, including the Lake Ontario basin and Lake Erie (Hubbs and Lagler, 1958). These fish are found in brackish and freshwaters, ascend streams, and are landlocked in many ponds. The white perch has a basic diet of fish, amphipods, and dipterans.

At the Nine Mile Point area in 1973, white perch comprised 7% of the total catch from gill nets, trawls, and seines. Based upon monthly catch per unit effort, white perch were most abundant during July and August.

Spottail Shiner (<u>Notropis hudsonius</u>)

This species occurs from Delaware to Georgia and is a representative of the most abundant family of fishes in the Great Lakes Region, the minnows (Cyprinidae). Their great abundance accounts for the importance of this group of fishes in the food chain of many predaceous fish (Hubbs and Lagler, 1958). At Nine Mile Point area in 1973, spottail shiner provided 5% of the total catch by gill nets, trawls, and seines. According to monthly catch per unit effort, spottail shiners were most abundant during July.

Yellow Perch (<u>Perca flavescens</u>)

The yellow perch is a common freshwater fish occurring throughout west-central and Eastern Canada and the U.S. from the Hudson Bay Drainage southward to Ohio inland, and to South Carolina in coastal streams and estuaries (Hobbs and Lagler, 1958). Although found primarily in freshwater, the species has been identified as occurring in the slightly brackish waters of the Hudson, Delaware and Patuxent Rivers (DeSylva et al., 1962; QLM, 1974; Mihursky, unpublished data).

The yellow perch is an important food and sport fish throughout the southern portion of the Great Lakes region. It comprises a significant part of the commercial and angler catches. Spawning runs occur during the spring in the lower reaches of streams, entering the Great Lakes and at shallow depths in the Lakes (Hubbs and Lagler, 1958). In Nine Mile Point

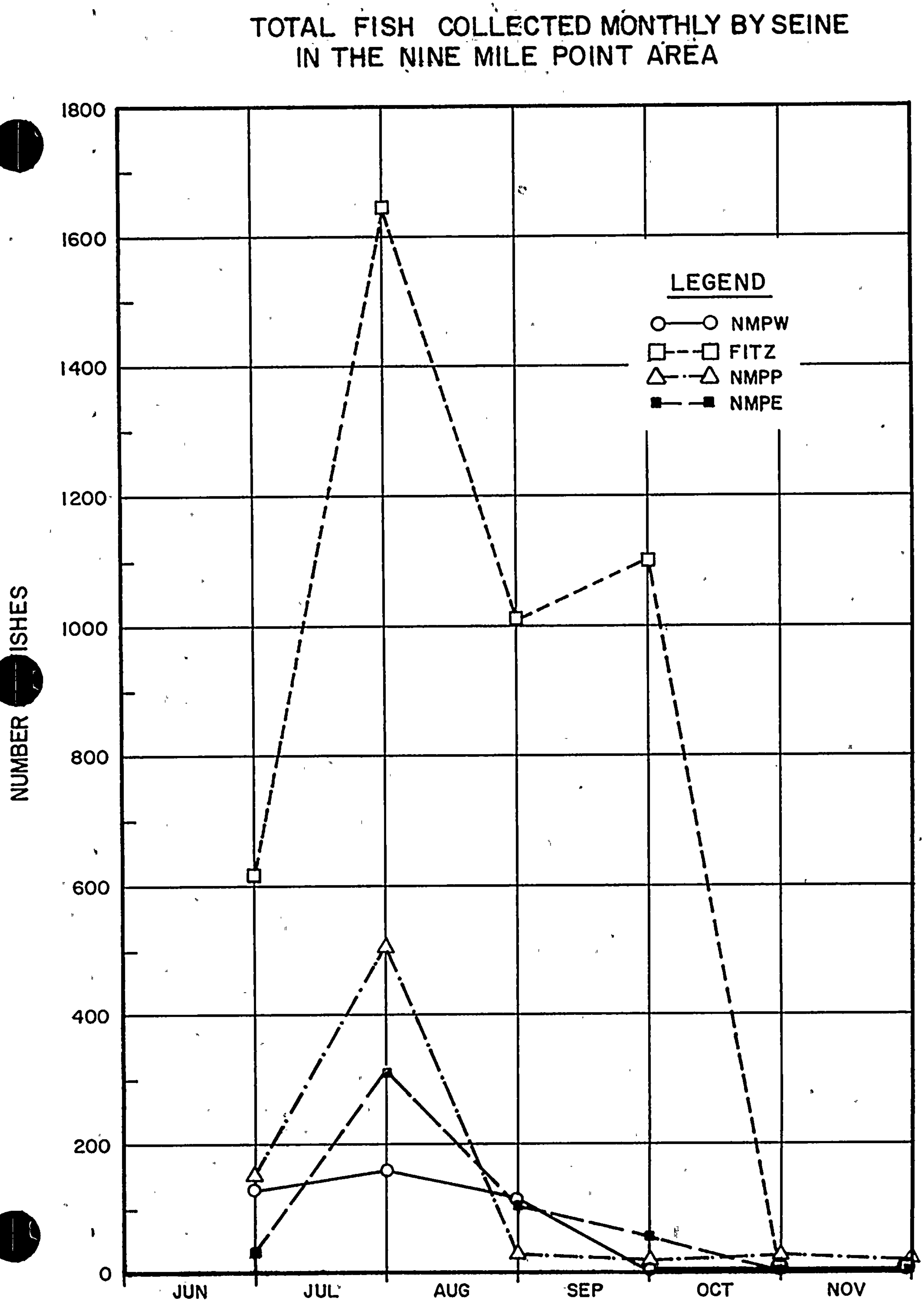
area in 1973, yellow perch provided 4% of the total catch by gill nets, trawls, and seines. With regard to monthly catch per unit effort, yellow perch were most abundant during July and August.

The remainder of the RESULTS AND DISCUSSION section has been divided into five parts. Each gear (seines, trawls, and gill nets) is discussed separately. The fourth section discusses the fish communities as represented by the various gear. The final section assesses fish communities before and after operation of Nine Mile Point Nuclear Power Station Unit One. Within each gear section the abundance and distribution of the component species is considered and is followed by a discussion of community structure as determined from the abundance and diversity characteristics of the fishes in the collections.

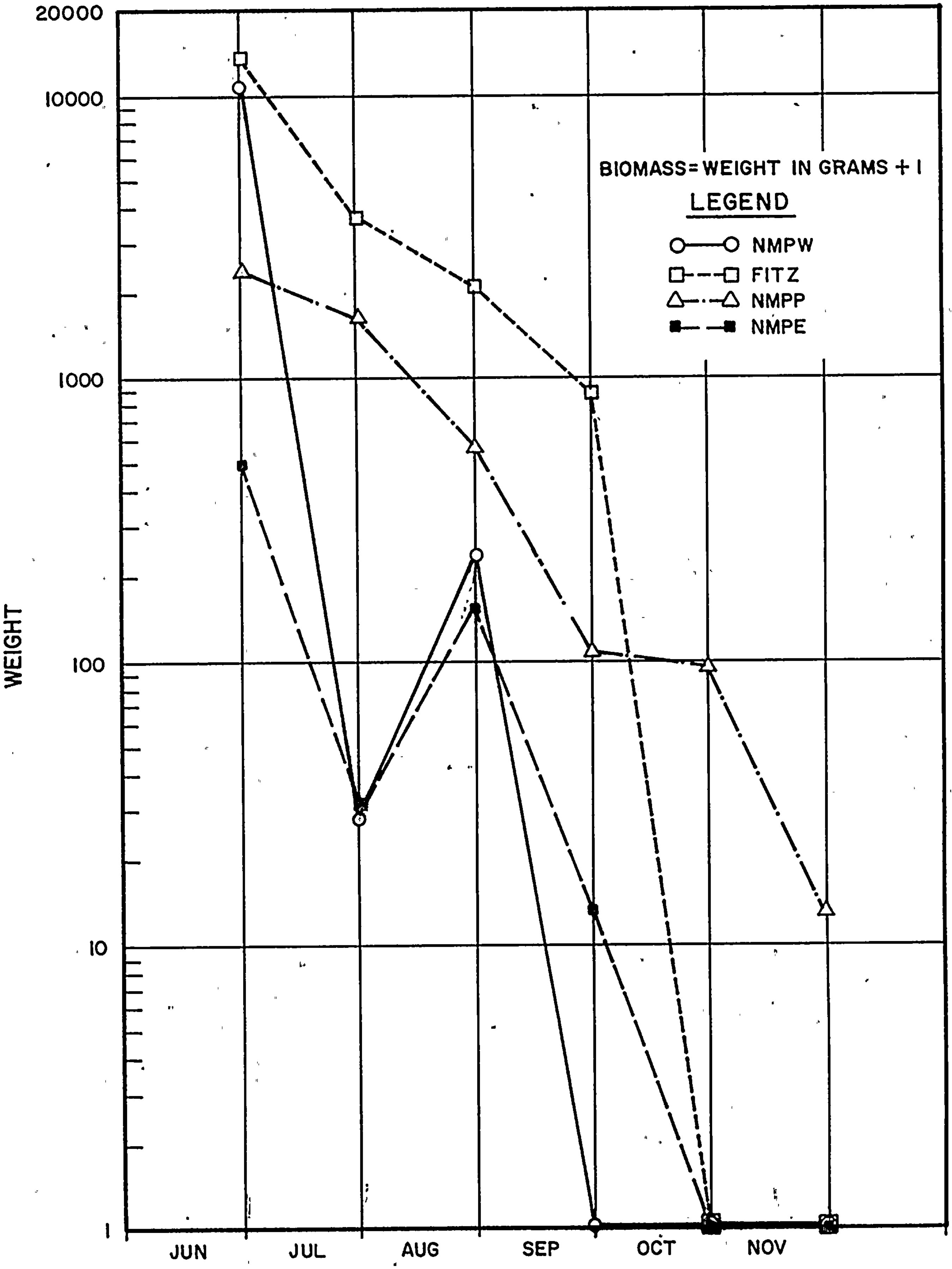
1. SEINES

a. Distribution and Abundance

Seine collections at FITZ generally produced the greatest numbers (Figure III-2) and biomass (Figure III-3) of fishes of the four seining areas (see Appendix V-B). Numerical abundance peaked at all stations during July, while biomass was greatest during June. This same trend was evident when monthly numerical and biomass data were plotted together for each transect


TOTAL FISH COLLECTED MONTHLY BY SEINE
IN THE NINE MILE POINT AREA
LEGEND
NMPW
FITZ
NMPP
NMPE
NUMBER ISHES
0
200
400
600
800
1000
1200
1400
1600
1800
JUN
JUL
AUG
SEP
OCT
NOV

TOTAL FISH BIOMASS COLLECTED MONTHLY BY SEINE IN THE NINE MILE POINT AREA



(Figures III-4, III-5, III-6, and III-7). This suggests that fewer large fishes were present in the inshore areas during June and that a large number of smaller fishes were present during July.

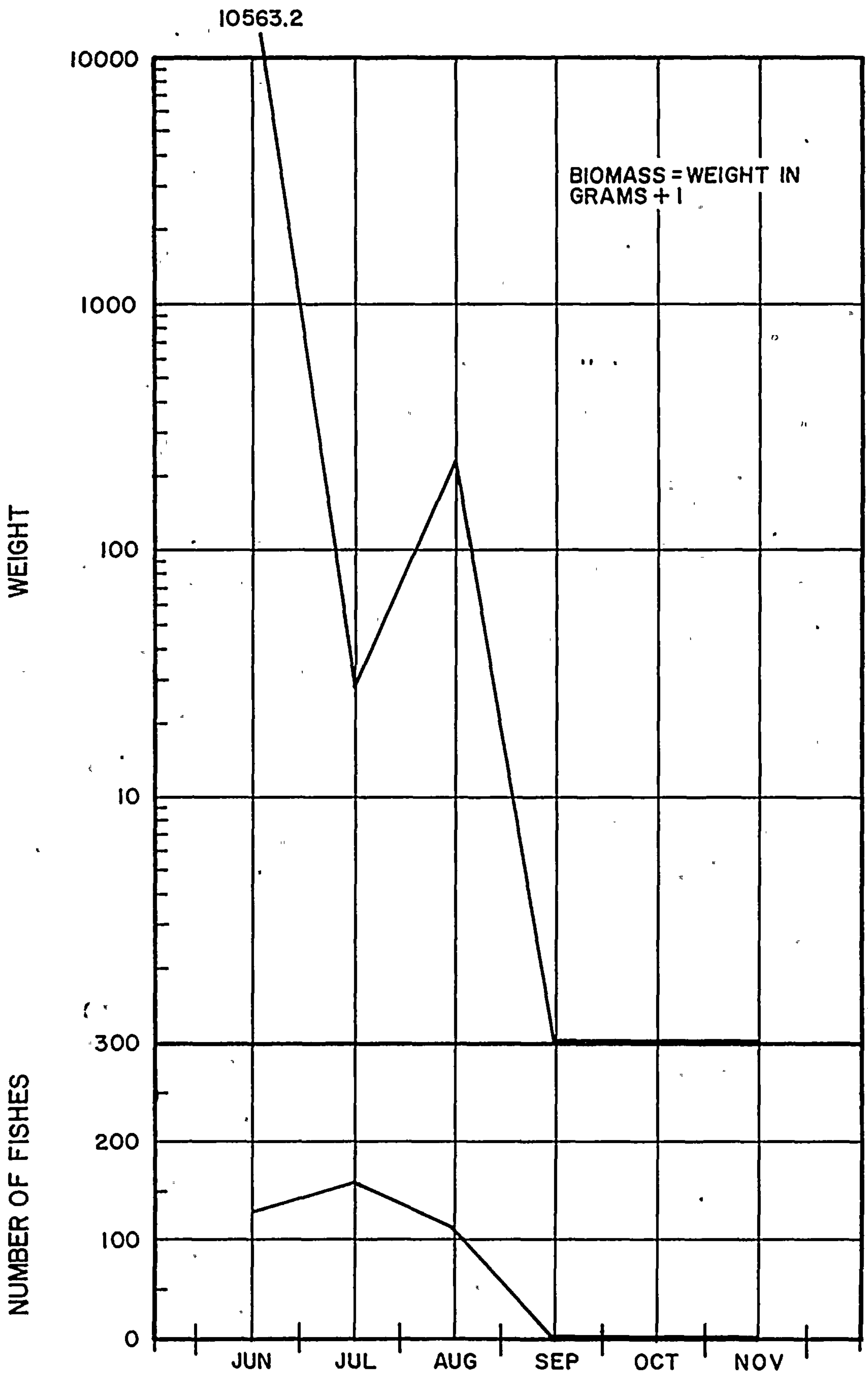
Alewives contributed substantially in numbers and biomass in the June and July collections (see Table III-4 and III-5). Examination of Table III-5 indicates that larger alewives were collected by seine during June than during July. Mean total length of alewives during the June collections was 14.3cm; during July; mean total length was 4.2cm.

Numerical and biomass abundance of fishes from each seine collection are plotted in Figures III-8 and III-9, respectively. The July peak in numerical abundance was wholly attributable to the 27 July collection. The 15 June collections account for the high biomass values observed in that month. Variations in catch between sampling dates within any given month were highly variable. Numerical abundance data for the two dates during each month were compared by the Wilcoxon signed rank test (see Appendix I-F). The results are summarized below:

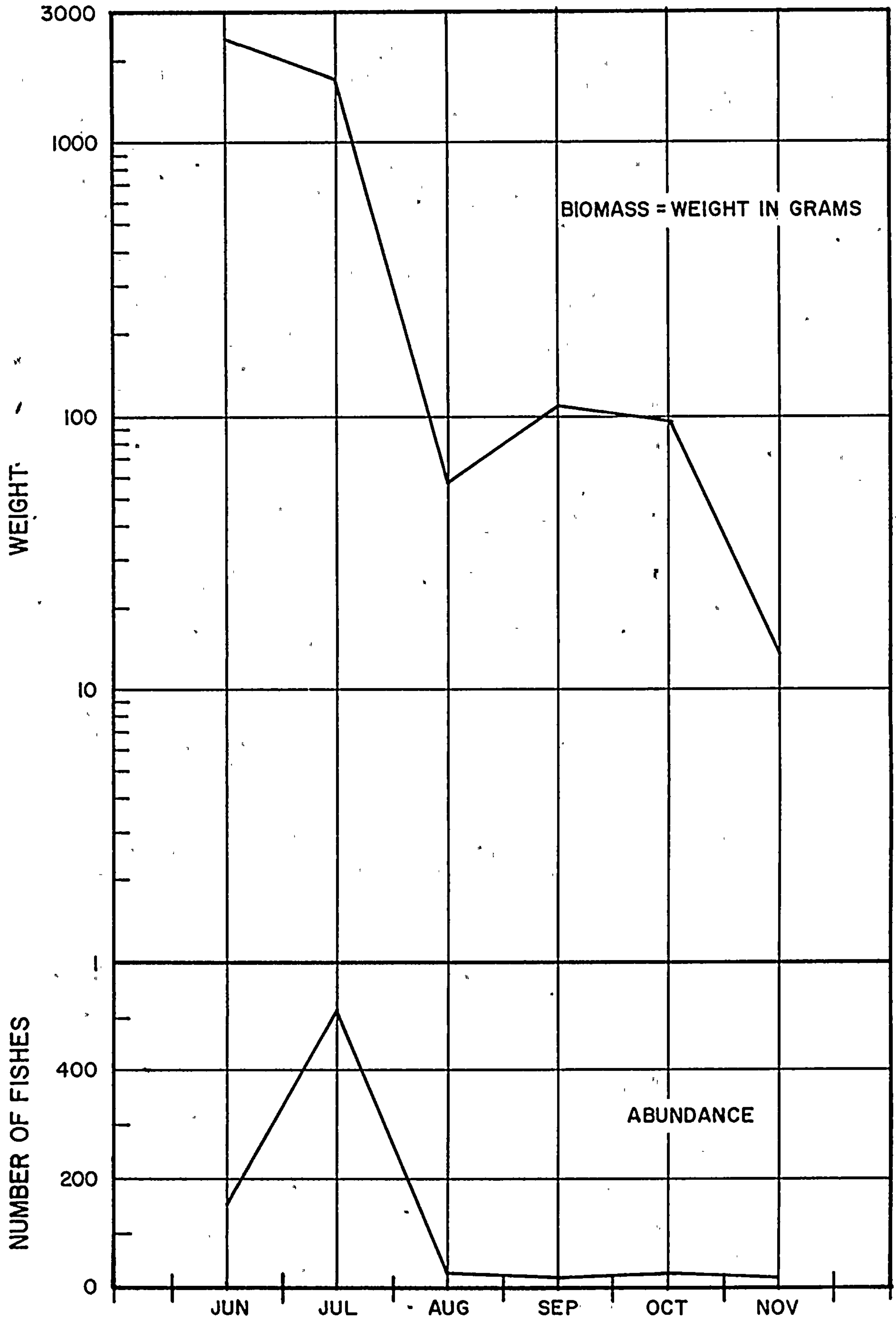
Month	June	July	August	September†
Dates	15 29	13 27	24 31	14 21
Ts	0	6	23	5
Critical Range	$6 \leq Ts \leq 39$	$1 \leq Ts \leq 20$	$14 \leq Ts \leq 64$	$0 \leq Ts \leq 15$
α	0.054*	0.062*	0.052*	0.062*

†October and November sample sizes inadequate.
*Significant at the probability level indicated.

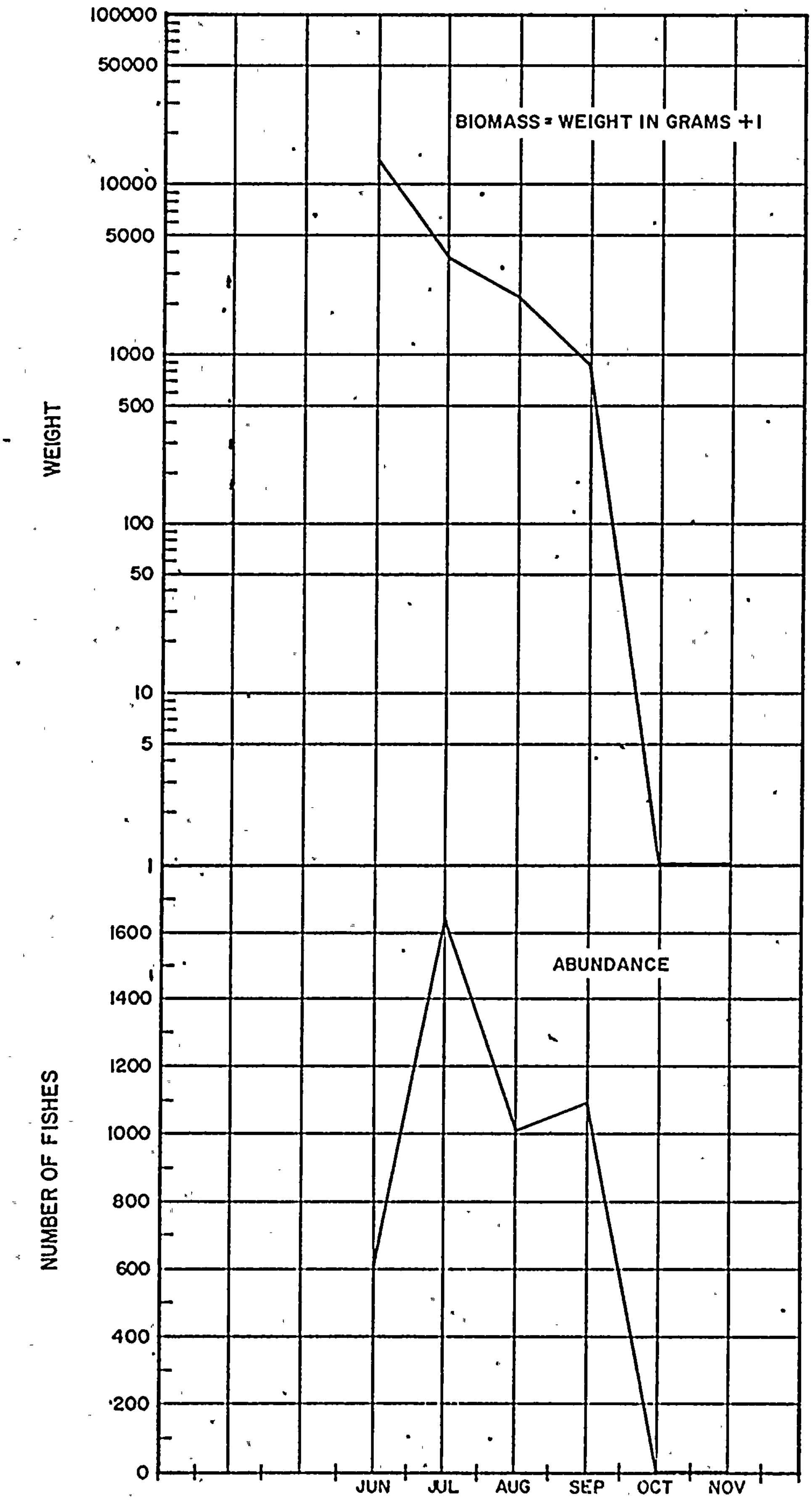
MONTHLY SEINE COLLECTIONS AT TRANSECT NINE MILE POINT WEST



MONTHLY SEINE COLLECTIONS AT TRANSECT NINE MILE POINT PLANT



MONTHLY SEINE COLLECTIONS OF TRANSECT FITZPATRICK



MONTHLY SEINE COLLECTIONS AT TRANSECT NINE MILE POINT EAST

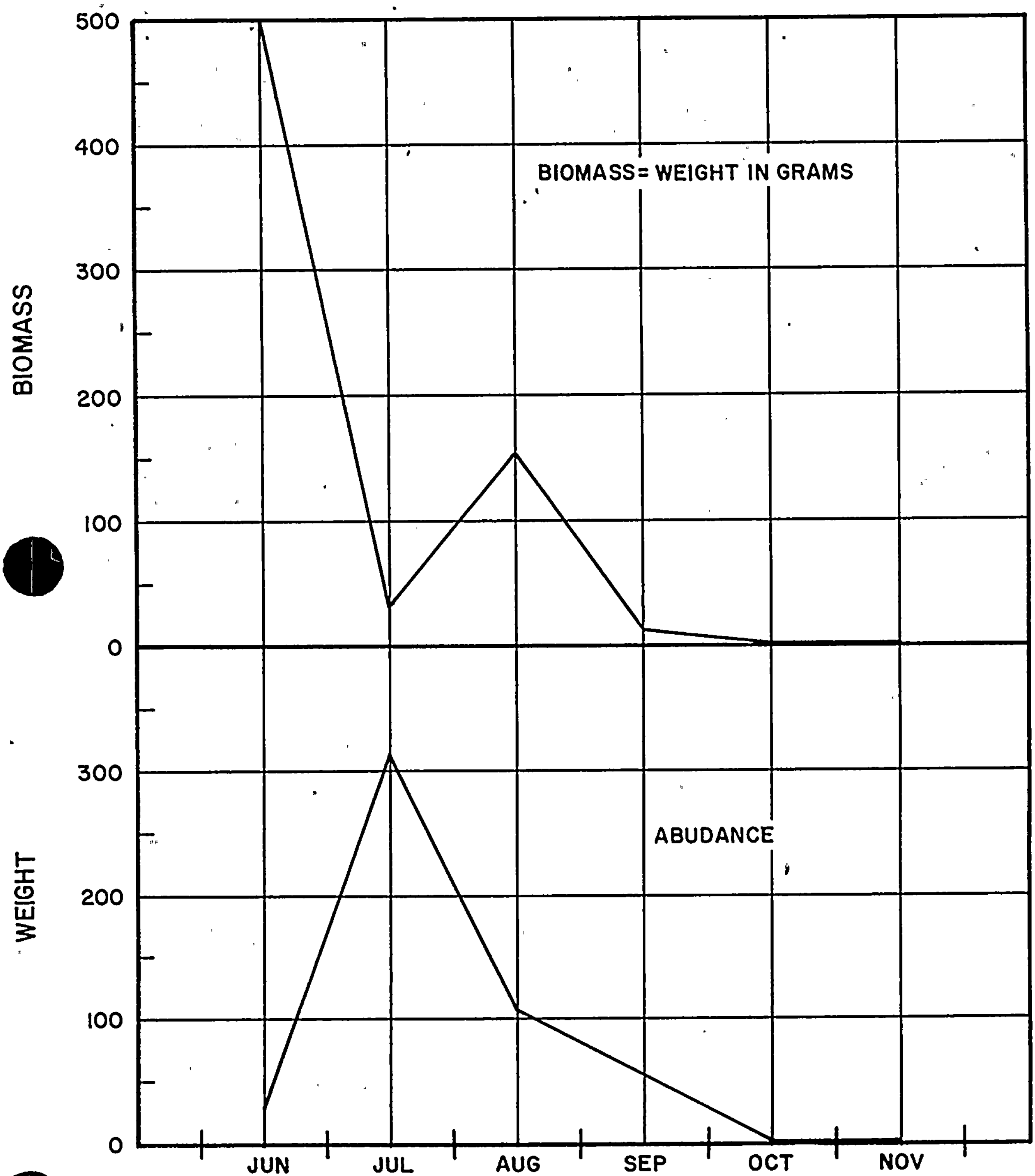


TABLE III-4

CATCH AND PERCENT COMPOSITION OF SEINE COLLECTIONS IN THE NINE MILE POINT AREA

JUNE

	NMPW No. Caught	NMPW %	NMPP No. caught	NMPP %	FITZ No caught	FITZ %	NMPE No. caught	NMPE %
Alewife	43	33.33	104	68.42	536	87.58	19	61.29
Rainbow Smelt	1	0.78	1	0.66	5	0.82	1	3.23
Threespine Stickleback	1	0.78	2	1.32	10	1.63	10	32.26
Spottail Shiner	63	48.84	38	25.00	52	8.50		
Emerald Shiner	19	14.73			3	0.49	1	3.23
Yellow Perch	1	0.78	4	2.63	2	0.33		
Carp	1	0.78	1	0.66				
Smallmouth Bass					4	0.65		
White Sucker			2	1.32				
Total	129		152		612		31	

JULY

	NMPW No. Caught	NMPW %	NMPP No. caught	NMPP %	FITZ No caught	FITZ %	NMPE No. caught	NMPE %
Alewife	158	99.37	507	99.80	1508	91.78	314	100.00
Rainbow Smelt					1	0.06		
Spottail Shiner	1	0.63			127	7.73		
Smallmouth Bass					4	0.24		
Gizzard Shad					3	0.18		
Banded Killifish			1	0.20				
Total	159		508		1643		314	100.00

TABLE III-4 Cont'd

AUGUST

	NMPW No. caught	%	NMPP No. caught	%	FITZ No. caught	%	NMPE No. caught	%
Alewife			1	4.00	834	82.74		
Spottail Shiner	43	38.39			20	1.98	105	98.13
White Perch	66	58.93	4	16.00	148	14.68	1	0.93
Smallmouth Bass	1	0.89	1	4.00	1	0.10		
Yellow Perch	1	0.89					1	0.93
Emerald Shiner			8	32.00	3	0.30		
Gizzard Shad					1	0.10		
Black Crappie					1	0.10		
Banded Killifish	1	0.89						
Bluegill Sunfish			9	36.00				
Longnose Dace			1	4.00				
Unidentified			1	4.00				
Total	112		25		1008		107	

SEPTEMBER

	NMPW No. caught	%	NMPP No. caught	%	FITZ No. caught	%	NMPE No. caught	%
Alewife					1099	99.91	55	100.00
Emerald Shiner	NO				1	0.09		
Smallmouth Bass	FISH		3	16.67				
Pumpkinseed	CAUGHT		14	77.78				
Black Crappie			1	5.56				
Total			18		1100		55	

TABLE III-4 Cont'd

OCTOBER

	NMPW No. caught	%	NMPP No. caught	%	FITZ No. caught	%	NMPE No. caught	%
Spottail Shiner	No		21	87.50	No		No	
Emerald Shiner	fish		1	4.17	fish		fish	
Pumpkinseed	caught		1	4.17	caught		caught	
Unidentified			1	4.17				
Total			24					

NOVEMBER

	NMPW No. caught	%	NMPP No. caught	%	FITZ No. caught	%	NMPE No. caught	%
Emerald Shiner	No		13	100.00	No		No	
	fish				fish		fish	
	caught				caught		caught	
Total			13					

TABLE III-5

BIOMASS (IN GRAMS) AND PERCENT COMPOSITION OF SEINE COLLECTIONS IN THE NINE MILE POINT AREA.

JUNE

	NMPW Biomass	%	NMPP Biomass	%	FITZ Biomass	%	NMPE Biomass	%
Alewife	672.6	6.37	1976.0	82.14	12596.0	93.50	444.8	89.03
Rainbow Smelt	2.0	0.02	17.5	0.73	32.6	0.24	21.8	4.36
Threespine Stickleback	2.3	0.02	2.7	0.11	21.9	0.16	24.9	4.98
Spottail Shiner	896.2	8.48	254.6	10.62	756.9	5.62		
Emerald Shiner	122.0	1.16			16.3	0.12	8.1	1.62
Yellow Perch	14.1	0.13	75.1	3.13	19.7	0.15		
Carp	8853.0	83.82	61.5	2.56				
Smallmouth Bass					28.7	0.21		
White Sucker			10.4	0.43				
Total	10562.2		2397.8		13472.1		499.6	

JULY

	NMPW Biomass	%	NMPP Biomass	%	FITZ Biomass	%	NMPE Biomass	%
Alewife	15.8	58.52	1673.1	99.91	6635.2	94.97	98.0	100.00
Rainbow Smelt					8.7	0.12		
Spottail Shiner	11.2	41.48			190.5	2.73		
Smallmouth Bass					5.9	0.08		
Gizzard Shad					146.2	2.09		
Banded Killifish			1.5	0.09				
Total	27.0		1674.6		6986.5		98.0	

TABLE III-5 Cont'd

AUGUST

	NMPW		NMPP		FITZ		[illegible]PE	
	Biomass	%	Biomass	%	Biomass	%	Biomass	
Alewife			0.6	1.05	3002.4	84.87		
Spottail Shiner	84.4	36.43			32.5	0.92	147.0	94
White Perch	133.5	57.62	19.7	34.62	466.6	13.19	1.1	0
Smallmouth Bass	5.1	2.20	2.0	3.51	7.1	0.20		
Yellow Perch	5.7	2.46					7.4	4
Emerald Shiner			26.4	46.40	1.8	0.05		
Gizzard Shad					23.8	0.67		
Black Crappie					3.5	0.10		
Banded Killifish	3.0	1.29						
Bluegill Sunfish			5.5	9.67				
Longnose Dace			0.9	1.68				
Unidentified			1.8	3.16				
Total	231.7		56.9		3537.7		155.55	
SEPTEMBER								
Alewife					879.2	99.97	13.9	10
Emerald Shiner	No				0.3	0.03		
Smallmouth Bass	fish		34.4	31.68				
Pumpkinseed	caught		68.5	63.08				
Black Crappie			5.7	5.25				
Total			108.6		879.5		13.9	

TABLE III-5 Cont'd

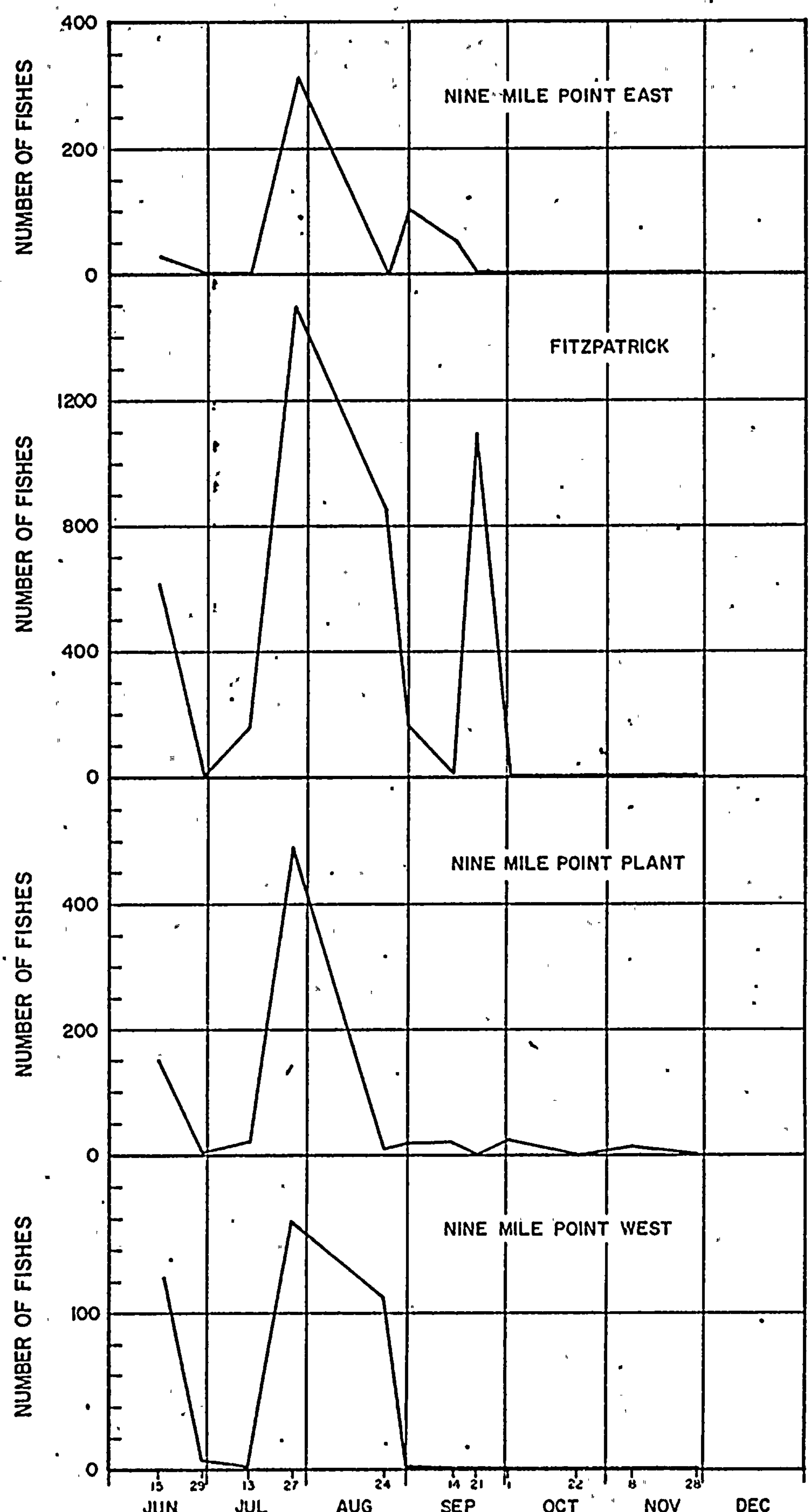
OCTOBER

	NMPW Biomass	%	NMPP Biomass	%	FITZ Biomass	%	NMPE Biomass	%
ottail Shiner			61.0	64.55				
erald Shiner	No		5.9	6.24	No		No	
npkinseed	fish		25.0	24.46	fish		fish	
identified	caught		2.6	2.75	caught		caught	
Total			94.5					

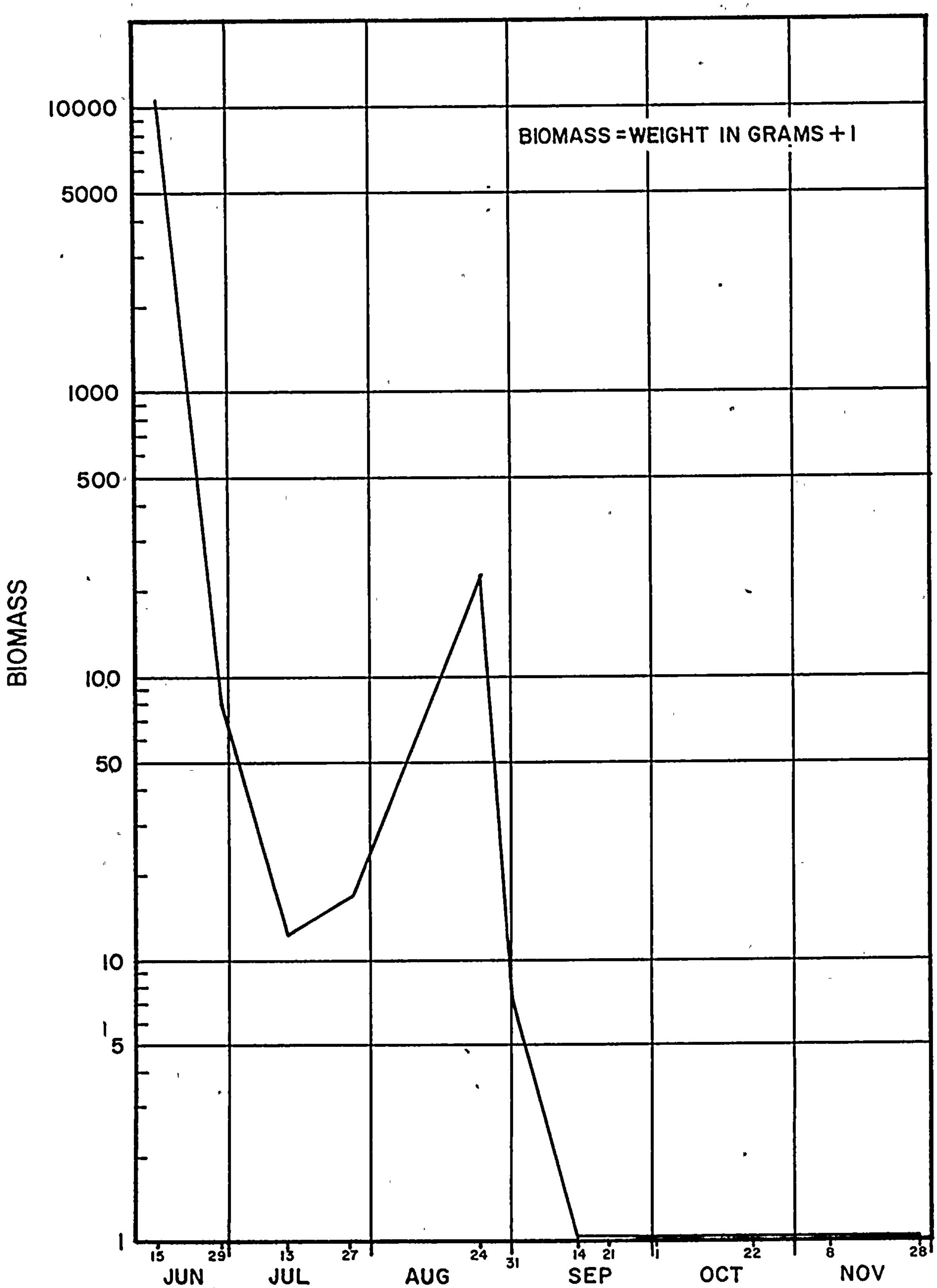
NOVEMBER

	NMPW Biomass	%	NMPP Biomass	%	FITZ Biomass	%	NMPE Biomass	%
eral[illegible]hiner	No		13.0	100.00	No		No	
	fish				fish		fish	
	caught				caught		caught	
Total			13.0					

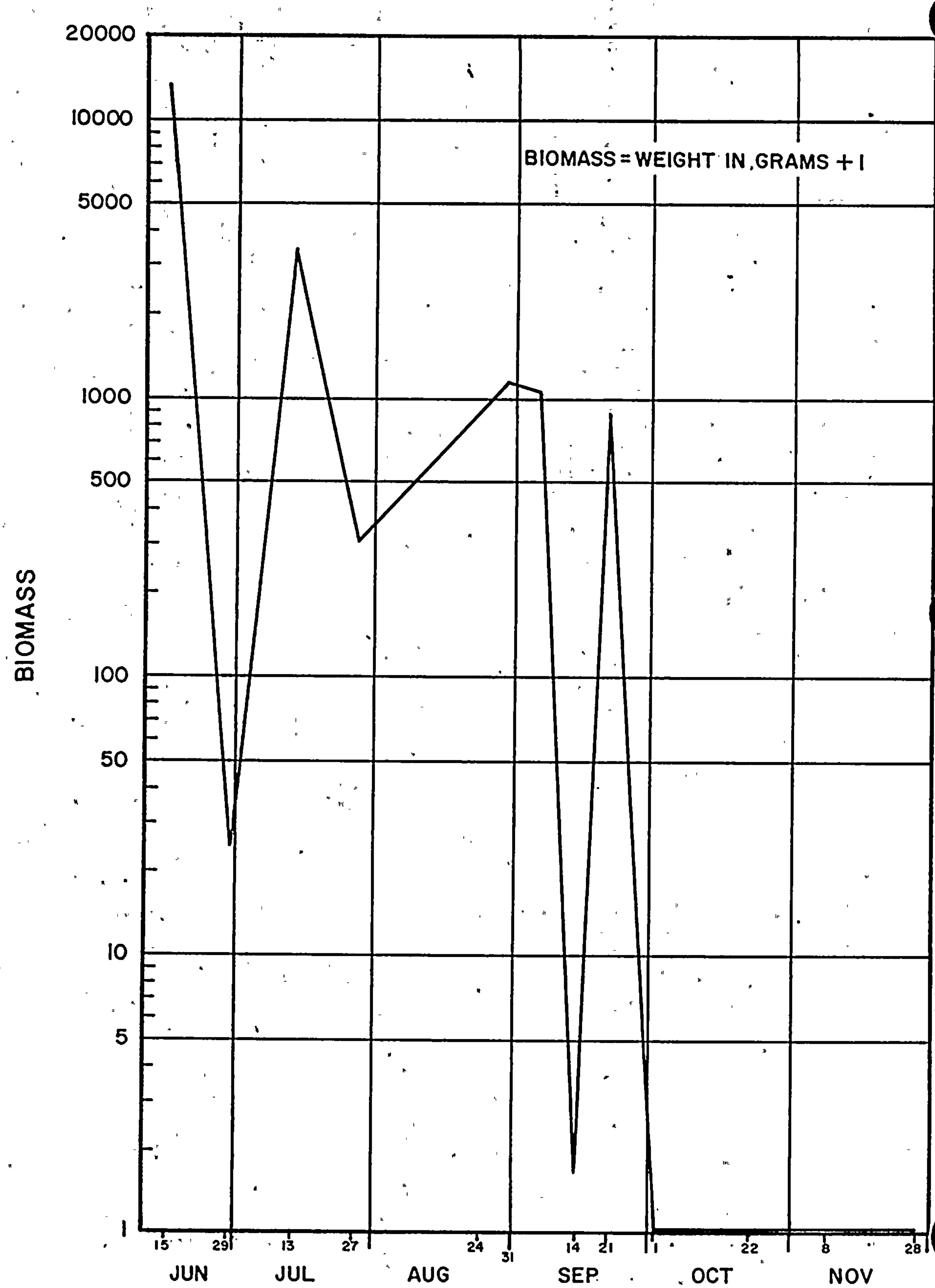
TOTAL NUMBER OF FISHES COLLECTED BY DATE DURING SEINE COLLECTION AT NINE MILE POINT AREA



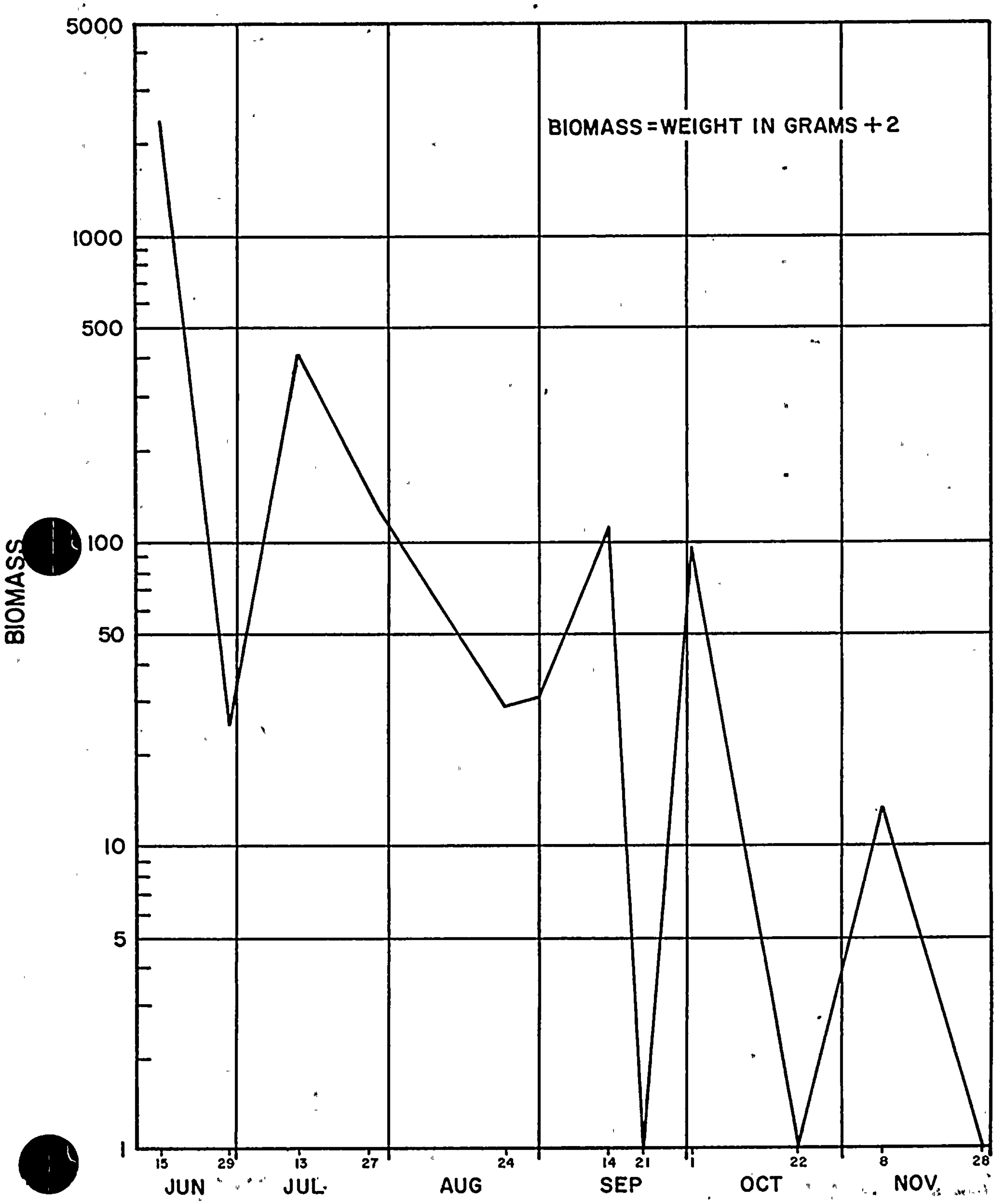
TOTAL FISH BIOMASS COLLECTED BY DATE DURING SEINE COLLECTIONS AT NINE MILE POINT WEST



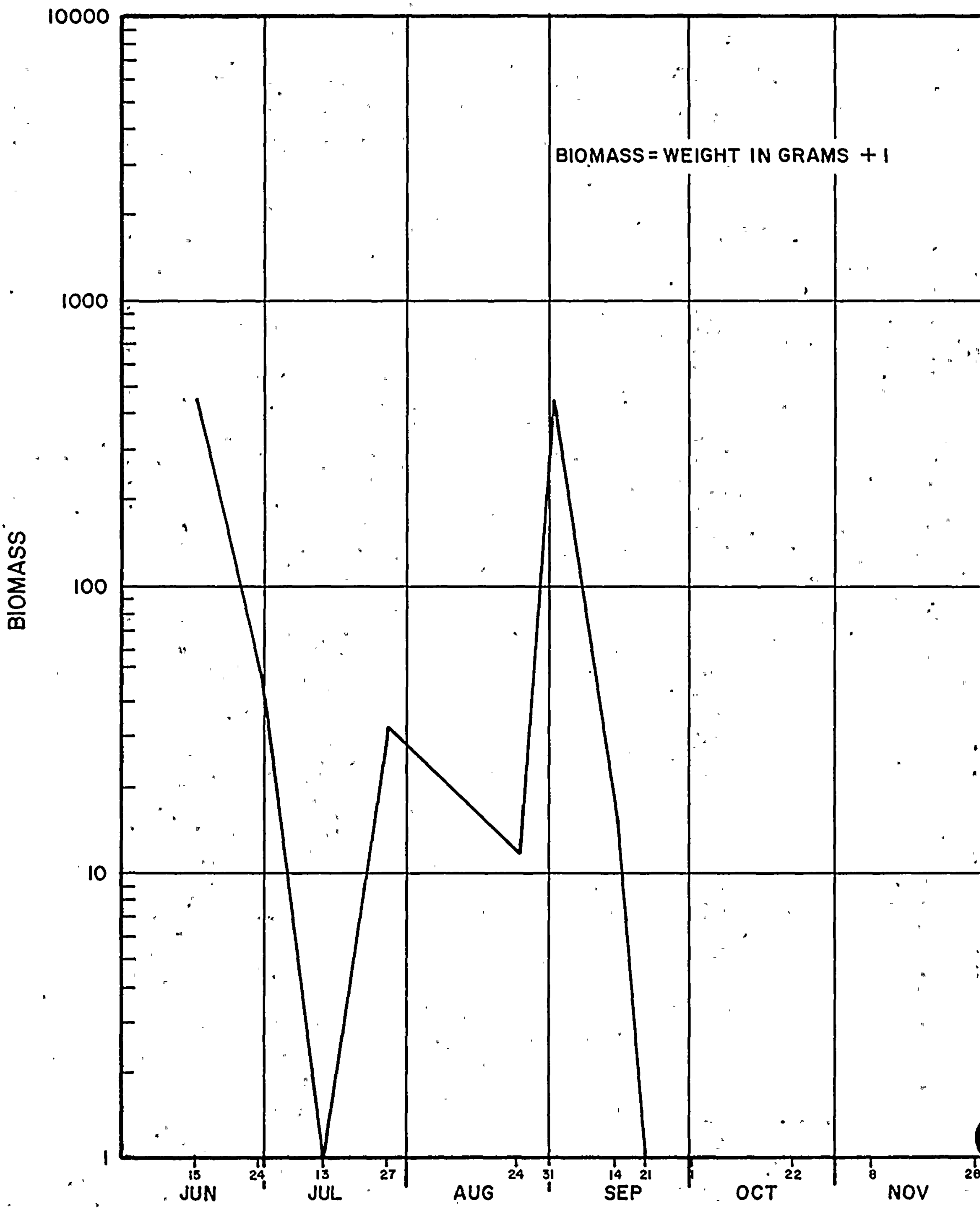
TOTAL FISH BIOMASS COLLECTED BY DATE DURING SEINE COLLECTIONS AT FITZPATRICK



TOTAL FISH BIOMASS COLLECTED BY DATE DURING OF NINE MILE POINT PLANT SEINE COLLECTIONS



TOTAL FISH BIOMASS COLLECTED BY DATE DURING SEINE COLLECTOINS AT NINE MILE POINT EAST



These procedures indicate that at a probability level of 5.4%, the 15 June collection was significantly greater than the 29 June collection. More fishes were collected on 1 October than on 22 October and more were caught on 11 November than on 28 November. During both of these months, all fishes were caught on a single date which prevented statistical testing of the data.

