NIAGARA MOHAWK POWER CORPORATION
POWER AUTHORITY OF THE STATE OF NEW YORK

1974
NINE MILE POINT AQUATIC ECOLOGY STUDIES
LMS Project Nos. 191-21, 22, 23

VOLUME II
(Chapters VII - X)

December 1975

LAWLER, MATUSKY & SKELLY ENGINEERS
ENVIRONMENTAL SCIENCE & ENGINEERING CONSULTANTS
415 ROUTE 303
TAPPAN, NEW YORK 10983

NIAGARA MOHAWK POWER CORPORATION

POWER AUTHORITY OF THE STATE OF NEW YORK

1974

NINE MILE POINT AQUATIC ECOLOGY STUDIES

LMS Project Nos. 191-21, 22, 23

VOLUME II

(Chapters VII - X)

DECEMBER 1975

LAWLER, MATUSKY & SKELLY ENGINEERS
Environmental Science & Engineering Consultants
415 Route 303
Tappan, New York 10983

VII. NEKTON

A. INTRODUCTION

Lawler, Matusky & Skelly Engineers has been conducting ecological studies of the fishery in the vicinity of Nine Mile Point Nuclear Station for three years. The earlier studies (Storr, 1969 a, b; 1970 a-f; 1971 a-e; 1972 a, b, c), employed fathometric surveys and gill net collections, whereas the 1973 and 1974 LMS studies included periodic sampling with trawls, gill nets, and seines.

An analysis of power plant impact upon resident or migratory fish populations includes not only the effect of impingement on the population, but also an analysis of changes in fish behavior, an estimate of mortality, and an analysis of the size and distribution of resident and migratory populations as influenced by plant operation. Results of the 1973 sampling program in the Nine Mile Point vicinity (QLM, 1974) indicated the following:

> Trends noted by Beeton (1969) and Christie (1973), indicating decreases in the stocks of indigenous salmon, lake trout, and whitefish in Lake Ontario, were substantiated.
>
> There were trends indicating an overall increase in the abundance of alewives and rainbow smelt, a small increase in the white perch population, and relatively stable populations of yellow perch and smallmouth bass.
>
> Because the fish community was dominated by one or two species for most of each year, it was not considered to be diverse.
>
> No major change was detected in species diversity, species richness, or evenness over the course of investigations in the Nine Mile Point vicinity. However, these observations were based on a small preoperational data base compared to the data from the more extensive postoperational studies.

The 1974 sampling represents a postoperational assessment of nearby fish communities for Nine Mile Point Nuclear Station Unit 1 and a preoperational study for the James A. FitzPatrick Nuclear Power Plant. Fish populations were sampled to determine:

> variation over time of species abundance and biomass both within and outside of the thermal influence of Nine Mile Point Nuclear Station,
>
> variation in community structure as defined by habitat and species behavior, and
>
> population dynamics of selected species.

B. MATERIALS AND METHODS

1. Sampling Locations and Dates

In 1974, fish collections were made at the same locations as in 1973 (QLM, 1974).

Sampling stations are illustrated in Figure VII-1. The dates during which gill net, trawl, and seining collections were conducted are presented in Table VII-1.

2. Sampling Procedures

a. Seines

Collections were made with a 50 x 8 ft seine with an 8 x 8 x 8 ft bag; two 100 ft lines were attached to bridles at either end of the net. The sampling boat extended the net approximately 100 ft offshore and with the net's 50 ft length parallel to the shore. Two shore crew members stationed 50 ft apart pulled the net into shallow water, from which it was subsequently hauled onto the beach.

b. Trawls

Trawls were conducted parallel to shore in an east to west direction for 15 minutes at a constant RPM. The equipment and procedure used follows that in 1973 (QLM, 1974). Rough bottom topography precluded trawling directly along the bottom.

c. Gill Nets

Experimental multifilament gill nets were set parallel to shore similar to the procedure in 1973 (QLM, 1974).

Special gill net collections were made to provide fish for stomach content analysis. The handling of the fish was similar to the procedure used in 1973 (QLM, 1974) except that the excised stomach and esophagus of each specimen were injected with 5% formalin, and then stored in labeled vials containing 10% buffered formalin until analyses could be completed.

3. Laboratory Procedures

All fishes were identified to the level of species. The weight (to the nearest 0.1 gram), total length (to the nearest mm), and sex were recorded for all fish if more than 60 individuals of a species were collected, the collection was subsampled for the determinations of length, weight, and sex. Total numbers of each species were determined for each collection.

FISH SAMPLING STATIONS

NINE MILE POINT - 1974

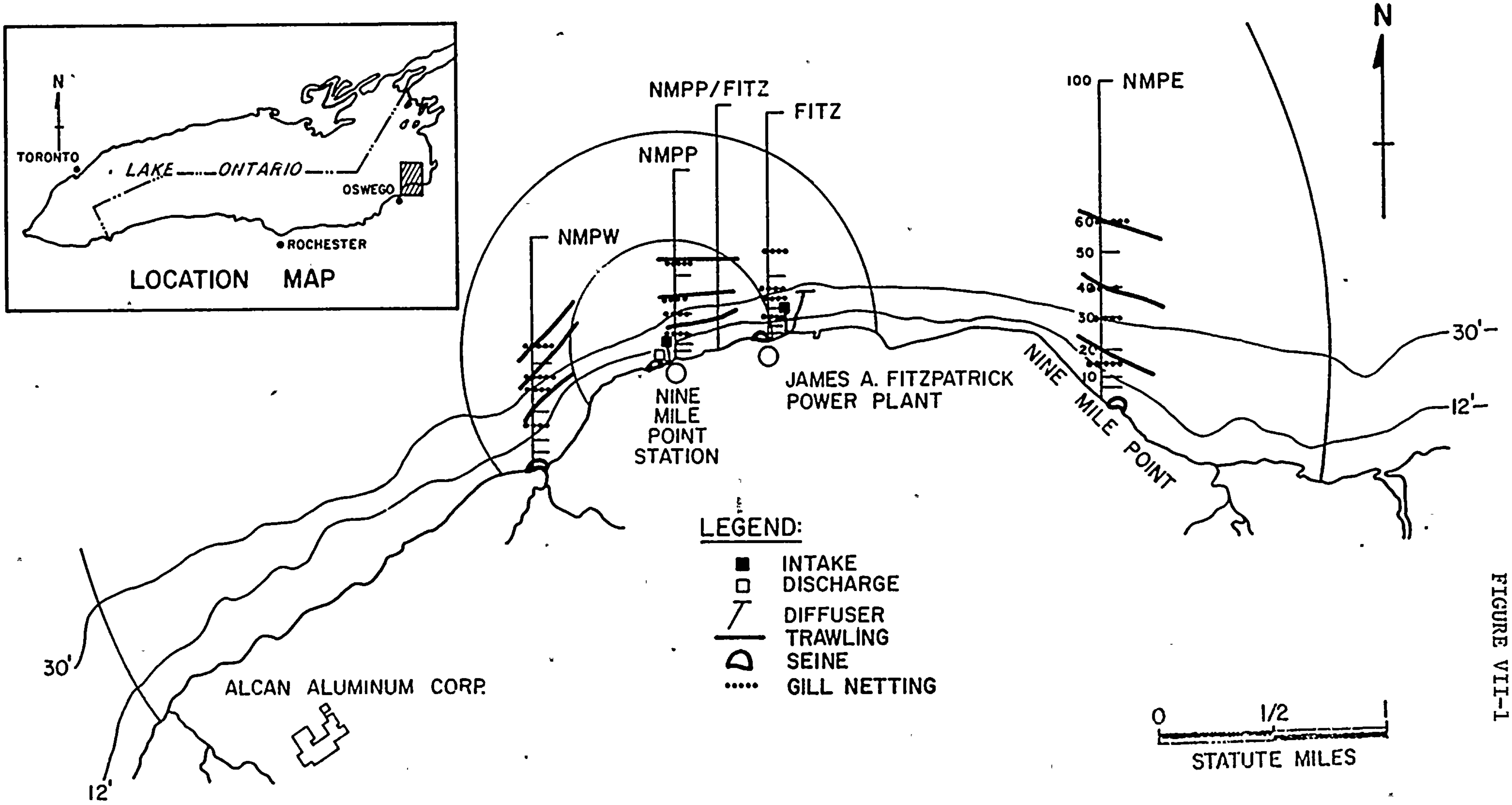


FIGURE VII-1

TABLE VII-1

DATES OF ECOLOGICAL FISH COLLECTIONS

NINE MILE POINT - 1974

GILL NETS	TRAWLS	SEINES	SPECIAL GILL NETS*
11 - 13 APR	18 - 21 APR	22 APR	5 May
17 - 19 APR	26 - 28 APR	29 APR	16 May
23 - 25 APR	6, 9 - 10 MAY	12 MAY	17 May
6 - 8 MAY	20 MAY	29 MAY	13 Jun
19 - 21 MAY	6 - 7 JUN	5 JUN	14 Jun
21 - 23 MAY	18 - 19 JUN	19 JUN	17 Oct
3 - 5 JUN	9,13 - 15 JUL	8 JUL	7-8 Nov
5 - 7 JUN	23 - 24 JUL	23 JUL	
17 - 19 JUN	8 - 9 AUG	6 AUG	
19 - 21 JUN	22 - 23 AUG	20 AUG	
9 - 11 JUL	10,18 - 19 SEP	12 SEP	
23 - 25 JUL	24, 26 SEP	25 SEP	
25 - 27 JUL	8 OCT	16 OCT	
7 - 9 AUG	24 - 24 OCT	31 OCT	
20 - 22 AUG	6 - 8 NOV	8 NOV	
9 - 12 SEP	19 NOV	24 NOV	
23 - 25 SEP		13 DEC	
8 - 11 OCT			
24 - 28 OCT			
7 - 9 NOV			
19 - 20 NOV			
6 - 7 DEC			

* Stomach analysis program

Alewives (*Alosa pseudoharengus*), rainbow smelt (*Osmerus mordax*), white perch (*Morone americana*), yellow perch (*Perca flavescens*), and smallmouth bass (*Micropterus dolomieui*) were analyzed for the following parameters:

a. Age and Growth

White perch, alewife, smallmouth bass, and yellow perch scales were removed and analyzed according to methods reported previously (QLM, 1974). Rainbow smelt scales were removed in accordance with the method used by Dryfoos (1965); analytical techniques were the same as those used for the other four species.

The body length-scale length relationship for all sizes and age classes of fish was determined in order to select the proper method of back calculating growth (Hile and Jobes, 1941; Schuck, 1949). Body length-scale length (L/Sc) ratios were calculated from average weighted total body lengths and average weighted total scale lengths for 5 or 10 mm intervals of total body length. The data were arranged by increasing body lengths and inspected for trends of increasing or decreasing L/Sc ratios and/or differences or breaks in the ratios. Regression techniques were used to determine the L/Sc relationship or line of best fit to the body length-scale length data. A Bartlett's test of homogeneity of variances ($\alpha = 0.05$) was conducted prior to the ANOVA on the regression.

Tests of significance of a linear regression and deviation from linearity were made at $\alpha = 0.05$. When the body-scale length relationship was linear, a proportional method for back calculating growth was used. When the body-scale relationship was linear and the L/Sc ratio was constant, the following formula was used:

$$L' = S \frac{L}{SC}$$

where: L' = length of fish in mm when annulus x was formed
S = length of scale from focus to annulus x
Sc = total length of scale
L = length of fish at time of capture

When the L/Sc ratio was determined to be constant for all lengths of a particular species, or constant for certain lengths or age classes, a mean weighted L/Sc ratio was calculated for that species; when the L/Sc ratio was constant but different for certain length intervals of the species being studied, a weighted mean L/Sc ratio was calculated for each interval. A maximum of two such intervals was noted for each species subjected to age and growth

analyses. The weighted mean L/Sc ratio was then used to "correct" the scale measurements. The total body lengths were divided by the weighted mean L/Sc ratio and a new "corrected" total scale length was generated. The corrected total scale length was then divided by the actual total scale length. The quotient was used as a correction factor to multiply each annulus measurement for that particular fish. If two constant L/Sc ratios were evident over the range of lengths and/or age classes, a different correction factor was used for particular range of lengths.

b. <u>Coefficient of Maturity</u>

Gonads (ovaries or testes) were excised from 20 fish (10 females, 10 males) chosen at random from each collection for each of the five selected species, and weighed to the nearest 0.01 gram. Coefficient of maturity was determined by the following formula:

$$\text{Coefficient of maturity} = \frac{\text{Gonad wt.}}{\text{Fish wt.} - \text{Gonad wt.}} \times 100$$

Approximate spawning time was determined by graphing the seasonal change in the coefficient of maturity (Nikolsky, 1963).

c. <u>Fecundity</u>

Ovaries were removed from alewives, white perch, rainbow smelt, and yellow perch captured just prior to the approximated spawning time and fixed in modified Gilson's fluid (Bagenal and Braum, 1971). A total of 40 ovaries evenly distributed among the mature age classes of each species were collected where possible. Differences in egg sizes for the four species dictated that two methods be used for estimating fecundity; these methods were previously described by LMS (QLM, 1974).

d. <u>Stomach Analysis</u>

Food preferences of white perch and yellow perch were determined by stomach analysis; insufficient numbers of smallmouth bass were captured to permit similar studies to be conducted for this species. Perch used in this analysis were separated into size (length) groups so that possible changes in food preference with increased growth would become apparent (Table VII-2).

Stomach analyses methods follow those reported by LMS (QLM, 1974).

TABLE VII-2

SIZE GROUPS FOR FOOD PREFERENCE STUDIES

NINE MILE POINT - 1974

SIZE CATEGORY	LENGTH (cm)	
	WHITE PERCH	YELLOW PERCH
0	0 - 8.0	0 - 9.0
1	8.1 - 12.1	9.1 - 12.3
2	12.2 - 17.7	12.4 - 15.4
3	17.8 - 20.2	15.5 - 18.7
4	20.3 - 21.8	18.8 - 21.7
5	21.9 - 23.3	21.8 - 24.2
6	23.4 - 24.2	24.3 - 26.6
7	24.3 - 25.0	26.7 - 28.3
8	25.1 - 26.0	28.4 +
9	26.1 +	

C. RESULTS AND DISCUSSION

1. Community Composition

A total of 97,493 fishes were collected by all three types of sampling gear over the nine-month survey period in 1974 (Table VII-3); this represented a 63% increase over 1973 when 59,672 fishes were collected over a seven month collection period.

A total of 42 species were collected in 1974 as compared to 37 species in 1973 (Table VII-4). Only three species were not collected in the lake sampling program in 1974 that were collected in 1973: black bullhead (*Ictalurus melas*), banded killifish (*Fundulus diaphanus*), and bluegill sunfish (*Lepomis macrochirus*). The species collected by LMS for the first time in the 1974 lake sampling program were redfin pickerel (*Esox americanus*), brook silverside (*Labidesthes sicculus*), coho salmon (*Oncorhynchus kisutch*), rainbow trout (*Salmo gairdneri*), northern hogsucker (*Hypentelium nigricans*), lake trout (*Salvelinus namaycush*), bowfin (*Amia calva*), and channel catfish (*Ictalurus punctatus*). All of these fish species have been previously reported by other investigators of Lake Ontario (Scott and Crossman, 1973).

The alewife was the most frequently collected species and accounted for the greatest percentage of fish caught in both 1973 (QLM, 1974) and 1974 (Table VII-5). The percent composition for alewives in 1973 was 75% and in 1974, 74%. The percent composition for the remaining species in 1974 was similar to that in 1973: 12% rainbow smelt (2% in 1973); 5.6% spottail shiner (5% in 1973); 3% white perch (7% in 1973); and 1.5% yellow perch (4% in 1973). The differences between 1973 and 1974 were probably related to the more frequent use of multifilament gill nets than monofilament gill nets. The remaining 37 species collected in 1974 represented 4% of the number of fish collected.

Species diversity (H), evenness (J), and species richness (S-1) were calculated separately for the surface and bottom gill net data, for each transect, and for each month using the Brillouin Index (Appendix Tables VII-1, 2).

A plot of these data by month (Figure VII-2) illustrates several phenomena. First, there are consistent differences in the diversity values among the sampling transects: NMPW and NMPP transects generally have lower values throughout the year. Secondly, diversity reaches a peak during October, but begins to increase toward this peak during September. Peculiarly enough, catch per effort during these months was low compared to other months (Table VII-5).

TABLE VII-3

FISH COLLECTED BY SEINES, TRAWLS, AND GILL NETS

NINE MILE POINT - 1974

Common Name	Seines	Surface Trawl		Bottom Trawl		Total Trawls		Surface Gill Nets		Bottom Gill Nets		Total Gill Nets		TOTAL	
	#	#	#/effort	#	#/effort	#	#/effort	#	#/effort	#	#/effort	#	#/effort	#	% Comp.
Alewife	3351	679	2.35	2514	8.67	3193	5.41	36,917	41.97	31,113	30.74	68,030	35.57	74526	74.60
Rainbow smelt	2	67	0.23	109	0.39	176	0.31	5,622	4.32	5902	3.63	11,524	3.93	11702	11.71
Spottail shiner	14	4	0.01	13	0.04	17	0.03	50	0.04	5,377	3.98	5,427	2.29	5458	5.60
Emerald shiner	77	23	0.08	7	0.02	30	0.05	1	< .01	1	< .01	2	< .01	109	0.15
Mottled sculpin		1	< .01	5	0.02	6	0.01			17	0.01	17	0.01	23	0.02
Threespine stickleback	6	16	0.05	5	0.02	21	0.03			2	< .01	2	< .01	29	0.03
Trout perch				5	0.02	5	0.01	3	< .01	512	0.49	515	0.28	520	0.53
Yellow perch	1							10	0.01	1,558	1.52	1,568	0.87	1569	1.50
White perch	108	3	0.01	4	0.02	7	0.01	100	0.11	3,023	3.01	3,123	1.77	3238	3.24
White sucker										660	0.57	660	0.32	660	0.68
White bass								25	0.03	29	0.03	54	0.03	54	0.06
Rock bass				2	0.01	2	< .01	1	< .01	211	0.21	212	0.12	214	0.22
Smallmouth bass	7							3	< .01	261	0.27	264	0.16	271	0.28
Gizzard shad	2			3	0.02	3	0.01	573	0.54	427	0.37	1,000	0.45	1005	1.03
Johnny darter	1			5	0.02	5	0.01			2	0.01	.2	< .01	8	0.01
Brown bullhead	2							4	< .01	58	0.07	62	0.04	64	0.07
Lake chub								1	< .01	167	0.14	168	0.08	168	0.17
American eel		1	0.01	1	< .01	2	< .01	1	< .01	2	< .01	3	< .01	5	0.01
Sea lamprey								4	< .01	2	< .01	6	< .01	6	0.01
Pumpkinseed	3									12	0.01	12	.01	15	0.02
Carp										1	< .01	1	< .01	1	< 0.01
Black crappie										1	< .01	1	< .01	1	< 0.01
Longnose dace	1													1	< 0.01
Brown trout								60	0.08	15	0.02	75	0.04	75	0.08
Stonecat										85	0.05	85	0.03	85	0.09
Chinook salmon		1	< .01			1	< .01	16	0.02	15	0.02	31	0.02	32	0.03
Yellow Bass										1	< .01	1	< .01	1	< 0.01
Golden shiner	4							1	< .01			1	< .01	5	0.01
Gar				1	< .01	1	< .01	2	< .01	1	< .01	3	< .01	4	< 0.01
Freshwater drum										3	< .01	3	< .01	3	< 0.01
Burbot										1	< .01	1	< .01	1	< 0.01
Walleye										3	< .01	3	< .01	3	< 0.01
Brook silverside	1													1	< 0.01
Redfin pickerel	1													1	< 0.01
Lake trout										4	< .01	4	< .01	4	< 0.01
Rainbow trout								21	0.03	4	0.01	25	0.02	25	0.03
Coho salmon								10	0.01	3	< .01	13	0.01	13	0.01
Northern hogsucker										2	< .01	2	< .01	2	< 0.01
Shallow water cisco										1	< .01	1	< .01	1	< 0.01
Bowfin								1	< .01			1	< .01	1	< 0.01
Channel catfish										3	< .01	3	< .01	3	< 0.01
Northern pike								1	< .01	4	< .01	5	< .01	5	0.01
UID	1							1	< .01			1	< .01	2	< 0.01

GRAND TOTAL 99,917

TABLE VII-4

SPECIES INVENTORY OF FISH COLLECTED IN THE NINE MILE POINT
VICINITY OF LAKE ONTARIO IN 1973 AND 1974
NINE MILE POINT - 1974

Family	Scientific Name	Common Name	Collected in 1973	Collected in 1974
Petromyzontidae	Petromyzon marinus	Sea lamprey	x	x
Lepisosteidae	Lepisosteus osseus	Longnose gar	x	x
Anguillidae	Anguilla rostrata	American eel	x	x
Clupeidae	Alosa pseudoharengus	Alewife	x	x
	Dorosoma cepedianum	Gizzard shad	x	x
Salmonidae	Salmo gairdneri	Rainbow trout	o	x
	S. trutta	Brown trout	x	x
	Oncorhynchus kisutch	Coho salmon	o	x
	Oncorhynchus tshawytscha	Chinook salmon	x	x
	Coregonus arteaii	Cisco or Lake herring	x	x
	Salvelinus namaycush	Lake trout	o	x
Osmeridae	Osmerus mordax	Rainbow smelt	x	x
Esocidae	Esox americanus	Redfin pickerel	o	x
	Esox lucius	Northern pike	x	x
Cyprinidae	Cyprinus carpio	Carp	x	x
	Notemigonus crysoleucas	Golden shiner	x	x
	Rhinichthys cataractae	Longnose dace	x	x
	Notropis atherinoides	Emerald shiner	x	x
	N. cornutus	Common shiner	x	x
	N. hudsonius	Spottail shiner	x	x
	Couesius plumbeus	Lake chub	x	x
Catostomidae	Catostomus commersoni	White sucker	x	x
	Hypentelium nigricans	Northern hogsucker	o	x
Ictaluridae	Ictalurus melas	Black bullhead	x	o
	I. nebulosus	Brown bullhead	x	x
	I. punctatus	Channel catfish	o	x
	Noturus flavus	Stonecat	x	x
Percopsidae	Percopsis omiscomaycus	Trout perch	x	x

TABLE VII-4 (Continued)

Family	Scientific Name	Common Name	Collected in 1973	Collected in 1974
Gadidae	Lota lota	Burbot	x	x
Atherinidae	Labidesthes sicculus	Brook silverside	o	x
Cyprinodontidae	Fundulus diaphanus	Banded killifish	x	o
Gasterosteidae	Gasterosteus aculeatus	Threespine stickleback	x	x
Cottidae	Cottus bairdii	Mottled sculpin	x	x
Percichthyidae	Morone americana	White perch	x	x
	M. chrysops	White bass	x	x
	M. mississippiensis	Yellow bass	x	x
Centrarchidae	Ambloplites rupestris	Rock bass		
	Lepomis gibbosus	Pumpkinseed	x	x
	L. macrochirus	Bluegill sunfish	x	o
	Micropterus dolomieui	Smallmouth bass	x	x
	Promoxis nigromaculatus	Black crappie	x	x
Percidae	Etheostoma nigrum	Johnny darter	x	x
	Perca flavescens	Yellow perch	x	x
	Stizostedion vitreum	Walleye	x	x
Sciaenidae	Aplodinotus grunniens	Freshwater drum	x	x
Amiidae	Amia calva	Bowfin	o	x

x – Collected
o – Not collected

TABLE VII-5

ABUNDANCE OF FISH CAUGHT IN GILL NET SAMPLING PROGRAM BY TRANSECT AND MONTH
(AVERAGE NUMBER/12 HOURS)

NINE MILE POINT - 1974

NMPN TRANSECT

SPECIES	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
Alewife	30.45 (40.95)	47.00 (71.65)	28.18 (34.57)	47.35 (65.45)	29.48 (61.51)	11.64 (19.98)	6.41 (8.29)	2.81 (5.13)	2.86 (4.02)	22.91
Rainbow smelt	19.78 (24.91)	8.06 (22.08)	0.84 (1.42)	0.06 (0.31)	0.0 (0.0)	0.25 (0.70)	0.59 (1.02)	0.23 (0.52)	0.14 (0.38)	3.33
Spottail shiner	0.63 (1.63)	0.97 (1.99)	0.29 (0.91)	0.81 (2.72)	0.57 (1.20)	0.80 (2.31)	1.08(2.21)	1.98 (5.61)	0.0 (0.0)	0.79
White perch	0.23 (0.53)	0.83 (2.27)	0.66 (1.83)	1.23 (4.26)	0.91 (2.71)	0.49 (1.33)	0.53 (0.89)	0.04 (0.20)	0.0 (0.0)	0.55
Yellow perch	0.13 (0.40)	0.09 (0.37)	0.38 (1.18)	1.02 (3.73)	0.36 ((0.90)	0.29 (0.69)	0.43 (0.96)	0.10 (0.37)	0.14 (0.38)	0.33
Smallmouth bass	0.13 (0.40)	0.09 (0.28)	0.04 (0.19)	0.13 (0.53)	0.16 (0.53)	0.16 (0.50)	0.12 (0.33)	0.06 (0.24)	0.0 (0.0)	0.10
White sucker	0.03 (0.16)	0.06 (0.24)	0.23 (0.57)	0.21 (0.67)	0.18 (0.47)	0.35 (0.67)	0.61 (0.95)	0.25 (0.64)	0.29 (0.49)	0.25
Trout perch	0.05 (0.22)	0.54 (1.04)	0.25 (0.55)	0.08 (0.27)	0.02 (0.13)	0.04 (0.19)	0.04 (0.20)	0.02 (0.14)	0.0 (0.0)	0.12
Gizzard shad	0.13 (0.33)	0.0 (0.0)	0.13 (0.51)	0.02 (0.14)	0.05 (0.23)	0.27 (0.62)	0.02 (0.54)	0.02 (0.14)	0.14 (0.38)	0.11
TOTAL	51.35 (55.44)	57.80 (76.36)	30.32 (35.14)	51.37 (68.22)	32.09 (60.82)	14.60 (20.28)	9.92(12.98)	6.31 (9.99)	3.29 (3.73)	28.56

NMPP TRANSECT

SPECIES	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
Alewife	30.03 (40.49)	50.86 (68.11)	51.96 (79.21)	105.87(184.38)	32.53 (53.47)	9.44 (15.19)	6.48(15.47)	7.88(15.72)	10.29(14.30)	34.59
Rainbow smelt	22.64 (35.01)	5.71 (7.75)	0.32 (0.69)	0.09 (0.46)	0.18 (0.82)	0.31 (0.68)	0.60 (1.02)	0.43 (0.96)	0.0 (0.0)	3.36
Spottail shiner	0.41 (1.23)	1.31 (2.31)	1.43 (5.94)	1.45 (6.51)	0.76 (1.76)	0.67 (1.92)	1.02 (2.82)	1.31 (4.17)	0.29 (0.49)	0.94
White perch	0.26 (0.75)	1.69 (4.65)	0.68 (2.20)	1.91 (5.55)	0.65 (1.58)	1.24 (2.69)	0.83 (1.67)	0.10 (0.31)	0.0 (0.0)	0.82
Yellow perch	0.26 (0.75)	0.69 (1.57)	1.59 (5.08)	1.89 (6.13)	0.53 (1.09)	0.85 (2.04)	1.02 (1.54)	0.18 (0.53)	0.14 (0.38)	0.79
Smallmouth bass	0.10 (0.38)	0.26 (0.78)	0.0 (0.0)	0.23 (0.52)	0.16 (0.46)	0.71 (1.34)	0.15 (0.41)	0.04 (0.20)	0.0 (0.0)	0.18
White sucker	0.10 (0.45)	0.31 (0.80)	0.29 (0.68)	0.66 (1.70)	0.11 (0.37)	0.29 (0.74)	0.54 (0.92)	0.27 (0.57)	0.14 (0.38)	0.30
Trout perch	0.05 (0.22)	0.43 (0.95)	0.32 (0.90)	0.09 (0.28)	0.11 (0.50)	0.04 (0.19)	0.02 (0.14)	0.02 (0.14)	0.0 (0.0)	0.12
Gizzard shad	0.08 (0.35)	0.43 (0.98)	0.0 (0.0)	0.17 (0.52)	0.05 (0.30)	1.02 (1.85)	2.15 (4.36)	2.10 (6.33)	0.14 (0.38)	0.68
TOTAL	54.23 (63.29)	61.51 (84.04)	62.89 (85.50)	112.74(192.02)	35.56 (52.54)	15.20 (16.20)	12.94(19.57)	12.76(20.37)	10.71(14.37)	42.06

( ) = one standard deviation

TABLE VII-5
(Continued)

FITZ TRANSECT

SPECIES	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		AVE.
Alewife	65.56	(63.35)	42.78	(52.[illegible])	39.45	([illegible])	[illegible]	([illegible])	[illegible]	([illegible])	14.07	(23.76)	8.12	(14.21)	14.71	(30.89)	5.27	(8.81)	38.22
Rainbow smelt	39.83	(60.30)	2.97	(4.62)	0.54	(0.81)	0.04	(0.20)	0.15	(0.73)	0.13	(0.43)	0.75	(1.32)	0.80	(1.44)	0.43	(0.53)	5.07
Spottail shiner	2.78	(5.18)	1.19	(3.09)	1.71	(4.86)	6.69	(11.26)	2.91	(5.76)	2.55	(4.75)	7.39	(15.40)	9.06	(20.51)	4.71	(5.71)	4.32
White perch	0.59	(1.30)	1.41	(3.36)	2.82	(9.33)	3.21	(6.20)	2.64	(9.44)	2.86	(7.02)	1.12	(2.17)	0.20	(0.58)	0.14	(0.38)	1.67
Yellow perch	1.12	(3.88)	0.56	(1.40)	1.61	(3.86)	4.35	(7.76)	0.82	(1.87)	1.41	(3.91)	0.90	(1.54)	0.10	(0.31)	0.14	(0.38)	1.22
Smallmouth bass	0.07	(0.26)	0.06	(0.10)	0.05	(0.23)	0.10	(0.31)	0.38	(1.28)	0.77	(2.44)	0.10	(0.36)	0.0	(0.0)	0.0	(0.0)	0.17
White sucker	0.12	(0.40)	0.09	(0.30)	0.55	(1.03)	0.71	(1.60)	0.18	(0.43)	0.59	(1.20)	0.51	(1.01)	0.14	(0.35)	0.14	(0.38)	0.34
Trout perch	0.17	(0.44)	1.03	(2.01)	0.88	(2.58)	0.92	(1.47)	0.65	(1.65)	0.27	(0.82)	0.12	(0.43)	0.06	(0.24)	0.29	(0.49)	0.49
Gizzard shad	0.05	(0.22)	0.63	(1.54)	0.02	(0.13)	0.19	(0.53)	0.13	(0.34)	1.93	(3.62)	1.20	(2.68)	0.96	(4.13)	0.0	(0.0)	0.57
TOTAL	98.10	(89.26)	50.78	(55.75)	47.50	(57.08)	127.79	(153.16)	50.96	(72.35)	24.54	(29.97)	20.22	(23.22)	26.16	(38.86)	11.43	(7.76)	50.83

NIPE TRANSECT

SPECIES	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		AVE.
Alewife	64.08	(79.45)	29.03	(43.97)	32.57	(50.30)	78.70	(100.27)	47.71	(78.70)	13.31	(31.92)	9.39	(12.38)	7.31	(23.52)	1.00	(1.15)	31.46
Rainbow smelt	40.00	(54.69)	2.76	(7.85)	0.95	(1.86)	0.10	(0.36)	0.0	(0.0)	0.15	(0.62)	0.76	(1.16)	0.90	(1.54)	0.43	(0.53)	5.12
Spottail shiner	1.28	(1.96)	3.59	(8.16)	3.50	(8.71)	2.38	(5.05)	1.13	(2.59)	4.09	(10.69)	6.61	(12.10)	0.69	(1.47)	0.71	(1.11)	2.66
White perch	0.41	(0.85)	0.62	(1.41)	2.38	(7.81)	4.46	(11.30)	8.13	(27.98)	7.71	(14.00)	2.10	(3.95)	0.20	(0.54)	0.0	(0.0)	2.55
Yellow perch	0.72	(2.18)	0.71	(1.53)	1.16	(2.36)	1.28	(2.35)	0.80	(1.38)	0.60	(1.40)	1.29	(2.44)	0.22	(0.76)	0.29	(0.76)	0.79
Smallmouth bass	0.13	(0.34)	0.24	(0.78)	0.09	(0.44)	0.12	(0.33)	0.20	(0.48)	0.20	(0.45)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.11
White sucker	0.08	(0.35)	0.21	(0.77)	0.68	(1.08)	0.40	(0.78)	0.32	(1.08)	0.31	(0.63)	0.29	(0.58)	0.33	(0.59)	0.29	(0.49)	0.32
Trout perch	0.21	(0.73)	1.12	(1.98)	0.89	(1.82)	0.30	(0.74)	0.11	(0.37)	0.25	(0.84)	0.41	(0.96)	0.12	(0.39)	0.0	(0.0)	0.38
Gizzard shad	0.03	(0.15)	0.09	(0.38)	0.0	(0.0)	0.06	(0.31)	0.04	(0.19)	0.62	(1.19)	1.22	(3.10)	0.18	(0.67)	0.0	(0.0)	0.25
TOTAL	106.49	(122.72)	38.74	(52.87)	42.09	(57.38)	87.76	(101.99)	55.64	(77.67)	27.65	(38.75)	22.08	(27.60)	10.16	(24.54)	2.71	(1.80)	43.70

( ) = one standard deviation
AVE = Average

SPECIES DIVERSITY (H)* BY MONTH OF FISH COLLECTED IN BOTTOM GILLNETS +

NINE MILE POINT, 1974

* VALUE BASED ON FISH ABUNDANCE IN DAY AND NIGHT COLLECTIONS

+ DEPTH CONTOURS (FT): 15, 30, 40, 60

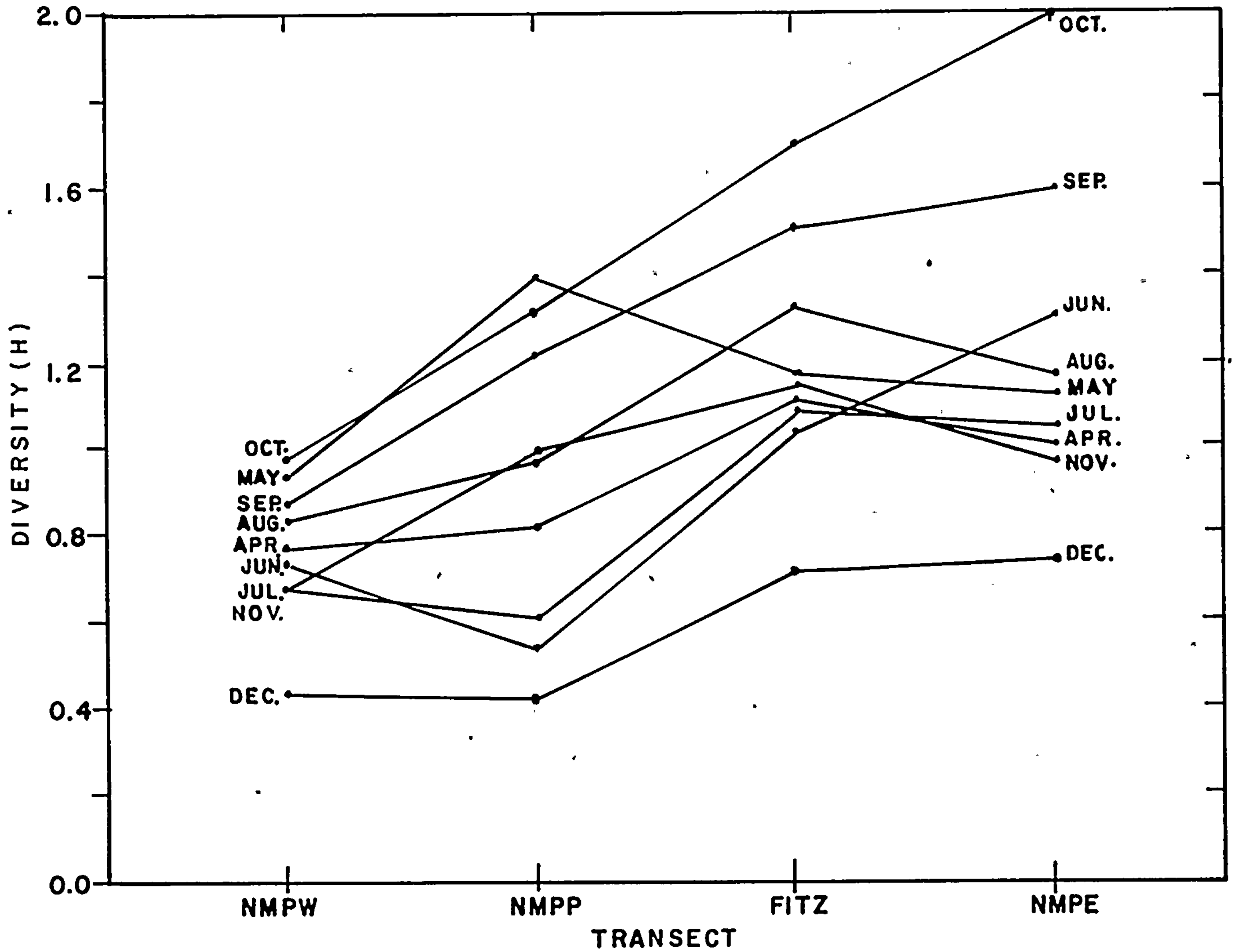


FIGURE VII-2

SPECIES DIVERSITY (H)* BY TRANSECT OF FISH COLLECTED IN GILLNETS+

NINE MILE POINT, 1974

* VALUE BASED ON FISH ABUNDANCE IN DAY AND NIGHT COLLECTIONS
+ SURFACE AND BOTTOM GILL NETS: 30, 40, 60 FT. DEPTH CONTOURS
BOTTOM GILL NETS: 15 FT. DEPTH CONTOUR.

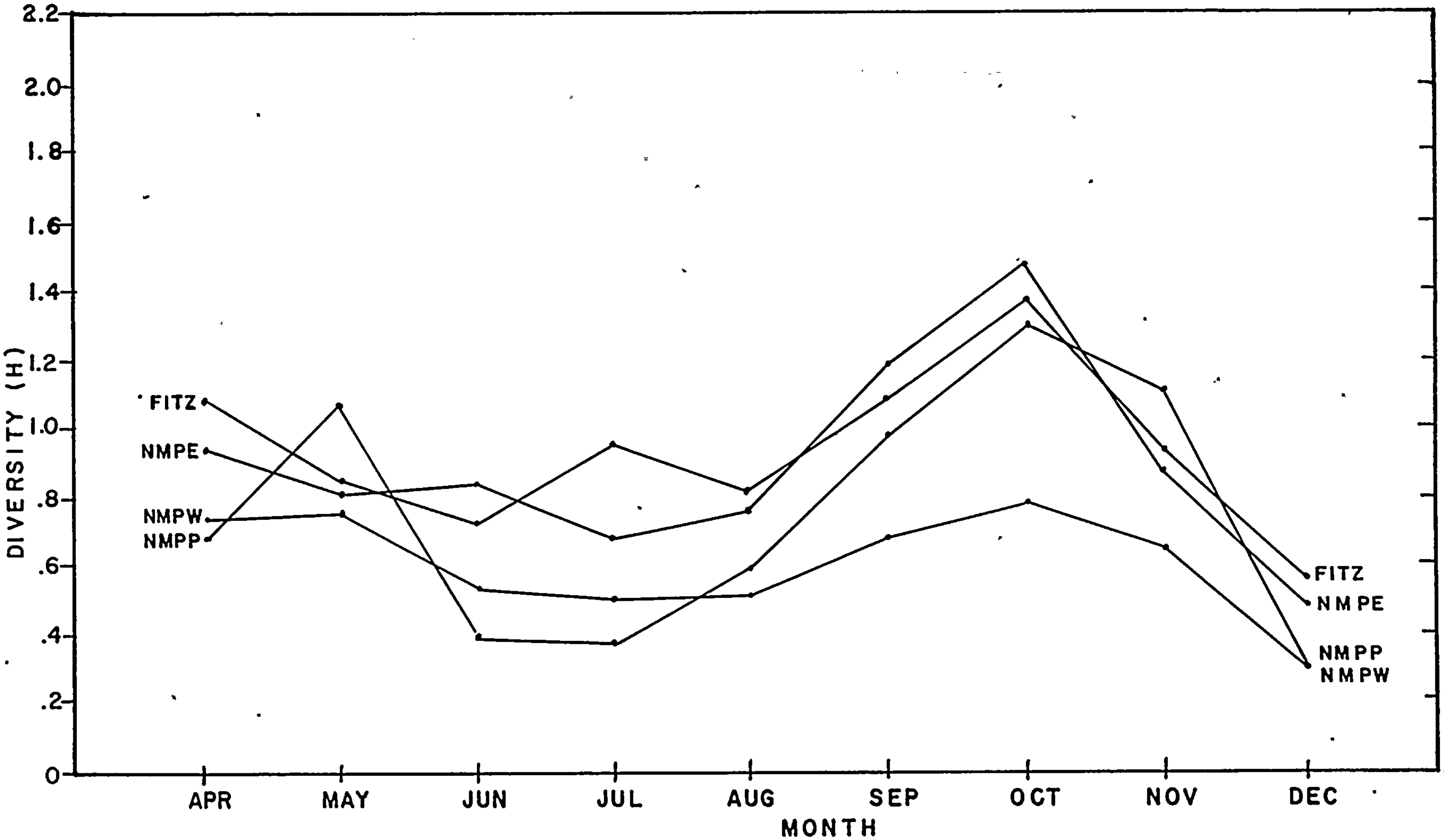


FIGURE VII-3

This increase in diversity is due primarily to the decrease in catch per effort of alewives from September to November. The decreased alewife catch results in a more uniform distribution of individuals among the species, whereas when alewives predominate their numbers cause the diversity (as a measure of heterogeneity) to decrease.

A transect-realted pattern of diversity differences emerges when the diversity data are plotted against the four sampling transects (Figure VII-3). Only the bottom gill net and total gill net data were included in this analysis since the surface collections yielded few fish.

This graph indicates a general trend toward decreasing diversity from east to west in the vicinity of Nine Mile Point, and illustrates the influence of the species-rich Mexico Bay region.

The scatter of the diversity values at any one location indicates the dynamic nature of the fish community at that location. That is, the diversity of the fish community at NMPE is subject to greater fluctuation during the yearly cycle, whereas NMPW is subject to the least change, and the NMPP and FITZ areas are of an intermediate character (Figure VII-3). It may be speculated that the fish community at NMPE is of a more dynamic nature than that at NMPW. Species diversity has been related to community stability by various writers (e.g., Wilson and Bossert, 1971) because of its similarity to the entropy measure used in thermodynamics, i.e., it specifies the degree of uncertainty of the state of being. However, there is no direct mathematical way to relate diversity to stability; in fact, it is doubtful whether any direct relationship could be developed. Nonetheless, modeling of community dynamics utilizes the diversity index as one measure of the complexity of a community, and it is in this connection that diversity values are provided.

In previous years' reports, data on the distribution and abundance of fish were grouped so that species-specific information was lost. Sufficient data were gathered in 1974 in the vicinity of Nine Mile Point to justify a species-specific approach; therefore, the remainder of this section is organized as an in-depth discussion of five abundant species: alewife, rainbow smelt, white perch, yellow perch and smallmouth bass. The remaining 33 species will be considered under the general category of "other species."

It is interesting to note that the top two fish species in biomass and abundance collected in the Nine Mile Point vicinity (alewife and rainbow smelt were introduced into Lake Ontario. In addition to the phenotypic differences between individuals occupying different habitats and for varying lengths of time (e.g., smaller, large-headed alewives from Lake Ontario and larger, relatively smaller-headed

alewives from the North Atlantic), there are numerous behavioral differences. Ecosystem instability due to the introduction of exotic flora and fauna is well documented (Lack, 1944, 1945; Andrewartha and Birch, 1954; Elton, 1958; Dixon, 1964; and Mayr, 1966). For this reason, questions concerning the long-range stability of populations in new habitats, or the normal behavior of individuals, cannot be answered with the same assurance as for stable populations.

This observation points out that the precision with which ecological surveys can aid in the prediction of power plant impact (aside from direct mortality) is dependent upon a multitude of factors, not the least of which is the duration of a particular community structure. For Lake Ontario, into which three of the most abundant species have only recently been introduced, the problems implicit in the analysis of community structure, energy flow, and stability are magnified.

2. Alewife (Alosa pseudoharengus)

a. Trophic Level and Importance

The alewife is an anadromous species that usually inhabits salt water, but returns to fresh water to spawn. It is indigenous to eastern North America from Newfoundland to North Carolina and is now landlocked in many rivers and lakes of Canada and the United States (Scott and Crossman, 1973). Alewives now occur throughout the five Great Lakes, presumably as a result of the passage of Lake Ontario fish through the Welland Canal System.

Although the Lake Ontario alewife population does not currently represent a commercially important resource, a profitable commercial fishery has been operating for several years on Lake Michigan. On Lake Ontario, a pilot project to investigate the economic feasibility of trawling for alewives and smelt is currently being carried out under the joint control of the Industrial Development Branch of the Federal Department of Fisheries and the Ontario Department of Lands and Forests of Canada.

The landlocked alewife is usually considered a nuisance because of its annual die-off and the resultant masses of decomposing carcasses which litter the shoreline and clog municipal and industrial water lines. These die-offs have been attributed to the inability of alewives to tolerate rapid temperature changes, especially after overwintering (Graham, 1957).

In addition to requiring costly cleanup operations, the alewife also represents a biological threat to indigenous lake fish populations. Because adult alewives feed principally on zooplankton such as copepods, cladocerans, mysids, and ostracods, they are

in competition with other fish populations for food; historically, this process invariably leads to the reduction of one population and an increase in another. In Lake Ontario, this may result in the elimination of more desirable forage species such as the emerald shiner and slimy sculpin (Smith, 1973).

Alewives have been reported to be an important food source for large piscivorous fishes such as the lake trout and freshwater burbot. Coho salmon, recently introduced into Lake Michigan, eat large numbers of alewives (Scott and Crossman, 1973), and may reduce the size of alewife populations in the lake. Alewives have also been reported in the stomachs of rainbow trout, cisco, northern pike, smallmouth bass, yellow walleye, and yellow and white perch.

b. Seasonal Distribution and Abundance

Graham (1956) concluded that in the Bay of Quinte region the greatest number of alewives arrived inshore during late June, with the migration ending in late July. The inshore movement of adult alewives in the Nine Mile Point vicinity occurs during April and coincides with the seasonal onset of sexual activity. Spawning activity begins shortly after the arrival of the first schools and reaches its height during the first two weeks of July (Section c.i, Fecundity and Time of Spawning).

The adults leave the inshore waters immediately after spawning, with the majority moving into the deep water of Lake Ontario in late August in the Bay of Quinte region (Graham, 1956). Young-of-the-year stay within the vicinity of the spawning grounds until at least the late larval stage is reached. They then migrate to protected shallow areas from September to December (Graham, 1956). Juvenile alewives migrate inshore in the spring like the adults. They tend to gather in shallow water at dark and at the bottom in 6 to 10 ft of water during daylight hours (Scott and Crossman, 1973).

Most alewives were collected with bottom trawls in May (Appendix VII-3), with beach seines in September (Appendix VII-4), and with gill nets in July (Table VII-5). The distribution of alewives within the vicinity of Nine Mile Point is most accurately reflected in gill net collections. Beach seine collections are selective for fish located close to shore and are usually composed primarily of young fish, and trawling yielded insufficient numbers of fish for precise statistical evaluation.

A three-way analysis of variance (ANOVA) comparing the gill net catch per unit effort by sample depth among three seasons (spring

- April, May, June; summer - July, August, September; and fall - October, November and December) revealed that alewives were more abundant in the evening hours and during the spring and summer periods than during the fall (Appendix VII-5). This trend agrees with previously published observations that alewives return to the deeper water of Lake Ontario following spawning activity (Graham, 1956; Scott and Crossman, 1973).

For surface gill net collections there was no difference in the distribution of fish among the transects (Appendix VII-5). However, bottom gill net collections yielded significantly more alewives from the FITZ transect than from the other three transects (Appendix VII-5). This pattern of distribution, if it remains consistent, may forecast large impingement catches at the FitzPatrick Nuclear Plant.

Two-way analyses of variance were run separately for the day and night gill net collections to compare the distribution of fish among sampling seasons and depths (surface and bottom) so that differences in the diurnal behavior of the fish could be identified (Appendix VII-6). There was no significant interaction between the two variables during daylight hours; there were, however, significantly more fish collected from the bottom than from the surface during daylight hours. Conversely, at night more fish were collected at the surface than at the bottom, and there was a significant interaction between sample depth and season during the night. This may be correlated with the night spawning activity of alewives in shallow waters.

c. <u>Reproduction</u>

(i) Fecundity and Time of Spawning

Spawning time of alewives was determined by examining the coefficient of maturity data for 825 males and 873 females collected in the vicinity of Nine Mile Point from April through November, 1974 (Appendix VII-7, Figure VII-4).

Peak spawning occured during the first two weeks of July, a time when the surface water temperature ranged from 13.5° to 22.0°C (56.3°-71.6°F). The average surface temperature was 20.6°C (69.1°F) while the average bottom temperature was 16.8°C (62.2°F). Similar spawning temperatures have been reported for freshwater alewife populations in Maine, 13°-21°C (Rounsefell and Springer, 1945), Wisconsin, 13°-16°C (Threinen, 1958), and New Jersey, 17°-19°C (Gross, 1959).

Examination of alewife ovaries collected near the spawning peak revealed eggs at two distinct stages of development,

FIGURE VII-4

ALEWIFE REPRODUCTIVE CYCLE DURING THE

1974 SPAWNING SEASON IN THE

NINE MILE POINT VICINITY

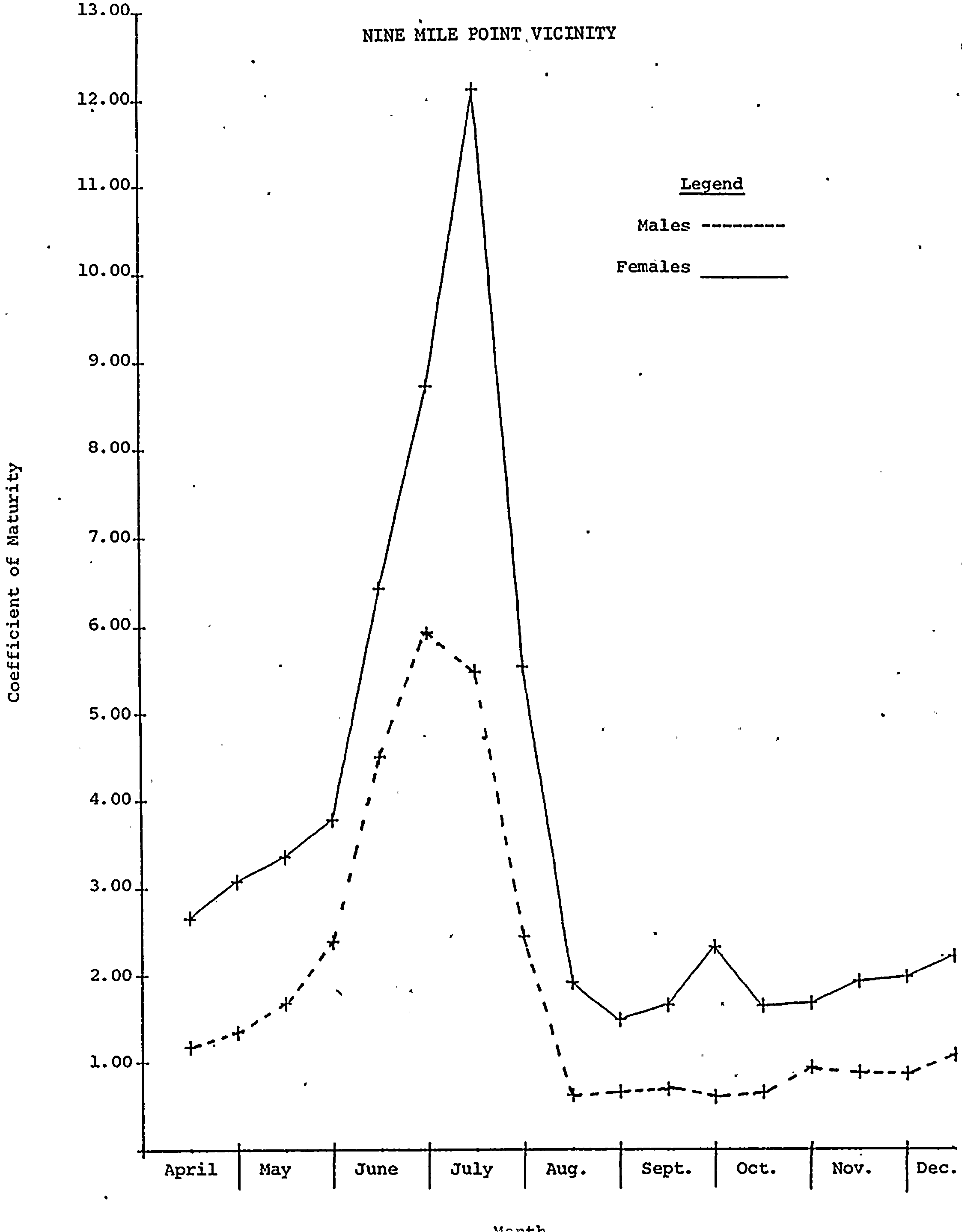


TABLE VII- 6

TOTAL LENGTH, WEIGHT AND NUMBERS OF EGGS PER FISH ACCORDING TO AGE, IN A SAMPLE OF 27 ALEWIVES

NINE MILE POINT - 1974

Age	No. of Fish	Total Length (mm.) Range	Total Length (mm.) Mean	No. of mature eggs per fish Range	No. of mature eggs per fish Mean	Standard Deviation	Weight of fish (g) Range	Weight of fish (g) Mean
III	4	158 - 173	163	16,650 - 26,847	20,442.3	± 4,695.7	32.2 - 38.2	36.0
IV	17	158 - 172	165	7,364 - 28,422	20,921.5	± 5,480.3	30.7 - 40.6	35.1
V	6	158 - 166	161	17,762 - 33,062	24,155	± 6,528.4	31.8 - 37.9	33.8

distributed homogeneously throughout the ovary. The smaller, white eggs ranged in size from 0.2 to 0.4mm with an average diameter of 0.3mm. The larger, yolk-laden eggs which were those most likely to be spawned during the short spawning season varied from 0.5 to 0.8mm with an average diameter of 0.56mm. The eggs of marine alewives are larger, averaging 0.90mm in diameter (Mansueti and Hardy, 1967).

Fecundity of fish was related to body length and weight, ovary weight and age of the fish (Appendix VII-8, Table VII-6) by the following equations:

Regression Equation	Correlation Coefficient (r)
Y = 4.9741 + 0.0040 x Body Length (mm)	r = 0.18
Y = 4.3488 + 0.0080 x Body Weight (g)	r = 0.02
Y = 4.1419 + 0.0407 x Ovary Weight (g)	r = 0.21
Y = 4.1614 + 0.0382 x Age (Years).	r = 0.18

where Y = the logarithm of the number of mature eggs.

The low correlation coefficients indicate the high variability in fecundity estimates based on the parameters of fish age and size (body length) and ovary weight. An analysis of variance on the relationship of age and fecundity showed no significant differences ($p < 0.05$) among the various age groups. The fecundity estimates varied from 7,364 eggs to 36,574 mature eggs with a mean of 21,378 eggs for alewives ranging in size from 153 - 177 mm (Appendix VII-8).

Total egg counts for fish in this study ranged from 8,981 to 50,274 eggs with a mean of 31,613 eggs. In 1973 (QLM, 1974), the total egg counts for 11 alewives from the Nine Mile Point vicinity of Lake Ontario ranged from 25,797 to 67,739 eggs, with a mean of 46,821 eggs for fish ranging from 156 to 181 mm in total length. A range in total egg production of 11,147 to 22,407 eggs per female was reported for alewives of similar size in Lake Michigan (Norden, 1967). Since only mature eggs are spawned during a season, total egg count may overestimate the actual fecundity of freshwater alewives.

(ii) Sex Ratio

For the nine-month sampling period in the Nine Mile Point vicinity, more female alewives were collected by gill nets and trawls than males (Table VII-7); the males constituted 22.69% and females, 77.31%. The dominance of females in the lake collections was reported in 1973 (QLM, 1974) with 9.8% males and 90.2% fe-

TABLE VII-7

SEX RATIOS FOR ALEWIVES COLLECTED
BY GILL NETS AND TRAWLS
NINE MILE POINT - 1974

MONTH COLLECTED	MALE		FEMALE	
	ABUNDANCE	PERCENT	ABUNDANCE	PERCENT
APR	1,356	22.97	4,547	77.03
MAY	831	21.71	2,996	78.29
JUN	924	17.50	4,357	82.50
JUL	1,940	28.01	4,986	71.99
AUG	293	23.57	950	76.43
SEP	239	18.95	1,022	81.05
OCT	354	22.26	1,236	77.74
NOV	283	20.73	1,082	79.27
DEC	52	21.05	195	78.95
TOTAL	6,272	22.69	21,371	77.31

males. Bigelow and Schroeder (1953) and Kissil (1969) report that spawning groups of anadromous alewives usually contain more males than females. If the Nine Mile Point vicinity had been spawning ground, it would have been expected that more males would be caught than females. One possible conclusion based on the preponderance of females in these samples is that the Nine Mile Point vicinity is not a spawning area. It should be noted, however, that alewife eggs and larvae constituted a significant portion of the abundance of ichthyoplankton collected in the Nine Mile Point vicinity (see Chapter VB.3). Another possible explanation for the difference in abundance between the sexes is, as suggested by Pritchard (1929), that females live longer than males and therefore over time a predominance of females would be apparent.

d. Age and Growth

(i) Body-Scale Relationship

The body length-scale length relationship (L/Sc) for alewives was determined for 286 males and females ranging in size from 76 to 242 mm (Appendix VII-9).

Alewives less than 110 mm in length (one year old fish) exhibited larger L/Sc ratios than fish over 110 mm in length (2+ year old fish). The L/Sc ratios of these larger alewives were relatively constant with increasing length. The larger L/Sc ratios of the one-year-old alewives can be explained by the fact that scale formation is usually associated with the attainment of a specific length (21-29 mm total length; Norden, 1967). At the time of scale formation and for a subsequent period of time, the scale is relatively small in relation to the body length. The relative size of the scale then increases with increasing body length until the body-scale relationship becomes constant at a body length of approximately 110 mm in the case of alewives.

The body length-scale length relationship for alewives is best described by the following two straight lines:

$$L = 50.55 + 31.29S \quad \text{Fish} < 110 \text{ mm total body length,}$$
$$L = 67.66 + 33.41S \quad \text{Fish} > 110 \text{ mm total body length}$$

where L is total body length in millimeters and S is the scale radius in millimeters. Tests of significance of a linear regression and deviations from linearity were made, and both regressions were linear ($p = 0.05$). Assuming that the L/Sc ratio was in fact constant for alewives greater than 110 mm, an average weighted L/Sc ratio of 59.35 was

used to correct the scale measurements for the second and successive annuli. Since the L/Sc ratios of alewives 110 mm and smaller were relatively constant, and all the fish were approximately the same age, an average weighted L/Sc ratio of 64.15 was used to correct the first annulus measurements on all fish.

(ii) Time of Annulus Formation

Annulus formation had occurred in 36% of the alewives captured during June, 43% during July, and 100% during August (Appendix VII-10). At Nine Mile Point during 1973, annulus formation began as early as April, reached 29 and 42% for the alewives captured during May and June respectively, and peaked during July and August with 66 and 65%, respectively (QLM, 1974). Norden (1967), reported that in Lake Michigan, 15% of alewives formed their annulus during June and the remainder during July; these results are similar to the time of annulus formation at Nine Mile Point.

(iii) Age and Growth Calculation

The average back calculated total body length at annulus formation and the standard error of the mean are presented for each year class for 106 male and 131 female alewives (Appendix VII-11). Forty-four additional one-year-old alewives, for which the sex could not be determined, were included in both the male and female tables for comparative purposes. Two estimates of growth are given in these tables: (1) the grand average weighted calculated length and (2) the summation of the grand average annual increment of length for each succeeding year of life (see Section C.4, white perch, for an explanation of the differences between these two estimates). These two growth estimates were in agreement except for the sixth year of life for which the grand average calculated lengths were greater (Appendix VII-11). These two observations indicate that the alewife population does not appear to be exploited by the selective destruction of the faster growing individuals (EL-Zarka, 1959).

The 95% confidence intervals for the grand average calculated lengths did not overlap through age three for females and age four for males (Appendix VII-11), so that total body length can be used as a valid indicator of age for these age groups. The empirical average total length at capture for each age group (Table VII-8) was in agreement with the average back calculated length (Appendix VII-11); empirical lengths may be expected to exceed the back calculated lengths because the former are calculated from alewives collected throughout the year, whereas back calculated lengths are determined at the time of annulus formation.

TABLE VII-.8

AVERAGE TOTAL LENGTH AT CAPTURE
AND SIZE RANGE OF ALEWIVES

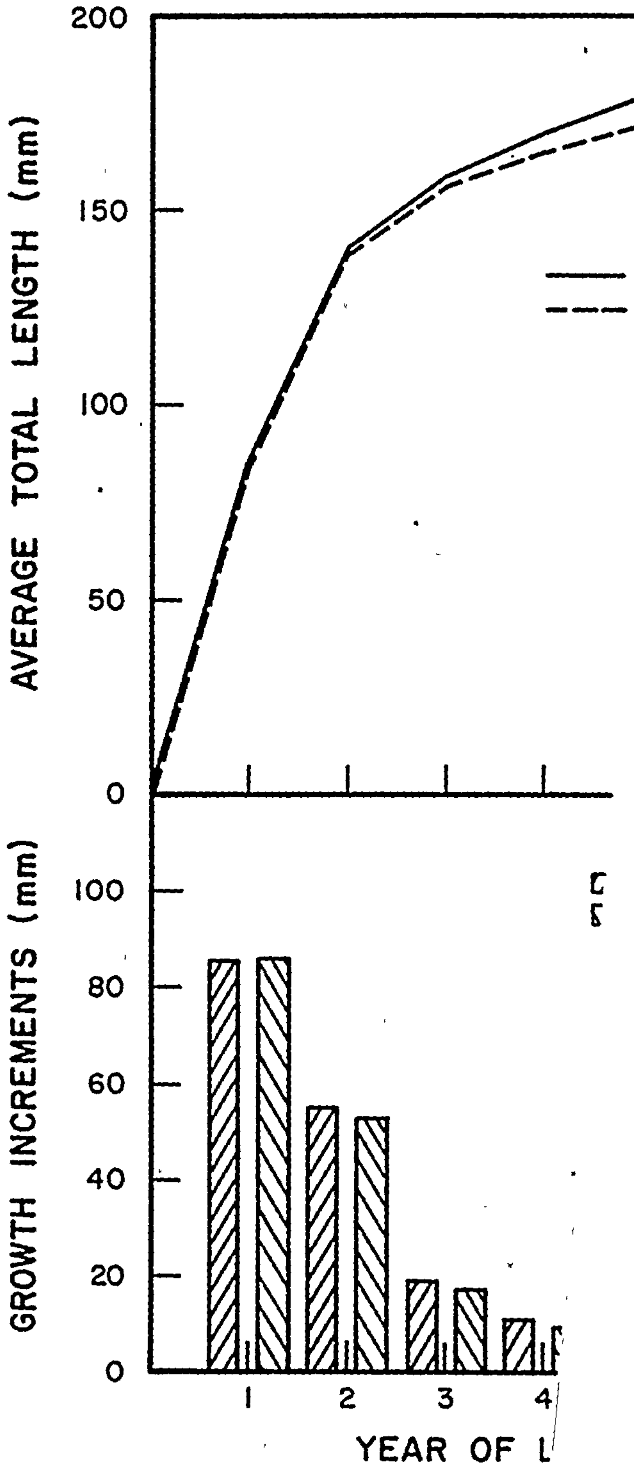
NINE MILE POINT - 1974

Sex	Age Group	Average Length (mm)	Number	Range (mm)
Not Determined	I	103.5	40	76.0 - 120.0
	II	115.8	4	111.0 - 127.0
	III	124.0	1	----
MALE	I	----	0	----
	II	142.1	13	127.0 - 175.0
	III	158.2	18	144.0 - 183.0
	IV	158.1	48	138.0 - 200.0
	V	160.5	22	142.0 - 194.0
	VI	198.8	5	171.0 - 232.0
FEMALE	I	114.0	4	111.0 - 118.0
	II	140.4	8	123.0 - 158.0
	III	162.9	28	143.0 - 186.0
	IV	167.3	48	144.0 - 196.0
	V	165.5	37	151.0 - 213.0
	VI	198.2	10	166.0 - 242.0

---- Not applicable

GROWTH CURVES
AND ANNUAL GROWTH INCR
OF MALE AND FEMAL
ALEWIVES

NINE MILE POINT
1974



The growth curves (calculated from the summation of the grand average annual increments of length) for both male and female alewives assumed approximately the same form; however, females were larger after the second and subsequent years of life (Figure VII-5). Alewives displayed rapid growth during the first two years of life. After the first and second years of life, alewives were 43% and 67%, respectively of the length attained after six years of growth. Growth declined rapidly during the second and third years of life, and generally continued to decline through age six.

T-tests ($p = 0.05$) on the differences between the grand average calculated lengths of male and female alewives for each year of life revealed that female alewives were significantly larger than males at age three and four (Appendix VII-11). No significant differences were exhibited at ages one, two, five, or six.

Female alewives retained a cumulative size advantage through age five. Pritchard (1929) reported that female alewives in Lake Ontario were larger than males after the third year of life. Havey (1961) and Odell (1934) also reported the more rapid growth of female alewives in freshwater landlocked situations.

The average annual increments of growth of male and female alewives, for each year of life, are presented in Appendix VII-11, and Figure VII-5. The ratios of the grand average increment of length of sexes and the differences between the increments of sexes for each year of life (Table VII-9), represent the relative and actual growth advantage of a sex.

The maximum attained age for both males and females was six years. The maximum ages of alewives caught off Nine Mile Point during 1973 was six years for males and seven years for females (QLM, 1974). Pritchard (1929) previously reported a maximum age of six years for males and seven years for females in Lake Ontario.

(iv) Comparison With Other Populations

The mean back calculated lengths from this and other growth studies are presented in tabular form for comparison (Table VII-10). The back calculated standard lengths from Odell (1934) were converted to total length (TL) using the following formula derived from Nine Mile Point alewives:

$$TL = 1.2513 \times \text{standard length}$$

TABLE VII- 9

COMPARISON OF CALCULATED GROWTH
OF MALE AND FEMALE ALEWIVES FOR EACH YEAR OF LIFE

NINE MILE POINT - 1974

Year of Life	A Grand Average Annual Increment (mm)		B Average Total Length (mm)		C Percent Annual Change In Increment		D Rate of Growth (Percent Annual Increase In Total Length)		E Ratio of Increment of Sexes	F Difference Between Increments of Sexes (Female Advantage)	G Cumulative Size Advantage (Female)
	M	F	M	F	M	F	M	F			
1	85.91	85.36	85.91	85.36					0.99	-0.55	-0.55
2	53.41	54.65	139.32	140.01	-37.83	-35.38	62.17	64.02	1.02	1.24	0.69
3	16.60	18.82	155.92	158.83	-68.92	-65.56	11.92	13.44	1.13	2.22	2.91
4	9.16	11.21	165.08	170.04	-44.82	-40.44	5.87	7.06	1.22	2.05	4.96
5	6.46	9.39	171.54	179.43	-29.48	-16.24	3.91	5.52	1.45	2.93	7.89
6	8.31	5.53	179.85	184.96	28.64	-41.11	4.84	3.08	.67	-2.78	5.11

M - Males
F - Females

Columns
A and B - From Appendix VII-11

C = $\frac{100\ (A2 - A1)}{A1}$; $\frac{100\ (A3 - A2)}{A2}$ etc. for each sex

D = $\frac{100\ (A2)}{B1}$; $\frac{100\ (A3)}{B2}$ etc. for each sex

E = $\frac{A1F}{A1M}$: $\frac{A2F}{A2M}$ etc. for each year of life

F = A1M - A1F etc. for each year of life

G = Successive summation of column G

TABLE VII-10

COMPARISON OF THE AVERAGE TOTAL LENGTH OF FISH
AT EACH YEAR OF LIFE FOR ALEWIVES
REPORTED FROM LAKES IN THE UNITED STATES*

YEAR OF LIFE	NINE MILE POINT (PRESENT STUDY)	NINE MILE POINT (QLM, 1974)	PORT CREDIT LAKE ONTARIO (Prichard, 1929)	BAY OF QUINTE LAKE ONTARIO (Prichard, 1929)	LAKE MICHIGAN (Norden, 1967)	SENECA LAKE, N.Y. (Odell, 1934)
	LENGTH (mm)	LENGTH (mm)	LENGTH (mm)	LENGTH (mm)	LENGTH (mm)	LENGTH (mm)
1	86 (44)	110 (2)	99 (7)		94 (147)	70 (113)
2	135 (21)	145 (28)	128 (5)	140 (1)	140 (177)	145 (89)
3	152 (46)	157 (83)	143 (11)	143 (2)	159 (1028)	154 (284)
4			153 (34)	148 (14)	173 (502)	171 (49)
5	161 (96)	165 (145)	162 (35)	157 (17)		174 (15)
6	168 (59)	183 (31)	180 (3)	179 (9)		
7	198 (15)	204 (7)		187 (1)		
8		217 (1)				

* Numbers which appear in parentheses represent the number of fish measured in determining average length.

In the absence of statistical analysis and because of the variety of methods used to back calculate length, only generalizations can be made about relative growth rates.

Alewives from the Nine Mile Point vicinity of Lake Ontario generally appeared to grow more rapidly after the first year of life than alewives from Port Credit and the Bay of Quinte, Lake Ontario (Pritchard, 1929). Graham (1956) reported that Atlantic alewives of both sexes mature one year later than landlocked Lake Ontario alewives, grow more quickly throughout their life, and attain a larger size than Lake Ontario alewives. He suggested that the freshwater environment hastens the onset of sexual maturity and that this results in an inhibition of growth. This in part explains the lack of enthusiasm over making the Lake Ontario alewife population a commercially valuable asset, since these fish are usually thin and bony compared to ocean stocks.

(v) Length Frequency

The analysis of the length frequency distribution of fish populations gives insight into individual growth rates throughout the year, the presence of fish of different sizes (ages) within the area, and a graphic comparison of the relative abundance of young fish to older fish. Figure VII-6 shows the length frequency distribution on a monthly basis for alewives. In April the population within the vicinity of Nine Mile Point consisted mainly of adults between 15 and 19 cm in length. By May, a few yearling fish (age group I) began to appear, indicating the start of their inshore migration to feeding grounds. This trend continued until August when the inshore population was dominated by yearling fish between 9 and 12 cm long.

e. Biomass

The determination of the average weight per individual, in conjunction with length frequency data (Figure VII-6, Table VII-11), indicates the periods of recruitment of young fish into a population. The maximum period of recruitment of young alewives in the Nine Mile Point vicinity occurred during August. This recruitment was greatest at the NMPE and NMPW transects, indicating the influence of Mexico Bay and the possible use of the area between the Oswego Steam Station and the Nine Mile Point Nuclear Station as feeding grounds for young fish. The average weight of the 67,456 fish analyzed was 27.65 grams.

3. Rainbow Smelt (Osmerus mordax)

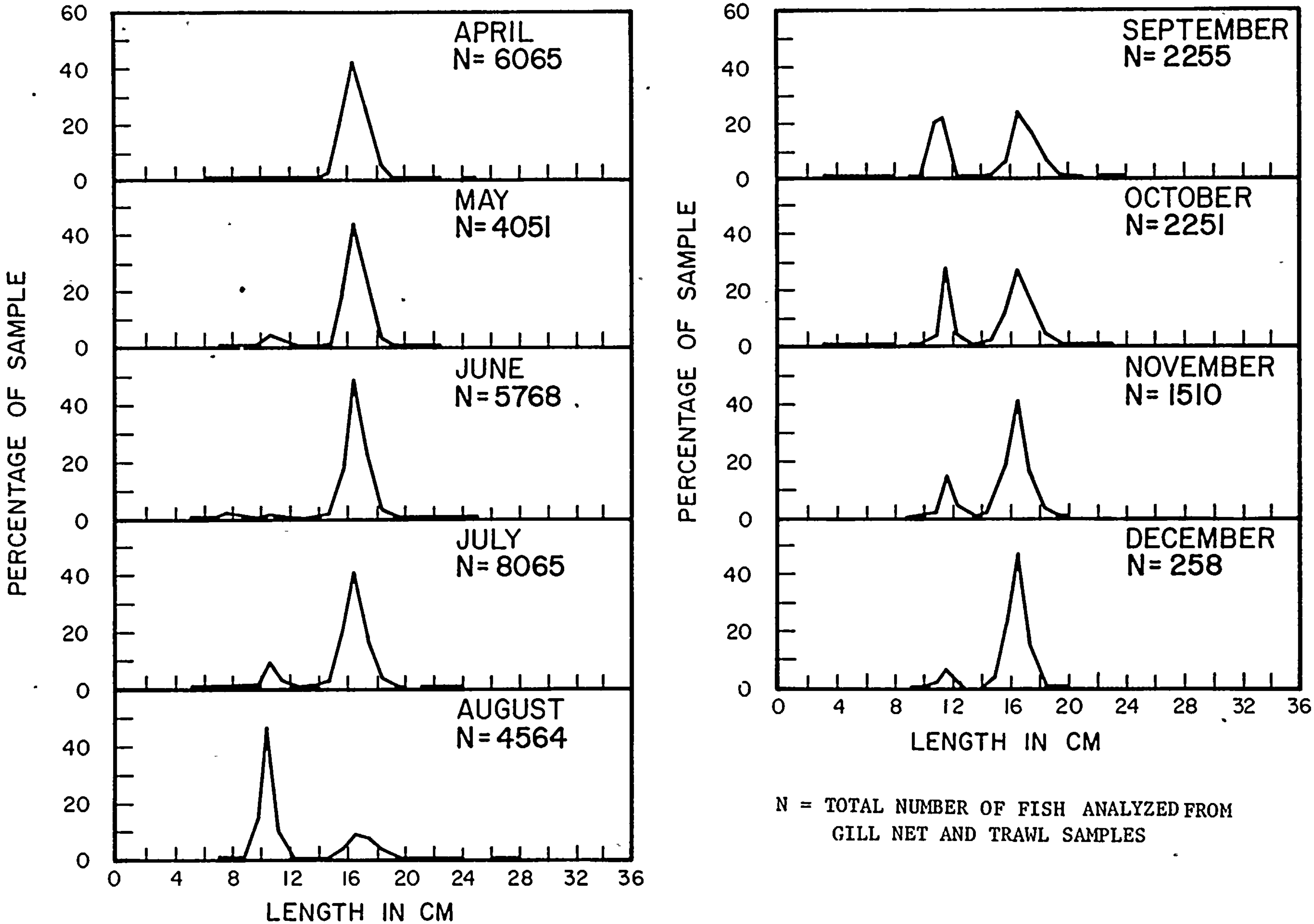
a. Trophic Level and Importance

In the past, the range of the rainbow smelt in eastern North America was restricted to the Atlantic coastal drainage area

LENGTH FREQUENCY DISTRIBUTION FOR LAKE ALEWIFE

NINE MILE POINT

1974



N = TOTAL NUMBER OF FISH ANALYZED FROM GILL NET AND TRAWL SAMPLES

FIGURE V.I-6

TABLE VII-11

TOTAL BIOMASS AND AVERAGE BIOMASS PER INDIVIDUAL
FOR ALEWIVES
COLLECTED WITH GILL NETS

NINE MILE POINT - 1974

TRANSECT	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)
NMPE	139325	34.1	34910	32.0	64352	31.6	110326	24.3	36814	12.6	18068	20.4	26626	33.2	12345	26.5	501	33.4
FITZ	121791	33.8	76188	29.7	65710	30.4	173843	29.3	38409	15.6	18163	23.5	19212	25.9	26273	28.5	2385	28.7
NMPP	74471	31.8	74251	28.3	106182	32.3	176663	29.4	30337	18.3	13323	27.4	16074	22.5	15673	27.5	4485	29.9
NMPW	77857	33.1	79716	31.0	50745	31.7	81510	27.0	20993	12.7	15941	22.3	17740	26.1	6005	27.1	1280	29.8

extending from New Jersey north to Labrador. It is uncertain whether the smelt is native to Lake Ontario; Hubbs and Lagler (1958) support this hypothesis, whereas Scott and Crossman (1973) are of the opposite opinion. In either case, Mason (1933) was first to report rainbow smelt in Lake Ontario in 1931 and these fish now occur in all of the Great Lakes and in many other Canadian and United States lakes. A successful smelt fishery has existed in the Great Lakes since the late 1950's, particularly in Lake Erie, where the fishery has expanded dramatically in less than 20 years from 65,750 pounds in 1950 to 15,913,984 pounds in 1966.

b. Seasonal Distribution and Abundance

The rainbow smelt, like the alewife, leave the deep water of large lakes in the spring to spawn in streams. In Lake Ontario spawning occasionally occurs in shallow water on gravel shoals. Rupp (1965) believes that this shore spawning may be as successful as stream spawning. In Lake Ontario, spawning runs of ripe smelt begin in March, when water temperatures are at least 48°F (13.5°C), and continue through May (McKenzie, 1964), at temperatures up to 65°F (18.3°C). Spawning occurs upstream at night and the spawners return to the lake during the day (Bailey, 1964 and McKenzie, 1964).

