NIAGARA MOHAWK POWER CORPORATION

POWER AUTHORITY OF THE STATE OF NEW YORK

fcc

1973
NINE MILE POINT AQUATIC ECOLOGY STUDIES

QL&M Project Nos. 191-14,15,17

VOLUME II

FISH IMPINGEMENT
WATER QUALITY

August 1974

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IV. FISH IMPINGEMENT

A. INTRODUCTION

The inclusion of screening devices within the intake structures of steam electric generating stations (SES) was originally intended to remove larger particulates, including fishes, from the cooling water flow. Removal of these materials is necessary to prevent interruption of electric generating processes dependent upon the constant supply of large volumes of cooling water (Edsall and Yocum, 1972). The volume and velocity characteristics of water flow at many intake structures occasionally result in the accumulation of large numbers of fishes on the intake screens (impingement). Swimming capabilities, endurance and metabolic requirements of fishes may influence the number impinged at any given time.

Records detailing impingement of fishes at power stations are not readily obtainable and for the most part, data prior to 1970 are scattered and incomplete. Edsall and Yocum (1972), in their study of the effects of once-through cooling on Lake Michigan, provide probably the most complete summary of industry-related impingement on the Great Lakes, although it is almost certainly an incomplete list.

Impingement of fishes has been documented in Lake Huron, Lake Erie and Lake Michigan (Edsall and Yocum, 1972) and at various locations in Lake Ontario (QL&M, 1973 a and b).

The details of impingement, such as species, sizes of fish impinged and condition of fish, are scanty in most reports (see Edsall and Yocum, 1972). However, increased appreciation of the potential effects of impingement has resulted in more detailed record keeping by utilities (Benda, 1972; Consumer's Power Co., 1972; QL&M, 1973a and b).

Since approximately 1970, sufficient information has been gathered from power stations on the Great Lakes to determine seasonal periodicity of impingement and the relative magnitude of losses to the Lake populations caused by impingement.

The quantities of fishes impinged at water intakes on the Great Lakes are generally greatest during the spring and early summer. Species composition of the winter catch is likely to be different than during the spring and early summer, and the magnitude of the catch is less.

Examination of available impingement records from electric utilities and water filtration plants on the Great Lakes showed that the species impinged most frequently and in the greatest numbers are schooling fishes, such as alewives, gizzard shad, smelt and shiners. The greatest impingement problems are usually associated with spawning migrations of seasonal inshore-offshore movements of fish in response to the seasonal thermoperiod of Lake water. As described by Edsall and Yocum (1972), populations of landlocked alewives have presented the most serious impingement problems in Lakes Michigan, Huron, Erie, and Ontario.

Those conditions most generally associated with fish impingement problems are those which are most difficult to control. These are: seasonal migration of vast numbers of fish; reduced swimming endurance during colder months; and rapid habituation of the fish's nervous system to "decoy" (frightening and luring) mechanisms. Because of the geologic, hydrologic and biologic uniqueness of each site, fish impingement at each steam electric station must be approached as an individual case.

Impingement studies at Nine Mile Point Unit 1 were conducted to

determine the effects of impingement on fish populations of Lake Ontario and to recommend procedures to minimize fish impingement at the installation.

In-plant studies were designed to provide:

1) an accurate estimate of the numbers of fish impinged per year;
2) an inventory of species and life-history stages of various species impinged;
3) annual, seasonal, monthly, and diurnal variations on the numbers of fish and numbers of species impinged;
4) biological characteristics of the fishes impinged, including estimates of age, length, weight, sex and relative condition;
5) relationship of impingement to environmental parameters, such as temperature, cooling water flow, light and currents.

Studies of fish populations on Lake Ontario were performed concurrently in the vicinity of the intake to determine:

1) abundance and distribution of "Lake" fish populations;
2) types of fish present in the Lake;
3) biological characteristics of "Lake" fish;
4) community characteristics of "Lake" fish.

This report contains a discussion of:

1) impingement rates;
2) species composition of impingement samples;

3) comparisons between impingement samples and Lake collections, and
4) relationships between impingement and the physical and chemical environment.

The impact of impingement on populations of alewife and rainbow smelt is discussed in the final section.

B. RESULTS AND DISCUSSION

1. DAY-NIGHT COMPARISONS OF FISH IMPINGEMENT RATES

Alewives and rainbow smelt impingement rates were tested individually for day-night differences. Hourly impingement rates were determined for each species. Rates from 0800, 1200, and 1600 hours were used to represent daytime collections and rates from 2000, 2400 and 0400 hours provided night data. Since both species exhibited strong seasonal trends in abundance, day-night data were selected from those periods when abundance was greatest for each species. This minimized the influence of collections which produced no fish.

Weekly alewife impingement rate data from 4 April to 27 June (Table IV-1) were compared by rank sum test for large samples (Snedecor and Cochran, 1967; see Appendix VI-A). Test results (Table IV-2) showed that alewife impingement rates were significantly greater ($p<0.05$) at night than during the day. The mean rate of alewife impingement during the day was 751.63 fish/hr; the mean night rate was 3107.59 fish/hr.

Weekly rainbow smelt impingement rate data from 7 November to 26-27 December were tested by Student's t-test (Snedecor and Cochran, 1967) for day-night differences. The mean daytime impingement rate for rainbow smelt during that

Table IV-1. Hourly alewife impingement rates (no./hr) at Nine Mile Point Nuclear Power Station Unit for selected dates in 1973 and summary of rank sum test for large samples for day-night comparisons.

Date	Day 0800	Day 1200	Day 1600	Night 2000	Night 2400	Night 0400
4 April	231	337.5	82	69.5	172.5	207
11 April	8,220	3,348	11,880	22,200	62,040	31,080
18 April	41.5	540.5	491.35	439.25	467.5	300
25 April	40	180.5	95.5	106.5	69.5	54
2 May	335	332.9	329.5	220.05	310	367.5
9 May	108.5	88.5	103.5	76.55	109.15	147.5
16 May	335.3	273.35	193	245.5	344	283
23 May	88	71	88	74.5	93.25	89.5
30 May	48.5	37	37.2	30.5	34.7	43
6 June	60	38	61	42	41.5	39.5
14 June	147.25	145.5	94	173.5	256.1	175.55
20 June	91.1	172	148.7	61	89.5	136.6
27 June	99.45	178.1	121.45	199.8	153.5	153
TOTAL	9,845.6	5,742.85	13,725.2	23,938.65	64,181.2	33,076.15
MEAN	757.35	441.76	1,055.78	1,841.43	4,937.02	2,544.32

Rank sum test for large samples:

Test Z = 2.134

Critical Z = 1.96
α = 0.05

Table IV-2 . Hourly rainbow smelt impingement rates (no./hr) at Nine Mile Point Nuclear Power Station Unit for selected dates in 1973 and summary of Student's t-test for day-night comparisons.

	Day			Night		
Date	0800	1200	1600	2000	2400	0400
7 Nov.	9	6.5	14.5	37.5	38.5	30
14 Nov.	12	6.5	3.5	52	36.5	9
21 Nov.	28	1	3	4.5	9.5	8
28 Nov.	19	63.5	5	9	6	15
5 Dec.	216.4	116	187	26.5	41.1	59
12 Dec.	5.5	2.5	1	8.25	15.1	37
19 Dec.	14	7	18.84	39	24.5	19.5
26-7 Dec.	12.15	11	13.85	26.95	21.45	23.5
TOTAL	316.05	214	246.69	203.7	192.65	201
MEAN	39.51	26.75	30.84	25.46	24.08	25.13

Student's t-test:

Test t = -0.392
d.f. = 76

Critical t = 1.97
α = 0.05

eight week period was 32.36 fish/hr. During the same period, the mean night impingement rate was 24.89 fish/hr. There were no significant differences between daytime and night impingement rates for smelt. It should be noted that, with the exception of 5 December when daytime rates were much higher, night impingement rates were generally greater than daytime rates (Table IV-3).

Offshore sampling of fishes in the Nine Mile Point area showed that more fishes were caught by trawl at night than during the day (Chapter III, this report). Storr's 24-hour fathometric surveys of the same area (1971a, 1971b, 1972a, 1972b, undated) revealed a movement of fishes into shallow, near-shore areas at night. Storr also noted greater fish concentrations at night than during the day. QL&M (1973b) reported that night trawl and impingement collections in the Nine Mile Point area yielded more fishes than corresponding day collections.

Differences in daytime and night impingement rates may reflect diurnal activity cycles of the species involved, or they may reflect changes in position of fish in the water column due to day-night vertical migrations.

In the case of the alewife, survey data showed that daily inshore-offshore migrations result in the fish being more abundant in shoal water (10-30 ft.) at night and, consequently, more vulnerable to impingement.

2. SPECIES COMPOSITION

a. Species Listed by Collection

Fish impingement sampling at Nine Mile Point Nuclear Power Station during 1973 was dominated by alewife, *Alosa pseudoharengus*. A list of all species

TABLE IV-3

TOTAL FISH IMPINGEMENT CATCH

NINE MILE POINT

FOR THE YEAR OF 1973

SPECIES	TOTAL NUMBER	% OF TOTAL
Alewife (Alosa pseudoharengus)	644,681*	97.82%
Rainbow Smelt (Osmerus mordax)	10,751	1.63
Three-spine Stickleback (Gasterosteus aculeatus)	775	0.12
Gizzard Shad (Dorosoma cepedianum)	659	0.10
White Bass (Morone chrysops)	628	0.10
Mottled Sculpin (Cottus bairdi)	285	0.04
White Perch (Morone americana)	249	0.04
Common Shiner (Notropis cornutus)	134	0.02
Troutperch (Percopsis omiscomaycus)	152	0.02
Emerald Shiner (Notropis atherinoides)	142	0.02
Yellow Perch (Perca flavescens)	145	0.02
Johnny Darter (Etheostoma nigrum)	119	0.02
Lamprey Eel (Petromyzon marinus)	91	0.01
Spottail Shiner (Notropis hudsonius)	69	0.01
Rock Bass (Ambloplites rupestris)	35	0.01
White Sucker (Catastomus commersoni)	24	<0.01
Lake Chub (Couesius plumbeus)	18	<0.01
Smallmouth Bass (Micropterus dolmieui)	20	<0.01
Bluegill Sunfish (Lepomis macrochirus)	9	<0.01
American Eel (Anguilla rostrata)	8	<0.01
Mudminnow (Umbra limi)	7	<0.01
Pumpkinseed (Lepomis gibbosus)	4	<0.01
Walleye (Stizostedion vitreum)	4	<0.01
Shiner (Notropis Sp.)	5	<0.01
Brown Bullhead (Ictalurus nebulosus)	4	<0.01
Stonecat (Noturus flavus)	3	<0.01
Golden Shiner (Notemigonus chrysoleucas)	3	<0.01
Carp (Cyprinus carpio)	3	<0.01
Northern Channel Catfish (Ictalurus punctatus)	2	<0.01
Goldfish (Carassius auratus)	5	<0.01
Black Crappie (Pomoxis nigromaculatus)	1	<0.01
Blunt Nose Minnow (Pimephales notatus)	1	<0.01
Logperch (Percina caprodes)	1	<0.01
Brown Trout (Salmo trutta)	1	<0.01
Northern Pike (Esox lucius)	1	<0.01
Brook Stickleback (Culaea inconstans)	1	<0.01
Creek Chub (Semotilus atromaculatus)	1	<0.01
TOTAL	659,041	

*Estimated

**Taken from Water Quality Certification Report Vol. II, No.2, February, 1974.

collected in rank order, the number collected and percent of total is presented in Table IV-4. The number of organisms collected and percentage composition values for each collection on a seasonal basis is presented in Table IV-1 and Appendix VI-A.

The size of the collections varied from two fish (15 August) to more than 500,000 fish (estimated) washed from the screens in a single 24-hour period (11 April, 1973). The general trend in impingement was a spring peak decreasing to low rates in summer. Impingement increased gradually during the fall and winter seasons.

b. Seasonal Cycles

The sample collection data presented in Table IV-5 were reduced to number of fish collected per month to better determine seasonal fluctuations in impingement. Where broad trends were noted, the months were combined into seasons, with each three-month period starting with January, and denoted as winter, spring, summer and fall, respectively.

Rainbow smelt, the second most abundant species collected in 1973, occurred in all months of 1973. The smallest numbers were collected during the summer months and the greatest number during the fall. Wells (1968), working in Lake Michigan, reported that smelt prefer deeper waters in the summer and become more abundant in shallow water areas during the fall due to recruitment of young-of-the-year fish. This finding is consistent with the smaller numbers impinged in the summer and increased numbers in the fall. Smelt are early spring spawners, migrating into small shallow streams (Baldwin, 1948)

TABLE IV-4

FISH IMPINGEMENT COLLECTIONS AT NINE MILE POINT, 1973 BY SAMPLING DATE AND BY SPECIES

Species	1-2-73		1-16-73		1-29-73		2-12-73		2-28-73		3-14-73		3-21-73		3-28-73		Totals for Winter 1973	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Alewife	1	0.17	2	0.28					8	4.68	4	4.21	15,997	96.93	26,663	99.16	42,675	94.21
Rainbow Smelt	473	79.10	528	73.54	205	75.65	35	63.64	114	66.67	83	87.37	506	3.06	197	0.73	2,141	4.73
Three Spine Stickleback	16	2.68	77	10.72	13	4.80			1	0.58	2	2.11					109	0.24
Gizzard Shad	42	7.02	13	1.81	26	9.59	1	1.81	1	0.58	1	1.05			16	0.06	100	0.22
White Bass			5	0.70					1	0.58							6	0.01
Mottled Sculpin	8	1.34	7	0.97	1	0.37	3	5.45	30	17.54					6	0.02	55	0.12
White Perch	10	1.67	6	0.84	4	1.48	3	5.45	2	1.17					1	0.00	26	0.06
Common Shiner					1	0.37											1	0.00
Troutperch	3	0.50	2	0.28			2	3.64									7	0.02
Emerald Shiner	15	2.51	24	3.34	16	5.90	5	9.10	4	2.34	2	2.11			2	0.00	68	0.20
Yellow Perch	22	3.68	38	5.29			4	7.27	1	0.58	1	1.05					66	0.15
Johnny Darter					1	0.37			1	0.58							2	0.00
Lamprey Eel									3	1.75					4	0.01	7	0.02
Spottail Shiner	3	0.50	3	0.42			2	3.64									8	0.02
Rock Bass			2	0.28					1	0.58					1	0.00	4	0.01
White Sucker	1	0.17															1	0.00
Lake Chub			5	0.70	1	0.37											6	0.01
Smallmouth Bass			1	0.14					2	1.17							3	0.01
Bluegill Sunfish																		
American Eel									1	0.58							1	0.00
Mudminnow	2	0.33	1	0.14							1	1.05					4	0.01
Pumpkinseed																		
Walleye																		
Shiner																		
Brown Bullhead	1	0.17	1	0.14													2	0.00
Stone Cat									1	0.58							1	0.00
Golden Shiner																		
Carp	1	0.17															1	0.00
Northern Channel Catfish			2	0.28													2	0.00
Goldfish					2	0.74					1	1.05					3	0.01
Black Bullhead																		
Black Crappie			1	0.14													1	0.00
Bluntnose Minnow																		
Logperch																		
Brown Trout																		
Northern Pike																		
Brook Stickleback																		
Creek Chub																		
TOTAL	598		718		270		55		171		95		16,503		26,890		45,300	100.05

TABLE IV-4 (con't)

SPRING 1973

Species	4-4-73 #	4-4-73 %	4-11-73 #	4-11-73 %	4-18-73 #	4-18-73 %	4-26-73 #	4-26-73 %	5-2-73 #	5-2-73 %	5-9-73 #	5-9-73 %
Alewife	4422	97.91	544,854	99.79	9270	98.06	2116	83.57	7512	97.96	2585	93.39
Rainbow Smelt	89	1.97	608	0.11	166	1.75	372	14.69	130	1.70	144	5.20
Threespine Stickleback			32	0.00	5	0.00	8	0.31	5	0.06	8	0.29
Gizzard Shad	1	0.00	240	0.04	1	0.00						
White Bass												
Mottled Sculpin					8	0.08	9	0.35	10	0.13	16	0.58
White Perch	1	0.00	120	0.02	1	0.00	1	0.04			1	0.04
Common Shiner												
Trout Perch			60	0.01			6	0.24	4	0.05	6	0.22
Emerald Shiner	1	0.00							2	0.02		
Yellow Perch							3	0.12			1	0.04
Johnny Darter							7	0.27	4	0.05	5	0.18
Lamprey Eel			64	0.01			4	0.16	1	0.01		
Spottail Shiner												
Rock Bass	1	0.00					3	0.12				
White Sucker							1	0.04				
Lake Chub	1	0.00										
Smallmouth Bass												
Bluegill Sunfish												
American Eel												
Mudminnow							1	0.04				
Pumpkinseed												
Walleye												
Shiner												
Brown Bullhead												
Stone Cat					2	0.00						
Golden Shiner												
Carp											1	0.04
N. C. Catfish												
Goldfish							1	0.04				
Black Bullhead												
Black Crappie												
Bluntnose Minnow												
Logperch											1	0.04
Brown Trout												
Northern Pike												
Brook Stickleback												
Creek Chub												
TOTALS	4516		545,978		9453		2532		7668		2768	

Species	5-16-73 #	5-16-73 %	5-23-73 #	5-23-73 %	5-30-73 #	5-30-73 %	6-6-73 #	6-6-73 %	6-13-73 #	6-13-73 %	6-20-73 #	6-20-73 %	6-27-73 #	6-27-73 %	Totals for Spring 1973 #	Totals for Spring 1973 %
Alewife	6821	91.09	2130	84.62	875	76.55	1173	81.06	4150	97.21	2777	93.21	3675	93.13	592,360	99.27
Rainbow Smelt	365	4.87	310	12.32	191	16.71	161	11.13	20	0.49	126	4.23	210	5.32	2,892	0.48
Threespine Stickleback	202	2.69	29	1.15	41	3.59	65	4.49	66	1.55	37	1.24	18	0.46	516	0.09
Gizzard Shad															242	0.04
White Bass	1	0.01													1	0.00
Mottled Sculpin	23	0.30	18	0.72	10	0.87	13	0.90	7	0.16	10	0.34	2	0.05	126	0.02
White Perch			3	0.12			1	0.07					2	0.05	130	0.02
Common Shiner	3	0.04	1	0.04			8	0.55	8	0.19	14	0.47	18	0.46	52	0.00
Trout Perch	10	0.13	3	0.12	8	0.70	11	0.76	3	0.07	4	0.13	17	0.43	132	0.02
Emerald Shiner	1	0.01													4	0.00
Yellow Perch	2	0.03	1	0.04			1	0.07	1	0.02	4	0.13	2	0.05	15	0.00
Johnny Darter	53	0.70	13	0.52	11	0.96	3	0.20	4	0.09	4	0.13			104	0.02
Lamprey Eel	1	0.01	1	0.04											71	0.01
Spottail Shiner			5	0.20	3	0.26	10	0.69	8	0.19	1	0.03	1	0.03	28	0.00
Rock Bass	3	0.04	1	0.04					1	0.02			1	0.03	10	0.00
White Sucker															1	0.00
Lake Chub			1	0.04											2	0.00
Smallmouth Bass									1	0.02	2	0.07			3	0.00
Bluegill Sunfish																
American Eel	1	0.01	1	0.04	1	0.09	1	0.07							4	0.00
Mudminnow															1	0.00
Pumpkinseed																
Walleye																
Shiner																
Brown Bullhead																
Stone Cat															2	0.00
Golden Shiner					3	0.26									3	0.00
Carp	1	0.01													2	0.00
N. C. Catfish																
Goldfish															1	0.00
Black Bullhead																
Black Crappie																
Bluntnose Minnow																
Logperch															1	0.00
Brown Trout																
Northern Pike																
Brook Stickleback	1	0.01													1	0.00
Creek Chub																
TOTALS	7488		2517		1143		1447		4269		2979		3946		596,704	99.97

TABLE IV-4 (con't)
SUMMER 1973

	7-4-73		7-11-73		7-18-73		7-25-73		8-1-73		8-8-73		8-15-73		8-22-73		8-29-73		9-5-73		9-12-73		9-19-73		9-26-73		Total Summer 1973	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Alewife	1655	91.99	833	90.74	159	84.13	93	33.21	17	94.44	7	43.75	2	100	1	4.76	31	83.78	15	78.95	23	56.09	120	55.55	45	23.68	3001	80.11
Rainbow Smelt	80	4.45	1	0.10			169	60.36			2	12.50			13	61.90	3	8.11			3	7.32	91	42.13	139	73.16	501	13.37
Three Spine Stickleback	7	0.39	20	2.18			1	0.36									1	2.70			1	2.44					30	0.80
Gizzard Shad																												
White Bass			1	0.10																							1	0.03
Mottled Sculpin	5	0.28	3	0.33	1	0.53	5	1.78							1	4.76									1	0.53	16	0.43
White Perch	2	0.11	1	0.10											1	4.76									1	0.53	5	0.13
Common Shiner	28	1.56	18	1.36	8	4.23	4	1.43			1	6.25			3	14.28	1	2.70	1	5.26			1	0.46	3	1.58	68	1.82
Troutperch	6	0.33	1	0.10	1	0.53									1	4.76											9	0.24
Emerald Shiner											1	6.25					1	2.70									2	0.05
Yellow Perch	9	0.50	17	1.85	9	4.76	1	0.36			5	31.25							1	5.26	11	26.83			1	0.53	54	1.44
Johnny Darter	1	0.06	2	0.22			2	0.71							1	4.76							1	0.46			7	0.19
Lamprey Eel			3	0.33	2	1.06	1	0.36																			6	0.16
Spottail Shiner			1	0.10	1	0.53																					2	0.05
Rock Bass	2	0.11	1	0.10	2	1.06	1	0.36															1	0.46			7	0.19
White Sucker			3	0.33	3	1.59	1	0.36	1	5.55									1	5.26	1	2.44	2	0.93			12	0.32
Lake Chub	3	0.17	6	0.65																							9	0.24
Smallmouth Bass			1	0.10	1	0.53													1	5.26	1	2.44					4	0.11
Bluegill Sunfish																												
American Eel	1	0.06					1	0.36																			2	0.05
Mudminnow																												
Pumpkinseed																					1	2.44					1	0.03
Walleye			4	0.44																							4	0.11
Shiner																												
Brown Bullhead							1	0.36																			1	0.03
Stone Cat																												
Golden Shiner																												
Carp																												
Northern Channel Catfish																												
Goldfish					1	0.53																					1	0.03
Black Bullhead																												
Black Crappie																												
Bluntnose Minnow					1	0.53																					1	0.03
Logperch																												
Brown Trout			1	0.10																							1	0.03
Northern Pike			1	0.10																							1	0.03
Brook Stickleback																												
Creek Chub																												
TOTAL	1799		918		189		280		18		16		2		21		37		19		41		216		190		3746	

TABLE IV-4 (con't)

FISH IMPINGEMENT COLLECTIONS AT
NINE MILE POINT, 1973 BY
SAMPLING DATE AND BY SPECIES

Species	10-3-73 #	10-3-73 %	10-10-73 #	10-10-73 %	10-17-73 #	10-17-73 %	10-24-73 #	10-24-73 %	10-31-73 #	10-31-73 %	11-7-73 #	11-7-73 %	11-14-73 #	11-14-73 %	11-21-73 #	11-21-73 %	11-28-73 #	11-28-73 %	12-5-73 #	12-5-73 %	12-19-73 #	12-19-73 %	12-26-73 #	12-26-73 %	Total Fall 1973 #	Total Fall 1973 %	Total 1973 #	Total 1973 %
Alewife	11	45.83	9	36.00	109	30.70	24	27.27	49	63.63	781	40.47	886	53.28	102	27.79	952	59.09	2834	58.67	117	17.20	54	9.41	6645	50.00	644,681	97.82
Rainbow Smelt	10	41.66	9	36.00	148	41.69	19	21.59	7	9.09	526	27.25	671	40.35	192	52.32	411	25.51	1940	40.17	531	78.20	454	79.09	5217	39.26	10,751	1.63
Three Spine Stickleback					19	5.35			11	14.28	56	2.90	4	0.24	12	3.27	2	0.12	3	0.06			10	1.74	120	0.90	775	0.12
Gizzard Shad					10	2.32	28	31.82			117	6.06	18	1.08	13	3.54	89	5.52	10	0.21	8	1.18	17	2.96	317	2.39	659	0.10
White Bass			2	8.00							316	16.37	59	3.55	30	8.17	134	8.32	37	0.77	7	1.03	5	0.87	620	4.67	628	0.10
Mottled Sculpin	1	4.17			16	4.51			1	1.30	29	1.50	9	0.54	4	1.09	3	0.19	1	0.02	6	0.88	15	2.61	88	0.66	285	0.04
White Perch			4	16.00	19	5.35	5	5.68	1	1.30	38	1.97	1	0.06	4	1.09	6	0.37			3	0.44	4	0.70	88	0.66	249	0.04
Common Shiner					8	2.25			2	2.60					2	0.54	1	0.06							13	0.10	134	0.02
Troutperch									2	2.60	1	0.05					1	0.06							4	0.03	152	0.02
Emerald Shiner					10	2.82	3	3.41			40	2.07	1	0.06	1	0.27	2	0.12			4	0.59	7	1.22	68	0.51	142	0.02
Yellow Perch					1	0.28	3	3.41			2	0.10			1	0.27	1	0.06	1	0.02	1	0.14			10	0.08	145	0.02
Johnny Darter	1	4.17					1	1.14	1	1.30	1	0.05			1	0.27	1	0.06							6	0.05	119	0.02
Lamprey Eel											1	0.05	1	0.06			2	0.12	1	0.02	1	0.14	1	0.17	7	0.05	91	0.01
Spottail Shiner											16	0.83	6	0.36					2	0.04	1	0.14	5	0.87	31	0.23	69	0.01
Rock Bass			1	4.00			1	1.14	1	1.30			2	0.12	4	1.09	2	0.12					2	0.35	14	0.11	35	0.01
White Sucker	1	4.17			3	0.85	2	1.82	2	2.60			2	2.60			2	0.12							10	0.08	24	<0.01
Lake Chub											1	0.05													1	0.01	18	<0.01
Smallmouth Bass					1	0.28	1	1.14			3	0.16			4	0.27	1	0.06							10	0.08	20	<0.01
Bluegill Sunfish					6	1.69					1	0.05					1	0.06	1	0.07					9	0.07	9	<0.01
American Eel													1	0.06											1	0.01	8	<0.01
Mudminnow																	2	0.12							2	0.02	7	<0.01
Pumpkinseed													2	0.12											3	0.02	4	<0.01
Walleye																											4	<0.01
Shiner					5	1.13																			5	0.04	5	<0.01
Brown Bullhead							1	1.14																	1	0.01	4	<0.01
Stone Cat																											3	<0.01
Golden Shiner																											3	<0.01
Carp																											3	<0.01
N.C. Catfish																											2	<0.01
Goldfish																											5	<0.01
Black Bullhead																												
Black Crappie																											1	<0.01
Bluntnose Minnow																											1	<0.01
Logperch																											1	<0.01
Brown Trout																											1	<0.01
Northern Pike																											1	<0.01
Brook Stickleback																											1	<0.01
Creek Chub											1	0.05													1	0.01	1	<0.01
TOTALS	24		25		355		88		77		1930		1663		367		1661		4830		679		574		13291		659,041	

TABLE IV-5

SPECIES LIST AND TOTAL NUMBERS OF FISH

PER MONTH DURING NINE MILE POINT IMPINGEMENT

STUDY, 1973

Species	January #	January %	February #	February %	March #	March %	April #	April %	May #	May %	June #	June %
Alewife	3	0.19	8	3.54	42664	98.11	560662	99.68	19923	92.30	11775	93.15
Rainbow Smelt	1206	76.04	149	65.93	786	1.81	1235	0.22	1140	5.28	517	4.09
Three Spine Stkb.	106	6.68	1	0.44	2	>0.01	45	0.01	285	1.32	186	1.47
Gizzard Shad	81	5.11	2	0.88	17	0.04	242	0.04				
White Bass	5	0.32	1	0.44					1	>0.01		
Mottled Sculpin	16	1.01	33	14.60	6	0.01	17	>0.01	77	0.36	32	0.25
White Perch	20	1.26	5	2.21	1	>0.01	123	0.02	4	0.02	3	0.02
Common Shiner	1	0.06							4	0.02	48	0.38
Troutperch	5	0.32	2	0.88			66	0.01	31	0.14	35	0.28
Emerald Shiner	55	3.47	9	3.98	4	0.01	1	>0.01	3	0.01		
Yellow Perch	60	3.78	5	2.21	1	>0.01	3	>0.01	4	0.02	8	0.06
Johnny Darter	1	0.06	1	0.44			7	>0.01	86	0.40	11	0.09
Lamprey Eel			3	1.33	4	0.01	68	0.01	3	0.01		
Spottail Shiner	6	0.38	2	0.88					8	0.04	20	0.16
Rock Bass	2	0.13	1	0.44	1	>0.01	4	>0.01	4	0.02	2	0.02
White Sucker	1	0.06					1	>0.01				
Lake Chub	6	0.38					1	>0.01	1	>0.01		
Smallmouth Bass	1	0.06	2	0.88							3	0.02
Bluegill Sunfish												
American Eel			1	0.44					3	0.01	1	0.01
Mudminnow	3	0.19			1	>00.1	1	>0.01				
Pumpkinseed												
Walleye												
Shiner												
Brown Bullhead	2	0.13										
Stone Cat			1	0.44			2	>0.01				
Golden Shiner									3	0.01		
Carp	1	0.06							2	0.01		
Northern Channel Catfish	2	0.13										
Goldfish	2	0.13			1	>0.01	1	>0.01				
Black Crappie	1	0.06										
Bluntnose Minnow												
Logperch									1	>0.01		
Brown Trout												
Northern Pike												
Brook Stickleback									1	>0.01		
Creek Chub												
TOTAL	1586		226		43488		562479		21584		12641	
% TOTAL 1973 CATCH		0.24		0.03		6.60		85.35		3.28		1.92
Number hours sampled	25		28		72		96		120		96	
Average no./hour	63		8		604		5859		180		132	

Species	July #	July %	August #	August %	September #	September %	October #	October %	November #	November %	December #	December %
Alewife	2740	86.00	58	61.70	203	43.56	202	35.50	2721	48.84	3722	52.05
Rainbow Smelt	250	7.85	18	19.15	233	50.00	193	33.92	1800	32.31	3224	45.08
Three Spine Stkb.	28	0.88	1	1.06	1	0.21	30	5.27	74	1.33	16	0.22
Gizzard Shad							38	6.68	237	4.25	42	0.59
White Bass	1	0.03					2	0.35	539	9.68	79	1.10
Mottled Sculpin	14	0.44	1	1.06	1	0.21	18	3.16	45	0.81	25	0.35
White Perch	3	0.09	1	1.06	1	0.21	29	5.10	49	0.88	10	0.14
Common Shiner	58	1.82	5	5.32	5	1.07	10	1.76	3	0.05		
Troutperch	8	0.25	1	1.06	13	2.79	2	0.35	2	0.04		
Emerald Shiner			2	2.13			13	2.28	44	0.79	11	0.15
Yellow Perch	36	1.13	5	5.32			4	0.70	4	0.07	2	0.03
Johnny Darter	5	0.16	1	1.06	1	0.21	3	0.53	3	0.05		
Lamprey Eel	6	0.19							4	0.07	3	0.03
Spottail Shiner	2	0.06							22	0.39	9	0.13
Rock Bass	6	0.19			1	0.21	3	0.53	8	0.14	3	0.04
White Sucker	7	0.23	1	1.06	4	0.86	8	1.41	2	0.04		
Lake Chub	9	0.28							1	0.02		
Smallmouth Bass	2	0.06			2	0.43	2	0.35	5	0.09	3	0.04
Bluegill Sunfish							6	1.05	2	0.04	1	0.01
American Eel	2	0.06							1	0.02		
Mudminnow									2	0.04		
Pumpkinseed					1	0.21			2	0.04	1	0.01
Walleye	4	0.13										
Shiner							5	0.88				
Brown Bullhead	1	0.03					1	0.18				
Stone Cat												
Golden Shiner												
Carp												
Northern Channel Catfish												
Goldfish	1	0.03										
Black Crappie												
Bluntnose Minnow	1	0.03										
Logperch												
Brown Trout	1	0.03										
Northern Pike	1	0.03										
Brook Stickleback												
Creek Chub									1	0.02		
TOTAL	3186		94		466		569		5571		7151	
% TOTAL 1973 CATCH		0.48		0.01		0.07		0.09		0.85		1.09
Number hours sampled	96		120		96		120		96		96	
Average no./hour	33		1		5		5		58		74	

from open water areas. The dominance of smelt in winter impingement collections corresponded with this inshore spawning movement.

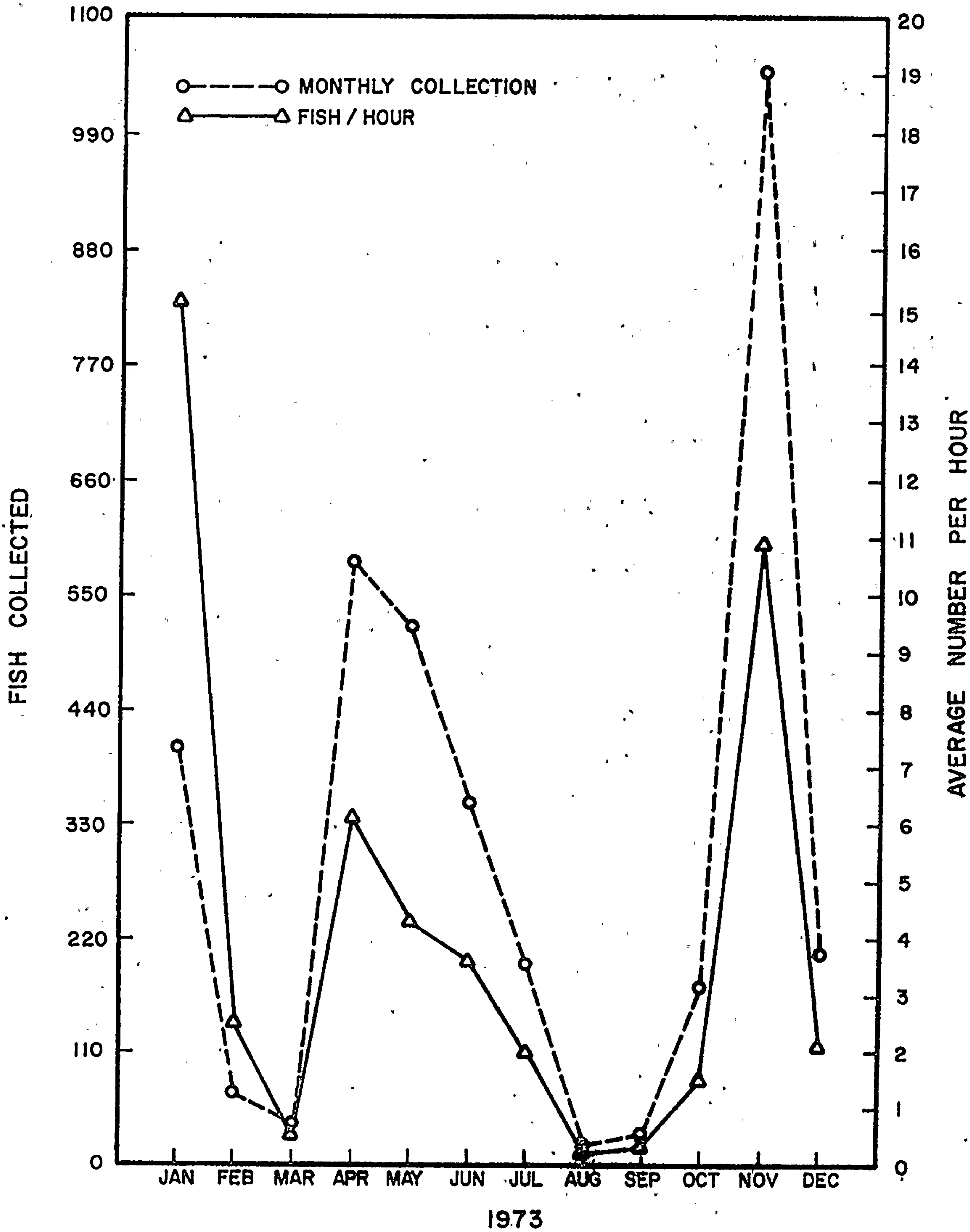
Alewife dominance in impingement samples began during late March and continued through midsummer. The greatest numbers were recorded during April. Wells (1968) found inshore movement of alewife in Lake Michigan beginning around 11 March with a maximum movement around 15 April. Graham (1956), working on the western end of Lake Ontario observed shoreward migration in April with the greatest numbers found during middle to late June. Graham also noted a post-spawning movement by adults back to deep water in mid-September. Young-of-the-year alewife were first collected by Wells (1968) during October, reaching maximum numbers during November. Length frequency data show that young-of-the-year alewives dominated impingement collections from August through December (Figure III-37). Deleting the numbers of alewives and rainbow smelt, the remaining 1.2% of the 1973 impingement collection was composed of 3,609 fish representing 35 species. Seasonal trends in abundance for these fish are plotted by month in terms of actual fish collected and fish collected per hour of sampling (Figure IV-1). The January peak was primarily due to three-spined sticklebacks and gizzard shad. Gizzard shad are known to frequent areas of thermal influence, especially during fall and winter (Miller, 1960; Bodola, 1966).

During April, gizzard shad and white perch comprised the majority of the sample. Gizzard shad spawn during June and July. However, it is not uncommon to find large numbers prior to and during this spawning time in shallow water (Bodola, 1966). Miller (1960) reports spawning of gizzard shad

FIGURE IV-1

MONTHLY IMPINGEMENT & AVERAGE NUMBER PER HOUR

OF ALL SPECIES EXCEPT ALEWIFE AND RAINBOW SMELT



from late winter (mid-March) through most of the summer. Gizzard shad were not collected from May through September, which would indicate that spawning occurs prior to the May sampling date and that the adult fish move away from the shallow water at the end of spawning. White perch also spawn at the same time, and the numbers impinged probably reflect inshore movement for spawning.

Following the summer low, impingement rates increased during October, peaked during November, and then declined during December. The November peak is primarily due to white bass, but is partially the result of the presence of young-of-the-year gizzard shad. The white bass collected in November were young-of-the-year fish averaging 9.0-10.0 cm in total length, and their presence in the intake area and impingement collections may be associated with young gizzard shad, a primary food source. Bonn (1952) working with feeding habits of young white bass in Texas, observed a definite preference for gizzard shad.

3. LAKE AND PLANT COMPARISONS

a. Relative Abundance

The purpose of comparing relative abundance in the plant and in the Lake was to determine if trends in impingement followed trends of species abundance in Lake Ontario fish catches. A certain amount of predictability could be relied on for future impingement studies if it were found consistently that impingement itself was closely associated with known life history parameters for a species. Data from Lake surveys have shown that species at Nine Mile Point conform closely to the characteristics described in the literature, especially species such as alewife and rainbow smelt.

Plant and Lake abundance data for a species were presented in two different ways: first, as a comparison of relative abundance expressed in percent of total catch in the plant and in the Lake; second, as the number of fish collected per unit of fishing effort (Lake) compared to the number of impinged fish collected per million gallons of cooling water flow (a different, yet consistent, measure of effort).

It should be emphasized that these expressions do not intend numerical comparison of the actual populations collected in the plant and Lake. They can only be used to compare the timing of peaks of relative species abundance found in the plant and the Lake and to analyze the vulnerability to impingement of certain life history stages of the various species with season.

Alewife and rainbow smelt, due to their abundance in both Lake and impingement collections, were the species used for this comparison. Peak impingement periods for smelt were January-February and August-September. Peak impingement for alewives occurred from March-July.

Alewives were present in Lake catches throughout the 1973 sampling season (Figure IV-2). Peak representation for smelt in Lake catches occurred during May (14%) and November (15%). These peaks of representation in the total Lake catch are noticeably out of phase with peak representation during August and September for impingement collections (Figure IV-3). Percent representation of smelt in Lake catches during August and September was depressed by relatively high numbers of white perch and yellow perch collected during this period. The fact that peaks of relative abundance between impingement and Lake catches do not coincide closely suggests that the two generalized categories of collection

NINE MILE POINT
ALEWIFE
1973

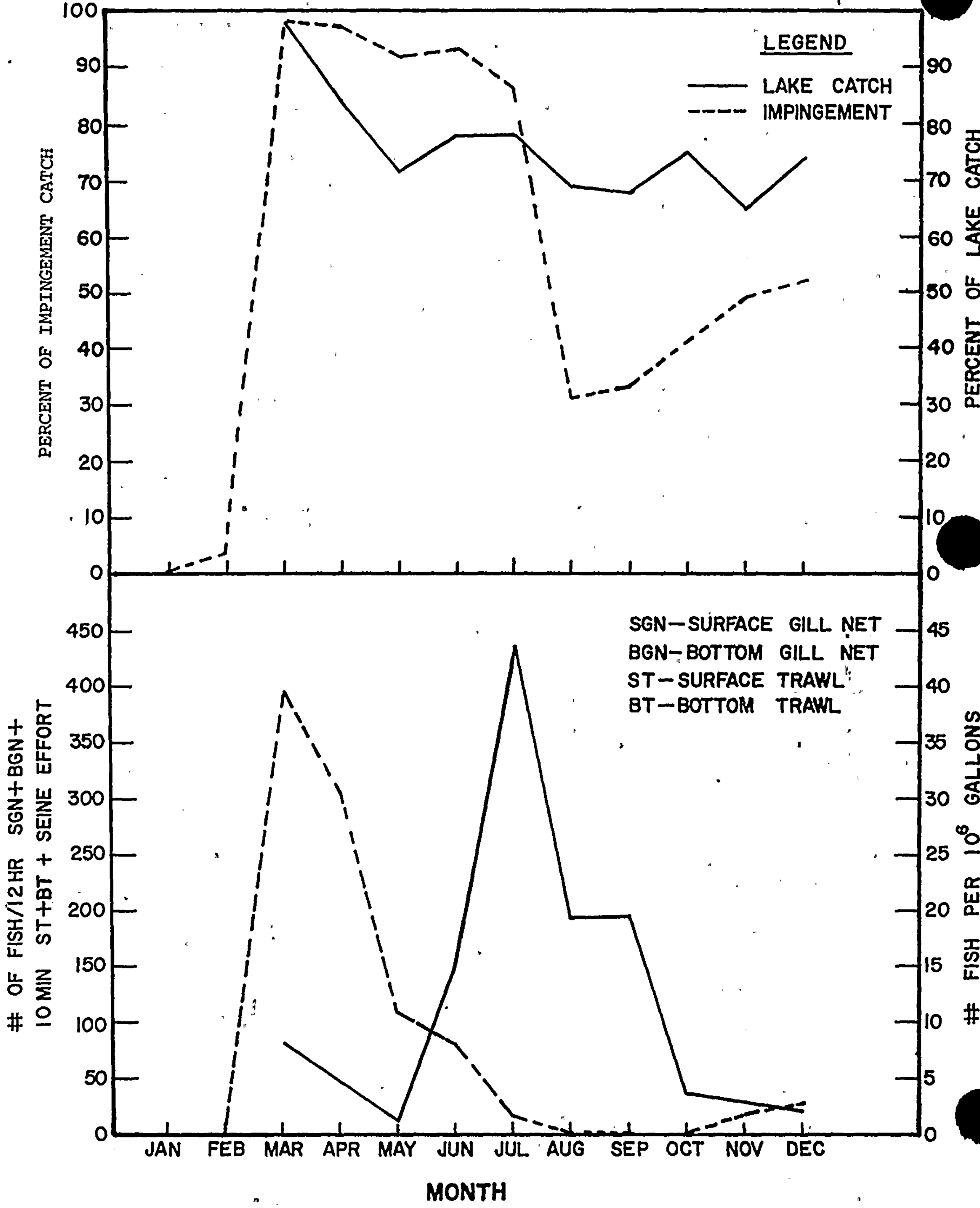
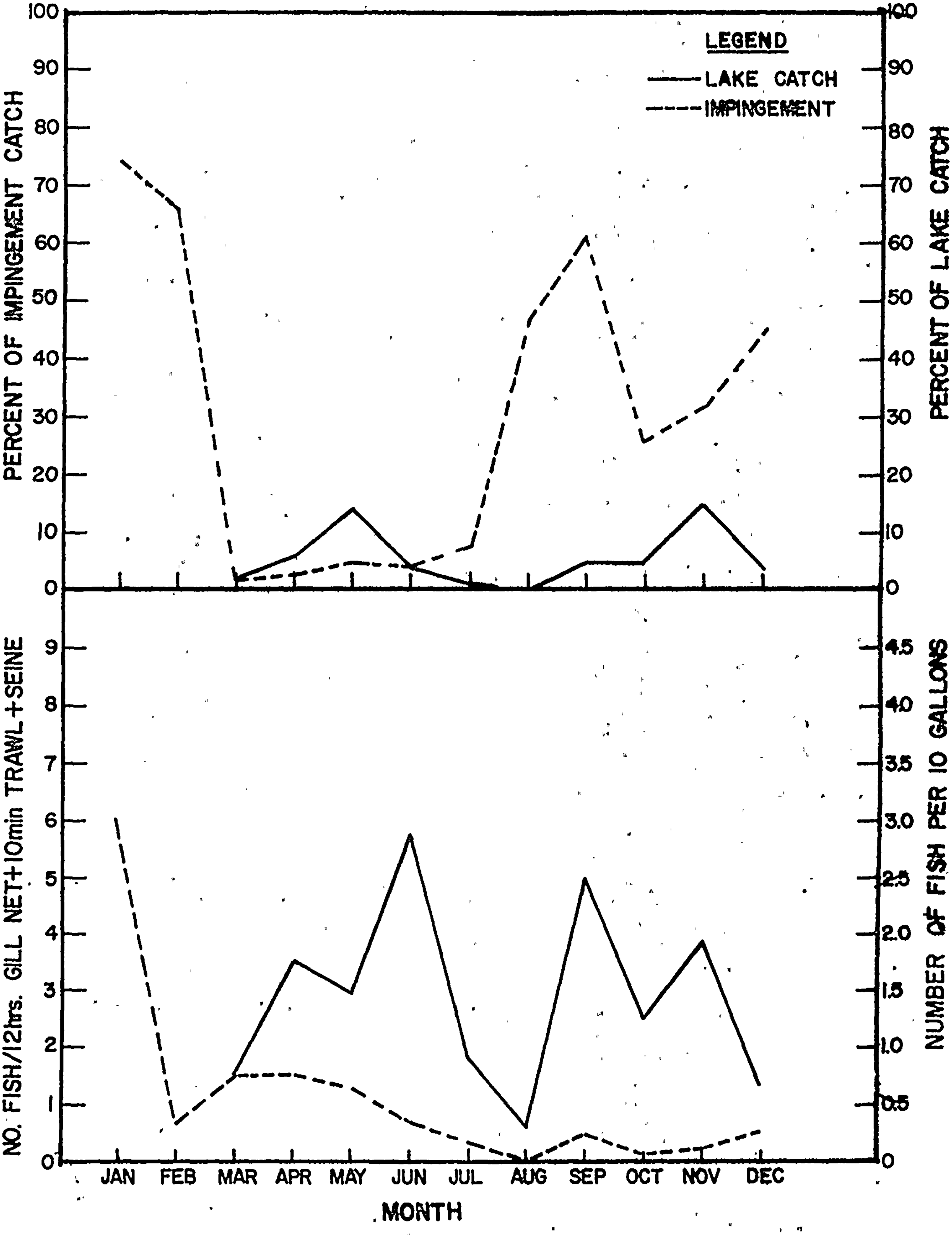


FIGURE IV-3

NINE MILE POINT
RAINBOW SMELT
1973



(impingement vs. gill nets, trawls, and seines) may be selective for different segments of the population.