Significantly more fishes were collected at FITZ than at NMPW (Table III-6). October and November collections were significantly lower than June, July, and August collections (Table III-6). Fish biomass was significantly greater at FITZ than at NMPE. NMPW and NMPP did not differ from either of the other stations (Table III-7). June, July and August collections yielded more biomass than September, October, and November collections (see Table III-7).

Evidence of relatively high quantities of microzooplankton in this area near FITZ were reported in Chapter I (this report). This was a generalized trend over all depths but was not evident in the nearshore, 10 ft. area. Phytoplankton concentrations were fairly high at FITZ along the 10 ft. contour, although higher concentrations were observed at NMPE. Benthic biomass was greater on the 10 ft. countour than on any others, however, this was largely due to the presence of Cladophora (Chapter II, this report). Benthic abundance and biomass was greatest along the NMPE transect.

TABLE III-6 - Two-Way Analysis of Variance of monthly seine collection Data. Data Transformed to $\log_{10}$ data plus one.

SOURCE	d.f.	S.S.	M.S.	F ratio*
Transect	3	4.406	1.469	3.574**
Month	5	19.926	3.985	9.70**
Transect x Month	15	6.167	0.411	
Total	24	21.888		

*Critical F values are: $F_{3,15} = 3.29$; $F_{5,15} = 2.90$

**Significant difference at $\alpha 0.05$

B. Student-Newman-Kuels Procedure for Determining Sources of First Order Effective Significance. Groups Underscored by a Single Line are not Significantly Different at $p<0.05$.

RANK	1	2	3	4
MEAN $\log_{10}$ (Data +1)	0.662	0.743	1.041	1.435
Transect	NMPW	NMPE	NMPP	FITZ

(Underscored: NMPE NMPP FITZ; NMPW NMPE NMPP)

RANK	1	2	3	4	5	6
Mean $\log_{10}$ (Data+1)	0.143	0.175	0.834	1.428	1.573	1.794
Month	Nov.	Oct.	Sept.	June	Aug.	July

(Underscored: Sept. June Aug. July; Nov. Oct. Sept.)

TABLE III-7 - Two-Way Analysis of Variance of monthly seine biomass data. Data Transformed to $\log_{10}$ data plus one.

SOURCE	d.f.	S.S.	M.S.	F ratio*
Transect	3	6.291	2.097	3.495**
Month	5	39.792	7.958	13.26**
Transect x Month	15	9.003	0.600	
Total	24	20.984		

*Critical F values are: $F_{3,15} = 3.29$; $F_{5,15} = 2.90$

**Significant difference at α 0.05

B. Student-Newman-Kuels Procedure for Determining Sources of First Order Effective Significance. Groups Underscored by a Single Line are not Significantly Different at $p<0.05$.

RANK	1	2	3	4
MEAN $\log_{10}$ (Data +1)	0.856	0.953	1.472	1.648
Transect	NMPE	NMPW	NMPP	FITZ

RANK	1	2	3	4	5	6
Mean $\log_{10}$ (Data+1)	0.143	0.248	0.798	1.827	1.929	2.572
Month	Nov.	Oct.	Sept.	July	Aug.	June

QL&M (1973) seined near the present NMPP and NMPW stations in September, 1972. Two collections at NMPP yielded nine fishes and one collection at NMPW produced one fish (QL&M, 1973). Although the seining was conducted at night, the numbers of fishes collected was comparable to the September 1973 collections. Eighteen fish were caught at NMPP and none at NMPW. The 1972 collections included alewives, carp, lake chub, longnose dace, spottail shiner, and white bass (QL&M, 1973) and 1973 collections were composed of smallmouth bass, pumpkinseed, and black crappie. This difference in species composition may reflect day-night changes in nearshore fish communities due to onshore-offshore migrations associated with diurnal behavior patterns (see Nikolsky, 1963).

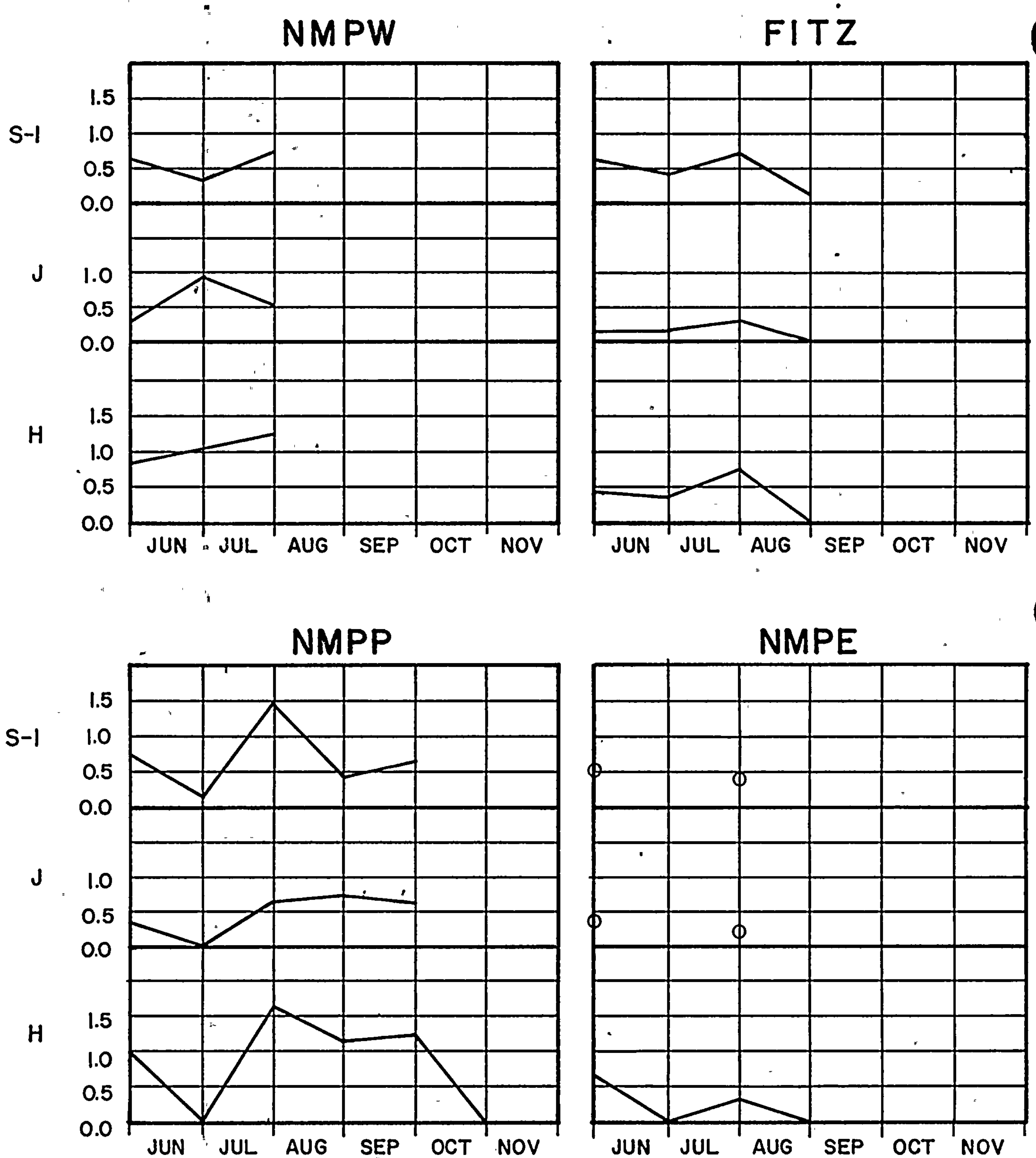
b. Community Structure

Species composition of the monthly seine collections were quite variable (Table III-4). During July, alewives contributed 92% to 100% of the fish collected at all four transects. Except for October and November, when no fish were collected, alewives generally made up a large percentage (>33%) of each collection. Alewife contribution was small in September at NMPW and NMPP. At FITZ alewives comprised more than 80% of each collection during which fish were caught. Spottail shiners, white perch, and emerald shiners dominated collections after the alewife contribution was subtracted. During August at NMPE, spottail shiners composed 98% of the catch (107 fish); during November, emerald shiners composed 100% of the catch (13 fish) at NMPP.

Percentage composition of monthly collections based on biomass (Table III-5) was generally similar to percent composition based on numerical abundance. Alewife biomass contribution was approximately the same as the numerical contribution of that species except at NMPW during June. During June, alewives composed 33% of the abundance and 6% of the biomass. This was due to the capture of one large carp that month which contributed less than 1% of the numerical abundance and 84% of the biomass. Spottail shiners, white perch, and emerald shiners contributed much of the remaining biomass. Species diversity (H), evenness (J), and species richness (d) were calculated for all seine collections and for pooled data for each month. Collections in which only one species was collected have H values of 0.000 and J values of 1.000. Values could not be calculated for collections which yielded no fishes. When H is 0.000 and J is 1.000 species, richness (d) is undefined.

Diversity values (H) for monthly seine abundance data (Figure III-10) were usually lowest at all transects in July due to the dominance of alewives in the collections. At FITZ the lowest value was recorded in September. Evenness was nearly constant at FITZ, indicating that the individual fishes were generally divided similarly among the species over the four months that fishes were collected. At the other stations the division of individuals between the species was more variable. Species richness fluctuated

SPECIES DIVERSITY (H), EVENNESS (J), AND SPECIES RICHNESS (S-1) OF NINE MILE POINT AREA SEINE COLLECTIONS CALCULATED VALUES ARE BASED ON NUMERICAL ABUNDANCE



in direct proportion to changes in (H) with the exceptions of NMPP (October) and NMPW (July).

Variations in H, J, and d for individual collection dates were similar to those observed on a monthly basis (Appendix V-B). Greatest abundance diversity (H = 1.487) was recorded at NMPP on 31 August. J values of 1.000 were calculated for single species collections. Of the multispecies collections, J was greatest (0.789) on 29 June at NMPW.

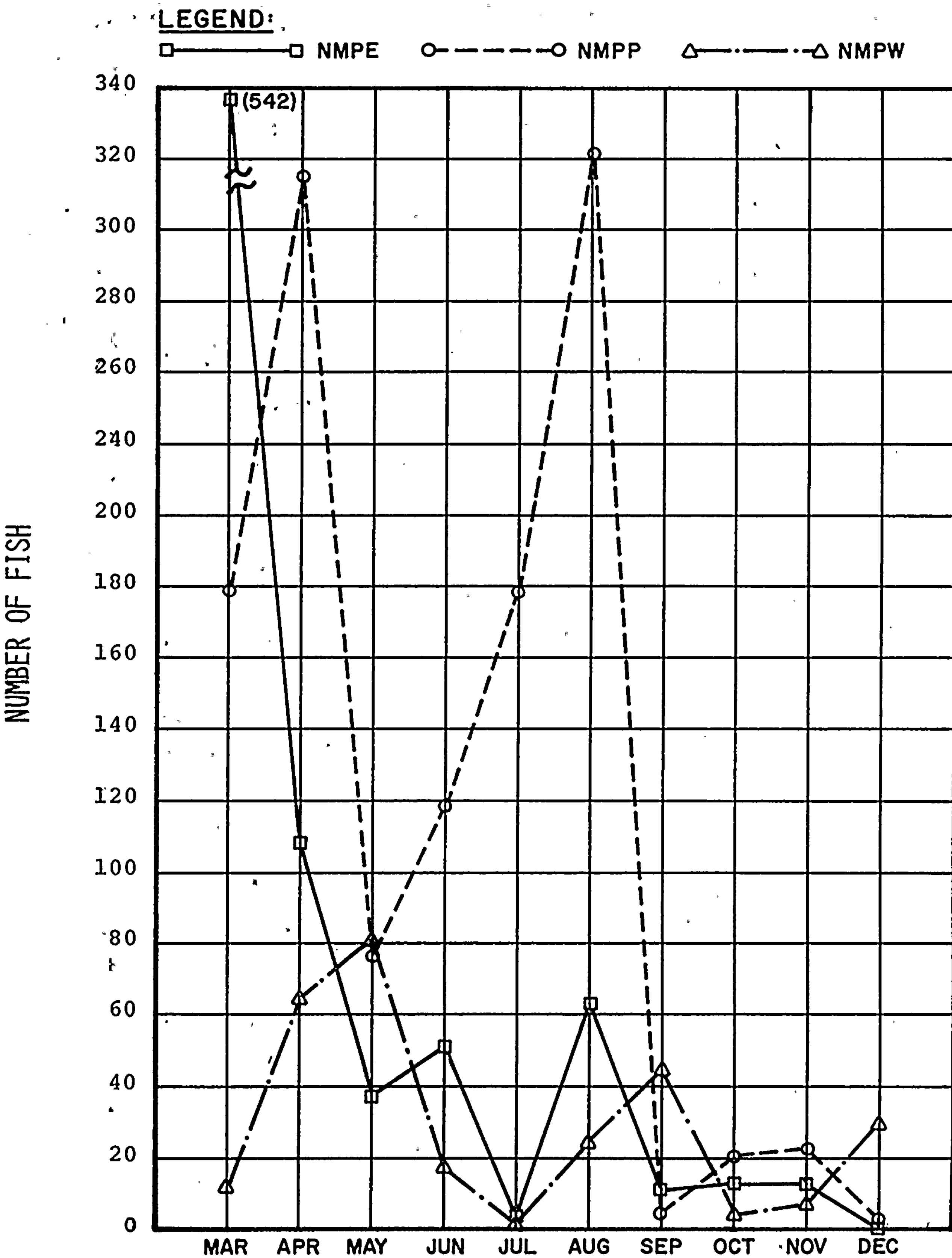
Abundance, diversity and species richness values were higher at NMPP than at the other stations. Diversity was generally lowest at NMPE. Fishes were collected at NMPP during all sampling months, while collections at the other stations yielded no fishes in October and November. This evidence indicates that nearshore fish communities persist in the NMPP area at least from June through November.

2. TRAWLS

a. Distribution and Abundance

The total trawl catch for all the 1973 collections was 917 fishes divided among 18 species (Table III-2). Catch per unit effort (calculated catch per standard ten minute trawl) was greatest in March and lowest in December (Figure III-11). Excluding March (735 fishes), April and August catches per unit effort, 468 and 389 fishes, respectively, were greater

MONTHLY TRAWL CATCH PER UNIT EFFORT FOR EACH TRANSECT SURFACE AND BOTTOM DATA FROM ALL DEPTH CONTOURS COMBINED



than values for all other months. The number of fishes caught per unit effort was generally greater at NMPP than at NMPE (Figure III-11; see Appendix V-C). Catches at NMPE exceeded those at NMPP during March and September; NMPW catches were larger than those at NMPP during May, September, and December.

Trawl collections at NMPP and NMPW in 1972 (QL&M, 1973) were comparable to 1973 collections at those locations. During 1972 a total of 58 trawls of 15 minutes each were made at both transects from April through October, 1085 fishes were collected at NMPP and 1282 at NMPW (QL&M, 1973). Catch per unit effort increased from April to June and generally decreased through October at both transects. Slight increases in catch at NMPP were observed during August and October and at NMPW during September and October. Fishes were fairly uniformly distributed between the transects as indicated below:

1972 Catch Per Unit Effort (Based on Data from QL&M, 1973)

Transect	April	May	June	July	August	September	October
NMPP	1.9	20.7	43.5	2.0	4.7	2.9	4.9
NMPW	4.0	20.9	38.8	18.3	1.3	11.2	2.9

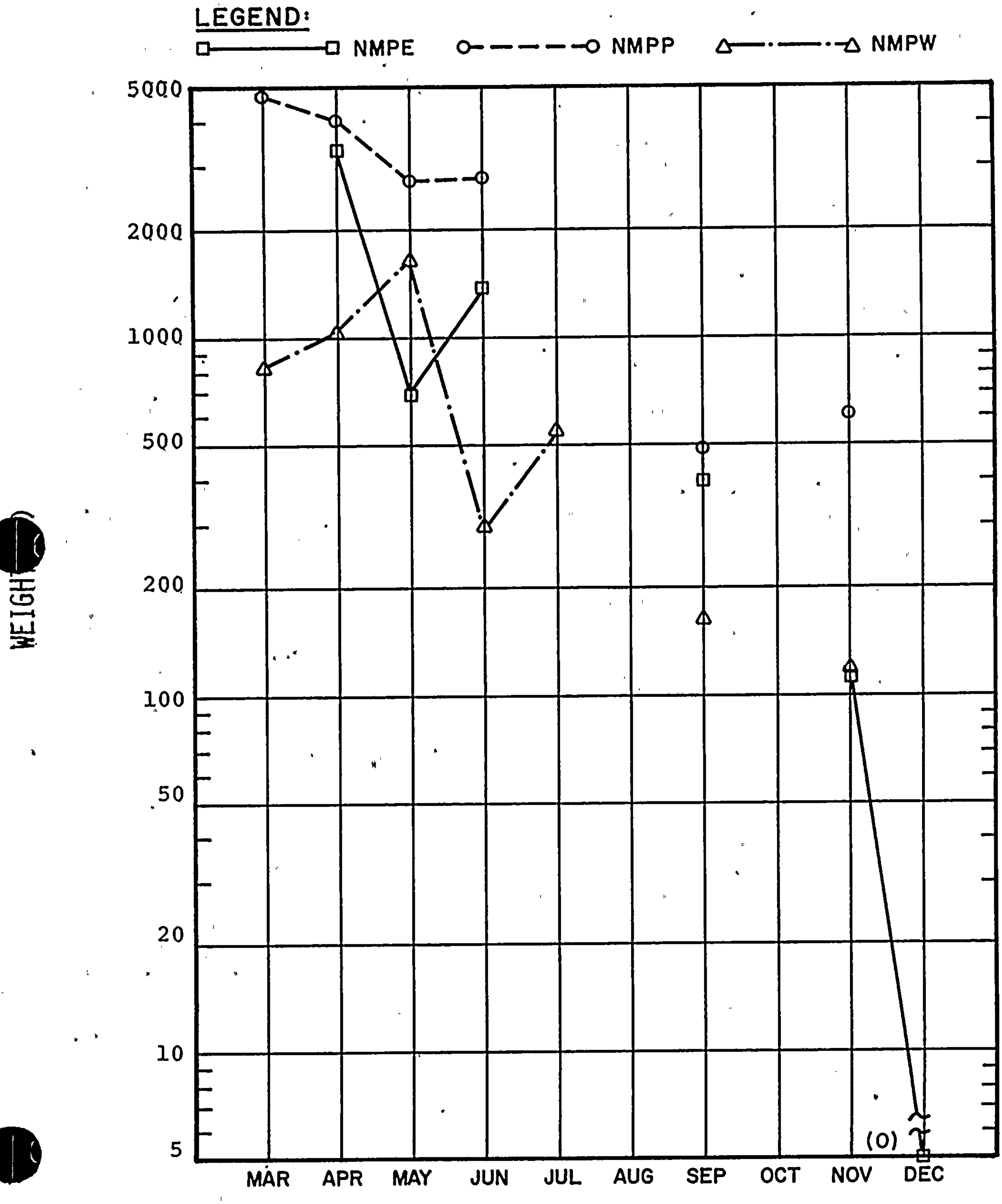
With the exception of July and September, when catches differed by factors of 9 and 3.9, respectively, fish yields at both transects were similar each month.

Monthly biomass per unit effort, and fish weight collected per 10 minute effort for each transect was calculated and plotted (Figure III-12). Biomass per unit effort was greatest at NMPP during those months for which values are available for all transects. Monthly biomass was greater during April, May, and June than during September and November.

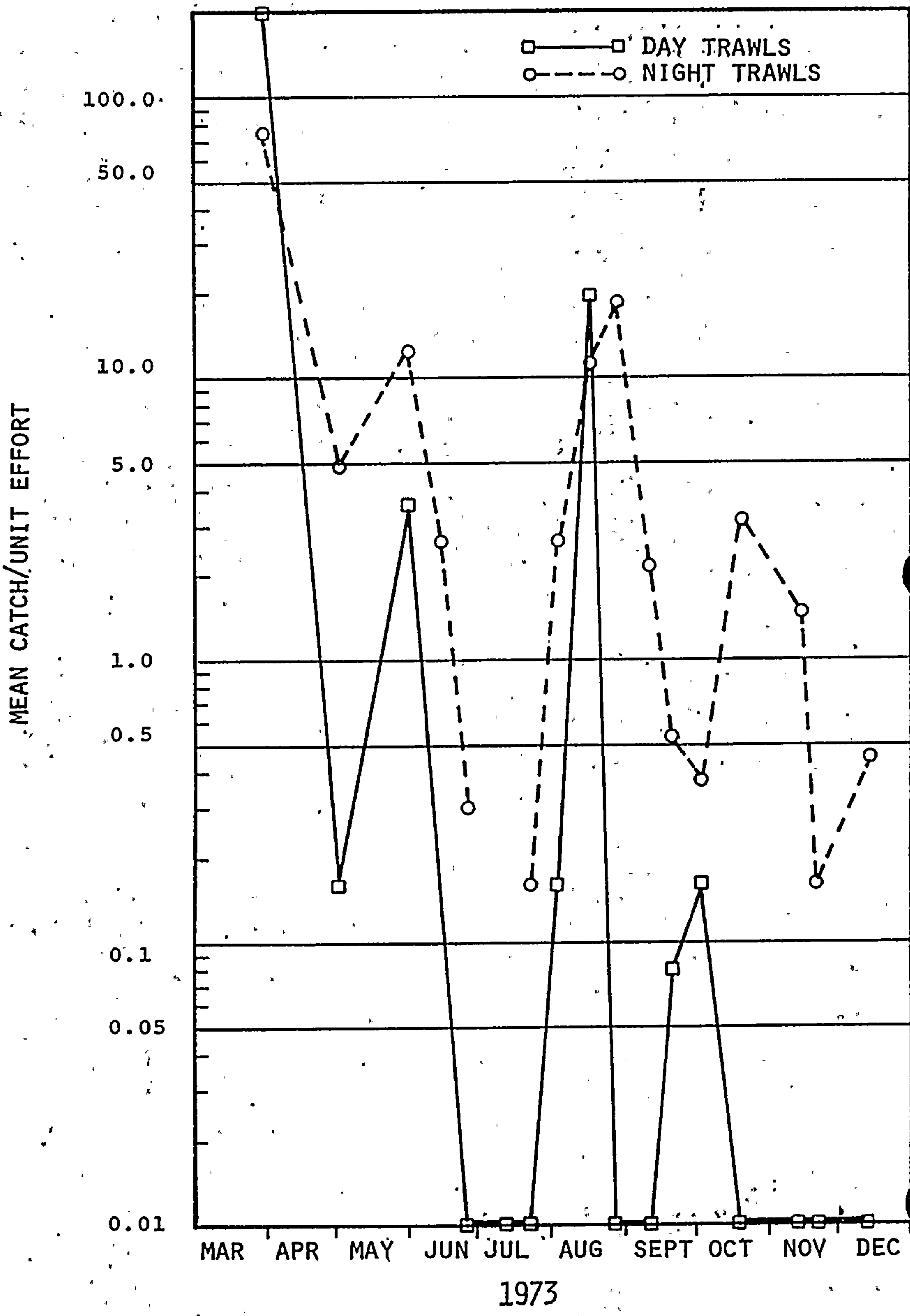
Trawls were conducted during daylight hours (day) and after dusk (night) on most sampling dates. Mean catch per unit effort for surface trawls at all transects demonstrated that night collections were more productive than day collections (Figure III-13). Day surface trawl catches exceeded night surface catches only on 28 March and 14 August. Differences between day and night bottom trawl catches (Figure III-13) were not as distinct as for surface trawls. Day bottom catches were greater than night bottom catches, on 25 April, 25 June, and 14 August. Variability in night trawling success was greater for bottom collections than for surface collections. Both figures (Figures III-13 and III-14) show a reduction in catch by both day and night surface trawls from March through December.

Catch and biomass per unit trawl effort were assigned to seasons by date to facilitate comparison of day and night collections. Comparisons were made separately for surface and bottom collections. Each transect was tested separately. Seasons were defined as follows:

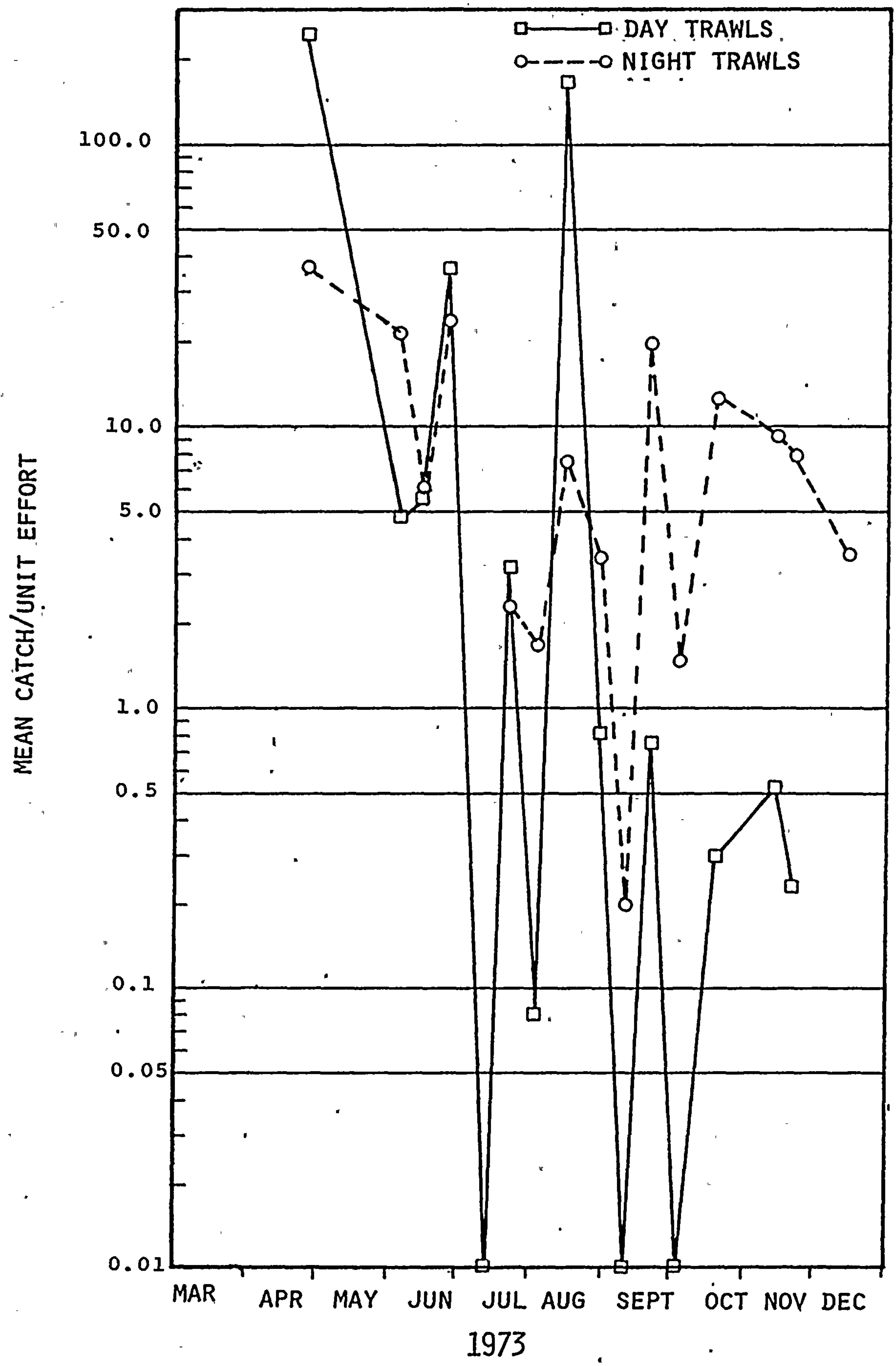
MONTHLY TRAWL BIOMASS PER UNIT EFFORT FOR EACH TRANSECT, SURFACE AND BOTTOM DATA FROM EACH DEPTH CONTOUR COMBINED.



MEAN CATCH PER UNIT EFFORT
FOR DAY AND NIGHT SURFACE TRAWLS,
DATA FOR ALL TRANSECTS AND DEPTH CONTOURS COMBINED.



MEAN CATCH PER UNIT EFFORT
FOR DAY AND NIGHT BOTTOM TRAWLS,
DATA FOR ALL TRANSECTS AND DEPTHS COMBINED.



Season	Dates
Spring	April 25 - June 25
Summer	July 22 - September 20
Fall - Winter	October 2 - December 13

Seasonal grouping of data was used to minimize the influence of cancelled trawls (due to inclement weather) on the analysis. By grouping this data, the influence of cancelled trawls was reduced and comparable data was available for testing. Monthly and daily comparisons were not feasible statistically when the data were incomplete due to cancelled trawls. Combining the data into seasonal groups also reduced the influence of differing fish availability due to photoperiodically controlled activity rhythms.

Night surface trawls collected significantly more fishes than day surface trawls at NMPE during Spring and Summer, during all seasons at NMPP and during Summer and Fall-Winter at NMPW (Table III-8). Night surface and bottom trawls at NMPP generally caught significantly more fishes than day surface and bottom trawls at that transect. Significant differences between day and night trawls at the NMPE, NMPW transects occurred less frequently.

Fish biomass collected by night surface and bottom trawls was generally greater than biomass collected by day surface and bottom trawls. Biomass from night surface trawls was significantly greater than day surface trawls during Spring and Summer at NMPE and NMPP and during Fall-Winter at NMPP (Table III-9). Night bottom trawl biomass was greater than day bottom trawl biomass at all transects during Fall-Winter, at NMPE and NMPW during

TABLE III-8. Day-Night Comparisons of Catch per Unit Effort for Surface and Bottom Trawls at Transects NMPW, NMPP, and NMPE. Data (Appendix V-C) From all Depth Contours at Each Transect Combined. Tested by Paired-t at $\alpha = 0.05$ and Wilcoxon Signed Rank Procedures.

PAIRED t-TEST

TRANSECT	SEASON	DEPTH	d.f.	t-VALUE	PROBABILITY
NMPW	Spring	Surface	8	-2,129	$0.050 \leq p \leq 0.100$
	Spring	Bottom	6	-3,642*	$0.010 \leq p \leq 0.025$
	Summer	Bottom	11	-1,845	$0.050 \leq p \leq 0.100$
	Fall-Winter	Bottom	11	-4.912*	$p \leq 0.001$
NMPP	Spring	Surface	8	-3.052*	$0.010 \leq p \leq 0.025$
	Spring	Bottom	7	-1.488	$0.100 \leq p \leq 0.200$
	Summer	Surface	14	-2.825*	$0.010 \leq p \leq 0.025$
	Fall-Winter	Bottom	11	-4.326	$0.001 \leq p \leq 0.005$
NMPE	Spring	Surface	11	-4.405*	$0.001 \leq p \leq 0.005$
	Spring	Bottom	11	-2.027	$0.050 \leq p \leq 0.100$
	Summer	Surface	17	-3.081	$0.005 \leq p \leq 0.010$
	Summer	Bottom	17	-0.921	$0.200 \leq p \leq 0.400$
	Fall-Winter	Surface	14	-0.802	$0.400 \leq p \leq 0.500$

WILCOXON SIGNED RANK TEST

TRANSECT	SEASON	DEPTH	n	T^+	T^-	T_S	Critical Range	α
NMPW	Summer	Surface	8	1.5	34.5	1.5	$4 \leq T_S \leq 34$	0.054*
	Fall-Winter	Surface	6	0.0	21.0	0.0	$1 \leq T_S \leq 20$	0.062*
NMPP	Summer	Bottom	14	27.0	78.0	27.0	$21 \leq T_S \leq 84$	0.050
	Fall-Winter	Surface	9	0.0	45.0	0.0	$6 \leq T_S \leq 39$	0.054*
NMPE	Fall-Winter	Bottom	10	0.0	55.0	0.0	$8 \leq T_S \leq 47$	0.048*

*Significant at those probability values

TABLE III-9. Day-night comparisons of biomass per unit effort for surface and bottom trawls at transects NMPW, NMPP, and NMPE. Data (Appendix V - C) from all depth contours at each transect combined. Tested by paired t (α = 0.05) and Wilcoxon signed rank procedures.

Paired † test

TRANSECT	SEASON	DEPTH	d.f.	t-value	Probability
NMPW	Spring	Surface	8	-2.141	$0.050 \leq p \leq 0.100$
NMPW	Spring	Bottom	5	-3.096	$0.025 \leq p \leq 0.050$
NMPP	Spring	Bottom	7	-1.771	$0.100 \leq p \leq 0.200$
NMPP	Summer	Bottom	13	-2.066	$0.050 \leq p \leq 0.100$
NMPP	Fall-Winter	Bottom	6	-4.559	$0.001 \leq p \leq 0.005$
NMPE	Spring	Bottom	11	-2.115	$0.050 \leq p \leq 0.100$
NMPE	Summer	Surface	17	-2.304	$0.025 \leq p \leq 0.050$
NMPE	Summer	Bottom	15	-3.186	$0.005 \leq p \leq 0.010$

Wilcoxon Signed Rank Test

TRANSECT	SEASON	DEPTH	n	T+	T-	Ts	Critical Range	
NMPW	Summer	Surface	8	4	32	4	$4 \leq T \leq 32$	0.054
NMPW	Summer	Bottom	8	1	35	1	$4 \leq T \leq 32$	0.054
NMPW	Fall-Winter	Surface	5	0	15	0	$0 \leq T \leq 15$	0.062
NMPW	Fall-Winter	Bottom	9	0	45	0	$6 \leq T \leq 39$	0.054
NMPP	Spring	Surface	7	0	28	0	$2 \leq T \leq 26$	0.046
NMPP	Summer	Surface	10	0	55	0	$8 \leq T \leq 47$	0.048
NMPP	Fall-Winter	Surface	7	0	28	0	$2 \leq T \leq 26$	0.046
NMPE	Spring	Surface	9	0	45	0	$6 \leq T \leq 39$	0.054
NMPE	Fall-Winter	Surface	4	1	9	1	$0 \leq T \leq 10$	0.124
NMPE	Fall-Winter	Bottom	7	0	28	0	$2 \leq T \leq 26$	0.046

* Significant at the probability values listed

Summer, and at NMPW during Spring (Table III-9). Significant differences in catch were generally reflected by the biomass data.

The absence of significant differences between day and night surface trawls at NMPW suggest that similar weights of fishes were collected under both conditions.

Daily light-dark cycles influence the movements and relationships of fishes (Nikolsky, 1963; Odum, 1971). Changes in light intensity may trigger a variety of responses in fishes such as feeding, schooling, vertical movements, spawning, and other physiological processes (see Schwassman, 1971). Carlander and Cleary (1949) have demonstrated by gill net collections that several species, including sauger and yellow perch, are more active at night than during the day. Day and night bottom trawls in the Hudson River near Indian Point, New York were reported by Raytheon (1972) to be quite similar. Surface trawls in the same area exhibited differences between day and night collections (Raytheon, 1972). QL&M (1974) reported collecting more blueback herring at night than during the day in the Hudson River near Roseton, New York. Greater numbers of fishes were collected by trawl at night than during the day in Lake Ontario in 1972 (QL&M, 1973).

Increased catches at night suggests that fishes were more susceptible to trawl capture than during the day. The increase in vulnerability may be due to increased activity associated with nocturnal conditions or movements more specifically related to feeding behavior patterns (see Schwassmann, (1971). Increased activity may be due to the dispersal of schools (see Schwassmann, 1971).

Diurnal variations in the vertical distribution of plankton in the water column are well-documented (see Russel-Hunter, 1970) and may affect day-night fish catches. Visual perception of the net by fishes during daylight hours may partially explain the relatively low day trawl catches.

Day and night surface and bottom trawls were conducted at each transect to provide information on the vertical distribution of fishes in the water column. Mean monthly catch per unit effort for day and night collections at all transects combined was greater for bottom trawls than for surface trawls (Figure III-15). Each monthly bottom trawl produced many times more fishes than surface trawls. For example, July surface and bottom trawls caught 0.06 and 20.5 fishes per unit effort, respectively. During May, surface trawls captured 8.6 fishes and bottom trawls captured 13 fishes per unit effort. Monthly bottom trawls at NMPW and NMPP in 1972 generally produced more fishes than surface trawls (QL&M, 1973).

Mean monthly biomass per unit effort was greater for bottom trawls than for surface trawls (Figure III-16). Maximum bottom trawl biomass was observed during April and minimum biomass during December. Greatest surface trawl biomass was recorded during March and lowest values during July and December. October surface trawl biomass exceeded bottom trawl biomass during May, surface and bottom values were nearly identical. Biomass per unit effort diminished from April to December for both surface and bottom collections.

Surface and bottom trawl catch per unit effort data were examined for day and night influence on catches. Day bottom trawls generally produced more fishes than day surface trawls (Figure III-17). From April through June and during November, considerably more fishes were collected by bottom

MEAN MONTHLY CATCH PER UNIT EFFORT
FOR SURFACE AND BOTTOM TRAWL COLLECTIONS.
DATA FROM ALL TRANSECTS AND DEPTHS COMBINED.

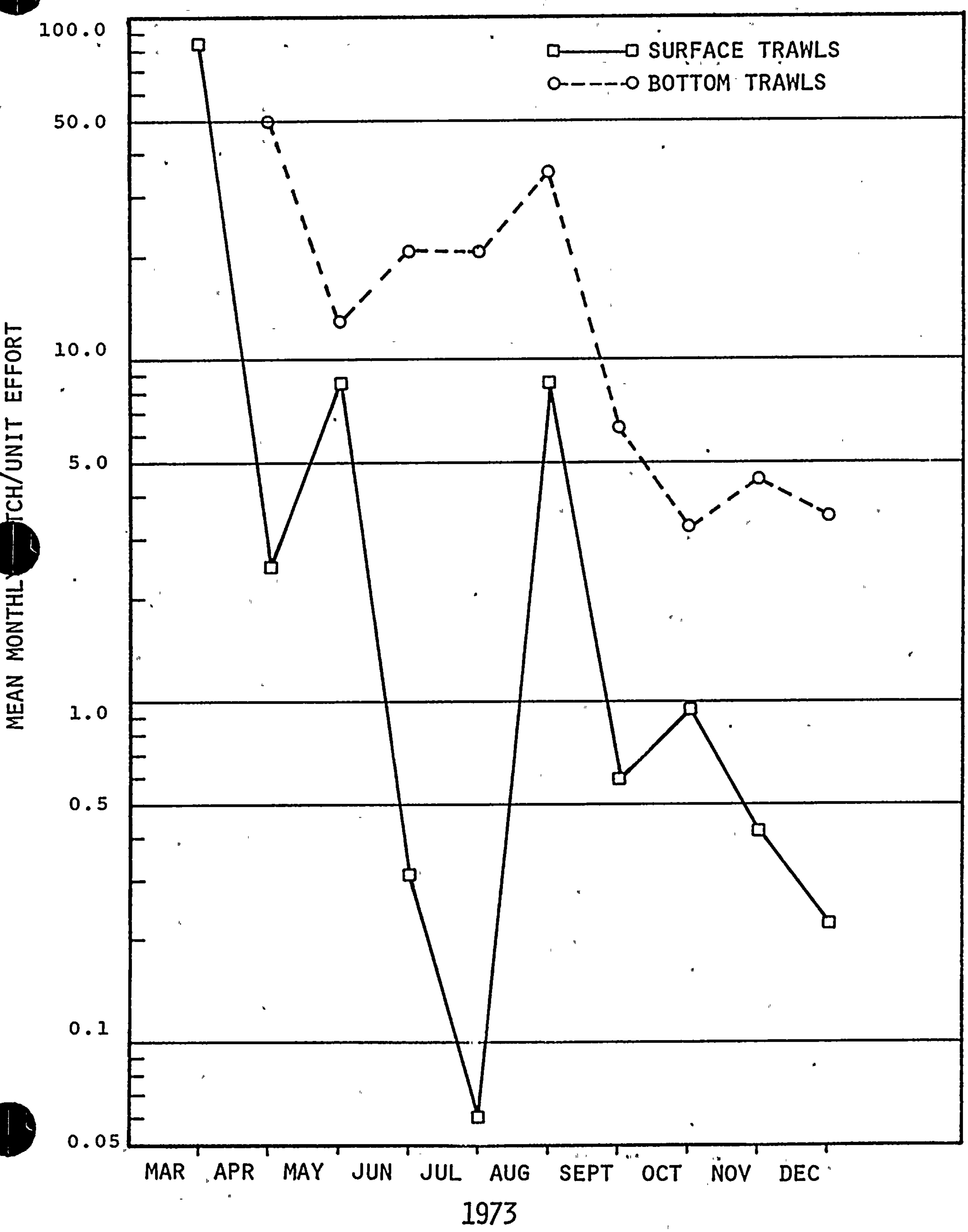
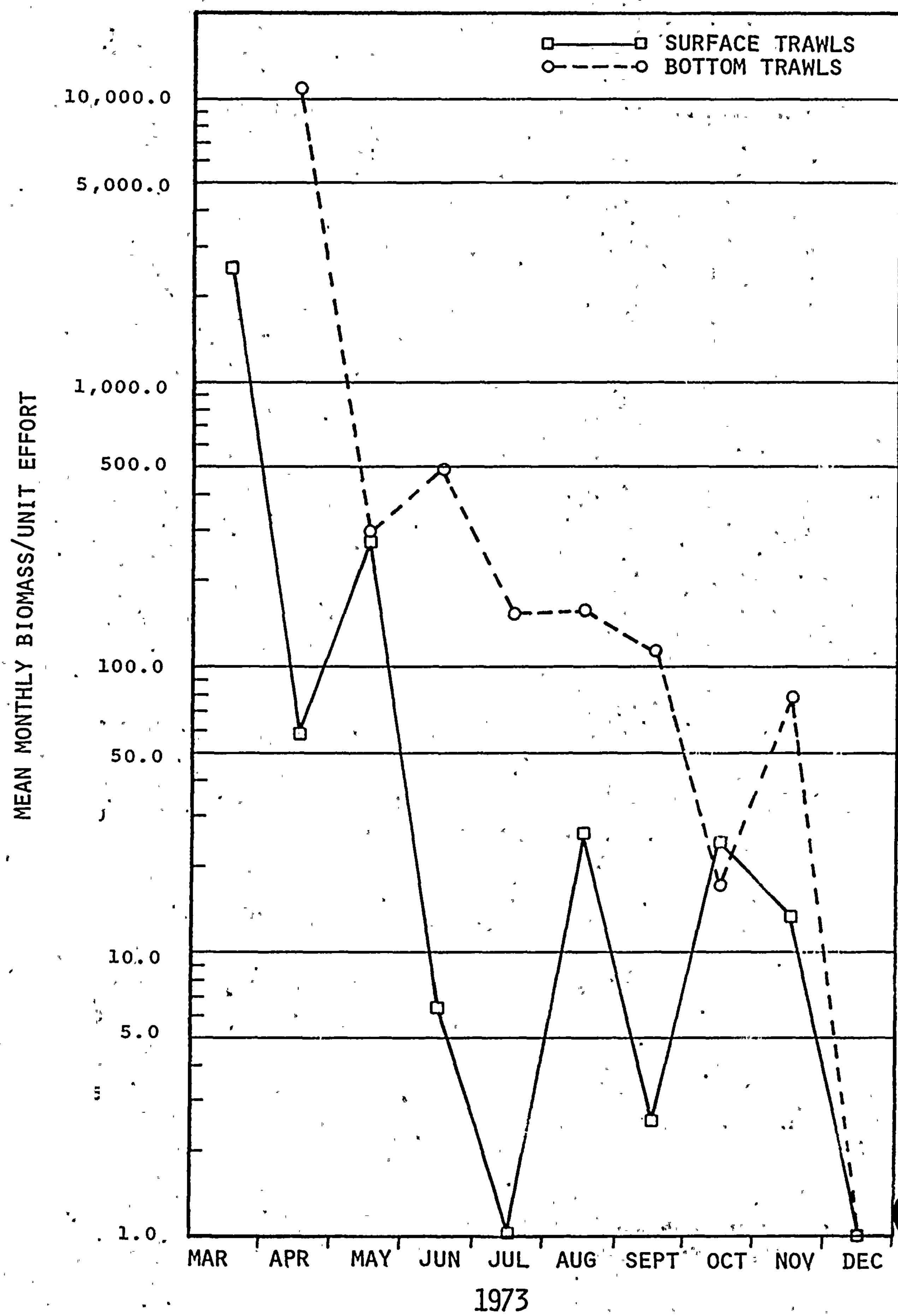
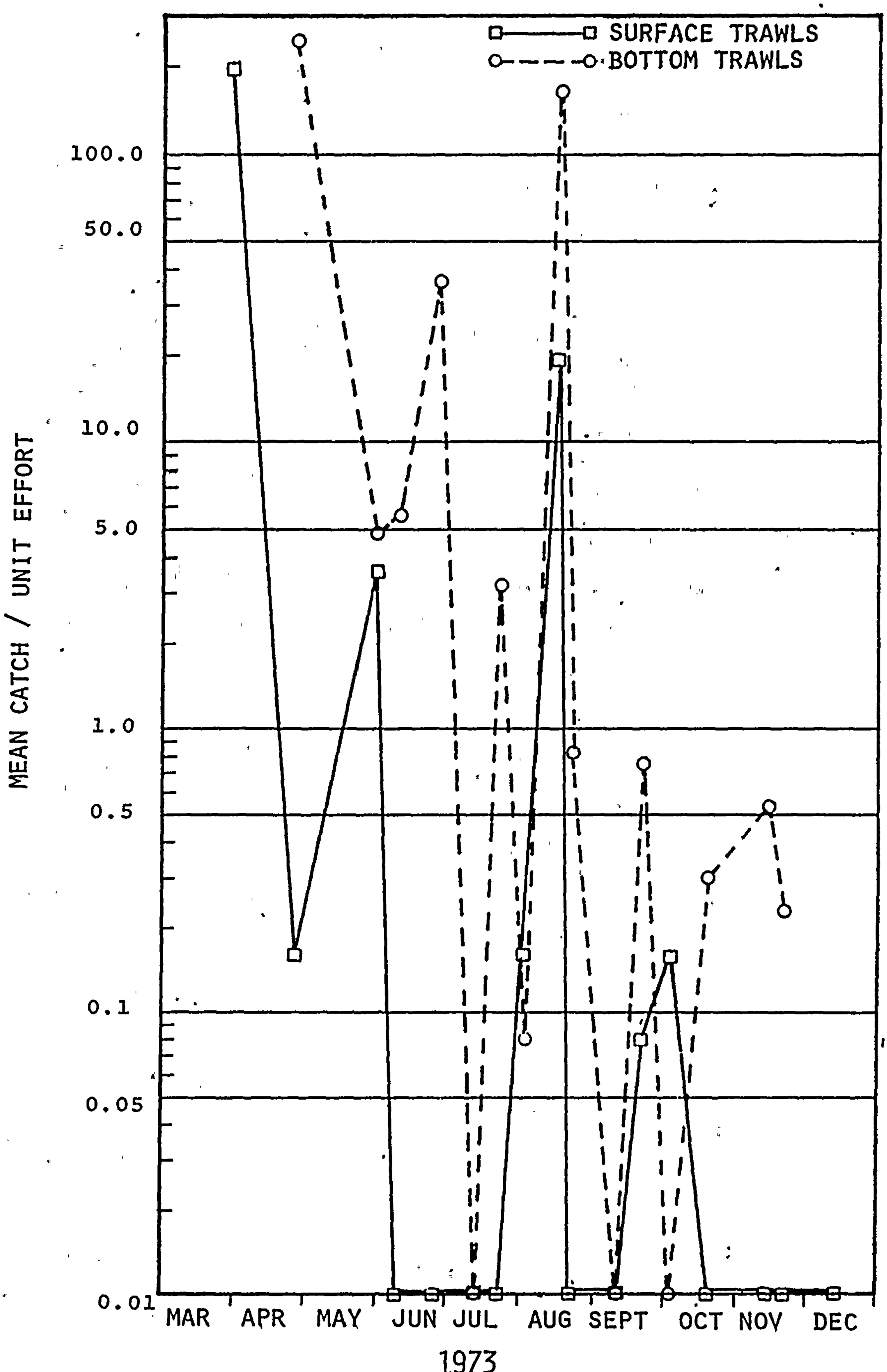


FIGURE III-16

MEAN MONTHLY BIOMASS PER UNIT EFFORT
FOR SURFACE AND BOTTOM TRAWL COLLECTIONS.
DATA FROM ALL TRANSECTS AND DEPTHS COMBINED.



MEAN CATCH PER UNIT EFFORT
FOR EACH DAY TIME TRAWL COLLECTION
DATA FOR ALL TRANSECTS AND DEPTH CONTOUR COMBINED.



trawling. Extremely variable catches by both trawls were recorded from July to October. Surface catches exceeded bottom catches on 2 August and 2 October. Day surface and bottom catches diminished from April through December.

Night bottom trawls generally produced more fishes than night surface trawls (Figure III-18: night trawls were cancelled on 13 July due to rough water). Differences between night surface and bottom catches were not as great as those observed for day collections. Night surface and bottom catches generally differed by a factor of 10 or less. Surface catch per unit effort was greater than bottom trawl catch for all collections during August and on 10 September. All August and most September collections were dominated by alewives; the high surface catches may indicate a vertical redistribution of those fishes (see Wells, 1968; Schwassmann, 1971; Christie, 1973). Catches generally decreased from April to December.

Surface and bottom day collections and surface and bottom night collections were compared on a seasonal basis (Table III-10). Comparisons were made for each of the three seasons at each transect. Testing could not be conducted on day collections at NMPW and NMPE during Fall-Winter. Day bottom catches were significantly greater than day surface catches at NMPP during all three seasons. Significant differences between day surface and bottom collections were not apparent at NMPW and NMPE (Table III-10). Night bottom collections yielded significantly more fishes than night surface trawls during Spring and Fall-Winter at all transects (Table III-10).

MEAN CATCH PER UNIT EFFORT FOR EACH NIGHT TRAWL COLLECTION.
DATA FOR ALL TRANSECTS AND DEPTH CONTOURS COMBINED.

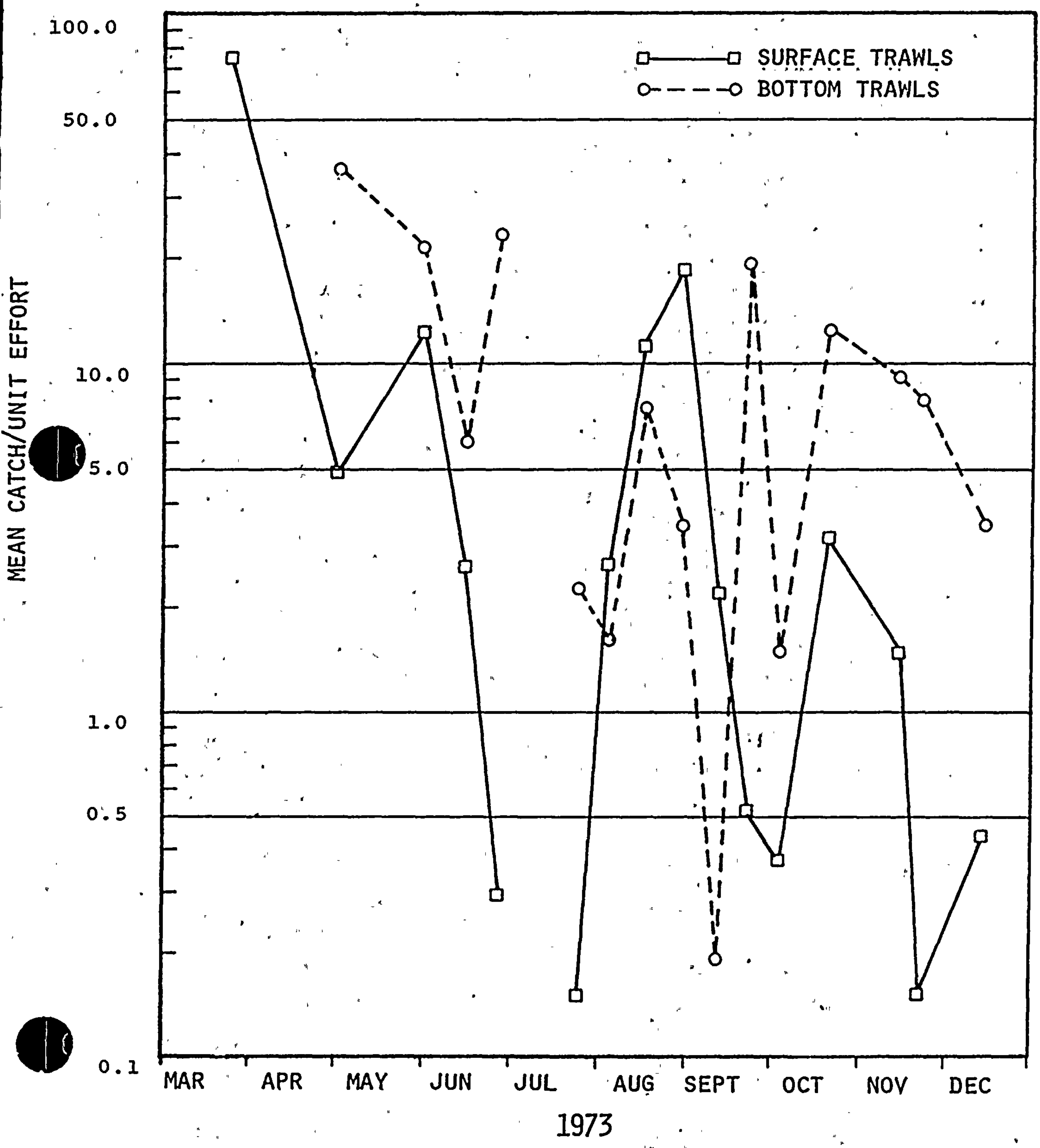


TABLE III-10. Comparison of surface and bottom trawl catch per unit effort for day and night collections at transects NMPW, NMPP, and NMPE. Data (Appendix V-C) from all depth contours at each transect combined. Tested by paired t ($\alpha = 0.05$) and Wilcoxon signed rank procedures.

