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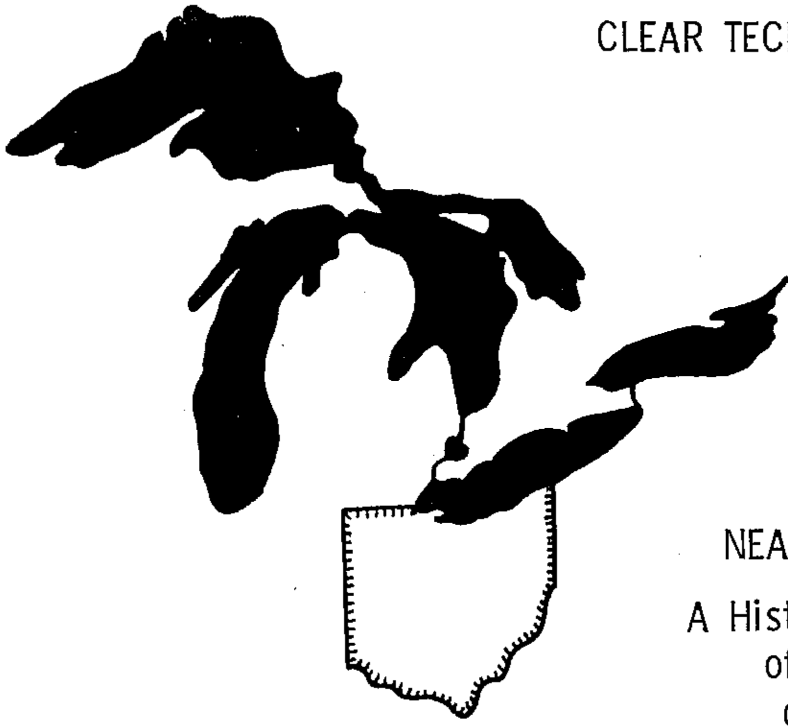

WATER QUALITY OF THE NEARSHORE ZONE OF LAKE ERIE:

A Historical Analysis and Delineation of Nearshore Characteristics of the United States Waters

By

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INTRODUCTION

As the signatories to the Great Lakes Water Quality Agreement in 1972 the Canadian and United States Governments authorized by Article VI, 1, (a) of the Agreement, the development of an international surveillance plan to collect, analyze and disseminate information relating to the water quality of the Great Lakes. Within the institutional framework of the International Joint Commission, the conceptual basis for the international surveillance plan was developed and initially presented in the 1974 IJC, Great Lakes Water Quality Board Report, Appendix B. Refinements for the Lake Erie surveillance plan resulted from the Great Lakes Surveillance Symposium (Herdendorf, 1976).

The overall surveillance design consists of six general design components: inputs, whole lake, outflows, data quality, data management and reporting. The whole lake component consists of a mainlake component and a nearshore component. The latter includes water intake, beach and cladophora elements. Nearshore areas receive all the tributary and point source inputs into the lake. As the area initially impacted by waste and runoff inputs, these areas are the first to show the results of further degradation and should be the first to show indications of improvement following the implementation of abatement programs. The heavy and increasing use of nearshore areas of Lake Erie for imcompatible public and private purposes including recreation, water supplies and waste disposal emphasizes the importance of this component of the surveillance plan.

The purpose of this report is to present the historical levels and trends of physical-chemical water quality measurements as described in previous studies conducted in nearshore areas of Lake Erie. This presentation is largely restricted to a discussion of the U.S. waters of the lake. The information base used in this study resulted from an intensive review of all work known to have been undertaken in nearshore areas of Lake Erie. To investigate long-term and/or lake wide trends, systematically collected data is most valuable. The bulk of existing data occurs in reports of water intake facilities. The remaining data comes largely from short-term, localized efforts. Studies extending longer than one year are rare. Studies prior to 1963 are rare. Data collected during previous studies in nearshore areas of the U.S. waters of Lake Erie has been compiled by Cooper (1978).

Investigation of trends is complicated by the variety of analytical techniques employed by various studies and at different points in time. The accuracy and precision of all data vary with sampling technique and analytical methodology. Older data may not be comparable to more recent data due to changes in sample handling and analysis. In some studies, methodologies are not stated. Variations in sampling techniques present such problems, e.g. a surface sample may vary from one taken at the actual surface to one taken 1.5 meters beneath the surface.

Analyses of nearshore water samples typically identify higher concentrations of chemical constituents rather than main lake samples. Factors such as short-term climatic events, diurnal differences and sample collection near point sources or tributaries or in areas isolated from the main lake by coastal currents, physical barriers, or thermal barriers result in a wider range of values for any given parameter measured in nearshore areas. The resulting wide variability of nearshore water quality measurements further complicates any attempt to discern long-term trends. Limited sampling programs in past studies make analysis of variability impossible.

The complications apparent in the collected data file make the use of many previous studies unacceptable for analyzing trends. The usefulness of the data file is that it does indicate probable sources, approximate levels of magnitude of the reported measurements and general patterns of distribution in given localities.

The factors which complicate the study of trends equally complicate the study of the lakeward extension of nearshore waters for the purposes of defining the nearshore zone. Despite the inherent complications, this study assumes that selected data is similar and can be used to discuss trends as well as the limits of the nearshore zone.

PHYSICAL AND CHEMICAL CHARACTERISTICS OF FRESHWATER

The quality of water in the nearshore zone of Lake Erie relates directly to variations in the quality of tributary inputs. The characteristics of the entire drainage basin of the lake contribute to create the conditions measured at any one point in time. All constituents of the water mass are not considered detrimental. Therefore, the majority are not considered in efforts to monitor water quality. Most constituents can act as tracers or can serve as indicators to characterize relationships between tributary, nearshore and main lake water masses (Pinsak and Meyer, 1976).

Physical Characteristics

In water quality studies, the physical characteristics of interest normally include temperature, electrical conductance and transparency. These parameters are useful indicators of variations in water density. Temperature, pressure and the chemical composition of the water combine to affect density.

Temperature. In Lake Erie, water temperature varies primarily with depth. Because of difference in storage capacity coupled with thermal properties of water, temperature in shallow coastal waters increases offshore during winter and inshore during summer. Temperature is an important and common parameter included in water quality studies. Due to the limited scope and time interval of most studies, erroneous trends and projections may result. The source of interpretation errors rests inthe mobility of water masses and cyclical variations observed during short periods of study (Pinsak, 1976). The importance of temperature rests in its effects on water density, circulation and stratification as well as its effects on the growth, migration, reproductive success and distribution of aquatic organisms. The latter effect is partly due to lower oxygen solubility at elevated temperatures.

Specific Conductance (conductivity). The conductance of electricity in water is a measure of the concentration of dissociated ions in solution. Conductivity is presumed to be proportional to the concentration of dissolved materials. The relationship between total dissolved solids (TDS, mg/l) and conductivity (C, measured in micromhos/cm) can be expressed as: TDS=RxC where R normally approximates 0.65. The conversion factor (R) is an average one applicable to relatively dilute solutions, less than 2000 mg/l. Areal variation in conductivity measurements conform generally to those of the constituents. Deviations from the general pattern in the nearshore zone serve to indicate point sources and sinks by emphasizing concentrations of individual constituents. Conductivity measurements are not sensitive to organic constituents nor to trace metals (Pinsak, 1976).

Transparency. In lake water, transparency refers to the transmission of light from natural or an artificial source. Attenuation is the restriction of light transmission by any included substance. Transparency of lake water is inconstant, nonuniform and unstable in time and space. Variations in measurements are the most evident in the nearshore zone and, secondarily, throughout the epilimnion. Sources of variability in transparency measurements include physiography of the lake basin, depth, bottom type, tributary and other inputs, wind speed and direction as well as the thermal structure of the lake. A common means of measuring light penetration has been the Secchi disc and, more recently, photoelectric cells (Pinsak, 1976). In general, a decrease in transparency in all three basins occurs from July to November.

Color. Water color is caused by substances in solution that have been derived from organic sources (plankton, vascular aquatic plants, tannins and humic materials) and inorganic sources (metallic substances, various chemicals and dyes). Water color is measured on an arbitrary scale of 0 to 1000 platinum units. The amount of color changes with runoff inputs and with the season of the year (Pinsak, 1976; Pinsak and Meyer, 1976).

Suspended solids. Suspended materials such as clay, silt, fine organic matter, bacteria, plankton and colloidal material have a considerable effect on light penetration, thereby limiting photosynthesis. Light attenuation in the nearshore zone is largely the product of these materials. Most types of point-source inputs increase the suspended solids content of lake water (Pinsak, 1976).

Turbidity. Turbidity and suspended solids are terms commonly confused and sometimes used interchangeably. Turbidity is a direct result of the presence of suspended matter in part and is an arbitrary measure of light penetration into water. A turbidity measurement is an expression of the optical property of a water sample which causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. Water clarity, the attenuation of light between a source and a photocell receiver, is the reciprocal of turbidity (Pinsak and Meyer, 1976).

Chemical Characteristics

In water quality studies, the chemical characteristics of interest include a wide range of natural constituents evolved by the weathering of naturally occurring soils and bedrock combined with agricultural-municipal-industrial constituents evolved as a function of land use and other human activity (Upchurch, 1976).

Dissolved solids. Dissolved solids characterize the total load derived from natural weathering in the tributary drainage basins, bottom sediments, plus the combined inputs of cultural discharges. The sum of all constituents includes carbonates, bicarbonates, chlorides, sulfates, phosphates and nitrates of calcium, magnesium, sodium and potassium with traces of other compounds. Localized anomalous variations in dissolved solids concentrations are good indicators of problem areas. The major sources of dissolved material into Lake Erie are the Detroit River, Toledo and the Maumee River basin, the Grand River basin of Ohio, the Cleveland area and Cuyahoga River basin, and that portion of Ontario between Long Point and Port Colbourne (Pinsak and Meyer, 1976; Upchurch, 1976).

Chloride. Chloride (Cl^-) is the only commonly occurring aqueous constituent in Lake Erie that can be considered conservative (i.e., it does not combine with other aqueous or solid phases and is not removed by chemical precipitation, absorption or adsorption on mineral surfaces, metabolic processes or chelating). As such, chloride concentrations are used as an index of chemical loading and buildup in the Great Lakes. High concentrations indicate pollution by sewage and certain industrial processes. Highway salting and subsequent runoff results in a seasonal influx into the nearshore zone (Pinsak and Meyer, 1976; Upchurch, 1976).

Sulfate. Sulfates in Lake Erie can be formed by solution of gypsum and sodium sulfate associated with limestone and dolomite; during decomposition of organic detribus and sewage; and as wastes from industries such as oil refineries, chemical plants and gas manufacturing facilities (Pinsak and Meyer, 1976).

Hydrogen ion concentration (pH). pH is an index of the hydrogen ion activity of water. It is an indicator, but not a measure, of acidity or alkalinity. The distribution of pH values measured in the nearshore zone indicates sources of abnormal acid or basic waste discharge and the degree of equilibration of the carbon system with the atmosphere and sediment. Due to the buffering capacity of natural waters, pH is not useful for identification of pollution sources. The primary use of pH is in determining reaction paths in systems that are dependent on pH (Pinsak and Meyer, 1976; Upchurch, 1976).

Total hardness. Hardness of water is defined practically as the concentration of calcium and magnesium expressed as calcium carbonate. Calcium and magnesium concentrations in the nearshore zone are largely derived from natural sources. Calcium ions and salts are among the most common constituents in water. They are leached from rock and soil and occur in municipal and industrial discharge waters. Magnesium is common and its salts are very soluble at normal pH (Pinsak and Meyer, 1976).

Alkalinity. Alkalinity is a measure of the buffering capacity of water. It is a combination of bicarbonate, carbonate and hydrogen ion concentration. It is more useful than pH because it represents the products of reactions involving hydrogen ions and CO_2. High alkalinity values indicate possible influx of material with a high carbonate content (Pinsak and Meyer, 1976; Upchurch, 1976).

Dissolved oxygen. The dissolved oxygen concentration is a measure of the amount of elemental oxygen in the water. Percent saturation is a more meaningful way of reporting oxygen values in that the solubility of oxygen in water is a function of water temperature, the partial pressure of oxygen in air and the mineral content of the water. Using percent saturation, the oxygen level is related to the total amount of oxygen that can be contained by the water at a specific temperature, air pressure and ionic strength.

It is an index of the capability of the body of water to support a well-balanced biological community (Upchurch, 1976).

Biochemical oxygen demand (BOD). Biochemical oxygen demand is a measure of the removal of oxygen from water by organic material. It is an oxidation process. High BOD values indicate oxidation by carbonaceous material, nitrogen compounds, sulfur compounds and inorganic compounds is leading to lower dissolved oxygen concentrations which, in turn, often is detrimental to the normal fauna of the aquatic ecosystem (Upchurch, 1976).

Chemical oxygen demand (COD). Chemical oxygen demand is a measurement of the material that can be oxidized by a strong chemical oxidant. Like BOD, the measurement is expressed in terms of oxygen equivalent. It differs from BOD in that BOD is a measure of the amount of organic material that can be oxidized while COD is a measure of the total oxidizable material present (Upchurch, 1976). Chemical oxygen demand measurements are not indicators of true oxygen demands exerted by microbial respiration, rather they represent the upper limits of this demand.

Oxidation-reduction potential (Eh). The oxidation-reduction or redox potential is used to determine the potential of an environment to oxidize or reduce material. If the Eh is negative, compounds will be reduced, while positive Eh indicates a tendency to oxidation. Oxygen availability is the major factor controlling Eh. The Eh measurement represents a combination of inorganic and metabolic reactions. The importance of Eh is evident when considering the interaction of tributary and lake water, especially in harbors. Wastes that are not oxidized in the confined area of the harbor cause water quality degradation when transported into the nearshore zone and the main lake (Upchurch, 1976).

Phosphorus. Phosphorus is a major nutrient and plays an important role in animal and plant metabolism. The major sources of phosphorus are from the atmosphere, leaching of soil and rock, erosion, agricultural runoff, decomposition of plants and animals, chemical manufacturing, spillages, detergents, industrial and domestic sewage effluents. Phosphorus combines easily to form the dissolved form of orthophosphate (PO_4). In lake water, phosphorus occurs in a wide variety of compounds. Water quality studies typically report orthophosphate, soluble phosphorus and total phosphorus measurements. Total phosphate includes soluble as well as all particulate phosphorus compounds. It reflects the total load of phosphorus in the body of water. Orthophosphate is the form most readily utilized by plants and is a measure of the phosphorus available for primary production. The difference between total soluble and soluble orthophosphate is designated organic phosphate and is primarily polyphosphate (Pinsak and Meyer, 1976; Upchurch, 1976).

Nitrogen. Nitrogen is a major nutrient and plays an important role in metabolism. The major sources of nitrogen input into the nearshore zone are from the atmosphere; agricultural and municipal runoff; and industrial and domestic discharges. The principal forms of interest in water quality studies are nitrate, nitrite and ammonia. Ammonia is a gas which is soluble in water in the form of ammonium hydroxide. The extent to which ammonium hydroxide dissociates to give ammonia gas is pH dependent. The pH of natural water is such that the ammonium ion predominates. Slight increases in pH will result in an increase in ammonia levels with a resultant increase in its toxicity. When a reduced form of nitrogen, either organic nitrogen, ammonia or nitrite, is introduced into the nearshore zone, oxidation takes place. Nitrate represents the fully oxidized form of nitrogen in natural waters. (Pinsak and Meyer, 1976; Upchurch, 1976).

Silica. Silica is a nutrient which plays a major role in diatom production. Diatoms synthesize silica into their tests and thereby lower silica concentrations in lake water. The greatest demand occurs in late winter and early spring.

AREAL ANALYSIS

The purpose of the areal analysis is to review the results of water quality related studies conducted in specific nearshore areas. This study located sufficient material to warrant discussion and presentation of findings for the lower Detroit River, the Michigan waters of Lake Erie, Maumee Bay, Locust Point, Huron, Cleveland, Ashtabula, Conneaut, Erie and Buffalo. Where information permits, historical trends are noted. Recent data is related to IJC Existing or Proposed Water Quality Standards (see Appendix A).

Detroit River

The purpose of this discussion is to summarize reported conditions near the mouth of the Detroit River. Most studies of the Detroit River terminate at River Mile 3.9. This area is important in that inflow to Lake Erie from the Detroit River accounts for approximately 90% ($5296 m^3/sec$) of the total outflow to Lake Ontario. The distribution of chemical constituents across the mouth of the river directly alters Lake Erie water quality in the adjacent nearshore areas of Michigan and Ontario. The relatively high rate of flow tends to retard, but not entirely eliminate transverse mixing. Studies (Pollution of Boundary Waters, 1951; Report to the Board of Commissioners, Wayne County, 1955; Environmental Control Technology Corporation, 1974) consistently demonstrate higher concentrations of materials along the Michigan and Ontario shorelines. This littoral stratification with pollution effects remaining near the respective shore is illustrated with dissolved solids, ammonia-nitrogen, nitrate-nitrogen, total phosphorus and phenol data (Tables 1-5). The region extending 2500 ft. from the Michigan shoreline is most severely impacted. Water quality between 2500 to 5500 ft. offshore improves markedly. The best water is generally at or near the ship channel. The lowest values for many parameters measured throughout Lake Erie are recorded for the mid-channel portion of the mouth of the Detroit River.

Historically, the first report (Dole, 1909) to note measurements of water quality in Lake Erie and Lake Huron both above and below the Detroit River indicated high quality water. A bacteriological study in 1913 (IJC, 1918) revealed relatively high concentrations of *E. coli* along the U.S. shoreline in the vicinity of the Rouge River and in the region extending from the mouth of the river to below Pointe Mouillee. In Canadian waters, high concentrations occurred at the mouth of the river and diffused in a fanlike pattern. Background levels were recorded approximately 12 miles from the river mouth. A more intensive survey in the region was conducted between 1946 and 1948 (IJC, 1951). The latter study indicated the effects of increased populations and industrial activity. The highest concentrations of chemical constituents occurred along the U.S. shoreline. The shoreline distribution is illustrated in Table 5 using average phenol values. More recent data from the last 10 years indicates a degree of recovery or stabilization of water quality. The diluting effects of upper lakes water results in most measurements at the mouth of the river falling at or below existing or proposed standards (Environmental Control Technology Corporation, 1974).

TABLE 1

AVERAGE DISSOLVED SOLIDS CONCENTRATION (mg/l)
ACROSS DETROIT RIVER MILE POINT 3.9, 1971-1973

Feet from U.S. shore	1971	1972	1973
2500	173	192	188
5500	151	164	163
7500	140	162	162
9500	129	153	162
11,500	125	150	157
14,500	130	145	158
16,500	155	197	180
18,500	189	212	218
19,000	230	245	210
20,000 - Can. shore			

SOURCE: USEPA Rept. No. EPA-905/9-74-013

TABLE 2

AVERAGE AMMONIA-NITROGEN CONCENTRATIONS (mg/l)
ACROSS DETROIT RIVER MILE POINT 3.9, 1946-1973

Feet from U.S. shore	1946-48[1]	1967-69[2]	1969-71[2]	1971-73[2]
500	0.20	-	-	-
1500	0.23	-	-	-
2500	0.28	0.57	0.60	0.55
3500	0.21	-	-	-
5500	-	0.27	0.32	0.29
6500	0.15	-	-	-
7500	-	0.17	0.22	0.17
8500	0.07	-	-	-
9500	-	0.06	0.07	0.09
11,500	0.0	0.08	0.08	0.08
13,500	0.0	-	-	-
15,000	0.0	0.04	0.03	0.05
16,500	0.0	0.03	0.04	0.05
17,500	0.002	-	-	-
18,500	0.001	0.03	0.05	0.07
19,000	0.001	-	-	-
19,300	0.001	-	-	-
20,000 - Can. shore				

[1] Pollution of Boundary Waters. IJC Rept. 312 p.

[2] USEPA Rept. No. EPA-905/9-74-013

TABLE 3

AVERAGE NITRATE-NITROGEN CONCENTRATION (mg/l)
ACROSS DETROIT RIVER MILE POINT 3.9, 1964-1974

Feet from U.S. shore	1964-65	1967-69	1969-71	1971-73	1973-74
2500	-	0.34	0.64	0.63	0.32
5500	0.25	0.20	0.32	0.46	0.23
9500	0.22	0.15	0.18	0.25	-
11,500	0.21	0.15	0.20	0.22	-
15,000	0.20	0.15	0.16	0.20	-
16,500	0.20	0.17	0.16	0.18	-
18,500	0.26	0.20	0.19	0.23	-
20,000 - Can. shore					

SOURCE: USEPA Rept. No. EPA-905/9-74-013

TABLE 4

AVERAGE TOTAL PHOSPHORUS CONCENTRATION (mg/l)
ACROSS DETROIT RIVER MILE POINT 3.9, 1968-1972

Feet from U.S. shore	1968-70	1970-72
2500	0.36	0.24
5500	0.22	0.17
7500	0.15	0.13
9500	0.12	0.08
11,500	0.08	0.06
15,000	0.07	0.05
16,500	0.07	0.04
18,500	0.08	0.04
20,000 - Can. shore		

SOURCE: USEPA Rept. No. EPA-905/9-74-013

TABLE 5

AVERAGE PHENOL CONCENTRATION (ug/l)
ACROSS DETROIT RIVER MILE POINT 3.9, 1946-1973

Feet from U.S. shore	1946-48[1]	1962-63[2]	1967-69[2]	1971-73[2]
500	11	-	-	-
1500	13	-	-	-
2500	9	9.5	5.9	5.9
3500	10	-	-	-
4500	8	-	-	-
5500	-	5.0	3.7	4.0
6500	6	-	-	-
7500	-	3.7	2.3	2.7
8500	4	-	-	-
9500	-	3.2	2.4	1.5
11,500	4	3.0	2.3	1.0
13,500	3	-	-	-
15,000	4	3.1	2.1	1.0
16,500	2	2.7	2.0	1.0
17,500	3	-	-	-
18,500	4	2.5	2.0	1.1
19,000	3	2.4	2.0	1.0
19,300	5	-	-	-
20,000 - Can. shore				

[1] Pollution of Boundary Waters. 1951. Rept. IJC. 312 p.

[2] USEPA Rept. No. EPA-905/9-74-013

Michigan Waters of Lake Erie, Pointe Mouillee to Woodtick Peninsula

The purpose of this discussion is to summarize reported conditions in the Michigan waters of western Lake Erie. The flat gently sloping bottom in this region results in a broad expanse of shallow water forming the widest nearshore area along the lake. Depending upon climatic conditions, three sources of water containing relatively high concentrations of chemical constituents have an impact on water quality in this region: nearshore Detroit River water from the north, River Raisin inputs, and Maumee Bay water from the south.

Studies of water quality in Michigan water have been concentrated in the Monroe navigation channel near the mouth of the River Raisin. High concentrations of E. coli were noted at the mouth of the river in 1913. Background numbers were recorded four to six miles offshore (IJC, 1918). Very low dissolved oxygen readings were recorded 3/4 mile from the river mouth in August and September of 1920 (Reighard, In:Wright, 1955). Dissolved oxygen measurements 3/8 mile from the river mouth were the lowest of four stations sampled in the region during 1926 (Osburn,In: Wright, 1955). Hydrogen ion concentrations ranged between 7.8 and 8.2 during the latter study. A more intensive study during the summer months of 1930 (Wright, 1955) indicated conditions were quite variable in the nearshore area immediately adjacent to the river mouth. Reversals of water flow at the river mouth accompanied by a longshore current prevented the investigators from any interpretation of the wide ranges among the various values recorded. In general, dissolved oxygen values were often low, ranging from zero to nine mg/l, within 1/2 mile of the river mouth. Several parameters were measured two miles offshore during 1928 and 1930. Temperature, dissolved oxygen and alkalinity values two miles offshore resembled those of the main lake portion of the western basin. Chloride values ranged between 10 and 20 mg/l in both nearshore and offshore areas. Ammonia, nitrogen and alkalinity values were higher in the vicinity of the river mouth.

Limited sampling between 1946 and 1948 (IJC, 1951) measured dissolved oxygen concentrations at the mouth of the River Raisin ranging between 1.4 and 8.5 mg/l. In the region, chloride measurements ranged between 14 and 38 mg/l, phenols between 0.0 and 30 mg/l, total solids between 140 and 210 mg/l offshore in the navigation channel and turbidities between 6 and 39 mg/l. Five day biochemical oxygen demand measurements (BOD) at stations located 1.5 to 3.5 km offshore in the navigation channel ranged between 0.0 and 4.6 mg/l. BOD measurements at the mouth of the River Raisin ranged between 5.8 and 71.4 mg/l.

The first study of water quality in recent years was reported in the Lake Erie Environmental Summary, 1963-1964 (1968). Without reporting actual data, this study noted a serious oxygen depletion problem at the mouth of the River Raisin, concentrations of sulfates at the Monroe municipal water intake at levels twice that of the western basin average, nearshore chloride concentrations in excess of 40 mg/l and potassium concentrations in excess of 4 mg/l. The study concluded that large quantities of potassium and chloride ions originate along the Michigan shore. Other limited water quality studies were conducted in the Monroe navigation channel and adjacent nearshore areas by the U.S. Army Corps of Engineers (1974) and investigators from Michigan State University (Parkhurst, 1971; Cole, 1972) between 1968 and 1971. The latter studies encountered the continuing oxygen depletion problem in the navigation channel as well as dissolved solids and phenol concentrations in excess of currently existing or proposed standards.

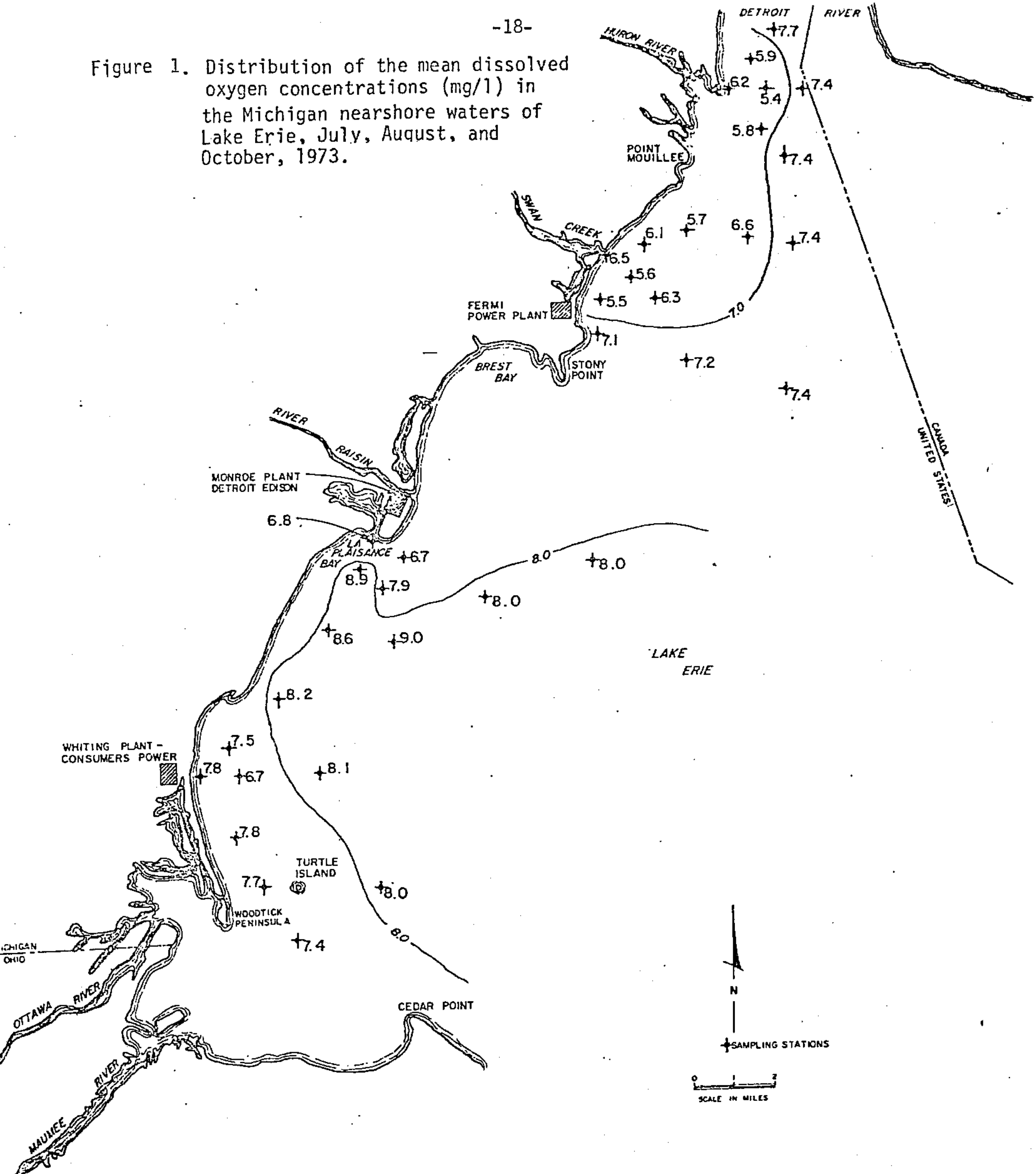
The most extensive study in this region was conducted between late July and early October, 1973, by the Michigan Department of Natural Resources (Waybrant and Siler, 1976). Four survey areas comprised the study. Area 1 (stations 1-7), located offshore from the mouth of the Huron River, was selected to determine the impact of the river's large domestic and industrial waste load. Area 2 (stations 8-18), located offshore from the mouth of Swan Creek, is in the vicinity of the Fermi II nuclear power plant site. Area 3 (stations 19-26) was sampled to assess the combined effect from the Monroe Power Plant and the River Raisin. The sampling sites radiated out from the plant discharge. The entire flow of the river is circulated through the plant at times of low river flow and full power production. Area 4 stations (27-35) were concentrated offshore from the Whiting Power Plant discharge and along the northern border of Maumee Bay.

The distribution of mean dissolved oxygen, dissolved solids and total phosphorus values in the region are presented in figures 1-3. The distribution of mean total phosphorus, orthophosphorus and chlorophyll a concentrations in each of the four study areas are presented in figures 4-6. A wide range of values for total phosphorus (0.01-0.25 mg/l) and orthophosphorus (0.01-0.07 mg/l) were recorded during the MDNR study. Even wider ranges were recorded at Lake Erie Nutrient Study (OSU) stations 3 km and 13 km offshore (Table 6). Mean values for both parameters were similar at comparable stations of both studies. Chlorophyll a values at individual stations were equally variable in both the MDNR and OSU studies. Overall, chlorophyll a values were highest at point source stations (1-Huron River, 8-Swan Creek, 20-Monroe Power Plant, 35-Whiting Power Plant) and decreased with greater distance offshore. The lowest mean values were recorded 13 km offshore and from the island region.

Mean station values for sodium (Na), Magnesium (Mg), calcium (Ca) and sulfate (SO_4) ions (Figures 7-8) display concentration patterns similar to the distribution of total dissolved solids values (Figure 2). The highest values in each area were recorded at the four point source stations with values decreasing offshore. The nearshore waters outside of the mid-channel plume of the Detroit River generally had high sodium ratios (Figure 7) probably due to local sources as indicated by the high values for the point source stations. Sulfate values were highest at point source stations, mid-range at nearshore stations and lowest at stations near the Detroit River mid-channel plume. Study of sulfate data indicates the nearshore waters contain both domestic and industrial waste materials. Conductivity measurements display a similar distribution pattern, reflecting the total dissolved solids levels. Lower mean conductivity values and the relatively narrow range of all measurements at stations 3 km and 13 km offshore are indicative of the effect of cleaner water from the mid-channel plume of the Detroit River. High conductivity measurements recorded in area 4 are indicative of the intrusion of Maumee Bay waters.

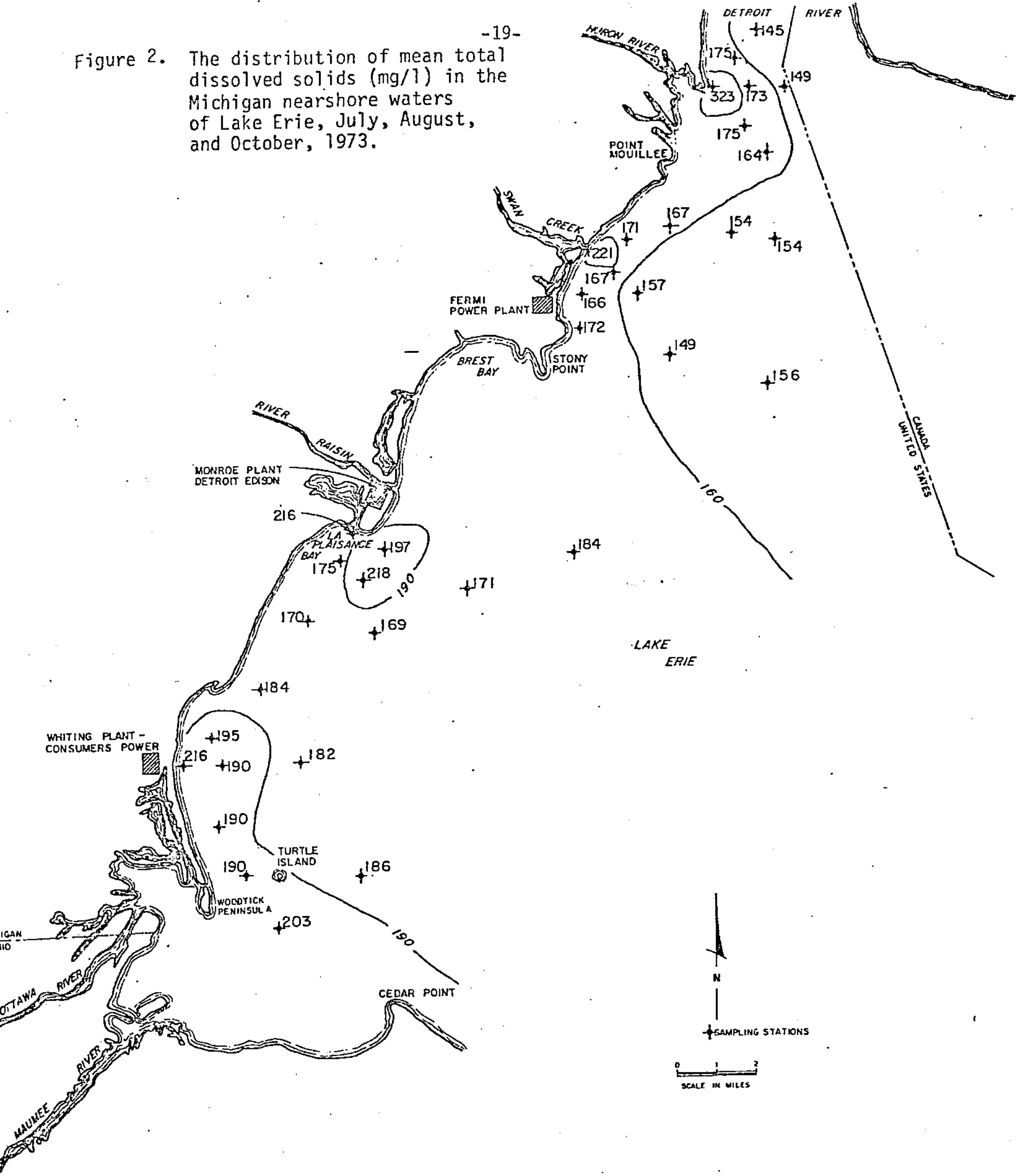
Water quality measurements recorded by Wright (1955) in 1930 for temperature, dissolved oxygen, ammonia nitrogen and organic nitrogen are near or within the ranges recorded recently (Cole, 1972; Waybrant and Siler, 1976). Comparison of data from the 1930 and 1973 studies indicates water transparency has decreased over the 40 year interval. Similar comparison of nitrate concentrations indicates an increase over this period (0.2 to 0.17 mg/l-Wright; 0.40 mg/l-Cole; 0.32 mg/l-Waybrant and Siler).

Figure 1. Distribution of the mean dissolved oxygen concentrations (mg/l) in the Michigan nearshore waters of Lake Erie, July, August, and October, 1973.



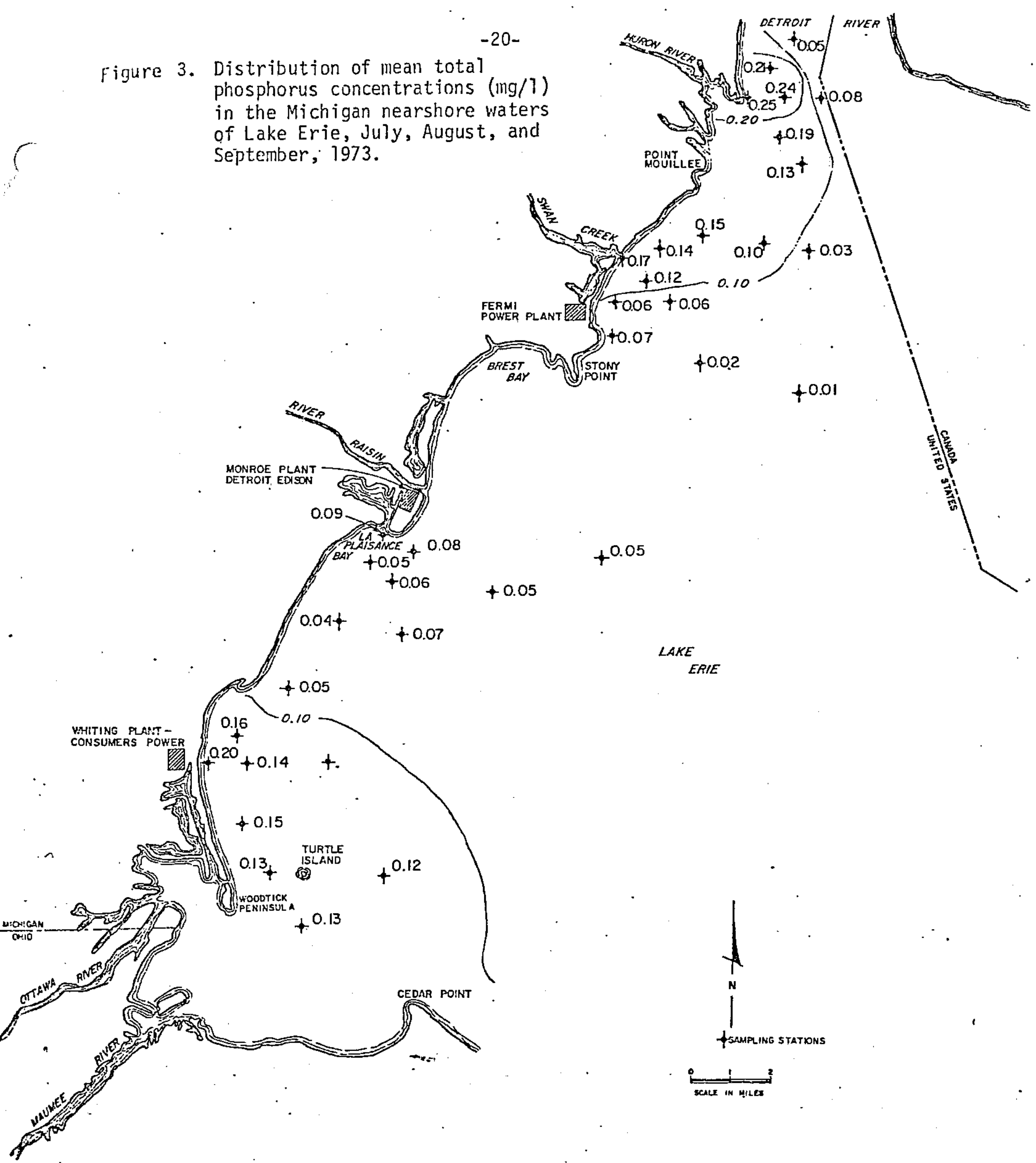
SOURCE: Waybrant, R.C. and D. Siler. 1976. Limnological survey of the Michigan waters of Lake Erie. Mich. Dept. Natural Resources, Water Quality Div. 61 p.

Figure 2. The distribution of mean total dissolved solids (mg/l) in the Michigan nearshore waters of Lake Erie, July, August, and October, 1973.