Peaks in abundance for alewife in Lake collections (Fish/Unit Effort) and impingement collections (Fish/MG) were out of phase (Figure IV-2). Peak abundance for impingement collections occurred during March and April and for Lake collections during July through September. The results of length frequency analysis (Figure III-37) showed that the spring impingement peak was composed almost entirely of adult fish (~15.6 cm in length). The timing of peak abundance in impingement collections coincided well with the pre-spawning, shoreward migration (Wells, 1968).

Length frequency data show that peak abundance for alewives in Lake catches during the summer and early fall peak abundance period were primarily of young-of-the-year fish (Figure III-37). Alewife impingement was low at this time, indicating that although young alewives were abundant in the Lake, they were not vulnerable to impingement. Alewife spawning began during June in Lake Ontario and peak spawning occurred during July 1973 (see Reproduction section). These data showed that unspawned, sexually mature alewives comprised the bulk of the impinged alewife population at Nine Mile Point during 1973.

The comparison between smelt abundance in the Lake (Fish/Unit Effort) and in impingement collections (Fish/MG) was not as definitive as the comparison for alewives. During the time of peak abundance in impingement collections (January and February), fishing effort in the Lake was not feasible due to ice and other inclement weather conditions.

b. Relative Condition Factors

The length-weight relationship for a species is not meant to be used as a precise mathematical or statistical parameter to define a population. Instead, it should be used as a tool to provide generalized information of a comparative nature. If certain trends are indicated by length-weight analysis, these trends can then be examined more closely by using other techniques to assess their biological or ecological consequence.

Relative condition factors (see Materials and Methods section) were calculated for alewives and rainbow smelt impinged at Nine Mile Point. Condition factors for fishes collected during a given sampling period were computed from the length-weight equations for the same species collected from the Lake during the same sampling period. The length-weight equations of Lake fish were used as a baseline for comparisons between the fatness of impinged fish and the fatness of "average" Lake fish (Swingle and Shall, 1971). The relative condition factor (Kn) of an impinged fish was always 1.0 if it was equal to the condition factor for a Lake fish of the same length. Whenever impinged fish were in poorer condition than the Lake fish, the relative condition was less than 1.0, and when the condition of impinged fish was better than that of Lake fish, Kn was greater than 1.0. For example, a Kn value of 1.2 for an impinged fish would indicate that it weighed 20% more than a lake fish of the same length and, hence, that it was in better condition.

One date was chosen to be analyzed for each species. Alewives were analyzed for the collection date of June 13, and smelt for the date of December 28. The weighted Kn for all impinged fish was lower than 1.0, indicating that

impinged alewives and rainbow smelt were thinner than Lake fish (Tables IV-6 and IV-7). There was a general trend of decreasing condition for alewives with increased length intervals, and it was hypothesized that the increased swimming ability of larger fish enabled them to avoid impingement for a longer period of time. This trend was not evident for rainbow smelt.

This type of analysis is subject to bias from several sources. Sampling bias may result from differential treatment of Lake and plant fish. For example, if impinged fish were analyzed fresh and Lake fish were analyzed after preservation in formalin, Lake fish would be generally heavier and apparently in better condition than impinged fish due to the fact that preserved fish tend to shrink in length and gain weight (Parker, 1963). Lake fish and impinged fish were preserved in formalin during the 1973 Nine Mile Point study, thus eliminating this type of bias.

The second source of sampling bias may result from gill nets being used as the main collection method for Lake fish. Tesch (1971) points out that a sample from a gill net of a particular size is usually unsuitable for length-weight analysis because the net tends to be selective, depressing the slope of weight on length and lowering the apparent condition of the fish. Experimental gill nets of the type used for the Nine Mile Point study reduced this type of bias, and results show that Lake fish collected in gill nets were in better condition than impinged fish.

A third source of possible bias may result if the baseline length-weight equation for a species in the Lake was calculated from a population with a sex ratio different from the impinged population. For example, assuming

TABLE IV-6

Baseline Length-Weight Equation for Lake and Relative Condition Factors (Kn) for Impinged Alewives at Nine Mile Point on 13 June, 1973 on Lake Ontario

LAKE

BASELINE LENGTH-WEIGHT EQUATION	CORRELATION COEFFICIENT	SAMPLE SIZE
Log W=-5.924 + 3.348 Log L	0.961	125

IMPINGEMENT

LENGTH INTERVAL (cm)	MEAN Kn	SAMPLE SIZE
7.0 - 7.9	1.261	1
9.0 - 9.9	1.016	12
10.0 - 10.9	0.933	5
11.0 - 11.9	0.927	3
12.0 - 12.9	1.068	6
13.0 - 13.9	0.934	42
14.0 - 14.9	0.894	239
15.0 - 15.9	0.892	192
16.0 - 16.9	0.846	44
17.0 - 17.9	0.780	20
18.0 - 18.9	0.737	3
19.0 - 19.9	0.368	1
WEIGHTED MEAN Kn FOR ALL IMPINGED ALEWIVES	0.892	568

TABLE IV-7

Baseline Length-Weight Equation for Lake and Relative Condition Factors (Kn) for Impinged Rainbow Smelt at Nine Mile Point on 28 December, 1973 on Lake Ontario

LAKE

BASELINE LENGTH-WEIGHT EQUATION	CORRELATION COEFFICIENT	SAMPLE SIZE
$\text{Log } W = -5.316 + 3.045 \text{ Log } L$	0.995	91

IMPINGEMENT

LENGTH INTERVAL (cm)	MEAN Kn	SAMPLE SIZE
4.0 - 4.9	0.886	1
5.0 - 5.9	0.905	39
6.0 - 6.9	0.831	151
7.0 - 7.9	0.851	90
8.0 - 8.9	0.861	11
9.0 - 9.9	0.763	3
10.0 - 10.9	0.764	1
11.0 - 11.9	0.781	3
12.0 - 12.9	0.822	6
13.0 - 13.9	0.767	8
14.0 - 14.9	0.766	7
15.0 - 15.9	0.757	1
16.0 - 16.9	0.910	4
17.0 - 17.9	0.979	2
18.0 - 18.9	0.943	2
WEIGHTED MEAN Kn for ALL IMPINGED SMELT	0.844	329

that the length-weight relationship for male and female alewives were entirely different and that the sex ratio was heavily in favor of females in the Lake population, the Kn values calculated for impinged alewives may be biased if the impinged population were predominently male. Although this is a somewhat extreme example, the bias can be eliminated by providing large sample sizes of both Lake and plant fish for which sex is known. The length-weight analysis and calculation of condition factors could then be carried out separately for each sex. Sex ratio data for alewives showed that females greatly predominated in both the Lake and impingement collections at Nine Mile Point during 1973 (Table III-43; Reproduction section).

c. Species Diversity

Diversity indices are mathematical models which permit summarization of large amounts of information about numbers and species and enable comparison of different data (Whilm and Dorris, 1966, 1967; Sager and Hasler, 1969). The mathematical method is not an alternative to observation and experimentation but is a necessary supplement (Nicholson, 1954). Three indices were calculated for the fish impingement collections made at the Nine Mile Point Unit 1 and a representative collection from the Lake in the vicinity of the intake structure.

The Lake collection indices are mean monthly indices based on trawl and gill net collections from the Nine Mile Point (NMPP) transect. The trawls selected were surface and bottom from 20 and 40 feet and the gill nets were surface and bottom from 20 and 40 feet and mid-depth at 15 feet. The plant intake is located in approximately 25 feet of water and the collections used in the Lake

indices were selected as the best representing the community available for impingement. Impingement diversity values were mean monthly indices for number of fish impinged per hour.

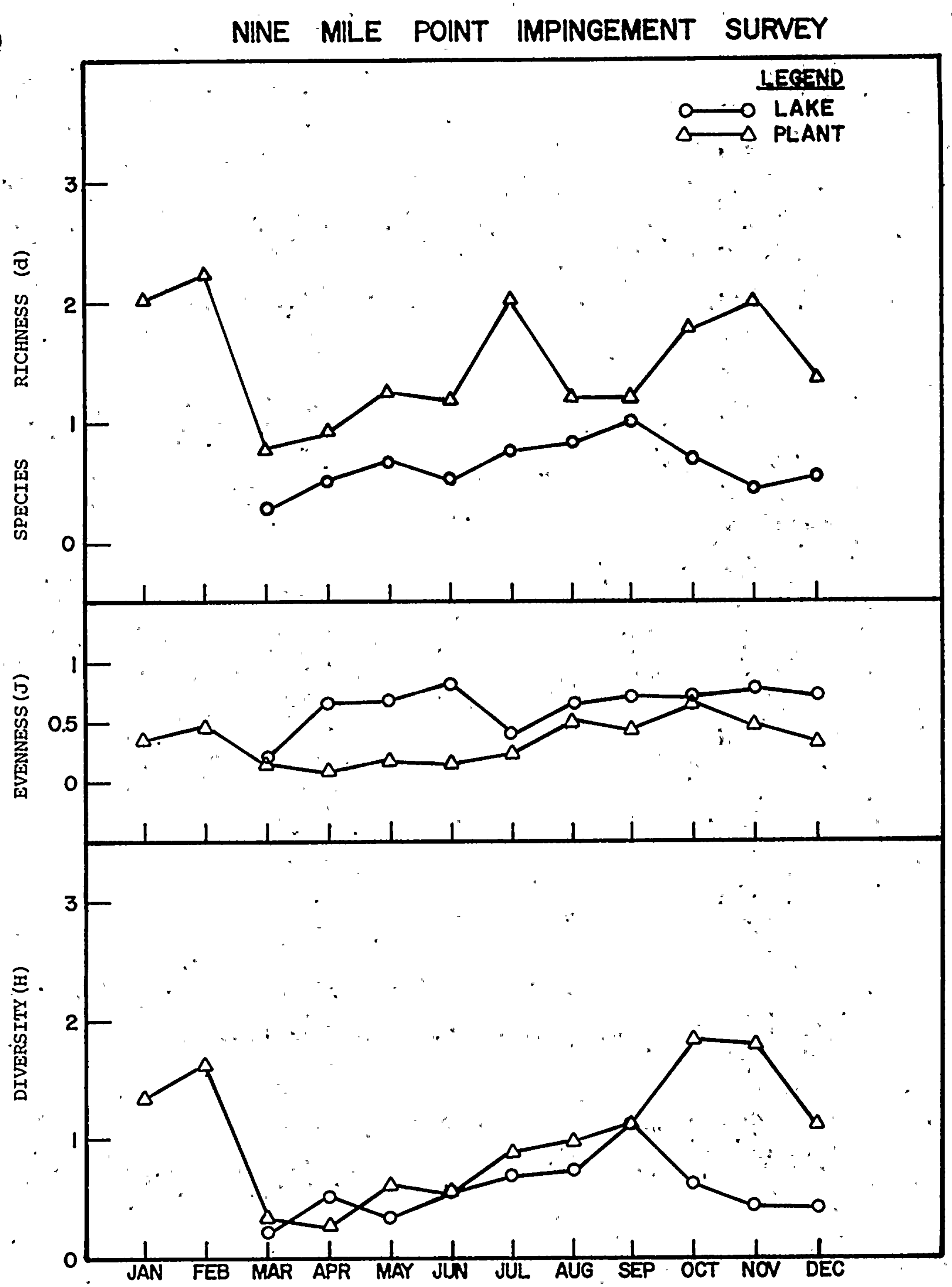
The indices calculated were: a) diversity (H') based on information theory, b) evenness (J), and c) species richness (d).

The formulas employed in the indices calculations and their diagnostic capabilities were discussed in the fisheries section. Graphic presentation of the comparable Lake and plant indices is given in Figure IV-4.

(i) Information Theory Diversity

The Lake diversity index (H') pattern showed a March low, increasing gradually through the spring and summer months to a September high. The index value decreased rapidly from September through the fall period. The increase in diversity was consistent with the shoreward spawning and feeding movements of fish species during the spring - summer period. Indices for the fall period indicated a migration from the shallow to deep waters and a resultant decrease in diversity.

Diversity index values for the plant span a longer time interval than the Lake. The winter months of January and February exhibited a high diversity which declined rapidly in March to a value comparable to the Lake index. The impingement diversity was similar to the Lake diversity through the spring and summer period. However, unlike the Lake, impingement diversity increased through October with a downward trend beginning in November and continuing in December. Comparable data from the Lake


NINE MILE POINT IMPINGEMENT SURVEY
LEGEND
LAKE
PLANT
SPECIES RICHNESS (d)
EVENNESS (J)
DIVERSITY (H)
0
0.5
1
2
3
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

were not available for January and February, however, the available data indicated a large number of species in the immediate area of the plant. This possibly is due to the fish preferring an area of warmer water around the plant discharge.

The sharp decrease of the March impingement diversity was due to a decline from February to March in the number of species collected, combined with an increase in the average number of fish collected. The number of species declined from 12 to 6, and the average number of fish increased from 113 per collection date to 29,500 per collection date. The increase in fish abundance was due to greater numbers of impinged alewives beginning on 21 March. The spring - summer diversity index for both plant and Lake collections were similar. The fall increase of impingement diversity compared to Lake collection diversity was due to a higher average number of species present in the impingement samples. Young-of-the- year fish, which were not well-represented in gill net collections, composed a large portion of the impingeable Lake population during the fall and contributed to increased impingement diversity.

(ii) Species Evenness (J)

Species evenness is a ratio of the observed diversity (H') to the maximum possible diversity (H max). Maximum diversity would occur when the number of individuals collected were evenly distributed between the species (Pielou, 1966; Dahlberg and Odum, 1970; Hurlbert, 1971). The greater the evenness value, the more efficient the community structure, since the

energy flow within the food web can follow more pathways.

Lake evenness was greater than the impingement evenness values during all months. This suggests a selective aspect of impingement in comparison to the Lake collections. The Lake value was highest during the spring, declined during the early summer and gradually increased through late summer and fall. The only winter value, March, was lower than any other monthly average. A distinct seasonal cycle of evenness was found by Dahlberg and Odum (1970) in an estuary using this index; they attributed it to juveniles in the study area. The spring increase in evenness in Lake Ontario could be due to adults moving into the shallow area to spawn. The August decline may represent post-spawning movement to deeper water. The late summer-fall increase would represent the young-of-the-year being collected in the study area. Impingement collections show a late winter decline and gradual increase through the spring - summer - early fall period, then gradually declining. Impingement evenness was low during all seasons due to the dominance of alewives in impingement collections.

(iii) Species Richness (d)

Species richness emphasizes the number of species present rather than total abundance of individuals (Hurlbert, 1971; McErlean et al., 1973). This index is more sensitive to seasonal fluctuations than the diversity index which equates the individuals more to the number of species collected (Dahlberg and Odum, 1970).

Lake species richness mirrors the diversity index value having an early spring low, increasing through the spring and summer then declining during the fall. The seasonal movement of fish species would account for this pattern. For all months with comparable index values the impingement species richness is higher than Lake collection values, suggesting greater species selectivity in the Lake collection technique. A similar pattern to that seen for species richness was observed for diversity, except for the sharp increase in species richness during July when 22 species were collected in impingement samples. This increase was due to the collection of several species, such as brown trout, represented by only one individual and absent from other warm water months.

In general, the diversity indices suggest selectivity of the Lake sampling techniques compared to impingement collections. This was specifically evident from the greater diversity index and species richness during fall impingement collections due to the inability of gill nets, the major sampling gear, to collect representative numbers of young-of-the-year fish. A general seasonal trend for both Lake and impingement collections was characterized by smaller index values in the spring, increasing through the summer and declining in the fall. This corresponded to the general shoreward movement of fish during the warmer months and their return to deeper water during cold water periods.

4. PHYSICAL CONDITIONS

Evaluation of abiotic parameters and their effects on community structure with time is useful in determining trends in population movements. Temperature is

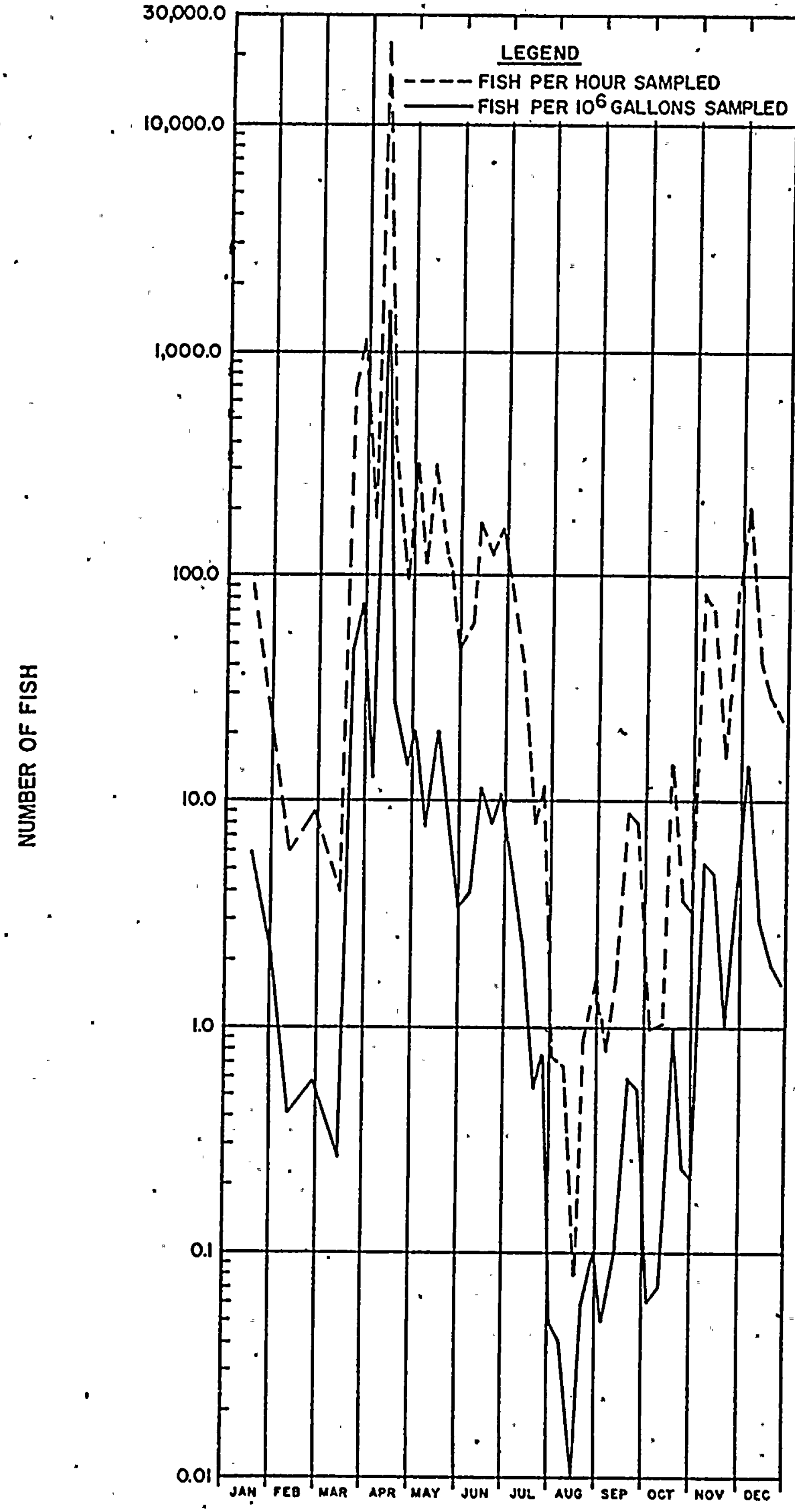
a primary factor governing the movement of organisms, especially in the temperate zones (Brylinsky and Mann, 1973). Seasonal differences in temperature between the shore and open water areas of a lake and preference of organisms for different temperatures at different stages of their development determines to a great extent their distribution patterns.

The number of fish collected from the impingement collections by date is shown graphically in Figure IV-5. The numbers are reduced to fish impinged per 10^6 gallons of cooling water sampled and fish impinged per hour of sampling. The actual numbers were log transformed for ease of display, and since both graphs reflect the same trends in collection, both methods are similar for comparison of the data. A graph of average daily temperature from the intake forebay and discharge taken during the impingement sampling is presented in Figure IV-6. The change in temperature (ΔT) of the cooling water due to passage through the condensers is shown also.

There is a seasonal trend between the number of fish impinged and the water temperature. The spring warming of the water corresponds to the inshore migration of many species of fish for spawning. The increased number of fish in the shallower water areas is reflected in the increased numbers of fish impinged. The number of fish impinged declined substantially during the summer as the water temperature reached its highest yearly values. The low impingement rates were due to a post-spawning migration from the shore area to deeper waters.

The cooling of the water in the shore area during the fall corresponded to an increase in impingement rates. The fall impingement collection was composed mostly of young-of-the-year fish. These young fish remained in the shore zone during the summer for feeding and protection, moving to deeper

NINE MILE POINT IMPINGEMENT SURVEY
FISH IMPINGEMENT RATE BASED ON COOLING WATER FLOW AND HOURS SAMPLED
1973



TEMPERATURE (°F & Δt) AT NINE MILE POINT INTAKE FOREBAY AND DISCHARGE

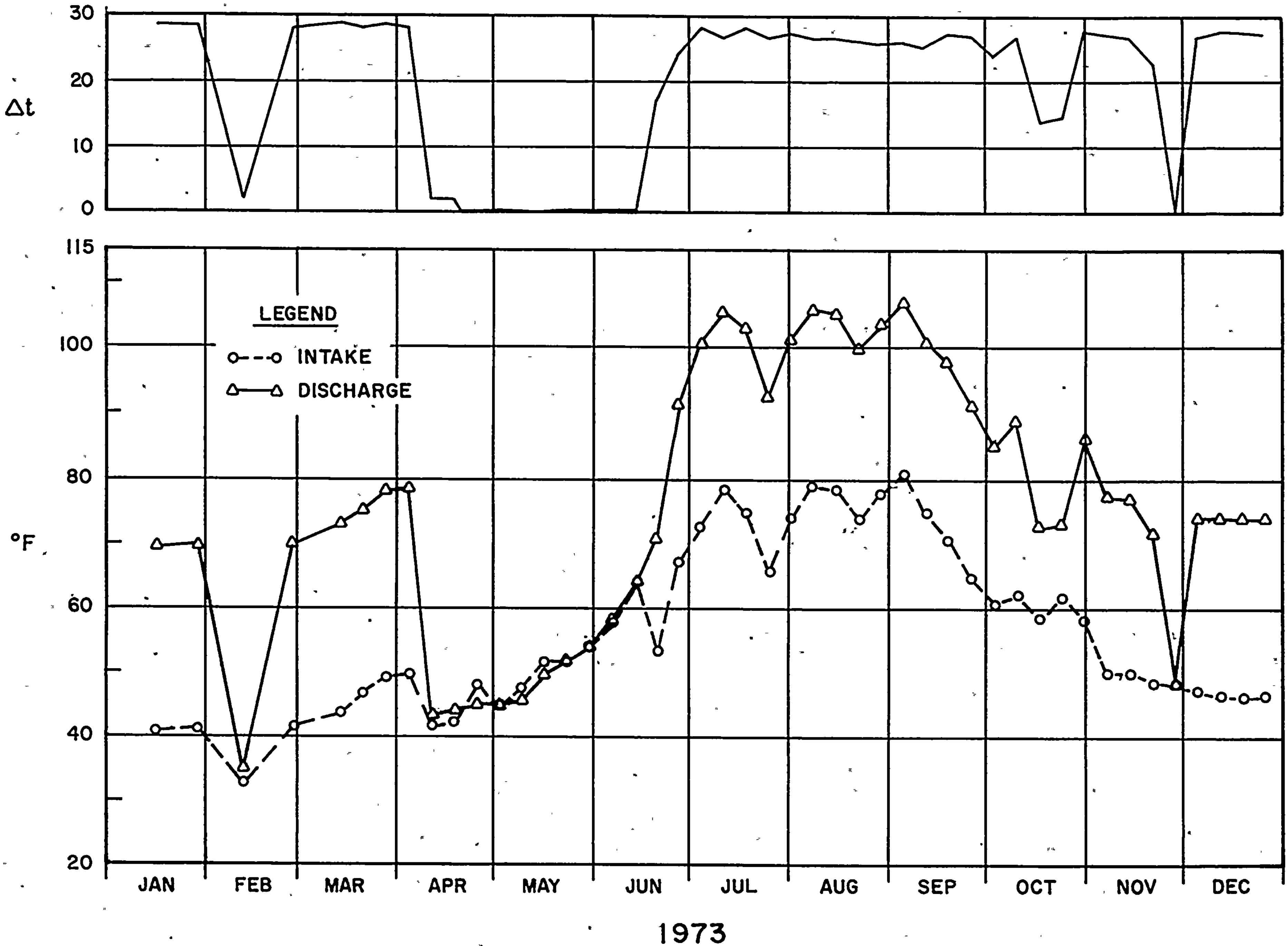


FIGURE IV-6

water areas as the littoral conditions became less desirable in the fall. Several of the fish species collected during the fall, such as gizzard shad, alewife, and white bass, are known to prefer warm water areas (Bodola, 1966; Bonn, 1952; Graham, 1956). These species may have been located in the area influenced by the warm water discharge, thereby increasing their impingement rate at this time of year. Migration of young-of-the-year from the littoral zone and species preference for the warm water discharge may be two reasons accounting for the increased fall impingement.

When 42 and 52°F temperatures are recorded in autumn, November and December, day length is diminished and temperatures are decreasing toward winter minima. These conditions may be associated with increased fish activity as they move offshore for overwintering. Increased activity during spring and autumn may contribute substantially to the high impingement rates recorded during these periods.

Aside from direct temperatures and seasonal activity influences on impingement rates, a third possible contributing factor is the temperature preference of fish. The Nine Mile Point Nuclear Power Station Unit One discharge is located about 800 feet south southwest of the intake. Heated water diffuses from the discharge and creates a plume which disperses laterally and toward the surface. Fish in the discharge area encounter temperatures which most likely do not approach maximum tolerable temperatures, but they may experience rapid changes between ambient Lake and heated discharge temperatures (Moss, 1970). Avoidance reactions of fishes to heated waters may be marked by increased activity. As fishes move toward areas of preferred temperatures, areas uninfluenced by the discharge, individuals passing by the intake may become susceptible to impingement. Since relative discharge and ambient Lake

water temperatures generally differ greatly during spring, fall, and winter periods, the impingement rates recorded at those times may be partially attributable to temperature selection movements of fishes.

C. IMPLICATIONS OF FISH IMPINGEMENT

Fish populations are maintained in states of dynamic equilibria through the influence of intra-and interspecific competition.
Interspecific competition has become more keen as man has developed the technology to commercially exploit fish stocks. Increased exploitation of fishes may result in drastic reductions of stocks as observed in Lake Ontario (Christie, 1973) or, more ideally, in the regulation of commercial and sport fisheries as has been done in the Chesapeake Bay region.

An additional source of competition for fish stocks has developed through the use of large volumes of surface waters for cooling and other industrial processes. The accumulation of fishes may clog municipal water supply stations (Breder and Niqrelli, 1936) or interrupt industrial operations Dawson, 1967; Smith, 1970; Edsall and Yocum, 1972.) Cropping of fishes by water intake systems may disrupt the equilibrium maintained within the ecosystem if this cropping compounds the effects of existing competition patterns.

The dominating fish species in the Nine Mile Point area of Lake Ontario are alewives with rainbow smelt ranked fourth in total overall abundance (Chapter III, this report). Collections of fishes impinged at the Nine Mile Point Nuclear Power Station were dominated by alewives, rainbow smelt

were the second most important impinged species. To aid in interpretation of impingement data for these two species, the population biology and ecological implications of impingement of each species is discussed below:

1. **ALEWIFE (*Alosa pseudoharengus*)**

Alewives contribute an important commercial species in the Great Lakes. For a representative year, 1971, landings of alewives totalled 29,654,000 pounds (lb). All alewives were landed from trawl, trap and gill net operations in Lake Michigan. These landings composed 66.4% of the total commercial catch for Lake Michigan that year, and 29.3% of the total 1971 commercial fish landings for the Great Lakes. Only yellow perch and rainbow smelt were landed in numbers approaching that of alewives (19,196,000 lb. and 17,131,000 lb., respectively). Commercial production of alewives has been substantial in Lake Michigan since 1957 (220,000 lb), reaching a peak in 1967 (41,895,000 lb); in general, commercial landings have been consistent since 1966, fluctuating about a mean of 32,212,000 lb.

Because of the relatively small size attained by the Great Lakes' alewives in comparison to Atlantic populations (157mm versus 248mm for age class VI, Lake Ontario and Atlantic females, respectively

[Graham, 1956]), the alewives of the Great Lakes are not considered a prime fish for human consumption (Smith, 1970). Most of the commercial catch is utilized in the preparation of fish protein concentrate. Commercial fishing pressure on the Great Lakes'alewife stocks is low, with the exception of Lake Michigan (Graham, 1956).

The lack of commercial fishing pressure and the rapid onset of maturity among landlocked alewives has resulted in rapid growth of alewife populations when introduced to new environments. Generation time in landlocked populations is short; most age class II and virtually all age class III fish spawn. Alewives in the Great Lakes often attain an age of 6 years or more (Graham, 1956; Brown, 1972). In several recorded instances, notably in Lake Michigan, population expansion of the alewife exceeded the carrying capacity of the Lake environment, resulting in massive die-offs (Brown, 1972). Overpopulation notwithstanding, alewives regularly undergo a mass "natural die-off" during the late spring and early summer months. This phenomenon has been recorded regularly from Lake Ontario since the 1880's and earlier (Pritchard, 1929) and in other freshwater populations (Odell, 1934; Tothschild, 1966; Brown, 1968; Stanley, 1969).

Brown (1968) has studied live and dead fish caught at the height of mass mortalities and described even dead and dying fish as "robust," often with full stomachs. Graham (1956) suggested that the mortalities

could be attributed to temperature shock. During mass mortalities, representatives of all age classes are present. Thus, while annual mortalities may be an important factor in limiting alewife populations, particularly in underfished stocks, the cause of the mortality is likely to be physico-chemical rather than biologic.

Most data regarding the landlocked alewife are from Lakes Michigan and Ontario. Commercial landings for Lake Michigan suggest that yield from fishable stocks is approximately in equilibrium, at a mean of some 32 million pounds annually (1966 to 1972 range 27 M to 42 M lb.) composed of fishes greater than 2 years of age (Table IV-8). Approximate numbers of fish landed are likewise expressed in Table IV-8, based upon an annually adjusted average adult weight of 1.3 oz. per fish (derived from data in Brown, 1972; mean adjusted for increase over the time interval, 1965 to 1970).

While a more precise estimate of number caught may have been derived using mean weight determined for each year's alewife samples (Brown, 1972), placement of the maximum error would have been four orders of magnitude less than the first significant figure for the maximum year (1967).

TABLE IV-8

COMMERCIAL CATCH OF ALEWIVES (*Alosa pseudoharengus*) IN LAKE MICHIGAN, 1957 TO 1972

Landings

Year	Weight (lb. x 10^3)	Number (Calculated)
1957	220	2,706,000
1958	1,356	16,678,800
1959	1,264	15,547,200
1960	2,370	29,151,000
1961	3,199	39,347,700
1962	4,742	58,236,600
1963	5,396	66,370,800
1964	11,743	144,438,900
1965	14,007	172,286,100
1966	29,002	356,724,600
1967	41,895	515,308,500
1968	27,194	334,486,200
1969	29,248	359,750,400
1970	33,467	411,644,100
1971	29,654	364,744,200
1972	35,034	430,918,200

Based upon experimental fishing performed in 1964 and 1969, calculated estimates of the pounds of alewives available to bottom trawls were made (Brown, 1972). Projected catch in pounds and numbers are presented in Table IV-9. The stock estimates provided here (Table IV-9) must be taken as conservative, since sampling efficiency of trawls was assumed to be 100%, rather than the more likely efficiency of 25 to 30%. Reigle (correspondence to Great Lakes Fishery Laboratory, 1966), adjusted the figures presented here to compensate for trawl avoidance and alewives in mid-water. He chose to double the estimated figure (see Brown, 1972).

Alewife population estimates for Lake Ontario derived in precisely the same manner as those derived for Lake Michigan (i.e., experimental trawl captures (lbs/acre or number/acre) averaged over time, depth and location) provide a picture of relative abundance of the fish stock throughout the year. Distribution characteristics of the population differs markedly with season (Pritchard, 1929; Graham, 1956; Wells, 1968; QL&M, 1972; GLFL Cruise Reports, 1972 a, b, c, d, e). Seasonally averaged abundance to trawls is in fact the more desirable statistic, since the schooling characteristics of the alewife in the spring may tend to increase catch per effort and bias the stock estimate upward.

During May of 1972 the Great Lakes Fishery Laboratory (Bureau of Sport Fisheries and Wildlife) undertook a program to assess fish stocks in Lake

TABLE IV-9

ALEWIVES (Alosa pseudoharengus)
AVAILABLE TO BOTTOM TRAWLS
IN LAKE MICHIGAN, 1963 TO 1970 (After Brown, 1972)

Year	lbs. Available * Millions of lbs.	Available * Billions of Fish	Lbs. Available [1] Millions of lbs.	Available [1] Billions of Fish
1963	605	7.26	284	3.40
1964	490	5.88	231	2.77
1965	1,131	13.57	530	6.36
[illegible]	2,093	25.12	983	11.80
[illegible]	2,450	29.40	1,150	13.80
1968	1,059	12.71	497	5.96
1969	333	3.99	156	1.87
1970	599	7.19	281	3.37

*Projected from 1964 data

[1]Projected from 1969 data

Ontario. The results of five cruises (R/V Kaho cruise II, IV, VI, VIII, and X) from May to October, 1972, were utilized in the development of the following stock estimates for alewives in Lake Ontario.

Mean numbers of alewives trawled, by cruise, are presented as numbers per acre and pounds per acre in Table IV-10. A mean weight per alewife of 1.5 oz. was derived from cruise report summary sheets. This estimate was considered high in relation to samples collected contemporaneously with the R/V Kaho by Quirk, Lawler and Matusky Engineers (1973). Thus, the average of 1.3 oz. per fish (derived from Brown, 1972), was used in construction of Table IV-10.

Stock estimates (Table IV-11) made herein are highly conservative:

1. The estimated crop is based upon bottom trawl catch per unit effort. However, depth sounding studies carried out by R/V Kaho indicated that a substantial proportion of alewives are distributed at mid-depth and were not caught by the experimental bottom trawls.
2. The stock estimate is based upon a 100% efficiency for the bottom trawl gear. Trawl gear is substantially less than 100% efficient and may fish at less than 50% efficiency. Reigle of the Great Lakes Fishery Laboratory (memo, 1966) presumes stock to be at least double that based upon catch records due to avoidance of nets.

TABLE IV-10

RELATIVE ABUNDANCE OF ALEWIVES (Alosa pseudoharengus)
IN LAKE ONTARIO AT ALL STATIONS, BY MONTH, 1972
Data From The Great Lakes Fishery Laboratory, Ann Arbor, Michigan

Month of Cruise	Numbers Per Acre	Pounds Per Acre
May, II	1,179	95.8
June, IV	225	18.2
July - Aug., VI	146	11.9
Aug. - Sept., VIII	121	9.8
Oct., X	106	8.6
MEAN	335	28.9

Population stock estimate for 62% of the Lake surface area:

	1,036,032,000	84,341,760

TABLE IV-11

ALEWIFE (Alosa pseudoharengus)
STOCK ESTIMATES FOR MEAN, MINIMUM, AND MAXIMUM ABUNDANCE VALUES
FOR ALL STATIONS, 1972
Data From The Great Lakes Fishery Laboratory, Ann Arbor, Mighigan

Abundance Level	No. Acre^{-1}	Pounds Acre^{-1}	Stock Estimate No.	Pounds
Maximum	1,179	95.8	3,440,793,600	279,582,720
Minimum	106	8.6	309,350,400	25,098,240
Mean	355	28.9	1,036,032,000	84,341,760

3. The stock estimate is based upon size-selective fishing gear: age groups I and II are not represented in proportion to their small size.

4. The stock estimate is made using 62% of the surface area of the Lake in converting catch per acre to stock. This conforms to the surface area bounded by the shoreline and the 60 fathom contour. The R/V Kaho captured alewives in bottom trawls beyond the 60 fathom mark.

Impingement rates at the Nine Mile Point Nuclear Power Station for 1973 suggest that a total of more than 5,000,000 alewives were or would be killed by impingement on the intake screens.

The effects of this impingement on the alewife population in Lake Ontario may be assessed by first placing the impingement rate in the perspective of the alewife stock estimate for Lake Ontario.

When Nine Mile Point Unit One impingement rates for alewives are compared with the stock estimates from the total Lake, the numbers of fish impinged constitute 0.4% of the alewife stock estimated from mean rates of catch per acre (Table IV-12). At the minimum level of abundance, 106 alewives per acre, the plant impingement is 1.6% of the Lake population (Table IV-12). At the maximum abundance level, alewife impingement at Nine Mile Point is about 0.1% of the alewife stock in Lake Ontario.

TABLE IV-12

RATIOS OF ANNUAL IMPINGEMENT OF ALEWIVES (*Alosa pseudoharengus*)
AT NINE MILE POINT UNIT ONE
TO LAKE ONTARIO ALEWIFE STOCK ESTIMATES

Abundance Level	No. Acre	Stock	Impingement	Ratio x 100 (%)
Maximum	1,179	3,440,793,600	5,000,000	0.1
Minimum	106	309,350,400	5,000,000	1.6
Mean	355	1,036,032,000	5,000,000	0.4

These figures may be placed in the perspective of the rates of capture for the only Lake in which the alewife is fished commercially, Lake Michigan (Table IV-8). In Lake Michigan, commercial landings have run at the rate of approximately 30 million pounds per year, or 350 million alewives per year, since 1968. These landings compose a minimum of 8% of the estimated stock (Brown, 1972). Thus, the cropping rate of Nine Mile Point ($\bar{x}$ = 0.4%) in an unfished alewife population is but 5% of the commercial cropping rate in Lake Michigan waters.

Studies of the effects of alewife cropping in Lake Michigan indicate that the rates of commercial harvest, estimated at 7 to 18% have improved the condition of the alewife population (Brown, 1972):

1. Average weights of mature fish have increased since 1965-66 when the population was overcrowded.

2. Percent yield to the fishery per recruitment has increased.

In the underexploited population of Lake Ontario, it is very likely that the population is overcrowded, approaching the carrying capacity of the system. Mean weight per adult individual in Lake Ontario is much less than in Lake Michigan, indicating overcrowded conditions. Under these circumstances, it may be concluded that cropping of the alewives at the Nine Mile Point Nuclear Power Station; 1) will have no deleterious effect on the alewife abundance in Lake Ontario, and 2) may, by removal of some portion of the population, have some effect on improving the

overall condition of the total stock. However, the beneficial effect is unlikely to be felt by the Lake population as a whole. The localized effect of impingement of alewives in the vicinity of Nine Mile Point, Mexico Bay, and Oswego is difficult to assess due to the errant nature of the alewife.

From a comparison of Tables IV-11 and IV-13, it may be seen that alewives are more abundant in the vicinity of Nine Mile Point than the Lake average. Stock estimates for the Lake from the mean number at Nine Mile Point exceed the mean Lake estimate by 980 million. Thus, removal of large numbers of fish from the Nine Mile Point area are likely to have less effect on the population than removal of similar numbers from another location.

If we estimate the "vicinity" of Nine Mile Point to be a zone 6 miles by 3 miles (18 square miles; 11,520 acres) an estimate of alewives available in this area may be made using the conservative abundance estimates employed before, and data from the Nine Mile Point transect (R/V Kaho cruise reports). Abundance estimates for the vicinity are available with time and reflect the inshore-offshore seasonal migration patterns of the alewife. Greatest concentrations occurred during May, when the region had an estimated 3,100,032 fish. Maximum removal rate for this period reached 400,000 fish per day. At this maximum rate, 12% of the fish were removed per day. Estimates of emigration and immigration for this "vicinity" cannot be made. It is reasonable to assume

TABLE IV-13

RELATIVE ABUNDANCE OF ALEWIVES (Alosa pseudoharengus)
IN LAKE ONTARIO AT OSWEGO (NINE MILE POINT), BY MONTH, 1972
Data From The Great Lakes Fishery Laboratory, Ann Arbor, Michigan

Month	Cruise	No. Per Acre	Pounds Per Acre
May	II	2,691	218.8
June	IV	84	6.8
July - Aug.	VI	372	30.2
Aug. - Sept.	VIII	145	11.8
October	X	110	8.9
MEAN		680.4	55.3

Stock estimate for 62% of the Lake surface area:

	1,985,407,200	161,365,000

a rather continuous movement of alewives inshore from deeper waters during the early spring. Thus, in our best approximation during the period of heaviest removal, the migration movements of the species would result in a continual replacement of fishes cropped by the plant. The 12% removal rate for the maximum 1973 impingement would not represent a depletion of an isolated population, but would draw from a stable population of approximately 3 million fish.

The sum total of possible effects due to impingement of alewives must consider a variety of factors in addition to potential stock depletion. In all the Great Lakes, save Lake Michigan, the alewife is not exploited commercially. The alewife in Lakes Ontario, Erie, and Huron may be considered to be overcrowded, and therefore constitute a nuisance due to its overabundance. As mentioned previously the nuisance value of the alewife rests in the clogging of industrial and utility water intakes and fouling of beaches and the Lakes bottom. However, the alewife has been shown to be a biological as well as an aesthetic nuisance.

The overabundance of alewives may have serious effects on the zooplankton populations of the Great Lakes. Brooks and Dodson (1965) demonstrated a change in size composition of planktonic crustacea over time which was due to the heavy feeding of alewives. The changes in the zooplankton were considered deleterious to other, more desirable species first, due to reduction of zooplankton populations, and second, due to removal of zooplankton size classes suitable to commercially exploited species, such as cisco, chub, whitefish, and juveniles of many game

species. For these reasons, one important ramification of alewife cropping is that zooplankton may be improved in direct proportion to the rate of removal of the alewife.

If alewife cropping were to gradually deplete the populations, it is doubtful that serious ecological imbalance would follow. The presence of alewives in the Great Lakes has displaced and depleted several forage fish species. In the absence of the alewife it is likely these species would increase in abundance. It is important to note that the species displaced are, generally, more suitable as food for important game fishes (lake trout, yellow perch, smallmouth bass) than is the alewife. It is theoretically possible to envision an increase in the populations of game species with time.

2. RAINBOW SMELT (*Osmerus mordax*)

A commercial fishery for smelt has existed in Lake Michigan since 1931; in Lake Ontario since 1952, and intermittently in Lakes Huron and Superior since 1935 and 1938, respectively (GLFC, 1962). The importance of these fisheries became evident in 1942-43, when disease virtually eliminated the species from Lake Michigan (Van Oosten, 1947). The economic impact of the disrupted fishery was felt nationally. Current commercial production of smelt from the Great Lakes is substantial, totalling 17,131,000 pounds in 1971; 76% of this production originated in Lake Erie.

Commercial production of smelt in three of the five Great Lakes suggest that the species is very abundant. Low commercial yields from Huron and Ontario are considered to be a reflection of fishing intensity rather than an indication of low stocks. Yield of smelt for 1971 is presented in Table IV-14.

The numbers of fish presented in Table IV-14 are projections based upon an average of 2.4 ounces per individual fish (Van Oosten, 1947). Examination of catch data for several years in Lakes Michigan and Ontario (Tables IV-15 and IV-16) indicate that smelt stocks in these systems are abundant and stable, if not increasing.

Abundance of smelt in Lake Ontario may be made from the catch records of the R/V Kaho cruises, May to October, 1972. Table IV-17 presents the catch data for Lake Ontario based upon the mean for all stations, in numbers and pounds. Table IV-18 is a summary of R/V Kaho smelt catch for the Oswego (Nine Mile Point) Transect.

In this estimate smelt stocks were calculated using the mean catch per acre for the total Lake (Table IV-18), and estimates were made for the Lake population based upon collections from the Oswego Transect (Table IV-20). It is apparent from comparison of Tables IV-19 and IV-20 that the smelt population at the Oswego Transect is substantially less than the Lake mean. Monthly estimates of abundance of smelt in the 3 mile by 6 mile "vicinity" of Nine Mile Point were made based upon the seasonal abundance at the Oswego Transect (Table IV-21).

TABLE IV-14

COMMERCIAL LANDINGS OF SMELT (*Osmerus mordax*) IN THE GREAT LAKES, 1971

Lake	Weight (lb. x 10^3)	Number
Ontario	205	1,353,000
Erie	13,312	86,671,200
Huron	3	19,800
Michigan	1,343	8,863,800
Superior	2,448	16,156,800

TABLE IV-15

COMMERCIAL LANDINGS OF SMELT (*Osmerus mordax*)
LAKE MICHIGAN, 1945-1971

Year	Weight (lb. x 10^3)	Number	Year	Weight (lb. x 10^3)	Number
1945	101	666,600	1949	6,004	39,626,400
1946	267	1,762,200	1960	3,267	21,562,200
1947	786	5,187,600	1961	2,152	14,203,600
1948	1,131	7,464,600	1962	1,546	10,203,600
1949	1,540	10,164,000	1963	1,203	7,939,800
1950	2,417	15,952,200	1964	969	6,395,400
1951	3,399	22,433,400	1965	927	6,118,200
1952	5,111	33,732,600	1966	1,111	7,332,600
1953	5,181	34,194,600	1967	1,224	8,078,400
1954	5,811	38,352,600	1968	1,789	11,807,400
1955	5,416	35,745,600	1969		
1956	7,368	48,628,800	1970		
1957	7,024	46,358,400	1971	1,343	8,863,800
1958	9,102	60,073,200			

TABLE IV-16

COMMERCIAL LANDINGS OF SMELT (*Osmerus mordax*)
LAKE ONTARIO, 1952-1971

Year	Weight (lb. x 10^3)	Number
1952	253	1,669,800
1953	289	1,907,400
1954	270	1,782,000
1955	243	1,603,800
1956	272	1,795,200
1957	177	1,168,200
1958	296	1,953,600
1959	208	1,372,800
1960	188	1,240,800
1961	223	1,471,800
1962	202	1,333,200
1963	170	1,122,000
1964	129	854,400
1965	202	1,333,200
1966	141	930,600
1967	155	1,023,000
1968	168	1,108,800
1969	--	--
1970	--	--
1971	205	1,353,000

TABLE IV-17

SMELT (Osmerus mordax) ABUNDANCE IN LAKE ONTARIO.
ESTIMATES OF TOTAL LAKE ABUNDANCE BASED ON
DATA FROM THE GREAT LAKES FISHERY LABORATORY, ANNE ARBOR, MICHIGAN

Month	Smelt-All Stations	No./Acre	Pounds/Acre
May	1,690	422.5	64.2
June	4,540	504.4	76.7
July - Aug.	3,648	364.8	55.4
Aug. - Sept.	2,588	258.8	39.3
October	1,107	110.7	16.8
MEAN		332.24	50.5

TABLE IV-18

SMELT (*Osmerus mordax*) ABUNDANCE, OSWEGO TRANSECT
DATA FROM THE GREAT LAKES FISHERY LABORATORY, ANN ARBOR, MICHIGAN

Month	Total	No./Acre	Pounds/Acre
May	361	90.3	13.8
June	480	68.6	10.5
July - Aug.	482	96.4	14.7
Aug. - Sept.	225	37.5	5.7
October	749	107	16.4
MEAN		79.96	

TABLE IV-19

SMELT (*Osmerus mordax*) STOCK ESTIMATE FOR LAKE ONTARIO
BASED ON MEAN, MINIMUM, AND MAXIMUM ABUNDANCE VALUES
Data From The Great Lakes Fishery Laboratory, Ann Arbor, Michigan

Abundance Level	Catch $Acre^{-1}$	Stock Estimate
Maximum	504.4	1,472,040,900
Minimum	110.7	323,066,880
Mean	332.24	969,609,200

TABLE IV-20

SMELT (Osmerus mordax) STOCK ESTIMATE FOR LAKE ONTARIO
FROM MEAN CATCH RATES OSWEGO (NINE MILE POINT) TRANSECT ONLY
Data From The Great Lakes Fishery Laboratory, Ann Arbor, Michigan

Abundance Level	No./Acre	Stock Estimate
Maximum	107	312,268,800
Minimum	37.5	109,440,000
Mean	79.96	233,355,260

TABLE IV-21

STOCK ESTIMATES OF SMELT (Osmerus mordax)
IN THE VICINITY OF OSWEGO (NINE MILE POINT), BY MONTH, 1972.
Data From The Great Lakes Fishery Laboratory, Ann Arbor, Michigan

Month	No./Acre	Stock Estimate
May	90.3	1,040,256
June	68.6	790,272
July - Aug.	96.4	1,110,528
Aug. - Sept.	37.5	432,000
October	107	1,232,640
MEAN	79.96	929,139.2

The overall effect of impingement at Nine Mile Point Unit One on the Lake Ontario smelt population may be assessed by comparing the known impingement rates of smelt to the Lake population (Table IV-22). The yearly impingement rates of smelt are extremely small in relation to the total estimated smelt stock in the Lake. The minimum stock estimate is 323,066,880 smelt. Removal of 88,851 fish from this stock represents a depletion of 0.02%.