Paired †

Day

TRANSECT	SEASON	d.f.	t-value	PROBABILITY
NMPW†	Spring	9	-2.018	$0.050 \leq p \leq 0.100$
NMPP	Summer	14	-2.249*	$0.025 \leq p \leq 0.050$
NMPE†	Summer	19	-1.239	$0.200 \leq - \leq 0.400$
		NIGHT		
NMPW	Spring	7	-2.563	$0.025 \leq p \leq 0.050$
	Summer	12	-1.723	$0.100 \leq p \leq 0.200$
NMPP	Spring	7	-4.216	$0.001 \leq p \leq 0.005$
	Summer	14	0.263	$p > 0.500$
	Fall-Winter	14	-2.541	$0.010 \leq p \leq 0.025$
NMPE	Spring	11	-2.256	$0.025 \leq p \leq 0.050$
	Summer	17	0.922	$0.200 \leq p \leq 0.400$

WILCOXON SIGNED RANK

Day

TRANSECT	SEASON	n	T†	T-	T_S	Critical Range	α
NMPW†	Summer	6	2.5	18.5	2.5	$1 \leq T_S \leq 20$	0.062
NMPP	Spring	11	0.0	66.0	0.0	$11 \leq T_S \leq 55$	0.54*
	Fall-Winter	6	0.0	21.0	0.0	$1 \leq T_S \leq 20$	0.062*
NMPE†	Spring	11	14.5	51.5	14.5	$11 \leq T_S \leq 55$	0.054
			NIGHT				
NMPW	Fall-Winter	13	3.0	88.0	3.0	$17 \leq T_S \leq 74$	0.048*
NMPE	Fall-Winter	10	0.0	55.0	0.0	$8 \leq T_S \leq 47$	0.048*

* Significant at the probability values noted.

† Inadequate sample size for NMPW and NMPE day fall-winter

Day bottom trawls generally collected more biomass than day surface trawls (Figure III-19). Of the dates for which both surface and bottom data were available, surface biomass was greater on 2 August and 2 October. Night bottom trawl biomass was greater than night surface trawl biomass (Figure III-20). Night surface trawl biomass per unit effort appeared to decrease from March through December. Trends in night bottom trawl biomass were not evident due to the incompleteness of July, August and September data.

Bottom trawl biomass generally was significantly greater ($p < .05$) than surface trawl biomass for both day and night collections (Table III-11). Night bottom trawls collected more fish biomass than night surface trawls in Spring and Fall-Winter at all three transects and during Summer at NMPW. Significant differences between surface and bottom trawl biomass generally coincided with seasons exhibiting significant differences in total numerical catch. Low surface and high bottom trawl collections occurred most consistently at NMPP during Spring.

Day and night surface and bottom trawls were conducted along the 20, 40 and 60 ft. depth contours of each transect to provide information on the possible depth distribution of fishes in Lake Ontario. Monthly catch per unit effort was usually greatest along the 20 ft. contour at NMPW (Figure III-21), along the 60 ft. contour at NMPE (Figure III-22) and was highly variable at all NMPP contours (Figure III-23). Maximum monthly catch per unit effort occurred during March at all transects with peak values occurring at the 20 ft. depth at NMPW and NMPE and at 60 ft. at NMPP.

MEAN BIOMASS PER UNIT EFFORT
FOR DAY SURFACE AND BOTTOM TRAWLS BY DATE.

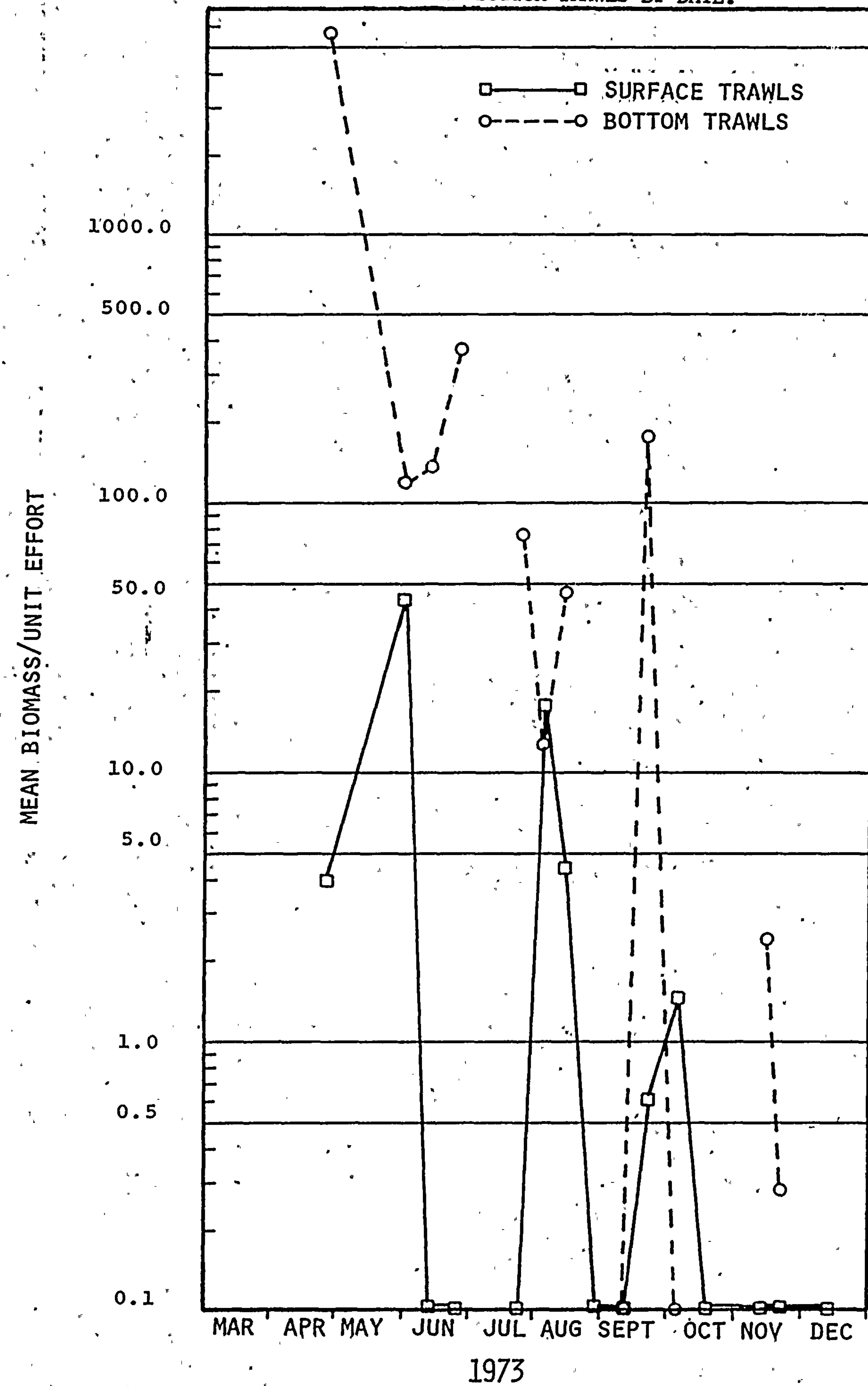


FIGURE III-20

MEAN BIOMASS PER UNIT EFFORT
FOR NIGHT SURFACE AND BOTTOM TRAWLS BY DATE.

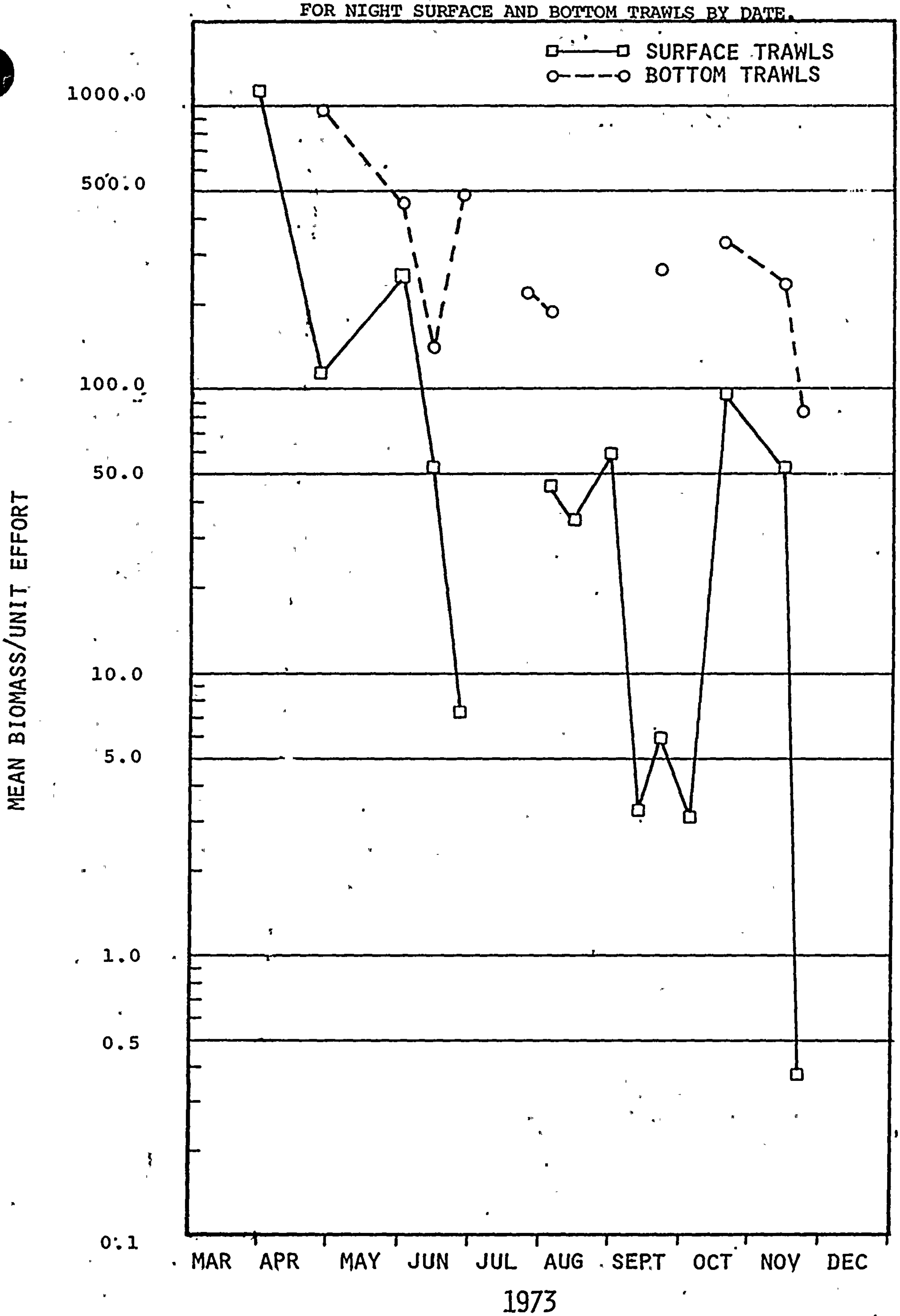


TABLE III-11. Comparison of Surface and Bottom Trawl Biomass per Unit Effort for Day and Night Collections at Transects NMPW, NMPP, and NMPE. Data (Appendix V-C) From all Depth Contours at Each Transect Combined. Tested by Paired-t at $\alpha = 0.05$ and Wilcoxon Signed Rank Procedures.

Paired - t - Day

Transect	Season	d.f.	t-Value	Probability
NMPW'	Spring	8	-1.530	$0.100 \le p \le 0.200$
NMPE'	Summer	18	-0.132	$p > 0.500$
		Night		
NMPW	Spring	7	-2,637	$0.025 \le p \le 0.050$
	Summer	9	-3.424	$0.005 \le p \le 0.010$
	Fall-Winter	10	-3.711	$0.001 \le p \le 0.005$
NMPP	Spring	7	-3.380	$0.010 \le p \le 0.025$
	Summer	10	-2.038	$0.050 \le p \le 0.100$
	Fall-Winter	9	-3.232	$0.010 \le p \le 0.025$
NMPE	Spring	11	-2.256	$0.025 \le p \le 0.050$
	Summer	16	-1.547	$0.100 \le p \le 0.200$
	Fall-Winter	11	-3.569	$0.001 \le p \le 0.005$

WILCOXON SIGNED RANK - DAY

TRANSECT	Season	n	T^+	T^-	T_S	Critical Range	α
NMPW'	Summer	4	1.0	9.0	1.0	$0 \le T_S \le 10$	0.124
NMPP	Spring	11	0.0	66.0	0.0	$11 \le T_S \le 55$	0.054*
	Summer	6	0.0	21.0	0.0	$1 \le T_S \le 20$	0.062*
	Fall-Winter	3	0.0	6.0	0.0	$0 \le T_S \le 6$	0.250
NMPE'	Spring	11	6.0	60.0	6.0	$11 \le T_S \le 55$	0.054*

*Significant at the probability values noted.
'Inadequate sample size for NMPW and NMPE day Fall-Winter.

FIGURE III-21

MONTHLY CATCH PER UNIT EFFORT
FOR SURFACE TRAWL COLLECTIONS AT NINE MILE POINT WEST.

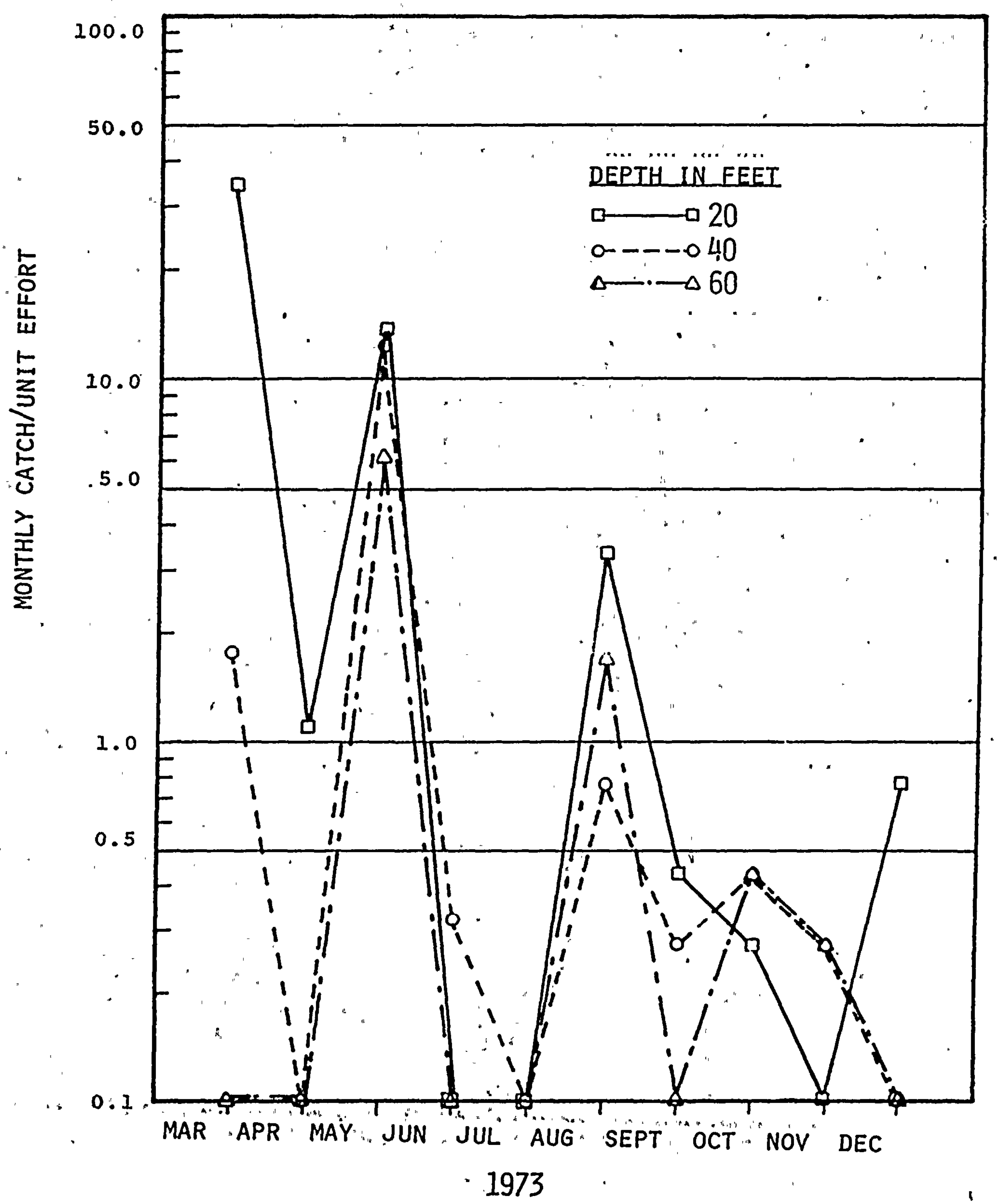
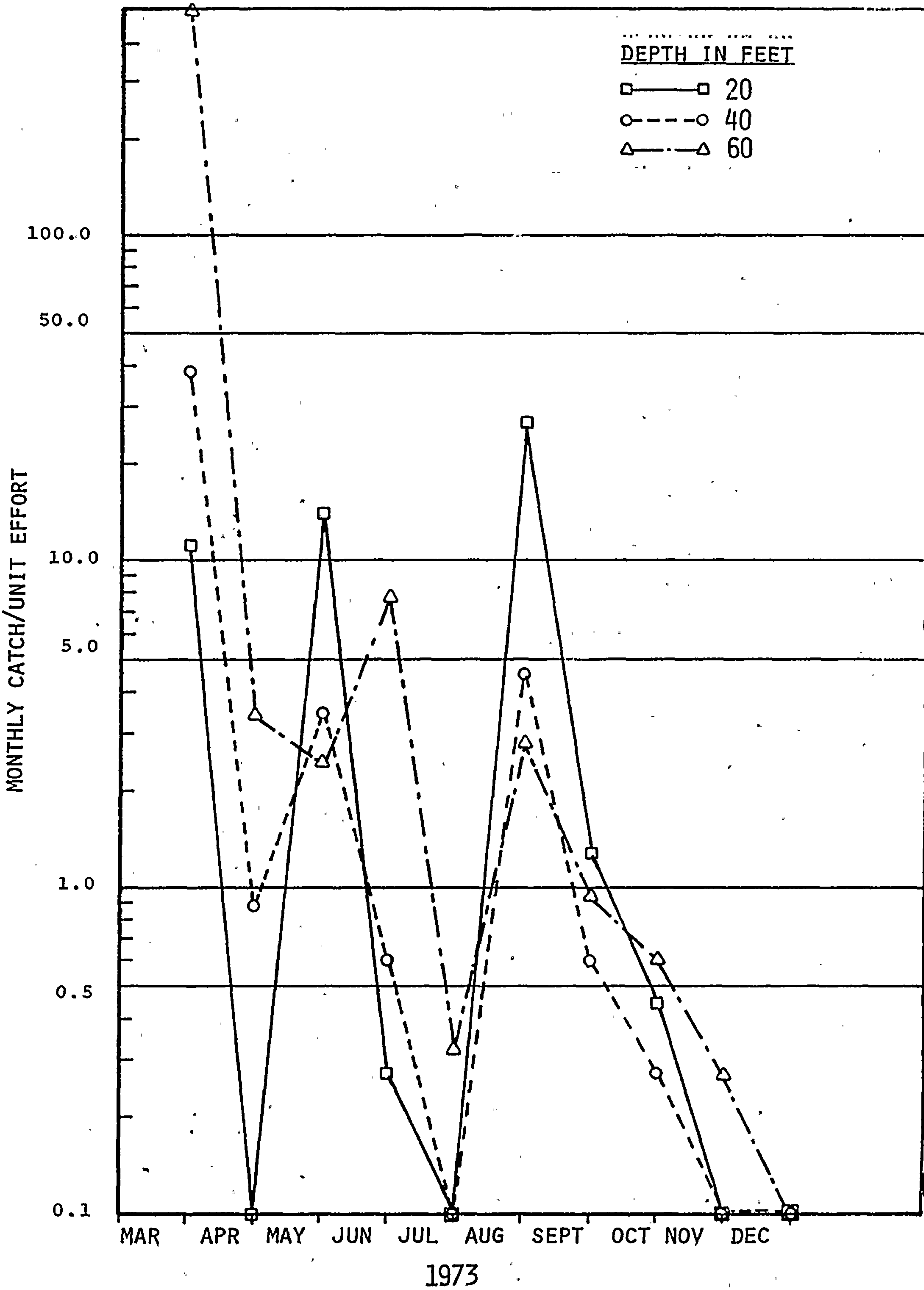
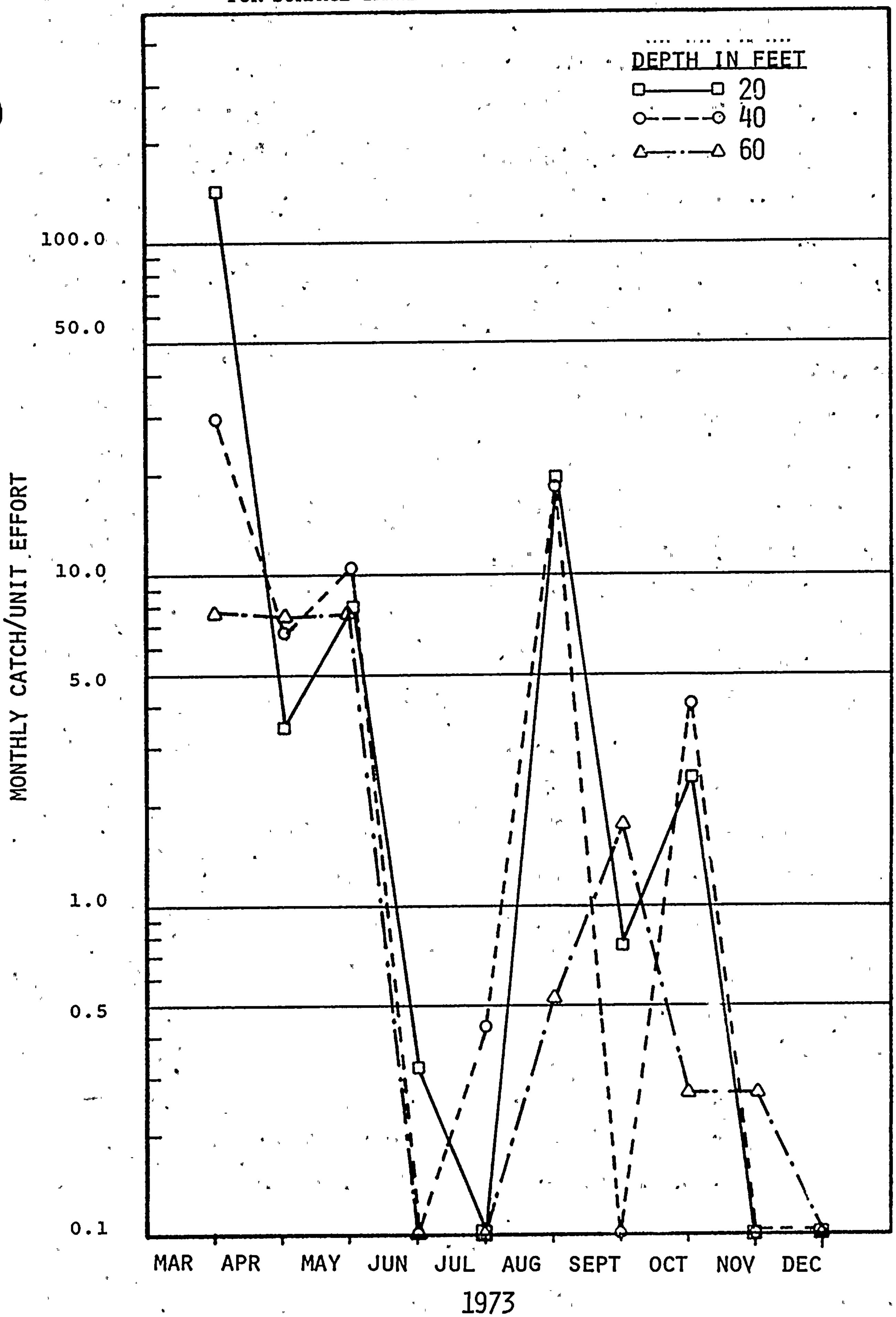


FIGURE III-22

MONTHLY CATCH PER UNIT EFFORT
FOR SURFACE TRAWL COLLECTIONS AT NINE MILE POINT EAST.



MONTHLY CATCH PER UNIT EFFORT
FOR SURFACE TRAWL COLLECTIONS AT NINE MILE POINT PLANT.



Bottom trawl catch per unit effort was generally greatest at the 20 ft. contour at NMPW (Figure III-24) from April to August. August collections at each depth were more variable, with catches at 40 ft. dominating in September and November and catches at 60 ft. dominating in December. Consistently more fishes were caught at NMPP at the 20 ft. contour (Figure III-25) than any of the other depths. On five occasions catch per unit effort was less than 1.0 and occurred most frequently at the 60 ft. contour. Four collections at NMPE exhibited reduced catches per unit effort at all depths during July and August (Figure III-26). Catches increased during September at the 20 and 40 ft. contour and decreased at 60 ft. Catch per unit effort was relatively constant at the 60 ft. contour from April through September. Catch values ranged from 1.5 to 2.5.

QL&M (1973) observed this same trend toward increased catches of fish in shallower water. Trawls conducted along the 20 ft. contour at both NMPW and NMPP generally caught more fishes than trawls along the 40 ft. contour (QL&M, 1973). Wells (1968) demonstrated that alewives, rainbow smelt, spottail shiners, trout perch, and other species of Lake Michigan fishes were more prevalent in shallow waters (<60 ft.) throughout most of the year. During May and June, Wells (1968) collected more alewives from 3 fathoms (18 ft.) of water than from 5 (30 ft.) or 10 (60 ft.) fathoms; during April, July, August, and November more alewives were captured at 10 fathoms. Consistently more rainbow smelt and trout perch were taken at 5 fathoms than at 3 or 10 fathoms (Wells, 1968). Bottom trawls conducted near Nine Mile Point yielded more fishes from 10 fathoms of water than from 5 fathoms (U.S.B.S.F.W., 1972, a-e). Trawls were not conducted in shallower waters during the U.S. Bureau of Sport Fisheries and Wildlife surveys.

FIGURE III-24

MONTHLY CATCH PER UNIT EFFORT
FOR BOTTOM TRAWL COLLECTIONS AT NINE MILE POINT WEST.

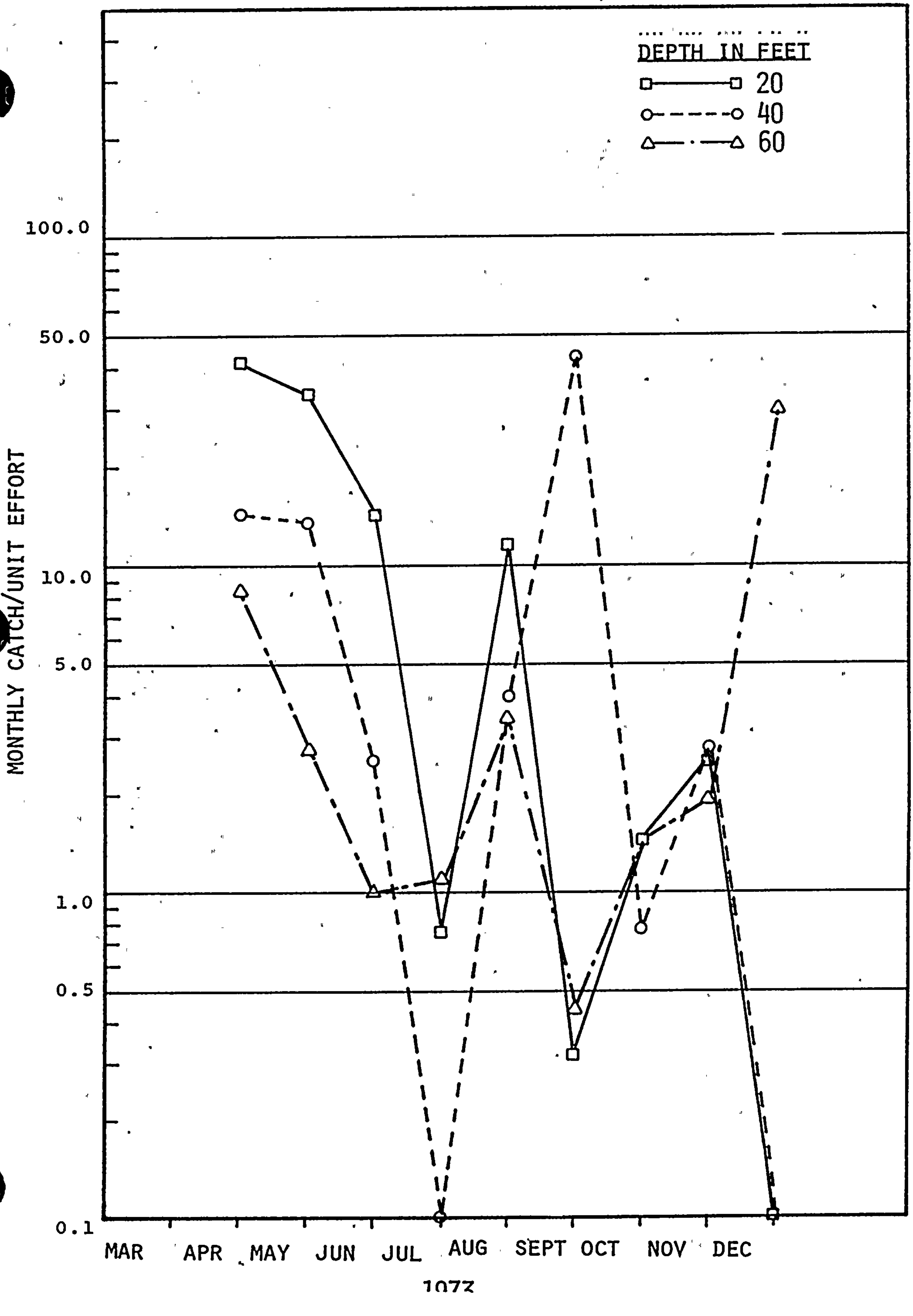


FIGURE III-25

MONTHLY CATCH PER UNIT EFFORT
FOR BOTTOM TRAWL COLLECTIONS AT NINE MILE POINT PLANT.

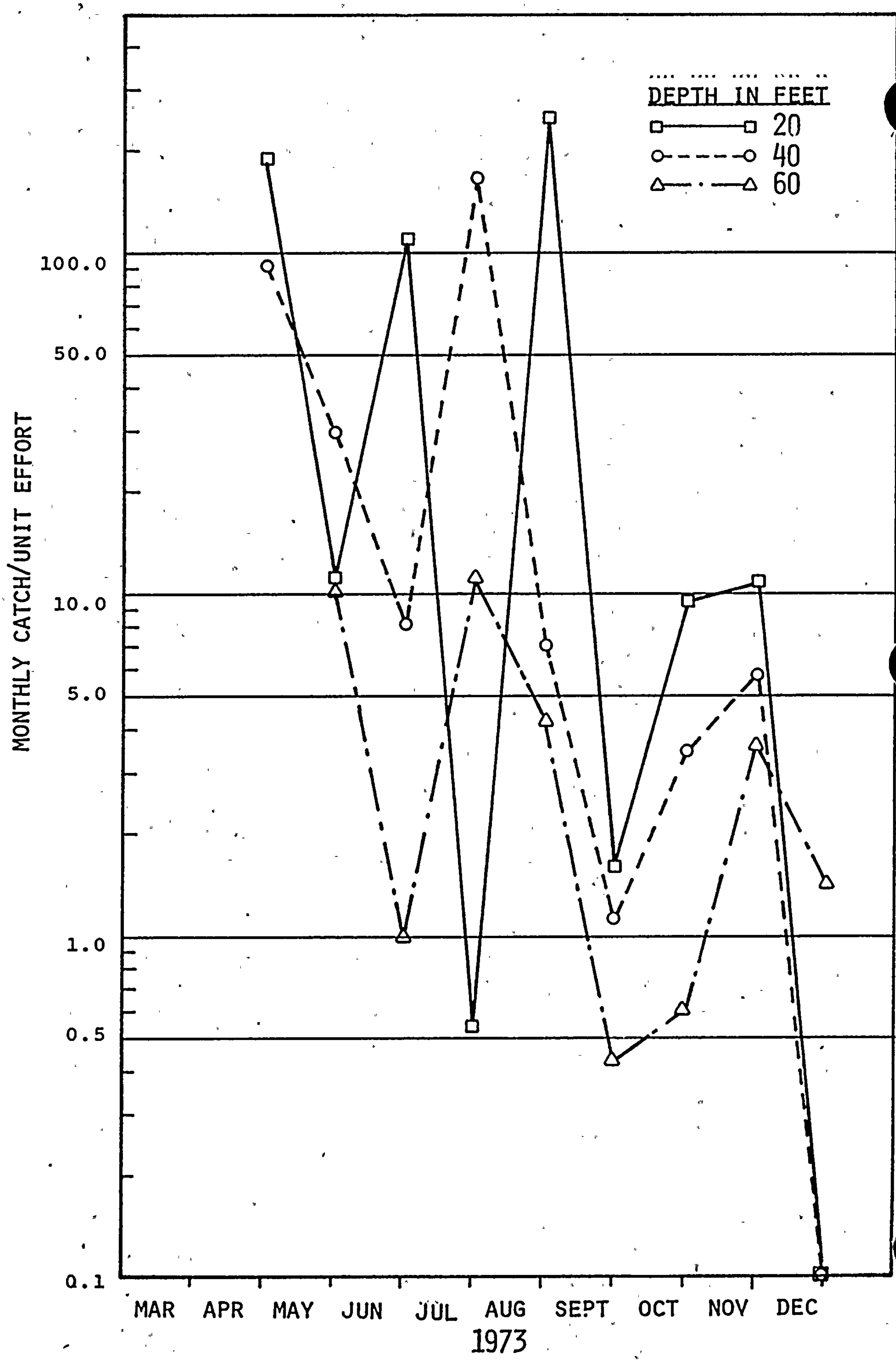
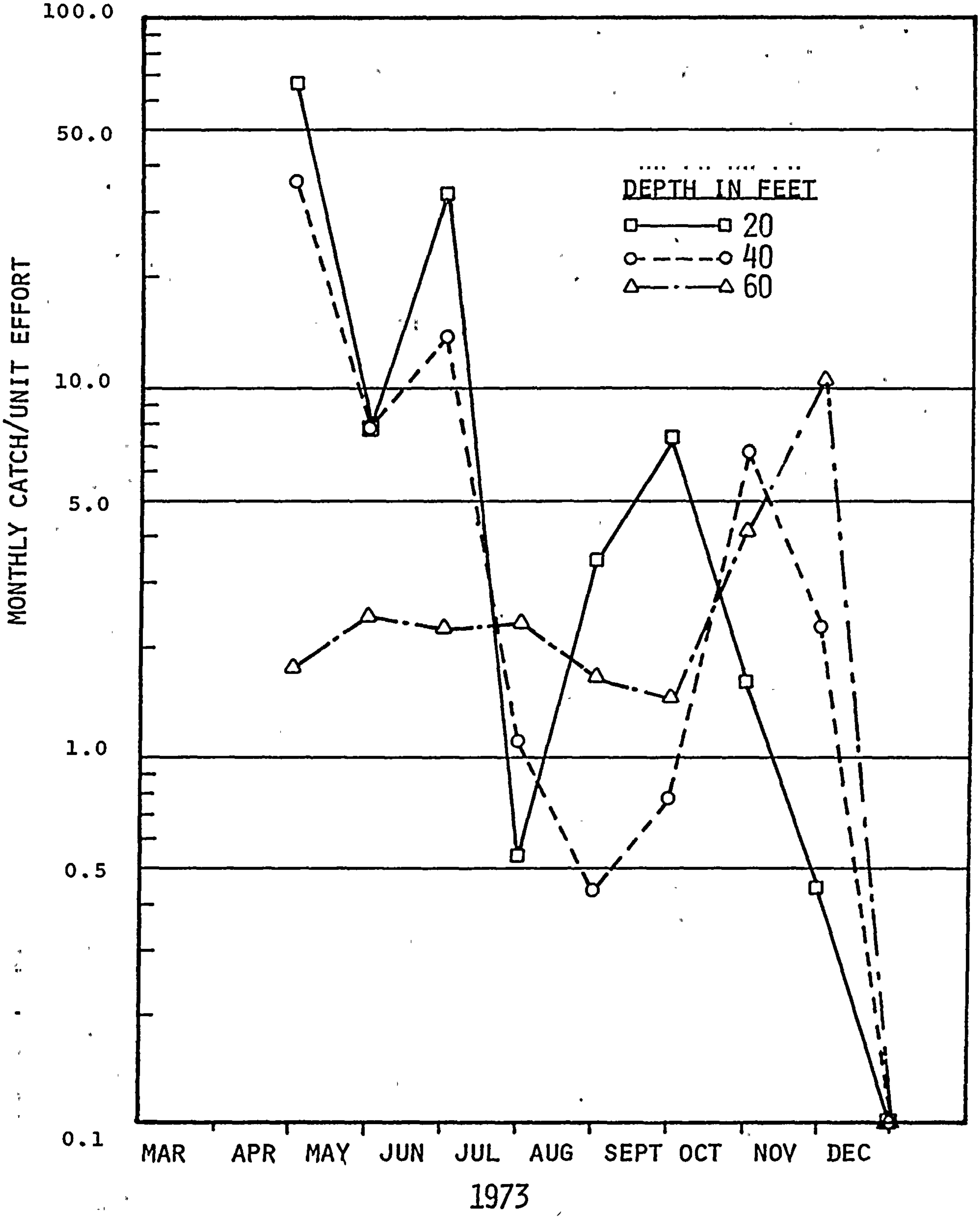


FIGURE III-26

MONTHLY CATCH PER UNIT EFFORT
FOR BOTTOM TRAWL COLLECTIONS AT NINE MILE POINT EAST.



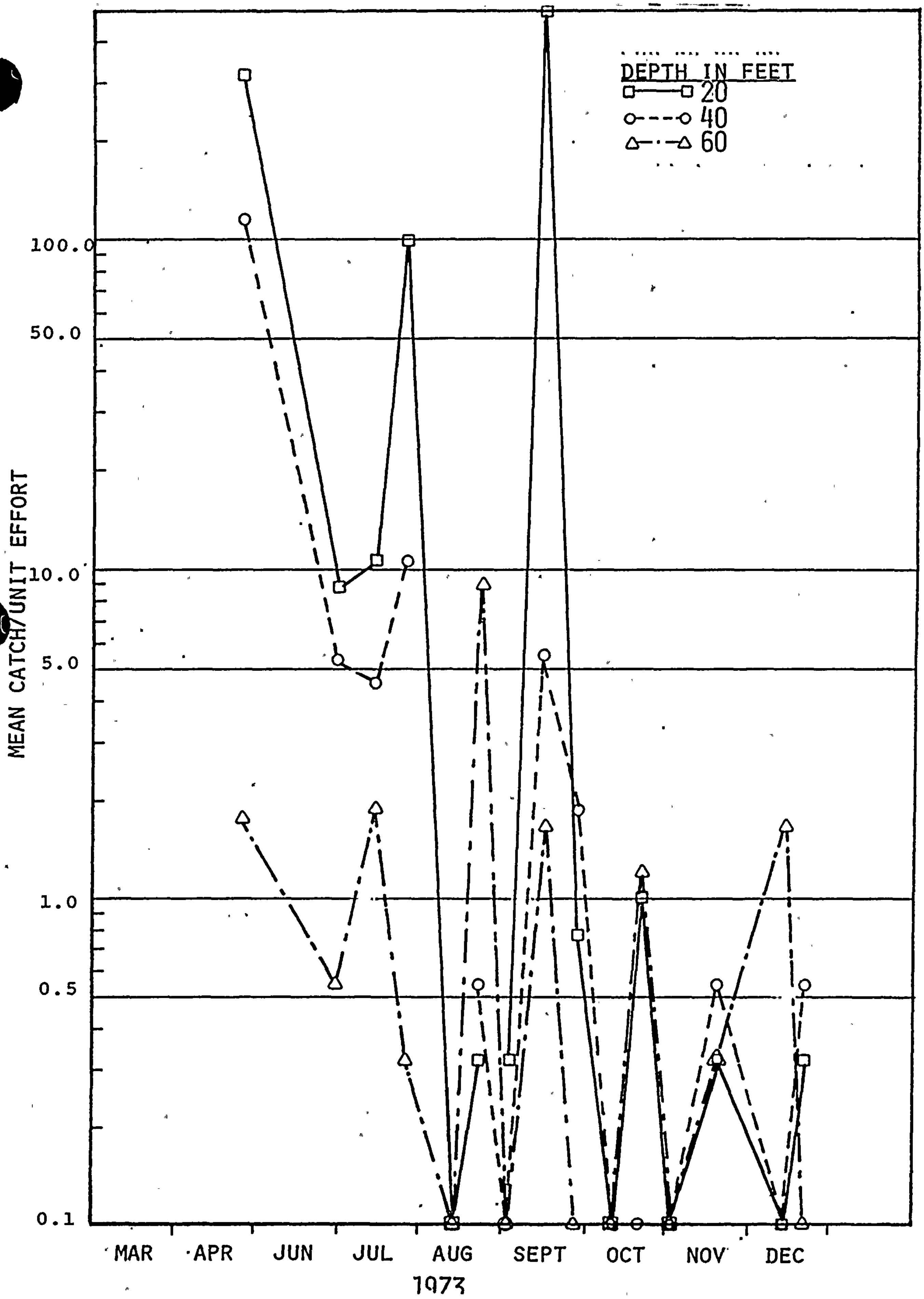
Bottom trawls were generally more productive than surface trawls along each depth contour. Day bottom trawl catch per unit effort was quite variable (Figure III-27). From April through June and 2 and 4 August, collections were greatest at 20 ft. and least at 60 ft. with the catch at 40 ft. always being slightly less than the 20 ft. catches; 2 August until 20 November the greatest daily catches were recorded at the 40 and 60 ft. contours.

Night bottom trawls at 20 ft. produced more fishes per unit effort during April and June and on 18 October and 13 November than were collected from the other depths (Figure III-28). Greatest catches on other dates (14 August and 20 September) were usually recorded for the 40 ft. contour. On 2 August, 20 November and 13 December catches were greatest at 60 ft.

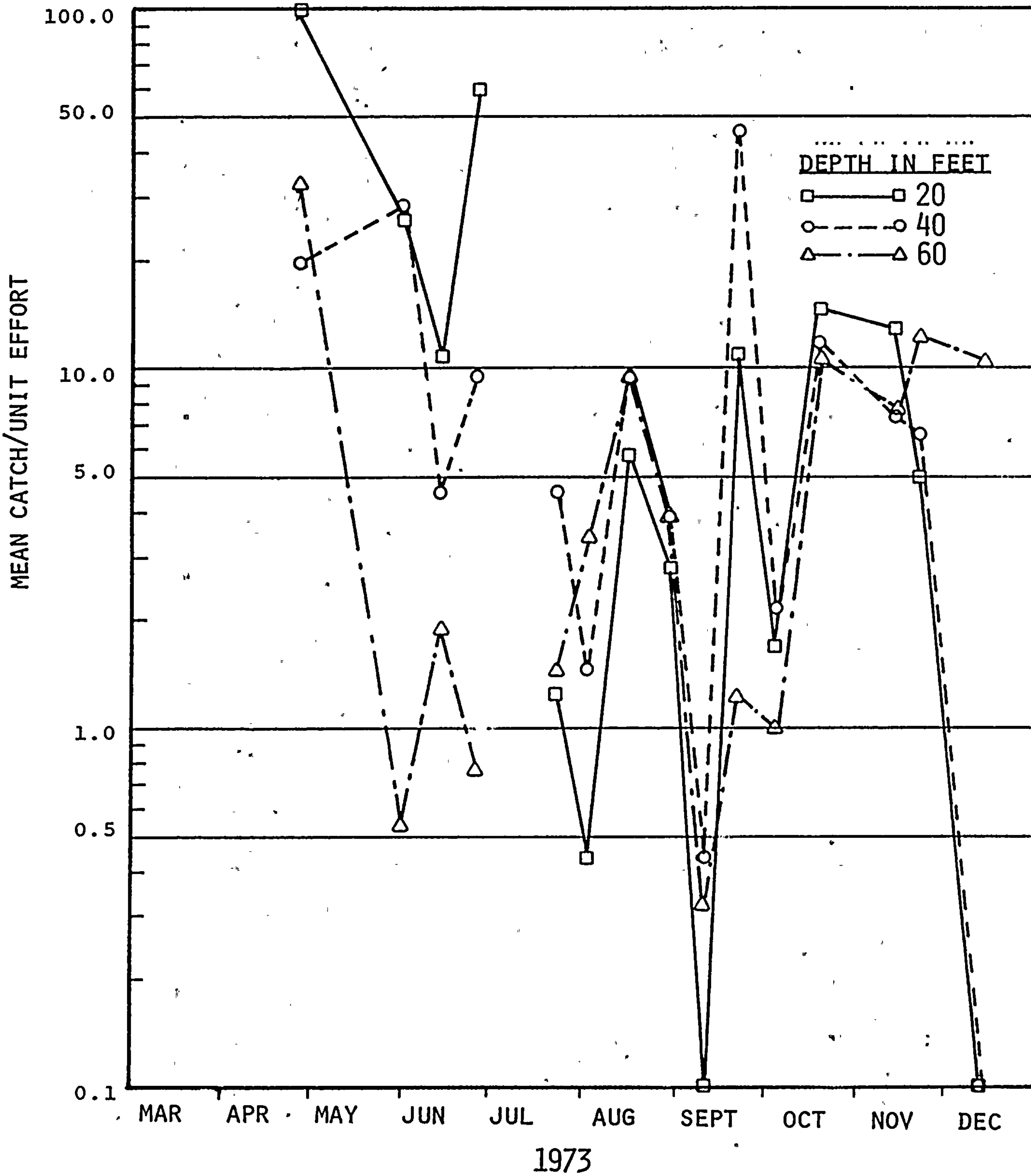
Night bottom trawl catch per unit effort was generally greater than day bottom catches along all three contours (Figures III-29, III-30, and III-31). Day catches exceeded night catches at 20 ft. on 25 April, 13 and 25 June (Figure III-30). On 22 July at the 60 ft. depth day bottom trawls yielded more fishes than night bottom trawls (Figure III-31).

Reduction in the frequency in which day collections exceeded night collections with increasing depth suggests that near-shore day-night fluctuations in abundance are more extreme in deeper waters. The fish community at 60 ft. of water was apparently less subject to diel fluctuations in abundance. Variations between day and night bottom catches was not as great at a depth of 60 ft. than at the other depths (Figures III-29, III-30, III-31).

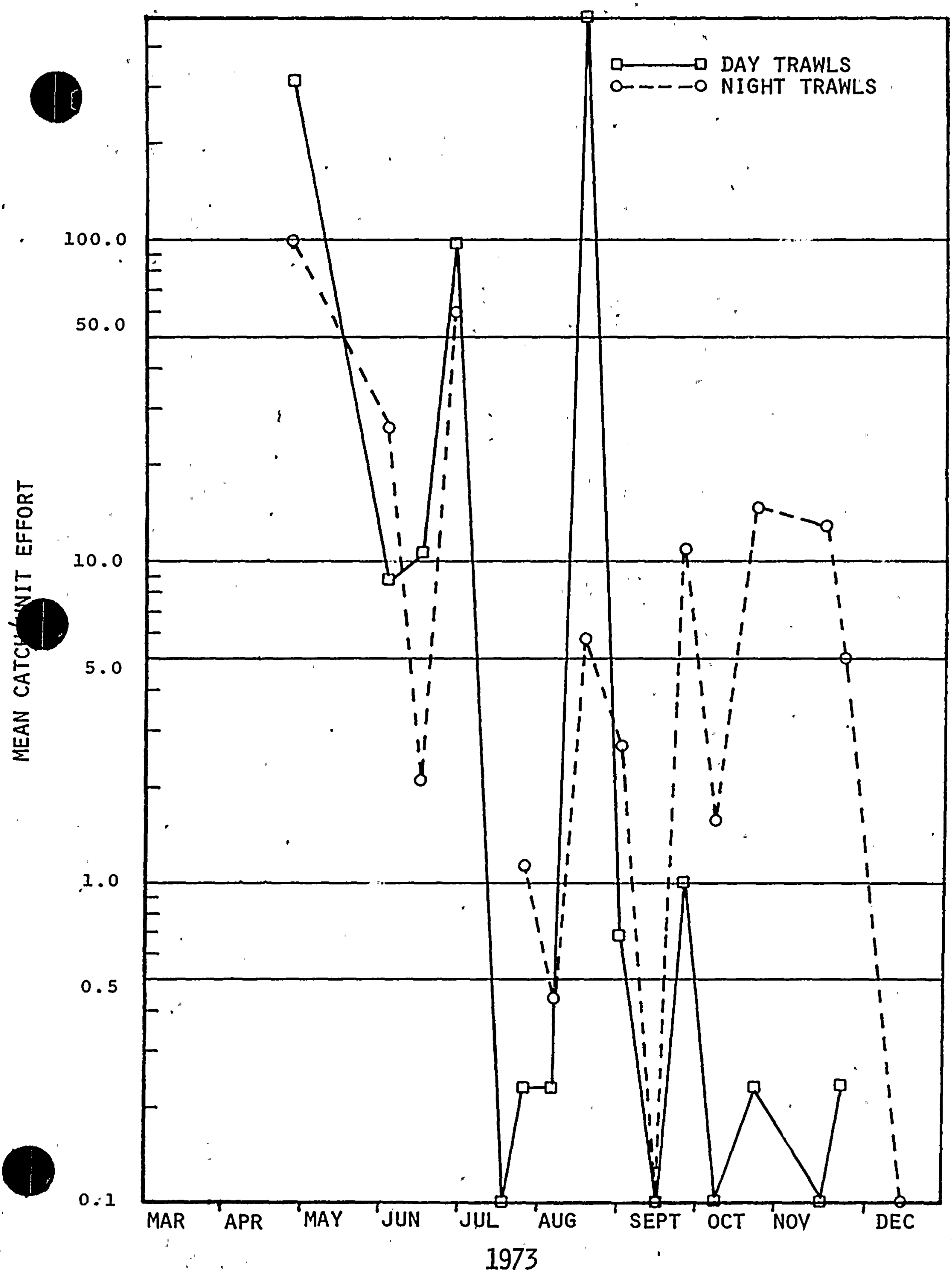
MEAN CATCH PER UNIT EFFORT FOR DAY BOTTOM TRAWL COLLECTIONS ALONG THE 20, 40 AND 60 FEET CONTOURS. VALUES ARE MEANS FOR ALL TRANSECTS ON EACH COLLECTION DATE.