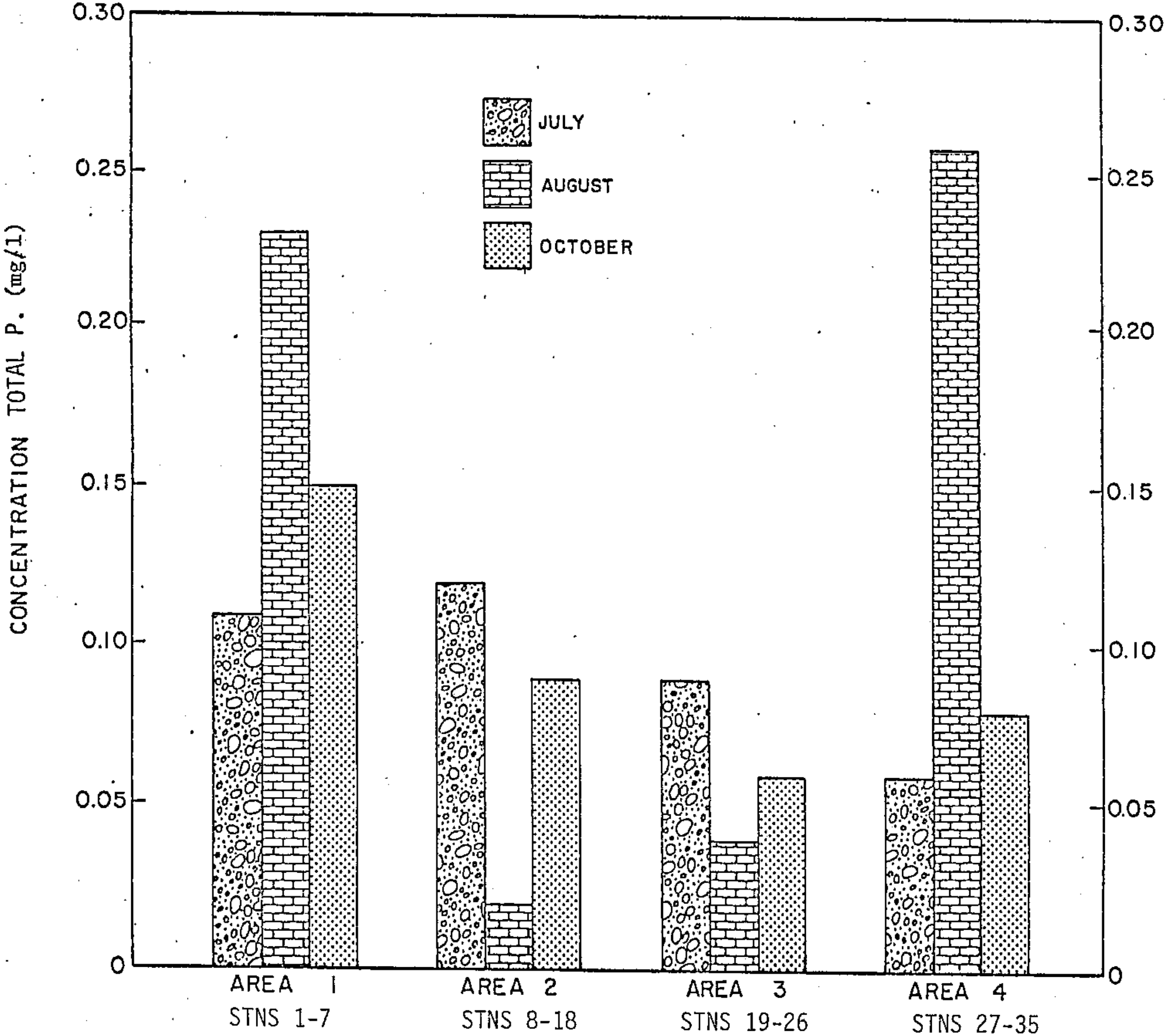
SOURCE: Waybrant, R.C. and D. Siler. 1976. Limnological survey of the Michigan waters of Lake Erie. Mich. Dept. Natural Resources, Water Quality Div. 61 p.

Figure 3. Distribution of mean total phosphorus concentrations (mg/l) in the Michigan nearshore waters of Lake Erie, July, August, and September, 1973.



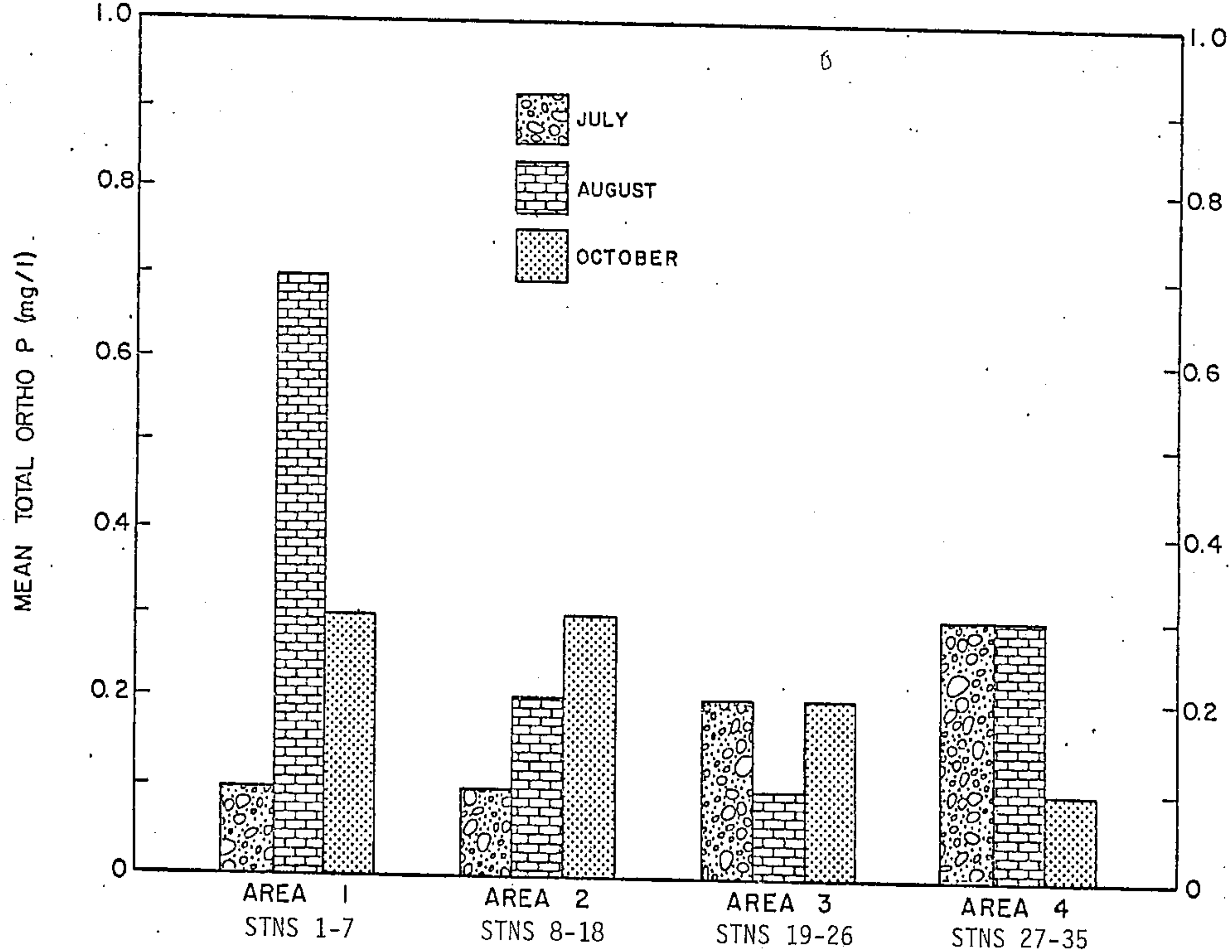
SOURCE: Waybrant, R.C. and D. Siler. 1976. Limnological survey of the Michigan waters of Lake Erie. Mich. Dept. Natural Resources, Water Quality Div. 61 p.

Figure 4. Mean seasonal total phosphorus con trations in the four areas of the Michigan nearshore waters of Lake Erie, 1973.



SOURCE: Waybrant, R.C. and D. Siler. 1976. Limnological survey of the Michigan waters of Lake Erie. Mich. Dept. Natural Resources, Water Quality Div. 61 p.

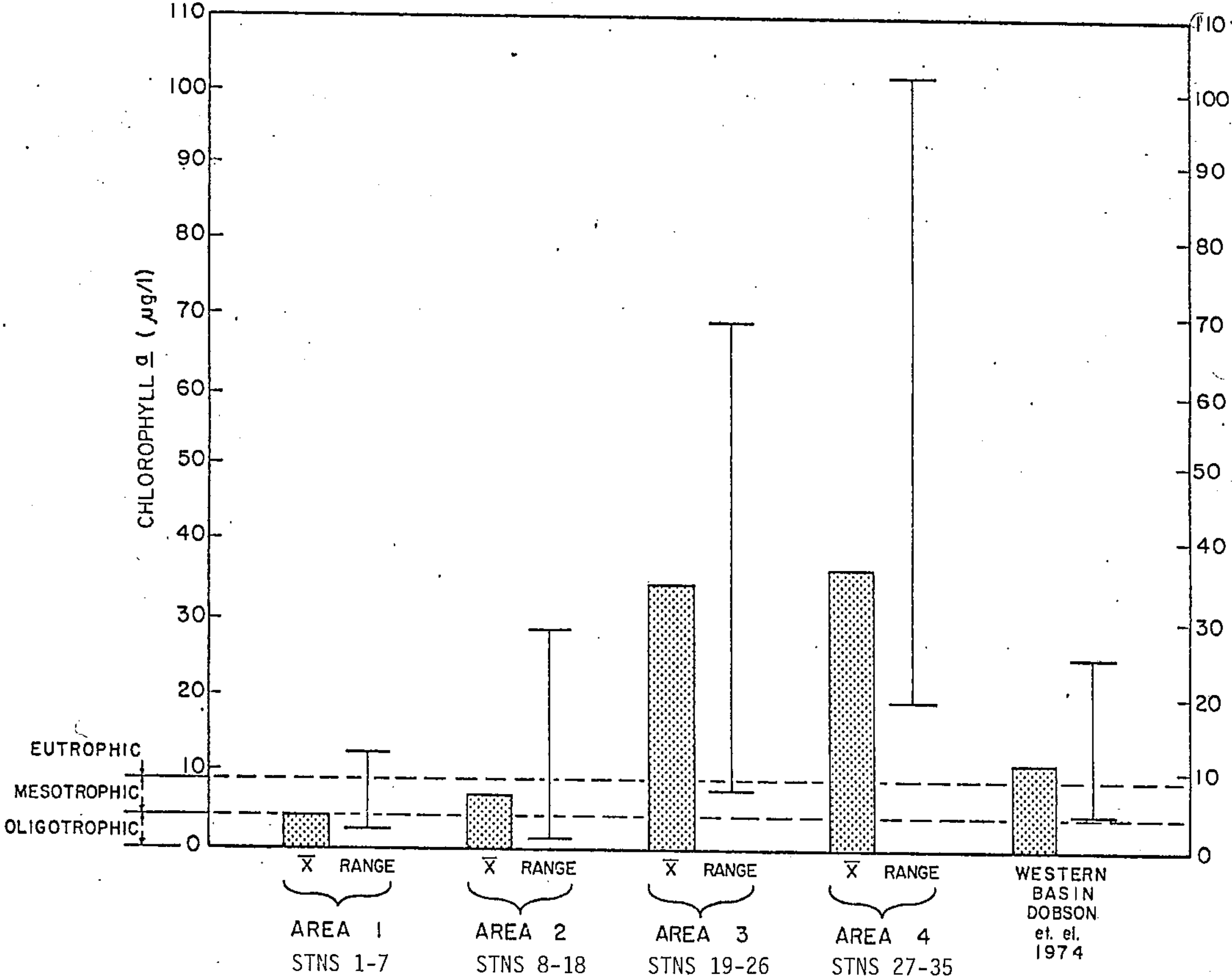
Figure 5. Mean seasonal total orthophosphorus concentrations in the four sampling areas in the Michigan nearshore waters of Lake Erie, 1973



SOURCE: Waybrant, R.C. and D. Siler. 1976. Limnological survey of the Michigan waters of Lake Erie. Mich. Dept. Natural Resources, Water Quality Div. 61 p.

FIG. 6.

CHLOROPHYLL *a* MEANS AND RANGES IN THE WESTERN BASIN OF LAKE ERIE, WITH THE RIVER MOUTH STATIONS, 1, 8, 20, AND 35 EXCLUDED.



SOURCE: Waybrant, R.C. and D. Siler. 1976. Limnological survey of the Michigan waters of Lake Erie. Mich. Dept. Natural Resources, Water Quality Div. 61 p.

TABLE 6

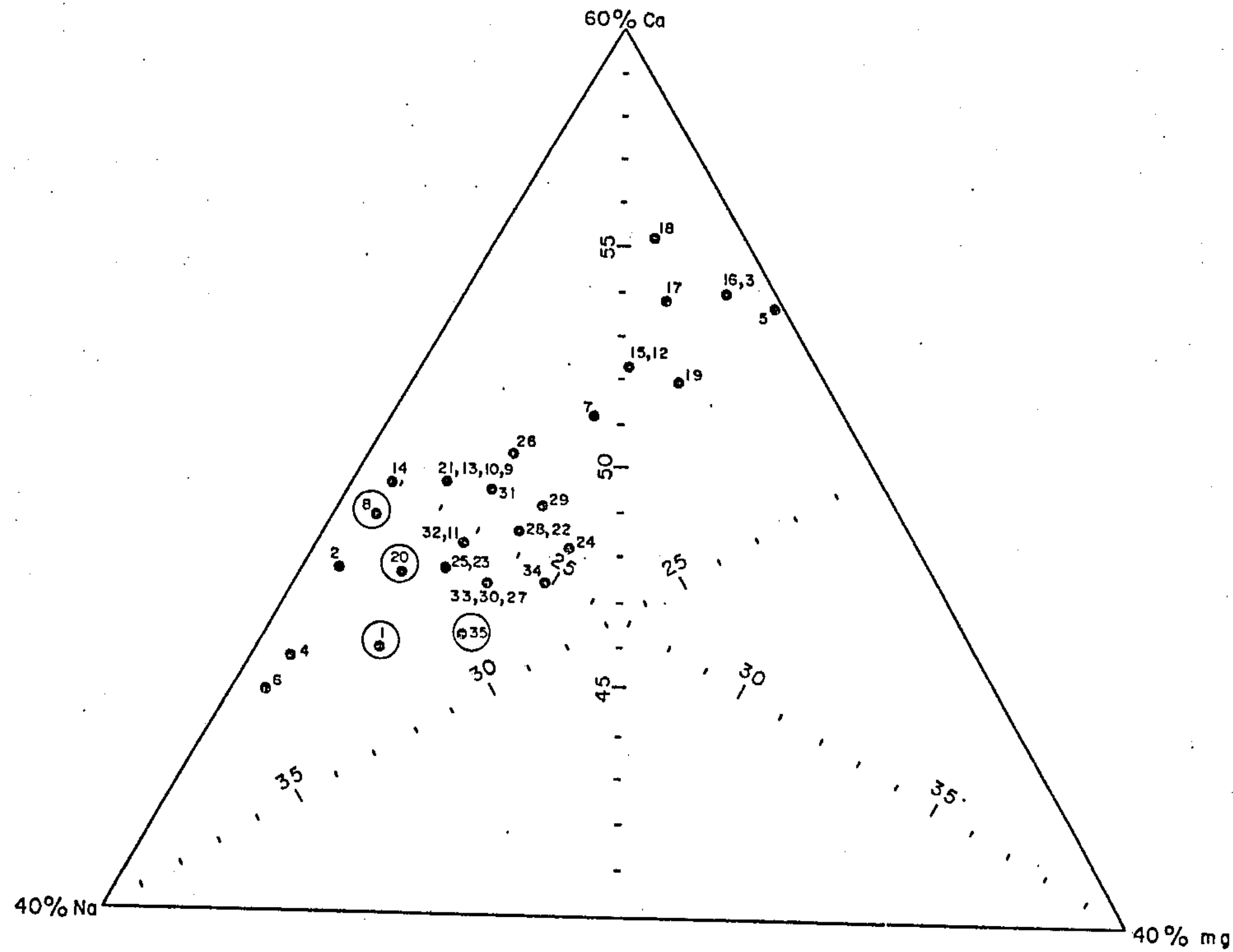
Summary of Water Quality Measurements Taken Three Kilometers (Station 75) and Thirteen Kilometers (Station 60) Offshore in Michigan Waters of Lake Erie, 1973-1975

Parameter	Year	Station 75 Range	Station 75 Mean	Station 60 Range	Station 60 Mean	Island Region of Western Basin Mean
Temperature (^{o}C)	1973	5.5 - 26.0	18.7	6.2 - 26.0	18.0	-
	1974	0.2 - 24.5	14.5	1.0 - 24.0	13.4	-
	1975	28 - 24.5	12.9	1.5 - 24.3	12.8	-
Transparency (m)	1974	0.3 - 1.8	0.9	0.6 - 2.1	1.3	1.5
	1975	0.5 - 1.1	0.8	0.1 - 1.4	0.7	1.1
Conductivity (μmhos/cm)	1973	222 - 294	260	223 - 244	231	251
	1974	248 - 322	279	214 - 293	232	259
	1975	194 - 271	235	197 - 278	235	224
Dissolved Oxygen (mg/l)	1973	3.2 - 13.4	9.7	6.6 - 11.6	9.4	9.3
	1974	7.3 - 14.2	10.5	4.4 - 13.3	10.1	10.0
	1975	7.3 - 12.9	10.0	7.9 - 13.4	10.3	9.6
Ammonia Nitrogen (μg/l-N)	1973	2 - 97	49	4 - 124	44	46.5
	1974	1 - 303	102	4 - 97	35	25.2
	1975	8 - 159	64	2 - 68	18	89.3
Total Phosphorus (μg/l-P)	1973	24 - 115	59	15 - 114	52	35
	1974	24 - 80	53	12 - 54	35	33.6
	1975	24 - 88	56	19 - 71	31	44
Dissolved Phosphorus (μg/l-P)	1973	1 - 14	8	0 - 4	2	4.6
	1974	0 - 27	10	1 - 6	2	3.8
	1975	1 - 25	11	0 - 10	3	9.0
Chorophyll a (μg/l)	1973	17.32 - 30.15	23.74	4.64 - 8.93	7.29	10.65
	1974	7.4 - 44.99	21.65	2.09 - 37.68	12.62	10.88
	1975	1.21 - 52.7	15.98	2.8 - 50.16	14.62	12.58

SOURCE: Lake Erie Nutrient Study. Center for Lake Erie Area Research, The Ohio State University, Columbus, Ohio.

FIGURE 7.

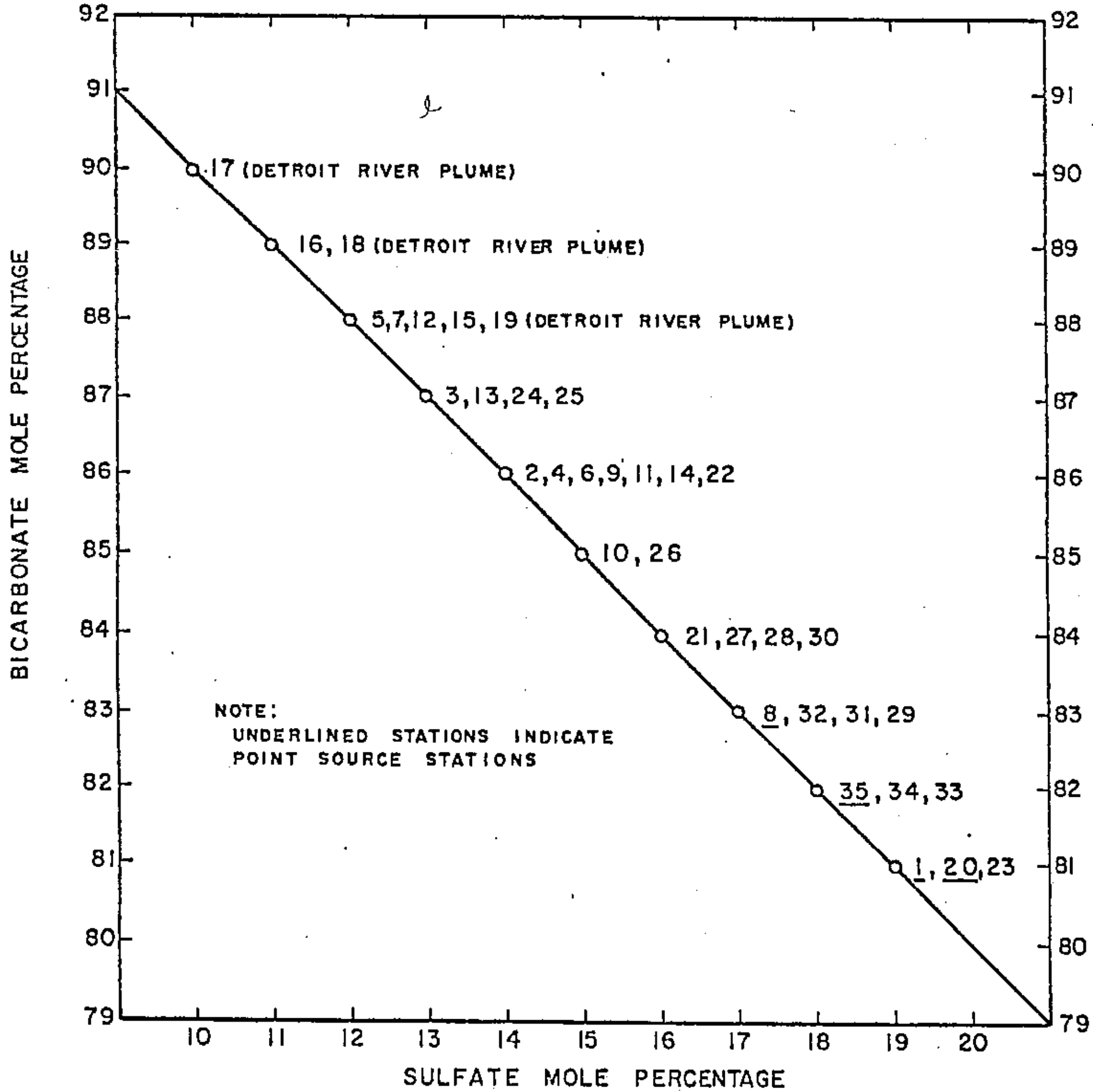
MOLE PERCENTAGES FOR THE MAJOR CATIONS AT THE THIRTY-FIVE STATIONS IN LAKE ERIE, 1973



(20) CIRCLED NUMBERS INDICATE POINT SOURCE STATIONS.

SOURCE: Waybrant, R.C. and D. Siler. 1976. Limnological survey of the Michigan waters of Lake Erie. Mich. Dept. Natural Resources, Water Quality Div. 61 p.

FIGURE 8.
MOLE PERCENTAGES FOR BICARBONATE AND SULFATE AT THE THIRTY—FIVE STATIONS IN LAKE ERIE, 1973



SOURCE: Waybrant, R.C. and D. Siler. 1976. Limnological survey of the Michigan waters of Lake Erie. Mich. Dept. Natural Resources, Water Quality Div. 61 p.

MAUMEE BAY

The purpose of this section is to summarize water quality related studies conducted in Maumee Bay. The quality of water in the bay is directly related to the quality of Maumee River inputs. Conditions in the lower 15 miles of the Maumee River vary seasonally with changes in flow (Figure 9) and as lake water masses affect water level and quality in an estuarine-type quasi-tidal interaction. Virtually all tributaries entering Lake Erie on the Ohio and Michigan shore have similar lower reaches (Brant and Herdendorf, 1972). Horowitz, et al. (1975) considered the lower reach of the Maumee River a sloshing reservoir where river water is progressively mixed with backflow from the lake (Figure 10). This portion of the river was also considered a settling basin where solids from upriver are sedimented and occasionally scoured during periods of major flushing. River water in the lower reach can be relatively stagnant for long intervals, particularly during the summer and early fall. The river maintains its down-channel current at discharge rates in excess of 200 m^3/s (7065 cfs).

Maumee Bay is a broad, shallow (maximum depth - 3 meters below low water datum) shelf where Maumee River water is diluted by water from the Western Basin of Lake Erie. Dilution patterns vary with seasonal changes in tributary inputs and as storm activity alters currents and resuspends sediments in the bay (Herdendorf, et al., 1977). There is an outward current flow along the Toledo navigation channel 75 percent of the time (Miller, 1968, 1969). Dredge spoil ridges and islands on either side of the navigation channel largely confines Maumee River flow to the channel, thereby inhibiting dispersion of river water throughout the bay (Fraleigh, et al., 1975; Pinsak and Meyer, 1976).

The lower reach of the Maumee River and Maumee Bay have received more extensive study than any other portion of the nearshore zone of Lake Erie. The Maumee Bay data base has been reviewed and analyzed in excellent fashion by Pinsak and Meyer (1976). This effort largely summarizes their study of water quality. The tributaries warm and cool earlier than the main lake. During the late spring the water temperature of the bay is warmer than that of the Western Basin because tributary inputs are warmer (Figure 11). The resulting thermal and density differences between Maumee River and Bay waters effectively confines river water in the navigation channel. From late spring to summer, the separation disappears and the restriction of river water to the channel is much less evident. In the fall, colder river water flows in the bottom of the navigation channel into the Western Basin beyond the limits of the bay. The southeastern portion of the bay is impacted by the heated discharge of the Toledo Edison generating plant (Figure 12). During the fall, 90 percent of the southeastern portion of the bay is warmer than Western Basin waters. During the late fall, approximately 35 percent is warmer. No warming or cooling trend could be discerned in the average annual temperatures recorded at the mouth of the Maumee River between 1929 and 1975.

A continuing low oxygen problem at the mouth of the Maumee River has been evident since 1930 (Table 7). Dissolved oxygen concentrations at the mouth of the river vary on an annual cycle with the lowest percent saturation between June and October (Figure 13). Between 1968 and 1974, dissolved oxygen concentrations have increased 60 percent at the mouth of the river. Mean annual dissolved oxygen concentration in Maumee Bay is 7.9 mg/l. Highest dissolved oxygen concentrations in the region occur beyond the mouth of the bay.(Table 8). Biochemical oxygen demand (B.O.D.) at the river mouth decreased 40 percent from 9.7 to 6.8 mg/l between 1968 and 1973. The overall B.O.D. decrease since 1968 indicates an improvement in water quality locally.

Hydrogen ion concentration (pH) in the lower reach of the River varies from 6.9 to 8.4, with a mean of 7.6. Comparison of the 1964-1973 mean of 7.6 with the 1951-1952 mean of 7.9 indicates a less alkaline condition during the period. The mean pH value in Maumee Bay is 7.8 with slight increases apparent at input points. In the navigation channel, pH increases, reaching background levels near the mouth of the bay (9.6 km from the river mouth). Specific conductance and alkalinity values (Figures 14, 15) decrease abruptly at the river mouth. Background levels occur at or beyond the limits of the bay. Highest values for both parameters are recorded during the peak runoff period, December to March. The southeastern portion of the bay is influenced by the Toledo Edison discharge. Marked variations in alkalinity and conductivity measurements at the Toledo municipal water intake, located east of Maumee Bay 3.5 km offshore, indicate occasional offshore drift of the water mass flowing out of Maumee Bay.

The results of similar analyses of other parameters are summarized in Tables 9 and 10. Deviation of each parameter from the mean value in various sectors of the bay is displayed in Figures 16 through 25. Measurements of dissolved oxygen, total dissolved solids, iron and phenols at the mouth of the Maumee River frequently exceed existing or proposed standards (see Appendix A). Maumee Bay is frequently defined as the area from the river mouth to a line joining the southern end of Woodtick Peninsula on the west to the end of Little Cedar Point of the east. Water quality studies lead to the conclusion that this entire area is part of the nearshore zone. Background concentrations for most parameters typically occur beyond the defined limits of the bay.

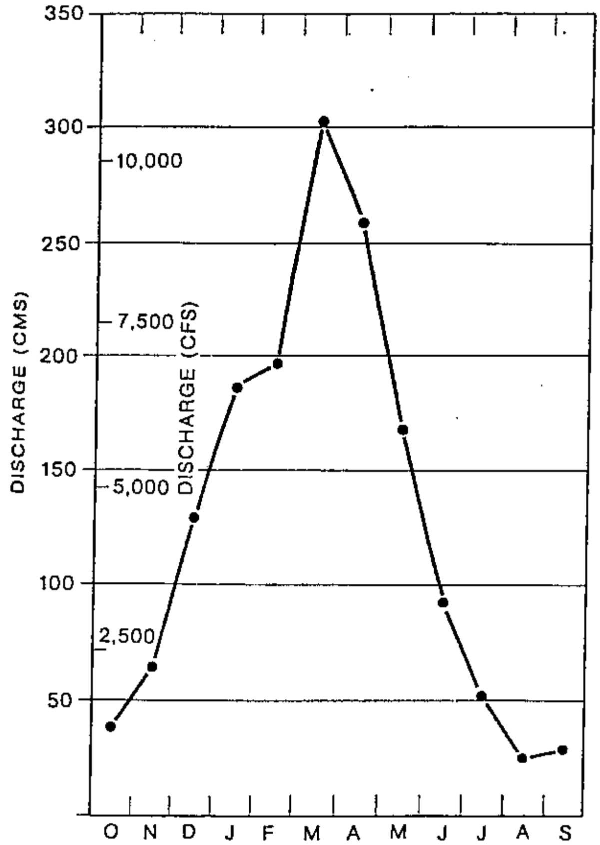


Figure 9.--Mean monthly discharge from the Maumee River, 1899-1972.

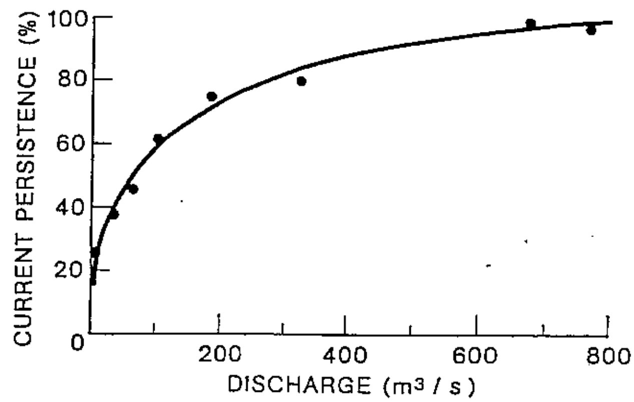


Figure 10.--Percent current persistence downriver vs. discharge from the Maumee River (from Miller, 1969).

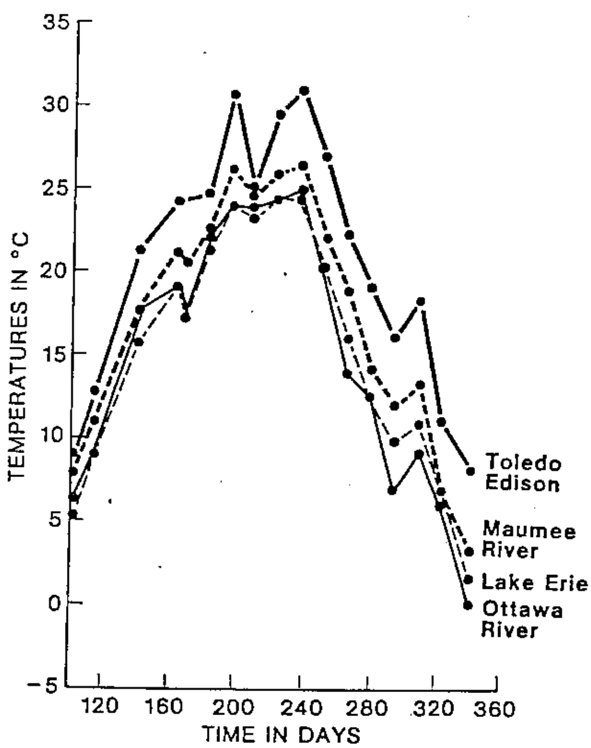


Figure 11.--Maumee Bay source water temperature, 1974.

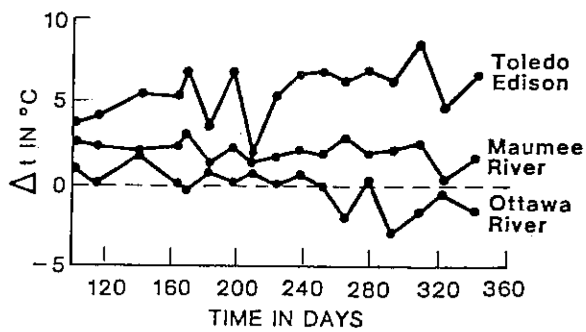


Figure 12.--Temperature differences from Lake Erie.

SOURCE: Pinsak, A.P. and T.L. Meyer. 1976. Environmental baseline for Maumee Bay. Great Lakes Basin Commission, Maumee River Basin Level B Study. 164 p.

TABLE 7

WATER QUALITY MEASUREMENTS TAKEN IN THE TOLEDO NAVIGATION CHANNEL FROM THE MAUMEE RIVER MOUTH TO TOLEDO HARBOR LIGHT, 1928-1975

PARAMETER	NO. OF SAMPLING DATES	RIVER MOUTH	7 km	14 km (HARBOR LT)	STUDY PERIOD	SOURCE
Temperature (°C)	13	14.3 - 25.9	14.25 - 24.8	14.1 - 22.95	1929-1930	Wright (1955)
	2	25.0 - 26.0	23.5 - 24.0	23.5 - 24.5	1946-1948	IJC (1951)
	4	-	-	0.2 - 23.5	1967-1968	FWPCA (1968)
	11	2 - 24	-	-	1968	Kovacik, et al. (1976)
	11	0.0 - 27	-	-	1969	Kovacik, et al. (1976)
	10	0.6 - 25	-	-	1970	Kovacik, et al. (1976)
	12	0.0 - 24	-	-	1971	Kovacik, et al. (1976)
	12	2 - 30	-	-	1972	Kovacik, et al. (1976)
	3	-	-	18 - 26	1973	Waybrant and Siler(1976)
	15	6.8 - 26.5	5.8 - 24.8	-	1974	Fraleigh et al. (1975)
	13	-	-	2.25 - 24.9	1975	Herdendorf and Cooper (1975)
Dissolved Oxygen (mg/l)	13	1.0 - 10.5	6.2 - 10.0	7.2 - 11.9	1929-1930	Wright (1955)
	2-3	1.8 - 4.7	8.6 - 10.7	9.5 - 10.8	1946-1948	IJC (1951)
	4	-	-	7.7 - 12.8	1967-1968	FWPCA (1968)
	11	1.0 - 11.8	-	-	1968	Kovacik, et al. (1976)
	11	0.7 - 12.0	-	-	1969	Kovacik, et al. (1976)
	10	0.6 - 10.5	-	-	1970	Kovacik, et al. (1976)
	12	1.5 - 12.6	-	-	1971	Kovacik, et al. (1976)
	12	3.1 - 12.8	-	-	1972	Kovacik, et al. (1976)
	3	-	-	6.5 - 10.6	1973	Waybrant and Siler (1976)
	13-15	2.7 - 11.5	6.7 - 12.7	-	1974	Fraleigh, et al. (1975)
	4	4.8 - 7.7	-	-	1974	Horowitz, et al. (1975)
	12	-	-	7.0 - 13.0	1975	Herdendorf and Cooper (1975)

TABLE 7 (Con't)

WATER QUALITY MEASUREMENTS TAKEN IN THE TOLEDO NAVIGATION CHANNEL
FROM THE MAUMEE RIVER MOUTH TO TOLEDO HARBOR LIGHT, 1928-1975

PARAMETER	NO. OF SAMPLING DATES	RIVER MOUTH	7 km	14 km (HARBOR LT)	STUDY PERIOD	SOURCE
pH (std uts)	13	7.5 - 8.5	7.9 - 8.6	7.9 - 8.7	1928-1930	Wright (1955)
	4	-	-	8.1 - 9.4	1967-1968	FWPCA (1968)
	11	7.1 - 8.1	-	-	1968	Kovacik, et al. (1976)
	11	6.9 - 8.6	-	-	1969	Kovacik, et al. (1976)
	11	7.4 - 8.1	-	-	1970	Kovacik, et al. (1976)
	12	7.3 - 8.3	-	-	1971	Kovacik, et al. (1976)
	12	7.5 - 8.1	-	-	1972	Kovacik, et al. (1976)
	3	-	-	8.5 - 9.6	1973	Waybrant and Siler (1976)
	15	7.6 - 8.2	8.0 - 9.0	-	1974	Fraleigh, et al. (1975)
	4	-	-	8.33 - 8.67	1975	Herdendorf and Cooper (1975)
Conductivity (µmhos/cm)	4	-	-	2.85 - 310	1967-1968	FWPCA (1968)
	11	190 - 740	-	-	1968	Kovacik, et al. (1976)
	11	287 - 600	-	-	1969	Kovacik, et al. (1976)
	11	370 - 675	-	-	1970	Kovacik, et al. (1976)
	12	190 - 700	-	-	1971	Kovacik, et al. (1976)
	12	375 - 725	-	-	1972	Kovacik, et al. (1976)
	2	-	-	250 - 300	1973	Waybrant and Siler (1976)
	15	303 - 555	171 - 400	-	1974	Fraleigh, et al. (1975)
	12	-	-	205 - 315	1975	Herdendorf and Cooper (1975)
Total Solids (mg/l)	2	260 - 280	190 - 230	-	1946-1948	IJC (1951)
	3	-	-	163 - 228	1967	FWPCA (1968)
	10	332 - 501	-	-	1969	Kovacik, et al. (1976)
	11	257 - 508	-	-	1970	Kovacik, et al. (1976)
	12	264 - 707	-	-	1971	Kovacik, et al. (1976)
	12	272 - 603	-	-	1972	Kovacik, et al. (1976)

TABLE 7 (Con't)

WATER QUALITY MEASUREMENTS TAKEN IN THE TOLEDO NAVIGATION CHANNEL FROM THE MAUMEE RIVER MOUTH TO TOLEDO HARBOR LIGHT, 1928-1975

PARAMETER	NO. OF SAMPLING DATES	RIVER MOUTH	7 km	14 km (HARBOR LT)	STUDY PERIOD	SOURCE
Suspended Solids (mg/l)	10	20 - 143	-	-	1969	Kovacik, et al. (1976)
	11	19 - 206	-	-	1970	Kovacik, et al. (1976)
	12	11 - 319	-	-	1971	Kovacik, et al. (1976)
	12	5 - 203	-	-	1972	Kovacik, et al. (1976)
	3	-	-	21 - 44	1973	Waybrant and Siler(1976)
	15	15 - 124	9 - 102	-	1974	Fraleigh, et al. (1975)
	1	-	-	36	1975	Herdendorf and Cooper (1975)
Dissolved Solids (mg/l)	3	-	-	153 - 212	1967	FWPCA (1968)
	10	230 - 590	-	-	1969	Kovacik, et al. (1976)
	11	238 - 440	-	-	1970	Kovacik, et al. (1976)
	12	234 - 430	-	-	1971	Kovacik, et al. (1976)
	12	69 - 598	-	-	1972	Kovacik, et al. (1976)
	3	-	-	169 - 201	1973	Waybrant and Siler(1976)
	9-15	121 - 453	167 - 246	-	1974	Fraleigh, et al. (1975)
	3	318 - 415	-	-	1974	Horowitz, et al. (1975)
Transparency (m)	2	0.4 - 0.5	-	0.6 - 0.8	1970	Herdendorf and Cooper (1975)
	6	0.3 - 0.6	-	-	1971	Herdendorf and Cooper "
	3	0.2 - 0.6	-	-	1972	Herdendorf and Cooper "
	14-16	0.05 - 0.3	0.2 - 0.5	-	1974	Fraleigh, et al. (1975)
	13	-	-	0.2 - 1.7	1975	Herdendorf and Cooper (1975)

TABLE 7 (Con't)

WATER QUALITY MEASUREMENTS TAKEN IN THE TOLEDO NAVIGATION CHANNEL

FROM THE MAUMEE RIVER MOUTH TO TOLEDO HARBOR LIGHT, 1928-1975

PARAMETER	NO. OF SAMPLING DATES	RIVER MOUTH	7 km	14 km (HARBOR LT)	STUDY PERIOD	SOURCE
Turbidity (JTU)	11	22 - 150	-	-	1968	Kovacik, et al. (1976)
	9	28 - 180	-	-	1969	Kovacik, et al. (1976)
	11	26 - 120	-	-	1970	Kovacik, et al. (1976)
	2	7.0 - 54.0	-	0.5 - 13.5	1970	Herdendorf and Cooper (1975)
	6	14.0 - 51.0	-	-	1971	Herdendorf and Cooper
	3	3.9 - 140.0	-	-	1971	Kovacik, et al. (1976)
	3	16.0 - 150.0	-	-	1972	Herdendorf and Cooper (1975)
	12	13 - 175.0	-	-	1972	Kovacik, et al. (1976)
	1	-	-	27	1973	Waybrant and Siler(1973)
	1	36	-	52 - 55	1975	Herdendorf and Cooper (1975)
Chloride (mg/l)	6	14.2 - 24.1	12.0 - 15.6	10.4 - 13.7	1929-1930	Wright (1955)
	2-5	18 - 28	10 - 23	18 - 20	1946-1948	IJC (1951)
	4	-	-	16 - 22	1967-1968	FWPCA (1968)
	11	14 - 42	-	-	1968	Kovacik, et al. (1976)
	11	16 - 77	-	-	1969	Kovacik, et al. (1976)
	11	20 - 63	-	-	1970	Kovacik, et al. (1976)
	12	27 - 61	-	-	1971	Kovacik, et al. (1976)
	12	19 - 53	-	-	1972	Kovacik, et al. (1976)
	14-17	22 - 55	17 - 28	-	1974	Fraleigh, et al. (1975)
	1	145	-	87	1975	Herdendorf and Cooper (1975)

TABLE 7 (Con't)

WATER QUALITY MEASUREMENTS TAKEN IN THE TOLEDO NAVIGATION CHANNEL
FROM THE MAUMEE RIVER MOUTH TO TOLEDO HARBOR LIGHT, 1928-1975

PARAMETER	NO. OF SAMPLING DATES	RIVER MOUTH	7 km	14 km (HARBOR LT)	STUDY PERIOD	SOURCE
Alkalinity (as mg/l $CaCO_3$)	11-15	104 - 154	96 - 118	89 - 105	1929-1928	Wright (1955)
	1	115 - 120	96 - 99	-	1946-1948	IJC (1951)
	3	-	-	89 - 95	1967-1968	FWPCA (1968)
	4	104 - 120	88 - 96	-	1974	Fraleigh, et al. (1975)
Nitrate Nitrogen (mg/l)	5-7	0.02-0.08	0.02-0.06	0.04-0.11	1930	Wright (1955)
	11	0.0 - 9.1	-	-	1968	Kovacik, et al. (1976)
	11	0.4 - 8.4	-	-	1969	Kovacik, et al. (1976)
	10	0.7 - 4.4	-	-	1970	Kovacik, et al. (1976)
	12	0.1 - 8.6	-	-	1971	Kovacik, et al. (1976)
	12	4.9 - 11.6	-	-	1972	Kovacik, et al. (1976)
	14-16	0.09 - 3.8	0.2 - 4.1	-	1974	Fraleigh, et al. (1975)
Total Phosphorus (mg/l)	4	-	-	0.05-0.08	1967-1968	FWPCA (1968)
	3	-	-	0.06-0.24	1973	Waybrant and Siler(1976)
	15-17	0.13 - 0.26	0.00-0.28	-	1974	Fraleigh, et al. (1975)
Dissolved Phosphorus (mg/l)	4	-	-	0.02-0.06	1967-1968	FWPCA (1968)
	11	0.4 - 2.0	-	-	1968	Kovacik, et al. (1976)
	11	0.3 - 1.4	-	-	1969	Kovacik, et al. (1976)
	10	0.2 - 1.0	-	-	1970	Kovacik, et al. (1976)
	12	0.1 - 0.6	-	-	1971	Kovacik, et al. (1976)
	12	0.1 - 0.3	-	-	1972	Kovacik, et al. (1976)
	3	-	-	0.01-0.05	1973	Waybrant and Siler (1978)
	15-17	0.02-0.10	0.00-0.08	-	1974	Fraleigh, et al. (1975)

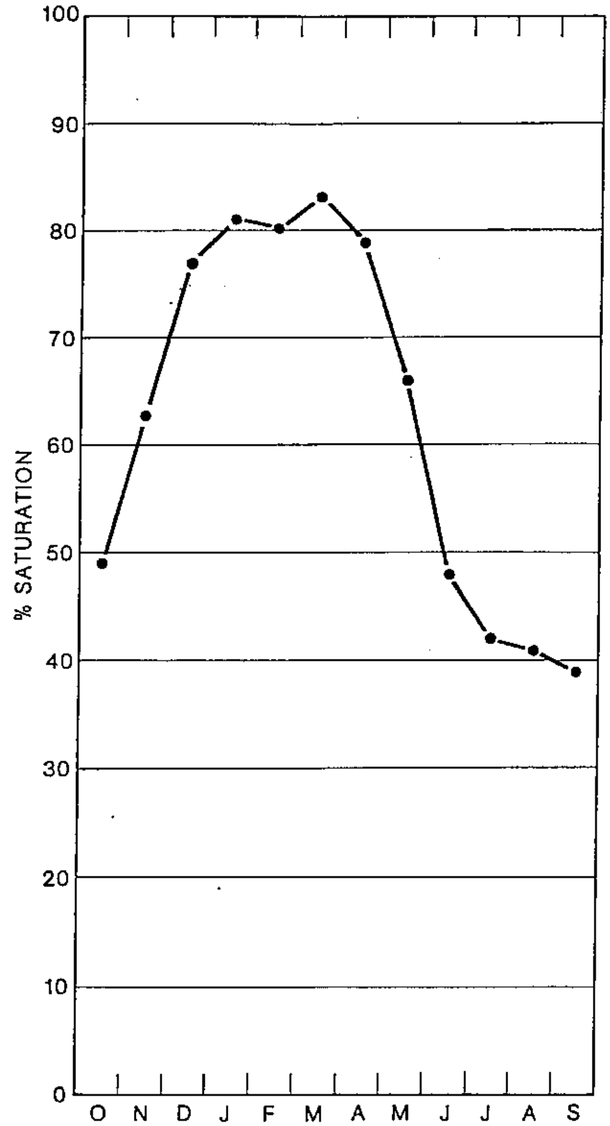


Figure 13. Mean monthly dissolved oxygen at the mouth of the Maumee River, 1964-1972.