Considering that smelt stocks in the Nine Mile Point area are estimated to be less than the mean of the entire Lake, comparisons of the removal of smelt by impingement to the Lake stock estimate based upon catch per effort at Oswego (Table IV-23), and to the estimated stocks in the "vicinity" of Nine Mile Point (Table IV-24) were made.

Smelt stock depletion based upon Lake estimates derived from Nine Mile Point smelt catch per unit effort is greater due to the reduced abundance of smelt at the Oswego Transect. The annual impingement figures in relation to the minimum stock estimate from Oswego catch data represent 0.08% of the population. The impingement rate is 0.03% of the mean estimate of 233,355,260 and 0.02% of the maximum stock estimate from Nine Mile Point data (Table IV-23).

When annual impingement rates are placed in the perspective of smelt stocks in the "vicinity" of Nine Mile Point Unit One (6 x 3 miles), the removal by impingement represents 9.6% of the smelt available (range 7.2% to 20.5%). However, these figures are based upon a total yearly impingement figure, in comparison with a population estimate from dif-

TABLE IV-22

RATIOS OF ANNUAL IMPINGEMENT OF SMELT (*Osmerus mordax*)
AT NINE MILE POINT UNIT ONE
TO LAKE ONTARIO SMELT STOCK ESTIMATES FOR THE ENTIRE LAKE

Abundance Level	No./Acre	Stock	Yearly Impingement	Percent
Maximum	504.4	1,472,040,900	88,851	0.006
Minimum	110.7	323,066,880	88,851	0.02
Mean	332.2	969,609,200	88,851	0.009

TABLE IV-23

RATIOS OF ANNUAL IMPINGEMENT OF SMELT (Osmerus mordax)
AT NINE MILE POINT UNIT ONE
TO SMELT STOCK ESTIMATES FOR LAKE ONTARIO NEAR OSWEGO

Abundance Level	No./Acre	Stock	Yearly Impingement	Percent
Maximum	107	312,268,800	88,851	0.02
Minimum	37.5	109,440,000	88,851	0.08
Mean	79.96	233,355,260	88,851	0.03

TABLE IV-24

RATIOS OF ANNUAL IMPINGEMENT OF SMELT (*Osmerus mordax*)
AT NINE MILE POINT UNIT ONE
TO OSWEGO "VICINITY" SMELT STOCK ESTIMATES

Abundance Level	No./Acre	Stock in Vicinity	Yearly Impingement	Percent
Maximum	107	1,232,640	88,851	7.2
Minimum	37.5	432,000	88,851	20.5
Mean	79.96	929,139	88,851	9.6

ferent months of the year. In point of fact, during the period of minimum abundance of smelt (June through September), very few smelt are impinged. During periods of maximum abundance, more are impinged.

Annual impingement of smelt based on 1973 figures were compared with commercial catch data over 10 years, 1961-1971 (Table IV-25). This comparison showed that the cropping rate of smelt by the plant represents approximately 7.9% of the smelt landed by commercial fishermen in the Lake. It should also be noted that most of the commercial smelt production in Lake Ontario was from Canadian waters. Thus, the cropping effect of the plant is not additive to any intensive commercial fishing effort in the vicinity of Nine Mile Point Unit One.

Cropping of the rainbow smelt by impingement poses no threat to the local or Lake populations. Furthermore, the cropping rate by the Utility is minor in comparison to the cropping of the population by commercial fishermen.

Potential ramifications of smelt population reductions include economic and biological aspects. Economically, reduction of the smelt population by a significant proportion may affect the livelihood of commercial fishermen on the Canadian side of the Lake. However, since the commercial landings represent approximately 1% of the conservative estimate of the smelt stock, it is likely that commercial yield per unit effort would not be affected unless stocks were depleted in excess of several hundred million fish.

TABLE IV-25

RATIOS OF ANNUAL IMPINGEMENT OF SMELT (Osmerus mordax) AT NINE MILE POINT UNIT ONE TO COMMERCIAL SMELT CATCHES IN LAKE ONTARIO

Year	Catch (lbs x 10^3)	Estimated Number $x10^3$	1973 Yearly Impingement $x10^3$	Percent
1961	223	1,471	88.8	6.03
1962	202	1,333	88.8	6.6
1963	170	1,122	88.8	7.9
1964	129	851	88.8	10.4
1965	202	1,333	88.8	6.6
1966	141	930	88.8	9.5
1967	155	1,023	88.8	8.6
1968	168	1,108	88.8	8.0
1969	--	--	--	--
1970	--	--	--	--
1971	205	1,353	88.8	6.5

$\overline{x} = 7.9$

Biologically the smelt, an introduced species, is in direct competition for food with many species endemic to the Great Lakes. Further, the adult smelt is known to prey upon the eggs and larvae of valuable forage fish, such as the emerald shiner and the common shiner. It is suspected that the smelt preys upon the juvenile forms of the lake trout and Atlantic salmon.

The rainbow smelt occupies a position of intermediate importance in the complex food chains of the Great Lakes. Its principal food sources support substantial populations of other species simultaneously. A decrease in smelt would primarily assist in the expansion of populations of competitors, such as chubs, whitefish, yellow perch, rockbass, and young smallmouth bass.

Smelt are preyed upon by several game species: yellow perch, bass, sauger, walleye. Decreased population would result in these species utilizing other food resources. Given that situation, it is likely that the alternative forage fish populations, such as shiners, would expand directly in proportion to the decrease in smelt because of reduced competition and predation upon juveniles.

V. WATER QUALITY

A. INTRODUCTION

1. GENERAL

The water quality of Lake Ontario is dependent upon the interaction of numerous factors, including geomorphology and hydrology, hydrodynamics, meteorology and man-made inputs.

The smallest of the Great Lakes in surface area (7340 square miles), Lake Ontario, has an average depth of approximately 280 feet. The Lake basin is generally an elongated, east-west trough with steeper banks on the southern side than on the northern. The deepest water (802 feet) is found in the southeast region of the Lake. Approximately 200,000 cubic feet per second of water flow into Lake Ontario from Lake Erie via the Niagara River. This represents the largest source of inflow. An average outflow of some 230,000 to 240,000 cubic feet per second is carried to the Atlantic Ocean by the St. Lawrence River. Other major inputs include Twelve Mile Creek, the Trent River, the Black River, the Genesee River and the Oswego River (see Figure V-1).

Lake Ontario was formed about 10,000 years ago during periods of severe glaciation. Marine sedimentary rock-strata largely composed of shale and limestone underlie the Lake. The shoreline is eroding at a relatively rapid rate, providing a source of unconsolidated sands, clays and gravels to the Lake. This source and other sources have provided a sediment layer up to 35 feet deep, but such layers are generally much shallower except in the deep region of the Lake.

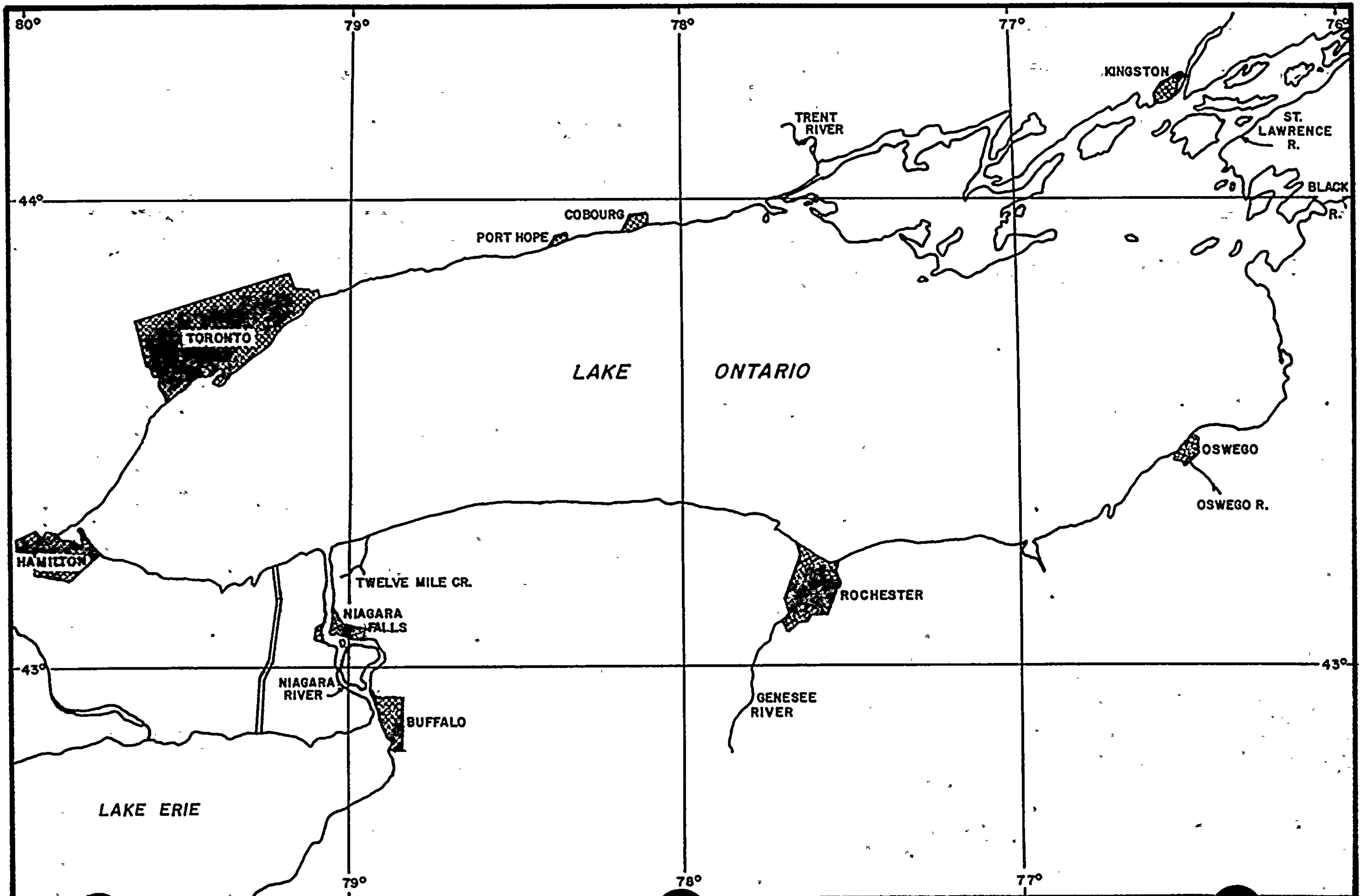


FIGURE V-1

LOC[illegible]ON MAP

The currents in Lake Ontario have been studied via hydrodynamic theory, field observations and hydraulic models. The state of knowledge regarding currents indicates that wind driven currents predominate in the Lake with density induced circulation and associated geostrophic currents being secondary in their influence. The general current pattern is counterclockwise, with surface currents travelling eastward along the southern shore at a mean speed in the order of 5cm/sec. This general pattern can reverse under the influence of winds from the north, northeast, east, or southeast.

Lake Ontario is located near the mainstream of many cyclonic wind systems which cross North America. Therefore, substantial tropospheric mixing occurs during most of the year and stagnant conditions occur infrequently. There is a decided preference for wind directions ranging from west, through south, to southeast. On the south shore, the predominant wind is WSW at a mean speed of 10 to 11 mph from November to April and is SW at 8 mph from May to October. Relatively short, cool summers with average temperatures near 70°F and rather severe winters with average temperatures near 25°F are prevalent. Precipitation is moderate and rather uniformly distributed throughout the year. Mean annual precipitation is about 32 inches, while mean annual evaporation is about 27 inches. Relative humidity varies from about 65 to 75% and is quite uniform on a monthly average basis. Lake temperatures have been reported to range from 29°F in the winter to about 78°F in the summer. Some areas of the Lake are characterized by a nearly isothermal condition with frequent occurrences of a transient unstable thermocline.

The large area of Lake Ontario and its heat capacity provide periodic onshore and offshore breezes due to the differential heating of land and water surfaces. The exposure of the surrounding area to Lake Ontario and the flatness of the terrain cause wind speeds to be higher near the Lake than those experienced in most inland areas, (International. Joint Commission, 1969).

Major cities on Lake Ontario include Toronto and Hamilton in the western region and Rochester and Oswego in the southeastern region. The major source of most pollutants is the Niagara River. Excluding the Niagara, the Oswego River is the major point source of several pollutants. The Oswego River drains some 5,100 square miles and receives municipal wastes equivalent to some 500,000 people (International Joint Commission, 1969).

2. PREVIOUS WATER QUALITY STUDIES

As for most bodies of water, intensive interest in water quality has been a fairly recent phenomenon. Reasonably comprehensive studies of Lake Ontario were completed around 1915 and 1947. However, truly comprehensive studies were not undertaken until the early 1960's. A number of studies were executed throughout the 1960's, and studies continue into the present decade. Table V-1 presents a summary of water quality surveys for Lake Ontario performed under the auspices of several state, national and international agencies.

The above referenced studies have shown that Lake Ontario generally has the highest concentration of inorganic pollutants of all of the Great Lakes. This is because it drains the chain of Great Lakes, receiving its major source of water and pollutants from Lake Erie via the Niagara River. As for the other Great Lakes, inorganic pollutant concentrations have been increasing steadily since about 1910. The rates of increase of several inorganic constituents, such as Mg and Ca, are decreasing since the concentrations have reached values representative of equilibrium conditions for the precipitated solid phases. The changes in nutrient concentrations are less well known, but evidence exists that ammonia levels have followed a similar course.

Because of its great depth and dilution capacity, adverse eutrophication effects have been minimal relative to those for Lake Erie. Oxygen saturation is usually above 80% in the hypolimnion and averages over 90%. Epilimnion values may exceed 120%, indicating excessive primary productivity. During thermal stratification, significant

TABLE V-1

WATER QUALITY SURVEYS ON LAKE ONTARIO UNDERTAKEN BY VARIOUS AGENCIES

	SURVEY TITLE	SOURCE & DATE OF REPORT	AUTHOR	SURVEY DATE(s)	AGENCY	EXTENT OF SURVEY AREA	NO. OF STATIONS DATA EXTRACTED FROM	ANALYSIS	COMMENTS
1)	Chemistry of Western Lake Ontario	Pub. #9, GLRD, IST, 1962	Kramer	8,11/59	Univ. of Western Ontario	Westend to Long. 79°08.4	17	T, Eh, pH, Ca, Mg, Na, K, Alk.	Individual Sta. Data Listed
2)	A Pollution Study of Western Lake Ontario	5th Conf. G.L Research, Univ. Mich. GLRD. Publ. #9, 1962	Matheson	1960-61	City of Hamilton	Hamilton to Bronte & to Fifty Mile Pt.	8	NH_3-N, Synthetic Detergent, TCol	Combined Stations' Mean Given for coliform.
3)	Chemical Characteristics of Lake Ontario	GLFC, Tech. Report #14, 1964	Allen	9/64	USBCF	Lakewide	106	Na, K, Ca, Si, pH, Alk, DO, SpC	Individual Sta. Data Listed. Sta. no.'s 68, 69 & 73, 74 are near Oswego & Nine Mile Point
4)	Long Term Changes in Water Chemistry at a Single Sampling Station in Lake Ontario	8th Conf. G.L. Research, Univ. Mich. GLRD. Pub. #13, 1965	Schenk & Thompson	1923-1954	OWRC & City of Toronto	Toronto Is. Filtration Plant	1	pH, Alk, TH, NH_3-N, Cl, Tur	Past Data was analysed.
5)	Principal Ions & Dissolved Oxygen in Lake Ontario	10th Conf. G.L Research, 1967	Dobson	6/66 - 9/66	Canadian Gov't.	Lakewide	47	Ca, Mg, Na, K, SO_4, Cl, Alk, SpC.	Only Combined stations' mean + 2 individual stations listed
6)	Investigations of Daily Variations in (W.Q.) Parameters at two Lake Ontario Locations near Toronto	12th Conf. G.L. Research, 1969: IAGLR.	Brydges	7/68 - 10/68	OWRC	Toronto Harbor & Near Shore Lake Ontario	2	TKN, NH_3-N, NO_2-N, NO_3-N, TP, Fe, Cl, pHL, pH, Tur, Chl-a	Only combined stations' mean, graphs.
7)	Dissolved Mineral Quality of Great Lakes Waters	"	Weiler & Chawla	10,11/68	CCIW	Lakewide	Approx. 12	Ca, Mg, Na, K, SO_4, Cl, HCO_3, F, Zn, Cu, Pb, Fe, Ni, Cr, Mn, Sr	Only combined stations' mean, max & min listed
8)	Nutrients in Lake Ontario	13th Conf. G.L. Research, 1970: IAGLR.	Shiomi & Chawla	5/69 - 3/70	CCIW	Lakewide	60	TP, SP, Si, NO_3-N, NH_3-N	Only combined stations' mean listed

TABLE V-1 Cont'd

WATER QUALITY SURVEYS ON LAKE ONTARIO UNDERTAKEN BY VARIOUS AGENCIES

SURVEY TITLE	SOURCE & DATE OF REPORT	AUTHOR	SURVEY DATE(s)	AGENCY	EXTENT OF SURVEY AREA	NO. OF STATIONS DATA EXTRACTED FROM	ANALYSIS	COMMENTS
9) Distribution of Trace Elements and Clorophyll a in Lake Ontario	"	Chau, et.al.	5,7,9/69	CCIW	Lakewide	45	Cd,Cr,Co,Cu,Fe,Pb, Mn,Mo,Ni,Sr,V,Zn	Only Regional mean listed (west,central, east)
10) CCIW Water Quality Monitoring Program	Accounts Dept. CCIW, Burlington ONT., 1974 Computer printout	____	4,5,6,7,9,10, 11/72	CCIW	Lakewide	32	T,D.O.,pH, Tur, SpC, NH_3-N,NO_3-N,Si,TP, Alk, Cl,Fe,Mn,TOC.	QL&M has data for 6 individual stations along approx. long. 77°00., Sta. nos. 25-30.
11) CCIW Water Quality Monitoring Program	"	____	9/72	CCIW	Lakewide	95	Above + Mg,Cd,Cr, Co,Cu,Pb,Mo,Ni,Sr, Zn.	QLM has data for 11 individual sta. between long 76°30.0 & 77°00.0; sta. nos. 73-78,83-87. Sta. 86 is near Oswego. Sta. 87 is near Nine Mile Point.
12) Water Quality Data (No Formal Title)	Computer Printout	____	1964-72	NYSDEC	Eastman Kodak Water Intake at Rigney Bluff, 4000'out & 21' below surface.	1	Col,Tur,pH,NH_3-N, NO_3-N,NO_2-N,COD, PO_4,SO_4,Na,K,Fe,Mn, F,ABS,Cl,SpC,TH, OH Alk, HCO_3 Alk, CO_3 Alk, TDS, TSS, TVS, VSS, Ca, Mg	Some Analyses incomplete; W.Q. Percentile summary available for 10/67-9/70 data.
13) Water Quality Data (No Formal Title)	Computer Printout	____	1964-72	NYSDEC	Monroe Co. Water Auth. Water Intake, 4200' out & 21' below surface at Rochester City Filtration Plant.	1	As,Cu,Hg,Pb,Col,Tur, pH,DO,BOD,TCol,FCol, NH_3-N, ORG-N,NO_3-N, NO_2-N,COD,PO_4,SO_4, Na,K,Fe,Mn,F,ABS,Cl, SpC,TH,OH Alk HCO_3 & CO_3 Alk,TDS,TSS, VSS,TVS,Ca,Mg.	"
14) Water Quality Data (No Formal Title)	Computer Printout	____	1964 - 72	NYSDEC	Oswego City Water intake, 6500'out & 40' below surface.	1	"	"

TABLE V-1 Cont'd

WATER QUALITY SURVEYS ON LAKE ONTARIO UNDERTAKEN BY VARIOUS AGENCIES

SURVEY TITLE	SOURCE & DATE OF REPORT	AUTHOR	SURVEY DATE(s)	AGENCY	EXTENT OF SURVEY AREA	NO. OF STATIONS DATA EXTRACTED FROM	ANALYSIS	COMMENTS
15) Water Quality Percentile (no Formal Title)	Computer printout	———	10/67 - 9/70	NYSDEC	800' from U.S. Shore at Coast Guard Sta. at Fort Niagra	1	"	Only W.Q. Percentile Summary available '67-'70.
16) Rochester Program Office - Surveillance Data.	EPA Storet System Tabulations obtained '72-'73.	———	8/68 - 12/70	Region II EPA	N.Y. Central Bridge between Utica & W. Bridge, Mouth of Oswego R. Storet No. 3828 + Sta's 188-193. ('66)	3	pH, SpC, Alk, Tur, DO, BOD, COD, NH_3-N, NO_3-N, ORG-N, TP, SP TDS, TSS, TS, Cl, SO_4, Si, Ca, Mg, Fe.	Sta. No.'s 188 & 189 are near Nine Mile Point.
17) Rochester Program Office Chemical & Physical Parameters	"	———	6/66 - 9/66	Region II EPA	Mexico Bay in S.E. Region of Lake	10	Same as above + Na & K.	Individual Sta. data Listed. Sta. No's 180-187 are near Oswego.
18) Rochester Program Office, U.S. Coast Guard Cruise 109	"	———	6/69	Region II EPA	Lakewide	30	pH, SpC, Alk, Tur, DO, TVS, COD, NH_3-N, NO_3-N, ORG-N, TP, SP, TDS, TSS, Cl, SO_4, Si, Ca, Mg, Fe, K.	Individual Sta. data listed. Sta. No. 20 is near Nine Mile Point.
19) Rochester Field Office, Oswego Harbor Sediments	"	———	1967 - 72	Region II EPA	Oswego Harbor	6	TVS, COD, TKN, O & G, Hg, Pb, Zn, Cu, Cd, Ni, Cr.	Individual Sta. data listed
20) Table 2A, Sampling Stations- Lake Ontario	Unknown	———	4/57 - 10/57	Unknown	From Outlet at Tibbets Pt. to Oswego	20	Col, Odor, Tur, pH, CO_2, DO, BOD, TH, Cl, Alk, TCol	Individual data listed for various pts. at each station.
21) "	"	———	"	"	From Oswego to Fairbanks Pt.	4	"	"
22) "	"	———	"	"	From Smoky Pt. to Braddock Pt.	16	"	"

TABLE V-1 Cont'd

WATER QUALITY SURVEYS ON LAKE ONTARIO UNDERTAKEN BY VARIOUS AGENCIES

SURVEY TITLE	SOURCE & DATE OF REPORT	AUTHOR	SURVEY DATE(s)	AGENCY	EXTENT OF SURVEY AREA	NO. OF STATIONS DATA EXTRACTED FROM	ANALYSIS	COMMENTS
23) "	"	—	"	"	From Hilton Beach to Olcott	10	"	"
24) "	"	—	"	"	From Hopkins Cr. to Fort Niagra	8	"	"
25) Report to the IJC on the pollution of Lake Erie, Lake Ontario, and the Int. Section of the St. Lawrence River.	IJC: Vol 3-Lake Ontario & the Int. Section of the St. Lawrence R. 1970	—	—	ILEWPB & ILO-SLR WPB	—	—	TP, PO_4-P, NH_3-N, TKN, NO_2-N, NO_3-N, Si, DO, BOD, Alk, TH, SO_4, Na, K, Fe, SpC, Ca, Mg, TDS, pH, Tur, Col, TSS,	p. 61-122, compilation, graphs, Tables & comparisons of FWPCA 1965 survey & NHW 1967 survey
26) General Water Quality Data	EPA Storet System	—	6/72 - Into '74	IFYGL	Some Biological & Chemical Data Inputed to STORET System Beginning Some Time in 1974.			EPA
27) Eutrophication of the St. Lawrence Great Lakes	Limnol. Oceanogr 10: 240-254, 1965	Beeton	1965					
28) Lake Ontario Environmental Summary. 1965	U.S. EPA 902/9-73-002			RegionII Rochester Field Office				
29) Great Lakes Water Quality annual Report to the IJC	Great Lakes Water Quality Board April, 1973.							
30) Annotated Bibliography of Limnological and Related Studies on Lake Ontario and its tributaries I. Chemistry II. Biology III. Physical	Great Lakes Lab. State University College at Buffalo 5 Porter Ave. Buffalo, N.Y. 14201 Special Report #12 15 Jan., 1972. (716-862-5422)	Baldwin & Sweeney						
31) Limnological Data Reports Lake Ontario	Published by Canadian Oceanographer Data Centre 1966 9 cruises 67 11 " 68 9 " 69 9 " 70 13 "			CCIW				

KEY FOR TABLE V-1

GLRD	Great Lakes Research Division
IST	Institute of Science & Technology
GLFC	Great Lakes Fishery Commission
G.L.	Great Lakes
IAGLR	International Association for G.L. Research
CCIW	Canadian Center for Inland Waters
USBCF	United States Bureau of Commercial Fisheries
OWRC	Ontario Water Resources Commission
NYSDEC	New York State Dept. of Environmental Conservation
EPA	Environmental Protection Agency
IJC	International Joint Commission
ILE WPB	International Lake Erie Water Pollution Board
ILO-SLRWPB	International Lake Ontario-St. Lawrence Water Pollution Board
IFYGL	International Field Year for the Great Lakes
FWPCA	Federal Water Pollution Control Administration
NHW	Dept. of National Health & Welfare

chemical stratification may occur, but at relatively low mean values of nutrients. This vertical stratification is a result of seasonal variation in productivity and chemical composition. Nutrients such as orthophosphate, nitrate and silica generally increase from surface to bottom, reflecting uptake by phytoplankton in the photosynthetic zone. During spring and fall overturns, the Lake becomes homogenous. Based on estimates of gross nitrogen and phosphorus inputs, Lake Ontario is on the borderline between "safe" and "dangerous" according to Vollenweider's (1968) criteria for eutrophication. Finally, based on an assessment of oxygen saturation, transparency, nutrient concentrations, nutrient loadings, morphometry, and biological populations, Lake Ontario has been estimated to be between oligotrophic and mesotrophic (IJC, 1969).

Data from many of the studies listed in Table V-1 have been analyzed and are presented in Table V-2 as semi-quantitative values representative of offshore waters of Lake Ontario under mixed conditions. As discussed above, some of the nutrient values vary temporally and vertically. The major ionic species vary little, but the trace elements and compounds may vary greatly. For example, copper was found to vary between 5 and 177μg/l during 1968 studies (Weiler and Chawla, 1969) and between 0 and 2,200μg/l during 1967 studies (IJC, 1969). Such variation is due in part to analytical technique variations at very low concentrations.

However, some of the variations correlate with one another. For example, Cu, Fe, Mn, Zn, and Pb were found to reach peak concentrations in 1968 at approximately the same time, namely in late June or early July (Weiler and Chawla, 1968). Additionally, for three survey dates

TABLE V-2

Values Characteristic of
Lake Ontario, Off Shore, Mixed

Parameter		Concentration (mg/l unless shown otherwise)
Calcium	(Ca)	40
Magnesium	(Mg)	8
Sodium	(Na)	12
Potassium	(K)	1.5
Chloride	(Cl)	28
Sulfate	(SO_4)	30
Bicarbonate	(HCO_3)	115
	pH (units)	8.0
Total Dissolved Solids	(TDS)	200
Specific Conductance	(SpC) (μmhos/cm)	300
Orthophosphate Phosphorus	(OP)	.015
Total Phosphate Phosphorus	(TP)	.025
Ammonia Nitrogen	(NH_3-N)	.03
Nitrate Nitrogen	(NO_3-N)	.20
Nitrite Nitrogen	(NO_2-N)	.002
Total Kjeldahl Nitrogen	(TKN)	.2
Silicon Dioxide	(SiO_2)	.5
Turbidity	(Tur) (TU)	2
Total Suspended Solids	(TSS)	3
Phenol	(Phl)	.002
Total Coliforms	(TCol) (counts per 100 ml)	<1
Cadmium	(Cd)	.0001
Chromium	(Cr)	.001
Cobalt	(Co)	.0001
Copper	(Cu)	.01
Iron	(Fe)	.01
Lead	(Pb)	.003
Lithium	(Li)	.002
Manganese	(Mn)	.001
Nickel	(Ni)	.002
Strontium	(Sr)	.18
Zinc	(Zn)	.01

in 1969, Co, Cu, Fe, Mn and Zn were found to vary similarly from high values in western Lake Ontario to relatively low values in eastern Lake Ontario. No such patterns were found for Cd, Cr, Pb, Mo, Ni, Sr, or V (Chau et.al., 1970). In any case, values for several trace metals might be expected to vary from expected mean values by up to two orders of magnitude. No explanations for such behavior have been advanced in the literature.

Water quality for near-shore stations has been found to vary from that of offshore stations in an irregular manner, affected by local sources of pollution, increased productivity of shallow waters and the vagaries of currents. Nevertheless, it is expected that the water quality of stations several hundred to several thousand feet from shore and several thousand feet from pollutant sources would be similar to that for offshore stations.

Since 1970, QL&M has been surveying the general ecology of the near-shore waters and sediments in the general area of Oswego and Nine Mile Point. These studies are summarized in Table V-3. To effect a comparison of QL&M survey work and to help analyze the local water quality conditions in the study area, other data collected from survey stations in the same general area have been tabulated together with their water quality parameters in Tables V-4 and V-5. Table V-4 presents a comparison of values in the Oswego area, and Table V-5 covers the Nine Mile Point area. The values presented in these tables are mean values measured over various time periods unique to each survey. The station numbers in Figure V-2 refer to the station location numbers in Tables V-4

TABLE V-3

WATER QUALITY SURVEYS ON LAKE ONTARIO UNDERTAKEN BY QL&M

Source & Date of Report	Project No.	Survey Date(s)	Station Designation	Sampling Site	Mile Point	Sample Depth	Sampling Freq.	Analysis	Comments
1) NMPC OSS, Appendix B, p.20, Tables 1-21, 4/71.	191-2	6/70-11/70	1 - 8 No Figure available.	Oswego Harbor	±0. At mouth - Oswego River.	S	Weekly	T, DO, BOD, pH, SpC, TS, TSS, TDS, TVS Cl, NO_3-NO_2, NH_3, TP, Tur	MEAN VALUES LISTED FOR INDIV. STATIONS
2) NMPC OSS, p.VI-4, Table 17, 4/71	191-2	7/70-11/70	8a, 8b, 8c, 8d	See Maps. Figure	-1.0	S	Weekly for 17 weeks	BOD, pH, PO_4, NO_3-NO_2, NH_3, TS, TSS, TVS, TDS, Cl, SpC,	Combined Sta. Mean Listed & compared to NYSDEC Value (Table I, Ref.14)
3) NMPC OSS Unit 6, Vol. I Table 15, 11/72	191-7	4,6-9, 11/72	8a, 8b, 8c, 8d	See Map	-1.0	S	Monthly for 6 Mo.	"	"
4) NMPC OSS Unit 6, Vol. IV App.D, Table 43, or Vol. I, Table 14, 11/72	191-7	4,6-9, 11/72	In 30' & 40' of Water	OSWP	-1.0	S & B	Monthly for 6 Mo.	Alk, Col, SpC, (phl), BOD, COD, TKN, NH_3-N, NO_3-N, TP, Cl, SO_4, TS, TSS, Hg, Cu, Cr, Ca, Be, Pb, V, Zn, OP, pH, DO.	Max. & Mins. Listed
5) "	"	"	Unit 1-4 Intake & Discharge	OSWPI OSWPD	-1.0	"	"	"	"
6) NMPC NMP NUC.P.S. Unit 2, Vol I, Table 18, or Vol.III, App.C, Table C-24, 2/73	191-9	4,6-9, 11/72	In 30' & 40' of Water	NMPC	+6.6	S & B	Monthly for 6 Mo.	Alk, Col, SpC, Tur, (phl), BOD, COD, TKN, NH3-N, NO_3-N, TP, OP, TVS, Cl, SO_4, TS, TSS, Be, Cd, Cr, Cu, Pb, Hg, V, Zn, pH, T,	Max. & Mins. Listed
7) "	"	"	Unit 1 Intake & Discharge	NMPI NMPD	+6.6	"	"	"	"

TABLE V-3 Cont'd

WATER QUALITY SURVEYS ON LAKE ONTARIO UNDERTAKEN BY QL&M

Source & Date of Report	Project No.	Survey Date(s)	Station Designation	Sampling Site	Mile Point	Sample Depth	Sampling Freq.	Analysis	Comments
8) NMPC NMP NUC.P.S. Unit 2, General Ecological Surveys, 1973.	191-15	1973	In 20' of Water	NMPW	+4.8	S & B	Twice per Mo.	T,SpC,pH,CO_2,DO, BOD ,COD,Tur,TS, TSS,OP,TP,NO_3-N, TKN, Si, Chl-a	
9) "	"	"	In 60' of Water	NMPW	+4.8	S & B	"	"	
10) "	"	"	In 20' of Water	NMPC	+6.6	S & B	"	"	
11) "	"	"	In 60' of Water	NMPC	+6.6	S & B	"	"	
12) "	"	"	In 20' of Water	NMPE	+8.8	S & B	"	"	
13) "	"	"	In 60' of Water	NMPE	+8.8	S & B	"	"	
14) "	"	"	In 20' of Water	NMPC	+6.6	S & B	Mo.	T,pH,Alk,Col, SpC, Tur,DO,BOD ,COD,TS, TDS,TSS,TVS,Sett R, NH_3-N,ORG-N,TKN,NO_3-N,OP,TP,TOC, SO_4, F, Cl, phl, SUR, Al, As, Ba, Be, Cd, Ca, Cr, Cu, Fe, pB, Mg, Mn, Hg, Ni, K, Se, Ag, Na, Si, V, Zn, & Radioactivity - Alpha, Beta & Gamma & Tritium, TH Tcol,Fcol, Cn.	

TABLE V-3 Cont'd

WATER QUALITY SURVEYS ON LAKE ONTARIO UNDERTAKEN BY QL&M

Source & Date of Report	Project No.	Survey Date(s)	Station Designation	Sampling Site	Mile Point	Sample Depth	Sampling Freq.	Analysis	Comments
15) NMPC Nuc. Power Sta. Unit 2, General Ecological Surveys, 1973.	191-15	1973	In 45' of Water	NMPC	+6.6	S & B	Mo.	"	
16) "	"	"	Unit 1 Intake	NMPI	+6.6	S	Mo.	"	
17) "	"	"	Unit 1 Discharge	NMPD	+6.6	S	Mo.	"	
18) "	"	"	Unit 1 Intake Composite	NMPICO	+6.6	—	Mo.	"	
19) "	"	"	Unit 1 Discharge Composite	NMPDCO	+6.6	—	Mo.	"	
20)			In approx. 20', 40', 50' 60', 100' of Water	NMPC NMPW NMPE	+6.6 +4.8 +8.8	Every meter	Weekly	pH, DO, spc, T,	
21) NMPC OSS General Ecological Surveys 1973	191-16	1973	In 20' of Water	OSWP	-1.0	S & B	Mo.	Alk, T, pH, CO_2, SpC, Col, DO, BOD, COD, TS, TDS, TSS, TVS, OP, TP, NH_3-N, NO_3-N, ORGN, TKN, Cl, SO_4, phl, SettR, FCol, Cr, Mg, Ni, Zn, V, Na, Tcol, TH, Tur, Be, Cd, Cu, Fe, K, Pb	
22) "	"	"	In 45' of Water	OSWP	-1.0	S & B	Mo.	"	
23) "	"	"	Unit 1-4 Intake	OSWPI	-1.0	S	Mo.	"	
24) "	"	"	Unit 1-4 Discharge	OSWPD	-1.0	S	Mo.	"	
25) "	"	"	In approx. 20', 40' of Water	OSWW	-3.0	Every meter	Weekly	pH, DO, SpC, T	
26) "	"	"	In approx. 20', 40', 50', 100', of Water	OSWP	-1.0	"	"	"	

KEY FOR TABLE V-3

NMPC	Niagara Mohawk Power Corporation
OSS	Oswego Steam Station
App.	Appendix
NMP Nuc.P.S.	Nine Mile Point Nuclear Power Station
NMPW	Nine Mile Point West Transect
NMPC	Nine Mile Point Center Transect
NMPE	Nine Mile Point East Transect
NMPP	Nine Mile Point Power Plant
NMPI	Power Plant Intake
NMPD	Power Plant Discharge
NMICO	Power Plant Intake Composite
NMPDCO	Power Plant Discharge Composite
S	Surface
B	Bottom
Bimo	Bimonthly
Mo	Monthly
OSWP	In Front of Oswego Steam Station
OSWI	Plant Intake
OSWD	Plant Discharge
NYSDEC	New York State Dept. of Environmental Conservation

TABLE V-4 COMPARISON OF WATER QUALITY PARAMETERS[1] AT STATIONS IN THE OSWEGO REGION OF LAKE ONTARIO INCLUDING THE OSWEGO RIVER

LOCATION I.D. NO.	1	2	3	4	5	6		7	7a	8		QL&M SURVEYS											
Name of W.Q. SAMPLING STATION (s) (STA NO.: S REFER TO RESPECTIVE SURVEY)	OswegoCity Water Intake in Approx.60' of Water	STA.'s 181 & 181A Near the Oswego Power Plant Site		STA.'s 68 & 69 in Approx 100' of Water 68: 43°29'x76°36' 69: 43°29'x76°32'		STA. 86 in 72' of Water at 43°28.5' x 76°32'		STA. at R/R Bridge on Oswego River	STA. 187, 2.5 Mi.NE of Mouth of Oswego River	STA. 184 Near Mouth of Oswego River		TRANSECT OUT FROM OSWEGO POWER PLANT OSPP											
												in 30' of water		in 40' of water		Intake & Discharge		in 20' of water		in 45' of water		Intake & Discharge	
AGENCY	NYSDEC	EPA - Rochester		USBCF		CCIW		EPA - Rochester		EPA - Rochester								OSS1		OSS2		OSS3	OSS4
Ref. No. in TableI	14	17		3		11		16	17	17													
SURVEY DATE (s)	'64-'72	6/66-9/66		9/64		9/72		8/68-12/70	'66	'66		'72		'72		'72		'73		'73		'73	
SAMPLING DEPTH	40'	0'	0'	0'	0'	3'	66'	–	0'	0'	23'	S	B	S	B	I	D	S	B	S	B	I	D
No. PARAMETER		181	181A	68	69																		
1 pH	8.0	8.7	8.6	–	8.6	8.6	8.5	–	8.7	8.1	8.4							8.2	7.9	8.0	8.0	7.9	7.9
2 Color CU																		5.0	5.0	5.0	5.0	5.0	5.0
3 Sp.Conductance μmhos/cm	299			268	268	324	326	1002.2	320	826.7	362.0	387	590	321	522	324	324	311	370	321	319	370	360
4 Turbidity TU	8.8	.9	1.0			.9	.9	5.7	1.3	2.2	1.0	6.5	8.2	3.1	5.5	5.5	5.0	4.4	4.1	4.1	5.5	5.6	6.2
5 Carbon Dioxide mg/l																							
6 Alkalinity $CaCO_3$ mg/l	105	90	94	–	102	88.8	88.8	110.2	92.66	90.3	93.0	85.2	87.5	81.5	94.5	91.3	89.3	87	91.6	86.7	93.8	87.7	87.8
7 Total Hardness mg/l	149																	152	150	148	147	150	
8 D.O. mg/l		10.6	10.8	–	9.1	9.1	8.9	9.76	10.23	7.7	10.0							9.3	9.2	9.8	9.5	10.2	9.7
9 BOD "	1.3							5.08	3.4			2.25	1.65	1.65	1.38	1.79	1.78	1.57	2.14	1.57	1.43	2.4	2.0
10 COD "	8.2							20.7	–			6.33	12.9	6.05	9.68	12.3	12.1	7.33	13.40	8.5	8.33	9.8	9.7
11 TOC "																							
12 TIC "																							
13 T.S. "	242							827.3	–			239	398	252	379	250	239	281	313	263	274	284	276
14 T.D.S. "	232	204	205					795.4	253.66	354.5	274.5							273	276	259	267	277	270
15 T.V.S. "	99											73.4	129.1	93	134	94	98	91	100	84	84	92.9	89
16 T.S.S. "	10							14.5				6.0	13.7	2.0	6.9	4.4	10.1	9	37.1	6.1	6.9	7.3	6.8
17 V.S.S. "	5																						
18 NH_3-N "	.22	.06	.08			.018	.021	0.25	.053	.22	.10	.095	.486	.836	.63	.17	.226	.10	.167	.083	.10	.10	.067
19 ORGANIC-N "	.30	.27	.41					1.66	.333	.57	.31							.21	.77	.15	.55	.31	.35
20 TKN "						.213	.152			.94	.51	.72	1.16	1.73	2.06	.613	.963	.36	.78	.26	.61	.49	.55
21 NO_3^- -N "	.15	.05	.10			.001	.005	0.47	.07	.16	.10	.245	.30	.203	.35	.26	.20	.15	.22	.15	.159	.23	.22
22 NO_2^- -N "	.004																						
23 Ortho PO_4-P "												.028	.053	.030	.063	.035	.035	.015	.016	.013	.026	.017	.011
24 Total Phosphorus-P "	.05	.02	.02			.022	.018	0.194	.053	.047	.033	.057	.126	.067	.077	.294	.074	.034	.066	.031	.037	.03	.025
25 Oil&Grease "																							
26 Phenol "												.018	.011	.021	.01	.024	.027	.012	.02	.015	.013	.010	.020
27 Chloride "	29.0	25.0	25.0			28.9	28.8	222.5	32.33	106.7	34.0	36.6	47.1	38.9	63.6	47.4	43.4	49.1	47.4	42.1	44.7	48.2	46.6
28 Sulfate "	29.7	34.0	37.0					75.7	35.5	6.17	37.0	25.4	27.2	17.9	26.2	29.0	38.7	36.3	39.5	34.2	32.3	36.3	33.1
29 Beryllium Be"												0	T	T	.003	.001	0	.017	.005	.019	.005	.005	.003
30 Cadmium Cd"												.005	.003	.007	.004	.005	.002	0	0	0	0	0	0
31 Calcium Ca"	44.0	39.0	44.0	35.4	35.8			103.2	38.75	73.0	38.2												
32 Chromium Cr"												.001	.002	.001	.001	.002	.003	.128	.114	.036	.092	.028	.042
33 Copper Cu"												0	–	0	.012	.036	.012	.280	.33	.36	.36	.42	.33
34 Iron Fe"	.09							.427										1.0	1.25	.21	.23	.20	.40
35 Lead Pb"												T	0	.079	0	.025	T	0	.085	.12	0	.04	0
36 Magnesium Mg"	9.6	9.2	9.1					28.2	9.55	13.7	9.5							9.3	8.4	8.2	8.0	7.6	8.1
37 Manganese Mn"	.01																						
38 Mercury Hg"												.001	.001	–	.009	.005	.002						
39 Nickel Ni"																		.02	.03	.08	.13	.02	0
40 Potassium K"	1.5	1.4	1.4	1.3	1.2				1.4	2.3	1.7							1.62	1.62	1.62	1.58	1.54	1.62
41 Silicon Si"		.11	.20	.33	.33	.117	.063	.898	.67	.37	.20												
42 Sodium Na"	16.1	12.0	13.0	12.1	11.4				12.	54	20							15.7	15.3	15.4	13.3	15.4	16.4
43 Vanadium V"												0	–	0	Trace	Trace	Trace	.07	.03	.13	.167	0	0
44 Zinc Zn"												0.001	.009	.002	.013	.006	.006	.007	.017	.014	.006	.008	.008
45 T. Coliform No./100ml.	59																	952	1729	183	338	426	357
46 F. Coliform No./100ml.																		27	19.7	26.3	5.0	32.3	37.7
47 Chlorophyll-a																							

1. Numbers are mean values over time period respective to each survey.

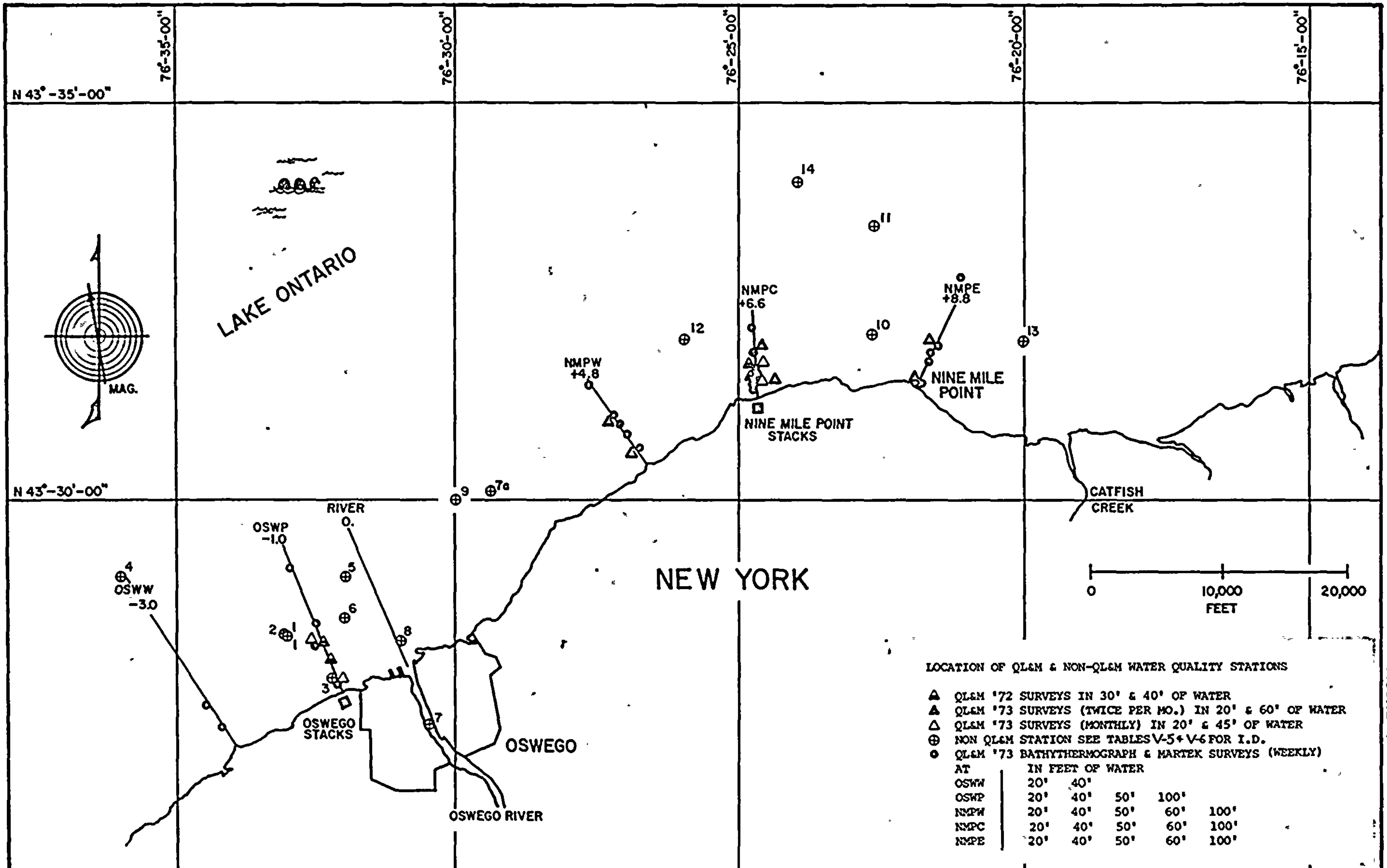
Location I.D. No.	Data collected on;	Location I.D. No.	Data Collected on:	Location I.D. No.	Data collected on;
1	5/13/64 - 8/16/72 Monthly	4	9/14/64	7	8/21/68 - 12/15/70 Twice/MO.
2	6/2, 7/30, 9/24 '66	5	9/14/64	7a	6/2, 7/30, 9/23 '66
3	6/2, 7/30, 9/23 '66	6	9/19/72	8	6/2, 8/2, 9/23 '66