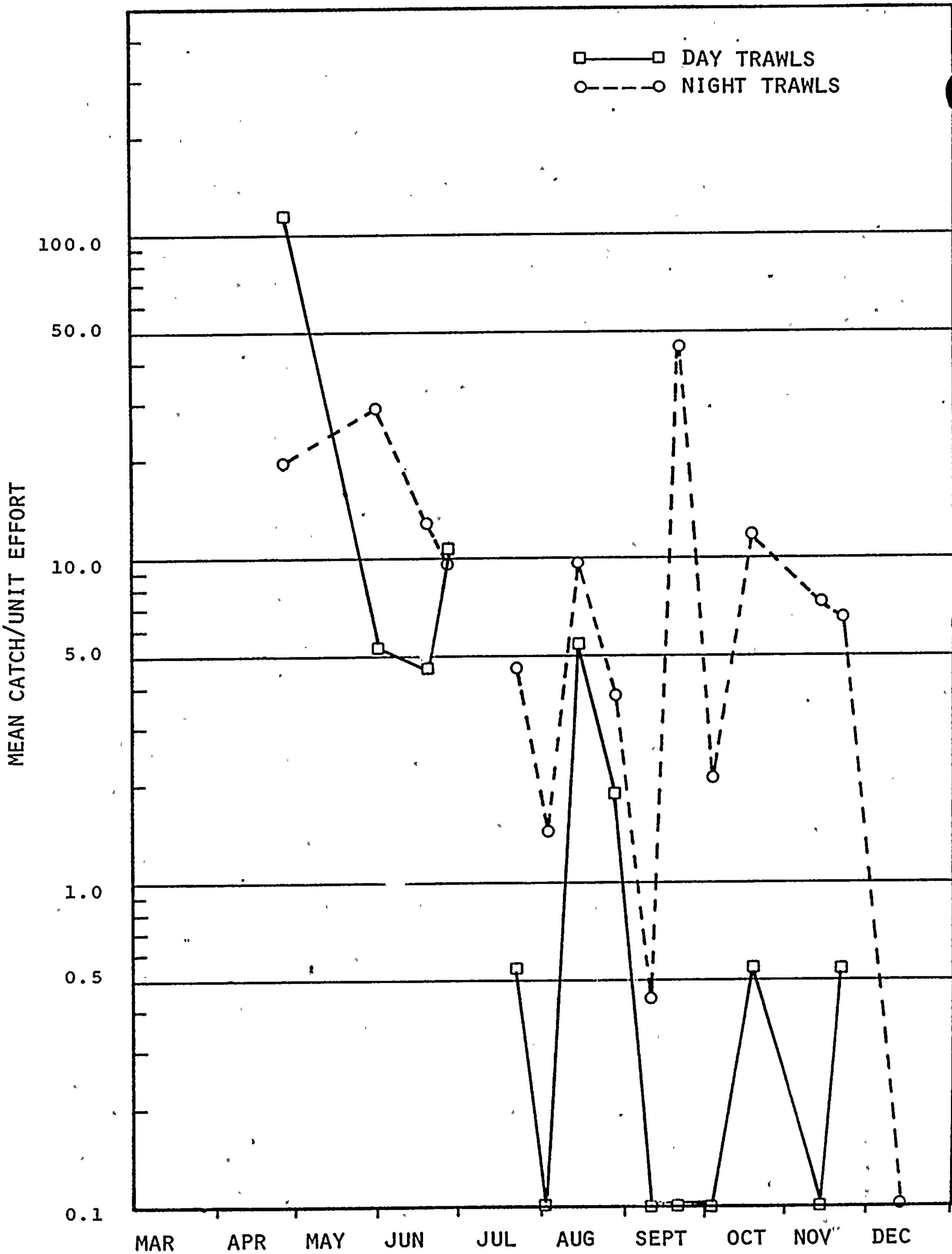
MEAN CATCH PER UNIT EFFORT FOR NIGHT BOTTOM TRAWL COLLECTIONS ALONG THE 20, 40 AND 60 FEET CONTOURS. VALUES ARE MEANS FOR ALL TRANSECTS ON EACH COLLECTION DATE.



MEAN CATCH PER UNIT EFFORT FOR DAY AND NIGHT BOTTOM TRAWL COLLECTIONS ALONG THE 20 FT. DEPTH CONTOUR. VALUES ARE MEANS FOR ALL TRANSECTS ON EACH COLLECTION DATE

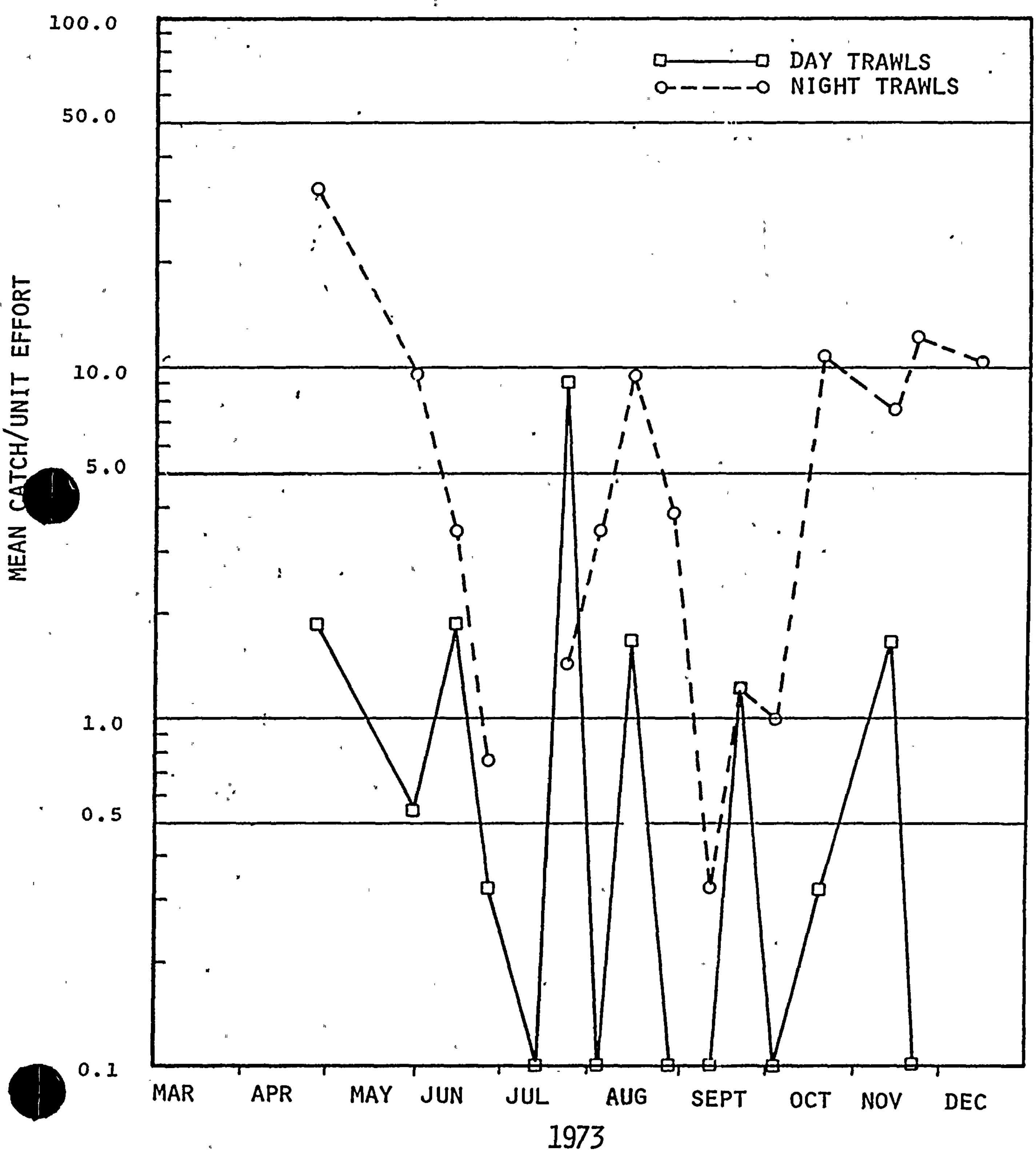


MEAN CATCH PER UNIT EFFORT FOR DAY AND NIGHT BOTTOM TRAWL COLLECTIONS ALONG THE 40 FEET DEPTH CONTOUR. VALUES ARE MEANS FOR ALL TRANSECTS ON EACH COLLECTION DATE.



1973

MEAN CATCH PER UNIT EFFORT FOR DAY AND NIGHT BOTTOM TRAWL COLLECTIONS ALONG THE 60 FT. DEPTH CONTOUR. VALUES ARE MEANS FOR ALL TRANSECTS ON EACH COLLECTION DATE.



Three-way analysis of variance was used to test the influence of transect, collection date and depth contour on catch per unit effort for day and night, surface and bottom trawls. Day surface trawls exhibited significant interactions between depth and date and between transect and date (Table III-12). This indicated that surface trawl abundance at each depth contour of each transect was influenced by date. Catches on 14 August were the greatest of the entire sampling program. 30 May catches were the second largest and were significantly different from day surface trawl collections on all other dates. All other collection dates were determined to be similar statistically. Day bottom trawls exhibited a significant interaction between depth contour and date indicating that abundance along each contour was strongly affected by date (Table III-13). Collections at NMPP were significantly greater than those at NMPW and NMPE (see Figure III-12). Transects NMPW and NMPE were not statistically different.

Night surface trawl catch per unit effort was found to have significant depth contour-transect and date-transect interactions (Table III-14). Collections on 30 May and 14 and 27 August were considered similar and each was greater than catches on any of the other collection dates. Night bottom trawls exhibited significant differences in catch between dates (Table III-15). Catches on 30 May were the greatest and on 13 December the lowest. Other dates were divided among three groups on which similar numbers of fishes were caught.

Both day and night surface trawls on 30 May and 14 August produced more fish per unit effort than were collected on any other date. The only exception was on 27 August when the night surface catch was similar to

TABLE III-12 - Three-Way Analysis of Variance of day surface trawl catch per unit effort. Data Transformed to $\log_{10}$ data plus one.

SOURCE	d.f.	S.S.	M.S.	F ratio*
Depth Contour	2	0.284	0.142	1.527
Transect	2	0.096	0.048	0.539
Date	13	4.934	0.380*	2.517**
Depth Contour x Transect	4	0.214	0.054	1.742
Depth Contour x Date	26	2.411	0.093*	3.000**
Transect x Date	26	2.304	0.089*	2.871**
Depth Contour x Transect x Date	52	1.611	0.031	
Total	125	11.856		

*Critical F values are: $F_{13,37} = \sim 1.99$; $F_{26,52} = \sim 1.70$; $F_{26,52} = \sim 1.70$

**Significant difference at α 0.05

B. Student-Newman-Kuels Procedure for Determining Sources of First Order Effective Significance. Groups Underscored by a Single Line are not Significantly Different at $p<0.05$.

RANK	1	2	3	4	5	6	7
MEAN $\log_{10}$ (Data +1)	0	0.025	0.041	0.049	0.049	0.460	0.670
DATE (Month-Day)	6-13,25 7-22,8,27 10-18,11-13 11-20,12-12	9-20	10-2	8-2	4-25	5-30	8-14

(Underscore lines: ranks 1–5 grouped; rank 6 alone; rank 7 alone.)

TABLE III-13 - Three-Way Analysis of Variance of day bottom trawl catch per unit effort. Data Transformed to $\log_{10}$ data plus one.

SOURCE	d.f.	S.S	M.S.	F ratio*
Depth Contour	2	2.035	1.018	1.885
Transect	2	0.884	0.442*	3.778**
Date	11	10.587	0.962	1.781**
Depth Contour x Transect	4	0.206	0.051	0.436**
Depth Contour x Date	22	11.885	0.540*	4.615**
Transect x Date	22	3.515	0.160	1.368
Depth Contour x Transect x Date	44	5.154	0.117	
Total	107	34.267		

*Critical F values are: $F_{2,40} = 3.21$; $F_{22,44} = \sim 1.80$

**Significant difference at α 0.05

B. Student-Newman-Kuels Procedure for Determining Sources of First Order Effective Significance. Groups Underscored by a Single Line are not Significantly Different at $p<0.05$.

RANK	1	2	3
MEAN $\log_{10}$ (Data +1)	0.240	0.259	0.440
TRANSECT	NMPE	NMPW	NMPP

(NMPE and NMPW are underscored by a single line; NMPP is underscored separately.)

TABLE III-14. Three-Way Analysis [illegible]riance of night surface trawl catch per unit effo[illegible] Data Transformed to $\log_{10}$ data plus one.

SOURCE	d.f.	S.S.	M.S.	F ratio*
Depth Contour	2	0.354	0.177	0.898
Transect	2	1.769	0.885	3.417
Date	11	15.543	1.413	11.126**
Depth Contour x Transect	4	0.789	0.197	3.031**
Depth Contour x Date	22	1.283	0.058	0.892
Transect x Date	22	2.784	0.127	1.954**
Depth Contour x Transect x Date	44	2.874	0.065	
Total	107	25.397		

*Critical F Values are: $F_{11,22} = 2.26$; $F_{4,44} = 2.58$; $F_{22,44} = \sim 1.8$

**Significant difference at $\alpha = 0.05$

B. Student-Newman-Kuels Procedure for Determining Sources of First Order Effective Significance. Groups Underscored by a Single Line are not Significantly Different at $p<0.05$.

RANK	1	2	3	4	5	6	7	8	9	10	11	12
MEAN $\log_{10}$ (Data + 1)	0.041	0.049	0.087	0.098	0.118	0.135	0.239	0.419	0.535	0.884	1.036	1.073
DATE (Month-Day)	11-20	7-22	10-2	6-25	12-12	9-20	11-13	10-18	4-25	8-14	5-30	8-27

Underscored groups: 11-20 through 10-18; 10-18 through 4-25; 8-14 through 8-27.

TABLE III-15 - Three-Way Analysis of Variance of night bottom trawl catch per unit effort. Data Transformed to $\log_{10}$ data plus one.

SOURCE	d.f.	S.S.	M.S.	F ratio*
Depth Contour	2	0.444	0.222	1.018
Transect	2	0.653	0.327	1.500
Date	9	8.682	0.965	4.427**
Depth Contour x Transect	4	0.402	0.101	0.463
Depth Contour x Date	18	5.299	0.294	1.349
Transect x Date	18	2.388	0.133	0.610
Depth Contour x Transect x Date	36	7.835	0.218	
Total	89	25.704		

*Critical F values are: $F_{9,36} = 2.15$

**Significant difference at α0.05

B. Student-Newman-Kuels Procedure for Determining Sources of First Order Effective Significance. Groups Underscored by a Single Line are not Significantly Different at $p<0.05$.

RANK	1	2	3	4	5	6	7
MEAN $\log_{10}$ (Data +1)	0.205	0.341	0.375	0.526	0.719	0.749	0.817
DATE (Month-Day)	12-13	10-2	7-22	8-27	9-20	11-20	11-13

RANK	8	9	10
MEAN $\log_{10}$ (DATA + 1)	0.932	0.995	1.247
DATE (Month-Day)	6-25	10-18	5-30

catches on 30 May and 14 August. Day bottom trawl collections differed between transects, while night bottom trawl collections exhibited differences between dates.

A similar series of tests was conducted to examine biomass per unit effort data for the influence of depth contour, transect and date. Day surface trawl biomass was affected by the interaction of transect and season (Table III-16). Biomass collected on 30 May was greater than that collected on any other date. Day bottom trawl biomass collection was influenced by the interaction of depth contour and date (Table III-17). Greatest biomass was collected on 13 June; collections on 10 September and 2 October were the lowest.

Night surface trawl biomass was significantly greater at NMPP than at NMPW and NMPE (Table III-18). Biomass collected per unit effort at NMPW and NMPE was similar. Night bottom trawl biomass collections were greater at the 20 ft. depth contour than at the 60 ft. contour (Table III-19). Biomass collected at the 40 ft. contour could be considered similar to that at either of the other contours.

Little consistency was apparent between the results of the analysis of variance for catch and biomass per unit effort data (Tables III-12 to III-19). Day surface trawl data indicated 14 August as the numerically most productive date and 30 May as the second most productive. These ranks were reversed for biomass when 30 May was first and 14 August was second. Day bottom trawl catches differed by date and biomass by transect. Night surface trawl biomass differed by transect and numerical catch by date. Biomass varied by depth contour and catch by date for night bottom trawls.

TABLE III-16 - Three-Way Analysis of Variance of day surface trawl biomass per unit effort. Data Transformed to $\log_{10}$ data plus one.

SOURCE	d.f.	S.S.	M.S.	F ratio*
Depth Contour	2	0.236	0.118	1.269
Transect	2	0.364	0.182	0.587
Date	14	9.611	0.687	2.216**
Depth Contour x Transect	4	0.576	0.144	1.548
Depth Contour x Date	28	2.772	0.099	1.065
Transect x Date	28	8.689	0.310	3.333**
Depth Contour x Transect x Date	56	5.231	0.093	
Total	134	27.479		

*Critical F values are: $F_{4,28} = 2.06$; $F_{28,56} =\sim 1.67$

**Significant difference at α0.05

B. Student-Newman-Kuels Procedure for Determining Sources of First Order Effective Significance. Groups Underscored by a Single Line are not Significantly Different at p<0.05.

RANK	1	2	3	4	5	6	7
MEAN $\log_{10}$ (Data +1)	0	0.082	0.168	0.283	0.399	0.441	0.984
DATE (Month-Day)	6-13,25 7-22, 8-27, 9-10, 11-18, 11-13, 20,12-13	9-20	10-2	4-25	8-2	8-14	5-30

TABLE III-17 - Three-Way Analysis of Variance of day bottom trawl biomass per unit effort. Data Transformed to $\log_{10}$ data plus one.

SOURCE	d.f.	S.S.	M.S.	F ratio*
Depth Contour	2	3.232	1.616	1.639
Transect	2	2.447	1.224	2.336
Date	10	35.129	3.513	3.563**
Depth Contour x Transect	4	1.471	0.368	0.702
Depth Contour x Date	20	19.724	0.986	1.882**
Transect x Date	20	9.176	0.459	0.876
Depth Contour x Transect x Date	40	20.976	0.524	
Total	98	92.155		

*Critical F values are: $F_{10,20} = 2.35$; $F_{20,40} = 1.84$

**Significant differences at α0.05

B. Student-Newman-Kuels Procedure for Determining Sources of First Order Effective Significance. Groups Underscored by a Single Line are not Significantly Different at $p<0.05$.

RANK	1	2	3	4	5	6	7	8	9	10
MEAN $\log_{10}$ (Data +1)	0	0.058	0.227	0.233	0.521	0.794	0.828	1.102	1.503	1.814
DATE (Month-Day)	9-10,11-20 10-2		8-2	11-13	9-20	8-14	7-22	5-30	6-25	6-13

TABLE III-18 - Three-Way Analysis of Variance of night surface trawl biomass per unit effort. Data Transformed to $\log_{10}$ data plus one.

SOURCE	d.f.	S.S.	M.S.	F ratio*
Depth Contour	2	1.883	0.942	1.892
Transect	2	5.631	2.816	5.655**
Date	10	56.129	5.613	11.271**
Depth Contour x Transect	4	3.499	0.875	1.757
Depth Contour x Date	20	12.200	0.610	1.225
Transect x Date	20	10.152	0.508	1.020
Depth Contour x Transect x Date	40	19.916	0.498	
Total	98	109.412		

*Critical F values are: $F_{2,40} = 3.23$; $F_{10,40} = 2.07$
**Significant difference at $\alpha 0.05$

B. Student-Newman-Kuels Procedure for Determining Sources of First Order Effective Signifcance. Groups Underscored by a Single Line are not Significantly Different at p<0.05.

RANK	1	2	3
MEAN $\log_{10}$ (Data + 1)	0.878	0.978	1.426
Transect	NMPW	NMPE	NMPP

RANK	1	2	3	4	5	6	7	8	9	10	11
MEAN $\log_{10}$ (Data + 1)	0.60	.205	.373	.543	.701	1.230	1.385	1.422	1.454	2.299	2.362
Date	11/20	10/2	9/20	6/25	11/13	8/14	4/25	10/18	8/27	3/28	5/30

TABLE III-19 - Three-Way Analysis of Variance of night bottom trawl biomass per unit effort. Data Transformed to $\log_{10}$ data plus one.

SOURCE	d.f.	S.S.	M.S.	F ratio*
Depth Contour	2	6.956	3.478	4.764*
Transect	2	2.756	1.378	1.888
Date	6	8.099	1.350	1.849
Depth Contour x Transect	4	1.034	0.258	0.353
Depth Contour x Date	12	8.617	0.718	0.984
Transect x Date	12	1.826	0.152	0.208
Depth Contour x Transect x Date	24	17.516	0.730	
Total	62	46.804		

*Critical F values are: $F_{2,24} = 3.40$

**Significant difference at α 0.05

B. Student-Newman-Kuels Procedure for Determining Sources of First Order Effective Significance. Groups Underscored by a Single Line are not Significantly Different at $p<0.05$.

RANK	1	2	3
MEAN $\log_{10}$ (Data +1)	1.498	1.995	2.305
Depth Contour	60 ft.	40 ft.	60 ft.

b. Community Structure

Percentage composition of each month's surface and bottom collections was determined from catch per unit effort data for day and night trawls combined. Most surface collections were dominated by alewives (Table III-20), which were the only species caught on 25 occasions. Single species catches were recorded at NMPW during September for emerald shiners, during October for rock bass and during November for rainbow smelt. Collections consisting of only emerald shiners and rainbow smelt occurred at the 40 ft. depth contour and for rock bass along the 20 ft. contour. On 27 occasions no fishes were caught in the surface trawls.

During May, six species were collected by surface trawl (Table III-20). This represents the maximum number of species collected in any month. May collections produced alewives, rainbow smelt, emerald shiners, three-spine sticklebacks, spottail shiners and gizzard shad. Five species were caught during August, September and October. Alewives and emerald shiners were collected during these three months, rainbow smelt and gizzard shad during September and October, rock bass during August and October, white perch and trout perch during August and spottail shiners during September. April trawls yielded alewives and rainbow smelt, while only alewives were collected during July.

Three-spine sticklebacks were caught only during May and white bass only during December (Table III-20). Mottled sculpins appeared only during the March and November trawls at the 20 ft. contour of NMPW and at the 20 ft. contour at NMPP, respectively. Hubbs and Lagler (1958) reported that this species of sculpin is a shore zone inhabitant, which may ex-

TABLE III-20

MONTHLY CATCH PER UNIT EFFORT AND PERCENT COMPOSITION OF SURFACE TRAWL COLLECTIONS
IN THE NINE MILE POINT AREA

MARCH

	NMPE 20		NMPE 40		NMPE 60		NMPP 20		NMPP 40		NMPP 60		NMPW 20		NMPW 40		NMPW 60	
	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%
Alewife	9.67	87.91	37.33	97.39	494.67	100.00	137.67	96.73	28.00	95.47	3.67	47.85	27.33	90.11	1.67	100.00		
Rainbow Smelt	1.33	12.09	1.00	2.61			4.33	3.04	1.33	4.53	4.00	52.15	1.67	5.51			No	
Spottail Shiner							0.33	0.23					0.33	1.09			fish	
Mottled Sculpin													1.00	3.03			caught	
Total	11.00		38.33		494.67		142.33		29.33		7.67		30.33		1.67			

APRIL

	NMPE 20		NMPE 40		NMPE 60		NMPP 20		NMPP 40		NMPP 60		NMPW 20		NMPW 40		NMPW 60	
	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%
Alewife	No fish		0.67	100.00	2.67	79.94	2.00	60.06	3.67	55.02	7.33	100.00	1.00	100.00	No fish		No fish	
Rainbow Smelt	caught				0.67	20.06	1.33	39.94	3.00	44.98					caught		caught	
Total			0.67		3.34		3.33		6.67		7.33		1.00					

MAY

	NMPE 20		NMPE 40		NMPE 60		NMPP 20		NMPP 40		NMPP 60		NMPW 20		NMPW 40		NMPW 60	
	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%
Alewife	2.33	16.65	2.33	69.97	2.33	100.00	6.33	79.22	3.67	35.49	5.00	65.27	11.67	85.31	9.67	80.58	3.33	55.59
Rainbow Smelt	1.33	9.91	0.33	9.91			1.33	16.65	0.67	6.48	2.33	30.42			1.33	11.08	2.33	38.90
Emerald Shiner	0.33	2.36					0.33	4.13			0.33	4.31	0.67	4.90	1.00	8.33	0.33	5.51
Threespine Stickleback	10.00	71.48	0.67	20.12					6.00	58.03								
Spottail Shiner													0.67	4.90				
Gizzard Shad													0.67	4.90				
Total	13.99		3.33		2.33		7.99		10.34		7.66		13.68		12.00		5.99	

TABLE III-20 Cont'd

	NMPE 20 Catch	%	NMPE 40 Catch	%	NMPE 60 Catch	%	NMPP 20 Catch	%	NMPP 40 Catch	%	NMPP 60 Catch	%	NMPW 20 Catch	%	NMPW 40 Catch	%	NMPW 60 Catch	%
JUNE																		
Alewife	0.17	100.00	0.50	100.00	0.67	40.12	0.22	100.00	No fish caught		No fish caught		No fish caught		0.22	100.00	No fish caught	
Rainbow Smelt					0.83	49.70												
Troutperch					0.17	10.18												
Total	0.17		0.50		1.67		0.22								0.22			
JULY																		
Alewife	No fish caught		No fish caught		0.22	100.00	No fish caught		0.33	100.00	No fish caught		No fish caught		No fish caught		No fish caught	
Total					0.22				0.33									
AUGUST																		
Alewife	20.11	97.86	3.89	89.84	2.44	91.73	19.78	100.00	18.22	98.81	5.11	97.89	3.20	100.00	0.53	80.30	1.60	100.00
Emerald Shiner	0.33	1.61	0.33	7.62	0.22	8.27			0.22	1.19					0.13	19.70		
Rock Bass	0.11	0.54																
White Perch			0.11	2.54														
Troutperch											0.11	2.11						
Total	20.55		4.33		2.66		19.78		18.44		5.22		3.20		0.66		1.60	
SEPTEMBER																		
Alewife	1.17	100.00	0.50	100.00	0.50	64.94	0.44	66.67	No fish caught		1.50	89.82	0.33	100.00			No fish caught	
Rainbow Smelt					0.17	22.08					0.17	10.18						
Spottail Shiner					0.17	22.08												
Gizzard Shad							0.22	33.33										
Emerald Shiner															0.17	100.00		
Total	1.17		0.50		0.84		0.66				1.67		0.33		0.17			

TABLE III-20 Cont'd

OCTOBER

	NMPE 20 Catch	%	NMPE 40 Catch	%	NMPE 60 Catch	%	NMPP 20 Catch	%	NMPP 40 Catch	%	NMPP 60 Catch	%	NMPW 20 Catch	%	NMPW 40 Catch	%	NMPW 60 Catch	%
Alewife					0.33	66.00	1.67	71.37	3.17	79.25	0.17	100.00			0.33	100.00	0.33	100.00
Rainbow Smelt	0.17	50.00	0.17	100.00	0.17	34.00	0.17	7.26										
Emerald Shiner	0.17	50.00					0.50	21.37	0.33	8.25								
Gizzard Shad									0.50	12.50								
Rock Bass													0.17	100.00				
Total	0.34		0.17		0.50		2.34		4.00		0.17		0.17		0.33		0.33	

NOVEMBER

	NMPE 20 Catch	%	NMPE 40 Catch	%	NMPE 60 Catch	%	NMPP 20 Catch	%	NMPP 40 Catch	%	NMPP 60 Catch	%	NMPW 20 Catch	%	NMPW 40 Catch	%	NMPW 60 Catch	%
Alewife					0.17	100.00	0.50	59.52	0.83	35.62							0.17	100.00
Rainbow Smelt	No		No				0.17	20.24	0.33	14.16	No		No		0.17	100.00		
Mottled Sculpin	fish		fish				0.17	20.24			fish		fish					
Gizzard Shad	caught		caught						1.17	50.21	caught		caught					
Total					0.17		0.84		2.33						0.17		0.17	

DECEMBER

	NMPE 20 Catch	%	NMPE 40 Catch	%	NMPE 60 Catch	%	NMPP 20 Catch	%	NMPP 40 Catch	%	NMPP 60 Catch	%	NMPW 20 Catch	%	NMPW 40 Catch	%	NMPW 60 Catch	%
Alewife	No		No		No		0.33	100.00	0.33	33.33	No		0.66	100.00	No		No	
Rainbow Smelt	fish		fish		fish				0.33	33.33	fish				fish		fish	
White Bass	caught		caught		caught				0.33	33.33	caught				caught		caught	
Total							0.33		0.99				0.66					

plain its presence at only the 20 ft. contour. Spottail shiners were caught at the 20 ft. contour of NMPW during March and May, at the 20 ft. contour of NMPP during March and at the 60 ft. contour of NMPE during September. Wells' (1968) data indicate that spottail shiner catches at 5 fathoms (30 ft.) were greater than at any other depths in the Lake Michigan study.

Bottom trawls collected more species than surface trawls. Two species were collected during December and five or more during each of the remaining months (Table III-21). Most of the fishes collected by bottom trawl were alewives. On ten occasions this species composed 100% of the collection. All other collections produced up to nine additional species. Alewives were caught in all bottom trawls except for the July collection at the 40 ft. contour of NMPW. Rainbow smelt were collected in all months with the exception of December (Table III-21). Yellow perch were taken at the 20 ft. contour of NMPE during April and June, at the 20 ft. contour of NMPP during April and September, and at the 40 ft. contour at NMPP during September. Wells (1968) demonstrated that most yellow perch were found below 10 fathoms (60 ft.) from February through May. Yellow perch moved into water less than 7 fathoms (42 ft.) depth during June and returned to deeper water during October and November (Wells, 1968). During the Lake Ontario fisheries survey, no yellow perch were collected by bottom trawl in less than 10 fathoms (60 ft.) of water at the Oswego (Mexico Bay) transect (Great Lakes Fish Lab., 1972 b-e).

White perch were caught at the 20 ft. contour of NMPE during August, all depths at NMPE and at 60 ft. at NMPW during September, and at the 60 ft. contour of NMPE during November. Contributions by white perch to the

TABLE III-21

MONTHLY CATCH PER UNIT EFFORT AND PERCENT COMPOSITION OF BOTTOM TRAWL COLLECTIONS IN THE NINE MILE POINT AREA. (NO COLLECTIONS WERE MADE IN MARCH).

APRIL

	NMPE 20		NMPE 40		NMPE 60		NMPP 20		NMPP 40		NMPP 60		NMPW 20		NMPW 40		NMPW 60	
	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%
Alewife	17.00	25.76	36.33	100.00	1.67	100.00	179.00	90.86	89.33	99.27	39.67	96.76			12.33	88.07	7.00	83.93
Rainbow Smelt	18.00	27.27					2.67	1.35	0.33	0.37	1.33	3.24			0.67	4.79	0.67	8.03
Yellow Perch	1.67	2.53					1.00	0.51										
White Sucker	1.33	2.02					0.67	0.34					No					
Spottail Shiner	14.67	22.23					3.00	1.52	0.33	0.37								
Lake Chub	0.33	0.50											Trawls					
Mottled Sculpin	0.67	1.02					0.33	0.17							0.67	4.79	0.67	8.03
Troutperch	8.33	12.62					9.33	4.74										
White Perch	1.67	2.53					0.67	0.34										
Johnny Darter	2.33	3.53					0.33	0.17							0.33	2.36		
Total	66.00		36.33		1.67		197.00		89.99		41.00				14.00		8.34	

MAY

	NMPE 20		NMPE 40		NMPE 60		NMPP 20		NMPP 40		NMPP 60		NMPW 20		NMPW 40		NMPW 60	
	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%
Alewife	3.00	39.11	6.33	82.64	2.33	100.00	10.67	97.00	24.00	81.80	9.00	90.00	27.30	82.83	7.33	54.99	2.66	100.00
Rainbow Smelt	2.00	26.08	1.33	17.36			0.33	3.00	4.67	15.92	1.00	10.00	1.33	4.04	6.00	45.01		
Threespine Stickleback	1.00	13.04											0.33	1.00				
White Perch	0.67	8.74																
Spottail Shiner	0.67	8.74							0.67	2.28			0.67	2.03				
Troutperch	0.33	4.30																
Johnny Darter													2.33	7.07				
Mottled Sculpin													1.00	3.03				
Total	7.67		7.66		2.33		11.00		29.34		10.00		32.96		13.33		2.66	

TABLE III-21 Cont'd

JUNE

	NMPE 20		NMPE 40		NMPE 60		NMPP 20		NMPP 40		NMPP 60		NMPW 20		NMPW 40		NMPW 60	
	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%
Alewife	8.33	24.36	11.33	82.88	2.00	92.17	97.33	88.84	4.22	52.75	0.44	50.00	7.56	53.96	1.56	63.67	0.89	100.00
Rainbow Smelt	3.17	9.27	1.50	10.97	0.17	7.83	7.56	6.90	3.56	44.50	0.44	50.00	3.56	25.41	0.67	27.35		
Troutperch	7.50	21.93	0.17	1.24									0.22	1.57				
Johnny Darter	8.67	25.35	0.50	3.66			1.78	1.62	0.22	2.75			1.11	7.92	0.22	8.98		
Mottled Sculpin	2.50	7.31	0.17	1.24			2.67	2.44					1.56	11.13				
Spottail Shiner	2.50	7.31					0.22	0.20										
White Sucker	0.50	1.46																
Yellow Perch	0.33	0.96																
Rock Bass	0.17	0.50																
Total	34.20		13.67		2.17		109.56		8.00		0.88		14.01		2.45		0.89	

JULY

	NMPE 20		NMPE 40		NMPE 60		NMPP 20		NMPP 40		NMPP 60		NMPW 20		NMPW 40		NMPW 60	
	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%
Alewife	0.22	50.00	0.67	67.00	0.67	30.18	0.22	50.00	156.67	94.17	10.33	93.91	0.33	50.00			1.00	100.00
Rainbow Smelt			0.33	33.00	1.11	50.00			9.67	5.81	0.67	6.09			No fish caught			
Mottled Sculpin	0.22	50.00																
Troutperch					0.44	19.82												
American Eel							0.22	50.00					0.33	50.00				
Total	0.44		1.00		2.22		0.44		166.34		11.00		0.66				1.00	

TABLE III-21 Cont'd

	NMPE 20 Catch	NMPE 20 %	NMPE 40 Catch	NMPE 40 %	NMPE 60 Catch	NMPE 60 %	NMPP 20 Catch	NMPP 20 %	NMPP 40 Catch	NMPP 40 %	NMPP 60 Catch	NMPP 60 %	NMPW 20 Catch	NMPW 20 %	NMPW 40 Catch	NMPW 40 %	NMPW 60 Catch	NMPW 60 %
AUGUST																		
Alewife	33.56	98.71	0.11	33.33	1.11	71.61	247.07	99.88	6.11	87.41	3.22	78.35	11.47	98.88	1.33	34.46	3.20	96.10
Rainbow Smelt	0.11	0.32			0.44	28.39			0.44	6.29	0.22	5.35			2.40	62.18		
Mottled Sculpin									0.22	3.15	0.11	2.68					0.13	3.90
Trout perch									0.11	1.57	0.56	13.63						
Johnny Darter			0.11	33.33					0.11	1.57								
White Perch	0.11	0.32																
Smallmouth Bass	0.22	0.65																
Rock Bass							0.27	0.12					0.13	1.12				
Threespine Stickleback															0.13	3.36		
American Eel			0.11	33.33														
Total	34.00		0.33		1.55		247.34		6.99		4.11		11.60		3.86		3.33	
SEPTEMBER																		
Alewife	3.00	41.84	0.33	49.25	0.67	50.00	0.83	55.33	0.67	66.34	0.33	100.00	0.22	100.00	13.56	31.28	0.17	50.00
Rainbow Smelt					0.50	37.31			0.17	16.83					26.89	62.03		
White Perch	2.17	30.26	0.17	25.37	0.17	12.69											0.17	50.00
Spottail Shiner	1.83	25.52													0.67	1.55		
Yellow Perch							0.17	11.33	0.17	16.83								
Troutperch			0.17	25.37											1.56	3.60		
Smallmouth Bass							0.50	33.33										
White Sucker	0.17	2.37																
Johnny Darter															0.67	1.55		
Total	7.17		0.67		1.34		1.50		1.01		0.33		0.22		43.35		0.34	

TABLE III-21 Cont'd

	NMPE 20		NMPE 40		NMPE 60		NMPP 20		NMPP 40		NMPP 60		NMPW 20		NMPW 40		NMPW 60	
	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%
OCTOBER																		
Alewife	1.00	66.67	6.00	89.96	3.83	95.75	8.67	92.83	2.83	84.73	3.33	95.14	1.17	87.31	0.50	74.63	1.33	100.00
Rainbow Smelt	0.50	33.33	0.67	10.04	0.17	4.25			0.17	5.09	0.17	4.86	0.17	12.69				
Gizzard Shad							0.50	5.35							0.17	25.37		
Emerald Shiner							0.17	1.82										
Spottail Shiner									0.17	5.09								
Troutperch									0.17	5.09								
Total	1.50		6.67		4.00		9.34		3.34		3.50		1.34		0.67		1.33	
NOVEMBER																		
Alewife	0.17	50.00	1.17	53.92	2.50	24.15	10.17	95.31	4.17	73.54	2.17	62.00	1.33	53.20	1.50	56.18	1.00	54.64
Rainbow Smelt			1.00	46.08	6.17	59.61	0.50	4.69	1.33	23.46	1.33	38.00	0.17	6.80	1.17	43.82	0.83	45.36
Brown Bullhead	0.17	50.00																
Troutperch					0.17	1.64												
White Bass					0.17	1.64												
White Perch					0.17	1.64												
Spottail Shiner					1.17	11.30												
Emerald Shiner									0.17	3.00								
Gizzard Shad													1.00	40.00				
Total	0.34		2.17		10.35		10.67		5.67		3.50		2.50		2.67		1.83	
DECEMBER																		
Alewife	No fish caught		No fish caught		No fish caught		No fish caught		No fish caught		1.33	100.00	No fish caught		No fish caught		28.67	97.72
Spottail shiner																	0.67	2.28
Total											1.33						29.34	

September collections ranged from 21.7 to 50.0% (Table III-21). White perch composed 1.6 and 0.3% of the November and August collections, respectively. Christie (1970) reports greater commercial catches of white perch in the Bay of Quinte than in other Canadian waters of Lake Ontario.

Recent increases in the white perch population of the Bay of Quinte have not occurred in the Lake at large (Christie, 1973). The presence of white perch almost exclusively at NMPE (closest transect to the Bay of Quinte) suggests a possible seasonal expansion of that population.

White perch were only caught at 10 and 15 fathoms (60 and 90 ft.) in Mexico Bay during October of the Lake Ontario fish survey (Great Lakes Fish Lab., 1972 e). Smallmouth bass were collected at the 20 ft. contour of NMPE during August and at the same depth at NMPP during September (Table III-21). One smallmouth bass was caught at 10 fathoms (60 ft.) in Mexico Bay during August and September 1972 by the Great Lakes Fishery Laboratory (1972 d).

Several species were occasional contributors to bottom trawl collections. Lake chubs contributed less than 1% of the April catch at the 20 ft. contour of NMPE. Mottled sculpins were caught from April through August and were usually found along the 20 ft. contour. During August, the notable exception, this species was found at 40 and 60 ft. at NMPP. Johnny darters were collected during April, May, June, August and September at the 20 and 40 ft. contours and contributed from less than 1% to more than 33% of the various collections.

American eels made up one-third of the August collections along the 40 ft. contour at NMPE. One-half of the November catch at the NMPE 20 ft. contour was contributed by brown bullheads. Gizzard shad made up 5.4% and 24.4% of the October collections at NMPE (20 ft.) and NMPW (40 ft.), respectively and 40.0% of the NMPW (20 ft.) November collection.

Trout perch were taken from 20 and 40 ft. waters during April, May and June and from 40 and 60 ft. water afterwards. Wells (1968) caught more trout perch at 5 and 7 fathoms (30 and 42 ft., respectively) than at any other depths from May through August. The Great Lakes Fisheries Laboratory (1972 b-e) collected more trout perch from 10 fathoms (60 ft.) than from 5 fathoms (30 ft.) from June through October in Mexico Bay.

Alewives dominated the 1972 collections at NMPW and NMPP (QL&M, 1973). Rainbow smelt were collected each month except July at both transects and during October at NMPW (QL&M, 1973). Yellow perch were taken only at NMPW and white perch only at NMPP; smallmouth bass were not caught (QL&M, 1973). American eels were caught at NMPP during May, July and September at NMPP and during June at NMPW (QL&M, 1973). Johnny darters and mottled sculpins were collected during April, May or June at both transects and gizzard shad at NMPP in October (QL&M, 1973). These data were not differentiated by depth contour or by method (surface or bottom).

Trends in both surface and bottom trawl biomass per unit percentage composition (Table III-22 and III-23) were similar to those observed for catch per unit effort composition (Table III-20 and III-21). Biomass structure of collections numerically dominated by alewives were generally

TABLE III-22

MONTHLY BIOMASS (IN GRAMS) PER UNIT EFFORT AND PERCENT COMPOSITION OF SURFACE TRAWL COLLECTIONS IN THE NINE MILE POINT AREA.

	NMPE 20 Biomass	NMPE 20 %	NMPE 40 Biomass	NMPE 40 %	NMPE 60 Biomass	NMPE 60 %	NMPP 20 Biomass	NMPP 20 %	NMPP 40 Biomass	NMPP 40 %	NMPP 60 Biomass	NMPP 60 %	NMPW 20 Biomass	NMPW 20 %	NMPW 40 Biomass	NMPW 40 %	NMPW 60 Biomass	NMPW 60 %
MARCH																		
Alewife	ND		1017.33	98.83	12791.88	100.00	3708.02	97.91	785.53	98.00	107.93	68.76	745.70	95.89	47.53	100.00		
Rainbow Smelt	ND		12.07	1.17			77.87	2.06	16.07	2.00	49.03	31.24	27.50	3.54			No	
Spottail Shiner							1.40	0.04					1.47	0.19			fish	
Mottled Sculpin													3.00	0.39			caught	
Total			1029.40		12791.88		3787.29		801.60		156.96		777.67		47.53			
APRIL																		
Alewife	No		18.10	100.00	53.33	86.21	60.60	82.75	103.83	68.96	187.70	100.00	30.93	100.00	No fish		No fish	
Rainbow Smelt	fish				8.53	13.79	12.63	17.25	46.73	31.04					caught		caught	
	caught																	
Total			18.10		61.86		73.23		150.56		187.70		30.93					
MAY																		
Alewife	60.40	67.48	68.13	94.59	62.03	100.00	131.70	92.79	84.23	74.67	114.37	78.66	264.80	89.51	236.60	91.89	80.93	72.48
Rainbow Smelt	12.87	14.38	2.60	3.61			8.50	5.99	18.67	16.55	29.23	20.10			11.07	4.30	29.20	26.15
Emerald Shiner	1.27	1.42					1.73	1.22			1.80	1.24	5.33	1.80	9.80	3.81	1.53	1.37
Threespine Stickleback	14.97	16.72	1.30	1.80					9.90	8.78								
Spottail Shiner													11.33	3.83				
Gizzard Shad													14.37	4.86				
Total	89.51		72.03		62.03		141.93		112.80		145.40		295.83		257.47		111.66	

TABLE III-22 Cont'd

	NMPE 20 Biomass	%	NMPE 40 Biomass	%	NMPE 60 Biomass	%	NMPP 20 Biomass	%	NMPP 40 Biomass	%	NMPP 60 Biomass	%	NMPW 20 Biomass	%	NMPW 40 Biomass	%	NMPW 60 Biomass	%
JUNE																		
Alewife	4.27	100.00	13.57	100.00	17.15	56.88	3.53	100.00	No fish caught		No fish caught		No fish caught		5.69	100.00	No fish caught	
Rainbow Smelt					10.65	35.32												
Troutperch					2.35	7.79												
Total	4.27		13.57		30.15		3.53								5.69			
JULY																		
Alewife	No fish caught		No fish caught		7.00	100.00	No fish caught		ND		No fish caught		No fish caught		No fish caught		No fish caught	
Total					7.00													
AUGUST																		
Alewife	10.98	31.50	10.88	82.99	63.91	98.11	22.65	100.00	28.94	96.02	39.39	93.67	0.55	100.00	4.04	84.34	16.52	100.00
Emerald Shiner	2.31	6.63	2.16	16.48	1.23	1.89			1.20	3.98	2.66	6.33			0.75	15.66		
Rock Bass	21.57	61.88																
White Perch			0.07	0.53														
Troutperch																		
Total	34.86		13.11		65.14		22.65		30.14		42.05		0.55		4.79		16.52	
SEPTEMBER																		
Alewife	0.25	100.00	0.08	100.00	0.20	24.10	7.29	89.67	No fish caught		4.78	97.55	6.42	100.00			No fish caught	
Rainbow Smelt					0.10	12.05					0.12	2.45						
Spottail Shiner					0.53	63.86												
Gizzard Shad							0.84	10.33										
Emerald Shiner															1.12	100.00		
Total	0.25		0.08		0.83		8.13				4.90		6.42		1.12			

TABLE III-22 Cont'd

OCTOBER

	NMPE 20 Biomass	%	NMPE 40 Biomass	%	NMPE 60 Biomass	%	NMPP 20 Biomass	%	NMPP 40 Biomass	%	NMPP 60 Biomass	%	NMPW 20 Biomass	%	NMPW 40 Biomass	%	NMPW 60 Biomass	%
Alewife					9.37	75.32	47.57	86.10	97.65	89.40	0.43	100.00			10.48	100.00	6.53	100.00
Rainbow Smelt	2.72	88.60	3.23	100.00	3.07	24.68	3.30	5.97										
Emerald Shiner	0.35	11.40					4.38	7.93	2.93	2.68								
Gizzard Shad									8.65	7.92								
Rock Bass													21.75	100.00				
Total	3.07		3.23		12.44		55.25		109.23		0.43		21.75		10.48		6.53	

NOVEMBER

	NMPE 20 Biomass	%	NMPE 40 Biomass	%	NMPE 60 Biomass	%	NMPP 20 Biomass	%	NMPP 40 Biomass	%	NMPP 60 Biomass	%	NMPW 20 Biomass	%	NMPW 40 Biomass	%	NMPW 60 Biomass	%
Alewife					4.28	100.00	13.28	95.61	35.63	36.39							0.08	100.00
Rainbow Smelt	No		No				0.18	1.30	0.37	0.38	No		No		2.32	100.00		
Mottled Sculpin	fish		fish				0.43	3.10			fish		fish					
Gizzard Shad	caught		caught						61.92	63.24	caught		caught					
Total					4.28		13.89		97.92						2.32		0.08	

DECEMBER

	NMPE 20	NMPE 40	NMPE 60	NMPP 20	NMPP 40	NMPP 60	NMPW 20	NMPW 40	NMPW 60
Alewife	No	No	No	ND	ND	No	ND	No	No
Rainbow Smelt	fish	fish	fish			fish		fish	fish
White Bass	caught	caught	caught			caught		caught	caught
Total									

TABLE III-23

MONTHLY BIOMASS (IN GRAMS) PER UNIT EFFORT AND PERCENT COMPOSITION OF BOTTOM TRAWL COLLECTIONS IN THE NINE MILE POINT AREA. NO COLLECTIONS WERE MADE IN MARCH.

APRIL

	NMPE 20		NMPE 40		NMPE 60		NMPP 20		NMPP 40		NMPP 60		NMPW 20		NMPW 40		NMPW 60	
	Biomass	%	Biomass	%	Biomass	%	Biomass	%	Biomass	%	Biomass	%	Biomass	%	Biomass	%	Biomass	%
Alewife	391.90	17.43	934.27	100.00	58.73	100.00	78826.09	98.14	2251.05	99.30	1003.80	99.46			623.00	98.64	333.80	92.33
Rainbow Smelt	59.97	2.67					28.40	0.04	8.53	0.38	5.43	0.54			2.20	0.35	22.47	6.22
Yellow Perch	167.37	7.44					141.13	0.18					No					
White Sucker	1272.07	56.57					884.87	1.10					Trawls					
Spottail Shiner	215.30	9.57					75.93	0.09	7.40	0.33								
Lake Chub	0.77	0.03																
Mottled Sculpin	3.63	0.16					8.20	0.01							4.67	0.74	5.27	1.46
Troutperch	124.40	5.53					327.80	0.41										
White Perch	9.23	0.41					26.47	0.03										
Johnny Darter	4.07	0.18					1.00	0.001							1.73	0.27		
Total	2248.71		934.27		58.73		80319.89		2266.98		1009.23				631.60		361.54	

MAY

	NMPE 20		NMPE 40		NMPE 60		NMPP 20		NMPP 40		NMPP 60		NMPW 20		NMPW 40		NMPW 60	
	Biomass	%	Biomass	%	Biomass	%	Biomass	%	Biomass	%	Biomass	%	Biomass	%	Biomass	%	Biomass	%
Alewife	80.90	37.01	175.07	93.47	62.30	100.00	244.67	95.36	561.80	86.92	219.87	95.03	633.70	95.34	160.17	61.86	52.10	100.00
Rainbow Smelt	6.27	2.87	12.23	6.53			1.90	4.64	67.43	10.43	11.50	4.97	11.47	1.73	98.77	38.14		
Threespine Stickleback	2.40	1.10											0.97	0.15				
White Perch	109.20	49.95																
Spottail Shiner	12.73	5.82							17.13	2.65			11.17	1.68				
Troutperch	7.10	3.25																
Johnny Darter													3.77	0.57				
Mottled Sculpin													3.57	0.54				
Total	218.60		187.30		62.30		256.57		646.36		231.37		664.65		258.94		52.10	

TABLE III-23 Cont'd

	NMPE 20		NMPE 40		NMPE 60		NMPP 20		NMPP 40		NMPP 60		NMPW 20		NMPW 40		NMPW 60	
	Biomass	%	Biomass	%	Biomass	%	Biomass	%	Biomass	%	Biomass	%	Biomass	%	Biomass	%	Biomass	%
JUNE																		
Alewife	226.43	23.15	291.77	94.54	33.10	95.54	2537.44	96.03	105.69	77.99	8.00	67.91	196.58	91.95	37.76	74.07	23.93	100.00
Rainbow Smelt	4.13	0.42	15.42	5.00	1.45	4.20	90.73	3.43	29.60	21.84	3.78	32.09	8.69	4.06	12.62	24.75		
Troutperch	46.50	4.75	0.30	0.10									2.00	0.94				
Johnny Darter	14.07	1.44	0.60	0.19			2.78	0.11	0.22	0.16			1.96	0.92	0.60	1.18		
Mottled Sculpin	12.33	1.26	0.52	0.17			9.44	0.36					4.56	2.13				
Spottail Shiner	48.07	4.91					1.96	0.07										
White Sucker	544.83	55.70																
Yellow Perch	50.00	5.11																
Rock Bass	31.80	3.25																
Total	978.16		308.61		34.55		2642.35		135.51		11.78		21379		50.98		23.93	
JULY																		
Alewife	6.36	96.36	ND		22.71	64.96	6.00	4.02	164.83	94.35	289.50	98.71	9.20	1.78	No		27.57	100.00
Rainbow Smelt			ND		4.47	12.79			9.87	5.65	3.77	1.29			fish			
Mottled Sculpin	0.24	3.64																
Troutperch					7.78	22.25												
American Eel							143.13	95.98					506.67	98.22				
Total	6.60				34.96		149.13		174.70		293.27		515.87				27.57	

TABLE III-23 Cont'd

AUGUST

	NMPE 20 Biomass	%	NMPE 40 Biomass	%	NMPE 60 Biomass	%	NMPP 20 Biomass	%	NMPP 40 Biomass	%	NMPP 60 Biomass	%	NMPW 20 Biomass	%	NMPW 40 Biomass	%	NMPW 60 Biomass	%
Alewife	33.23	-	3.34	2.16	ND		ND		ND	-	ND		ND	-	ND	-	52.29	-
Rainbow Smelt	ND	-			ND				ND	-	ND				ND	-		
Mottled Sculpin									0.52	-	ND						ND	-
Troutperch									0.03	-	ND							
Johnny Darter			0.24	0.16					0.02	-								
White Perch	11.69	-																
Smallmouth Bass	ND	-																
Rock Bass							ND						21.72	-				
Threespine Stickleback															0.49	-		
American Eel			151.20	97.69														
Total	-		154.78						-				-				-	

SEPTEMBER

	NMPE 20 Biomass	%	NMPE 40 Biomass	%	NMPE 60 Biomass	%	NMPP 20 Biomass	%	NMPP 40 Biomass	%	NMPP 60 Biomass	%	NMPW 20 Biomass	%	NMPW 40 Biomass	%	NMPW 60 Biomass	%
Alewife	84.92	22.86	4.63	29.10	5.98	66.44	31.25	7.62	11.53	20.25	5.00	100.00	4.89	100.00	93.04	66.39	0.30	3.87
Rainbow Smelt					0.45	5.00			0.08	0.14					28.62	20.42		
White Perch	216.02	58.16	1.23	7.73	2.57	28.56											7.45	96.13
Spottail Shiner	11.37	3.06													6.87	4.90		
Yellow Perch							32.07	7.82	45.33	79.61								
Troutperch			10.05	63.17											10.82	7.72		
Smallmouth Bass							346.98	84.57										
White Sucker	59.10	15.91																
Johnny Darter															0.80	0.57		
Total	371.41		15.91		9.00		410.30		56.94		5.00		4.89		140.15		7.75	

TABLE III-23 Cont'd

OCTOBER

	NMPE 20 Biomass	%	NMPE 40 Biomass	%	NMPE 60 Biomass	%	NMPP 20 Biomass	%	NMPP 40 Biomass	%	NMPP 60 Biomass	%	NMPW 20 Biomass	%	NMPW 40 Biomass	%	NMPW 60 Biomass	%
Alewife	22.95	-	ND		ND		ND	-	ND		56.25	-	ND		16.18	94.29	ND	
Rainbow Smelt	ND	-	ND		ND				ND		ND	-	ND					
Gizzard Shad							14.13	-							0.98	5.71		
Emerald Shiner							7.0	-										
Spottail Shiner									ND									
Troutperch									ND									
Total	-						-				-				17.16			

NOVEMBER

	NMPE 20 Biomass	%	NMPE 40 Biomass	%	NMPE 60 Biomass	%	NMPP 20 Biomass	%	NMPP 40 Biomass	%	NMPP 60 Biomass	%	NMPW 20 Biomass	%	NMPW 40 Biomass	%	NMPW 60 Biomass	%
Alewife	5.08	21.90	21.73	94.48	31.62	51.73	333.20	99.81	104.00	97.70	46.02	95.44	41.05	68.34	32.32	95.23	18.82	94.38
Rainbow Smelt			1.27	5.52	13.33	21.81	0.65	0.19	2.12	1.99	2.20	4.56	4.10	6.83	1.62	4.77	1.12	5.62
Brown Bullhead	18.12	78.10																
Troutperch					0.95	1.55												
White Bass					3.12	5.10												
White Perch					0.57	0.93												
Spottail Shiner					11.53	18.86												
Emerald Shiner									0.33	0.31								
Gizzard Shad													14.92	24.84				
Total	23.20		23.00		61.12		333.85		106.45		48.22		60.07		33.94		19.94	

DECEMBER

	NMPE 20	NMPE 40	NMPE 60	NMPP 20	NMPP 40	NMPP 60	NMPW 20	NMPW 40	NMPW 60
Alewife	No fish caught	No fish caught	No fish caught	No fish caught	No fish caught	ND	No fish caught	No fish caught	ND
Spottail Shiner									
Total									

dominated by alewife biomass. Differences between the percentage contribution of one species to the numerical structure and to the biomass structure occurred when a few large or many small individuals were present. For instance, at the 20 ft. contour of NMPE during April, rainbow smelt formed 27.3% of the bottom trawl catch and 2.7% of the biomass. At the same time, white suckers contributed 2.0% of the catch and 56.6% of the biomass. The rainbow smelt in that collection were mostly small individuals, while the white suckers were considerably larger. Fifty-four rainbow smelt ranging in weight from 0.4 to 3.1g and four white suckers (weight range: 453.1-1399.9g) were caught in the collection.