Seine collections (2 fish) and trawl collections (176 fish) (Appendix VII-3) were insufficient to illustrate the distribution of rainbow smelt in the Nine Mile Point vicinity; therefore, gill net collections, which yielded over 11,000 fish, were analyzed for these data. Inshore gill nets collected rainbow smelt in greatest numbers in April (Table VII-5). No collections were made in the Nine Mile Point vicinity in March, which is the reported time for the onset of the spawning migrations of this species (McKenzie, 1964).

A two-way analysis of variance (ANOVA) on the day gill net catch per effort for rainbow smelt (Appendix VII-12), comparing the distribution by sampling depth (bottom and surface) and among the three seasons (spring, summer, and fall), revealed that more fish were collected from the bottom than from the surface, and that more were collected during the spring than during either the summer or fall months. A similar ANOVA for the night collections (Appendix VII-12) revealed that more fish were collected from the surface, and more in the spring than during the other seasons. Since rainbow smelt diurnal distribution differed between sampling depth, these parameters were treated independently in the analysis of distributional differences among transects. A three-way ANOVA was performed on the distribution of smelt among seasons, between day and night, and among the four sampling transects (Appendix VII-13). These tests showed that there were

no significant differences in the distribution of rainbow smelt among the four sampling transects.

c. Reproduction

(i) Fecundity and Time of Spawning

Rainbow smelt spawning occurred during April as determined by examining the coefficient of maturity data for 688 males and 1,056 females collected in the vicinity of Nine Mile Point from January through December (Appendix VII-14; Figure VII-7). There is evidence to suggest that rainbow smelt use the Nine Mile Point vicinity as a spawning ground because trawl collections in this area in April contained mature females, and rainbow smelt fish eggs and larvae were present in the ichthyoplankton samples (see VB-3).

For the 24 sexually mature female smelt examined, ovaries contained eggs ranging in diameter form 0.4 to 1.1 mm with a mean diameter of 0.7 mm. Bailey (1964) reported that the egg diameters for rainbow smelt in Lake Superior ranged from 0.79 to 0.99 mm with a mean of 0.86 mm. Fecundity estimates were determined using total egg counts since no different egg types were present.

The fecundity of rainbow smelt varied from a total of 6,212 eggs for a fish 138 mm and 18.8g to 29,050 eggs for one 213mm and 57.9g with a mean of 17,002 eggs (Appendix VII-15). Fecundity can be related to body length, body weight, ovary weight, and age of the fish (Appendix VII-15) by the following equations:

Regression Equation	Correlation Coefficient (r)
Y = 3.0913 + .0069 x Body Length (mm)	r = .76
Y = 3.7858 + .0139 x Body Weight (g)	r = .83
Y = 3.8237 + .0686 x Ovary Weight	r = .79
Y = 4.0124 + .0576 x Age (years)	r = .26

where Y equals the logarithm of the toal number of eggs.

The correlation coefficients indicate a positive relationship between fecundity and these parameters; however, fecundity estimates may vary even after these factors have been taken into account.

The low correlation between age and fecundity indicates that age cannot be used to predict fecundity. On the other hand, fecundity can be related to length, weight, and ovary weight; and the highest correlations exist between the number of eggs extruded and the size of the female, with the longer, heavier females having more eggs (Appendix VII-15; Table VII-12).

FIGURE VII-7

RAINBOW SMELT REPRODUCTIVE CYCLE DURING THE
1974 SPAWNING SEASON
IN THE VICINITY OF NINE MILE POINT

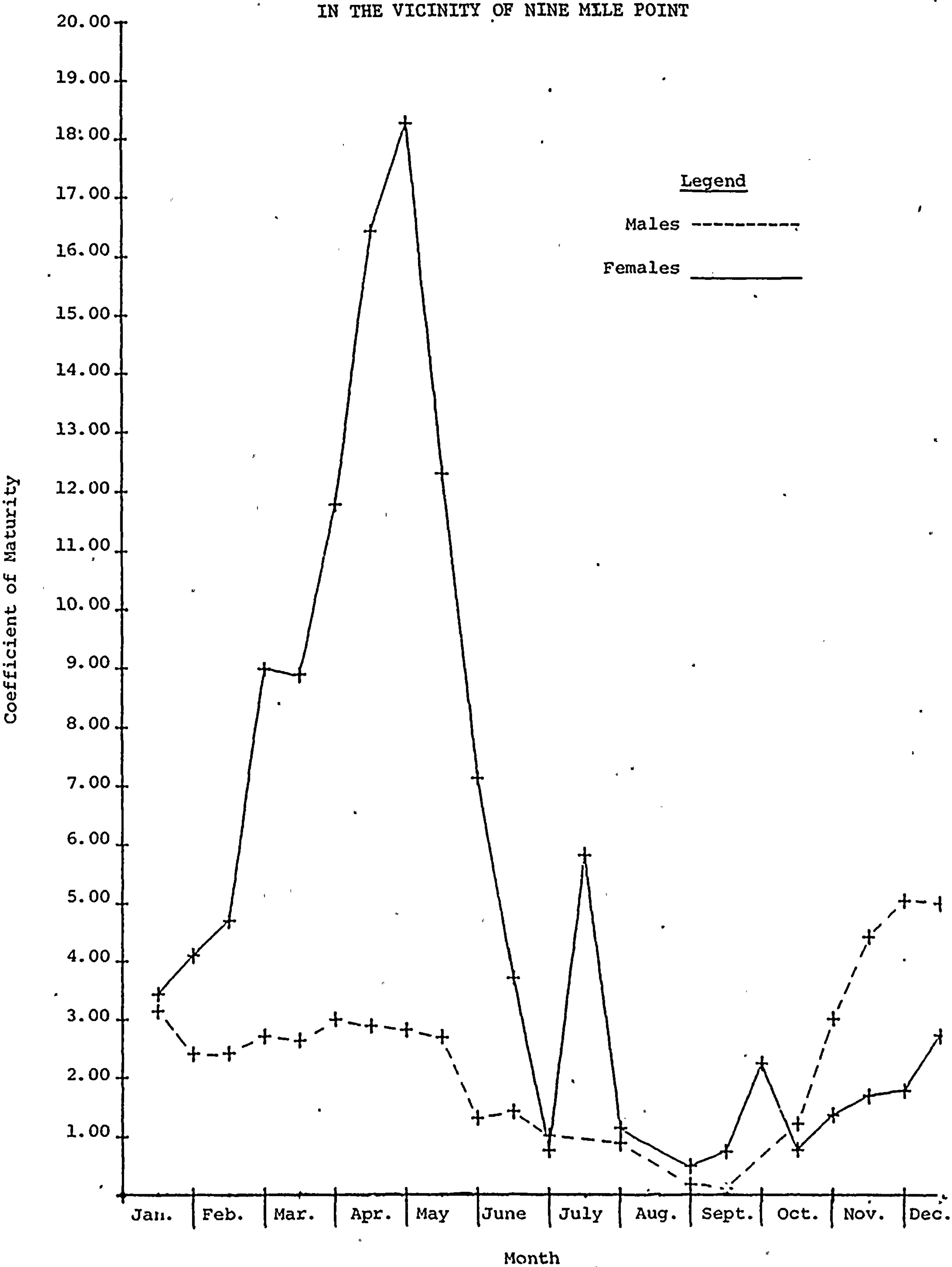


TABLE VII-12

TOTAL LENGTH, WEIGHT AND NUMBERS OF EGGS PER FISH ACCORDING TO AGE, IN A SAMPLE OF 19 RAINBOW SMELT

NINE MILE POINT - 1974

Age	No. of Fish	Total Length (mm.)		No. of total eggs per fish			Weight of fish (g)	
		Range	Mean	Range	Mean	Standard Deviation	Range	Mean
III	13	132 - 213	156	8,185 - 32,117	17,129	7629	14.7 - 57.9	27.3
IV	4	161 - 182	171	15,774 - 28,379	21,379	5404	30.9 - 46.7	36.7
V	2	155 - 156	156	12,885 - 21,737	17,311	6259	26.5 - 40.7	33.6

A listing of fecundity data from some other investigations performed on rainbow smelt in the Great Lakes follows:

Reference	Location	Size of Females	Number of Females	Mean # of Eggs Per Female
Bailey (1964)	Lake Superior	188 - 224 mm	10	31,338
Baldwin (1950)	Lake Huron	140 - 224 mm	5	20,500
Van Oosten (1940)	Lake Michigan	185 - 196 mm	-	25,000

When allowance is made for the size of the fish, the estimates of Baldwin (1950) and Van Oosten (1940) are most nearly comparable to those of this study.

(ii) Sex Ratio

Of 5,542 rainbow smelt collected by trawls and gill nets from April to December 1974, 50.3% were males and 49.7% were females (Table VI-13); most were collected in April and May. During the remainder of the year (June-December), females predominated in the collections with 73 males and 410 females. MacCullen and Regier (1970) found that males predominated in spawning areas during both the early and late parts of the spawning season. The sex ratio information (i.e., the high abundance of females), suggests that this species does not use the Nine Mile Point area as a spawning ground.

d. Age and Growth

(i) Body-Scale Relationship

The body length-scale length relationship (L/Sc) of rainbow smelt was determined for 307 males and females ranging in size from 125 to 244 mm (Appendix VII-16).

The L/Sc ratio did not change significantly with increasing body total length, and was best described by the equation

$$L = 16.6 + 72.15S,$$

where L is total body length in millimeters and S is the scale radius in mm. A test of significance of a linear regression and deviations from linearity were made and the relationship did not differ significantly from a straight line ($p < 0.05$). Assuming a constant L/Sc ratio, an average weighted L/Sc ratio of 79.85 was used to correct the scale measurements for each annulus.

TABLE VII-13

SEX RATIOS FOR RAINBOW SMELT COLLECTED
BY GILL NETS AND TRAWLS
NINE MILE POINT - 1974

MONTH COLLECTED	MALE		FEMALE	
	ABUNDANCE	PERCENT	ABUNDANCE	PERCENT
APR	2,335	56.10	1,827	43.90
MAY	380	42.36	517	57.64
JUN	27	20.30	106	79.70
JUL	1	9.09	10	90.91
AUG	2	18.18	9	81.82
SEP	4	12.50	28	87.50
OCT	26	14.86	149	85.14
NOV	12	10.71	100	89.29
DEC	1	11.11	8	88.89
TOTAL	2,788	50.3	2,754	49.7

(ii) Time of Annulus Formation

Monitoring of rainbow smelt annulus formation began in mid-April, and the time of formation was determined for 307 male and female rainbow smelt (Appendix VII-17). Fourteen percent of the smelt collected during April, and 12% collected during May, had formed their annulus. Peak annulus formation (72%), based on a significant sample size, occurred during June; all smelt sampled after June had formed their annulus. In 1973, peak annulus formation of smelt in the Nine Mile Point vicinity also occurred during June (89%) and was complete by August (QLM, 1974). Bailey (1964) reported the completion of annulus formation for Lake Superior smelt between mid-June and 24 August, and its occurrence earlier in the younger age classes; however, no such trend was noted at Nine Mile Point.

(iii) Age and Growth Calculation

The average back calculated lengths at annulus formation and the standard error for each year of life for 206 female and 101 male smelt are presented in Appendix VII-18. Two growth estimates are indicated: (1) the grand average calculated length, and (2) the summation of the grand average annual increment of lengthl; these were in agreement through age five for both sexes. A small divergence noted for the female smelt estimates at ages six and seven can be attributed to the small sample size. The agreement between the growth estimates indicates that the smelt population does not appear to be exploited by the selective destruction of the faster growing individuals (El-Zarka, 1959). The 95% confidence intervals for the grand average calculated lengths did not overlap through age four for females; the earlier overlapping after age two for males can be attributed to the small numbers of 4 and 5-year old fish. Length can be used as a valid indicator of age for the age groups that did not overlap. The average empirical lengths at capture for male and female smelt agreed well with the calculated lengths, except for age class II (Table VII-14), which appeared larger probably because most of these fish were caught in late summer/early fall and had acquired a significant amount of growth since annulus formation.

The growth curves (calculated from the summation of the grand average annual increments of length) for both male and female smelt had the same form, although females appeared larger after the first year of life (Figure VII-8). A t-test (p = 0.5) on the differences between the grand average calculated

TABLE VII-14

AVERAGE TOTAL LENGTH AT CAPTURE AND SIZE RANGE OF RAINBOW SMELT

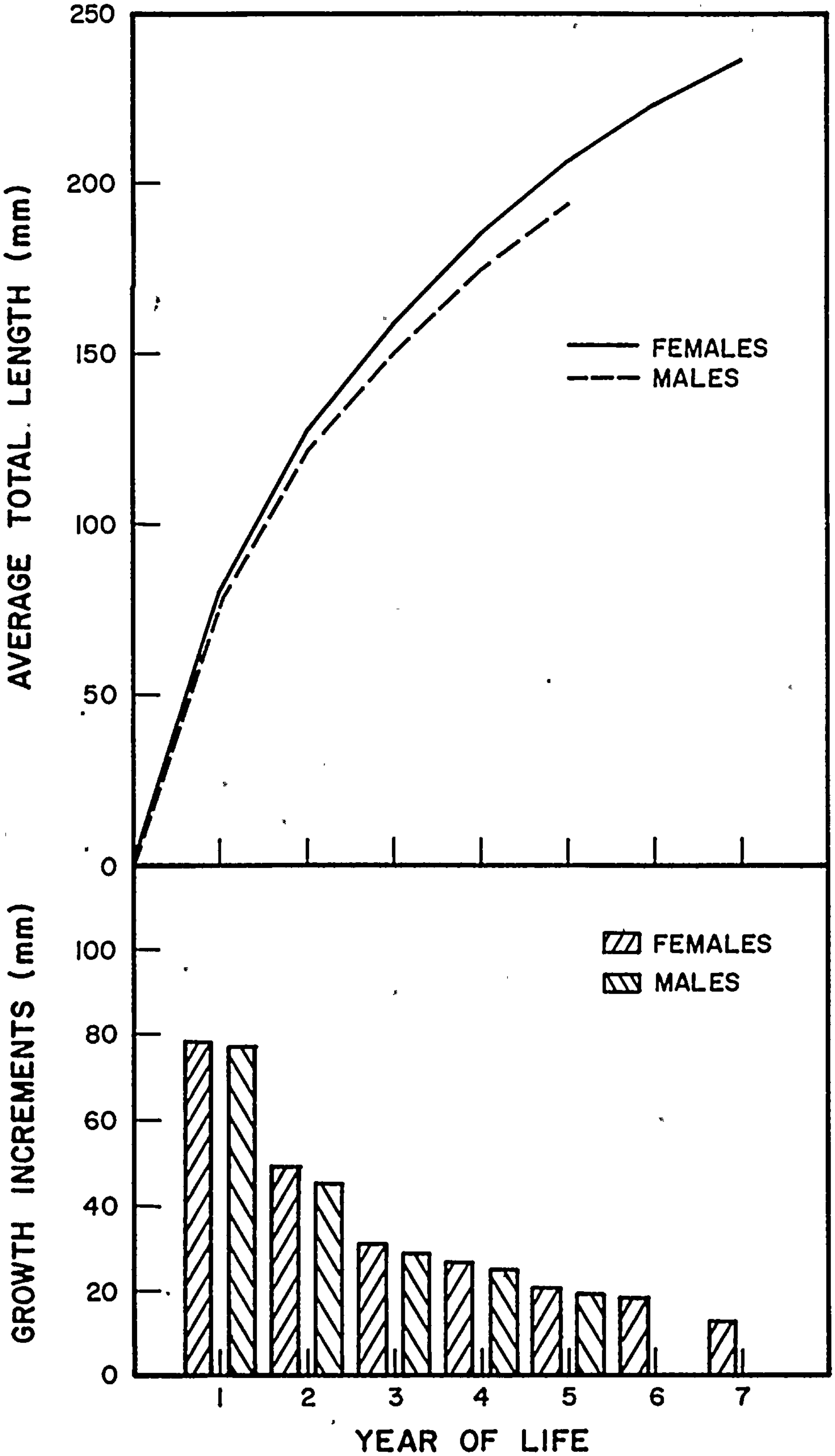
NINE MILE POINT - 1974

SEX	AGE GROUP	AVERAGE LENGTH (mm)	NUMBER	RANGE (mm)
FEMALE	I	----	0	----
	II	152.9	8	141.0 - 169.0
	III	158.1	107	137.0 - 215.0
	IV	187.1	49	142.0 - 242.0
	V	210.9	31	155.0 - 243.0
	VI	218.1	10	198.0 - 237.0
	VII	220.0	1	----
MALE	I	148.0	1	----
	II	148.1	29	126.0 - 172.0
	III	148.7	67	131.0 - 209.0
	IV	179.0	3	164.0 - 204.0
	V	189.0	2	161.0 - 217.0

---- Not applicable

GROWTH CURVES AND ANNUAL GROWTH INCREMENTS OF MALE AND FEMALE RAINBOW SMELT

NINE MILE POINT 1974



lengths of male and female smelt for each year of life revealed that females were significantly larger than males at age two and older. McKenzie (1958) reported that female smelt in the Miramichi River, New Brunswick, Canada, were also larger than males after the second year of growth; Bailey (1964) reported that age three and older female smelt in Lake Superior were larger than males. Burbidge (1969) found that female smelt in Lake Michigan attained a greater mean length than males after the second year of life, but that the female size advantage was significant only for the fourth year of life. The more rapid growth of female smelt was also reported by Van Oosten (1944) in Green Bay, Lake Michigan; by Baldwin (1950) in South Bay, Lake Huron; and by Hale (1960) in western Lake Superior. The average annual growth increments of male and female smelt, for each year of life, are presented in Appendix VII-18, and Figure VII-8. The ratio of the grand average annual increment of length and the difference between the increments of sexes for each year of life (Table VII-15); represent the relative and actual growth advantage of each sex. Except during the first year of life, when growth was similar for both sexes, the annual increments of growth were greater for female smelt than for males. The annual increment advantage of female smelt decreased with age, but the cumulative size advantage increased to a maximum of 11.88 mm at age five (Table VII-16). Comparisons of growth between the sexes could not be made after the fifth year of life as this was the maximum age of male smelt collected; the maximum age of females was seven years. Bailey (1964) reported the maximum attained age for female smelt was seven years and for males, five years in Lake Superior.

(iv) Comparison with Other Populations

The mean back calculated lengths from this and other smelt growth studies are presented in tabular form (Table VII-16). In the absence of statistical analysis, only generalizations can be made about relative growth rates. Another important consideration is the method used to back calculate length. Beckman (1942) used length at capture as estimates of length at each age. These estimates are probably overestimates, because fish caught at two different times of the year (February and June) were averaged to obtain one length estimate. Burbidge (1969) may also have overestimated length at the various ages, as he used average length at capture from fish collected over a one-year period. The first-year growth of Nine Mile Point smelt was greater than that of smelt in

TABLE VII-15

COMPARISON OF CALCULATED GROWTH
OF MALE AND FEMALE RAINBOW SMELT FOR EACH YEAR OF LIFE

NINE MILE POINT - 1974

Year of Life	A Grand Average Annual Increment (inches)		B Average Total Length (inches)		C Percent Annual Change in Increment		D Rate of Growth (Percent Annual Increase in Total Length)		E Ratio of Increment of Sexes	F Difference Between Increments of Sexes (Female Advantage)	G Cumulative Size Advantage (Females)
	M	F	M	F	M	F	M	F			
1	77.14	78.31	77.14	78.31					1.02	1.17	1.17
2	44.58	49.07	121.72	127.38	42.21	37.34	57.79	62.66	1.10	4.49	5.66
3	28.98	31.38	150.70	158.76	34.99	36.05	23.81	24.63	1.08	2.40	8.06
4	24.44	26.56	175.14	185.32	15.67	15.36	16.22	16.73	1.09	2.12	10.18
5	19.37	21.07	194.51	206.39	20.74	20.67	11.06	11.37	1.09	1.70	11.88
6	-	17.88	-	224.27	-	15.14	-	8.66	-	-	-
7	-	12.22	-	236.49	-	31.66	-	5.45	-	-	-

M - Males
F - Females

Columns
A and B - From Appendix VII-18
C = $\frac{100\ (A2 - A1)}{A1}$; $\frac{100\ (A3 - A2)}{A2}$ etc. for each sex
D = $\frac{100\ (A2)}{B1}$; $\frac{100\ (A3)}{B2}$ etc. for each sex

E = $\frac{A1F}{A1M}$: $\frac{A2F}{A2M}$ etc. for each year of life
F = A1M - A1F etc. for each year of life
G = Successive summation of column G

TABLE VII-16

COMPARISON OF THE AVERAGE TOTAL LENGTH OF FISH AT EACH YEAR OF LIFE FOR RAINBOW SMELT REPORTED FROM LAKES IN THE UNITED STATES*

YEAR OF LIFE	LAKE ONTARIO NINE MILE POINT (PRESENT STUDY)	LAKE ONTARIO NINE MILE POINT (QLM, 1973)	GULL LAKE, MICHIGAN (Burbidge, 1969)	LAKE SUPERIOR (Bailey, 1964)	CRYSTAL LAKE, MICH. (Beckman, 1942)	LAKE MICHIGAN GREEN BAY (Schneberger, 1937)
	LENGTH (mm)	LENGTH (mm)	LENGTH (mm)	LENGTH (mm)	LENGTH (mm)	LENGTH (mm)
1	78	103	60 (11)	66	112 (12)	
2	126 (37)	137	150 (141)	152 (307)	178 (92)	178
3	155 (174)	157	163 (123)	187 (256)	196 (100)	254
4	185 (52)	183	180 (24)	219 (121)	208 (35)	305
5	205 (33)	207	198 (7)	237 (39)	210	356
6	216 (10)	228	187 (2)	251 (10)		
7	220 (1)			309 (1)		

* Numbers which appear in parantheses represent the number of fish measured in determining average length.

Lake Superior and Gull Lake, Michigan, and comparable to the rate for smelt in Crystal Lake, Michigan. Growth for the second through the seventh year of life for Nine Mile Point smelt appears lower than for the three lake populations mentioned above, with the exception of ages four through six for Gull Lake.

(v) Length-Frequency

The length-frequency distribution plotted for rainbow smelt collected with trawls and gill nets are illustrated in Figure VII-9. These data show that the majority of smelt present within the Nine Mile Point vicinity are between 14 and 17 cm long and hence most are probably in age group III and older. As was noted earlier (QLM, 1974), these fish presumably represent migrants on the way to spawning grounds.

e. Biomass

The biomass data for rainbow smelt (Table VII-17) indicate a trend toward an increase in the average weight per individual from April to June. The decrease in the average weight of fish caught during July, particularly at the three western transects, is indicative of the recruitment of young fish; the length frequency data (Figure VII-9) confirmed this observation. The average weight of the 11,298 rainbow smelt analyzed from gill net collections in 1974 was 27.07 grams.

4. White Perch (Morone americana)

a. Trophic Level and Importance

White perch occur only within the northeastern coastal area of North America, including the region from the upper St. Lawrence River and southern Gulf of St. Lawrence to South Carolina; in freshwater it commonly inhabits ponds and lakes close to the sea. This species, a relative newcomer to Lake Ontario, is now resident throughout the Great Lakes (Scott and Crossman, 1973), gaining access to Lake Ontario presumably via the Oswego River, from Hudson River populations moving northward and westward through the Mohawk River and Erie Barge Canal (Scott and Christie, 1963).

White perch thrive in a variety of habitats, but the growth rate is variable depending on the ecosystem and the structure of the population. Scott and Crossman (1973) state that "old landlocked populations in small oligotrophic lakes in the Atlantic coastal region will possibly have a slower rate of growth than newly expanding populations, such as those in Lake Ontario."

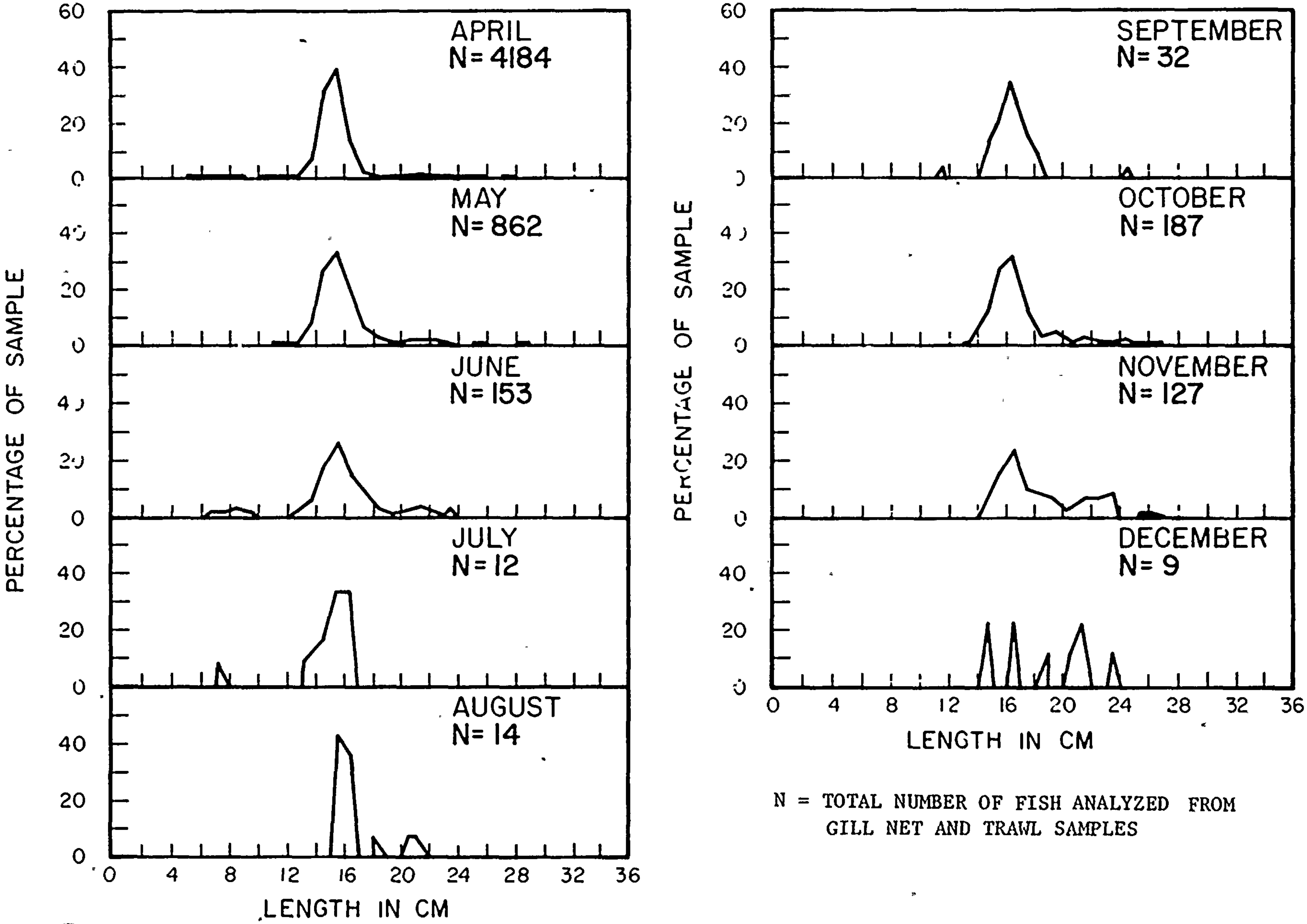
TABLE VII-17

TOTAL BIOMASS AND AVERAGE BIOMASS PER INDIVIDUAL
FOR RAINBOW SMELT
COLLECTED WITH GILL NETS

NINE MILE POINT - 1974

TRANSECT	APR TOTAL biomass (g)	APR AVER. (g)	MAY TOTAL biomass (g)	MAY AVER. (g)	JUN TOTAL biomass (g)	JUN AVER. (g)	JUL TOTAL biomass (g)	JUL AVER. (g)	AUG TOTAL biomass (g)	AUG AVER. (g)	SEP TOTAL biomass (g)	SEP AVER. (g)	OCT TOTAL biomass (g)	OCT AVER. (g)	NOV TOTAL biomass (g)	NOV AVER. (g)	DEC TOTAL biomass (g)	DEC AVER. (g)
NMPE	75452	25.9	2968	29.7	1534	26.5	226	45.2	0	0	223	31.9	2529	34.6	2670	51.4	193	38.7
FITZ	76801	26.7	5443	28.4	1210	40.4	41	20.9	273	39.1	193	27.7	2978	33.1	1785	42.5	322	64.4
NMPP	45855	27.1	8304	27.1	569	31.6	147	24.6	263	26.4	553	30.9	2886	42.4	1444	45.1	0	0
NMPW	42692	26.3	23760	25.6	1552	33.0	70	23.4	0	0	338	28.2	1749	30.7	673	51.8	21.9	21.9

LENGTH FREQUENCY DISTRIBUTION FOR LAKE RAINBOW SMELT
NINE MILE POINT
1974



N = TOTAL NUMBER OF FISH ANALYZED FROM
GILL NET AND TRAWL SAMPLES

FIGURE VII-9

The species appears well suited for a predaceous life (Scott and Crossman, 1973). The constituents of their diet change with growth, from a predominance of microzooplankton, to aquatic insect larvae, and then to fish, including yellow perch, smelt, johnny darters, and other white perch (Cooper, 1941; Leach, 1962). During the spring, 93 stomachs were excised from white perch and analyzed for number and percent composition of food items (Table VII-18). These perch ranged in size from 10.2 cm to 31.9 cm, with the majority longer than 21.1 cm. During the fall, 10 stomachs from white perch ranging in size from 14.5 cm through 23.5 cm were analyzed. The white perch analyzed had consumed a larger variety of food items during the spring than the fall; fish eggs were the predominant diet in the spring, and amphipods were the dominant food item in the stomachs analyzed during the fall. Stomachs of white perch larger than 21.1 cm in total length contained primarily fish (alewives identified) during both seasons. They are fished commercially in the Chesapeake Bay region and in the Bay of Quinte in Lake Ontario, where their successful competition with game fishes for available food could be a serious problem (Scott and Crossman, 1973).

b. Seasonal Distribution and Abundance

The distribution and abundance of white perch, like that of alewives and rainbow smelt, is best described through an analysis of the gill net data (Table VII-5). Beach seining produced a total of 108 fish (107 in August and September) (Appendix VII-4) and trawling produced 8 fish (Appendix VII-3).

A two-way ANOVA was conducted on day and night gill net data, comparing white perch distribution between sampling depths and among seasons (Appendix VII-19). Throughout the year, during both day and night sampling, more fish were collected in the bottom gill nets than in the surface gill nets. For daytime collections, there were no differences among seasons; however, more fish were collected at night during the summer (July, August, September) than during either the spring (April, May, June) or fall (October and November). Sheri and Power (1969) found vertical diel movement of white perch with concentrations of fish near the bottom during the day, but near the surface at night; this was not observed during the present study.

Because of significant differences in white perch distribution by sample depth and season in the case of night collections, depth was considered separately during the analyses of transect differences. A three-way ANOVA was conducted on gill net data from surface and bottom collection with the variables of day/night,

TABLE VII-18

STOMACH CONTENT ANALYSIS OF WHITE PERCH
COLLECTED IN BOTTOM GILL NETS AT 15 DEPTH CONTOUR+

NINE MILE POINT - 1974

SPRING			SAMPLE SIZE: 93
FOOD ORGANISMS	PERCENT FREQUENCY OF OCCURRENCE	TOTAL NUMBERS OF ORGANISMS CONSUMED	PERCENT COMPOSITION
Amphipods (Gammarus)	25.8	115	3.7
Dipteran larvae	16.1	218	7.1
Dipteran pupae	9.7	134	4.4
Pisces	31.2	78	2.5
Pisces eggs	7.5	2516	82.0
Cladocerans	0.0	9	0.3
Number of empty stomachs = 2			

FALL			SAMPLE SIZE: 10
Amphipods	50.00	55	96.0
Pisces	20.00	2	4.0
Number of empty stomachs = 1			

+ NMPE, FITZ, NMPP, and NMPW transects.

seasons, and transects (Appendix VII-20). There were no significant differences in the distribution of white perch among all the transcts based on surface collections; however, the abundance at NMPE transect was greater than that reported from NMPW transect. The largest bottom collection was also made at NMPE transect, and the second greatest abundance collected at the FITZ transect, with no significant difference between NMPW and NMPP transects. These data indicate that white perch are congregating neither in the thermally rich surface water, nor in the immediate vicinity of the Nine Mile Point Nuclear Station.

c. Reproduction

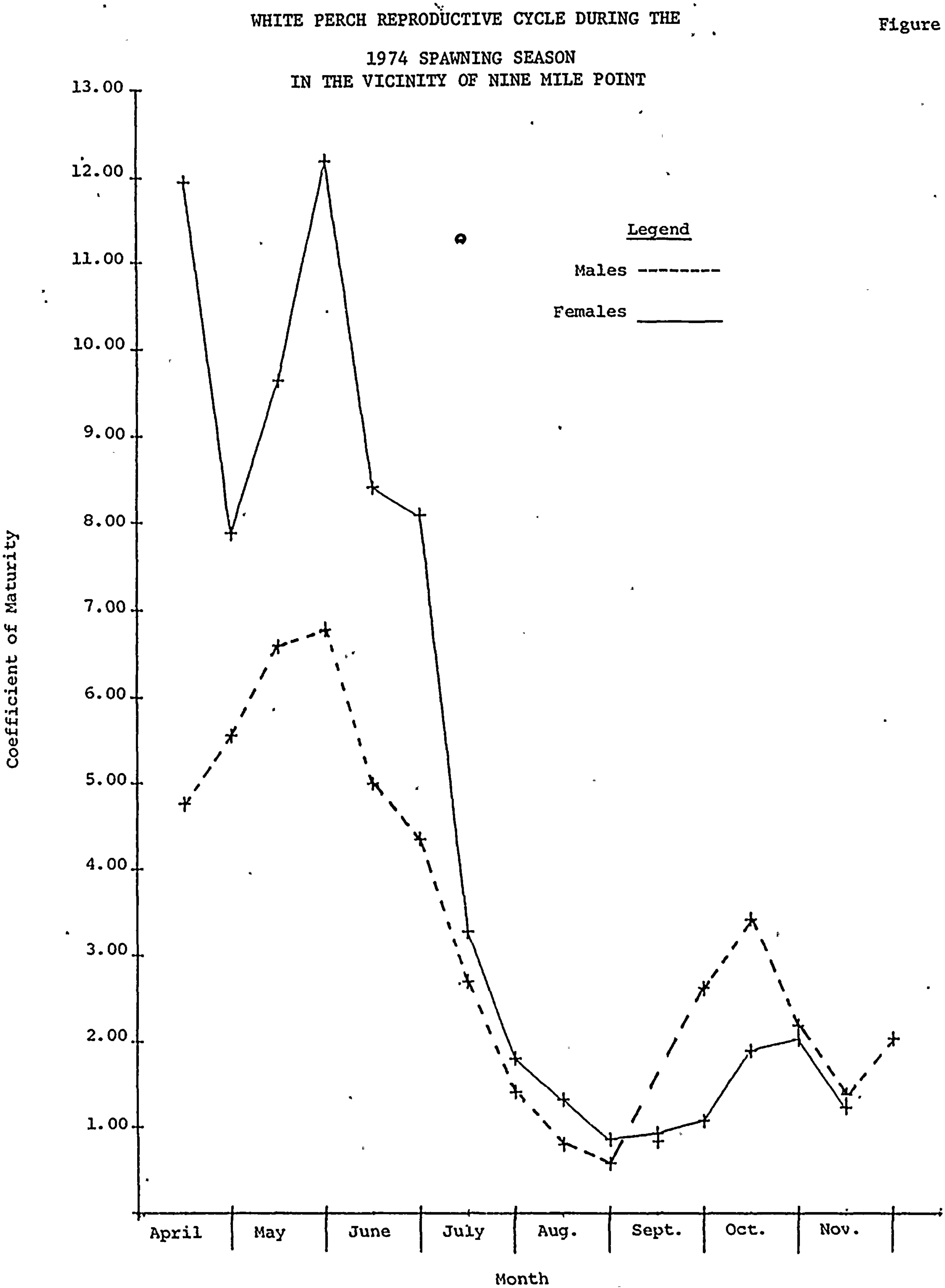
(i) Fecundity and Time of Spawning

The spawning time was determined by examining the coefficient of maturity data for 408 male and 429 female white perch collected from April through November (Appendix VII-21). A plot of these data at approximately bimonthly intervals (Figure VII-10) showed that maturation of the gonads occured in late May; the first white perch larvae were collected on 22 May (see Ichthyoplankton Section). The water temperature at this time varied from 5.5° to 13.0°C (41.9°-55.4°F), averaging 10.8°C (51.4°F) on the surface and 7.2°C (45.0°F) on the bottom. Sheri and Power (1968) reported that white perch in the Bay of Quinte, Lake Ontario, commenced spawning in mid-May and that spawning extended to the end of June, a period when water temperatures were in the range of 11° to 15°C (51.8°-59°F); this is in agreement with the findings from the present study.

Examination of the ovaries of 39 sexually mature female white perch (Appendix VII-22) revealed eggs of two distinct sizes distributed homogeneously throughout the ovary. The smaller eggs were white and opaque and ranged from 0.2 to 0.4 mm in diameter with a mean egg diameter of 0.38 mm. Only the larger, yolk-laden eggs ranging from 0.5 to 0.9 mm with a mean diameter of .63 mm were used in fecundity estimations since these would most likely have been spawned in 1974. Conover (1958) found that the ovaries of white perch in the Roanoke River, North Carolina, also contained eggs of two distinct sizes; the larger eggs had the same mean diamter (.63mm) as those observed in this study.

The fecundity of white perch varied from 76,618 mature eggs for a fish 212 mm in total length and a body weight of 157.7 g to 327,378 eggs for one fish 279 mm in length and a body

Figure VII-10



weight of 459.1 g (Appendix VII-22). Fecundity can be related to body, length, body weight, ovary weight and age (Appendix VII-22; Table VII-16) by the following equations:

Regression Equation	Correlation Coefficient (r)
Y = 4.0163 + .0049 x Body Length (mm)	r = .65
Y = 4.8620 + .0012 x Body Weight (g)	r = .70
Y = 4.8480 + .0097 x Ovary Weight (g)	r = .73
Y = 4.8691 + .0631 x Age (Years)	r = .63

where Y equals the logarithm of the number of mature eggs.

The correlation coefficients indicate that there is a definite positive relationship between fecundity and these parameters. The data presented in Table VII-19 indicate that as the females grow older or increase in length there is an increase in the mean number of mature eggs.

The reproductive potential of white perch appears to be variable among populations from different bodies of water. Sheri and Power (1968) estimated the fecundity of white perch in the Bay of Quinte area of Lake Ontario to range from 5,210 eggs for an age group I fish to 247,681 eggs for an age group VIII fish, with an average of 65,360 eggs. These counts are much lower than those of the present study possibly because the authors observed three distinct egg sizes within the ovary and counted only the largest size. Mansueti (1961), noting that only a portion of the total number of eggs in an ovary of an individual are released during two or three spawning acts over a period of two weeks.

Among the results of other fecundity studies, the estimates by QLM (1974) for Lake Ontario and Taub (1969) for Quabbin Reservoir, Mass., are the most comparable. QLM (1974) estimated the mean total egg production of 32 white perch ranging in length from 118-298 mm at 159,881 eggs. Taub (1969) estimated the mean total egg production for 10 fish ranging from 265 to 302 mm in length at 271,000 eggs. The mean total egg production for white perch from the present study for 34 fish ranging in length from 192-250 mm was 161,530 eggs while five larger fish ranging from 266-325 mm had a mean total egg production of 308,530 eggs. The present study fecundity estimates, based on specific length intervals, are in close aggrement with those reported by QLM (1974 and Taub [1969]).

TABLE VII-19

TOTAL LENGTH, WEIGHT AND NUMBERS OF EGGS PER FISH ACCORDING TO AGE, IN A SAMPLE OF 39 WHITE PERCH

NINE MILE POINT - 1974

Age	No. of Fish	Total Length (mm.) Range	Total Length (mm.) Mean	No. of Mature Eggs per fish Range	No. of Mature Eggs per fish Mean	Standard Deviation	Ratio	Weight of fish (g) Range	Weight of fish (g) Mean
III	7	192 - 232	216	76,618 - 159,953	108,007	±28,813		121.3 - 216.7	185.8
IV	15	222 - 247	230	90,935 - 260,490	144,329	±50,278	1:1.34	182.5 - 260.4	213.8
V	10	215 - 266	236	94,818 - 316,797	167,782	±72,917	1:1.55	180.6 - 400.4	248.2
VI	3	227 - 276	252	14,166 - 188,638	166,800	±19,718	1:1.54	207.3 - 380.9	306.8
VII	2	250 - 271	264	212,205 - 277,026	219,616	± 7,706	1:2.03	319.7 - 420.1	372.0
VIII	1	-	279	-	327,378	-	1:3.03	-	[illegible]
XII	1	-	325	-	319,600	—	1:2.96	-	670.6

- Not Applicable

(ii) Sex Ratio

The numbers of male and female white perch collected in gill nets and trawls throughout the year are presented in Table VII-20. There was no annual difference between the percentages of male and female fish collected inshore from April through December. Hildebrand and Schroeder (1928) reported a preponderance of males on the spawning grounds during May in Chesapeake Bay. Based on sex arios calculated in the present study, it appears that white perch spawned in the Nine Mile Point vicinity in 1974, and that the spawning activity reached a peak in June, when 249 males were collected and only 114 females. This observation is in agreement with the May peak in gonad maturation and the initial collection of larval white perch on 22 May (Table VB-7).

d. Age and Growth

(i) Body-Scale Relationship

The body length-scale length relationship (L/Sc) of white perch was determined for 402 male and females ranging in size from 62 to 327 mm (Table VII-21). L/Sc ratios were greater for white perch under 104 mm in length (one-year old fish) than for fish over 104 mm in length (2 + year old fish); for these larger white perch (349 fish), ratios were relatively constant with increasing length. L/Sc ratios were larger for the one-year old fish because at scale formation, which is associated with the attainment of a certain length (Mansueti, 1961; Marcy and Richards, 1974; St. Pierre and Davis, 1972), the scale is relatively small in relation to body length. The relative size of the scale increases with body length until a body length of approximately 104 mm is reached; after this time the body-scale relationship is constant. White perch that day recently formed scales (fish of 20-30 mm total length; Mansueti, 1961; St. Pierre and Davis, 1972; Marcy and Richards, 1974) and young fish (less than 62 mm) were absent from the collections.

The body length-scale length relationship for white perch was best described by two straight lines:

$$L = 31.04 + 50.28S, \text{ for fish } \leq 104\text{mm}$$

$$L = 10.54 + 65.36S, \text{ for fish } \geq 104\text{mm}$$

where L is total body length in millimeters, and S is the scale radius in millimeters. Tests of linearity and deviations from linearity were made, and both regressions were linear ($p < 0.05$). Assuming a constant L/Sc ratio for white perch over 104mm, an average weighted L/Sc ratio of 68.35 was used

TABLE VII-20

SEX RATIOS FOR WHITE PERCH COLLECTED
BY GILL NETS AND TRAWLS
NINE MILE POINT - 1974

	MALE		FEMALE	
MONTH	ABUNDANCE	PERCENT	ABUNDANCE	PERCENT
APR	46	52.27	42	47.73
MAY	87	44.62	108	55.38
JUN	249	68.60	114	31.40
JUL	236	41.11	338	58.89
AUG	211	52.88	188	47.12
SEP	336	49.12	348	50.88
OCT	170	50.60	166	49.40
NOV	12	70.59	5	29.41
DEC	0	---	2	100.00
TOTAL	1347	50.72	1309	49.28

--- Not applicable

TABLE VII-21

BODY LENGTH-SCALE LENGTH RATIOS (L/Sc)
OF 402 MALE AND FEMALE WHITE PERCH

NINE MILE POINT - 1974

LENGTH INTERVAL (cm)	AVERAGE BODY LENGTH (cm)	L/Sc	N
6.0 - 6.9	6.5	80.45	11
7.0 - 7.9	7.5	78.21	10
8.0 - 8.9	8.4	80.85	22
9.0 - 9.9	9.3	87.82	7
10.0 - 10.9	10.4	87.54	3
11.0 - 11.9	11.8	70.67	2
12.0 - 12.9	12.6	66.99	12
13.0 - 13.9	13.6	66.7	6
14.0 - 14.9	14.5	73.64	4
15.0 - 15.9	15.5	68.19	21
16.0 - 16.9	16.4	68.71	25
17.0 - 17.9	17.3	68.00	16
18.0 - 18.9	18.4	66.04	11
19.0 - 19.9	19.5	65.95	24
20.0 - 20.9	20.3	67.78	30
21.0 - 21.9	21.4	68.13	32
22.0 - 22.9	22.5	67.69	33
23.0 - 23.9	23.4	68.66	31
24.0 - 24.9	24.4	68.58	24
25.0 - 25.9	25.4	67.73	28
26.0 - 26.9	26.3	69.14	17
27.0 - 27.9	27.4	71.65	17
28.0 - 28.9	28.4	72.95	5
29.0 - 29.9	29.2	71.62	5
30.0 - 30.9	30.5	70.49	3
31.0 - 31.9	31.3	74.49	2
32.0 - 32.9	32.7	72.51	1

N = Number of Fish

to correct the scale measurements for the second and successive annuli. Since all the smaller fish were approximately the same age (size), an average weighted L/Sc ratio of 81.57 was used to correct the first annulus measurements on all fish.

(ii) Time of Annulus Formation

The time of annulus formation was determined by examining the scales from 375 white perch collected between April and October (Appendix VII-23). Annulus formation had occurred in 47% of the white perch captured during July and 99% during August. During 1973, the majority of white perch at Nine Mile Point had formed their annulus by September, with the peak also occurring during August (QLM, 1974). Similar occurrence of annulus formation was reported by Sheri and Power (1969) during a 10-year study of annulus formation in white perch inhabiting the Bay of Quinte; peak annulus formation occurred during July for five years, during June for two years, and during August for two years. While earlier annulus formation in younger white perch has been reported (Wallace, 1971; QLM, 1974) it was not evident in the present study.

The time of annulus formation must be determined in order to compute the age of a fish (QLM, 1974). Because this time is species-specific and influenced by environmental conditions, it may provide insight into differential growth rates by delineating the start and length of the growing season. The agreement among the data presented herein and previously published reports (as cited above) indicate that the beginning and termination of the growing seasons are similar among white perch populations.

(iii) Age and Growth Calculation

The average back calculated lengths at annulus formation and the standard error of the mean for each year of life are presented in Appendix VII-24 for 166 male and 157 female white perch. Fifty-eight one-year-old white perch for which sex could not be determined were included in both the male and female tables for comparative purposes. Two estimates of growth are calculated: (1) the grand average weighted calculated length and (2) the summation of the grand average annual increment of length for each succeeding year of life. The latter parameter is more descriptive of the biological growth potential in different years of life for a species because the irregularities caused by the successive dropping out of age groups with increasing age are eliminated (Hile, 1941; El-Zarka, 1959; Bailey, 1964).

The grand average weighted calculated lengths serve to show the regression of size on age in stocks from which larger, older individuals are selectively removed (El-Zarka, 1959). On the other hand, the summation of the grand average annual increments indicates the average growth if the stocks are not subjected to selective destruction of those individuals with more rapid growth. In the present study, the two growth estimates were in agreement, indicating that the white perch population does not appear to be exploited.

The 95% confidence intervals of the grand average calculated lengths did not overlap through age four for male white perch and age six for females (Appendix VII-24). For these age groups, length can be used as a valid indicator of age. The empirical average lengths at capture for each age group by sex (Table VII-22) were agreement with the grand average calculated lengths for male and female white perch (Appendix VII-24).

The growth curves (calculated from the summation of the grand average annual increments of length) for both male and female white perch (Figure VII-11) had approximately the same form; however, females appeared larger after the second and subsequent years of life. Differences between the grand average calculated lengths of male and female white perch were located with t-tests for each year of life. These tests also confirmed that females were significantly larger ($p < 0.05$) than males after the second year of life. The faster growth of female white perch has been reported in Lake Ontario (QLM, 1974), and throughout the range of the species (Mansueti, 1961; Miller, 1963; Wallace, 1971; St. Pierre and Davis, 1972).

The maximum growth of Nine Mile Point white perch occurred during the first two years of life (Figure VII-11). At the end of the the first and second years' growth, white perch were 24.67% and 48.43%, respectively, of the length attained after 10 years of growth. The rate of growth expressed as the percent annual increase in total length declined from 98.28% for males and 95.23% for females at age two, to 25.82% and 30.92%, respectively, after the third year of life (Appendix VII-24). Growth continued to decline rapidly through age five, after which the decline continued but at a slower rate.

The average annual increments of growth of male and female white perch, for each year of life, are presented in Table VII-23, Figure VII-11. The ratios of the grand average increment of length and the differences between the increments

TABLE VII-22

AVERAGE TOTAL LENGTH AT CAPTURE
AND SIZE RANGE OF WHITE PERCH

NINE MILE POINT - 1974

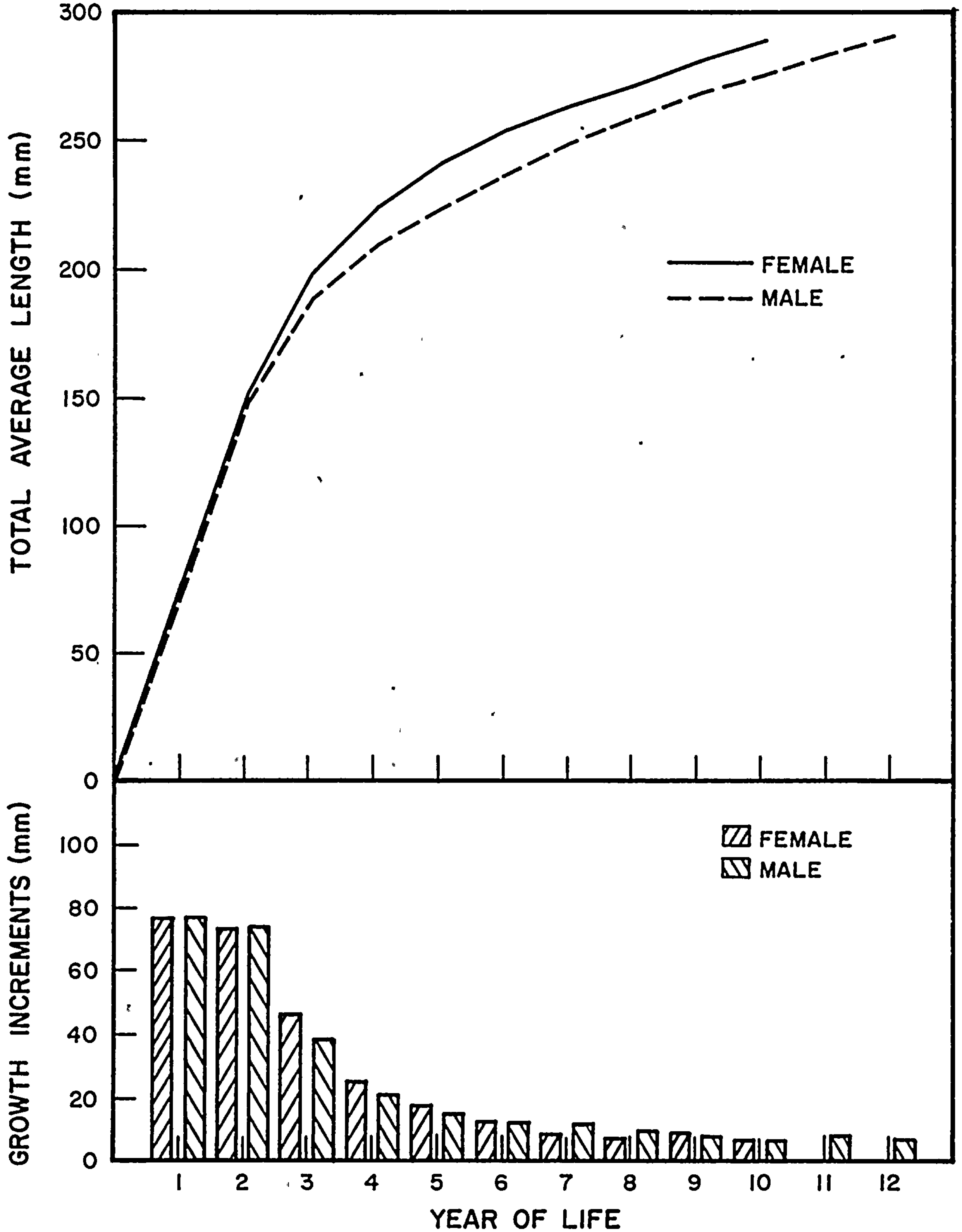
SEX	AGE GROUP	AVERAGE LENGTH (mm)	NUMBER	RANGE (mm)		
Not Determined	1	84.40	58	62	-	132
Male	2	153.57	37	126	-	182
	3	190.20	30	160	-	212
	4	212.48	31	185	-	243
	5	223.18	22	206	-	240
	6	235.93	15	200	-	252
	7	237.25	12	169	-	271
	8	239.50	8	197	-	267
	9	262.43	7	231	-	291
	10	273.00	1	-		-
	11	295.50	2	290	-	301
	12	301.00	1	-		-
Female	2	160.48	21	125	-	181
	3	202.15	27	170	-	235
	4	215.71	24	163	-	245
	5	237.73	33	193	-	267
	6	243.47	15	212	-	274
	7	266.23	13	252	-	290
	8	272.17	18	240	-	307
	9	276.25	4	258	-	287
	10	318.50	2	310	-	327

--- Not applicable

FIGURE VII-11

GROWTH CURVES AND ANNUAL GROWTH INCREMENTS OF MALE AND FEMALE WHITE PERCH

NINE MILE POINT 1974



for each year of life represent the relative and actual advantage of a sex, respectively. Growth of both male and female white perch was similar during the first two years of life but females showed a larger growth advantage during the third year of life. The cumulative size advantage for females increased through age six to a maximum of 17mm; the annual increment advantage of the females decreased from age three through six (Table VII-22), and the cumulative size advantage for females decreased during the seventh and eight years of life to 12.06mm. Growth of both sexes at age nine and ten was similar, with females registering a slight advantage. Because ten years was the maximum age for female white perch collected, growth comparisons after this were not possible. Males may have a greater longevity as male fish 12 years of age were collected.

(iv) Comparison with Other Populations

The mean back calculated lengths from this and seven other studies are presented in Table VII-24. The back calculated lengths were converted to total length (TL) where necessary, using the following formula derived from Nine Mile Point white perch:

$$TL = 1.0445 \times \text{fork length}$$
$$TL = 1.2218 \times \text{standard length}$$

An important consideration in making growth comparisons is the method used to back calculate length. With the exception of Conover (1958), who used a nomograph, the remaining authors used the simple proportion method (Lee, 1920) with a correction factor, which is synonymous with the y-intercept in the regression of body length on scale length.

$$L = S \frac{(L')}{(Sc)}$$

The first year growth of Nine Mile Point white perch is comparable to that of other fast growing populations; however, perch from this area appear to grow faster during the second through the eighth year of life than fish from other all populations, with the exception of the Connecticut River white perch. Growth after age five appears to slow down and is approximately equal to that of three other populations, but is still faster than three (Table VII-24). Nine Mile Point white perch appear to grow faster than white perch in the Bay of Quinte for ages two through six, whereas white perch from the Bay of Quinte appear to grow more rapidly

TABLE [illegible]23

COMPARISON OF CALCULATED GROWTH OF MALE AND FEMALE WHITE PERCH FOR EACH YEAR OF LIFE

NINE MILE POINT - 1974

YEAR OF LIFE	A GRAND AVERAGE ANNUAL INCREMENT (mm)		B AVERAGE TOTAL LENGTH (mm)		C PERCENT ANNUAL CHANGE IN INCREMENT		D RATE OF GROWTH (PERCENT ANNUAL INCREASE IN TOTAL LENGTH)		E RATIO OF INCREMENT OF SEXES	F DIFFERENCE BETWEEN INCREMENTS OF SEXES (FEMALE ADVANTAGE)	G CUMULATIVE SIZE ADVANTAGE (FEMALE) (mm)
	M	F	M	F	M	F	M	F			
1	77.41	77.32	75.41	77.32					1.03	1.91	1.91
2	74.11	73.63	149.52	150.95	-4.43	-4.77	98.28	95.23	.99	-.48	1.43
3	38.60	46.67	188.12	197.62	-47.92	-36.62	25.82	30.92	1.21	8.07	9.50
4	21.50	25.57	209.62	223.19	-44.30	-45.21	11.43	12.94	1.19	4.07	13.57
5	15.00	18.07	224.62	241.26	-30.23	-29.33	7.16	8.10	1.20	3.07	16.64
6	12.74	13.10	237.36	254.36	-15.07	-27.50	5.67	5.43	1.03	.36	17.00
7	12.29	9.60	249.65	263.95	- 3.53	-26.72	5.18	3.77	.78	-2.69	14.31
8	9.96	7.71	259.61	271.67	-18.96	-19.69	3.99	2.92	.77	-2.25	12.06
9	8.33	9.36	267.94	280.98	-16.73	+20.75	3.21	3.43	1.12	.98	13.04
10	7.32	7.41	275.26	288.39	-12.12	-20.41	2.73	2.64	1.01	.09	13.13
11	8.61	-	283.87	-	+47.62	-	3.13	-	-	-	-
12	7.29	-	291.16	-	-15.33	-	2.57	-	-	-	-

M - Males
F - Females

Columns
A and B - From Appendix VII-24

C = $\frac{100\ (A2 - A1)}{A1}$; $\frac{100\ (A3 - A2)}{A2}$ etc. for each sex

D = $\frac{100\ (A2)}{B1}$; $\frac{100\ (A3)}{B2}$ etc. for each sex

E = $\frac{A1F}{A1M}$: $\frac{A2F}{A2M}$ etc. for each year of life

F - A1M - A1F etc. for each year of life

G - Successive summation of column G

TABLE VII-24

COMPARISON OF THE AVERAGE TOTAL LENGTH OF FISH
AT EACH YEAR OF LIFE FOR WHITE PERCH
REPORTED FROM LAKES IN THE UNITED STATES*

YEAR OF LIFE	LAKE ONTARIO NINE MILE POINT (PRESENT STUDY)	LAKE ONTARIO NINE MILE POINT (QLM, 1974)	BAY OF QUINTE LAKE ONTARIO (SHERI & POWER, 1969)	ROANOKE RIVER NO. CAROLINA (CONOVER, 1958)	CONN. RIVER (LOWER) (MARCY and RICHARDS, 1974)	STATE OF CONN. AVER. (WHITWORTH & SAUTER, 1972)	DELAWARE RIVER NEAR ARTIFICIAL ISLAND (WALLACE, 1971)	JAMES RIVER VIRGINIA (St. Pierre & Davis, 1972)	YORK RIVER VIRGINIA (St. Pierre & Davis, 1972)
	LENGTH (mm)	LENGTH (mm)	LENGTH (mm)	LENGTH (mm)	LENGTH (mm)	LENGTH (mm)	LENGTH (mm)	LENGTH (mm)	LENGTH (mm)
1	76 (58)	94 (1)	84 (120)	70 (283)	87 (110)	81 (464)	68 (161)	80 (132)	83 (79)
2	149 (58)	158 (24)	133 (146)	114 (149)	181 (80)	131 (457)	140 (491)	127 (89)	124 (231)
3	190 (57)	195 (59)	172 (157)	156 (84)	227 (71)	166 (416)	164 (214)	157 (150)	152 (224)
4	213 (55)	213 (46)	197 (138)	188 (79)	258 (60)	194 (295)	181 (189)	182 (120)	179 (81)
5	230 (55)	225 (32)	218 (124)	215 (49)	281 (27)	223 (172)	193 (84)	200 (115)	200 (76)
6	241 (30)	241 (17)	234 (83)	237 (42)	311 (7)	245 (77)	204 (49)	215 (85)	221 (49)
7	254 (25)	249 (14)	253 (57)	254 (28)	345 (1)	252 (16)	213 (18)	232 (38)	242 (22)
8	264 (26)	255 (9)	274 (35)	266 (6)		267 (6)	218 (11)	249 (15)	261 (8)
9	274 (11)	260 (6)	289 (6)					267 (2)	274 (4)
10	299 (3)	277 (3)	289 (2)					277 (1)	285 (1)
11	296 (2)								
12	301 (1)								

* Numbers which appear in parentheses represent the number of fish measured in determining average length.

after the eighth year of life; however, small sample sizes in these age groups make comparisons dubious.

(v) Length Frequency

The length frequency distributions of white perch are presented in Figure VII-12. During April the catch was made up of fish in age class III or IV and yearlings (estimated from total length), with a small percentage of age class II individuals. In May most of the fish were mature adults of age class III to VI, and presumably represented the spawning population. The same trend continued until October when the main portion of fish were age class I and II. The young-of-the-year are not observed on these graphs because the seine data were not included in these analyses.

The younger, sexually immature fish did not appear in the vicinity of Nine Mile Point until October and November. These groups of fish were probably feeding aggregations, and were collected from only the FITZ transect.

e. Biomass

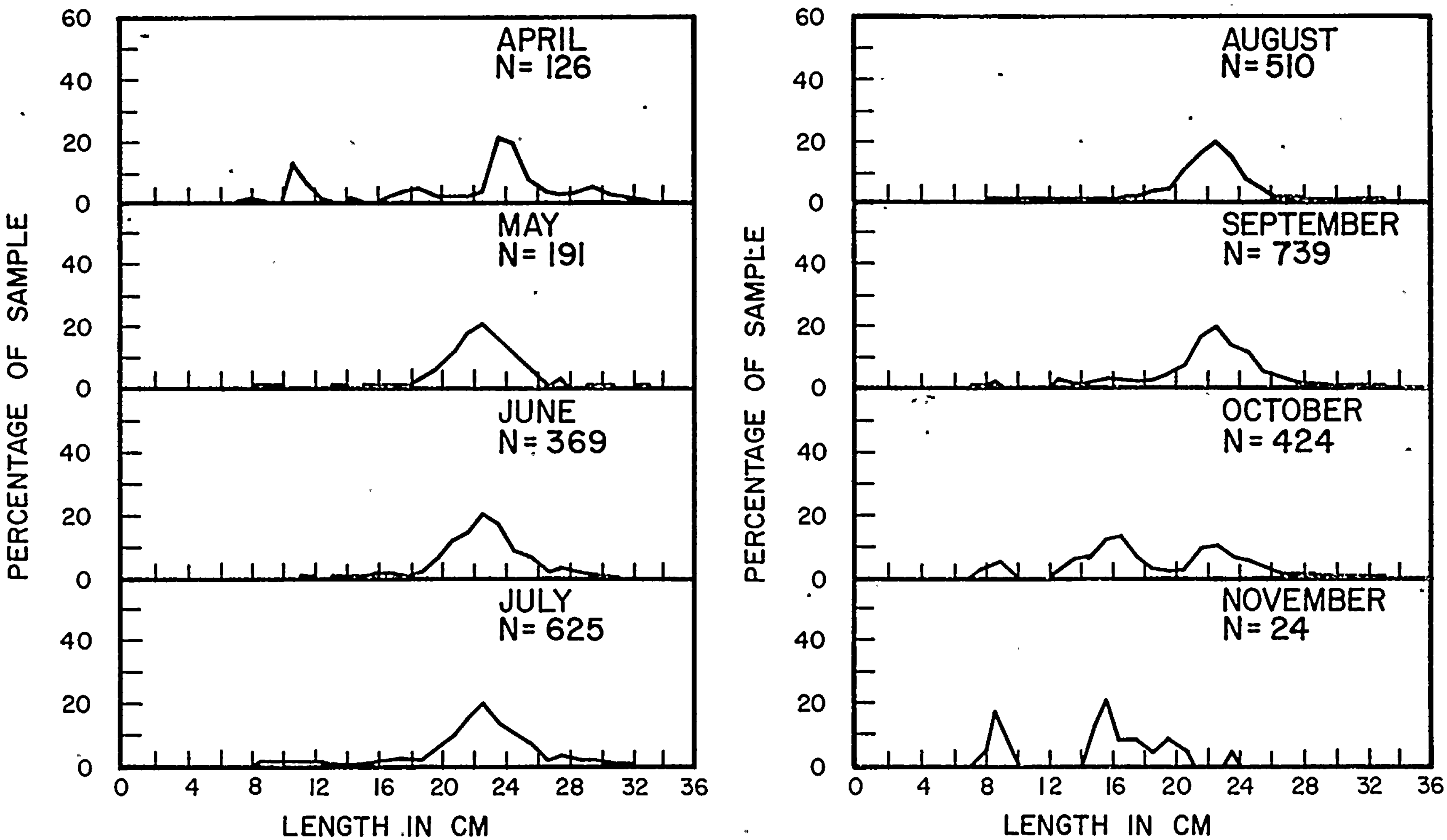
The biomass data for white perch (Table VII-25) indicate that the average weight of individuals of this species generally increased during the spring. Periods of recruitment of young fish, based on biomass data, were observed during October and November which is in agreement with findings from the length frequency data (Figure VII-12). The average weight of the 3109 white perch analyzed was 196.15 grams. The primary period of recruitment (October) was most evident at FITZ transect, whereas the secondary recruitment period (April) was observed primarily at NMPE transect, with FITZ transect showing an older population.

5. Yellow Perch (*Perca flavenscens*)

a. Trophic Level and Importance

The literature does not agree as to the species designation for the yellow perch; however, in the Northern Hemisphere, the fish referred to under the common name of yellow perch has a circumpolar distribution in fresh water. In North America, the yellow perch occurs along the Atlantic coast from Nova Scotia south to Florida and Alabama (Scott and Crossman, 1973). Throughout this range it is a commercially valuable species. Yellow perch are most abundant in the open water of large lakes with moderate vegetation (Scott and Crossman, 1973); however, they are also successful in ponds and quiet rivers. Both the young and adults form loose

LENGTH FREQUENCY DISTRIBUTION FOR LAKE WHITE PERCH
NINE MILE POINT
1974



N = TOTAL NUMBER OF FISH ANALYZED FROM GILL NET AND TRAWL SAMPLES

FIGURE VII-12

TABLE VII-25

TOTAL BIOMASS AND AVERAGE BIOMASS PER INDIVIDUAL
FOR WHITE PERCH
COLLECTED WITH GILL NETS

NINE MILE POINT - 1974

TRANSECT	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)
NMPE	4002	148.3	4590	229.5	27635	211.0	54944	221.5	67206	219.6	108161	210.8	29663	146.9	391	30.1	0	0
FITZ	9934	216.0	11158	202.9	30550	193.4	38132	213.0	27278	177.1	31772	191.4	10738	103.3	711	79.1	7.0	7.0.
NMPP	3656	174.1	18172	224.3	9500	226.2	24905	207.5	8459	217.7	15994	199.9	12457	148.3	617	103.0	0	0
NMPW	3329	166.5	9118	217.1	9889	267.3	16299	209.0	10964	215	3839	137	5521	120.0	207	103.7	0	0

aggregations of 50 to 200 individuals, apparently according to size. The groups of young fish are found predominately in shallow, near shore waters. Schools of adults, located predominantly in the deeper waters, are more compact in the summer (Scott and Crossman, 1973). The yellow perch is the first species so far discussed in this section which is a member of the natural community of Lake Ontario.

Contents of the stomachs of 48 yellow perch collected in bottom gill nets at the 15 ft depth contour were examined (Table VII-26); these fish ranged in size from 16.0 to 26.8 cm during the spring and from 18.6 to 27.4 cm during the fall, with the exception of one 16.0 cm length fish. The fish collected during the spring contained a greater variety of food items in their stomachs than those recorded from the fall collection. Of the stomachs examined, 53.7% contained fish (mottled sculpin and alewives identifiable) and 26.8% contained fish eggs and Gammarus fasciatus.

During the fall sampling period, the stomachs of yellow perch were analyzed. Fish (alewife identified) and amphipods were the only identifiable materials.

b. Seasonal Distribution and Abundance

Scott (1955), Hergenrader and Hasler (1968), and Muncy (1962) reported a yellow perch spring migratory movement. In northeastern Lake Ontario (Bay of Quinte), yellow perch were observed moving to the spawning grounds in the spring (Griffiths, 1974). Storr (1973) observed migratory movements to southeastern Lake Ontario spawning grounds in winter. In addition to the migratory movements related to spawning, daily, seasonal, vertical, and horizontal movements have been reported, and are probably in response to temperature and distribution of food.

Table VII-5 presents the monthly abundance of yellow perch caught in gill nets for each transect; no yellow perch were collected with the otter trawl (Appendix VII-3), and one was collected in June by beach seine (Appendix VII-4). Therefore, statistical analyses were conducted only on the gill net data.

Two-way ANOVAs, one each for day and night, were conducted comparing yellow perch distribution by sampling depth (surface and bottom) and among seasons (Appendix VII-25). Significantly more yellow perch were collected in the bottom gill nets than the surface nets during both day and night, suggesting that the yellow perch in the vicinity of Nine Mile Point select bottom waters. According to Scott and Crossman (1973), these fish move up and down in the water column daily. More fish were generally collected during

TABLE VII-26

STOMACH CONTENT ANALYSIS OF YELLOW PERCH
COLLECTED IN BOTTOM GILL NETS AT 15 DEPTH CONTOUR+

NINE MILE POINT - 1974

SPRING			SAMPLE SIZE: 42
FOOD ORGANISMS	PERCENT FREQUENCY OF OCCURRENCE	TOTAL NUMBERS OF ORGANISMS CONSUMED	PERCENT COMPOSITION
Amphipods (Gammarus)	26.8	217	19.2
Dipteran larvae	7.3	5	0.4
Dipteran pupae	7.3	6	0.5
Mysids	2.4	1	0.1
Pisces	53.7	55	4.9
Pisces eggs	26.4	844	74.6
Gastropods	2.4	1	0.1
Decapods	4.9	2	0.2
Number of empty stomachs = 0			

FALL			SAMPLE SIZE: 6
Amphipods	16.0	21	84.0
Pisces	33.0	4	16.0
Number of empty stomachs = 2			

+ NMPE, FITZ, NMPP, and NMPW transects.

the summer (July, August and September) than during the spring; however, no consistent trend was observed for the fall collections. The greater abundance of yellow perch in the Nine Mile Point area at a time other than their spawning season indicates indirectly that they did not utilize this area for spawning.

In addition, three-way ANOVAs, one each for bottom and surface collections, were conducted comparing the distribution of fish between day and night, among the seasons, and among the sampling transects (Appendix VII-26). A significant sampling depth x season interaction was shown for daytime catches (Appendix VII-25); three-way ANOVAs (Appendix VII-26) performed to define this interaction more precisely showed a significant difference among seasons only for bottom catches. Bottom gill net catch data indicate that more yellow perch were collected from the NMPE and FITZ transects than from the NMPW transect. The number of fish caught at the NMPP transect could not be separated from that caught at the other transects, thus, indicating that the yellow perch were not concentrated in the immediate vicinity of the Nine Mile Point Nuclear Station.

Everest (1973) found at the Hearn Generating Station in northwestern Lake Ontario that yellow perch, which were found only from June to November, were concentrated in the plume area as compared to a control area. This occurred especially during October, when these fish were collected at temperatures between 13-22°C, but when ambient temperatures were around 9-11°C. The final temperature preference for the species has been experimentally determined at 21-24°C (Ferguson, 1958). The data and results presented in this report do not support the results obtained by Everest (1973). If yellow perch were selecting the thermal plume at Nine Mile Point, then collection data would be expected to indicate: 1) more fish at the surface 2) more fish at NMPP transect. Neither result was obtained.

c. Reproduction

(i) Fecundity and Time of Spawning

The time of spawning was determined by examining the coefficient of maturity data for 351 males and 537 female yellow perch collected in the vicinity of Nine Mile Point from January through December 1974 (Appendix VII-27). A plot of these data at approximately bimonthly intervals revealed that peak spawning occurred during the first two weeks in April (Figure VII-13). Water temperature during this period was 0.7°-6.2°C (33.3°-43.2°F) with a mean temperature of 3.3°C (37.9°F). Muncy (1962) reported yellow perch movement to the spawning

grounds in the Severn River, Maryland from late February to early March, a period when water temperatures were 3.9°-6.7°C (39°-44°F).

The ovaries of the 18 sexually mature females examined contained eggs of one type ranging in diameter from 0.6 to 1.5 mm with a mean of 0.93 mm. The fecundity estimates (Appendix VII-28), based on total egg counts, ranged from 4,840 eggs (fish body length 150 mm, weight 42.2 g) to 50,000 eggs (290 mm length, 429.3 g weight), with a mean of 25,077 eggs. The relationship of fecundity to total body length, weight,ovary weight, and age (Appendix VII-28; Table VII-27) is shown in the following equations:

Regression Equation	Correlation Coefficient (r)
Y = 2.9474 + .0061 x Body Length (mm)	r = .90
Y = 3.9416 + .0020 x Body Weight (g)	r = .85
Y = 4.0718 + .0053 x Ovary Weight (g)	r = .80
Y = 3.7912 + .1009 x Age (years)	r = .74

where Y equals the logarithm of the total number of eggs.

The high correlation coefficients for body length and weight and ovary weight indicate that fecundity is closely related to these parameters and that, generally the longer, heavier fish generally contain more eggs (Appendix VII-28). Age, however, did not provide a good estimate of fecundity due to the variability within individual age groups (Table VII-27); however, there were not enough fish per age group to test this data statistically.

Sheri and Power (1969) estimated the fecundity of yellow perch in the Bay of Quinte, Lake Ontario, at from 3,035 to 61,465 total eggs for fish 131-257 mm long. Muncy (1962) reported totals from 5,900 to 109,000 eggs for yellow perch from 173 to 358 mm in length in the Severn River, Maryland. Mean egg production for 20 fish ranging in size from 173-295 mm was 17,940 eggs, while mean egg production for five larger females (302-358 mm) was 32,200 eggs (Muncy, 1962). When allowance is made for the size of the female, these estimates appear to be comparable to those of this study.