TABLE V-4 COMPARISON OF WATER QUALITY PARAMETERS[1] AT STATIONS IN THE NINE-MILE REGION OF LAKE ONTARIO

LOCATION I.D. NO.	9		10	11	12	13	14		NINE MILE POINT CENTER TRANSECT IN FEET OF WATER						OLM SURVEYS		NMPC								NMPE				NMPW			
Name of W.Q. SAMPLING STATION(s) (STA.NO.: S REFER TO RESPECTIVE SURVEY)	STA.20 on U.S. C.G.Cruise 109 43°30'-00 x 76°30'-00		STA's 188 & 189 near NMP		STA's 73 & 74 in approx. 50' of water 73: 43°32'x76°26' 74: 43°32' x 76°20'		STA. 87 in 186' of water at 43°34'x76° 24'		30'		40'		Intake Discharge		NMP-3 20'		NMP-4 60'		NMP-7 20'		NMP-8 45'		Intake Discharge		NMP-5 20'		NMP-6 60'		NMP-1 20'		NMP-2 60'	
AGENCY	EPA-ROCHESTER		EPA-ROCHESTER		USBCF		CCIW																NMP-9	NMP-10								
Ref.No.in TableI	18		16		3		11																									
SURVEY DATE(s)	'6/69		'66		9/64		9/72		'72		'72		'72		'73		'73		'73		'73		'73		'73		'73		'73		'73	
SAMPLING DEPTH	0'	59'	0'		0'		3'	164'	S	B	S	B	I	D	S	B	S	B	S	B	S	B	I	D	S	B	S	B	S	B	S	B
No. PARAMETER	20		188	189	73	74	87																									
1 pH	8.55	8.65	8.67	8.77	-	8.3	8.55	8.02							8.3	8.2	8.3	8.2	7.8	7.8	8.0	7.9	7.8	8.0	8.3	8.2	8.3	8.2	8.3	8.3	8.4	8.3
2 Color CU																			5.0	11.4	5	5.6	6.4	7.1								
3 Sp.Conductance M µmhos/cm	284	240	325	319.3	277	270	331	346	328	342	311	357	329	334	293	281	263	242	340	342	331	332	274	309	278	278	276	254	302	283	278	244
4 Turbidity TU	3.30	1.75	1.3	1.4			0.7	0.6	3	6	4	5	3	4	2.4	6.1	3.0	4.4	3.2	4.7	3.2	2.9	4.2	3.4	3.1	7.3	3.2	4.8	4.4	4.8	2.9	10.4
5 Carbon Dioxide mg/l																																
6 Alkalinity $CaCO_3$ mg/l	116	110	92	94.3	-	97	90.6	98.5	91.0	90.0	86.0	86.0	89.0	84.0					88.8	91.8	87.4	90.7	87.4	89.3								
7 Total Hardness mg/l																			145	146	140	135	158	148								
8 D.O. mg/l	10.5	12.3	10.6	10.7	-	9.0									9.7	9.8	9.9	9.9	11.7		10.2	10.3	9.9	9.9	9.8	9.7	9.97	9.8	9.7	9.8	9.8	9.7
9 BOD "			1.5	1.7					3	2	2	1	2	2	1.9	1.6	2.1	1.6	1.63	1.85	1.25	1.75	1.3	1.5	2.4	1.9	2.1	1.7	1.8	1.7	2	1.5
10 COD "	9.07	6.19	-	-					17	17	12	11	12	8	14.0	13.8	12.5	13.1	12.8	11.7	13.2	11.0	11.7	9.9	14.9	15.4	13.9	10.4	12.8	11.	14.5	13.7
11 TOC "																			6.2	3.8	4.4	4.6	4.7	5.8								
12 TIC "																																
13 T.S. "	276	336	-	-					279	266	270	253	273	274	235	253	232	223	237	238	265	239	248	241	233	244	221	234	241	233	221	239
14 T.D.S. "	260	287	239	222															234	236	262	234	239	238								
15 T.V.S. "									113	90	110	102	113	119					73	67	71	81	75.7	73								
16 T.S.S. "	16	49	-	-											4.1	19.4	2.7	7.4	3.1	3.1	4.5	6.2	8	3.3	4.2	22.6	3.9	15.6	3.8	7.8	2.3	26.3
17 V.S.S. "																																
18 NH_3-N "	0.04	0.05	0.076	0.07			0.023	0.007	1.18	.31	.48	.24	.50	.48					.02	.03	.02	.013	.017	.043								
19 ORGANIC-N "	0.35	0.28	0.26	0.32															.15	.23	.27	.613	.563	.31								
20 TKN "							0.204	0.339	1.94	.99	1.29	.99	.89	1.38	.39	.54	.46	.47	.31	.52	.43	.63	.58	.361	.52	.50	.53	.44	.39	.41	.48	.49
21 NO_3^- -N "	0.13	0.12	0.097	0.11			.0023	0.066	.22	.23	.21	.25	.27	.27	.1	.15	.11	.15	.15	.15	.116	.13	.171	.137	.12	.136	.08	.13	.119	.117	.09	.17
22 NO_2^- -N "																																
23 Ortho PO_4-P "							.0011	0.016	.018	.025	.02	.025	.015	.015	.011	.016	.006	.009	.007	.007	.013	.005	.006	.009	.009	.013	.004	.011	.005	.01	.006	.013
24 Total Phosphorus-P "	0.036	0.099	0.011	0.017			0.021	0.025	.07	.083	.06	.06	.06	.09	.04	.07	.046	.02	.049	.036	.039	.027	.036	.041	.086	.08	.038	.101	.06	.06	.04	.055
25 Oil & Grease "																																
26 Phenol "									.31	.24	.35	.217	.226	.32					.022	.032	.038	.034	.019	.041								
27 Chloride "	44	26	27.7	27.3			28.5	28.0	51.5	46	53	49	53	41					36.6	38.3	36.6	37.3	36.8	40.1								
28 Sulfate "	25.5	21.5	34.0	33.5					29.2	28.7	30.8	28.9	27.7	28.2					27.3	28.6	28.4	29.2	29.1	28.6								
29 Beryllium Be "									.002	.005	.013	.002	.004	.001					.008	.001	.004	.012	.001	.004								
30 Cadmium Cd "									.015	.008	.005	.001	.010	.011					.003	.009	.003	.003	.001	.0002								
31 Calcium Ca "	44.9	40.9	39.8	41.4	36.4	35.1																										
32 Chromium Cr "							.006	.008	.012	0	.008	0	0	0					.016	.013	.013	.008	0	0								
33 Copper Cu "							.008	.008	.001	.070	0	.050							.052	.053	.083	.075	.069	.05								
34 Iron Fe "	.130	.060					.004	.003											.194	.31	.31	.137	.16	.05								
35 Lead Pb "									.110	.013	0	.038	.019	.038					.019	.007	.021	.052	.035	.009								
36 Magnesium Mg "	12.0	12.0	9.3	9.35															8.0	8.2	7.1	7.3	8.5	8.4								
37 Manganese Mn "							0.2	0.2											.078	.08	.07	.056	.074	.04								
38 Mercury Hg "									.001	.001	T	.001	.005	.002																		
39 Nickel Ni "							.006	.006											.026	.04	.04	.019	.019	.018								
40 Potassium K "			1.4	1.4	1.3	1.3													1.96	1.86	1.8	1.84	1.77	1.9								
41 Silicon Si "	0.33	0.33	0.22	0.12	0.33	0.37	0.049	0.234							.75	1.0	1.0	.5	2.3	1.3	.25	1.5	2.25	0	.88	1.0	.13	1.0	.88	.88	.5	.75
42 Sodium Na "			13	13	11.5	11.9													16.9	16.8	17.4	17.0	14.8	16.4								
43 Vanadium V "									.021	.14	.059	.067	.058	.027					0	0	0	.043	.06	0								
44 Zinc Zn "							.004	.004	.007	.090	.019	.115	.163	.085					.036	.02	.05	.082	.045	.011								
45 T. Coliform No./100ml.																			53.4	49	70.6	93.4	78.3	43.8								
46 F. Coliform No./100 ml.																			2.3	.42		3.0	2.8	17.1								
47 Chlorophyll-a															5.9	7.2	6.5	6.3							6.5	6.0	4.9	6.2	4.1	5.4	4.7	4.4

1. Numbers are mean values over time period respective to each survey.

Location I.D. No.	Data collected on
9	6/3, 8/2, 9/22-'66
10	6/3, 8/2, 9/22-'66
11	9/16/64
12	9/16/64
13	9/16/64
14	9/19/72



76°-35'-00"
76°-30'-00"
76°-25'-00"
76°-20'-00"
76°-15'-00"
N 43°-35'-00"
N 43°-30'-00"
LAKE ONTARIO
MAG.
14
11
NMPC
+6.6
NMPE
+8.8
12
10
13
NMPW
+4.8
NINE MILE
POINT
NINE MILE POINT
STACKS
9
7a
CATFISH
CREEK
RIVER
0.
OSWP
-1.0
4
OSWW
-3.0
5
6
8
NEW YORK
0
10,000
FEET
20,000
OSWEGO
STACKS
7
OSWEGO
OSWEGO RIVER
LOCATION OF QL&M & NON-QL&M WATER QUALITY STATIONS
QL&M '72 SURVEYS IN 30' & 40' OF WATER
QL&M '73 SURVEYS (TWICE PER MO.) IN 20' & 60' OF WATER
QL&M '73 SURVEYS (MONTHLY) IN 20' & 45' OF WATER
NON QL&M STATION SEE TABLES V-5 + V-6 FOR I.D.
QL&M '73 BATHYTHERMOGRAPH & MARTEK SURVEYS (WEEKLY)
AT | IN FEET OF WATER
OSWW | 20' 40'
OSWP | 20' 40' 50' 100'
NMPW | 20' 40' 50' 60' 100'
NMPC | 20' 40' 50' 60' 100'
NMPE | 20' 40' 50' 60' 100'

FIGURE V-2

and V-5. The transect numbers represent miles from the Oswego River mouth. Location 7 on Table V-5 presents data for the Oswego River as mean values over a two and one-half year period. Compared to other locations and to the values in Table V-2, it is evident that the Oswego River is relatively high in most pollutants, including nutrients, organic material and major inorganic ions. Total dissolved solids and chlorides are conservative parameters which may be used to estimate dispersion of the Oswego River in Lake Ontario. It may be assumed that coliform counts are also quite high relative to normal Lake conditions and may be used to estimate qualitatively the presence of trace amounts of Oswego River constituents.

B. 1973 WATER QUALITY INVESTIGATIONS

1. SAMPLING STATIONS AND FREQUENCY

Water quality and related samples collected near the Nine Mile Point promontory and near the Oswego Steam Station (OSS) included weekly field measurements, bi-monthly (twice per month) collections in conjunction with biological sampling, monthly collections for extensive water quality analyses and special collections for dissolved oxygen loss at the plant, bottom sediment characterization and storm drain and sanitary effluent characterization programs. The specific locations of Lake sampling stations are shown in Figure V-2 and are described below.

2. COLLECTION PROCEDURES

a. Weekly Field Measurements

Weekly surveys were conducted from April to December 1973 at various depths at Nine Mile Point Plant Unit 1 transect (NMPP or NMPC), east transect (NMPE) and west transect (NMPW) and at Oswego Plant transect (OSWP) and Oswego west transect (OSWW). Measurements of temperature at one meter intervals were made to define thermal stratification. Most measurements were made with a Martek Mark II multiprobe analyzer, in which case pH, DO and specific conductivity were also measured. On occasion, measurements were made with a Montedoro Whitney Model TF-20 thermistor or a GM Model OC-1/S bathythermograph.

b. Bi-Monthly Collections

Bi-monthly water collections were made from June through December at NMPP-1 transect and at the east and west transects. Samples were taken at 20 and 60 ft. depths along each transect using a four liter PVC Van Dorn sampler. The water was dispensed into one gallon polyethylene bottles for immediate transport to the laboratory. Temperature, DO, pH, and specific conductivity measurements were made with the Martek Mark II. Free CO_2 was determined in the field by titration.

c. Monthly Collections

Monthly water collections were made from March to December at the NMPP-1 intake and discharge and at the NMPP-1 transect. The Lake samples were taken at 20 and 45 ft. depths using a four liter PVC Van Dorn sampler.

The water was dispensed into one gallon polyethylene bottles and sterile 300ml pyrex BOD bottles for chemical and bacteriological analyses, respectively. Temperature, DO, pH and specific conductivity measurements were made with the Martek Mark II. Intake and discharge grab samples were collected using similar techniques. Seven day intake and discharge composite samples collected by the plant compositor were also transferred to appropriate sample containers and taken to the laboratory for analysis.

d. Dissolved Oxygen Loss

Surface samples for DO and temperature were taken at NMPP-1 intake and discharge forebays on a weekly basis. Samples were collected at six hour intervals from noon one day to noon the following day at 1500, 2100, 0300, and 0900 hours. On 21 June, 15 August and 17 October more extensive surveys were conducted during which DO and temperature were determined hourly for 24 hours. Samples were collected by a four liter PVC Van Dorn sampler and dispensed into 300ml BOD bottles. All samples were overflowed approximately three volumes and fixed according to the azide modification of the Winkler method. Water temperature was determined by mercury thermometer.

e. Bottom Sediments

Bottom sediments were collected on 22 October at the FitzPatrick transect (FITZ), the NMPP-1 transect and at the east and west transects at 20 and 40 ft. depths. Collections were performed by scuba divers. The samples were placed in ice chests and transported to the laboratory for analysis.

f. Effluent Analysis

The NMPP-1 sanitary sewage treatment plant effluent was monitored monthly from August to December. The wastes are treated by a packaged activated sludge plant with secondary clarification and chlorination. The chlorinated effluent is discharged into an oxidation pond. Pond overflow trickles through a swampy area where it is either lost by evaporation or eventually reaches the lake via a "discharge channel." Surface grab samples were taken every six hours for 24 hours from the discharge channel and placed in ice chests. Twenty four hour composite samples were taken of the oxidation pond influent and effluent by FMI Model RRP metering pumps which pumped at a constant rate into two gallon polyethylene containers placed in an ice chest.

A separate 48 inch storm drain located at the edge of the Lake on the west side of the Nine Mile Point Unit 1 plant was also sampled monthly from August to December. Grab samples were taken every 6 hours for 24 hours, placed in ice chests and transported to the laboratory for analysis.

3. <u>LABORATORY ANALYSES</u>

a. Bi-Monthly Collections

BOD, COD, TSS, TKN, NO_3-N, TP, Turbidity, orthophosphate, Si, Chlorophyll _a_, pH, TS.

b. Monthly Collections

Alkalinity; BOD, COD, TS, TDS, Settleable Solids, TVS, TKN, NH_3-N, NO_3-N, TP, Color, Turbidity, Total Coliform, Fecal Coliform, Organic N,

CN, F, TOC, ferro or ferri cyanide, orthophosphate, SO_4, Cl, Al, As, Ba, Be, Cd, Ca, Cr, Cu, Fe, Pb, Mg, Mn, Hg, Ni, K, Se, Ag, Na, Zn, V, Si, phenols, surfactants, radioactivity (inplant samples only; gross α, gross β, ^3H, spectroscopic), pH, total hardness.

c. Bottom Sediments

COD, TP, TKN, moisture content, TS, TVS, Cr, Cu, Hg, Zn (COD and TP were determined for the water present in the sampling containers after collection).

d. Effluent Analyses

Alkalinity, BOD, COD, TS, TDS, TSS, TVS, TKN, NH_3-N, NO_3-N, TP, Total coliform, fecal coliform, Zn, phenols, $SO_3^=$, chlorine residual.

4. <u>LABORATORY ANALYTICAL PROCEDURES</u>

The U.S. Environmental Protection Agency has promulgated mandatory guidelines establishing test procedures for the analysis of pollutants. These methods of analysis are outlined in the <u>Federal Register</u> (38 [199] 28758) dated October 16, 1973. They are also included under Title 40, Code of <u>Federal Regulations,</u> Part 136, with few exceptions. All analyses conducted by QLM Laboratories, Inc., either conform to these guidelines or permission has been requested through the EPA Region II laboratory to use our current standard methods (for fluoride and selenium only). Field measurement for total chlorine residual at Nine Mile Point used the orthotolidine technique. Analyses for parameters not covered in the EPA documents follow the accepted procedures published in one of the following documents:

Standard Methods for the Examination of Water and Wastewater

13th Edition, 1971. This publication is available from the American Public Health Association.

Annual Book of Standards, Part 23, "Water, Atmospheric Analysis," 1972. This publication is available from the American Society for Testing and Materials. (A new edition is in press).

Methods for Chemical Analysis of Water and Wastes, 1971. Environmental Protection Agency. (A new edition is in its final draft stage).

A tabular compilation of QL&M analytical methods can be found in Appendix VII-4.

C. RESULTS AND DISCUSSION

1. WEEKLY WATER QUALITY RESULTS

The results from the weekly water quality studies are presented in summarized form in Table V-6. Sections 2 and 3 below include analyses of T, pH, DO and specific conductivity values for monthly and bi-monthly water quality studies.

2. ANALYSIS OF THERMAL DATA

a. General

Vertical temperature profile data in the Nine Mile Point area were obtained to establish the existing thermal conditions and the extent of vertical temperature gradients shoreward of a depth of 100 ft. The

TABLE V-6

SUMMARY OF BATHYTHERMOGRAPH & MARTEK READINGS DURING 1973
AT OSWEGO AND NINE MILE POINT

DATE		4/30	5/7	5/14	5/24	5/29	5/30	6/4	6/5	6/8	6/11	6/13	6/14	6/18
LOCATION SAMPLING SITE (TRANSECT)	IN FT. OF WATER				Number of Readings Taken Depth Range Meters Temperature Range °C D.O. Range mg/l pH Range Conductivity Range Micro-MHOS									
OSWW	20										9 0 - 8 17.0-14.0 11.8-12.0 8.8- 9.0 260-270			
	40					11 0-10 8.1- 7.7 11.8-12.0 7.8- 7.9 220 - 220					15 0 - 14 15.0 - 17.8 13.2 - 12.0 8.8 - 9.3 260 - 280			
OSWP	20					14 0-13 7.0- 9.0 12.4-12.0 7.6- 7.9 210 - 240					10 0 - 9 15.2 - 17.0 13.6 - 12.8 9.0 - 9.1 260 - 270			
	40					13 0 - 12 9.0 - 7.0 12.0 -12.4 7.5 - 7.9 210 - 240								
	50													
	100	10 0-26 4.5-4.4 - - -	17 0 -30 6.4-5.0 - - -	18 0-28.5 5.6-5.2 - - -	25 0-33 9.5-5.8 - - -			27 0 - 30 13-5.4 - - -			32 0- 31 15 - 6.8 - - -			36 0 - 35 10 -3.8 - - -
NMPW	20									8 0 - 7 18.0-17.0 13.2-12.9 8.8 370 - 440				
	40								14 0 -13 16.2- 9.0 13.6-11.4 8.4 -8.6 240 -470					
	50							15 0 -14 13.0-8.0 - - -			9 1 - 16 16.0-13.0 - - -			17 0 - 16 6.0 - 4.1 - - -
	60								20 0 - 19 16.0- 8.2 13.8-11.6 8.4 -8.8 220 - 320					
	100			17 0 -29.5 6.5-5.0 - - -	20 0 -32 10.5-6.8 - - -		32 1 -33 11- 3.8 - - -	16 1 -28 12.5-5.8 - - -			18 0 - 33 13.5-7.0 - - -			34 0 - 33 9.1 - 3.7 - - -

TABL[illegible]t'd

SUMMARY OF BATHYTHERMOGRAPH & MARTEK READINGS DURING 1973
AT OSWEGO AND NINE MILE POINT

DATE		4/30	5/7	5/14	5/24	5/29	5/30	6/4	6/5	6/8	6/11	6/13	6/14	6/18
LOCATION SAMPLING SITE (TRANSECT)	IN FT. OF WATER				Number of Readings Taken Depth Range Meters Temperature Range °C D.O. Range mg/l pH Range Conductivity Range Micro-MHOS									
NMPC	20									7 1 - 6 16.8-15.7 12.5-12.7 8.6- 8.7 310-390				
	40						14 1 - 13 10.5- 8.3 11.5-14.9 "8.4- 9.1 225 - 240		14 0 - 13 14.4- 8.2 12.0-12.8 8.2- 8.4 210 -370					
	60								19 0 - 18 14.1- 8.0 13.2-11.6 8.2- 8.4 220 -370	21 0 - 20 16.2- 7.1 11.3-13.7 8.69-7.7 360- 212				
	100	10 0-29 4.2-3.9 - - -	12 0 - 30 7.5-4.9 - - -	9 0 - 31 5.4-5.0 - - -	18 0 - 35 10.9-7.0 - - -		31 0 - 35 10 - 3.7 - - -	28 0- 30 13-5.4 - - -			22 0 - 33 3.8-8.2 - - -			36 0 - 35 11.1-3.8 - - -
NMPE	20									7 0 - 6 16.4-14.8 12.6-13.2 8.4- 8.6 340 - 305				
	40												14 0 - 13 16.5-15.0 11.8-12.8 8.6- 8.9 270 - 310	
	50							11 0- 16 11-7.9 - - -			16 0 - 16 15.5-11.5 - - -			18 0 - 17 14.4-51 - - -
	60									21 0 - 20 15.8- 8.1 11.8-14.1 7.8- 8.6 290 - 235				
	100			11 0-28.5 5.9-5.1 - - -	23 0 - 32 9.0-6.8 - - -		33 0 - 35 11.6-3.8 - - -	17 0 - 30 11 - 5.0 - - -			21 0 - 34 14.9-7.8 - - -			34 0 - 34 14.5-4.9 - - -
FITZ	30								14 0- 13 13.5- 9.5 11.8-13.1 8.2- 8.3 260- 380					

TABLE V-6 Cont'd

SUMMARY OF BATHYTHERMOGRAPH & MARTEK READINGS DURING 1973
AT OSWEGO AND NINE MILE POINT

DATE		6/20	6/25	6/26	6/28	6/29	7/2	7/9	7/10	7/16	7/23	7/30	8/6	8/13
LOCATION SAMPLING SITE (TRANSECT)	IN FT. OF WATER				Number of Readings Taken Depth Range Meters Temperature Range °C D.O. Range mg/l pH Range Conductivity Range Micro-MHOS									
OSWW	20		8 0-7 18.2-14.9 13.4-13.9 9.1- 9.3 260 - 280				9 0- 8 18.1-12.9 10.3-11.1 8.8- 8.9 260 - 280		8 0 - 7 22.9-21.5 8.7- 8.8 8.8- 8.8 290 - 300			8 0 - 7 22.2-22.0 8.4- 9.0 8.8- 8.0 300- 300		8 0 - 7 24.0-23.8 9.6- 9.9 - 300 - 300
	40		14 0 - 13 17.5 - 7.3 11.2 -13.9 8.3 - 9.3 218 - 278			16 0 - 15 17.0- 9.0 11.0-11.8 8.5- 9.0 230- 270	15 0 -14 18.9- 7.5 10.4-11.6 8.8- 8.9 220 - 290		14 0 - 13 23.0-21.8 14.2-15.2 8.8- 8.8 295 - 300			14 0 - 13 22.1-22.0 9.2-12.0 8.8- 8.8 300 - 300		13 0 - 12 24.0-23.9 8.8-10.6 - 300 - 300
OSWP	20		8 0 - 7 17.8-12.9 12.4-13.7 8.9- 9.3 260 - 300		8 0 - 7 15.3-13.1 11.6-12.0 8.7- 8.8 250 - 262		8 0 - 7 18.2-11.2 9.9-10.4 8.8- 8.9 255- 320		8 0 - 7 22.5-21.9 - 8.8- 8.8 300 - 300			8 0 - 7 22.1-22.0 8.4- 9.4 8.8- 8.8 300 - 300	8 0 - 7 23.1-22.9 8.3-10.2 8.8- 8.8 305- 320	8 0 - 7 24.0-24.0 8.8-10.0 - 300 - 300
	40		15 0 - 14 17.5- 8.0 11.4-13.8 8.4- 9.3 220- 280		16 0 -15 16.0- 9.0 10.6-12.0 8.1- 8.9 225 - 265		15 0 - 14 19.2- 8.1 10.1-11.7 8.8- 8.9 230 - 305					14 0 - 13 22.1-22.0 10.0-10.8 8.8- 8.8 300- 300	14 0 - 13 23.0-22.4 8.8-10.3 8.8- 8.8 300 - 315	14 0 - 13 23.9-23.4 9.2- 9.7 - 300 - 300
	50		17 0 -16 17.2- 6.9 11.2-14.0 8.3- 9.3 215-275				17 0- 16 19.8 -8.0 10.2-11.8 8.8- 8.9 230- 305	15 0 - 14 22.5-21.6 - - -		17 0 - 16 22.5-21.9 8.0-10.7 8.8- 8.8 300- 420	18 0 - 17 22.2- 5.5 9.0-11.9 8.8- 8.9 215- 355	17 0 - 16 22.1-21.5 9.8- 9.6 8.8- 8.8 300 - 300	18 0 - 17 23.0-22.3 8.0-10.3 8.8- 8.8 300 - 310	17 0 - 16 23.6-23.1 9.2-10.0 - 300 - 300
	100		34 0-33 20.0- 4.8 11.4-13.7 8.2- 9.3 195- 420				34 0 - 33 20.0- 6.0 10.5-11.5 8.8- 8.9 200 - 290	29 0 - 28 20.9-11.8 - - -		34 0 - 33 22.1-17.1 8.2- 8.8 8.8- 8.9 280 - 385	34 0 - 33 21.4- 4.5 9.8-12.4 8.7- 8.8 200 - 500	34 0 - 33 22.1- 7.0 9.6-10.8 8.7- 8.8 210 - 300	34 0 - 33 22.8-11.5 8.3-10.2 8.8- 8.9 245 - 305	34 0 -33 23.2-16.0 7.6-10.8 - 280 - 300
NMPW	20	8 0 - 7 11.2- 9.5 12.0-11.6 8.8 220 - 275	6 0 - 5 17.9-14.7 13.6-11.8 9.16-8.84 300 - 260	6 0 - 5 16.2-14.0 11.4-12.7 8.76-9.4 320 - 410			8 0 - 7 21.8-16.0 10.8-12.0 8.8- 8.9 305 - 340					8 0 - 7 24.0-22.5 8.2-11.2 8.8- 8.8 440 - 540	7 0 - 6 24.8-24.6 10.1-11.4 8.9- 8.9 220- 555	8 0 - 7 24.9-24.2 8.3-11.2 - 480 - 580
	40						14 0 - 13 21.5 -8.0 10.0-12.0 8.8- 8.9 210 - 320					14 0 - 13 23.2-22.0 7.8-10.0 8.8 -8.0 300 - 400	14 0 - 13 24.1-22.9 8.3-11.0 8.8- 8.9 330 - 380	14 0 - 13 24.1-23.2 8.0-10.3 - 300 - 570
	50		17 0 -16 19.5- 6.4 11.1-15.6 8.2- 9.3 215 - 470	17 0 - 16 19.5- 6.4 11.1-15.6 8.2- 9.3 215 - 470			17 0 - 16 21.8- 7.4 10.0-12.1 8.8 -8.9 210-330	17 0 - 16 22.6-20.8 - - -		17 0 - 16 22.0-20.4 7.5- 8.8 8.8- 8.9 280 - 320	17 0 - 16 23.2- 5.7 8.9-11.0 8.8- 8.9 220- 320	17 0 - 16 23.2-21.4 8.0-12.4 8.8- 8.8 300 - 360	10 1 - 17 24.2-22.9 8.1-10.6 8.8- 8.9 325 - 350	17 0 - 16 24.1-23.0 9.2-10.3 - 300 - 360
	60	20 0 - 19 11.2- 7.2 11.9-11.4 8.3- 8.6 220 - 280	20 0 -19 19.2- 6.0 15.6-11.0 9.3- 8.2 470 - 210	19 0 - 18 17.0- 6.0 10.8-13.6 8.16-9.14 210 - 360								21 0 - 20 23.0-21.0 8.7 -9.6 8.8 -8.8 300 - 320		21 0 - 20 24.1-23.0 8.4-10.8 - 300 - 350
	100			33 0 - 32 18.9- 5.0 11.0-16.1 8.2- 9.3 200 - 465			34 0 - 33 21.5- 5.2 10.1-11.9 8.8 -8.9 200 [illegible]	30 0 - 29 22.0-14.0 - - -		34 0 - 33 22.0-20.0 7.2- 8.8 8.8- 8.8 280 - 320	33 0 - 32 23.0- 4.5 9.0-12.4 8.8- 8.9 200 - 320	34 0 - 33 23.0- 8.9 9.5-10.0 8.8 -8.8 220 - 320	34 0 - 33 23.6-11.5 8.1-10.6 8.8- 8.9 250 - 315	33 0 - 32 24.0-21.0 7.8-10.4 - 290 - 320

TAB[illegible]nt'd

SUMMARY OF BATHYTHERMOG[illegible]ARTEK READINGS DURING 1973
AT OSWEGO AND NINE MILE POINT

DATE		6/20	6/25	6/26	6/28	6/29	7/2	7/9	7/10	7/16	7/23	7/30	8/6	8/13
LOCATION SAMPLING SITE (TRANSECT)	IN FT. OF WATER				Number of Readings Taken Depth Range Meters Temperature Range °C D.O. Range mg/1 pH Range Conductivity Range Micro-MHOS									
NMPC	20	7 0 - 6 9.0 - 6.5 12.0-11.6 8.8 210 - 220	8 0 - 7 20 - 14.3 14.3-12.1 9.1- 8.9 400 - 370	7 0 - 6 18.5-14.2 11.8-14.0 8.74-9.16 360 - 370			8 0 - 7 22.8-18.2 9.6-11.3 8.9- 8.9 310 - 340	6 0 - 5 26.1-21.6 8.3- 9.5 8.9- 8.9 295 - 395				8 0 - 7 25.0-22.0 8.8- 9.6 8.8- 8.8 300 - 320	8 0- 7 27.0-23.2 8.9-10.9 8.9- 8.9 370-450	8 0 - 7 29.5-23.4 8.5-10.0 - 300 - 460
	40		12 0 - 11 22 - 8.9 15.2-10.4 9.3- 8.3 435 - 240				15 0 -14 22.9- 9.2 9.9-11.3 8.8- 8.9 245 - 340					14 0 -13 24.0-21.5 7.7- 9.6 8.8 -8.8 300 - 320	14 0-13 27.5-23.0 8.9-11.1 8.8- 8.9 370 - 430	14 0-13 28.9-23.3 8.9-10.4 - 300 - 360
	50													
	60	21 0 - 20 10-5.2 12-11.6 8.3-8.4 200 - 240	19 0 - 18 20.5- 7.1 15.9-10.4 9.3- 8.1 422 - 210	22 0 - 21 17.8- 6.2 10.6-13.0 8.16-9.14 200 - 360								21 0 - 20 24.0-21.0 9.2-10.0 8.8- 8.8 300 - 420		20 0 - 19 28.0-23.1 8.8-10.5 - 300 - 340
NMPE	20	8 0 - 7 14.5-12.1 11.8-11.2 8.9 250 - 260	8 0 - 7 18.5-17 15.0-13.9 9.2- 8.1 340-320	8 0 - 7 16.0- 8.9 10.3-13.0 8.1- 9.1 238 - 275			8 0 - 7 20.0-16.0 8.8-11.4 8.9- 8.9 300 - 340	7 0 - 6 22.5-22.1 8.5- 9.1 8.8- 8.9 335 - 340				8 0 - 7 23.1-22.2 8.4-10.0 8.8- 8.8 250 - 320	8 0 - 7 24.0-23.0 8.9-10.9 8.8- 8.9 330 - 335	8 0 - 7 25.3-24.4 8.4-11.2 - 340 - 380
	40		13 0- 12 18.6-12.9 14.2-11.2 9.2- 8.7 295 - 270				14 0 -13 20.0- 9.0 9.6-11.6 8.8- 8.9 240- 320					14 0 -13 23.0-22.0 9.2-10.2 8.8- 8.8 300-320	14 0-13 23.5-22.9 8.0-11.0 8.8- 8.9 320- 340	14 0-13 24.5-23.8 9.6-11.3 - 300 - 340
	50		16 0 -15 18.5- 9.0 10.1-13.9 8.2- 9.3 240 - 285				17 0 - 16 20.7-7.9 10.1-11.7 8.8- 8.9 235 - 320	16 0 -15 27.1-21.1 8.9- 9.4 8.8- 8.8 295 - 310		17 0 -16 22.1-22.0 7.0- 8.8 8.8- 8.9 310 - 315	18 0 - 17 27.6- 5.9 8.6-11.1 8.8- 8.8 210- 300	17 0 - 16 23.0-27.0 8.6-10.0 8.8- 8.8 300 - 320	17 0 - 16 23.9-22.5 7.8-11.1 8.8- 8.9 315 - 340	16 0 - 15 24.0-23.4 9.0-10.8 - 300 - 320
	60	21 0 - 20 14.9- 5.2 - 8.8- 9.0 200 - 260	19 0 -18 18 - 6.5 14.1-10.3 9.3- 8.1 275 - 210	22 0 - 21 16.0- 5.0 10.4-14.3 8.18-9:21 200 - 270			17 0 - 16 27.5-20.5 8.8- 9.4 8.8- 8.9 295 - 330					21 0 - 20 23.0-17.0 8.4-10.0 8.8- 8.8 280 - 320		21 0 - 20 24.0-23.3 9.0-10.8 - 300 - 320
	100		33 0 - 32 18.9- 5.0 10.4-17.3 8.2- 9.2 190 - 275				33 0 -32 21.1- 5.0 10.0-12.4 8.8- 8.9 200- 310	28 0 - 27 27.5-19.2 9.0- 9.5 8.3- 8.9 270 - 300		35 0 -34 21.9-21.0 8.6-16.5 8.8- 8.8 300 - 300	34 0 - 33 22.0- 3.0 9.0-12.3 8.8- 8.9 200 - 300	34 0 - 33 22.9-16.0 9.2-10.0 8.8 -[illegible] 260 - 320	34 0 -33 24.0-15.9 7.9-10.9 8.8- [illegible] 270 - 370	33 0 - 32 24.0-21.0 8.0-10.6 - 260 - 300
FITZ	30													

TABLE V-6 Cont'd

SUMMARY OF BATHYTHERMOGRAPH & MARTEK READINGS DURING 1973
AT OSWEGO AND NINE MILE POINT

DATE		8/20	8/27	9/13	9/17	9/28	10/1	10/10	10/19	10/22	10/23	10/28	11/5	11/13
LOCATION SAMPLING SITE (TRANSECT)	IN FT. OF WATER				Number of Readings Taken Depth Range - Meters Temperature Range °C D.O. Range mg/l pH Range Conductivity Range Micro-MHOS									
OSWW	20	8 0 - 7 22.2- 9.4 9.6-11.3 - 245 - 375	10 0 - 9 22.9-18.0 - - -	8 0 - 7 22.0-21.7 8.0- 8.0 - 280 -290	6 0 - 5 20.7-20.2 7.2- 7.6 - 290 - 300	8 0 - 7 17.9-16.0 7.8- 8.9 - 275 - 280	8 0 - 7 16.0-15.9 8.6- 8.8 - 270- 200	8 0 - 7 14.0-13.7 - - 260 - 260	8 0 - 7 11.8-11.4 - - -	8 0 - 7 11.4-11.2 - - -			8 0 - 7 6.4-5.8 - - -	8 0 - 7 7.8-7.0 10.2-10.8 - 185 - 185
	40	15 0 -14 22.4- 6.2 9.1-11.4 - 220 - 385	13 0 -12 22.8-17.2 - - -	14 0 -13 22.0-21.7 7.6- 8.1 - 285 -290	14 0 -13 20.7-20.2 7.4- 7.8 - 295 - 300	14 0 -13 18.2- 7.8 7.5- 8.4 - 210 - 280	15 0 -14 15.8-13.8 8.0- 8.9 - 260 - 270	14 0 -13 14.0-13.2 - - 210 - 260	14 0 -13 11.8-11.4 - - -	14 0 -13 11.7-11.6 - - -			14 0 -13 6.7- 6.3 - - -	15 0 -14 7.9- 7.1 10.2-10.6 - 185 - 190
OSWP	20	8 0 - 7 22.5- 9.9 7.6 -9.8 - 250 - 490		8 0 - 7 22.0-21.2 8.3 -8.7 - 285 - 300	8 0 - 7 20.2-20.1 8.0 -8.3 - 295 - 300	8 0 - 7 18.0-13.0 7.7- 8.2 - 265 - 280	8 0 - 7 16.0-15.4 8.5- 8.7 - 260 - 280	8 0 -7 14.1-13.8 - - 285 - 310	8 0 -7 11.4-10.8 - - -	7 0 - 6 11.7-11.5 - - -			8 0 - 7 5.7-5.1 - - -	8 0 - 7 6.8-6.4 10.6-11.0 - 180 - 180
	40	14 0 - 13 22.9- 6.3 7.8-11.1 - 215 - 540	11 0 - 10 23.3-17.8 - - -	14 0 -13 22.0-21.0 8.0- 9.4 - 285 - 290	14 0 - 13 20.9-20.2 7.0- 7.4 - 295 - 300	14 0 - 13 18.0-10.8 7.3- 8.4 - 240 - 470	14 0 - 13 16.0-15.4 8.4- 8.7 - 230 - 265	14 0 - 13 14.1-13.7 - - 265 - 300	15 0 - 14 11.7-11.3 - - -	14 0 -13 11.7-11.7 - - -			12 0 -11 6.2-6.0 - - -	15 0 -14 7.2-6.2 10.1-10.8 - 175 -180
	50	18 0 -17 23.0- 5.5 8.6-11.2 - 215 - 405	13 0 - 12 23.0-17.5 - - -	17 0 - 16 22.0-21.1 7.5- 8.5 - 240-290	18 0 - 17 20.0-16.5 6.8- 7.6 - 280- 300	18 0 - 17 17.2- 8.1 8.0- 8.7 - 220 - 300	18 0 - 17 16.0-14.9 8.3- 8.9 - 260 - 270	17 0 -16 14.1-13.0 - - 260 - 260		17 0 -16 11.8-11.7 - - -		17 0 -16 6.4-6.2 - - -		
	100	34 0 - 33 23.5- 4.6 8.0-12.7 - 200 - 315	30 0 - 29 23.0-14.0 - - -	34 0 - 33 22.0-21.2 7.5- 8.5 - 265 - 290	29 0 - 28 20.7- 6.9 7.1 -8.5 - 210 - 295	39 0 - 33 17.1- 6.0 8.4- 8.7 - 200 - 320	33 0 - 32 16.1- 8.1 8.2- 8.9 - 215- 270	34 0 - 33 15.5-11.2 - - 240 - 260	35 0 - 34 12.4-11.9 - - -	33 0 - 32 11.9-11.8 - - -			34 0 -33 8.3-6.8 - - -	35 0 - 34 8.0 -7.8 10.0-10.6 - 180 -180
NMPW	20	8 0 - 7 23.2-20.3 8.7- 9.8 - 220 - 330	7 0 - 6 23.5-23.4 - - -	8 0 - 7 22.9-22.0 7.1- 8.0 - 260 - 300	8 0 - 7 21.5-20.9 7.6- 8.2 - 295 - 295	8 0 - 7 20.8-10.0 7.6- 8.7 - 260 - 290			8 0 - 7 11.7-11.3 - - -	8 0 - 7 11.9-11.2 - - -			8 0 - 7 8.3-8.1 - - -	8 0 - 7 6.5-6.0 10.5-11.0 - 200- 220
	40	15 0 -14 23.2- 6.2 8.6-10.2 - 220 -315	12 0 - 11 23.1-19.0 - - -	13 0 -12 22.8-22.0 7.0- 7.8 - 300 - 300	14 0 -13 22.0-17.9 7.5- 0.3 - 295-295	14 0 -13 18.9- 7.9 7.5- 8.8 - 210- 280			16 0 -15 11.4-11.4 - - -	14 0-13 12.0-11.6 - - -			15 0-14 8.6-7.7 - - -	
	50	18 0 -17 23.2- 5.9 8.3-10.5 - 215- 320	16 0 - 15 23.0-17.5 - - -	18 0 - 17 22.9-21.9 6.9- 7.7 - 295 - 305	17 0 - 16 21.9-12.0 7.2- 8.1 - 250 - 295	17 0 - 16 18.9- 7.9 7.4- 8.8 - 210- 280		17 0 - 16 17.9-13.0 - - 250 -270	13 0 - 17 11.9-11.4 - - -	17 0 - 16 12.0-11.7 - - -			18 0 -17 8.6- 7.8 - - -	
	60	21 0- 20 23.5- 5.8 7.5-10.7 - 215-315	20 0 - 19 23.1-16.5 - - -	21 0 - 20 22.6-21.2 6.9- 7.7 - 200-335	21 0 - 20 21.0- 9.0 7.2- 7.9 - 230-295	21 0 - 20 18.2- 7.1 7.4- 8.8 - 205- 280		21 0 - 20 18.0-12.9 - - 245-270	21 0 - 20 11.9-11.4 - - -	21 0 - 20 12.0-11.8 - - -			21 0-20 8.6-7.3 - - -	21 0 - 20 7.8- 6.8 10.0-11.0 - 190- 205
	100	34 0 - 33 23.7- 5.0 8.4-12.2 - 203-315	30 0 - 29 23.0-12.8 - - -	33 0 - 32 22.2-21.7 6.9- 7.0 - 295-305	31 0 -30 20.9- 6.5 6.6- 8.2 - 205-295	34 0 - 33 18.5- 6.0 7.6- 9.2 - 205 -280		34 0 - 33 16.5-11.0 - - 235-265	35 0 - 34 12.2-11.4 - - -	33 0 - 32 12.0-11.8 - - -			35 0- 34 8.7-6.5 - - -	35 0 - 34 8.0-6.9 10.0-11.0 - 180 -200

TABLE V-6 Cont'd

SUMMARY OF BATHYTHERMOGR[illegible]TEK READINGS DURING 1973
AT OSWEGO A[illegible]ILE POINT

DATE		8/20	8/27	9/13	9/17	9/28	10/1	10/10	10/19	10/22	10/23	10/28	11/5	11/13
LOCATION SAMPLING SITE (TRANSECT)	IN FT. OF WATER				Number of Readings Taken Depth Range Meters Temperature Range °C D.O. Range mg/l pH Range Conductivity Range Micro - MHOS									
NMPC	20	8 0 - 7 23.5- 8.5 9.2- 9.9 - 240 - 315	4 0 - 3 26.5-23.4 - - -	7 0 - 6 24.8-22.0 6.9- 7.7 - 250 - 300	8 0 - 7 25.5-20.9 7.6- 8.0 - 295- 295	8 0 - 7 20.0-10.0 7.2- 8.8 - 240 - 280		8 0 - 7 19.5-13.9 - - 260 - 290	8 0 - 7 11.9-11.1 - - -				8 0 - 7 14.2-8.2 - - -	8 0 - 7 9.1- 7.0 10.2-11.0 - 190- 200
	40	14 0 - 13 23.5- 5.9 7.8-10.6 - 215 - 315	6 0 - 5 25.0-23.0 - - -	14 0 -13 24.0-22.0 6.8- 8.0 - 295- 310	14 0 - 13 21.0-14.5 7.5 -8.1 - 270 - 295	14 0 - 13 18.8- 8.0 8.8- 7.2 - 220 - 260		14 0 - 13 16.5-13.1 - - 250 - 260	16 0 - 15 12.1-11.4 - - -	14 0 - 13 11.7-11.5 - - -			15 0 - 14 8.4-8.4 - - -	15 0 -14 8.2- 6.9 10.2-12.0 - 180 - 190
	50							17 0 - 16 16.2-13.0 - - 240- 260	18 0 - 17 11.9-11.4 - - -	17 0 - 16 11.8-11.5 - - -				18 0 - 17 8.2 -6.9 10.1-10.6 - 175 - 185
	60	21 0 - 20 23.5- 5.8 7.8-10.7 - 220 - 315	17 0 - 16 24.0-16.8 - - -	21 0 - 20 23.8-22.0 6.8- 7.7 - 295 - 310	21 0 - 20 20.9- 7.6 7.1- 7.9 - 215 - 295	21 0 - 20 18.1- 6.9 7.2- 8.8 - 210 - 280		21 0 - 20 16.1-12.8 - - 245 - 270	21 0 - 20 12.1-11.4 - - -	21 0 - 20 11.8-11.6 - - -				
	100							34 0 - 33 16.8-10.0 - - 270 - 230	34 0 -33 12.1-11.1 - - -	33 0 - 32 11.9-11.8 - - -				34 0 - 33 7.9- 7.1 9.9-10.6 - 175 - 185
NMPE	20	8 0 - 7 23.6-23.0 6.4-11.0 - 315- 315	8 0 - 7 23.1-22.6 - - -	7 0 - 6 22.0-22.0* 7.3- 8.9 - 245 - 310	8 0 - 7 20.2-19.9 8.1 - 8.3 - 260 - 285	8 0 - 7 19.0-17.9 8.4 -8.6 - 280 - 280		8 0 - 7 16.2-15.9 - - 240- 260	8 0 - 7 12.2-11.4 - - -	8 0 - 7 11.3-11.2 - - -		8 0 - 7 10.6-10.3 - - -		8 0 - 7 7.5-7.3 9.7-10.1 - 160 - 160
	40	14 0 - 13 23.6- 6.3 6.9-10.0 - 220 - 315	12 0 - 11 23.0-22.0 - - -	14 0 - 13 22.0-22.0* 7.3- 8.1 - 280 - 305	13 0 - 12 20.9-19.9 7.5- 7.8 - 280 - 295	14 0 - 13 18.8- 9.8 7.1- 8.7 - 240 - 275		14 0 - 13 16.1-15.8 - - 255- 270	15 0 - 14 12.8-11.7 - - -	15 0 - 14 11.6-11.4 - - -		15 0 - 14 10.8-10.8 - - -		15 0 - 14 7.5- 7.4 10.0-10.2 - 175 - 175
	50	18 0 - 17 23.6- 6.2 6.7-10.2 - 220- 320	15 0 - 14 23.0-16.0 - - -	17 0 - 16 22.0-22.0* 7.1- 7.9 - 295 - 295	17 0 - 16 20.8-20.0 7.6- 8.1 - 240- 285	17 0 - 16 18.8- 8.5 7.3- 8.7 - 240 - 280		18 0 - 17 16.1-13.1 - - 255 - 270	18 0 - 17 12.8-12.2 - - -	17 0 - 16 11.6-11.4 - - -		18 0 - 17 10.6-10.6 - - -		18 0 - 17 7.3- 7.2 9.9-10.1 - 170- 175
	60	29 0 - 19 23.8- 5.9 7.6-10.7 - 215-315	19 0 - 18 23.0-15.4 - - -	18 0 - 17 22.0-22.0* 7.2- 7.8 - 295 - 295	19 0 - 18 21.0-20.0 7.3- 8.4 - 270 - 295	21 0 - 20 18.5- 7.8 7.3- 8.8 - 200 - 280		21 0 - 20 16.2-13.0 - - 255 - 270	21 0- 20 12.8-12.2 - - -	21 0 - 20 11.6-11.6 - - -		21 0 - 20 11.1-10.8 - - -		21 0 - 20 7.7- 7.2 9.9-10.6 - 170 - 175
	100	34 0 - 33 23.9-5.0 8.9-12.3 - 205-315	31 0 - 30 23.0-13.0 - - -	31 0 - 30 22.1-22.1* 6.8- 8.6 - 295 - 295	33 0 - 32 20.9- 6.2 6.5- 8.0 - 205 - 295	34 0 - 33 19.0- 5.9 7.0 -8.7 - 200 - 280		34 0 - 33 16.2-10.0 - - 230 - 265	35 0 - 34 11.8-11.1 - - -	33 0 - 32 11.7-11.0 - - -				35 0 - 34 8.0- 7.2 9.9 -10.4 - 170 - 180
FITZ	30													

