191-034

NIAGARA MOHAWK POWER CORPORATION

OSWEGO STEAM STATION UNITS 1-4

INTAKE CONSIDERATIONS

NPDES PERMIT # NY 0002186

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SUMMARY OF REPORT

Station and Site Description

The Oswego Steam Station Units 1-4 is an oil-fired electrical generating facility constructed during the period 1938-1959 with a combined maximum capacity of 408 MWe. The plant is located on the southeastern shore of Lake Ontario in the city of Oswego, New York. Cooling water to dissipate waste heat in the condensers is withdrawn from Lake Ontario through a submerged intake structure located in 5.5 m (18 ft) of water approximately 76 m (550 ft) north of the northwestern tip of the Oswego Turning Basin breakwall. The submerged intake is octagonal, and its alternating intake openings measure 1.4 x 4.4 m (4.6 x 14.5 ft) and 1.6 x 3.7 m (5.3 x 12.0 ft), respectively. The openings permit water withdrawal from 360 degrees around the intake structure; a cap constructed of wood planks restricts intake of water in the vertical direction. Circulating water velocity at the intake openings is calculated to be 0.45 m/sec (1.46 fps) under maximum plant operation of 21.52 m^3/sec (751.09 cfs) through the available intake area of 48.42 m^2 (521.2 ft^2).

Baseline Hydrographic Characteristics

Hydrographic characteristics are important to limnological studies as they in part determine seasonal and short-term environmental conditions which, in turn, influence the structure of the biotic community. Lake Ontario is a large, temperate lake that experiences seasonal changes in its thermal structure. In general, the lake can be classified as a dimictic water body, indicating a spring and fall turnover. Surface water temperature in the vicinity of Oswego Units 1-4 ranges from 0.0°C (32.0°F) during the winter to a high of 25.5°C (77.9°F) recorded during 1970. Overall, temperatures in excess of 23.3°C (73.9°F) occur only 10% of the time during the summer months and less than 4% of the time on an annual basis. Vertical temperature profiles were found to be present in the study area primarily during the summer; however, they were highly transient.

Studies of local current patterns indicate that approximately 70% of the time currents flow along the shore, and that east-to-west and west-to-east currents are equally represented. Once an alongshore current is established it persists for approximately 36-hrs before upwellings or internal oscillations alter the pattern. During the periods of stable alongshore currents, velocity ranges from less than 1.0 cm/sec (0.03 fps) up to 15.0 cm/sec (0.49 fps), with a velocity of 5.2 cm/sec (0.17 fps) recorded 90% of the time.

Other Water Intake Structures

Other water intake structures in Oswego County and their location relative to Oswego Steam Station Units 1-4 include: Nine Mile Point Nuclear Station Unit 1, 12.2 km (7.6 mi) east; James A. FitzPatrick Nuclear Power Plant, 13.0 km (8.1 mi) east; Alcan Aluminum Corporation, 6.8 km (4.2 mi) east; Oswego Steam Station Unit 5, immediately west; and the potable water intake for the City of Oswego, 0.4 km (0.2 mi) west.

Baseline Biological Studies and Community Composition

Cooling water flow withdrawn from a water body through an intake structure has the potential to impact adversely biotic populations entrained in the cooling water flow. Collections of planktonic organisms (entrainment samples) and organisms large enough to be entrapped on the traveling screens (impingement samples) were conducted from January 1975 through March 1976. These studies were part of an ongoing study at the intake of Oswego Units 1-4 initiated in 1973. Results of the current survey, previous surveys from Oswego Units 1-4, and surveys of Lake Ontario in the vicinity of Oswego Steam Station and Nine Mile Point were used to establish the baseline biological condition, and are summarized below:

1. Entrainment

a. Phytoplankton

A total of 176 taxa, representing seven major divisions, were identified from whole water phytoplankton entrainment samples. The dominant groups were green algae, diatoms, and blue-green algae. Diatom species were generally more numerous during cold water periods, while green and blue-green algae dominated the summer and early fall period. Overall, the phytoplankton entrainment data collected at the intake indicate seasonal abundance patterns and productivity similar to nearby Lake Ontario stations. Comparisons of species inventories and abundance patterns between the intake and a Lake Ontario station in the immediate vicinity of the intake structure suggest non-selective entrainment of phytoplankton populations.

b. Microzooplankton

Populations of microzooplankton entrained by the Oswego Steam Station Units 1-4 during the 1974-1976 study period were similar in composition to populations collected at Lake Ontario locations in the primary study area for the same time period. Dominant groups collected at both locations were rotifers and protozoans, with cladocerans and copepods contributing to the abundance on a more seasonal basis.

c. Macrozooplankton

The majority of the macrozooplanktonic organisms entrained are characterized as inshore species which are subject to entrainment throughout their life cycle. Three taxonomic groups were found to dominate the macrozooplankton entrained: *Leptodora kindtii*, *Gammarus fasciatus*, and hydroids. *Leptodora kindtii* was the dominant population during August and September and *Gammarus* was entrained in greatest numbers during July and August when their abundance was greatest at nearby lake stations. Hydroids were sporadic in their abundance in entrainment collections, which did not correspond to abundance patterns observed at lake stations. In general, the composition of the macrozooplankton entrained differed from the nearshore lake assemblage in that sessile hydroids and *G. fasciatus* were more abundant in entrainment collections. The same trend in entrainment was observed in previous sampling efforts comparing in-plant collections to Lake Ontario samples from the primary study area. The differences in collection data suggest the presence of a resident sessile community on or in the intake structure.

d. Ichthyoplankton

Sampling efforts for fish eggs and larvae over the 1975-1976 sampling period indicate that a diverse assemblage utilized the nearshore area on a seasonal basis. Eggs of five fish species were identified, with the greatest percentage consisting of alewife eggs. Larvae of nine species of fish were collected; of these, the alewife represented the dominant percentage, while the larvae of rainbow smelt, white perch, and johnny darter were also common. Seasonal patterns of abundance of both eggs and larvae were similar between years and closely corresponded to developmental stages projected from adult spawning patterns.

e. Impingement

During impingement monitoring of the traveling screens of Oswego Units 1-4 from January 1973 though March 1976, 35 fish species were collected and identified; these species exhibited distinct seasonal patterns of abundance and developmental stage.

The alewife was the dominant species found in impingement collections. Alewives overall composed more than 80% of the total impingement, and, during the spring when this species migrates from the open lake to the nearshore area to spawn, they represent more than 99% of the fish collected. The second most abundant species, which dominated the nearshore area during the late winter/early spring period just prior to the alewife dominance, is the rainbow smelt.

Estimated yearly impingement for 1975 at Oswego Units 1-4 (362,859 fish) was below yearly estimates for 1973 (1,700,000) and 1974 (2,200,000). The lower 1975 estimate of impingement compared to previous years reflects the lower abundance of alewives observed in the shore zone at both Nine Mile Point and Oswego, and the variance associated with the sampling design.

Potential Stresses and Impacts of Plant Operation

Operation of electrical generating facilities with once-through cooling systems can detrimentally affect organisms entrained in the cooling water flow in a number of ways. Planktonic organisms including phytoplankton, zooplankton, and ichthyoplankton, which are small enough to pass through the protective screening devices, are subjected to several types of stress including:

a. Mechanical damage resulting from contact with pumps and tubing walls and shear within the circulating water system
b. Heat dissipated through condenser tubes (thermal shock)
c. Chemical additives to cooling water (none added at Oswego Steam Station)
d. Changes in hydrostatic pressure and partial pressures of dissolved gases.

Entrainment of planktonic organisms does not result in 100% mortality, as the ability to survive this process is dependent on species and life stages entrained. Although mortality estimates are variable, the mortality due to entrainment was assumed to be 100% for the purpose of this study.

Organisms too large to pass through the traveling screens are entrapped there and suffer mortality through suffocation, loss of protective scales and slime, and mechanical damage. As noted for planktonic organisms, the degree of impact is species-specific.

Plant Operational Impact

Plant operational impact was determined for populations existing in a water body segment in the immediate vicinity of the intake for Oswego Units 1-4 and defined by current patterns in the nearshore area.

Planktonic populations were assumed to be homogeneously distributed in the water body segment, and plant impact was calculated as the percentage of the defined water body segment volume withdrawn by the plant. The maximum cropping estimate is based on a 36-hr persistent community structure, since after this time upwellings and wind induced currents would alter the structure. Based on this analysis, a maximum

of 0.44% cropping would be attributed to plant operation for any given established assemblage of planktonic organisms.

Fish eggs, because of the spawning habits and morphological adaptions of eggs of the dominant species, were not considered to be homogeneously distributed in the water body segment. The number of entrained eggs was calculated from the volume of cooling water flow for the period during which they were present in 1975. It was concluded that the total estimated number entrained by Oswego Units 1-4 was equivalent to the potential number of eggs spawned by 64 female alewives.

Plant operational impact on fish populations was calculated using two separate techniques to estimate the dominant populations in the water body segment. An estimate of impingement impact based on 1974 gill net data and 1974 yearly impingement led to the conclusion that, for six species, seasonal cropping ranged from zero to 3.23%. The greatest impact was noted for the spring spawning populations of alewife and rainbow smelt. The seasonal cropping estimates are presented in Table S-1a.

Impingement cropping was also calculated by basing the estimate of the water body segment population on trawl samples collected during 1975 in the vicinity of Nine Mile Point, and comparing this to 1975 Oswego Units 1-4 impingement. Impact was calculated using different gear efficiency values for four fish species; the daily and seasonal cropping estimates are presented in Table S-1b. For the presentation of plant impact, a trawl efficiency of 100% was used, representing the most conservative estimate.

Comparison of the cropping estimates, though tenuous due to the selectivity of the sampling techniques, and because two separate years were used for each estimate, points to minimal impact of the plant on the dominant fish populations in the southeastern section of Lake Ontario. The relatively high daily cropping rate for gizzard shad is the result of their seasonal concentration in the nearshore area, and suspected low trawl efficiency for this species.

Overall, the estimate of plant operational impact on the aquatic community in the vicinity of the Oswego Steam Station as a result of the withdrawal of cooling water by Units 1-4 is minimal and not anticipated to affect community parameters adversely.

TABLE S-1

a. SEASONAL CROPPING ESTIMATES FOR IMPINGEMENT[a]

OSWEGO STEAM STATION UNITS 1-4 - 1974

SPECIES	PERCENT CROPPING	
	SPRING	SUMMER
Alewife	3.23	0.46
Rainbow smelt	2.05	0.29
Spottail shiner	0.08	0.41
White perch	0.05	0.10
Yellow perch	0.52	0.11
Smallmouth bass	0.00	0.00

b. ESTIMATED DAILY AND SEASONAL CROPPING BY IMPINGEMENT[b]

OSWEGO STEAM STATION UNITS 1-4 - 1975

SPECIES	PERCENT CROPPING PER DAY	ESTIMATED SEASONAL[c] CROPPING %
Alewife	0.023	2.12
Gizzard shad	0.228	20.98
Rainbow smelt	0.017	1.56
Threespine stickleback	0.018	1.66

[a]Based on gill net population estimates
[b]Based on 100% trawl efficiency population estimates
[c]Season based on 92 consecutive days (daily rate x 92)

I. INTRODUCTION

A. BACKGROUND

The Oswego Steam Station Units 1-4 (Figure I-1) have a maximum combined generating capacity of 401 MWe. These units were constructed and began commercial operation during the period 1938 to 1956.

The effects of the discharge of heated effluents from these units upon the biota in the Oswego Harbor-Turning Basin and Lake Ontario are discussed in detail in the 316(a) demonstration for this plant. Niagara Mohawk Power Corporation submits herein information on the Oswego Units 1-4 intake system. This report includes a delineation of the potential stresses of entrainment and impingement associated with facility operation, and an assessment of these stresses on the biota in the vicinity of the intake.

B. DEMONSTRATION APPROACH AND RATIONALE

The 1972 Amendments to the Federal Water Pollution Control Act (Public Law 92-500) require, in Section 316(b), that intake structures reflect the best technology available for minimizing adverse environmental impact (EPA, 1976). Determination of adverse environmental impact can be made only following in-depth biological surveys in the vicinity of the intake structure.

Impingement and entrainment data were collected at the intake of Oswego Units 1-4 over a sufficient period of time and in sufficient detail to permit the impact of the plant's withdrawal of cooling water from Lake Ontario to be estimated. Results of previous biological studies have been submitted to EPA and this document summarizes those results and the information collected in the current sampling program.

The information provided in this document will permit the EPA to evaluate the effects of the operation of the intake facility of Oswego Steam Station Units 1-4. It is demonstrated herein that the intake structure exhibits low potential impact and will not adversely affect the aquatic community.

C. FORMAT OF THE DOCUMENTATION

In the development of this document, Niagara Mohawk synthesized biological and hydrological information from the Oswego/Nine Mile Point area to present estimates of impact on the aquatic community through plant operation. Sections of the report that are presented in the 316(a) submission for Oswego Units 1-4 are not repeated in this document; however, specific references are cited under the proper sections.

LOCATION OF OSWEGO STEAM STATION

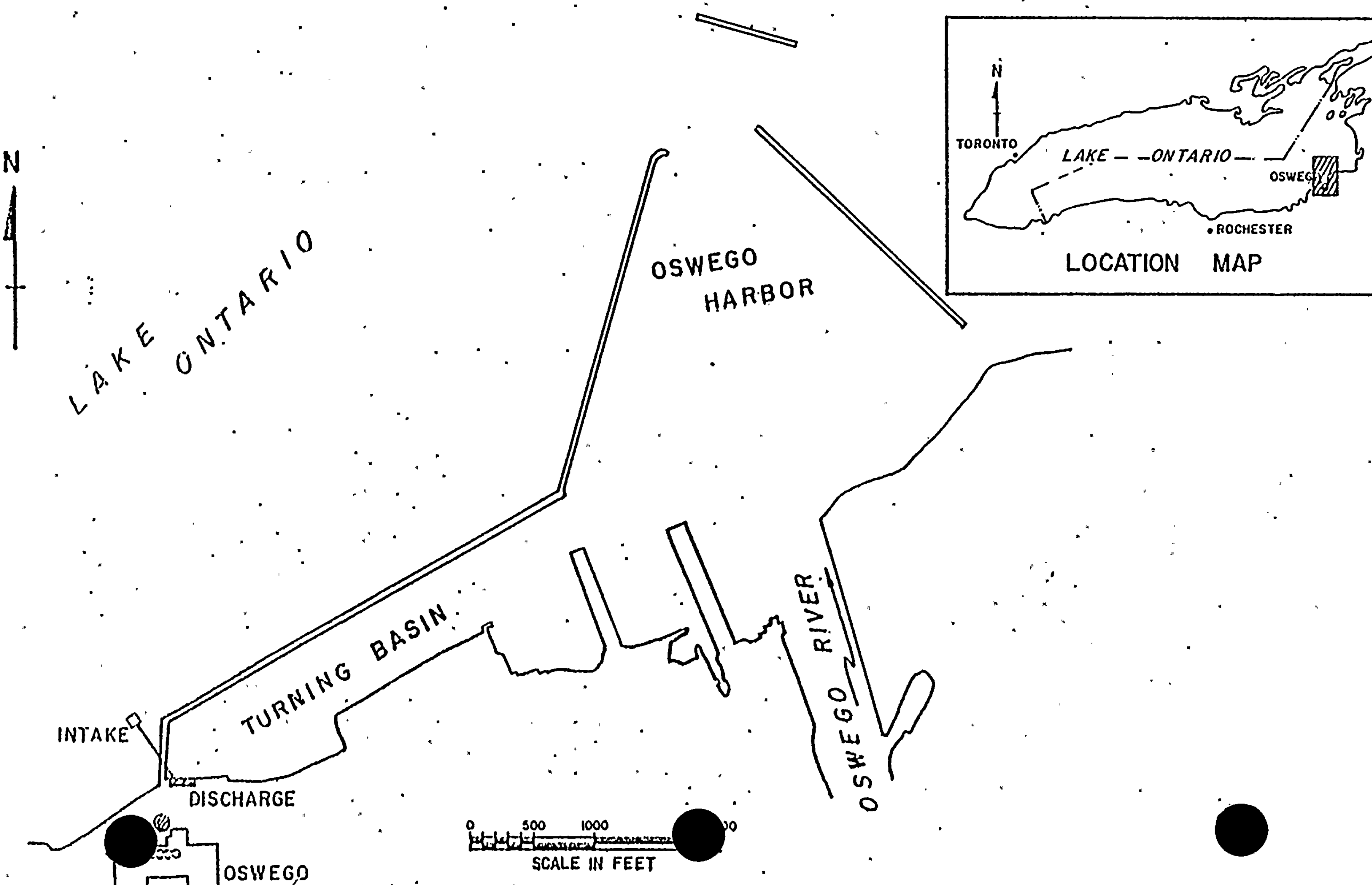


FIGURE II-

This report is organized to describe the geographical site and generating facility, the biological community, and intake impacts on that community. Chapter II of this document (by reference to the 316(a) demonstration) describes the plant and related operational parameters necessary in the assessment of plant impact. Chapter III presents the baseline hydrographic characteristics of the primary study area, and includes discussions of the climatology, geology, and water quality of the Oswego Steam Station vicinity.

Chapter IV presents information relative to baseline biological studies and community composition in the primary study area and data obtained from the in-plant collections. This information is the main supportive evidence for the assessment of plant operational impact.

Potential stresses and impacts of the circulation of cooling water are discussed in Chapter V and the actual assessment of impact resulting from the operation of Oswego Units 1-4 is documented in Chapter VI.

REFERENCE CITED

CHAPTER I

Environmental Protection Agency. 1976. Guidance for determining best technology available for the location, design, construction, and capacity of cooling water intake structures for minimizing adverse environmental impact. Section 316(b) P.L. 92-500. Draft 2.

II. STATION DESCRIPTION

Information describing the Oswego Steam Station is presented in Chapter II, Sections B-D, of the 316(a) submission for Oswego Units 1-4. The reader is referred to this document for a detailed description and operating parameters for Oswego Units 1-4.

III. BASELINE HYDROGRAPHIC CHARACTERISTICS

A. INTRODUCTION

In order to evaluate the impact of an intake structure upon the biota in the adjacent water body, information concerning water quality, currents, basin morphometry, and climatological conditions is necessary. In addition, the hydrographic characteristics of the primary study area are used to determine a biologically meaningful water body segment to be utilized in the impact chapter of this report. Information concerning the topography, geology, water quality and climatology in the vicinity of the Oswego Steam Station is presented in Chapter II, Sections E-G of the Oswego Units 1-4 316(a) Demonstration.

B. GENERAL FEATURES OF LAKE ONTARIO

1. General Seasonal Temperature Structure

a. Spring Warming and the Thermal Bar

Lake Ontario is a large, temperate lake which experiences seasonal changes in its thermal structure. Heating of the lake begins roughly in mid-March and lasts until mid-September. The onset of heating is indicated by the rise of surface water temperatures, particularly in the shallow littoral zones where the temperature rises more rapidly than in regions just offshore. By May this difference has created a sharp horizontal temperature gradient with inshore water temperatures above 4°C (39°F) and the offshore water below 4°C (39°F). The transition zone is a convergence zone where water from the warmer inshore region mixes with the colder offshore water (Rodgers, 1966). As a consequence of the nonlinear temperature/density relationship of fresh water, the mixed water produced in this transition zone is heavier than the water on either side and sinks, setting up a vertical circulation. The transition zone, which acts as a thermal bar and which inhibits the free exchange of water between the shallow littoral zone and the deeper part of the lake, moves gradually and steadily offshore with spring warming of the lake until it dissipates in late June. It is estimated that the spring thermal bar may exist for as long as eight weeks (Sweers, 1969).

During the movement of the thermal bar the inshore water continues to heat up and a thermocline develops which separates the warm surface water from the cold deep water. The thermocline restricts vertical mixing to the epilimnion, but in mid-lake on the offshore side of the thermal bar the mixing can and does extend from surface to bottom. Four weeks after emergence of the bar the inshore area constitutes roughly half the area of the lake (Sweers, 1969).

b. Summer Stratification

The disappearance of an offshore surface temperature minimum in late June can be used to define the start of the summer season in the lake. In general, vertical stratification is established over the entire basin by the combined effects of lake heating and the advection of the warmer near-shore water. The sporadic appearance of surface temperature minima during summer is related to upwelling episodes. As heating continues, stratification intensifies, and the thermocline is more sharply defined with vertical temperature gradients in excess of 1°C/m (0.6°F/ft). As a consequence of stratification, heat transfer and mixing are confined largely to the epilimnion. The lake's mean surface temperature reaches 21°C (69.8°F), and the hypolimnion temperature varies with depth, ranging between 3.8 and 4.0°C (38.0° and 39.2°F) (Sweers, 1969). The thermocline forms near the surface in early summer but descends due to continued heating and reaches a characteristic depth of approximately 21 m (70 ft) (Casey, Fisher, and Kleveno, 1965).

c. Fall Cooling

In late September the heating process is reversed, the lake mean surface temperature rapidly drops below 17°C (62.6°F) and the rate of descent of the thermocline increases. The intensity of the maximum vertical temperature gradient decreases as the surface layer and deeper water effectively mix. This process is the consequence of convection caused by cooling at the surface and is enhanced by the weakening of the thermocline which permits wind-induced turbulence to extend to greater depths.

In some respects the fall cooling events resemble the spring warming. When near-shore waters cool below the temperature of maximum density, a "reverse" thermal bar develops separating colder inshore water from warmer offshore water. The fall thermal bar has a weaker thermal gradient than the spring bar and inhibits horizontal mixing to a lesser extent.

d. Winter Cooling

The breakdown of stratification throughout the lake marks the onset of the winter season. The main offshore water mass is well mixed, attaining a nearly isothermal condition. The precise date of overturn differs from year to year depending on the incidence of storm passage. The lake surface is cooled to below 4°C (39°F) and surface isotherms tend to be parallel to shore. As cooling continues and surface temperatures decrease below 4°C (39°F), the vertical stratification is again described by a thermocline with colder buoyant water above the warmer 4°C (39°F) water. Vertical circulation at times extends as deep as 100 m (328 ft) (Sweers, 1969).

With continued cooling ice forms in the near-shore region. Under normal conditions the greatest extent of ice cover is found in the east end of the lake in mid-March. In a severe winter ice covers about 25% of the lake surface (U.S. Army Corps of Engineers, 1975).

2. Lake General Circulation

In its simplest form the large-scale general circulation of Lake Ontario is observed to be counter-clockwise (cyclonic flow) with flow to the east along the south shore in a relatively narrow band and somewhat less pronounced flow to the west along the north shore. The conceptual model that explains this average circulation is presented here with a minimum of detail.

A cool mound of water is found to extend from surface to bottom in spring and from below the thermocline to the bottom in summer and fall (Sweers, 1969). The baroclinic flow resulting from the horizontal temperature differences is initially directed outward from mid-lake towards the shore; although the Coriolis effect is acting to turn the flow to the right (clockwise) its effect is diminished due to bottom friction. This outward flow brings water to the inshore area where it begins to pile up. A surface slope, higher inshore than in mid-lake, develops into a barotropic current initially directed lakeward. The barotropic current tends to the right because of the Coriolis effect. The result is that the Coriolis effect and the barrier effect of the coastline trap the flow against the shoreline. The flow continues along the shoreline in a counter-clockwise direction as long as the surface slope is maintained.

Inflow from the Niagara River causes the western end of the lake to be higher than the eastern end (on the average). The resulting flow down the gradient is held against the lake's south shore by the Coriolis effect, thereby enhancing the already existing barotropic flow along the south shore. Wind stress averaged over the year tends further to accelerate the flow to the east and decelerate the flow to the west.

The general circulation in winter is less well documented. In late fall after overturn has occurred, the lake is essentially isothermal, thereby permitting a freer exchange of water from surface to bottom. Average wind direction in winter is primarily from the west-northwest. The net surface flow that results is eastward with westward return flow developing below the surface. The surface layer in the western end is advected to the east and is replaced by subsurface water (Sweers, 1969). This large-scale upwelling at the upwind end of the lake and downwelling at the downwind end mixes the surface and subsurface water on a scale that is not likely to occur during the rest of the year.

Conservative pollutants that are limited to the upper layer during the time of a well-developed thermocline are diluted when the hypolimnetic water is made available for mixing. In spring, with the development of the thermocline, the bottom water is again partially insulated from the surface layer.

The general circulation described above is documented by observations collected over long periods (months). The circulation patterns that are observed at any given time, however, are more complex as a result of the transient wind distribution and the lake's response to the nonsteady wind. Sometimes a major wind shift can alter the currents in a matter of hours, while at other times some features of the current pattern have continued even with an opposing wind (Csanady, 1972a). The response time of the currents to a shift in wind distribution is partially related to the scale of the current; large features such as the coastal jet respond more sluggishly, whereas nearer to shore the response is seen to be more rapid, six hours or less. Additionally, the deeper the current, the more slowly it responds. A shift in the currents as a result of wind changes eventually changes the lake surface slope and the temperature field, forcing an alteration in much of the lake's circulation patterns..

3. Perturbations of the General Circulation Pattern

Two particular examples of wind-induced changes in the general circulation are upwelling and internal oscillations. Upwelling occurs when a water mass is forced toward the surface and it occurs to some degree in all lakes during all seasons (Mortimer, 1971). It is most conspicuous during seasons of stratification when the upwelled water is much colder than the surface water that it displaces. Wind stress and associated currents depress the thermocline to below equilibrium level at the downwind end of the basin, while at the upwind end the thermocline is displaced upward and may intersect the surface. The upwelling motions are strongly modified by the Coriolis force with the result that depression of the thermocline is greatest to the right of the downwind end of the basin and upwelling is strongest to the left of the downwind end (Mortimer, 1971). For example, in Lake Ontario, a west wind causes upwelling along the northwest shore, and the thermocline is deepest along the southeast shore.

A varity of mechanisms have been proposed to account for the observed periodic displacement of the thermocline. The most direct explanation is that an upwelling event displaces the thermocline from equilibrium by converting kinetic energy of the wind to potential energy of the thermocline position. When the wind stress is removed, internal waves are set in motion and contribute to the dissipation of the energy. Internal waves increase in amplitude after storms, and in Lake Ontario the oscillations have a period near 17.5 hours, roughly three complete

oscillations every two days. These oscillation events are a regular feature of lake temperature records and are prominent in the intake temperature records at many power plants.

4. Local Currents

Current measurements have been made at both the Nine Mile Point (FitzPatrick) and Oswego power station sites. The more extensive data were obtained at Nine Mile Point.

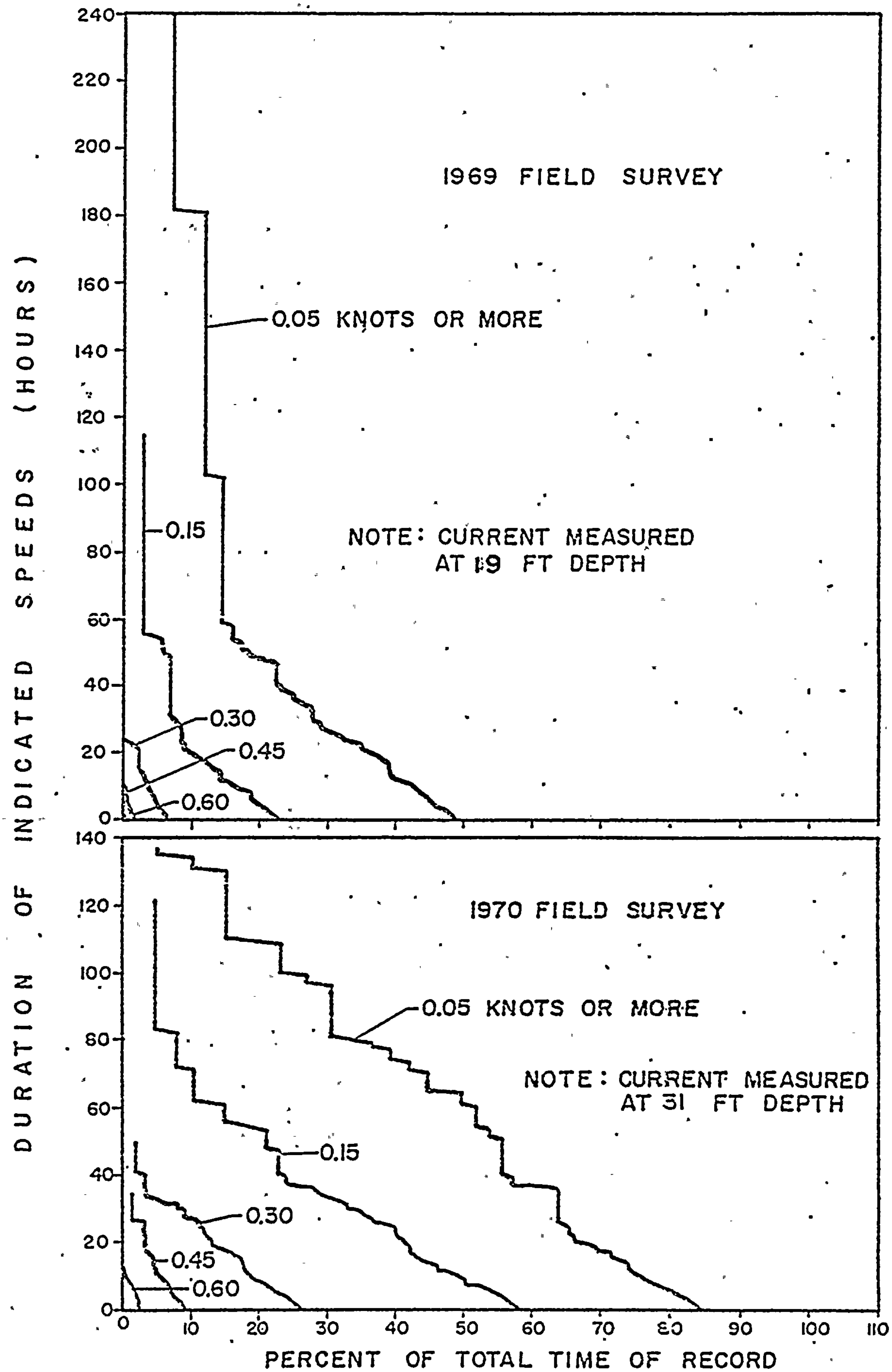
In the course of preoperational studies for the James A. FitzPatrick Nuclear Power Plant, current measurements were made off the Nine Mile Point promontory from May to October 1969, and July to October 1970. Two fixed underwater towers were placed in the lake, one in 7.3 m (24 ft) of water, and one in 14.0 m (46 ft) of water. The instruments provided average hourly current speed and direction. In addition, two drogue surveys were conducted in 1969 to obtain the overall current pattern at the site. These studies were reported by Gunwaldson et al. (1970) and PASNY (1971). Figure III-1 presents frequency-duration data derived from these studies. The data obtained are consistent with wind current frequencies reported by Palmer and Izatt (1970) for a similar water depth near Toronto.

The field data clearly illustrate a correlation between summer currents and wind speed. The correlation is an accepted principle of hydrodynamics as theorized by Ekman (1928) and subsequently verified by numerous oceanographers (Neumann and Pierson, 1966). Measurements of wind currents at lightships (Haight, 1942) have been analyzed to determine the ratio of current speed to wind speed. Reported values of this ratio, commonly called the "wind factor," range between .005 and .030.

Wind speed frequency data indicate that over the year a speed in excess of 32 km/hr (20 mph) occurs 21.6% of the time based on readings averaged over a 6-hour period. For the summer months, June through September, winds in excess of 32 km/hr (20 mph) occur 13.9% of the time. The current speed of 6-hour duration exceeded with comparable frequency in 14 m (46 ft) of water is about 15 cm/sec (0.5 fps) (see Figure III-2). For a persistence of 24 hours, the current speed exceeded 13.9% of the time is 13.7 cm/sec (0.45 fps).

The predominant direction of currents in the studies described above is alongshore, as dictated by continuity. On those occasions when onshore or offshore currents were observed, their magnitudes were substantially less than those for alongshore currents. The reported frequencies of various current directions during the summer are presented in Figure III-2. This figure indicates that currents alongshore from the west or east are equally frequent at 35% of the time for each. Onshore and offshore currents each account for 5% of the observations. The remaining 20% of the observations were below the meter

DURATION OF LAKE ONTARIO CURRENT



threshold, 0.05 knots (2.5 cm/sec, 0.09 fps). At the 6.4 m (21 ft) depth in 14.0 m (46 ft) of water the mean onshore current speed was 3.0 cm/sec (0.09 fps) and the mean offshore current speed was 6.0 cm/sec (0.2 fps). On the other hand, longshore currents from the west and east averaged 9 cm/sec (0.3 fps). Typical longshore currents from east or west were double the current speeds observed for onshore or offshore currents, with the offshore currents being generally faster. An evaluation of currents at the Sterling generating facility site near Little Sodus Bay approximately 13 km (8 mi) west of Oswego indicated the same trend in current direction (Figure III-2). Alongshore currents at the 1.5-2 m (5-7 ft) depth averaged 43% of the time and at the 4.5 m (14-16 ft) depth they accounted for 22% of the total recorded time.

Vertical profiles of currents have been recorded in several lake studies. Current profiles with depth, however, are sensitive to the turbulent momentum exchange coefficient and ambient stratification. A theoretical profile was computed for the homogeneous shallow waters found near the Nine Mile Point site and indicates the absence of any significant Ekman spiral.

Lake currents were measured at selected locations in the immediate vicinity of the Oswego Steam Station on five days between 12 October and 11 November 1970 (Table III-1). These surface current velocities were mostly longshore with speeds that ranged from very low (less than 1.0 cm/sec, 0.03 fps) up to 15 cm/sec (0.50 fps). This is in general agreement with the measurements at Nine Mile Point.

5. Local Lake Thermal Structure

Data on the thermal structure of the lake in the vicinity of Oswego were available from studies conducted offshore of the James A. Fitz-Patrick Nuclear Power Plant during 1969 and 1970, from temperature data recorded in the intake for Oswego Units 1-4 from 1968 through 1975, and from studies conducted offshore of the Oswego-Nine Mile Point area during 1973. A short description of each of these studies is presented in subsequent paragraphs. These data were used to determine the vertical temperature variations and the surface temperatures in the vicinity of Oswego.

In conjunction with the lake current studies carried out in 1969 and 1970 as part of the preoperational surveys for the James A. Fitz-Patrick plant (PASNY, 1971), three types of water temperature measurements were made, including:

- intermittent vertical profiles obtained in 18.3 and 30.5 m (60 and 100 ft) of water,

LAKE ONTARIO CURRENT DIRECTIONS

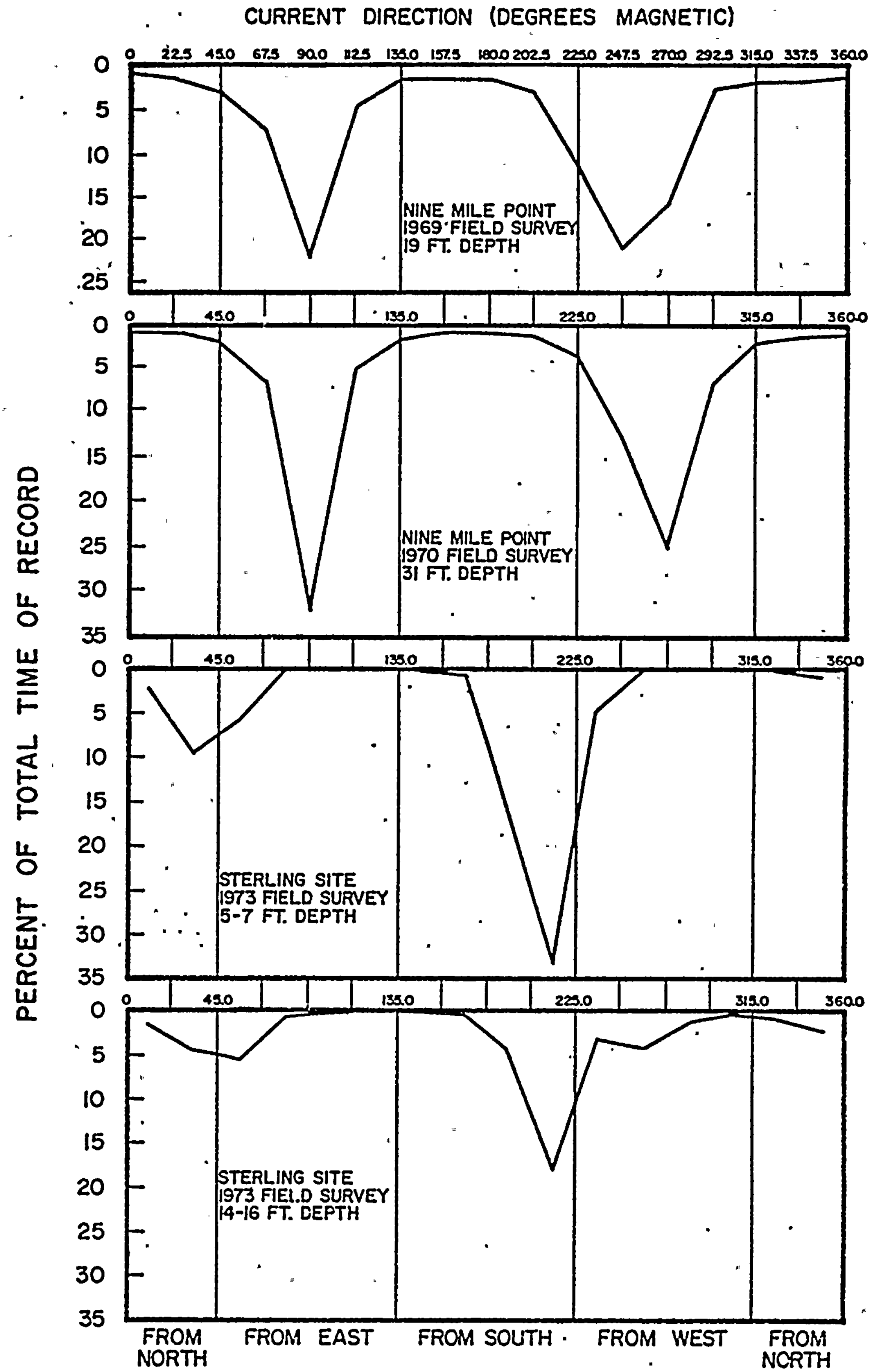


TABLE III-1

SURFACE CURRENT VELOCITY IN LAKE ONTARIO

OSWEGO VICINITY - 1970

STATION	12 OCT TRANSECT 1	12 OCT TRANSECT 2	20 OCT TRANSECT 1	20 OCT TRANSECT 2	27 OCT TRANSECT 1	27 OCT TRANSECT 2	8 NOV TRANSECT 1	8 NOV TRANSECT 2	11 NOV TRANSECT 1	11 NOV TRANSECT 2
1	.07	.05	.20	.20	.30	.10		.54	.14	.10
2	.05	.12	.24	.34	.34	.14		.24	.10	.10
3	.05	.14	.27	.30	.30	.24		.17	.24	.10
4	.03	.20	.42	.34	.44	.27		.47	.10	.24
5	.07	.10	.30	.34	.47	.44		.50	.17	.03
AVERAGE	.05	.12	.29	.30	.37	.24		.38	.15	.11

- continuous temperature recordings, obtained with seven self-contained underwater instruments mounted on two underwater towers, at various depths, and

- surface temperatures measured by airborne infrared radiometry.

