NIAGARA MOHAWK POWER CORPORATION

OSWEGO STEAM STATION UNITS 1-4

316(A) DEMONSTRATION SUBMISSION

NPDES PERMIT # NY 0002186

NIAGARA MOHAWK POWER CORPORATION

NIAGARA MOHAWK

300 ERIE BOULEVARD, WEST
SYRACUSE, N. Y. 13202

December 21, 1976

Gerald M. Hansler, P. E.
Regional Administrator
Region II
U. S. Environmental Protection Agency
26 Federal Plaza
New York, New York 10007

Re: Oswego Steam Station - Units 1-4
NPDES Permit No. NY0002186

Dear Mr. Hansler:

On June 28, 1974, Niagara Mohawk Power Corporation (Niagara Mohawk) requested, pursuant to Section 316(a) of the Federal Water Pollution Control Act (the Act), that the final NPDES permit for Oswego Steam Station Units 1-4 should include alternative thermal effluent limitations. The alternative limitations which Niagara Mohawk requests would allow discharge of heat from the main condenser into Lake Ontario such that the discharge temperature will not exceed 34.5°C (94°F), and the discharge-intake temperature difference will not exceed 7.8°C (14°F) during June-September, and 17.8°C (32°F) during October-May. No other temperature limitation should apply. A demonstration in support of that request was submitted to Region II on August 2, 1974. The major premises in support of that position were:

1. The cases in which the lake criteria have been observed to be exceeded are few, and are in part the result of Oswego River temperatures being higher than lake temperatures.

2. No adverse effects have been observed. Significant beneficial influences on sewage effluents, storm waters and harbor dredging can be demonstrated.

3. There are considerable structural design and construction problems associated with integration of the circulating water systems of the existing 30-year-old plant with the new Oswego Unit 5.

On February 24, 1975, Region II issued NPDES Permit NY0002186 for Units 1-4 which did not include the alternate limitation requested by Niagara Mohawk. The permit imposes after July 1, 1977, a limitation on the thermal component of the discharge such that the water temperature at the surface of the lake shall not be raised more than 3 Fahrenheit degrees over the temperature that existed before the addition of heat of artificial origin. Niagara Mohawk believes that the imposition of this limitation which necessitates an expensive modification to the cooling water discharge facility is ecologically unnecessary and economically burdensome.

Niagara Mohawk notes that neither the NPDES permit issued for Units 1-4 nor EPA's regulations require the submittal of Section 316(b) data at this time. However, in accordance with the request of the Regional staff, we have addressed the anticipated effect on Lake Ontario of impingement and entrainment of aquatic biota that results from the operation of Units 1-4 in a second document entitled, "Intake Considerations".

Niagara Mohawk believes that the attached Section 316(a) demonstration and the intake considerations document, together with other data already submitted, supports a decision that the requested alternate thermal effluent limitation for Units 1-4 will assure the protection and propagation of a balanced indigenous population of fish, shellfish and wildlife in and on Lake Ontario.

We further believe that it is in the public interest to modify the provisions of the NPDES permit for Units 1-4 as requested herein.

Please be assured that representatives of Niagara Mohawk are ready to respond to any questions you may have on the attached documents and would be pleased to meet with you and your staff as you deem necessary.

Very truly yours,

NIAGARA MOHAWK POWER CORPORATION

R C Clancy

R. C. Clancy, Vice President
Research and Environmental Affairs

Encl.

NIAGARA MOHAWK POWER CORPORATION
OSWEGO STEAM STATION
UNITS 1-4

316(a) DEMONSTRATION SUBMISSION
NPDES PERMIT NY0002186

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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 at a depth of approximately 5.5 m (18 ft), and is discharged to the surface waters at the extreme western end of the Oswego Turning Basin (Figure S-1). A total volume of 21.52 m^3/sec (763 cfs) at maximum plant operation is passed through the plant (travel time 9.8 min) and the maximum temperature increase to the cooling water is 6.9°C (12.4°F). Discharge velocity at the face of the discharge structure is calculated to be 0.37 m/sec (1.2 ft/sec).

During the past five-year period, there have been only two plant shutdowns of all units, totaling 92 minutes, occurring during the warm water period of July 1973. These shutdowns, which were of short duration during a period when the plant was operating at a minimum level, were not observed to result in any adverse impact on biological organisms in the receiving water.

The Oswego Harbor-Turning Basin complex which receives the thermal discharge from Oswego Units 1-4 has a water surface area of approximately 1.13 km^2 (280 acres) with a channel maintained by dredging to a depth of 7.3 m (24 ft). Dredged material consists of sand and "muck" and is considered by the U.S.E.P.A. to be polluted and unacceptable for open lake disposal.

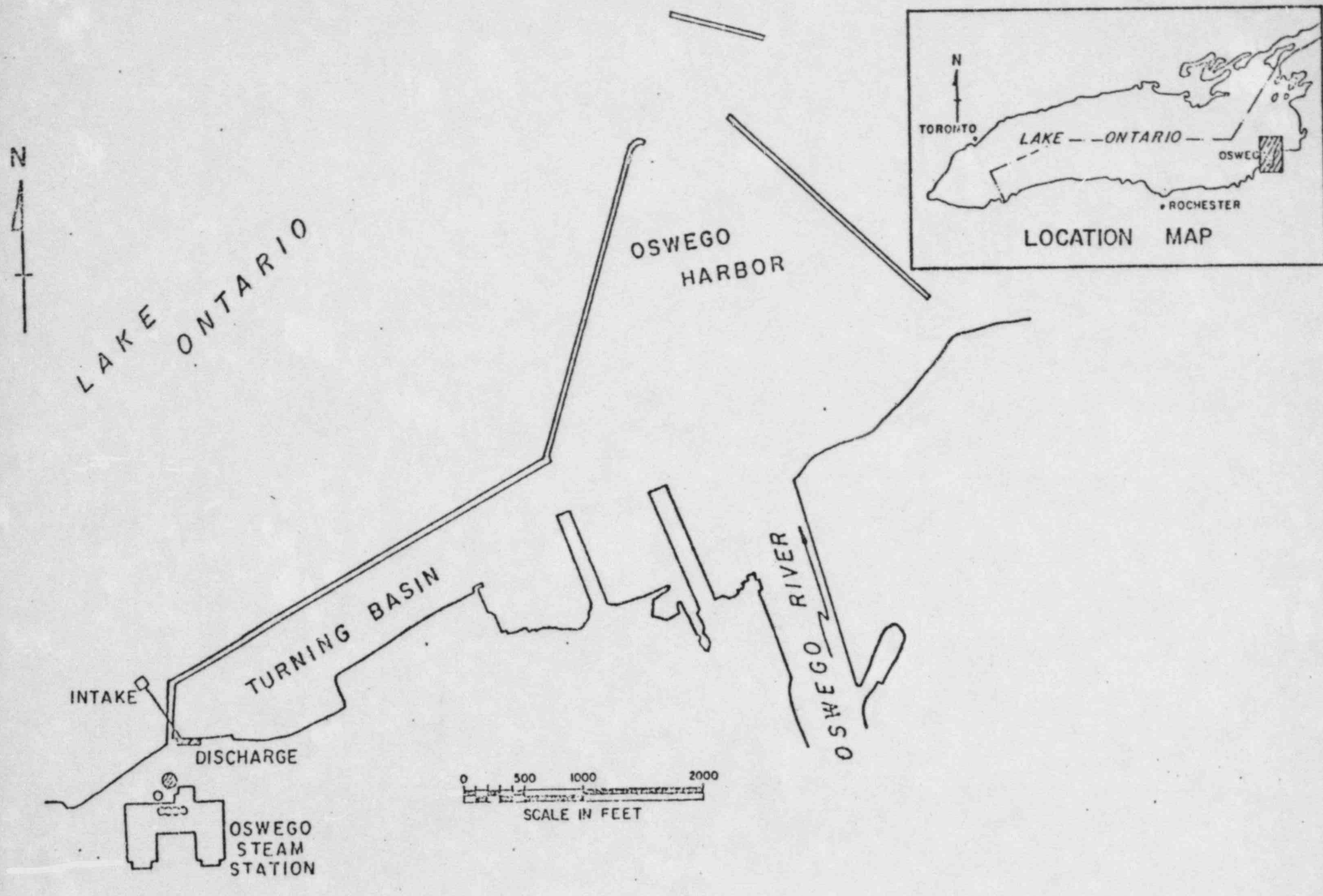
The turning basin and Oswego Harbor area are formed by a stone breakwater which is open to the lake at the eastern (harbor) end, where it also receives the flow of the Oswego River. Several large shallow areas with extensive macrophyte growth are present along the southern shore of the turning basin.

Physical and Chemical Information

Chemical analyses of the waters in the Oswego Harbor-Turning Basin complex, augmented by measurements of Lake Ontario water prior to discharge into the turning basin and by NYSDEC findings from the Oswego River, indicate that the water quality is affected by the input of domestic organic wastes. However, dilution and current patterns maintain the circulation patterns in the turning basin, providing suitable water quality for aquatic organisms. Water temperature ranged from 0.0 to 23.5°C (32.0-74.3°F) at the surface and 0.0 to 17.8°C (32.0-64.0°F) at

FIGURE S-1

LOCATION OF OSWEGO STEAM STATION



the bottom over the 12-month survey in 1975-1976. Differences between surface and bottom temperatures reflect the thermal discharge of Units 1-4 and the seasonal intrusion of the warmer Oswego River water. The lowest dissolved oxygen level recorded was 6.7 mg/l and the calculated percent oxygen saturation averaged 99% with a low value of 96%. The impact of domestic and industrial pollutants as well as urban runoff was evident in the comparatively high concentrations of such parameters as biochemical oxygen demand, chemical oxygen demand, and coliform bacteria, in addition to nutritive sources such as nitrogen and phosphorus which are essential to primary production. The addition of the thermal discharge to the turning basin improves the basin's water quality by introducing Lake Ontario water which promotes dilution and flushing.

Climatological information for the Oswego vicinity points to the influence of Lake Ontario through increased humidity and precipitation. The area generally has short, mild summer periods alternating with long, cold and snowy winters. Winds in the area are highly variable; prevailing wind direction is southwesterly.

Plume Description

The temperature distributions and flow patterns within the Oswego Harbor-Turning Basin complex, and the behavior of the harbor outflow to Lake Ontario, are determined by the seasonally varying density relationships between the various water sources. The spring condition is characterized by high flows from the Oswego River, which experiences a more rapid seasonal increase in temperature than does the lake. The power plant effluent may be either positively or negatively buoyant relative to the river water during the spring warming period, depending on the lake intake temperature, plant generation, and the operation of the tempering gate. River water intrusion into the turning basin was highest during the spring of 1975, due to the high river flows and low plant discharge flows.

The early summer patterns indicate an intrusion of cold lake water into the harbor and turning basin, beneath the warm, buoyant river flow. The discharge is again variable in its buoyancy relative to the turning basin waters, which have intruding river water in the upper layer and intruding lake water in the lower layer. The late summer structure is characterized by the negatively buoyant river flow, which is due to the high chloride content of the river. The buoyant plant discharge flows out of the turning basin on the surface, and mixes with the river flow as it proceeds to the harbor mouth. The harbor outflow is negatively buoyant and tends to flow out into the lake along the bottom.

The fall structure is dominated by increased river intrusion into the turning basin and increased mixing of the discharge waters with the river waters in the harbor. The harbor outflow remains negatively buoyant and tends to spread along the lake bottom.

Sewage and runoff from the west side of the city of Oswego are discharged into the turning basin at two locations. Modeling comparisons of the dissolved oxygen distributions in the turning basin with and without the plant discharge into the western end of the basin indicate that the plant discharge has the beneficial effect of providing advective transport of the waste out of the basin. Without the discharge induced transport, high BOD levels and low DO concentrations would result in the basin. In addition, the plant-induced transport provides for the removal of the products of bacterial decay, thus preventing the development of anaerobic sediment conditions.

Biological Studies and Community Composition

The biological community in the Oswego Harbor-Turning Basin complex was evaluated during the period April 1975 through March 1976 on the basis of monthly collections using several different sampling techniques. The objective of the survey was to establish, on a spatial and temporal basis, the various populations which make up the community and to determine whether the thermal discharge altered the community structure.

The phytoplankton sampling program yielded information on a diverse assemblage of organisms dominated by members of the Chlorophyceae, Bacillariophyceae, and Myxophyceae. Overall, species representation and total plankton abundance reached a single peak during the late summer months, and the lowest values were observed during the cold water months of winter. Numerical dominance was maintained by diatom species, similar to the structure found in nearby Lake Ontario waters; however, the greatest persistence in representation throughout the study period was observed for blue-green algae, which characterize the high nutrient levels found in the turning basin. Algal species designated as nuisance species were found to exist in bloom proportions within the harbor-turning basin complex, but the most frequent blooms were noted near the mouth of the Oswego River, reflecting its influence on the aquatic community. Algal biomass (chlorophyll a) exhibited a longitudinal gradient with the lowest values near the thermal discharge and the highest values near the mouth of the Oswego River. Lake Ontario water, which constitutes the water of the thermal discharge, is normally low in algal abundance, explaining the lower biomass near the discharge. The ratio of chlorophyll a to estimated productivity, a relationship which indicates the photosynthetic rate of the phytoplankton, pointed to an overall stimulation by the thermal discharge. The phytoplankton community was found to be diverse with the individual populations exhibiting normal life cycle activity.

Aquatic invertebrates classified as microzooplankton, which are important to the transfer of energy within the aquatic ecosystem, were represented by 79 taxa, of which the rotifers were the dominant group. Spatial distribution was observed to be influenced by hydrodynamic patterns resulting from the interaction of currents generated by density differences in Lake Ontario, the Oswego River, and the thermal discharge from Oswego Units 1-4. In addition, during periods when large populations were observed in samples from the intake of Units 1-4, their viability after passage through the plant influenced the community, especially in the western end of the turning basin. Life cycle activity was observed to follow normal patterns for the dominant organisms collected.

The macrozooplankton, represented by organisms characteristic of slow-moving, warm water, lentic environments was found to be dominated by the amphipod Gammarus fasciatus, while the predaceous cladoceran Leptodora kindtii was the major species during August and September. Seasonal abundance patterns and life cycle activity were not altered by the discharge from Oswego Units 1-4, but followed reported cycles as observed in other study areas as well as nearby Lake Ontario. Spatial distribution was strongly influenced by the water current patterns resulting from density gradients between the thermal discharge of Oswego Units 1-4, the Oswego River, and Lake Ontario waters.

A diverse assemblage of benthic macroinvertebrates was observed in the Oswego Harbor and Turning Basin; seven phyla were represented, of which Oligochaeta was the dominant taxon. Where information was available on the life histories for the representative dominant populations, normal development patterns were observed. Seasonal patterns of total abundance indicated peak abundance during March and lowest abundance in September. The overall pattern, however, was not consistent among sampling stations primarily as a result of population differences especially at the Oswego Harbor station which was directly influenced by lotic populations normally associated with the Oswego River. Comparison of the current benthological data to the results of previous studies in the harbor-turning basin indicate continuity of the major benthic populations on a seasonal basis. The overall community structure was found to be similar to those observed in other large bays and harbors along the southern shore of Lake Ontario characterized by elevated nutrient levels. The thermal discharge from Oswego Units 1-4 was not observed to have a detrimental effect on the benthic community structure.

The most intensive sampling efforts were employed to evaluate the role of the Oswego Harbor-Turning Basin on the dynamics of the Lake Ontario fishery. Sampling to evaluate fish egg and larval abundance and distribution indicated a species representation and abundance of dominant organisms similar to that found at other southeastern

Lake Ontario locations, except for the addition of greater numbers of warm water centrarchid and cyprinid species. A total of seven species were represented in the egg collections and 16 species in the larval collections. The eggs and larvae of the alewife composed the major fraction of the collections; however, the environmental conditions, primarily the type of substrate in the turning basin, are not preferred conditions by the alewife, supporting the hypothesis that pump entrainment of Lake Ontario populations accounts for much of the alewife abundance. The large weedy areas found along the southern shore of the turning basin are the preferred type of spawning and nursery areas for several fish species, primarily members of the cyprinid and centrarchid families, which were collected in the larval tows. The presence of species known to prefer this type of habitat in low numbers at channel stations and the subsequent observation of young-of-the-year specimens in seine collections strongly suggests that the area is used for spawning and as a nursery by several warm water species. Larvae of game fish such as yellow perch, white bass, and white perch were collected in the study area, pointing to the importance of the turning basin in the maintenance of a viable Lake Ontario fishery. Normal life cycle development patterns were observed for the major populations, and the spatial distribution pattern was found to be dependent on species, stage of development, and the longitudinal temperature gradients related to water masses in the turning basin.

The Oswego Harbor-Turning Basin was found to support a nekton community typical of warm water in contrast to the community structure typical of colder waters found in adjacent Lake Ontario. Seining efforts in the shallow weedy sections along the southern shore of the turning basin indicated several species, primarily forage fish, such as golden, emerald, and spottail shiners, present over much of the year whereas they were only found for a short period at lake locations. Species such as the gizzard shad, yellow perch, and largemouth bass utilize the area as a nursery ground in contrast to lake population which were found to be transitory, and in lower abundance.

More mature fish collected in the channel area by trawls and gill nets exhibited a distinct seasonal pattern in abundance as well as a spatial distribution within the study area.Gizzard shad was the dominant species during the winter months, and peak concentrations were observed in the thermal discharge of Oswego Units 1-4. White perch were present throughout the study period, apparently preferring the bottom water layers, and moving to the warmer discharge area during the winter. Alewife, the dominant spring and summer species, was collected in greatest numbers in the harbor area and fewest near the plant's discharge. During the fall, water temperature gradually cooled and the alewife migrated from the Oswego Harbor, although it remained longest in the area of the thermal discharge. The abundance of gizzard shad exhibited a marked increase during the fall, when the fish was numerically dominant in the harbor area. The diversity of the fish community was found to be more stable than at nearby lake sampling locations in part because of the moderating influences of the Oswego River and the Oswego Units 1-4 thermal discharge. Life history data point to normal life cycle patterns for the dominant species collected, and comparison of the data from the current study to previous studies suggests a viable community structure that is not detrimentally affected by the thermal discharge of Oswego Units 1-4.

Potential Thermal Discharge Impacts

Thermal discharges can affect aquatic populations directly by increasing or decreasing the ambient water temperature in excess of the tolerance levels of the species or at a rate faster than the physiological adjustments of the organism. In addition, indirect effects relating to alteration of the trophic structure or the habitat could have severe consequences to populations in the area that are subject to the influence of the thermal discharge.

Of the dominant fish species collected in the Oswego Harbor-Turning Basin complex, only the rainbow smelt has an upper temperature tolerance level that would be exceeded by temperatures recorded in the study area. Summer temperatures would probably preclude the presence of cold water species such as salmonids found in Lake Ontario; however, these fish are infrequent members of the littoral zone at this time of year. Organisms associated with the turning basin are normally associated with warm water habitats, and it is doubtful that the thermal discharge would have a negative impact on their life cycle activities.

Impact of the Thermal Discharge

Field sampling efforts and subsequent laboratory analyses indicate the presence in the Oswego Harbor-Turning Basin of an indigenous aquatic community characteristic of temperate, warm, eutrophic embayments. Seasonal variability and spatial distribution were found to be influenced by water currents induced by density gradients among the various water masses that enter the harbor-turning basin complex. The thermal discharge introduces Lake Ontario water of good quality to the western end of the basin, where it dilutes the water emanating from waste discharges and the Oswego River, and assists in flushing the basin; this helps to maintain a suitable habitat for aquatic organisms. At each trophic level evaluated, a diversity of populations was found exhibiting life cycle activity that is, characteristic of the population when present in the littoral zone of a lake.

Comparison of the assemblage of benthic and nektonic organisms in the present study to previous studies points to a persistent community structure. Overall, it was determined that an indigenous community is present in the turning basin and functions as an integral unit, and that there is no observable detrimental impact from the thermal discharge of Oswego Units 1-4.

I. INTRODUCTION

A. BACKGROUND

On 22 May 1974, the staff for Region II of the U.S. Environmental Protection Agency (EPA) issued a draft National Pollutant Discharge Elimination System (NPDES) permit for the Oswego Steam Station Units 1-4 (OSS 1-4) (NY 0002186) in accordance with the provisions of the Federal Water Pollution Control Act (FWPCA). On 28 June 1974, Niagara Mohawk Power Corporation (NMPC) requested that the Regional Administrator impose alternative thermal effluent limitations to those described in the draft permit pursuant to Section 316(a) of the FWPCA. Niagara Mohawk provided documentary evidence in support of its request of 2 August 1974. On 24 February 1975, NMPC was issued the final NPDES Permit for OSS 1-4. The final permit did not include the requested alternative thermal effluent limitations.

The Final Effluent Guidelines and Standards (40 CFR 423) do not require closed-cycle cooling for OSS 1-4. The final NPDES permit (condition 10(c) on page 9 of 24) cites the New York Criteria Governing Thermal Discharges as the limiting regulation with respect to the thermal discharge of OSS 1-4. This document will demonstrate that the subject permit condition is more stringent than necessary to assure the protection and propagation of the balanced indigenous population in and on the receiving water body, the Oswego Harbor and Turning Basin of Lake Ontario. This document further supports the position of NMPC that the existing mode of discharge assures the necessary protection and propagation.

In a memorandum transmitted with the final permit, and in discussions with NMPC, the technical staff of Region II indicated that the information submitted previously (2 August 1974) in support of the request for alternative thermal effluent limitations was insufficient. In response, Niagara Mohawk has prepared this document supplementing its original Section 316(a) submittal in areas identified by the Region II staff.

The content of this document generally follows the procedures presented in the draft document entitled "316(a) Technical Guidance-Thermal Discharges" (the guidance manual), published 30 September 1974 by the Water Planning Division of the EPA, and the guidance provided by the Region II staff in their memorandum and during the technical meetings. The information contained herein includes some of the previously submitted data as well as new information. Niagara Mohawk believes that its original conclusions are verified and reinforced by this supplemental submission.

B. DEMONSTRATION APPROACH AND RATIONALE

The Oswego Steam Station Units 1-4 was constructed during the period 1938-1959. The thermal effluent discharges into the western end of the Oswego Turning Basin. The biotic community in the Oswego Turning Basin-Harbor complex was investigated on a limited scale during 1970 and on a more extensive basis between April 1975 and March 1976. The biological data gathered by these surveys provides the basis for assessing plant-induced harm.

As stated in the guidance manual, the rationale and approach for demonstration of no prior appreciable harm do not require demonstration "that every species which would occur under optimal conditions is present, as long as it demonstrates that the community as a whole, and all major components thereof are intact" (page 26). The guidance manual (page 23) cites seven specific points to be considered in evaluating "appreciable harm." These are:

1. Substantial increase in abundance or distribution of any nuisance species or heat-tolerant community not representative of the highest community development achievable in receiving waters of comparable quality.

2. Substantial decrease of formerly indigenous species, other than nuisance species.

3. Changes in community structure to resemble a simpler successional stage than is natural for the locality and season in question.

4. Unaesthetic appearance, odor, or taste of the waters.

5. Elimination of an established or potential economic or recreational use of the waters.

6. Reduction of the successful completion of life cycles of indigenous species, including those of migratory species.

7. Substantial reduction of community heterogeneity or trophic structure.

Each of these points is addressed in this demonstration.

The ultimate question raised by the guidance manual is whether or not there has been prior appreciable harm to the balanced indigenous community in the vicinity of the thermal discharge of

Oswego Steam Station Units 1-4 as a result of that discharge. To the contrary, it is shown in this submission that over the period of plant operation the thermal discharge has acted as a moderating input to the Oswego Turning Basin, bringing in water of good quality and flushing out impurities discharged to the receiving water from other sources. Plant operation has helped to establish a balanced community with no prior appreciable harm evident.

C. FORMAT OF THE DOCUMENTATION

This document provides the specific information required for a Type I Demonstration.

Chapter I presents the demonstation approach and rationale and the basis for using Demonstration Type I as defined in the guidance manual.

Chapter II presents a description of the Oswego Steam Station Units 1-4 and its associated operating parameters. Included in this chapter are water quality information from the plant and Oswego Turning Basin, and geological and climatological data for the Oswego vicinity.

Chapter III details studies conducted in the Oswego Turning Basin to characterize the thermal plume and structure of the receiving water body on a seasonal basis. A predictive model of dissolved oxygen and biochemical oxygen demand within the turning basin in conjunction with the plant discharge is also described in this chapter.

Chapter IV presents a description, based on site-specific investigations, of the biological communities by trophic level found in the vicinity of the Oswego Steam Station Units 1-4 discharge. The results of biological surveys at other locations and of previous surveys in the Oswego Turning Basin are used to develop the community structure and to evaluate the dynamics.

The potential impact of a thermal discharge on biota in receiving water is discussed in Chapter V and the overall evaluation of the impact of the thermal discharge is discussed in Chapter VI.

The surface level opening of the discharge, which has a horizontal axis of 90° to the shoreline of the turning basin (Figure II-1), measures 13.6 m x 6.9 m (44.5 x 22.5 ft) and is divided into four sections, each with a controlling gate. Depth at the discharge is maintained by dredging and has a mean of 5.0 m (16.5 ft) and an extreme of 5.8 m (19 ft).

Station net thermal efficiency is reported to be 31%, which corresponds to a station heat rejection rate of 4.43×10^9 Btu/hr. The heat loss of 2.114×10^9 Btu/hr to the cooling water corresponds to 47% of the station heat rejection rate; the remaining 22% being lost in-plant and through the stacks.

3. Cooling Water System - Plant Operational Profiles

The plant generally does not operate at peak generating capacity, even during peak demand periods. Under normal summer operational conditions, because of the increased demand and warmer ambient temperature of the cooling water, all eight circulating water pumps are used. Decreased demand and lower ambient temperature of cooling water during the winter months necessitates only one pump each for Units 1-3 and both pumps for Unit 4 (Unit 4 has a divided water box, requiring both pumps).

During periods when the temperature of Lake Ontario falls below the optimum temperature for peak condenser cooling efficiency, a portion of the heated discharge is recirculated as tempering water, which is added to the intake ahead of the trash racks (Figure II-2). The tempering flow is not measured, but its effect is to decrease the amount of water withdrawn from the lake. The periods during which tempering flow has occurred at Units 1-4 since 1 January 1973 are presented below:

DURATION OF TEMPERING AT OSWEGO STEAM STATION UNITS 1-4

FROM	TO
1 JAN 73	9 APR 73
18 DEC 73	16 APR 74
5 JAN 75	6 MAY 75
24 DEC 75	20 APR 76

Tempering flow is regulated by means of a gate (Figure II-2) between the discharge and intake; the mean tempering flow has been calculated to be 20% of the total plant flow during the cold water periods.

4. Time Temperature Profile

In order to evaluate the possible range of temperature exposures that an organism passing through the cooling water system of the plant might experience, estimates of the time-temperature history of the cooling water flow have been made. The travel times inside the cooling water system are given in Table II-1 for a typical unit. The initial temperature rise occurs at the condensers and no cooling is assumed until the turning basin discharge.

After discharge to the turning basin, the time-temperature regime that an organism would experience is dependent on the flow patterns existing in the turning basin-harbor complex. The various seasonal flow patterns are discussed in Chapter III of the report.

5. Discharge Permit Information

Niagara Mohawk Power Corporation applied to the U.S. Environmental Protection Agency for a National Pollutant Discharge Elimination System (NPDES) permit for the Oswego Steam Station Units 1-4. On 22 May 1974 a draft permit was issued. Subsequently, a final permit numbered NY0002186 (NPDES 75-163) was issued effective 31 March 1975 with an expiration date of 30 March 1980. The permit includes the discharges from three outfalls at Units 1-4.

DISCHARGE NUMBER	DESCRIPTION
0-001	Surface discharge containing condenser and auxiliary cooling water with small amounts (24,400 gpd) of boiler blowdown and water treatment wastes. Maximum flow 476 MGD.
0-01A	Intake screen backwash which discharges into discharge number 0-001. Maximum flow 0.26 MGD.
0-003	Fly ash pond overflow containing sluiced fly ash, yard drainage, and boiler chemical cleaning (one boiler is cleaned every 3 years and there are 4 boilers associated with Units 1-4). Maximum flow 0.24 MGD.

All discharges enter the turning basin extension of the Oswego Harbor at points located east of the Oswego Harbor breakfront and west of Liberty Street.

TABLE II-1

TRAVEL TIME THROUGH TYPICAL UNIT UNDER FULL FLOW CONDITIONS

OSWEGO STEAM STATION UNITS 1-4

LOCATION		TRAVEL TIME (SEC)	CUMULATIVE TRAVEL TIME (SEC)
FROM	TO		
LAKE INTAKE	INTAKE FOREBAY	124	124
INTAKE FOREBAY	CONDENSER INLET	273	397
CONDENSER INLET	OUTLET	4.3	401.7
CONDENSER OUTLET	DISCHARGE	187	588.7 (9.8 min)

Limitations on the main discharge 0-001 are listed in the final permit as presented below:

a. Discharge temperature shall not exceed 34.5°C (94°F).

b. Discharge-intake temperature difference shall not exceed:
(1) 7.8°C (14°F) during June-September, and
(2) 17.8°C (32°F) during October-May.

c. The net rate of addition of heat to the receiving water shall not exceed 0.54×10^9 Kcal/hr (2.13×10^9 Btu/hr).

d. Chemical algicides shall not be added to the cooling water system.

e. The pH shall not be less than 6.0 nor greater than 9.0 at any time.

Required limitations beginning on 1 July 1977 and lasting until the expiration of the permit pertaining to the thermal discharge at Units 1-4 state:

> The water temperature at the surface of a lake shall not be raised more than 3 Fahrenheit degrees over the temperature that existed before the addition of heat of artificial origin.
>
> In lakes subject to stratification as defined in Part 652*, thermal discharges that will raise the temperature of the receiving waters shall be confined to the epilimnion.
>
> In lakes subject to stratification as defined in Part 652*, thermal discharges which will lower the temperature of the receiving waters shall be discharged to the hypolimnion, and shall meet the water quality standards contained in Parts 701* and 702* in all respects.
>
> In order to assure the protection and propagation of a balanced indigenous population of shellfish, fish and wildlife, thermal limitations based upon load allocations and other factors may be imposed and/or appropriate mixing zone dimensions may be defined (if not already done so) in accordance with the procedural requirements of Condition 2.

*These "Parts" are in Title 6, Official Compilation of Codes, Rules, and Regulations of New York State.

II. STATION AND SITE DESCRIPTION

A. INTRODUCTION

This section of the demonstration is presented to familiarize the reader with design features of the Oswego Steam Station Units 1-4 and the station's operating history. The text includes information on the physical and chemical characteristics of the water bodies in the vicinity of the electrical generating facility and related climatological data.

B. GEOGRAPHIC LOCATION

The Oswego Steam Station is located on the southeastern shore of Lake Ontario in the city and county of Oswego, New York, at 76° 31' west longitude and 42° 28' north latitude. In 1970 the population of the city of Oswego was estimated at 24,000; it is approximately 210 km (130 mi) from the Niagara River and 75 km (45 mi) from the St. Lawrence River. The plant site, shown in Figure II-1, is at the western end of the Oswego Harbor-Turning Basin complex approximately 1650 m (5415 ft) west of the confluence of the Oswego River with the lake.

C. PLANT OPERATION

The Oswego Steam Station consisted originally of four generating units (Units 1-4) with a combined maximum capacity of 407 MWe, and an average 1973 unit load factor of 53.8. Units 1-4 were constructed during the period 1938-1959, and operated on coal until 1971 when they were converted to burn fuel oil.

During September 1975, a fifth oil-fired electrical generating unit with a maximum capacity of 890 MWe commenced commercial operation. A sixth unit, whose rated capacity is also 890 MWe, is currently under construction and scheduled to begin operation in 1979. The two newer units, Units 5-6, are not under consideration in this demonstration as they each have separate intake and discharge structures.

1. Cooling Water System: Intake

The system for circulating cooling water to dissipate waste heat from the condensers is of the once-through type. The flow is regulated by eight pumps; six pumps, two each for Units 1-3, with a rated capacity of 2.63 m^3/sec (41,750 gpm); and two pumps for Unit 4, each with a rated capacity of 2.52 m^3/sec (40,000 gpm). Total condenser flow is 20.82 m^3/sec (330,500 gpm) at maximum capacity and the combined four-unit temperature rise (ΔT) is 6.8°C (12.4°F).

LOCATION OF OSWEGO STEAM STATION

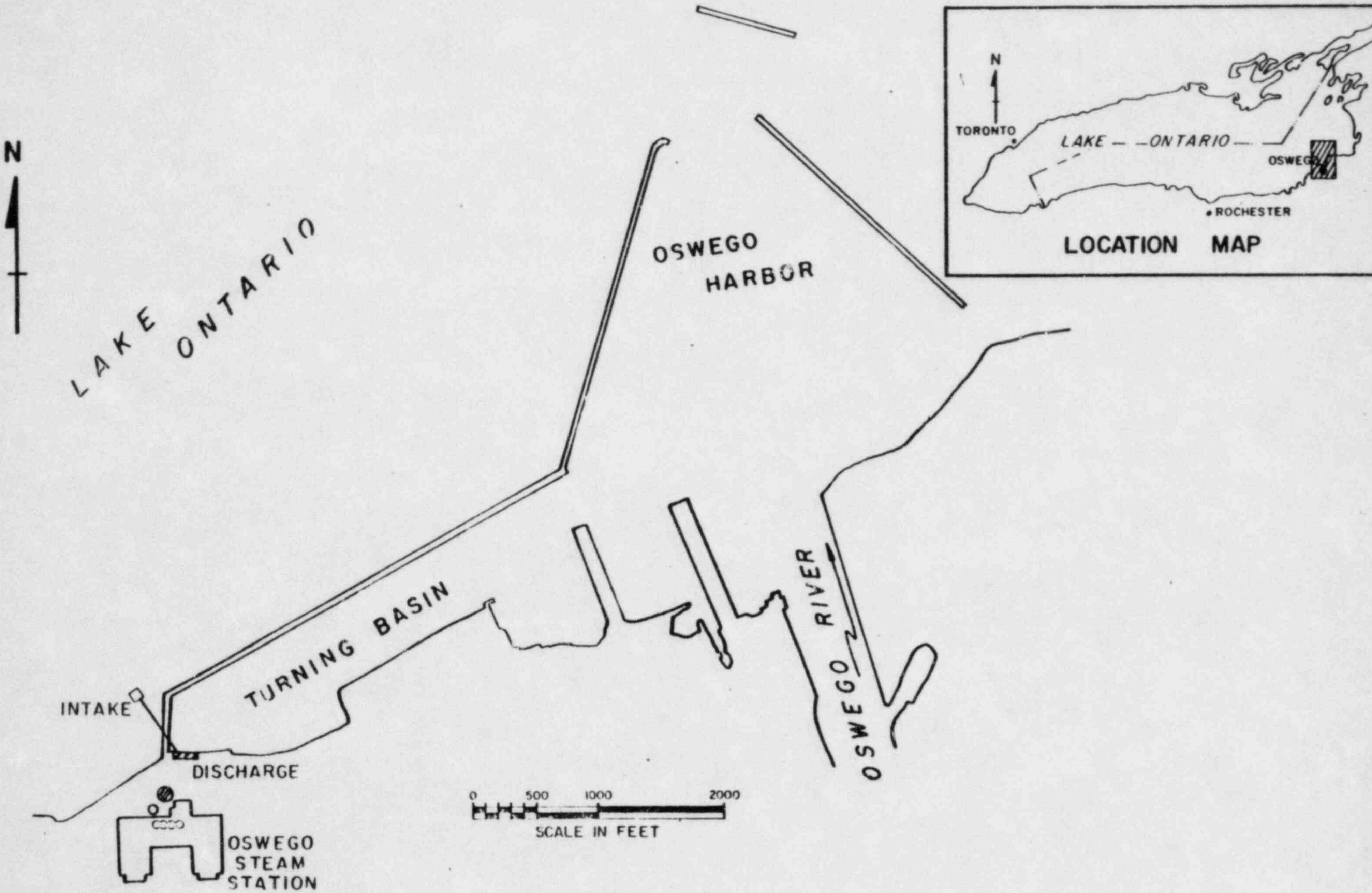


FIGURE II-1

In addition to cooling water flow, service water for the four unit system is 0.7 m^3/sec (11,100 gpm), with an estimated temperature rise of 2.8°C (5°F). Total four-unit plant flow is therefore 21.52 m^3/sec (491.9 MGD), and, when the plant is operating at the maximum rating, the temperature rise is 6.9°C (12.4°F).

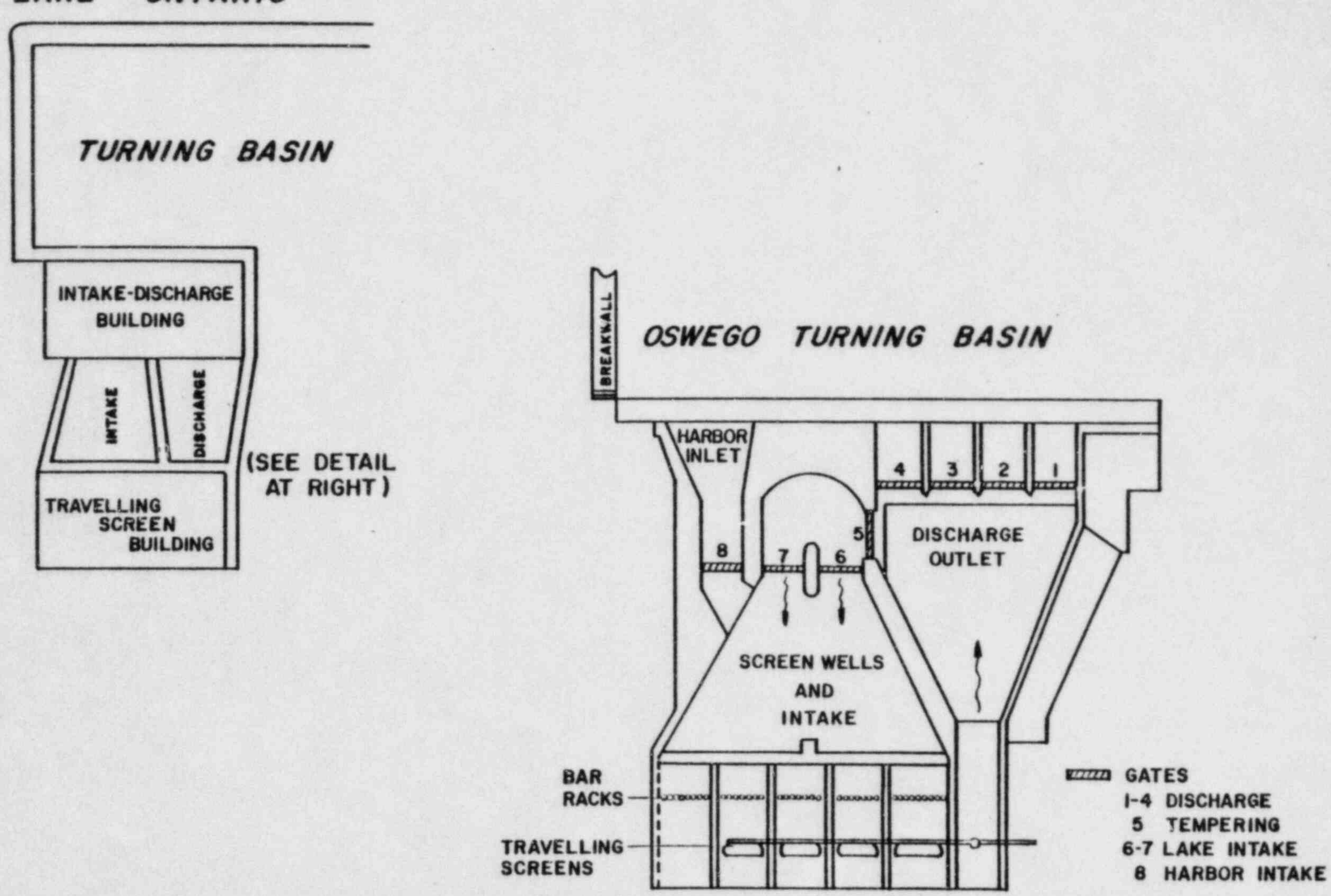
Cooling water is withdrawn from Lake Ontario through a submerged intake structure located in 5.5 m (18 ft) of water approximately 76 m (550 ft) north of the northwestern tip of the Oswego Turning Basin breakwall. The submerged intake is octagonal, and its alternating intake openings measure 1.4 x 4.4 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 (761.09 cfs) through the available intake area of 48.42 m^3 (521.2 ft^2). A tunnel with a mean velocity of 1.7 m/sec (5.5 fps) conducts the cooling water under the western end of the turning basin to the screen house (Figure II-2).

As the schematic diagram of the screen house and intake forebay indicates (Figure II-2), the cooling water flows first through trash racks, which are constructed of metal bars with 7.6 cm (3 in) spacings. The trash racks are cleaned on a periodic schedule and prevent coarse material from reaching the travelling screens. Four travelling screens with a mesh size of 9.5 mm (0.375 in) remove smaller material from the circulating water upstream of the pumps and condenser tubes. Travelling screens are scheduled to wash for 3 minutes every hour; however, within the scheduled wash cycle, screen wash is done on a manual basis when pressure differentials develop across the screens due to clogging. Large amounts of material, primarily the alga Cladophora, necessitate the operation of the travelling screens on a continuous schedule during the spring of the year. Screen wash from all four travelling screens empties into a common channel and is removed from the plant site. Impingement samples are collected from the common discharge channel downstream of the last screen by means of a specially designed basket.

2. Cooling Water System: Discharge

After passage through the condensers, the cooling water is transported through a surface level canal approximately 160 m (525 ft) in length to the western end of the turning basin. Average velocity in the discharge canal is 1.2 m/sec (3.8 fps), reducing to 0.37 m/sec (1.2 fps) at the face of the discharge.

SCHEMATIC DIAGRAM OF OSWEGO STEAM STATION UNITS 1-4



DETAIL

FIGURE II-2

Thermal Discharges

> All thermal discharges to the waters of the State shall assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife in and on the body of water.

At the present time, effluent limitations pertaining to the thermal discharge are under suspension pending the outcome of an adjudicatory hearing.

In addition, the discharges relating primarily to chemicals shall be limited at all times so as to be in full compliance with all the applicable requirements of Sections 701 and 702 of Title 6, Official Compilation of Codes, Rules and Regulations - Classifications and Standards Governing Quality and Purity of Waters of New York State. To meet the water quality standards and the required limitations of the permit, discharge 0-003 has been diverted to a treatment facility maintained on the plant site by Niagara Mohawk Power Corporation.

6. Effluent Water Quality Data

Commencing in July 1975 as a result of NPDES permit requirements for the Oswego Steam Station Units 1-4 discharges, a monitoring program for certain physical and chemical parameters was initiated. Minimum, maximum, and average values for the parameters monitored at the thermal discharge are reported to the Regional Administrator for Region II of the Federal E.P.A. on a monthly schedule. Table II-2 presents the parameters evaluated and their monthly average values. In addition, recent monthly discharge reporting submissions have included results from the required chemical analyses. During the period from July 1975 to April 1976, the average monthly values for discharge temperature, difference in temperature between intake and discharge, net heat addition, and pH have all been below the effluent limitations with only the maximum difference between intake and discharge exceeding the 7.8°C summer limit during September 1975.

7. Records of Plant Shutdowns during the Last Five Years

The EPA Technical Guidance Manual for the preparation of a 316(a) demonstration requests information on all plant shutdowns which resulted in the complete stoppage of heated effluent flow during the past five years. An assessment of the effects of each shutdown on the aquatic biota is also requested.

Since 1 January 1970, Units 1-4 at the Oswego Steam Station have experienced no complete shutdowns which resulted in the disruption of heated effluent flow except on a single date, 1 July 1973. On

TABLE II-2

MEAN[a] MONTHLY DISCHARGE PARAMETERS[b]

OSWEGO STEAM STATION UNITS 1-4 - 1975-1976

DISCHARGE 0-001

	1975						1976		
PARAMETER	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
DISCHARGE TEMPERATURE (°C)	26.7	26.1	18.9	17.2	16.1	11.7	12.2	11.1	11.7
DISCHARGE/INTAKE TEMPERATURE DIFFERENCE (°C)	4.4	4.4	4.4	4.7	5.6	6.7	7.8	7.5	7.2
NET HEAT ADDITION (Btu x 10^9)	0.98	1.02	1.23	1.35	1.22	1.20	1.35	1.18	0.77
pH	8.15	8.53	8.43	8.30	8.22	8.19	8.12	8.13	8.16

[a] Mean of Dates

[b] Niagara Mohawk Power Corp., 1976

this date, Units 1, 2, and 3 were all off line; Unit 4, which was on line, experienced a disruption in service between 0152 and 0220 hrs and finally dropped off line at 1129 hrs. Unit 3 came on line at 1233 hrs.

The durations of the outages were 28 minutes and 64 minutes. These brief plant shutdowns were not monitored to evaluate environmental impact; however, it must be noted that biological stress was neither observed by plant personnel nor recorded by local residents following the outages. The thermal plume in the turning basin could not dissipate in such short periods, hence no biological stress would be expected.

D. MORPHOLOGY AND GEOLOGY

1. Lake Ontario

A description of the topography and geology of the lake bottom in the vicinity of the Oswego Steam Station was compiled from borings, fathometric surveys, direct observation by divers, and existing charts (Figure II-3). The bedrock immediately underlying the Oswego area is the Oswego Sandstone of Upper Ordovican age (Rickard and Fisher, 1970). Shales and limestones as well as sandstones are found to the south. To the west of the station the lake shore is in a near natural condition and the lake bottom shelves gradually to a depth of about 12.1 m (40 ft) at a distance of 610 m (2,000 ft) from shore. East of the plant the breakwater cuts off the natural shoreline, and although the breakwater is, for the most part, simply a rough pile of large rocks, its face is precipitous and the depth at the foot of the breakwater is between 5.5 and 7.6 m (18-25 ft).

Direct diver observations indicated that the lake bottom west of the Oswego Steam Station is fairly consistent in character, being generally composed of flat rock and completely free of sediment. Many rhomboidal slabs of broken-off bedrock, measuring roughly 1.2 by 1.5 m (4 ft by 5 ft), are located in the near-shore area to a depth of 3 m (10 ft). Most of the area, however, is composed of dense glacial till which forms a series of steps extending progressively out into the lake, each bed or step of different depth ranging from a few inches to more than a foot. The bottom is strongly fractured or jointed with some erosion occurring in the cracks.

In the 3-6.1 m (10-20 ft) depth, the loose slabs and the wider cracks gradually become less evident so that at the 6.1 m (20 ft) depth, the bottom is almost exclusively smooth, although some rounded boulders and small pieces of flat rock can be found. Beyond the 6.1 m (20 ft) depth, the bottom is similar, with patches of loose rock and sand intruding in places.

OSWEGO HARBOR AND TURNING BASIN

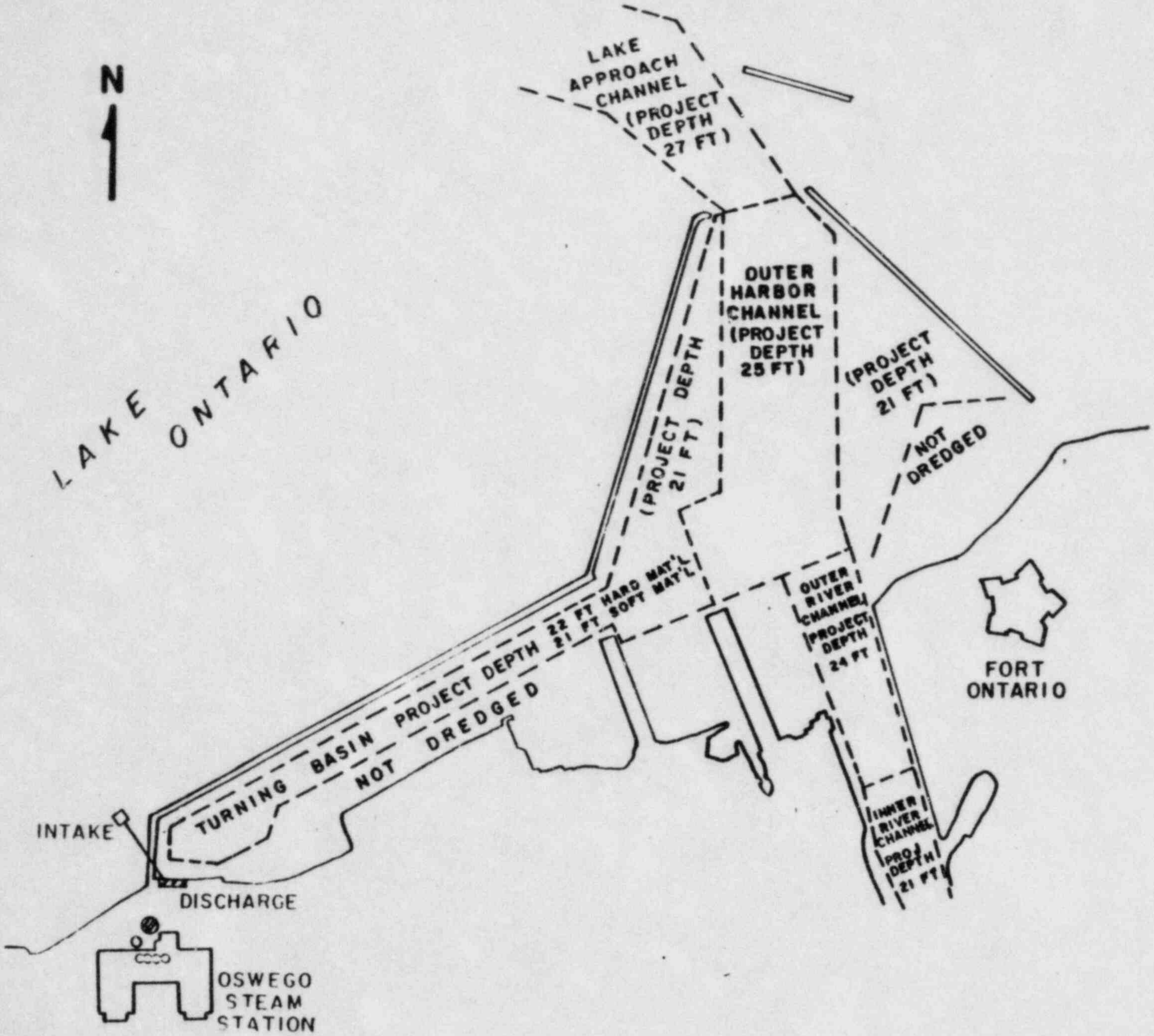


FIGURE II-3

Immediately west of the power plant is a section of the lake which resembles a bay, with a bottom composed primarily of rounded stones up to 0.3 m (12 inches) in diameter. Beyond a depth of 2.1 m (7 ft), the lake bottom is similar to that described above, while at depths over 6.1 m (20 ft depth), the bottom is sandy, consisting in most part of a thin layer of sand over the glacial till.

East of the steam station and up to the harbor entrance, the breakwater, composed of rocks which slope down into the lake at about a 45° angle, acts as the lake shoreline. Lakeward of the base of the breakwater, the bottom consists of an apron of large flat-sided rocks 1.2 x 1.5 x 1.5 m (4 x 5 x 5 ft), as well as sand. The rock apron extends only a short distance out into the lake, about 9.1 m (30 ft), beyond which the lake bottom is swept clean. Near the eastern end of the breakwater adjacent to the mouth of the river, considerable amounts of sand appear to have been deposited.

In addition to the direct observations made by divers of the lake bottom, borings were taken in the lake bottom from a point just offshore of the plant out into the lake to a distance of 457 m (1,500 ft). The analysis of the boring samples confirmed that an overburden of varying thickness forms the lake bottom beyond a depth of approximately 2.0 m (7 ft) and that the lake bottom is composed of compacted till in shallower depths. Generally, the area is characterized by patches of loose sandy silt varying in thickness from a few centimeters to as much as 0.6 m (2 ft), overlying a dense glacial till. The glacial till is a preconsolidated heterogeneous mixture of gray-brown silt, sand, gravel, and boulders.

2. Harbor Area (including the Turning Basin and Oswego River)

The Oswego Harbor area, depicted in Figure II-3, consists of a 280-acre outer harbor protected by a manmade breakwater and inner harbor channels in the Oswego River (Corps of Engineers, 1975). The characteristics of the harbor channels and structures are described in Table II-3. The harbor is maintained by the U.S. Army Corps of Engineers under authorization dating back to 1827. Channel dredging and maintenance of breakwaters is conducted only as necessary, as determined by an annual inspection. Harbor maintenance activities for the area are summarized in Table II-4; the turning basin was last dredged during August of 1975.

In the vicinity of the harbor, the Oswego River varies from 122 to 152 m (400-500 ft) in width and is dredged to a depth of 7.1 m (24 ft). Its yearly average flow is 6,137 cfs.

Sediments within the harbor are derived from the west-to-east drift of sedimentary materials within Lake Ontario, surface runoff, bank

TABLE II-3

PHYSICAL CHARACTERISTICS OF OSWEGO HARBOR

I. HARBOR NAVIGATION CHANNELS

HARBOR	CHANNEL	LENGTH (ft)	WIDTH (ft)	DEPTH (ft)
OUTER HARBOR CHANNELS	Lake approach channel	2,300	500- 800	27
	Outer harbor channel	2,700	800-1100	25
	Channel between outer harbor channel and the east arrowhead breakwater	2,400	1,200	21
	Channel between outer harbor channel and the west arrowhead breakwater	3,300	100- 800	21
	West outer harbor channel (turning basin)	3,600	250- 400	21 ft in soft material 22 ft in hard material
OSWEGO RIVER CHANNELS	Outer river channel	1,600	400- 500	24
	Inner river channel	1,000	400	21
LAKE ONTARIO SHOALS	-------	—	—	25

II. HARBOR STRUCTURES

BREAKWATER	COMPOSITION	LENGTH (ft)	WIDTH (ft)	DEPTH (ft)
EAST ARROWHEAD	Rubblemound	2,200	10	8.5
WEST ARROWHEAD	Rubblemound	2,700	10	8.5
OUTER WEST	Timber-crib, stone-filled, concrete-capped, stone riprapped	4,515	35	10-13
DETACHED	Rubblemound, concrete-capped	850	8	13

TABLE II-4

SUMMARY OF OPERATIONS AND MAINTENANCE ACTIVITIES[a] IN OSWEGO HARBOR

1964-1973

I. HARBOR NAVAGATION CHANNEL MAINTENANCE

SURVEY OPERATIONS	
FREQUENCY	Annually
AVERAGE DURATION	2 weeks
SWEEP OPERATIONS	
FREQUENCY	Annually or as needed
AVERAGE DURATION	1 week
DREDGE OPERATIONS	
FREQUENCY	Annually
AVERAGE DURATION	13 days
MONTHS	May-September
AVERAGE HARBOR AREA DREDGED	80,830 square yards
AVERAGE LENGTH OF DREDGE CUT	3,064 ft
AVERAGE WIDTH OF DREDGE CUT	191 ft
AVERAGE NUMBER OF LOADS	166 ft
AVERAGE SIZE OF LOAD	608 cubic yards
AVERAGE PUMPING TIME	32.3 minutes
AVERAGE FUEL CONSUMPTION	20,622 gallons
AVERAGE DISTANCE TO DISPOSAL AREA	1.7 miles

II. HISTORICAL VOLUMES OF DREDGED MATERIALS AND COSTS

YEAR	NON-DREDGING COSTS[b]	VOL. OF MATERIAL (cu. yds.)	COST OF DREDGING
1964	$ 5,519	60,505	$ 32,964
1965	13,345	no dredging	
1966	6,870	40,515	15,722
1967	9,290	93,211	33,443
1968	9,225	no dredging	
1969	7,000	81,721	65,270
1970	5,315	no dredging	
1971	7,887	no dredging	
1972	12,690	243,622	142,100
1973	8,140	88,973	66,778
ANNUAL AVERAGE	$ 8,528	60,855	$ 35,628
PER OPERATION	$ 8,528	101,425	$ 59,380

[a]Corps of Engineers, 1975.

[b]Non-dredging costs include costs for inspections, surveys, and snagging and clearing operations. Historical date presented for fiscal years.

and shoreline erosion, and municipal-industrial wastes. The Corps of Engineers (1975) describes the samples as being a mixture of sand unacceptable for open-lake disposal." Therefore, materials dredged from the Oswego Harbor will be placed in a diked disposal area as soon as an acceptable disposal facility has been constructed. Until this disposal area is constructed dredge spoils are dumped in the lake.

E. PHYSICAL AND CHEMICAL WATER QUALITY CHARACTERISTICS

An understanding of the physical and chemical properties and the processes occurring within Lake Ontario, the Oswego Harbor and Turning Basin, and the Oswego River is essential to a complete evaluation of the effects of the intake and discharge of cooling waters from the Oswego Steam Station Units 1-4. The following paragraphs describe the physical [i.e., flow, current, and temperature (T)] and chemical [e.g. pH, dissolved oxygen (DO), specific conductance (SPC)] characteristics of the waters in the Oswego vicinity as monitored in 1975 and 1976 by Lawler, Matusky and Skelly Engineers (LMS). These water quality characteristics are then analyzed in light of New York State water quality standards, proposed EPA criteria, and previous physical and chemical water quality surveys conducted in the Oswego area of Lake Ontario by LMS and others.

1. Lake Ontario in Vicinity of Oswego Harbor

a. Currents

Field investigations of currents in Lake Ontario and Oswego Harbor were made by Quirk, Lawler and Matusky Engineer (QLM) in 1970. They indicated that currents in Lake Ontario within the vicinity of Oswego Harbor are affected primarily by winds. Current measurements made during isothermal conditions revealed that since no density gradients existed, the surface currents generally moved at approximately a 45° angle to the right of the direction toward which the wind was blowing. Deeper countercurrents moved in directions opposite to the surface currents, thus replacing surface waters that moved out into the lake. The lake shoreline acted as a barrier to expected water transport pathways under certain conditions of wind direction. Figure II-4 presents several wind-induced current systems. Since the major wind components are from the south and west (Figure II-4), the main direction of flow for surface currents is to the east along the lake shoreline.

When the lake waters at the shoreline exhibited thermal stratification, currents were influenced by both wind direction and

The New York State Department of Environmental Conservation (NYSDEC) classification for Lake Ontario beyond the borders of Oswego Harbor is Class A, while the waters of Oswego Harbor and Turning Basin and the mouth of the Oswego River are Class C (State of New York, 1972). Standards promulgated by the NYSDEC for Class A and Class C waters are presented in Table II-7, along with the water quality criteria proposed by the Environmental Protection Agency (EPA) (USEPA, 1973; NYSDEC, 1974).

The proposed EPA criteria do provide a second and generally more stringent model with which to evaluate the observed water quality in the surveyed areas.

Water quality parameters, as measured in 1970 in Lake Ontario, met all but one of the NYSDEC standards for Class A waters (QLM, 1971). The average pH of 9.0 (range of 8.4 to 9.6) recorded in 1970 was above the allowable NYSDEC pH range of 6.5 to 8.5. These relatively high pH values may have been erroneous since the highest pH recorded in 1975 was only 8.7, and the overall improvement in water quality from 1970 to 1975 was not of sufficient magnitude to account for such a marked difference in pH values between the two years. In 1975-1976, pH values at some times exceeded the allowable maximum of pH 8.5 (maximum 8.78, Jan. 1976), although the mean of 8.1 was within the NYSDEC limitations.

The number of samples for total coliform count is insufficient for calculating the monthly geometric mean (which is the basis for the NYSDEC total coliform criteria); however, the range of total coliform concentrations measured within the intake (5-380 cols/100 ml) may indicate violation of the total coliform standards at some times. In addition, since there is no stated criterion for fecal coliforms for Class A waters, the implication is that no fecal coliforms should be present. Since fecal coliform were observed to be present in concentrations ranging from 0 to 274 cols/100 ml, their presence may also have constituted a violation of NYSDEC standards. Lower coliform concentrations in the Nine Mile Point vicinity of the lake (total coliform range of 0-121 cols/100 ml) indicate that the lake waters near Oswego Harbor are somewhat more polluted than other portions of the lake due to the pollutants carried by the Oswego River (LMS, 1975a). The average total coliform concentration in mixed offshore waters of the lake is approximately 1 col/100 ml (LMS, 1974).

Comparison of 1975 intake water quality to the proposed EPA water quality criteria reveals that the mean concentrations of two out of fifteen (15) applicable water quality parameters [ammonia nitrogen (NH_3N) and total phosphorus (TP)] exceeded the

TABLE II-7

WATER QUALITY STANDARDS AND CRITERIA

OSWEGO VICINITY

PARAMETER	UNITS	NYSDEC CLASS "A" STANDARDS[a]	NYSDEC CLASS "C" STANDARDS[b]	PROPOSED EPA WATER QUALITY CRITERIA
DISSOLVED OXYGEN	mg/l	$\geq$5.0[c]	$\geq$5.0[c]	FW: °C / DO Minimum 27.5-36 / 5.8 21 / 6.2 16 / 6.5 1.5-7.7 / 6.8
pH	units	6.5-8.5	6.5-8.5	FW 6.0-9.0 PS,R 5.0-9.0
AMMONIA-NITROGEN	mg/l	$\leq$1.6 (at pH 8.0 or above)	$\leq$1.6 (at pH 8.0 or above)	FW $\leq$0.016 PS $\leq$0.5
NITRATE-NITROGEN	mg/l	-	-	PS $\leq$10.0
TOTAL SUSPENDED SOLIDS	mg/l	-	-	FW $\leq$80
TOTAL PHOSPHORUS	mg/l-P	-	-	R $\leq$0.025 mg/l in lakes where P is limiting nutrient R $\leq$0.050 mg/l at point where a river enters a lake or reservoir R $\leq$0.100 mg/l for flowing stream
SULFATE	mg/l	-	-	PS $\leq$250
PHENOL	mg/l	$\leq$0.005	-	PS $\leq$0.001
CHROMIUM	mg/l	-	-	PS $\leq$0.05
IRON	mg/l	-	-	PS $\leq$0.3
CYANIDE	mg/l	$\leq$0.1	$\leq$0.1	PS $\leq$0.2
TOTAL DISSOLVED SOLIDS	mg/l	$\leq$500	None at concentration detrimental to aquatic life	-
COPPER	mg/l	$\leq$0.2	$\leq$0.2	PS $\leq$1.0
CADMIUM	mg/l	$\leq$0.3	$\leq$0.3	PS $\leq$0.01 FW $\leq$0.03 (Hard Water) FW $\leq$0.004 (Soft Water)
ZINC	mg/l	$\leq$0.3	$\leq$0.3	PS $\leq$0.5
TOTAL COLIFORM	cols/100 ml	$\leq$50 (geometric mean)	$\leq$10,000 (geometric mean)	FW $\leq$2000
FECAL COLIFORM	cols/100 ml	-	$\leq$2,000 (geometric mean)	R $\leq$2,000 (average) R $\leq$4,000 (maximum)

[a] Class A standards are applicable to Lake Ontario beyond the Oswego Harbor
[b] Class C standards are applicable to the Oswego River, Turning Basin, and Harbor
[c] The DO standard is $\geq$5.0 mg/l as a daily average and $\geq$4.0 mg/l at all times

- No applicable data available
FW - Propagation of freshwater aquatic life
PS - Uses of ater for public supply after normal treatment

WIND INDUCED CURRENTS*
OSWEGO VICINITY

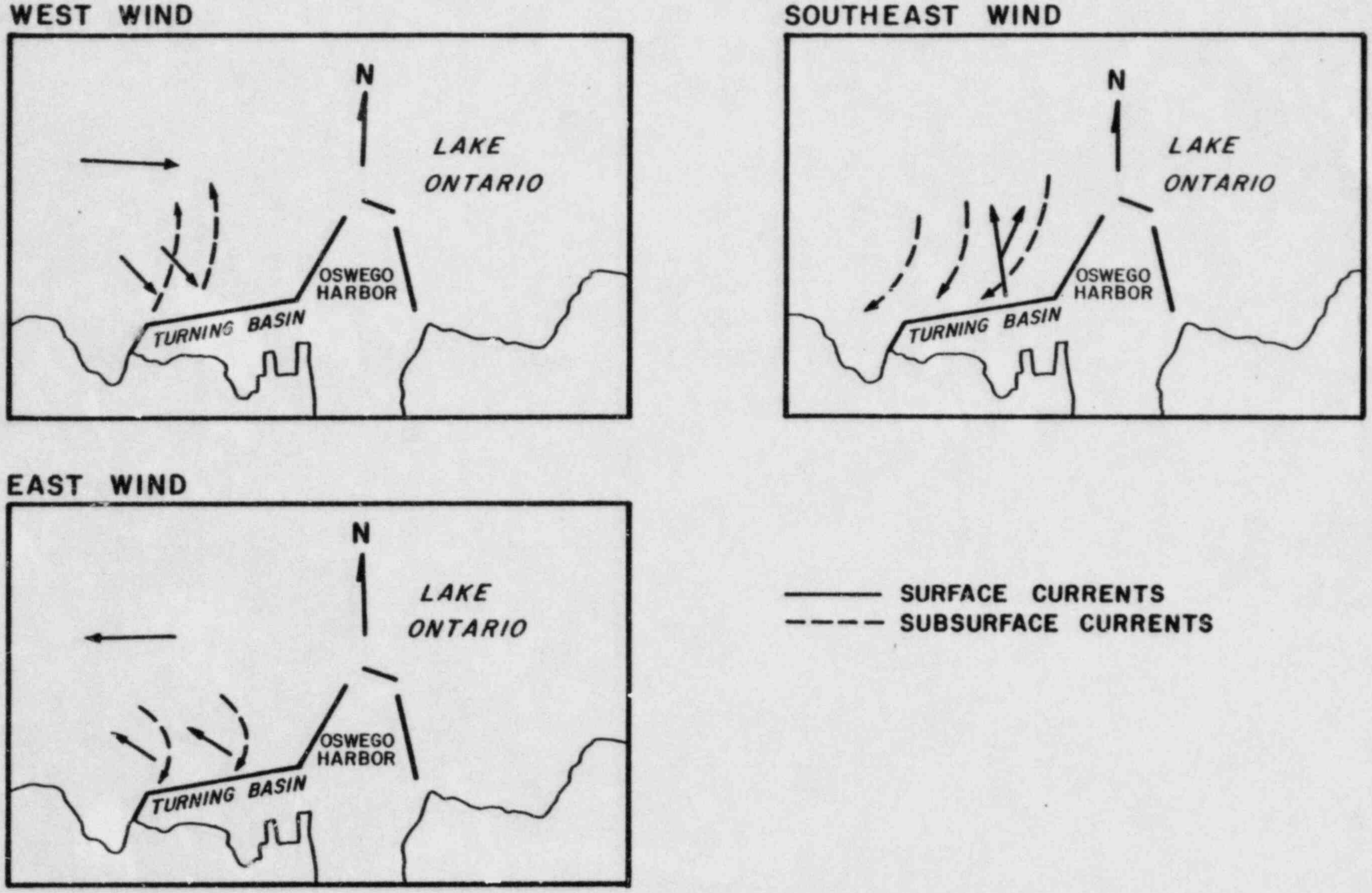


FIGURE II-4

*OLM, 1971

density gradients. Thus, wind movement of warmer surface waters may result in either upwellings of cold water or downwellings of warm water near the shoreline, depending upon wind direction.

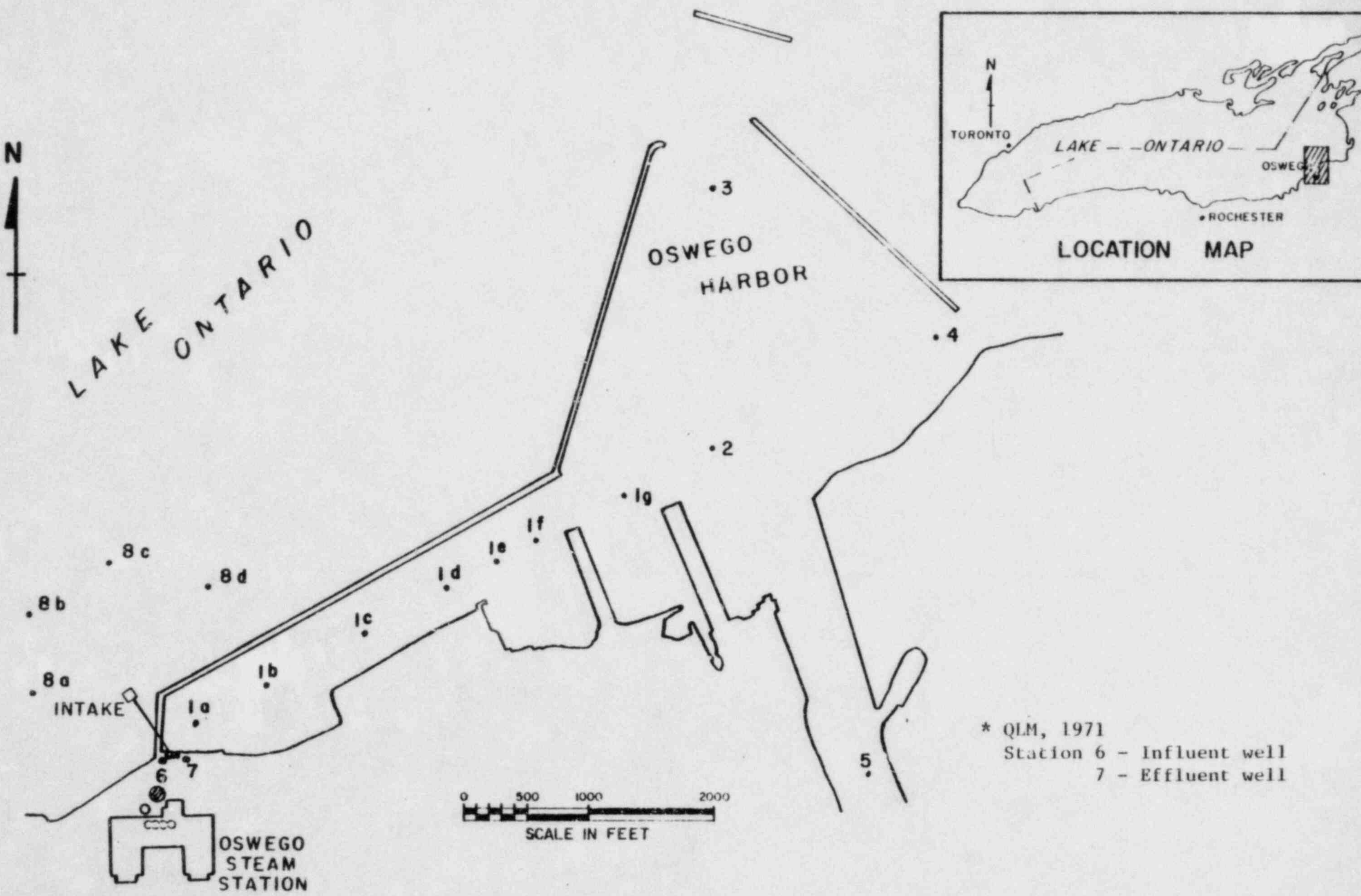
b. Water Quality

The results of water temperature and chemistry measurements made of the Oswego Harbor area and Lake Ontario in 1970 by the Lake Ontario Environmental Laboratory of the State University College in Oswego, New York, were presented by QLM in their 1971 report on the Oswego Steam Station (QLM, 1971). Figure II-5 indicates the water quality sampling locations monitored on a weekly basis from June through November 1970. The average concentrations of several of these selected parameters measured in the vicinity of the intake of Units 1-4 are summarized in Table II-5. A comparison of these 1970 water quality measurements with the water quality measurements made by LMS in the Unit 1-4 intake structure from January 1975 to March 1976 (Table II-6) indicates a general pattern of improvement in water quality from 1970 to 1975, particularly with regard to such constituents as DO, pH, total solids (TS), total dissolved solids (TDS), and orthophosphate (PO_4P). Nevertheless, increases in the concentrations of biochemical oxygen demand (BOD), total suspended solids (TSS), and ammonia (NH_3) are also noted between 1970 and 1975.

A comparison of the 1975-1976 water quality measurements made within the intake of Units 1-4 at the Oswego Steam Station with the 1975 water quality measurements made in the Nine Mile Point area of Lake Ontario (Appendix D; LMS, 1976a) reveals the existence of generally similar water quality at both locations. Lake Ontario waters near the Oswego Steam Station have somewhat higher BOD, TS, TDS, and PO_4P than the waters in the Nine Mile Point vicinity, which probably reflects the influence of the Oswego River inflow.

Water temperature at the Oswego Steam Station intake, as measured from January to December 1975, ranged between 0.1 to 23.0°C (32.2-73.4°F) with a mean of 10.1°C (50.2°F). Bottom water temperatures in the Nine Mile Point vicinity of the lake, measured from April to December 1975, averaged slightly more than 1°C (1.8°F) warmer than those recorded during the same time period at Oswego. Temperatures in bottom lake waters near Oswego Harbor in 1970 (July through November) averaged 16.3°C (61.4°F), or approximately 2.5°C (4.5°F) higher than temperatures measured during a comparable time period in 1975 in the Units 1-4 intake (Figure II-6).

CHEMICAL AND TEMPERATURE SAMPLING LOCATIONS*
OSWEGO VICINITY – 1970



* QLM, 1971
Station 6 - Influent well
7 - Effluent well

FIGURE II-5

INTAKE AND DISCHARGE WATER TEMPERATURE

OSWEGO STEAM STATION UNITS 1-4 – 1975-1976

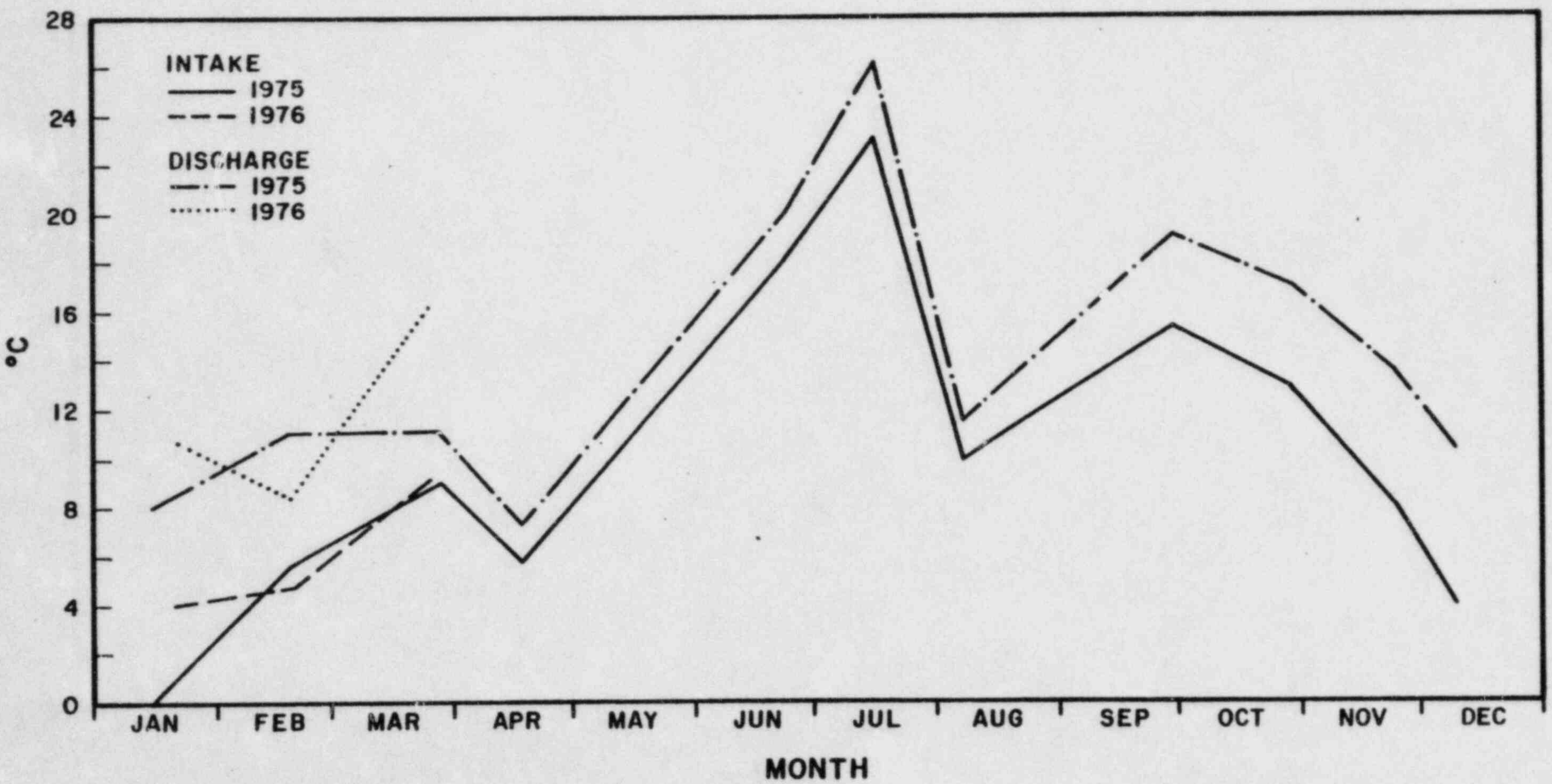


FIGURE II-6

TABLE II-5

MEAN CONCENTRATIONS OF SELECTED PARAMETERS*

OSWEGO STEAM STATION UNITS 1-4 - JUNE-NOVEMBER 1970

PARAMETER	UNIT	MEAN CONCENTRATION
DISSOLVED OXYGEN	mg/l	9.6
BIOCHEMICAL OXYGEN DEMAND	mg/l	1.89
pH	units	9.0
TEMPERATURE	°C	18.4
TOTAL SOLIDS	mg/l	262
SUSPENDED SOLIDS	mg/l	5.5
DISSOLVED SOLIDS	mg/l	255.8
VOLATILE SOLIDS	mg/l	7.1
CHLORIDE	mg/l	58.7
NH_3 (AS N)	mg/l	0.014
TOTAL PO_4 (AS P)	mg/l	0.026

*QLM, 1971

TABLE II-6

SUMMARY OF WATER QUALITY CHARACTERISTICS

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

PARAMETER	UNIT	MAXIMUM		MINIMUM		MEAN		STANDARD DEVIATION		NO. OF SAMPLES	
		INTAKE	DISCHARGE	INTAKE	DISCHARGE	INTAKE	DISCHARGE	INTAKE	DISCHARGE	INTAKE	DISCHARGE
pH	units	8.7	8.6	7.5	7.5	8.1	8.1	0.4	0.3	15	15
SPC	mho/cm at 25°C	533	546	245	265	320	332	65	66	15	15
T	°C	23.0	26.0	0.1	7.3	9.2	13.6	6.2	5.4	14	14
ALK	mg/l	108.0	106.0	81.0	83.0	91.6	92.3	7.6	6.7	8	8
DO	mg/l	13.7	13.3	7.8	8.6	11.9	11.5	1.7	1.4	15	15
TBOD	mg/l	6	5	2	0	3	3	1	1	15	15
TCOD	mg/l	24	22	1	3	12	12	8	6	8	8
TS	mg/l	336	327	188	195	221	228	49	42	8	8
TDS	mg/l	243	241	177	169	198	203	21	22	8	8
TVS	mg/l	76	86	45	49	62	66	10	14	8	8
TSS	mg/l	93	86	2	2	20	22	24	24	15	15
NH_3N	mg/l	0.30	0.30	0.00	0.00	0.10	0.10	0.13	0.12	12	12
NO_3N	mg/l	0.49	0.47	0.02	0.06	0.29	0.27	0.16	0.15	15	15
PO_4	mg/l P	0.04	0.06	0.00	0.00	0.02	0.02	0.02	0.02	15	15
TP	mg/l P	0.07	0.08	0.02	0.02	0.04	0.05	0.02	0.02	8	8
PHL	mg/l	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8	8
Cl	mg/l	39	52	25	25	29	32	5	9.44	8	8
SO_4	mg/l	44.0	46.0	16.0	20.0	25.9	27.5	8.8	8.7	8	8
TCOL	cols/100ml	380	448	5	2	85	113	102	133	13	14
FCOL	cols/100ml	274[a]	927[b]	0	0	45[a]	123[b]	74	252	14	14
TKN	mg/l	1.20	0.70	0.05	0.30	0.65	0.54	0.37	0.14	8	8
CR	mg/l	<0.10	<0.10	<0.10	<0.10	–[c]	–[c]	–	–	8	8
MG[d]	mg/l	9.10	9.73	7.40	7.48	8.15	8.41	0.70	0.96	7	7
NA	mg/l	33.50	32.60	12.00	11.00	18.28	18.50	7.46	7.07	8	8
V	mg/l	<0.2	<0.2	<0.2	<0.2	–[c]	–[c]	–	–	8	8
ZN	mg/l	0.070	0.020	<0.003	<0.003	–[c]	–[c]	–	–	8	8
O+G	mg/l	7.0	NA	<0.1	NA	3.1	NA	5.6	NA	7	NA

NA - Not available

\- Not applicable

[a] A value of 964 measured on 16 July 1975 was not included since this 964 cols/100 ml of fecal coliform would have exceeded the TCOL count of 95 cols/100 ml.

[b] A value of 166 cols/100 ml of fecal coliform measured on 23 June 1975 was not used since it would have exceeded the measured TCOL count of 70 cols/100 ml for that same date and station

[c] If greater than 75% of samples below detection limit, no mean was calculated

[d] Erroneously recorded results in April not included

proposed criteria; that is, the recorded concentrations were above values of $\leq$0.016 mg/l for NH_3N in fresh waters and $\leq$ 0.025 mg/l for TP in lakes where phosphorus may be acting as the limiting nutrient in algal growth. One parameter, TSS, at some times exceeded the proposed criteria of $\leq$80 mg/l, although its mean concentration of 20 mg/l was below the maximum criterion. The high concentrations of TSS, TP, and NH_3N again may reflect the influence of the Oswego River and its many wastewater inputs.

c. Intake-Discharge Water Quality Characteristics

A summary of the maximum, minimum, mean, and standard deviation of the concentrations of parameters measured in both the intake and discharge structures of Units 1-4 from January 1975 to March 1976 is presented in Table II-6. The temperature rise of the cooling water averaged 4.5°C (8.1°F) based on a yearly period from January through December. These results are consistent with the independent data on temperature recorded by the Niagara Mohawk Power Corporation at the intake and discharge of Units 1-4 (Table II-2). This increase in water temperature from intake to discharge generally resulted in a concomitant slight decrease in DO, except during the summer (July, August and September) when initially low concentrations of DO in the intake were raised, despite temperature increases. Such an increase in DO concentrations between intake and discharge was probably the result of mechanical aeration of the water as it passed through the cooling system, exceeding any losses of DO due to temperature rises.

Increases in the concentration of total and fecal coliforms during passage from the cooling water intake to the discharge (Figure II-7) may reflect enhanced bacterial growth due to temperature increases within the system.

The slight but consistent increases in magnesium (Mg) and the general increases in chlorides (Cl) and SPC between the intake and the discharge (Figure II-8) may be a result of chemicals added to intake water as part of a treatment process.

2. Oswego River

a. Flow

Oswego River flows are monitored by the NYSDEC in the City of Oswego at Bridge Street (river mile point 0.6), and during the period from May 1964 to September 1974 they averaged 6,660 cfs (NYSDEC, 1976). The long-term average flow based on the 33-year

TOTAL AND FECAL COLIFORM CONCENTRATIONS
OSWEGO STEAM STATION UNITS 1-4 — 1975-1976

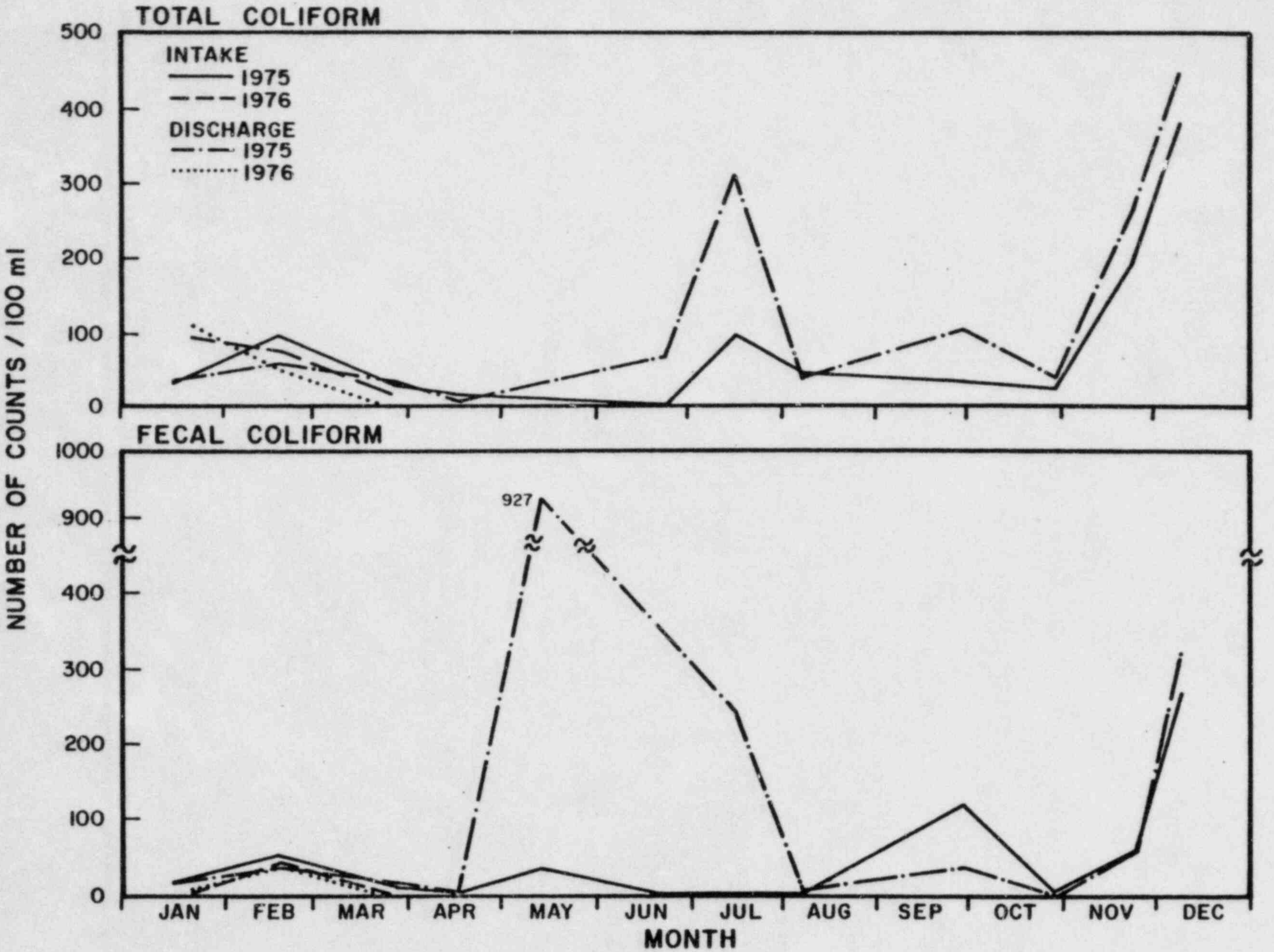
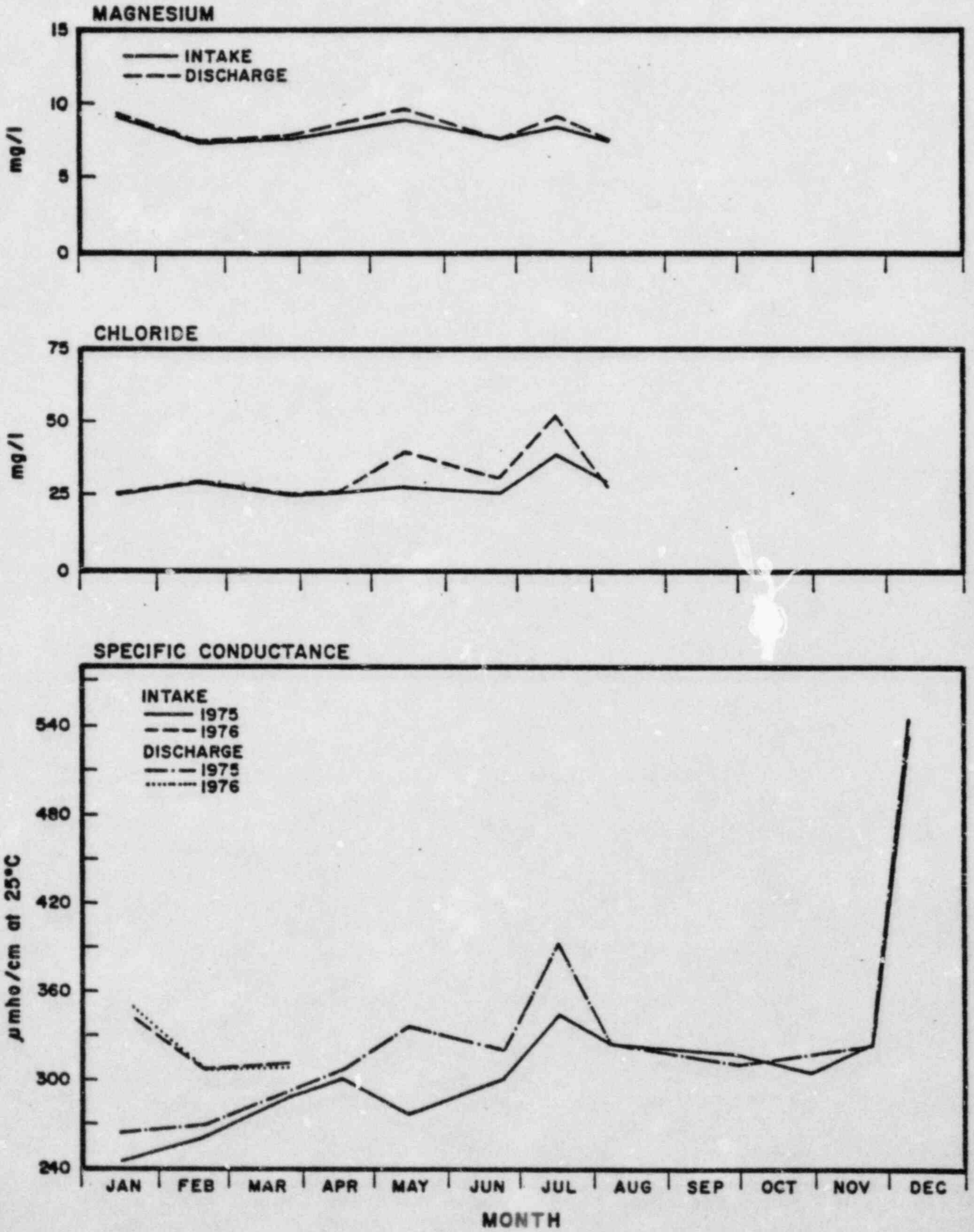


FIGURE II-7

FIGURE II-8

CONCENTRATIONS OF MAGNESIUM, CHLORIDE AND SPECIFIC CONDUCTANCE

OSWEGO STEAM STATION UNITS 1-4—1975-1976



period from 1933 to 1967 was 6,137 cfs. The maximum flow on record of 37,500 cfs occurred on 28 March 1936 and the minimum flow of 353 cfs occurred on 14 August 1949. The minimum average seven-consecutive-day flow with a once-in-ten-year recurrence frequency is 720 cfs (LMS, 1975a). Figure II-9 presents the average monthly flow of the period from May 1964 to September 1974. The lowest average flow, 2,512 cfs, occurred in July; and November had the highest average flow of 13,700 cfs.

b. Water Quality

Sampling of the water quality of the Oswego River has been conducted since May 1964 by the NYSDEC at Bridge Street (MP 0.6) in the City of Oswego; Table II-8 presents a summary of the measured average monthly concentrations of water quality parameters. LMS also conducted a water quality sampling program at the same location on the Oswego River from April to August 1975. Figure II-10 presents the seasonal variation of temperature (°C) and DO within the Oswego River as measured by both LMS and the NYSDEC. As expected, temperature fluctuations of the Oswego River were greater than those of Lake Ontario (Figure II-6). Since the Oswego River is relatively small, its waters heat and cool more rapidly than those of the larger water body; the Oswego River also has generally higher summer temperatures and lower winter temperatures than the lake.

The Oswego River, which traverses through urban, suburban and rural areas within its 1,3204 km^2 (5,098 sq mi) drainage basin, receives a large variety and amount of discharges, including domestic and industrial wastewater and urban and agricultural runoff. Therefore, it is not difficult to understand why water quality of the Oswego River often does not meet the NYSDEC Class C standards (Table II-7) and also often fails to meet several EPA proposed criteria.

Examination of DO concentration data collected by the NYSDEC and by LMS indicates that the waters of the Oswego River at times do not meet the proposed EPA freshwater criterion for that parameter and may be violating the NYSDEC minimum average daily DO standard of 5.0 mg/l, although no violation of the 4.0 mg/l instantaneous DO standard was recorded. Low concentrations of DO (i.e., 4-5 mg/l) are particularly likely to occur during the summer months (June, July, August, and September) of high temperature and low river flow. The average monthly percent of DO saturation, as calculated from the data obtained by the NYSDEC for 1964 to 1974, ranged from a high of 101% in April to a low of 75% in July.

Ammonia-nitrogen (NH_3N), pH, and total coliform concentrations also violated Class C standards at some times. Although the

TABLE II-8

MEAN MONTHLY WATER QUALITY[a] OF OSWEGO RIVER AT BRIDGE STREET (M.P.0.6)

PARAMETERS	UNITS	JAN		FEB		MAR		APR		MAY		JUN	
pH	units	7.4	(2)	7.4	(5)	7.6	(7)	7.7	(7)	8.1	(12)	7.9	(16)
BOD_5	mg/l	4.1	(2)	3.5	(5)	3.9	(6)	3.3	(7)	3.2	(12)	2.6	(16)
DO	mg/l	12.5	(2)	13.4	(5)	12.0	(7)	12.0	(7)	10.0	(12)	8.0	(16)
TCOL	cols/100 ml	11000	(2)	5838	(5)	24334	(7)	66679	(7)	19592	(12)	57210	(16)
FCOL	cols/100 ml	-		-		-		-		120	(1)	75	(1)
NH_3N	mg/l	0.871	(2)	0.859	(3)	0.886	(4)	0.429	(5)	0.465	(8)	0.491	(11)
NO_3N	mg/l	0.33	(2)	0.61	(3)	0.65	(4)	0.44	(5)	0.45	(8)	0.34	(11)
PO_4P	mg/l	0.12	(2)	0.13	(3)	0.20	(4)	0.07	(5)	0.10	(8)	0.09	(11)
SO_4	mg/l	74.5	(2)	88.3	(3)	82.6	(4)	67.2	(5)	77.3	(8)	71.4	(11)
NA	mg/l	92.5	(2)	98.7	(3)	99.8	(4)	72.4	(5)	68.8	(8)	83.6	(11)
COD	mg/l	11.0	(2)	14.7	(3)	15.1	(4)	15.8	(4)	19.8	(8)	22.0	(11)
SPC	mhos cm at 25°C	976	(2)	951	(3)	853	(4)	725	(5)	781	(8)	729	(10)
ALK	mg/l as $CaCO_3$	128	(1)	125	(2)	125	(2)	102	(5)	115	(6)	147	(10)
TS	mg/l	780	(2)	700	(3)	639	(4)	692	(5)	597	(8)	632	(11)
TSS	mg/l	17	(2)	8	(3)	24	(4)	29	(4)	32	(8)	33	(11)
TDS	mg/l[b]	764	(2)	691	(3)	615	(4)	650	(4)	548	(8)	564	(11)
MG	mg/l	12.3	(2)	11.2	(3)	14.1	(4)	8.3	(4)	13.0	(8)	11.0	(11)
T	°C	0.5	(2)	0.5	(5)	1.9	(7)	8.0	(7)	14.5	(12)	20.5	(16)
% DO SATURATION		87		93		87		101		97		88	

[a]NYSDEC, 1976
[b]By subtraction
( ) - No. of samples

TABLE II-8 (Continued)

MEAN MONTHLY WATER QUALITY[a] OF OSWEGO RIVER AT BRIDGE STREET (M.P.0.6)

PARAMETERS	UNITS	JUL		AUG		SEP		OCT		NOV		DEC	
pH	units	8.0	(14)	8.3	(14)	8.1	(13)	7.8	(13)	7.7	(8)	7.5	(4)
BOD_5	mg/l	2.6	(13)	3.3	(14)	3.4	(13)	3.5	(13)	3.2	(8)	2.9	(4)
DO	mg/l	6.5	(13)	6.9	(14)	7.7	(13)	9.4	(13)	4.4	(8)	12.7	(4)
TCOL	cols/100 ml	133846	(13)	98324	(14)	198375	(12)	24310	(11)	19135	(8)	9200	(4)
FCOL	cols/100 ml	80	(1)	45	(1)	190	(1)	-		-		-	
NH_3N	mg/l	0.432	(9)	0.298	(10)	0.35	(10)	0.356	(11)	0.504	(6)	0.277	(2)
NO_3N	mg/l	0.39	(9)	0.23	(10)	0.22	(10)	0.38	(11)	0.36	(6)	0.35	(2)
PO_4P	mg/l	0.16	(9)	0.17	(10)	0.19	(10)	0.16	(10)	0.29	(6)	0.16	(2)
SO_4	mg/l	73.3	(8)[c]	80.4	(10)	77.1	(10)	77.8	(11)	76.2	(6)	65.0	(2)
NA	mg/l	133.4	(9)	113.9	(9)	149.7	(10)	112.5	(11)	171.2	(6)	46.8	(2)
COD	mg/l	18.6	(9)	26.9	(10)	21.2	(10)	25.7	(9)	31.3	(6)	23.3	(2)
SPC	μmhos cm at 25°C	1064	(9)	1189	(10)	1276	(10)	1274	(11)	960	(6)	536	(2)
ALK	mg/l as $CaCO_3$	108	(9)	103	(10)	104	(10)	110	(10)	105	(4)	116	(1)
TS	mg/l	861	(9)	957	(10)	1006	(10)	1019	(10)	823	(6)	491	(2)
TSS	mg/l	27	(9)	27	(10)	28	(10)	28	(9)	23	(6)	12	(2)
TDS	mg/l[b]	836	(9)	930	(10)	978	(10)	893	(9)	800	(6)	479	(2)
MG	mg/l	12.1	(9)	17.0	(10)	17.3	(10)	15.0	(10)	13.4	(6)	11.0	(1)
T	°C	23.4	(13)	24.0	(14)	20.8	(14)	14.2	(14)	6.7	(8)	2.4	(4)
% DO SATURATION		75		81.		85		91		93		93	

[a]NYSDEC, 1976

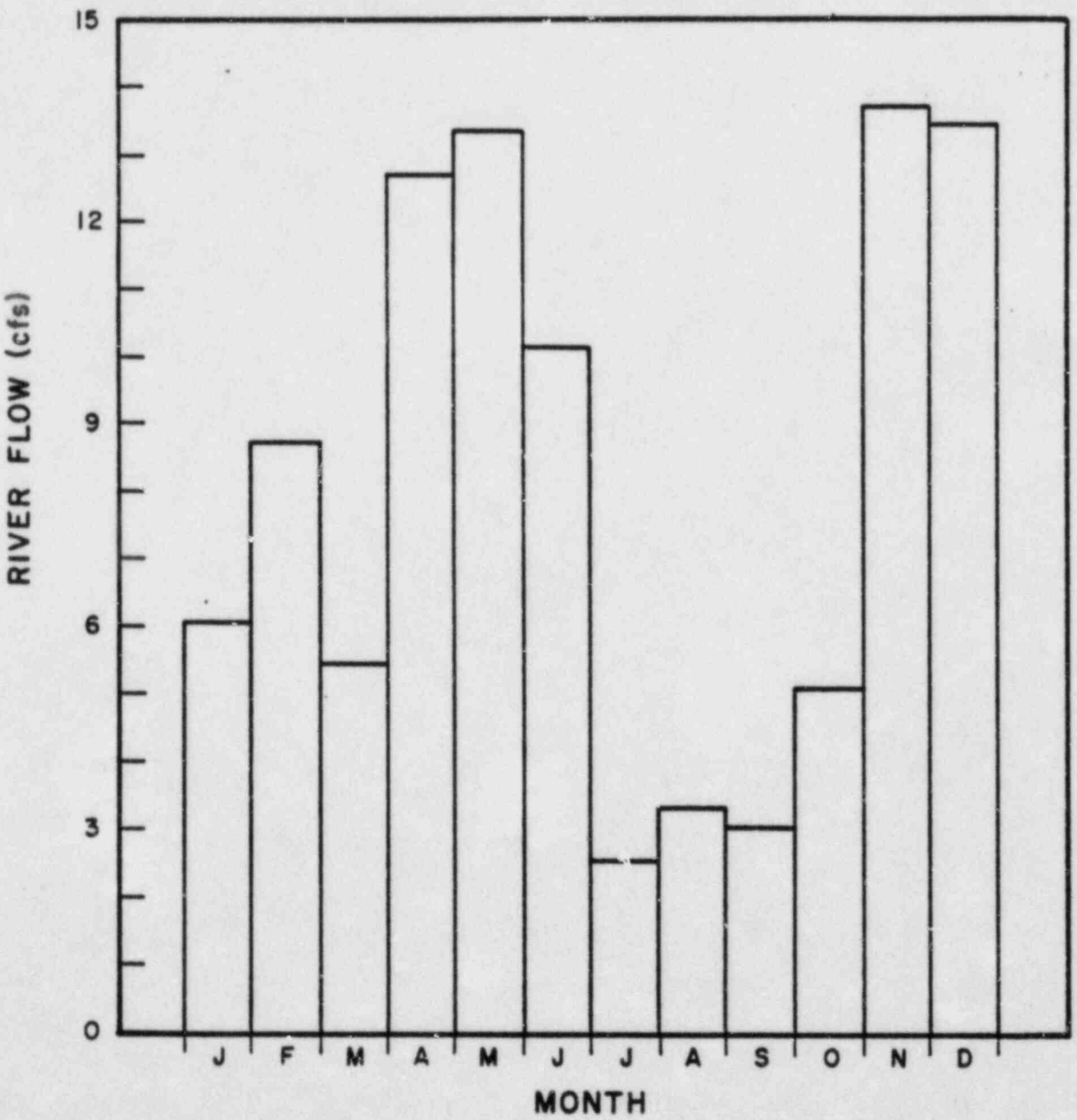
[b]By subtraction

[c]Note an erroneously high value of 694 mg/l for July 1966 was not included in the July SO_4 mean

( ) - No. of samples

MEAN MONTHLY OSWEGO RIVER FLOW*

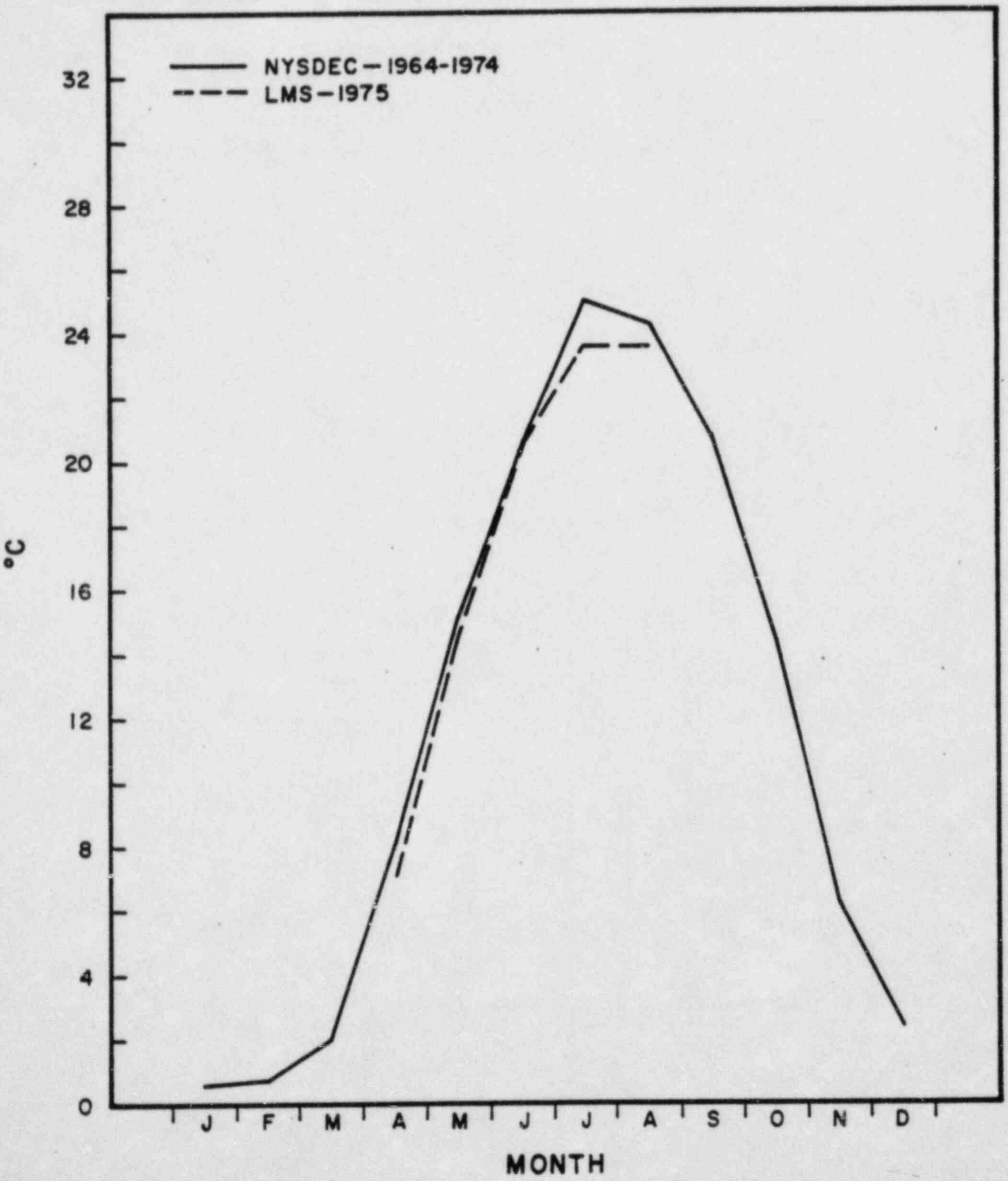
MAY 1964 — SEPTEMBER 1974



*NYSDEC, 1976

MEAN MONTHLY OSWEGO RIVER TEMPERATURES

1964-1974 AND 1975



average pH measured by the NYSDEC from 1964 to 1974 was 7.8, pH values of above 8.5 were also recorded. The NYSDEC standard for NH_3N of $\leq$ 1.6 mg/l was exceeded several times, particularly during the period prior to 1968; concentrations of NH_3N have markedly improved in recent years to levels well below the allowable maximum.

Although the sampling frequency for total coliform, used by the NYSDEC and LMS, is insufficient for direct comparison of the data to the Class C standard, it would appear that the standard for total coliform is being violated at some times (Figure II-11). Again, marked improvement in the concentration of total coliform is noted when the concentrations measured in 1975 are compared to those of previous years. Of the proposed EPA water quality criteria, three, including the standards for NH_3N, total phosphorus (TP), and total coliform, were at some times exceeded within the Oswego River.

In comparing overall water quality between Lake Ontario and the Oswego River, several differences (other than temperature, which has already been discussed) are noteworthy. The concentration of such ions as sodium (Na), magnesium (Mg), sulfate (SO_4) and chloride (Cl), as well as SPC and total dissolved solids (TDS) (which are the measures of such ions and other dissolved substances) are much higher for the river than for the lake. Greater pollutional influences upon the river than on the lake are seen in the greater concentration of such constituents as ammonia-nitrogen (NH_3N), nitrate-nitrogen (NO_3N), and phosphate-phosphorus (PO_4P) in the river as compared to the lake.

3. Oswego Turning Basin and Harbor

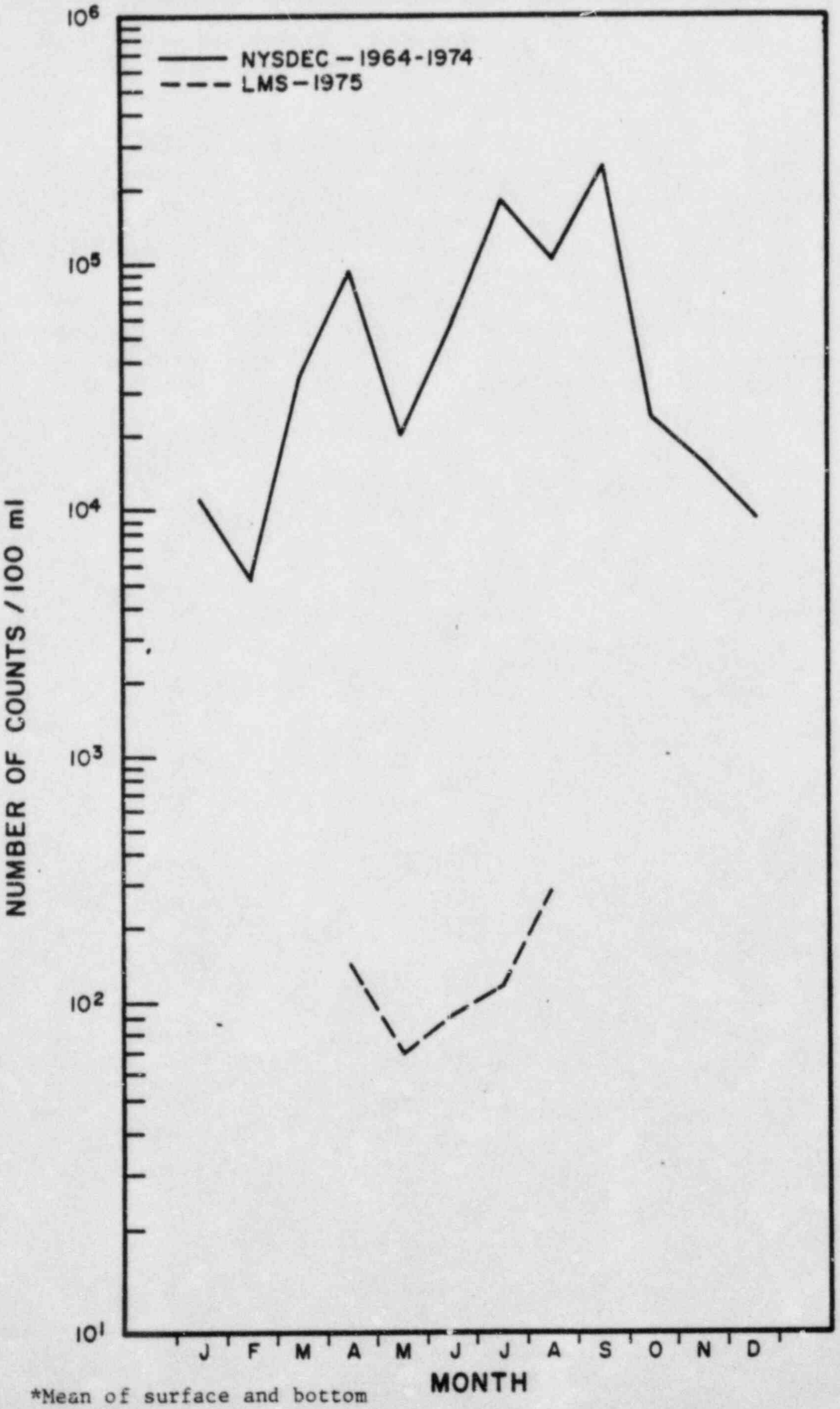
a. Currents

The currents within the Oswego Turning Basin and Harbor, particularly as they are influenced by temperature, have been examined by QLM in 1970 and by LMS in 1975 and 1976 (see Chapter III). The Corps of Engineers (COE), in their draft environmental impact statement for proposed dredging operations in Oswego Harbor, described the effects of wind speed and direction on currents within Oswego Harbor (COE, 1975).

Currents within Oswego Harbor are the result of a complex interaction of wind, river flow, and lake water (QLM, 1971). Differences in temperature and total dissolved solids between the river and the lake create density gradients which in turn set up current patterns influenced by wind speed and direction.

FIGURE II-11

MEAN MONTHLY TOTAL COLIFORM CONCENTRATIONS* IN THE OSWEGO RIVER 1964-1974 AND 1975



*Mean of surface and bottom

River flow is always the major factor in the formation of currents in Oswego Harbor; its predominant influence is apparent when no density gradients and therefore no stratification exists between river and lake water in the harbor. When significant density gradients do exist, lake waters may move into the harbor, depending on the strength of the river flow, either at the bottom of the water column (if lake water is denser) or at the top of the water column (if river water is denser) [QLM, 1971; LMS, 1975b; LMS, 1976b; LMS, 1976c]. The influence of the interactions of wind direction and river flow on currents in the Oswego Harbor is shown in Figure II-12 (COE, 1975).

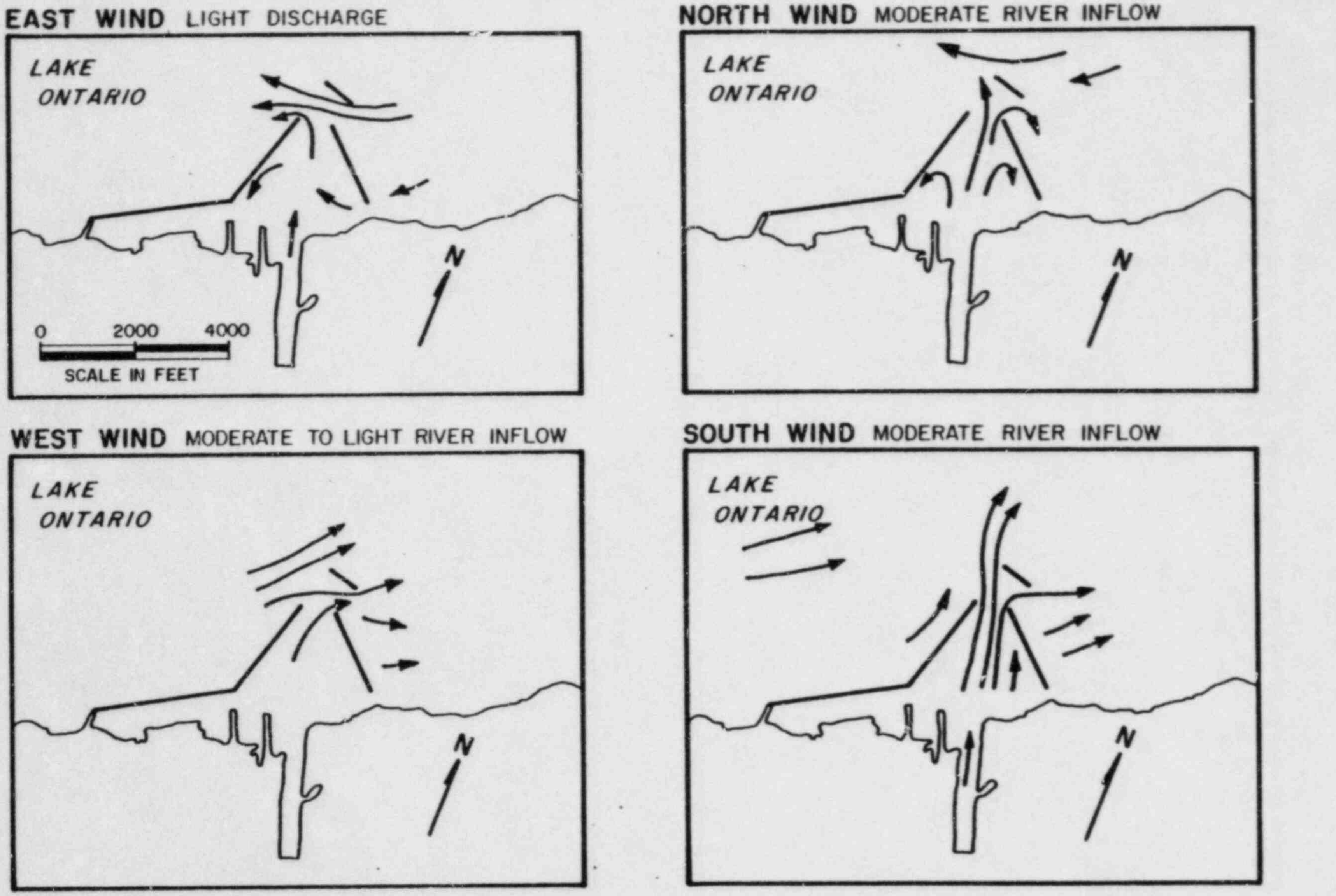
b. Water Quality

A summary of the maximum, minimum, mean, and standard deviation of the concentration of water quality constituents measured by LMS in the Oswego Harbor and Turning Basin at both surface and bottom stations from April 1975 to March 1976 is presented in Table II-9. The following section on water quality discusses: a) those water quality parameters of particular importance to biological communities (e.g., temperature, DO, nitrogen, and phosphorus); b) those water quality parameters dealing with dissolved ion concentrations (e.g., Na, SO_4, SPC, and TDS); c) those water quality parameters measuring pollutional influences (BOD, COD, TCOL, and FCOL); d) those water quality parameters measuring the occurrence of toxic heavy metals; and d) the influence of TSS on the operation of the Oswego Steam Station.

Average yearly surface and bottom water temperatures in the turning basin and harbor were highest at the western end of the turning basin, reflecting the entrance of the thermal discharge of Oswego Units 1-4 at this point. As expected, average surface temperatures were higher than bottom temperatures throughout the basin, reflecting the influence of both the thermal discharge and the generally warmer waters of the Oswego River. Within the eastern section of Oswego Harbor, the influence of the thermal discharge on temperatures diminished as the effects of encroaching lake waters became more pronounced. The formation of temperature patterns influenced by thermal discharge of Oswego Units 1-4, the Oswego River, and Lake Ontario are discussed in Chapter III and in Appendix B.

Concentrations of DO within the turning basin and harbor are primarily a function of temperature and water source and vary seasonally (Figure II-13; Appendix D). Both temperature and DO concentrations showed greater variation in surface than in bottom waters, with the lowest DO concentration (6.7 mg/l)

WATER CURRENTS IN OSWEGO HARBOR *



*U.S. Army Corps of Engineers, Buffalo District

FIGURE II-12

SURFACE CONCENTRATIONS OF TEMPERATURE AND DISSOLVED OXYGEN

OSWEGO TURNING BASIN – 1975-1976

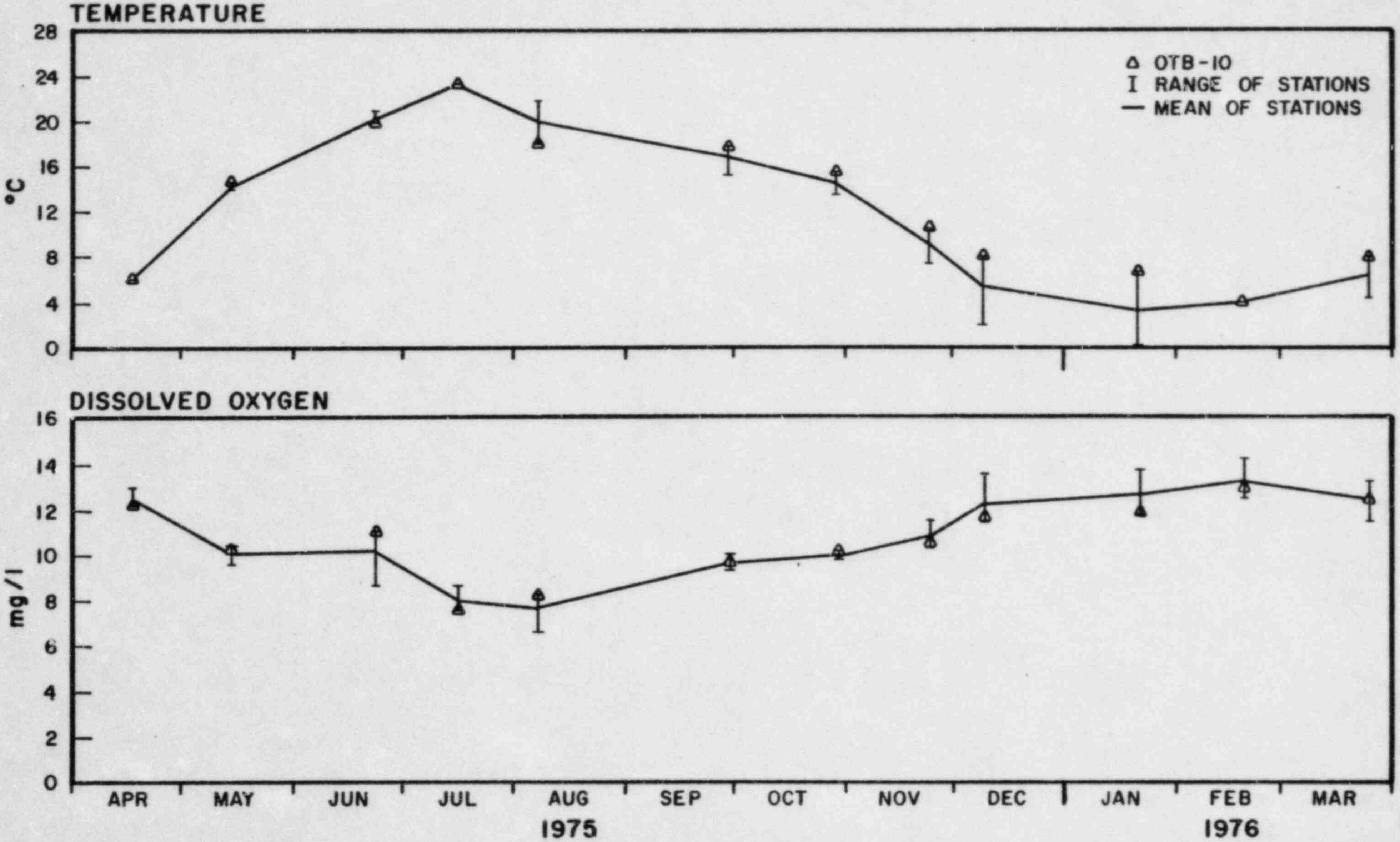


FIGURE II-13

recorded at Station 4 (Figure II-13) at the eastern end of the turning basin. All measured DO concentrations met both the NYSDEC Class C standards and EPA proposed criteria. DO concentrations were generally higher in the harbor than in the turning basin, although no significant differences in DO concentration existed within different portions of the turning basin.

The yearly average percent of DO saturation for all stations (surface and bottom) was approximately 99%, with Stations 5 and 6, on the eastern end of the turning basin, having the lowest yearly average DO saturation of 96%.

Concentrations of nitrogen and phosphorus, two important algal nutrients, were high in both the harbor and the turning basin. The Oswego River and local inputs of domestic sewage and other wastewaters and runoff contributed to the high average concentrations of these nutrients (Table II-9).

Figure II-14 shows the fluctuations of surface concentrations of orthophosphate (PO_4P), total phosphorus (TP), and nitrate-nitrogen (NO_3N) within the turning basin and harbor which influence the seasonal fluctuations in biological populations, particularly algae. Concentrations of TP, PO_4P, and NO_3N were lowest during periods of high biological activity, i.e., late spring, summer, and early fall. Fluctuations in the bottom concentrations of these parameters generally followed the same pattern as surface fluctuations except that average concentrations were somewhat higher in bottom waters, particularly those for TP. High bottom concentrations of TP reflect the higher amounts of soluble inorganic phosphorus which has settled to the bottom water layers. Average concentrations of TP (0.05 mg/l at surface, 0.07 mg/l at bottom) equal or exceed the proposed EPA criterion of $\leq$0.050 mg/l TP at the point where a river enters a lake or reservoir in which phosphorus is the limiting nutrient. Concentrations of NH_3N met the NYSDEC standards of $\leq$ 1.6 mg/l (at pH 8.0 or above) but exceeded the EPA proposed maximum concentration of 0.016 mg/l NH_3N for fresh waters.