(ii) Sex Ratio

Data on the monthly abundance of yellow perch by sexes are presented in Table VII-28. Scott and Crossman (1973) and Muncy (1962) state that males arrive on the spawning grounds

FIGURE VII-13

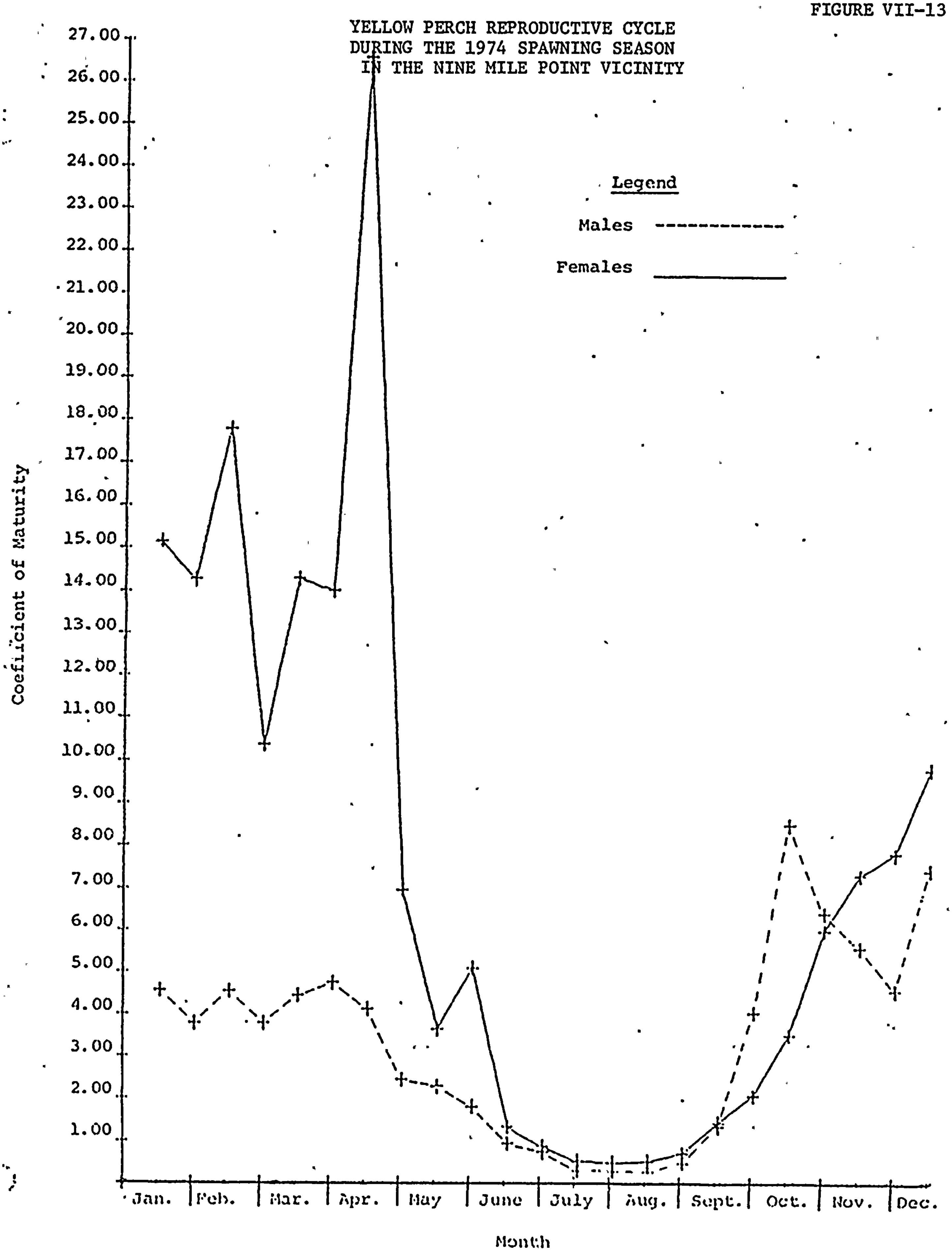


TABLE VII-27

TOTAL LENGTH, WEIGHT AND NUMBERS OF EGGS PER FISH ACCORDING TO AGE, IN A SAMPLE OF 11 YELLOW PERCH

NINE MILE POINT - 1974

Age	No. of Fish	Total Length (mm.) Range	Total Length (mm.) Mean	No. of Total Eggs per fish Range	No. of Total Eggs per fish Mean	Standard Deviation	Weight of fish (g) Range	Weight of fish (g) Mean
IV	1	-	187	-	16,310	-	-	97.8
V	3	184 - 242	217	9,854 - 31,159	21,890	10,919	87.1 - 224.1	156.0
VI	3	230 - 250	239	18,862 - 29,185	23,552	5,226	207.1 - 217.1	212.1
VII	1	-	293	-	44,010	-	-	381.7
VIII	2	220 - 265	243	28,601 - 48,140	38,371	13,816	142.0 - 360.9	251.5
IX	1	-	290	-	50,000	-	-	429.3

- Not applicable

before females and remain there longer; the females leave immediately after spawning. Therefore, more males will be found on the spawning grounds during the reproductive season. However, the sex ratio was biased toward females in the vicinity of Nine Mile Point during the spawning season for yellow perch (April, May, June). This observation, in addition to the fact that few larvae were collected from the area, indicates that yellow perch probably did not use the Nine Mile Point vicinity as a spawning ground. In addition, Storr (1973) showed that 40% of the yellow perch tagged and released in the Nine Mile Point vicinity moved eastward out of the area. The majority were recaptured at North Sandy Pond, an area which has been assumed to be the spawning grounds for the southern population of yellow perch in Lake Ontario. A few strands of yellow perch eggs were found by divers during the harvesting of buoy periphyton collections near Nine Mile Point, indicating that at least one fish spawned within the area.

d. Age and Growth

(i) Body-Scale Relationship

The body length-scale length relationship (L/Sc) for yellow perch was determined for 237 male and female yellow perch ranging in size from 81 to 323 mm (Appendix VII-29). No clear trend was observed with increasing body length. The body-scale relationship was described by the equation

$$L = 38.72 + 46.92S,$$

where L is total body length in millimeters and S is the scale radius in millimeters. The relationship between body length and scale radius was linear ($p < 0.05$); thus a constant L/Sc ratio was assumed, and an average weighted L/Sc ratio of 59.77 was used to correct the scale measurements.

(ii) Time of Annulus Formation

The time of annulus formation was determined by examining scales from 170 yellow perch caught between April and October. Annulus formation was complete in some yellow perch during April and May, peaked during June, and was complete for all fish examined by July (Appendix VII-30); a similar pattern occurred in the Nine Mile Point vicinity in 1973 (QLM, 1974). These data are also consistent with results from a Lake Erie study that reported annulus formation in yellow perch between early April and mid-July (Jobes, 1952).

TABLE VII-28

SEX RATIOS FOR YELLOW PERCH COLLECTED BY GILL NETS AND TRAWLS

NINE MILE POINT - 1974

MONTH COLLECTED	MALES		FEMALES	
	ABUNDANCE	PERCENT	ABUNDANCE	PERCENT
APR	24	19.35	100	80.65
MAY	32	33.33	64	66.67
JUN	96	39.51	147	60.49
JUL	160	35.24	294	64.76
AUG	32	29.91	75	70.09
SEP	39	36.79	67	63.21
OCT	79	35.91	141	64.09
NOV	9	33.33	18	66.67
DEC	4	57.14	3	42.86
TOTAL	475	34.32	909	65.68

(iii) Age and Growth Calculation

The back calculated lengths at annulus formation and the standard error at annulus formation for each year of life for 124 females and 102 male yellow perch are presented in Appendix VII-31. The two growth estimates, (1) the grand average calculated length and (2) the summation of the grand average annual increment of length for each succeeding year of life, were in agreement, indicating that the yellow perch population is not exploited by the selective destruction of the faster growing individuals (El-Zarka, 1959). The 95% confidence intervals for the grand average calculated lengths did not overlap through age four for both female and male yellow perch. Therefore length can be used as a valid indicator of age for these age groups.

The growth curves (calculated from the summation of the grand average annual increments of length) for both male and female yellow perch (Figure VII-14) had the same form; however, females generally appeared to be larger. A t-test of the yearly differences in grand average calculated length, however, revealed no significant differences ($p > 0.05$). Hile and Jobes (1942) and El-Zarka (1959) reported that female yellow perch were larger after age two. Hile and Jobes (1941) found the same pattern of growth after the third year of life. The average total length at capture for each age group by sex (Table VII-29) was in agreement with the grand average back calculated lengths (Appendix VII-31).

The average annual growth increments of male and female yellow perch, for each year of life, are presented in Appendix VII-31 and Figure VII-14. The greatest increment of growth for Nine Mile Point yellow perch occurred during the first year of life.

This is unlike the pattern reported in the Nine Mile Point vicinity for white perch, alewife and smelt, which displayed a sharp drop in growth. The ratio of the grand average annual increment (Table VII-30), representing the relative advantage of a sex, was generally near unity except for age three and five. This indicated similar growth in both sexes and confirms the results of the t-test on the grand average calculated length.

(iv) Comparison with Other Populations

Statistical comparisons of Nine Mile Point yellow perch growth with that of other populations were not possible. The mean

GROWTH CURVES AND ANNUAL GROWTH INCREMENTS OF MALE AND FEMALE YELLOW PERCH

NINE MILE POINT 1974

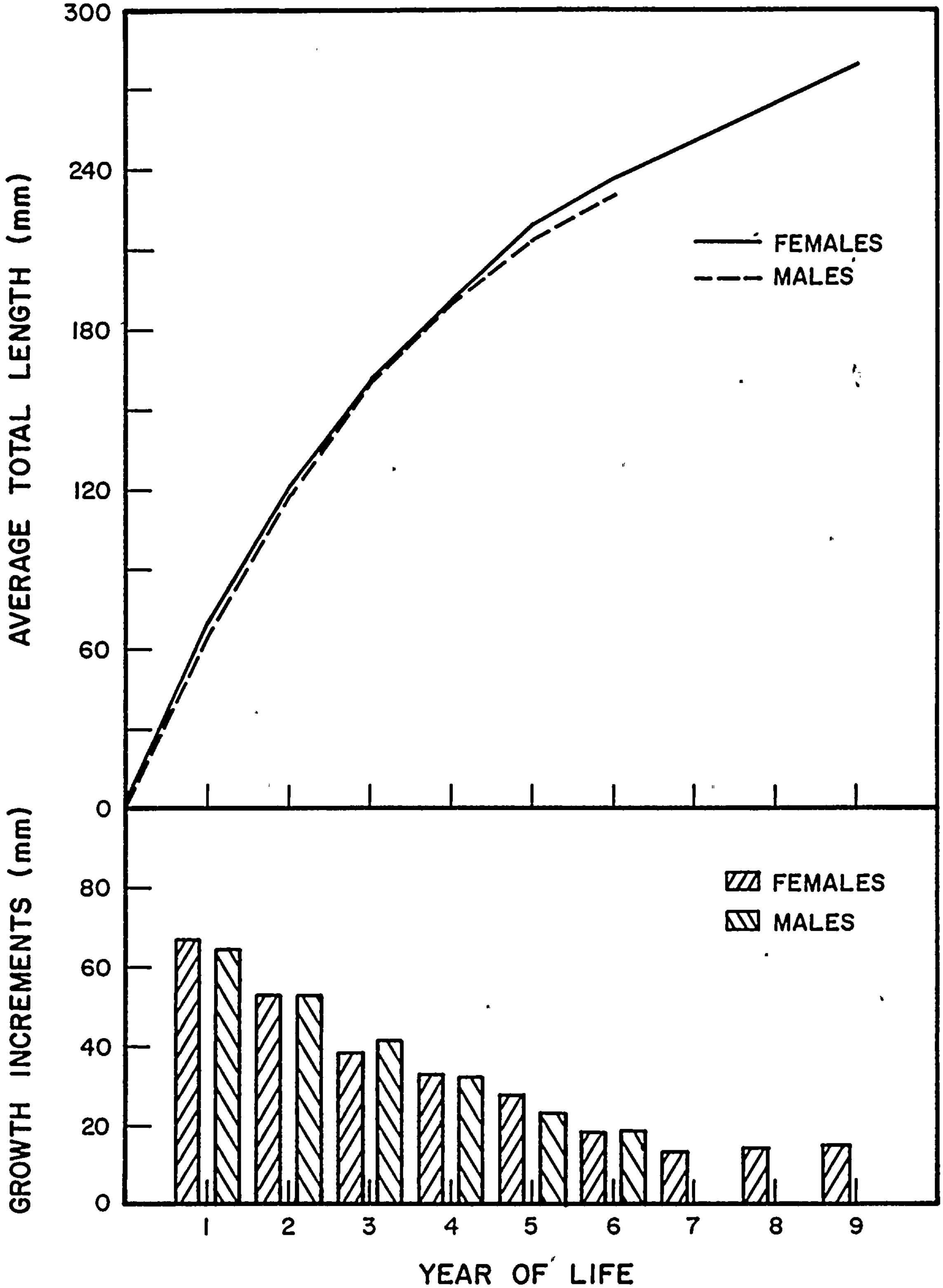


TABLE VII-29

AVERAGE TOTAL LENGTH AT CAPTURE
AND SIZE RANGE OF YELLOW PERCH

NINE MILE POINT - 1974

SEX	AGE GROUP	AVERAGE LENGTH (cm)	NUMBER	RANGE (cm)
Not Determined	I	9.98	5	9.1 - 10.5
	II	13.57	6	10.8 - 15.7
MALES	I	-	0	---
	II	16.12	19	10.5 - 19.9
	III	17.18	22	13.7 - 20.5
	IV	19.34	33	13.2 - 21.8
	V	21.94	18	19.2 - 26.2
	VI	22.88	10	18.0 - 28.2
FEMALES	I	11.5	4	10.2 - 14.8
	II	14.41	32	10.8 - 17.2
	III	15.75	32	13.2 - 19.2
	IV	18.76	23	14.7 - 23.7
	V	24.38	16	18.8 - 27.7
	VI	23.63	8	18.7 - 28.8
	VII	25.86	7	24.0 - 28.3
	VIII	28.35	2	27.4 - 29.3
	IX	32.3	1	---

--- Not applicable

TABLE VII-30

COMPARISON OF CALCULATED GROWTH
OF MALE AND FEMALE YELLOW PERCH
OF EACH YEAR OF LIFE

NINE MILE POINT - 1974

YEAR OF LIFE	A GRAND AVERAGE ANNUAL INCREMENT (mm)		B AVERAGE TOTAL LENGTH (mm)		C PERCENT ANNUAL CHANGE IN INCREMENT		D RATE OF GROWTH (PERCENT ANNUAL INCREASE IN TOTAL LENGTH)		E RATIO OF INCREMENT OF SEXES	F DIFFERENCE BETWEEN INCREMENTS OF SEXES (FEMALE ADVANTAGE)	G CUMULATIVE SIZE ADVANTAGE (FEMALE)
	M	F	M	F	M	F	M	F			
1	64.25	67.02	64.25	67.02	-	-	-	-	1.04	2.77	2.77
2	53.36	53.41	117.61	120.43	-16.95	-20.31	83.05	79.69	1.00	.05	2.82
3	41.77	38.19	159.38	158.62	-21.72	-28.50	35.52	31.71	.91	-3.58	-.76
4	32.07	33.01	191.45	191.63	-23.22	-13.56	20.12	20.81	1.03	.94	.18
5	22.70	27.67	214.15	219.30	-29.22	-16.18	11.86	14.44	1.22	4.97	5.15
6	18.49	18.05	232.64	237.35	-18.55	-34.77	8.63	8.23	.98	-.44	4.71
7	-	13.57	-	250.92	-	24.82	-	5.72	-	-	-
8	-	14.23	-	265.15	-	4.86	-	5.67	-	-	-
9	-	14.70	-	279.85	-	3.30	-	5.54	-	-	-

- = Not applicable

M - Males
F - Females

Columns
A and B - From Appendix VII-31

C = $\frac{100\ (A2 - A1)}{A1}$; $\frac{100\ (A3 - A2)}{A2}$ etc. for each sex

D = $\frac{100\ (A2)}{B1}$; $\frac{100\ (A3)}{B2}$ etc. for each sex

E = $\frac{A1F}{A1M}$: $\frac{A2F}{A2M}$ etc. for each year of life

G = A1M - A1F etc. for each year of life

H = Successive summation of column G

back calculated lengths from this and seven other yellow perch growth studies are presented in Table VII-31. These lengths were converted to total length (TL) where necessary, using the following formula from Muncy (1962):

$$TL = \frac{\text{standard length}}{.84}$$

The back calculated lengths reported by Hile and Jobes (1941), Jobes (1952), and El-Zarka (1959) were determined by the direct proportion method after taking into account the constancy of the body-scale length ratio for fish at two years of age and older. The other authors cited in Table VII-31 used the direct proportion method without determining the body-scale relationship. These studies using the direct proportion method should yield smaller lengths than the studies in which the data were corrected for one-year old fish; the length at the other ages should be comparable.

Yellow perch in the vicinity of Nine Mile Point appear to grow at a rate which is similar to, or possibly somewhat slower than that of yellow perch in Green Bay, Lake Michigan; they also grow more slowly than yellow perch in Nebish Lake, three Iowa lakes, and Lake Erie. On the other hand, they grow faster than populations in Weber Lake and Silver Lake (Hile and Jobes, 1941). In Saginaw Bay, Lake Huron, one study indicated that local yellow perch populations grew more rapidly than Nine Mile Point populations (Hile and Jobes, 1941), whereas a subsequent study found slower yellow perch growth in that area than at Nine Mile Point for fish of ages one to five (El-Zarka, 1959). Comparisons of growth for fish of age six and older are tenuous because of the difficulty of locating and reading the sixth and successive annuli.

The back calculated lengths determined for yellow perch at Nine Mile Point during 1974 should have resembled 1973 values closely but were, in fact, dissimilar (Table VII-31). However, subjecting the 1974 scale data for this species to the same method of back calculating length as was used in 1973 yielded almost identical results for age one fish. Thus, the divergence between the two years can be explained only as differences in the analysis of the scale data.

(v) Length-Frequency Distribution

The length-frequency data (Figure VII-15) indicate a trimodal distribution of ages, including fish of age groups two through

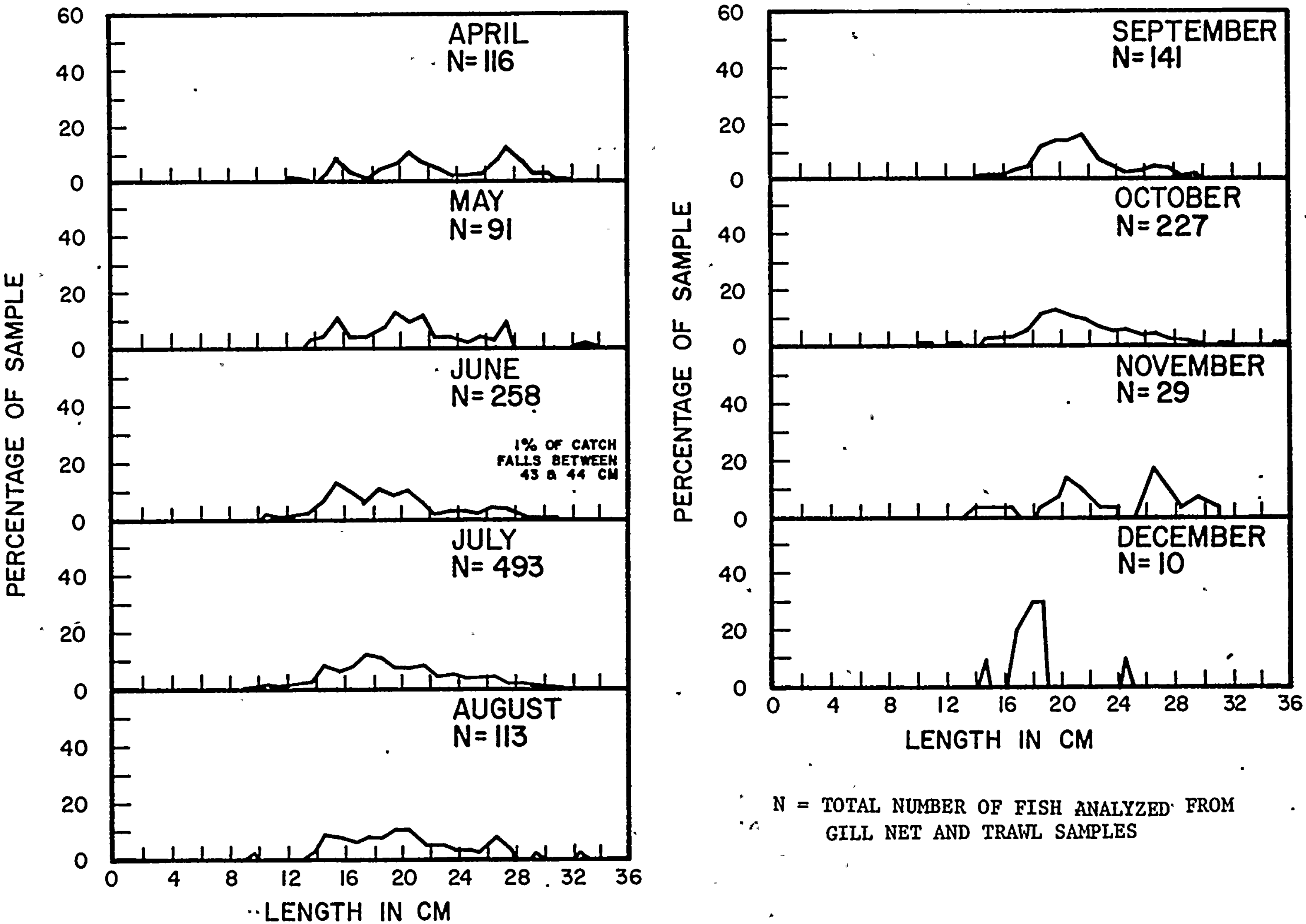
TABLE VII-31

COMPARISON OF THE AVERAGE TOTAL LENGTH (mm) OF FISH AT EACH YEAR OF LIFE FOR YELLOW PERCH REPORTED FROM LAKES IN THE UNITED STATES*

YEAR OF LIFE	Lake Ontario Nine Mile Point (Present Study)	Lake Ontario Nine Mile Point (QLM, 1974)	Green Bay Lake Michigan (Hile and Jobes, 1942)	Saginaw Bay Lake Huron (Hile and Jobes, 1941)	Lake Erie (Jobes, 1952)	Saginaw Bay Lake Huron (El-Zarka, 1959)	Three Iowa Lakes (Parsons)	Three Wisconsin Lakes (Schneberger, 1935) Nebish Lake	Weber Lake	Silver Lake
1	66 (4)	110	73 (2)	77	92	66 (18)	68 (74)	66 (159)	58 (3)	44
2	117 (51)	149	118 (58)	137 (20)	174	107 (565)	177 (86)	136 (306)	113 (389)	80 (148)
3	155 (54)	182	160 (128)	202 (308)	219	142 (1623)	235 (346)	175 (114)	145 (81)	113 (558)
4	189 (56)	211	198 (241)	248 (170)	248	178 (1006)	280 (16)	213 (39)	175 (278)	133 (239)
5	219 (48)	241	227 (212)	279 (137)	271	193 (173)	302 (39)		199 (248)	149 (93)
6	234 (18)	254	262 (98)	315 (17)	288	239 (12)			215 (69)	169 (21)
7	256 (7)	270	285 (8)	338 (5)		315 (3)			231 (13)	202 (2)
8	287 (2)		319 (4)			356 (1)			245 (3)	
9	318 (1)		360 (1)							

* Numbers which appear in parentheses represent the number of fish measured in determining average length.

LENGTH FREQUENCY DISTRIBUTION FOR LAKE YELLOW PERCH
NINE MILE POINT
1974



N = TOTAL NUMBER OF FISH ANALYZED FROM GILL NET AND TRAWL SAMPLES

FIGURE VII-15

eight, during April and May. Proportionately fewer older fish were present during June. For the remainder of the year, ages one through eight fish were fairly uniformly represented.

Throughout the year age classes three through five predominated in collections, due possibly to the use of gill nets, which are size selective. Some yearlings were collected during June, July and August, but no young-of-the-year yellow perch were collected with seines, trawls, or gill nets (Table VII-3), and few in larval tows (Table VB-8).

e. Biomass

The biomass data for yellow perch (Table VII-32) showed a peak in recruitment of young fish in the Nine Mile Point vicinity during the spring; however, the monthly peaks varied by transect: NMPE, NMPW, and FITZ transects showed a peak in June and NMPP transect in May. The length frequency data (Figure VII-15) confirm only the June peak based on average biomass per individual. The average weight of 1554 yellow perch analyzed from gill net collections was 145.92 grams.

6. Smallmouth Bass (Micropterus dolomieui)

a. Trophic Level and Importance

Smallmouth bass are naturally distributed throughout the fresh waters of eastern central North America, including the Great Lakes-St. Lawrence system and the Ohio, Tennessee, and upper Mississippi Rivers (Bailey, 1938); the species has also been widely introduced into Canadian waters. Throughout its range it is important as a sport fishery.

The smallmouth bass spawns in the late spring and early summer in the Great Lakes. Males build a nest on a sandy, gravelly, or rocky bottom in 2 to 20 ft (61-610 cm) of water, usually near the protection of rocks, logs or submerged vegetation. Males frequently return to the same nesting area year after year, in fact over 85% to within 150 yards of previous years' nesting sites.

The diet of adult smallmouth bass includes a variety of crayfish and fish, such as yellow perch, johnny darter, Iowa darter, log perch, northern pike, sculpins, sticklebacks, white suckers, bluntnose minnow, emerald shiner, spottail shiner, cyprinids, yellow walleye, white bass, freshwater drum, trout perch, sunfishes, rock bass, ciscoes, and smaller smallmouth bass. Competition with other species for food is minimal because of this varied diet, and the success

TABLE VII-32

TOTAL BIOMASS AND AVERAGE BIOMASS PER INDIVIDUAL
FOR YELLOW PERCH
COLLECTED WITH GILL NETS

NINE MILE POINT - 1974

TRANSECT	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)
NMPE	7942	155.7	4111	164.4	4760	79.3	7796	102.6	5607	136.8	5805	170.8	12509	154.4	2069	229.9	599	149.8
FITZ	10609	182.9	3389	116.9	8485	97.5	35010	130.6	4491	112.3	7558	142.6	11307	146.8	1121	280.3	166	83.3
NMPP	1588	122.2	3538	118.0	17813	176.4	18009	176.6	4624	185.0	6794	174.2	10152	169.2	2228	202.6	88	88.8
NMPW	1201	133.5	1248	178.4	2210	116.4	11342	162.0	4723	236.2	2682	167.7	4514	167.2	724	144.9	82.7	82.7

of stocking programs throughout the world can be at least partly attributed to the wide range of foods accepted by the smallmouth bass.

The stomachs of four smallmouth bass, ranging in size from 35.2 to 41.9 cm, were analyzed during the 1974 sampling season. One stomach was empty, three stomachs contained partly decomposed fish, and two of these also contained decapods in various stages of decomposition; the third fish stomach contained five small alewives. These data support the view that adult smallmouth bass eat crayfish and small forage fish (e.g., the alewife).

b. Seasonal Distribution and Abundance

Six smallmouth bass were collected by beach seine, two each in June, July, and August (Appendix VII-4), and none in trawl collections (Appendix VII-3). Bottom gill nets collected 261 bass, and surface gill nets only three; for this reason, the statistical analysis of the distribution of this species was performed on the bottom gill net data (Table VII-5).

The three-way ANOVA compared differences between day and night, among seasons, and among transects (Appendix VII-32). There was no statistical difference in abundance either between day and night or among sampling transects. A statistical difference in abundance among transects was expected, based on qualitative information from QLM divers and fisherman, who reported that smallmouth bass actively congregate within the area of the Nine Mile Point discharge. In addition, John Kelso (personal communication, Canada Center for Inland Waters, Burlington) reported that smallmouth bass in 1973 made frequent forays into "hot" areas of the Pickering Generating Station discharges. Sonic tagging showed that the fish entered the hot areas for only a few minutes, and then returned to the area just outside of the plume where they remained until the next foray. No transect difference was apparent in the Nine Mile Point Nuclear Station vicinity; this may have been due to the relatively small numbers of smallmouth bass collected.

More smallmouth bass were collected, however, during the summer (July, August, September) than during either spring (April, May, June) or fall (October, November, December).

c. Reproduction

(i) Fecundity and Time of Spawning

Fecundity measurements were not performed on smallmouth bass because these fish were not present in collections during

the spring. In addition, the time of spawning could not be determined.

(ii) Sex Ratio

The sexes were equally represented among smallmouth bass collected with gill nets in the vicinity of Nine Mile Point over the year (Table VII-33). Smallmouth bass spawn as pairs, and therefore it should be expected that in a spawning area individuals would be distributed equally between the sexes. However, these data cannot be interpreted as evidence of bass spawning in the area.

d. Age and Growth

(i) Body-Scale Relationship

The body length-scale length (L/Sc) relationship was determined for 142 male and female smallmouth bass (Appendix VII-33). Accurate determination for each age was impossible because 77% of the smallmouth bass were over 300mm in length and only 33 fish were smaller. The nature of the L/Sc relationship (linear, curvilinear, etc.) was also not determinable because most fish captured fell into too few length intervals (approximately 310-390mm). The literature indicates that the L/Sc relationship is linear throughout the fishes' life (Reynolds, 1965), or linear after the first or second year of life (Everhart, 1949, 1950). For the purposes of back calculating the growth of smallmouth bass, the L/Sc relationship was assumed to be linear at all ages. However, if it is, in fact, similar to Everhart's (1950) observation in Cayuga Lake (i.e., smaller for young fish), the lengths of one and two year old fish may be overestimated. A mean weighted L/Sc ratio of 80.46 was used to correct the scale measurements.

(ii) Time of Annulus Formation

Annulus formation began during May and June, peaked during July (52%) and was essentially complete by August (Appendix VII-34). Reynolds (1965) reported that annulus formation in smallmouth bass occurred in late May in the Des Moines River, Iowa; Suttkus (1955) observed that annulus formation for smallmouth bass was completed during May and June for a small stream population in Falls Creek, New York.

(iii) Age and Growth Calculation

The average back calculated lengths at annulus formation and the standard error of the mean for each year of life were computed

TABLE VII-33

SEX RATIOS FOR SMALLMOUTH BASS COLLECTED BY GILL NETS*

NINE MILE POINT - 1974

MONTH COLLECTED	MALES		FEMALES	
	ABUNDANCE	PERCENT	ABUNDANCE	PERCENT
APR	9	50.00	9	50.00
MAY	7	24.14	22	75.86
JUN	4	40.00	6	60.00
JUL	9	42.86	12	57.14
AUG	21	52.50	19	47.50
SEP	35	44.87	43	55.13
OCT	6	46.15	7	53.85
NOV	8	88.89	1	11.11
DEC	0	---	0	---
TOTAL	99	45.41	119	54.59

* Smallmouth bass not collected in trawls.
---- Not applicable

for 59 male and 71 female smallmouth bass (Appendix VII-35). The two estimates of growth, (1) the grand average weighted calculated length and (2) the summation of the grand average annual increment of length for each succeeding year of life, diverged for both male and female fish of ages 8 through 11. The current growth rate is faster than the growth rate calculated for those fish of age 8 through 11.

The 95% confidence intervals for the grand average calculated lengths did not overlap for females, but overlapped after age 7 for males (Appendix VII-35). Length can be used as a valid indicator of age for only those age groups that did not overlap. The empirical average lengths at capture (Table VII-34) were in agreement with the back calculated lengths of only the older age groups (8-11) the lack of agreement for the younger age classes probably resulted from few fish being collected in these age groups.

The growth curves (calculated from the summation of the grand average annual increments of length) for both male and female smallmouth bass had the same form, but males appeared larger at all ages (Figure VII-16). A t-test of the differences between the grand average calculated lengths of male and female smallmouth bass for each year of life revealed that males were significantly larger at ages 1, 3, 5, 6, 8 and 9 ($p < 0.05$). In 1973, QLM (1974) reported that only five-year-old males were significantly larger than females. Stone et al. (1954) reported little difference in the growth of male and female smallmouth bass in the St. Lawrence region of Lake Ontario; Suttkus (1955) also found no difference in the growth between the sexes for smallmouth bass in Fall Creek, New York.

The average annual growth increments of male and female smallmouth bass are presented in Appendix VII-35 and Figure VII-16. The ratios of the grand average increment of length and the differences between the increments for each year of life (Table VII-35) represent the relative and actual growth advantage of a sex for each year of life, respectively. Males were largest during the first year of life; females grew faster during the second and third years, thus decreasing the male advantage, but the male advantage increased during the fourth year of life. Growth at ages five through nine was similar for the sexes, and females showed a growth advantage during the tenth year of life. During the 1974 study, the oldest males caught were 10 years and females 11 years. The maximum age of smallmouth bass caught at Nine Mile Point

TABLE VII-34

AVERAGE TOTAL LENGTH AT CAPTURE AND SIZE RANGE OF SMALLMOUTH BASS

NINE MILE POINT - 1974

SEX	AGE YEARS	AVERAGE LENGTH (cm)	NUMBER	RANGE (cm)	
Not Determined	1	9.00	7	7.6	10.8
	2	17.33	4	15.7	18.8
MALES	1	13.10	1		
	2	16.53	4	14.4	18.7
	3	--	0	--	--
	4	--	0	--	--
	5	28.10	1	--	--
	6	31.55	4	27.8	37.6
	7	35.32	13	27.8	38.5
	8	34.89	18	27.9	38.7
	9	35.77	15	31.0	37.3
	10	36.60	3	35.5	37.4
FEMALES	1	--	0	--	--
	2	16.4	2	13.8	19.0
	3	--	0	--	--
	4	26.36	5	25.1	28.4
	5	28.83	3	27.8	29.4
	6	26.45	2	25.7	27.2
	7	34.52	13	28.7	40.6
	8	34.26	14	30.8	40.4
	9	35.06	19	31.1	40.0
	10	35.85	11	33.3	37.8
	11	37.33	4	36.4	37.9

-- Not applicable

FIGURE VII-16

GROWTH CURVES AND ANNUAL GROWTH INCREMENTS OF MALE AND FEMALE SMALLMOUTH BASS

NINE MILE POINT 1974

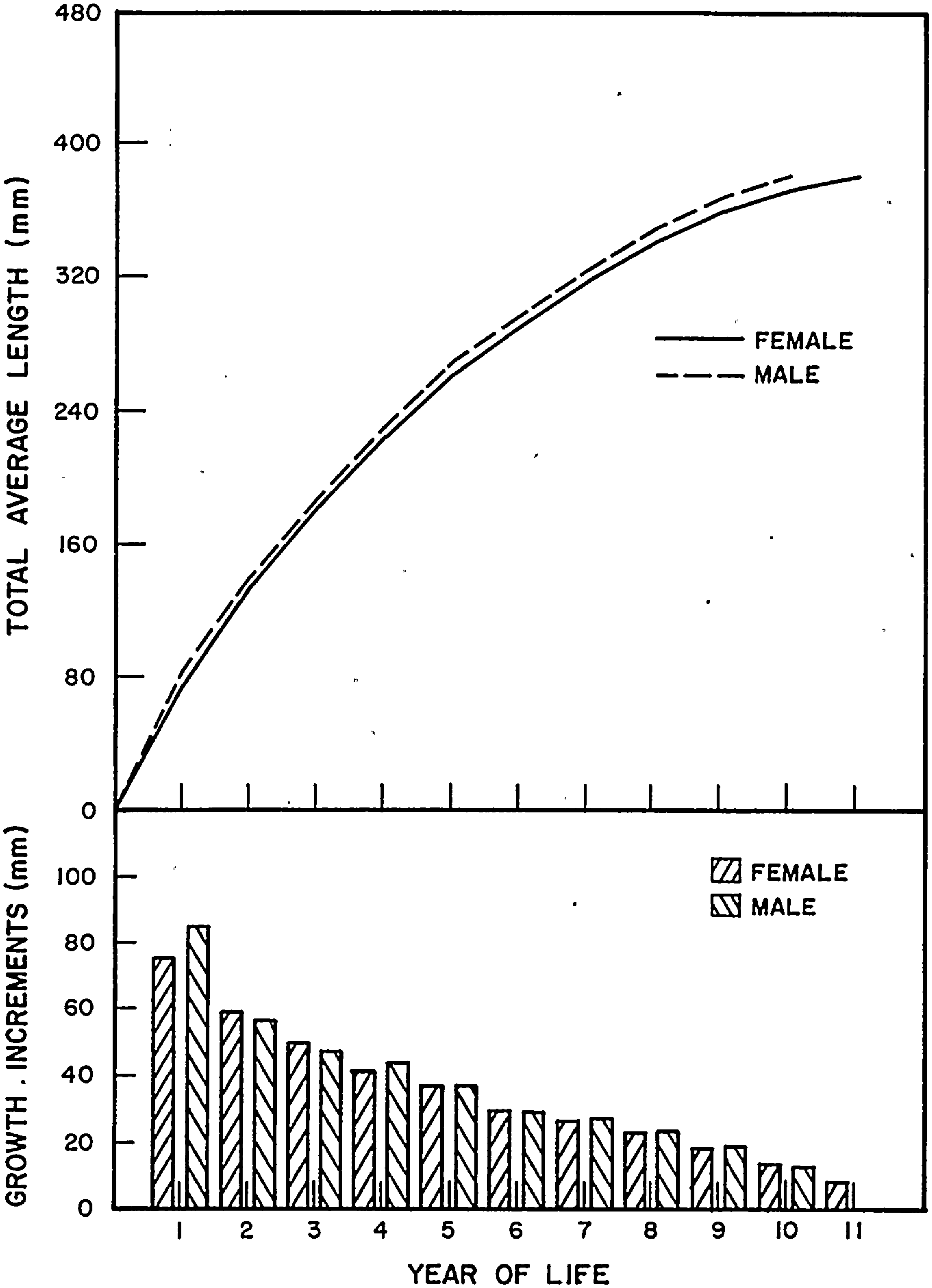


TABLE VII-35

COMPARISON OF CALCULATED GROWTH
OF MALE AND FEMALE SMALLMOUTH BASS
OF EACH YEAR OF LIFE

NINE MILE POINT - 1974

YEAR OF LIFE	A GRAND AVERAGE ANNUAL INCREMENT (mm)		B AVERAGE TOTAL LENGTH (mm)		C PERCENT ANNUAL CHANGE IN IN INCREMENT		D RATE OF GROWTH (PERCENT ANNUAL INCREASE IN TOTAL LENGTH)		E RATIO OF INCREMENT SEXES (F/M)	F DIFFERENCE BETWEEN INCREMENTS OF SEXES (MALE ADVANTAGE)	G CUMULATIVE SIZE ADVANTAGE (MALE)
	M	F	M	F	M	F	M	F			
1	85.05	75.44	85.05	75.44					.89	9.61	9.61
2	56.66	59.25	141.71	134.69	33.38	21.46	66.26	78.54	1.05	-2.59	7.02
3	47.18	49.11	188.88	183.8	16.73	17.11	33.29	36.46	1.04	-1.93	5.09
4	43.96	41.08	232.84	224.88	6.82	16.35	23.27	22.35	.93	2.88	7.97
5	37.17	37.21	270.01	262.87	15.45	9.42	15.96	16.55	1.001	-.04	7.93
6	28.93	29.84	298.95	291.93	22.17	19.8	10.71	11.35	1.03	-.91	7.02
7	27.29	26.88	326.24	318.81	5.67	9.92	9.13	9.21	.98	.41	7.43
8	23.73	23.34	349.97	342.15	13.05	13.17	7.27	7.32	.98	.39	7.83
9	19.15	18.45	369.11	360.6	19.3	20.95	5.47	5.39	.96	.70	8.52
10	12.39	13.84	381.50	374.44	35.3	24.99	3.36	3.84	1.12	-1.45	7.07
11	--	8.05	--	382.49	--	41.84	--	2.15	--		
12	--	--	--	--	--	--	--	--			

-- = Not applicable
M - Males
F - Females

Columns
A and B - From Appendix VII-35.

$C = \frac{100\ (A2 - A1)}{A1}; \quad \frac{100\ (A3 - A2)}{A2}$ etc. for each sex

$D = \frac{100\ (A2)}{B1}; \quad \frac{100\ (A3)}{B2}$ etc. for each sex

$E = \frac{A1F}{A1M} : \frac{A2F}{A2M}$ etc. for each year of life

G = A1M - A1F etc. for each year of life

during 1973 was 13 years for females and 14 years for males (QLM, 1974).

The greatest growth increment (Figure VII-16) occurred during the first year of life, when smallmouth bass grew to 21.1% of their age-ten length. The largest declines in the growth rate occurred during the second and third years of life for which the rate of growth, expressed as the percent annual increase in total length, declined to 72.9 and 35.02%, respectively. Growth continued to decline through the remaining years of life at a relatively constant rate.

(iv) Comparison with Other Populations

The mean back calculated lengths from this study and five other smallmouth bass growth studies are presented in Table VII-36. An important consideration in making growth comparisons is the method for back calculating length at each age. The 1973 Nine Mile Point growth study (QLM, 1974) and Reynolds (1965) used correction factors of 80.9mm and 40.64mm, respectively, without first adequately describing the body-scale relationship, so that they probably overestimated the lengths at the younger ages. Webster (1954) calculated length by averaging the lengths of each respective age class at the end of the growing season; Turner and MacCrimmon (1970) used length at capture between early spring and late autumn to calculate length at each age. The average back calculated lengths reported in these studies probably are overestimated for all age classes. Because length estimates are not given for the younger age classes by Stone et al. (1951) and Webster (1954), it is assumed that the lengths were derived from the average of lengths at capture and thus are probably overestimated.

Based on these limitations, the following points can be enumerated. The difference between the estimated growth of smallmouth bass at Nine Mile Point for 1973 and 1974 was the greatest at ages one and two but decreased with increasing age; estimates of growth were similar at ages six to eight. The growth estimates at Nine Mile Point were similar to those at Tadenac Lake, Ontario for ages one to four and to the St. Lawrence River-Lake Ontario area for ages five to seven. The growth estimates for fish in these two studies were greater than Nine Mile Point estimates for the remaining years of life. Smallmouth bass in Cayuga Lake, Lake Michigan, and the Des Moines River, Iowa, appear to grow faster than smallmouth bass at Nine Mile Point.

TABLE VII-36

COMPARISON OF REPORTED AVERAGE TOTAL LENGTH°
AT EACH YEAR OF LIFE FOR SMALLMOUTH BASS
FROM OTHER WATER BODIES**

YEAR OF LIFE	Nine Mile Point Lake Ontario, 1974 (Present Study)	Nine Mile Point Lake Ontario, (QLM, 1974)	Tadenace Lake, Ontario (Turner and MacCrimmon, 1970)	Lake Ontario St. Lawrence River (Stone et al., 1951)	DesMoines River, Iowa (Reynolds, 1965)	Cayuga Lake, New York (Webster, 1954)	Lake Michigan (Latta, 1963)*
1	93	133	91 (41)	—	119	—	99
2	142	175	163 (3)	—	229	163	160
3	188	209	189 (17)	—	297	213	205
4	231	241	230 (23)	262	341	262	246
5	263	274	291 (43)	277	389	347	292
6	296	290	315 (51)	302		348	335
7	315	310	362 (21)	318		373	371
8	329	329	249 (4)	348		396	401
9	334	350	412 (2)	366		424	427
10	327						
11	338						

° length in mm.
* From Turner and MacCrimmon, 1970
** Numbers which appear in parentheses represent the number of fish measured in determining average length.

(v) Length-Frequency Distribution

The length frequency distributions for the smallmouth bass (Figure VII-17) indicate that during April and May, only large (old) fish were collected. Three slightly smaller bass were collected in June and several age classes were collected during July. Overall there was a predominance of large (old) smallmouth bass, suggesting an unstable population based on the fact that stable fish populations are more heavily represented by the younger age class. However, it should be noted that most of this discussion is based on collections by gill nets, which are size selective.

e. Biomass

The biomass data for smallmouth bass (Table VII-37) showed an abrupt decrease in the average weight of individuals collected from NMPE, FITZ, and NMPP transects and a twofold increase for fish collected at NMPW transects from April to May. The greatest period of recruitment occurred during July, particularly at the FITZ transect; this is in agreement with the length frequency data (Figure VII-17). The average weight of the 271 smallmouth bass analyzed was 756.96 grams.

7. Other Species

This category includes the remaining 37 species, which consisted of 8607 fish, or 8.8% of the fish collected in 1974 in the Nine Mile Point vicinity (Table VII-3). A brief description follows for those species comprising at least 0.15% of the total fish collected during the 1974 study.

Spottail shiner

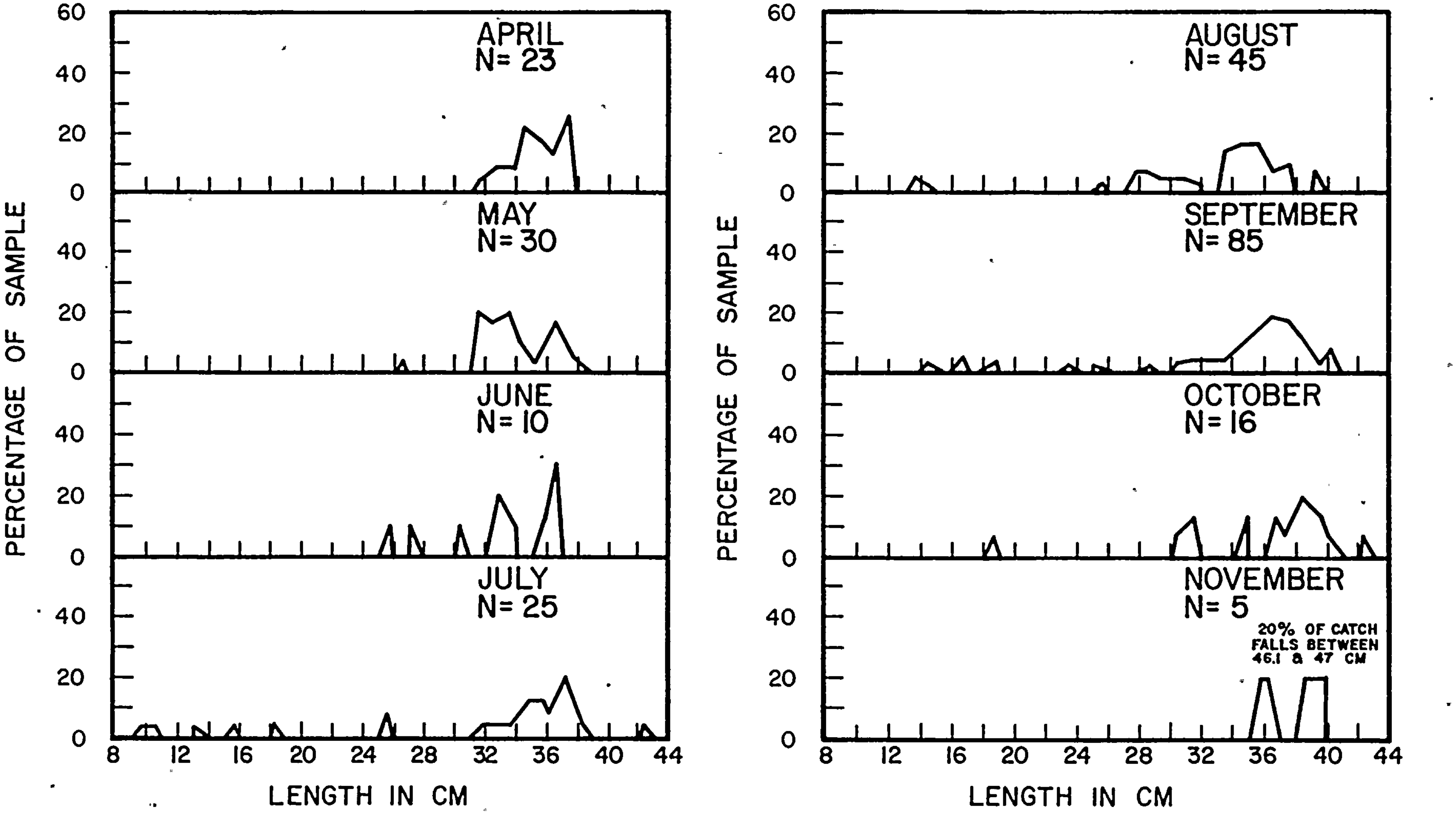
The spottail shiner was the most frequently collected species (5459 fish) in this category and accounted for 5.6% of all the fish collected. It is also the most abundant (based on catch/effort) natural fish (not a species introduced by man) in the vicinity of Nine Mile Point.

Bottom gill nets (Table VII-3) yielded 5377 of the 5459 spottail shiners collected, indicating that shiners tend to prefer the bottom. This distribution is probably correlated with the feeding habits of spottails, which consume principally plankton (e.g., *Daphnia*, *Bosmina*, and *Leptodora*) and aquatic insect larvae (e.g., chironomids), organisms which are usually abundant in bottom collections.

LENGTH FREQUENCY DISTRIBUTION FOR LAKE SMALLMOUTH BASS

NINE MILE POINT

1974



N = TOTAL NUMBER OF FISH ANALYZED FROM GILL NET AND TRAWL SAMPLES

FIGURE VII-17

TABLE VII-37

TOTAL BIOMASS AND AVERAGE BIOMASS PER INDIVIDUAL
FOR SMALLMOUTH BASS
COLLECTED WITH GILL NETS

NINE MILE POINT - 1974

TRANSECT	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)	TOTAL biomass (g)	AVER. (g)
NMPE	5639	939.9	6310	788.8	3656	731.2	5123	853.9	7987	726.2	8591	781.1	0	0	0	0	0	0
FITZ	1862	931.0	1358	679.1	1713	571.2	1379	275.9	15566	778.3	22558	777.9	4048	1012.0	0	0	0	0
NMPP	8825	802.3	10045	717.6	0	0	5595	508.7	4396	549.6	31754	835.7	7841	784.1	2049	1024	0	0
NMPP	3127	625.6	3831	1277.1	1549	774.7	4959	619.9	4308	538.5	6987	776.4	5185	864.2	2988	996.3	0	0

Gizzard shad

The gizzard shad, with 1.03% of the total catch, was the second most frequently collected species in this group. Scott and Crossman (1973) stated that gizzard shad are rare in Lake Ontario. In 1973 (QLM, 1974) only 383 gizzard shad were collected by QLM in the Nine Mile Point vicinity; however, in 1974, 1005 fish were collected, which tends to indicate that the species is either no longer rare or is congregating in the area.

Gizzard shad have shown a tendency to overpopulate areas they inhabit, due perhaps to their rapid growth rate, which inhibits predations on shad over age two, since these are usually too large to be eaten by most predators. Its relative increase in abundance during 1974 may forecast problems with large gizzard shad populations in the future.

The gill net data (Appendix VII-3) show that the most shad were collected from both the NMPP and FITZ transects, especially during September, October, and November. Because the plant was off line during the other cool months (April, May and December) in which gill net collections were made, the data from these months cannot be used to indicate whether or not shad were more abundant in the plume area. Gizzard shad were represented equally in surface and bottom collections; therefore it is not apparent that they preferentially located themselves in the warmer surface waters as was suggested by Bodola (1966) for Lake Erie populations. Their association with the NMPP transect may be in response to greater food availability. Adult gizzard shad feed predominantly on plankton, whose productivity is often increased in thermally rich waters, especially during cooler months.

White Sucker

The white sucker accounted for 0.68% of the total catch. The 660 fish collected were taken with the bottom gill net (Table VII-3), correlating with the fact that they are bottom feeders; they were distributed approximately equally among the four transects.

Trout perch

In the vicinity of Nine Mile Point, 512 of the 520 trout perch collected (0.53% of total fish), were caught in the bottom gill nets (Table VII-3). These fish were most abundant in May which coincides with the time of spawning reported for this species in Heming Lake, Manitoba (Lawler, 1954).

Trout perch

In the vicinity of Nine Mile Point, 512 of the 520 trout perch collected (0.53% of total fish), were caught in the bottom gill nets (Table VII-3). These fish were most abundant in May which coincides with the time of spawning reported for this species in Heming Lake, Manitoba (Lawler, 1954).

Rock Bass

In 1974, 214 rock bass (0.22% of total fish) were collected in the vicinity of Nine Mile Point 211 with bottom gill nets. This species is territorial and is associated with the bottom, particularly during the periods of spawning and parental care.

Lake Chub

In the vicinity of Nine Mile Point, 168 lake chub (0.17% of total fish) were collected, all but one with the bottom gill nets (Table VII-5).

Emerald Shiner

More than half (77) of the 109 emerald shiners (0.15% of total fish) collected (Table VII-3) were caught with the beach seine (Appendix VII-4), and most from August to December.

In Lake Ontario the emerald shiner probably ranks second only to the spottail shiner in its community role as a forage fish. Unfortunately, its numbers have been decreasing recently, perhaps as a result of competition for food with the alewife.

Salmonids

The salmonids (brown trout, lake trout, rainbow trout, coho salmon, shallow water cisco, and chinook salmon) were all collected in greater numbers in 1974 (Table VII-3) than in 1973 (QLM, 1974).

The salmon and salmon-like fish are among the most important sport fishes of the Great Lakes. The brown trout, rainbow trout, cisco, and lake trout are native inhabitants of the Great Lakes; the coho and chinook salmon are species which were introduced with the intent that they would prey selectively on alewives. There have been recent reports that some may already be spawning in Lake Ontario.

Considering the fact that the salmonids are all large piscivorous fish, it is noteworthy that 141 were collected in the vicinity of Nine Mile Point in 1974. This is an increase of 105 fish over the 36 collected in 1973, suggesting that an established salmon fishery in Lake Ontario may be becoming a realization.

Rare and/or Endangered Species

Lake Sturgeon (*Acipenser fulvescens*)

The lake sturgeon was once quite abundant in the Great Lakes, but has now been almost eliminated, especially in Lake Erie (Harkness and Dymond, 1961. Lake sturgeons migrate up streams and rivers to spawn in depths of 2 to 15 ft in areas of swift water movement. Hence, it is unlikely that the species spawn in the vicinity of Nine Mile Point or that the power plant has any direct impact upon the lake sturgeon population. No lake sturgeons were collected in either 1973 (QLM, 1974) or 1974 in either the general ecological surveys or from impingement collections.

Blue Walleye (*Stizostedion vitreum glaucum*)

The blue walleye was placed on the Rare and Endangered list (McAllister, 1970) as rare or perhaps extinct. Scott and Crossman (1973) conclude that it has totally disappeared from Lake Erie and Ontario. None were collected in either 1973 (QLM, 1974) or 1974 by QLM.

Kiyi (*Coregonus kiyi*)

The kiyi was indigenous to the Great Lakes basin, but has virtually disappeared from Lake Ontario and probably persists only in Lake Superior. None were collected by QLM in either 1973 (QLM, 1974) or 1974.

Blackfin Cisco (*Coregonus nigripinnis prognathus*)

The blackfin cisco once ranged throughout all the Great Lakes except Lake Erie, but now has disappeared from Lake Ontario and Lake Michigan. There were none collected in either 1973 (QLM, 1974) or 1974 by QLM.

Shortnose Cisco (*Coregonus reighardi*)

The shortnose cisco was a valuable commercial species in Lake Ontario, but is now very rare (Scott and Crossman, 1973). None were collected by QLM in either 1973 (QLM, 1974) or 1974.

D. CONCLUSIONS

Eight species were collected during 1974 which were not collected in 1973: redfin pickerel, brook silverside, coho salmon, rainbow trout, northern hogsucker, lake trout, bowfin, and channel catfish.

Ninety-six percent of the fish collected belonged to the five species listed here in order of abundance: alewife, rainbow smelt, spottail shiner, white perch, and yellow perch.

The alewife was the most abundant species based on catch per effort. The inshore movement of alewives occurred in April and continued through July, coinciding with the time period reported in the literature. The temporal occurrence of this shoreward migration was apparently not affected by the Nine Mile Point Nuclear Station.

Significantly more alewives were collected from the bottom waters of the FitzPatrick transect than from the bottom waters of the other transects. If this trend continues and is indicative of a preference of the alewives for this area, then this may forecast high impingement of alewives at the FitzPatrick power station.

Based on the coefficient of maturity data, the alewives in the vicinity of Nine Mile Point spawned in July as has been reported in the literature. The presence of heated water did not appear to delay or hasten the onset of reproductive activity. Egg counts from sexually mature females were similar to those reported in the literature for the species. More females were collected than males throughout the year, indicating that the population probably did not utilize the vicinity of Nine Mile Point as a spawning ground.

Growth of alewives in the vicinity of Nine Mile Point was within the reported range of growth for other alewife populations, both within Lake Ontario and in other water bodies.

The rainbow smelt represented 12% of the total number of fish collected. The spring onshore movement of rainbow smelt occurred during the time which is considered natural, i.e., as reported in the literature. There were no significant differences in the distribution of rainbow smelt among the four sampling transects, indicating that the fish showed no marked preference for any particular transect.

The estimated time of spawning for the rainbow smelt population within the vicinity of Nine Mile Point occurred during April and May. This spawning period agrees with the time reported in the literature.

Growth of rainbow smelt in the vicinity of Nine Mile Point was within the reported growth range for the species.

More white perch were collected from the bottom waters than from the surface waters, with significantly more from the NMPE and FITZ transects than the other two transects. There were no significant differences in the distribution of white perch in the surface waters among the sampling transects. These results indicate

that white perch are congregating neither in the thermally rich surface waters nor in front of the Nine Mile Point plant.

The white perch in the vicinity of Nine Mile Point spawned during late May and June. This spawning time agrees with the published accounts on the reproductive period for other populations. In addition, fecundity estimates for female white perch in the vicinity of Nine Mile Point are within the expected range for the species.

Growth of white perch in the vicinity of Nine Mile Point was similar to growth reported for this species in other water bodies.

Yellow perch accounted for 1.5% of the fish collected in the vicinity of Nine Mile Point. More yellow perch were collected from the bottom waters than from the surface waters, and from the NMPE and FITZ transects than from the NMPW transect. The number of fish yielded by the NMPP transect was intermediate between the NMPE and FITZ totals and those for NMPW, indicating that the yellow perch were not concentrated in the immediate vicinity of the plant.

The spawning period for the yellow perch in the Nine Mile Point vicinity corresponds with that reported for the species. The fecundity estimates for female yellow perch were within the expected range for the species.

Growth of yellow perch in the vicinity of Nine Mile Point was within the natural range for growth of this species.

Smallmouth bass were collected predominantly from the bottom waters. There were no significant differences in the catch/effort of smallmouth bass between either day and night or among sampling transects.

Growth of smallmouth bass in the vicinity of Nine Mile Point was similar to growth of other smallmouth bass populations.

No rare or endangered fish species were found within the vicinity of Nine Mile Point.

REFERENCES CITED

Andrewartha, H.G. and L.C. Birch. 1954. The distribution and abundance of animals. Univ. of Chicago Press, Chicago.

Bagenal, T.B. and E. Braum. 1971. Eggs and early life history, p.167-198. In: W.E. Ricker (ed.) methods for assessment of fish production in freshwater. IBP Handbook No. 3. Blackwell Sci. Publ., Oxford. 348p.

Bailey, M.M. 1964. Age, growth, maturity, and sex composition of the American smelt, Osmerus mordax (Mitchell), of western Lake Superior. Trans. Amer. Fish. Soc. 93(4):382-395.

Bailey, R.M. 1938. The fishes of the Merrimack watershed, p. 149-185. In Biological survey of the Merrimack watershed. N.H. Fish Game Dept. Survey Rept. 3.

Baldwin, N.S. 1950. The American smelt, Osmerus mordax (Mitchill), of South Bay, Manitoulin Island, Lake Huron. Trans. Amer. Fish Soc. 78:176-180.

Beckman, W.C. 1942. Length-weight relationship, age, sex ratio and food habits of the smelt from Crystal Lake, Benzie County, Michigan. Copeia 2:120-124.

Beeton, A.M. 1969. Changes in the environment and biota of the Great Lakes, p.150-187. In Eutrophication: causes, consequences, correctives. Nat. Acad. Sci., Washington, D.C.

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. Fish. Bull Fish and Wildl. Serv. 74(53):577p.

Bodola, A. 1966. History of the gizzard shad, Dorosoma cepedianum (Le Sueur), in western Lake Erie. Fish Bull. 65(2):391-425.

Burbidge, R.G. 1969. Age, growth, length-weight relationship, sex ratio, and food habits of American smelt, Osmerus mordax (Mitchell), from Gull Lake, Michigan. Trans. Amer. Fish. Soc. 98(4):622-631.

Christie, W.J. 1973. A review of the changes in the fish species composition of Lake Ontario. Great Lakes Fish Comm. Tech. Rept. No. 23: 65p.

Conover, N.R. 1958. Investigations of the white perch, Morone americana (Gmelin), in Albemarle Sound and the lower Roanoke River, North Carolina. M.S. Thesis, North Carolina State College, Raleigh. 58p.

REFERENCES CITED
(Continued)

Cooper, G.P. 1941. A biological survey of lakes and ponds of the Androscoggin and Kennebec River drainage systems in Maine. Maine Dept. Inland Fish., Gamefish Surv. Rept. 4: 228p.

Dryfoos, R.L. 1965. The life history and ecology of the longfinned smelt in Lake Washington. Ph.D. Thesis, Univ. of Washington. 229p.

Elton, C.S. 1958. The ecology of invasions by animals and plants. Methuen, London.

El-Zarka, Salah El-Din. 1959. Fluctuations in the population of yellow perch, Perca flavescens (MitchIll), in Saginaw Bay, Lake Huron. Fish Bull. 151, 59: 365-415.

Everest, G. 1973. Some effects of heated effluents on fish populations at three thermal generating stations. M.SS Thesis, Univ. Toronto. 157p.

Everhart, H.W. 1949. Body length of the smallmouth bass at scale formation. Copeia. 2:110-115.

Everhart, H.W. 1950. A critical study of the relation between body length and several scale measurements in the smallmouth bass, Micropterus dolomieui Lacepede. J. Wildl. Mgmt. 14(3): 266-276.

Ferguson, R.G. 1958. The preferred temperature of fish and their midsummer distribution in temperate lakes and streams. J. Fish. Res Bd. Canada 15(4): 607-624.

Graham, J.J. 1956. Observations on the alewife, Pomolobus pseudoharengus (Wilson), in freshwater. Univ. Toronto Stud. Biol. Ser. 62, Publ. Ont. Fish. Res. Lab. 74: 43p.

Graham, J.J. 1957. Some observations on the schooling movements of the alewife in Lake Ontario. Canadian Field-Nat. 71(3): 115-116.

Griffiths, J.S. 1974. Preoperations aquatic biological studies-Lennox GS, 1973. Report to Ontario Hydro.

Gross, R.W. 1959. A study of the alewife, Alosa pseudoharengus (Wilson) in some New Jersey lakes, with special reference to Lake Hopatcona. M.S. Thesis, Rutgers Univ. 52p.

REFERENCES CITED
(Continued)

Hale, J. 1960. Some aspects of the life history of the smelt (Osmerus mordax) in western Lake Superior. Minnesota Fish Game, Invest., Ser. 2:25-41.

Harkness, W.J.K. and J.R. Dymond. 1961. The lake sturgeon: the history of its fishery and problem of conservation. Ont. Dept. Lands Forests, Fish Wildl. Br. 121p.

Havey, K.A. 1961. Restoration of anadromons alewifes at Long Pond, Maine. Trans. Amer. Fish. Soc. 90(3):281-286.

Hergenrader, G.L. and A.D. Hasler. 1968. Influence of changing seasons on schooling behavior of yellow perch. J. Fish. Res. Bd. Canada 25(4):711-716.

Hildebrand, S.F. and W.C. Schroeder. 1928. Fishes of Chesapeake Bay Bull. U.S. Bur. Fish. 43(1):366p.

Hile, R. 1941. Age and growth of the rock bass, Ambloplites rupestris (Rafinesque), in Nebish Lake, Wisconsin. Trans. Wis. Acad. Sci., Arts, and Lett. 33:189-337.

Hile, R. and F.W. Jobes. 1941. Age, growth, and production of yellow perch, Perca flavescens (Mitchill), of Saginaw Bay. Trans. Amer. Fish. Soc. 70:102-122.

Hile, R. and F.W. Jobes. 1942. Age and growth of the yellow perch, Perca flavescens (Mitchill) in the Wisconsin waters of Green Bay and northern Lake Michigan. Pop. Mich. Acad. Sci., Arts and Lett. 27:241-266.

Hubbs, C.L. and K.F. Lagler. 1958. Fishes of the Great Lakes Region. Univ. Michigan Press., Ann Arbor. xvx-213p.

Jobes, F.W. 1952. Age, growth and production of yellow perch in Lake Erie. U.S. Fish Wildl. Serv. Fish. Bull. 52:205-266.

Kissil, G. 1969. Contributions to the life history of the alewife, Alosa pseudoharenqus (Wilson) in Connecticut. Ph.D. Thesis, University of Connecticut, Storrs, Conn. 111p.

Lack, D. 1944. Ecololgical aspects of species-formation in passer-ine birds. Ibis 86:260-286.

REFERENCES CITED
(Continued)

Lack, D. 1945. The ecology of closely related species with special refference to cormorant (Ph. carbo) and shag (P. aristotelis) J. Animal Ecol. 14:12-16.

Lawler, G.H. 1954. Observations on the trout-perch Percopsis osmiscomaycus (Walbaum), at Heming Lake, Manitoba. J. Fish. Res. Bd. Canaada. 11(1):1-4.

Leach, J.P. 1962. Summer food and feeding of white perch Roccus americanus (Gmelin) in the Bay of Quinte. M.A. Thesis, Univ. of Toronto, Canada. 58p.

Le Cren, E.D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (Perca pluviatilis). J. Anoim. Ecol. 20(2):201-219.

Lee, R.M. 1920. A review of the methods of age and growth determination in fishes by means of scales. Fishery Invest. London. Ser. 2,4,2, 32p.

MacCullen, W.R. and M.A. Regier. 1970. Distribution of smelt, Osmerus mordax and the smelt fishery in Lake Erie in the early 1960's. J. Fish Res. Bd. Canada 27:1823-1846.

Mansueti, A.J. and J.D. Hardy. 1967. Development of fishes of the Chesapeake Bay region. I. National Res. Inst., Univ. of Maryland, Baltimore, Md. 202p.

Mansueti, R.J. 1961. Movements, reproduction, and mortality of the white perch, Roccus americanus [Morone americana], in the Patuxent estuary, Maryland. Chesapeake Sci. 2(3-4):142-204.

Marcy, B.C. and F.P. Richards. 1974. Age and growth of the white perch (Morone americana) in the lower Connecticut River. Trans. Amer. Fish. Soc. 1:117-120.

Mayr, E. 1966. Animal species and evolution. The Belkrap Press of Harvard University Press, Cambridge, Mass. 797p.

McAllister, D.E. 1970. Rare or endangered Canadian fishes. Can. Field-Natur. 84(1):5-26.

Mason, E.J.R. 1933. Smelts in Lake Ontario. Copeia. 1933(1):34.

McKenzie, R.A. 1958. Age and growth of smelt, Osmerus mordax (Mitchill), of the Miramichi River, New Brunswick. J. Fish. Res. Bd. Canada. 15(6):1313-1327.

McKenzie, R.A. 1964. Smelt life history and fishery in the Miramichi River, New Brusnwick. Fish. Res. Bd. Canada Bull. 144:77p.

Miller, L.W. 1963. Growth, reproduction and food habits of the white perch, Roccus americanus (Gmelin) in the Delaware River estuary. M.S. Thesis, Univ. of Delaware. 62p.

Muncy, R.J. 1962. Life history of the yellow perch, Perca flavescens, in estuarine waters of the Severn River, a tributary of Chesapeake Bay, Maryland. Chesapeake Sci. 3(3):143-159.

Nikolsky, G.V. 1963. The ecology of fishes. (Translation by L. Birkett) Academie Press, New York. 352p.

Norden, C.R. 1967. Age, growth and fecundity of the alewife, Alosa pseudoharengus (Wilson), in Lake Michigan. Tran. Amer. Fish. Soc. 96(4):387-393.

Odell, T.T. 1934. The life history and ecological relationships of the alewife (Pomolobus pseudoharengus [Wilson]) in Seneca Lake, N.Y. Amer. Fish. Soc. Trans. 64:118-124. [Also Ph.D. Thesis, Cornell Univ., Ithaca, N.Y. 62p.]

Pritchard, A.L. 1929. The alewife (Pomolobus pseudoharengus), in Lake Ontario. Univ. Toronto Stud. Biol. Ser. 33:39-54.

Quirk, Lawler and Matusky Engineers. 1974. 1973 Nine Mile Point aquatic ecology studies - Nine Mile Point Generating Station. Prepared for Niagara Mohawk Power Corp.

Reynolds, J.B. 1965. Life history of the smallmouth bass, Micropterus dolomieui, in the Des Moines River, Boone County, Iowa. Iowa State Sci. 39:417-436.

Rousefell, G.A. and L.P. Stringer. 1945. Restoration and management of the New England alewife fisheries with special reference to Maine. Trans. Amer. Fish. Soc. 73:394-424.

Rupp, R.S. 1965. Shore-spawning and survival of eggs of the American smelt. Trans. Amer. Fish. Soc. 94(2):160-168.

St. Pierre, R.A. and J. Davis. 1972. Age, growth and mortality of the white perch, Morone americana, in the James and York Rivers, Virginia. Chesapeake Sci. 13(4):272-281.

REFERENCES CITED
(Continued)

Schneberger, E. 1937. The biological and economic importance of smelt in Green Bay. Trans. Amer. Fish. Soc. 66: 139-142.

Schuck, H.A. 1949. Problems in calculating size of fish at various ages from proportional measurements of fish and scale sizes. Jour. Wildl. Mgmt. 13(3): 298-303.

Scott, D.M. 1955. Additional records of two fishes, Erimyzone sucetta kennerlyi and Hadropterus copelandi, from southern Ontario, Canada. Copeia. 1955(2): 151.

Scott, W.B. and W.J. Christie. 1963. The invasion of lower Great Lakes by the white perch Roccus americanus (Gmelin). J. Fish. Res. Bd. Canada. 20(5): 1189-1195.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Bd. Canada Bull. 184:966p.

Sheri, A.N. and G. Power. 1968. Reproduction of white perch, Roccus americanus in the Bay of Quinte, Lake Ontario. J. Fish. Res. Bd. Canada. 25(10): 2225-2231.

Sheri, A.N. and G. Power. 1969. Annulus formation on scales of white perch, Morone americana (Gmelin), in the Bay of Quinte, Lake Ontario. Trans. Amer. Fish. Soc. 98(2): 322-326.

Smith, S.H. 1973. Application of therory and research in fishery management of the Laurentian Great Lakes. Trans. Amer. Fish Soc. 102(1): 156-163.

Stone, U.B., D.G. Pastro, and R.M. Roecker. 1951. A Study of Lake Ontario - St. Lawrence River Smallmouth Bass. N.Y.S. Cons. Dept., Div. Fish and Game, Res. Ser. 2. 25 p.

Stone, U.B., D.G. Pasko, and R.M. Roecker. 1954. A study of Lake Ontario - St. Lawrence River smallmouth bass. N.Y. Fish and Game J. 1(1): 1-26.

Storr, J.F. 1969a. Fish net catch report from Nine Mile Point, August 12-15, 1969. Letter to R. Clancy, Niagara Mohawk Power Corporation, September 2.

Storr, J.F. 1969b. Fish distribution study, Nine Mile Point, July 27, 1968. Letter to R. Clancy, Niagara Mohawk Power Corporation, December 15.

REFERENCES CITED (CONTINUED)

Storr, J.F. 1970a. Fish net catch report for Nine Mile Point. October 7-10, 1969. Letter to R. Clancy, Niagara Mohawk Power Corporation, May 22.

Storr, J.F. 1970b. Fish net studies off Nine Mile Point, May 26-29, 1970. Letter to R. Clancy, Niagara Mohawk Power Corporation, July 14.

Storr, J.F. 1970c. Analysis of food preference of yellow perch (Perca flavescens) collected at Nine Mile Point, July 8-11, 1970. Letter to R. Clancy, Niagara Mohwak Power Corporation, July 31.

Storr, J.F. 1970d. Fish net studies off Nine Mile Point, July 8-11, 1970. Letter to R. Clancy, Niagara Mohawk Power Corporation, August 13.

Storr, J.F. 1970e. Fish net study off Nine Mile Point, August 19-22, 1970. Letter to R. Clancy, Niagara Mohawk Power Corporation, September 4.

Storr, J.F. 1970f. Fish net study, Nine Mile Point, October 21-24, 1970. Letter to R. Clancy, Niagara Mohawk Power Corporation, November 30.

Storr, J.F. 1971a. Fish distribution studies of four periods in 1970. Letter to R. Clancy, Niagara Mohawk Power Corporation, February 17.

Storr, J.F. 1971b. Fish net study, Nine Mile Point, June 1-2, 1971. Letter to R. Clancy, Niagara Mohawk Power Corporation, July 9.

Storr, J.F. 1971c. Fish net catch study, Nine Mile Point, June 29-July 2, 1971. Letter to R. Clancy, Niagara Mohawk Power Corporation, September 2.

Storr, J.F. 1971d. Fish distribution study-Nine Mile Point. June 1-12, 1971. Letter to R. Clancy, Niagara Mohawk Power Corporation, October 7.

Storr, J.F. 1971e. Fish net catch study, Nine Mile Point, August 17-20, 1971. Letter to R. Clancy, Niagara Mohawk Power Corporation, October 19.

Storr, J.F. 1972a. Fish distribution, Nine Mile Point, August 17-19,1971. Letter to R. Clancy, Niagara Mohawk Power Corporation, January 3.

REFERENCES CITED (CONTINUED)

Storr, J.F. 1972b. Fish distribution study Nine Mile Point, November 1-2 and 5, 1971. Letter to R. Clancy, Niagara Mohawk Power Corporation, January 12.

Storr, J.F. 1972c. Fish food preference, Nine Mile Point, November 2, 4-6, 1971. Letter to R. Clancy, Niagara Mohawk Power Corporation, January 17.

Storr, J.F. 1973. Summary of studies to evaluate ecological effects from the introduction of a thermal discharge into Lake Ontario in the area of the Nine Mile Point Nuclear Station Unit One. Niagara Mohawk Power Corp.

Suttkus, R.D. 1955. Age and growth of a small-stream population of 'stunted' smallmouth black bass, Micropterus dolomieu dolomieu (Lacepede). N.Y. Fish and Game J. 2(1): 83-94.

Taub, S.H. 1969. Fecundity of the white perch. Prog. Fish Cult. July 1969: 166-168.

Threinen, C.W. 1958. Life history, ecology, and management of the alewife Pomolobus pseudoharengus (Wilson). Publ. Wisc. Conserv. Dept. No. 223: 8p.

Turner, G.E. and H.R. MacCrimmon. 1970. Reproduction and growth of small mouth bass, Micropterus dolomieui, in a Precambrian lake. J. Fish. Res. Bd. Canada 27(2): 395-400.

Van Oosten, J.K. 1940. The smelt, Osmerus mordax (Mitchill). Michigan Dept. Conserv.: 13p. (Revised 1942).

Van Oosten, J.K. 1944. Mortality of smelt Osmerus mordax (Mitchill) in Lake Huron and Michigan during the fall and winter of 1942-43. Trans. Amer. Fish. Soc. 74(1944): 310-337.

Wallace, D.C. 1971. Age, growth, year, class, strength, and survival rates of white perch, Morone americana (Gmelin) in the Delaware River in the vicinity of Artifical Island. Chesapeake Sci. 12: 205-218.

Webster, D.A. 1954. Smallmouth bass, Micropterus dolomieui, in Cayuga Lake. Part I. Life history and environment. Cornell Univ. Agr. Exp. Sta. Mem. 327:39 p.

Whitworth, W.F. and S. Sauter. 1972. Age and growth of some common fishes of Connecticut. Storrs Agr. Exp. Sta., Univ. Conn. Res. Rept. 37, 42p.