The 1970 studies in the Oswego vicinity consisted of weekly temperature measurements at four locations just offshore of the Oswego Units 1-4 intake. Temperature was recorded at one-meter increments from surface to lake bottom, for seventeen consecutive weeks from July through November 1970 (QLM, 1971). During 1973, vertical temperature profiles were recorded from west of Oswego to east of Nine Mile Point, weekly from June through mid-December along five transects (QLM, 1974 .).

Data from these studies were used to evaluate the vertical temperature structure and to determine whether or not persistent stratification exists near the Oswego site. Vertical temperature profiles revealed the existence of transient thermal gradients equal to or greater than 1°C per meter (1.8°F per 3.3 ft) throughout the study area. The gradients appeared to be seasonal since they existed primarily in the summertime. However, they were not "seasonally stable," since they were generated and destroyed by surface heating and cooling and mixing within the water column over periods dependent upon meteorological conditions. Although gradients were observed during sequential weeks for up to a three week period, the gradients observed were at different temperatures and at different depths from week to week and, therefore, were not persistent. In addition, when the gradients were observed, they appeared to be uniform from station to station. A more complete discussion is presented in the documents previously submitted to the EPA (QLM, 1971, 1974a).

These data were also used to determine the surface temperature in the Oswego area. During 1970 the maximum surface temperature recorded was 25.5°C (77.9°F). Since the lake is generally isothermal in the top 6 m (20 ft), the temperature obtained at the intake depth of 4.9 m (16 ft) may be considered to be representative of the surface water temperatures. The analysis shows that, for the summer months, temperature in excess of 23.3°C (74°F) occurred only 10% of the time during the summer and less than 1% of the time on an annual basis.

6. Summary of Thermal Structure and Circulation of Lake Ontario at Oswego

The temporal thermal structure of Lake Ontario is characteristic of temperate zone dimictic lakes which experience spring and fall turnovers. Warming of the waters in the spring proceeds from the shore zone toward deeper water depths until a distinct surface-to-bottom gradient is established. During the fall the surface waters cool and the thermal

stratification eventually breaks down, permitting mixing of waters at all levels. Temporal patterns in water temperature and warming trends are important to the evaluation of migratory patterns and population dynamics of biological populations.

Currents in the shore zone of Lake Ontario are primarily alongshore which are altered by upwellings and wind currents blowing from the lake or from the shore. In the Oswego vicinity, the dominant current direction was found to be alongshore, with current velocities ranging from less than 1.0 cm/sec up to 15 cm/sec. These currents would influence the movement of planktonic organisms in the shore zone and could possibly direct the movement or duration of movement of natatory organisms.

C. OTHER EXISTING WATER INTAKE STRUCTURES IN THE OSWEGO VICINITY

1. Oswego Water Supply

The city of Oswego's water supply intake is located about 1890 m (6200 ft) out into the lake, at a depth of 16.5 m (54 ft). Water withdrawal from the lake in 1970 was 17 MGD (26.30 cfs, 0.746 m^3/sec) for the city of Oswego and 36.5 MGD (55.70 cfs, 1.581 m^3/sec) for the Metropolitan Water Board of Onondaga County, a combined maximum capacity total of 53 MGD (82 cfs, 2.327 m^3/sec).

2. Nine Mile Point Unit 1

The Nine Mile Point Nuclear Station Unit 1, which has been in operation since 1959, uses a boiling water reactor to provide 610 MWe (net) of electrical power. The station is located approximately 11 km (7 miles) east of the Oswego Steam Station.

The cooling water for Unit 1 is taken from the lake into a hexagonal intake structure located in a water depth of approximately 5.5 m (18 ft) about 259.1 m (850 ft) from the shoreline. The flow characteristics are outlined in Table III-2.

3. James A. FitzPatrick Nuclear Power Plant

The James A. FitzPatrick Nuclear Power Plant, which has been in 50% to 80% operation since July 1975, uses a boiling water reactor to provide 821 MWe (net) of electrical power. The station is located approximately 13 km (8 miles) east of the Oswego Steam Station.

The cooling water for the unit is taken from the lake into a pie-shaped intake structure located in a water depth of 7.92 m (26 ft) about 274.3 m (900 ft) from the shoreline. The flow characteristics are outined in Table III-2. Due to the distance of about 7 miles (8.6 km) between the Nine Mile Point and Oswego units, no interacting effects are expected at the intakes.

TABLE III-2

INTAKE CHARACTERISTICS FOR OSWEGO UNITS 1-4,
NINE MILE UNIT 1, FITZPATRICK UNIT, AND OSWEGO UNIT 5

PARAMETER	OSWEGO UNITS 1-4	NINE MILE UNIT 1	FITZPATRICK UNIT	OSWEGO UNIT 5
DESIGN FLOW	762 cfs 21.58 m^3/sec	635 cfs 17.98 m^3/sec	825 cfs 23.36 m^3/sec	635 cfs 17.98 m^3/sec
MAXIMUM APPROACH VELOCITY TO THE INTAKE	1.30-1.75 fps 0.40-0.53 m/sec	1.90 fps 0.58 m/sec	1.20 fps 0.37 m/sec	1.00 fps 0.30 m/sec
MAXIMUM VELOCITY THROUGH INTAKE BARS	3.20 fps 0.98 m/sec	2.00 fps 0.61 m/sec	1.40 fps 0.43 fps	1.20 fps 0.37 m/sec
MAXIMUM APPROACH VELOCITY AT TRAVELLING SCREENS	0.94 fps 0.29 m/sec	0.85 fps 0.26 m/sec	-	0.97 fps 0.30 m/sec

4. Oswego Steam Station Unit 5

The Oswego Steam Station Unit 5 has a maximum output of 850 MWe (net). This unit began operation during September 1975.

The cooling water for this unit is taken from the lake into a hexagonal shaped intake structure located in a water depth of 6.71 m (22 ft) about 365.8 m (1200 ft) from the shoreline. The flow characteristics are outlined in Table III-2. The operational impact of this unit was evaluated in a 316 demonstration submitted during 1975.

5. Alcan Aluminum Corporation

Alcan Aluminum Corp., located to the east of the Oswego Harbor, has an intake structure located in Lake Ontario. Plant use is currently 0.37 m^3/sec (95 MGD), part of which comes from municipal water supply.

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IV. BASELINE BIOLOGICAL STUDIES AND COMMUNITY COMPOSITION

A. INTRODUCTION

The operation of industrial complexes requiring cooling water intake structures have the potential to impact adversely the aquatic community through damage to biological populations entrained in the cooling water flow. In order to assess the magnitude of the impact, the diel and seasonal patterns of species, abundance, biomass, and population dynamics must be directly determined.

For several years, the biological community in the vicinity of the Oswego Steam Station Units 1-4 was characterized, and the organisms removed from this community through plant operation quantified. In addition, sampling programs conducted at locations near the primary study area, such as the Nine Mile Point studies, are useful in establishing baseline biological conditions.

Information relative to baseline studies and community composition collected prior to January 1975 are presented in reports previously submitted to the EPA. The following sections of Chapter IV summarize the biological data collected at the Oswego Units 1-4 intake facility between January 1975 and March 1976, and relate these to the findings from previous years' collections at the intake and nearby Lake Ontario locations.

B. PLANKTON

1. Phytoplankton

a. Species Inventory

(i) Intake

The phytoplankton identified in samples collected from the intake of Oswego Steam Station Units 1-4, and the dates on which they occurred, are listed in Table IVB-1. A total of 176 taxa were identified, and these represented 73 green algae (Chlorophyceae), 37 diatoms (Bacillariophyceae), 19 blue-green algae (Myxophyceae), 18 yellow-brown algae (Chrysophyceae), 14 cryptophytes (Cryptophyceae), 9 dinoflagellates (Dinophyceae), and 6 euglenoids (Euglenophyceae). The largest number of green algal taxa were identified during the summer and fall, while the largest number of diatom taxa were isolated during the spring, fall, and early winter. Blue-green algal taxa were most numerous in late summer/early fall; dinoflagellate and euglenoid forms were present in greatest diversity

TABLE IV-B-1

PHYTOPLANKTON SPECIES INVENTORY

OSWEGO STEAM STATION UNITS 1-4 - 1975-1976

SPECIES	1975 APR 30	MAY 15	JUN 16	JUL 16	AUG 12	SEP 8	OCT 17	NOV 23	DEC 9	1976 JAN 26	FEB 24	MAR 23
MYXOPHYCEAE												
Chroococcales												
Anacystis aeruginosa					X							
Aphanocapsa delicatissima						X						
Aphanothece nidulans										X		
Chroococcus limneticus					X							
C. minutus						X						
C. dispersus				X								
C. dispersus var. min	X	X	D	D	X	D	D	D	X	X	X	
Coelosphaerium kuetzingia		X					D					
Gomphosphaeria lacustris					X	X			X			
Merismopedia tenuissima				X	X							
Oscillatoriales												
Oscillatoria agardhii	X	X					X					
O. limnetica	X	D	D	X	X	D	X	X	D	D	D	D
O. geminata		X	X		X	X	X					
O. minima						X						D
O. amphibia							X					
Nostocales												
Anabaena sp.					X							
A. planctonica						X						
Aphanizomenon flos-aquae			X			X	X		X			
Scytonematales												
Plectonema sp.									X			
CHLOROPHYCEAE												
Volvocales												
Carteria sp.					X				X			
C. cordiformis						X					X	
Chlamydomonas sp.	X	X			X	X	X	X	X	X	X	X
C. globosa	X			X	X	X		X	X	X	X	X
C. pseudopertyi	X											
Eudorina elegans				X								
Pandorina morum					X							
Pedinomonas minutissima	X	X				X	X	X	X	X		
Polytoma sp.	X					X	X	X				
P. microsphaericum	X											
P. granuliferum						X						
Furcilia sp.						X						
Tetrasporales												
Gloeocystis vesticulosa					X							
Sphaerocystis schroeteri					X							
Tetraspora lacustris		X	X		X	X						
Ulothricales												
Ulothrix sp.			X									
Oedogoniales												
Oedogonium sp.	X					X	X	X	X	X	X	X
Zygnematales												
Mougeotia sp.			X	X	X	X						
Desmidiales												
Closterium sp.							X	X	X	X	X	
C. aciculare					X		X	X	X	X	X	
Cosmarium sp.	X							X				
Staurastrum sp.					X			X	X			

TABLE IV-B-1 (Continued)

PHYTOPLANKTON SPECIES INVENTORY

SPECIES	1975 APR 30	MAY 15	JUN 16	JUL 16	AUG 12	SEP 8	OCT 17	NOV 23	DEC 9	1976 JAN 26	FEB 24	MAR 23
CHLOROPHYCEAE (Continued)												
Chlorococcales												
Actinastrum hantzschii					X				X			
Ankistrodesmus falcatus	X	X	X	D	X	X	X	X	X	X	X	X
A. spirotaenia	X	X	X			X	X	X	X	X	X	
A. nannoselene				X	X		X		X		X	
Chodatella ciliata					X							
C. subsalsa					X	X						
C. quadriseta			X				X					
Chlorella sp.				X	X	X	X	X	X			
Coelastrum microporum				X	X	X	X					
C. reticulatum					X							
Crucigenia tetrapedia				X								
Dictyosphaerium ehrenbergianum					X		X					
D. pulchellum				X	X	X						
Echinosphaerella limnetica							X					
Franceia droescheri					X	X						
Golenkinia radiata			X		X				X			
Kirchneriella contorta				X								
K. subsolitaria									X			
Micractinium pusillum	X	X	X	X	X	X	X					
Oocystis sp.				X	X	X	X	X	X	X	X	
O. borgei								X				
O. lacustris							X	X				
O. pusilla							X					
Pediastrum boryanum							X				X	
P. duplex				X	X		X					X
P. simplex					X		X					
P. tetras				X	X							
Scenedesmus abundans			X	X		X					X	
S. acuminatus	X								X		X	
S. bijuga	X	X	X	X	X	X	X	X	X	X		X
S. brasiliensis				X								
S. denticulatus				X								
S. dimorphus				X	X	X	X		X	X		
S. incrassatulus									X			
S. opoliensis								X		X		
S. quadricauda	X		X	X	X	X	X	X	X	X	X	
S. bijugatus						X						
S. intermedius									X			
Schroederia judayi				X	X	X			X	X		
Selenastrum minutum				X					X	X		
Tetraedron caudatum			X									
T. minimum				X	X	X	X		X	X		
T. muticum						X						
Tetrastrum staurogeniaeforme	X	X		X					X	X	X	X
T. elegans							X					
Treubaria setigerum							X					
T. triappendiculata	X				X	X			X			
Coranastrum aestivale				X	X	X	X					
Polymastigales												
Paramastix sp.						X						
P. conifera	X											
P. minuta										X		

TABLE IV-B-1 (Continued)

PHYTOPLANKTON SPECIES INVENTORY

SPECIES	1975 APR 30	MAY 15	JUN 16	JUL 16	AUG 12	SEP 8	OCT 17	NOV 23	DEC 9	1976 JAN 26	FEB 24	MAR 23
EUGLENOPHYCEAE												
Euglena sp.	X											
E. gasterosteus		X										X
Phacus sp.									X			
P. pyrum									X	X		
Trachelomonas sp.									X			
Rhabdomonas sp.											X	
CHRYSOPHYCEAE												
Chrysomonodales												
Dinobryon sp.						X		X				
D. sociale		X	X			X			X			
Mallomonas sp.						X					X	
Synura uvella	X											
Chrysochromulina parva	X	D	X	X	D	D	X	X		X	X	X
Chromulina sp.							X		X		X	
Stelexmonas sp.	X									X	X	X
Kephyrion sp.					X			X	X	X		
Rhizochrysidales												
Rhizochrysis sp.	X	X	X		X	X				X		
Chrysosphaerales												
Chrysococcus sp.							X		X		X	
Chrysamoeba sp.						X	X					
Ochromondales												
Ochromonas sp.	X	X	D	D	X	X	X	X	X	X	X	
Uroglena sp.	X											
Craspedomonadales												
Codonosigopsis robini							X		X	X		
Monadales												
Monas sp.							X		X			
Rhynchomonas sp.									X			
Bodo sp.									X	X	X	
Isochrysidales												
Erkenia subaequiciliata									X		X	X
BACILLARIOPHYCEAE												
Centrales												
Coscinodiscus rothii				X		X	X		X	X	X	
Cyclotella atomus	X	X	X	D	X	X	X	D	X	X	X	X
C. glomerata								X	X	X	X	X
C. meneghiniana						X	X		X		X	X
C. pseudostelligera							X					
Melosira binderana	D	X	X				X	X	D	D	X	D
M. distans									X			
M. granulata	X								X			
M. islandica	X								X	X	X	X
M. italica								X				
M. italica var. subarcti				X	X		X		X			
M. italica v. tenuissima							X					
Stephanodiscus astrea	X								X			
S. hantzschii	D	X	X	X	X	X	X	X	D	D	X	X
S. niagarae	X									X	X	
S. astrea var. min	X		X			X	X	X	X	X	X	X

TABLE IV-B 1 (Continued)

PHYTOPLANKTON SPECIES INVENTORY

	1975									1976		
SPECIES	APR 30	MAY 15	JUN 16	JUL 16	AUG 12	SEP 8	OCT 17	NOV 23	DEC 9	JAN 26	FEB 24	MAR 23
Pennales												
Asterionella formosa	X	X	X			X	X	X	X	X	X	X
Diatoma elongatum	X	X	X			X			X	X	X	X
D. elongatum v. tenuis	X										X	
Fragilaria capucina	X	X	X			X	X		X	X		
F. crotonensis	X	X	X		X	X	X			X	X	
F. vaucheriae	X	X	X									
Navicula sp.									X			
N. crytocephala								X			X	
N. tripunctata								X			X	X
N. salinarum									X			
Nitzschia sp.					X			X		X		
N. acicularis	X	X	X		X		X		X			
N. dissipata						X		X	X			
N. gracilis	X	X								X	X	
N. holsatica						X						
N. vermicularis	X											
Rhoicosphenia curvata							X				X	X
Synedra sp.											X	X
S. acus		X							X	X		
S. ulna	X	X							X		X	
Tabellaria fenestrata		X					X		X	X	X	
CRYPTOPHYCEAE												
Cryptomonas erosa			X	X	X	X	X	X	X	X	X	X
C. ovata	X	X	X	X				X			X	
C. erosa var. reflexa		X	X		X	X	X	X				X
C. caudata	X			X					X	X	X	
C. marssonii			X	X	X	X		X	X		X	
C. phaseolus				X	X	X						
C. reflexa	X	X	X	X		X	X	X				X
C. pyrenoidifera												X
Katablepharis ovalis	X	X	X	X	X	X	X	X	X	X	X	X
Rhodomonas minuta		X	X	X			X	X	X		X	
R. minuta var. nannopl	X	D	X	X	X	D	X	D	X	X	X	X
Sennia parvula						X						
Cryptaulax rhomboidea										X	X	
Chilomonas paramaecium		X										
DINOPHYCEAE												
Gymnodiniales												
Gymnodinium sp.	X					X						
G. helveticum	X	X						X		X	X	X
G. varians	X					X				X	X	
G. eurytopum												X
Peridiniales												
Ceratium hirundinella						X						
Glenodinium sp.	X	X									X	
G. pulvisculus							X			X		
Peridinium sp.		X			X							
P. aciculiferum	X	X			X							

X = Present

D = Dominant species representing ≥ 10% of total abundance

during the cooler months of the year. There was no apparent seasonal pattern in the number of yellow-brown and cryptophyte taxa present. Chroococcus dispersus var. minimus, Oscillatoria limnetica, Ankistrodesmus falcatus, Scenedesmus bijuga, S. quadricauda, Chrysochromulina parva, Ochromonas sp., Cyclotella atomus, Stephanodiscus hantzschii, Katablepharis ovalis, and Rhodomonas minuta var. nannoplanktica were ubiquitous species within the major groups and often numerically dominant (10% or more of total abundance).

(ii) Lake

A total of 254 phytoplankton taxa were identified in samples collected from the Nine Mile Point vicinity of Lake Ontario (a few miles east of the Oswego Steam Station) during April-December 1975 (LMS, 1976a). More taxa were identified in this area than at the intake of Oswego Units 1-4 due to greater sampling efforts in the Nine Mile Point vicinity; however, the relative number of taxa in the seven major groups was similar in both areas. In addition, the ubiquitous and dominant taxa at Oswego Units 1-4 were, with few exceptions, among the ubiquitous and dominant taxa present in the Nine Mile Point vicinity.

(iii) 1974 Study

During 1974, phytoplankton studies were conducted in the Oswego vicinity of Lake Ontario and at the intake and discharge of Oswego Units 1-4. Of the 144 phytoplankton taxa identified, 36 were found only in lake samples and 17 were unique to in-plant samples. Most of the phytoplankton identified during 1974 were also present in both lake and in-plant samples during 1973, and were identified by previous investigators of Lake Ontario phytoplankton (see for example: Jackson et al., 1964; Nalewajko, 1966, 1967; QLM, 1974; Vollenweider, 1974; LMS, 1975a). The greatest number of taxa were green algal forms, followed by diatoms and blue-green algae. Other algal classes, including dinoflagellates, euglenoids, yellow-brown algae, and cryptomonads, contributed relatively small numbers of taxa to the community.

The variations between species present in the lake and those in in-plant collections probably do not reflect selective entrainment, but rather the differences in sampling intensity (twice as many lake samples were collected and analyzed during 1974, increasing the chances of finding the less abundant taxa in lake samples).

b. Abundance and Percent Composition

(i) Intake

Three peaks in total phytoplankton abundance were recorded at the intake of Oswego Steam Station Units 1-4 during the 1975-1976 study (Figure IVB-1). The June and September/October 1975 peaks represented primarily blue-green algal concentrations, while the January 1976 peak reflected primarily diatom concentrations (Figure IVB-1; Table IVB-2). Green algae peaked during August and January, yellow-brown algae peaked during May, August, and January, and cryptophytes peaked during May and September (Figures IVB-1 and IVB-2). Euglenoids and dinoflagellates combined never exceeded 1% of total algal numbers (Table IVB-2).

Beginning in April 1975, diatoms were succeeded by yellow-brown algae and cryptophytes in May; these two groups were subsequently replaced by blue-green algae in June (Table IVB-2). Blue-green algae and green algae were co-dominants during July and, with yellow-brown algae, during August. This mixed assemblage was succeeded by blue-green algae in September; this group remained dominant during October and November. Diatoms succeeded blue-green algae in December and remained dominant or co-dominant with blue-green algae through March 1976.

(ii) Lake

In the lake, characterized by studies in the Nine Mile Point vicinity from April to December 1975 (LMS, 1976a), three peaks in blue-green algae abundance were recorded: during June, July, and early September. The seasonal pattern for this group in the lake was, therefore, similar to the pattern recorded at the intake of Oswego Units 1-4 over the comparable time span. The patterns for diatoms and green algae in the lake were also similar to patterns observed at the intake.

(iii) 1974 Study

Seasonal patterns of total phytoplankton abundance were recorded in the Oswego vicinity of Lake Ontario during 1974; a trimodal pattern of abundance similar to that at OSWP-20 ft, the lake sampling station closest to the intake structure of Oswego Steam Station Units 1-4, was observed at the intake and discharge of Units 1-4 (LMS, 1976b). The seasonal distribution of ash-free dry weight (biomass) at both lake and in-plant sampling locations also appeared to be trimodal.

TABLE IVB-2

PERCENT COMPOSITION* OF THE ABUNDANCE OF MAJOR PHYTOPLANKTON GROUPS

OSWEGO STEAM STATION UNITS 1-4 - 1975-1976

INTAKE

DATE	BLUE-GREEN ALGAE	DIATOMS	GREEN ALGAE	CRYPTO-PHYTES	YELLOW-BROWN ALGAE	EUGLENOIDS	DINO-FLAGELLATES
30 APR	15.34	49.97	15.47	4.43	13.90	0.09	0.80
15 MAY	16.72	5.89	5.66	24.76	46.12	0.03	0.82
16 JUN	63.57	4.45	7.26	4.99	19.72	0.00	0.00
16 JUL	32.13	14.19	38.57	6.08	9.02	0.00	0.00
12 AUG	25.03	0.92	36.50	8.98	27.96	0.00	0.61
8 SEP	42.45	3.64	16.72	17.36	19.50	0.00	0.34
17 OCT	64.72	3.60	16.85	9.26	5.33	0.00	0.04
23 NOV	42.63	18.57	10.86	23.32	4.42	0.00	0.20
9 DEC	23.26	48.28	16.68	3.49	7.72	0.57	0.00
26 JAN	17.64	46.30	14.63	1.35	19.84	0.05	0.18
24 FEB	37.48	35.94	15.88	7.62	2.33	0.11	0.64
23 MAR	28.17	46.25	9.62	10.96	4.42	0.10	0.48

*Mean of R-1 and R-2

ABUNDANCE OF MAJOR GROUPS OF PHYTOPLANKTON

OSWEGO STEAM STATION UNITS 1-4 —— 1975 —— 1976

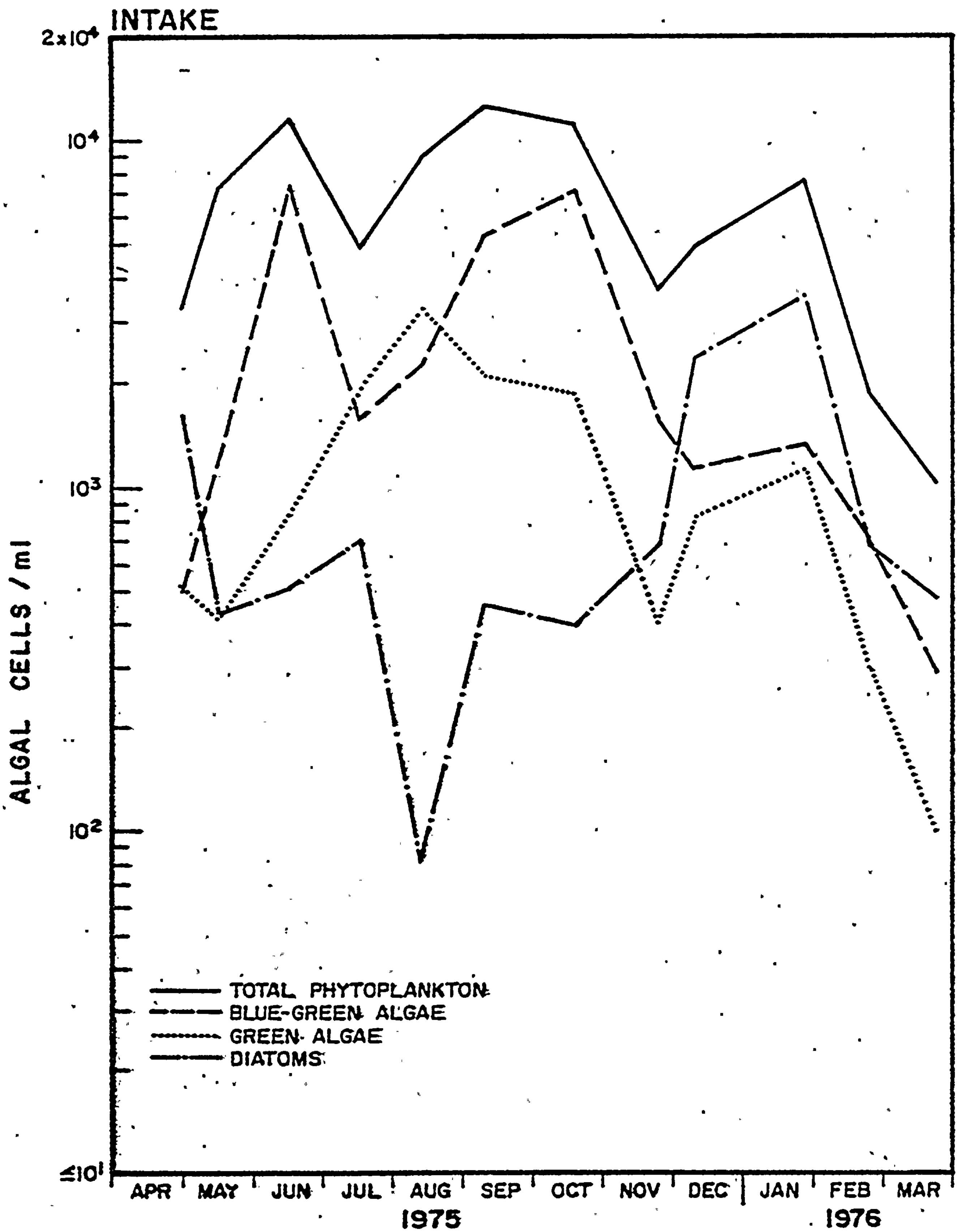
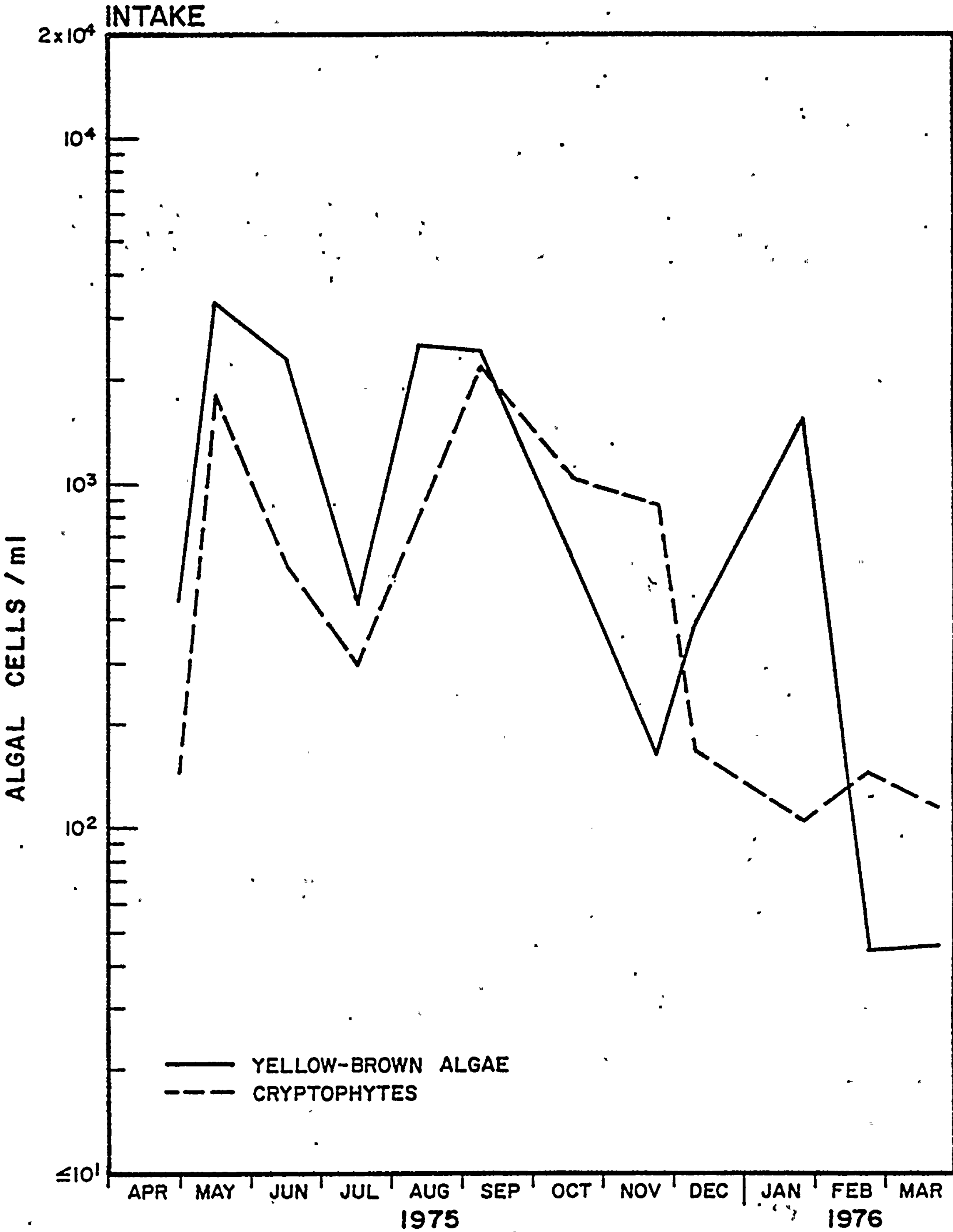


FIGURE IVB-2

ABUNDANCE OF SELECTED GROUPS OF PHYTOPLANKTON

OSWEGO STEAM STATION UNITS 1-4 —— 1975 — 1976



During both 1974 and 1973, diatoms dominated the phytoplankton community in the lake during the late spring peaks in algal abundance (LMS, 1975b). Thereafter, diatom numbers decreased to a midsummer minimum. During the fall months diatom concentrations fluctuated, although their relative abundance generally increased. Seasonal patterns in diatom concentrations and relative abundance at the intake and discharge of Oswego Steam Station during 1974 were similar to those recorded at OSWP-20 ft.

Green algae were numerically dominant in samples collected from July to November 1974 and during July and August 1973 (LMS, 1974). Maximum concentrations were found in September collections during both years, except at the OSWP-40 ft station, where a November maximum was noted during 1974. Seasonal patterns of green algal numbers and relative abundance at Oswego Steam Station intake and discharge were similar to those described for the lake.

Blue-green algae were a relatively small component of the total algal community in the Oswego vicinity during 1974, generally composing less than 25% of total phytoplankton numbers in the study area. A bimodal pattern of seasonal abundance seemed to be typical during both years of the study, with maxima found during the late spring/early summer and late summer/early fall. The fall maximum was generally of greater magnitude than the spring maximum, particularly during 1973. The seasonal distribution of blue-green algae was generally similar between the lake and in-plant sampling locations.

c. Chlorophyll a (Biomass)

(i) Intake

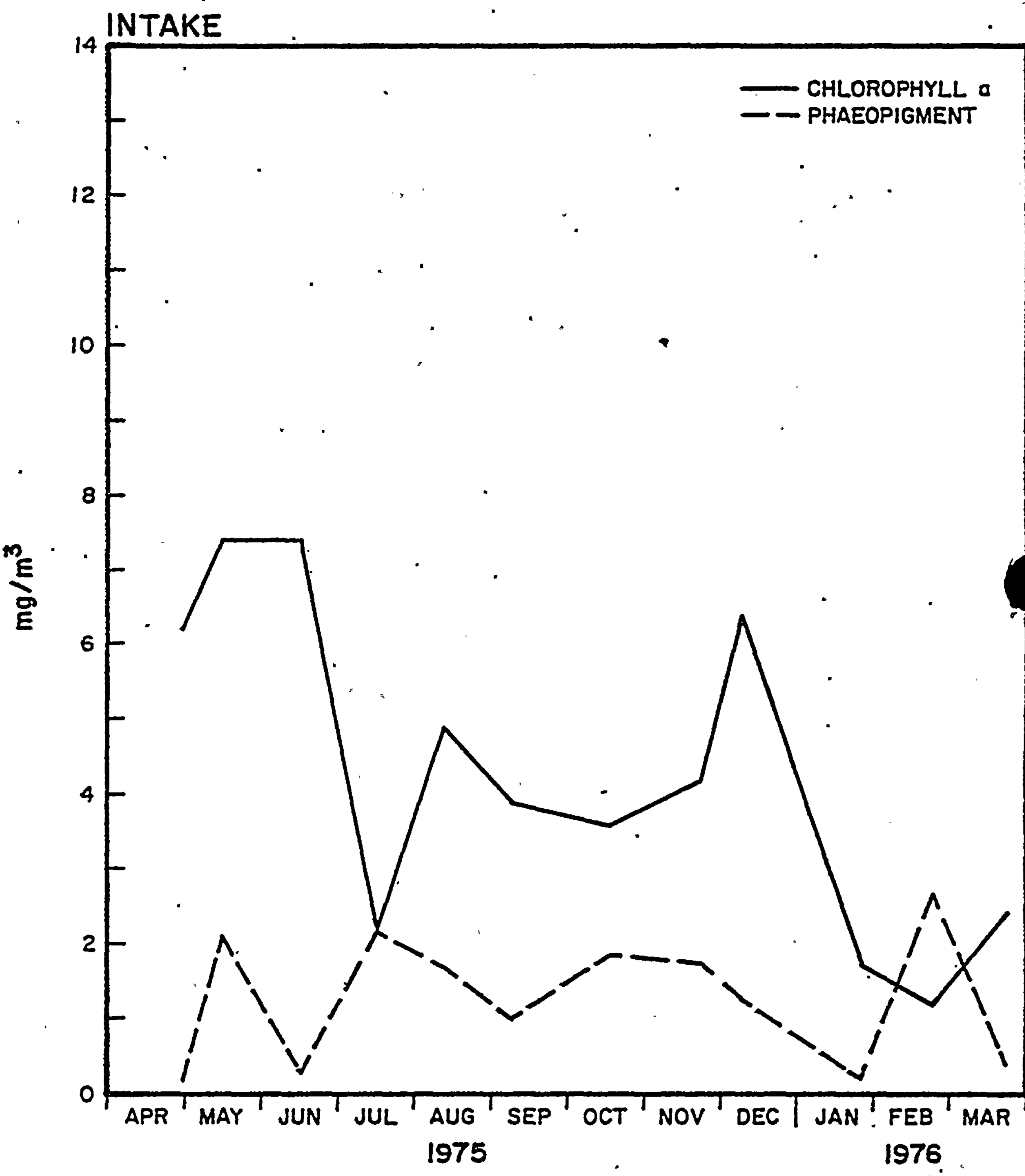
Chlorophyll a is one of the dominant algal pigments and is present in members of all of the major taxa identified in samples from the Oswego intake. Although concentrations of chlorophyll a usually vary with time depending on the physiological status of the population, this parameter is frequently used as an indicator of the standing stock of algal biomass at the community level.