TABLE V-6 Cont'd

SUMMARY OF BATHYTHEMOGRAPH & MARTEK READINGS DURING 1973
AT OSWEGO AND NINE MILE POINT

DATE		11/21	11/26	12/4	12/10	
LOCATION SAMPLING SITE (TRANSECT)	IN FT. OF WATER				Number of Readings Taken Depth Range Meters Temperature Range °C D.O. Range mg/l pH Range Conductivity Range Micro-MHOS	
OSWW	20	8 0 - 7 6.8- 6.7 10.5-11.2 - 255 - 260	8 0 - 7 6.5 - 6.4 10.4 -10.6 - 280 - 295	8 0 - 7 5.9 - 5.8 - - -	8 0 - 7 5.6 - 5.5 - - 245 - 250	
	40	15 0 - 14 6.9 - 6.2 10.5- 11.1 - 255 - 260	15 0 - 14 6.8 - 6.7 10.4-11.4 - 255 - 260		15 0 - 14 5.8 - 5.7 - - 250 - 250	
OSWP	20	8 0 - 7 6.6 - 6.2 10.5-10.8 - 295 - 430	8 0 - 7 6.8 - 6.1 10.4-10.7 - 260 - 320	8 0 - 7 6.8 - 5.7 - - -	8 0 - 7 5.2 - 5.1 - - 260 - 275	
	40	15 0 - 14 6.6 - 5.9 - - 260 - 600	15 0 - 14 7.1- 6.1 10.2-10.8 - 230 - 320		15 0 - 14 5.5 - 5.3 - - 275 - 285	
	50	17 0 - 16 7.0 - 5.8 10.8- 11.0 - 250 - 600	18 0 - 17 7.2 - 6.2 10.0- 10.9 - 225 - 330	18 0 - 17 6.3 - 5.8 - - -	18 0 - 17 6.1- 5.5 - - 225 - 260	
	100		34 0 - 33 6.5 - 6.1 10.2 -10.5 - 225 - 230	34 0 - 33 6.4 - 6.1 Incompleted Data	35 0 - 34 6.2 - 6.0 - - 225 - 265	
NMPW	20		8 0 - 7 7.0 - 7.0 10.4 -10.5 - 230 - 230	11 0 - 20 6.2 - 5.7 - - -	8 0 - 7 6.2 - 6.1 - - 240 - 240	
	40		15 0 - 14 7.1 - 7.0 10.3-10.6 - 230 - 230		15 0 - 14 6.1 -6.1 - - 240 - 240	
	50		18 0 - 17 7.1- 7.0 10.3-10.7 - 230 -235	26 0 - 50 6.8- 5.7 - - -	18 0 - 17 6.2- 6.1 - - 240 - 240	
	60	21 0 - 20 7.1- 7.0 10.5-10.7 - 240-245	21 0 - 20 7.1 - 7.0 10.2-10.5 - 230 - 235	20 0 - 20 7.4 - 6.6 - - -	21 0 - 20 6.1 - 6.0 - - 240 - 240	
	100		35 0 - 34 7.2- 7.0 10.1-10.5 - 225 - 230	25 0 - 25 7.8 - 7.0	35 0 - 34 6.3 - 6.1 - - 230 - 230	

TABLE V-6 C[illegible]

SUMMARY OF BATHYTHERMOGRAPH & M[illegible]ADINGS DURING 1973
AT OSWEGO AND NINE [illegible]OINT

DATE		11/21	11/26	12/4	12/10	
LOCATION SAMPLING SITE (TRANSECT)	IN FT. OF WATER			Number of Readings Taken Depth Range Meters Temperature Range °C D.O. Range mg/l pH Range Conductivity Range Micro-MHOS		
NMPC	20	8 0 - 7 7.6- 6.8 10.6-10.8 - 245 - 255	8 0 - 7 6.9- 6.8 10.6-14.9 - 230 - 230	11 0 - 20 10.2- 6.3 - - -	8 0 - 7 7.1 - 5.9 9.8 -11.2 - 240 - 245	
	40	15 0 - 14 7.1- 6.8 10.4-10.5 - 240 - 250	15 0 -14 7.0 - 6.9 10.4-10.6 - 230 - 235	6 0 - 6 6.7- 6.5 - - -	15 0 - 14 6.8 - 6.0 9.7 -10.8 - 240 - 245	
	50	18 0 - 17 7.4 - 6.9 10.3 -10.8 - -	18 0 - 17 7.0 - 6.9 10.3-10.54 - 230 - 235		18 0 - 17 6.8 - 6.0 9.8 -10.8 - 240 - 240	
	60	21 0 - 20 7.2- 7.0 10.3-10.5 - 210 - 220	21 0 - 20 7.0 - 6.9 10.3-10.5 - 235 - 235	11 0 - 10 6.9- 6.5	21 0 - 20 6.8 - 6.0 9.8 -10.8 - 240 - 240	
	100		35 0 - 34 7.2 - 7.1 10.2 -10.5 - 230 - 230	22 0 - 21 7.0- 6.2	35 0 - 34 6.4- 6.1 9.9-11.2 - 230 - 235	
NMPE	20	8 0 - 7 6.0 - 6.0 11.1-11.5 - 220 - 220	8 0 - 7 6.4 - 6.2 10.5 -10.9 - 230 - 230	8 0 - 7 6.8 - 6.5	8 0 - 7 5.6 - 5.6 9.8 - 9.8 - 225 - 225	
	40	15 0 - 14 6.5 - 6.2 10.2-11.0 - 210 - 220	15 0 - 14 6.9 - 6.9 10.4 -10.5 - 235 - 240	21 0 - 40 6.0 - 6.5 - - -	15 0 - 14 5.9 - 5.9 9.7 - 9.7 - 230 - 230	
	50	18 0 - 17 6.8 - 6.6 10.5-10.6 - 210 - 210	18 0 - 17 6.9 - 6.9 10.3 -10.5 - 235 - 240	25 0 - 50 6.7 - 6.3 - - -	18 0 - 17 5.9 - 5.9 9.8 -10.9 - 230 - 230	
	60	21 0 - 20 7.0 -6.9 10.3-10.8 - 210 - 220	21 0 - 20 7.0 - 6.9 10.3 -10.5 - 235 - 235	11 0 - 10 6.0 - 6.4 - - -	21 0 - 20 5.9 - 5.9 10.6 -11.4 - 240 - 240	
	100		35 0 - 34 7.1- 7.0 10.3-10.4 - 230 - 230	21 0 - 20 6.5 - 6.3	35 0 - 34 6.0 - 6.0 9.8 -10.4 - 220 - 230	
FITZ	30					

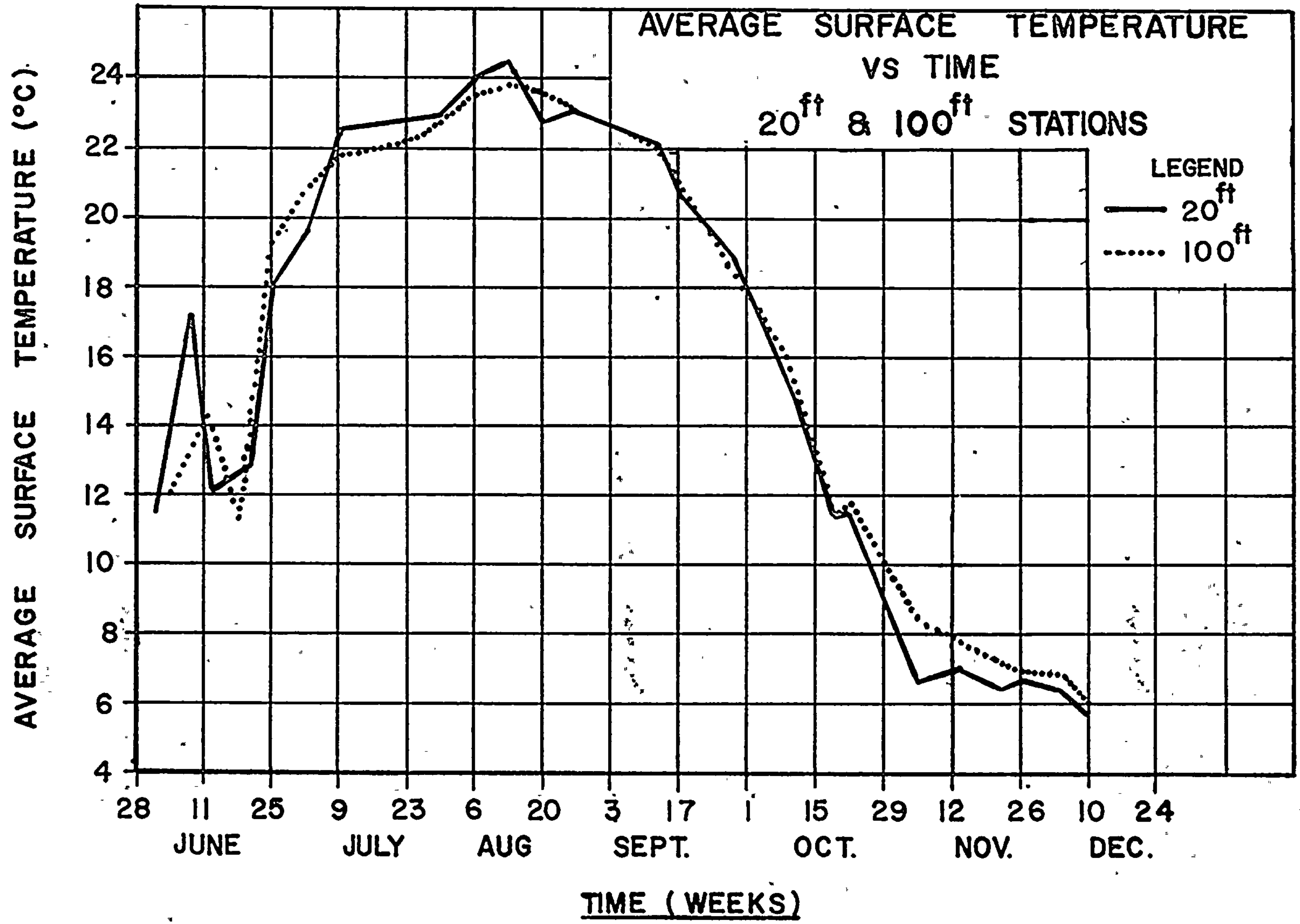
measurements were taken along five transects covering a water surface area of approximately 17 square miles (see Figure V-2). Vertical temperature profiles were analyzed in relation to the provisions of New York State thermal criteria and to the locations of the existing and proposed thermal discharges of the electric generating stations. The New York State thermal criteria for lakes specify in part:

> "In lakes subject to stratification, the thermal discharge shall be confined to the epilimnetic area." (6 NYCRR, Part 704.1).

b. Discussion of Thermal Data

The temperature measured during the survey ranged between 4°C (39°F) and 29°C (84°F). There was no prevailing thermal structure during the May through December period. Vertical temperature cross-sections for the OSWP and NMPP transects (see Appendix VII-5) show the transient nature of the thermal structure.

Figure V-3 shows the average surface temperatures for the stations in water depths of 20 and 100 ft, respectively. As shown in this figure, temperatures at both stations were approximately 12°C (54°F) on 4 June, rose to a maximum temperature of approximately 24°C (75°F) on 13 August and then declined to approximately 6°C (43°F) on 10 December. A drop in the average surface temperatures of between 3°C (5.4°F) and 5°C (9°F) seems to have occurred during the week between June 11 and 18. This drop in temperature can probably be attributed to "upwelling" generated by wind from the south.



AVERAGE SURFACE TEMPERATURE
VS TIME
20ft & 100ft STATIONS
LEGEND
20ft
100ft
AVERAGE SURFACE TEMPERATURE (°C)
24
22
20
18
16
14
12
10
8
6
4
28
11
25
9
23
6
20
3
17
1
15
29
12
26
10
24
JUNE
JULY
AUG
SEPT.
OCT.
NOV.
DEC.
TIME (WEEKS)

FIGURE V-3

Surface temperatures are plotted for the 50 ft. depth station on the NMPW transect (see Figure V-4). This transect was selected because it is considered to be out of the influence of the existing Nine Mile Point Unit 1 discharge. The plot follows the same pattern as the previous plot; however, the temperature drop during the week between June 11 and 18 appears to be more pronounced.

Figure V-5 shows the monthly mean surface temperatures for the entire Lake as prepared by Yu and Brutsaert (1968) and Figure V-6 shows the monthly mean surface temperature measured at the 100 ft stations during the 1973 survey (June through December). Comparison of these data indicates that the average surface temperatures in the southeastern section of the Lake (Figure V-7) are higher than those for the overall Lake by approximately 1.8°C (3.2°F) during the seven months of the year surveyed. This phenomenon is associated with the mass adjustment to the steady current along the south shore of the Lake. Since the stations used in this study are shallower than the mean Lake depth, higher temperature may also result from the shallower portion of the Lake, heating more than the deeper central portion of the Lake.

c. Principles of Lake Stratification

Hutchinson (1957) discusses lake hydrodynamics and thermodynamics and outlines classifications based on mixing properties of lakes. Using his criterion, Lake Ontario would be classified as a dimictic lake. That is, the overturns, which occur in both spring and fall, result from summer surface temperatures being above 4°C.(39°F), while the

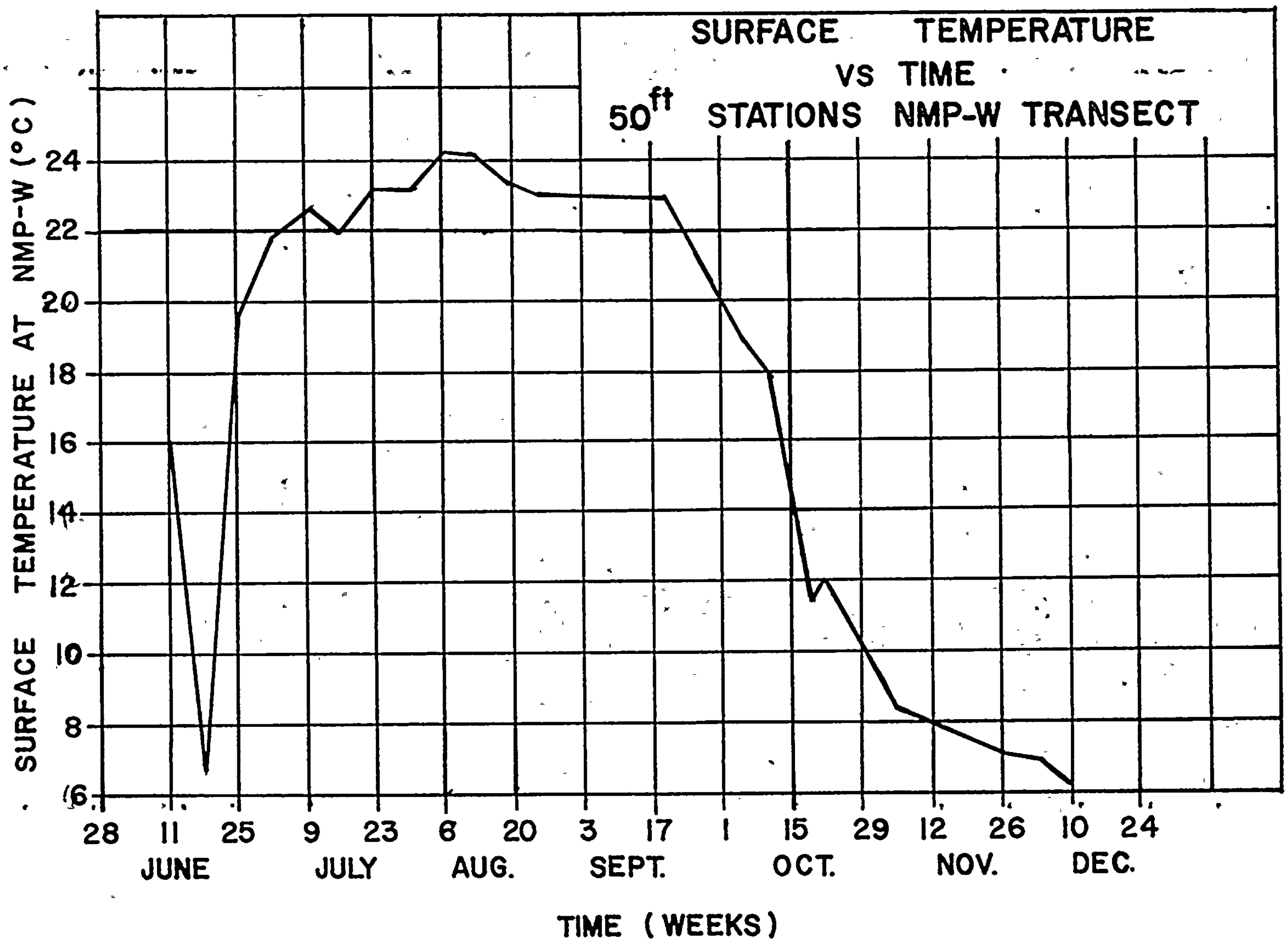
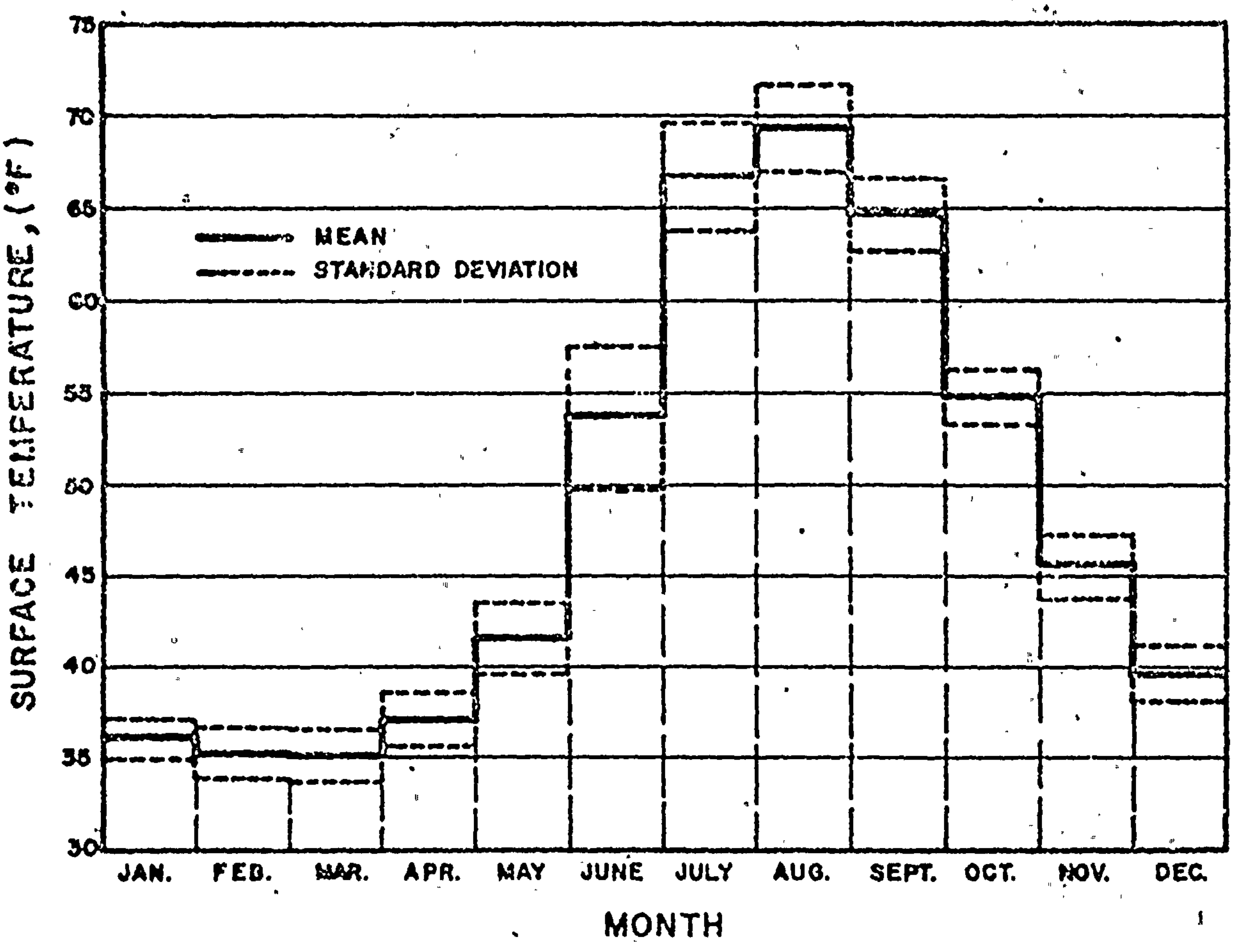
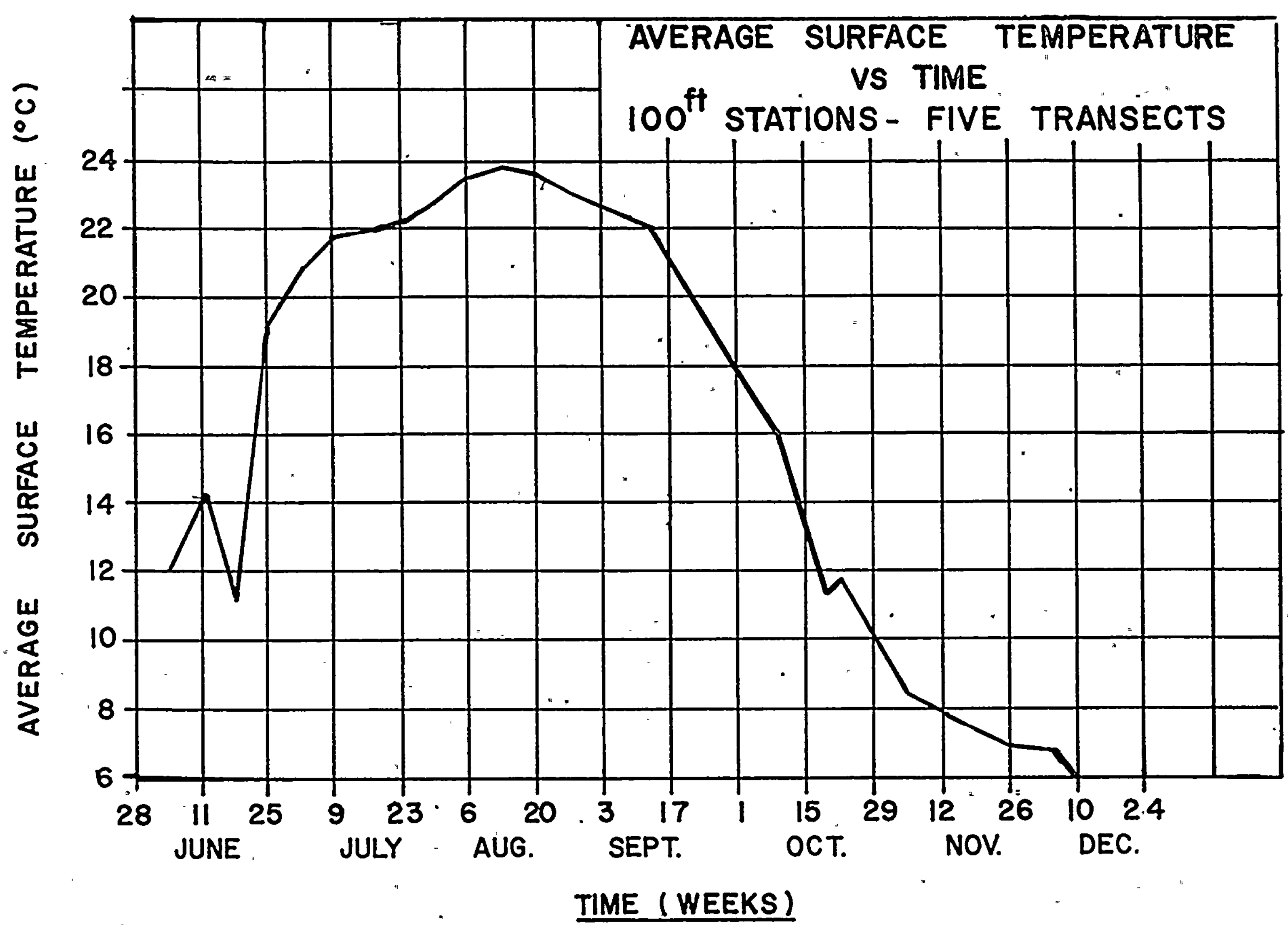

SURFACE TEMPERATURE
VS TIME
50ft STATIONS NMP-W TRANSECT
SURFACE TEMPERATURE AT NMP-W (°C)
24
22
20
18
16
14
12
10
8
6
28
11
25
9
23
6
20
3
17
1
15
29
12
26
10
24
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
TIME (WEEKS)

FIGURE V-4

MONTHLY MEAN SURFACE TEMPERATURE FOR LAKE ONTARIO

(AFTER YU AND BRUTSAERT, 1968)

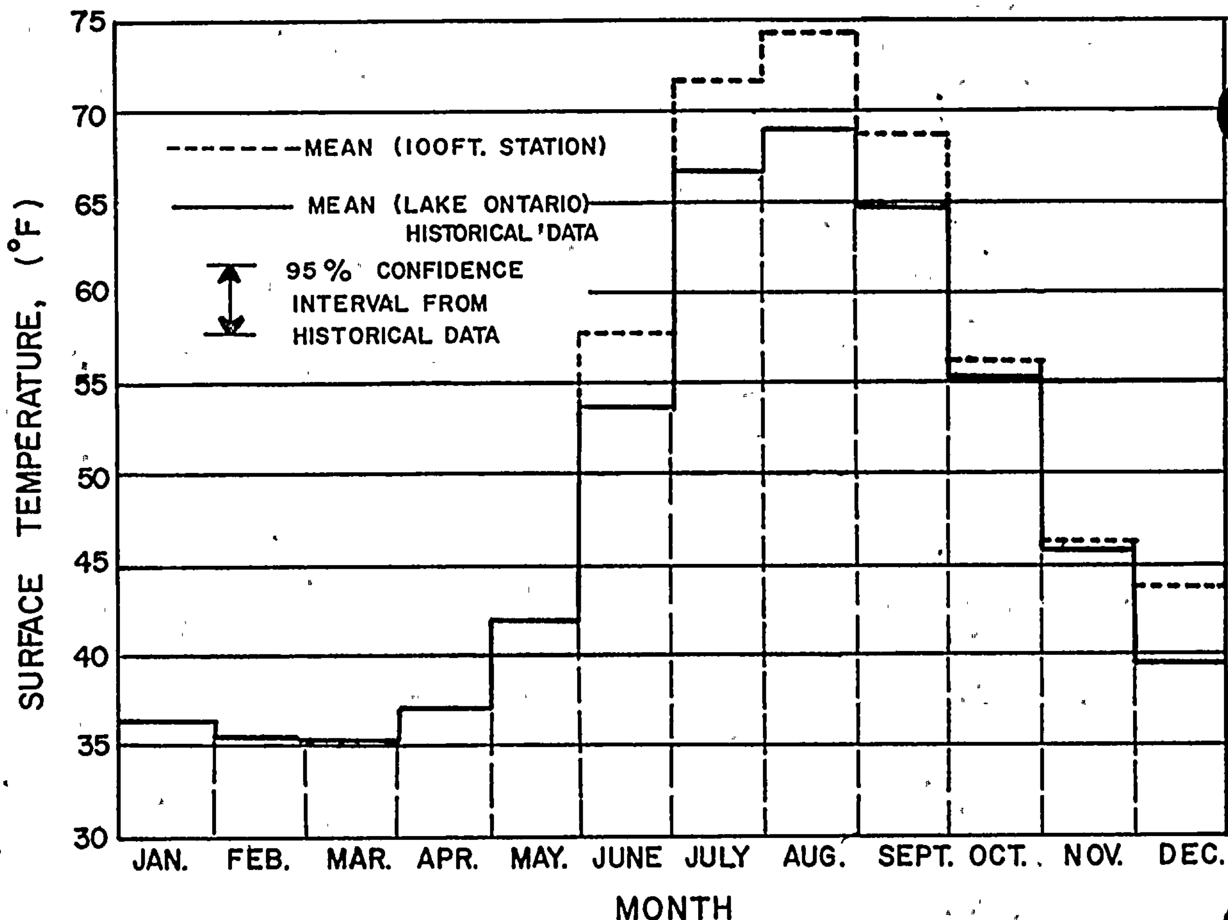




AVERAGE SURFACE TEMPERATURE
VS TIME
100ft STATIONS - FIVE TRANSECTS
AVERAGE SURFACE TEMPERATURE (°C)
24
22
20
18
16
14
12
10
8
6
28
11
25
9
23
6
20
3
17
1
15
29
12
26
10
24
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
TIME (WEEKS)

FIGURE V-6

MONTHLY MEAN SURFACE TEMPERATURE AT 100 FT. STATIONS DURING 1973 SURVEY



winter temperatures throughout the water column are colder than 4°C. Thus, the surface waters of Lake Ontario are hydrostatically unstable during two transient periods, the spring and the fall.

The location of Lake Ontario at a temperate latitude results in summer heating of the surface layer of the Lake. The heating process, which is most intense in early summer, results from the net balance of several heat flux terms across the atmosphere-water interface. These terms include solar radiation absorption at the water surface, infrared heat fluxes from the atmosphere to the water and from the water to the atmosphere, sensible heat exchange and latent heat of evaporation transferred from the water to the atmosphere. In the absence of other non-thermal processes, such heat transfers at the interface would result in temperatures within a lake which decay approximately exponentially with depth.

In addition to the thermodynamic processes at the air-water interface, the hydrodynamics of the near-surface lake waters modify the thermal structure within a lake. The most important feature in development of stratification in a lake is surface mixing induced by wind-driven currents and waves. This turbulence mixes the warmer surface layer into deeper layers, resulting in more intense temperature gradients at deeper depths. Superimposed on these thermal, dynamic and turbulent heat transfers are wind-driven currents which can advect cooler or warmer waters into a local area.

As early summer progresses and the temperature structure is established in the upper layers of a lake, the circulation becomes affected in turn by the temperature structure. Temperature gradients tend to reduce the vertical transport of turbulent energy due to the stability of the stratification. This phenomenon acts to limit the transfer of surface heated water into deeper depths, thereby creating maximum temperature gradients at some intermediate depth.

The above phenomena are primarily dependent on meteorology and, thus, are influenced by day-to-day changes in weather conditions. Weak or intense temperature gradients can be generated in the upper layers of a lake and superimposed on each other. The result of such superposition is frequently a complex thermal structure in the upper layers of lakes.

Based on extensive studies of the upper layers of waterbodies, Kraus (1972) concluded, "The most interesting deduction, perhaps, from the preceding arguments is the impossibility of establishing a stationary state, except in very special circumstances." Lake Ontario is no exception to the above-described complicated thermo-hydrodynamics of the upper layer of a lake.

Although each lake responds characteristically to the local meteorology and its basin parameters, Hutchinson (1957) has deduced several trends in development of temperature gradients within various types of lakes. Since surface heating is mixed downward by turbulent motions, a larger lake will tend to develop more surface turbulence by wave action and, hence, to mix heat into deeper layers. In shallow lakes, of sufficient expanse, the heat is frequently mixed throughout the water body by the turbulence. In deeper lakes, heating tends to mix down to depths of 10 to 20 meters (33 to 66 ft). In the limiting case of oceanic stratification, surface

heating is eventually mixed down to the main oceanic thermocline at depths near 100 meters (330 ft). Due to Lake Ontario's depth and size, this limiting depth is approximately 30 meters (98 ft)

d. New York State Thermal Criteria

The New York State criterion*prohibits the discharge into the hypolimnion of lakes subject to stratification. The definitions used in implementing this criterion are outlined below (10NYCRR, Part 73.10):

"K. Stratified Lake - A stratified lake is a lake where an epilimnion, thermocline and hypolimnion are present naturally during summer periods due to differences in densities of water found at various depths of the lake.

L. Thermocline - A thermocline is that first seasonally stable layer of a stratified lake found between the epilimnion and the hypolimnion where the temperature drop equals or exceeds 1°C (1.8°F) per meter (39.37 inches).

M. Epilimnion - Epilimnion is that layer of a stratified lake lying above the thermocline which is warm, more or less freely circulating, affected by wind action and of approximately uniform temperatures.

N. Hypolimnion - Hypolimnion is that layer of a stratified lake below the thermocline."

---

*It should be noted that changes to the New York State criteria have been proposed by the U.S. Environmental Protection Agency (1973); however, the proposed changes do not affect the criterion for lakes.

e. Determination of Stratification

Using the above definitions in conjunction with the 1973 temperature data, the stratification in the vicinity of Nine Mile Point, primarily at the proposed discharge depths, was determined. It should be noted that changes to the New York State criteria have been proposed by the U.S. Environmental Protection Agency (1973); however, the proposed changes do not affect the criterion for lakes.

The temperature data were analyzed to determine whether the temperature gradients equalled or exceeded 1°C per meter (1.8°F per 3.3 ft), whether the gradients defined a seasonally stable or persistent layer and, if a layer did exist, its relative location with respect to the proposed discharges. Throughout the discussion below, stratification refers to the existence of a stratified layer, within which the temperature gradient is 1°C per meter or greater.

During the survey period, 472 vertical temperature profiles were obtained in the study area. Thirty-one profiles exhibited gradients in excess of 1°C/meter attributed to the existing NMP Unit 1 discharge. These occasions define transient stratification sometimes throughout a stratified layer up to 5 meters thick. Table V-7 lists the depths at which stratification was recorded at the various stations during 1973. The numbers in the table refer to the depths at which the water temperature dropped more than 1°C/meter (1.9°F/3.3 ft). Figure V-8 is a pictorial representation of this tabularized data for the 50 ft stations since this is the station nearest the deepest proposed discharge location or Nine Mile Point Units 1 and 2 and the James A. FitzPatrick plant.

TABLE V-7

DEPTHS OF STRATIFICATION [illegible]GO-NINE MILE POINT, MAY - DECEMBER 1973

STATION / DATE	OSWEGO WEST 20ft	OSWEGO WEST 40ft	OSWEGO PLANT 20ft	OSWEGO PLANT 40ft	OSWEGO PLANT 50ft	OSWEGO PLANT 100ft	NINE MILE POINT WEST 20ft	NINE MILE POINT WEST 40ft	NINE MILE POINT WEST 50ft	NINE MILE POINT WEST 60ft	NINE MILE POINT WEST 100ft	NINE MILE POINT PLANT 20ft	NINE MILE POINT PLANT 40ft	NINE MILE POINT PLANT 50ft	NINE MILE POINT PLANT 60ft	NINE MILE POINT PLANT 100ft	NINE MILE POINT EAST 20ft	NINE MILE POINT EAST 40ft	NINE MILE POINT EAST 50ft	NINE MILE POINT EAST 60ft	NINE MILE POINT EAST 100ft
5/29		-		-																	
5/30								3-4 7-8						-				-			
6/1			-	-								-									
6/4					1-2	3-4			10-11		1-2			11-12		3-4			-		-
6/5								0-2 3-4 8-9		0-1 2-3 5-6			1-3		2-4						
6/8							-					-			10-11 13-14		-			15-17	
6/11		1-2		-	-	1-2 21-22			-		-			-		14-15			-		-
6/12							-			-		-			-		-			-	
6/14																		11-12			
6/18					6-8	3-4			-		-			2-4		4-5			3-4 7-9		6-7 10-11
6/20							-			18-19		4-5			8-10		-			10-14	
6/25	3-4	5-6 8-9 10-12	4-6	4-7 9-10	2-3 6-7 8-11	3-9	2-3 4-5	7-11	2-3 5-6 9-10	2-3 5-6 8-11	2-3 5-6 7-12	2-3 4-5	0-3 5-9	1-3 5-10	1-3 5-9 11-12	1-2 5-8 14-15	-	0-1 10-11	1-2 11-14	10-12 13-15 16-17	
6/26								4-5		5-7 9-13		0-2 4-5			5-6 7-8 10-12		1-6			2-4 7-8 10-11	
6/28			-	6-7																	
6/29	6-7	6-7 12-13 14-15																			

TABLE V-7 Cont'd

DEPTHS OF STRATIFICATION, OSWEGO-NINE MILE POINT, MAY - DECEMBER 1973

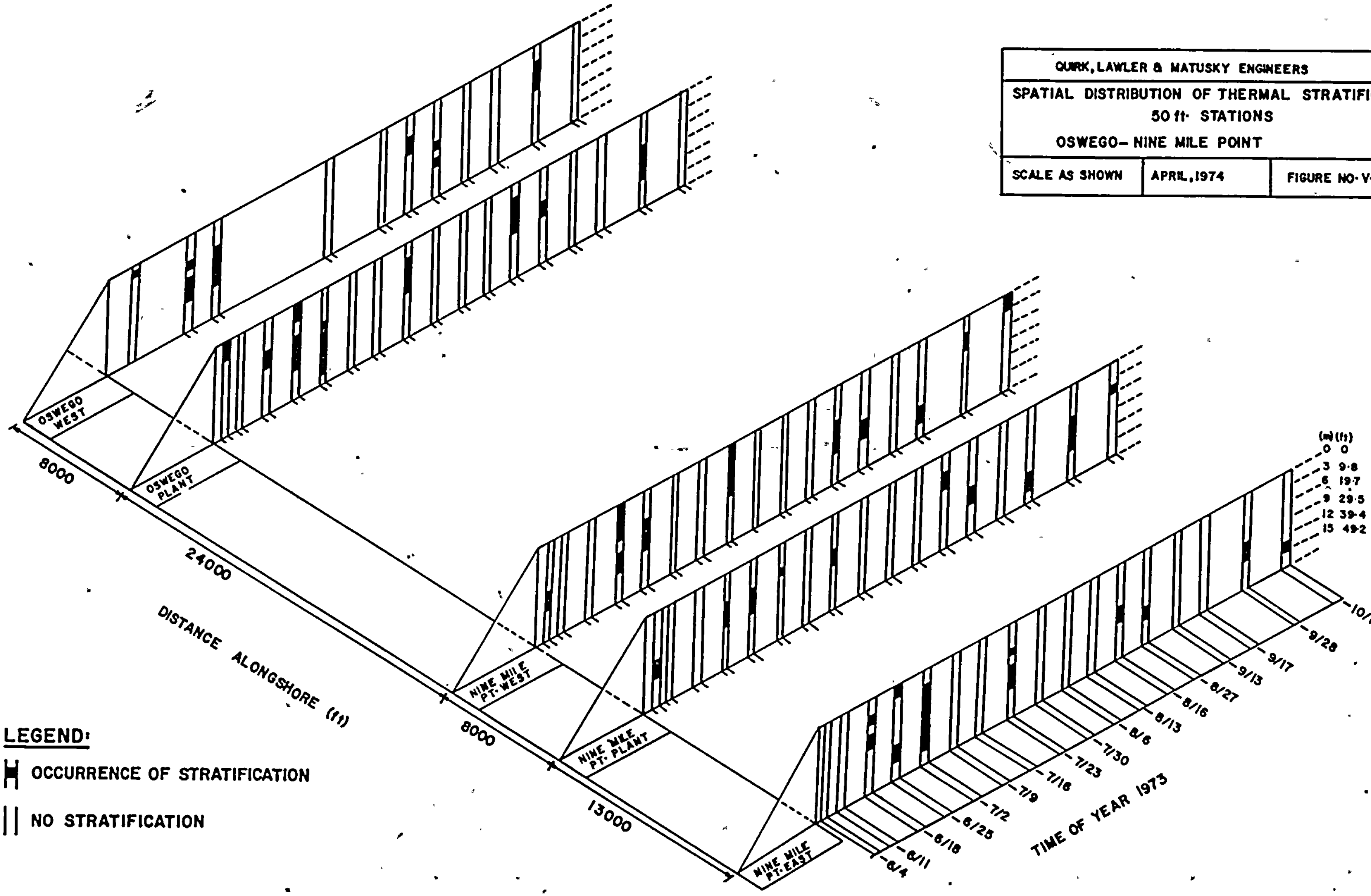
STATION / DATE	OSWEGO WEST		OSWEGO PLANT				NINE MILE POINT WEST					NINE MILE POINT PLANT					NINE MILE POINT EAST				
	20ft	40ft	20ft	40ft	50ft	100ft	20ft	40ft	50ft	60ft	100ft	20ft	40ft	50ft	60ft	100ft	20ft	40ft	50ft	60ft	100ft
7/2	4-6 7-8	5-8 9-12	2-3 5-7	5-6 7-9 10-11	6-8 10-12 14-15	8-11 13-14 21-22	3-5	5-11	5-8 10-11		4-7	2-3	0-2 5-10	0-1 5-7 8-10		4-6 8-11	6-7	3-7 11-13	3-4 6-11 12-15		3-5 7-8 9-12
7/9					-	22-25 26-27			-		25-27 28-29	0-1		4-5		23-24 28-30	-		-	14-15	-
7/10	-	-	-		-																
7/16					-	30-32			-		-			1-2		-			-		-
7/23					3-4 5-8	4-9			1-4 5-9		2-8			1-5 6-8		2-4 6-10			4-5 8-12		6-11 12-14
7/30	-	-	-	-	-	20-24 29-30	-	-	-	-	26-30	0-2	1-2	1-2	0-1	28-29 30-31	-	-	-	17-19	22-23 24-25 26-27
8/6			-	-	-	24-25 27-30	-	-	-		22-23 24-26 27-28	0-2	0-1	0-1		26-30	-	-	-		-
8/13	-	-	-	-	-	30-31	-	-	-	-	-	0-2	0-3	0-2	0-1	29-31	-	-	-	-	-
8/20	5-7	4-7	3-5	2-6 7-8	3-8	5-12	-	4-5 6-9 11-12	6-11	5-11	8-15	3-4	3-6	3-7	4-8	7-14	-	7-10	7-11	8-11	8-12 13-14
8/27	8-9	8-9 11-12		6-7 9-10	6-8	8-11 21-22	-	8-10	9-10	9-11	9-11 12-13 26-28	0-2	0-1	0-1 9-10	8-9	10-13 27-29	-	-	11-13	11-13	11-13
9/13	-	-	-	-	-	-	-	-	-	-	-	0-1	-	-	0-1	-	-	-		-	-
9/17	-	-	-	-	16-17	18-23	-	1-2 12-13	12-16	10-18	17-23	0-2	11-13	12-16	13-16	15-19	-	-	-	-	-
9/28	-	0-1 3-8	5-7	6-10	7-9 10-12	11-14	0-2 3-5 6-7	3-6	3-6	3-8	6-9 10-11	3-5		5-8 9-10	5-10 13-14	4-7 9-10 13-14	-	8-11	9-13	9-12	11-16
10/1	-	13-14	-	-	-	16-17															
10/10	-	-	-	-	-	-	-	0-3	0-1	0-2	9-10	0-2 4-5	-	4-5	9-10	-	-	-	14-15	-	-
[illegible]19	-	-	-	-	-	-	-	-	[illegible]	-	-	-	-	-	-	-	-	-	[illegible]		-

TABLE V-7 Cont'd

DEPTHS OF STRATIFICATION, OSWEGO-NINE MILE POINT, MAY - DECEMBER 1973

STATION / DATE	OSWEGO WEST		OSWEGO PLANT				NINE MILE POINT WEST					NINE MILE POINT PLANT					NINE MILE POINT EAST				
	20ft	40ft	20ft	40ft	50ft	100ft	20ft	40ft	50ft	60ft	100ft	20ft	40ft	50ft	60ft	100ft	20ft	40ft	50ft	60ft	100ft
10/22	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-
10/28																	-	-	-	-	
11/5	-	-	-	-	-	-	-	-	-	-	-	0-2	-								
11/13	-	-	-	-	-	-	-			-	-	0-1	-	-		-	-	-	-	-	
11/21	-	-	-	-	-					-	-	0-1	-	-	-		-	-	-	-	
11/26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12/4	-	-	-		-	-	-	-	-	-	-	1-2	ID	-	ID	ID		-	-	-	-
12/10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

QUIRK, LAWLER & MATUSKY ENGINEERS		
SPATIAL DISTRIBUTION OF THERMAL STRATIFICATION 50 ft· STATIONS OSWEGO– NINE MILE POINT		
SCALE AS SHOWN	APRIL, 1974	FIGURE NO· V–8



Between 27 May and 18 June the 50 ft. stations along each transect did not indicate the existence of stratification, as defined above. The stratified layers which did exist during this early period of the survey were located at various depths with no consistent pattern so that a seasonally stable thermocline did not exist.

On 18 June two stations along the OSWP and NMPE transects showed a stratified layer at a mid-depth of 6 to 9 meters (20 to 30 ft.) while the stations along the two middle transects showed no stratification. This difference may be due to the bottom topography at the various stations. Starting from shore the NMPW and NMPP transects have relatively steep bottom slopes, reaching the 100 ft. depth in approximately 6000 ft. offshore. In comparison, the two Oswego transects and NMPE transects reach a 100 ft. depth at about 11,000 ft. offshore. Thus, for 18 June, the stratified layer may have been located farther offshore than could be reported for the 50 ft. stations at NMPW and NMPP while being reported at the other stations. The 100 ft. station's results were similar to the 50 ft. station.

All stations reported a stratified layer on 25 June. There were two layers of stratified water, the major one occurring at a 10 meter (33 ft.) depth with the other being nearer the surface. The following week (2 July) all stations again reported a stratified layer but it had moved deeper in the water column to the 15 meter (49 ft.) depth. The layer was also thicker, now being from 6 to 12 meters (20 to 39 ft.) in thickness. The 60 ft. and 100 ft. stations on these dates had a similar temperature structure, rarely reporting the stratified layer any deeper than for the 50 ft. stations.