APPENDIX VII-1

SPECIES DIVERSITY (H), SPECIES RICHNESS (S-1), AND EVENNESS (J) FOR TOTAL GILL NET COLLECTIONS°

NINE MILE POINT - 1974

TRANSECTS+	INDICES	MONTHS								
		APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NMPE	H	0.930	0.806	0.828	0.664	0.761	1.206	1.529	0.867	0.445
	S-1	0.543	0.729	0.627	0.534	0.702	0.988	0.914	1.026	0.539
	J	0.589	0.574	0.672	0.371	0.655	0.638	0.640	0.757	0.811
	N	32	29	55	43	50	41	39	30	7
FITZ	H	1.069	0.820	0.728	0.964	0.818	1.134	1.437	0.944	0.555
	S-1	0.673	0.735	0.662	0.690	0.734	1.004	0.942	0.740	0.635
	J	0.615	0.554	0.529	0.390	0.619	0.687	0.628	0.377	0.475
	N	34	32	51	42	51	43	42	25	7
NMPP	H	0.670	1.089	0.394	0.377	0.599	0.972	1.299	1.173	0.322
	S-1	0.516	1.075	0.441	0.439	0.640	1.063	1.064	1.057	0.702
	J	0.485	0.625	0.381	0.335	0.646	0.743	0.712	0.622	0.659
	N	30	30	52	45	51	46	34	25	7
NMPW	H	0.703	0.720	0.526	0.453	0.491	0.638	0.790	0.619	0.321
	S-1	0.452	0.697	0.591	0.452	0.588	0.818	1.018	0.754	0.633
	J	0.529	0.588	0.526	0.388	0.690	0.711	0.658	0.620	0.945
	N	32	30	53	43	52	43	39	25	6

° day and night collections
\+ depth contours: 30, 40, 60 ft - surface and bottom; 15 ft bottom
N number of samples.

APPENDIX VII-2

SPECIES DIVERSITY (H), SPECIES RICHNESS (S-1), AND EVENNESS (J) FOR BOTTOM GILL NET COLLECTIONS°

NINE MILE POINT - 1974

TRANSECTS+	INDICES	MONTHS APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NMPE	H	1.044	1.131	1.337	1.010	1.168	1.639	2.013	1.023	0.778
	S-1	0.747	0.998	0.991	0.789	1.051	1.301	1.140	1.231	0.944
	J	0.520	0.741	0.776	0.416	0.739	0.753	0.747	0.876	0.811
	N	20	19	32	28	32	28	26	20	4
FITZ	H	1.186	1.112	1.025	1.181	1.322	1.567	1.712	1.170	0.711
	S-1	0.868	0.944	0.879	0.918	1.147	1.368	1.178	0.814	0.792
	J	0.547	0.677	0.585	0.458	0.746	0.788	0.681	0.462	0.470
	N	24	19	32	30	31	29	26	16	4
NMPP	H	0.791	1.473	0.594	0.662	0.935	1.253	1.318	1.051	0.474
	S-1	0.708	1.382	0.632	0.714	0.980	1.350	1.270	1.386	1.082
	J	0.533	0.740	0.449	0.358	0.760	0.811	0.792	0.722	0.979
	N	17	18	32	24	32	32	22	15	4
NMPW	H	0.779	0.955	0.776	0.740	0.800	0.874	0.955	0.739	0.475
	S-1	0.564	0.931	0.864	0.717	0.937	1.133	1.324	0.903	0.784
	J	0.483	0.648	0.595	0.434	0.799	0.776	0.813	0.687	0.918
	N	22	17	32	26	31	30	25	16	3

° day and night collections
+ depth contours: 15, 30, 40, 60 ft
N number of samples

APPENDIX VII-3

TRAWL SAMPLING PROGRAM BY SEASONS
ABUNDANCE IN CATCH/EFFORT (NUMBER/15 min)

NINE MILE POINT - 1974

SPRING - APRIL

SURFACE

SPECIES	NMPW DAY 20ft	NMPW DAY 40ft	NMPW DAY 60ft	NMPW DAY $\Sigma c/e/s$ / Σs	NMPW NIGHT 20ft	NMPW NIGHT 40ft	NMPW NIGHT 60ft	NMPW NIGHT $\Sigma c/e/s$ / Σs	NMPP DAY 20ft	NMPP DAY 40ft	NMPP DAY 60ft	NMPP DAY $\Sigma c/e/s$ / Σs	NMPP NIGHT 20ft	NMPP NIGHT 40ft	NMPP NIGHT 60ft	NMPP NIGHT $\Sigma c/e/s$ / Σs	NMPE DAY 20ft	NMPE DAY 40ft	NMPE DAY 60ft	NMPE DAY $\Sigma c/e/s$ / Σs	NMPE NIGHT 20ft	NMPE NIGHT 40ft	NMPE NIGHT 60ft	NMPE NIGHT $\Sigma c/e/s$ / Σs
Alewife	0	0	8.0	2.67	37.50	17.50	16.50	23.83	0	0	0	0	20.50	8.50	5.0	11.33	0	0	0	0	0	0.50	0	0.17
Mottled sculpin	0	0	0	0	0.50	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rainbow smelt	0	0	0	0	1.0	0.50	1.0	0	0	0	0	0	2.0	0.50	3.0	1.83	0	0	0	0	0	1.0	0	0.33
Rock bass	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0.17	0	0	0	0	0	1.50	0	0.50
Spottail shiner	0	0	0	0	0	1.0	0	0	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Threespine stickleback	0	0	0	0	1.0	0	0	0	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White perch	0.50	0	0	0.17	0	0.50	0	0.17	0	0	0	0	0	0	0	0	0.50	0	0	0.17	0	0	0	0

BOTTOM

SPECIES	NMPW DAY 20ft	NMPW DAY 40ft	NMPW DAY 60ft	NMPW DAY $\Sigma c/e/s$ / Σs	NMPW NIGHT 20ft	NMPW NIGHT 40ft	NMPW NIGHT 60ft	NMPW NIGHT $\Sigma c/e/s$ / Σs	NMPP DAY 20ft	NMPP DAY 40ft	NMPP DAY 60ft	NMPP DAY $\Sigma c/e/s$ / Σs	NMPP NIGHT 20ft	NMPP NIGHT 40ft	NMPP NIGHT 60ft	NMPP NIGHT $\Sigma c/e/s$ / Σs	NMPE DAY 20ft	NMPE DAY 40ft	NMPE DAY 60ft	NMPE DAY $\Sigma c/e/s$ / Σs	NMPE NIGHT 20ft	NMPE NIGHT 40ft	NMPE NIGHT 60ft	NMPE NIGHT $\Sigma c/e/s$ / Σs
Alewife	0	0	0.50	0.17	57.50	34.50	29.0	40.33	0.50	0	0	0.17	68.0	16.50	37.0	40.50	0	0	0	0	1.0	5.50	47.0	17.83
Gizzard shad	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0.17	0	0	0	0	0	0.50	0	0.17
Johnny darter	0	0	0	0	0.50	0.50	0.50	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mottled sculpin	0	0	0	0	0.50	0	0.50	0.33	0	0	0.50	0.17	0.50	0	0.50	0.33	0	0	0	0	0	0	0	0
Rainbow smelt	0	0	0	0	16.0	2.40	0.50	6.33	0	0	0	0	7.0	1.50	1.50	3.33	0	0	0	0	0	4.00	0.5	1.50
Rock bass	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0.17	0	0	0	0	0.50	0	0	0.17
Spottail shiner	0	0	0	0	3.0	0	0	1.00	0	0	0	0	0	0	2.50	0.83	0	0	0	0	0	0	0	0
Trout perch	0	0	0	0	0	0	1.0	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White perch	0	0	0	0	0	0	0.50	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SPRING - MAY

SURFACE

SPECIES	NMPW DAY 20ft	NMPW DAY 40ft	NMPW DAY 60ft	NMPW DAY $\Sigma c/e/s$ / Σs	NMPW NIGHT 20ft	NMPW NIGHT 40ft	NMPW NIGHT 60ft	NMPW NIGHT $\Sigma c/e/s$ / Σs	NMPP DAY 20ft	NMPP DAY 40ft	NMPP DAY 60ft	NMPP DAY $\Sigma c/e/s$ / Σs	NMPP NIGHT 20ft	NMPP NIGHT 40ft	NMPP NIGHT 60ft	NMPP NIGHT $\Sigma c/e/s$ / Σs	NMPE DAY 20ft	NMPE DAY 40ft	NMPE DAY 60ft	NMPE DAY $\Sigma c/e/s$ / Σs	NMPE NIGHT 20ft	NMPE NIGHT 40ft	NMPE NIGHT 60ft	NMPE NIGHT $\Sigma c/e/s$ / Σs
Alewife	2.0	0	0	0.67	65.0	15.50	6.50	29.0	0	0	0	0	24.0	9.0	18.0	17.0	0.50	0	0	0.17	18.0	2.0	3.0	7.67
Rainbow smelt	0.50	0	0	0.17	0	4.0	4.0	2.67	0	0	0	0	0.50	1.50	4.0	2.00	0	0	0	0	3.0	0	3.50	2.17
Threespine stickleback	0.50	0	0	0.17	0.50	0.50	0	0.33	0	0	2.0	0.67	0	0	0	0	0.50	0.50	1.0	0.67	0.50	0	0	0.17

BOTTOM

SPECIES	NMPW DAY 20ft	NMPW DAY 40ft	NMPW DAY 60ft	NMPW DAY $\Sigma c/e/s$ / Σs	NMPW NIGHT 20ft	NMPW NIGHT 40ft	NMPW NIGHT 60ft	NMPW NIGHT $\Sigma c/e/s$ / Σs	NMPP DAY 20ft	NMPP DAY 40ft	NMPP DAY 60ft	NMPP DAY $\Sigma c/e/s$ / Σs	NMPP NIGHT 20ft	NMPP NIGHT 40ft	NMPP NIGHT 60ft	NMPP NIGHT $\Sigma c/e/s$ / Σs	NMPE DAY 20ft	NMPE DAY 40ft	NMPE DAY 60ft	NMPE DAY $\Sigma c/e/s$ / Σs	NMPE NIGHT 20ft	NMPE NIGHT 40ft	NMPE NIGHT 60ft	NMPE NIGHT $\Sigma c/e/s$ / Σs
Alewife	4.0	0.50	0.50	1.67	21.50	257.5	137.0	138.67	1.0	0.5	0	0.50	5.50	32.50	56.50	31.50	0	0	0	0	23.0	29.50	10.0	20.83
Gar	0	0	0	0	0.50	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rainbow smelt	0	0	0.50	0.17	0.50	0	0.50	0.33	0	0	0	0	0.50	3.50	0	1.33	0	0	0	0	1.0	0	1.0	0.67
Spottail shiner	0	0	0	0	0	0.50	0	0.17	0	0	0	0	0	0.50	0	0.17	0	0	0	0	0	0	0	0
White perch	0	0	0	0	0	0.50	0	0.17	0	0.50	0	0.17	0	0	0	0	0	0	0	0	0.50	0	0	0
Trout perch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17

SPRING - JUNE

SURFACE

SPECIES	NMPW DAY 20ft	NMPW DAY 40ft	NMPW DAY 60ft	NMPW DAY $\Sigma c/e/s$ / Σs	NMPW NIGHT 20ft	NMPW NIGHT 40ft	NMPW NIGHT 60ft	NMPW NIGHT $\Sigma c/e/s$ / Σs	NMPP DAY 20ft	NMPP DAY 40ft	NMPP DAY 60ft	NMPP DAY $\Sigma c/e/s$ / Σs	NMPP NIGHT 20ft	NMPP NIGHT 40ft	NMPP NIGHT 60ft	NMPP NIGHT $\Sigma c/e/s$ / Σs	NMPE DAY 20ft	NMPE DAY 40ft	NMPE DAY 60ft	NMPE DAY $\Sigma c/e/s$ / Σs	NMPE NIGHT 20ft	NMPE NIGHT 40ft	NMPE NIGHT 60ft	NMPE NIGHT $\Sigma c/e/s$ / Σs
Alewife	1.0	0.50	0	0.50	1.50	1.0	6.50	3.0	0	0.50	0	0.17	1.50	2.0	6.0	3.17	0	0	0	0	2.0	1.0	0	1.0
American Eel	0	0	0	0	0.50	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chinook salmon	0.50	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rainbow smelt	0	0	0.50	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Threespine stickleback	0.50	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0.17

BOTTOM

SPECIES	NMPW DAY 20ft	NMPW DAY 40ft	NMPW DAY 60ft	NMPW DAY $\Sigma c/e/s$ / Σs	NMPW NIGHT 20ft	NMPW NIGHT 40ft	NMPW NIGHT 60ft	NMPW NIGHT $\Sigma c/e/s$ / Σs	NMPP DAY 20ft	NMPP DAY 40ft	NMPP DAY 60ft	NMPP DAY $\Sigma c/e/s$ / Σs	NMPP NIGHT 20ft	NMPP NIGHT 40ft	NMPP NIGHT 60ft	NMPP NIGHT $\Sigma c/e/s$ / Σs	NMPE DAY 20ft	NMPE DAY 40ft	NMPE DAY 60ft	NMPE DAY $\Sigma c/e/s$ / Σs	NMPE NIGHT 20ft	NMPE NIGHT 40ft	NMPE NIGHT 60ft	NMPE NIGHT $\Sigma c/e/s$ / Σs
Alewife	8.50	1.0	1.0	3.50	26.40	5.0	3.0	11.83	13.50	0	1.0	4.83	54.50	19.50	3.0	25.67	0	2.50	0	0.83	4.0	7.0	1.0	4.0
Rainbow smelt	0	0	0	0	0.50	2.0	0.50	1.00	0	0	0	0	2.50	3.50	1.0	2.33	0.50	0	0	0.17	0	1.0	0.50	1.50
Threespine stickleback	0	0	0	0	0	0	0	0	0	0	0	0	1.50	0	0	0.50	0.50	0	0	0.17	0.50	0	0	0.17

$$\frac{\Sigma c/e/s}{\Sigma s} = \frac{\Sigma \text{ catch/effort/sample}}{\Sigma \text{ samples}}$$

APPENDIX VII-3
(CONTINUED)

SPECIES	NMPW DAY 20ft	NMPW DAY 40ft	NMPW DAY 60ft	NMPW DAY Σc/e//s / Σs	NMPW NIGHT 20ft	NMPW NIGHT 40ft	NMPW NIGHT 60ft	NMPW NIGHT Σc/e//s / Σs	NMPP DAY 20ft	NMPP DAY 40ft	NMPP DAY 60ft	NMPP DAY Σc/e//s / Σs	NMPP NIGHT 20ft	NMPP NIGHT 40ft	NMPP NIGHT 60ft	NMPP NIGHT Σc/e//s / Σs	NMPE DAY 20ft	NMPE DAY 40ft	NMPE DAY 60ft	NMPE DAY Σc/e//s / Σs	NMPE NIGHT 20ft	NMPE NIGHT 40ft	NMPE NIGHT 60ft	NMPE NIGHT Σc/e//s / Σs
SUMMER - JULY — SURFACE																								
Alewife	0	0	0	0	0.50	0	0	0.17	0	0	0.50	0.17	3.50	1.50	9.0	4.67	0	0	0	0	0.50	0	0	0.17
American Eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0.17	0	0	0	0	0	0	0	0
Spottail shiner	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0.17	0	0	0	0	0	0	0	0
BOTTOM																								
Alewife	0.50	0.50	0.50	0.50	18.50	18.50	6.50	14.50	0	1.0	1.0	0.67	20.50	28.0	6.50	18.33	0.50	0.50	0.50	0.50	18.50	18.50	6.50	14.50
American Eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0.17	0	0	0	0	0	0	0	0
Rainbow smelt	0	0	0	0	0	0	0.50	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUMMER - AUGUST — SURFACE																								
Alewife	0	0	0	0	0	0	0	0	0	0	0	0	2.0	0.50	1.0	1.17	0	0	0	0	0.50	0	0	0.17
BOTTOM																								
Alewife	0	0.50	0	0.17	2.50	0	5.50	2.67	0.50	0	0.50	0.33	6.50	8.0	8.0	7.50	0	0	0	0	0	10.50	3.0	4.50
Johnny darter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0.17	0	0	0	0	0	0	0	0
Trout perch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0.33	0	0	0	0	0	0	0	0
SUMMER - SEPTEMBER — SURFACE																								
Alewife	0	0	0	0	1.50	1.50	0	1.00	0	0	0	0	2.0	0	2.0	1.33	0	0	0	0	0.50	0.50	1.0	0.67
Emerald shiner	0	0	0	0	0	0	0	0	0	7.50	0	2.50	0	0	0	0	0	0	0	0	2.50	0.50	1.0	1.33
Rainbow smelt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0.17
Spottail shiner	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0.17
BOTTOM																								
Alewife	0	0	0	0	6.50	1.50	5.0	4.33	0	0	0	0	1.0	0	0.50	0.50	0	0	0	0	1.50	3.50	0.50	1.83
White perch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0.17

APPENDIX VII-3
(CONTINUED)

ALL - OCTOBER — SURFACE

PECIES	NMPW								NMPP								NMPE							
	DAY				NIGHT				DAY				NIGHT				DAY				NIGHT			
	20ft	40ft	60ft	Σc/e//s / Σs	20ft	40ft	60ft	Σc/e//s / Σs	20ft	40ft	60ft	Σc/e//s / Σs	20ft	40ft	60ft	Σc/e//s / Σs	20ft	40ft	60ft	Σc/e//s / Σs	20ft	40ft	60ft	Σc/e//s / Σs
	NO FISH CAUGHT				NO FISH CAUGHT				NO FISH CAUGHT				NO FISH CAUGHT				NO FISH CAUGHT				NO FISH CAUGHT			
BOTTOM																								
lewife	0	0.50	0	0.17	1.0	1.50	1.50	1.33	0	0	0	0	8.0	3.50	3.50	5.00	0	0	0	0	1.0	2.50	0.50	1.33
merald shiner	0	0	0	0	0	0	0	0	0	0	0	0	3.0	0.50	0	1.17	0	0	0	0	0	0	0	0
ainbow smelt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0.17	0	0	0	0	0	0	0	0

ALL - NOVEMBER — SURFACE

lewife	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0.17	0	0	0	0	0	0	0.50	0.17
BOTTOM																								
lewife	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0.50	0	0.50	0	0	0	0	0	0	0	0
izzard shad	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0	0	0.33	0	0	0	0	0	0	0	0

APPENDIX VII-4

NUMBERS OF FISH COLLECTED BY BEACH SEINE

NINE MILE POINT - 1974

SPECIES	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Alewife	6	64	29	119	590	2498	3	0	0
Rainbow smelt	0	1	0	0	1	0	0	0	0
Spottail shiner	0	1	0	3	10	0	0	0	0
White perch	0	1	0	0	41	66	0	0	0
Yellow perch	0	0	1	0	0	0	0	0	0
Smallmouth bass	0	0	0	2	2	2	0	0	0
Brown bullhead	0	0	0	0	0	0	2	0	0
Johnny darter	0	0	0	0	0	1	0	0	0
Gizzard shad	0	0	0	1	1	0	0	0	0
Emerald shiner	0	2	0	0	6	7	8	12	36
Pumpkinseed	0	0	2	1	0	0	0	0	0
Threespine stickleback	0	4	2	0	0	0	0	0	0
Brook silverside	0	2	0	0	0	0	0	0	0
Longnose dace	0	0	1	0	0	0	0	0	0
Golden shiner	0	0	0	3	0	1	0	0	0
Redfin pickerel	0	0	0	0	1	0	0	0	0

ABUNDANCE OF ALEWIFE
GILL NET - SAMPLE DEPTH

NINE MILE POINT - 1974

SURFACE

THREE WAY ANOVA
log transformed

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
Photoperiod (day/night)	1	142.6831	331	79.6136	593.217 (a)
Seasons*	2	12.6242	334	79.5139	26.514 (a)
Transects	3	0.3416	335	79.6140	0.479 (b)
Photoperiods x Seasons	2	0.2810	326	78.9667	0.580 (b)
Photoperiods x Transects	3	0.3682	326	76.9667	0.507 (b)
Seasons x Transects	6	0.2839	326	78.9667	0.195 (b)
Total	343	235.5487			

(a) Significant at α < 0.0005
(b) Not significant at α = 0.25

Student-Newman-Keuls Test - Seasons (α = 0.05) Largest: Summer Spring Fall: Smallest

BOTTOM

THREE WAY ANOVA
log transformed

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
Photoperiods (day/night)	1	11.6585	446	174.8520	29.738 (a)
Seasons	2	16.3963	449	178.9558	20.569 (a)
Transects	3	4.1636	450	177.7589	3.544 (b)
Photoperiods x Seasons	2	3.1736	441	171.4638	4.081 (b)
Photoperiods x Transects	3	0.4409	441	171.4638	0.378 (c)
Seasons x Transects	6	4.5447	441	171.4638	1.948 (d)
Total	458	211.8414			

(a) Significant at α < 0.0005
(b) Significant at α < 0.025 but not at α < 0.01
(c) Not significant at α = 0.25
(d) Significant at α < 0.10 but not at α = 0.05

Student-Newman-Keuls Test - Seasons (α = 0.05) Largest: Spring Summer Fall: Smallest
Student-Newman-Keuls Test - Transect (α = 0.05) Largest: FITZ NMPP NMPE NMPW: Smallest
Abundance greater at night than during the day.

* Spring = April - June; Summer = July - Sept; Fall = Oct - Dec.

APPENDIX VII-6

ABUNDANCE OF ALEWIFE
GILL NET - PHOTOPERIOD

NINE MILE POINT - 1974

DAY

TWO WAY ANOVA
log transformed

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
SAMPLE DEPTH	1	20.4325	415	161.6728	52.449 (a)
SEASONS*	2	8.7828	415	161.6728	11.272 (a)
DEPTH X SEASONS	2	0.4283	413	161.2445	0.549 (b)
TOTAL	418	188.5330			

(a) Significant at $\alpha < 0.0005$
(b) Not significant at $\alpha = 0.25$

Student-Newman-Keuls Test - Seasons ($\alpha = 0.05$) Largest: Summer Spring Fall: Smallest
Sample mean for bottom greater than that for surface

NIGHT

TWO WAY ANOVA
log transformed

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
SAMPLE DEPTH	1	25.9479	380	100.7917	97.827 (a)
SEASONS	2	21.2664	380	100.7917	40.089 (a)
DEPTH X SEASONS	2	1.6942	378	99.0975	3.231 (b)
TOTAL	383	148.1806			

(a) Significant at $\alpha < 0.0005$
(b) Significant at $\alpha < 0.05$

Student-Newman-Keuls Test - Seasons ($\alpha = 0.05$) Largest: Spring Summer Fall: Smallest
Sample mean for surface greater than sample mean for bottom.
*Spring = April - June; Summer = July - Sept; Fall = Oct - Dec

APPENDIX VII-7

COEFFICIENT OF MATURITY VALUES, SAMPLE SIZE AND COLLECTION DATES FOR ALEWIVES

NINE MILE POINT - 1974

Collection Date	MALES Sample Size	MALES Coefficient of Maturity	FEMALES Sample Size	FEMALES Coefficient of Maturity
11-19 Apr	104	1.18	104	2.66
23-24 Apr	101	1.35	104	3.08
6-8 May	44	1.68	73	3.36
19-23 May	95	2.39	111	3.78
3-9 Jun	106	4.50	106	6.43
17-21 Jun	50	5.92	50	8.73
9-11 Jul	50	5.48	50	12.12
23-27 Jul	50	2.45	50	5.54
7-9 Aug	25	0.62	25	1.92
20-22 Aug	25	0.66	25	1.49
9-12 Sep	25	0.69	25	1.66
23-25 Sep	25	0.60	25	2.33
8-11 Oct	25	0.65	25	1.65
24-28 Oct	25	0.94	25	1.68
7-9 Nov	25	0.88	25	1.93
19-20 Nov	25	0.86	25	1.98
6-7 Dec	25	1.08	25	2.22
Total	825		Total 873	

APPENDIX VII-8

SUMMARY OF FECUNDITY DATA FOR 38 ALEWIVES

NINE MILE POINT - 1974

Fish length (mm)	Fish Weight (g)	Ovary Wt. (g)	Age	Total Number of Eggs	Number of Mature Eggs	Log Number of Mature Eggs	Collection Date	Coefficient of Maturity
153	29.9	3.88	-	25,124	15,074	4.1782	10 Jul	14.91
158	31.9	3.56	IV	32,662	15,351	4.1861	10 Jul	12.56
158	32.3	4.10	III	34,866	26,847	4.4289	10 Jul	14.54
158	32.9	5.24	V	48,620	33,062	4.5193	10 Jul	18.94
158	35.3	4.30	-	46,890	36,574	4.5632	10 Jul	13.87
158	36.4	3.71	III	27,339	21,051	4.3233	10 Jul	11.35
159	31.8	4.76	V	36,126	31,068	4.4923	10 Jul	17.60
159	31.8	4.76	V	21,193	17,802	4.2505	10 Jul	17.60
159	32.0	3.92	V	23,371	17,762	4.2495	10 Jul	13.96
159	33.6	3.70	-	33,178	25,215	4.4017	10 Jul	12.37
159	34.0	3.70	IV	31,373	15,059	4.1778	10 Jul	12.21
160	30.7	3.67	IV	33,498	27,803	4.4441	10 Jul	13.58
160	36.4	4.89	IV	36,696	24,586	4.3907	10 Jul	15.52
161	37.0	3.78	III	24,131	16,650	4.2214	10 Jul	11.38
162	31.4	3.45	IV	39,532	20,557	4.3130	10 Jul	12.34
162	35.9	4.56	IV	27,838	21,992	4.3423	10 Jul	14.55
163	33.2	3.53	IV	31,665	16,149	4.2081	10 Jul	11.90
163	31.8	4.75	-	50,274	29,662	4.4722	10 Jul	13.[illegible]
164	31.0	3.66	-	33,361	26,022	4.4153	10 Jul	13.39
165	37.5	4.78	-	26,546	15,928	4.2022	10 Jul	14.60
165	34.9	4.44	IV	26,176	23,035	4.3624	10 Jul	14.58
165	36.5	4.91	V	32,178	22,525	4.3527	10 Jul	15.54
166	37.9	3.98	V	31,543	22,711	4.3562	10 Jul	11.73
166	38.0	3.86	IV	44,660	24,116	4.3823	10 Jul	11.31
166	37.2	4.91	IV	30,124	23,497	4.3710	10 Jul	15.21
166	37.9	6.24	IV	37,761	20,391	4.3094	10 Jul	19.70
168	32.3	4.00	IV	8,981	7,364	3.8671	10 Jul	14.13
168	36.0	3.81	IV	20,172	15,936	4.2024	10 Jul	11.84
169	35.5	5.42	-	39,071	22,271	4.3477	10 Jul	18.02
169	32.3	4.04	IV	35,451	24,461	4.3885	10 Jul	14.30
170	34.7	5.03	IV	34,860	26,494	4.4231	10 Jul	16.95
172	40.6	5.17	IV	38,408	28,422	4.4537	10 Jul	14.59
172	38.6	4.30	IV	24,641	20,452	4.3107	10 Jul	12.54
172	45.8	4.72	-	32,512	19,832	4.2974	10 Jul	11.49
173	38.2	5.06	III	35,878	17,221	4.2361	10 Jul	15.27
174	37.8	4.51	-	20,006	18,806	4.2743	10 Jul	13.55
175	39.1	4.06	-	24,584	19,667	4.2937	10 Jul	11.59
177	38.1	5.35	-	20,019	14,614	4.1648	10 Jul	16.34

Type of Egg Count	Mean	Range	Standard Deviation	Confidence Limits (α = .05)
Total No. of Eggs	31,613	8,981 - 50,274	8,590	28,768 - 34,458
No. of Mature Eggs	21,378	7,364 - 36,574	5,863	19,796 - 23,680

APPENDIX VII-9

BODY LENGTH - SCALE LENGTH RATIOS (L/Sc)
OF 286 MALE AND FEMALE ALEWIVES
NINE MILE POINT - 1974

LENGTH INTERVAL (mm)	MEAN TOTAL BODY LENGTH (mm)	MEAN L/Sc	N
75 - 79	77.0	63.64	3
80 - 84	84.0	63.11	2
85 - 89	85.0	70.25	1
90 - 94	91.0	60.83	1
95 - 99	95.8	65.80	5
100 - 104	102.6	62.68	5
105 - 109	108.3	63.48	9
110 - 114	112.2	61.34	13
115 - 119	117.0	59.97	6
120 - 124	121.5	55.50	2
125 - 129	127.0	55.34	3
130 - 134	131.7	53.45	3
135 - 139	137.5	57.72	4
140 - 144	142.1	56.52	12
145 - 149	147.0	60.34	21
150 - 154	151.7	57.20	34
155 - 159	157.1	64.31	30
160 - 164	161.8	60.76	30
165 - 169	166.5	56.33	34
170 - 174	171.2	60.03	25
175 - 179	176.6	60.77	18
180 - 184	181.5	66.70	6
185 - 189	186.8	58.16	4
190 - 194	192.0	51.19	4
195 - 199	195.5	51.37	2

APPENDIX VII-9
(CONTINUED)

LENGTH INTERVAL (mm)	MEAN TOTAL BODY LENGTH (mm)	MEAN L/Sc	N
200 - 204	201.5	48.72	2
205 - 209	---	---	-
210 - 214	213.0	51.77	2
215 - 219	218.0	49.79	1
220 - 224	---	---	-
225 - 229	226.0	60.43	1
230 - 234	232.0	51.95	1
235 - 239	---	---	-
240 - 244	242.0	60.87	2
245 - 249	---	---	-

N = Number of fish
--- = Not applicable

APPENDIX VII-10

ANNULUS FORMATION BY MONTH AND AGE GROUP
IN ALEWIVES (*Alosa pseudoharengus*)

NINE MILE POINT - 1974

Age Group	April		May		June		July		August	
	Number Annulus Formed	Number Annulus Not Formed	Number Annulus Formed	Number Annulus Not Formed	Number Annulus Formed	Number Annulus Not Formed	Number Annulus Formed	Number Annulus Not Formed	Number Annulus Formed	Number Annulus Not Formed
I		8		17		6	7		6	
II		4		7		1	2	8	3	
III		10		7	6	3	4	4	13	
IV		44		30	6	4	3	1	8	
V		24		21		6		5	3	
VI		6		6		1		3		
VII				1						
N =	0	96	0	89	12	21	16	21	33	0
	0	100%	0	100%	36%	64%	43%	57%	100%	0

APPENDIS VII-11

AVERAGE CALCULATED TOTAL LENGTH AND STANDARD ERROR AT ANNULUS FORMATION OF ALEWIVES

NINE MILE POINT - 1974

YEAR CLASS	NUMBER OF FISH	AGE GROUP	AVERAGE CALCULATED TOTAL LENGTH (mm) AND STANDARD ERROR AT ANNULUS FORMATION: I	II	III	IV	V	VI
			MALES					
1973	44	I	98.40					
			±2.02					
1972	13	II	81.63	138.42				
			±3.83	±3.65				
1971	18	III	86.14	139.17	155.42			
			±3.25	±3.01	±3.28			
1970	48	IV	80.37	133.33	148.92	157.34		
			±1.58	±1.45	±1.36	±1.48		
1969	22	V	77.53	129.94	145.20	154.59	160.10	
			±2.26	±2.53	±2.09	±2.23	±2.50	
1968	5	VI	76.33	131.08	164.60	179.87	190.49	198.80
			±7.35	±10.59	±7.79	±9.88	±10.42	±11.53
		Grand average calculated length (weighted)	85.91	134.14	150.14	158.04	165.73	198.80
		Grand average increment of length (weighted)	85.91	53.41	16.60	9.16	6.46	8.31
		Sum of grand average increments	85.91	139.32	155.92	165.08	171.54	179.85
		Confidence interval of (α=0.05) grand calculated lengths	83.83	131.67	147.75	155.29	161.18	157.40
			87.99	136.61	152.53	160.79	170.28	240.20
			FEMALES					
1973	44	I	98.40					
			±2.02					
1972	8	II	82.00	140.38				
			±5.84	±3.94				
1971	28	III	88.54	142.26	160.38			
			±2.98	±2.80	±2.27			
1970	48	IV	82.97	140.08	157.53	167.12		
			±1.89	±2.05	±1.68	±1.54		
1969	37	V	74.26	125.37	143.35	156.89	165.54	
			±1.98	±2.39	±1.65	±1.64	±2.18	
1968	10	VI	74.23	129.80	160.20	170.53	182.67	198.20
			±4.56	±10.22	±8.91	±8.53	±8.45	±9.79
		Grand average calculated length (weighted)	85.36	135.62	154.13	163.49	169.18	198.20
		Grand average increment of length (weighted)	85.36	54.65	18.82	11.21	9.39	5.53
		Sum of grand average increment	85.36	140.01	158.83	170.04	179.43	184.96
		Confidence interval of (α=0.05) grand calculated lengths	83.26	132.68	151.65	160.73	163.95	186.67
			87.46	138.56	156.61	166.25	174.41	209.73

APPENDIX VII-12

ABUNDANCE OF RAINBOW SMELT
GILL NET - PHOTOPERIOD

NINE MILE POINT - 1974

DAY

TWO WAY ANOVA
log transformed

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
SAMPLE DEPTH	1	2.6737	415	26.4939	41.881 (a)
SEASONS*	2	5.1177	415	26.4939	40.081 (a)
DEPTH X SEASONS	2	2.6023	413	23.8916	22.492 (a)
TOTAL	418	33.7847			

(a) Significant at α < 0.0005

Student-Newman-Keuls Test - Seasons (α = 0.05) Largest: Spring Summer Fall: Smallest
Sample mean for bottom greater than that for surface

NIGHT

TWO WAY ANOVA
log transformed

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
SAMPLE DEPTH	1	1.0056	380	46.0972	8.290 (a)
SEASONS	2	25.1612	380	46.0972	103.708 (b)
DEPTH X SEASONS	2	1.0314	378	45.0658	4.326 (c)
TOTAL	383	72.1731			

(a) Significant at α < 0.005 but not at α = 0.0025
(b) Significant at α < 0.0005
(c) Significant at α < 0.025 but not at α = 0.01

Student-Newman-Keuls Test - Seasons (α = 0.05) Largest: Spring Fall Summer: Smallest
The sample mean for surface is greater than that for bottom.

* Spring = April - June; Summer = July - Sept; Fall = Oct - Dec.

ABUNDANCE OF RAINBOW SMELT
GILL NET - SAMPLE DEPTH

NINE MILE POINT - 1974

SURFACE

THREE WAY ANOVA
log transformed

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
Photoperiods (day/night)	1	10.5813	331	33.6644	104.039 (a)
Seasons*	2	8.6103	334	33.7274	42.633 (a)
Transects	3	0.0055	335	26.4309	0.023 (b)
Photoperiods X Seasons	2	7.3188	326	26.3021	45.356 (a)
Photoperiods X Transects	3	0.0729	326	26.3021	0.301 (b)
Seasons X Transects	6	0.0522	326	26.3021	0.108 (b)
Total	343	52.9431			

(a) Significant at $\alpha < 0.0005$
(b) Not significant at $\alpha = 0.25$

Student-Newman-Keuls Test - Seasons ($\alpha = 0.05$) Largest: Spring Fall Summer: Smallest
Greater abundance at night than during the day.

BOTTOM

THREE WAY ANOVA
log transformed

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
Photoperiods (day/night)	1	1.0232	446	42.0811	10.844 (a)
Seasons	2	16.8882	449	42.9372	88.301 (b)
Transects	3	0.4978	450	42.0233	1.777 (c)
Photoperiods X Seasons	2	0.9780	441	40.9808	5.262 (d)
Photoperiods X Transects	3	0.1027	441	40.9808	0.368 (e)
Seasons X Transects	6	0.9581	441	40.9808	1.718 (c)
Total	458	61.4288			

(a) Significant at $\alpha < 0.0025$ but not at $\alpha = 0.001$
(b) Significant at $\alpha < 0.0005$
(c) Significant at $\alpha < 0.25$ but not at $\alpha = 0.10$
(d) Significant at $\alpha < 0.01$ but not at $\alpha = 0.005$
(e) Not significant at $\alpha = 0.25$

Student-Newman-Keuls Test - Seasons ($\alpha = 0.05$) Largest: Spring Fall Summer: Smallest
Greater abundance at night than during the day.

* Spring = April-June; Summer = July-Sept; Fall= [illegible]-Dec

APPENDIX VII-14

COEFFICIENT OF MATURITY VALUES, SAMPLE SIZE AND COLLECTION DATES FOR RAINBOW SMELT

NINE MILE POINT - 1974

Collection Date	MALES Sample Size	MALES Coefficient of Maturity	FEMALES Sample Size	FEMALES Coefficient of Maturity
1-15 Jan*	50	3.14	85	3.44
16-31 Jan*	41	2.41	93	4.10
1-15 Feb*	43	2.42	70	4.70
16-28 Feb*	26	2.71	72	8.99
1-15 Mar*	42	2.64	51	8.89
16-31 Mar*	78	3.00	100	11.79
11-19 Apr	112	2.89	112	16.44
23-25 Apr	112	2.82	112	18.28
6-8 May	89	2.70	101	12.30
19-23 May	43	1.32	76	7.14
3-9 Jun	9	1.43	39	3.72
17-21 Jun	3	1.02	5	0.77
9-11 Jul	-	-	4	5.83
23-27 Jul	1	0.89	2	1.14
7-9 Aug	-	-	-	-
20-22 Aug	2	0.19	9	0.50
9-12 Sep	1	0.12	16	0.75
23-25 Sep	-	-	7	2.24
8-11 Oct	13	1.22	25	0.78
24-28 Oct	10	3.01	25	1.36
7-9 Nov	8	4.43	25	1.69
19-20 Nov	4	5.05	19	1.78
6-7 Dec	1	5.00	8	2.72
Total	688		Total 1056	

*Data for these dates were obtained from impingement samples.

\- Not applicable

APPENDIX VII-15

SUMMARY OF FECUNDITY DATA FOR 24 RAINBOW SMELT
NINE MILE POINT - 1974

Fish Length (mm)	Fish Weight (g)	Ovary Wt. (g)	Age	Total Number of Eggs	Log Number of Eggs	Collection Date	Coefficient of Maturity
132	14.7	2.43	III	8,185	3.9130	9 May	19.80
137	17.9	3.24	III	12,243	4.0879	18 Apr	22.10
138	18.8	4.45	-	6,212	3.7932	9 May	31.01
141	20.0	3.54	III	16,959	4.2294	18 Apr	21.5
142	20.2	4.44	III	13,651	4.1352	18 Apr.	28.17
146	23.0	4.43	III	11,330	4.0542	9 May	23.86
146	20.8	3.18	III	11,095	4.0451	18 Apr	18.05
147	24.3	3.90	III	16,525	4.2181	18 Apr	19.12
155	26.5	3.65	V	12,885	4.1101	18 Apr	15.97
156	26.7	4.50	III	12,668	4.1027	26 Apr	20.27
156	40.7	6.76	V	21,737	4.3372	18 Apr	19.92
160	27.9	6.74	-	15,713	4.1963	1-2 May	31.85
161	30.9	5.62	IV	15,774	4.1979	9 May	22.23
165	32.5	5.30	-	19,028	4.2794	18 Apr	19.49
166	32.8	6.38	IV	20,612	4.3141	9 May	24.15
167	30.9	5.40	III	16,863	4.2269	26 Apr	21.18
169	24.2	3.91	-	11,646	4.0662	6-7 May	19.27
171	35.1	6.58	III	14,085	4.1488	9 May	23.07
173	37.6	7.61	III	27,902	4.4456	9 May	25.38
174	36.4	8.73	IV	20,365	4.3089	9 May	31.55
177	35.7	5.84	-	20,904	4.3202	18 Apr	19.56
182	46.7	8.50	IV	28,766	4.4589	18 Apr	22.25
183	35.0	8.05	-	23,854	4.3776	18 Apr	29.37
213	57.9	8.98	III	29,050	4.4631	6 May	18.36

Type of Egg Count	Mean	Range	Standard Deviation	Confidence Limits (α = .05)
Total Number of Eggs	17,002	6,212 - 29,050	6,210	14,379 - 19,625

APPENDIX VII-16

BODY LENGTH - SCALE LENGTH RATIOS (L/Sc)
OF MALE AND FEMALE RAINBOW SMELT

NINE MILE POINT - 1974

LENGTH INTERVAL (mm)	MEAN TOTAL BODY LENGTH(mm)	L/Sc	N
120 - 124	-	-	-
125 - 129	126	92.38	1
130 - 134	132.5	72.56	4
135 - 139	137.1	79.29	25
140 - 144	142	78.67	23
145 - 149	146.4	78.63	43
150 - 154	151.7	77.32	28
155 - 159	156.6	80.14	46
160 - 164	161.9	78.17	24
165 - 169	166.9	82.3	18
170 - 174	171.9	80.29	13
175 - 179	177.1	78.61	7
180 - 184	181.3	83.01	4
185 - 189	186.6	79.17	7
190 - 194	192.0	85.56	1
195 - 199	196.3	79.67	4
200 - 204	203.2	81.25	6
205 - 209	206.6	81.27	9
210 - 214	211.8	82.67	11
215 - 219	217.1	82.05	8
220 - 224	221.3	85.25	9
225 - 229	227.5	81.19	8
230 - 234	232.0	87.51	2
235 - 239	236.7	78.93	3
240 - 244	242.0	80.59	4
245 - 249	-	-	-

\- Not applicable

APPENDIX VII-17

ANNULUS FORMATION BY MONTH AND AGE GROUP
IN RAINBOW SMELT (*Osmerus mordax*)

NINE MILE POINT - 1974

Age Group	April		May		June		July		Aug.		Sept.		Oct.	
	Number Annulus Formed	No. annulus not formed	Number annulus formed	No. annulus formed	Number Annulus Formed	No. annulus not formed	Number annulus formed	No. annulus not formed	Number Annulus formed	No. annulus not formed	Number annulus formed	No. annulus not formed	Number Annulus formed	No. annulus not formed
I													1	
II	2	7	2	5	4		1		1				9	
III	18	108	6	31	5	3							3	
IV	2	17	1	20	10	2							3	
V	2	12	1	11	3	1	1						2	
VI		2		3	1	3							2	
VII				1										
N=	24	146	10	71	23	9	2		1				20	
	14%	86%	12%	88%	72%	28%	100%		100%				100%	

APPENDIX VII-18

AVERAGE CALCULATED TOTAL LENGTH AND STANDARD ERROR AT ANNULUS FORMATION OF RAINBOW SMELT

NINE MILE POINT - 1974

YEAR CLASS	NUMBER OF FISH	AGE GROUP	AVERAGE CALCULATED TOTAL LENGTH (mm) AND STANDARD ERROR ANNULUS FORMATION						
			I	II	III	IV	V	VI	VII
			MALES						
1972	29	II	79.35 ±2.25	128.56 ±2.41					
1971	67	III	75.97 ±1.19	118.69 ±1.42	147.72 ±1.47				
1970	3	IV	87.84 ±13.85	126.68 ±14.83	155.17 ±14.36	179.00 ±12.58			
1969	2	V	68.12 ±2.40	116.28 ±15.98	144.28 ±16.26	169.63 ±19.09	189.00 ±28.00		
		Grand average calculated length (weighted)	77.14	121.72	147.93	175.25	189.00		
		Grand average increment of length (weighted)	77.14	44.58	28.98	24.44	19.37		
		Sum of grand average increments	77.14	121.72	150.70	175.14	194.51		
		Confidence interval (α=0.05) grand average calculated lengths	74.95 79.33	119.16 124.26	144.85 151.00	124.38 226.12	166.76 544.17		
			FEMALES						
1972	8	II	85.70 ±2.87	145.27 ±3.88					
1971	107	III	80.69 ±1.03	128.48 ±1.20	157.47 ±1.49				
1970	49	IV	74.91 ±1.84	121.35 ±2.71	158.20 ±2.82	185.44 ±3.62			
1969	31	V	75.28 ±2.01	127.41 ±3.20	159.37 ±2.95	185.92 ±3.45	208.86 ±4.13		
1968	10	VI	73.25 ±3.10	132.07 ±3.07	160.24 ±3.26	183.73 ±4.47	199.26 ±5.25	217.09 ±4.72	
1967	1	VII	75.38	144.11	146.69	171.21	189.50	207.86	220.08
		Grand average calculated length (weighted)	78.31	127.38	158.03	185.26	206.11	216.25	220.08
		Grand average increment of length (weighted)	78.31	49.07	31.38	26.56	21.07	17.88	12.22
		Sum of grand average increment	78.31	127.38	158.76	185.32	206.39	224.27	236.49
		Confidence interval (α=0.05) grand average calculated lengths	76.76 79.86	125.30 129.46	155.69 160.36	180.26 190.06	199.09 213.13	204.93 227.56	

ABUNDANCE OF WHITE PERCH
GILL NET - PHOTOPERIOD

NINE MILE POINT - 1974

DAY

TWO WAY ANOVA
log transformed

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
SAMPLE DEPTH	1	2.6627	415	21.4221	51.583 (a)
SEASONS*	2	0.1237	415	21.4221	1.198 (b)
DEPTH X SEASONS	2	0.0385	413	21.3836	0.372 (b)
TOTAL	418	24.1352			

(a) Significant at $\alpha < 0.0005$
(b) Not significant at $\alpha = 0.25$

Bottom sample greater than surface sample mean

NIGHT

TWO WAY ANOVA
log transformed

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
SAMPLE DEPTH	1	12.8139	380	50.5559	96.314 (a)
SEASONS	2	4.7421	380	50.5559	17.822 (a)
DEPTH X SEASONS	2	1.9593	378	48.5967	7.620 (b)
TOTAL	383	67.9539			

(a) Significant at $\alpha < 0.0005$
(b) Significant at $\alpha < 0.001$ but not at $\alpha = 0.0005$

Student-Newman-Keuls Test - Seasons ($\alpha = 0.05$) Largest: Summer Fall Spring: Smallest
Sample mean for bottom greater than sample mean for surface

* Spring = April - June
Summer = July - Sept.
Fall = Oct. - Dec.

APPENDIX VII-20

ABUNDANCE OF WHITE PERCH
GILL NET - SAMPLE DEPTH

NINE MILE POINT - 1974

SURFACE

THREE WAY ANOVA
log transformed

SOURCES	DF	SS	DF (ERR)	SS (ERR)	F
Photoperiod (day/night)	1	0.4025	331	4.6407	28.709 (a)
Seasons *	2	0.2249	334	4.9086	7.652 (b)
Transects	3	0.1107	335	4.8148	2.567 (c)
Photoperiods X Seasons	2	0.1048	326	4.5309	3.772 (d)
Photoperiods X Transects	3	0.0049	326	4.5309	0.116 (e)
Seasons X Transects	6	0.2746	326	4.5309	3.292 (f)
Total	343	5.6533			

(a) Significant at $\alpha < 0.0005$
(b) Significant at $\alpha < 0.001$ but not at $\alpha = 0.0005$
(c) Significant at $\alpha < 0.10$ but not at $\alpha = 0.05$
(d) Significant at $\alpha < 0.025$ but not at $\alpha = 0.01$
(e) Not significant at $\alpha = 0.25$
(f) Significant at $\alpha < 0.005$ but not at $\alpha = 0.0025$

Student-Newman-Keuls Test - Seasons ($\alpha = 0.05$) Largest: Summer Spring Fall: Smallest
Student-Newman-Keuls Test - Transect ($\alpha = 0.10$) Largest: NMPE FITZ NMPP NMPW: Smallest
Greater abundance at night than during the day.

BOTTOM

THREE WAY ANOVA
log transformed

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
Photoperiod (day/night)	1	7.9828	446	61.0112	57.961 (a)
Seasons	2	4.1697	449	62.3056	15.024 (a)
Transects	3	4.0180	450	61.0367	9.874 (a)
Photoperiod X Seasons	2	2.4567	441	57.7155	9.386 (a)
Photoperiod X Transects	3	0.9542	441	57.7155	2.430 (b)
Seasons X Transects	6	2.1441	441	57.7155	2.731 (c)
Total	458	79.3871			

(a) Significant at $\alpha < 0.0005$
(b) Significant at $\alpha < 0.10$ but not at $\alpha = 0.05$
(c) Significant at $\alpha < 0.025$ but not at $\alpha = 0.01$

Student-Newman-Keuls Test - Seasons ($\alpha = 0.05$) Largest: Summer Fall Spring: Smallest
Student-Newman-Keuls Test - Transect ($\alpha = 0.05$) Largest: NMPE FITZ NMPW NMPP: Smallest
Greater abundance at night than during the day.

* Spring = April - June; Summer = July - Sept; Fall = Oct - Dec.

APPENDIX VII-21

COLLECTION OF MATURITY VALUES, SAMPLE SIZE AND COLLECTION DATES FOR WHITE PERCH

NINE MILE POINT - 1974

Collection Date	MALES Sample Size	MALES Coefficient of Maturity	FEMALES Sample Size	FEMALES Coefficient of Maturity
11-19 Apr	2	4.76	4	11.95
23-25 Apr	43	5.56	36	7.88
6-8 May	23	6.59	41	9.65
19-23 May	49	6.78	54	12.20
3-9 Jun	18	5.00	35	8.41
17-21 Jun	19	4.35	11	8.09
9-11 Jul	50	2.70	50	3.28
23-27 Jul	50	1.42	50	1.81
7-9 Aug	25	0.80	25	1.33
20-22 Aug	25	0.58	25	0.86
9-12 Sep	25	0.84	26	0.93
23-25 Sep	25	2.62	25	1.08
8-11 Oct	25	3.42	25	1.90
24-28 Oct	20	2.19	16	2.03
7-9 Nov	6	1.39	6	1.23
19-20 Nov	3	2.04	-	-
Total	408		429	

- Not applicable

APPENDIX VII-22

SUMMARY OF FECUNDITY DATA FOR 39 WHITE PERCH

NINE MILE POINT - 1974

Fish Length (mm)	Fish Weight (g)	Ovary Wt. (g)	Age	Total Number of Eggs	Number of Mature Eggs	Log Number of Mature Eggs	Collection Date	Coefficient of Maturity
192	121.3	13.02	III	114,158	99,268	4.9968	20 May	12.02
211	193.9	37.69	III	138,735	117,925	5.0216	20 May	24.13
212	157.7	16.23	III	107,913	76,618	4.8843	17 May	11.47
215	180.6	25.51	V	145,574	129,561	5.1125	20 May	16.45
221	203.7	33.30	III	156,219	99,980	4.9999	17 May	19.54
222	193.8	29.11	IV	203,782	187,479	5.2730	20 May	17.78
222	195.5	16.54	III	91,030	79,196	4.8987	24 Apr	9.19
223	182.5	28.28	IV	154,230	126,469	5.1020	17 May	18.34
223	190.2	28.06	IV	156,510	142,424	5.1536	20 May	17.31
224	189.5	31.24	V	159,818	150,229	5.1768	20 May	19.74
225	210.9	34.11	III	137,885	123,112	5.0903	20 May	19.29
225	216.5	30.22	IV	237,269	173,206	5.2386	17 May	16.22
226	202.6	18.90	V	141,754	133,249	5.1247	20 May	10.29
226	204.3	25.79	IV	130,006	118,306	5.0730	20 May	14.45
227	204.6	14.50	IV	118,017	102,675	5.0115	24 Apr	7.63
227	207.3	19.78	VI	151,791	141,166	5.1497	20 May	[illegible]
227	214.2	30.71	IV	108,256	90,935	4.9587	17 May	16.74
229	218.7	21.54	IV	98,202	94,274	4.9744	21 May	10.93
230	233.1	32.27	V	152,387	144,768	5.1607	20 May	16.07
231	238.8	29.56	IV	238,796	226,856	5.3558	20 May	14.13
232	216.7	29.68	III	185,992	159,953	5.2040	23 May	15.87
232	240.9	37.97	V	302,154	281,003	5.4487	20 May	18.71
234	234.5	36.00	IV	156,815	150,542	5.1777	20 May	18.14
234	260.4	34.34	IV	286,539	260,490	5.4158	23 May	15.19
236	207.5	23.80	IV	131,285	94,525	4.9755	17 May	12.96
236	232.7	30.30	IV	163,601	158,693	5.2006	17 May	14.97
237	227.2	24.17	V	107,833	105,676	5.0240	23 May	11.90
238	228.0	35.92	IV	168,139	131,148	5.1178	17 May	18.70
238	240.4	34.43	V	104,196	94,818	4.9769	16 May	16.72
245	281.6	33.65	VI	210,611	170,595	5.2320	20 May	13.57
246	273.3	33.05	V	189,034	166,350	5.2210	6 May	13.76
247	255.7	32.95	IV	125,774	106,908	5.0290	17 May	14.79
249	294.2	34.12	V	196,664	155,365	5.1914	20 May	13.12

APPENDIX VII-22 (Continued)

Fish Length (mm)	Fish Weight (g)	Ovary Wt. (g)	Age	Total Number of Eggs	Number of Mature Eggs	Log Number of Mature Eggs	Collection Date	Coefficient of Maturity
250	319.7	46.40	VII	221,047	212,205	5.3268	20 May	16.98
266	400.4	49.75	V	337,018	316,797	5.5008	20 May	14.19
271	420.1	40.09	VII	283,783	227,026	5.3561	21 May	10.55
276	380.9	57.20	VI	245,229	188,638	5.2756	20 May	17.67
279	459.1	71.30	VIII	341,019	327,378	5.5150	20 May	18.39
325	670.6	69.82	XII	335,750	319,600	5.5046	20 May	11.62

Type of Egg Count	Mean	Range	Standard Deviation	Confidence Limits (α = .05)
Total Number of Eggs	180,380	91,030 - 341,019	70,555	157,310 - 203,450
Number of Mature Eggs	158,600	76,618 - 327,378	67,542	136,515 - 180,685

APPENDIX VII-23

ANNULUS FORMATION BY MONTH AND AGE GROUP IN WHITE PERCH

NINE MILE POINT - 1974

Age Group	April		May		June		July		August		September		October	
	# Formed	# Not Formed	# Formed	# Not Formed	# Formed	# Not Formed	# Formed	# Not Formed	# Formed	# Not Formed	# Formed	# Not Formed	# Formed	# Not Formed
1		10					14						2	3
2		2		1		3	4	1	3		26	2	25	
3		7		7		12	4	7	12		6		4	
4		10		8		4	4	8	23					
5		6	1	10		6	3	7	19	1	3			
6		4		3		8	2	3	10		1		1	
7		4	2	2		1	2	5	7		4	1		
8		5		1		6	2	7	4		1		2	
9		2	1	1		5		1	1		2			
10						1					1		1	
11						1			1					
12		1												
N= 375	0	51	4	30	0	47	35	39	80	1	44	3	35	3
		100%	11%	89%	0	100%	47%	53%	99%	1%	94%	6%	92%	8%

APPENDIX VII-24

AVERAGE CALCULATED TOTAL LENGTH
AND STANDARD ERROR AT ANNULUS FORMATION
OF WHITE PERCH

NINE MILE POINT - 1974

YEAR CLASS	NUMBER OF FISH	AGE GROUP	AVERAGE CALCULATED TOTAL LENGTH (mm) AND STANDARD ERROR AT ANNULUS FORMATION											
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
			MALE											
1973	58	I	79.59											
			±1.45											
1972	37	II	70.85	152.57										
			±2.29	± 2.13										
1971	30	III	71.54	150.54	190.05									
			±2.99	±2.78	±2.55									
1970	31	IV	77.02	152.52	189.10	210.47								
			±2.95	±3.00	±3.23	±2.55								
1969	22	V	75.95	148.81	187.29	208.47	222.61							
			±3.52	±4.97	±3.59	±2.39	±2.18							
1968	15	VI	71.91	146.86	188.31	208.51	223.25	234.79						
			±4.46	±6.18	±4.91	±4.38	±3.70	±3.18						
1967	12	VII	79.41	140.82	177.14	198.55	212.52	233.44	236.04					
			±3.28	±8.59	±9.72	±10.58	±9.33	±8.63	±8.19					
1966	8	VIII	63.89	119.40	158.46	187.45	204.14	218.80	229.84	239.50				
			±4.15	±8.49	±12.39	±10.92	±10.44	±9.28	±8.73	±7.74				
1965	7	IX	84.56	139.30	177.96	196.10	213.41	228.92	242.40	252.68	260.63			
			±5.85	± 7.69	±11.49	±10.40	±9.58	±8.70	±8.20	±7.55	±7.06			
1964	1	X	65.70	140.46	192.55	211.48	255.63	243.06	254.07	260.42	265.14	268.28		
1963	2	XI	83.00	151.97	193.83	214.82	234.19	248.14	261.36	272.23	279.99	285.38	292.39	
			±1.26	±5.37	±8.27	±5.81	±1.81	±1.74	±2.19	±3.83	±2.29	±3.11	±3.96	
1962	1	XII	84.18	146.60	185.63	209.00	232.38	246.46	263.61	276.05	282.34	288.56	292.35	301.00
	224	Grand average calculated length (weighted)	75.41	148.06	185.38	205.49	218.38	229.17	238.98	250.83	266.53	281.90	293.71	301.00
		Grand average increment of length (weighted)	75.41	74.11	38.60	21.50	15.00	12.74	12.29	9.96	8.33	7.32	8.61	7.29
		Sum of grand average increments	75.41	149.52	188.12	209.62	224.62	237.36	249.65	259.61	267.94	275.26	283.87	291.10
		Confidence interval of (α=0.05)	73.43	144.94	181.40	200.94	212.65	221.39	227.90	238.14	249.48	225.83	222.34	
		grand average calculated lengths	77.39	151.18	189.36	210.04	224.11	236.95	250.06	263.52	283.58	337.92	365.08	

YEAR CLASS	NUMBER OF FISH	AGE GROUP	AVERAGE CALCULATED TOTAL LENGTH (mm) AND STANDARD ERROR AT ANNULUS FORMATION — I	II	III	IV	V	VI	VII	VIII	IX	X
			FEMALE									
1973	58	I	79.59 ±1.45									
1972	21	II	76.50 ±2.30	160.48 ± 2.32								
1971	27	III	74.19 ±2.55	151.13 ± 3.27	200.85 ± 3.59							
1970	24	IV	78.71 ±2.88	147.58 ± 4.58	189.69 ± 4.61	215.68 ± 3.64						
1969	33	V	80.58 ±3.02	149.81 ± 4.46	193.29 ± 4.37	217.59 ± 3.83	237.73 ± 3.34					
1968	15	VI	72.17 ±3.40	146.39 ± 5.57	190.54 ± 6.18	215.33 ± 6.03	229.22 ± 5.16	242.46 ± 4.87				
1967	13	VII	77.26 ±4.17	146.61 ± 4.48	200.91 ± 6.25	230.19 ± 4.97	248.35 ± 4.27	257.03 ± 3.66	265.29 ± 3.50			
1966	18	VIII	72.76 ±3.52	144.01 ± 5.04	195.25 ± 5.66	221.17 ± 5.45	239.63 ± 4.93	254.28 ± 4.77	263.92 ± 4.69	271.99 ± 4.56		
1965	4	IX	77.56 ±4.32	148.03 ± 6.13	192.82 ±12.46	212.59 ±15.06	229.20 ±13.84	250.18 ±11.68	262.41 ± 7.41	267.96 ± 7.52	276.25 ± 6.76	
1964	2	X	71.49 ±9.83	172.34 ± 3.12	216.83 ± 3.33	248.58 ± 2.92	267.61 ± 1.24	278.76 ± 1.17	291.47 ± 1.10	300.22 ± .28	311.36 ± 4.50	318.50 ± 8.50
		Grand average calculated length (weighted)	77.32	150.11	195.16	219.34	238.56	252.18	265.73	273.67	287.95	318.50
		Grand average increment of length (weighted)	77.32	73.63	46.67	25.57	18.07	13.10	9.60	7.71	9.31	7.41
		Sum of grand average increments	77.32	150.95	197.62	223.19	241.26	254.36	263.95	271.67	280.98	268.39
		Confidence interval of (α=0.05) grand average calculated lengths	75.43-79.21	146.78 153.44	191.08 199.26	215.02 223.66	234.02 243.09	246.55 257.81	259.51 271.95	264.97 282.37	266.80 309.10	165.31 471.69

APPENDIX VII-25

ABUNDANCE OF YELLOW PERCH
GILL NET - PHOTOPERIOD

NINE MILE POINT - 1974

DAY

TWO WAY ANOVA
log transformed

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
DEPTH	1	52.9188	415	225.5231	97.379 (a)
SEASONS*	2	3.8803	415	225.5231	3.570 (b)
DEPTH X SEASONS	2	3.4326	413	222.0905	3.192 (b)
TOTAL	418	284.1090			

(a) Significant at α < 0.0005
(b) Significant at α < 0.05 but not at α = 0.025

Student-Newman-Keuls Test - Seasons (α = 0.05) Largest: Summer Fall Spring: Smallest
Sample mean for bottom greater than that for surface

NIGHT

TWO WAY ANOVA
log transformed

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
DEPTH	1	6.1578	380	20.8884	112.022 (a)
SEASONS	2	0.3489	380	20.8884	3.173 (b)
DEPTH X SEASONS	2	0.2283	378	20.6601	2.089 (c)
TOTAL	383	27.3657			

(a) Significant at α <0.0005
(b) Significant at α <0.05 but not at α = 0.025
(c) Significant at α <0.25 but not at α = 0.10

Student-Newman-Keuls Test - Seasons (α = 0.10) Largest: Summer Fall Spring: Smallest
Sample mean for bottom greater than that for surface

* Spring = April-June; Summer = July-September; Fall = October-December

APPENDIX VII-26

ABUNDANCE OF YELLOW PERCH
GILL NET - SAMPLE DEPTH

NINE MILE POINT - 1974

SURFACE

THREE WAY ANOVA
log transformed

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
PHOTOPERIOD (day/night)	1	0.0002	331	3.6866	0.018 (a)
SEASONS *	2	0.0041	334	3.7017	0.185 (a)
TRANSECTS	3	0.0084	335	3.7591	0.248 (a)
PHOTOPERIOD X SEASONS	2	0.0107	326	3.6009	0.486 (a)
PHOTOPERIOD X TRANSECTS	3	0.0740	326	3.6009	2.234 (b)
SEASONS X TRANSECTS	6	0.0901	326	3.6009	1.359 (b)
TOTAL	343	3.7884			

(a) Not significant at α = 0.25
(b) Significant at α < 0.25 but not at α = 0.10

BOTTOM

THREE WAY ANOVA
log transformed

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
PHOTOPERIOD (day/night)	1	0.0422	446	45.7745	0.411 (a)
SEASONS	2	1.5991	449	45.9895	7.806 (b)
TRANSECTS	3	1.4886	450	49.9373	4.861 (c)
PHOTOPERIOD X SEASON	2	0.0873	441	45.6460	0.422 (a)
PHOTOPERIOD X TRANSECTS	3	0.0420	441	45.6460	0.135 (a)
SEASONS X TRANSECTS	6	0.2476	441	45.6460	0.399 (a)
TOTAL	458	49.1528			

(a) Not significant at α = 0.25
(b) Significant at α < 0.0005
(c) Significant at α < 0.0025 but not at α = 0.001

Student-Newman-Keuls Test - Seasons (α = 0.05) Largest: Summer Fall Spring: Smallest
Student-Newman-Keuls Test - Transect (α = 0.05) Largest: NMPE FITZ NMPP NMPW: Smallest
* Spring=April-June; Summer=July-September; Fall=October-December.

APPENDIX VII-27

COEFFICIENT OF MATURITY VALUES, SAMPLE SIZE AND COLLECTION DATES FOR YELLOW PERCH

NINE MILE POINT - 1974

	MALES		FEMALES	
COLLECTION DATE	SAMPLE SIZE	COEFFICIENT OF MATURITY	SAMPLE SIZE	COEFFICIENT OF MATURITY
1 - 15 Jan*	1	4.51	1	15.16
16 - 31 Jan*	3	3.73	4	14.27
1 - 15 Feb*	4	4.49	2	17.79
16 - 28 Feb*	1	3.73	10	10.36
1 - 15 Mar*	8	4.39	4	14.28
16 - 31 Mar*	8	4.69	22	14.01
1 - 15 Apr*	6	4.06	21	26.62
16 - 30 Apr	19	2.39	95	6.90
6 - 8 May	9	2.23	16	3.58
19 - 23 May	17	1.75	27	5.03
3 - 9 Jun	40	0.88	60	1.28
17 - 21 Jun	13	0.69	8	0.83
9 - 11 Jul	50	0.24	50	0.48
23 - 27 Jul	50	0.22	50	0.44
7 - 9 Aug	15	0.21	25	0.47
20 - 22 Aug	12	0.43	25	0.65
9 - 12 Sep	15	1.28	25	1.37
23 - 25 Sep	25	3.97	25	2.00
8 - 11 Oct	25	8.44	25	3.43
24 - 28 Oct	16	6.33	22	5.91
7 - 9 Nov	5	5.50	9	7.24
19 - 20 Nov	2	4.49	9	7.74
6 - 7 Dec	4	7.36	2	9.75
TOTAL	351		537	

* Data for these dates were obtained from impingement samples

APPENDIX VII-28

SUMMARY OF FECUNDITY DATA FOR 18 YELLOW PERCH

NINE MILE POINT - 1974

Fish Length (mm)	Fish Weight (g)	Ovary Wt. (g)	Age	Total Number of Eggs	Log Number of Eggs	Collection Date	Coefficient of Maturity
150	42.2	7.72	-	4,840	3.6848	15 Apr	22.39
184	87.1	20.83	V	9,854	3.9936	15 Apr	31.43
187	97.8	20.14	IV	16,310	4.2125	15 Apr	25.93
199	124.9	29.99	-	16,459	4.2164	15 Apr	31.60
213	156.2	33.84	-	21,671	4.3359	15 Apr	27.66
219	157.6	35.04	-	18,979	4.2783	15 Apr	28.59
219	181.5	39.60	-	20,933	4.3208	27 Mar	27.91
220	142.0	31.43	VIII	28,601	4.4564	19 Mar	28.43
225	156.7	39.73	V	24,658	4.3920	29 Mar	33.97
230	207.1	55.82	VI	22,608	4.3543	15 Apr	36.90
236	212.1	51.10	VI	29,185	4.4652	26 Apr	31.74
238	199.6	46.86	-	24,579	4.3906	25 Mar	30.68
240	206.7	39.35	-	20,543	4.3127	25 Mar	23.51
242	224.1	61.20	V	31,159	4.4936	22 Apr	37.57
250	217.1	36.65	VI	18,862	4.2756	20 Apr	20.31
265	360.9	103.90	VIII	48,140	4.6825	5 Apr	40.43
290	429.3	138.41	IX	50,000	4.6990	23 Apr	47.58
293	381.7	129.30	VII	44,010	4.6436	8 Apr	51.23

Type of Egg Count	Mean	Range	Standard Deviation	Confidence Limits (α = .05)
Total Number of Eggs	25,077	4,840 - 50,000	12,131	19,044 - 31,110

APPENDIX VII-29

BODY LENGTH-SCALE LENGTH RATIOS (L/Sc) OF MALE AND FEMALE YELLOW PERCH

NINE MILE POINT - 1974

LENGTH INTERVAL (mm)	AVERAGE BODY LENGTH (mm)	L/Sc	N
90 - 94	91	56.66	1
100 - 104	102.7	64.23	3
105 - 109	106.5	59.40	6
110 - 114	114	63.19	1
115 - 119	115.5	56.76	2
120 - 124	123	65.78	1
125 - 129	125	56.26	1
130 - 134	131.4	57.11	5
135 - 139	137.7	61.56	6
140 - 144	141.5	57.61	8
145 - 149	146.2	59.94	16
150 - 154	151.8	60.02	17
155 - 159	156.9	68.49	16
160 - 164	161.6	65.00	10
165 - 169	166.3	60.72	6
170 - 174	171.4	59.51	13
175 - 179	177.2	59.66	5
180 - 184	181.7	56.91	9
185 - 189	186.8	59.10	12
190 - 194	192.0	55.85	8
195 - 199	197.4	60.76	15
200 - 204	201.9	59.21	10
205 - 209	206.6	57.20	9

N = Number of Fish

LENGTH INTERVAL (mm)	AVERAGE BODY LENGTH (mm)	L/Sc	N
210 - 214	211.7	58.50	6
215 - 219	217.3	63.37	8
220 - 224	221.2	61.94	6
225 - 229	---	---	0
230 - 234	231.8	56.23	8
235 - 239	237.0	71.82	1
240 - 244	242	58.34	2
245 - 249	246	54.41	2
250 - 254	251	58.81	2
255 - 259	256	53.62	1
260 - 264	261	58.16	2
265 - 269	267.3	60.63	7
270 - 274	273	55.90	3
275 - 279	277.7	56.35	3
280 - 284	282.5	59.17	2
285 - 289	288	62.94	1
290 - 294	293	58.67	1
295 - 299	---	---	0
300 - 304	---	---	0
305 - 309	---	---	0
310 - 314	---	---	0
315 - 319	---	---	0
320 - 324	323	55.61	1
325 - 329	---	---	0

--- Not applicable

APPENDIX VII-30

ANNULUS FORMATION BY MONTH AND AGE GROUP IN YELLOW PERCH (*Perca flavescens*)

NINE MILE POINT - 1974

Age Group	April		May		June		July		August		September		October	
	# Formed	# Not Formed	# Formed	# Not Formed	# Formed	# Not Formed	# Formed	# Not Formed	# Formed	# Not Formed	# Formed	# Not Formed	# Formed	# Not Formed
1							3		1		2		2	
2	2		1		7	3	14		11					
3	4	2	3	3	13	2	3		5					
4	3	2	1	6	7	6	6		8					
5	1	5		4	8	2	7		2					
6		1	1	3		2	5							
7							3		3					
8							1		1					
9									1					
N = 170	10	10	6	16	35	15	42	0	32	0	2	0	2	0
	50%	50%	27%	73%	70%	30%	100%	0	100%	0	100%	0	100%	0

APPENDIX VII-31

AVERAGE CALCULATED TOTAL LENGTH AND STANDARD ERROR AT ANNULUS FORMATION OF YELLOW PERCH

NINE MILE POINT - 1974

YEAR CLASS	No. of FISH	AGE GROUP	I	II	III	IV	V	VI	VII	VIII	IX
						MALES					
1972	19	II	68.60 ±2.05	132.42 ±3.54							
1971	22	III	64.29 ±1.78	117.37 ±2.56	158.98 ±4.13						
1970	33	IV	63.71 ±2.06	112.46 ±2.74	150.68 ±3.04	184.77 ±2.94					
1969	18	V	61.12 ±1.66	114.66 ±4.18	161.05 ±4.71	191.94 ±4.18	215.93 ±3.96				
1968	10	VI	62.90 ±4.06	112.32 ±8.85	157.86 ±7.84	185.40 ±8.77	205.77 ±9.38	224.26 ±8.76			
		Grand average calculated length (weighted)	64.25	117.61	155.99	186.99	212.30	224.26			
		Grand average increment of length (weighted)	64.25	53.36	41.77	32.07	22.70	18.49			
		Sum of grand average increments	64.25	117.61	159.38	191.45	214.15	232.64			
		Confidence interval of (α=0.05) grand average calculated lengths	62.23- 66.27	114.21- 121.01	151.62- 160.37	181.94- 192.04	203.38- 221.22	204.44- 244.08			
						FEMALES					
1973	4	I	77.54 ±4.00								
1972	32	II	68.27 ±2.27	130.12 ±2.84							
1971	32	III	69.43 ±1.75	118.37 ±2.21	150.15 ±2.10						
1970	23	IV	61.91 ±3.12	113.18 ±3.84	150.00 ±4.24	180.13 ±3.91					
1969	15	V	65.46 ±2.93	118.44 ±6.32	163.36 ±7.53	201.60 ±7.87	230.68 ±7.19				
1968	8	VI	65.49 ±3.09	113.12 ±4.00	155.04 ±8.66	184.44 ±10.93	212.21 ±12.76	232.24 ±12.79			
1967	7	VII	67.87 ±6.16	122.40 ±9.62	164.97 ±10.08	194.99 ±6.72	220.83 ±8.58	237.37 ±7.77	249.20 ±7.06		
1966	2	VIII	66.38 ±1.82	107.62 ±3.44	168.29 ±0.86	204.87 ±4.69	230.18 ±4.19	246.65 ±2.60	266.38 ±3.49	279.17 ±10.08	
1965	1	IX	56.24	101.49	169.99	233.58	256.83	272.73	286.18	303.28	317.[illegible]
		Grand average calculated length (weighted)	67.02	120.08	154.62	190.19	224.88	238.83	256.33	287.21	317.9
		Grand average increment of length (weighted)	67.02	53.41	38.19	33.01	27.67	18.05	13.57	14.23	14.7
		Sum of grand average increments	67.02	120.43	158.62	191.63	219.30	237.35	250.92	265.15	279.3
		Confidence intervals of (α=0.05) grand average calculated lengths	64.75 69.29	116.04 123.32	150.09 159.15	183.29 197.09	213.68 236.08	222.05 255.60	240.51 272.15	159.29 415.13	

APPENDIX VII-32

ABUNDANCE OF SMALLMOUTH BASS
GILL NET - SAMPLE DEPTH

NINE MILE POINT - 1974

BOTTOM

ANOVA
Sq. root transformation

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
Photoperiod (Day/Night)	1	0.0878	446	73.0291	0.536 (a)
Seasons*	2	7.0364	449	74.3090	21.258 (b)
Transects	3	0.1940	450	73.8561	0.394 (a)
Photoperiod x Seasons	2	0.6124	441	72.2580	1.869 (c)
Photoperiod x Transects	3	0.1495	441	72.2580	0.304 (a)
Seasons x Transects	6	1.4529	441	72.2580	1.478 (c)
Total	458	81.7910			

(a) Not significant at $\alpha = 0.25$
(b) Significant at $\alpha < 0.0005$
(c) Significant at $\alpha < 0.25$ but not at $\alpha = 0.10$

Student-Newman-Keuls Test - Seasons ($\alpha = 0.05$) Largest: Summer Fall Spring: Smallest
*Spring = April - June; Summer = July - Sept; Fall = Oct - Dec.