Species which were caught infrequently usually contributed less to the biomass structure than to the numerical structure. Lake chubs made up to 0.[illegible]% of the fishes caught by bottom trawl at 20 ft. at NMPE during April and 0.03% of the biomass. At the same depth and transect during May the three-spine stickleback contributed 13.0% of the numbers and 1.1% of the biomass. October catches of gizzard shad along the 40 ft. contour made up 25.4 and 5.7% of the catch and biomass, respectively. During November at the 20 ft. contour of the same transect, gizzard shad contributed 40.0% of the abundance and 24.8% of the biomass.

Because of the limited influence of transitory species on biomass structure, the impact of these species on energy flow through the more persistent fish communities may be minimal. Since the transitory species stay in the area for such a short time, alterations or interruptions of energy flow

patterns may be rapidly reestablished after the departure of the transients.

The components of community structure, diversity, evenness, and richness, may be defined by single numerical values which describe the relationships between individuals and species within the community (Dahlberg and Odum, 1970). Temporal or spatial fluctuations in the values of these components provide quantitative information about variations in community structure. Qualitative changes such as the replacement of one species by another must be evaluated from species lists or percentage composition data.

Community structure components were calculated for day and night, surface and bottom trawls at each depth contour of each transect (Appendix V-C). When no fishes were caught, diversity (H) was zero, evenness (J) was 1.000 and species richness (d) was undefined. Since values presented in Appendix V-C were calculated from the collection data and since values could not be determined for collections which produced no fishes, numerous gaps appear. The following discussion of trends in community structure is based on Appendix V-C which includes collections during which no fish were caught.

Higher diversity values were generally recorded for bottom collections than for surface collections. Day and night surface trawl diversity usually ranged between 0.000 and 1.000. Of the three surface collections which exceeded 1.000 all were night trawls. These exceptions occurred at the 60 ft. depth of NMPW on 28 March, at 40 ft. at NMPP on 13 November, and at 20

ft. at NMPE on 30 May. Trends in surface trawl evenness and species richness patterns were generally masked by the gaps in the data.

The most complete series of surface trawl data were recorded for night collections at the 20 ft. contour at NMPP and at the 60 ft. contour of NMPE. At the 20 ft. contour of NMPP diversity was relatively high during April, May, late September, and early October. Diversity was generally low from June to early September and again during late October and early November. Individuals tended to be evenly divided among the species from August through December. Species richness increased from March through June and reached peak values on 2 October and 27 November. Between those dates species richness decreased substantially.

At the 60 ft. contour of NMPE night surface trawl diversity was high on 25 April, 13 June, 10 and 20 September, and 18 October. September and October diversity values were the most consistently high values for the year although a collection yielding no fishes was conducted on 2 October. Individuals were generally evenly divided among the species at all times. The number of species in each collection ranged from one to five. Species richness values were generally zero with only one collection (20 September) exceeding one and a few falling between zero and one.

Bottom trawls indicated that community structure was different at night than during the day. Most values for the three components of community structure were greater for night collections. At NMPW and NMPE diversity for night

collections generally decreased with increasing depth, while at NMPP diversity values were similar at all depths. Minimum diversity was consistently observed at 60 ft. at NMPW. Greatest diversity was observed at the 20 ft. depth of NMPE on 25 April, 30 May, 25 June, and 20 September and at the 20 ft. contour of NMPP on 25 June. Maximum day bottom trawl diversity was recorded on 25 June.

Species richness of night bottom trawl collections generally followed similar fluctuation patterns as were observed for diversity. Greatest values were recorded from the 20 ft. contour of NMPE; slightly lower values were recorded from the 20 ft. contours of NMPP and NMPW. Individuals were nearly evenly distributed among the species at the 60 ft. contours of NMPW and NMPE and 20 ft. at NMPE. Evenness was highly variable for the other collections, ranging from uniform division among the species to collections where one species contributed most individuals although several were present.

Trends in the temporal fluctuations in community structure were not readily evident at NMPW and NMPP. At NMPE the 20 and 40 ft. depths exhibited high diversity, evenness and species richness values in the night collections on 25 June. Diversity values at all three depths of that transect increased from late October into November. This trend was also apparent at 60 ft. at NMPP and at 20 ft. at NMPW. Highest diversity and species richness values were observed at the 60 ft. contour of NMPP on 27 August.

3. <u>GILL NETS</u>

a. Abundance and Distribution

The distribution and abundance of fishes in the vicinity of the Nine Mile Point Nuclear Power Station may be compared at the NMPW, NMPP, FITZ, and NMPE transects based upon total gill net (surface and bottom) catch per unit effort from June through December 1973. The total gill net catch during 1973 was contributed by 33 species of fishes (Table III-2) with the largest contribution of catch per unit effort attributed to bottom gill net collections. The total gill net catch per unit effort (calculated 12-hour catch) is illustrated in Figures III-32 through III-35. Surface gill net collections were not made at the 15 ft. depth contour for all transects. Catch per unit effort was not calculated for NMPW and NMPE for November 1973 due to insufficient data base.

At the NMPE 15 ft. station, maximum catch per unit effort for bottom gill nets occurred during July, with the second yearly increase observed in September. Alewives and white perch provided 79% of the total catch per unit effort in bottom gill nets during September. Similar increases during July and September were noted at the NMPE 30 and 40 ft. stations. At both depths, the yearly pattern showed an increase in catch per unit effort from June through July, a decrease in August, a second yearly increase in September, and a decrease from October through December. At the NMPE 30 ft. station, surface gill net values were similarly high

TOTAL CATCH PER UNIT EFFORT FOR SURFACE AND BOTTOM GILL NET COLLECTIONS
AT NINE MILE POINT EAST TRANSECT
ACCORDING TO DEPTH AND MONTH

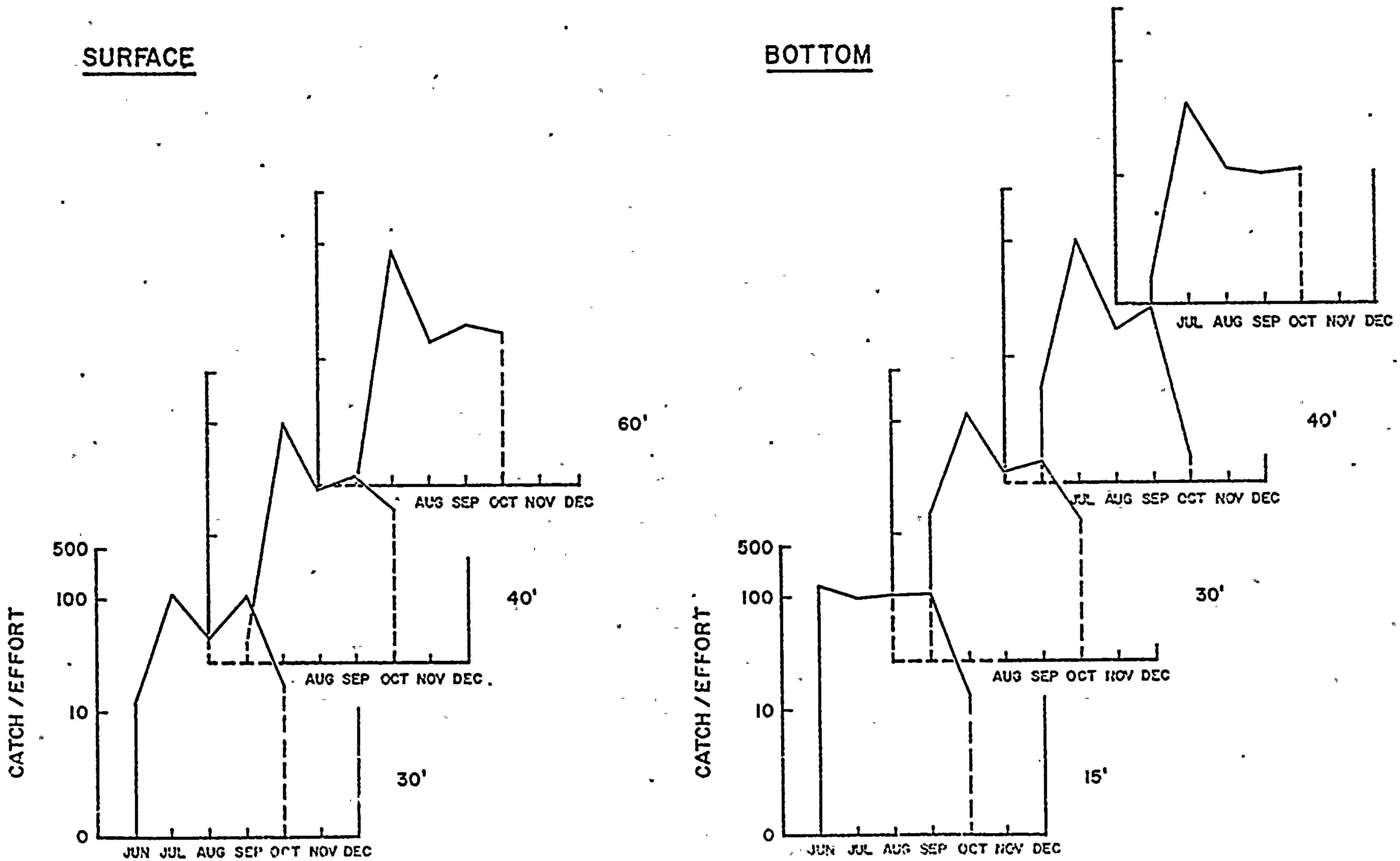


FIGURE III-32

TOTAL CATCH PER UNIT EFFORT FOR SURFACE AND BOTTOM GILL NET COLLECTIONS
AT NINE MILE POINT WEST TRANSECT
ACCORDING TO DEPTH AND MONTH

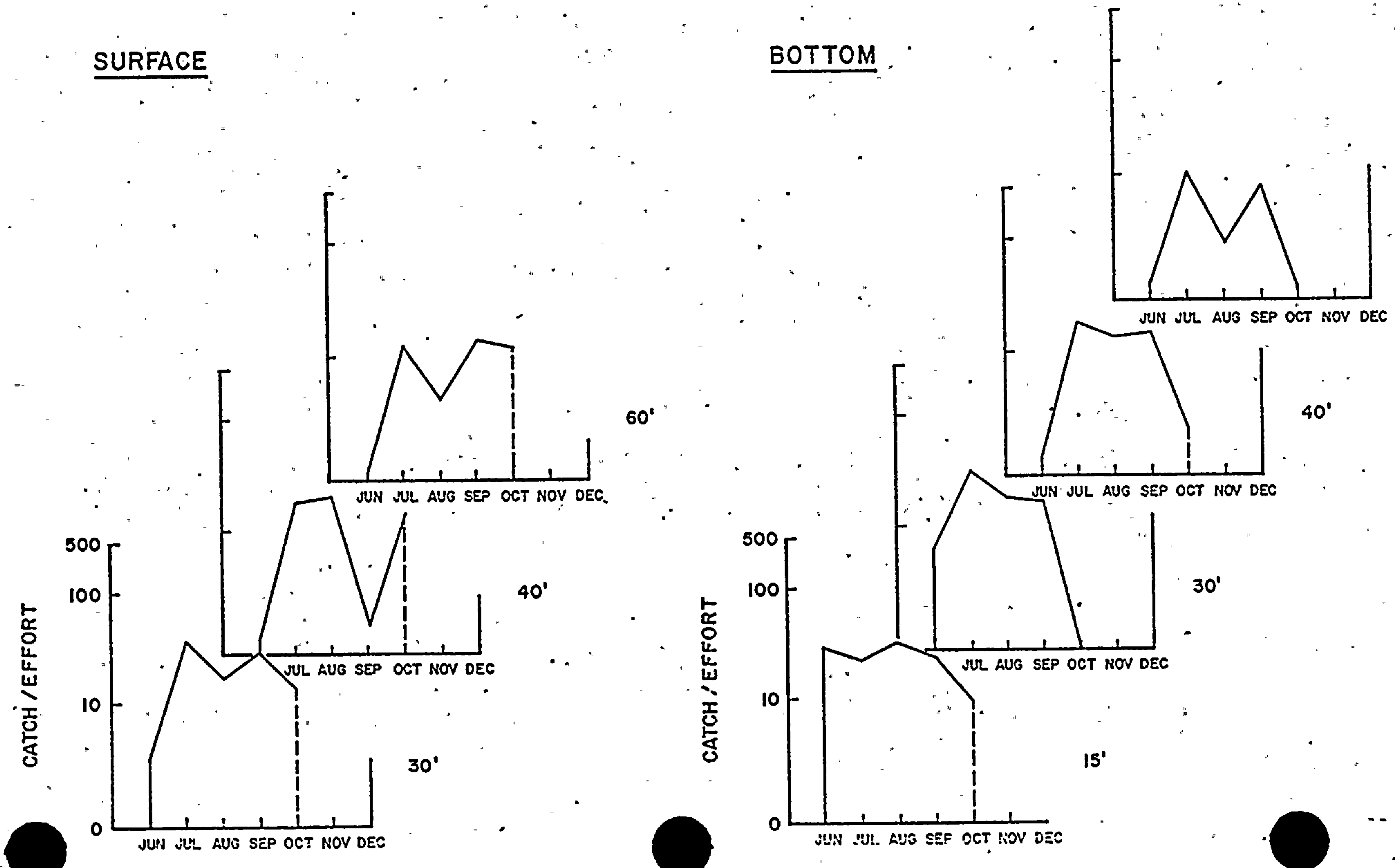


FIGURE III-33

TOTAL CATCH PER UNIT EFFORT FOR SURFACE AND BOTTOM GILL NET COLLECTIONS AT NINE MILE POINT PLANT TRANSECT ACCORDING TO DEPTH AND MONTH

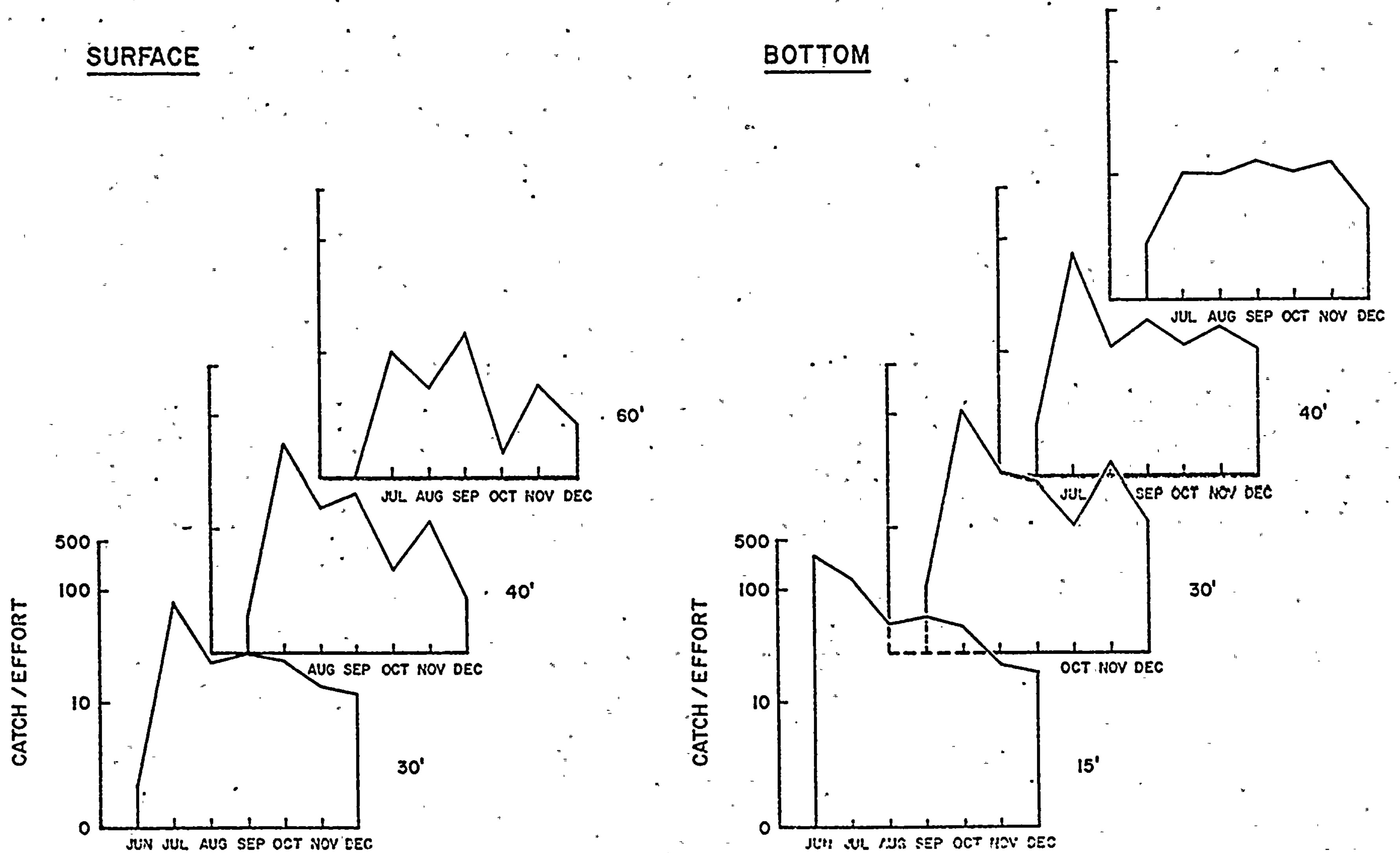


FIGURE III-34

TOTAL CATCH PER UNIT EFFORT FOR SURFACE AND BOTTOM GILL NET COLLECTIONS
AT FITZPATRICK TRANSECT
ACCORDING TO DEPTH AND MONTH

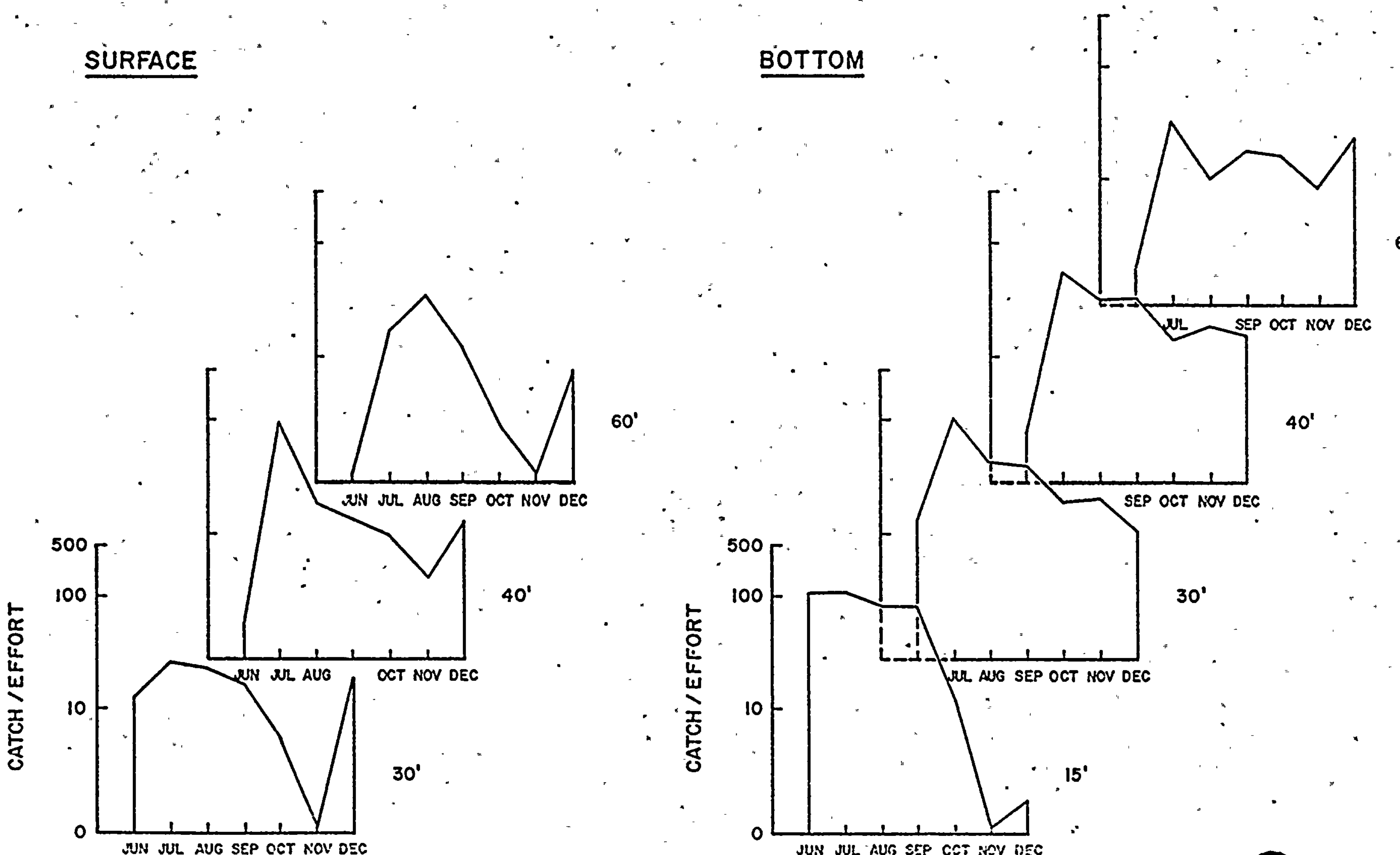


FIGURE III-35

during July (133.56) and September (110.34). At the NMPE 30 ft. station, maximum catch per unit effort values were calculated during July for surface (133.56) and bottom (163.32) gill net collections. At the NMPE 60 ft. station, surface gill nets showed high values during July (93.96) and September (35.37); high bottom values were observed during July (67.56) with small increases during October (16.36) and again during December (12.17).

At the NMPE transect, catch per unit effort was generally greater in bottom gill net collections. The yearly trend showed an increase from June to July followed by a general decrease through December and preceded by occasional increases during the fall. Catch per unit effort at the NMPW 15 ft. station for surface and bottom gill nets displayed similar monthly trends (Figure III-33). At NMPW 15 ft. station June and August increases were observed although the catch per unit effort (59.41) was less than the NMPE 15 ft. station (124.03). A smaller increase in catch per unit effort was noted during December (15.96). At the NMPW 30 and 60 ft. depth contours, monthly peak values in catch per unit effort were calculated during July and September. In July, higher yearly values were determined at the 30 ft. station for surface and bottom catches (62.76 and 55.92, respectively) compared to the 60 ft. station. At the NMPW 40 ft. station, high values in surface catch per unit effort were recorded during August (37.51) and October (23.35). In addition, the catch per unit effort for bottom gill nets showed July and September yearly peaks. December catch

per unit effort for the 30, 40, and 60 ft. contours were higher for the bottom than surface gill net collections. In addition, the December bottom catch per unit effort determination at NMPW 60 ft. contour (17.88) was higher than the July and September peaks (12.6 and 9.35, respectively).

At the NMPW transect, alewives, spottail shiner, and yellow perch were the most abundant species collected in the July surface and bottom gill net (see Appendix V-D). In September, alewives and rainbow smelt provided the greatest numbers of fish collected per unit effort from surface and bottom gill nets.

At NMPP (Figure III-34) and FITZ (Figure III-35) transects similar yearly maxima in catch per unit effort occurred during July with smaller secondary increases recorded later in the year. However, at the 15 ft. station at NMPP and FITZ transects, peak catches per unit effort occurred during June and decreased through July and August with a small, secondary increase in fish caught during September. During December, the bottom value at the FITZ 15 ft. station (2.88) was much reduced compared to NMPP (35.76) bottom value.

At the NMPP and FITZ transects, three yearly increases in catch per unit effort were observed for the 30 and 40 ft. contours in the bottom gill net collections. The yearly maxima for both transects occurred during July with two secondary peaks during September and November. At the FITZ transect, surface catch per unit effort values showed two yearly peaks at

the 30 and 40 ft. stations, with a maximum during July and a secondary increase during December. Surface values at NMPP 30 and 40 ft. stations, showed an increase in fish caught during September. The September peak was intermediate to the July and November increases at the 40 ft. station. Both FITZ and NMPP transects were similar with regard to trends in catch per unit effort variation with depth. A July maximum was evident at most depths for surface and bottom collections. Both transects reflected a general decrease in catch per unit effort following the yearly July maximum. Two secondary increases in catch per unit effort occurred, usually during September and either November or December.

At the FITZ 60 ft. station surface and bottom differences in catch per unit effort were indicated. Surface catch per unit effort was greatest during August (57.89), decreased through September and October to a low during November (0.48), and increased during December (8.64). Bottom values at the FITZ 60 ft. station showed three yearly increases, one during July (56.04), a small increase during September (32.00) and an increase during December (42.48). At the NMPP 60 ft. station, three yearly increases in surface catch per unit effort occurred, a maximum during September (28.08), a second increase during July (11.04) and an increase during November (7.44). Bottom collections at the NMPP 60 ft. station reflected three yearly increases during July (10.92), September (20.64), and November (20.16).

During July and September at the NMPP transect, alewives, and to a lesser degree yellow perch, represented the major portion of the catch per unit effort for surface and bottom trawls. Throughout July and September at the FITZ transect, alewives, spottail shiner, and yellow perch provided the most fish caught per unit effort by surface and bottom gill nets.

In summary, greater numbers of fish were caught per unit effort during July for surface and bottom gill net collections at all transects. Bottom gill net collections were generally greater than surface in regard to catch per unit effort throughout 1973.

Surface and bottom catch per unit effort values at NMPE were generally greater than NMPW, NMPP, and FITZ transects. In surface gill net collections, alewives, white perch, rainbow smelt, and yellow perch provided the greatest numbers of fish collected during 1973. In bottom gill net collections, alewives, white perch, yellow perch, and spottail shiner contributed the major portion of the total catch per unit effort in 1973.

Surface gill net catch per unit effort data were tested for differences between transects, depth contours, and collection date(s) by three-way analysis of variance. Selected dates were used to provide a representative data base which was sufficient to carry out the test procedures. Consequently, data from the following collection periods were used for the analysis:

18 July - 20	22 August - 24	2 December - 8
3 July - 6 and 4 - 7	20 September	

Significant differences were found between depths and collection dates (Table III-24); catches did not differ significantly between transects. Surface collections along the 30 and 40 ft. contours were similar and both were greater than collections at the 60 ft. contour. Collections from the July sampling period yielded more fishes per unit effort (Table III-24) than any of the other sampling dates tested. The August and September collections were similar and together ranked second for the greatest number of fishes caught. Of the five sampling periods, fewest fishes caught per unit effort were from 18-20 June.

Bottom gill net catch per unit effort was tested by three-way analysis of variance in the same three factors: transect, depth contour, and collection date. Collection dates used for testing the bottom gill net data were 4 and 18 June, 18 July, 8 and 22 August, 25 September, and 2-8 December. These dates were chosen to provide an adequate data base on which to make comparisons.

Fewer fishes were caught at NMPW than at the other transects (Table III-25). Fish catches at NMPP, NMPE, and FITZ were similar on each of the seven sampling dates. Collection at the 30 ft. contour produced the greatest number of fishes and those at the 60 ft. depth the fewest. This was similar to the depth distribution trend observed for surface gill nets. In each instance, fewest fishes were caught at the 60 ft. contour and the greatest numbers were caught at the 30 ft. contour. Catches along the 40 ft. contour were similar to those at the 30 ft. contour for surface gill nets.

TABLE III-24.

A. Three-way analysis of variance of surface gill net catch per unit effort. Data transformed to $\log_{10}$ data plus one.

Source	d.f.	S.S.	M.S.	F-ratio*
Depth contour	2	1.389	0.694	8.785**
Transect	3	0.483	0.161	2.038
Date	4	15.116	3.780	47.848**
Depth contour x transect	6	0.362	0.060	0.811
Depth contour x date	8	0.350	0.045	0.570
Transect x date	12	1.798	0.150	1.899
Depth contour x transect x date	24	1.888	0.079	
TOTAL	59	21.396		

*Critical F values are: $F_{2,24}(0.05) = 3.40$; $F_{4,24}(0.05) = 2.78$
**Significant difference at α 0.05

B. Student-Newman-Kuels procedure for determining sources of first order effect significance. Groups underscored by a single line are not significantly different at $p<0.05$.

Rank	1	2	3
Mean $\log_{10}$ (data +1)	1.011	1.213	1.383
Depth contour	60 ft.	40 ft.	30 ft.

Rank	1	2	3	4	5
Mean $\log_{10}$ (data +1)	0.298	1.089	1.378	1.476	1.771
Date	June 18-20	Dec. 2-8	Aug. 22-24	Sept. 20	July 3-6 & 4-7

TABLE III-25

A. Three-way analysis of variance of bottom gill net catch per unit effort. Data transformed to $\log_{10}$ data plus one.

Source	d.f.	S.S.	M.S.	F-ratio*
Depth contour	2	3.236	1.618*	23.114**
Transect	3	1.427	0.476*	6.800**
Date	6	11.845	1.974*	28.200**
Depth contour x transect	6	0.274	0.046	0.657
Depth contour x date	12	1.644	0.137	1.957
Transect x date	18	1.313	0.073	1.043
Depth contour x transect x date	36	2.524	0.070	
TOTAL	83	22.263		

*Critical F values are: $F_{2,36}(0.05) = 5.25$ (3.26); $F_{3,36}(0.01) = 4.38$; $F_{6,36}(0.01) = 3.35$

**Significant difference at α 0.05

B. Student-Newman-Kuels procedure for determing sources of first order effect significance. Groups underscored by a single line are not significantly different at $p<0.05$.

Rank	1	2	3	4
Mean $\log_{10}$ (data +1)	1.030	1.211	1.289	1.385
Transect	NMPW	NMPP	NMPE	FITZ

Rank	1	2	3
Mean $\log_{10}$ (data +1)	0.990	1.226	1.470
Depth contour	60 ft.	40 ft.	30 ft.

Rank	1	2	3	4	5	6	7
Mean $\log_{10}$ (data +1)	0.443	1.017	1.247	1.250	1.465	1.526	1.653
Date	June 18	June 4	Dec.2-8	Aug. 22	Aug. 8	Sept. 25	July 18

Fewer fishes were caught on 18 June (Table III-25) compared to the other collection dates. Collections on 18 July, 8 August, and 25 September were similar and were the greatest of the collection dates. 22 August and 2-8 December collections were nearly identical and could be considered similar to the 8 August collection.

Dates used in the surface and bottom gill net analysis were seldom identical, but were generally comparable. Both surface and bottom gill net collections were greatest in July and lowest in June. June collections were lower than December collections for both methods. When ranked in decreasing order, July catches were greater, September catches second, and August catches third, for both surface and bottom gill nets.

Surface and bottom gill net catch per unit effort for selected dates were tested for differences in catch at each depth contour. Paired t and Wilcoxon signed rank tests were used to test the data. Surface and bottom catches from all transects were pooled for each depth contour. Selected dates and pooled transect data were used to provide a broader data base on which to base the comparisons. On 12 October more fishes were caught per unit effort by bottom gill nets at the 60 ft. contour than by surface gill nets at the same contour on that date (Table III-26). Differences between surface and bottom catches did not differ significantly on any of the other dates tested.

TABLE III-26

Comparison of surface and bottom gill net catch per unit effort at the 30, 40, and 60 ft. depth contour. Data from all transects combined. Tested by paired t-test and Wilcoxon signed rank procedures.

Paired t
30 feet

Date	d.f.	t-value	Probability
June 4	3	-1.380	$0.200 \le p \le 0.400$
June 18	3	-1.145	$0.200 \le p \le 0.400$
July 4	3	-1.701	$0.100 \le p \le 0.200$
July 18	3	-1.177	$0.200 \le p \le 0.400$
August 8	3	-2.237	$0.100 \le p \le 0.200$
August 22	3	0.000	$p > 0.500$
September 25	3	0.198	$p > 0.500$
October 12	1	-0.964	$p > 0.500$
November 26	1	-1.812	$0.200 \le p \le 0.400$
December 2	3	-0.013	$p > 0.500$

40 feet

Date	d.f.	t-value	Probability
June 4	3	-2.960	$0.050 \le p \le 0.100$
June 18	3	0.518	$p > 0.500$
July 4	3	-0.176	$p > 0.500$
July 18	2	-0.194	$p > 0.500$
August 8	3	0.003	$p > 0.500$
August 22	3	0.138	$p > 0.500$
September 25	3	-1.311	$0.200 \le p \le 0.400$
October 12	2	-0.066	$p > 0.500$
October 31	1	-1.836	$0.200 \le p \le 0.400$
November 26	1	-2.354	$0.200 \le p \le 0.400$
December 2	3	-0.133	$p > 0.500$

60 feet

Date	d.f.	t-value	Probability
June 4	2	-2.215	$0.100 \le p \le 0.200$
July 4	2	1.001	$0.400 \le p \le 0.500$
July 18	3	1.476	$0.200 \le p \le 0.400$
August 8	2	1.823	$0.200 \le p \le 0.400$
August 22	3	1.298	$0.200 \le p \le 0.400$
September 25	3	0.761	$p > 0.500$
October 12	1	-21.876*	$0.025 \le p \le 0.050$
November 26	1	-2.799	$0.200 \le p \le 0.400$
December 2	3	-1.634	$0.200 \le p \le 0.400$

*Significant at the probability level of $\alpha = 0.05$

TABLE III-26 (continued)

Wilcoxon Signed Rank

30 feet

Date	n	T+	T-	T_S	Critical Range	χ
October 31	4	8	2	2	$0 \leq T_S \leq 10$	0.124

60 feet

Date	n	T+	T-	T_S	Critical Range	χ
June 18	4	0	10	0	$0 \leq T_S \leq 10$	0.124
October 31	2	0	3	0	$0 \leq T_S \leq 3$	0.500

Surface and bottom gill net catch per unit effort was compared at each depth of each transect over the entire sampling period. Comparisons were made by paired t tests. Bottom gill net catches were significantly larger at the 60 ft. contour of NMPP and at the 40 ft. contour of FITZ than surface catches at those locations (Table III-27). Significant differences were not observed between surface and bottom gill net collections at any other location.

b. Community Structure

During 1973, bottom gill net collections were made on a monthly basis at 15, 30, 40, and 60 ft. contours. In addition, surface gill nets were set at 30, 40, and 60 ft. contours at all transects (see Appendix V-E).

Diversity (H) based upon abundance was calculated for each transect at 15, 30, 40, and 60 ft. depths (see Materials and Methods). Additionally, diversity components evenness (J), and species richness (d) were also calculated at all transects (see Materials and Methods). Diversity was calculated for surface and bottom samples at all transects with the exception of the 15 ft. contour at NMPP, FITZ, and NMPE. Bottom values were not calculated at transect NMPE 15 ft. November values for NMPW and NMPE were not calculated since no fish were caught during those sampling periods (see Appendix V-E).

TABLE III-27

Comparison of surface and bottom gill net catch per unit effort at the 30, 40, and 60 ft. depth contours of each transect. Data pooled for selected collection dates. Tested by paired-t.

30 feet

Transect	d.f.	t-value	Probability
NMPW	8	0.768	$0.400 \leq p \leq 0.500$
NMPP	10	0.094	$p > 0.500$
FITZ	10	-2.188	$0.050 \leq p \leq 0.100$
NMPE	8	-0.523	$p > 0.500$

40 feet

Transect	d.f.	t-value	Probability
NMPW	8	0.452	$p > 0.500$
NMPP	10	-0.681	$p > 0.500$
FITZ	9	-5.386*	$p > 0.001$
NMPE	7	0.649	$p > 0.500$

60 feet

Transect	d.f.	t-value	Probability
NMPW	6	1.055	$0.200 \leq p \leq 0.400$
NMPP	9	-3.090*	$0.010 \leq p \leq 0.025$
FITZ	10	-0.668	$p > 0.500$
NMPE	6	-0.266	$p > 0.500$

*Significant at the probability level of α 0.05

c. Surface Gill Net Diversity

Gill net diversity values may be compared according to transect for surface collections at the various depth contours. At NMPW, two monthly increases were observed, one during June and another during August at the 15 ft. station (Appendix V-E). The highest diversity was recorded in the August collection (1.90); the lowest diversity value was recorded during October (0.05) at the 15 ft. station. Diversity values at NMPW 30 ft. contour reflected two similar increases during the months of June and August. Surface diversity values calculated for the NMPW 40 ft. depth show a shift to high July and September values. At the NMPW 60 ft. station, diversity values were uniformly low (0.30) from July through September.

Surface diversity values were more variable at NMPE transect with regard to depth contour (Appendix V-E). At the NMPE 20 ft. station, monthly increases were observed during June and September, with a maximum (H) value of 1.00 in September. The lowest diversity value was calculated at NMPW 20 ft. during the October collection. A similar, monthly shift in maximum surface diversity was observed at NMPE 40 ft. station with high values calculated during August and October. The yearly maximum diversity value was indicated at NMPE 40 ft. during December. Highest diversity was calculated during July and October. The maximum diversity for surface gill net collections occurred at NMPE 60 ft. (2.00) during the July collections and represented the highest diversity for the NMPE transect. Diversity was not calculated for the month of June at NMPE transect due to the lack of a sufficient data base.

Surface diversity values were generally higher at NMPP and FITZ (Appendix V-E) than at NMPE and NMPW transects.

At FITZ 30 ft. depth, highest yearly diversity was recorded during September and December, with the maximum surface diversity (1.66) indicated at the FITZ 30 ft. station. The lowest surface diversity recorded for the 30 ft. station at NMPP (0.00) and FITZ (0.00) occurred during November. Surface gill net diversity at NMPP and FITZ 40 ft. stations were quite similar according to the number of yearly increases (during July, September, and November) and range of values, with relatively large fluctuations in diversity observed at NMPP.

Surface gill net diversity calculated for NMPP and FITZ 60 ft. stations showed a monthly high during September. At NMPP, two yearly diversity increases were observed at the 60 ft. station, a high diversity during September and low diversity during November. Surface diversity values were not calculated during June at NMPP 60 ft. At FITZ 60 ft. depth, three relatively small increases in surface diversity were observed during the months of July, September, and December. These diversity increases resemble FITZ 40 ft. station both in number of yearly increases and range of diversity values.

d. Bottom Gill Net Diversity

Gill net abundance diversity may be compared among transects for bottom collections according to depth and month. At NMPE, maximum diversity was

recorded at all depths during July. During July, maximum species diversity (1.55) was indicated at the 15 ft. contour for NMPE. Bottom diversity at NMPE-15 ft. station was higher throughout 1973 compared to diversity calculations at the 20, 40, and 60 ft. contours. In addition, this observation is supported by consistently higher species richness (d) values at the 15 ft. station compared to the 20, 40, and 60 ft. depths. At all depths at NMPE, the lowest diversity values were recorded during December. Diversity calculations were not made during November 1973, since bottom gill net collections were not made during this period. In addition, bottom diversity calculations were not determined at NMPE 60 ft. during October 1973. The largest yearly fluctuations in bottom diversity were noted at NMPE 60 ft.

At the NMPP transect maximum bottom diversity values were recorded during August and September for the 15 ft. depth. At the NMPP 30 ft. station maximum diversity was indicated during September and October. Bottom gill net diversity values were highest during September and November at NMPP 40 and 60 ft. stations. At the NMPP 60 ft. station, bottom diversity values were also high during September (1.47) and November (1.42).

During September and November at the FITZ transect, yearly high diversity values were indicated at the 30 and 40 ft. stations. During September, the highest bottom gill net diversity was indicated at the FITZ transect. At the FITZ 15 ft. station, high yearly diversity was noted during July and September. Similarly, at the FITZ 60 ft. station, maximum bottom diversity was noted during September and December. Low diversity at the FITZ 60 ft.

station was recorded during June. Based upon depth and transect, the highest yearly diversity was recorded at the FITZ transect.

At the NMPW transect, bottom gill net diversity was not calculated at the 15 ft. station, at the NMPW 30 ft. station during October and November and at NMPW 40 and 60 ft. stations during November. At the NMPW 30 ft. station, maximum diversity was noted during July for bottom gill net collections (Figure III-36). At the NMPW 40 ft. station, maximum diversity was recorded during July and September with low diversity indicated during June.

Diversity values, based on abundance, showed variations with depth, transect and month for surface and bottom. Diversity ranged from a low of 0.00 (NMPE 20 ft.) to a high of 2.30 (FITZ 30 ft.). At all transects, bottom diversity was generally higher than at the surface. Correspondingly, species richness (d) generally increased with increase in diversity indicating that the observed increase in diversity was not due only to a more even distribution of numbers among species. Species richness (d) varied from 0.30 (NMPE 60 ft.) to 1.70 (FITZ 40 ft.). Species evenness (J) generally decreased with increasing diversity values (H) [see Appendix V-E).

Generally higher surface diversity was indicated at NMPP and FITZ transects throughout 1973 than at NMPE and NMPW transects. Monthly variations between these two transects indicates that these two locations are quite similar with regard to gill net diversity.

Species diversity was generally higher for bottom gill net collections for all transects during 1973. Compared to surface collections, bottom gill

LENGTH-FREQUENCY
FROM JUNE THROUGH SEPTEMBER
OF LAKE CATCHES

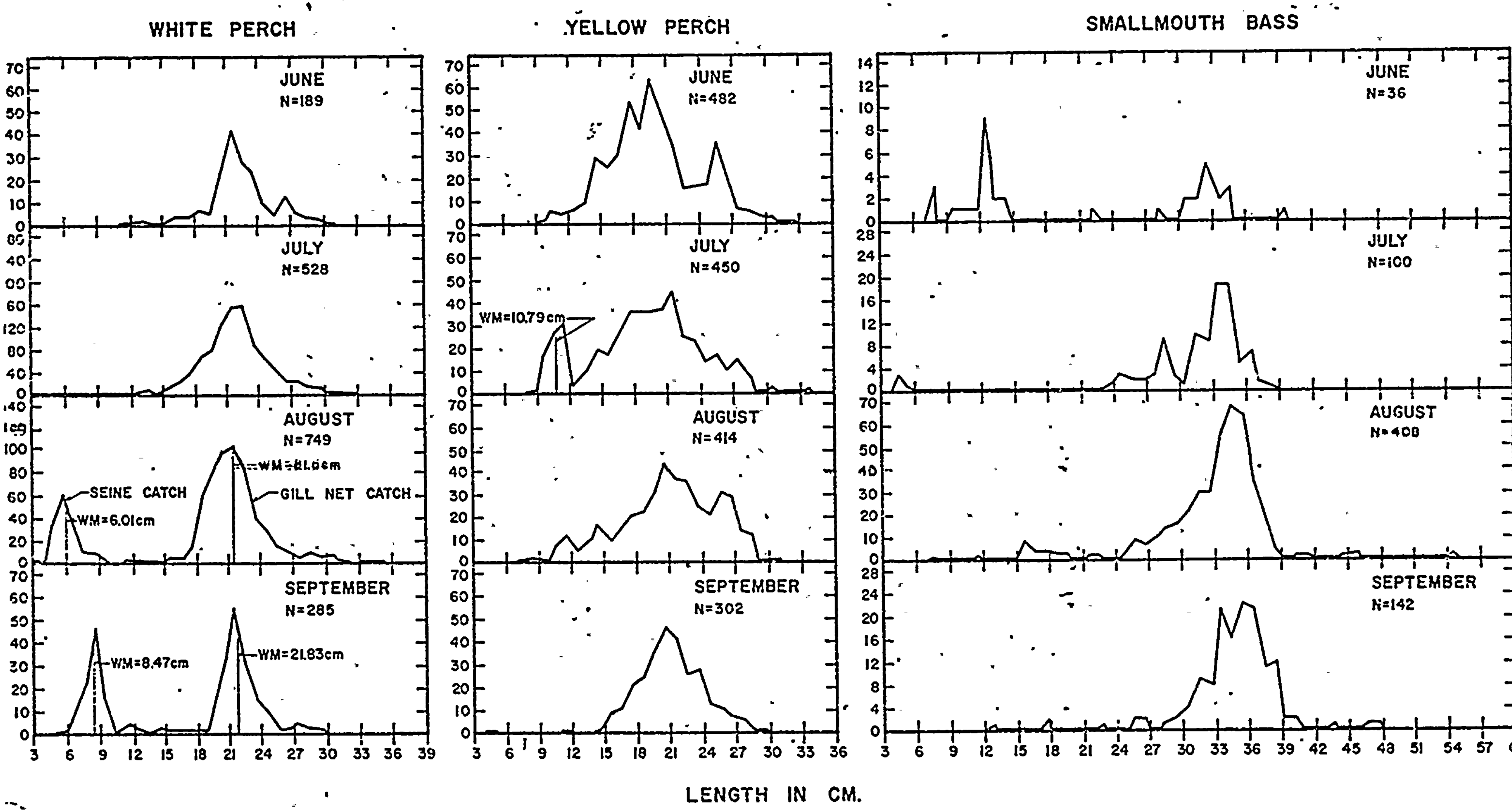


FIGURE III-36

net diversity was generally higher at all depths and transects, with few exceptions. High diversity was usually recorded during the summer with low diversity occurring during the winter. For all transects, species richness was greatest at the FITZ transect. In addition, the highest monthly diversity was calculated during September at the FITZ transect.

4. STOMACH CONTENT ANALYSIS

Production processes in bodies of water are directly concerned with the trophic ecology of fishes. Intensity of feeding and the indirect food relations of fishes comprise one of the basic divisions of fisheries biology. Knowledge of daily and seasonal shifts in diet have emphasized the inaccuracy of basing food studies on species collected at only one time; however, this may not be the case for specialized feeders and fish that are either diurnal or nocturnal. The trend is, therefore, toward a more quantitative and qualitative characterization of fish diets to assess the way in which food habits are influenced by habitat, dietary preferences, fish size, age, daily feeding periodicities, competitor species, season, temperature, and availability of food.

Stomach content analysis may not only prove to be a valuable tool in the determination of trophic level interrelationships but may also be utilized to assess the population dynamics of a given dietary group (plankton, benthos, other fish) by the examination of predator-prey interactions. Although many ecological interactions among organisms are complex

and indirect, predator-prey relationships, as observed through stomach content analysis, is a method of illustrating the direct effect of one group of organisms on the population dynamics of another. This method is not intended to oversimplify trophic level interactions, but stomach content analysis may be utilized as a step in the interpretation of the importance of one type of organism to another in the ecosystem.

Stomach samples collected from fish captured in 1973 were examined to determine the kinds and numbers of food items consumed and the volume of each item present. Samples were obtained on a monthly basis from August through November 1973. During each monthly sampling period, day and night collections were made. A total of 263 fish were analyzed for stomach contents. These data were used to evaluate the feeding preferences of selected species present in the Nine Mile Point area. Three species were selected for analysis based upon their importance and their position as top carnivores in the fish community: smallmouth bass, *Micropterus dolomieui*; white perch, *Morone americana*; and yellow perch, *Perca flavescens*.

a. Smallmouth Bass (*Micropterus dolomieui*)

A total of 41 smallmouth bass were analyzed to determine their stomach contents. The lengths of the fish collected ranged from 16.7 to 41.5cm and are indicated as Groups I through VIII (Table III-27(a)). Fish

TABLE III-27(a)

SIZE CATEGORIES

Size Category	Length (cm) White Perch	Yellow Perch	Smallmouth Bass
I	0-11.0	0-8.4	0-17.1
II	11.1-16.7	8.5-14.0	17.2-20.7
III	16.8-19.8	14.1-18.6	20.8-23.7
IV	19.9-21.6	18.7-23.6	23.8-26.9
V	21.7-23.1	23.7-27.9	27.0-29.5
VI	23.2-24.9		29.6-31.5
VII	25.0-25.5		31.6-33.1
VIII	25.6-26.5		

stomach analyses were performed during August, September, and October. Stomach content analyses are presented in Appendix V-F.

The major or dietary components of smallmouth bass collected at all Nine Mile Point transects were fish and decapod crustaceans. Smallmouth bass were collected by gill nets at the 15 ft. depth during August and October 1973 at NMPP, FITZ and NMPW. On 5 September 1973 a single collection was made at NMPE. During August and September sampling periods, fish were collected prior to dusk and during the early evening hours. The predominant size grouping of smallmouth bass collected at all transects was greater than 33.1cm in length (Group VIII). Other less abundant groups collected during this sampling period include Groups I, II, IV, V, VI, VII.

During August and September, all size groups of smallmouth bass selected decapods (crayfish) and unidentified fish as the major dietary components. At NMPW 15 ft. collection on 28 August, a single alewife was identified in the stomach of a smallmouth bass measured at 34.3cm (Group VIII). In all stomachs analyzed (30) during August and September, crayfish, when present, comprised from 11.8% to 73.7% of the total food volume. However, on 5 September, two unidentified fish were observed in a smallmouth bass (Group VII) collected at the NMPE 15 ft. station and comprised 69.1% of the total food volume. One hundred percent of the stomachs of smallmouth bass taken in April were empty and the alimentary tracts were shrunken.

At Nine Mile Point, forty-one smallmouth bass from 16.7 to 41.5cm were analyzed for stomach contents to determine feeding preferences. The smallmouth bass diet consisted of fish and decapod crustaceans (crayfish). Smallmouth bass apparently decrease food consumption from fall to winter and are probably not active winter feeders.

b. White Perch (Morone americana)

A total of 108 white perch were analyzed to determine their stomach contents. The lengths of the fish collected ranged from 8.1 to 31.9cm and were assigned to Groups I through VIII (Materials and Methods). The predominant size group was Group III (16.8 - 19.8cm). Stomach analyses were performed on fish caught during August, September, and October during the day and night. Stomach contents analyses are presented in Appendix V-F.

A total of 53 white perch were analyzed from night collections made on 27-28 August. The major dietary components indicated were amphipods, dipterans, and gastropods. Twenty-six white perch comprising Group III (16.8 - 19.8cm) were collected during these night hours. All stomachs contained food organisms. At NMPW 15 ft. on 27 August, fifteen white perch stomachs contained primarily amphipods and unidentified fish. The amphipod Gammarus fasciatus composed 98.0% of the total organisms consumed. G. fasciatus also accounted for 63.8% of the total volume of stomach contents; this amphipod was present in all of the stomachs analyzed. Fifty-nine unidentified fish comprised 1.6% of the organisms consumed and 19.0% of

the total food volume. Fish were present in more than 50% of the white perch examined, an average of 3.2 fish per white perch. Other food items including decapods, gastropods (Physa sp.) and dipterans comprised less than 1% of the total organisms and total food volume. Seven stomachs from evening collections of Group IV (19.9 - 21.6 cm) white perch contained primarily G. fasciatus (99.3% of total organisms consumed) and unidentified fish (0.3% of total organisms). G. fasciatus represented 92.6% of the total food volumes. Other food items consumed included decapods and gastropods (Physa sp., Amnicola sp., Goniobasis livescens). Unidentified matter constituted 5.9% of the total food volume.