SOURCE: Pinsak, A.P. and T.L. Meyer. 1976. Environmental baseline for Maumee Bay. Great Lakes Basin Commission, Maumee River Basin Level B Study. 164 p.

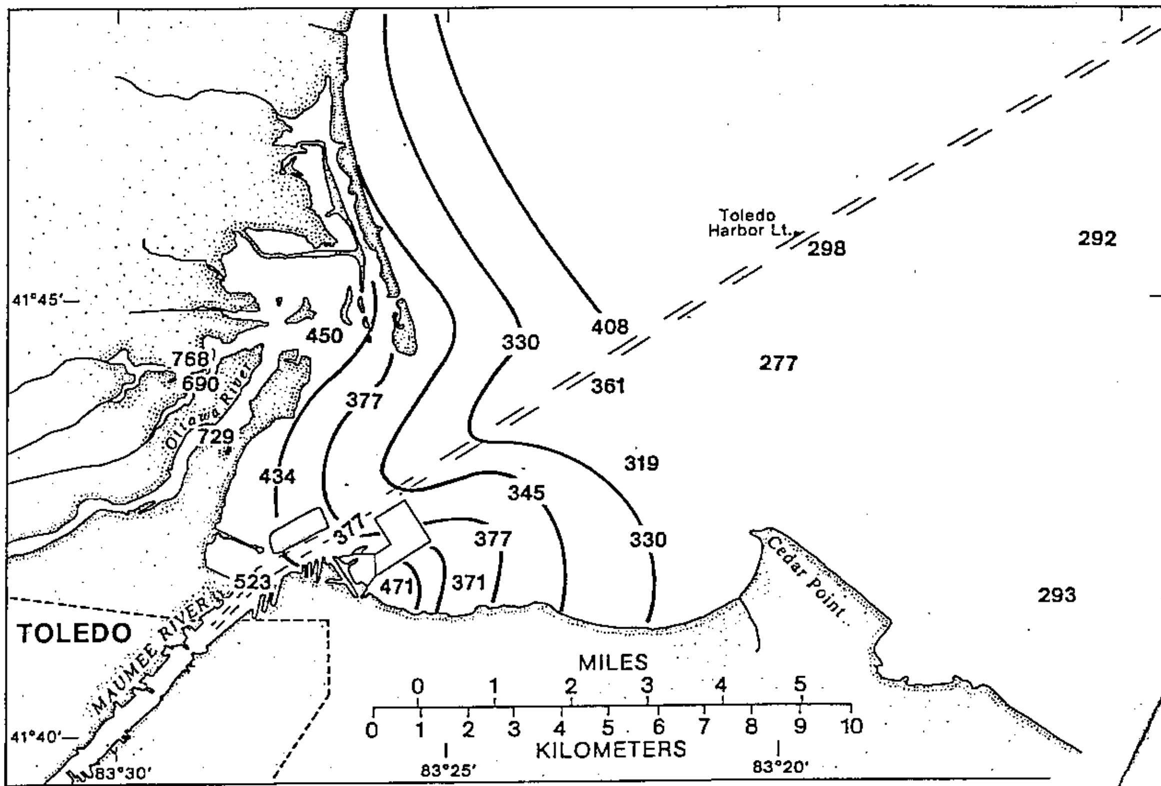


Figure 14. Specific conductance in Maumee Bay.

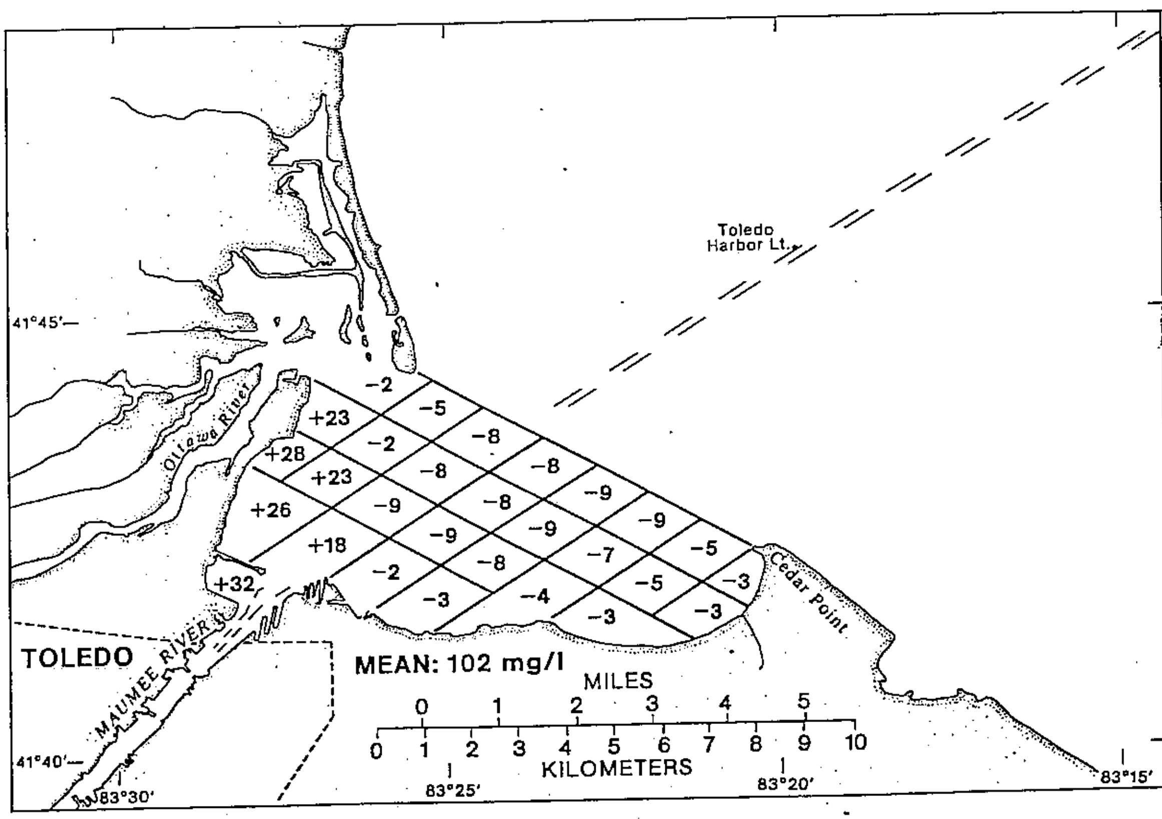


Figure 15. Deviation of alkalinity in Maumee Bay.

SOURCE: Pinsak, A.P. and T.L. Meyer. 1976. Environmental baseline for Maumee Bay. Great Lakes Basin Commission, Maumee River Basin Level B Study. 164 p.

TABLE 9

WATER QUALITY CHANGES IN MAUMEE BAY

PARAMETER	MAUMEE BAY MEAN	ANNUAL PERIOD OF LOW CONCENTRATION	ANNUAL PERIOD OF PEAK CONCENTRATION	PERCENT CONCENTRATION INCREASE AT RIVER MOUTH	PERCENT CONCENTRATION DECREASE IN FIRST 8 to 10 km	DISTANCE FROM RIVER MOUTH TO BACKGROUND CONCENTRATION (km)	PERCENT DECREASE IN CONCENTRATION TO BACKGROUND CONCENTRATION
Turbidity (JTU)	53	Sept.	April	150 over mean (109) (1968-1974)	70 (8 km)	24	-
Color (std uts)	23	-	Nov-May (Mar-May)	-	75 (8 km)	-	-
Dissolved Solids (mg/l)	254	July-Nov.	Dec.-Mar.	40 (1950-1974)	80 (8.8 km)	16.1	-
Sodium (mg/l)	19	-	Nov.-Feb.	20 (1950-1974)	-	12.8	-
Calcium (mg/l)	47	-	Nov.-Jan.	-	-	-	36
Potassium (mg/l)	4.7	-	June-Sept.	54 (1950-1973)	-	14	50
Magnesium (mg/l)	13	-	-	≃20 (1950-1973)	113 (9.6 km)	16	-
Total Hardness (mg/l)	159	-	-	≃15 (1950-1973)	-	-	-
Sulfate (mg/l)	60	July-Nov.	Nov.-Mar.	35 (1950-1973)	-	12.8	130
Total Phosphorus (mg/l)	0.13	-	Dec.-Mar.	-	200 (8 km)	12.8	-
Nitrate-Nitrogen (mg/l)	5.8	-		0.0 (1968-1973)	570 (9.6 km)	-	-

SOURCE: Pinsak and Meyer (1976)

Table 10. Comparison of constituents in Maumee River and Bay with Standards.

Parameter	Mean near mouth of Maumee River	Loading to Maumee Bay, kg/yr	Mean concentration increasing or decreasing	Maumee Bay/ Toledo area standard	Lake Erie nearshore standard	Mean concentration in Maumee Bay
Methylene blue-active substance	0.7 mg/l	6.4×10^5	Decrease	0.5 mg/l	0.05 mg/l	**
Oil	1.9 mg/l	7.4×10^6	**	*	0.05 mg/l	2.4 mg/l
Fluoride	0.5 mg/l	2×10^6	Increase	1.3 mg/l	0.15 mg/l	**
Sulfate	77 mg/l	3×10^8	Increase	*	*	60 mg/l
Total alkalinity as Ca Co_3	134 mg/l	5.1×10^8	No change	*	*	102 mg/l
Total hardness	222 mg/l	8.5×10^8	Increase	*	130 mo.av. 180 max.day	159 mg/l
pH	7.6		Increase	6 - 9	7 - 8.8	7.8
Silica	7.9 mg/l	3.0×10^7	No change	*	*	2.3 mg/l
Calcium	53 mg/l	2.0×10^8	No change	*	*	47 mg/l
Sodium	25 mg/l	9.5×10^7	Increase	*	*	19 mg/l
Chloride	34 mg/l	1.3×10^8	Increase	250 mg/l	25 mo.av. 30 max.day	30 mg/l
Magnesium	17 mg/l	6.5×10^7	Increase	*	*	13 mg/l
Dissolved solids	370 mg/l	1.4×10^9	Decrease	500 mg/l mo. av.	200 mg/l	254 mg/l
Total phosphorus as P	0.36 mg/l	8.8×10^5	Decrease	1 mg/l	0.025 mg/l	0.13 mg/l
Orthophosphate	0.060 mg/l	2.3×10^3	**	*	*	0.043 mg/l
Suspended solids	281 mg/l	11.2×10^8	Decrease	*	*	37 mg/l
Nitrate	15.7 mg/l	5.9×10^7	Increase	*	*	5.8 mg/l
Nitrite	0.15 mg/l	5.7×10^5	Increase	*	*	**
Ammonia	1.5 mg/l	5.7×10^6	Decrease	*	*	**
Phenols	35.0 mg/l	1.3×10^5	**	10.0 mg/l	1.0 mg/l	**

* No Standard
** Insufficient Data

SOURCE: Pinsak, A.P. and T.L. Meyer. 1976. Environmental baseline for Maumee Bay. Great Lakes Basin Commission, Maumee River Basin Level B Study. 164 p.

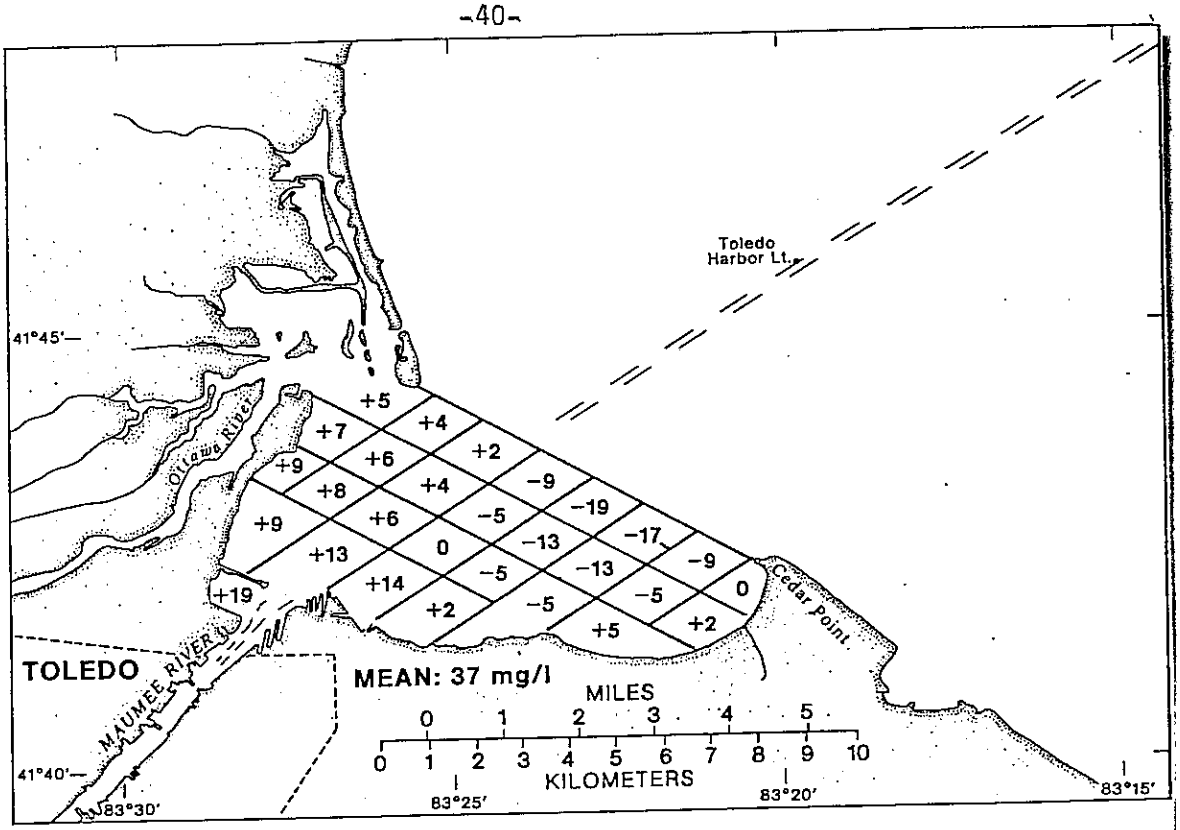


Figure 16. Deviation of suspended solids in Maumee Bay.

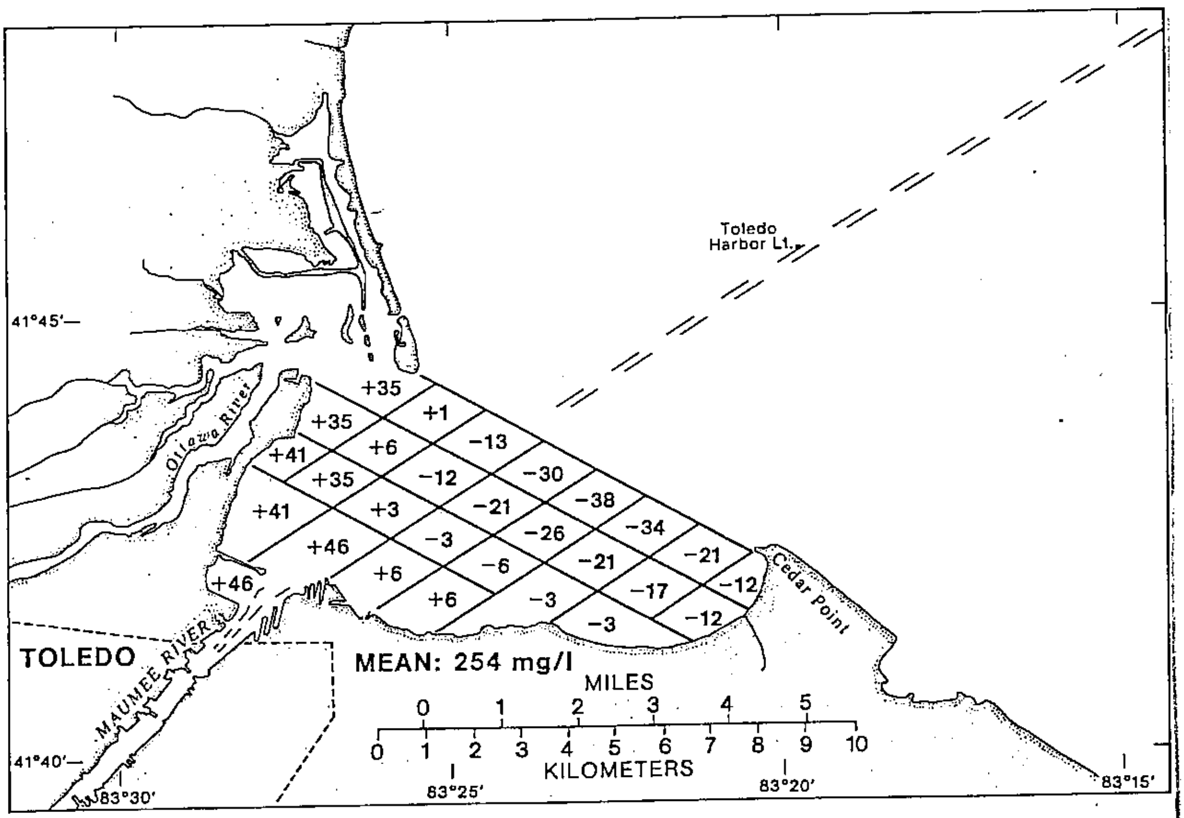


Figure 17. Deviation of dissolved solids in Maumee Bay.

SOURCE: Pinsak, A.P. and T.L. Meyer. 1976. Environmental baseline for Maumee Bay. Great Lakes Basin Commission, Maumee River Basin Level B Study. 164 p.

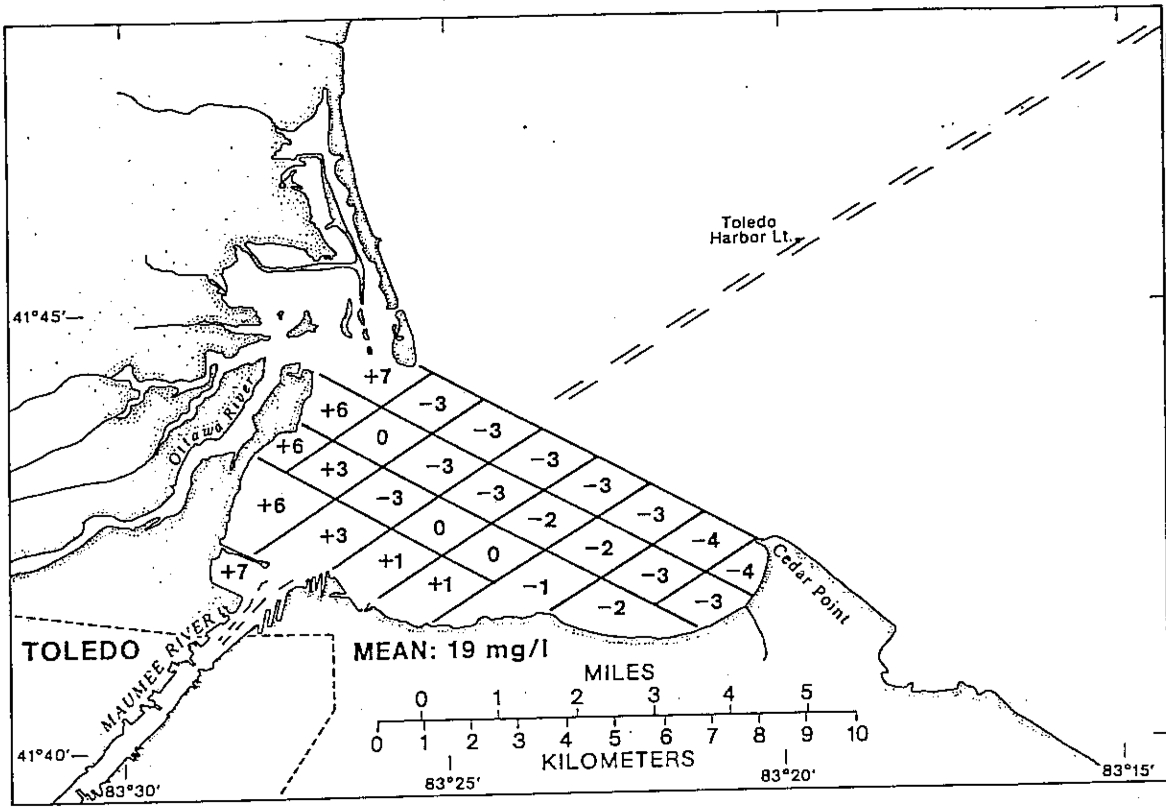


Figure 18. Deviation of sodium in Maumee Bay.

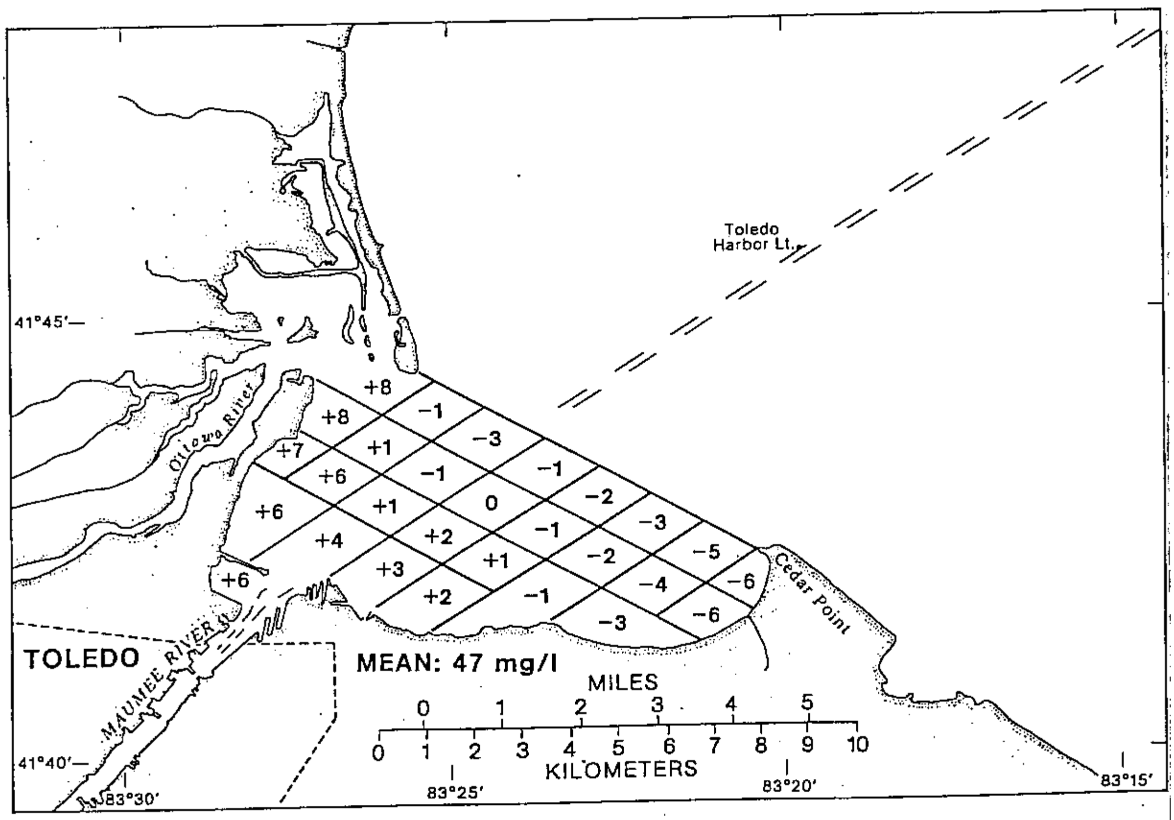


Figure 19. Deviation of calcium in Maumee Bay.

SOURCE: Pinsak, A.P. and T.L. Meyer. 1976. Environmental baseline for Maumee Bay. Great Lakes Basin Commission, Maumee River Basin Level B Study. 164 p.

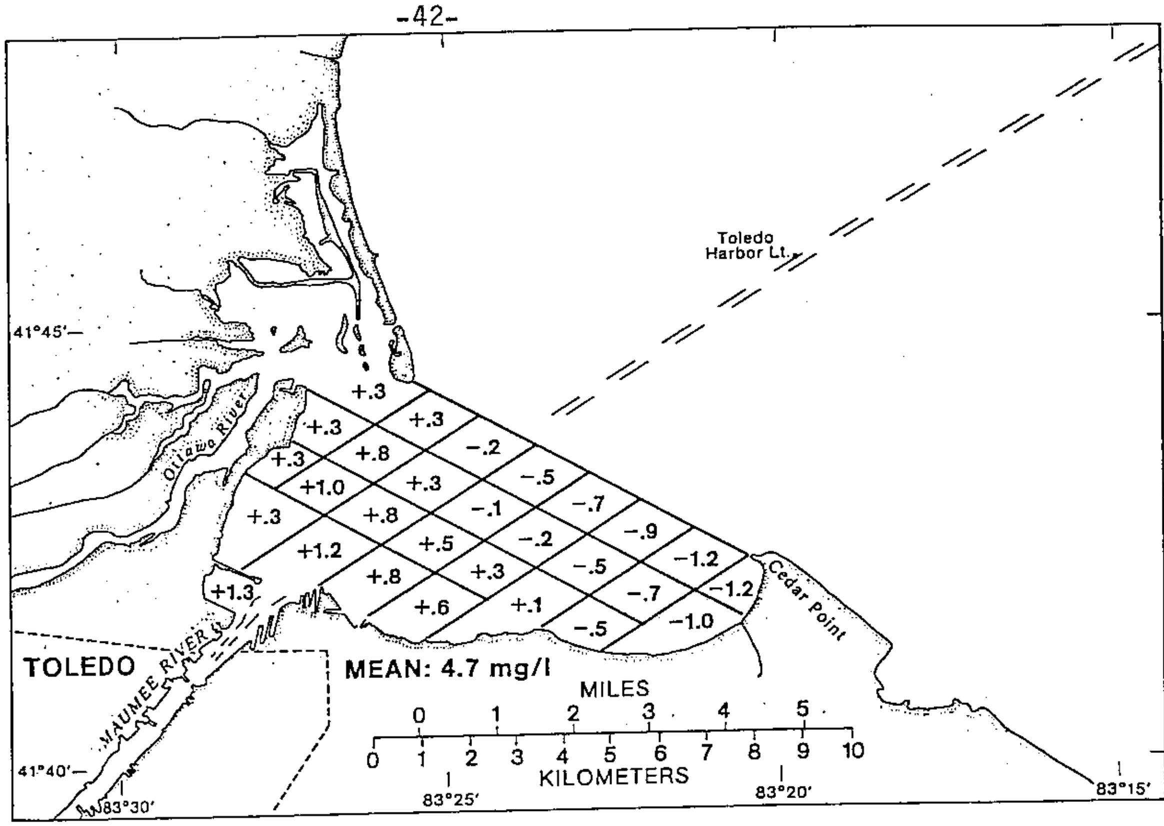


Figure 20. Deviation of potassium in Maumee Bay.

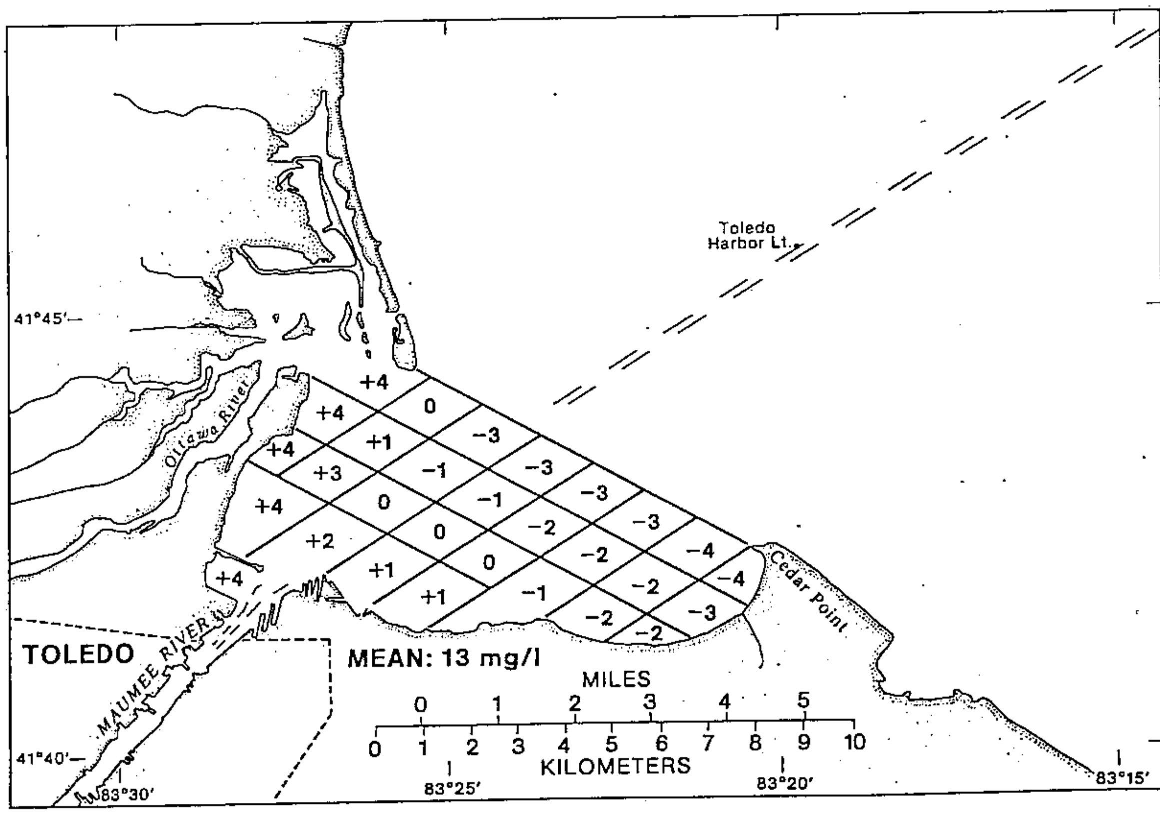


Figure 21. Deviation of magnesium in Maumee Bay.

SOURCE: Pinsak, A.P. and T.L. Meyer. 1976. Environmental baseline for Maumee Bay. Great Lakes Basin Commission, Maumee River Basin Level B Study. 164 p.

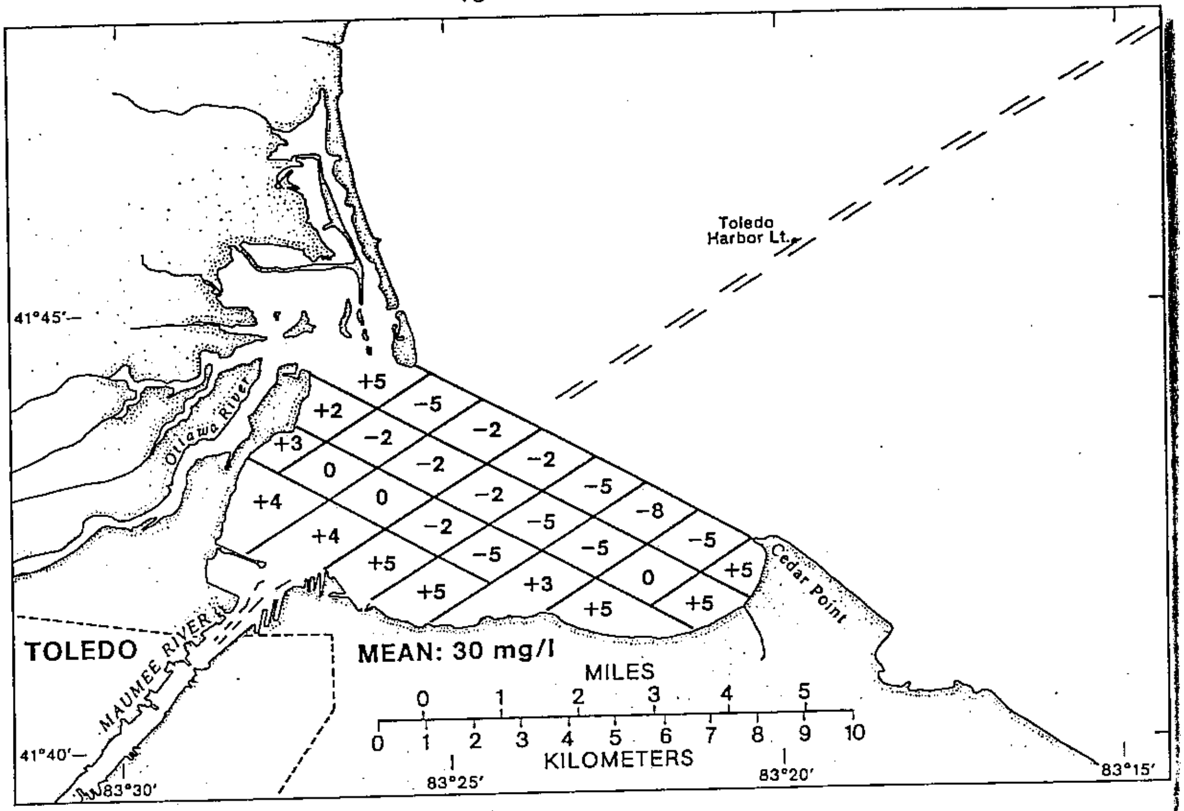


Figure 22. Deviation of chloride in Maumee Bay.

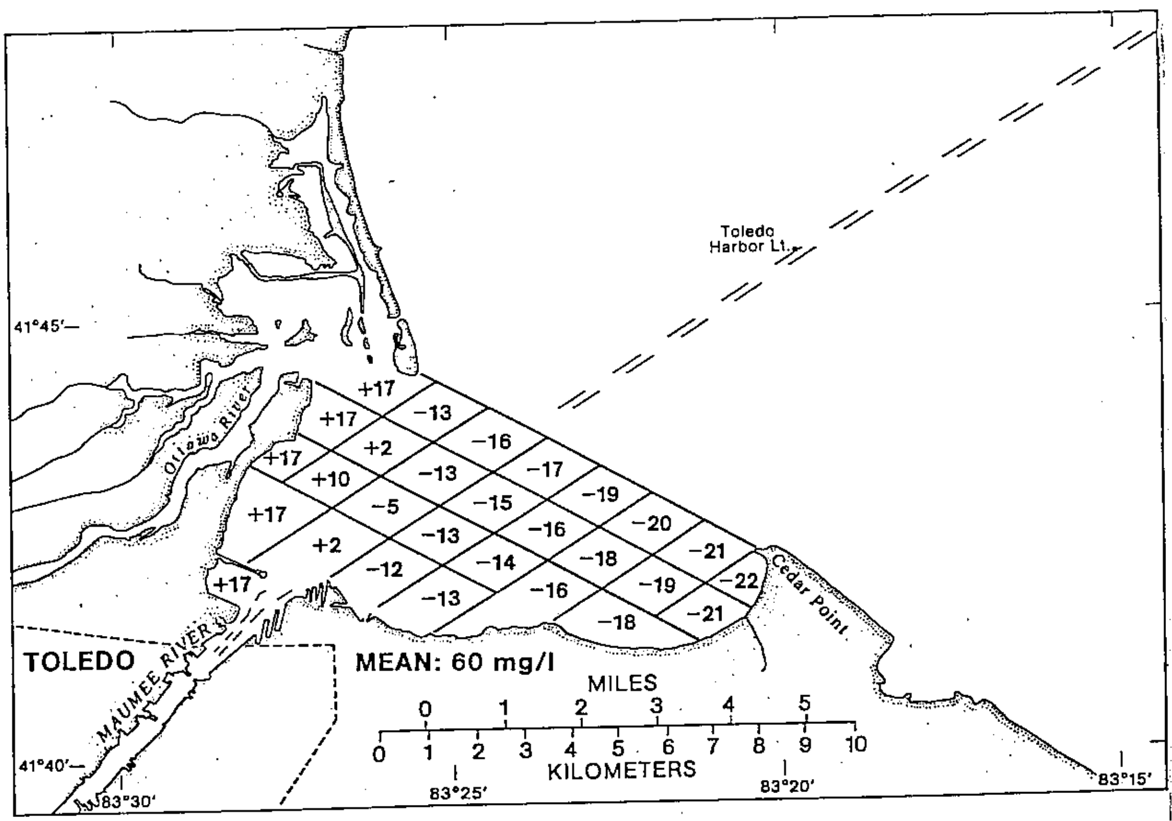


Figure 23. Deviation of sulfate in Maumee Bay.