Three peaks in chlorophyll a were recorded at the intake of Oswego Units 1-4 during 1975-1976 (Figure IVB-3), preceding, but corresponding approximately with peaks in total phytoplankton abundance (Figure IVB-1). The earlier occurrence of chlorophyll a peaks suggests that the quantity of this

FIGURE IVB-3

CONCENTRATIONS OF CHLOROPHYLL A AND PHAEOPIGMENT

OSWEGO STEAM STATION UNITS 1-4—1975-1976



pigment per cell diminished during periods of increasing abundance. Peaks in concentrations of phaeopigments, the inactive degradation products of photosynthetic pigments, were generally positively correlated with depressed chlorophyll _a_ concentrations, indicating that the physiological status of the community was less than optimum at such times (Figure IVB-3). Temporal differences in the magnitude of peaks in chlorophyll _a_ and total abundance reflect differences in species composition and interspecific differences in chlorophyll _a_ content.

(ii) Lake

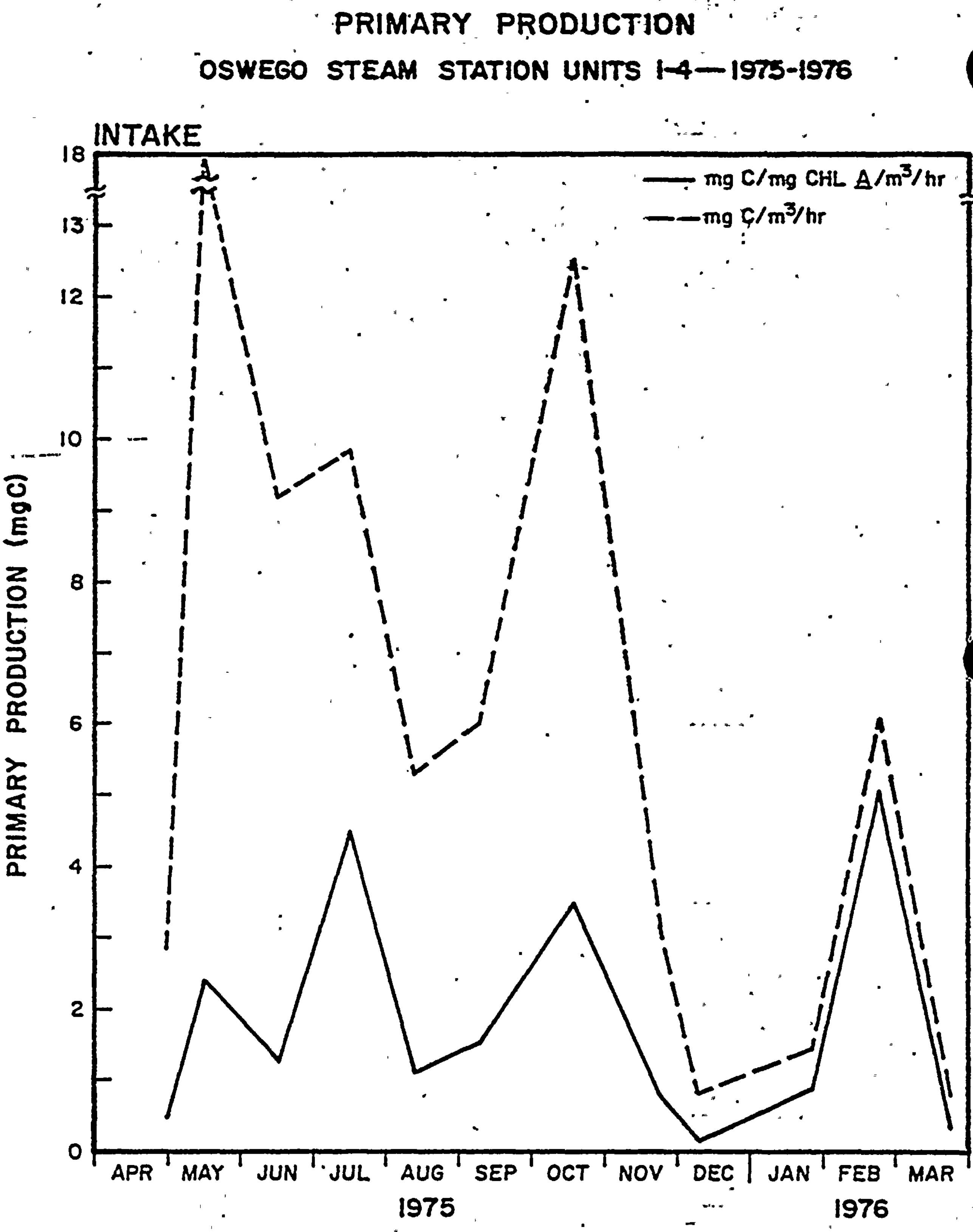
The seasonal distribution of chlorophyll _a_ in the nearshore area of Lake Ontario during 1975, as characterized in the nearby Nine Mile Point vicinity (LMS, 1976a), was generally similar to that described for the intake of Oswego Units 1-4. The only major difference was the absence of a well defined peak in the lake during December. Generally greater values were recorded for the lake, probably because these represented surface water samples, as opposed to intake collections which originated from the bottom layers of the lake water column.

(iii) 1974 Study

The seasonal distribution of chlorophyll _a_ in the lake in the vicinity of Oswego varied with sampling site, but the general pattern was a major spring peak followed by a smaller late summer peak (LMS, 1976b). While the seasonal distribution of chlorophyll _a_ concentrations measured concomitantly at the intake of Oswego Units 1-4 did not correspond exactly to patterns at lake sampling sites, both spring and late summer peaks were recorded.

d. Primary Production

Primary production is a measure of the rate of production of plant material. The ^{14}C method applied during 1975-1976 studies at the intake of Oswego Units 1-4 provides an estimate of net primary production (Strickland and Parsons, 1968). Three peaks in primary production were indicated: May/June/July, October, and February (Figure IVB-4). These peaks corresponded in general with peaks in production per unit biomass (chlorophyll _a_), indicating that the three maxima were not due entirely to seasonal fluctuations in standing stock. The peaks in production unexpectedly appeared to be positively correlated with peaks in phaeopigment concentrations (Figure IVB-3).


PRIMARY PRODUCTION
OSWEGO STEAM STATION UNITS 1-4—1975-1976
INTAKE
mg C/mg CHL A/m³/hr
mg C/m³/hr
PRIMARY PRODUCTION (mgC)
18
13
12
10
8
6
4
2
0
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
1975
1976

Other studies of Lake Ontario (e.g., Glooshenko et al., 1974) have documented the spring peak in primary production in inshore waters and a smaller fall peak, as observed at the intake of Oswego Units 1-4. However, the February peak recorded at the intake was not observed during studies in the lake due to inability to sample during the winter months.

e. Summary

Overall, the data show that the seasonal distribution of phytoplankton standing stock and production were similar in the lake and at in-plant sampling locations. Patterns of abundance in particular were essentially the same at the intake and at OSWP-20 ft, the 1974 lake sampling location closest to the intake, suggesting that phytoplankton are not selectively entrained into Oswego Steam Station Units 1-4. Comparisons of taxonomic inventories for lake and in-plant collections generally confirm the non-selectivity of this process.

2. Microzooplankton

a. Introduction

Microzooplankton, for the purposes of this demonstration, will constitute those invertebrate species retained by a 76μ mesh net. These organisms are generally primary consumers, feeding upon algae and particulate organic matter; some taxa, however, are predaceous on other zooplankters (e.g., some rotifers, cyclopoid copepods). Microzooplanktonic organisms are also subject to predation by higher trophic levels (e.g., by planktivorous fish such as alewife).

This chapter will present background biological data on the lake microzooplankton populations in the Oswego vicinity of Lake Ontario during 1973-1974, and will examine the abundance and species composition of the zooplankton entrained by the Oswego Steam Station Units 1-4 (1974 and 1975-1976). A cropping estimate and the rationale for such an approach in quantifying impact is presented in Chapter V. Methods and materials are summarized in Appendix A.

b. Species Inventory

The species identified in collections from lake surveys of the Oswego vicinity (1973-1974) and from entrainment surveys (1974-1976) are presented in Table IVB-3. During 1974, more species were identified from lake collections than from in-plant collections; this was most likely due to a greater sampling effort in the

TABLE IV B-3

MICROZOOPLANKTON SPECIES INVENTORY

OSWEGO STEAM STATION UNITS 1-4 AND VICINITY - 1973-1976

	IDENTIFIED IN 1973	IDENTIFIED IN 1974			IDENTIFIED IN 1975-1976 - IN-PLANT ONLY											
	LAKE ONLY	LAKE AND IN-PLANT	IN-PLANT ONLY	LAKE ONLY	APR 30	MAY 15	JUN 16	JUL 16	AUG 12	SEP 12	OCT 17	NOV 23	DEC 9	JAN 26	FEB 24	MAR 29
PROTOZOA																
Actinopoda	X															
Lobosa																
Testacealobosa																
Difflugiidae																
Difflugia sp.	X	X							X							
Suctoria																
Tentaculiferida																
Acinetidae																
Acineta sp.		X										X	X	X		X
Thecacineta sp.		X									X				X	X
Tokophyra sp.			X													
Podophryidae																
Paracineta sp.		X														
Ciliata																
Spirotrichida																
Halteriidae																
Strombidium sp.	X															
Tintinnidae																
Codonella sp.	X															
C. cratera		X					X		X	X	X	X			X	X
Peritrichida																
Epistylidae							X	X	X	X	X	X			X	
Epistylis sp.	X	X														
Vorticellidae	X	X			X	X				X	X		X	X	X	
Holotrichida																
Gymnostomina sp.	X			X												
Didiniidae																
Didinium sp.	X															
Zoomastigophorea																
Polymastigida																
Multicilia sp.	X															
ROTIFERA																
Bdelloidea								X								
Monogonta																
Ploima																
Brachionidae																
Brachionus sp.	X		X													
B. angularis				X			X		X				X	X		
B. benni				X												
B. budapestinensis				X												
B. calyciflorus		X											X	X		
B. caudatus		X														
B. leydicii				X												
B. urceolaris				X												
Euchlanis sp.				X												
Kellicottia sp.	X															
K. bostoniensis		X									X					
K. longispina		X				X	X				X	X	X	X	X	X
Keratella cochlearis	X	X				X	X	X	X	X	X	X	X	X	X	X
K. crassa								X	X	X	X	X	X	X	X	
K. earlinae							X	X	X	X	X	X	X	X		X
K. hiemalis																X
K. quadrata	X	X				X	X		X			X	X	X	X	X
K. valga							X						X			
Notholca sp.	X	X														
N. acuminata		X				X							X		X	X
N. squamula				X		X										
N. striata				X		X										
Platyias patulus				X												

TABLE IVB-3 (Continued)

MICROZOOPLANKTON SPECIES INVENTORY

	IDENTIFIED IN 1973	IDENTIFIED IN 1974			IDENTIFIED IN 1975-1976 - IN-PLANT ONLY											
	LAKE ONLY	LAKE AND IN-PLANT	IN-PLANT ONLY	LAKE ONLY	APR 30	MAY 15	JUN 16	JUL 16	AUG 12	SEP 12	OCT 17	NOV 23	DEC 9	JAN 26	FEB 24	MAR 29
ROTIFERA (Continued)																
Trichocercidae																
Trichocerca sp.	X			X												
T. cylindrica		X							X							
T. multicrinis		X						X	X	X		X				X
T. porcellus											X	X	X			
Gastropidae																
Ascomorpha sp.		X							X							
A. ecaudis				X					X							
Chromogaster sp.	X															
C. ovalis		X														
Asplanchnidae																
Asplanchna sp.	X	X														
A. priodonta													X			
Notommatidae																
Cephalodella sp.			X									X				
Synchaetidae																
Ploesoma sp.	X	X														
P. hudsoni									X							
P. lenticulare		X							X	X						
P. truncatum		X										X				
Polyarthra sp.	X	X										X				
P. dolichoptera					X	X	X			X						
P. euryptera				X							X					
P. longiremis			X													
P. major					X		X	X	X	X	X	X	X		X	
P. remata						X	X	X	X	X	X	X	X			
P. vulgaris			X				X	X	X	X	X	X	X	X	X	
Synchaeta sp.	X	X														
S. lackowitziana		X				X				X	X	X	X	X	X	X
S. pectinata		X			X	X					X	X	X			X
S. stylata		X				X	X	X	X	X	X					
S. tremula		X														
Flosculariaceae																
Testudinellidae																
Filinia sp.	X															
F. longiseta		X					X	X	X	X			X			
Hexarthridae																
Hexarthra sp.								X								
Conochilidae																
Conochilus sp.	X	X														
C. unicornis							X	X	X				X			
Collothecidae																
Collotheca mutabilis		X								X	X	X	X			
ARTHROPODA																
Crustacea																
Cladocera																
Bosminidae																
Bosmina sp.	X	X														
B. longirostris							X	X		X	X	X	X	X		
Chydoridae																
Chydorus sphaericus		X								X						
Daphnidae																
Ceriodaphnia sp.	X															
C. quadrangularis		X														
C. lacustris		X							X	X						
Daphnia sp.	X	X														
D. galeata mendotae		X														
D. retrocurva		X									X	X	X			
Sididae																
Diaphanosoma sp.	X															
Leptodoridae																
Leptodora kindtii[a]	X															

TABLE IVB-3 (Continued)

MICROZOOPLANKTON SPECIES INVENTORY

	IDENTIFIED IN 1973 LAKE ONLY	IDENTIFIED IN 1974			IDENTIFIED IN 1975-1976 - IN-PLANT ONLY											
		LAKE AND IN-PLANT	IN-PLANT ONLY	LAKE ONLY	APR 30	MAY 15	JUN 16	JUL 16	AUG 12	SEP 12	OCT 17	NOV 23	DEC 9	JAN 26	FEB 24	MAR 29
Copepoda																
Calanoida[b]								X		X	X	X	X	X		X
Centropagidae																
Limnocalanus macrurus														X		
Diaptomidae																
Diaptomus spp.		X											X			
D. oregonesis														X		
D. sicilis				X												
Temoridae																
Eurytemora affinis				X												
Harpacticoida[b]															X	
Cyclopoida[b]						X	X	X	X	X	X	X	X	X	X	
Diacyclops bicuspidatus thomasii		X									X	X	X	X	X	X
Acanthocyclops vernalis		X														
Tropocyclops prasinus mexicanus		X						X		X	X	X				
UID adults	X															
UID nauplii	X					X	X	X	X	X	X	X	X	X	X	X

[a] *Leptodora kindtii* not analyzed in 1974-1976 microzooplankton samples

[b] Includes unidentified juvenile forms

lake resulting in the collection of relatively rare species. During 1975 year-round sampling enhanced by identification to lower taxonomic levels increased the number of species listed for in-plant collections.

The majority of the species identified from entrainment collections during 1974 and 1975-1976 were also identified from the lake collections during 1974 (Table IVB-4). Those that were not represented in both were relatively rare.

c. Abundance and Community Composition

(i) Lake Collections

Rotifers dominated the microzooplankton community in the Oswego vicinity of Lake Ontario during 1974 as well as during 1973 (LMS, 1974), with maximum rotifer abundances found during July of both years (Figure IVB-5). However, rotifer abundance patterns after July differed between years. In 1974, rotifer populations generally declined in abundance through the summer months while in the summer of 1973, rotifer concentrations remained fairly constant. The differences observed between years could have been due in part to higher summer water temperatures during 1973 than 1974. No spatial differences in total rotifer distribution were indicated in the primary study area based on the 1974 collection data (LMS, 1976b).

Cladocerans were the second most abundant microzooplankton group observed during both 1973 and 1974. There was some variation in temporal patterns of abundance between years; a distinct bimodal pattern, with a low in September, was observed during 1973, while in 1974 a single period of abundance, encompassing the summer and early fall months, was evident (Figure IVB-6). The peak cladoceran concentrations occurred at approximately the same times (July/August and late October) during both years of study; however, like rotifers, cladocerans were somewhat less abundant during the 1974 maxima. Spatial distribution of cladoceran abundance showed some interstation differences, as concentrations were significantly lower at OSWP-40 ft than at other stations during 1974 (LMS, 1976b).

Copepods represented a smaller fraction of total microzooplankton abundance than either rotifers or cladocerans during both 1973 and 1974 (LMS, 1974, 1976b). Figure IVB-7 shows a single abundance peak for copepods during 1974, when the greatest concentration was recorded during August at all four lake sampling stations. Although no significant difference

TABLE IV B-4

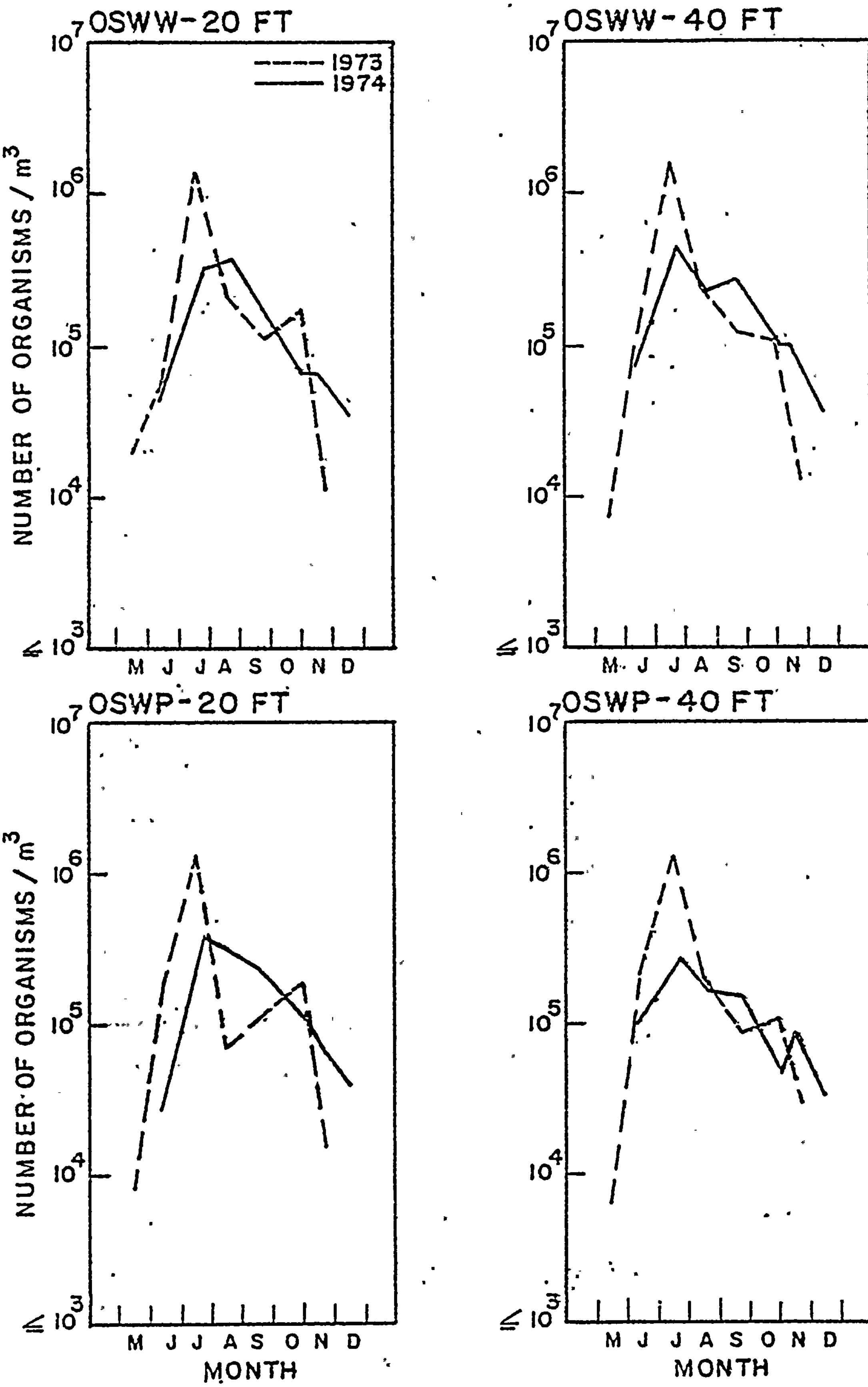
NUMBER OF MAJOR TAXA IDENTIFIED DURING MICROZOOPLANKTON COLLECTIONS

OSWEGO STEAM STATION UNITS 1-4 AND VICINITY - 1974-1975*

TAXA	NO. OF TAXA IDENTIFIED IN 1974			NO. OF TAXA IDENTIFIED IN 1975	
	LAKE	IN-PLANT	LAKE AND IN-PLANT	IN-PLANT	COMMON TO 1974-LAKE
PROTOZOA	8	8	7	6	6
ROTIFERA	37	29	25	37	23
CLADOCERA	7	7	7	3	3
COPEPODA	6	4	4	9	3

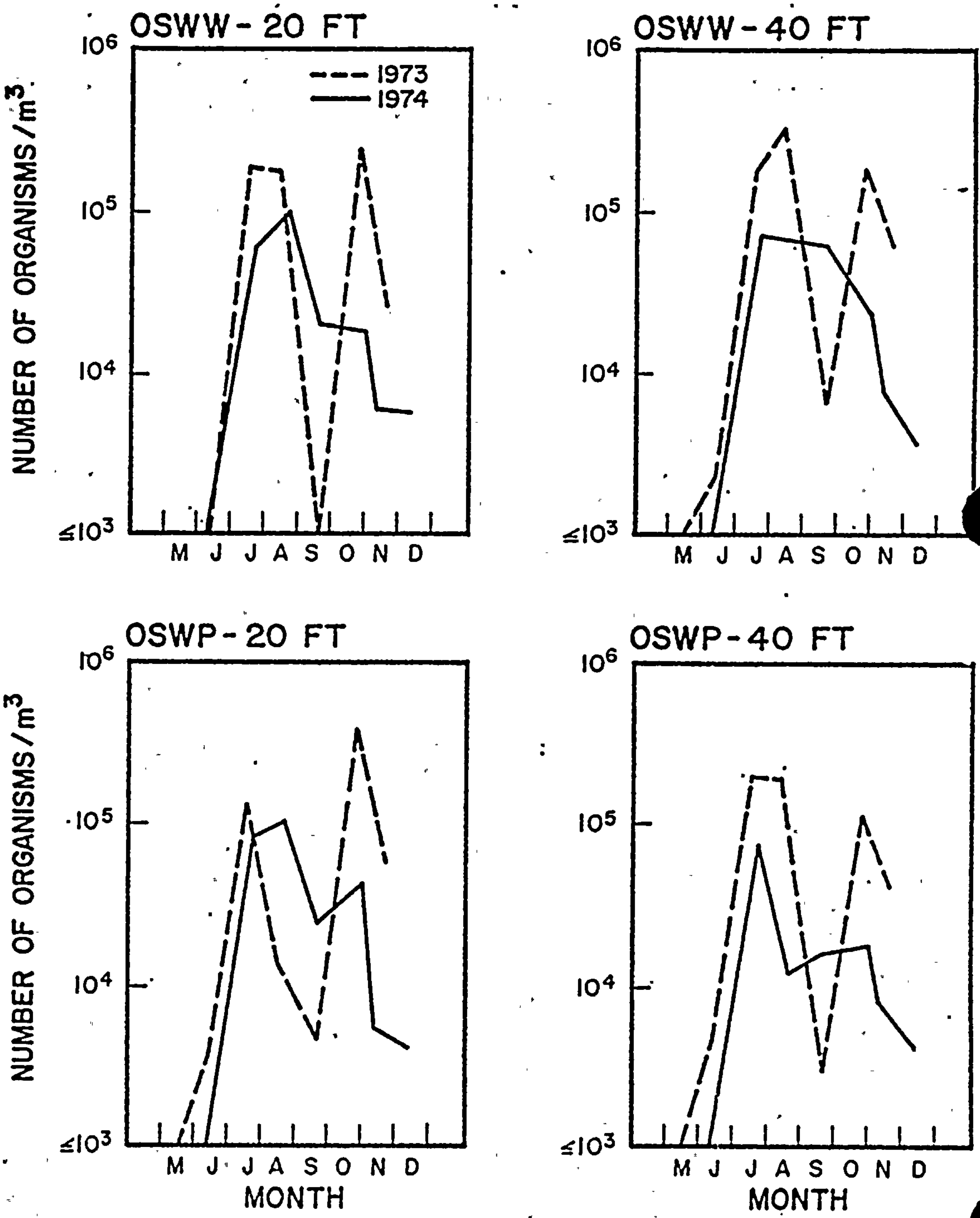
*Based on Table IVB-3

ABUNDANCE*OF ROTIFERA
OSWEGO VICINITY — 1973-1974



*Original sample.

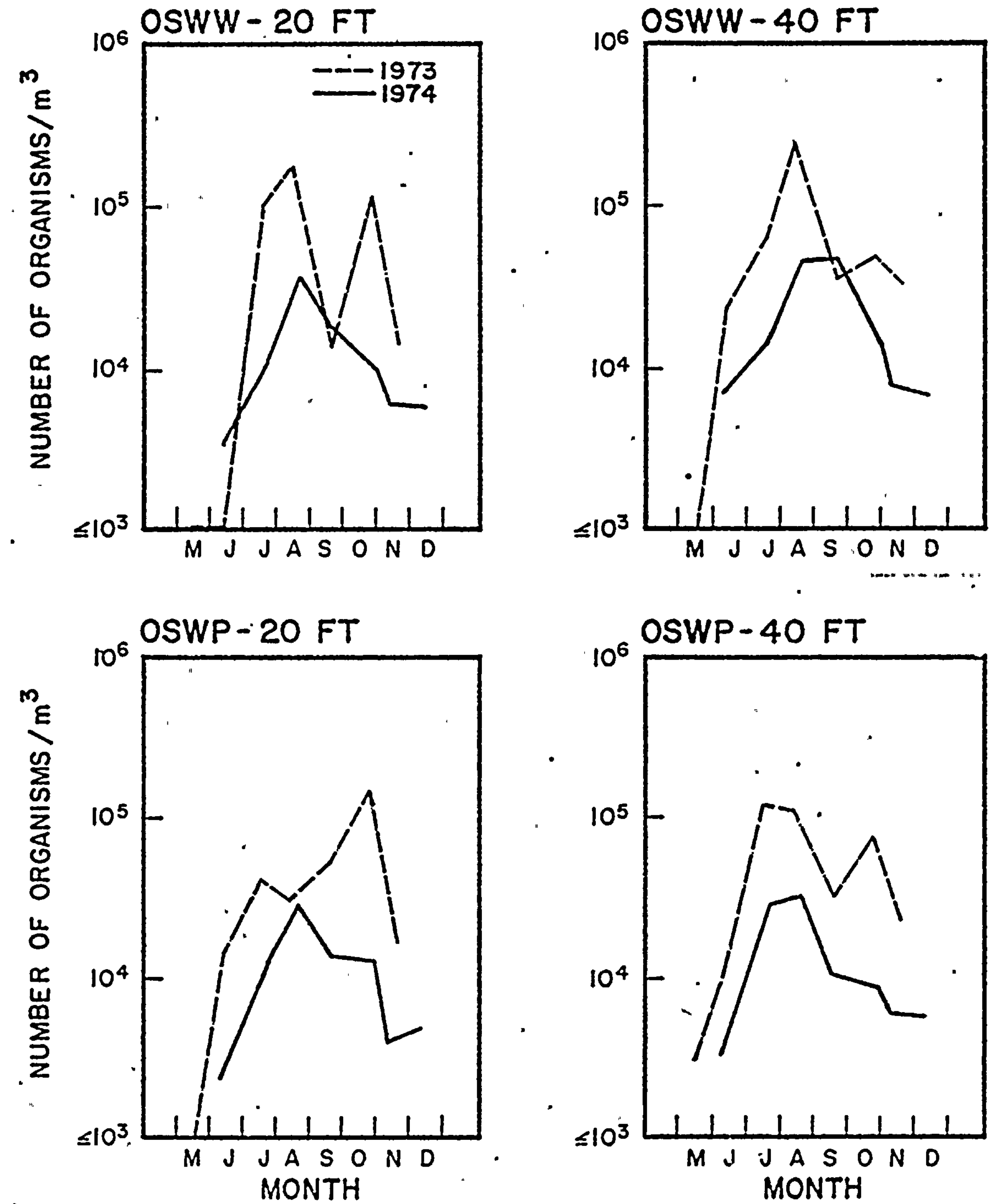
ABUNDANCE* OF CLADOCERA
OSWEGO VICINITY - 1973-1974



*Original sample

ABUNDANCE*OF COPEPODA

OSWEGO VICINITY - 1973-1974



*Original sample.

in copepod abundance among lake stations was found, a significant date x station interaction (LMS, 1976b) showed that copepods were generally more abundant at OSWW-40 ft than at OSWW-20 ft and that the differences in abundance between OSWP-40 ft and OSWW-20 ft stations were significant, but not consistent in order of magnitude.

Protozoans represented a minor fraction of the microzooplankton community during both study years; the peak abundance periods were May and August in 1973 and early November in 1974 (Figure IVB-8). No spatial differences were indicated for protozoan abundance during 1974 at the primary study area sampling locations (LMS, 1976b).

Studies were conducted at nearby Nine Mile Point by LMS in 1973, 1974, and 1975 (LMS, 1975a, 1976b; QLM, 1974), and the results of these studies parallel the temporal patterns described above for previous years at Oswego.

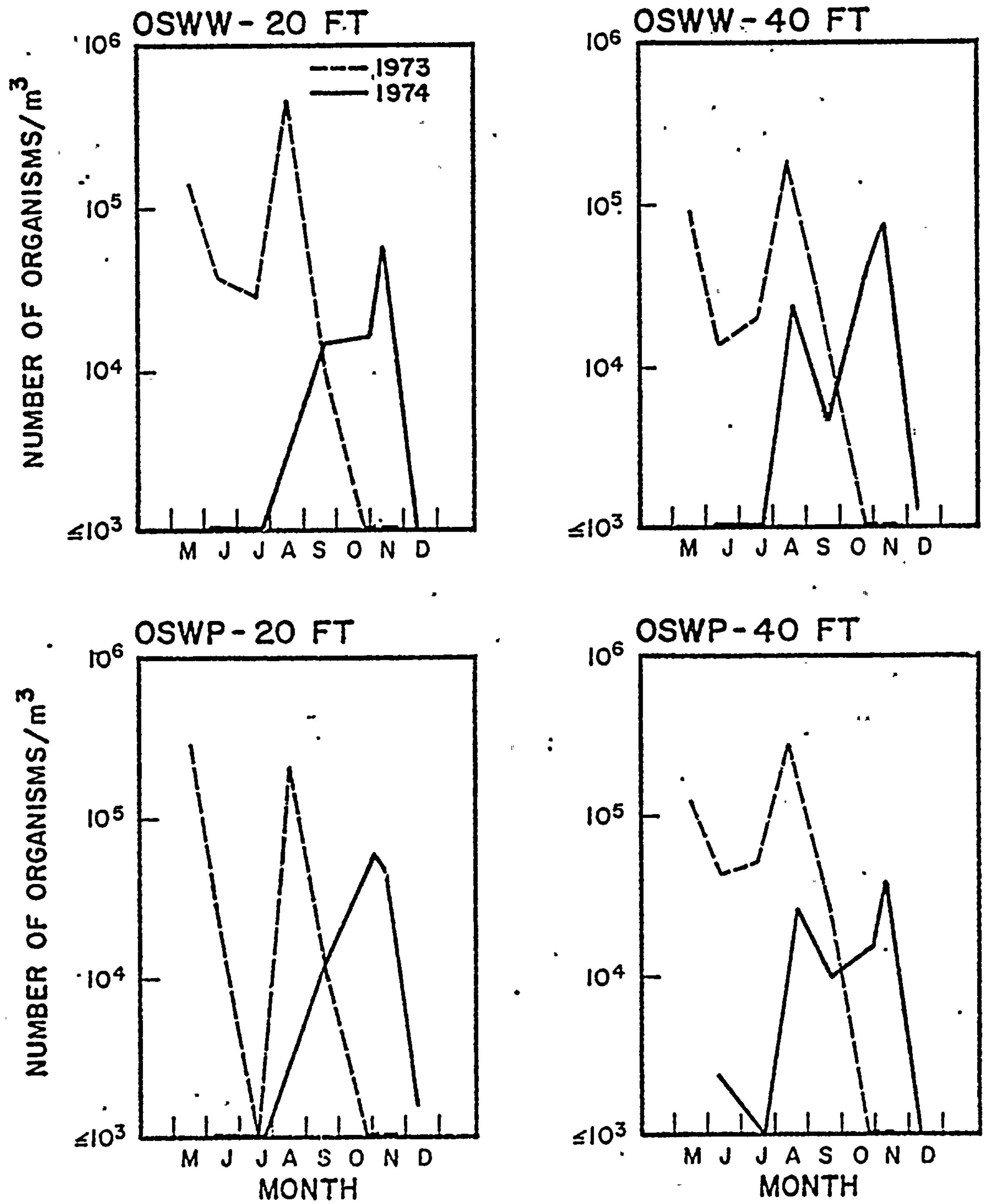
(ii) Plant

The zooplankton community entrained by Oswego Steam Station Units 1-4 was numerically dominated by rotifers and protozoans during the 1974-1976 period. A reversal of community dominants, however, was observed for two months between years, i.e., during 1974 rotifers were dominant during August and protozoans during November while the reverse was true during 1975 (Figure IVB-9).

Entrainment abundances are discussed for four dominant groups of organisms: Protozoa, Rotifera, Cladocera, and Copepoda. Protozoan entrainment was quite variable, showing no correlation between years (Figure IVB-10). Rotifers were entrained in greatest numbers during June 1975 and July 1974, with low levels entrained during the winter months of 1975-1976 (Figure IVB-10). Both cladoceran and copepod entrainment exhibited unimodal peaks during 1974 with copepod entrainment greatest during August and cladoceran entrainment covering the period from July to September. During 1975, entrainment was bimodal (May and October for cladocerans, June and October for copepods) for both taxa (Figure IVB-10).

The data presented on entrained microzooplankton populations indicate that the entrained community during 1975 was not in phase with the seasonal patterns observed during 1974. As a result of this shift in abundance for the four groups, percent composition (Figure IVB-9) was also altered. It is not known whether a shift in the nearshore lake community

ABUNDANCE* OF PROTOZOA
OSWEGO VICINITY - 1973-1974



*Original sample.