Two group V individuals were found to have consumed only G. fasciatus. Five white perch (Group IV) collected at NMPW consumed primarily G. fasciatus (91.0% by volume; 100.0% by number). Two Group VI (23.2 - 24.9 cm) individuals again consumed mainly G. fasciatus (67.6% by volume) and unidentified fish (21.4% by volume). Other less abundant food items indluded gastropods (Valvata sp., Physa sp., and Goniobasis livescens) which comprised 0.3% of the total food volume. A single white perch (Group VIII, 24.6 - 26.5cm) consumed primarily G. fasciatus and one alewife.

Forty-seven white perch were analyzed from collections at NMPE 15 ft. on 5 September. Groups II, III, IV, V, VI, VII, and IX were represented in the stomach content analyses. The lack of stomach analyses at other stations in the Nine Mile Point vicinity precludes geographical analysis during this period.

Diurnal variation in food preferences were examined by analyses of twenty-eight white perch collected during the night on 5 September at NMPE 15 ft. Individuals from Groups II through VII, in addition to Group IX were analyzed. The major dietary components of three Group II individuals were amphipods and

fish. Gammarus fasciatus comprised 60.4% of the total food volume and 99.3% of the total organisms consumed. Unidentified fish accounted 9.9% of the total food volume in these Group II white perch. The major food preference of the remaining white perch were amphipods (G. fasciatus and Pontoporeia sp.). However, in the stomach analyses of four Group V white perch, unidentified fish represented 10.4% of the total food volume and only 0.4% of the total organisms consumed during the night collections. All other food items, including gastropods (Valvata sp., Physa sp., and Amnicola sp.), pelecypods (Sphaeriidae), dipterans and trichopterans, represented less than 5% of the total food volume in all remaining groups examined. White perch did not show significant changes in dietary preferences during the night hours; however, there appeared to be a general relative decrease in selection of other fish during the night. Day and night diets were similarly diverse and indicated the major food preference to be amphipods among all groups analyzed.

Three white perch stomachs were analyzed from night collections on 8 October at the NMPP 15 ft. station. Two Group III and one Group VII individuals were represented in the analyses. Gammarus fasciatus was the major food preference for the single Group VII white perch and accounted for 72.9% of the total food volume while comprising 90.3% of the total organisms consumed. Isopods composed 12.5% of the total food volume from this single Group VII individual. Stomach analyses of two Group III white perch showed G. fasciatus and a single alewife represented 63.6% of the total food volume. The single alewife composed 58.1% of the total food volume which may indicate a decrease in the total quantity food items consumed.

Feeding preference in the white perch depended largely on the location and availability of food items on a seasonal basis. White perch were apparently

able to compete successfully with other fish for available food items. The white perch fed throughout the year and its diet showed seasonal fluctuations (McClane, 1964). Crustaceans, water fleas and small fish compose the larger portion of the white perch diet during the summer. During the winter and early spring, they feed upon insect larvae and nymphs found on pond bottoms. Reid (1972), studying the utilization of crayfish as forage, found that in a lake containing crayfish, perch less than 20.1cm in length ate mainly insects; white perch from 20.1 to 28.0cm in length fed upon insects, fish and crayfish; perch greater than 28.0cm in length fed primarily upon crayfish.

The diet of white perch is, therefore, dependent upon age, season, and the availability of food. Stomach analyses of fish collected at Nine Mile Point showed a diet of fish, amphipods, and dipterans. They will feed upon organisms most readily available and will shift dietary preferences to account for the abundance of prey organisms. When food supply declines, white perch will concentrate on the most readily available item.

c. Yellow Perch (*Perca flavescens*)

A total of 114 yellow perch stomachs were examined to determine feeding preferences from August through November 1973. The lengths of the fish collected measured 13.0 to 27.5cm and are indicated as Group II through Group VI (Materials and Methods). Most analyses were performed on yellow perch collected during morning hours. Stomach content analyses are presented in Appendix V-F.

From morning collections made at the NMPP 15 ft. station on 28 August, five (Group III) yellow perch were collected for analysis. The major dietary components found in two stomachs were amphipods (*Pontopereia sp.*)

which comprised 36.2%, by volume, of the total food volume and 95.2% of the total number of organisms consumed. Unidentified matter contributed 1.1% of the total volume. Dipterans contributed 1.1% of the total food volume and 4.8% of the total organisms consumed. On 29 August at the NMPP 15 ft. station, forty-nine yellow perch were collected for stomach examination. Groups III, IV, and V were represented in this collection. Amphipods and fish were the major food items in Groups III and IV; the gastropods Valvata sp. and Amnicola sp. contributed more than 50% of the single Group V individual. Although amphipods were present in considerable numbers (greater than 98.5% of total organisms consumed), no volume displacement calculations were made. All stomachs contained food items; unidentified matter contributed more than 45% of the total volume found in all stomachs. In the stomachs of the twenty-four Group V yellow perch, unidentified fish comprised 14.5% of the total food volume and 0.9% of the total number of organisms selected as food. In addition, two alewives contributed 6.6% of the total food volume in these Group III individuals.

At the FITZ 15 ft. station, forty-five yellow perch were collected from morning collections for stomach content analyses and were divided among Groups I, III, IV, and V. In all stomachs, G. fasciatus contributed greater than 70% of the total organisms consumed; the amphipod Pontoporeia sp. only composed 1.3% in Group I. Additional food items identified in the stomachs of three Group I (0.0-8.4cm) yellow perch included dipterans, which provided for 12.8% (by volume) of total food consumed. Unidentified matter composed 42.3% of the stomach volume of

this group. Stomach analysis of twenty-four Group III (14.1 - 18.6cm) yellow perch indicated the occasional dominance of the gastropod Physa sp. in the yellow perch diet. This gastropod provided 76.6% of the total organisms selected. The gastropod Physa sp. occurred in only 5.5% of the stomachs analyzed. In addition, observation of the Group III yellow perch shows that the amphipod, G. fasciatus provided 97.8% of the total organisms consumed and only 8.3% of the total food volume.

During September at the NMPE 15 ft. station, one Group III and four Group V fish stomachs were collected for analysis. A single amphipod, G. fasciatus, provided 100.0% of the total organisms in the Group III yellow perch. Unidentified matter contributed all the food volume consumed. This apparent seasonal decrease of food intake is further supported by analyses from six yellow perch collected during October. From morning collections made on 24 October two Group V yellow perch were collected for stomach analysis from the NMPW 15 ft. station. In addition, two Group V yellow perch were analyzed from evening collection on 24 October at the NMPP 30 ft. station. During both periods of time at both stations, fish and unidentified matter composed the only stomach items, representing 33% and 69% of the total food volume consumed, respectively. Two yellow perch collected on 25 October at the NMPP 15 ft. station and belonging to Group IV had only one fish between them which provided 52.8% of the total volume. Unidentified matter provided 45.6% of the total food volume. In addition, only unidentified

matter was found in the stomach of a single white perch on the same date at NMPP 15 ft. station. The stomach analysis of one Group IV and one Group V yellow perch at the NMPP 30 ft. station in November indicated relatively empty stomachs with unidentified matter providing 100% of the total food volume. The yellow perch, therefore, showed a general decrease in quantity and kinds of food consumed during day and night at the stations sampled. This observation may also reflect competition for different kinds of organisms (fish) as others become less abundant (amphipods).

The yellow perch is generally considered to be facultative planktivore, feeding mostly on small fish, some crustaceans and insects. The larvae feed on zooplankton and insect larvae; when they grow to a length of 5.0 to 7.5 cms, their diet changes to larger zooplankton, insects, crayfish, snails, and small fish, including those of their own species (McClane, 1964). Tharatt (1959) found that alewives were the principal food of yellow perch in Saginaw Bay. Tharatt's results, when tabulated according to the length of fish examined, showed distinct differences between size groups in terms of dietary components. For fish 6.4 to 7.4cms long, copepods were the chief dietary constituents, but none were found in perch 13.7cms or longer. For fish 6.4 to 13.7cms long, small crustaceans, especially cladocerans and copepods, were important items. For fish greater than 11.4cms in length, larger amphipods, water mites, pelecypods, and gastropods were major constituents of the diet. The first appearance of fish as food items was in perch 10.0cms long. Fish made up an increasingly larger part of the

diet with the increase in size of the yellow perch. The forage fish most often consumed were alewives and smelt.

Keast (1968) compared winter and early spring feeding of yellow perch by comparing the weight of food in the alimentary canal. The yellow perch is known to be an active winter feeder and is often caught by ice fishermen. At a water temperature of 6.5 to 7.0°C, fish contained only a few food items, i.e. isopods, chironomid larvae, and a few fish eggs. Active feeding is suspended prior to mating and commences immediately after ovulation. By May, all the yellow perch stomachs sampled contained food. Chironomid larvae were the most abundant, followed by some isopods, amphipods and copepods.

Galbraith (1967) examined the size of zooplankton consumed by yellow perch. Although many species of zooplankton were present, the yellow perch consumed Daphnia almost exclusively and were very size selective. When other cladocerans or copepods were found in the stomachs, they were at least as large as the smallest Daphnia consumed (1.3mm). Brooks (1968) also noted that yellow perch retain full interest in Daphnia down to about 1.3mm. Accordingly, if yellow perch are present in large enough quantities, they can influence the zooplankton populations in a lake in the same manner as the alewife.

Maloney and Johnson (1955) examined food items of yellow perch in two Minnesota lakes during two summers and found that the stomach contents changes somewhat with the progression of the summer. During June and July, the predomi-

nant food for the young-of-the-year was planktonic crustaceans with insects becoming increasingly important as the summer advanced. Yearling and older yellow perch ate insects (43%), fish (32%), crustacea (21%), and other organisms. By late July crustacea were replaced by fish as the most important food item.

Seaburg and Molye (1964) studied the quality of food ingested by 97 fish ranging from 8.9 to 19.8cm in length during the summer in Minnesota and found the greatest stomach volumes in May. For yellow perch longer than 12.7cm, 66% of the stomach volume consisted of fish (darters, minnows, and some perch). No fish were found in the stomachs of perch smaller than 12.7cm. The most common insects ingested were dragonfly nymphs; chironomid larvae were next in importance.

Muncy (1962) examined the stomach contents of 209 yellow perch and found the major food items to be small crustaceans and insects, especially chironomid larvae. Only larger fish, 8.9 to 9.2cm total length, contained fish. Differences in food items were found in different locations. A higher percent of empty stomachs were found shortly after midnight.

In Lake Opinicon, Ontario, Keast and Welsh (1968) determined feeding periods based on mean weights of stomach contents per gram body weight for different times during a 24-hour period. The samples were taken during the summer months, an accelerated feeding season. The yellow perch was found to be a diurnal feeder, with a peak in the weight of stomach contents at dusk and another in mid-morning (10 a.m.). Active feeding appeared to begin around

7 a.m. and 6 p.m. Hasler and Bardach (1949) found definite migratory movements to certain well-defined feeding areas towards sunset and again at dawn. The food consumed during the two feeding periods was similar.

At Nine Mile Point, yellow perch showed a basic diet of fish and crustaceans in addition to gastropods and dipterans. When fish are not available, yellow perch will modify their diets to include crustaceans and insects.

d. Summary

1. The smallmouth bass has a basic diet of fish and crayfish. The amount and types of food consumed will depend on the available food items, locations, and feeding time of the year. Smallmouth bass reduce food consumption from fall to winter and are probably not active winter feeders.

2. The white perch has a basic diet of fish, amphipods, and dipterans. The amount and types of food will depend on the availability of food items and feeding locations. The white perch will feed upon the organisms most readily available and will shift dietary preferences to account for the abundance of prey organisms. The white perch will, therefore, concentrate on the most readily available food items when food supply declines.

3. The yellow perch has a basic diet of fish and crustaceans (particularly amphipods) in addition to gastropods and dipterans. The amount and types of food consumed will depend on available food items and feeding location. When other fish are not available as a food source, the diet will change to include crustaceans and insects. The amount of food consumed appears to decrease during the winter. The yellow perch will, therefore, supplement their diets during a seasonal decline in food supply.

4. There is a general overlap in the diets of the three species considered. Fish, crayfish, amphipods, and various insects are eaten by all of the fish but in different quantities and at different times. The standing food crop has to be diverse in order to sustain a sufficient fish population. However, the feeding behavior of the individual fish species permits co-inhabiting of the area by reducing competition for food to a certain extent. For example, when the supply of forage fish is high, piscivorous species will consume these preferred items. However, when this supply declines, some species, e.g. yellow perch, will expand their diets to fill their dietary necessities and other species, e.g. white perch, will restrict their diets concentrating on the most available food items.

The feeding systems for these three species is further balanced in that some species, e.g. smallmouth bass, will decrease their consumption rates as the seasons progress concurrent with the decrease in major food supply. White perch will compete with the yellow perch somewhat for major food items, but is capable of consuming other items present, e.g. trichoptera and other insects, when these are not preferred by the yellow perch.

5. AGE AND GROWTH

a. Introduction

Age is one of the most important parameters in a study of the population dynamics of fish. The age composition of the stock, the relative strengths of the different age groups and the maximum life span are, within certain limits, a species characteristic. Fish with short generation times, including smelt and alewives, are adapted to living under conditions of high and variable mortality. Their population dynamics ensure a rapid replacement of the stock.

On the other hand, species such as sturgeon, in which the population may contain several decades of age groups, are adapted to living under conditions of a relatively stable food supply and negligible annual fluctuations in the mortality of sexually mature individuals. If a substantial part of this popula-

tion should die, its replacement would be slow (Nikolsky, 1963). Age and growth information is a prerequisite for any study in which impact due to man-induced mortality within a population is to be evaluated. Examples of such impact are commercial fisheries and impingement on the screens of an electric generating station.

Age and growth studies consist mainly of scale reading and analysis of length frequency/distribution in a population. The age of a fish and its relative growth as determined from scales are complemented by body length measurements on large, representative samples to yield an accurate determination of the growth rate characteristic of a given population.

Since a scale contains much of the historical information necessary to determine the factors influencing fish growth, back-calculation of growth over several seasons must be determined (see Materials and Methods section). Growth rates are an index to population densities, and slow growth rates may be symptomatic of overcrowded conditions. If there were a source of attrition in a population, such as a power plant intake with high impingement rates, it would benefit investigators to know if this "cropping" was occurring in an overcrowded, stunted population or if the population was already at the optimum density for good growth and survival.

The use of back-calculation methods on scales from five year old white perch collected in 1972, for instance, supplies information on growth rates for each year from 1967 through 1971. A data file can be built up for data on

growth rates from previous years which can be accumulated, and therefore a correlation between growth rates and environmental parameters (rainfall, solar radiation, water temperature, population densities) can be made.

Body-length measurements provide additional data on species population dynamics. The length-frequency composition of a fish population which reproduces seasonally will often exhibit modes at the lower end of the scale, which correspond to the youngest age groups. These modes will be most pronounced for species with a short spawning season and rapid, uniform growth. Older age groups, because of increased overlapping growth and a decline of numbers due to various sources of mortality, show modes for age groups which tend to decrease and blend together.

Length-frequency and length distribution analyses were made in this study to provide information on growth rates of young-of-the-year fish, age composition of the population, and inshore-offshore movements of adult and juvenile fish. Body length measurements were also used to validate length at annulus formation derived from scale analysis for younger age groups of selected species. Length-frequency and back-calculation data are presented for five major species occurring at Nine Mile Point (alewife, rainbow smelt, yellow perch, white perch and smallmouth bass).

b. Results and Discussion

(i) Yellow Perch

The body-scale relationship for 206 male and female yellow perch was expressed as $L = 52.3 + 59.7S$ ($r=0.83$)*, where L = total body length (mm) and S = total scale length (mm) (see Materials and Methods section). The correction factor (52.3mm) used in this study, a value which theoretically approximates yellow perch body length at the time of scale formation, may be largely due to a deficiency of young-of-the-year fish in the data from which the regression of body length on scale length was calculated.

A more likely correction factor of 20.3mm was found by Muncy (1962) for yellow perch in the Severn River, Maryland. Over-estimation of correction factors is common where young-of-the-year fish are poorly represented in the data. This is due to the fact that the constant ratio mentioned by Van Oosten (1929) between annual increment in scale length and annual increment in body length does not always hold true throughout the life of the fish. The ratio may decrease for some fish since the scales may grow proportionately faster than the body length at scale formation (correction factors) than would be found in nature. It is possible to avoid this problem by using only young-of-the-year fish for the regression of body length on scale length (Koski, 1973; Marcy and Richards, 1974; QL&M, 1974). The slope of the regression of body length on scale length during the early period of rapid fish growth (young-of-the-year) is often steeper than it is afterwards, resulting

*Correlation coefficient.

in a lower y-intercept than when older, slower growing fish are used.

Examination of 110 yellow perch during June and July showed that annuli for 1973 had been formed in all fish but one during June; annulus formation was 100% complete during July. These data are consistent with findings from Lake Erie (Jobes, 1952) that annulus formation was completed between early April and the middle of July.

Length attained at the end of each year of life, i.e. at annulus formation, is presented for 37 male and 124 female yellow perch from year classes 1964 through 1972 collected at Nine Mile Point during 1973 (Table III-28). Ninety-five percent confidence intervals of mean back-calculated lengths did not overlap through age group IV for males and age group V for females. Females were generally larger than males of the same age, and this difference in growth was significant through age group IV (Table III-28). Greater growth for female yellow perch in each year of life was also reported by Schneberger (1935) for several Wisconsin lakes, by Hile and Jobes (1942) for Lake Michigan, by Jobes (1952) for Lake Erie, and by Muncy (1962).

First year length increments were greater than in any other year composing approximately 41% and 44% of the mean total length attained in six years of growth for both males and females, respectively. Similar growth patterns were reported from Lake Michigan (Hile and Jobes, 1942), Lake Erie (Jobes, 1952), and Maryland (Munch, 1962); however, Schneberger (1935) reported that greatest growth in yellow perch in Wisconsin occurred during the second year of life.

TABLE III-28

CALCULATED GROWTH (mm) OF MALE AND FEMALE YELLOW PERCH YEAR CLASSES 1966 - 1972 COLLECTED AT LAKE ONTARIO AT NINE-MILE POINT DURING 1973.

Year Class	Age Group	Number Of Fish	Mean Length At Capture	Calculated Total Length at End of Year 1	2	3	4	5	6	7	8	9
							MALE					
1972	I	8	111.8	93.6	-	-	-	-	-	-		
1971	II	6	129.5	99.8	122.8	-	-	-	-	-		
1970	III	10	164.0	98.7	133.0	157.2	-	-	-	-		
1969	IV	8	193.6	104.6	133.7	160.5	185.2	-	-	-		
1968	V	2	226.0	101.6	137.1	174.4	198.0	217.5	-	-		
1967	VI	2	249.0	141.5	169.3	193.1	215.7	229.4	238.7	-		
1966	VII	1	290.0	116.1	160.0	196.9	223.8	243.1	265.4	284.6		
Grand Average				102.0	134.8	164.7	194.8	227.4	247.6	284.6		
Sample Size				37	29	23	13	5	3	1		
Standard Deviation				13.98	15.59	17.39	19.58	28.45	17.65	-		
Standard Error				2.30	2.89	3.63	5.43	12.72	10.19	-		
Confidence Interval (α = 0.05)				97.3-106.7	128.9-140.7	157.2-172.2	183.1-206.6	194.7-260.1	215.2-280.0	-		
Average Annual Increment				102.0	32.8	29.9	30.1	32.6	20.2	37		
							FEMALE					
1972	I	10	106.5	89.5	-	-	-	-	-	-	-	-
1971	II	19	140.1	101.7	132.0	-	-	-	-	-	-	-
1970	III	15	167.9	110.8	143.0	168.9	-	-	-	-	-	-
1969	IV	25	207.4	110.1	146.9	173.0	192.8	-	-	-	-	-
1968	V	24	252.2	120.1	161.0	196.6	223.9	243.5	-	-	-	-
1967	VI	23	268.8	123.9	167.1	199.0	223.1	242.5	257.1	-	-	-
1966	VII	4	274.5	110.2	148.6	178.0	203.9	230.8	229.0	266.6	-	-
1965	VIII	3	298.3	116.9	160.2	190.4	221.8	244.5	261.0	266.7	290.5	-
1964	IX	1	310.0	128.2	175.8	233.1	244.7	262.0	270.8	281.6	292.8	303.5
Grand Average				112.0	151.6	186.0	213.1	242.6	254.3	268.5	291.1	303.5
Sample Size				124	114	95	80	55	31	8	4	1
Standard Deviation				17.75	23.03	28.44	28.92	21.88	31.37	19.10	7.66	-
Standard Error				1.59	2.16	2.92	3.23	2.95	5.63	6.75	3.83	-
Confidence Interval (α = 0.05)				110.5-113.6	147.3-155.9	180.2-191.8	206.7-219.6	236.6-248.47	242.8-265.8	252.9-284.1	280.4-301.7	
Average Annual Increment				112.0	39.6	34.4	27.1	29.5	11.7	14.2	22.6	12.4

Yellow perch growth rates recorded from the Nine Mile Point area of Lake Ontario were compared to growth rates found in seven other aquatic environments (Table III-29). Data of other investigators were converted from standard length (SL) to total length (TL) using the ratio determined by Muncy (1962), where SL/TL = 0.84. Growth in Lake Ontario was substantially slower than in Lake Erie. Since Lake Ontario is oligotrophic and Lake Erie is considered mesotrophic (Beeton, 1969), the differences in growth rates may be a function of nutrition or of water temperature differences between the deeper Ontario and shallower Erie. The data show that first year growth for yellow perch in Lake Ontario was greater than that found in any other study. These results were analyzed to determine if they were biased by gill net selectivity or annulus interpretation.

Validation of annulus interpretation was conducted by comparison of actual mean total lengths at capture with predicted total lengths based on back-calculation analysis. If the interpreted annuli serve as true indicators of age and growth, the mean total length for each age group at capture should be greater than the mean back-calculated length at the last formed annulus, and less than the mean back-calculated length at the succeeding annulus. Examination of the data in Table III-28 and III-29 shows that there were some discrepancies in annulus interpretation in the younger age groups.

Scale data combined with length-frequency data from June through September showed that yellow perch from age group II and above predominated in Lake catches (Tables III-28 and III-29; Figure III-36). Young-of-the-year fish

TABLE III-29

MEAN CALCULATED TOTAL LENGTHS* (mm) AT ANNULUS FORMATION FOR YELLOW PERCH BASED ON SEVERAL STUDIES

	LOCATION AND REFERENCE							
Annulus Formation	Nebish Lake, Wisconsin Schneberger, 1935	Weber Lake, Wisconsin Schneberger, 1935	Silver Lake, Wisconsin Schneberger, 1935	Saginaw Bay, Lake Huron Hile and Jobes, 1941	Green Bay, Lake Michigan Hile and Jobes, 1942	Lake Erie Jobes, 1952	Severn River, Maryland Muncy, 1962	Nine-Mile Point Lake Ontario (QLM, 1974)
1	66	58	44	77	73	92	106	110
2	136	113	80	137	118	174	163	149
3	175	145	113	202	160	219	199	182
4	213	175	133	248	198	248	226	211
5		199	149	279	227	271	248	241
6		215	169	315	262	288	264	254
7		231	202	338	285		275	270
8		245			319		282	
9					360		290	

$$\text{*Total length} = \frac{\text{Standard Length}}{0.84} \quad \text{(Muncy, 1962)}$$

were almost non-existent in these catches and one year old fish made up a substantial proportion of the catch only during July (Figure III-36). This age composition may be representative of the yellow perch population present at the Nine Mile Point area during June through September, but it is more likely to be a biased estimate on selectivity for larger fish by gill nets which accounted for almost all of the yellow perch caught during this time period. An increased seining effort, trap netting and shallow water trawling may provide a more reliable index to young and yearling abundance for inshore waters in the vicinity of Nine Mile Point.

(ii) White Perch

The body-scale relationship for 570 male, female and immature white perch collected at Nine Mile Point was described by the regression $L = 32.7 + 60.04S$ ($r = 0.90$), where L is total body length in millimeters and S is scale radius in millimeters. The regression intercept of 32.7mm was used as the correction factor for total body length at scale formation in this study. Calculated correction factors for other studies are: Mansueti (1961a) - 16.3mm standard length in Maryland; Wallace (1971) - 22.4mm fork length in Delaware; St. Pierre and Davis (1972) - 20.9 fork length in the James and York Rivers, Virginia; QL&M (1974) - 31.9mm in the Hudson River.

Time of annulus formation is a species characteristic which is influenced by environmental conditions and varies with location and year. During a ten-year study on Lake Ontario,

Sheri and Power (1969) found that annulus formation for five of the years studied occurred during July, but it occurred during June for two years and during August for two other years. In the present study annulus formation white perch was complete by October and most annuli had been formed by September 1973. The peak of annulus formation appeared to fall between August and September.

Determination of time at annulus formation and knowledge of the relationship between time and formation and age of the fish ensured a more accurate assignment of fish to their proper class. For example, a fish with two annuli collected during June or July 1973, and which showed a wide band of growth at the edge of its scale, was designated as three years old (third annulus not formed) and assigned to the 1970 year class. A fish collected at the same time with two annuli but with a narrow band of growth following the last annulus, was designated at two+ years old (second annulus recently formed) and placed in the 1971 year class.

Length attained at the end of each year of life, i.e. at annulus formation, is presented for male and female white perch from year classes 1963 through 1972 collected at Nine Mile Point (Table III-30). Ninety-five percent confidence intervals of mean back-calculated lengths did not overlap through age group VI. Females were significantly larger than males after the first two years of life (Table III-30).

E III-30

CALCULATED GROWTH (mm) OF MALE AND FEMALE WHITE PERCH YEAR CLASSES 1964 - 1972 COLLECTED AT LAKE ONTARIO AT NINE-MILE POINT DURING 1973.

Year Class	Age Group	Number Of Fish	Mean Length At Capture	Calculated Total Length at End of Year 1	2	3	4	5	6	7	8	9	10
								MALE					
1972	I	0	-	-	-	-	-	-	-	-	-	-	
1971	II	14	179.6	100.4	166.2	-	-	-	-	-	-	-	
1970	III	28	202.9	96.0	164.9	194.2	-	-	-	-	-	-	
1969	IV	20	209.4	93.4	155.3	188.9	205.8	-	-	-	-	-	
1968	V	16	216.6	88.8	143.3	183.1	201.3	212.4	-	-	-	-	
1967	VI	9	237.9	96.3	165.7	197.6	217.4	228.5	235.3	-	-	-	
1966	VII	4	243.0	81.4	149.4	191.7	212.7	227.3	237.3	242.4	-	-	
1965	VIII	3	241.3	101.1	152.7	173.0	196.8	213.8	225.6	233.8	239.4	-	
1964	IX	2	249.0	81.2	141.4	185.7	206.6	222.1	231.8	237.6	243.3	248.2	
Grand Average				94.2	158.1	190.0	206.7	219.4	233.8	238.4	241.0	248.2	
Sample Size				96	96	82	55	35	19	9	5	2	
Standard Deviation				13.10	21.21	16.67	16.55	16.90	13.39	13.70	16.85	29.99	
Standard Error				1.34	2.15	1.84	2.23	2.86	3.07	4.57	7.53	21.21	
Confidence Interval (α= 0.05)				91.5-96.8	153.9-162.4	186.4-193.7	202.2-211.1	213.6-225.2	227.4-240.2	228.1-248.8	221.6-260.3	157.0-339.4	
Average Annual Increment				94.2	63.9	31.9	16.7	12.7	14.4	4.6	2.6	7.2	
								FEMALE					
1972	I	1	184.0	96.7	-	-	-	-	-	-	-	-	-
1971	II	10	181.7	100.0	166.8	-	-	-	-	-	-	-	-
1970	III	31	207.9	95.6	162.6	200.3	-	-	-	-	-	-	-
1969	IV	26	217.4	95.0	158.5	198.8	215.5	-	-	-	-	-	-
1968	V	16	223.9	90.5	152.4	195.2	213.5	219.6	-	-	-	-	-
1967	VI	8	243.6	91.1	148.7	195.9	221.0	234.0	242.3	-	-	-	-
1966	VII	10	252.8	91.3	152.1	202.2	223.8	237.2	245.1	251.7	-	-	-
1965	VIII	6	267.3	93.5	159.0	196.6	218.3	237.6	250.1	258.6	265.0	-	-
1964	IX	4	259.5	89.5	155.5	204.9	221.7	231.6	239.3	246.7	252.0	257.4	-
1963	X	3	277.7	92.5	155.2	199.5	221.5	237.1	250.2	258.2	262.9	271.1	277.0
Grand Average				94.0	158.1	198.9	217.6	230.2	245.1	253.5	260.6	263.3	277.0
Sample Size				115	114	104	73	47	31	23	13	7	3
Standard Deviation				13.70	20.87	17.43	16.12	18.74	17.62	18.04	21.76	27.15	15.50
Standard Error				1.28	1.96	1.71	1.89	2.73	3.17	3.76	6.04	10.26	8.95
Confidence Interval (α= 0.05)				91.5-96.6	154.2-162.0	195.5-202.3	213.8-221.4	224.7-235.8	238.6-251.5	245.7-261.3	247.6-273.7	239.0-287.5	248.5-305.5
Average Annual Increment				94.0	64.1	40.8	18.7	12.6	14.9	8.4	7.1	2.7	13.7

The fact that female white perch grow more rapidly than males is well-established in the literature (Mansueti, 1961a; Miller, 1963; Wallace, 1971; St. Pierre and Davis, 1972; Texas Instruments, 1973; QL&M, 1974). St. Pierre and Davis (1972) suggested that the smaller size of males may reflect their earlier age at sexual maturation. First year growth in length by each sex was greater than in any other year, composing 36% to 37% of the mean total length attained by nine-year-old fish. Validation of annulus interpretation, as discussed previously for yellow perch, indicated discrepancies in the expected relationship between fish length at capture and predicted length at annulus formation (Table III-30).

White perch growth rates recorded from the Nine Mile Point area of Lake Ontario were compared to growth rates found in twelve other aquatic environments (Table III-31). Data of other investigators were converted from total length (TL) to standard length (SL) by the equation SL = 1.3 + 0.83 TL (Marcy and Richards, 1974). This comparison shows that white perch growth rates found in the Nine Mile Point study exceed those found in nine of the twelve studies. Only Connecticut River white perch (Marcy and Richards, 1974), landlocked white perch in the Quabbin Reservoir, Massachusetts (Taub, 1969) and landlocked perch in Sebasticook Lake, Maine (Auclair, 1956), grew more rapidly than white perch landlocked in Lake Ontario. The data for Quabbin Reservoir, Sebasticook Lake and Lake Ontario show relatively good growth rates for freshwater populations of white perch which do not participate in

TABLE III-31

MEAN CALCULATED STANDARD LENGTHS (mm) AT AN[illegible]FORMATION FOR WHITE PERCH BASED ON SEVERAL STUDIES*

LOCATION AND REFERENCE

Annulus Formation	Sebasticook Lake, Maine Auclair (1954)	Quabbin Reservoir, Massachusettes Taub (1965)	Connecticut River (Km 199-176; upper) Roger Reed (personal communication)	Connecticut River (Km 11-74; lower) Marcy (1973)	State of Conn. Whitworth & Sauter (1972)
1st	-	74	81	71	73
2nd	152	127	146	148	107
3rd	201	171	177	186	137
4th	226	193	204	211	160
5th	246	200		230	184
6th	279	222		255	202
7th		233		282	
8th		251			
9th		264			
10th		273			

Annulus Formation	Delaware River Estuary Miller (1963)	Delaware River near Artificial Is. Wallace (1971)	Patuxent River, Maryland Mansueti (1961)	James River, Virginia, St. Pierre and Davis (1972)	York River, Virginia St. Pierre and Davis (1972)
1st	73	68	73	61	64
2nd	117	110	113	99	97
3rd	138	130	135	124	120
4th	153	144	151	144	142
5th	167	154	164	159	159
6th	181	162	181	172	176
7th	193	170	198	186	193
8th	204	174	209	199	209
9th	248		221	214	220
10th	257		241	222	229

Annulus Formation	Roanoke River, North Carolina Conover (1958)	Hudson River Bowline MP 35 QLM (1974)	Bay of Quinte Lake Ontario Sheri and Power (1969)	Nine-Mile Point Lake Ontario Present Study
1st	56	64	64	77
2nd	87	109	105	130
3rd	120	132	136	161
4th	146	143	156	175
5th	168	150	174	189
6th	188	164	187	199
7th	204		202	206
8th	218		219	211
9th			232	214
10th			232	229

*Data converted to standard length by the equation SL = -1.31 + 0.83TL

the extensive, semi-anadromous spawning migrations typical for estuarine white perch populations.

The growth rates reported from the Nine Mile Point study are substantially greater than those reported by Sheri and Power (1969) for the Bay of Quinte, Lake Ontario (Table III-31). The faster growth rates found for white perch in the Nine Mile Point study may result from the fact that all white perch used in the 1973 age-growth study were captured by gill nets. Analysis of the length distribution for a random sample of 600 white perch collected by gill nets from June through September shows the following results:

NUMBER OF FISH ANALYZED	MEAN TOTAL LENGTH (cm)	STANDARD DEVIATION	STANDARD ERROR	95% CONFI[illegible]E INTERVAL (cm)
600	21.4	3.637	0.148	21.1 - 21.7

These data indicate that size selectivity for larger and faster growing fish from younger age groups was present in gill net catches, due either to location of the gill netting stations or to inherent size-selectivity of the nets themselves.

Mansueti (1961b) found that the comparatively rapid growth calculated for fish caught by gill nets was consistent with the expectation that such selective gear would take a comparatively large segment of the faster growing and larger-than-average individuals from younger age groups within the population. Theoretically, such bias is overcome by the use of experimental gill nets with several panels of finely graded mesh, such as thos

used at Nine Mile Point (see Materials and Methods). However, it is evident that the efficiency of gill netting, which involves fish swimming into the net and becoming entrapped, decreases as the fish become smaller, especially if a coarse twine size is used in the smaller meshes. The small mesh sizes of the monofilament gill nets used on Lake Ontario through October 1973 were composed of 15 lb. test (#139) monofilament, which is a very coarse twine for small fish. Preliminary data indicate that the multifilament nets with finer twine size, in use since November 1973 (see Materials and Methods), will reduce the size-selectivity evident in 1973 collections.

Scale data combined with length-frequency data showed that white perch from age group III and above predominated in lake gill net catches from June through September (Table III-30; Figure III-36). Although some young-of-the-year white perch appeared in seines during July, substantial numbers did not appear until August (Figure III-36).

Length-frequency information shows that young-of-the-year white perch grew to a mean total length of approximately 6cm between the time of spawning and the month of August. The young-of-the-year population at Nine Mile Point had grown to about 8.5cm by mid-September, and this information was used in verifying first-year growth of 9.4cm established by scale analysis.

(iii) Smallmouth Bass

The body-scale relationship for 152 male, female and immature smallmouth bass was expressed as $L = 80.9 + 58.8S$ $(r=0.82)$, where L = total body length (mm) and S = total scale length (mm). The regression intercept of 80.9mm was used as the correction factor for total body length at scale formation. Everhart (1950) calculated a correction factor of 20 to 21mm fork length using specimens less than 150mm in length. This correction factor increased to 56-57mm fork length using fish more than 150mm in body length. The high intercept used in the Nine Mile Point study appears to result from the fact that young and yearling smallmouth bass were not adequately represented in the regression data.

Annulus formation for Lake Ontario smallmouth bass was complete by October and most annuli had been formed by September 1973; Suttkus (1955) reported that annulus formation occurred during May and early June for a small stream population of smallmouth bass.

Length attained at the end of each year of life, i.e. at annulus formation, is presented for male and female smallmouth bass from year classes 1959 through 1972 collected at Nine Mile Point (Table III-32). Ninety-five percent confidence intervals of mean back-calculated lengths did not overlap through age group IV for males and through age group VI for females. There was a general tendency after the first year of growth for males to be

TABLE III-32

CALCULATED GROWTH (mm) OF MALE AND FEMALE SMALL MOUTH BASS YEAR CLASSES 1959 - 1970 COLLECTED FROM LAKE ONTARIO AT NINE-MILE POINT DURING 1973.

Year Class	Age Group	Number of fish	Mean Length At Capture	Calculated Total Length at End of Year													
				1	2	3	4	5	6	7	8	9	10	11	12	13	14
MALE																	
1970	III	2	186.5	119.1	160.2	186.5	-	-	-	-	-	-	-	-	-	-	-
1969	IV	5	236.5	125.7	165.8	199.8	231.4	-	-	-	-	-	-	-	-	-	-
1968	V	6	247.3	125.6	169.4	201.8	226.6	245.3	-	-	-	-	-	-	-	-	-
1967	VI	2	241.0	129.2	156.1	180.4	208.7	220.7	238.5	-	-	-	-	-	-	-	-
1966	VII	5	317.4	130.9	179.2	214.6	247.9	311.3	294.0	311.3	-	-	-	-	-	-	-
1965	VIII	11	356.6	137.1	185.2	226.5	259.9	352.5	315.7	336.4	352.5	-	-	-	-	-	-
1964	IX	5	352.4	139.3	181.2	219.6	251.7	279.2	300.4	322.5	341.1	352.0	-	-	-	-	-
1963	X	2	349.0	127.9	175.2	215.2	233.0	257.8	277.7	297.4	309.8	324.3	335.7	-	-	-	-
1962	XI	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1961	XII	1	375.0	137.6	187.8	223.1	247.7	268.0	285.2	307.6	327.9	340.8	348.2	359.0	368.6	-	-
1960	XIII	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1959	XIV	1	395.0	137.5	185.9	226.7	261.2	285.3	300.2	316.0	330.9	343.8	356.0	368.0	378.3	385.7	390.3
Grand Average				131.7	176.0	212.2	243.7	295.8	298.6	323.5	343.1	343.7	343.9	363.5	373.4	385.7	390.3
Sample Size				40	40	40	38	34	27	25	20	9	4	2	2	1	[illegible]
Standard Deviation				9.68	18.78	26.62	31.06	53.78	32.66	26.59	25.54	20.94	25.72	6.42	6.85	-	[illegible]
Standard Error				1.53	2.97	4.21	5.04	9.22	6.29	5.32	5.71	6.98	12.86	4.54	4.85	-	[illegible]
Confidence Interval (α= 0.05)				128.6-134.8	170.0-182.0	203.7-220.7	233.5-253.9	277.1-314.5	285.7-311.5	312.6-334.5	331.1-355.0	327.9-359.4	308.2-379.7	344.0-383.0	352.6-394.3	-	-
Average Annual Increment				131.7	44.3	36.2	31.5	52.1	2.8	24.9	19.6	0.6	0.2	19.6	9.9	12.3	4.6
FEMALE																	
1972	I	1	78.0	133.2	-	-	-	-	-	-	-	-	-	-	-	-	
1971	II	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1970	III	2	189.0	123.1	155.0	189.0	-	-	-	-	-	-	-	-	-	-	
1969	IV	1	257.0	145.7	171.1	193.0	239.5	-	-	-	-	-	-	-	-	-	
1968	V	10	273.5	139.1	181.5	210.6	239.0	268.0	-	-	-	-	-	-	-	-	
1967	VI	15	292.2	132.5	175.5	210.4	241.8	266.9	284.4	-	-	-	-	-	-	-	
1966	VII	29	306.6	132.8	176.0	209.4	241.6	265.4	287.0	303.0	-	-	-	-	-	-	
1965	VIII	24	314.5	131.4	170.0	202.7	231.7	259.2	280.4	297.8	312.1	-	-	-	-	-	
1964	IX	7	363.7	143.7	187.3	224.7	262.0	289.7	314.2	334.9	351.1	362.1	-	-	-	-	
1963	X	1	342.0	129.7	160.0	194.3	231.2	257.6	276.1	294.5	320.9	332.8	342.0	-	-	-	
1962	XI	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1961	XII	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1960	XIII	1	389.0	135.9	166.1	190.9	214.3	236.3	269.3	299.6	323.0	345.0	360.1	372.5	382.1	389.0	
Grand Average				133.2	175.0	208.1	239.8	265.8	286.5	304.4	321.0	356.9	351.1	372.5	382.1	389.0	
Sample Size				91	90	90	88	87	77	62	33	9	2	1	1	1	
Standard Deviation				15.53	19.11	23.32	29.69	33.92	32.94	34.77	37.45	15.98	12.83	-	-	-	
Standard Error				1.63	2.03	2.47	3.16	3.64	3.75	4.42	6.52	5.33	9.07	-	-	-	
Confidence Interval (α= 0.05)				130.0-136.5	171.0-179.1	203.2-213.1	233.5-246.1	258.6-273.0	279.1-294.0	295.6-313.2	307.7-334.2	344.9-369.0	312.1—390.1	-	-	-	
Average Annual Increment				133.2	41.8	33.1	31.7	26.0	20.7	17.9	16.6	35.9	5.8	21.4	9.6	6.9	

larger than females of the same age, although there was no significant difference in growth rates between sexes except in the fifth year of life (Table III-32). Stone et al. (1954) found little difference in rate of growth between sexes of smallmouth bass in the St. Lawrence region of Lake Ontario, and Suttkus (1955) also found no significant difference between male and female growth rates.

First year growth in length by each sex was greater than during any other year, composing approximately 38% and 42% of the mean total length attained by eight year old males and females, respectively. This is in agreement with Suttkus (1955) who reported that the maximum annual increase in length occurred during the first year.

Verification of annulus interpretation by comparison of fish length at capture with predicted length at annulus formation (Tables III-32 and III-33) indicated that some annuli may have been misinterpreted. Small sample sizes may have contributed to the observed discrepancies in the expected relationship between fish length at capture and predicted lengths at previous and succeeding annuli.

Smallmouth bass growth rates recorded from the Nine Mile Point area of Lake Ontario were compared to growth rates found in several other studies (Table III-32). First year growth provided the greatest differences between the Nine Mile Point study and other studies. The smallmouth bass catch at Nine

TABLE III-33

Mean lengths (mm) at various ages of smallmouth bass based upon several studies *

	LOCATION AND REFERENCES				
Age	Tadenac Lake Ontario Turner and MacCrimmon '70	Lake Michigan Latta (1963)	Fall Creek+ N.Y. Suttkus (1955)	Lake Ontario-St. Lawrence -River Stone, et al (1954)	Nine-mile Point Lake Ontario Present Study
I	91	99	74	-	133
II	163	160	138	-	175
III	189	205	173	-	209
IV	230	246	213	262	241
V	291	292	234	277	274
VI	315	335		302	290
VII	362	371		318	310
VIII	249	401		348	329
IX	412	427		366	350
X				391	

* Conversion of fork length to total length based on ratio of 1:1.044 (Suttkus, 1955)

+ Data taken from a "stunted" population

Mile Point area of Lake Ontario were compared to growth rates found in several other studies (Table III-32). First year growth provided the greatest differences between the Nine Mile Point study and other studies. The smallmouth bass catch at Nine Mile Point during 1973 amounted to 828 fish, 97.8% of which were captured by gill nets. The mean length of the entire catch appears to be more than 30cm (Figure III-36), indicating that the gill nets used were size-selective for faster growing fish from the younger age groups and larger fish in general. This aspect of growth rates based on gill net collections has been discussed previously for yellow perch and white perch.

(iv) Alewife

Good correlation between body length and scale length was not demonstrated, and this may have been due to the relatively narrow size-range of larger alewives collected and used for scale analysis. The regression intercept of 57.91mm was therefore chosen from the literature and used as the correction factor in this study (Marcy, 1969).

Annulus formation occurred on the following schedule for Lake Ontario alewife:

	March	April	May	June	July	August	September	October
Number Examined	31	52	42	175	161	171	112	44
Percent Formed	0	4%	29%	42%	66%	65%	91%	93%

Rothschild (1966) reported that annulus formation in freshwater alewives occurred during early summer and that difficulty in determining time of annulus formation may be due to slow growth of older fish.

Length attained at the end of each year of life, i.e. at annulus formation, is presented for male and female alewife from year classes 1966 through 1972 collected at Nine Mile Point (Table III-34). Ninety-five percent confidence intervals of the mean back-calculated lengths did not overlap through age group II for males and age group VI for females. Females were generally larger than males of the same age and this difference was significant after the first two years of life (Table III-34). Marcy (1969) found that females were larger than males in anadromous Atlantic coast populations of alewife, and Harvey (1961) reported that females grew more rapidly than males in a landlocked, freshwater population. He suggested that slower growth of male alewife may result from their early maturation. First year growth in length by each sex was greater than in any other year, comprising 67% to 69% of the mean total length attained by four-year-old fish (Table III-35). Nordon (1967) found similar growth rates for Lake Michigan alewives, which accrued 55.7% of their four-year growth in the first year. The higher percentage for first year growth in Lake Ontario alewives may have been partially due to gill net selectivity for the fastest growing members of the younger age groups. Validation of annulus interpretation, as discussed previously, indicated departures from the expected relationship between fish length at capture and predicted length at annulus formation (Table III-35).

TABLE III-34

CALCULATED GROWTH (mm) OF MALE AND FEMALE ALEWIFE YEAR CLASSES 1967 - 1972 COLLECTED IN LAKE ONTARIO AT NINE-MILE POINT DURING 1973.

Year Class	Age Group	Number Of Fish	Mean Length At Capture	Calculated Total Length at End of Year 1	2	3	4	5	6	7
				MALE						
1972	I	0	-	-	-	-	-	-	-	
1971	II	6	157.0	111.5	147.9	-	-	-	-	
1970	III	20	153.1	109.5	140.6	150.2	-	-	-	
1969	IV	27	155.9	107.1	140.0	148.8	155.1	-	-	
1968	V	1	233.0	116.9	174.1	194.0	206.7	223.1	-	
1967	VI	1	236.0	120.8	179.0	205.9	219.6	230.8	236.0	
Grand Average				108.9	142.4	151.5	159.1	226.9	236.0	
Sample Size				55	55	49	29	2	1	
Standard Deviation				8.19	11.53	13.92	19.47	5.45	-	
Standard Error				1.10	1.56	1.99	3.62	3.85	-	
Confidence Interval (= 0.05)				106.7-111.1	139.3-145.5	147.5-155.5	151.8-166.5	210.3-243.5		
Average Annual Increment				108.9	33.5	9.1	7.6	67.8	9.1	
				FEMALE						
1972	I	2	126.5	102.5	-	-	-	-	-	-
1971	II	22	126.5	110.5	134.1	-	-	-	-	-
1970	III	63	165.3	111.0	149.3	162.3	-	-	-	-
1969	IV	118	163.3	109.3	145.1	154.7	162.9	-	-	-
1968	V	30	178.8	113.2	152.2	164.4	172.3	178.5	-	-
1967	VI	6	199.2	113.3	153.3	170.3	182.7	189.1	198.5	-
1966	VII	1	217.0	139.5	165.5	184.5	192.0	199.5	206.0	217.0
Grand Average				110.4	146.1	158.8	165.7	180.8	199.6	217.0
Sample Size				242	240	218	155	37	7	1
Standard Deviation				13.68	13.36	14.81	13.64	16.21	11.86	-
Standard Error				0.88	0.86	1.00	1.10	2.67	4.48	-
Confidence Interval (= 0.05)				108.7-112.1	144.4-147.8	156.8-160.8	163.5-167.9	175.4-186.2	189.0-210.1	-
Average Annual Increment				110.4	35.7	12.7	6.9	15.1	18.8	17.4

TABLE III-35

Mean Calculated Total Lengths (mm) at Annulus Formation for Alewife

Age Group	Location and References		
	Long Pond, Maine Harvey (1961)	Lake Michigan Nordon (1967)	Nine-Mile Point Lake Ontario Present Study
I	135	94	110
II	221	140	145
III	274	159	157
IV	302	173	165
V	315		183
VI			204
VII			217

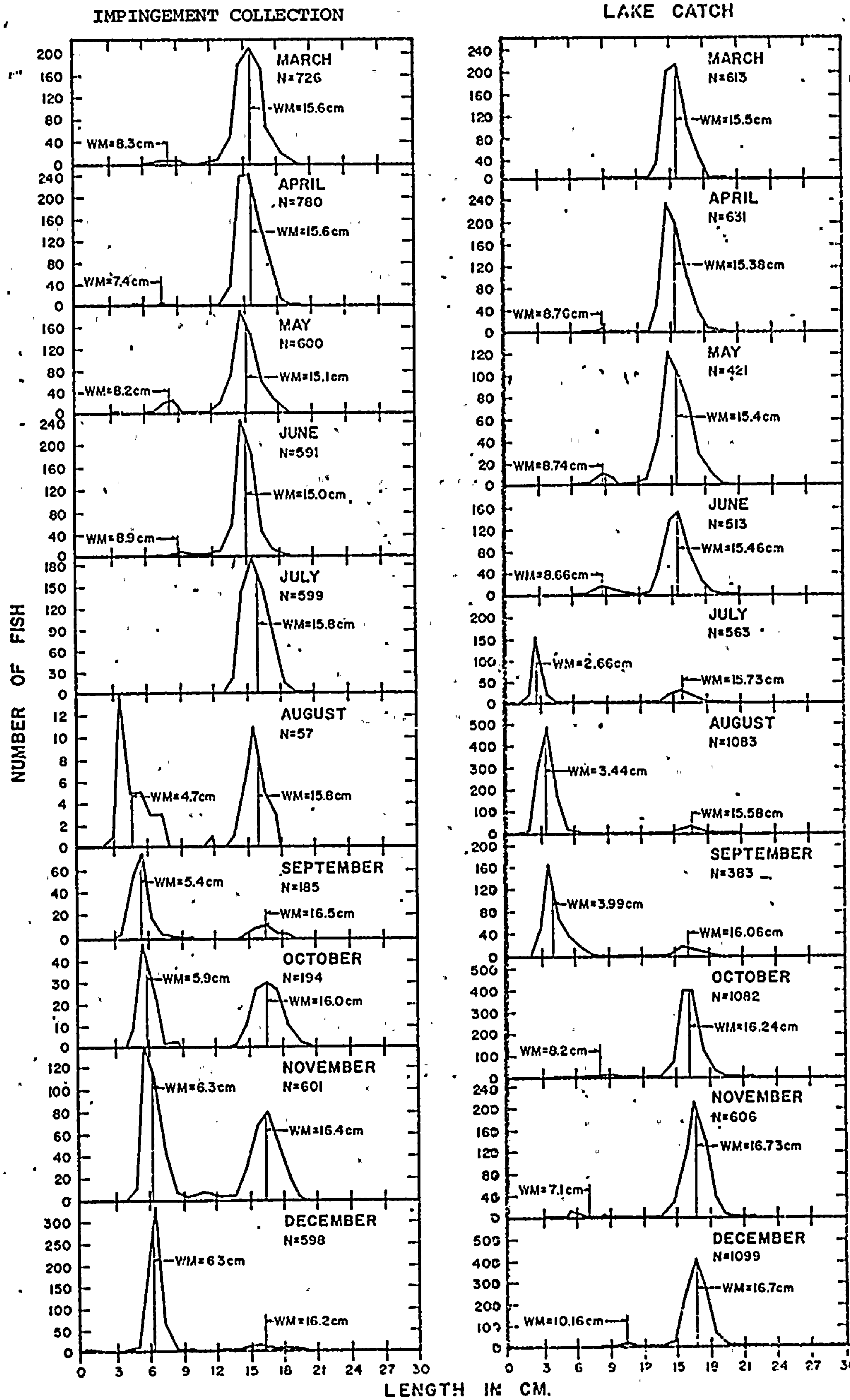
Alewife growth rates recorded from the Nine Mile Point area of Lake Ontario were compared to growth rates found for other freshwater alewife populations (Table III-34). It is apparent that few age and growth studies have been conducted on freshwater alewives and that calculated growth for Lake Ontario alewives was very similar to that found in Lake Michigan (Nordon, 1967).

Scale data in conjunction with length-frequency data showed that the alewife catch during March through June 1973 consisted mainly of fish from age groups II, III, and IV (Figure III-37; Table III-34). The April, May, and June catches showed a secondary peak representing yearling fish (age group I) averaging approximately 8.7cm in length. Young-of-the-year alewife were first recruited into the seine fishery at a mean length of 2.7cm during July, and young-of-the-year abundance was greatest during August collections (Figure III-37). These findings agree well with larval data which showed that the first appearance of alewife larvae at Nine Mile Point was during June and that peak abundance occurred during July 1973.

Young-of-the-year alewives dominated collections from July through September when their mean length was approximately 4cm. After September, the distinctness of the young-of-the-year mode was lost, and it was difficult to determine mean length for alewife in the 1973 year class at the end of the first growing season (Figure III-37). However, the persistence of the yearly peak with a mean length of approximately 8.7cm during April

LENGTH-FREQUENCY
ALEWIFE

Figure III-37



through June indicates that the average back-calculation estimate of 11cm for the first year alewife growth may be an overestimate (Table III-34).