SOURCE: Pinsak, A.P. and T.L. Meyer. 1976. Environmental baseline for Maumee Bay. Great Lakes Basin Commission, Maumee River Basin Level B Study. 164 p.

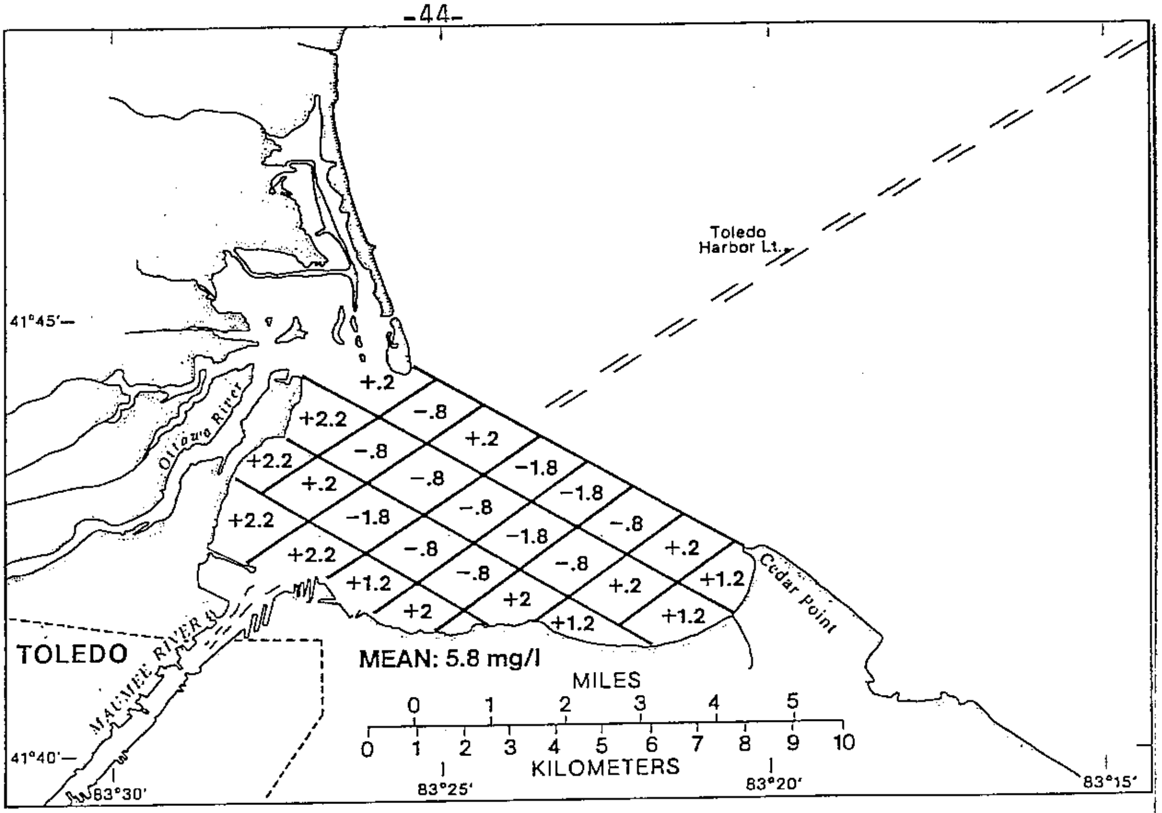


Figure 24. Deviation of nitrate in Maumee Bay.

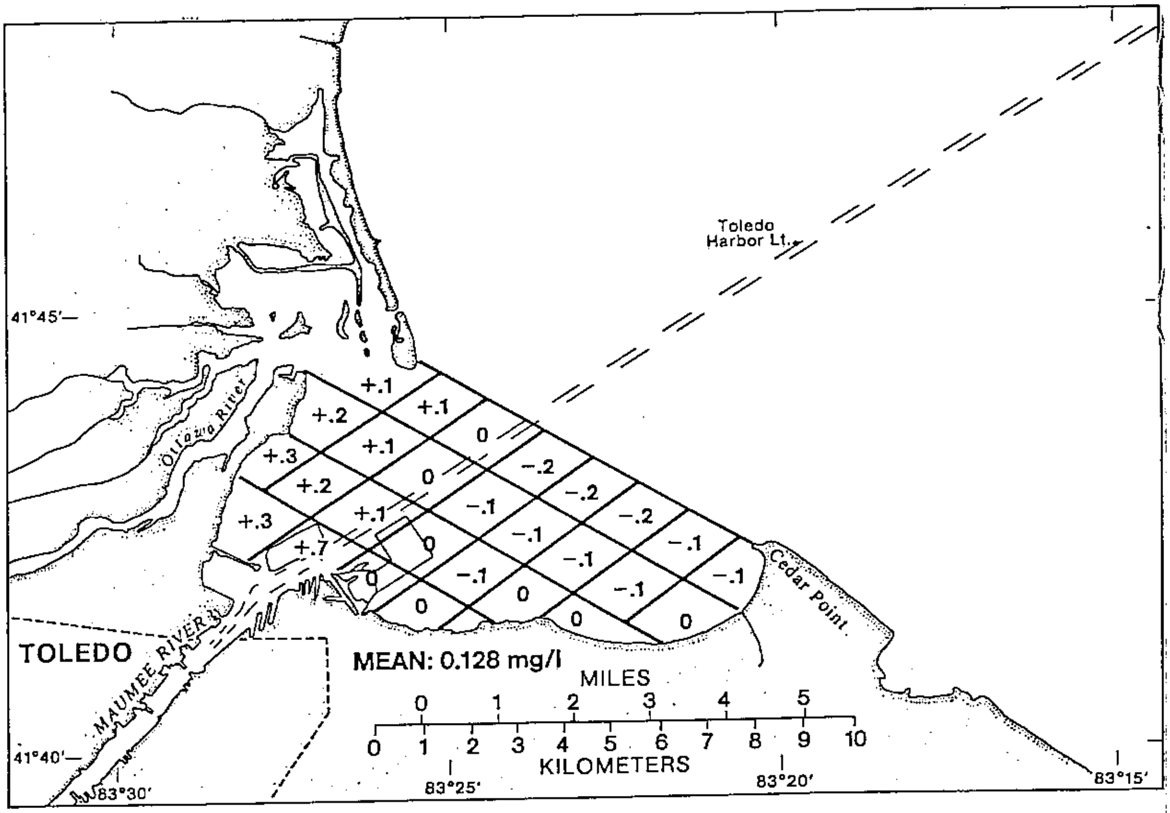


Figure 25. Orthophosphate in the Maumee River.

SOURCE: Pinsak, A.P. and T.L. Meyer. 1976. Environmental baseline for Maumee Bay. Great Lakes Basin Commission, Maumee River Basin Level B Study. 164 p.

Locust Point

The quality of the water in the vicinity of the Davis-Besse Nuclear Power Station at Locust Point during the period April through July 1977 was typical for the south shore of western Lake Erie and showed normal seasonal change. Water temperature rose nearly 13°C during the period from April to July while the dissolved oxygen level fell 5 ppm. The turbulence of the early spring period and the corresponding high sediment load are reflected in the high turbidity and suspended solids values and low transparency observed for April (Figure 26). A 5-fold improvement in the clarity of the water took place between April and May. The biochemical oxygen demand was rather low during the entire period even at the time of high turbidity, indicating that the suspended material was largely of an inorganic nature. In a like manner, most dissolved substances in the water were highest in the early spring and decreased later in the season (Figures 27-29). Alkalinity and pH remained relatively constant while the major ions such as calcium and sulfate decreased significantly. Biological nutrients, such as nitrate and phosphorus, also showed notable decreases as spring algal populations utilized these materials.

The water quality in the vicinity of Locust Point during the period of July through November 1977 was typical for western Lake Erie and showed normal seasonal change. Water temperature fell 19°C during the 5-month period while the dissolved oxygen (DO) level rose 5 ppm (Figure 30). In July 1977 the DO at Station 1 (bottom) dropped to 3.0 ppm, the lowest value recorded since 1972.

Year	Dissolved Oxygen Range
1974	5.7 - 14.1 ppm
1975	7.2 - 13.6 ppm
1976	5.0 - 12.5 ppm
1977	3.0 - 12.2 ppm

Biochemical oxygen demand, which is related to the suspended organic material in the water, was low and nearly constant throughout the year. Dissolved substances in the water were highest in the spring and fall samples; conductivity showed a significant decrease between April and June but remained relatively stable in the summer (Figure 27). Specific ions such as calcium, sulfate, and chloride were also highest in April and were fairly stable throughout the fall (Figure 28). The important nutrients, such as nitrate and phosphate, for primary productivity by green and blue-green algae had a peak in the spring, decreased markedly during the summer and then increased in the fall (Figure 29). A diatom bloom in April resulted in a low value for silica, whereas the green and blue-green algae utilized nitrogen in the summer and fall.

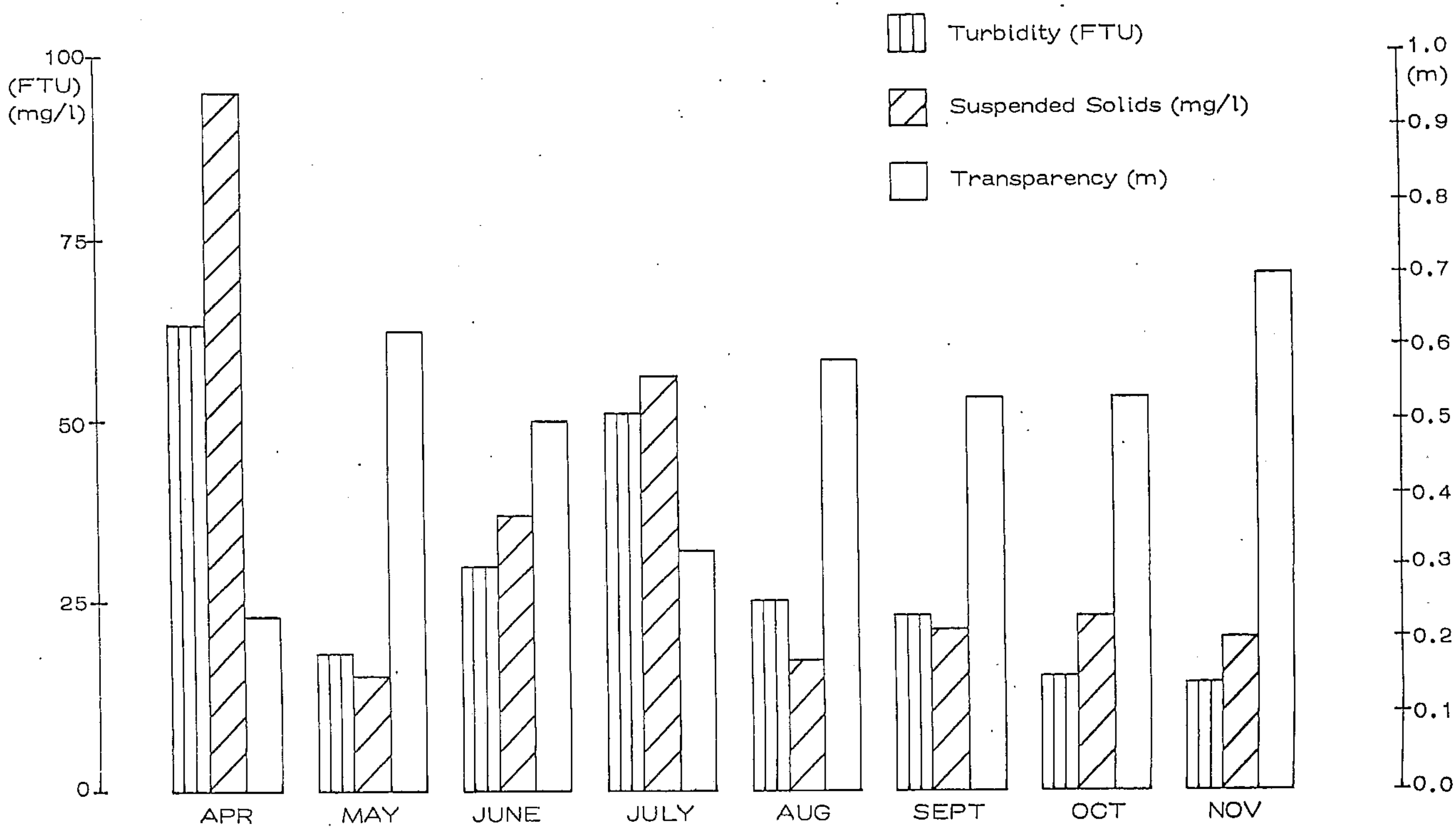
The alkalinity and pH of the water remained fairly constant throughout the year. Lake Erie is primarily a bicarbonate solution with a corresponding moderately alkaline pH of approximately 8.3. The bicarbonate in the water provides an abundant source of carbon for algae production. The pH showed a slight rise in summer (8.9 maximum) which corresponded with the bloom of the blue-green, Aphanizomenon sp.

Stations 1, 8, and 13 are located approximately 0.15, 0.9, and 0.45 km offshore respectively. Generally a slight temperature decrease was noted in an offshore direction in the spring. Slight decreases were also found for such parameters as conductivity, most of the specific ions, alkalinity, B.O.D., suspended and dissolved solids, and turbidity throughout the year. Conversely, transparency increases away from the shore. Station 8 (the farthest offshore) had the best water quality; Station 1 (nearshore) had the poorest quality for most parameters. Water quality measurements further offshore (Table 11) indicate better quality with increasing distance from the shoreline. Offshore, transparency increases and specific conductance decreases, indicating lowerlevels of dissolved and suspended solids. The differential in water quality values was greatest in spring and fall which may have been related to seasonal storms. During the summer no difference was found between the inshore and offshore stations.

Differences between the surface and bottom water quality were slight because of the shallowness of this portion of Lake Erie. Some depression in the level of dissolved oxygen and small increases in the concentrations of dissolved and suspended solids were noted near the bottom, particularly at Station 1.

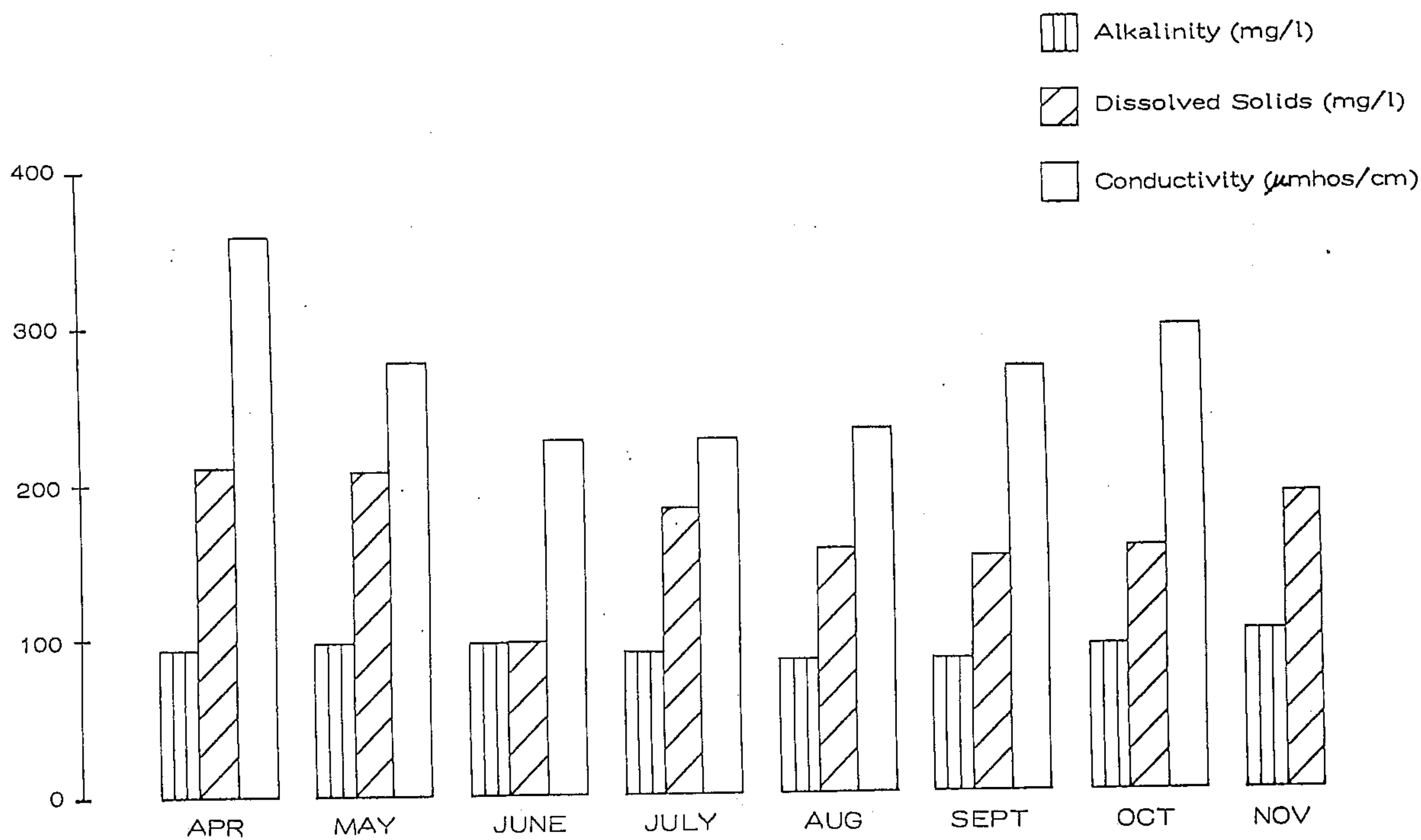
The Ohio State University, Center for Lake Erie Area Research initiated water quality studies at Locust Point in July 1972. Over the past six years most parameters have shown typical seasonal cycles with only small variations from year to year. Cycles for eight water quality parameters from June 1972 through November 1977 are shown on Figures 30-32. Temperature and dissolved oxygen show typical seasonal cycles for each year with only minor variations from one year to the next. Dissolved oxygen appears to have undergone more depletion in 1976 and 1977 than in previous years. Hydrogen-ion concentration and alkalinity remained fairly stable over the period. Transparency, turbidity, phosphorus and conductivity values have shown radical variations which are probably due to storms that have disturbed the bottom sediments. Phosphorus levels were low in 1977 compared to earlier years. In general, however, no significant deviations from the normal quality of the water in this part of western Lake Erie have been observed in the past six years (Herdendorf, 1978).

FIGURE 26. MEAN MONTHLY TURBIDITY, SUSPENDED SOLIDS, AND TRANSPARENCY MEASUREMENTS FOR LAKE ERIE AT LOCUST POINT DURING 1977



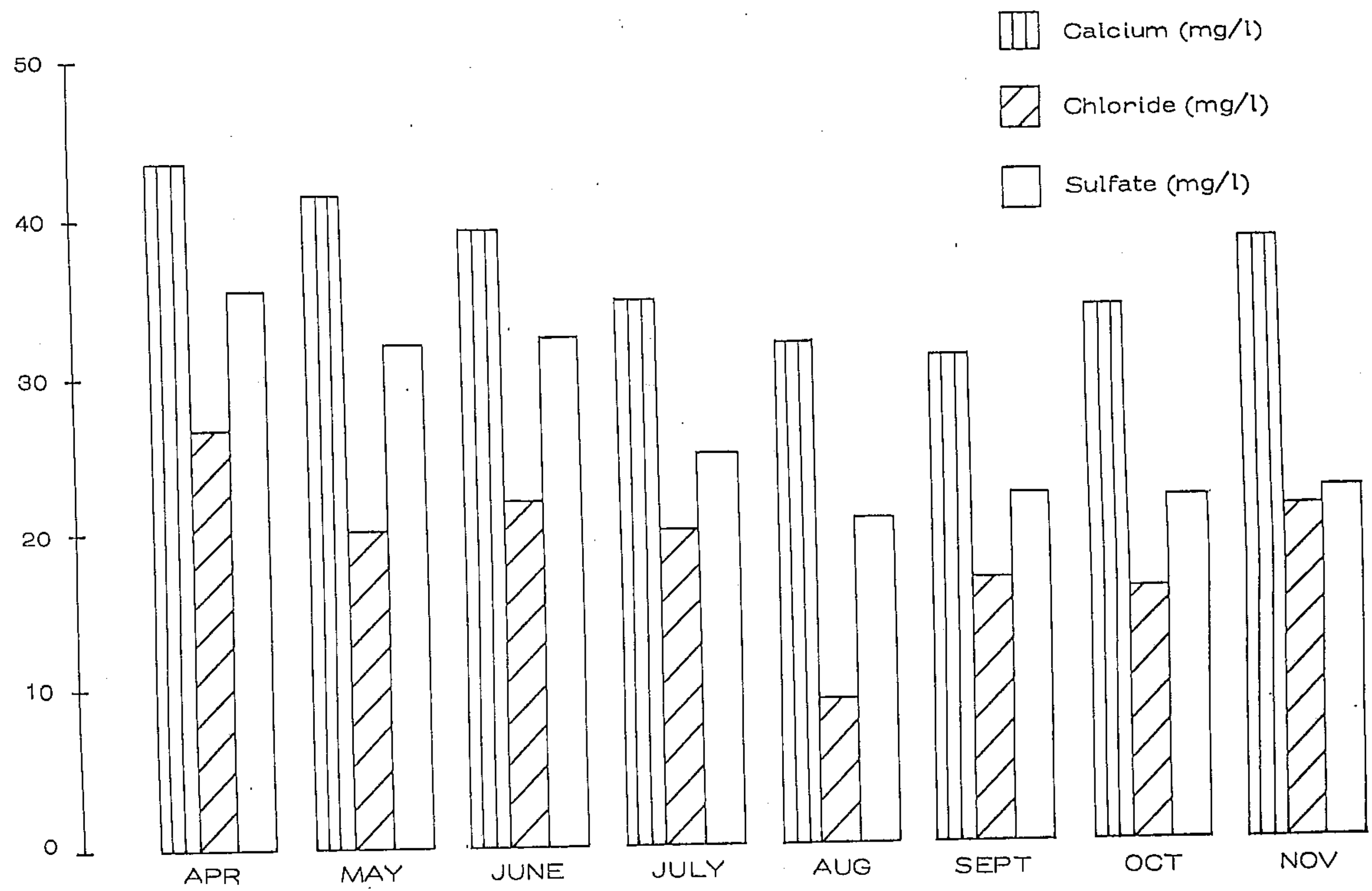
SOURCE: Herdendorf, C.E. 1978. CLEAR Tech. Rept. No. 82. Ohio State Univ., Columbus, Ohio. 27 p

FIGURE 27. MEAN MONTHLY ALKALINITY, DISSOLVED SOLIDS AND CONDUCTIVITY MEASUREMENTS FOR LAKE ERIE AT LOCUST POINT DURING 1977.



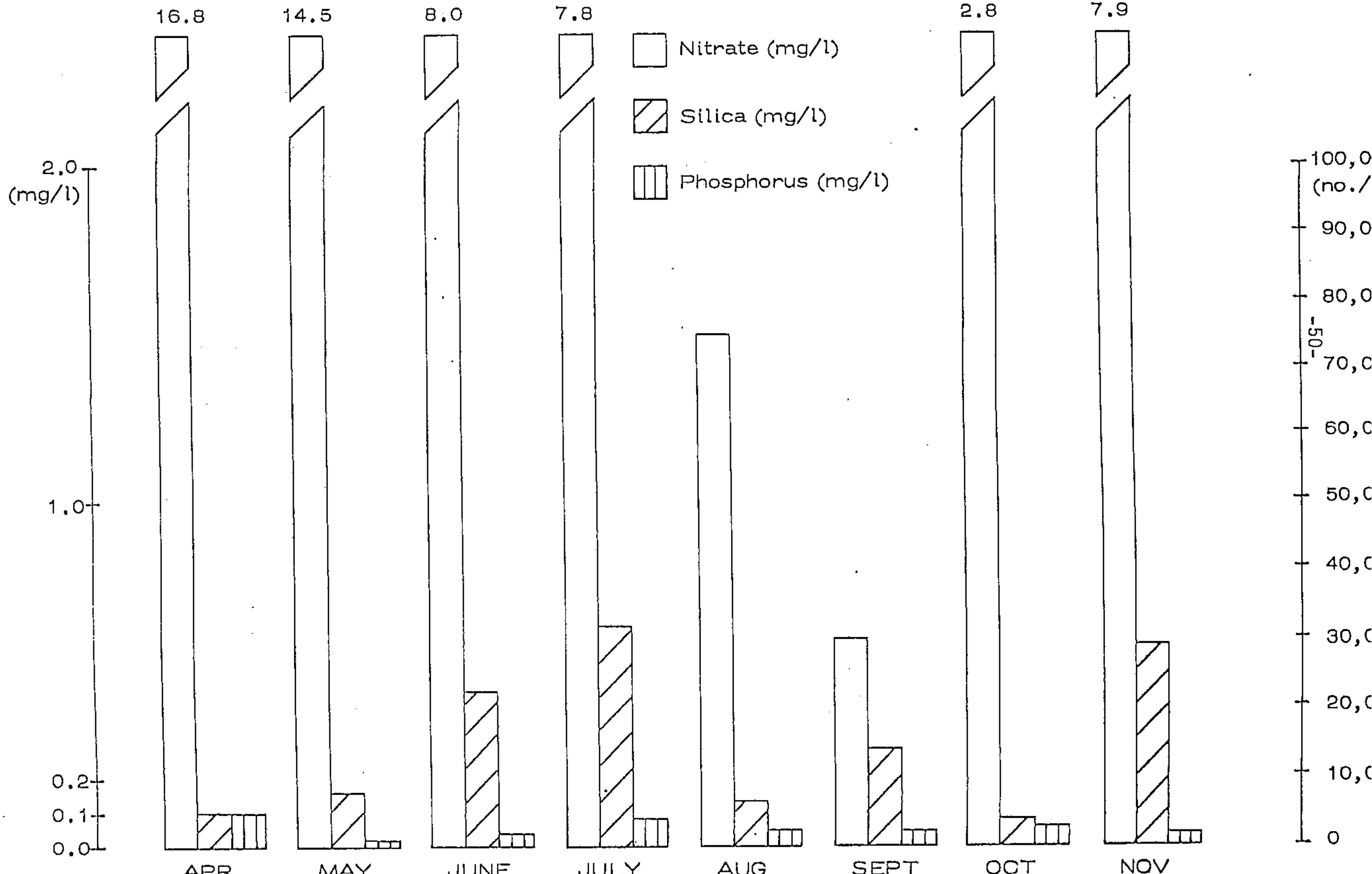
SOURCE: Herdendorf, C.E. 1978. CLEAR Tech. Rept. No. 82. Ohio State Univ., Columbus, Ohio. 27 p

FIGURE 28. MEAN MONTHLY CALCIUM, CHLORIDE AND SULFATE CONCENTRATIONS IN LAKE ERIE AT LOCUST POINT DURING 1977



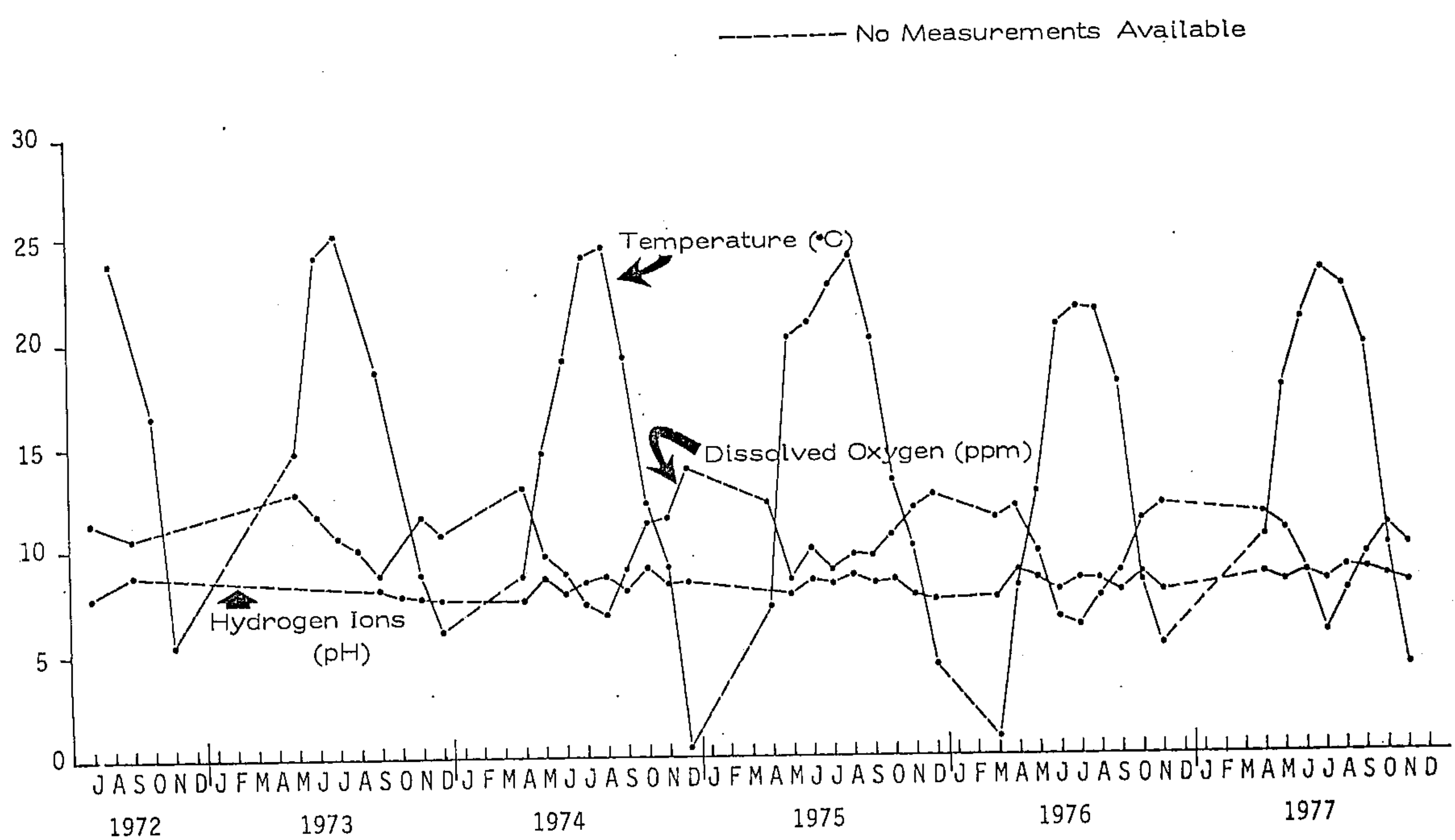
SOURCE: Herdendorf, C.E. 1978. CLEAR Tech. Rept. No. 82. Ohio State Univ., Columbus, Ohio. 27 p

FIGURE 29. MEAN MONTHLY NITRATE, PHOSPHORUS, AND SILICA CONCENTRATIONS IN LAKE ERIE AT LOCUST POINT DURING 1977



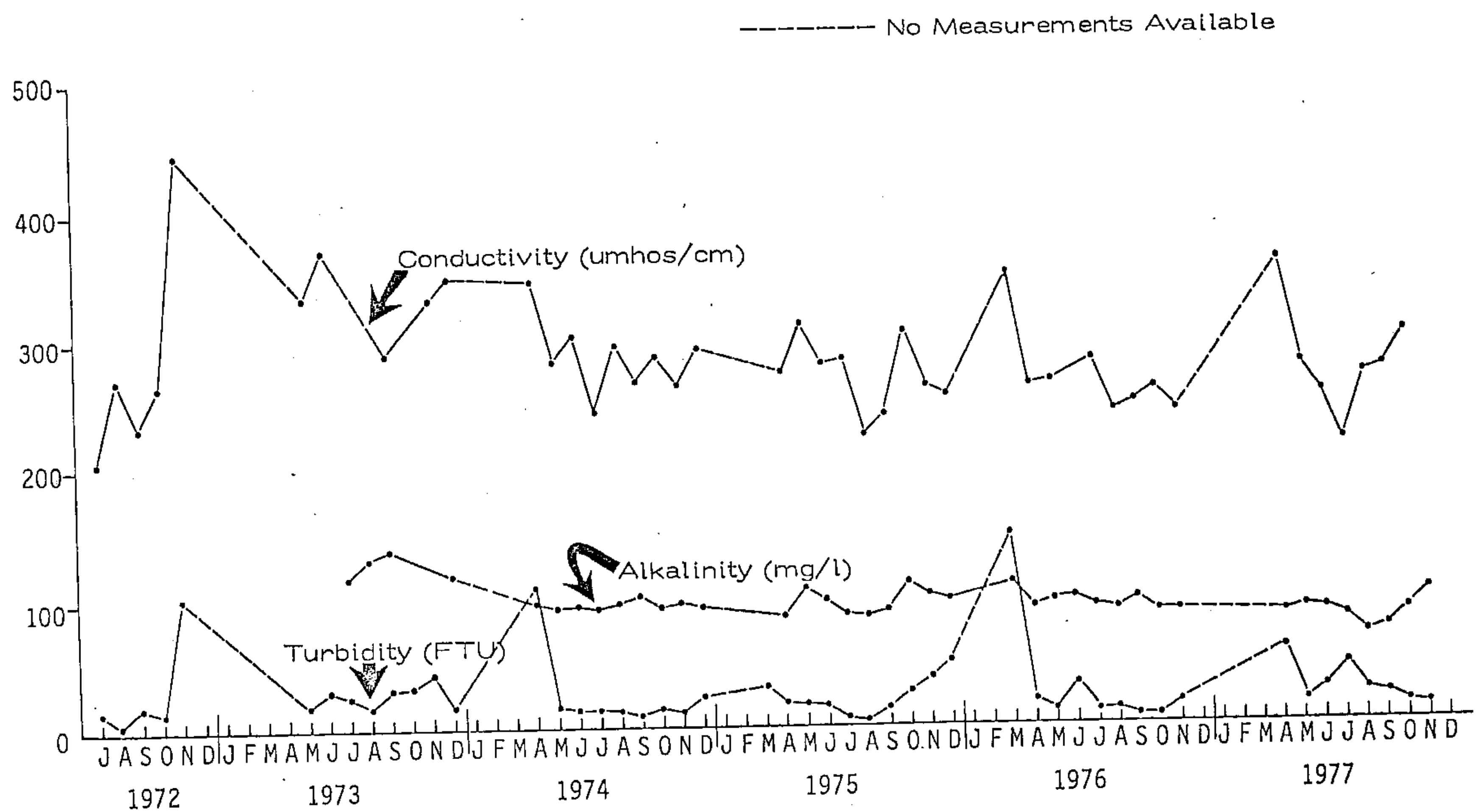
SOURCE: Herdendorf, C.E. 1978. CLEAR Tech. Rept. No. 82. Ohio State Univ., Columbus, Ohio. 27 p

FIGURE 30. CYCLES IN MEAN MONTHLY TEMPERATURE, DISSOLVED OXYGEN, AND HYDROGEN ION MEASUREMENTS FOR LAKE ERIE AT LOCUST POINT FOR THE PERIOD 1972–1977



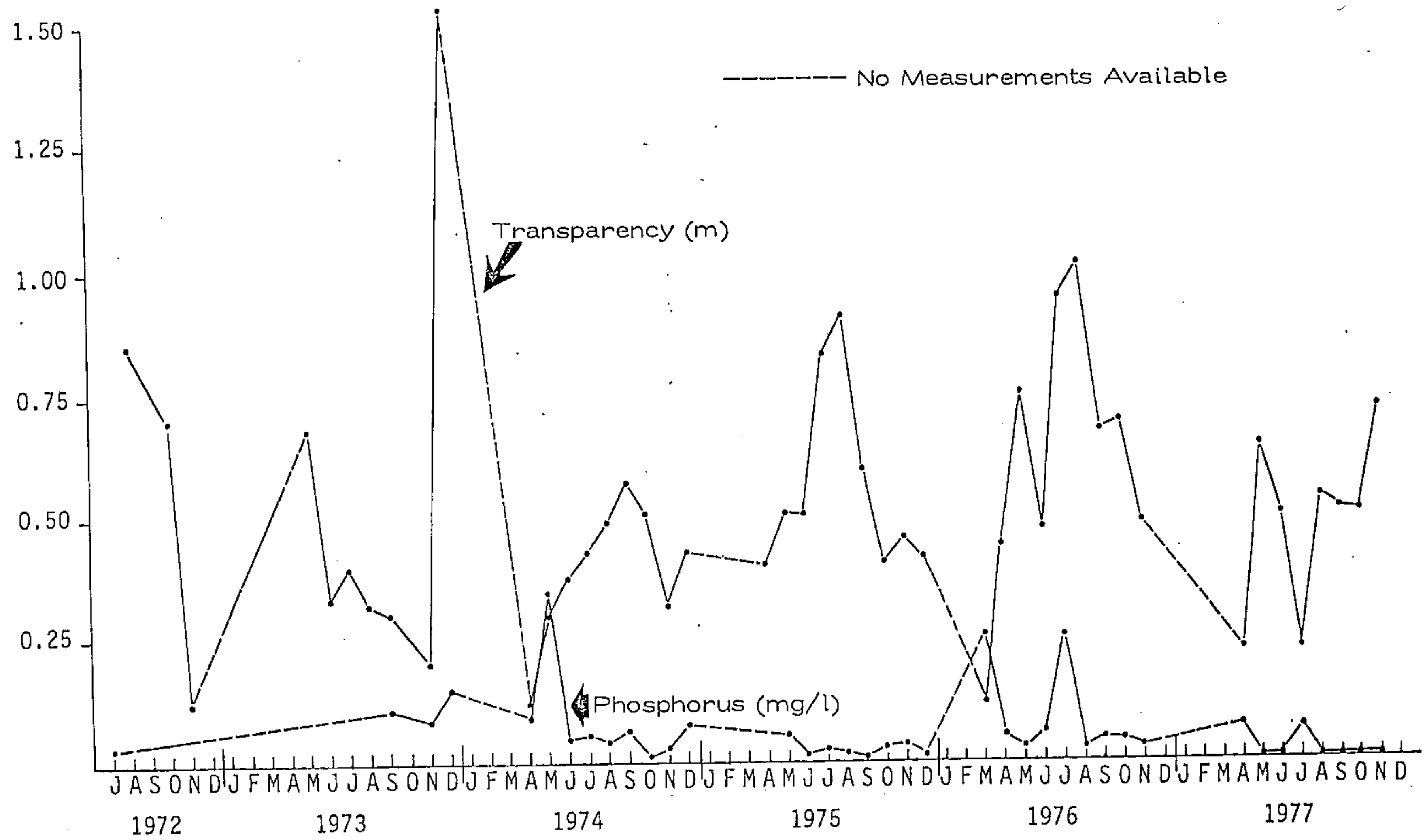
SOURCE: Herdendorf, C.E. 1978. CLEAR Tech. Rept. No. 82. Ohio State Univ., Columbus, Ohio. 27 p

FIGURE 31. CYCLES IN MEAN MONTHLY CONDUCTIVITY, ALKALINITY AND TURBIDITY MEASUREMENTS FOR LAKE ERIE AT LOCUST POINT FOR THE PERIOD 1972-1977



SOURCE: Herdendorf, C.E. 1978. CLEAR Tech. Rept. No. 82. Ohio State Univ., Columbus, Ohio. 27 p

FIGURE 32. CYCLES IN MEAN MONTHLY TRANSPARENCY AND PHOSPHORUS MEASUREMENTS FOR LAKE ERIE AT LOCUST POINT FOR THE PERIOD 1972-1977



SOURCE: Herdendorf, C.E. 1978. CLEAR Tech. Rept. No. 82. Ohio State Univ., Columbus, Ohio. 27 p

TABLE 11

SUMMARY OF WATER QUALITY MEASUREMENTS TAKEN 1.6 AND 15 KILOMETERS OFFSHORE OF LOCUST POINT, OTTAWA COUNTY, OHIO, 1974-1975

PARAMETER	YEAR	STATION 76 (1.6 km offshore) RANGE	STATION 76 MEAN	STATION 58 (15 km offshore) RANGE	STATION 58 MEAN	ISLAND REGION OF WESTERN BASIN MEAN
Temperature (°C)	1974 1975	5.5-24.0 4.0-25.8	15.9 17.7	4.0-23.2 1.0-24.0	15 16.4	- -
Transparency (m)	1974 1975	0.2-1.5 0.3-2.2	0.7 1.0	0.5-2.2 0.8-2.0	1.2 1.2	1.5 1.1
Conductivity (μmhos/cm)	1974 1975	252-322 212-314	284 237	234-269 191-223	257 212	259 224
Dissolved Oxygen (mg/l)	1974 1975	7.8-11.6 8.9-13.0	9.9 10.2	5.2-12.0 7.2-13.6	9.8 9.4	10 9.6
Ammonia Nitrogen (μg/l-N)	1974 1975	0-73 2-23	20 10	4-121 18-60	33 36	25.2 89.3
Total Phosphorus (μg/l-P)	1974 1975	15-92 27-80	46 48	21-56 32-55	38 40	33.6 44
Dissolved Phosphorus (μg/l-P)	1974 1975	2-92 0-14	46 4	0-18 2-25	6 9	3.8 9
Chlorophyll a (μg/l)	1974 1975	2.24-41.02 12.6-36.98	19.71 24.24	2.55-18.87 3.04-23.94	10.79 13.66	10.88 12.58

SOURCE: Lake Erie Nutrient Study. Center for Lake Erie Area Research, The Ohio State University, Columbus, Ohio.