APPENDIX VII-33

BODY LENGTH-SCALE LENGTH RATIOS (L/Sc)
OF 142 MALE AND FEMALE SMALLMOUTH BASS

NINE MILE POINT - 1974

LENGTH INTERVAL (mm)	MEAN LENGTH (mm)	L/Sc	N
70 - 79	76.0	74.29	2
80 - 89	84.0	71.37	2
90 - 99	--	--	0
100 - 109	106.5	94.92	2
110 - 119	--	--	0
120 - 129	--	--	0
130 - 139	134.5	94.06	2
140 - 149	144.0	89.66	1
150 - 159	157.0	82.98	1
160 - 169	165.0	89.63	3
170 - 179	--	--	0
180 - 189	186.0	82.89	3
190 - 199	190.0	85.51	1
200 - 209	--		0
210 - 219	--		0
220 - 229	--		0
230 - 239	--		0
240 - 249	--		0
250 - 259	256.0	80.94	4
260 - 269	267.0	80.91	1
270 - 279	277.0	70.97	5
280 - 289	284.0	79.53	3
290 - 299	292.0	74.57	3
300 - 309	305.3	78.06	4
310 - 319	314.9	75.68	8
320 - 329	325.6	82.56	7
330 - 339	334.4	77.55	11
340 - 349	344.6	83.56	13
350 - 359	354.2	80.35	18
360 - 369	363.8	83.08	16
370 - 379	373.8	76.87	18
380 - 389	384.3	84.70	9
390 - 399	392.0	86.02	1
400 - 409	403.8	77.92	4

N = Number of Fish

APPENDIX VII-34

ANNULUS FORMATION BY MONTH AND AGE GROUP IN SMALLMOUTH BASS (*Micropterus dolomieui*)

NINE MILE POINT - 1974

AGE GROUP	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV	
	# FORMED	# NOT FORMED	# FORMED	# NOT FORMED	# FORMED	# NOT FORMED	# FORMED	# NOT FORMED	# FORMED	# NOT FORMED	# FORMED	# NOT FORMED	# FORMED	# NOT FORMED	# FORMED	# NOT FORMED
1							2	2	2		1	2				
2							2		1		5		2			
3																
4				1		1	1		1		1					
5								1	3							
6						1			2	1	2					
7		3		3	1	1	1	1	4		14					
8		4		8		1	1	2	8		9				1	
9		2		8		2	2	4	4		11	1	1			
10			1	1			2		3	1	4			1		
11				3							2					
12																
N=149	0	9	1	24	1	6	11	10	28	2	49	3	3	1	1	0
		100%	4%	96%	14%	86%	52%	48%	93%	7%	94%	6%	75%	25%	100%	

APPENDIX VII-35

AVERAGE CALCULATED TOTAL LENGTH AND STANDARD ERROR AT ANNULUS FORMATION OF SMALLMOUTH BASS

NINE MILE POINT - 1974

YEAR CLASS	No. of FISH	AGE GROUP	I	II	III	IV	V	VI	VII	VIII	IX	X	
							FEMALE						
1973		I											
1972	2	II	89.60 ±6.52	148.95 ±10.95									
1971		III											
1970	5	IV	78.19 ±3.81	151.91 ± 8.33	220.33 ± 6.82	260.03 ± 9.44							
1969	3	V	62.33 ±5.29	124.07 ± 4.08	177.02 ± 3.48	238.24 ± 7.93	282.54 ± 5.25						
1968	2	VI	62.6 ± .21	118.55 ± 6.2	160.59 ± 2.56	198.20 ± 9.76	239. ± .99	264.5 ± 7.5					
1967	13	VII	80.47 ±6.83	145.32 ± 7.44	195.58 ± 7.32	236.54 ± 8.65	274.34 ± 9.3	309.6 ± 9.96	340.61 ± 9.66				
1966	14	VIII	75.95 ±5.7	130.91 ± 6.77	178.66 ± 7.38	220.93 ± 8.33	258.82 ± 8.49	288.6 ± 9.07	317.53 ± 7.78	341.06 ± 6.44			
1965	18	IX	73.66 ±3.62	128.14 ± 3.34	177.68 ± 5.91	219.29 ± 6.51	256.82 ± 7.09	283.31 ± 6.72	306.06 ± 6.56	329.55 ± 5.28	346.1 ± 4.17		
1964	11	X	77.49 ±5.23	140.06 ± 5.16	180.89 ± 5.08	216.27 ± 4.64	248.00 ± 3.83	276.52 ± 3.65	302.33 ± 5.17	323.50 ± 4.73	344.08 ± 4.57	337.45 ± 4.47	
1963	3	XI	62.44 ±2.89	109.37 ± 3.97	156.30 ± 7.22	194.54 ± 7.67	234.73 ± 5.89	269.21 ± 3.68	297.37 ± 5.37	326.90 ± 4.34	348.95 ± 3.14	364.52 ± 3.76	372.57 ± 2.9
1962		XII											
		Grand average calculated length (weighted)	75.44	134.703	199.365	224.48	275.892	287.592	315.257	331.433	345.672	358.965	372.57
		Grand average increment of length (weighted)	75.44	59.248	49.109	41.08	37.21	29.84	26.882	23.341	18.45	13.841	8.05
		Sum of grand average increments	75.44	134.588	183.797	224.877	262.87	291.927	318.809	342.15	360.6	374.441	382.491
		Confidence interval of (α=0.05) Grand average calculated lengths	74.14 76.75	133.24 136.16	193.74 204.99	218.231 230.729	268.525 283.259	280.18 295.00	308.005 322.51	325.17 331.43	344.06 347.3	350.94 366.99	357.89 387.89

YEAR CLASS	No. of FISH	AGE GROUP	I	II	III	IV	V	VI	VII	VIII	IX	X
			MALES									
1973	1	I	131									
1972	4	II	85.95	158.17								
			±5.19	±4.92								
1971		III										
1970		IV										
1969	1	V	128.51	191.72	219.36	251.87	281.0					
1968	4	VI	93.28	153.99	193.11	229.54	279.51	309.22				
			±20.72	±31.44	±30.30	±28.32	±21.29	±18.08				
1967	13	VII	102.8	156.18	207.35	250.87	285.99	315.77	343.50			
			±7.51	±7.66	±7.32	±8.37	±6.54	±6.93	±8.52			
1966	18	VIII	85.25	141.17	186.94	230.75	267.73	294.53	323.23	345.53		
			±6.72	±7.37	±7.75	±8.06	±6.75	±6.73	±6.44	±6.36		
1965	15	IX	66.43	124.89	173.69	219.36	255.03	285.74	311.48	337.06	355.64	
			±2.22	±3.55	±4.8	±5.79	±6.13	±6.50	±6.04	±4.33	±4.64	
1964	3	X	57.99	114.85	163.37	215.45	255.77	283.90	308.58	331.64	353.61	366.00
			±3.49	±7.48	±11.69	±18.37	±13.73	±12.62	±11.76	±8.77	±7.05	±5.69
1963		XI										
1962		XII										
		Grand average calculated length (weighted)	85.046	141.894	187.92	231.881	250.533	297.759	324.113	340.843	355.301	366
		Grand average increment of length (weighted)	85.046	56.662	47.176	43.96	37.17	28.932	27.29	23.73	19.145	12.39
		Sum of grand average increments	85.046	141.708	188.884	232.844	270.014	298.946	326.236	349.966	369.111	381.501
		Confidence interval of (α=0.05) grand average calculated lengths	78.70 91.38	134.39 149.39	179.63 196.21	223.01 240.75	243.067 258	290.289 305.229	316.36 331.87	333.21 348.47	346.67 363.92	341.5 390.5

VIII. 1974 NINE MILE POINT ENTRAINMENT STUDIES

A. INTRODUCTION

Previous entrainment studies conducted at Nine Mile Point Nuclear Station Unit 1 (QLM, 1974) established that:

Lake populations of phytoplankton, microzooplankton, and macrozooplankton were not selectively entrained.

Net and gross primary production were reduced between the plant intake and discharge bays, due apparently to increases in respiration rate between the two locations. Chlorophyll *a* concentrations measured in the discharge equaled or exceeded concentrations in the intake forebay on most of the sampling dates, i.e no deleterious effects were apparent.

Comparisons of microzooplankton and ichthyoplankton abundance between the intake and discharge bays indicated that these organisms exhibited a patchy distribution, since there were instances of greater abundance in discharge waters than in intake waters and there was no significant difference in the abundance between the intake and the discharge bays. Analyses of variance indicated significantly fewer macrozooplanktonic *Leptodora kindtii* and cladocerans (exclusive of *Leptodora*) in the discharge than in the intake forebay.

Viability studies indicated relatively fewer living microzooplankters in discharge waters than in intake waters during summer and fall; the reverse pattern was true during early winter. These differences in viability were significant at $\alpha = 0.05$.

Although variable numbers of dead and live fish larvae were collected in the intake forebay, only dead larvae were collected in the discharge bay except during December when live larvae were also collected.

B. MATERIALS AND METHODS

1. Phytoplankton

a. Field Collection

Samples were collected just below the lake surface with Van Dorn water bottles, as described for lake phytoplankton (Section V.A.2.).

Two samples were collected in the intake forebay and, three minutes later, two samples were taken in the discharge aftbay for determination of algal pigment concentration, taxonomic identification, and enumeration. In addition, samples were collected at both in-plant stations for estimation of primary production by the ^{14}C-assimilation method. Four sets (two light and one dark bottle per set) of samples were collected from each station as described in Section V.A.2. and returned to the laboratory in a cooled light-proof container for simulated in situ incubation. Samples were collected twice per month from January through December (Table VIII-1) during the day and at night.

b. Laboratory Analysis

Analyses for chlorophyll a concentration, primary production, and species identification and enumeration followed the procedures described for lake phytoplankton samples (Section V.A.2.), except that samples for estimation of primary production were returned to the laboratory and incubated under constant illumination (1000 lux) at ambient lake temperature. One set of samples from each location was incubated for 7, 24, 48, or 72 hours.

2. Microzooplankton

a. Field Collection

Microzooplankton were collected with a specially designed sampling apparatus containing a 76 mesh plankton net (Figure VIII-1), supported just below the surface of the water in intake forebay #3 (east forebay); three minutes later, a similar sample was collected in the discharge aftbay. Immediately after the sampling apparatus was raised from the intake or discharge, the plankton net was slowly withdrawn from the plastic container, and viability analyses were conducted. After these analyses, a "replicate" set of samples was collected and analyzed according to the same procedure.

Microzooplankton samples were collected on the same dates as phytoplankton and chlorophyll a samples (Table VIII-1). Plant flow rates and intake and discharge temperatures were measured at the time of each microzooplankton collection.

b. Viability Analysis

Viability analyses were conducted in the field according to the following procedure. Discharge samples were analyzed first, while the intake samples were retained in a bath of intake water at ambient temperature. Each sample was thoroughly mixed and

TABLE VIII-1

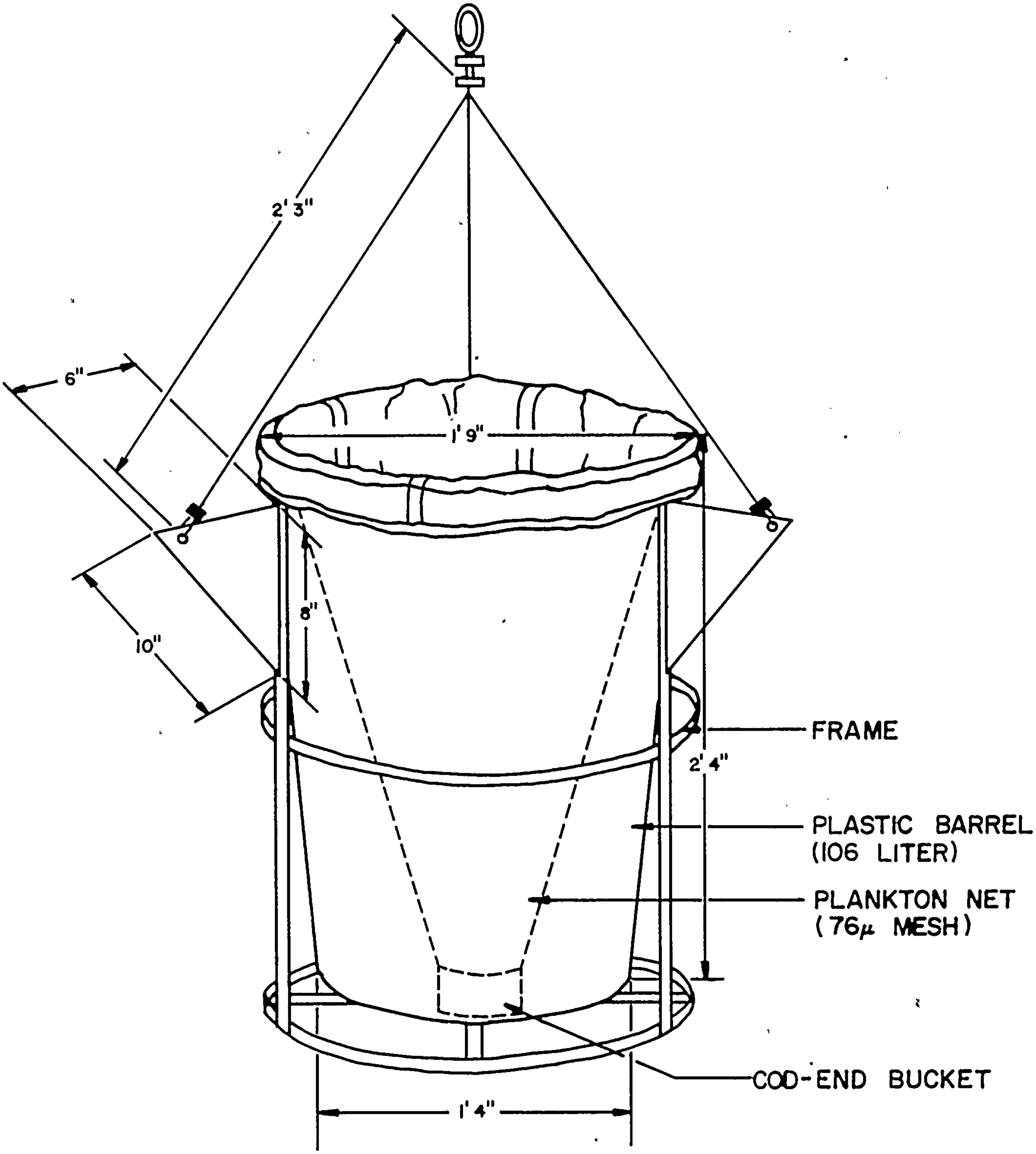
IN-PLANT ENTRAINMENT COLLECTION DATES
NINE MILE POINT NUCLEAR STATION UNIT 1
1974

Phytoplankton, Microzooplankton, and Chlorophyll a	Macrozooplankton and Ichthyoplankton[t]
9 January*	9 January
23 January*	23 January
6 February*	13 February
20 February*	27 February
20 March*	20 March
27 March	27 March
10 April	10 April
24 April	8 May
8 May	22 May
22 May	5 June°
5 June	19 June°
19 June	10 July°
10 July	24 July
24 July	7 August
7 August	21 August
21 August	11 September
11 September	25 September
25 September	9 October
9 October	23 October
23 October	6 November
6 November	20 November
20 November	4 December
4 December	18 December
18 December	

* Microzooplankton collection dates only.
t Samples were collected at the following times on each sample date: 1100, 1300, 1500, 2100, 2300, 0100, 0300, 0500, 0700 and 0900 hours.
° No surface sample was taken from the intake forebay.

FIGURE VIII-1

SAMPLING APPARATUS FOR ENTRAINED MICROZOOPLANKTON



transferred to a Tipet[R] constant volume subsampler. Two 1.0 ml aliquots were placed in separate Sedgewick-Rafter counting chambers. Both samples were examined at 100 magnifications and the total number of dead (totally lacking mobility in appendages or internal organs) protozoans, rotifers, copepods, and cladocerans recorded. Each chamber was then sealed with Canada Balsam and all organisms killed by placing the chamber on a hot plate for three minutes at a low heat setting. Both chambers were then returned to the laboratory where they were examined again, and the total number of organisms counted.

The abundance of microzooplankton was calculated according to the following formula:

$$D = \frac{N \times V_s}{V_F}$$

where: D = abundance of organisms (live, dead, or total/m^3)
N = total number of organisms counted (live, dead, or total) in two Sedgwick-Rafter cells
V_s = volume of sample concentrate plus volume of subsample (ml)
V_F = volume of water sampled (m^3)

3. Macrozooplankton and Ichthyoplankton

a. Field Collection

Macrozooplankton and ichthyoplankton were collected with 0.5 m mouth diameter plankton nets (4:1 length-to-mouth diameter ratio) equipped with PVC cod-end buckets; both net and bucket were of #0 mesh (571 μ). A TSK Pigmy-Pattern Flow Meter was positioned approximately one-third across the mouth diameter of the net to measure the volume of water sampled.

A net was set in two of the intake forebays, one just below the surface (west bay) and the other at mid-depth (middle bay). The depths from which samples were collected in these two bays were reversed after 11 September and remained as such for the remainder of the sampling period. Three minutes after the setting of the intake nets, a similar plankton net was lowered to mid-depth in the discharge aftbay. After five minutes of sampling, the nets were retrieved and washed down from the outside. The cod-end buckets were immediately placed in ambient temperature water baths.

Samples were collected twice per month from January through December with collection dates spaced approximately two weeks apart (Table

VIII-1). On each sampling date, samples were collected at 1100, 1300, 1500, 2100, 2300, 0100, 0300, 0500, 0700, and 0900 hours. In addition, water flow through the plant and intake and discharge temperatures were measured.

b. Viability Analysis

The samples were analyzed in the field for the total number of live, stunned, and dead ichthyoplankton, measuring less than 50 mm in length, as determined with the aid of a magnifier (3 magnifications). All ichthyoplankton were subsequently removed from the sample and preserved in 70% ethanol. The remaining sample was then poured into a graduated cylinder and the volume measured. A 10 ml subsample was withdrawn by a wide bore pipet and the number of live or dead macrozooplankton of specific taxa were counted (those listed in Section V.B.2). To expedite rapid evaluation of the status the community, intake samples were examined for dead organisms, whereas discharge samples were examined for live organisms, assuming fewer dead organism at the intake and fewer live orangisms at the discharge. This procedure was repeated as many times as possible in a 15-minute period.

The sample and subsamples were subsequently preserved in 10% buffered formalin and returned to the laboratory where the total number of macrozooplankton collected was determined.

The number of entrained macrozooplankton and ichthyoplankton/1000m^3 was calculated in the manner described for lake macrozooplankton and ichthyoplankton (Section V.B.2b).

C. RESULTS AND DISCUSSION

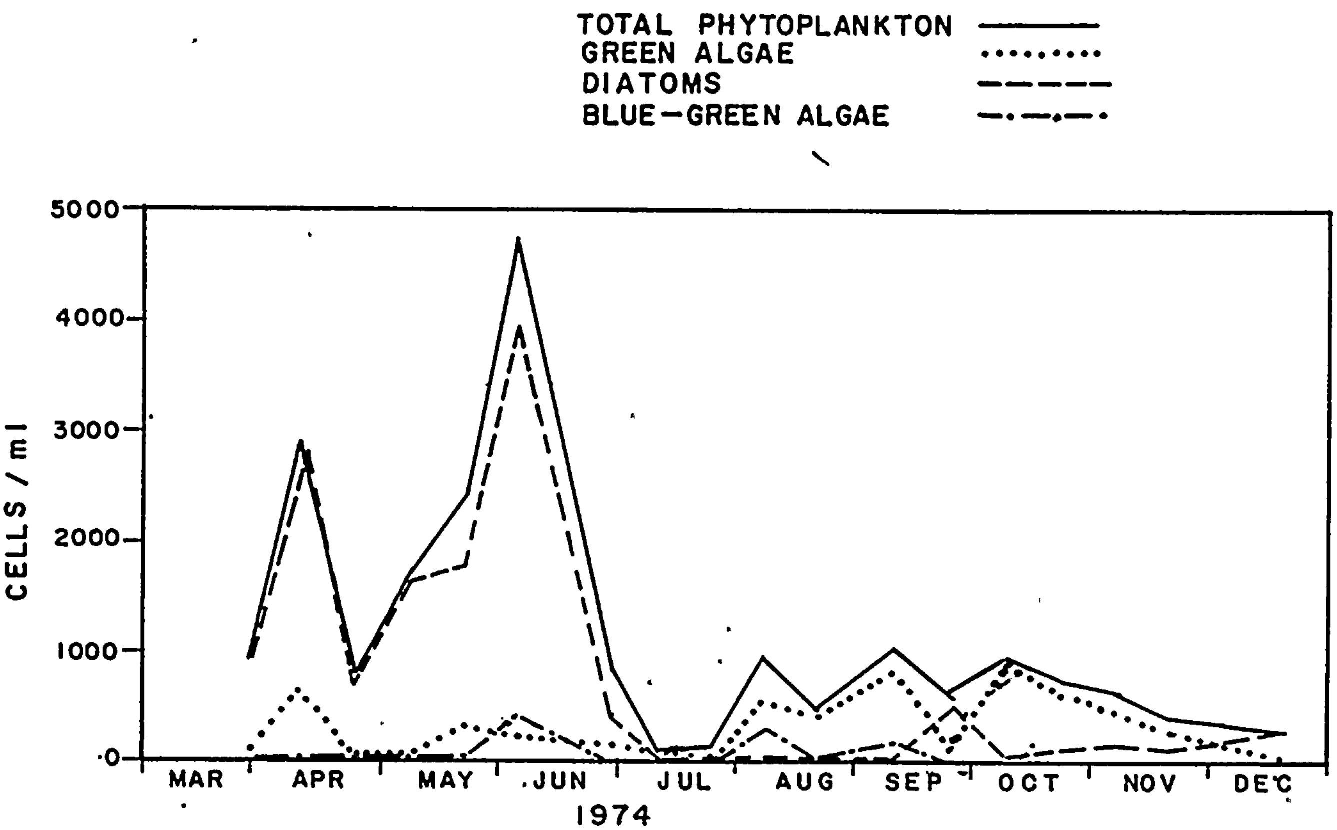
1. Phytoplankton

a. Abundance and Seasonal Succession

Seasonal patterns of abundance and succession of phytoplankton in Lake Ontario in the Nine Mile Point vicinity (Figure VA-2) and in the Nine Mile Point Nuclear Station Unit 1 intake forebay (Figure VIII-2) were compared. Spring peaks were observed both in the lake and in the intake forebay. The occurrence of a greater concentration of algal cells in the intake forebay samples than in the lake samples during the spring peak may have resulted from the patchy distribution of phytoplankton both in the surface waters and in the water column, and from the fact that the date of collection varied between the two locations. This spring peak was followed by a rapid decline in algal concentrations to comparably low summer and fall values in both lake and intake forebay collections.

ABUNDANCE OF ENTRAINED PHYTOPLANKTON *
NINE MILE POINT NUCLEAR STATION

1974



* MEANS OF REPLICATES FROM DAY COLLECTIONS AT THE INTAKE.

In both the lake and intake forebay collections, the winter (Table VIII-2) and early spring (Appendix V-1a-c, Table VIII-2) phytoplankton community was composed of 85% diatoms, with *Melosira binderana* and *Stephanodiscus tenuis* dominant. The summer and fall community (Appendix V-1d-i, Table VIII-2) was dominated by the green algae, and in particular *Mougeotia* spp.

b. Effects of Entrainment

(i) Abundance

Comparisons of the mean total phytoplankton abundance determined for the intake and discharge bays of Nine Mile Point Nuclear Station Unit 1 showed no consistent differences in abundance between the two bays;, the differences observed were generally less than 500 algal cells/ml (Figure VIII-3). A three-way analysis of variance (Appendix VIII-1), confirmed the observation that differences in abundance between the two stations within the plant were not significant at $\alpha < 0.05$ for either total phytoplankton, diatoms, green algae, or blue-green algae. Differences in abundance among dates, reflecting the seasonal pattern described previously, and the date by photoperiod interaction was significant at $\alpha < 0.05$ for all four groups. The results of a Student-Newman-Keuls test (Appendix VIII-1) showed that the source of the date X photoperiod interaction was the occurrence of significant differences between day and night abundance on only five of the 12 dates analyzed. These findings suggest, since there was no consistent diurnal pattern, that phytoplankton concentrations in the Nine Mile Point vicinity can vary significantly within a day, and support hypotheses concerning the influence of advection on plankton distribution patterns in the lake (Section V.A).

(ii) Chlorophyll *a* and Phaeopigments

Chlorophyll *a* concentrations (corrected for phaeopigments, which are chlorophyll degradation products) at the intake and discharge bays of Nine Mile Point Nuclear Station Unit 1 ranged between 0.0 and 15.4 µg/l during 1974. The highest values were recorded during June and corresponded to the peak of diatom abundance.

Comparisons of chlorophyll *a* concentrations at the intake and discharge bays of Nine Mile Point Nuclear Station Unit 1 during day and night collections (Figure VIII-4) showed a slight reduction in values, 1-2 µg/l at the discharge aftbay on more than half of the collection dates. Paired t-tests

TABLE VIII-2

ABUNDANCE (cells/ml) OF THE TOP THREE DOMINANT SPECIES
OF ENTRAINED PHYTOPLANKTON
FROM DAY COLLECTIONS

NINE MILE NUCLEAR STATION UNIT 1
INTAKE FOREBAY ∅, 1974

COLLECTION DATE			
27 MAR	Stephanodiscus spp. (D) 455.0	Melosira binderana (D) 274.4	Asterionella formosa (D) 150.1
10 APR	Stephanodiscus tenuis (D) 1779.0	Melosira binderana (D) 378.1	Melosira spp. (D) 376.5
24 APR	Stephanodiscus hantzschii (D) 324.2	Asterionella formosa (D) 151.4	Melosira binderana (D) 118.0
8 MAY	Melosira binderana (D) 1338.5	Asterionella formosa (D) 125.8	Tabellaria fenestrata (D) 68.3
22 MAY	Melosira binderana (D) 1083.5	Melosira islandica (D) 206.8	Cryptomonas spp. (CR) 188.1
5 JUN	Melosira binderana (D) 3627.5	Stephanodiscus spp. (D) 135.0	Scenedesmus (2 cell) (G) 79.0
19 JUN	Melosira binderana (D) 358.1	Cryptomonas spp. (CR) 81.2	Chroococcus dispersus (BG) 74.9
10 JUL	Melosira binderana (D) 18.1	Scenedesmus dimorphus (D) 14.7	Pediastrum duplex (G) 11.6
24 JUL	Single cell green (G) 29.6	Coelastrum microporum (G) 20.1	Gloeocystis vesiculosa (G) 19.6
7 AUG	Polycystis incerta (BG) 236.7	Pediastrum duplex (G) 182.2	Coelastrum microporum (G) 180.7
21 AUG	Scenedesmus quadricauda (G) 90.7	Phacotus lenticularis (G) 72.3	Mougeotia spp. (G) 61.4
11 SEP	Mougeotia spp. (G) 427.2	Coelastrum microporum (G) 119.3	Gomphosphaeria lacustris (BG) 71.7
25 SEP	Mougeotia spp. (G) 254.8	Fragilaria capucina (D) 74.2	Coelastrum microporum (G) 68.5

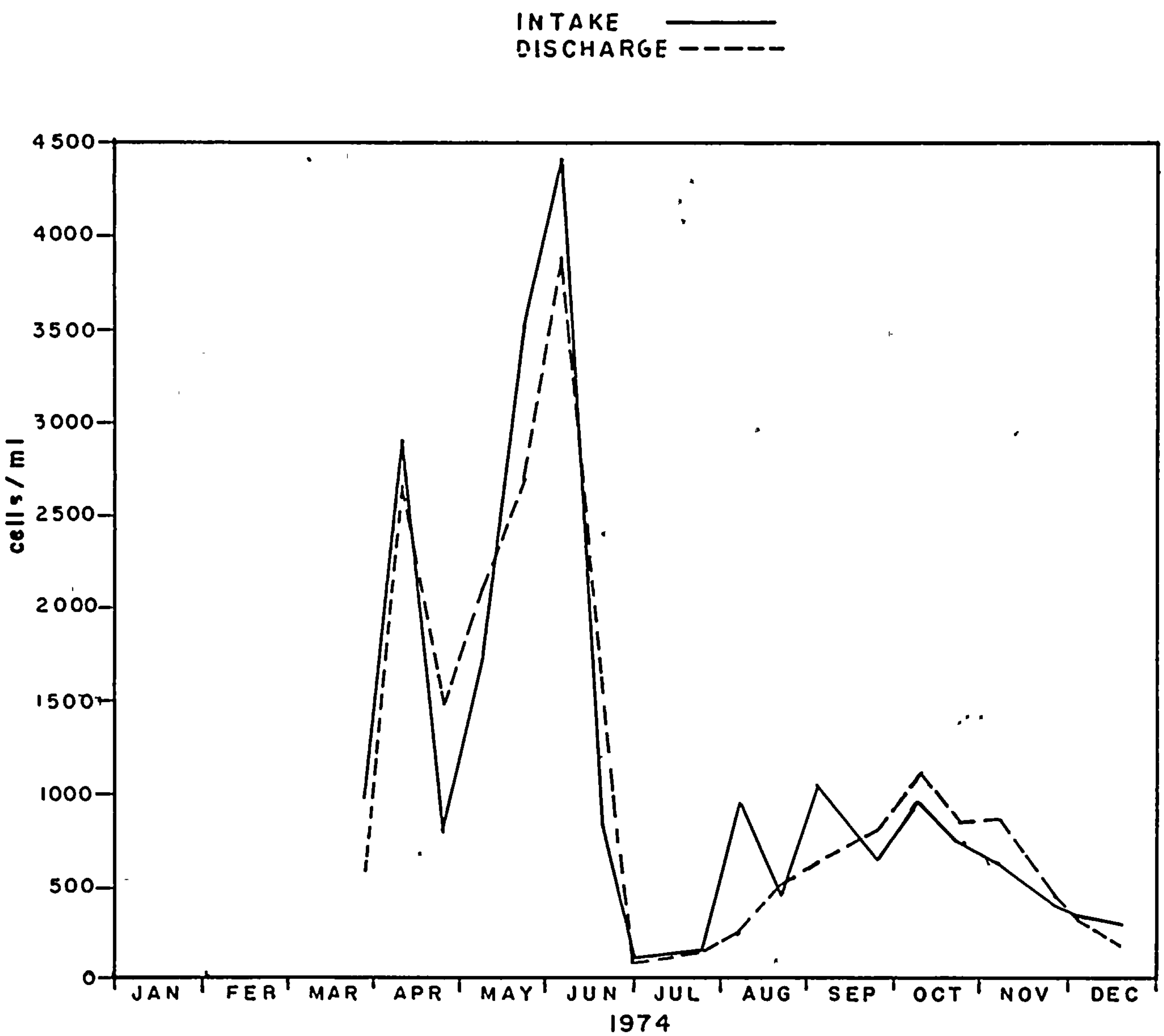
TABLE VIII-2 (Continued)

COLLECTION DATE			
9 OCT	Mougeotia spp. (G) 671.4	Diatoma tenue var. elongatum (D) 38.5	Pediastrum duplex (G) 34.3
23 OCT	Mougeotia spp. (G) 342.4	Coelastrum microporum (G) 115.0	Fragilaria capucina (D) 58.5
6 NOV	Mouteotia spp. (G) 356.1	Diatoma tenue var. elongatum (D) 81.1	Scenedesmus quadricauda (G) 33.7
20 NOV	Mougeotia spp. (G) 204.1	Diatoma tenue var. elongatum (D) 114.1	Scenedesmus bijuga (G) 9.5
4 DEC	Diatoma tenue var. elongatum (D) 117.2	Mougeotia spp. (G) 94.5	Melosira binderana (D) 50.6
18 DEC	Fragilaria capucina (D) 97.8	Melosira binderana (D) 44.9	Asterionella formosa (D) 34.5

KEY

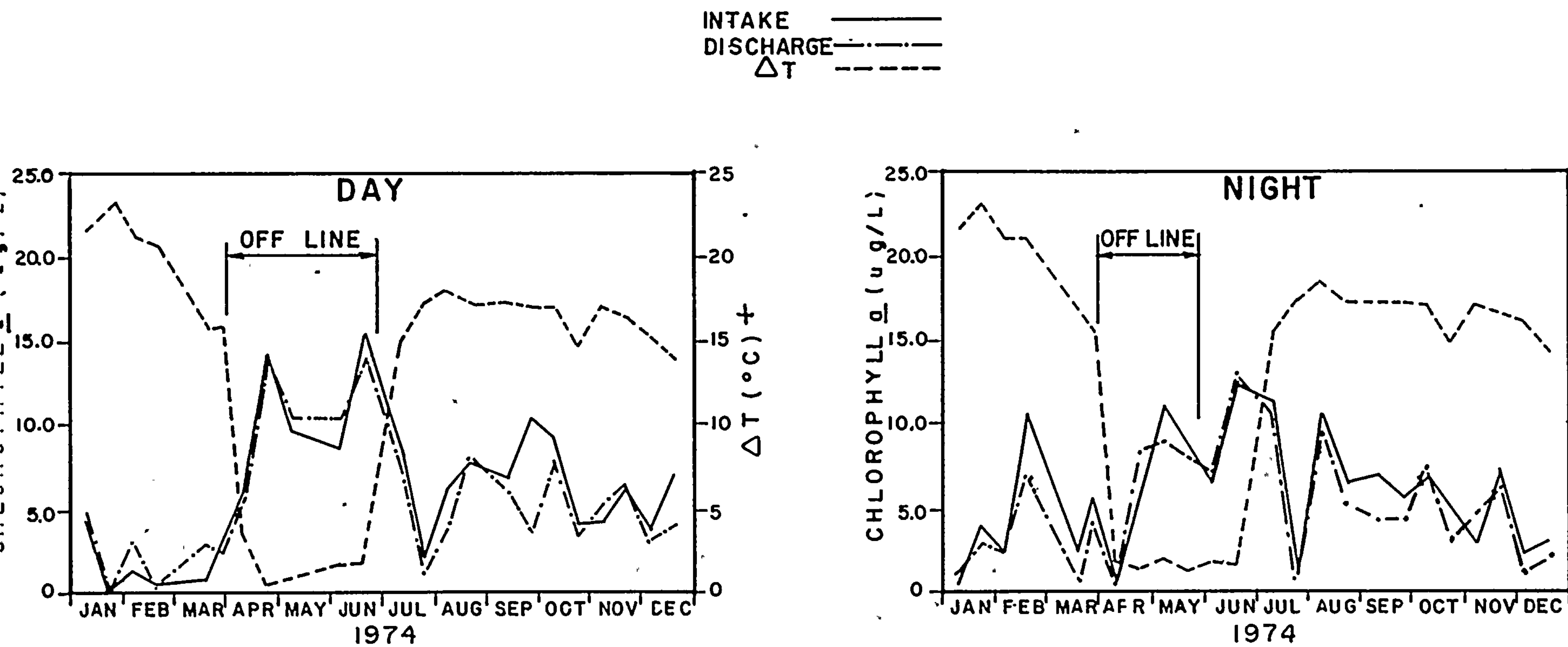
D = Diatom
G = Green Algae
BG = Blue-Green Algae
CR = Cryptomonad

ABUNDANCE OF TOTAL PHYTOPLANKTON *
NINE MILE POINT NUCLEAR STATION
1974



* MEAN OF REPLICATES FROM DAY & NIGHT COLLECTIONS.

CHLOROPHYLL a CONCENTRATIONS* IN ENTRAINED WATER
NINE MILE POINT NUCLEAR STATION
1974



NOTE: * MEAN OF REPLICATES
+ DIFFERENCE BETWEEN INTAKE & DISCHARGE BAY SURFACE TEMP. AT TIME OF COLLECTION

FIGURE VIII-4

indicated that, overall, there were no statistically significant differences between intake and discharge chlorophyll a values during the day (23 d.f.; t_{calc} = 0.862; t_{crit} = 2.069) and at night (23 d.f.; t_{calc} = 1.588; t_{crit} = 2.069) at the 0.05 significance level.

Phaeopigment concentrations tended to be slightly higher at the discharge than at the intake bay during the day and at night (Figure VIII-5). This result was expected since phaeopigments are the degradation products of chlorophylls, and, as noted above, chlorophyll a values tended to be lower in the discharge than the intake bay.

Diurnal differences similar to those observed among phytoplankton abundance occurred in chlorophyll a and phaeopigment concentrations; there was no consistent diurnal pattern. Therefore, it appears as if the fluctuations in chlorophyll a and phaeopigment concentrations are related to daily fluctuations of phytoplankton standing stock in the Nine Mile Point vicinity of Lake Ontario.

(iii) Primary Production Rates

Comparisons of primary production rates (7 hour incubation*, mean of day and night values) at the intake and discharge bays of Nine Mile Point Nuclear Station Unit 1 showed a trend toward increased photosynthesis in the discharge samples during the late winter and spring months and decreased production during the summer and fall (Figure VIII-6). Nine Mile Point Unit 1, however, was off-line during the spring; therefore, samples collected did not measure total plant effect during that time.

Paired t-tests showed that, overall, there was no significant difference in mean primary production rate measured at the intake and discharge at α=0.05 (40 d.f.; t_{calc} = 0.771; t_{crit} = 2.021).

c. Conclusions

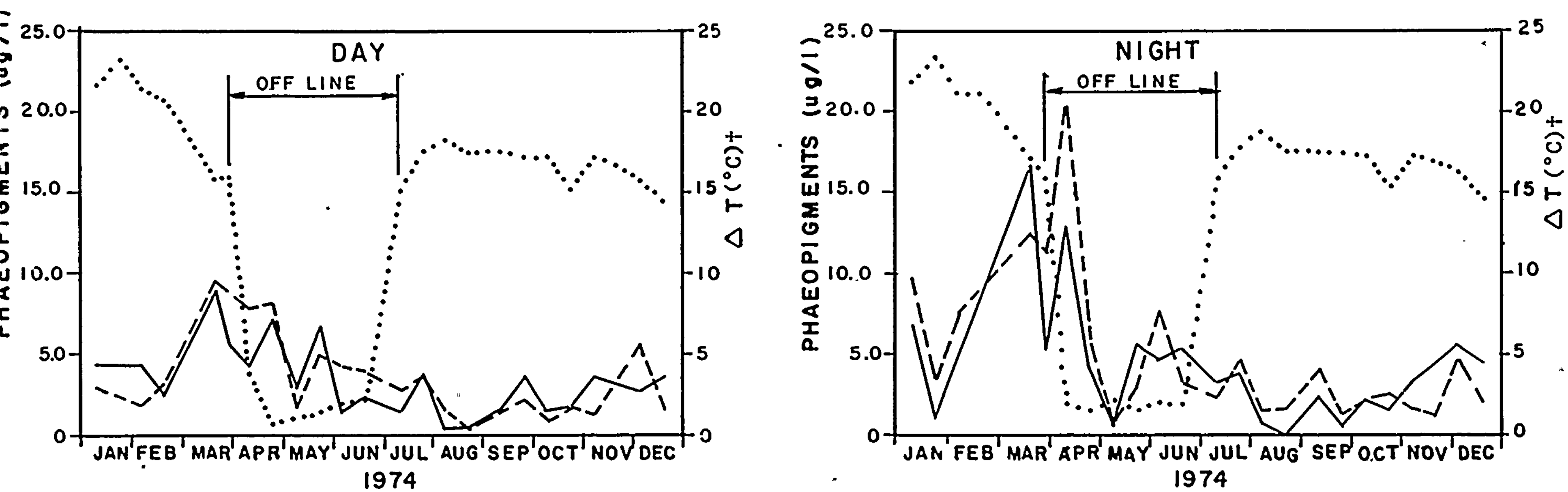
(i) Differences in seasonal patterns of phytoplankton abundance at Nine Mile Point Nuclear Station Unit 1 intake forebay

* It was concluded that the long incubation periods (24, 48, and 72 hours) may have resulted in non-representative production estimates due to the constant illumination and the possibility of recycling of labeled carbon compounds.

PHAEOPIGMENT CONCENTRATIONS* IN ENTRAINED WATER
NINE MILE POINT NUCLEAR STATION

1974

INTAKE ————
DISCHARGE – – – –
ΔT ••••••••

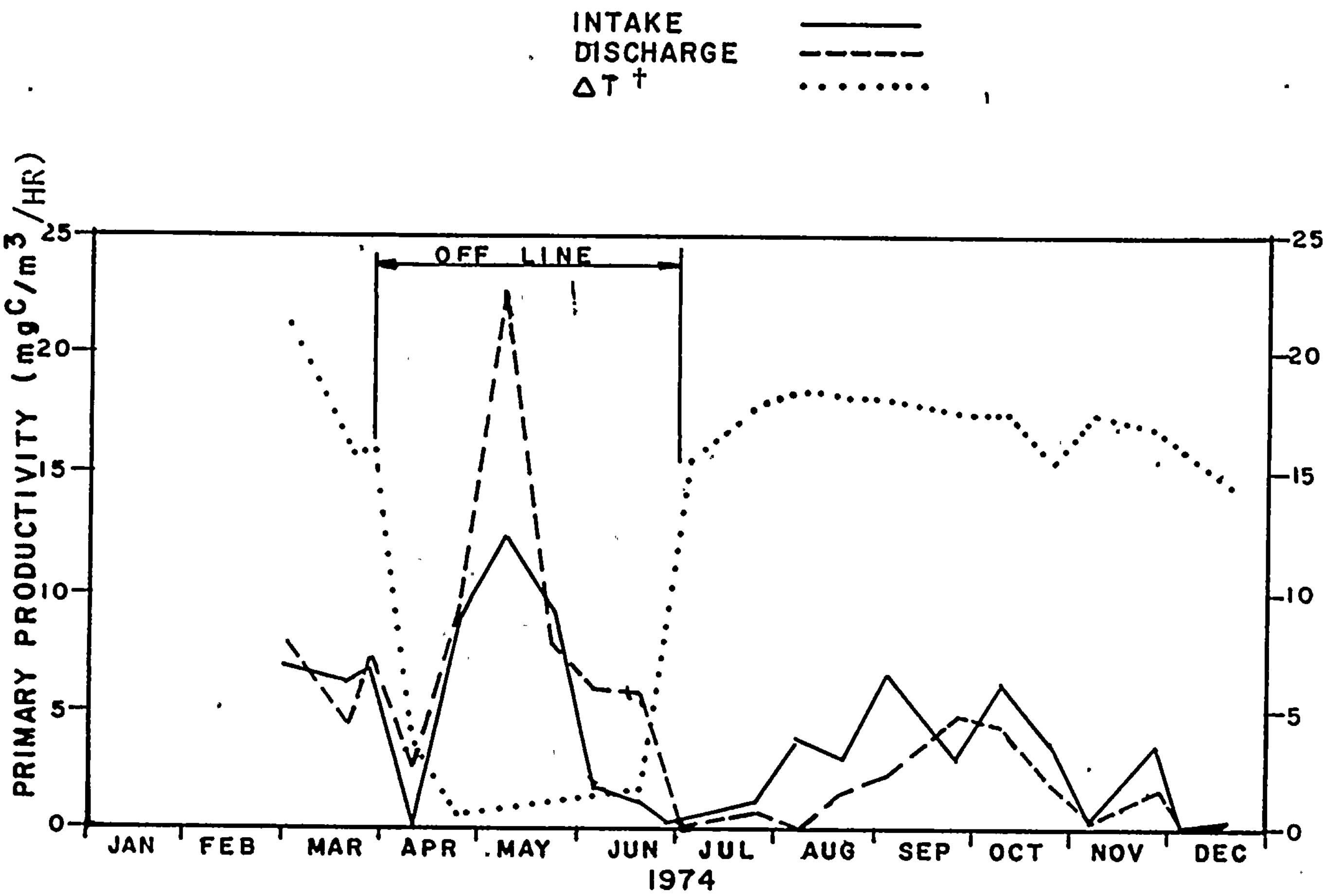


* MEAN OF REPLICATES

† DIFFERENCE BETWEEN INTAKE & DISCHARGE BAY SURFACE TEMP. AT TIME OF COLLECTION

FIGURE VIII-5

PRIMARY PRODUCTIVITY *
NINE MILE POINT NUCLEAR STATION
1974



* MEAN OF DAY & NIGHT VALUES

† DIFFERENCE BETWEEN INTAKE & DISCHARGE BAY SURFACE TEMP. AT TIME OF COLLECTION

and in the Nine Mile Point vicinity did not appear to be related to the selective entrainment of phytoplankton.

(ii) Algal and chlorophyll a concentrations and primary production rates were not significantly different between the intake and discharge bays. However, chlorophyll a concentrations tended to decrease (and phaeopigment concentrations to increase) between the intake and discharge, indicating that entrainment may have caused some metabolic changes in phytoplankton. Primary production rates between the intake and discharge bays fluctuated seasonally, i.e., enhanced production at the discharge during late winter and inhibited production during the summer and fall indicating further that metabolic changes probably occurred during entrainment.

(iii) Diurnal differences in abundance and biomass were observed at both the intake and discharge of Nine Mile Point Nuclear Station Unit 1. No consistent diurnal pattern in abundance and chlorophyll a values was observed between the intake and discharge samples; the difference observed reflected daily changes of phytoplankton standing stock in the Nine Mile Point vicinity.

2. Microzooplankton

a. Community Composition

The microzooplankton entrained at Nine Mile Point Nuclear Station Unit 1 during 1974 (Table VIII-3) included rotifers, copepods, cladocerans, and protozoans; the entrained microzooplankton community was similar in composition to that reported in the Nine Mile Point vicinity of Lake Ontario during 1974 (Section V.B.1). As in the lake, rotifers generally composed the largest fraction of the microzooplankton sample, followed in decreasing order of relative abundance by copepods, protozoans, and cladocerans (Appendix VIII-2).

Although a number of species were found only in intake or discharge samples, the occurrence of such differences was limited to the rarer organisms (i.e., those occurring in low concentrations) numerically dominant taxa were observed in both intake and discharge samples. These results indicate that entrainment through Nine Mile Point Nuclear Station Unit 1 does not selectively eliminate particular microzooplankton species.

b. Abundance

As in the lake microzooplankton study, "replicate" samples were collected as part of the entrainment microzooplankton study.

TABLE VIII- 3

ENTRAINED MICROZOOPLANKTON SPECIES INVENTORY
NINE MILE POINT NUCLEAR STATION, UNIT 1 - 1974

PROTOZOA
- Lobosa
  - Testacealobosa
    - Difflugiidae
      - Difflugia sp.
- Suctoria
  - Tentaculiferida
    - Acinetidae
      - Thecacineta sp.
      - Tokophrya sp.
    - Podophryidae
      - Paracineta sp.
- Ciliata
  - Spirotrichida
    - Tintinnidae
      - Codonella cratera
  - Peritrichida
    - Epistylidae
      - Epistylus sp.
    - Vorticellidae
      - Vorticella spp.
  - Holotrichida
    - Gymnostomina*
      - Gymnostomina sp.

ROTIFERA
- Monogononta
  - Ploima
    - Brachionidae
      - Brachionus sp.
      - B. calicyflorus
      - Euchlanis sp.
      - Kellicottia sp.
      - K. longispina
      - Keratella cochlearis
      - K. quadrata
      - Nothulca sp.
      - N. acuminata
    - Lecanidae
      - Lecane sp.
    - Trichocercidae
      - Trichocerca spp.
      - T. cylindrica
      - T. multicrinus
    - Gastropidae
      - Chromogaster sp.
      - C. ovalis
    - Asplanchnidae
      - Asplanchna spp.
    - Synchaetidae
      - Ploesoma spp.
      - P. hudsoni
      - P. lenticulare
      - Polyarthra spp.
      - P. longiremus
      - P. euryptera
      - Synchaeta spp.
      - S. pectinata
      - S. stylatata
      - S. tremula
  - Flosculariaceae
    - Testudinellidae
      - Filinia longiseta
    - Conochilidae
      - Conochilus unicornis
    - Conothecaceae
      - Collontheca sp.
      - C. mutabilis

ARTHROPODA
- Crustacea
  - Cladocera
    - Bosminidae
      - Bosmina spp.
    - Chydoridae
      - Alona quadrangularis
      - Chydorus sphaericus

*Suborder

TABLE VIII-3 (continued)

ENTRAINED MICROZOOPLANKTON SPECIES INVENTORY
NINE MILE POINT NUCLEAR STATION, UNIT 1, 1974

ARTHROPODA (continued)
- Daphnidae
  - *Ceriodaphnia* sp.
  - *C. lacustris*
  - *Daphnia* spp.
  - *D. retrocurva*
- Sididae
  - *Diaphanosoma* sp.
- Copepoda*
  - Calanoida
    - Diaptomidae
      - *Diaptomus* spp.
      - *D. sicilis*
    - Temoridae
      - *Eurytemora affinis*
  - Cyclopoida
    - *Diacyclops bicuspidatus thomasi*
    - *Tropocyclops prasinus mexicanus*
  - Harpacticoida

*Subclass

Since paired t-tests showed no significant difference between mean original and mean replicate values at the intake ($t = 1.340$ with 42 d.f.) or at the discharge ($t = 0.219$ with 42 d.f.) at $\alpha = 0.05$, the data from original samples are presented in the summary tables and figures. However, original and replicate values were used in all statistical analyses.

This section briefly describes the seasonal trends of major microzooplankton taxa based on abundance values recorded from the Nine Mile Point Nuclear Station intake channel and from lake samples. The entrainment study provided information on abundance of microzooplankton in Lake Ontario during the winter months of 1974 when samples could not be collected from the lake because of inclement weather conditions. Seasonal trends in abundance in lake and in-plant samples are discussed for comparable sampling months.

(i) Rotifers

Rotifer abundance decreased from early January 1974 to the annual minimum during late February, and then increased to the annual maximum during late June. Thereafter, rotifer abundance gradually decreased through December (Figure VIII-7). Since the seasonal trends of rotifer abundance in the intake forebay and in the lake (Figure V.B.-1) were similar during months when both locations were sampled, it is probable that abundance trends observed in the intake forebay during the winter paralleled those in the lake.

Rotifer abundance values were generally higher in discharge waters than in intake waters (Figure VIII-7), however, the difference in mean abundance between these two sites was not significant at $\alpha = 0.05$ (Appendix VIII-3). Comparisons of rotifer abundance in day and night collections (Figure VIII-7) showed no consistent diurnal pattern, and this observation was supported by the ANOVA which showed a lack of significance at $\alpha = 0.05$ for mean abundance by photoperiods (Appendix VIII-3).

(ii) Copepods

The annual minimum in copepod abundance, based on intake samples, occurred during late January/early February and was followed by a gradual increase to the annual maximum during August. Abundance declined during the fall months; December copepod abundance values approximated those of May/June (Figure VIII-8). Temporal distribution patterns of copepod abundance were similar in lake (Figure V.B.-2) and intake forebay samples during the April-December period,

ENTRAINED ROTIFER ABUNDANCE
NINE MILE POINT, 1974.

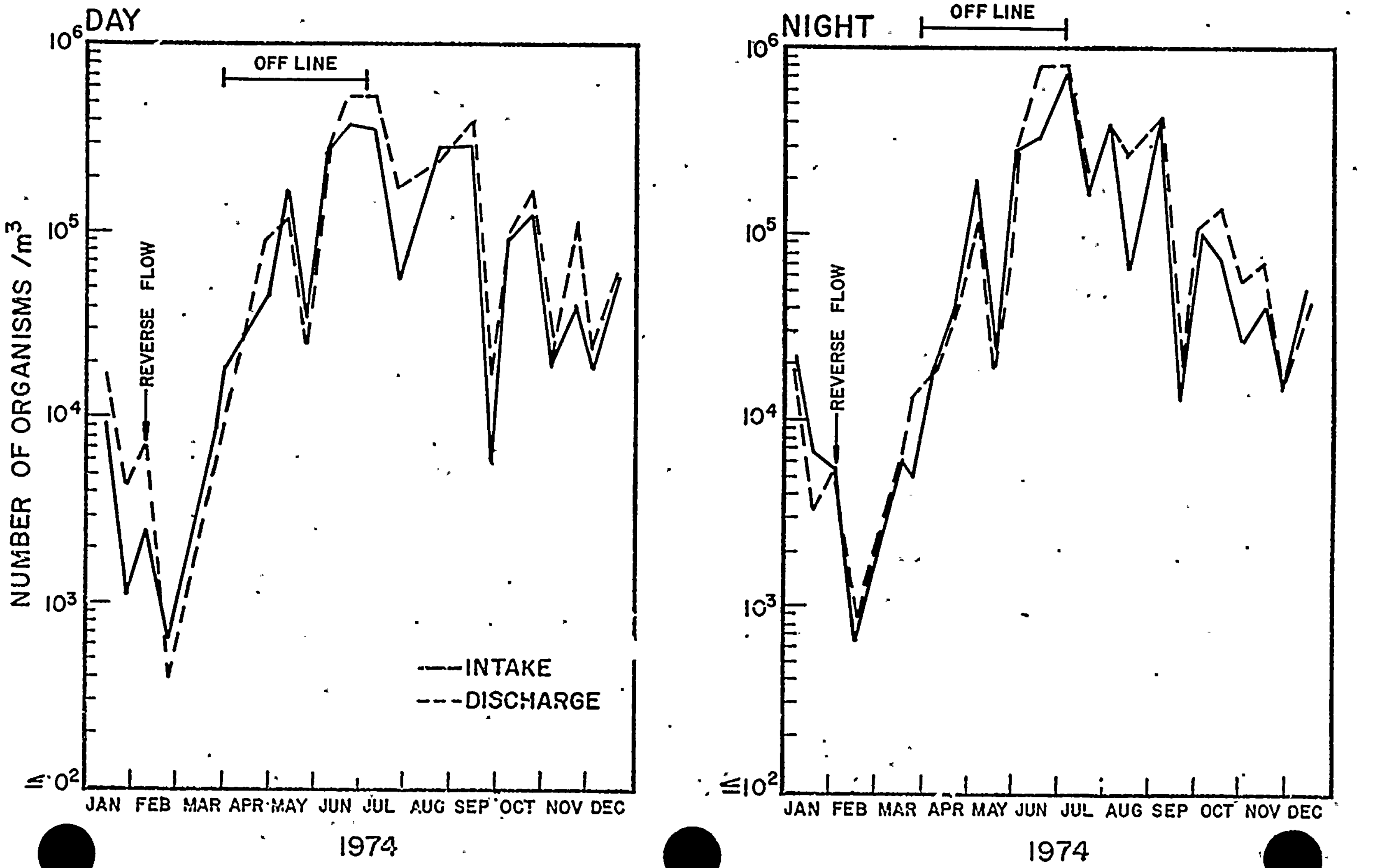


FIGURE VIII-7

ENTRAINED PROTOZOAN ABUNDANCE
NINE MILE POINT, 1974

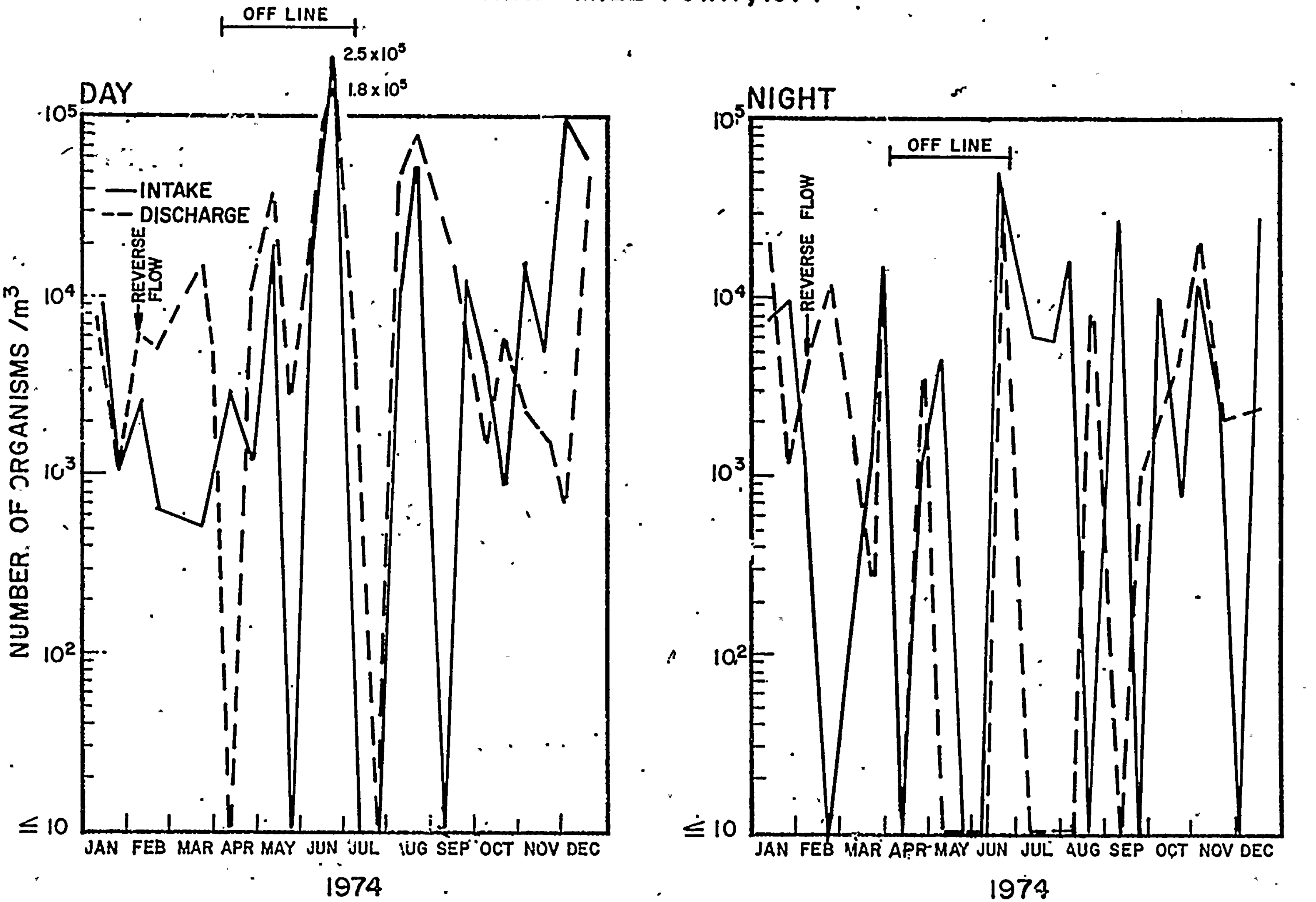


FIGURE VIII-9

suggesting that, as for rotifers, winter intake copepod abundance was indicative of copepod abundances in the lake during the winter.

Comparisons of copepod abundance values between intake and discharge bay samples and between day and night collections showed no consistent intake/discharge or diurnal pattern (Figure VIII-8). These visual observations were supported by the analyses of variance tests (Appendix VIII-3,) which showed that the mean abundances of day/night collections, and intake/discharge collections were not significantly different.

(iii) Protozoans

The seasonal trends in lake protozoan abundance (Figure V.B.-4) were not confirmed by patterns observed in the intake forebay because of the temporal variability of the data (Figure VIII-9). However, the combined intake and lake abundance data suggested that the annual protozoan abundance minimum occurred during winter, with the annual maximum during summer.

Comparisons of the abundance of protozoans collected in the intake and discharge bays of Nine Mile Point Nuclear Station indicated no consistent relationship; however, protozoans were generally more abundant in the day samples than in the night samples (Figure VIII-9). These findings were corroborated by the results of statistical analyses (Appendix VIII-3) which showed that the difference in mean protozoan abundance between the intake and discharge bays was not significant at $\alpha = 0.05$ but, that the mean diurnal difference was significant ($\alpha < 0.025$).

(iv) Cladocerans

Cladoceran abundance at the intake declined from January to the annual minimum during late winter/early spring, after which abundances increased rapidly to a late spring/early summer maximum (Figure VIII-10). Seasonal trends in lake (Figure V.B.-3) and intake forebay abundance data were similar during the period of concomitant lake and in-plant sampling, suggesting that winter intake abundances for cladocerans were, as for rotifer and copepod abundances, reflective of the winter lake abundances.

Comparison of the abundance of cladocerans between stations indicated no significant difference at $\alpha = 0.05$ in mean abundance between intake and discharge samples (Appendix VIII-3).

The trend toward greater cladoceran abundance in the intake canal than in the discharge canal was noted, only for day collections, but was not significant based on the station x photoperiod interaction. Diurnal patterns were significant; at α=0.05 the mean abundance was greater in night collections than in day collections.

The results of the 1974 microzooplankton entrainment study were similar to those of 1973 (QLM, 1974) in that they showed no significant differences in mean abundance values between the intake and the discharge bays, indicating that any mechanical destruction of entrained microzooplankton was undetectable.

c. Mortality

The results of this aspect of the 1974 microzooplankton entrainment study are presented graphically in Figures VIII-11 through VIII-14, which show the percentage of dead rotifers, copepods, protozoans, and cladocerans in the intake and the discharge samples on each collecting date. Also included are the mean change of temperature through the plant and mean percent tempering on each collecting date. These illustrations indicate that the percent immediate entrainment mortality (% dead in discharge minus % dead in intake) was greatest during the winter and summer months. On an annual basis, the percent dead of three of the four major groups composing the microzooplankton (i.e., rotifers, copepods, protozoans) was significantly greater in the discharge than in the intake forebay (Appendix VIII-4); no significant difference was observed for cladocerans. However, on several dates, negative entrainment mortality (i.e., % dead in intake greater than % dead in discharge aftbay) was recorded, a result which indicates that mortality estimates are imprecise; as a consequence, they were not calculated according to sampling date. Entrainment samples collected in the discharge bay frequently showed readings of 100% dead only for protozoans.

Because the trends in percent dead microzooplankton during 1973 (QLM, 1974) and 1974 were similar during comparable seasons, this suggests that the observed temporal changes in the entrainment samples were a function of temperature acclimation. Specifically, it is proposed that the effect of the short exposure (three minutes) of microzooplankton to elevated temperatures at Nine Mile Point Nuclear Station is less pronounced during the summer when ambient temperatures are relatively high. However, during the winter, increases in percent tempering prolong exposure of a portion of the microzooplankton to elevated temperatures and increase the temperature differential between lake and discharge waters, thus increasing the effect of entrainment.

ENTRAINED CLADOCERAN ABUNDANCE
NINE MILE POINT, 1974

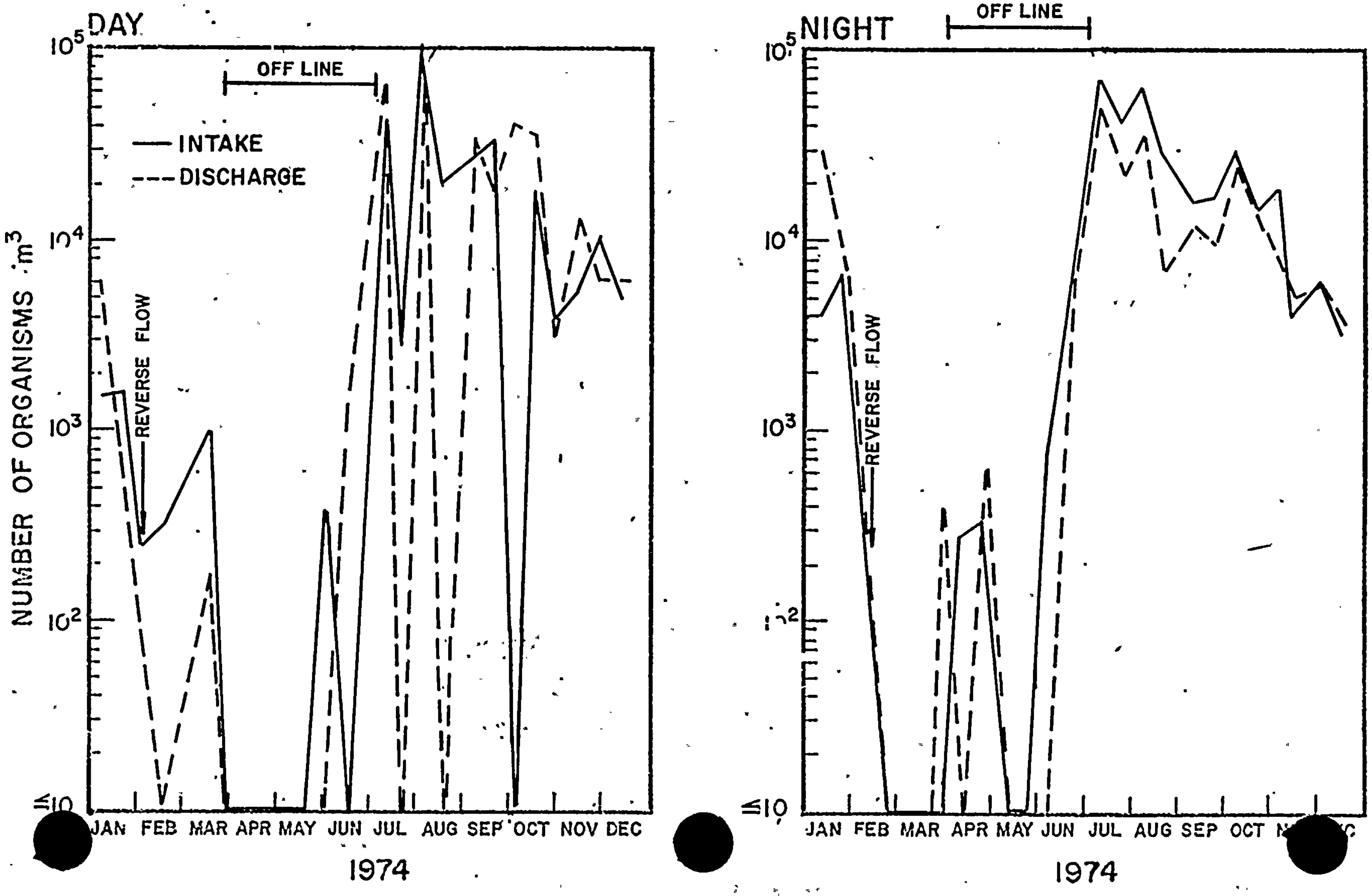


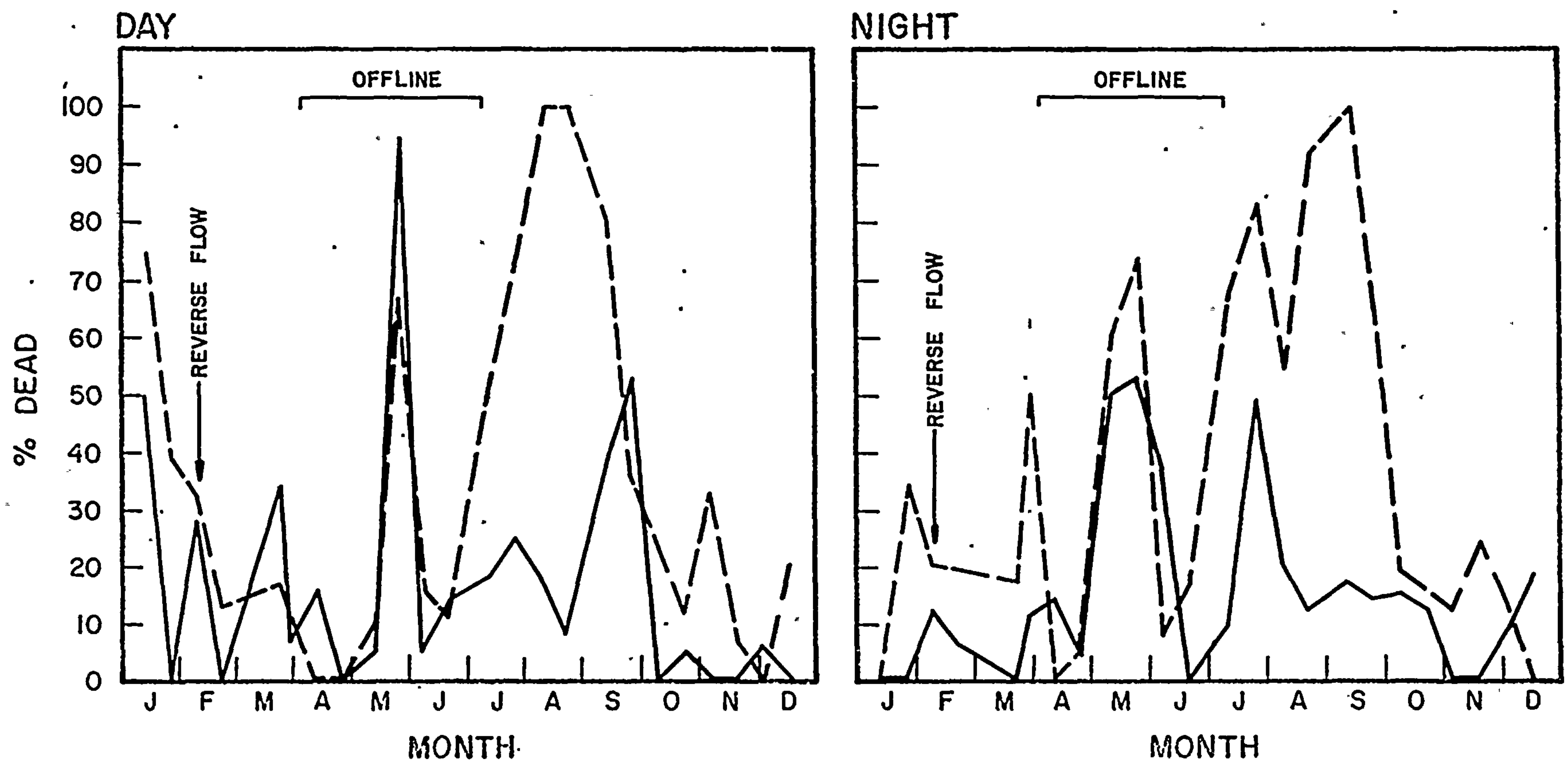
FIGURE VIII-10

COPEPOD MORTALITY
NINE MILE POINT
1974

——— INTAKE
- - - - DISCHARGE

ΔT*(F°)	39	39	38	38	29	29	–	–	–	–	–	–	28	32	33	31	31	31	30	27	31	30	29	26	X
TEMPERING (%)	29	34	34	27	17	17	–	–	–	–	–	–	10	8	8	8	8	8	9	10	9	10	11	12	X

ΔT*(F°)	39	39	38	38	29	29	–	–	–	–	–	–	23	32	33	31	31	31	30	27	31	30	29	26
TEMPERING (%)	29	34	34	27	17	17	–	–	–	–	–	–	10	8	8	8	8	8	9	10	9	10	11	12



* Mean difference between the Lake (C318) and Outlet (319) Temperature Probes for each collecting date (Nine Mile Point Nuclear Station Plant Generation data).

FIGURE VIII-12

ROTIFER MORTALITY
NINE MILE POINT
1974

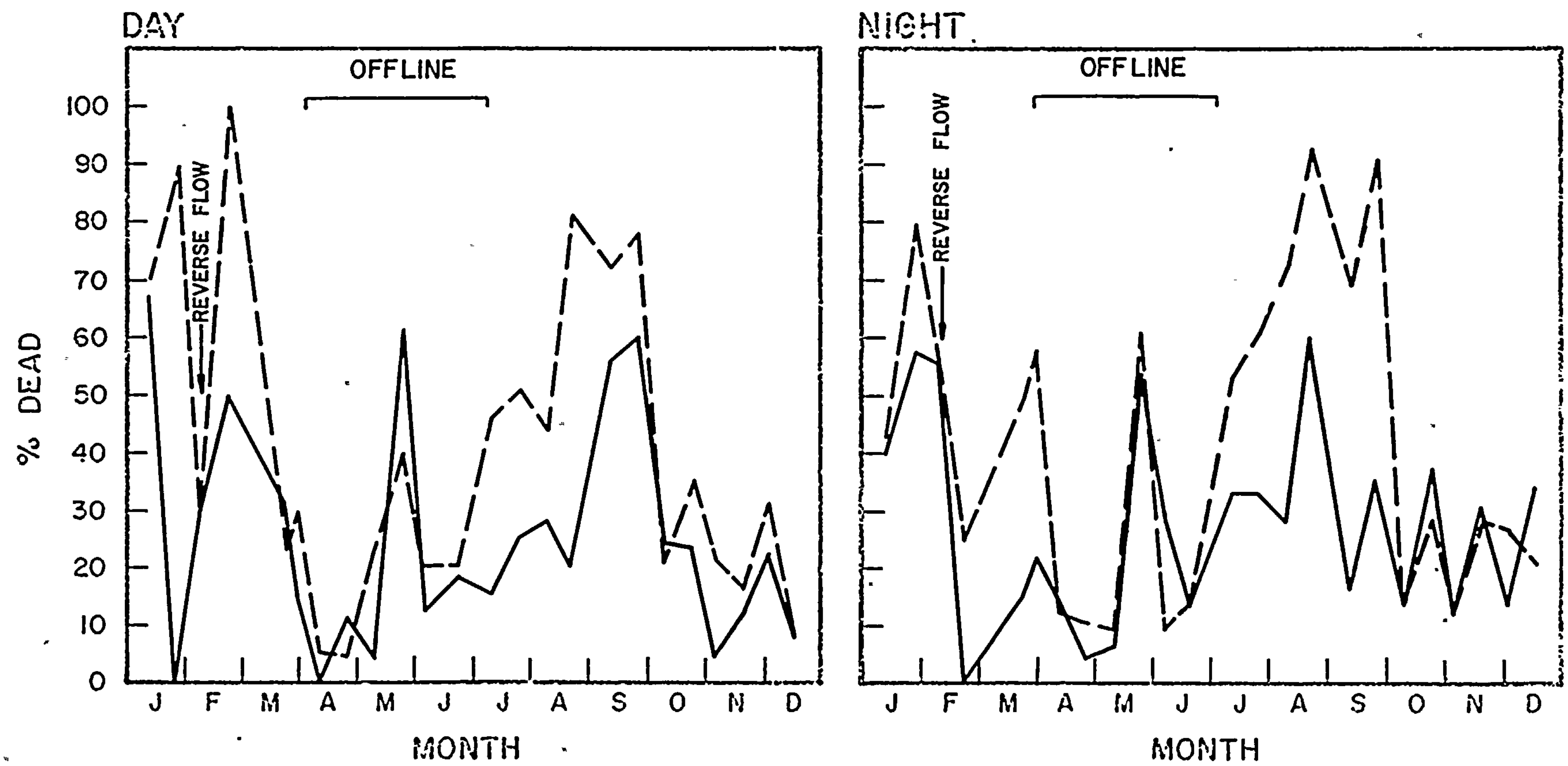
——— INTAKE
- - - - DISCHARGE

Day:

ΔT*(F°)	39	39	39	38	29	29	—	—	—	—	—	—	28	32	33	31	31	31	30	27	31	30	29	28
TEMPERING (%)	29	34	34	27	17	17	—	—	—	—	—	—	10	3	8	8	8	8	9	10	9	10	11	12

Night:

ΔT*(F°)	39	39	39	38	29	29	—	—	—	—	—	—	23	32	33	31	31	31	30	27	31	30	29	28
TEMPERING (%)	29	34	34	27	17	17	—	—	—	—	—	—	10	8	8	6	8	8	9	10	9	10	11	12



* Mean difference between the Lake (C318) and Outlet (C319) Temperature Probes for each collecting date (Nine Mile Point Nuclear Station Plant Generation data).

FIGURE VIII-11

CLADOCERAN MORTALITY
NINE MILE POINT
1974

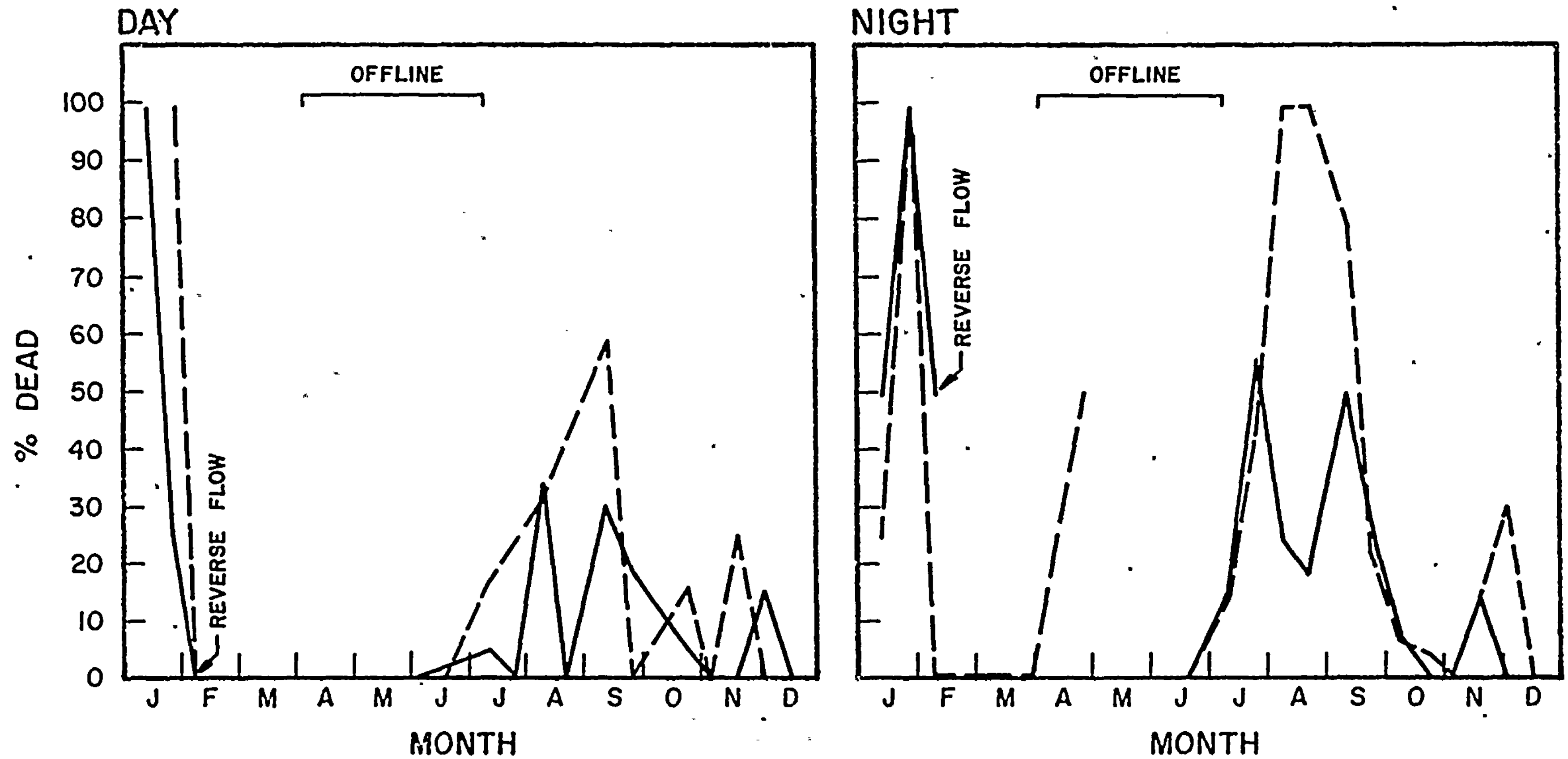
—— INTAKE
---- DISCHARGE

Day:

ΔT*(F°)	39	39	38	38	29	29	—	—	—	—	—	—	23	32	33	31	31	31	30	27	31	30	29	26	X
TEMPERING (%)	23	34	34	27	17	17	—	—	—	—	—	—	10	8	8	3	8	8	9	10	9	10	11	12	X

Night:

ΔT*(F°)	39	39	38	38	29	29	—	—	—	—	—	—	28	32	33	31	31	31	30	27	31	30	[illegible]	[illegible]
TEMPERING (%)	23	34	34	27	17	17	—	—	—	—	—	—	10	8	8	8	8	8	9	10	9	10	11	12



* Mean difference between the Lake (C318) and Outlet (C319) Temperature Probes for each collecting date (Nine Mile Point Nuclear Station Plant Generation data).