The concentration of such ions as sodium (Na), chloride (Cl), and sulfate (SO_4), as well as SPC and TDS, decreased markedly proceeding from the Oswego River, through the harbor, then to the eastern end of the turning basin, and finally to the western end of the turning basin as the influence of lake waters from the thermal discharge of Oswego Units 1-4 became greater. Concentrations of Mg ions generally followed the same pattern of

TABLE II-9

SUMMARY OF WATER QUALITY CHARACTERISTICS FOR STATIONS OTB-4, OTB-6, AND OTB-10

OSWEGO TURNING BASIN - APRIL 1975-MARCH 1976

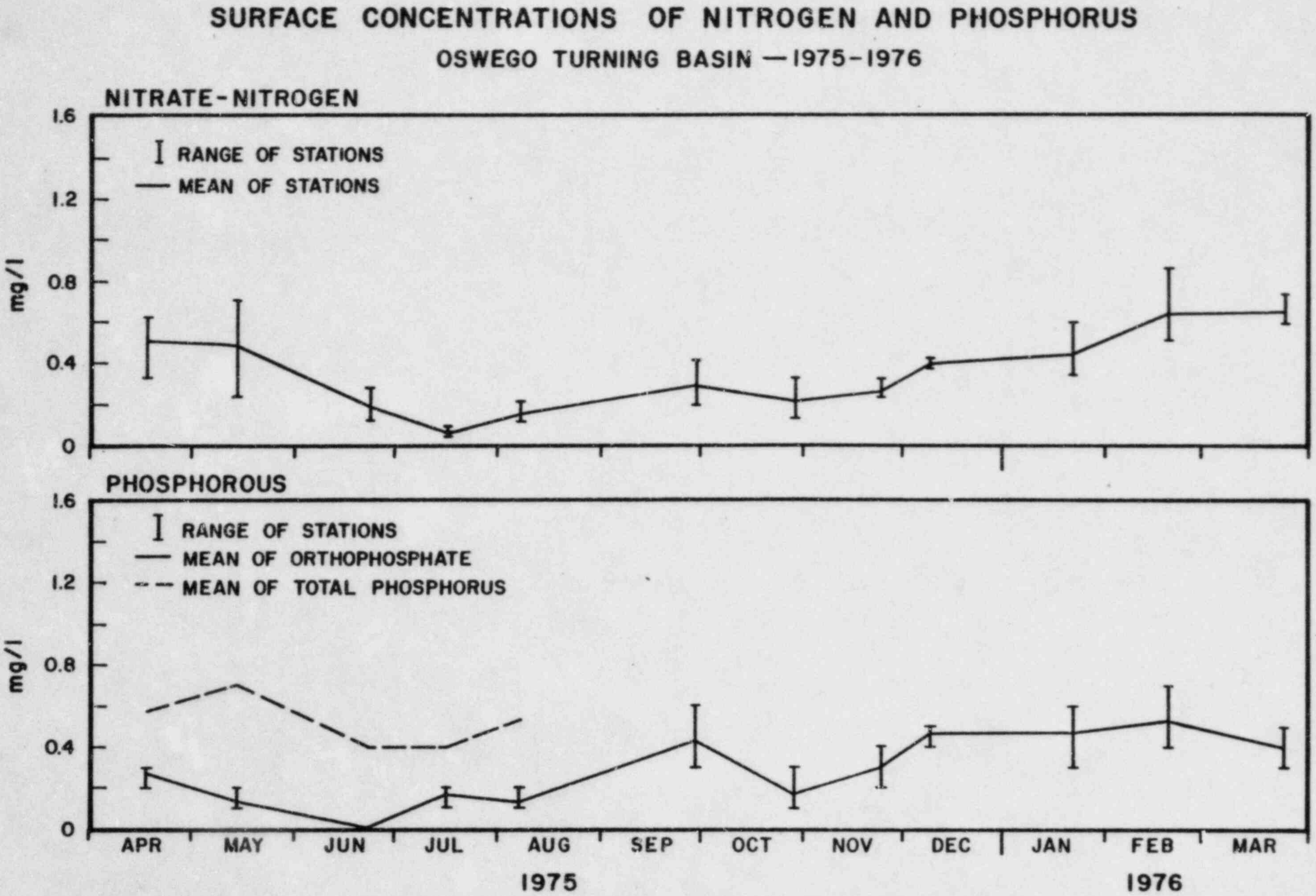
PARAMETER	UNIT	DEPTH	NO. OF SAMPLES	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
pH	unit	S	36	8.6	7.6	8.1	0.2
		B	36	8.5	7.8	8.1	0.2
SPC	μmho/cm at 25°C	S	36	961	319	517	160
		B	36	817	308	528	151
T	°C	S	36	23.5	0	12.0	7.1
		B	33	17.8	0	9.2	5.1
ALK	mg/l	S	15	118.0	81.0	98.0	12.0
		B	15	117.0	82.0	98.0	14.0
DO	mg/l	S	36	14.3	6.7	10.8	1.9
		B	36	14.4	7.1	11.0	1.8
TBOD	mg/l	S	36	5	1	3	1
		B	36	5	0	3	1
TCOD	mg/l	S	15	31	8	20	7
		B	15	26	6	16	6
TS	mg/l	S	15	674	199	364	129
		B	15	435	196	304	91
TDS	mg/l	S	15	663	195	347	129
		B	15	405	175	276	87
TVS	mg/l	S	15	232	43	111	45
		B	15	145	15	80	34
TSS	mg/l	S	36	29	3	11	6
		B	36	168	3	27	31
NH_3N	mg/l	S	15	0.40	0.10	0.26	0.10
		B	15	0.40	0.10	0.25	0.09
NO_3N	mg/l	S	36	0.86	0.05	0.36	0.21
		B	36	0.91	0.04	0.41	0.22
PO_4-P	mg/l-P	S	36	0.07	0.00	0.03	0.02
		B	36	0.14	0.00	0.04	0.03

TABLE II - 9 (Continued)

SUMMARY OF WATER QUALITY CHARACTERISTICS
FOR STATIONS OTB-4, OTB-6, AND OTB-10

PARAMETER	UNIT	DEPTH	NO. OF SAMPLES	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
TP	mg/l-P	S	15	0.08	0.03	0.05	0.02
		B	15	0.14	0.02	0.07	0.04
PHL	mg/l	S	15	0.013	0.000	0.001	0.003
		B	15	0.000	0.000	0.000	0.000
Cl	mg/l	S	15	191	31	85	47
		B	15	110	30	60	29
SO_4	mg/l	S	15	67	22	43	14
		B	15	57	21	37	10
TCOL	cols/100 ml	S	31	19200	52	6413	5365
		B	31	12400	44	3797	3801
FCOL	cols/100 ml	S	36	6740	94	1617	1517
		B	36	2860	16	794	777
TKN	mg/l	S	15	1.10	0.40	0.74	0.23
		B	15	1.10	0.20	0.66	0.26
CR	mg/l	S	15	<0.10	<0.10	*	*
		B	15	<0.10	<0.10	*	*
MG	mg/l	S	15	13.00	7.80	10.20	1.41
		B	15	11.80	7.80	9.58	1.56
NA	mg/l	S	15	79.00	17.80	39.77	17.68
		B	15	50.00	11.00	27.99	11.81
V	mg/l	S	15	<0.20	<0.20	*	*
		B	15	<0.20	<0.20	*	*
ZN	mg/l	S	15	.084	<0.010	<0.019	0.019
		B	15	.064	<0.010	<0.019	0.014
O+G	mg/l	S	21	16.9	0.2	3.8	4.4

*Mean and standard deviation not calculated since >75% of samples are below detection limit



SURFACE CONCENTRATIONS OF NITROGEN AND PHOSPHORUS
OSWEGO TURNING BASIN — 1975-1976
NITRATE-NITROGEN
1.6
1.2
0.8
0.4
0
mg/l
I RANGE OF STATIONS
— MEAN OF STATIONS
PHOSPHOROUS
1.6
1.2
0.8
0.4
0
mg/l
I RANGE OF STATIONS
— MEAN OF ORTHOPHOSPHATE
-- MEAN OF TOTAL PHOSPHORUS
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
1975
1976

FIGURE II-14

occurrence described above, although the concentration decreased less sharply from river to turning basin. The direct relationship of ion concentration to river water described above is also illustrated in Figure II-15, which shows the seasonal as well as spatial patterns for SPC in both the river and the turning basin-harbor complex.

The impact of domestic and industrial pollutants as well as urban runoff upon Oswego Harbor and Turning Basin can be seen in the concentrations of such parameters as biochemical oxygen demand (BOD), chemical oxygen demand (COD), total coliforms (TCOL) and fecal coliforms (FCOL); all of these in some way reflect the amount of organic waste material present in the water.

The fact that average concentrations of BOD in the turning basin and harbor are similar to those of the Oswego River (i.e, approximately 3 mg/l) indicates that domestic wastewaters are being directly discharged to the harbor-turning basin complex. On the other hand, the lower concentration of COD in the harbor and turning basin compared to the river may have been due either to the dilution capabilities of the lake waters in the thermal discharge of Units 1-4 or to the oxidation of river-borne organic materials without substantial additions of wastewaters which are not easily biodegradable (i.e., exert COD rather than BOD).

Concentrations of total and fecal coliforms were also higher (by one or two orders of magnitude) within the turning basin than within either the river or the harbor for each month when samples were taken (Figure II-16). The high coliform concentrations (Table II-9) reflect domestic sewage entering the turning basin. These high coliform concentrations, which at times may have exceeded the proposed EPA criteria may also have been violating the NYSDEC coliform standards for Class C waters (Table II-7).

The concentration of such heavy metals as chromium (Cr), vanadium (V), and zinc (Z) was negligible in all locations. The concentration of phenols exceeded zero (0.000) mg/l on only one occasion (14 May 1975), when a concentration of 0.013 mg/l was recorded in Oswego Harbor; this resulted in an average concentration of 0.001 mg/l for the sampling period, equal to the maximum allowable concentration for phenols in the proposed EPA criteria. Likewise, except for one pH value of 8.6 recorded on 23 June 1975 in the turning basin, pH values within the turning basin and harbor met the NYSDEC standards and never exceeded the EPA proposed criteria.

Average concentrations of TSS (23 mg/l) within the turning basin were higher than those of either the harbor (14 mg/l) or

SURFACE AND BOTTOM SPECIFIC CONDUCTANCE VALUES

OSWEGO TURNING BASIN — 1975-1976

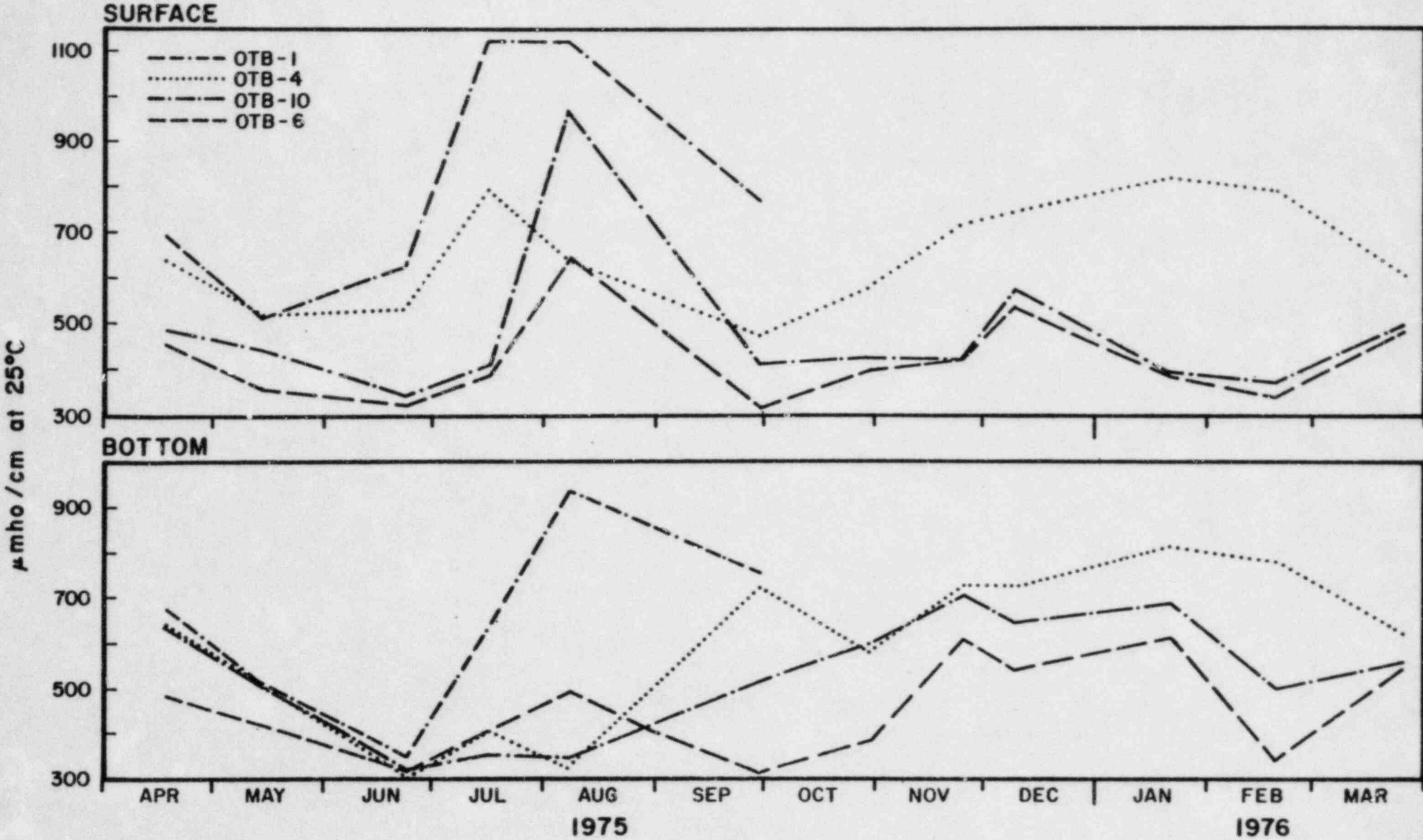
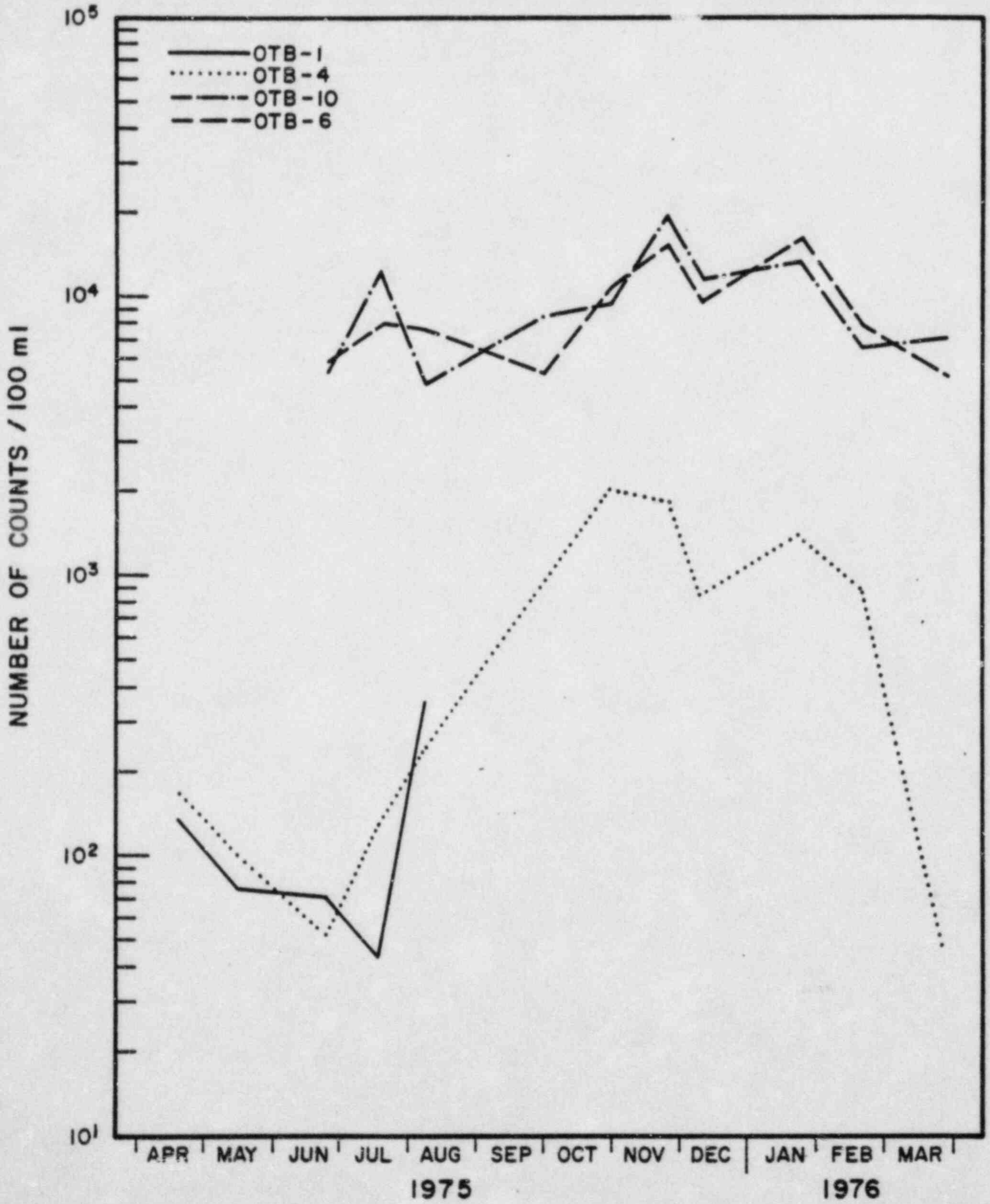


FIGURE II-15

SURFACE CONCENTRATIONS OF TOTAL COLIFORM

OSWEGO TURNING BASIN—1975-1976



the river (12 mg/l); this value probably reflects the influence of lake waters from the thermal discharge whose average TSS concentration was 22 mg/l. The high TSS concentration in the intake waters is used to the advantage of the steam station; chlorine, which is used as a biocide in the cooling water systems of many power generating stations, is not needed at the Oswego Steam Station because the suspended particulates within the cooling water scour away any slime buildup within the piping.

4. Summary and Conclusions

The thermal discharge of Oswego Steam Station Units 1-4 enters the western end of the Oswego Turning Basin and does alter the natural physical and chemical regime of the basin and harbor. However, the physical and chemical water quality changes brought about by the discharge improve rather than degrade the overall water quality of the turning basin and harbor. The thermal discharge acts not only as dilution water for normally occurring pollution discharges but also promotes flushing of these pollutants via density-induced currents in an area which, under natural conditions, would be subject to pollutional stagnation.

F. CLIMATOLOGICAL INFORMATION

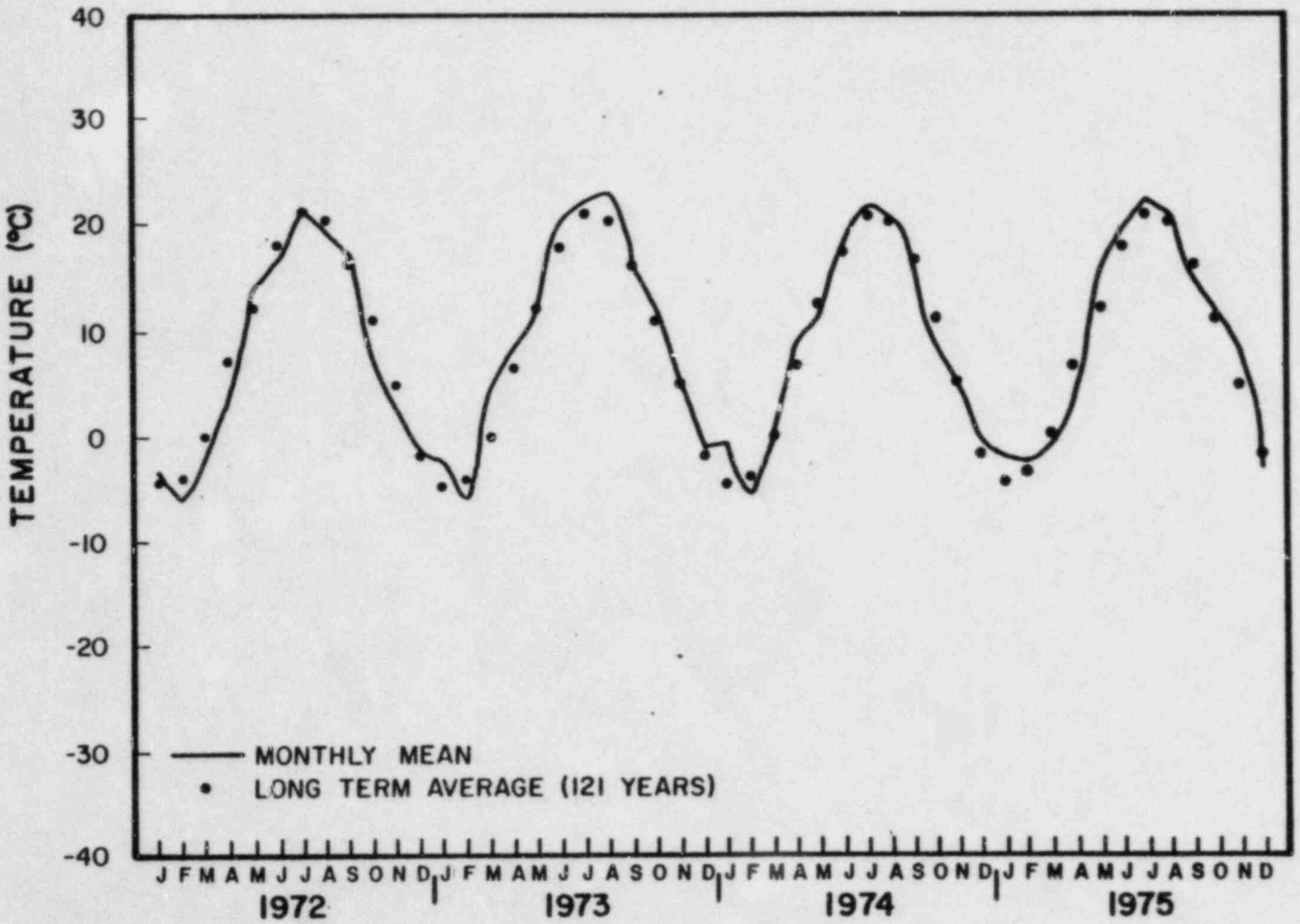
Climatological information is important in evaluating the characteristics of a thermal discharge with respect to such processes as heat transfer between the water body and the atmosphere. As such, it is suggested in the 316(a) Technical Guidance Manual (U.S.E.P.A., 1974) that climatological data be included as part of any demonstration of thermal discharge assessment. In addition, climatological variables, such as precipitation and air temperature, are directly associated with existing baseline conditions of the water body, and affect the composition and development of the aquatic community. Climatological data were obtained from the Oswego East weather station (U.S. Department of Commerce, 1973, 1974, 1975, 1976).

The general climate of the area is moist continental with nearby Lake Ontario exerting a strong moderating effect on local conditions. The lake is an important source of moisture, thereby raising the humidity and adding to the year-round rainfall and winter snowfall. The area generally experiences comparatively long, cold, and snowy winters with short, mild summers.

1. Temperature

Air temperature data for the area are summarized in Figure II-17 Mean monthly temperatures during 1975 were similar to the long-term average. Highest temperatures generally occur in July and the lowest in January; during 1975, the highest temperature of the

MEAN MONTHLY AIR TEMPERATURE*
OSWEGO VICINITY – 1972-1975



*Based on data from Oswego East (U.S. Dept. of Interior, 1973,1974,1975,1976)

FIGURE II-17

year (30.6°C, 87°F) was recorded on 14 July, and the lowest (-0.6°C, -5°F) on 8 February. The last spring freeze (-0.6°C, 31°F) occurred on 5 May and the first fall freeze (0.0°C, 32°F) on 18 October.

The moderating effect of the lake on the air temperature is also significant. Continental polar air is warmed in passing over the lake and maritime tropical air is cooled by cooler lake temperatures.

2. Precipitation

Precipitation is usualy sufficient to meet the needs of the area and is fairly evenly distributed over the year, although monthly precipitation varies from year to year. Mean precipitation data for 1972-1975 and the mean monthly precipitation for the past 129 years are presented in Figure II-18. During the period of most intense biological sampling efforts in 1975 (June - September), precipitation was higher than the long-term average. In the winter, most of the precipitation is in the form of snow, and flurries are a frequent occurrence.

3. Winds

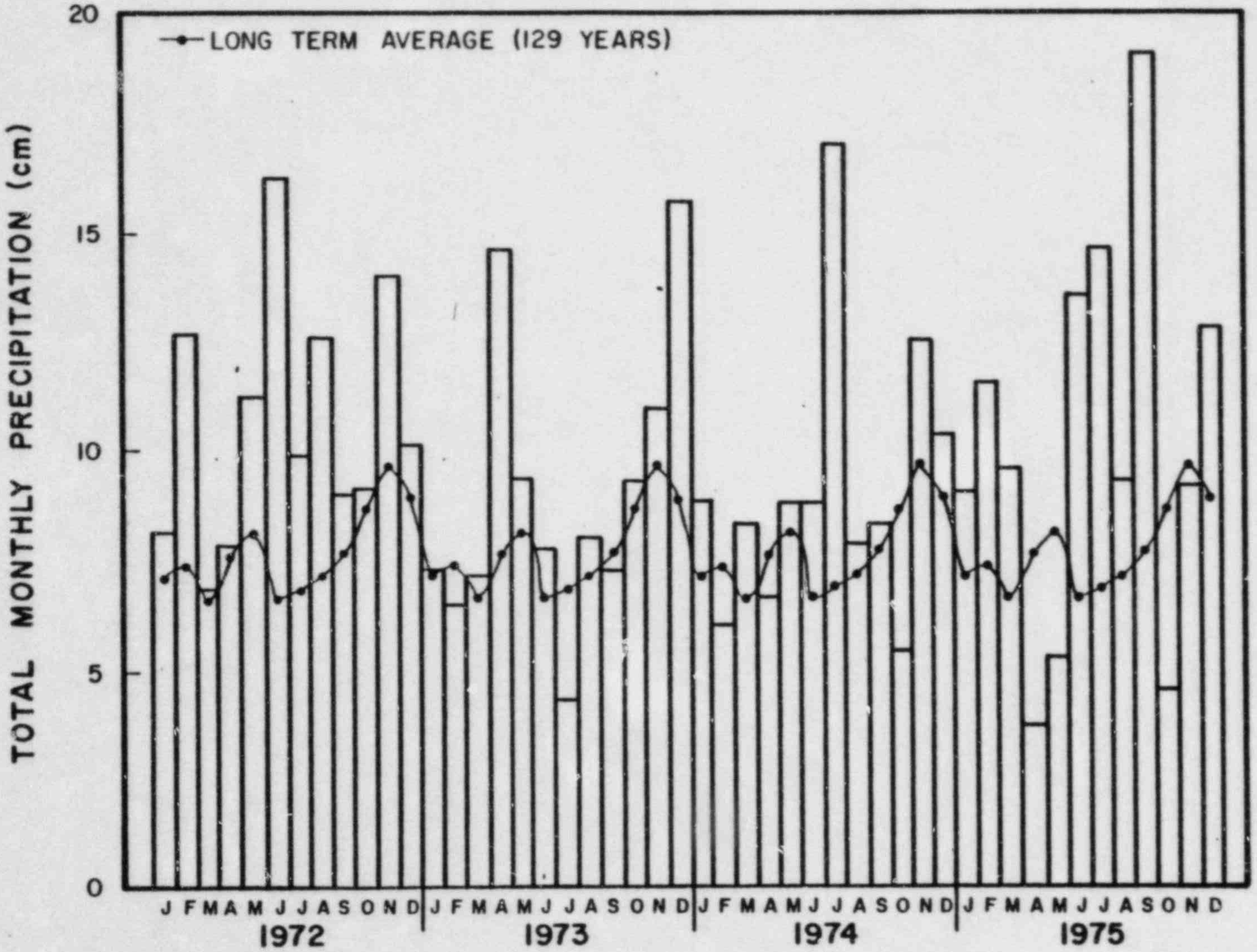
National Oceanographic and Atmospheric Administration Climatic Charts (U.S. Dept. Commerce, 1968) show surface winds to be highly variable throughout the year with the prevailing wind direction being southwesterly. Wind data for the Oswego area are summarized in Figure II-19, which indicates that peak winds of more than 31 m/sec (70 miles per hour) have been recorded (AEC, 1973).

Because land and water bodies heat and cool differently, diurnal heating results in land-lake temperature differences. This thermal gradient causes local winds from land to water or from water to land. The intensity and direction of the wind will depend on the magnitude and direction of the established thermal gradient, as well as upon the magnitude of the larger scale pressure gradient.

For example, although the thermal gradient is strongest during the early spring, and therefore conducive to a strong lake breeze, this effect can be masked or completely negated by the opposing pressure gradient force. Conditions are most favorable for frequent land-lake breeze during the summer when differential heating of the land and water surfaces is usually stronger than the pressure gradient force.

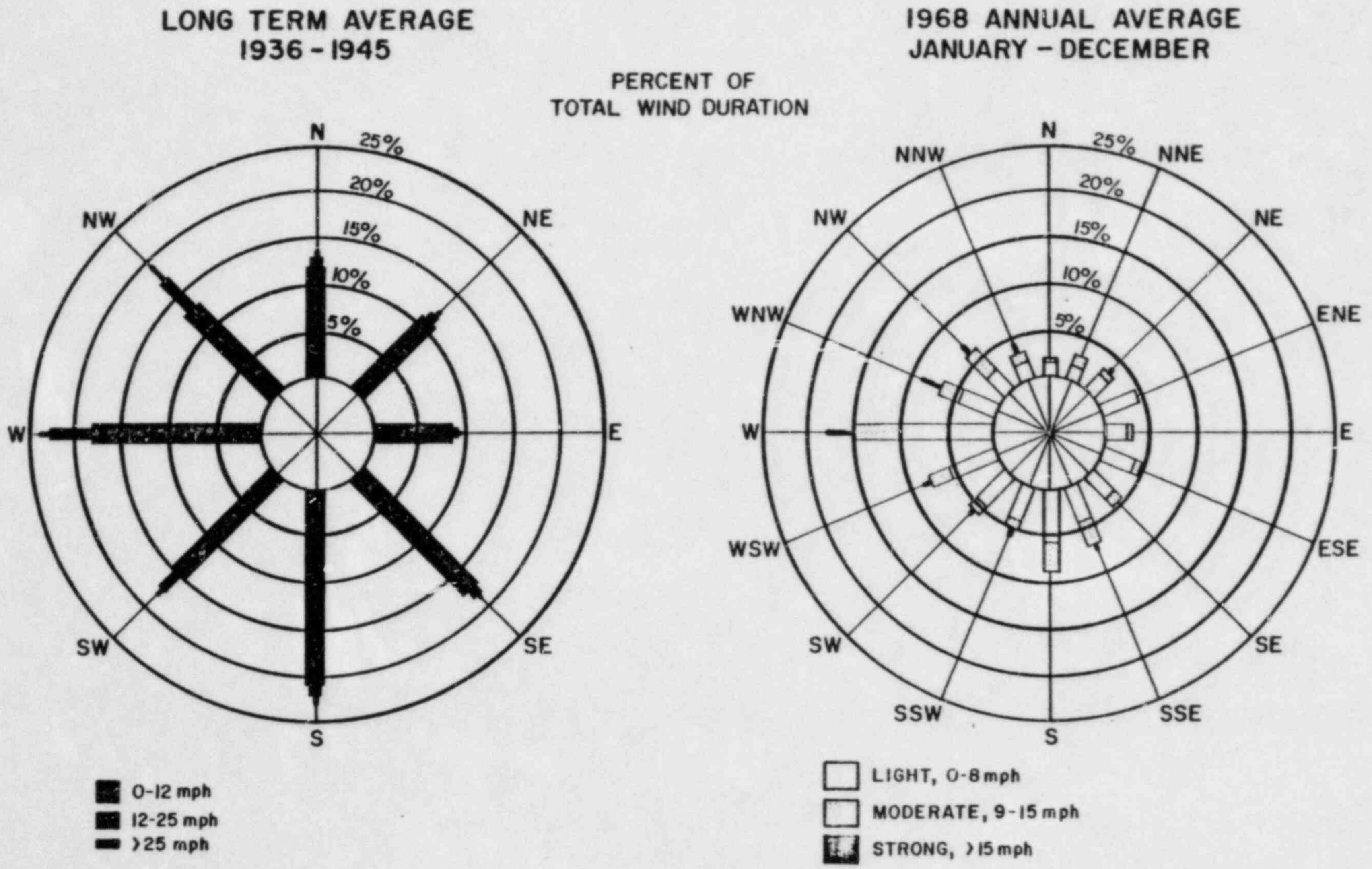
MEAN MONTHLY PRECIPITATION*

OSWEGO VICINITY – 1972-1975



*Based on data from Oswego East (U.S. Dept. of Interior, 1973,1974,1975,1976)

WIND DIRECTION AND SPEED
OSWEGO VICINITY-1936-1945 AND 1968



from QLM (1971)

FIGURE II-19

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LOCATIONS OF VERTICAL SECTIONS
OSWEGO TURNING BASIN — 1975-1976

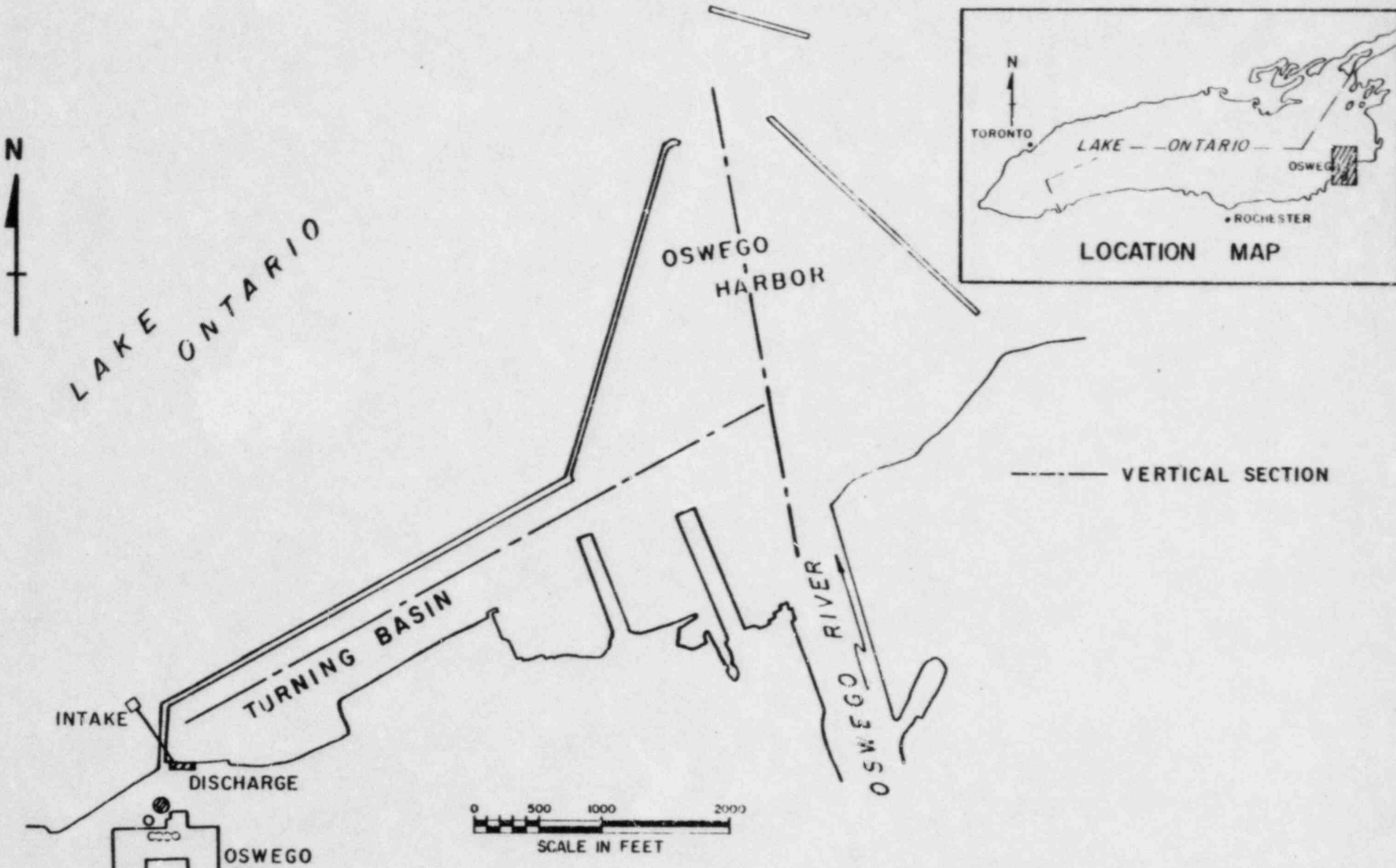
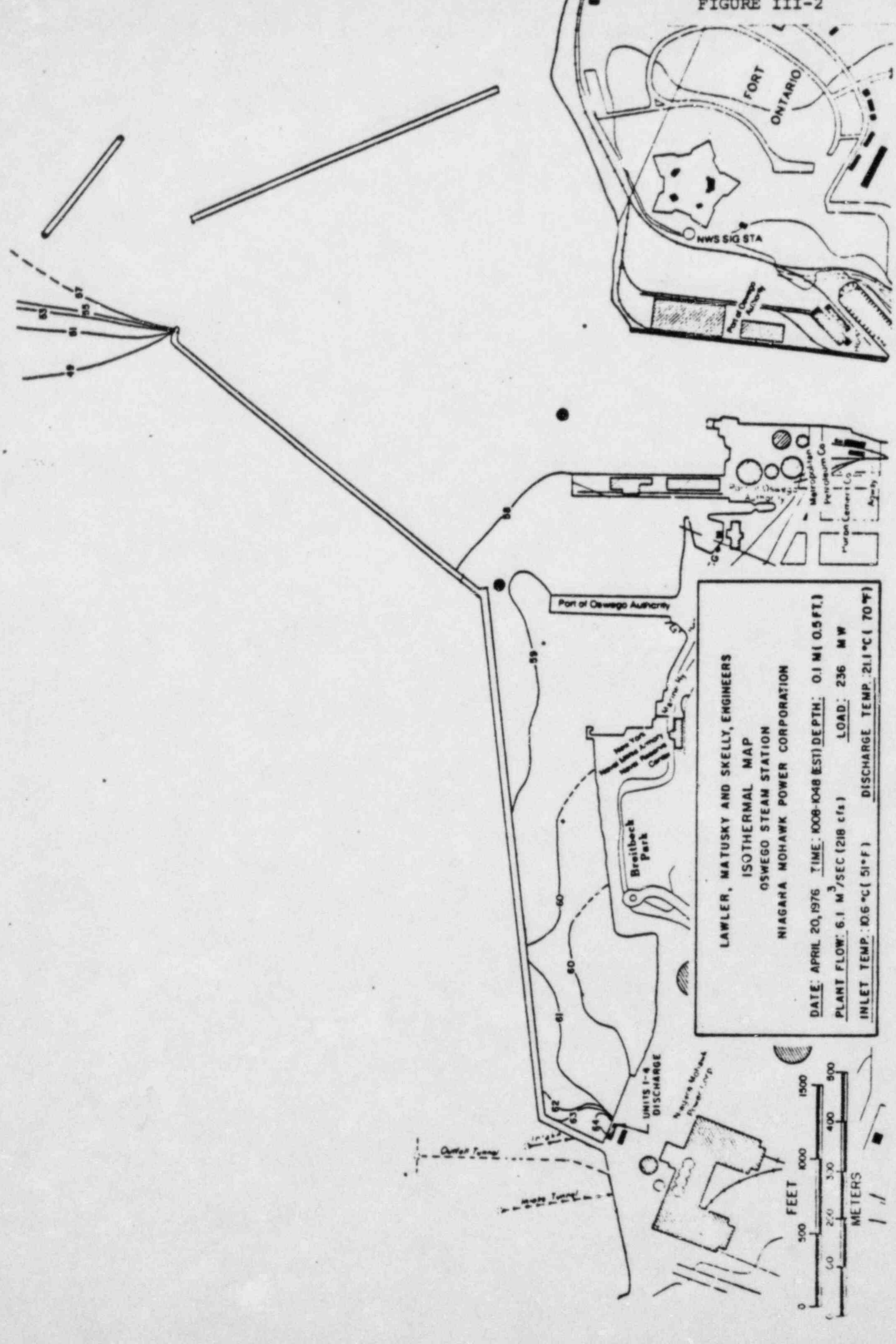


FIGURE III-1

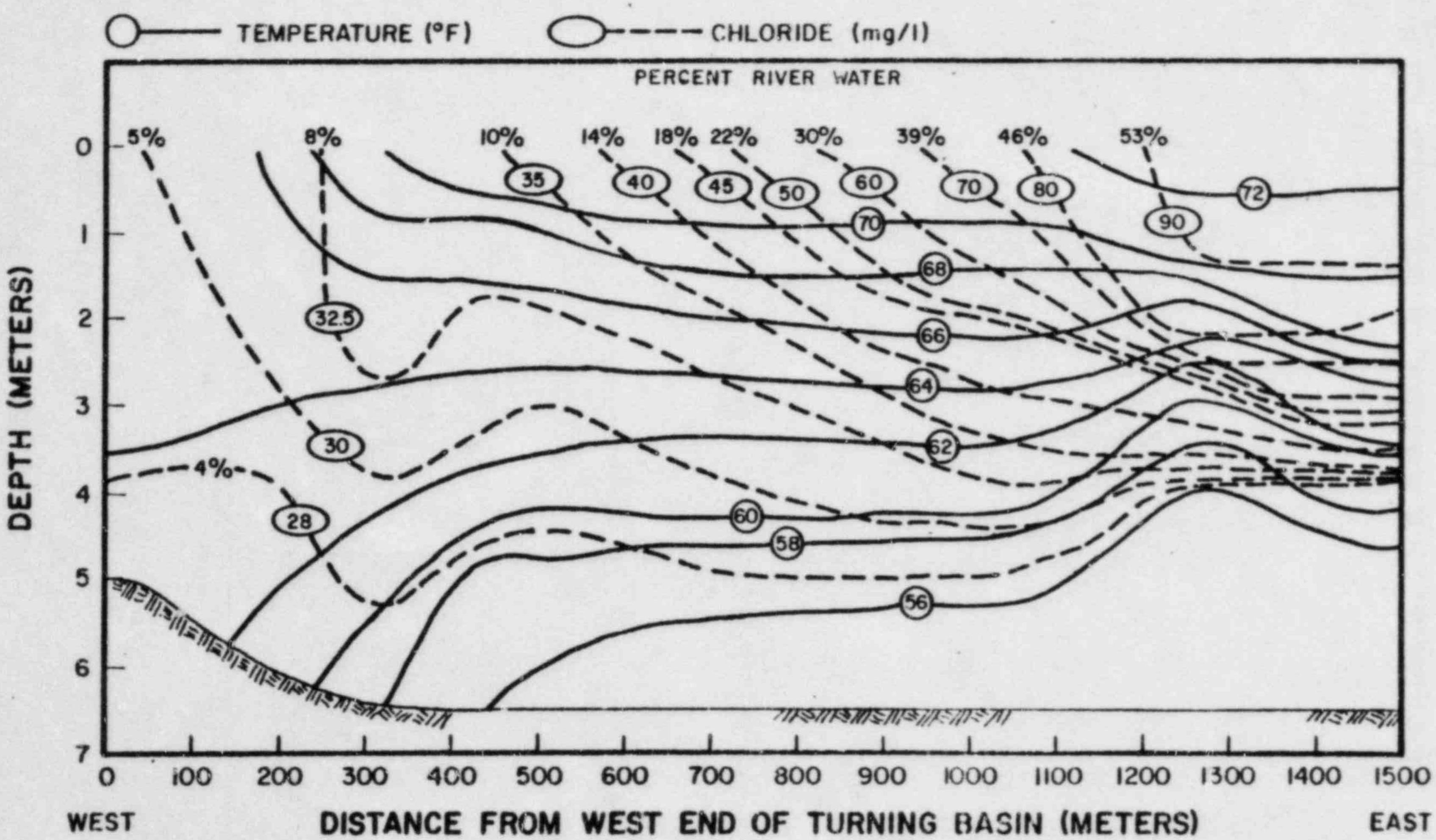
FIGURE III-2



LAWLER, MATUSKY AND SKELLY, ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: APRIL 20, 1976 TIME: 1008-1048 (EST) DEPTH: 0.1 M (0.5 FT.)
PLANT FLOW: 6.1 M³/SEC (218 cfs) LOAD: 236 MW
INLET TEMP: 10.6°C (51°F) DISCHARGE TEMP: 21.1°C (70°F)
FORT ONTARIO
NWS SIG STA
Port of Oswego Authority
Breitbeck Park
UNITS 1-4 DISCHARGE
Outfall Tunnel
Intake Tunnel
FEET
0 500 1000 1500
METERS
58
59
60
61
62
63
64

LONGITUDINAL SECTION OF THERMAL SURVEY

OSWEGO TURNING BASIN — 26 JUNE 1975



SECTION FROM RIVER MOUTH TO HARBOR MOUTH OF THERMAL SURVEY

OSWEGO TURNING BASIN — 26 JUNE 1975

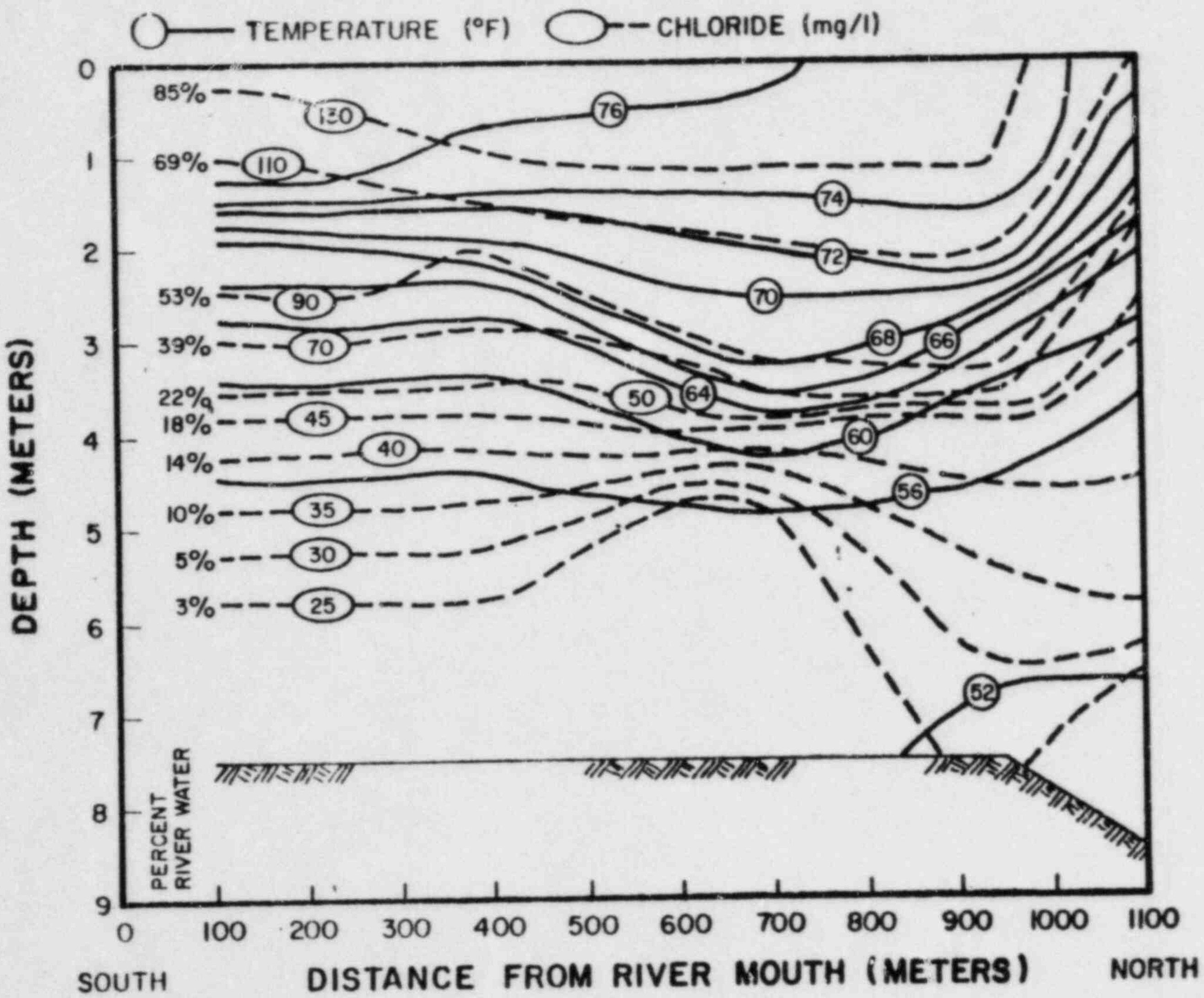


FIGURE III-4

III. PLUME DESCRIPTION

A. INTRODUCTION

The available data base for describing the temperature distributions in the Oswego River-Harbor-Turning Basin complex in relation to the Oswego Steam Station Units 1-4 discharge consists of the following:

1. four triaxial temperature and conductivity surveys performed in 1975-1976 (June, August, November 1975, and April 1976) in fulfillment of the requirements of the NPDES permit issued to the plant;

2. 27 thermal overflights conducted in 1969;

3. temperatures obtained during weekly water quality surveys from 26 June to 24 November 1970, performed in conjunction with the 1970 ecological investigation of Lake Ontario and Oswego Harbor; and

4. two water mass studies of the outer harbor and turning basin (7 August and 10 December 1970), consisting of vertical profiles of temperature and conductivity.

Except for the four 1975-1976 seasonal surveys, the methodologies employed and the results obtained during the above studies have already been presented in the 1971 Oswego report (QLM, 1971). The 1969 overflight data consist of surface temperature distributions only, and the weekly 1970 studies consist of vertical temperature and water quality profiles at eleven stations in the river-harbor-turning basin area. The two 1970 water mass studies consisted of vertical profiles of temperature and conductivity at ten stations in the same area. All of the 1969-1970 studies extended over both warm summer water temperature conditions and colder spring and fall conditions.

While each of the 1969-1970 studies yielded useful information on the distribution and water movements in the harbor-turning basin complex, the 1975-1976 triaxial surveys provide the most complete data set, describing the vertical and horizontal distribution of temperature and conductivity during spring, early and late summer, and late fall periods. For this reason, and since the earlier studies are described in the 1971 report (QLM, 1971), this chapter will discuss primarily the results of the 1975-1976 surveys, with reference to and comparison with the earlier studies made where appropriate.

In addition to the analysis of the temperature distributions in the turning basin-harbor area in relation to the Oswego Steam Station

Units 1-4 discharge, this chapter also examines the distribution of dissolved oxygen (DO) and biochemical oxygen demand (BOD) in the turning basin under various plant operating and water body conditions.

B. SEASONAL TEMPERATURE DISTRIBUTION AND MIXING CHARACTERISTICS

1. 1975-1976 Survey Conditions

The results of the four 1975-1976 triaxial thermal surveys are presented in Appendix A of this report, along with a description of the equipment and methodology employed during the surveys. The results are presented as isotherm maps which show the horizontal distribution of temperature at depths of 0.1, 1.5, 3.0, and 4.6 meters (0.5, 5, 10 and 15 ft) [6.1 meters (20 ft) in April 1976] for each of the four seasonal surveys. Table III-1 summarizes the prevailing Oswego River and Lake Ontario temperatures, and the pertinent plant operating data during each of the surveys. It should be noted that the Oswego River and Lake Ontario temperatures represent vertical averages at those locations and therefore may not coincide with the isotherm values shown at those locations when either the lake or river temperatures were stratified.

Table III-1 indicates that the Oswego River temperature was higher than Lake Ontario temperatures during all the surveys, although the small November difference of 0.1°C (0.2°F) indicates that the two water bodies were approaching equality of temperature at that time of the year. This agrees with the findings of the 1971 report that the Oswego River warmed more rapidly than Lake Ontario in the spring and summer months but cooled at approximately the same rate in the fall. This temperature relationship will be examined further when the water movements are discussed. The average net plant load during the four surveys was 250 MWe (63% of the net capacity) with a minimum of 236 MWe (59%) and a maximum of 260 MWe (65%). Thus, all surveys were done at loads exceeding the 54% average load factors given in Chapter II.

The discharge flows for all the 1975 surveys were constant at 13.3 m^3/sec (469 cfs), the flow corresponding to operation of five of the eight pumps. The lower flow in April of 1976 [6.1 m^3/sec (218 cfs)] was due to the operation of only three of the eight circulating water pumps and the recirculation of a portion of the discharge water through the intake (tempering). The tempering flow also accounts for the high plant temperature rise [10.5°C (19°F)] during the April 1976 survey compared to the 1975 surveys [average ΔT=4.7°C (8.7°F)]. The Oswego Steam Station 1-4 discharge temperatures shown in Table III-1 are greater than the Oswego River temperatures for all the surveys except the June 1975 survey, when

TABLE III-1

PREVAILING PHYSICAL CONDITIONS DURING THERMAL SURVEYS

OSWEGO STEAM STATION UNITS 1-4 AND VICINITY - 1975-1976

SURVEY	LAKE ONTARIO		OSWEGO RIVER				PLANT OPERATING CONDITIONS						
	TEMP.*		TEMP.*		FLOW		NET LOAD	DISCHARGE FLOW		DISCHARGE TEMP.		ΔT	
DATE	°C	°F	°C	°F	m^3/sec	cfs	MWe	m^3/sec	cfs	°C	°F	°C	°F
26 JUN 1975	11.9	53.4	25.1	77.1	77.0	2,750	257	13.3	469	17.2	63	5.5	10
28 AUG	22.4	72.3	24.1	75.4	72.2	2,580	247	13.3	469	26.7	80	3.9	7
6 NOV	11.7	53.0	11.8	53.2	168.3	6,010	260	13.3	469	16.4	61	4.6	8
20 APR 1976	6.3	43.0	14.3	57.8	490.0	17,500	236	6.1	218.	21.1	70	10.5	19

*Mean temperature of the water column

natural warming of the river was sufficient to raise the river temperature above the plant discharge temperature. The maximum difference between the discharge temperature and the river temperature [6.8°C(1.2.°F)] occurred during the April 1976 survey when the highest plant temperature rise also occurred. The average temperature difference between the plant discharge and the Oswego River temperatures was 1.5°C (2.8°F) for the four surveys.

2. Observed Temperature Distributions and Mixing Characteristics

The results of the 1975-1976 triaxial surveys are presented in Figures III-1 through III-13 in this chapter, with additional figures in Appendix A. Figure III-1 illustrates the locations of the longitudinal sections shown in the following figures. Three figures are then presented for each survey date: a surface (0.1 m depth) isotherm map, and two longitudinal vertical sections, one in the turning basin and one in the harbor. The pertinent plant operating data for each survey are given on the surface isotherm map, and the vertical section drawings show isopleths of both temperature and chloride concentration.

As described in Chapter II, the Oswego River carries a higher concentration of chloride ions than Lake Ontario waters, thus providing a tracer to distinguish Oswego River source water from Lake Ontario source water when the two are mixed. For each survey the chloride concentrations have been used to determine the relative presence of river and lake waters in the turning basin and harbor area. The results of this analysis are shown on the sectional plots for each survey in the form of percent river water values associated with each chloride isopleth. It should be noted that the chloride tracer allows the separation of river from lake water but does not determine whether the source of the lake water is that discharged by the Oswego Steam Station into the turning basin or lake water entering the harbor area directly, without passing through the plant.

Since in the following discussion of the data, the relative density of the various water sources in the turning basin-harbor complex will be of importance, it should be noted that in the 10-15°C (50-60°F) temperature range, a positive difference in chloride concentration of approximately 44 mg/l will counteract the buoyancy induced by a 0.56°C (1°F) temperature difference. In the 21-27°C (70-80°F) temperature range, a chloride concentration difference of approximately 86 mg/l is required to counteract a 0.56°C (1°F) temperature difference. Thus at times of the year when the Oswego River is only a few degrees warmer than Lake Ontario waters, the chloride concentrations in the river may cause it to be negatively buoyant relative to the colder lake water.

The results of the 26 June 1975 triaxial survey are shown on Figures III-2 through III-4. The surface temperature distribution depicted in Figure III-2 is dominated by the inflow of the relatively warm Oswego River to the main harbor area [77 m^3/sec (2750 cfs)]. The river is 13.2°C (23.7°F) warmer than the lake water and 7.9°C (14.2°F) warmer than the Oswego Steam Station Units 1-4 discharge. The river chloride concentration was 150 mg/l at the time of the survey; this value, when compared to the lake concentration of 22 mg/l, would make the river water density equivalent to lake water at a temperature of approximately 0.8°C (1.5°F) less than the river temperature. Thus the river water at 25.1°C (77.1°F) was less dense than the natural lake water or plant discharge water despite the higher chloride content.

The buoyancy of the Oswego River water causes it to spread laterally in the harbor as it flows northward toward the harbor entrance to the lake. The lateral spreading extends westward into the turning basin where the intruding river water meets and mixes with the cooler discharge waters from the plant. Figures III-3 and III-4 illustrate the behavior more clearly. Figure III-4 shows the river water occupying the upper portion of the water column in the harbor with the lower portion occupied by colder lake water (less than 3% river water). The colder lake water near the bottom is most likely lake water intruding through the harbor mouth as a result of the density gradient created by the lighter river water. Figure III-3 shows the western end of the turning basin to be predominantly occupied by lake water over the full depth (5-6.5 m). As previously stated, the source of the lake water cannot be determined as no tracer substance differentiated discharge water from intruded lake water. Since the lowest discharge temperature recorded in the 24 hours preceding the survey was 15.5°C (60°F), it can be assumed that any lake waters colder than this temperature can be attributed to lake water intrusion through the harbor. Water warmer than 15.5°C (60°F) may have been a mixture of discharged lake water and intruded lake water, or pure discharged waters.

As the discharge waters proceed eastward in the turning basin, they mix with the surface-intruding river water and the bottom-intruding lake water. Figure III-3 indicate that the discharged waters flow out of the turning basin in the central portion of the water column, above the intruding lake water and beneath the intruding river water while mixing with both. The mixed flow then encounters the northward flowing river waters and with further mixing, continues toward the harbor mouth above the cooler intruding lake water. As the combined river and discharge flow encounters the narrowing harbor section, the upper layer flows are forced deeper until they leave the harbor and encounter lake water, where they again rise to the upper layers.

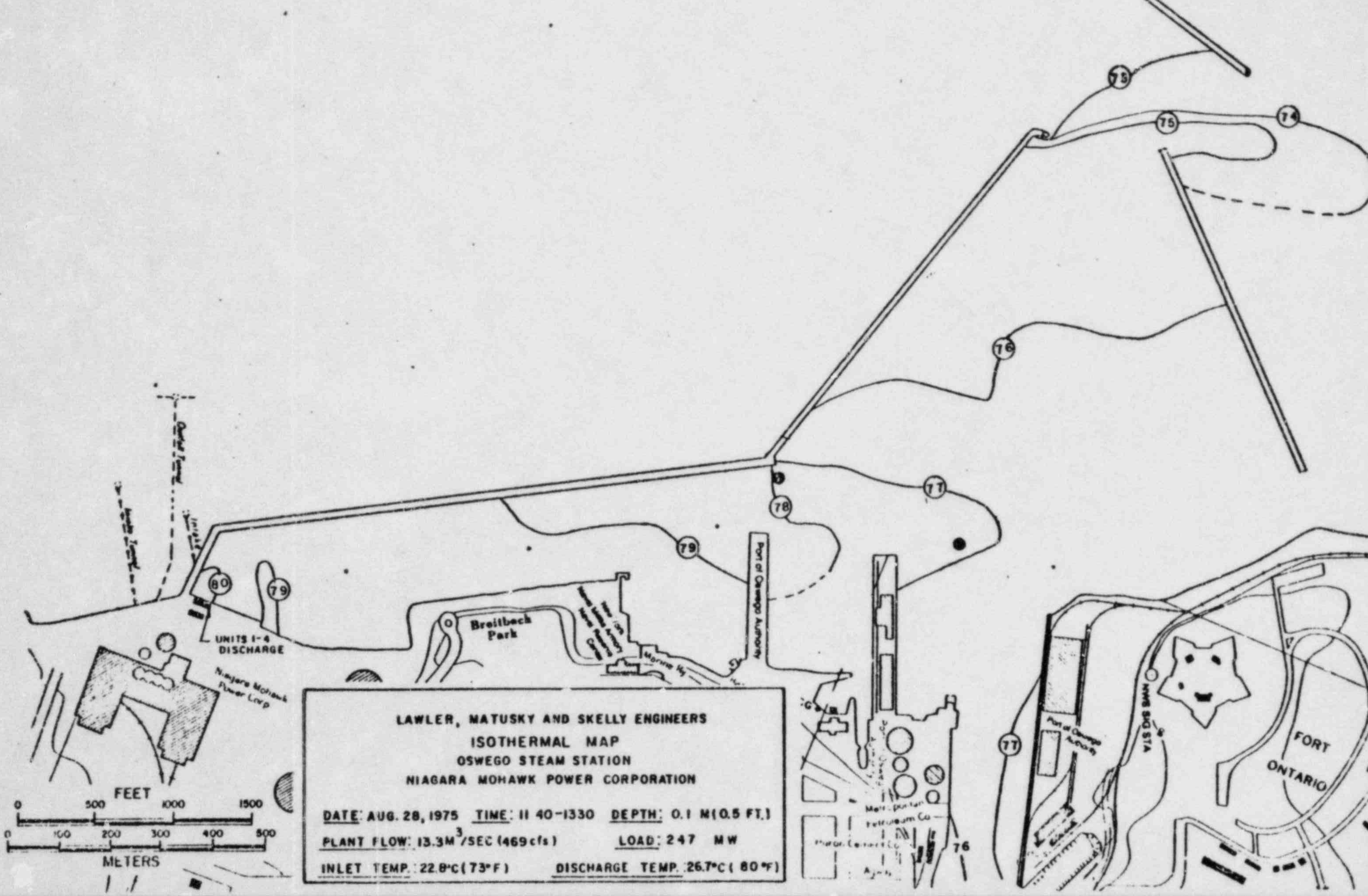
This pattern of density-induced flows would be expected to occur during parts of May, June, and July when the spring warming has heated the Oswego River well above the lake temperature and the low intake temperature in the lake causes even the plant discharge temperature to be below the river temperature. Fluctuations in the discharge temperature due to varying plant generating loads will alter the turning basin flow structure as will the daily cycle of warm days and cool nights, but the predominance of the surface-flowing river water and bottom-intruding lake water will persist.

It is of interest to note that the Oswego River's thermal contribution to Lake Ontario was approximately fourteen times the contribution from the Oswego plant.

Figures III-5 through III-7, the 28 August 1975 survey results, show a marked change in the temperature and flow structure from the June survey. The river temperature was now 1.7°C (3.1°F) warmer than the average lake temperature, and less than 1.1°C (2°F) warmer than the lake surface temperatures. The river flow [72.2 m^3/sec (2580 cfs)] was approximately the same as the June flow [77 m^3/sec (2750 cfs)] but chloride concentrations rose to 400 mg/l in the river and 25 mg/l in the lake. During the August survey the river temperature was 2.6°C (4.7°F) cooler than the plant discharge temperature. Figure III-5, the August surface temperature distribution, shows the discharge entering the western portion of the turning basin at 26.7°C (80°F) and then flowing eastward toward the harbor while experiencing some cooling due to atmospheric heat loss and dilution. The discharge waters then spread into the harbor and mixed with river water in the upper portion of the water column. The longitudinal sections shown in Figures III-6 and III-7 illustrate the intrusion of river water into the turning basin along the bottom while the discharge water rose above the river water as it flowed toward the harbor; considerable mixing took place at the junction of the turning basin and harbor where the percentage of river water at the surface increased from 14 to 74% in a distance of 300 m (984 ft). The cooler river water with its high chloride content was more dense than the discharge waters from the Oswego Steam Station, and its intrusion into the turning basin was caused by this density difference between the discharge waters at the western end of the turning basin and the heavy river waters in the harbor.

Figure III-7 shows that the highest percentages of river water were present in the lower portion of the water column in the harbor area, with the lower percentages, indicative of the presence of lake water, near the surface. The percentage of river water in the surface waters increased toward the harbor mouth, indicating that the discharge waters were mixing with the river water as the combined flow proceeded toward the harbor mouth. If lake water had been intruding into the harbor, the percentage of river water would have been expected to decline toward the harbor mouth, showing increasing dilution toward the source

FIGURE III-5


LAWLER, MATUSKY AND SKELLY ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: AUG. 28, 1975 TIME: 11 40-1330 DEPTH: 0.1 M (0.5 FT.)
PLANT FLOW: 13.3M³/SEC (469 cfs) LOAD: 247 MW
INLET TEMP.: 22.8°C (73°F) DISCHARGE TEMP.: 26.7°C (80°F)
FEET
0
500
1000
1500
METERS
0
100
200
300
400
500
73
74
75
76
77
78
79
80
UNITS 1-4 DISCHARGE
Niagara Mohawk Power Corp
Breitbeck Park
Port of Oswego Authority
FORT ONTARIO
NWS SIG STA

LONGITUDINAL SECTION OF THERMAL SURVEY
OSWEGO TURNING BASIN — 28 AUGUST 1975

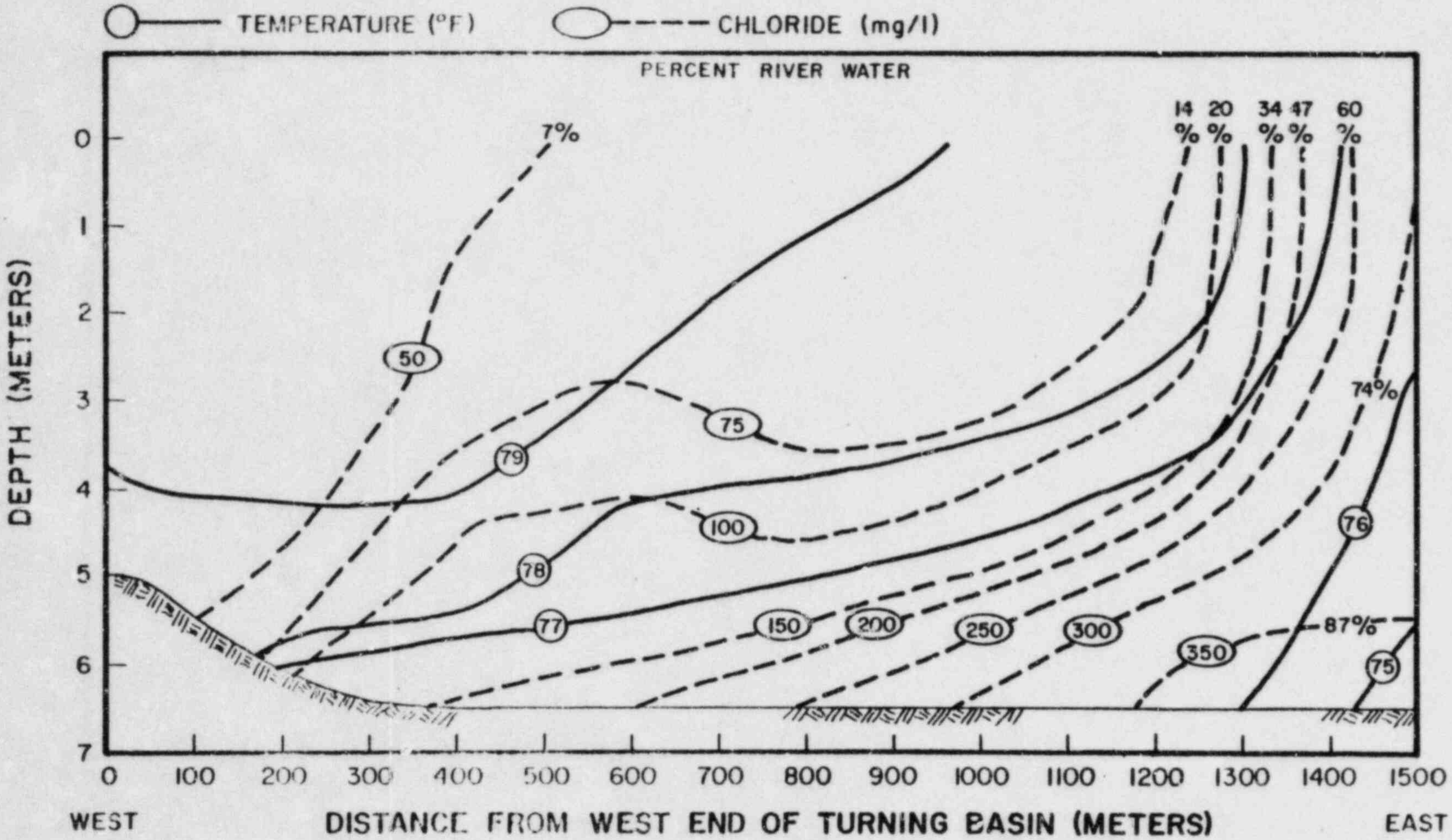


FIGURE III-6

SECTION FROM RIVER MOUTH TO HARBOR MOUTH OF THERMAL SURVEY

OSWEGO TURNING BASIN — 28 AUGUST 1975

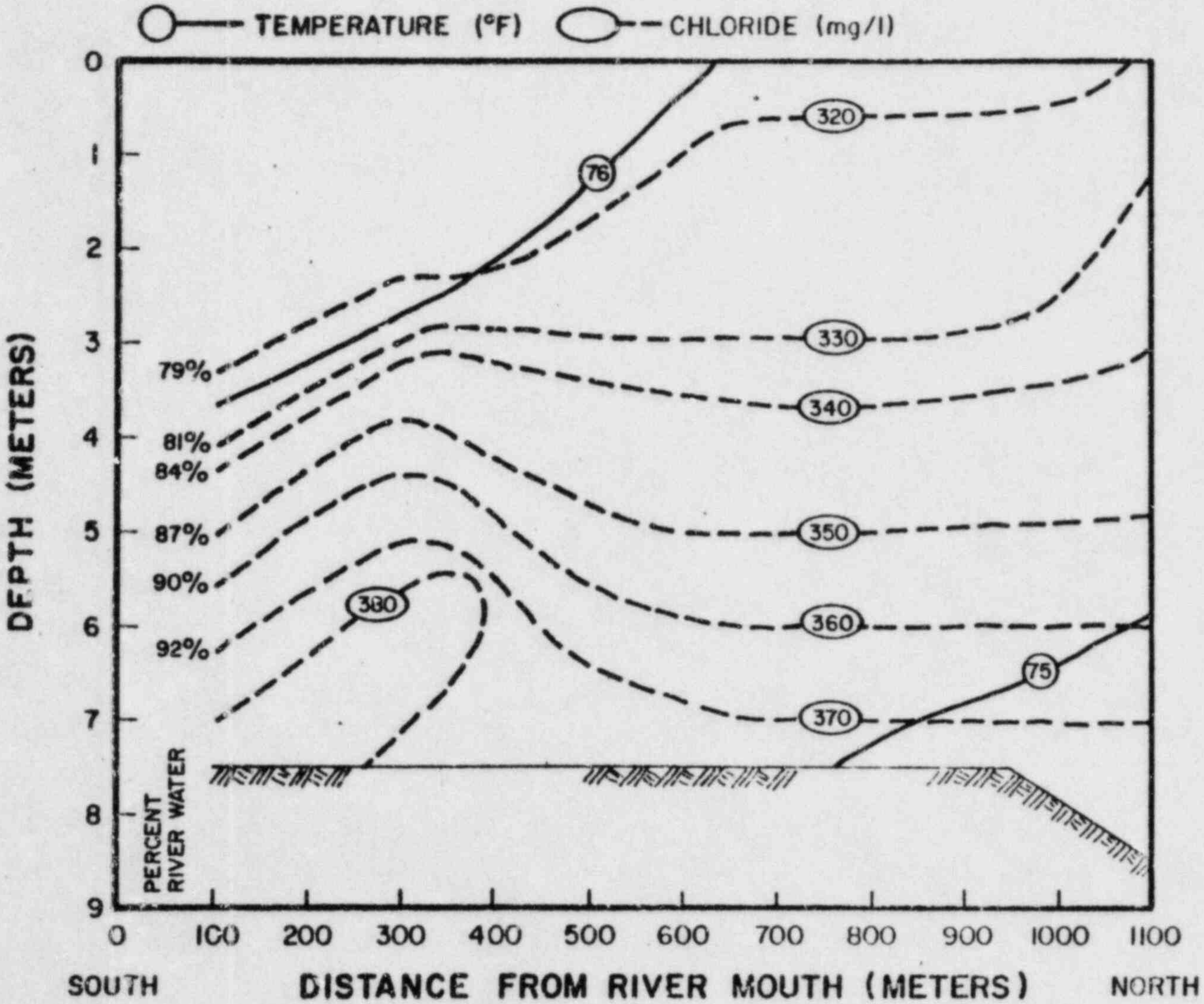


FIGURE III-7

of dilution water. The harbor outflows to the lake spread primarily along the lake bottom due to the high chloride content, which was sufficient to overcome the thermal buoyancy of the river water relative to the lake water. The chloride content of the river water was sufficient to counteract approximately a 24°C (4.3°F) temperature differential.

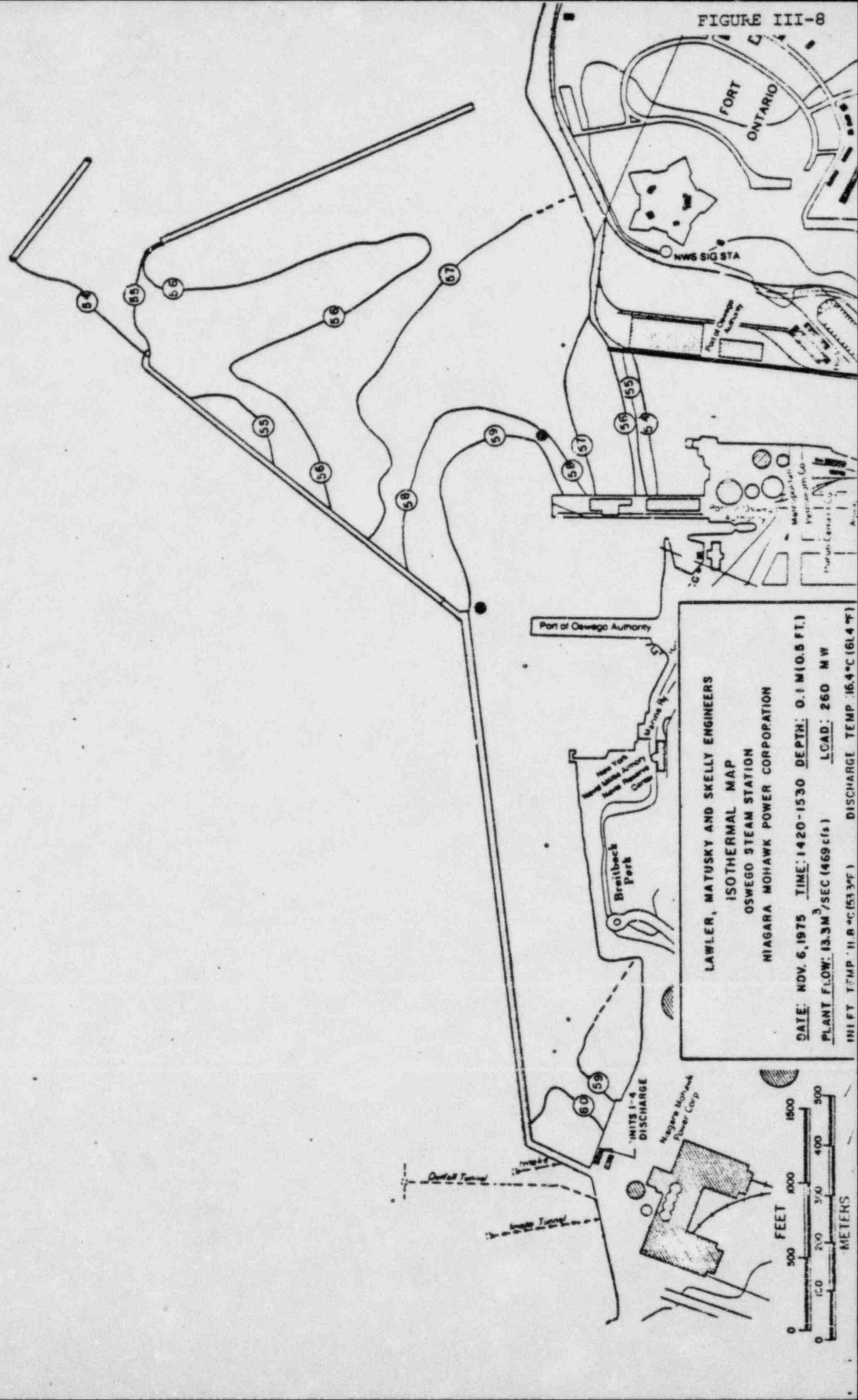
Vertical profiles in the lake just outside the harbor show inverse thermal stratification (warmer water underlying colder water), with temperature differentials of 0.5°C (1°F) between surface and bottom. Conductivity profiles at the same positions clearly indicate the spreading of the river plume in the bottom layers to the east of the harbor.

In summary, the August survey results are representative of the flow patterns to be expected when the river and lake temperatures are sufficiently similar to preclude the development of a density gradient between the harbor and lake that would induce lake water intrusion into the harbor. The chloride content of the river will counteract a small temperature-induced density differential. The turning basin flow structure is representative of the conditions expected with a discharge temperature warmer than that of the receiving water. The buoyant discharge waters flow on the surface, above intruding, heavy river water, a flow structure similar to that observed in the 1971 report, where westward currents of 1.5 cm/sec (0.05 fps) were reported in the lower portion of the water column in the turning basin (QLM, 1971). When the thermal contribution of Oswego Steam Station Units 1-4 to the lake is compared with that of the Oswego River, the plant added less than 1/3 of the Oswego River's contribution at the time of the August survey.

The results of the November 1975 survey, shown in Figures III-8 through III-10, reflect the same basic flow structure as the August results. The river and lake temperatures were very close, 11.8 and 11.7°C (53.2 and 53.0°F), respectively, with the plant discharge temperature at 16.4°C (61.4°F). The river and lake chloride values were 170 mg/l and 29 mg/l, respectively, a difference sufficient to counteract approximately a 1.8°C (3.2°F) temperature-induced buoyancy. The Oswego River flow was 169 m^3/sec (6010 cfs) during the November survey.

The surface distribution (Figure III-8) shows the discharge flowing eastward out of the turning basin and spreading north and south. The southward spreading was checked by the northward river flow, as evidenced by the proximity of isotherms across the river mouth, also indicative of mixing. The northward spreading and convection showed less rapid temperature reductions, indicative of slower mixing and atmospheric cooling. The maximum surface temperature of 15.6°C (60°F),

FIGURE III-8


LAWLER, MATUSKY AND SKELLY ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: NOV. 6, 1975 TIME: 1420-1530 DEPTH: 0.1 M (0.5 FT.)
PLANT FLOW: 13.3M³/SEC (469 cfs) LOAD: 260 MW
INLET TEMP 11.8°C (53.3°F) DISCHARGE TEMP 16.4°C (61.4°F)
FORT ONTARIO
NWS SIG STA
Port of Oswego Authority
Breitbeck Park
UNITS 1-4 DISCHARGE
Niagara Mohawk Power Corp
Outfall Tunnel
Intake Tunnel
FEET
0
500
1000
1500
METERS
0
100
200
300
400
500
54
55
66
56
67
55
56
59
58
57
58
56
55
59
60

LONGITUDINAL SECTION OF THERMAL SURVEY

OSWEGO TURNING BASIN — 06 NOVEMBER 1975

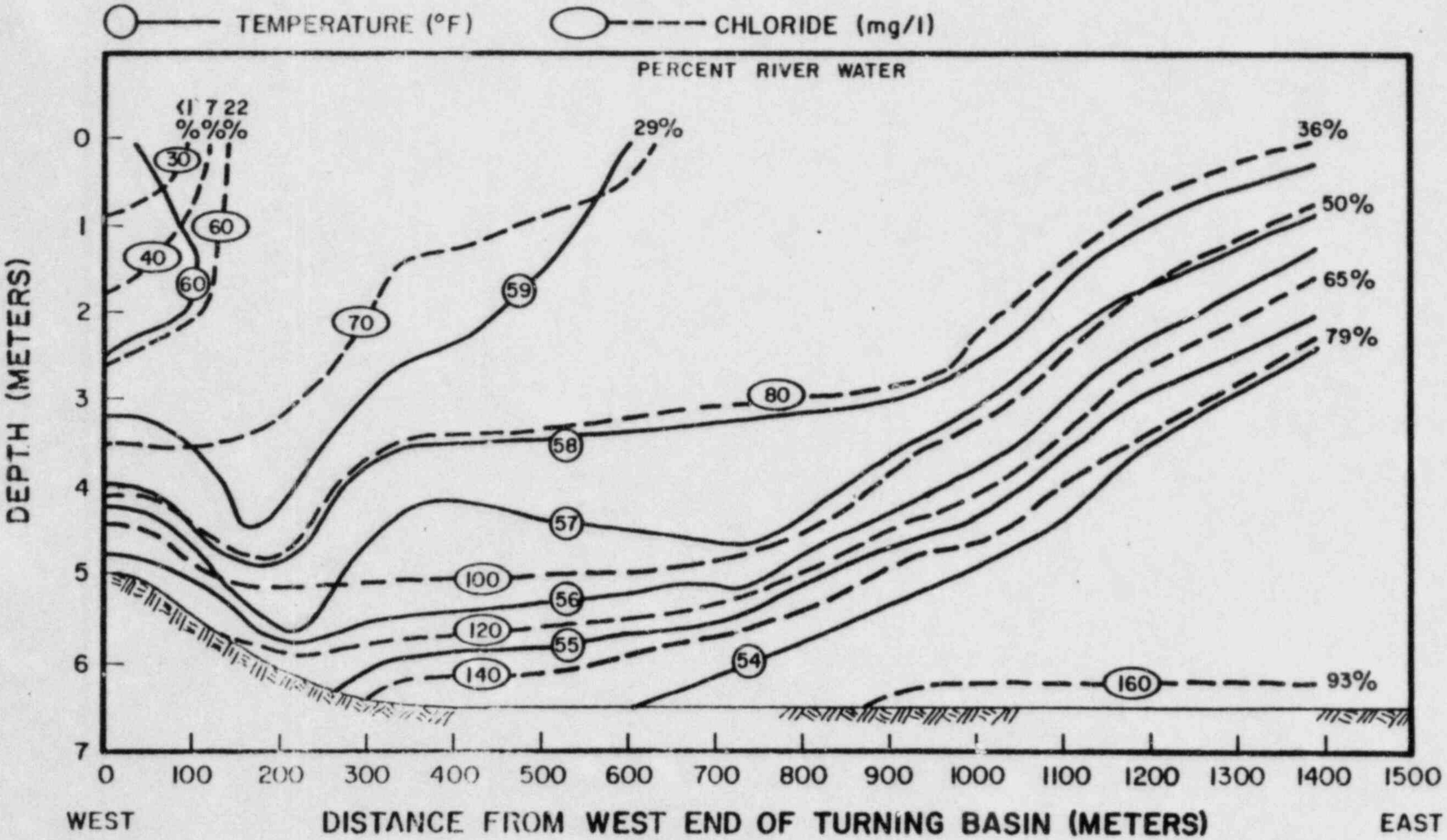


FIGURE III-9

SECTION FROM RIVER MOUTH TO HARBOR MOUTH OF THERMAL SURVEY

OSWEGO TURNING BASIN — 06 NOVEMBER 1975

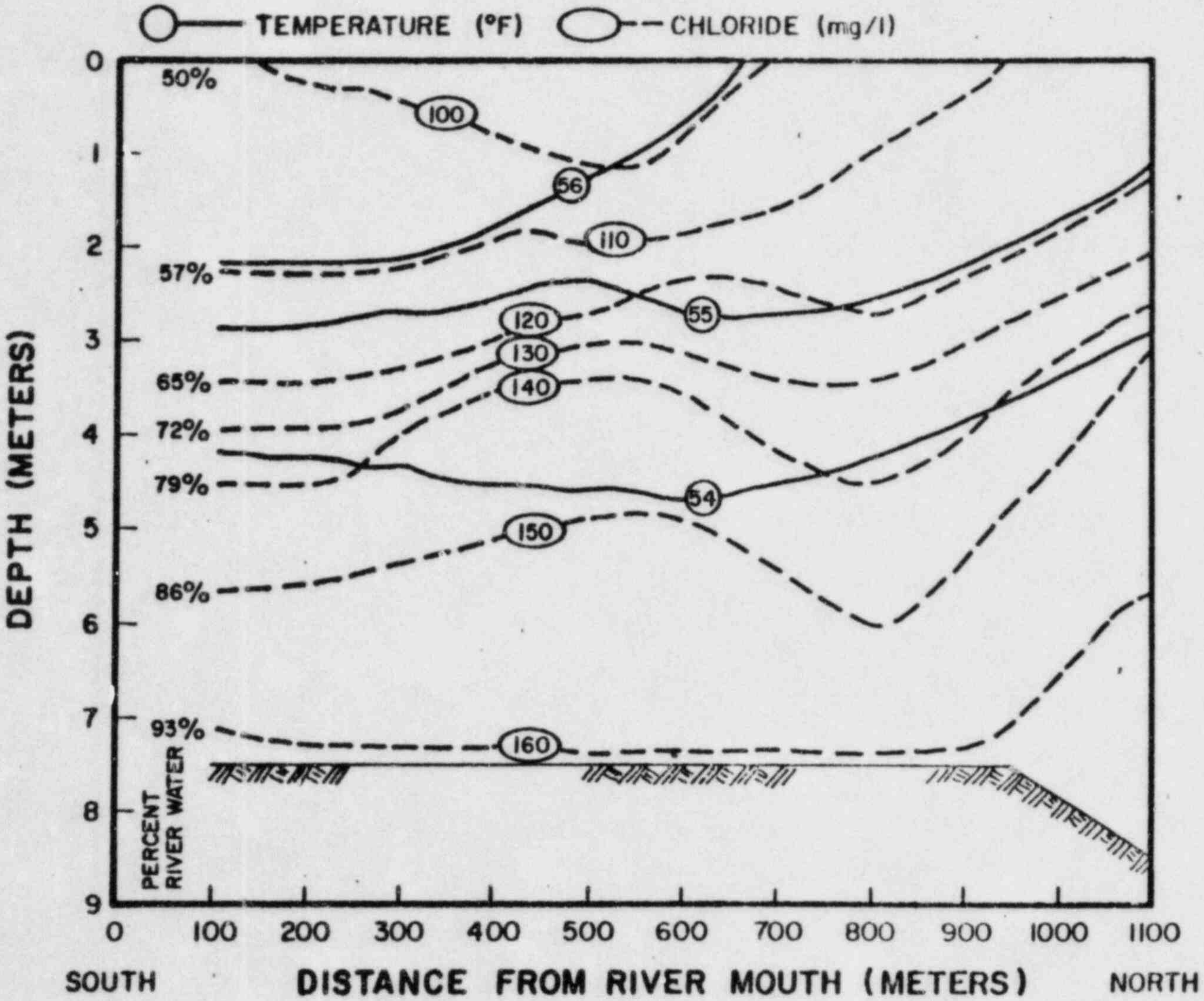


FIGURE III-10

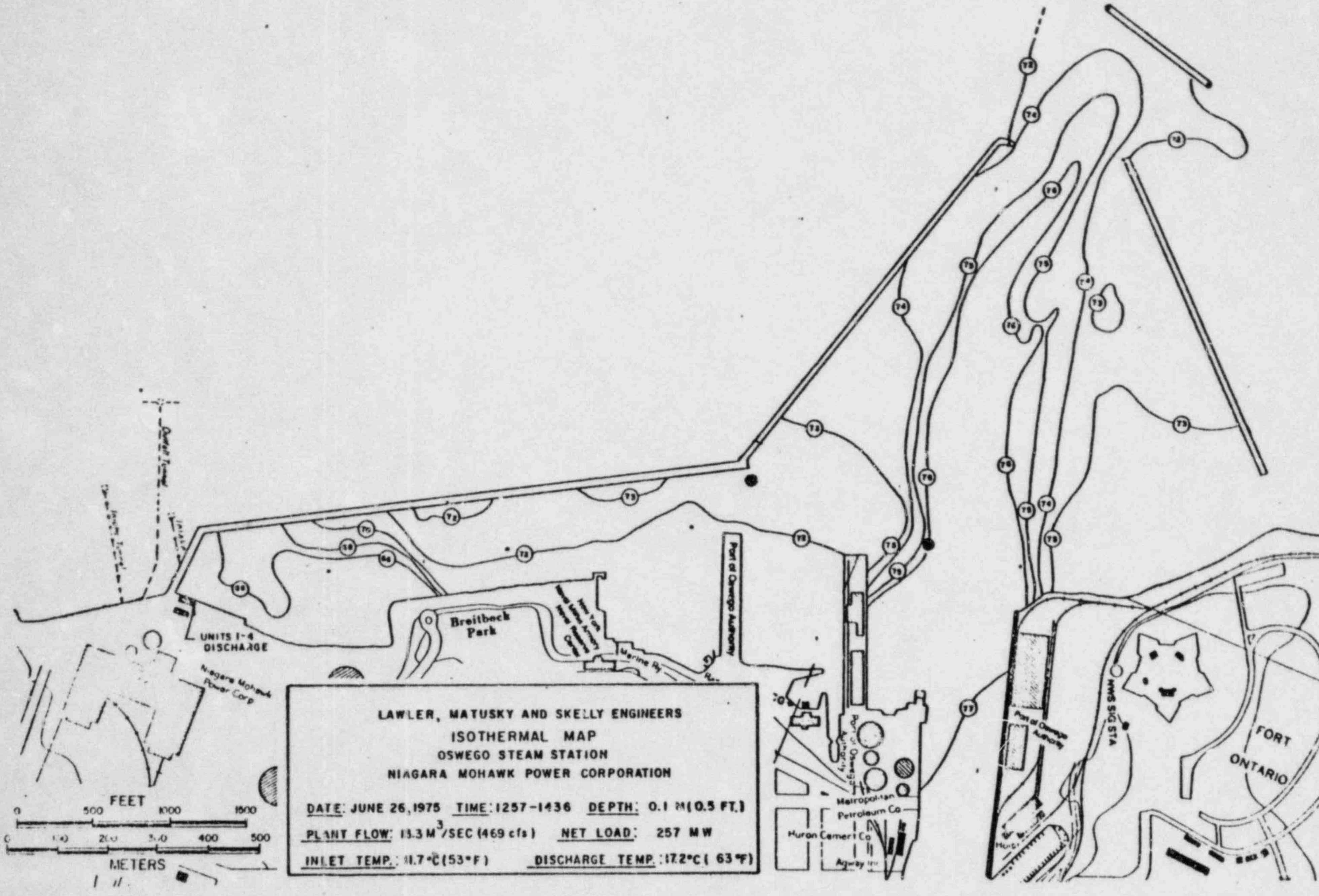


FIGURE III-11

LONGITUDINAL SECTION OF THERMAL SURVEY

OSWEGO TURNING BASIN — 20 APRIL 1976

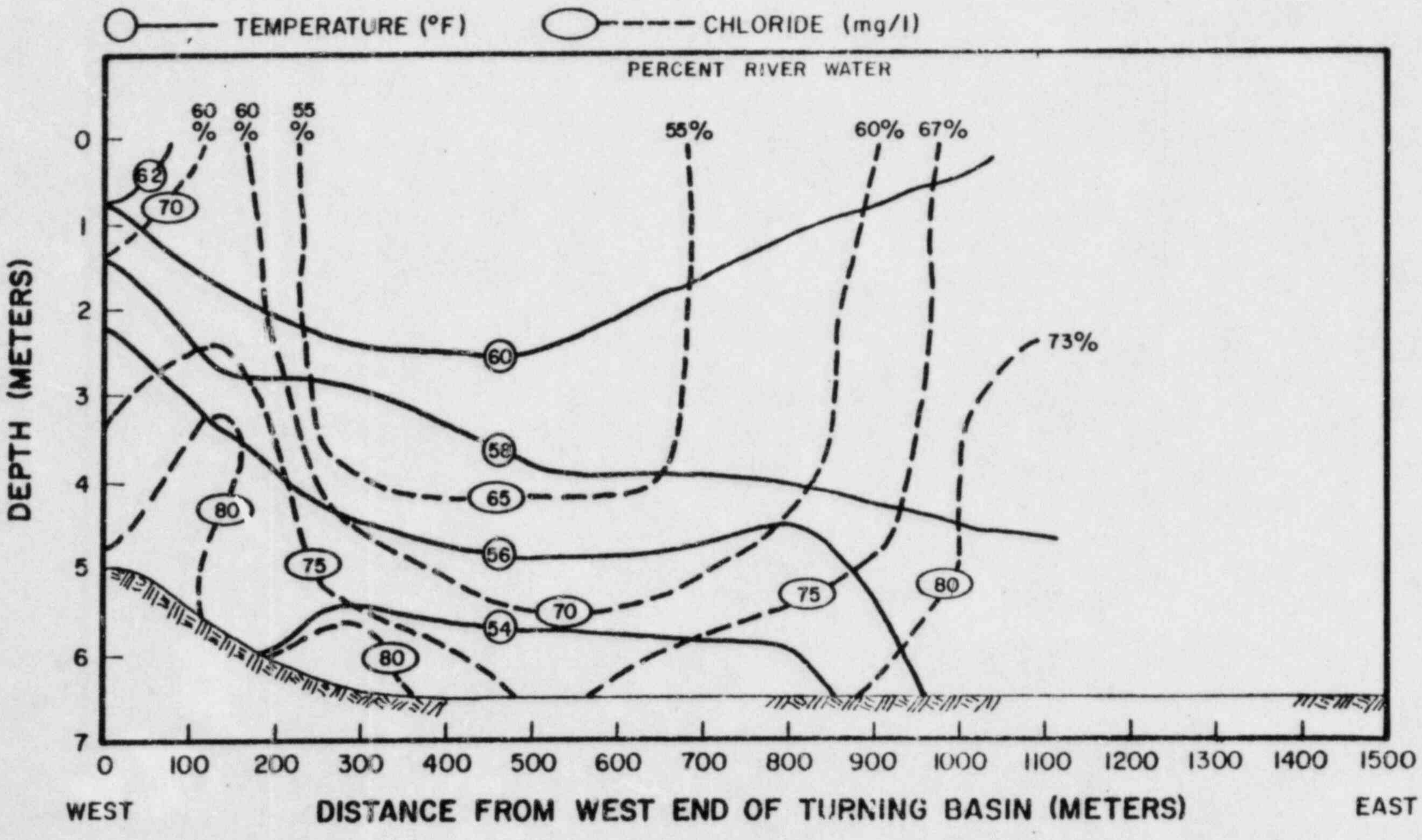


FIGURE III-12

SECTION FROM RIVER MOUTH TO HARBOR MOUTH OF THERMAL SURVEY

OSWEGO TURNING BASIN — 20 APRIL 1976

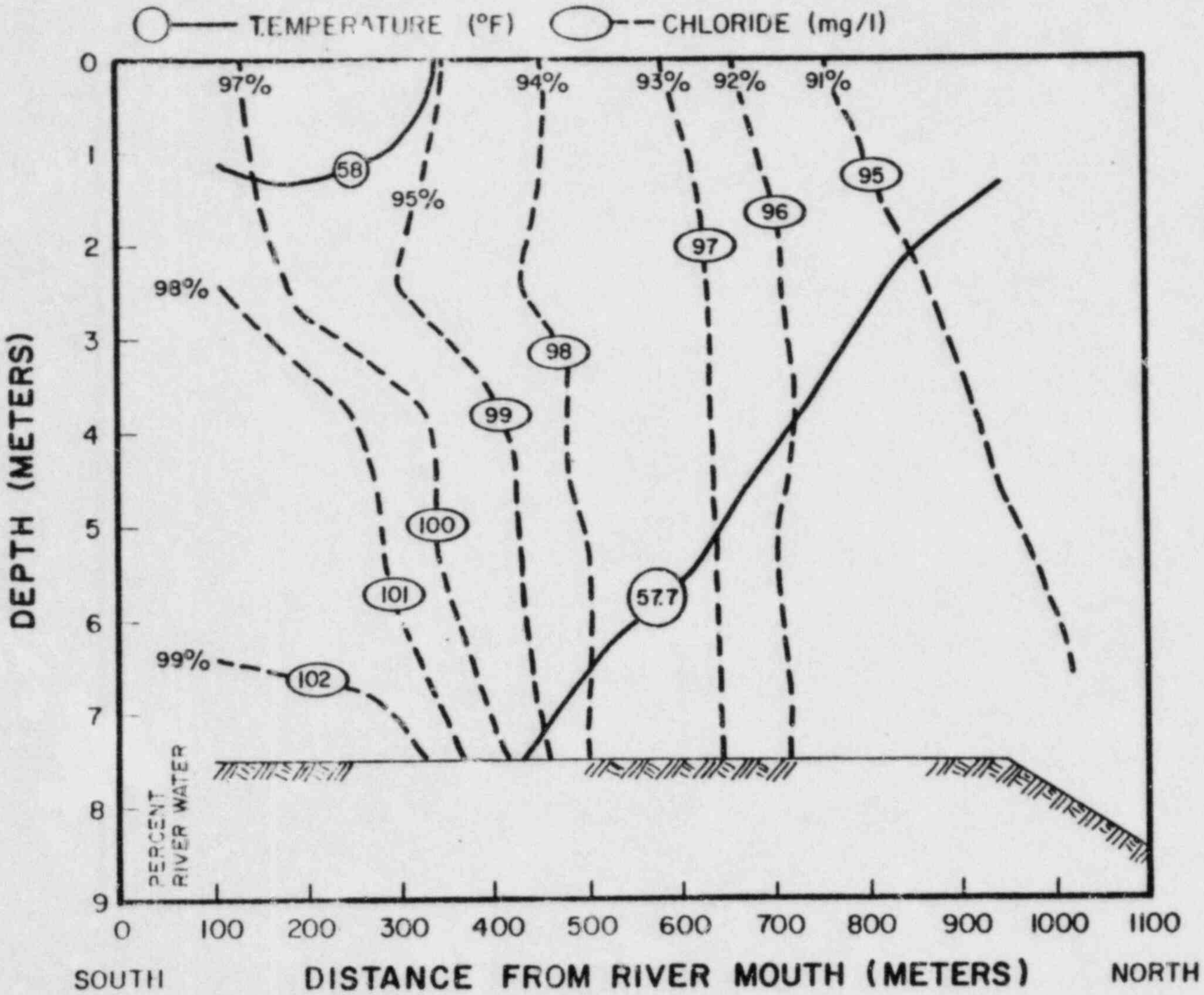


FIGURE III-13

measured near the discharge, was reduced to 12.8°C (55°F) at the point of the harbor discharge to the lake. Thus the maximum surface temperature at the harbor mouth was less than 1°C (1.8°F) warmer than the lake temperature [11.8°C (53.2°F)]. Figures III-9 shows the river water intruding the full length of the turning basin, with greater than 50% river water being present at the extreme western end of the turning basin. The discharge water mixed with the intruding river water as they flowed eastward, rising to the upper portions of the water column as they encountered the strong gradient of the intruding wedge of river water in the eastern portion of the turning basin. The discharge waters then spread in the harbor as described above, mixing further with the river flow especially near the river mouth where the southward spreading surface waters encountered the northward flowing river waters. Greater vertical mixing of the discharge waters occurred than during the August survey, possibly due to the decrease in chloride content in the river water and the resultant decrease in relative density. The vertical profile outside the harbor mouth shows evidence of the harbor discharge spreading along the bottom to the northwest, where inverse thermal stratification was observed in the form of ambient lake water (T = 11.4°C, Cl^- = 29 mg/l) above waters of higher chloride content (Cl^- = 45 mg/l) and higher temperature (11.8°C). These observations were made at a point approximately 500 meters (1640 ft) northwest of the harbor mouth.

In summary, the major changes from the late summer flow structure to that of the fall were the increased intrusion of river water into the turning basin and increased vertical mixing in the harbor area.

The April 1976 results, shown in Figures III-11 through III-13, were dominated by the high Oswego River flow of 490 m^3/sec (17,500 cfs) at the time of the survey. The river and lake temperature were 14.4°C (57.8°F) and 11.7°C (52.9°F), respectively, with a plant discharge temperature of 21.1°C (70°F). The lake temperature represents a vertical average of the lake temperatures just west of the harbor mouth as the lake was thermally stratified during the survey, varying from 13.5°C (56.1°F) at the surface to 10.4°C (50.5°F) at the 9 m (30 ft) depth. A vertical profile measured 1500 m (5000 ft) north of the harbor mouth showed lake temperatures of 9.1°C (48.2°F) and 5.3°C (41.5°F) at the surface and bottom, respectively.

The surface distribution (Figure III-11) shows the discharge at the western end of the turning basin initially mixing and cooling rapidly, then flowing eastward to the harbor with reduced mixing and cooling. At the junction of the turning basin and harbor, mixing and cooling of the discharge waters had reduced the temperature to 14.4°C (58°F), only 0.1°C (0.2°F) warmer than the river flow. The isothermal conditions in the main harbor area were attributable to essentially complete mixing of the plant discharge waters with the river flow, and the short detention time in the harbor at the high river flows. The high flows would have contributed to the mixing by raising the turbulence levels in the harbor, and would have minimized any atmospheric effects by reducing the detention time.

Figure III-12, the sectional view of the turning basin, shows extensive intrusion of river water into the entire turning basin. The cold water at the bottom of the turning basin was due to a mixture of river water and colder discharge waters discharged prior to the survey under conditions of low plant load, and reduced intake temperatures. The harbor section (Figure III-13) shows a high degree of vertical mixing, indicated by the near-vertical chloride isopleths. Some intrusion of lake water into the harbor may be indicated by the reduction in chloride concentration toward the harbor mouth. Vertical profiles done just east of the harbor mouth show slightly higher chloride concentrations (86.0 mg/l) at the surface than at the bottom (78.5 mg/l) in the presence of surface temperatures 0.7°C (1.2°F) above bottom temperature. This indicates that the warmer river water was rising toward the surface when it encountered the cooler lake water.

It would seem likely that as the river continues to warm, and the high spring flows diminish, that the flow structure observed in April would approach that observed in June 1975, as the river becomes increasingly buoyant relative to the lake water. Also, the buoyancy of the discharge waters relative to the river water will drop sharply when the tempering gates are closed, and the discharge temperature is reduced. In 1976, the gates were closed on 21 April, the day following the thermal survey.

The thermal contribution of Oswego Steam Station Units 1-4 during the spring survey was approximately 5% of the Oswego River contribution, using the average lake temperature immediately outside the harbor.

3. Summary of Seasonal Behavior of the Oswego Steam Station Units 1-4 Discharge and the Turning Basin-Harbor Complex

The temperature distributions and flow patterns within the Oswego Harbor-Turning Basin complex, and the behavior of the harbor outflow to Lake Ontario, are determined by the density relationships between the various water sources, which are in turn dependent on the temperature and chloride content of the sources. The spring condition is characterized by high flows from the Oswego River, which experiences a more rapid seasonal increase in temperature than does the lake. This results in the transition from a negatively buoyant river flow relative to the lake, to a positively buoyant flow, despite the chloride content of the river. The power plant effluent may be either positively or negatively buoyant relative to the river water during the spring warming period, depending on the lake intake temperature, plant generation, and the operation of the tempering gate. River water intrusion into the turning basin was highest during the spring, due to the high river flows and low plant discharge flows.

The early summer patterns indicate an intrusion of cold lake water into the harbor and turning basin, beneath the now warm, buoyant river flow. The discharge is again variable in its buoyancy relative to the turning basin waters, which have intruding river water in the upper layer and intruding lake water in the lower layer. The late summer structure is dominated by the now negatively buoyant river flow, due to a high chloride content. The buoyant discharge flows out of the turning basin on the surface, and mixes with the river flow as it proceeds to the harbor mouth. The harbor outflow is negatively buoyant and tends to flow out into the lake along the bottom.

The fall structure is dominated by increased river intrusion into the turning basin and increased mixing of the discharge waters with the river waters in the harbor. The harbor outflow is still negatively buoyant and tends to spread along the lake bottom.

C. BOD AND DO MODEL

1. Introduction

The purpose of this section is to quantify the effect of the cooling water discharge from the Oswego Steam Station Units 1-4 on the BOD and DO concentrations in the turning basin of Oswego Harbor. A one-dimensional, steady-state mathematical model is employed to estimate, for various temperature and flow conditions, the BOD and DO concentrations that represent extreme conditions that may occur in the turning basin.

Sewage and runoff from the west side of the city of Oswego are discharged into the basin at the two locations shown in Figure III-14, the waste discharge from the 12 inch pipe outfall is negligible compared with the west side waste input into the basin near the discharge from Units 1-4. The Oswego Westside Treatment Plant, now under construction, is expected to provide tertiary treatment of the sewage, thereby considerably reducing the concentrations of BOD, suspended solids, and phosphorus discharged into the basin. The thermal discharge from the generating station provides dilution for the existing raw sewage discharge and will have a similar effect

LOCATION OF OSWEGO TURNING BASIN AND WASTE INPUT

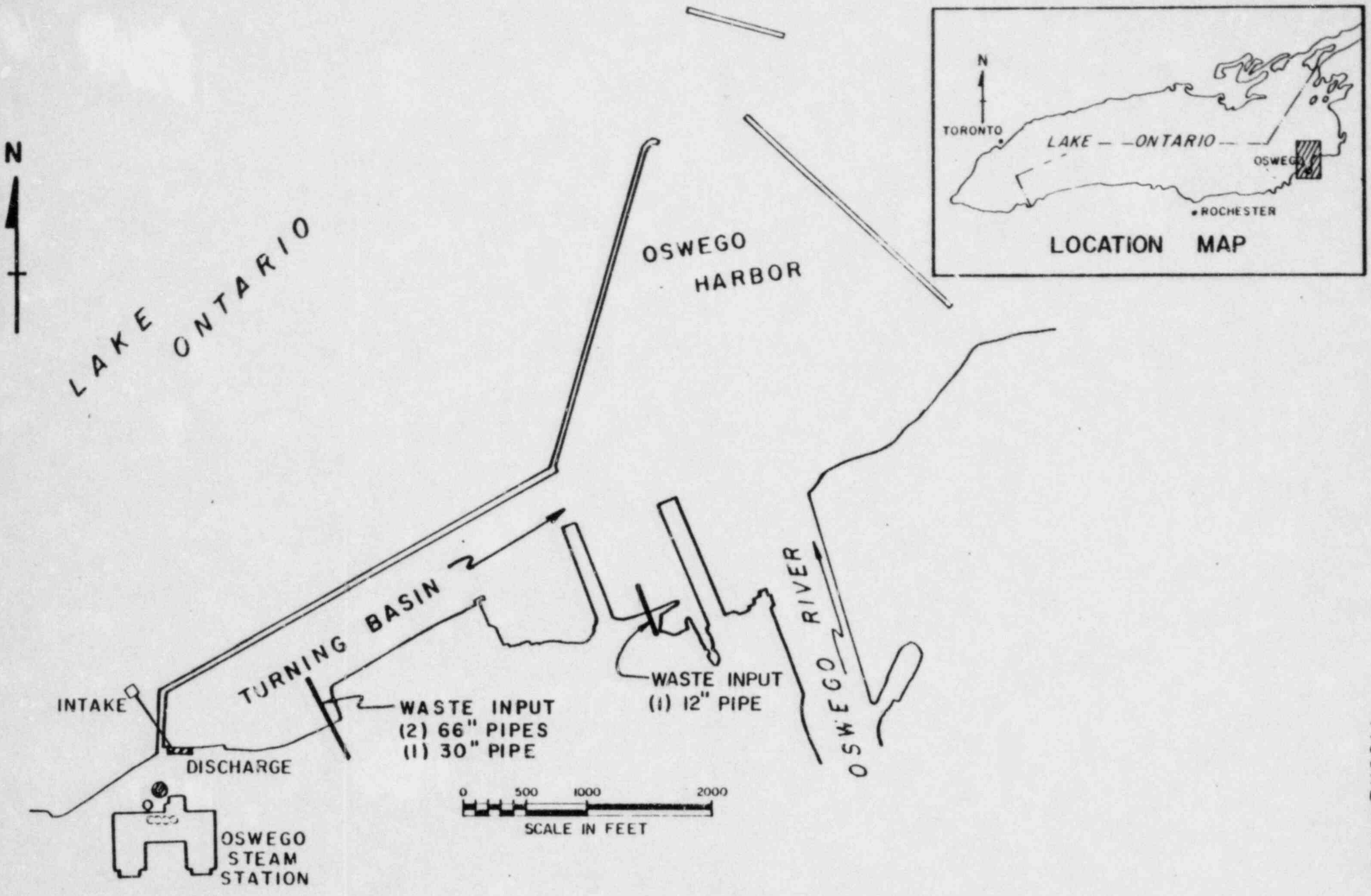


FIGURE III-14

on the proposed treatment plant's effluent, an effect which was considered in the design and licensing of the treatment plant.

Waters from the plant's heated discharge, the lake and the Oswego River interact in the harbor and the turning basin, resulting in a unique circulation pattern. This circulation, induced by temperature and density differences among the three water bodies, influences the temporal and spatial variations of the water quality parameters in the turning basin; these, in turn, affect the dynamics of the aquatic populations of the basin.

2. Outline of the Model

The one-dimensional mathematical model is described in detail in Appendix B. Development of this steady-state model is based on the classical theory of Streeter and Phelps, in which the natural purification process of a receiving water body is expressed mathematically. The mass balance equations consider the advective and dispersive properties of the flow, the decay rates of the sewage effluents discharged into the basin, and the natural aeration rates of the water body. Lateral and vertical variations are negligible or implicitly lumped into other terms.

Solutions of the coupled equations yield average concentrations of BOD and DO at any given cross section in the turning basin as a result of the sewage and runoff inflow, and the flow conditions influenced by the waste water discharge, which is varied seasonally.

3. Discussion of Model Results

The BOD and DO concentrations computed at 200 ft intervals within the channel, under the various flow and seasonal conditions, are presented in Appendix B. The average values in the turning basin are summarized in Table III-2. Figures III-15 and III-16 compare the concentration levels under the assumed stratified and nonstratified conditions in the summer and winter.

Under full capacity discharge of the power plant, the maximum BOD concentration in the summer (temperature = 20°C) for a nonstratified flow is 1.7 mg/l at the point of waste input, resulting in a dilution of 228. An average BOD concentration under this condition is 7.27 mg/l, which results in an average dilution of 257. The oxygen deficit from this waste input is very small, and DO is therefore generally high (average, 9 mg/l) throughout the channel. Even if there is stratification in the summer, the BOD level is still about 1.7 mg/l at the discharge point, with an average value of 1.3 mg/l in the basin. In winter, when the heated discharge from the plant is reduced, the maximum BOD obtained under nonstratified

TABLE III-2

SUMMARY OF THE AVERAGE BOD AND DO CONCENTRATIONS IN THE TURNING BASIN UNDER VARIOUS CONDITIONS

I. SUMMER

TRANSPORT MODE CONDITIONS	PARAMETER	ADVECTION AND DISPERSION 1	ADVECTION ONLY 2	DIFFUSION ONLY 3
NON-STRATIFIED CONDITION	BOD	1.27	1.28	21.61
	DO	9.00	9.00	3.49
STRATIFIED CONDITION	BOD	1.29	1.29	41.25
	DO	9.01	9.01	(-1.42)

II. WINTER

NON-STRATIFIED CONDITION	BOD	3.07	3.07	53.63
	DO	14.60	14.60	5.58
STRATIFIED CONDITION	BOD	3.10	3.10	102.29
	DO	14.62	14.62	(-2.52)

BOD AND DO PROFILES UNDER FULL AND NO FLOW SUMMER CONDITIONS

OSWEGO TURNING BASIN — 1975-1976

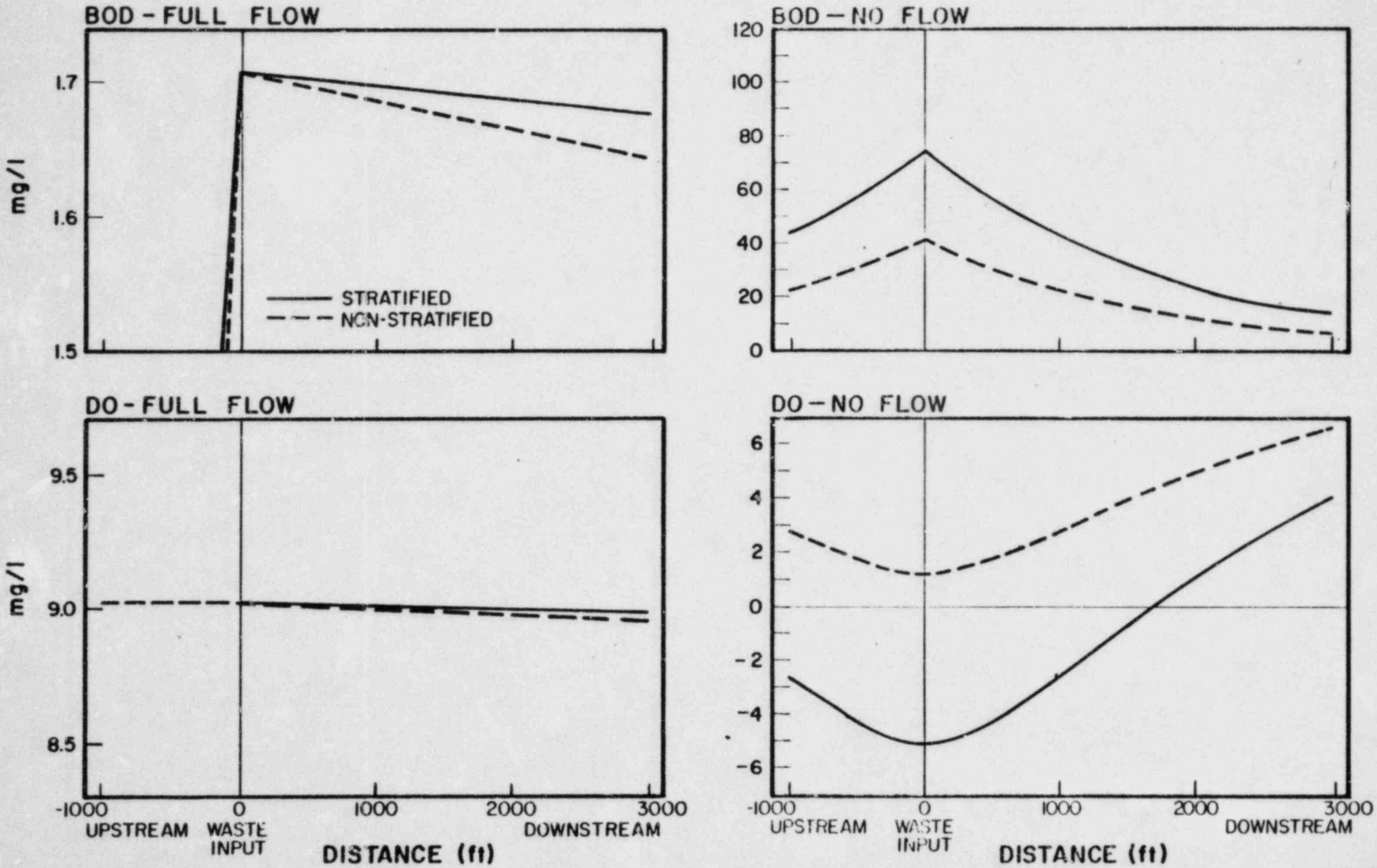


FIGURE III-15

BOD AND DO PROFILES UNDER FULL AND NO FLOW WINTER CONDITIONS

OSWEGO TURNING BASIN — 1975-1976

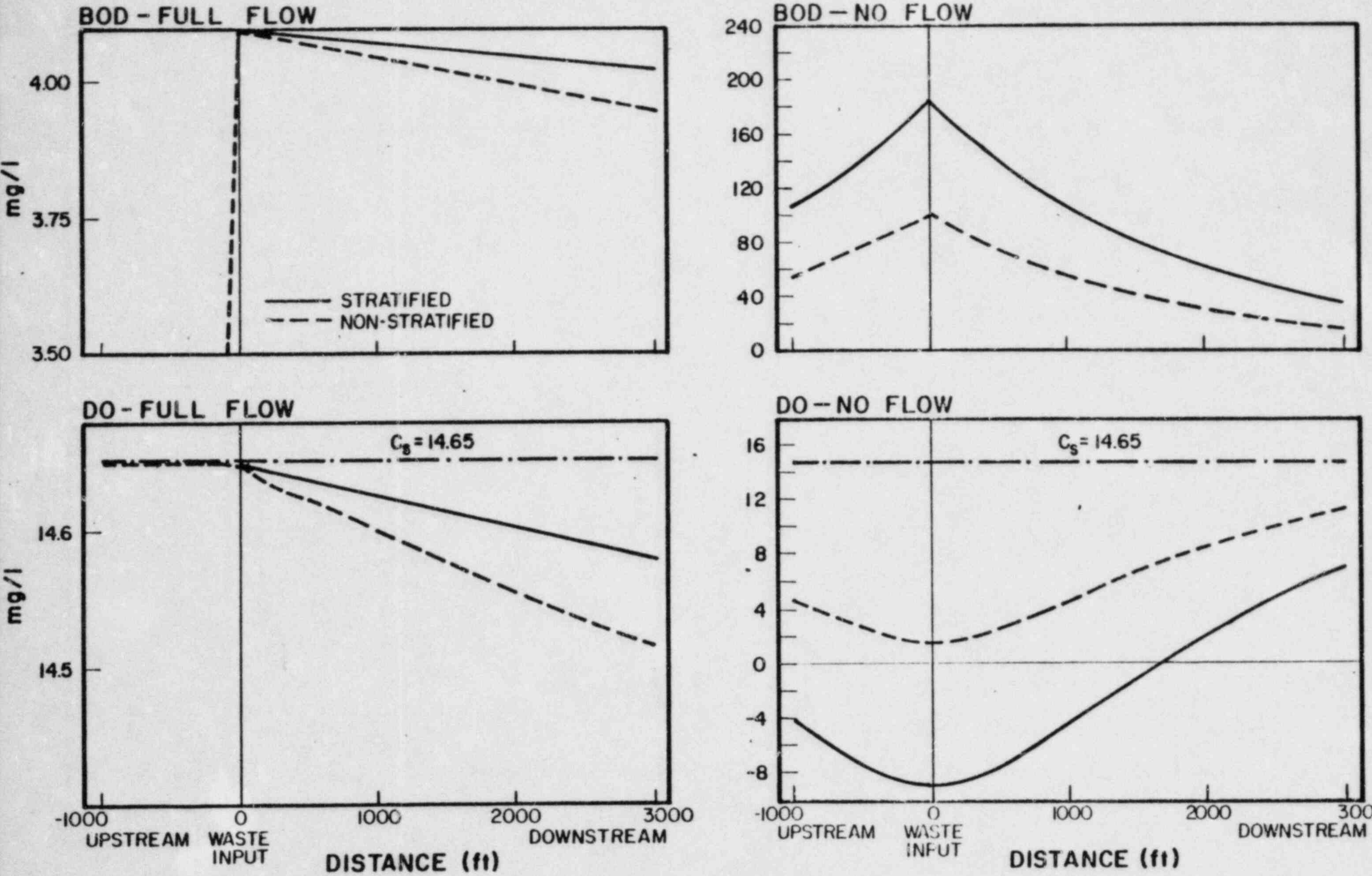


FIGURE III-16

conditions is 4 mg/l, with an average value of 3 mg/l in the turning basin; values under stratified flows are similar. Winter DO levels are generally high (average, 14.6 mg/l) exceeding summer levels because of high DO saturation, caused by low winter temperatures.

With no flows, the BOD concentrations are very high, 41.5 mg/l at the discharge point under summer nonstratified condition, 75 mg/l for summer stratified condition, 101 mg/l for winter nonstratified condition, and 185 mg/l under winter stratified condition. These result in extremely low levels of DO and anaerobic conditions in certain portions of the channel.

4. Conclusions

The results show that the main transport of the waste in the turning basin is by advection induced by the plant discharge. The dispersion effect is minimal, as shown by the similarity of the two cases considering full flow, one with dispersion, and the second in which dispersion has been neglected. In both winter and summer, without any flow, the BOD levels are very high, resulting in very low DO concentrations, as compared with cases with channel flow. In a stratified condition, in both summer and winter, part of the basin would be anaerobic.

Comparions of the flow and no-flow conditions indicates that the power plants' discharge has a definite beneficial influence on the turning basin and the Oswego Harbor water quality.

The effect of stratification has been simply represented by confining the flows in the upper half layer of the channel, resulting in a faster flow into the harbor; in general its effect is very small on the BOD and DO levels, in either of the seasons. As shown in the figures, differences in the concentration profiles are due mainly to the differences in discharge flow rates, rather than to the hydrodynamic characteristics of the induced circulation patterns.

The model results compare favorably with the field measurements of BOD and DO concentrations in the turning basin.

DO levels are greatly dependent on the saturation concentration, temperature, or the time of measurement, and cannot be exactly related to the calculated values.

Since field data are normally obtained under a single operating power plant condition, the steady-state model provides a good tool for obtaining expected concentration levels of BOD and DO under varying seasonal conditions of power plant discharge into the basin. However, further refinement of the model parameters is necessary to describe the circulation patterns induced by the discharge based on these two parameters.

REFERENCE CITED

CHAPTER III

Quirk, Lawler and Matusky Engineers. 1971. Effect of circulating water systems on Lake Ontario and Oswego Harbor water temperature and aquatic biology [Oswego Steam Station Unit 5]. Prepared for Niagara Mohawk Power Corp.

IV. BIOLOGICAL STUDIES AND COMMUNITY COMPOSITION

A. INTRODUCTION

The following sections present biological data encompassing several trophic levels and a discussion of the data in relation to the characterization of the biological community in the vicinity of the Oswego Steam Station. The biological information was collected in support of a demonstration to evaluate the thermal discharge from Oswego Steam Station Units 1-4 on the biota in the receiving water body. A detailed description of the biological sampling program with sampling location maps is presented in Appendix C.

B. PLANKTON

1. Phytoplankton

a. Introduction

Phytoplankton are those generally microscopic unicellular, colonial, and filamentous algae which live suspended in the water column. Their abundance and distribution is a function primarily of water temperature, the quality and quantity of light, concentrations of dissolved, organic and inorganic nutrients, grazing pressure by consumers, and water circulation patterns. As primary producers, phytoplankton form the base of the food web in many aquatic ecosystems, and their numbers and kinds, which reflect water quality, may influence the numbers and kinds of other biota in the system.

b. Species Inventory

A total of 261 phytoplankton taxa representing seven major groups were identified in samples collected from the Oswego Harbor and Turning Basin (including the intake of Oswego Steam Station Units 1-4) during 1975-1976 (Table IV.B-1). Green algal forms constituted the largest number of taxa identified (107), followed by diatoms (64), blue-green algae (31), cryptomonads (21), yellow-brown algae (19), dinoflagellates (12), and euglenoids (7). While a smaller number of taxa were identified at the intake (178) than at Oswego Turning Basin stations (255), all of the most abundant taxa except *Melosira varians* were found at the intake as well as at turning basin stations.

Species of blue-green algae were among the most abundant throughout the year (Table IV.B-1); *Chroococcus dispersus* var. *minor* and *Oscillatoria limnetica* could be considered characteristic of the study area. Species of green algae were among the dominants

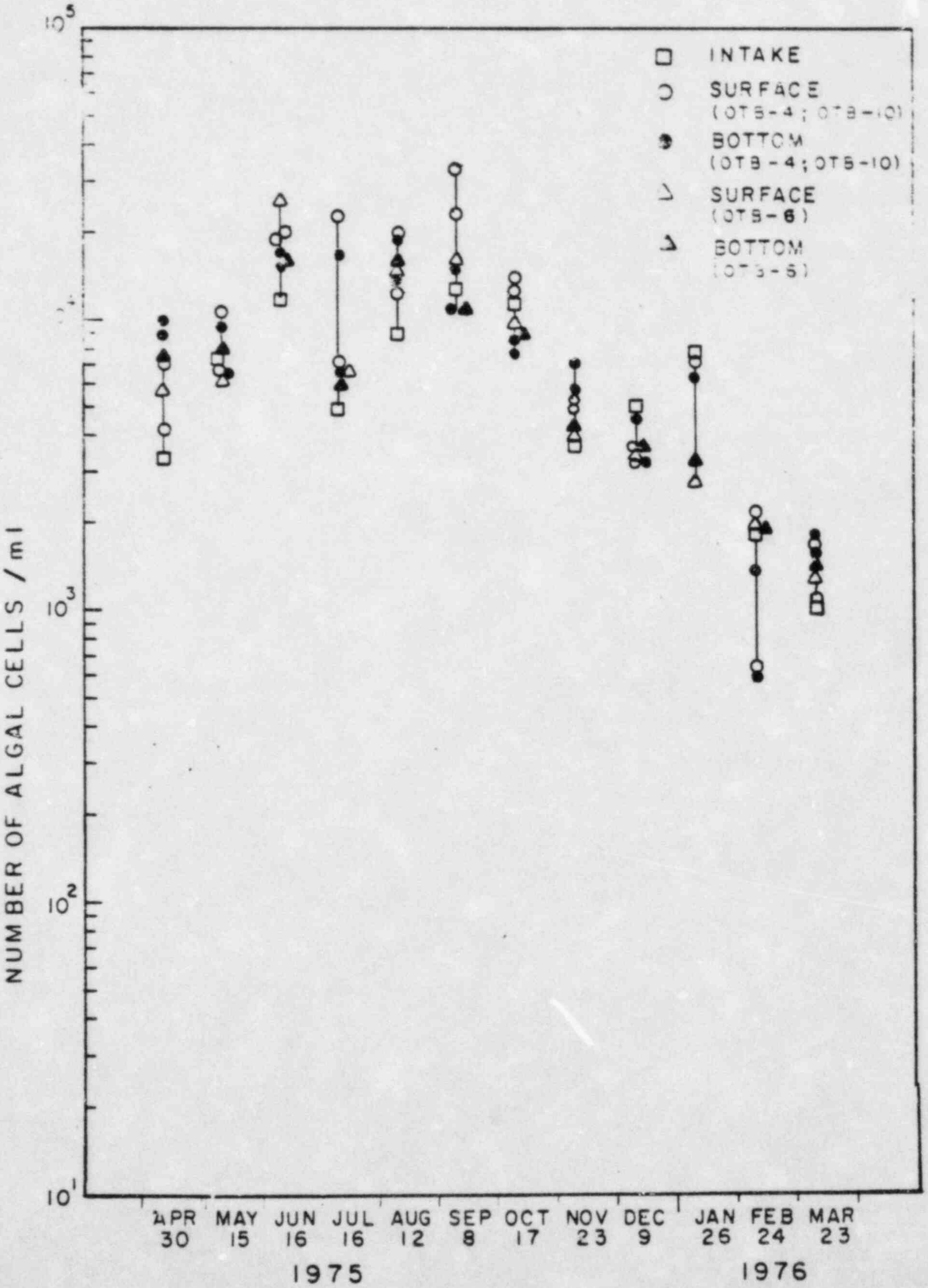
TABLE IVB-1

OCCURRENCE OF PHYTOPLANKTON BY DATE
OSWEGO HARBOR AND TURNING BASIN 1975 - 1976

TAXA	30APR	15MAY	16JUNE	16JULY	12AUG	08SEP	17OCT	23NOV	09DEC	26JAN	24FEB	23MAR
MYXOPHYCEAE												
ANACYSTIS AERUGINOSA				D	D	D	X		X			
APHANOCAPSA PULCHRA					X							
APHANOCAPSA DELICATISSIMA			X	X	D	X						
APHANOCAPSA ELACHISTA								X				
APHANOTHECE NIDULANS										X		
CHROOCOCCUS LIMNETICUS				X	X							
CHROOCOCCUS MINUTUS						X						
CHROOCOCCUS DISPERSUS		X	X	X		X	X	X			X	
CHROOCOCCUS DISPERSUS VAR. MIN	X	X	D	D	X	D	D	D	X	D	X	X
CHROOCOCCUS MINIMUS								X				
COELOSPHAERIUM KUETZINGIA		X		X	X	X	X	D	X	X	X	X
COELOSPHAERIUM NAEGELIANU							X		X			
COELOSPHAERIUM PALLIDUM					X		X		X			
GOMPHOSPHAERIA LACUSTRIS			X		X	X	X		X			
MERISMOPEDIA GLAUCA						X						
MERISMOPEDIA TENUISSIMA				D	D	D	X	X	X		X	
LYNGBYA LIMNETICA									X			
OSCILLATORIA SP.				X					X			
OSCILLATORIA AGARDHII	X	X	X	X	X	X	X	X	X	X	X	
OSCILLATORIA LIMNETICA	X	D	D	X	X	X	D	X	X	D	D	D
OSCILLATORIA GEMINATA		X	X		X	X	X		X			
OSCILLATORIA MINIMA					X	X	X	X	X		D	X
OSCILLATORIA AMPHIBIA					X	X	X	X		D	X	
PHORMIDIUM SP.											X	
RHAPHIDIOPSIS SP.				X	X	X						
ANABAENA SP.	X			X	X	X	X		X			
ANABAENA SPIROIDES						X						
ANABAENA INAEQUALIS						X	X				X	
ANABAENA PLANCTONICA					X	X						
APHANIZOMENON FLOS-AQUAE		X	X	X	X	X	X	X	X			X
PLECTONEMA SP.								X	X			
CHLOROPHYCEAE												
UNIDENTIFIED CHLOROPHYCEAE	X	X	X		X						X	
CARTERIA SP.	X		X		X				X	X		
CARTERIA CORDIFORMIS			X	X	X	X	X		X		X	X
CARTERIA KLEBSII			X	X			X	X				
CHLAMYDOMONAS SP.	X	X	X	X	X	X	X	X	X	D	X	X
CHLAMYDOMONAS GLOBOSA	X	X	X	X	X	X	X	X	X	D	X	X
CHLAMYDOMONAS PSEUDOPERTYI	X	X										
EUDORINA ELEGANS			X	X	X	X		X	X			
PANDORINA MORUM					X	X		X				
PEDINOMONAS MINUTISSIMA	X	X	X	X	X	X	X	X	X	D	X	X
LOBOMONAS SP.								X	X			
CHLOROGONIUM SP.			X					X				
CHLOROGONIUM METAMORPHUM						X						X
POLYTOMA SP.	X	X	X			X	X	X	X	D	X	X
POLYTOMA MICROSPHAERICUM	X	X		X		X	X					X

ABUNDANCE OF TOTAL PHYTOPLANKTON*

OSWEGO VICINITY — 1975-1976



*Mean of replicates

(ii) Diatoms (Bacillariophyceae)

Diatoms composed a large fraction of total phytoplankton abundance, particularly during the cooler months of the year (Table IV.B-2). Diatoms reached peak abundance during the spring months, decreased during summer, increased to a second but smaller maximum during late fall/early winter, and then decreased to a midwinter minimum in abundance (Figure IV.B-2). This seasonal pattern is typical for diatoms in Lake Ontario (e.g., LMS, 1975, 1976a) and reflects the cool-water optimum for growth common in members of this algal group (Canale and Vogel, 1974).