Port Clinton

Water quality data from the vicinity of Port Clinton is limited in large part to water intake records. These data are summarized in Table 12. Over the 40 year period of record, mean alkalinity values have remained nearly stable while mean chloride levels have increased approximately 30 percent. During the 20 year interval 1950-1952 to 1973-1974, mean hydrogen ion concentrations (pH) and mean sulfate values were little changed. Mean conductivity values dropped over the period. Mean conductivity values were approximately 15 percent lower 4 km. offshore (Table 8). In all instances, the range of recorded values is wider in recent years. Occasional low dissolved oxygen concentrations were recorded in 1973 and 1974.

TABLE 12

SUMMARY OF WATER QUALITY MEASUREMENTS TAKEN AT OR NEAR THE PORT CLINTON WATER INTAKE, 1930-1974

DATE / PARAMETER	May 13 - Sept. 16/1930[a]		Sept./1950-Feb./1952[b]		Jan. 9-Dec. 18/1973[c]		Jan. 1-Sept. 30/1974[c]		Oct. 1-Dec. 31/1974[c]	
	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN
pH (STD UTS)	7.8-8.5	8.15	7.1-8.0	7.66	1.9-8.7	7.68	7.2-8.5	7.65	7.2-7.8	7.6
Conductivity µmhos/cm at 25°c	-	-	282-365	308	100-480	243.7	140-350	234.5	170-220	204
Sulfate (mg/l)	-	-	19-41	28	11.0-95.5	30.6	11-141	34	12.5-37	18.8
Chloride (mg/l)	11.8-22.7	14.8	11-24	18	10-34	21.3	18-32	23	30-46	36.7
Total Hardness (mg/l)	-	-	119-170	135	-	-	114-240	142.8	112-132	123.5
Alkalinity (mg/l)	94-101	96.6	-	-	44-156	95.8	88-145	99	94-102	96.6
Dissolved Oxygen (mg/l)	7.6-9.9	8.3	-	-	1.4-19.0	10.24	3.4-16.5	10.3	9.1-15.4	10.7

SOURCES: [a] Wright (1955)

[b] Lake Erie Pollution Survey - Supplement (1953)

[c] STORET

Huron, Ohio

The purpose of this section is to summarize the available water quality data and related reports from the Huron area. The Huron Harbor Dike Study (Gedeon, 1977) is the only comprehensive water quality study completed in the vicinity of Huron. The results of this study are graphically presented in Figures 33-46. Graphic interpretation is based on average parameter concentrations of stations grouped within the dike facility (located on the western breakwall at the harbor entrance), immediately adjacent to the dike, within the navigation channel at the Huron River mouth, and 1-1.5 km offshore. River mouth stations exhibited the greatest range of variability reflecting either lake conditions, river conditions or river water being overridden by lake water. Depending on wind speed and direction, it was possible for open lake water to override river due to temperature and density differences of the discrete water masses. However, no evidence of hypolimnetic open lake water intruding into the Huron Harbor area was observed during the course of the study.

Water temperatures followed the annual cycle gradually increasing from approximately 6°C in early April to nearly 23°C in late July and early August (Figure 33). Temperatures declined rapidly in late summer and fall, reaching 3.5°C in early November. Average dissolved oxygen concentrations in the study area steadily decreased from approximately 10 mg/l in April to about 3 mg/l in mid-September (Figure 34). Similar conditions have been recorded 4 km offshore while anoxic conditions occur 17.5 km offshore during the late summer (Table 13). In the fall, dissolved oxygen values increased rapidly, reaching over 11 mg/l by early November. With oxygenated water present throughout the study period, oxidation-reduction potential (Eh) values indicated a relatively high potential (Figure 35). Chemical oxygen demand (COD) values were highest during storm periods in early April when bottom sediments were resuspended (Figure 36).

Average hydrogen ion concentrations (Figure 37) in the study area, exclusive of the interior of the dike facility, averaged 8.2. Average conductivity values (Figure 38) adjacent to the dike averaged 218 µmhos/cm while offshore station values averaged 283 µmhos/cm. Mean values similar to the latter have been recorded 4 km and 17.5 km offshore of Huron (Table 13). Seasonal changes in turbidity values (Figure 39) reflect runoff carried by the river as well as sediment resuspension in the nearshore zone, both associated with spring and fall storm periods.

Average ammonia values (Figure 40) near the dike and offshore were identical, 0.04 mg/l. Mean ammonia values 4 km and 17.5 km offshore from 1973 through 1975 were approximately 0.02 mg/l (Table 13). Nitrate-nitrite concentrations (Figure 41) near the dike, at the river mouth and offshore averaged 0.38, 0.40 and 0.39 mg/l, respectively. Excessively high April values probably reflect contaminated samples rather than high nutrient runoff or resuspension. Kjeldahl-nitrogen concentrations (Figure 42) doubled between mid-April and early August.

Average phosphorus values, both ortho (dissolved) and total, were highest at the river mouth, 31 µg/l and 79 µg/l, respectively. Offshore values averaged 22 μg/l for ortho-phosphorus and 65 μg/l for total phosphorus. During the 1973-1975 period, mean values for ortho-phosphorus ranged between 6 and 7 μg/l and between 3 and 11 μg/l at stations 4 km and 17.5 km offshore (Table 13), respectively. Mean annual values for total phosphorus ranged between 7 and 42 μg/l and between 20.7 and 26 μg/l at the respective offshore stations (Table 13).

Iron concentrations (Figure 45) adjacent to the dike averaged 0.873 mg/l. Offshore stations averaged 0.850 mg/l. The very high values recorded from all samples can probably be attributed to loss of taconite during transfer from lake carrier to rail cars in the Port of Huron. These values exceed the 0.3 mg/l limit of current or proposed standards (see Appendix A).

Published water quality records from the Huron water intake for 1950 through 1952 and 1973 through 1974 are summarized in Table 14. Mean conductivity, sulfate and total hardness values show little change. Mean chloride values increased approximately 16 percent over the 20 year interval.

Water quality data has been collected east of Huron in the vicinity of the intake structure site for the proposed Erie Nuclear Plant. Records from September, 1973 to August, 1974, are summarized in Table 15.

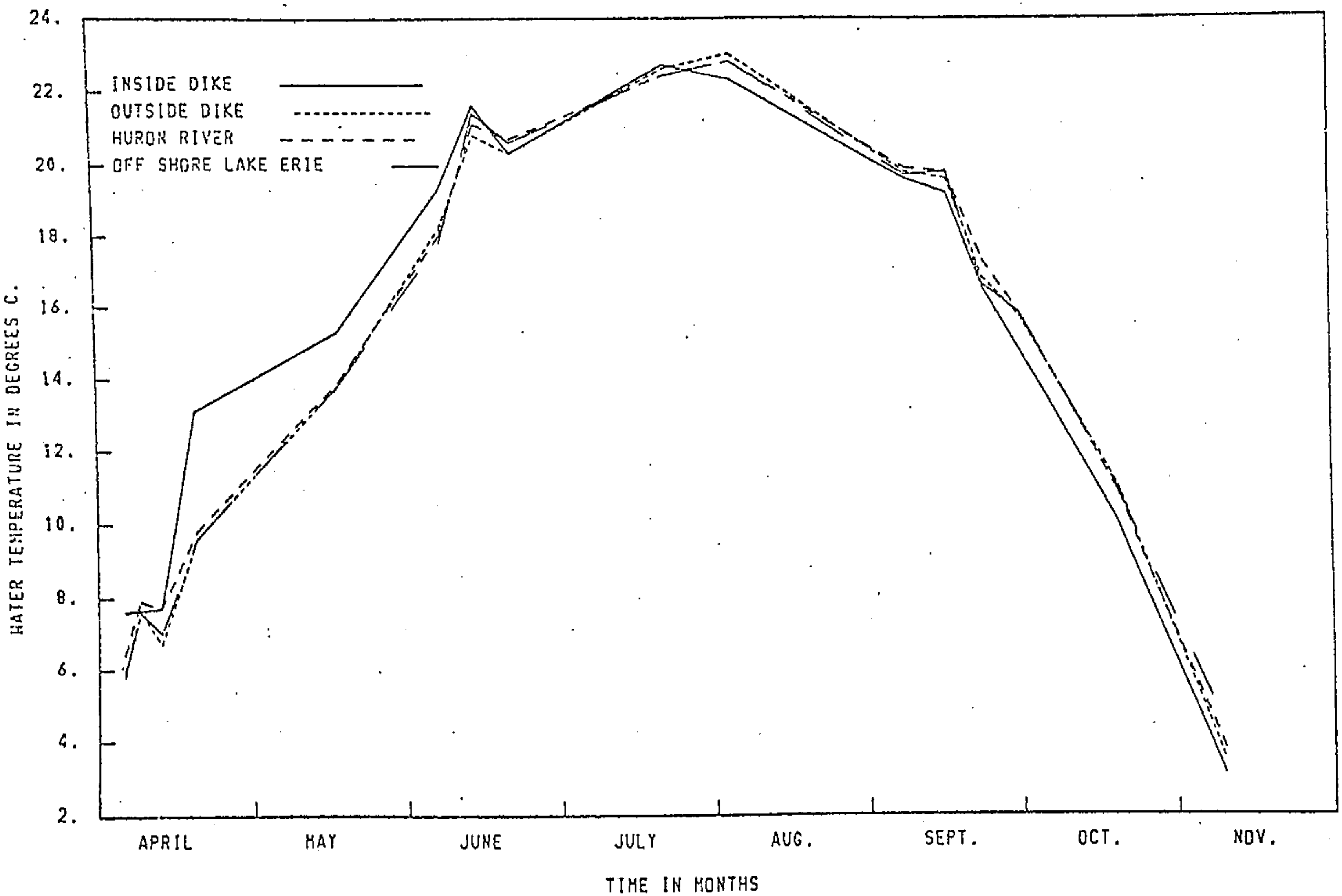


FIGURE 33. WATER TEMPERATURE IN DEGREES C. VS TIME, 1976

SOURCE: Gedeon, A.S. 1977. 1976 Huron Harbor, Ohio, dike study. USEPA Region V Michigan-Ohio District Office. 126 p.

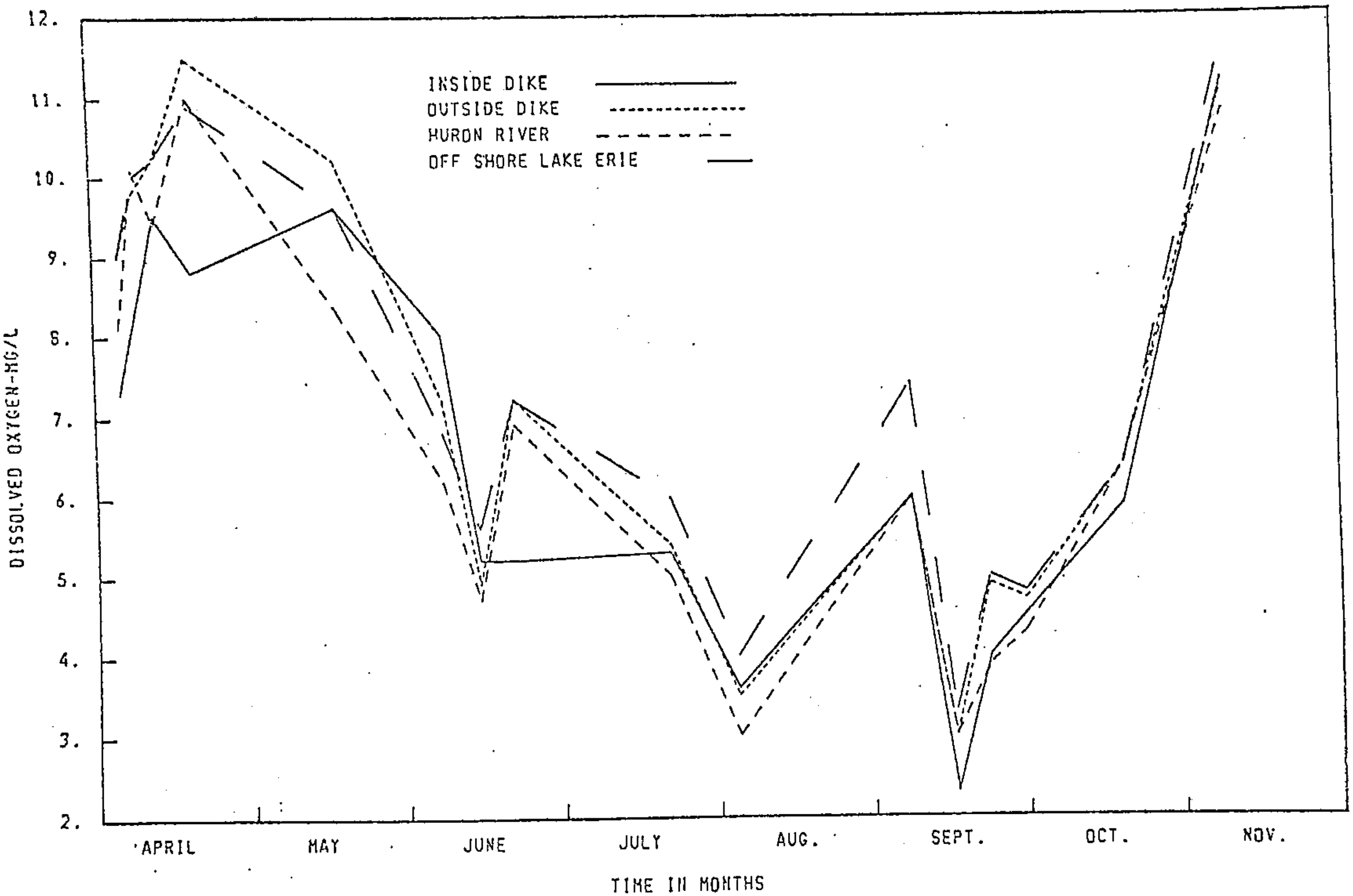


FIGURE 34. DISSOLVED OXYGEN-MG/L VS TIME, 1976

SOURCE: Gedeon, A.S. 1977. 1976 Huron Harbor, Ohio, dike study. USEPA Region V Michigan-Ohio District Office 126 p.

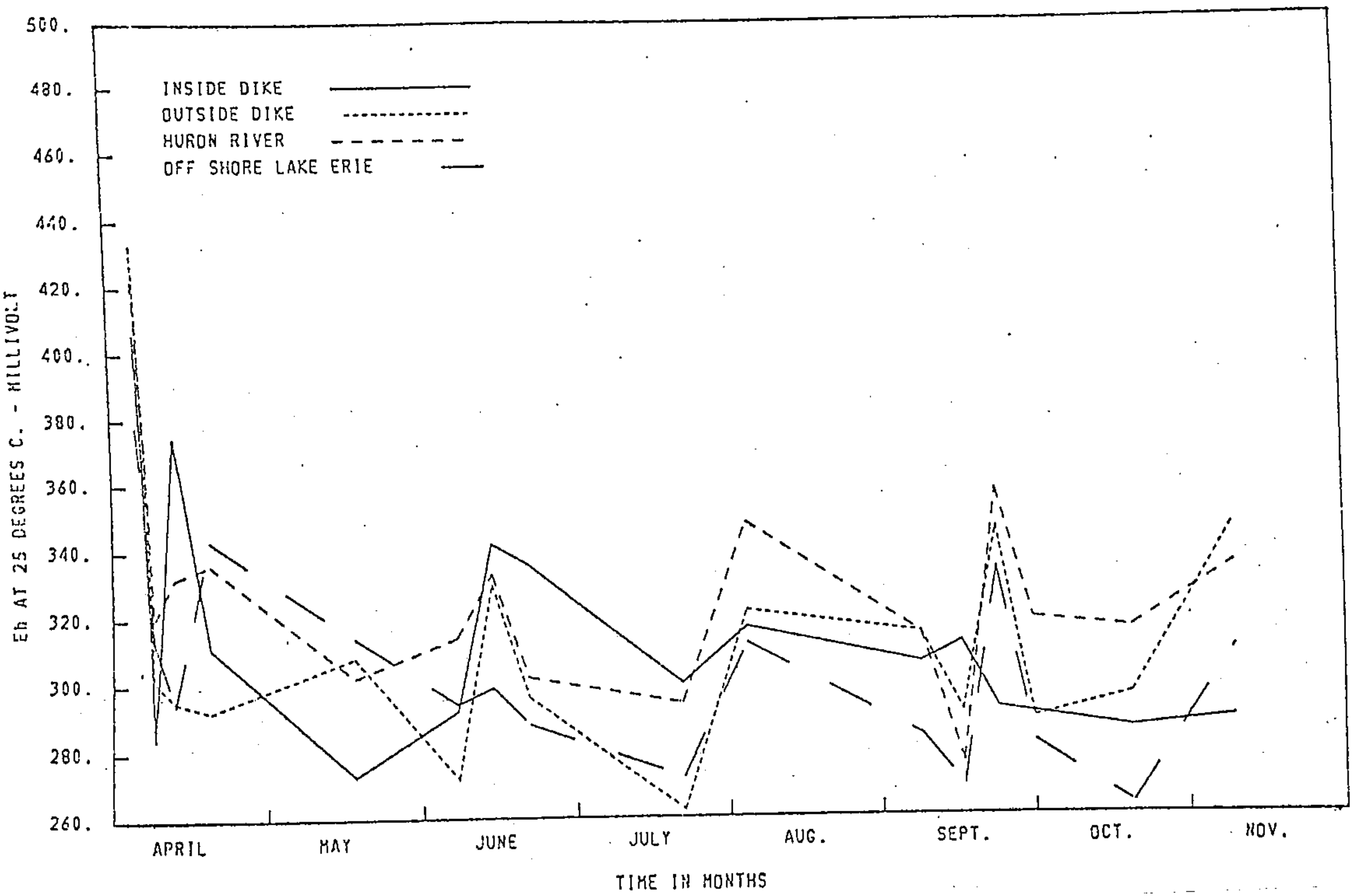


FIGURE 35. Eh AT 25 DEGREES C. - MILLIVOLTS VS TIME, 1976

SOURCE: Gedeon, A.S. 1977. 1976 Huron Harbor, Ohio, dike study. USEPA Region V Michigan-Ohio District Office 126 p.

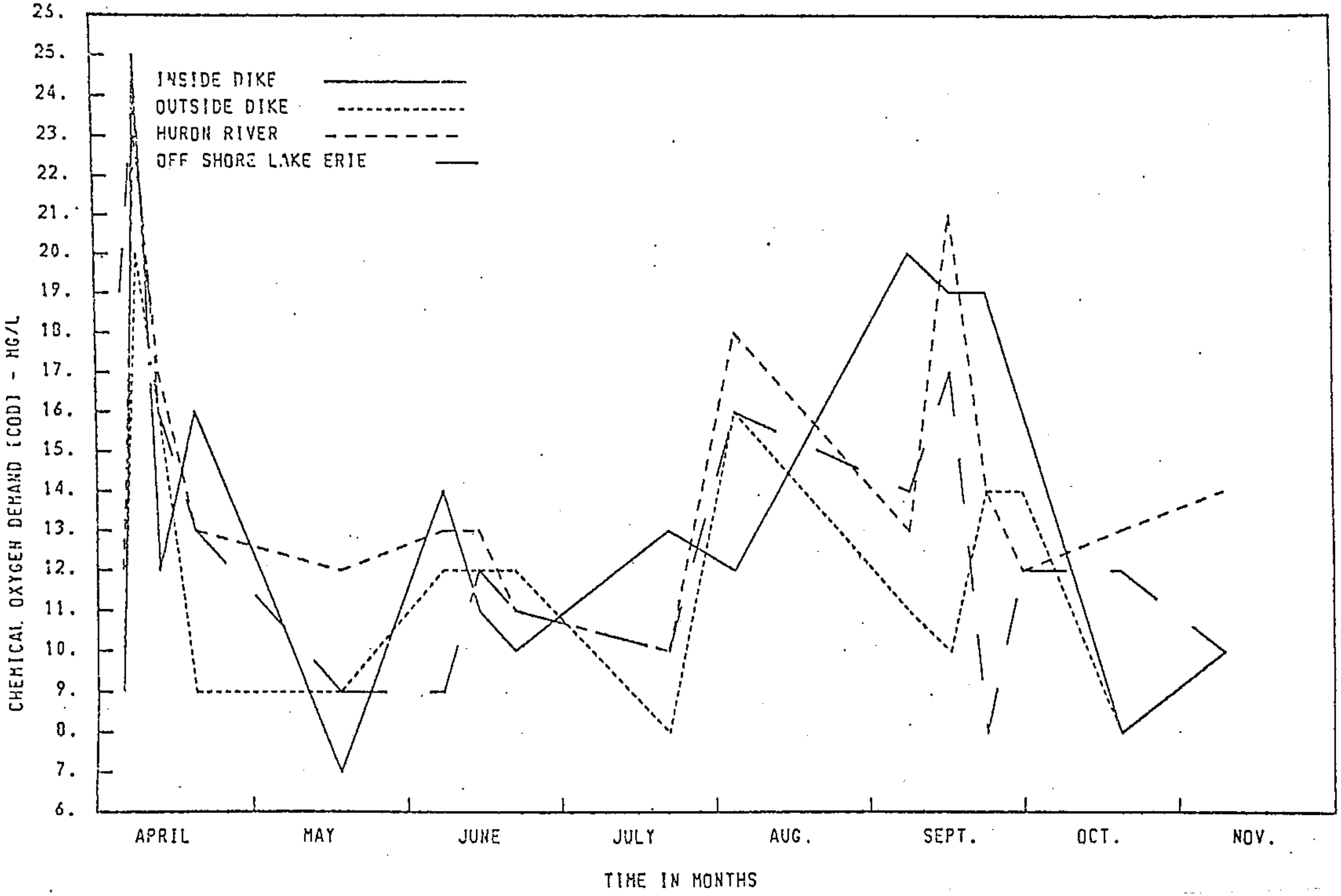


FIGURE 36. CHEMICAL OXYGEN DEMAND (COD) - MG/L VS TIME, 1976

SOURCE: Gedeon, A.S. 1977. 1976 Huron Harbor, Ohio, dike study. USEPA Region V Michigan-Ohio District Office 126 p.

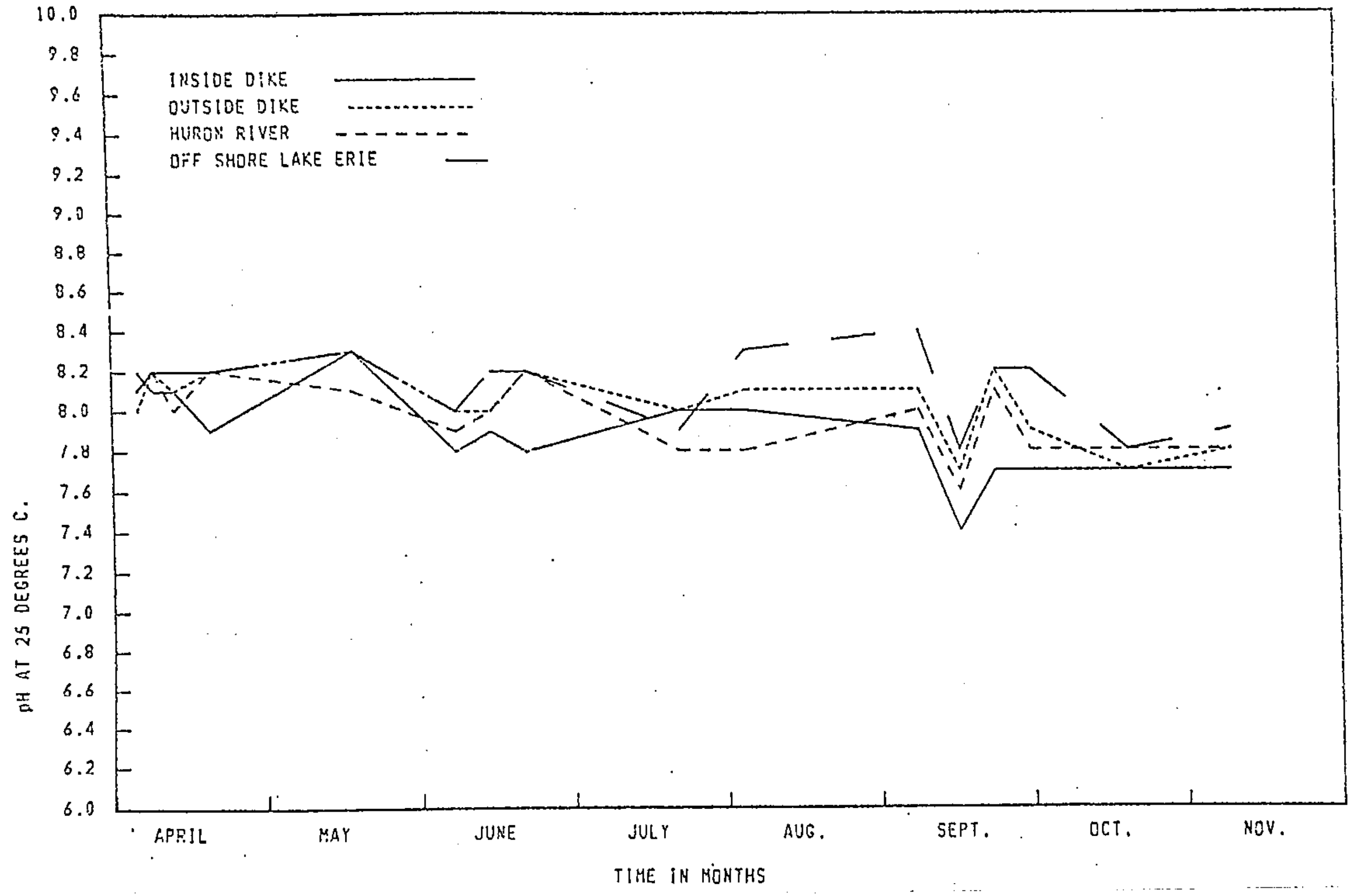


FIGURE 37. pH AT 25 DEGREES C. VS TIME, 1976

SOURCE: Gedeon, A.S. 1977. 1976 Huron Harbor, Ohio, dike study. USEPA Region V Michigan-Ohio District Office 126 p.

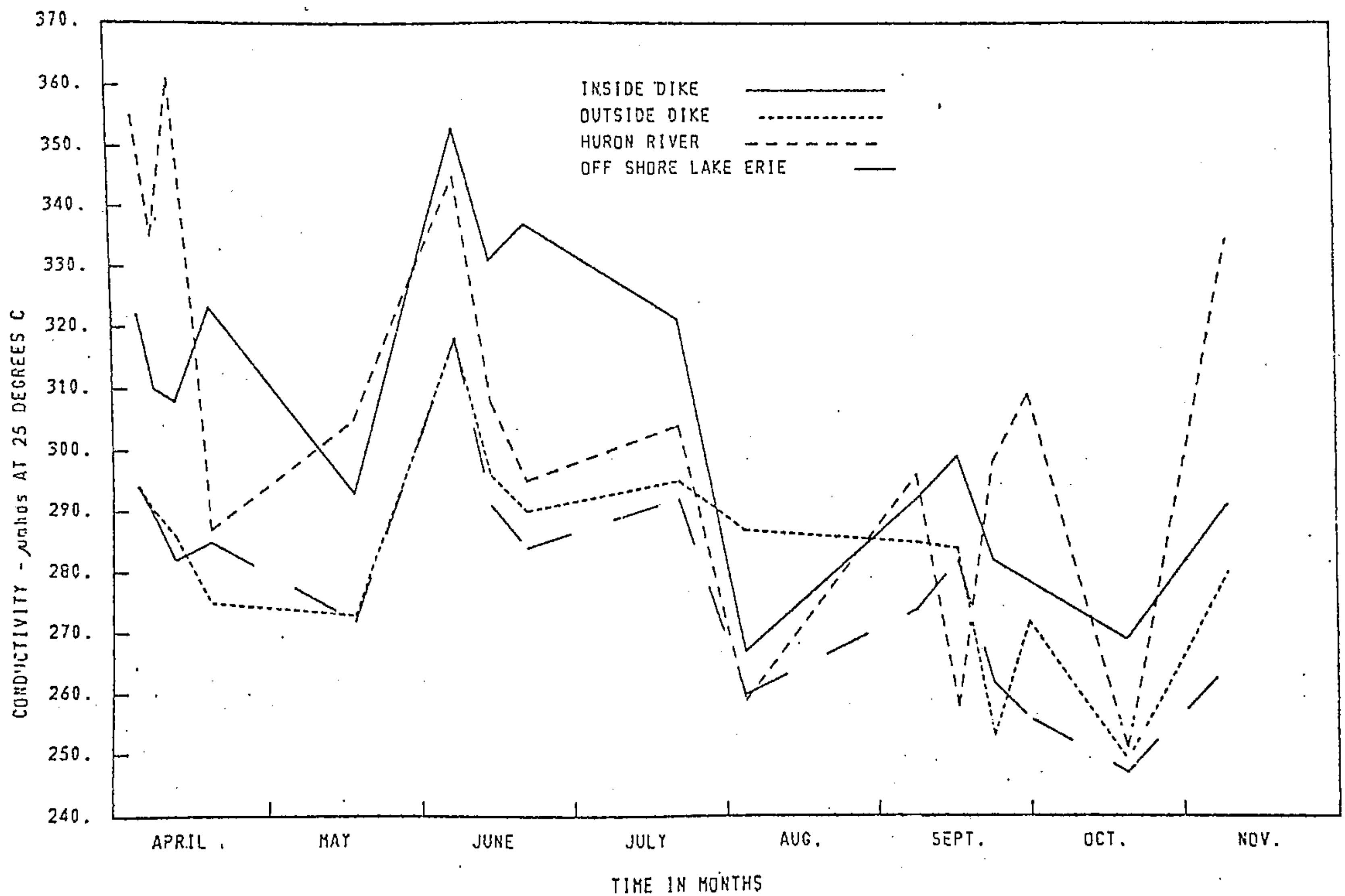


FIGURE 38. CONDUCTIVITY - µmhos AT 25 DEGREES C. VS TIME, 1976

SOURCE: Gedeon, A.S. 1977. 1976 Huron Harbor, Ohio, dike study. USEPA Region V Michigan-Ohio District Office 126 p.

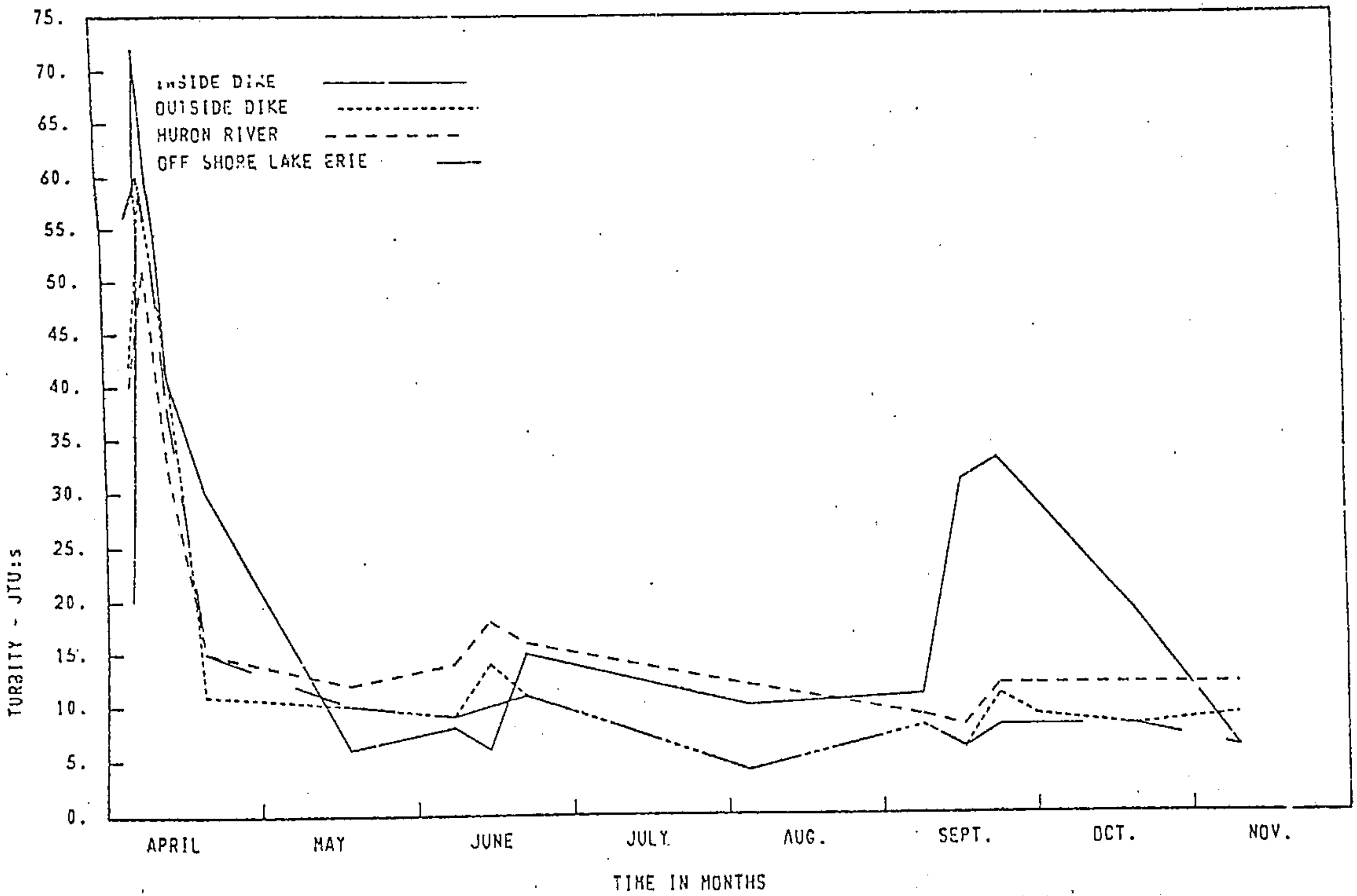


FIGURE 39. TURBIDITY IN JTU:s VS TIME, 1976

SOURCE: Gedeon, A.S. 1977. 1976 Huron Harbor, Ohio, dike study. USEPA Region V Michigan-Ohio District Office 126 p.

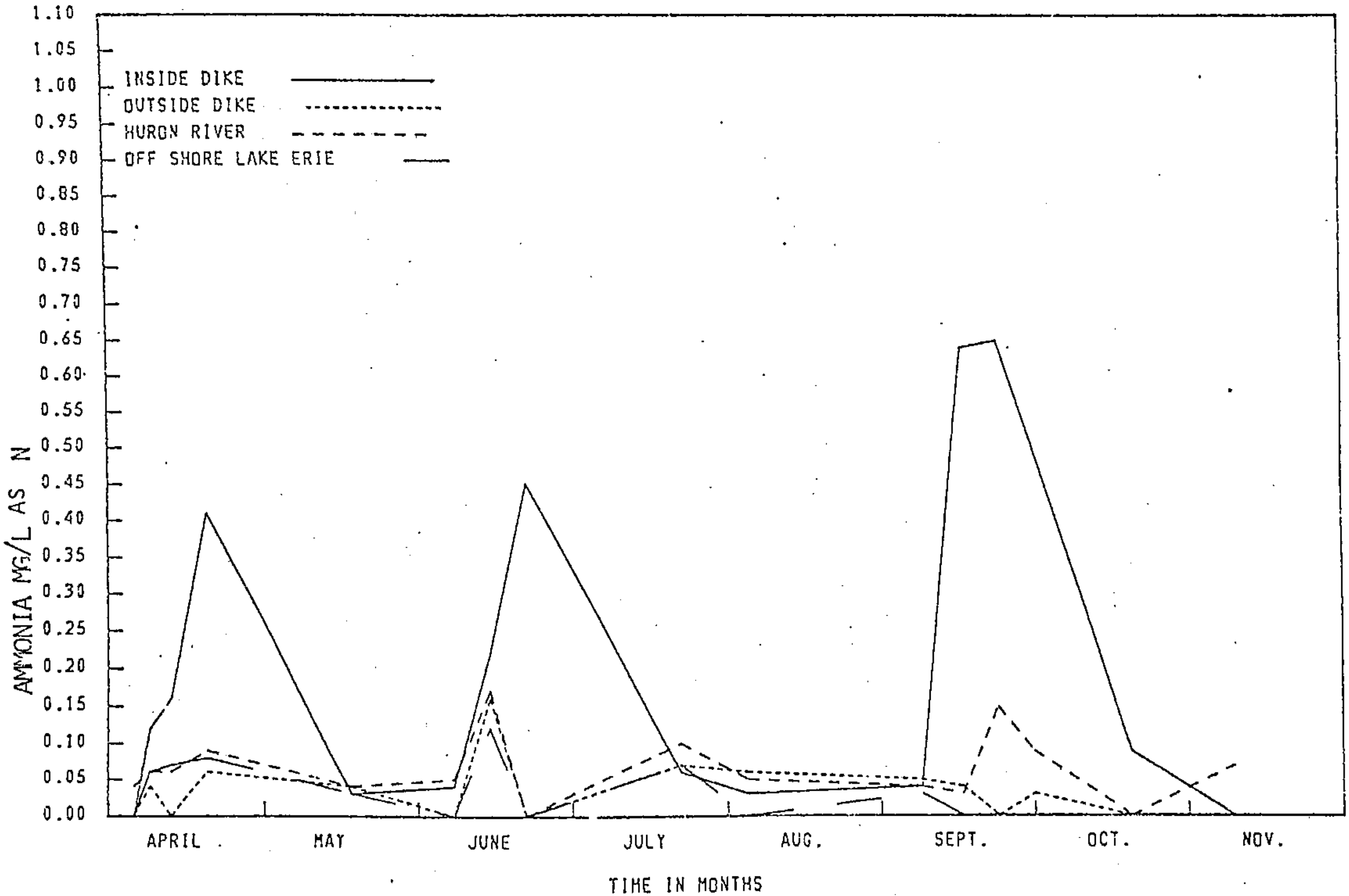


FIGURE 40.AMMONIA - MG/L as N VS TIME, 1976

SOURCE: Gedeon, A.S. 1977. 1976 Huron Harbor, Ohio, dike study. USEPA Region V Michigan-Ohio District Office. 126 p.