PERCENT COMPOSITION OF MICROZOOPLANKTON ABUNDANCE IN ENTRAINMENT COLLECTIONS
OSWEGO STEAM STATION UNITS 1-4 — 1974 AND 1975-1976

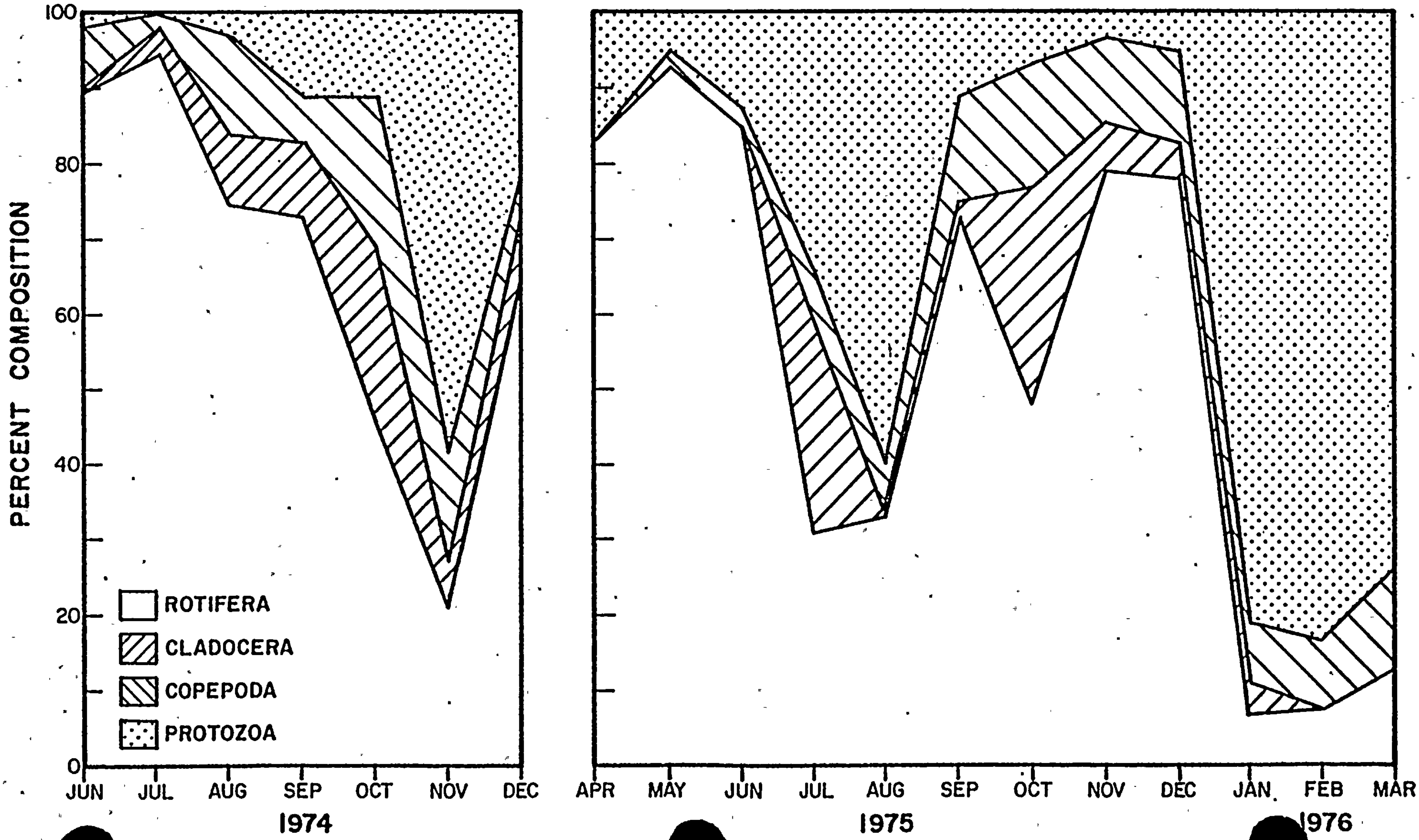
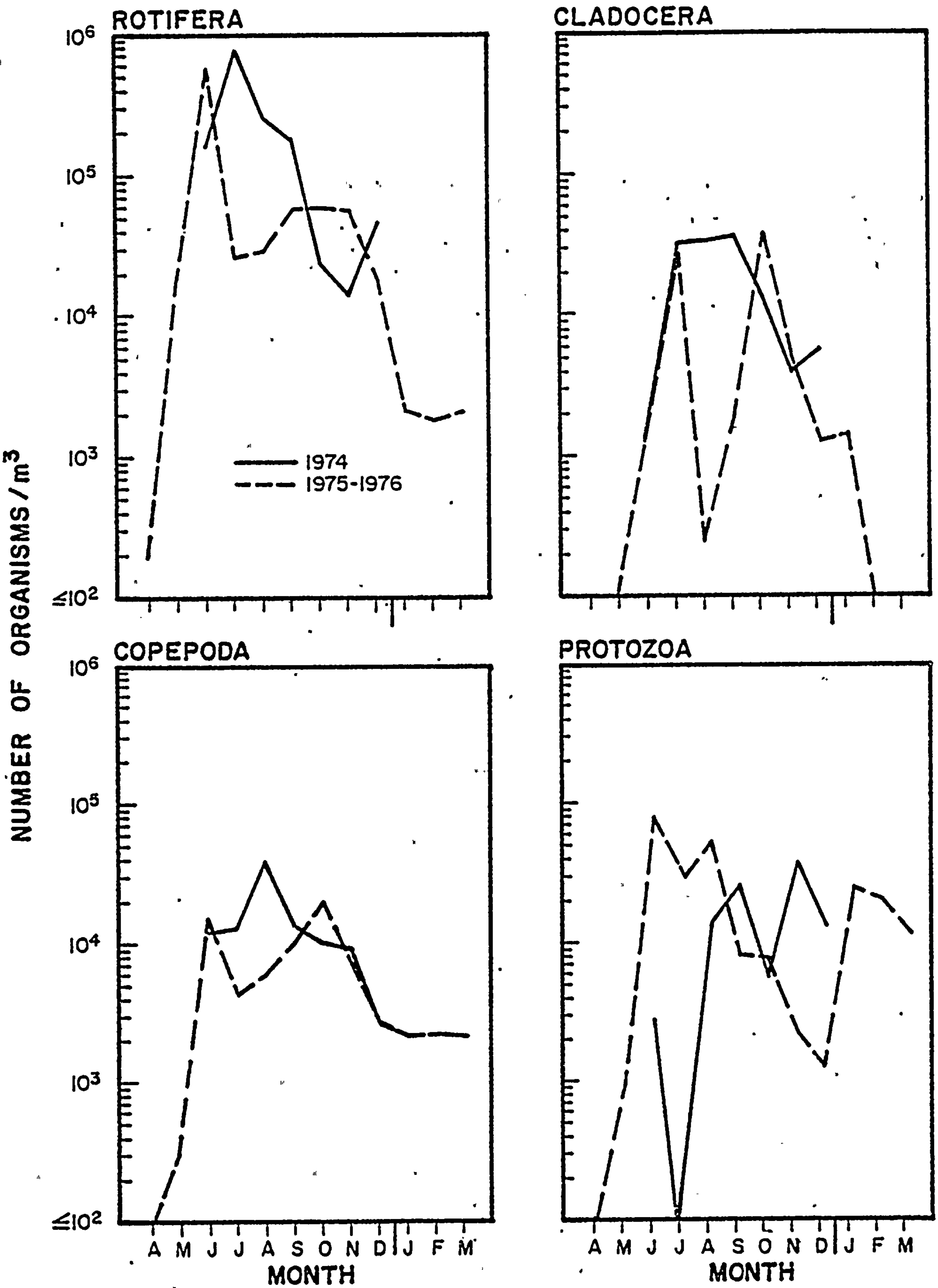


FIGURE IVB-9

FIGURE IVB-10

ABUNDANCE OF MAJOR GROUPS OF MICROZOOPLANKTON

OSWEGO STEAM STATION UNITS 1-4 — 1974-1976



structure and abundance in the Oswego vicinity may have caused this. During 1973, however, bimodal seasonal patterns were observed for cladocerans and copepods, similar to those observed in-plant during 1975. Water temperatures were higher during 1973 and 1975 than during 1974, a factor which may have altered the dynamics of the community (Figure IVB-11).

d. Summary

Microzooplankton entrained by the Oswego Steam Station Units 1-4 during 1974-1976 were qualitatively similar to populations in the Oswego vicinity of the lake during 1973 and 1974.

The seasonal trends of entrainment abundance for the four major groups during 1974 paralleled their trends in the lake.

During 1975, abundances of the major microzooplankton groups in entrainment collections were asynchronous with the 1974 trends for entrainment, but resembled the 1973 trends for lake abundance (which also differed from 1974 lake trends). A common factor between 1973 and 1975 was the observation of higher summer water temperatures than during 1974, a factor which may have been sufficient to regulate the dynamics of the various zooplankton populations.

3. Macrozooplankton

a. Introduction

Macrozooplankton are an integral facet of the Lake Ontario ecosystem, functioning as consumers at lower trophic levels and, in addition, providing a food source for upper trophic level organisms including fish.

Some of these organisms are planktonic for their entire life cycle, while others are planktonic only during a specific stage of their life cycle or during a particular photoperiod. Several taxa collected during this program were not plankton *per se* but represent benthic fauna incidentally collected by the plankton tows (e.g., mollusks).

Entrainment of macrozooplankton may be a species-specific phenomenon, with a given species more susceptible to entrainment as a consequence of its preferred depth distribution, its diel vertical migratory behavior, its particular life stage, or various physical factors. For example, during periods of destratification due to seiche activity or overturn, hypolimnetic organisms such as *Mysis relicta* (Mysidacea) or *Pontoporeia affinis* (Amphipoda) may be subject to entrainment by a power station.

INTAKE WATER TEMPERATURES

OSWEGO STEAM STATION UNITS 1-4 — 1973-1976

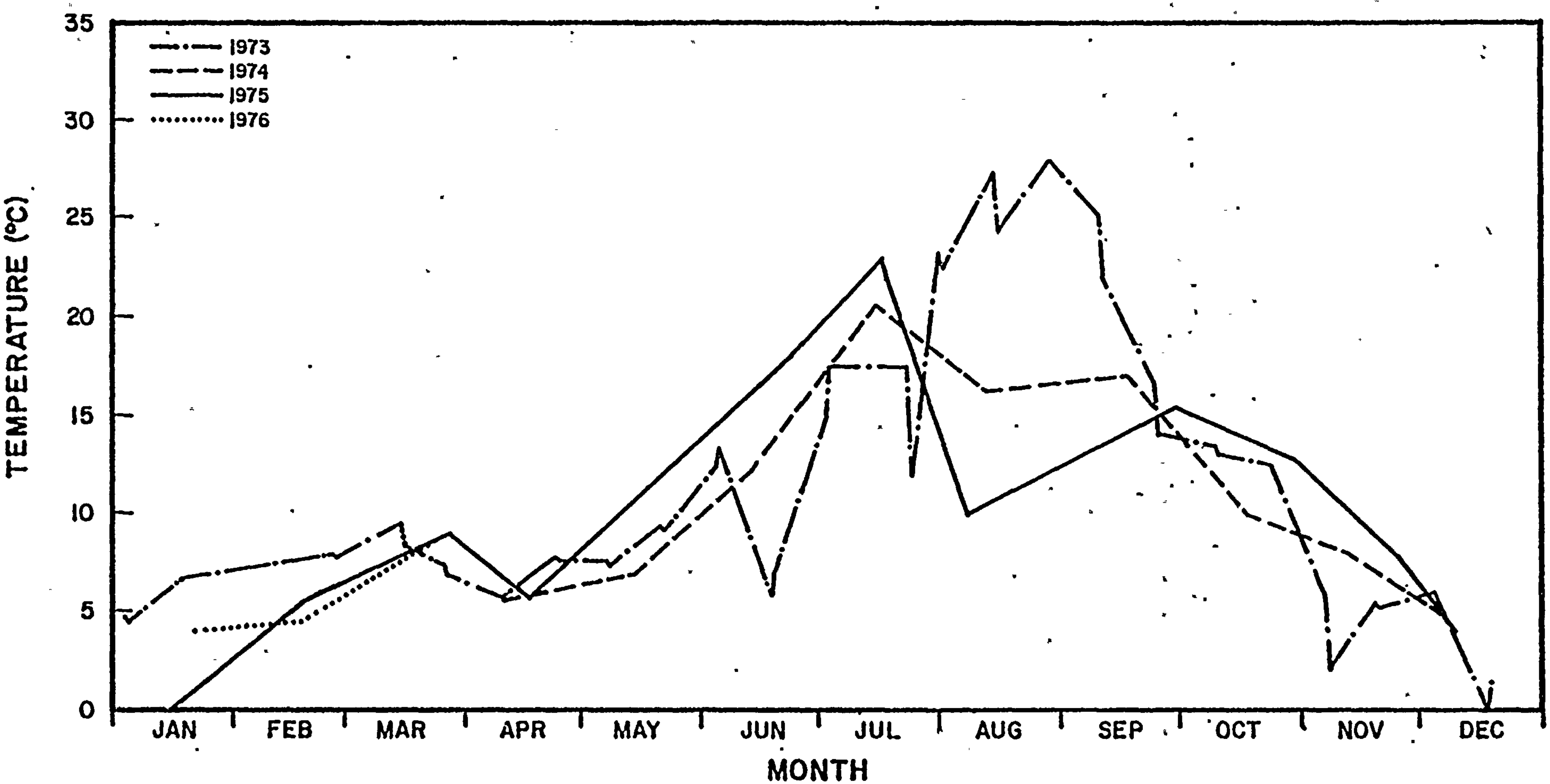


FIGURE IVB-11

Once entrained, these organisms are subjected to an array of stresses, e.g., temperature shock, mechanical damage, shear, changes in hydrostatic pressure, and partial pressure of dissolved gasses. Mortality due to these stresses may be direct or latent. Latent mortality of organisms which survive entrainment itself may occur through predation of stunned or disoriented organisms, or increased susceptibility of these plankters to infection or fungal growths. Some organisms, such as mysids and the cladoceran Leptodora kindtii, are particularly susceptible to entrainment mortality (Lauer et al. 1974; LMS, 1975a) while others, such as amphipods, seem more resistant (Lauer et al., 1974).

This chapter will describe the nearshore lake macrozooplankton community in the vicinity of the Oswego Steam Station during 1974. The results of entrainment surveys conducted at the plant during 1974 and 1975-1976 will also be discussed.

Methods and materials are described in Appendix A.

b. Species Composition

During 1974, 41 taxa of macrozooplankton were identified from lake and in-plant collections. Of these, 16 species were dipterans and 8 genera were Hydracarina. Seventeen of these taxa were identified only from lake collections while one species, Tanytarsus (Diptera: Chironomidae) was observed only in in-plant collections (Table IVB-5). Sixteen taxa were identified from entrainment collections conducted from April 1975 through March 1976. The primary differences noted between numbers of taxa identified in each study period can be ascribed to differing levels of identification (e.g., identifications of dipterans was to species in 1974 whereas during 1975-1976 it was only to order).

The majority of the macrozooplanktonic organisms identified from entrainment collections at Oswego Units 1-4 are characterized as inshore species which would be subject to entrainment throughout their life cycle. Two species, however, are hypolimnetic (Pontoporeia affinis and Mysis oculata relicta) and would be subject to entrainment only when the lake water in the vicinity of the intake was destratified by an upwelling. Several taxa (e.g., annelids) are infaunal and would not normally be entrained in great abundance.

c. Community Abundance and Percent Composition

(i) Nearshore Lake

Information from macrozooplankton collections in the Oswego vicinity of Lake Ontario during April-October 1974, showed

TABLE IVB-5

MACROZOOPLANKTON SPECIES INVENTORY

OSWEGO STEAM STATION UNITS 1-4 AND VICINITY - 1974-1976

SPECIES	IDENTIFIED IN 1975-1976	IDENTIFIED IN 1974		
	IN-PLANT	LAKE AND IN-PLANT	IN-PLANT ONLY	LAKE ONLY
COELENTERATA				
Hydrozoa				
Hydroida	X			
Hydridae				
Hydra americana	X	X		
Clavidae				
Cordylophora caspia	X.			
PLATYHELMINTHES				
Turbellaria	X	X		
ASCHELMINTHES				
Nematoda	X	X		
ANNELIDA				
Polychaeta				
Sabelliformia				
Sabellidae				
Manayunkia speciosa	X	X		
Oligochaeta	X			
Hirudinea				X
MOLLUSCA				
Gastropoda	X	X		
Pelecypoda	X			X
ARTHROPODA				
Arachnida				
Acarina (Hydracarina)	X			
Hygrobatidae				
Hygrobates spp.		X		
Unionicolidae				X
Unionicola sp.				
Unionicola sp.I.		X		
Pionidae				X
Foreila sp.		X		
Foreila sp.I.				X
Piona sp.				
Lebertidae				
Lebertia sp.		X		
Limnesiidae				
Limnesia spp.				X
Crustacea				
Cladocera				
Leptodoridae				
Leptodora kindtii	X	X		
Podocopa (Ostracoda)	X	X		

TABLE IVB-5 (Continued)

MACROZOOPLANKTON SPECIES INVENTORY

SPECIES	IDENTIFIED IN 1975-1976 IN-PLANT	IDENTIFIED IN 1974 LAKE AND IN-PLANT	IN-PLANT ONLY	LAKE ONLY
ARTHROPODA (Continued)				
Mysidacea				
Mysida				
Mysis oculata relicta		X		
Isopoda				
Asellidae				
Asellus communis				X
Amphipoda				
Gammaridae				
Gammarus fasciatus	X	X		
Haustoriidae				
Pontoporeia affinis	X	X		
Talitridae				
Hyalella azteca	X			
Decapoda	X			
Insecta				
Ephemeroptera				X
Neuroptera				
Sisyridae				
Climacia areolaris				X
Odonata				X
Trichoptera	X	X		
Diptera	X			
Ceratopogonidae				X
Chaoboridae				
Chaoborus flavicans (=*albipes*)		X		
Chironomidae (Tenedipedidae)				
Chironomus sp.		X		
Cricotopus sp.		X		
Cryptochironomus sp.				X
Endochironomus sp.				X
Glyptotendipes sp.				X
Micropsectra sp.		X		
Parachironomus sp.		X		
Paratendipes sp.				X
Phaenopsectra sp.		X		
Potthastia sp.				X
Procladius sp.		X		
Psectrocladius sp.		X		
Rheotanytarsus sp.				X
Tanytarsus sp.			X	
Simulidae				

X = Taxonomic level identified

that two species, Leptodora kindtii (Cladocera) and Gammarus fasciatus (Amphipoda), dominated the inshore community (Figures IVB-12 and IVB-13). Other taxa (Diptera, Hydracarina) were relatively unimportant contributors to community abundance.

Macrozooplantkon standing crop was at its highest level during August and early September, primarily as a consequence of peak L. kindtii abundance. G. fasciatus became important to community abundance only in nighttime collections, reflecting increased nocturnal activity of an otherwise epibenthic/benthic organism.

(ii) Oswego Steam Station Units 1-4

During the period January 1975 through March 1976, entrainment studies were conducted during nighttime hours; these surveys provided estimates of plant entrainment as well as supplying information that was otherwise unavailable on the nearshore lake macrozooplankton, since the lake sampling programs did not include winter sampling.

Three organisms were found to comprise the major fraction of the entrained macrozooplankton: L. kindtii, G. fasciatus, and hydroids (Figures IVB-14 and IVB-15). L. kindtii was the dominant species in entrainment collections during August-September of 1974 and 1975, mirroring its seasonal trend in the lake during 1974 (Figures IVB-12 and IVB-13). G. fasciatus was entrained in greatest numbers during July and August, and its abundance in the lake was also greatest during July. The hydroids, which are sessile epifauna, were observed to be abundant on various dates not corresponding to any seasonal pattern (Figures IVB-14 and IVB-15).

d. Distribution and Life Cycle of Three Most Abundant Taxa in Entrainment Collections

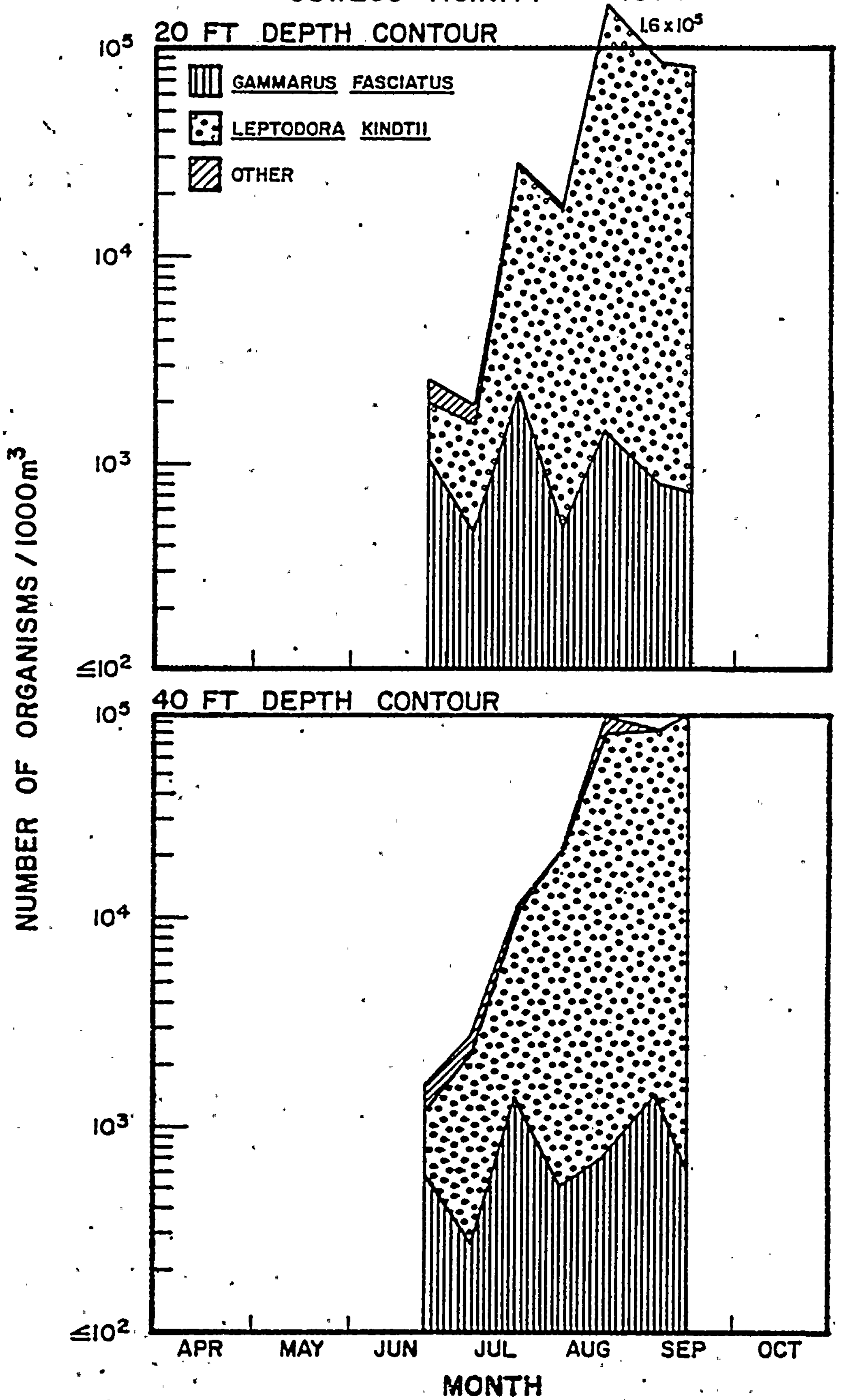
(i) Leptodora kindtii

Life cycle information on this species is presented in the 316(a) Demonstration for Oswego Units 1-4. Seasonal distribution of L. kindtii indicated a summer peak during both 1974 and 1975 (Figures IVB-14 and IVB-15) similar to that reported in the literature (see LMS, 1976b); L. kindtii was first collected during May and persisted in entrainment collections through November (1975), although L. kindtii was still present in the plankton collections through December 1975 near Nine Mile Point (LMS, 1976a).

FIGURE IVB-13

ABUNDANCE* OF SELECTED SPECIES OF MACROZOOPLANKTON IN NIGHT COLLECTIONS

OSWEGO VICINITY — 1974



*Mean of all depths and stations.

ABUNDANCE OF SELECTED SPECIES OF MACROZOOPLANKTON IN ENTRAINMENT COLLECTIONS

OSWEGO STEAM STATION UNITS 1-4 —— 1974

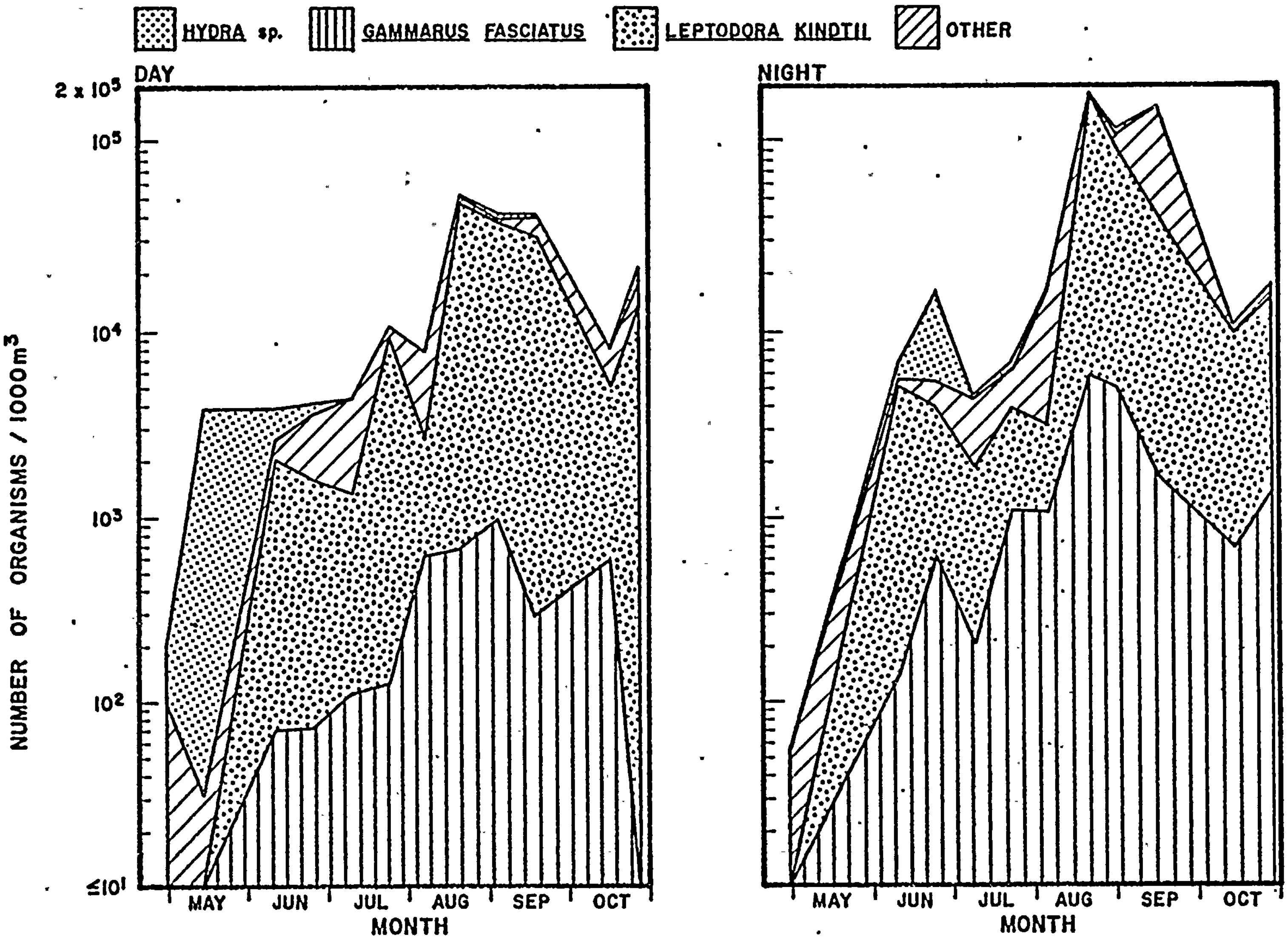


FIGURE IV B-14

ABUNDANCE OF SELECTED SPECIES OF MACROZOOPLANKTON IN ENTRAINMENT COLLECTIONS

OSWEGO STEAM STATION UNITS 1-4 —— 1975-1976

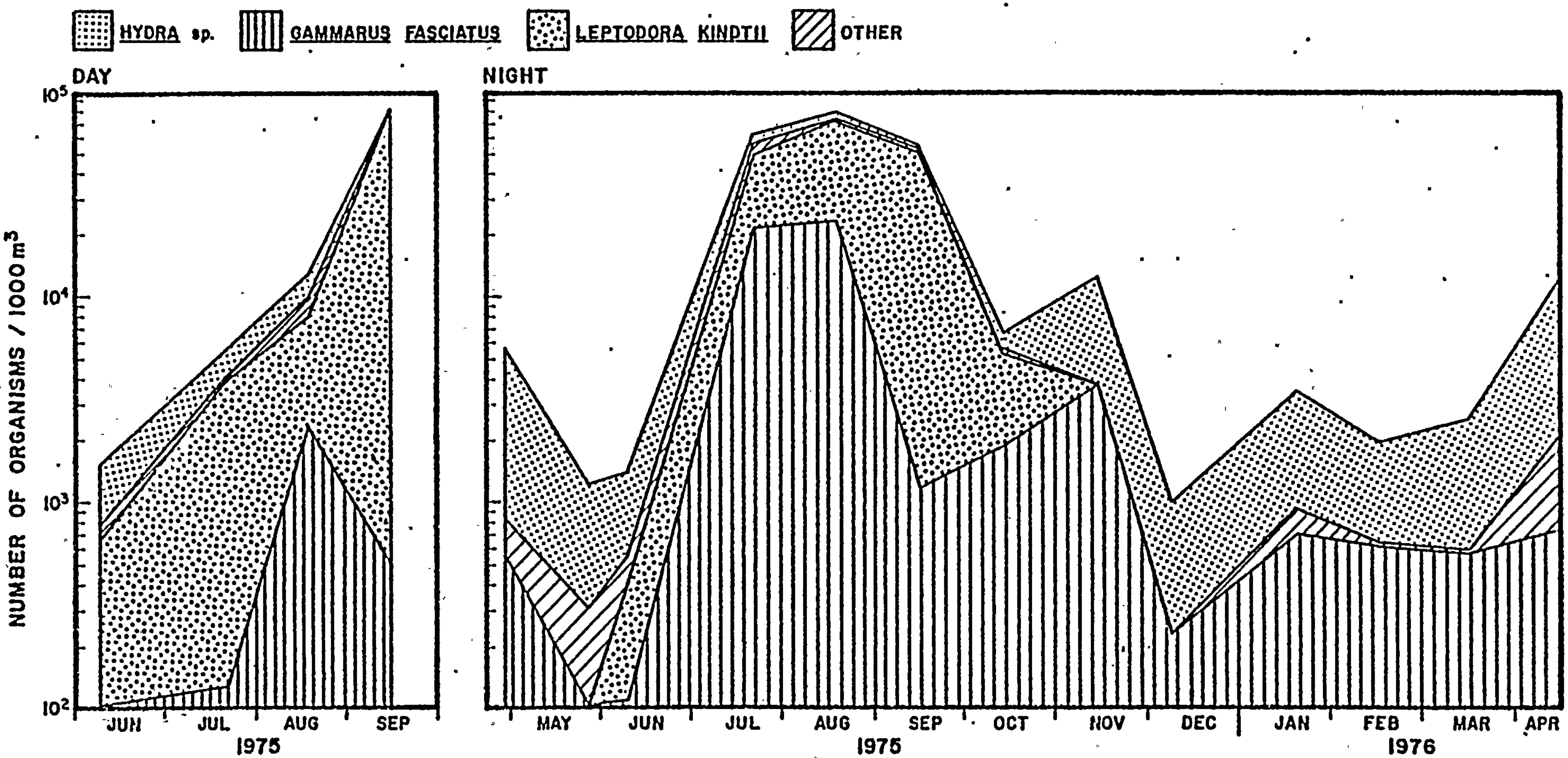


FIGURE IV B-15

(ii) Gammarus fasciatus

Life history information for *G. fasciatus* is presented in Chapter IV of the Oswego 316(a) demonstration. Based on 1975-1976 entrainment collections, *G. fasciatus* was present during the entire year, with greater numbers entrained at night (Figures IVB-14 and IVB-15). A July-September period of maximum abundance was indicated for both lake and in-plant collections (Figures IVB-12 through IVB-15).

(iii) Hydra americana and Cordylophora caspia (= lacustris)

Hydra americana and *Cordylophora caspia*, a colonial species (Pennak, 1953), both members of the coelenterate family Hydridae were collected from entrainment samples at the Oswego Steam Station Units 1-4 during 1974 and 1975-1976. *Cordylophora* is considered to be primarily a brackish water species, but it has frequently been observed from freshwater habitats (see Davis, 1957, for historical records of the freshwater distribution of *C. lacustris*). Freshwater colonies are smaller than those found in brackish waters, averaging 10-15 mm high (Hyman, 1959). Both species are sessile, epifaunal forms which may be found attached to a variety of substrata in littoral areas or in streams.

Hydras are, generally, most abundant in the late spring/early summer; their numbers decline in late summer, with a secondary peak often observed in September-October (Pennak, 1953). Reproductive stages of *Cordylophora* collected from a brackish lagoon in British Columbia have been observed between mid-May and mid-July (Mace and Mackie, 1970).

Both species are carnivores, preying chiefly upon copepods, cladocerans, and dipteran larvae (Pennak, 1953; Mace and Mackie, 1970). Colonial hydroids in general (Gosner, 1971) and *Cordylophora*, specifically, have been observed to contribute to the growth of fouling communities in estuarine/marine environments (Thomas, 1970; LMS, 1976c).

As indicated above, the distribution of these two species did not correspond to any seasonal pattern. The observation that hydroids were more abundant in entrainment collections than in lake plankton collections during 1974 was substantiated statistically (Table IVB-6), suggesting that hydroids may be growing in or on the intake structure, and that plankton nets do not adequately sample these epifaunal organisms in the lake.

TABLE IVB-6

STATISTICAL ANALYSIS OF HYDROIDA ABUNDANCE IN DAY/NIGHT COLLECTIONS

OSWEGO STEAM STATION UNITS 1-4 AND VICINITY - 1974

THREE-WAY ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	DF (ERR)	MS (ERR)	F
DATES	4	5.5487	40	40.7901	1.360++
SITES*	2	101.6259	38	39.1343	49.340+
PHOTOPERIODS (DAY/NIGHT)	1	0.9971	34	36.7298	0.923++
DATE X SITE	8	4.5571	28	34.2180	0.466++
DATE X PHOTOPERIOD	4	2.1725	28	34.2180	0.445++
SITE X PHOTOPERIOD	2	0.3370	28	34.2180	0.138++
DATE X SITE X PHOTOPERIOD	8	5.6775	20	28.5404	0.497++
TOTAL	49	151.2096			

++ Not significant at $\alpha=0.25$
+ Significant at $\alpha< 0.0005$

STUDENT-NEWMAN-KEULS TEST - SITES* ($\alpha = 0.05$)
Largest: In-Plant OSWP-20 bottom OSWP-20 surface: Smallest

*OSWP - 20 ft Station - Bottom sample
OSWP - 20 ft Station - Surface sample
IN-PLANT - Intake Bay

e. Existence of a Sessile Community in or on the Intake Structure of Oswego Steam Station Units 1-4

The possibility that a resident sessile community may be growing on the Oswego Steam Station Units 1-4 intake makes it difficult to estimate plant cropping of associated organisms, since it is not possible to determine the percentage of the entrained organisms that are from the lake proper and the percentage of organisms that are associated with the sessile community. Examples of such commensals include diatoms, filamentous green algae, mollusks, and amphipods (Thomas, 1970; Feeley and Wass, 1971; LMS, 1976c). G. fasciatus is known to inhabit algae (Cladophora) (LMS, 1975a) and has been found to inhabit sessile epifauna (Feeley and Wass, 1971).

A two-way analysis of variance was applied to determine whether Gammarus abundance in entrainment collections was significantly different from that in bottom tows at OSWP-20 ft. The results of the ANOVA indicated that there was no significant difference at $\alpha = 0.05$ (Table IVB-7), suggesting that plant entrainment of Gammarus reflects the distribution of this organism in the lake near the intake structure. Other evidence, however, does support the hypothesis that a community of hydroids and amphipods exists in or on the Oswego Steam Station Units 1-4 intake.

f. Summary

The composition of the macrozooplankton entrained by the Oswego Steam Station Units 1-4 differed from the nearshore lake macrozooplankton in that hydroids and Gammarus fasciatus were more abundant in entrainment collections. This phenomenon is due either to the existence of a fouling community in or on the intake structure or the entrainment of benthic and epibenthic forms not sampled by the plankton tows in the lake near the intake. The possible existence of a fouling community makes it difficult to assess plant impact on organisms which live in the lake proper and are commensal with hydroids.

4. Ichthyoplankton

a. Introduction

Ichthyoplankton represent the early developmental stages (eggs and larvae) of fish. Because the fish species present in Lake Ontario generally produce one generation per year, the consequences of power plant-induced mortality may be greater than in organisms such as zooplankton which have several generations on an annual cycle. Mortality of ichthyoplankton due to entrainment by power

TABLE IV B-7

STATISTICAL ANALYSIS OF *GAMMARUS FASCIATUS* ABUNDANCE

OSWEGO STEAM STATION UNITS 1-4 - 1974

TWO-WAY ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F
PHOTOPERIODS (DAY/NIGHT)	1	6127265.58	612765.58	5.53
STATIONS[a]	1	2292386.33	2292386.33	2.07
RESIDUAL	28	32278010.42	1107961.32	
TOTAL	30	39442569.00		

[a]Stations: OSWP - 20 ft Station - Bottom sample
IN-PLANT - Oswego Steam Station Units 1-4

plants may be the result of the interactions of various stresses; mechanical damage, however, has been identified as perhaps the major cause of mortality (Marcy, 1974).

This chapter summarizes the information available on the nearshore ichthyoplankton community in the vicinity of the Oswego Steam Station. Patterns of entrainment relative to the lake distributions are discussed.