(v) Rainbow Smelt

The body-scale relationship for 194 male and female rainbow smelt was expressed as $L = 49.9 + 54.7S$ ($r=0.77$) where L = total body length (mm) and S = total scale length (mm). The regression intercept of 49.9mm was used in this study as the correction factor for total body length at scale formation. McKenzie (1958) reported that smelt in the Miramichi River, New Brunswick, develop scales at a length of 20 to 25mm standard length.

Annulus formation for Lake Ontario rainbow smelt was 89% completed during June and 100% completed during July 1973. Bailey (1964) reported that annulus formation in Lake Superior smelt began after 6 June and was 100% complete by 24 August and that older fish formed annuli later than younger fish.

Length attained at the end of each year of life, i.e. at annulus formation, is presented for male and female smelt from year classes 1967 through 1972 collected at Nine Mile Point (Table III-36). Ninety-five percent confidence intervals of mean back-calculated lengths did not overlap up through age group II for males and up through age group IV for females. Females were larger than males of the same age. This difference was significant only for age group III. Bailey (1964) found that female smelt were larger than

TABLE III-36

CALCULATED GROWTH (mm) OF MALE AND FEMALE RAINBOW SMELT YEAR CLASSES 1967 - 1971 COLLECTED FROM LAKE ONTARIO AT NINE-MILE POINT DURING 1973.

Year Class	Age Group	Number Of Fish	Mean Length At Capture	Calculated Total Length at End of Year 1	2	3	4	5	6
				MALE					
1971	II	20	146.1	108.8	134.9	-	-	-	-
1970	III	9	157.7	97.7	126.1	145.2	-	-	-
1969	IV	3	172.0	99.1	126.5	145.2	162.5	-	-
1968	V	0	-	-	-	-	-	-	-
1967	VI	1	226.0	99.2	136.1	160.8	198.5	213.0	223.1
Grand Average				100.3	131.8	146.5	171.5	213.0	223.1
Sample Size				33	33	13	4	1	1
Standard Deviation				9.51	10.94	12.08	22.24	-	-
Standard Error				1.66	1.90	3.35	11.12	-	-
Confidence Interval (α= 0.05)				97.0-103.7	127.9-135.6	139.2-153.7	140.6-202.4	-	-
Average Annual Increment				100.3	31.5	14.7	25.0	41.5	10.1
				FEMALE					
1972	I	1	131.0	116.1	-	-	-	-	-
1971	II	52	146.8	101.6	137.3	-	-	-	-
1970	III	54	158.4	99.6	130.9	151.9	-	-	-
1969	IV	24	182.0	105.5	140.1	162.5	176.4	-	-
1968	V	16	211.0	111.6	151.7	165.4	191.9	204.2	-
1967	VI	6	233.0	115.7	155.4	184.1	193.0	212.2	228.7
Grand Average				103.2	137.7	158.6	184.0	206.4	228.7
Sample Size				153	152	100	46	22	6
Standard Deviation				11.13	16.15	18.44	24.13	21.25	19.70
Standard Error				0.90	1.31	1.84	3.56	4.53	8.04
Confidence Interval (α= 0.05)				101.4-104.9	135.1-140.3	154.9-162.2	176.8-191.2	197.0-215.8	209.0-248.4
Average Annual Increment				103.2	34.5	20.9	25.4	22.4	22.3

males after the second year of growth, and Burbidge (1969) found that females attained a greater mean length than males in age groups I through V. This difference in growth of the sexes of the Great Lakes has also been demonstrated by: Van Oosten (1947) in Green Bay, Lake Michigan; Baldwin (1950) in South Bay, Lake Huron; and Hale (1960) in western Lake Superior. The significance of these observations lies in the fact that biased sex ratio data may result from size-selective collection techniques.

First year length increases for each sex was greater than in any other year, comprising approximately 45% of the mean total length attained by six-year-old fish. Growth studies of smelt in Gull Lake, Michigan (Burbidge, 1969) and Lake Superior (Bailey, 1964) showed that greatest growth occurred in the second year of life.

Rainbow smelt growth rates recorded from the Nine Mile Point area of Lake Ontario were compared to growth rates found in several other aquatic environments (Table III-37). Growth rates from Crystal Lake (Beckman, 1942) were derived from actual length at capture rather than back-calculation methods. Because first year growth was based upon one-year-old fish collected during June when second year growth had already begun, it is evident that the first year growth estimate for Crystal Lake smelt was high. The Nine Mile Point estimate of first year growth was the next highest (Table III-37), but length-frequency analysis from April through November 1973 indicates that this estimate is also high (Figure III-38). April length-

TABLE III-37

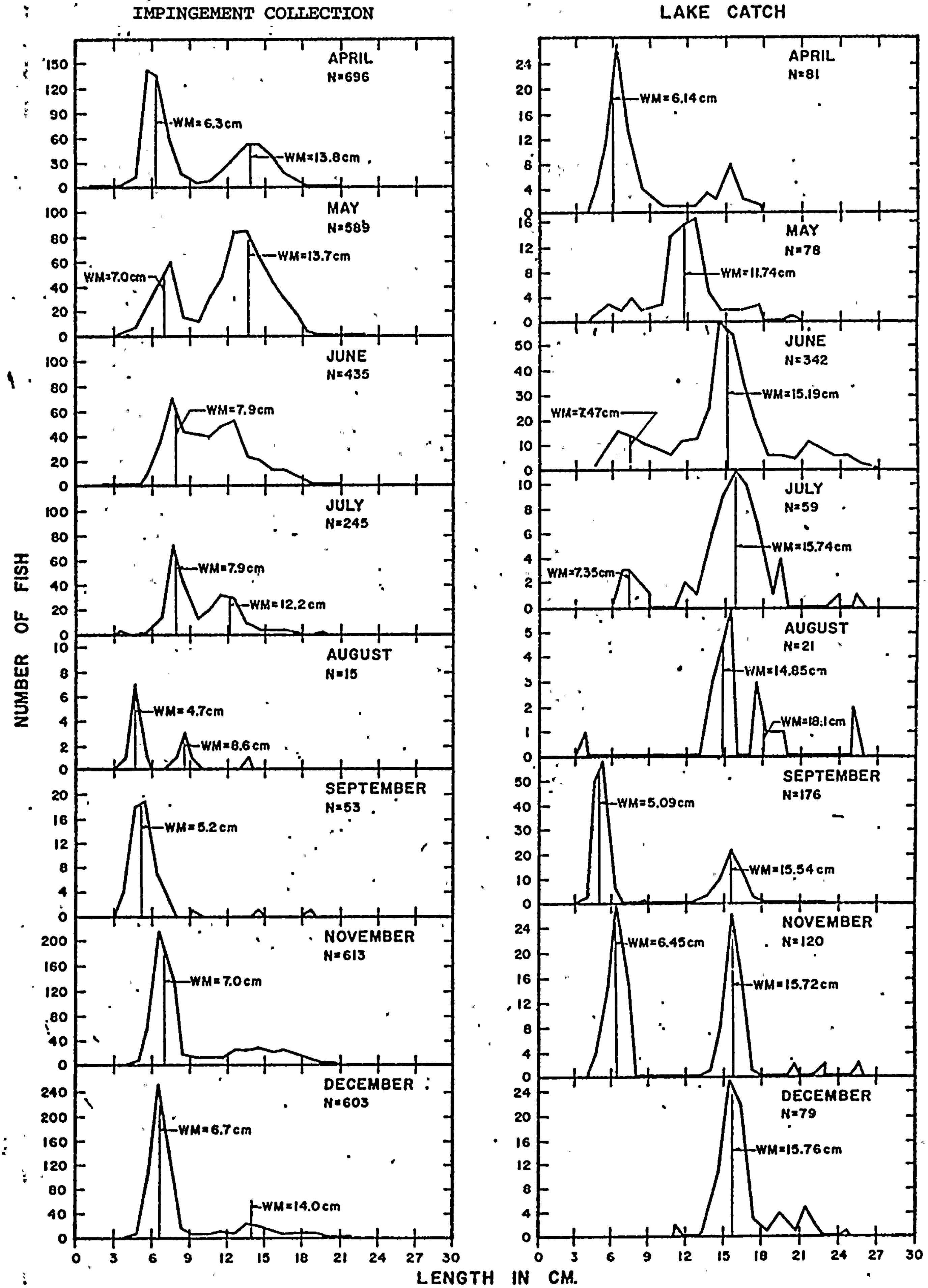
Mean lengths (mm) at various ages of rainbow smelt based upon several studies

	LOCATION AND REFERENCE				
Age Group	Crystal Lake Michigan Beckman (1942)	Green Bay, Lake Michigan Schneberger (1937)*	Lake Superior Bailey (1964)	Gull Lake, Michigan Burbidge (1969)	Nine-mile Point Lake Ontario Present Study
I	112	———	66	60	103
II	178	178	150	150	137
III	196	254	188	163	157
IV	209	305	212	180	183
V	210	356	229	198	207
VI			257	187	228
VII			310		

* After Beckman (1942)

LENGTH-FREQUENCY
RAINBOW SMELT

Figure III-38



frequency data (Figure III-38) shows a peak of 63 smelt with a mean total length of 61.4mm. Smelt do not spawn until April (Baldwin, 1948); since these fish are too large to be members of the 0 age group, they must be from age group I. Young-of-the-year smelt first became abundant in 1973 collections during September when their mean total length was 50.9mm (Figure III-38). By November, which is near the end of the growing season, their mean total length has increased to 64.5mm (Figure III-38). It is apparent from these data that 60 to 65mm is a more useful estimate of first year growth than the estimate of 103mm derived from back-calculation data. Some controversy exists as to whether or not all smelt form a detectable annulus between their first and second years of growth (McKenzie, 1958; Bailey, 1964). First year growth rates based on back-calculation data would be over estimated for Nine Mile Point smelt if the first annulus were not detectable in samples from late hatching smelt used in back calculations.

6. REPRODUCTION

a. Introduction

Successful reproduction is an important biological factor ensuring the survival of a species in the face of natural mortality and potential adverse environmental conditions. There are several factors which need to be studied in order to characterize the dynamics of reproduction for a fish

species. Among these are spawning periodicity, age at sexual maturity, sex ratio, and fecundity.

(i) Spawning Periodicity

The degree of reproductive success is often dependent upon accurate timing of spawning for those temperate-zone organisms which exhibit little or no parental care, including many of the fish species found in Lake Ontario. It is advantageous for young fish to have a long growing season in the first year, i.e. to begin life as close to the beginning of the growing season as possible. However, it is essential that the food reserves in the egg and yolk sac are not depleted prior to the availability of a suitable food supply for feeding larvae.

The yolk sac in several fish species is assimilated within four to seven days of hatching (Mansueti, 1958; Lasker, 1962; Humphries and Cumming, 1973), and the length of time prior to death by starvation for larval fish after yolk depletion appears to be only a matter of hours (Morris, 1955; Shelbourne, 1957; Bishai, 1960). Therefore, spawning must be synchronized with the annual cycle of food supply. It is also clear that spawning synchronization, if it is to serve as a mechanism of evolutionary success, must be preserved from year to year in spite of the fact that many environmental stimuli, such as water temperature, rainfall, and solar radiation may vary widely from one reproductive season to another.

One of the main concerns related to thermal effluents from electric generating stations is that the reproductive cycle and gonad maturation of fish may be affected by increased water temperature (Brungs, 1971; Edsall and Yocum, 1972). Therefore, a study of spawning cycles for resident fish species is essential to the evaluation of impact from thermal discharges.

(ii) Age at Maturity

Age at maturity, i.e. the length of time to reach sexual maturity, is one of the parameters by which fish populations can regulate their density. The onset of maturity is usually related to the attainment of a particular size of the individual, and the slower the growth rate of the fish, the later the onset of maturity (Mansueti, 1961a; Nikolsky, 1963). Therefore, when population density increases and/or the food supply decreases for example, there is often a concomitant retardation in growth rate resulting in a later onset of sexual maturity. In stable populations the largest age classes numerically are the youngest age classes. Hence, elimination of the youngest age class from a breeding population can have an immediate effect on recruitment for the year and a long-range reduction in the breeding potential of the stock.

Sexual maturity seems to be a function of size rather than age (Mansueti, 1961) and usually occurs later in life at higher latitudes due to lower temperatures and shorter growing seasons (Nikolsky, 1963).

(iii) Sex Ratio

Sex ratio, or the relationship between numbers of males and numbers of females in an area during a given time or over an entire catch period, can be used to aid in determining spawning movements, spawning locations, and differential mortality between sexes. Spawning areas for smelt, for example, are typically characterized by a sex ratio dominated by males at the start of the run, a 1:1 ratio during the peak and a preponderance of females toward the end (Baldwin, 1948; Bailey, 1964). Mansueti (1961a) found that white perch sex ratio on spawning grounds in the Patuxent River favored males during the spawning season and, at the same time, the lower estuary had a sex ratio which favored females. Bigelow and Schroeder (1953) reported that male alewives greatly outnumbered the females on the spawning grounds.

In addition to providing information on spawning dynamics, sex ratio analysis, in conjunction with knowledge of age groups, can supply information on mortality rates and longevity of the different sexes within a species. Sheri and Power (1968) found that the ratio of female to male white perch in Lake Ontario tended to increase with age, suggesting that females experienced a lower mortality rate. Other investigators have reported a similar

trend for rainbow smelt (McKenzie, 1958; Burbidge, 1969). Knowledge of sex ratio dynamics is necessary in order to make an intelligent estimate of egg production, which is an important input to many biological population models.

(iv) Fecundity

Another important facet of fish reproduction is fecundity, which is defined as the total number of mature eggs spawned per female during a season. In addition to being a necessary input for mathematical modelling of fish populations, fecundity may reflect physical and biological conditions in the environment. Blaxter (1969) stated that considerable intraspecific variations in fecundity from year to year, is certainly related to environmental effects, which is well-established in the literature. Rounsefell (1957), for example, noted that higher temperatures resulted in lower fecundities; Bagenal (1966) reported that high population densities were correlated with low fecundity; Scott (1961) indicated that insufficient food supply caused a reduction in egg count. These ecological parameters affecting fecundity are all subject to man's influence upon the aquatic environment as well as natural variation within the ecosystem itself.

b. Results and Discussion

Spawning periods for five fish species were investigated by plotting gonad weight expressed as a percentage of the body weight (coefficient of maturity)

against time. In order to obtain a true picture of the cyclic aspect of reproduction, this relationship should be followed through several annual cycles. However, 1973 data were collected mainly around the time of spawning for each species and, in some cases, most of the data were collected after the spawning peak.

(i) Yellow Perch

A total of 424 yellow perch were analyzed for coefficient of maturity between 25 April and 21 September 1973 (Table III-38). A graph of these data shows that yellow perch spawning had begun by 25 April (Figure III-39). The next date for which data are available is 4 June; it is difficult to interpolate the spawning curve during the month of May.

Muncy (1962) reported that yellow perch from the Severn River, Maryland, began spawning in the beginning of March when water temperatures varied between 36°F and 44°F. Peak spawning occurred around mid-March when water temperatures ranged from 38°F to 45°F. Similar temperature ranges have been reported for yellow perch spawning in California (Curtis, 1949; Coots, 1956).

The descending portion of the yellow perch spawning curve (indicating spawning) occurred during April and May 1973 when the water temperature in the vicinity of Nine Mile Point ranged from 40°F to 50°F (Figure III-40). Therefore, it appears that the temperature regime within which spawning occurred in Lake Ontario is similar to that reported in the literature.

TABLE III-38

COEFFICIENT OF MATURITY VALUES, SAMPLE SIZE AND COLLECTION DATES FOR YELLOW PERCH COLLECTED DURING 1973 IN THE VICINITY OF NINE-MILE POINT, LAKE ONTARIO

Males			Females		
Collection Date	Sample Size	Coefficient of Maturity	Collection Date	Sample Size	Coefficient of Maturity
4/25	3	2.16	4/25	2	2.53
6/4	68	1.00	6/4-6/6	269	1.33
6/18	13	0.53	6/18	39	1.57
6/25	2	0.37			
7/4	26	1.07			
9/21	2	2.62			
	114			310	

YELLOW PERCH REPRODUCTIVE CYCLE AT NINE MILE POINT DURING THE 1973 SPAWNING SEASON

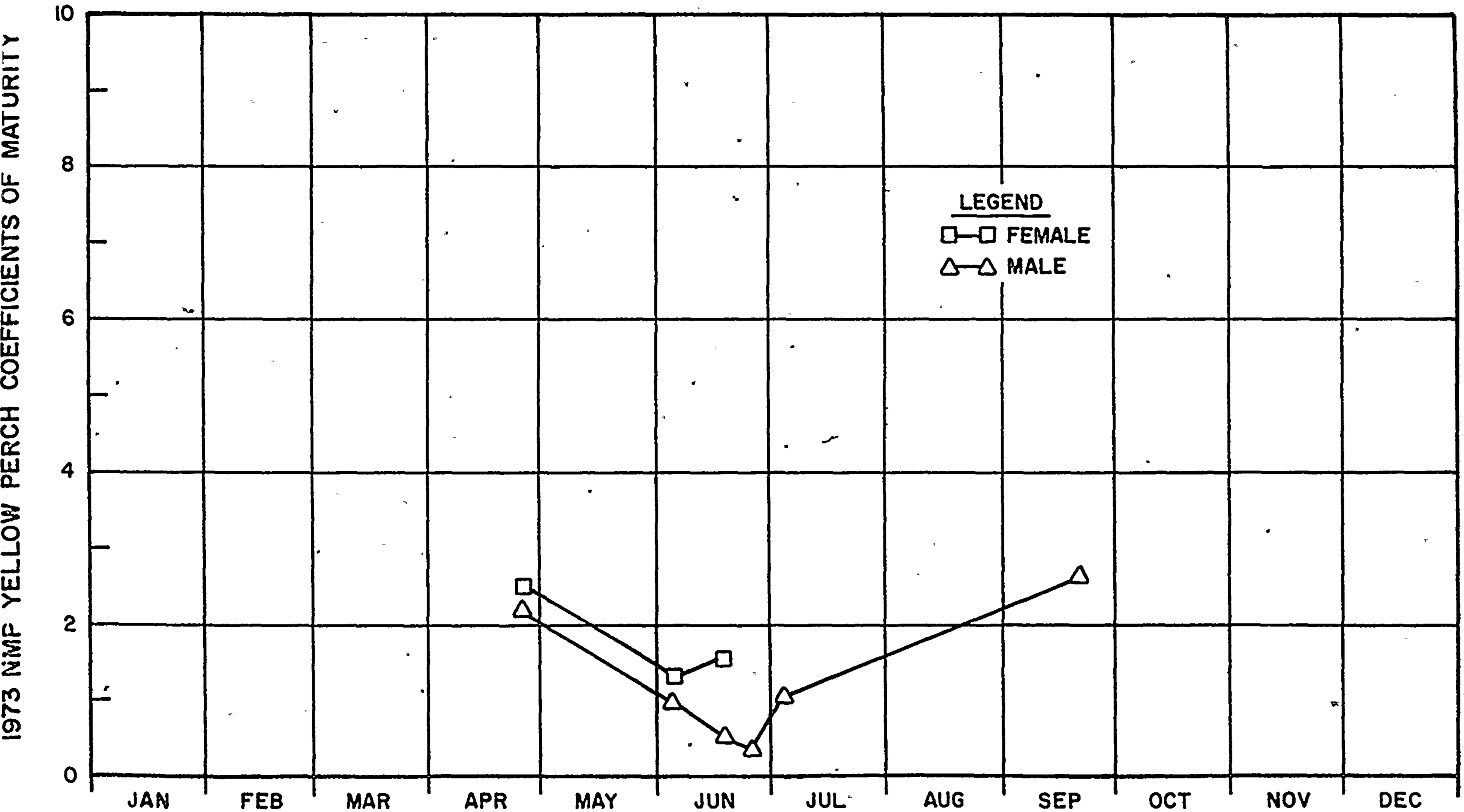


FIGURE III-39

WHITE PERCH REPRODUCTIVE CYCLE AT NINE MILE POINT DURING THE 1973 SPAWNING SEASON

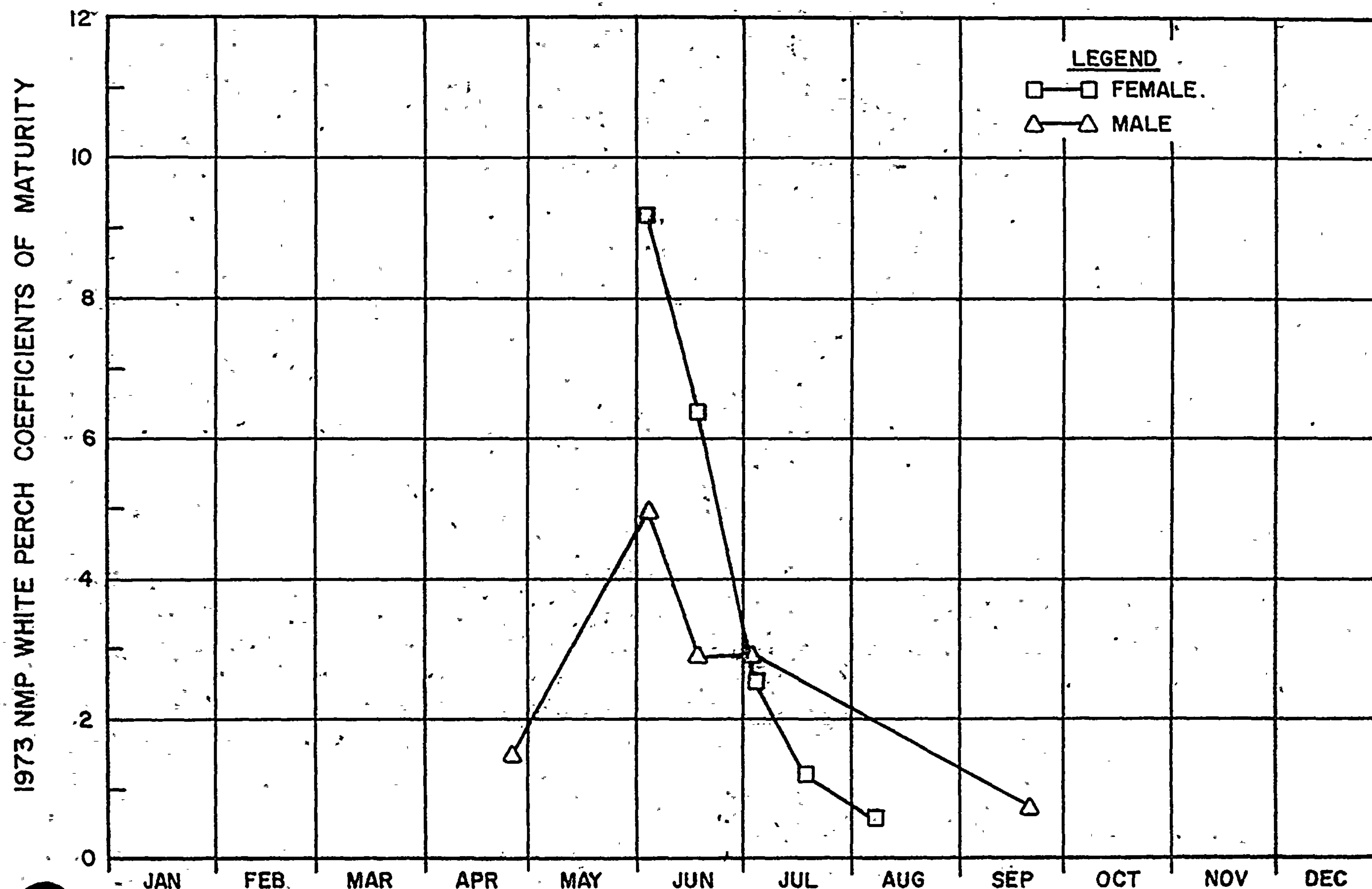


FIGURE III-40

Gonadal maturation is an important part of fish reproductive cycles and often occurs during periods of low water temperature when fish are relatively inactive and body growth has almost ceased for the year. Brungs (1971) suggested that fathead minnows (Pimephales promelas) require low pre-spawning temperatures to achieve normal gonadal maturation, and Edsall and Yocum (1972) indicated that yellow perch need a similar temperature regime prior to early spring spawning.

(ii) White Perch

The spawning condition of 190 male and 474 female white perch was examined between 25 April and 21 September 1973 (Table III-39). A plot of the data shows that white perch spawning began sometime between 4 June and 18 June Figure III-40). Small sample sizes tend to confuse the male spawning curve, but the female curve shows peak spawning activity from early June through mid-July when water temperatures ranged from 50°F to 72°F. Other investigators have reported similar reproductive performance for white perch. Thoits (1958) stated that Maine white perch spawned from 27 May through 22 July when water temperatures were between 58°F and 60°F. Miller (1963) found that peak spawning for white perch in the Delaware River

TABLE III-39

COEFFICIENT OF MATURITY VALUES, SAMPLE SIZE AND COLLECTION DATES FOR WHITE PERCH COLLECTED DURING 1973 IN THE VICINITY OF NINE-MILE POINT, LAKE ONTARIO

Males			Females		
Collection Date	Sample Size	Coefficient of Maturity	Collection Date	Sample Size	Coefficient of Maturity
4/25	2	1.47	6/4	78	9.27
6/4	79	4.97	6/18	32	6.40
6/18	7	2.90	7/4	73	2.52
7/4	97	2.91	7/18	206	1.21
9/21	5	0.76	8/8	85	0.52
	190			474	

occurred during the latter part of June and early July and that the average spawning temperature was 59°F to 60.8°F. Sheri and Power (1968) reported that white perch spawning in Lake Ontario took place from the middle of May to the end of June when water temperatures ranged from 51.8°F to 59.0°F.

For comparison, white perch spawning cycles in the Hudson River during 1971 and 1972 are shown in relation to water temperature and photoperiod (Figure III-41). Analysis of a two year reproductive cycle for white perch on the Hudson River supplied evidence that the timing of white perch spawning was more closely related to photoperiod (day length) than water temperature, (QL&M, 1974). This agrees with observations by Bunning (1967) and Schwassmann (1971) that the physiological clock upon which organisms depend for orientation to the proper time of year is somewhat independent from temperature fluctuations. Schwassmann (1971) stated that the many environmental fluctuations correlated with the annual cycle of seasonal change, the systematically changing length of day seemed to provide one of the most reliable time markers which could account for the accuracy in occurrence of annual breeding behavior in fish. Additional information was provided by Kaya and Hassler (1972) who demonstrated in the laboratory that gonadal recrudescence (seasonal increase in gonad at activity) was stimulated in adult male and female green sunfish (Lepomis cyanellus) only by a combination of both elevated water temperatures (>59.0°F) and long photoperiod (15 hr.) Manipulation of either parameter by itself was not sufficient to induce gonadal maturation.

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WHITE PERCH REPRODUCTIVE CYCLE AT BOWLINE DURING 1971 & 1972 SPAWNING SEASONS

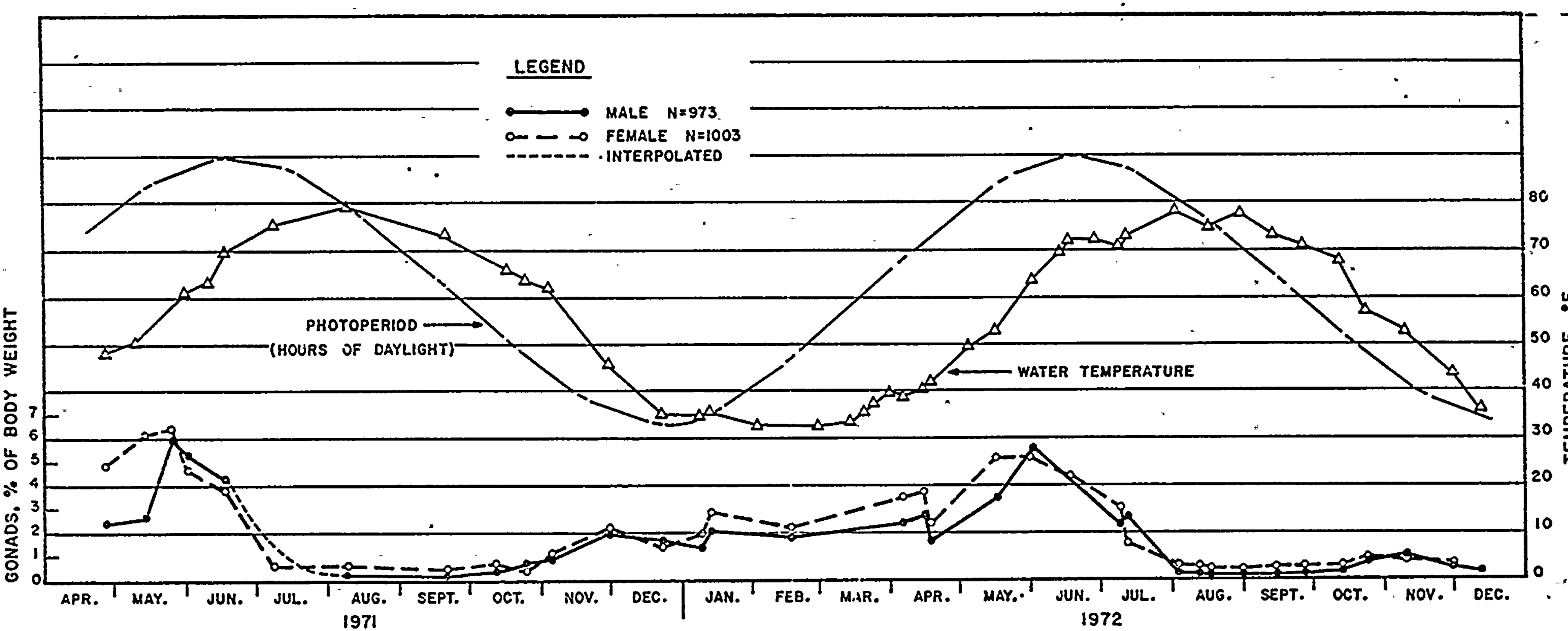


FIGURE III-41

These findings are mentioned in order to emphasize that slight localized temperature increases due to the effect of electric generating stations on Lake Ontario are not likely to influence spawning periodicity such as that described for white perch and yellow perch. This statement, of course, does not apply to those fish which actively seek waters within the influence of a thermal plume and overwinter in such areas.

Fecundity measurements were made on 32 white perch collected at Nine Mile Point during June 1973 (Table III-40). The range of fish lengths was 118 to 293mm and the range for egg counts was 16,116 to 520,332 eggs. The relationship between white perch fecundity and body length, body weight and ovary weight was as follows:

	Body Length (x)	Body Weight (x)	Ovary Weight (x)
Log Number of Eggs (y)	$y = 4.955 + 0.0006x$	$y = 4.958 + 0.0006x$	$y = 4.856 + 0.0111x$
Correlation Coefficient (r)	0.08	0.20	0.36

The generally low correlation coefficients in the above table denote a low capability to predict fecundity based on the three parameters investigated. Sheri and Power (1968) investigated fecundity of 50 white

TABLE III-40

SUMMARY OF FECUNDITY DATA FOR 32 WHITE PERCH COLLECTED FROM LAKE ONTARIO AT NINE MILE POINT DURING JUNE, 1973.

(mm) Fish Length	(g) Fish Weight	(g) Ovary Weight	Number of Eggs	Log Number of Eggs	Collection Date
118	176.1	28.31	179,711.6	5.255	6/6
132	185.2	15.5	264,167.0	5.422	6/6
172	85.6	7.71	57,919.8	4.763	6/5
177	77.8	7.97	85,485.8	4.932	6/4
190	103.5	13.22	126,482.4	5.102	6/4
201	143.1	9.69	109,212.0	5.038	6/4
205	135.6	14.40	59,416.6	4.774	6/4
207	151.5	8.75	98,766.6	4.995	6/4
208	135.2	12.35	98,998.6	4.996	6/4
212	150.6	9.19	153,711.4	5.187	6/4
215	188.2	22.15	253,222.8	5.404	6/5
216	160.7	14.13	76,950.6	4.886	6/4
216	176.5	20.52	16,116.4	4.207	6/4
217	160.7	22.45	98,313.4	4.993	6/4
219	181.9	26.09	196,205.6	5.293	6/4
220	151.5	13.30	60,561.8	4.782	6/4
230	205.2	18.64	183,486.4	5.264	6/4
234	233.9	14.78	121,695	5.085	6/5
235	207.9	14.25	58,175.8	4.765	6/4
235	214.6	26.29	130,380.2	5.115	6/5
237	248.8	20.37	292,198.4	5.466	6/4
239	238.0	27.71	291,791.8	5.465	6/6
262	321.3	29.85	161,067.6	5.207	6/5
266	339.7	40.33	520,332.0	5.716	6/4
270	352.3	23.01	155,143	5.191	6/18
270	363.4	46.32	185,400.0	5.268	6/4
277	393.2	30.87	264,230.6	5.422	6/18
278	374.8	33.49	166,891.4	5.222	6/5
281	403.8	43.95	311,867.25	5.494	6/6
292	404.3	26.89	230,162.4	5.362	6/17
295	493.4	33.77	17,407.2	4.241	6/18
298	378.0	35.13	90,729.2	4.958	6/6

Number of Fish	Mean Fish Length	Mean Egg Count	Range Egg Count	Standard Deviation	Confidence Limits ($\alpha = 0.05$)
32	228.9	159,881	16,116 -520,332	105,108.8	121,976 -197,786

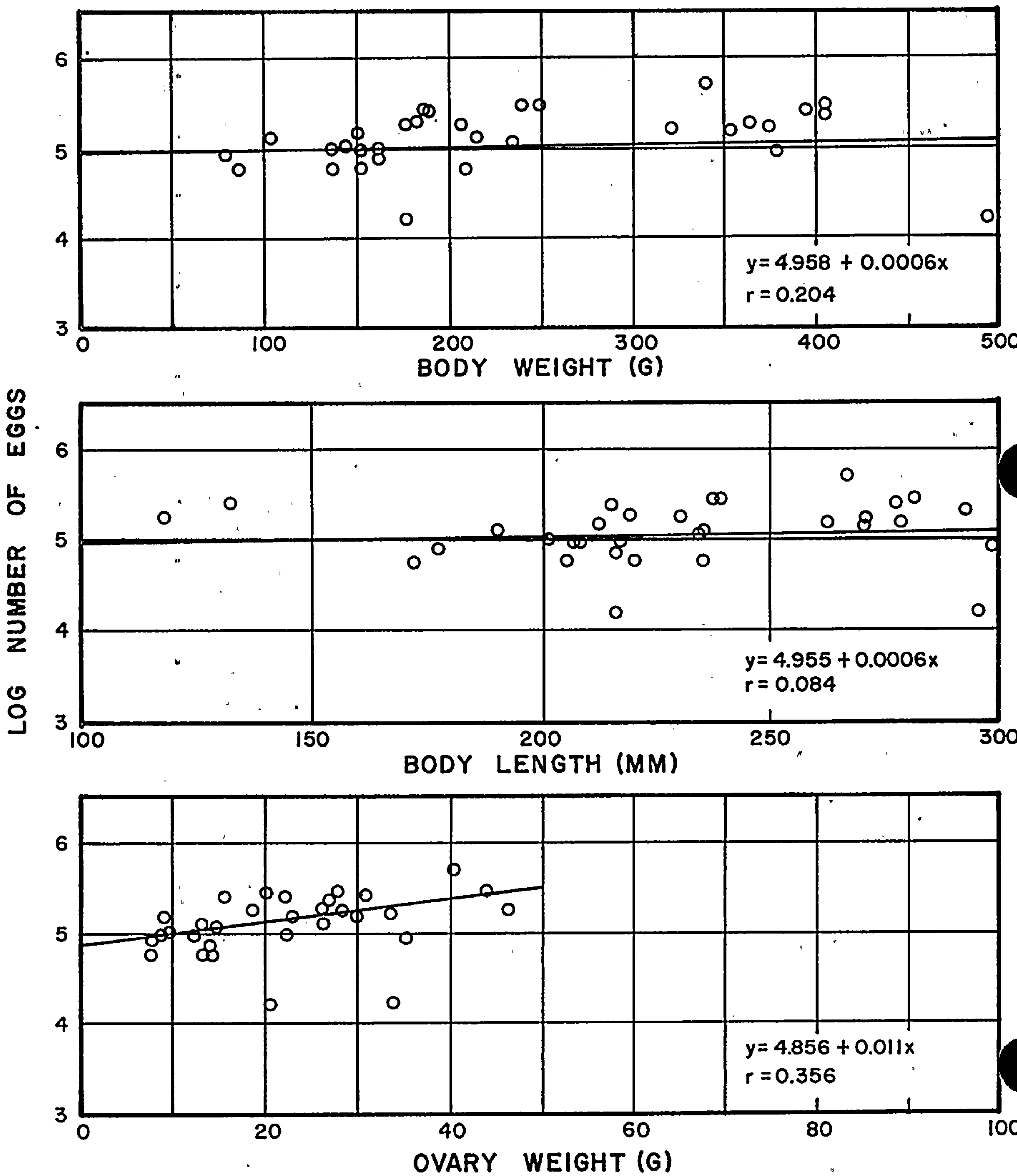
perch in the Bay of Quinte, Lake Ontario, and found relatively high correlation coefficient for the relationship between fecundity vs. weight of ovaries (r = 0.83) and fecundity vs. length of fish (r = 0.82).

One reason for lack of correlation in the Nine Mile Point data may be the fact that white perch had already begun spawning when fecundity samples were collected between 4 June and 18 June (Figure III-42). Sheri and Power (1968) found that white perch spawning in the Bay of Quinte took place from mid-May to the end of June between 1957 and 1966. Partial spawning and differential spawning times for individual fish would necessarily cause scattered counts among fish collected after the onset of spawning.

Fecundity is a measurement of egg production and therefore only those eggs which are to be spawned should be counted. A study of Hudson River white perch revealed that approximately 12,971 eggs were retained by each individual female after spawning (Texas Instruments, 1973). Sheri and Power (1968) accounted for egg retention by counting only those eggs in the largest of three size categories found in mature white perch ovaries. Egg counts from the Nine Mile Point study are total egg counts with no reference to egg size.

NINE MILE POINT

RELATIONSHIP BETWEEN LOG NUMBER OF EGGS VS BODY WEIGHT, BODY LENGTH & OVARY WEIGHT FOR 32 WHITE PERCH



(iii) Rainbow Smelt

The spawning conditions of 204 female and 44 male rainbow smelt were examined between 28 March and 15 December 1973 (Table III-41). Some insight into the spawning dynamics of smelt can be gained from a graph of these data, although the sample sizes are small. The lack of synchrony between male and female spawning curves is evident (Figure III-43) and is characteristic for a population which does not spawn in the area sampled, and which moves in sexually segregated waves to the spawning grounds. Smelt are not open water lake spawners, but typically ascend streams and small freshets to spawn (Baldwin, 1948). Spawning runs in the area of the Great Lakes begin during early April, and males predominate during the first part of the runs, often composing 90% of the catch. Females do not become numerous until the latter part of the spawning runs (Baldwin, 1948; Bailey, 1964).

Figure III-43 indicates that the first part of the smelt run had begun when sampling was initiated at Nine Mile Point during March 1973 and that most of the mature male smelt were already in or near the mouths of spawning streams. However, gill net sampling appeared to collect mature females near the peak of the run during April, although the small sample size of seven females in April may not be representative of the spawning population.

TABLE III-41

COEFFICIENT OF MATURITY VALUES, SAMPLE SIZE AND COLLECTION DATES FOR RAINBOW SMELT COLLECTED DURING 1973 IN THE VICINITY OF NINE-MILE POINT, LAKE ONTARIO

Males			Females		
Collection Date	Sample Size	Coefficient of Maturity	Collection Date	Sample Size	Coefficient of Maturity
3/28	5	2.22	3/28	22	8.64
4/26	3	2.18	4/26	7	19.96
6/4	8	1.62	5/31	1	2.08
8/22	2	0.47	6/4	54	2.82
9/17	2	2.36	7/18	7	0.31
10/8	5	1.59	8/22	9	0.64
11/26	9	2.88	9/17	4	0.93
12/2	10	3.89	9/26	6	1.01
			10/8	29	1.84
			11/26	23	2.24
			12/2	39	3.35
			12/15	1	1.82
	44			204	

RAINBOW SMELT REPRODUCTIVE CYCLE AT NINE MILE POINT DURING THE 1973 SPAWNING SEASON

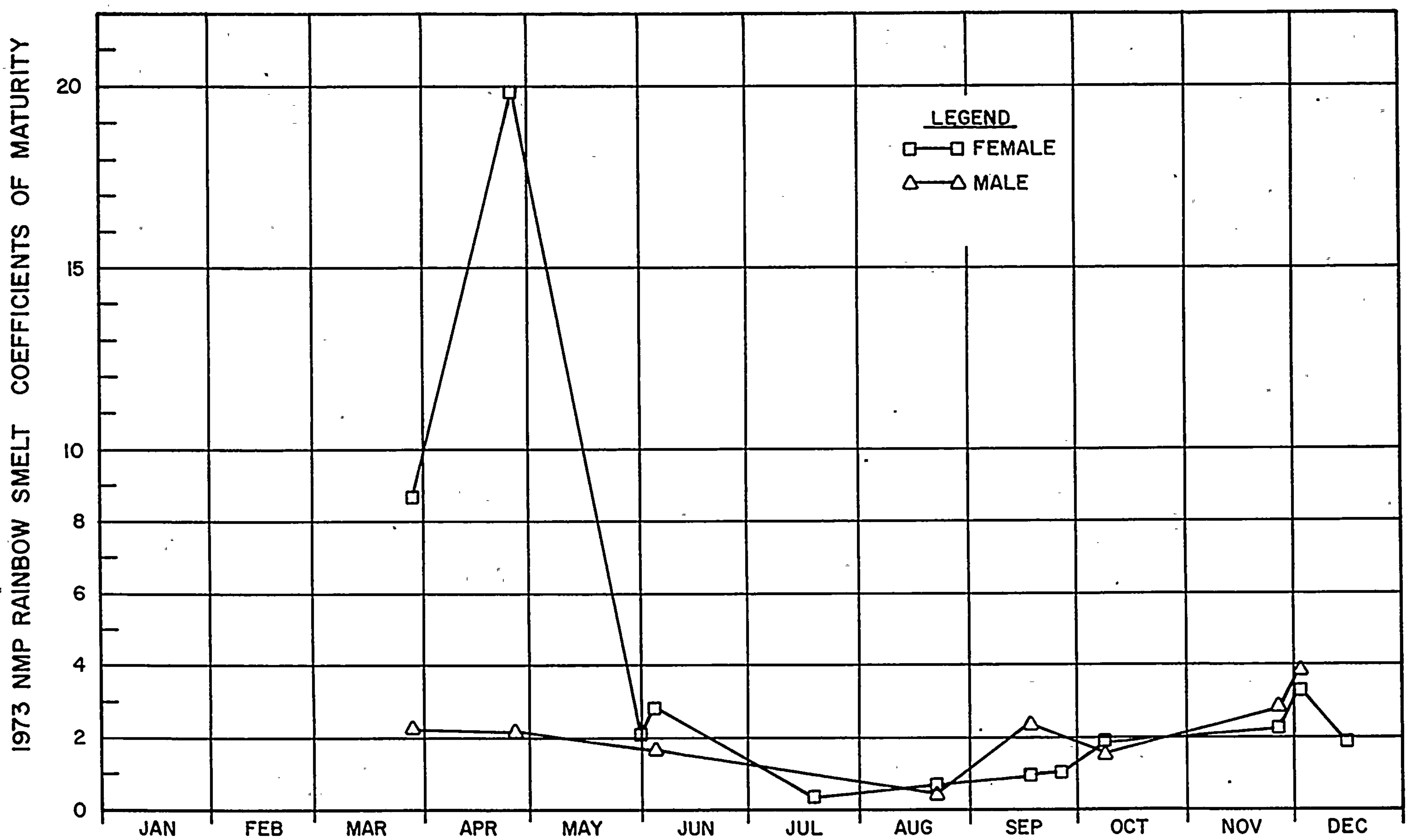


FIGURE III-43

(iv) Alewives

The spawning condition of 313 male and 731 female alewives were examined between 4 June and 2 December 1973 (Table III-42). A plot of the data shows that peak alewife spawning occurred during July, but that the gonadal peaks for male and female alewives were somewhat out of phase (Figure III-44). The females reached peak maturity by approximately 4 June, whereas the males had apparently built up their gonadal peak around 18 June. This lack of synchrony between male and female maturity peaks is characteristic for a population which does not spawn in the area sampled and which moves in sexually segregated waves to the spawning grounds. A similar situation was discussed previously for rainbow smelt in the area of Nine Mile Point.

Breder and Rosen (1966) stated that landlocked alewives retained their migratory habits as much as possible and tended to move up to the head of the Lake for spawning. The head of Lake Ontario is the western end, since prevailing currents move from west to east. It is very possible that the bulk of alewife spawning in Lake Ontario during 1973 occurred someplace other than the Nine Mile Point area. This hypothesis is supported by the fact that the sex ratio for alewives at Nine Mile Point during the spawning period was greatly in favor of females (Table III-43).

Sex ratios are often biased when females are larger than males of the same age (see Age and Growth section) and when collection techniques rely

TABLE III-42

COEFFICIENT OF MATURITY VALUES, SAMPLE SIZE AND COLLECTION DATES FOR ALEWIVES COLLECTED DURING 1973 IN THE VICINITY OF NINE-MILE POINT, LAKE ONTARIO

Males			Females		
Collection Date	Sample Size	Coefficient of Maturity	Collection Date	Sample Size	Coefficient of Maturity
6/4	25	4.98	6/4	100	7.90
6/18	12	5.49	6/18	100	9.36
7/4	5	3.29	7/4	100	11.42
7/18	37	2.36	7/18	100	6.80
8/8	59	0.67	8/8	100	1.41
8/22	85	0.66	8/24	103	1.10
9/17	20	0.67	10/31	69	1.56
9/22	19	0.57	12/4	51	1.64
10/8	9	0.70	12/16	8	2.05
10/31	13	0.80			
11/26	7	0.93			
12/2	22	1.05			
	313			731	

ALEWIFE REPRODUCTIVE CYCLE AT NINE MILE POINT DURING THE 1973 SPAWNING SEASON

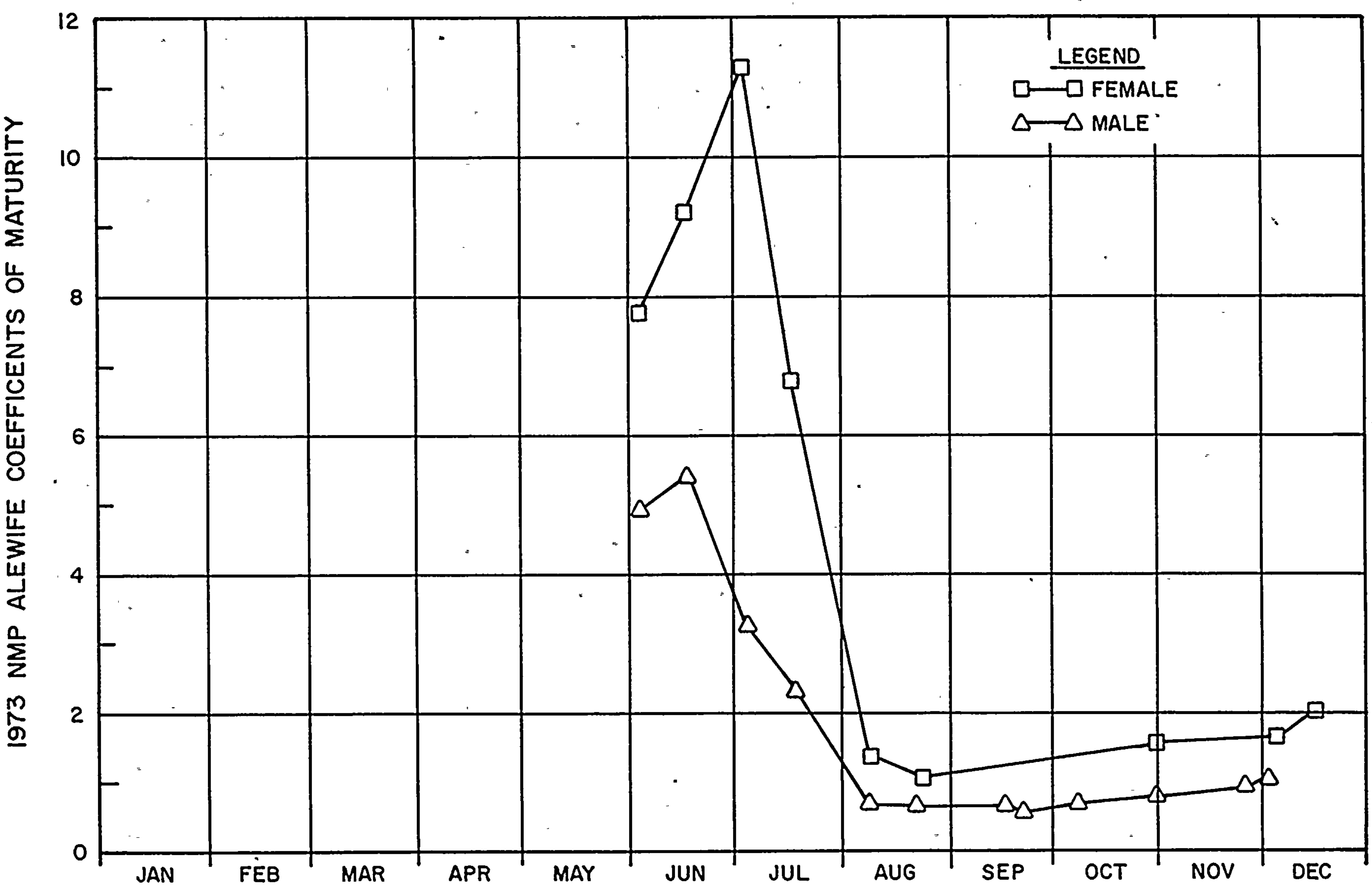


FIGURE III-44

TABLE III-43

COMPARISON OF SEX RATIOS FOR ALEWIVES COLLECTED BY GILL NETS AND TRAWLS VERSUS IMPINGEMENT AT NINE-MILE POINT, LAKE ONTARIO DURING 1973.

	Number of Males		Percent Males in Total Catch		Number of Females		Percent Females in Total Catch		Male:Female Sex Ratio	
Month Collected	Lake	Impingement	Lake	Impingement	Lake	Impingement	Lake	Impingement	Lake	Impingement
January	-	0	-	0	-	1	-	100		
February	-	-	-	-	-	-	-	-		
March	5	932	2.6	41.5	191	1313	97.4	58.5	1:38.2	1:1.4
April	16	122	8.2	18.3	180	544	91.8	81.7	1:11.1	1:4.5
May	13	205	6.6	21.4	183	753	93.4	78.6	1:14.1	1:3.7
June	22	44	11.2	4.1	174	1035	88.8	95.5	1:7.9	1:23.5
July	8	34	4.1	1.3	188	2574	95.9	98.7	1:23.5	1:75.7
August	55	0	28.1	0	141	26	71.9	100	1:2.6	0:26.0
September	31	1	15.8	3.2	165	30	84.2	96.8	1:5.3	1:30.0
October	7	11	3.6	9.0	189	111	96.4	91.0	1:27	1:10.1
November	9	114	4.5	14.6	191	665	95.5	85.4	1:21.2	1:5.8
December	26	2	13.3	1.9	170	101	86.7	98.1	1:6.5	1:50.5
Annual Average			9.8	17.0			90.2	83.0	1:9.2	1:4.9

mainly on size-selective gear such as gill nets. However, impingement collections, which appear to be a fairly representative sample of the alewife population, also reflected a high preponderance of females at Nine Mile Point during June, July, and August (Table III-43). Spawning populations of anadromous alewives are typically characterized by greater numbers of males than females (Bigelow and Schroeder, 1953; Kissil, 1969), and similar findings were reported for landlocked alewives in Cayuga Lake, New York (Rothschild, 1966). The data collected during 1973 suggest that the Nine Mile Point area was not used extensively as a spawning ground for Lake Ontario alewife.

Fecundity measurements were made on 11 alewives collected at Nine Mile Point during June 1973 (Table III-44). The range of fish lengths was 156 to 181mm and the range of egg counts was 25,798 - 67,739 eggs. A range in egg production from 11,147 to 22,407 eggs per female was reported for similar sized alewives collected from Lake Michigan during July 1965 (Norden, 1967). Both of these estimates are based on total egg count and, because they do not account for egg retention, may overestimate actual egg production of freshwater alewives. Data from anadromous Connecticut River alewives show that females retained approximately 22,000 eggs after spawning (Kissil, 1969). The relationship between alewife fecundity and body length, body weight and ovary weight is as follows:

	Body Length (x)	Body Weight (x)	Ovary Weight (x)
Log Numbers of Eggs (y)	$y = 4.513 + 0.0005x$	$y = 4.2862 + 0.0106x$	$y = 4.6002 + 0.0124x$
Correlation Coefficient (r)	0.28	0.24	0.09

TABLE III-44

SUMMARY OF FECUNDITY DATA FOR 11 ALEWIVES COLLECTED FROM LAKE ONTARIO AT NINE MILE POINT IN JUNE, 1973.