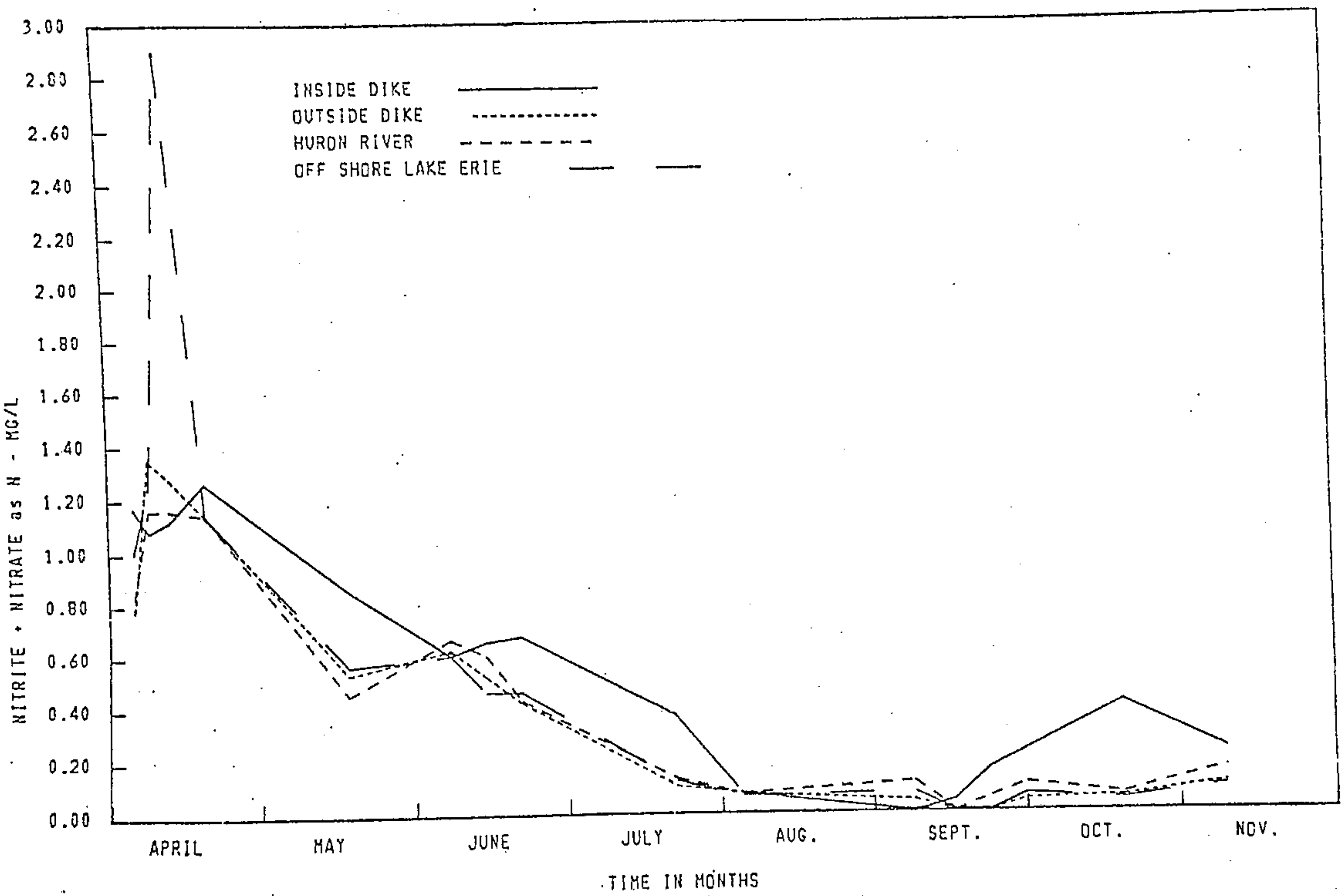


FIGURE 41. NITRITE + NITRATE as N - MG/L VS TIME

SOURCE: Gedeon, A.S. 1977. 1976 Huron Harbor, Ohio, dike study. USEPA Region V Michigan-Ohio District Office. 126 p.

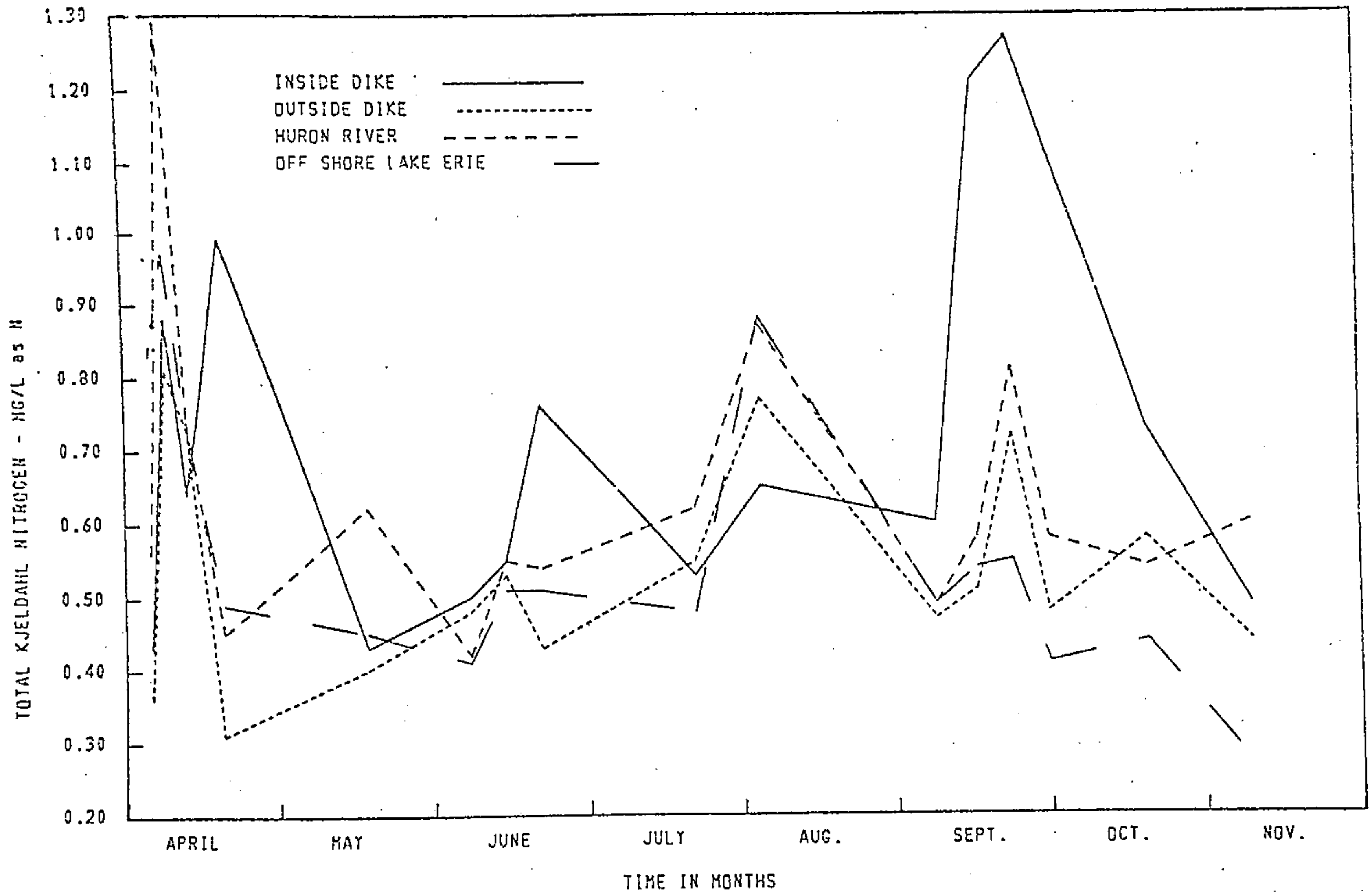


FIGURE 42. TOTAL KJELDAHL NITROGEN - MG/L as N VS TIME, 1976

SOURCE: Gedeon, A.S. 1977. 1976 Huron Harbor, Ohio, dike study. USEPA Region V Michigan-Ohio District Office. 126 p.

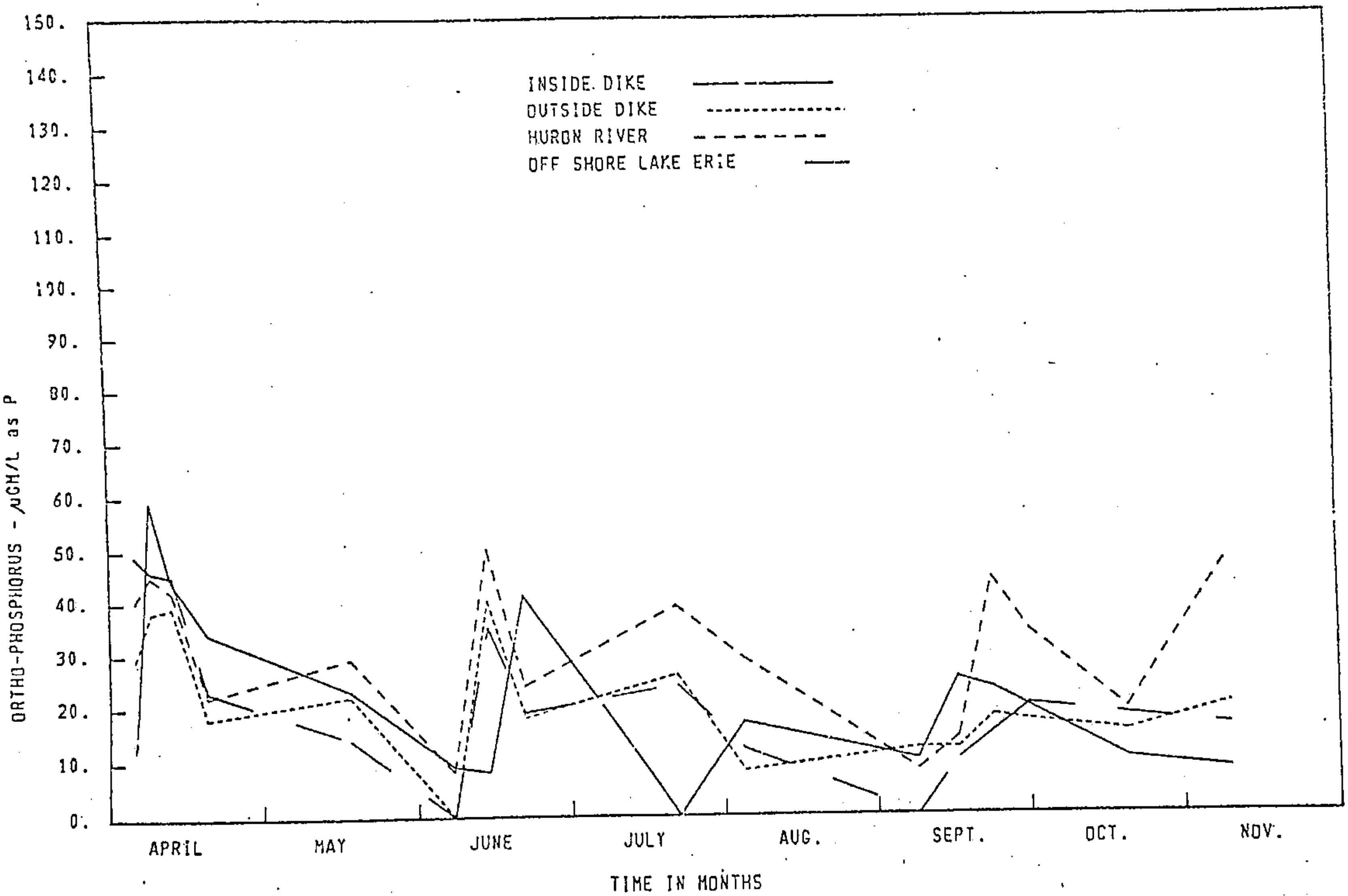


FIGURE 43.ORTHO-PHOSPHORUS - μGM/L as P VS TIME, 1976

SOURCE: Gedeon, A.S. 1977. 1976 Huron Harbor, Ohio, dike study, USEPA REGION V Michigan-Ohio District Office. 126 p.

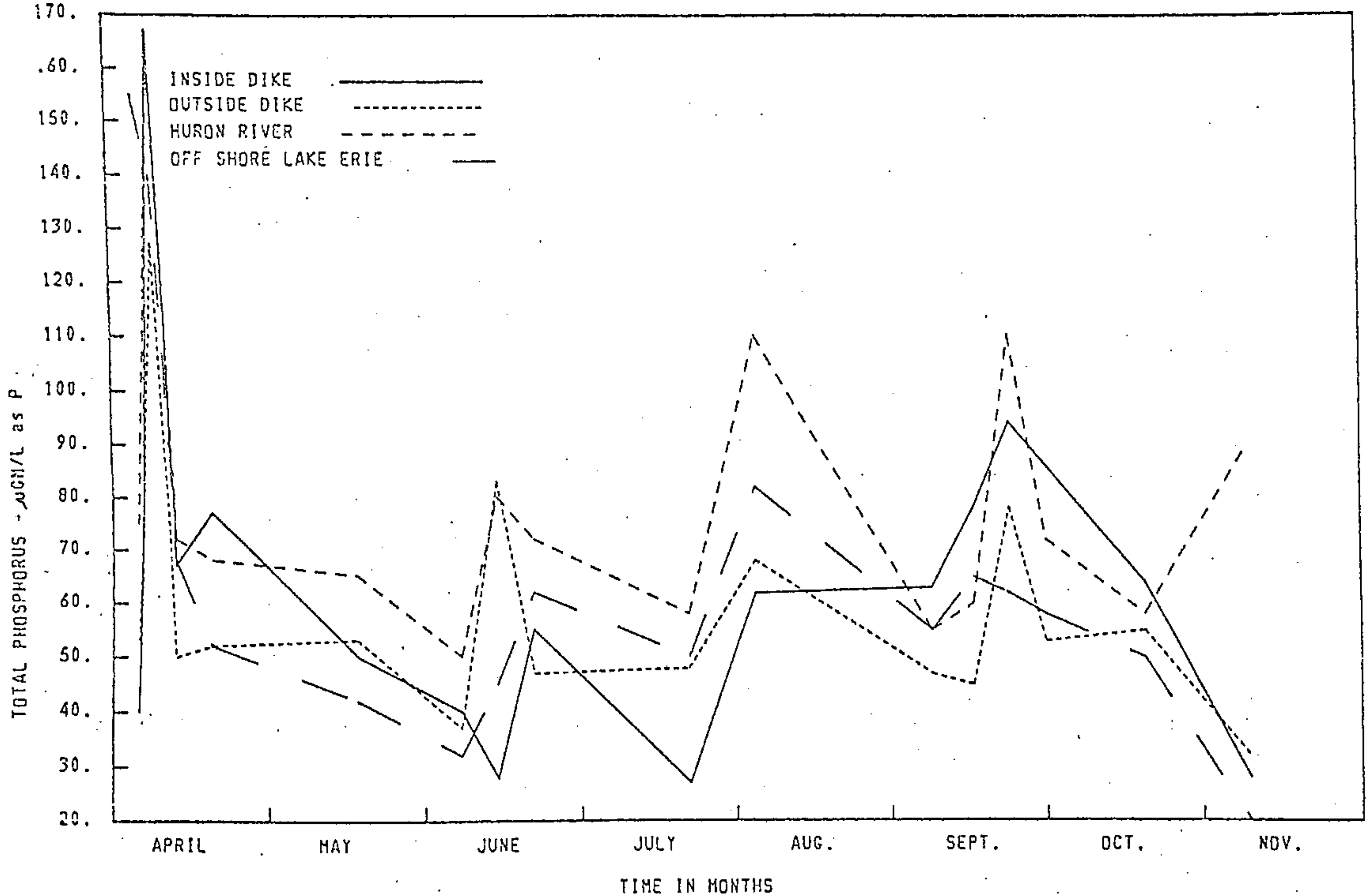


FIGURE 44. TOTAL PHOSPHORUS - µGM/L as P VS TIME, 1976

SOURCE: Gedeon, A.S. 1977. 1976 Huron Harbor, Ohio, dike study. USEPA Region V Michigan-Ohio District Office 126 p.

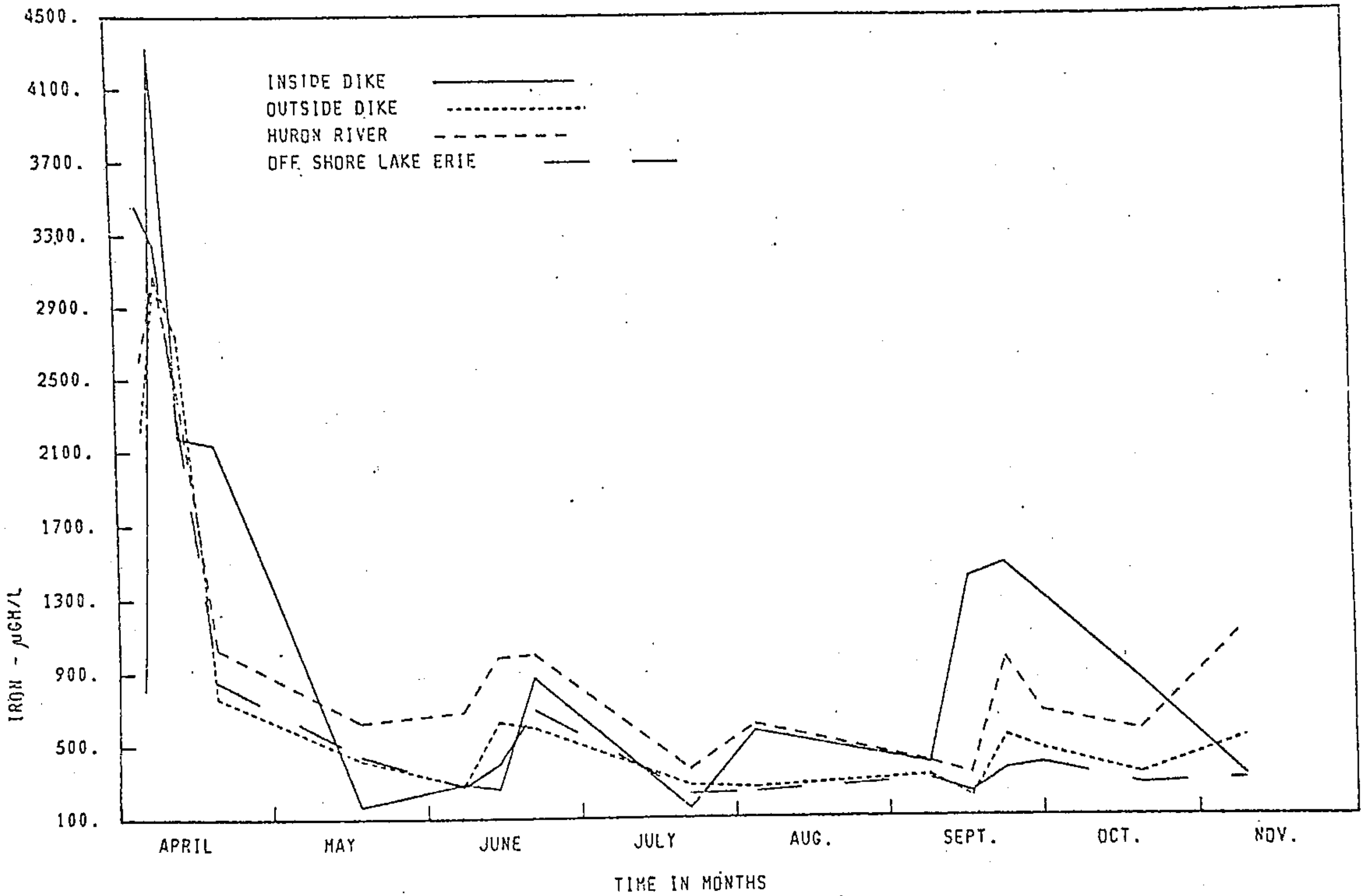


FIGURE 45. IRON IN μMG/L VS TIME, 1976

SOURCE: Gedeon, A.S. 1977. 1976 Huron Harbor, Ohio, dike study. USEPA Region V Michigan-Ohio District Office 126 p.

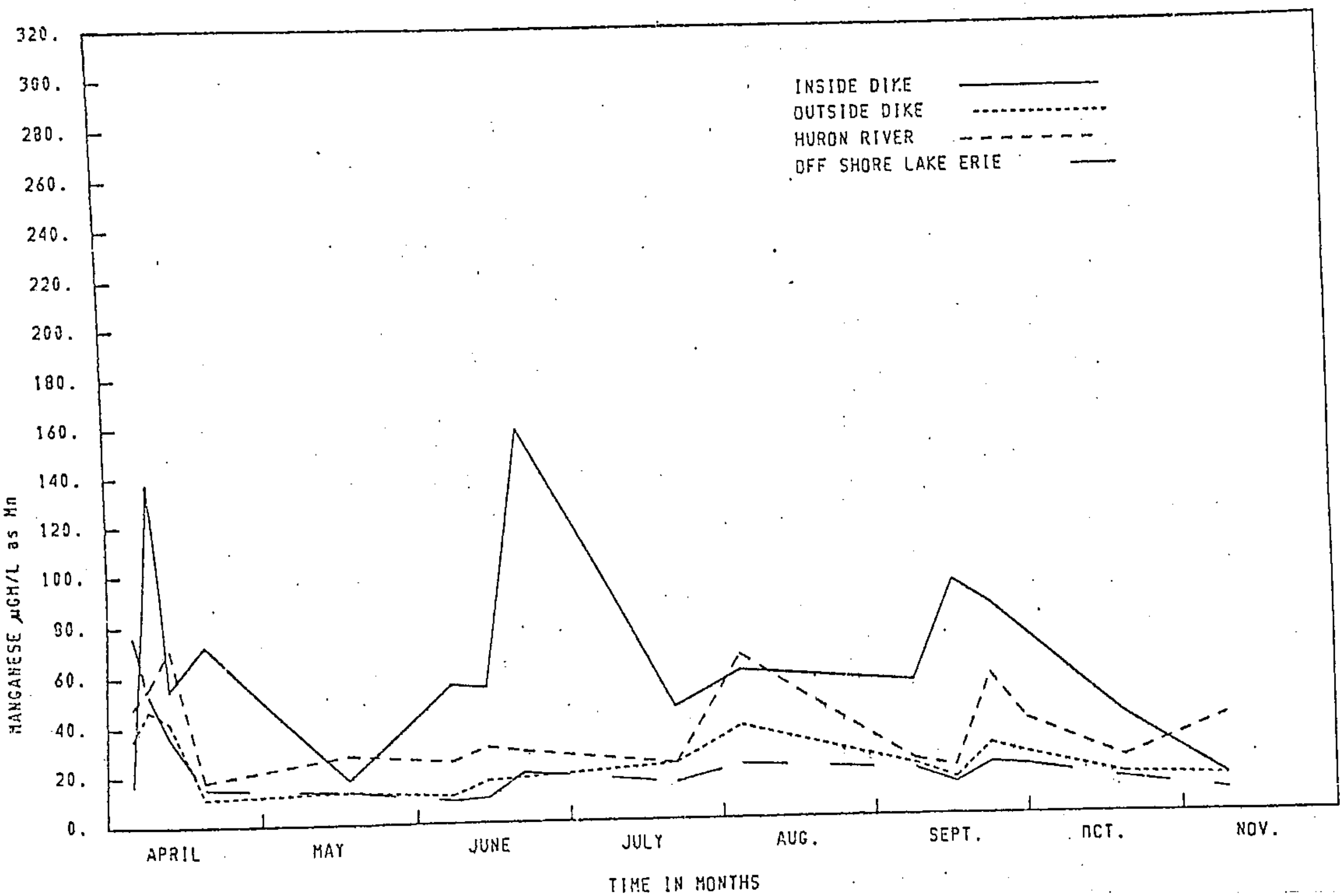


FIGURE 46. MANGANESE µMG/L as Mn VS TIME, 1976

SOURCE: Gedeon, A.S. 1977. 1976 Huron Harbor, Ohio, dike study. USEPA Region V Michigan-Ohio District Office 126 p.

TABLE 13

SUMMARY OF WATER QUALITY MEASUREMENTS
TAKEN FOUR KILOMETERS (STATION 53) AND 17.5 KILOMETERS (STATION 52)
OFFSHORE OF HURON, OHIO, 1973-1975

Parameter	YEAR	STATION 53 (4 km. offshore) RANGE	STATION 53 MEAN	STATION 52 (17.5 km. offshore) RANGE	STATION 52 MEAN	MAIN LAKE WESTERN CENTRAL BASIN MEAN
Temperature (°C)	1973	10.75-26.2	20.1	6.2-25.5	18.1	-
	1974	2.0 -24.0	13.3	2.5-24.0	13.6	-
	1975	2.3 -22.3	13.9	1.5-23.0	12.1	-
Transparency (m)	1974	0.2 - 2.5	1.2	0.2-3.6	2.0	3.4
	1975	0.3 - 6.5	2.6	0.5-6.3	2.4	3.4
Conductivity (µmhos/cm)	1973	256 -306	277	255-295	272	281
	1974	267 -328	288	265-310	285	285
	1975	221 -287	247	237-285	259	258
Dissolved Oxygen (mg/l)	1973	0.2 -12.2	9.0	0.0-12.08	8.9	8.7
	1974	4.6 -13.8	10.2	0.0-13.3	9.8	10.0
	1975	2.0 -12.6	9.1	2.6-13.0	9.9	9.9
Ammonia Nitrogen (µg/l)	1973	4 -56	23	5-59	25	36.3
	1974	1 -60	22	0-266	29	22.5
	1975	4 -88	24	4-218	39	25.0
Total Phosphorus (µg/l)	1973	12 -70	34	2-36	20	20.7
	1974	0 -15	7	23-60	36	26.0
	1975	16 -89	42	12-64	31	23.7
Dissolved Phosphorus (µg/l)	1973	0 -12	6	0-13	5	8.1
	1974	0 -15	7	0-82	11	5.9
	1975	1 -13	7	0-12	3	6.7
Chlorophyll a	1973	5.29-15.08	10.64	5.29-11.55	8.13	-
	1974	1.07-26.45	10.35	1.16-35.52	8.96	6.1
	1975	2.84-21.25	11.97	2.89-18.46	9.38	7.2

SOURCE: Lake Erie Nutrient Study. Center for Lake Erie Area Research, The Ohio State University, Columbus, Ohio.

TABLE 14

SUMMARY OF WATER QUALITY MEASUREMENTS
TAKEN AT THE HURON WATER INTAKE[1], 1950-1974

Parameter	SEPT/1950-FEB/1952 [a]		JAN 3-DEC 28/1973 [b]		JAN 2-SEPT 30/1974 [b]		NOV 25-DEC 31/1974 [b]	
	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN
pH (std uts)	7.2-8.1	-	7.7-8.5	8.2	7.3-8.8	7.88	7.3-7.8	7.6
Conductivity (μmhos/cm at 25°C)	283-340	294	235-410	288.5	272-350	303.8	-	-
Sulfate (mg/l)	22-41	27	-	-	17-40	26.4	15-35	22.2
Chloride (mg/l)	14-20	18	2.6-30	20.9	16-27	23	21-23	22.2
Total Hardness (mg/l)	151-202	128	108-208	133.9	114-160	132.7	120-182	142

[1] 0.67 km offshore

SOURCES: [a] Lake Erie Pollution Survey-Supplement (1953)
[b] STORET

TABLE 15

A SUMMARY OF CHEMICAL CONSTITUENTS OF LAKE ERIE NEAR THE PROPOSED SITE FROM SEPTEMBER 1973 TO AUGUST 1974 (~0-51)*

Concentrations are in mg/liter, or as specifically indicated[a]

Constituents	Surface samples		Bottom samples	
	Minimum	Maximum	Minimum	Maximum
Total hardness	105	141	105	150
Total alkalinity	73	113	81	101
pH	7.1	8.6	7.2	8.4
Turbidity, Jtu[b]	2	63	3	63
Suspended solids	<3	90	13	123
Specific conductance, mho/cm	229	355	231	422
Dissolved solids	145	216	146	217
Cl^-	14	22	14	21
SO_4^{2-}	7	32	7	33
H_2S	<0.02	<0.02	<0.02	<0.02
NO_3^- (as N)	<0.2	13.7	<0.02	11.4
NO_2^{2-} (as N)	<0.01	0.05	<0.01	0.03
NH_3 (as N)	<0.07	0.12	<0.06	0.09
Kjeldahl N (as N)	0.05	1.00	<0.07	3.70
Total PO_4^{2-} (as P)	0.01	0.40	0.01	0.35
Ortho PO_4^{2-} (as P)	<0.01	0.30	<0.01	0.06
Total Si (as Si)	0.2	25.0	0.9	26.4

[a]Sodium and potassium concentrations were below 11.0 and 2.3 mg/liter respectively.

[b]Jackson turbidity units.

Source: T. A. Edsall, "Electric Power generation and Its Influence on Great Lakes Fish," pp. 453–462, Tables 8-29, 8-30, and 8-45, in *Proceedings of the Second Federal Conference on the Great Lakes,* Great Lakes Basin Commission, 1976.

* Nearshore Master Plan Station Number

SOURCE: U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation. 1977. Draft Environmental Statement for Erie Nuclear Plant, Units 1 and 2. NUREG - 0337. p. 2-28.

Cleveland, Ohio

Changes in water quality in the vicinity of Cleveland are evident in records accumulating since 1850. This record documents deterioration of water quality in the nearshore zone with the advent of industrialization and population increase in the metropolitan area. These changes are adequately detailed by Garlauskas (1974) and Bentley, et al. (1975). The purpose of this section is to summarize records not treated in the latter studies and to present analyses of water quality data collected by the Water Quality Control Laboratory of the City of Cleveland. The Cleveland Water Quality Control Laboratory conducted an extensive mid-depth sampling program in Lake Erie between 1974 and 1978. The graphic analyses (Figures 47-56) herein are the result of this analysis.

Water quality measurements taken at five points in Cleveland harbor during the summer of 1929 are displayed in Figure 57. The range of recorded values from the harbor area is compared with values from 10 km offshore (Table 16). Table 17 presents a similar comparison of values recorded in the harbor with values recorded throughout the main lake portion of the Central Basin during 1963 and 1964. The range of values recorded in 1965-1966 and 1973 at the Division water intake, located 6.7 km offshore, is presented in Table 18. The summary in Table 19 was prepared from 1975 records of water quality measurements at the mouth of the Cuyahoga River, the harbor mouth, the Division water intake and a sampling station approximately midway between the harbor mouth station and the intake station. Measurements from beyond the harbor mouth and 13 km offshore during the spring, summer and fall seasons of 1973 through 1975 are summarized in Table 20.

Over the period of modern record, 1929-1975, water quality parameters measured in the immediate vicinity of Cleveland Harbor and the mouth of the Cuyahoga River often represent the extremes recorded from the entire lake. Conditions recorded at points two to 13 km offshore do not reflect the extremes nor the wide range of variation observed in measurements taken in the harbor area (Table 20). In terms of time span and number of parameters, the earlier records (Table 16) are based on very limited sampling programs. Low dissolved oxygen concentrations have been measured in the harbor area during the summer months since 1929 (Tables 16, 17, 19). Oxygen depletion also occurs offshore (Table 20). Hydrogen ion concentrations in the harbor occasionally approached neutral (Table 16) or slightly acidic (Table 17, Figure 50) conditions during the period of record. Hydrogen ion concentrations offshore resemble main lake conditions. The range of values for alkalinity and chloride measurements has been wider due to high values in the harbor area (Tables 16, 17, 19).

In 1975, water temperature at the harbor mouth followed the annual trend, gradually increasing from 2°C in early April to 24°C in late July and early August (Figure 47). Abnormally high values recorded at these stations on August 6 is attributed to equipment calibration problems and are not plotted on Figure 47. Temperature declined rapidly in late summer and fall, reaching 5°C in early December. Offshore temperatures followed a similar summer-fall pattern. Dissolved oxygen concentrations at the harbor mouth were relatively low, 7.0-7.2 mg/l, in early April (Figure 48). Concentrations declined steadily to 0.2 mg/l in mid-July. From August through November, dissolved oxygen concentrations remained relatively low while following a trend toward higher values. Concentrations measured in December exceeded 8 mg/l. With the exception of late August, values at the two offshore stations were quite similar. The record of chemical oxygen demand (COD) reveals a wide range of values at the river mouth and harbor mouth with mean values of 22.6 mg/l and 16.6 mg/l, respectively (Figure 49). The offshore stations displayed a narrower range of values and overall slightly lower chemical oxygen demand conditions (Table 19). Mean conductivity values (Table 19) at the river mouth and harbor mouth were very high. Conductivity measurements at the two offshore stations were quite similar and reflected main lake conditions (Figure 51, Table 20). The values for the nutrient parameters (ammonia, nitrite-nitrate, organic nitrogen, ortho-phosphorus, and total phosphorus) were typically highest at the river mouth and lowest offshore. The greatest variability occurred in records from the river mouth (Figures 52, 53, 54, 55, 56). With a few exceptions, conditions recorded at the two offshore stations are representative of main lake conditions. Exceptional values probably indicate a plume of nearshore water extending offshore due to storm events.

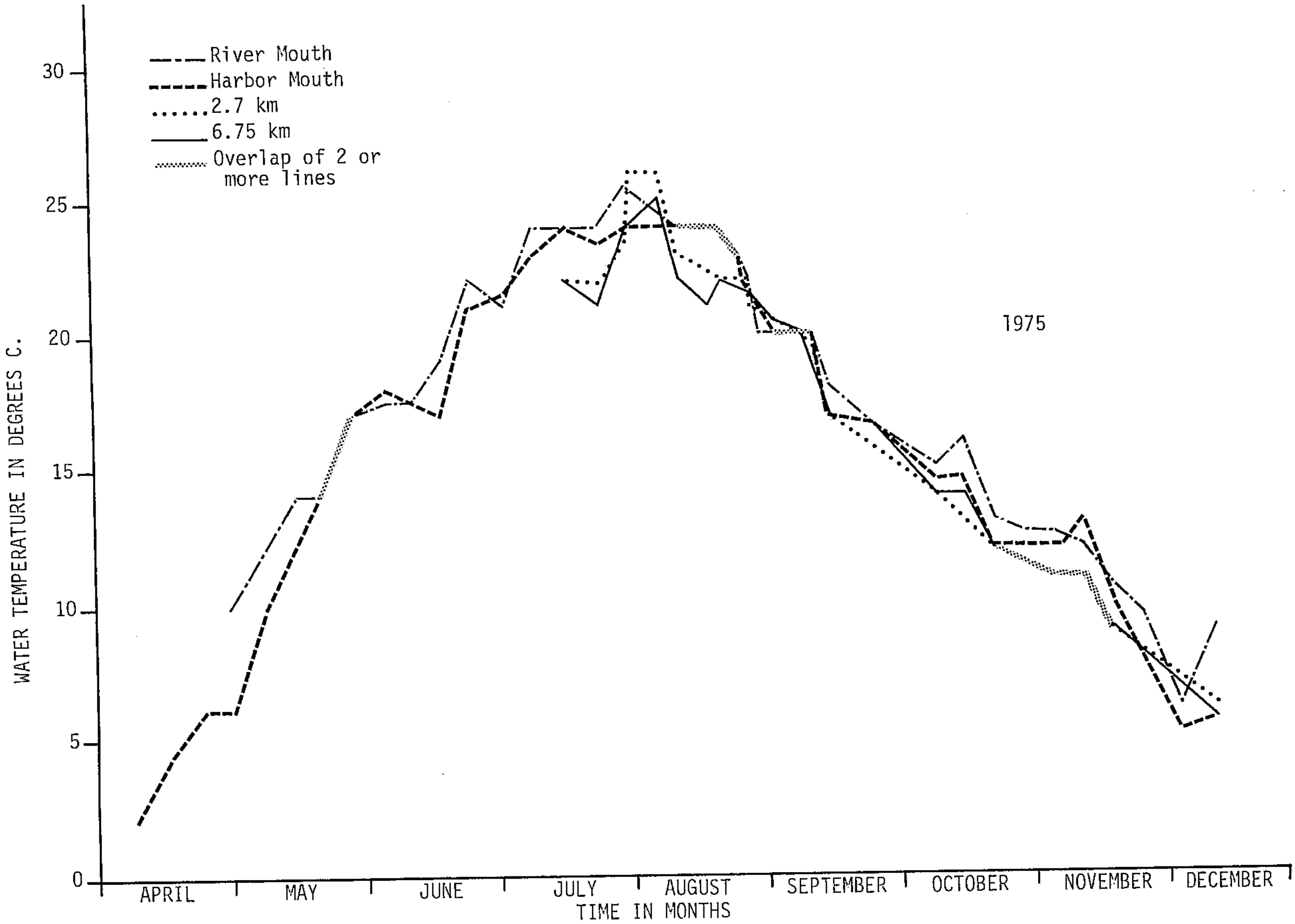


FIGURE 47. WATER TEMPERATURE IN DEGREES C VS TIME.

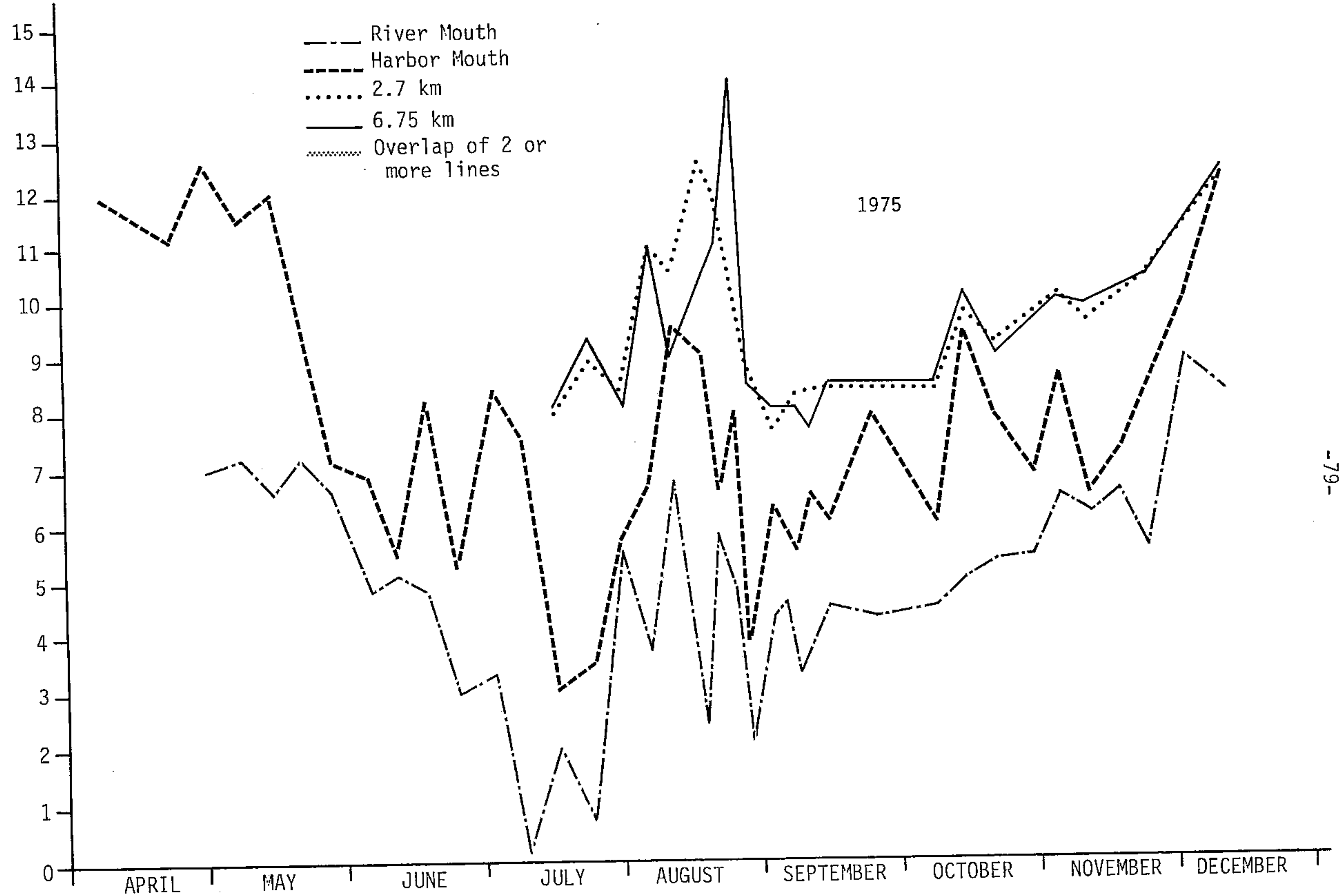


FIGURE 48. DISSOLVED OXYGEN-MG/L VS TIME.