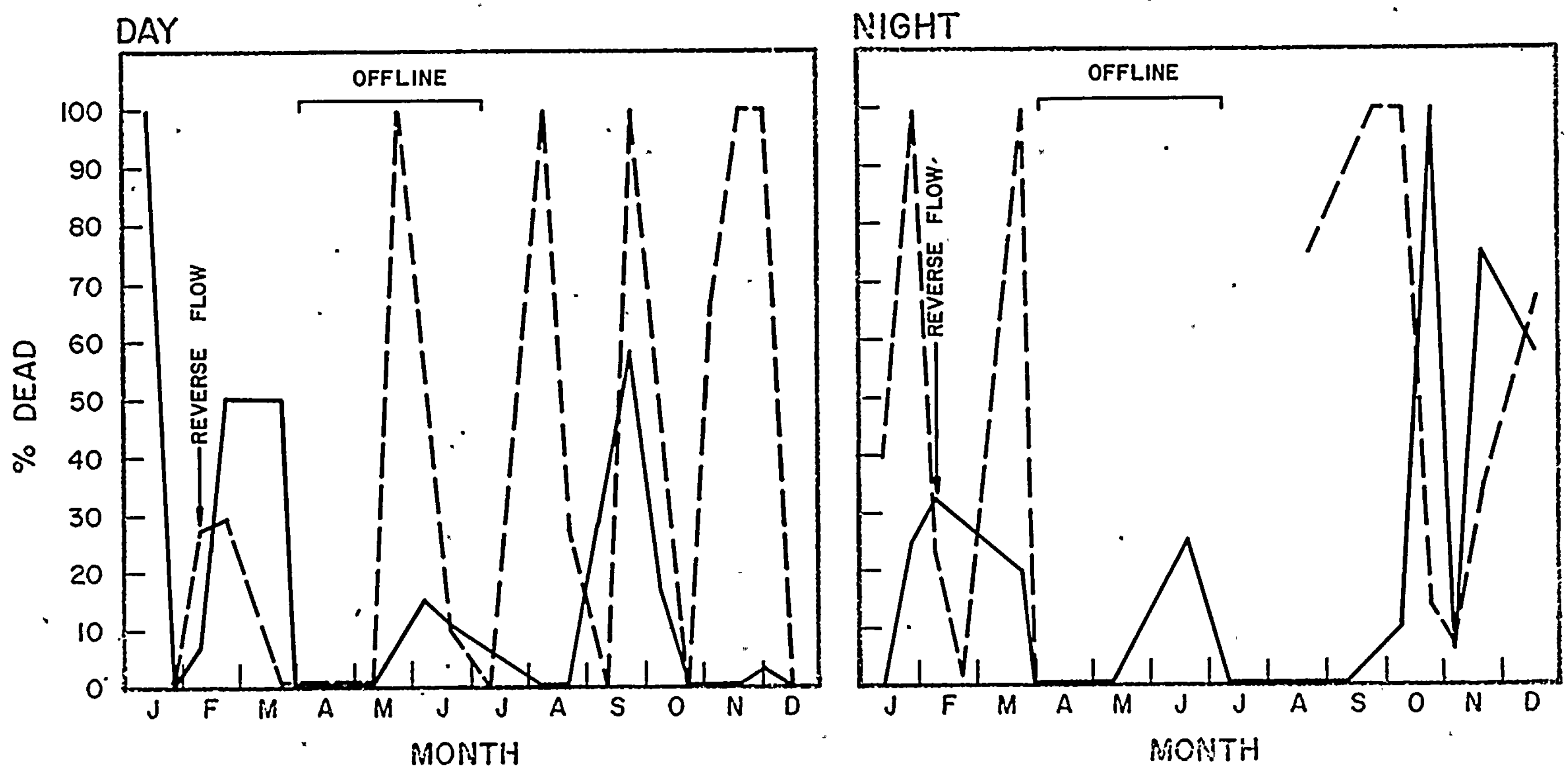
FIGURE VIII-14

PROTOZOAN MORTALITY
NINE MILE POINT
1974

——— INTAKE
– – – – DISCHARGE

ΔT*(F°)	39	39	30	28	29	29	—	—	—	—	—	—	28	32	33	31	31	31	30	27	31	30	29	26	X
TEMPERING (%)	29	34	34	27	17	17	—	—	—	—	—	—	10	8	8	8	8	8	9	10	9	10	11	12	X

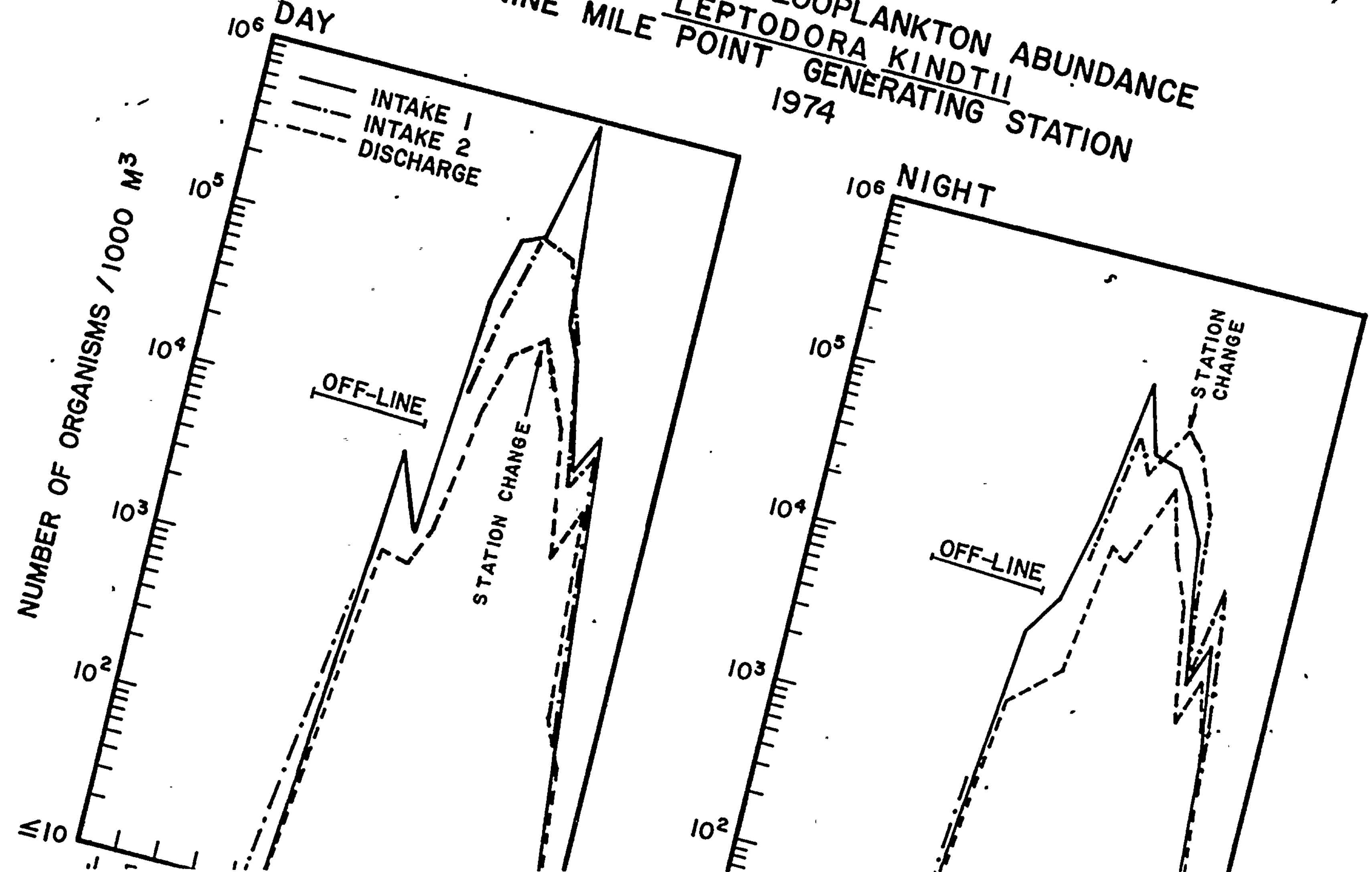
ΔT*(F°)	39	39	39	33	29	29	—	—	—	—	—	—	28	32	33	31	31	31	30	27	31	30	29	26
TEMPERING (%)	30	34	34	27	17	17	—	—	—	—	—	—	10	8	8	8	8	8	9	10	9	10	11	12



* Mean difference between the Lake (318) and Outlet (319) Temperature Probes for each collecting date (Nine Mile Point Nuclear Station Plant Generation data).

FIGURE VIII-13

ENTRAINED MACROZOOPLANKTON ABUNDANCE
LEPTODORA KINDTII
NINE MILE POINT GENERATING STATION
1974



d. Conclusions

1. The composition of the microzooplankton community entrained at Nine Mile Point Nuclear Station Unit 1 was similar to that reported in Lake Ontario in the vicinity of the plant. Rotifers were the dominant organisms, with copepods, protozoans, or cladocerans constituting a significant portion of the community depending on the season. There were no differences in the dominant species collected in the intake and the discharge bays, which suggests that the effects of microzooplankton entrainment at this plant are not species-specific.

2. The seasonal trends of rotifer, copepod, and cladoceran abundance in the intake forebay were similar to trends in the lake, thus indicating the non-selectivity of microzooplankton entrainment. Protozoan abundance was highly variable both among and within collecting dates and it was, therefore, not possible to determine whether this group of organisms was selectively entrained.

3. Entrainment mortality varied seasonally for the four major microzooplankton groups; the highest immediate mortality occurred during winter and summer. The seasonal trend in microzooplankton mortality was related to the duration of exposure to elevated temperatures, the acclimation levels of the microzooplankton, and the magnitude of temperature elevation between the lake and discharge. The mean abundance of dead rotifers, copepods, and protozoans was significantly greater in the discharge bay than in the intake bay. Although instances of higher percent-dead microzooplankton at the intake than at the discharge precluded calculation of percent mortality by date, it was noted that 100% mortality occurred only infrequently and only for protozoans.

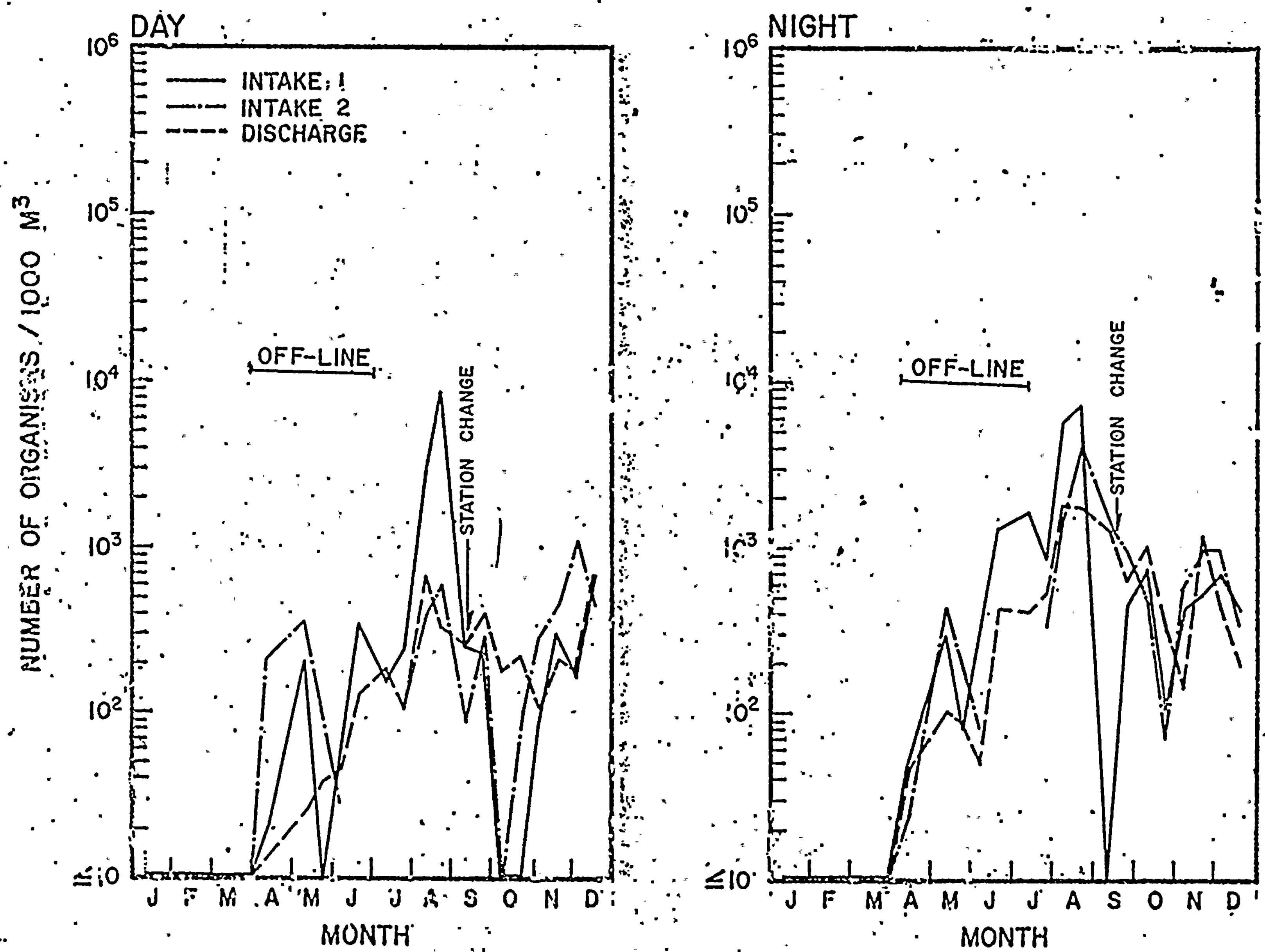
3. Macrozooplankton

Entrainment data are available for all of the macrozooplankters identified in the lake study; however, only the results for Leptodora kindtii, Gammarus fasciatus, and Diptera are presented since these taxa were discussed in detail from the lake study (Section V.B.2). Pontoporeia affinis and Mysis oculata relicta were as rare in entrainment samples as in the lake adjacent to Nine Mile Point (LMS, 1975) and these organisms are, therefore, not discussed herein.

a. Seasonal Patterns of Abundance and Comparison with Patterns in the Lake

The seasonal patterns of entrained Leptodora kindtii abundance (Figure VIII-15) were similar to seasonal patterns observed at

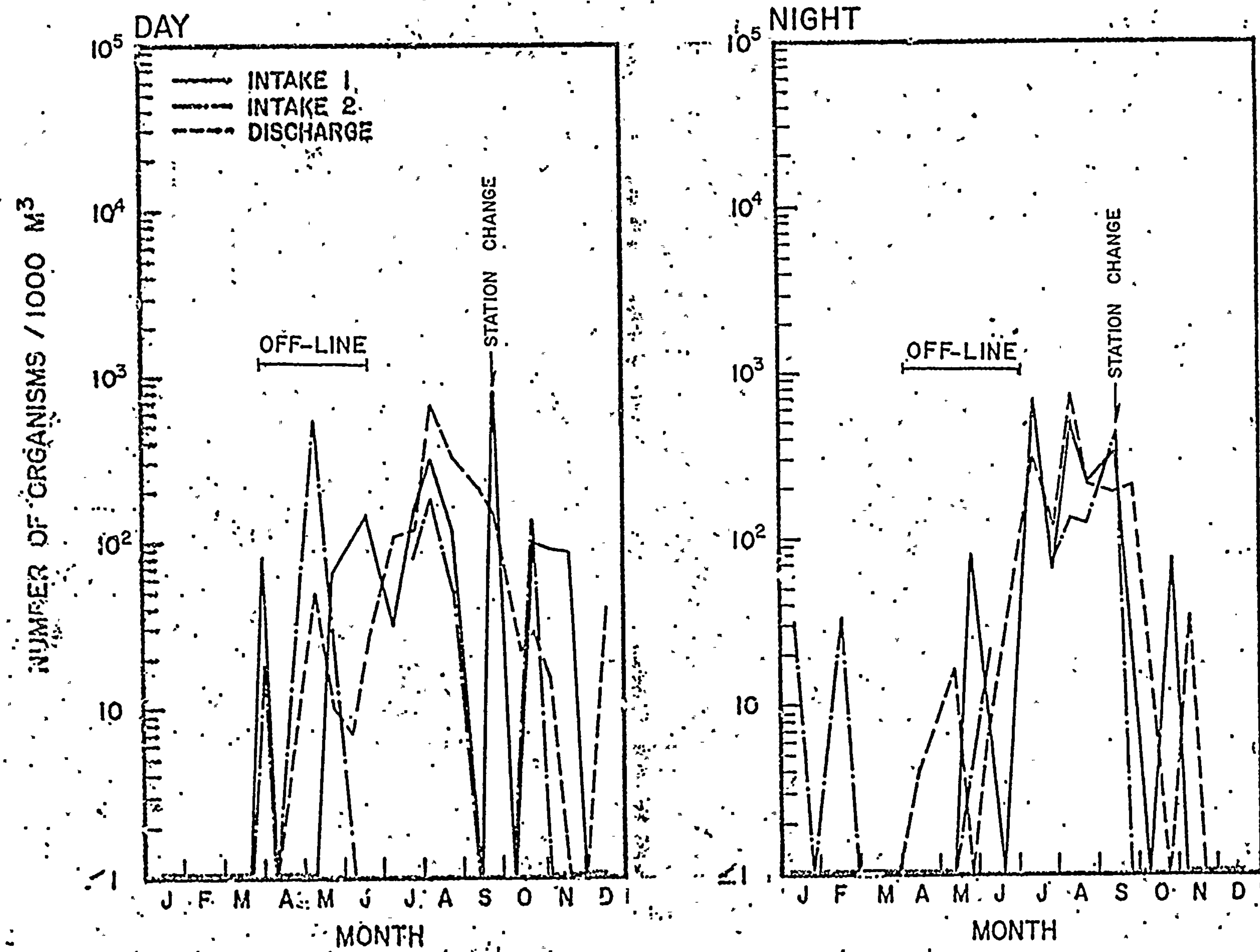
ENTRAINED MACROZOOPLANKTON ABUNDANCE
GAMMARUS FASCIATUS
NINE MILE POINT GENERATING STATION
1974



Station change: change in depth of sample in intake bays after 11 September.

FIGURE VIII-16

ENTRAINED MACROZOOPLANKTON ABUNDANCE
DIPTERA
NINE MILE POINT GENERATING STATION
1974



Station change: change in depth of sample in intake bays after 11 September.

FIGURE

suggests that macrozooplankton were not homogeneously distributed in the intake forebay. A complete mixing of water would be expected in the intake canal, but not in the intake forebay, based on a preliminary velocity profile study in front of the trash racks. (Table IX-10). Differences in mean abundance values between intake stations were frequently two to threefold for Leptodora, Gammarus, and Diptera, and occasionally as much as an order of magnitude.

A three-way analysis of variance, based on total macrozooplankton abundance, was conducted to examine further the spatial distribution of entrained macrozooplankton, (off-line periods were deleted from the analysis). There was no significant ($\alpha = 0.05$) difference in mean macrozooplankton abundance among intake and discharge stations, but a station X date interaction was significant (Appendix VIII-5). The ranking of factors within a source by the Student-Newman-Keuls tests indicated that differences among dates reflected seasonal patterns of abundance (maximum in August/September) and that the station X date interaction reflected variations in macrozooplankton distribution among entrainment stations with date (Table VIII-4). The distribution patterns isolated through the Student-Newman-Keuls test indicated a homogeneous distribution of entrained macrozooplankton, and also that the difference in abundance between intake and discharge samples was on the average smaller in magnitude than the variability within the samples from a particular location.

c. Conclusions

Comparisons of seasonal trends, magnitudes, and variations in the abundance of Leptodora kindtii, Gammarus fasciatus, and Diptera in the intake forebay of Nine Mile Point Nuclear Station Unit 1 and in the Nine Mile Point vicinity of Lake Ontario indicated that entrainment is species-specific only insofar as vertical distribution patterns are species-specific. For example, organisms distributed in the lower portion of the water column, e.g., Gammarus fasciatus, were more susceptible to entrainment than organisms distributed more evenly throughout or concentrated at the surface of the water column.

Statistical analyses of Leptodora, Gammarus, and dipteran concentrations at in-plant entrainment stations indicated that these organisms were homogeneously distributed; there was no statistical difference in mean macrozoopalnkton abundance among stations (intake surface and mid-depth, and discharge mid-depth). The distribution pattern among stations varied significantly among dates; however, the difference between surface and mid-depth samples in the intake forebay was not significant.

TABLE VIII-4

RESULTS OF STUDENT-NEWMAN-KEULS TESTS*
FOR ENTRAINED MACROZOOPLANKTON

NINE MILE POINT NUCLEAR STATION - 1974

1. For significant differences among dates ($\alpha = 0.05$)

Largest: 11 SEP 21 AUG 7 AUG 24 JUL 23 JAN 9 JAN 20 MAR 27 MAR 14 FEB 27 FEB

2. For significant station X date interaction ($\alpha = 0.05$); stations ranked in decreasing order of abundance

9 JAN	I#1 D I#2	27 MAR	D I#2 I#1
23 JAN	I#2 D I#1	24 JUL	I#1 I#2 D
14 FEB	I#2 I#1 D	7 AUG	I#1 I#2 D
27 FEB	D I#2 I#1	21 AUG	I#2 I#1 D
20 MAR	D I#1 I#2	11 SEP	I#1 I#2 D

I#1 =intake: middle bay, mid-depth
I#2 =intake: west bay, surface
D =discharge: mid-depth

* Compiled from Appendix VIII-5.

4. Ichthyoplankton

a. Community Composition

Six species of fish larvae were identified in collections from the intake and discharge bays at the Nine Mile Point Nuclear Station Unit 1 (Table VIII-5). These species were also reported from the lake ichthyoplankton collections.

A total of 262 fish larvae were collected between 8 May and 22 August 1974; alewife and johnny darter were the prevalent species, constituting 40% and 33% of the total larvae collected, respectively. Rainbow smelt ranked third (23%) and the other three species combined represented less than 5% of the total number collected, with each collected on only one of the 24-hour collection dates.

Eggs from six species were collected in the entrainment samples from 10 April to 8 August 1974; fish eggs were also present in lake ichthyoplankton collections beginning in April (Table VB-7). Alewife and rainbow smelt were the prevalent species, constituting 82% and 1% of the total eggs collected, respectively. Eggs of the burbot, white sucker, common shiner, and gizzard shad were collected on one sampling date only and together composed less than 1% (15 eggs) of the total eggs collected.

b. Seasonal Patterns of Abundance and Distribution

Although entrainment sampling at the intake and discharge bays of Nine Mile Point Nuclear Station Unit 1 commenced in January, larvae were collected only from May through December, 1974. Table VIII-6 indicates the dates on which each larval fish species was collected and its relative percentage of the mean daily abundance.

The alewife, johnny darter, and rainbow smelt larvae were collected from the three sampling sites within the plant, whereas the carp and white perch were collected only at the plant discharge station and the yellow perch only in the intake forebay. Variability in the concentration of larvae of these three species among collection locations reflects the small numbers of larvae entrained, the twice-monthly sampling program, and small sampling volumes. The abundance and the period of collection of alewife larvae entrainment samples reflected the dominance of this species in the near-shore waters in the Nine Mile Point vicinity (Table VB-8). As noted in lake collections, two peaks of alewife larval abundance were observed; the primary peak occurred during the first week of August and the secondary peak during the first

TABLE VIII-5

ENTRAINED ICHTHYOPLANKTON AND FISH EGGS SPECIES INVENTORY

NINE MILE POINT NUCLEAR STATION UNIT 1 - 1974

FAMILY	COMMON NAME	SCIENTIFIC NAME
Catostomidae	White sucker **	Catostomus commersoni
Clupeidae	Alewife *	Alosa pseudoharengus
	Gizzard shad **	Dorosoma cepedianum
Cyprinidae	Carp *	Cyprinus carpio
	Common shiner **	Notropis cornutus
Gadidae	Burbot **	Lota lota
Osmeridae	Rainbow smelt *	Osmerus mordax
Percichthyidae	White perch *	Morone americana
Percidae	Johnny darter *	Etheostoma nigrum
	Yellow perch *	Perca flavescens

* Larval species identified.
** Fish eggs only.

TABLE VIII-6

OCCURRENCE OF FISH LARVAE SPECIES IN INTAKE AND DISCHARGE COLLECTIONS

NINE MILE POINT NUCLEAR STATION UNIT 1 - 1974

DATE	ALEWIFE	CARP	RAINBOW SMELT	WHITE PERCH	JOHNNY DARTER	YELLOW PERCH
8- 9 MAY			*			
22-23 MAY			*			
5- 6 JUN			*			
19-20 JUN			*	X	X	
10-11 JUL	*	X	*		*	X
24-25 JUL	*				X	
7- 8 AUG	*		X			
21-22 AUG	*		*			

* Indicates presence at ≥ 10% of total larvae for that date.
X Indicates presence at < 10% of total larvae for that date.

part of July. A small decline in entrained alewife larval abundance at the end of July was associated with a similar decline in lake alewife larvae.

Johnny darters were present in three entrainment collections, (Table VIII-6) encompassing the second half of June through the end of July, with the peak abundance recorded from 10-11 July (average of 765 larvae/1000m^3) This species occurred in the lake collections (Table VB-8) approximately a month earlier than in the entrainment collections and continued to be collected in lake samples through the end of August. The differences noted between lake and plant collections of johnny darter probably reflected the benthic nature of this species, for which spawning and early larval development occurs in nests constructed under rocks (Scott and Crossman, 1973).

Rainbow smelt larvae first appeared in entrainment collections (8-9 May) (Table VIII-6) concomitant with their initial collection in the lake ichthyoplankton samples (Table VB-8). The greatest concentration of rainbow smelt was entrained on 22-23 May; their concentration gradually decreased through the remainder of the spring and summer months. The appearance of smelt larvae in entrainment samples paralleled their appearance in lake collections.

Yellow perch, white perch, and carp larvae occurred in concentrations of 235, 28, and 16 larvae/1000 m^3, respectively, on the single dates when they were present in entrainment samples. Low concentrations were also observed in lake collections for these species within the same period, suggesting that these larvae are not prevalent in the Nine Mile Point vicinity and that plant operation would not, therefore, adversely affect the populations in the lake.

Table VIII-7 lists the species of fish whose eggs were identified, the dates of collection, and average concentration of eggs collected on that date.

The July peak in the entrainment samples corresponded with the peak period in the lake (Appendix VB-16); both peaks both dominated by alewife eggs, which were collected in entrainment samples from 10-11 July through the first week in August with peak egg abundance (9258 eggs/1000m^3) recorded on 10-11 July. The period of alewife egg entrainment was compressed compared to that observed in the lake collections; i.e., the first appearance of alewife eggs in entrainment collections occurred one month subsequent to their initial collection in the lake. In addition lake collections of alewife eggs persisted through August; however, the concentrations were very small after the 17 July peak.

TABLE VIII-7

AVERAGE ABUNDANCE OF FISH EGGS
COLLECTED IN INTAKE AND DISCHARGE SAMPLES

NINE MILE POINT NUCLEAR STATION UNIT 1 - 1974

DATE	FISH SPECIES (eggs/1000 m^3)						
	RAINBOW SMELT	BURBOT	WHITE SUCKER	COMMON SHINER	GIZZARD SHAD	ALEWIFE	UNIDEN-TIFIABLE
10-11 APR	1	3					1
8- 9 MAY	202						7
22-23 MAY	22		2				132
5- 6 JUN	1						3
19 JUN				2			115
10-11 JUL					6	9258	2385
24-25 JUL						2648	24
7- 8 AUG						687	2

Rainbow smelt eggs were the second most abundant species collected in the entrainment samples with the greatest concentration (202 eggs/1000m^3) entrained on 8-9 May. Collection of rainbow smelt eggs in the entrainment samples occurred approximately two weeks prior to their collection in the lake samples.

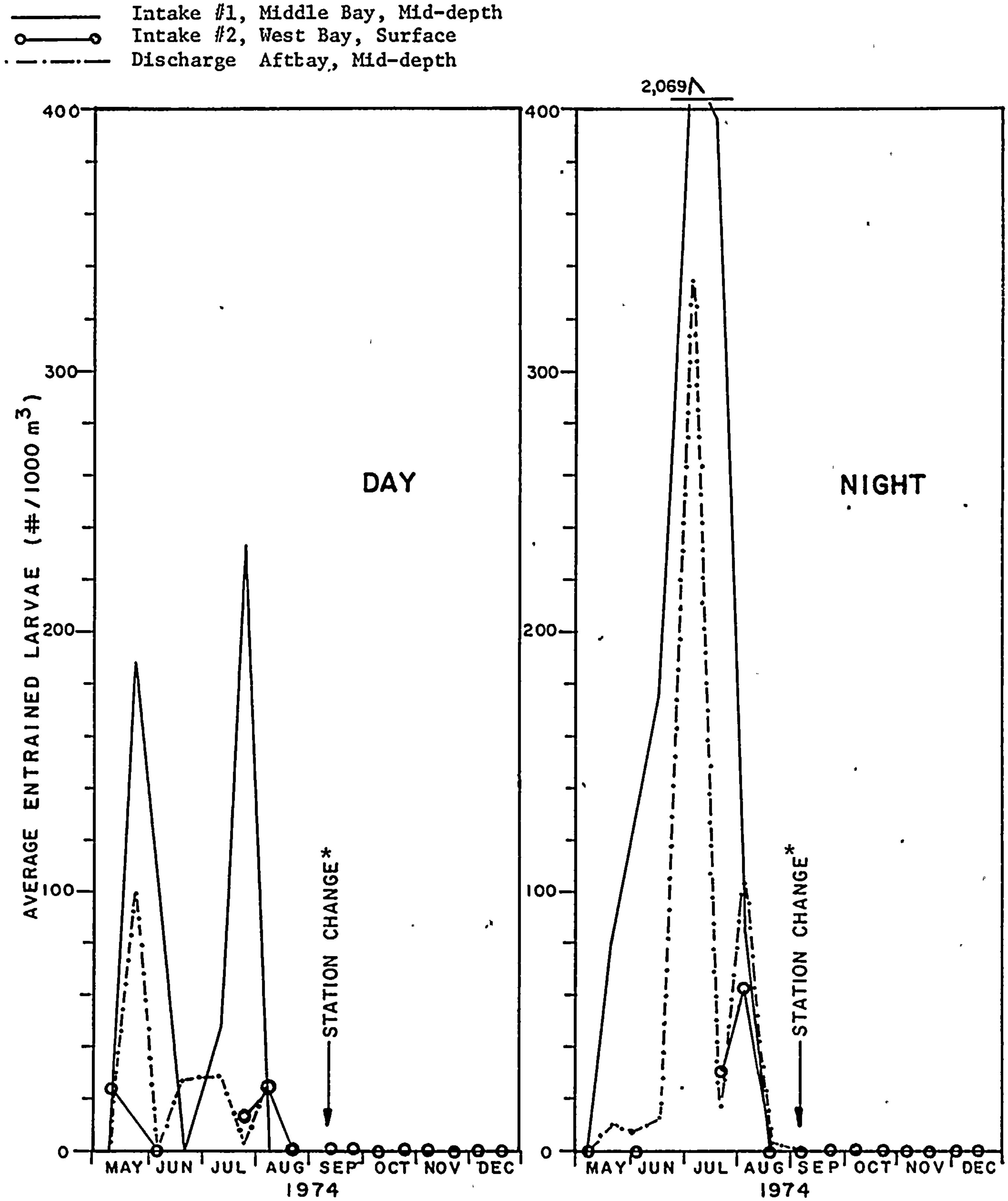
c. Diel Patterns

The concentrations of total fish larvae collected during day and night sampling efforts at the three Nine Mile Point Nuclear Station Unit 1 sampling locations are graphically presented in Figure VIII-18. Statistical analyses based on specific sampling dates (Appendix VIII-7) indicated that there were significantly greater concentrations of fish larvae in night collections than in day entrainment collections ($\alpha = 0.05$); this observation was consistent with that reported from the lake (Appendix VB-16). The greater abundance of fish larvae in night collections has been observed by several investigators (Carlson and McCann, 1969; Noble, 1970; QLM, 1974), and is primarily the result of increased larval activity and consequently greater numbers of individuals present in the water column during the night hours.

During both day and night collections, there was a trend toward increased larval concentrations in the intake forebay mid-depth sample. The three-way analysis at variance conducted on a small data base, indicated no significant difference in mean abundance among stations; however, the station x date interaction was significant. It was noted that during periods of peak larval abundance, the abundances in the surface intake and discharge samples were similar, whereas, both were significantly different than that from the mid-depth intake station (Appendix VIII-7;see also Section VIIIc.3.

Two peaks in total larval concentration were observed for the day samples: one on 22 May and the second on 24 July. The May abundance peak consisted primarily of entrained rainbow smelt larvae, whereas the July peak was predominately due to alewife larvae. Only a single peak in abundance was noted for night samples; night concentrations increased continuously from 9 May to the 11 July peak which was followed by a rapid decline in larval concentrations in August. The difference in periods of peak concentrations between day and night entrainment collections is related to the development of the larval populations and their subsequent distribution patterns. Specifically, in both day and night collections, larval concentration increased during May, with the greater numbers recorded from the day sample. The rainbow smelt larvae dominated the May and June collection, but as these larvae matured, their migration offshore during

AVERAGE ABUNDANCE OF TOTAL ICHTHYOPLANKTON
NINE MILE POINT NUCLEAR STATION
1974



* After 11 September: Intake #1, Surface
Intake #2, Mid-depth

the evening hours decreased their abundance in the day entrainment samples, while the night concentration remained constant. Alewife larvae, which constituted the greatest concentration in July entrainment samples, are more active at night and thus their numbers were responsible for the observed peak at that time. The absence of fish larvae in entrainment samples after the end of August was a consequence of the maturation of the larvae and their subsequent movement from the shore area into open waters.

d. Length Frequency

Length frequencies for larvae of rainbow smelt, alewife, and johnny darter collected at the three Nine Mile Point Nuclear Station Unit 1 in-plant sampling stations are presented in Tables VIII-8 and VIII-9. The mean length for larvae of all three species corresponds to the mean length reported from collections in Lake Ontario in the Nine Mile Point vicinity (Tables VB-9, VB-12, and VB-11, respectively). The similarity in mean lengths indicates that the entrained population was drawn from the population present in the immediate vicinity of the plant's intake structure.

The low abundance of fish larvae collected by entrainment sampling precludes any definitive statement on the effect of ichthyoplankton entrainment on the fish population.

e. Ichthyoplankton Viability

Fish larvae collected at the two sample depths in the intake forebay and the discharge bay were examined in the field for viability one hour after the time of collection (Table VIII-10). The viability observations conducted during 1974 were based on very small samples and, therefore, must be considered as qualitative information.

Schubel (1974), in a review of some of the current information available on power plant entrainment of fish eggs and larvae including white perch and alewives, cited studies which indicate that fish egg viability varies with species and increases as egg development advances. However, other work conducted at the Stony Brook laboratory (Schubel, 1974 and 1975) indicated no appreciable difference in egg viability with development. Schubel observed that, for fish larvae, viability was dependent on the ambient water temperature (acclimation temperature) and duration of larval exposure to the elevated temperature, in addition to mechanical-pressure damage. Marcy (1973) evaluated fish larvae entrainment at a nuclear generating station on the Connecticut River and concluded that mortality was high after the organisms had passed through the plant, with approximately 80% of the total mortality due to mechanical damage and 20% attributed to thermal shock and exposure (ΔT 12.5°C).

TABLE VIII-8

LENGTH FREQUENCY DISTRIBUTIONS
BY DATE FOR ENTRAINED RAINBOW SMELT

NINE MILE POINT NUCLEAR STATION, UNIT 1 - 1974

LENGTH INTERVAL (mm)	SAMPLING DATES - 1974					
	8 MAY	22-23 MAY	5 JUN	19-20 JUN	11 JUL	8 AUG
1.1- 2.0						
2.1- 3.0						
3.1- 4.0		1				
4.1- 5.0		1				
5.1- 6.0	1	18		1		
6.1- 7.0	1	16	2	1		
7.1- 8.0		2				
8.1- 9.0						
9.1-10.0				2		
10.1-11.0				2		
11.1-12.0				1		
12.1-13.0					1	
13.1-14.0				1		
14.1-15.0						
15.1-16.0						1
16.1-17.0					1	
MEANS	6.0	5.9	6.5	10.8	14.5	15.5

TABLE VIII-9

LENGTH FREQUENCY DISTRIBUTIONS
BY DATE FOR ENTRAINED ALEWIFE AND JOHNNY DARTER

NINE MILE POINT NUCLEAR STATION, UNIT 1 - 1974

LENGTH INTERVAL (mm)	SAMPLING DATES - 1974						
	ALEWIFE				JOHNNY DARTER		
	10-11 JUL	24-25 JUL	7-8 AUG	21-22 AUG	20 JUN	10-11 JUL	24-25 JUL
1.1- 2.0							
2.1- 3.0	2	1					
3.1- 4.0	27	7					
4.1- 5.0	4	4			1	1	
5.1- 6.0	1	5				23	
6.1- 7.0	3					46	1
7.1- 8.0	2					20	
8.1- 9.0	2					1	
9.1-10.0			5				
10.1-11.0			10			1	
11.1-12.0	1		5				
12.1-13.0	1		7				
13.1-14.0			3		1		
14.1-15.0			2				
15.1-16.0			2				
16.1-17.0							
17.1-18.0				1			
18.1-19.0							
19.1-20.0			1				
20.1-21.0			1				
MEAN (mm)	4.3	4.3	11.7	17.5	9.0	6.5	6.5

TABLE VIII-10

VIABILITY OF ENTRAINED ICHTHYOPLANKTON

NINE MILE POINT NUCLEAR STATION UNIT 1 - 1974

DATE	STATION LOCATION	SURVIVAL NUMBER LIVE	NUMBER STUNNED	NUMBER DEAD
8-9 MAY	Intake #1	1	0	0
	Intake #2	0	0	0
	Discharge	1	0	0
22 MAY	Intake #1	0	0	0
	Intake #2	1	0	3
	Discharge	0	0	26
5-6 JUN	Intake #1	-	-	-
	Intake #2	0	0	0
	Discharge	0	0	2
19 JUN	Intake #1	-	-	-
	Intake #2	1	0	0
	Discharge	0	0	7
10-11 JUL	Intake #1	-	-	-
	Intake #2	15	0	15
	Discharge	2	0	103
24-25 JUL	Intake #1	2	0	2
	Intake #2	3	0	5
	Discharge	0	0	5
7-8 AUG	Intake #1	0	2	5
	Intake #2	0	0	2
	Discharge	11	0	15
21 AUG	Intake #1	2	0	0
	Intake #2	0	0	0
	Discharge	0	0	1

Intake Forebay #1 = Surface sample
Intake Forebay #2 = Mid-depth sample
Discharge = Mid-depth sample
- = No sample

At Nine Mile Point Nuclear Station Unit 1, 92% of all ichthyoplankton collected from the discharge canal were dead, 50% and 56%, respectively, from the surface and mid-depth intake canal. Based on an average sampling gear mortality of 53%, 39% of the total ichthyoplankton collected in the discharge canal were killed due to plant induced factors (i.e., mechanical stress and ΔT). Assuming no net mortality, plant induced factors resulted in an 83% mortality of the live ichthyoplankton, or 17% larval survival after passage through the condensers.

D. CONCLUSIONS

Eggs and larvae of ten species of fish were collected in the intake and discharge bays of Nine Mile Point Nuclear Station Unit 1 from 10 April though 22 August 1974. The dominant species in both egg and larval collections was the alewife; rainbow smelt was the second most abundant species.

The eggs and larvae of the rainbow smelt, the adults which were spawned in early spring in the Nine Mile Point vicinity, dominated the spring/early summer entrainment collections. Eggs of the winter-spawning burbot and larvae of the white perch and johnny darter were also present in the spring collections. During the summer months of July and August, alewife dominated the entrainment collections. Except for the burbot and white perch, all other species were collected as either eggs or larvae during the summer period.

The greatest concentrations of fish larvae were entrained during night hours, similar to the presence of higher concentrations of larvae in the Nine Mile Point vicinity at night.

Viability studies of fish larvae indicated an average of only 4% larval survival after passage through the condensers of the nuclear stations. The low survival value may have been a result of the sampling method as well as the effects of plant passage.

REFERENCES CITED

Carlson, F.T. and J.A. McCann. 1969. Hudson River fisheries investigations, 1965-1968. Hudson River Policy Comm. and Consolidated Edison Co. of New York, Inc. 50p. with app.

Lawler, Matusky and Skelly Engineers. 1975. Nine Mile Point Data Report January-December 1974. Prepared for Niagara Mohawk Power Corp.

Marcy, B.C. 1973. Vulnerability and survival of young Connecticut River fish entrained at a nuclear power plant. J. Fish. Res. Bd. Canada 30(8):1195-1203.

Noble, R.L. 1970. Evaluation of the Miller high-speed sampler for sampling yellow perch and walleye fry. J. Fish. Res. Bd. Canada 27(6):1033-1044.

Quirk, Lawler and Matusky Engineers. 1974. 1973 Nine Mile Point aquatic ecology studies - Nine Mile Point Generating Station. Prepared for Niagara Mohawk Power Corp.

Schubel, J.R. 1974. Effects of exposure to time-excess temperature histories typically experienced at power plants on the hatching success of fish eggs. Estuar. Coast. Mar. Sci. 2(2):105-116.

Schubel, J.R. 1975. Some comments on the thermal effects of power plants on fish eggs and larvae, p. 31-54. IN S.B. Saila (ed.) Fisheries and energy production - a symposium. Lexington Books, Lexington, Mass.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Bd. Canada Bull. 184: 966p.

APPENDIX VIII-1

ENTRAINED PHYTOPLANKTON ABUNDANCE
NINE MILE POINT NUCLEAR STATION UNIT 1 - 1974

I. TOTAL PHYTOPLANKTON

THREE-WAY ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
STATIONS (INTAKE/DISCHARGE BAYS)	1	0.0356	71	2.5856	0.978 (a)
PHOTOPERIODS (DAY/NIGHT)	1	0.0022	71	3.6650	0.043 (a)
DATES*	11	9.5851	81	4.0303	17.513 (b)
STATIONS X PHOTOPERIODS	1	0.0813	59	2.0577	2.331 (c)
STATIONS X DATES	11	0.4466	59	2.0577	1.164 (a)
PHOTOPERIODS X DATES	11	1.5260	59	2.0577	3.978 (b)
STATIONS X PHOTOPERIODS X DATES	11	0.4148	48	1.6429	1.102 (a)
TOTAL	95	13.7345			

(a) Not Significant at $\alpha = 0.25$
(b) Significant at $\alpha < 0.0005$
(c) Significant at $\alpha < 0.25$

STUDENT-NEWMAN-KEULS TEST - DATES ($\alpha = 0.05$)
Largest: 9 Oct 11 Sep 6 Nov 23 Oct 25 Sep 7 Aug 20 Nov 21 Aug 18 Dec 4 Dec 24 Jul 10 Jul: Smallest

STUDENT-NEWMAN-KEULS TEST - PHOTOPERIOD COMPARISON BY DATE (= 0.05)

a.	10 JUL	Largest:	Night Day:	Smallest	g.	9 OCT	Largest:	Day Night:	Smallest
b.	24 JUL	Largest:	Day Night:	Smallest	h.	23 OCT	Largest:	Day Night:	Smallest
c.	7 AUG	Largest:	Night Day:	Smallest	i.	6 NOV	Largest:	Night Day:	Smallest
d.	21 AUG	Largest:	Day Night:	Smallest	j.	20 NOV	Largest:	Night Day:	Smallest
e.	11 SEP	Largest:	Night Day:	Smallest	k.	4 DEC	Largest:	Day Night:	Smallest
f.	25 SEP	Largest:	Night Day:	Smallest	l.	18 DEC	Largest:	Night Day:	Smallest

II. DIATOMS

THREE-WAY ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
STATIONS (INTAKE/DISCHARGE BAYS)	1	0.0506	71	10.2803	0.349 (a)
PHOTOPERIODS (DAY/NIGHT)	1	0.0058	71	14.2890	0.029 (a)
DATES*	11	28.2243	81	15.3484	13.541 (b)
STATIONS X PHOTOPERIODS	1	0.0190	59	9.1829	0.122 (a)
STATIONS X DATES	11	1.0784	59	9.1829	0.630 (a)
PHOTOPERIODS X DATES	11	5.0871	59	9.1829	2.971 (c)
STATIONS X PHOTOPERIODS X DATES	11	1.1823	48	8.0006	0.645 (a)
TOTAL	95	43.6482			

(a) Not Significant at $\alpha = 0.25$
(b) Significant at $\alpha < 0.0005$
(c) Significant at $\alpha < 0.005$

STUDENT-NEWMAN-KEULS TEST - DATES ($\alpha = 0.05$)
Largest: 18 DEC 20 NOV 23 OCT 4 DEC 6 NOV 9 OCT 25 SEP 11 SEP 7 AUG 10 JUL 21 AUG 24 JUL:Smallest

STUDENT-NEWMAN-KEULS TEST - PHOTOPERIOD COMPARISON BY DATE ($\alpha = 0.05$)

10 JUL	Largest:	Day Night:	Smallest	9 OCT	Largest:	Night Day:	Smallest
24 JUL	Largest:	Night Day:	Smallest	23 OCT	Largest:	Day Night:	Smallest
7 AUG	Largest:	Night Day:	Smallest	6 NOV	Largest:	Day Night:	Smallest
21 AUG	Largest:	Day Night:	Smallest	20 NOV	Largest:	Night Day:	Smallest
11 SEP	Largest:	Night Day:	Smallest	4 DEC	Largest:	Day Night:	Smallest
25 SEP	Largest:	Day Night:	Smallest	18 DEC	Largest:	Night Day:	Smallest

* Data omitted on dates when plant was off-line.

III. GREEN ALGAE

THREE-WAY ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
STATIONS (INTAKE/DISCHARGE BAYS)	1	0.0306	71	2.7704	0.784 (a)
PHOTOPERIODS (DAY/NIGHT)	1	0.0515	71	3.8918	0.940 (a)
DATES*	11	17.5840	81	4.2658	30.354 (b)
STATIONS X PHOTOPERIODS	1	0.0379	59	2.3206	0.964 (a)
STATIONS X DATES	11	0.4119	59	2.3206	0.952 (a)
PHOTOPERIODS X DATES	11	1.5333	59	2.3206	3.544 (c)
STATIONS X PHOTOPERIODS X DATES	11	0.2809	48	2.0397	0.601 (a)
TOTAL	95	21.9698			

(a) Not Significant at $\alpha = 0.25$
(b) Significant at $\alpha < 0.0005$
(c) Significant at $\alpha < 0.001$

STUDENT-NEWMAN-KEULS TEST - DATES ($\alpha = 0.05$)
Largest: 9 Oct 11 Sep 25 Sep 6 Nov 23 Oct 7 Aug 20 Nov 21 Aug 24 Jul 10 Jul 4 Dec 18 Dec: Smallest

STUDENT-NEWMAN-KEULS TEST - PHOTOPERIOD COMPARISON BY DATE ($\alpha = 0.05$)

a. 10 JUL Largest: Night Day: Smallest
b. 24 JUL Largest: Night Day: Smallest
c. 7 AUG Largest: Night Day: Smallest
d. 21 AUG Largest: Day Night: Smallest
e. 11 SEP Largest: Night Day: Smallest
f. 25 SEP Largest: Night Day: Smallest
g. 9 OCT Largest: Day Night: Smallest
h. 23 OCT Largest: Night Day: Smallest
i. 6 NOV Largest: Night Day: Smallest
j. 20 NOV Largest: Night Day: Smallest
k. 4 DEC Largest: Day Night: Smallest
l. 18 DEC Largest: Night Day: Smallest

IV. BLUE-GREEN ALGAE

THREE-WAY ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
STATIONS (INTAKE/DISCHARGE BAYS)	1	0.0033	71	26.0552	0.009 (a)
PHOTOPERIODS (DAY/NIGHT)	1	0.0241	71	30.4589	0.056 (a)
DATES*	11	20.7134	81	34.3219	4.444 (b)
STATIONS X PHOTOPERIODS	1	0.0222	59	22.1478	0.059 (a)
STATIONS X DATES	11	3.8852	59	22.1478	0.941 (a)
PHOTOPERIODS X DATES	11	8.2889	59	22.1478	2.007 (c)
STATIONS X PHOTOPERIODS X DATES	11	6.5304	48	15.6174	1.825 (d)
TOTAL	95	55.0849			

(a) Not significant at $\alpha = 0.25$
(b) Significant at $\alpha < 0.0005$
(c) Significant at $\alpha < 0.05$
(d) Significant at $\alpha < 0.10$

STUDENT-NEWMAN-KEULS TEST - DATES ($\alpha = 0.05$)
Largest: 11 SEP 7 AUG 20 NOV 6 NOV 24 SEP 21 AUG 25 SEP 9 OCT 4 DEC 10 JUL 18 DEC 23 OCT: Smallest

STUDENT-NEWMAN-KEULS TEST - PHOTOPERIOD COMPARISON BY DATE ($\alpha = 0.05$)

10 JUL Largest: Night Day: Smallest:
24 JUL Largest: Day Night: Smallest:
7 AUG Largest: Day Night: Smallest:
21 AUG Largest: Day Night: Smallest:
11 SEP Largest: Night Day: Smallest:
25 SEP Largest: Night Day: Smallest:
9 OCT Largest: Night Day: Smallest
23 OCT Largest: Night Day: Smallest
6 NOV Largest: Night Day: Smallest
20 NOV Largest: Day Night: Smallest
4 DEC Largest: Day Night: Smallest
18 DEC Largest: Night Day: Smallest

APPENDIX VIII -2

ENTRAINED MICROZOOPLANKTON ABUNDANCE

NINE MILE POINT NUCLEAR STATION UNIT 1 - 1974

DATE	TIME[2]	FLOW[1]	STATION[3]	TOTAL MICROZOOPLANKTON (no. X $10^4/m^3$)	PERCENT COMPOSITION TOTAL MICROZOOPLANKTON ROTIFERS	COPEPODS	CLADOCERANS	PROTOZOANS
9 JAN	D	945	IN	2.754	35.29	23.54	5.88	35.29
	D	945	D	3.450	43.48	17.39	17.39	21.74
	N	945	IN	3.816	55.56	11.11	11.11	22.22
	N	945	D	7.937	22.58	6.45	38.72	32.25
23 JAN	D	945	IN	0.453	24.94	12.58	37.53	24.94
	D	945	D	0.860	52.67	26.28	5.23	15.81
	N	945	IN	3.041	22.66	15.09	24.53	37.72
	N	945	D	1.619	20.01	11.98	59.98	8.03
6 FEB	D	945	IN	0.767	34.29	24.51	3.39	37.81
	D	945	D	1.690	44.62	13.85	1.54	40.00
	N	945	IN	1.015	55.17	27.59	6.90	10.34
	N	945	D	1.228	42.43	12.54	2.52	42.51
20 FEB	D	945	IN	0.474	14.20	64.51	7.10	14.20
	D	945	D	0.937	4.38	34.79	0.00	60.83
	N	945	IN	0.364	18.96	81.04	0.00	0.00
	N	945	D	1.401	5.71	0.00	0.00	94.29
20 MAR	D	945	IN	1.469	59.97	29.07	7.28	3.68
	D	945	D	2.623	24.40	10.83	0.69	64.09
	N	945	IN	1.184	54.05	32.43	0.00	13.51
	N	945	D	0.877	64.31	32.16	0.00	3.53
27 MAR	D	945	IN	2.552	77.66	17.63	0.00	4.70
	D	945	D	1.895	54.83	12.88	0.00	32.30
	N	945	IN	2.754	18.16	19.21	0.00	62.64
	N	945	D	2.820	47.70	12.34	1.52	38.44
10 APR	D	945	IN	3.502	81.27	9.37	0.00	9.37
	D	945	D	3.020	94.37	5.63	0.00	0.00
	N	945	IN	1.910	87.85	10.63	1.52	0.00
	N	945	D	2.002	88.51	11.49	0.00	0.00
24 APR	D	472.5	IN	5.865	78.91	18.93	0.00	2.17
	D	472.5	D	11.255	83.48	5.21	0.00	11.31
	N	472.5	IN	5.780	82.42	14.55	0.61	2.42
	N	472.5	D	5.275	77.14	13.71	1.31	7.85

1 Pumping rate (m^3/min)
2 Time: Day (D); Night (N)
3 Station (Sta): Intake bay (IN); Discharge Bay (D)

APPENDIX VIII - 2 (Continued)

DATE	TIME	FLOW	STATION	TOTAL MICROZOOPLANKTON (no. X $10^4/m^3$)	PERCENT COMPOSITION TOTAL MICROZOOPLANKTON			
					ROTIFERS	COPEPODS	CLADOCERANS	PROTOZOAN
8 MAY	D	945	IN	20.447	83.94	5.35	0.00	10.71
	D	945	D	16.990	71.25	4.67	0.00	24.08
	N	945	IN	22.057	96.46	1.09	0.00	2.45
	N	945	D	11.848	98.90	1.10	0.00	0.00
22 MAY	D	945	IN	4.043	89.12	10.88	0.00	0.00
	D	945	D	3.133	88.51	2.65	0.00	8.84
	N	945	IN	3.289	73.34	26.66	0.00	0.00
	N	945	D	2.358	83.67	16.33	0.00	0.00
5 JUN	D	945	IN	32.357	28.677	1.951	0.042	1.697
	D	945	D	30.411	27.177	0.900	0.000	2.334
	N	945	IN	31.678	29.556	2.046	0.076	0.000
	N	945	D	32.086	29.899	2.187	0.000	0.000
19 JUN	D	945	IN	66.726	39.801	2.049	0.000	24.876
	D	945	D	76.612	55.242	2.617	0.145	18.608
	N	945	IN	42.801	34.795	1.386	0.462	6.158
	N	945	D	89.398	82.323	1.732	0.433	4.910
10 JUL	D	945	IN	44.458	37.048	2.470	4.940	0.000
	D	945	D	67.737	56.415	4.340	6.793	0.189
	N	945	IN	85.401	74.351	2.532	7.827	0.691
	N	945	D	91.494	83.055	2.813	5.626	0.000
24 JUL	D	945	IN	7.240	5.792	1.158	0.290	0.000
	D	945	D	25.358	18.226	7.132	0.000	0.000
	N	945	IN	27.425	16.840	5.613	4.330	0.642
	N	945	D	24.521	17.440	4.721	2.360	0.000
7 AUG	D	945	IN	32.860	14.774	5.604	11.208	1.274
	D	945	D	39.991	21.651	3.821	9.425	5.094
	N	945	IN	78.232	43.302	7.217	7.217	20.496
	N	945	D	49.268	39.260	5.902	4.106	0.000
21 AUG	D	945	IN	47.576	29.242	9.051	2.089	7.194
	D	945	D	45.377	26.981	9.321	0.000	9.075
	N	945	IN	18.245	6.911	8.293	3.041	0.000
	N	945	D	38.166	27.085	9.357	0.739	0.985
11 SEP	D	945	IN	41.609	31.555	7.261	2.793	0.000
	D	945	D	58.438	41.585	10.506	3.721	2.626
	N	945	IN	48.274	40.038	3.408	1.704	3.124
	N	945	D	47.256	42.450	3.471	1.335	0.000

APPENDIX VIII - 2 (Continued)

DATE	TIME	FLOW	STATION	TOTAL MICROZOOPLANKTON (no. X $10^4/m^3$)	PERCENT COMPOSITION TOTAL MICROZOOPLANKTON ROTIFERS	COPEPODS	CLADOCERANS	PROTOZOANS
25 SEP	D	945	IN	7.548	0.590	1.769	3.774	1.415
	D	945	D	6.537	1.783	2.179	1.981	0.594
	N	945	IN	6.963	1.315	3.791	1.857	0.000
	N	945	D	4.601	1.265	2.186	1.035	0.115
9 OCT	D	945	IN	12.905	9.320	3.047	0.000	0.538
	D	945	D	16.388	9.411	2.515	4.300	0.162
	N	945	IN	16.827	10.741	1.551	3.342	1.193
	N	945	D	17.514	11.504	3.091	2.661	0.258
23 OCT	D	945	IN	14.713	13.274	4.359	1.981	0.099
	D	945	D	27.890	17.241	6.085	3.854	0.710
	N	945	IN	12.022	7.514	2.839	1.586	0.083
	N	945	D	19.421	14.256	3.099	1.584	0.482
6 NOV	D	945	IN	5.372	2.245	0.882	0.401	1.844
	D	945	D	3.487	2.408	0.498	0.332	0.249
	N	945	IN	7.625	2.758	1.379	2.109	1.379
	N	945	D	10.880	5.879	1.492	0.877	2.632
20 NOV	D	945	IN	6.502	4.477	0.906	0.586	0.533
	D	945	D	14.584	11.456	1.565	1.389	0.174
	N	945	IN	6.225	4.309	1.163	0.479	0.274
	N	945	D	9.845	7.089	1.969	0.551	0.236
4 DEC	D	945	IN	16.827	1.889	2.661	1.116	11.161
	D	945	D	3.745	1.911	1.070	0.688	0.076
	N	945	IN	3.939	1.630	1.630	0.679	0.000
	N	945	D	3.607	1.508	1.443	0.656	0.000
18 DEC	D	945	IN	14.242	6.074	0.942	0.524	6.702
	D	945	D	13.301	6.321	0.943	0.660	5.377
	N	945	IN	9.843	5.232	0.975	0.355	3.281
	N	934	D	5.454	3.698	1.109	0.370	0.277

APPENDIX VIII-3

ENTRAINED MICROZOOPLANKTON ABUNDANCE

NINE MILE POINT NUCLEAR STATION UNIT 1 - 1974

I. ROTIFERS

THREE-WAY ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
STATIONS (INTAKE/DISCHARGE BAYS)	1	0.0876	125	3.7546	2.916 (a)
PHOTOPERIODS (DAY/NIGHT)	1	0.0344	125	4.5129	0.953 (b)
DATES	20	57.7033	144	4.9468	83.986 (c)
STATIONS X PHOTOPERIODS	1	0.0257	104	3.2693	0.818 (b)
STATIONS X DATES	20	0.4596	104	3.2693	0.731 (b)
PHOTOPERIODS X DATES	20	1.2179	104	3.2693	1.937 (d)
DATES X STATIONS X PHOTOPERIODS	20	0.9224	84	2.3469	1.651 (e)
TOTAL	167	62.7978			

(a) Significant at $\alpha < 0.25$
(b) Not Significant at $\alpha = 0.25$
(c) Significant at $\alpha < 0.0005$
(d) Significant at $\alpha < 0.025$
(e) Significant at $\alpha < 0.10$

II. COPEPODS

THREE WAY ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
STATIONS (INTAKE/DISCHARGE BAYS)	1	0.0226	125	15.0499	0.188 (a)
PHOTOPERIODS (DAY/NIGHT)	1	0.1130	125	16.3528	0.864 (a)
DATES	20	43.0236	144	18.3540	16.878 (b)
STATIONS X PHOTOPERIODS	1	0.0267	104	12.9953	0.214 (a)
STATIONS X DATES	20	2.0279	104	12.9953	0.811 (a)
PHOTOPERIODS X DATES	20	3.3308	104	12.9953	1.333 (c)
DATES X STATIONS X PHOTOPERIODS	20	2.9386	84	10.0567	1.227 (c)
TOTAL	167	61.5399			

(a) Not Significant at $\alpha = 0.25$
(b) Significant at $\alpha < 0.0005$
(c) Significant at $\alpha < 0.25$

APPENDIX VIII-3 (CONTINUED)

III. PROTOZOANS

THREE-WAY ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
STATIONS (INTAKE/DISCHARGE BAYS)	1	4.3933	125	282.7383	1.942 (a)
PHOTOPERIODS (DAY/NIGHT)	1	13.3725	125	278.6972	5.998 (b)
DATES	20	138.0241	144	319.6529	3.109 (c)
STATIONS X PHOTOPERIODS	1	5.0444	104	231.6938	2.264 (a)
STATIONS X DATES	20	46.0001	104	231.6938	1.032 (d)
PHOTOPERIODS X DATES	20	41.9590	104	231.6938	0.942 (d)
DATES X STATIONS X PHOTOPERIODS	20	59.4989	84	172.1949	1.451 (a)
TOTAL	167	480.4871			

(a) Significant at $\alpha < 0.25$
(b) Significant at $\alpha < 0.025$
(c) Significant at $\alpha < 0.0005$
(d) Not Significant at $\alpha = 0.25$

IV. CLADOCERANS

THREE-WAY ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
STATIONS (INTAKE/DISCHARGE BAYS)	1	0.1292	125	95.5743	0.169 (a)
PHOTOPERIODS (DAY/NIGHT)	1	9.6157	125	142.0876	8.459 (b)
DATES	20	348.3756	144	157.7720	15.898 (c)
STATIONS X PHOTOPERIODS	1	0.0340	104	79.8219	0.044 (a)
STATIONS X DATES	20	15.7184	104	79.8219	1.024 (a)
PHOTOPERIODS X DATES	20	62.2317	104	79.8219	4.054 (c)
DATES X STATIONS X PHOTOPERIODS	20	9.7533	84	70.0686	0.585 (a)
TOTAL	167	515.9265			

(a) Not Significant at $\alpha = 0.25$
(b) Significant at $\alpha < 0.005$
(c) Significant at $\alpha < 0.0005$

APPENDIX VIII-4

ENTRAINED MICROZOOPLANKTON MORTALITY

NINE MILE POINT NUCLEAR STATION UNIT 1 - 1974

I. ROTIFERS

THREE-WAY ANALYSIS OF VARIANCE
(Arcsine Transformed)

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
STATIONS (INTAKE/DISCHARGE BAYS)	1	1.2609	154	11.2090	17.324 (a)
PHOTOPERIODS (DAY/NIGHT)	1	0.0420	154	11.2090	0.577 (b)
DATES	23	4.0510	153	11.2088	2.404 (c)
STATIONS X PHOTOPERIODS	1	0.0002	153	11.2088	0.003 (b)
TOTAL	179	16.5630			

(a) Significant at α <0.0005
(b) Not Significant at α = 0.25
(c) Significant at α <0.0025

II. COPEPODS

THREE-WAY ANALYSIS OF VARIANCE
(Arcsine Transformed)

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
STATIONS (INTAKE/DISCHARGE BAYS)	1	2.5007	152	18.3376	20.728 (a)
PHOTOPERIODS (DAY/NIGHT)	1	0.0015	152	18.3376	0.012 (b)
DATES	23	7.5872	151	18.3359	2.717 (a)
STATIONS X PHOTOPERIODS	1	0.0017	151	18.3359	0.014 (b)
TOTAL	177	28.5334			

(a) Significant at α <0.0005
(b) Not Significant at α = 0.25

III. PROTOZOANS

THREE-WAY ANALYSIS OF VARIANCE
(Arcsine Transformed)

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
STATIONS (INTAKE/DISCHARGE BAYS)	1	1.6120	119	28.8831	6.641 (a)
PHOTOPERIODS (DAY/NIGHT)	1	0.5305	119	28.8831	2.186 (b)
DATES	23	11.8609	118	28.6596	2.123 (c)
STATIONS X PHOTOPERIODS	1	0.2235	118	28.6596	0.920 (d)
TOTAL	144	43.4998			

(a) Significant at α < 0.025
(b) Significant at α < 0.25
(c) Significant at α < 0.005
(d) Not significant at α = 0.25

APPENDIX VIII-4 (CONTINUED)

IV. CLADOCERANS

THREE WAY ANALYSIS OF VARIANCE
(Arcsine Transformed)

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
STATIONS (INTAKE/DISCHARGE BAYS)	1	0.6225	110	17.7666	3.854 (a)
PHOTOPERIODS (DAY/NIGHT)	1	0.0864	110	17.7666	0.535 (b)
DATES	23	15.8673	109	17.7173	4.244 (c)
STATIONS X PHOTOPERIODS	1	0.0493	109	17.7173	0.303 (b)
TOTAL	135	34.6858			

(a) Significant at $\alpha < 0.10$
(b) Not significant at $\alpha = 0.25$
(c) Significant at $\alpha < 0.0005$

APPENDIX VIII-5

ENTRAINED MACROZOOPLANKTON ABUNDANCE

NINE MILE POINT NUCLEAR STATION UNIT 1 - 1974

I.

THREE-WAY ANALYSIS OF VARIANCE
(log transformed)

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
STATIONS**	2	0.4506	278	248.0228	0.252 (a)
PHOTOPERIODS*	1	0.2253	269	207.4835	0.292 (a)
DATES[τ]	9	556.9234	285	252.4128	65.869 (b)
STATIONS X PHOTOPERIODS	2	3.4706	258	196.1523	2.287 (c)
STATIONS X DATES	18	48.3999	258	196.1523	3.537 (b)
PHOTOPERIOD X DATES	9	7.8606	258	196.1523	1.149 (a)
STATIONS X PHOTOPERIODS X DATES	18	18.0431	240	178.1092	1.351 (c)
TOTAL	299	813.4826			

*(sliding time scale for day and night periods; values within each period treated as replicate samples.)

(a) Not significant at $\alpha = 0.25$
(b) Significant at $\alpha < 0.0005$
(c) Significant at $\alpha < 0.25$

STUDENT-NEWMAN-KEULS - DATES ($\alpha = 0.05$) (Plant offline April-June)
Largest: 11 Sept 21 Aug 7 Aug 24 Jul 23 Jan 9 Jan 20 Mar 27 Mar 13 Feb 27 Feb: Smallest

STUDENT-NEWMAN-KEULS - STATIONS X DATES ($\alpha = .05$)

9 JAN Largest: I#1 D I#2 : Smallest
23 JAN Largest: I#2 D I#1 : Smallest
14 FEB Largest: I#2 I#1 D : Smallest
27 FEB Largest: D I#2 I#1:Smallest
20 MAR Largest: D I#1 I#2:Smallest
27 MAR Largest: D I#2 I#1: Smallest
24 JUL Largest: I#1 I#2 D : Smallest
7 AUG Largest: I#1 I#2 D : Smallest
21 AUG Largest: I#2 I#1 D : Smallest
9 SEP Largest: I#1 I#2 D : Smallest**

** STATIONS:
I#1 = Intake, mid-depth, middle bay
I#2 = Intake, surface, west bay
D = Discharge, mid-depth, aftbay
Depth change occurs after 11 September 1974
I#1 = Intake, surface, middle bay
I#2 = Intake, mid-depth, west bay
D = Discharge, mid-depth, aftbay

τ = 9 Jan through 11 Sept, 25 Sept through 18 Dec data were omitted from the statistical analysis due to the change in sample depth in the intake forebay (see Appendix VIII-6).
5 June through 10 July data were omitted as no surface sample was taken and the plant was off-line.
10 April through 22 May data were omitted as the plant was off-line.

APPENDIX VIII-6

ENTRAINED MACROZOOPLANKTON (NUMBER/1000m^3)

NINE MILE POINT NUCLEAR STATION UNIT 1 - 1974

DATE	TIME	STATION *	PONTOPORIEA AFFINIS	GAMMARUS FASCIATUS	LEPTODORA KINDTII	DIPTERA	HYDROIDA
9 JAN	D	I#1	0	0	0	0	1094
		I#2	0	0	0	0	109
		D	0	0	0	0	588
	N	I#1	0	0	0	0	765
		I#2	0	0	0	31	402
		D	0	0	0	0	643
23-24 JAN	D	I#1	0	0	0	0	827
		I#2	0	0	0	0	177
		D	0	0	0	0	1,280
	N	I#1	0	0	0	0	2,584
		I#2	0	0	0	0	2,005
		D	0	0	0	0	695
14 FEB	D	I#1	0	0	0	0	0
		I#2	0	0	0	0	82
		D	0	0	0	0	91
	N	I#1	0	0	0	0	245
		I#2	0	0	0	34	654
		D	0	0	0	0	41
27-28 FEB	D	I#1	0	0	0	0	0
		I#2	0	0	0	0	158
		D	0	0	0	0	314
	N	I#1	0	0	0	0	0
		I#2	0	0	0	0	25
		D	0	0	0	0	133
20 - 21 MAR	D	I#1	0	0	0	0	104
		I#2	0	0	0	0	138
		D	0	0	0	0	536
	N	I#1	0	0	0	0	0
		I#2	0	0	0	0	101
		D	0	0	0	0	292
27 MAR	D	I#1	0	0	0	83	629
		I#2	0	0	0	19	317
		D	0	0	0	0	286
	N	I#1	0	0	0	0	0
		I#2	0	0	0	0	263
		D	0	0	0	0	728
10 - 11 APR	D	I#1	0	20	0	0	133
		I#2	0	207	0	0	260
		D	3	14	0	0	369
	N	I#1	0	47	0	0	116
		I#2	0	22	0	0	373
		D	0	44	0	4	534
8 - 9 MAY	D	I#1	0	200	0	0	1,271
		I#2	0	359	0	546	1,279
		D	27	24	0	50	2,708
	N	I#1	690	300	0	0	115
		I#2	0	430	0	0	183
		D	48	101	0	16	1,061

APPENDIX VIII-6 (CONTINUED)

DATE	TIME	STATION *	PONTOPORIEA AFFINIS	GAMMARUS FASCIATUS	LEPTODORA KINDTII	DIPTERA	HYDROIDA
22 - 23 MAY	D	I#1	0	0	0	65	422
		I#2	N.S.	N.S.	N.S.	N.S.	N.S.
		D	0	37	0	10	351
	N	I#1	0	81	0	76	1,235
		I#2	N.S.	N.S.	N.S.	N.S.	N.S.
		D	0	83	0	0	357
5 - 6 JUN	D	I#1	N.S.	N.S.	N.S.	N.S.	N.S.
		I#2	0	29	751	0	414
		D.	0	45	108	7	623
	N	I#1	N.S.	N.S.	N.S.	N.S.	N.S.
		I#2	0	83	514	21	425
		D	0	50	143	7	444
19 - 20 JUN	D	I#1	0	347	6,121	144	12,325
		I#2	N.S.	N.S.	N.S.	N.S.	N.S.
		D.	0	126	1,431	24	1,985
	N	I#1	0	1,332	4,532	0	11,754
		I#2	N.S.	N.S.	N.S.	N.S.	N.S.
		D	0	470	1,675	36	2,021
10 - 11 JUL	D	I#1	0	151	2,041	31	1,845
		I#2	N.S.	N.S.	N.S.	N.S.	N.S.
		D	0	181	1,306	109	511
	N	I#1	0	1,646	8,460	705	30,812
		I#2	N.S.	N.S.	N.S.	N.S.	N.S.
		D.	0	412	2,462	318	561
24 - 25 JUL	D	I#1	0	241	59,956	145	8,429
		I#2	0	113	16,433	82	707
		D	0	102	2,537	119	306
	N	I#1	0	871	30,471	68	3,313
		I#2	0	343	16,245	72	2,678
		D	0	534	3,047	121	427
7 - 8 AUG	D	I#1	0	2,901	152,300	324	5,698
		I#2	0	378	65,928	181	1,619
		D	0	684	13,261	695	472
	N	I#1	0	5,965	198,016	536	5,610
		I#2	0	1,444	95,214	133	1,460
		D	0	1,821	19,164	762	209
21 - 22 AUG	D	I#1	0	8,722	171,918	128	4,178
		I#2	0	588	173,024	54	11,801
		D	115	333	32,055	389	102
	N	I#1	0	7,585	79,920	222	19,021
		I#2	56	4,221	58,633	124	679
		D	382	1,782	16,461	217	291
11 - 12 SEP	D	I#1	0	246	961,330	0	54,548
		I#2	0	85	147,194	0	3,086
		D	0	242	44,523	224	2,188
		I#1	0	0	71,973	345	54,444
		I#2	0	1,566	120,105	435	7,700
		D	8	1,296	50,927	192	3,935

DATE	TIME	STATION*	PONTOPORIEA AFFINIS	GAMMARUS FASCIATUS	LEPTODORA KINDTII	DIPTERA	HYDROIDA
25 - 28 SEP.	D	I#1	0	224	60,785	812	3,988
		I#2	0	289	82,376	0	8,232
		D	0	396	23,169	157	6,000
	N	I#1	0	458	48,742	21	6,932
		I#2	0	991	94,001	0	33,082
		D	18	642	21,031	215	3,676
9 - 10 OCT	D	I#1	0	0	32,291	0	7,494
		I#2	0	0	32,590	0	8,526
		D	0	174	13,579	23	8,979
	N	I#1	0	765	27,964	0	3,581
		I#2	0	491	42,682	0	1,218
		D	0	1,025	11,122	18	5,264
23 - 24 OCT	D	I#1	0	0	7,978	100	8,909
		I#2	0	85	6,509	135	4,422
		D	0	216	2,428	29	4,900
	N	I#1	0	106	3,888	79	4,912
		I#2	0	73	4,279	0	3,477
		D	0	340	2,226	0	11,231
6 - 8 NOV	D	I#1	0	80	13,944	94	4,113
		I#2	0	271	10,985	0	2,948
		D	0	103	4,849	15	3,435
	N	I#1	0	421	7,548	0	2,602
		I#2	0	555	16,019	0	3,550
		D	0	152	4,312	35	4,443
20 - 21 NOV.	D	I#1	0	299	1,985	87	6,003
		I#2	0	417	1,238	0	6,576
		D	0	204	269	0	1,783
	N	I#1	0	526	1,100	0	5,528
		I#2	0	970	2,007	0	4,715
		D	0	1,174	1,575	0	4,002
4 - 5 DEC	D	I#1	0	158	85	0	1,040
		I#2	0	1,030	97	0	231
		D	0	174	129	0	220
	N	I#1	0	710	53	0	1,597
		I#2	0	972	0	0	480
		D	0	431	101	0	251
18 - 19 DEC	D	I#1	0	573	0	0	5,762
		I#2	0	460	0	0	7,953
		D	0	660	0	40	1,408
	N	I#1	0	472	0	0	1,446
		I#2	0	359	0	0	2,266
		D	0	209	0	0	1,255

N.S. = No Sample
Time:
D = Day
N = Night

*Station:
I#1 = Intake, mid-depth, middle bay
I#2 = Intake, surface, west bay
D = Discharge, mid-depth, aftbay
Depth change occurs after 11 September
I#1 = Surface, middle bay
I#2 = Mid-depth, west bay

APPENDIX VIII-7

ENTRAINED ICTHYOPLANKTON ABUNDANCE

NINE MILE POINT NUCLEAR STATION UNIT 1 - 1974

ICHTHYOPLANKTON

THREE-WAY ANALYSIS OF VARIANCE
(log transformed)

SOURCE	DF	SS	DF (ERR)	SS (ERR)	F
STATIONS*	2	0.5313	110	61.4726	0.475 (a)
PHOTOPERIODS (DAY/NIGHT)	1	2.2312	107	50.8048	4.699 (b)
DATES	3	19.0480	111	63.1800	11.155 (c)
STATIONS X PHOTOPERIODS	2	0.3910	102	48.3154	0.413 (a)
STATIONS X DATES	6	12.7662	102	48.3154	4.492 (c)
PHOTOPERIODS X DATES	3	2.0984	102	48.3154	1.477 (d)
STATIONS X PHOTOPERIODS X DATES	6	0.5084	96	47.8070	0.170 (a)
TOTAL	119	85.3816			

(a) Not significant at $\alpha = 0.25$
(b) Significant at $\alpha < 0.05$
(c) Significant at $\alpha < 0.0005$
(d) Significant at $\alpha < 0.25$

STUDENT-NEWMAN-KEULS - DATES (α=0.05)
Largest: 7 AUG 24 JUL 21 AUG 11 SEP

STUDENT-NEWMAN-KEULS - STATION X DATE (each at α = 0.05)

24 Jul Largest: I#1 D I#2: Smallest
7 Aug Largest: D I#2 I#1: Smallest
21 Aug Largest: D I#1 I#2: Smallest
11 Sep Largest: No larvae at any station

* STATIONS:
I#1 = Intake, middle bay, mid-depth
I#2 = Intake, west bay, surface
D = Discharge, aftbay, mid-depth
After 11 September; station change
I#1 = Middle bay, surface
I#2 = West bay, mid-depth

IX. IMPINGEMENT

A. INTRODUCTION

Nine Mile Point Nuclear Power Station Unit 1 is located on the south shore of Lake Ontario in the town of Scriba near Oswego, New York. The unit has been in operation since December 1969 and utilizes once-through condenser cooling. The condenser cooling system requires a flow of 360 million gallons per day (MGD) and the service water pumps circulate an additional 26 MGD. Withdrawal of the 386 MGD total flow from Lake Ontario results in entrainment of lake debris, plankton and fish into the plant forebay; here trash racks and travelling screens remove the fish and large depris to protect the pumps and condenser from clogging. Since impingement of fish at the plant's screens could constitute a significant impact on the Lake Ontario ecosystem, this process requires evaluation.