During most months of study, diatom abundance was greater in the turning basin, particularly at OTB-4 (Appendix D), than at the intake (Figure IV.B-2), indicating that the river was the primary source of diatoms in the turning basin. Lower diatom concentrations in the surface waters at OTB-6 and OTB-10 on the majority of the survey dates (Appendix D), indicate that the predominant circulation pattern was penetration of river water along the bottom of the turning basin, followed by mixing with lake water at the west end of the basin, and return of the mixed water to the river at the surface of the basin. Only during January was diatom abundance at OTB-6 lower than abundances at both the intake and OTB-10.

(iii) Green Algae (Chlorophyceae)

Green algae also composed a substantial fraction of total phytoplankton abundance, especially during late spring/early summer (Table IV.B-3). Relative abundance of this group tended to be greater at turning basin and harbor stations than at the intake of Oswego Units 1-4. The seasonal pattern of green algal abundance was unimodal with maximum concentrations recorded during midwinter (Figure IV.B-3), as is usual in Lake Ontario (e.g., LMS, 1975,1976a).

The spatial distribution patterns of green algae differed somewhat from that described for diatoms. Although abundance at OTB-4 was generally greater than at the other survey stations and the station x depth interactions indicated that green algal distribution was a function primarily of water circulation patterns, concentrations of green algae were at times slightly reduced in the turning basin to lower levels than recorded at both the intake and OTB-4 (Appendix D). These lower turning basin values were found from August through January, although they were most apparent at OTB-6 during the latter months

TABLE IVB -1 (Continued)

OCCURRENCE OF PHYTOPLANKTON BY DATE

TAXA	DATES 30APR	15MAY	16JUNE	16JULY	12AUG	08SEP	17OCT	23NOV	09DEC	26JAN	24FEB	23MAR
POLYTOMA GRANULIFERUM						X		X			X	
MESOSTIGMA VIRIDE						X	X					
SCOURFIELDIA CORDIFORMIS											X	
FURCILIA SP.						X				X		
GYROMITUS SP.						X						
ELAKOTOTHRIX GELATINOSA												X
GLOEOCYSTIS GIGAS	X	X	X		X	X	X				X	
GLOEOCYSTIS PLANKTONICA					X							
GLOEOCYSTIS VESICULOSA			X		X	X	X					
SPHAEROCYSTIS SCHROETERI			X	X	X	X	X	X	X			
TETRASPORA LACUSTRIS	X	X	X		X	X	X		X		X	
ULOTHRIX SP.	X		X			X						
ULOTHRIX SUBCONSTRICTA				X								
OEDOGONIUM SP.	X		X	X	X	X	X	X	X	D	X	X
MOUGEOTIA SP.	X	X	X	X	X	X	X	X	X	X	X	
CLOSTERIUM SP.		X	X		X	X	X	X	X	X	X	X
CLOSTERIUM ACICULARE		X		X	X	X	X	X	X	X	X	X
COSMARIUM SP.	X			X	X		X	X	X		X	X
STAURASTRUM SP.				X	X	X	X	X	X			
ACTINASTRUM HANTZSCHII	X	X			X				X			X
ANKISTRODESMUS FALCATUS	X	X	X	D	X	X	X	X	X	X	X	X
ANKISTRODESMUS SPIRALIS									X			
ANKISTRODESMUS SPIROTAENIA	X	X	X	X		X	X	X	X	D	X	X
ANKISTRODESMUS NANNOSELENE			X	X	X	X	X	X	X	X	X	
CHODATELLA CILIATA			X		X		X		X	X		
CHODATELLA CITRIFORMIS							X					
CHODATELLA SUBSALSA	X	X	X	X	X	X	X	X	X			
CHODATELLA QUADRISETA		X	X	X	X	X	X	X	X			
CHLORELLA SP.			X	X	X	X	X	X	X	X	X	X
COELASTRUM CAMBRICUM					X	X						
COELASTRUM MICROPORUM	X	X	X	D	X	X	X	X	X		X	
COELASTRUM RETICULATUM				X	X							
CRUCIGENIA RECTANGULARIS				X	X	X						
CRUCIGENIA TETRAPEDIA			X	X	X		X	X	X			
CRUCIGENIA QUADRATA				X								
CRUCIGENIA APICULATA			X	X	X							
DICTYOSPHAERIUM EHRENBERGIANUM	X	X		X	X	X	X					
DICTYOSPHAERIUM PULCHELLUM	X	X	X	X	X	X	X	X	X			
ECHINOSPHAERELLA LIMNETICA					X	X	X		X			
ERRERELLA BORNHEMIENSIS					X							
FRANCEIA DROESCHERI			X	X	X	X		X			X	
FRANCEIA TUBERCULATA				X								
GOLENKINIA RADIATA	X	X	X	X	X	X	X	X	X			X
KIRCHNERIELLA CONTORTA		X	X	X	X		X	X	X	D	X	
KIRCHNERIELLA SUBSOLITARIA						X			X		X	
MICRACTINIUM PUSILLUM	X	X	X	X	X	X	X	X	X	X	X	X
NEPHROCYTIUM AGARDIANUM				X	X		X		X			
OOCYSTIS SP.	X	X	X	X	X	X	X	X	X	D	X	X
OOCYSTIS BORGEI	X	X	X	X	X	X	X	X	X	X	X	
OOCYSTIS LACUSTRIS	X						X	X		X	X	
OOCYSTIS PARVA			X									
OOCYSTIS PUSILLA	X		X	X	X		X					
OOCYSTIS SOLITARIA				X		X						

TABLE IVB-1 (Continued)

OCCURRENCE OF PHYTOPLANKTON BY DATE

TAXA	30APR	15MAY	16JUNE	16JULY	12AUG	08SEP	17OCT	23NOV	09DEC	26JAN	24FEB	23MAR
PEDIASTRUM BORYANUM	X	X	X	X	X		X		X	D	X	
PEDIASTRUM DUPLEX		X	X	X	X		X	X				X
PEDIASTRUM SIMPLEX				X	X	X	X				X	
PEDIASTRUM TETRAS			X	X	X							
QUADRIGULA CHODATII		X			X							
SCENEDESMUS ABUNDANS	X	X	X	X	X	X	X	X	X	X	X	X
SCENEDESMUS ACUMINATUS	X	X	X						X			
SCENEDESMUS ACUTIFORMIS								X				X
SCENEDESMUS BIJUGA	X	X	X	X	X	X	X	X	X	D	D	D
SCENEDESMUS BRASILIENSIS		X	X	X	X	X	X					
SCENEDESMUS DENTICULATUS				X	X	X	X	X			X	
SCENEDESMUS DIMORPHUS	X	X	X	X	X	X	X	X	X	D	X	X
SCENEDESMUS INCRASSATULUS			X	X	X		X	X	X			
SCENEDESMUS LONGUS					X							
SCENEDESMUS OBLIQUUS		X	X									
SCENEDESMUS OPOLIENSIS	X			X	X	X	X	X	X	X		
SCENEDESMUS QUADRICAUDA	X	X	X	D	X	X	X	X	X	D	X	X
SCENEDESMUS BIJUGATUS	X	X			X	X						
SCENEDESMUS INTERMEDIUS	X			X	X	X	X		X		X	
SCHROEDERIA JUDAYI			X	X	X	X	X	X	X	D	X	X
SCHROEDERIA SETIGERA						X		X	X			
SELENASTRUM MINUTUM	X	X	X	X	X	X	X	X	X	D	X	X
TETRAEDRON CAUDATUM		X	X	X		X	X	X	X		X	
TETRAEDRON MINIMUM	X	X	X	X	X	X	X	X	X	X	X	X
TETRAEDRON MUTICUM				X	X	X	X		X			
TETRAEDRON REGULARE					X	X						
TETRAEDRON TRIGONUM					X							
TETRAEDRON ARTHRODESMIFORME			X									
TETRASTRUM SP.												X
TETRASTRUM HETERACANTHUM	X					X	X		X			X
TETRASTRUM STAUROGENIAEFORME	X	X	X	X	X	X	X	X	X	D	X	X
TETRASTRUM ELEGANS	X						X					
TREUBARIA SETIGERUM			X		X	X	X					
TREUBARIA TRIAPPENDICULATA	X		X		X	X	X	X	X	X	X	
WESTELLA LINEARIS				X								
CORANASTRUM AESTIVALE				D	X	X	X	X				
PARAMASTIX SP.						X		X	X	X		
PARAMASTIX CONIFERA	X	X								X	X	X
PARAMASTIX MINUTA										X		
EUGLENOPHYCEAE												
EUGLENA SP.	X	X		X	X			X				X
EUGLENA GASTEROSTEUS	D	X		X			X	X	X			X
PHACUS SP.				X			X	X	X			
PHACUS PYRUM			X		X	X	X	X	X	X	X	X
TRACHELOMONAS SP.		X				X	X	X	X			
LEPOCINCLIS SP.		X										
RHABDOMONAS SP.						X					X	
CHRYSOPHYCEAE												
UNIDENTIFIED CHRYSOMONADALES	X											
DINOBRYON SP.			X	X	X	X	X	X		X		X
DINOBRYON SOCIALE	X	X	X			X	X	X	X		X	X

TABLE IVB-1 (Continued)

OCCURRENCE OF PHYTOPLANKTON BY DATE

TAXA	DATES 30APR	15MAY	16JUNE	16JULY	12AUG	08SEP	17OCT	23NOV	09DEC	26JAN	24FEB	23MAR
MALLOMONAS SP.	X			X	X	X	X		X	X	X	X
SYNURA UVELLA	X	X										X
CHRYSOCHROMULINA PARVA	D	D	X	X	D	D	X	X	X	X	X	X
CHROMULINA SP.	X		X		X	X	X		X	D	X	X
STELEXMONAS SP.	X	X	X	X	X		X		X	D	X	X
KEPHYRION SP.	X	X			X	X	X	X	X	X	X	
RHIZOCHRYSIS SP.	X	X	X		X	X	X	X	X	X	X	X
CHRYSOCOCCUS SP.							X		X	X	X	X
CHRYSAMOEBA SP.						X	X	X	X	X	X	
OCHROMONAS SP.	X	X	X	D	D	X	X	X	X	D	X	X
UROGLENA SP.	X	X					X	X	X	X	X	X
CODONOSIGOPSIS ROBINI	X	X		X		X	X		X	D	X	
MONAS SP.							X	X	X	X	X	X
RHYNCHOMONAS SP.					X	X	X		X		X	
BODO SP.							X		X	D	X	X
ERKENIA SUBAEQUICILIATA									X	X	X	X
BACILLARIOPHYCEAE												
COSCINODISCUS ROTHII		X	X	X	X	X	X	X	X	X	X	X
CYCLOTELLA ATOMUS	X	D	D	D	X	D	X	D	X	D	D	X
CYCLOTELLA GLOMERATA					X	X		X	X	D	X	D
CYCLOTELLA MENEGHINIANA	X	X	X	X	X	X	X	X	X		X	X
CYCLOTELLA PSEUDOSTELLIGERA							X	X				
MELOSIRA SP.										X		
MELOSIRA BINDERANA	D	X	X				X	X	D	D	X	X
MELOSIRA DISTANS								X	X			
MELOSIRA GRANULATA	X	X	X	X	X	X	X	X	X		X	X
MELOSIRA ISLANDICA	X	X	X	X	X	X		X	X	D	X	X
MELOSIRA ITALICA	X	X	X	X	X	X	X	X	X			X
MELOSIRA ITALICA VAR. SUBARCTI	X	X	X	D	X	X	X	X	X	X		X
MELOSIRA VARIANS									X	D		X
MELOSIRA GRANULATA VAR. ANGUST				X	X	X	X	X	X			
MELOSIRA ITALICA V. TENUISSIMA							X					
STEPHANODISCUS ASTREA	X				X		X		X	D	X	X
STEPHANODISCUS HANTZSCHII	D	D	D	X	X	X	X	X	D	D	D	D
STEPHANODISCUS NIAGARAE	X	X	X				X	X	X	X	X	X
STEPHANODISCUS ASTREA VAR. MIN	X	X	X	X	X	X	X	X	X	D	X	X
ACHNANTHES LANCEOLATA											X	X
AMPHIPRORA SP.												X
ASTERIONELLA FORMOSA	X	X	X	X		X	X	X	X	D	D	X
COCCONEIS SP.			X									
COCCONEIS PLACENTULA							X					
COCCONEIS PEDICULUS			X									
CYMATOPLEURA SOLEA	X	X	X			X					X	
DIATOMA ELONGATUM	X	X	X	X	X	X	X	X	X	D	X	X
DIATOMA VULGARE								X	X	X	X	X
DIATOMA TENUE VAR. ELONGATUM			X									
DIATOMA ELONGATUM V. TENUIS	X	X	X								X	X
EUNOTIA CURVATA	X											X
FRAGILARIA CAPUCINA	X	X	X			X	X	D	X	X	X	X
FRAGILARIA CROTONENSIS	X	X	X	X	X	X	X	X	X	D	X	X
FRAGILARIA VAUCHERIAE	X	X	X	X		X	X	X	X		X	X
GOMPHONEMA ACUMINATUM										X		

TABLE IVB-1 (Continued)

OCCURRENCE OF PHYTOPLANKTON BY DATE

TAXA	DATES 30APR	15MAY	16JUNE	16JULY	12AUG	08SEP	17OCT	23NOV	09DEC	26JAN	24FEB	23MAR
GOMPHONEMA OLIVACEUM	X								X			X
GOMPHONEMA PARVULUM									X	X	X	X
GYROSIGMA SP.	X						X					
GYROSIGMA ACUMINATUM										X		
MERIDION CIRCULARE												X
NAVICULA SP.	X	X				X		X	X	X	X	X
NAVICULA CRYTOCEPHALA	X	X	X		X	X	X	X	X	X	X	X
NAVICULA TRIPUNCTATA	X							X	X	X	X	X
NAVICULA CAPITATA	X								X		X	
NAVICULA LANCEOLATA	X	X					X	X				
NAVICULA SALINARUM	X	X				X	X	X	X	X	X	
NITZSCHIA SP.	X	X	X		X	X	X	X	X	D	X	X
NITZSCHIA ACICULARIS	X	X	X		X	X	X	X	X	X	X	X
NITZSCHIA DISSIPATA	X	X	X	X	X	X	X	X	X	X	X	X
NITZSCHIA FONTICOLA									X			
NITZSCHIA GRACILIS	X	X	X							X	X	X
NITZSCHIA HOLSATICA					X	X	X		X			
NITZSCHIA PALEA	X	X					X	X	X		X	X
NITZSCHIA SIGMOIDEA											X	
NITZSCHIA VERMICULARIS	X		X		X						X	X
NITZSCHIA RECTA		X										
RHOICOSPHENIA CURVATA	X					X	X	X	X	X	X	X
SURIRELLA ANGUSTATA				X								X
SURIRELLA OVALIS	X											
SYNEDRA SP.	X	X	X				X	X		X	X	X
SYNEDRA ACUS	X	X	X		X	X			X	D	X	X
SYNEDRA ULNA	X	X	X		X				X		X	X
SYNEDRA AFFINIS		X										
TABELLARIA FENESTRATA	X	X	X				X	X	X	D	X	X
CRYPTOPHYCEAE												
CRYPTOMONAS SP.	X								X		X	X
CRYPTOMONAS EROSA	X	X	X	X	X	X	X	X	X	X	X	X
CRYPTOMONAS OVATA	X	X	X	X		X	X	X	X	X	X	X
CRYPTOMONAS EROSA VAR. REFLEXA	X	X	X	X	X	X	X	X	X		X	X
CRYPTOMONAS CAUDATA	X			X			X		X	X	X	X
CRYPTOMONAS MARSSONII	X	X	X	X	X	X	X	X	X		X	X
CRYPTOMONAS PHASEOLUS	X	X	X	X	X	X				X	X	X
CRYPTOMONAS PUSILLA					X	X	X		X			
CRYPTOMONAS REFLEXA	X	X	X	X	X	X	X	X	X		X	X
CRYPTOMONAS ROSTRATA		X			X							
CRYPTOMONAS PARAPYRENOIDIFERA				X								
CRYPTOMONAS 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	X	X	X
RHODOMONAS MINUTA VAR. NANNOPL	X	D	X	D	X	D	X	D	X	X	X	X
SENNIA PARVULA	X	X				X	X				X	X
CRYPTAULAX SP.			X						X			
CRYPTAULAX RHOMBOIDEA							X			X	X	
CHROOMONAS SP.		X										
MONOMASTIX SP.									X		X	
CHIL[illegible]NAS [illegible]AMAE[illegible]	[illegible]	[illegible]	[illegible]								[illegible]	[illegible]

CHILOMONAS PARAMAECIUM x ^ ^

TABLE IVB-1 (Continued)

OCCURRENCE OF PHYTPLANKTON BY DATE

TAXA	DATES 30APR	15MAY	16JUNE	16JULY	12AUG	08SEP	17OCT	23NOV	09DEC	26JAN	24FEB	23MAR
DINOPHYCEAE												
GYMNODINIUM SP.	X		X	X	X	X	X	X	X	X		X
GYMNODINIUM HELVETICUM	X	X						X	X	X	X	X
GYMNODINIUM VARIANS	X		X	X	X	X	X		X	X	X	X
GYMNODINIUM ORDINATUM												X
GYMNODINIUM EURYTOPUM						X		X			X	X
CERATIUM HIRUNDINELLA						X						
GLENODINIUM SP.	X	X	X	X			X		X		X	X
GLENODINIUM PULVISCULUS				X	X	X	X			X		
PERIDINIUM SP.	X	X			X							
PERIDINIUM ACICULIFERUM	X	X	X	X	X	X						X
PERIDINIUM CINCTUM							X					
PERIDINIUM CUNNINGTONII					X							
OTHER												

FOOTNOTES:
D INDICATES PRESENCE AT > 15 PERCENT OF TOTAL AT ONE OR MORE STATIONS
X INDICATES PRESENCE AT ONE OR MORE STATIONS

primarily during early summer and winter, as were species of yellow-brown algae. Diatoms, notably Cyclotella atomus, Melosira binderana, and Stephanodiscus hantzschii, were among the dominant species primarily during the spring and winter months. All of the genera noted above, except Chroococcus, are typically associated with organically polluted water (Palmer, 1969).

c. Abundance and Percent Composition

(i) Total Phytoplankton

The annual cycle of total phytoplankton abundance was unimodal with peak numbers recorded during September and minimal numbers recorded during March. Small peaks were also noted during June and January (Figure IV.B-1). The observed pattern is typical of that reported for many freshwater bodies, including Lake Ontario (Munawar and Nauwerck, 1971; Munawar et al., 1974; Vollenweider et al., 1974; Stoermer et al., 1975; LMS, 1975, 1976a). Only the small pulse in abundance during January was unexpected.

As shown in Figure IV.B-1, there was considerable variation in the relationship of phytoplankton abundance at OTB-6, the turning basin station closest the discharge of Oswego Units 1-4, to other stations in the study area. This variation suggests that the turning basin is a mixing zone for discharged lake and intruded river water and that circulation patterns are generally complex. Simple gradients from lake (intake) abundance to river abundance were observed on few survey dates, indicating that, overall, the river probably has a greater influence on the turning basin system than the discharge of Oswego Units 1-4. However, on some dates phytoplankton distribution patterns and circulation patterns were simple enough to interpret. For example, on 16 June, concentrations in surface waters were greater than in bottom waters and bottom water concentrations were slightly greater than intake concentrations. This pattern suggests that river phytoplankton penetrated the turning basin in surface waters, were mixed with lake phytoplankton at the west end of the turning basin, and discharged along the bottom of the turning basin. The results of an intensive temperature/conductivity survey on 26 June (Chapter III) confirmed this water circulation pattern. Thus, the spatial distribution of phytoplankton in the turning basin on any given date will be a function of water circulation patterns in the basin and the concentrations of phytoplankton in the river and lake.

TABLE IV B-2

PERCENT COMPOSITION* OF BACILLARIOPHYCEAE

OSWEGO VICINITY - 1975-1976

DATE	DEPTH	INTAKE	OTB-6	OTB-10	OTB-4
30 APR 1975	S	49.97	50.71	60.09	68.24
	B	-	67.95	34.91	75.25
15 MAY	S	5.89	21.92	39.52	52.36
	B	-	44.57	41.83	47.22
16 JUN	S	4.45	14.79	40.35	35.85
	B	-	19.71	21.48	36.47
16 JUL	S	14.19	15.50	16.67	16.72
	B	-	16.31	19.58	14.73
12 AUG	S	0.92	3.22	6.43	12.03
	B	-	4.12	5.15	11.71
8 SEP	S	3.64	4.42	4.53	14.58
	B	-	8.63	14.21	9.34
17 OCT	S	3.60	5.57	7.58	11.47
	B	-	11.05	11.12	21.81
23 NOV	S	18.57	21.70	25.16	32.63
	B	-	25.56	19.89	25.79
9 DEC	S	48.28	38.11	32.26	49.41
	B	-	40.89	43.41	44.12
26 JAN 1976	S	46.30	9.75	33.86	NS
	B	-	15.09	34.34	NS
24 FEB	S	35.94	39.91	38.94	24.62
	B	-	30.23	36.35	20.79
23 MAR	S	46.25	37.88	47.87	48.10
	B	-	53.53	52.67	48.51

*Mean of two replicates

- Not applicable, samples at the intake were from mid-depth.
NS - No sample

TABLE IVB-3

PERCENT COMPOSITION* OF CHLOROPHYCEAE

OSWEGO VICINITY - 1975-1976

DATE	DEPTH	INTAKE	OTB-6	OTB-10	OTB-4
30 APR 1975	S	15.47	23.62	15.84	18.42
	B	-	19.88	19.39	16.14
15 MAY	S	5.66	13.22	19.49	18.36
	B	-	17.06	12.92	18.18
16 JUN	S	7.26	13.42	41.84	39.62
	B	-	14.05	15.74	27.29
16 JUL	S	38.57	43.32	45.42	44.67
	B	-	46.50	58.87	35.25
12 AUG	S	36.50	26.17	17.41	22.61
	B	-	31.15	25.67	24.13
8 SEP	S	16.72	20.86	12.81	17.60
	B	-	26.33	31.18	20.40
17 OCT	S	16.85	15.07	12.67	37.17
	B	-	36.00	37.94	45.75
23 NOV	S	10.86	10.20	8.91	31.16
	B	-	8.97	22.95	26.92
9 DEC	S	16.68	22.58	22.69	23.81
	B	-	24.89	28.48	28.26
26 JAN 1976	S	14.63	17.24	9.34	NS
	B	-	12.21	13.46	NS
24 FEB	S	15.88	16.93	13.77	16.60
	B	-	14.20	9.12	30.03
23 MAR	S	9.62	16.58	17.31	27.19
	B	-	26.07	23.19	28.37

*Mean of two replicates

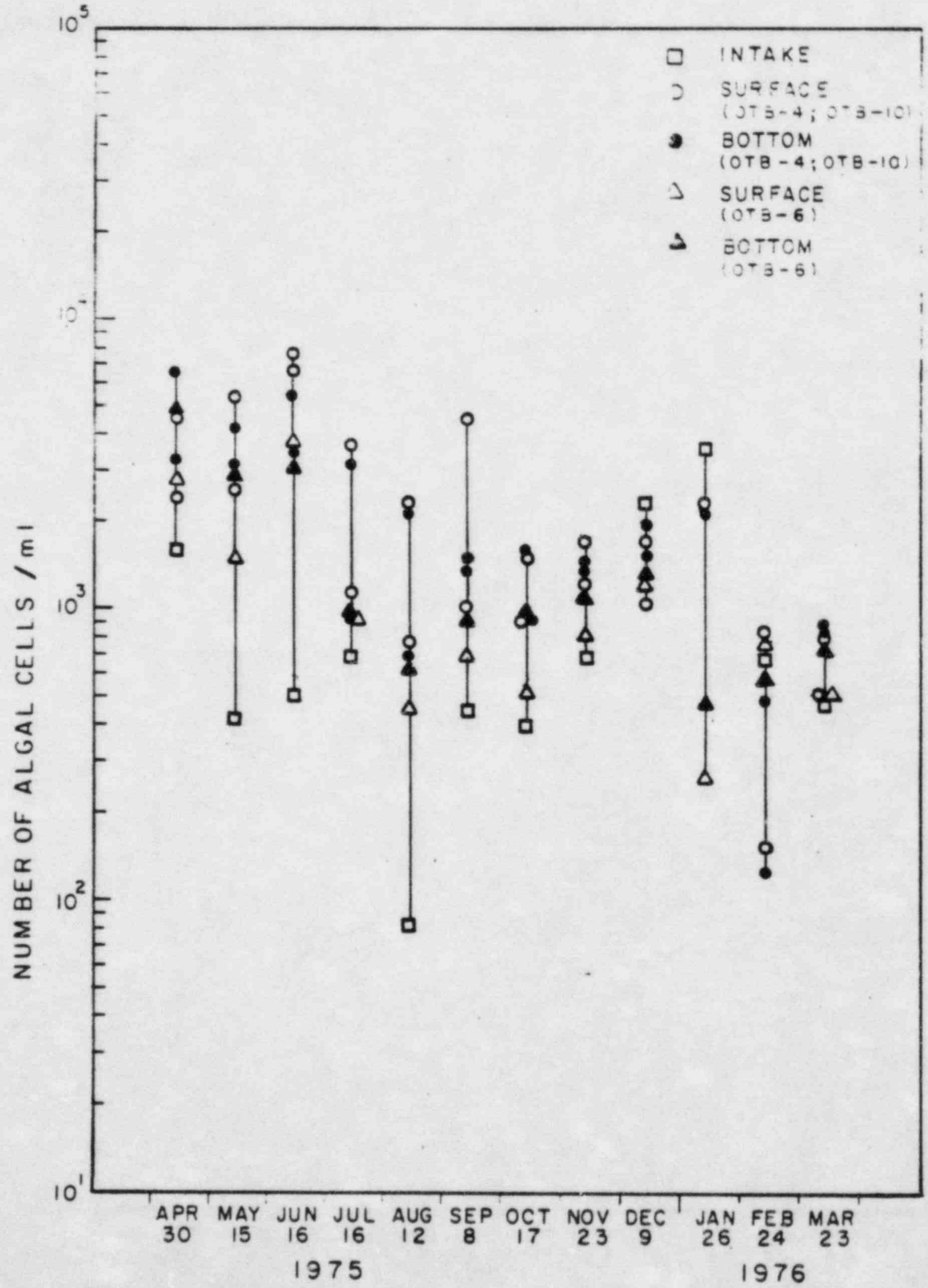
-Not applicable, samples at the intake were from mid-depth.

NS - No sample

FIGURE IV.B-2

ABUNDANCE OF BACILLARIOPHYCEAE*

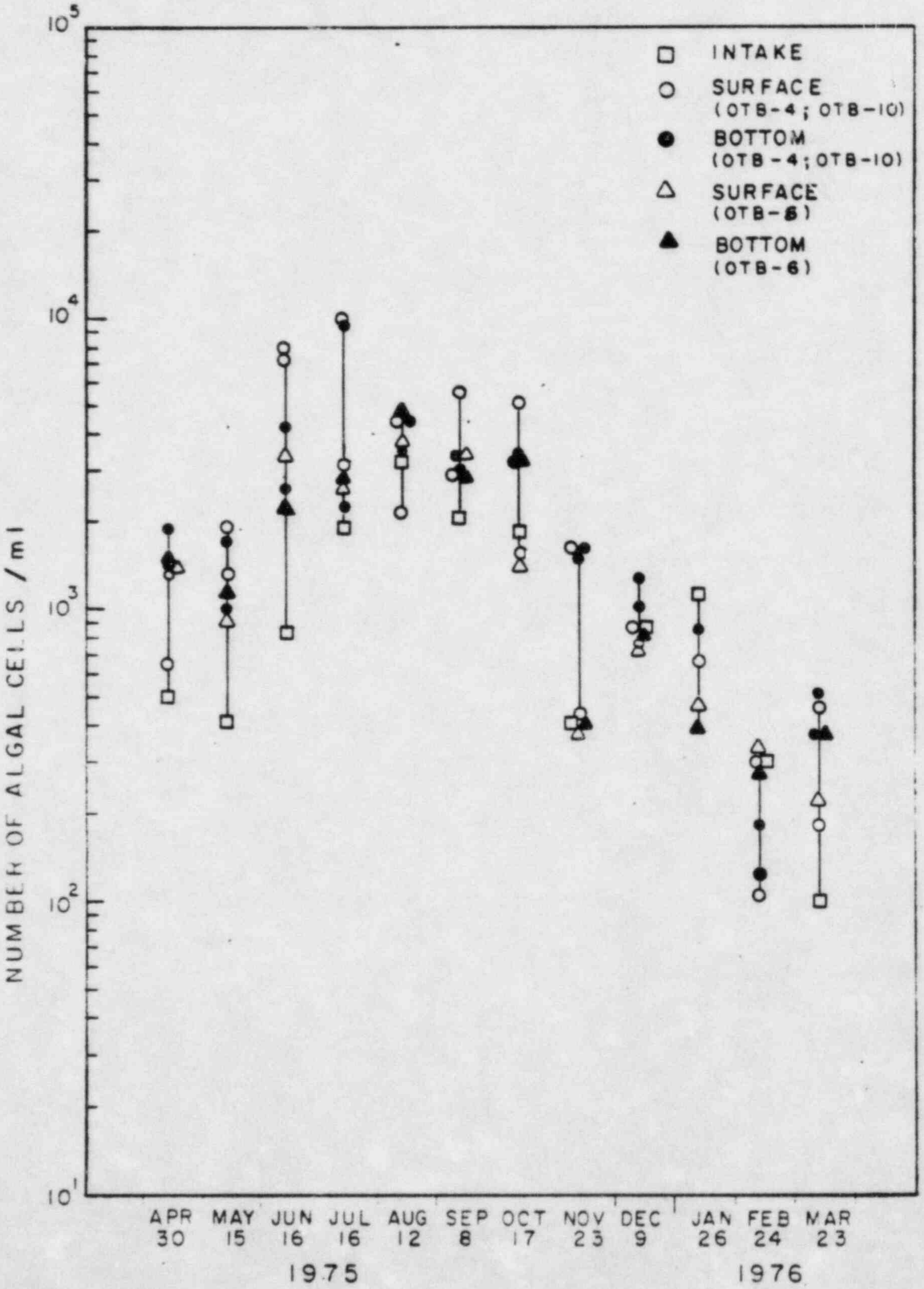
OSWEGO VICINITY — 1975-1976



*Mean of replicates

ABUNDANCE OF CHLOROPHYCEAE*

OSWEGO VICINITY — 1975-1976



*Mean of replicates

of this period, and may reflect the operational effects of Oswego Steam Station Units 1-4.

(iv) Blue-green Algae (Myxophyceae)

As indicated in Table IV.B-4, blue-green algae composed a large fraction of total phytoplankton concentrations during much of the year, particularly during the warmer months. The seasonal pattern of blue-green algae concentrations was similar to that of the total phytoplankton community: peak concentrations recorded during September; minimum concentrations during March; and secondary peaks during June and January (Figure IV.B-4). With exception of the secondary peaks in abundance, this seasonal pattern is similar to seasonal patterns reported for Lake Ontario (e.g., LMS, 1975,1976a). The secondary peak during January could be due to the presence of algae flushed into the river and lake by increased fall and winter surface runoff; however, the causes of the June pulse are unknown.

The spatial distribution of blue-green algae was highly variable and their abundance did not appear to reflect the influence of water circulation patterns in the basin. This could be due to the effects of natural variance arising from the tendency of colonial and filamentous blue-green algae to form clumps. However, there was some indication that the portion of the turning basin represented by station OTB-10 may be environmentally unique as far as blue-green algae are concerned, since either maximum or minimum concentrations were recorded more often there than at other sampling locations (Appendix D).

d. Nuisance Algal Blooms

When algal populations reach high densities, they may cause taste and odor problems, clog filters, and result in increased BOD. Palmer (1962) identified a number of "nuisance" species known to cause these problems. A list of these nuisance species observed in the Oswego Turning Basin is presented in Table IV.B-5, which also indicates the dates and stations at which these species exceeded concentrations of 500,000 algal cells/liter. The choice of this criterion for algal bloom proportions is arbitrary; however, because Whipple et al. (1948) noted that densities greater than 500,000 cells/liter caused "little trouble" and above 1×10^6 cells/liter "noticeable trouble," this concentration was considered a reasonable conservative value.

TABLE IVB-4

PERCENT COMPOSITION* OF MYXOPHYCEAE

OSWEGO VICINITY - 1975-1976

DATE	DEPTH	INTAKE	OTB-6	OTB-10	OTB-4
30 APR 1975	S	15.34	7.66	6.84	2.17
	B	-	3.85	12.58	1.25
15 MAY	S	16.72	17.69	16.41	12.13
	B	-	19.93	13.37	6.80
16 JUN	S	63.57	61.42	11.63	17.53
	B	-	52.69	52.87	23.00
16 JUL	S	32.13	27.98	18.88	23.90
	B	-	28.48	16.79	34.87
12 AUG	S	25.03	23.12	25.06	42.33
	B	-	21.18	26.69	39.83
8 SEP	S	42.45	51.73	39.34	59.30
	B	-	49.23	36.28	49.66
17 OCT	S	64.72	63.04	66.96	44.43
	B	-	48.91	36.64	23.11
23 NOV	S	42.63	37.25	34.32	23.94
	B	-	36.51	44.87	39.02
9 DEC	S	23.26	31.62	36.10	19.78
	B	-	29.92	19.65	20.98
26 JAN 1976	S	17.64	31.67	13.07	NS
	B	-	28.22	10.70	NS
24 FEB	S	37.48	33.05	36.81	37.29
	B	-	43.61	44.37	29.70
23 MAR	S	28.17	32.33	16.46	15.76
	B	-	8.94	13.26	14.62

* Mean of two replicates

- Not applicable samples at the intake were from mid-depth.

NS - No sample

TABLE IV B-5

OCCURRENCE OF NUISANCE ALGAE BY STATION*

OSWEGO TURNING BASIN - 1975-1976

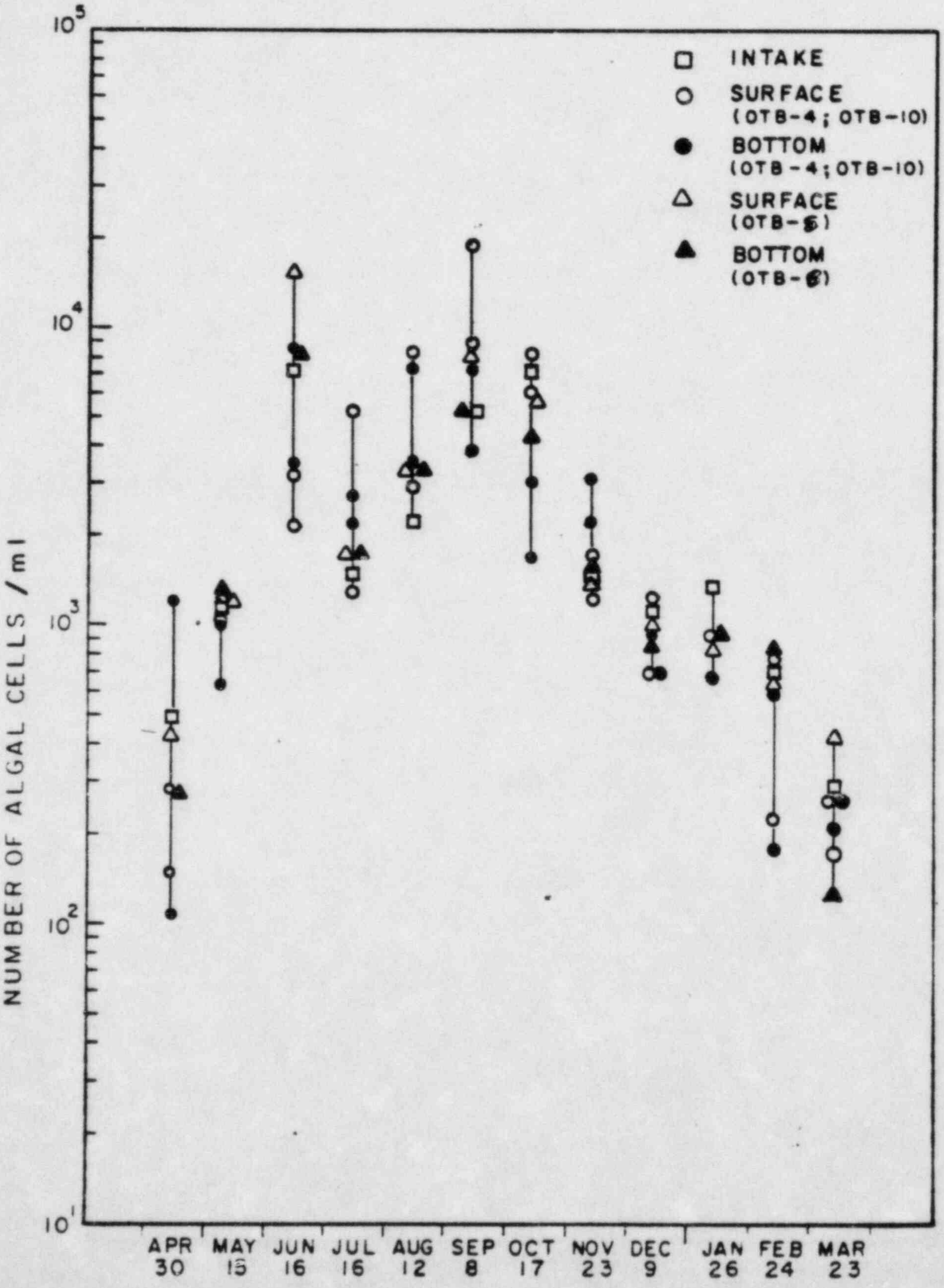
SPECIES	1975 APR				MAY				JUN				JUL			
STATIONS	4	10	6	I	4	10	6	I	4	10	6	I	4	10	6	I
MYXOPHYCEAE																
Anacystis aeruginosa													X			
Aphanizomenon flos-aquae																
Gomphosphaeria lacustris																
Oscillatoria amphibia																
CHLOROPHYCEAE																
Chlamydomonas globosa									X	X						
Dictyosphaerium ehrenbergianum																
D. pulchellum														X		
Gloeocystis planktonica																
Pandorina morum																
Pediastrum tetras																
Scenedesmus abundans																
S. quadricauda									X	X			X	X		
Tetraedron muticum																
EUGLENOPHYCEAE																
Euglena sp.		X			X		X									
CHRYSOPHYCEAE																
Phacus pyrum																
Synura uvella																
BACILLARIOPHYCEAE																
Asterionella formosa	X															
Cyclotella meneghiniana																
Diatoma vulgare																
Fragilaria crotonensis																
Gomphonema parvulum																
Melosira granulata																
M. varians																
Navicula cryptocephater																
Nitzschia acicularis																
Stepanodiscus hantzschii	X	X	X		X	X	X		X	X	X					
S. niagarae																
Synedra acus																
S. ulna																
Tabellaria festrata																
CRYPTOPHYCEAE																
Cryptomonus erosa													X			
DINOKONTAE																
Ceratium hirundinella																
Peridinium cinctum																

SPECIES	1975 AUG				SEP				OCT				NOV			
STATIONS	4	10	6	I	4	10	6	I	4	10	6	I	4	10	6	I
MYXOPHYCEAE																
Anacystis aeruginosa	X	X		X	X	X	X									
Aphanizomenon flos-aquae					X	X				X		X				
Gomphosphaeria lacustris																
Oscillatoria amphibia					X						X					
CHLOROPHYCEAE																
Chlamydomonas globosa																
Dictyosphaerium ehrenbergianum																
D. pulchellum	X				X											
Gloeocystis planktonica																
Pandorina morum																
Pediastrum tetras																
Scenedesmus abundans																
S. quadricauda	X				X	X										
Tetraedron muticum																
EUGLENOPHYCEAE																
Euglena sp.																
CHRYSOPHYCEAE																
Phacus pyrum																
Synura uvella																
BACILLARIOPHYCEAE																
Asterionella formosa																
Cyclotella meneghiniana																
Diatoma vulgare																
Fragilaria crotonensis																
Gomphonema parvulum																
Melosira granulata					X											
M. varians																
Navicula cryptocephater																
Nitzschia acicularis																
Stepanodiscus hantzschii																
S. niagarae																
Synedra acus																
S. ulna																
Tabellaria festrata																
CRYPTOPHYCEAE																
Cryptomonus erosa																
DINOKONTAE																
Ceratium hirundinella																
Peridinium cinctum																

SPECIES	1975 DEC				1976 JAN				FEB				MAR			
STATIONS	4	10	6	I	4	10	6	I	4	10	6	I	4	10	6	I
MYXOPHYCEAE																
Anacystis aeruginosa																
Aphanizomenon flos-aquae																
Gomphosphaeria lacustris																
Oscillatoria amphibia																
CHLOROPHYCEAE																
Chlamydomonas globosa																
Dictyosphaerium ehrenbergianum																
D. pulchellum																
Gloeocystis planktonica																
Pandorina morum																
Pediastrum tetras																
Scenedesmus abundans																
S. quadricauda																
Tetraedron muticum																
EUGLENOPHYCEAE																
Euglena sp.																
CHRYSOPHYCEAE																
Phacus pyrum																
Synura uvella																
BACILLARIOPHYCEAE																
Asterionella formosa																
Cyclotella meneghiniana																
Diatoma vulgare																
Fragilaria crotonensis																
Gomphonema parvulum																
Melosira granulata																
M. varians																
Navicula cryptocephater																
Nitzschia acicularis																
Stepanodiscus hantzschii	X	X	X	X				X								
S. niagarae																
Synedra acus																
S. ulna																
Tabellaria festrata																
CRYPTOPHYCEAE																
Cryptomonus erosa																
DINOKONTAE																
Ceratium hirundinella																
Peridinium cinctum																

*Stations:
4 = OTB-4; 10 = OTB-10; 6 = OTB-6; I = Intake

ABUNDANCE OF MYXOPHYCEAE*
OSWEGO VICINITY — 1975-1976



*Mean of replicates

Nine of the 33 potential nuisance algae exceeded the bloom criterion on at least one date. Stephanodiscus hantzschii, a species associated with filter clogging, reached bloom proportions more frequently than the other nuisance algae. Two particularly obnoxious taste and odor-causing algae, Anacystis aeruginosa and Aphanizomenon flos-aquae, reached bloom proportions in the late summer/early fall.

The frequency with which blooms occurred at each station was:

OTB-4	OTB-10	OTB-6	INTAKE
20	14	7	4

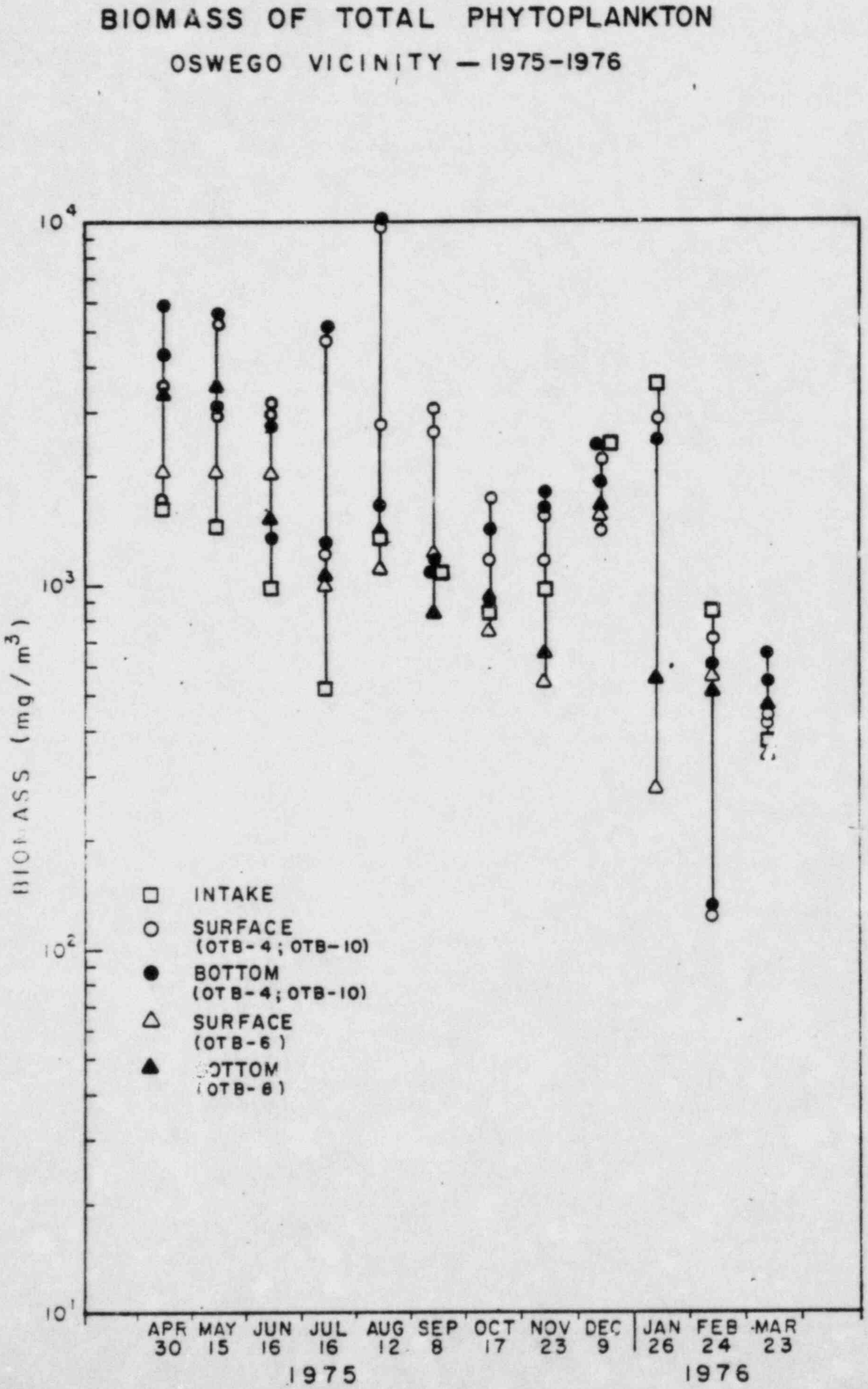
The greater number of nuisance algal blooms at OTB-4 may be explained by its location in the Oswego Harbor where it is influenced primarily by the organically enriched Oswego River water. The lower number of blooms at the intake reflects the less eutrophied lake waters. OTB-6, near the plant's discharge, also had fewer occurrences of algal blooms than the other turning basin stations, reflecting the presence of discharged lake water of low algal abundance.

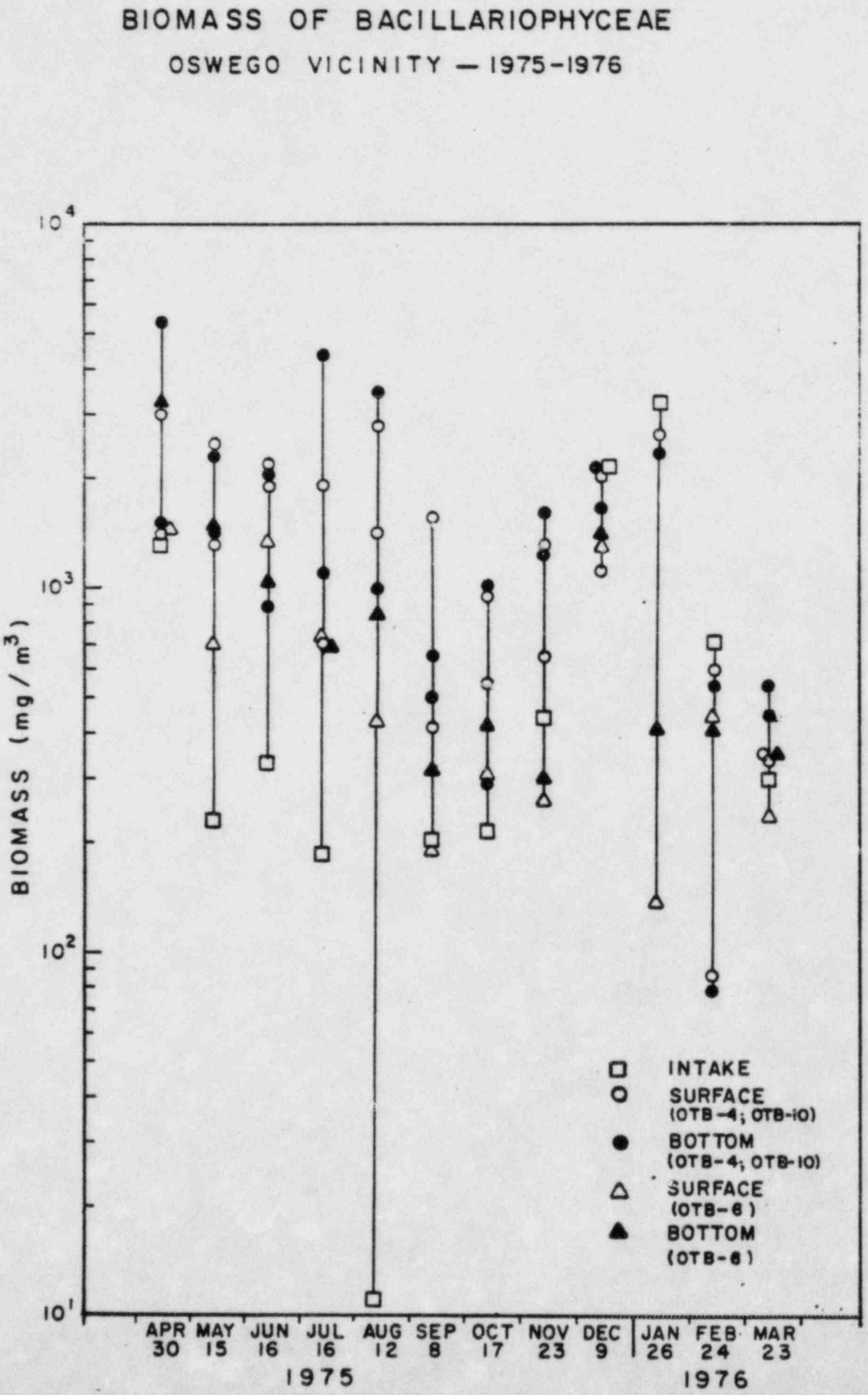
e. Phytoplankton Biomass

The algal groups which composed the greatest biomass of phytoplankton were Bacillariophyceae, Chlorophyceae, and Cryptophyceae. The data for these and total algal biomass are presented in Figures IV.B-5 through IV.B-8, which permit a visual comparison of biomass near the plant's discharge with that of the other turning basin stations.

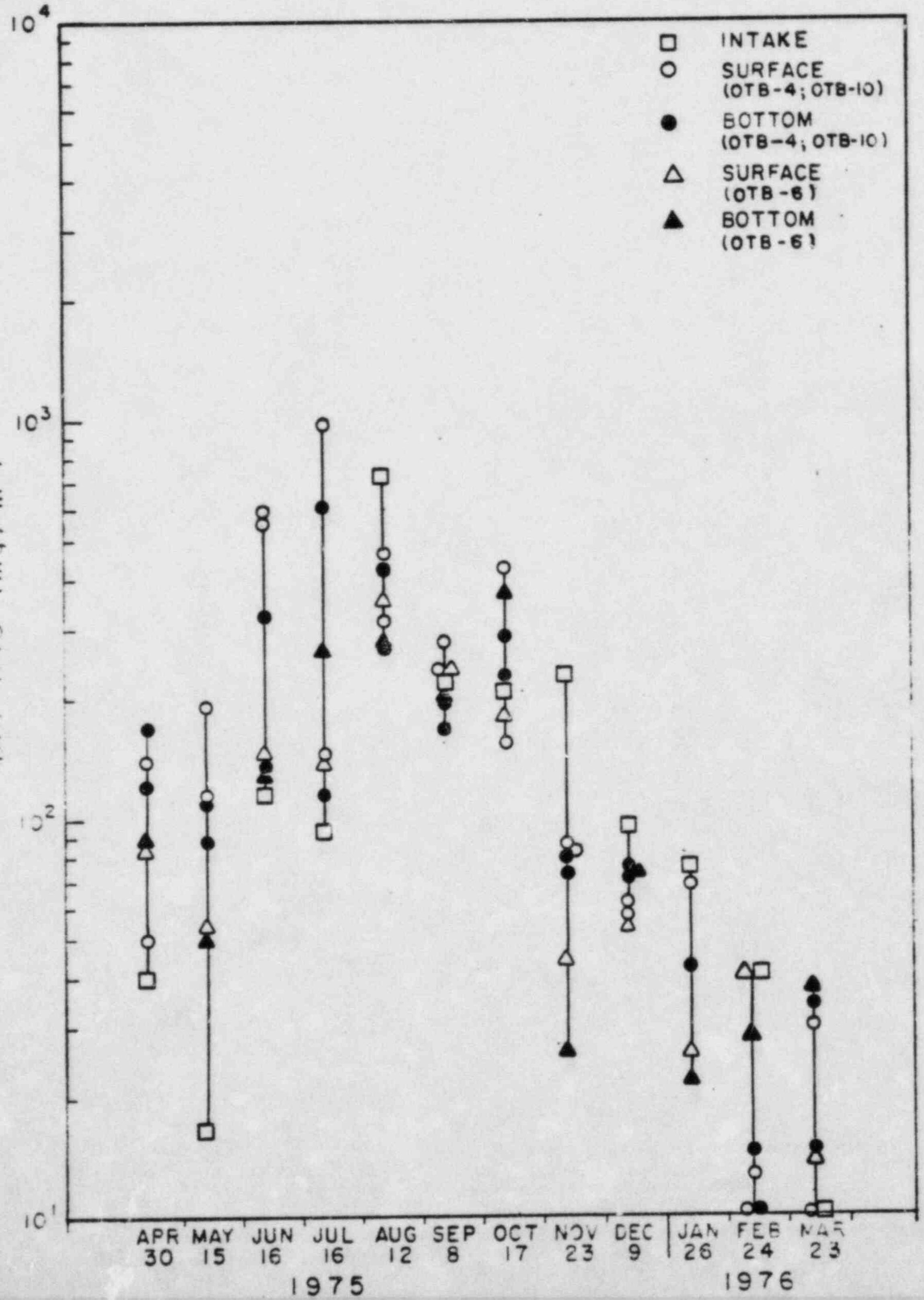
Total algal biomass (Figure IV.B-5) was generally between 1,000 and 6,000 mg/m^3 from April 1975 through January 1976; biomass at all stations was less than 1,000 mg/m^3 in February and March 1976. The data show that from April through November algal biomass was low at the plant intake stations; the OTB-6 surface and bottom stations also had generally lower biomass (e.g., July, August, October and November), which probably reflects the discharge of lake water comparatively low in algal biomass.

Bacillariophyceae (diatoms) composed the greatest percentage of total algal biomass; fluctuations in the biomass of this group (Figure IV.B-6) were reflected in fluctuations in total algal biomass (Figure IV.B-5). Although diatom biomass was lowest in February and March, there was no apparent seasonal pattern.

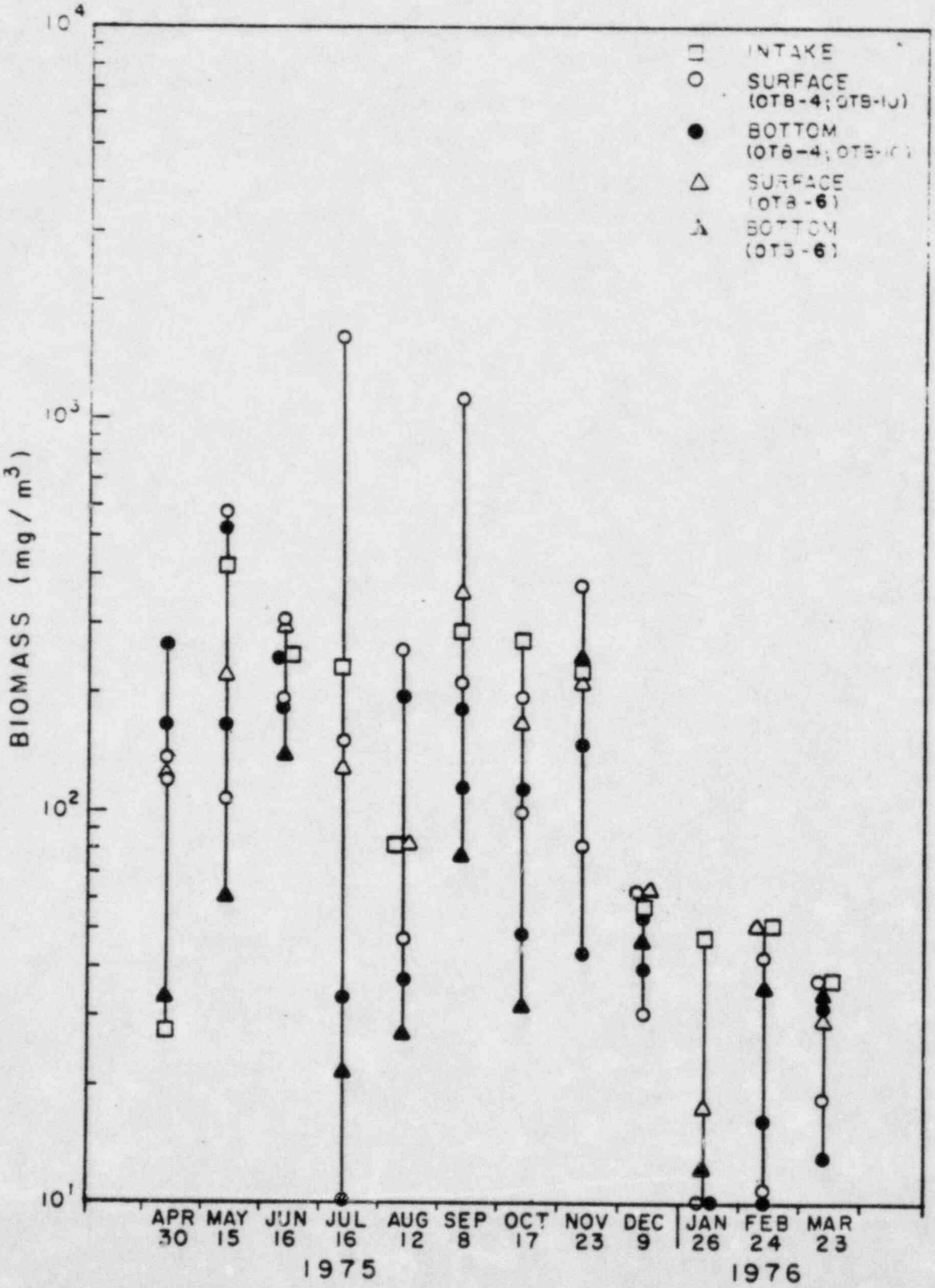

BIOMASS OF TOTAL PHYTOPLANKTON
OSWEGO VICINITY — 1975-1976
BIOMASS (mg/m³)
10⁴
10³
10²
10¹
INTAKE
SURFACE (OTB-4; OTB-10)
BOTTOM (OTB-4; OTB-10)
SURFACE (OTB-6)
BOTTOM (OTB-6)
APR 30
MAY 15
JUN 16
JUL 16
AUG 12
SEP 8
OCT 17
NOV 23
DEC 9
JAN 26
FEB 24
MAR 23
1975
1976


BIOMASS OF BACILLARIOPHYCEAE
OSWEGO VICINITY — 1975-1976
BIOMASS (mg/m³)
10⁴
10³
10²
10¹
APR 30
MAY 15
JUN 16
JUL 16
AUG 12
SEP 8
OCT 17
NOV 23
DEC 9
JAN 26
FEB 24
MAR 23
1975
1976
INTAKE
SURFACE (OTB-4; OTB-10)
BOTTOM (OTB-4; OTB-10)
SURFACE (OTB-6)
BOTTOM (OTB-6)

BIOMASS OF CHLOROPHYCEAE
OSWEGO VICINITY — 1975-1976



BIOMASS OF CRYPTOPHYCEAE
OSWEGO VICINITY — 1975-1976



Biomass was generally lower at the intake station than in the turning basin, and from April 1975 through January 1976 OTB-6 samples frequently had lower biomass values than collections at the other stations, a phenomenon which may reflect the discharge of lake water.

In contrast to the diatoms, the Chlorophyceae (green algae) demonstrated a seasonal pattern in biomass with a peak (maximum ≈ 1000 mg/m^3) during the summer (Figure IV.B-7). Summer and early fall development of this algal group is well known (Patrick, 1969; Vollenweider et al., 1974; LMS, 1975). The intake station had lower green algal biomass from April through July, but biomass at this station was comparatively high from August through February, suggesting that the spectrum of environmental factors affecting biomass differed between the lake and Oswego River. The OTB-6 station had lower biomass values than other turning basin stations in May, June, November, and January; however, only the May and June values can be attributed to discharge of lake water having low green algal biomass. On the other sample dates biomass at OTB-8 was not consistently higher or lower than at other stations.

Cryptophyceae overall exhibited a higher biomass in April-November 1975 than in December 1975 and January-March 1976, possibly indicating a seasonal pattern (Figure IV.B-8); the maximum biomass was 1,600 mg/m^3, in July. In contrast to the diatoms and green algae, cryptophyceae biomass at the intake stations was comparatively high. These small planktonic cryptophyte species are probably more typical of lakes than rivers.

The OTB-6 bottom station had consistently lower Cryptophyceae biomass than other turning basin stations from April through October 1975, suggesting that this area was unfavorable to the growth of these algae. Biomass of OTB-6 surface samples was not low and, therefore, the lower biomass in the bottom samples cannot be attributed to power plant effect.

f. Phytoplankton Pigments and Production

Chlorophyll *a* is one of several plant pigments which are important in the process of photosynthesis. Because the concentration of chlorophyll *a* is considered a useful indicator of potential productivity (Odum, 1971), data on the spatial and temporal distribution of this pigment are useful in the comparison of water masses.

Chlorophyll *a* concentration data (Figure IV.B-9) at the Oswego Units 1-4 intake station and the Oswego Turning Basin stations were examined for spatial and temporal variations. The chlorophyll *a*

CHLOROPHYLL A CONCENTRATIONS

OSWEGO VICINITY — 1975-1976

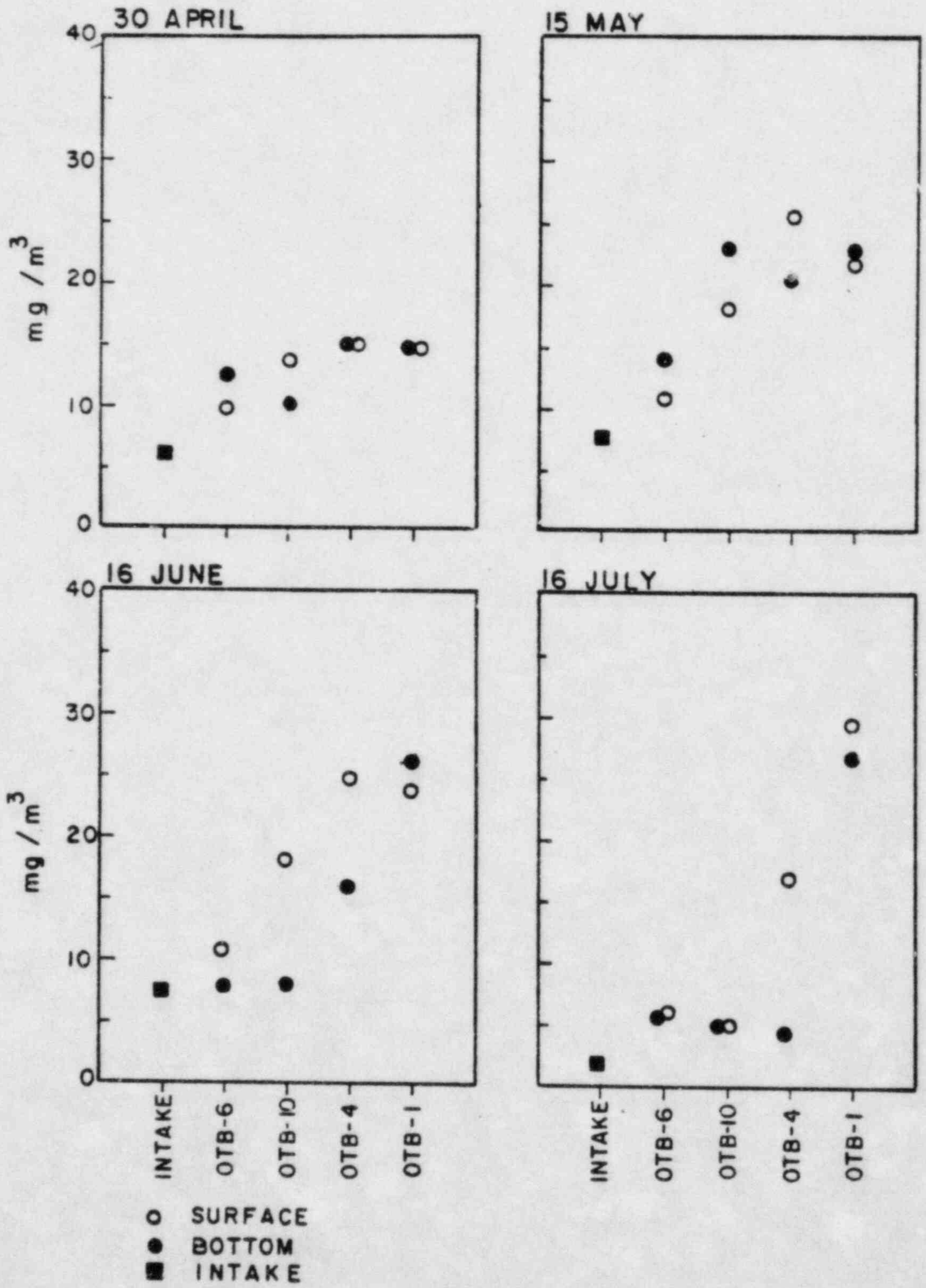
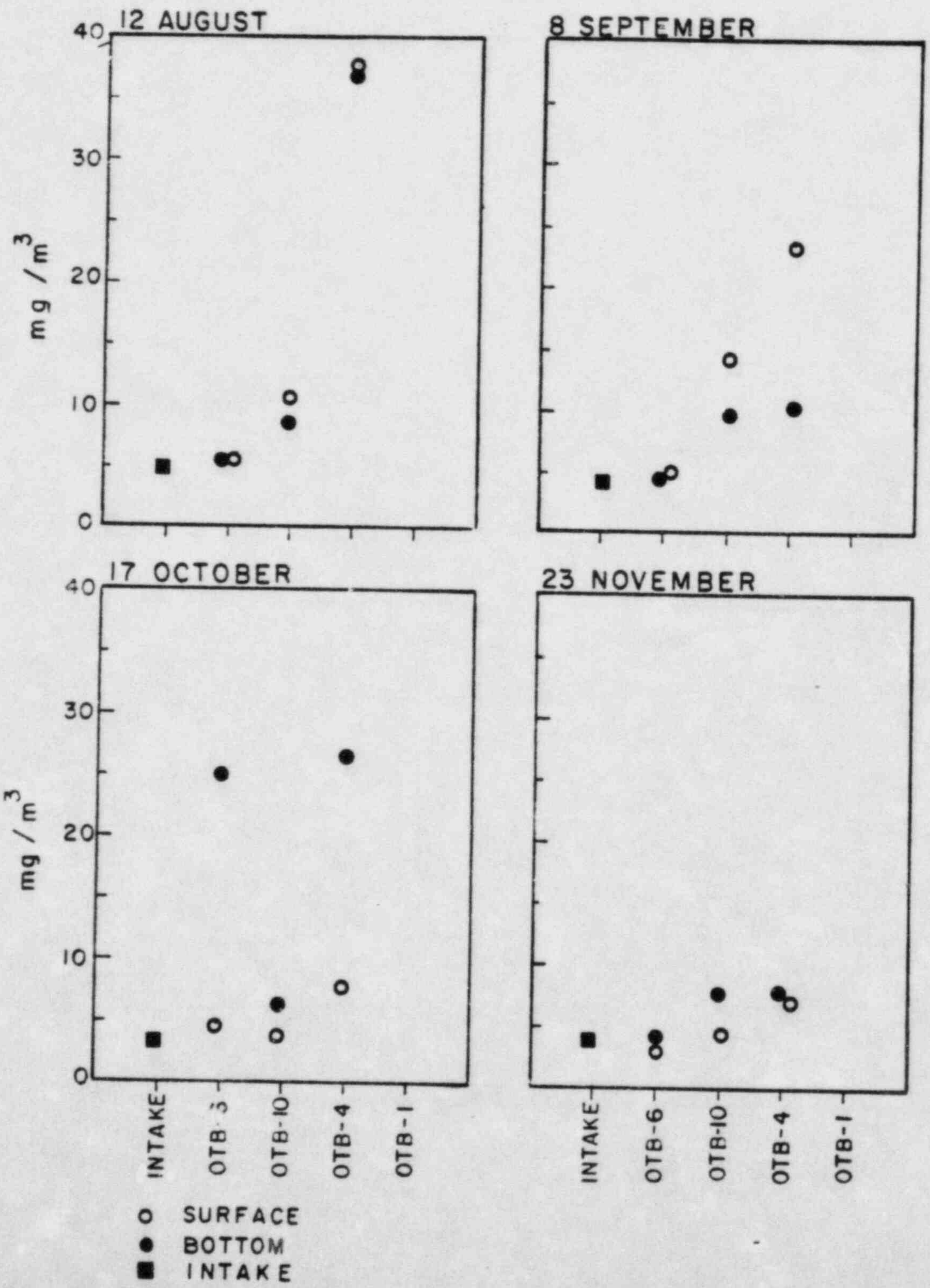


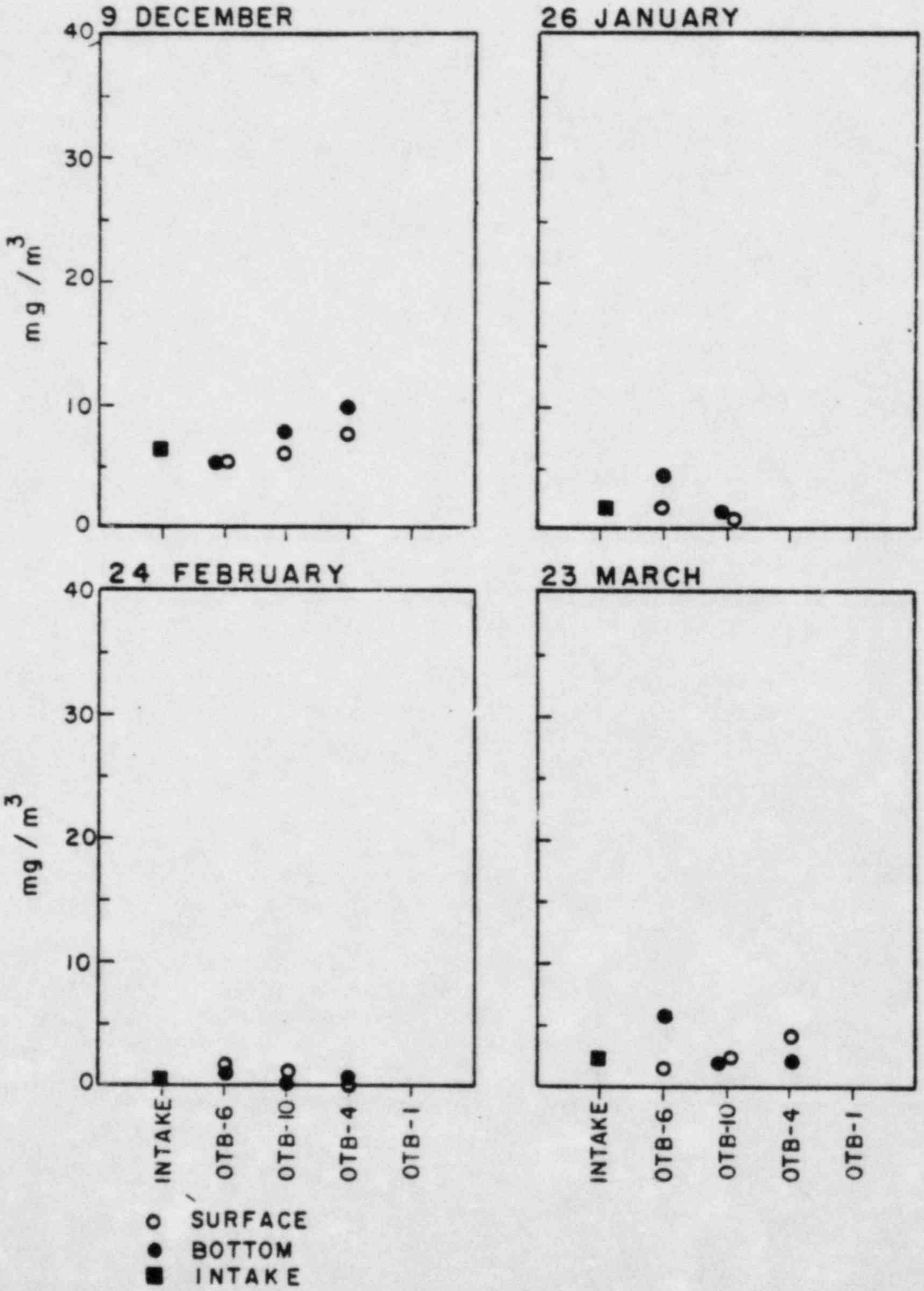
FIGURE IVB-9
Continued

CHLOROPHYLL A CONCENTRATIONS

OSWEGO VICINITY — 1975-1976



CHLOROPHYLL A CONCENTRATIONS
OSWEGO VICINITY — 1975-1976



concentration at the intake station, which is representative of Lake Ontario, reflects the concentration in water discharged by the plant into the turning basin. Station OTB-6 is located nearest the discharge in the turning basin; OTB-10 is located further down the turning basin; OTB-4 is located still further down the basin near the mouth of Oswego Harbor and in the direct path of the Oswego River discharge. Station OTB-1, sampled only on the first four dates (April-July), is located in the Oswego River upstream of the turning basin, and is used to identify the river's chlorophyll a concentrations.

The analysis of these data focused on the two primary ways in which cooling water discharge might affect phytoplankton in the Oswego Turning Basin:

1. hydrodynamic effects resulting from variable mixing of discharged lake water with Oswego River water, and

2. thermal effects resulting from differences between the discharge and receiving water temperatures.

Comparison of the relative contributions of the Oswego River and lake water to the chlorophyll a standing crop in the turning basin reveals that on each of the four sampling dates, chlorophyll a concentration was higher at the Oswego River station (OTB-1) than at the lake intake station (Figure IV.B-9). Chlorophyll a concentrations at stations within the turning basin were intermediate and generally increased from station OTB-6 (nearest the point of lake discharged water) to station OTB-4 (further from the discharge).

This pattern indicates that discharge (lake) waters, low in chlorophyll a, are being mixed with river waters higher in chlorophyll a, resulting in a chlorophyll a concentration gradient. The data for August, September, October, and November 1975 indicate the same gradient within the turning basin (Figure IV.B-9); OTB-1 was not sampled on these dates. During December 1975 and January, February, and March 1976 this pattern was not evident (Figure IV.B-9); however, this was a period of low primary production in both the river and lake, and of low chlorophyll a concentrations.

At times (e.g., 16 June) dissimilar chlorophyll a concentrations were observed in the surface and bottom samples at the same location. These differences suggest that the water column was not well mixed and that stratification existed; the river and lake water within the turning basin remained distinct.

The thesis that chlorophyll a distribution reflects hydrodynamic processes within the turning basin is supported by temperature and water quality data collected during the thermal survey program (Chapter III). These surveys were conducted on 24 June 1975, 28 August 1975, 6 November 1975, and 20 April 1976, and are considered to characterize circulation patterns during the seasons.

The thermal survey data for 24 June, a period when chlorophyll a was high (Appendix A), will be used to demonstrate the importance to phytoplankton distribution of hydrodynamic processes. These data indicate that, within the turning basin, Oswego River water composed a higher percentage of the surface water, whereas discharged lake and lake-intruded water were a higher percentage of the bottom waters (see Chapter III for a detailed discussion). This occurred as lighter Oswego River water entered the basin at the surface and mixed with discharged lake water, which, although it had been heated, was still colder and therefore denser than river water and consequently flowed out of the basin primarily along the bottom.

The pattern of chlorophyll a distribution in the turning basin suggests that this kind of circulation process also occurred on 16 June (Figure IV.B-9). Chlorophyll a concentrations were high in the river water (station OTB-1) and low in the intake (lake) water; at the intermediate stations (OTB-6, OTB-10, and OTB-4) chlorophyll a concentration was higher at the surface than the bottom since river water composed a greater proportion of surface waters. In addition, the chlorophyll a value at the OTB-10 bottom station was the same as in the OTB-6 bottom and intake waters, suggesting that comparatively unmixed lake water, discharged by the plant, was flowing down the basin along the bottom from OTB-6 to OTB-10. Community structure analysis of the microzooplankton on this date, 16 June (Section IV.B.2), also reflected expected hydrodynamic processes.

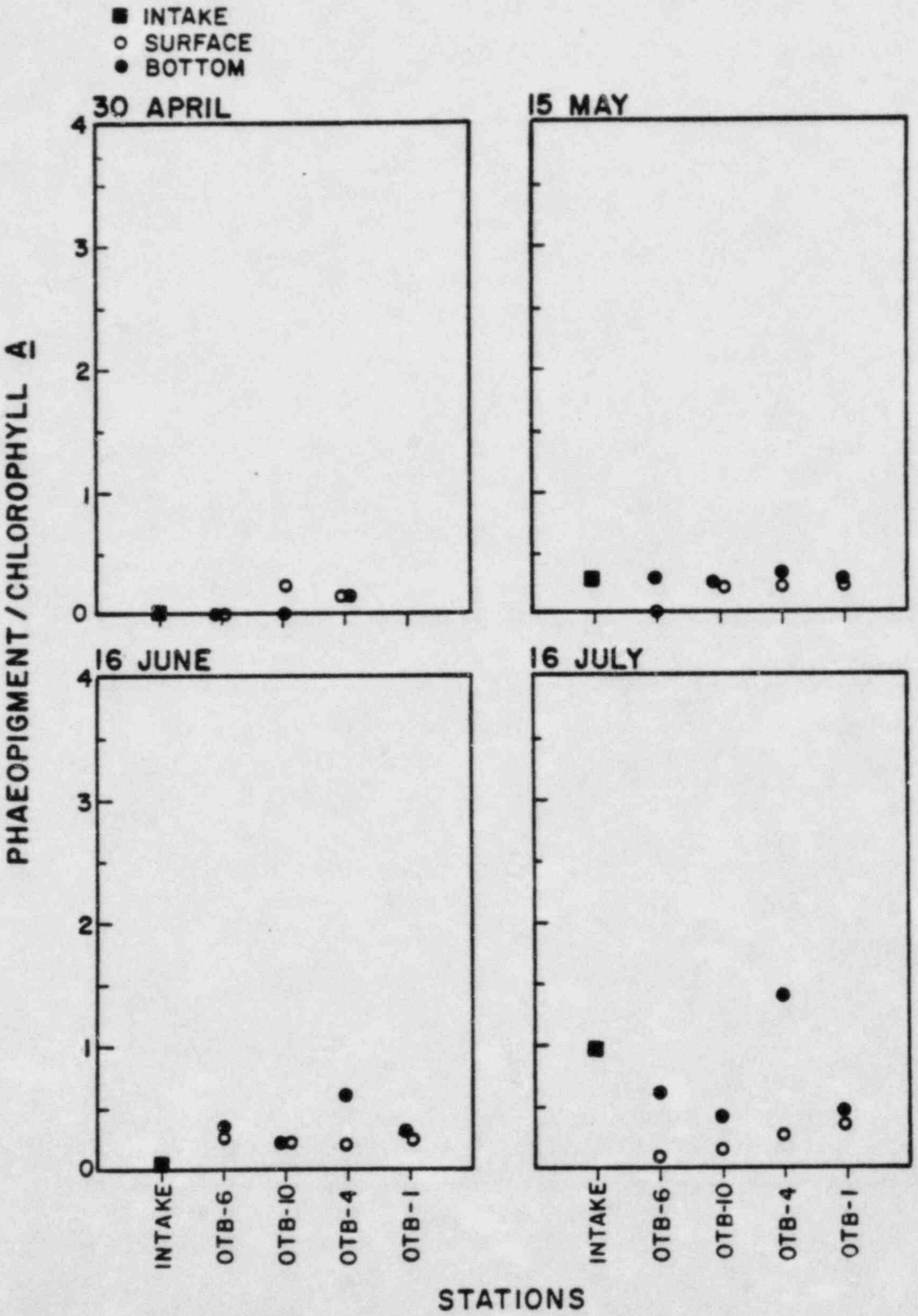
Phaeopigments are the natural degradation products of chlorophyll a, and as such the relationship between the amounts of these two pigments is a useful indicator of phytoplankton condition. The phaeopigment/chlorophll a ratio will be used here to compare spatial variation in phytoplankton condition; the higher the ratio, the higher the component of dead or senescent planktonic algae.

Data on phaeopigment/chlorophyll a ratios are presented for each month in Figure IV.B-10. Station OTB-6 was nearest the Oswego Steam Station's thermal discharge, where highest ratios might be expected as a result of power plant impact. On 30 April, 15 May, 16 June, 16 July, and 17 October of 1975 and 26 January,

FIGURE IV B-10

PHAEOPIGMENT/CHLOROPHYLL A RATIOS*

OSWEGO VICINITY — 1975-1976

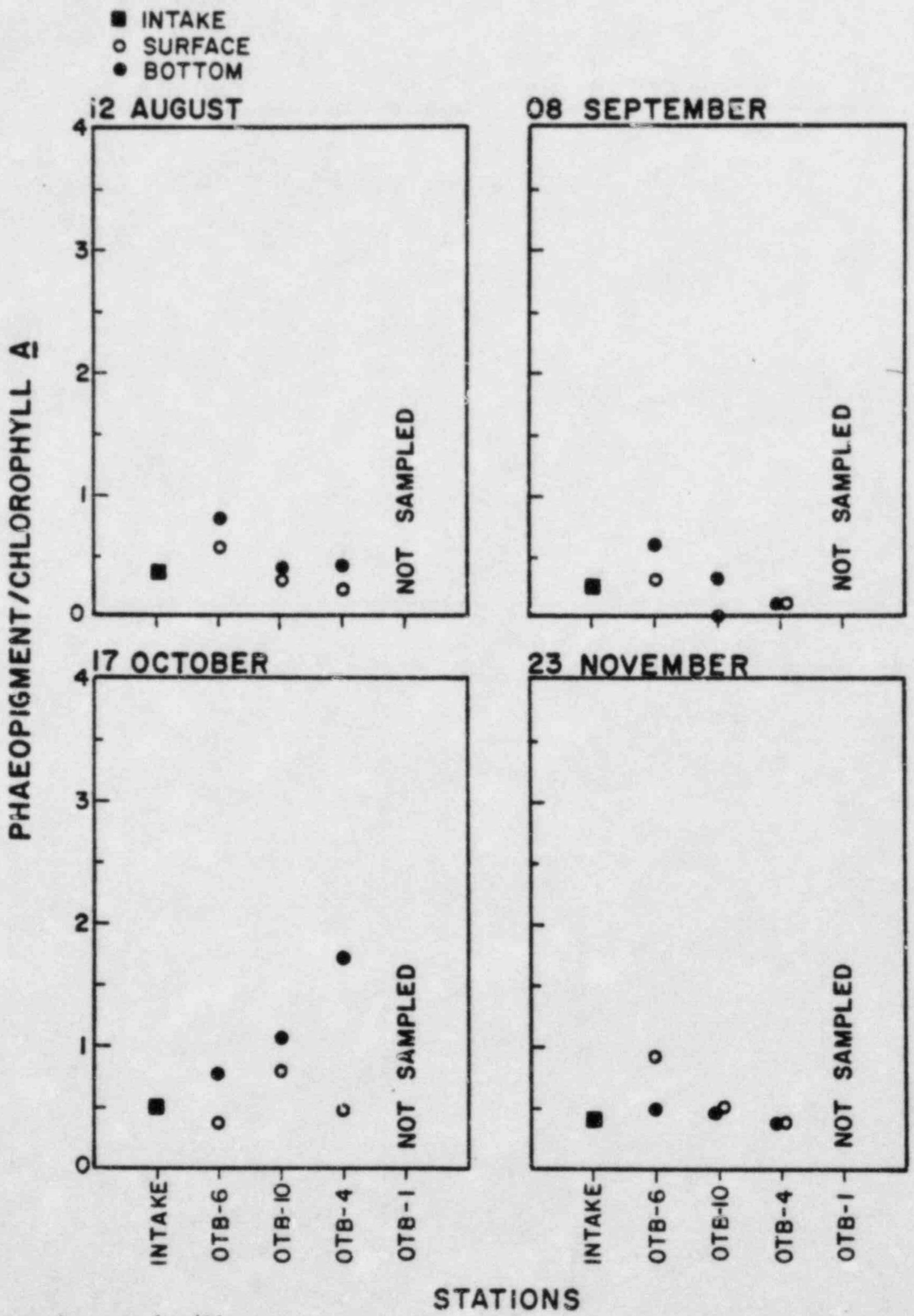


* $\frac{\text{Phaeopigment } (\mu g/l)}{\text{Chlorophyll } a\ (\mu g/l)}$

(Continued)

PHAEOPIGMENT/CHLOROPHYLL A RATIOS*

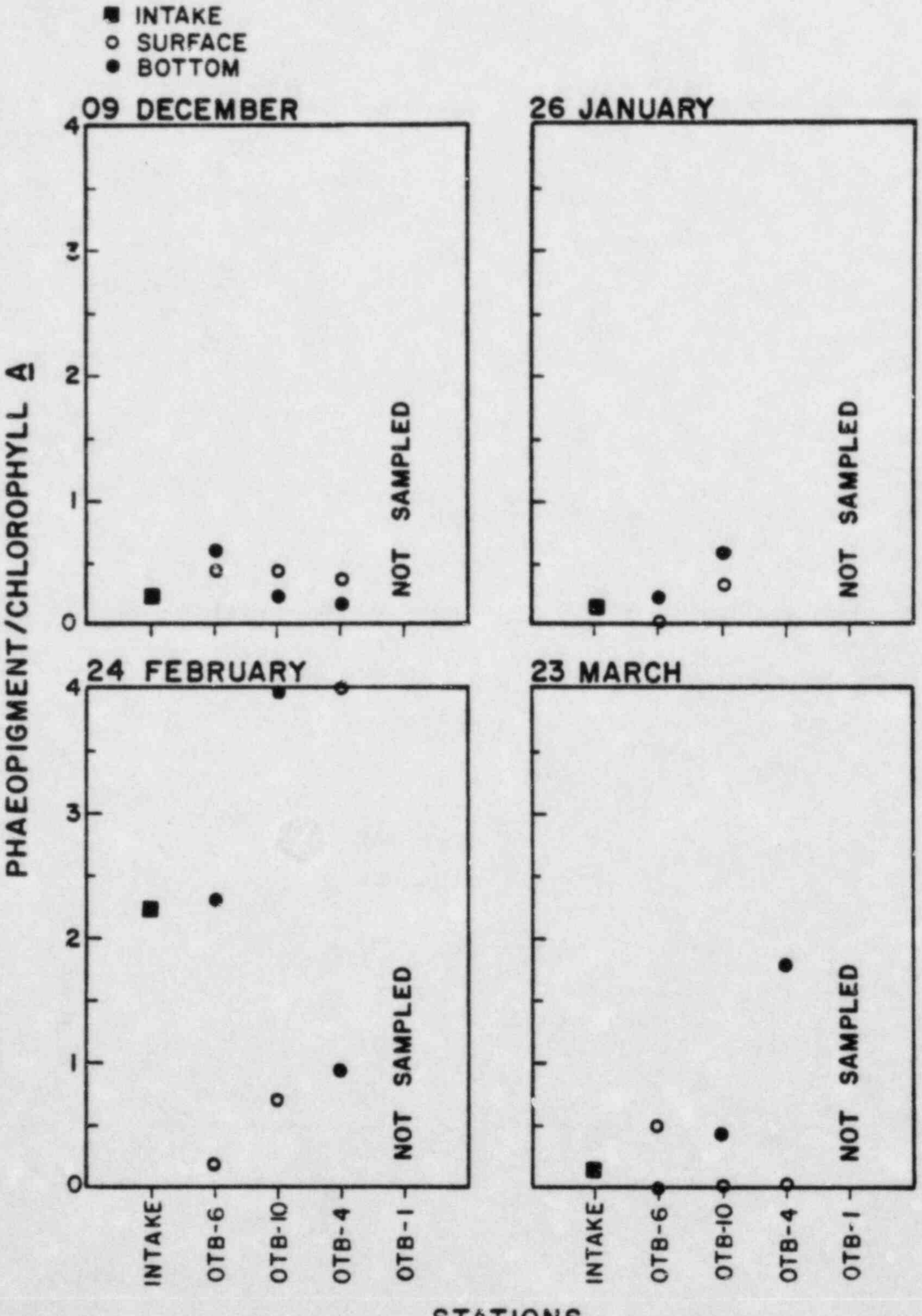
OSWEGO VICINITY — 1975-1976



* $\frac{\text{Phaeopigment } (\mu g/l)}{\text{Chorophyll } \underline{a} \ (\mu g/l)}$

PHAEOPIGMENT/CHLOROPHYLL A RATIOS*

OSWEGO VICINITY — 1975-1976



*Phaeopigment (μg/l)
Chorophyll a (μg/l)

24 February, and 23 March of 1976 (8 out of the 12 sampling dates) the ratio at OTB-6 did not indicate deleterious power plant effects. On the other four dates (12 August, 8 September, 23 November, and 9 December, 1975), the phaeopigment/chlorophyll a ratio was higher at either the OTB-6 surface or bottom station than at other stations; this indicates a possible power plant effect.

The productivity of algae entrained into the discharge plume could be inhibited, stimulated, or unaffected depending on the magnitude and direction of temperature change and the ambient temperature (Morgan and Stross, 1969; Hamilton et al., 1970; Brooks, 1974). In order to elucidate the effects of temperature on phytoplankton production and, subsequently, on standing crop, estimates of photosynthetic rates (mg C/mg Chl a/hr) are useful; these generally reflect the physiological effects of nutrients, temperature, and light (Parsons and Takahashi, 1973).

Estimates of photosynthetic rates in the Oswego Turning Basin are presented in Figure IV.B-11. The data for December 1975 and January, February, and March 1976 are not included since chlorophyll a and productivity were low and small differences due to sampling error would result in large fluctuations in photosynthetic rate estimates.

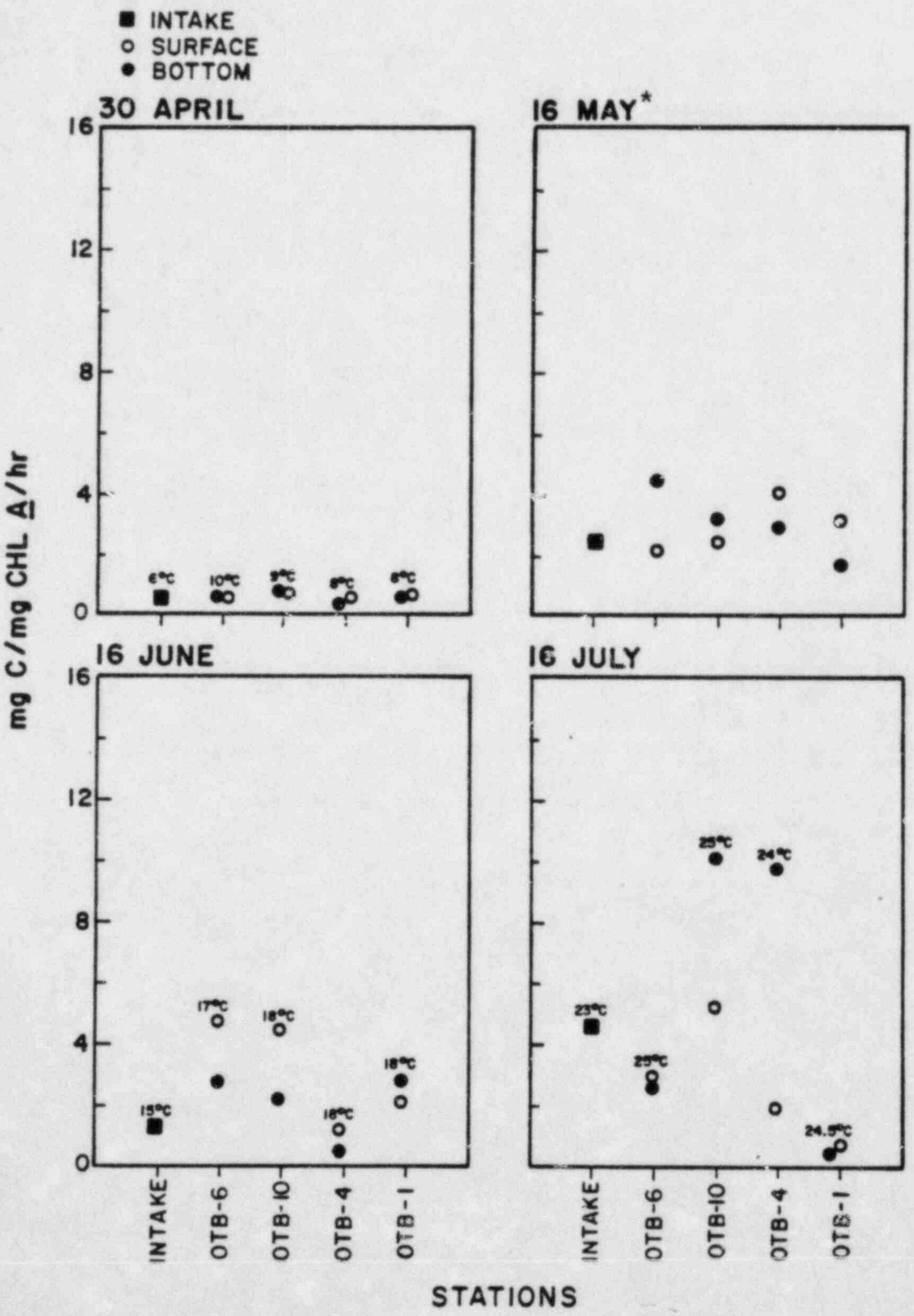
As a result of the four-hour ^{14}C productivity incubation period, bottles containing the phytoplankton held at the discharge are exposed to discharge temperatures for a longer period than normal due to circulation. The photosynthetic rates exhibited by these samples will therefore exaggerate possible discharge effects and so may be considered conservative estimates. In order to detect discharge temperature effects, the photosynthetic rates at OTB-6 (nearest the discharge) were compared to rates at other stations (Figure IV.B-11). The results of these comparisons are summarized below:

DEPTH	HIGHEST RATE OF FIVE STATIONS	LOWEST RATE OF FIVE STATIONS
Surface	3 of 8 dates	2 of 8 dates
Bottom	5 of 8 dates	none of 8 dates

The data show that higher photosynthetic rates at OTB-6 were observed more frequently than lower rates; if these differences are due to the plant's discharge, then in most cases the plant is stimulating production.

PHOTOSYNTHETIC RATE

OSWEGO VICINITY — 1975-1976



*No temperature data available

PHOTOSYNTHETIC RATE
OSWEGO VICINITY — 1975-1976

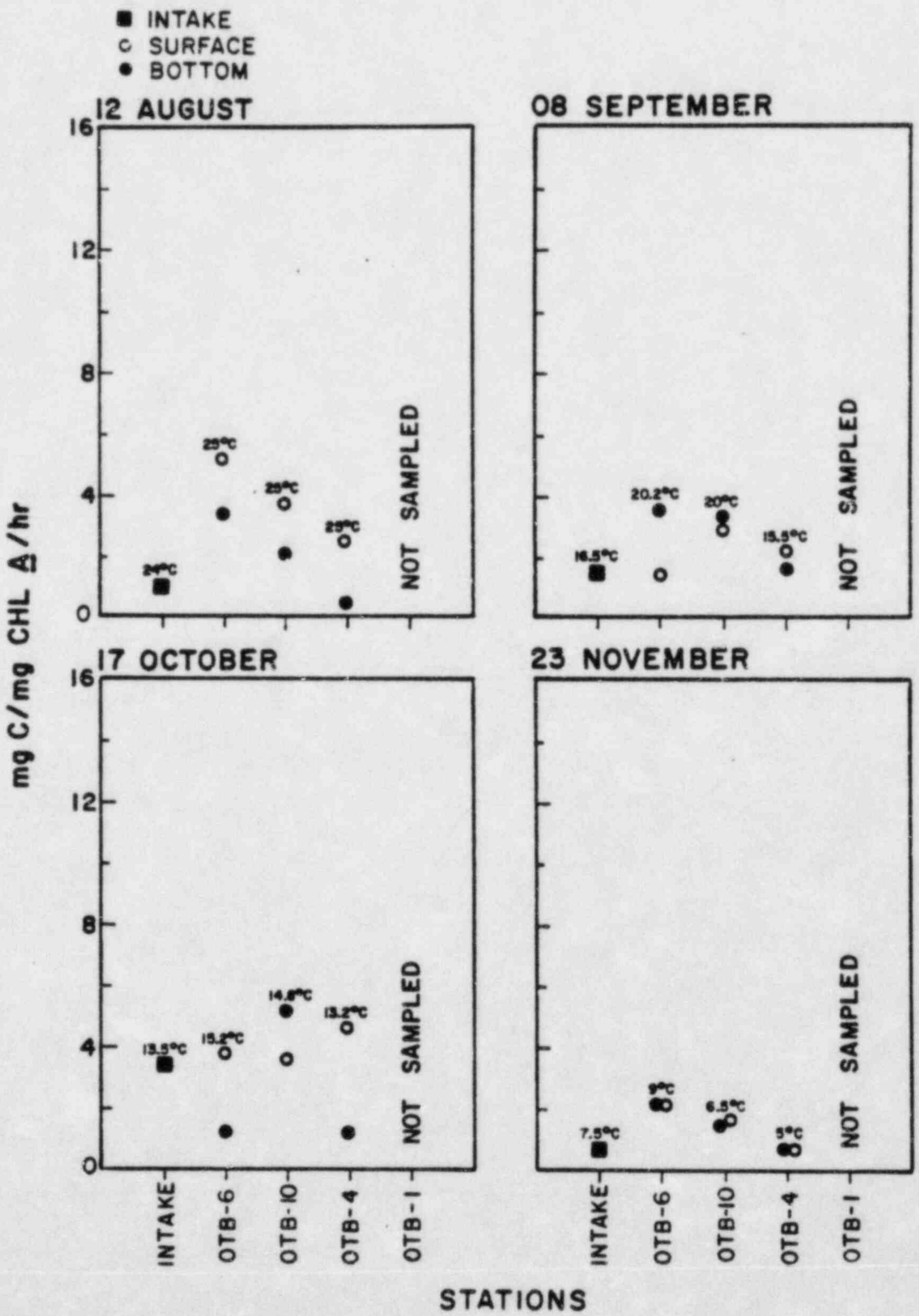
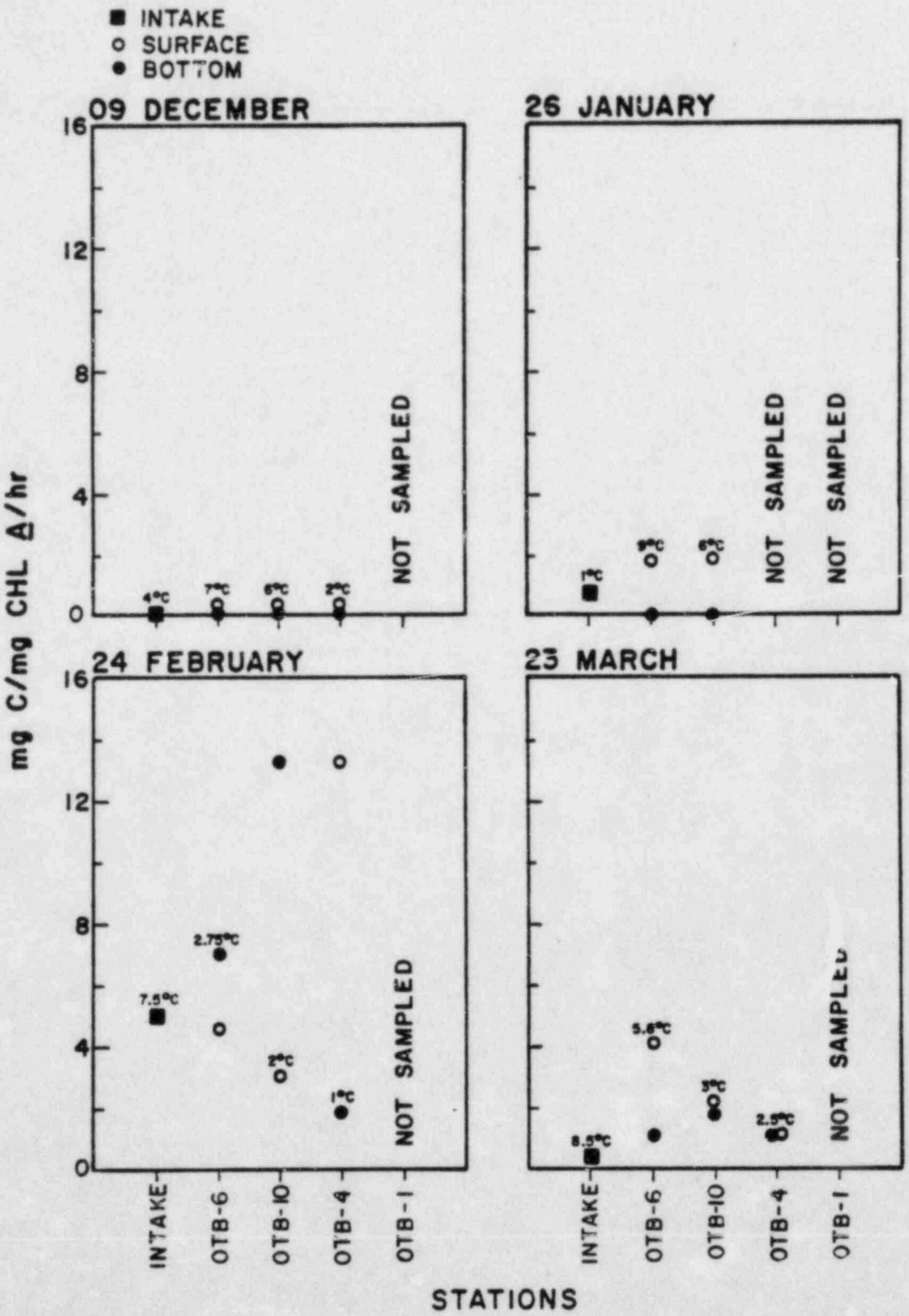


FIGURE IV B-11
(Continued)

PHOTOSYNTHETIC RATE

OSWEGO VICINITY — 1975-1976



Temperature measurements made during the incubation of the ^{14}C bottles indicated no apparent relation between these and the estimater of photosynthetic rate (Figure IV.B-11). However, these measurements were made only once during incubation and do not represent the average temperature to which the sets of bottles were exposed.

Primary production (mg $C/m^3/hr$) is affected by variations in chlorophyll a concentration. Data on primary production in the Oswego Turning Basin (Figures IVB-12) show that production fluctuated greatly throughout the turning basin without any consistent pattern. The relative importance of chlorophyll a to primary production was examined using regression analysis; the analysis of variance for the regression is:

Source of Variation	D.F.	Sum of Sq	Mean Sq	F Value
Attributable to regression	1	18988.65	18988.65	60.28
Deviation from regression	88	27722.56	315.03	
Total	89	46711.21		

The F value is significant at $\alpha \leq .001$ (1,88); the correlation coefficient is 0.638. Chlorophyll a is considered an important factor affecting production; other parameters which cause production to vary are seasonal variations in photosynthetic rate resulting from changes in light, temperature, and nutrient regimes. In addition, spatial variations in photosynthetic rates were observed for most sampling dates.

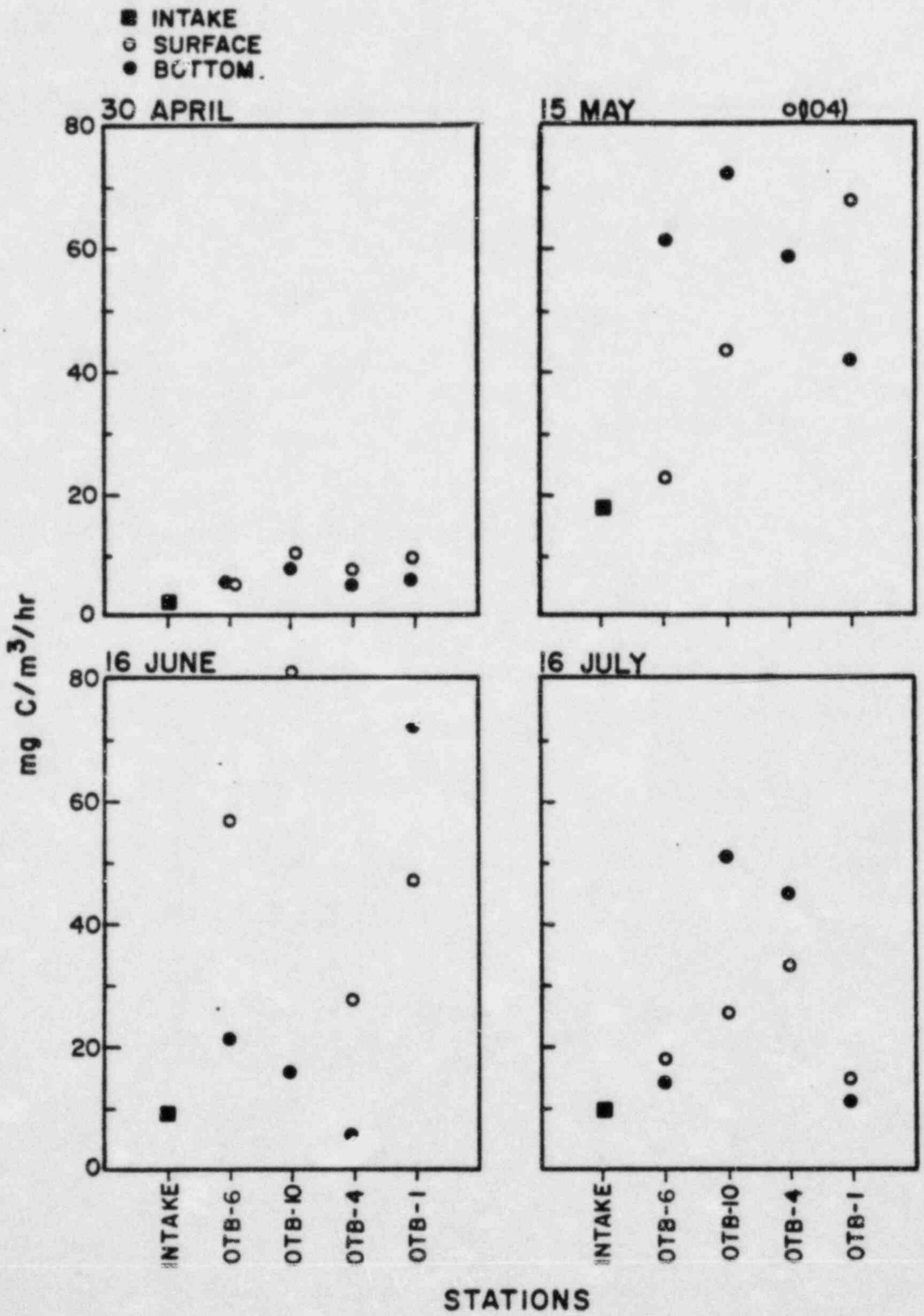
In summary, the following points may be made regarding chlorophyll a, photosynthetic rate, and production in the turning basin:

1. Spatial variation in the distribution of chlorophyll a may be explained by expected circulation patterns.

2. Photosynthetic rates demonstrated no consistent pattern but indicated that any actual power plant effect is stimulatory.

3. Primary production showed no consistent spatial pattern, although part of the variation in primary production may be explained by variations in chlorophyll a.

PRIMARY PRODUCTION
OSWEGO VICINITY — 1975-1976



PRIMARY PRODUCTION

OSWEGO VICINITY — 1975-1976

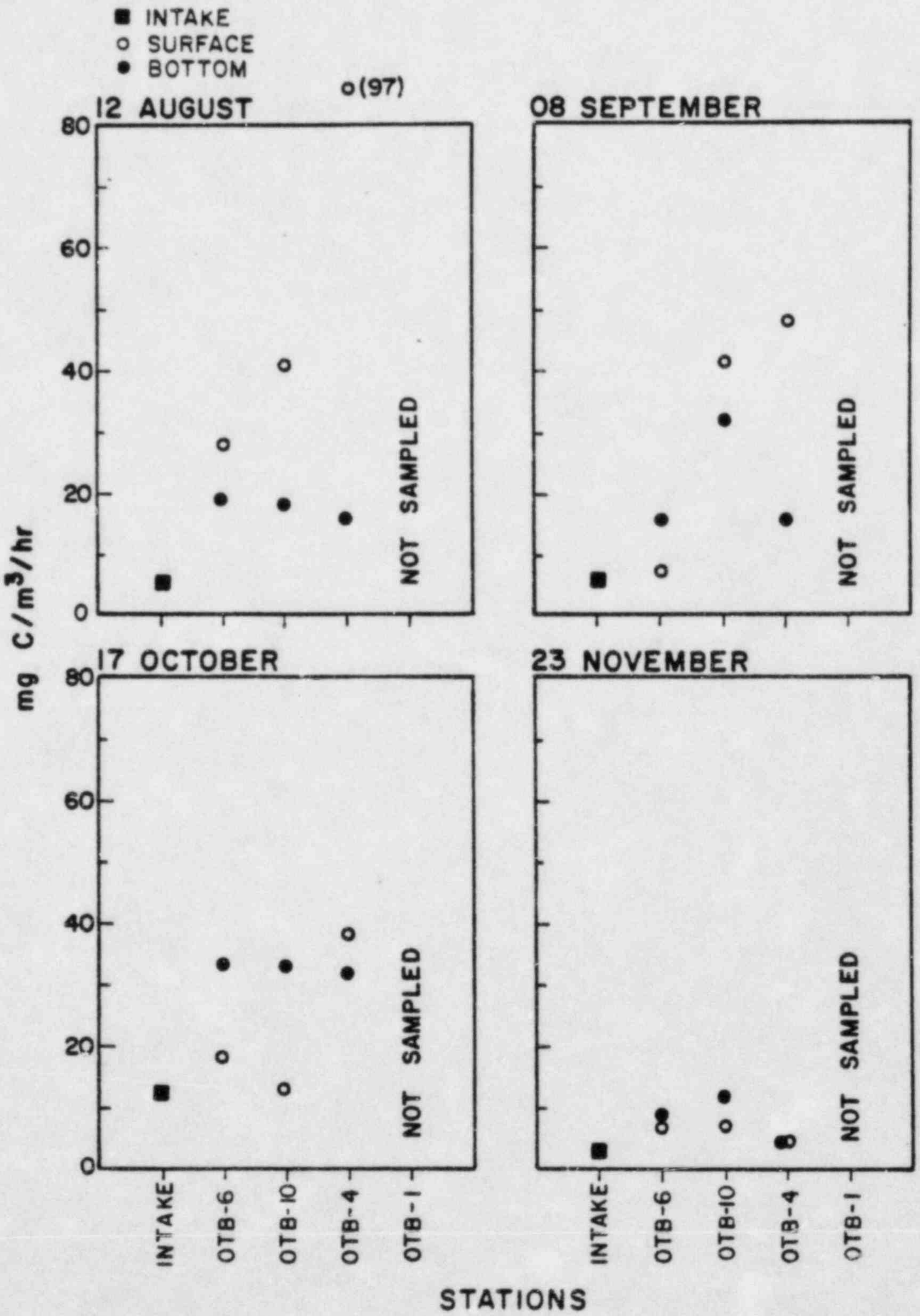
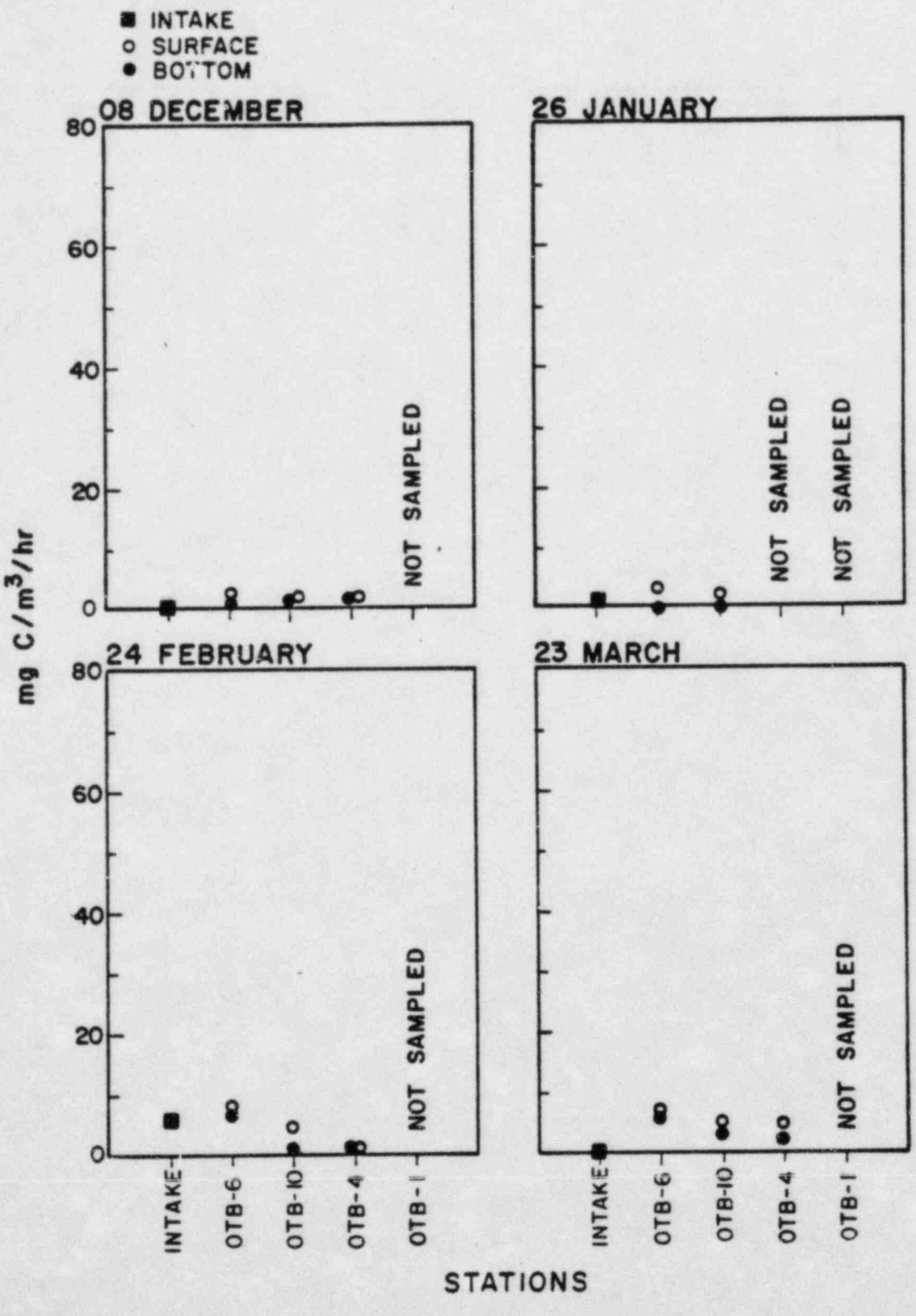


FIGURE IV B-12
(Continued)

PRIMARY PRODUCTION
OSWEGO VICINITY — 1975-1976



2. Microzooplankton

a. Introduction

Microzooplankton* feed primarily on algae and particulate organic matter and are in turn consumed by the larger macrozooplankton, ichthyoplankton, and planktivorous fishes. The abundance, distribution, and species composition of microzooplankton are therefore important to energy and material transfer through the aquatic food web.

During 1975 a program was established to examine the microzooplankton community in the Oswego Turning Basin and the possible effects of the Oswego Steam Station Units 1-4 on that community. Sampling was conducted monthly (April 1975 - March 1976); surface and bottom samples were collected at four locations in the basin and mid-depth samples were collected at the plant's intake on Lake Ontario. The details of sampling are presented in Appendix C.

The potential effects of power generation by the Oswego Steam Station on the microzooplankton include species-specific alteration of reproductive and developmental rates due to thermal discharges and increased mortality due to entrainment stresses. Also, since the lacustrine community entrained can be expected to be different from the riverine community of the Oswego River, mixing of these communities and formation of a unique third community in the turning basin is probable.

In this section, the information obtained from the field study is examined to determine whether temporal and spatial distribution patterns in abundance and community composition exist that indicate the influence of power plant operation. Patterns are interpreted in light of the chemical and physical factors which indicate environmental conditions in the turning basin; information from the published literature on the ecology of the dominant organisms in the microzooplankton community is also considered. The major emphasis is to describe the condition of the commmunity in and mixed with discharged cooling water.

b. Microzooplankton Species Inventory

A species inventory of microzooplankton collected in the Oswego Turning Basin and at the intake of Units 1-4 of the Oswego Steam

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* Microzooplankton are those planktonic animals retained on a 76μ mesh net.

Station is presented in Table IV.B-6. This table also indicates the presence of each organism identified by collection date, and notes those organisms which comprised more than 15% of the total microzooplankton concentrations at one or more stations.*

A total of 79 taxa were observed, including 51 rotifers, 10 copepods, and 9 each of cladocerans and protozoans. The examination of community composition at the species level can be useful in evaluating the ecology of an area. In this connection, it is interesting to compare species inventories for the Oswego Turning Basin and Lake Ontario as listed by LMS (1976b) for the nearby Nine Mile Point vicinity. Eight species were observed in the turning basin samples and not at Nine Mile Point: the rotifers *Colurella* sp., *Keratella hiemalis* and *Lecane* sp., the cladocerans *Daphnia parvula*, *D. pulex* and *Alona guttatis*, the copepods *Diaptomus oregonensis* and *Mesocyclops edex*.

Colurella is a littoral organism usually found browsing over plants, scraping up small organisms with its head shield (Ward and Whipple, 1959). Aquatic vascular plants have been observed to be abundant in the turning basin's shallow waters but not in the Nine Mile Point vicinity; this may explain the occasional occurrence of *Colurella* among the turning basin's plankton but not at Nine Mile Point. *Lecane* has a distribution pattern similar to that of *Colurella*.

K. hiemalis was observed in the turning basin and intake collections on only one date, 29 March. Since it was collected from the lake water at the intake it is not considered a useful indicator of community difference between the turning basin and Lake Ontario. Pejler (1957) has described this species as a cold-tolerant stenothermal form.

The cladoceran *Daphnia pulex* is usually a pond form, having little importance in lake plankton (Hutchinson, 1967). This is reflected in laboratory studies of its ecology; it can live in water containing large amounts of bacterial seston (Pacaud, 1939) and requires large (>60 mm diameter) food organisms (Hrbáčková-Esslova, 1963), which are often typical of eutrophied pond situations. In addition, Herbert (1954) and Pacaud (1939) observed that this species could tolerate lower oxygen levels than most typical freshwater species. The more pond-like habitat of the Oswego Turning Basin (e.g., extensive beds of aquatic vegetation, shallower waters) may explain why *D. pulex* was observed there and not in the Nine Mile Point vicinity of the lake.

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* Organisms comprising more than 15% of the total are considered dominant and have been designated with a D.

TABLE IVB-6

OCCURRENCE OF MICROZOOPLANKTON BY DATE
OSWEGO HARBOR AND TURNING BASIN 1975 - 1976

TAXA	30APR	15MAY	16JUNE	16JULY	12AUG	12SEP	17OCT	23NOV	09DEC	26JAN	24FEB	29MAR
PROTOZOA												
DIFFLUGIA SP.		X	X	X	X	X						
CODONELLA CRATERA	X	X	X	X	X	X	X	X	X	X	X	X
VORTICELLIDAE	D	D	X	X	X	X	D	D	D	D	D	D
EPISTYLIDAE		X	X	D	D	X	D	X	X	D	D	X
ACINETA SP.	X	X			X	X	X	X	X	X	X	X
TOKOPHYRA SP.	X	X										
THECACINETA SP.	X		X	X	X	X					X	X
PARACINETA SP.		X					X	X		X		
STAUROPHYRA ELEGANS	X	X	X									
ROTIFERA												
BDELLOIDEA	X			X	X		X	X	X	X	X	X
BRACHIONUS ANGULARIS	X	X	X	D	X	X	X	X	X	X	X	X
BRACHIONUS CALYCIFLORUS	X	X	X	X	D		X	D	D	X	X	X
BRACHIONUS HAVANAENSIS			X		X							
BRACHIONUS QUADRIDENTATUS		X	X	X	X	X	X	X	X			X
BRACHIONUS URCEOLARIS		X					X	X	X	X	X	X
BRACHIONUS CAUDATUS			X	X	X							
BRACHIONUS BUDAPESTINENSIS					X	X						
COLURELLA SP.			X	X								
EUCLANIS DILATATA	X	X	X			X	X		X	X		
KELLICOTTIA BOSTONIENSIS						X	X	X	X	X	X	X
KELLICOTTIA LONGISPINA	X	X	X	X			X	X	X	X	X	X
KERATELLA CRASSA	X	X	X	X	X	D	X	X	X	X	X	X
KERATELLA COCHLEARIS	X	X	D	X	X	X	X	D	X	X	X	X
KERATELLA EARLINAE	X	X	D	D	X	X	D	X	X	X	X	X
KERATELLA HIEMALIS												X
KERATELLA QUADRATA	X	X	X	X	X	X	X	X	D	X	X	X
KERATELLA VALGA	X	X	X		X		X	X	X	X		
LEPADELLA SP.	X	X			X							
NOTHOLCA ACUMINATA	X	X				X		X	X	X	X	D
NOTHOLCA SQUAMULA	X	X	X							X	X	X
NOTHOLCA STRIATA	X	X										
PLATYAS PATULUS									X			
TRICHOTRIA SP.									X			
LECANE SP.							X					
MONOSTYLA SP.	X			X				X	X			X
CEPHALODELLA SP.							X	X	X	X	X	X
TRICHOCERCA CYLINDRICA					X	X						
TRICHOCERCA MULTICRINIS			X	X	X	X	X	X	X	X		X
TRICHOCERCA PORCELLUS							X	X	X			
ASCOMORPHA SP.	X				X							
ASCOMORPHA ECAUDIS	X				X							
CHROMOGASTER OVALIS	X											
ASPLANCHNA PRIODONTA	X	X	X	X	X	X	X	X	X	X	X	X
PLOESOMA LENTICULARE			X	X	X	X						
PLOESOMA HUDSONI					X	X						
PLOESOMA TRUNCATUM	X		X	X	X	X	X					

TABLE IVB-6 (Continued)

TAXA	30APR	15MAY	16JUNE	16JULY	12AUG	12SEP	17OCT	23NOV	09DEC	26JAN	24FEB	29MAR
POLYARTHRA SP.								X	X			
POLYARTHRA EURYPTERA			X	X	X	X	X					
POLYARTHRA VULGARIS	X	X	X	X	X	X	X	D	X	X	X	X
POLYARTHRA DOLICHOPTERA	D	X	X	X	X	X						X
POLYARTHRA MAJOR	D	X	X	X	X	X	D	X	X	X	X	X
POLYARTHRA REMATA	X	X	D	X	X	X	X	X	X	X		
SYNCHAETA LACKOWITZIANA	X	D	X		X	X	X	X	X	X	D	D
SYNCHAETA PECTINATA	D	X	X				X	X	D	X	X	D
SYNCHAETA STYLATA		X	X	X	X	D	X	X	X			
HEXARTHRA SP.				X	X	X						
FILINIA LONGISETA	X	X	X	X	X	X		X	X	X	X	X
CONOCHILOIDES SP.				X								
CONOCHILUS UNICORNIS	X	X	D	D	X	X	X	X	X			
COLLOTHECA MUTABILIS			X		X	X	X	X	X			
CLADOCERA												
DIAPHANOSOMA LEUCHTENBERGIANUM				X	X				X			
CERIODAPHNIA LACUSTRIS	X			X	X	X	X					
DAPHNIA PARVULA				X								
DAPHNIA RETROCURVA	X		X	X	X	X	X	X	X		X	X
DAPHNIA PULEX									X		X	X
BOSMINA COREGONI			X	X	X	X	X	X	X	X	X	X
BOSMINA LONGIROSTRIS	X	X	X	D	X	D	D	D	X	X	X	X
ALONA GUTTATA												X
CHYDORUS SPHAERICUS	X	X	X	X	X	X	X	X	X		X	X
COPEPODA												
COPEPODA NAUPLII	X	X	X	X	D	X	X	X	X	D	D	D
CALANOIDA JUVENILE	X	X	X	X	X	X	X	X	X	X	X	X
EURYTEMORA AFFINIS				X			X	X	X			
DIAPTOMUS SP.				X				X	X	X		X
DIAPTOMUS MINUTUS												X
DIAPTOMUS OREGONENSIS									X	X	X	X
LIMNOCALANUS MACRURUS										X		
CYCLOPOIDA JUVENILE	X	X	X	X	X	X	X	X	X	X	D	X
ACANTHOCYCLOPS VERNALIS			X	X	X	X						
DIACYCLOPS BICUSPIDATUS THOMAS				X			X	X	X	X	X	X
MESOCYCLOPS EDAX				X								
TROPOCYCLOPS PRASINUS MEXICAN				X	X	X	X	X	X	X	X	X
HARPACTICOIDA								X	X			X
HARPACTICOIDA JUVENILE						X	X	X	X		X	X

FOOTNOTES:

D INDICATES PRESENCE AT > 15 PERCENT OF TOTAL AT ONE OR MORE STATIONS
X INDICATES PRESENCE AT ONE OR MORE STATIONS

There was little specific data on the cladocerans Daphnia parvula and Alona guttata. However, species of Alona are commonly found associated with aquatic vegetation (Ward and Whipple, 1959) and A. guttata may be a typical littoral form.