Methods and materials are summarized in Appendix A.

b. Species Inventory

Eleven species of fish larvae were identified from lake collections during 1974 (Table IVB-8). Alewife was the dominant species, but rainbow smelt, white perch, mottled sculpin, and johnny darter were also relatively abundant on various sampling dates (LMS, 1975b). The latter three species are all inshore species (Scott and Crossman, 1973), as are several others listed in Table IVB-8 (e.g., pumpkinseed, carp, emerald shiner).

Ten species of fish eggs and 13 species of fish larvae (Table IVB-9) were identified from entrainment collections conducted at Oswego Steam Station Units 1-4 during 1974 and 1975-1976. Again, alewife was the most abundant species (Figure IVB-16). Eggs of two species (alewife and smelt) and four species of larvae (alewife, smelt, carp, white perch, and johnny darter) were common to both 1974 and 1975 collections. These represent the more abundant inshore lake species. Those species not collected during both years were relatively rare due to their littoral and/or nesting behavior (e.g., centrarchids).

c. Community Abundance

During 1974, fish egg abundance was greatest during June and July, with greater numbers collected at night (Table IVB-10). No eggs were collected after 6 August (the program terminated on 29 October).

Abundance of fish larvae in the lake was greatest during August, reflecting the standing crop of alewife larvae (LMS, 1975b). The appearance of larvae of the various species was closely correlated with their appearance as reported in the literature (see Scott and Crossman, 1973, for a review). Burbot were collected in April, folowed by rainbow smelt and yellow perch in May and early June. White perch appeared between mid-May and mid-June, and were most abundant on 24 June; there was also evidence of the extended spawning which is characteristic of this species,

TABLE IVB-8

ICHTHYOPLANKTON SPECIES INVENTORY

OSWEGO STEAM STATION UNITS 1-4 AND VICINITY - 1974

FAMILY	COMMON NAME	SCIENTIFIC NAME	IDENTIFIED IN 1974		
			LAKE AND IN-PLANT	IN-PLANT ONLY	LAKE ONLY
Centrarchidae	Pumpkinseed	*Lepomis gibbosus*			X
Clupeidae	Alewife	*Alosa pseudoharengus*	X		
Cottidae	Mottled sculpin	*Cottus bairdi*	X		
Cyprinidae	Carp	*Cyprinus carpio*	X		
	Common shiner	*Notropis cornutus*		X	
	Emerald shiner	*Notropis atherinoides*	X		
Gadidae	Burbot	*Lota lota*			X
Ictaluridae	Brown bullhead	*Ictalurus nebulosus*			X
Osmeridae	Rainbow smelt	*Osmerus mordax*	X		
Percichthyidae	White perch	*Morone americana*	X		
Percidae	Johnny darter	*Etheostoma nigrum*	X		
	Yellow perch	*Perca flavenscens*	X		

X = Taxonomic level identified

TABLE IV.B-9

OCCURRENCE OF ICHTHYOPLANKTON BY DATE

OSWEGO STEAM STATION UNITS 1-4 - 1974-1976

I. FISH LARVAE

	1974												1975													1976			
	APR	MAY	JUN		JUL		AUG		SEP		OCT		APR	MAY	JUN		JUL		AUG		SEP		OCT	NOV	DEC	JAN	FEB	MAR	APR
SPECIES	29	13	10	24	8	22	5	19	2	16	14	28	28	26	9	23	7	21	4	18	1	15	13	14	8	19	16	15	12
Centrarchidae																													
Lepomis sp.																		X	X										
Clupeidae																													
Alosa pseudoharengus Alewife				X	X		X	X		X						X	X	X	X	X		X							
Cottidae																													
Cottus baridi Mottled sculpin						X	X																						
Cyprinidae																													
Cyprinus carpio Carp			X		X											X		X	X										
Notropis atherinoides Emerald shiner					X																								
N. cornutus Common shiner					X																								
N. hudsonius Spottail shiner																		X											
Pimephales notatus Bluntnose minnow																X													
Gasterosteidae																													
Gasterosteus aculeatus Threespine stickleback																		X											
Osmeridae																													
Osmerus mordax Rainbow smelt					X		X						X	X							X								
Percichthyidae																													
Morone americana White perch					X													X		X	X								
Percidae																													
Etheostoma nigrum Johnny darter				X	X										X	X	X	X											
Perca flavescens Yellow perch					X																								

TABLE IV.B-9 (Continued)

OCCURRENCE OF ICHTHYOPLANKTON BY DATE

II. FISH EGGS

SPECIES	1974												1975																1976			
	APR	MAY	JUN		JUL		AUG		SEP		OCT		APR	MAY	JUN		JUL		AUG		SEP		OCT	NOV	DEC	JAN	FEB	MAR	APR
	29	13	10	24	8	22	5	19	2	16	14	28	28	26	9	23	7	21	4	18	1	15	13	14	8	19	16	15	12
Clupeidae																													
Alosa pseudoharengus Alewife			X	X	X	X	X							X	X	X	X	X	X	X									
Dorosoma cepedianum Gizzard shad			X	X	X																								
Cyprinidae																													
Carassius auratus Goldfish					X																								
Cyprinus carpio Carp			X																										
Notropis cornutus Common shiner		X																											
Gadidae																													
Lota lota Burbot	X	X																									X		
Osmeridae																													
Osmerus mordax Rainbow smelt	X	X											X																X
Percichthyidae																													
Morone americana White perch														X		X													
Percidae																													
Perca flavescens Yellow perch				X																									
Stizostedian vitreum vitreum Walleye															X			X		X									

MEAN MONTHLY ABUNDANCE AND PERCENT COMPOSITION OF FISH LARVAE IN ENTRAINMENT COLLECTIONS

OSWEGO STEAM STATION UNITS 1-4 — 1974 AND 1975-1976

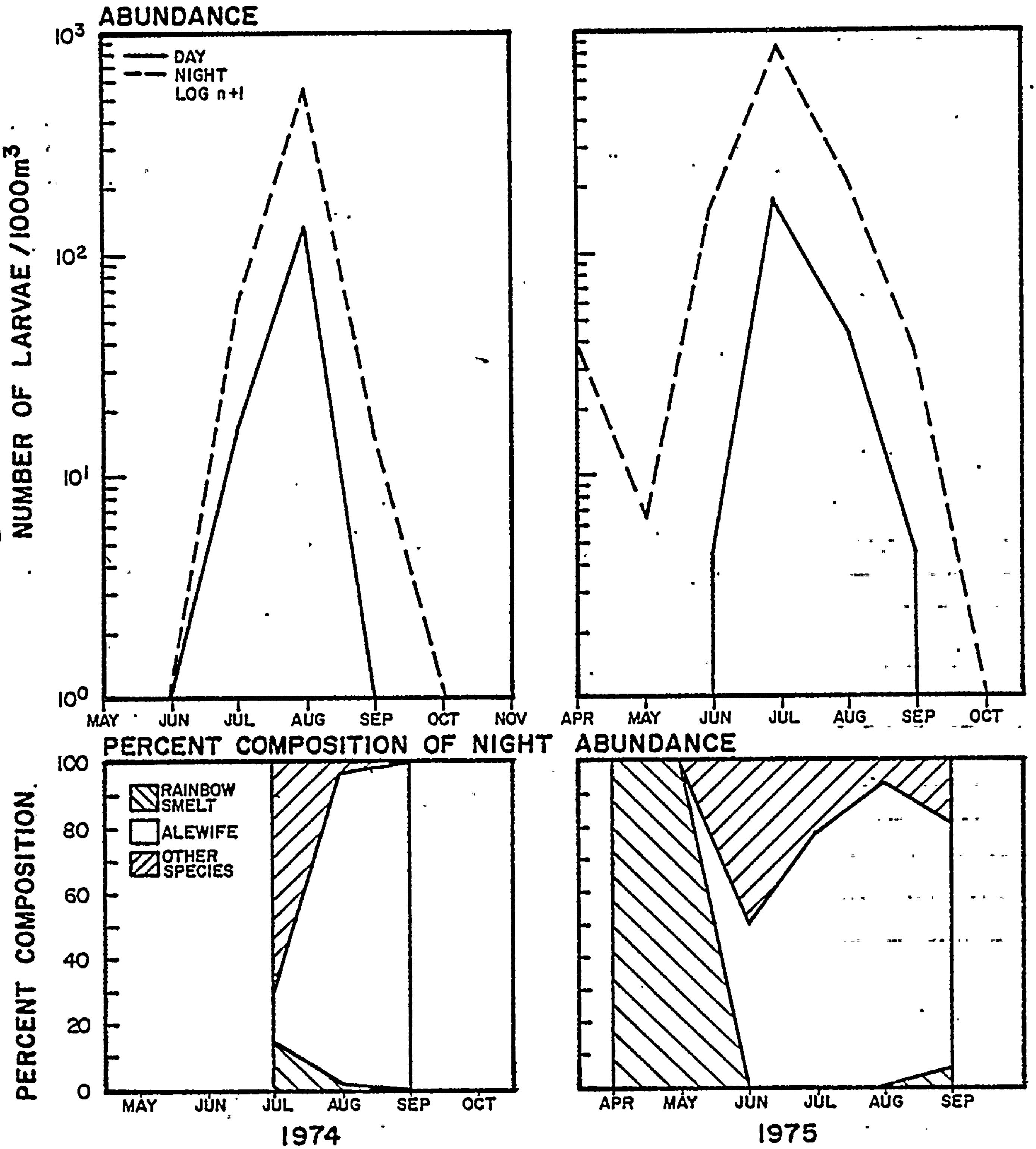


TABLE IVB-10

ABUNDANCE* OF FISH EGGS IN DAY/NIGHT COLLECTIONS

OSWEGO STEAM STATION UNITS 1-4 AND VICINITY - 1974-1976

DATE	1974			
	LAKE		UNITS 1-4	
	DAY	NIGHT	DAY	NIGHT
5 APR	0	NS		
29 APR			0	0
13 MAY			2121	NS
14 MAY	0.7	NS		
10 JUN	4	NS	65	69
24 JUN	83	NS	546	1006
25, 26 JUN	NS	303		
8 JUL	16	306	265	3245
22 JUL	38	461	0	235
5 AUG			231	574
6 AUG	0.2	0.8		
19 AUG	0	0	0	0
2 SEP			31	97
6 SEP	0	0		
16 SEP	0	NS	0	0
18, 19 SEP	NS	0		
14 OCT			0	0
14, 16 OCT	0	NS		
28 OCT			0	0
29 OCT	0	NS		

TABLE IV B-10 (Continued)

ABUNDANCE* OF FISH EGGS IN DAY/NIGHT COLLECTIONS

DATE	OSWEGO STEAM STATION UNITS 1-4			
	1975		1976	
	DAY	NIGHT	DAY	NIGHT
19 JAN			NS	0
16 FEB			NS	17
15 MAR			NS	0
12 APR			NS	138
28 APR	NS	339		
26 MAY	NS	22		
9 JUN	48	582		
23 JUN	59	749		
7 JUL	19	7221		
21 JUL	131	4399		
4 AUG	8	21		
18 AUG	212	7		
1 SEP	0	0		
15 SEP	0	0		
13 OCT	NS	0		
14 NOV	NS	0		
8 DEC	NS	0		

*Number per 1000 m^3
NS = No sample

in that a second group of larvae was present through late July and August. Alewife, mottled sculpin, and johnny darter larvae were present from mid-June through September. Other species were collected relatively infrequently (LMS, 1975b).

By September, few larvae were collected by the sampling gear, indicating that these post-larval juveniles were being recruited into the fishery and were, because of their increased swimming abilities, able to avoid the gear.

Entrainment of fish eggs by Oswego Steam Station Units 1-4 was greatest during June (1974) and July (1975) (Table IVB-10) and greater at night than during the day.

Fish larvae were entrained in greatest numbers during July and August of 1974 and 1975, with two species contributing most to the entrainment: rainbow smelt (spring 1975) and alewife (July through October) (Figure IVB-16).

d. Discussion of Major Species: Early Life History and Distribution

Rainbow smelt and alewife larvae were indicated to be seasonal dominants in entrainment collections (Figure IVB-19) at the Oswego Steam Station Units 1-4 during 1974 and 1975-76, and are discussed in detail.

(i) Rainbow Smelt

Rainbow smelt spawn when water temperatures range between 10-15°C (50-59°F). Ripe smelt generally ascend streams to spawn, but in the Great Lakes offshore spawning on gravel shoals may be more important. The eggs are adhesive and hatch within 2-3 weeks (depending upon temperature). After hatching, the larvae are about 5 mm in length; they grow rapidly, attaining lengths of 51 mm by August (Scott and Crossman, 1973).

Lake collections during 1974 yielded few smelt larvae, with the greatest number collected along the 20 ft contour on 24-25 June (LMS, 1976b) (Figure IVB-17). Length frequency data, derived from the 1974 lake collections (Table IVB-11), suggest rapid growth; however, few larvae were actually collected.

Entrainment of rainbow smelt was greater during 1975 than during 1974. Again, the actual numbers of larvae entrained were quite low (Figure IVB-16).

TABLE IVB-11

LENGTH FREQUENCY DISTRIBUTION OF RAINBOW SMELT LARVAE BY DATE

OSWEGO VICINITY - 1974

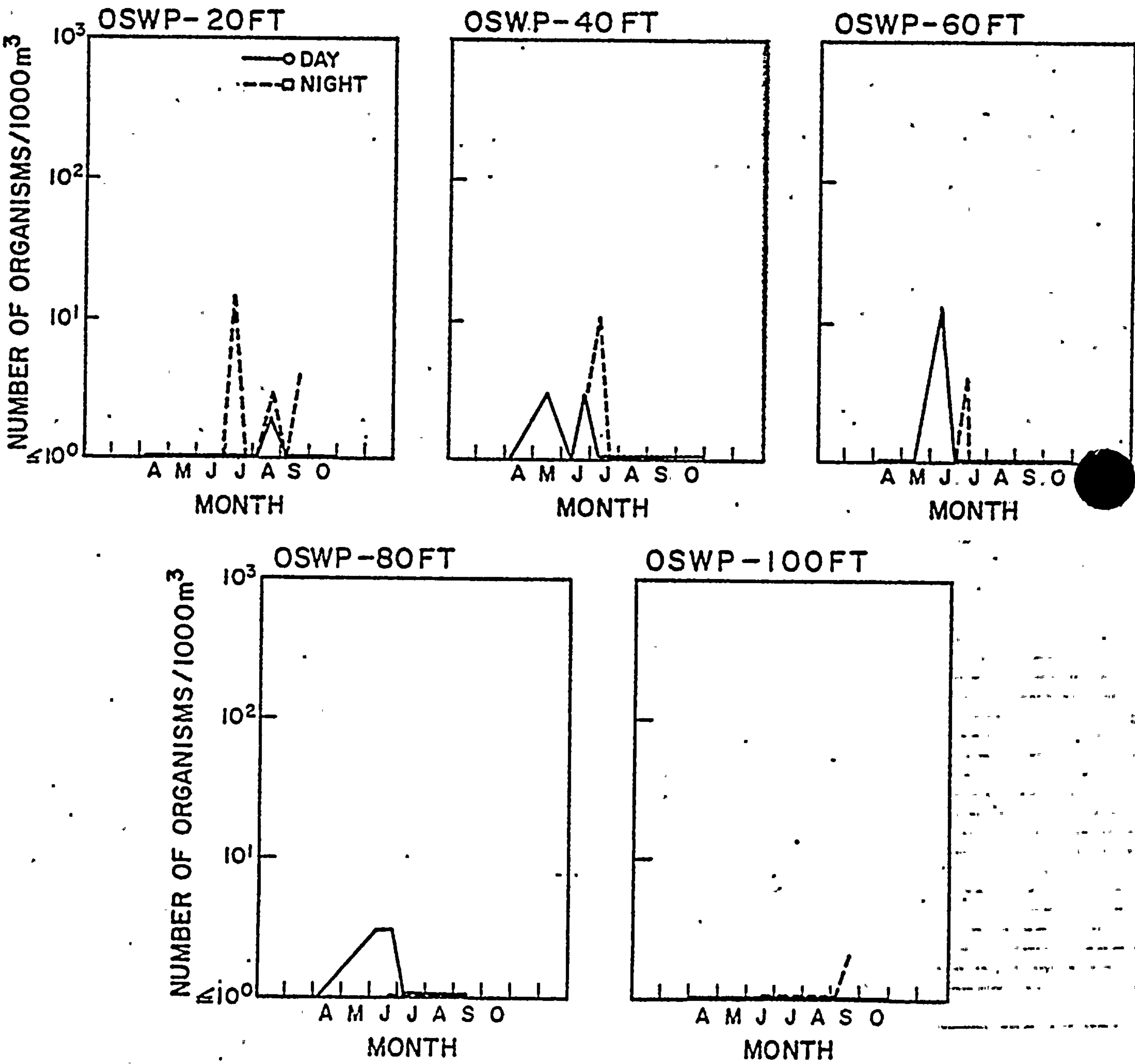
SAMPLING DATE

SIZE INTERVAL (mm)	14 MAY	10 JUN	24 JUN	8 JUL	22 JUL	6 AUG	19 AUG	6 SEP	16-19 SEP
1.1-2.0									
2.1-3.0									
3.1-4.0			1						
4.1-5.0			2						
5.1-6.0			1						
6.1-7.0	1	6							
7.1-8.0	1	9	2						
8.1-9.0		2	1				1		
9.1-10.0		1	6	2					
10.1-11.0			3						
11.1-12.0			3	1					
12.1-13.0			1						
13.1-14.0				1	1				
14.1-15.0									
15.1-16.0				1	1				
16.1-17.0				5					
17.1-18.0				3	2				
18.1-19.0				3	4				
19.1-20.0				2	1				
20.1-21.0				1					
21.1-22.0									
22.1-23.0									
23.1-24.0									
24.1-25.0					2				1
25.1-26.0									
26.1-27.0									
27.1-28.0									
28.1-29.0									
29.1-30.0									
30.1-31.0									
31.1-32.0						1			1
32.1-33.0							1		
33.1-34.0									
34.1-35.0									1
35.1-36.0									
36.1-37.0							2		
37.1-38.0							1		1
38.1-39.0									1
39.1-40.0									2
40.1-41.0									1
41.1-42.0									
42.1-43.0							1		
43.1-44.0									3
44.1-45.0									1
51.1-52.0									1
53.1-54.0									1
N	2	18	20	19	11	1	6	0	14
Mean Length (mm)	7.0	7.4	8.7	16.3	18.8	31.5	32.2	-	40.4

N = Number of larvae collected

FIGURE IVB-17

ABUNDANCE* OF RAINBOW SMELT LARVAE
OSWP TRANSECT
OSWEGO VICINITY – 1974



*Mean of surface and bottom

(ii) Alewife

The early life history of the alewife is presented in the Oswego Steam Station Units 1-4 316(a) demonstration.

In lake collections during 1974, alewife larvae were most abundant along the 20 and 40 ft depth contours, with greatest densities recorded during August (Figure IVB-8). The occurrence of two spawning contingents was hypothesized after identification of a bimodal abundance pattern (LMS, 1976b). The mean length of alewife larvae (Table IVB-12) also suggested the occurrence of two spawning contingents, with the observed decrease in mean length between 22 July and 6 August.

Alewife entrainment also peaked during August of 1974 and 1975, although somewhat greater numbers were entrained during 1975 (Figure IVB-16).

f. Summary

The ichthyoplankton community near the Oswego Steam Station Units 1-4 intake consists of a variety of species. The abundance of the community is wholly reflective of the midsummer presence of the alewife; rainbow smelt, while present in low numbers, is the most abundant spring spawner. Other species are infrequently collected; littoral and/or nest dwelling species are usually not directly subject to entrainment.

C. NEKTON

1. Introduction

The limnetic nektonic community comprises primarily fish species which represent the higher trophic levels of the food web. Power plant withdrawal of cooling water subjects the organisms in these higher trophic levels to impact in two ways: indirectly, by altering the abundance and composition of the lower trophic levels, and directly, through impingement on the protective screens of the cooling-water system.

Fish populations in the vicinity of the intake of the Oswego Steam Station Units 1-4, were collected by trawls, seines, and gill nets and evaluated on a seasonal basis since 1973. During the same time period an impingement monitoring program was conducted to document the magnitude and representation of fish collected as a result of operation of the cooling water intake.

TABLE IVB-12

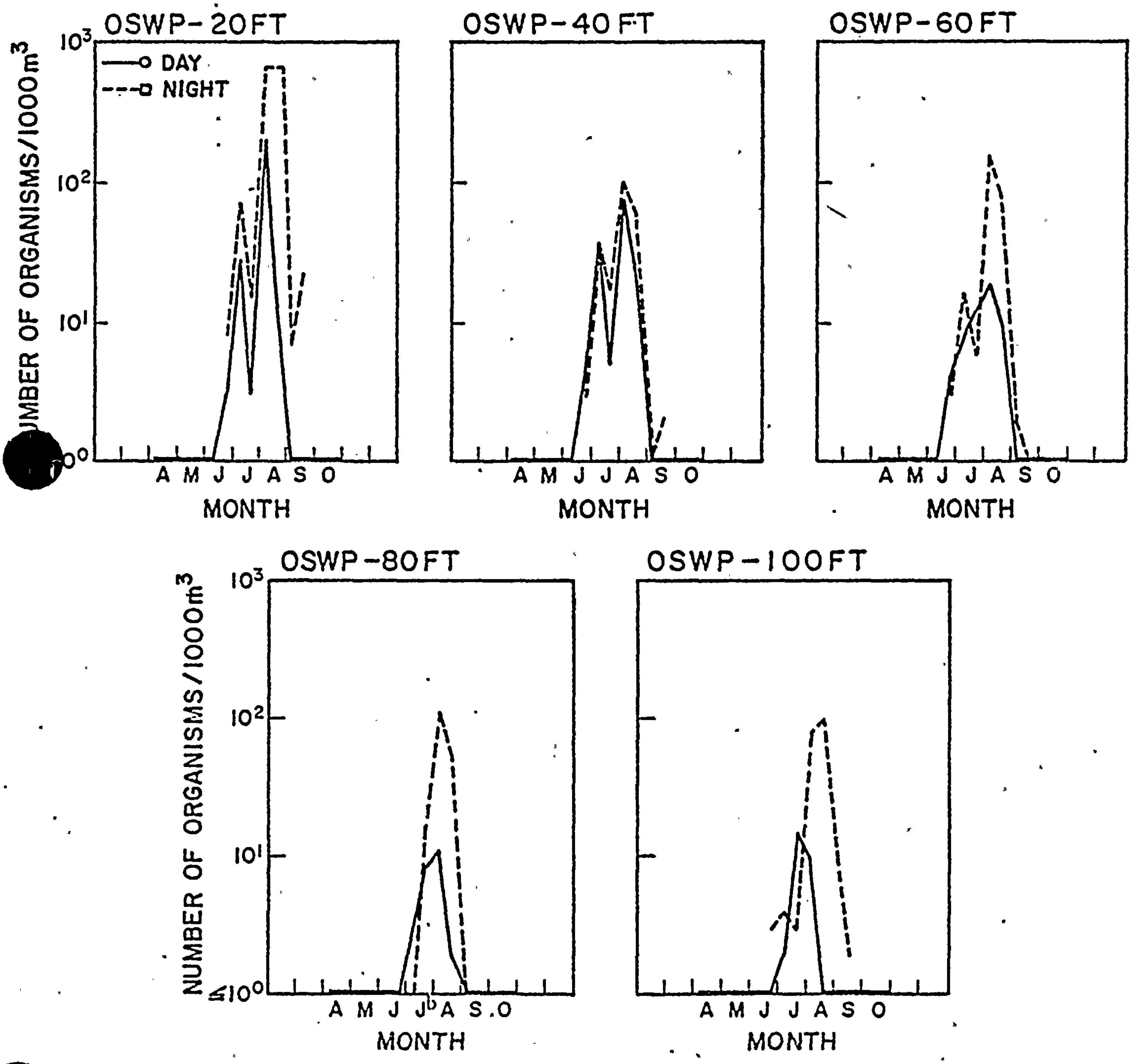
LENGTH FREQUENCY DISTRIBUTION OF ALEWIFE LARVAE BY DATE

OSWEGO VICINITY - 1974

	SAMPLING DATE						
SIZE INTERVAL (mm)	24 JUN	8 JUL	22 JUL	6 AUG	19 AUG	6 SEP	16-19 SEP
1.1-2.0	8						
2.1-3.0	18	7	1				
3.1-4.0	25	36	2	9	1		
4.1-5.0	21	75	15	111			
5.1-6.0	1	40	11	105	1		
6.1-7.0	2	28	19	144			
7.1-8.0	1	26	28	174	7		
8.1-9.0		21	8	204	24		
9.1-10.0		15	9	209	48		
10.1-11.0	1	21	19	206	67		1
11.1-12.0	1	12	25	173	90	1	
12.1-13.0	1	4	13	74	102		
13.1-14.0		1	11	23	31		
14.1-15.0	1	4	13	21	99		
15.1-16.0	1	2	1	15	46		
16.1-17.0	1	2	2	21	75		
17.1-18.0	2	1	1	8	48		
18.1-19.0	1	2	1	16	80	1	
19.1-20.0			1	7	58	1	1
20.1-21.0				1	43	4	
21.1-22.0					20	4	5
22.1-23.0					19	5	
23.1-24.0					9	3	4
24.1-25.0					11	3	2
25.1-26.0			1			3	2
26.1-27.0					2	3	2
27.1-28.0				1	1	4	3
28.1-29.0						1	2
29.1-30.0						3	1
30.1-31.0					2	3	4
31.1-32.0					1		3
32.1-33.0						2	
33.1-34.0						1	4
34.1-35.0							2
35.1-36.0							6
36.1-37.0						1	5
37.1-38.0							1
38.1-39.0						1	1
39.1-40.0							
40.1-41.0					1	1	3
41.1-42.0							
42.1-43.0							
43.1-44.0							1
44.1-45.0							2
45.1-46.0						1	1
46.1-47.0						1	
47.1-48.0							1
48.1-49.0							
49.1-50.0							
50.1-51.0							1
N	85	297	181	1522	886	47	58
Mean Length (mm)	4.7	6.7	9.6	9.2	15.2	26.7	28.6

N = Number of larvae collected

ABUNDANCE[a] OF ALEWIFE LARVAE
OSWP TRANSECT
OSWEGO VICINITY - 1974



[a]Mean of surface and bottom
[b]Bottom sample only

The following section presents the impingement data obtained during the period from January 1975 through March 1976, and discusses these data in relation to previous impingement monitoring data and fishery information from the primary study area. An estimate of plant operational impact on the nektonic community through impingement is presented in Chapter VI. Methods and materials for the biological program are summarized in Appendix A.

2. Species Inventory

During the period from January 1975 through March 1976, a total of 27 species were identified from the travelling screen collections at the Oswego Steam Station Units 1-4 (Table IVC-1). By comparison, 34 species were collected in both 1973 and 1974. Only the splake, a recently introduced hybrid, was not recorded previously. Species taken in 1973-1974 and not in 1975 include the American eel (n=2), black bullhead (n=1), black crappie (n=4), bowfin (n=1), brown bullhead (n=8), brook stickleback (n=3), carp (n=3), central mudminnow (n=1), fathead minnow (n=2), mosquito fish (n=4), northern pike (n=6), redfin pickerel (n=1), tessellated darter (n=3), and walleye (n=2). Their total represents only 0.01% of the catch during the three-year period. During the winter months of 1975 a bimonthly diel sampling schedule was used to evaluate impingement on the travelling screens at Oswego Units 1-4. The winter sampling schedule was modified for the spring and summer months to include one, 24-hr collection period alternating biweekly with a 12-hr diurnal collection. The spring/summer period is characterized by the greatest use of the shore zone by nektonic populations, and the reduction of the sampling schedule to one nocturnal collection per month -- a time when many species are more active -- may have contributed to the lower 1975 species representation.

3. Abundance and Percent Composition

Abundance and percent composition of fish collected from the travelling screens of Oswego Units 1-4 is presented for each species by month in Table IVC-2a for 1975 and Table IVC-2b for the winter months of 1976.

A total of 21,318 fish were collected and identified during the 1975 monitoring program with the lowest impingement recorded in August (95) and maximum impingement in June (4,685). The most diverse representation of fish species was observed during the months of March and April (14), while the lowest species representation occurred in August when only three fish species composed the impingement collection.

Of the 27 species of fish impinged on the Oswego Units 1-4 travelling screens during 1975, the alewife dominated with 17,303 individuals

TABLE IVC-1

COMMON AND SCIENTIFIC NAMES OF IMPINGED FISH

OSWEGO STEAM STATION UNITS 1-4 - JAN 1975 - MARCH 1976

COMMON NAME	SCIENTIFIC NAME
ALEWIFE	ALOSA PSEUDOHARENGUS
BLUEGILL	LEPOMIS MACROCHIRUS
BURBOT	LOTA LOTA
CHANNEL CATFISH	ICTALURUS PUNCTATUS
EMERALD SHINER	NOTROPIS ATHERINOIDES
FRESHWATER DRUM	APLODINOTUS GRUNNIENS
GIZZARD SHAD	DOROSOMA CEPEDIANUM
GOLDFISH	CARASSIUS AURATUS
JOHNNY DARTER	ETHEOSTOMA NIGRUM
LAKE CHUB	COUESIUS PLUMBEA PLUMBEA
LAKE TROUT	SALVELINUS NAMAYCUSH
LOGPERCH	PERCINA CAPRODES
LONGNOSE DACE	RHINICHTHYS CATARACTAE
MOTTLED SCULPIN	COTTUS BAIRDI
PUMPKINSEED	LEPOMIS GIBBOSUS
RAINBOW SMELT	OSMERUS MORDAX
ROCK BASS	AMBLOPLITES RUPESTRIS
SEA LAMPREY	PETROMYZON MARINUS
SMALLMOUTH BASS	MICROPTERUS DOLOMIEUI
SPLAKE TROUT	
SPOTTAIL SHINER	NOTROPIS HUDSONIUS
THREESPINE STICKLEBACK	GASTEROSTEUS ACULEATUS
TROUT PERCH	PERCOPSIS OMISCOMAYCUS
WHITE BASS	MORONE CHRYSOPS
WHITE PERCH	MORONE AMERICANA
WHITE SUCKER	CATOSTOMUS COMMERSONI
YELLOW PERCH	PERCA FLAVESCENS

TABLE IVC-2 a

ABUNDANCE AND PERCENT COMPOSITION OF IMPINGEMENT COLLECTIONS
OSWEGO STEAM STATION UNITS 1-4 - 1975

SPECIES	JAN NO.	JAN PCNT	FEB NO.	FEB PCNT	MAR NO.	MAR PCNT	APR NO.	APR PCNT
ALEWIFE	29	22.3	1	0.7	8	6.2	4400	66.4
AMERICAN EEL	0	0.0	0	0.0	0	0.0	0	0.0
BLACK CRAPPIE	0	0.0	0	0.0	0	0.0	0	0.0
BLUEGILL	0	0.0	0	0.0	1	0.8	0	0.0
BROWN BULLHEAD	0	0.0	0	0.0	0	0.0	5	0.1
BROWN TROUT	0	0.0	0	0.0	0	0.0	0	0.0
CHANNEL CATFISH	0	0.0	0	0.0	0	0.0	0	0.0
EMERALD SHINER	1	0.8	5	3.6	6	4.7	11	0.2
FRESHWATER DRUM	0	0.0	5	3.6	0	0.0	0	0.0
GIZZARD SHAD	34	26.2	21	15.1	9	7.0	0	0.0
JOHNNY DARTER	0	0.0	0	0.0	0	0.0	0	0.0
LAKE CHUB	0	0.0	1	0.7	0	0.0	1	*
LARGEMOUTH BASS	0	0.0	0	0.0	0	0.0	0	0.0
LONGNOSE DACE	1	0.8	0	0.0	0	0.0	0	0.0
MOTTLED SCULPIN	4	3.1	5	3.6	7	5.4	41	0.6
PUMPKINSEED	0	0.0	0	0.0	0	0.0	0	0.0
RAINBOW SMELT	59	45.4	82	59.0	76	58.9	1689	25.5
ROCK BASS	0	0.0	0	0.0	0	0.0	6	0.1
SEA LAMPREY	0	0.0	0	0.0	1	0.8	1	*
SMALLMOUTH BASS	0	0.0	0	0.0	0	0.0	0	0.0
SPOTTAIL SHINER	0	0.0	0	0.0	1	0.8	2	*
THREESPINE STICKLEBACK	0	0.0	11	7.9	3	2.3	436	6.5
TROUT PERCH	0	0.0	5	3.6	2	1.6	4	0.1
WHITE BASS	0	0.0	0	0.0	1	0.8	1	*
WHITE PERCH	2	1.5	3	2.2	10	7.8	28	0.4
WHITE SUCKER	0	0.0	0	0.0	1	0.8	0	0.0
YELLOW PERCH	0	0.0	0	0.0	3	2.3	3	*
TOTAL	130	100.1	139	100.0	129	100.2	6628	99.9
TOTAL MONTHLY FLOW SAMPLED (MG)	361		582		441		[illegible]18	

* LESS THAN 0.1 PERCENT
(MG) MILLION GALLONS, ALL UNITS COMBINED

TABLE IVC-2a (Continued)

ABUNDANCE AND PERCENT COMPOSITION OF IMPINGEMENT COLLECTIONS
OSWEGO STEAM STATION UNITS 1-4 - 1975

SPECIES	MAY NO.	MAY PCNT	JUN NO.	JUN PCNT	JUL NO.	JUL PCNT	AUG NO.	AUG PCNT
ALEWIFE	1994	97.6	4670	99.7	2794	97.4	92	96.8
AMERICAN EEL	0	0.0	0	0.0	0	0.0	1	1.1
BLACK CRAPPIE	0	0.0	0	0.0	0	0.0	0	0.0
BLUEGILL	0	0.0	0	0.0	0	0.0	0	0.0
BROWN BULLHEAD	0	0.0	0	0.0	0	0.0	0	0.0
BROWN TROUT	0	0.0	0	0.0	1	*	0	0.0
CHANNEL CATFISH	0	0.0	0	0.0	0	0.0	0	0.0
EMERALD SHINER	0	0.0	0	0.0	0	0.0	0	0.0
FRESHWATER DRUM	0	0.0	0	0.0	0	0.0	0	0.0
GIZZARD SHAD	0	0.0	0	0.0	0	0.0	0	0.0
JOHNNY DARTER	4	0.2	0	0.0	0	0.0	0	0.0
LAKE CHUB	0	0.0	0	0.0	0	0.0	0	0.0
LARGEMOUTH BASS	0	0.0	0	0.0	4	0.1	0	0.0
LONGNOSE DACE	0	0.0	0	0.0	0	0.0	0	0.0
MOTTLED SCULPIN	8	0.4	1	*	3	0.1	0	0.0
PUMPKINSEED	0	0.0	0	0.0	1	*	0	0.0
RAINBOW SMELT	32	1.6	6	0.1	0	0.0	0	0.0
ROCK BASS	0	0.0	1	*	4	0.1	0	0.0
SEA LAMPREY	0	0.0	0	0.0	0	0.0	0	0.0
SMALLMOUTH BASS	0	0.0	0	0.0	1	*	0	0.0
SPOTTAIL SHINER	0	0.0	1	*	45	1.6	2	2.1
THREESPINE STICKLEBACK	0	0.0	4	0.1	2	0.1	0	0.0
TROUT PERCH	2	0.1	1	*	1	*	0	0.0
WHITE BASS	0	0.0	0	0.0	0	0.0	0	0.0
WHITE PERCH	3	0.1	1	*	1	*	0	0.0
WHITE SUCKER	0	0.0	0	0.0	3	0.1	0	0.0
YELLOW PERCH	0	0.0	0	0.0	9	0.3	0	0.0
TOTAL	2043	100.0	4685	99.9	2869	99.8	95	100.0
TOTAL MONTHLY FLOW SAMPLED (MG)	180		383		624		599	

* LESS THAN 0.1 PERCENT
(MG) MILLION GALLONS, ALL UNITS COMBINED

TABLE IVC-2a (Continued)

ABUNDANCE AND PERCENT COMPOSITION OF IMPINGEMENT COLLECTIONS
OSWEGO STEAM STATION UNITS 1-4 - 1975

SPECIES	SEP NO.	SEP PCNT	OCT NO.	OCT PCNT	NOV NO.	NOV PCNT	DEC NO.	DEC PCNT	TOTAL NO.	TOTAL PCNT
ALEWIFE	1621	93.7	859	68.1	803	54.7	32	22.9	17303	81.2
AMERICAN EEL	0	0.0	0	0.0	0	0.0	0	0.0	1	*
BLACK CRAPPIE	3	0.2	0	0.0	0	0.0	0	0.0	3	*
BLUEGILL	1	0.1	0	0.0	66	4.5	0	0.0	68	0.3
BROWN BULLHEAD	0	0.0	0	0.0	0	0.0	0	0.0	5	*
BROWN TROUT	0	0.0	0	0.0	0	0.0	0	0.0	1	*
CHANNEL CATFISH	0	0.0	0	0.0	0	0.0	16	11.4	16	0.1
EMERALD SHINER	2	0.1	1	0.1	10	0.7	1	0.7	39	0.2
FRESHWATER DRUM	2	0.1	0	0.0	7	0.5	1	0.7	15	0.1
GIZZARD SHAD	51	2.9	363	28.8	429	29.2	44	31.4	951	4.5
JOHNNY DARTER	0	0.0	0	0.0	0	0.0	0	0.0	4	*
LAKE CHUB	0	0.0	0	0.0	0	0.0	0	0.0	2	*
LARGEMOUTH BASS	0	0.0	0	0.0	0	0.0	0	0.0	4	*
LONGNOSE DACE	0	0.0	0	0.0	0	0.0	0	0.0	1	*
MOTTLED SCULPIN	17	1.0	14	1.1	48	3.3	17	12.1	165	0.8
PUMPKINSEED	1	0.1	0	0.0	0	0.0	1	0.7	3	*
RAINBOW SMELT	7	0.4	1	0.1	44	3.0	23	16.4	2019	9.5
ROCK BASS	0	0.0	0	0.0	0	0.0	2	1.4	13	0.1
SEA LAMPREY	0	0.0	0	0.0	0	0.0	0	0.0	2	*
SMALLMOUTH BASS	0	0.0	1	0.1	0	0.0	0	0.0	2	*
SPOTTAIL SHINER	12	0.7	5	0.4	11	0.7	0	0.0	79	0.4
THREESPINE STICKLEBACK	1	0.1	0	0.0	0	0.0	1	0.7	456	2.1
TROUT PERCH	0	0.0	0	0.0	0	0.0	1	0.7	16	0.1
WHITE BASS	0	0.0	1	0.1	0	0.0	0	0.0	3	*
WHITE PERCH	10	0.6	15	1.2	26	1.8	0	0.0	99	0.5
WHITE SUCKER	0	0.0	1	0.1	0	0.0	0	0.0	5	*
YELLOW PERCH	2	0.1	0	0.0	25	1.7	1	0.7	43	0.2
TOTAL	1730	100.1	1261	100.1	1469	100.1	140	99.8	21318	100.1
TOTAL MONTHLY FLOW SAMPLED (MG)	1281		952		651		591		7463	

* LESS THAN 0.1 PERCENT
(MG) MILLION GALLONS, ALL UNITS COMBINED

TAB[illegible]C-2b

ABUNDANCE AND PERCENT COMPOSITION OF IMPINGEMENT COLLECTIONS
OSWEGO STEAM STATION UNITS 1-4 - 1976

	JAN		FEB		MAR		TOTAL	
SPECIES	NO.	PCNT	NO.	PCNT	NO.	PCNT	NO.	PCNT
ALEWIFE	44	3.9	0	0.0	151	23.1	195	9.3
CHANNEL CATFISH	5	0.4	2	0.6	2	0.3	9	0.4
EMERALD SHINER	98	8.7	31	9.9	8	1.2	137	6.5
FRESHWATER DRUM	0	0.0	0	0.0	1	0.2	1	*
GIZZARD SHAD	882	78.4	89	28.4	247	37.7	1218	58.2
GOLDEN SHINER	0	0.0	1	0.3	0	0.0	1	*
JOHNNY DARTER	0	0.0	0	0.0	1	0.2	1	*
LARGEMOUTH BASS	0	0.0	1	0.3	0	0.0	1	*
LONGNOSE DACE	1	0.1	0	0.0	0	0.0	1	*
MOTTLED SCULPIN	13	1.2	13	4.2	10	1.5	36	1.7
PUMPKINSEED	7	0.6	0	0.0	1	0.2	8	0.4
RAINBOW SMELT	61	5.4	121	38.7	142	21.7	324	15.5
ROCK BASS	0	0.0	1	0.3	0	0.0	1	*
SMALLMOUTH BASS	0	0.0	3	1.0	1	0.2	4	0.2
SPLAKE TROUT	0	0.0	1	0.3	0	0.0	1	*
SPOTTAIL SHINER	0	0.0	2	0.6	1	0.2	3	0.1
THREESPINE STICKLEBACK	0	0.0	2	0.6	3	0.5	5	0.2
TROUT PERCH	0	0.0	0	0.0	1	0.2	1	*
WHITE BASS	4	0.4	40	12.8	59	9.0	103	4.9
WHITE PERCH	10	0.9	4	1.3	25	3.8	39	1.9
WHITE SUCKER	0	0.0	0	0.0	1	0.2	1	*
YELLOW PERCH	0	0.0	2	0.6	1	0.2	3	0.1
TOTAL	1125	100.0	313	99.9	655	100.4	2093	99.4
TOTAL MONTHLY FLOW SAMPLED (MG)	591		494		503		1085	

* LESS THAN 0.1 PERCENT
(MG) MILLION GALLONS, ALL UNITS COMBINED

or approximately 80% of the total. During the spring through early fall period, alewives composed more than half of each monthly impingement collection, reaching peak dominance in June when they represented 99.7% of the total.