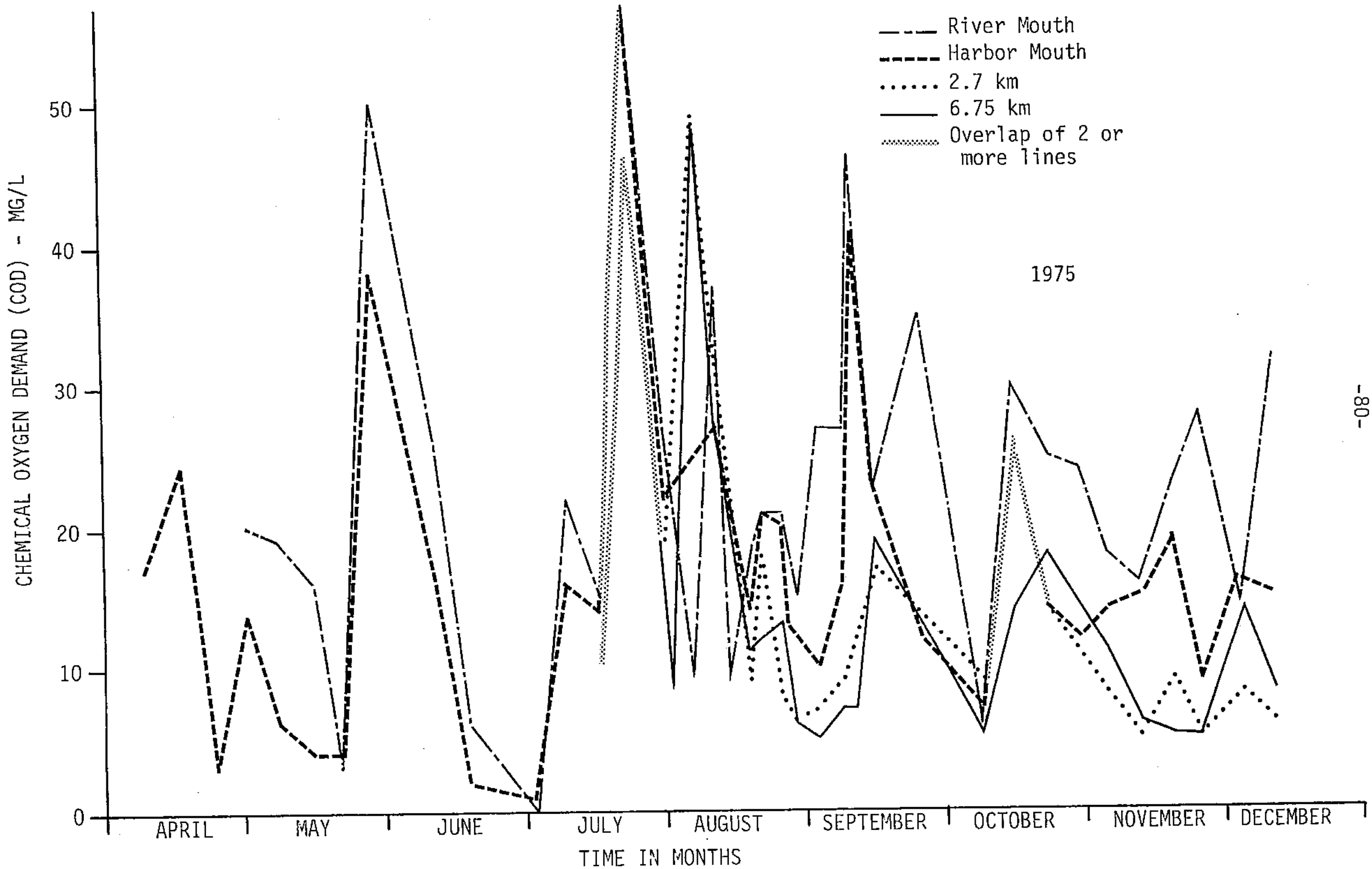


FIGURE 49. CHEMICAL OXYGEN DEMAND (COD) - MG/L VS TIME.

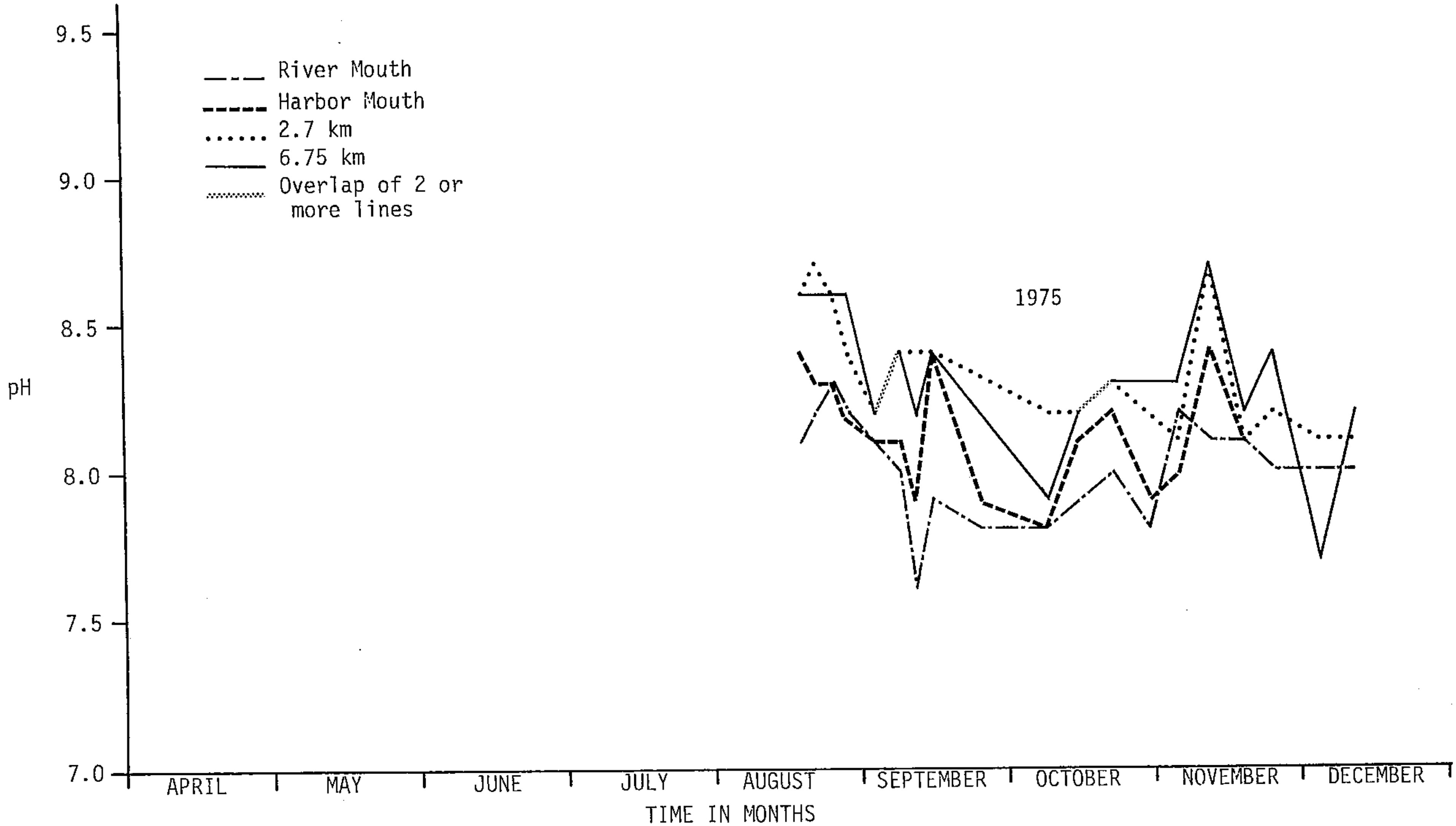


FIGURE 50. pH VS TIME.

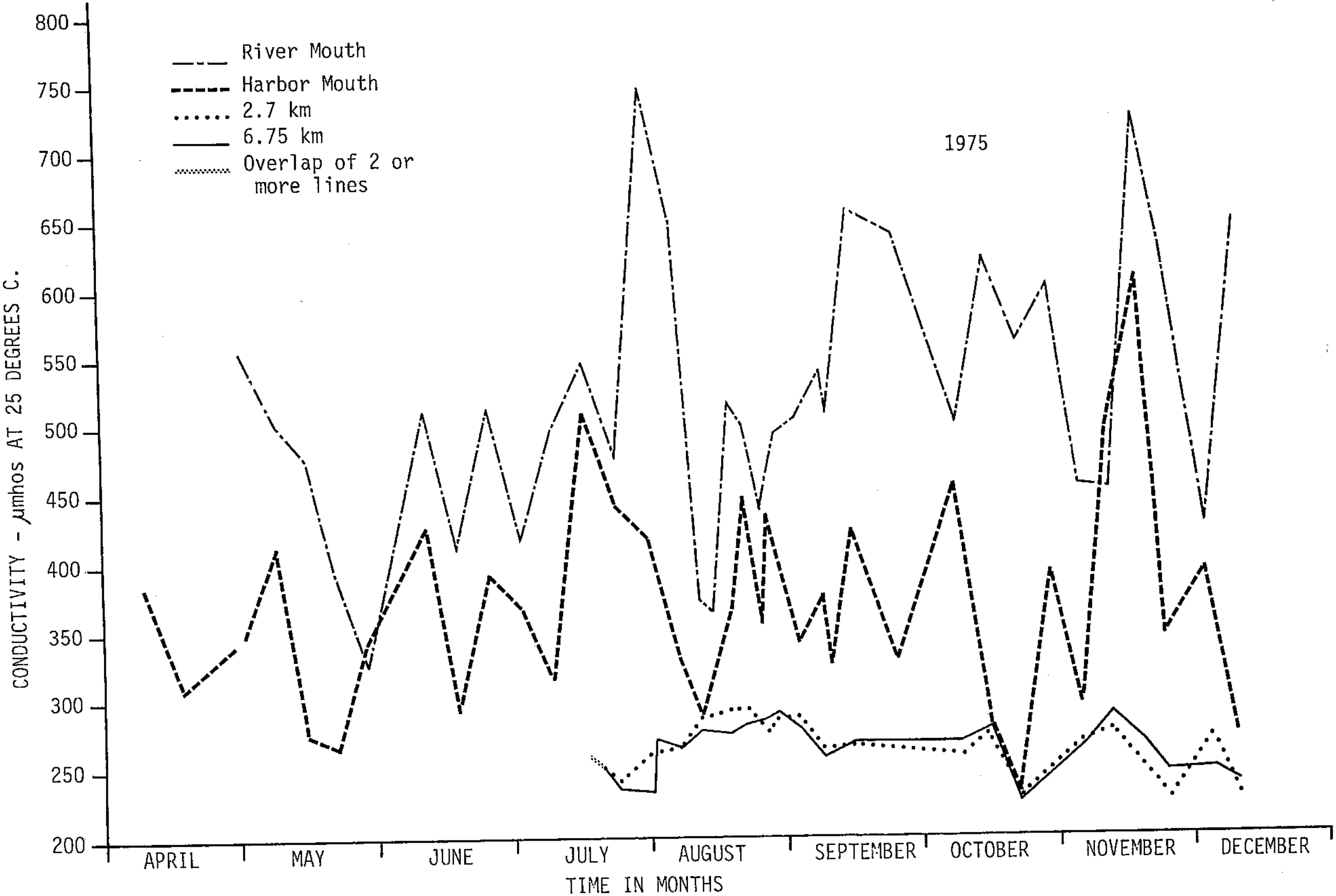


FIGURE 51. CONDUCTIVITY - µmhos AT 25 DEGREES C. VS TIME.

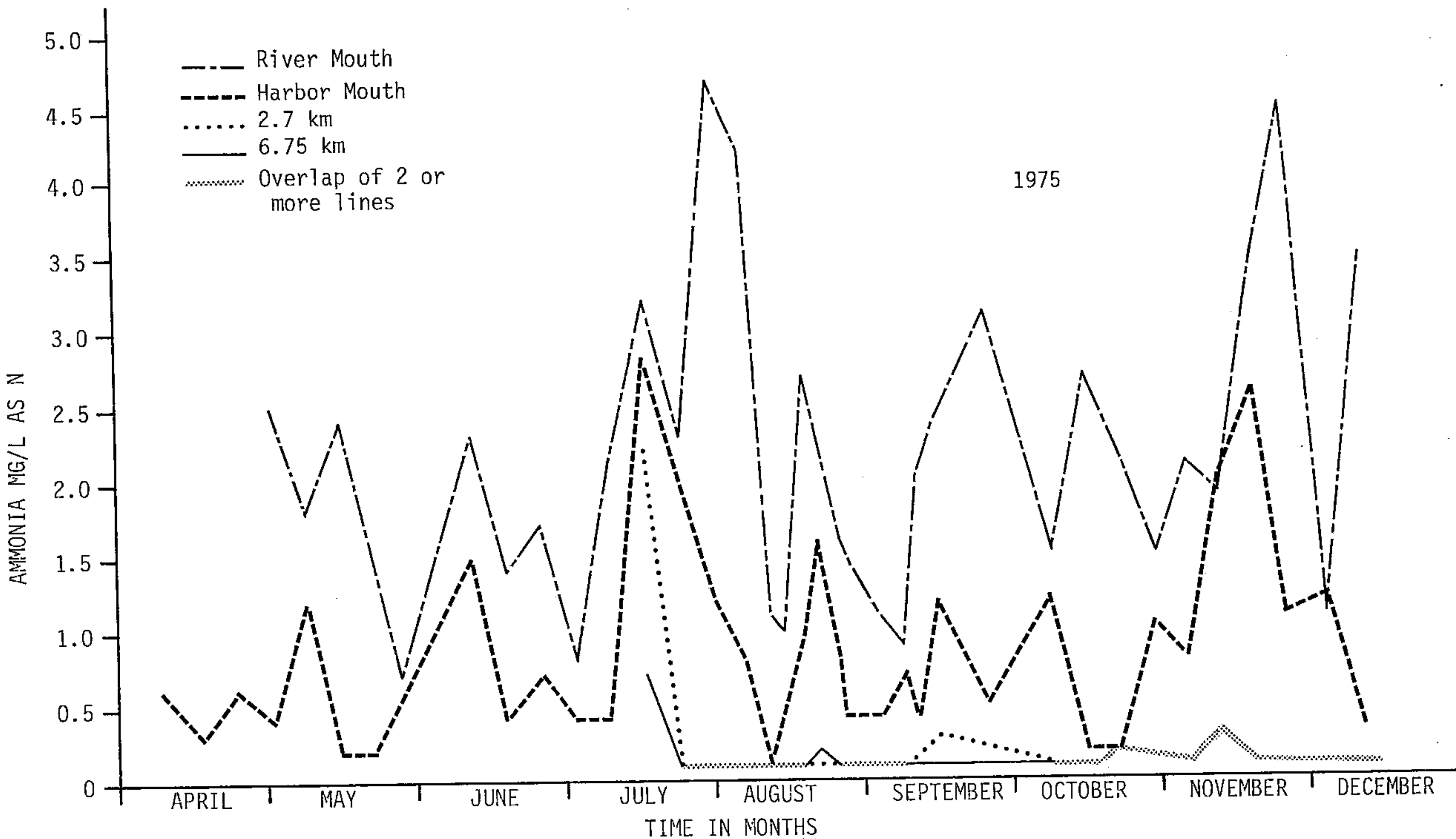


FIGURE 52. AMMONIA - MG/L AS N VS TIME.

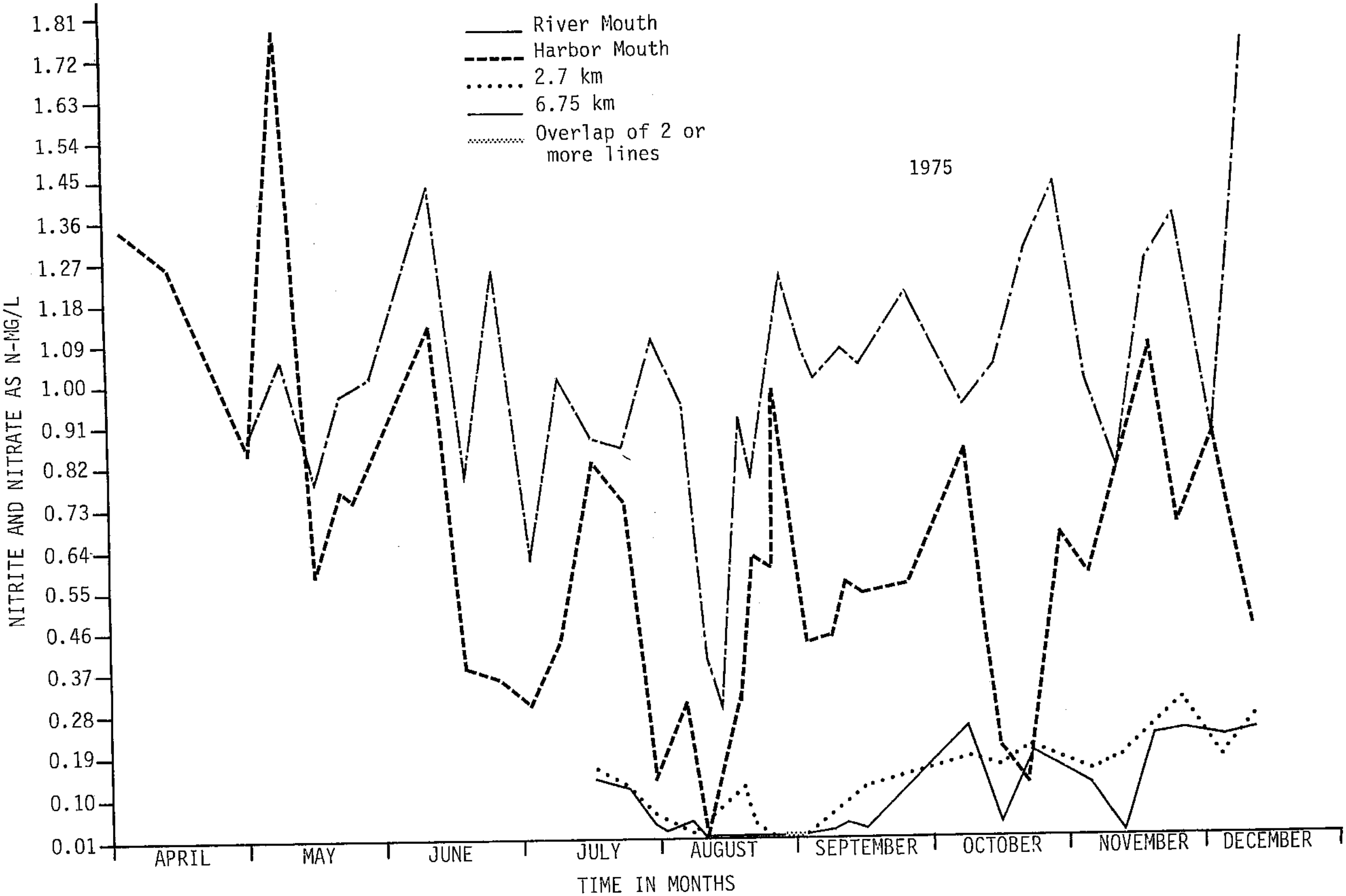


FIGURE 53. NITRITE AND NITRATE.

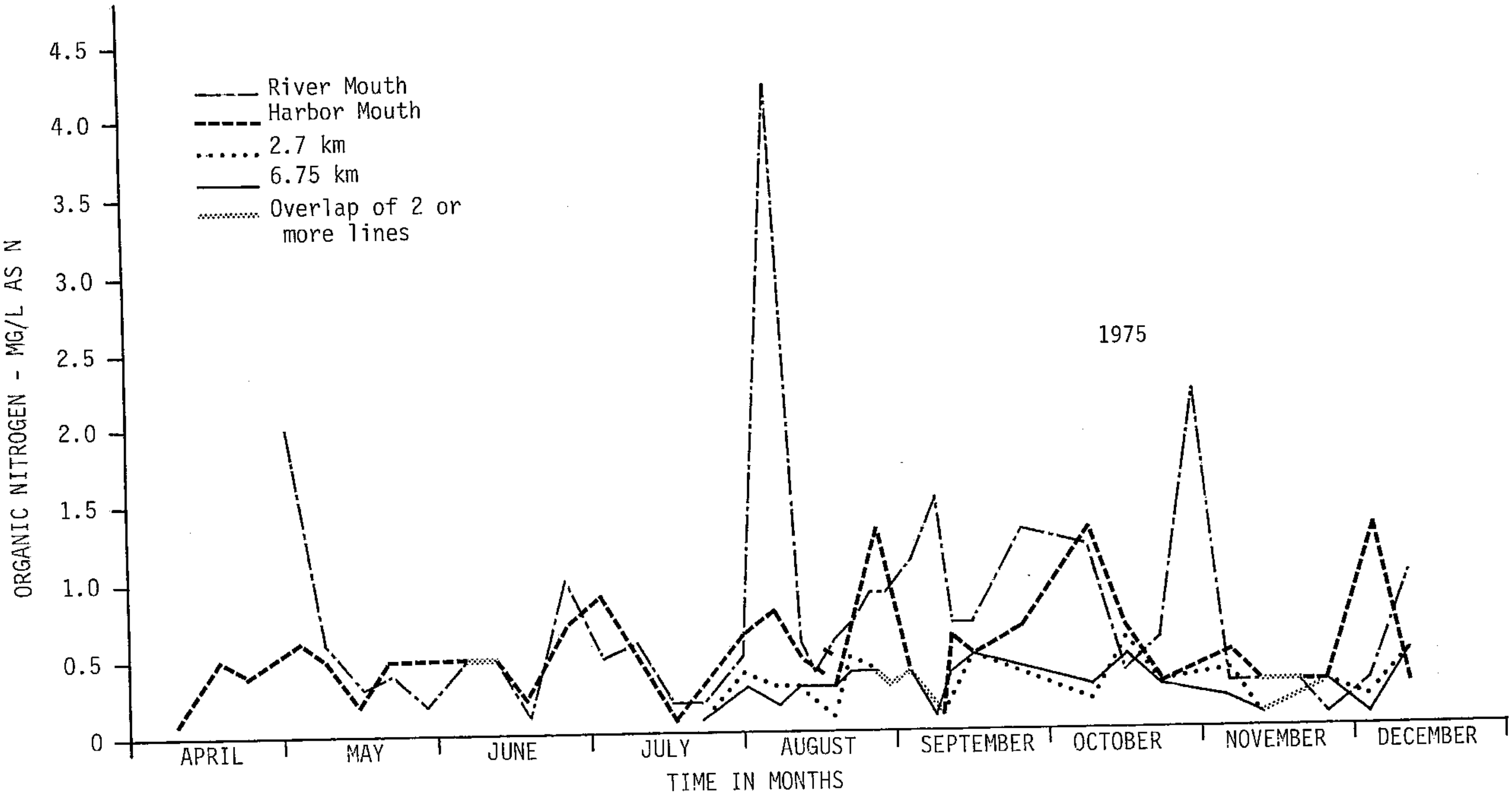


FIGURE 54. ORGANIC NITROGEN - MG/L AS N VS TIME.

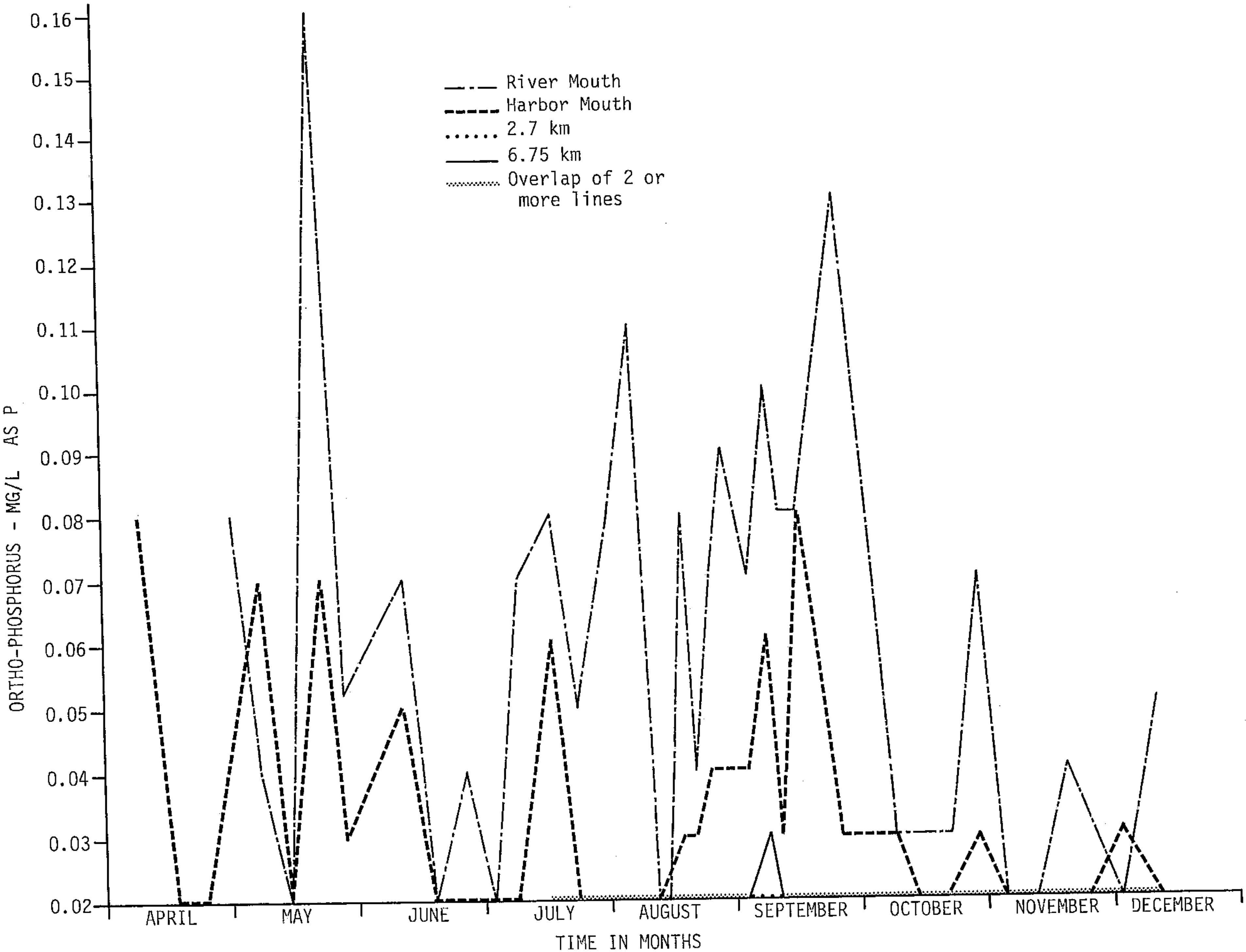


FIGURE 55. ORTHO-PHOSPHORUS - UGM/L AS P VS TIME.

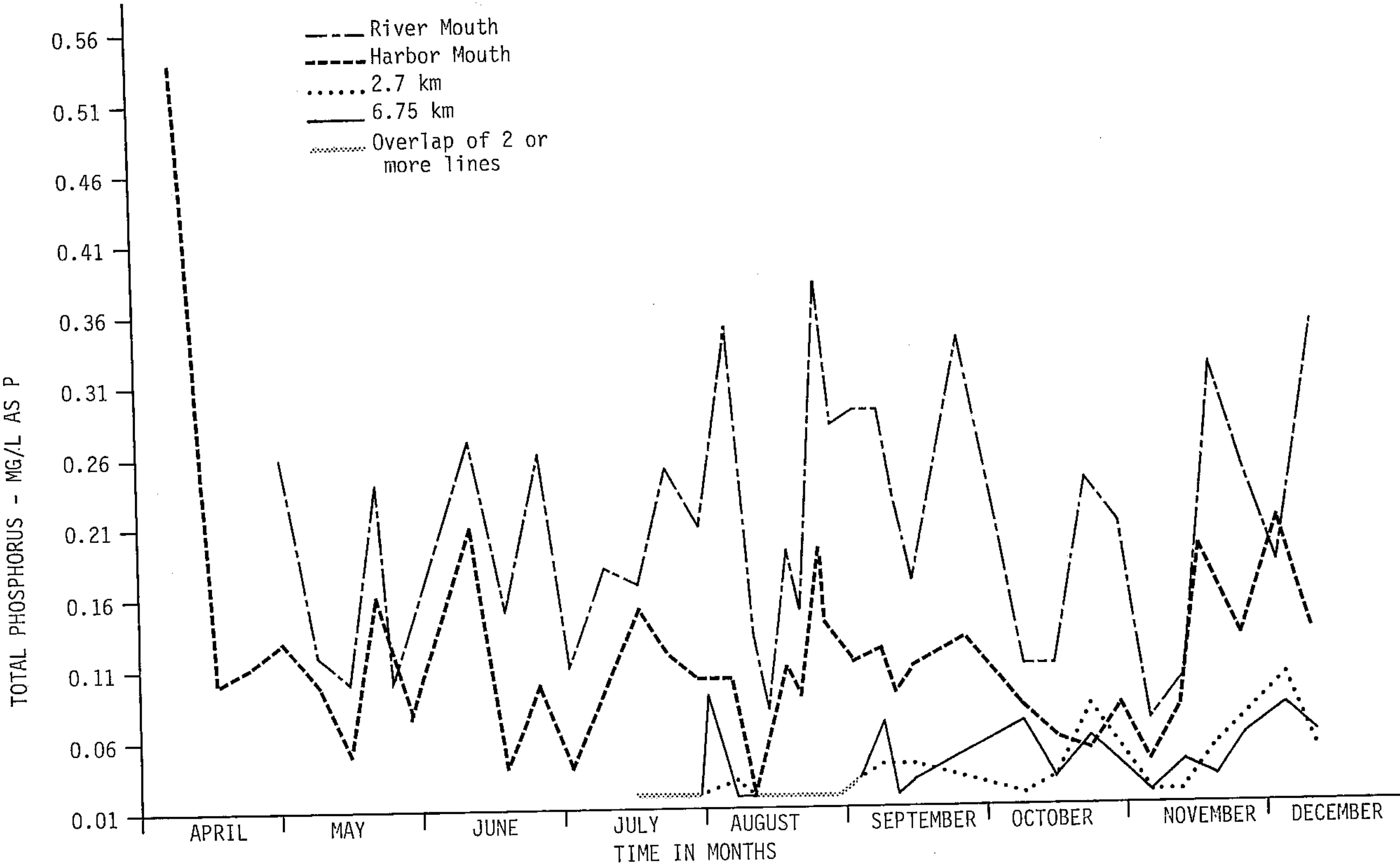


FIGURE 56. TOTAL PHOSPHORUS.

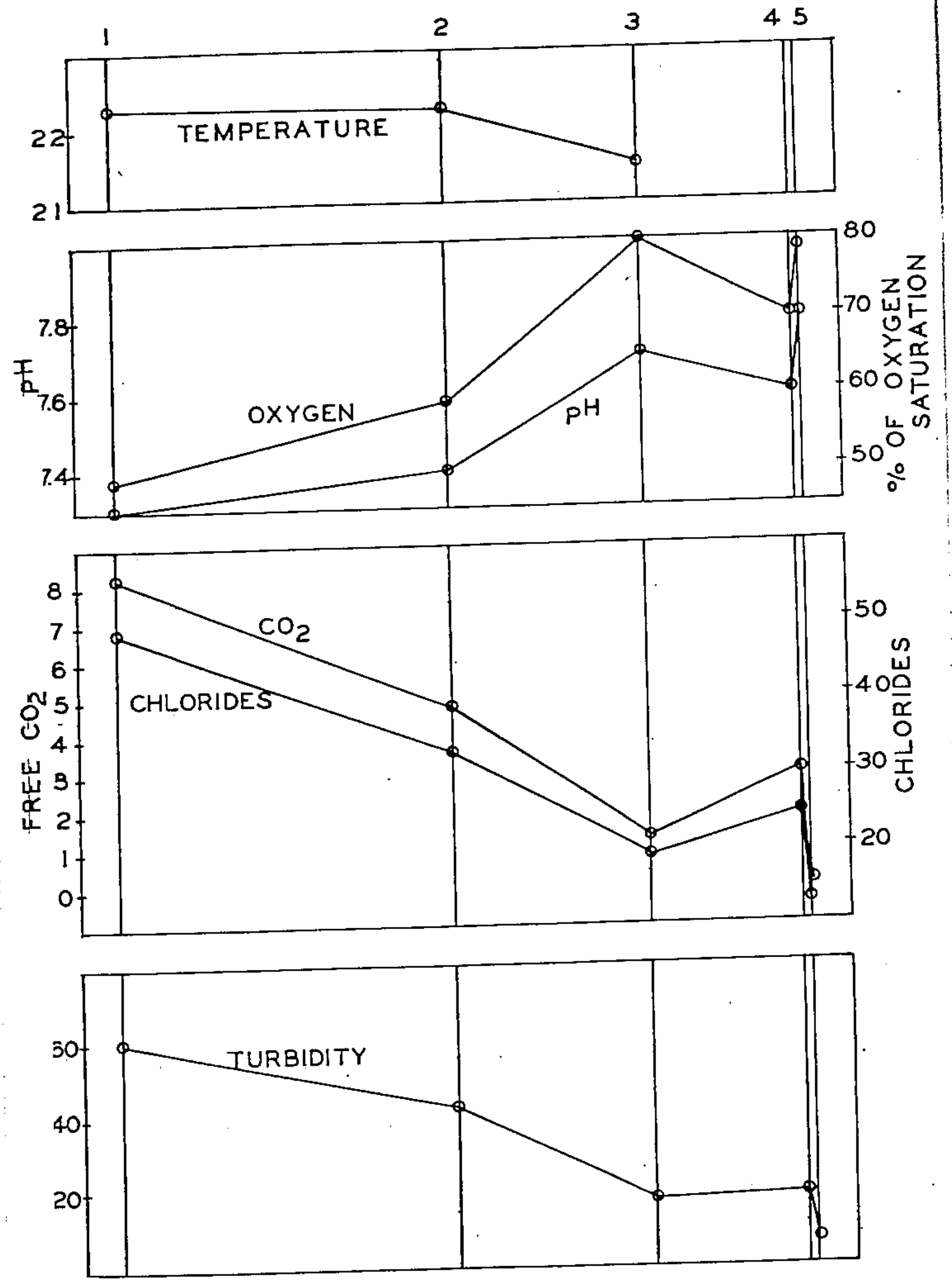


Figure 57. --Surface samples from Cleveland Harbor. 1929

SOURCE: Fish, C.J., et al. 1960. Spec. Scient. Rept.-Fish No. 334. USF&WS. 198 p.

TABLE 16

RANGE OF WATER QUALITY MEASUREMENTS
TAKEN IN SURFACE WATERS OF CLEVELAND HARBOR
AND 10 KILOMETERS OFFSHORE DURING 1929

Sampling Site	Cleveland Harbor Area	10 km Offshore
Parameter / Date	July 15-Sept. 19/1929	June 18-Sept. 19/1929
Temperature °C	-	21.3-21.7
Dissolved Oxygen mg/l	0.29-7.1	8.4-8.6 (8/18-9/19 only)
CO_2 mg/l	-0.5-+21.5	-3.0--1.7
Alkalinity mg/l as Ca CO_3	91-106	97-99
pH std uts	7.1-7.8	8.2-8.3
Chloride mg/l	13.3-46.5	12.2-12.8
Turbidity mg/l as SiO_2	6-125	2-4

SOURCE: Fish, et al. (1960)

TABLE 17

SUMMARY OF WATER QUALITY MEASUREMENTS
TAKEN IN CLEVELAND HARBOR AND LAKE ERIE, 1963-1964

Parameter	Cleveland Harbor[a]	Main Lake Central Basin[b]		Whole Lake[b]
	Range	Range	Average	Average
Temperature	16-21	-	-	-
Dissolved Oxygen (% sat)	70-95	-	-	-
pH (std uts)	6.7-9.5	-	-	-
Dissolved Solids (mg/l)	180-370	137-239	178	177.6
Total Solids (mg/l)	180-680	159-218	185	185.8
Chlorides (mg/l)	14-88	19-46	24	23.9
Alkalinity (mg/l)	81-130	71-130	97	-
COD (mg/l)	8-22	3.1-16.0	7.1	7.36

SOURCES: a Lake Erie Environmental Summary

b Proceedings, Pollution of Lake Erie and Its Tributaries

TABLE 18

SUMMARY OF WATER QUALITY MEASUREMENTS
TAKEN AT THE DIVISION WATER INTAKE[1]
OF THE CITY OF CLEVELAND, 1965-1973

Parameter		July/1965-June/1966 [a]	Jan. 9-Dec. 18/1973	
		Range	Range	Mean
pH	(std uts)	7.4-8.5	8.1-8.2	8.15
Turbidity	(JTU)	1.0-100.0	0.42-64	6.3
Chlorides	(mg/l)	16.0-30.0	17-27	21.4
Alkalinity	(mg/l)	77-100	70-96	90
Hardness	(mg/l as $CaCO_3$)	122-130	120-146	130.5

[1] 6.73 km. (21,000ft) offshore

SOURCES: [a] Great Lakes Framework Study, Appendix 7

[b] STORET

TABLE 19

SUMMARY OF WATER QUALITY MEASUREMENTS TAKEN
IN THE VICINITY OF CLEVELAND FROM APRIL TO DECEMBER, 1975

	RIVER MOUTH		HARBOR MOUTH		2.75 KM OFFSHORE		6.7 KM OFFSHORE	
Parameter	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Temperature (°C)	6.0-29.0	17.49	2.0-30.	15.87	5.5-25.0	16.88	6.0-28.0	18.15
Dissolved oxygen	0.2-8.9	4.94	3.0-12.6	7.91	7.7-12.6	9.71	7.7-14.0	9.58
Transparency (m)	0.1-1.0	.469	0.1-1.5	.69	.4-5.0	2.02	0.5-6.8	3.10
Chloride	33. -148.	67.51	8.3-66.	37.76	15. -29.	22.3	16. -34	22.96
Organic nitrogen	<0.1-4.2	.80	<0.1-1.3	.51	<0.1-1.3	.34	< 0.1-0.5	.287
Ammonia-nitrogen	0.7-4.7	2.16	0.1-2.8	.862	<0.1-2.2	.23	< 0.1-0.7	.143
Nitrite-nitrogen	0.05-0.294	.134	0.006-0.82	.079	<0.001-0.016	.006	<0.001-0.012	.0048
Nitrate-nitrogen	0.23-1.28	.886	<0.01-1.32	.56	<0.01-0.30	.122	< 0.01-0.24	.09
Ortho-phosphorus	<0.02-0.16	.06	<0.02-0.08	.035	<0.02-0.02	<.02	< 0.02-0.03	.020
Total phosphorus	0.10-0.38	.20	0.02-.53	.113	<0.02-0.10	.0352	<0.02-0.09	.037
BOD_5	2.-7.	3.11	1.-16.	2.89	1.-2.	1.43	< 1.-2.	1.39
COD	<1.-57.	22.62	< 1.-56.	16.63	<5.-49.	15.19	< 5.-48.	13.87
Total organic carbon	6.-23.	10.77	5.-14.	8.19	4.-14	7.76	4.-10	6.74
Total solids	247-577.	380.57	177-424	265.57	149-235	189.05	148-220	195.35
Suspended solids	3.-70.	27.66	<1.-59.	18.86	< 1.-15.	7.19	< 1-41	7.43
Total volatile solids	25.-346	75.35	7.-108.	60.64	10.-127	52.00	10-125	47.52
Specific conductance (μmhos/cm)	324.-744.	517.94	229-607	366.00	228.-291.	263.48	218.-289.	262.65

SOURCE: Unpublished data. Water Quality Control Laboratories, City of Cleveland.
Units in mg/l except where noted.

TABLE 20

SUMMARY OF WATER QUALITY MEASUREMENTS
TAKEN TWO KILOMETERS AND 13 KILOMETERS OFFSHORE
OF CLEVELAND, OHIO, 1973-1975

		STATION 44 (2 km. offshore)	STATION 44	STATION 45 (13 km. offshore)	STATION 45	MAIN LAKE WESTERN CENTRAL BASIN
Parameter	Year	Range	Mean	Range	Mean	Mean
Temperature (°C)	1973	8.2-26.0	18.5	9.5-25.2	18.6	-
	1974	3.0-22.8	13.4	3.0-22.8	12.3	-
	1975	1.5-23.0	12.6	1.0-23.3	12.5	-
Transparency (m)	1974	0.5-4.5	2.3	0.7-10.1	3.4	3.4
	1975	0.3-3.0	1.1	0.8-8.0	3.3	3.4
Conductivity (µmhos/cm)	1973	266-322	284	277-318	290	281
	1974	260-351	303	265-330	291	285
	1975	238-387	262	224-291	257	258
Dissolved Oxygen (mg/l)	1973	0.1-11.0	9.2	1.5-11.0	9.0	8.7
	1974	2.5-13.4	10.1	0.3-12.9	10.3	10.0
	1975	4.8-13.3	9.9	2.2-13.3	9.6	9.9
Ammonia nitrogen (µg/l-N)	1973	6-100	31	7-117	44	36.3
	1974	1-121	42	0-121	16	22.5
	1975	0-316	45	2-190	39	25.0
Total phosphorus (µg/l-P)	1973	7-198	50	9-41	21	20.7
	1974	17-41	27	9-56	23	26.0
	1975	15-96	42	7-55	25	23.7
Dissolved phosphorus (µg/l-P)	1973	2-13	6.3	1-16	7	8.1
	1974	1-12	6	1-56	23	5.9
	1975	1-24	6	0-18	4	6.7
Chlorophyll a (µg/l)	1973	1.04-8.98	4.08	2.59-8.48	5.78	-
	1974	2.41-11.03	6.14	0.04-14.69	4.75	6.1
	1975	3.6-23.09	10.55	1.3-15.51	6.33	7.6

SOURCE: Lake Erie Nutrient Study. Center for Lake Erie Area Research, The Ohio State University, Columbus, Ohio.