Mesocyclops edax was observed in only one sample on one date (16 July) in the Oswego Turning Basin. It is a typical planktonic species, reaching maximum numbers in lakes during the summer (Hutchinson, 1967). Therefore, its occurrence in the turning basin is considered incidental and not indicative of conditions there as compared to the lake.

The taxa unique to the turning basin compared to the lake were among the less abundant forms. The dominant zooplankton in the Oswego Turning Basin on three or more of the twelve sampling dates included protozoans of the families Vorticellidae and Epistylidae, the rotifers Brachionus calyciflorus and Keratella earlinae, the cladoceran Bosmina longirostris, and copepod nauplii. With the exception of B. calyciflorus a typically littoral species (Ruttner-Kolisko, 1974), these organisms were also dominant in Lake Ontario at Nine Mile Point (LMS, 1976b).

Comparison of species inventories indicates that the zooplankton species composition in the Oswego Turning Basin was generally similar to that of the lake in the Nine Mile Point vicinity. The few species which were not common appear to reflect habitat differences; the turning basin is a shallow, semi-enclosed water body with extensive littoral areas harboring aquatic macrophytes, while the lake at Nine Mile Point is a deeper, exposed area in which no vascular plants grow. These presence/absence differences do not reflect different water quality conditions (i.e., pollution tolerant organisms vs pollution intolerant organisms).

c. Abundance of Selected Microzooplankton Taxa

The Oswego Turning Basin is hypothesized to constitute a mixing zone for two communities: the microzooplankton in the lake, i.e., in the cooling water discharged from Oswego Units 1-4, and that community in the Oswego River. Therefore, on a given date, the spatial distribution of microzooplankton abundance is a function primarily of the hydrodynamics of the mixing process in the basin. Both simple and complex gradients in microzooplankton concentrations, reflecting the mixing of different water masses, probably occurred on dates when lake (as indicated by Intake 1-4) and river (as indicated by OTB-4) concentrations differed. On dates when lake and river concentrations were similar, suggesting similar environmental conditions, spatial distribution patterns in the turning basin may have reflected the influence of human activities (domestic and industrial discharges) in the basin.

In the following subsections the spatial distribution patterns of total microzooplankton, total copepods, Keratella earlinae, and Bosmina longirostris will be described; the results of analyses of variance will be presented to indicate whether differences in abundance among stations were statistically significant.

(i) Total Microzooplankton

Total microzooplankton abundance generally increased during the spring months to a June maximum at Intake 1-4 and OTB-6, the station closest to the discharge of Oswego Units 1-4 (Table IV.B-7). Maximum microzooplankton concentrations were recorded during late April at OTB-4, the station most influenced by the Oswego River. Both the April and June maxima were observed at OTB-10, particularly in bottom waters, suggesting that this station, located approximately midway between OTB-6 and OTB-4, represents a transition zone between two habitats.

This observation was confirmed by the results of an ANOVA (analysis of variance) among dates, stations, and depths which showed that there were significant differences in mean microzooplankton abundance among turning basin stations and between mean values at the intake and the average of all turning basin stations and depths on seven of ten study dates. Most importantly, on all of the dates when significant differences were isolated, a posteriori tests showed that abundance at OTB-10 was not significantly different from that at one or both of the other stations in the turning basin (Appendix D), indicating the transitional nature between habitats in the mid-region of the turning basin. These tests also showed that abundances tended to be significantly greater at OTB-4 (under the influence of the river) than at OTB-6 (under the influence of the plant's discharge) during the late fall and winter, whereas during the spring, summer, and early fall the opposite pattern was frequently observed. The similarity in intake and OTB-4 abundance values during February and March, together with the low values at OTB-6 and OTB-10 (Table IV.B-7), suggest unsuitable environmental conditions at the latter two stations at those times. These low values could also reflect the influence of grazing by overwintering fish populations or the influx of surface runoff as well as the effects of power plant operation. It is also possible that OTB-4 was representative of lake rather than river conditions during the winter months and that OTB-6 and OTB-10 microzooplankton concentrations reflected the intrusion of undetermined river populations.

TABLE IV B-7

ABUNDANCE* OF TOTAL MICROZOOPLANKTON

OSWEGO VICINITY - 1975-1976

DATE	INTAKE UNITS 1-4	OTB-6		OTB-10		OTB-4	
		SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM
30 APR 1975	251	233678	192677	312925	748926	886801	965588
15 MAY	18233	170237	220408	233613	197196	261262	280052
16 JUN	633020	550982	751398	358495	836919	380834	360807
16 JUL	85920	133733	160416	206204	213104	118586	177200
12 AUG	88829	142976	157900	133520	155030	150697	147165
12 SEP	77863	88767	159246	119264	111739	40974	75102
17 OCT	122574	94279	110782	68417	31798	46812	45793
23 NOV	72025	13945	18241	46196	23820	43455	39327
9 DEC	24894	40721	24450	28655	25042	53431	50115
26 JAN 1976	30974	11886	13512	7951	7318	NS	NS
24 FEB	24711	6090	5006	5739	5172	35476	37643
29 MAR	16284	4605	4711	2358	3691	11397	14914
MEAN	99631.5	124324.9	151562.3	126944.8	196646.3	185256.8	199427.8

NS - No sample

*Number of organisms/$0.5m^3$

The station x depth interactions were indicative of the water circulation patterns in the turning basin on some dates. For example, the pattern of abundance on 16 June suggests that warm water from the river penetrated the turning basin at the surface, was mixed with cooler denser water in the discharge plume, and returned to the harbor along the bottom of the turning basin. This circulation pattern was confirmed by the results of an intensive temperature/conductivity survey conducted on 26 June (Chapter III). Such patterns were not apparent on all dates due to the complexity of mixing patterns and natural variability in the distribution of microzooplankton populations.

(ii) Keratella earlinae

Abundance of Keratella earlinae ranged from no organisms collected at most stations in April and May to 559,248 organisms/m^3 at the intake on 16 June (Table IV.B-8). The average abundance for all stations throughout the sampling period was 35,344 organisms/m^3.

The timing of seasonal maxima differed only slightly among intake and turning basin stations. An ANOVA showed that the abundance of K. earlinae did not differ significantly among stations within the turning basin (Appendix D), although it was higher at these stations than at the intake on 16 July and 12 August. Overall, these results suggest that, generally, K. earlinae was evenly distributed in the turning basin and that this species is tolerant of a wide range of environmental conditions. Little published data available on factors affecting the growth and distribution of K. earlinae populations. Hutchinson (1967) suggests it is a warm water species and this partially describes populations in the turning basin (i.e., very low abundance in the winter and spring, high abundance in June). However, in the warmest months (August and September) abundance was not at maximum levels.

K. earlinae commonly occurs with K. cochlearis, for which there are published data on population growth. This species feeds on particulate organic matter and algae (Pejler, 1957; Pourriot, 1957; Erman, 1962) and together with K. earlinae probably plays an important role in the transfer of energy and material through the Oswego Turning Basin food web; both species may be particularly important in the diet of ichthyoplankton (Ruttner-Kolisko, 1974). Those data which do exist for K. cochlearis were obtained for temperatures $\leq$20°C, slightly

TABLE IV B-8

ABUNDANCE* OF KERATELLA EARLINAE

OSWEGO VICINITY - 1975-1976

DATE	INTAKE UNITS 1-4	OTB-6		OTB-10		OTB-4	
		SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM
30 APR 1975	0	0	0	0	745	0	0
15 MAY	0	110	0	0	0	0	1945
16 JUN	279624	142193	222132	118075	204415	137937	58473
16 JUL	1297	23396	16633	24501	16442	20433	15232
12 AUG	273	9188	10875	9316	10823	5679	6674
12 SEP	1859	797	1381	4343	3609	2902	2792
17 OCT	6608	3183	4713	4959	4999	10774	12953
23 NOV	8873	2019	2309	5940	2964	5861	2693
9 DEC	2028	2697	1657	1978	1146	2862	2399
26 JAN 1976	257	219	70	99	126	NS	NS
24 FEB	0	60	79	0	0	100	0
29 MAR	114	24	28	0	24	129	71

NS - No sample
*Number of organisms/0.5 m^3

lower than summer temperatures in the turning basin (~23.5°C) and therefore are useful for evaluating effects of water temperature over most of its range. Developmental rates and reproductive rates increased with increasing temperature (Edmondson, 1964; Pourriot and Deluzarcher, 1971; Lindstrom and Pejler, 1975) and it is reasonable to expect that this relationship probably persisted over the complete range of temperature (up to 24°C) in the turning basin. Lindstrom and Pejler (1975) estimated the generation time of K. cochlearis to be three days at 20°C. Such a short generation time with rapid population growth could be expected to compensate for any losses resulting from power plant impact within the temperature regime of the turning basin.

(iii) Bosmina longirostris

This species was the most abundant cladoceran in the turning basin, ranging in abundance from no organisms collected at many stations in March, April, and May to 136,276 organisms/m^3 at the OTB-10 surface station in July (Table IV.B-9). The average abundance for all stations and dates was 12,696 organisms/m^3. The timing of seasonal maxima was similar at the intake and OTB-6 and at OTB-10 and OTB-4, but dissimilar between these two pairs, indicating the mixing of different populations in the turning basin.

Analysis of variance was conducted for data collected on the six July-December sampling dates when B. longirostris was present at most stations (Appendix D). The abundance of B. longirostris was significantly higher at OTB-6 and/or OTB-10 than at OTB-4 on 16 July, 12 September, 17 October; no significant differences were observed for other dates. The higher abundance on 17 October could have been due to the discharge of lake water rich in Bosmina since this organism was significantly more abundant at the intake than in the turning basin. However, this cannot explain the higher abundance at OTB-6 and/or at OTB-10 on the other two dates, a phenomenon which suggests that B. longirostris populations may reside within the turning basin. Concentrations appeared to be reduced in the turning basin during the winter months, perhaps due to the influence of natural factors or human activites (see discussion for total microzooplankton).

This species has been observed to reach peak abundance at various seasons in different water bodies and may occur in abundance at several times during the year in the same water body

TABLE IVB-9

ABUNDANCE* OF BOSMINA LONGIROSTRIS

OSWEGO VICINITY - 1975-1976

DATE	INTAKE UNITS 1-4	OTB-6 SURFACE	OTB-6 BOTTOM	OTB-10 SURFACE	OTB-10 BOTTOM	OTB-4 SURFACE	OTB-4 BOTTOM
30 APR 1975	0	0	304	792	0	0	0
15 MAY	0	0	419	0	106	0	917
16 JUN	1463	724	663	362	3611	1143	1526
16 JUL	24838	27323	21774	68138	31837	18025	15626
12 AUG	0	3971	10733	2821	7100	2291	3315
12 SEP	569	17132	46928	15056	22791	3739	9228
17 OCT	32632	19962	25336	16998	4659	2409	2020
23 NOV	3286	2283	2212	5526	988	1841	1415
9 DEC	1143	1838	1608	1705	1631	1873	1344
26 JAN 1976	1416	110	70	275	220	NS	NS
24 FEB	0	60	0	0	68	200	139
29 MAR	0	0	0	0	24	27	0
MEAN	7657.3	6116.9	9170.6	9306.1	6086.2	2868.0	3230.0

NS - No sample
*Number of organisms/0.5 m^3

(Ischreyt, 1926; Rylov, 1935; Chandler, 1940; Borecky, 1956; Patalas, 1956; Hrbáček and Novotra-Dvořaková, 1965). Because the abundance of B. longirostris is highly variable and fluctuates seasonally, this suggests that populations of these organisms in various water bodies differ in their response to temperature and/or other environmental factors. The lack of a common definable seasonal pattern for B. longirostris has been noted by Hutchinson (1967).

(iv) Copepoda

Copepod abundance ranged from no organisms collected at the intake on 30 April to 94,660 organisms/m^3 at the OTB-4 bottom station on the same sampling date (Table IV.B-10). The average abundance for all stations and dates was 18,172 organisms/m^3, most of which were nauplii. The timing of seasonal maxima among turning basin stations was similar, but different between intake and basin stations, indicating that the river was the primary source of copepod populations.

Analysis of variance (Appendix D) showed that copepod abundance was significantly higher in July and August, a seasonal pattern which is in agreement with that of copepods in Lake Ontario (Watson and Carpenter, 1974; LMS, 1976a). On three of the five dates when there were significant differences in copepod abundance among stations within the turning basin, abundance was higher at OTB-6 and/or OTB-10 than at OTB-4. This can be explained by the discharge into the basin of lake water rich in copepods in June (when significantly higher copepod abundance was recorded at the intake) and September; however, in July, the turning basin had significantly higher copepod abundance than the intake.

Concentrations of copepods were significantly higher at OTB-4 than at OTB-6 on 15 May and 29 March. The lower abundance at OTB-6 on the former date may be explained by the discharge of lake water of low copepod abundance (the intake station had significantly lower abundance than the turning basin stations on this date). However, this does not explain the lower abundance at OTB-6 and OTB-10 on 29 March, since copepod abundance was significantly greater at the intake than in the turning basin, and intake and OTB-4 concentrations were similar. This pattern was observed for total microzooplankton and B. longirostris and was probably due to the same factors (see discussion for total microzooplankton).

TABLE IV B-10

ABUNDANCE* OF COPEPODA

OSWEGO VICINITY - 1975-1976

DATE	INTAKE UNITS 1-4	OTB-6		OTB-10		OTB-4	
		SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM
30 APR 1975	0	3903	7813	6103	28688	35766	47330
15 MAY	318	3821	8634	8691	14463	13286	20313
16 JUN	15599	14564	9634	1883	9596	2441	1994
16 JUL	4642	19940	34215	17215	41465	6520	22418
12 AUG	6189	24886	34046	22691	21129	17722	36523
12 SEP	10897	6852	11158	5525	8617	1853	6153
17 OCT	20115	9606	6200	2010	1591	309	838
23 NOV	7880	2902	3561	5425	3315	2617	2688
9 DEC	2889	5735	2548	3106	3159	3356	2865
26 JAN 1976	2310	1759	1231	883	1446	NS	NS
24 FEB	2334	2144	1183	1637	1189	2493	2548
29 MAR	2213	884	751	441	577	3762	3637
MEAN	6282.2	8083.0	10081.2	6300.8	11269.6	8193.2	13391.6

NS - No sample

*Number of organisms/0.5 m^3

d. Discussion of Distributional Trends

The data indicate that in many cases the distribution of microzooplankters can be explained by such hydrodynamic features as:

(1) input of lake water via discharge into the turning basin, resulting in higher or lower abundance at the stations near the discharge;

(2) intrusion of lake water into the Oswego Harbor as seen on 29 March at OTB-4; and

(3) intrusion of river water, resulting in mixing of river and lake populations in the turning basin.

Undoubtedly this is a gross oversimplification of the processes affecting microzooplankton in the turning basin, but hydrodynamics do appear to be the major factor affecting distribution, masking the subtle differences in developmental and reproductive rates as a result of variations in temperature and food quality as well as in interspecific competition. Two species which appeared independent, to some extent, of large-scale hydrodynamic effects were Bosmina longirostris and Keratella earlinae, which may have been resident in or tolerant of conditions in the turning basin. The data for several other taxa not described in detail here (total protozoans, total rotifers, Vorticellidae, Polyarthra dolichoptera, Keratella cochlearis, Brachionus calyciflorus, and Diacyclops bicuspidatus thomasii) were also examined and with the exception of D. bicuspidatus thomasii the average abundance for the year increased from the intake station through the turning basin with maximum abundance occurring at the harbor station OTB-4 (Tables IV.B-11 through IV.B-17). This gradient conforms to the basic hydrodynamic pattern of lake water of low organism abundance, discharged via the power plant, mixing with Oswego River water of high organism abundance. The copepod D. bicuspidatus thomasii is probably a lake species which is not abundant in the turning basin.

e. Community Structure

Variations in microzooplankton community structure were examined for each date; hierarchical classification analysis was used for this examination. A similarity matrix was generated using Sander's (1960) index and the groupings, or clusters, were formed by the unweighted pair group, also called group average method (Sneath and Sokal, 1973). Stations were classified using species abundances for comparisons. The results of these analyses are presented as dendrograms (Appendix D), one dendrogram for each

TABLE IV B-11

ABUNDANCE* OF PROTOZOA

OSWEGO VICINITY - 1975-1976

DATE	INTAKE UNITS 1-4	OTB-6		OTB-10		OTB-4	
		SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM
30 APR 1975	42	219934	161711	282880	639422	806276	844755
15 MAY	945	80185	106522	61807	82594	44298	79047
16 JUN	78802	42315	53818	22325	58004	26279	45872
16 JUL	29630	9024	16386	15457	26435	20059	23095
12 AUG	52754	18614	24156	33823	30010	28300	12333
12 SEP	8502	2726	2229	12088	11401	6229	6897
17 OCT	7946	20430	29382	15160	9310	15749	12431
23 NOV	2450	236	80	5175	117	9736	8811
9 DEC	1322	603	469	701	482	2637	4253
26 JAN 1976	25060	6442	8945	3756	1502	NS	NS
24 FEB	20530	1166	2203	1831	2134	30239	32264
29 MAR	11963	1085	432	496	312	4598	7352
MEAN	19995.5	33563.3	33861.1	37958.3	71810.3	90400.0	97919.1

NS - No sample
*Number of organisms/0.5 m^3

TABLE IV.B-12

ABUNDANCE* OF ROTIFERA

OSWEGO TURNING BASIN - 1975-1976

DATE	INTAKE UNITS 1-4	OTB-6		OTB-10		OTB-4	
		SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM
30 APR 1975	209	9841	22849	23150	78581	44759	73503
15 MAY	16970	86231	104730	163115	99927	203140	179775
16 JUN	537156	492885	687283	333925	765341	350373	311415
16 JUL	26810	74963	75000	103918	107071	73121	112972
12 AUG	29646	93415	85751	72913	93963	101949	90848
12 SEP	56706	61143	97649	85853	67818	35645	51822
17 OCT	59043	40106	44201	32243	14083	27841	29558
23 NOV	56825	8032	11103	28916	18854	28388	25669
9 DEC	19452	31749	19597	22910	19398	44323	41154
26 JAN 1976	2188	3575	3266	3037	4118	NS[a]	NS[a]
24 FEB	1847	2720	1620	2222	1748	2544	2483
29 MAR	2108	2636	3528	1421	2754	2851	3807
MEAN	67413.33	75608.00	96381.42	72801.92	106138.00	83175.82	83909.64

NS - No sample

[a]Sample not taken due to ice.

*Number of organisms/0.5 m^3

TABLE IV B-13

ABUNDANCE* OF VORTICELLIDAE

OSWEGO VICINITY - 1975-1976

DATE	INTAKE UNITS 1-4	OTB-6		OTB-10		OTB-4	
		SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM
30 APR 1975	42	219563	157516	281175	633347	792514	810528
15 MAY	945	76773	100315	56015	72112	38469	67008
16 JUN	0	1956	2062	8239	7319	3207	8262
16 JUL	0	0	124	0	112	258	454
12 AUG	0	344	556	560	724	145	862
12 SEP	620	117	108	191	0	3639	4325
17 OCT	605	1296	4043	946	5115	7923	3919
23 NOV	0	73	0	3129	0	8960	8217
9 DEC	866	296	469	311	444	2499	4039
26 JAN 1976	24930	881	2344	487	1345	NS	NS
24 FEB	17098	1046	984	971	532	25854	28848
29 MAR	11607	788	405	459	253	4521	7120
MEAN	4726.1	25261.1	22410.5	29373.6	60108.6	80726.3	85780.2

NS - No sample

*Number of organisms/0.5 m^3

TABLE IV B-14

ABUNDANCE* OF *POLYARTHRA DOLICHOPTERA*

OSWEGO VICINITY - 1975-1976

DATE	INTAKE UNITS 1-4	OTB-6		OTB-10		OTB-4	
		SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM
30 APR 1975	125	522	1852	2207	3782	6620	4149
15 MAY	2438	11893	11258	325347	15101	20152	10622
16 JUN	2925	14102	994	9752	16893	6324	32340
16 JUL	0	0	134	0	0	327	0
12 AUG	0	0	0	995	0	413	0
12 SEP	285	0	0	0	0	0	358
17 OCT	0	0	0	0	0	0	0
23 NOV	0	0	0	0	0	0	0
9 DEC	0	0	0	0	0	0	0
26 JAN 1976	0	0	0	0	0	NS	NS
24 FEB	0	0	0	0	0	0	0
29 MAR	0	24	27	37	72	27	0
MEAN	481.1	2211.8	1188.8	3794.0	2987.3	3078.5	4315.4

NS - No sample

*Number of organisms/0.5 m^3

TABLE IVB-15

ABUNDANCE* OF KERATELLA COCHLEARIS

OSWEGO VICINITY - 1975-1976

DATE	INTAKE UNITS 1-4	OTB-6		OTB-10		OTB-4	
		SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM
30 APR 1975	0	0	0	1172	0	1665	0
15 MAY	657	2594	3278	8746	9324	31699	41839
16 JUN	9424	23628	19207	78458	69804	103245	111389
16 JUL	1167	6559	6092	4632	11325	13843	16251
12 AUG	481	11860	7012	6350	12994	6880	3877
12 SEP	8136	117	391	338	280	246	1681
17 OCT	2873	3097	2023	1818	681	3101	1665
23 NOV	12452	681	759	1489	976	1744	895
9 DEC	1498	1440	403	503	737	575	502
26 JAN 1976	128	221	202	218	32	NS	NS
24 FEB	135	0	40	97	0	0	0
29 MAR	235	0	28	0	0	103	0
MEAN	3098.8	4183.1	3286.3	8651.8	8846.1	14827.4	16190.8

NS - No sample
*Number of organisms/0.5 m^3

TABLE IVB-16

ABUNDANCE* OF BRACHIONUS CALYCIFLORUS

OSWEGO VICINITY - 1975-1976

DATE	INTAKE UNITS 1-4	OTB-6		OTB-10		OTB-4	
		SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM
30 APR 1975	0	353	767	792	745	0	0
15 MAY	0	5693	18301	14043	14814	17575	20665
16 JUN	0	0	0	0	502	0	0
16 JUL	0	0	0	0	0	0	121
12 AUG	0	3971	14563	2108	12350	6298	25807
12 SEP	0	0	0	0	0	0	0
17 OCT	0	0	0	0	113	0	117
23 NOV	0	101	304	2884	3952	4166	5749
9 DEC	3571	8598	8511	6940	5556	16157	18025
26 JAN 1976	128	549	320	367	754	NS	NS
24 FEB	0	0	0	97	0	150	70
29 MAR	0	0	0	0	0	27	0
MEAN	308.3	1605.4	3563.8	2269.3	3232.2	4033.9	6414.0

NS - No sample

*Number of organisms/0.5 m^3

TABLE IV B-17

ABUNDANCE* OF DIACYCLOPS BICUSPIDATUS THOMASII

OSWEGO VICINITY - 1975-1976

DATE	INTAKE UNITS 1-4	OTB-6		OTB-10		OTB-4	
		SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM
30 APR 1975	0	0	0	0	0	0	0
15 MAY	0	0	0	0	0	0	0
16 JUN	0	0	0	0	0	0	0
16 JUL	0	226	393	0	0	0	0
12 AUG	0	0	0	0	0	0	0
12 SEP	0	0	0	0	0	0	0
17 OCT	403	182	135	0	114	0	0
23 NOV	145	146	160	496	117	49	0
9 DEC	74	99	185	0	187	328	0
26 JAN 1976	128	0	139	0	0	NS	NS
24 FEB	109	52	119	97	0	150	69
29 MAR	811	98	107	19	0	78	234
MEAN	139.2	66.9	103.2	51.0	34.8	55.0	27.6

NS - No sample
*Number of organisms/0.5 m^3

sampling date (Appendix D). The station clusters depicted by the dendrograms were then illlustrated on a longitudinal cross section of the Oswego Turning Basin including the intake for Units 1-4 of the Oswego Steam Station (Figure IV.B-13). In most cases the stations were grouped into either two or three clusters and were not split any further.

Several spatial patterns in community structure were observed. On 6 of the 12 sampling dates, the community structure at the intake station differed from that at the turning basin stations, as indicated by the low degree of similarity. Two dates (30 April and 16 July) were characterized by a cluster of surface stations and a cluster of bottom stations within the turning basin, yet there were no distinct differences between the relative abundance of total microzooplankton in surface and bottom samples (Figure IV.B-13). The water temperatures on 16 July indicated that the basin was vertically homeothermic. However, conductivity measurements (Appendix A) on this date indicate that high conductivity river water was flowing into the turning basin along the bottom and mixing at the surface with discharged lake water of low conductivity; this circulation pattern could have accounted for the surface-bottom stratification in the zooplankton community on 16 July.

On 15 May, 16 June, 12 September, 17 October, 23 November, and 9 December, the OTB-4 surface and bottom stations, which are near the harbor breakwall, formed a different cluster than the OTB-6 surface and bottom stations which are near the plant's discharge. At times the OTB-10 surface station, located between OTB-6 and OTB-4, clustered with the OTB-6 stations while the OTB-10 bottom station clustered with the OTB-4 stations (15 May, 17 October), giving the impression of water (possibly Oswego River) moving up the turning basin along the bottom and water in the upper turning basin moving down over the surface. On 17 October, water temperature measurements showed warmer waters in the turning basin region nearest the discharge, whereas the temperature at the OTB-10 surface station more closely resembled that at OTB-6 than at OTB-4. Thus, based upon water temperature distributions for 17 October, the pattern in zooplankton community structure mirrored the expected flow of water masses in the turning basin; cooler (denser) river water probably moved into the basin along the bottom, while warmer (lighter) discharged lake water mixed with river water flowing out of the basin at the surface.

On one date (16 June) the OTB-10 bottom station clustered with the OTB-6 bottom station and the OTB-10 surface with the OTB-4 surface station, suggesting the movement of water down the turning basin along the bottom. This was the expected flow pattern based

SCHEMATIC DISTRIBUTIONS OF MICROZOOPLANKTON ASSOCIATIONS

OSWEGO TURNING BASIN — 1975-1976

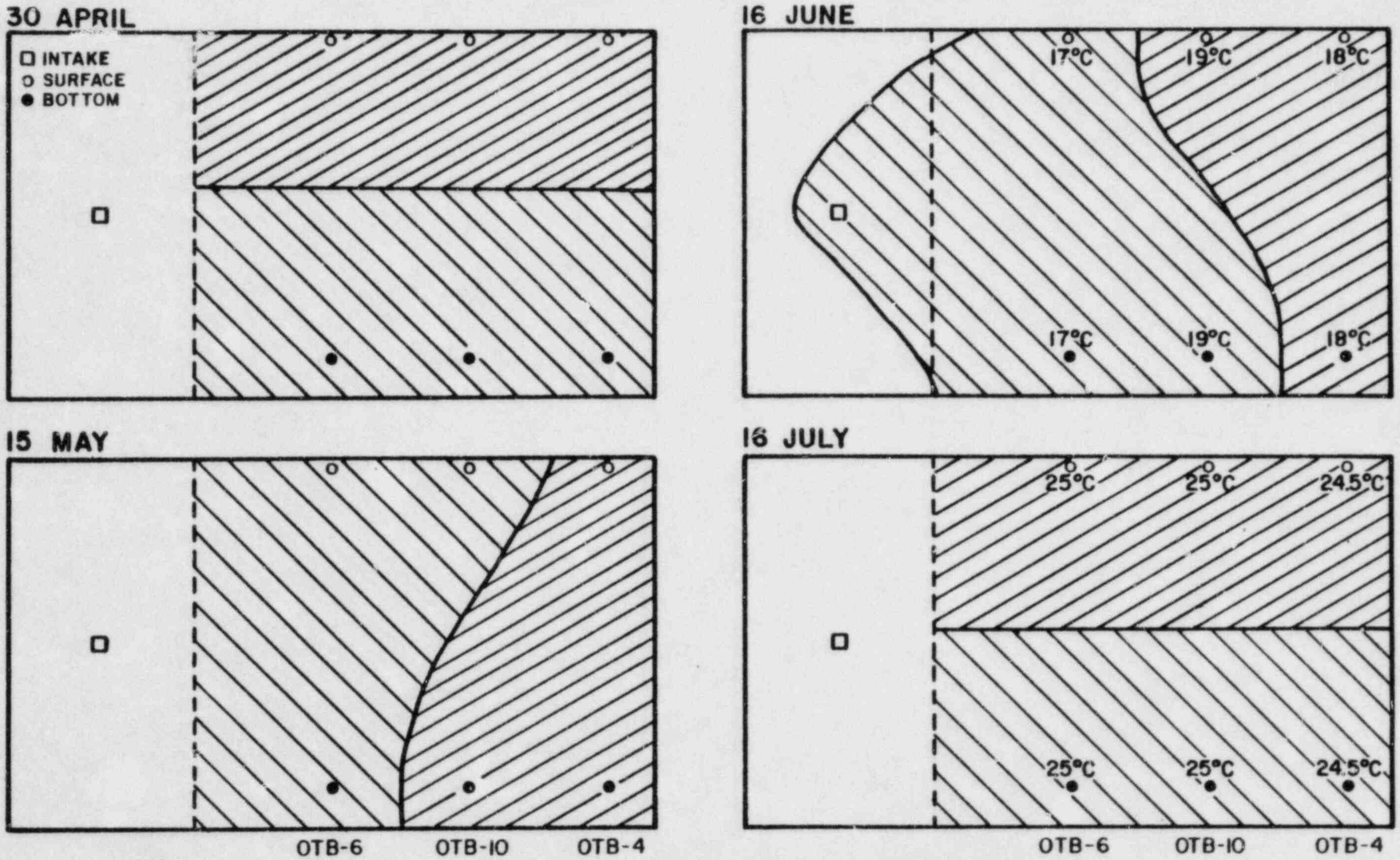


FIGURE IV B-13

SCHEMATIC DISTRIBUTIONS OF MICROZOOPLANKTON ASSOCIATIONS

OSWEGO TURNING BASIN — 1975-1976

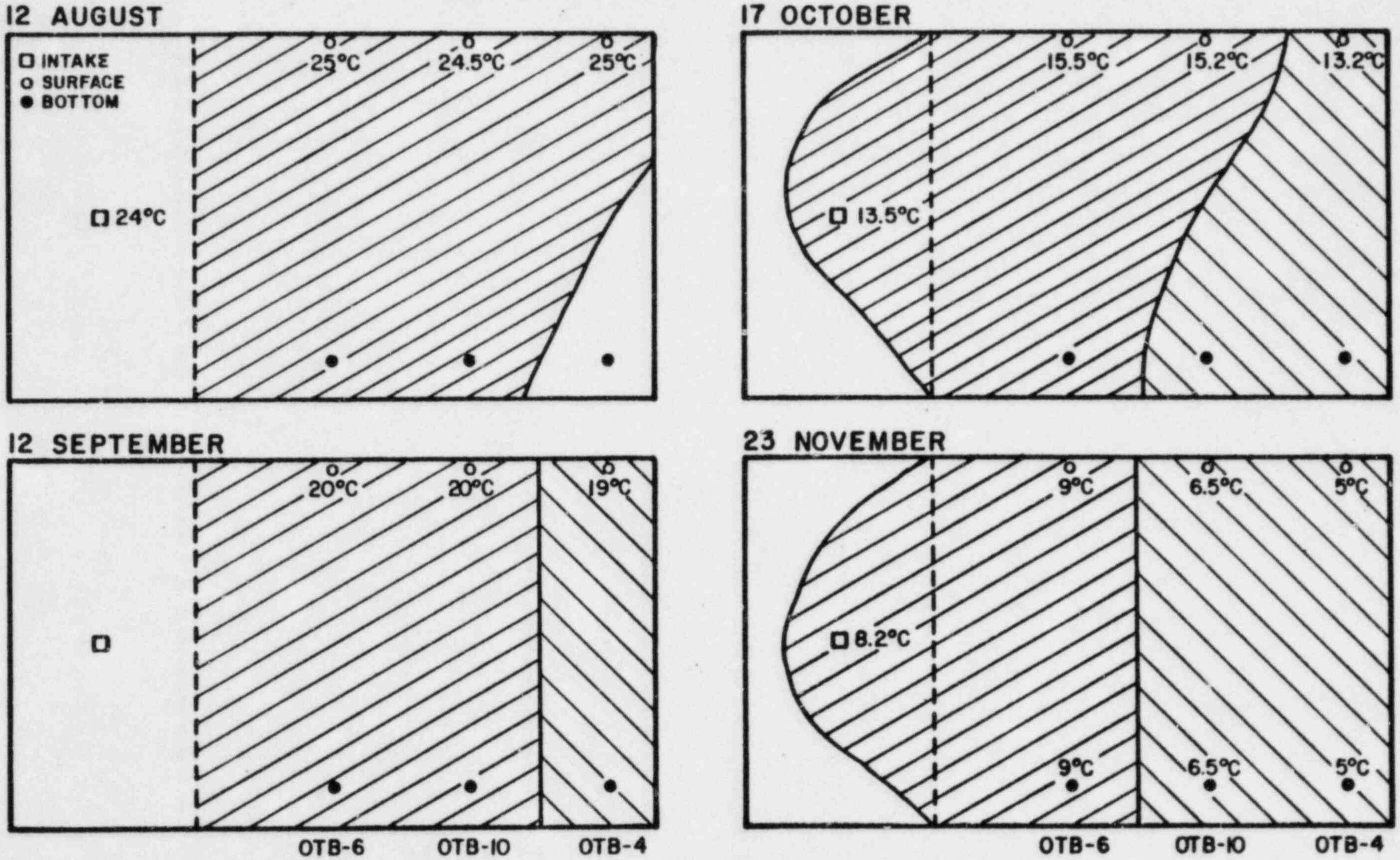


FIGURE IV B-13 (Continued)

SCHEMATIC DISTRIBUTIONS OF MICROZOOPLANKTON ASSOCIATIONS

OSWEGO TURNING BASIN — 1975-1976

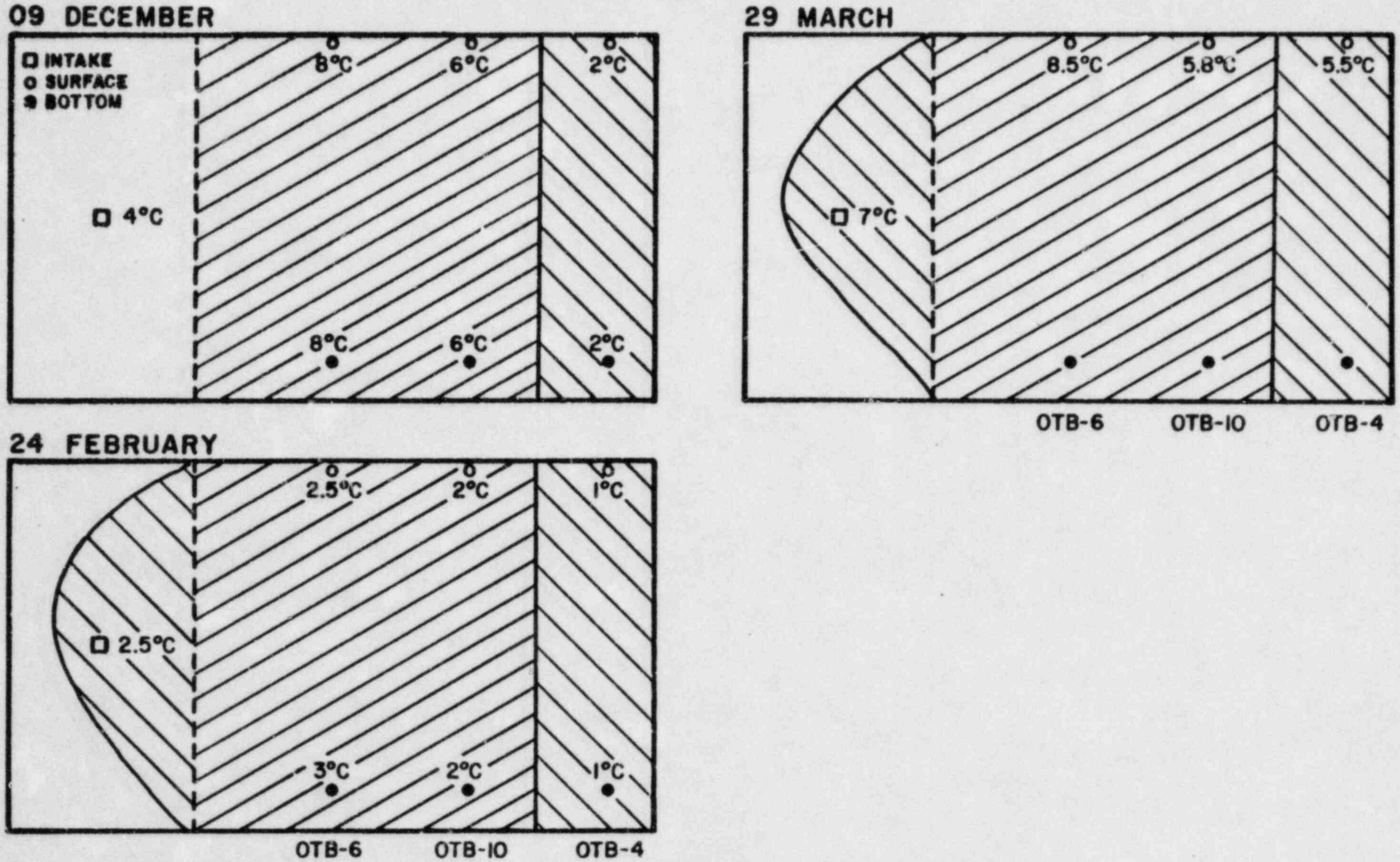


FIGURE IV B-13
(Continued)

on temperature measurements. The water near the discharge was cooler (denser) than Oswego River water and would therefore sink and flow out of the basin along the bottom.

Dates on which the intake clustered with turning basin stations corresponded to dates on which the relative abundance of total microzooplankton at the intake was at least 15% of the total observed for all stations (Figure IV.B-14). This suggests that for 16 June, 17 October, and 23 November the concentration of zooplankton drawn in from the lake at the plant's intake and discharged into the basin was high enough to affect the zooplankton community structure near the discharge (OTB-6) and, at times, further down the turning basin (OTB-10). When the relative abundance of total microzooplankton at the intake was less than 15% (particularly on 30 April and 15 May) the effect of power plant discharge of lake water into the turning basin was the dilution of turning basin zooplankton abundance without alteration of the structure of the zooplankton community.

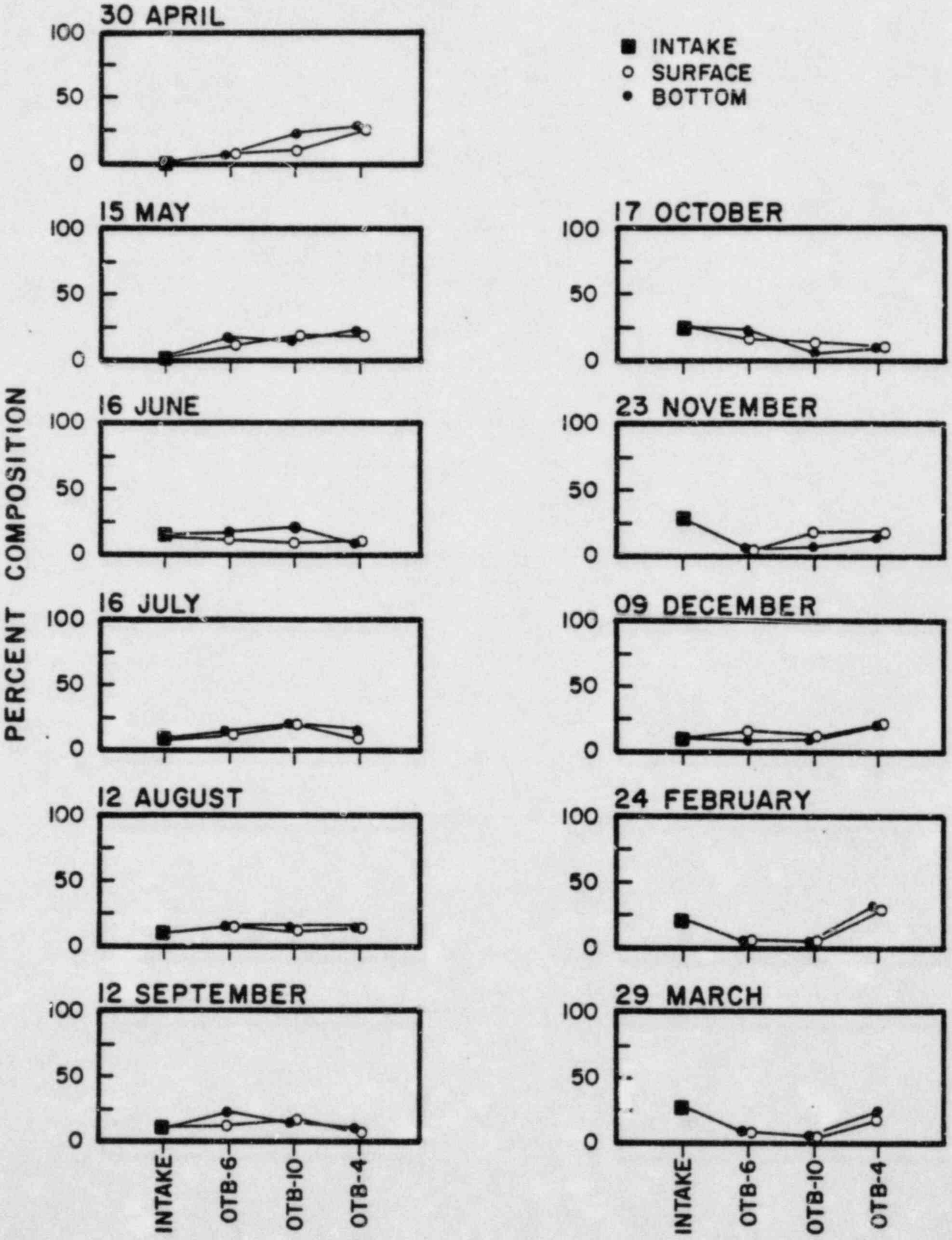
The data for 2 February and 29 March 1976 indicate similarities in community structure and relative abundance of total microzooplankton between the intake and the OTB-4 surface and bottom stations. This suggests the intrusion of lake water into the Oswego Harbor near OTB-4 and the consequent similarity of the zooplankton at these stations and in the lake water at the plant's intake. Community structure at OTB-6 and OTB-10 was similar on these dates and, as described earlier, abundance tended to be lower at these two stations than at intake and OTB-4. The spatial distribution patterns on these dates could reflect the intrusion of Oswego River water into the turning basin or the influence of natural factors, such as grazing by overwintering fish populations, or human activites, such as industrial and domestic waste discharge, on zooplankton populations in the turning basin.

In summary, the Oswego Turning Basin is characterized by complex water circulation patterns. Water may be contributed to the basin from the discharge of heated lake water by the Oswego Steam Station, the intrusion of lake water through the mouth of the Oswego Harbor, and the Oswego River. These waters may mix and/or, due to density differences, may form distinct water strata within the basin.

The characteristics of the zooplankton community within the turning basin reflect these different water circulation patterns. Water temperature measurements, used as indicators of water density and flow characteristics, support this thesis. Therefore the plant's discharge serves primarily as a source of heated lake water to the turning basin and the resultant patterns in zooplankton community structure appear to reflect hydrodynamic processes.

PERCENT COMPOSITION OF TOTAL MICROZOOPLANKTON

OSWEGO TURNING BASIN — 1975-1976



3. Macrozooplankton

a. Introduction

For the purposes of this demonstration, the macrozooplankton community of the Oswego Turning Basin will represent those invertebrate zooplankters retained by a 571μ mesh net. Included in this community are holoplankton, those organisms which are planktonic throughout their life cycle (except as eggs) (e.g., the cladoceran Leptodora kindtii), and meroplankton or temporary plankton, reflecting development stages of various organisms (e.g., dipteran pupae); predators (L. kindtii, odonata nymphs, and hydracarina) and detritovores (isopods, Gammarus fasciatus, and dipterans); organisms with a distinct seasonal abundance peak (L. kindtii) and organisms which may undergo irregular cycles corresponding to the production of several generations during a year (G. fasciatus). The macrozooplankton community, then, is a heterogeneous assemblage of organisms able to occupy an array of niches. This section will attempt to show that the macrozooplankton community is capable of sustaining itelf on an annual basis and that the fauna is typical of shallow, lentic water bodies.

Appendix C summarizes the field and laboratory methods and describes the sampling locations.

b. Species Composition

A total of 22 taxa of invertebrates were identified from macrozooplankton collections in the Oswego Turning Basin from April 1975 through March 1976 (Table IV.B-18). A supplementary listing of benthic invertebrates is found in section C of this chapter.

c. Community Composition

Throughout most of the survey period, the macrozooplankton community in the Oswego Turning Basin was numerically dominated by the amphipod Gammarus fasciatus, a species common to warm, slow-moving, water bodies (Clemens, 1950; Bousfield, 1958, 1973); during August and September, however, the cladoceran Leptodora kindtii constituted the dominant fraction (Figure IV.B-15). Hydracarina and dipterans ranked next in abundance and percent composition; other taxa were minor contributors to community abundance in the turning basin.

In composition, the macrozooplankton community of the turning basin was similar to communities represented in inshore areas of Lake Ontario in the vicinity of the Oswego Steam Station (LMS, 1976b) and Nine Mile Point (LMS, 1976a). In this and subsequent community analyses, epifauna (hydroids and mollusks) were excluded.

Infaunal oligochaetes were included since they were occasionally collected in surface samples. Section C, which describes the benthic distributions of the oligochaetes and molluscs in the Oswego Turning Basin, provides a more accurate assessment of their abundance than the pattern depicted by plankton tows. The hydroids, however, are colonial, and are difficult to quantify accurately.

d. Interstation Affinities: Cluster Analysis

In order to measure the degree of structural similarities between the seven macrozooplankton sampling stations, Sander's (1960) Similarity Index was used. The formula for this is:

$$\text{Percent Similarity} = \sum_i (\text{Max } P_{ai}, P_{bi})$$

P = percent composition of the community comprised by "i" organisms at Stations a and b.

In this approach a matrix of similarity values between stations is produced; this matrix, which is sometimes presented as a trellis diagram, is then analyzed by a clustering strategy (unweighted pair-group average) and a dendrogram is produced (Sneath and Sokol, 1973).

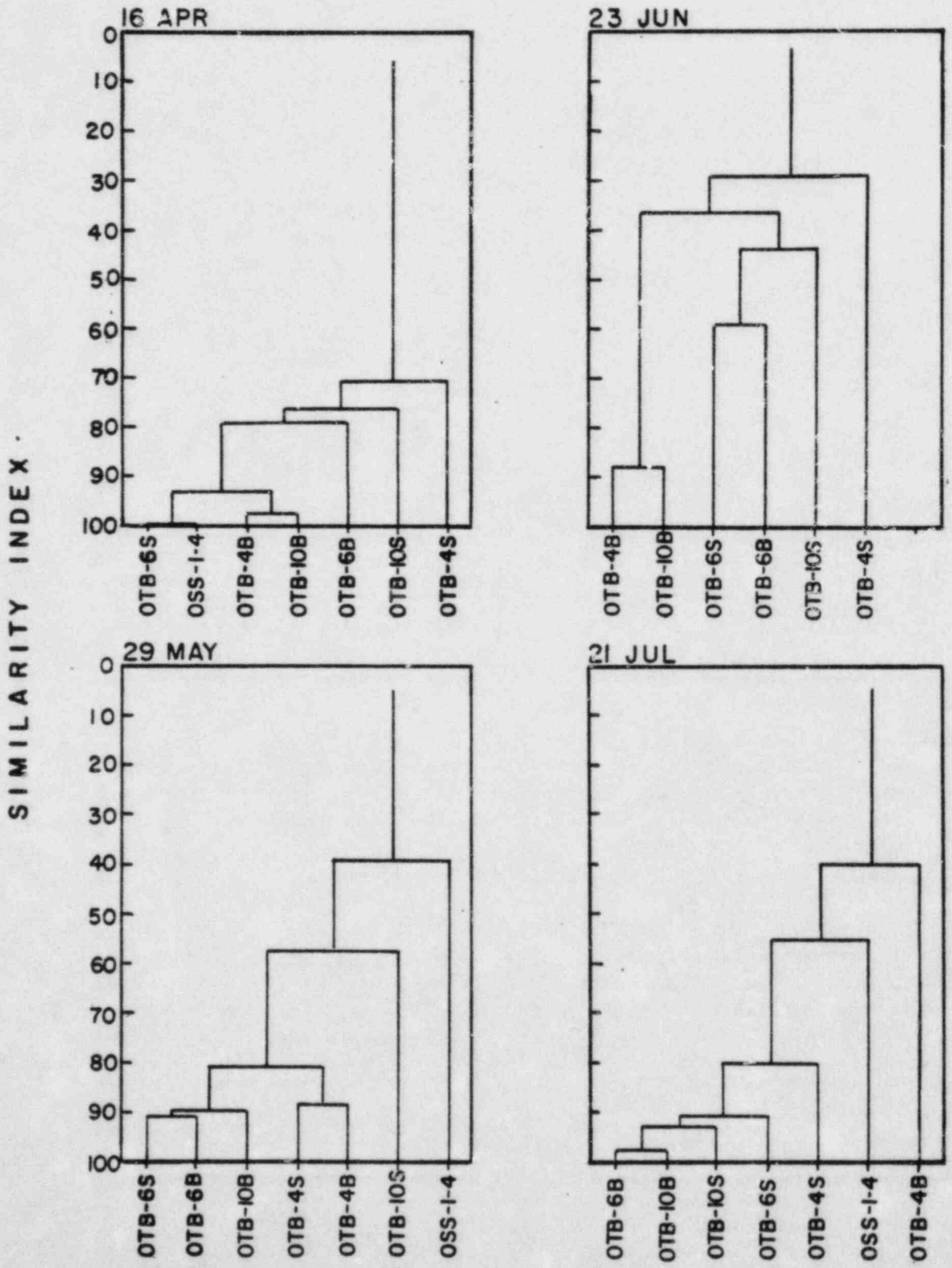
For these analyses, Mollusca and Hydroida were excluded (as indicated above); a cluster was formed for each night sampling date (by depth). The Units 1-4 intake station was included in this analysis.

Preliminary evaluation of the clustering results did not suggest any consistent interstation distributions within the Oswego Turning Basin; adjacent stations at a given sample depth clustered together as frequently as did the two depths at a given station (Figure IV.B-16).

Comparisons of clusters formed on three dates (16 April, 23 June, and 18 August) which corresponded to thermal surveys of the turning basin, showed that station affinities were linked with the distributions of water masses of different densities (Figure IV.B-16). Appendix B presents temperature profile related to longitudinal cross sections of the Oswego Turning Basin.

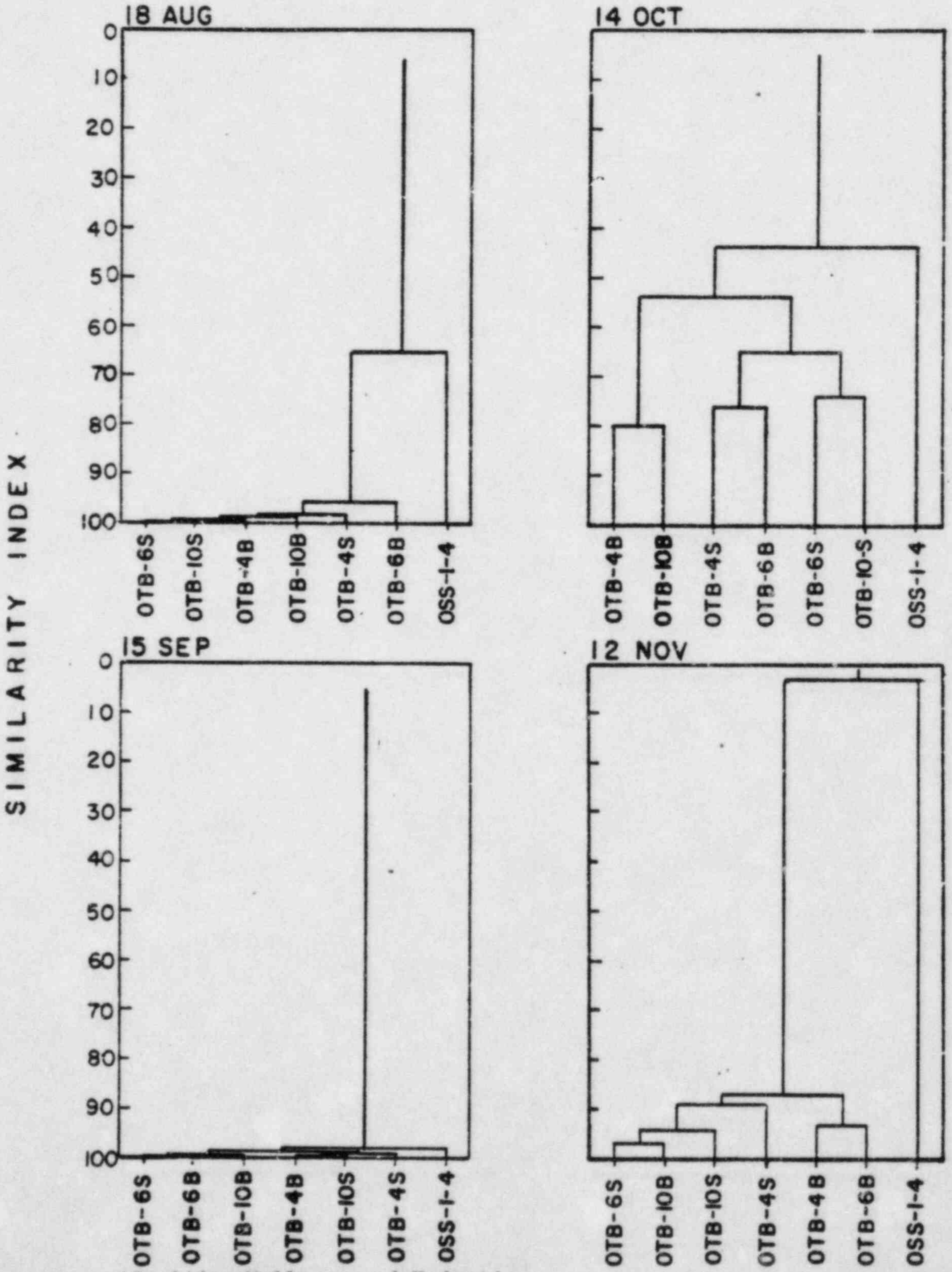
Therefore, macrozooplankton distribution within the basin may not be directly affected by the thermal discharge of Oswego Steam Station Units 1-4, but instead may be influenced by the distributions of these stratified (by temperature and conductivity) water masses resulting from the flows of the Units 1-4 discharge and the Oswego River.

SIMILARITY OF MACROZOOPLANKTON* COLLECTIONS
OSWEGO VICINITY — 1975 - 1976



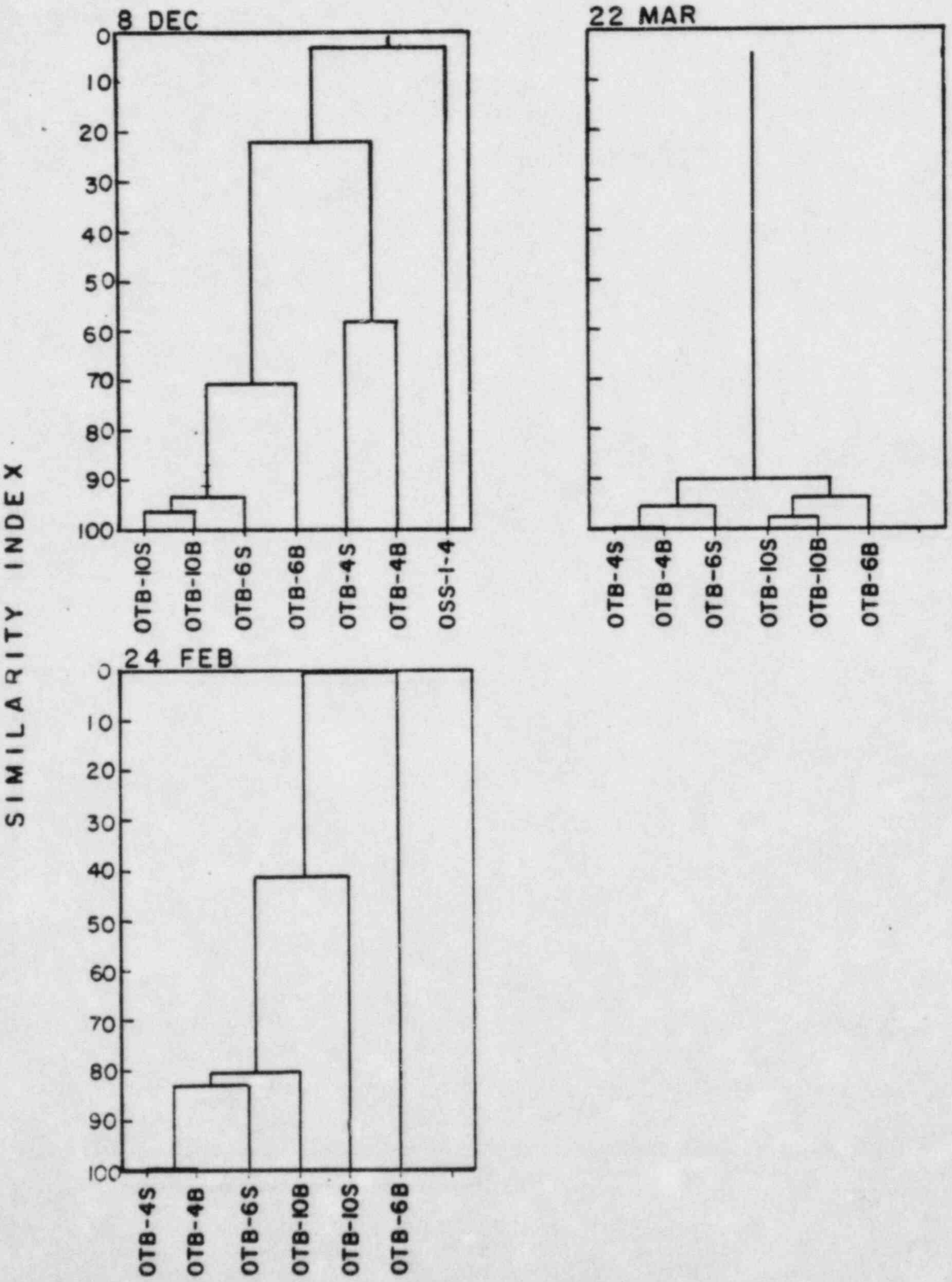
*Excludes Mollusca and Hydroida

SIMILARITY OF MACROZOOPLANKTON* COLLECTIONS
OSWEGO VICINITY — 1975 - 1976



*Excludes Mollusca and Hydroida

SIMILARITY OF MACROZOOPLANKTON* COLLECTIONS
OSWEGO VICINITY — 1975 - 1976



*Excludes Mollusca and Hydroida

e. Life History and Distributions of Major Taxa

Four macrozooplankton taxa were selected for presentation of life history information and seasonal and interstation distributions within the Oswego Turning Basin. These taxa (Hydracarina, *Leptodora kindtii*, *Gammarus fasciatus*, and dipterans) were observed to comprise the major fraction of the macrozooplankton community in the basin (Figure IV.B-17).

- Hydracarina

Water mites are typically found in shallow, lentic environments, often associated with aquatic vegetation. These species are typically swimming species, whereas other species, inhabitants of running waters, are usually benthic (Crowell, 1960).

The hydracarina undergo a four-stage life cycle: egg, larva, nymph, and adult. The eggs are attached to a variety of submerged objects and usually hatch within one to six weeks. The larvae are generally parasitic, particularly on Chironomidae (Diptera) larvae. Both nymphs and adults are free-living and predatory (Crowell, 1960). Reported prey items of Hydracarina adults include Chironomidae larvae (Paterson, 1970), Ephemeroptera nymphs, and asellid isopods (Uchida, 1932; cited in Paterson, 1970).

The temperature requirements of the various species are unknown. Abundance of hydracarina in night collections in the turning basin showed two peaks (May and October), and no hydracarina were collected from January through March 1976 (Figure IV.B-17).

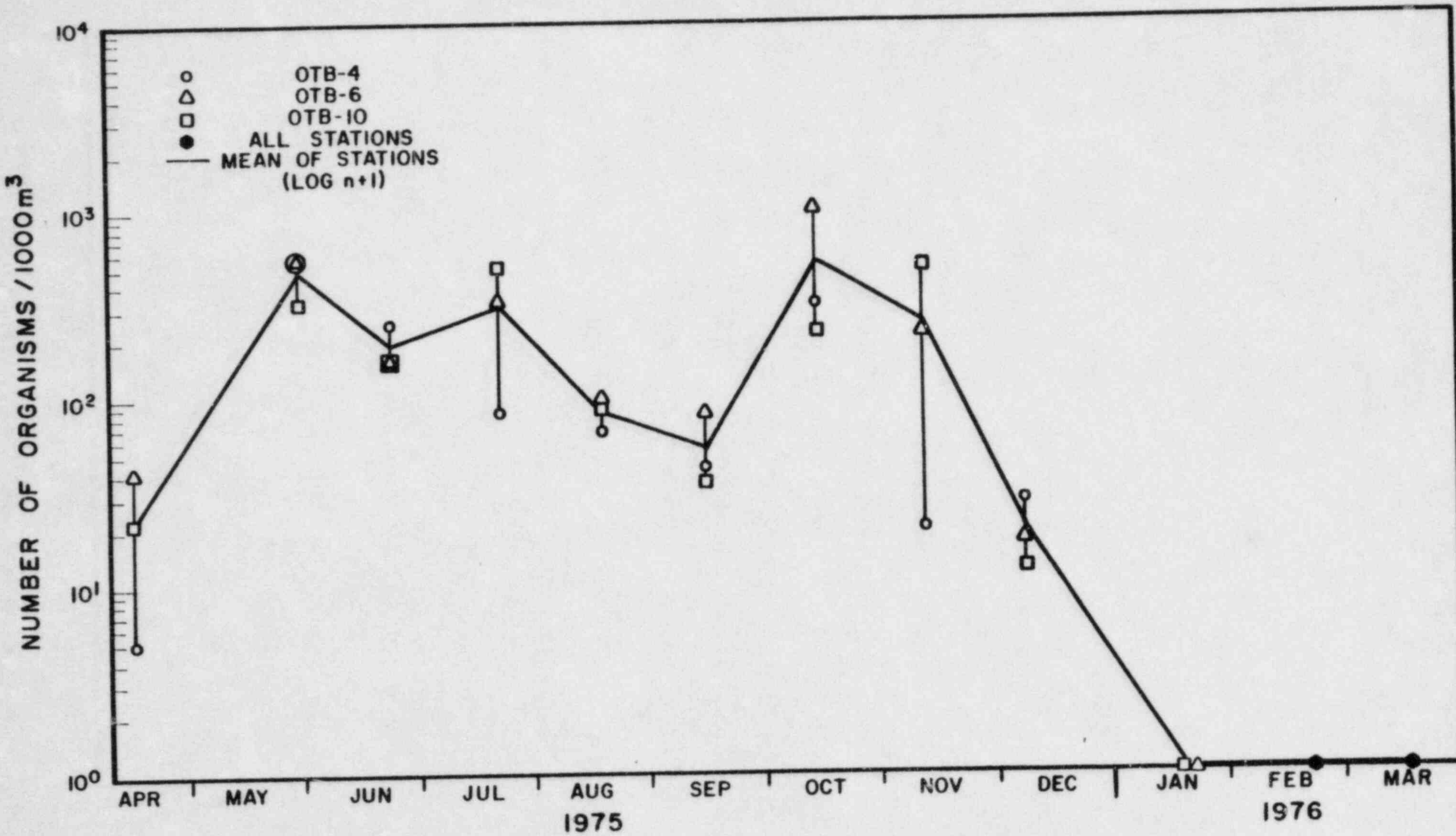
Interstation patterns of abundance suggested a trend of greater abundance of water mites at the station located near the thermal discharge (OTB-6) during August through October (night collections). Entrainment abundances at the intake of Oswego Steam Station Units 1-4 peaked on 21 July (248 organisms/1000 m^3), and on other dates were never in excess of 100 organisms/1000 m^3. Thus, the interstation differences from August through October were not considered as reflecting any additive effects from entrainment, nor did the magnitude the interstation differences suggest any attraction to the plant's discharge.

- *Leptodora kindtii* (Cladocera)

L. kindtii is an aestival holoplankter (Hutchinson, 1967; Cummins et al., 1969a), abundant in nearshore areas of Lake Ontario (LMS,

ABUNDANCE* OF HYDRACARINA IN NIGHT COLLECTIONS

OSWEGO TURNING BASIN — 1975-1976



*Mean of Depths

FIGURE IV B-17

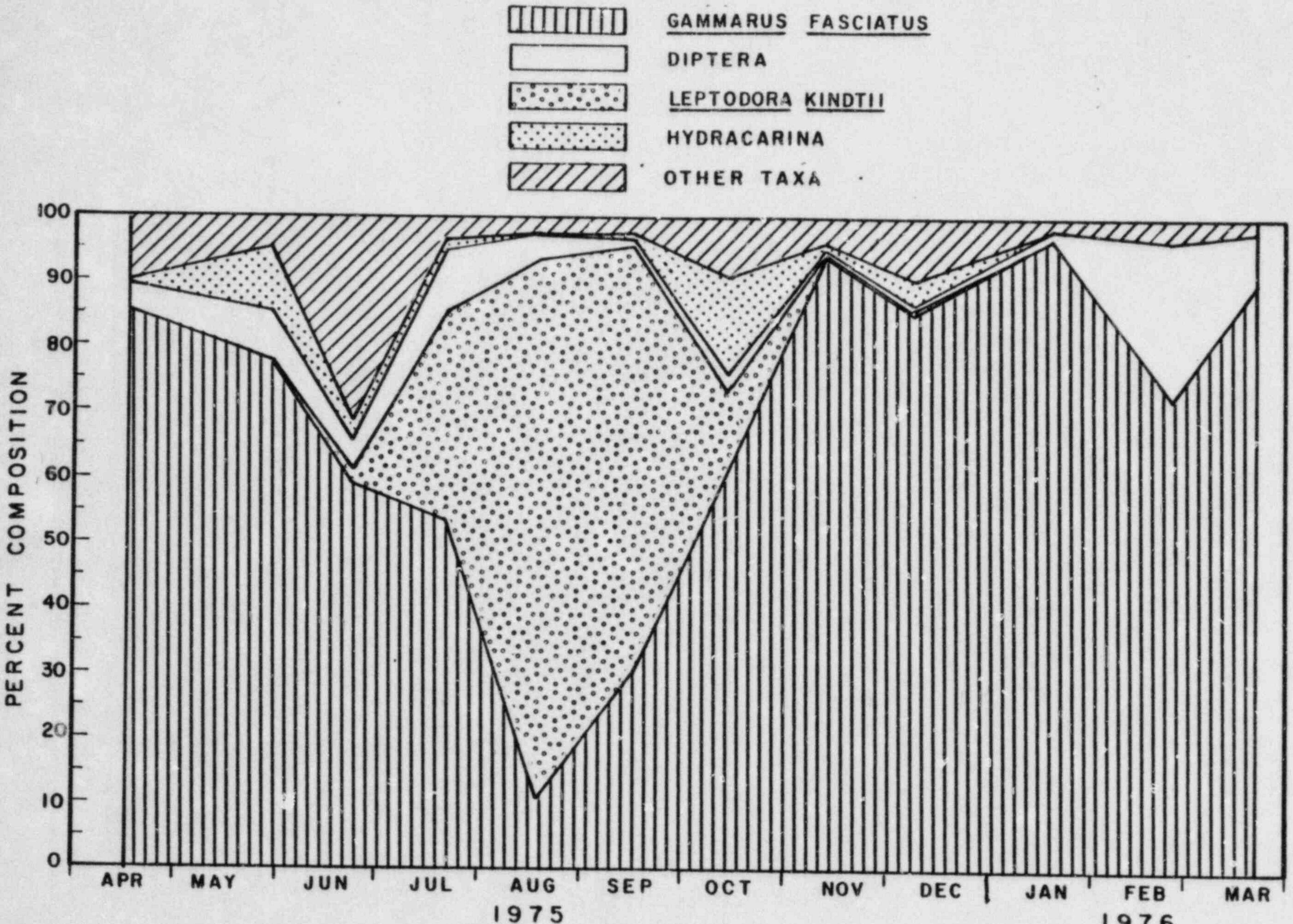
TABLE IV B-18

OCCURRENCE OF MACROZOOPLANKTON BY DATE

OSWEGO TURNING BASIN - 1975-1976

TAXA	1975									1976		
	16 APR	29 MAY	23 JUN	21 JUL	18 AUG	15 SEP	14 OCT	12 NOV	8 DEC	19 JAN	24 FEB	22 MAR
COELENTERATA												
Hydroida	X	X	X	X	X	X	X	X	X	X	X	
PLATYHELMINTHES												
Turbellaria	X		X	X	X	X	X	X	X			X
ASCHELMINTHES												
Nematoda					X							
ANNELIDA												
Oligochaeta	X	X	X	X	X	X	X	X	X	X	X	X
Hirudinea		X	X	X								
MOLLUSCA												
Gastropoda	X	X	X	X	X			X				
Pelecypoda (bivalvia)	X		X	X		X						
ARTHROPODA												
Hydracarina	X	X	X	X	X	X	X	X	X			
Leptodora kindtii	X	X	X	X	X	X	X	X	X			
Podocopa		X		X	X							
Mysis oculata relicta		X										X
Isopoda	X	X	X	X								X
Gammarus fasciatus	X	X	X	X	X	X	X	X	X	X	X	X
G. pseudolimnaeus		X										
Crangonyx sp.								X				
Pontoporeia affinis	X			X				X				
Hyalella azteca							X	X				
Ephemeroptera nymph		X	X				X				X	
Odonata				X		X	X	X				
Trichoptera			X			X	X	X	X			
Diptera	X	X	X	X	X	X	X	X	X			
Diptera larvae										X	X	X

PERCENT COMPOSITION OF MACROZOOPLANKTON ABUNDANCE*
IN NIGHT COLLECTIONS
OSWEGO TURNING BASIN — 1975-1976



*Mollusca and hydroida excluded; mean of all stations and depths; no OTB-4 collection during Jan.

FIGURE IV.B-15

TABLE IV B- 19a

OCCURRENCE OF ICHTHYOPLANKTON BY DATE

FISH EGGS

	1975													1976		
SPECIES	16 APR	29 MAY	9 JUN	23 JUN	7 JUL	21 JUL	4 AUG	18 AUG	2 SEP	15 SEP	13 OCT	12 NOV	8 DEC	19 JAN	24 FEB	22 MAR
Clupeidae																
Alosa pseudoharengus Alewife			X	X	X	X	X	X	X			X				
Dorosoma cepedianum Gizzard shad			X	X	X											
Gadidae																
Lota lota Burbot									X							
Osmeridae																
Osmerus mordax Rainbow smelt	X	X	X	X												
Percichyidae																
Morone americana White perch		X	X	X	X											
Percidae																
Perca flavescens Yellow perch				X												
Stizostedion vitreum vitreum Walleye			X	X	X	X	X					X				

TABLE IV B-19b

NIAGARA MOHAWK POWER CORP.
1975-1976 AQUATIC ECOLOGY STUDIES

OCCURRENCE OF ICHTHYOPLANKTON BY DATE

OSWEGO TURNING BASIN - 1975-1976

FISH LARVAE

SPECIES	1975												1976			
	16 APR	29 MAY	9 JUN	23 JUN	7 JUL	21 JUL	4 AUG	18 AUG	2 SEP	15 SEP	13 OCT	12 NOV	8 DEC	19 JAN	24 FEB	22 MAR
Catostomidae																
Moxostoma sp.						X										
Centrarchidae																
Lepomis sp.				X	X	X	X	X								
Lepomis macrochirus Bluegill sunfish						X										
Micropterus sp.					X	X	X									
Clupeidae																
Alosa pseudoharengus Alewife		X	X	X	X	X	X	X	X	X	X	X				
Dorosoma cepedianum Gizzard shad			X	X	X		X									
Cyprinidae																
Cyprinus carpio Carp		X	X	X	X	X	X	X								
Notropis atherinoides Emerald shiner				X			X									
Notropis hudsonius Spottail shiner							X									
Gadidae																
Lota lota Burbot	X															
Gasterosteidae																
Gasterosteus aculeatus Threespine stickleback				X												
Osmeridae																
Osmerus mordax Rainbow smelt		X	X	X		X		X	X							
Percichthyidae																
Morone americana White perch		X	X	X	X	X	X	X	X							
Morone chrysops White bass			X	X		X										
Percidae																
Etheostoma nigrum Johnny darter		X	X	X	X	X	X									
Perca flavescens Yellow perch				X												

1975a, 1976a). It is important, both as a predator of crustacean zooplankton (Sebestyen, 1931, 1960; Cummins et al., 1969) and as a selected prey item for various species of planktivorous fish, including alewife (Sebestyen, 1960, Wells, 1970; Costa and Cummins, 1972).

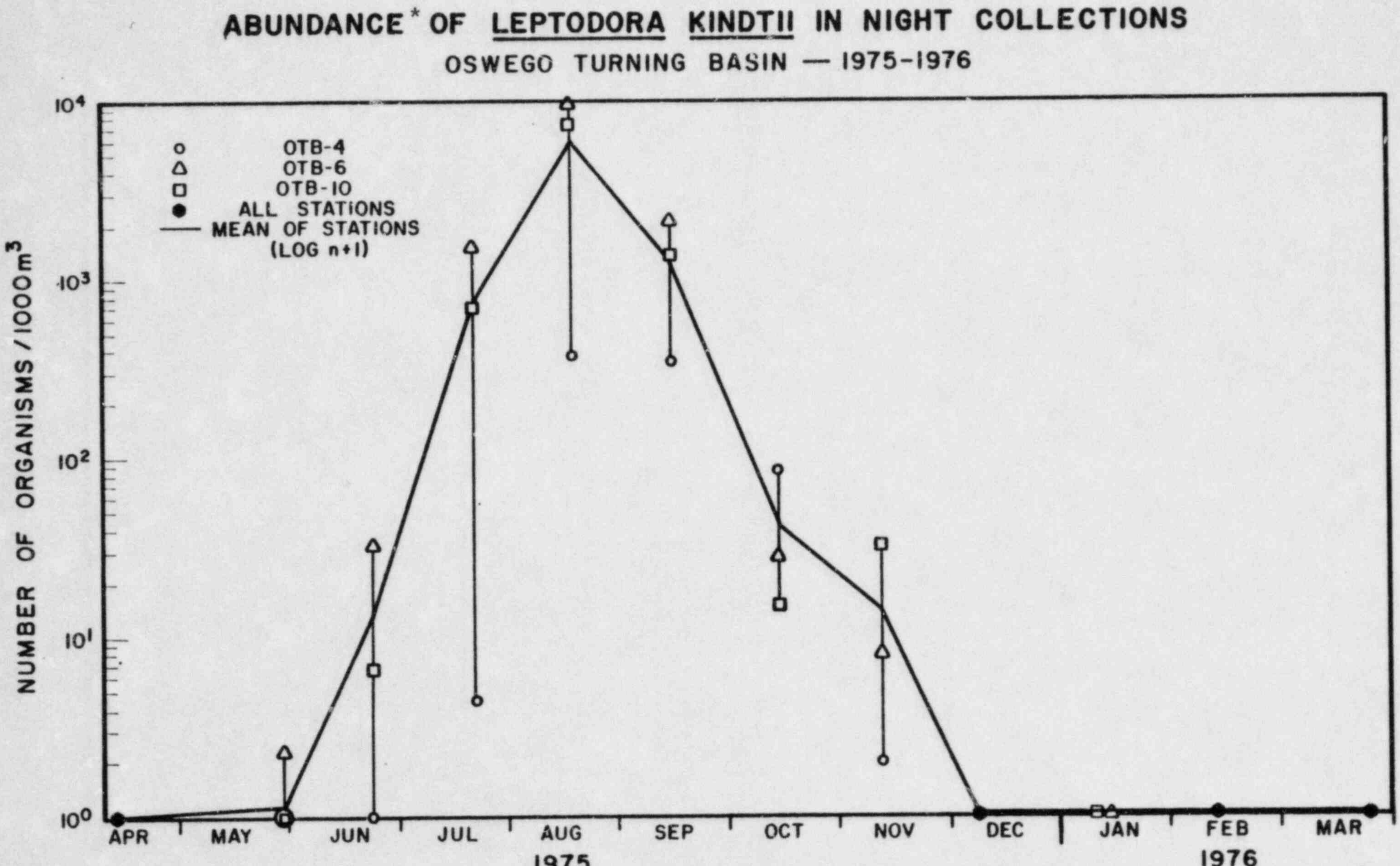
Leptodora populations show two phases of development during an annual cycle. During spring and summer months they are planktonic, with peak abundance occurring during late summer/early fall. The population declines, due to mortality, through the late fall/early winter (mean water temperature 4.8°C; range 9.4-1.0°C; Cummins et al., 1969) at which point Leptodora have disappeared from the plankton. Overwintering occurs as fertilized resting eggs which are free at the bottom of the water body, remain there until water temperatures become more favorable and developmental processes are initiated (Sebestyen, 1960); Cummins et al., (1969) reported that the first appearance of Leptodora in the spring occurred when the water temperatures were approximately 19°C (range: 8.9-24.0°C).

Leptodora has been observed to attain a greater standing crop in more productive lakes (Cummins, et al., 1969; LaRow, 1975), probably as a consequence of its predation on herbivorous zooplankton. Standing crop variation between years in a given water body is also probably related to fluctuations in prey availability (Cummins et al., 1969).

On the basis of behavior and trophic relationships two size classes are distinguishable: 2-5 mm Leptodora occupy the upper strata of lakes during daytime hours, whereas 6-12 mm individuals migrate to surface waters at night. The smaller individuals prey upon bacteria, algae, and detritus, whereas the larger Leptodora are predaceous on zooplankton (Cummins et al., 1969). L. kindtii abundance in the turning basin reached the summer (18 August) maximum characteristic of the species. It was not present in collections made prior to 29 May or after 12 November (Figure IV.B-18). Interstation distributions indicated that, during the July-September sampling dates, night abundances at OTB-6 (discharge) and OTB-10 were similar to each other and significantly greater (at α = .05) than the abundances at OTB-4 (Appendix D).

Since L. kindtii is a soft-bodied form, it is unlikely to survive the entrainment process intact (LMS, 1975). Therefore, the distribution of L. kindtii within the turning basin was considered to be unaffected by entrainment additions.

The data presented here suggest that L. kindtii is a resident of the Oswego Turning Basin. The night abundances in the basin



*Mean of Depths

FIGURE IV B-18

were generally 2-16 times lower than those of the nearshore lake, as indicated by data collected at OSS1-4 and at Nine Mile Point (LMS, 1976b) from June to September. The exception was August, when entrainment abundances (51,563 organisms/1000 m^3) were approximately 50% of the abundance at OTB-6.

Individual populations of L. kindtii have exhibited marked fluctuations in abundance between years (Cummins et al., 1969; LaRow, 1975), thus, the reduced abundances in the turning basin, compared to the nearshore lake, may not be indicative of an inimical environment but may reflect natural variations of standing crop.

- Gammarus fasciatus

The amphipod Gammarus fasciatus is distributed east of the Mississippi River in both tidal and non-tidal Atlantic coast drainages from southern New England south to tributaries of the Chesapeake Bay and in the Great Lakes from the upper limit of tidal influence on the St. Lawrence River to Lake Superior (Bousfield, 1969, 1973).

G. fasciatus is both semipelagic and benthic (Bousfield, 1973) and is a known associate of aquatic macrophytes (Clemens, 1950), algae (e.g., Cladophora) (LMS, 1975; Barton and Hynes, 1975), and attached epifauna (e.g., Cordylophora caspia - lacustris) (Feeley and Wass, 1971).

Clemens* (1950), in describing the reproductive cycle of G. fasciatus noted that the sexes are separate and that reproduction is entirely sexual. Males are longer at sexual maturity than females, whose size at maturity is temperature-dependent; at 6°C (42.8°F) females mature at 8.8 mm, while at 26°C (78.8°F) they mature at 5.4 mm. Egg production is positively correlated with body length and season. Clemens (1950) observed that the average monthly egg production per female decreased from April to December; the average number of eggs per female for the entire season was seventeen. Mature females lay eggs subsequent to each adult moult, and copulation occurs just subsequent to moulting, during ovulation, and for a short time afterward. During incubation, the fertilized eggs are carried in a brood pouch or marsupium under the female. The incubation period is temperature dependent; at constant temperatures of 24, 22, 20, 18, and 15°C (75.2, 71.6, 68.0, 64.4, and 59.0°F) incubation lasted 7, 8, 9, 14, and 22 days, respectively. The maximum number of incubation periods or broods produced per female per year was estimated to be 17 in Lake Erie.

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* Bousfield (1958) raised the point that Clemens' work (1950) actually was done on three or four species rather than just G. fasciatus.

However, the actual number of broods produced per female is probably between five and eleven.

Immature gammarids reached maturity after seven moults with the interval between moults decreasing with increased temperature. In the laboratory at 21°C (69.8°F), G. fasciatus young required 42 to 53 days to reach maturity, whereas at temperatures varying from 14 to 22°C (57.2° to 71.6°F) young achieved maturity in 66 to 85 days.

An omnivorous feeder, G. fasciatus devours living and dead plant and animal matter, and may prey upon such zooplankton as Daphnia, Leptodora, and copepods (Clemens, 1950). It also consumes benthic organisms such as insect larvae, oligochaetes, and small isopods (Burbanck, personal communication, 1972); in addition, male gammarids in particular are cannibalistic. G. fasciatus plays an important role in the trophic structure of many aquatic environments, since it is in turn consumed by a wide variety of fish and invertebrate predators (Scott and Crossman, 1973; LMS, 1974, 1975).

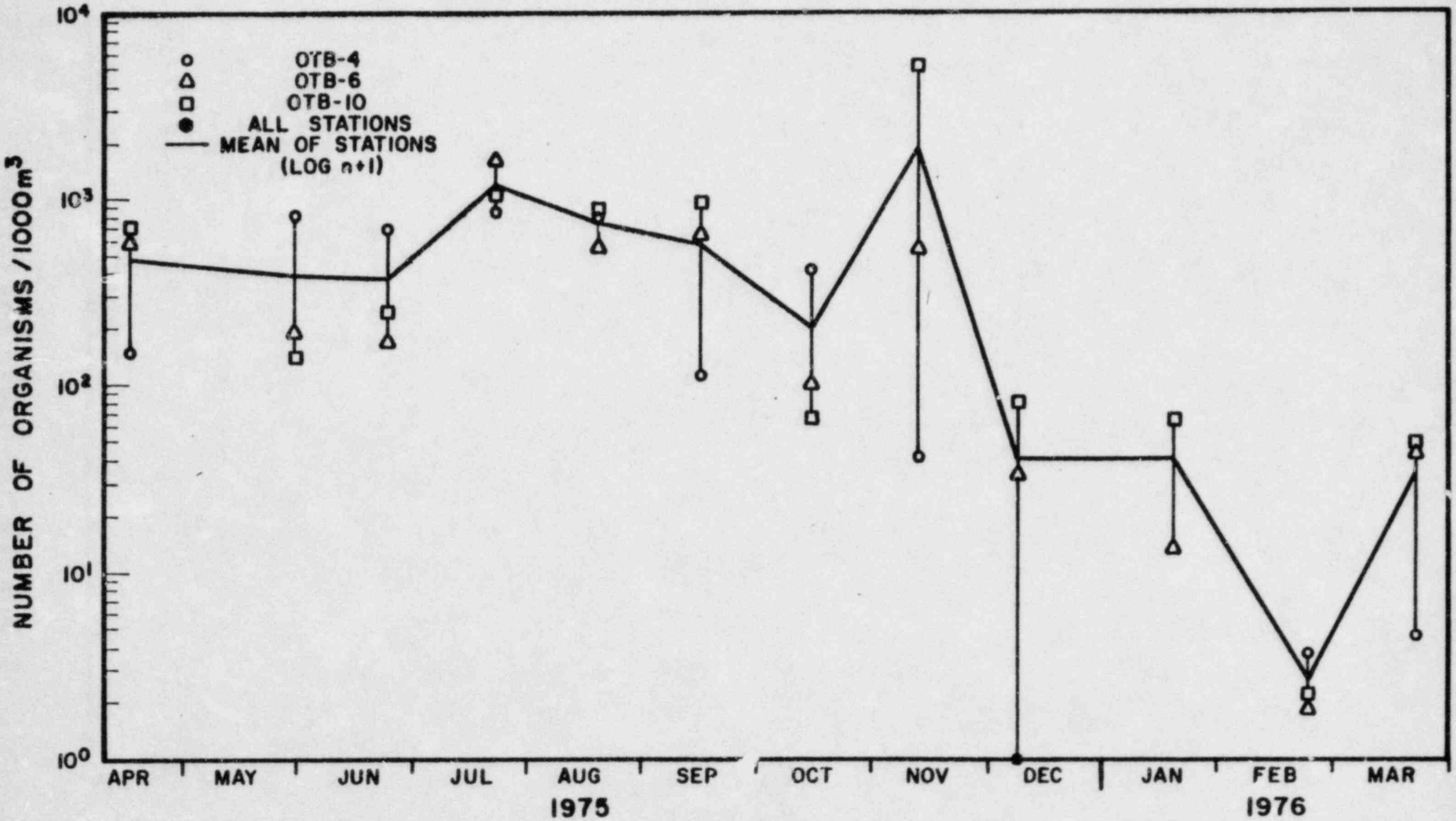
Pentland (1930) observed that G. fasciatus is capable of enduring high temperatures. Sprague (1963) found that the ultimate lethal temperature for G. fasciatus was 34.6°C; this represents the highest temperature to which the TL_m^{24} (that temperature at which 50% of the test organisms die after 24 hours) can be raised by acclimation. A 10°C rise in acclimation temperature (from 10°C to 20°C) increased the TL_m^{24} by 1.9°C. Females were more resistant than males.

Sprague (1963) also investigated resistance to reduced levels of dissolved oxygen. At a 20°C acclimation temperature, the TL_m^{24} was 4.3 mg/l (Sprague commented that this level seemed rather high).

G. fasciatus distribution within the turning basin did not suggest any pronounced seasonality of abundance (Figure IV.B-19). The maximum nighttime abundance, occurring during November, may have been affected by a rainstorm that evening. Interstation distributions indicated that the abundance at OTB-4, the station influenced by the Oswego River, fluctuated little during May-August and was the station with highest abundance during May and June when surface water temperatures (night) were 1.5-2°C warmer than at OTB-6. The latter observation may indicate an

ABUNDANCE* OF GAMMARUS FASCIATUS IN NIGHT COLLECTIONS

OSWEGO TURNING BASIN — 1975-1976



*Mean of depths

FIGURE IV.B-19

earlier reproductive effort by a population influenced by the earlier warming of Oswego River waters (see section II.E). During November and December, when the Oswego River cooled faster than the rest of the turning basin, G. fasciatus abundances were lower at OTB-4 than at other stations. In addition, recruitment of G. fasciatus into the benthic community was indicated during this same period (see section C), suggesting that apparent alterations in standing crop over time may also reflect changes in habitat.

- Diptera

The dipteran community in the Oswego Turning Basin was comprised of two families: Chironomidae (= Tendipedidae) and Culicidae (Chaoborus sp.) (see section C; planktonic dipterans were only identified to order). Chironomid larvae may be benthic or epiphytic; Chaoborus larvae are both benthic and planktonic. Dipterans, particularly chironomids, are cosmopolitan in distribution.

Chironomid larvae are found in a wide variety of environmental conditions; distributions at the species level, however, have been shown to be affected by substrate type, pH, dissolved oxygen, temperature, and food supply, (Mason, 1974). Chironomid larvae may be detritivores and/or carnivores (Roback, 1969; Menzie, 1976), and predatory species may consume oligochaetes (Loden, 1974), cladocerans, and other chironomids (Roback, 1969); they are also important in the diet of various species of fish.

Temperature elevations may act to accelerate or terminate development of chironomid larvae. Nebeker (1973) found that in Tanytarsus dissimilis growth rates increased between 21-28°C, and that no increase was noted between 30-32°C; between 33-36°C, no adult emergence was observed, and at 36°C embryonic development ceased. Mason (1974) noted that the pollution tolerant Chironomus spp. could not survive at 32°C in standing water due to decreased resistance to bacterial infection.

The actual number of generations produced annually is a species-specific phenomenon. Emergence of adult chironomids is generally greatest (in terms of numbers of species) during the warmest parts of the year (Miller, 1941).

Chaoborus larvae may be found in more profundal areas than the chironomids. Roth (1968) observed that C. flavicans was most abundant in 6-9.5 m of water in a lake in Michigan whose maximum depth was 9.5 m. As Chaoborus larvae mature, they change both habitat and behavior. First instar larvae remain in the epilimnion and undergo no vertical migration; second and third instar larvae show progressively greater migration and a broader depth distribution; fourth instar larvae are benthic during the daytime, with marked nocturnal vertical migration (Teraguchi and Northcote, 1966). The nature of this migration is regulated in part by low oxygen tension (LaRow, 1970) and a critical light threshold (Teraguchi and Northcote, 1966; Chaston, 1969).

Adult emergence is species-dependent; Stahl (1966) observed maximum emergence during May for C. flavicans and during June, July, and August for C punctipennis in an Indiana lake. Chaoborus larvae are predaceous, feeding upon copepods and cladocerans (Stahl, 1966; Swift and Fedorenko, 1975).

Planktonic abundance of larval dipterans (primarily Chironomidae; J. Simmonds, pers. comm.) showed irregular fluctuations during spring through fall months, with maximum numbers collected on 18 August (night) at OTB-6 (Figure IV.B-20). Winter abundances were lower, reflecting benthic overwintering. This pattern did not coincide with results of entrainment collections; maximum numbers of larvae were entrained on 21 July (557 larvae/1000 m^3 at night). On 18 August, 181 larvae/1000 m^3 were entrained, in contrast to greater than 500 larvae/1000 m^3 collected at OTB-6 on the same date. This apparent irregularity during the warmer months may represent the interactions of different species (see section C) or different modes of behavior among different instars within a species.

Dipteran pupae, on the other hand, did show a marked seasonality, with maximum abundance occurring during July and August (Figure IV.B-21); the warmest months are typically the time of peak emergence (Miller, 1941).

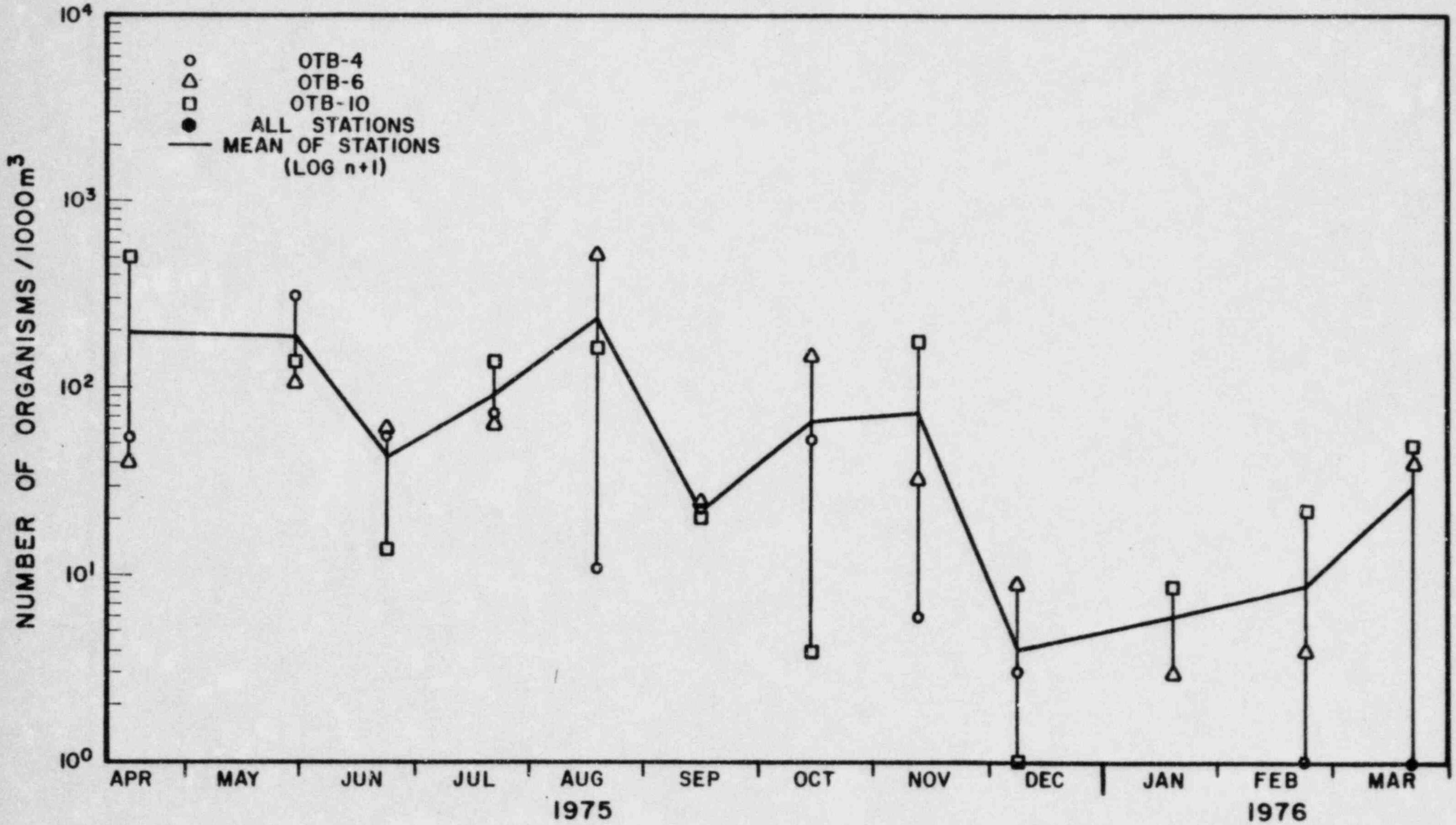
Interstation patterns did not reflect accelerated developmental rates as a consequence of thermal inputs, an effect which would have been indicated by earlier and/or greater abundance of pupae at OTB-6. The observed emergence patterns, as indicated by pupal abundance, may be obscuring the emergence patterns of individual species, and should therefore be interpreted with caution.

f. Summary

The macrozooplankton community of the Oswego Turning Basin from April 1975 to March 1976 was characterized by a fauna common to shallow, sluggish, or standing water biotopes: Hydracarina, L. kindtii, asellid isopods, G. fasciatus, Hyalella azteca, and developmental stages of various insect species. Many of these

ABUNDANCE* OF DIPTERA LARVAE IN NIGHT COLLECTIONS

OSWEGO TURNING BASIN — 1975-1976

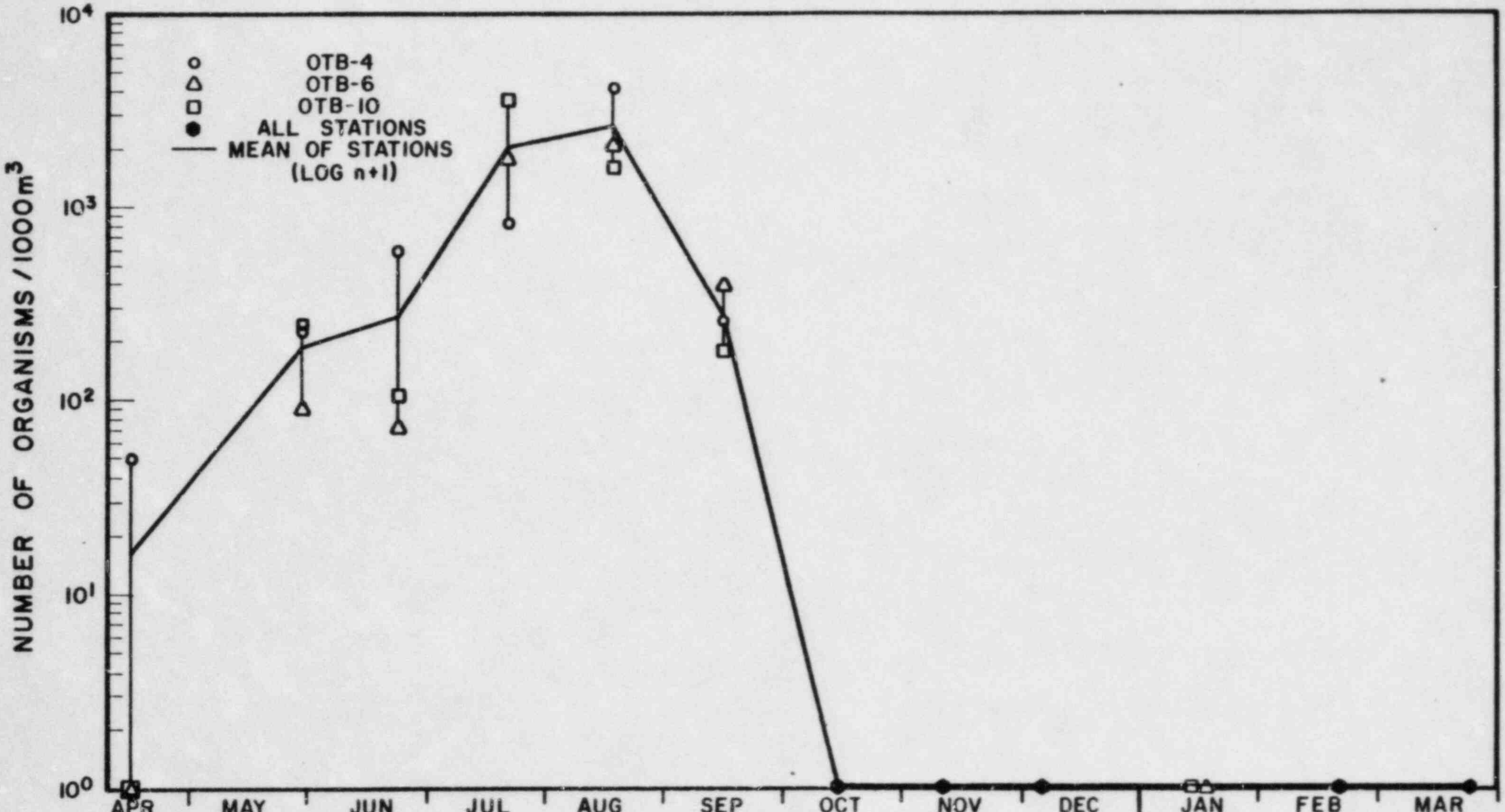


*Mean of depths

FIGURE IV.B-20

ABUNDANCE* OF DIPTERA PUPAE IN NIGHT COLLECTIONS

OSWEGO TURNING BASIN — 1975-1976



*Mean of depths

FIGURE IV B-21

organisms are also tolerant of varying degrees of nutrient enrichment and temperature: L. kindtii (LaRow, 1975), Asellus (Isopoda), and H. azteca (Sprague, 1963; Resh and Unzicker, 1975), and a number of chironomid species (Resh and Unzicker, 1975).

The data collected for the dominant species (L. kindtii, G. fasciatus) indicated seasonal abundance fluctuations which were unaffected by the Oswego Steam Station discharge. The data for dipterans showed that maximum emergence occurred during the warmest months, as Miller (1941) had reported; however the lack of species identifications precludes an accurate assessment. Hydracarina, for which species information is also lacking, were difficult to evaluate because the life history data on this group are very sparse.

The survey results do suggest that the macrozooplankton community is "intact" and that the fauna should be characteristic of this type of water body. The discharge of heated effluent from the Oswego Steam Station Units 1-4 appears not to have markedly altered the macrozooplankton community of the Oswego Turning Basin.

4. Ichthyoplankton

a. Introduction

The study of the ichythyoplankton community of the Oswego Turning Basin was undertaken to determine whether this area is important as a spawning and nursery area for fish species which are resident either in the turning basin or in the lake. In addition, the study was designed to determine whether the thermal discharge from Oswego Steam Station Units 1-4 has had or could have a deleterious effect on this community. The field and laboratory materials and methods are presented in Appendix C.

b. Species Inventory

Eggs of seven species of fish were collected from the Oswego Turning Basin during the April 1975-March 1976 survey period (Table IVB-19a). Eggs occurring most frequently belonged to the alewife (8 dates) and walleye (6 dates). Most species were collected during the spring and summer although burbot, walleye, and, inexplicably, alewife eggs were collected during fall months.

Fifteen species of larval fish were identified from the Oswego Turning Basin (Table IVB-19b); alewife, carp, and white perch were most frequently identified. All species were collected during the spring summer months, with alewife larvae persisting into November.

c. Abundance and Percent Composition

Fish Eggs

Fish eggs were collected in the Oswego Turning Basin from April through November 1975, with peak densities occurring on 23 June (Figure IVB-22). Of the most abundant species, rainbow smelt eggs were collected first (16 April at OTB-10), followed by white perch eggs (29 May at OTB-10), and alewife eggs (9 June); this latter species accounted for 91.7% of all eggs collected. Eggs of species other than rainbow smelt, white perch, and alewife were infrequently collected (Table IVB-20).

Qualitative and quantitative variations in fish egg distribution were indicated along the longitudinal gradient of the turning basin. Percent composition of total fish eggs per station (Table IVB -20) showed that alewife eggs became less important as the distance from the discharge (OTB-6) increased; both gizzard shad and white perch increased their contribution to the percent composition along the same gradient. Quantitatively, the numbers of eggs collected decreased away from the discharge (especially for alewife); however, both gizzard shad and white perch eggs were collected in greatest numbers at OTB-4, which was the station furthest from the discharge.

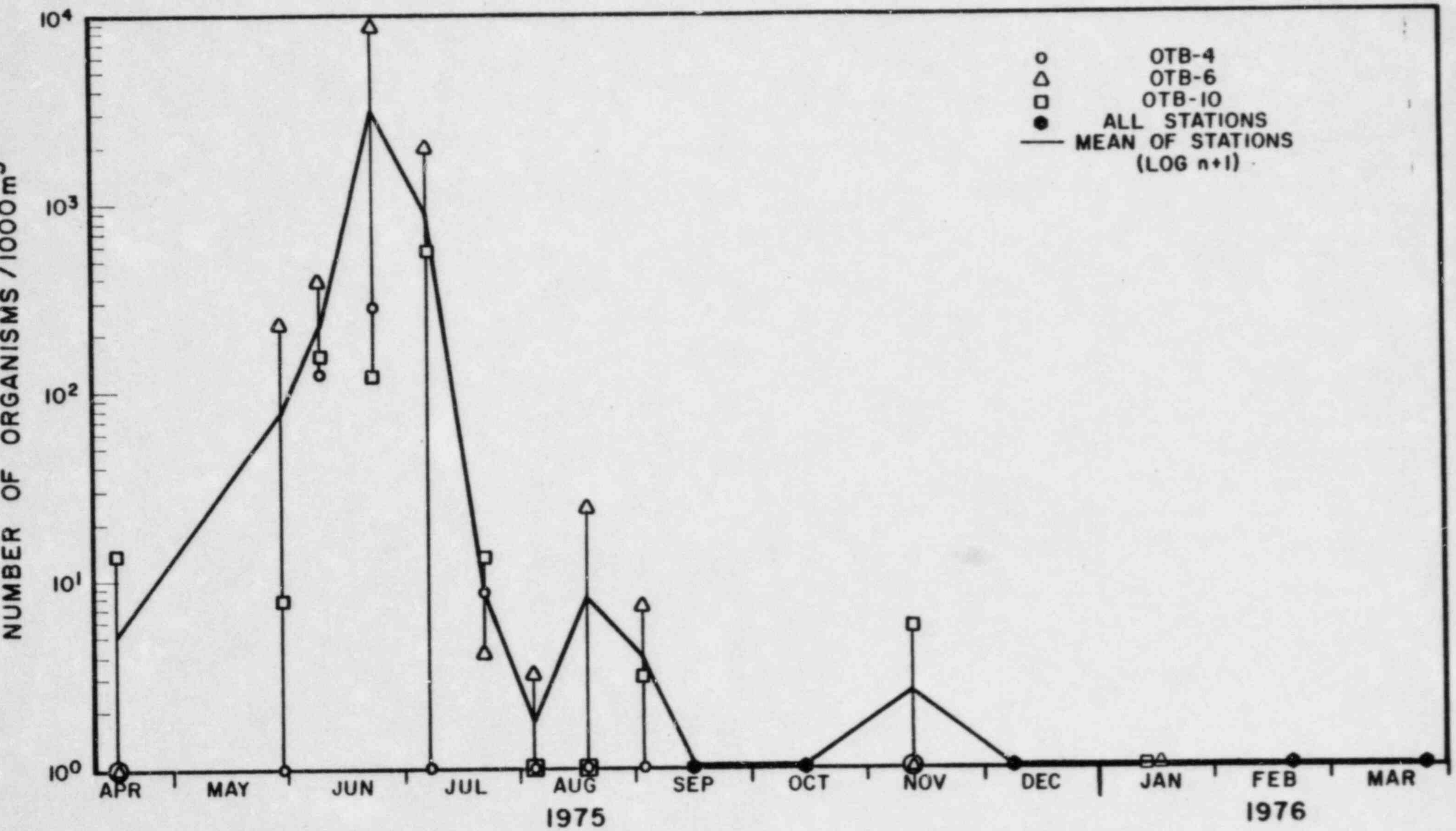
These results suggest that the majority of the eggs (alewife) collected in the turning basin were the result of entrainment by the Oswego Steam Station and not the product of spawning within the basin itself. Additional evidence for this hypothesis is presented in the discussion of alewife egg and larvae distribution (IVB-4d). Two species, gizzard shad and white perch, appeared to be resident spawners within the turning basin; however, the actual location and magnitude of this process is unknown since both species release adhesive eggs in shallow water (Scott and Crossman, 1973).

Fish Larvae

Fish larvae were collected in the Oswego Turning Basin from April through October 1975, with peak numbers collected in night samples during July and August (Figure IVB-23). The earliest appearing species was burbot, which was collected on 16 April (2.5-7.5 larvae/1000 m^3); carp, rainbow smelt, johnny darter, white perch, and alewife larvae composed the next group, and were first present on 29 May (Table IVB-21). Alewife (58.9% of total) was the most abundant species collected over all dates, followed by white perch (13.69%) and carp (8.8%). The distributions of these three species will be discussed below.

ABUNDANCE* OF TOTAL FISH EGGS IN NIGHT COLLECTIONS

OSWEGO TURNING BASIN — 1975-1976



*Mean of depths

FIGURE IV B-22

TABLE IV.B-20

PERCENT COMPOSITION* OF FISH EGGS BY STATION

OSWEGO TURNING BASIN - APRIL 1975-MARCH 1976

SELECTED SPECIES

	INTAKE	OTB-6	OTB-10	OTB-4
Alewife	92.28	95.29	87.82	47.60
Burbot	0.23	0.02	0.00	0.00
Gizzard shad	0.00	0.14	1.07	14.63
Rainbow smelt	6.54	3.53	3.85	0.00
White perch	0.15	0.89	5.34	16.16
Yellow perch	0.00	0.02	0.00	1.97
Others	0.81	0.14	2.35	19.87

*Based on all samples

TABLE IV.B-21

PERCENT COMPOSITION OF ICHTHYOPLANKTON BY STATION

OSWEGO TURNING BASIN - APRIL 1975-MARCH 1976

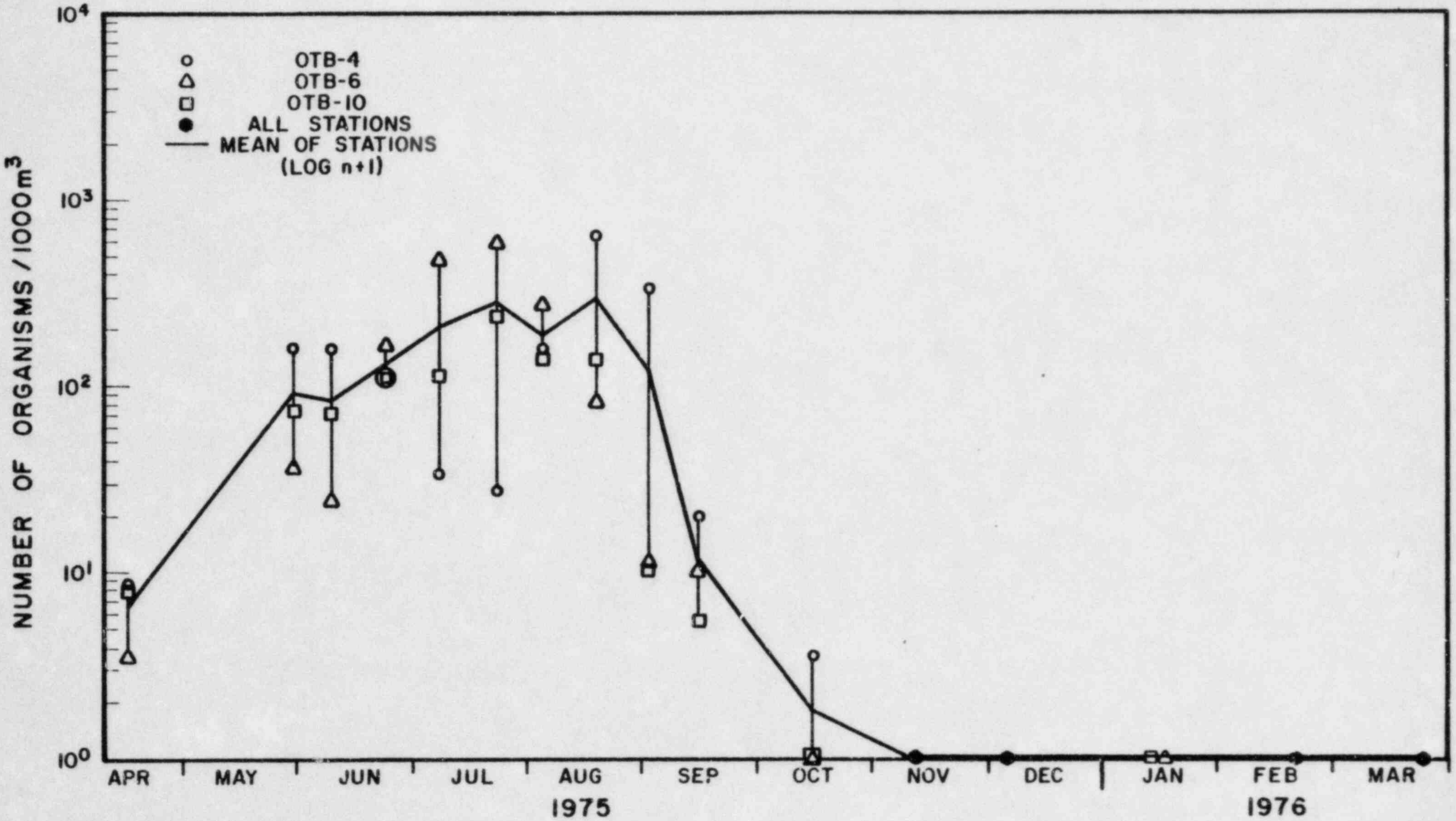
SELECTED SPECIES

	OTB-6	OTB-10	OTB-4
Alewife	50.21	48.37	73.54
Burbot	0.15	0.38	0.45
Carp	15.17	10.95	1.25
Johnny darter	4.38	1.46	0.95
Rainbow smelt	2.88	2.98	0.92
White perch	5.64	18.06	19.17
Yellow perch	0.38	0.00	0.30
Others	21.25	17.68	3.36

* Night collections

ABUNDANCE* OF TOTAL FISH LARVAE IN NIGHT COLLECTIONS

OSWEGO TURNING BASIN — 1975-1976



* Mean of depths

FIGURE IV B-23

Total larval abundance was greater at OTB-6 (39.5%) and OTB-4 (38.9%) than at OTB-10 (21.6%). However, the distribution of larvae over time showed a shift in maximum abundance from OTB-4 (16 April-9 June) to OTB-6 (23 June-4 August) and then back to OTB-4 (18 August-14 October). Qualitative gradients also existed along the turning basin. Alewife was most abundant and comprised a greater percentage of the total larvae at OTB-4 (Table IVB-21); carp, johnny darter, and rainbow smelt were collected most frequently in the warmer areas (OTB-6, 10) of the turning basin, and white perch were most abundant away from the discharge.

Alewife, johnny darter, and smelt larvae abundances near the discharge are theorized to have been the result of entrainment, but carp and white perch were most likely resident within the turning basin; the predominance of alewife at OTB-4 was a late summer phenomenon and may have represented later spawning near Oswego Harbor by a separate contingent of alewives.

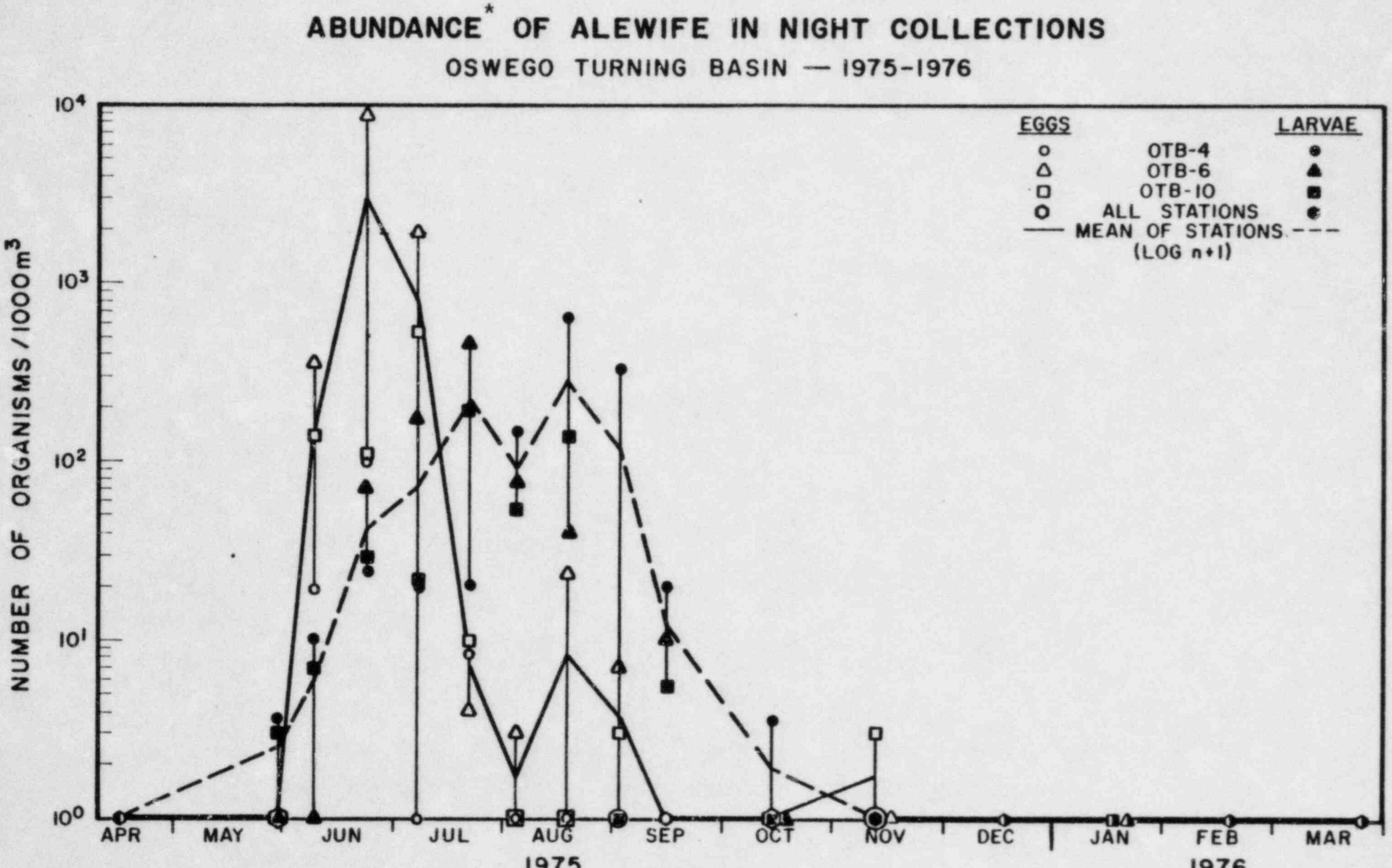
d. Early Life History and Distributions of Abundant Species within the Oswego Turning Basin

Alewife

Spawning of the alewife, *Alosa pseudoharengus*, occurs in Lake Ontario from late April through early July (Graham, 1956; LOTEL, 1975), when lake temperatures have warmed to 15.6°C (60°F) (Edsall, 1970). The demersal eggs are shed at random in shallow waters and hatching takes place in six days at 15.6°C (Scott and Crossman, 1973).

Growth rates of alewife larvae in the Nine Mile Point vicinity of Lake Ontario indicate that the larvae increase from a "just hatched" length of 3.9 mm in late June to 25.8 mm by mid-September (LMS, 1975). The larvae remain on the spawning grounds at least until the late larval stage; they then emigrate to deeper waters (Scott and Crossman, 1973). Norden (1968) investigated the feeding of larval alewives in Lake Michigan and found them to be planktivorous, preying upon copepods and cladocerans.

In the Oswego Turning Basin, alewife eggs were present from 9 June (when surface water temperatures ranged between 15-18.9°C) through to 2 September, with several eggs collected in November (Table IVB-19a). Maximum egg abundances were collected on 23 June at OTB-6 (discharge) (Figure IVB-24). Larvae and juveniles were collected between 29 May and 12 November with the greatest number collected during July and August (Figure IVB-24).



* Mean of dpeths

FIGURE IV B-24

The distribution of alewife eggs in the turning basin, with greatest numbers collected at OTB-6 (Table IVB-20; Figure IVB-24) suggests that their presence in the turning basin is a result of entrainment through the Oswego Steam Station. Data collected on the adult fish community did not indicate that the turning basin was a major spawning site for the alewife (see Section D).

Interstation distribution of alewife larvae, on the other hand, does not present as clear a pattern. Initially, abundances were greater at OTB-6 (reflecting entrainment); during August through October, however, more larvae were collected at OTB-4 (Figure IVB-24).

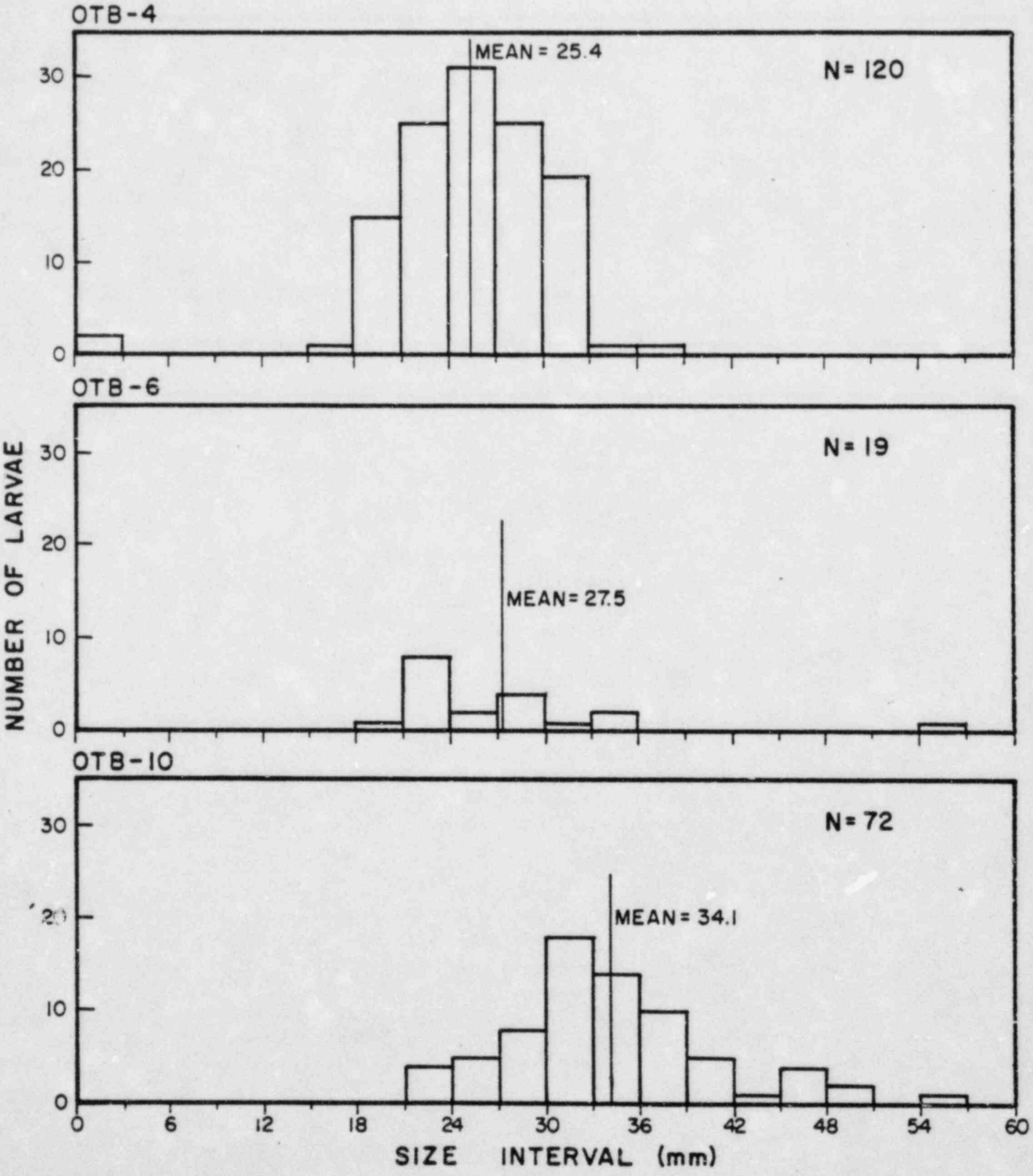
The mean length data (Figure IVB-25) suggest that more than two spawning contingents were present in the Oswego vicinity. Mean lengths of alewife larvae at OTB-6, 10, and OSS 1-4 (entrainment station) were similar, reflecting the entrainment of a lake population, and lagged behind OTB-4 until mid-August. This suggests either that spawning occurred earlier near the harbor entrance or that growth processes were accelerated at this station. The distributional data on adult alewives indicate a greater likelihood that the former occurred.

On 18 August, the mean length of larvae at OTB-4 decreased and was surpassed by that parameter at the other stations. Length frequency histograms of the two August dates (Figures IVB-26 and IVB-27) show a marked shift in the length frequency distribution at OTB-6 and 10, while OTB-4 experienced little change, except for the appearance of two larvae less than 3 mm in total length. This may indicate the presence of a later spawning contingent near the Oswego Harbor and/or migration of the larvae of another spawn into the vicinity of the Oswego Steam Station intake.

The hypothesis that the abundance of alewife eggs and larvae at OTB-6 represented entrainment rather than spawning within the turning basin is supported by the effects of substrate type on fish ontogeny. If some fraction of alewife eggs is assumed capable of surviving the stresses of entrainment, these (demersal) eggs would then be deposited in an unfavorable environment. Sediment analyses of the turning basin have indicated that the substrate is composed primarily of sand, "muck" (U.S. Army Corps of Engineers, 1975), and detritus; the siltation rate is also quite high and in fact the U.S. Army Corps of Engineers removes an annual average of 60,885 cubic yards (U.S.A.C.E., 1975). This type of substrate has been shown to contribute to high mortality rates of striped bass and northern pike eggs (Bayliss, 1968; Hassler, 1970). It is assumed that demersal alewife eggs would

LENGTH FREQUENCY DISTRIBUTION OF ALEWIFE LARVAE

OSWEGO TURNING BASIN — 18 AUGUST 1975



meet the same fate. Therefore, the presence of alewife eggs and larvae in the proximity of the Oswego Steam Station Units 1-4 discharge during the survey was considered to be a result of entrainment.

White Perch

White perch are reported to spawn between mid-May and June when water temperatures range between 11-15°C (51.8-59°F) (Scott and Crossman, 1973). Spawning of the adhesive eggs takes place in shallow water over a variety of substrates, and hatching occurs in 4 to 4-1/2 days at 15°C (59°F) (Thoits, 1958), although hatching time generally decreases with increasing temperature. Larvae are 2.3 mm at hatching and may attain 40-65 mm total length by July or August.

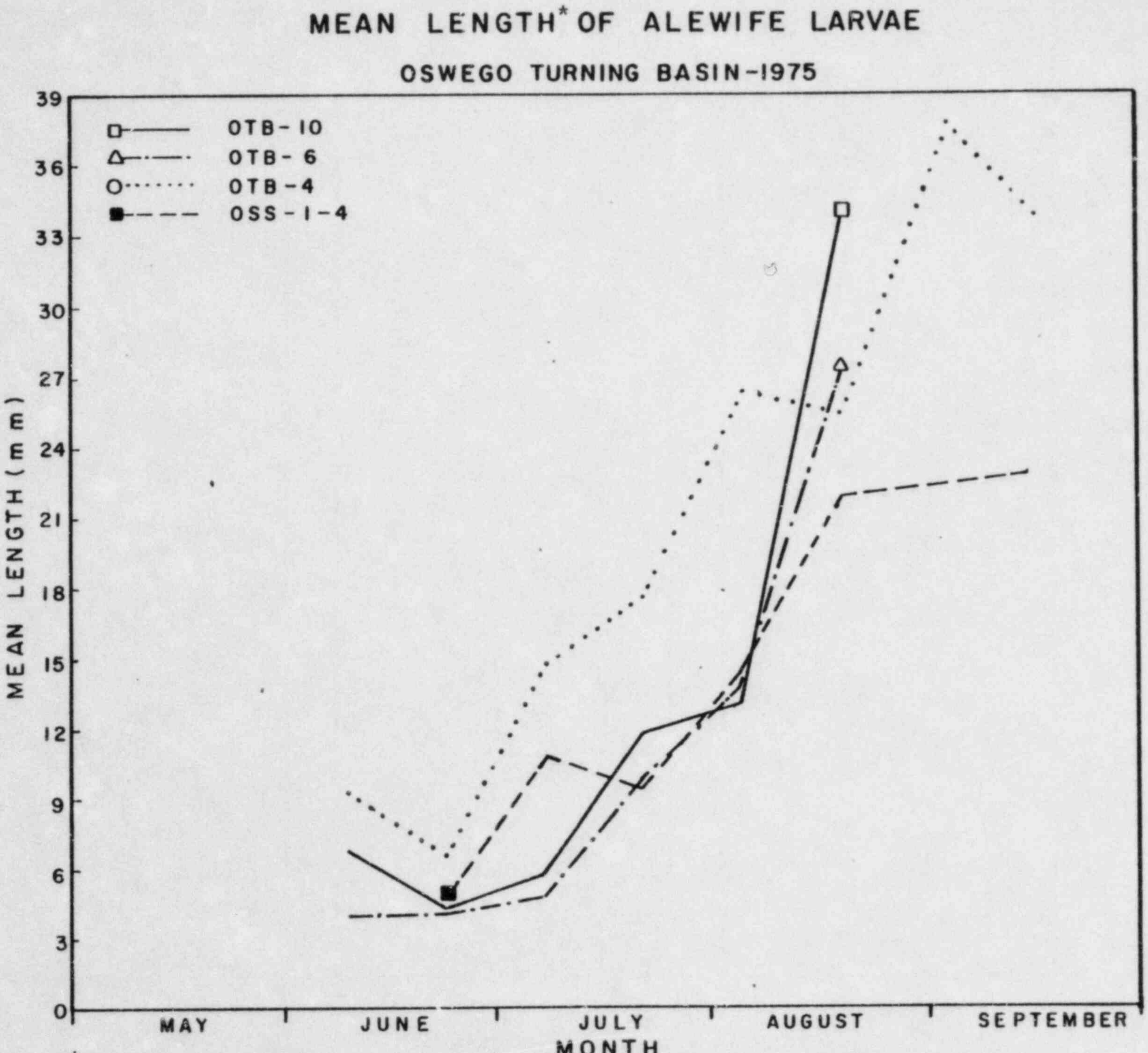
White perch eggs were first collected in the Oswego Turning Basin on 29 May when surface water temperatures ranged between 16.5-18°C (61.7-64.4°F). The greatest number of eggs were collected on 23 June when temperatures were 19.8-24.0°C (67.6-75.2°F) (Figure IVB-28). Larvae first appeared on the same date as the eggs, and were most abundant from 29 May through June. The appearance of the larval maximum prior to the egg maximum and at a higher temperature than reported for maxiumum spawning indicates that the primary location(s) and times of spawning within the turning basin have not yet been identified.