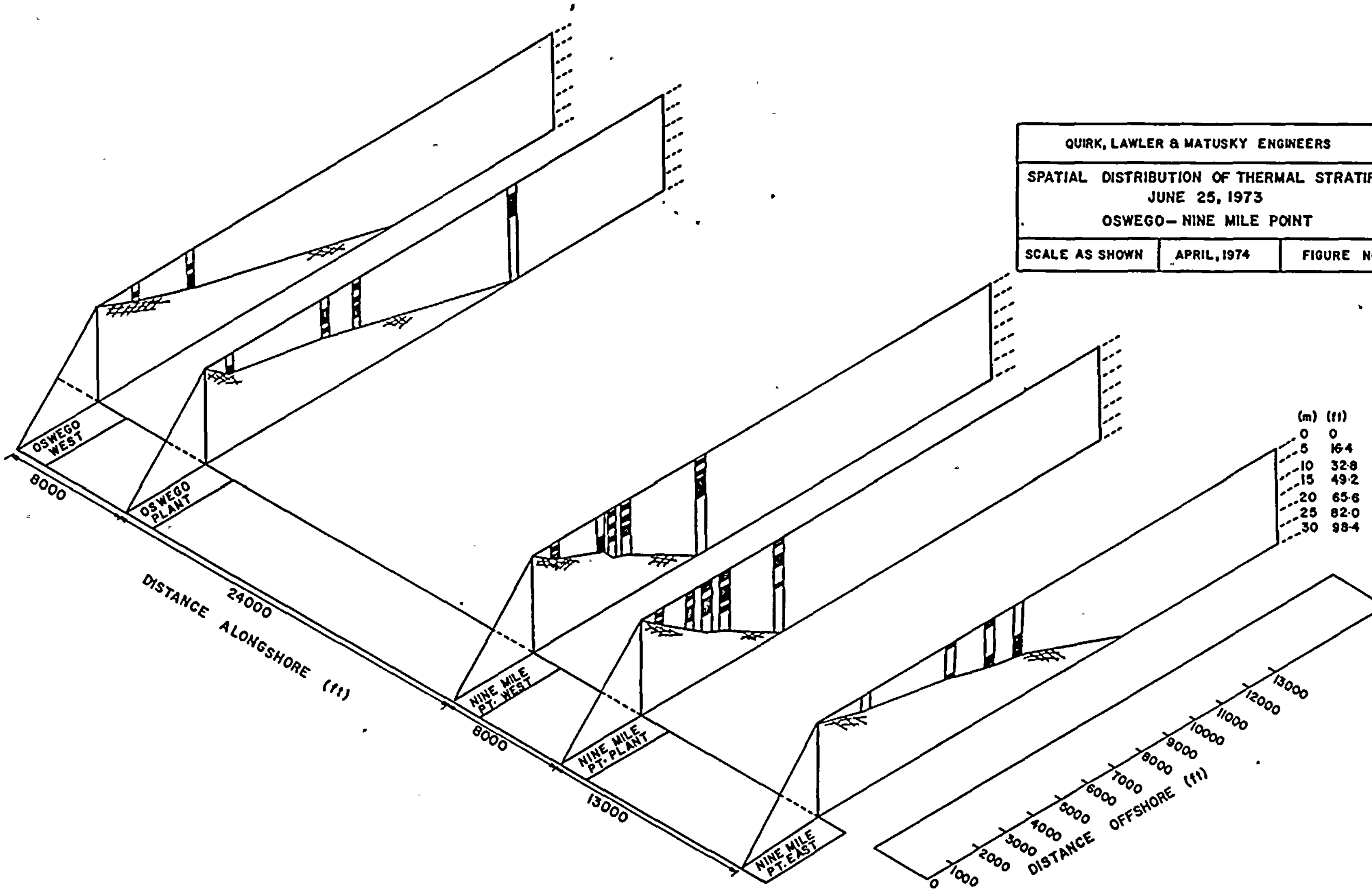
These data show that the thermocline was a definite layer that extended from the shallow areas to the deeper waters remaining at the same depth. Figure V-9 illustrates all 21 stations as recorded on 25 June. The well-defined multiple stratified layers are seen in this figure.

For the next two week period (sampling dates 9 July and 16 July), none of the stations reported significant stratification. A slight stratification was recorded on 9 July at NMPP; however, this occurred only between the 5 and 6 meter depths where the temperature dropped 1.4°C (2.5°F). On both of these dates some of the 100 ft. stations reported a deep stratified layer at some 25 meters (82 ft.). This indicates that the thermocline had moved offshore and deeper for these dates.

On 23 July stratification had reappeared at all stations. It was at the 6 to 9 meter (20 to 30 ft.) depth for the east transect, while it had risen to the surface for the farther western transects. This difference from one transect to the next was probably due to the transient nature of the Lake response to meteorological conditions. A slightly deeper layer was at the 100 ft. stations.

The stratification had disappeared for all 50 ft. stations on 30 July and was not seen through the next two weeks (sampling dates 6 August and 13 August). Similar to the previous periods of no stratification, a deep stratified layer at 25 meters (82 ft.) was reported at the 100 ft. stations.

On 20 August, the stratification reappeared at all stations near mid-depth, and was 1-2 meters (3.3 to 6.6 ft.) deeper at the eastern stations



QUIRK, LAWLER & MATUSKY ENGINEERS		
SPATIAL DISTRIBUTION OF THERMAL STRATIFICATION JUNE 25, 1973 OSWEGO– NINE MILE POINT		
SCALE AS SHOWN	APRIL, 1974	FIGURE NO· V–9

than at those towards the west. The layer also tended to be thicker at the west transects. The stratification continued on 27 August, and the layer had become more uniform and was now between the 12 to 15 meter (39 to 49 ft.) depth for all stations. A secondary thermal gradient was seen at about 24 meters (79 ft.) at the 100 ft. stations.

Stratification disappeared by 13 September at all the stations. Four days later, on 17 September, a deep thermal gradient was recorded at NMPW and NMPP with the depth between 12 and 16 meters (39 and 52 ft.). The topography along these transects was probably the reason the gradient existed at these stations. The 100 ft. stations exhibited a similar situation for that day, indicating that a thermal gradient was present, but located deeper. By the following week, this stratified layer had moved into shallower water and was recorded at all five transects.

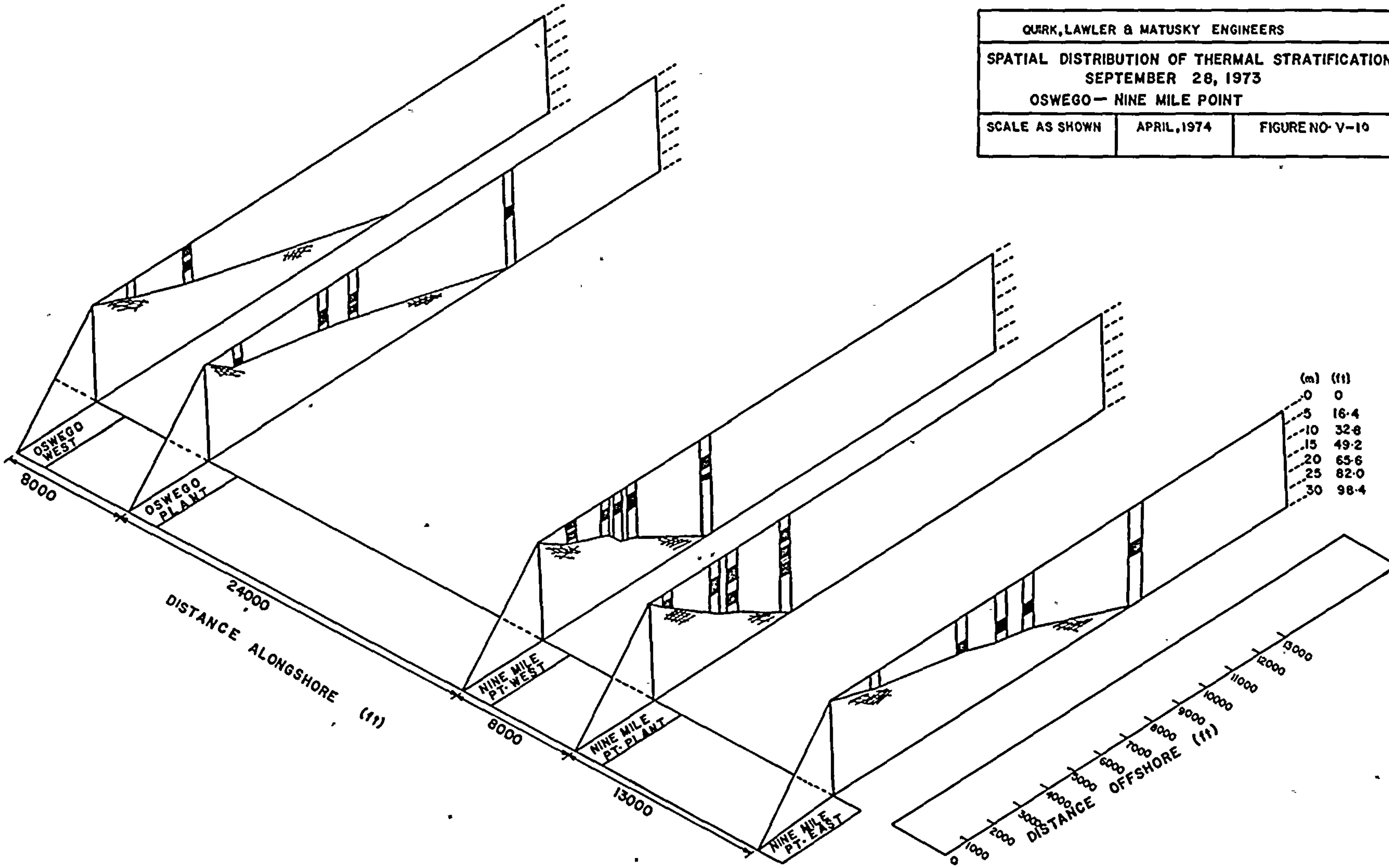
The layer was about 5 meters thick, being deeper in the eastern end of the survey area. Figure V-10 shows the depths of stratification for 28 September as it was measured offshore at all 21 recording stations. The figure illustrates that a definite layer of stratified water was at approximately the same depth for each location.

The last survey date that a stratified layer was recorded was 10 October. Starting with the easternmost transect, NMPE, the layer was at 14-15 meters (46-49 ft.) and approached the surface for the western transects. The layer was at the surface by NMPW and absent at the Oswego stations. Beyond this date, no stratification was recorded at any of the 50 ft. stations. The only station that had any stratification beyond 10 October was the 20 ft. NMPP station which was considered to be affected by the

QUIRK, LAWLER & MATUSKY ENGINEERS

SPATIAL DISTRIBUTION OF THERMAL STRATIFICATION
SEPTEMBER 28, 1973
OSWEGO — NINE MILE POINT

SCALE AS SHOWN	APRIL, 1974	FIGURE NO. V-10



Nine Mile Point Unit 1 thermal discharge. This stratification is caused by the plant discharge.

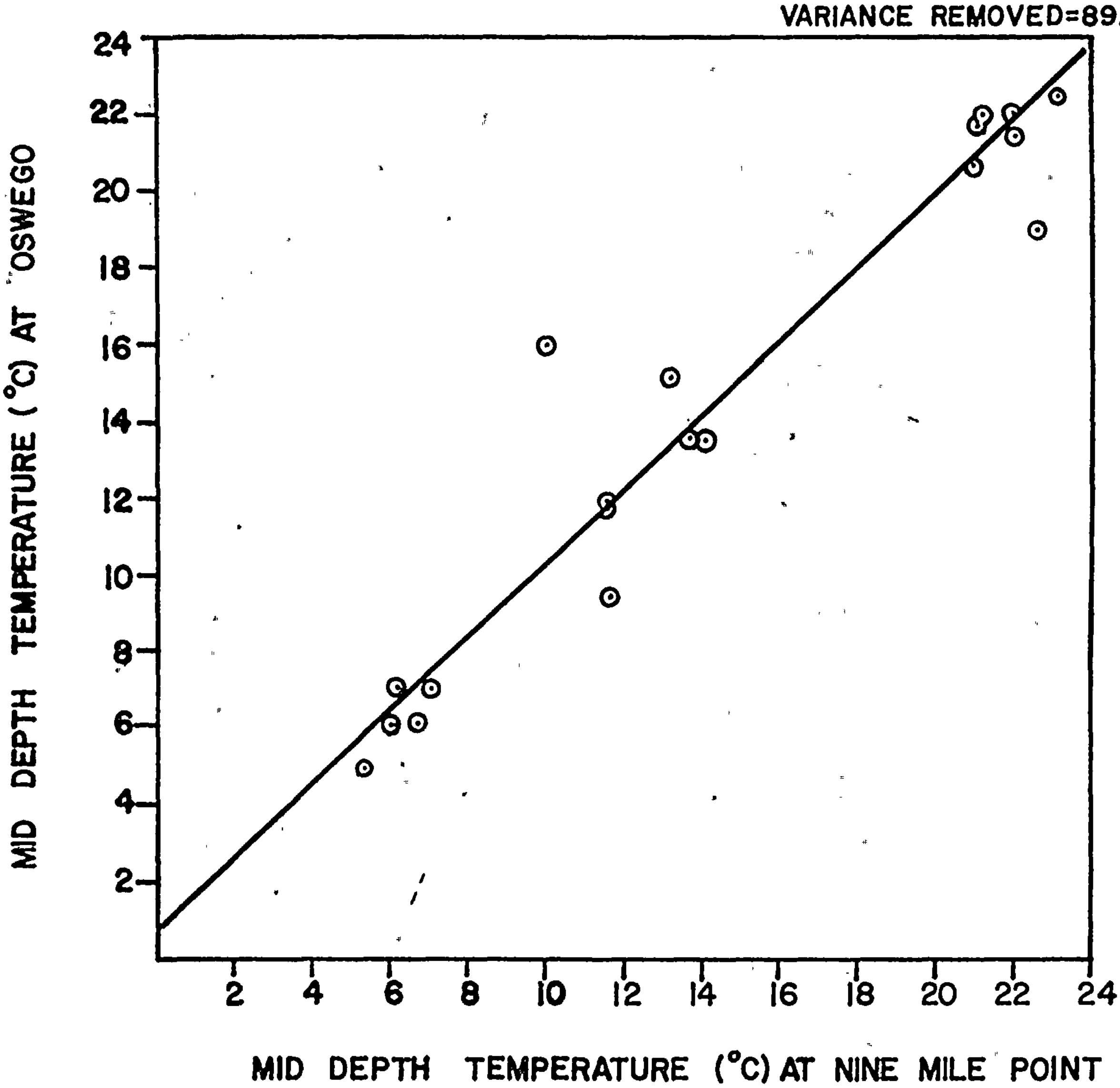
f. Comparison Between Nine Mile Point and Oswego Thermal Profile Stations

Comparisons have been made between the vertical temperature profiles measured at the 50 ft. stations at Nine Mile Point plane of discharge transect and the Oswego Station transect at the same water depth. The mid-depth water temperatures at these two stations are compared in Figure V-11 and show a high correlation. The nineteen pairs of data points plotted in Figure V-11 and the correlation coefficient of 0.95 indicate that practically all temperature fluctuations at the Oswego 50 ft. station could be predicted from data obtained at the Nine Mile Point 50 ft. station. The temperature differences of up to 4.4°C (8°F) result from slight differences in vertical temperature profiles on occasions when the vertical temperature gradient was large at each of the stations.

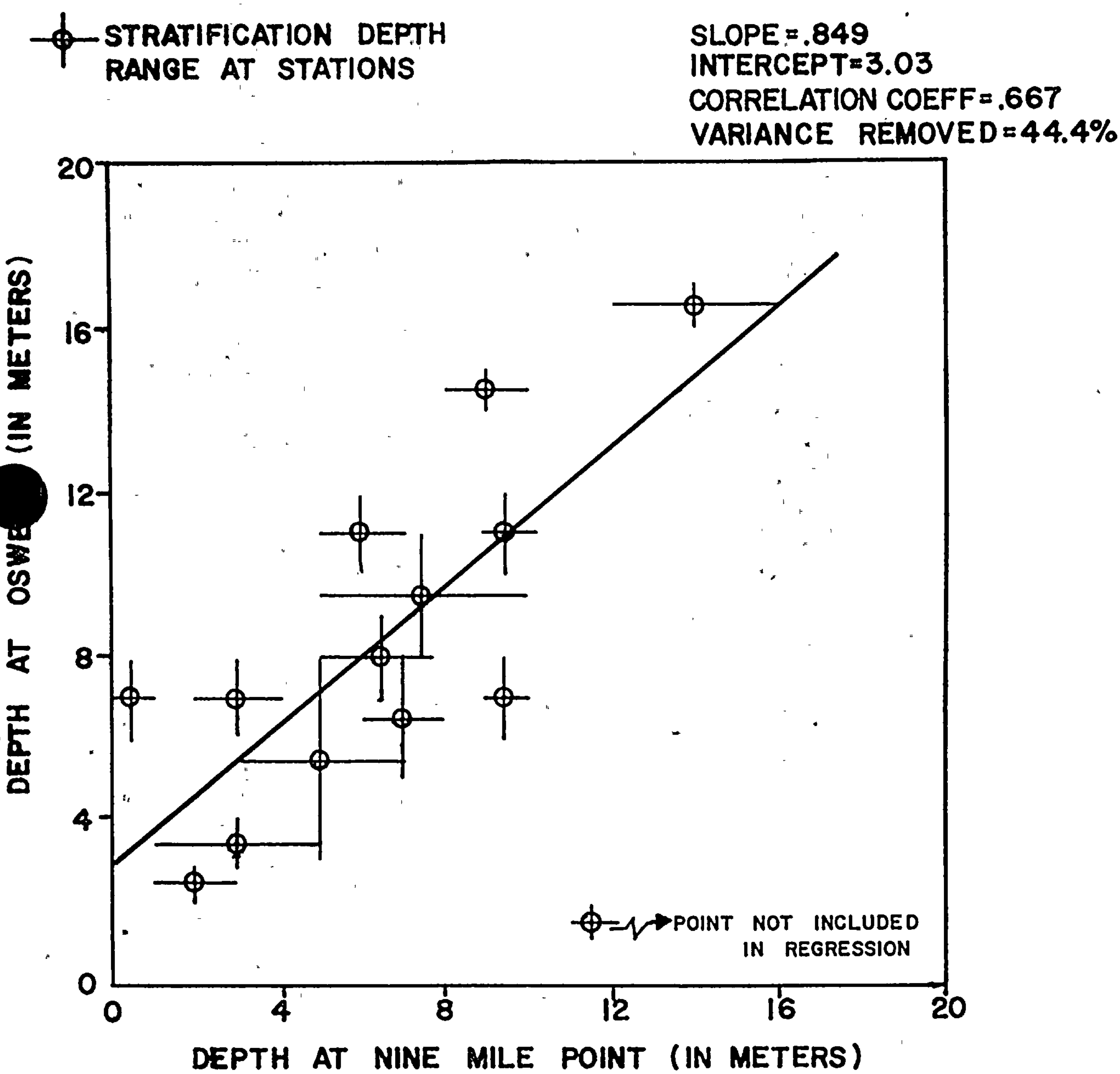
Comparisons have also been made for the occasional dates on which stratification existed in the area. Figure V-12 illustrates the depth ranges over which vertical temperature gradient exceeded 1°C/meter at the Oswego Station, as compared to the Nine Mile Point Station. Although depth differentials do exist between the stations, the scatter about the regression line illustrated is approximately 2-3 meters. The Oswego Station is generally characterized by slightly deeper stratification than the Nine Mile Point Station, with the differences possibly being attributable to effects of local topography on the baroclinic mode of alongshore circulation. It is also possible that the mean difference

PLOT OF MID DEPTH (8M) TEMPERATURE (°C) AT PLANT TRANSECTS IN 50' OF WATER AT NINE MILE VS OSWEGO

SLOPE=.951
INTERCEPT=.8
CORRELATION COEFF=.947
VARIANCE REMOVED=89.7%



PLOT OF DEPTH OF STRATIFICATION AT NINE MILE POINT VS OSWEGO IN 50' OF WATER AT PLANT TRANSECTS



is not statistically significant, but the lack of data points makes analysis difficult. It should be noted that one point on the illustration was deleted from the regression analysis since it indicated very shallow stratification near Oswego on a date when stratification at Nine Mile Point was near the 12 meter depth. The very small depth range in which the stratification existed at both stations confirms that the layer was thin and probably not continuous between the two locations.

The relative frequencies of stratification at each of these two stations have been discussed above. That analysis indicated that vertical temperature gradients in excess of 1°C/meter were more frequently observed at the Nine Mile Point 50 ft. station than at the Oswego Station at a comparable depth. The above analyses confirm the consistency of thermal profile data between the two stations. In fact, temperatures at mid-depth can usually be predicted within 2.3°C (4.1°F) at one station from data taken at the other. The depth of stratification can be predicted to an accuracy of several meters at one station from data taken at the other, and stratification frequency measured at the Nine Mile Point Station represents a conservative estimate of the frequency expected at the Oswego Station at a comparable depth.

3. BI-MONTHLY AND MONTHLY SURVEYS

The analytical results of the monthly and bi-monthly water quality surveys are presented in full in Appendix VII-9. Following analysis in the laboratory, the chemical data for each sample were entered into

a computer storage system along with all the pertinent identifying information. The computer storage system allows data to be retrieved from the file in different groupings, according to some combination of sampling date, station designation and sample depths. In addition to retrieval of the selected data, the data can be analyzed statistically by selected programs within the computer system and can be plotted in the form of raw data or means over selected stations.

a. Selected Data Presentation

Figures V-13 through V-23 present data for representative water quality parameters as a function of time during 1973. For each parameter the figures are presented in pairs. Each figure has surface and bottom plots for the mean values of the several stations at the indicated total station depth. The pairs of figures then compare results for shallow stations to those for deeper stations.

Data for plant intake and discharge stations have been omitted, since they represent water composited with depth and location to a degree.

Based on data shown in the figures, the following statements may be made:

1. Expected seasonal variation was found for DO. Only limited vertical variation in DO was apparent, and this variation was not necessarily related to periods of strong thermal stratification. Percent saturation values were generally in the 70 to 90% range, with extreme values of approximately 60% and 120%. Saturation values were not obviously seasonal. Stations at depths of 20 ft. differed only slightly from those at depths of 60 ft.

FIGURE V-13

WATER QUALITY PARAMETER VS TIME. VALUES ARE AVERAGES OF NINE MILE EAST, WEST & CENTER TRANSECTS IN 20 & 60 FEET OF WATER

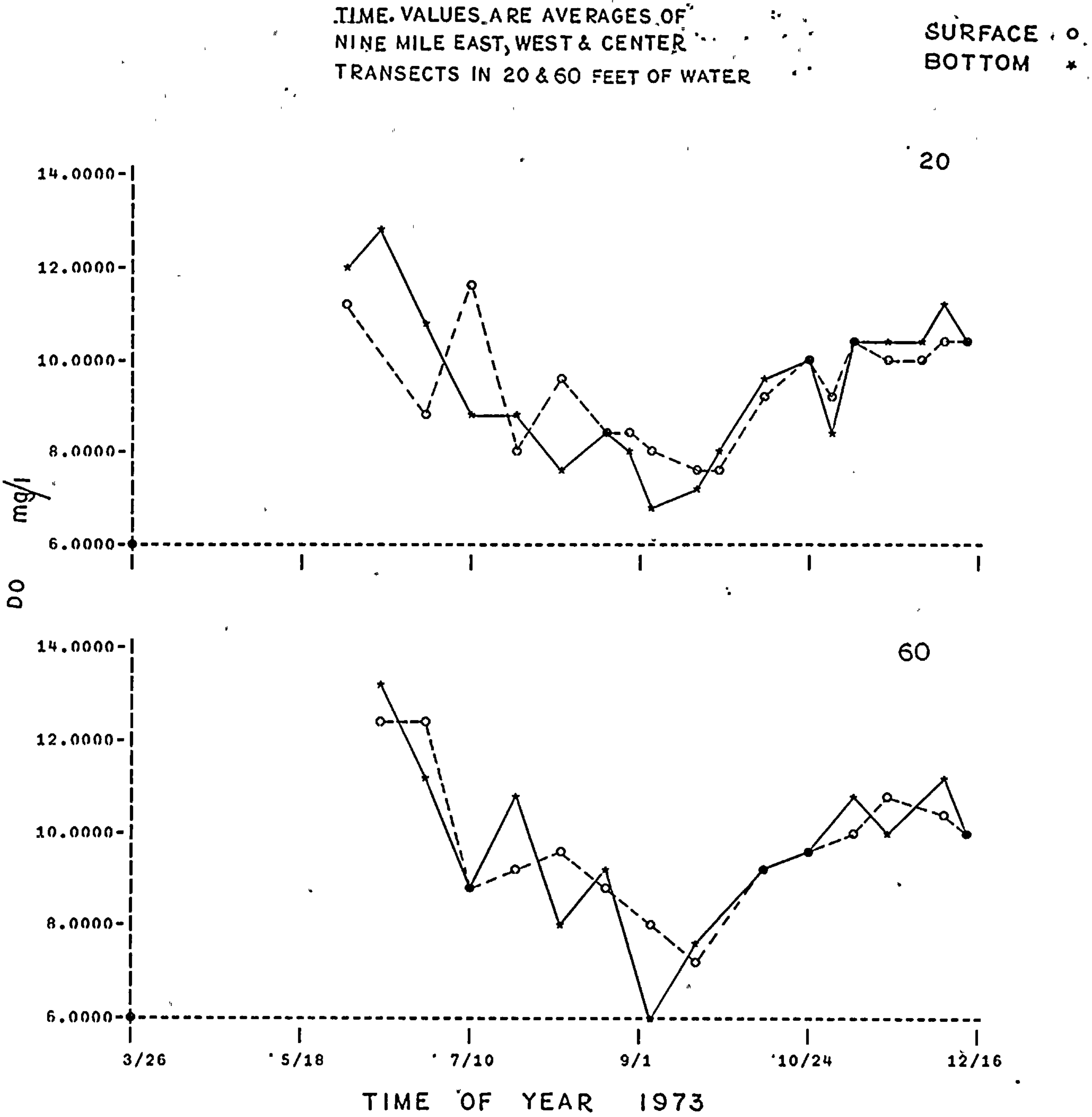


FIGURE V-14
WATER QUALITY PARAMETER VS TIME. VALUES ARE AVERAGES OF NINE MILE EAST, WEST & CENTER TRANSECTS IN 20 & 60 FEET OF WATER

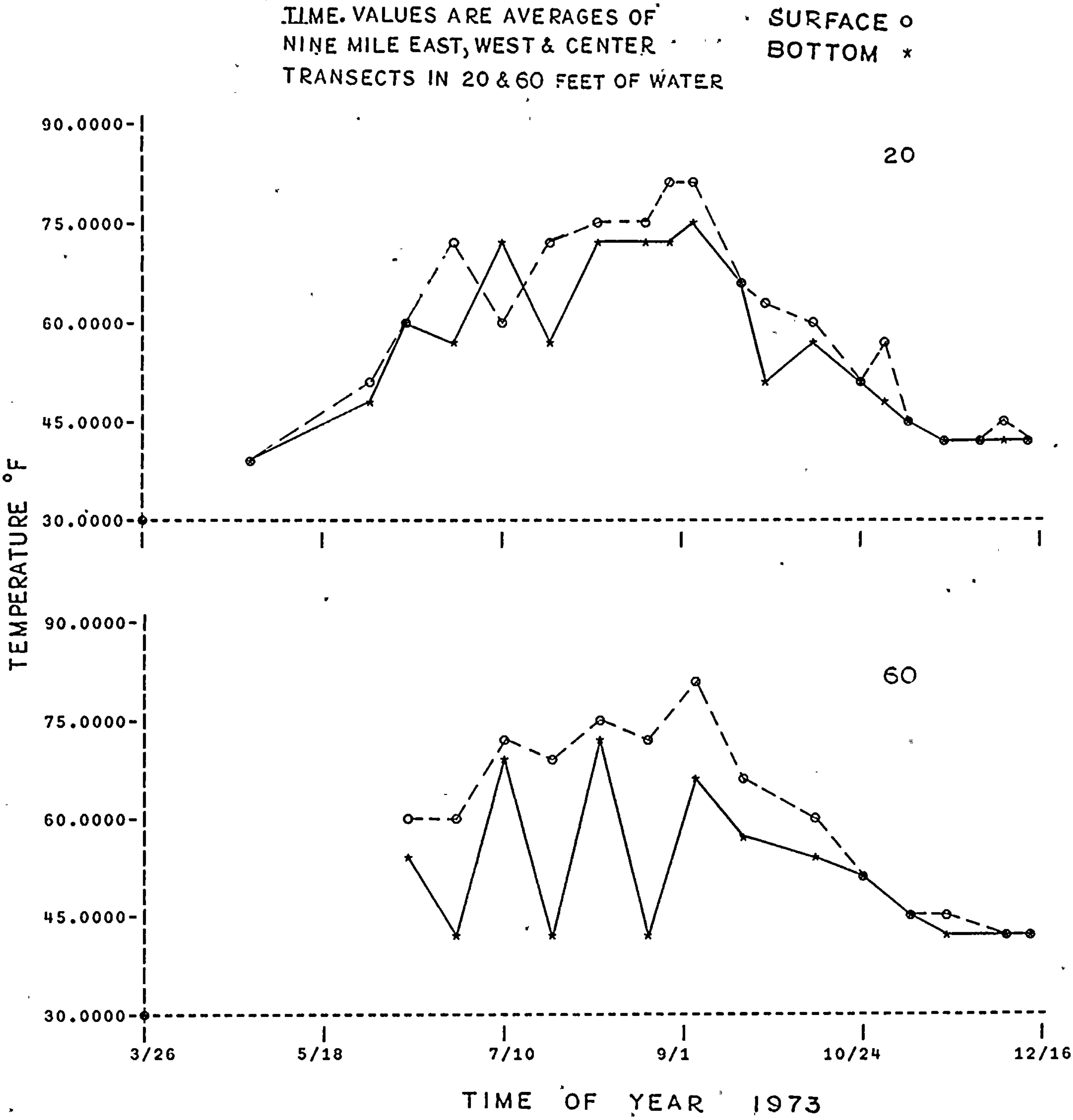


FIGURE V-15
WATER QUALITY PARAMETER VS TIME. VALUES ARE AVERAGES OF NINE MILE EAST, WEST & CENTER TRANSECTS IN 20 & 60 FEET OF WATER

SURFACE o
BOTTOM *

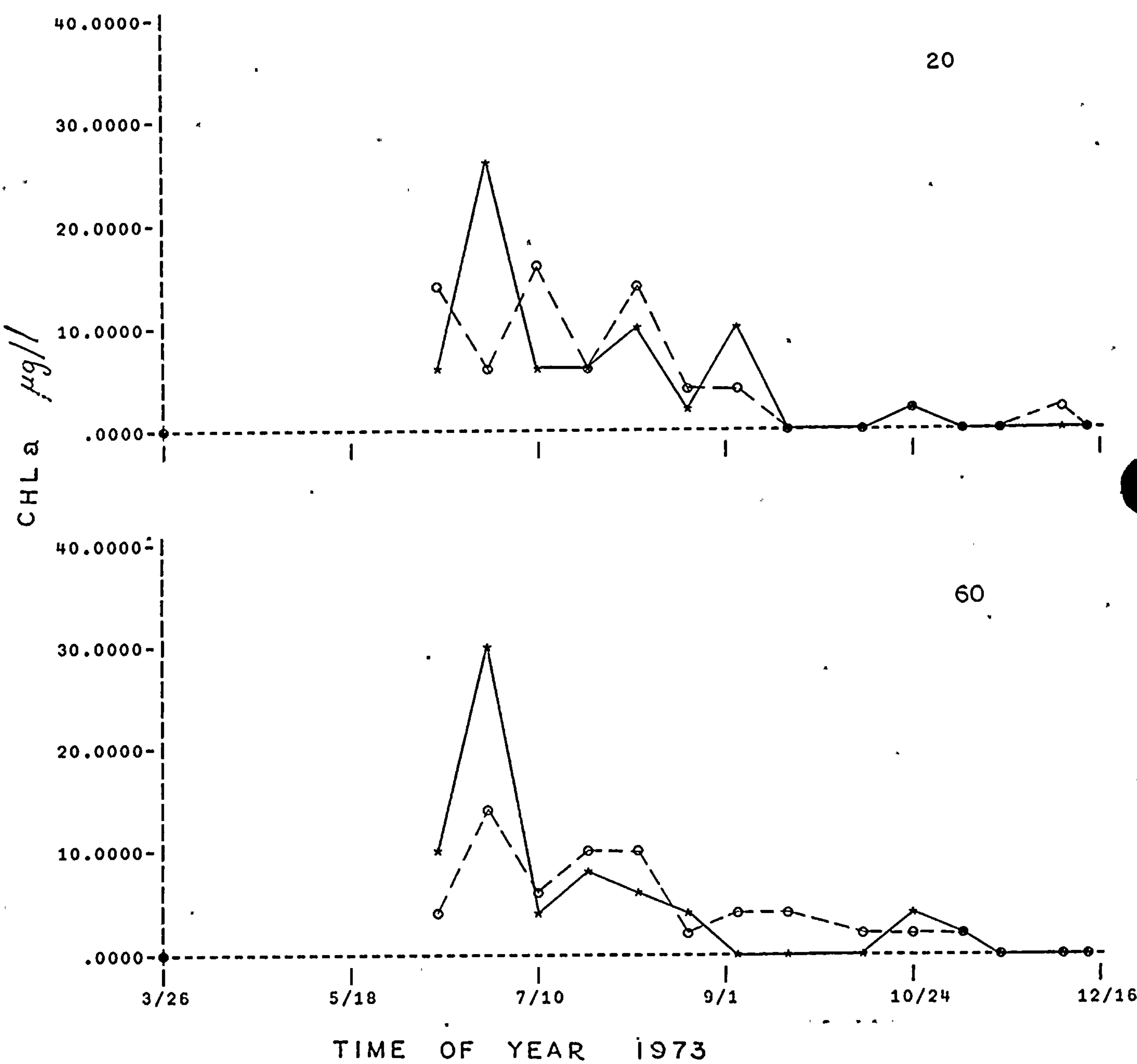


FIGURE V-16
WATER QUALITY PARAMETER VS TIME. VALUES ARE AVERAGES OF NINE MILE EAST, WEST & CENTER TRANSECTS IN 20 & 60 FEET OF WATER

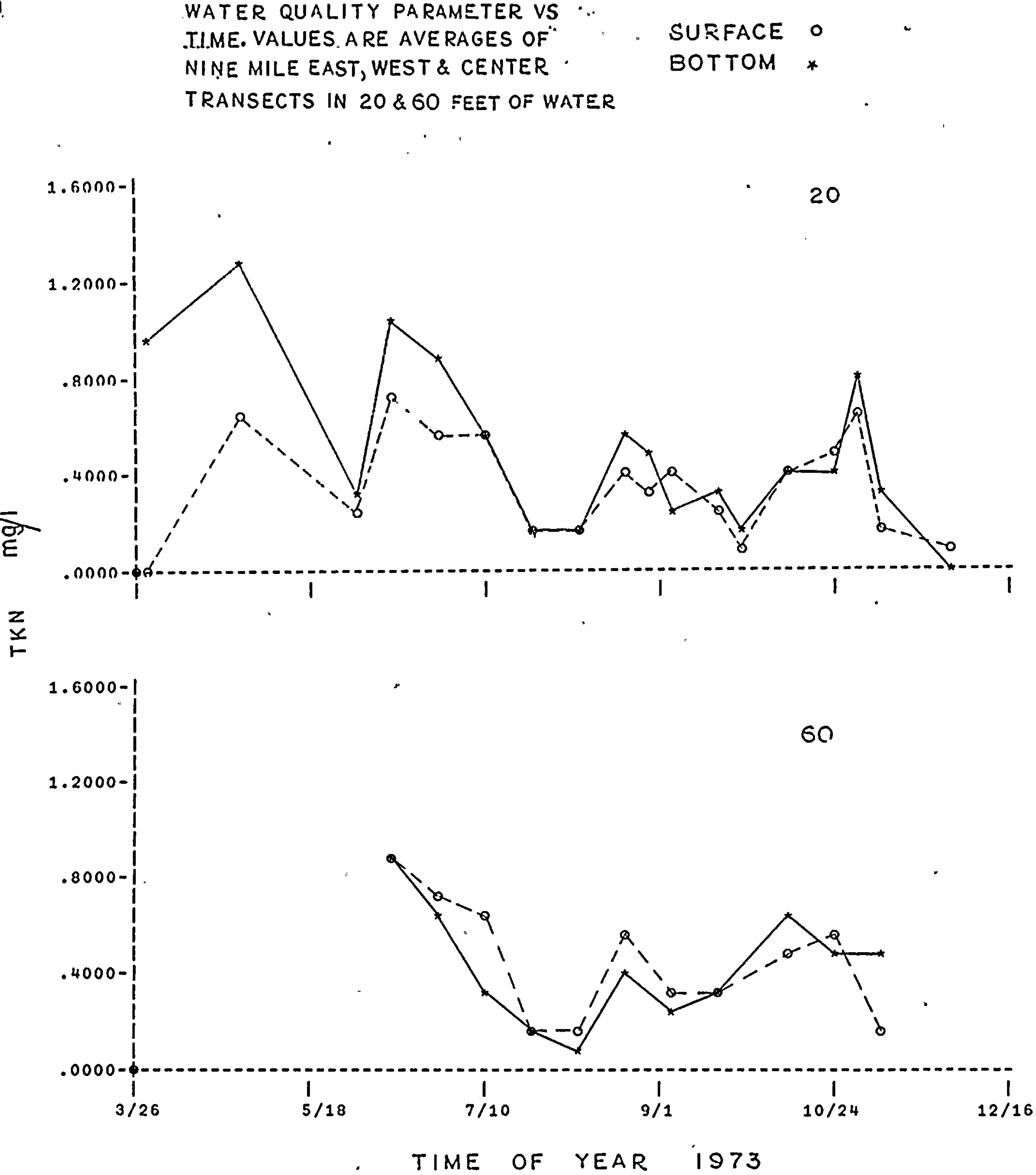


FIGURE V-17
WATER QUALITY PARAMETER VS TIME. VALUES ARE AVERAGES OF NINE MILE EAST, WEST & CENTER TRANSECTS IN 20 & 60 FEET OF WATER

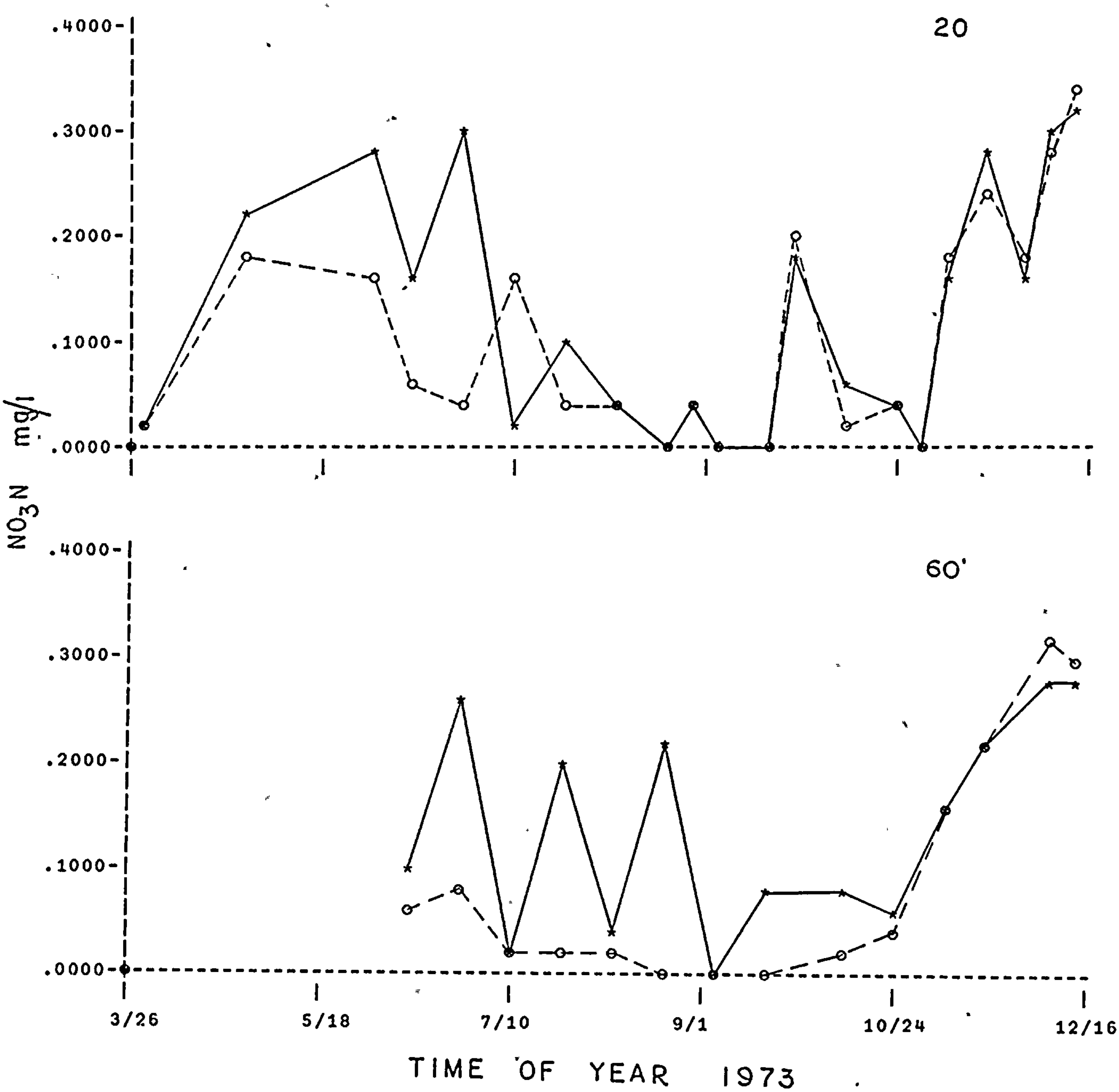


FIGURE V-18
WATER QUALITY PARAMETER VS TIME. VALUES ARE AVERAGES OF NINE MILE EAST, WEST & CENTER TRANSECTS IN 20 & 60 FEET OF WATER

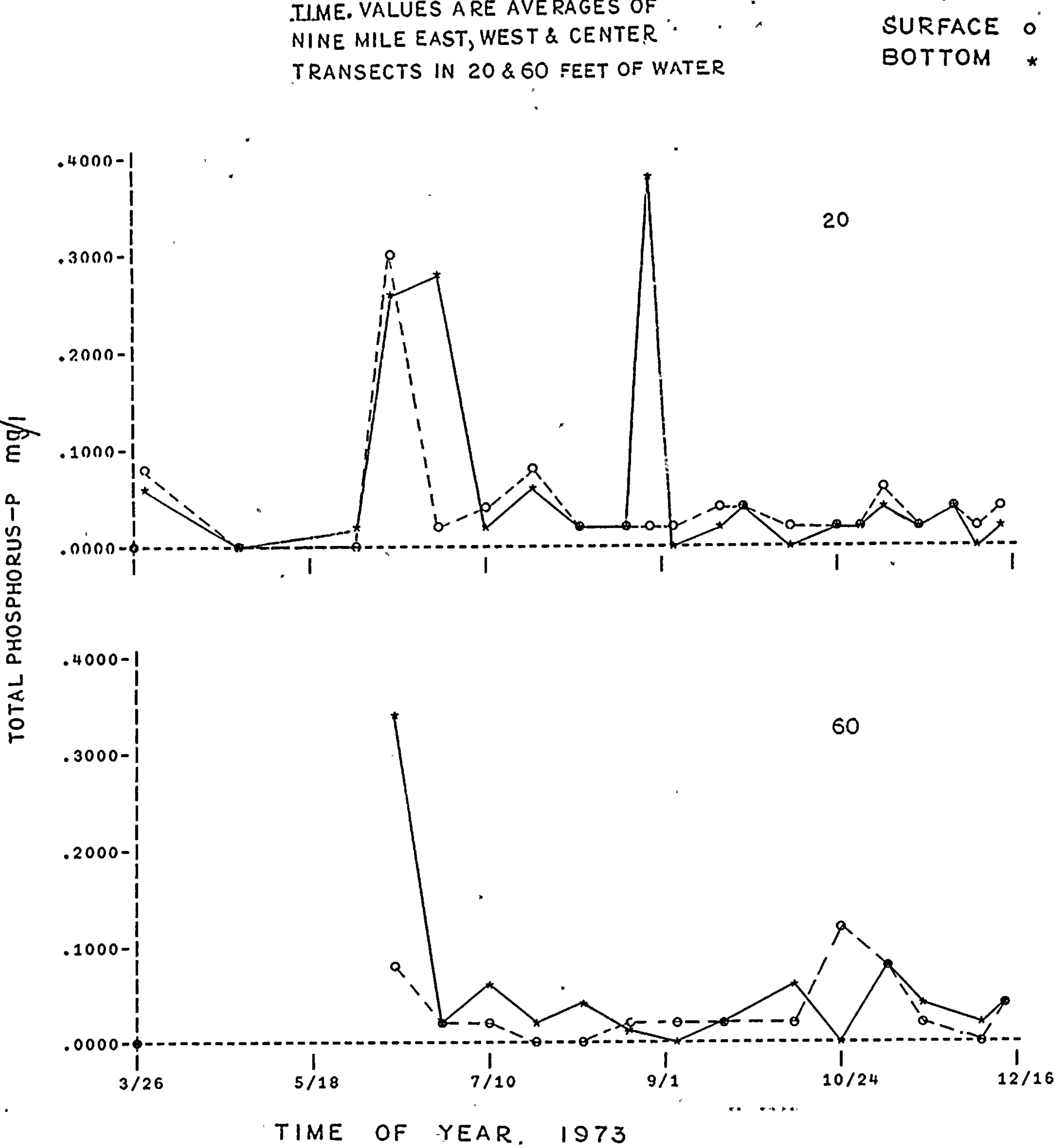


FIGURE V-19
WATER QUALITY PARAMETER VS TIME. VALUES ARE AVERAGES OF NINE MILE EAST, WEST & CENTER TRANSECTS IN 20 & 60 FEET OF WATER

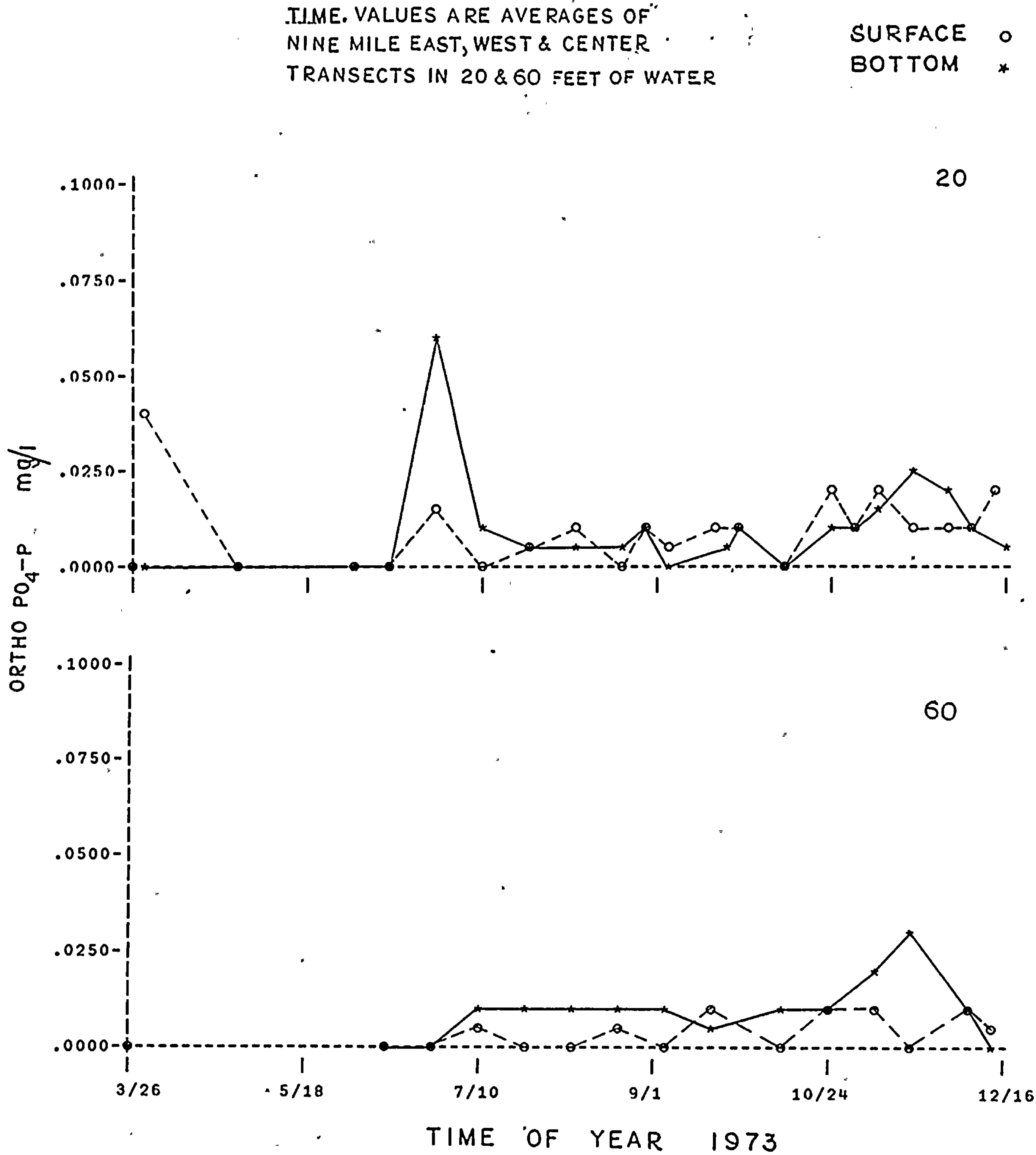


FIGURE V-20
WATER QUALITY PARAMETER VS TIME. VALUES ARE AVERAGES OF NINE MILE EAST, WEST & CENTER TRANSECTS IN 20 & 60 FEET OF WATER