Preoperational and postoperational biological studies of the lake ecosystem near Nine Mile Point were conducted from 1969 to the present. Specific studies of fish impingement at Unit 1 began in May of 1972. The 1972 impingement study (QLM, 1973) consisted of variable collection periods. Alewives and rainbow smelt dominated the collections (i.e., 45% and 31% of the collection, respectively). However, the collections in 1972 did not include the spring spike in impingement, which was characteristic of subsequent years. The alewives were most numerous in spring and early summer while rainbow smelt were most abundant during the winter. A total of 29 species were identified from the 129 hours of collection during 1972.

During January and February of 1973, samples were collected hourly for a 24-hour period every other week. During March through December, samples were collected hourly for a 24-hour period every week. The report on the 1973 collections (QLM, 1974) confirmed the 1972 dominance and seasonal trends of alewives and rainbow smelt in impingement samples. The species inventory for 1973, based on 1,061 hours of collection, included 37 species. From this data, it was estimated that five million fish, weighing a total of 406,000 lbs, were impinged during 1973. The estimated numbers of impinged alewives and rainbow smelt were compared with the estimated Lake Ontario stocks of these species. Nine Mile Point Unit 1 annual cropping rates were 0.4% for alewives and 0.01% for rainbow smelt.

The specific objectives of the 1974 impingement program were as follows:

to characterize further the seasonal patterns of impingement;
to determine current impingement rates and their relationship to plant factors;
to assess the effect of impingement on the immediate survival and viability of selected species, based on plant and environmental factors;

to evaluate the variability of the annual impingement rate in order to determine the sampling program required for adequate estimation of the annual impingement.

B. MATERIAL AND METHODS

1. Sampling Locations and Procedures

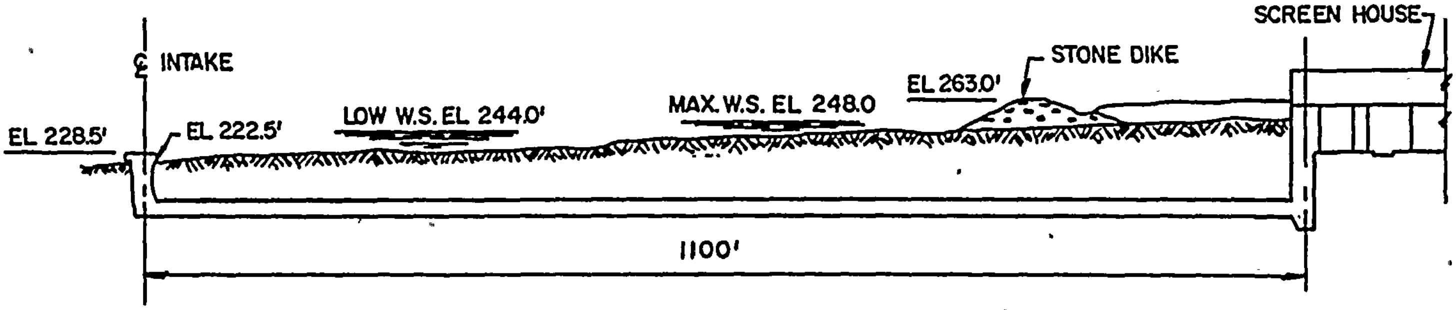
Cooling water for Unit 1 of the Nine Mile Point Nuclear Station is supplied by two circulating water pumps plus two service water pumps with a combined capacity of approximately 386 MGD. The water is withdrawn from Lake Ontario through a submerged intake structure located approximately 850 ft from shore in 24.5 ft of waterlow water datum (LWD). The structure is hexagonal with six slotted ports each 5.5 ft by 10.3 ft (Figure IX-1) resulting in an average inlet approach velocity of 1.8 feet per second (fps). The cooling water flows from the lake structure to the plant via a tunnel (as shown on Figure IX-1) at an average velocity of 7.6 fps, and enters the plant through the intake forebay as illustrated in Figure IX-2. The forebay contains trash racks with bars at six inch spacing, and three vertical travelling screens of 3/8 inch mesh. The average approach velocity to the racks and screens is 0.85 fps. Under normal operating procedures, all screens are simultaneously rotated and backwashed for three minutes every hour. The screens are washed more frequently if clogging occurs within an hour. Screen washings flow through steel and concrete sluiceways into the cooling water discharge bay.

Fish collections were made at two locations during the 1974 studies. A steel mesh basket with slanted sides was submerged in the discharge bay immediately below the sluiceway to collect the fish washings. The basket was lined with 1/4 inch mesh netting and fitted at the top with a removable guard to prevent collected fish from overflowing. A basket of netting was also placed through a hatch in the trough between the middle and east travelling screens to sample impinged fish from the east screen on days when viability studies were conducted.

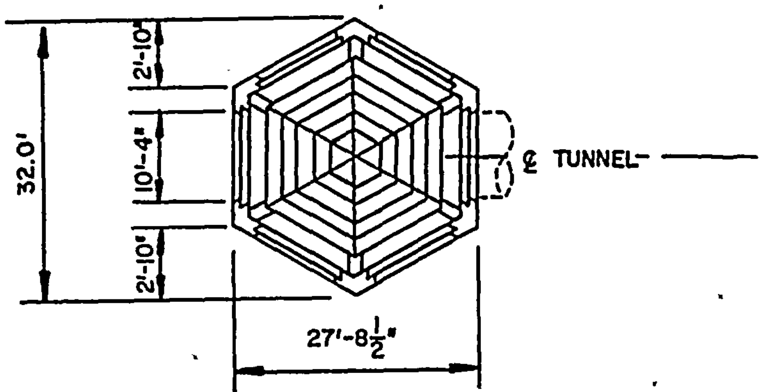
2. Sampling Frequency

Impingement sampling was initiated in January and continued through December. A 24-hour composite sample was collected every Monday and Friday; hourly samples were collected over a 24-hour period on each Wednesday. During periods of increased impingement (more than 20,000 fish in a 24-hour period), the frequency of sampling was increased by instituting daily sampling in addition to the regularly scheduled three-day a week sampling program. This sampling frequency was continued until the number of fish collected dropped below 20,000 fish/day. Fish collected on these additional sampling days were identified to species level and enumerated only.

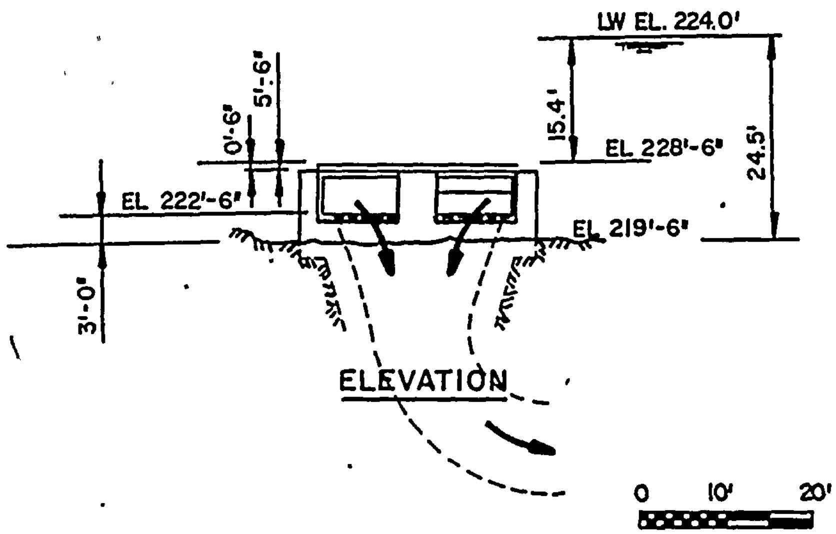
SCHEMATIC DIAGRAM OF THE INTAKE STRUCTURE NINE MILE POINT PLANT, 1974



INTAKE TUNNEL (LOOKING EAST)



PLAN

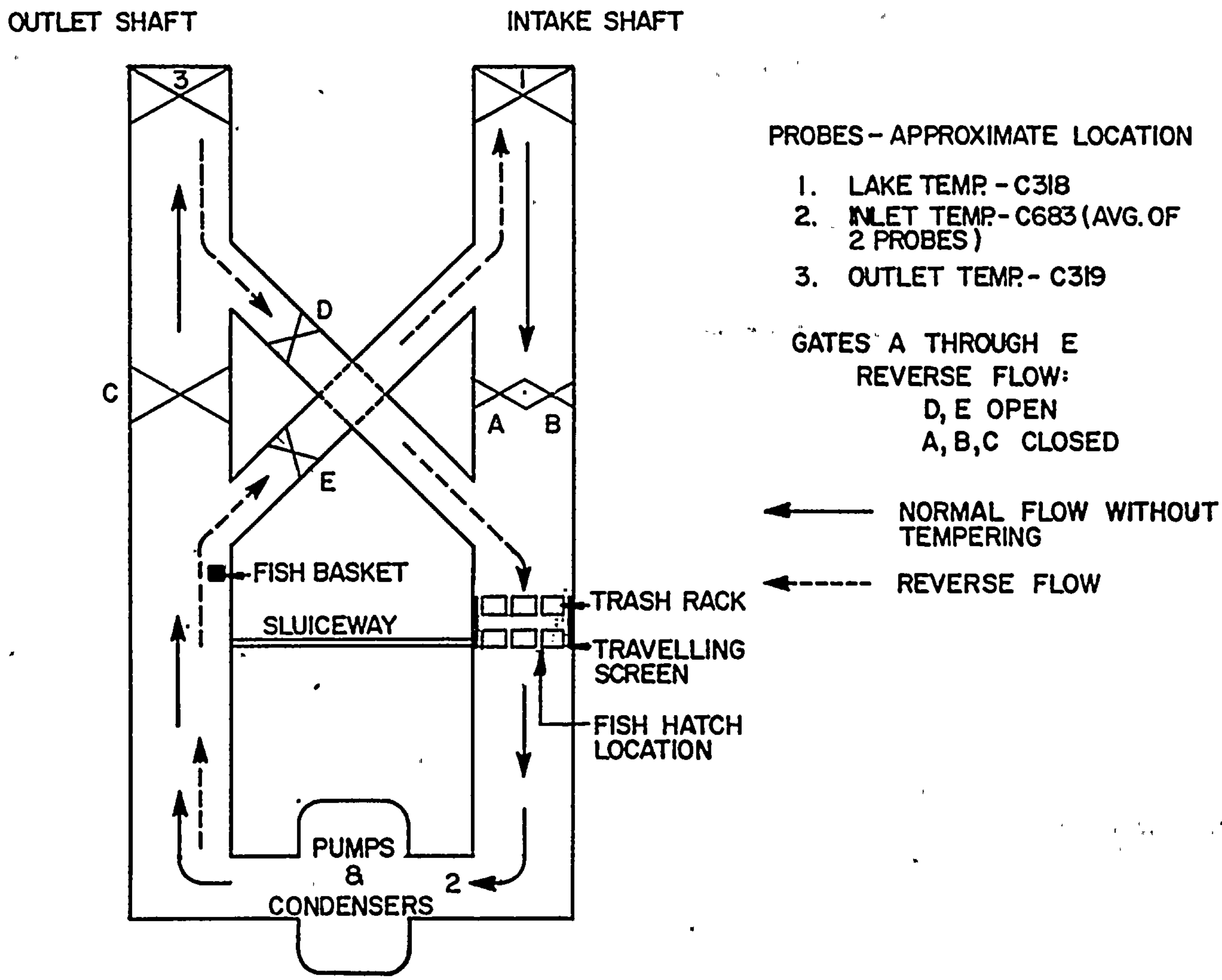


ELEVATION

INTAKE

ALL ELEVATIONS ARE REFERENCED TO USLS 1935 DATUM

SCHEMATIC DIAGRAM OF CIRCULATING WATER FLOW PATTERNS AND TEMPERATURE PROBE LOCATIONS NINE MILE POINT, 1974



3. Method of Collection

a. Composite Daily Collections (Monday and Friday)

During each daily collection the following data were recorded at the initiation and the termination of sampling: water temperature at the intake, discharge, and immediately upstream of the condenser box; percent tempering; number of circulating pumps and travelling screens operating; screen wash cycle and duration; plant output; and ambient weather conditions.

The fish basket was placed in the discharge channel at 1000 hours and remained in place until it was retrieved at 1000 hours the following day. The trash racks and travelling screens were cleared of fish at both initiation and termination of the daily collection so that the catch could be quantified for the collection period. All fish were identified to the species level and enumerated at the plant; if large numbers of fish (>2,000) were collected during one sampling period, each species was randomly subsampled utilizing a random numbers table. The samples were preserved in 10% buffered formalin and returned to the laboratory for analysis and species verification.

b. Hourly Sampling (Wednesday)

The trash racks were cleared before each 24-hour sampling period as described previously. The fish basket was placed in the discharge bay at 1000 hours and was retrieved immediately after each hourly three-minute screen wash for a period of 24 consecutive hours. The fish hatch basket for the east screen was also put in place and retrieved following each hourly wash.

Specimens of those species in addition to alewife and rainbow smelt that were likely to be impinged in numbers in excess of 100 per day were removed from both the hatch basket and the discharge bay basket each hour for the viability study. A maximum of 50 live fish were carefully removed from the collecting baskets with a dip net, and placed in buckets containing intake water at ambient temperature. The contents of the buckets were then gently introduced into a viability pool supplied with circulating ambient water from the intake bay. Fish were observed after 45 minutes and were considered dead when opercular movement was no longer noticeable.

Water samples for dissolved oxygen (DO) determination were taken every four hours from in front of the trash racks and at the fish basket location. These samples were fixed in the field by the azide modification of the Winkler method (A.P.H.A., 1971); they were then transported to the laboratory for titration.

c. Continuous Wash

When the travelling screens were continuously washed due to large Cladophora accumulation or large numbers of impinged fish, the following sampling scheme was instituted:

No. Fish Impinged/Hr.	Sampling Duration at the Fish Basket/Hr.
Less than 2,000	1 hour
2,000 - 8,000	15 Minutes
8,000 - 40,000	3 minutes
More than 40,000	1 minute

During times of continuous wash, sampling at the east screen hatch was not possible. Under these conditions, samples for viability observations were collected every four hours (Wednesday samples only) from the fish basket only; the basket was placed in the discharge bay for 1-15 minutes, depending on the numbers of impinged fish. A maximum of 50 fish were collected and placed in a viability pool; the initial survival, as well as viability after 45 minutes, was recorded.

4. Laboratory Analysis

All fish in hourly impingement collections (Wednesday) were initially identified to the species level and enumerated in the field; these findings were verified in the laboratory, where length (to nearest 0.1 cm), body and gonad weight (to nearest 0.1 g), and sex and sexual maturity of each individual were determined. Scales were removed from individuals of the most abundant species. All fish in daily impingement collections were identified, enumerated, weighed, and measured for length.

In most cases the collections were made from all three travelling screens. However, at times when one or two of the screens were not in operation, the numbers of fish collected were extrapolated assuming uniform impingement among screens. Similarly, during the continuous wash sampling program when subsampling was necessary, the numbers of fish impinged were extrapolated according to the hourly rate. As a result of these two adjustments for subsampling, all data reported herein are the estimated total impingement rates for the plant for the number of hours sampled.

Length-weight relationships were determined for males, females, and the two sexes combined, if an analysis of covariance determined that the sexes were not significantly different. The relationship between length and weight is expressed by the equation:

$$\log W = \log a + b \log L$$

Where: W = weight
L = length
a = y-intercept
b = regression coefficient

C. RESULTS AND DISCUSSION

1. Species Inventory

A total of 48 species were identified in impingement collections during the 1974 sampling program. These species are presented according to taxonomic classification in Table IX-1. Eleven species and one unidentified sucker were collected during 1974 that were not found in 1973 impingement collections. These additional species may reflect the increased collection effort in 1974. The new species consisted of 124 individuals and represented less than 0.01% of the total impingement catch during 1974. The common shiner (*Notropis cornutus*) was the only species not collected in 1974 that had been collected in 1973, when it was represented by 134 individuals.

The estimated number of fish impinged per sampling period per month is presented in Table IX-2 in decreasing order of species abundance. Monthly fish collections were analyzed in terms of fish impinged per hour to facilitate yearly, seasonal, and monthly comparisons. The number of hours sampled each month is listed in Table IX-2 with the annual abundance distribution among species. Table IX-3 presents the estimated weight of fish impinged per sampling period per month.

Alewife and rainbow smelt were the dominant species, contributing nearly 95% of the estimated biomass and 98% of the total abundance. Threespine stickleback were abundant during the period March through July; however, this small fish (average length 51 mm) accounted for only 11.2 kg or 0.10% of the total biomass impinged. Some of the less abundant, but larger fish, such as the white perch and gizzard shad, contributed 1.0% each to the annual biomass, but only 0.5% and 0.2%, respectively, to the estimated total number of fish collected.

The following table compares the annual average characteristics of the impinged fish populations in 1973 with those in 1974:

	% Composition		% Biomass	
	1973	1974	1973	1974
Alewife	97.8	94.4	94.5	91.2
Rainbow smelt	1.6	3.3	1.8	3.8
Others	0.6	2.3	1.3	5.0

TABLE IX-1

SPECIES INVENTORY OF FISHES IN IMPINGEMENT COLLECTIONS

NINE MILE POINT - 1974

SCIENTIFIC NAME*	COMMON NAME
Family Petromyzontidae	
Petromyzon marinus	Sea lamprey
Family Lepisosteidae	
Lepisosteus sp.	Gar**
Family Anguillidae	
Anguilla rostrata	American eel
Family Clupeidae	
Alosa pseudoharengus	Alewife
Dorosoma cepedianum	Gizzard shad
Family Salmonidae	
Salmo trutta	Brown trout
Oncorhynchus kisutch	Coho salmon**
Doregonus artedii	Cisco or Lake herring**
Salvelinus namaycush	Lake trout***
Family Osmeridae	
Osmerus mordax	Rainbow smelt
Family Esocidae	
Esox lucius	Northern pike
Family Cyprinidae	
Carassius auratus	Goldfish
Pimephales promelas	Fathead minnow**
Pimephales notatus	Bluntnose minnow
Semotilus atromaculatus	Creek chub
Umbra limi	Mud minnow
Cyprinus carpio	Carp
Notemigonus crysoleucas	Golden shiner
Rhinichthys cataractae	Longnose dace**
Notropis hudsonius	Spottail shiner
Notropis atherinoides	Emerald shiner
Couesius plumbeus	Lake chub
Semotilus margarita	Pearl dace**
Family Catostomidae	
Catostomus commersoni	White sucker
Catostomus sp.	Sucker (UID)**

TABLE IX-1 (CONTINUED)

SCIENTIFIC NAME*	COMMON NAME
Family Ictaluridae	
Ictalurus nebulosus	Brown bullhead
Icalurus punctatus	Channel catfish
Noturus flavus	Stonecat
Family Percopsidaé	
Percopsis omiscomaycus	Trout perch
Percina caprodes	Log perch
Family Gadidae	
Lota lota	Burbot**
Family Gasterosteidae	
Gasterosteus aculeatus	Threespine stickleback
Culara inconstans	Brook stickleback
Family Cottidae	
Cottus bairdi	Mottled sculpin
Family Percichthyidae	
Morone americana	White perch
Morone chrysops	White bass
Family Centrarchidae	
Ambloplites rupestris	Rock bass
Lepomis macrochirus	Bluegill
Lepomis gibbosus	Pumpkinseed
Micropterus dolomieui	Smallmouth bass
Pomoxis nigromaculatus	Balck crappie
Family Percidae	
Etheostoma nigrum	Johnny Darter
Perca flavescens	Yellow perch
Stizostedion vitreum	Walleye
Family Sciaenidae	
Aplodinotus grunniens	Freshwater drum**
Family Amiidae	
Amia calva	Bowfin**
Family Aphredoderidae	
Aphredoderus sayanus	Pirate perch**

* According to a list of common and scientific names of fishes from the United States and Canada. Amer. Fish. Soc. Spec. Publ. No. 6 3rd ed.

** Not collected during 1973 impingement program.

UID = unidentified species.

ESTIMATED NUMBER OF FISH IMPINGED

DURING SAMPLING PERIODS AT NINE MILE POINT NUCLEAR STATION UNIT 1, 1974

SPECIES	January #	January %	February #	February %	March #	March %	April #	April %	May #	May %	June #	June %
Alewife	305	5.06	165	2.34	435	2.59	63,825	83.91	768,058	97.57	66,867	96.62
Rainbow Smelt	4,324	71.73	3,523	49.91	6,716	40.03	8,424	11.08	14,698	1.87	1,333	1.93
Threespine Stickleback	133	2.21	438	6.21	2,354	14.03	734	0.97	1,471	0.19	514	0.74
White Perch	147	2.44	639	9.05	2,407	14.35	1,516	1.99	140	0.02	10	0.01
Emerald Shiner	126	2.09	324	4.59	1,968	11.73	359	0.47	21	<0.01		
White Bass	310	5.14	841	11.92	1,511	9.01	176	0.23	4	<0.01	3	<0.01
Gizzard Shad	349	5.79	584	8.27	773	4.61	197	0.26	5	<0.01		
Mottled Sculpin	99	1.64	189	2.68	82	0.49	281	0.37	911	0.16	101	0.15
Spottail Shiner	48	0.80	53	0.75	204	1.22	199	0.26	455	0.06	109	0.16
Trout Perch	22	0.36	28	0.40	75	0.45	107	0.14	687	0.09	48	0.07
Johnny Darter	1	0.02					8	0.01	450	0.06	117	0.07
Yellow Perch	89	1.48	125	1.77	90	0.54	77	0.10	59	0.01	12	0.02
Rock Bass	23	0.38	54	0.77	63	0.38	17	0.02	48	0.01	38	0.05
Smallmouth Bass	18	0.30	26	0.37	14	0.08	12	0.02	61	0.01	21	0.03
Brown Bullhead	3	0.05	5	0.07	1	0.01	3	<0.01				
Lake Chub			2	0.03	32	0.19	30	0.04	31	<0.01	5	0.01
Freshwater Drum	14	0.23	31	0.44	17	0.10	1	<0.01				
Stonecat							24	0.03	25	<0.01	2	<0.01
Sea Lamprey	5	0.08	9	0.13	8	0.05	7	0.01	12	<0.01	14	0.02
White Sucker	3	0.05	6	0.09	5	0.03	3	<0.01	2	<0.01		
Bluegill Sunfish	1	0.02	4	0.06	1	0.01	2	<0.01	2	<0.01		
American Eel	1	0.02	1	0.01			2	<0.01	2	<0.01	9	0.01
Logperch					1	0.01	23	0.03	3	<0.01		
Mudminnow	1	0.02	1	0.01	9	0.05	8	0.01	1	<0.01		
Pumpkinseed	1	0.02	3	0.04					2	<0.01		
Lake Trout												
Fathead Minnow							9	0.01	4	<0.01		
Burbot					2	0.01	1	<0.01				
Black Crappie	1	0.02			1	0.01						
Creek Chub			1	0.01	2	0.01	2	<0.01	2	<0.01		
Goldfish	1	0.02	2	0.03	2	0.01	4	<0.01				
Channel Catfish			1	0.01	1	0.01	2	<0.01				
Brook Stickleback							3	<0.01				
Notropis spp.					1	0.01	3	<0.01				
Cisco	1	0.02										
Northern Pike					1	0.01						
Bowfin			1	0.01	1	0.01						
Carp	1	0.02	1	0.01								
Coho Salmon												
Longnose Dace			1	0.01								
Gar												
Bluntnose Minnow												
Brown Trout					1	0.01						
Golden Shiner												
Pearl Dace												
Pirate Perch	1	0.02										
Sucker UID												
Walleye							1	<0.01				
TOTAL	6,028		7,058		16,778		76,060		787,154		69,203	
# Hrs. Sampled	288		288		312		336		528		290	
Avg. #/Hr.	20.9		24.5		53.8		226.4		1,490.8		238.6	

TABLE IR-2 Continued

ESTIMATED NUMBER OF FISH IMPINGED

SPECIES	July #	July %	August #	August %	September #	September %	October #	October %	November #	November %	December #	December %	Annual Total #	Annual Total %
Alewife	67,446	97.39	132,613	99.77	29,561	94.35	10,426	95.92	13,164	97.34	28,284	91.02	1,181,149	94.40
Rainbow Smelt	186	0.27	142	0.11	277	0.88	127	1.17	187	1.38	1,770	5.70	41,707	3.33
Threespine Stickleback	1,039	1.50			2	0.01	4	0.04			25	0.08	6,714	0.54
White Perch	5	0.01	3	<0.01	1,223	3.90	105	0.97	20	0.15	146	0.47	6,361	0.51
Emerald Shiner			1	<0.01	2	0.01	7	0.06	3	0.02	128	0.41	2,939	0.23
White Bass					1	<0.01					4	0.01	2,850	0.23
Gizzard Shad	1	<0.01			1	<0.01	10	0.09	81	0.60	485	1.56	2,486	0.20
Mottled Sculpin	134	0.19	21	0.02	124	0.40	69	0.63	22	0.16	62	0.20	2,095	0.17
Spottail Shiner	140	0.20	37	0.03	43	0.14	14	0.13	7	0.05	39	0.13	1,348	0.11
Trout Perch	105	0.15	17	0.01	1	<0.01					5	0.02	1,095	0.09
Johnny Darter	94	0.14	4	<0.01	15	0.05	2	0.02	2	0.01			693	0.06
Yellow Perch	43	0.06	49	0.04	34	0.11	14	0.13	7	0.05	48	0.15	647	0.05
Rock Bass	10	0.01	6	<0.01	6	0.02	1	0.01	3	0.02	13	0.04	282	0.02
Smallmouth Bass	8	0.01	7	0.01	1	<0.01			1	0.01	3	0.01	172	0.01
Brown Bullhead					6	0.02	68	0.63	13	0.10	12	0.04	111	0.01
Lake Chub	7	0.01	1	<0.01	1	<0.01							109	0.01
Freshwater Drum									1	0.01	1	<0.01	65	0.01
Stonecat	6	0.01	1	<0.01	3	0.01	1	0.01	1	0.01	1	<0.01	64	0.01
Sea Lamprey									1	0.01	2	0.01	58	<0.01
White Sucker	4	0.01	7	0.01	3	0.01	15	0.14			1	<0.01	49	<0.01
Bluegill Sunfish	3	<0.01			16	0.05	4	0.04	1	0.01	3	0.01	37	<0.01
American Eel	5	0.01	2	<0.01	5	0.02	2	0.02	1	0.01	3	0.01	33	<0.01
Logperch													27	<0.01
Mudminnow	1	<0.01									2	0.01	23	<0.01
Pumpkinseed	2	<0.01			2	0.01			2	0.01	10	0.03	22	<0.01
Lake Trout									5	0.04	16	0.05	21	<0.01
Fathead Minnow													13	<0.01
Burbot	2	<0.01	2	<0.01	4	0.01	1	0.01					12	<0.01
Black Crappie											8	0.03	10	<0.01
Creek Chub	2	<0.01											9	<0.01
Goldfish													9	<0.01
Channel Catfish											2	0.01	6	<0.01
Brook Stickleback	2	<0.01											5	<0.01
Notropis spp.	1	<0.01											5	<0.01
Cisco					1	<0.01			1	0.01			3	<0.01
Northern Pike	1	<0.01	1	<0.01									3	<0.01
Bowfin													2	<0.01
Carp													2	<0.01
Coho Salmon	1	<0.01	1	<0.01									2	<0.01
Longnose Dace	1	<0.01											2	<0.01
Gar									1	0.01	1	<0.01	2	<0.01
Bluntnose Minnow	1	<0.01											1	<0.01
Brown Trout													1	<0.01
Golden Shiner			1	<0.01									1	<0.01
Pearl Dace	1	<0.01											1	<0.01
Pirate Perch													1	<0.01
Sucker UID	1	<0.01											1	<0.01
Walleye													1	<0.01
TOTAL	69,252		132,916		31,332		10,870		13,524		31,074		1,251,249	
#Hrs. Sampled	338		360		312		312		312		312			
Avg. #/Hr.	204.9		369.2		100.4		34.8		43.3		99.6			

TABLE IX-3

ESTIMATED BIOMASS (g) OF FISH IMPINGED
DURING SAMPLING PERIODS AT
NINE MILE POINT NUCLEAR STATION UNIT 1, 1974

Species	January Biomass	January %	February Biomass	February %	March Biomass	March %	April** Biomass	April** %	May** Biomass	May** %	June Biomass	June %
Alewife	8,385.9	11.13	4,517.1	3.68	11,655.8	4.03	1,319,355.2	86.45	3,654,735.5	97.03	771,091.4	94.92
Rainbow Smelt	29,757.5	39.50	37,876.1	30.87	116,730.0	40.37	140,375.7	9.20	68,559.1	1.82	7,795.4	0.96
Threespine Stickleback	239.3	0.32	825.0	0.67	4,279.2	1.48	1,459.7	0.10	1,785.1	0.05	1,037.4	0.13
White Perch	5,024.8	6.67	14,978.3	12.21	61,180.1	21.16	27,257.7	1.79	3,409.1	0.09	494.1	0.06
Emerald Shiner	500.3	0.66	1,234.8	1.01	9,056.9*	3.13	1,478.7	0.10	63.5	<0.01		
White Bass	3,403.4	4.52	12,530.9	10.21	22,661.5*	7.84	2,667.1	0.17	566.7	0.02	1,392.3	0.17
Gizzard Shad	10,685.4	14.18	20,806.2	16.96	28,745.3*	9.94	8,823.2	0.58	80.9	<0.01		
Mottled Sculpin	379.7	0.50	830.6	0.68	418.0	0.14	1,141.8	0.07	2,217.4	0.06	297.8	0.04
Spottail Shiner	403.3	0.54	410.4*	0.33	1,308.5*	0.45	1,505.2	0.10	1,806.5	0.05	1,728.6	0.21
Trout Perch	140.9	0.19	273.6	0.22	612.7	0.21	943.6	0.06	4,346.7	0.12	506.0	0.06
Johnny Darter	3.3	<0.01					23.2	<0.01	962.0	0.03	228.7	0.03
Yellow Perch	5,121.6	6.80	7,348.8	5.99	10,238.3*	3.54	6,687.3	0.44	2,636.0	0.07	839.1	0.10
Rock Bass	3,147.6	4.18	11,405.2*	9.30	7,685.2*	2.66	2,669.6	0.17	7,425.2	0.20	10,488.6	1.29
Smallmouth Bass	890.6	1.18	2,554.7	2.08	4,002.0*	1.38	6,163.5	0.40	16,386.8	C.44	9,484.5	1.17
Brown Bullhead	325.2	0.43	273.0	0.22	*		637.6	0.04				
Lake Chub			60.9	0.05	806.6	0.28	962.9	0.06	270.5	0.01	113.0	0.01
Freshwater Drum	304.6	0.40	1,024.9	0.84	432.5	0.15						
Stonecat							673.7	0.04	379.9	0.01	19.1	<0.01
Sea Lamprey	870.0	1.15	1,611.8	1.31	622.2*	0.22	658.2	0.04	466.1	0.01	2,126.2	0.26
White Sucker	3,341.2	4.44	2,667.3*	2.17	4,281.8*	1.48	791.4	0.05				
Bluegill Sunfish	2.2	<0.01	65.5	0.05	5.4	<0.01	7.1	<0.01	3.2	<0.01		
American Eel	1,203.2	1.60	200.0	0.16			606.0	0.04	343.3	0.01	4,741.6	0.58
Logperch					18.7	0.01	206.9	0.01				
Mudminnow	6.0	0.01	7.8	0.01	37.0	0.01	52.4	<0.01				
Pumpkinseed	32.5	0.04	58.7	0.05					164.4	<0.01		
Lake Trout												
Fathead Minnow							26.5	<0.01	18.8	<0.01		
Burbot					2,417.0	0.84	78.0	0.01				
Black Crappie	3.0	<0.01			12.5	<0.01						
Creek Chub			26.6	0.02	13.7*	<0.01	4.6	<0.01				
Goldfish	24.4	0.03	350.4	0.29	454.5	0.16	494.0	0.03				
Channel Catfish					6.1	<0.01	16.7	<0.01				
Brook Stickleback							3.5	<0.01				
Notropis spp.					*		5.4	<0.01				
Cisco	70.7	0.09										
Northern Pike					296.2	0.10						
Bowfin			700.7	0.57	345.0	0.12						
Carp	1,053.5	1.40	38.7	0.03								
Coho Salmon												
Longnose Dace			2.5	<0.01								
Gar												
Bluntnose Minnow												
Brown Trout					851.3	0.29						
Golden Shiner												
Pearl Dace												
Pirate Perch	9.0	0.01										
Sucker UID												
Walleye							394.2	0.03				
TOTAL	75,329.1		122,680.5		289,174.0		1,526,170.6		3,766,626.7		812,383.8	

*All enumerated fish not weighed.
**Dates samples were not weighed: 4/27, 5/2, 5/7, 5/9, 5/14, 5/16, 5/18, 5/25, 5/30.

TABLE IX-3 Continued

ESTIMATED BIOMASS (g) OF FISH IMPINGED

Species	July** Biomass	%	August** Biomass	%	September Biomass	%	October Biomass	%	November Biomass	%	December Biomass	%	Annual Total Biomass	%
Alewife	1,187,882.1	98.57	1,755,565.6	99.17	578,513.9	96.55	182,071.6	88.82	236,900.0	95.71	658,979.7	87.96	10,369,653.8	91.21
Rainbow Smelt	746.2	0.06	328.4	0.02	2,274.5	0.38	1,880.5	0.92	3,112.9	1.26	22,404.1	2.99	431,840.4	3.80
Threespine Stickleback	1,495.2	0.12			2.5	<0.01	5.9	<0.01			49.5	0.01	11,178.8	0.10
White Perch	437.7	0.04	143.6	0.01	6,960.6	1.16	893.5	0.44	187.5	0.08	7,919.5	1.06	128,886.5	1.13
Emerald Shiner			13.0	<0.01	8.6	<0.01	25.4	0.01	15.8	0.01	744.1	0.10	13,141.1	0.12
White Bass					22.0	<0.01					272.5	0.04	43,516.4	0.38
Gizzard Shad					2.5	<0.01	812.9	0.40	5,113.0	2.07	42,774.3	5.71	117,843.7	1.04
Mottled Sculpin	325.2	0.03	62.3	<0.01	453.7	0.08	281.1	0.14	81.3	0.03	306.3	0.04	6,795.2	0.06
Spottail Shiner	1,201.6	0.10	341.4	0.02	403.7	0.07	181.9	0.09	104.3	0.04	580.4	0.08	9,975.8	0.09
Trout Perch	503.6	0.04	98.5	0.01	15.8	<0.01					52.1	0.01	7,493.5	0.07
Johnny Darter	151.8	0.01	4.2	<0.01	35.4	0.01	3.8	<0.01	2.6	<0.01			1,415.0	0.01
Yellow Perch	3,354.4	0.28	4,179.4	0.24	3,667.5	0.61	1,435.3	0.70	384.5	0.16	4,934.3	0.66	50,826.5	0.45
Rock Bass	2,073.1	0.17	996.7	0.06	1,305.1	0.22	296.5	0.14	291.9	0.12	3,223.3	0.43	51,008.0	0.45
Smallmouth Bass	1,051.4	0.09	2,642.5	0.15	4.4	<0.01			8.1	<0.01	517.1	0.07	43,705.6	0.38
Brown Bullhead					788.5	0.13	7,207.4	3.52	825.6	0.33	627.9	0.08	10,685.2	0.09
Lake Chub	125.3	0.01	20.0	<0.01	3.7	<0.01							2,362.9	0.02
Freshwater Drum									18.1	0.01	18.1	<0.01	1,798.2	0.02
Stonecat	224.8	0.02	119.2	0.01	135.4	0.02	13.8	0.01	8.2	<0.01	20.1	<0.01	1,594.2	0.01
Sea Lamprey									201.7	0.08	562.3	0.08	7,118.5	0.06
White Sucker	3,317.6	0.28	4,155.7	0.23	2,662.0	0.44	8,823.5	4.30			1,024.5	0.14	31,065.0	0.27
Bluegill Sunfish	5.3	<0.01			49.5	0.01	137.5	0.07	27.6	0.01	4.6	<0.01	307.9	<0.01
American Eel	125.6	0.01			375.7	0.06	691.4	0.34			1,627.8	0.22	9,914.6	0.09
Logperch													225.6	<0.01
Mudminnow	3.2	<0.01									16.0	<0.01	122.4	<0.01
Pumpkinseed	2.1	<0.01			43.0	0.01			43.6	0.02	230.0	0.03	574.3	0.01
Lake Trout									88.0	0.04	208.3	0.03	296.3	<0.01
Fathead Minnow													45.3	<0.01
Burbot	206.2	0.02	199.3	0.01	551.7	0.09	220.6	0.11					3,672.8	0.03
Black Crappie											16.9	<0.01	32.4	<0.01
Creek Chub	10.7	<0.01											55.6	<0.01
Goldfish													1,323.3	0.01
Channel Catfish											29.9	0.27	52.7	<0.01
Brook Stickleback	0.6	<0.01											4.1	<0.01
Notropis spp.													5.4	<0.01
Cisco					933.4	0.16			55.0	0.02			1,059.1	0.01
Northern Pike			72.6	<0.01									368.8	<0.01
Bowfin													1,045.7	0.01
Carp													1,092.2	0.01
Coho Salmon	1,865.2	0.15	1,161.7	0.07									3,026.9	0.03
Longnose Dace	2.4	<0.01											4.9	<0.01
Gar									37.4	0.02	2,000.0	0.27	2,037.4	0.02
Bluntnose Minnow	2.7	<0.01											2.7	<0.01
Brown Trout													851.3	0.01
Golden Shiner			125.1	0.01									125.1	<0.01
Pearl Dace													--	
Pirate Perch													9.0	<0.01
Sucker UID													--	
Walleye													394.2	<0.01
TOTAL:	1,205,114.0		1,770,229.2		599,213.1		204,982.6		247,507.1		749,143.6		11,368,554.3	

*All enumerated fish not weighed.

**Samples not weighed: 7/15, 8/13, 8/15.

For both years the percentages of abundance and biomass r
by the two dominant species and other species were simila
high percentage values for the dominant species and high
between years suggests that similar environmental conditi
on a seasonal cycle over the two study years.

2. Seasonal Patterns of Impingement

The seasonal patterns of impingement were examined to det
trends of occurrence of various species. For the purpose
data interpretation, the months were grouped into the fol
winter, January-March; spring, April-June; summer, July-S
fall, October-December.

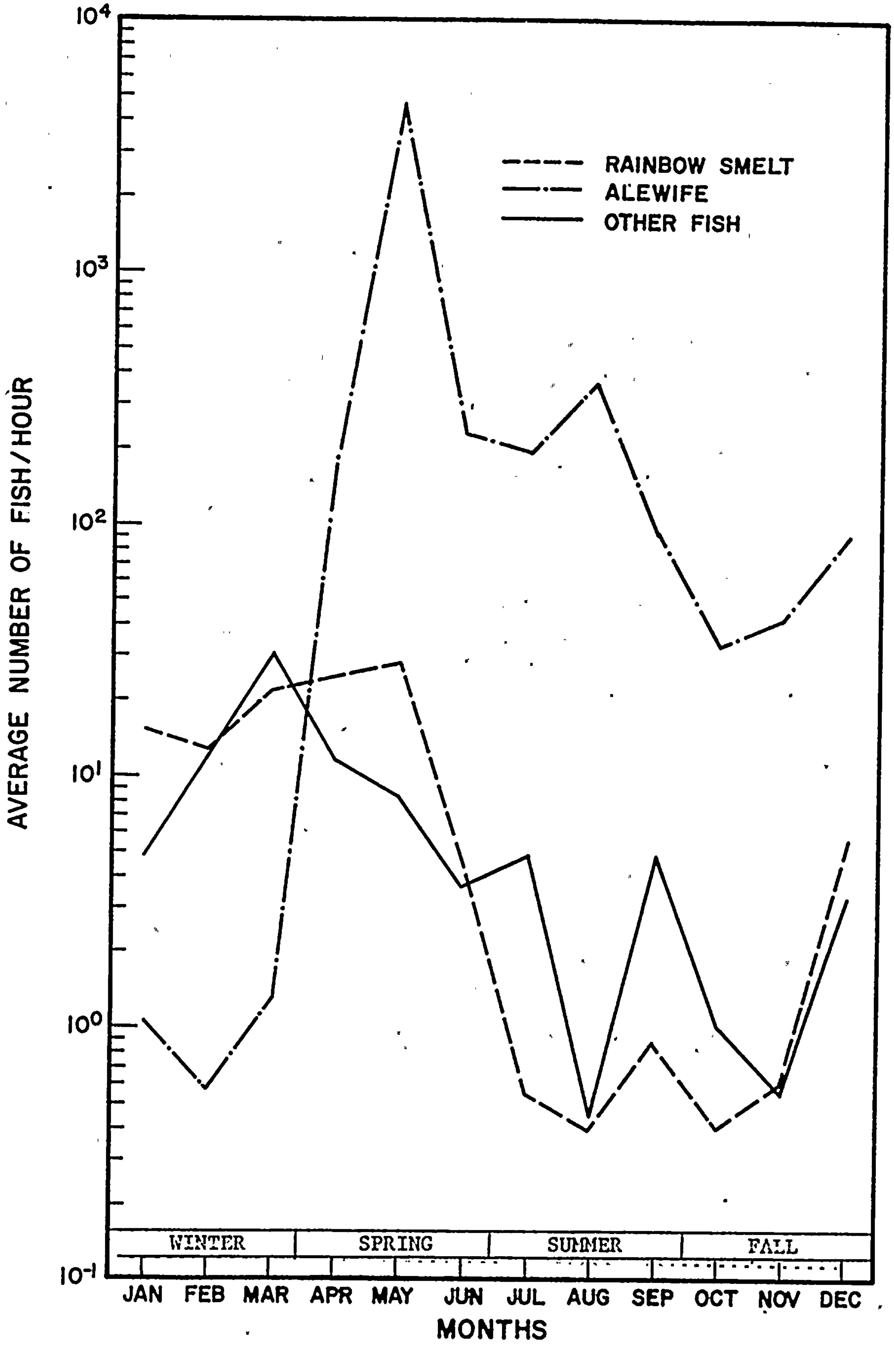
a. Abundance

Alewives and rainbow smelt represented 94.4% and 3.3%
of all impinged fish sampled during 1974. The remain
of the fish were divided among 46 species. Alewives
the impingement catch from spring through fall during
rainbow smelt dominated the winter collections, parti
in January (71.7% of the sample). Other species of r
importance during the winter were white bass and giz
which together provided 10.9% of the catch during Ja
second most abundant species (after rainbow smelt) i
and March was white bass, which represented 11.9% an
the samples in these months, respectively. The impi
emerald shiner, threespine stickleback, and white pe
steadily during the winter, with their maximum year
recorded during March.

Seasonal fluctuations were observed in fish impinge
(fish/hour) during 1974. The general trend was for
low average impingement rates during the winter ($\overline{X}$
hour), followed by a maximum during the spring ($\overline{X}$
hour), the latter attributable largely to alewives
ment then steadily decreased during the summer ($\overline{X}$
hour), after which a sharp decrease was noted in t
= 59.2 fish/hour).

Because the seasonal trends reflected primarily t
of the two dominant species, alewife and rainbow
for the other species were masked; therefore, the
rate for species other than alewife and rainbow s
the two dominant species were calculated separat
basis. The 12-month impingement for the three g
as the average number of fish impinged per hour
IX-3.

AVERAGE NUMBER OF FISH IMPINGED PER HOUR
NINE MILE POINT
1974



Alewives exhibited very low impingement rates during the winter months; these rates increased rapidly in April and peaked during the month of May. The average monthly impingement of alewives declined during June to a level of approximately 100 fish/hour through the early summer months. Impingement dropped in September and October with a resulting average impingement rate during the fall of approximately 15 fish/hour. The seasonal increase of alewives in impingement collections was probably related to their inshore spawning migrations. Norden (1967) and Wells (1968) reported the period from the middle of March through May as the time of peak migration of Lake Michigan alewives from deeper water to the shallower shore zone to spawn. Graham (1956) observed migration of alewives to the inshore area in western Lake Ontario during April with maximum numbers recorded during June. Following spawning, the adult alewife population moves offshore into deeper waters during mid-September (Graham, 1956); similar offshore migrations of alewives (to depths of 20 fathoms during late summer) were observed by Christie (1973).

Rainbow smelt impingement reached its peak during the May collections, averaging approximately 22 fish/hour. During the period from January to May, similar monthly impingement averages were exhibited, reflecting the migratory movement of smelt to the near-shore area in preparation for the spring spawning movement to streams and rivers (Wells, 1968; Scott and Crossman, 1973). Impingement of rainbow smelt declined during June, with the lowest average impingement values recorded during the summer/early fall months. Numbers of rainbow smelt impinged per hour increased in December.

The seasonal cycles of impingement for alewife and rainbow smelt, expressed as the average number of fish impinged per hour on a monthly basis in the years 1972, 1973, and 1974, are listed in Table IX-4. Alewife impingement reached a peak rate in late April 1973, and in early May 1974. The occurrence of the peak rate in 1972 is uncertain due to a lack of sampling from January through April. Rainbow smelt impingement rates fluctuated over the three years; however, the periods of peak impingement corresponded to late fall through early spring.

A primary control parameter in fish movement is ambient water temperature (Bardach and Bjorklund, 1957). Table IX-5 lists the impingement rates and the intake water temperatures determined for the Wednesday collections. The annual cycles of both impingement and water temperature are apparent. Periods of peak alewife abundance, which were similar between years, were probably related to the general warming trend of the water during the spring months

TABLE IX-4

MONTHLY FISH IMPINGEMENT RATES+
AT NINE MILE POINT NUCLEAR STATION UNIT I

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Alewife	1972	N.S.	N.S.	N.S.	N.S.	78.5	289.3	56.1	13.1	3.0	7.4	3.4	0.1
	1973	0.1	0.3	592.5	5841.4	166.1	123.0	28.4	0.6	2.2	1.8	28.3	38.5
	1974	1.0	0.6	1.4	190.0	1454.6	230.5	199.6	368.4	94.7	33.4	42.2	90.6
Rainbow Smelt	1972	N.S.	N.S.	N.S.	N.S.	27.4	245.3	17.0	1.4	1.0	4.3	0.3	16.1
	1973	47.9	5.3	10.9	12.9	9.5	5.4	2.6	0.2	2.5	1.7	18.7	33.3
	1974	15.0	12.2	21.5	25.1	27.9	4.6	0.6	0.4	0.9	0.4	0.6	5.7

+Number/hour

N.S. = No sample

TABLE IX-5

INTAKE TEMPERATURE AND IMPINGEMENT RATE FOR WEDNESDAY COLLECTIONS AT NINE MILE POINT UNIT 1, 1974

DATE [1]	LAKE TEMPERATURE [2] (°F)	ESTIMATED FISH IMPINGEMENT [3] (FISH/HR.)
2 JAN	35.70	75.37
9 JAN	34.20	30.50
16 JAN	32.60	19.43
23 JAN	35.73	10.13
30 JAN	37.61	17.27
6 FEB	35.67	5.17
13 FEB	32.45	29.42
20 FEB	32.63	12.96
27 FEB	34.08	69.79
6 MAR	37.47	10.28
13 MAR	34.54	19.71
20 MAR	N.D.	45.88
27 MAR	32.74	114.49
3 APR	35.91	61.32
10 APR	35.70	195.33
17 APR	42.82	333.17
24 APR	45.45	470.88
1 MAY	45.95	824.75
8 MAY	44.49	1126.54
15 MAY	45.93	103.00
22 MAY	52.47	136.72
29 MAY	51.75	691.42
5 JUN	51.83	182.46
12 JUN	53.68	71.05
19 JUN	57.52	186.44
26 JUN	55.70	174.85
3 JUL	62.55	150.45
10 JUL	67.21	223.79
17 JUL	67.75	236.58
24 JUL	66.77	43.29
31 JUL	67.40	96.32
7 AUG	68.86	27.84
14 AUG	58.03	760.75
21 AUG	70.64	308.71
28 AUG	72.56	37.25
4 SEP	51.04	75.46
11 SEP	68.29	106.99
18 SEP	65.84	42.46
25 SEP	63.05	22.89
2 OCT	58.46	26.33
9 OCT	56.33	67.75
16 OCT	53.34	39.58
23 OCT	51.63	42.71
30 OCT	50.11	41.17
6 NOV	48.48	28.83
13 NOV	46.69	24.13
20 NOV	44.49	36.79
27 NOV	43.30	32.54
4 DEC	40.27	8.67
11 DEC	37.61	31.79
18 DEC	34.22	194.63
25 DEC	34.88	43.61

[1] beginning of 24 hr. sample
[2] plant generation data - daily average of temperature at discrete times (1000,1600, 2200, 0400, 1000 hrs.)
N.D. = no data available
[3] based on 3 screens operation

and its indirect result on other parameters such as available food sources. Rainbow smelt were impinged at greater rates when the water temperature was low and were impinged less frequently during the summer/early fall months when temperatures were warmer.

In general, maximum impingement for all species except alewife and rainbow smelt occurred during the winter months of 1974; after this peak, a steady decline in impingement followed during the spring/early summer months. The greatest average monthly impingement was observed during March (31 fish/hour), primarily due to the presence of threespine stickleback, white perch, and the emerald shiner; white bass also reached its maximum impingement level during the month of March (Table IX-2). Miller (1960) observed the spawning of gizzard shad from late winter through summer, and this may be correlated with the presence of gizzard shad in increased numbers in impingement collections from December through March.

A small increase in impingement was observed during the late summer/early fall period as a result of greater impingement of white perch. The same trend in abundance for species other than alewife and rainbow smelt was observed in 1973 (QLM, 1974); however, the spring peak in impingement occurred in March of 1974, compared with April of 1973. In 1973, a peak in impingement occurred in November which exceeded the April peak.

b. Biomass

The estimated biomass of impinged fish is presented by month in Table IX-3. Alewives contributed 91.2% of the total biomass collected during 1974 and rainbow smelt contributed 3.8%. Seasonal trends of species dominance as determined by biomass were similar to those indicated for abundance, i.e., an increase in biomass of impinged fish during winter, a yearly maximum during spring, and a steady decline during summer and fall. Alewives contributed more than 85% of the total biomass during spring through fall. During winter, rainbow smelt composed the greatest part of fish biomass (>30%), followed by gizzard shad and white perch, which contributed 13% each. Alewives constituted only 6% of the total biomass during winter.

To evaluate the seasonal trends in fish species biomass, the average weight of the dominant species was calculated for each month and presented in Table IX-6. The dominant species (i.e., alewife, rainbow smelt, smallmouth bass, yellow perch, and white perch) were collected during most of the year, permitting trends in average weight to be determined. Where sufficient data were available, the average biomass was related to monthly length frequency intervals.

TABLE IX-6

AVERAGE WEIGHT OF IMPINGED FISH FOR SCHEDULED COLLECTIONS+

NINE MILE POINT - 1974

DOMINANT SPECIES

MONTH	ALEWIFE		RAINBOW SMELT		SMALLMOUTH BASS		YELLOW PERCH		WHITE PERCH	
	AVERAGE WEIGHT*	N	AVERAGE WEIGHT	N	AVERAGE WEIGHT	N	AVERAGE WEIGHT	N	AVERAGE WEIGHT	N
JAN	27.5	305	6.9	4324	49.5	18	57.5	89	34.2	147
FEB	27.4	165	10.8	3523	98.3	26	58.8	125	23.4	639
MAR	26.8	435	17.4	6716	307.8	13	116.3	88	25.4	2407
APR	22.2	59301	17.1	8215	513.6	12	90.4	74	18.0	1514
MAY	10.2	358663	7.7	8874	512.1	32	82.4	32	46.1	74
JUN	11.5	66867	5.8	1333	451.6	21	69.9	12	49.4	10
JUL	20.0	59288	4.1	180	210.3	5	93.2	36	109.4	4
AUG	19.8	88528	7.6	43	440.4	6	104.5	40	71.8	2
SEP	19.6	29561	8.2	277	4.4	1	107.9	34	5.7	1223
OCT	17.5	10426	14.8	127	—	—	102.5	14	8.5	105
NOV	19.5	12163	16.6	187	8.1	1	54.9	7	9.4	20
DEC	23.3	28284	12.7	1770	172.4	3	102.8	48	54.2	146

Average weight of all fish (weighed) impinged in 1974 = 14.6

+ = Monday, Wednesday and Friday collections.
N = Number of fish weighed/month

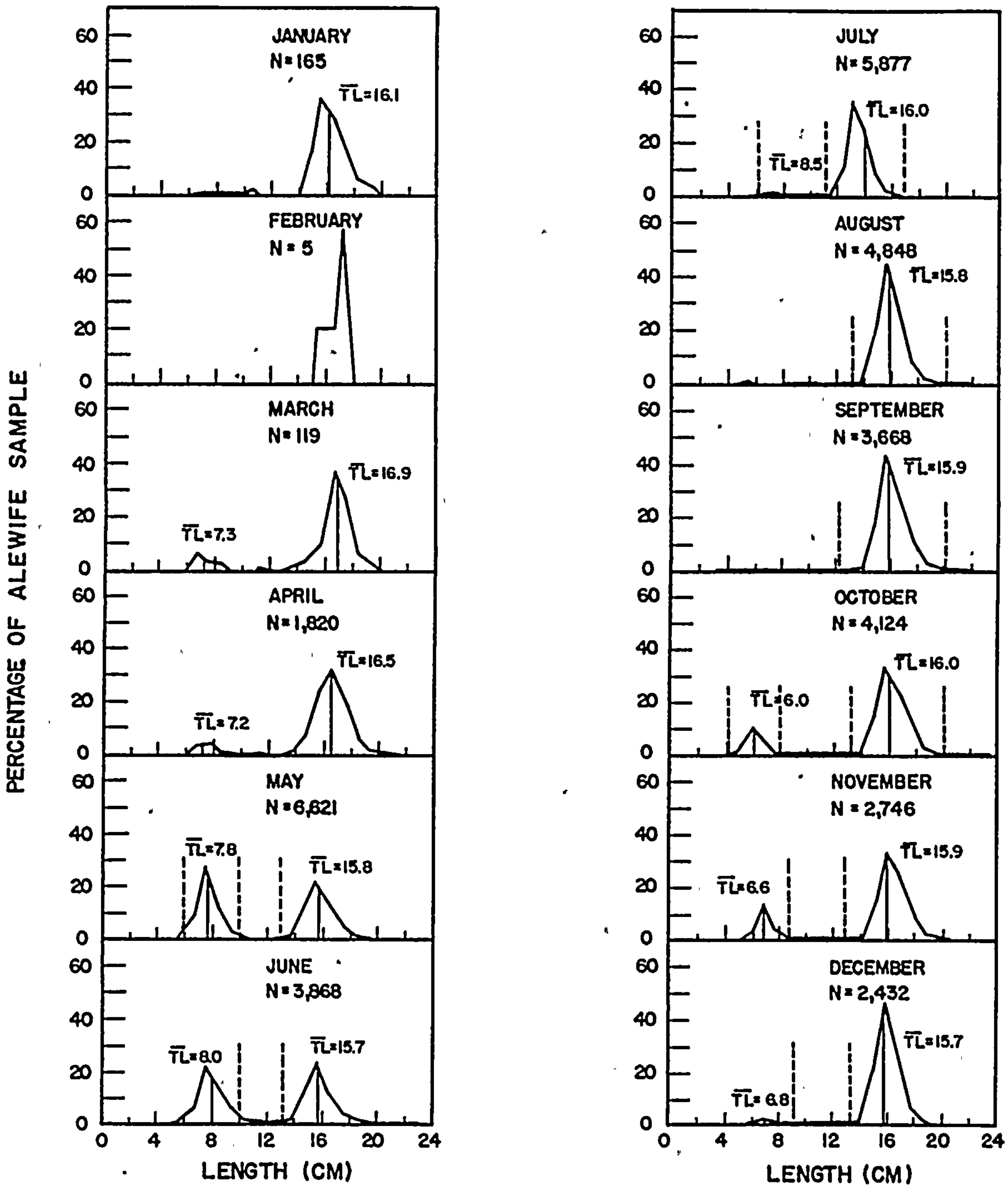
* Average weight in grams.

Average biomass of individual alewives impinged during the winter months was similar, in the range of 27 g. The average alewife biomass decreased in April, reaching the lowest yearly average of 10.2 g/fish in May. Length frequency data for alewives, presented in Figure IX-4, indicate that the recruitment of yearling fish began in March, and that in May this size fish composed the dominant percentage of the individuals measured for length. The biomass of the June sample, 11.5 g/fish, very closely approximated the average May value, with a similar length frequency composition. The period of lowest average biomass corresponds to the period of maximum abundance of alewives in impingement collections, and this, combined with length frequency data, suggests that a large number of sexually immature fish accompanied the spring spawning migration. Biomass fluctuated slightly during the rest of the year, but average fish biomass generally increased. The small decrease observed in October average biomass generally relates to the recruitment of young-of-the-year fish as noted in the discussion of length frequency. Calculation of length frequency during all months disclosed a major group of alewives with a weighted mean total length of approximately 15.8 cm; this group corresponds in size to age group II and III fish in Lake Michigan (Norden, 1967), suggesting a continuous presence in the near-shore area of adult alewives which do not migrate to deeper waters as reported by Graham (1956) and Wells (1968).

The average monthly biomass of rainbow smelt was the highest during the late winter/early spring period. Length frequency data (Figure IX-5) indicate that the winter/early spring population consisted of yearlings (greatest percentage in the winter months) with more mature specimens becoming numerous especially in the later winter period. The adults normally migrate from the shore zone to deeper water following spawning (Wells, 1968). The decrease in average fish biomass calculated during the late spring/early summer and the absence of the larger size group in June reflect this movement. Length frequency data point to the continuous presence of yearling fish in the shore area throughout the year. The general increase in average biomass from the low of 4.2 g/fish in July through the fall reflects the growth of the yearlings. Recruitment of young-of-the-year fish was first observed in September, when the average mean length was 4.7 cm, and the young-of-the-year contingent was evident in impingement samples throughout the fall months.

The numbers of smallmouth bass collected in the Wednesday sampling and analyzed for biomass and length frequency were too small to evaluate seasonal trends adequately. Preliminary evaluation

LENGTH FREQUENCY DATA OF IMPINGED ALEWIVES
NINE MILE POINT, 1974

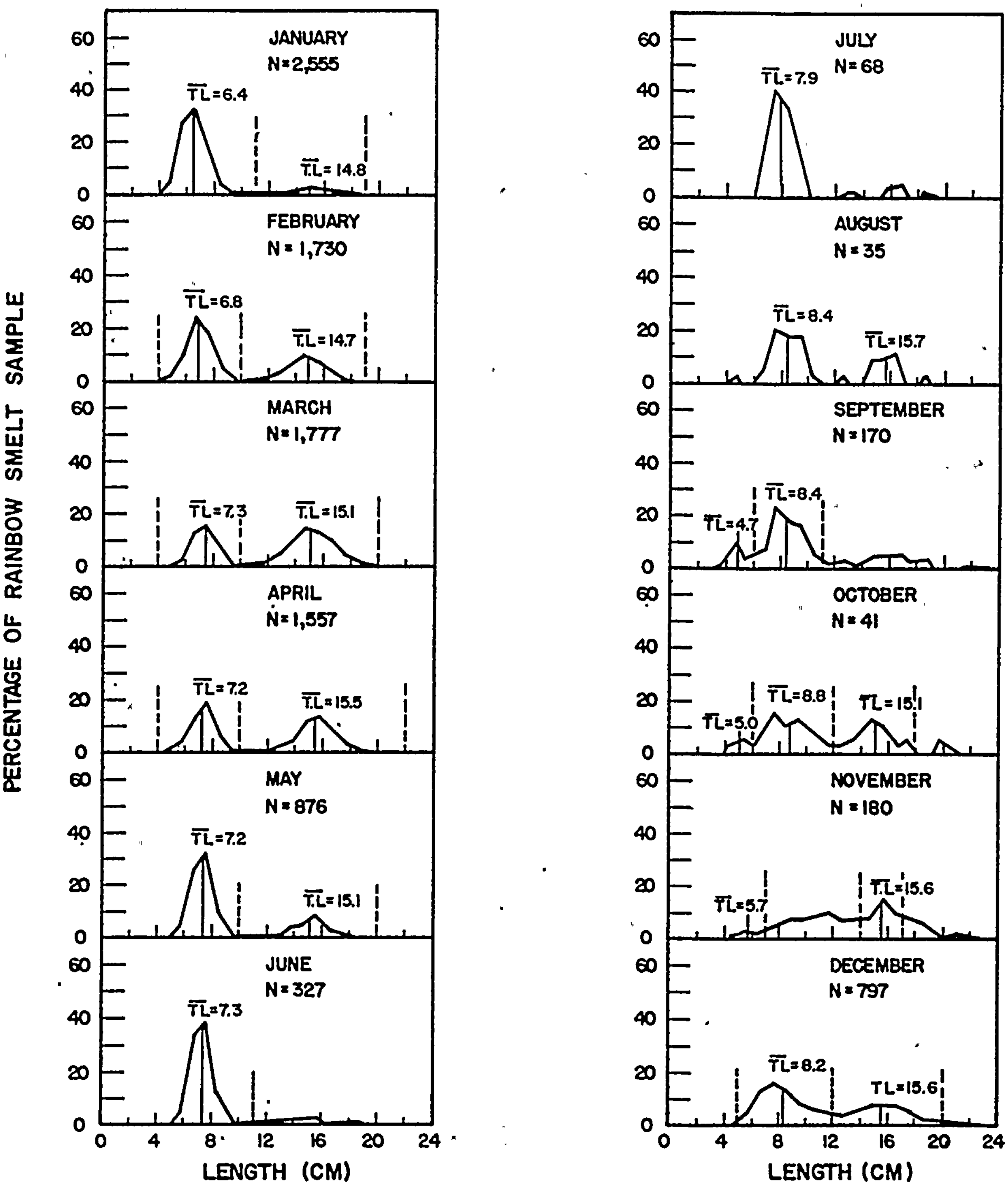


(DOTTED LINE REPRESENTS CUT-OFF POINT BETWEEN AGE GROUPS WHERE CONTINUOUS DISTRIBUTION IS PRESENT)
N = TOTAL NUMBER ALEWIVES ANALYZED

TL=MEAN TOTAL LENGTH

FIGURE IX-5

LENGTH FREQUENCY DATA OF IMPINGED RAINBOW SMELT
NINE MILE POINT, 1974



(DOTTED LINE REPRESENTS CUT-OFF POINT BETWEEN AGE GROUPS
WHERE CONTINUOUS DISTRIBUTION IS PRESENT)

N = TOTAL NUMBER RAINBOW SMELT ANALYZED

of the available biomass data and comparison with the literature (Scott and Crossman, 1973) indicate that the smallmouth bass population impinged consisted mainly of yearlings, with young-of-the-year appearing in the fall.

Based on length frequency data (Figure IX-6), yellow perch collected on the Nine Mile Point plant screens were a homogeneous group of yearlings and older fish (Scott and Crossman, 1973). Average fish biomass generally increased over the year, suggesting that spawning by this species was very limited, although the area may be important as a nursery ground. Wells (1968) reports that yellow perch younger than age group III were commonly found in shallower water in southern Lake Michigan, although young-of-the-year fish were not observed.

From January through June, the greatest percentage of impinged white perch were yearlings, with several larger fish present (Figure IX-7). Average biomass was fairly stable through the winter, averaging around 28 g/fish. White perch were uncommon in impingement collections during July and August; however, the young-of-the-year with an average biomass of 5.7 g/fish and weighted mean total length of approximately 7.0 cm were collected in September. Young-of-the-year were the dominant group through the fall months, although a small number of larger fish present in December increased the average fish biomass.

3. Day-Night Comparison of Impingement

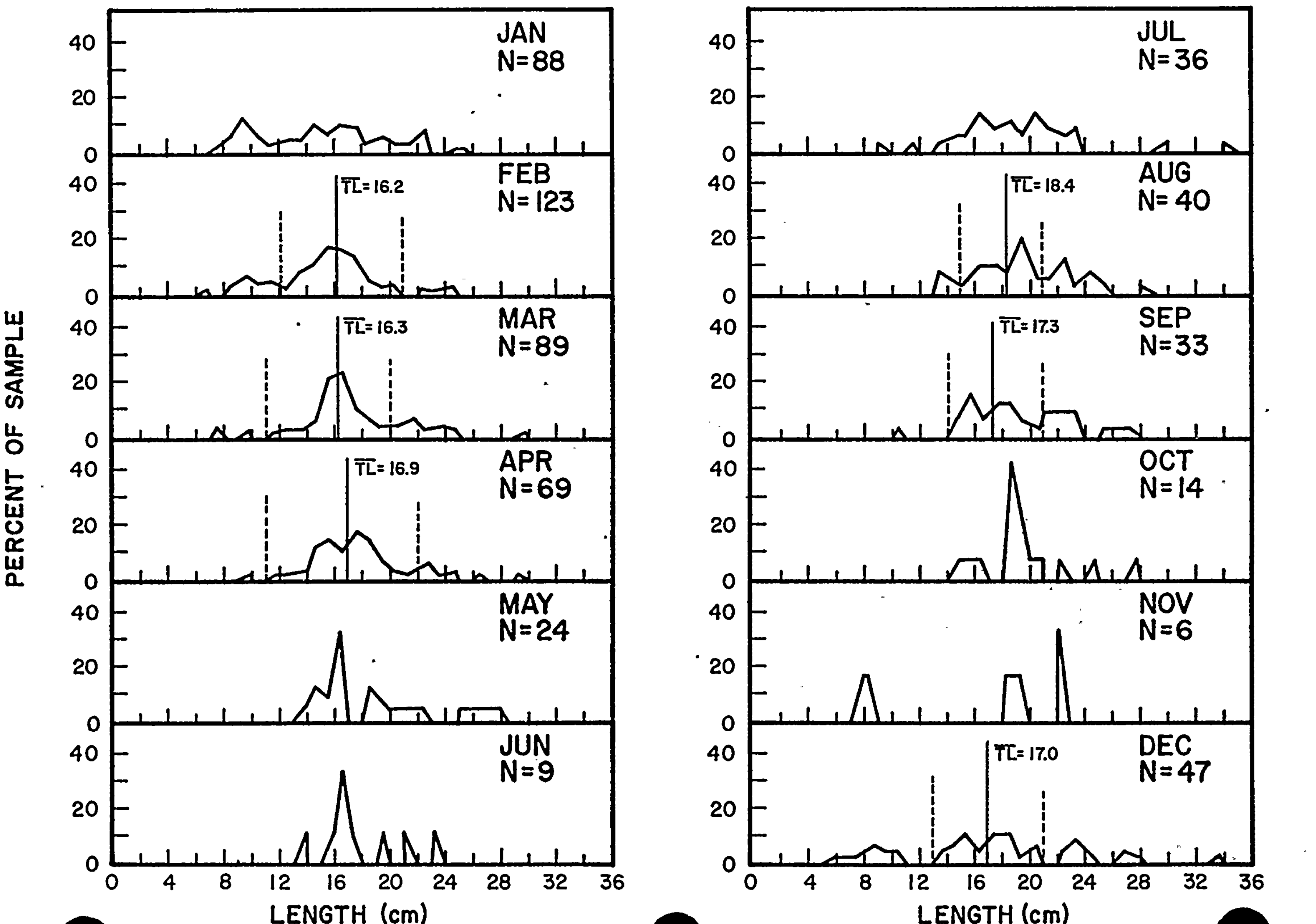
Changes in photoperiod (daylight-night cycles) or in the intensity of light have been observed to influence the movements and physiological activity of fish populations (Nikolsky, 1963; Odum, 1971). Carlander and Cleary (1949) demonstrated greater nighttime activity of fish, as indicated by increased numbers of fish in night gill net collections. Greater fish concentrations were noted by Storr (1971 a, b; 1972 a, b) in shallow water at Nine Mile Point during night hours. Evidence for such cycles was also found on specific sampling dates in the 1973 ecological survey at Nine Mile Point (QLM, 1974).

At Nine Mile Point Nuclear Station Unit 1, the 1974 hourly impingement rate for Wednesday collections was examined on a monthly basis for alewives and rainbow smelt. Diurnal impingement collections were grouped into four periods (day, night, dawn, and dusk), whose lengths were adjusted according to the time of local sunrise and sunset. Dawn and dusk were defined as the one-hour period which begins before and ends after sunrise and sunset, respectively. To test for diurnal differences on a monthly basis, a two-way analysis of variance (ANOVA) was conducted for the two dominant species, alewives and rainbow smelt (Appendix IX-1). The Student-Newman-Keuls (SNK) ranking procedure was used to determine sources of first-order significance.

LENGTH FREQUENCY DISTRIBUTION FOR IMPINGED YELLOW PERCH

NINE MILE POINT

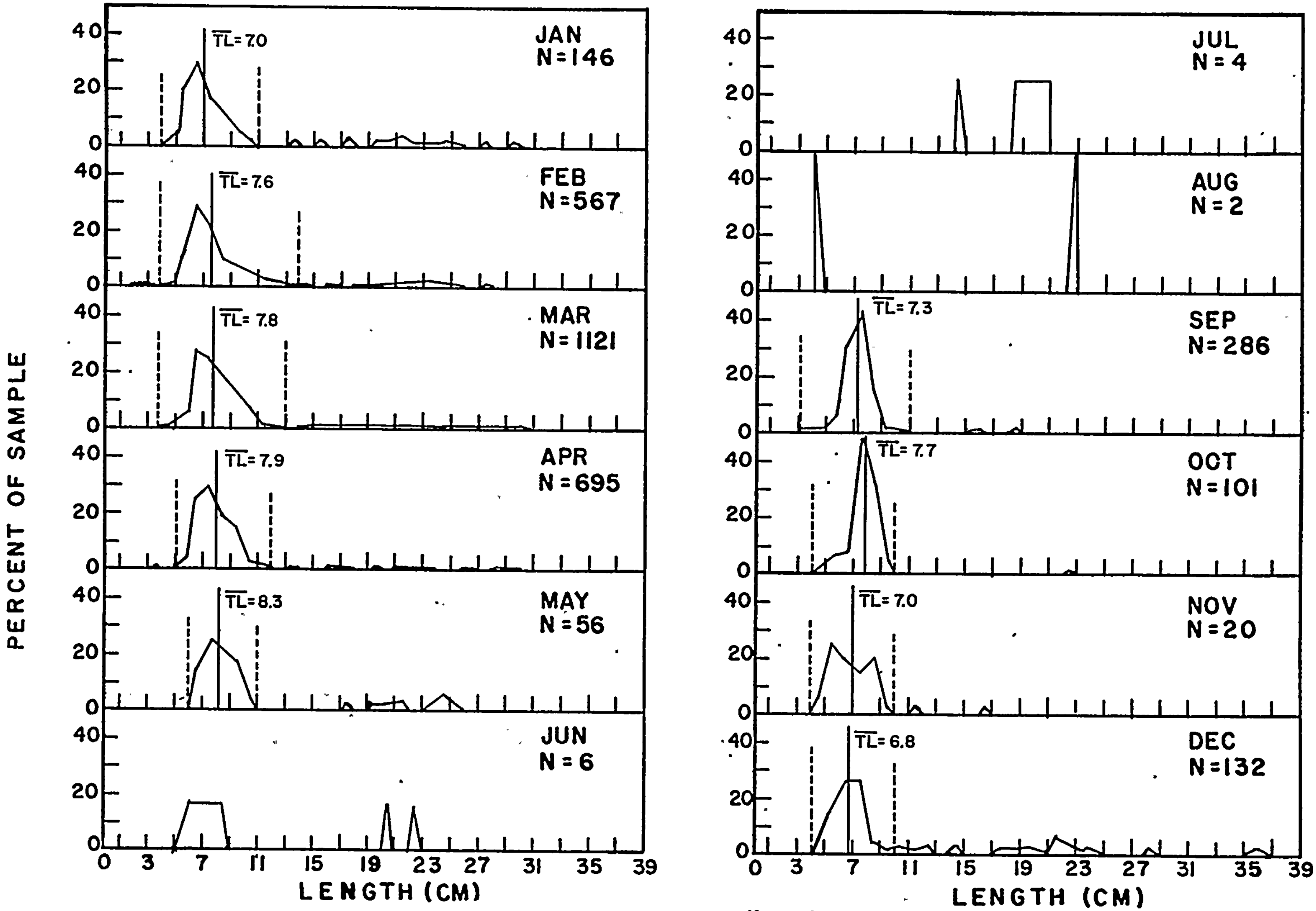
1974



N = TOTAL NUMBER OF FISH ANALYZED

FIGURE IX-6

LENGTH FREQUENCY DISTRIBUTION FOR IMPINGED WHITE PERCH
NINE MILE POINT
1974



N = TOTAL NUMBER OF FISH ANALYZED

FIGURE IX-7

These analyses indicated significant (α = 0.01) diurnal differences in rainbow smelt impingement rates; more rainbow smelt were impinged per hour during the night than during the other three periods (Appendix IX-1). The greatest number of rainbow smelt were impinged during April (α = 0.0005), with the least during the summer and fall seasons; no significant difference shown between summer and fall months.

The impingement rate of alwives showed no significant difference among photoperiods. However, there was a significant difference in impingement rate by month (α = 0.0005); more alewives were impinged per hour during May and July than during the remainder of the year and significantly more than during the winter months.

4. In-Plant Viability Studies

Survival (i.e., initial observation of fish placed in viability pools) and short-term viability studies (i.e., observation of fish after 45 minutes in viability pools) were conducted on a subsample of selected impinged fish at Nine Mile Point Nuclear Station Unit 1 during the period January-December, 1974. The species selected for viability observations were the alewife, rainbow smelt, gizzard shad, and threespine stickleback. Alewives were present in all impingement collections and therefore were evaluated for viability throughout the entire year (Table IX-7). Rainbow smelt were observed during the winter, spring, early summer, and late fall periods (Table IX-8). Gizzard shad were studied only during the winter, and threespine stickleback during the month of July (Table IX-9).