The interstation variations suggest that larvae were initially most abundant near the harbor (OTB-4); they may subsequently have migrated into the turning basin proper as they matured. Redistribution due to entrainment was not indicated since white perch larvae were entrained in low abundance (4-17.5 larvae/1000 m^3) on only three dates (night collections on 22 July, 19 August, and 2 September).

There was little difference between stations in the mean length of white perch larvae through June; July and August data are less complete (Figure IVB-29) but the mean length at OTB-6 appears to have lagged behind that at OTB-10.

Carp

Carp spawn in weedy, littoral areas when water temperatures are at least 17°C (62.5°F). Spawning may occur over a protracted period of time (May-August in the Great Lakes), but declines when temperatures reach 26°C (78.8°F) and ceases at 28°C (82.4°F). Scott and Crossman (1973) reported that hatching takes place in 3-6 days, although water temperature requirements were not given.

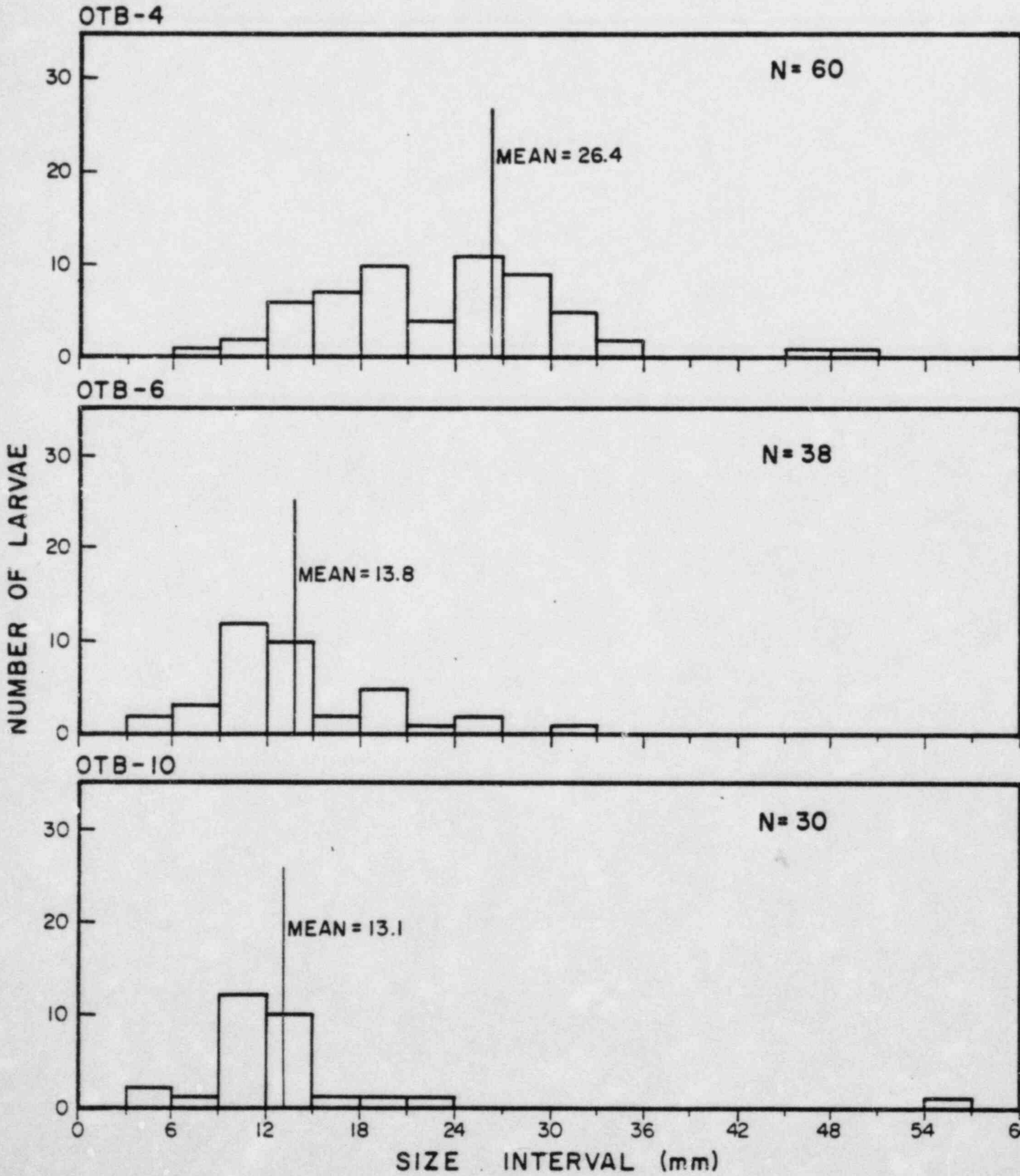


*Mean of ≥ 5 larvae/station/date

FIGURE IV.B-25

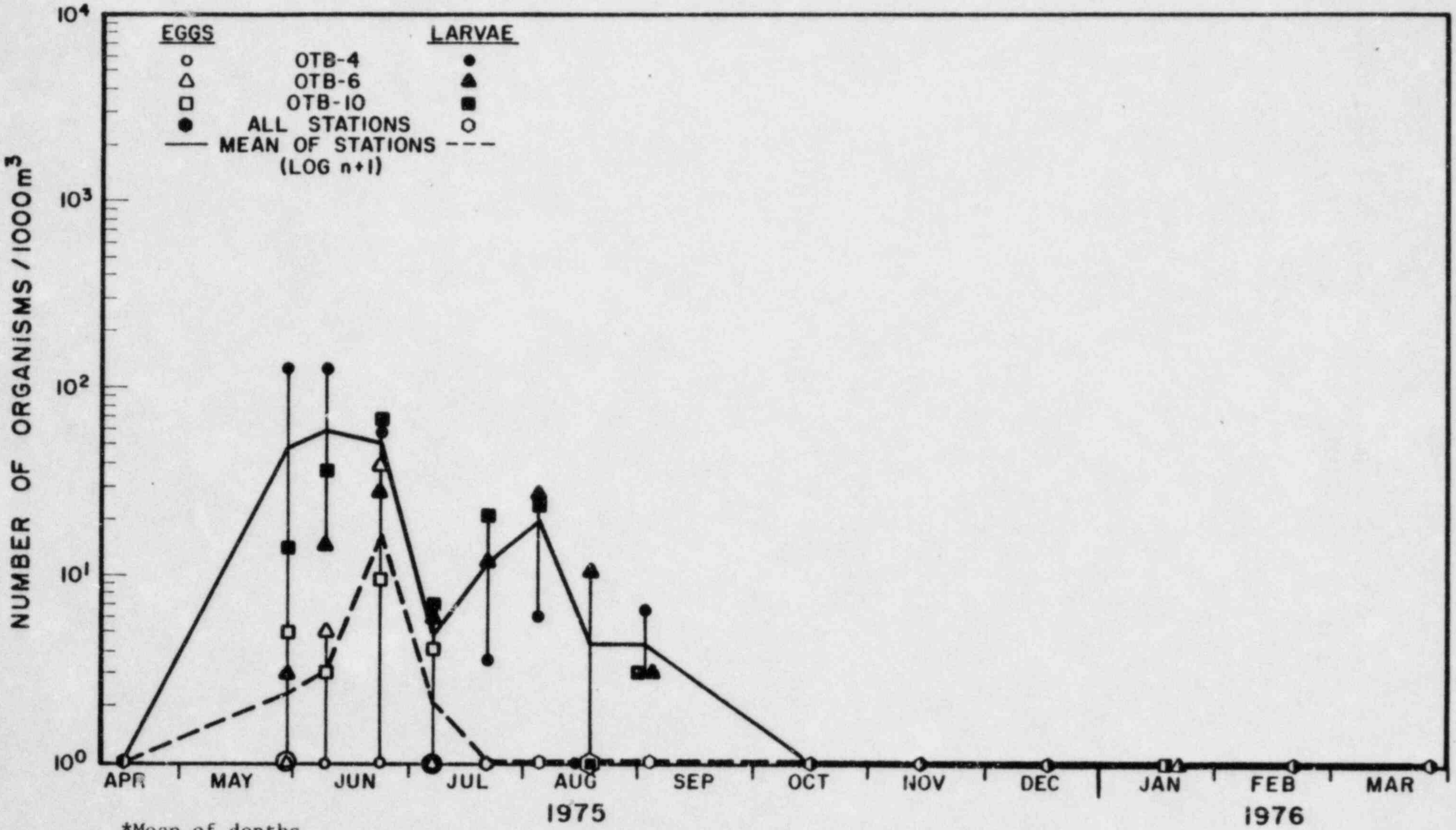
LENGTH FREQUENCY DISTRIBUTION OF ALEWIFE LARVAE

OSWEGO TURNING BASIN — 04 AUGUST 1975



ABUNDANCE* OF WHITE PERCH IN NIGHT COLLECTIONS

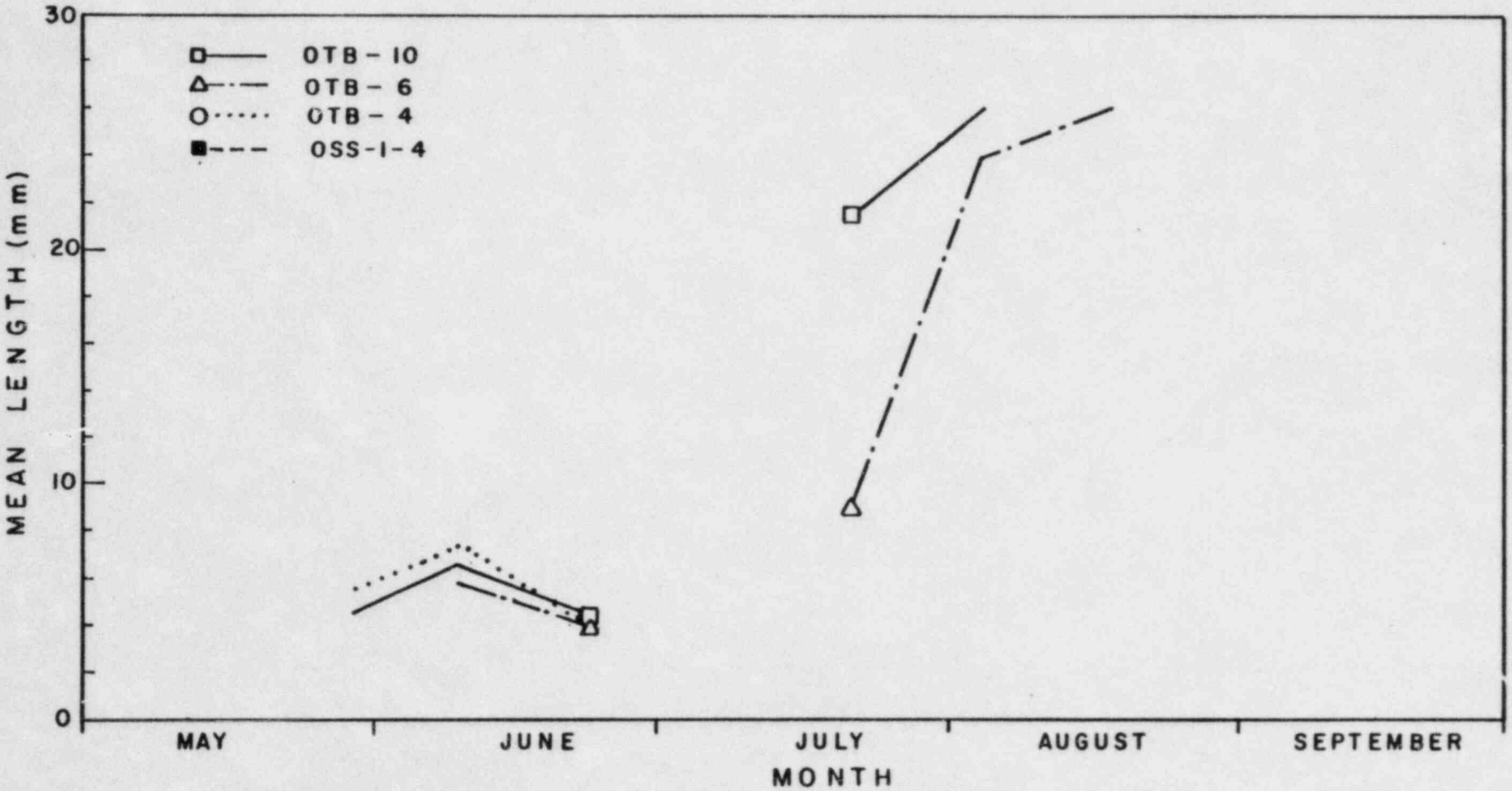
OSWEGO TURNING BASIN — 1975-1976



*Mean of depths

MEAN LENGTH* OF WHITE PERCH LARVAE

OSWEGO TURNING BASIN-1975



*Mean of ≥ 5 larvae/station/date

FIGURE IV.B-29

No carp eggs were collected at any of the sampling stations included in this survey. Carp spawn in areas rich in aquatic vegetation and their eggs are adhesive (Scott and Crossman, 1973). Therefore, the collection of eggs in the open water areas of the turning basin would have been unexpected and, also, not considered indicative of the spawning habits of the fish.

Larvae were first collected when surface water temperatures in the turning basin were 16.5-18°C. The distribution of carp larvae showed a bimodal abundance peak (Figure IVB-30) with the greatest number of larvae collected at OTB-6 (discharge) on 7 July. Carp larvae were generally absent from OTB-4, the station furthest from both the Oswego Steam Station discharge, and, perhaps more important, areas of macrophyte growth.

Length frequency data (Table IVB-22) indicated that there was little difference in larval size between dates and stations. This apparent slow growth may represent dispersal of different spawning contingents into the open water of the Oswego Turning Basin and should not be considered indicative of carp development within the basin.

Summary and Conclusions

The ichthyoplankton community of the Oswego Turning Basin, as described by this survey, could be considered to represent two groupings: residents (e.g., white perch and carp) and those species present in the turning basin as a consequence of entrainment (alewife and smelt).

The most commonly occurring species were collected at times and in water temperatures corresponding to the literature requirements for normal development (Appendix E). Plume entrainment of resident species should not pose a problem since the majority are littoral zone organisms.

A variety of species were collected from this area including the young of such gamefish as yellow perch, bass, and white perch, as well as the larvae of forage species (*Notropis* spp.).

The most abundant species, alewife, was most likely there as a result of entrainment, since the turning basin is apparently an unfavorable habitat for egg and larval development due to substrate type. The presence of these pumped-through larvae may act as a supplement to the diet of yearling yellow perch, white perch, and sunfish (the two former species were very abundant during summer months in the turning basin; see Section IV-D).

TABLE IV B-22

LENGTH FREQUENCY OF CARP LARVAE

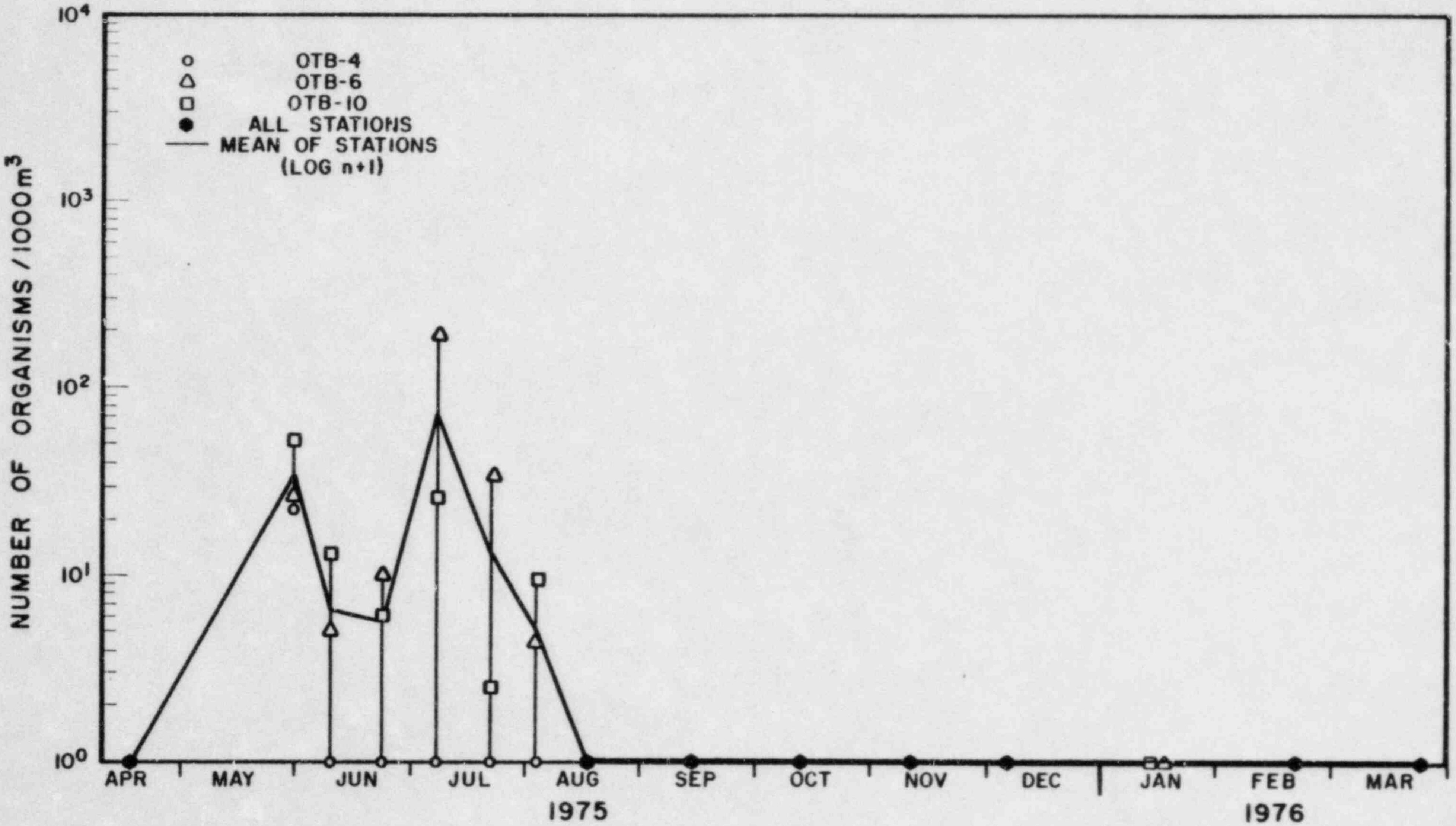
OSWEGO TURNING BASIN - 1975

INTERVAL (mm)	29 MAY			9 JUN			23 JUN			7 JUL			21 JUL			4 AUG			18 AUG		
	OTB-4	OTB-6	OTB-10	OTB-4	OTB-6	OTB-10	OTB-4	OTB-6	OTB-10	OTB-4	OTB-6	OTB-10	OTB-4	OTB-6	OTB-10	OTB-4	OTB-6	OTB-10	OTB-4	OTB-6	OTB-10
0.1-1.0		2									1						1				
1.1-2.0																					
2.1-3.0																					
3.1-4.0																					
4.1-5.0		4	3			3					48	8		1		1	2	2		1	
5.1-6.0	6	5	21		2	3		7	2		49	9		14		2	2	5			1
6.1-7.0	2		1						1					6	1						
MEAN	5.6	4.0	5.4	-	5.6	4.9	-	5.6	5.9	-	5.1	5.0	-	5.6	6.2	5.0	4.0	5.2	-	4.7	5.6

- Not applicable; no larvae caught

ABUNDANCE* OF CARP LARVAE IN NIGHT COLLECTIONS

OSWEGO TURNING BASIN — 1975-1976



*Mean of depths

FIGURE IV B-30

White perch, the second most abundant species, appear capable of existing successfully within the turning basin. The data on carp were much less complete because of their littoral habit. However, the lush aquatic vegetation along the southern shore of the turning basin should offer a suitable habitat for this species as well. Other species were collected too infrequently to assess their distribution.

In summary, the resident ichthyoplankton of the Oswego Turning Basin are primarily the progeny of littoral spawning species, while open water species (alewife and smelt) find the turning basin an inhospitable habitat and are there as a consequence of entrainment.

C. BENTHOS

1. Introduction

Benthic organisms are those attached to the bottom, resting on the bottom, or living in the sediment of a body of water (Odum, 1971). Many benthic organims, because they have limited or no mobility, have proved to be good indicators of local environmental perturbations. Benthic organisms also provide food for fish and this direct trophic link may communicate changes in benthic assemblages directly to fish populations. Oligochaetes (segmented worms), amphipods (scud), insect larvae, and mollusks are common food items in the diet of freshwater fish.

Field and laboratory methods and station locations are described in Appendix C.

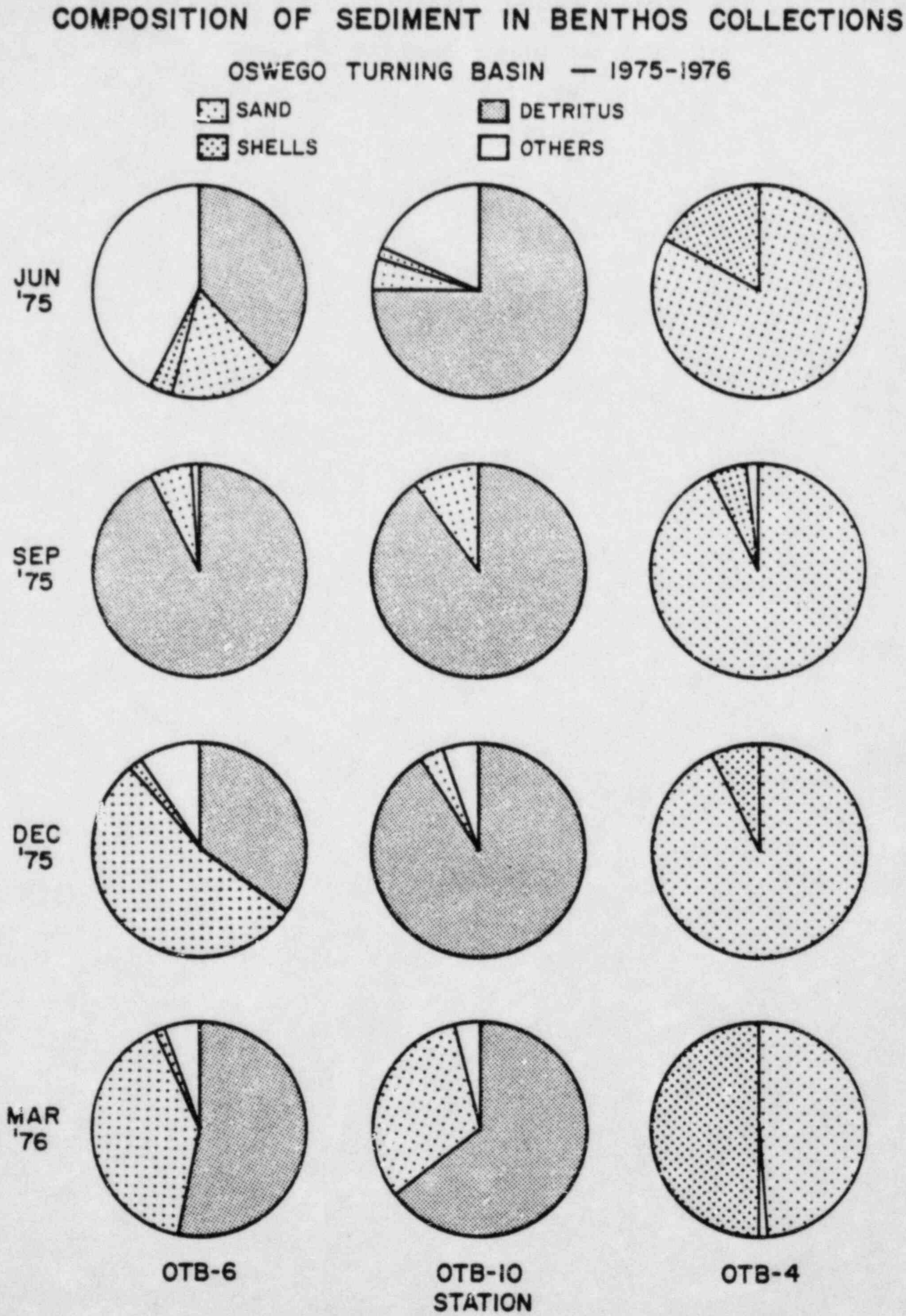
2. Results and Discussion

a. Composition of Sediment

Sediment composition was determined after sieving (0.420 mm mesh opening) and the size fraction greater than 420μ estimated for each sample. Estimations from two replicates collected at each station per date were averaged and plotted on 'pie' diagrams (Figure IV.C-1). In general, OTB-6 and OTB-10 showed a considerable detrital load, while OTB-4 contained more sand and shell. Large macrophyte populations observed in shallow areas of the turning basin may have contributed substantially to detrital loads reported at OTB-6 and OTB-10. Relatively low water velocities in this area would result in the deposition of suspended sand and the settling of detritus.

Sediment chemical and physical parameters were not tested by LMS; however, such tasks were performed by the EPA from samples

FIGURE IVC-1


COMPOSITION OF SEDIMENT IN BENTHOS COLLECTIONS
OSWEGO TURNING BASIN — 1975-1976
SAND
DETRITUS
SHELLS
OTHERS
JUN '75
SEP '75
DEC '75
MAR '76
OTB-6
OTB-10
STATION
OTB-4

taken in Oswego Harbor in May 1972 (Table IV.C-1). Soils were a mixture of sand and muck and EPA judged sediments from the maintained channels to be polluted. The high values of chemical oxygen demand (COD) at the west end of the harbor were judged to be largely inorganic based on the Kjeldahl nitrogen values (EPA station 385; Figure IV.C-2). Levels of oil-grease and mercury were also high (Section III-d).

b. Species Inventory

A diversity of benthic macroinvertebrates were collected, including seven Phyla and 68 groups identified to at least the generic level (Table IV.C-2). The Phylum Rhynchocoela (Nemertea) may be considered a generic identification because it contains only one freshwater genus, Prostoma, and only one species indigenous to North America, P. rubrum (Hyman, 1951; Pennak, 1953). A few introduced species occur on the inventory including Bithynia tentaculata, a snail probably introduced from Europe (Harman and Berg, 1971), Peloscolex ferox, a segmented worm also probably introduced from Europe (Brinkhurst, 1965), and Valvata piscinalis, a snail native to Europe (Harman and Berg, 1971).

c. Distribution of Biomass

The seasonal distribution of biomass, computed as an average of all samples in the Oswego Turning Basin (six replicates per month), shows a depression in September and a March peak (Figure IV.C-3), which is due to the influx of the snail Bithynia tentaculata to station OTB-4, probably from the Oswego River. Annelid biomass, almost exclusively Tubificidae, shows a similar pattern, varying only from 24.5 to 56.1 g/m^2, and dominating the total biomass in June, September, and December.

Total biomass at OTB-6, located nearest the Oswego Units 1-4 thermal discharge, was low in September (Figure IV.C-3), but highest in December. Biomass was dominated by annelids, mostly tubificids, and mollusks were an appreciable percentage (24.7%) only in December. OTB-6 and OTB-10 (turning basin station) show much similarity in biomass distribution (Figure IV.C-3): both had minimum values in September, maximum biomass of mollusks in December, dominance by oligochaete annelids, and relatively similar levels of biomass in each month. Biomass decreased from December to March at OTB-6, but increased during this period at OTB-10.

Station OTB-4, located in the outer harbor area, differed from the others (Figure IV.C-3), with minimum total and oligochaete biomass occurring in December, and a dominance of mollusks (mostly

TABLE IV C-1

SEDIMENT CHEMISTRY: OSWEGO HARBOR

MAY 1972[a]

PARAMETERS	UNITS	STATION NUMBER					
		381	382	383	385	386	389
VOLATILE SOLIDS	%	0.5	4.3	4.5	1.9	5.0	2.3
CHEMICAL OXYGEN DEMAND	%	0.3	6.1	5.4	9.1	23.3	2.9
TOTAL KJELDAHL NITROGEN	mg/kg	112	2100	2000	430	b	1220
OIL & GREASE	mg/kg	48	1212	1529	450	562	941
MERCRUY	mg/kg	1.01	0.34	2.34	0.55	1.33	0.46
LEAD	mg/kg	1.5	4.2	4.1	1.9	2.2	3.5
ZINC	mg/kg	1.6	6.2	7.3	4.6	5.6	5.2

[a] Source: U.S. Environmental Protection Agency, 1973.
[b] Data not listed in original source.

TABLE IVC-2

BENTHOS SPECIES INVENTORY

OSWEGO TURNING BASIN - 1975

TAXON

CNIDARIA
HYDROZOA
ATHECATA
CLAVIDAE
CORDYLOPHORA
C.LACUSTRIS
HYDRIDAE
HYDRA
H.AMERICANA

RHYNCHOCOELA

PLATYHELMINTHES
TURBELLARIA
TRICLADIDA
PLANARIIDAE

ASCHELMINTHES
NEMATODA
CHROMADOROIDEA
PLECTIDAE
ANONCHUS
ENOPLIDA
ALAIMIDAE
ALAIMUS
DORYLAIMIDA
DORYLAIMIDAE
DORYLAIMUS
LAIMYDORUS
RHABDITIDA
RHABDITIDEA
BUTLERIUS

MOLLUSCA
GASTROPODA
MESOGASTROPODA
VALVATIDAE
VALVATA
V. PINCINALIS
BULIMIDAE
AMNICOLA
A.INTEGRA
A.LIMNOSA
BITHYNIA TENTACULATA
PLEUROCERIDAE
GONIOBASIS
G.LIVESCENS

TAXON

BASOMMATOPHORA
PHYSIDAE
PHYSA
P.INTEGRA
PLANORBIDAE
GYRAULUS
G.PARVUS
HELISOMA
H.ANCEPS
PROMENETUS
P. EXACUOUS
ANCYLIDAE
FERRISSIA
F.TARDA
BIVALVIA
HETERODONTIDA
SPHAERIIDAE
PISIDIUM
SPHAERIUM

ANNELIDA
POLYCHAETA
SABELLIDA
SABELLIDAE
MANAYUNKIA
M.SPECIOSA
OLIGOCHAETA
PLESIOPORA
TUBIFICIDAE
AULODRILUS
A.LIMNOBIUS
A.PLURISETA
A.PIQUETI
LIMNODRILUS
L.HOFFMEISTERI
L.UDEKEMIANUS
L.CLAPAREDIANUS
L.PROFUNDICOLA
L.CERVIX
L.SPIRALIS
L. CERVIX VARIANT
L. HOFFMEISTERI VARIANT
ILYODRILUS
I.TEMPLETONI
PELOSCOLEX
P.FREYI
P.FEROX
P.MULTISETOSUS

TABLE IVC-2 (Continued)

BENTHOS SPECIES INVENTORY

TAXCN

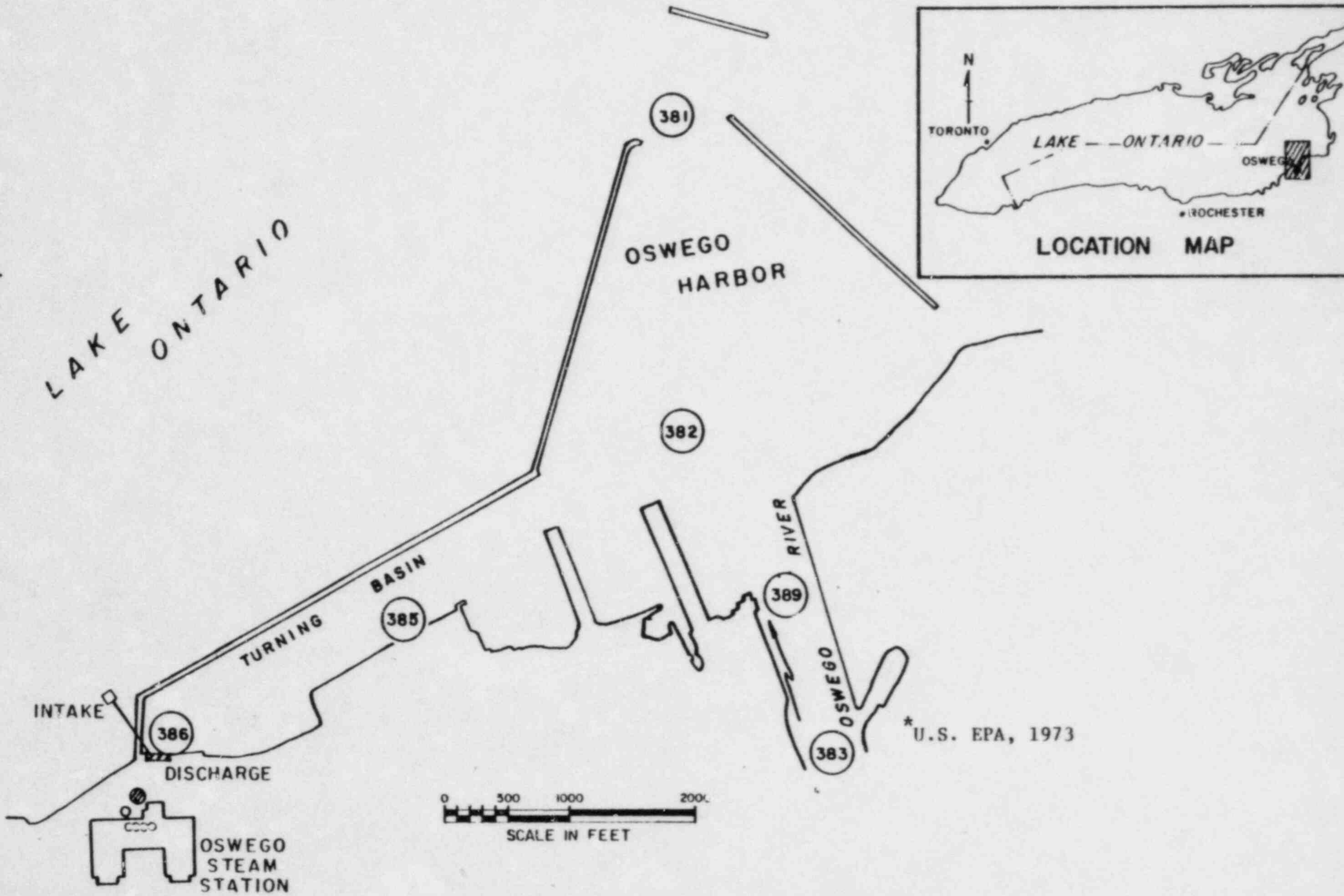
P.MULTISETCSUS LONGICENTUS
TUBIFEX
T.TUBIFEX
POTAMOTHRIX
P.MCLCAVIENSIS
P.VEJCCVSKYI
NAICICAE
NAIS
N.BRETSCHERI
N.ELINGUIS
N. COMMUNIS
CPHICCNAIS
C.SERPENTINA
PARANAIS
P.FRICI
UNICINAIS
U.UNCINATA
CERC
HIRUCINEA
RHYNCHOBCELLICA
GLOSSIPHCNIICAE
HELCBCELLA
H.STAGNALIS
GLCSSIPHCNIA
G. COMPLANATA

ARTHRCPOCA
ARCHNICA
ACARI
LIMNESIICAE
LIMNESIA
HYGRCBATICAE
HYGRCBATES
H.SP 3
ARRENURUS
INSECTA
CCONATA
TRICHOPTERA
LEPTOCERICAE
CECETIS
ARTHRIPSOCES
CIPTERA
CULICICAE
CHACBCRUS
C.PUNCTIPENIS
C.ALBIPES
TENCIPECICAE
CALCPSECTRA

TAXCN

CHIRCNOMUS
CRICCTCPUS
CRYPTCCHIRONOMUS
CICROTENCIPES
HARNISCHIA
PCLYPECILUM
PRCCLACIUS
CRUSTACEA
ISCPCCA
ASELLICAE
ASELLUS
AMPHIPCCA
GAMMARICAE
GAMMARUS
G.FASCIATUS
TALLTRICAE
HYALELLA
H. AZTECA
CSTRACCCA

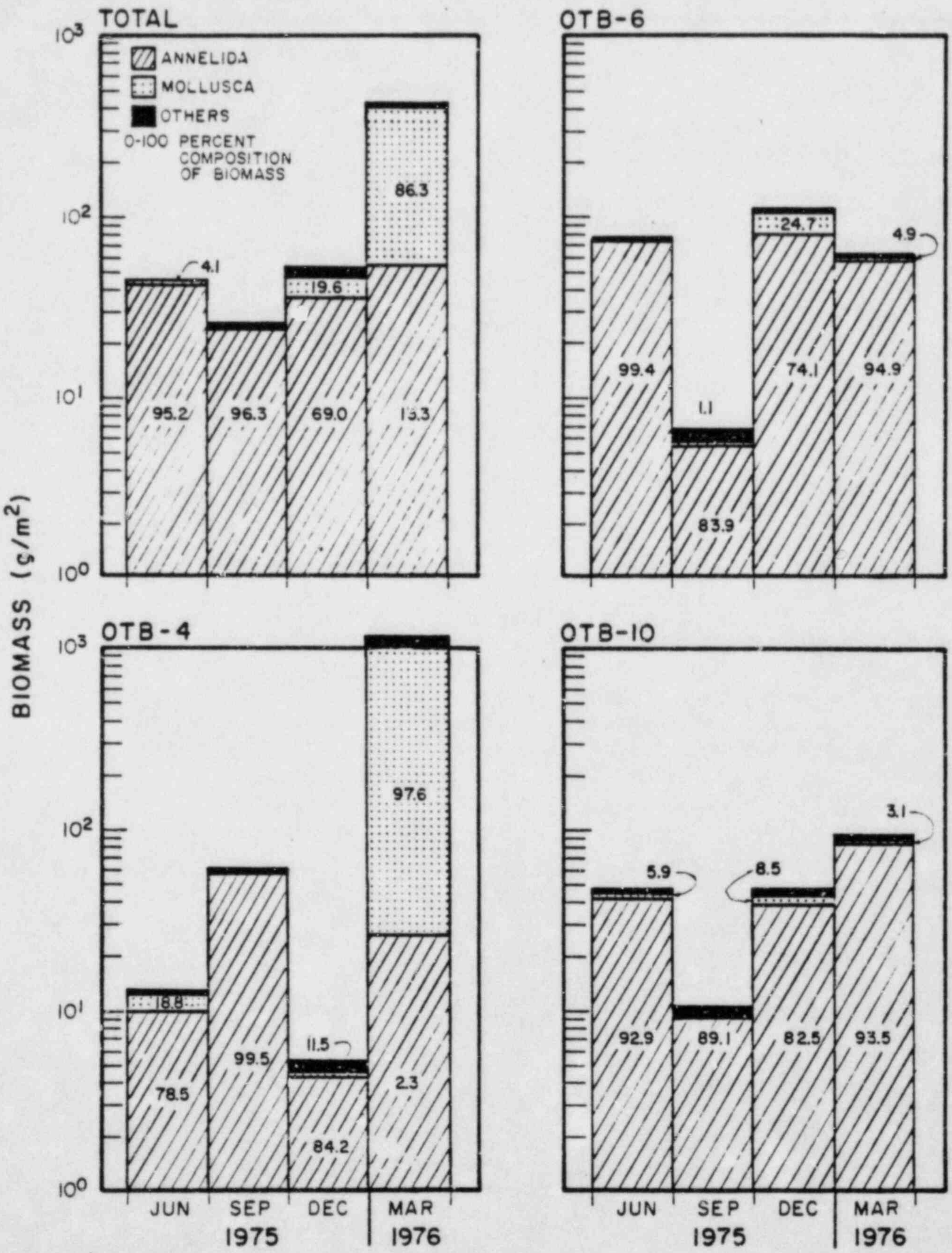
SEDIMENT SAMPLING STATIONS*
OSWEGO TURNING BASIN – MAY 1972



*U.S. EPA, 1973

FIGURE IV.C-2

DISTRIBUTION OF MACROINVERTEBRATE BIOMASS
OSWEGO TURNING BASIN - 1975-1976



Bithynia tentaculata) in March, resulting in a very high total biomass in that month. September biomass, low at the other two stations, was the second highest for OTB-4, and annelid abundance during September was highest for that station. The distribution of both annelid and total abundance at OTB-4 appears to lag behind the distribution at OTB-6 and OTB-10 by one sampling period (three months).

d. Distribution of Taxa

Annelids (mostly oligochaetes) were the most abundant phylum sampled at all stations except OTB-4 in March (Figure IV.C-4); that sample was composed predominantly of mollusks, of which nearly all were Bithynia tentaculata. Arthropods represented an appreciable proportion of the community only at OTB-4 in June, OTB-6 in September, and OTB-10 in December.

e. Biological Data and Abundance of Some Important Species

In this section, biological data and abundances of benthic organisms will be reported. Literature data will be synthesized with data from the Oswego Turning Basin. Total benthic organisms and total oligochaetes will be discussed first.

The oligochaetes are one of the dominant groups in most samples and will be considered in detail. Tubificids are the most common oligochaete found in almost all water bodies.

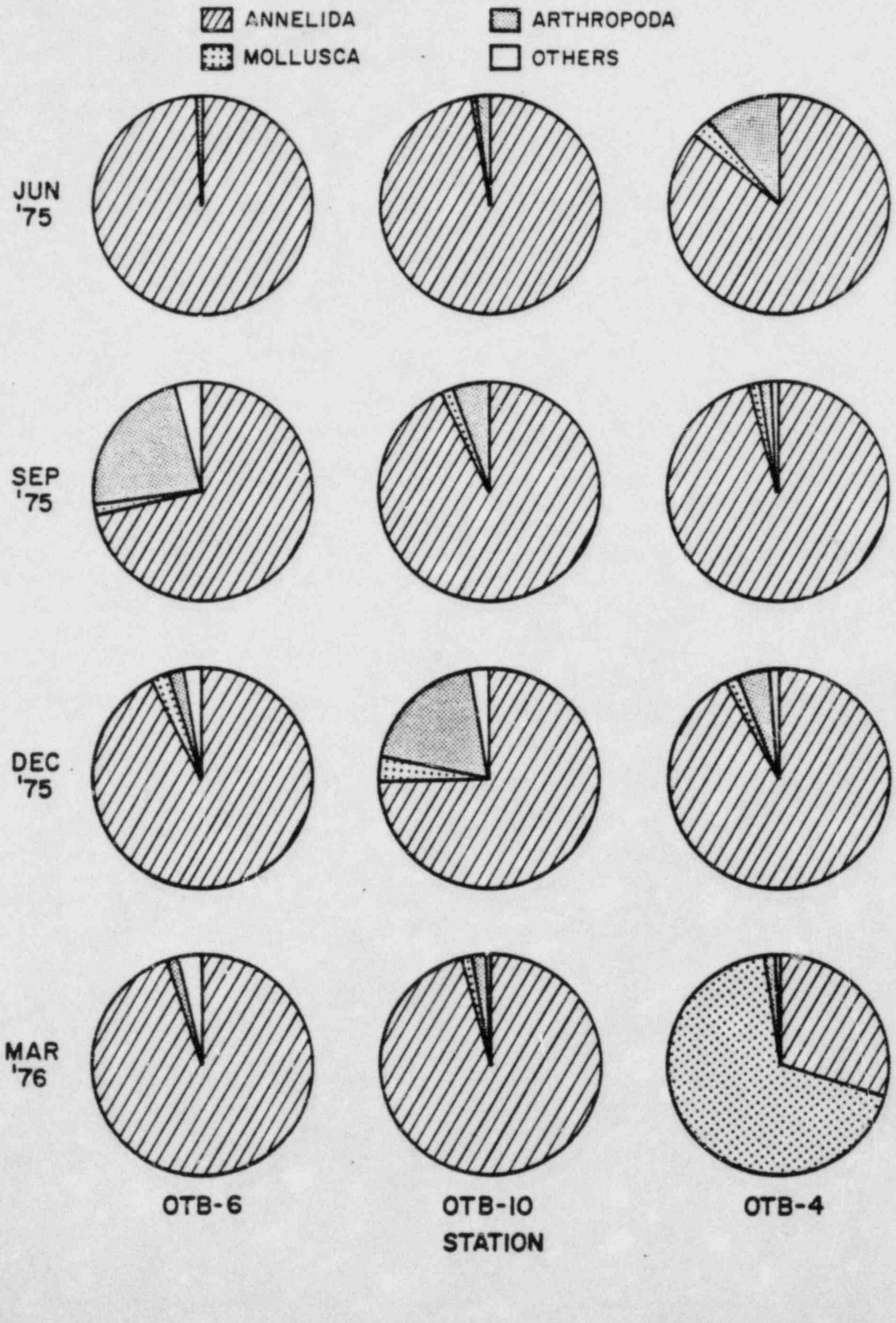
In describing several of the major species which occur in Oswego Harbor and Turning Basin, the autecological designations of the relationship of an organism to organic and other pollution proposed by Fjerdingstad (1965) have been adopted.

These are:

- saprobionic: species that occur (in large number) only in heavily polluted waters
- saprophilous: organisms that occur generally in polluted waters but may occur also in other communities; i.e., organisms that to a certain extent are indifferent
- saproxenous: organisms that occur generally in biotopes other than polluted ones but may be able to survive even in the presence of pollution
- saprophobous: organisms that will not survive in polluted waters.

DISTRIBUTION OF MACROINVERTEBRATE ABUNDANCE

OSWEGO TURNING BASIN — 1975-1976



(i) All Benthic Organisms

The total abundance of benthic organisms (Figure IV.C-5) assumed a different seasonal pattern at each station. At OTB-4, abundances were low in June and December and high in September and March. At OTB-6 the opposite pattern occurred: highest abundances in June and December, lower in March, and lowest in September. A third pattern of abundance was apparent at OTB-10: decreasing from June to September, increasing in December, and increasing again in March.

Analysis of variance was used to determine whether significant differences in abundance occurred between stations within each sampling period (Appendix D). A main effect, difference between months, was found ($\alpha = .05$). Tukey's T procedure indicated higher total abundance in March than in June, December, and September combined, and lowest total abundance in September than the other three months combined. This confirms the graphical analysis that seasonal fluctuations do occur.

The hypothesis of interstation differences within each sampling period (month) was then tested (Appendix D). Significant differences occurred in June, December ($\alpha = .01$) and September ($\alpha = .05$). In June and December the total abundance at OTB-4 was significantly lower than at the other two stations, but it was significantly higher in September. This is evidence that OTB-4, more exposed to the lake and receiving greater influence from the Oswego River, may represent a community subject to different influences and may, therefore, respond in different ways from the more protected turning basin stations, OTB-6 and OTB-10.

(ii) All Tubificids

The abundance of tubificids followed the pattern of total abundance very closely (Figure IV.C-6). Tubificids comprised a large portion of total oligochaetes, which in turn were a large portion of the total biomass. Tubificid abundance is of concern because of the close association of many of these species with areas of pollution.

For the period May to August during the years 1968-1970, average tubificid abundance in the shallow zone ($\leq$36 m) of Lake Ontario was reported to be 5,007 organisms/m^2, 15,674/m^2 in the inner Oswego Harbor, and 1,893 organisms/m^2 in the entrance to Oswego Harbor (Kinney, 1972). Estimates of tubificid abundances in the Oswego Harbor-Turning Basin complex from the current study were higher overall than the values obtained by Kinney mainly due to the sampling conducted at

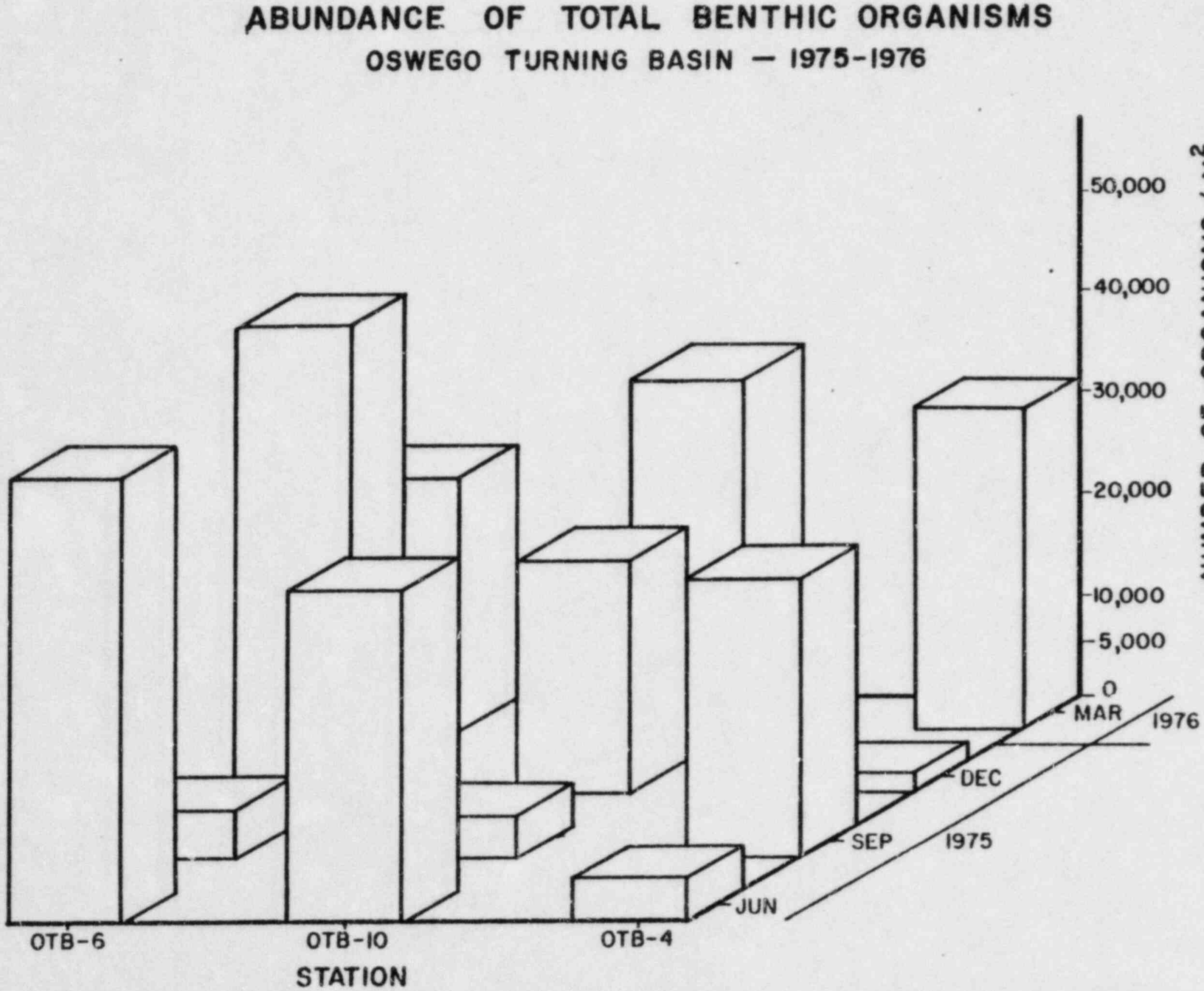

ABUNDANCE OF TOTAL BENTHIC ORGANISMS
OSWEGO TURNING BASIN — 1975-1976
NUMBER OF ORGANISMS / M^2
50,000
40,000
30,000
20,000
10,000
5,000
0
MAR
1976
DEC
SEP
1975
JUN
OTB-6
OTB-10
OTB-4
STATION

FIGURE IVC-5

ABUNDANCE OF TUBIFICIDAE
OSWEGO TURNING BASIN - 1975

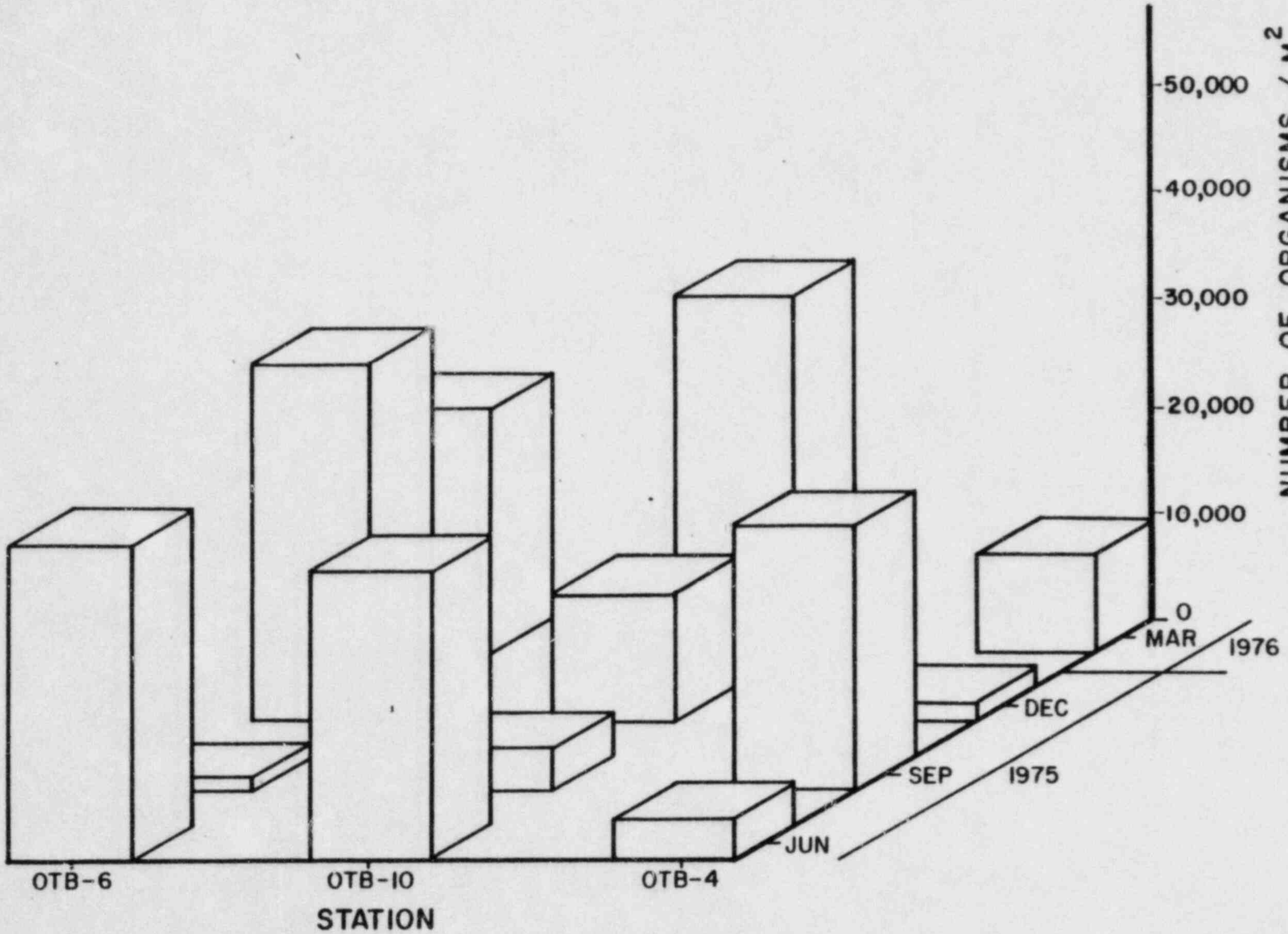


FIGURE IVC-6

OTB-6 situated at the thermal discharge and closest to the major sewage discharge pipe at the western end of the turning basin. The highest concentration of tubificid worms, 33,280 organisms/m^2, was recorded at OTB-6 in December, and the lowest density, 1,376 organisms/m^2, also occurred at OTB-6 in September. The greater abundance at OTB-6 during December, a period normally characterized with low abundance due to seasonal low water temperatures, and the lowest during September possibly reflects population inhibition at times of high water temperature followed by prolonged activity through the fall as a result of the thermal discharge. Station OTB-10 corresponds to the inner Oswego Harbor station sampled by Kinney (1972), and for the time period during which the 1968-1970 samples were collected the average abundance was 15,336 organisms/m^2. The similarity of tubificid abundance among years at OTB-10 indicates a stable pattern in population dynamics.

Schuytema and Powers (1966) reported total oligochaete densities of 140 organisms/m^2 in offshore stations, 820 organisms/m^2 in harbor and inshore stations, and 3,060 organisms/m^2 in the polluted Saginaw Bay stations. These samples were taken in Lake Huron with a Peterson grab and a U.S. Standard No. 30 mesh sieve.

(iii) Limnodrilus hoffmeisteri (Tubificidae)

In the Great Lakes, the ubiquitous and cosmopolitan genus Limnodrilus is the largest and perhaps most complex genus of tubificids (Hiltunen, 1967). L. hoffmeisteri is the most abundant and widely distributed species of this genus, common and abundant everywhere (Brinkhurst, 1965). The fauna of small ponds is frequently limited to the ubiquitous species Tubifex tubifex and Limnodrilus hoffmeisteri (Brinkhurst and Jameison, 1971), both of which have very high ecological tolerances and ability to invade many sites.

During 1961, the genus Limnodrilus included the most common species in western Lake Erie, and L. hoffmeisteri was the most abundant species. Its numbers were greatest near the mouths of the Detroit, Raison, and Maumee rivers, three major tributaries which are polluted with organic waste, and declined toward the open lake (Hiltunen, 1969). A similar pattern of distribution was observed in Saginaw Bay, Lake Huron, where the distribution of L. hoffmeisteri correlated well with the known flow of the polluted Saginaw River water out of the bay. Limnodrilus hoffmeisteri was widely distributed in Lake Michigan, where it was not abundant in clean waters but was abundant in polluted waters and could be classified as saprophilous (Hiltunen, 1967). In the polluted River Trent, Great Britain, L. hoffmeisteri is one of only four species found and was many times the most abundant organism in the heated effluent of a power plant, indicating high tolerance of thermal extremes, as well as of pollution (Aston, 1973).

Because it is cosmopolitan, ubiquitous, environmentally tolerant, and generally abundant in areas of organic pollution, L. hoffmeisteri has been named as both an indicator organism and a member of several indicator associations such as: L. hoffmeisteri, L. profundicola, L. udekemianus, and T. tubifex, on the River Trent (Aston, 1973); L. hoffmeisteri, T. tubifex, and Peloscolex multisetosus in Toronto Harbor (Brinkhurst and Chua, 1969); L. hoffmeisteri, L. cervix, and L. maumeensis at the outfall of a sewage treatment plant in Ludington Harbor, Lake Michigan (Hiltunen, 1967); and L. hoffmeisteri, T. tubifex, L. udekemianus and L. helveticus found in a stream receiving colliery and pig farm wastes near Liverpool (Brinkhurst and Kennedy, 1965).

Limnodrilus is a synchronous functional hermaphrodite and although cross-fertilization is the general rule, uniparental reproduction is possible. Asexual reproduction is thought not to occur (Kennedy, 1966).

The eggs are laid in small cocoons which may quite easily be mistaken for small spheres of mud (Aston, 1973). Rate of growth to sexual maturity may be highly variable, ranging from a period of five weeks in laboratory-reared worms at 25 and 30°C (Aston, 1973) to an estimated six months to one year for field populations (Kennedy, 1966). Worms may breed in their first or second year of life or later, and gonads may be resorbed after breeding occurs. Breeding takes place throughout the entire year and the peak breeding period appears to be related to both seasonal temperature cycles and environmental productivity. The period of greatest breeding activity has been reported as March in a brook near Liverpool (Brinkhurst and Kennedy, 1965); from May until December in several locations in Great Britain (Kennedy, 1966); and in May to early October in Lake Michigan (Hiltunen, 1967). Howmiller and Beeton (1970) reported evidence of seasonality in Green Bay, Lake Michigan, with most mature worms occurring in May. In general where the habitat is very productive (either by eutrophication or pollution), breeding takes place over the winter, although a period of extremely low temperature may cause a temporary cessation of activity. In less productive habitats, breeding occurs mainly in spring and summer (Kennedy, 1966). In southern Lake Michigan, Hiltunen (1967) reported a cessation of breeding activity before fall overturn of the lake.

Both temperature and dissolved oxygen can affect egg production in L. hoffmeisteri. Within the range of 5 to 30°C highest mean and variation of egg production occur at 25°C. The number of eggs per cocoon was greatest between 15 and 25°C (averaging slightly more than 5 eggs/cocoon). Temperature influences the rate of reproduction considerably more than concentration of dissolved oxygen (DO), as long as the DO is above 2 ppm. Temperature effects on growth may be partially the result of an increased bacterial fauna at higher temperatures, providing L. hoffmeisteri and tubificids in general with more food (Aston, 1973).

There is evidence that tubificids do not selectively ingest certain species of bacteria, but that they do selectively digest them. Partitioning of the bacterial flora may be a form of resource partitioning by the three sympatric tubificids, L. hoffmeisteri, T. tubifex, and P. multisetosus (Brinkhurst and Chua, 1969). The distribution of L. hoffmeisteri in the Oswego Turning Basin is shown in Table IV.C-3.

Analysis of variance was performed to determine whether differences in the abundance of the tubificid L. hoffmeisteri were statistically significant (Appendix D). A main effect, difference in abundance due to dates, was found to be significant (α = .01) but the nested effects of differences among stations within months were not significant for any month. When the main effect was tested by Tukey's T procedure, September abundance was found to be significantly less than the combination of March, June, and December. The fall slump in L. hoffmeisteri abundance was statistically significant, and both March and June abundances were higher than the combination of December and September. This may reflect a winter or early spring reproductive period, as was found by Kennedy (1966), and follows the pattern of abundance reported in southern Lake Michigan by Hiltunen (1967). Therefore, L. hoffmeisteri appears to be following its normal life cycle and reproductive period in the Oswego Turning Basin. The absence of significant differences among stations within months suggests that this normal life cycle is found at all stations in the turning basin. Limnodrilus eggs and larvae are not pelagic so that a large proportion of those organisms which were present in the turning basin probably did not migrate there.

(iv) Other Species of Limnodrilus

Two variants of L. cervix were recognized from OTB samples, both of which have been found only in polluted and eutrophic areas of Lake Michigan and are classfied as saprobionts (Hiltunen, 1967). In western Lake Erie and in Lake Michigan, their distribution is limited to areas near polluted river mouths, where they have been found in abundance (Hiltunen, 1967, 1969). The distribution of L. cervix within the Great Lakes is discontinuous and it has been reported only from areas of organic pollution in Lakes Huron, Michigan, Ontario, and Superior (Hiltunen, 1969).

The temporal distribution of L. cervix (Table IV.C-3) was similar to that of L. hoffmeisteri and followed the distributional pattern typical of many oligochaetes. As with L. hoffmeisteri, this is evidence that these organisms are completing natural life cycles and population dynamics within the turning basin. Populations of L. cervix were concentrated at OTB-6 and OTB-10, and may have been responding to: raw sewage effluents in the turning basin; higher detrital loads in the sediment due to low current velocities; the heated effluent of Oswego Steam Station; or, most probably, a combination of all of these.

The distribution of L. claparedeanus was similar to that of L. cervix in Green Bay, Lake Michigan, and individuals having characteristics of both L. cervix and L. claparedeanus have been reported (Howmiller and Beeton, 1970). These L. claparedeanus - L. cervix intermediates are also termed L. cervix variants (Hiltunen, 1967), and their taxonomic position is uncertain (Hiltunen, 1969). The distribution of L. claparedeanus is similar to that of L. cervix in Lake Erie (Hiltunen, 1969), being greatest close to polluted river mouths. In Oswego Turning Basin, L. claparedeanus occurs mostly at OTB-10 and its distribution does not follow that of L. cervix. L. claparedeanus may not complete its life cycle in the turning basin (Table IV.C-3).

L. profundicola (= helveticus) has been reported from rivers receiving organic pollution and is one of only four tubificid species found living in the polluted River Trent, Great Britain, above and below a thermal discharge from an electric generating plant (Aston, 1973). In Lake Michigan, L. profundicola was found to be a dominant species in clean inshore (shallower than 40 m) areas, yielding dominance to P. multisetosus, L. hoffmeisteri, I. templetoni, T. tubifex, and species of Potamothrix in areas of organic enrichment. L. profundicola was sampled only three times in 1975, once at each station

TABLE IV C-3

ABUNDANCE OF SELECTED *LIMNODRILUS* SPECIES[a]

OSWEGO TURNING BASIN - 1975-1976

I. *L. cervix*[b]

STATION	1975			1976
	JUN	SEP	DEC	MAR
OTB- 6	6368	160	1040	3296
OTB-10	1648	320	1168	3616
OTB- 4	1104	528	112	1360

II. *L. claparedianus*

OTB- 6	0	0	0	0
OTB-10	0	48	48	688
OTB- 4	32	0	0	0

III. *L. hoffmeisteri*[b]

OTB- 6	3280	96	2928	4272
OTB-10	2512	304	864	4480
OTB- 4	944	352	240	960

IV. *L. profundicola*

OTB- 6	352	0	0	0
OTB-10	96	32	0	0
OTB- 4	0	0	0	48

V. *L. udekemianus*

OTB- 6	1216	48	176	1072
OTB-10	864	48	352	432
OTB- 4	48	96	32	48

[a]Mean of two replicates; number of organisms/m^2

[b]Both variations combined

(Table IV.C-3). The highest density (352 organisms/m^2) occurred at OTB-6 in June.

L. udekemianus is frequently restricted to littoral areas, although it has been reported from both sublittoral and profundal zones (Brinkhurst and Jamieson, 1971), and it was not found in depths greater than 36.5 m in Lake Michigan (Hiltunen, 1967). Although the distribution of L. udekemianus in Lake Erie was probably associated with river discharge, it may have been more affected by depth, distance from shore, or both (Hiltunen, 1969). Unlike other members of the genus, this species can be recognized when immature and its recorded numbers are likely to be disproportionately high.

It was one of only four tubificid species found above and below a thermal effluent in the polluted River Trent, Great Britain (Aston, 1973). Brinkhurst (1965) has described its distribution as widespread and common, often in organically polluted rivers.

The seasonal distribution of L. udekemianus was typical of that of most oligochaetes and similar to that of L. hoffmeisteri (Table IV.C-3). Based on the data shown, this species is probably completing its life cycle and normal population dynamics in the turning basin. L. udekemianus was more concentrated in the western end of Oswego Turning Basin, possibly responding to raw sewage effluents in that area, quieter waters where more detritus settles, and the heated effluent of Oswego Steam Station.

(v) Peloscolex multisetosus

Peloscolex multisetosus has two recognized subspecies, P. multisetosus and P. longidentus; the former is more abundant than the latter in the Great Lakes (Hiltunen 1967, 1969; Howmiller and Beeton, 1970), where it appears to be most abundant in polluted areas (Hiltunen, 1967, 1969; Howmiller and Beeton, 1976) with highly organic sediments.* It is an unspecialized detritus feeder which probably utilizes both bacteria and dissolved nutrients in the sediment (Brinkhurst and Chua, 1969).

P. multisetosus was concentrated at the western stations (OTB-6 and OTB-10) and was not found at OTB-4 (Table IV.C-4) during 1975, possibly due to sewage effluents, calm water

* Although it was present in the open water of Lake Michigan, Hiltunen (1967) stated that Peloscolex multisetosus "thrives in bays and harbors which receive excessive nutriment."

TABLE IV C-4

ABUNDANCE OF THREE OLIGOCHAETA SPECIES[a]

OSWEGO TURNING BASIN - 1975-1976

I. *Peloscolex multisetosus*[b]

STATION	1975 JUN	1975 SEP	1975 DEC	1976 MAR
OTB- 6	688	208	528	400
OTB-10	1296	464	176	352
OTB- 4	0	0	0	0

II. *Tubifex tubifex*

OTB- 6	352	0	176	2064
OTB-10	704	96	816	2592
OTB- 4	32	0	0	352

III. *Dero* sp.

OTB- 6	0	1984	0	176
OTB-10	1728	304	2928	0
OTB- 4	160	2416	32	48

[a]Mean of two replicates; number of organisms/m^2

[b]Both variations combined

with detrital sedimentation, and the warm Oswego Steam Station effluent. It is probably completing its life cycle in the basin.

The two other species of Peloscolex, P. ferox and P. freyi are generally found in mesotrophic or eutrophic areas which are relatively unpolluted (Howmiller and Beeton, 1970). P. ferox is common in the palaearctic zone, but has limited distribution in North America and was possibly introduced from Europe (Brinkhurst, 1965). These organisms were found in low numbers only at OTB-6 and OTB-10.

(vi) Tubifex tubifex

Tubifex tubifex (Muller) is cosmopolitan and widely distributed in North America. It is not common outside of organically polluted areas (Brinkhurst, 1965), the most productive lakes, and also the least productive lakes where few competing species are present (Brinkhurst and Jamieson, 1971). In moderately productive lakes in which a number of species occur it is less abundant. The fauna of small ponds is frequently limited to T. tubifex and L. hoffimeisteri, possibly because of limitations in the ability of other species to invade such sites (Brinkhurst and Jamieson, 1971).

Tubifex tubifex is considered a freshwater indicator organism and is included in almost every indicator association. In cases of extreme pollution, T. tubifex and L. hoffmeisteri may make up the entire fauna. As conditions improve, T. tubifex will become less abundant and other species will come back into the community.

Tubifex tubifex has been found both above and below a thermal effluent in the polluted River Trent, Great Britain, where only four other species of oligochaetes were recorded (Aston, 1973).

In the Great Lakes, Hiltunen (1969) found T. tubifex present in western Lake Erie but noted that its "distribution and abundance was not noteworthy." Brinkhurst (1967) did not record this species from Saginaw Bay, Lake Huron, in spite of the polluting influence of the Saginaw River. In Lake Michigan, T. tubifex was widely distributed, and abundant in polluted waters although not abundant in clean waters (Hiltunen, 1967). It was found only in the May 1967 and May 1969 samples in a two-year sampling program (sampling period: October 1967 to September 1969) in Green Bay, Lake Michigan (Howmiller and Beeton, 1970). In Lake Michigan, populations of T. tubifex decline in late summer and fall, possibly suggesting a cessation of sexual activity before turnover of the lake. There is evidence that recruitment may be gradual from spring to fall (Hiltunen, 1967).

Temperature does not affect total egg production between 10 and 25°C, although the number of eggs per cocoon decreases (Aston, 1973). The role of microflora as food of worms has been investigated by Brinkhurst and Chua (1969), and their results indicate that tubificids selectively digest bacteria although they do not selectively ingest them.

T. tubifex exhibited normal population fluctuations in Oswego Turning Basin and is probably completing a normal life cycle there (Table IV.C-4). Population densities were lowest at OTB-4, the eastern station, where the polluted Oswego River is probably more diluted by lake water and currents probably make sediments less stable than at the western stations. Raw sewage effluents, calm, protected waters which allow detrital sedimentation, and the warm Oswego Steam Station effluent may favor populations of T. tubifex at the western stations.

(vii) Naididae

Naid oligochaetes are also common, and one, Dero sp., occurs in large numbers in a majority of samples from Oswego Turning Basin.

Dero digitata has been found both in polluted and unpolluted areas. It was the most common naidid collected in Green Bay, which is polluted both from pulp and paper mill effluents and from industrial and human wastes (Howmiller and Beeton, 1970), and in Saginaw Harbor, Lake Huron, which is polluted from the inflow of the Saginaw River (Brinkhurst 1967). Shrivastava (1962, cited in Hiltunen, 1967) found Dero in water contaminated by industrial effluents, although Dero digitata has also been reported from some clean habitats (Howmiller and Beeton, 1970). Unlike most other tubificids, Dero, although tube-dwelling, swims (Brinkhurst, 1964) and might be able to avoid the most intolerable conditions. Its ability to swim may also explain its very strong seasonal fluctuation in South Green Bay, where it was observed to be abundant in October 1966, but gone by May 1967 (Howmiller and Beeton, 1970), and in Oswego Harbor (Table IV.C-4).

The distribution of Dero sp. is sporadic in the Oswego Turning Basin, as might be expected for a mobile species (Table IV.C-4). This distribution indicates that Dero sp. is completing probably a normal life cycle in the Oswego Turning Basin.

Nais elinguis, another naid occurring in Oswego Turning Basin, is frequently found in large numbers in polluted streams (Brinkhurst, 1965).

(viii) Other Species

Other species of importance are Gammarus fasciatus, which is treated in depth in Section 1c, and the gastropod Bithynia tentaculata, which occurred in March at OTB-4. Bithynia is a pollution tolerant gastropod, introduced from Europe, which occurs in very large numbers in the Oswego River (Harman and Berg, 1971; Kinney, 1972)).

The abundance of the amphipod Gammarus fasciatus does not follow the pattern described for either total organisms or total Tubificidae (Figure IV.C-7). Because Gammarus has the ability to swim, benthic abundances of this organism may not reflect the total population abundance. Estimates of Gammarus abundance in the water column are present in section 1c.

Gammarus fasciatus disappeared from both the plankton and the benthos of OTB-4, at the entrance of Oswego Harbor, in December, although chemical data collected in this study do not indicate any reason for the phenomenon. On the other hand, the highest abundance for G. fasciatus also occurred in December, but at OTB-10, indicating an accumulation of Gammarus at this station, possibly even a movement from the less protected OTB-4 area to OTB-10. Gammarus abundance was also highest among the plankton at OTB-10 during the December sampling period.

f. Diversity and Classification Analysis

Shannon-Wiener diversity values (base 2) ranged from 1.25 to 3.67 (Table IV.C-5), averaging 2.90 (0.87 base 10). Average diversity for all stations did not vary greatly seasonally and was lowest in March (2.48) and highest in December (3.13). Among stations, the highest diversity values all occurred at OTB-10 (the average was 3.54). The lowest diversity occurred at OTB-4 in March (1.25) when this station was dominated by Bithynia tentaculata.

Classification (cluster analysis) of stations was performed using percent similarity $[\sum_i^S \min (p_{ia}, p_{ib})]$, calculated by summing the minimum percent of each species i that occur in either station a or station b, and unweighted pair-group average clustering strategy (Sneath and Sokal, 1973). Species were then clustered by the same procedure, using the percent similarity of species

TABLE IVC-5

SHANNON-WIENER DIVERSITY VALUES (BASE 2) FOR BENTHOS

OSWEGO TURNING BASIN - 1975-1976

	STATION			
DATE	OTB 6	OTB 10	OTB 4	MEAN
JUN	2.69	3.63	2.96	3.09
SEP	2.31	3.60	2.72	2.88
DEC	2.89	3.67	2.86	3.13
MAR	2.92	3.27	1.25	2.48
MEAN	2.70	3.54	2.45	2.90

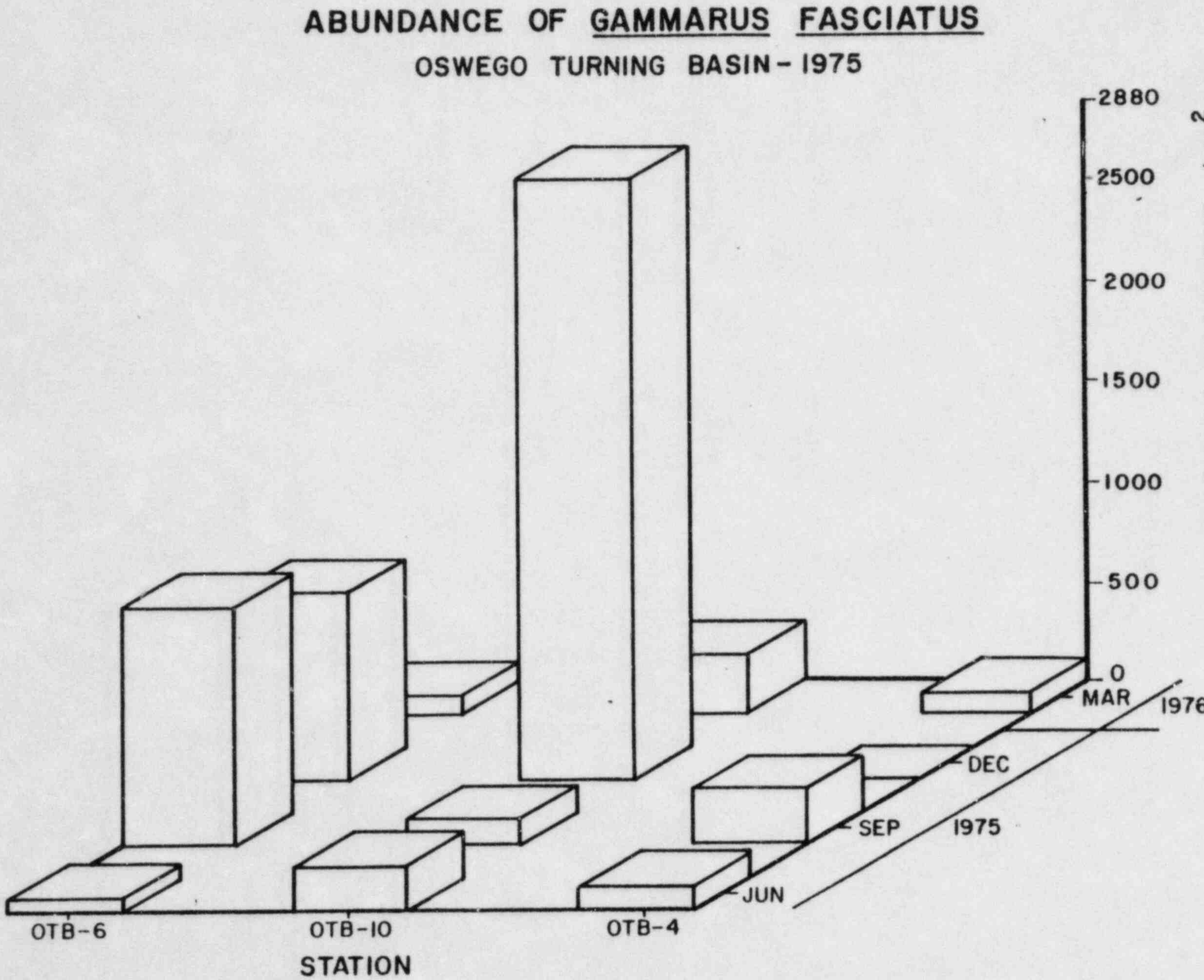

ABUNDANCE OF GAMMARUS FASCIATUS
OSWEGO TURNING BASIN - 1975
2880
2500
2000
1500
1000
500
0
NUMBER OF ORGANISMS / M2
MAR
1976
DEC
SEP
1975
JUN
OTB-6
OTB-10
OTB-4
STATION

FIGURE IVC-7

among stations. The species cluster was restricted to the oligochaete community, which dominated the majority of stations.

Furthermore, species which only occurred at one station were eliminated, as they would have yielded the least information. In clustering species each replicate sample was considered separately; in clustering stations, each station (two replicates) was considered a unit. The first analysis yielded groups of similar stations, the second groups of similar species. The results of cluster analyses are presented as dendrograms.

In March, OTB-4 was very dissimilar to the group of other stations (Figure IV.C-8); dominance there of the snail *Bithynia tentaculata* resulted in the lowest recorded diversity (Table IV.C-5) of this study. The remaining group of stations appear to form three groups: group A, consisting of OTB-6 in June and OTB-6 in December; group C, of OTB-6 in September, OTB-10 in December, and OTB-4 in September; and group B, of the remaining stations.

The oligochaete community appeared to form six groups (Figure IV.C-9).

The resulting clusters of stations and species were then tabulated (Table IV.C-6) to determine whether particular associations of species (I-VI) were restricted to certain groups of stations (A-D).

Species group I consists of two species of *Limnodrilus* and *Potamothrix moldaviensis*, saprobionic or saprophilous species which are widely distributed in Lake Ontario. They were scattered among the four groups of stations.

Species group II contains oligochaetes, commonly classified as saprobionts (see section 2e); they are ubiquitous and common in the turning basin (Table IV.C-6), as well as in many organically polluted harbors in the Great Lakes. This group includes *Tubifex tubifex*, *Ilyodrilus templetoni*, and three species of *Limnodrilus*.

Species group III appears to have been typical, along with the common group II, at OTB-6. Species group III, *Peloscolex multisetosus*, *Paranais frici* and *Nais* sp., were probably responsible for the close association between OTB-6 in June and December and their separation from the rest of station group B.

Species group IV, also including only three species, was scattered in distribution somewhat like species group I. The majority of individuals in species group IV occurred in June at OTB-6 and OTB-10. These appeared to be summer species in the turning basin but not at the entrance.

TABLE IV C-6

ALLOCATION OF MACROINVERTEBRATE SPECIES TO SPECIES GROUPS
AND THEIR DISTRIBUTION AMONG STATION GROUPS

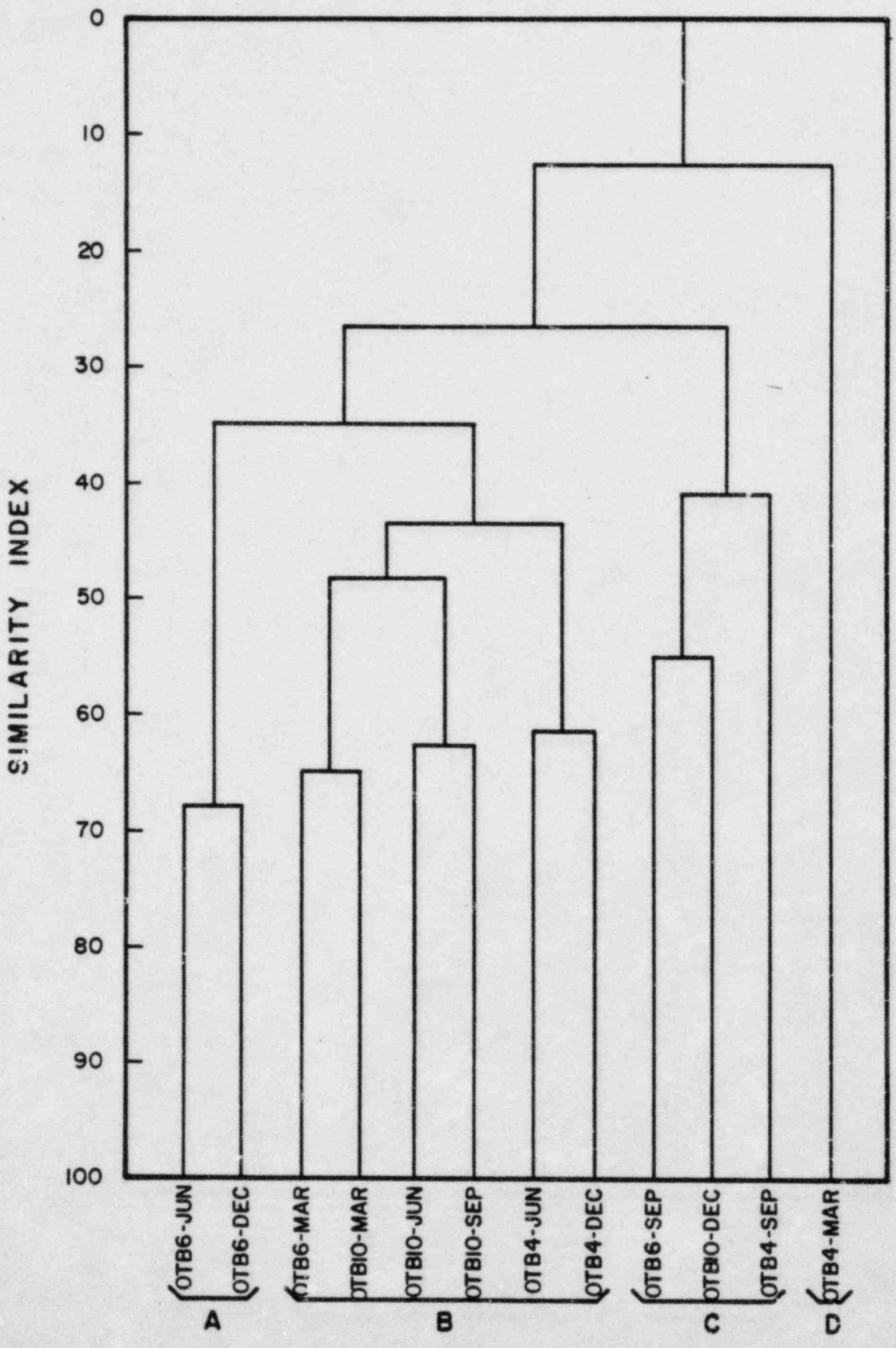
OSWEGO TURNING BASIN - 1975

STATION GROUPS

SPECIES GROUP	SPECIES	A		B						C			D
		OTB-6 JUN	OTB-6 DEC	OTB-6 MAR	OTB-10 MAR	OTB-10 JUN	OTB-10 SEP	OTB-4 JUN	OTB-4 DEC	OTB-6 SEP	OTB-10 DEC	OTB-4 SEP	OTB-4 MAR
I	Limnodrilus claparedianus				688		48	32			48		
	Limnodrilus spiralis	352			352			32	32		48		
	Potamothrix moldaviensis	352			432	96		96	96			176	384
II	Limnodrilus udekemianus	12.6	176	1072	432	864	48	48	32	48	352	96	48
	Limnodrilus cervix variant	3616	176	3024	1632	528	224	64		64	688		176
	Limnodrilus hoffmeisteri	3280	2928	4272	4480	2512	304	944	240	96	864	352	960
	Tubifex tubifex	352	176	2064	2592	704	96	32			816		352
	Limnodrilus cervix	2752	864	272	1984	1120	96	1040	112	96	480	528	1168
	Ilyodrilus templetoni		352	352	1120	96	48			32	96		256
III	Peloscolex multisetosus	688	528	352			112			112	48		
	Paranais frici	12576	7232	736		528				48	1936		
	Nais sp.	352	1392	384			32			48	304		48
IV	Limnodrilus profundicola	352				96	32						48
	Nais bretscheri	528				352							
	Uncinais uncinata	864								48			
V	Aulodrilus pigueti		352			1120	32	48	32		128	1120	352
	Dero sp.			176		1728	304	160	32	1984	2928	2416	48
	Peloscolex multisetosus longitentus			48	352	2064	352			96	128		
	Aulodrilus limnobius										48	1632	
VI	Aulodrilus pluriseta				176		32			32	48		704
	Potamothrix vejdovskyi												80
OTHERS	Bithynia tentaculata	32	736			32		32			112		21008
	Gammarus fasciatus	64	928	96	288	224	128	112		1168	2960	272	96

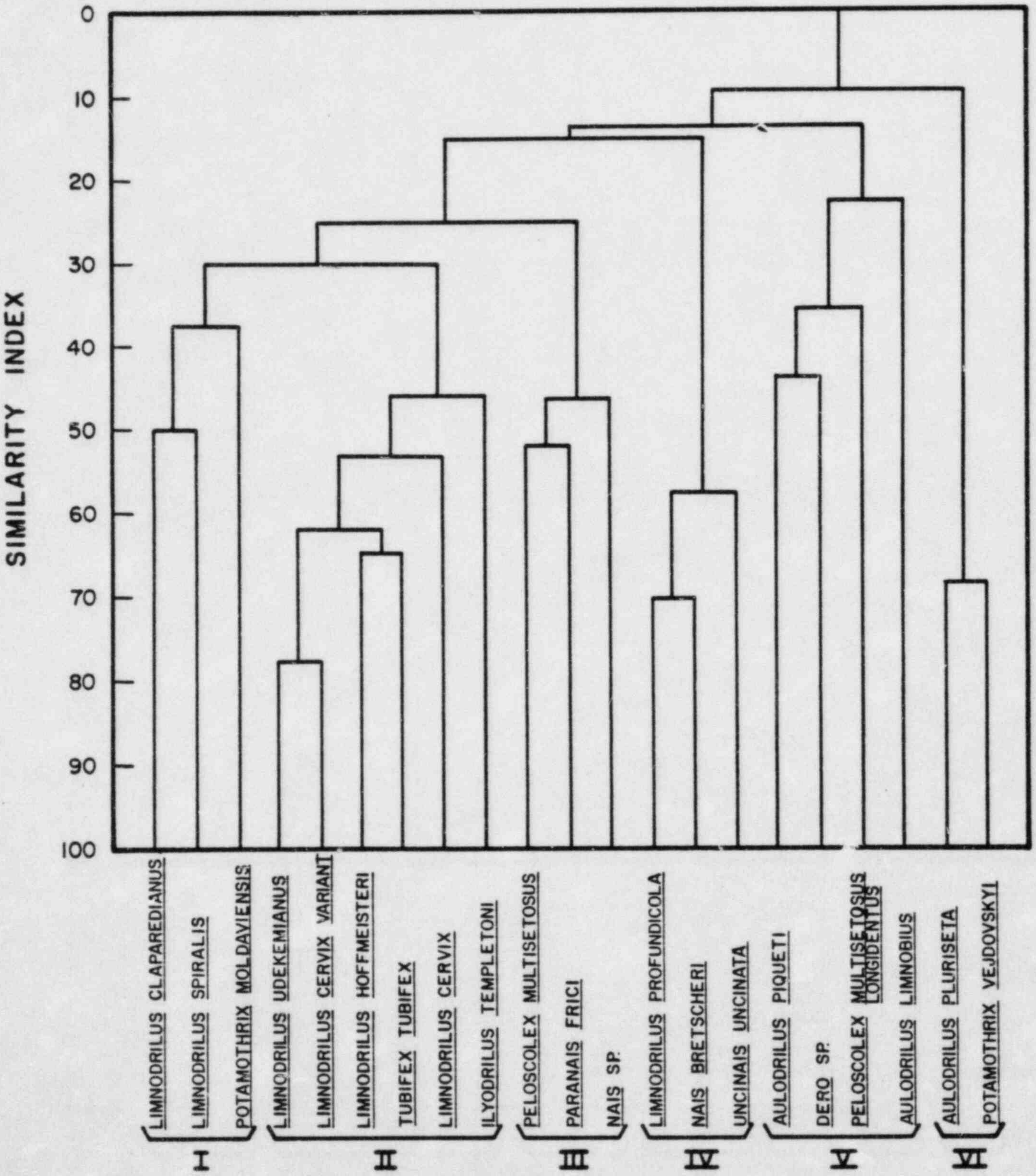
SIMILARITY OF BENTHIC COLLECTIONS BY DATE

OSWEGO TURNING BASIN-1975-1976



SIMILARITY OF OCCURRENCE OF SELECTED SPECIES IN BENTHIC COLLECTIONS

OSWEGO TURNING BASIN — 1975-1976



Species group V occurred mostly in station groups B and C. One species of group V, Dero sp., plus Gammarus fasciatus dominate station group C and the abundance of these two species affects the separation of group C from the other stations.

The small group VI, comprised of Aulodrilus pluriseta and Potamothrix vejdovskyi, occurred mostly at OTB-4 in March, and along with the snail, Bithynia tentaculata, indicate the difference between OTB-4 and the other stations.

From this analysis, the following overview of the Oswego Turning Basin benthic communities can be seen. The entire turning basin can be generally characterized by a persistent, common association of the species Gammarus fasciatus, Limnodrilus cervix, L. cervix variant, L. hoffmeisteri, L. udekemianus, Ilyodrilus templetoni, and T. tubifex. In addition to this group, station 6 is characterized by the assocation of Peloscolex multisetosus, Nais sp., and Paranais frici. Dero sp. with G. fasciatus dominated OTB-4 and OTB-6 in September and OTB-10 in December. Ecological data on these species was presented in section 2e and will not be repeated here.

Station group B consisted of one-half of the sampled stations and probably most typifies the community. All of the highest diversity values except one (see Table IV.C-6) occur in group B. Groups A, C and D may result from periodic colonization by other species or associations (such as Bithynia tentaculata for group D, Dero sp. and Gammarus fasciatus for group C, and Paranais frici for group A). Such short term colonizations decrease local diversity values because of the high dominance of one or two species. Periodic colonization by different groups is not atypical of benthic communities and indicates that normal community dynamics are probably in progress.

g. Comparison of Oswego Turning Basin (1975) with Oswego Harbor (1968-1969)

The macrobenthos of Oswego Harbor was sampled by Environmental Protection Agency Rochester Field Station personnel in 1968 and 1969 (Kinney, 1972). One sampling station at the mouth of Oswego Harbor was not far from OTB-4 in the present study. Another group of stations in the inner harbor was in the area of OTB-10 in this study. Although there was no station corresponding to OTB-6, these investigators did sample in the mouth of the Oswego River. All samples were collected from May to August in 1968 and 1969, and are most comparable to the June 1975 samples of this study. A summary of sampling dates and locations appears as Table IV.C-7.

TABLE IV.C-7

OSWEGO HARBOR SAMPLING STATIONS, 1968-1969*

STATION NUMBER	LOCATION	SAMPLING DATES	NUMBER OF SAMPLES	DEPTH RANGE (ft)	BOTTOM TYPE
9	Oswego Harbor Entrance	June 1968 and May-July 1969	2	8.0-11.0	Silt-Clay
10	Inner Oswego Harbor	May-July 1969	5	5.0- 9.0	Silt-Clay
12	Oswego River	June-August 1968 May 1969	4	6.0-10.0	Silt-Detritus

* Kinney, 1972

The benthos of Oswego Harbor from 1968-1969 and from 1975 may be compared (Kinney 1972). Some differences in the faunal inventories and abundances may result from the use of different sizes of grab samplers (Kinney used a Ponar, LMS a 6 x 6 inch Petit-Ponar) and different sieve sizes (Kinney used a No. 30 sieve with 0.59 mm or 0.0232 inch openings, LMS a No. 40 sieve with 0.42 mm or 0.0165 inch openings). The smaller mesh size used by LMS will favor the inclusion of such smaller organisms as Nematoda, naid oligochaetes, and ostracods. Relative densities of larger organisms, however, should be the same or similar and presence-absence comparisons may be the most useful.

Many more species were collected in June of 1975 than in the May to August period of 1968-1969 (Table IV.C-8). Those whose mature forms are large enough not to be accounted for by sieve size difference are the rhyncocoel, Prostoma; the snails Valvata piscinalis, Amnicola integra, A. limnosa, Goniobasis livescens, and Heliosoma anceps; the tubificid oligochaetes Aulodrilus limnobius, A. pigueti, Peloscolex freyi, Potamothrix moldaviensis; the leeches Helobdella stagnalis and G. complanota, and the amphipod Hyalella azteca. Some species and genera, such as the order Chironomidae were observed during the present LMS study and were not noted in the Kinney report; however, this was probably due to the lumping of these groups under higher categories of identification by Kinney.

Of the tubificids, A. limnobius has been found to favor polluted areas and A. pigueti to tolerate them (Hiltunen, 1969), whereas Peloscolex freyi favors mesotrophic or eutrophic areas which are relatively unpolluted (Howmiller and Beeton, 1970), and Potamothrix moldaviensis is most abundant in areas of nutrient enrichment. The snails and leeches are typical fauna of protected mesotrophic areas (MacKenthun et al., 1964; Harman and Berg, 1971) and Helobdella was found frequently associated with gross organic contamination and thriving under anaerobic conditions (Resh and Unzicker, 1975). The amphipod Hyalella is considered tolerant of pollution and frequently associated with moderate levels of organic contamination (Resh and Unzicker, 1975). None of the forms found in 1975 and not in 1968-1969 are organisms associated with clean or oligotrophic waters.

Organisms found in 1968-1969 but not in 1975 include a snail, Valvata sincera; the annelid Stylodrilus heringianus; two chironomids, Parachironomus abortivus and Tanytarsus sp. One of these species, S. heringianus, found in substantial numbers at the Oswego Harbor station in 1968-1969 (67 organims/m^2), is a species generally restricted to clean waters and sandy sediments (Brinkhurst

TABLE IV C-8

ABUNDANCE[a] OF MACROINVERTEBRATES
COLLECTED IN TWO SURVEYS[b] IN THE OSWEGO VICINITY

1968-1969 AND 1975

TAXON	OSWEGO TURNING BASIN 1975[c]		OSWEGO HARBOR ENTRANCE		INNER OSWEGO HARBOR		OSWEGO RIVER 1968-1969
	JUN	YEARLY	1968-1969	1975[d]	1968-1969	1975[e]	
CNIDARIA							
Hydrozoa							
Athecata							
Clavidae							
Cordylophora sp.		16					
C. lacustris							
Hydridae							
Hyra sp.							
H. americana	16	4				48	
RHYNCHOCOELA	16	<16					
PLATYHELMINTHES		16					
Turbellaria							
Tricladida							
Planariidae	16	144				32	
ASCHELMINTHES							
Nematoda	16	16				64	
Chromadoroidea							
Plectidae							
Anonchus sp.		<16					
Enoplida							
Alaimidae							
Alaimus sp.	16	<16					
Dorylaimida							
Dorylaimidae							
Dorylaimus sp.	16	16		32			
Laimydorus sp.		16					
Rhabditida							
Rhabditidea							
Butlerius sp.		<16					
MOLLUSCA							
Gastropoda							
Mesogastropoda							
Valvatidae							
Valvata sp.		16					
V. piscinalis	16	32		32			
V. sincera					40		153
V. tricarinata							3
Bulimidae		<16					
Amnicola sp.		<16					
A. integra		<16					
A. limnosa		16					
Bithynia tentaculata	32	1840	162	32	110	32	20167
Pleuroceridae							
Goniobasis sp.							
G. livescens		16					
Pleurocera sp.							7

TABLE IV C-8
(Continued)

ABUNDANCE[a] OF MACROINVERTEBRATES
COLLECTED IN TWO SURVEYS[b] IN THE OSWEGO VICINITY

TAXON	OSWEGO TURNING BASIN 1975[c]		OSWEGO HARBOR ENTRANCE		INNER OSWEGO HARBOR		OSWEGO RIVER 1968-1969
	JUN	YEARLY	1968 1969	1975[d]	1968 1969	1975[e]	
MOLLUSCA (Continued)							
Basommatophora							
Physidae							
Physa sp.		16	5				25
P. integra		<16					
Planorbidae							
Planorbula							3
Gyraulus sp.			13				19
G. parvus		16					
Helisoma sp.							
H. anceps	16	<16				32	
Promenetus sp.							
P. exacuous		16					
Ancylidae		<16					
Ferrissia sp.							
F. tarda		<16					
Bivalvia							
Heterodontida							
Sphaeriidae			13				10
Pisidium sp.	64	96		64		112	
Spaherium sp.		<16					
ANNELIDA							
Polychaeta							
Sabellida							
Sabellidae							
Manayunkia sp.							
M. speciosa		80					
Oligochaeta	880	240		48		2416	
Plesiopora							
Lumbriculidae							
Stylodrilus heringianus			61				
Tubificidae	11824	10880	657	1280	7656	18160	25
Aulodrilus sp.							
A. limnobius	16	144		48			
A. pluriseta		80					
A. piqueti	544	272		48		1120	
Limnodrilus sp.							
L. hoffmeisteri	2160	1664	388	784	3881	2416	41
L. udekemianus	704	368		48	358	864	
L. claparedianus	16	64	136	32	505		
L. profundicola	144	48	38			96	
L. cervix	1632	880	375	1040	3113	1120	
L. spiralis	128	64	102	32	407		
L. cervix variant	1408	848		64		528	
L. hoffmeisteri variant	85	112		160		96	

TABLE IV C-8
(Continued)

ABUNDANCE[a] OF MACROINVERTEBRATES
COLLECTED IN TWO SURVEYS[b] IN THE OSWEGO VICINITY

TAXON	OSWEGO TURNING BASIN 1975[c] JUN	YEARLY	OSWEGO HARBOR ENTRANCE 1968 1969	1975[d]	INNER OSWEGO HARBOR 1968 1969	1975[e]	OSWEGO RIVER 1968-1969
ANNELIDA (Continued)							
Ilyodrilus sp.							
I. templetoni	48	192				96	
Peloscolex sp.							
P. freyi		16				256	
P. ferox		<16					
P. multisetosus	224	160					
P. multisetosus longidentus	432	192			135	1296	
Tubifex sp.							
T. tubifex	368	608					
Potamothrix sp.			136	32	119	704	
P. moldaviensis	176	144		96		96	
P. vejdovskyi		16					
Naididae							
Nais sp.	112	208					
N. bretscheri	228	80				352	
N. elinguis		<16					
N. communis		16					
Ophidonais sp.							
O. serpentina	64	16					11
Paranais sp.		16					
P. frici	4368	1920					
Uncinais sp.							33
U. uncinata	288	80					
Dero sp.	624	816		160		1728	
Hirudinea							
Rhynchobdellida							
Glossiphoniidae							
Helobdella sp.							
H. stagnalis		<16					
Glossiphonia sp.							
G. complanata		<16					
ARTHROPODA							
Archnida							
Acari							
Limnesiidae							
Limnesia sp.		16					
Hygrobatidae							
Hygrobates sp.							
H. sp. 3		16					
Arrenurus sp.		<16					
Insecta							
Odonata		<16					
Trichoptera							
Leptoceridae							

TABLE IV C-8
(Continued)

ABUNDANCE[a] OF MACROINVERTEBRATES
COLLECTED IN TWO SURVEYS[b] IN THE OSWEGO VICINITY

TAXON	OSWEGO TURNING BASIN 1975[c] JUN	OSWEGO TURNING BASIN 1975[c] YEARLY	OSWEGO HARBOR ENTRANCE 1968 1969	OSWEGO HARBOR ENTRANCE 1975[d]	INNER OSWEGO HARBOR 1968 1969	INNER OSWEGO HARBOR 1975[e]	OSWEGO RIVER 1968-1969
ARTHROPODA (Continued)							
Trichoptera (Continued)							
Oecetis sp.	16	<16					
Arthripsodes sp.	16	<16					
Diptera							
Culicidae							
Chaoborus sp.							
C. punctipenis		<16					
C. albipes		<16					
Tendipedidae	48	16	104	96		32	
Calopsectra sp.	32	16		80			
Chironomus sp.	16	64		48	15		
Cricotopus sp.		16			4		
Cryptochironomus sp.		<16					
Dicrotendipes sp.		<16					
Harnischia sp.		<16					
Parachironomus abortivus			10				
Polypedilum sp.		<16					
Procladius sp.	96	48		112		160	
Tanytarsus sp.			10				
Crustacea							
Isopoda							
Asellidae							
Asellus sp.	16	80				32	45
Amphipoda							
Gammaridae							
Gammarus sp.							
G. fasciatus	128	528	475	112	30	224	119
Talltridae							
Hyalella sp.							
H. azteca		<16					
Ostracoda	80	96		32		80	
TOTAL	27104	23408	2661	4512	15904	32896	20677

[a] Number of organisms/m^2

[b] Kinney, 1968-1969 (1972) and LMS, 1975 (Present study)

[c] Mean of two replicates and stations

[d] Mean of station OTB-4

[e] Mean of station OTB-10

and Jamieson, 1971). The absence of this species in the more recent survey may be the result of no stations being located as close to the harbor mouth in 1975 as Kinney's station, where lake water might dilute the organically enriched Oswego River water. Populations of S. heringianus can be expected to drop and disappear as water conditions deteriorate (Hiltunen, 1967). In 1968-1969, "the Oswego Harbor macrobenthos reflected heavy nutrient loading in both the species composition and the total standing crop densities. The inner harbor area supported communities consisting almost exclusively of saprophilous and saprobionic species" (Kinney, 1972). This evaluation would also have been true in 1975.

h. Comparison of Oswego Turning Basin in 1970 and in 1975

The benthos of Oswego Turning Basin was sampled for the Niagara Mohawk Power Corp. during 1970 (QLM, 1971). Oligochaetes dominated the samples in 1970 and these oligochaete species were identified: Ilyodrilus templetoni, Limnodrilus hoffmeisteri, and L. cervix variant; other species may have been present. In 1975, oligochaetes also dominated samples and these three species had not disappeared.

Other taxa identified in 1970 and which also occurred in 1975 were amphipods, the chironomid genera Chironomus and Procladius, turbellarian flat worms, gastropods of the genus Amnicola and Valvata, and Bithynia tentaculata, and bivalves of the genus Sphaerium. No taxa were recorded in 1970 that were not recorded in 1975; however, many taxa were identified in 1975 which were not recorded in 1970. Comparison with the 1968-1969 study and the present study indicates no major changes in benthic composition and indicates that a persistent benthic community is inhabiting the turning basin.

3. Conclusions

The benthos of the Oswego Turning Basin has an indigenous, ubiquitous association consisting of at least the species Gammarus fasciatus, Limnodrilus cervix, L. cervix variant L. hoffmeisteri, L. udekemianus, Ilyodrilis templetoni, and Tubifex tubifex. Six other associations occurring in the turning basin were also identified, several of which continued throughout the year.

The benthic community was diverse, with seven phyla and 68 groups identified to generic or specific level. Diversity values averaged 2.90 (Shannon-Wiener to the base 2) and ranged from 1.25 to 3.67.

Species abundances and biomass indicated a productive community. Many of the species and groups found are common food items for higher trophic levels. Beyond the direct evidence of finding indigenous populations of organisms, the fluctuations of abundance of L. hoffmeisteri indicated that this numerically dominant organism was completing its normal life cycle in the turning basin. Other species whose temporal patterns of abundance indicated completion of normal life cycle are: Limnodrilus cervix, L. udekemianus, Peloscolex multisetosus, Tubifex tubifex, and Dero sp. Several species are concentrated either at OTB-6 or at OTB-6 and OTB-10, the western stations. These are: L. cervix, L. profundicola, L. udekemianus, P. multisetosus, and T. tubifex, species which can be described as saprobionic and thermophilic. Comparison with a published study indicated continuity of the benthos community between 1968-1969 and 1975-1976.

The benthos of the Oswego Harbor and Turning Basin consisted mainly of organisms described as saprobionic and saprophilous. Such communities are typical of inshore, harbor, and river mouth communities of most of the larger bays and harbors in the American section of Lake Ontario, locations which are heavily enriched or polluted (Kinney, 1972), and typical of eutrophic ponds and lakes.

D. NEKTON

1. Introduction

In many respects, the Oswego Turning Basin is a unique area for fish communities. Fairly extensive weedy shoals along the southern shoreline provide excellent habitats for the young of several species. The breakwalls afford protection against wind-driven waves and, in combination with the seasonally warm inflow of the Oswego River, maintain uniform temperature regimes in the enclosed waters. In addition, sediment analyses show that the western end of the turning basin contains little sand and mostly detritus, whereas the substratum of Station OTB-4, located near the harbor entrance, consists mostly of sand and shell. Both observations indicate the presence of quieter waters in the western area of the harbor. These and other factors contribute to the successful role of the Oswego Turning Basin as nursery ground for many young fish and for the production of a considerable standing crop of adults.

During 1975 and the winter months of 1976, fishes were sampled with three gear types: seines, trawls, and gill nets. Since these sampling devices differ in their selectivity and efficiency, their combined effort produces a more representative picture of the existing fish community than would the yield of any single gear. Seines for example, emphasize the near-shore area and the smaller fishes, while trawls capture several demersal and sedentary (territorial) types which are not readily susceptible to gill nets. The latter gear is most efficient in capturing the larger, actively swimming forms.

2. Species Inventory and Distributional Trends

A total of 13,176 individuals comprising 44 species and 21 families were collected during the twelve-month survey (Tables IV.D-1 and IV.D-2). Species diversity in the turning basin compares favorably with that of past collections in the vicinity of Oswego where, during a three-year period (1973-1975), a total of 60 species from 21 families were collected at Nine Mile Point and at two lake transects near the Oswego Steam Station. Thus 73% of the total species from the Oswego area were captured during the single year of sampling in the turning basin, despite the fact that the comparable effort during any year of this period averaged only half of that expended at the latter sites.

Qualitative comparisons may also be made with a study in which fish were obtained from bottom gill nets during the period August-December, 1970 (QLM, 1971). Seven species comprised 91% of the total in these collections, and these included the white perch (61%), alewife (20%), and gizzard shad(10%). Other species of numerical importance were the yellow perch (3%), rainbow smelt (2%), spottail shiner (1%), and brown bullhead (1%).

During these same months in 1975, white perch made up 72% of the total in bottom gill net collections in the Oswego Turning Basin; this species was followed, in order of abundance, by gizzard shad (6%), spottail shiner (6%), yellow perch (6%), alewife (5%), and brown bullhead (1%). Two species not recorded in 1970 collections included the carp and freshwater drum, which had <1% and 1%, respectively, of the total in 1975. In addition, rainbow smelt were not captured in the turning basin during these months in 1975. Although the dominant fish species in both surveys were essentially the same, the minor variations exhibited in the data could be potentially significant. Recently, the possibility has been examined of a general downward trend in numbers of rainbow smelt and alewives in the Oswego vicinity (LMS, 1976a). On the other hand, an increase in the numbers of carp, generally regarded as a nuisance species, and freshwater drum is also evident, although the latter species has been on the increase in the lake as well.

Nineteen species comprised 99% of the total catch in the turning basin, unlike lake collections where greater dominance usually results in fewer species making up this total (LMS, 1974, 1975, 1976b). For example, at Nine Mile Point, 10 and 13 species contributed 99% of the catch in 1974 and 1975, respectively; similarly 10, 2, and 13 species made up this total in 1973, 1974 and 1975 (Table IV.D-3), respectively, at the Oswego lake transects. The difference may be attributed largely to the lower number of alewives present and to greater equitability of species abundance in the turning basin. Only

TABLE IVD-1

ABUNDANCE OF FISH IN SEINE, TRAWL, AND GILL NET COLLECTIONS

OSWEGO TURNING BASIN - 1975

		TRAWLS						GILL NETS						TOTALS	
	SEINES*	SURFACE		BOTTOM		TOTAL		SURFACE		BOTTOM		TOTAL			
SPECIES	NO.	NO.	C/F	NO.	C/F	NO.	C/F	NO.	C/F	NO.	C/F	NO.	C/F	NO.	%
Alewife	31	192	12.00	379	22.29	571	17.30	3311	72.20	303	6.72	3614	39.74	4216	32.00
Gizzard shad	335	97	6.06	514	30.24	611	18.52	1581	34.47	119	2.64	1700	18.70	2646	20.08
Spottail shiner	1252	1	0.06	336	19.76	337	10.21	27	0.59	194	4.31	221	2.43	1810	13.74
White perch	1			389	22.88	389	11.79	274	5.97	1088	24.15	1362	14.98	1752	13.30
Golden shiner	934			2	0.12	2	0.06	24	0.52	1	0.02	25	0.27	961	7.29
Yellow perch	308			68	4.00	68	2.06	4	0.09	89	1.98	93	1.02	469	3.56
Emerald shiner	177	218	13.63	19	1.12	237	7.18	1	0.02			1	0.01	415	3.15
Pumpkinseed	204			1	0.06	1	0.03							205	1.56
Threespine stickleback	118	8	0.05			8	0.24							126	0.96
Rock bass	73			4	0.24	4	0.12			14	0.31	14	0.15	91	0.69
Bluegill	75			1	0.06	1	0.03	1	0.02			1	0.01	77	0.58
Brown bullhead	33			7	0.41	7	0.21	21	0.46	13	0.29	34	0.37	74	0.56
Largemouth bass	57													57	0.43
White sucker	1			12	0.71	12	0.36			20	0.44	20	0.02	33	0.25
Rainbow smelt		3	0.19	26	1.53	29	0.88	2	0.04	1	0.02	3	0.03	32	0.24
Northern pike	2							20	0.44	6	0.13	26	0.29	28	0.21
Carp	7			4	0.24	4	0.12	1	0.02	11	0.24	12	0.13	23	0.17
Walleye	7			1	0.06	1	0.03	10	0.22	4	0.09	14	0.15	22	0.17
Johnny darter	5			15	0.88	15	0.45							20	0.15
Freshwater drum				4	0.24	4	0.12			12	0.27	12	0.13	16	0.12
White bass				2	0.12	2	0.06	11	0.24	2	0.04	13	0.14	15	0.11
Black crappie	10							2	0.04			2	0.02	12	0.09
Brown trout								10	0.22	2	0.04	12	0.13	12	0.09
Trout perch				5	0.29	5	0.15	1	0.02	6	0.13	7	0.08	12	0.09
Bowfin								3	0.07	5	0.11	8	0.09	8	0.06
Burbot				1	0.06	1	0.03			5	0.11	5	0.05	6	0.05
Coho salmon	1							5	0.11			5	0.05	6	0.05
Lake chub	2							1	0.22	1	0.02	2	0.02	4	0.03
Rainbow trout								3	0.07	1	0.02	4	0.04	4	0.03
Longnose gar								2	0.04	1	0.02	3	0.03	3	0.02
Mottled sculpin				3	0.18	3	0.09							3	0.02
Smallmouth bass										3	0.07	3	0.03	3	0.02
Splake trout	2							1	0.02			1	0.01	3	0.02
Fathead minnow	2													2	0.02
American eel				1	0.06	1	0.03							1	0.01
Banded killifish	1													1	0.01
Bluntnose minnow	1													1	0.01
Brook silverside	1													1	0.01
Channel catfish										1	0.02	1	0.01	1	0.01
Couesius sp.	1													1	0.01
Goldfish										1	0.02	1	0.01	1	0.01
Golden redhorse										1	0.02	1	0.01	1	0.01
Sea lamprey										1	0.02	1	0.01	1	0.01
Silvery minnow	1													1	0.01

TABLE IV-D-2

SPECIES INVENTORY OF NEKTON IN GILL NET COLLECTIONS

OSWEGO TURNING BASIN - 1975-1976

FAMILY	COMMON NAME	SCIENTIFIC NAME
Amiidae	Bowfin	Amia calva
Anguillidae	American eel	Anguilla rostrata
Atherinidae	Brook silverside	Labidesthes sicculus
Catostomidae	Golden red horse	Moxostoma erythrurum
	Northern hogsucker	Hypentelium nigricans
	White sucker	Catostomus commersoni
Centrarchidae	Black crappie	Pomoxis nigromaculatus
	Bluegill sunfish	Lepomis macrochirus
	Largemouth bass	Micropterus salmoides
	Pumpkinseed	Lepomis gibbosus
	Rock bass	Ambloplites rupestris
	Smallmouth bass	Micropterus dolomieui
Clupeidae	Alewife	Alosa pseudoharengus
	Gizzard shad	Dorosoma cepedianum
Cottidae	Mottled sculpin	Cottus bairdi
Cyprinidae	Bluntnose minnow	Pimephales notatus
	Carp	Cyprinus carpio
	Emerald shiner	Notropis atherinoides
	Fathead minnow	Pimephales promelas
	Golden shiner	Notemigonus crysoleucas
	Goldfish	Carassius auratus
	Lake chub	Couesius plumbeus
	Silvery minnow	Hybognathus nuchalis
	Spottail shiner	Notropis hudsonius
	chub	Couesius sp.
Cyprinodontidae	Banded killifish	Fundulus diaphanus
Esocidae	Northern pike	Esox lucius
Gadidae	Burbot	Lota lota
Gasterosteidae	Threespine stickleback	Gasterosteus aculeatus
Ictaluridae	Brown bullhead	Ictalurus nebulosus
	Channel catfish	Ictalurus punctatus
	Stonecat	Noturus flavus

TABLE IV - D-2 (continued)

SPECIES INVENTORY OF NEKTON IN GILL NET COLLECTIONS

FAMILY	COMMON NAME	SCIENTIFIC NAME
Lepisosteidae	Longnose gar	Lepisosteus osseus
Osmeridae	Rainbow smelt	Osmerus mordax
Percichthyidae	White bass	Morone chrysops
	White perch	Morone americana
Percidae	Johnny darter	Etheostoma nigrum
	Walleye	Stizostedion v. vitreum
	Yellow perch	Perca flavescens
Percopsidae	Trout-perch	Percopsis omiscomaycus
Petromyzontidae	Sea lamprey	Petromyzon marinus
Salmonidae	Brown trout	Salmo trutta
	Chinook salmon	Oncorhynchus tshawytscha
	Coho salmon	Oncorhynchus kisutch
	Lake trout	Salvelinus namaycush
	Rainbow trout	Salmo gairdneri
	Splake trout	Salvelinus namaycush x fontinalis
Sciaenidae	Freshwater drum	Aplodinotus grunniens

TABLE IV.D-3

ABUNDANCE OF FISH IN SEINE AND GILL NET COLLECTIONS

OSWEGO VICINITY - 1975

SPECIES	SEINES	SURFACE GILL NETS		BOTTOM GILL NETS		TOTAL GILL NETS		TOTALS	
	NO.	NO.	C/F	NO.	C/F	NO.	C/F	NO.	%
Alewife	1330	3345	38.90	1863	10.90	5208	20.27	5471	78.13
Spottail shiner	45	3	0.03	486	2.84	489	1.90	494	7.06
White perch	1	2	0.02	312	1.83	314	1.22	315	4.50
Rainbow smelt	1	52	0.60	129	0.75	181	0.70	182	2.60
Gizzard shad	0	15	0.17	113	0.66	128	0.50	128	1.83
Yellow perch	0	0	0	103	0.60	103	0.40	103	1.47
White sucker	0	0	0	71	0.42	71	0.28	71	1.01
Lake chub	0	0	0	58	0.34	58	0.23	58	0.83
Rock bass	0	0	0	43	0.25	43	0.17	43	0.61
Smallmouth bass	0	0	0	40	0.23	40	0.16	40	0.57
Brown trout	0	10	0.12	4	0.02	14	0.05	14	0.20
Coho salmon	3	6	0.07	2	0.01	8	0.03	11	0.16
Stonecat	0	0	0	9	0.05	9	0.04	9	0.13
Brown bullhead	0	0	0	8	0.05	8	0.03	8	0.11
Walleye	0	0	0	7	0.04	7	0.03	7	0.10
Chinook salmon	0	4	0.05	3	0.02	7	0.03	7	0.10
White bass	0	0	0	5	0.03	5	0.02	5	0.07
Emerald shiner	4	0	0	0	0.00	0	0	4	0.06
Carp	0	0	0	4	0.02	4	0.02	4	0.06
Trout perch	0	0	0	3	0.02	3	0.01	3	0.04
Burbot	0	0	0	3	0.02	3	0.01	3	0.04
Lake trout	0	0	0	3	0.02	3	0.01	3	0.04
Gold shiner	3	0	0	0	0	0	0	3	0.04
Freshwater drum	0	0	0	3	0.02	3	0.01	3	0.04
Rainbow trout	0	2	0.02	0	0	2	0.01	2	0.03
Pumpkinseed	0	0	0	2	0.01	2	0.01	2	0.03
Sea lamprey	0	0	0	1	0.01	1	0.004	1	0.01
Bowfin	0	0	0	1	0.01	1	0.004	1	0.01
Goldfish	0	0	0	1	0.01	1	0.004	1	0.01
Northern hogsucker	0	0	0	1	0.01	1	0.004	1	0.01
Longnose dace	1	0	0	0	0	0	0	1	0.01
Brook stickleback	1	0	0	0	0	0	0	1	0.01
Johnny darter	1	0	0	0	0	0	0	1	0.01
Largemouth bass	1	0	0	0	0	0	0	1	0.01
Channel catfish	0	0	0	1	0.01	1	0.004	1	0.01
Total	1391	3439		3279		6718		7002	

32% of the total captured by all gear types were alewives, compared to an average of about 75% in lake collections. In addition, because the rainbow smelt was not sampled intensively during its period of maximum abundance (April) in near-shore waters, the impact of this dominant species on the turning basin collections may have been diminished. An alternative explanation, however, may simply be that smelt prefer cooler waters than those found in the harbor.

When the species making up 99% of the total abundance (i.e., the community dominants) are compared to those captured in the lake, it is apparent that a warm water community characteristic of shallow eutrophic lakes and ponds is present. Specifically, the centrarchids (largemouth bass, bluegill sunfish, pumpkinseed sunfish), northern pike, carp, brown bullhead, golden shiner, bowfin, and longnose gar are all most frequently associated with this type of environment. The warm, protected waters of the basin also provide a habitat suitable for large numbers of gizzard shad. This species contributed 20% of the total abundance in the turning basin in 1975, but was found in much lower numbers at Nine Mile Point and at the Oswego lake transects, where it usually contributed only 1-2% of the total.

The presence of considerable habitat suitable for large numbers of small forage fishes contributes to additional differences between the harbor and lake. Thus, the golden, spottail, and emerald shiners, the threespine stickleback, and the pumpkinseed sunfish were among the dominant species in the turning basin. The remaining major species were similar for both areas, and included the white and yellow perch.

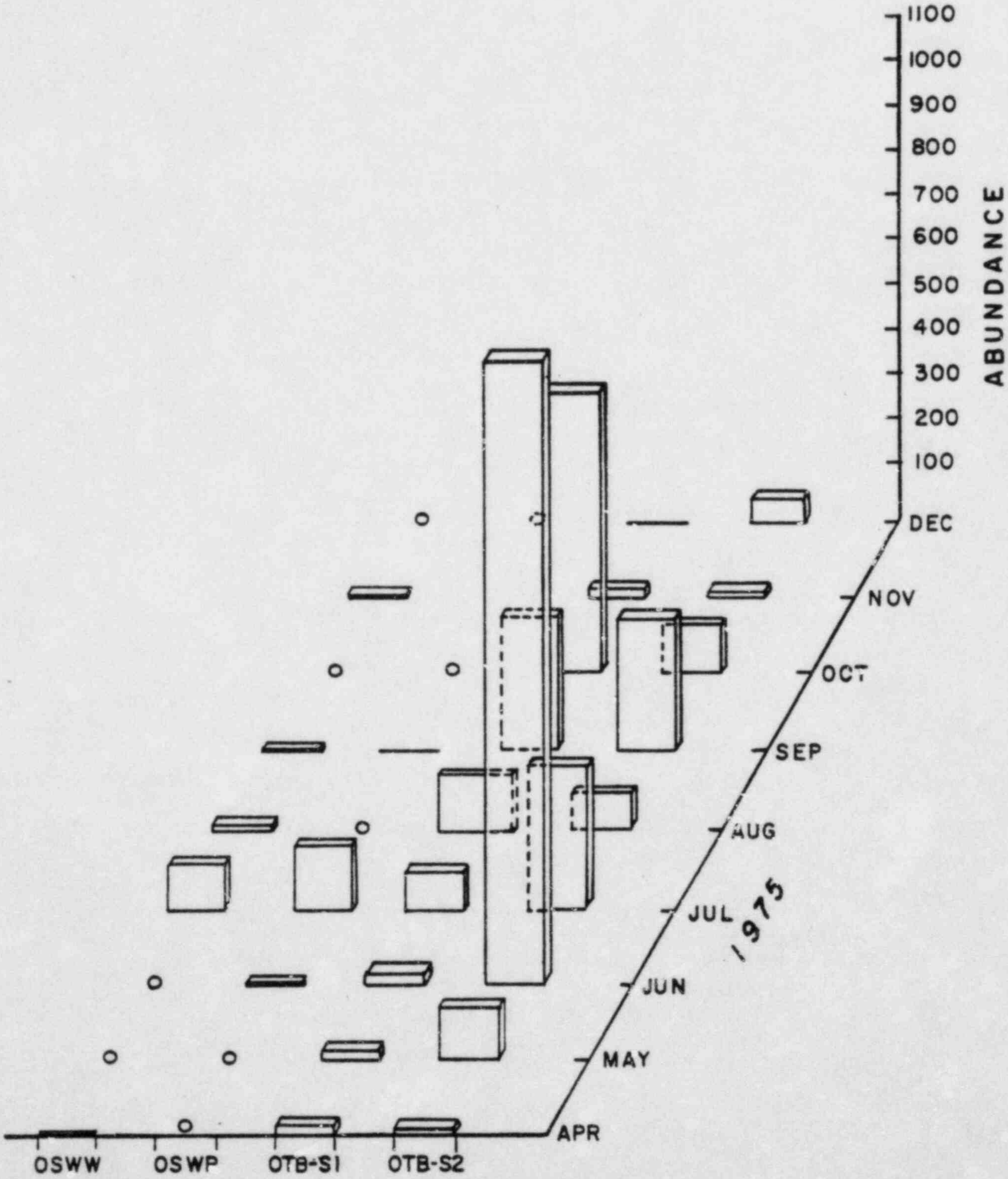
a. Seines

Monthly abundance in the shallow water zone of the turning basin was, on the average, much greater than at similar sites in the lake (Figure IV.D-1), particularly during the period from June through October. Species and percent composition in 1975 lake seine collections are compared in Figure IV.D-2 for both areas. The Nine Mile Point data represent twice the sampling effort since collections at four transects (LMS, 1975) are being compared to two at both Oswego sites.