The second most abundant fish species in the 1975 impingement collections was the rainbow smelt, which composed approximately 10% of the yearly total. Rainbow smelt were the most abundant during the winter/spring months when Lake Ontario water temperatures are low, and reached maximum abundance in April with 1,689 individuals, or 26% of the April collection.

Other species which exhibited seasonal abundance patterns during 1975 were the gizzard shad, present during the winter and fall months and making up 4.5% of the yearly total, and the threespine stickleback, which represented 2.1% of the yearly total with 96% of the 456 individuals collected in April.

During the winter months of 1976 a total of 2,093 fish were collected, of which the dominant species, the gizzard shad, composed 58.2% of the total (Table IVC-2b). This represented a substantial increase in percent composition for the gizzard shad compared to the same three months of 1975 when it made up only 16.8% of the total. The spring spawning migration of alewife was evident in March, and the winter abundance of rainbow smelt was also noted. In general, a comparison of the 1975 and 1976 winter month impingement collections indicates a higher abundance and species diversity in 1976 and dominance by the gizzard shad.

4. Lake and Plant Comparisons

a. Species Representation

The total number of species collected from the screens in 1975 represents 77% of the number of species captured in the lake. Inherent differences in the lake vs. plant sampling scheme, in addition to the differential abilities of various fish species to avoid the intake or, at least, not utilize the area of the intake, result in several differences between lake and impingement samples (Table IVC-3). Interestingly, five of the impinged species were not found in lake collections, a disparity in part related to the in-plant sampling period extending through the winter months when, for example, the longnose dace not observed during any other time of the year was collected. Differences may also have been partly due to sampling gear efficiency. Bluegill sunfish have never been prominent in lake collections (QLM, 1974; LMS, 1975b, 1976b),

TABLE IVC-3

DOMINANCE OF FISH IN LAKE* AND IMPINGEMENT COLLECTIONS

OSWEGO STEAM STATION UNITS 1-4 AND VICINITY - 1975

LAKE*		IMPINGEMENT	
SPECIES	PERCENT OF TOTAL ABUNDANCE	SPECIES	PERCENT OF TOTAL ABUNDANCE
Alewife	77.5	Alewife	80.3
Spottail shiner	7.3	Rainbow smelt	10.8
White perch	4.7	Gizzard shad	4.2
Rainbow smelt	2.7	Threespine stickleback	2.1
Gizzard shad	1.9	Mottled sculpin	0.8
Yellow perch	1.5	White perch	0.5
White sucker	1.1	Spottail shiner	0.4
Lake chub	0.9	Bluegill sunfish	0.3

*Surface and bottom gill net collections

although they have frequently been present in impingement samples. Similarly, the mottled sculpin was often observed on the screens in 1975, yet it was not collected at all in the lake. The less common species, therefore, may not be sampled quantitatively in the present program.

b. Impingement Estimates

Monthly estimates of total impingement are shown in Tables IVC-4 and Table IVC-5. Two methods of calculating these values, based on the number of fish collected per hour of plant operation and on the number per million gallons of cooling water flow, are indicated. The results of the two methods in general agree: 362,859 (based on fish/hr) and 368,291 (based on flow) fish were impinged. The small difference in the two estimates can be attributed in part to the short-duration changes in cooling water use and to the subsequent alteration in intake velocities. Each estimate has proved useful in describing the magnitude of fish impingement, and both methods are presented to enable comparison of impingement at Oswego Units 1-4 to other plants and impingement surveys. However, only the number of fish based on the hours of plant operation will be used in this discussion to conform with previous analyses conducted on impingement collections at the Oswego Steam Station Units 1-4 (LMS 1974, 1976b).

The 1975 impingement estimated at 362,859 represents a dramatic reduction from the 1973 and 1974 impingement estimates of approximately 1,700,000 and 2,200,000 fish respectively. A similar downward trend was observed in calculated impingement at the nearby Nine Mile Point area during 1975 (LMS, 1976a). This was caused primarily by reduced numbers of alewives, suggesting a smaller year class strength returning to the littoral zone to spawn. However, another factor must be considered in comparing the 1975 impingement estimates to those of previous years: the sampling variance and the sampling schedule during the spring/early summer period of 1975. The sampling program between April and September (outlined in Appendix A) consisted of biweekly sampling, with one date consisting of a 12-hr day sample and the alternate date consisting of two 12-hr contiguous samples. This schedule results in two diurnal collections and one nocturnal collection per month, which could bias the estimated impingement of a nocturnal seasonal migrant. For example, approximately 71% of the alewives collected were from night sampling efforts with a range of 32 to 3142 per 12-hr period. Sampling efforts at Lake Ontario stations during 1975 were of the same magnitude as 1974; however, almost 14,000 more alewives were taken during 1974. Hence, the lower abundance in the primary study area coupled with the single nocturnal sample per month explain, in part, the lower estimated impingement in 1975.

TABLE IV-C-4

IMPINGEMENT RATE ESTIMATES FOR ALL SPECIES COMBINED
BASED ON FISH COLLECTED PER HOUR

OSWEGO STEAM STATION UNITS 1-4 - 1975-1976

MONTH	MEAN NUMBER OF FISH PER HOUR	ESTIMATED MEAN NUMBER OF FISH PER DAY	ESTIMATED MEAN NUMBER OF FISH PER MONTH
JAN 1975	2.71	65	2,015
FEB	3.00	72	2,016
MAR	2.65	64	1,969
APR	69.81	1676	50,265
MAY	63.15	1516	46,981
JUN	163.25	3918	117,540
JUL	108.04	2593	80,383
AUG	2.65	64	1,969
SEP	22.18	532	15,970
OCT	26.27	631	19,546
NOV	30.60	735	22,035
DEC	2.92	70	2,170
JAN 1976	23.48	564	17,469
FEB	6.30	151	4,382
MAR	9.10	218	6,768

TABLE IV-C-5

IMPINGEMENT RATE ESTIMATES FOR ALL SPECIES COMBINED
BASED ON FISH COLLECTED PER MILLION GALLONS PLANT FLOW

OSWEGO STEAM STATION UNITS 1-4 - 1975-1976

MONTH	AVERAGE DAILY PLANT FLOW (MG)	MEAN NUMBER OF FISH PER MILLION GALLONS	ESTIMATED MEAN NUMBER OF FISH PER DAY	ESTIMATED MEAN NUMBER OF FISH PER MONTH
JAN 1975	174.50	0.36	63	1,953
FEB	246.60	0.24	59	1,652
MAR	235.50	0.29	68	2,108
APR	211.20	9.09	1919	57,570
MAY	174.70	11.79	2059	63,829
JUN	232.50	16.53	3844	115,320
JUL	357.50	5.70	2037	63,147
AUG	368.20	0.16	60	1,860
SEP	442.20	1.33	588	17,640
OCT	456.90	1.32	605	18,755
NOV	351.00	2.12	746	22,380
DEC	281.80	0.24	67	2,077
JAN 1976	282.33	1.91	538	16,678
FEB	261.34	0.65	169	4,901
MAR	170.80	1.37	234	7,554

c. Yearly Comparison of Impingement Estimates: 1973-1975

Estimated monthly impingement by year for the period 1973-1975 is shown in Figure IVC-1. Peak values occurred in the spring and early summer in each year and may be attributed mainly to the onshore movement of adult and juvenile alewives (Graham, 1956; LMS, 1974, 1975b). Since water temperatures and possibly photoperiod in spring influence the onset of the shoreward migration, the relative position of the abundance peaks may differ between years (Figure IVC-1). Furthermore, their resolution may also be affected by the actual sampling dates in a given year, e.g., whether a collection is made at the beginning or the end of the month.

Impingement rates were considerably lower (e.g., an order of magnitude in April) during the April-July period of 1975, compared to previous years (Figure IVC-1); this was due primarily to the collection of fewer alewives in 1975 (Table IVC-6). Their numbers were also lower in the Oswego lake catches during the 1975 sampling year, and similarly, at Nine Mile Point, 14,198 fewer alewives were caught by all gear types, despite a larger total sampling effort in 1975 than in the previous year.

Impingement rates were low during August of 1973 and 1975, largely because of the movement of fish, primarily the dominant alewife, to deeper water after spawning, and the presence in the primary study area of juveniles not collected by the fish monitoring techniques. This was not the case in 1974 (Figure IVC-1) when immature alewife, spawned in the previous year, remained in the nearshore area and constituted the bulk of the catch (Table IVC-6).

Individual impingement rates by date for 1975 are shown in Figure IVC-2 for those species constituting 95% of the total catch. Four species - the alewife with 81.2% of the total (Table IVC-2a), followed by the rainbow smelt (9.5%), gizzard shad (4.5%), and threespine stickleback (2.1%) - composed approximately 97% of the total impingement collection. Alewife were impinged throughout most of the year, with the major peak occurring in June; the remaining species exhibited a distinct seasonality with the period of impingement covering a relatively brief time period. Threespine stickleback, for example, were collected only in April (with a single exception), corresponding to the arrival of this species on the inshore spawning grounds. Similarly, rainbow smelt were collected from the travelling screens during their spring spawning migration, primarily in April and May. Gizzard shad were collected in the late fall, with numbers peaking in December. Their susceptibility to impingement at Oswego may be altered by the effect of the nearby Unit 5 outfall since this species is known to congregate around warm water discharges (Gammon, 1971; Reutter and Herdendorf, 1976).

TABLE IVC-6

MEAN MONTHLY IMPINGEMENT RATE* FOR ALEWIFE

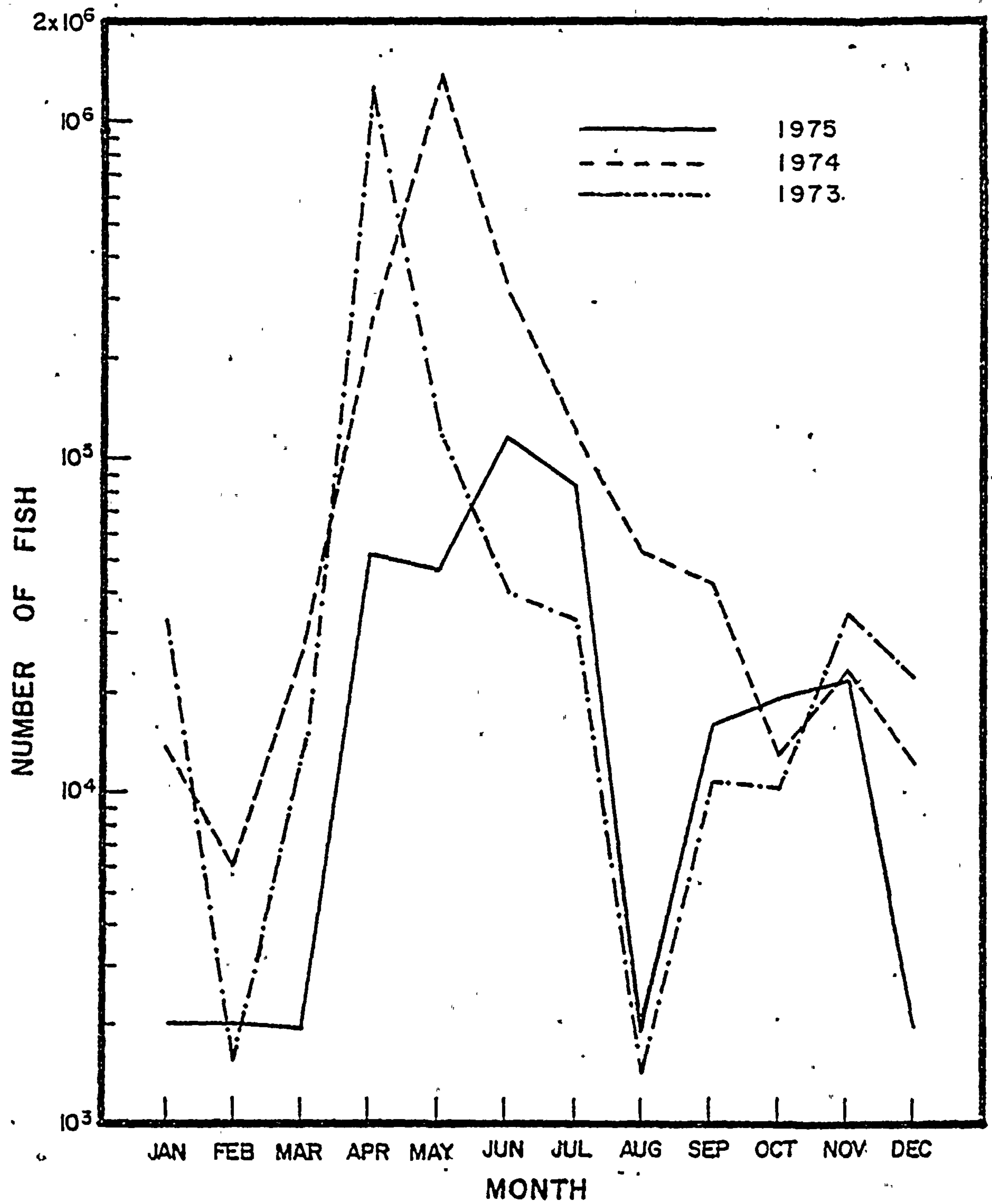
OSWEGO STEAM STATION UNITS 1-4 - 1973-1975

YEAR	APR	MAY	JUN	JUL
1973	890.7	138.8	51.8	38.6
1974	249.4	1684.4	422.8	150.4
1975	43.3	61.7	162.8	99.8

*Number of fish/hour

FIGURE IVC-1.

ESTIMATED MONTHLY FISH IMPINGEMENT
OSWEGO STEAM STATION UNITS 1 - 4 — 1973 - 1975



In the latter part of April, impingement sampling was conducted over five consecutive 24-hour intervals. The catch of alewife and rainbow smelt during this period displayed an initial drop with a subsequent upward trend to nearly the same level as the first day (Figure IVC-2). Flow through the plant did not change markedly throughout the study, although the number of pumps in operation varied over the course of the day. It is difficult to determine the cause of the observed pattern since impingement rates depend upon many interacting factors. For example, the number of pumps in operation may cause changes in velocity profiles at the intake, in some instances actually attracting fish (Merriman and Thorpe, 1976). Alternatively, the pattern depicted for the 23-28 April period may simply reflect day-to-day differences in fish densities near the intake ("patchiness") and thus may represent the norm for this time interval. Superimposed over this ecological "noise" are seasonal patterns and, possibly, changes associated with shorter term phenomena, e.g., upwellings and currents in the area.

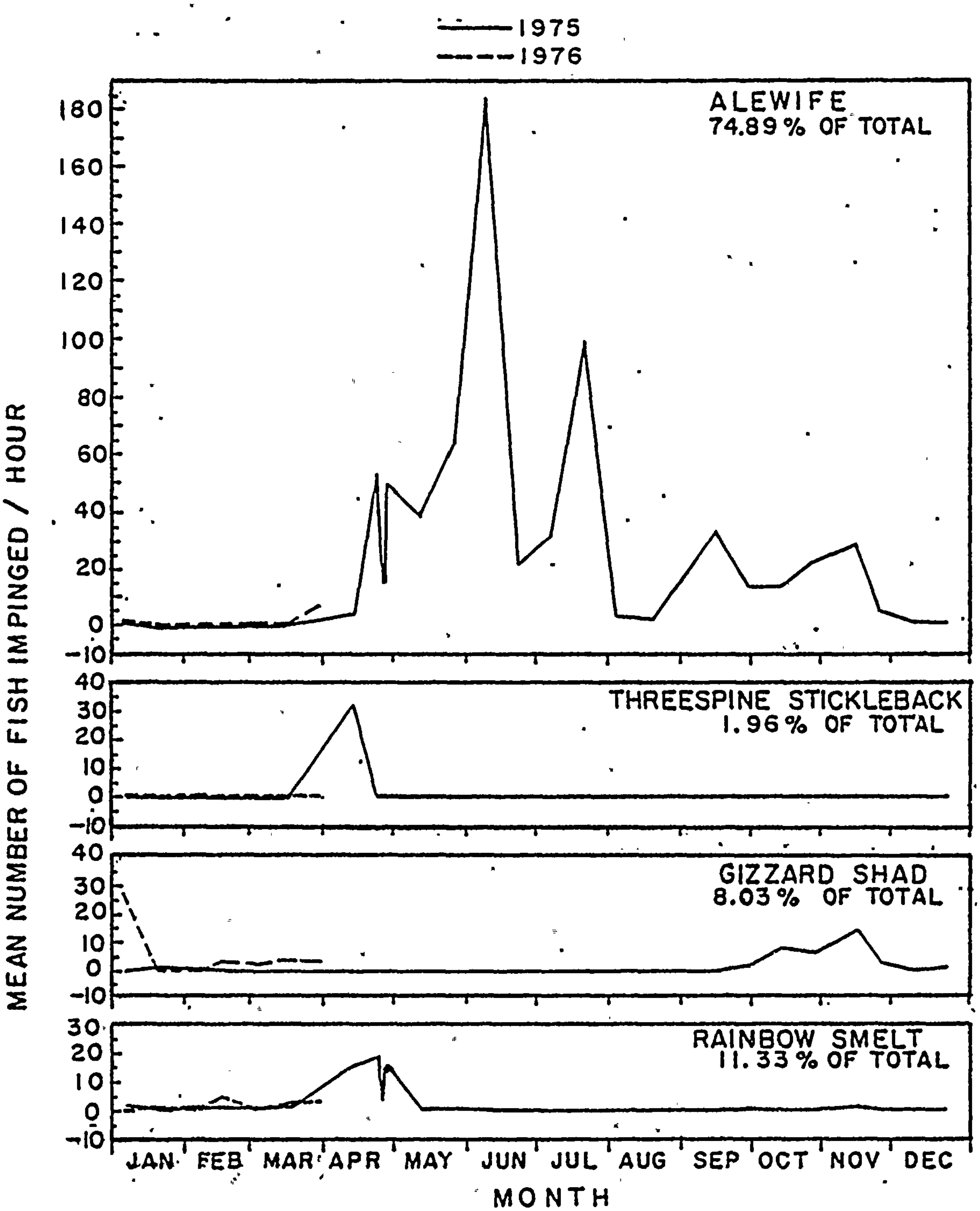
Of much greater magnitude, although not as finely resolved, are the differences in the alewife catch in June and July (Figure IVC-2). Impingement dropped off sharply in late June and remained at relatively low levels in early July. The trend in the data is easily explained, however. Alewives tend to be more active inshore at night (Graham, 1956); because the 9 June and 21 July samples consisted of both day and night collections, whereas those of 23 June and 7 July represent daytime samples only, the nocturnal activity peak during the latter two dates was missed entirely.

Length-frequency data for rainbow smelt (Figure IVC-3) indicate that two distinct age categories were impinged during the period of maximum inshore abundance. Young-of-the-year and older fish were present on the screens from January through April, although in February of 1976 most were first year specimens with a mean length of 6.22 cm. Length frequency data for 1973 indicate that adult smelt were also abundant in fall collections (QLM, 1974). Wells (1968) reported that Lake Michigan smelt preferred deeper waters in the summer and became more abundant nearshore in the fall as a result of recruitment of young. Insufficient numbers of smelt were obtained in the fall of 1975 to construct length frequency curves; however, the low number, suggests a different pattern between the two years.

Length-frequency data for gizzard shad indicate that most fish impinged were young-of-the-year with some yearlings; however, during the months of January and December 1975, adults estimated to range in age from 2 to 4 years (Figure IVC-4) were present.

MEAN ABUNDANCE OF SELECTED SPECIES OF FISH IN IMPINGEMENT COLLECTIONS

OSWEGO STEAM STATION UNITS 1-4—1975-1976



FREQUENCY OF LENGTH INTERVALS OF RAINBOW SMELT
OSWEGO STEAM STATION UNITS 1-4—1975-1976

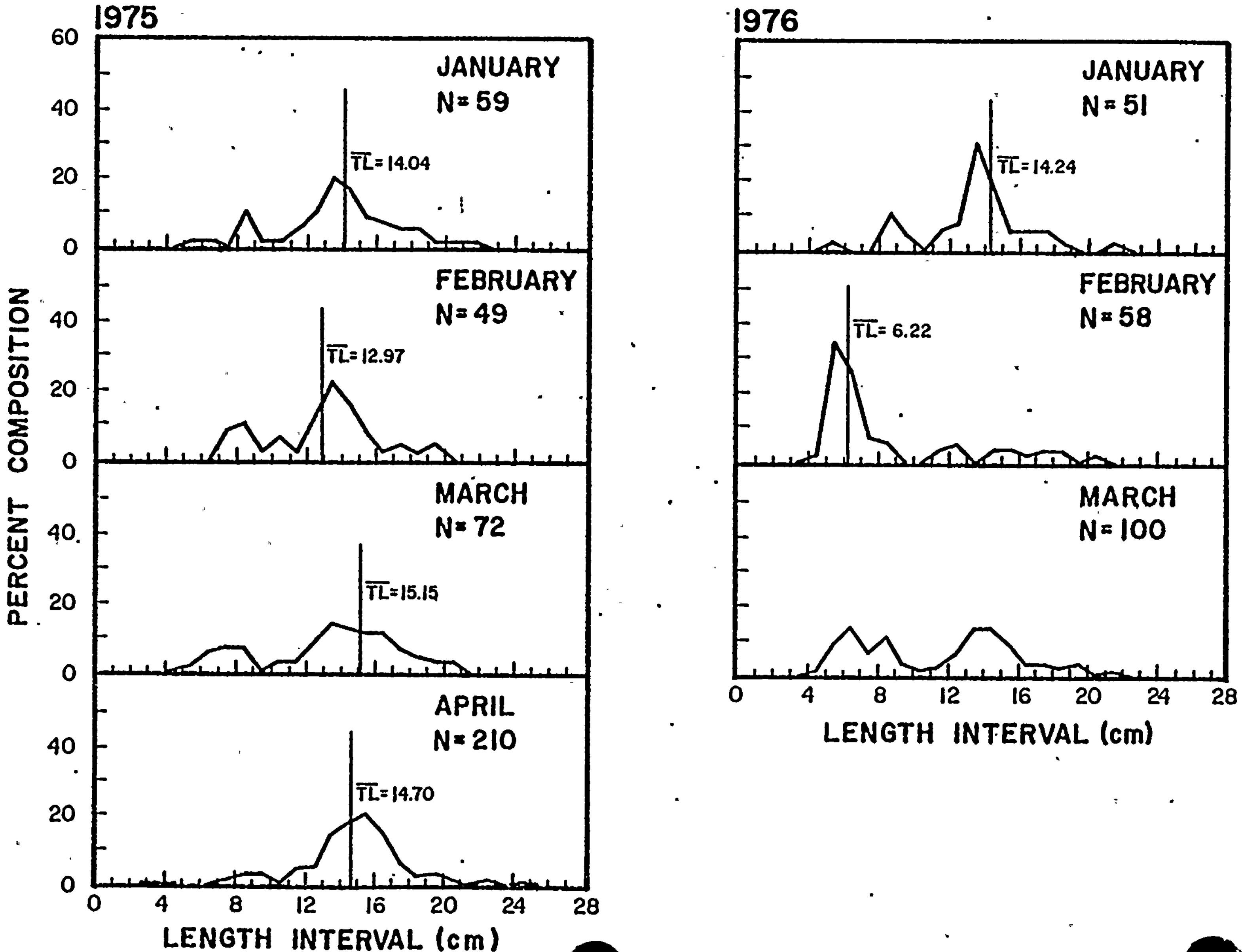


FIGURE IVC-3

Young-of-the-year were particularly abundant during the fall, generally supporting the observation of Bodola (1966) that gizzard shad were most numerous in Lake Erie during late summer and early fall when their abundance was increased by the recruitment of first-year fish. Thus, unlike the pattern for the dominant alewife, it is the earlier life stages (immature fish) of the rainbow smelt and gizzard shad which are most susceptible to impingement.

Age class composition based on length frequency measurements of the dominant alewife population impinged during 1975-1976 (Figure IVC-5) indicated the same general trend reported for 1973 and 1974 (LMS, 1974, 1976b). Sexually immature adults composed the majority of the alewives impinged during the winter months, with sexually mature adults present during the remainder of the year. Young-of-the-year recruitment was first evident in August, and the young remained in the shore area through November, as represented by impingement samples. Graham (1956) reports that alewife leave the shore zone after spawning; however, the consistent pattern at Oswego, of large numbers of individuals in the length frequency range of sexually mature fish through the year, suggests a longer residence time in the littoral zone.

Two other species were occasionally abundant in impingement samples. White perch were taken in maximum numbers in the spring (March-April) and again in the fall (September-November). Their absence from summer collections may be related to their movement into very shallow water to spawn (Scott and Crossman, 1973), although this behavior was reported to occur in May and June.

Mottled sculpin, because of their demersal behavior and preference for rocky habitats during the spawning season (Scott and Crossman, 1973) are not readily amenable to collection by standard gear. In the past, trawls have proven the most effective means of collecting this species over sandy habitats, however, these were not used at Oswego in 1975, and consequently sculpin are underrepresented in lake samples. Maximum numbers of sculpin were impinged in the spring and fall, perhaps in relation to greater movement prior to and after the spawning cycle (males are strongly territorial and guard their nest during the breeding season).

5. Discussion of Dominant Species

Nektonic species that are numerically abundant in intake monitoring collections are important in evaluations of plant impact, not only because of their dominance, but also because they exhibit seasonal and spatial distributional trends, normally represent several trophic levels, and may include recreational or commercially important species.

FREQUENCY OF LENGTH INTERVALS OF GIZZARD SHAD

OSWEGO STEAM STATION UNITS I-4—1975-1976

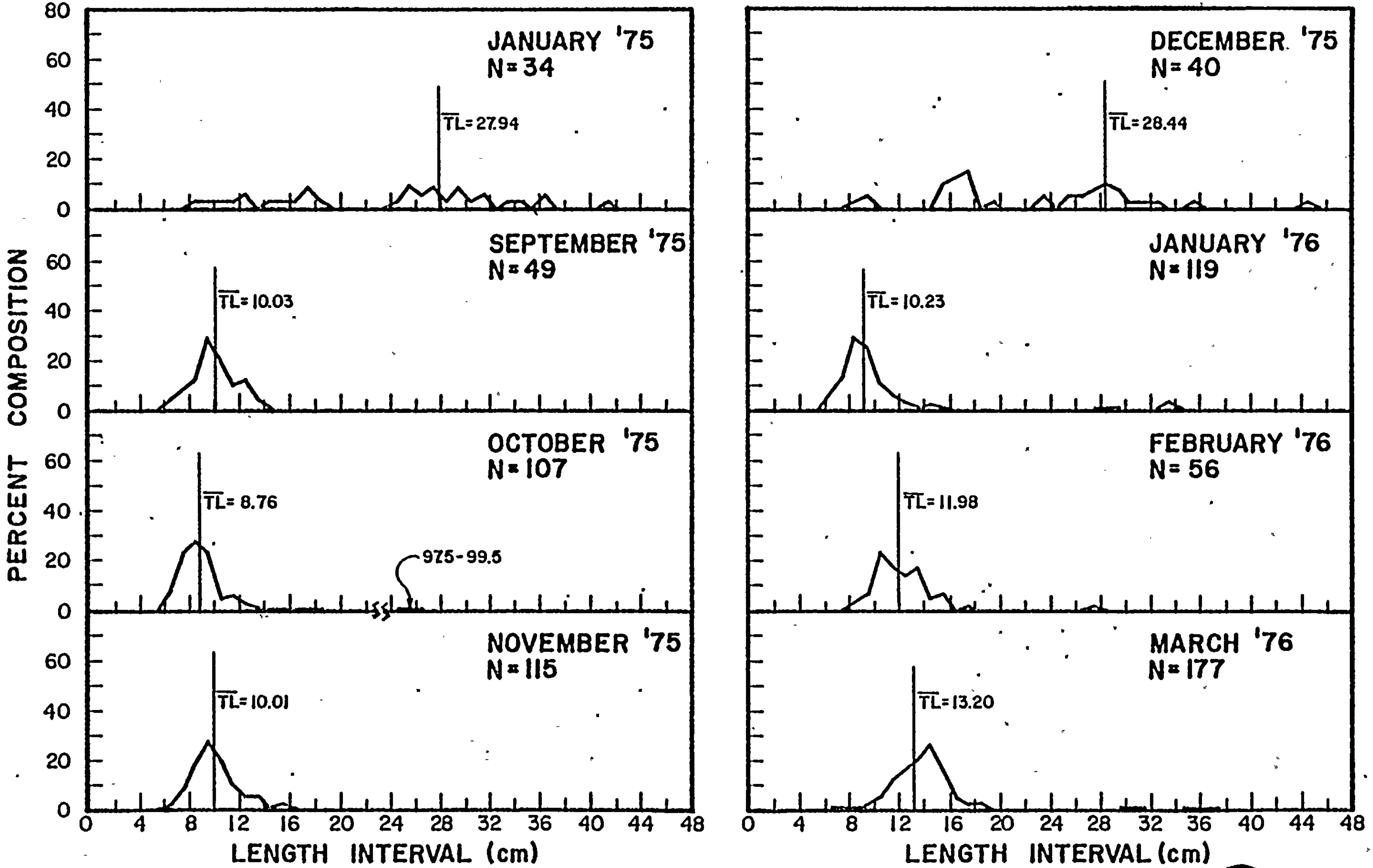
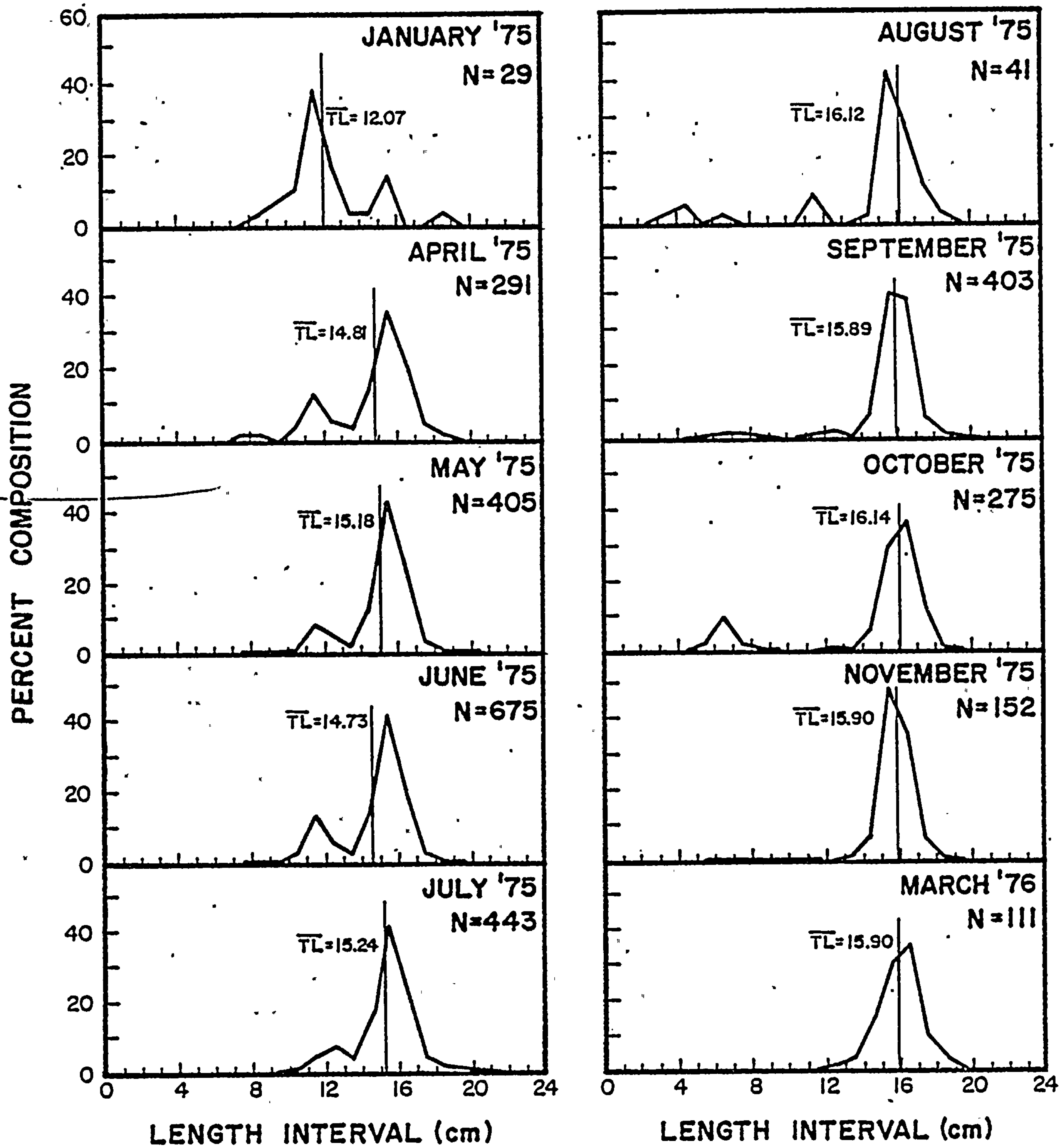


FIGURE IVC-4

FREQUENCY OF LENGTH INTERVALS OF ALEWIFE
OSWEGO STEAM STATION UNITS 1-4—1975-1976



Life history information for dominant species collected from the travelling screens at Oswego Units 1-4, with the exception of the rainbow smelt and mottled sculpin, are presented in the accompanying 316(a) demonstration. Rainbow smelt and mottled sculpin were not collected in abundance in the Oswego Turning Basin and, therefore, were not discussed in the 316(a) document. A synopsis for the rainbow smelt, based on previously recorded information from the Oswego area, is presented below. A literature survey for the mottled sculpin is also included.

a. Rainbow Smelt (*Osmerus mordax*)

The original range of the rainbow smelt in eastern North America was restricted to the Atlantic coastal drainage basin from New Jersey to Labrador; whether the smelt is native to Lake Ontario is uncertain. Hubbs and Lagler (1958) believe that it is, whereas Scott and Crossman (1973) are of the opposite opinion. In either case, the first report of rainbow smelt taken from Lake Ontario was in 1931 by Mason (1933). This fish occurs in all of the Great Lakes and in many other Canadian and United States lakes. The smelt is an anadromous species, leaving the sea or large lakes in spring to spawn in freshwater streams. In Lake Ontario, spawning often occurs along the lake edge in shallow water on gravel shoals; Rupp (1965) believes that shore spawning may be as successful as stream spawning.