Fish Length (mm)	Fish Weight (g)	Ovary Weight (g)	Number of Eggs	Log Number of Eggs	Collection Date
156	33.2	4.19	55,162.2	4.742	6/17
161	32.9	3.63	40,396.4	4.606	6/19
161	34.1	3.33	54,345.0	4.735	6/19
163	37.4	4.41	25,797.6	4.412	6/18
166	31.6	4.47	28,655.8	4.457	6/19
166	38.7	4.94	67,739.2	4.831	6/19
167	35.6	4.69	61,378.0	4.788	6/19
168	39.4	6.47	47,332.2	4.675	6/19
172	30.9	3.45	37,442.8	4.573	6/19
178	34.5	4.32	44,920.2	4.652	6/19
181	31.6	3.32	51,861.6	4.715	6/19

Number of Fish	Mean Fish Length (mm)	Mean Egg Count	Range Egg Count	Standard Deviation	Confidence Limits (α = 0.05)
11	167.182	46,821	25,797.6-67,739.2	13,061.9	38,038.57-55,603.43

The correlation coefficients indicate that the predictive capability of these equations is low.

(v) Smallmouth Bass

The spawning condition of 49 male and 132 female smallmouth bass was examined between 4 June and 9 August 1973 (Table III-45). A plot of the data shows that the peak of female spawning activity occurred during the latter part of June and July (Figure III-45). The apparent lack of participation by males suggested by the spawning curve may be due to the nesting habits of this species. Beeman (1924) stated that the male alone selects the location and prepares the nest prior to spawning. After the nest is built, the male stays in the immediate vicinity. The nests are usually in 2 to 12 feet of water, thus presenting the possibility that sexually mature, spawning males would be absent from the major areas of gill net collection at Nine Mile Point.

Stone et al. (1954) stated that there was considerable variation in the spawning time of smallmouth bass in the eastern Lake Ontario - Thousand Islands region, which is a major spawning area for Lake Ontario smallmouth bass. Relatively early spawning (latter part of May or early June) was characteristic of the bass which spawned in streams, near creek mouths or in the shallow waters of some of the bays. Those bass influenced by the cold water of Lake Ontario did not spawn until the latter part of

TABLE III-45

COEFFICIENT OF MATURITY VALUES, SAMPLE SIZE AND COLLECTION DATES FOR SMALLMOUTH BASS COLLECTED DURING 1973 IN THE VICINITY OF NINE-MILE POINT, LAKE ONTARIO

Males			Females		
Collection Date	Sample Size	Coefficient of Maturity	Collection Date	Sample Size	Coefficient of Maturity
6/4	7	0.59	6/4	10	5.52
6/19	2	0.44	6/19	3	9.98
7/19	9	0.24	7/4	16	4.70
8/9	31	0.13	7/19	46	2.30
			8/9	57	0.84
	49			132	

SMALLMOUTH BASS REPRODUCTIVE CYCLE AT NINE MILE POINT DURING THE 1973 SPAWNING SEASON

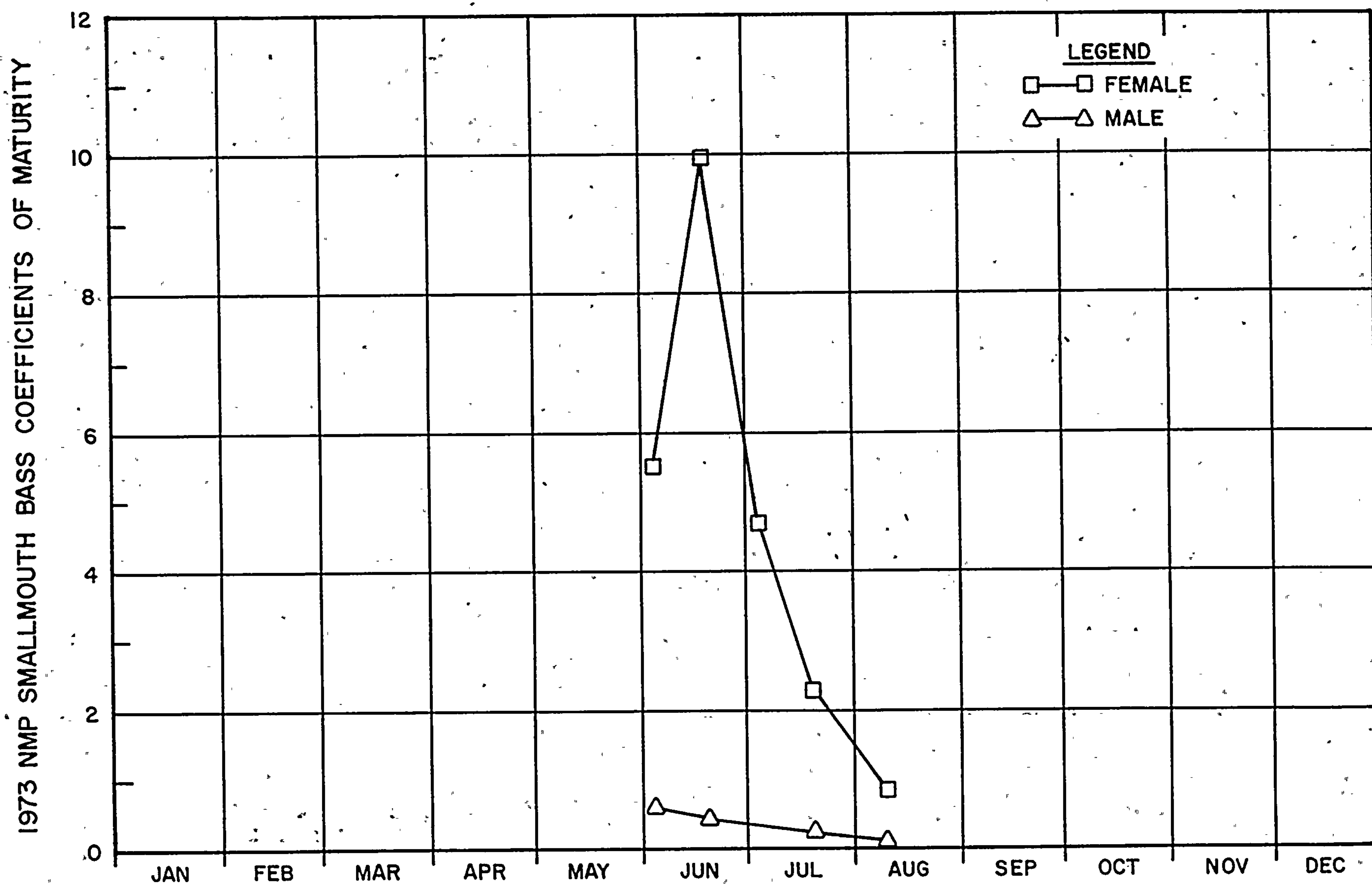


FIGURE III-45

June or well into July. Hubbs and Bailey (1938) reported that smallmouth bass spawning occurred at water temperatures of 59°F to 65°F, and Stone et al. (1954) observed spawning within a temperature range of 61°F to 70°F. Lake temperatures in the vicinity of Nine Mile Point intake from mid-June through July, which is the spawning period indicated by Figure III-45, ranged from 53°F to 79°F.

Fecundity measurements were made on 21 smallmouth bass collected at Nine Mile Point from 4 June through 9 August 1973 (Table III-46). The range of fish lengths was 260 to 397mm, and the range for egg counts was 1,531 to 33,796 eggs. The low egg counts for some of the fish collected on later sampling dates indicate that they may have already begun spawning and probably should not have been included in fecundity analysis.

The relationship between smallmouth bass fecundity and body length, body weight and ovary weight was as follows:

	Body Length (x)	Body Weight (x)	Ovary Weight (x)
Log Number of Eggs (y)	$y = 2.599 + .0038x$	$y = 3.420 + .0007x$	$y = 3.645 + .005x$
Correlation Coefficient (r)	$r = 0.37$	$r = .42$	$r = .39$

The low correlation coefficients denote a low ability to predict fecundity based on these data. These relationships are shown in Figure III-46.

TABLE III-46

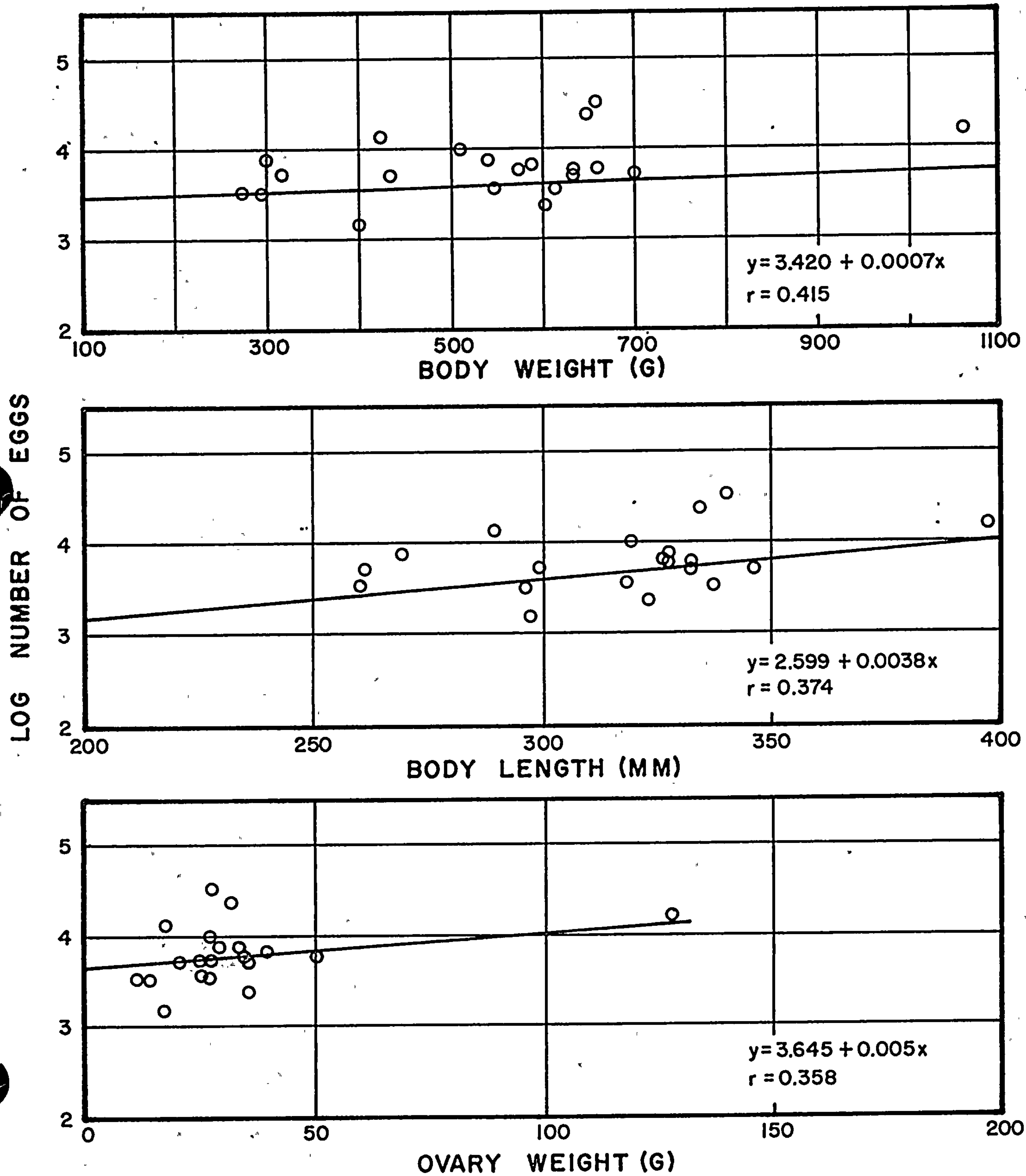
SUMMARY OF FECUNDITY DATA FOR 21 SMALLMOUTH BASS COLLECTED FROM LAKE ONTARIO AT NINE MILE POINT IN JUNE & JULY, 1973.

Fish Length (mm)	Fish Weight (g)	Ovary Weight (g)	Number of Eggs	Log Number of Eggs	Collection Date
260	273.1	11.73	3,377.6	3.529	7/3
261	317.1	20.80	5,241.2	3.719	6/4
269	298.6	29.12	7,795.6	3.892	7/3
289	420.6	17.66	13,781.0	4.139	7/20
296	294.1	14.10	3,240.8	3.511	7/7
297	398.9	17.33	1,531.4	3.185	8/9
299	433.8	25.02	5,327.0	3.726	7/3
318	545.3	25.53	3,741.8	3.573	7/7
319	506.8	27.22	10,464.6	4.020	6/6
323	600.7	35.89	2,477.2	3.394	6/4
326	587.0	39.26	6,894.8	3.839	6/18
327	539.5	33.59	7,753.2	3.889	6/4
327	571.4	50.17	6,108.8	3.786	6/19
332	630.8	34.57	5,778.2	3.762	7/7
332	630.8	35.56	5,173.4	3.714	7/7
332	657.5	34.90	6,290.2	3.799	7/18
334	646.1	31.54	24,409.2	4.388	7/20
337	613.3	27.21	3,518.6	3.546	7/18
340	657.0	27.41	33,796.2	4.529	7/20
346	699.1	27.66	5,363.4	3.729	7/3
397	1057.5	127.80	16,778	4.225	6/4

Number of Fish	Mean Fish Length (mm)	Mean Egg Count	Range Egg Count	Standard Deviation	Confidence Limits ($\alpha = 0.05$)
21	317.190	8516.295	1,531.4-33,796.2	7882.5	4,921.28-12,111.31

NINE MILE POINT

RELATIONSHIP BETWEEN LOG NUMBER OF EGGS VS BODY WEIGHT, BODY LENGTH & OVARY WEIGHT FOR 21 SMALLMOUTH BASS



7. FISH COMMUNITIES AND NINE MILE POINT UNIT ONE OPERATION

Project objectives for the 1973 fisheries study were to assess the effect of Nine Mile Point Nuclear Power Station Unit One operation on the fish communities in the Nine Mile Point area. At the same time this work would be used to describe these communities before operation was initiated at the Nine Mile Point Nuclear Power Station Unit 2 and the James A. FitzPatrick Nuclear Power Plant. To meet these objectives, emphasis was placed on community characteristics, diversity, evenness and species richness of the fishes in the Nine Mile Point area.

a. Historical Perspective

Lake Ontario fish populations have undergone enormous changes since the first descriptions were written (see Christie, 1973). Recorded changes have included: extinction of valuable trout and salmon stocks (Smith, 1968; Christie, 1973); drastic reduction of ciscoe populations (Christie, 1973); introduction of alewives, white perch, rainbow smelt, and others (see Dymond, 1944; Miller, 1963; Scott and Christie, 1963; Christie, 1973); and the development of new commercial fisheries (see Hurley, 1973).

The causes of these changes in Lake Ontario fish communities are nebulous at best. Christie (1973) suggested that overfishing was largely responsible for the decline of commercial fisheries. Loss of access to spawning areas in streams tributary to the Lake may have contributed to the decline

of early trout and salmonid fisheries (Christie, 1973). The influence of introduced species on endemic populations has yet to be fully evaluated.

Changes in any biotic community are often ascribed to environmental pollution, although support for this claim is generally difficult to establish. Schneck and Thompson (1965) reported long-term increases in plankton abundance, free ammonia, chlorides, calcium carbonate, and turbidity in the Toronto region of Lake Ontario from 1923 to 1954. The relationship between these changes and fish populations has not been assessed.

The only conclusions to be drawn from this information is that Lake Ontario constitutes an extremely variable chemical and biological environment and that much of the variability may be attributed to human activity in the watershed. Assessment of recent changes in Lake Ontario fish communities must be made in view of historical background of those communities.

b. Fish Communities Prior to Plant Operation

The most extensive records of Nine Mile Point area fish communities before Unit One operation was initiated were those compiled by Dr. John F. Storr, whose work included fathometric surveys of fish distribution in the area and gill net sampling of the fish community (Figure III-47). Data from these investigations described the communities under pre-operational conditions.

Fish monitoring sites in the Nine Mile Point area from 1969 to 1973. Stations designated W-1, W-2, and E-1 to E-9 were used by Storr for fathometric surveys. Storr's gill net collections were made at E-1, E-3, or E-4 (see text). QL&M gill net collections were conducted along the three indicated transects (NMPP, FITZ, and NMPE) and at Nine Mile Point West (not shown). Broken lines indicate depth contours. Drawn from Storr (Undated a). Not to scale.

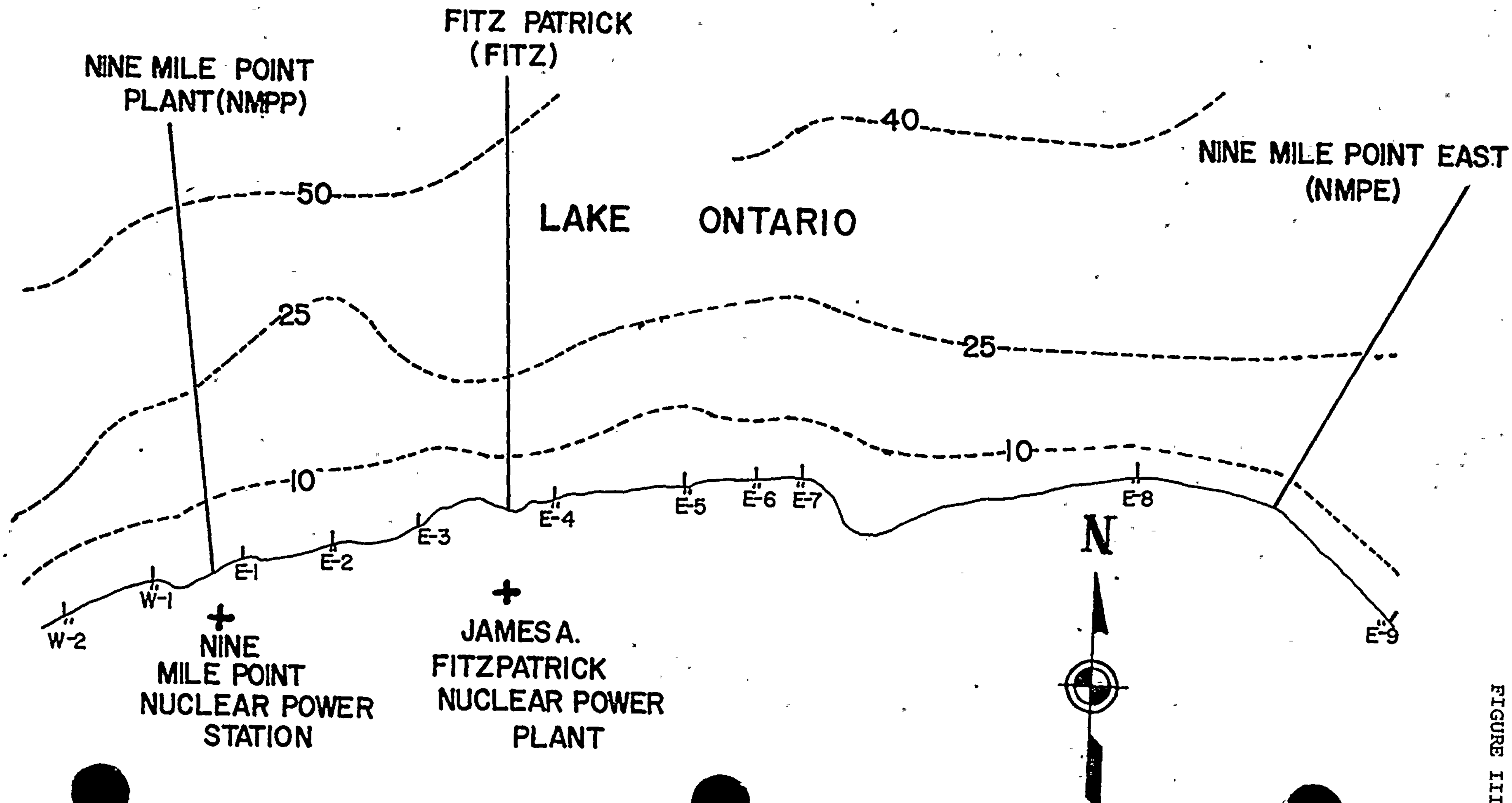


FIGURE III-47

Diversity components (species diversity (H), evenness (J), and species richness (d)) were calculated from Storr's (1969a and 1970a) data, using the Brillion formula (see Materials and Methods section). Storr's gill netting procedure was described in an early report (Storr, 1969a); briefly, the nets were set in the afternoon, fished overnight, retrieved about 24 hours after setting, and reset. The procedure was repeated until four collections had been made.

Calculations were based on the number of individuals of each species caught in each collection as was done in this report. Diversity components were not determined on the basis of catch per unit, since the ratio of the number of individuals in each species to the total number of individuals in the collection would remain the same. Catch per unit effort standardizes the time factor but does not allow for temporal fluctuations in fish abundance. To a certain degree, the longer a gear is fished the greater the number of species caught.

August 1969 species diversity values were generally higher than those recorded in October of that year (Table III-47). Nearshore and bottom gill nets at both depths exhibited greater diversity than surface gill net collections. One to six species were caught by surface nets and three to nine species by bottom and nearshore nets over both months. Individuals were fairly well-distributed among the species; most evenness values exceeded 0.500 (Table III-47). The ratio of the number of species to the number of individuals, species richness, was generally greater in August than in October. The lowest values for all diversity components were recorded for the 30 ft. surface gill nets.

TABLE III-47

Number of species (S), number of fishes (N), species diversity (H), evenness (J), and species richness (d) of gill net collections in the Nine Mile Point area in August and October 1969. Data from Storr (1969a and 1970a respectively). Collections made offshore from the James A. FitzPatrick Nuclear Power Plant (Storr's E-4 transect).

		AUGUST, 1969 (E-4)				OCTOBER, 1969 (E-4)			
		12	13	14	15	7	8	9	10
	S	8	8	8	7	5	3	4	4
	N	98	67	70	52	55	72	10	27
Near-shore	H	1.773	1.768	1.678	2.144	1.545	0.587	1.130	1.404
	J	0.619	0.618	0.559	0.799	0.729	0.393	0.635	0.687
	d	1.527	1.665	1.648	1.519	0.998	0.468	1.303	0.910
	S	6	2	2	3	2	2	1	2
	N	9	2	7	5	4	3	17	9
15 ft. surface	H	1.654	0.500	0.401	0.869	0.646	0.528	0.000	0.574
	J	0.806	1.000	0.394	0.626	1.000	0.613	1.000	0.556
	d	2.276	1.443	0.514	1.243	0.721	0.910		0.455
	S	9	5	7	8	9	6	4	8
	N	149	107	123	85	98	110	45	45
15 ft. bottom	H	1.949	0.998	1.951	2.323	1.552	1.575	1.100	2.021
	J	0.621	0.437	0.700	0.783	0.482	0.626	0.580	0.694
	d	1.599	0.856	1.247	1.576	1.745	1.064	0.788	1.839
	S	1	3	2	2	2	1	2	2
	N	65	55	30	41	33	3	33	45
30 ft. surface	H	0.000	0.371	0.164	0.131	0.274	0.000	0.464	0.122
	J	1.000	0.239	0.180	0.126	0.264	1.000	0.448	0.118
	d		0.499	0.294	0.269	0.286		0.286	0.263
	S	7	7	6	4	5	7	7	8
	N	65	66	18	18	57	45	34	55
30 ft. bottom	H	2.038	1.322	1.651	1.204	1.410	1.875	2.000	2.166
	J	0.767	0.488	0.803	0.634	0.627	0.704	0.711	0.714
	d	1.437	1.432	1.730	1.038	0.989	1.576	1.701	1.747

c. Fish Communities After Plant Operation Began

Commercial operation of Unit One began in December 1969. Periodic fathometric and gill net surveys were conducted by Storr (1970b, e, f, and g; and 1971a) during 1970 in an attempt to assess the initial impact of the plant on local fish communities. The first post-operational collections were made from 26 to 29 May 1970; however, Storr (1970b) reported that no electricity was generated between "mid-winter" and the sampling dates.

During the May collections, large numbers of dead and dying alewives were observed on the Lake surface and net catches of this species were reduced with respect to catches in June 1969 (Storr, 1970b). Yellow perch generally were the second most abundant species in the gill nets (Storr, 1970b). Surface collections usually produced fewer fishes than bottom and nearshore collections which yielded similar numbers (Storr, 1970b). Northern redhorse suckers were collected from the nearshore and 15 ft. surface nets only; few rainbow smelt were captured (Storr, 1970b).

Storr (1970b) reported that May 1970 collections were greatly reduced from those of June 1969. The alewife catch was reduced to 10% of the June 1969 collection and other species exhibited a 76% reduction in numbers caught; the nearshore net collected 87% fewer fishes (Storr, 1970b). Storr (1970b) suggested that this great reduction in near-shore catch may have been due to turbulent water conditions.

Calculation of diversity components for Storr's (1970b) May 1970 data indicated that greatest diversity was exhibited by collections from the nearshore net (Table III-48). The 15 ft. surface collection on 29 May and the 15 ft. bottom collection on 27-28 May produced no fishes. Evenness values were generally above 0.500; the prominent exceptions were the 15 ft. bottom collections on 26 and 29 May when alewives contributed 86 and 82% of the respective collections. Species richness values were relatively high nearshore, diminished somewhat at 15 ft., and further reduced for the 15 ft. surface collection, while the bottom net at this depth exhibited increased values.

Fathometric surveys on 28 May demonstrated that concentrations of up to 53 fishes per 1000 ft.^{2} were present in the area between the current NMPP and FITZ transects (Storr, 1971a). Similar concentrations were observed slightly west of NMPP. Low concentrations of fishes were observed on 28 May 1970 in the area corresponding with NMPE.

A 24-hour fathometric survey of the area between Unit One and the FitzPatrick plant on 28-29 May indicated the presence of extremely high (>400 fishes per 1000 ft.^{2}) concentrations of fishes between 2200 and 0215 hours (Storr, 1971a). These concentrations were observed 600 to 1600 feet offshore, while lower concentrations were recorded nearer to shore. Much lower concentrations were observed through the remainder of the 24-hour period.

TABLE III-48

Number of species (S), number of fishes (N), species diversity (H), evenness (J), and species richness (d) of gill net collections in the Nine Mile Point area in May and July 1970. Data from Storr (1970b and e respectively). Collections made offshore from Nine Mile Point Nuclear Station Unit One (E-1) and from the James A. FitzPatrick Nuclear Power Plant (E-4).

		E-1		E-4	E-1		E-4	
		May 26	May 27-28	May 29	July 8	July 9	July 10	July 11
Near-shore	S	7	5	6	10	7	7	8
	N	11	35	35	92	68	92	65
	H	1.879	1.524	1.805	2.233	1.931	1.695	1.428
	J	0.818	0.747	0.691	0.715	0.688	0.639	0.517
	d	2.502	1.125	1.406	1.990	1.422	1.327	1.677
15 ft. surface	S	3	6	No Fishes Caught	3	4	2	3
	N	9	22		18	25	5	4
	H	0.886	1.390		0.754	0.550	0.664	0.896
	J	0.745	0.562		0.565	0.301	0.677	0.782
	d	0.910	1.618		0.692	0.932	0.621	1.443
15 ft. bottom	S	4	No Fishes Caught	5	6	5	4	5
	N	37		62	124	165	112	101
	H	0.623		0.820	0.930	1.520	1.532	1.774
	J	0.332		0.364	0.358	0.680	0.803	0.793
	d	0.831		0.969	1.037	0.783	0.636	0.867
30 ft. surface	S	2	2	2	3	1	NO Fishes Caught	1
	N	4	10	6	13	12		6
	H	0.646	0.549	0.431	0.750	0.000		0.000
	J	1.000	0.688	0.598	0.519	1.000		1.000
	d	0.721	0.434	0.558	0.780			
30 ft. bottom	S	2	4	6	5	4	6	5
	N	4	18	33	57	16	30	10
	H	0.500	1.608	1.533	0.989	1.418	1.042	1.230
	J	0.774	0.847	0.622	0.440	0.875	0.472	0.732
	d	0.721	1.038	1.430	0.989	1.082	1.470	1.737

Species diversity values calculated from Storr's (1970c) July 1970 data were greatest for nearshore collections, were lower for 15 ft. bottom collections, and were further reduced for the 30 ft. bottom collection (Table III-48). Diversity of surface gill net collections were generally lower than those determined for bottom or nearshore collections. Evenness values were generally high (>0.500) except in those instances where one or two species contributed most of the individuals (Table III-48).

During the August collections, an increased number of species were collected by surface nets than had been collected by these nets on previous dates (Storr, 1970f). Alewives were minor contributors to all collections except for 30 ft. surface catches off Unit 1 on 20 August and off FitzPatrick on 21 and 22 August 1970. Storr (1970f) reports that August 1970 collections were reduced from August 1969 catch levels at both sampling areas. Large reductions in catches of alewives and white perch occurred while smallmouth bass and bullhead, Ictalurus nebulosus, catches increased. The five most abundant species in the August 1969 collections were (in descending order): white perch, alewife, yellow perch, minnow (Notropis sp.), and northern redhorse sucker; in August 1970 the rankings were: white perch, smallmouth bass, alewife, yellow perch, and bullhead (Storr, 1970f).

Species diversity calculated from Storr's (1970f) August 1970 nearshore collections off the FitzPatrick plant was somewhat greater than values calculated for the same site in August 1969 (Table III-49 and see Table III-47). Nearshore individuals were more evenly distributed among

TABLE III-49

Number of species (S), number of fishes (N), species diversity (H), evenness (J), and species richness (d) of gill net collections in the Nine Mile Point area in August and October 1970. Data from Storr (1970f and g respectively). Collections made offshore from Nine Mile Point Nuclear Power Station Unit One (E-1) and from the James A. FitzPatrick Nuclear Power Plant (E-3).

		AUGUST			OCTOBER			
		E-1		E-3	E-1		E-3	
		19	20	21-22	21	22	23	24
Near-shore	S	7	8	3	4	7	6	6
	N	64	37	33	94	80	38	73
	H	1.706	2.131	1.199	1.225	1.751	2.054	1.979
	J	0.655	0.739	0.843	0.615	0.642	0.852	0.812
	d	1.443	1.939	0.572	0.660	1.369	1.375	1.165
15 ft. surface	S	No	1	9	3	3	4	4
	N	Fish	1	30	10	21	13	45
	H	Caught	0.000	2.168	1.204	1.046	1.522	1.482
	J		1.000	0.770	0.858	0.768	0.891	0.782
	d			2.352	0.869	0.657	1.170	0.788
15 ft. bottom	S	8	8	6	8	9	7	9
	N	38	47	35	20	32	87	84
	H	1.742	1.910	1.910	1.894	2.249	1.983	2.197
	J	0.592	0.632	0.731	0.714	0.762	0.726	0.726
	d	1.924	1.818	1.406	2.337	2.308	1.344	1.806
30 ft. surface	S	4	2	4	1	2	2	2
	N	15	8	51	1	4	2	2
	H	1.058	0.601	0.332	0.000	0.646	0.500	0.500
	J	0.531	0.784	0.162	1.000	1.000	1.000	1.000
	c	1.108	0.481	0.763		0.721	1.443	1.443
30 ft. bottom	S	7	4	5	8	3	8	6
	N	68	28	7	25	9	32	27
	H	2.116	1.522	1.471	1.994	0.686	2.254	1.764
	J	0.754	0.874	0.837	0.791	0.576	0.891	0.726
	d	1.422	0.900	2.056	2.175	0.910	2.020	1.517

the species in August 1970 than in August 1969, although the reduced number of species in 1970 was evident from the low species richness value. Values for the other collections in that area were similar for both years. Values for diversity components calculated for Storr's (1970f) collections off Unit One in August 1970 were generally high (Table III-49). With the exception of low values for the 15 ft. surface collections, little differences in any of the components were observed between the collections.

Species diversity was greater for October 1970 collections near the FitzPatrick plant than near Unit One (Table III-49). Nearshore, bottom, and 15 ft. surface collections exhibited relatively high values (>1.482) while low values were observed for 30 ft. bottom collections. Individuals were quite evenly divided among the species in all collections; values ranged fr[illegible] 0.726 to 0.891 in most instances (30 ft. surface values for evenness were 1.000). High species richness values were recorded for all collections near the FitzPatrick plant (Table III-49).

All diversity components for gill net collections near the FitzPatrick plant were generally greater in October 1970 (Table III-49) than in October 1969 (Table III-47). October 1969 values for evenness and species richness rarely exceeded those calculated for 1970 data and only the 1969 30 ft. bottom collection had species diversity values greater than 1970 species diversity values for the corresponding collection. It should be pointed out that the October 1969 collections were made along Storr's E-4 transect and the October 1970 collections were along his E-3 transect (Table III-49).

Species diversity values calculated for Storr's (1971c) June 1970 data [illegible] generally greatest for nearshore collections, decreased for 15 or 30 ft.

surface collections, and increased for 15 or 30 ft. bottom collections (Table III-50). Nearshore communities by Unit One were somewhat more diverse than similar communities near the FitzPatrick plant; no real differences were evident between diversity values at similar depths at each location. Distribution of individuals among the species was fairly high (even) with the exception of surface collections at both depth contours and both sampling areas (Table III-50). Low evenness values resulted from collections made up largely of a single species with minimal contributions by other species. Species richness values were relatively high for nearshore, 15 ft. surface and bottom, and 30 ft. bottom collections, while values for 30 ft. surface collections were rather low (Table III-50).

Fish concentrations near the FitzPatrick plant on 3-4 June 1971 were somewhat lower than those recorded off of Unit One at the same time (Storr, 1971f). Highest fish concentrations, 78 per 1000 ft.^{2}, were observed approximately 900 ft. offshore at 0415 hr. Concentrations ranging from 5-40 fishes per 1000 ft.^{2} were scattered throughout the sampling period although concentrations were generally low after 0610 hr.

All nearshore collections were dominated by yellow perch, 15 ft. surface collections by alewives, and 15 ft. bottom collections by yellow perch, troutperch, or minnows (Storr, 1971e). Surface and bottom collections at 30 ft. were dominated by alewives and yellow perch. Surface collections at both depth contours were composed of alewives, yellow perch, and white perch. Consistent contributors to nearshore and bottom collections aside from the dominating species were: white perch, sucker (Catostomus commersonii), rock bass, and smallmouth bass (Storr, 1971e).

TABLE III-50

Number of species (S), number of fishes (N), species diversity (H), evenness (J), and species richness (d) of gill net collections in the Nine Mile Point area in June 1971. Data from Storr (1971c). Collections made offshore from Nine Mile Point Nuclear Station Unit One (E-1) and from the James A. FitzPatrick Nuclear Power Plant (E-4).

		E-1					E-3				
		June 1	June 2	June 3	June 11	June 12	June 1	June 2	June 3	June 11	June 12
Near-shore	S	10	9	5	6	8	8	8	7	11	7
	N	148	249	81	127	33	44	95	131	109	54
	H	1.989	1.892	1.753	1.834	2.052	2.199	2.048	1.556	2.003	1.817
	J	0.595	0.596	0.789	0.736	0.787	0.771	0.672	0.551	0.571	0.650
	d	1.801	1.450	0.910	1.032	2.002	1.850	1.537	1.231	2.132	1.504
15 ft. surface	S	7	6	No Collection	No Collection	No Collection	3	6	No Collection	No Collection	No Collection
	N	94	93				57	75			
	H	0.802	1.144				0.636	0.609			
	J	0.293	0.449				0.430	0.240			
	d	1.321	1.103				0.495	1.158			
15 ft. bottom	S	4	6	No Collection	No Collection	No Collection	6	3	No Collection	No Collection	No Collection
	N	19	23				25	3			
	H	1.441	1.479				1.558	0.862			
	J	0.713	0.577				0.694	1.000			
	d	1.019	1.595				1.553	1.820			
30 ft. surface	S			2	3	2	No Collection	No Collection	2	2	4
	N	NO Collection	No Collection	8	6	10			4	27	32
	H			0.601	0.894	0.332			0.646	0.176	0.803
	J			0.784	0.910	0.416			1.000	0.169	0.455
	d			0.481	1.116	0.434			0.721	0.303	0.866
30 ft. bottom	S	No Collection	No Collection	4	5	5	No Collection	No Collection	1	4	8
	N			8	29	57			8	17	24
	H			1.214	1.427	1.482			0.000	0.871	2.039
	J			0.860	0.606	0.659			1.000	0.493	0.838
	d			1.443	1.188	0.989				1.059	2.203

Greatest diversity values for 29 June-2 July collections (calculated from Storr, 1971g) were generally found for nearshore and 15 and 30 ft. bottom collections at both locations (Table III-51). Low diversity values for surface collections reflect catches composed of few individuals of few species. Evenness values for nearshore collections ranged from 0.366 to 0.581, indicating that individuals were unevenly distributed between species. One or two species (dominating species) consisted of relatively large numbers of individuals, while the other species present contributed little to the total number of individuals. Species richness values (Table III-51) fluctuated considerably between collections, indicating the variability in the number of species and the number of individuals in each collection (Table III-51).

Greater numbers of species and individuals were collected by nearshore nets in late June-early July 1971 as were caught in early June 1970 (see Tables III-50 and III-51). This is not readily evident from Table III-48, since data from near Unit One and the FitzPatrick plant were combined in the original report (Storr, 1970e). Low values for the various diversity components were calculated for surface net collections of both years. Further comparisons are inappropriate, since data for individual collection area are not available for 1970.

TABLE III-51

Number of species (S), number of fishes (N), species diversity (H), evenness (J), and species richness (d) of gill net collections in the Nine Mile Point area from June 29-July 2, 1971. Data from Storr (1971e). Collections made offshore from Nine Mile Point Nuclear Power Station Unit One (E-1) and from the James A. FitzPatrick Nuclear Power Plant (E-4).

		E-1				E-3			
		June 29	June 30	July 1	July 2	June 29	June 30	July 1	July 2
	S	8	7	6	5	8	7	8	5
	N	96	92	99	70	134	59	130	36
Near-shore	H	1.457	1.264	1.073	0.788	1.502	1.469	1.681	1.050
	J	0.523	0.476	0.420	0.366	0.498	0.545	0.581	0.493
	d	1.534	1.327	1.088	0.942	1.429	1.471	1.438	1.116
	S	1	1	No Collection	No Collection	3	2	No Collection	No Collection
	N	3	2			8	12		
15 ft. surface	H	0.000	0.000			0.726	0.504		
	J	1.000	1.000			0.472	0.614		
	d					0.962	0.402		
	S	6	8	No Collection	No Collection	8	2	No Collection	No Collection
	N	53	23			121	4		
15 ft. bottom	H	1.696	1.934			2.164	0.646		
	J	0.644	0.670			0.758	1.000		
	d	1.259	2.233			1.460	0.721		
	S	No Collection	No Collection	2	2	No Collection	No Collection	2	3
	N			4	5			3	20
30 ft. surface	H			0.500	0.464			0.528	0.712
	J			0.774	0.473			0.613	0.437
	d			0.721	0.621			0.910	0.668
	S	No Collection	No Collection	3	2	No Collection	No Collection	5	5
	N			39	19			51	24
30 ft. bottom	H			0.965	0.224			1.531	1.682
	J			0.669	0.214			0.704	0.719
	d			0.546	0.340			1.017	1.259

August 1969 near-shore collections were dominated by white perch and yellow perch; alewives and white perch were the greatest contributors to surface collections; and alewives, white perch, and yellow perch were most abundant in bottom gill nets (Storr, 1969a). These collections were made offshore from the FitzPatrick plant. In the same area during August 1970, white perch were the most abundant species in near-shore collections, yellow perch in 15 ft. surface and bottom collections, and alewives in 30 ft. surface collections (Storr, 1970f). No single species dominated the 30 ft. bottom collection. Northern redhorse suckers were caught in 1969 and 1970 August collections (Storr, 1968a, and 1970f) but none were caught in June, July, or August 1971 (Storr, 1971c, 1971 e, and 1971g).

Species diversity values calculated for Storr's (1971g) August 1971 data were relatively high for nearshore and 15 and 30 ft. bottom collections in both areas (Table III-52). Species diversity for surface collections was quite low, since most collections were comprised of a single species. High evenness and species richness values were associated with high species diversity values (Table III-52). Similar values were observed at both areas.

August species diversity and evenness of nearshore collections by the FitzPatrick plant were generally similar in 1969 (Table III-47), 1970 and 1971 Table III-49 and Table III-52). Species richness in August 1970 was lower than in the other two years. Diversity component values for surface collections were quite low with the exception of the 21-22 August 1970-15 ft. surface collection where the following values were determined:

TABLE III-52

Number of species (S), number of fishes (N), species diversity (H), evenness (J), and species richness (d) of gill net collections in the Nine Mile Point area in August 1971. Data from Storr (1971g). Collections made offshore from Nine Mile Point Nuclear Power Station Unit One (E-1) and from the James A. FitzPatrick Nuclear Power Plant (E-3).

		E-1				E-3			
		August 17	August 18	August 19	August 20	August 17	August 18	August 19	August 20
Near-shore	S	7	8	9	5	7	5	9	7
	N	42	56	41	14	30	22	32	82
	H	1.970	1.718	2.213	1.519	1.402	1.594	2.154	1.686
	J	0.800	0.640	0.736	0.679	0.556	0.746	0.730	0.599
	d	1.605	1.739	2.154	1.516	1.764	1.294	2.308	1.362
15 ft. surface	S	1	1	No Collection	No Collection	No Fishes Caught	2	No Collection	No Collection
	N	1	2				4		
	H	0.000	0.000				0.646		
	J	1.000	1.000				1.000		
	d						0.721		
15 ft. bottom	S	6	6	No Collection	No Collection	6	5	No Collection	No Collection
	N	14	23			30	44		
	H	1.733	1.891			1.976	1.438		
	J	0.800	0.738			0.895	0.607		
	d	1895	1.595			1.470	1.057		
30 ft. surface	S	No Collection	No Collection	No Fishes Caught	1	No Collection	No Collection	No Fishes Caught	2
	N				2				5
	H				0.000				0.664
	J				1.000				0.677
	d								0.621
30 ft. bottom	S	No Collection	No Collection	5	5	No Collection	No Collection	6	7
	N			27	14			20	19
	H			1.678	1.590			1.685	1.805
	J			0.773	0.710			0.740	0.689
	d			1.214	1.516			1.669	2.038

H = 2.168, J = 0.770, and d = 2.352. Values of diversity components for 15 and 30 ft. bottom collections were comparable for each year. It should be noted that the collection site sampled in August 1969 (Storr, 1969a) was slightly east of the August 1970 (Storr, 1970f) and 1971 (Storr, 1971g) sampling areas.

Relatively high species diversity values were calculated from Storr's (1972e) November 1971 data for nearshore and 15 and 30 ft. bottom collections (Table III-53). Moderately high values were determined for 15 and 30 ft. surface collections. Individuals were rather evenly distributed among the species in all collections; evenness values ranged from 0.601 to 0.979 for multispecies collections and a value of 0.000 was calculated for collections composed of a single species. Species richness values fluctuated within a relatively narrow range indicating a fairly constant relationship between the number of species and number of individuals in each collection. Values for the three diversity components were similar for corresponding collections at both locations (Table III-53).

QL&M (1973) initiated gill netting in the Nine Mile Point area in September 1972. Collections were made at mid-depth in 15 ft. of water and at the surface and bottom in water 30 and 40 ft. deep in September and October. Sampling areas were immediately offshore from Unit One (NMPP) and at a control site west of the plant (NMPW). QL&M (1973) based comparisons.

TABLE III-53

Number of species (S), number of fishes (N), species diversity (H), evenness (J), and species richness (d) of gill net collections in the Nine Mile Point area in November 1971. Data from Storr (1972e). Collections made offshore from Nine Mile Point Nuclear Power Station Unit One (E-1) and from the James A. FitzPatrick Nuclear Power Plant (E-3).

		E-1				E-3			
		November 2	November 4	November 5	November 6	November 2	November 4	November 5	November 6
Near-shore	S	6	No Collection	No Collection	7	6	4	5	7
	N	61			36	139	78	32	133
	H	2.190			1.895	1.719	1.705	1.415	1.810
	J	0.907			0.760	0.688	0.856	0.645	0.680
	d	1.216			1.674	1.013	0.689	1.154	1.227
15 ft. surface	S	4	2	3	No Collection	3	1	3	No Collection
	N	25	7	10		12	11	16	
	H	1.390	0.733	1.030		0.913	0.000	0.972	
	J	0.760	0.719	0.734		0.726	1.000	0.661	
	d	0.932	0.514	0.869		0.805		0.721	
15 ft. bottom	S	8	7	4	No Collection	8	5	6	No Collection
	N	92	64	18		60	207	76	
	H	2.225	1.789	1.437		2.136	1.382	1.747	
	J	0.758	0.687	0.757		0.738	0.601	0.675	
	d	1.548	1.443	1.038		1.710	0.750	1.155	
30 ft. surface	S	No Collection	No Collection	No Collection	3	No Collection	No Collection	No Collection	3
	N				12				7
	H				1.230				1.018
	J				0.979				0.767
	d				0.805				1.028
30 ft. bottom	S	No Collection	NO Collection	No Collection	7	No Collection	No Collection	No Collection	6
	N				28				52
	H				2.229				2.044
	J				0.948				0.794
	d				1.801				1.265

between the two areas on night collections because storms destroyed six nets set for September day collections. Data from all nets at each area were combined in their report (QL&M, 1973).

Total numbers of fishes collected by night gill netting in September 1972 were greater at NMPW than at NMPP (QL&M, 1973). The converse was true in October. Catches at NMPP increased from September to October and decreased at NMPW over the same period (QL&M, 1973). During September rock bass were most abundant at NMPP and alewives at NMPW; during October rainbow smelt and white suckers were most abundant at NMPP and NMPW, respectively (QL&M, 1973). Other species which contributed to most collections were yellow perch, spottail shiners, smallmouth bass, and white perch.

Values for diversity components were calculated for QL&M's (1973) data for September and October 1972 night gill netting and are given below:

		NMPP		NMPW	
		SEPTEMBER	OCTOBER	SEPTEMBER	OCTOBER
No. of Species	(S)	7	9	8	4
Total No. of Individuals	(N)	41	80	52	16
Diversity	(H)	2.256	2.248	2.383	1.315
Evenness	(J)	0.796	0.699	0.828	0.812
Species Richness	(d)	1.616	1.826	1.772	1.082

Numbers of species and individuals caught in September at NMPP were consistent with those reported by Storr in August 1969 near the FitzPatrick plant (1969) and in August 1970 near NMPP (1970). Species diversity values were generally higher in 1972 than those calculated for previous years (see Tables III-47 and III-49) although this was probably due to pooling data from all nets. Evenness and species richness values were similar to those calculated from Storr's (1969a, 1970a, and 1970f and g) data for August and October of 1969, 1970, and 1971.

A series of gill net collections were made east of Nine Mile Point in Mexico Bay in 1972. Collections were made with bottom gill nets set at 5 or 10 fathoms (30 or 60 feet) by the Great Lakes Fishery Laboratory (1972 a-d). Collections were conducted during May, June, July, and September.

Greatest catches at 60 ft. were made during July (Great Lakes Fish. Lab., 1972c) and lowest catches in June (Great Lakes Fish. Lab., 1972b). May and September collections at that depth produced 217 and 122 fishes, respectively (Great Lakes Fish. Lab. 1972a and d). Similar numbers of fish were caught at 30 ft. in July and September (Great Lakes Fish. Lab., 1972a and d). Alewives dominated gill net collections during all months at each depth. Contributions by other species were minimal in May and June and in July at 60 ft. White perch made up 17% of the July 30 ft. catch, 40% of the September 30 ft. catch, and 24% of the 60 ft. catch in September.

Diversity components were calculated for gill net catches by the Great Lakes Fisheries Laboratory (1972 a-d) are given below:

		MAY 13	JUNE 25	JULY 29	SEPTEMBER 11
		(30 feet)			
No. of species	(S)			11	11
Total No. of Individuals	(N)			892	725
Diversity	(H)	No Collection	No Collection	1.565	1.292
Evenness	(J)			0.459	0.371
Species Richness	(d)			1.472	1.518
		(60 feet)			
No. of Species	(S)	5	5	7	10
Total No. of Individuals	(N)	217	45	1546	122
Diversity	(H)	0.406	0.759	0.218	1.496
Evenness	(J)	0.176	0.364	0.078	0.473
Species Richness	(d)	0.744	1.051	0.817	1.873

Greater species diversity was evident for collections made at 30 ft. rather than at 60 ft. Species diversity and evenness values were quite low for 60 ft. collections as a result of the large numbers of a single species, alewives, in the collections. Low evenness values were apparent for collections at 30 ft. Distribution of species between the total number of individuals was similar for all collections, since species richness values were within a relatively narrow range.

Gill net collections in the Nine Mile Point area in 1973 were discussed by QL&M (this report). July catches were greatest and June and December catches were lowest, while collections along the 30 and 40 ft. contours produced more fishes than collections at 60 ft. Similar catches were made at NMPP, FITZ, and NMPE, while catches at NMPW were lower. Species diversity

values generally fluctuated around 1.000; values exceeding 2.000 were rarely encountered. Individuals were similarly divided among the species at all times; i.e. evenness was fairly constant. Species richness values were quite variable, but generally followed the same trends as observed for species diversity.

Alewives were major contributors to all 1973 gill net collections. Percentage contribution by this species to total monthly catches at each transect ranged from 40 to more than 90. Yellow perch, white perch, rainbow smelt, smallmouth bass, and spottail shiners were relatively abundant in many gill net collections. These six species made up 96% of the total collection. Twenty-seven other species captured at various times and locations by gill nets composed the remaining 4% of the total gill net catch.

Numbers of species and individuals caught and values for each diversity component of each 1973 collection were similar to those reported for corresponding months and locations in previous years. Most species caught were collected in previous years although certain rare species were reported in the area for the first time. Brown trout, freshwater drum, and burbot were not reported previously.

Since gill netting was the only collection procedure used during pre- and post-operational surveys of Nine Mile Point area fishes, considerations of plant impact must be based on these data. The available pre-operational data are derived from Storr's (1969a and 1970a) collections near the Fitz-Patrick plant during August and October 1969. Unit One influence may be

evident near the FitzPatrick plant, since water circulation patterns in that area are generally west to east (Gunwaldsen et al., 1970; Landsberg et al., 1970; QL&M, 1973).

Mean values for each diversity component for all comparable August gill net collections over the entire five years of sampling near the Fitz-Patrick plant are presented in Table III-54. Bottom collections at the 15 and 30 ft. contours were quite similar for the four years when collections were made. Mean numbers of species, species diversity and richness, and evenness fluctuated within narrow ranges. The number of individuals collected varied considerably from year to year, but the relationship between individuals and species were similar. Surface collections at 30 ft. in 1973 caught more species and individuals than did collections in previous years. Consequently, values of diversity components for these collections were markedly higher in 1973 than for earlier collections (Table III-54).

No major, persisting changes in species diversity, species richness, or evenness have been detected in the course of these investigations. It should be noted, however, that the pre-operational data base is extremely small in view of the more extensive post-operational studies.

TABLE III-54

Number of species (S), number of fishes (N), species diversity (H), evenness (J), and species richness (d) of August gill net collections offshore from the James A. FitzPatrick Nuclear Power Plant from 1969 through 1973[1]. Transect locations are indicated below each year. Values are means for all collections at each sampling site. The number of observations is in parentheses.

		1969 E-4 (4)	1970 E-3 (1)	1971 E-3 (2)	1972*	1973 Fitz (=E-3) (7)
	S	7	6	6		6
	N	116	35	37		96
15 ft bottom	H	1.805	1.910	1.707		1.540
	J	0.635	0.731	0.751		0.651
	d	1.320	1.406	1.264		1.302
	S	2	4	1		5**
	N	48	51	3		57
30 ft surface	H	0.167	0.332	ND		1.196
	J	0.386	0.162	ND		0.647
	d	0.354	0.763	ND		0.975
	S	6	5	7		6
	N	42	7	20		85
30 ft bottom	H	1.554	1.471	1.745		1.412
	J	0.673	0.837	0.715		0.626
	d	1.409	2.056	1.854		1.102

* no collections in that area in August 1972

ND could not be determined

** mean of six collections

1 1969 data from Storr (1969a)
1970 data from Storr (1970f)
1971 data from Storr (1971s)
1973 data from this report

Species composition of gill net collections have changed over the five years of sampling. Alewives and smelt have generally become more abundant and white perch catches have increased marginally, while yellow perch and smallmouth bass contributions have been similar over the study period. More species were collected in 1973 than in previous years, although this is probably due to the increased number of areas sampled and increased sampling effort.