As shown in Figure IV.D-2, species richness was greater in the turning basin during every sampling month. Unlike the lake, where the alewife usually dominated the inshore collections, dominance was shared by several species in the Oswego Turning Basin. Furthermore, several forage species were particularly abundant in the harbor including the golden shiner, spottail shiner, emerald shiner, and the threespine stickleback. These fishes are consumed by a wide variety of predators in the area including centrarchids, salmonids, percichthyids, percids, and esocids. Notably, very few young alewives were present in the

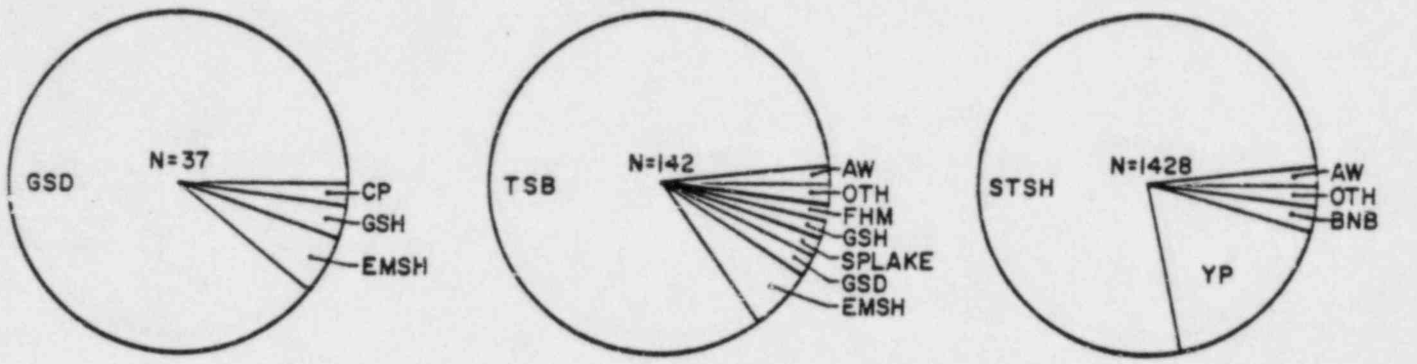
ABUNDANCE OF FISH IN 50 FT SEINE COLLECTIONS

OSWEGO VICINITY — 1975

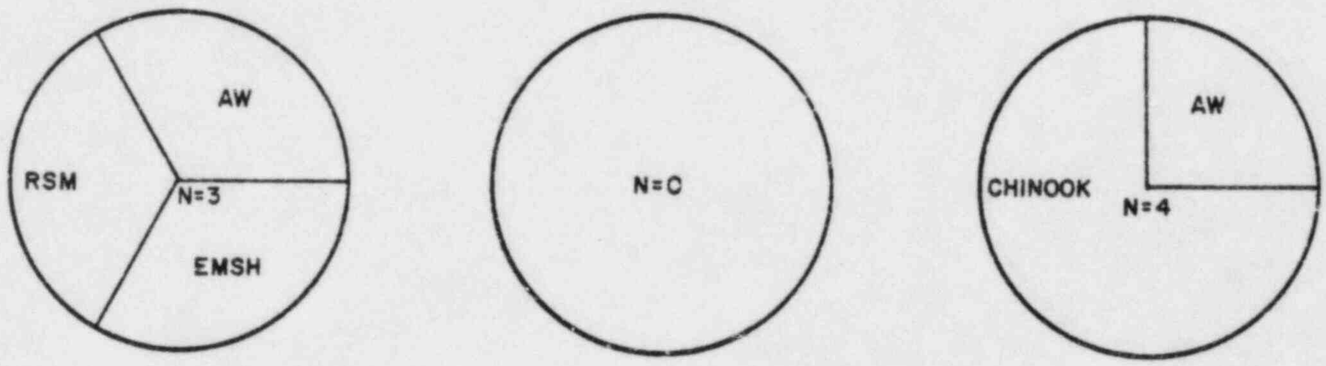


PERCENT COMPOSITION OF MONTHLY SEINE COLLECTIONS IN THE OSWEGO TURNING BASIN AND LOCATIONS IN LAKE ONTARIO 1975

OSWEGO TURNING BASIN



OSWEGO VICINITY



NINE MILE POINT VICINITY

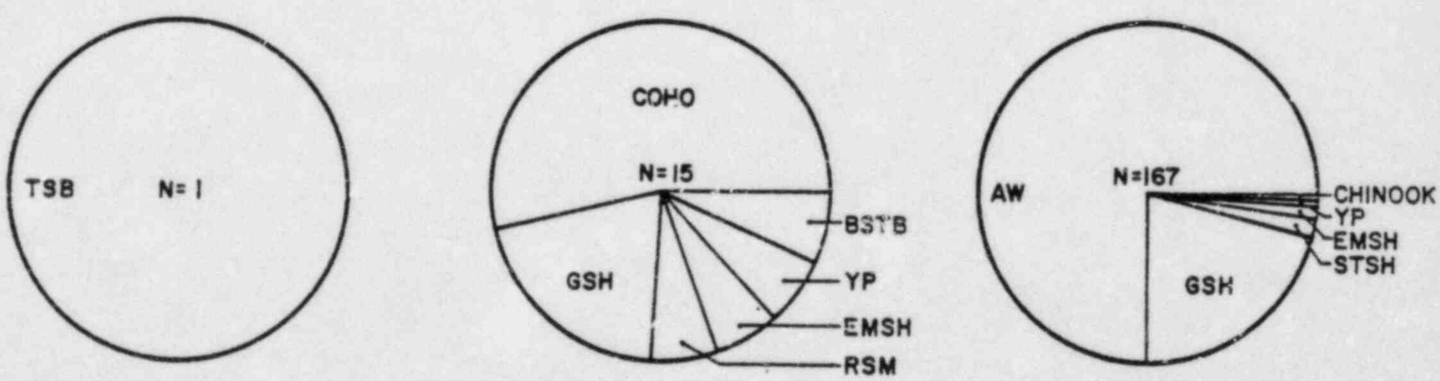


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FIGURE IVD-2
Continued

PERCENT COMPOSITION OF MONTHLY SEINE COLLECTIONS IN THE OSWEGO TURNING BASIN AND LOCATIONS IN LAKE ONTARIO 1975

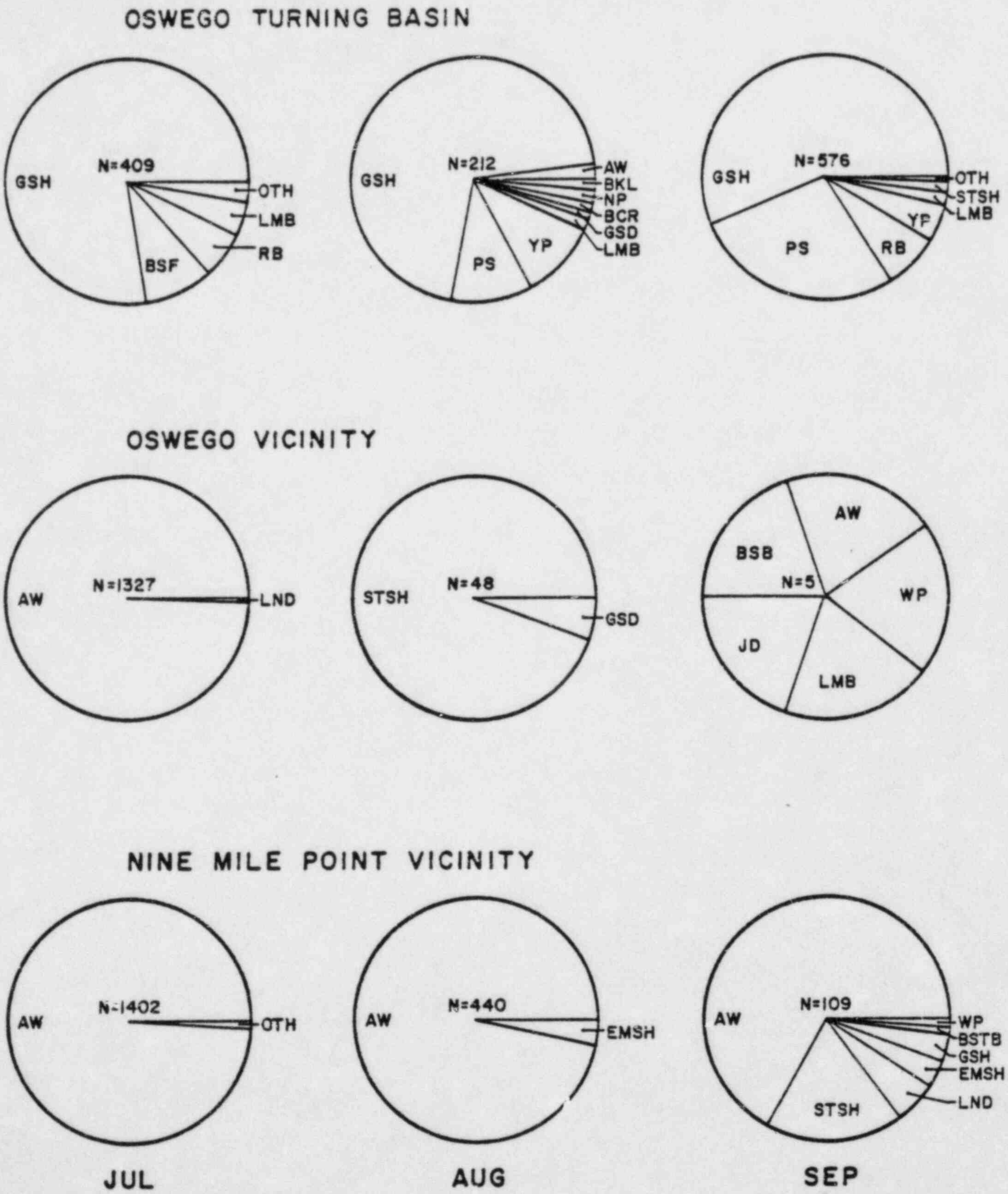


FIGURE IVD-2
Continued

PERCENT COMPOSITION OF MONTHLY SEINE COLLECTIONS IN THE OSWEGO TURNING BASIN AND LOCATIONS IN LAKE ONTARIO 1975

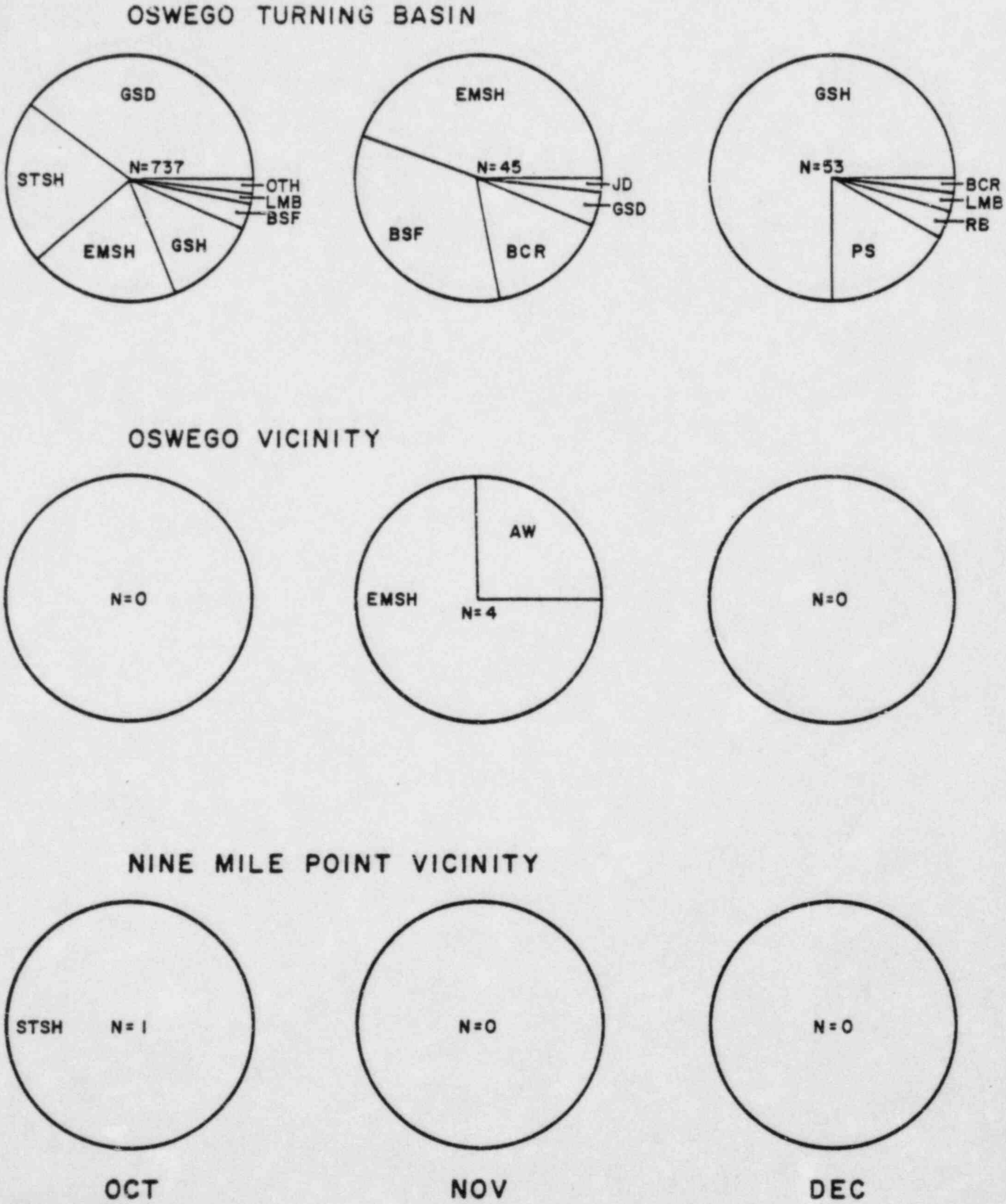


FIGURE IV D-2
(Continued)

AW	Alewife
BCR	Black crappie
BKL	Banded killifish
BNB	Brown bullhead
BSF	Bluegill sunfish
BSTB	Brook stickleback
Chinook	Chinook salmon
Coho	Coho salmon
CP	Carp
EMSH	Emerald shiner
FHM	Fathead minnow
GSD	Gizzard shad
GSH	Golden shiner
JD	Johnny darter
LMB	Largemouth bass
LND	Longnose dace
NP	Northern pike
PS	Pumpkinseed
RB	Rock bass
RSM	Rainbow smelt
Splake	Splake trout
STSH	Spottail shiner
TSB	Threespine stickleback
WP	White perch
YP	Yellow perch

harbor collections, a fact which is apparently a result of this species not utilizing the turning basin as a nursery area. Insufficient data were available to plot length frequency distributions for specimens from seine collections, except for the yellow perch. Although this sample was also relatively small, the distribution shown in Table IV.D-4 clearly demonstrates that young perch utilize the near-shore nursery area and exhibit rapid growth throughout the summer months.

The more stable temperature regime in the turning basin also allows some utilization of the near-shore area during the winter; in November and December, for example, 98 individuals and nine species were collected in the harbor compared to a total of only four individuals of two species collected at lake stations (Figure IV.D-2).

b. Trawls

Relatively few fishes were collected by trawling during the study period. A large percentage of individual hauls did not yield any fishes at all: 62% of all surface and 34% of bottom hauls were empty. In addition, the lowest number of species was obtained by this gear type, 23 as compared to 32 in the gill nets.

More fish were captured at the bottom than at the surface (Figure IV.D-3); however, the species that dominated at the two levels differed. The emerald shiner was most abundant in the surface catches with 42% of the total (Table IV.D-1). This species is a pelagic or open water form which usually congregates at the surface during the spring and summer (Scott and Crossman, 1973), and is also an important forage fish whose abundance seems to fluctuate widely from year to year. The other species captured by surface trawls consisted mainly of alewives (37%) and gizzard shad (19%). Dominance in bottom collections was evenly distributed among four species including the gizzard shad (29%), white perch (22%), alewife (21%), and spottail shiner (19%). Other species were captured in relatively low numbers during the year.

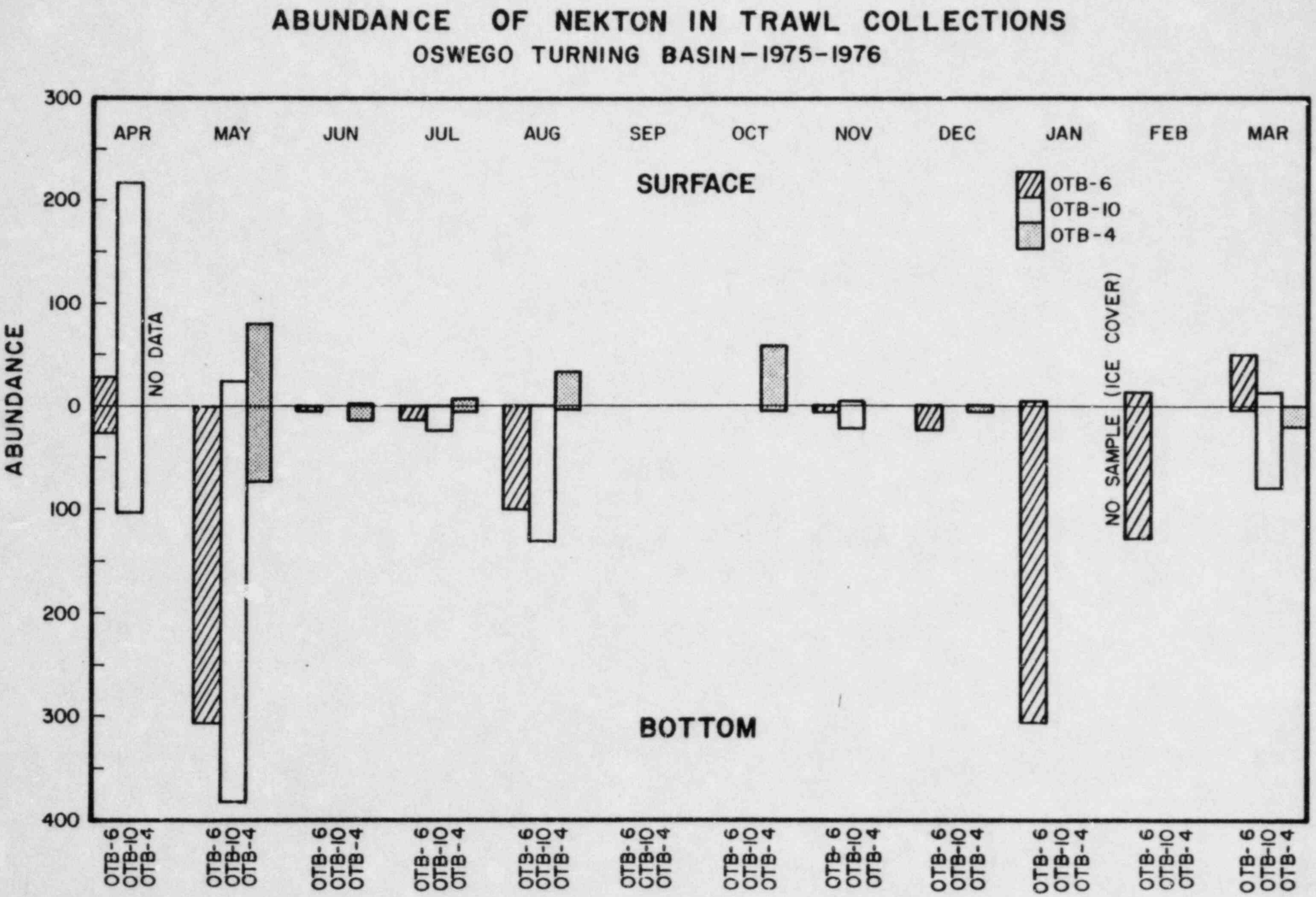
Few individuals were captured during the summer and early fall. The two largest hauls occurred in August at OTB-6 and OTB-10, where 88 and 67%, respectively, of the total catch were white perch. The winter collections consisted mainly of gizzard shad, a species that seemed to favor the warmer water of the harbor. In the early spring, depending on the station, different species, including the emerald shiner, spottail shiner, white perch, and alewife, dominated the catches.

TABLE IVD-4

LENGTH FREQUENCY DISTRIBUTION OF YELLOW PERCH IN SEINE COLLECTIONS

OSWEGO TURNING BASIN - 1975

LENGTH (cm)	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2.0- 2.4									
2.5- 2.9			36						
3.0- 3.4			49						
3.5- 3.9			5						
4.0- 4.4									
4.5- 4.9				1					
5.0- 5.4									
5.5- 5.9					1				
6.0- 6.4					1				
6.5- 6.9									
7.0- 7.4					3				
7.5- 7.9		1			3	2			
8.0- 8.4					5	1			
8.5- 8.9					4	3			
9.0- 9.4					4	6	1		
9.5- 9.9						7	2		
10.0-10.4					1	3	1		
10.5-10.9						3			
11.0-11.4						1			
11.5-11.9							1		
12.0-12.4									
12.5-12.9									
13.0-13.4									
13.5-13.9									
14.0-14.4									
14.5-14.9			1						
			1 (19.5)	1 (16.1)					



ABUNDANCE OF NEKTON IN TRAWL COLLECTIONS
OSWEGO TURNING BASIN—1975-1976
ABUNDANCE
300
200
100
0
100
200
300
400
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
SURFACE
BOTTOM
OTB-6
OTB-10
OTB-4
NO DATA
NO SAMPLE (ICE COVER)

c. Gill Nets

Gill nets captured more species and a larger number of individuals than any other gear. Because of the greater efficiency of this gear, most of the in-depth community analyses will be restricted to samples obtained by this method.

Sufficient numbers of alewives, gizzard shad, and white perch were captured for statistical analysis. Accordingly, a three-way ANOVA was conducted to test three main effects: dates, depths, and stations and their corresponding interactions. The results are shown in Table IV.D-5. Significantly ($\alpha = .05$) more gizzard shad were captured during the winter, at the surface and at the station nearest the thermal discharge (OTB-6). The significant date x station interaction is attributed mainly to the large numbers collected at station OTB-6 during December and January. The preference of gizzard shad for the warm waters at the western end of the basin during the winter is clearly demonstrated here.

A significant difference ($\alpha = .05$) was evident in the depth distribution of alewives in the turning basin (Table IV.D-6). More fish were collected at the surface than at the bottom during 1975. Since most collections were made at night, the results agree with past observations which indicate that alewife are more abundant in surface waters in the evening. Over the course of the year the distribution of alewife among the three stations did not differ significantly; however, during those months of maximum abundance (May-July), fewer alewife were usually present at the western end of the turning basin.

White perch preferred the bottom layer as indicated by the significant ($\alpha = .01$) depth effect in Table IV.D-7. A significant ($\alpha = .05$) depth x station interaction was also observed with more fish captured at the bottom at OTB-6 than elsewhere. A Tukey T procedure indicated this difference to be significant ($\alpha = .05$).

3. Community Analysis

a. Diversity

The Shannon-Weaver diversity measure (H') commonly used in ecological studies has often proven valuable in assessing community structure and environmental quality. However, a knowledge of community composition is also essential since H' indicates little about the species makeup of a sample. Community analyses used to describe the impact of the Oswego Steam Station will, therefore, include species composition in several different aspects, thereby examining in greater detail those parameters correlated with the observed values of diversity.

TABLE IV D-5

STATISTICAL ANALYSIS OF GIZZARD SHAD ABUNDANCE IN GILL NET COLLECTIONS

OSWEGO TURNING BASIN - 1975-1976

THREE-WAY ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F
DATES	9	1069.2148	118.8016	2.61*
DEPTHS	1	338.0718	338.0718	7.42*
STATIONS	2	525.5532	262.7766	5.77*
DATE x DEPTH	9	496.5728	55.1748	1.21
DEPTH x STATION	18	1902.2740	105.6819	2.32*
DEPTH x STATION	2	269.9695	134.9848	2.96+
ERROR	18	820.3536	45.5752	
TOTAL	59	5422.0097		

* Significant at α=.05
+ Significant at α=.10

ESTIMATED MEANS FOR STATIONS

STATION	ESTIMATED MEAN
OTB-4	0.504
OTB-6	7.276
OTB-10	1.648

TUKEY T PROCEDURE - STATIONS (α = .05)
Largest : OTB-6 OTB-10 OTB-4: Smallest

ESTIMATED MEANS FOR DEPTHS

DEPTH	ESTIMATED MEAN
Surface	5.516
Bottom	0.769

TABLE IV D-6

STATISTICAL ANALYSIS OF ALEWIFE ABUNDANCE IN GILL NET COLLECTIONS

OSWEGO TURNING BASIN - 1975-1976

THREE-WAY ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F
DATES	9	409.710	45.523	2.08+
DEPTHS	1	309.615	309.615	14.11*
STATIONS	2	2.095	1.048	0.05
DATE x DEPTH	9	332.601	36.956	1.68
DEPTH x STATION	18	440.805	24.498	1.12
DEPTH x STATION	2	2.353	1.177	0.05
ERROR	18	394.927	21.940	
TOTAL	59	1892.106		

* Significant at α =.01
+ Significant at α =.10

ESTIMATED MEANS FOR DEPTHS

DEPTH	ESTIMATED MEAN
Surface	5.055
Bottom	0.512

ESTIMATED MEANS FOR STATIONS

STATION	ESTIMATED MEAN
OTB-4	2.882
OTB-6	2.948
OTB-10	2.522

TABLE IV D- 7

STATISTICAL ANALYSIS OF WHITE PERCH ABUNDANCE IN GILL NET COLLECTIONS

OSWEGO TURNING BASIN - 1975-1976

THREE-WAY ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F
DATES	9	22.5805	2.5089	2.09+
DEPTHS	1	37.1480	37.1480	30.93**
STATIONS	2	5.1779	2.5890	2.16
DATE x DEPTH	9	26.9857	2.9984	2.50*
DEPTH x STATION	18	33.1378	1.8410	1.53
DEPTH x STATION	2	11.5056	5.7528	4.79*
ERROR	18	21.6189	1.2011	
TOTAL	59	158.1544		

* Significant at $\alpha = .05$
** Significant at $\alpha = .01$
\+ Significant at $\alpha = .10$

ESTIMATED MEANS FOR DEPTHS

DEPTH	ESTIMATED MEAN
Surface	0.409
Bottom	1.982

ESTIMATED MEANS FOR STATION x DEPTH INTERACTION

	ESTIMATED MEAN		
DEPTH	OTB-4	OTB-6	OTB-10
Surface	0.498	0.193	0.535
Bottom	1.266	2.984	1.697

TUKEY T PROCEDURE - STATION x DEPTH ($\alpha = .05$)
SURFACE: No significant difference
BOTTOM: Largest: OTB-6 OTB-10 OTB-4: Smallest

Shannon-Weaver diversity values for gill net catches are shown in Figure IV.D-4. The most evident trend in the data is the large seasonal variation in diversity at every station except OTB-6, a pattern related to the number of alewives appearing in the catches. For example, the low diversity recorded in May, June, and July at OSWW, OSWP, and OTB-4 results from a large influx of alewives into the vicinity (Table IV.D-8). The absence of this species in the western end of the turning basin during this same period produces higher values of H'.

Interestingly, the seasonal progression and range of diversity values are quite similar for the lake transects (OSWW, OSWP) and OTB-4. This reflects the influence of the lake community upon the eastern end of the turning basin, a phenomenon which is not surprising in view of the proximity of this site to the harbor mouth.

Although station OTB-6 exhibited the highest average seasonal diversity and the lowest variation (in 1975), three additional monthly values were added to Figure IV.D-4 to point out that this may simply reflect the absence of the dominant alewife during most of the year and not more subtle changes in environmental quality (acting to improve conditions). When values for January, February, and March 1976 are included in the calculation of mean diversity, OTB-6 no longer exhibits the highest value. On the other hand, if the corresponding values of H' (1.53, 1.29, 1.13) at OTB-10 during these months were to be added to Figure IV.D-4, the mean diversity value at this station would not be reduced. The depressed values at the former station are caused by the capture of overwintering gizzard shad, while no such effect is observed at OTB-10. It seems apparent, therefore, that the diversity pattern observed in 1975 and early 1976 is influenced primarily by the presence or absence of the dominant species in the area. The 1975 pattern in the Oswego Turning Basin probably derives from the general low abundance of alewives in the harbor and turning basin, and from the east-to-west gradient of decreasing numbers during those months of maximum abundance.

Unlike the near-shore community in the Oswego Turning Basin, which exhibits much greater seasonal diversity (Figure IV.D-4) than corresponding lake areas, diversity measured by gill net collections in the OTB displays a similar range of values to that of collections in the open lake (Figure IV.D-4). However, dominance (D) differs considerably (Table IV.D-8). The alewife was the most abundant species recorded at both lake transects in every month. In the turning basin, on the other hand, two other species, the white perch and gizzard shad, shared dominance with the alewife. In addition, in those months that the alewife

TABLE IV D-8

DIVERSITY INDICES OF FISH IN SURFACE AND BOTTOM GILL NET COLLECTIONS

OSWEGO VICINITY - 1975

I. OSWEGO TURNING BASIN

STATION	INDEX	APR	MAY	JUN	JUL	AUG[a]	SEP	OCT	NOV[b]	DEC	MEAN
OTB-6	H'	1.479	1.716	1.406	1.362	1.838	2.158	1.722	1.654	1.666	1.67
	D	49.21[c]	51.72[d]	71.96[d]	67.51[d]	54.81[e]	39.61[d]	42.52[d]	42.43[e]	45.42[d]	
	J'	0.400	0.496	0.501	0.410	0.613	0.583	0.543	0.589	0.645	
	N	254	174	107	511	104	361	635	304	262	
OTB-10	H'	1.648	0.998	1.524	2.425	2.226	1.438	1.738	1.128	1.482	1.62
	D	62.05[c]	84.90[d]	72.92[d]	39.34[e]	51.94[e]	71.88[d]	54.19[e]	76.04[e]	61.54[c]	
	J'	0.460	0.270	0.508	0.808	0.621	0.416	0.470	0.402	0.741	
	N	224	821	144	61	129	384	334	192	52	
OTB-4	H'	2.234	1.275	0.683	0.797	1.476	1.018	1.623	1.275	1.922	1.37
	D	48.48[c]	74.96[d]	87.89[d]	88.24[d]	72.58[c]	77.19[d]	45.99[e]	73.89[e]	40.00[c]	
	J'	0.705	0.402	0.228	0.240	0.492	0.439	0.512	0.425	0.961	
	N	33	595	578	306	124	114	187	226	5	

II. OSWEGO VICINITY[f]

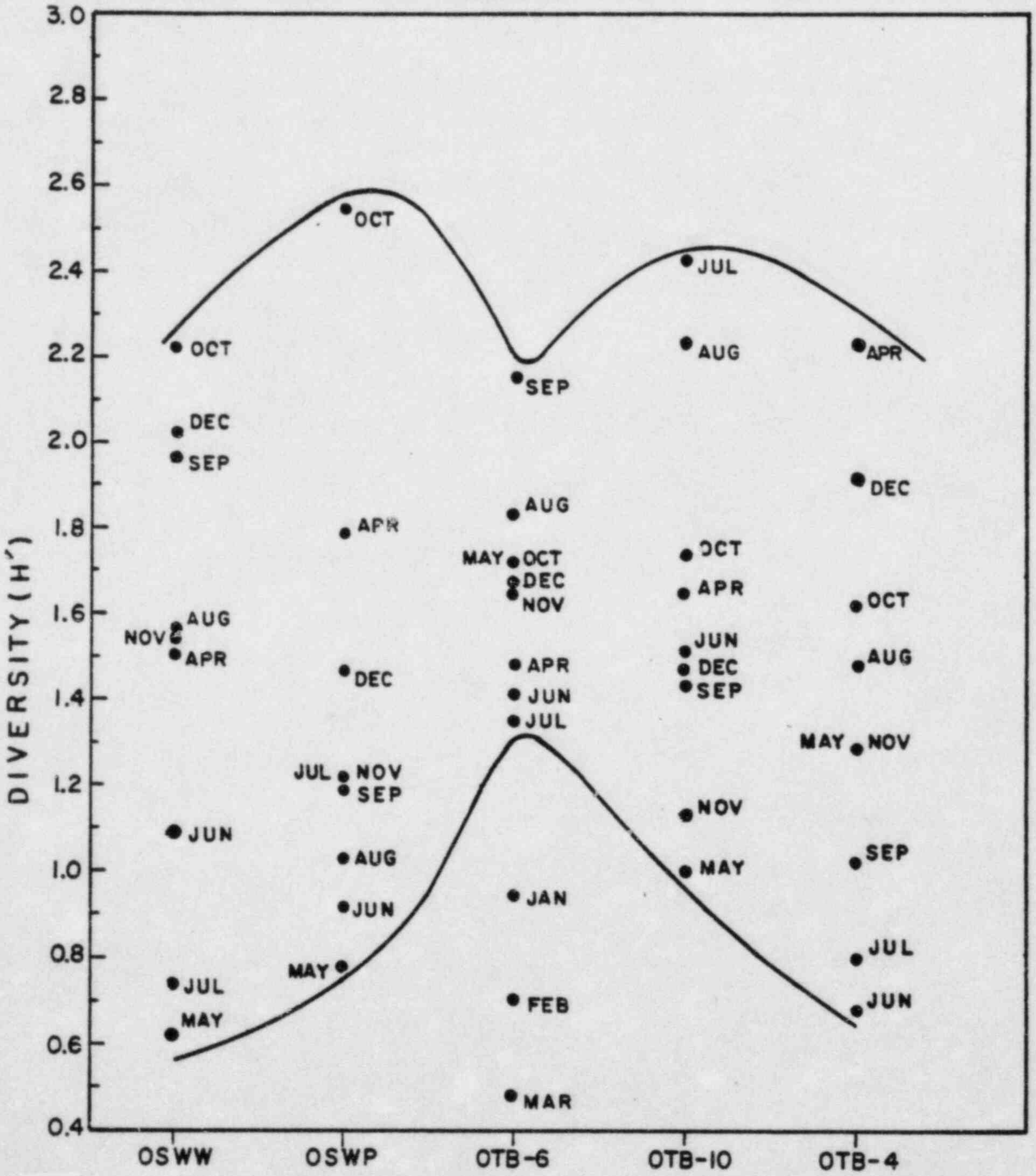
STATION	INDEX	APR	MAY	JUN	JUL[g]	AUG	SEP	OCT	NOV	DEC	MEAN
OSWP	H'	1.787	0.766	0.902	1.211	1.033	1.190	2.545	1.206	1.466	1.35
	D	60.22	87.81	84.51	81.67	85.19	83.44	44.87	81.65	50.79	
	J'	0.564	0.242	0.261	0.310	0.299	0.312	0.652	0.326	0.567	
	N	274	722	581	300	243	326	263	436	63	
OSWW	H'	1.517	0.621	1.085	0.736	1.563	1.974	2.223	1.551	2.034	1.48
	D	59.81	91.89	81.12	89.27	68.22	57.64	57.46	73.09	44.44	
	J'	0.457	0.163	0.362	0.213	0.493	0.533	0.584	0.467	0.642	
	N	321	913	376	634	214	432	228	301	90	

[a] Sample actually taken on 18 September
[b] Surface sample only at OTB-10
[c] White perch dominance
[d] Alewife dominance
[e] Gizzard shad dominance
[f] Alewife dominant species at both stations during all months

[g] Two less samples were taken at OSWW than at OSWP.
NS - No sample
H' - Species diversity
D - Species richness
J' - Species evenness
N - Number of fish

MONTHLY DIVERSITY VALUES OF FISH

OSWEGO VICINITY — 1975 — 1976



dominated in the harbor, it usually did so by a smaller percentage than in the lake. Of the three exceptions, two occurred at station OTB-4 which, as has been stated previously, is influenced to a greater degree by the lake ichthyofauna.

b. Community Composition

A percent similarity matrix was constructed from monthly station data and clustered utilizing the average linkage strategy (Clifford and Stephenson, 1975). This procedure is effective in grouping similar entities (stations) based on some predefined basis for association.

The results are summarized in Figure IV.D-5, where monthly collections were pooled to obtain a representative community pattern for each station. As expected, the turning basin stations (OTB-4, 6, 10) formed a separate cluster with relatively high (82%) similarity. Station 4 differed slightly, reflecting the influence of the lake community on this site. As a group the harbor stations were most similar to the inshore (15 ft) lake community. The deeper lake stations (OSWW-40, OSWP-40) formed a very tight cluster (PS = 97%) and were relatively different (PS = 62%) from all other stations.

The biological basis for distinguishing the three communities may be seen in Table IV.D-9. Four characteristic differences are noted:

a) Certain species, such as the gizzard shad and white perch, are collected in much greater numbers in the turning basin than in the lake.

b) Conversely, several species are more abundant in the lake; for example, more white suckers are caught in the nearshore (15 ft) area. Similarly, the spottail shiner constituted a larger proportion of the lake catch especially at the 15 ft depth. The alewife, on the other hand, was particularly abundant at the deeper lake stations and this factor was primarily responsible for the close resemblance (based on percent similarity) between OSWW-40 and OSWP- 40.

c) Several species, including the golden shiner, northern pike, bowfin, and longnose gar, were collected only in the turning basin. This is not to say that they are entirely excluded from the lake, (e.g., LMS, 1975); rather, it is simply a matter of degree, with the majority of these warm water forms expected in the turning basin.

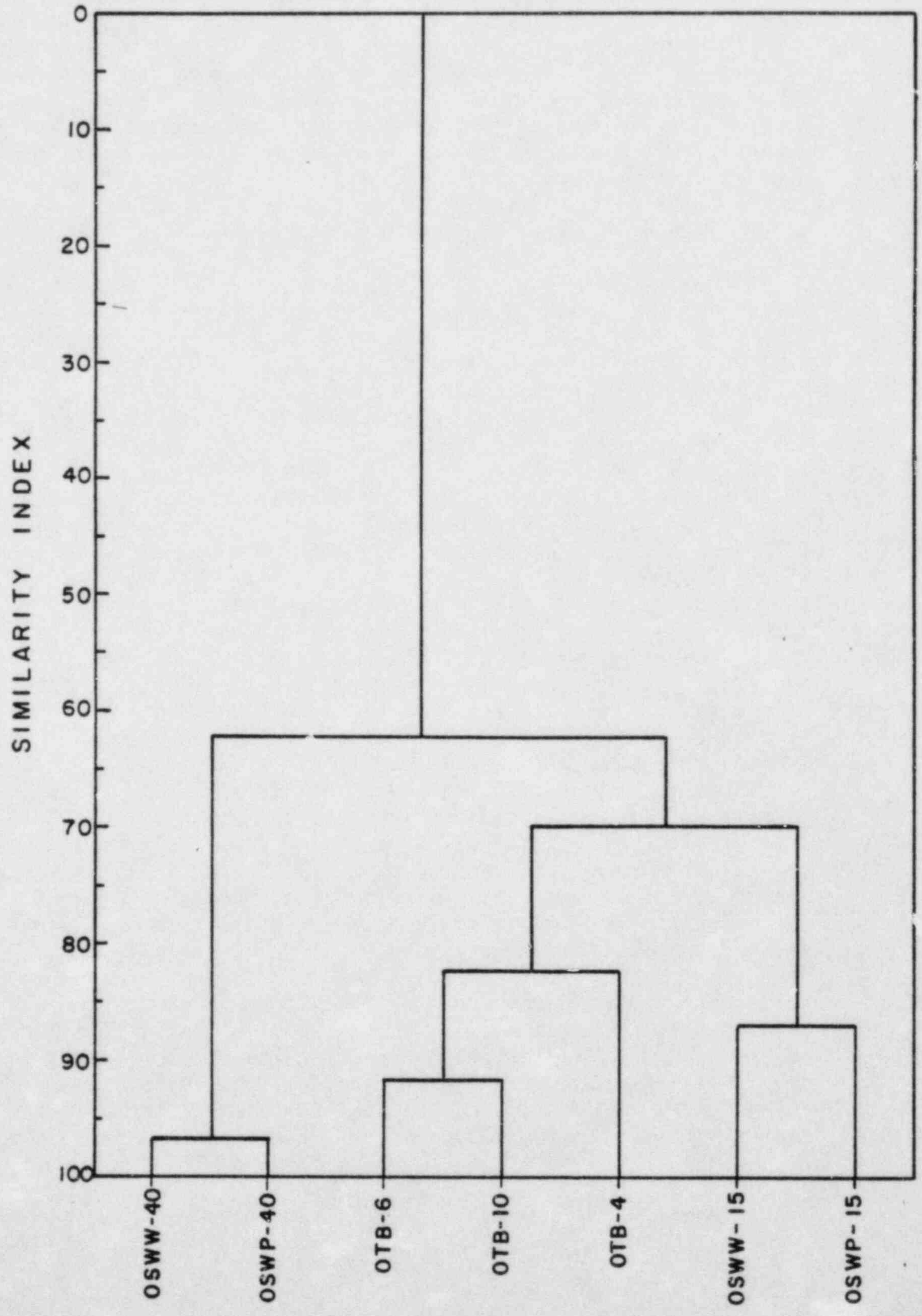
TABLE IV D-9

PERCENT COMPOSITION OF FISH IN GILL NET COLLECTIONS

OSWEGO VICINITY - APRIL-DECEMBER 1975

SPECIES	OTB-6	OTB-10	OTB-4	OSWW-15	OSWP-15	OSWW-40	OSWP-40
Alewife	42.6	47.4	62.3	52.6	63.5	87.2	88.2
Spottail shiner	3.9	3.0	2.1	14.4	12.5	4.9	3.0
Yellow perch	1.4	1.4	1.1	2.5	3.2	0.6	1.1
Gizzard shad	27.6	25.5	16.3	5.1	3.2	0.7	0.7
White perch	22.0	17.3	16.7	12.0	9.8	1.3	1.6
White sucker	0.2	0.4	0.3	2.1	2.1	0.6	0.4
Brown trout	0.2	0.2	0.1	0.2	0.2	0.3	0.2
Walleye	0.3	0.1	0.2		0.2	0.1	0.1
Carp	0.3	0.2	0.1	0.1	0.2		0.1
Trout-perch	0.1	0.1	0.1	0.1		0.1	
White bass	0.1	0.2	0.3		0.2		0.2
Freshwater drum	0.2	0.2	0.1		0.1		0.1
Brown bullhead	<0.1	1.4	0.1	0.1	0.6		
Coho salmon	0.2	<0.1		0.1		0.3	
Rainbow trout	0.1	<0.1				<0.1	0.1
Burbot	0.1	<0.1	0.1	0.1	0.2		
Rainbow smelt	<0.1	0.1		6.1	1.6	2.3	2.0
Lake chub	<0.1		0.1	1.5	0.2	0.6	1.3
Rock bass	0.2	0.3	0.1	1.4	0.9	0.4	0.3
Smallmouth bass		0.1		1.0	1.0	0.5	0.3
Lake trout						<0.1	0.1
Chinook salmon				0.1	0.1	0.1	0.2
Stonecat catfish				0.6	0.1		0.1
Golden shiner	0.3	0.7	0.1				
Northern pike	0.1	1.0	0.1				
Bowfin	0.2	0.2					
Longnose gar	<0.1	<0.1	0.1				

SIMILARITY OF FISH COLLECTIONS
OSWEGO VICINITY — APRIL-DECEMBER 1975



d) Similarly, several species normally associated with cold water assemblages were excluded to various degrees from the harbor. These included the rainbow smelt, lake chub, smallmouth bass, stonecat, lake trout, and chinook salmon.

In summary, three distinct communities were observed; a warm water assemblage characteristic of the turning basin, with reduced numbers of those taxa usually associated with cooler temperature; a nearshore community influencing station OTB-4 and differing from the deep water assemblage primarily in terms of the percent composition of its constituent species. The deeper stations were further distinguished on the basis of large numbers of alewives in the catch and diminished numbers of spottail shiners, white perch, yellow perch, white suckers, and brown bullhead.

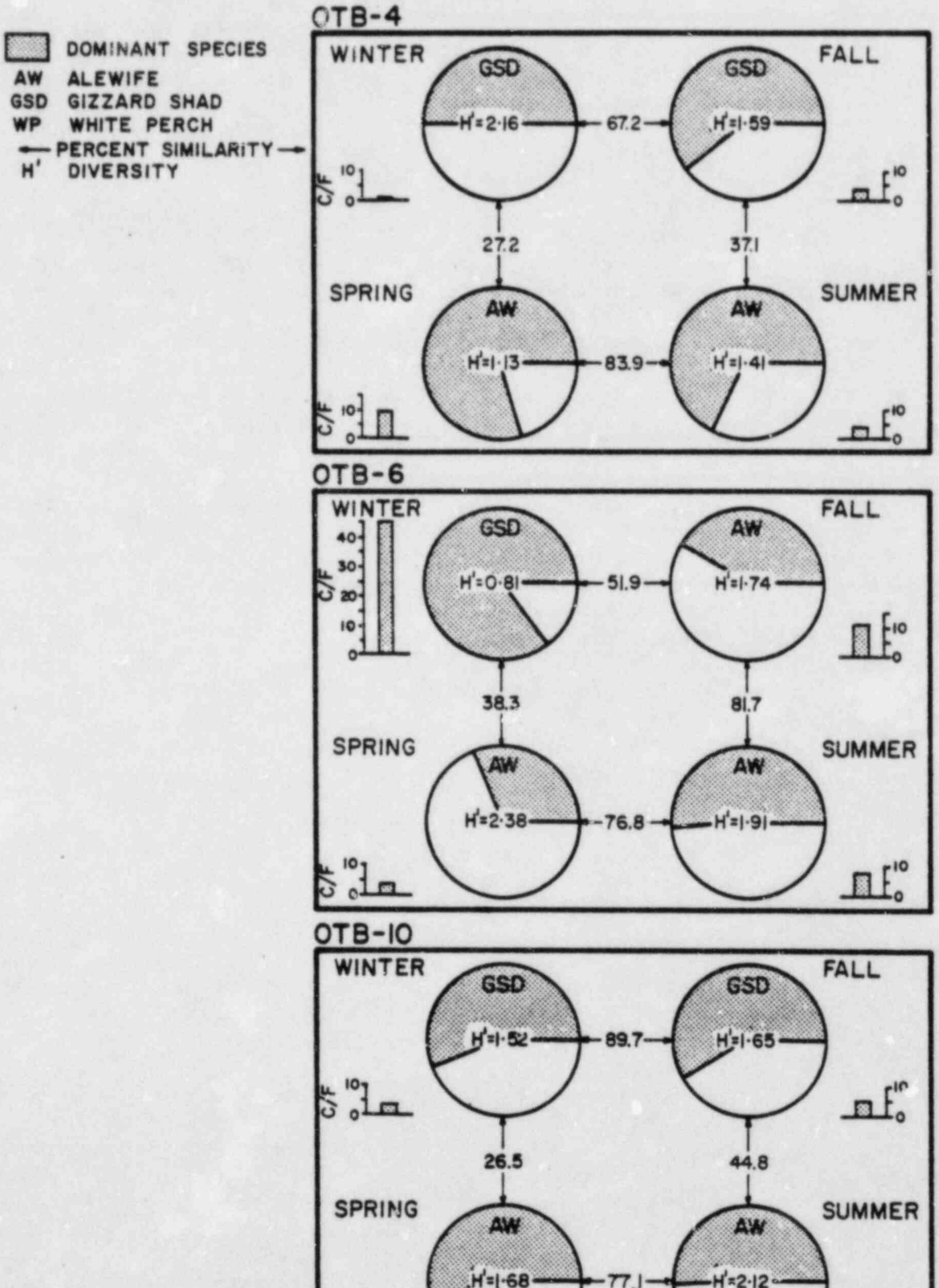
The community inventory for turning basin collections is shown seasonally in Figure IV.D-6. The cycle for each station is shown separately to provide a basis for comparison. These data were arranged in this way to facilitate investigation of any detectable differences in migratory behavior associated with the plume (e.g., avoidance during the summer and attraction during the winter), or any other seasonally induced patterns.

The data display several important characteristics. The seasonal progression of community dominance was similar at all stations, with the gizzard shad usually most abundant during the fall and winter and the alewife predominating in the spring and summer. Because relatively few alewives were collected in the spring at OTB-6, diversity attained the highest recorded diversity value. Correspondingly, the large number of gizzard shad caught in the winter at OTB-6 depressed the diversity value (0.81) to the lowest of the study. Another trend in the data occurs in the seasonal differences in the Percent Similarity indices. There is a distinct seasonal turnover between the spring/summer and fall/winter periods, i.e., the percent similarities are relatively lower, except between OTB-6 summer and fall communities. In this case the high similarity is probably the combined effect of the warmer water (maintaining the summer assemblage) and the presence (in the fall) of greatest numbers of alewives in the western end of the turning basin. Most of the observed differences were related to the seasonal turnover among the community dominants described previously.

A distinct seasonal pattern was not evident in diversity values; OTB-4 displayed higher levels in the fall/ winter and, conversely OTB-6 and OTB-10 had higher diversity values in the spring/summer. This resulted mainly from the absence of alewives at the western end of the turning basin (OTB-6 and OTB-10) during the spring/summer, thereby increasing evenness and the subsequent H' values. The

CATCH PER EFFORT, DIVERSITY, DOMINANCE AND SIMILARITY OF SEASONAL FISH COLLECTIONS

OSWEGO TURNING BASIN - 1975



presence of greater numbers of alewives in the fall and their general absence from the western harbor during the spring/summer may reflect both an avoidance reaction by this species to the thermally enriched waters and the subsequent unsuitability of this area as a spawning ground.

4. Discussion of Important Species

Sufficient data have been collected from Lake Ontario in the vicinity of the Oswego Steam Station (QLM, 1974; LMS 1974, 1975) to prepare a life history synopsis for several species. This information will serve as a basis for comparison, the goal being a demonstration of successful completion of the life cycle for those species (or their life stages) utilizing the Oswego Turning Basin.

Extensive biological monitoring during the past four years clearly demonstrated the existence of an ecological continuum between the Oswego area and nearby (5 mi) Nine Mile Point (QLM, 1974; LMS, 1974, 1975); therefore, all data may be considered collectively in this analysis. Most of the discussion, however, is based upon an April-December collecting period since winter conditions usually precluded sampling at other times. Furthermore, because differences between yearly collections of each species were primarily qualitative, the discussion will be based upon the most recently available data (1973 and 1974) covering the combined study area, and will be supplemented from other reports. Any important differences observed among years or between study sites (Oswego, Nine Mile Point) will be discussed separately.

a. Alewife (*Alosa pseudoharengus*)

The alewife is an anadromous species that spends most of its adult life in marine waters and returns to fresh water to spawn. It occurs from Newfoundland to North Carolina (Scott and Crossman, 1973), and, in addition is found as many landlocked populations along its range.

In Lake Ontario, adult alewives reside in the open lake and migrate inshore during the spring and summer to spawn in streams or in near-shore shallows with sand and gravel bottoms.

In the Oswego area, however, some alewives are present throughout the year. The major inshore movement of adults, accompanied by juveniles, occurs in April in association with the onset of the reproductive cycle. Yearly collections (QLM, 1974; LMS, 1974) indicate greater abundance of this species in the evening hours during the spring and summer than during the fall, a trend that agrees with the observations of other studies. Graham (1956) reported that most alewives return to deeper waters of Lake Ontario upon completion of the spawning cycle.

Spawning in the area begins shortly after the arrival of the first schools and reaches a peak in early July, as indicated by coefficient of maturity data (QLM, 1974; LMS, 1974). Surface water temperatures at this time generally range from 13.5 - 22.0°C (56.3 - 71.6°F), and average about 20.6°C (69.1°F), with a corresponding average bottom temperature of 16.8°C (62.2°F). These values are similar to other spawning temperatures reported for freshwater alewife (Rounsefell and Springer, 1945; Threinen, 1958; Gross, 1959).

According to studies conducted on the growth history of alewife in the Oswego study area, annulus formation had occurred in 36% of the alewives captured during June, in 43% during July, and in 100% during August (LMS,1975). At this same site during 1973, annulus formation began as early as April, reached 29 and 42% for the alewife captured during May and June, respectively, and peaked during July and August with 66 and 65%, respectively (QLM, 1974). Norden (1967), reported that 15% of alewife collected in Lake Michigan formed their annulus during June and the remainder during July; these results are similar to those observed in the Nine Mile Point vicinity.

Based on body length-scale length relationships, growth curves for both male and female alewife assume approximately the same form (LMS, 1975), although females have been observed to be larger after the second year of life and to retain this cumulative size advantage through age five. Pritchard (1929) reported that female alewife in Lake Ontario were larger than males after the third year of life. Havey (1961) and Odell (1934) also reported the more rapid growth of female alewife in landlocked freshwater populations during the first two years of life, accounting for 43 and 67%, respectively, of the length attained at age six. The maximum age normally reported for both males and females is six years, although female alewife collected off Nine Mile Point during 1973 reached seven years of age (QLM, 1974). Pritchard (1929) previously reported a maximum age of six years for males and seven years for females in Lake Ontario.

Growth increments of alewife populations from the study vicinity have been compared with those reported for other alewife populations. While individuals from this section of the lake generally appeared to grow more rapidly after the first year of life than alewife from Port Credit and the Bay of Quinte, Lake Ontario (Table IV.D-10), Graham (1956) reported that Atlantic alewife of both sexes mature one year later, grow more quickly throughout their life, and attain a larger size than landlocked Lake Ontario alewife. He suggested that the freshwater environment hastens the onset of sexual maturity and that this results in an inhibition of growth.

TABLE IV D-10

COMPARISON OF THE AVERAGE TOTAL LENGTH[a] OF FISH AT EACH YEAR OF LIFE FOR ALEWIFE REPORTED FROM LAKES IN THE UNITED STATES[b]

YEAR OF LIFE	LAKE ONTARIO OSWEGO TURNING BASIN (PRESENT STUDY)	LAKE ONTARIO NINE MILE POINT (LMS, 1975)	LAKE ONTARIO NINE MILE POINT (QLM, 1974)	LAKE ONTARIO PORT CREDIT (PRITCHARD, 1929)	LAKE ONTARIO BAY OF QUINTE (PRITCHARD, 1929)	LAKE MICHIGAN (NORDEN, 1967)	SENECA LAKE, N.Y. (ODELL, 1934)
1	97 (228)	86 (44)	110 (2)	99 (7)		94 (147)	70 (113)
2	135 (227)	135 (21)	145 (28)	128 (5)	140 (1)	140 (177)	145 (89)
3	154 (145)	152 (46)	157 (83)	143 (11)	143 (2)	159 (1028)	154 (284)
4	162 (116)			153 (34)	148 (14)	173 (502)	171 (49)
5	166 (74)	161 (96)	165 (145)	162 (35)	157 (17)		174 (15)
6	170 (6)	168 (59)	183 (31)	180 (3)	179 (9)		
7		198 (15)	204 (7)		187 (1)		
8			217 (1)				

[a]Length in millimeters
[b]Numbers which appear in parentheses represent the number of fish measured in determining average length

Length frequency data indicate that in April the population within the Oswego/Nine Mile Point vicinity consisted mainly of adults 15-19 cm in length (LMS, 1975). During May a few yearling fish (age group I) began to appear in the gill nets, indicating the start of their inshore migration to summer feeding grounds. This trend continues into August when the nearshore populations are dominated by yearling fish 9-12 cm long. Young-of-the-year alewife were first recruited into seine collections at a mean length of 3.7 cm during August (QLM, 1974), the month of peak abundance for small alewife in the study area. However, young alewife (mean length of 2.7 cm) at Nine Mile Point were first collected during July, indicating a possible succession in appearance from east to west (QLM, 1974). Scott and Crossman (1973) reported that juvenile alewife may be found in shallow water at night and on the bottom in 2-3 m (6-10 ft) of water during the day. Odell (1934) noted that in Seneca Lake, New York, alewife fry migrate to mid-depth lake waters during the fall and winter. Graham (1956) also indicated that young-of-the-year alewife remain near the spawning grounds until the late larval stage, whereupon they migrate to shallow protected areas before moving into deep water. The young may attain a length of 51-75 mm by the fall (Scott and Crossman, 1973).

Feeding studies are not available for alewife from the Oswego area; however, the literature indicates that the adults are filter-feeders and prey principally on zooplanktonic organisms such as cladocerans, copepods, and mysids. In fresh water they therefore compete with the indigenous forage fish species for food (Scott and Crossman, 1973).

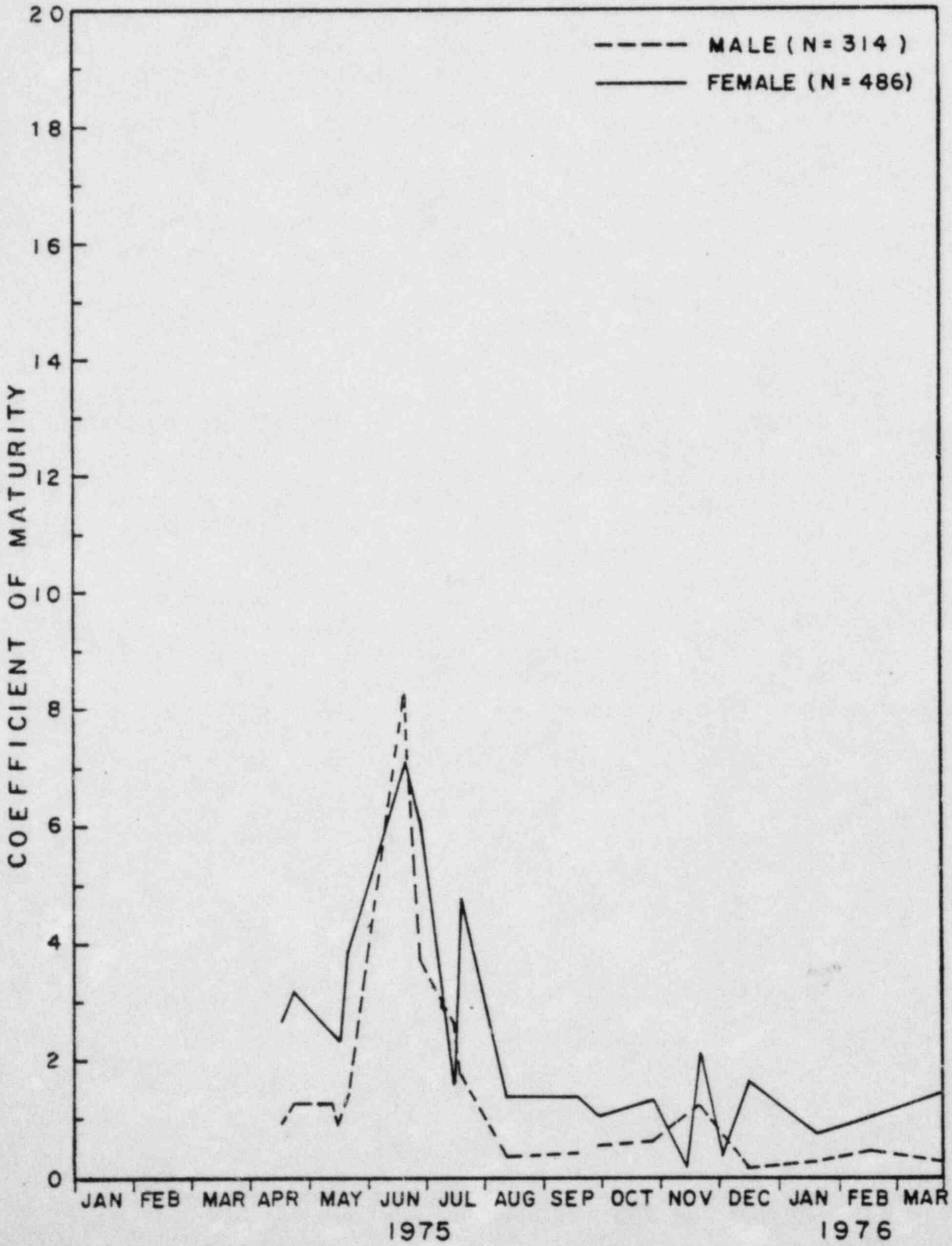
The range of lethal threshold temperatures for this species is 23.0-32.2°C (73.4-90.0°F) with acclimation temperatures of 20°C (68°F) to 20.3°C (68.5°F), respectively. Graham (1956) reported a 23°C (73.4°F) lethal threshold [at a 20°C (68°F) acclimation temperature] for alewives immediately after they rose from the cold depth where they overwintered. Preferenda, however, indicate that the alewife will migrate from (avoidance) the lethal temperature toward 21.3°C (70.3°F). Overwintering fish are continually under an osmoregulatory stress and their ability to withstand a thermal stress at this time of the year is at a minimum when compared to other times of the year.

Population Biology of Alewife in the Oswego Turning Basin

Coefficient of maturity data for alewife (Figure IV.D-7) indicate that some spawning may take place in the Oswego Turning Basin since both males and females in ripe condition were captured. Eggs and larvae were also collected (see Section IV.B.4), and it is believed that at least some of these were spawned in the

COEFFICIENT OF MATURITY OF ALEWIFE

OSWEGO TURNING BASIN—1975-1976



outer harbor, as opposed to being entrained in plant flow. Peak values were observed in June for both sexes, which is in good agreement with lake data from Oswego in 1974 but slightly out of phase with observations from the Nine Mile Point vicinity during the same period (LMS, 1975). The differences, however, are within the normal year-to-year range of variation for this species (Scott and Crossman, 1973).

Growth increments were calculated by age class for alewife (sexes combined) from the Oswego Turning Basin (Table IVD-10). In general, alewife collected in the turning basin exhibited a similar rate of growth and attained similar lengths for each year as populations collected in other freshwater areas. It should be noted, however, that because of the variety of back calculation techniques used in the different surveys, only generalizations can be made about relative growth rates. Growth rates of turning basin alewives were quite similar to the rates found for alewife collected during 1974 at Nine Mile Point (LMS, 1975). The area around Oswego (including the turning basin) thus seems to sustain relatively high growth rates for this species, possibly relating to the high organic and nutrient load of the Oswego River which empties into the lake nearby (Jackson et al., 1964).

Females displayed a growth advantage over males throughout life (Appendix D), an observation in general agreement with previous work on the Oswego area (LMS, 1974, 1975). In addition, the maximum attained age of six years for both males and females concurs with past observations at Oswego.

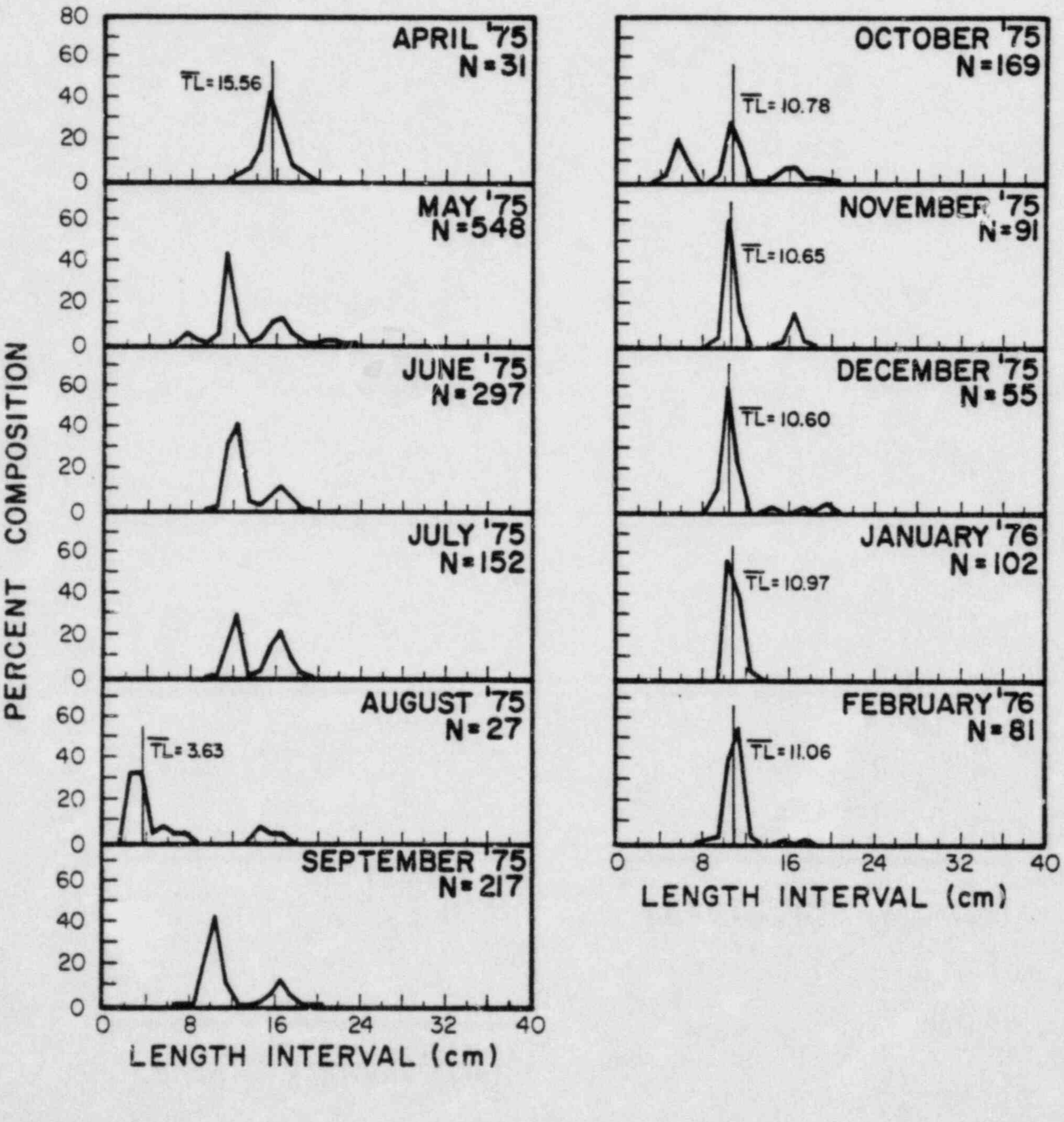
Length-frequency data for alewives collected in the Oswego Turning Basin also support the conclusions drawn from past studies (Figure IV.D-8). Adults ranging from 12.0 to 20.0 cm in total length constituted 100% of the catch in April. Yearlings appeared in May and dominated the catch through August, when large numbers of young-of-the-year appeared; thereafter, with the exception of October, few young-of-the-year were collected. Juveniles formed the bulk of the catch after August, and, interestingly, exhibited little growth (based on average total length) through the fall, a phenomenon which may be related to gear selectivity or emigration.

As mentioned previously, alewife fry were first collected at Nine Mile Point in July; therefore, the same delayed appearance and possible west-to-east progression was encountered in the 1975 Oswego Turning Basin collections.

The presence of substantial numbers of juveniles and some adult alewives in winter collections (January-February) indicates that this species overwinters in the turning basin. However, many

FREQUENCY OF LENGTH INTERVALS OF ALEWIFE

OSWEGO TURNING BASIN — 1975-1976



adults and a few juveniles were also collected in December 1974 at Nine Mile Point (LMS, 1975), perhaps indicating that overwintering in the Oswego vicinity may be a general phenomenon.

In summary, the available life history data for alewife from the Oswego Turning Basin indicate that the majority of the observed differences between these and other populations are qualitative and that, insofar as these parameters are concerned, there is no discernible impact of thermal effluent from the Oswego Steam Station.

b. White Perch (Morone americana)

White perch occur along the Atlantic Coast of North America from New Brunswick, Prince Edward Island, and Nova Scotia to South Carolina. This species has been introduced into Lake Ontario and is common in the Hudson River below Albany, New York (Scott and Crossman, 1973).

White perch were collected in all months in the vicinity of Oswego with maximum numbers occurring during the summer, especially in July. During 1974 the spawning season for this species commenced in May at a time when water temperatures ranged from 5.5 to 13.0°C (41.9-55.4°F). The corresponding average values were 10.8°C (51.4°F) on the surface and 7.2°C (45.0°F) on the bottom (LMS, 1975). Sheri and Power (1968) reported that the spawning season for white perch in the Bay of Quinte, Lake Ontario, began in mid-May and continued through June at water temperatures ranging from 11-15°C (51.8-59°F).

Growth study data for this species demonstrate that annulus formation had occurred in 47% of the white perch captured during July 1974 and 99% during August (LMS, 1975). During 1973, the majority of white perch at Nine Mile Point had formed their annulus by September, with the peak also occurring during August (QLM, 1974). Similar occurrence of annulus formation was reported by Sheri and Power (1969) during a 10-year study of annulus formation in white perch inhabiting the Bay of Quinte; peak annulus formation occurred during July for five years, during June for two years, and during August for two years. While earlier annulus formation in younger white perch has been reported (Wallace, 1971; QLM, 1974) it was not evident in the Nine Mile Point vicinity.

The growth curves for both male and female white perch had approximately the same form; however, females were significantly larger after the second and subsequent years of life. More rapid growth of female white perch has been previously reported in Nine Mile Point area (QLM, 1974) and throughout the range of the species (Mansueti, 1961; Miller, 1963, Wallace, 1971; St. Pierre and Davis, 1972).

The maximum growth of Nine Mile Point white perch occurred during the first two years of life. At the end of the first and second years' growth, white perch were 24.6 and 48.43%, respectively, of the length attained after 10 years of growth. The rate of growth expressed as the percent annual increase in total length declined from 98.28% for males and 95.23% for females at age two, to 25.82 and 30.92%, respectively, after the third year of life. Growth continued to decline rapidly through age five, after which the decline continued but at a slower rate.

The first year growth of Nine Mile Point white perch is comparable to that of other fast growing populations (Table IV D-11); however, perch from this area appear to grow faster during the second through the eighth year of life than fish from all other populations, with the exception of the Connecticut River. Nine Mile Point white perch appear to grow faster than white perch in the Bay of Quinte for ages two through six, whereas the latter population appears to grow more rapidly after the eighth year of life; however, small sample sizes in these age groups made comparisons dubious.

Length frequency distributions of 1975 samples of Nine Mile Point white perch (LMS, 1974) indicate that during April the catch was made up of fish in age class III or IV and yearlings, with a small percentage of age class II individuals. In May most of the fish were mature adults of age class III to VI, and presumably represented the spawning population. The same trend continued until October when the main portion of fish were age class I and II. The younger, sexually immature fish did not appear in the area until October and November.

The 1975 food studies program at Nine Mile Point produced sufficient numbers of white perch to quantify several aspects of their feeding habits (LMS, 1976b). The major food items consumed by specimens greater than 210 mm in length included fishes, the amphipod <u>Gammarus</u>, and members of the insect orders Diptera, especially <u>Cricotopus</u>, and Trichoptera, principally <u>Athripsodes</u>. Smaller white perch (161-210 mm) did not differ in the qualitative composition of their diet; however, the proportions of the various items differed substantially. Both size classes consumed substantial numbers of Oligochaeta.

Previous studies, particularly those of Cooper (1941) and Richards (1960) indicate a changing composition in white perch diet with increasing body length, from aquatic insects and crustaceans to fishes. Other investigations of freshwater populations corroborate these conclusions, although absolute composition may differ slightly. In general, feeding habits of white perch are governed

TABLE IV D-11

COMPARISON OF THE AVERAGE TOTAL LENGTH[a] OF FISH AT EACH YEAR OF LIFE FOR WHITE PERCH REPORTED FROM LAKES AND RIVERS IN THE UNITED STATES[b]

YEAR OF LIFE	LAKE ONTARIO OSWEGO TURNING BASIN (PRESENT STUDY)	LAKE ONTARIO NINE MILE POINT (LMS, 1975)	LAKE ONTARIO NINE MILE POINT (QLM, 1974)	LAKE ONTARIO BAY OF QUINTE (SHERI & POWER, 1969)	ROANOKE RIVER NO. CAROLINA (CONOVER, 1958)	CONN. RIVER (LOWER) (MARCY & RICHARDS 1974)	STATE OF CONN. AVER. (WHITWORTH, & SAUTER 1972)	DELAWARE RIVER NEAR ARTIFICIAL ISLAND (WALLACE, 1971)	JAMES RIVER VIRGINIA (ST. PIERRE & DAVIS, 1972)	YORK RIVER VIRGINIA (ST. PIERRE & DAVIS, 1972)
1	110 (350)	76 (58)	94 (1)	84 (120)	70 (283)	87 (110)	81 (464)	88 (161)	80 (132)	83 (79)
2	175 (342)	149 (58)	158 (24)	133 (146)	114 (149)	181 (80)	131 (457)	120 (491)	127 (89)	124 (231)
3	206 (254)	190 (57)	195 (59)	172 (157)	156 (84)	227 (71)	166 (416)	164 (241)	157 (150)	152 (224)
4	225 (164)	213 (55)	213 (46)	197 (138)	188 (79)	258 (60)	194 (295)	181 (189)	182 (120)	179 (81)
5	234 (90)	230 (55)	225 (32)	218 (124)	215 (49)	281 (27)	223 (172)	193 (84)	200 (115)	200 (76)
6	252 (23)	241 (30)	241 (17)	234 (83)	237 (42)	311 (7)	245 (77)	204 (49)	215 (85)	221 (49)
7	260 (9)	254 (25)	249 (14)	253 (57)	254 (28)	345 (1)	252 (16)	213 (18)	232 (38)	242 (22)
8	268 (7)	264 (26)	255 (9)	274 (35)	266 (6)		267 (6)	218 (11)	249 (15)	261 (8)
9	294 (4)	274 (11)	260 (6)	289 (6)	266				267 (2)	274 (4)
10	320 (3)	299 (3)	277 (3)	289 (2)					277 (1)	285 (1)
11	331 (3)	296 (2)								
12	341 (2)	301 (1)								
13	334 (1)									

[a] Length in millimeters

[b] Numbers which appear in parentheses represent the number of fish measured in determining average length

largely by seasonal abundance of prey organisms and this species may, therefore, be considered a non-selective (generalized) feeder.

Thermal data on white perch are relatively scant; however, Meldrim and Gift (1971) studied estuarine populations and determined the upper avoidance threshold to be 34.7 and 6.6°C for acclimation temperatures of 24.8 and 1.1°C, respectively. In addition, the same investigators determined preferred temperatures at 32 and 31°C for 24 and 30°C acclimation regimes.

Population Biology of White Perch from the Oswego Turning Basin

As evidenced by body length to scale length analysis, the white perch population collected in the Oswego Turning Basin exhibited a higher growth rate and attained greater length at each year of life than populations in other Lake Ontario locations (Table IVD-11). First-year growth for this species was the greatest in the turning basin, the average value of 110 mm being in reasonably good agreement with the empirical values of 124 mm determined for age one fish (both sexes combined) (Appendix D). Comparison with populations in other geographic locations (Table IVD-11) indicates that only the population in the lower Connecticut River attained greater mean length, and that this is because of a much greater growth rate during their second growing year.

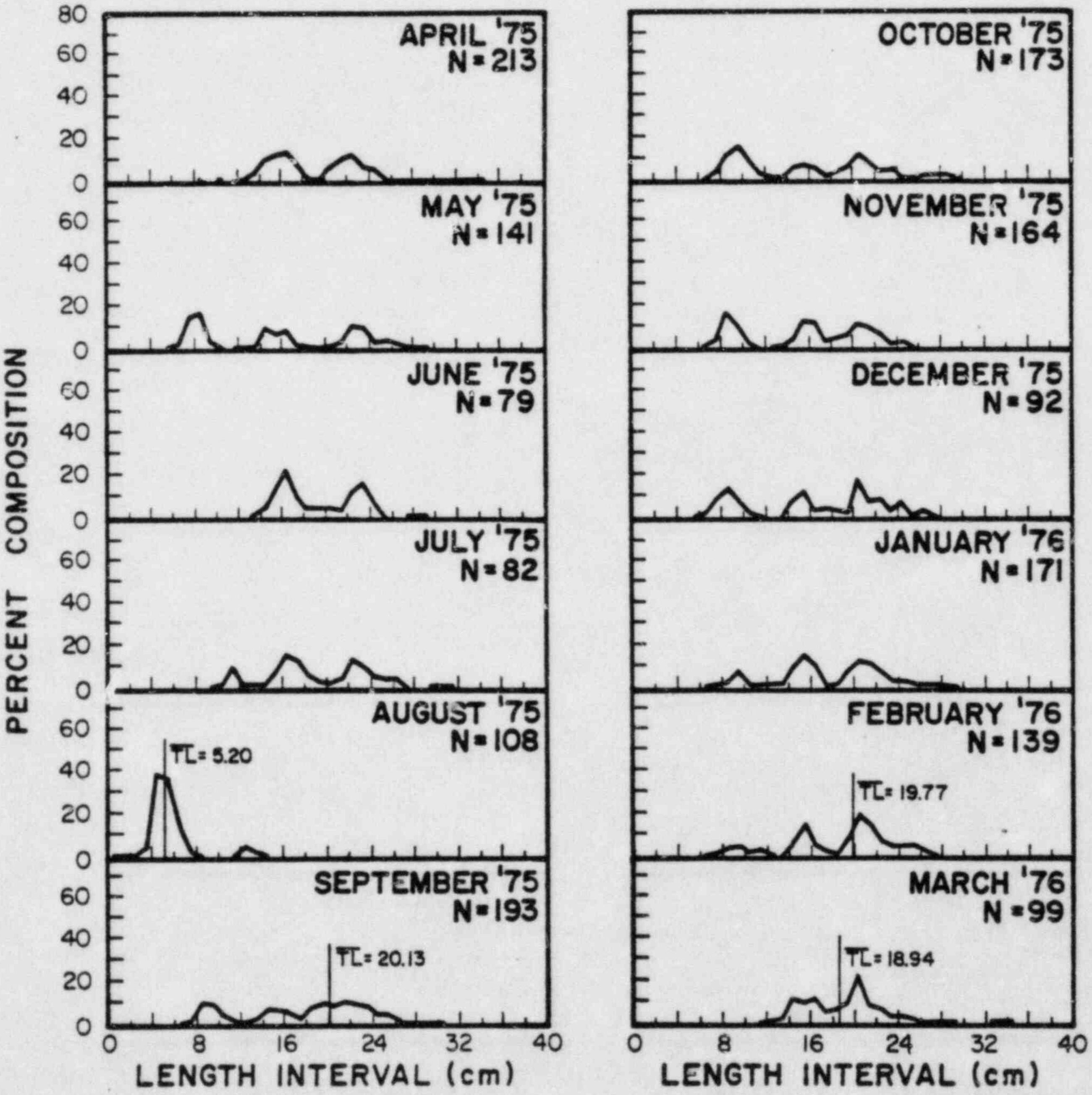
Females retained a size advantage throughout life, a result which agrees with that observed for lake fish in the vicinity of Oswego. Maximum growth of females in the turning basin occurred during their first two years, when they reached 33 and 53%, respectively, of the length achieved at 13 years of age. Corresponding values for males up to age eight were 42 and 66%, respectively. Apparently, the turning basin provides a habitat conducive to rapid growth of young, as described previously.

Evidence that the Oswego Turning Basin serves as a nursery area for white perch may be seen in Figure IV.D-9. Small white perch (yearlings) were present in considerable numbers in the May and July collections. In addition, the bulk of the August sample consisted of young-of-the-year fish with a mean total length of 5.2 cm. These smaller individuals exhibited rapid growth through September and remained a major constituent of the catch through February. In other respects the length frequency distribution of white perch in the basin differed only in minor detail from that of the lake population. These differences probably reflect the relatively small monthly samples available from the harbor and not any biological phenomena.

In conclusion, the accumlated life history data demonstrate that only minor differences occur between white perch growth recorded in the turning basin and comparable data from the lake and, that

FREQUENCY OF LENGTH INTERVALS OF WHITE PERCH

OSWEGO TURNING BASIN — 1975-1976



as far as these parameters are concerned, growth rates for this species are actually enhanced in the turning basin.

c. Yellow Perch (*Perca flavescens*)

There is some question as to whether there are one, two, or three separate species of yellow perch-like fish in the Northern Hemisphere. In any case, the yellow perch and its sister species or sub-species have a circumpolar distribution in fresh water. In North America, the yellow perch occurs from Nova Scotia south along the Atlantic coast, previously to South Carolina, but now apparently to Florida and Alabama.

The yellow perch is a commercially valuable species throughout its range, and consequently there is considerable literature on various aspects of its life history. These fish are considered very adaptable because of the wide range of habitats in which they are found, including warm to cooler areas from large lakes to ponds, or quiet rivers. They are most abundant in the open water of large lakes with moderate vegetation (Scott and Crossman, 1973). Yellow perch are usually considered shallow water fishes and are usually not collected in water depths below 9.2 m (30 ft).

Both the young and adults form loose aggregations of 50 to 200 individuals segretated by size. The groups of young are found in shallower water and nearer shore than adults. Individuals in schools of adults are close together in summer and more separate in winter (Scott and Crossman, 1973).

Scott (1955), Hergenrader and Hasler (1968), and Muncy (1962) found that yellow perch undertake a spring migratory movement. Storr (1973) reported that, in the southeastern portion of Lake Ontario, migratory movements to the spawning ground occurred in the winter. In addition, movements inshore and out, vertical diel movements, and seasonal movements into and out of deeper water have been reported. These latter movements are probably responses to temperature and distribution of food. In the Bay of Quinte, Lake Ontario, yellow perch make yearly spring movements in large numbers to the spawning grounds (Griffiths, 1974).

Abundance data for yellow perch collected from the Nine Mile Point vicinity in 1974 show that more fish were generally collected during the summer (July, August, and September) than during the spring; no consistent trends were observed in the fall (LMS, 1975). The occurrence of maximum yellow perch abundance in this area at a time other than the commonly recognized spawning period for this species indicates indirectly that they do not utilize the area as a major spawning ground. In addition, in a study by Storr (1973), 40% of yellow perch tagged and released in the Nine Mile Point vicinity moved eastward out of the area, with the majority recaptured at North Sandy Pond, an area assumed to be the spawning grounds for the yellow perch population in southern Lake Ontario.

Based upon coefficient of maturity data, the predicted time of spawning for yellow perch occurred during the first two weeks in April when water temperatures were in the range of 0.7-6.2°C (33.3-43.2°F), with a mean temperature of 3.3°C (37.9°F). Muncy (1962) reported yellow perch movement to the spawning grounds in the Severn River, Maryland, from late February to early March, a period when water temperatures were 3.9-6.7°C (39-44°F).

Substantial data have also been compiled regarding age and growth for this species at Nine Mile Point. Annulus formation was complete in some yellow perch during April and May, peaked during June, and was complete for all fish examined by July, similar to the pattern observed in 1973 (QLM, 1974). These data are also consistent with results from a Lake Erie study that reported annulus formation in yellow perch between early April and mid-July (Jobes, 1952).

The growth curves calculated from scale data for both male and female yellow perch had the same form; however, females generally appeared to be larger. Growth was observed to be greatest during the first year of life. Hile and Jobes (1942) and El-Zarka (1959) reported that female yellow perch were larger after age two. Hile and Jobes (1941) found the same pattern of growth after the third year of life.

Yellow perch in the Nine Mile Point vicinity appear to grow at a rate which is similar to, or possibly somewhat slower than that of yellow perch in Green Bay, Lake Michigan; they also grow more slowly than yellow perch in Nebish Lake, three Iowa lakes, and Lake Erie (Table IV.D-12). On the other hand, they grow faster than populations in Weber Lake and Silver Lake (Hile and Jobes, 1941). In Saginaw Bay, Lake Huron, one study indicated that local yellow perch populations grew more rapidly than Nine Mile Point populations (Hile and Jobes, 1941), whereas a subsequent study found slower yellow perch growth in that area than at Nine Mile Point for fish of ages one to five (El-Zarka, 1959). Comparisons of growth for fish of age six and older are tenuous because of the difficulty of locating and reading the sixth and successive annuli. It should be noted here that slight differences in the methods used to calculate lengths are responsible for at least some of the discrepancies in Table IV.D-12.

TABLE IV-D-12

COMPARISON OF THE AVERAGE TOTAL LENGTH[a] OF FISH AT EACH YEAR OF LIFE FOR YELLOW PERCH REPORTED FROM LAKES IN THE UNITED STATES[b]

YEAR OF LIFE	LAKE ONTARIO OSWEGO TURNING BASIN (PRESENT STUDY)	LAKE ONTARIO NINE MILE POINT (LMS, 1975)	LAKE ONTARIO NINE MILE POINT (QLM, 1974)	LAKE MICHIGAN GREEN BAY (HILE AND JOBES, 1942)	LAKE HURON SAGINAW BAY (HILE AND JOBES, 1941)	LAKE ERIE (JOBES, 1952)	LAKE HURON SAGINAW BAY (EL-ZARKA, 1959)	THREE IOWA LAKES (PARSONS, 1950)	THREE WISCONSIN LAKES (SCHNEBERGER, 1935)		
									NEBISH LAKE	WEBER LAKE	SILVER LAKE
1	106 (52)	66 (4)	110	73 (2)	77	92	66 (18)	68 (74)	66 (159)	58 (3)	44
2	160 (42)	117 (51)	149	118 (58)	137 (20)	174	107 (565)	177 (86)	136 (306)	113 (389)	80 (148)
3	201 (18)	155 (54)	182	160 (128)	202 (308)	219	142 (1623	235 (346)	175 (114)	145 (81)	113 (558)
4	270 (4)	189 (56)	211	198 (241)	248 (170)	248	178 (1006)	280 (16)	213 (39)	175 (278)	133 (239)
5	288 (1)	219 (48)	241	227 (212)	279 (137)	271	193 (173)	302 (39)		199 (248)	149 (93)
6		234 (18)	254	262 (98)	315 (17)	288	239 (12)			215 (69)	169 (21)
7		256 (7)	270	285 (8)	338 (5)		315 (3)			231 (13)	202 (2)
8		287 (2)		319 (4)			356 (1)			245 (3)	
9		318 (1)		360 (1)							

[a]Length in millimerers

[b]Numbers which appear in parentheses represent the number of fish measured in determining average length

The length-frequency data for yellow perch indicate a trimodal distribution of ages, including fish of age groups II-VIII, during April and May. Proportionately fewer older fish were present during June at Nine Mile Point. For the remainder of the year, ages were fairly uniformly represented (LMS, 1975a).

Throughout the year, age classes III-V predominated in collections, due possibly to the use of gill nets, which are size selective. Some yearlings were collected during June, July, and August, but no young-of-the-year yellow perch were collected with seines, trawls, or gill nets and few in larval tows.

The food habits of yellow perch in the Oswego area have not been studied in depth. Previous studies indicate that food selection changes with size and season but is largely restricted to immature insects, other invertebrates, and fishes. Young perch feed on cladocerans, ostracods, and chironomid larvae while larger individuals consume members of the insect orders Ephemeroptera and Odonata, with decapod crustaceans and small fishes also being important food items.

Temperatures studies by Everest (1973) show that at the Hearn Generating Station on Lake Ontario yellow perch were concentrated in the plume area as compared to a control area, especially during October. Yellow perch at this site were found only from June to November. During October they were collected at temperatures of 13 -22°C (55.4-71.6°F) at a time when ambient temperatures were around 9-11°C (48.2-51.8°F). The final temperature preference of the species has been experimentally determined at 21-24°C (69.8-75.2°F) (Ferguson, 1958).

Population Biology of the Yellow Perch in the Oswego Turning Basin

The accuracy of yellow perch growth data from the turning basin is somewhat diminished by small sample sizes (Table IVD-12) and by differences in the method of back calculating growth; however, some very general comparisons may be made. Growth most closely resembled that of populations from Lake Erie and Three Lakes, Iowa. Generally, females from the turning basin grew more rapidly than males, after their first year, but for both sexes growth (as a percentage of the maximum) was greatest during the first year of life (Appendix D).

Unlike length frequency results from the Nine Mile Point vicinity, where few small yellow perch were caught, the majority of individuals collected in the Oswego Turning Basin were young-of-the-year. In those months when sufficient samples were obtained (June, August, and September), 30-60% of the entire catch consisted of fry (Figure IV.D-10). These individuals grew rapidly during the summer, from a mean length of 2.84 cm in June to a mean length of 9.73 cm in September.

In conclusion, growth parameters for this species in the Oswego Turning Basin indicate that this area serves in an important nursery capacity for young yellow perch and, furthermore, is capable of sustaining a population of rapidly growing adults.

d. Threespine Stickleback (*Gasterosteus aculeatus*)

The threespine stickleback is widely distributed in fresh and marine waters of North America, ranging from Chesapeake Bay north to the Hudson Bay region. This species spawns during the summer (June-July) in fresh water, building its nest in shallow, sandy areas (Scott and Crossman, 1973). The male entices the female to the nest by a distinctive courtship display; eggs are then laid in clusters and are adhesive to each other. Breder and Rosen (1966) stated that hatching occurs in seven days at 19°C (66.2°F). The males tend the eggs and the young for several days after hatching.

Growth is rapid during the first year, but slows during the second year of life, with a maximum size of 102 mm attained in fresh water. Sexual maturity is attained during the first year and individuals probably do not live longer than 3-1/2 years.

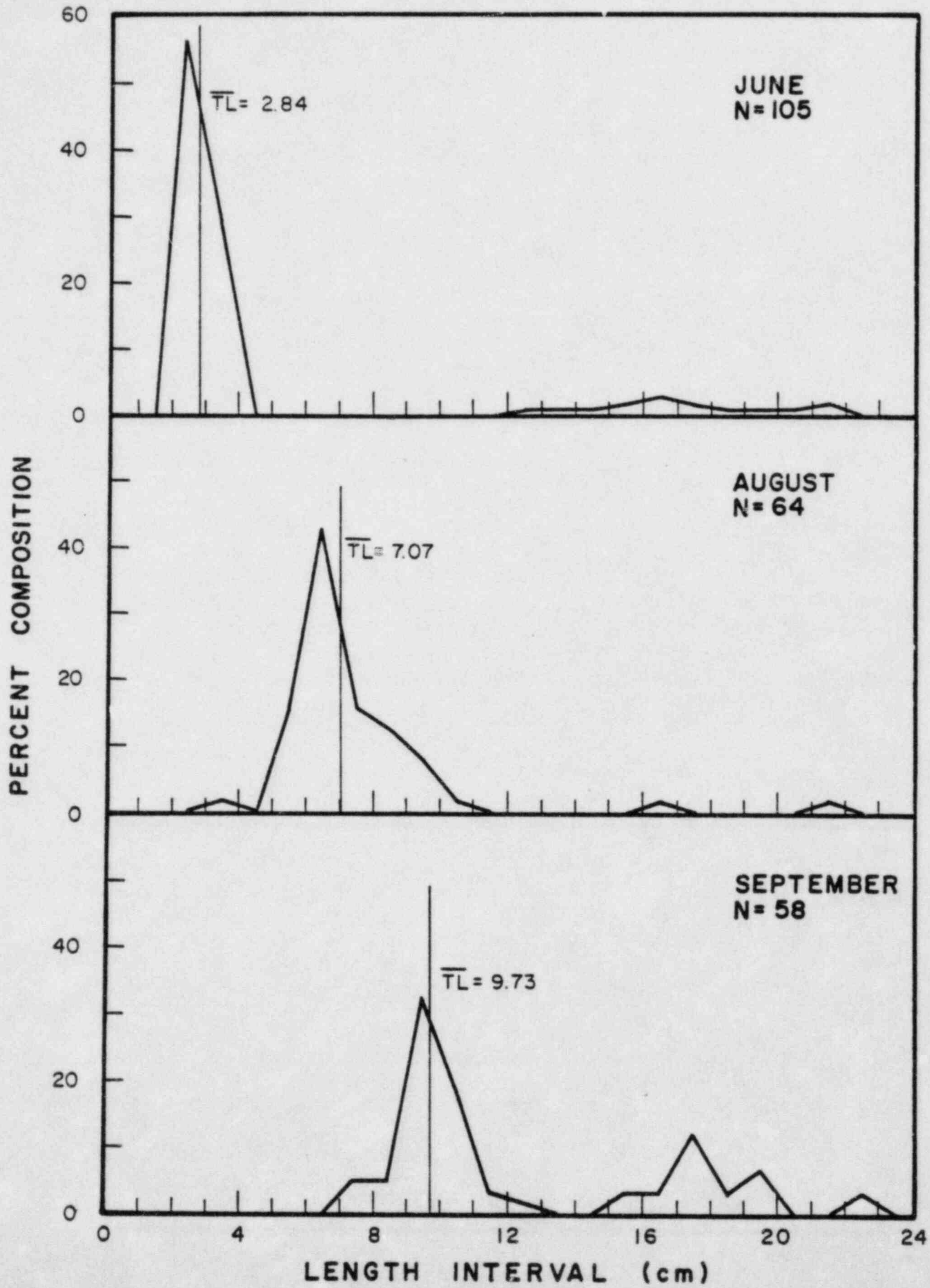
A voracious feeder, the threespine stickleback consumes various annelids, crustaceans, insects, and eggs and larvae of fish. They, in turn, are preyed upon by fish-eating birds as well as by larger fish including trout and salmon, and, therefore, serve as an important forage species. No life history data are available for this species from the Oswego Turning Basin, because of the small numbers collected.

e. Golden Shiner (*Notemigonus crysoleucas*)

The golden shiner is found in fresh waters on the east coast of North America from the Maritime Provinces south to Florida, and in the west to the Dakotas and Texas (Hubbs and Cooper, 1936). A lacustrine species, the golden shiner shows preference for clear, weedy, quiet waters with extensive shallows. It is an actively swimming fish that moves in schools over wide areas.

Spawning occurs in the New York area from May to July at water temperatures of about 20°C (68°F)(Dobie et al., 1956). The adhesive eggs are usually deposited over filamentous algae or rooted aquatic plants, and in fact, aquatic vegetation is essential for successful spawning (Cooper, 1935, 1936).

FREQUENCY OF LENGTH INTERVALS OF YELLOW PERCH
OSWEGO TURNING BASIN — 1975



Growth rates vary greatly depending on temperature and food availability. Usually a length of about 76 mm is reached during the second summer, 102 mm during the third, 114 during the fourth, and 140 mm by the fifth summer (Cooper, 1936). In some nutrient rich waters, however, 76 mm lengths were recorded in the first summer. Shiners mature at lengths between 64 and 89 mm, usually in their second summer. The oldest specimen recorded by Cooper (1936) was in its eighth summer.

The main foods of this species are: cladocerans, flying insects, chironomid pupae, and filamentous algae (Keast and Webb, 1966). Occasional dietary items include dragonfly nymphs, beetles molluscs, and water mites. Little difference has been observed between the diet of young and that of adults. The authors concluded that this species was a midwater and surface feeder. The golden shiner is also an important forage species and is consumed by many game fish.

Brett (1944) reported a lethal temperature of 34.4°C (94°F) for adults acclimated at 22°C (71.6°F). More recently, Alpaugh (1972) observed that shiners acclimated at 22°C (71.6°F) died at temperatures between 39.5 and 40°C (103-104°F) when exposed to a rate increase of 0.75°C (1.35°F)/day.

Trembley (1961) has also described temperature preferences for this species. Exposed to a gradient of 25-32.2°C (77-90°F), shiners were observed to swim throughout the maximum levels. When subjected to a gradient of 28.9-37.2°C (84-99°F), most individuals tended to gather in the cooler zone. In water reaching 37.8°C (100°F), active avoidance occurred.

A seasonally varying response for individuals 1.5-4.5 inches long was recorded by Nickum (1966). In the spring a rapid temperature rise of 11.1° to 26.7°C (52-80.1°F) in one week resulted in 90% mortality, while weekly changes of 16.1 (61°F) and 21.7°C (71.1°F)(to a maximum level of 26.7°C) in the winter produced zero and 5% mortality, respectively. Only diseased fish succumbed to changes of 20°C (68°F) or less during both seasons. Within the first 6 hours at any weekly ΔT, mortality did not exceed 5%; however, fish usually continued to die throughout the weekly interval.

Hart (1952) estimated the upper incipient lethal temperature at approximately 35°C (95°F) for this species. In similar experiments the same author predicted that 50% of the fish acclimated at 25°C (77°F) would survive in 35°C (95°F) water for 100 minutes. Field observations support this contention as Trembley (1960) noted that a school of shiners frightened from water between

25 (77°F) and 26.1°C (79°F) into 36° (96.3°F) water were eventually able to regroup at the lower temperature with the loss of only two individuals.

f. Emerald Shiner (*Notropis atherinoides*)

Emerald shiners are found in lakes and rivers from Canada south through the Mississippi Valley (Alabama to the Trinity River, Texas) and to the Gulf of Mexico.

Spawning begins in mid-May (Carlander, 1969) and usually extends through August. The optimum range of temperature at this time is cited as being 20-27°C (68-81°F)(Gray, 1942; Campbell and MacCrimmon, 1970). Eggs are spawned in mid-July in Lake Erie and hatch in less than 24 hours at a water temperature of 23.9°C (75°F).

Growth studies (Brown, 1974) indicate that the optimum temperature for juvenile growth ranges between 24 (75°F) and 31°C (88°F)(McCormick and Kleiner, 1970). In one study in Lake Erie, growth terminated during the latter part of September when water temperature dropped to 21.1°C (70°F)(CFR, 1961). Young-of-the-year grow to lengths of about 51 mm by mid-November and by the following autumn reach lengths of about 76 mm (MacCrimmon, 1956). Few individuals survive beyond their third year (Fuchs, 1967).

Emerald shiners are pelagic or open water species, congregating in large schools. They are very important forage fish, and are consumed in large numbers by many game fish including the lake trout and smallmouth bass. In fact, Van Oosten and Deason (1938) noted that emerald shiners made up about 64% of the food of lake trout, especially in spring, and Doan (1940) listed this species as the chief food source of smallmouth bass in Lake Erie. Burbot, rainbow trout, and northern pike also consume large numbers of emerald shiners (MacCrimmon, 1956).

The diet of emerald shiners consists largely of microcrustaceans, midge larvae, and algae. Gray (1942) found large numbers of *Diaptomus*, *Daphnia*, *Cyclops* and *Bosmina* in guts of fish collected in Lake Erie.

After subjecting young emerald shiners to both instantaneous and gradual temperature rises, Wells (1914) concluded that resistance was higher to the latter regime. In general, large fish were more resistant to high temperatures, especially in the spring (March-April), than were smaller individuals. The same author reported the lethal temperature of this species to be 27-28°C (80.6-82.4°F).

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More recently, Hart (1947) found a seven-day upper LT_{50} of 30.7°C for juveniles acclimated at 25°C (77°F). Other experiments by this investigator demonstrated that 34°C (93.2°F) was resisted for 35 minutes (Hart, 1947). In a study conducted in a Canadian lake, the preferred temperature of this species was reported as 25°C (77°F)(Campbell and McCrimmon (1970) although Proffitt and Benda (1971) observed emerald shiners in waters up to 31.1°C (88°F) around a heated discharge.

5. Threatened and Endangered Species

Lists of threatened and endangered species are published by the U.S. Department of the Interior. A review of these publications, current issues of the Federal Register, and technical literature indicates that the following species from the Great Lakes or Lake Ontario in particular are considered threatened, endangered, or rare:

1. Lake sturgeon (*Acipenser fulvescens*)
2. Blue pike (*Stizostedion vitreum glaucum*)
3. Kiyi (*Coregonus kiyi*)
4. Blackfin cisco (*Coregonus nigripinnis prognathus*)
5. Shortnose cisco (*Coregonus reighardi*)

None of these fish have been collected in the vicinity of either Nine Mile Point or Oswego in the course of the extensive biological monitoring programs of the last three years.

The guidance manual suggests that descriptions of these species be provided and this is done in the following paragraphs.

Lake Sturgeon (*Acipenser fluvescens*)

Once the lake sturgeon was quite abundant in Lake Ontario; in fact, in 1855 a commercial sturgeon processing plant was established at Sandusky, Ohio. Since then the lake sturgeon, especially in Lake Erie, has been almost eliminated. A detailed description of the decline of the Great Lakes sturgeon fishery can be found in Harkness and Dymond (1961).

No lake sturgeons were collected in 1973, 1974, or 1975 in either the general ecological surveys or impingement collections.

Blue Walleye (*Stizostedion vitreum glaucum*) (also known as blue pike)

This species consisted of two subspecies, the yellow walleye, *Stizostedion v. vitreum*, and the blue walleye, *S. v. glaucum*. The blue walleye was placed on the Rare and Endangered list (McAllister, 1970) as rare or perhaps extinct. Scott and Crossman (1973) conclude that it has totally disappeared from Lakes Erie and Ontario.

None were collected in 1973, 1974, or 1975 by sampling programs near the site.

Blackfin Cisco (*Coregonus nigripinnis prognathus*)

The blackfin cisco once ranged throughout all the Great Lakes except Lake Erie, but now has disappeared from Lakes Ontario and Michigan. There were none collected in 1973, 1974, or 1975 by LMS.

Kiyi (*Coregonus kiyi*)

The kiyi was indigenous to the Great Lakes basin and was limited in distribution to the deeper waters of Lakes Ontario, Huron, Michigan and Superior. It has virtually disappeared from Lake Ontario and probably persists only in Lake Superior. None were collected by LMS in 1973, 1974, or 1975.

Shortnose Cisco (*Coregonus reighardi*)

The shortnose cisco was once a valuable commercial species in Lake Ontario until at least the 1940's. It is now very rare and only two individuals have been reported in the literature in recent years (Wells, 1969). None were collected by LMS in 1973, 1974, or 1975.

6. Nuisance Species

The fish fauna of Lake Ontario and the other Great Lakes have undergone changes in composition due to the decline of piscivorous species such as the lake trout and the increase of recently introduced species including alewife, rainbow smelt, white perch, and gizzard shad (Miller, 1957; Christie, 1974). Mayr (1966) discusses the potential impact of an invading species on one already established in an area. In general, through competition for food or space, the invading (introduced) species may increase at the expense of the resident population, and in time they may completely eliminate the resident species. Christie (1974) suggests that the populations of alewife, rainbow smelt, and white perch did not directly cause the decline of the large piscivores, e.g., the lake trout or Atlantic salmon, but increased as a result of lack of predatory pressure as the piscivores were overfished or damaged by the sea lamprey. Further, the alewife may have caused a decline in the abundance of some planktivores with which it competes, e.g., slimy sculpin and the shiners.

The landlocked alewife population is usually considered a nuisance species because of its annual die-off. The resultant masses of decomposing carcasses litter the shoreline and reduce its recreational values for swimming. The dead fishes may clog municipal and industrial water intakes. Significant expenditures of time and money by state and local agencies and private citizens are involved in removing the alewives from the beaches. The annual die-offs normally occur during the spring/early summer months and have been attributed to the inability of the cold water-acclimated population to tolerate the warmer shore zone waters on their spawning migration (Graham, 1957).

The alewife represents a biological threat to indigenous lake fish populations because adult alewives feed principally on zooplankton such as copepods, cladocerans, mysids, and ostracods (Rhodes and McComish, 1975). They are in direct competition for these food items with resident forage species in Lake Ontario, including emerald shiner and slimy sculpin (Smith, 1973). At present the impact of the alewife in Lake Ontario is not completely understood, but its vast numbers and competition for food with other species has probably had some effect on the fish community structure. The alewife has been reported to be an important food item in the diet of piscivorous fishes such as the lake trout and freshwater burbot. Coho salmon, recently introduced into Lake Michigan and Lake Ontario, eat large numbers of alewives (Scott and Crossman, 1973), and may eventually reduce the size of the alewife population. Other fish species including rainbow trout, cisco, smallmouth bass, and perch are also known to feed on alewives.

Rainbow smelt was first reported in Lake Ontario in 1931 (Mason, 1933) and the species now occurs in all areas of the lake to a reported depth of 46 m (Christie, 1974). The abundance of smelt in Lake Ontario strongly suggests its impact on resident species. Young smelt feed on invertebrates while the adults consume invertebrates and other fish. This diet places them in competition with other species at the younger stage of development and makes them a serious predatory threat to less abundant species as adults (Christie, 1974). Smelt in the Great Lakes today are the subject of an extensive commercial fishery.

The white perch, a relative newcomer to Lake Ontario, is now resident throughout the Great Lakes. It gained access to Lake Ontario presumably via the Oswego River, from Hudson River populations moving northward and westward through the Mohawk River and Erie Barge Canal (Scott and Christie, 1963). White perch thrive in a variety of habitats, but the growth rate varies widely and is dependent on the region and on the environmental situation of the population under study. Scott and Crossman (1973) state that "old landlocked populations in small oligotrophic lakes in the Atlantic coastal region will possibly have a slower rate of growth than newly expanding populations, such as those in Lake Ontario."

The species appears well suited for a predaceous life (Scott and Crossman, 1973). As young, they eat microzooplankton; as the fish grow, aquatic insect larvae become important in their diet. Adults reportedly consume a high percentage of fish eggs and fishes including yellow perch, smelt, johnny darters, and other white perch (Cooper, 1941; Leach, 1962). The food preference of the white perch at each stage of development is similar to that of the yellow perch, and both populations also have similar habitat preferences (Scott and Crossman, 1973).

The similarity in food and habitat preferences brings white perch into competition with the resident yellow perch. The white perch is generally regarded as an excellent pan fish, but in areas overpopulated by the species they seldom attain a size large enough to attract anglers. They are fished commercially in the Chesapeake Bay region and in the Bay of Quinte region of Lake Ontario, where their successful competition with game fishes for available food could be a serious problem. Mansueti (1961), in a comprehensive study of the white perch in the Patuxent River estuary in Maryland, indicated that the population tends to be unstable due to the multiple spawnings over several years by adults, the tendency to overpopulate in closed systems, and the competition for food with resident species.

The gizzard shad is another (probable) introduced species in Lake Ontario (Miller, 1956) that appears to be increasing in abundance. Young gizzard shad are reported to be forage fish for several piscivorous species; however, their rapid growth makes them too large for most predatory fish by age two (Bodola, 1966). Miller (1960) points to the rapid growth of gizzard shad, especially in productive shallow, warm water areas as a problem to resident populations because of intensive competition, and loss of energy to higher trophic levels. Feeding preference studies on the gizzard shad indicate that young individuals feed on zooplankton; after development of the gizzard and gill rakers, adults consume phytoplankton (Cramer and Marzolf, 1970). The feeding preference of the gizzard shad brings them into competition with certain resident forage species such as the emerald shiner.

Like the alewife, the gizzard shad undergoes massive mortalities in the Great Lakes, thus creating problems along the shores. Miller (1957) noted that the peak gizzard shad abundance in Lake Erie occurred in the fall and that the species was particularly attracted to industrial thermal discharges. Gammon (1971) observed gizzard shad in a thermal plume with a temperature up to 34°C (93.2°F). Sampling conducted at Nine Mile Point during 1974 suggested that gizzard shad are located in the warmer water areas during the colder months. No die-offs of gizzard shad have been observed to date during plant shutdowns.

7. Conclusions

Previous studies of the lake community indicate that an ecological continuum exists between the Oswego Steam Station and the Nine Mile Point areas. On the other hand, data recently compiled from the Oswego Turning Basin show this locality to be unique in several respects.

The combined influence of the Oswego River and heated effluent from the power plant tend to stabilize temperatures over the course of the year. The western end of the basin in particular is usually warmer than the lake and protected against wave action by the breakwaters. The basin consequently supports a typically warmwater assemblage of fishes. Some overlap occurs between those species that normally frequent cooler waters (e.g., the rainbow smelt) and certain thermophilic species, such as the gizzard shad and longnose gar; however, the data clearly indicate that a separation of communities occurs in the turning basin. This conclusion is supported firmly by the results of the cluster analysis (Figure IV.D-5) described in Section 3.d. As shown in the figure, stations in the harbor form a discrete cluster apart from the lake community. Specific differences are described in the same section and are summarized in Table IV.D-9.

In addition to supporting a unique community, the turning basin apparently serves as a nursery ground for several species. Considerable numbers (compared to the lake) of young white and yellow perch, both important recreational species, were captured by seine and trawl during 1975 (Tables IV.D-1 and IV.D-3), pointing to the area as a nursery ground. They were present over a large part of the year and, on the basis of length frequency distributions, were observed to grow rapidly throughout the summer and early fall.

The extensive weedy shoal areas of the harbor also support a large (relative to other site in the Oswego vicinity; LMS 1974, 1975, 1976a) forage base, including several small centrachids and cyprinid species. These are also described in section 2.

Rather than having any detrimental impact on the Oswego Turning Basin, the thermal discharge from the plant tends to reinforce the seasonally stable temperature regimes induced by the Oswego River. This, in combination with the isolating effect of the breakwalls, permits a typical "pond" community to exist containing relatively high standing crops of adults and young throughout the year (Table IV.D-4). Diversity remained high in the near-shore areas, even during winter, as indicated in Figure IV.D-4. In addition, comparison of the community diversity of the turning basin with that in the lake for all gear types (Table IV.D-1) indicated that, for any given year, the majority of species (73%) from the area were captured in the basin with less than half the sampling effort than was required at similar lake sites. This attests to the species richness of the Oswego Turning Basin. Diversity is further enhanced by the presence of fewer alewives, a recognized nuisance species, in the harbor than in the lake.

The population biology of individual species utilizing the turning basin further demonstrates lack of impact of the plant's thermal discharge. Both scale analysis and length frequency studies indicate that growth of several species in the Oswego Turning Basin is rapid, and that no discernible detrimental effects such as selective mortality or diminished growth occur. The data compare favorably with those derived from other investigations in demonstrating that the observed differences between population in Lake Ontario and other areas are primarily qualitative.

In summary, a species-rich, viable community exists in the Oswego Turning Basin and has undergone little evident change since 1970. The relatively scanty data collected during that year indicate that, with the possible exception of the carp, the dominant members of the community remain essentially the same. The data also show that for those species, particularly the alewife and rainbow smelt, for which a change has been observed, a similar trend has been noted in the lake. In addition, for those life history parameters studied, the differences noted between turning basin specimens and those from other areas is largely qualitative.

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V. DISCUSSION OF POTENTIAL THERMAL DISCHARGE IMPACTS

A. INTRODUCTION

The thermal discharge from a steam electric generating station has the potential to produce changes in the aquatic communities of the receiving water body. These may be direct effects due to the elevated temperature of the thermal discharge, or they may be indirect effects which are related more to the method of discharge than to the thermal component. Both types of potential effects are discussed in this chapter with respect to the dominant species.

B. POTENTIAL DIRECT EFFECTS

1. Thermal Thresholds of Dominant Fish Species

The direct effects of heat addition on aquatic organisms are related to the ambient water temperature, the magnitude of the temperature rise, the type of discharge structure, the duration of exposure of an organism, the amount of area and/or volume affected, and the kinds of organisms present and their physiological state.

The life history information for the dominant fish species indicates species-specific responses to ambient and plume temperature. Little behavioral information is available on fish avoidance of or preference for thermal plumes.

All changes either within a fish or between the fish and its environment ultimately are initiated through a physiological response, and can lead to alterations of the behavior or ecological structure. More fundamentally, physiological changes within fish can be viewed as acute effects, which can be equated with death, or latent effects, which may include alterations in osmosis, metabolism, excretion, respiration, brain function, reproduction, growth, or other functions.

The "zone of tolerance" characterizes the range between the high and low lethal temperatures of a given species after acclimation. The available information on the thermal tolerances of the dominant fish species is presented in Appendix E. Within this temperature range, the fish can survive, but some alterations in the physiological characteristics of the fish occur with changes in temperature.

Temperature effects can be modified by the past thermal history of the fish. Temperature acclimation is a physiological adjustment by the organism to a given thermal level, an ability which is limited within a range of temperatures. The maximum upper or lower acclimation points have been called the "ultimate incipient lethal level" by Fry (1947). When a change in water temperature large enough to be of physiological significance occurs, without sufficient time for acclimation, a condition referred to as "thermal shock" can occur. This is characterized by disorientation and cessation of directed activities and can result from high or low temperatures. The critical thermal maximum (CTM) is the thermal point at which the locomotor activity becomes disorganized and the fish loses its ability to escape from conditions that may cause death.

Thermal studies are often conducted to determine the lethal limits or boundaries of an organism, levels which are specific to a given species and to life stage. These lethal thresholds, which are characterized as those temperatures at which 50% of a sample will survive, are typically referred to as "incipient lethal temperatures" and indicate the point at which temperature begins to exhibit its lethal effects. They bound the zone of temperature tolerance.

Under natural conditions, the selection of a particular region of thermal conditions from a temperature gradient has been termed thermal preference. Fry (1947) further defined that temperature "around which all individuals will ultimately congregate, regardless of their thermal experience before being placed in the gradient" as the final preferendum. Ferguson (1958) presents a review of many early investigations which dealt primarily with temperature preference from field data.

Recent work has shown that the effects of temperature are influenced by many other factors, e.g., the length, weight, sex, and age of the fish as well as photoperiod, light intensity, diet, water chemistry, and salinity (Halsband, 1953; Sullivan and Fisher, 1953; Hoar, 1955; Fisher, 1958; McCawley, 1958; Hoar and Robertson, 1959; Cragie, 1963; Sprague, 1963; Smirnova, 1967; Garside and Jordon 1968; Barker et al., 1970; Meldrim and Gift, 1971; Cherry et al., 1975).

The thermal data for each fish species have been reviewed and critical conditions for quantitative evaluation have been identified; particular attention is focused on the occurrence of lethal warm temperatures and temperature elevations.

The summer lethal thermal thresholds for dominant fish species are listed in Table V-1. Because some associated acclimation temperatures are not specified (see Appendix E for the complete available data list), the thresholds may in some cases be conservatively low due to acclimation temperatures below the normal summer Lake Ontario ambient temperature. In addition, the summer lethal temperatures are near ambient for all species except white perch, whose upper lethal threshold is 6.6°C (43.9°F) in winter and 34.7°C (94.5°F) in summer. Only one dominant species, the rainbow smelt, has a lethal threshold temperature which may exclude its presence downstream

TABLE V-1

LETHAL THRESHOLD TEMPERATURES FOR SELECTED FISH SPECIES

SPECIES	SUMMER LETHAL THRESHOLD
Alewife	23° -32.2°C (73.4°-90.0°F)
Rainbow smelt	21.5°-28.5°C (70.7°-83.3°F)
Smallmouth bass	35° C (95°F)
Threespine stickleback	25.8°-33° C (78.4°-91.4°F)
White perch	34.7°C (94.5°F)
Yellow perch	29° -32° C (84.2°-89.6°F)
Golden shiner	33.4°-35° C (92.1°-95° F)
Emerald shiner	30.7°-31.1°C (87.2°-88° F)

of the initial portion of the discharge. Other pertinent temperature data are described under the species-specific headings in Chapter IV.

2. Thermal Thresholds of Dominant Invertebrate Species

Increased temperature increases metabolic rate, resulting in changes in growth, development, and reproduction. The ability to tolerate a certain temperature varies with species, age, stage of development, physical condition, ambient temperature, magnitude of temperature change, rate of temperature change, duration of exposure, concentration of oxygen, salinity, and indirect effects such as turbulence. Invertebrates, like fish, are able to acclimate within certain temperature limits. Thermal tolerance studies have been conducted on relatively few invertebrates, and the amount of information is limited.

Temperature tolerance data are available for three species found in the turning basin: Gammarus fasciatus, Hyalella azteca, and Asellus sp. In the turning basin Asellus were not identified beyond generic level, but A. intermedius (= communis) is the dominant isopod present in Lake Ontario and tolerates a broad spectrum of ecological conditions (Sprague, 1963).

The ultimate 24-hour and 48-hour LC-50 values (temperature which is lethal for 50% of the individuals) for these species is given in Table V-2 (from Sprague, 1963). It must be noted that invertebrates may be restricted to temperature regimes much lower than that indicated by LC-50 values, which reflect only the upper physiological limit. In such cases, indirect temperature effects may influence distribution.

3. Plume Entrainment

Most entrainment studies have been concerned with the effects of condenser cooling systems on those organisms contained in the cooling water flow. A second category of entrainment studies is the evaluation of the potential impact on organisms entrained into the discharge stream within the mixing zone of the receiving water body, a phenomenon called plume entrainment.

Entrainment of this type affects primarily planktonic organisms, i.e., those forms whose movements are more or less dependent on water currents (Odum, 1971). This group includes phytoplankton, zooplankton, and ichthyoplankton. Because of their greater mobility, larger fishes and certain invertebrates would not be affected to any considerable degree.

The stresses experienced by planktonic organisms entrained in the thermal plume are very different from those experienced in pump entrainment. Organisms drawn into the mixing plume experience relatively

TABLE V-2

THERMAL CONCENTRATION AND TOLERANCE VÆLECTED

I. SELECTED INVERT

SPECIES		
Asellus intermedius	3(°F)	3F)
Gammarus fasciatus	3(°F)	3F)
Hyalella azteca	3?°F)	3F)
Gammarus pseudolimnaeus	2?°F)	2F)

II. GAMMARUS FASCIATUS

EXPERIMENTAL TEMPERATURE (°C)	ACCLIMATED TO 10°C MALE	FEMMALE	ACCLI TO :
29		7(1700	
30		8 210	
31		3 90	
3:		1	
33			

LC-50 - Concentrations lethal to 50% of o a giv
LT-50 - Time (minutes) necessary for 50% of orga
at a given concentration
*Sprague, 1963

small thermal elevations above ambient levels, and the time or duration of exposure is highly variable. The temperature-time exposures are determined by the momentum of the discharge, type of discharge structure, and the hydrology of the receiving water body. For example, low or high discharge velocities, and depth of discharge (surface vs. submerged) delineate the area affected by the thermal discharge and also the length of time during which organisms would be exposed to its effects.

The Oswego Steam Station has a maximum surface water discharge of 1.2 fps. The results of several thermal surveys taken during 1975 and 1976 indicate that the plume usually occupies the entire water column (15 ft depth) at the western end of the turning basin.

a. Phytoplankton

Dryer and Bensen (1957) studied the effect of power plant operation on freshwater phytoplankton in Tennessee. They concluded that no significant increase or decrease in cell numbers could be associated with the plant's thermal effluent. Patrick (1969) studied periphyton on glass slides incubated above and below a steam electric generating plant's thermal discharge and noted no significant difference in abundance or biomass values.

Warinner and Brehmer (1966) and Morgan and Stross (1969) have examined power plant effects on phytoplankton production. Both studies indicated that either inhibition or stimulation of photosynthesis may occur, depending on ambient conditions. Morgan and Stross (1969) found that photosynthesis was stimulated by a temperature increase of 6.0-9.2°C (10.8-16.6°F) when ambient temperatures were 16°C (60.8°F) or cooler and inhibited when the temperature increase occurred at ambient temperatures of 20°C (68°F) or warmer. Hamilton et al. (1970) found that photosynthetic rates were stimulated by thermal elevations of 6 to 7°C (10.8-12.6°F) at ambient temperatures up to 23.5°C (74.3°F); rates were depressed by heating the water 6°C (10.8°F) from 27 to 33°C (80.6-91.4°F). If it is assumed that the results of these studies are applicable to the phytoplankton populations in the Oswego Turning Basin, production of phytoplankton entrained into the discharge plume might be inhibited only during the late summer and possibly stimulated at other times of the year. Ambient temperatures above which temperature elevations have resulted in inhibition of photosynthesis are 20°C (68°F) (Morgan and Stross, 1969) and 27°C (80.6°F) (Hamilton et al., 1970). Hamilton et al. (1970) observed no further stimulation of photosynthesis as a result of temperature elevation above an ambient temperature of 23.5°C (74.3°F). This latter temperature is considered a compromise between the two studies, and temperatures elevated above this value could result in inhibition of photosynthesis. Monthly average water temperatures in the Oswego Turning Basin have been observed to exceed 23°C (74.3°F) only during the late summer (August).

New York University (1975) evaluated the effects of simulated plume entrainment on phytoplankton through measurements of productivity and chlorophyll _a_ content following a four-hour exposure period. Chlorophyll _a_ content was not affected by increased temperatures, whereas productivity, as determined by ^{14}C-uptake studies, exhibited seasonal differences upon exposure to increased temperature.

Brooks (1974) concluded that any reduction in summer primary productivity caused by the power plant would not be expected to cause extensive alteration in the flow of energy through the food chain because:

1) decreases in productivity were confined to a relatively small portion of the water body in the immediate vicinity of the thermal discharge and for only a brief period during the warmer months, and

2) primary production rates were reduced at a time when overall primary production in the system was at its seasonal maximum, while primary consumers were at their seasonal minimum.

Temperature is important in determining the species composition of the phytoplankton (Margalef, 1958). As the temperature of receiving water is elevated, there may be shifts in the algal flora from diatoms to green or blue-green forms. Patrick (1969) observed separate phtyoplankton groups exhibiting dominance, depending on the temperature of the water at a power station; diatoms were dominant when the water temperature ranged between 20-30°C (68-86°F), greens dominant between 30-35°C (86-95°F), and blue-greens dominant above 35°C (95°F). The latter algae have often been associatd with the formation of obnoxious blooms which result in health and aesthetic problems (Ruttner, 1963; Margalef, 1958). However, phytoplankton populations can respond quickly to environmental changes (Margalef, 1958). Consequently, changes in species composition, abundance, and productivity which can result from local phenomena generally diminish quickly with increasing distance from the point of disturbance.

b. Zooplankton and Ichthyoplankton

Zooplankton are essential in the transfer of energy and nutrients through the trophic structure of aquatic systems. They feed principally on algae and detritus and are in turn grazed upon by fish and other invertebrates (Odum, 1971). Ichthyoplankton, including the eggs and early larval forms of fish, are temporary members of the planktonic community.

A number of workers have found that zooplankton were not detrimentally effected as a result of power plant operation. Markowski (1959) observed no effects on zooplankton caused by the thermal discharges of several power generating stations located on marine waters. Whitehouse (1971) found no significant effect on the composition, abundance, or seasonal fluctuations of resident zooplankton populations in a cooling pond receiving the thermal discharge from a small generating station. WAPORA, Inc. (1972) evaluated the thermal discharge of four power stations along the Ohio River and concluded that the zooplankton populations were not altered as a result of the thermal discharges. Davies and Jensen (1974), in an extensive survey at three power plants situated on different types of water bodies, concluded that there was no lasting or permanent effect on resident populations of zooplankton in the receiving waters. NYU (1975) studied zooplankton plume entrainment by drifting Gammarus spp., the dominant zooplankton group in the vicinity of the Indian Point plant, through the thermal plume for a one-hour exposure period. They obseved 100% survival on two separate occasions following the exposure to the elevated plume temperatures and to the additional stress of chlorine.

Zooplankton entrained into the discharge plume will be subjected to smaller temperature rises than those present within the condenser system and will not be subjected to the more detrimental mechanical effects. Therfore, little mortality is expected as a result of zooplankton entrainment in the discharge plume.

The same principles applied to zooplankton plume entrainment have been observed for ichthyoplankton. Nakatani (1969) observed no detrimental effects of heated effluents on salmon eggs or young in the Columbia River and, in fact, concluded that the warmer water during the early winter may actually be beneficial to egg incubation. NYU (1975) evaluated the impact of plume entrainment on juvenile striped bass (Morone saxatilis) at Indian Point by drifting specimens through the thermal plume; no significant mortality was observed to result from exposure to elevated plume temperatures. Thus, mortality due to ichthyoplankton entrainment in the plume is expected to be insignificant.

4. Distributional Trends

The Oswego Turning Basin may be compared with a cooling pond since the thermal discharge is effectively contained by the system of breakwalls. Thermal surveys conducted on several dates in 1975 and 1976 and routine temperature data indicate that a fairly uniform increasing temperature gradient usually occurs from west to east in the basin. At times the thermal plume may extend over the entire water column in the vicinity of the discharge, while in other instances cooler river water may be found below the plume as far west as OTB-6. In addition, intrusion of colder lake water into the intake as a result of upwelling may cause a "sinking" discharge plume, since the temperature rise across the plant still results in a plume cooler than the incoming river water.

Because of these conditions, fishes and other organisms may experience widely varying temperature regimes over relatively short periods. However, the net effect is still basically a warmer western end of the turning basin with temperature gradually cooling toward the harbor mouth. As a result of this pattern, temperatures during the summer are observed to exceed the thermal maximum of several species, particularly the alewife, rainbow smelt, brown trout, and coho salmon.

The thermally enriched waters of the basin generally seem to reduce the utilization of this area by several species especially the alewife and rainbow smelt; the alewife, in fact, may not utilize the western end of the turning basin as a spawning area at all. On the other hand, certain species such as the gizzard shad and white perch are attracted to the plume during the cooler months and are thus benefited by plant operation, as are numerous forage species that utilize the extensive weedy shoals in this area. The combination of nutrient enrichment due to the nearby sewage outfall and the thermal effluent maintain high productivity in this area and provide a rich nursery habitat for several species including the young of white and yellow perch. Lower trophic levels are also maintained, such as the large forage base which consists of the golden, emerald, and spottail shiners and several centrarchid species.

In conclusion, the potential for supporting a warm water assemblage in the turning basin seems realized, with several species excluded to varying degrees and others benefited by the thermal additon.

5. Shutdown Effects

Cold shock, a phenomenon which may result in fish kills, is caused by a rapid decrease in temperature when the addition of heated water is terminated during the colder part of the year. Cherry et al. (1975) found that all of the thirteen species of cyprinid, centrarchid, ictalurid, and salmonid fishes tested preferred warmer temperatures at ambient temperatures below 18°C (64.4°F). Nine of these species preferred warmer temperatures when the ambient temperature was as high as 27°C (80°F), suggesting that for some species, attraction to thermal plumes may occur almost the entire year. Meldrim and Gift (1971) reported that preferred temperatures for white perch and several other marine, estuarine, and anadromous species were usually higher than the ambient acclimation temperatures. For those species which are known to be present in the Oswego Turning Basin, these data indicate a high potential for attraction to thermal plumes.

The severity of cold shock stems from the physiological fact that fishes cannot acclimate to descending temperatures (Speakman and Krenkel, 1972), as well as they can acclimate to ascending temperatures. Jones (1964) pointed out that the adaptation to high temperatures may take place in a matter of hours, but that adjustment to colder conditions may take many days. Thus Brett (1944) found that fathead minnows took over 20 days to become acclimated to 16°C (60.8°F) after previously living at 24°C (75.2°F), but became acclimated to 28°C (82.4°F) from 20°C (68.0°F) in 24 hours (Brett, 1944).

The degree of potential impact presented by a thermal effluent depends upon several factors of plant design such as rate of dilution, ΔT, and amounts of water discharged. A plant with a small discharge, low ΔT, and efficient dilution would have low potential for fish kills caused by cold shock. The stability of the heated area is of prime importance when evaluating the potential for cold shock problems. The American Nuclear Society (1974) stated that cold shock complications resulted from the creation of a warm "habitat" which, during the colder months, is occupied by aquatic organisms in preference to nearby waters. The habitat concept entails that the heated plume be somewhat stable in terms of location. This is the case for heated water discharged into a cove, bay, canal, creek, or small river, or any other restricted area such as the Oswego Turning Basin which remains as a separated environment with temperatures above those in contiguous waters. Most incidents of mortality from cold shock have been recorded from such areas.

C. POTENTIAL INDIRECT EFFECTS

1. The Effects of Currents and Dissolved Oxygen

The discharge of water by a power plant can have the following possible effects:

1. the production of currents which may act as a near-field attractant to fish,

2. potential reduction in dissolved oxygen by biological oxygen demand or heating.

That fish and other organisms orient themselves with water currents has been known at least since Gudger (1949) described a group of trout (Salmo gairdneri) arrayed in extremely regular ranks near the bottom of a swiftwater stream. Breder (1959) generalizes, for schools of fish in flowing water, that "it is possible to arrange the distribution and form of the schools into almost any outline desired by suitable adjustment of the amount of flow and its direction." Thus, the currents created by the discharge may assume patterns which, in the nearfield, affect the orientation of fish. Kelso (1974), working with several species of fish in the vicinity of two Canadian power plants with surface level discharges, concluded that the fish were attracted by the currents produced by the discharge rather than by its heat. He found that the fish made what appeared to be feeding forays into the heated areas, remained there for some 20 minutes, and then left the area. This behavior occurred both when the plants were rejecting heat and when the circulating pumps were operating but no heat was being discharged. Insufficient quantitative information precludes an assessment of this impact on fishes but the food web of fish near the plume is not expected to differ from the natural habits of the fish, thus no net change in fish abundance can be related to the thermal discharge.

The effect of the thermal component of the discharge on levels of dissolved oxygen has also been considered. Two factors could cause a reduction in the oxygen concentration as the cooling water passes through the condenser system of Oswego Units 1-4: sudden reduction in pressure and heat. In addition, rising temperature affects oxygen demands: Biological Oxygen Demand (BOD) increases about 2% for each 1°C rise above 20°C (FWPCA, 1967).

Fish eggs, larvae, and adults require oxygen concentrations of at least 2-4 mg/l for sustained growth and reproduction, although the exact quantity depends on the species. Values this low are rarely, if ever, found in the vicinity of Oswego Steam Station Units 1-4 discharge (LMS, 1974).

Oxygen concentrations recorded by LMS in 1973 ranged from 9.2 to 10.2 mg/l (Chapter II). With a subsequent increase in temperature of 4°C (7.2°F) the expected level would be 8.5 to 9.4 mg/l (Fair et al., 1968). These values are well within the acceptable range for survival, growth, and reproduction of the fishes present.