SURFACE o
BOTTOM *

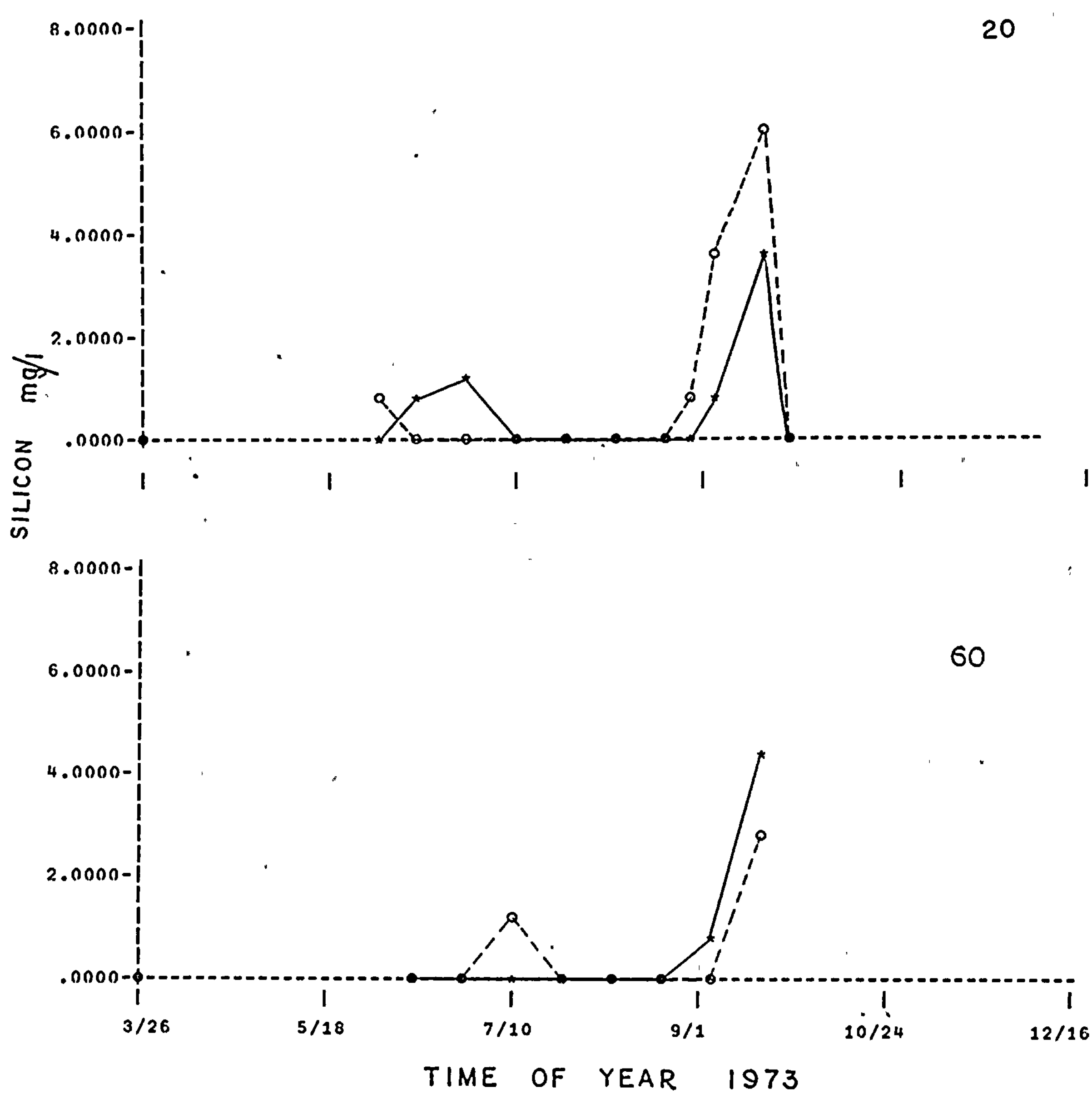


FIGURE V-21

WATER QUALITY PARAMETER VS TIME. VALUES ARE AVERAGES OF NINE MILE EAST, WEST & CENTER TRANSECTS IN 20 & 60 FEET OF WATER

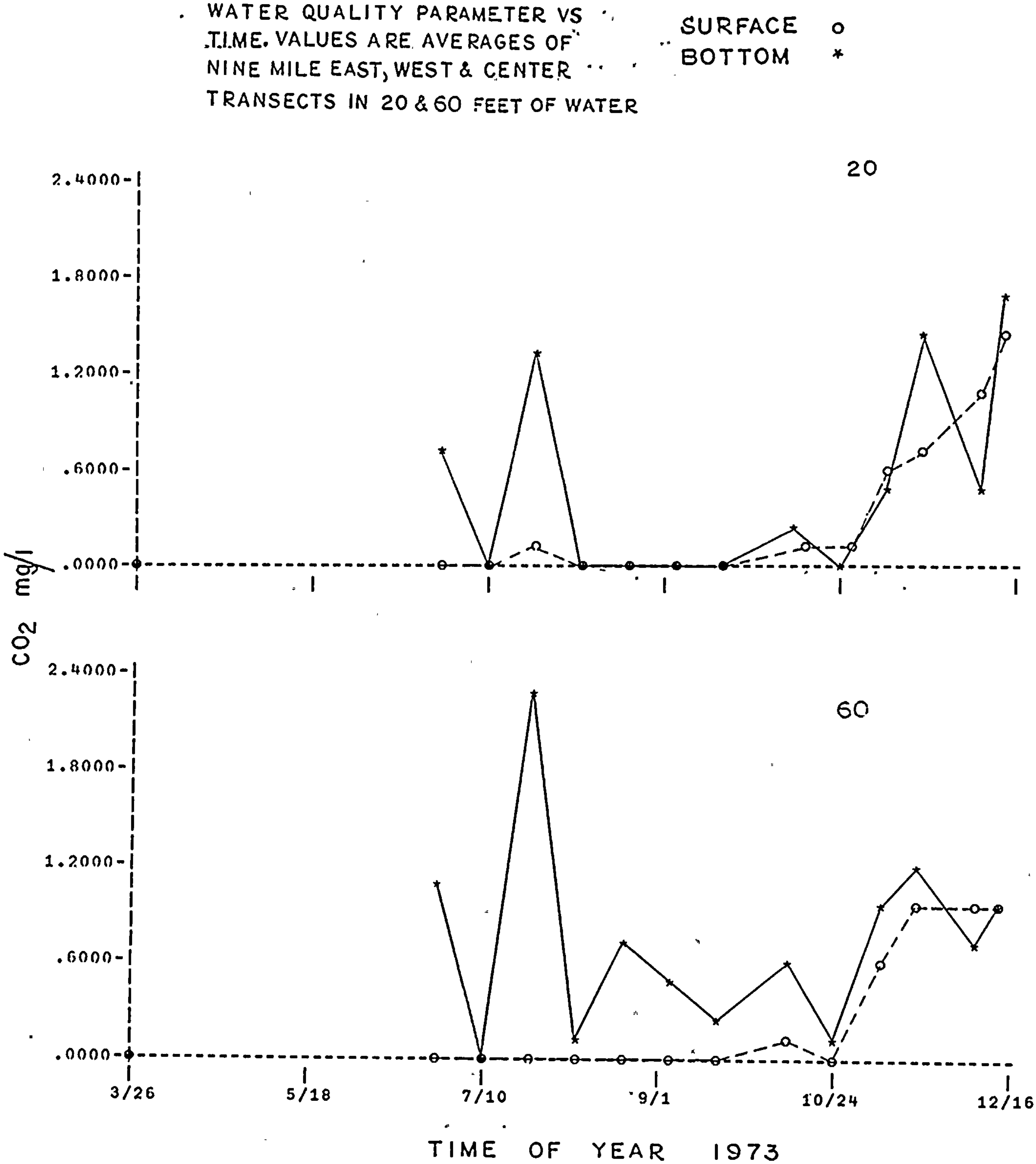


FIGURE V-22
WATER QUALITY PARAMETER VS TIME. VALUES ARE AVERAGES OF NINE MILE EAST, WEST & CENTER TRANSECTS IN 20 & 60 FEET OF WATER

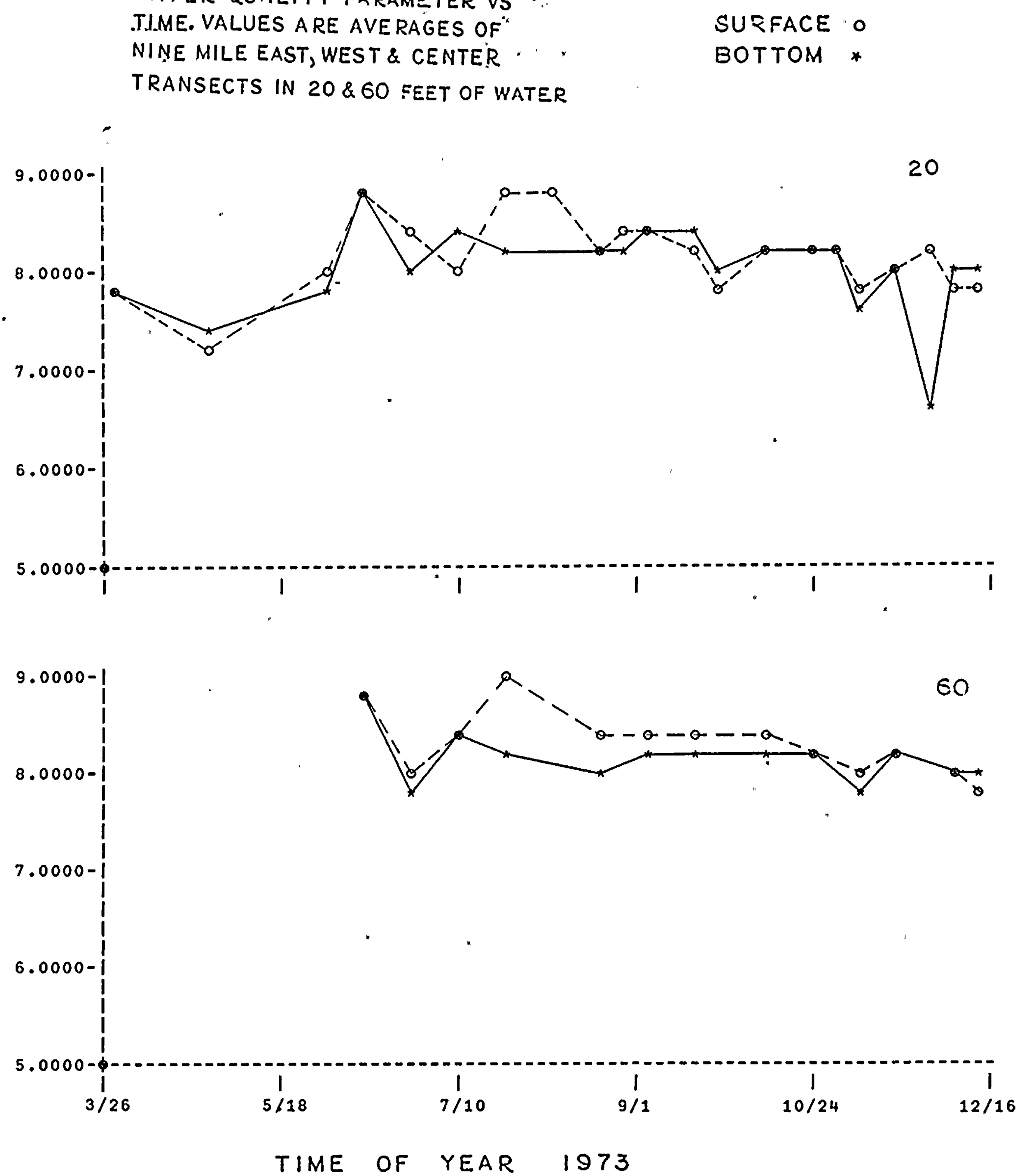
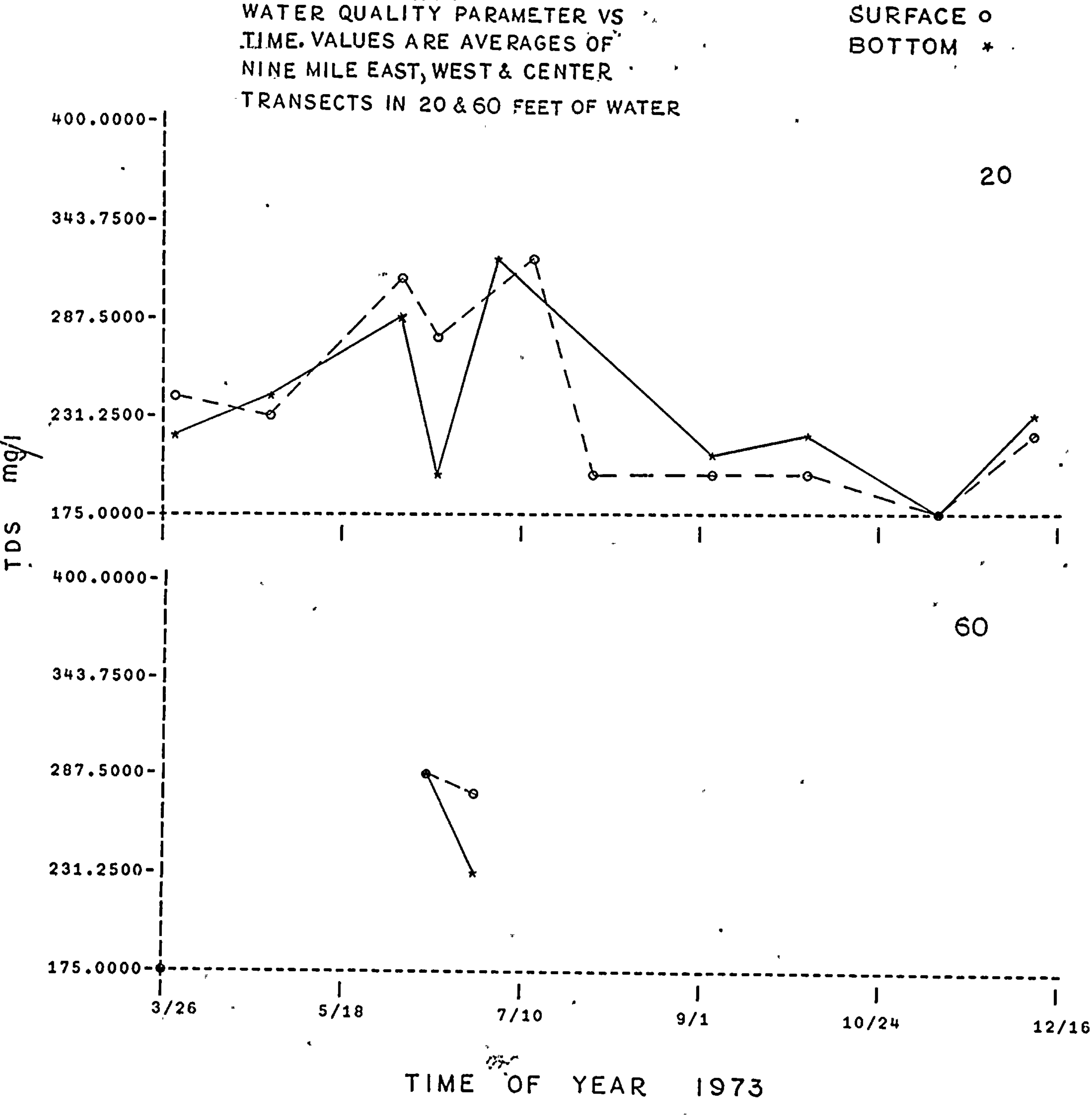


FIGURE V-23
WATER QUALITY PARAMETER VS TIME. VALUES ARE AVERAGES OF NINE MILE EAST, WEST & CENTER TRANSECTS IN 20 & 60 FEET OF WATER



2. Unstable vertical temperature variation was evident, and this variation was much more pronounced at 60 ft. depth stations than at 20 ft. depth stations (see Section 2 above).

3. Chlorophyll a values peaked from late June to early July and remained relatively high until mid-September. This period of time parallels that of generally high total whole water phytoplankton counts. No significant differences were found for 20 ft. depth stations versus 60 ft. depth stations or for surface versus bottom samples.

4. Except for March and April, no significant differences between surface and bottom samples were found for TKN values. Twenty ft. depth stations were similar to 60 ft. depth stations. There was an apparent seasonal variation, with summer values being relatively low. Excluding surface samples at 20 ft. depth stations, TKN values generally paralleled total whole water phytoplankton counts; the peaks more closely correspond to chlorophyll a peaks than to phytoplankton abundance (see Chapter I).

5. NO_3-N values exhibited a seasonal pattern with low values occurring in the summer, and they exhibited a relation to the transient vertical temperature variation. It is reasonable to expect conversion of NO_3-N to phytoplankton cell material, but such conversion is not obvious from chlorophyll a or TKN patterns. The periods of lowest NO_3-N values do correspond to periods of green and blue-green algae dominance.

6. Total phosphorus variations indicate that the late June peak in chlorophyll a may have been related to a concomitant drop in total phosphorus concentration, although bottom samples at 20 ft. depth stations did not exhibit this pattern. The source of the total phosphorus peak in early June is not clear, but total phosphorus and TKN appear to vary in a somewhat similar manner.

7. Orthophosphate exhibits a peak in late June at the 20 ft. depth stations, but not at the 60 ft. depth stations. The peaks are not immediately explainable.

8. Silicon values are similar for 20 and 60 ft. depth stations and for surface and bottom samples. The September peak just precedes the second diatom peak, and the early July peak just follows the first diatom peak.

9. CO_2 values indicate relatively high values in bottom samples during the summer, particularly at 60 ft. depth stations. There is also a seasonal trend, with summer values being relatively low, particularly at 20 ft. depth stations. The former observation presumably reflects oxidative processes in the hypolimnion during stratification, while the latter observation probably reflects algal uptake of dissolved CO_2. The late October increase in CO_2 parallels the decline in total whole water phytoplankton abundance.

10. pH values are probably related to the CO_2 values discussed above. Summer values are relatively high at 20 ft. depth stations because of CO_2 depletion and bottom values are relatively low at 60 ft. depth stations because of the slightly higher CO_2 content.

11. Total dissolved solids values exhibit a May through July peak. No explanation is immediately available for this phenomenon, but the values are supported by those for specific conductivity, Na and Cl.

Table V-8 presents means, maxima, minima and standard deviations for all samples for all stations for the entire Nine Mile Point 1973 monthly and bi-monthly water quality surveys. As a point of reference, values presented in Table V-2 are repeated here (i.e., values representative of Lake Ontario offshore waters under mixed conditions from previous studies). Major parameters, such as total dissolved solids, conductivity, pH, alkalinity, and major ions (Ca, Mg, Na, Cl, SO_4), are very similar for the 1973 Nine Mile Point results and expected Lake Ontario results. Dissolved nutrients, such as orthophosphate, NH_3-N, and NO_3-N, are also quite similar. However, several parameters representing particulate matter to a large degree are distinctly higher for the 1973 Nine Mile Point results. These include: TKN, TSS, TP and turbidity. These relatively high values may reflect particulate inputs to the Lake from point sources, land runoff, or sediment resuspension. Many of the trace and/or heavy metals are also higher for the 1973 Nine Mile Point samples than for expected offshore Lake Ontario conditions. In the case of Fe, Mn, and Si, these results are probably significant and may reflect differences between near-shore and off-shore stations due to suspended particulates or non- equilibrium conditions. Suspended matter is expected to be higher in metal concentrations than the dissolved fraction of the water, and suspended matter is higher for these near-shore stations than for off-shore conditions. In the case of the other trace metals, the values may be higher at these

TABLE V-8

WATER QUALITY PARAMETERS OVER ALL STATIONS*
AT
NMP, ALL TIME, OVER ALL DEPTHS (S&B)**

PARAMETER	# SAMPLES	MAX.	MIN.	MEAN	STD. DEV.	VALUES FROM TABLE V-2 LAKE ONTARIO OFFSHORE, MIXED
pH (units)	230	9.10	6.60	8.15	.402	8.0
T (°F)	217	103.0	40.0°F	58.6°F	13.4°F	
Alk	75	120.0	73.0	89.0	8.30	94
DO	210	13.8	5.80	9.83	1.59	
BOD	223	6.00	0	1.79	.892	
COD	230	65.0	0	13.0	9.90	
TOC	38	18.0	0	5.18	3.86	
TDS	75	525.0	135.0	240.0	58.3	200
TSS	240	260.0	0	8.57	23.0	3
NO_3N	240	.41	0	.127	.116	.20
TKN	200	1.40	0	.464	.307	.2
OP	240	.080	0	.0092	.0130	.015
TP	240	.910	0	.0528	.0943	.025
Cl	75	70.0	26.0	37.5	12.23	28
Cu	74	.410	0	.0644	.0927	.01
Fe	75	1.92	0	.176	.288	.01
Mn	58	.360	0	.0578	.0849	.001
Zn	67	.638	0	.0453	.1005	<1
TCol (cts/100ml)	61	430.	0	63.8	78.0	
FCol (cts/100ml)	59	550.0	0	13.4	72.2	
Ag	49	.0120	0	.0013	.0030	
Al	47	.2730	0	.0158	.0452	
As	14	.0060	0	.0004	.0016	
Ba	31	.5000	0	.0706	.1328	
Be	74	.0510	0	.0049	.0094	
Cd	74	.0670	0	.0040	.0093	.0001
Cr	73	.1600	0	.0123	.0260	.001
Hg	24	0	0	0	0	
K	74	2.46	1.32	1.88	.368	1.5
Mg	52	10.1	.320	7.55	1.80	.8
Na	74	31.6	8.75	16.4	5.91	12.
Ni	66	.200	0	.0313	.0424	.002
Pb	55	.240	0	.0232	.0460	.003
Se	21	0	0	0	0	
Si	31	7.00	0	1.00	2.00	.2
V	51	.300	0	.0235	.0815	
SpC (µmhos/cm)	190	490.0	80.0	279.0	51.5	300
TH	30	175.0	115.0	144.0	13.8	
Col (Cu)	59	45.0	0	6.53	5.82	
Tur (Tu)	240	52.0	0	4.35	6.10	2
TS	240	530.0	145.0	237.0	49.1	
TVS	67	155.0	10.0	75.9	27.5	
NH_3N	62	.200	0	.0258	.051	.03
OrgN	38	1.00	0	.328	.262	
Phl	67	.169	0	.0277	.040	.002
SO_4	75	39.0	22.0	28.7	4.56	30
F	38	.200	.100	.118	.0393	
Cn	46	0	0	0	0	

*Includes data taken at intake and discharge locations.
**All units in mg/l unless indicated.

near-shore stations for similar reasons. However, the reported values for this latter group of metals are affected by analytical sensitivity limits which are much higher than the average, offshore concentrations from previous studies (many of these values were determined after tedious extraction techniques). This problem is discussed further in Section b below. Finally, several parameters which are higher for the 1973 Nine Mile Point stations than for expected off-shore Lake Ontario, or are high in general, indicate definite pollution from point sources (e.g., the Oswego River) or from diffuse sources (i.e., runoff). These parameters include total and fecal coliforms, phenols and possibly Na and Cl, all of which are indicative of municipal pollution.

Despite the indications of slight pollution, none of the parameters indicate harmful or unusually polluted conditions based on mean values and expected ranges (refer to Table V-7, Section B2).

b. Metals Results

The results for the trace and/or heavy metals are difficult to analyze for the 1973 Nine Mile Point samples because on the basis of previous studies many of the actual values are expected to be less than the detection limits for the normally accepted procedures (atomic absorption spectrophotometry for all except As and Se). For any analytical procedure, there is always a chance of having a positive result near the limit of detection even when the actual value is zero. In fact, by common definition, one expects such an occurrence at least five percent of the time. If interfering substances are present at very low levels, the problem will be compounded. Moreover, such occurrences will

strongly bias reported mean values. Table V-9 presents information for the trace and/or heavy metals with respect to detection limits. Based on the foregoing discussion and on a subjective evalution of numbers of positive results reported and maximum values reported, it can be argued that the existence of Cd, Cr, Hg, Se, Pb, Al, Ni, V, Ag and As at concentrations above the stated detection limits at any time in 1973 was uncertain. On the other hand, Cu, Fe, Mn and Zn were consistently found at concentrations above the stated detection limits. All of these four metals have been indicated as significant in previous studies. Be and Ba appear to be borderline cases. Of course, positive evidence does exist for the existence of detectable concentrations of all of the above metals except Se and Hg which were never detected.

c. Simple Statistics and Correlations

Appendix VII presents the 1973 water quality data for monthly and bi-monthly programs in statistical form for different combinations of location, depth and date. Each table contains a listing of the chemical parameters analyzed; the number of samples fitting the group description at the head of the table and the maximum, minimum, mean, variance and standard deviation for each parameter. Following the first table is a matrix of correlation coefficients for each possible pair of parameters. Several sets of the above tables are presented for each sample group (i.e., each combination of location, depth and date), each set having a different list of parameters. For convenience of referencing, the analyses are divided into major categories according to several typical groupings of the samples. Table V-10 lists these

TABLE V-9

TRACE AND/OR HEAVY METALS
1973 NINE MILE POINT WATER QUALITY INVESTIGATIONS

Metal	Detection Limit mg/l	Number Of Values Reported Out Of Total Number Greater Than Detection Limit	Number of Values Reported Out Of Total Number Greater Than Ten Times The Detection Limit	Maximum Reported Value mg/l
Be	.002	29/74	6/74	.051
Cd	.002	26/74	4/74	.067
Cr	.01	21/73	1/73	.16
Cu	.005	64/75	12/75	.41
Fe	.01	56/75	37/75	1.92
[illegible]	.03	14/55	0/55	.24
[illegible]	.01	38/59	14/59	.36
Hg	.001	0/24	0/24	0
Ni	.02	37/66	1/66	.20
V	.2	4/51	0/51	.30
Zn	.003	50/68	28/68	.64
Al	.02	9/47	1/47	.27
Ag	.002	10/48	0/48	.012
Ba	.03	9/31	3/31	.5
As	.005	1/14	0/14	.006
Se	.01	0/21	0/21	0

TABLE V-10

COMPUTER RETRIEVAL CATEGORIES

	CATEGORY	STATIONS	DEPTHS (ft.)	MONTHS	PARAMETERS*
OSWEGO (19116)	1	All, individually	All, individually	All, combined	1,2
	2	All, individually	All, combined	All, combined	1,2
	3	All, combined	All, combined	All, combined	1,2
NMP, BIMO (19115)	1	All, individually	All, individually	All, combined	3
	2	All, individually	All, combined	All, combined	3
	3	All, combined	All, combined	All, combined	3
	4	All, combined	All, combined	All, individually	3
	5	All, combined	Surface	All, combined	3
	6	All, combined	All between 10-30	All, combined	3
	7a	All, combined	All between 55-65	All, combined	3
NMP, MO (19115)	1	All, individually	All, individually	All, combined	4,5,6
	2	All, individually	All, combined	All, combined	4,5,6
	3	All, combined	All, combined	All, combined	4,5,6
	4	All, combined	All, combined	All, individually	4,5,6.
	5	All, combined	Surface	All, combined	4,5,6
	7	All, combined	All between 40-50	All, combined	4,5,6
OSWEGO + NMP BIMO + NMP MO	3	All, combined	All, combined	All, combined	7,8,9
	4	All, combined	All, combined	All, individually	7,8,9
	5	All, combined	Surface	All, combined	7,8,9
	6	All, combined	All between 10-30	All, combined	7,8,9
	7	All, combined	All between 40-50	All, combined	7,8,9
	7a	All, combined	All between 55-65	All, combined	7,8,9

*PARAMETERS

1- pH, T, ALK, FDO, TBOD, TS, TSS, NO_3N TKN OP, TP, Cl, SO_4, Na, Mg, Zn, TCOL, FCOL

2- SpC, TH, TUR, COL, NH_3N, ORGN, TDS, TVS, PHL, SETR, Be, Cd, Cr, Cu, Fe, K, Ni, Pb, V

3- pH, SpC, T, TUR, CO_2, FDO, TBOD, TCOD, TS, TSS, NO_3N, TKN, OP, TP, CHLA, Si

4- pH, T, ALK, FDO, TBOD, TCOD, TTOC, TDS, TSS NO_3N, TKN, OP, TP, Cl, Cu, Fe, Mn, Zn, TCOL, FCOL

5- SpC, TH, COL, TUR, TS, TVS, NH_3N, ORGN, PHL SO_4, F, CN, SETR, SUR

6- Ag, Al, As, Ba, Be, Cd, Cr, Hg, K, Mg, Na, Ni, Pb, Se, Si, V

7- pH, T, SpC, COL, TUR, ALK, TH, FDO, TBOD, TCOD, TTOC, TS, TDS, TVS, TSS, NH_3N, ORGN, TKN, NO_3N

8- OP, TP, PHL, Cl, SO_4, CHLA, CN, SETR, F, TCOL, FCOL

9- Ag, Al, As, Ba, Be, Cd, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Ni, Pb, Se, Si, V, Zn

categories and the sample groupings in each. The tables in Appendix VII-2 are not discussed in detail here, but they can be used to investigate water quality conditions in a number of ways under many possible circumstances of interest. In particular, statistical retrieval data for NMP-11 (7 day composite intake sample) and NMP-12 (7 day composite discharge sample) in category 2 indicate no significant differences at the 95% confidence level for all parameters measured, based on the Student's t-test.

Table V-8 presented provides an indication of variabilities of the various parameters for the entire Nine Mile Point data record. Using the value of 1.0 for the coefficient of variance (standard deviation divided by mean) as a criterion of degree of variability, the following parameters are indicated as highly variable:

orthophosphate	F Coliforms	Cd
total phosphate	Ag	Cr
Fe	Al	Pb
Mn	As	Ni
Zn	Ba	Si
T Coliforms	Be	V
NH_3-N	TSS	Tur
Phenols		

Judging from the position of the mean with respect to the minimum and maximum for these parameters, each is characterized by a highly skewed probability distribution with relatively many values between or including zero and the mean and relatively few values greater than the mean. This is particularly true for the trace compounds and is related to the sensitivity problem discussed above. It is true for TSS and turbidity because of the chance for relatively few high values caused by sampling

difficulties for bottom samples or by physical resuspension of sediments by wind and wave action.

The tables in Appendix VII-2 can also be used to investigate correlation between variables. Rather than dwell on each major category and group, the correlation matrices were searched for consistency of correlation coefficients between the several categories and groups. Pairs of parameters which were found to be correlated consistently are listed in Table V-11. Specific conductivity and temperature were also found to be significantly correlated, but the pair was not included in this discussion because of the sensitivity of the analytical determination of conductivity to temperature.

Since all these pairs except TSS-Tur involve temperature directly or indirectly, the correlations may be estimated initially to be associated with either seasonal temperature changes or vertical temperature variations. In order to illustrate the above correlations, time series plots were prepared for each of the monthly lake and bi-monthly stations for T, NO_3-N, and CO_2. These plots are presented in Figures V-24 through V-29. Monthly and bi-monthly stations at the NMPP transect in 20 ft. of water are grouped together because they represent the same approximate location. At least two mechanisms seem to be interfacing: vertical temperature variations and algal growth.

Algal growth at the expense of NO_3-N and CO_2 is indicated as a seasonal phenomenon controlled by temperature. Thus, as temperature increases, NO_3-N and CO_2 are depleted. The patterns are smoothest for the surface locations and least smooth for the 45 and 60 ft. bottom locations, with the 20 ft. bottom stations intermediate.

TABLE V-11

SIMILARITIES IN CORRELATION COEFFICIENTS WITHIN NMP BIMONTHLY COMPUTER RETRIEVAL CATEGORIES FOR SELECTED PARAMETER PAIRS

CATEGORY 1 (Coeff. Based on 14 Values)

Parameter Pair/Sign of Correl. Coeff.		STATION DESIGNATION NMP-1 S	NMP-1 B	NMP-2 S	NMP-2 B	NMP-3 S	NMP-3 B	NMP-4 S	NMP-4 B	NMP-5 S	NMP-5 B	NMP-6 S	NMP-6 B
DO - T	-	.62	.77	.51	.57	.54	.61	.50	.58	.48	.61	.34	.64
CO_2 - T	-	.75	.79	.83	.75	.73	.79	.80	.40	.69	.62	.84	.75
NO_3N - T	-	.83	.79	.85	.88	.87	.70	.81	.88	.78	.82	.84	.80
NO_3N-CO_2	+	.87	.69	.93	.58	.82	.64	.90	.30	.75	.53	.94	.55
TSS - Tur	+		.87		.70		.96		.79		.84		.67
pH - T	+	.74	.62	.61	.58	.57	.56	.60	.52	.75	.76	.70	.58

CATEGORY 2 (28 Values)

		NMP-1	NMP-2	NMP-3	NMP-4	NMP-5	NMP-6
DO - T	-	.47	.54	.48	.57	.49	.70
CO_2 - T	-	.75	.78	.75	.61	.67	.77
NO_3N - T	-	.80	.87	.79	.83	.80	.83
NO_3N - CO_2	+	.72	.72	.71	.58	.59	.68
TSS - Tur	+	.50	.70	.93	.71	.83	.59

CATEGORY 4 (24 values)

		JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
CO_2 - T	-	.72	.92	.72	.46	.18	.76	.23
TSS - Tur	+	.56	.78	.91	.50		.98	.76

		CAT 3 (168)	CAT 5 (84)	CAT 6 (84)	CAT 7A (84)
CO_2 - T	-	.70	.77	.80	.62
NO_3N - T	-	.81	.81	.77	.84
NO_3N - CO_2	+	.64	.84	.58	.43
TSS - Tur	+	.74		.88	.70