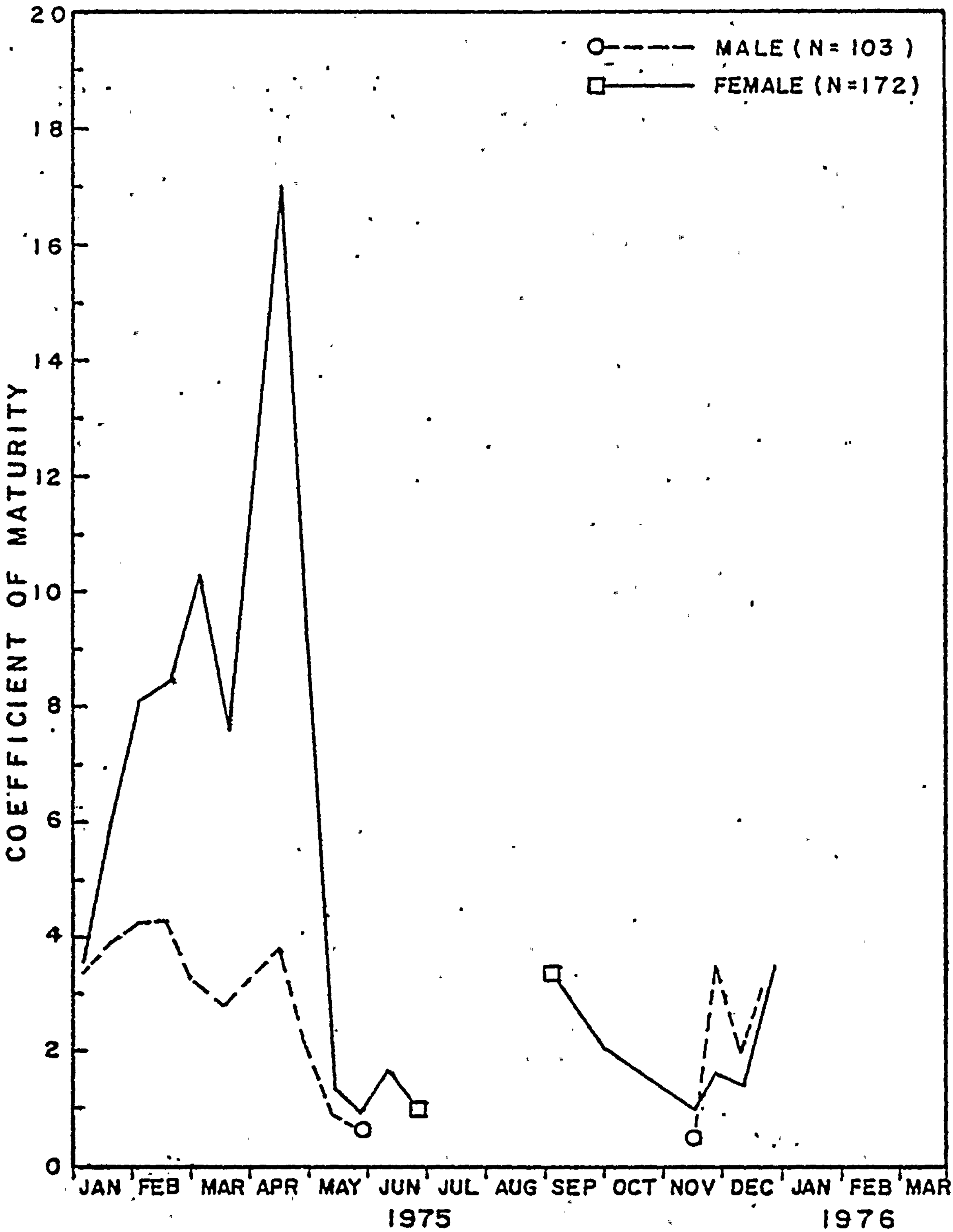
In the Oswego vicinity, rainbow smelt are collected in greatest numbers in impingement and lake samples during April (QLM, 1974; LMS, 1975b); however, sampling has not been conducted at lake stations during March, which is the reported time for the initiation of spawning migrations of this species (McKenzie, 1964). Statistical analyses conducted in the past (LMS, 1975b) indicate that more fish are collected during the spring than in summer or fall months.

This species spawns during April, as determined from coefficient of maturity data (Figure IVC-6). There is evidence to suggest that rainbow smelt use the area near Oswego/Nine Mile Point as a spawning ground because collections during this period have contained mature females, and smelt eggs and larvae were frequently present in ichthyoplankton samples.

Results from fecundity studies (LMS, 1974) show variation in rainbow smelt egg production from a total of 6,212 eggs for a specimen 138 mm in length to 29,050 eggs for a 213 mm individual, with a mean of 17,002 eggs. Comparable data from other areas (Van Oosten, 1940; Baldwin, 1950; Baily, 1964) are in reasonable agreement with these values when allowances are made for length.

COEFFICIENT OF MATURITY OF RAINBOW SMELT

OSWEGO STEAM STATION UNITS 1-4-1975



Considerable data have also been collected regarding the growth history of rainbow smelt in the Oswego area. Scale analyses indicate that 14% of the smelt collected during April 1974 (LMS, 1975b) and 12% collected during May had formed their annulus. In 1973, peak annulus formation of smelt in the Nine Mile Point vicinity 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.

Growth curves derived from body length-scale length relationships exhibited the same form for males and females, although females appeared larger after the first year of life (1974). Females were also significantly larger than males after their second year. Furthermore, with the exception of the first year of life when growth was similar for both sexes, the annual increments were greater for female smelt than for males. McKenzie (1958) reported that female smelt in the Miramichi River, New Brunswick, Canada, were also larger than males after the second year of growth; Baily (1964) reported that age three and older female smelt in Lake Superior were larger than males.

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 collected was seven years. Bailey (1964) reported the maximum attained age for female smelt was seven years and five years for males in Lake Superior.

The first-year growth of Nine Mile Point smelt was generally found to be greater than or comparable to that of smelt populations in other Great Lakes (Van Oosten, 1944; Baldwin, 1950; Hale, 1960; Bailey, 1964; Burbidge, 1969). These comparisons can only be made in general terms, however, since the methods used to calculate growth curves were somewhat different (LMS, 1975a).

Length frequency distributions calculated from 1974 rainbow smelt data from the vicinity of Nine Mile Point showed that the majority of smelt were 14-17 cm long. These fish presumably represent migrants on their way to the spawning grounds.

No data are available for feeding habits of this species in the Nine Mile Point/Oswego area; the literature characterizes the diet of adult smelt as consisting of insects, oligochaetes, crustaceans, and other fish, all of which have been shown to be abundant in the Oswego area.

Summer lethal thresholds reported for rainbow smelt range from 21.5-28.5°C (70.7-83.3°F). The lower range is not realistic since summer ambient temperatures sometimes exceed 25°C (77°F) during the period when smelt are present in the Oswego area, yet no die-offs have been observed by sampling crews working in the area.

b. Mottled Sculpin (Cottus bairdi)

The mottled sculpin has a widespread but discontinuous distribution in North America. It is found in the Tennessee River drainage of Georgia and Alabama, north to Labrador and west to the Great Lakes basin. From here, the distribution is discontinuous and includes parts of the Missouri and Columbia River drainage systems in Canada, Utah, Montana, Idaho, and Washington.

Spawning occurs in the spring, primarily in May and early June (Ricker, 1934). Eggs are deposited in an adhesive mass, usually under a rock or ledge, and the territorial male guards the nest alone. Water temperature at time of spawning is reported by Koster (1936) as 10°C (50°F), and hatching occurs about a month after egg deposition, the actual time depending on water temperatures. Spawning usually takes place at age three (Koster, 1936); however, several ripe two year old specimen were collected.

In eastern Ontario, the mottled sculpin is most frequently caught over sand bottoms (Toner, 1943) at summer temperatures of 16.6°C (61.9°F). This species is a benthic feeder which subsists mainly on insect larvae, including chironomid and caddisfly larvae and mayfly and stonefly nymphs. The diet of larger individuals is also supplemented with crustaceans, annelids, fishes, and fish eggs.

The mottled sculpin, in turn, is an important forage species which is consumed by various predators including the smallmouth bass, brook trout, and the water snake Natrix sipedor (Scott and Crossman, 1973).

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V. POTENTIAL STRESSES AND IMPACTS OF THE CIRCULATING WATER SYSTEM

A. POTENTIAL ENTRAINMENT IMPACTS

Once-through cooling of the condensers of steam electric generating stations requires the use of large amounts of water. Oswego Steam Station Units 1-4 circulates 21.6 m^3/sec (763 cfs) at maximum generation. As a result of this process, organisms living within the water body from which the cooling water is withdrawn may be subjected to a variety of stresses. Analyzing the effects of these stresses on the aquatic community requires a knowledge of three basic community parameters:

1. the size and resiliency of the affected population,
2. the life stages, species, and numbers of organisms subjected to the stress, and
3. the survival and viability of entrained organisms after passage through the power plant.

Research on aquatic communities that exist near power plants has been aimed at describing size of individual populations. The quantification of life stages, species, and numbers of organisms entrained relies on standard biological monitoring of the entrained water. The groups of organisms usually considered in entrainment impact analyses are the phytoplankton, zooplankton, and early life stages of fish. Experiments which have recently been conducted to determine the survival of entrained organisms have shown that stress results from a combination of such factors as:

1. heat dissipated through the condenser tubes into the cooling water
2. changes in hydrostatic pressure as the cooling water is pumped through the system
3. mechanical abrasion resulting from contact with pumps and tubing walls
4. shear stress developed in the moving water
5. chemical additives to the cooling water
6. changes in the partial pressure of gases within the water.

It has at times been assumed that all of the organisms entrained are killed, but this has been shown not to be the case. In fact, phytoplankton production appears to be stimulated during the cooler months. It is only during the summer when the algae are existing near their upper thermal tolerance point that the addition of heat becomes detrimental (Brooks, 1974; Curtz and Weis, 1974; LMS, 1975). Analyses of the effects of condenser passage on phytoplankton are usually performed using the uptake of radioactively labeled carbon(^{14}C), a test which

determines the overall response of all species and individuals within the sample. It is likely that some species are selectively eliminated while the growth of other species is enhanced.

Studies of the effect of entrainment on zooplankton have yielded similar results. Entrainment rarely causes 100% mortality and the response of an organism is specific. Icanberry and Adams (1974) found a high correlation between the temperature rise through the condenser and the percent mortality of the zooplankton. LMS (1975) has also found a correlation between temperature rise through a power plant and the percent mortality of Bosmina, copepod nauplii, and rotifers. A relationship was also noted between the length of time the organisms remained in the condenser tubes, the number of abrupt turns in the system, and organism mortality. Mortality estimates for zooplankton generally range from 10 to 30% (Davies and Jensen, 1973, 1974; Heinle et al., 1974; Icanberry and Adams, 1974; LMS, 1975). Massengill (1976) evaluated pump entrainment effects on zooplankton populations in the Connecticut River. He found very little impact on populations of Cladocera, and Copepoda; however, insect pupae (mainly Diptera) and Leptodora kindtii exhibited high mortality with only pumps operating and no heat addition.

For purposes of considering the effects of entrainment upon Lake Ontario organisms, 100% mortality of the organisms entrained was assumed. In fact, all organisms entrained were removed from the Lake Ontario assemblage and desposited in the Oswego Turning Basin [316(a) demonstration], where some become active members of that assemblage, while others return to the lake. All organisms were considered removed from the original community, thus resulting in the largest, most conservative, estimate of entrainment effects.

B. POTENTIAL IMPINGEMENT IMPACTS

The inclusion of screening devices within the intake structures of steam electric generating stations is intended to remove larger particulates, including fish, from the cooling water flow. Removal of these materials is necessary to prevent interruption of electric generating processes which are dependent upon a constant supply of large volumes of cooling water. The volume and velocity characteristics of water flow at many intake structures occasionally result in the accumulation of large numbers of fish on the intake screens (impingement).

Examination of available impingement records from electric utilities and water filtration plants on the Great Lakes shows that the species impinged most frequently and in the greatest numbers are schooling fishes, such as alewives, gizzard shad, rainbow smelt, and shiners. The greatest impingement is frequently associated with spawning migrations or seasonal inshore-offshore movements of fish in response to the seasonal thermoperiod of lake water.

The interplay of factors resulting in observed impingement levels is often difficult to control or otherwise isolate: Included are seasonal migration patterns, reduced swimming capability and endurance during colder months, and rapid habituation of the organism's nervous system to "decoy" (frightening and luring) mechanisms. Plant operating factors such as the number of pumps in operation (flow), velocity profiles at the traveling screens, and intake design are also important considerations. Because of the geologic, hydrologic, and biologic uniqueness of each site, a fish impingement study at any electric generating station must be approached as an individual case.

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VI. PLANT OPERATIONAL IMPACT

A. INTRODUCTION

The ecology of various planktonic and nektonic organisms in the vicinity of Oswego Steam Station is considered in earlier chapters. In this chapter a conservative concept of impact is described and the underlying assumptions investigated. Four different applications are given: one for plankton with limited or no mobility and whose distribution may be assumed to be homogeneous, two for the mobile nekton, and one for fish eggs.

B. WATER BODY SEGMENT IDENTIFICATION

1. Rationale

The quantification of impact on natural populations may be defined as the ratio of the number of affected organisms to the number of organisms possibly affected:

$$\text{Impact} = \frac{\text{Affected Population}}{\text{Available Population}}$$

For the purpose of this demonstration, the number of affected organisms is taken as the number of organisms impinged or entrained. In this case, therefore, "impact" is synonymous with cropping and the two terms are used interchangeably.

The use of cropping as a measure of impact ignores other, more subtle ecological interactions that may take place in the area where cropping occurs. Such ecologic interactions might include changes in competitive advantage by certain species, possibly resulting in local changes in species dominance or diversity, or local exclusion or invasion of some species. However, cropping is a direct measure of impact and any ecological effects should be observed first in the near field area. It is important, then, that an appropriate near-field area be designated.

Examination of the simple "impact" formula reveals the importance of choosing the near-field area judiciously. The magnitude of cropping or impact is inversely proportional to the estimate of the available population and the potentially affected area. Choice of a large population, e.g., the world population of alewives, will result in trivial impact estimations. Choice of an inordinately small population will inevitably yield an inflated estimation of impact.

The effects of power plant operation on the Lake Ontario ecosystem will most likely be first apparent in the near field, the area for

which the studies conducted by Niagara Mohawk Power Corp. from 1970 to the present provide the most data. It is possible to delineate a segment of the lake for which data exist, and which may justifiably be considered a potentially impacted ecological area. A water segment has been chosen in which both fish and planktonic organisms may potentially be impacted. For planktonic organisms, such a water segment should be of sufficient size to include expected excursions of floating organisms in the period of time between natural flushings or overturnings of water masses in the area. The next section will describe a rectangular water body segment, extending approximately 3.5 km (2.2 mi) from shore and 13 km (8.1 mi) along shore, to which near-field effects on planktonic populations are expected to be limited.

A water body segment is also a meaningful area in which to assess effects of impingement on fish populations. Fish, unlike plankton, possess powers of mobility which allows them to move against lake currents. A reasonable estimation of the potentially impingeable (available) fish population would be all those fish which might possibly swim to the intake structure within a determined amount of time, e.g., one day.

2. The Water Body Segment

The criteria used to select the water body segment are based on current data measured in the southeast corner of Lake Ontario as discussed in Chapter III.

The near-shore circulation is usually not still, but is either in a state of calm, steady longshore currents or in a state of transition during which frequent current reversals are observed. Many investigators (Landsberg, Scott, and Fenlon, 1970; Csanady, 1972a, 1972b; Pickett and Richards, 1974; QLM, 1974a) report current speeds in the very near-shore zone of about 0.1 knots (5.2 cm/sec, 0.17 fps) flowing predominantly along the shore. This is confirmed by the reported frequencies of occurrence shown in Figure III-1; consequently, 0.1 knots is accepted as a characteristic near-shore speed. In addition, these very near-shore currents are known to be persistent only in the along-shore direction, and onshore and offshore flow is associated with large-scale mixing with the main portions of the lake.

It has been reported (Csanady, 1970; QLM, 1974b) that fluorescent dye released in the near-shore area prior to a current reversal does not generally return to the point of discharge, suggesting that the current reversal accompanies an exchange of mass. That is, steady alongshore currents predominate during the interludes between the periodic naturally occurring flushings of the near-shore zone; during these flushings, large masses of offshore water replace the near-shore water and to some extent renew the near-shore populations.

The persistence of currents is presented in Figure III-1, which indicates that 90% of the currents of speed 0.1 knots (5.2 cm/sec, 0.17 fps) persist for periods of less than a day and a half (36 hrs) for a total excursion of approximately 6.5 km (4.1 mi). The reported frequencies of alongshore currents (east-to-west or west-to-east) indicate that both directions are likely to occur (Figure III-2). Therefore the segment extends 6.5 km (4.1 mi) in both directions. The offshore extent of the selected water body segment is bounded by the region frequently containing persistent large-scale lake features, such as the coastal jet.

The coastal jet is reported to be centered about 6-8 km (3.8-5.0 mi) (Csanady, 1972a) from shore; the near-shore edge of this fast-moving current has been reported to be within 4.8 km (3.0 mi) of shore (Scott, Jekel, and Fenlon, 1971). For this reason, the 30 m (98.4 ft) depth contour, which extends approximately 3.5 km (2.2 mi) from shore, has been chosen to be a conservative estimate of the offshore water body segment boundary.

The water body segment (Figure VI-1) has an approximate surface area of 45.5 km^2 (17.8 mi^2). The volume of water contained within this water body segment is 6.7 x 10^8 m^3 (2.4 x 10^{10} ft^3). The cross-sectional area through the water body segment normal to the along-shore flow has an approximate area of 5.1 x 10^4 m^2 (5.5 x 10^5 ft^2). The segment represents 0.042% of Lake Ontario's water volume of 1626 km^3 (390 mi^3). The characteristics of the water body segment are summarized in Table VI-1.

All those planktonic organisms carried passively through this water segment and all those within the segment whose mobility is small may be considered potentially entrainable.

The potentially affected populations of fish are defined as those fish which could swim to the intake in a predetermined amount of time, one day. This definition leads to a comparable water body segment identification for fish populations. Two swim speeds were used to estimate the area from which fish were potentially impingeable, 2 cm/sec (0.07 fps) and 12 cm/sec (0.39 fps). These values encompass, within a width of two standard deviations, the average swim speed for yellow perch and white sucker calculated from data collected by Kelso (in press). The average speed at which a fish swims is dependent on a number of factors, e.g., the species, size, age, water temperature, etc.; however, for the purposes of this demonstration, the generalization is made that the species in question swim at speeds within this range.

Based on the slower swim speed (2 cm/sec), any fish within a 1.7 km (1.1 mi) radius might reach the intake by swimming directly toward

TABLE VI-1

CHARACTERISTICS OF THE WATER BODY SEGMENT

WATER BODY SEGMENT		
Distance to offshore boundary	3.5 km	(2.2 mi)
Depth at offshore boundary	30 m	(98.4 ft)
Distance along shore	13 km	(8.1 mi)
Surface area	45.5 km^2	(17.8 mi^2)
Volume within bounds	6.7×10^8 m^3	(2.4×10^{10} ft^3)
Cross sectional area	5.1×10^4 m^2	(5.5×10^5 ft^2)

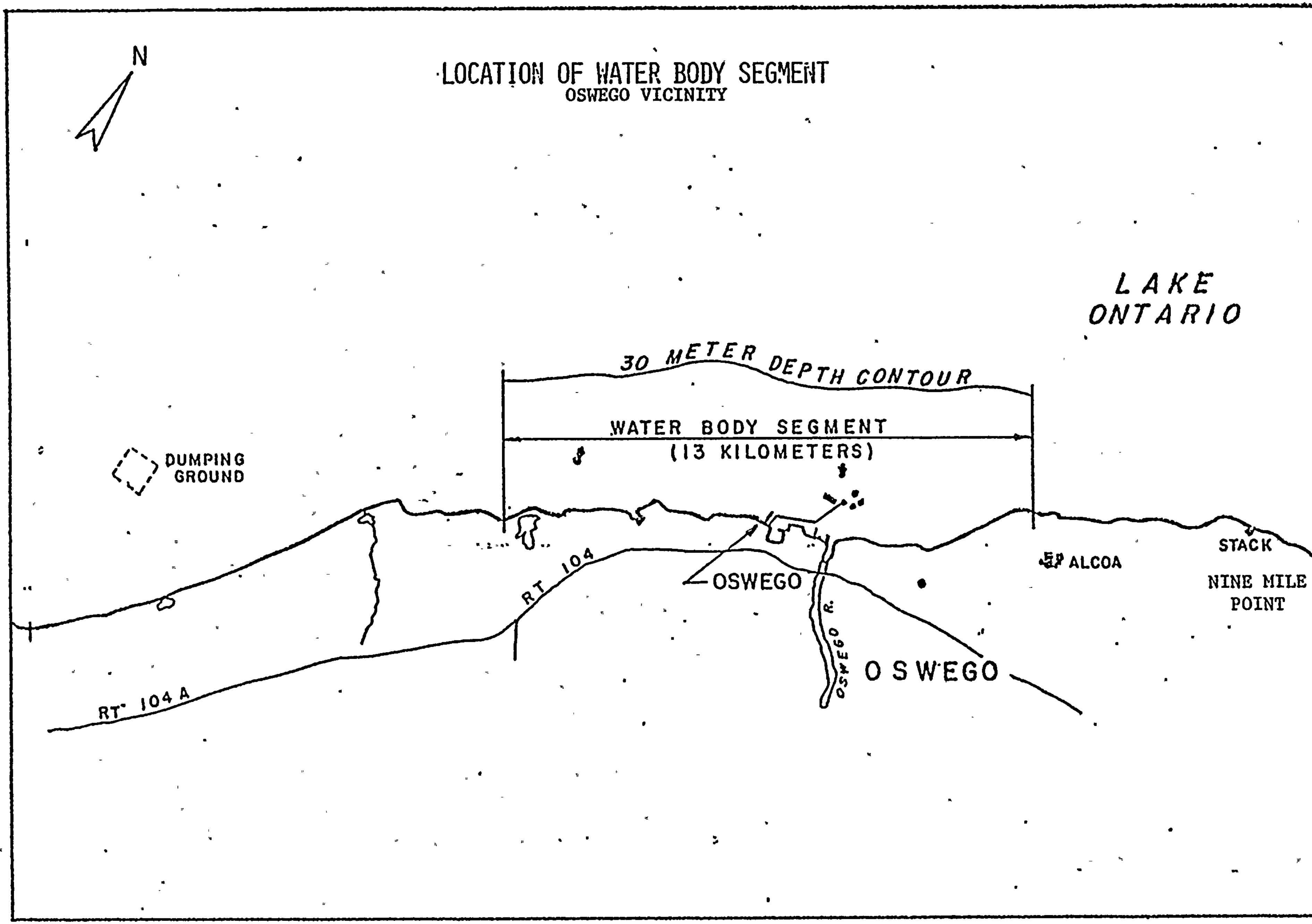
LOCATION OF WATER BODY SEGMENT
OSWEGO VICINITY
N
LAKE ONTARIO
30 METER DEPTH CONTOUR
WATER BODY SEGMENT
(13 KILOMETERS)
DUMPING GROUND
RT 104
RT 104 A
OSWEGO
OSWEGO R.
OSWEGO
ALCOA
STACK
NINE MILE POINT

FIGURE VI-1

it for 24 hrs or less. Those further than 1.7 km would not be able to reach the intake in 24 hrs. Although longshore currents favor fish swimming downstream, the frequency of eastern and western longshore currents is approximately equal (Figure III-2), and this effect will cancel out. The semicircle (r = 1.7 km) emcompassing the fish population potentially subject to impingement for one day falls within the water body segment whose offshore boundary is 3.5 km from shore and which extends 6.5 km to the east and west of the intake. A semicircle having a radius of 2.6 km (1.6 mi) would encompass fish populations subject to impingement if they maintained constant swimming speeds for a day and a half (36 hrs), the period of stable current patterns.

Based on the faster swim speed (12 cm/sec), the area in which a fish may potentially swim to the intake in 24 hrs or less is a semicircle with a radius of 10.4 km (6.5 mi) extending into the lake. This is probably the maximum potentially affected population since few, if any, fish will be expected to swim at this speed for one day directly to the intake. This larger radius completely encompasses the previously described water body segment. The area encompassing the fish populations potentially subject to impingement at the 12 cm/sec swim speed for 36 hrs has a radius of 15.6 km (9.7 mi).

The rectangular water body segment which encompasses the smaller estimate of the potentially affected population but is itself encompassed by the larger arc is a reasonable estimate of the area of potentially impacted fish populations. In addition, the water body segment is a reasonable area for assessing impact on planktonic populations. Therefore, any community effects of impingement and entrainment may be expected to occur within that water segment, which is, then, used in estimating impact.

C. ESTIMATION OF IMPACT

1. Estimation of Impact on Plankton

Plankton includes suspended animals and plants (zooplankton and phytoplankton), fish larvae (ichthyoplankton), and organisms temporarily suspended or suspended only during part of the life cycle (meroplankton and tychoplankton). Intensive sampling programs carried out for Niagara Mohawk in the Oswego area indicated that, in both 1973 and 1974, no persistent, discernible patterns in phytoplankton abundance were evident between the 20 and 40 ft depth contours (LMS, 1974, 1976a). In a nearby area sampled for Niagara Mohawk by LMS in 1975, the same lack of persistent, discernible patterns of phytoplankton abundance was found between the 20 and 60 ft depth contours (LMS, 1976b). Although there is no clear pattern of distribution for many zooplankters, many others have discernible patterns and will be considered separately. For

organisms such as phytoplankton, the average concentration within the water body segment will be assumed to be homogeneous. The impact of the intake will be calculated in two ways: (1) the total number of organisms removed by the intake divided by the total number determined to be in the water body segment and (2) the cumulative cropping over the 36-hr period during which along-shore drift of planktonic organisms would be persistent. Method (1) leads to the following formula:

$$\text{Impact (1)} = \frac{\text{Number of Organisms Entrained}}{\text{Number of Organisms Available}} =$$

$$\frac{\text{Number of Entrained Plankton/m}^3 \times \text{Intake Flow (m}^3\text{/day)}}{\text{Number of Lake Plankton/m}^3 \times \text{Segment Volume (m}^3\text{)}}$$

while Method (2) leads to the formula:

$$\text{Impact (2)} = \int_0^{1.5\text{ days}} \frac{\text{Number of Entrained Plankton/m}^3 \times \text{Intake Flow (m}^3\text{/day)}}{\text{Number of Lake Plankton/m}^3 \times \text{Segment Volume (m}^3\text{)}}\, dt$$

If the concentration of organisms (number/m^3) is assumed to be equal in the entrained flow and in the lake, and constant over each 1.5-day interval, then these two impact formulas reduce to:

$$\text{Impact (1)} = \frac{\text{Intake Flow}}{\text{Segment Volume}} \times 100 = (\%/\text{day})$$

and

$$\text{Impact (2)} = \frac{\text{Intake Flow} \times 1.5\text{ days}}{\text{Segment Volume}} \times 100 = (\%)$$

Application of analysis of variance to 1974 data indicates that for most species densities in the intake and the lake were not significantly different, a finding which supports this approach. Organisms withdrawn by the intake are not returned to the lake directly and will all be considered "impacted," although all will probably not be destroyed.

The contiguous water body segment previously described represents hydrographic conditions occurring approximately 90% of the time and has a volume of 6.7×10^8 m^3 (Table VI-1). The maximum flow through Units 1-4 with all circulating water pumps operating continuously is 21.6 m^3/sec. The maximum possible impact due to plant operation on the contiguous water body segment estimated by Method (1) is then 0.30% per day. This is interpreted to indicate that a maximum of 0.30% of the organisms contained in the defined water body segment are actually affected by the intake on a daily basis. This impact is lowered by water recirculation due to tempering (up to 20%) which reduces the intake flow rate, primarily during the winter months, and by the difference between actual plant flow and the maximal plant flow (a reduction of approximately 33% averaged over one year).

Between the periods of steady alongshore currents described above there are interludes of natural flushing when the water mass is replaced by offshore waters and, to some extent, nearshore populations may be exchanged with offshore ones. During these periods of overturning water masses the contiguous water mass segment concept breaks down.

Extrapolation of the calculated daily cropping to a continuous process is therefore defined by the persistence of flow in the segment for the duration of 1.5 days (36 hrs)(Method 2). During the period when a given planktonic population is present in the water body segment and exposed to the intake due to current patterns, the impact is estimated to be 0.44%.

2. Estimation of Impact on Fish Populations

As stated earlier, the selected water body segment may be considered a reasonable area in which to assess impact upon fish populations. Density estimates for fish populations in the water body segment are presented for both gill net and trawl collections.

a. Estimated Nekton Impact Based on Gill Net Data

Catches from gill nets set in the vicinity of Oswego in 1974 are used to estimate fish concentrations in the water body segment. It is assumed that gill net data are representative for six of the nine species of concern: alewives, rainbow smelt, spottail shiners, white perch, yellow perch, and smallmouth bass. Gill nets did not effectively catch threespine stickleback, coho salmon, or brown trout. Threespine stickleback populations were calculated from other data as described later in this section. Very few coho salmon or brown trout were collected in the field sampling programs and, therefore, no reliable estimates of concentrations for these species are available.

Gill net data are recorded as catch per twelve hour effort. The area of each gill net (11.2 m^2, 120 ft^2) and the sample period (12 hrs) are known; however, because fish are swimmers, they are not generally carried through the net by the ambient current. It is therefore necessary to use estimated swim speeds and to treat this as a flow through the net, that is, the catch is related to the swim speed as water flow is related to velocity. Two swim speeds, 2 cm/sec (0.07 fps) and 12 cm/sec (0.39 fps), discussed under Section VI-B-2, were used to obtain relative abundance estimates for the water body segment. For use in the discussion, the lake concentrations were calculated using a 2 cm/sec swim speed for six selected important species since the lower speed is believed to reflect more accurately the long-term movement patterns of fish.

Because threespine stickleback were not caught in gill nets, the swim speed approach described above was not possible for this species. Instead, trawl data from the adjacent Nine Mile Point study area are used to estimate impact on this species. The calculated concentrations of coho salmon and brown trout (Table VI-2a) are zero and near zero due to the small numbers collected in the field studies. New York State is currently stocking these species, although their capacity for self-propagation in Lake Ontario is doubtful and not documented. Because no concentrations are available for these species, recent annual stocking data serve, in the absence of population estimates, as a basis for comparison with the plant impact. In 1974 the state stocked 42,000 brown trout and 500,000 coho salmon in Lake Ontario. During 1974 there were no brown trout or coho salmon collected from the Oswego Units 1-4 travelling screens. Therefore the cropping estimate would be zero.

The concentration of fish in intake collections is calculated for Oswego Units 1-4 as the number of organisms of a selected species impinged during a 1974 sampling period divided by the volume of water that passed through the plant during that period. The daily concentrations were averaged and are presented for each month (Table VI-2b). The magnitude of impingement is the product of flow and concentration.

The fish concentrations shown in Table VI-2a are based on those gill net collections made within 24 hours of an impingement collection. Similarly, the impingement fish concentrations are only based on the data obtained when gill net collections were available within 24 hours of the impingement sample. Even after taking this precaution, the collections are not precisely comparable because of the schooling tendency of alewife and smelt, and as

TABLE VI-2

MEAN MONTHLY ABUNDANCE* OF FISH SPECIES

OSWEGO STEAM STATION UNITS 1-4 AND VICINITY - 1974

I. WATER BODY SEGMENT

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Alewife	NS	NS	NS	1.53	2.22	2.78	2.52	0.32	0.19	0.01	NS	NS
Rainbow smelt	NS	NS	NS	0.51	0.01	<0.01	0.0	0.0	<0.01	<0.01	NS	NS
Spottail shiner	NS	NS	NS	0.00	<0.01	0.01	<0.01	0.01	<0.01	<0.01	NS	NS
White perch	NS	NS	NS	0.04	0.02	0.05	0.02	0.03	0.02	0.01	NS	NS
Yellow perch	NS	NS	NS	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01	NS	NS
Smallmouth bass	NS	NS	NS	<0.01	<0.01	<0.01	0.0	<0.01	<0.01	0.0	NS	NS
Coho salmon	NS	NS	NS	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	NS	NS
Brown trout	NS	NS	NS	<0.01	0.0	<0.01	0.0	0.0	<0.01	0.0	NS	NS

Assumed swim speed of fish in the lake = 2 cm/sec

II. INTAKE OF OSWEGO STEAM STATION UNITS 1-4

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Alewife	<0.01	<0.01	<0.01	9.57	10.38	5.41	1.91	0.90	0.37	0.19	0.40	0.10
Rainbow smelt	0.02	0.05	0.14	0.61	0.67	0.04	<0.01	0.0	<0.01	<0.01	0.01	0.08
Spottail shiner	<0.01	<0.01	<0.01	<0.01	0.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.0
Threespine stickleback	0.0	<0.01	<0.01	<0.01	0.0	0.01	<0.01	0.0	<0.01	0.0	0.0	0.0
White perch	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.0
Yellow perch	<0.01	<0.01	<0.01	0.0	0.0	0.01	0.0	<0.01	<0.01	0.0	0.0	0.0
Smallmouth bass	<0.01	<0.01	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0
Coho salmon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brown trout	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01

*No.of fish/1000 m^3
NS = No sample

a consequence large variances in the data sets occur. To smooth out high impingement and high gill net collections, seasonal cropping factors are calculated for spring and summer. The fall gill net collections included fewer fish, perhaps as a result of slower swim speeds due to cooler water temperatures in the fall. Table VI-3 summarizes the calculated impingement cropping for each species for Oswego Units 1-4 in the water body segment. These calculations do not assess compensatory responses to cropping or the natural die-off rate which would mitigate any possible long-term impact.

The alewife has been the subject of intensive studies yet the behavior of this fish remains largely unpredictable. The in-plant impingement collections do indicate, however, that the impingement rate in spring is frequently characterized by a specific period of extremely high alewife concentration during a brief time interval. The concentrations reported in Table VI-2b include high values during the spring months of April, May, and June. The continuous cropping due to Oswego Units 1-4 during this period is predicted to be 3.23%. The predicted summer cropping estimate drops to 0.46% for Units 1-4.

Rainbow smelt migratory patterns are similar to those of the alewife, resulting in abrupt variations in concentration in the primary study area. The estimated spring cropping of rainbow smelt by Oswego Units 1-4 is 2.05% and the summer cropping ratio is again much smaller, 0.29%. The spottail shiner is a resident of the nearshore area, where it is present throughout the sampling period but in low concentrations relative to alewife and rainbow smelt. The impingement cropping rate due to Oswego Units 1-4 is minimal, and is estimated at 0.08% in the spring and 0.41% in the summer.

White perch were present in the primary study area throughout the 1974 sampling period. The predicted impact of cropping on the white perch population as a result of impingement at Oswego Units 1-4 is 0.05% in the spring and 0.10% in the summer. Yellow perch were also present in gill net collections throughout the period, exhibiting similar abundance during all months. The spring cropping estimate of yellow perch, however, is calculated to be 0.52% compared to a summer predicted cropping of 0.11%.