Specific studies have been conducted at Nine Mile Point Unit 1 to quantify the reduction in dissolved oxygen resulting from passage through the power plant. Analyses of the 1973 data documented that the reduction averaged 0.3 mg/l even though the inlet water was supersaturated. It is proposed that the reduction was slight due to the rapid passage of water through the plant.

D. SUMMARY

The operation of an electrical generating facility which utilizes large quantities of water for condenser cooling, and the subsequent thermal discharge from such a facility, may impact the biotic community in the receiving water body directly or indirectly. Direct plant operational impact results when the rate of temperature change to which an organism is exposed exceeds the rate of physiological adjustment, or when the thermally impacted area has temperatures above or below the thermal tolerance levels of the aquatic organisms. Rapid changes in temperature are experienced by primarily non-motile organisms entrained into thermal plume while sedentary populations are most likely to be exposed to temperatures above their thermal tolerance. Indirect effects relate to the currents generated at the point of discharge and to the physical/chemical properities of the warmer water in relation to the ambient receiving water.

An assessment of the potential discharge impacts based on the studies conducted at the station is presented in Chapter VI.

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VI. IMPACT OF THERMAL DISCHARGE ON THE OSWEGO TURNING BASIN

A. INTRODUCTION

The essense of a 316(a) Type I demonstration is to determine whether the indigenous community is intact and "balanced" and whether the thermal discharge has resulted in any appreciable harm to the community. This chapter synthesizes information presented in preceding chapters and demonstrates that the indigenous community is intact.

The community is first be defined, described, and characterized. Indication that the community is intact and "balanced" is based on consideration of the following criteria (EPA, 1974):

1. There exists a richness of taxa.
2. All expected trophic levels exist.
3. Certain species complete their life cycles successfully in a natural and normal fashion.
4. The community exhibits persistence.

Because the large number of species present makes it unreasonable to consider all species for criterion 3, dominant species from various taxonomic, trophic, and ecological descriptions are considered to be a sufficient sample. Potential economic and recreational use of the turning basin is addressed. Finally, those physical parameters determining the nature of the biological community are discussed, thereby placing the Oswego Steam Station effluent in context of the synecology of the basin.

B. SUMMARY OF THE BIOTA

Organisms sampled are classified by operational descriptions which take into account both the phylogenetic descriptions and sampling apparatus. For example, macrozooplankton are those invertebrate organisms retained by a 571 μ mesh net. Meroplankton (such as dipteran larvae) may be classified under more than one description (i.e., they are also benthic). Although some heterogeneity may be introduced by these classifications, they have proven to be useful designations and have stood the scientific community in good stead. The results of analysis of each separate group will be summarized, and the information then synthesized.

The phytoplankton was a large and diverse group of species including algae typical of open water, rivers, and ponds. Nine of 33 potential nuisance algae exceeded bloom criteria on at least one sampling date. Bloom conditions of nuisance algae were most often encountered at OTB-4, the station close to the harbor mouth, and least often at the intake. The number of bloom occurrences showed a definite decreasing trend from east to west. The pattern of chlorophyll a distribution indicated that discharge (lake) waters, low in chlorophyll a, were being mixed with river waters higher in chlorophyll a, on many dates. Spatial variation in chlorophyll a may have been explained largely by circulation patterns.

The macrozooplankton community of the Oswego Turning Basin was characterized by fauna common to shallow, sluggish, or standing water bodies. Many of these have high environmental tolerance to factors such as temperature and nutrient enrichment. Macrozooplankton distribution may have been associated with stratification of water masses within the turning basin.

The benthic community of the Oswego Turning Basin was diverse, with seven phyla and 68 groups identified to generic or specific levels. There existed an indigenous, ubiquitous, persistent community of at least the species Gammarus fasciatus, Limnodrilus cervix, L. cervix variant, L. hoffmeisteri, L. udekemianus, Ilyodrilus templetoni, and Tubifex tubifex. All of these species underwent normal seasonal fluctuations and probably completed all phases of their natural life cycle in the basin. Six other associations of organisms were identified in the basin.

Studies from 1968-1969 and 1970 indicate that the benthic assemblage was a persistent and probably stable community. The life histories of the individual organisms support that conclusion. The benthos of the harbor and turning basin were saprobionic and saprophilic, while saprobionic and thermophilic organisms were concentrated in the turning basin. The benthos was typical of inshore, harbor, and river mouth areas around eutrophic bays and harbors of Lake Ontario, and also typical of eutrophic ponds and lakes.

Three distinct associations of fish were recognized: a warm water assemblage characteristic of the turning basin, a near-shore assemblage, and a deep water assemblage. The former was differentiated by reduced numbers of those taxa associated with cooler temperature and increased numbers of warm water taxa. The latter two associations differed mainly in the relative abundances of the composite species. Species richness of all three communities was high; however, species diversity was low due to high seasonal dominance by gizzard shad or alewives. Alewives appeared to avoid the western harbor during spring/summer and probably did not use that area as a spawning ground.

The warm, protected waters of the basin produce a habitat suitable for large numbers of gizzard shad, and favoring species characteristic of shallow eutrophic lakes and ponds. These species included centrarchids (largemouth bass, bluegill, and pumpkinseed sunfish), northern pike, carp, brown bullhead, golden shiner, bowfin, and longnose gar.

Lake collections were dominated by alewives and rainbow smelt, whereas different trophic levels were represented in the turning basin: generalized feeders, herbivores, insectivores, and carnivores. White and yellow perch appeared to complete successfully all phases of their life cycles in the turning basin.

C. CHARACTERIZATION OF THE COMMUNITY

Based on evidence presented in preceding chapters and summarized above, the biotic community of Oswego Turning Basin may be described as an assemblage typical of warm, protected, eutrophic ponds, lakes, and lentic water bodies. It is not typical of the adjacent open waters or high-energy shallow zone of Lake Ontario. Rather, it is probably more comparable to protected embayments of the lake. However, it is a very complex ecosystem and exhibits the influences of the Oswego River, the open lake, various waste discharges, and the Oswego Steam Station. There is an east-west continuum present in which the west end of the turning basin has the characteristics of warm, protected, eutrophic, lentic water bodies and the east end (Oswego Harbor) has the mixed characteristics of open lake forms, polluted harbor forms, and polluted river forms of biota. Blooms of noxious algae are more severe in the east, and are indicative of a pollution gradient increasing from the clean warm Oswego Steam Station effluent to the polluted Oswego Harbor in the east.

D. CRITERIA FOR INTACT COMMUNITIES

As stated earlier, four criteria will be addressed: the richness of taxa, the presence and implications of various trophic levels, completion of life cycles by certain species, and evidence of community persistence.

The biological community occupying the Oswego Turning Basin is a diverse group of organisms of many trophic and phylogenetic descriptions. The diversity of the community is readily apparent from the number of taxa identified: 79 of microzooplankton, 22 of macrozooplankton, 68 of benthos, 44 of fish, and 261 of phytoplankton. Although some species are captured as both microzooplankton or macrozooplankton and benthos, many taxa have not been identified to the specific level and these numbers constitute low estimates of the number of taxa actually present. In addition, some groups were not sampled (epiphytes, macrophytes, aufwuchs) and other organisms (e.g., crayfish) may effectively avoid the sampling apparatus. In all, the biotic community is clearly seen to be diverse and complex.

It is evident from preceding chapters that many trophic levels are present. Fish in the turning basin, for example, are piscivores, insectivores, herbivores, and generalized feeders. The presence of organisms of different trophic types in the turning basin indicates either that food webs utilizing different primary sources are present, or that a well balanced and potentially stable community exists.

Primary producers (algae), grazers (such as copepods) and carnivorous plankters (such as Leptodora) indicate a functioning food web based on algal production. Detritus-feeders, such as oligochaetes, and their predators (fish, water mites, Prostoma) indicate a functioning detritus-based food web. The presence of top carnivores such as largemouth and smallmouth bass attest to the flow of energy through many successive trophic levels. The presence of diverse trophic types indicates the successful flow of energy through both primary production and detritus-based food webs.

There is evidence that organisms in the turning basin are completing natural life cycles there, and that the turning basin is being used both as a breeding area and as a nursery for several species of fish.

The dominant invertebrate species (Leptodora kindtii, Gammarus fasciatus, Limnodrilus hoffmeisteri, L. cervix, L. udekemianus, and Tubifex tubifex) all undergo normal seasonal fluctuations, indicating that these species are undergoing normal population dynamics. In addition, length-frequency data for both white and yellow perch indicate that these two species utilize the turning basin as a nursery ground. The young grow rapidly through the summer and length-frequency data do not show any consequential differences between populations in Oswego Turning Basin and Lake Ontario.

Fish eggs and early larvae were collected, indicating that species such as white and yellow perch use the turning basin as a breeding area. Weedy, shallow areas were not sampled for ichthyoplankton, but these would normally be the centers of spawning activity for many species.

Evidence of the persistence of the community found in the Oswego Turning Basin and Harbor can be found by comparing fish and benthos communities with those found in past studies (Chapters IV-D and IV-C, respectively). These comparisons indicate only a few changes in those communities over a period of five to seven years, and that the community is able to maintain itself through time (persistence) and has recovered from all ecological perturbations occurring in that time period (stability). The continued persistence of indigenous community in Oswego Turning Basin and its stability against perturbation are expected.

The Oswego River and the Oswego Turning Basin are classified as Class C water bodies by the New York State Department of Environmental Conservation (Title 6, part 703). Under this classification, the best usage is described as suitability for fishing and all others uses except as a source of water supply for drinking, culinary or food processing purposes and primary contact recreation. There is no evidence that the Oswego Steam Station has rendered the water unsuitable for fishing or other uses as stated.

The largest recreational area in the Town of Oswego is the Fort Ontario historical site. Recreational facilities include a swimming pool, four ballfields, a civic arts center, picnic areas, a skating rink, tennis courts and playground areas. Breitbeck Park also overlooks Oswego Turning Basin and Lake Ontario and provides recreational facilities.

Two marinas are present in the Town of Oswego which serve recreational boating and fishing interests. No commercial fishing is done in Oswego Harbor. LMS has collected many recreational and sport fish in Oswego Turning Basin and Harbor, including: panfish (white perch, yellow perch, black crappie, and rock bass), smallmouth bass, largemouth bass, brown trout, rainbow trout, coho salmon, northern pike, walleye, freshwater drum, and brown bullhead.

The fish community of the turning basin is more typical of a protected pond or lake and not of the open lake. Fishing in the turning basin should be typical of fishing in ponds and small lakes in the Oswego area. This is a result of the combined influences of the stone breakwaters, the Oswego River, and the Oswego Steam Station effluent. The characterization of the Oswego Turning Basin community follows in the next section.

Oswego Harbor has been a center for the economic and industrial growth of the Town of Oswego. Most of the industry is located along or adjacent to the mouth of the Oswego River and the Lake Ontario waterfront. The effluent of the Oswego Steam Station in no way detracts from the economic usage of the Port of Oswego.

E. PARAMETERS INFLUENCING THE BIOTIC COMMUNITY

The biotic community of Oswego Turning Basin is affected by four physical influences: the Oswego River, Lake Ontario, the Oswego Steam Station effluent, and the breakwater. The Oswego River carries high detrital and organic loads resulting from natural, agricultural, and municipal runoffs and both municipal and industrial discharges. Lake Ontario and the Oswego Steam Station discharge provide relatively clean water inputs to the basin.

Average yearly surface and bottom temperatures in the turning basin and harbor are highest at the extreme western end, reflecting the Oswego Steam Station discharge. Under most circumstances this water is the warmest and least dense water in the basin and it flows eastward, entraining the cooler river water flowing westward below it. When the river water is warmer than the discharge, the discharge may move eastward between the warm river water above and the cool lake water below. These currents flush the turning basin with clean lake water, lower in concentrations of sodium, magnesium, sulfate, chloride, specific conductance, total dissolved solids, ammonia-nitrogen, nitrate-nitrogen, and phosphate-phosphorus. Dissolved oxygen concentrations of discharged Oswego Steam Station effluent are higher than in the intake water except in the period between July and September.

Domestic and industrial pollutants and urban runoff result in high concentrations of fecal coliforms, total coliforms, biochemical oxygen demand, chemical oxygen demand, and total suspended solids. The effluent of the Oswego Steam Station promotes flushing of these polluted discharges from the harbor, and moderates temperature in the western turning basin.

The breakwater protects the relatively shallow harbor from wave action. Silt and detrital loads from the Oswego River and sewage discharges settle out in this area of low currents and must frequently be dredged. The resulting areas of sediment accumulation support large populations of macrophytes in the western turning basin. These meadows, which would not exist without the protection of the breakwater, can harbor populations of spawning fish and provide nursery areas for the young.

The last influence is the raw sewage effluents. The benthos of the turning basin, in particular, is typical of areas subject to high loads of organic wastes. Municipal outfalls in the turning basin are probably one source of these organics which contribute greatly to the sedimentation there.

F. SUMMARY

In summary, four influences combined determine that the biotic community of the Oswego Turning Basin will be typical of warm, protected, eutrophic areas. These influences are the Oswego River, Lake Ontario, Oswego Steam Station, and municipal effluents. The power plant influences the biota by moderating temperature and flushing the basin with lake water.

The indigenous biotic community of Oswego Turning Basin is intact, diverse, stable, complex, and persistent. It is somewhat typical of warm, protected, eutrophic areas, perhaps embayments, and shows some lacustrine and riverine characteristics. No appreciable harm was observed at any trophic level on the aquatic community in the Oswego Turning Basin due to the thermal discharge from Oswego Steam Station Units 1-4.

APPENDIX A

OSWEGO STEAM STATION
UNITS 1-4
THERMAL SURVEYS

26 JUNE 1975
28 AUGUST 1975
6 NOVEMBER 1975
20 APRIL 1976

191-035

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I. INTRODUCTION

A. PURPOSE

A thermal survey of the discharge from Niagara Mohawk Power Corporation's (NMPC) Oswego Steam Station was conducted on 26 June 1975, as specified in the NPDES permit and New York State's 401 certification. The survey included tri-axial temperature measurements, as well as vertical profiles of specific conductivity in the Oswego River-Harbor complex and in Lake Ontario. The purpose of the survey was to define the dissipation of the cooling water discharge from Oswego Steam Station Units 1-4 in the harbor complex and to describe the mixing of the discharge waters with the Oswego River flow entering the harbor.

B. STATION AND SITE DESCRIPTIONS

The Oswego Steam Station is located on the south shore of Lake Ontario in Oswego, New York (see Figure 1). The station presently consists of five generating units with a sixth under construction. At the time of the June survey only Units 1-4, with a combined maximum generating capacity of 407 MW, were operating; Unit 5 was not yet in operation. Cooling water for the station's Units 1-4 is withdrawn from Lake Ontario through a submerged intake at a point some 76 m (250 ft) north of the northwestern tip of the Oswego Harbor breakwater in 4.6 m (15 ft) of water. The maximum cooling water flow of 21.6 m^3/sec (762 cfs) is circulated through the condensers of the four units by eight pumps and returned through a surface discharge to the western leg, or "turning basin," of Oswego Harbor at a

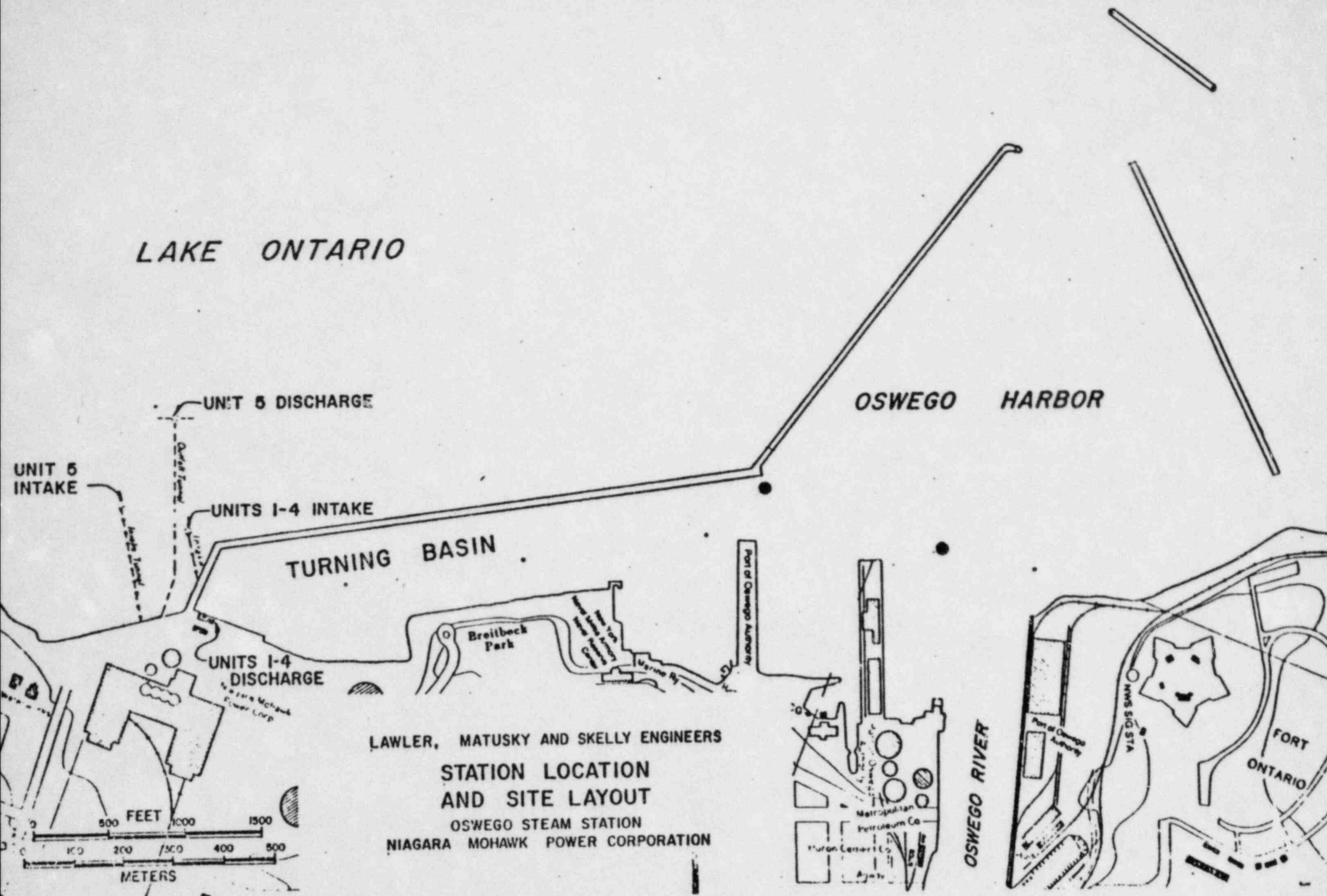

LAKE ONTARIO
OSWEGO HARBOR
UNIT 5 DISCHARGE
UNIT 5 INTAKE
UNITS 1-4 INTAKE
TURNING BASIN
UNITS 1-4 DISCHARGE
Breitbeck Park
Port of Oswego Authority
Metropolitan Petroleum Co
Huron Cement Co
OSWEGO RIVER
NWS SIG STA
FORT ONTARIO
FEET
0
500
1000
1500
0
100
200
300
400
500
METERS
LAWLER, MATUSKY AND SKELLY ENGINEERS
STATION LOCATION
AND SITE LAYOUT
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION

FIGURE A-1

maximum temperature rise of 6.9°C (12.4°F) above the condenser inlet water temperature. The intake design allows a portion of the discharge water to be diverted into the intake forebays to maintain the condenser inlet flow at the ideal temperature for maximum condenser efficiency when the ambient lake temperature is below that value. The gates controlling the tempering flow were closed during the June survey.

Unit 5 of the Oswego Steam Station is located on the west side of Units 1-4. Circulating water flows through an independent system whose intake is located approximately 260 m (850 ft) offshore in Lake Ontario. The discharge diffuser is located about 415 m (1,360 ft) offshore and is oriented approximately parallel to the east-west line of the existing breakwater.

The Oswego River flows into the harbor area from the south and mixes with the Units 1-4 discharge; the combined flow enters Lake Ontario at the harbor mouth. The Oswego River has a yearly average flow of about 173 m^3/sec (6100 cfs) and a minimum average seven-consecutive-day (MA7CD) once in ten year flow of 20 m^3/sec (720 cfs). Due to upstream discharges, the Oswego River contains concentrations of chlorides four to six times the concentration in Lake Ontario water, making it possible to determine the dilution of the river water in lake water by chloride concentration measurements.

II. METHODS AND MATERIALS

A. THERMAL MAPPING

An 11 m (36 ft) inboard boat, outfitted as shown in Figure 2, was used to measure temperatures in the vicinity of the plant. The temperature sensors were towed at depths of 0.1, 1.5, 3.0, and 4.6 meters (0.5, 5, 10 and 15 ft). The position of the boat was continuously determined by microwave range gear (Motorola Mini-Ranger). The temperature, position, date, and time were recorded on magnetic tape using an Endeco model 167 data acquisition system. The 167 system also provides a visual readout of the data on the boat so that the crew can monitor the data as it is collected. The equipment specifications are given in Table 1 below.

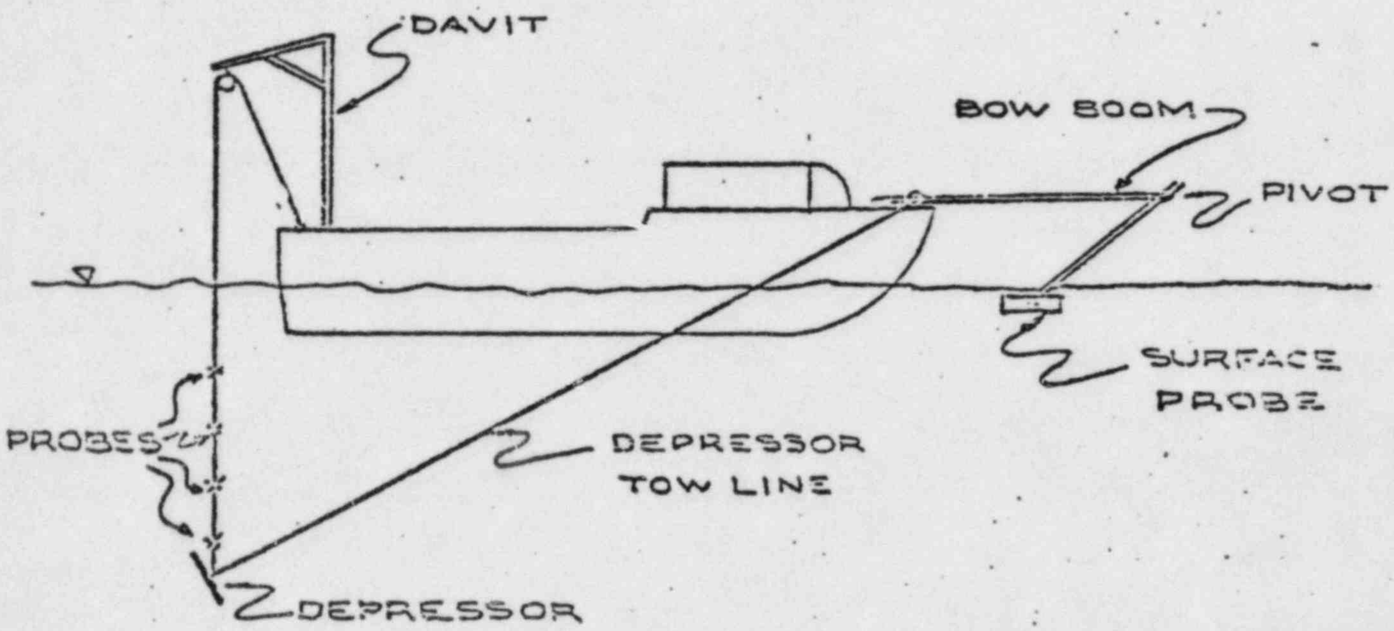
TABLE 1

EQUIPMENT SPECIFICATIONS

Parameter	Sensor Type	Supplier	Accuracy
Temperature	thermistor	Endeco	± .05°C (±0.1°F) (time constant = 0.5 sec)
Location	micro-wave	Motorola Inc.	± 3 m @ 20 miles
Conductivity (field)	electrode	Martek Inc.	± 2% full scale
Conductivity	platinum electrode	Yellow Springs Instruments	± 2% of reading

OSWEGO STEAM STATION THERMAL SURVEY

SURVEY BOAT SET-UP



B. VERTICAL PROFILES

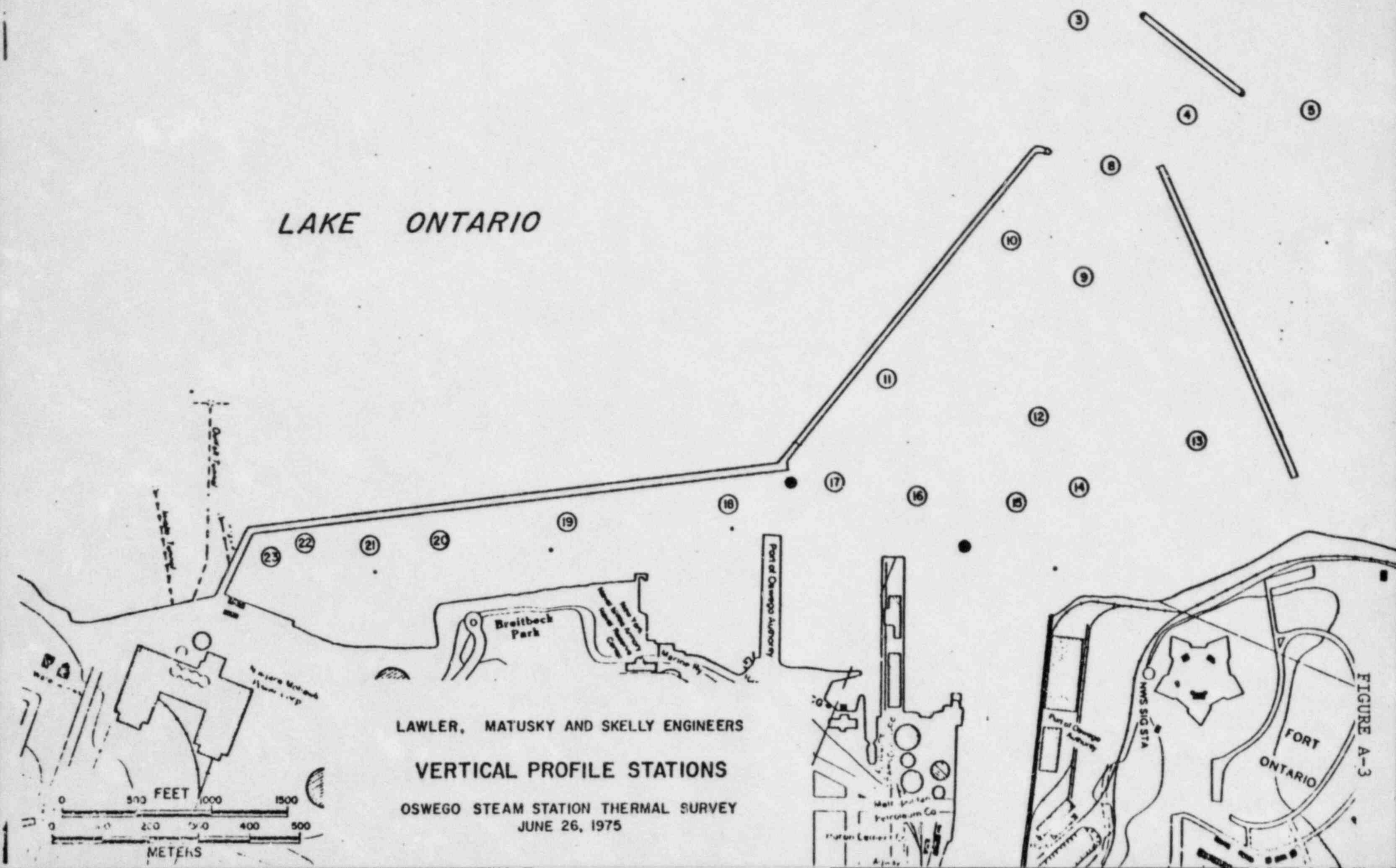
Vertical profiles of temperature and specific conductivity were obtained in the Oswego Harbor area and in Lake Ontario. The locations of the vertical profile recording stations are shown in Figure 3. The locational and temperature data were recorded on magnetic tape and the specific conductivity was recorded manually.

In addition to the field conductivity measurements, water samples were collected at selected stations and analyzed in the laboratory for chloride concentration and specific conductivity. The sample stations were selected to provide a full range of values for determining the relationship between specific conductivity and chloride concentration. The specifications for the conductivity meters are given in Table 1. The relationship was later used to convert all specific conductivities to chloride concentrations.

C. DATA REDUCTION

The recorded temperature and positional data were plotted by computer, separately for each depth. Isotherms were then drawn through the data at 0.55°C (1°F) intervals, where possible, to show the distribution of temperature in the study area. The isotherms were then traced on maps of the study area for presentation in this report.

The vertical profile positions were plotted by the computer along with a listing of the temperature data. The specific conductivity data were adjusted to conductivity at 25°C according to Standard Methods (APHA, 1971).



LAKE ONTARIO
3
4
5
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
Breitbach Park
Port of Oswego Authority
NWS SIG STA
FORT ONTARIO
LAWLER, MATUSKY AND SKELLY ENGINEERS
VERTICAL PROFILE STATIONS
OSWEGO STEAM STATION THERMAL SURVEY
JUNE 26, 1975
FEET
0
1000
1500
400
500
METERS

FIGURE A-3

D. CHANGES IN THE 20 APRIL 1976 SURVEY

While the general survey procedures were identical to those employed in the three previous surveys, some equipment changes were made for the April 1976 survey. A different data recording system was used and a fifth temperature sensor was added and towed at the 6.1 m (20 ft) depth. In addition, specific conductivit; was continuously sampled at the surface during the temperature mapping runs. The accuracy of the temperature recording system was ± 0.1°C (± 0.2°F).

III. RESULTS AND DISCUSSION

A. PLANT OPERATING DATA

Figure 4 shows the pertinent plant operating data for Units 1-4 on 25 and 26 June 1975. The survey period, 1230 to 1630 (EDT) on 26 June, is shown on Figure 4. The average net generation for the twelve hours preceding the survey period was 198 MW (53% of net capacity), based on hourly readings. The net generation of Units 1-4 was between 260 MW and 227 MW during the survey period, but averaged approximately 257 MW (68% of net capacity) during the tri-axial temperature mapping [1230-1430 (EDT)]. The net generation dropped to a low of 227 MW during the vertical profile measurements.

The declining discharge temperature from 25 to 26 June (shown in Figure 4) was the result of a decrease in the inlet temperature from 20.6°C (69°F) to the low of 11.7°C (53°F) recorded during the survey. This was most likely due to an upwelling of colder bottom water from the lake as a result of offshore winds. The effects of the decreasing discharge temperature on the temperature distribution in the turning basin will be discussed below.

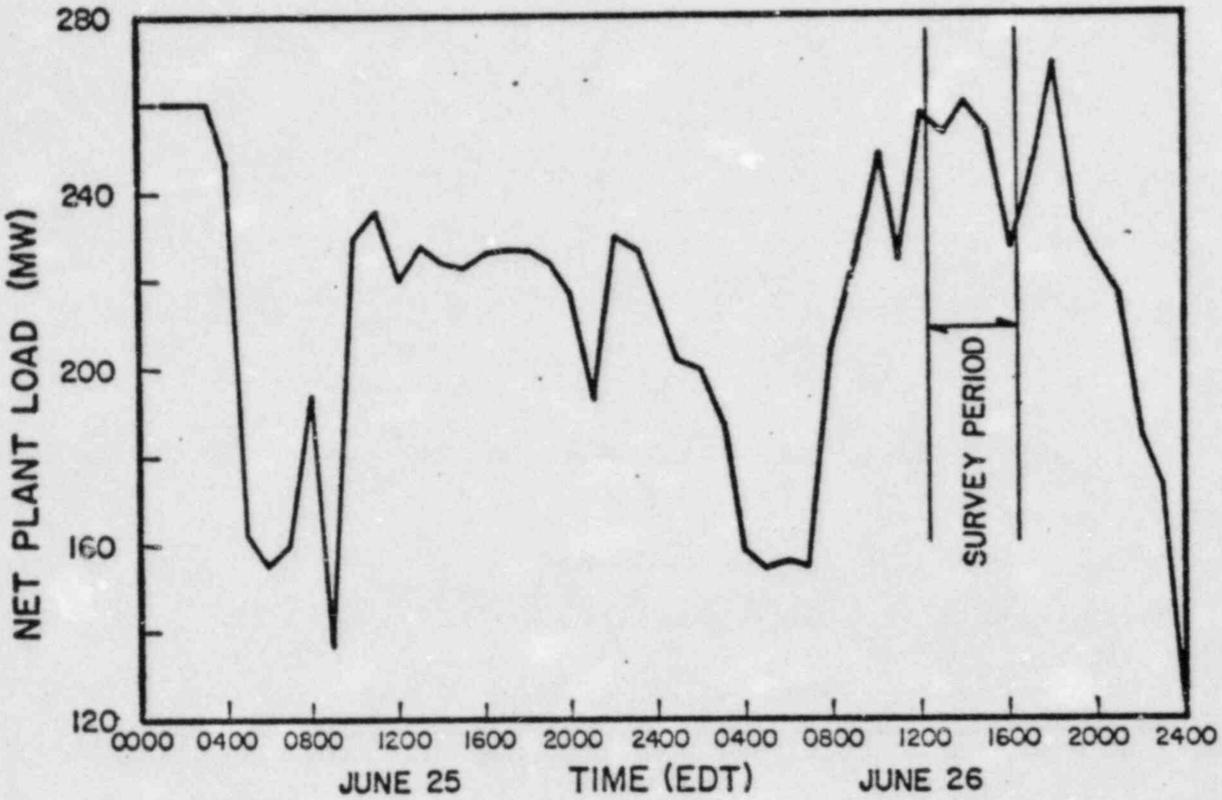
The cooling water inlet temperature remained at 11.7°C (53°F) during the entire survey period, while the plant induced temperature rise averaged 5.3°C (9.5°F) over the same period.

B. TRI-AXIAL TEMPERATURE DATA

The results of the tri-axial temperature mapping are shown in Figures 5 through 8. Each figure shows the distribution of absolute temperature

FIGURE A-4

UNITS 1-4 PLANT OPERATING CONDITIONS
OSWEGO STEAM STATION THERMAL SURVEY
JUNE 25 AND 26, 1975



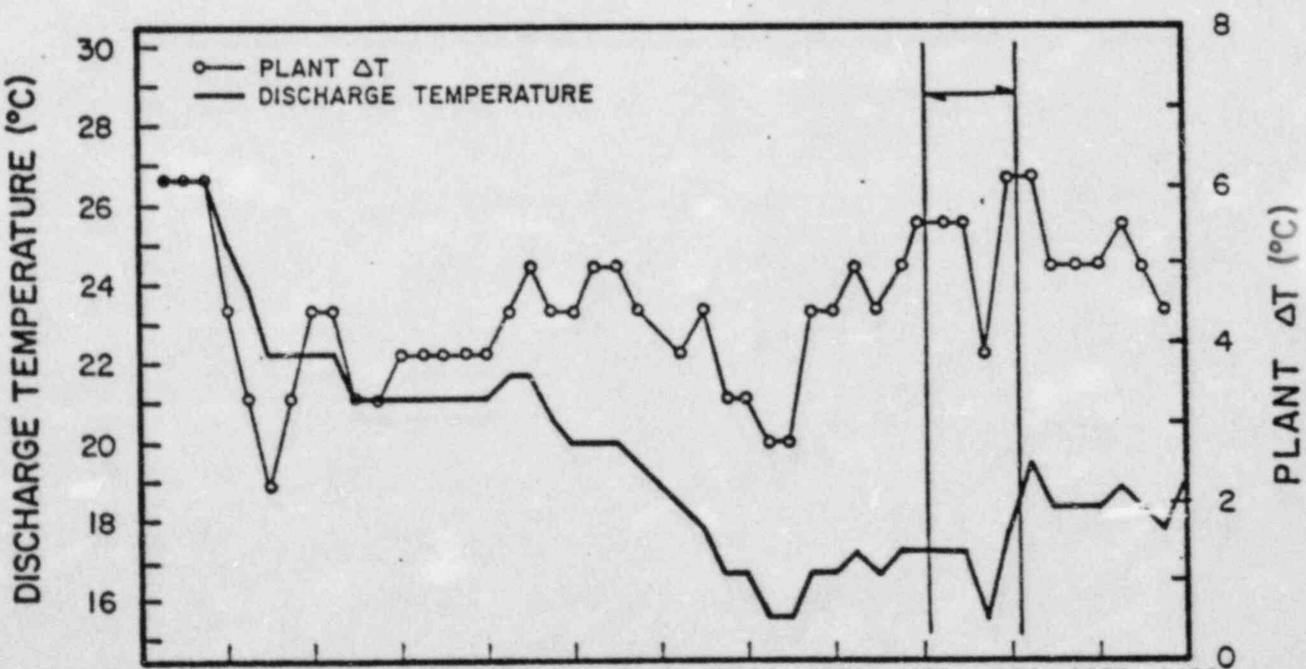


FIGURE A-5

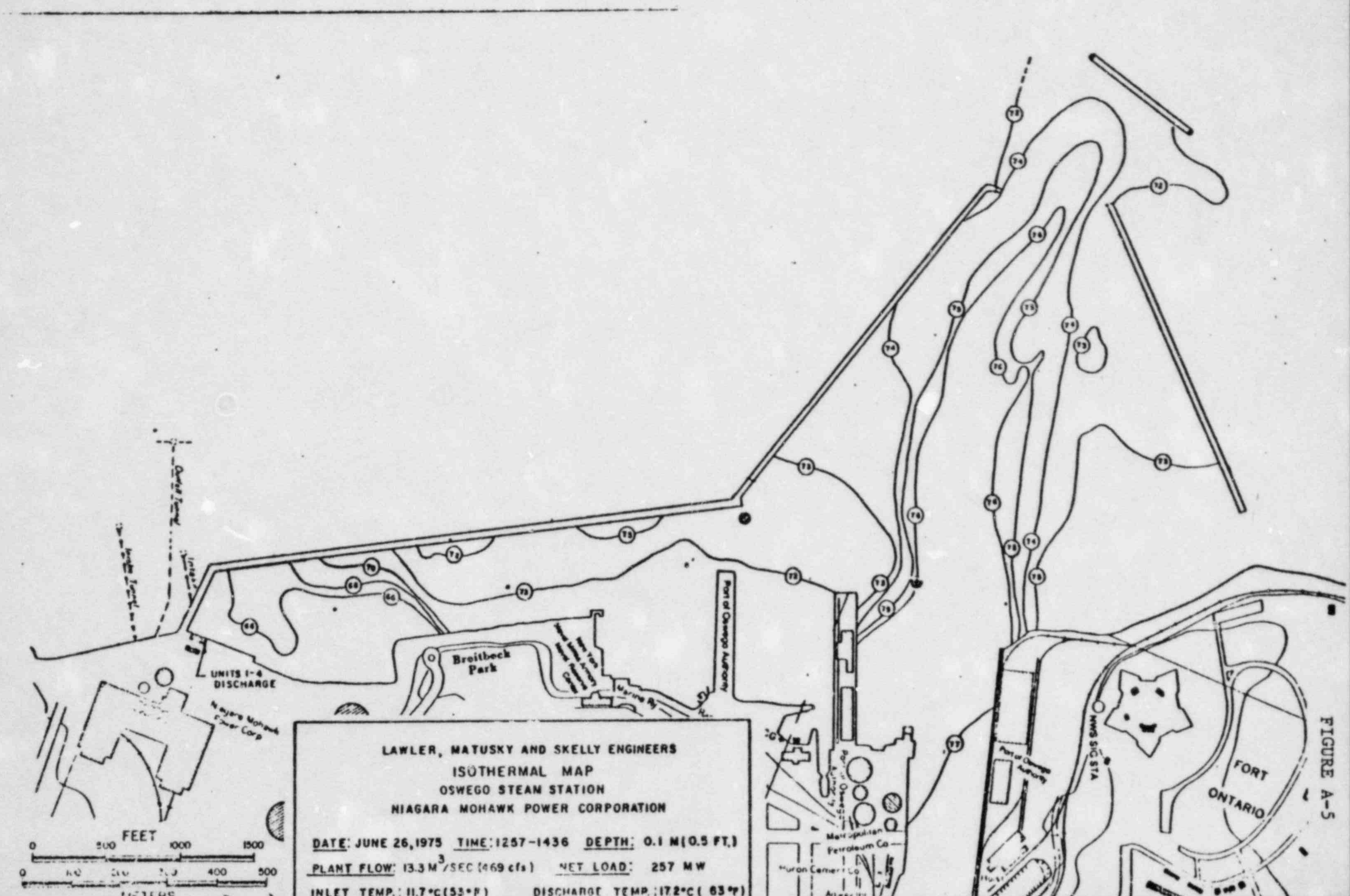
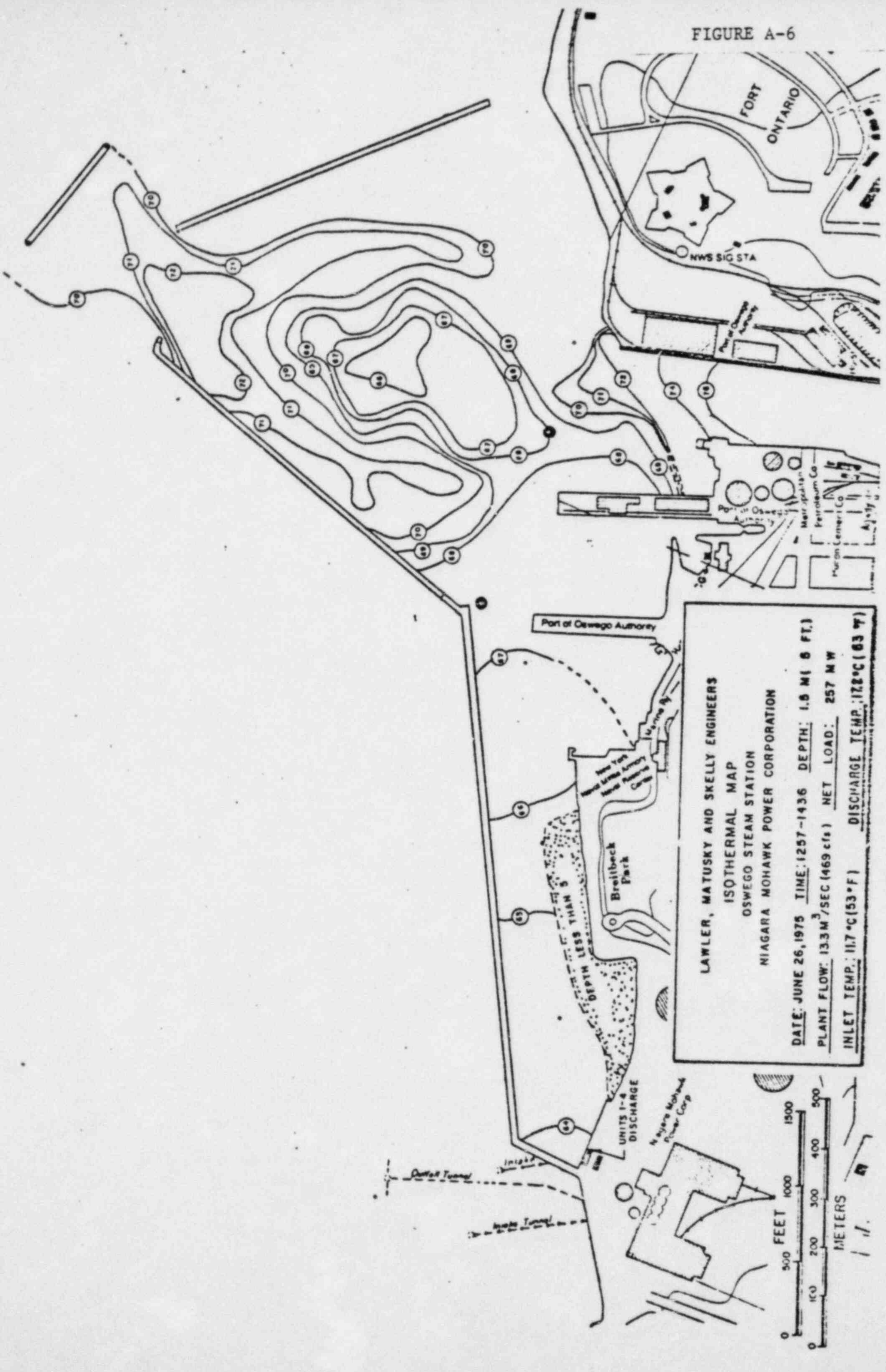

LAWLER, MATUSKY AND SKELLY ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: JUNE 26, 1975 TIME: 1257-1436 DEPTH: 0.1 M (0.5 FT.)
PLANT FLOW: 13.3 M3/SEC (469 cfs) NET LOAD: 257 MW
INLET TEMP.: 11.7°C (53°F) DISCHARGE TEMP.: 17.2°C (63°F)
FEET
0
500
1000
1500
0
400
500
FORT ONTARIO
NWS SIG STA
Port of Oswego Authority
Metropolitan Petroleum Co.
Breitbeck Park
UNITS 1-4 DISCHARGE
Niagara Mohawk Power Corp
Outlet Tunnel
Intake Tunnel

FIGURE A-6



LAWLER, MATUSKY AND SKELLY ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: JUNE 26, 1975 TIME: 1257-1436 DEPTH: 1.5 M (5 FT.)
PLANT FLOW: 13.3 M³/SEC (469 cfs) NET LOAD: 257 MW
INLET TEMP: 11.7°C (53°F) DISCHARGE TEMP: 17.2°C (63°F)
FORT ONTARIO
NWS SIG STA
Port of Oswego Authority
Breitbeck Park
DEPTH LESS THAN 5'
UNITS 1-4 DISCHARGE
Niagara Mohawk Power Corp
FEET
0 500 1000 1500
METERS
0 100 200 300 400 500

FIGURE A-7

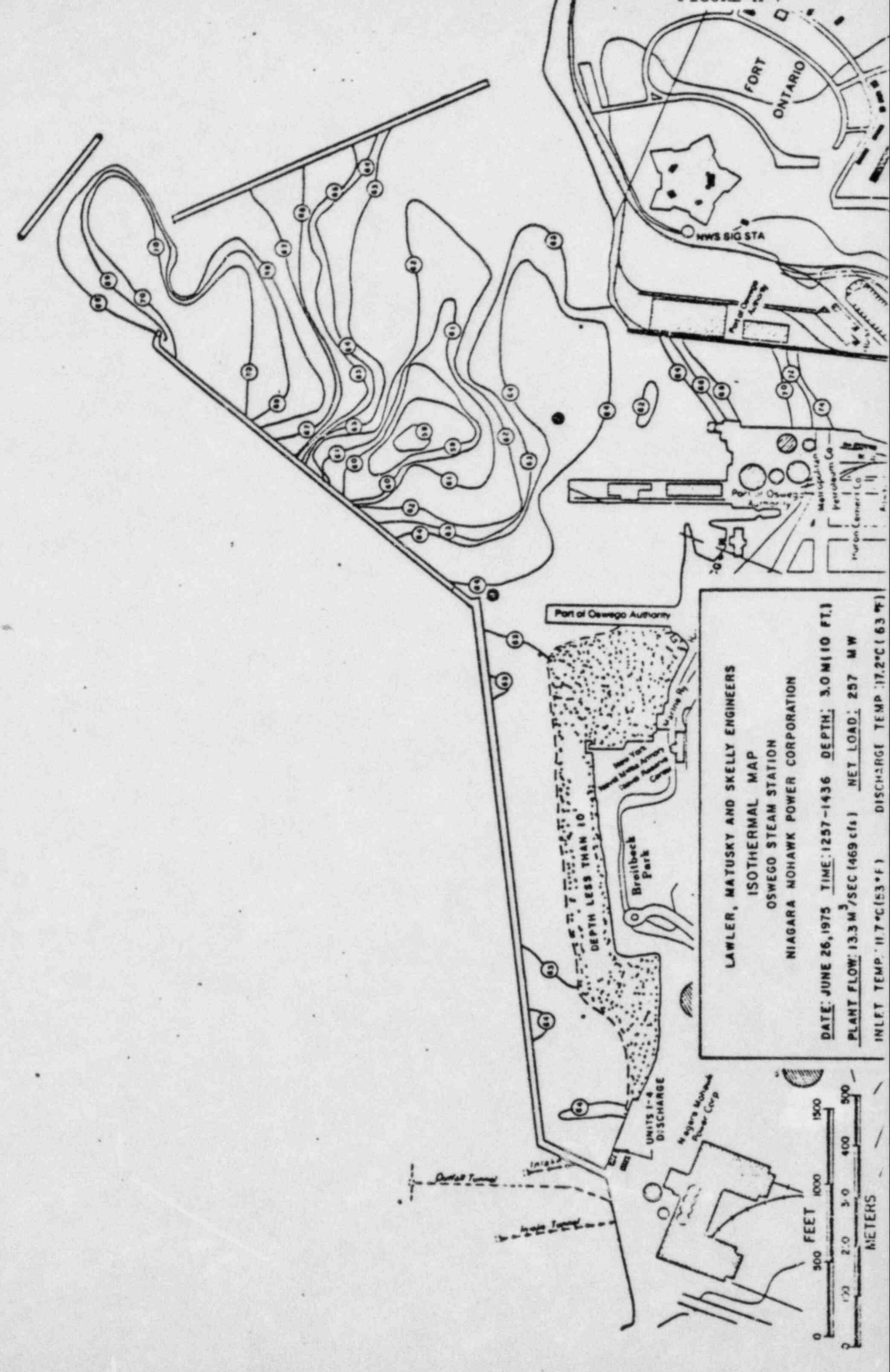

FORT ONTARIO
NWS SIG STA
Port of Oswego Authority
DEPTH LESS THAN 10
Breitbeck Park
UNITS 1-4 DISCHARGE
Niagara Mohawk Power Corp
LAWLER, MATUSKY AND SKELLY ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: JUNE 26, 1975 TIME: 1257-1436 DEPTH: 3.0 M (10 FT.)
PLANT FLOW: 13.3 M^3/SEC (469 cfs) NET LOAD: 257 MW
INLET TEMP: 11.7°C (53°F) DISCHARGE TEMP: 17.2°C (63°F)
FEET
METERS

FIGURE A-8


LAWLER, MATUSKY AND SKELLY ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: JUNE 26, 1975 TIME: 1257-1436 DEPTH: 4.6 M (15 FT.)
PLANT FLOW: 13.3 M³/SEC (469 cfs) NET LOAD: 257 MW
INLET TEMP: 11.7°C (53°F) DISCHARGE TEMP: 17.2°C (63°F)
FORT ONTARIO
NWS SIG STA
DEPTH LESS THAN 15'
Port of Oswego Authority
Breitbeck Park
UNITS 1-4 DISCHARGE
Niagara Mohawk Power Corp
Outfall Tunnel
Intake Tunnel
FEET
0 500 1000 1500
METERS
0 100 200 300 400 500

at the indicated depth. Isotherms were drawn at 0.55°C (1°F) intervals except where the proximity of 0.55°C (1°F) isotherms made them indistinguishable, in which case 1.1°C (2°F) intervals were used. Figures 9 and 10 are sectional views of the turning basin and harbor area, respectively. Figure 9 is a longitudinal section in the turning basin from west to east, while Figure 10 is a section from the river mouth, north to the harbor entrance to the lake. The profiles in Figures 9 and 10 were drawn from data collected during the vertical profiles. The profile stations used for the sectional plots are indicated on Figures 9 and 10.

The percentage values on Figures 9 and 10 are percent river water and were determined by converting each conductivity to a chloride concentration and then calculating the mixture of river water and lake water, of known concentrations, that would yield the measured concentration. The conversion of conductivity to chloride concentration was taken from Figure 11, which is a plot of specific conductivity versus chloride concentration data obtained from the water samples taken during the survey. The river and lake water chloride concentrations used in the calculations were 150 mg/l and 22 mg/l, respectively.

The surface temperature distribution in Figure 5 shows that the Oswego River was warmer than either Lake Ontario or the Oswego plant discharge. The river plume extends into the harbor and spreads laterally (east and west). The main body of the river water flows toward the harbor mouth in the upper layer.

OSWEGO STEAM STATION THERMAL SURVEY
JUNE 26, 1975

OSWEGO TURNING BASIN LONGITUDINAL SECTION

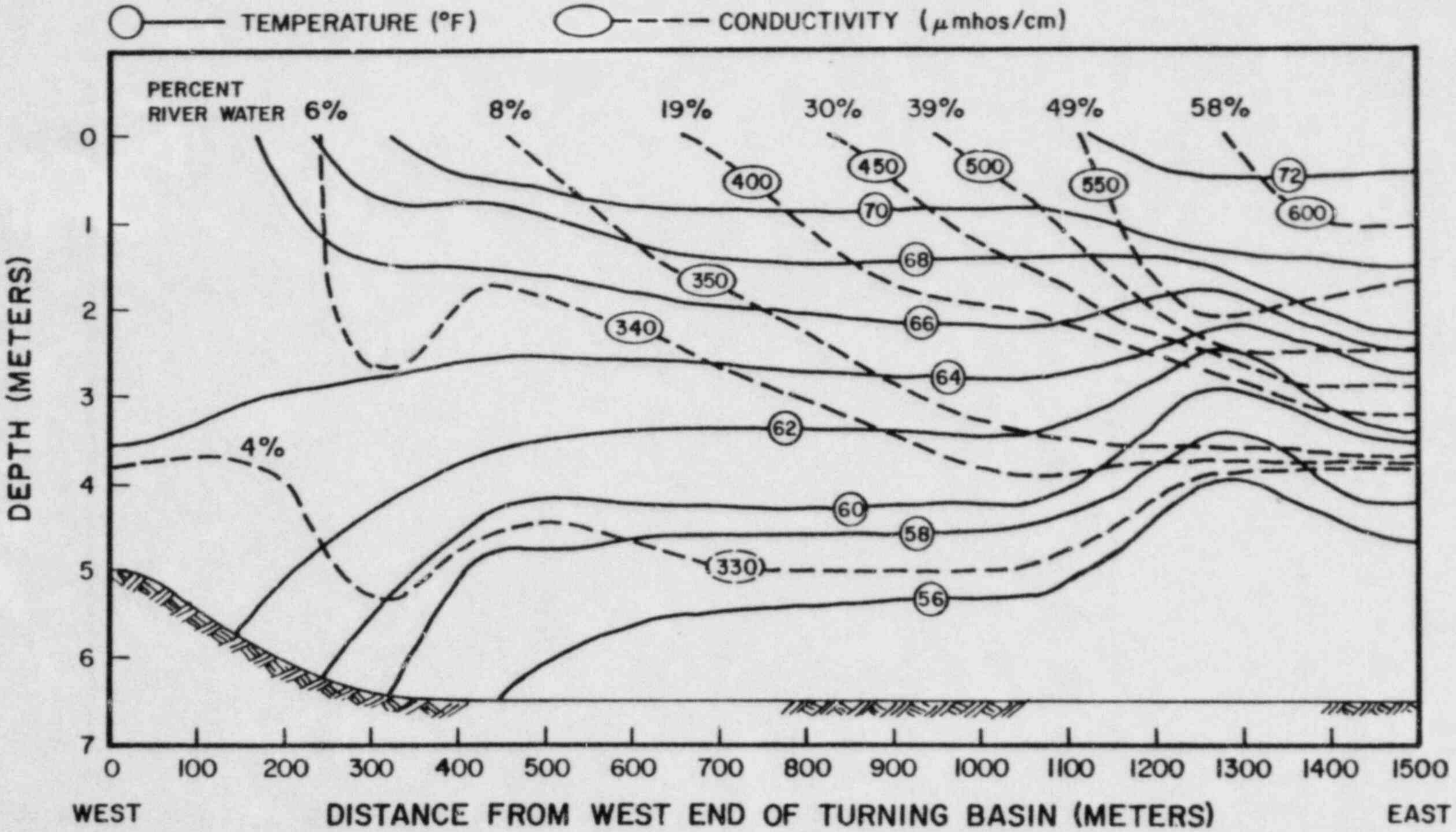


FIGURE A-9

OSWEGO STEAM STATION THERMAL SURVEY
JUNE 26, 1975

OSWEGO HARBOR
SECTION FROM RIVER TO HARBOR MOUTH

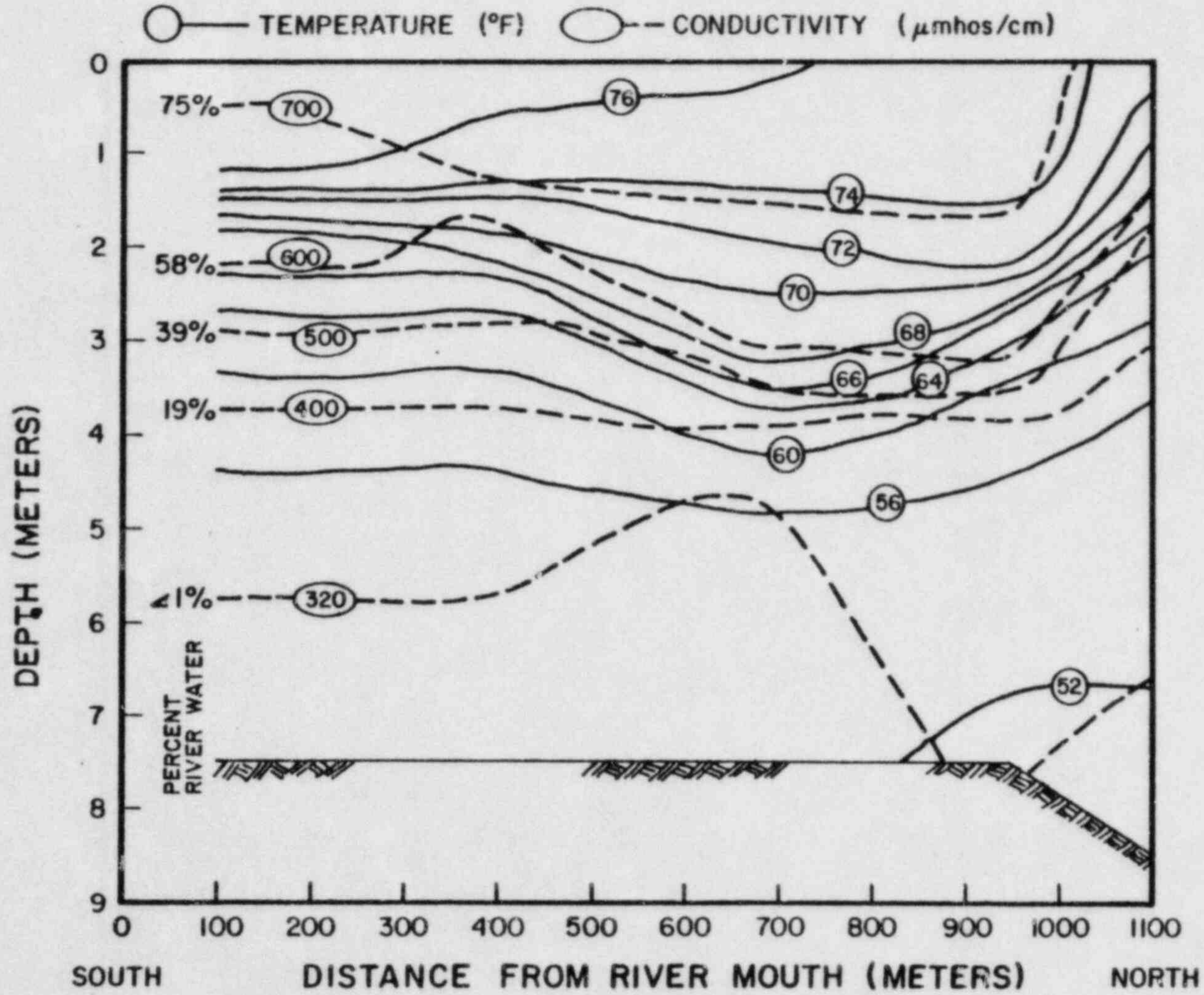
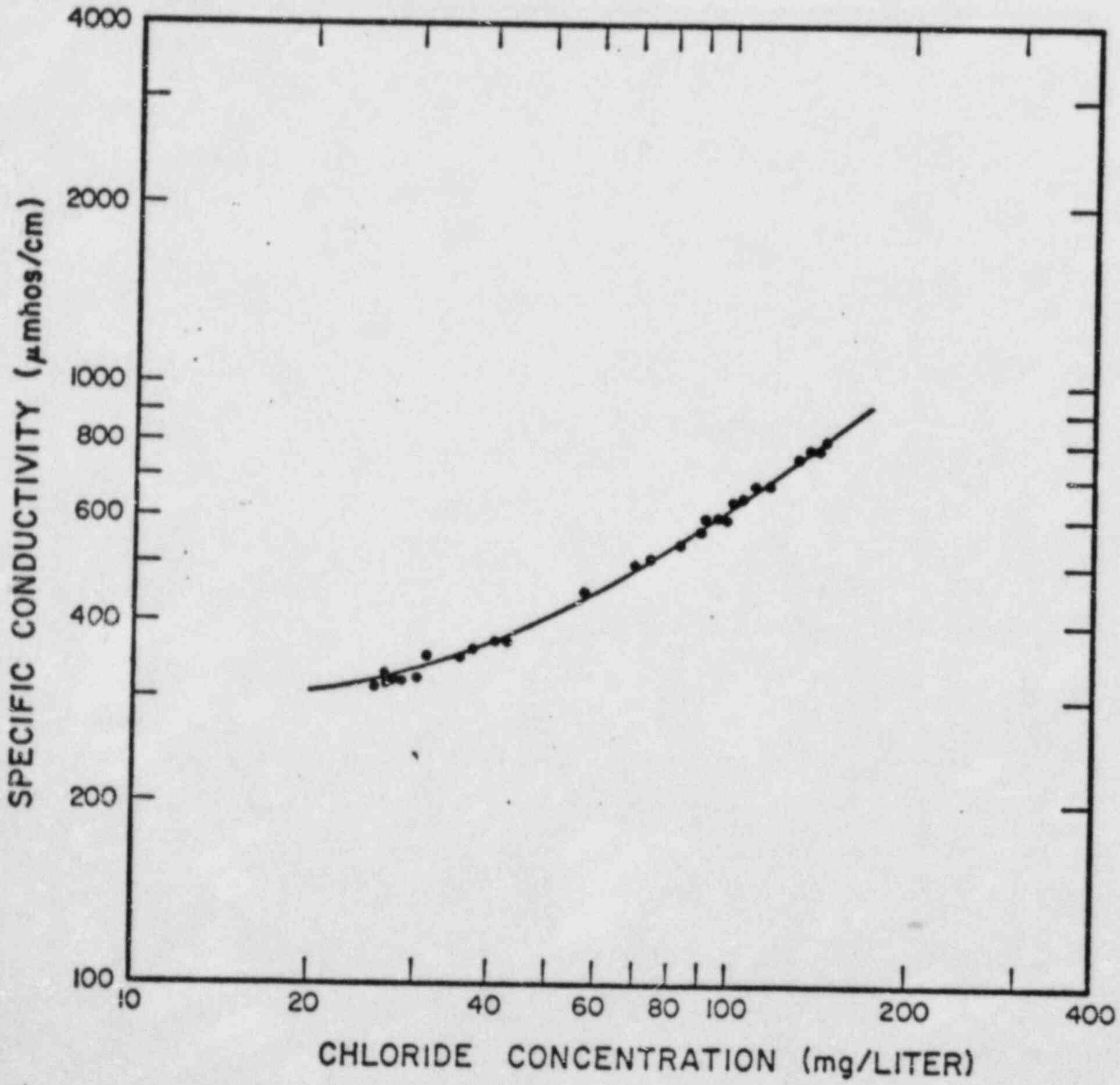


FIGURE A-10

OSWEGO STEAM STATION THERMAL SURVEY
JUNE 26, 1975

SPECIFIC CONDUCTIVITY VS CHLORIDE



The surface temperature distribution in the turning basin shows a 7°F increase from the plant discharge at the western end to the junction of the turning basin and the harbor at the eastern end. This increase in surface temperature can be accounted for by a combination of three factors: (1) the intrusion of warm river water into the turning basin on the surface, (2) the decreasing plant discharge temperature during the period prior to the survey, and (3) solar heating of the water in the turning basin. Examination of Figure 9 shows the greatest intrusion of river water into the turning basin near the surface, where the highest temperatures are recorded.

Figures 6, 7, and 8 show the horizontal distribution of temperature in the lower layers. Examination of Figures 6, 7, and 8 indicates that the river flow stays mainly in the upper layer, due to the bucyancy effect of its higher temperature. There does appear to be increased mixing of the river water into the lower layers near the harbor mouth, possibly as a result of the narrowing cross-section. The lower layer temperature distributions in the turning basin show a reduction of intruding river water with depth. Figure 9, the longitudinal section in the turning basin, shows the presence of essentially pure lake water (low conductivity and temperature) in the western end of the turning basin and in the lower layers.

The analysis of the temperature distributions in Figures 5 through 10 is complicated by 1) the unsteady state of the lake temperatures, prior to the survey, resulting in a declining discharge temperature and a variable temperature of intruding lake water, and 2) the inability to distinguish lake water that has intruded through the harbor mouth from lake water discharged by the plant. However, several general conclusions have been derived from these data. These are:

1. At the time of the June survey the Oswego River was approximately 13.3°C (24°F) above the lake inlet temperature and 7.8°C (14°F) above the plant discharge temperature.

2. The presence of cold water 11.1-14.4°C (52-58°F) in the lower layers of the harbor indicates the intrusion of lake water through the harbor mouth into the harbor area, the river, and the turning basin. This intrusion has been observed and reported in previous studies (QLM, 1971).

3. The warmer river water tends to flow out on the surface and spread laterally into the turning basin, producing temperatures in the turning basin and harbor well above the plant discharge temperature at the time of the survey. The river water mixes vertically at the mouth of the harbor due to the constriction of the cross-sectional area available for flow.

4. The plant discharge, under the conditions present during the survey, appears to occupy the western end of the turning basin and flows out into the harbor area beneath the intruding river water and above the intruding lake water. The degree to which the discharge waters mix with either the river water or intruded lake water is dependent on the lake temperature and plant operating conditions (generation and plant flow).

5. The temperature distributions observed during the June survey are representative of only one set of conditions (i.e., river much warmer than lake) and would be expected to change given different temperature relationships. The August and November surveys will be used in an attempt to define the effects of these conditions.

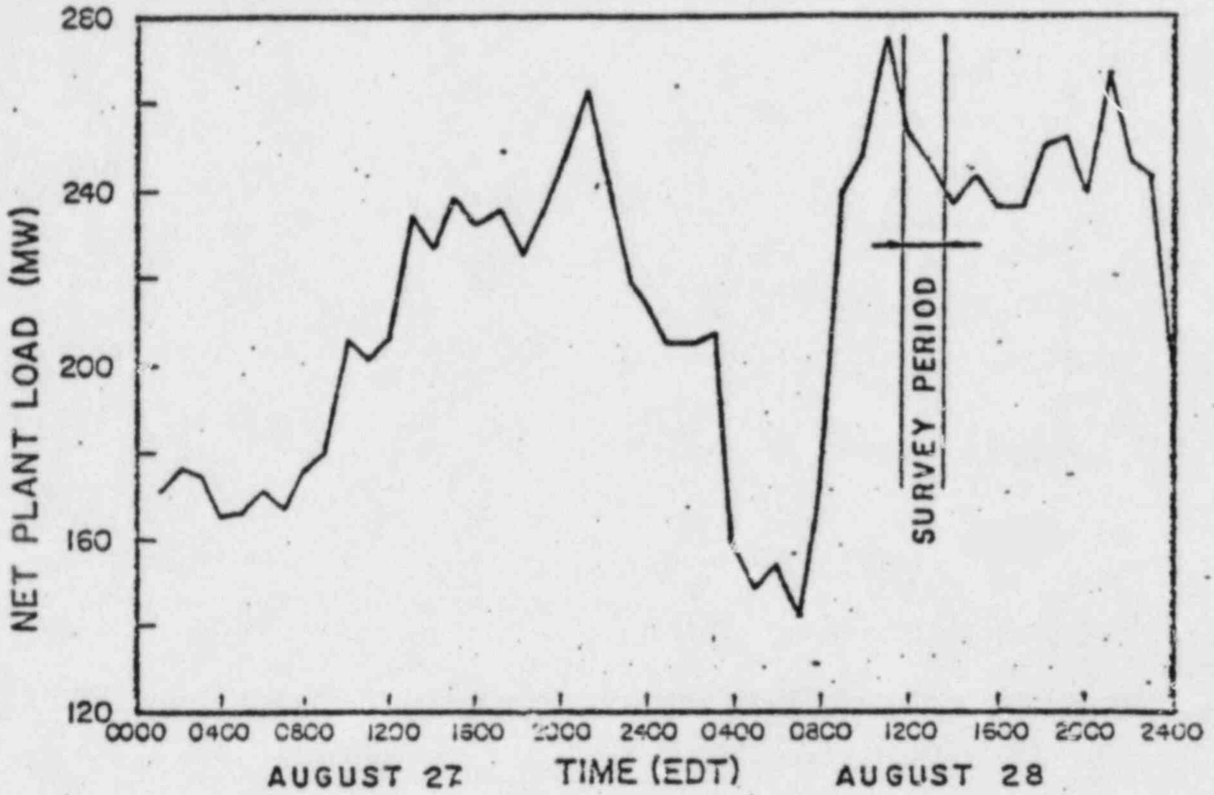
IV. RESULTS AND DISCUSSION: 28 AUGUST 1975 SURVEY

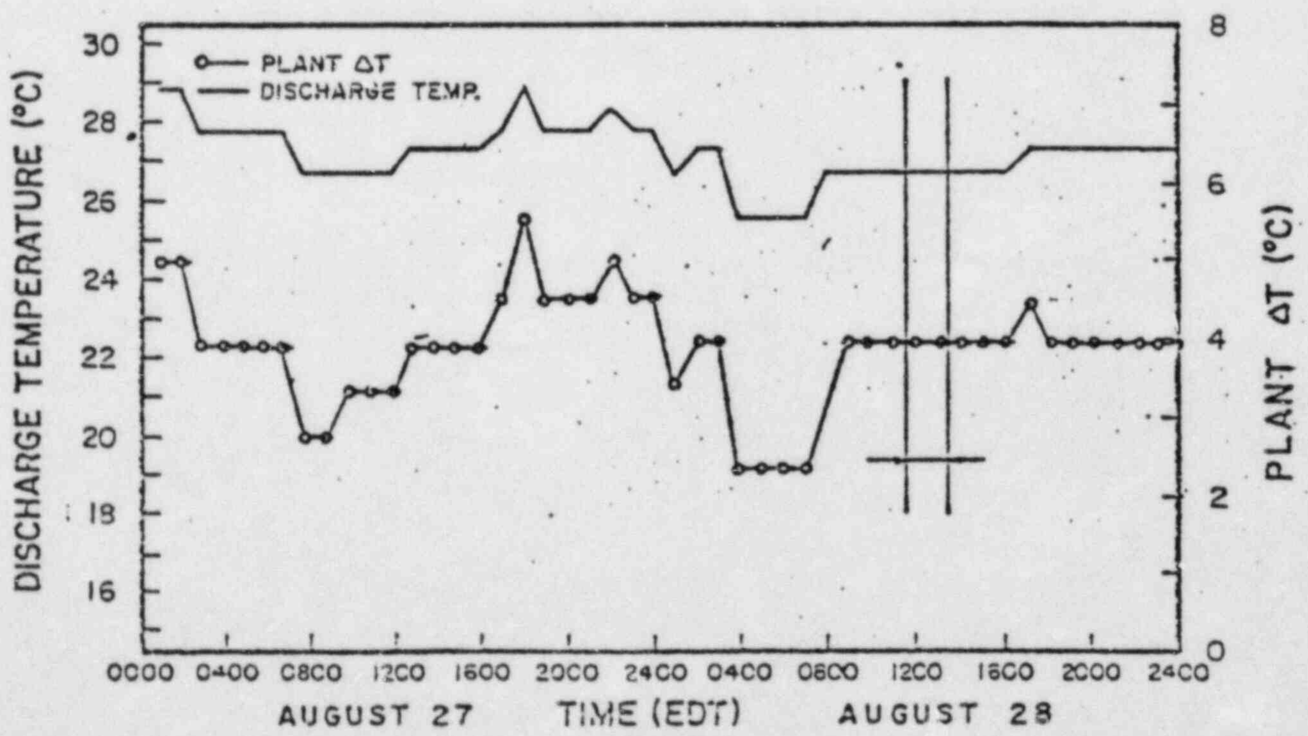
A. PLANT OPERATING DATA

Figure 1 shows the pertinent plant operating data for Units 1-4 on 27 and 28 August 1975. The survey period, 1140 to 1330 (EDT) on 28 August, is shown on Figure 12. The average net generation for the twelve hours preceding the survey period was 201 MWe (50% of net capacity), based on hourly readings. The net generation of Units 1-4 was between 251 MWe and 244 MWe during the survey period, averaging approximately 247 MWe (62% of net capacity) during the tri-axial temperature mapping. The net generation dropped to a low of 237 MWe during the vertical profile measurements [1345-1500 (EDT)]. Unit 5 was not in operation during the August survey.

The plant induced temperature rise (plant ΔT) and the Units 1-4 discharge temperature for 27 and 28 August are shown on Figure 12. The plant ΔT and discharge temperatures averaged 3.3°C (5.9°F) and 26.4°C (79.5°F) respectively for the twelve hours preceding the survey. The lake intake temperature remained between 22.8°C and 23.3°C (73°F and 74°F) for the same period. The plant ΔT and discharge temperature remained constant at 3.9°C (7.0°F) and 26.7°C (80°F) respectively during the thermal survey.

UNITS 1-4 PLANT OPERATING CONDITIONS
OSWEGO STEAM STATION THERMAL SURVEY
AUGUST 27 AND 28, 1975



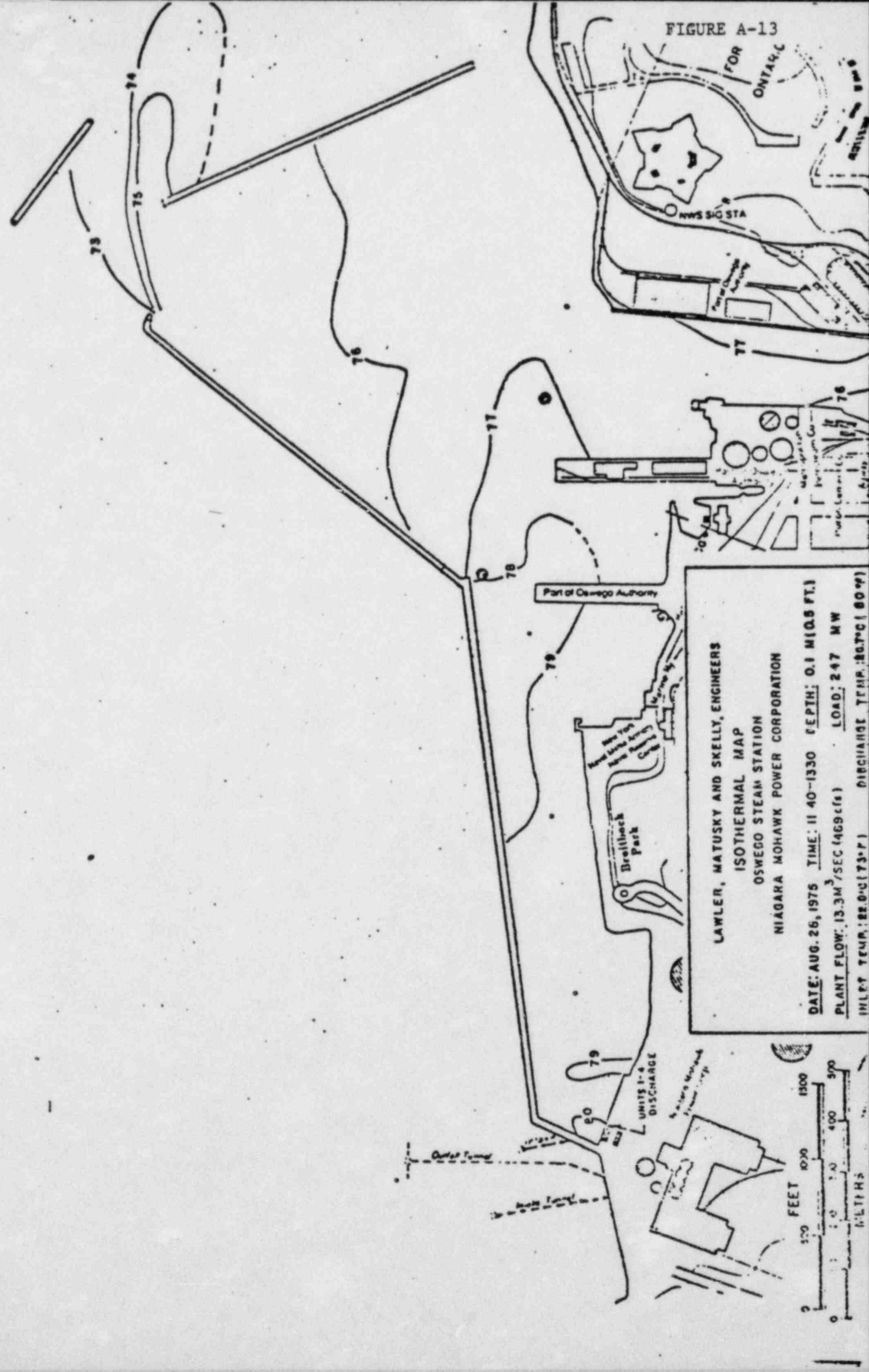


B. TRI-AXIAL TEMPERATURE DATA

The results of the 28 August tri-axial temperature mapping are shown in Figures 13 through 16. Each figure shows the distribution of absolute temperature (°F) at the indicated depth. Isotherms were drawn at 0.55°C (1°F) intervals.

Examination of Figures 13 through 16 shows the Units 1-4 discharge plume occupying the western end of the turning basin, from surface to the 15 ft depth. The vertical temperature and conductivity profiles confirmed the presence of lake water (discharge water) in the western end of the turning basin from surface to bottom. As the plume flows to the east, toward the harbor, it begins to rise, as the heavier (higher dissolved solids lower temperature) river water intrudes in the near bottom waters. Vertical profiles at the eastern end of the turning basin showed almost 100% river water in the bottom 2 meters (6 ft) of the water column, with mixed discharge and river water in the upper layers. The Oswego River temperature at the time of the survey was between 24.1°C and 24.6°C (75.4 and 76.3°F) and carried a high concentration of dissolved solids. Examination of the isotherms at the eastern end of the turning basin shows the greatest plume effect, 1°C, (2°F) ΔT between plume and river at the surface and no ΔT between plume and river, at the 4.6m (15 ft) depth. The

FIGURE A-13


LAWLER, MATUSKY AND SKELLY, ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: AUG. 26, 1975 TIME: 11 40-1330 DEPTH: 0.1 M (0.5 FT.)
PLANT FLOW: 13.3 M³/SEC (469 cfs) LOAD: 247 MW
Port of Oswego Authority
Breitbeck Park
NWS SIG STA
UNITS 1-4 DISCHARGE
FEET
73
74
75
76
77
78
79
80

SIMILARITY OF MICROZOOPLANKTON COLLECTIONS
OSWEGO TURNING BASIN-1975-1976

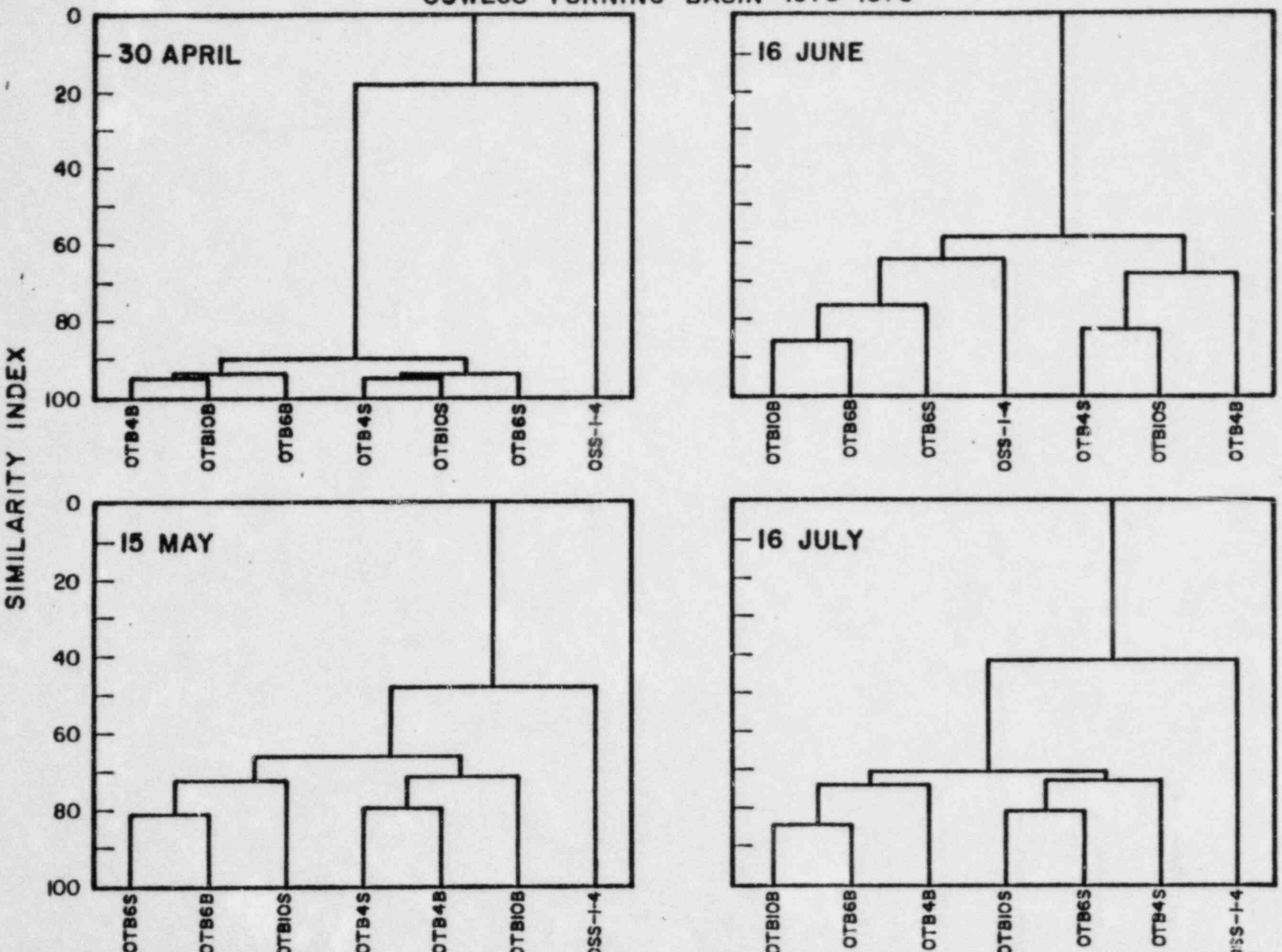
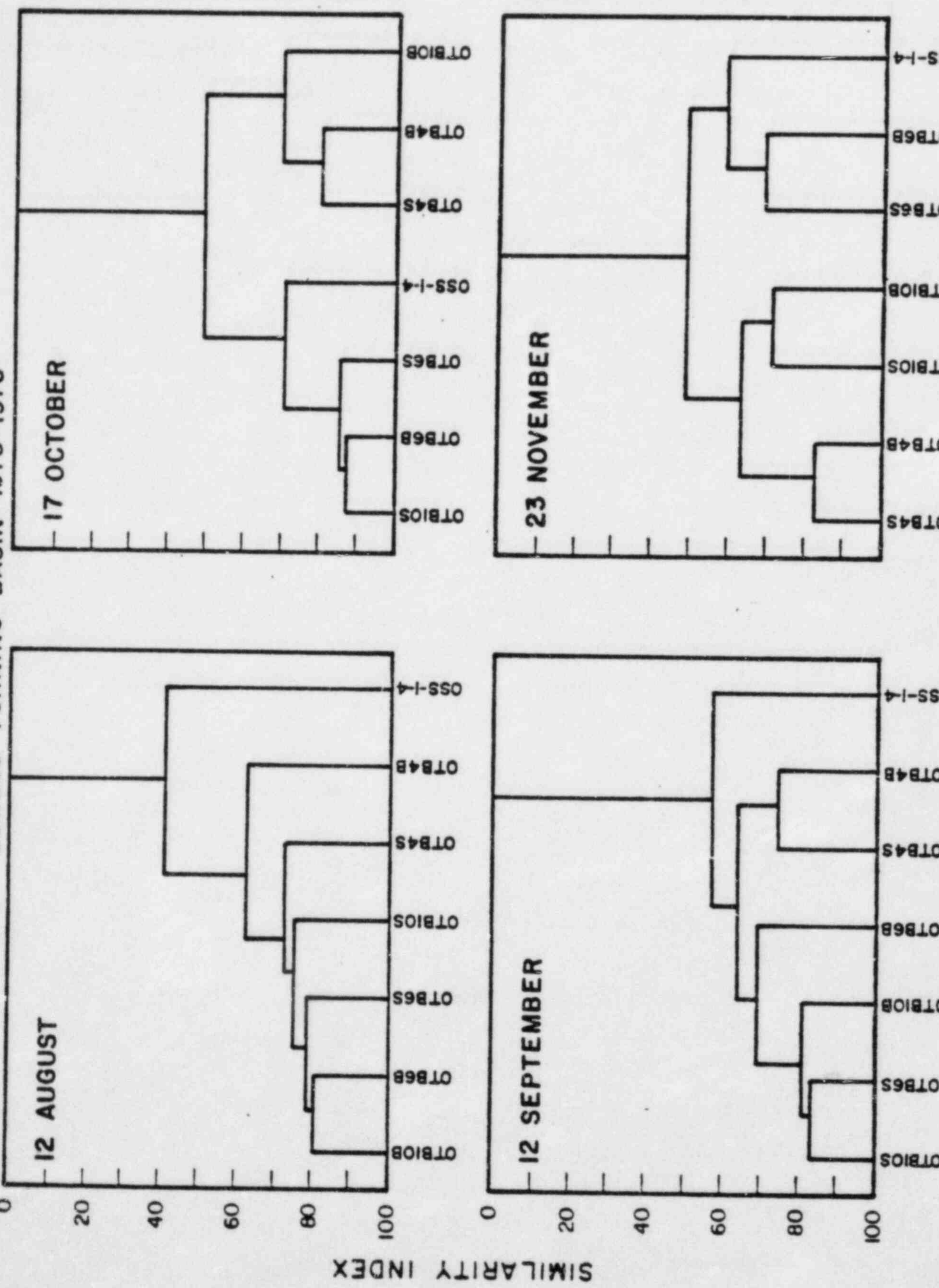


FIGURE D2-13

FIGURE D2-13
(Continued)

SIMILARITY OF MICROZOOPLANKTON COLLECTIONS
OSWEGO TURNING BASIN-1975-1976



SIMILARITY OF MICROZOOPLANKTON COLLECTIONS
OSWEGO TURNING BASIN-1975-1976

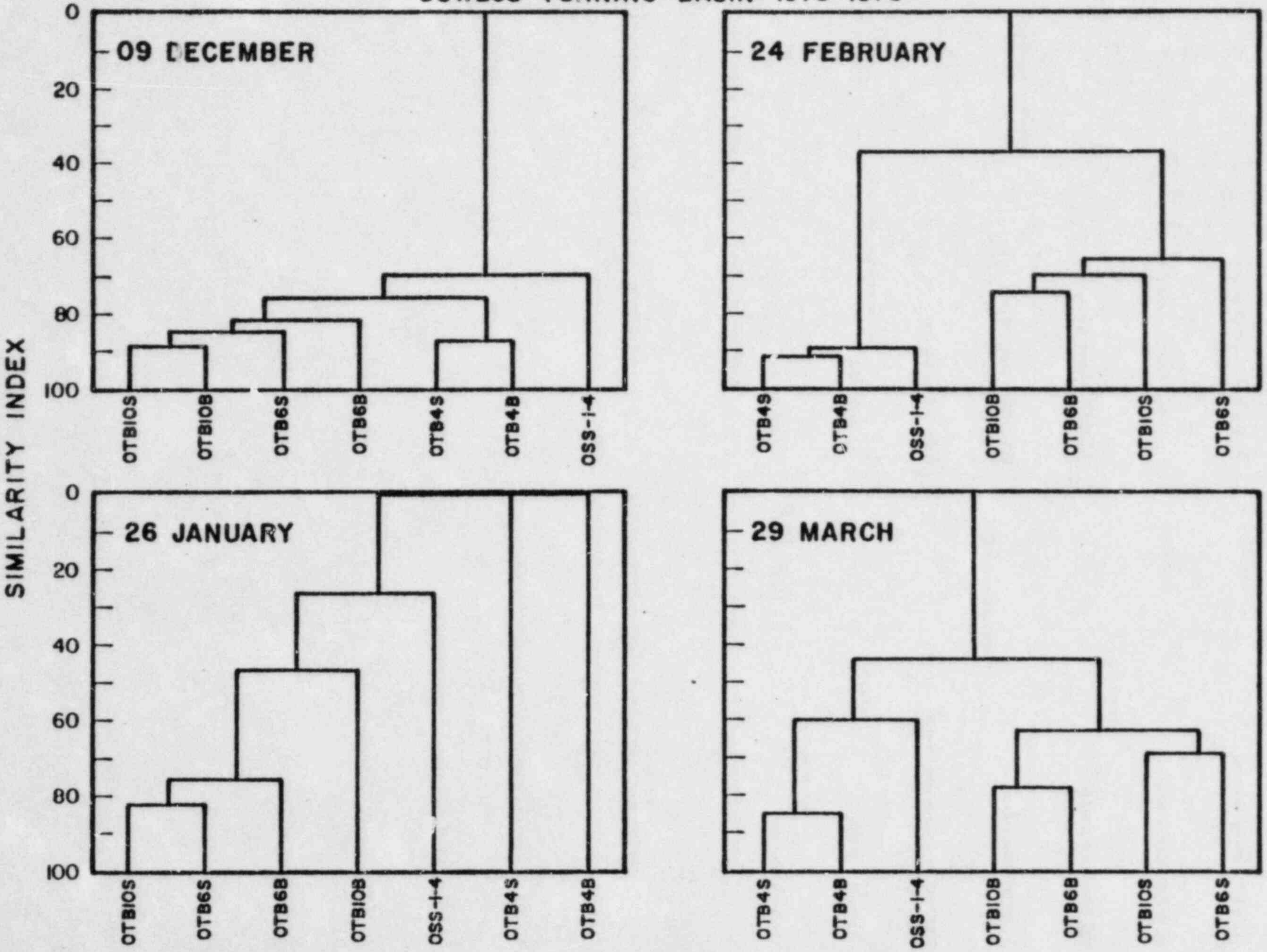


FIGURE D2-13
(Continued)

APPENDIX D 3-1

AGE AND GROWTH FOR ALEWIFE

OSWEGO TURNING BASIN - 1975-1976

MALES

I.

YEAR CLASS	NUMBER OF FISH AGED FROM EACH YEAR CLASS	MEAN LENGTH AT CAPTURE FOR AGE GROUPS I-VI	CALCULATED TOTAL LENGTH AT END OF YEAR														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			CORRECTION FACTORS														
			30.0	60.8	62.4	89.3	68.5	74.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			ALEWIFE MALES CAUGHT FROM 1975 TO 1975														
75	0	136.0 (I)	0.0														
74	1	119.7 (II)	136.0	0.0													
73	49	149.2 (III)	93.6	119.6	0.0												
72	5	156.6 (IV)	99.3	137.7	147.2	0.0											
71	15	161.0 (V)	95.7	141.0	149.4	156.3	0.0										
70	26	161.0 (VI)	94.6	139.5	148.5	156.9	160.9	0.0									
69	1	0.0 (VII)	93.4	142.2	148.7	156.2	159.2	161.0	0.0								
GRAND AVERAGE			94.9	129.5	148.7	156.6	160.8	161.0	0.0								
SAMPLE SIZE			97	96	47	42	27	1	0								
STANDARD DEVIATION			9.5	12.7	8.1	7.2	10.6	-0.0	-0.0								
AVERAGE ANNUAL INCREMENT			94.9	34.5	19.2	8.0	4.2	0.2	0.0								

APPENDIX D 3-2

AGE AND GROWTH FOR ALEWIFE

OSWEGO TURNING BASIN - 1975-1976

II. FEMALES

YEAR CLASS	NUMBER OF FISH AGED FROM EACH YEAR CLASS	MEAN LENGTH AT CAPTURE FOR AGE GROUPS I-VI	CALCULATED TOTAL LENGTH AT END OF YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		CORRECTION FACTORS	30.0	60.8	62.4	69.3	68.5	74.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		ALEWIFE FEMALES CAUGHT FROM 1975 TO 1976															
74	4	122.0 (II)	103.2	115.5													
73	29	162.1 (III)	91.9	122.3	0.0												
72	24	170.9 (IV)	100.3	148.0	161.0	0.0											
71	29	171.6 (V)	101.6	146.4	158.4	168.7	147.5										
70	40	178.6 (VI)	98.7	148.1	159.4	167.2	172.8	0.0									
69	5	0.0 (VII)	100.3	148.9	159.5	168.7	172.7	179.3	0.0								
GRAND AVERAGE			98.3	141.0	159.5	167.9	171.7	179.3	0.0								
SAMPLE SIZE			131	131	98	74	47	5	0								
STANDARD DEVIATION			10.6	15.2	10.2	11.6	14.3	16.5	-0.0								
AVERAGE ANNUAL INCREMENT			98.3	42.7	18.5	8.4	3.8	7.6	0.0								

APPENDIX D 3-3

AGE AND GROWTH FOR WHITE PERCH

OSWEGO TURNING BASIN - 1975-1976

I. MALES

CALCULATED TOTAL LENGTH AT END OF YEAR — CORRECTION FACTORS (years 1–15): 65.8 86.3 53.1 131.1 130.9 117.8 6.8 6.8 6.8 6.8 6.8 6.8 6.8 0.0 0.0

WHITE PERCH MALES CAUGHT FROM 1975 TO 1976

YEAR CLASS	NUMBER OF FISH AGED FROM EACH YEAR CLASS	MEAN LENGTH AT CAPTURE FOR AGE GROUPS I-VIII	1	2	3	4	5	6	7	8	9
75	2	120.3 (I)	114.5								
74	29	156.0 (II)	103.1	153.8							
73	49	198.4 (III)	112.0	168.6	199.6						
72	20	214.2 (IV)	116.0	182.5	200.5	216.7					
71	30	222.9 (V)	110.6	183.4	204.5	215.6	222.4				
70	12	237.9 (VI)	116.5	178.0	199.2	221.5	225.8	242.0			
69	8	253.0 (VII)	117.4	184.0	204.0	227.3	232.9	236.9	0.0		
68	1	261.0 (VIII)	118.3	210.1	218.9	236.2	243.1	247.5	253.0	0.0	
67	2	0.0 (IX)	120.0	166.4	190.9	234.3	242.6	250.0	253.7	261.0	0.0
GRAND AVERAGE			110.8	172.2	201.6	219.2	226.9	240.5	253.5	261.0	0.0
SAMPLE SIZE			153	149	104	66	41	13	3	2	0
STANDARD DEVIATION			11.4	18.4	16.9	14.4	13.4	17.1	21.1	28.3	-0.0
AVERAGE ANNUAL INCREMENT			110.8	61.3	29.4	17.7	7.7	13.6	13.0	7.5	0.0

APPENDIX D 3-4

AGE AND GROWTH FOR WHITE PERCH

OSWEGO TURNING BASIN - 1975-1976

II. FEMALES

WHITE PERCH FEMALES CAUGHT FROM 1975 TO 1976

YEAR CLASS	NUMBER OF FISH AGED FROM EACH YEAR CLASS	MEAN LENGTH AT CAPTURE FOR AGE GROUPS I-XIII	CALCULATED TOTAL LENGTH AT END OF YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORRECTION FACTORS			65.8	86.3	53.1	131.1	130.9	117.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	0.0	0.0
75	1	127.0 (I)	116.0														
74	35	159.1 (II)	102.0	158.5													
73	51	207.3 (III)	114.3	176.8	210.2												
72	24	225.0 (IV)	109.3	176.6	201.4	220.1											
71	65	237.3 (V)	112.2	185.4	213.3	228.8	237.9										
70	14	254.0 (VI)	119.5	174.6	211.8	233.5	238.5	256.0									
69	2	283.0 (VII)	119.0	187.5	198.2	241.5	256.8	263.3	283.0								
68	0	243.0 (VIII)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0							
67	1	249.0 (IX)	102.9	162.8	166.6	209.5	216.9	222.2	231.2	243.0	0.0						
66	1	0.0 (X)	117.8	172.2	174.0	212.6	234.8	238.5	237.0	243.8	249.0	0.0					
65	0	324.0 (XI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
64	1	352.0 (XII)	121.8	212.0	214.9	267.2	281.3	286.1	277.7	290.3	302.2	314.9	324.0	0.0			
63	1	339.0 (XIII)	133.0	202.7	223.2	275.5	290.4	298.1	289.3	307.7	321.1	331.1	344.5	352.0	0.0		
62	1	0.0 (XIV)	113.2	201.3	240.6	279.0	287.6	295.1	284.5	292.2	302.9	313.7	322.9	329.8	334.4	0.0	
GRAND AVERAGE			111.3	177.2	209.9	229.7	241.3	263.5	267.1	275.4	293.8	319.9	330.5	340.9	334.4	0.0	
SAMPLE SIZE			197	193	150	98	49	10	6	5	4	3	3	2	1	0	
STANDARD DEVIATION			10.6	17.7	17.7	16.7	19.8	27.7	25.9	30.0	31.1	9.7	12.2	15.7	-0.0	-0.0	
AVERAGE ANNUAL INCREMENT			111.3	65.9	32.7	19.8	11.6	22.1	3.7	8.3	18.4	26.1	10.6	10.4	-6.5	0.0	

APPENDIX D 3-5

AGE AND GROWTH FOR YELLOW PERCH

OSWEGO TURNING BASIN - 1975-1976

I. MALES

YEAR CLASS	NUMBER OF FISH AGED FROM EACH YEAR CLASS	MEAN LENGTH AT CAPTURE FOR AGE GROUPS I-III	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			CALCULATED TOTAL LENGTH AT END OF YEAR														
		CORRECTION FACTORS	38.6	29.0	47.2	167.9	167.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			YELLOW PERCH MALES CAUGHT FROM 1975 TO 1975														
74	0	168.6 (II)	0.0	0.0													
73	14	189.1 (III)	114.7	155.8	0.0												
72	11	0.0 (IV)	97.1	149.9	184.5	0.0											
GRAND AVERAGE			107.0	153.2	184.5	0.0											
SAMPLE SIZE			25	25	11	0											
STANDARD DEVIATION			24.6	25.8	17.7	-0.0											
AVERAGE ANNUAL INCREMENT			107.0	46.2	31.3	0.0											

APPENDIX D 3-6

AGE AND GROWTH FOR YELLOW PERCH

OSWEGO TURNING BASIN - 1975-1976

II.

FEMALES

YEAR CLASS	NUMBER OF FISH AGED FROM EACH YEAR CLASS	MEAN LENGTH AT CAPTURE FOR AGE GROUPS I-V	CALCULATED TOTAL LENGTH AT END OF YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		CORRECTION FACTORS	38.6	29.0	47.2	167.9	167.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		YELLOW PERCH FEMALES CAUGHT FROM 1975 TO 1975															
75	0	126.1 (I)	0.0														
74	10	181.4 (II)	100.1	0.0													
73	10	204.0 (III)	101.8	165.9	0.0												
72	3	272.7 (IV)	103.3	159.3	201.1	0.0											
71	3	294.0 (V)	121.[illegible]	183.4	233.6	269.9	0.0										
70	1	0.0 (VI)	114.5	154.4	219.1	270.4	287.7	0.0									
GRAND AVERAGE			103.9	166.6	217.6	270.0	287.7	0.0									
SAMPLE SIZE			27	17	7	4	1	0									
STANDARD DEVIATION			13.7	17.3	31.6	2.6	-0.0	-0.0									
AVERAGE ANNUAL INCREMENT			103.9	62.7	50.9	52.4	17.7	0.0									

APPENDIX E

TEMPERATURE DATA SHEETS

FISH TEMPERATURE DATA SHEET

Species: Alewife (Alosa pseudoharengus)

I. Lethal threshold:

	acclimation temperature	larvae	juvenile	adult	data source 3/
Upper	10		2	20	3
	15			23	5
	20			23	3
	Summer			26.7-32.2	6
	Summer		23		3
Lower	17			7	4

II. Growth 1/

	larvae	juvenile	adult	
Optimum and [range 2/]				

III. Reproduction:

	optimum	range	month(s)	
Migration				
Spawning		15.6-27.7		4
		13-16		2
Incubation and hatch		15.5-22 for 6to2 days		1
		17.7		7

IV. Preferred:

acclimation temperature	larvae	juvenile	adult	
Spring			21.2	8

1 As reported or net growth (growth in wt minus wt of mortality).
2 As reported or to 50% of optimum if data permit.
3 Data sources:

1. Rounsefell and Springer, 1945
2. Threiner, 1958
3. Graham, 1956
4. Dept. of Int., 1970
5. Altman and Dittmer, 1966
6. Trembley, 1960 for LD 50
7. Desall, 1970
8. Reutter and Hendendorf, 1974

FISH TEMPERATURE DATA SHEET

Species: Brown trout (Salmo trutta)

I. Lethal threshold:	acclimation temperature	larvae	juvenile	adult	data source 3/
Upper				23.5	5
	14-18			25	3
Lower					

II. Growth 1/	larvae	juvenile	adult	
Optimum and			18.3-23.9	2
[range 2/]			8-17	4
			12	6
			12.4-17.6	7

III. Reproduction:	optimum	range	month(s)	
Migration				
Spawning		6.7-8.9	Oct-Nov	1
Incubation and hatch	7.3 for 64 days 10.0 for 41 days			8

IV. Preferred:	acclimation temperature	larvae	juvenile	adult	

1/ As reported or net growth (growth in wt minus wt of mortality).
2/ As reported or to 50% of optimum if data permit.
3/ Data sources:

1. Mansell, 1965
2. Brynildson et al., 1963
3. Klein, 1962
4. Brett, 1970
5. Bishai, 1960
6. Swift, 1961
7. Ferguson, 1958
8. Bardech et al., 1972

FISH TEMPERATURE DATA SHEET

Species: Coho salmon (Oncorhynchus kisutch)

I. Lethal threshold:

	acclimation temperature	larvae	juvenile	adult	data source 3/
Upper	5		23		1
	10		24	21*(3)	1,3
	15		24		1
	20		25		1
	23		25		1

*Acclimation temp unknown

	acclimation temperature	larvae	juvenile	adult	data source
Lower	5		0.2		1
	10		2		1
	15		3		1
	20		5		1
	23		6		1

II. Growth 1/

	larvae	juvenile	adult	data source
Optimum and		15*		2
[range 2/]		(5-17)		6

*unlimited food

III. Reproduction:

	optimum	range	month(s)	data source
Migration		7-16(5)		5
Spawning		7-13(3)	Fall	3
Incubation and hatch			Winter-Spring	

IV. Preferred:

acclimation temperature	larvae	juvenile	adult	data source
Winter			13	4
Spring		11.4		7

1/ As reported or net growth (growth in wt minus wt of mortality).
2/ As reported or to 50% of optimum if data permit.
3/ Data sources:

1. Brett, 1952
2. Great Lakes Research Labortory, 1973
3. Anonymos, 1971
4. Edsall, 1970
5. Burrows, 1963
6. Averett, 1968
7. Reutter and Hendendorf, 1974

FISH TEMPERATURE DATA SHEET

Species: Emerald Shiner (Notropis athèrinoides)

I. Lethal threshold	acclimation temperature	larvae	juvenile	adult	data source[3/]
Upper				27-28	4
	25			30.7	5
Lower					

II. Growth[1/]	larvae	juvenile	adult	
Optimum and		29		3
[range[2/]		24-31		3

III. Reproduction:	optimum	range	month(s)	
Migration				
Spawning		20-27		1,2
Incubation and hatch				

IV. Preferred:	acclimation temperature	larvae	juvenile	adult	
				25-31.1	1,6

1. Campbell and MacCrimmon, 1970
2. Gray, 1942
3. McCormack and Kleiner, 1970
4. Wells, 1914
5. Hart, 1947
6. Proffitt and Benda, 1971

FISH TEMPERATURE DATA SHEET

Species: Golden Shiner (Notemigonus crysoleucas)

I. Lethal threshold	acclimation temperature	larvae	juvenile	adult	data source[3/]
Upper	22			33.4	1
	22			40.0	2
	25			35	7
Lower	0			26.7	7

II. Growth[1/]	larvae	juvenile	adult	
Optimum and				
[range[2/]				

III. Reproduction:	optimum	range	month(s)	
Migration				
Spawning	20.5	15.6-21		3.4.5
Incubation and hatch				

IV. Preferred:	acclimation temperature	larvae	juvenile	adult	
				25-32	6

1/ As reported or net growth (growth in wt minus wt of mortality).
2/ As reported or to 50% of optimum if data permit.
3/ Data sources:

1. Brett, 1944
2. Alpaugh, 1972
3. Carlander, 1959
4. NAS, 1973
5. Forney, 1957
6. Trembley, 1961
7. Hart, 1952

FISH TEMPERATURE DATA SHEET

Species: Rainbow smelt (Osmerus mordax)

I. Lethal threshold:	acclimation temperature	larvae	juvenile	adult	data source[3/]
Upper				21.5-28.5	1
Lower					

II. Growth [1/]	larvae	juvenile	adult	
Optimum and				
[range[2/]]				

III. Reproduction:	optimum	range	month(s)	
Migration			March-April	5
Spawning	8.9			2
Incubation		11-15	June	4
and hatch		6-10 for 29 to 19 days		3

IV. Preferred:	acclimation temperature	larvae	juvenile	adult	
				7.2	6

1 As reported or net growth (growth in wt minus wt of mortality).
2 As reported or to 50% of optimum if data permit.
3 Data sources:

1. Altman and Dittmer, 1966
2. Scott and Crossman, 1973
3. McKenzie, 1964
4. Sheri and Power, 1968
5. QLM, 1974 Nine Mile Study
6. Hart and Ferguson, 1966

FISH TEMPERATURE DATA SHEET

Species: Spottail shiner (Notropis hudsonius)

I. Lethal threshold:

	acclimation temperature	larvae	juvenile	adult	data source 3/
Upper	11			30.8	1
	7			30.3	1
Lower					

II. Growth 1/

	larvae	juvenile	adult	
Optimum and				
[range 2/]				

III. Reproduction:

	optimum	range	month(s)	
Migration				
Spawning	20			3,4
Incubation and hatch				

IV. Preferred:

acclimation temperature	larvae	juvenile	adult	
			14	2
Winter			10.2	5
Spring			14.5	5

1/ As reported or net growth (growth in wt minus wt of mortality).
2/ As reported or to 50% of optimum if data permit.
3/ Data sources:

1. Trembley, 1961, LD 50
2. Meldrim and Gift, 1971
3. Peer, 1961
4. Carlander, 1969
5. Reutter and Herdendorf, 1974

FISH TEMPERATURE DATA SHEET

Species: Smallmouth bass (Micropterus dolomieui)

I. Lethal threshold:

	acclimation temperature	larvae	juvenile	adult	data source 3/
Upper		38* (9)	35 (3)		9, 3

*acclimation not given

	acclimation temperature	larvae	juvenile	adult	data source 3/
Lower	15(3)	4(9)*	2(3)		3, 9
	18		4		3
	22		7		3
	26		10		3

*acclimation temperature not given

II. Growth 1/

	larvae	juvenile	adult	
Optimum and [range 2/]	28-29(2)	26 (3)		2, 3

III. Reproduction:

	optimum	range	month(s)	
Migration Spawning	17-18(5)	13(8)-21(7)	May-July(8)	5, 7, 8
	16.1-18.3	12.8-20.0		12
Incubation and hatch			May-July	

IV. Preferred:

acclimation temperature	larvae	juvenile	adult	
Summer			21-27	6
Winter			>8*(1)-28(4)	1, 4
21			20.3-21.3	10
			20-30**	11
Winter		18.0	12-13	13
Spring		19-24	15-16	13
Summer		31.0	30.0	13
Fall		24-27	21-23	13
Fall			26.6	14

1/ As reported or net growth (growth in wt minus wt of mortality)
2/ As rported or to 50% of optimum if data permit.
3/ Data sources:

1. Munther, 1968.
2. Peek, 1965.
3. Horning and Pearson, 1973.
4. Fergusen, 1958
5. Breder and Rosen, 1966
6. Emig, 1966.
7. Hubbs and Baily, 1938
8. Surber, 1974
9. Larimore and Duever, 1968
10. Ferguson, 1958
11. Cherry, et al., 1975
12. Scott and Crossman, 1973
13. Barans and Tubb, 1973
14. Reutter and Herdendorf 1974

FISH TEMPERATURE DATA SHEET

Species: Threespine stickleback (Gasterosteus aculeatus)

I. Lethal threshold	acclimation temperature	larvae	juvenile	adult	data source[3/]
Upper	19			25.8	1
	20			27.2	2
				31.7-33	3
Lower					

II. Growth[1/]	larvae	juvenile	adult	
Optimum and				
[range[2/]			< 37.1	3

III. Reproduction:	optimum	range	month(s)	
Migration				
Spawning				
Incubation and hatch		19 for 7 days		4

IV. Preferred:	acclimation temperature	larvae	juvenile	adult	

1/ As reported or net growth (growth in wt minus wt of mortality).
2/ As reported or to 50% of optimum if data permit.
3/ Data sources:

1. Blahm and Parente, 1970
2. Jordan and Garside, 1972
3. Altman and Pittner, 1966
4. Breder and Rosen, 1966

FISH TEMPERATURE DATA SHEET

Species: White perch (Morone americana)

I. Lethal threshold	acclimation temperature	larvae	juvenile	adult	data source 3/
Upper	1.1			6.6	2
	24.8			34.7	2
Lower					

II. Growth 1/	larvae	juvenile	adult	
Optimum and			23.9	1
[range 2/]				

III. Reproduction:	optimum	range	month(s)	
Migration				
Spawning		11-15	May-June	4
Incubation and hatch		15-20 for 4.5-1.2 days		3

IV. Preferred:	acclimation temperature	larvae	juvenile	adult	

1/ As reported or net growth (growth in wt minus wt of mortality).
2/ As reported or to 50% of optimum if data permit.
3/ Data sources:

1. Meldrim and Gift, 1971
2. Meldrim and Gift, 1971, minimum avoidance temperature
3. Scott and Crossman, 1973
4. Sheri and Power, 1968

FISH TEMPERATURE DATA SHEET

Species: Yellow perch (Perca flavescens)

I. Lethal threshold:	acclimation temperature	larvae	juvenile	adult	data source[3/]
Upper	5			21.3	1
	9-18			13-22	12
	10			25	1
	22-24			29-30	2
	25			29.7	3,1
Lower	25		4		1

II. Growth [1/]	larvae	juvenile	adult	
Optimum and				
[range[2/]]			13-20	5,6

III. Reproduction:	optimum	range	month(s)	
Migration				
Spawning	12(11)	7.2-12.8 (9)		9, 11
Incubation and hatch		5-10 (10)	March-June (11)	10, 11

IV. Preferred:	acclimation temperature	larvae	juvenile	adult	
				21-24	4
				19.7 (field)	4
	10		19.3	17.0	4
	15		23.0	20.0	4
	20		23.1	20.5	4
				10-29	7
	24		20.23		8
	Winter		10-13	7-12	13
	Winter			14.1	14
	Spring		18.0	13-16	13
	Summer		25-27	27.0	13

1. Hart, 1947
2. Black, 1953
3 Brett, 1956
4. Ferguson, 1958
5. Cobble, 1966
6. Weatharly, 1963
7. Barans and Tubb, 1973
8. McCauley, 1973
9. Breder and Rosen, 1966
10. QLM, 1974 Nine Mile Study
11. Jones, et al., 1973
12. Everest, 1973

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FIGURE A-15

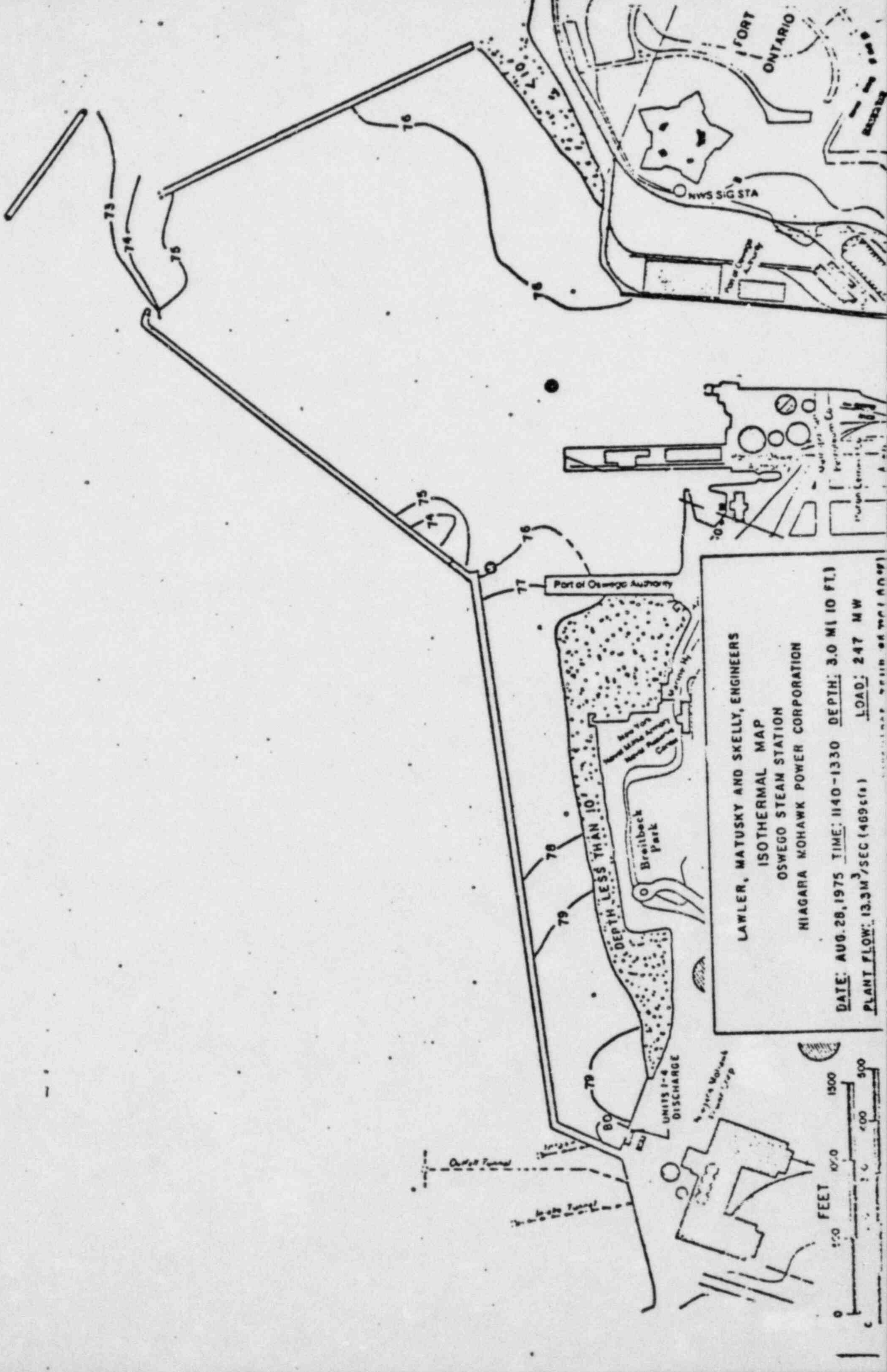
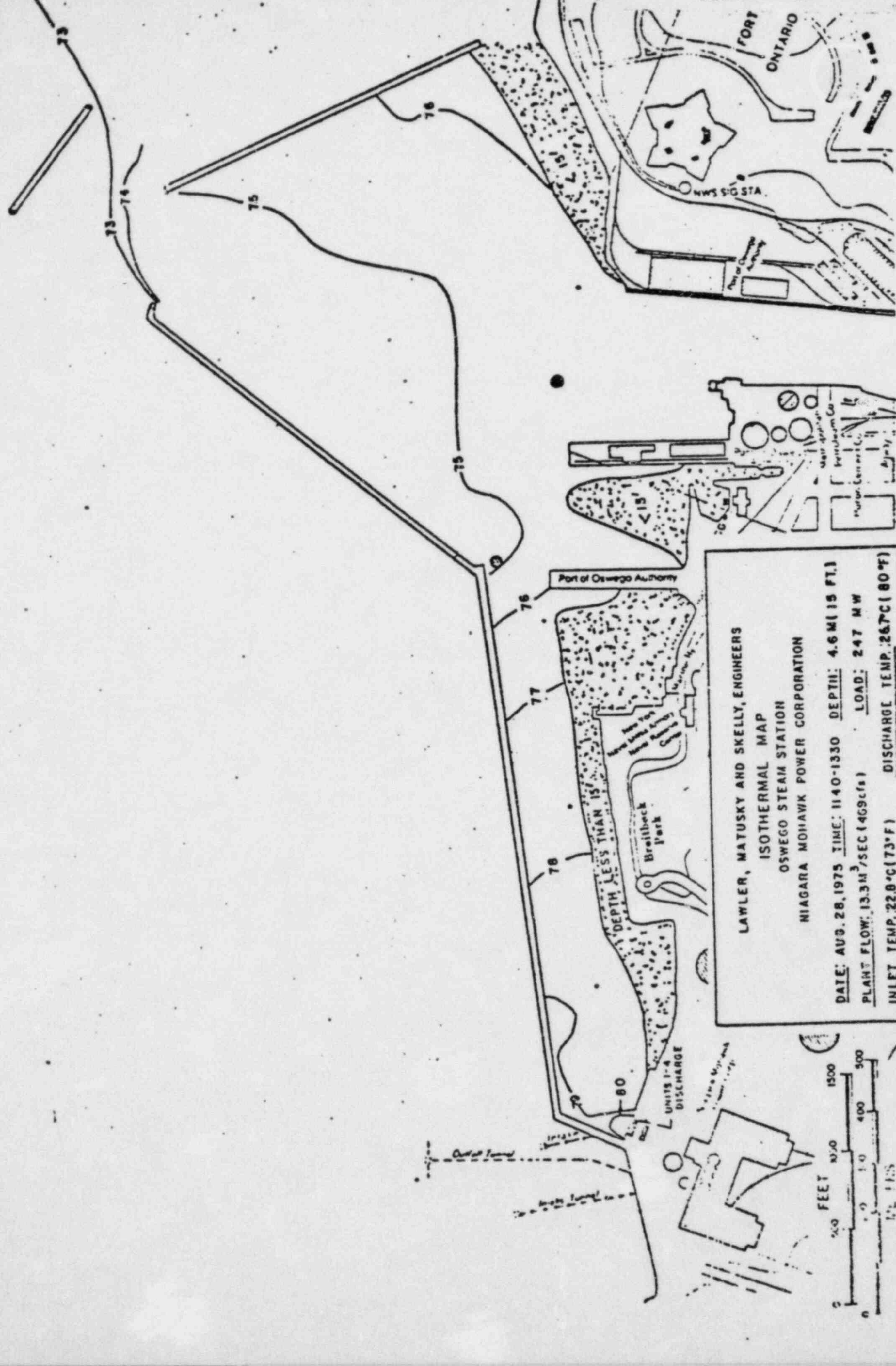

LAWLER, MATUSKY AND SKELLY, ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: AUG. 28, 1975 TIME: 1140-1330 DEPTH: 3.0 M (10 FT.)
PLANT FLOW: 13.3 M³/SEC (469cfs) LOAD: 247 MW
FORT ONTARIO
NWS SIG STA
Port of Oswego Authority
DEPTH LESS THAN 10'
Breitbeck Park
UNITS 1-4 DISCHARGE
Outfall Tunnel
Intake Tunnel
FEET
0
500
1000
1500
73
74
75
76
77
78
79
80

FIGURE A-16


LAWLER, MATUSKY AND SKELLY, ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: AUG. 28, 1975 TIME: 1140-1330 DEPTH: 4.6 M (15 FT.)
PLANT FLOW: 13.3 M3/SEC (469 cfs) LOAD: 247 MW
INLET TEMP. 22.8°C (73°F) DISCHARGE TEMP. 26.7°C (80°F)
FORT ONTARIO
NWS SIG STA.
Port of Oswego Authority
DEPTH LESS THAN 15'
<15'
Breitbeck Park
UNITS 1-4 DISCHARGE
73
74
75
76
77
78
79
80
FEET
0
500
1000
1500
METERS
0
100
200
300
400
500

isotherms in the harbor area show slightly decreasing temperatures with depth, and generally decreasing temperatures toward the harbor mouth. The vertical conductivity profiles in the harbor showed that the discharge waters mixed with the river water in the upper layers, while the bottom layers consisted of mainly river water.

As the combined discharge and river flow enters the lake at the harbor mouth, it tends to sink, due to the high dissolved solids concentrations and low temperature difference. The ambient lake temperature was approximately 22.8°C (73°F) at the time of the survey. Vertical profiles around the harbor mouth showed the mixed discharge river water sinking to the lower half of the water column as it flowed out and to the east. Both the vertical profiles and the isotherms indicate an ambient lake current from west to east, forcing all the harbor outflow to enter the lake through the eastern gap in the breakwaters.

Preliminary analysis of the vertical profiles do not indicate the presence of intruded lake water in the harbor area, as was observed in the June data.

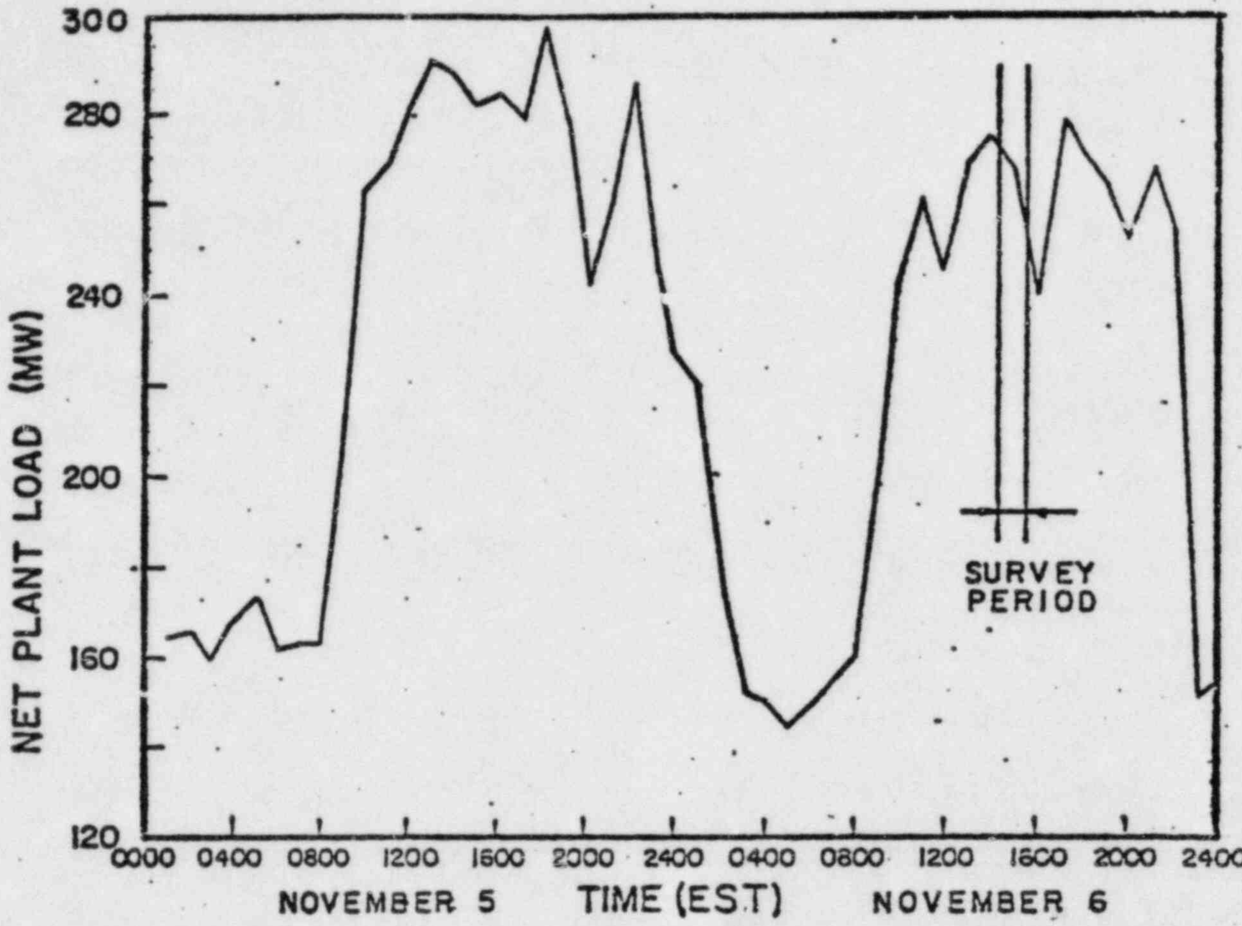
V. RESULTS AND DISCUSSION: 6 NOVEMBER 1975 SURVEY

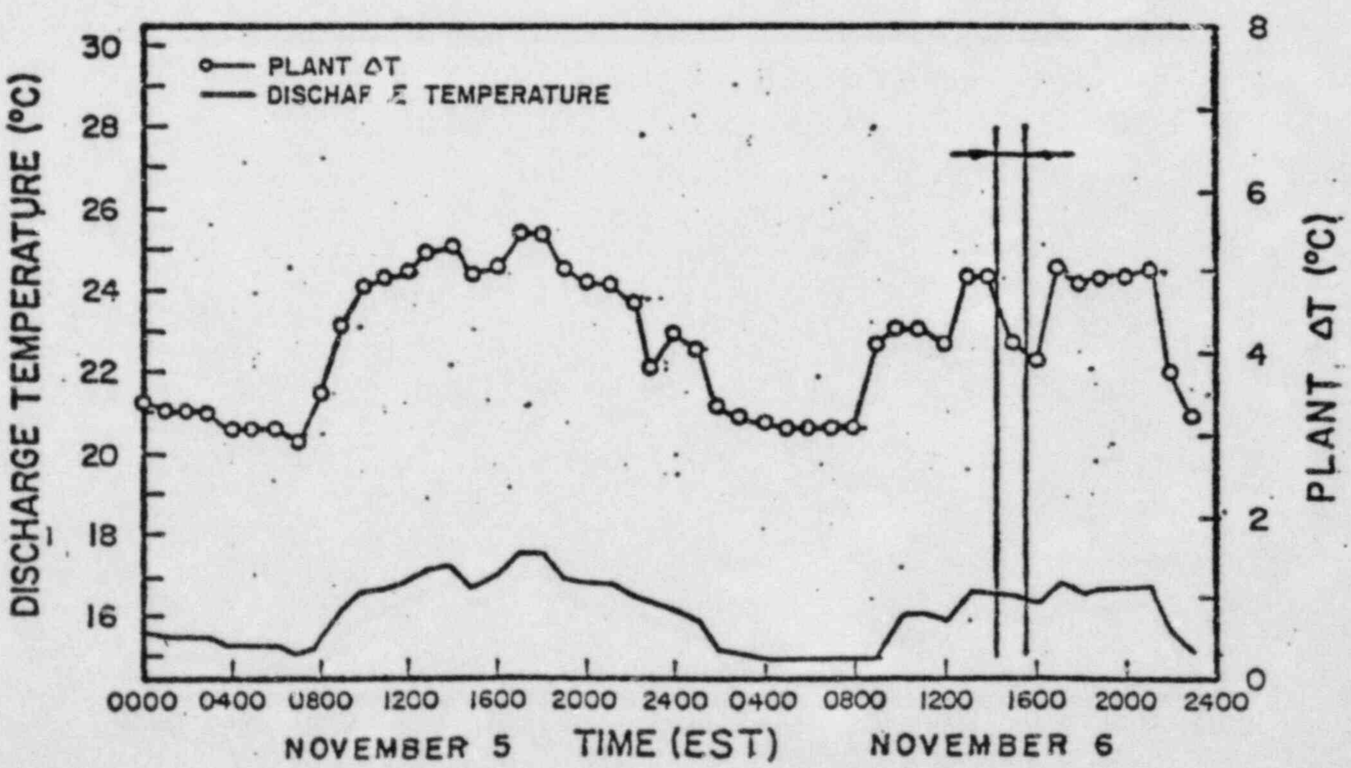
A. PLANT OPERATING DATA

Figure 17 shows the pertinent plant operating data for Units 1-4 on 5 and 6 November, 1975. The survey period, 1420-1530 (EST) on 6 November is shown on the figure. The average net generation for the twelve hours preceding the survey was 198 MWe (50% of capacity), based on hourly plant readings. The net generation for Units 1-4 was between 267 MWe and 275 MWe during the survey, averaging approximately 271 MWe (68% of capacity) during the thermal mapping. The net generation dropped to a low of 239 MWe during the vertical profile measurements. Unit 5 was not in operation during the November survey.