FIGURE V-24
WATER QUALITY PARAMETER VS TIME AT THE NINE MILE EAST TRANSECT IN 20' OF WATER

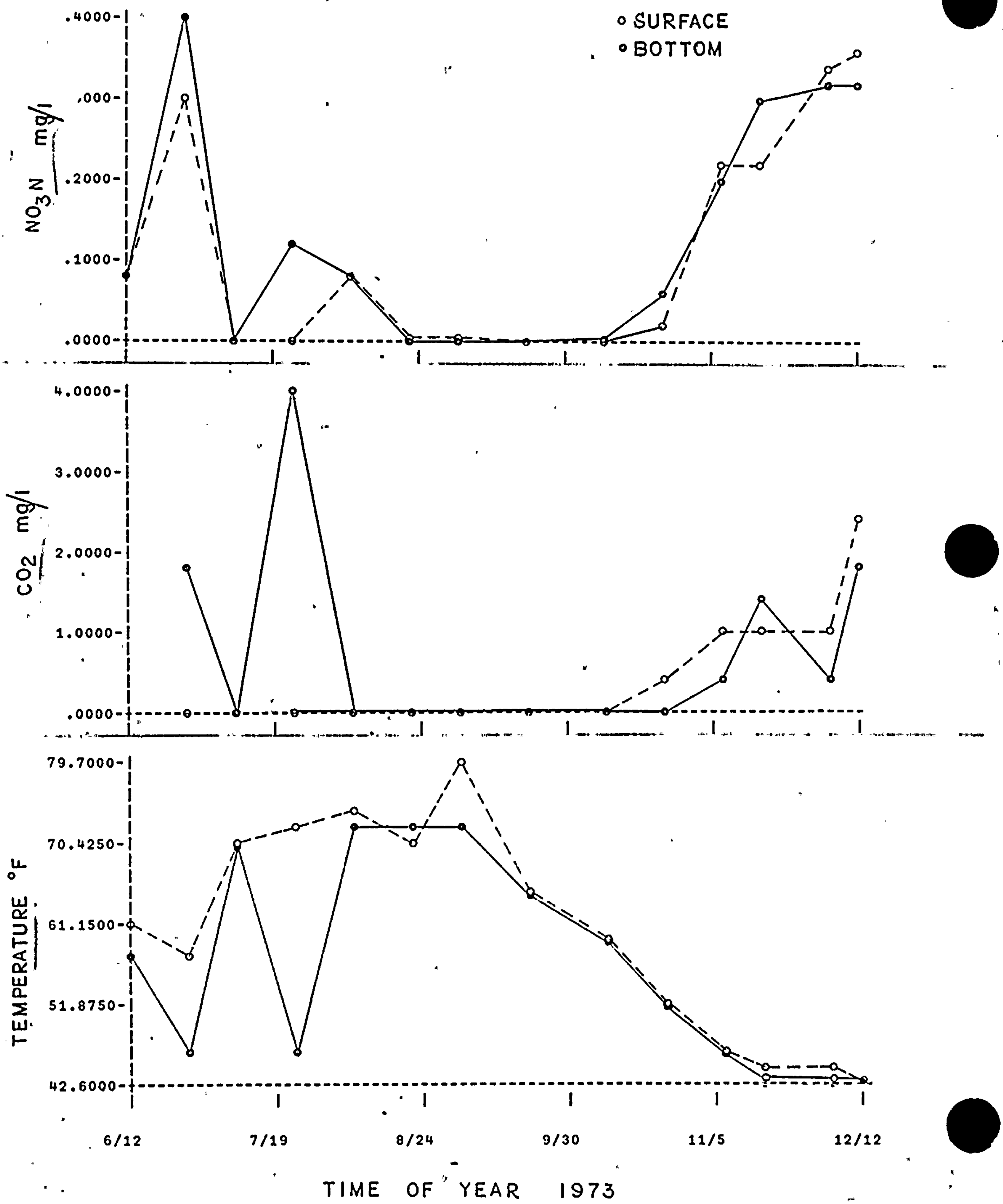


FIGURE V-25
WATER QUALITY PARAMETER VS TIME AT THE NINE MILE EAST TRANSECT IN 60' OF WATER

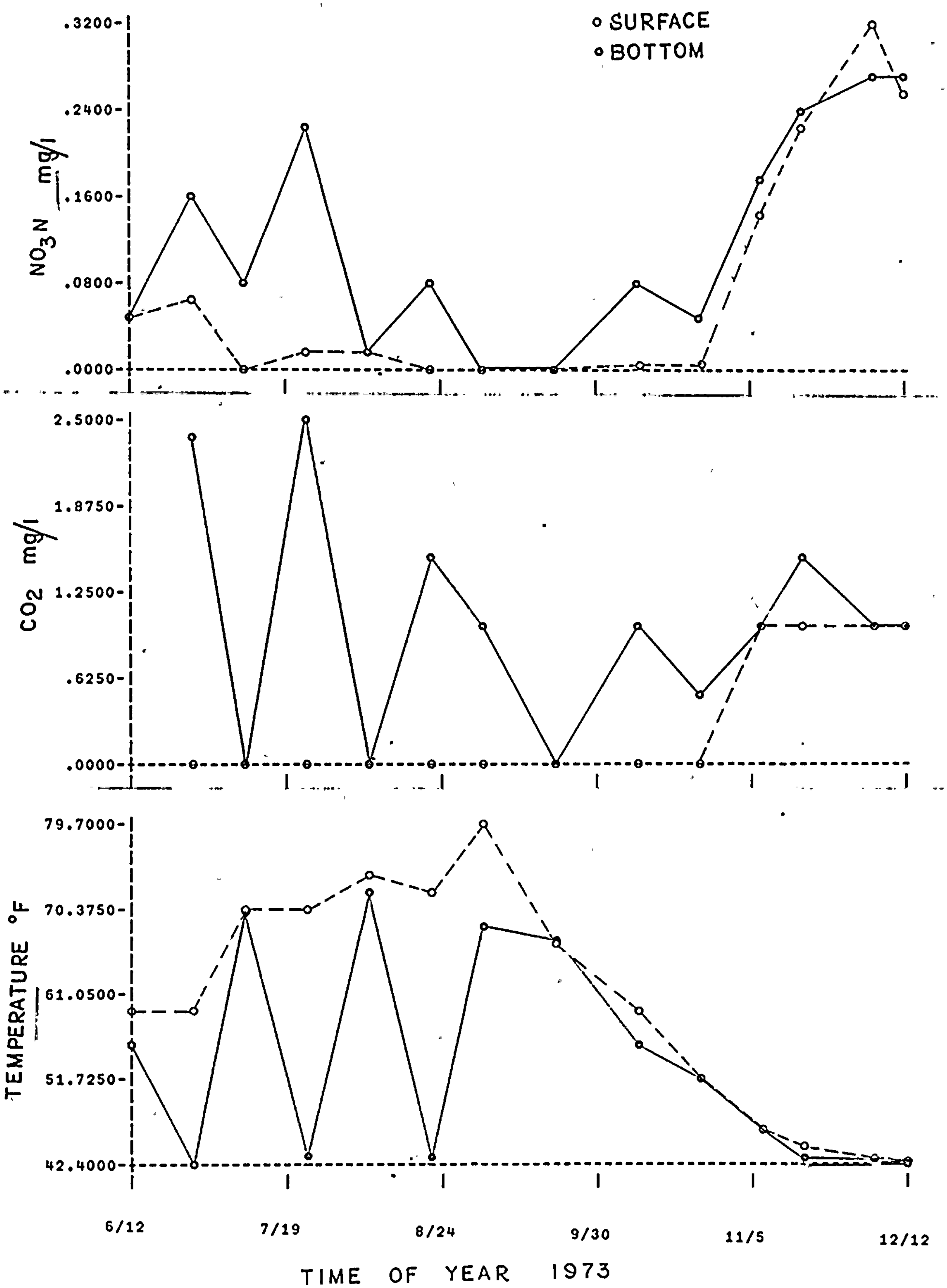


FIGURE V-26
WATER QUALITY PARAMETER VS TIME AT THE NINE MILE WEST TRANSECT IN 20' OF WATER

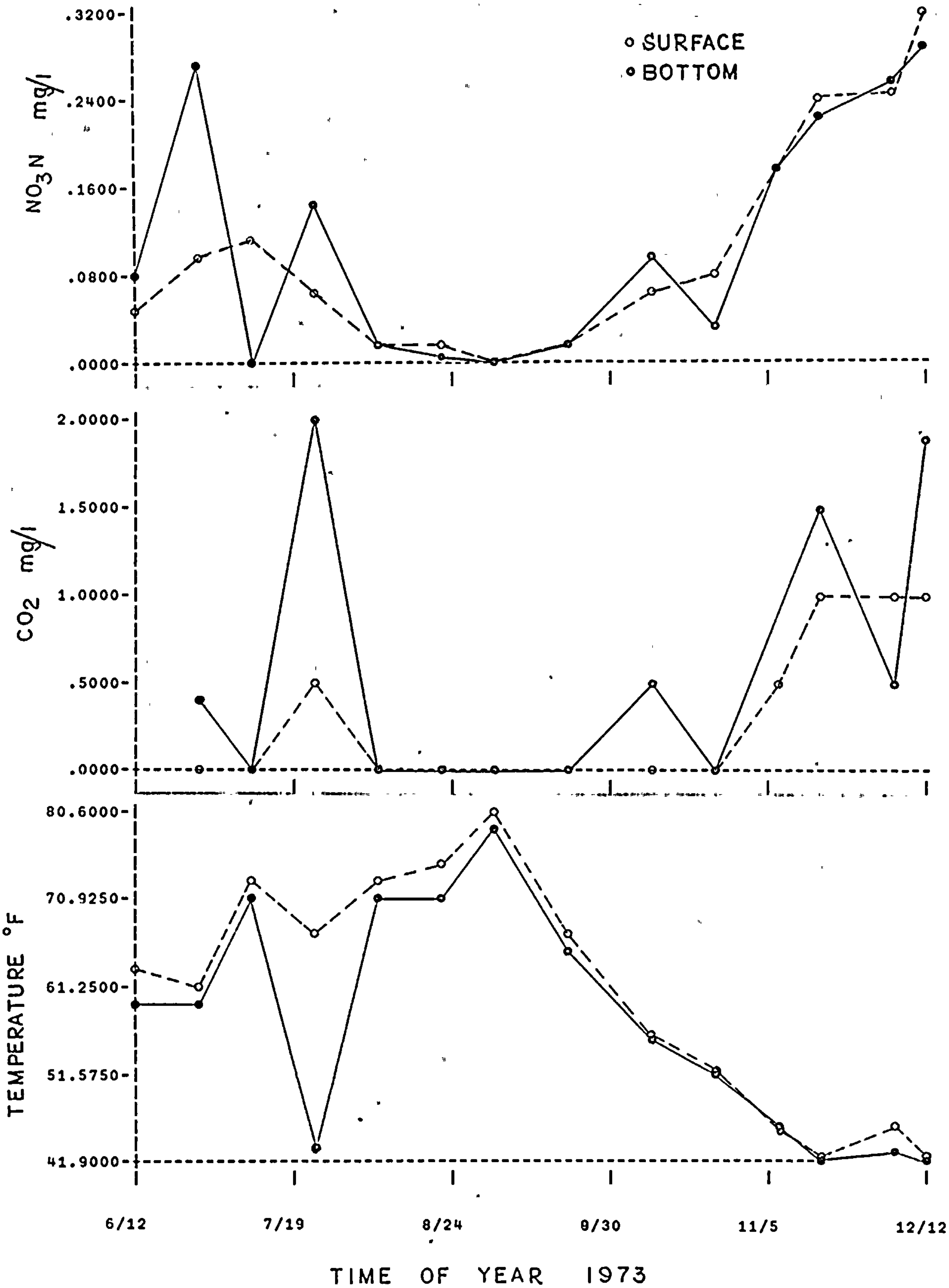


FIGURE V-27
WATER QUALITY PARAMETER VS TIME AT THE NINE MILE WEST TRANSECT IN 60' OF WATER

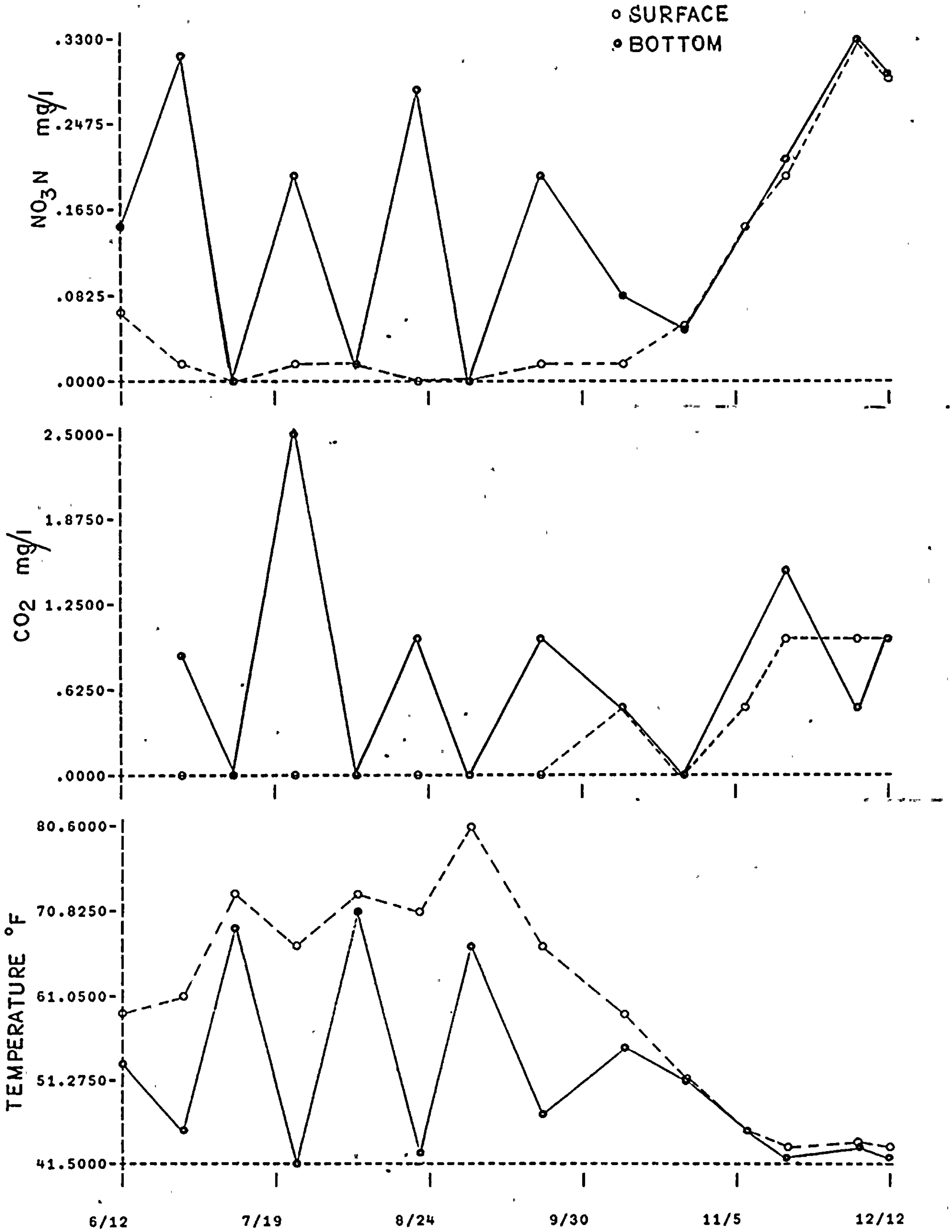


FIGURE V-28

WATER QUALITY PARAMETER VS TIME AT THE NINE MILE PLANT TRANSECT IN 45' OF WATER

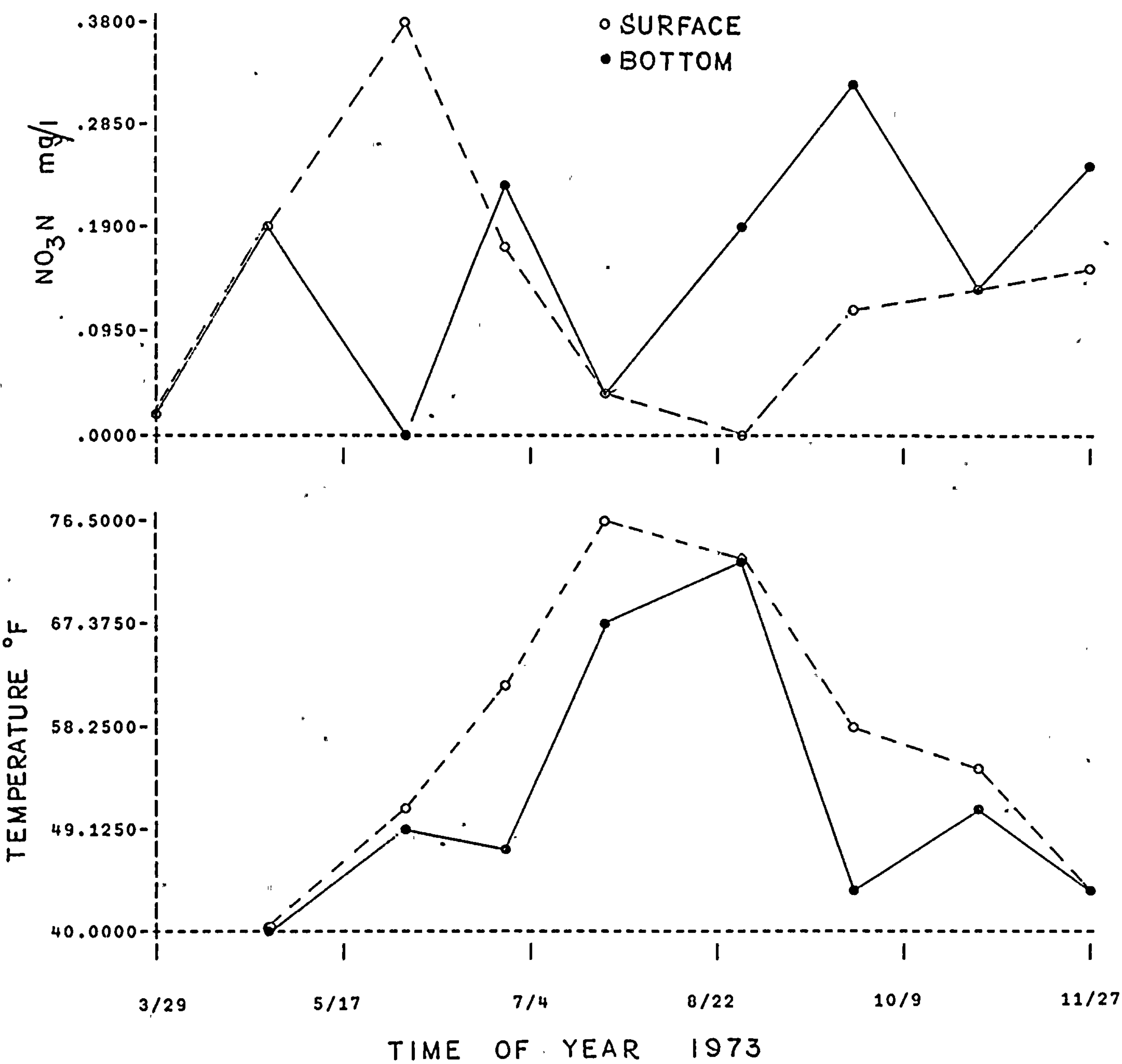
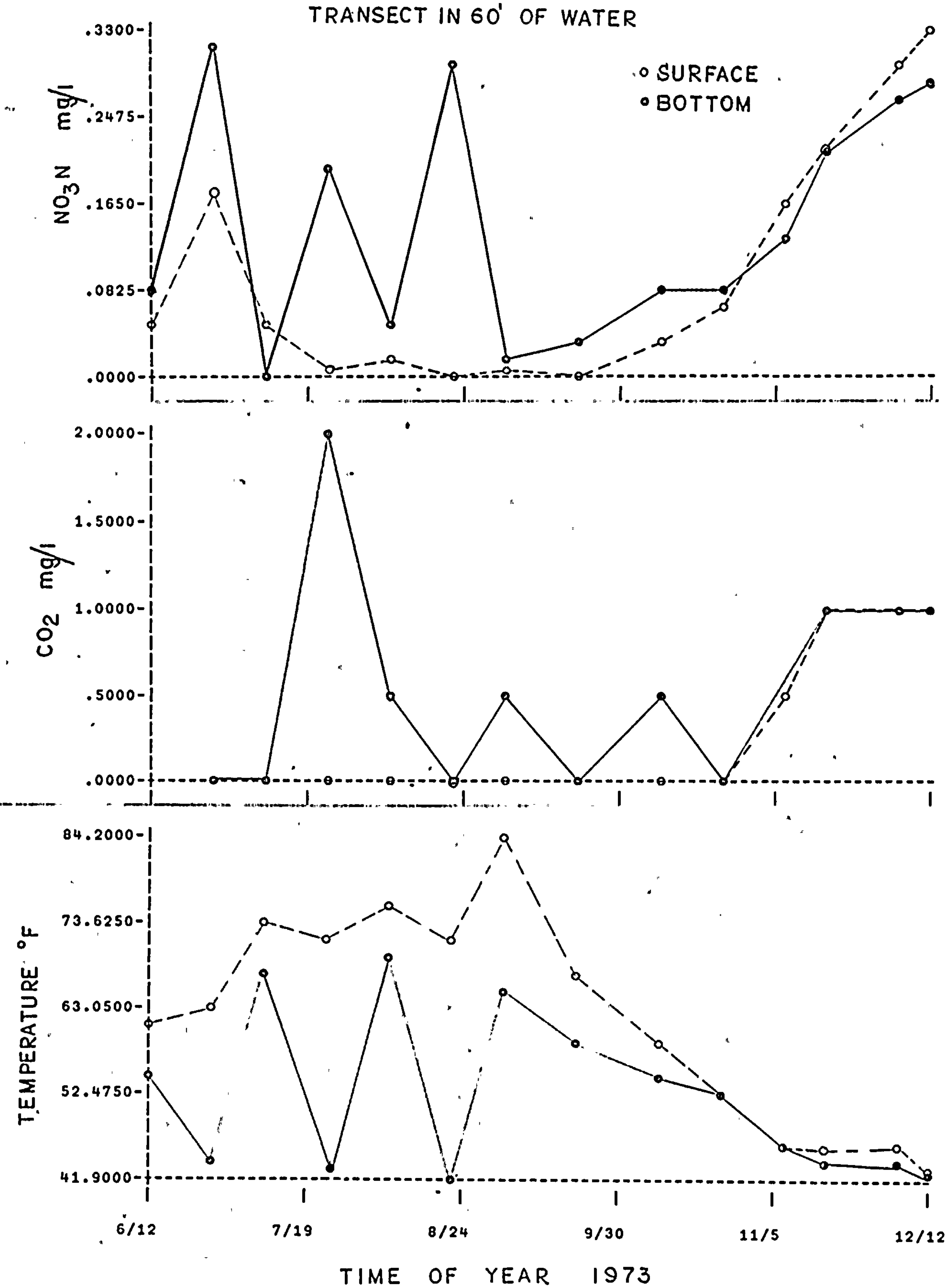


FIGURE V-29
WATER QUALITY PARAMETER VS TIME AT THE NINE MILE PLANT TRANSECT IN 60' OF WATER



The rougher patterns are due to the unstable vertical temperature variation in the relatively shallow stations used for this study. This vertical temperature variation moves in and out from June to October, influenced to varying degrees by the variation existing in the deeper portions of the Lake. The 45 and 60 ft. bottom locations naturally are affected to a greater extent than the 20 ft. bottom locations. The negative correlations for NO_3-N/T and CO_2/T and positive correlations for NO_3-N/CO_2 are quite obvious, as the unstable pattern for temperature of the bottom waters is followed by an analogous unstable pattern for CO_2 and NO_3-N in bottom waters. It is apparent that the colder, deeper waters of the Lake are relatively higher in NO_3-N and CO_2 than the shallow waters. This is due to oxidative processes in the confined, poorly illuminated deeper waters compared to the photosynthetic processes in the shallower waters. These deeper waters move in and out from near-shore areas under external influences, causing the vertical, thermal and chemical variation to be manifested.

d. Analysis of Variance

In order to test possible differences between sampling locations, depths and dates, several analysis of variance (ANOVA) routines were utilized within the computer system. The ANOVA methods were applied as described by Sokal and Rohlf (1969). Table V-12 summarizes the sample groupings and ANOVA techniques used. The parameter sets used were restricted to those for which nearly complete records were available and to those which were not below detection limit most of the time. The ANOVA routine results were converted into F ratios and tested for significance at the

TABLE V-12

ANALYSIS OF VARIANCE
1973 NINE MILE POINT
WATER QUALITY INVESTIGATIONS

ANOVA SET	ANOVA USED*	STATIONS USED	DEPTHS USED **	DATES USED	PARAMETERS USED
1	3-way	NMP-1 through NMP-6	S and B	6/12/73 through 12/12/73	pH, TP, Chla, TSS, OP, Tur, DO, COD, CO_2, TKN, TS, NO_3, T
2	2-way	NMP-1 through NMP-6	S and B	6/12/73 to 12/12/73, individually	pH, TS, TKN, CO_2, OP, Chla, NO_3, T
3	3-way	NMP-7 and NMP-8	S and B	3/29/73 through 11/27/73	Alk, FDO, TCOD, TTOC, TDS, TSS, NO3N, TKN, OP, TP, Cl, Cu, Fe, Mn, Zn, TCol, FCol, Phl, SO_4, F, Sur
4	2-way	NMP-7 through NMP-12	-	3/29/73 through 11/27/73	TS, TCOD, pH, TSS, NO3N, TKN, OP, TP, Alk, TDS, Cl, Cu, Fe, Zn, SO_4, Tur

* 3-way ANOVA performed according to Simpson et al.

2-way ANOVA performed according to Simpson et al.

** all bottom samples treated as the same depth despite actual vales of approximately 20, 45, or 60 feet for sample depths

.05 and .10 significance levels by reference to F-distribution tables according to procedures outlined by Simpson et. al., (1960). Tables V-13 through V-16 summarize the treatments and interactions found to be significant. When significant differences were found between stations, a Student-Newman-Keuls (SNK) test (Sokal and Rohlf [1969]) or a Least Significant Difference (LSD) test (Snedecor and Cochran [1967] was performed to establish homogenous subsets. These results are summarized in Tables V-17 and V-18 along with compilations of depth comparisons when significant depth differences were found.

For interpreting these ANOVA results, the first step was to analyze which parameters had main effects or interactions involving each of the two or three factors (depth, station, date). According to Simpson et. al., (1960) when an interaction between two factors in a 3-way ANOVA is significant, there is generally as much variation from level to level of the first factor at a fixed second factor level as there is from level to level of the second factor at a fixed first factor level. Thus, for example, station differences may be important if a main effect is indicated or if an interaction involving stations is indicated.

Using this reasoning for ANOVA set 1 (bi-monthly samples, 3-way ANOVA) station differences were important for pH, DO, CO_2, NO_3 and T. It is significant that these same parameters had consistently high correlation coefficients for statistical retrieval category 1 (individual depths and stations, combined dates). It may be surmised that the station differences are due to transient vertical temperature variation.

TABLE V-13

ANOVA SET 1
3-WAY ANOVA, NMP-1 through NMP-6

	TREATMENT			INTERACTION		
Parameter	Depth	Station	Date	Depth x Station	Depth x Date	Station x Date
pH, as $[H^+]$		xx	xx		xx	
TP			xx			
Chla			xx		xx	
TSS	xx					
OP	x				xx	
Turbidity	xx		xx			
[illegible]			xx		xx	xx
COD			xx			
CO_2	x	x			xx	
TKN			xx			
TS			xx		xx	
NO_3-N	xx		xx	xx	xx	xx
T	xx		xx	xx	xx	xx

xx Significant at less than .05 significance level

x Significant at less than .10 significance level

TABLE V-14

ANOVA SET 2
2-WAY ANOVA NMP-1 through NMP-6

Date	Depth	Station
6/12/73	T(xx), DO(xx)	T(x), DO(xx)
6/27/73	CO_2(x), NO_3(xx), T(xx), DO(xx) pH(x), OP(x), Chla(x)	NO_3(x)
7/9/73		pH(xx), TS(xx)
7/24/73	NO_3(xx), T(xx), DO(xx), pH(xx) OP(xx), CO_2(xx)	T(xx)
8/7/73	Chla(xx), T(xx), DO(xx)	OP(x), DO(xx)
8/22/73	T(xx), TS(x), OP(x)	OP(x), DO(xx)
9/4/73	TKN(xx), pH(xx), T(xx), DO(xx)	TKN(xx)
9/19/73	TS(x)	TS(x), OP(x)
10/9/73	T(xx), pH(x), CO_2(x), NO_3(xx)	NO_3(x)
10/23/73		Chla(xx), pH(x), T(x)
11/8/73	DO(xx) DATA INSUFFICIENT FOR ANALYSES EXCEPT FOR T AND DO	
11/18/73	T(xx), TS(x), CO_2(xx), OP(xx)	Chla(xx), T(xx), DO(x)
12/4/73	CO_2(xx), T(xx), DO(xx)	DO(x)
12/12/73	pH(x)	CO_2(x), NO_3(x)

xx Significant at less than .05 significance level

x Significant at less than .10 significance level

TABLE V-15

ANOVA SET 3
3-WAY ANOVA NMP-7 and NMP-8

	TREATMENT			INTERACTION		
Parameter	Depth	Station	Date	Depth x Station	Depth x Date	Station x Date
Alk			xx		xx	
FDO			xx		xx	
TCOD						
TTOC						xx
TDS			xx			
TSS						
NO_3-N						
TKN			xx			
OP						
TP						
Cl	xx*		xx	x	xx	
Cu			xx			
Fe				x		
Mn						xx
Zn						
TCol			xx			
FCol						
Phl			xx			
SO_4			xx			
F						
[illegible]	x	xx	xx			xx

xx Significant at less than .05 significance level
x Significant at less than .10 significance level
* Not significant at .10 level due to interaction.

TABLE V-16

ANOVA SET 4
2-WAY ANOVA NMP-7 through NMP-12

Parameter	Stations	Dates
TS		xx
TCOD		xx
pH		xx
TSS		xx
NO_3-N		xx
TKN		
OP		
TP		x
Alk		xx
TDS		xx
Cl		xx
Cu		xx
Fe		xx
Zn		xx
SO_4		xx
Tur		xx

TABLE V-17

ANOVA SET 1
HOMOGENEOUS SUBSETS

1. pH, as $[H^+]$ by SNK, α = .05

Rank	1	2	3	4	5	6
Mean x 10^8	1.141	1.223	1.237	1.277	1.311	1.548
pH	7.94	7.91	7.91	7.89	7.88	7.81
Station	NMP-2	NMP-1	NMP-6	NMP-4	NMP-3	NMP-5

2. CO_2 by LSD, α = .10

Rank	1	2	3	4	5
Mean	.3959	.4292	.5167	.6125	.6415
Station	NMP-3 &NMP-4	NMP-1	NMP-2	NMP-5	NMP-6

3. NO_3-N, Turbidity, TSS

Parameter	Surface Mean	Bottom Mean	
NO_3-N	.09667	.14192	B>S
Turbidity	3.3462	5.7308	B>S
TSS	3.4615	17.1153	B>S
Temperature	61.2	55.3	S>B
OP	.0067	.0122	B>S
CO_2	.330	.701	B>S

TABLE V-18

ANOVA SET 2
HOMOGENEOUS SUBSETS

1. Chla 8/7/73 SNK α = .05

Rank	1	2	3	4	5	6
Mean	5.85	8.5	9.1	10.5	12.5	15
Station	NMP-4	3	6	2	1	5

2. Chla 10/23/73 SNK α = .05

Rank	1	2	3	4	5	6
Mean	1.1	3.25	3.3	3.85	4.65	6
Station	NMP-5	3	6	2	1	4

3. Chla 11/18/73 SNK α = .05

Rank	1	2	3	4
Mean	0.6	0.85	1.1	1.9
Station	NMP-1&2	4&6	5	3

4. NO_3-N 6/27/73 LSD α = .10

Rank	1	2	3	4	5	6
Mean	.12	.17	.185	.195	.25	.35
Station	NMP-6	2	3	1	4	5

5. NO_3-N 8/7/73 SNK α = .05

Rank	1	2	3	4
Mean	.025	.03	.45	.9
Station	NMP-1	2&6	3&4	5

6. NO_3-N 10/9/73 LSD α = .10

Rank	1	2	3	4	5
Mean	.005	.05	.06	.065	.085
Station	NMP-5	3&6	2	4	1

TABLE V-18 Cont'd

HOMOGENEOUS SUBSETS

7. NO_3-N 12/12/73 LSD $\alpha = .10$

Rank	1	2	3	4	5	6
Mean	.17	.175	.275	.31	.33	.34
Station	NMP-2	1	6	4	3	5

8. DO 6/12/73 SNK $\alpha = .05$

Rank	1	2	3	4	5	6
Mean	11.85	12.6	12.75	13.05	13.1	13.4
Station	NMP-1	3	2	5	4	6

9. DO 8/7/73 SNK $\alpha = .05$

Rank	1	2	3	4	5	6
Mean	8.2	8.55	8.7	8.85	9.1	9.35
Station	NMP-1	3	4	2	5	6

10. DO 8/22/73 SNK $\alpha = .05$

Rank	1	2	3	4	5	6
Mean	8.2	8.55	8.7	8.75	8.95	10.05
Station	NMP-1	2	3	4	5	6

11. DO 11/18/73 LSD $\alpha = .10$

Rank	1	2	3	4	5
Mean	9.6	10.4	10.45	10.9	11.05
Station	NMP-3	4&5	6	2	1

12. DO 12/4/73 LSD $\alpha = .10$

Rank	1	2	3	4	5	6
Mean	10.45	10.65	11.2	11.25	11.3	11.45
Station	NMP-5	2	3	6	4	1

13. pH 7/9/73 SNK $\alpha = .05$

Rank	1	2	3	4	5
Mean, as $(H^+) \times 10^9$	2.25	2.5	2.84	3.57	3.98
Mean, as pH	8.64	8.60	8.55	8.45	8.40
Station	NMP-2	6	1&5	3	4

TABLE V-18 Cont'd

HOMOGENEOUS SUBSETS

14. pH 10/23/73 LSD $\alpha = .10$

Rank	1	2	3
Mean, as $(H^+)x10^9$	5.01	5.66	6.31
Mean, as pH	8.30	8.25	8.20
Station	NMP-1&2 &3&5	6	4

15. TS 7/9/73 SNK $\alpha = .05$

Rank	1	2	3	4	5
Mean	215	230	240	270	330
Station	NMP-6&2	5	4	3	1

16. TS 9/19/73 LSD $\alpha = .10$

Rank	1	2	3
Mean	210	220	225
Station	NMP-6	1&5	2&3&4

17. OP 8/22/73 LSD $\alpha = .10$

Rank	1	2	3	4
Mean	0	.005	.01	.015
Station	NMP-5	6&3	1&4	2

18. OP 9/19/73 LSD $\alpha = .10$

Rank	1	2	3
Mean	0	.005	.01
Station	NMP-1	4	2&3&5&6

19. CO_2 12/12/73 LSD $\alpha = .10$

Rank	1	2	3	4
Mean	1.00	1.25	1.45	2.15
Station	NMP-2&4 &6	3	1	5

20. TKN 9/4/73 LSD $\alpha = .05$

Rank	1	2	3	4	5
Mean	.25	.3	.35	.425	.475
Station	NMP-2&4	5	1	3	6

TABLE V-18 Cont'd

HOMOGENEOUS SUBSETS

T 6/12/73 LSD α = .10

Rank	1	2	3	4	5	6
Mean	56.95	58.35	59	60.15	62.15	62.5
Station	NMP-2	4	6	5	1	3

22. T 7/24/73 SNK α = .05

Rank	1	2	3	4	5	6
Mean	54.5	55.05	55.4	57.1	57.4	60.15
Station	NMP-2	1	3	4	6	5

23. T 10/23/73 LSD α = .10

Rank	1	2	3	4	5	6
Mean	52.55	52.6	52.65	52.7	52.75	52.9
Station	NMP-6	5	1	3	4	2

24. T 11/18/73 SNK α = .05

Rank	1	2	3	4	5	6
Mean	42.35	43.55	43.7	44.7	45.4	45.6
Station	NMP-1	2	5	6	4	3

TABLE V-18 Cont'd

SUBSETS BY DEPTH

Parameter	Date	Reading (mg/l where appropriate) Surface	Bottom	
NO_3-N	6/27/73	.128	.295	B>S
NO_3-N	7/24/73	.028	.188	B>S
NO_3-N	10/9/73	.03	.075	B>S
OP	6/27/73	0.0	.033	B>S
OP	7/24/73	.0017	.013	B>S
OP	8/22/73	.005	.01	B>S
OP	11/18/73	.0067	.028	B>S
Chla	6/27/73	.016	.030	B>S
Chla	8/7/73	.012	.008	S>B
FDO	6/12/73	12.4	13.2	B>S
FDO	6/27/73	12.2	11.2	S>B
FDO	7/24/73	8.58	10.6	B>S
FDO	8/7/73	9.78	7.8	S>B
FDO	9/4/73	8.07	6.53	S>B
FDO	11/8/73	10.2	10.75	B>S
FDO	12/4/73	10.6	11.5	B>S
pH	6/27/73	7.96	7.74	S>B
pH	7/24/73	8.84	6.75	S>B
pH	9/4/73	7.76	7.31	S>B
pH	10/9/73	7.56	7.30	S>B
pH	12/12/73	7.71	7.92	B>S
TKN	9/4/73	0.4	0.28	S>B
TS	8/22/73	204	211	B>S
TS	9/19/73	218	223	B>S

TABLE V-18 Cont'd

SUBSETS BY DEPTH

Parameter	Date	Reading (mg/l where appropriate) Surface	Bottom	
TS	11/18/73	222	288	B>S
CO_2	6/27/73	0	0.93	B>S
CO_2	7/24/73	.083	2.5	B>S
CO_2	10/9/73	.17	.5	B>S
CO_2	11/18/73	1.08	.67	S>B
CO_2	12/4/73	.92	1.42	B>S
T (°F)	6/12/73	61.4	58.2	S>B
T	6/27/73	61.9	50.4	S>B
T	7/24/73	70.0	43.5	S>B
T	8/7/73	75.5	72.4	S>B
T	8/22/73	74.2	57.9	S>B
T	9/4/73	81.8	72.6	S>B
T	10/9/73	60.8	56.7	S>B
T	11/18/73	45.0	43.5	S>B
T	12/4/73	45.0	43.7	S>B

Similarly, depth differences were important for pH, Ch a, TSS, OP, Tur, DO, CO_2, TS, NO_3 and T; that is, for all parameters tested except TP, TCOD, and TKN. It is particularly interesting to note that these three parameters measure, respectively, all forms of phosphorus, all organics, and all forms of nitrogen except NO and NO . It is possible that by measuring such total nutrient parameters, depth differences for soluble or particulate forms were missed.

Date differences were important for all parameters tested except TSS. It is expected that the dynamics of seasonal temperature variation and the induced biochemical seasonal variations would lead to date differences for many water quality parameters.

ANOVA set 1 analyses established depth and date as almost uniformly important factors for all parameters. The objective of ANOVA set 2 analyses was to investigate station differences more closely on an individual date basis. Thus, T, NO_3, pH, DO, CO_2, TS, Ch a, OP and TKN were found to exhibit significant differences between stations for at least one survey date.

ANOVA set 3 (monthly stations at NMPC transect) indicated significant station effects for TTOC, Fe, Mn and Surfactants. Only surfactants exhibited a main effect. The only depth effects were indicated for DO, Cl, Fe and Surfactants. However, only two, relatively closely spaced and shallow stations were available for this analysis, and the locations may have been mixed more than normally because of the influence of the condenser cooling water discharge.

ANOVA set 4 exhibited only date effects, and only TKN and OP had no date effects. Of course, NMP-9 through 12 (intake and discharge samples) would be expected to be similar, and NMP-7 and NMP-8 may have been subject to more than normal lake mixing, as indicated in the previous paragraph.

The second step in interpretation of the ANOVA and homogenous subsets analyses results was to determine patterns exhibited in the homogenous subsets determined by SNK or LSD procedures. Taken as a whole, no consistent patterns were exhibited in the homogenous subsets, either for a given parameter or for a given date.

Based on ANOVA set 2 homogenous subsets (Table V-18), Stations NMP-1 and NMP-2 (NMPW transect) could be found in the same subset for most of the cases in which significant station differences were found. However, for half of these cases one of the stations could be placed in a subset distinct from the other station. Similar statements can be made for the pair of stations NMP-3 and NMP-4. However, stations NMP-5 and NMP-6 could be placed in the same subset only for half of the cases of significant station difference, and one of these stations could be placed in a distinct subset two-thirds of the cases.

The 20 ft. depth stations were even more dissimilar; one station could be placed in a distinct subset 90% of the cases of station differences.

It was interesting to note that stations NMP-2 and NMP-6 could be placed in homogenous subsets almost as often as NMP-1 and NMP-2, and similarly, for NMP-1 and NMP-6. Thus, stations NMP-1, NMP-2 and NMP-6 appear to have been unusually similar.

4. DISSOLVED OXYGEN LOSS

Table V-19 presents a summary of the data on intake and discharge dissolved oxygen values. Percent saturation values were calculated from the observed temperatures assuming exactly one atmosphere of pressure and 20.9% oxygen. Taken as a whole, the data indicate a very low level of oxygen loss, in the order of 0.1 to 0.2mg/l, even though discharge percent saturation values indicate a potential loss on the order of 3mg/l. Data for the dates with more detailed sampling indicate a loss of 0.0 to 0.6mg/l, averaging 0.3mg/l for the six dates.

5. EFFLUENT SURVEY

Table V-20 presents a summary of the storm drain and discharge channel results by averaging the grab sample results over each 24 hour period and over all surveys. Table V-21 presents the oxidation pond results for each survey and as an average over all surveys.

The oxidation pond apparently has a significant effect on percent volatility of solids, suspended solids, fecal coliforms, chlorine residual, and pH. The influent to the pond is significant for its low BOD content and its low pH. Examination of activated sludge plant data verified the consistency of the low pH readings (which were present throughout the system), the consistency of the flow rate of approximately 1gpm, and the consistency of the chlorination. No immediate explanation is available for the low pH.

Oxidation pond effluent is apparently diluted significantly in the discharge channel, by the surface runoff from the swampy area.

TABLE V-19

SUMMARY OF INTAKE AND DISCHARGE AT NINE MILE POINT POWER PLANT

DATE 1973	Δ DO mg/l Intake-Discharge	INTAKE Temp. °C	INTAKE % Saturation	DISCHARGE Temp. °C	DISCHARGE % Saturation
1/3	0.2	4.7	104.7	10.2	118.8
1/4	0.1	4.4	103.8	9.2	115.6
1/16	-1.6	4.3	89.2	20.3	145.1
1/17	0.5	4.9	106.0	21.2	145.8
1/29	-0.1	5.1	100.0	21.2	143.6
1/30	0.8	4.4	109.2	20.6	147.3
2/28	0.5	4.9	107.2	20.9	146.3
2/29	0.8	5.6	107.9	21.2	142.2
3/14	0.4	6.8	113.5	22.8	155.1
3/15	0.5	6.8	112.5	22.4	153.7
3/21	1.2	8.6	123.5	24.4	156.4
3/22	1.0	8.0	116.7	23.7	150.6
3/28	1.2	9.4	115.2	25.3	144.2
3/29	0.7	9.5	113.3	25.6	148.2
4/4	0.4	9.4	118.7	25.4	159.4
4/5	0.8	10.0	121.7	25.9	157.4
4/12	-1.5	4.9	101.5	5.6	115.4
4/19	-0.4	5.7	112.0	5.6	115.4
4/25	0.0	9.5	120.5	12.9	130.6
4/26	0.1	8.4	119.4	12.9	132.0
5/2	-0.1	6.6	108.2	6.8	109.6
5/3	0.3	7.2	110.4	7.3	108.7
5/9	0.3	7.4			
5/10	0.4	7.5			
5/16	0.0	9.5	110.0	9.4	112.0
5/23	-1.5	10.7	112.5	10.9	114.7
5/30	0.1	12.2	107.8	12.3	108.0
6/6	0.1	14.4	119.2	14.7	121.9
6/13	0.2	17.7	125.8	18.0	124.7
* 6/21	0.3	11.4	102.6	20.4	120.0
* 6/22	0.0	13.3	107.9	22.7	129.1
* 6/27	0.6	19.4	124.9	33.0	151.0
7/4	0.6	22.2	119.1	38.2	145.1
7/13	0.0	25.8	92.4	40.9	117.3
7/19	-0.1	22.5	83.6	37.7	109.4
7/25	0.2	22.0	108.1	35.7	133.5
8/2	-0.2	22.9	86.8	38.1	114.6
8/8	0.0	25.6	99.7	40.5	125.5
* 8/15	0.0	25.9	91.0	40.9	115.3
8/16	0.0	25.7	87.0	40.8	109.7
8/22	0.0	23.2	94.6	38.3	120.5
8/29	0.0	24.1	95.4	37.7	118.9
9/5	0.0	27.1	98.2	41.5	124.1
9/12	0.1	23.7	94.1	38.4	118.4
9/19	-0.1	21.6	92.4	36.8	121.4
9/26	0.0	18.2	107.1	33.4	139.2
10/3	0.5	16.0	100.5	29.5	124.8
10/11	0.3	14.2	93.1	27.2	115.9
* 10/17	0.6	14.8	96.9	28.0	122.6
* 10/18	0.2	14.7	93.2	16.0	94.5
10/25	0.2	12.4	90.2	20.8	104.5
10/31	0.2	12.2	91.4	27.0	123.1
11/8	0.1	7.9	92.5	20.2	120.0
11/14	-0.5	8.6	87.5	21.9	121.1
11/21	0.2	8.5	95.8	20.6	121.4
11/28	-0.2	7.4	35.7	7.0	95.5
12/3	0.2	7.0	94.3	19.8	122.1
12/19	0.5	6.6	101.4	19.4	129.0
12/26	-0.1	7.8	106.5	19.5	128.6

Note: averages are generally based on four intake and discharge measurements, but dates marked with an * involved 12 to 24 intake and discharge measurements.

TABLE V-20

NINE MILE POINT EFFLUENT ANALYSIS
DAILY AVERAGE AT DISCHARGE CHANNEL AND STORM DRAIN

Parameter	DISCHARGE CHANNEL						STORM DRAIN					
	9/5-6	9/26-27	10/31-11/1	11/28-29	12/27-28	Avg. Over Time Period	9/5-6	9/26-27	10/31-11/1	11/28-29	12/27-28	Avg. Over Time Period
Total Solids mg/l	900	713	370	243	104	466	203	248	205	290	273	244
TDS mg/l	520	535	345	238	98	327	194	243	196	280	263	235
TSS mg/l	380	278	26	7	5	139	9	7	10	10	10	9.2
TVS mg/l	174	180	111	86	38		70	103	60	70	63	73
NH_3-N mg/l	3.89	0.165	0.80	0.336	0.028		0.792	0.006	0.30	0.253	0.075	
NO_3-N mg/l	0.90	0.203	2.06	0.221	0.155	.71	0.235	0.053	0.159	0.386	0.809	.328
T. Phos. mg/l	2.35	0.832	0.808	0.103	0.064	.83	0.040	0.032	0.078	0.047	0.056	.051
Ortho PO_4-P mg/l	1.44	0.622	0.453	0.045	0.008	.51	0.021	0.02	0.036	0.026	0.012	.023
Sulfate mg/l	85.7	52.5	56.9	58.2	14.3	53.5	26.4	27.1	31.6	43.4	41.1	33.9
Sulfite mg/l	0	1.13	0	0	0	.23	0	1.0	0	0	0	.2
Chloride mg/l	54.2	49	23	14	7	29	33.2	34	29	63	50	41.8
Chlorine Residuals mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Phenols mg/l	0	0	0.003	0	0	.001	0.013	0	0	0	0	.003
Surfactants mg/l	0.014	0.055	0.053	0.05	0.062	.047	0.004	0.035	0.02	0.025	0.037	.024
Total Coliform #/100ml	3600	8233	2067	160	45	2821	795	2260	260	308	315	788
Fecal Coliform #/100ml	8203	98	323	27	7	1732	133	4	9	19	18	36.6
Alkalinity as $CaCO_3$ mg/l	173	217	167	111	35	141	73	84	88	110	100	91
BOD mg/l	9	6	4	2	3	4.8	1	1	2	1	1	1.2
COD mg/l	110	31	47	46	35	53.8	38	20	9	19	18	36.6
pH mg/l	7.5	7.53	7.45	7.38	6.95	7.4	8.51	8.3	8.16	8.04	7.91	8.2
TKN mg/l	6.31	4.25	1.14	112.8		31	0.438	0.265	0.75	136.3		
Organic - N mg/l	-	<0.008	0.738	0.065		.27	-	0.024	0.516	0.025		
Fe mg/l	-	5.54	-	0.306			-	0.60	-	0.342		.47
Zn mg/l	-	0.126	-	0.018		.068	-	0.066	-	0.036		.051
Si mg/l	9.45	-	-	-			2.367	-	-			

TABLE V-21

ANALYSIS OF INFLUENT/EFFLUENT AT POWER PLANT OXIDATION POND - 24 HOUR COMPOSITES

	INFLUENT						EFFLUENT					
PARAMETERS	9/5-6	9/26-27	10/31-11/1	11/28-29	12/27-28	Avg.	9/5-6	9/26-27	10/31-11/1	11/28-29	12/27-28	Av
Total Solids mg/l	600	650	590	600	700	628	410	510	510	470	500	480
Total Dis. Solids mg/l	570	620	560	580	610	588	400	500	500	460	490	470
Total Sus. Solids mg/l	30	35	26	18	95	41	8	6	7	7	14	8.4
Total volatile solids mg/l	280	230	200	190	270	234	120	145	175	125	165	146
NH_3-N mg/l	6.52	8.42	0	15.18	3.74	6.77	5.02	.023	0	8.92	10.9	
NO_3-N mg/l	1.46	1.87	.779	23.40	69.12		2.98	2.99	1.22	12.6	34.5	
T. Phosphorus mg/l	5.90	5.83	7.72	6.53	12.87			3.04	4.84	3.10	7.28	
Ortho PO_4-P mg/l	4.59	3.18	5.77	4.52	4.67	4.55	5.71	2.11	3.70	3.06	4.12	3.7
Sulfate mg/l	88.9	123.7	106.0	130.6	126.4	115	66.5	73.3	108.	91.6	80.3	83.9
Sulfite mg/l		6.0	0	0	0			1.0	0	0	0	
Chloride mg/l	41.3	85	92	64	94	75	31.5	69	61	48	45	51
Chlorine Residual mg/l	6.0	4.0	<0.1	<0.1	< .1		<0.1	<0.1	<0.1	<0.1	<.1	<.1
Phenols mg/l		0	.013	0	0	0		0	.007	0	0	0
Surfactants mg/l	.036	.09	.06	.08	.085	.07	.054	.08	-	.07	.060	.06
Total Coliform No. /100ml	0	0	3180	1120	85		0	2190	1655	260	5	
Fecal Coliform "	0	0	1775	60	5		0	19	70	23	1	
Alkalinity as $CaCO_3$ mg/l	0	0	0	0	0	0	100	90	43	36	36	61
BOD mg/l		1	10	3	6		8	6	9	10	7	8
COD mg/l	145	95	60	29	385		200	110	50	25	195	116
pH	5.45	4.35	4.25	4.85	4.42		7.80	7.00	6.88	6.75	6.78	
TKN mg/l	6.31	4.25	1.14				.44	.27	.56			
Cr mg/l		< .008		<.008				<.008		<.008		

NOTE: Averages for parameters with high multiple ranges were not computed.

6. BOTTOM SEDIMENT CHARACTERISTICS

Chemical characteristics for the seven sediment samples collected are presented in Table V-22 along with values of total phosphate-P and COD in the water present in the collection containers due to sampling procedures. All of the sediments were sandy and had the low organic content and low moisture content expected for near-shore sediments. However, two samples had much higher organic content than the other five samples, as evidenced by both COD and TKN results.

When detected, metals concentrations were reasonably uniform except for the relatively high value of chromium (as compared to chromium values at other stations) at the FitzPatrick plant transect in 20 ft. of water. Total phosphorus values were also reasonably uniform, varying from .013% to .036%.

The significance of the results can be estimated by comparison to criteria for sediment constituents. The criteria for determining the acceptability of dredged spoil disposal to the nation's waters as of May 1971 are given below. Although the use of these criteria has been supplanted by other types of guidelines, they are still useful for comparison purposes.

Sediments in Fresh and Marine Waters	Concentration % (dry wt. basis)	mg/100g dry wt.
Volatile Solids	6.0	6,000
COD	5.0	5,000
TKN	0.10	100
Oil-Grease	0.15	150
Mercury	0.0001	0.1
Lead	0.005	5
Zinc	0.005	5

TABLE V-22

NINE MILE POINT SEDIMENT CHARACTERISTICS

NO	SAMPLE IDENTIFICATION / PARAMETERS	FITZ 20' GRAB 1205	NMPE 20' GRAB 1310	NMPW 20' GRAB 1000	NMPP 20' GRAB 1100	FITZ 40' GRAB 1140	NMPE 40' GRAB 1300	NMPW 40' GRAB 0950
1	COD mg/100g dry wt.	276	2837	265	293	344	389	2426
2	TP mg/100g dry wt.	16.70	18.74	13.31	15.63	19.21	36.20	22.77
3	TKN mg/100g dry wt.	10.39	49.82	4.84	10.25	10.24	10.82	45.15
4	Moisture content %	19.70	24.32	17.15	18.77	21.06	23.01	24.48
5	TS %	80.30	75.68	82.85	81.23	78.94	76.99	75.52
6	TVS %	0.52	0.43	0.36	0.26	0.20	0.40	0.70
7	Cr mg/100g	21.13	2.16	0.75	1.54	1.79	2.57	1.24
8	Cu mg/100g	0.70	0.34	0.16	0.17	<D.L.	<D.L.	0.89
9	Hg mg/100g	1.30	0.71	<D.L.	0.79	3.38	2.49	2.91
10	Zn mg/100g	4.70	<D.L.	<D.L.	<D.L.	<D.L.	5.04	<D.L.
11	Supernatent COD mg/l	25	26	20	47	157	17	40
12	Supernatent TP mg/l	0.14	0.30	0.16	0.15	0.18	0.27	0.20

All values were within the above limits except those for mercury. It is suspected that the relatively high values for mercury were due to interferences in the relatively non-sensitive flame atomic absorption method used for analyses.

The COD and TP values for the supernatant waters within the sample containers were, with one exception, similar to values found for Lake Ontario in that area. Therefore, little material measured by these two tests leached into the supernatant during handling of samples.

D. SUMMARY AND CONCLUSIONS

An intensive water quality investigation was conducted on Lake Ontario near Nine Mile Point from late March to December 1973. The objectives of this investigation were to define chemical quality in this area, including spatial and temporal variations, and to support ecological studies. Samples or field measurements were taken along three main transects - NMPW (1.8 miles west of the Nine Mile Point Nuclear Station Unit 1), NMPP or NMPC (at the plant), and NMPE (2.2 miles east of the plant) - in depths of water varying from 20 to 100 ft. Sample frequency varied from twice per week to once per month, and analyses varied from simple field measurements to comprehensive chemical analyses. Special programs included sediment analyses, dissolved oxygen loss in condenser cooling water and storm drain and sanitary waste treatment plant effluent sampling.

The results of these extensive analyses are presented and discussed in the following section in terms of previous Lake Ontario studies, general water quality and biochemical patterns on the basis of qualitative and quantitative

data analyses, including statistical data analyses. Key conclusions are presented below.

1. WATER QUALITY

a. Two major mechanisms affect water quality in the study area: transient vertical temperature variation and algal growth. Both mechanisms are affected by regular seasonal temperature variations and by irregular hydrodynamic phenomena.

b. The regular seasonal temperature variations cause a fairly regular dissolved oxygen variation with decreased dissolved oxygen paralleling increased temperature such that oxygen saturation remains in the 70 to 90% range.

c. The regular seasonal temperature variations cause algal growth variations with peak growth irregularly spread over the June to October period. This algal growth causes associated changes in parameters which reflect the presence and growth of algae themselves (e.g., Chl a and TKN) and which reflect algal metabolism (e.g., NO_3-N, CO_2, and Si).

d. Variations in other nutrients normally related to algae and algae growth cannot be directly explained on the basis of algal variations (e.g., total and orthophosphate phosphorus).

e. The irregular and unstable vertical temperature variation interacts with suspected oxidative processes in hypolimnion waters to cause high CO_2, low pH, high NO_3, and slightly low DO values in bottom waters when significant variation is present.

f. Taken as a whole, the water quality near Nine Mile Point is very similar to that expected for offshore Lake Ontario waters from previous studies over the last decade. Concentration of major ions and dissolved nutrients are, in particular, similar to these expected values.

g. Water quality parameters reflecting particulate matter are distinctly higher than expected for offshore waters. This is probably due to proximity to point and diffuse sources of pollution and to resuspension of bottom sediments.

h. The concentration of Fe, Mn and Si are also higher than expected values for offshore waters for similar reasons.

i. Cu and Zn are consistently present at detectable levels, along with Fe and Mn; however, the other trace metals (Cd, Cr, Hg, Se, Pb, Al, Ni, V, Ag and As) are rarely if ever present at detectable levels. Ba and Be are somewhat more likely to be present at detectable levels, but as a whole, trace metals do not appear to be present at levels which would cause toxicity problems.

j. There is no significant difference at the 95% confidence level between condenser cooling intake and discharge water for all 48 parameters measured.

k. A number of parameters are quite variable and have a skewed probability distribution with relatively few high values and relatively many low values. These include orthophosphate, total phosphorus, total coliforms, fecal coliforms, NH_3-N, Fe, Mn, Zn,

TSS, turbidity, Si and a number of trace metals. This variability at a low level is characteristic of relatively non-polluted water.

1. Analysis of variance (ANOVA) tests were more useful for bi-monthly samples (twice per month) than for monthly samples because of increased spatial and temporal coverage. The following conclusions reflect the results of ANOVA and related analyses.

(i) significant variation effects were attributed to depth and date for most parameters tested.

(ii) significant variation effects were attributed to station for pH, DO, CO_2, NO_3, and T using 3-way ANOVA (testing depth, date, station effects). These same parameters were found to be significantly correlated using linear regression analysis for pairs of values for retrieval category 1 (individual stations and depths, combined dates).

(iii) significant variation effects were also attributed to station for TS, Ch a, OP, and TKN on selected dates using 2-way ANOVA.

(iv) stations on transect NMPW were similar, even when station effects were significant, but one station could be placed in a distinct, homogenous subset half the time. Stations on transect NMPP (NMPC) showed similar behavior.

(v) stations NMP-1 and NMP-6 were relatively similar, as were NMP-2 and NMP-6. Thus, NMP-1 and NMP-2 on transect NMPW and NMP-6 on transect NMPE may form a reasonable boundary for local variations.

(vi) stations on transect NMPE were relatively dissimilar, as were three 60 foot depth stations and the three 20 foot depth stations. Thus, more along-shore (east-west) variation was evident than offshore variation.

2. TEMPERATURE

The 1973 temperature data provide more detail and continuity of observations than had previously been reported in the vicinity of Oswego-Nine Mile Point. These data indicate many of the dynamic features of lake stratification which have been reported in published literature.

Alternating periods of heating and cooling at the water surface combined with wind mixing produce the sharp temperature gradients which then propagate deeper in the Lake with time during the summer. In the uppermost layers, surface heating generates the stable stratification most frequently observed in summer. However, surface cooling produces cool unstable surface water which enhances vertical convective mixing producing an uppermost layer of more uniform temperature.

Vertical temperature profiles revealed the existence of transient thermal gradients equal to or greater than 1°C per meter (1.8°F per 3.2 ft.) throughout the study area. The gradients appeared to be seasonal in that they exist primarily in the summertime. They were not "seasonally stable," since they were generated and destroyed by surface heating and cooling and mixing within the water column over periods dependent upon meteorological conditions. Although gradients

were observed on sequential weeks for up to a three week period, the gradients observed were at different temperatures and at different depths from week to week and, therefore, were not persistent. In addition, when the gradients were observed, they appeared to be uniform from station to station.

3. DISSOLVED OXYGEN LOSS

The passage of water through the condenser cooling system can be expected to cause, on the average, no more than 0.3 mg/l loss of dissolved oxygen.

4. EFFLUENT SURVEY

The secondary treatment system for sanitary wastes provides reasonably good treatment. The main effect of the oxidation pond is to decrease coliform and to increase pH, probably through algal conversion of CO_2, to O_2.

5. SEDIMENT CHARACTERISTICS

All sediment samples were sandy and had low organic and low moisture content expected for near-shore sediments. Two samples had much higher organic content than the others; and one other sample had relatively high chromium content. Otherwise, the samples were relatively uniform in content for COD, TP, TKN, TS, TVS, Cr, Cu, Hg, and Zn.

Relatively high values reported for Hg (up to 3.4 mg/100g) may have been due to analytical interferences.

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