In summary, for nekton population concentrations in the water body segment estimated by gill nets, two species - alewife and rainbow smelt - are predicted to be the most heavily impacted of all the major fish species (3.23 and 2.05%, respectively)

TABLE VI-3

SEASONAL CROPPING ESTIMATES FOR IMPINGEMENT*

OSWEGO STEAM STATION UNITS 1-4 - 1974

SPECIES	PERCENT CROPPING	
	SPRING	SUMMER
Alewife	3.23	0.46
Rainbow smelt	2.05	0.29
Spottail shiner	0.08	0.41
White perch	0.05	0.10
Yellow perch	0.52	0.11
Smallmouth bass	0.00	0.00

*Based on gill net population estimates

by operation of Oswego Units 1-4. Peak impact is determined to occur during the spring as a result of spawning migrations to the nearshore area by adults of both species. By comparison, no other species is cropped by more than 0.52% in any season. The assumption of passive fish entrainment into the intake as computed for plankton organisms would produce an impact prediction of 0.3% cropping in the water body segment. The calculated impacts infer that some fish successfully avoid the intake structure while others are attracted. An alternative explantation is that the alewife and rainbow smelt concentrations during the spring are underestimated by the gill net sampling methodology (12-hr sets) or schedule (twice-monthly), resulting in overestimation of impingement impact. An alternate estimation procedure based on trawl data is provided below.

b. Estimated Impact Based on Trawl Data

In estimations of plant operational impact, population estimates based on trawl collections have the advantage of being calculated on known volumes of water sampled. Passive collection techniques such as gill nets have been found to be very selective, and do not obtain representative samples of the total population; on the other hand, active methods such as trawls are generally less selective and therefore more efficient (Weber, 1973). It is noteworthy that the gill net collections in the Oswego study area are highly representative of the dominant populations collected from the Oswego Units 1-4 travelling screens. However, impact assessment based on trawl data presented below, are lower than estimates calculated from gill net data.

Fish population densities can be estimated from trawl data when the calculated volume of water filtered by the net is combined with estimated trawl fishing efficiency. Trawl data used in the water body population estimates are taken from the more complete trawling program conducted during 1975 by LMS for Niagara Mohawk Power Corporation at Nine Mile Point since this will provide the strongest data base (LMS, 1976b). Previous studies by LMS at both Oswego and Nine Mile Point sites indicate that nektonic communities are similar in composition and abundance. The Nine Mile Point trawling program for 1975 is summarized in Table VI-4.

In order to determine the volume filtered by a trawl, the speed, duration, and mouth opening of the trawl must be quantified. Quality control studies on LMS trawls conducted in Lake Ontario

TABLE VI-4

TRAWL SAMPLING PROGRAM

NINE MILE POINT VICINITY - 1975

DATE	NUMBER OF SAMPLES COLLECTED	TRANSECTS[a]	CONTOUR DEPTHS[b]	SAMPLE DEPTHS[c]	PHOTOPERIODS[d]
15 APR	18	X	X	X	X
24, 26	18	X	X	X	X
6 MAY	18	X	X	X	X
20	18	X	X	X	X
3 JUN	18	X	X	X	X
17	18	X	X	X	X
1 JUL	18	X	X	X	X
15	18	X	X	X	X
5, 7 AUG	18	X	X	X	X
20	18	X	X	X	X
2, 3 SEP	18	X	X	X	X
16	18	X	X	X	X
7-8 OCT	18	X	X	X	X
23-24	18	X	X	X	X
12, 18 NOV	18	X	X	X	X
23, 24	18	X	X	X	X
8 DEC	18	X	X	X	X

[a] Transects: NMPW, NMPP/FITZ, and NMPE
[b] Contour depths: 20, 40, and 60 ft
[c] Sample depths: Surface and bottom
[d] Photoperiods: Day and night

report a range of trawl speeds under various weather conditions of 0.76 to 1.05 m/sec (2.5-3.4 fps) with a mean of 0.10 m/sec (3.08 fps). Trawls are always conducted for as close to 15 minutes as possible; the water segment trawled has a calculated length of 844 m (2,770 ft).

The area of the trawl mouth has been estimated from underwater photographs of the trawl used in both the Nine Mile Point and Oswego area studies. While fishing, the height of the mouth opening is approximately 0.46 m (1.5 ft) and the effective fishing width is approximately 4.6 to 4.9 m (15 to 16 ft). The area sampled by the trawl is estimated to be about 2.14 m^2 (23 ft^2); the volume filtered is 1,806 m^3 (6.4×10^4 ft^3) for the 15-min trawl period.

Trawls will not catch all fish within the volume filtered. For example, studies on the species Lagodon rhomboides, the pinfish, and Leiostomus xanthurus, the spot, indicate that trawl abundance estimates were only 9 to 51% of the true values (Kjelson and Colby, 1975 and in press). Three estimates of fish population densities in the water body segment based on Nine Mile Point trawl data will be made: one using a trawl efficiency of 100%, and two other using trawl efficiencies of 10 and 50% respectively, to reflect the trawl efficiency values of Kjelson and Colby. Population densities for the dominant species were calculated by converting the average number collected per 15-min trawl effort to number per volume filtered, and then considering the selected trawl efficiency, relating this to the volume of the water body segment. Cropping estimates are given in Table VI-5 for each estimated population within waterbody segments.

Four species of fish compose 95% of all individuals impinged at Oswego Units 1-4: alewife, rainbow smelt, gizzard shad and threespine stickleback; these four species are also well represented based on trawl data in the study area. Estimates of impingement cropping on these four species will be made for the period between 14 April and 15 November 1975, the same period over which population estimates can be made from the trawling program. This time period includes the peaks in abundance for alewife, rainbow smelt, and threespine stickleback in the Oswego area. Because these four species are susceptible to both capture by trawl and impingement, they should yield reasonable estimates of cropping in general. On a daily basis, estimates of the percent cropping by impingement range from 0.228 to 0.017%, assuming a trawl efficiency of 100%, to the minimum range of 0.023 to 0.002% for a population density based on 10% trawl efficiency (Table VI-5). The daily cropping of

TABLE VI-5

ESTIMATION OF IMPINGEMENT CROPPING
OF FOUR SELECTED FISH SPECIES

OSWEGO STEAM STATION UNITS 1-4 - 1975

SELECTED DOMINANT SPECIES	TRAWL COLLECTION DATA[a]		IMPINGEMENT COLLECTION DATA		POPULATION ESTIMATED AT THREE TRAWL EFFICIENCIES			PERCENT CROPPING PER DAY AT THREE EFFICIENCIES		
	TOTAL COLLECTED	AVERAGE NUMBER PER EFFORT[b]	ESTIMATED NUMBER COLLECTED	AVERAGE NUMBER PER DAY	10%	50%	100%	10%	50%	100%
ALEWIFE	3665	5.9890	10498	1312.3	2.25×10^7	1.12×10^7	5.60×10^6	0.002	0.012	0.023
GIZZARD SHAD	21	0.0343	588	73.5	1.29×10^5	6.43×10^4	3.22×10^4	0.023	0.114	0.228
RAINBOW SMELT	233	0.3807	477	59.6	1.43×10^6	7.14×10^5	3.57×10^5	0.002	0.009	0.017
THREESPINE STICKLEBACK	94	0.1536	203	25.4	5.76×10^5	2.88×10^5	1.44×10^5	0.002	0.009	0.018

[a] LMS, 1976

[b] Number per 15 minute

the four major species impinged is therefore considered to be very small in comparison with the impingeable population of these fish.

In general, increasing the amount of time for the estimate of impact will decrease the estimate of impact up to the point where the limit of the impingeable population is reached; this is due to the nature of the calculations. The cumulative impingement (I) for a time period (t) increases linearly with time in the simplest approximation, or I = kt, where k is the rate of impingement. The impingeable population (IP) is the concentration of fish (c) multiplied by the water body segment volume; the water body segment volume (V) is given by:

$$V = \pi r^2 \bar{d}$$

where $\bar{d}$ is the mean water body segment depth and r is the radius from the intake. For an assumed swim speed (v_s) the radius of the segment is:

$$r = v_s t$$

Thus:

$$V = \pi \bar{d}\, v_s^2 t^2$$

and the impact is:

$$\frac{I}{IP} = \frac{kt}{c\pi \bar{d}\, v_s^2\, t^2} = \frac{k}{c\pi \bar{d}\, v_s^2\, t^2}$$

For any values of k, c, $\bar{d}$, and v^S the estimate of the impingeable population will therefore increase as the square of time, while the estimate of impingement will increase only linearly. Therefore the cropping impact, I/IP, decreases with the time period considered (t).

From this it may be concluded that the calculated estimates of impingement impact (or percent cropping) are reasonable and conservative (i.e., maximum) estimates of short-term, near-field effects. Furthermore, data are lacking to make reasonable long-term or far-field estimates; however, if the above methods are applied, the impact of plant operation will decrease with time.

For three species - alewife, rainbow smelt, and threespine stickleback - estimations of cropping are close (alewife being twice either

of the other two). The estimates for gizzard shad are much higher, probably due to higher concentrations of impingeable populations in the Oswego primary study area than in the vicinity of Nine Mile Point as indicated by trawl collections. The accompanying 316(a) demonstration points to a large population of gizzard shad residing in the Oswego Turning Basin during the winter months.

c. Discussion of the Two Population Estimation Technique

A discussion of the two population estimation techniques employed to determine the plant operational impact of Oswego Units 1-4 must include comments addressing natural fluctuations in abiotic and biotic parameters and gear efficiency.

The two water body segment population estimates were calculated for two separate years, a time span over which natural changes in environmental conditions could have altered the structure of the aquatic community. Although there is no direct evidence of a change in the vicinity of the Oswego plant between the two years, the observed reduction in impingement in 1975 compared to 1974 indirectly suggests variability in community structure (Chapter IV-C). In addition, the use of collection data from the Nine Mile Point area, although the communities have been found to be structurally similar, could bias the estimates and affect the comparisons. Gear efficiency could also contribute to significant variability in estimates of community composition. In general, the use of an otter trawl (an active fishing technique) in the one estimate should be more efficient than the experimental gill nets in estimating nekton populations (Weber, 1973). However, because of the irregular bottom in the southeastern section of Lake Ontario it is difficult to conduct quantitive bottom trawls. The fact that gill nets are more selective for the dominant fish populations because of their schooling or mass migratory behavior may also contribute to differences in estimates of community structure.

Percent cropping values were obtained for alewife and rainbow smelt over a comparable period of time (April-October, 1974; April-November, 1975) for the two years which were used to estimate population abundance in the water body segment. The 1975 cropping estimate, based on a 100% trawl efficiency level, are 0.023 and 0.017% for the alewife and rainbow smelt, respectively (Table VI-5); the corresponding 1974 cropping estimates are 2.36 and 1.95%. Both methods, gill nets and trawls, exhibit inherent liabilities in estimating the nekton standing stock in the designated water body segment; however, both yield cropping estimates that indicate minimal impact on the nekton community through operation of Oswego Units 1-4.

3. Estimation of Impact on Fish Eggs

The distribution of fish eggs, unlike the pattern assumed earlier for ichthyoplankton, is not homogeneous through the water body segment because of the selective spawning behavior of adults, and morphological adaptions of the eggs. For example, rainbow smelt adults prefer to spawn in streams and smelt eggs are attached to the substrate by a short pedicel (Scott and Crossman, 1973). Large numbers of alewife eggs have been observed in the dense mats of Cladophora growing along the shore of Lake Ontario primarily because of the demersal adhesive qualities of the eggs (LMS, 1975a; LOTEL, 1975). Because the eggs are not homogeneously distributed and morphological adaptions preclude making a realistic estimate of abundance in the primary study area based on plankton net collections, an alternative method based on the estimated number of spawning females from 1974 gill net collections was used.

Estimates of percent cropping of fish eggs were calculated for June-August 1974, a period corresponding to peak spawning in the Oswego vicinity. Several assumptions were made as a basis for estimating the standing crop of fish eggs in the water body segment:

a. It was assumed that all eggs entrained by Oswego Steam Station Units 1-4 as well as those present in the lake were alewife. Other species which may spawn during this period include johnny darters and centrarchids (e.g., smallmouth bass, pumpkinseed). However, because these species are littoral, nest-building, territorial species (Scott and Crossman, 1973), it was assumed that their eggs would not be subject to entrainment. Observations of fish eggs entrained by Oswego Units 1-4 confirm that alewife eggs are dominant (LMS, 1975a; 1976a).

b. The standing crop of alewives was calculated from data collected during 1974 in the Oswego vicinity (Table VI-2a); sex ratio was taken from data collected at Nine Mile Point during 1974 (LMS, 1975b) and the standing crop of females in the water body segment was estimated from these data.

c. It was assumed that each female shed all of its eggs during spawning.

The number of eggs entrained by Oswego Units 1-4 was calculated based on volume of water withdrawn from the water body segment, and this was compared to the estimated number of eggs spawned by the female alewife population.

The results of these calculations (Table VI-6) suggest that entrainment by Oswego Steam Station Units 1-4 has minimal impact on the (alewife)

TABLE VI-6

ESTIMATED PERCENT CROPPING OF FISH EGGS IN WATER BODY SEGMENT

OSWEGO STEAM STATION UNITS 1-4 - 1974

MONTH	ALEWIFE DENSITY ($No./m^3$)[a]	ESTIMATED STANDING CROP WATER BODY SEGMENT I[b]	PERCENT FEMALES[c]	ESTIMATED STANDING CROP OF FEMALES	ESTIMATED RANGE OF STANDING CROP OF FISH EGGS[d]
JUN	2.7773×10^{-3}	1.8608×10^{6}	83%	1.5445×10^{6}	$4.0157 \times 10^{10} - 10.5030 \times 10^{10}$
JUL	2.5241×10^{-3}	1.6911×10^{6}	72%	1.2176×10^{6}	$3.1658 \times 10^{10} - 8.2797 \times 10^{10}$
AUG	0.3151×10^{-3}	0.2111×10^{6}	76%	0.1604×10^{6}	$0.4172 \times 10^{10} - 1.0911 \times 10^{10}$

DATE	FLOW (m^3)[e]	MEAN DENSITY OF ENTRAINED FISH EGGS ($No./m^3$)	ESTIMATED NO. OF EGGS ENTRAINED	MONTHLY MEAN OF EGGS ENTRAINED	RANGE OF ESTIMATED PERCENT CROPPING[f]	NO. OF FEMALES ACCOUNTED FOR BY CROPPING[g]
24 JUN	1793265.15	0.776	1.3916×10^{6}	1.3916×10^{6}	0.0035 - 0.0013%	53.5-20.5
8 JUL	1800223.48	1.755	3.1594×10^{6}	1.6591×10^{6}	0.0052 - 0.002%	63.8-24.4
22 JUL	1351015.15	0.118	1.5874×10^{5}			
5 AUG	1350079.54	0.402	5.4340×10^{5}	5.4340×10^{5}	0.013 - 0.005%	20.9- 8.0
19 AUG[h]	1346337.12	0.000				

[a]Based on 1974 gill net data

[b]Volume of WBS = $6.7 \times 10^{8}\ m^3$

[c]Based on LMS, 1975a

[d]Assumed 26,000-68,000 egg/female (LMS, 1975a)

[e]264 gal = m^3

[f] $\frac{\text{Estimated Range Eggs Entrained}}{\text{Monthly Mean of Eggs Standing Crop}} \times 100$

[g] $\frac{\text{Mean No. of Eggs Entrained}}{\text{Range of Estimated Eggs/Female: 26,000-68,000}}$

egg standing crop during the period June-August. To facilitate interpretation of the absolute numbers of eggs entrained, the number of females these eggs would represent was also calculated (Table VI-6) assuming a fecundity of 26,000-68,000 eggs per female. The spawn of 64 female alewives was equivalent to the greatest estimate of egg entrainment, this occurring during the month of July.

D. CONCLUSIONS

Plant operational impact upon passive planktonic organisms and fish eggs through entrainment, and on the dominant nekton populations through impingement on the travelling screens, was estimated for Oswego Steam Station Units 1-4. Estimates were calculated for an identified water body segment that represented a near-field area where possible plant operational impact might be evidenced. The water body segment represented a continuous, definable water mass which was persistent for a period of at least 36 hrs over 90% of the time.

The populations of passive planktonic organisms including phytoplankton, zooplankton, and ichthyoplankton were assumed to be homogeneously distributed in the water body segment. Conservative estimates of plant impact (assuming all organisms entrained were eliminated from the aquatic community) ranged from 0.30% on a daily basis to a continuous estimate based on the persistence of community structure in the water body segment of 0.44%. Plant impact on fish eggs determined for estimated numbers of eggs spawned in the water body segment was found to be very low; the estimated number entrained during the spawning season is equivalent to the total fecundity of 64 female alewife.

Two separate methods were employed to determine the standing stock of the dominant fish species including the alewife, rainbow smelt, spottail shiner, threespine stickleback, white perch, and gizzard shad in the water body segment. Estimates of impingement cropping were based on a comparison of the impingement abundance to the estimated number available to impingement. Plant operational impact based on gill net estimates of available populations for 1974 yielded cropping values ranging to 3.23% for the alewife during the spring. The rainbow smelt, like the alewife, had a higher cropping factor (2.05%) during the spring compared to other seasons. Maximum estimated cropping of other major populations did not exceed 0.52%. Trawl population estimates based on data collected in the vicinity of Nine Mile Point during 1975 yielded cropping estimates ranging from 0.002 to 0.228%.

Natural variability in environmental parameters and its effect on community structure between years and between sampling areas, in addition to differences in the efficiency of sampling gear used in

estimating population abundances, suggests non-comparability of impact estimates; however, both techniques yield minimal impact estimates of Oswego Units 1-4 on the Lake Ontario nekton populations.

Cropping rate estimates are made on the basis of the defined water segment. Home ranges for many species, such as alewives, are probably much larger than this, resulting in lower estimations of impact.

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APPENDIX A: MATERIALS AND METHODS:
OSWEGO STEAM STATION UNITS 1-4 BIOLOGICAL SURVEY

Sampling to evaluate impingement of nektonic populations on the fixed and travelling screens at the cooling water intake of Oswego Steam Station Units 1-4 commenced during 1972 and has continued through the spring of 1976. Planktonic organisms entrained in the cooling water were initially studied in 1973 on a seasonally varying schedule. Sampling program development and a description of sampling methods and laboratory procedures associated with each program are discussed in this appendix. A diagram of the Oswego Units 1-4 intake structure showing sampling locations is presented in Figure A-1. Sampling locations in the primary study area are presented in Figures A-2 and A-3.

1. Entrainment

a. Phytoplankton

Whole water samples for phytoplankton identification, abundance, and biomass determinations were collected at the intake bay of Oswego Steam Station Units 1-4. A Dayton pump with a pumping capacity of 25 l/min (6.5 g/min) was used to collect 20-liter replicate samples; these were then composited from the mid-water depth on a monthly schedule corresponding to the sampling schedule maintained for phytoplankton in the Oswego Turning Basin. From the homogeneously mixed composite sample two subsamples were taken; one sample of 350 ml was preserved with 3.5 ml Lugol's solution for species identification, and the second was a one-liter sample secured in a black plastic bag and transported to the laboratory in an ice bath in preparation for pigment analysis.

In the laboratory, two 10-50 ml aliquots, depending on sample density of the preserved samples, were sedimented for a minimum of 24 hrs and then examined using an inverted microscope (Utermohl, 1958). Total phytoplankton were enumerated under 300 and 600 magnifications in one or two strips across the sedimentation chamber; at least 300 individuals were counted for each sample examined (Lund et al., 1958). Samples were evaluated for species identification, abundance, and biomass with the enumeration results expressed as cells/ml. Biomass values, or fresh weight in mg/m^3 (assuming the specific gravity of phytoplankton to be 1.0), were computed from average cell dimensions by approximation to a geometric shape that most closely simulated the shape of the species. Biovolume determinations for each "common" species were made based on at least 20 measurements per species per sampling date. Measurements by sampling date accounted for temporal changes in cell sizes as a result of population dynamics.

SCHEMATIC DIAGRAM OF OSWEGO STEAM STATION UNITS 1-4

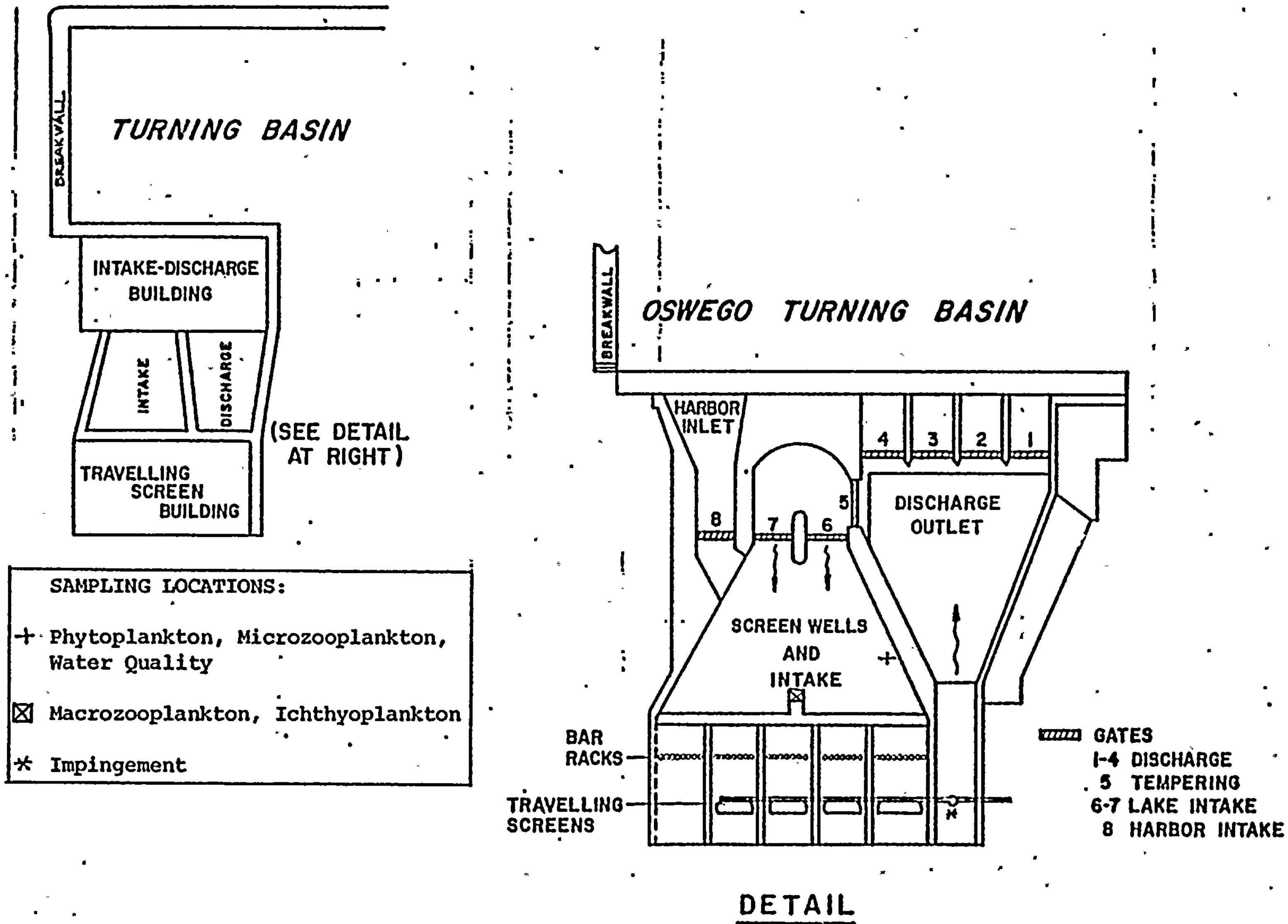

FIGURE A-1

PLANKTON SAMPLING STATIONS

OSWEGO VICINITY - 1974

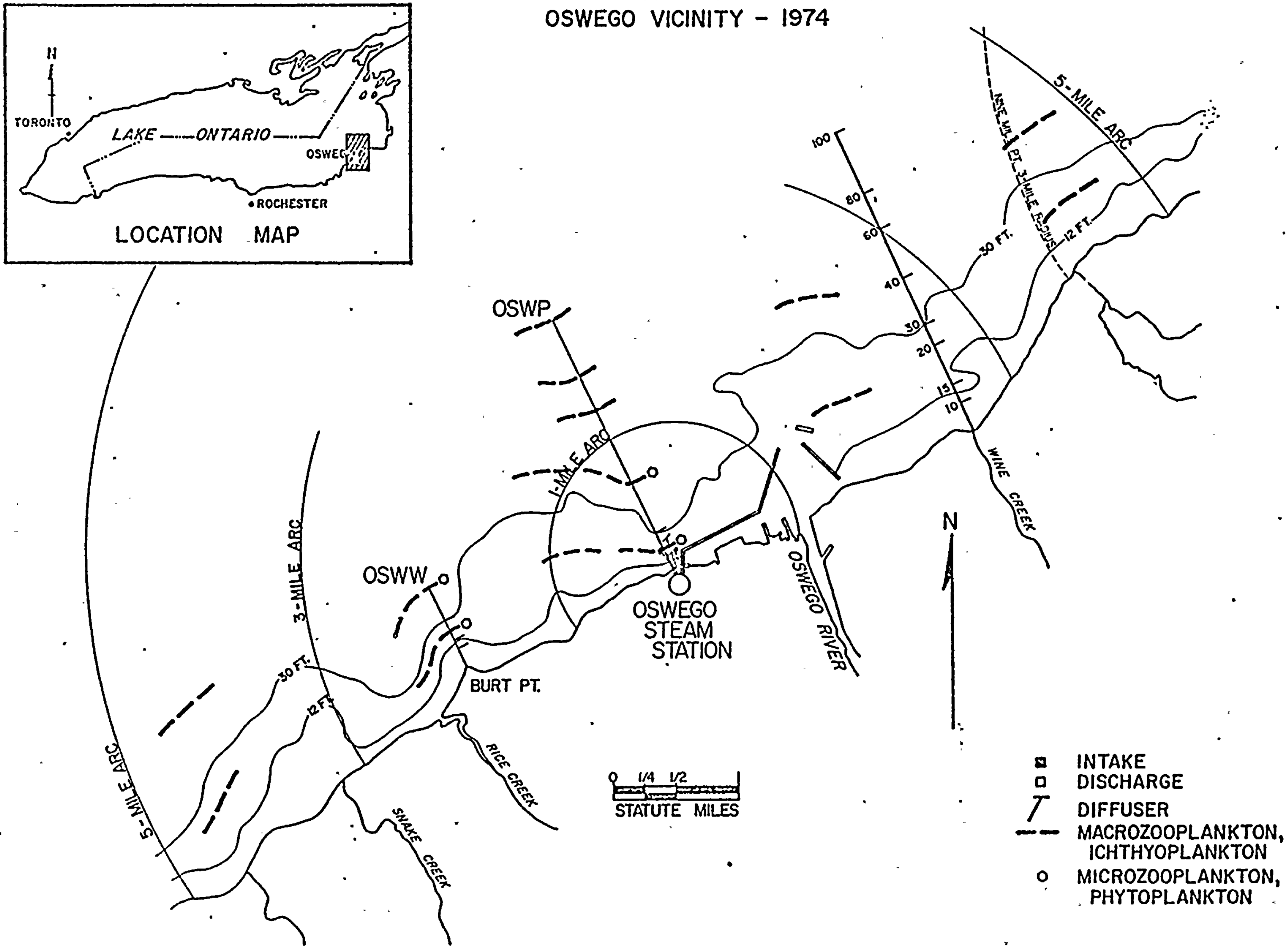

FIGURE A-2

FISH SAMPLING STATIONS
OSWEGO VICINITY - 1974

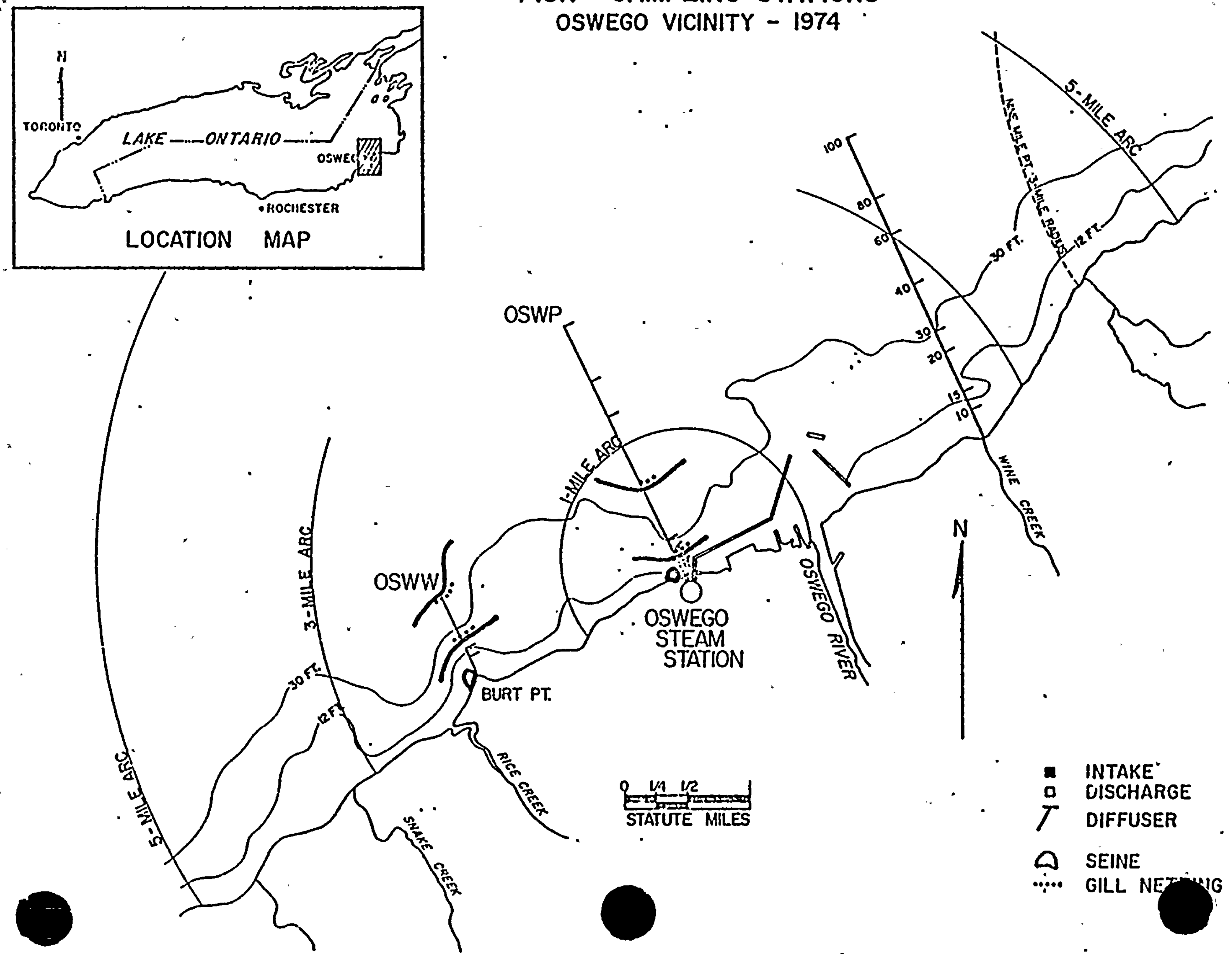

FIGURE A-3

Chlorophyll a and its photoreactive degradation product phaeophytin were measured spectrophotometrically using the method described by Golterman (1971). The results of the pigment analysis relate to the biomass of the planktonic community.

Primary productivity was estimated by the ^{14}C uptake method at the intake bay of Oswego Units 1-4, on the same schedule as work conducted in the turning basin. Inoculated samples collected from the mid-water depth in the intake were incubated in situ for four hrs at the 25% light transmittance level. Prior to the collection of the water sample, total incident radiation was measured with a hand-held Gossen light meter, and percent light transmittance was recorded by depth intervals in the intake as determined with a Whitney submarine photometer. Three bottles (two light, one dark) were filled with the sample water and inoculated with 1 ml of $NaH^{14}CO_3$ with a known activity of of 1 μCi/ml. Samples for the determination of total inorganic carbon (TIC) were taken from the same mid-depth water sample.

At the end of the incubation period, samples were placed in a dark box and returned to the laboratory where they were immediately filtered through membrane filters with a pore size of 0.45μ. After filtration, membranes were evaluated for radioactivity with a model SL30 Teledyne Intertechnique liquid scintillation counter. Productivity was expressed as grams carbon per cubic meter per hour (g C/m^3/hr).

b. Microzooplankton

Because of the low water velocity in the exposed intake area of Units 1-4, a pump was used to collect samples for microzooplankton analysis. Two hundred liters of water, measured in a calibrated plastic carboy, was pumped from the mid-water depth in the intake and filtered through a 76 μ mesh plankton net suspended in a bucket containing water to prevent net damage and loss of organisms. After filtration, the consolidated sample was preserved in buffered formalin to a 5% solution and transported to the laboratory. Samples of entrained microzooplankton were collected on a monthly schedule to correspond with the sampling program in the Oswego Turning Basin.

In the laboratory, intake samples were divided using a Folsom plankton splitter and each half analyzed as a replicate. Microinvertebrates were identified to the lowest possible taxonomic level with the aid of a phase contrast compound microscope and Sedgewick-Rafter counting chamber.

c. Macrozooplankton/Ichthyoplankton

Collections for the identification and enumeration of macroinvertebrates and fish eggs and larvae were conducted on a seasonally varying schedule in the intake of Oswego Units 1-4, corresponding to sampling efforts in the Oswego Turning Basin. During the months of April, May, October-December 1975 and January-March 1976, nocturnal samples only were collected on one date a month at 2300 and 0500 hrs. A twice-monthly diel sampling schedule was conducted during June-September 1975, with samples collected at 1100, 1700, 2300 and 0500 hrs.

Entrainment samples were collected with a 0.5-m Hensen plankton net lowered to a depth of 13 m (10 ft) in a frame located at the south center of the intake channel. Sample duration was 30 minutes, and flow through the net was monitored with a calibrated TSK flowmeter set off-center in the net's mouth. Samples were preserved in buffered formalin containing the vital stain Trypan Blue to a final concentration of 5% and tranported to the laboratory for further analyses.

At the laboratory fish eggs and larvae were separated, identified and enumerated. When more than 500 fish eggs were present in a sample, it was subsampled using a Folsom plankton splitter prior to identification; all fish larvae were identified. Length frequency and stage of development were analyzed for a maximum of 60 individuals per species selected at random from each sample.

Macrozooplankton were analyzed from all samples collected on the monthly schedule, and on one set of samples from the semi-monthly collections to approximate a 30-day period between sampling dates analyzed. All macroinvertebrates collected were identified to the taxonomic level of Order; selected populations, because of their community dominance or trophic level importance, were identified to the lowest taxonomic level possible. Selected species included the amphipods Gammarus fasciatus and Pontoporeia affinis, the freshwater polychaete Manayunkia speciosa, and the mysid Mysis oculata relicta. Organisms collected in the entrainment sampling were related to the volume of water sampled as numbers per 1000 cubic meters.

2. Impingement

Organisms impinged on the travelling screens at Oswego Units 1-4 were collected in a specially designed impingement basket placed in the common screen wash sluiceway. Impinged fish were collected

over a 24-hr period in alternate weeks*; once each four weeks the 24-hr collection was made in two 12-hr samples. At the initiation and termination of each sampling period, plant operating parameters, including number of circulating pumps and travelling screens operating, screen wash cycles, and plant generation data, were recorded. Hydrological data pertaining to water temperature and climatological information such as air temperature and wind direction were also noted at the time of impingement sampling. Fish impinged on the trash racks were also examined if the racks were cleaned at the time of scheduled travelling screen impingement collections.

Impinged organisms were identified and counted at the time of collection. If more than 60 individuals of a single species were collected during a sampling period they were subsampled using a random number table before the samples were returned to the laboratory for more detailed analyses. Fish were preserved in buffered formalin to a final concentration of 10%.

Laboratory analysis consisted of determining length, biomass, and sex of all individual fish up to 60 per species selected at random. Observations were made concerning the general condition of the fish, stages of gonadal development, presence of parasites, and possible fish tags. Gonad analysis to determine spawning readiness was conducted on a minimum of 25 males and 25 females of five selected species (alewife, rainbow smelt, white perch, yellow perch, and smallmouth bass) on a monthly schedule if they were collected during that time period. Scale analysis to determine age and growth was performed on the dominant species impinged by season. A minimum of 20 fish scales were evaluated per age class described by length frequency intervals of the two most dominant species per season.

Results of impingement sampling were related to hours of sampling and to volume of circulating cooling water actually sampled. Laboratory results permitted impinged populations to be compared to the lake nektonic community in the vicinity of the plant.

* Alternate week schedule included a 24-hr collection followed by a single 12-hr collection from 1 April through August 1975.

APPENDIX A

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