The plant induced temperature rise (plant ΔT) and the Units 1-4 discharge temperature are also shown on Figure 17. The plant ΔT and the discharge temperature averaged 3.7°C (6.6°F) and 15.5°C (59.9°F) respectively for the twelve hours preceding the survey, and averaged 4.8°C (8.7°F) and 16.7°C (62.1°F) respectively during the survey period. The lake inlet temperature was constant at 11.8°C (53.3°F) for the twelve hours preceding the survey and during the survey.

UNITS 1-4 PLANT OPERATING CONDITIONS
OSWEGO STEAM STATION THERMAL SURVEY
NOVEMBER 5 AND 6, 1975





B. TRI-AXIAL TEMPERATURE DATA

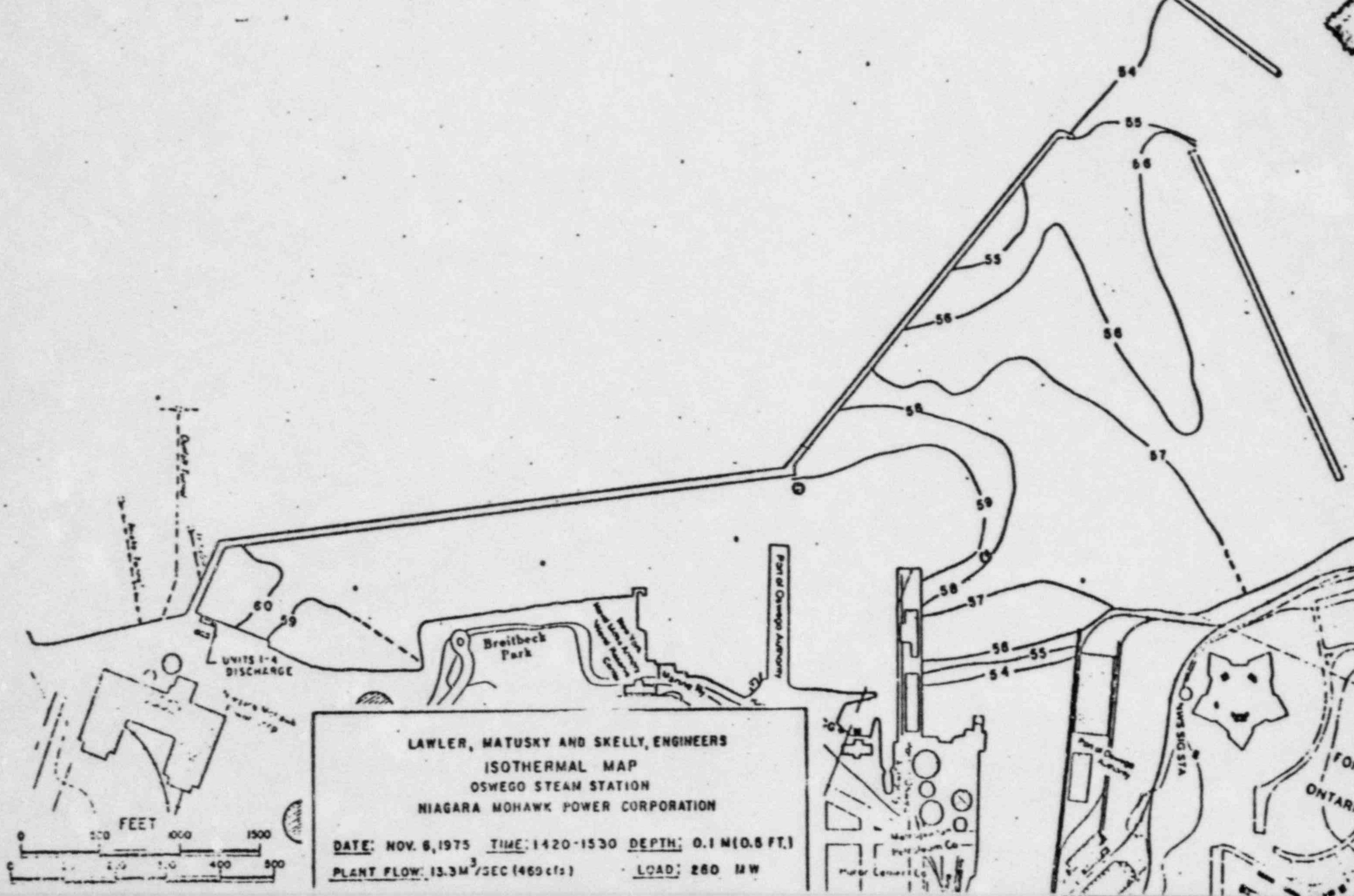
The results of the tri-axial temperature mapping are presented in Figure 18 through 21, for the four measurement depths (0.1, 1.5, 3.0, 4.6 meters).

At the time of the November survey, the Oswego River and Lake Ontario were both at approximately 22.8°C (73°F), with the river having a dissolved solids concentration approximately fifteen times that in the lake.

The isothermal maps in Figures 18 through 21 show the Units 1-4 plume flowing from west to east out of the turning basin in the upper layers. The vertical profiles of temperature and conductivity showed an intrusion of river water into the western end of the turning basin while the discharge waters rose to the upper layers as they flowed to the east.

As the plume waters, mixed with river water, enter the harbor area they spread in the upper layers and mix with the inflowing river water. The Units 1-4 discharge waters remain in the upper 3-4.6 m (10-15 ft) of the water column, with the bottom layers being composed of mostly river water.

FIGURE A-18


LAWLER, MATUSKY AND SKELLY, ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: NOV. 6, 1975 TIME: 1420-1530 DEPTH: 0.1 M (0.8 FT.)
PLANT FLOW: 13.3M³/SEC (469 cfs) LOAD: 260 MW
FEET
0
500
1000
1500
400
500
54
55
56
55
56
56
58
57
59
58
57
58
55
54
60
59
UNITS 1-4
DISCHARGE
Breitbeck
Park
Port of Oswego Authority
NWS SIG STA
FORT
ONTARIO

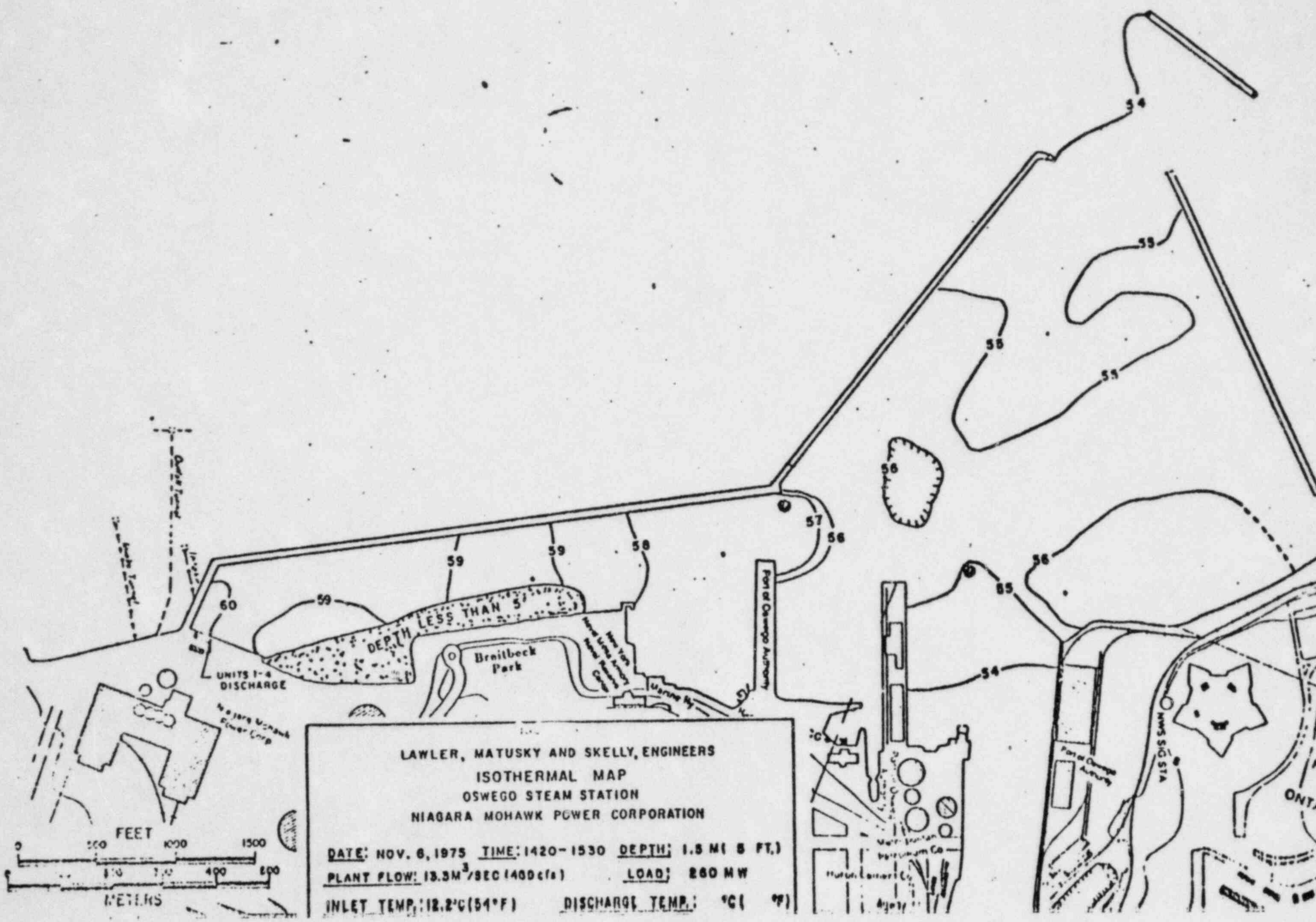

LAWLER, MATUSKY AND SKELLY, ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: NOV. 6, 1975 TIME: 1420-1530 DEPTH: 1.5 M (5 FT.)
PLANT FLOW: 13.3M3/SEC (400 cfs) LOAD: 260 MW
INLET TEMP: 12.2°C (54°F) DISCHARGE TEMP: °C (°F)
FEET
0
500
1000
1500
400
METERS
54
55
55
55
56
57
56
58
59
59
59
60
56
55
54
DEPTH LESS THAN 5'
UNITS 1-4
DISCHARGE
Breitbeck
Park
Port of Oswego Authority
NWS S.C. STA
Niagara Mohawk Power Corp.
FO.
ONTAR.

FIGURE A-19

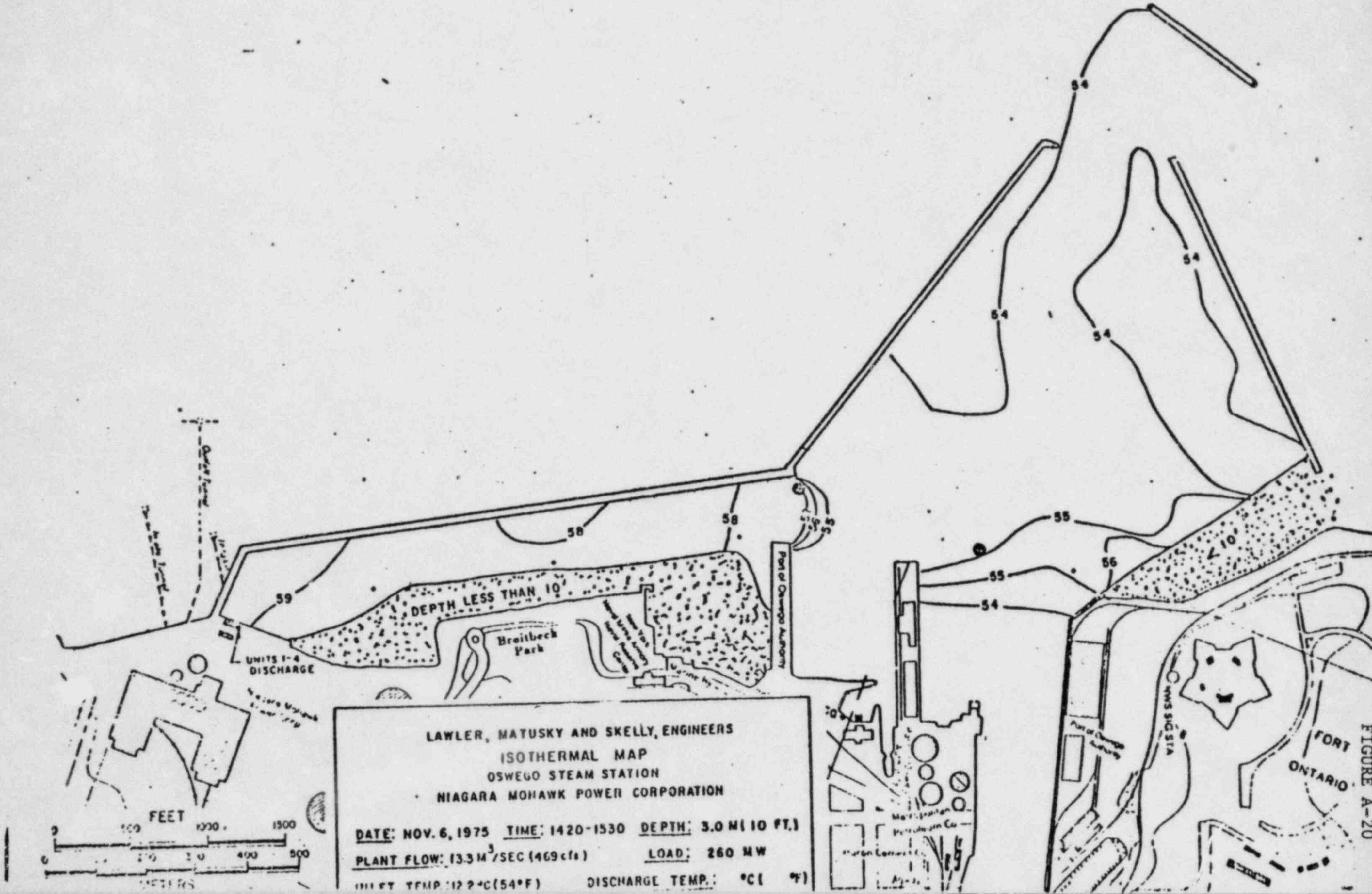

54
54
54
54
55
55
54
56
58
58
59
DEPTH LESS THAN 10'
< 10'
Breitbeck Park
UNITS 1-4 DISCHARGE
Port of Oswego Authority
FORT ONTARIO
FEET
0
1000
1500
400
500
LAWLER, MATUSKY AND SKELLY, ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: NOV. 6, 1975 TIME: 1420-1530 DEPTH: 3.0 M (10 FT.)
PLANT FLOW: 13.3 M³/SEC (469 cfs) LOAD: 260 MW
DISCHARGE TEMP.: °C (°F)

FIGURE A-20

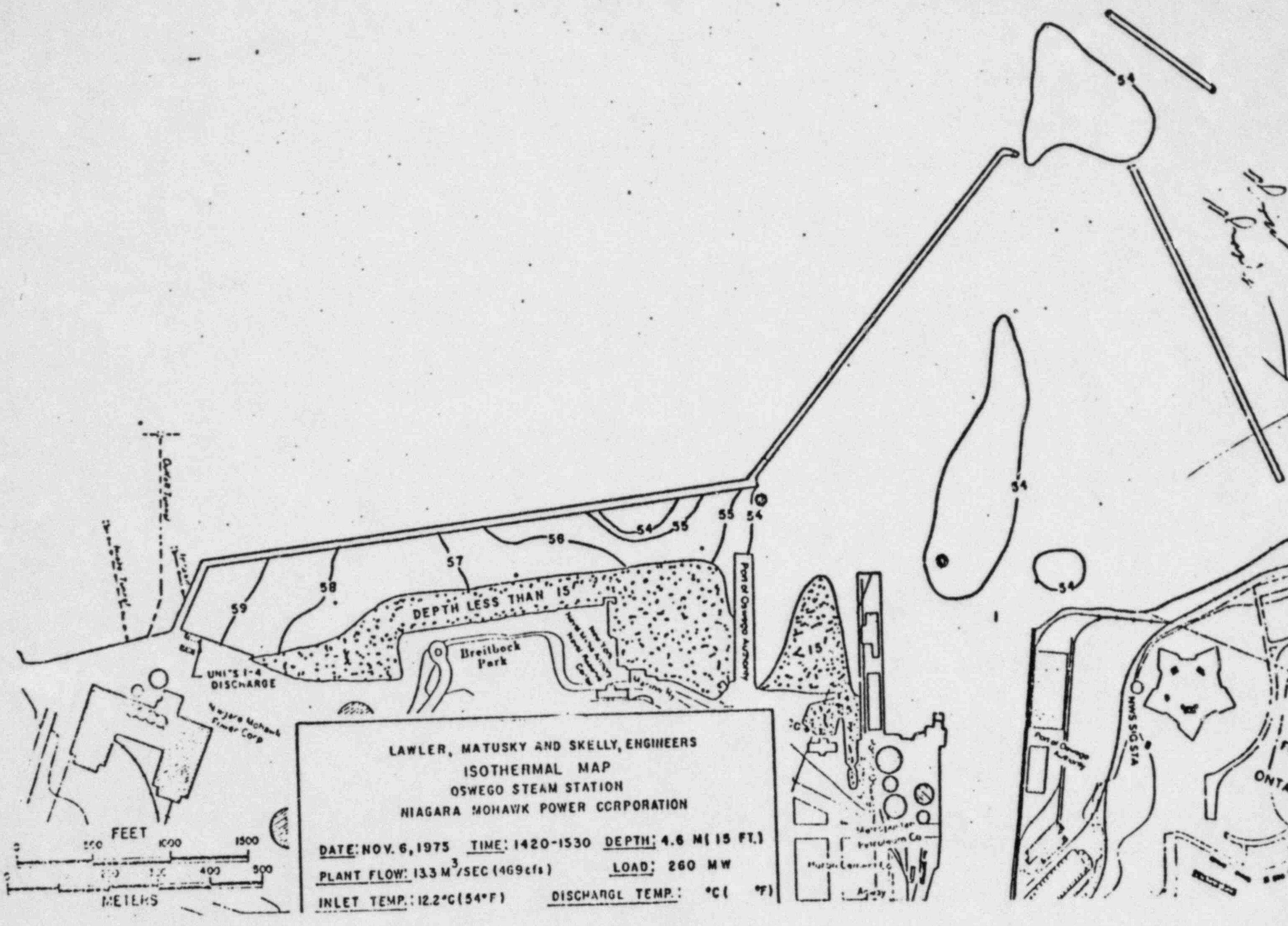

LAWLER, MATUSKY AND SKELLY, ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: NOV. 6, 1975
TIME: 1420-1530
DEPTH: 4.6 M (15 FT.)
PLANT FLOW: 13.3 M³/SEC (469 cfs)
LOAD: 260 MW
INLET TEMP.: 12.2°C (54°F)
DISCHARGE TEMP.: °C (°F)
FEET
0
500
1000
1500
METERS
100
200
400
500
54
55
56
57
58
59
DEPTH LESS THAN 15
< 15
UNITS 1-4
DISCHARGE
Breitbeck
Park
Port of Oswego Authority
Niagara Mohawk
Power Corp
NWS SIG STA
ONTAR

FIGURE A-21

As the combined discharge-river flow enters the lake, at the harbor mouth, it tends to sink below the lighter lake water. The original discharge temperature rise has by this point been reduced to within 0.5-1.0°C (1.9-1.8°F) of the ambient lake temperature through heat exchange to the atmosphere and mixing with the Oswego River flow.

As was the case in the August survey, the heavier river water flowing out of the harbor in the bottom layers prevents the intrusion of lake water into the harbor as was observed in the June survey.

VI. RESULTS AND DISCUSSION: 20 APRIL 1976 SURVEY

A. PLANT OPERATING DATA

Figure 22 shows the pertinent plant operating data for Units 1-4 on 19 and 20 April 1976. Unit 4 was out of service for the entire April survey. The survey period, 1008 to 1335 (EST) on 19 April, is shown on Figure 1. The average net generation for the twelve hours preceding the survey period was 173 MWe (43% of net capacity), based on hourly readings. The net generation of Units 1-4 was between 232 MWe and 238 MWe during the survey period, averaging approximately 234 MWe (59% of net capacity) during the tri-axial temperature mapping. The net generation remained constant at 237 MWe during the vertical profile measurements [1157-1335 (EST)]. Oswego Unit 5 was not in operation during the April survey.

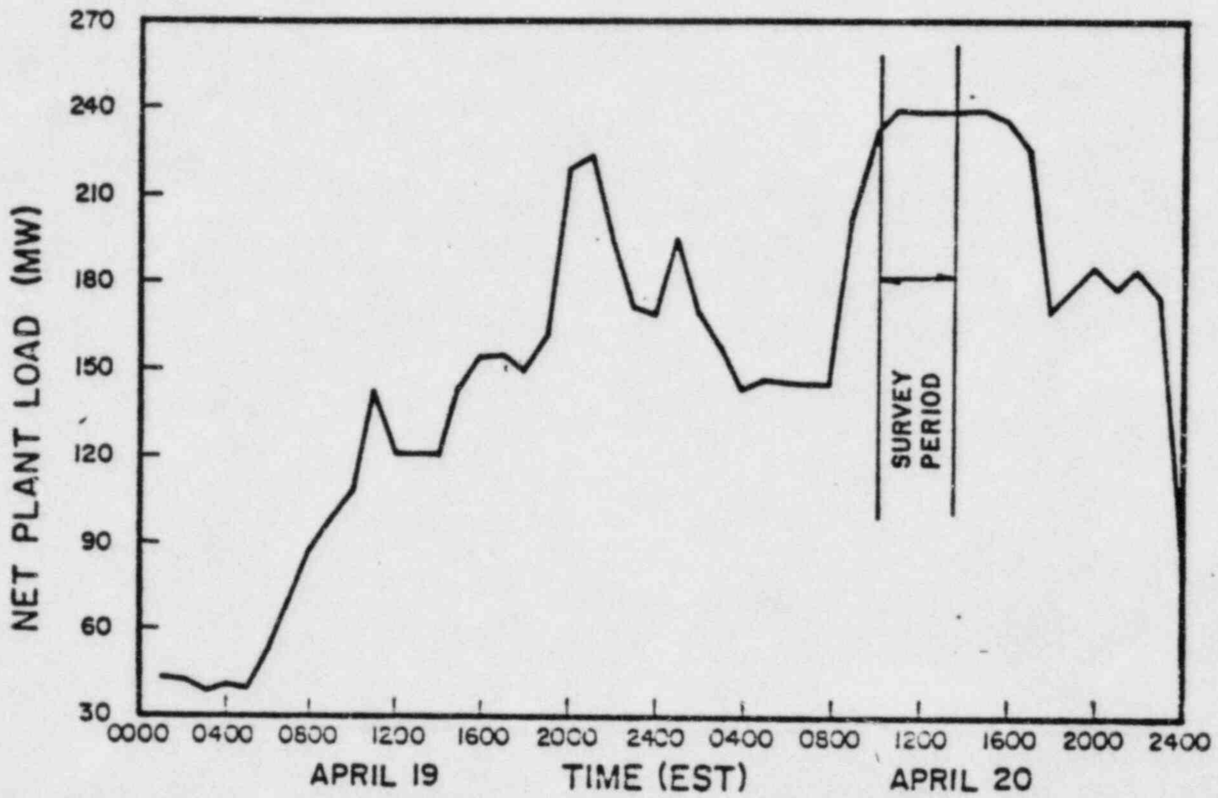
Each of the operating units (Units 1-3) had one circulating water pump in operation for the survey period, resulting in a total condenser cooling water flow of 7.8 m^3/sec (279 cfs). Since the tempering gates between the discharge and intake bays were open during the survey, allowing recirculation of a portion of the condenser circulating flow, the lake intake and turning basin discharge flows were reduced. The percent of the condenser circulating flow being recirculated (percent tempering) was calculated to have been between 20% and 25%, using temperature measurements in the vicinity of the Units 1-4 intake on 19 and 21 April 1976. Thus, the lake intake and turning basin discharge flow is estimated to have been 6.1 m^3/sec (218 cfs) during the survey.

The average temperature rise across the condensers (plant ΔT) and the Units 1-4 discharge temperature for 19 and 20 April are shown on Figure 1. The plant ΔT and discharge temperatures averaged 7.5°C (13.6°F) and 19.3°C (66.7°F) respectively for the twelve hours preceding the survey. The plant ΔT and discharge temperature remained constant at 10.6°C (19°F) and 21.1°C (70°F) respectively during the thermal survey.

B. TRI-AXIAL TEMPERATURE DATA

The results of the 20 April tri-axial temperature mapping are shown in Figures 23 through 27. Each figure shows the distribution of temperature (°F) at the indicated depth. Isotherms were drawn at 0.55°C (1°F) intervals, except at the harbor mouth, where the proximity of the isotherms necessitated plotting at 1.1°C (2°F) intervals.

UNITS 1-4 PLANT OPERATING CONDITIONS
OSWEGO STEAM STATION THERMAL SURVEY
APRIL 19 AND 20, 1976



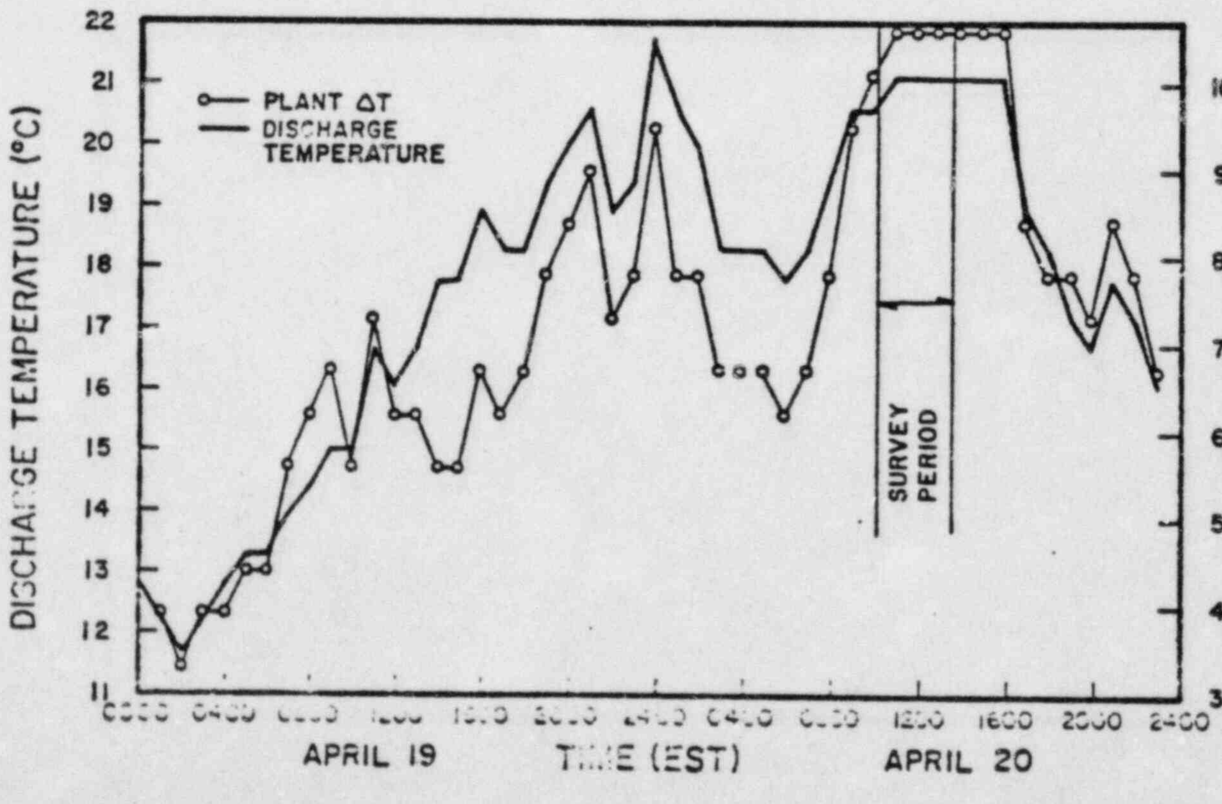
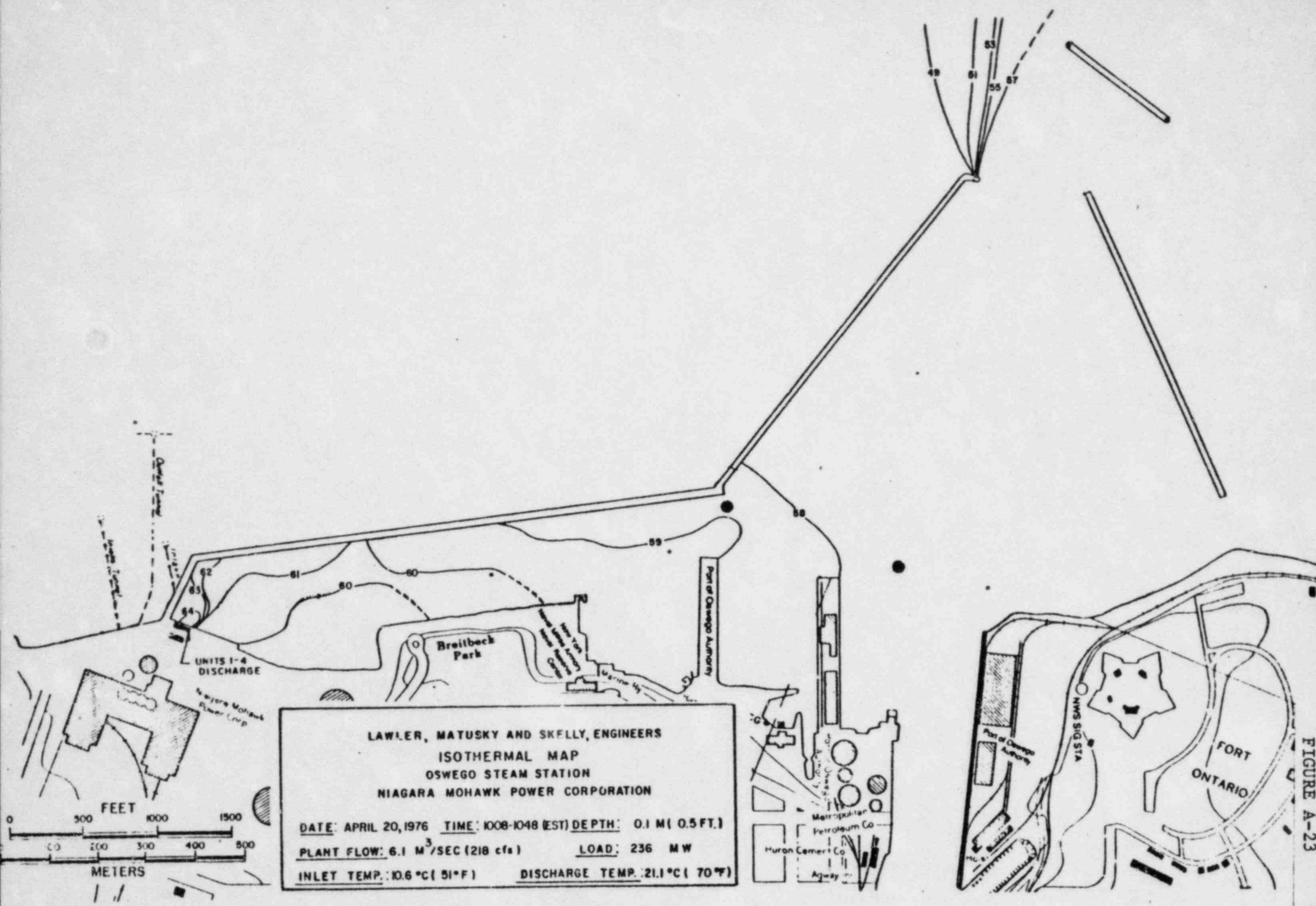
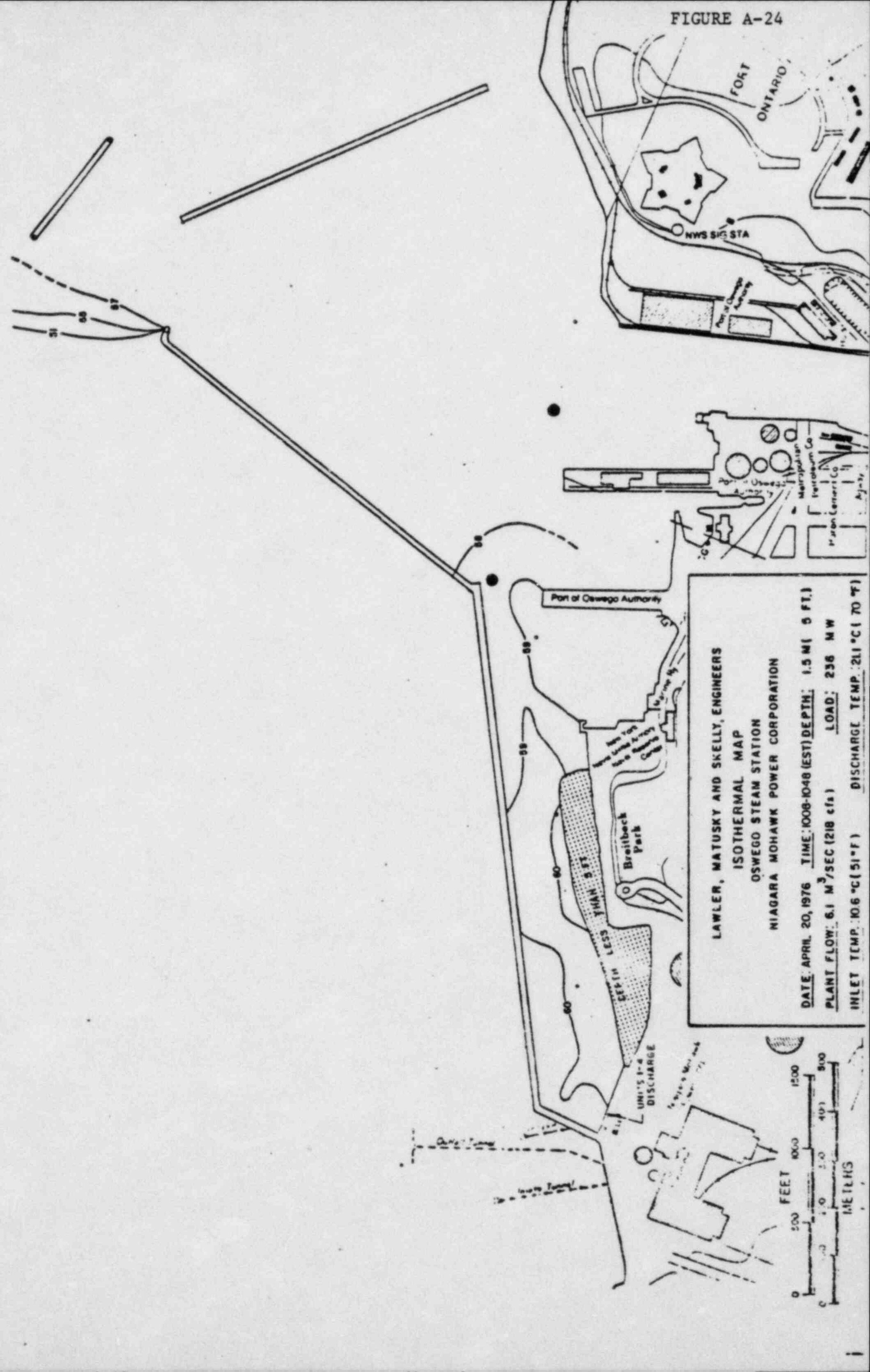


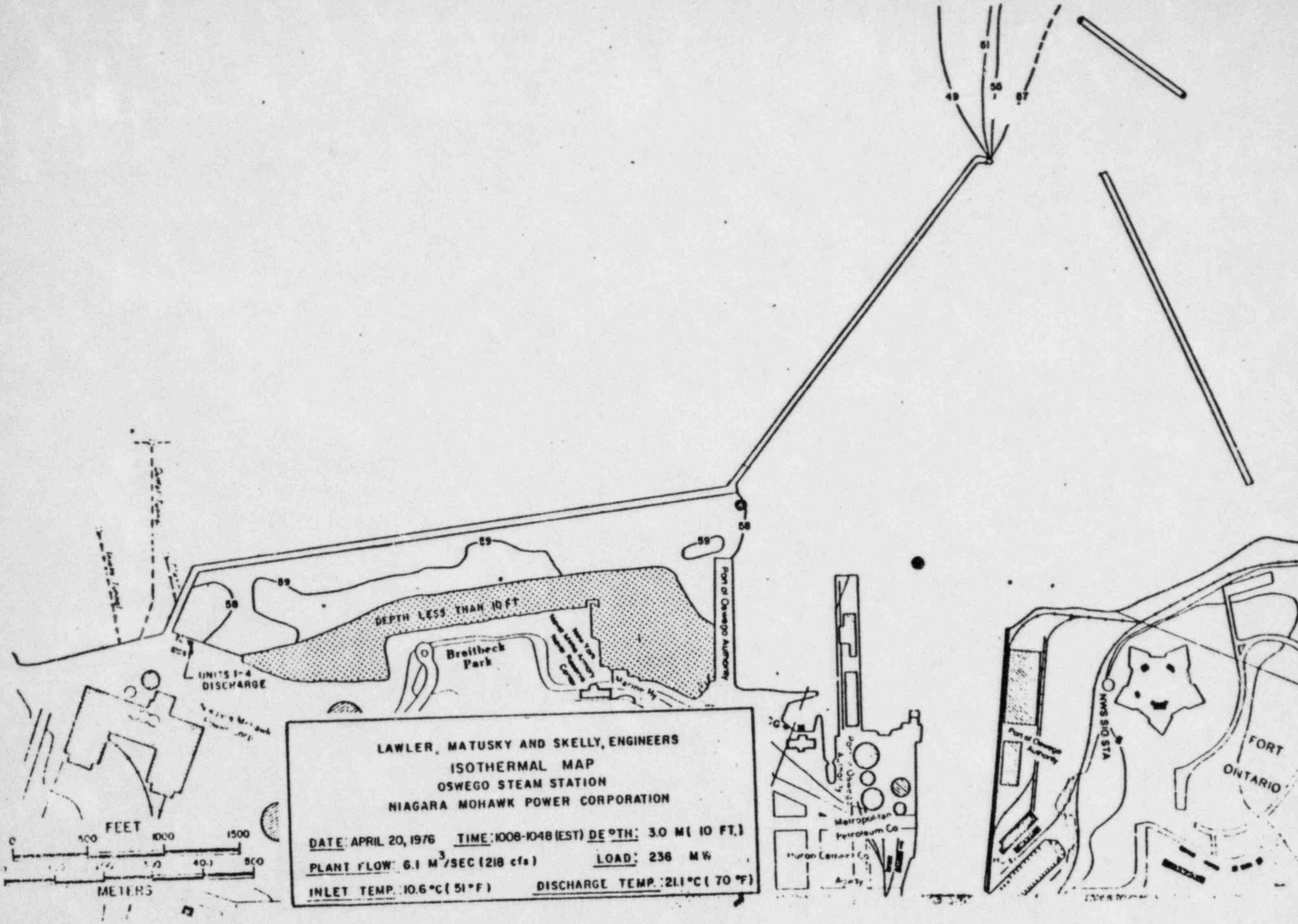
FIGURE A-23

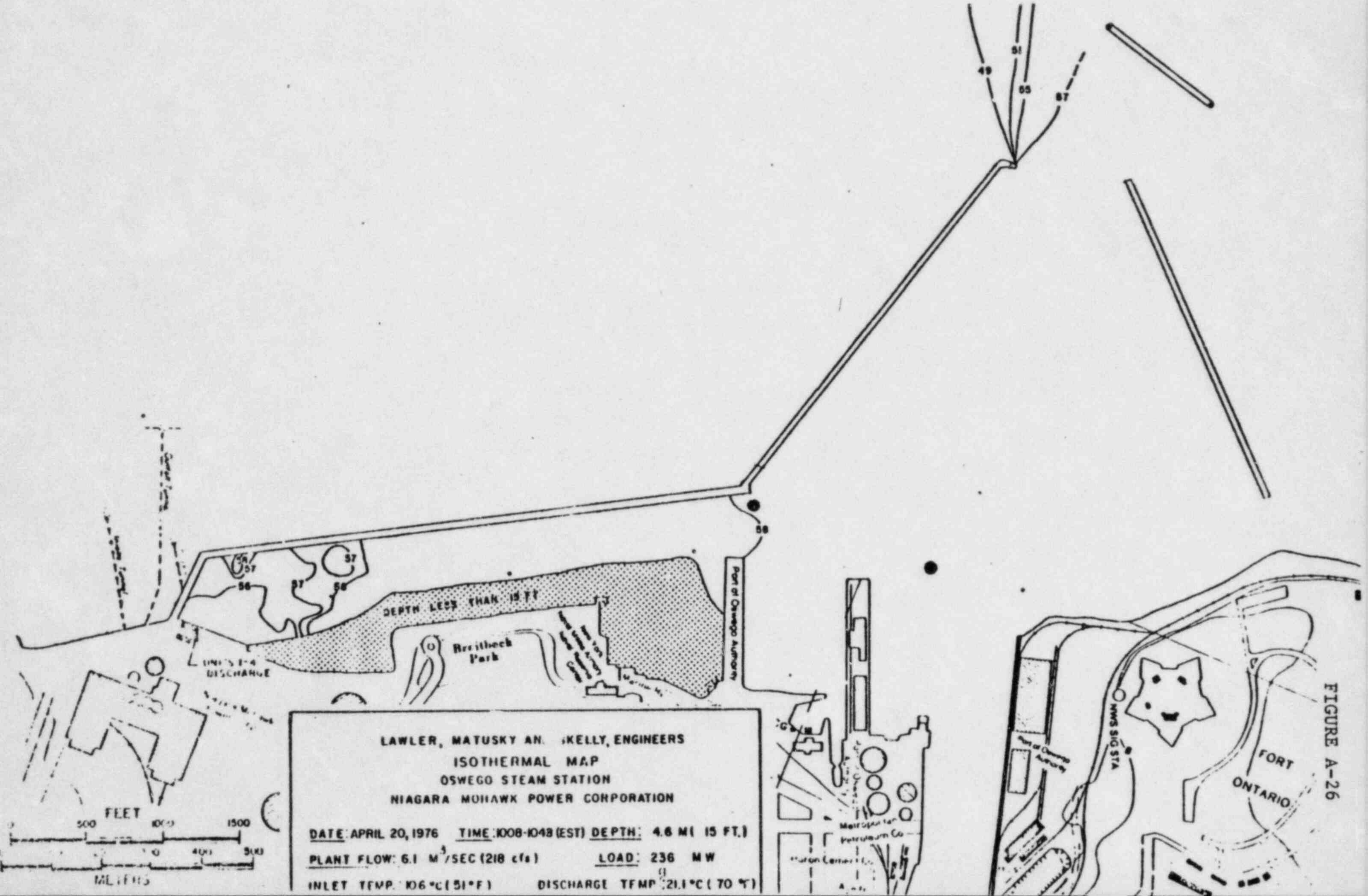


LAWLER, MATUSKY AND SKELLY, ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: APRIL 20, 1976 TIME: 1008-1048 (EST) DEPTH: 0.1 M (0.5 FT.)
PLANT FLOW: 6.1 M³/SEC (218 cfs) LOAD: 236 MW
INLET TEMP.: 10.6 °C (51 °F) DISCHARGE TEMP.: 21.1 °C (70 °F)
FORT ONTARIO
NWS SIG STA
Port of Oswego Authority
Breitbeck Park
UNITS 1-4 DISCHARGE
Niagara Mohawk Power Corp
Metropolitan Petroleum Co
Huron Cement Co
FEET
0
500
1000
1500
METERS
100
200
300
400
500
49
51
53
55
57
58
59
60
61
62
63
64

FIGURE A-24


LAWLER, MATUSKY AND SKELLY, ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: APRIL 20, 1976 TIME: 1008-1048 (EST) DEPTH: 1.5 M (5 FT.)
PLANT FLOW: 6.1 M3/SEC (218 cfs) LOAD: 236 MW
INLET TEMP. 10.6 °C (51 °F) DISCHARGE TEMP. 21.1 °C (70 °F)
FEET
0
500
1000
1500
METERS
500
FORT ONTARIO
NWS SIG STA
Port of Oswego Authority
Breitbeck Park
DEPTH LESS THAN 5 FT
UNITS 1-4 DISCHARGE
58
59
60

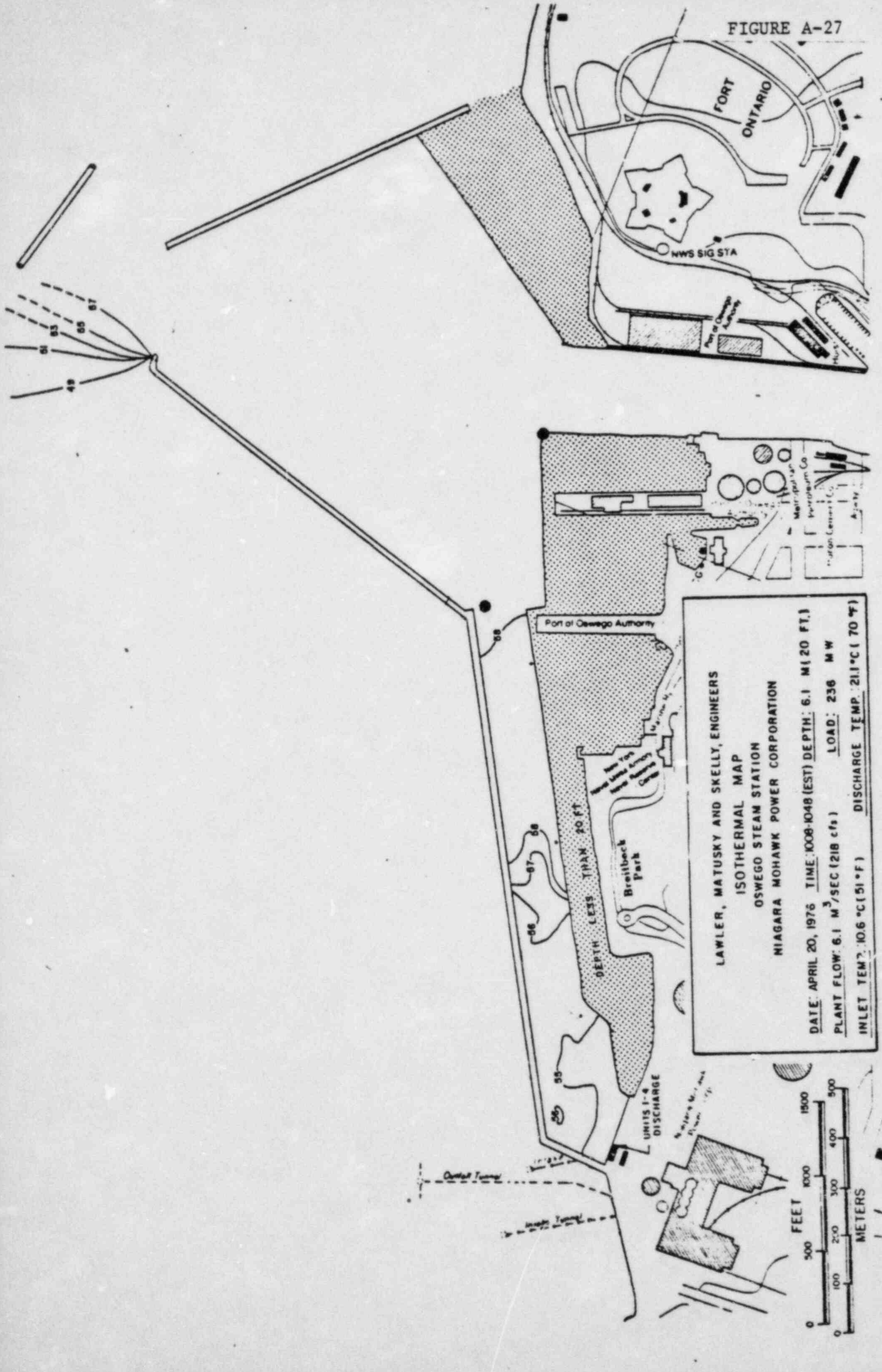

LAWLER, MATUSKY AND SKELLY, ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: APRIL 20, 1976
TIME: 1008-1048 (EST)
DEPTH: 3.0 M (10 FT.)
PLANT FLOW: 6.1 M3/SEC (218 cfs)
LOAD: 236 MW
INLET TEMP.: 10.6 °C (51 °F)
DISCHARGE TEMP.: 21.1 °C (70 °F)
DEPTH LESS THAN 10 FT
UNITS 1-4 DISCHARGE
Breitbeck Park
Port of Oswego Authority
Metropolitan Petroleum Co
NWS SIG STA
FORT ONTARIO
FEET
0
500
1000
1500
METERS
49
51
55
57
58
59
FIGURE A-25



49
51
55
57
58
57
56
57
58
DEPTH LESS THAN 15 FT
UNITS 1-4 DISCHARGE
Breitbeck Park
Port of Oswego Authority
NWS SIG STA
FORT ONTARIO
Metropolitan Petroleum Co
FEET
500
1000
1500
0
400
500
METERS
LAWLER, MATUSKY AN KELLY, ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: APRIL 20, 1976 TIME: 1008-1048 (EST) DEPTH: 4.6 M (15 FT.)
PLANT FLOW: 6.1 M³/SEC (218 cfs) LOAD: 236 MW
INLET TEMP. 10.6 °C (51 °F) DISCHARGE TEMP: 21.1 °C (70 °F)

FIGURE A-26

FIGURE A-27


LAWLER, MATUSKY AND SKELLY, ENGINEERS
ISOTHERMAL MAP
OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION
DATE: APRIL 20, 1976 TIME: 1008-1048 (EST) DEPTH: 6.1 M (20 FT.)
PLANT FLOW: 6.1 M3/SEC (218 cfs) LOAD: 236 MW
INLET TEMP: 10.6 °C (51 °F) DISCHARGE TEMP: 21.1 °C (70 °F)
FORT ONTARIO
NWS SIG STA
Port of Oswego Authority
DEPTH LESS THAN 20 FT.
Breitbeck Park
UNITS 1-4 DISCHARGE
FEET
0 500 1000 1500
METERS
0 100 200 300 400 500

Examination of Figures 23 through 27 shows the Units 1-3 discharge waters flowing out of the western end of the turning basin, above an area of colder [12.2-13.3°C (54-56°F)] water. The presence of the colder water in the western end of the turning basin is attributed to the low discharge temperatures [11.7-12.8°C (53-55°F)] prior to 0400 (EST) on 19 April (see Figure 22. Only Unit 3 was generating prior to 0400 on 19 April, but Units 1 and 2 each had one circulating water pump running, thus the thermal addition by Unit 3 was diluted by units 1 and 2 flow before discharge. As the discharge temperature rose on 19 April, due to Units 1 and 2 generation, the increase in buoyancy caused the discharge water to ride above the previously discharged colder waters. Since the increased discharge temperatures were maintained from 19 April through the survey period, the colder waters remained in the bottom layers at the far western end of the turning basin. The survey data show the discharge waters flowing easterly out of the turning basin, with vertical mixing progressively lessening the vertical temperature gradient until complete vertical mixing occurs when the turning basin flow enters the main harbor area. The entire harbor area is seen to be isothermal in both the horizontal and vertical dimensions indicating complete mixing of the Units 1-3 discharge with the harbor waters.

Vertical profiles of temperature and conductivity also showed the main harbor area to be completely mixed. The vertical profiles done in the turning basin showed the presence 60-75% river water (based on chloride concentration) throughout the entire length of the turning basin. Even the cold bottom waters at the western end of the turning basin contained 60-70% river water, indicating that river water had been present in the turning basin at the time of the cooler discharges on 19 April, 1976.

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APPENDIX B

DESCRIPTION OF THE BOD-DO MODEL

A. PRINCIPLES

Degradable waste concentrations can be described mathematically by considering the natural purification property of the receiving water body. A steady-state mathematical model for this process is based on the classical theory of Streeter and Phelps (1925). It can also be derived from the one-dimensional mass balance equation, which considers the longitudinal dispersion and net advective velocity of the flow, the decay rates, sources and sinks of the waste contaminant or dissolved substance. The one-dimensional equation applies to the water body in which lateral and vertical advection and dispersion are negligible or implicity implied in other terms.

The sources by which the DO may be replenished are (Eckenfelder, 1970):

1. DO concentration in the incoming flows into the channel
2. Photosynthesis
3. Reaeration, which may be natural or artificially induced

The sinks through which the DO is depleted are:

1. Biological oxidation of the carbonaceous organic matter
2. Oxidation of nitrogenous organic matter
3. Decomposition of bottom deposits
4. Respiration of aquatic plants
5. Chemical oxidation

B. EQUATIONS AND SOLUTIONS

To determine the long-term BOD and DO concentrations in the basin resulting from a continuous waste input under various flow and temperature conditions, the equations are solved with a simple boundary condition. The channel is assumed to be infinite in extent in both upstream and downstream directions. A source of waste is continuously discharged into the channel at a single point, X=0. With these conditions, the solutions, that is, the BOD and DO profiles, depend only on the waste loading and the input parameters. Different profiles therefore directly reflect the variations that are made in the waste loadings and input parameters. For the single source waste input, the maximum BOD always occurs at the point of waste discharge, X=0. Because the concentration curves and their derivatives may be discontinuous at this point, the solutions are broken up into the upstream (X<0) and downstream (X>0) regions. The boundary conditions are:

$$[L]_{x = \pm\infty} = 0 \qquad (1)$$

$$[D]_{x = \pm\infty} = 0 \qquad (2)$$

The equations and their solutions are summarized below, for the following three transport conditions:

1. advection and longitudinal dispersion (with average cross-sectional velocity U and longitudinal dispersion E)
2. turbulent longitudinal diffusion without advection of the thermal discharge
3. convection, of uniform velocity U and no, or negligibly small, diffusion.

1. Advection and Dispersion

EQUATION:

$$E \frac{d^2L}{d^2} - U \frac{dL}{dx} - K_{11}L = 0 \qquad (3)$$

$$E \frac{d^2D}{dx^2} - U \frac{dD}{dx} - k_{22} D + k_{12} L = 0 \qquad (4)$$

SOLUTION:

$$L = \frac{W}{AU \, m_{11}} \exp\left\{\frac{ux}{2E}\left(1 \pm m_{11}\right)\right\} \qquad (5)$$

$$D = \left(\frac{W}{Au}\right)\left(\frac{K_{12}}{K_{22} - K_{11}}\right)\left[\frac{\exp\left\{2E^{ux}\left(1 \pm m_{11}\right)\right\}}{m_{11}} - \frac{\exp\left\{2E^{ux}\left(1 \pm m_{2}\right)\right\}}{m_{22}}\right] \qquad (6)$$

(+) sign - upstream x <0 ;
(-) sign - downstream x >C

$$m_{11} = \left(1 + \frac{4K_{11}\ E}{U^2}\right)^{1/2} \quad (7)$$

$$m_{22} = \left(1 + \frac{4K_{22}\ E}{U^2}\right)^{1/2} \quad (8)$$

2. Diffusion Only

EQUATION:

$$E \ \frac{d\ L}{d^2} - U\ \frac{dL}{dx} - K_{11}L = 0 \quad (9)$$

$$E \ \frac{d^2D}{dx^2} - U\ \frac{dD}{dx} - k_{22}\ D + k_{12}L = 0 \quad (10)$$

SOLUTION:

$$L = \frac{W}{2An_{11}} \ \exp\left(\pm xp_{11}\right) \quad (11)$$

$$D = \left(\frac{W}{2A}\right)\left(\frac{K_{12}}{k_{22} - k_{11}}\right)\left[\frac{\exp\left(\pm xp_{11}\right)}{n_{11}} - \frac{\exp\left(\pm\ xp_{22}\right)}{n_{22}}\right] \quad (12)$$

(+) - upstream x<0
(-) - downstream x>0

$$n_{11} = \left(k_{11}E\right)^{1/2}; \quad n_{22} = \left(k_{22}E\right)^{1/2} \quad (13)$$

$$P_{11} = \left(\frac{K_{11}}{E}\right)^{1/2} \; ; \; P_{22} = \left(\frac{K_{22}}{E}\right)^{1/2} \qquad (14)$$

3. Pure Convection

EQUATION:

$$-U \frac{dl}{dx} - K_{11} L = 0 \qquad (15)$$

$$-U \frac{dD}{dx} - K_{22} D + K_{12} L = 0 \qquad (16)$$

SOLUTION:

$$L = 0 \qquad (x<0, \text{ upstream}) \qquad (17)$$

$$L = \frac{W}{Au} \exp\left(-xq_{11}\right) (x>0, \text{ downstream}) \qquad (18)$$

$$D = 0 \qquad (x<0, \text{ upstream}) \qquad (19)$$

$$D = \left(\frac{W}{Au}\right) \left(\frac{K_{12} - K_{11}}{K_{22}}\right) \left[\exp\left(-xq_{11}\right) - \exp\left(-xq_{22}\right)\right] \qquad (20)$$

$$(x>0, \text{ downstream})$$

L represents the BOD concentration at any location x of the uniform channel of cross-sectional area A, and D is the DO deficit concentration. The dissolved oxygen concentration equal to the DO saturation level, less the concentration D, or

$$C_s = C - D \qquad (21)$$

U is the cross-sectional average velocity in case (1), or the uniform velocity in the channel in case (3). E is the dispersion coefficient in case 1 or the longitudinal turbulent diffusion in case 2. K_{11}

is the decay coefficient associated with BOD while K_{22} is the oxygen rearation rate (or the decay coefficient associated with the DO deficit). K_{12} is the reaction coefficient, or deoxygenation rate, in which the term $K_{12}L$ acts a source of the oxygen deficit. The continuous waste discharge is given by W (mass/unit time).

C. COMPUTATIONS AND INPUT PARAMETERS

A computer program is written for the solutions given in Section 2 to obtain the BOD and DO profiles under different steady-state flow conditions.

Inputs for the calculations include:

1. The channel flow geometry under stratified or non-stratified conditions. The width of the channel is 280 ft, representing the dredged portion of the channel. Maximum upstream distance, at the western end of the channel is 1000 ft from the point of waste input. The maximum downstream distance is 3000 ft towards the harbor. The total depth of 30 ft is used for the non-stratified condition, with flow in one direction and towards the harbor. For the stratified condition, it is assumed that the flow in the channel takes place in the upper-half layer into which the waste is discharged. The flow in the lower half is relatively very small. A depth of 15 ft is used in the computations.

2. Estimated net velocity is based on the total flow; i.e.,

$$u = \left(Q_{upstream} + Q_{waste}\right)/area \qquad (22)$$

where $Q_{upstream}$ = upstream discharge from the Oswego Unit 1-4 discharge

Q_{waste} = Runoff and sewage discharge flow rate into the channel at X=0.

3. Estimated dispersion coefficients, based on the Taylor oxygen dispersion coefficient formula (Harleman, 1970):

$$E = 77\ UR_h^{5/6} \qquad (23)$$

In the case of negligible advection, the same value of E has been used, for the diffusion coefficient, as an extreme value that can be obtained from the effects of winds and currents in the turning basin.

Lower values of E, in fact, result in much slower transport of the waste, or a very high concentration around the waste input location.

4. Decay and reaeration rate parameters:

(a) K_{11} - BOD Decay Rate

A value of 0.10 at 20°C (summer temperature) is used as a normal biochemical oxidation rate for high degree biological effluent. (Raw sewage is oxidized at a much higher rate.) Effect of the temperature, or seasonal changes, is given by (Eckenfelder, 1970):

$$K_{11_T} = K_{11_{20°C}} \times 1.047^{T-20} \qquad (24)$$

where T is the temperature in °C.

(b) K_{12} - Deoxygenation Rate

This is set equal to K_{11}, by assuming that the BOD waste is carbonaceous only, and that no solids are present. In general, K_{11} and K_{12} need not be equal if factors other than deoxygenation are involved.

(c) K_{22} - Reaeration Rate

This is the rate at which oxygen is transferred into the water body from the atmosphere; it varies directly with channel velocity and inversely with the depth. Several empirical formulas have been proposed for this parameter. In this computation, a basic value of 0.35/day or 20°C, (which is much higher than any from the empirical relationships) has been used as an extreme value for all the flow conditions, for the basis of comparison. Trial runs with the empirical formulas also showed that the DO levels are not as sensitive to this parameter as they are to K_{11}, K_{12} and the BOD concentration in the channel. Simply stated, the rate of replenishment of the DO is generally small, even at a high natural reaeration rate. Variation with temperature is given by (Eckenfelder, 1970):

$$K_{22_T} = K_{22_{20°C}} \times 1.024^{T-20} \quad (25)$$

where T is the temperature in °C.

(d) C_s - Dissolved Oxygen

DO saturation level is a function of temperature, salinity, and barometric pressure. Its value if given by:

$$C_s = 14.652 - 0.41022\,T + 0.0079910\,T^2 - 0.0007774\,T^3 \quad (26)$$

where T is the temperature in °C.

5. Plant Discharge and Waste Flows

At full capacity operation the power plant discharges 762 cfs into the basin. Winter discharge into the basin is estimated to be 313.32 cfs, considering the tempering flow of 162.93 cfs, or abour 1/3 of the total 476.25 cooling water requirement in the winter season.

Waste flow is based on the Oswego West Treatment Plant design flow of 4 mgd (6.188 cfs).

6. BOD Loading

The raw sewage BOD is 200 mg/liter. This gives a BOD load of 6.6763×10^3 lbs/day (or 0.32×10^{10} mg/day).

TABLE B-1

BOD - DO PROFILES UNDER DIFFERENT STEADY-STATE FLOW CONDITIONS

GEOMETRIC, HYDRAULIC, AND RATE INPUT PATAMETERS

VARIABLE	VALUES AT SEASONAL CONDTIONS (CORRESPONDING TABLES)			
	B-2	B-3	B-4	B-5
CHANNEL DEPTH (ft) WIDTH (ft)	30 280	15.0 280.0	30 280	15 280
CROSS-SECTIONAL AREA (ft^2)	8400	4200	8400	4200
MAXIMUM LONGITUDINAL DISTANCE (ft) UPSTREAM DOWNSTREAM COMPUTATION DIST. INTERNAL (ft)	 -1000 3000 200	 -1000 3000 200	 -1000 3000 200	 -1000 3000 200
VELOCITY (ft/sec) (mi/day)	0.092 1.497	0.183 2.993	0.038 0.622	0.076 1.245
DISPERSION COEFFICIENT (ft^2/sec) (mi^2/day	3.060 0.0095	3.707 0.0115	1.272 0.0039	1.543 0.0048
BOD DECAY RATE (per day)	0.10	0.10	0.04	0.4
DEOXYGENATION RATE (per day)	0.10	0.10	0.04	0.4
DO REAERATION RATE (per day)	0.350	0.350	0.218	0.218
WASTE INPUT LOADING RATE (mg/day)	3.208×10^9	3.208×10^9	3.208×10^9	3.208×10^9
FLOW RATES - (cfs) WASTE EFFLUENT	 6.188	 6.188	 6.188	 6.188
CHANNEL FLOW (from plant)	762.00	762.00	313.32	313.32
TOTAL FLOW	768.188	768.188	319.508	319.508
TEMPERATURE [T (°C)]	20	20	0	0
DO SATURATION LEVEL [C_s(mg.1)]	9.02	9.02	14.62	14.62

TABLE B-2

MODEL RESULTS OF A SUMMER - NON-STRATIFIED CONDITION*

I. BOD (mg/1) PROFILE

I	XD	CBOD1	CBOD2	CBOD3
1	-1000.000	0.0000	22.4219	0.0
2	-800.000	0.0000	25.3567	0.0
3	-600.000	0.0000	28.6757	0.0
4	-400.000	0.0000	32.4291	0.0
5	-200.000	0.0043	36.6738	0.0
6	0.0	1.7045	41.4741	1.7060
7	200.000	1.7002	36.6738	1.7017
8	400.000	1.6959	32.4291	1.6974
9	600.000	1.6917	28.6757	1.6931
10	800.000	1.6874	25.3567	1.6888
11	1000.000	1.6831	22.4219	1.6845
12	1200.000	1.6789	19.8268	1.6803
13	1400.000	1.6746	17.5320	1.6760
14	1600.000	1.6704	15.5028	1.6718
15	1800.000	1.6662	13.7085	1.6676
16	2000.000	1.6620	12.1218	1.6634
17	2200.000	1.6578	10.7188	1.6592
18	2400.000	1.6536	9.4782	1.6550
19	2600.000	1.6494	8.3812	1.6508
20	2800.000	1.6452	7.4111	1.6466
21	3000.000	1.6411	6.5534	1.6425

II. DO (mg/1) PROFILE

I	XD	CDO1	CDO2	CDO3
1	-1000.000	9.0200	2.8573	9.0200
2	-800.000	9.0200	2.4094	9.0200
3	-600.000	9.0200	1.9958	9.0200
4	-400.000	9.0200	1.6449	9.0200
5	-200.000	9.0200	1.3952	9.0200
6	0.0	9.0186	1.2979	9.0200
7	200.000	9.0143	1.3952	9.0157
8	400.000	9.0101	1.6449	9.0115
9	600.000	9.0059	1.9958	9.0073
10	800.000	9.0018	2.4094	9.0031
11	1000.000	8.9977	2.8573	8.9990
12	1200.000	8.9937	3.3185	8.9950
13	1400.000	8.9897	3.7782	8.9910
14	1600.000	8.9858	4.2258	8.9870
15	1800.000	8.9819	4.6543	8.9831
16	2000.000	8.9780	5.0592	8.9792
17	2200.000	8.9742	5.4379	8.9754
18	2400.000	8.9705	5.7891	8.9716
19	2600.000	8.9668	6.1127	8.9679
20	2800.000	8.9631	6.4092	8.9642
21	3000.000	8.9595	6.6796	8.9605

*T = 20°C

I - Section index
XD - Distance (ft) from point of waste input
CBOD 1 - BOD concentration with dispersion and convection flow condition
CBOD 2 - BOD concentration with dispersion only
CBOD 3 - BOD concentration with convection only
CDO1 - DO concentration with dispersion and convection flow condition
CDO2 - DO concentration with disperion only
CDO3 - DO concentration with convection only

MODEL RESULTS OF A SUMMER STRATIFIED CONDITION*

I. BOD (mg/l) PROFILE

I	XD	CBOD1	CBOD2	CBOD3
1	-1000.000	0.0000	43.0985	0.0
2	-800.000	0.0000	48.1940	0.0
3	-600.000	0.0000	53.8921	0.0
4	-400.000	0.0000	60.2637	0.0
5	-200.000	0.0001	67.3888	0.0
6	0.0	1.7065	75.3562	0.0
7	200.000	1.7043	67.3888	1.7069
8	400.000	1.7022	60.2637	1.7048
9	600.000	1.7000	53.8921	1.7026
10	800.000	1.6979	48.1940	1.7004
11	1000.000	1.6957	43.0985	1.6983
12	1200.000	1.6936	38.5417	1.6962
13	1400.000	1.6914	34.4666	1.6940
14	1600.000	1.6893	30.8225	1.6919
15	1800.000	1.6872	27.5636	1.6897
16	2000.000	1.6850	24.6493	1.6876
17	2200.000	1.6829	22.0431	1.6855
18	2400.000	1.6808	19.7125	1.6833
19	2600.000	1.6786	17.6283	1.6812
20	2800.000	1.6765	15.7645	1.6791
21	3000.000	1.6744	14.0977	1.6769

II. DO (mg/l) PROFILE

I	XD	CDO1	CDO2	CDO3
1	-1000.000	9.0200	-2.5547	9.0200
2	-800.000	9.0200	-3.2758	9.0200
3	-600.000	9.0200	-3.9316	9.0200
4	-400.000	9.0200	-4.4794	9.0200
5	-200.000	9.0200	-4.8632	9.0200
6	0.0	9.0196	-5.0106	9.0200
7	200.000	9.0174	-4.8632	9.0178
8	400.000	9.0153	-4.4794	9.0157
9	600.000	9.0131	-3.9316	9.0136
10	800.000	9.0110	-3.2758	9.0115
11	1000.000	9.0089	-2.5547	9.0093
12	1200.000	9.0068	-1.8006	9.0073
13	1400.000	9.0048	-1.0377	9.0052
14	1600.000	9.0027	-0.2835	9.0031
15	1800.000	9.0006	0.4493	9.0010
16	2000.000	8.9986	1.1519	8.9990
17	2200.000	8.9966	1.8186	8.9970
18	2400.000	8.9946	2.4460	8.9949
19	2600.000	8.9925	3.0324	8.9929
20	2800.000	8.9906	3.5772	8.9909
21	3000.000	8.9886	4.0811	8.9889

*T = 20°C

I - Section index
XD - Distance (ft) from point of waste input
CBOD 1 - BOD concentration with dispersion and convection flow condition
CBOD 2 - BOD concentration with dispersion only
CBOD 3 - BOD concentration with convection only
CDO1 - DO concentration with dispersion and convection flow condition
CDO2 - DO concentration with disperion only
CDO3 - DO concentration with convection only

TABLE 5-4

MODEL RESULTS OF A WINTER NONSTRATIFIED CONDITION*

I. BOD (mg/1) PROFILE

I	XD	CBOD1	CBOD2	CBOD3
1	-1000.000	0.0000	55.7348	0.0
2	-800.000	0.0000	62.8737	0.0
3	-600.000	0.0000	70.9270	0.0
4	-400.000	0.0000	80.0118	0.0
5	-200.000	0.0104	90.2602	0.0
6	0.0	4.1045	101.8214	4.1078
7	200.000	4.0945	90.2602	4.0979
8	400.000	4.0846	80.0118	4.0879
9	600.000	4.0747	70.9270	4.0780
10	800.000	4.0648	62.8737	4.0681
11	1000.000	4.0549	55.7348	4.0582
12	1200.000	4.0451	49.4065	4.0483
13	1400.000	4.0353	43.7967	4.0385
14	1600.000	4.0255	38.8239	4.0287
15	1800.000	4.0157	34.4157	4.0189
16	2000.000	4.0059	30.5080	4.0092
17	2200.000	3.9962	27.0440	3.9994
18	2400.000	3.9865	23.9734	3.9897
19	2600.000	3.9768	21.2513	3.9800
20	2800.000	3.9672	18.8384	3.9704
21	3000.000	3.9576	16.6994	3.9607

II. DO (mg/1) PROFILE

I	XD	CDO 1	CDO 2	CDO 3
1	-1000	14.6500	4.5385	14.6500
2	- 800	14.6500	3.7150	14.6500
3	- 600	14.6500	2.9393	14.6500
4	- 400	14.6500	2.2676	14.6500
5	- 200	14.6500	1.7791	14.6500
6	0	14.6467	1.5849	14.6500
7	200	14.6369	1.7791	14.6401
8	400	14.6272	2.2676	14.6303
9	600	14.6177	2.9393	14.6207
10	800	14.6083	3.7150	14.6113
11	1000	14.5990	4.5385	14.6020
12	1200	14.5900	5.3712	14.5928
13	1400	14.5810	6.1866	14.5838
14	1600	14.5722	6.9680	14.5749
15	1800	14.5636	7.7046	14.5662
16	2000	14.5550	8.3909	14.5576
17	2200	14.5466	9.0244	14.5492
18	2400	14.5384	9.6049	14.5409
19	2600	14.5303	10.1338	14.5327
20	2800	14.5223	10.6134	14.5246
21	3000	14.5144	11.0467	14.5167

*T = $0^{o}C$

I - Section index
XD - Distance (ft) from point of waste input
CBOD 1 - BOD concentration with dispersion and convection flow condition
CBOD 2 - BOD concentration with dispersion only
CBOD 3 - BOD concentration with convection only
CDO1 - DO concentration with dispersion and convection flow condition
CDO2 - DO concentration with disperion only
CDO3 - DO concentration with convection only

MODEL RESULTS OF A WINTER - STRATIFIED CONDTION*

I. BOD (mg/l) PROFILES

I	XD	CBOD1	CBOD2	CBOD3
1	-1000.000	0.0000	106.9893	0.0
2	-800.000	0.0000	119.3637	0.0
3	-600.000	0.0000	133.1694	0.0
4	-400.000	0.0000	148.5718	0.0
5	-200.000	0.0002	165.7556	0.0
6	0.0	4.1014	184.9269	4.1024
7	200.000	4.0965	165.7556	4.0975
8	400.000	4.0915	148.5718	4.0925
9	600.000	4.0865	133.1694	4.0875
10	800.000	4.0816	119.3637	4.0826
11	1000.000	4.0766	106.9893	4.0776
12	1200.000	4.0717	95.8978	4.0727
13	1400.000	4.0667	85.9560	4.0677
14	1600.000	4.0618	77.0450	4.0628
15	1800.000	4.0569	69.0578	4.0579
16	2000.000	4.0519	61.8986	4.0529
17	2200.000	4.0470	55.4816	4.0480
18	2400.000	4.0421	49.7298	4.0431
19	2600.000	4.0372	44.5743	4.0382
20	2800.000	4.0323	39.9533	4.0333
21	3000.000	4.0274	35.8114	4.0284

II. DO (mg/l) PROFILE

I	XD	CDO 1	CDO 2	CDO 3
1	-1000	14.6500	-4.4073	14.6500
2	- 800	14.6500	-5.7426	14.6500
3	- 600	14.6500	-6.9792	14.6500
4	- 400	14.6500	-8.0320	14.6500
5	- 200	14.6500	-8.7844	14.6500
6	0	14.6490	-9.0787	14.6500
7	200	14.6440	-8.7844	14.6450
8	400	14.6391	-8.0320	14.6401
9	600	14.6343	-6.9792	14.6352
10	800	14.6294	-5.7426	14.6304
11	1000	14.6246	-4.4073	14.6256
12	1200	14.6199	-3.0347	14.6208
13	1400	14.6152	-1.6684	14.6161
14	1600	14.6105	-0.3383	14.6114
15	1800	14.6058	0.9354	14.6067
16	2000	14.6012	2.1403	14.6021
17	2200	14.5966	3.2692	14.5975
18	2400	14.5921	4.3190	14.5930
19	2600	14.5876	5.2893	14.5885
20	2800	14.5831	6.1817	14.5840
21	3000	14.5787	6.9992	14.5795

*T = 0°C

I - Section index
XD - Distance (ft) from point of waste input
CBOD 1 - BOD concentration with dispersion and convection flow condition
CBOD 2 - BOD concentration with dispersion only
CBOD 3 - BOD concentration with convection only
CDO1 - DO concentration with dispersion and convection flow condition
CDO2 - DO concentration with disperion only
CDO3 - DO concentration with convection only

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APPENDIX C: MATERIALS AND METHODS: OSWEGO TURNING BASIN ECOLOGICAL SURVEY

Biological and chemical samples were collected on a monthly schedule commencing in April 1975 and ending in March 1976 at several locations in Oswego Turning Basin and Oswego Harbor. In order to evaluate all trophic levels, a variety of techniques and different pieces of sampling equipment were used. The following section describes the equipment and technique employed for each parameter evaluated and presents a general discussion of the sampling program, including a description of laboratory procedures. Maps showing the sampling locations are presented for each general category.

1. Plankton: Phytoplankton

Figure C-1 shows the collection locations in the Oswego Turning Basin and Harbor for each planktonic group sampled.

Samples for phytoplankton identification, biovolume determination, and pigment analysis were collected monthly at three locations (Figure C-1) from April 1975 through March 1976. Two whole water samples were collected in replicate at each location with a 4 liter PVC Van Dorn bottle: one from 0.5 m below the water's surface, and a second approximately 1.0 m above the bottom sediments. The replicate samples were composited following collection. Two samples were withdrawn from each composited sample; one 350 ml. sample was preserved using Lugol's solution and designated for species identification, and a second 2-liter sample for pigment analysis was returned to the laboratory stored on ice in black plastic bags.

In the laboratory two aliquots ranging in volume from 10-50 ml were sedimented from the Lugol's preserved sample for 24 hrs and then examined using an inverted microscope (Utermohl, 1958). Enumeration was carried out under 300N and 600N magnifications in one or two strips of each magnification across the bottom of the sedimentation chamber. For each sample, at least 300 individuals were counted (Lund et al., 1958) with the results expressed as cells/ml. Cell volume was computed for major species on a temporal schedule from average cell dimensions by approximation to geometric shapes. The cell volume was converted to biomass as fresh weight assuming a specific weight of 1. Chlorophyll a and phaeophytin were determined spectrophotometrically using the method described in IBP Handbook No. 8 (Golterman, 1971).

Samples for the evaluation of primary productivity were collected on the same schedule as those for phytoplankton identification.

PLANKTON SAMPLING LOCATIONS
OSWEGO TURNING BASIN — 1975-1976

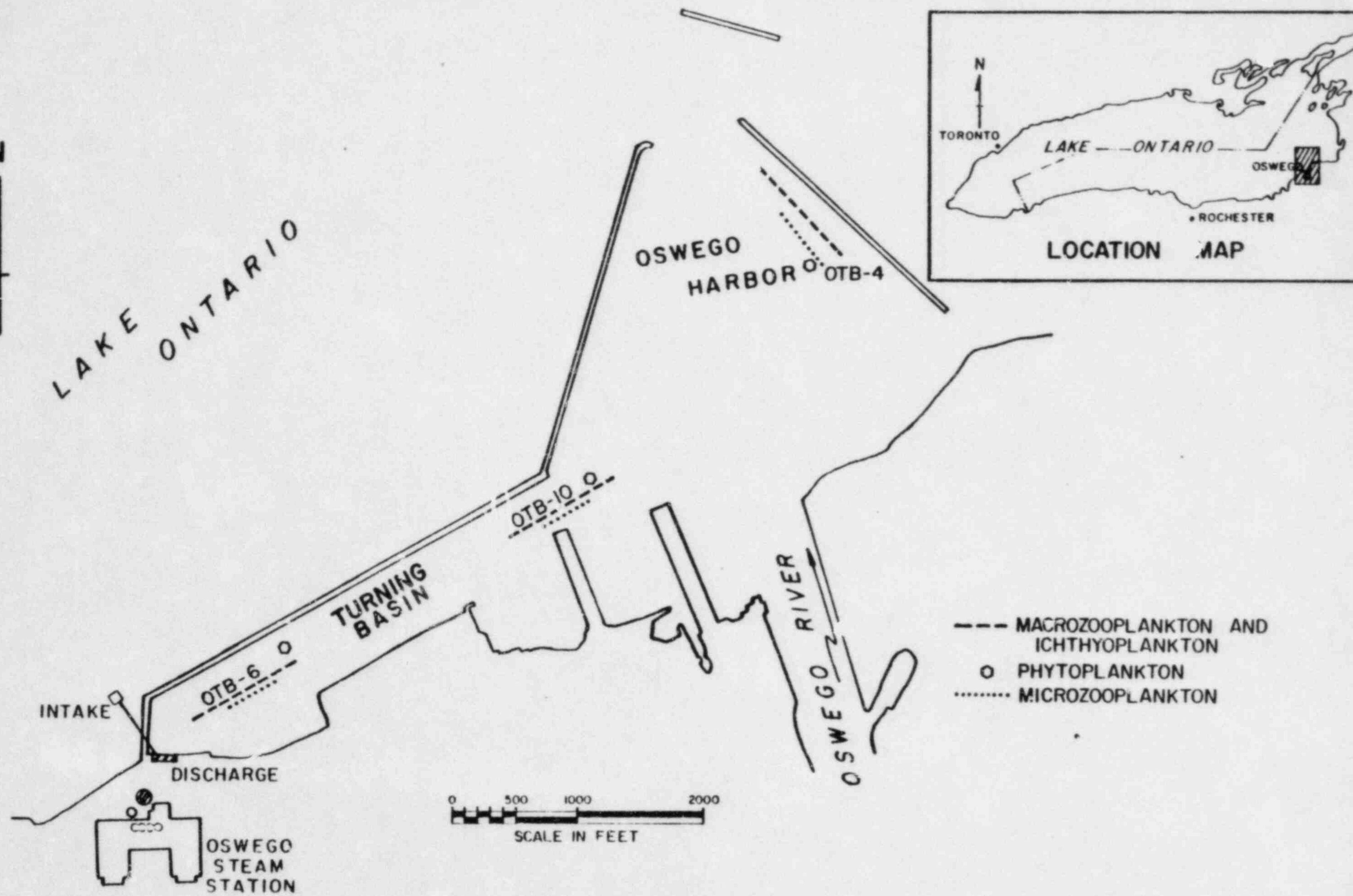


FIGURE C-1

Two whole water samples were collected at each location; one from the 25% light transmittance level, which was determined with a submarine photometer, and the second from one meter above the bottom sediments. Percent light transmittance at one meter intervals, total incident radiation, and samples for determination of total inorganic carbon were collected at the time of primary productivity incubations. Two light and one dark bottle containing water from each depth were inoculated with radioactive ^{14}C ($NaH^{14}CO_3$: 1 μCi/ml) and incubated in situ for four hours at the 25% light transmittance level. Following incubation, samples were filtered through a 0.45μ membrane filter and the ^{14}C uptake measured using a Teledyne Intertechnique model SL30 liquid scintillation counter. Results of the primary production study were expressed as $gC/m^2/hr$.

2. Plankton: Microzooplankton

Surface and bottom microzooplankton samples were collected using a 12.7 cm (5 in) Clarke-Bumpus sampler (76μ mesh) towed for 3-6 min. at approximately 130 cm/sec (2.5 knots). Collections were conducted on a monthly schedule at three locations (Figure C-1) from April 1975 through March 1976. Samples were preserved with buffered formalin to a final concentration of 5% and returned to the laboratory.

All samples were split into two equal fractions using a Folsom Plankton Splitter, and each fraction was analyzed for species composition and abundance. Analysis was accomplished through strip counts of a Sedgewick-Rafter cell at 100 magnification of a phase contrast compound microscope. Results of the analysis were related to total volume of water sampled as number of organisms per cubic meter.

3. Plankton: Macrozooplankton and Ichthyoplankton

Macrozooplankton and ichthyoplankton collections were conducted on a variable schedule in which more efforts were concentrated during the late spring and summer, the time when previous studies indicated the greatest number of fish larvae would be present. During the months of April and May 1975 and October 1975 through March 1976, single nocturnal monthly collections were made at three sampling locations (Figure C-1). Semimonthly day and night collections were conducted at the three sampling locations during the months of June through September 1975.

Surface and bottom samples were collected at the three locations by towing 1.0-meter Hensen plankton nets, with 571μ mesh apertures into the prevailing current. Sample volumes for the 5 min. tows were determined using calibrated TSK flow meters offset from center in the mouth of the plankton net. Samples were preserved with buffered formalin adjusted to a 5% concentration and returned to the laboratory.

Laboratory analysis commenced with the separation, identification, and enumeration of the fish eggs and larvae in the samples. Fish eggs, if present in quantities greater than 500, were 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 analysis was conducted on all samples collected on the monthly schedule and on one set of samples from the semimonthly collections to approximate a 30-day period between sampling dates analyzed. All macroinvertebrates collected were identified to the taxonomic level corresponding to Table C-1. Organisms collected in the macrozooplankton/ichthyoplankton program were related to the volume of water sampled as numbers per 1000 cubic meters.

4. Benthos

Benthic samples were collected in duplicate on a seasonal schedule at three stations (Figure C-2). Collections were made during the months of June, September, and December 1975 and March 1976. All samples were collected with a 15.24 x 15.24 cm (6 x 6 in) Ponar grab sampler, consolidated in the field, and returned to the laboratory where they were washed in a #40 U.S. standard sieve to remove the finer sediments and preserved in a 5% solution of buffered formalin and Phloxine B. Observations on sediment color and texture were made at the time of collection.

Benthic macroinvertebrates were separated from the organic and inorganic material and sorted into major taxonomic groups. If large quantities of detrital material were present, the sample was subsampled; separation was facilitated by the use of the biological stain phloxine B. Major taxonomic groups were biomassed using a wet weight procedure and the organisms within each group identified to the lowest possible taxonomic level. Results of the benthic surveys were related to bottom sediment area as number of organisms per square meter.

5. Water Chemistry

Surface and bottom samples for determination of selected water chemistry parameters (listed in Table C-1) were collected monthly from April 1975 through March 1976, at three Oswego Turning Basin and Harbor locations shown in Figure C-2. Samples were analyzed in accordance

TABLE C-1

MACROZOOPLANKTON LEVEL OF IDENTIFICATION

OSWEGO TURNING BASIN - 1975

CNIDARIA
- Hydroida

PLATYHELMINTHES
- Turbellaria

ASCHELMINTHES
- Nematoda

MOLLUSCA
- Gastropoda
- Pelecypoda

ANNELIDA
- Polychaeta
  - *Manayunkia speciosa*
- Oligochaeta
- Hirudinea

ARTHROPODA
- Acari
  - Hydracarina
- Insecta
  - Odonata
  - Ephemeroptera
  - Hemiptera
  - Trichoptera
  - Diptera (pupae & larvae)
  - Coleoptera
  - Lepidoptera
  - Neuroptera
  - Plecoptera
- Crustacea
  - Cladocera
    - *Leptodora kindtii*

Crustacea (Continued)
- Isopoda
- Amphipoda
  - *Crangonyx* sp.
  - *Gammarus fasciatus*
  - *Pontoporeia affinis*
  - *Hyalella azteca*
- Mysidacea
  - *Mysis oculata relicta*
- Decopoda
- Podocopa

WATER QUALITY AND BENTHOS SAMPLING LOCATIONS
OSWEGO TURNING BASIN — 1975-1976

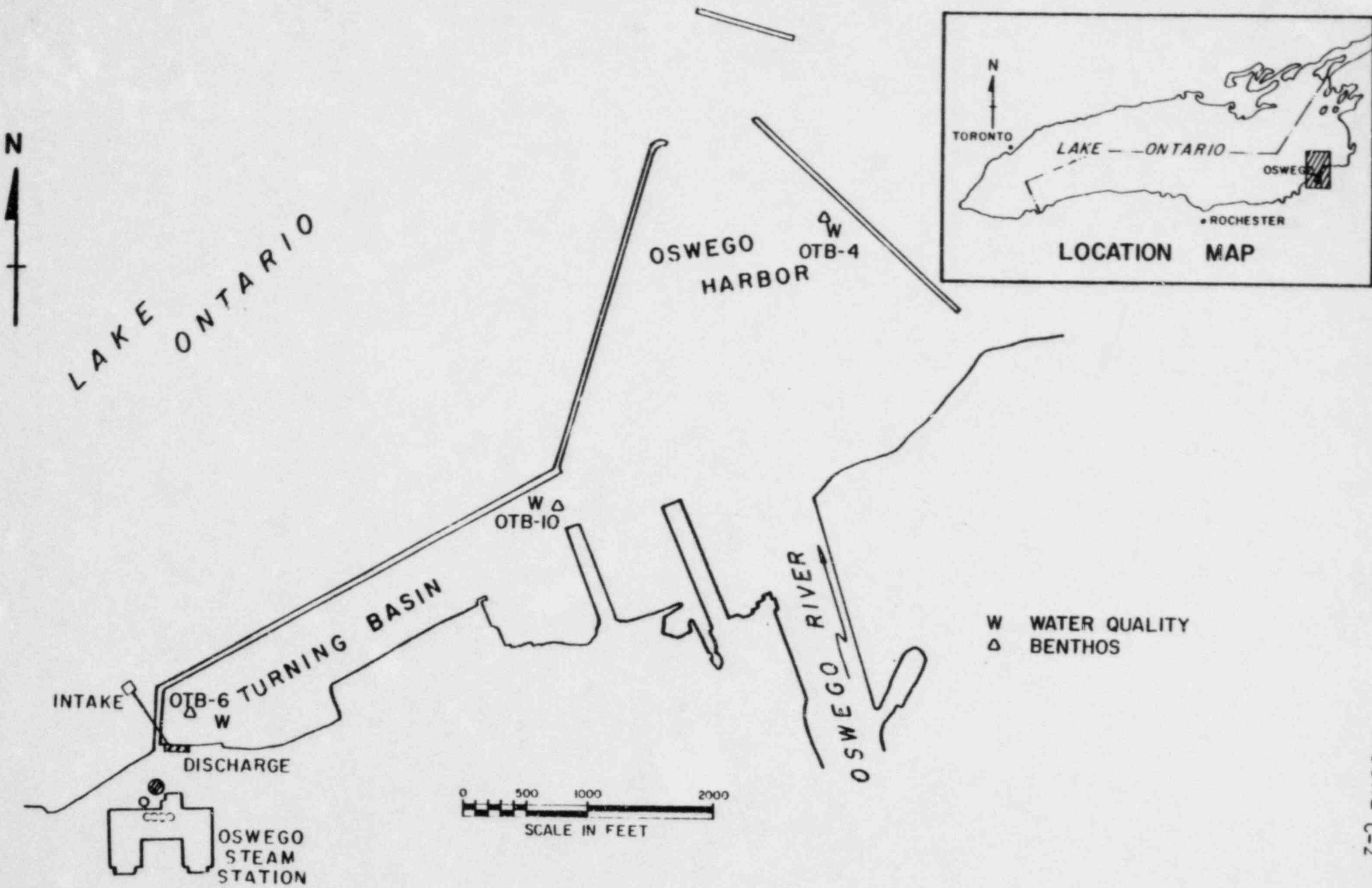


FIGURE C-2

with procedures outlined by American Public Health Association (APHA, 1971) or the U.S. Environmental Protection Agency (U.S.E.P.A., 1974).

6. Nekton

Fish species were collected at three general Oswego Turning Basin and Harbor locations shown in Figure C-3 on a monthly schedule from April 1975 through March 1976. Sampling equipment used in the survey is described as follows:

Seine - 50 x 8 ft bag seine with 1/2 in stretch mesh. Bag dimensions: 8 x 8 x 8 ft

Trawl - A flat otter trawl of 2 in stretched mesh in the wings and body and 1-1/2 in stretched mesh in the cod end. The cod end is lined with 1/2 in stetched mesh. The net has a 30 ft footrope, a 27 ft headrope and measures 24 ft from the middle of the headrope to the end of the cod end. The doors are 32 x 16 in with hydrofoils.

Gill net - 150 x 8 ft experimental multifilament net with six 25 ft panels. Panel net mesh sizes are 1/2, 3/4, 1, 1-1/2, 2 and 2-1/2 in bar mesh.

Seine hauls were conducted at two* locations, one just to the east of the Oswego Units 1-4 thermal discharge and a second site at the eastern end of Wrights Landing. Surface and bottom trawls of five minutes' duration were conducted only during the daylight hours at the designated stations. Gill nets were set perpendicular to the breakwall in the channel area at surface and bottom depths. Anchored gill nets were fished on a nocturnal schedule, set at approximately 1700 hrs and harvested the following morning at 0800 hrs. All fish collected were initially identified and counted at the time of collection. Fish were preserved in 10% buffered formalin and returned to the laboratory for further analysis.

In the laboratory all fish were identified and counted. All fish to a maximum of 60 individuals per species were subsampled through the use of random number tables, and then analyzed for length, biomass, and sex. Fish examined for length and weight were examined for general condition, stage of gonadal development, presence or absence of tags and presence of macroscopic parasites. Selected species including the alewife, rainbow smelt, yellow perch, white perch, and smallmouth

*Because dense vegetation precluded sampling during the summer at Wrights Landing, an alternate site (S-3) was sampled for those months.

NEKTON SAMPLING LOCATIONS
OSWEGO TURNING BASIN — 1975-1976

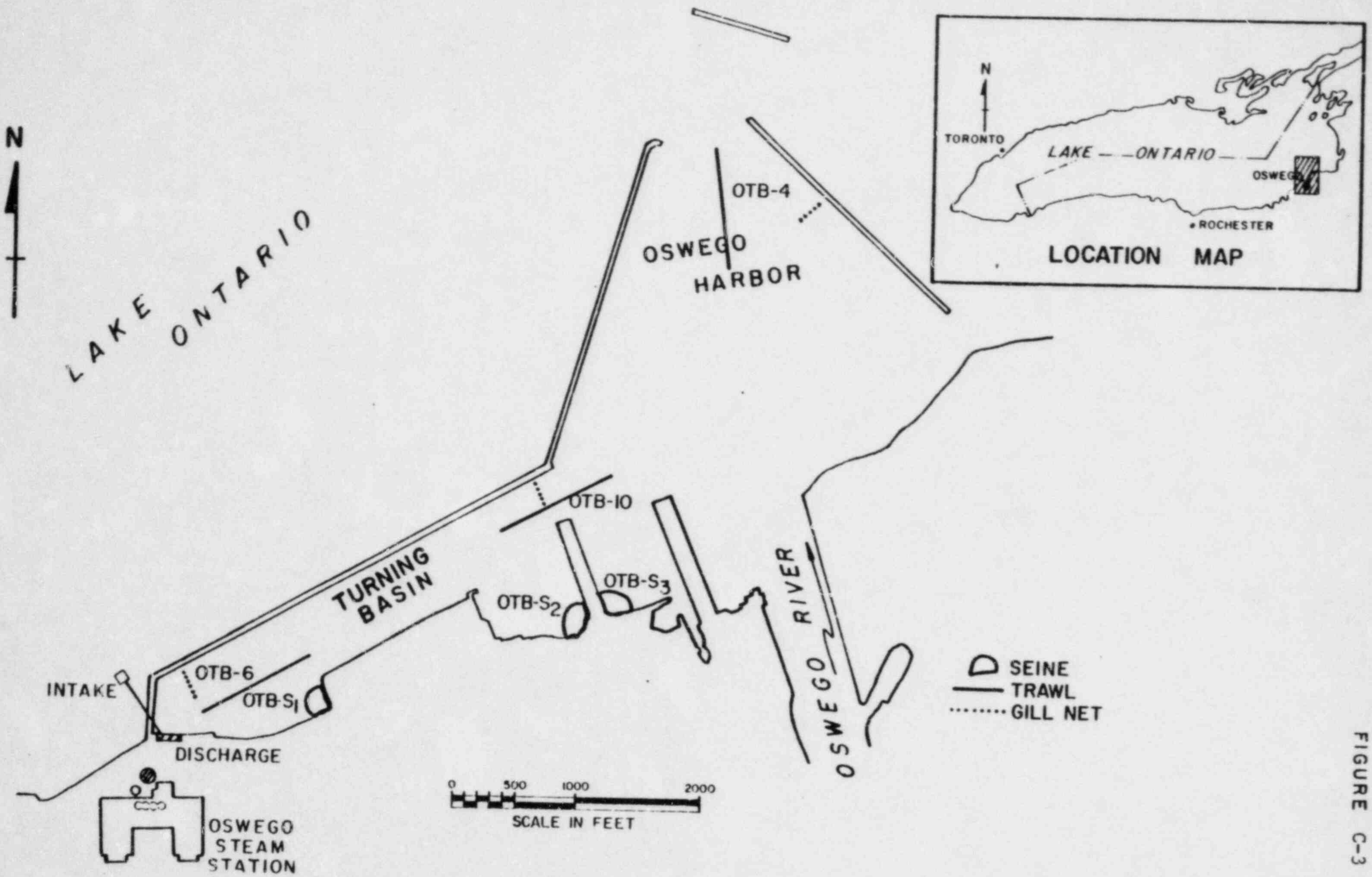


FIGURE C-3

TABLE C-2

EVALUATED CHEMICAL PARAMETERS

OSWEGO TURNING BASIN 1975-1976

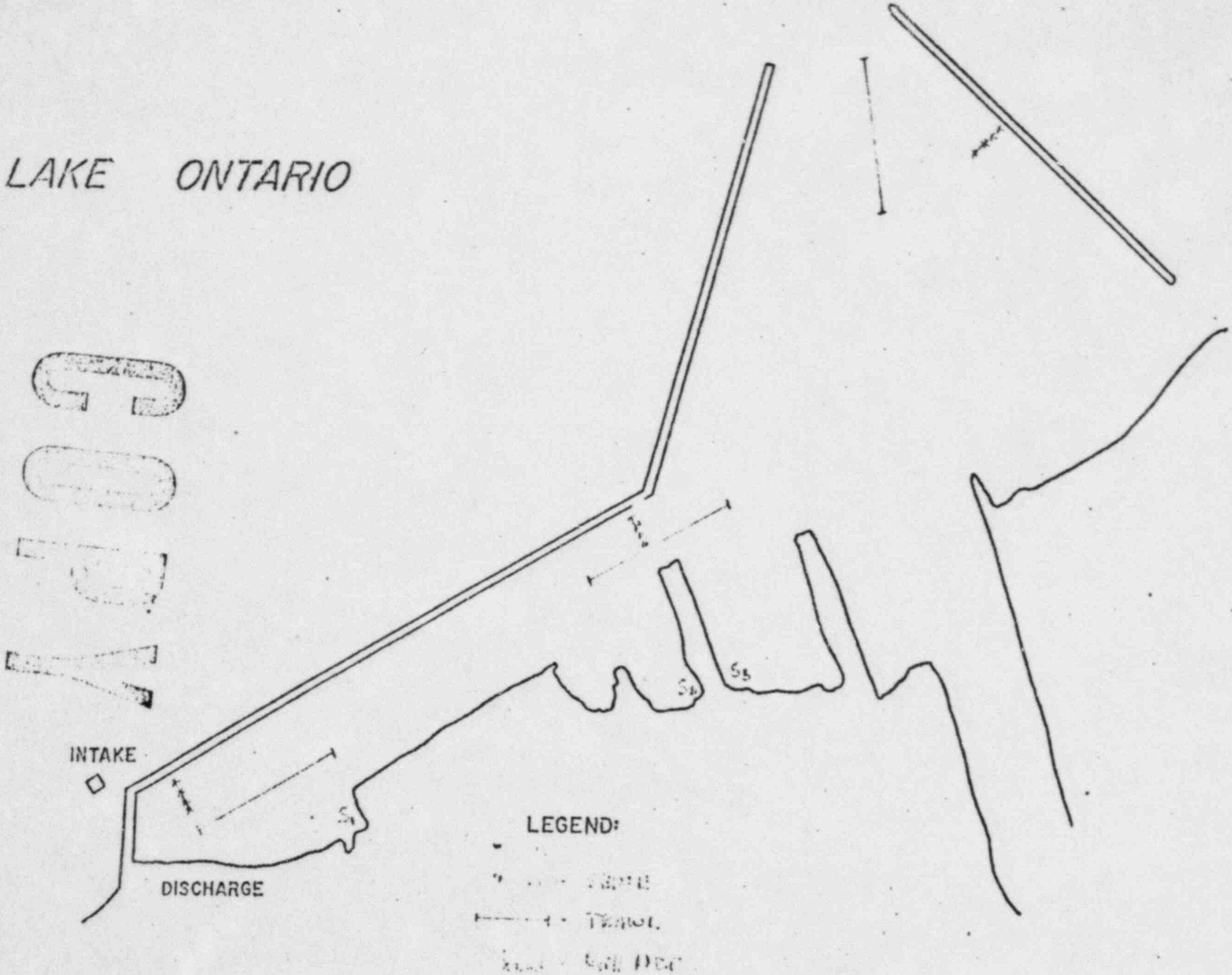
Biochemical Oxygen Demand (Five day) (BOD_5)
Total Suspended Solids (TSS)
Hydrogen Ion Activity (pH)
Specific Conductance (Sp. Cond.)
Orthophosphate ($O-PO_4$)
Nitrate Nitrogen (NO_3-N)
Water Temperature (T°C)
Dissolved Oxygen (DO)
Chloride (Cl)*
Suspended Solids (SS)*
Total Coliform Bacteria (TCOL)
Total Dissolved Solids (TDS)*
Total Solids (TS)*
Chemical Oxygen Demand (COD)*
Total Phosphate (TP)*
Ammonia* (NH_3-N)
Total Volatile Solids (TVS)*
Silicate (SO_4)*
Phenol* (PHL)
Oil and Grease$^+$ (O+G)
Fecal Coliform Bacteria (FCOL)

*Evaluated April-August 1975

+Evaluated September 1975 - March 1976

1979 OSWEGO TURNING BASIN STUDY

NEKTON SAMPLING LOCATIONS



COPY

FIGURE 2-3

bass were then analyzed by sampling date for additional parameters including scale age, gonad weight, and fecundity.* Growth determinations based on fish scales were performed on a maximum of 20 specimens per age class per select species.

*Ovaries were removed and stored but not analyzed.

APPENDIX C

SUMMARY OF MONTHLY AND BIMONTHLY WATER QUALITY PARAMETERS AT NINE MILE POINT VICINITY -- 1975[a,b]

ABBREV.	UNITS	NO. OF SAMPLES	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
AG	MG/L	36	<0.002	<0.002	0.000	0.000
AL	MG/L	36	1.660	<0.020	<0.135	0.294
ALK	MG/L CACO3	36	106.000	78.000	89.056	6.446
AS	MG/L	36	<0.028	<0.028	0.000	0.000
BA	MG/L	36	<0.500	<0.500	0.000	0.000
BE	MG/L	36	0.005	<0.005	0.000	0.000
CA	MG/L	342	111.800	32.100	41.741	5.934
CD	MG/L	36	<0.020	<0.020	0.000	0.000
CHLA	U-G/L	314	21.200	0.000	4.888	3.143
CL	MG/L	36	59.000	24.000	32.528	8.190
CN	MG/L	36	0. 000	0.000	0. 000	0. 000
COL	COLOUR UNITS	36	20.000	5.000	9.444	4.213
CO2	MG/L	314	3.000	0.000	0.855	0.854
CR	MG/L	342	0.100	<0.100	0.000	0. 000
CU	MG/L	36	0.050	<0.030	0.000	0. 000
DO	MG/L	340	14.700	7.100	10.571	1. 54
F	MG/L	36	0.200	<0.200	0.000	0. 000
FCOL	CTS/100 ML.	36	76.000	0.000	5.917	13.479
FE	MG/L	36	0.470	<0.020	<0.077	0.121
HG	MG/L	32	0.006	<0.002	0.000	0.008
K	MG/L	36	3.500	1.700	2.313	0.476
MG	MG/L	36	11.200	6.690	7.843	1.068
MN	MG/L	36	0.080	<0.020	0.000	0.000
NA	MG/L	342	41.800	9.200	17.179	6.113
NH3N	MG/L N	341	0.900	0.000	0.187	0.130
NI	MG/L	36	0.050	<0.050	0.000	0.000
NO3N	MG/L N	342	0.690	0.010	0.176	0.146
OP	MG/L P	342	0.200	0.000	0.005	0.000
PB	MG/L	36	< 0.080	<0.080	0.000	0.000
PH	UNITS	342	8.900	7.600	8.386	0.220
PHL	MG/L	36	0.050	0.000	0.002	0.008
SETR	MG/L	36	0.000	0.000	0.000	0.000
SIO2	MG/L	342	3.300	<0.100	<0.660	0.531
SO4	MG/L	342	74.000	22.000	29.129	4.423
SPC	U-MHO/CM AT 25• C.	342	440.000	259.000	322.515	28.765
SURF	MG/L	36	0.160	0.001	0.023	0.027
T	°C	342	24.500	0.800	13.485	6.247
TBOD	MG/L	342	4.000	0.000	1.819	0.873
TCOD	MG/L	342	48.000	0.000	11.974	6.606
TCOL	CTS/100 ML.	36	121.000	0.000	18.556	25.830
TDS	MG/L	36	297.000	179.000	208.778	27.586
TKN	MG/L N	342	5.100	0.050	0.434	0.329
TP	MG/L P	342	0.440	0.000	0.024	0.026
TS	MG/L	342	594.000	181.000	215.409	32.400
TSS	MG/L	342	493.000	1.000	7.512	31.016
TUR	FTU	342	400.000	0.000	5.436	24.699
TVS	MG/L	36	101.000	34.000	64.833	14.932
V	MG/L	36	<0.200	<0.200	0.000	0.000
ZN	MG/L	36	0.091	<0.010	<0.017	0.023

[a]Mean parameter value was not calculated and was recorded as 0 where >75% of sample data were below detection limit.

[b]LMS,1976

APPENDIX D-1

TEMPERATURE, DISSOLVED OXYGEN, AND PERCENT SATURATION OF DISSOLVED OXYGEN

OSWEGO TURNING BASIN - 1975-1976

DATE	DEPTH	TEMPERATURE (°C) OTB-4	OTB-10	OTB-6	DISSOLVED OXYGEN (mg/l) OTB-4	OTB-10	OTB-6	PERCENT SATURATION OF DO OTB-4	OTB-10	OTB-6
17 APR 1975	S	6.0	6.0	6.0	13.0	12.2	12.3	104	113	98
	B	6.0	6.0	6.0	12.9	12.9	12.6	103	103	101
14 MAY	S	14.0	14.0	14.5	9.6	10.5	10.3	92	101	100
	B	14.0	14.0	14.6	9.6	9.7	9.5	92	93	92
23 JUNE	S	21.0	20.0	20.0	8.7	10.7	11.1	97	116	121
	B	12.0	16.0	16.0	10.0	9.6	10.1	93	96	101
16 JULY	S	23.5	23.5	23.5	8.7	7.6	7.6	701	88	88
	B	NA	NA	NA	7.8	7.4	7.1	NA	NA	NA
7 AUG	S	20.0	22.0	18.0	8.1	6.7	8.3	88	76	87
	B	9.0	9.0	14.0	9.9	10.0	9.5	85	86	91
29 SEPT	S	15.3	17.8	17.8	10.1	9.4	9.7	100	99	102
	B	17.8	15.5	17.0	9.9	9.9	9.5	104	98	98
29 OCT	S	13.5	14.5	15.5	9.9	10.0	10.2	94	97	101
	B	13.5	13.5	15.5	9.9	9.7	10.2	94	92	101
24 NOV	S	7.5	9.5	10.5	11.6	10.5	10.6	96	92	95
	B	7.0	6.5	8.0	11.5	11.8	11.1	94	96	93
9 DEC	S	2.0	6.0	8.0	13.6	11.5	11.7	99	92	98
	B	2.0	6.0	8.0	13.5	12.4	11.4	98	99	96
2 JAN 1976	S	0.0	4.0	6.5	13.8	12.4	11.9	95	95	96
	B	0.0	2.0	7.5	12.1	12.5	13.0	83	91	108
19 FEB	S	4.0	4.0	4.0	14.3	12.6	13.0	109	96	99
	B	4.0	4.0	4.0	14.4	11.9	12.8	109	91	98
25 MAR	S	4.5	6.5	8.0	13.3	11.6	12.5	103	94	105
	B	4.2	5.0	6.0	13.2	12.8	12.5	101	100	100
MEAN	S				11.2	10.5	10.8	107	97	99
	B				11.2	10.9	10.8	96	95	98

NA - Not available

APPENDIX D 2-1

STATISICAL ANALYSIS OF TOTAL MICROZOOPLANKTON ABUNDANCE

OSWEGO TURNING BASIN - 15 MAY 1975 - 29 MARCH 1976

NESTED ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	MS	F
DATES	9	41.5917	4.6213	587.10**
SITES WITHIN DATES	60	7.9323		
BETWEEN DEPTHS WITHIN STATIONS	30	0.6504	0.0217	2.74**
BETWEEN STATIONS	30	7.2819		
BETWEEN OTB STATIONS	20	4.0118	0.2006	25.39**
OTB VS. INTAKE	10	3.2701	0.3270	41.39**
ERROR	70	0.5510	0.0079	
TOTAL	139	50.0750		

**Significant at $\alpha = .01$

ESTIMATED MEANS FOR DATES

DATE	ESTIMATED MEAN	95% CONFIDENCE INTERVAL
15 MAY 1975	154321	(138375, 172105)
16 JUN	521545	(467654, 581646)
16 JUL	148638	(133280, 165767)
12 AUG	136771	(122639, 152532)
12 SEP	91155	(81736, 101659)
17 OCT	66605	(59723, 74281)
23 NOV	31796	(28510, 35460)
9 DEC	32940	(29536, 36736)
24 FEB 1976	11540	(10347, 12870)
29 MAR	6383	(5723, 7119)

TUKEY T PROCEDURE - DATES ($\alpha = .05$)

	16	15	16	12	12	17	9	23	24	29	
Largest:	JUN	MAY	JUL	AUG	SEP	OCT	DEC	NOV	FEB	MAR:	Smallest

(Underlined groups: JUN; MAY JUL AUG; SEP; OCT; DEC NOV; FEB; MAR)

APPENDIX D 2-1
(Continued)

STATISICAL ANALYSIS OF TOTAL MICROZOOPLANKTON ABUNDANCE - 15 MAY 1975-29 MARCH 1976

ESTIMATED MEANS FOR SITES BETWEEN OTB STATIONS - BY DATE

DATE	OTB-4	OTB-10	OTB-8	MULTIPLE COMPARISIONS[a]
15 MAY 1975	267771	206527	193365	No Significant Difference
16 JUN	369800	546439	638969	Largest: OTB-8 OTB-10 OTB-4
16 JUL	142623	208544	145440	No Significant Difference
12 AUG	148624	143352	149051	No Significant Difference
12 SEP	60620	115249	118403	Largest: OTB-8 OTB-10 OTB- 4
17 OCT	46280	46386	101763	Largest: OTB-8 OTB-10 OTB- 4
23 NOV	41322	33067	15642	Largest: OTB-4 OTB-10 OTB- 8
9 DEC	49051	26749	31442	Largest: OTB-4 OTB- 8 OTB-10
24 FEB 1976	36532	5405	5319	Largest: OTB-4 OTB-10 OTB- 8
29 MAR	12837	2940	4649	Largest: OTB-4 OTB- 8 OTB-10

[a]Overall significance level of $\alpha = .05$ (using Bonferroni $t_{.05}$ value of 3.3)

ESTIMATED MEANS FOR OTB VS. INTAKE - BY DATE

DATE	ESTIMATED MEAN		t
	OTB	INTAKE	
15 MAY 1975	220313	18228	15.94*
16 JUN	505432	629602	1.41
16 JUL	162938	85659	4.11*
12 AUG	146986	88780	3.23*
12 SEP	93872	76425	1.32
17 OCT	60227	121852	4.51*
23 NOV	27752	71914	6.09*
9 DEC	34553	24724	2.14
24 FEB 1976	10165	24704	5.68*
29 MAR	5599	14016	5.87*

*Significant at $\alpha = .05$ (using Bonferroni $t_{.05}$ value of 2.92)

APPENDIX D2-2

STATISICAL ANALYSIS OF BOSMINA LONGIROSTRIS ABUNDANCE

OSWEGO TURNING BASIN - 16 JULY 1975

NESTED ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	MS	F
SITES	6	0.5285		
BETWEEN DEPTHS WITHIN STATIONS	3	0.1236	0.0412	12.48**
BETWEEN STATIONS	3	0.4049		
BETWEEN OTB STATIONS	2	0.4028	0.2014	61.03**
OTB VS. INTAKE	1	0.0021	0.0021	0.64
ERROR	7	0.0230	0.0033	
TOTAL	13	0.5515		

**Significant at α = .01

ESTIMATED MEANS FOR BETWEEN OTB STATIONS

STATION	ESTIMATED MEAN	95% CONFIDENCE INTERVAL	ARITHMETIC MEAN
OTB-4	16762	(1433, 19600)	16825
OTB-10	46499	(39766, 54372)	49987
OTB-8	24227	(20719, 28329)	24549

TUKEY T PROCEDURE - BETWEEN OTB STATIONS (α = .05)

Largest: OTB-10 OTB-8 OTB-4: Smallest

ESTIMATED MEANS FOR BETWEEN DEPTHS WITHIN STATIONS

STATION	DEPTH SURFACE	BOTTOM	t
OTB-4	18064	15605	1.08
OTB-10	68028	31783	5.75*
OTB-8	27262	21530	1.78

*Significant at α =.05 (using Bonferroni t test)

APPENDIX D 2-3

STATISICAL ANALYSIS OF BOSMINA LONGIROSTRIS ABUNDANCE

OSWEGO TURNING BASIN - 12 AUGUST 1975

TWO-WAY ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	MS	F
STATIONS	2	0.3576	0.1788	4.40+
DEPTHS	1	0.3884	0.3884	9.56*
STATION X DEPTH	2	0.0141	0.0071	0.17
ERROR	6	0.2437	0.0406	
TOTAL	11	1.0038		

+Significant at α = .10
*Significant at α = .05

ESTIMATED MEANS FOR DEPTHS

STATION	ESTIMATED MEAN	95% CONFIDENCE INTERVAL	ARITHMETIC MEAN
SURFACE	2713	(1706, 4313)	3027
BOTTOM	6214	(3909, 9878)	7049

APPENDIX D2-4

STATISICAL ANALYSIS OF BOSMINA LONGIROSTRIS ABUNDANCE

OSWEGO TURNING BASIN - 12 SEPTEMBER 1975

TWO-WAY ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	MS	F
STATIONS	2	1.0323	0.5162	34.34**
DEPTHS	1	0.3437	0.3437	22.86**
STATION X DEPTH	2	0.0379	0.0190	1.26
ERROR	6	0.0902	0.0150	
TOTAL	11	1.5041		

**Significant at α = .01

ESTIMATED MEANS FOR STATIONS

STATIONS	ESTIMATED MEAN	95% CONFIDENCE INTERVAL	ARITHMETIC MEAN
OTB-4	5655	(4004, 7985)	6484
OTB-10	18515	(13112, 26144)	18923
OTB-8	27782	(19675, 39230)	32030

TUKEY T PROCEDURE - STATIONS (α = .05)

Largest: OTB-8 OTB-10 OTB-4: Smallest

ESTIMATED MEANS FOR DEPTHS

DEPTH	ESTIMATED MEAN	95% CONFIDENCE INTERVAL	ARITHMETIC MEAN
SURFACE	9668	(7294, 12814)	11975
BOTTOM	21077	(15902, 27937)	26315

APPENDIX D 2-5

STATISICAL ANALYSIS OF *BOSMINA LONGIROSTRIS* ABUNDANCE

OSWEGO TURNING BASIN - 17 OCTOBER 1975

NESTED ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	MS	F
SITES	6	3.0780		
BETWEEN DEPTHS WITHIN STATIONS	3	0.3330	0.1110	41.11**
BETWEEN STATIONS	3	2.7450		
BETWEEN OTB STATIONS	2	2.0632	1.0316	382.07**
OTB VS. INTAKE	1	0.6818	0.6818	252.52**
ERROR	7	0.0192	0.0027	
TOTAL	13	3.0972		

**Significant at α = .01

ESTIMATED MEANS FOR OTB VS. INTAKE

SITE	ESTIMATED MEAN	95% CONFIDENCE INTERVAL	ARITHMETIC MEAN
OTB	7590	(6995, 8236)	11897
INTAKE	32429	(26548, 39613)	32632

ESTIMATED MEANS FOR OTB STATIONS

STATION	ESTIMATED MEAN	95% CONFIDENCE INTERVAL	ARITHMETIC MEAN
OTB-4	2196	(1906, 2530)	2214
OTB-10	8882	(7710, 10232)	10828
OTB-8	22415	(19457, 25821)	22649

TUKEY T PROCEDURE (α = .05)

Largest: OTB-8 OTB-10 OTB-4: Smallest

ESTIMATED MEANS FOR DEPTHS WITHIN STATIONS

STATION	DEPTH SURFACE	DEPTH BOTTOM	t
OTB-4	2394	2014	1.44
OTB-10	16982	4645	10.83*
OTB-8	19925	25215	1.97

*Significant at α = .05 (using Bonferroni t test)

APPENDIX D 2-6

STATISTICAL ANALYSIS OF *BOSMINA LONGIROSTRIS* ABUNDANCE

OSWEGO TURNING BASIN - 23 NOVEMBER 1975

NESTED ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	MS	F
SITES	6	0.7169		
BETWEEN DEPTHS WITHIN STATIONS	3	0.5677	0.1892	16.82**
BETWEEN STATIONS	3	0.1492		
BETWEEN OTB STATIONS	2	0.0728	0.0364	3.24
OTB VS. INTAKE	1	0.0764	0.0764	6.79*
ERROR	7	0.0787	0.0112	
TOTAL	13	0.7956		

*Significant at α = .05
**Significant at α = .01

ESTIMATED MEANS FOR BETWEEN DEPTHS WITHIN STATIONS

	DEPTH		
STATION	SURFACE	BOTTOM	t
OTB-4	1776	1368	1.07
OTB-10	5485	986	7.04*
OTB-8	2271	2184	0.16

*Significant at α = .05 (using Bonferroni t test)

ESTIMATED MEANS FOR OTB VS. INTAKE

SITE	ESTIMATED MEAN	95% CONFIDENCE INTERVAL	ARITHMETIC MEAN
OTB	2006	(1699, 2370)	2377
INTAKE	3263	(2171, 4905)	3286

APPENDIX D 2-7

STATISICAL ANALYSIS OF *BOSMINA LONGIROSTRIS* ABUNDANCE

OSWEGO TURNING BASIN - 9 DECEMBER 1975

NESTED ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	MS	F
SITES	6	0.0666		
BETWEEN DEPTHS WITHIN STATIONS	3	0.0123	0.0041	0.21
BETWEEN STATIONS	3	0.0543		
BETWEEN OTB STATIONS	2	0.0096	0.0048	0.24
OTB VS. INTAKE	1	0.0447	0.0447	2.26
ERROR	7	0.1383	0.0198	
TOTAL	13	0.2049		

APPENDIX D 2-8

STATISICAL ANALYSIS OF COPEPODA ABUNDANCE

OSWEGO TURNING BASIN - 15 MAY 1975-29 MARCH 1976

NESTED ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	MS	F
DATES	8	18.6816	2.3352	148.75**
SITES WITHIN DATES	54	12.4289		
BETWEEN DEPTHS WITHIN STATIONS	27	1.9696	0.0729	4.65**
BETWEEN STATIONS	27	10.4593		
BETWEEN OTB STATIONS	18	4.2330	0.2352	14.98**
OTB VS. INTAKE	9	6.2263	0.6918	44.07**
ERROR	63	0.9890	0.0157	
TOTAL	125	32.0995		

**Significant at α = .01

ESTIMATED MEANS FOR DATES

DATE	ESTIMATED MEAN	95% CONFIDENCE INTERVAL
15 MAY 1975	6053	(5189, 7062)
16 JUN	5467	(4686, 6378)
16 JUL	16227	(13909, 18931)
12 AUG	20575	(17637, 24003)
12 SEP	6281	(5384, 7328)
23 NOV	3566	(3057, 4161)
9 DEC	3151	(2701, 3676)
24 FEB 1976	1664	(1426, 1941)
29 MAR	1189	(1019, 1387)

TUKEY T PROCEDURE - DATES (α = .05)

	12	16	12	15	16	23	9	24	29	
Largest:	AUG	JUL	SEP	MAY	JUN	NOV	DEC	FEB	MAR:	Smallest

APPENDIX D 2-8
(Continued)

STATISICAL ANALYSIS OF COPEPODA ABUNDANCE - 15 MAY 1975-29 MARCH 1976

ESTIMATED MEANS FOR BETWEEN OTB STATIONS - BY DATE

DATE	STATIONS OTB-4	OTB-10	OTB-8	MULTIPLE COMPARISIONS[a]
15 MAY 1975	16201	10526	5710	Largest: OTB-4 OTB-10 OTB-8: Smallest
16 JUN	2116	3925	11835	La gest: OTB-8 OTB-10 OTB-4: Smallest
16 JUL	11690	26686	25736	Largest: OTB-10 OTB-8 OTB-4: Smallest
12 AUG	25428	21841	28750	No Significant Difference
12 SEP	3209	6881	8608	Largest: OTB-8 OTB-10 OTB- 4
23 NOV	2640	3905	2967	No Significant Difference
9 DEC	2861	3022	3780	No Significant Difference
24 FEB 1976	1932	1365	1571	No significant Difference
29 MAR	3632	452	760	Largest: OTB-4 OTB- 8 OTB-10: Smallest

[a]Overall significance level of α = .05 (using Bonferroni t criterion)

ESTIMATED MEANS FOR OTB VS. INTAKE - BY DATE

DATE	ESTIMATED MEAN OTB	INTAKE	t
15 MAY 1975	9912	313	15.67*
16 JUN	4615	15103	5.38*
16 JUL	20024	4595	6.68*
12 AUG	25181	6122	6.42*
12 SEP	5750	10675	2.81
23 NOV	3128	7837	4.17*
9 DEC	3197	2887	0.46
24 FEB 1976	1606	2056	1.12
29 MAR	1077	2152	3.14*

*Significant at α = .05 (using Bonferroni t criterion of 2.87)

APPENDIX D 2-9

STATISTICAL ANALYSIS OF *LEPTODORA KINDTII* ABUNDANCE

OSWEGO TURNING BASIN - 21 JULY 1975

ONE-WAY ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	MS	F
STATIONS	2	8.1020	4.0510	15.29*
ERROR	9	2.3851	0.2650	
TOTAL	11	10.4871		

* Significant at α = .01

ESTIMATED MEANS FOR STATIONS

STATION	ESTIMATED MEAN	95% CONFIDENCE INTERVAL	ARITHMETIC MEAN
OTB-4	130	(33, 499)	390
OTB-6	8639	(2260, 33017)	11642
OTB-10	5907	(1545, 22575)	7519

TUKEY T PROCEDURE - STATIONS (α = .05)

Largest: OTB-6 OTB-10 OTB-4 : Smallest

APPENDIX D 2-10

STATISTICAL ANALYSIS OF *LEPTODORA KINDTII* ABUNDANCE

OSWEGO TURNING BASIN - 19 AUGUST 1975

ONE-WAY ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	MS	F
STATIONS	2	2.6750	1.3375	6.02*
ERROR	9	1.9993	0.2221	
TOTAL	11	4.6743		

* Significant at $\alpha = .05$

ESTIMATED MEANS FOR STATIONS

STATION	ESTIMATED MEAN	95% CONFIDENCE INTERVAL	ARITHMETIC MEAN
OTB-4	9840	(2883, 33577)	38543
OTB-6	86877	(25461, 296427)	88390
OTB-10	110220	(32303, 376077)	124004

TUKEY T PROCEDURE - STATIONS ($\alpha = .05$)

Largest: OTB-10 OTB-6 OTB-4 : Smallest

APPENDIX D 2-11

STATISTICAL ANALYSIS OF *LEPTODORA KINDTII* ABUNDANCE

OSWEGO TURNING BASIN - 15 SEPTEMBER 1975

ONE-WAY ANALYSIS OF VARIANCE
(Log-Transformed)

SOURCE	DF	SS	MS	F
STATIONS	2	1.1445	0.5723	6.99*
ERROR	9	0.7368	0.0819	
TOTAL	11	1.8813		

* Significant at α = .05

ESTIMATED MEANS FOR STATIONS

STATION	ESTIMATED MEAN	95% CONFIDENCE INTERVAL	ARITHMETIC MEAN
OTB-4	4188	(1987,8826)	4334
OTB-6	23880	(11333,50317)	26823
OTB-10	10607	(5033.22350)	13549

TUKEY T PROCEDURE - STATIONS (α = .05)

Largest: OTB-6 OTB-10 OTB-4 : Smallest

APPENDIX D 2-12

STATISTICAL ANALYSIS OF *KERATELLA EARLINAE* ABUNDANCE

OSWEGO TURNING BASIN - 16 JUNE-9 DECEMBER 1975

NESTED ANALYSIS OF VARIANCE
(Log Transformed)

SOURCE	DF	SS	MS	F
DATES	6	36.3187	6.0531	56.37**
SITES WITHIN DATES	42	17.0637		
BETWEEN DEPTHS WITHIN STATIONS	21	0.6955	0.0331	0.31
BETWEEN STATIONS	21	16.3682		
BETWEEN OTB STATIONS	14	2.3067	0.1648	1.53+
OTB VS. INTAKE	7	14.0615	2.0088	18.70**
ERROR	49	5.2614	0.1074	
TOTAL	97	58.6438		

+Significant at $\alpha = .10$
**Significant at $\alpha = .01$

ESTIMATED MEANS FOR DATES

DATE	ESTIMATED MEAN	95% CONFIDENCE INTERVAL
16 JUN 1975	149017	(99354, 223505)
16 JUL	12478	(8319, 18716)
12 AUG	3620	(2413, 5430)
12 SEP	1959	(1306, 2939)
17 OCT	6044	(4029, 9065)
23 NOV	3683	(2456, 5525)
9 DEC	1977	(1318, 2966)

TUKEY T PROCEDURE - DATES ($\alpha = .05$)

	16	16	17	23	12	9	12	
Largest:	JUN	JUL	OCT	NOV	AUG	DEC	SEP:	Smallest

APPENDIX D 2-12
(Continued)

STATISICAL ANALYSIS OF *KERATELLA EARLINAE* ABUNDANCE - 16 JUNE-9 DECEMBER 1975

ESTIMATED MEANS FOR OTB VS INTAKE - BY DATE

	ESTIMATED MEAN		
DATE	OTB	INTAKE	t
16 JUN 1975	134521	275372	1.24
16 JUL	18362	1228	4.69*
12 AUG	8389	22	10.24*
12 SEP	1978	1852	0.11
17 OCT	5995	6343	0.10
23 NOV	311	8872	1.78
9 DEC	1986	1928	0.05

*Significant at α = .05 (using Bonferroni $t_{.05}$ value)