Individual organisms selected for viability observation were collected from the screen hatch basket located at the east travelling screen and from the fish basket located at the junction of the screen wash sluiceway and the discharge channel (Figure IX-2). The fish basket collected fish only from the middle and west travelling screens when the screen hatch basket was in place and from all three travelling screens when the hatch basket could not be used.

In general, the data for all four selected species indicate a greater viability in the fish hatch collections from the east travelling screen than from the fish basket throughout most of the year. The data also indicate that impinged gizzard shad and threespine sticklebacks exhibited relatively greater viability than alewives and rainbow smelt during comparable test periods. The higher viability of fish collected from the fish hatch location may be attributed to the fact that fish sampled at this location were subjected to less physical stress than those collected at the fish basket site. All fish impinged were washed from the travelling screens by water at a pressure ranging from 138 to 155 pounds per square inch (psi). Impinged fish exposed to this water pressure could have sustained physical damage by hitting

TABLE IX-7

SURVIVAL AND VIABILITY OF IMPINGED ALEWIVES
NINE MILE POINT NUCLEAR STATION UNIT 1
JANUARY - DECEMBER 1974

SAMPLING DATE	FISH BASKET SAMPLES: NO. OF FISH SAMPLED	FISH BASKET SAMPLES: PERCENT SURVIVAL	FISH BASKET SAMPLES: PERCENT VIABILITY	FISH HATCH SAMPLES: NO. OF FISH SAMPLED	FISH HATCH SAMPLES: PERCENT SURVIVAL	FISH HATCH SAMPLES: PERCENT VIABILITY
1/2-3/74	27	3.70	0	65	21.54	6.15
1/9-10/74	12	0	0	9	22.22	11.11
1/16-17/74	4	0	0	5	40.00	0
1/23-24/74	2	0	0	1	0	0
1/30-31/74	40	20.00	7.50	1	100.00	0
2/6-7/74†	2	0	0	0		
2/13-14/74	1	100.00	0	0		
2/20-21/74	1	0	0	1	100.00	0
2/27-28/74	0			0		
3/6-7/74	11	54.55	27.27	1	0	0
3/13-14/74	64	39.06	21.88	30	40.00	30.00
3/20-21/74	8	25.00	0	4	25.00	25.00
3/27-28/74	1	0	0	0		
4/3/74	163	73.62	50.92	25	84.00	48.00
4/10/74	1455	55.92	27.15	641	50.55	33.70
5/15/74	290	7.58	1.03	0		
5/22-23/74	845	21.78	16.92	0*		
5/29-30/74	292	10.96	7.19	0*		
6/5-6/74	291	7.22	2.06	0*		
6/12-13/74	1052	8.08	4.66	0*		
6/19-20/74	481	7.69	4.16	0*		
6/25-26/74	290	5.86	4.14	298	14.09	7.38

TABLE IX-7 Continued

SURVIVAL AND VIABILITY OF IMPINGED ALEWIVES

SAMPLING DATE	FISH BASKET SAMPLES: NO. OF FISH SAMPLED	FISH BASKET SAMPLES: PERCENT SURVIVAL	FISH BASKET SAMPLES: PERCENT VIABILITY	FISH HATCH SAMPLES: NO. OF FISH SAMPLED	FISH HATCH SAMPLES: PERCENT SURVIVAL	FISH HATCH SAMPLES: PERCENT VIABILITY
7/3-4/74	1763	2.61	1.76	1038	22.93	15.70
7/10-11/74	718	0	0	611	16.53	10.64
7/17-18/74	595	0	0	596	16.61	9.40
7/24-25/74	472	0.21	0	200	23.50	17.00
7/31-8/1/74	1161	0	0	694	24.06	18.73
8/7-8/74	305	3.93	1.97	193	20.21	16.58
8/14-15/74	571	36.43	25.04	519	32.37	22.54
8/21-22/74	300	0	0	300	14.67	10.00
8/28-29/74	610	0	0	382	15.18	10.21
9/4-5/74	732	32.24	25.81	405	52.09	44.69
9/11-12/74	1343	0.30	0.22	973	19.42	12.64
9/18-19/74	632	7.59	3.96	313	28.75	16.61
9/25-26/74	330	4.84	3.03	213	25.82	16.90
10/2-3/74	433	26.32	23.55	97	42.26	29.89
10/9-10/74	844	13.38	11.37	298	37.24	26.51
10/16-17/74	665	50.22	40.60	226	62.83	49.55
10/23-24/74	681	38.76	30.69	300	51.66	36.33
10/30-31/74	588	27.21	17.00	374	50.80	35.29
11/6-7/74	404	33.42	20.54	264	42.42	23.48
11/13-14/74	397	35.52	26.45	167	55.69	37.72
11/20-21/74	622	36.66	24.60	229	46.29	29.26
11/27-28/74	548	23.18	15.69	214	44.39	31.78
12/4-5/74	154	28.57	18.18	38	50.00	26.32
12/11-12/74	328	60.67	56.40	32	75.00	68.75
12/18-19/74	342	53.80	39.18	178	70.22	55.06
12/25-26/74	NO VIABILITY ANALYSES PERFORMED					

* Fish numbers too large to sample.

† Reverse [illegible]w.

TABLE IX-8

SURVIVAL AND VIABILITY OF IMPINGED RAINBOW SMELT
NINE MILE POINT NUCLEAR STATION 1
JANUARY - JUNE 1974

SAMPLING DATE	FISH BASKET SAMPLES NO. OF FISH SAMPLED	FISH BASKET SAMPLES PERCENT SURVIVAL	FISH BASKET SAMPLES PERCENT VIABILITY	FISH HATCH SAMPLES NO. OF FISH SAMPLED	FISH HATCH SAMPLES PERCENT SURVIVAL	FISH HATCH SAMPLES PERCENT VIABILITY
1/2-3/74	1099	0.45	0.45	474	10.55	4.43
1/9-10/74	405	0	0	247	11.74	6.88
1/16-17/74	231	3.03	1.73	104	9.62	4.81
1/23-24/74	154	4.55	0.65	10	10.00	10.00
1/30-31/74						
2/6-7/74†	89	0	0	0		
2/13-14/74	327	1.53	0.61	202	11.88	1.98
2/20-21/74	117	0.85	0	40	20.00	2.22
2/27-28/74	814	2.58	1.35	130	19.23	6.92
3/6-7/74	60	1.67	0	47	23.40	8.51
3/13-14/74	92	8.70	5.43	50	20.00	12.00
3/20-21/74	179	6.70	0	163	11.66	6.13
3/27-28/74	739	9.47	5.14	643	12.91	9.02
4/3/74	431	23.90	17.86	342	17.84	9.94
4/10/74	290	30.00	13.45	238	20.17	11.34
5/15/74	8	0	0	0		
5/22-23/74	37	5.41	5.41	0*		
5/29-30/74	4	0	0	0*		
6/5-6/74	3	0	0	0*		
6/12-13/74	59	8.47	3.39	0*		
6/19-20/74	6	33.33	16.67	0*		
6/26-27/74	4	0	0	2		

TABLE IX-8 Continued

SURVIVAL AND VIABILITY OF IMPINGED RAINBOW SMELT

SAMPLING DATE	FISH BASKET SAMPLES: NO. OF FISH SAMPLED	FISH BASKET SAMPLES: PERCENT SURVIVAL	FISH BASKET SAMPLES: PERCENT VIABILITY	FISH BATCH SAMPLES: NO. OF FISH SAMPLED	FISH BATCH SAMPLES: PERCENT SURVIVAL	FISH BATCH SAMPLES: PERCENT VIABILITY
7/3-4/74	27	3.70	0	13	7.69	0
7/10-11/74	3	0	0	2	0	0
12/4-5/74	0					
12/11-12/74	204	21.08	12.25	85	43.53	22.35
12/18-19/74 **	120	21.67	16.67	20	40.00	30.00
12/25-26/74	NO VIABILITY PERFORMED					

*Fish numbers too large to sample.
**Viability studies were not conducted on all impinged rainbow smelt collected.
†Reverse flow.

TABLE IX-9

SURVIVAL AND VIABILITY OF IMPINGED GIZZARD SHAD AND THREESPINE STICKLEBACKS
NINE MILE POINT NUCLEAR STATION UNIT 1, 1974
JANUARY - MARCH 1974

GIZZARD SHAD

	FISH BASKET SAMPLES			FISH HATCH SAMPLES		
SAMPLING DATE	NO. OF FISH SAMPLED	PERCENT SURVIVAL	PERCENT VIABILITY	NO. OF FISH SAMPLED	PERCENT SURVIVAL	PERCENT VIABILITY
1/2-3/74	28	64.29	50.00	3	66.67	0
1/9-10/74	2	100.00	100.00	4	50.00	25.00
1/16-18/74	20	35.00	25.00	1	100.00	100.00
1/23-24/74	13	69.23	46.15	1	100.00	100.00
1/30-31/74	35	14.29	2.86	2	0	0
2/6-7/74 †	9	33.33	33.33	0		
2/13-14/74	10	70.00	30.00	3	66.67	66.67
2/20-21/74	4	50.00	50.00	2	0	0
2/27-28/74	73	9.59	2.74	22	31.82	13.64
3/6-7/74	15	53.33	26.67	2	100.00	0
3/13-14/74	48	54.17	43.75	11	54.55	54.55
3/20-21/74	32	53.13	28.13	15	66.67	53.33
3/27-28/74	16	37.50	25.00	8	37.50	25.00

THREESPINE STICKLEBACK

7/3-4/74	16	18.75	18.75	12	41.66	41.66
7/10-11/74	54	0	0	27	59.26	51.85
7/17-18/74	3	0	0	1	0	0

† Reverse flow.

the screen housing walls or through the differential loss of protective scales and the accompanying mucous layer. Fish washed from the east screen were collected immediately. Fish washed from the west and middle travelling screens were conveyed along a steel-concrete sluiceway, where they undoubtedly received additional physical stress while in transit, to the fish basket suspended in the discharge bay. The fish were exposed to the heated discharge for one to four minutes prior to their collection from the fish basket. A 25°F temperature differential between the lake intake and discharge was typical when the plant was on-line, so that the species collected from the fish basket had been exposed to a rapid temperature increase between the intake canal and this location. In fact, the fish were subjected to temperatures as high as 100°F during the summer.

Gizzard shad acclimated under experimental conditions demonstrated a lethal temperature of 97.7°F (Hart, 1952; McKee and Wolf, 1963) compared to 73.4°F for acclimated alewives (Graham, 1956), and 70.7°-83.3°F for acclimated rainbow smelt (Altman and Dittmer, 1966). Since the fish collected in the fish basket had undergone previous physical stress in the sluiceway and were then subjected to discharge temperatures as high as 100°F without acclimation, the thermal death limit had undoubtedly been reached. The higher lethal limit reported in the literature for gizzard shad may explain the greater survival and viability of this species during the winter as compared to alewives and rainbow smelt. Altman and Dittmer (1966) also noted high lethal limits for threespine sticklebacks (89.1°-91.4°F) under experimental conditions. This species also showed relatively greater survival and viability (Tables IX-7, IX-8, and IX-9) compared to alewives during the same study period (July).

An additional aspect of the impingement process which could have contributed to the differential in survival and viability of the selected species between collection locations is the velocity of the circulating water through the travelling screens. A preliminary current velocity study obtained data at 0.5 m depth intervals in front of the bar racks on 14 March 1975. The results of the study are presented in tabular form (Table IX-10). The current data showed that velocities were greater for a given depth in front of the west and center position bar racks than at the east bar rack. The velocity profile information was obtained while the plant was tempering its cooling water flow by adding warmer discharge water through Channel D (Figure IX-2). The tempering water flow enters the intake channel on the west side and therefore may increase the velocity at the west and middle bar rack locations.

Fish survival and viability data were analyzed with reference to the effect of plant operation modes, particularly when the unit was

TABLE IX-10

NINE MILE POINT UNIT 1 BAR RACK VELOCITY PROFILES
EXPRESSED AS FEET PER SECOND

14 MARCH 1975

Location:	West Bar Rack			Middle Bar Rack			East Bar Rack		
	W——E			W——E			W——E		
Depth (meters)	1/4	1/2	3/4	1/4	1/2	3/4	1/4	1/2	3/4
.5	1.3	1.0	1.0	1.5	0.9	1.0	0	0.2	0.9
2.5	1.1	1.1	1.0	0.8	0.9	0.7	0	0.3	0.6
4.5	1.5	0.8	1.2	1.6	1.0	0.6	0	0	0.6
6.5	0.6	1.1	1.1	1.0	+0.3	0.5	0.3	0.5	0.5

Bottom at ~ 8m

off line and no plant-induced water temperature rise occurred. The off-line periods are listed in Table IX-11. Survival and viability of fish were examined during off-line conditions on 3-4 April and 10-11 April 1974; comparable numbers of fish were collected on both dates both the fish basket and screen hatch basket. Survival was relatively greater for rainbow smelt (Table IX-8) at the fish basket than at the screen hatch basket during the off-line periods; alewife survival and viability (Table IX-7) were similarly high at both locations.

Intake operating conditions (i.e., number of pumps and travelling screens operating) on 6-7 March were similar to those of 3-4 and 10-11 April, except for heat output (Table IX-12). The survival and viability of alewives and rainbow smelt were greater at the fish basket during the off-line sampling dates in April. Therefore, off-line conditions, characterized by the reduction in temperature differential and the lack of an accompanying exposure of fish in the fish basket, to a heated discharge apparently resulted in increased survival and viability at this site in comparison with on-line conditions.

5. Length-Weight Comparisons

It may be hypothesized that the impingement process is selective for the less healthy individuals of a given fish population and that, therefore, the impingement process may act as a beneficial cropping mechanism. To examine the validity of this hypothesis, length-weight relationships may be used as an indicator of the health or condition of a population. Generally, fish of a given length which are in good condition will weigh more than fish of the same length in a poorer condition. The ratio of length to weight was used to compare the condition of fish collected from the lake to that of the impinged fish at the Nine Mile Point Nuclear Station during 1974. Linear regression lines were fitted to logarithmic length-weight data for lake and impingement collections of alewife and rainbow smelt populations (Appendix IX-2 and IX-3) and tested for validity, i.e., homogeneity of variance and linearity. When the lines were not significantly non-parallel, the difference between the intercepts was tested for significance.

The lake fish analyzed were from trawl collections to minimize bias due to size selectivity of gill nets and seines (QLM, 1974). Lake and impingement samples analyzed were collected on either the same day or within several days of one another to obtain sufficient sample sizes for statistical analyses. Alewives were examined from trawl collections conducted on 20 May, 5 June and 18 June 1974, and from impingement collections during 5-6 June 1974. Rainbow smelt analyzed were from trawl and impingement collections conducted during 19-20 April 1974. To eliminate bias due to gonad weight, males and females from lake and impingement collections were examined separately.

Table IX-11

OFF-LINE PERIODS

NINE MILE POINT NUCLEAR STATION UNIT 1, 1974

		START	°F			EFFECTIVE	°F		
	DATE	TIME	LAKE	INLET	OUTLET	TIME	LAKE	INLET	OUTLET
Off	29 Mar	2100	32.4	36.9	52.3	2300	32.4	36.6	45.9
On*	5 Jul	0000	64.1	66.6	85.9	0100	65.8	68.4	93.0
Off	11 Oct	2100	55.9	58.6	85.4	12 Oct. 0400	59.6	58.4	137.9
On*	13 Oct	0900	56.8	56.4	115.7				
Off	9 Dec	2000	35.7	38.8	66.2	2155	35.3	38.07	37.69
On*	10 Dec	1200	33.6	36.8	37.5				
Off	20 Dec	2300	38.7	41.8	57.3	21 Dec. 0500	38.0	41.0	40.3
On*	31 Dec	1000	36.3	35.1	165.2				

*This date was chosen as date of on-line production because the temperature differential was greater than 25°F between lake intake and discharge.

TABLE IX-12

PLANT OPERATING CONDITIONS DURING MARCH AND APRIL

IMPINGEMENT COLLECTIONS AT NINE MILE POINT NUCLEAR STATION UNIT 1, 1974

DATE	OUTPUT (MW)	SCREEN WASH DURATION (Mins.)	NO. TRAVELLING SCREENS IN OPERATION	NO. CIRCULATING PUMPS IN OPERATION	WASH PRESSURE (psi)
3/6-7	592	3	2	2	143
3/13-14	490	3	2	2	143
3/20-21	490	3	2	2	143
3/27-28	491	3	2	2	143
4/3-4	0	3	2	2	143
4/10-11	0	3	2	2	140

Statistical analysis of alewives (Appendix IX-2) collected during May and June indicated that the mean weight for given length of males (118-178 mm) and of females (135-195 mm) was significantly greater for fish collected from trawls than for impinged fish. Male alewives collected from the lake were 10% heavier per length than those collected in the impingement samples; females were 13% heavier. Therefore, it is concluded that the alewives collected from the lake by trawls were in better condition than those collected from the intake screens.

Analysis of the length-weight relationship for female rainbow smelt (74-195 mm) collected during April 1974 (Appendix IX-3) showed no difference in weight per length of fish between lake and impingement samples. However, males (116-176 mm) collected in the lake were in better condition than impinged males (103-188 mm); males were 2 1/2% heavier per length from the lake samples than from the impingement samples. This observation may indicate, therefore, that weight per length comparisons should consistently be analyzed separately for males and females of a given species.

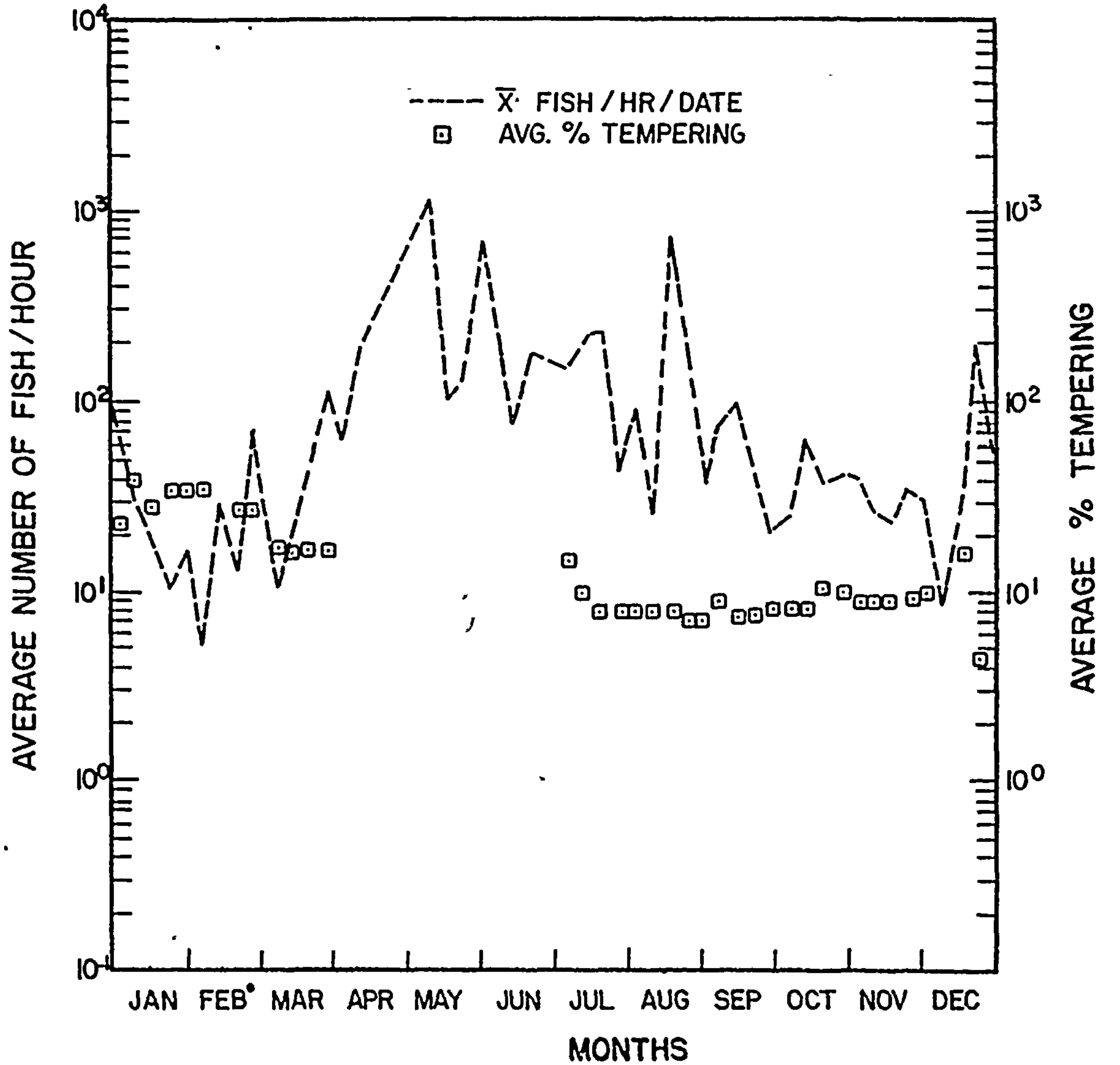
Several hypotheses may be presented as a result of these analyses. First, fish entering the plant intake structure in poor condition are unable to swim against the intake flow, and thus are more susceptible to impingement. Second, some fish may enter the intake structure, pass through the tunnels, and reside in the forebay area until their condition deteriorates to the point at which they are unable to swim against the water velocity and then are impinged. Eventually, all fish that enter the intake are collected on the travelling screens since the flow velocity in the tunnel is near 8 fps. Immediate impingement of fish within the forebay area during some seasons may be a function of crowded conditions which render fish less able to escape the travelling screens.

6. Impingement Rates in Relation to Plant Operation

Impingement rates at Nine Mile Point Nuclear Station were evaluated in relation to variations in plant flow and plant capacity factors to determine their potential effects. To facilitate observations relating to impingement, the number of fish impinged per hour is presented graphically by date in Figure IX-8.

Samples were collected during a period of reverse circulating water flow on 6-7 February. The average daily impingement rate was lower (3.4 fish/hr) during the reverse flow period than impingement rates from the preceding and succeeding normal flow periods, 30 January (11.4 fish/hr) and 13 February (19.4 fish/hr). During the normal and reverse flow periods, two circulating water pumps and two travelling screens were in operation. Although a lower impingement rate was observed during reverse flow, fluctuations in impingement rates of the same magnitude were observed when the plant was operating under normal flow conditions before and after 6-7 February; this

FISH IMPINGEMENT RATE*(FISH/HR.) AND PERCENT TEMPERING
(WEDNESDAY COLLECTIONS)
NINE MILE POINT, 1974



* mean of six hour intervals
° 6-7 Feb. reverse circulating water flow

FIGURE IX-8

described in Dunn and Clark (1974), and these hypotheses were conclusively rejected; the weekly Wednesday collection data are neither normally distributed nor independent samples. Hence, the well documented theories of normally distributed samples cannot be directly applied to these data.

b. Estimating the Annual Impingement

The set of impingement collections over any time period can be used to estimate the annual impingement by first assuming that the collections are representative samples for the sample period and then projecting this to a cumulative total. The annual impingement, estimated as an average of all impingement collections, was 2.2 million fish in 1974, compared with 5.0 million fish in 1973.

Sampling variability is the phenomenon whereby two samples drawn in the same way from a given population are not usually identical. One accepted practice for estimating the mean of a population from samples is through the utilization of a Student's-t distribution. This procedure uses the sample statistics and an empirical function (t-distribution) derived by sampling from a known normal distribution to estimate the population mean within specified confidence limits. The specific function used was:

$$\mu = \overline{X}_n + t(1 - \alpha, \delta) \frac{SD}{\sqrt{n}}$$

where:
- μ = is the estimate of the upper or lower limit of the population mean
- δ = the degree of freedom
- $(1 - \alpha)$ = the confidence level
- $\overline{X}$, SD, n = are the sample average, standard deviation, and sample size
- t = the t value selected from a table at δ degrees of freedom and $(1 - \alpha)$ confidence level

Only the upper bound will be used in evaluating the impingement data, since the annual total is to be overestimated rather than underestimated.

Since normal statistics are not directly applicable to these data (See IX.C.7a) and non-normal distributions have less refined theoretical bases and cannot conveniently be generalized, an effort was made to calculate a new parameter based on the collection data which would be normally distributed. A subsampling

method was developed to overcome some of the objections of nonstationarity and non-normality and to account for sampling variability. The average ($\overline{X}_n$) and standard deviation (SD_n) of a n-point subsample was calculated and the upper limit (at 90% confidence) of the subsample population was estimated with the Student's-t distribution from the equation above. Then, as with a n-point smoothing process, the first point is dropped and the next point in the series is picked up, and the process is repeated. The result is a running upper estimate of the mean at a specified confidence level. As this process resembles the moving average smoothing process, it is called the Student's-t n-point smoothing procedure.

The autocovariance function (Figure IX-9) demonstrated zero correlation for samples spaced about nine weeks apart, justifying a nine-week subsample (n = 9) to test the normality of the Student's-t smoothed statistics. The new variable thus represents the upper limit at 90% confidence of the mean impingement of a select set of nine collection days. The overlapping sets of nine weekly collection days produced a set of 52 pairs of estimated population means (μ values) from each year of data, using one collection per week.

If a curve is formed by plotting the μ values versus time, the upper estimate of impinged population is the area under the curve, i.e., the number of fish collected multiplied by the period from one sample to the next. The upper estimates of impingement for 1974 based on either Monday, Wednesday, or Friday collections are as follows:

Data set	Upper Estimate of Impingement (million fish)
1974 Monday	4.5
1974 Wednesday	2.0
1974 Friday	3.0

It is with greater than 90% confidence that the estimates in the table exceed the actual number of fish impinged. If sampling had been conducted on Friday only, for example, and not on Monday, Wednesday and Friday, the upper estimate of impingement would have been less than 3.0 million fish. Based on the mean of the upper estimate of impingement for Monday, Wedneday, and Friday collections using the Student's-t n-point smoothing procedure, it is estimated that the annual 1974 impingement is 2.5 million fish. This is 0.3 million fish greater than the estimate based on the average of all impingement collections in 1974.

D. CONCLUSIONS

The 1972, 1973, and 1974 sampling programs were characterized by the collection of an increasing number of fish species, from 29 the first year to 37 and 48, respectively. The new species were all collected in small numbers, indicating the probability that the expansion of the sampling programs from 129 collection hours in 1972 to nearly 4,000 hours in 1974 resulted in a greater likelihood of collecting species only rarely impinged. For example, the most abundant of the species collected for the first time in 1974 (e.g., freshwater drum) contributed less than 0.01% of the total sample.

The alewife dominated (> 90%) the species composition of impinged fish in both numbers and biomass in 1973 and 1974:

	% Composition			
	Abundance		Biomass	
	1973	1974	1973	1974
Alewife	97.8	94.4	94.5	91.2
Rainbow smelt	1.6	3.3	1.8	3.8
Others	0.6	2.3	1.3	5.0

Alewife impingement reached a peak rate in spring during 1973 and 1974. Rainbow smelt were collected primarily during the winter and spring months in both years; primarily younger fish were impinged during the remainder of the year. The timing of the occurrences of peak impingement rates for both alewife and rainbow smelt varied by a month between years, and corresponded to shoreward spawning migrations of the adults. The mean length of alewives in the peak impingement month of 1973 (April) was 15.6 cm (6.1 inches), and for the same month in 1974 was 16.5 cm (6.5 inches). The 1974 rainbow smelt collections also were composed of larger size fish.

Seasonal cycles of less abundant species such as white perch, threespine stickleback, and emerald shiner were also evident in both years and were related to spawning migrations or juvenile presence in the study area.

Length frequency comparisons for selected species collected in lake gill nets and trawls and in impingement samples indicated that lake fish had an average length greater than impinged fish at a given age, and they exhibited a higher growth increment between years. Length-weight relationships between lake and impinged fish indicated that lake fish were heavier than impinged fish per unit length in both 1973 and 1974.

In general, alewives, rainbow smelt, gizzard shad, and threespine stickleback demonstrated greater viability (survival after 45 minutes) in samples collected from the screen hatch basket, i.e., before passage down the sluiceway and into the discharge canal. The ability of fish to withstand the process of impingement is dependent on a variety of factors, including the species, the condition of the fish, and the time (season) of impingement.

The 1974 impingement data using the Student's-t n-point smoothing procedure (90% confidence level) yielded an estimated 2.5 million fish as the upper limit of annual impingement based on the mean value calculated from the upper limited determined for Monday, Wednesday, and Friday collections. An estimate of impingement based on the average of all impingement collections (50% confidence level) yielded a value of 2.2 million fish.

The 1973 data analyses compared the numbers of alewife and rainbow smelt with Lake Ontario stock estimates based on a 1972 survey of the lake. The following list compares 1973 and 1974 results.

		Lake Stock Estimate* (millions of fish)	% Composition In Gill Net Catch	Estimated Impingement (millions of fish)	% Cropping
Alewife	1973	1036	97.8	4.89	0.4
	1974	1036	94.5	2.36	0.2
Rainbow	1973	970	1.6	0.08	0.003
Smelt	1974	970	1.8	0.04	0.004

The cropping rates for both years were small, especially compared to the commercial cropping rates of these species and their natural mortality.

* Based on unpublished data on trawling in 1972. Data obtained from the Great Lakes Fishery Laboratory, Ann Arbor, Michigan.

REFERENCES CITED

Altman, P.L. and D.S. Dittmer (eds.). 1966. Environmental biology. Fed. Amer. Soc. Exptl. Bd., Bethesda, Md. 694p.

American Fisheries Society. 1970. A list of common and scientific names of fishes from the United States and Canada. 3rd. ed. Special Publ #6. 150p.

American Public Health Association (A.P.H.A.). 1971. Standard method for the examination of water and wastewater. M.J. Taras (chm. of eds.) Washington, D.C. 874p.

Bardach and Bjorklund. 1957. The temperature sensitivity of some American freshwater fishes. Amer. Natur. 91(859): 233-251.

Carlander, K.D. and R.E. Cleary. 1949. The daily activity patterns of some freshwater fishes. Amer. Midl. Nat. 41:447-452.

Christie, W.J. 1973. A review of the changes in the fish species composition of Lake Ontario. Great Lakes Fish. Comm. Tech. Report No. 23.65p.

Dunn, O.J. and V.A. Clark. 1974. Applied statistics: analysis of variance and regression. John Wiley & Sons, Inc., New York.

Graham, J.J. 1956. Observations on the alewife, Pomolobus pseudoharengus (Wilson), in freshwater. Univ. of Toronto Biol. Ser. No. 62., Ontario Fish Res. Lab. Publ. 74, 43p.

Hart, J.S. 1952. Geographic variations of some physiological and morphological characters in certain freshwater fish. Univ. Toronto Biol. Ser. No. 60. 79p.

McKee, J.E. and H.W. Wolf (ed.). 1963. Water quality criteria, 2nd. ed. Calif. State Water Control Board, Sacramento, Calif. Publ. 3-A.

Miller, R.R. 1960. Systematics and biology of the gizzard shad (Dorosoma cepedianum) and related fishes. U.S. Fish. Wildl. Serv. Fish. Bull. 60 (173):. 371-392.

Nikolsky, G.V. 1963. The ecology of fishes. Academic Press, New York. 352p.

Norden, C.R. 1967. Age, growth and fecundity of the alewife, Alosa pseudoharengus (Wilson), in Lake Michigan. Trans. Amer. Fish. Soc. 96(4):387-393.

REFERENCES CITED (Continued)

Odum, E.P. 1971. Fundamentals of ecology. W.B. Saunders Co., Philadelphia, Pa. 574p.

Quirk, Lawler & Matusky Engineers. 1973. Effect of circulating water on Lake Ontario water temperature and aquatic biology. Report prepared for Niagara Mohawk Power Corporation.

Quirk, Lawler & Matusky Engineers. 1974. 1973 Nine Mile Point aquatic ecology studies - Nine Mile Point Generating Station. Report prepared for Niagara Mohawk Power Corporation.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. J. Fish. Res. Bd. Canada, Bull 184. 966p.

Storr, J.F. 1971a. Fish distribution studies of four periods in 1970. Letter to R. Clancy, Niagara Mohawk Power Corporation, February 17.

Storr, J.F. 1971b. Fish net study, Nine Mile Point, June 1-2. 1971. Letter to R. Clancy, Niagara Mohawk Power Corporation, July 9.

Storr, J.F. 1972a. Fish distribution study, Nine Mile Point, August 17-19, 1971. Letter to R. Clancy, Niagara Mohawk Power Corporation, January 3.

Storr, J.F. 1972b. Fish distribution study, Nine Mile Point, November 1-2, and 5, 1971. Letter to R. Clancy, Niagara Mohawk Power Corporation, January 12.

Wells, L. 1968. Seasonal depth distribution of fish in southeastern Lake Michigan. U.S. Fish. Wildl. Serv. Fish. Bull. 67(1):1-15.

APPENDIX IX-1

ABUNDANCE OF IMPINGED FISH - PHOTOPERIODS
NINE MILE POINT - 1974

I. RAINBOW SMELT

TWO-WAY ANALYSIS OF VARIANCE
(LOG TRANSFORMED)

SOURCE	DF	SS	DF(ERR)	SS(ERR)	F
MONTH	10	33.1389	131	13.6292	31.852 (a)
PHOTOPERIOD*	3	1.3473	131	13.6292	4.317 (b)
MONTH X PERIOD	30	0.8042	101	12.8250	0.211 (c)
TOTAL	144	48.2070			

(a) Significant at $\alpha<0.0005$
(b) Significant at $\alpha<0.01$
(c) Not significant at $\alpha=0.25$

STUDENT-NEWMAN-KEULS - MONTHS ($\alpha = 0.05$)
Largest: APR JAN MAR FEB MAY DEC JUL SEP NOV OCT AUG: Smallest

STUDENT-NEWMAN-KEULS - PERIODS ($\alpha= 0.05$)
Largest: NIGHT DAWN DAY DUSK: Smallest

*(DAWN, DAY, NIGHT, DUSK)

II. ALEWIFE

TWO-WAY ANALYSIS OF VARIANCE
(LOG TRANSFORMED)

SOURCE	DF	SS	DF(ERR)	SS(ERR)	F
MONTH	10	68.4821	131	13.2582	67.665 (a)
PERIOD	3	0.6579	131	13.2582	2.167 (b)
MONTH X PERIOD	30	1.5772	130	11.6810	0.455 (c)
TOTAL	144	82.2489			

(a) Significant at $\alpha<0.0005$
(b) Significant at $\alpha<0.10$
(c) Not significant at $\alpha=0.25$

STUDENT-NEWMAN-KEULS - MONTHS ($\alpha= 0.05$)
Largest: MAY JUL SEP AUG OCT NOV APR DEC MAR JAN FEB: Smallest

APPENDIX IX-2

COMPARISON OF LENGTH-WEIGHT RELATIONSHIPS FOR ALEWIVES
COLLECTED FROM LAKE ONTARIO AND NINE MILE POINT INTAKE SCREENS
MAY - JUNE 1974

I. LENGTH-WEIGHT REGRESSION LINES

a. Males

Lake*: log W = -2.6644 + 1.8438 log L: N = 51 L = 124-174mm
Plant: log W = -3.4636 + 2.1894 log L: N = 93 L = 118-178mm

b. Females

Lake*: log W = -3.4923 + 2.2355 log L: N = 70 L = 144-195mm
Plant: log W = -3.1248 + 2.0454 log L: N = 133 L = 135-190mm

*Trawl data only

II. TEST OF PARALLELISM

a. Males

ANOVA

SOURCE	DF	SS	DF err	SS err	F-RATIO
Parallelism	1	.002666	140	.460633	0.810 (a)
Equality (given parallelism)	1	.087453	141	.463299	28.262 (b)

a. Not significant α = 0.25
b. Significant at α = < 0.0005

Estimated difference in intercepts based on lines with common slopes (Trawl-Imp.) = 0.0431 w/std. error = 0.010026
Ratio of trawl data to impingement = 1.104104 95% CI: (1.055, 1.156)

b. Females

ANOVA

SOURCE	DF	SS	DF err	SS err	F-RATIO
Parallelism	1	0.001166	179	.429291	0.486 (a)
Equality (given parallelism)	1	0.119000	180	.430457	49.761 (b)

a. Not significant α = 0.25
b. Significant at α = < 0.0005

Estimated difference in intercepts based on line with common slopes (Trawl-Imp.) = 0.0529 w/std. error = 0.00749
Ratio of trawl to impingement: = 1.129536 95% CI: (1.092, 1.169)

APPENDIX IX-3

COMPARISON OF LENGTH-WEIGHT RELATIONSHIPS FOR RAINBOW SMELT COLLECTED FROM LAKE ONTARIO AND FROM NINE MILE POINT INTAKE SCREENS APRIL 1974

I. LENGTH-WEIGHT REGRESSION LINES

a. Males

Lake*: $\log W = -5.4072 + 3.1106 \log L$: N = 25 L = 116-176mm
Plant: $\log W = -5.3407 + 3.0693 \log L$: N = 115 L = 103-188mm

b. Females

Lake*: $\log W = -5.4476 + 3.1299 \log L$: N = 42 L = 74-183mm
Plant: $\log W = -4.8459 + 2.8504 \log L$: N = 87 L = 114-195mm

*Trawl data only

II. TEST ON PARALLELISM

a. Males

ANOVA

SOURCE	DF	SS	DF err	SS err	F-RATIO
Parallelism	1	.000052	136	.332698	0.021 (a)
Equality (given parallelism)	1	.010938	137	.332750	4.503 (b)

a. Not significant $\alpha = 0.25$
b. Significant at $\alpha < 0.05$, but not at $\alpha = 0.025$

Estimated difference in intercepts based on lines with common slopes (Trawl-Imp.) = 0.023079 w/std. error =0.010863

Ratio of trawl data to impingement = 1.025328 95% CI: (1.003873, 1.107845)

b. Females

ANOVA

SOURCE	DF	SS	DF err	SS err	F-RATIO
Parallelism	1	.006982	125	.294345	2.965 (a)
Equality (given parallelism)	1	.001972	126	.301327	0.824 (b)

a. Significant at $\alpha < 0.10$, but not at $\alpha = 0.05$
b. Not significant at $\alpha = 0.25$

TELEDYNE ISOTOPES

IWL-3819-369

NINE MILE POINT NUCLEAR STATION
WATER MONITORING PROGRAM
SAMPLES FROM LAKE ONTARIO

Summary Report

April 1974 - December 1974

Prepared for

Lawler, Matusky & Skelly, Engineers
415 Route 303
Tappan, New York 10983

Prepared by

Teledyne Isotopes
50 Van Buren Avenue
Westwood, New Jersey 07675

TELEDYNE ISOTOPES

TABLE OF CONTENTS

		Page
I.	INTRODUCTION	1.
II.	SAMPLING LOCATIONS AND MAP	2.
III.	SAMPLE RESULTS	4.
IV.	DISCUSSION OF RESULTS AND TRENDS PLOTS	9.
	APPENDIX A - ANALYTICAL PROCEDURES	15.
	APPENDIX B - SUMMARY OF ANALYTICAL METHODS	16.
	APPENDIX C - GAMMA SPECTROSCOPY - DETECTION SENSITIVITIES	19.

TELEDYNE ISOTOPES

I. INTRODUCTION

This report presents the results of radioanalysis of water samples collected from Lake Ontario in the vicinity of the Niagara Mohawk Power Corporation, Nine Mile Point Nuclear Power Facility.

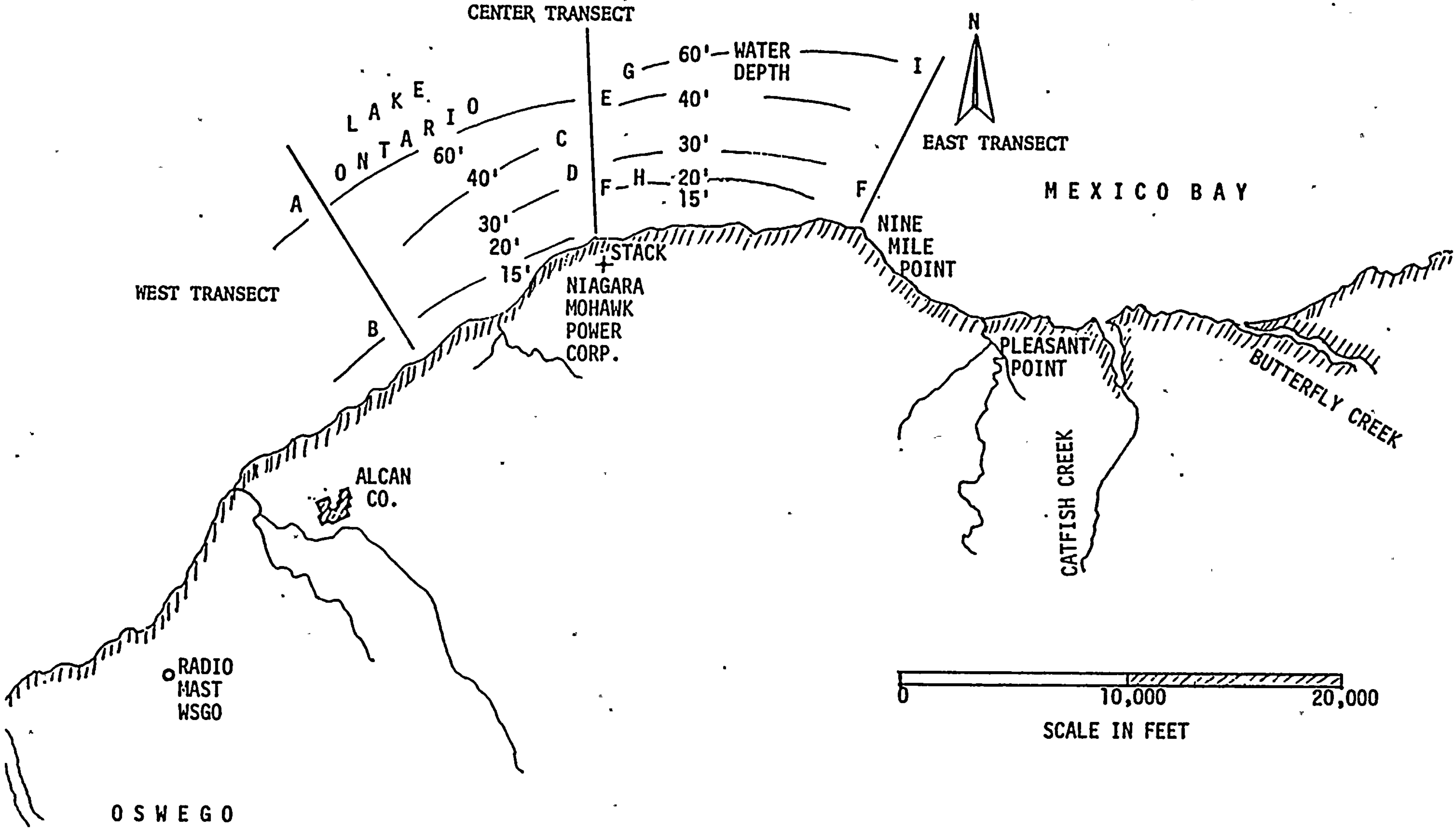
The samples were collected monthly by QLM Laboratories (now a division of Lawler, Matusky and Skelly, Engineers), from April 1974 through December 1974.

TELEDYNE ISOTOPES

II. SAMPLING LOCATIONS AND IDENTIFICATION

Water samples were collected monthly during the period April 1974 through December 1974 from two locations on Lake Ontario directly offshore from Nine Mile Point Nuclear Station - Unit 1. One location is approximately 1000 feet offshore and the second location is approximately 3000 feet offshore. Two samples were collected at each location; one from the lake surface and a second sample from near the lake bottom. The sample identification code is as follows:

Station Identification	Distance from Shore (Feet)	Depth of Water at Station (Feet)	Depth of Sample (Feet)
NMP-1	1000	20	0 (Just Below Surface)
NMP-2	1000	20	20 (Just Above Bottom)
NMP-3	3000	45	0 (Just Below Surface)
NMP-4	3000	45	45 (Just Above Bottom)


CENTER TRANSECT
60' WATER DEPTH
G
I
E
40'
LAKE ONTARIO
60'
C
30'
EAST TRANSECT
40'
D
F
H
20'
15'
F
MEXICO BAY
A
30'
20'
NINE MILE POINT
STACK
15'
WEST TRANSECT
NIAGARA MOHAWK POWER CORP.
B
PLEASANT POINT
BUTTERFLY CREEK
CATFISH CREEK
ALCAN CO.
RADIO MAST WSGO
0
10,000
20,000
SCALE IN FEET
OSWEGO
N

III. SAMPLE RESULTS

Each sample was analyzed for gross beta, gross alpha, tritium, and gamma emitting activities. The results are tabulated on the following pages.

NINE MILE POINT GENERATING STATION

ENVIRONMENTAL MONITORING 1974

STATION NMP-1

Collection Date	Gross Beta pCi/liter	Gross Alpha pCi/liter	Tritium pCi/liter	Gamma Emitters (Nuclide)
04/08/74	4.3 +-0.2 E 00	L.T. 1.7 E 00	3.6 +-0.4 E 02	ND
05/14/74	5.8 +-0.9 E 00	L.T. 2. E 00	3.3 +-0.4 E 02	ND
06/13/74	3.6 +-0.6 E 00	L.T. 5. E-01	NR	NR
07/15/74	3.5 +-0.6 E 00	L.T. 5. E-01	NR	NR
08/12/74	3.0 +-0.8 E 00	L.T. 1. E 00	4.2 ± 1.0 E 02	ND
09/17/74	4.2 +-0.9 E 00	L.T. 1. E 00	3.2 ± 1.0 E 02	ND
10/17/74	2.6 +-0.8 E 00	L.T. 1. E 00	2.8 ± 0.8 E 02	ND
11/12/74	5.4 +-1.0 E 00	L.T. 1. E 00	4.7 ± 1.0 E 02	ND
12/05/74	6.5 +-1.0 E 00	1.0 +-0.3 E 01	2.8 ± 1.0 E 02	ND
	4.3 +-1.3 E 00*		3.5 ± 0.7 E 02*	

NR = not requested

ND = none detected (See Appendix C - Gamma Spectroscopy Detector Sensitivities)

* Mean +- Standard Deviation

NINE MILE POINT GENERATING STATION

ENVIRONMENTAL MONITORING 1974

STATION NMP-2

Collection Date	Gross Beta pCi/liter	Gross Alpha pCi/liter	Tritium pCi/liter	Gamma Emitters (Nuclide)
04/08/74	4.4 +-0.2 E 00	L.T. 2. E 00	3.6 +-0.4 E 02	ND
05/14/74	3.6 +-0.6 E 00	L.T. 1.5 E 00	4.0 +-0.4 E 02	ND
06/13/74	3.2 +-0.5 E 00	L.T. 5. E-01	NR	NR
07/15/74	4.4 +-0.7 E 00	L.T. 5. E-01	NR	NR
08/12/74	3.8 +-0.9 E 00	L.T. 1. E 00	3.1 ± 0.8 E 02	ND
09/17/74	2.7 +-0.8 E 00	L.T. 1. E 00	3.6 ± 0.8 E 02	ND
10/17/74	3.9 +-0.9 E 00	L.T. 1. E 00	2.9 ± 0.8 E 02	ND
11/12/74	3.4 +-0.9 E 00	L.T. 1. E 00	2.9 ± 0.8 E 02	ND
12/05/74	3.9 +-0.9 E 00	L.T. 1. E 00	3.4 ± 0.8 E 02	ND
	3.7 +-0.6 E 00*		3.4 ± 0.4 E 02*	

NR = not requested

ND = none detected (See Appendix C - Gamma Spectroscopy Detector Sensitivities)

* Mean +- Standard Deviation

NINE MILE POINT GENERATING STATION

ENVIRONMENTAL MONITORING 1974

STATION NMP-3

Collection Date	Gross Beta pCi/liter	Gross Alpha pCi/liter	Tritium pCi/liter	Gamma Emitters (Nuclide)
04/08/74	2.9 +-0.5 E 00	L.T. 1.7 E 00	4.9 +-0.4 E 02	ND
05/14/74	5.0 +-0.8 E 00	L.T. 1.6 E 00	4.5 +-0.4 E 02	ND
06/13/74	2.9 +-0.5 E 00	L.T. 5. E-01	NR	NR
07/15/74	4.5 +-0.7 E 00	L.T. 5. E-01	NR	NR
08/12/74	3.0 +-0.8 E 00	L.T. 1. E 00	4.0 ± 1.0 E 02	ND
09/17/74	4.7 +-1.0 E 00	L.T. 1. E 00	5.5 ± 1.1 E 02	ND
10/17/74	3.3 +-0.9 E 00	L.T. 1. E 00	4.7 ± 1.0 E 02	ND
11/12/74	3.6 +-0.9 E 00	L.T. 1. E 00	4.6 ± 0.9 E 02	ND
12/05/74	3.0 +-0.8 E 00	L.T. 1. E 00	3.8 ± 0.9 E 02	ND
	3.7 +-0.8 E 00*		4.6 ± 0.6 E 02*	

NR = not requested

ND = none detected (See Appendix C - Gamma Spectroscopy Detector Sensitivities)

* Mean +- Standard Deviation

NINE MILE POINT GENERATING STATION

ENVIRONMENTAL MONITORING 1974

STATION NMP-4

Collection Date	Gross Beta pCi/liter	Gross Alpha pCi/liter	Tritium pCi/liter	Gamma Emitters (Nuclide)
04/08/74	2.7 +-0.5 E 00	L.T. 1.5 E 00	5.5 +-0.4 E 02	ND
05/14/74	3.1 +-0.5 E 00	L.T. 2. E 00	4.3 +-0.4 E 02	ND
06/13/74	3.7 +-0.6 E 00	L.T. 5. E-01	NR	NR
07/15/74	3.6 +-0.6 E 00	L.T. 5. E-01	NR	NR
08/12/74	4.9 +-1.0 E 00	L.T. 1. E 00	3.8 ± 1.0 E 02	ND
09/17/74	3.6 +-0.9 E 00	L.T. 1. E 00	2.8 ± 0.9 E 02	ND
10/17/74	3.1 +-0.9 E 00	L.T. 1. E 00	3.3 ± 1.0 E 02	ND
11/12/74	3.1 +-0.9 E 00	L.T. 1. E 00	3.0 ± 0.9 E 02	ND
12/05/74	3.1 +-0.8 E 00	L.T. 1. E 00	3.8 ± 0.9 E 02	ND
	3.4 +-0.6 E 00*		3.8 ± 0.9 E 02*	

NR = not requested

ND = none detected (See Appendix C - Gamma Spectroscopy Detector Sensitivities)

* Mean +- Standard Deviation

TELEDYNE ISOTOPES

IV. DISCUSSION OF RESULTS

The radioactivity of the nuclides monitored for the four sampling stations at the Nine Mile Point Nuclear Station - Unit 1 on Lake Ontario during 1973 and 1974 is shown graphically on the accompanying Trends Plots. The data is also given in tabular form in Section III.

From the Trends Plots, the following observations are made:

A. Gross Beta

The gross beta activity during 1974 remained at 3 to 7 picocuries per liter (pCi/ℓ), an average of 3.8±0.8 pCi/ℓ for the four sampling sites, indicating no detectable releases above background from the generating plant at each sampling period.

The results of this program compare to an average of 3.8 pCi/ℓ and a maximum of 6.9 pCi/ℓ reported in Environmental Radiation Bulletin Number 3, 1974, for the Ontario Filter Plant in Wayne County, New York.

Comparing the 1973 and 1974 gross beta activities, the same general pattern is observed with the exception of the high pulse detected in June 1973 at the surface stations, NMP-1 and NMP-3, and attributed in the 1973 Report to a plant release into Lake Ontario.

B. Gross Alpha

Most gross alpha measurements were below the limits of detection of less than 0.5 to less than 2.0 pCi/ℓ. Variations in the limits of detection result from the differing quantities of suspended material in each sample. Increasing weights of suspended material inhibit the detection of alpha particles and raise the limits of detection.

No changes in gross alpha activity were detected in the samples collected during 1973 and 1974.

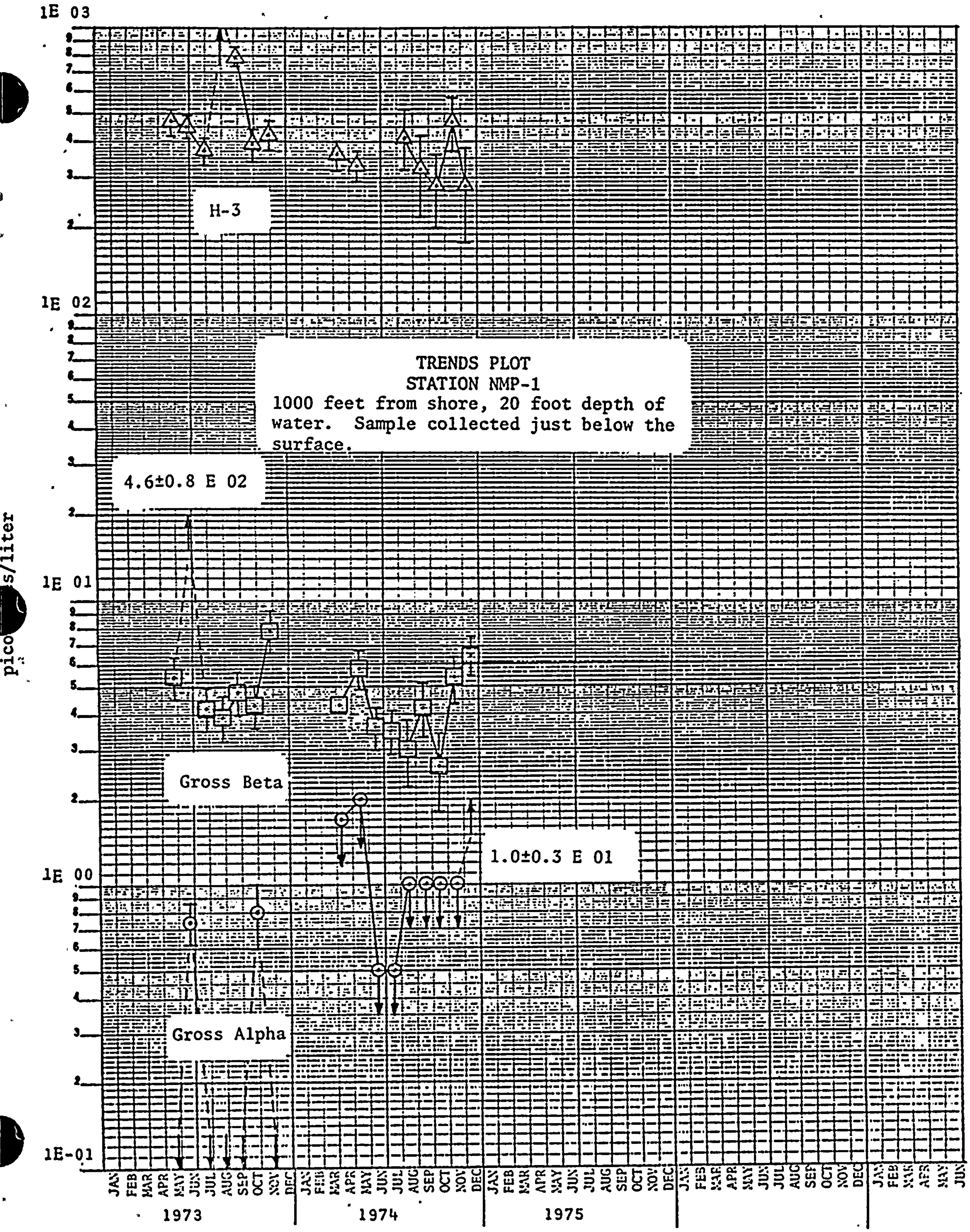
C. Tritium

Tritium (H-3) activities were monitored for samples collected during April, May and from August through December of 1974. The activity levels ranged from 280 to 550 pCi/ℓ and are statistically the same as most of the tritium measurements of samples collected during 1973. The exceptions are the high pulses monitored in August and September 1973 at Station NMP-1 and in August 1973 at Station NMP-2. No unusual pulses of tritium activity were monitored in the samples collected during 1974.

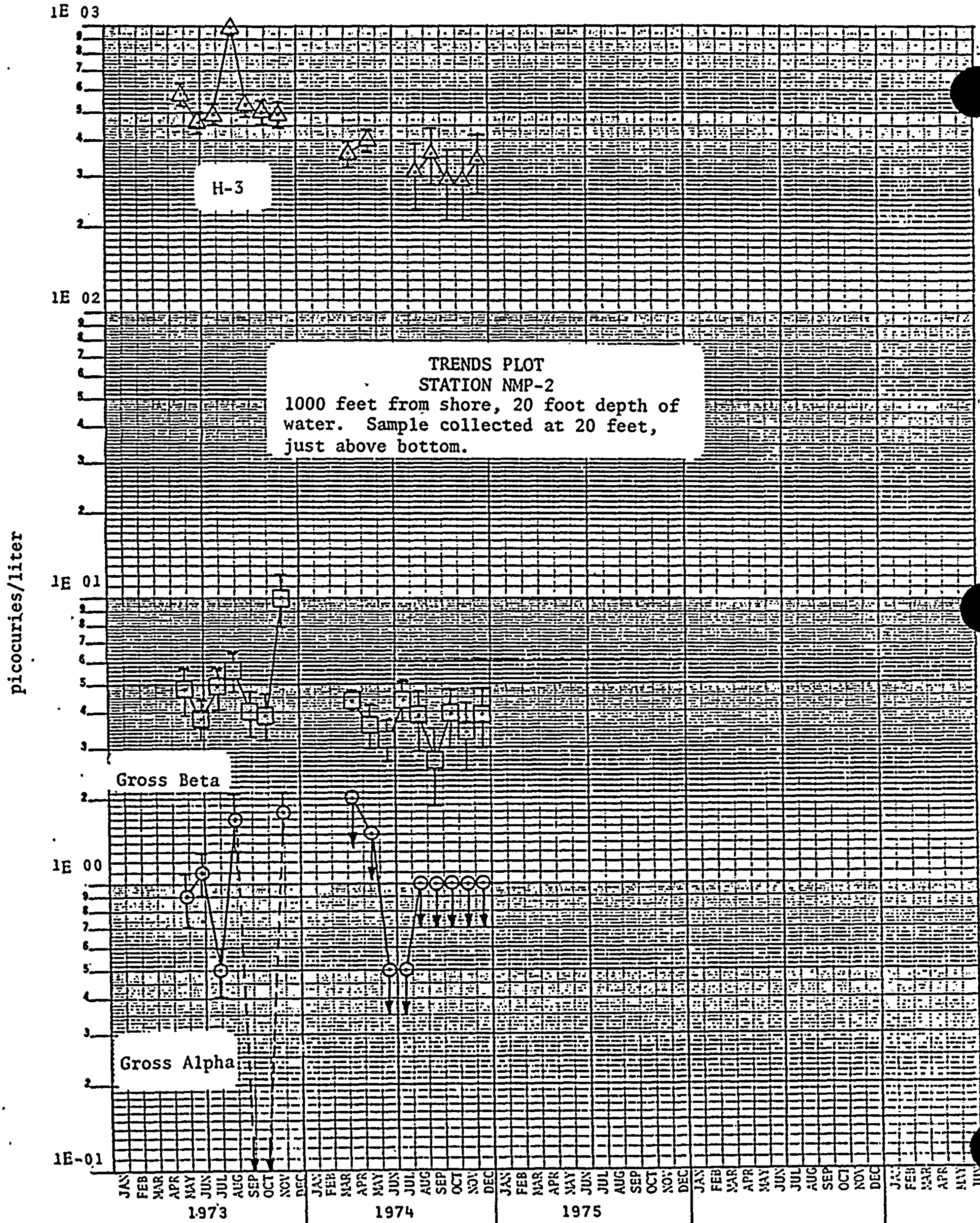
D. Gamma Emitters

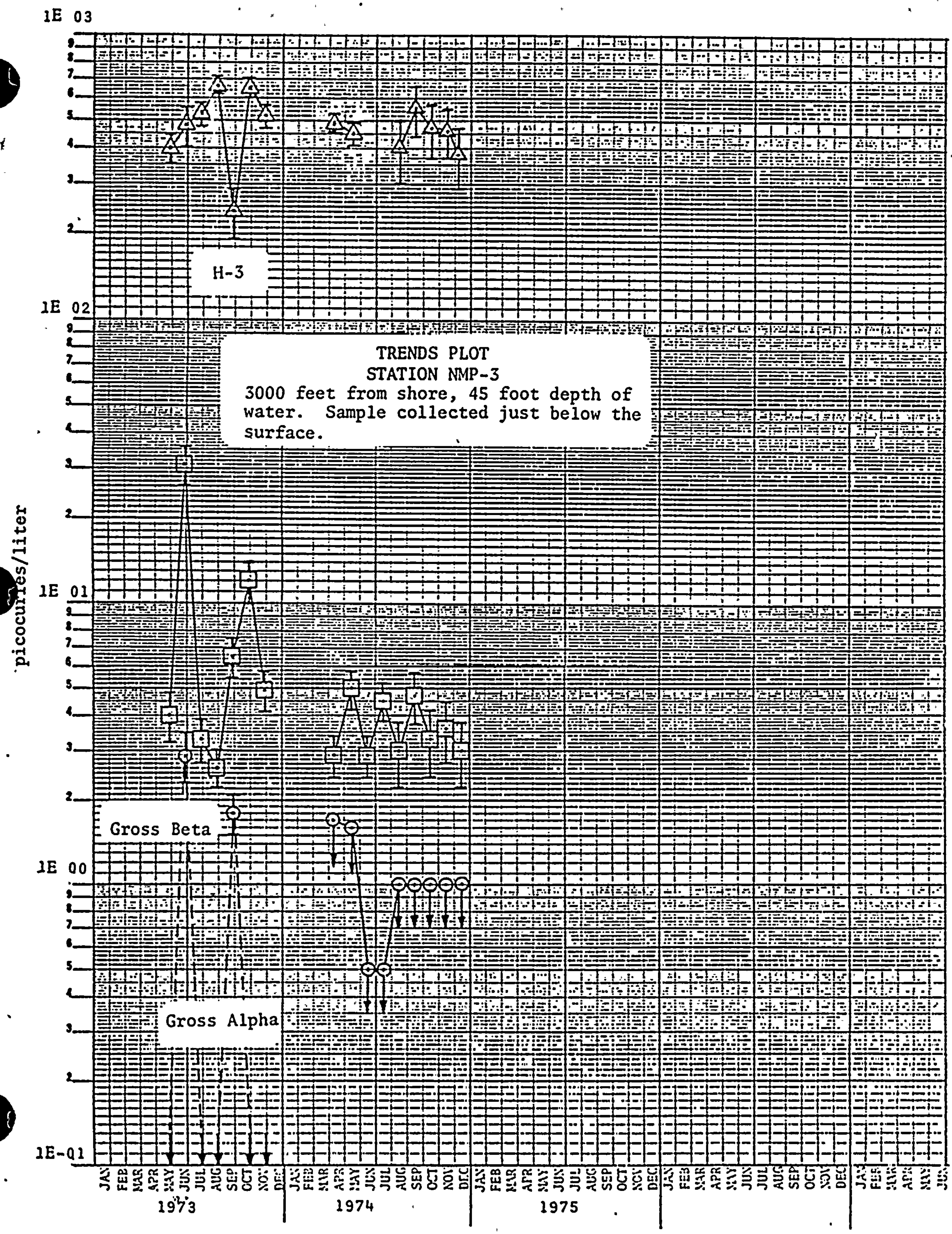
Gamma analyses by high resolution Ge(Li) spectrometry were performed on the Lake Ontario water samples collected during April, May and August through December 1974. No detectable levels of gamma activity were monitored in these samples. The detection sensitivities for gamma analysis are listed in Appendix "C".

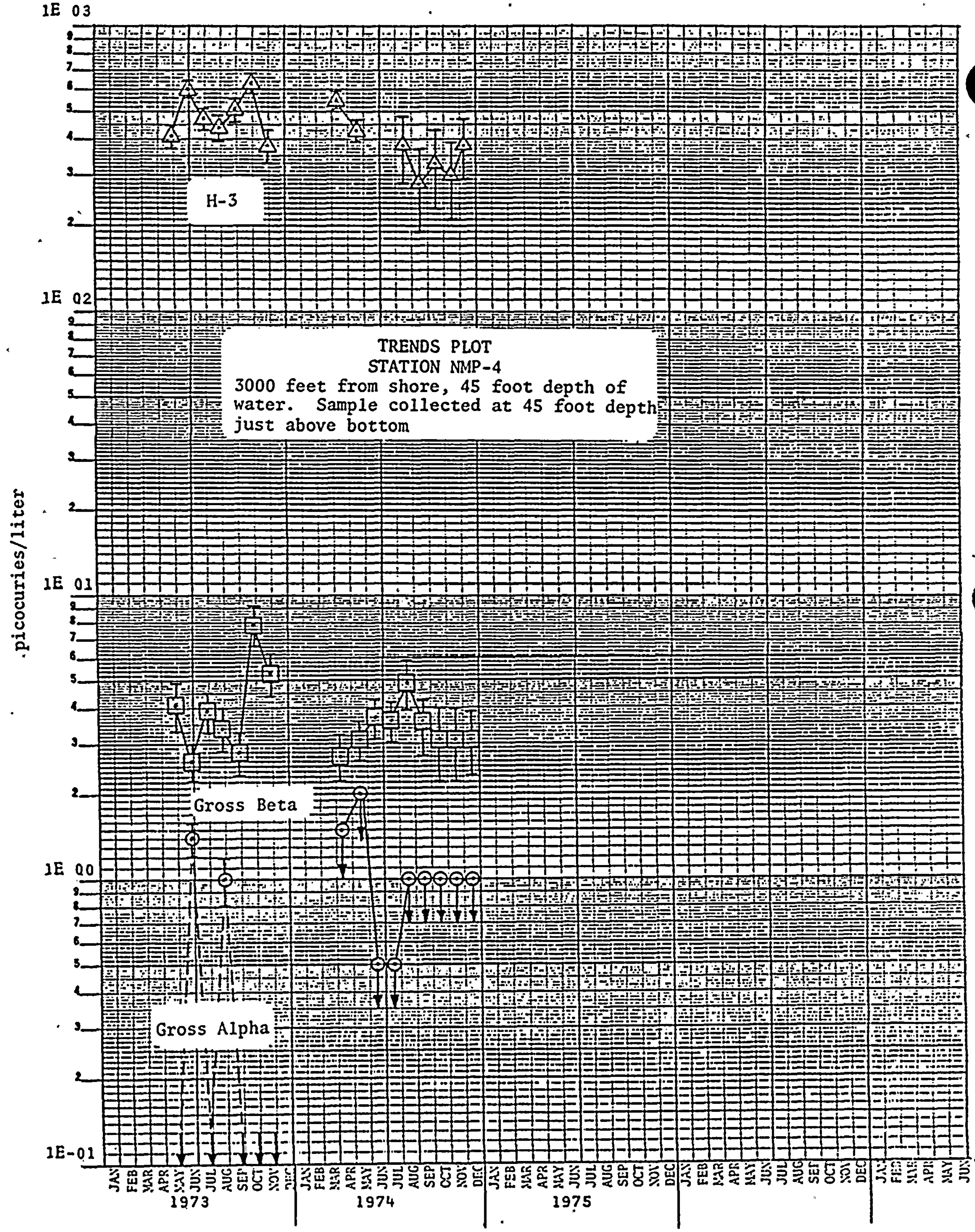
In summary, the results of the 1974 monitoring program of water samples from Stations NMP-1, NMP-2, NMP-3, and NMP-4 on Lake Ontario off the Nine Mile Point Nuclear Station - Unite 1 show no radioactivity above background levels.



1E 03
1E 02
1E 01
1E 00
1E-01
pico s/liter
H-3
TRENDS PLOT
STATION NMP-1
1000 feet from shore, 20 foot depth of water. Sample collected just below the surface.
4.6±0.8 E 02
Gross Beta
1.0±0.3 E 01
Gross Alpha
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1973
1974
1975


TRENDS PLOT
STATION NMP-2
1000 feet from shore, 20 foot depth of water. Sample collected at 20 feet, just above bottom.
H-3
Gross Beta
Gross Alpha
picocuries/liter
1E 03
1E 02
1E 01
1E 00
1E-01
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1973
1974
1975


TRENDS PLOT
STATION NMP-3
3000 feet from shore, 45 foot depth of water. Sample collected just below the surface.
H-3
Gross Beta
Gross Alpha
picocuries/liter
1E 03
1E 02
1E 01
1E 00
1E-01
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1973
1974
1975


TRENDS PLOT
STATION NMP-4
3000 feet from shore, 45 foot depth of water. Sample collected at 45 foot depth just above bottom
H-3
Gross Beta
Gross Alpha
picocuries/liter
1E 03
1E 02
1E 01
1E 00
1E-01
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1973
1974
1975

TELEDYNE ISOTOPES

APPENDIX A

ANALYTICAL PROCEDURES

RIVER OR LAKE WATER

Gross Beta/Gross Alpha

1. To 1 liter of sample, add 1 mℓ of nitric acid and evaporate to 1 - 2 mℓs volume.

2. Transfer to a 2 inch diameter stainless steel planchet and evaporate to dryness under an infrared heating lamp. Determine the weight of residue and submit for radioassay.

3. Count for 50 minutes in a Beckman-Sharp Wide Beta II counter for gross beta, then for gross alpha.

Tritium

An aliquot of sample is converted to hydrogen gas by reduction in a hot zinc furnace, mixed with methane counting gas, and radioassayed utilizing an internal low-level gas proportional counter. Very low levels of activity can be detected due to the sophistication of the counting equipment, the electronics, and the shielding.

Gamma Isotopic Analysis

One liter of sample is transferred to a 1 liter Marinelli wraparound counting beaker and counted for 8 hours on a high resolution gamma spectrometer. Specific gamma isotopes are indicated by peaks at discrete energies. The activity of each isotope is determined by computer-aided integration of the area under each peak.

APPENDIX B

SUMMARY OF ANALYTICAL METHODS AND MONITORING PARAMETERS

ISSUED: ________

MEDIA ____ / ____ ANALYSIS	LABORATORY ____ / ____ PROCEDURE	COUNTING SYSTEM ____ / COUNTING TIME	MDL/MOUNT ON COLLECTION DATE	MDL/MOUNT ON COUNTING DATE	OPERATING PARAMETERS: Chemical Yield %	Decay Factor Collection& Count Time	Recommended Sample Size	Sigma Multiplier per Mount	Background (CPM)	% Eff.	COMMENTS
WATER	RAD. CHEM.	GAS FLOW PROP.									
GROSS BETA (susp. and/or diss.)	separate fraction (susp. and/or diss.) evaporate water deposit residue in planchete dry and weigh maximum of 1 gr.	>50 min.	No decay correction	≥0.9 pCi/mount *	100	N.A.	>1 liter	>3	<1.7	≤41	*MDL/mount proportional to wt. of residue
GROSS ALPHA (susp. and/or diss.)	same sample as gross beta do not cover with pliofilm	>50 min.	No decay correction	≥0.4 pCi/mount *	100	N.A.	>1 liter	>3	<0.2	≤31	*MDL/mount proportional to wt. of residue
WATER	RAD. CHEM.	LOW LEVEL BETA									
Sr-89	strontium carrier chemical separation, strontium carbonate mount	>150 min.	4-5 pCi/sample	4 pCi/sample	>70 (Sr)	>0.76 <20 days	>1 liter 2 liters	>9.2	<1.3	>20	
Sr-90	yttrium carrier, chemical separation, yttrium oxalate mount	>150 min.	0.8 pCi/sample	0.8 pCi/sample	>70 (Sr) >90 (Y)	See I.F. See D.F.	Sample from Sr-89	>3.9	<1.0	>40	

APPENDIX B (cont.)

SUMMARY OF ANALYTICAL METHODS AND MONITORING PARAMETERS

ISSUED: ____________

MEDIA ____ / ____ ANALYSIS	LABORATORY ____ / ____ PROCEDURE	COUNTING SYSTEM ____ / COUNTING TIME	MDL/MOUNT ON COLLECTION DATE	MDL/MOUNT ON COUNTING DATE	OPERATING PARAMETERS: Chemical Yield %	Decay Factor Collection& Count Time	Recommended Sample Size	Sigma Multiplier per Mount	Background (CPM)	% Eff.	COMMENTS
WATER	RAD. CHEM.	LOW LEVEL BETA									(CONTINUED)
Cs-137	cesium carrier, ion exchange separation cesium chloroplatinate mount	>150 min.	1.0 pCi/sample	1.0 pCi/sample	>80	...	1 liter Sr-89, 90 aliquot	>3.8	<1.0	>25	
Ba-140	barium carrier, barium chromate separation, lanthanium carrier, lanthium oxide mount	>150 min.	1.0-2.5 pCi/sample	1.0 pCi/sample	>80 (Ba) >90 (La)	*>0.42 (<16 days)	1 liter Sr-89, 90 aliquot	>5.5	<1.0	>40	*Includes 4 days 81% La-140 ingrowth after Ba scavenge
I-131	iodine carrier ion exchange separation, palladium iodide mount	>150 min.	1.0-2.0 pCi/sample	1.0 pCi/sample	>60	>0.50 (<8 days)	2 liters	>5.7	<1.0	>25	
	TRITIUM CARBON-14	GAS PROP. or LIQUID SCINT.									
HTO	Distill aliquot, 2-3 mℓ in L.S. cocktail	L.S. 100 min.	1000 pCi/liter	1000 pCi/liter	100	N.A.	3 mℓ				
HTO	Distill aliquot, convert to HT,	Gas prop. 1000 min.	60 pCi/liter	60 pCi/liter			2 mℓ				

APPENDIX B (cont.)

SUMMARY OF ANALYTICAL METHODS AND MONITORING PARAMETERS

ISSUED: ________

MEDIA / ANALYSIS	LABORATORY / PROCEDURE	COUNTING SYSTEM / COUNTING TIME	MDL/MOUNT ON COLLECTION DATE	MDL/MOUNT ON COUNTING DATE	OPERATING PARAMETERS: Chemical Yield %	Decay Factor Collection & Count Time	Recommended Sample Size	Sigma Multiplier per Mount	Background (CPM)	% Eff.	COMMENTS
											(continued)
WATER	TRITIUM Carbon-14	GAS PROP or LIQUID SCINT.									
	Direct Count 2-3 mℓ in cocktail (environmental sample)	L.S. 100 min.									
C-14 $O_3^=$	acidify and evolve CO_2, collect as $CO_3^=$	GAS PROP. 1000 min.									
WATER	Ge(Li)	Gamma spectrometer									
Gamma emmiters	Aliquot assay in a standard geometry container. Non-destructive	480 min.	Apply decay factor from collection to count time	See Appendix C Ge(Li) for detection sensitivities	100	See D.F. for isotope	300 mℓ or 1 liter	>3	function of isotope and energy of gamma ray		

TELEDYNE ISOTOPES

APPENDIX C

Ge(Li) GAMMA SPECTROSCOPY DETECTION SENSITIVITIES BY HIGH RESOLUTION ENVIRONMENTAL SAMPLES

NUCLIDE	WATER (1 liter) pCi/ℓ *	SOIL & VEGETATION (400 gm) pCi/gm	FILTERS pCi/total filter
Be-7	8E+01	2E-01	2E+01
K-40	2E+02	5E-01	5E+01
Cr-51	8E+01	2E-01	8E+01
Mn-54	8	2E-02	2
Co-58	8	2E-02	2
Fe-59	1E+01	4E-02	3
Co-60	8	2E-02	2
Zr-95	1E+01	4E-02	3
Ru-103	8	2E-02	2
Ru-106	8E+01	2E-01	8E+01
I-131	1E+01	3E-02	2
Cs-134	9	2E-02	2
Cs-137	9	2E-02	2
Ba-140	3E+01	8E-02	6
La-140	2E+01	4E-02	2E+01
Ce-141	2E+01	4E-02	3
Ce-144	8E+01	2E-01	2E+01
Ra-226	6E+01	1E-01	1E+01
Th-228	1E+01	2E-02	1E+01
Zn-65	2E+01	3E-02	5

* Detection sensitivities on the counting date .