Fairport, Ohio

Water Quality in the vicinity of Fairport Harbor has been severely impacted by the discharge of the now defunct Diamond Alkali facility. The impact was evident in conductivity, dissolved and total solids values from the harbor (Table 21). Outside of the harbor, the impact of this discharge is evident in the range of conductivity and chloride values from the Painesville water intake (Table 22). During the period of comparable record, i.e. 1973, conductivity values 4.8 km offshore to the west of the harbor (station 35) and 3 km offshore to the east of the harbor (station 34) are representative of main lake (Table 23) rather than conditions 1.2 km offshore at the intake. Low dissolved oxygen concentrations occurred both offshore and nearshore during the late summer period.

TABLE 21

SUMMARY OF WATER QUALITY MEASUREMENTS
TAKEN IN FAIRPORT HARBOR AND LAKE ERIE, 1963-1964

	Fairport Harbor [a]	Main Lake Central Basin [b]		Whole Lake [b]
Parameter	Range	Range	Average	Average
Temperature	23-29	-	-	-
Dissolved Oxygen (% sat.)	80-130	-	-	-
pH (std uts)	7.1-8.7	-	-	-
Conductivity (μmhos/cm)	330-5920	260-353	300	298.9
Dissolved Solids (mg/l)	180-6000	137-239	178	177.6
Total Solids (mg/l)	190-6100	159-218	185	185.8
Alkalinity (mg/l)	90-110	71-130	97	-
COD (mg/l)	8-12	3.1-16.0	7.1	7.36

SOURCES: [a] Lake Erie Environmental Summary

[b] Proceedings, Pollution of Lake Erie and Its Tributaries

TABLE 22

SUMMARY OF WATER QUALITY MEASUREMENTS
TAKEN AT THE PAINESVILLE WATER INTAKE[1], 1950-1974

Parameter	SEPT./1950-FEB./1952[a]		JULY/1965-JUNE/1966[b]	JAN. 1-DEC./1973[c]		JAN. 1-SEPT. 30/1974[c]	
	Range	Mean	Range	Range	Mean	Range	Mean
Dissolved Oxygen (mg/l)	-	-	-	3.8-18.5	10.9	4.7-15.6	10.9
pH (std uts)	7.2-8.2	-	7.0-8.8	7.5-9.5	8.18	6.2-8.7	8.0
Conductivity (µmhos/cm)	252-579	346	-	176-688	370	100-4480	341
Sulfate (mg/l)	21-43	28	-	1.5-25	15.2	-	-
Chloride (mg/l)	18-106	38	22-43	2.5-109	36.2	17-138	43.2
Total Hardness (mg/l)	110-193	140	116-264	100-244	139	90-250	139.1
Nitrates (mg/l as NO_3)	0.4-2.5	1.1	0.0-1.0	-	-	-	-

[1] 1.2 km (3800ft) offshore

SOURCES: [a] Lake Erie Pollution Survey-Supplement (1953)

[b] Great Lakes Basin Framework Study, Appendix 7

[c] STORET

TABLE 23

SUMMARY OF WATER QUALITY MEASUREMENTS TAKEN 4.8 KILOMETERS OFFSHORE OF MENTOR (STN. 35) AND 3 KILOMETERS OFFSHORE OF GENEVA (STN. 34)

LAKE COUNTY, OHIO, 1973-1975

Parameter	Year	STATION 35 (4.8 km offshore) Range	STATION 35 Mean	STATION 34 (3 km offshore) Range	STATION 34 Mean	MAIN LAKE EASTERN CENTRAL BASIN Mean
Temperature (°C)	1973	9.2-27.0	18.6	9.0-26.0	17.3	-
	1974	2.5-23.0	14.0	3.0-23.5	13.2	-
	1975	3.8-22.0	13.0	4.5-24.2	15.0	-
Transparency (m)	1974	0.5-5.3	2.8	0.3-5.5	2.6	5.6
	1975	0.5-3.0	1.8	0.5-3.0	1.8	4.6
Conductivity (µmhos/cm)	1973	288-330	297	270-319	292	293
	1974	260-334	298	255-423	313	291
	1975	240-308	265	246-310	271	269
Dissolved Oxygen (mg/l)	1973	0.5-11.0	9.3	2.1-10.6	8.6	8.6
	1974	1.4-13.6	10.0	0.1-13.2	9.9	9.8
	1975	7.7-13.0	9.9	7.5-12.6	9.5	10.2
Ammonia Nitrogen (µg/l-N)	1973	3-74	29	4-45	15	43.2
	1974	0-71	22	4-59	21	15.1
	1975	3-158	33	4-76	24	16.3
Total Phosphorus (µg/l-P)	1973	9-45	22	10-48	25	11.8
	1974	8-48	22	8-42	23	15.1
	1975	13-86	31	11-79	27	15.4
Dissolved Phosphorus (µg/l-P)	1973	1-9	6	1-10	5	5.9
	1974	0-1	1	0-10	4	5.3
	1975	0-16	6	0-9	4	5.0
Chlorophyll *a* (µg/l)	1973	1.62-3.74	2.86	0.81-0.85	0.83	-
	1974	2.12-12.96	6.14	0.59-12.95	4.91	2.8
	1975	1.13-10.52	6.56	0.68-20.61	7.68	4.79

SOURCE: Lake Erie Nutrient Study. Center for Lake Erie Area Research, The Ohio State University, Columbus, Ohio.

Ashtabula, Ohio

The purpose of this discussion is to summarize water quality studies conducted in the vicinity of Ashtabula, Ohio. The Ashtabula River is the smallest of the 24 major tributaries flowing into Lake Erie. The annual low flow period in late August and September results in near stagnant conditions in the lower reach and in the harbor. Since 1950, the development of an industrial complex discharging into Field Brook has seriously impacted water quality in the 1.5 mile reach between the mouth of Field Brook and the harbor. Field Brook is the primary source of dissolved solids in this portion of the river (Figure 58). Downstream in the harbor and offshore, dissolved solids and conductivity measurements are essentially ambient for nearshore conditions (Terlecky, et al. 1975). Harbor values for these parameters generally exceed offshore values. Values for dissolved solids often exceed existing or proposed standards (Table 24).

The number of water quality studies conducted in the Ashtabula area are limited. In 1929, Fish (1960) conducted a limited surface water survey in the harbor (Figure 59) and navigation channel (Figure 60). Data collected in 1963 and 1964 allows comparison of harbor and main lake conditions (Table 25). During the period, the range of ammonia values recorded in the harbor exceeded the range of values recorded throughout the Central Basin. Similar comparisons can be made with more recent data (1972-1975) collected in the river portion of the harbor (Table 24) and offshore (Table 26). The range of conductivity values in the river exceeded the values recorded offshore. Offshore conductivity values exhibit a relatively narrow range of variability. Hydrogen ion concentrations (pH) recorded in the harbor area frequently approached neutral (7.0). On two occasions, slightly acidic conditions were monitored (Table 24).

Offshore, a well defined thermocline develops near the bottom during the summer months. Temperature and transmissivity profiles measured at a point 4.4 km offshore are presented in Figure 61. Due to hypolimnetic oxygen depletion during the summer months, the range of dissolved oxygen concentrations measured offshore (Table 26) indicates lower values offshore than measurements taken in the harbor (Table 24). Low dissolved oxygen concentrations have been reported 0.48 km offshore at the municipal water intake (Table 27). Mean chloride and hardness values measured at the intake increased between 1950 and 1973.

Mixing patterns of river discharge and nearshore lake water are indicated by studies conducted between 1960 and 1968. Most of the river discharges through the opening in the eastern breakwall (U.S. Lake Survey, 1968). Distribution of several parameters lakeward from the harbor area suggest that river discharge combined with the predominant eastward current flow of the lake produces a significant influence that may extend for 2 to 3 miles or more from the harbor entrance, at least during peak flow (Terlecky, et al. 1975). During low flow, this influence extends 1 to 1.5 miles from the harbor mouth (USDHEW, In Terlecky, et al., 1975).

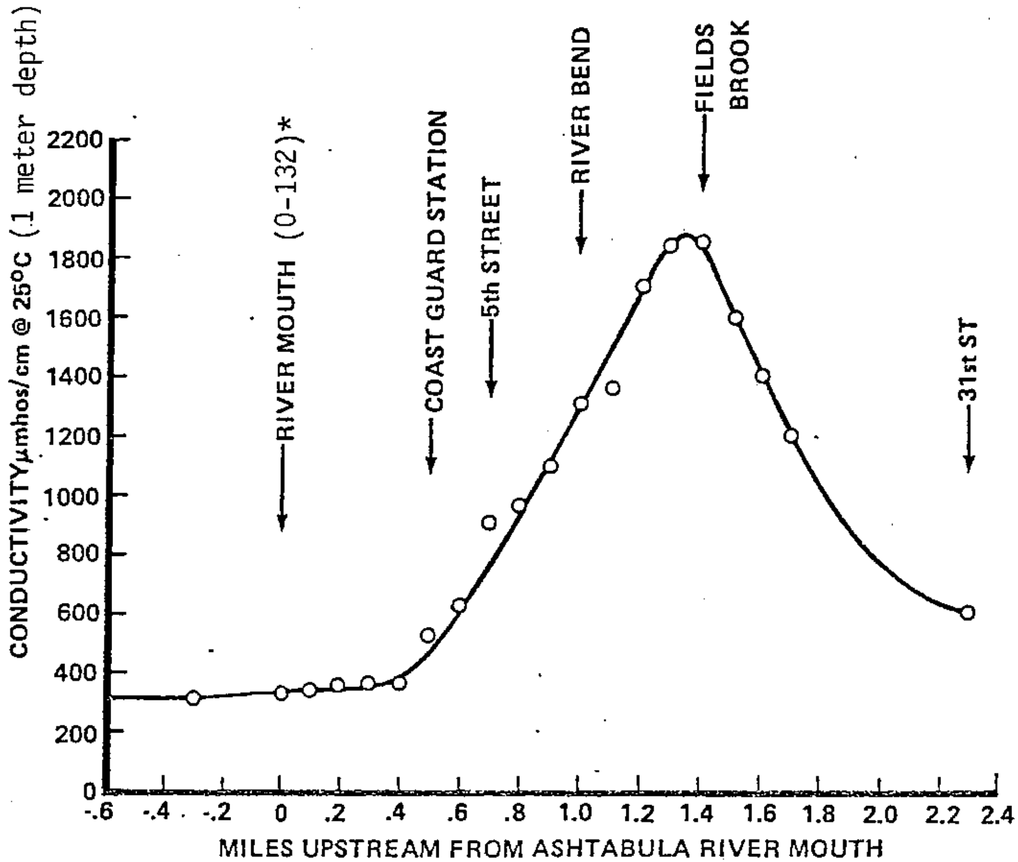


Figure 58. CONDUCTIVITY PROFILE OF ASHTABULA RIVER Estuary Zone, Sept. 5, 1973.

* Nearshore Master Plan Station Number

SOURCE: Terlecky, P.M., et al. 1975. USEPA Rept. No. EPA-905/9-74-008. 145 p.

Table 24.

Ashtabula River: Chemical Analyses, Water Year October 1972 to September 1973 (0-132)*

Date	Time	Total Calcium (Ca) (mg/1)	Total Magnesium (Mg) (mg/1)	Bicarbonate (HCO_3) (mg/1)	Carbonate (CO_3) (mg/1)	Dissolved Sulfate (SO_4) (mg/1)	Dissolved Chloride (Cl) (mg/1)	Dissolved Fluoride (F) (mg/1)	Total Fluoride (F) (mg/1)	Total Nitrate (N) (mg/1)
02 Oct	1640	—	—	34	0	41	43	.2	—	—
17 Oct	1100	—	—	88	0	72	250	.2	—	—
26 Oct	1330	—	—	—	-	—	—	—	—	—
17 Nov	1200	—	—	50	0	58	110	.2	—	—
27 Nov	1000	—	—	35	0	47	44	.1	—	—
22 Dec	2000	—	—	40	0	41	38	.1	—	—
31 Dec	1500	—	—	44	0	60	130	.1	—	—
04 Jan	1700	—	—	42	0	47	48	.1	—	—
10 Jan*	1030	—	—	—	-	45	17	—	—	—
19 Jan	1400	—	—	87	0	64	110	.2	—	—
02 Feb	1200	—	—	53	0	69	130	.1	—	—
20 Feb	—	—	—	110	0	29	29	.1	—	—
02 Mar	2200	—	—	85	0	67	99	.3	—	—
07 Mar*	1040	—	—	—	—	32	17	—	—	—
16 Mar	1200	—	—	29	0	34	30	.1	—	—
04 Apr	1550	—	—	60	0	60	138	.1	—	—
16 Apr	1600	—	—	73	0	57	116	.2	—	—
09 May	1200	—	—	74	0	66	172	.2	—	—
31 May	0915	—	—	68	0	50	57	.2	—	—
01 Jun	1200	—	—	39	0	26	38	.2	—	—
28 Jun	1100	—	—	102	0	53	180	.2	—	—
17 Jul*	1640	—	—	—	—	69	34	—	—	—
20 Jul	0945	—	—	113	0	70	300	.3	—	—
27 Jul	1200	—	—	115	0	44	170	.2	—	—
01 Aug	1535	110	11	113	0	55	300	—	.2	.01
15 Aug	1735	80	9.4	110	0	53	190	—	.1	.00
11 Sep*	1400	35	11	74	0	78	31	—	.1	.00
24 Sep	1200	64	9.5	111	0	47	120	—	.2	.00
27 Sep	1200	110	10	105	0	74	310	—	.2	.00

*Periodic grab samples taken at Lat 41°51'20", long 80°45'44".

* Nearshore Master Plan Station Number

SOURCE: Final EIS. Operations and Maintenance - Ashtabula Harbor 1975.
USACOE - Buffalo

Ashtabula River: Chemical Analyses, Water Year October 1972 to September 1973 (0-132)*
Table 24 (Cont'd)

Date	Dissolved Nitrate (N) (mg/l)	Total Nitrate (N) (mg/l)	Hardness (Ca,Mg) (mg/l)	Noncarbonate ness (mg/l)	Specific Conductance (Micromhos/cm)	Dissolved Solids (Residue at 180°C) (mg/l)	Total Residue (mg/l)	Temperature (DEG C)	Total Organic Carbon (C) (mg/l)	(pH units)	Dissolved Oxygen (DO) (mg/l)
02 Oct	1.1	---	90	62	300	178	---	15.5	---	6.9	10.3
17 Oct	.80	---	240	170	1090	624	---	13.0	---	7.1	11.5
26 Oct	---	---	---	---	---	---	---	10.0	1.0	6.9	10.3
17 Nov	.60	---	170	130	554	324	---	3.0	---	---	12.1
27 Nov	.80	---	90	62	309	168	---	4.0	---	---	---
22 Dec	.70	---	80	47	282	150	---	1.5	---	7.1	12.9
31 Dec	.50	---	160	120	590	330	---	6.0	---	---	11.9
04 Jan	.60	---	93	58	303	172	---	2.0	---	---	13.1
10 Jan*	.50	---	84	---	229	---	---	0.0	---	7.9	---
19 Jan	.60	---	180	110	623	358	---	3.0	---	---	13.1
02 Feb	.60	---	180	140	664	394	---	3.0	---	---	13.0
20 Feb	.40	---	130	40	318	170	---	1.0	---	7.7	13.7
02 Mar	.70	---	150	80	572	340	---	1.5	---	7.7	13.7
07 Mar*	.66	---	63	---	184	---	---	8.5	---	7.1	---
16 Mar	.60	---	68	44	225	118	---	13.0	---	6.8	10.9
04 Apr	.60	---	140	91	649	384	---	9.5	---	7.1	10.8
16 Apr	.70	---	160	100	593	352	---	10.0	---	7.3	11.2
09 May	1.1	---	180	120	811	486	---	15.0	---	7.3	8.4
31 May	.70	---	120	64	399	238	---	16.0	---	7.1	8.9
01 Jun	.60	---	74	42	227	164	---	18.0	---	7.1	8.7
28 Jun	1.2	---	220	140	140	560	---	23.0	---	7.3	4.2
17 Jul*	.10	---	150	---	391	---	---	29.5	---	7.3	---
20 Jul	1.3	---	310	220	1300	796	---	26.0	---	7.5	5.5
27 Jul	1.0	---	230	140	810	516	---	21.0	---	7.5	5.3
01 Aug	---	.91	---	---	1260	---	933	25.0	---	7.5	5.1
16 Aug	---	.68	---	---	909	---	597	25.5	---	7.5	7.7
11 Sep*	---	.17	---	---	389	---	272	19.0	---	7.8	---
24 Sep	---	.41	---	---	683	---	472	19.0	---	8.3	8.3
27 Sep	---	.65	---	---	1340	---	899	21.0	---	7.9	7.5

*Periodic grab samples taken at Lat 41°51'20", long 80°45'44".

* Nearshore Master Plan Station Number
SOURCE: Final EIS. Operations and Maintenance - Ashtabula Harbor 1975.
USACOE - Buffalo

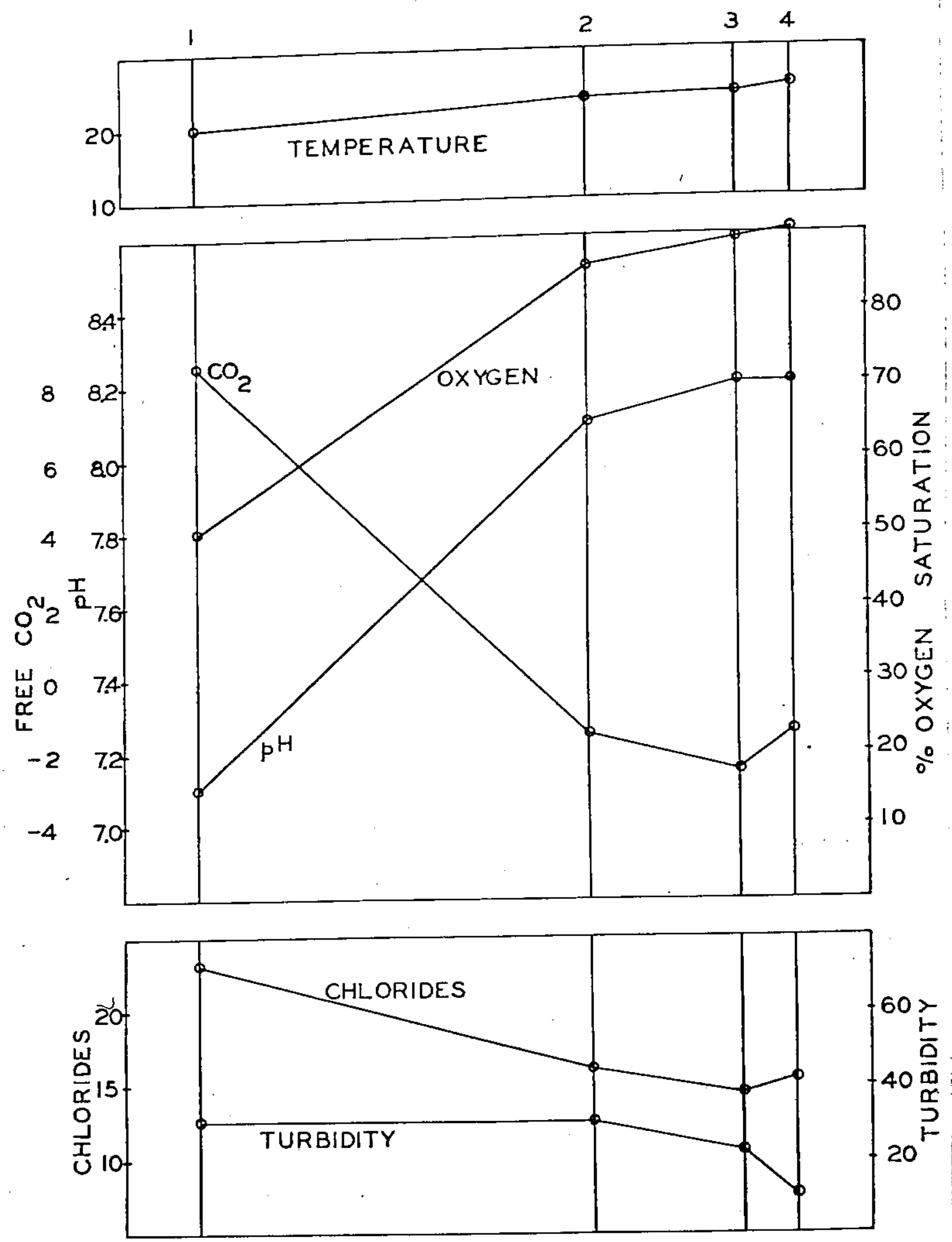


Figure 59.--Surface waters of Ashtabula Harbor. 1929

SOURCE: Fish, C.J., et al. 1960. Spec. Scient. Rept.-Fish No. 334. USF&WS. 198 p.

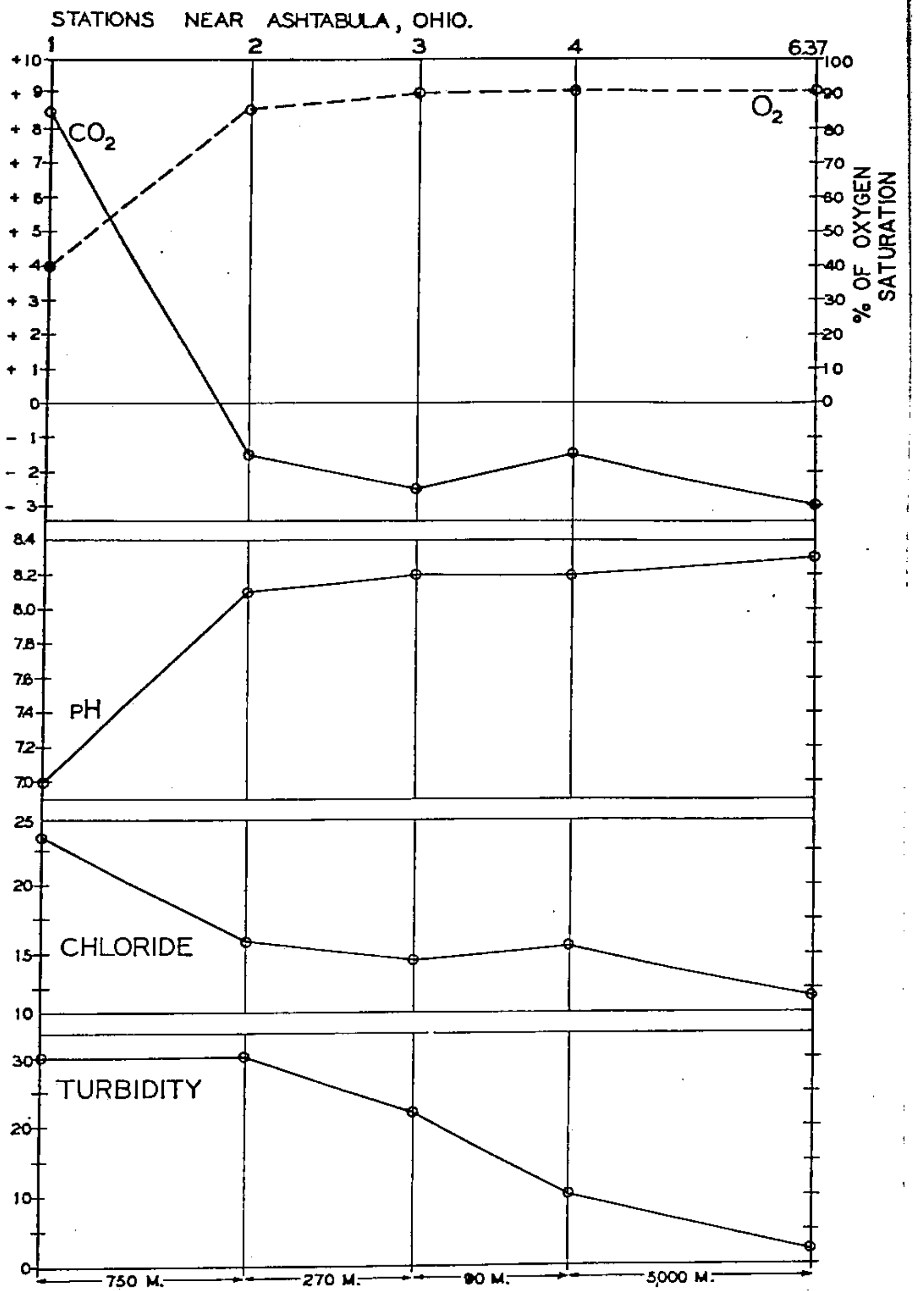


Figure 60. -Horizontal variation in chemical values of the surface waters near Ashtabula, Ohio. The scale from station No. 1 in Ashtabula River outward to station 06.37 is plotted as the logarithm of the distance in meters. 1929

SOURCE: Fish, C.J., et al. 1960. Spec. Scient. Rept.-Fish No. 334. USF&WS. 198 p.

TABLE 25

SUMMARY OF WATER QUALITY MEASUREMENTS TAKEN IN ASHTABULA HARBOR AND LAKE ERIE, 1963-1964

	Ashtabula Harbor[a]	Main Lake Central Basin[b]		Whole Lake[b]
Parameter	Range	Range	Average	Average
Temperature	15-17	-	-	-
Dissolved Oxygen (% sat.)	95-110	-	-	-
pH (std uts)	8.2-8.5	-	-	-
Chlorides (mg/l)	24-42	19-46	24	23.9
Dissolved Solids (mg/l)	170-230	137-239	178	177.6
Total Solids (mg/l)	180-250	159-218	185	185.8
Alkalinity (mg/l)	94-100	71-130	97	-
COD (mg/l)	7-11	3.1-16.0	7.1	7.36
Ammonia-Nitrogen	0.3-1.55	0.00-0.39	0.09	0.09

Sources: [a] Lake Erie Environmental Summary

[b] Proceedings, Pollution of Lake Erie and Its Tributaries

TABLE 26

SUMMARY OF WATER QUALITY MEASUREMENTS TAKEN
8 KILOMETERS OFFSHORE OF ASHTABULA, OHIO 1973-1975

Parameter	Year	Station 33 (8 km offshore) Range	Station 33 Mean	-Main Lake- Eastern Central Basin Mean
Temperature (^{o}C)	1973	9.0-26.0	18.1	-
	1974	3.2-23.5	13.0	-
	1975	3.5-23.8	14.5	-
Transparency (m)	1974	1.0-8.5	4.0	5.6
	1975	0.5-7.5	2.8	4.6
Conductivity (μmhos/cm)	1973	277-391	294	293
	1974	238-317	287	291
	1975	249-300	274	269
Dissolved Oxygen (mg/l)	1973	0.2-10.4	8.1	8.6
	1974	0.7-12.5	10.0	9.8
	1975	1.6-12.9	9.3	10.2
Ammonia Nitrogen (μg/l-N)	1973	6-43	20	43.2
	1974	1-58	17	15.1
	1975	0-56	19	16.3
Total Phosphorus (μg/l-P)	1973	3-20	13	11.8
	1974	6-32	18	15.1
	1975	11-38	23	15.4
Dissolved Phosphorus (μg/l-P)	1973	7-14	9	5.9
	1974	1-9	4	5.3
	1975	2-9	4	5.0
Chlorophyll a (μg/l)	1973	1.49-2.84	2.22	-
	1974	0.06-0.85	0.37	2.8
	1975	0.59-12.37	5.84	4.79

Source: Lake Erie Nutrient Study. Center for Lake Erie Area Research, The Ohio State University, Columbus, Ohio.

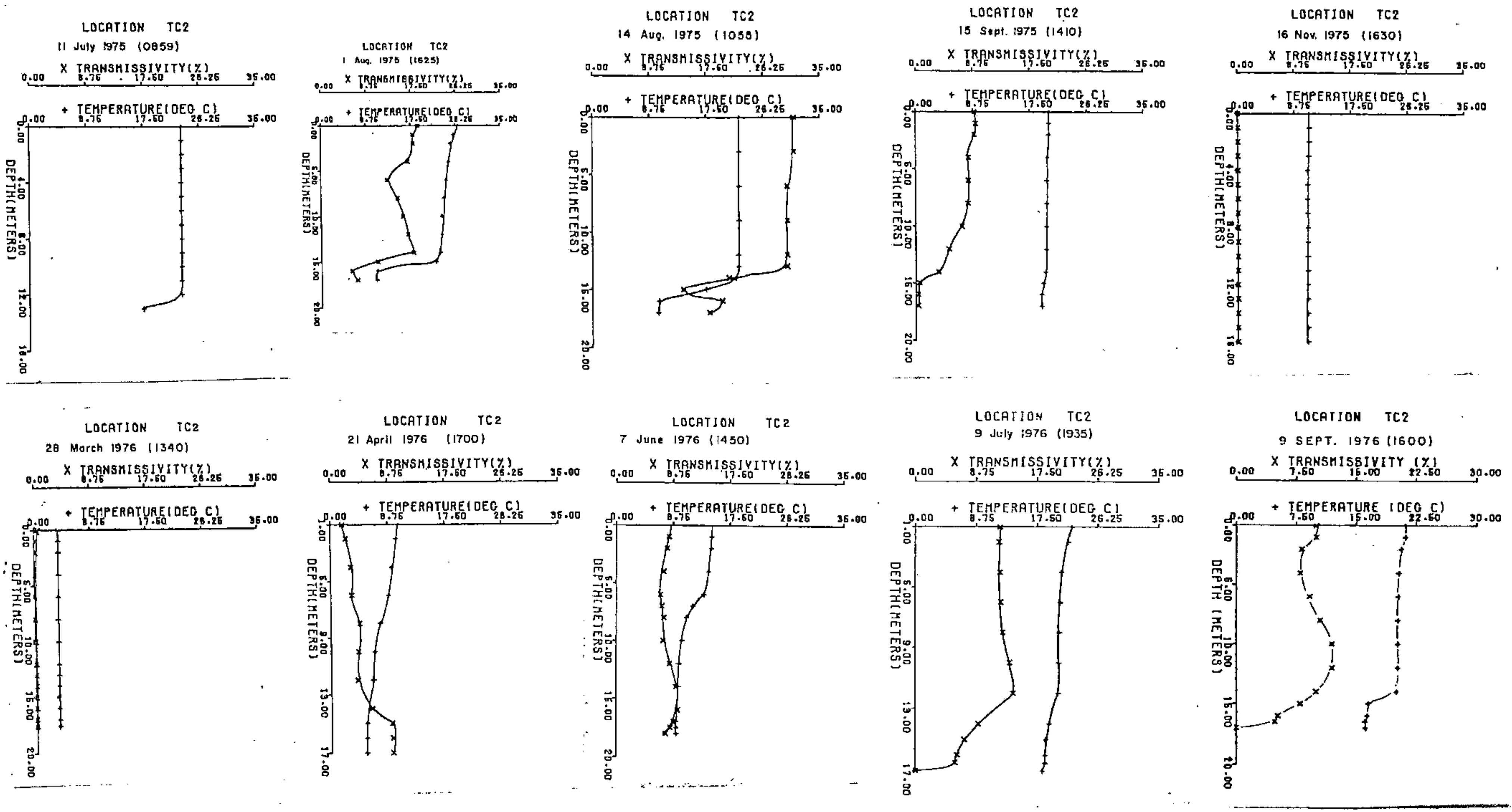


FIGURE 61. Vertical Profiles of Temperature and Transmissivity Measured near Station 0-131* (TC2) off Ashtabula, Ohio - 1975/1976

* Nearshore Master Plan Station Number

SOURCE: Danek, L.J., et al. 1977. Dredged Material Research Program Tech. Rept. D-77-42. Office of the Chief of Engineers, U.S. Army. Washington, D.C. 597 p.

TABLE 27

SUMMARY OF WATER QUALITY MEASUREMENTS TAKEN AT THE ASHTABULA WATER INTAKE[1], 1950 - 1974

Parameter	Sept./1950 - Feb./1952 [a]		Jan. 9 - Dec. 18/1973 [b]		Jan. 1 - Sept. 24/1974 [b]	
	Range	Mean	Range	Mean	Range	Mean
pH (std uts)	7.6-8.1	-	7.8-8.5	8.1	7.2-7.8	7.4
Conductivity (μmhos/cm at 25°C)	280-390	311	180-228	204	290-315	300
Sulfate (mg/l)	24-34	27	2-18	12.7	31-32	31
Chloride (mg/l)	18-44	24	20.0-39.5	27.9	25-38	33.7
Total hardness (mg/l)	117-152	130	122-152	133	128-140	133
Dissolved Oxygen (mg/l)	-	-	1.4-15.0	9.3	-	-

[1] 0.48 km (1500 ft) offshore

Source: [a] Lake Erie Pollution Survey - Supplement (1953)

[b] STORET

Conneaut, Ohio

The purpose of this discussion is to summarize the limited quantity of water quality data collected in the vicinity of Conneaut, Ohio, prior to the intensive 1977-1978 effort sponsored by U.S. Steel Corporation (Aquatic Ecology Associates, 1978). Portions of the latter study are presented herein.

Comparison of mean values measured at the municipal water intake during 1950-1952 and 1973 (Table 28) indicates at least a 19 percent drop in mean conductivity values and a 12 percent drop in mean sulfate concentrations. Comparison of mean chloride values for the same period indicates at least a 20 percent increase. Total hardness values were little changed. Parameters measured five km and 11 km offshore between 1973 and 1975 are largely representative of main lake conditions (Table 29). The range of conductivity values measured at the municipal intake (Table 28) demonstrates the considerable variability common to nearshore water compared with the relatively narrow range of values recorded offshore (Table 29). This observation is further evident in total alkalinity values before and after moving the intake further offshore in 1933 (Figure 62). The bars (Figure 62) are yearly ranges, based on monthly averages, for the years 1923 through 1942. More stable offshore conditions are apparent in the observation of the greatest post-1933 range (26 mg/l-1940) is equal to the least pre-1933 range of values (26 mg/l-1928).

The following discussion summarizes the results of a study conducted between May 1977 and April 1978 in the vicinity of the proposed U.S. Steel plant site at Conneaut. The study area is depicted in Figure 63. Measurements of total sulfide, residual chlorine, total cyanide, copper, cadmium, lead, mercury, total chromium and nickel were consistently at or below the minimum detectable levels throughout the study area. Mean values for temperature, dissolved oxygen, hydrogen ion concentration (pH), total hardness, specific conductance, calcium, nitrites, total iron, zinc, total organic carbon, biochemical oxygen demand (BOD), oil, total phosphate, soluble reactive phosphorus, total Kjeldahl nitrogen, phenol, fecal coliform, ammonia, chlorides, total dissolved solids, suspended solids and suspended volatile solids are presented graphically to show seasonal as well as tributary and nearshore variability (Figures 64-76).

Water temperatures recorded during the study typically revealed isothermal conditions throughout the water column (Figures 64-65). Isothermal conditions in the nearshore zone are attributable to vertical mixing associated with relatively shallow and turbulent water. Occasionally, a continuous thermal gradient was recorded. Cooler water temperatures were encountered with depth. Mixing of warmer spring and cooler fall waters of Conneaut Creek with harbor waters at the mouth of the creek led to a continuous gradient condition in the spring and fall months. Actual thermal stratification was not observed in the study area.

The annual cycle of dissolved oxygen concentrations was similar to other portions of the nearshore zone where higher concentrations associated with periods of low water temperatures and lower concentrations during periods of warmer temperatures (Figures 66 - 67). Very low oxygen concentrations were recorded at the mouth of Conneaut Creek during the month of August. Oxygen concentrations were depressed at the lakeward stations in early September. The biochemical oxygen demand (BOD) was low, generally below 2 mg/l (Figure 75). Outside of the harbor, conductivity values were quite similar (Figure 68-70). The greatest variability in conductivity was observed in values recorded in the harbor and at the mouth of Conneaut Creek. Generally, values recorded in the harbor were lower than values from the lake but higher than those in the creek. Periods marked by heavy rainfall and high discharge were characterized by low values in the harbor, while low rainfall and low discharge were associated with increased conductivity. Conneaut is an atypical tributary in that its waters are less conductive than Lake Erie waters. The hydrogen ion concentrations recorded throughout the study area ranged from 7.1 to 8.4 (Figure 71). Total hardness values ranged from 60 to 206 mg/l and calcium values ranged from 16 to 59 mg/l. Very little variability was observed between stations (Figure 71). Chloride values varied little during the entire study and, likewise, varied little among stations (Figure 70).

The highest concentrations of solids were recorded in the harbor and at the mouth of Conneaut Creek (Figure 72). Dissolved solids ranged from 99 to 285 mg/l. The lowest single dissolved solid value was recorded in the harbor and at the mouth of the creek in December. Measurements at lake stations display less variability than those from the harbor and creek. Suspended and suspended volatile solids values recorded in the harbor and creek were higher than lake values and were evidently influenced by stream flow, especially spring runoff.

Ammonia values varied considerably between lake and harbor stations (Figure 73). Concentrations of nutrients were relatively high (Figures 70, 73-74). Total Kjeldahl nitrogen (TKN) generally increased during the spring and summer months (Figure 74). This increase infers nitrogen fixation by phytoplankton. Occasional high nutrient values recorded in the creek were attributed to sewage effluent. Otherwise, values for the various nutrient parameters (nitrite, nitrate, soluble reactive phosphorus, total phosphorus) varied little among the station samples.

TABLE 28

SUMMARY OF WATER QUALITY MEASUREMENTS TAKEN AT THE CONNEAUT WATER INTAKE[1], 1950-1974

Parameter	Sept./1950-Feb./1952[a]		Jan.1-Dec.31/1973 [b]		Jan.1-Sept.30/1974 [b]		Oct. 3-Dec. 28/1974 [b]	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
pH std uts	7.4-8.2	-	6.8-12.4	7.8	7.6-8	7.8	7.6-7.8	7.77
Conductivity (μmhos/cm at 25°C)	279-353	303	160-340	245	150-940	235	190-280	243
Sulfate (mg/l)	23-31	26	12-52	22.7	12-41	21.6	12-21	15
Chloride (mg/l)	18-34	23	0.6-52	28.6	27-37	32	30-34	32
Total Hardness (mg/l)	116-138	126	75-142	122	100-140	127.9	120-128	125
Dissolved Oxygen (mg/l)	-	-	4.0-15.1	9.4	4.3-14.5	10.9	9.8-16.8	12.5

[1] 0.48 km (1500 ft) offshore

Sources: a Lake Erie Pollution Survey - Supplement (1953)

b STORET

TABLE 29

SUMMARY OF WATER QUALITY MEASUREMENTS TAKEN

5 KILOMETERS (STN. 23) AND 11 KILOMETERS OFFSHORE OF CONNEAUT, OHIO 1973-1975

Parameter	Year	STATION 23 (5 km offshore) Range	STATION 23 Mean	STATION 24 (11 km offshore) Range	STATION 24 Mean	MAIN LAKE EASTERN CENTRAL BASIN Mean
Temperature (°C)	1973	9.2-27.0	19.9	9.0-26.0	17.7	-
	1974	3.0-23.0	14.5	2.8-23.0	12.7	-
	1975	4.3-23.0	14.7	2.8-22.5	13.4	-
Transparency (m)	1974	1.0-6.3	3.5	1.1-6.8	3.8	5.6
	1975	0.3-5.0	2.4	0.5-7.3	3.3	4.6
Conductivity (µmhos/cm)	1973	270-388	292	281-317	299	293
	1974	279-327	299	277-327	292	291
	1975	252-333	279	250-328	274	269
Dissolved Oxygen (mg/l)	1973	5.4-10.8	9.4	0.2-11.0	9.1	8.6
	1974	6.9-12.8	10.1	4.8-12.6	10.0	9.8
	1975	6.9-13.1	9.8	3.9-13.4	9.5	10.2
Ammonia Nitrogen (µg/l-N)	1973	10-55	25	11-48	26	43.2
	1974	1-39	15	1-38	15	15.1
	1975	7-63	35	0-47	17	16.3
Total Phosphorus (µg/l-P)	1973	4-26	11	2-34	13	11.8
	1974	9-48	20	5-26	15	15.1
	1975	10-44	26	7-31	18	15.4
Dissolved Phosphorus (µg/l-P)	1973	1-12	6	0-9	4	5.9
	1974	0-3	1	0-4	1	5.3
	1975	0-15	5	0-11	4	5.0
Chlorophyll <u>a</u> (µg/l)	1973	1.81-2.69	2.22	2.05-2.86	2.35	-
	1974	0.45-11.89	4.13	0.54-7.50	2.90	2.8
	1975	0.72-15.66	7.27	1.44-13.48	5.48	4.79

Source: Lake Erie Nutrient Study. Center for Lake Erie Area Research, The Ohio State University, Columbus, Ohio.

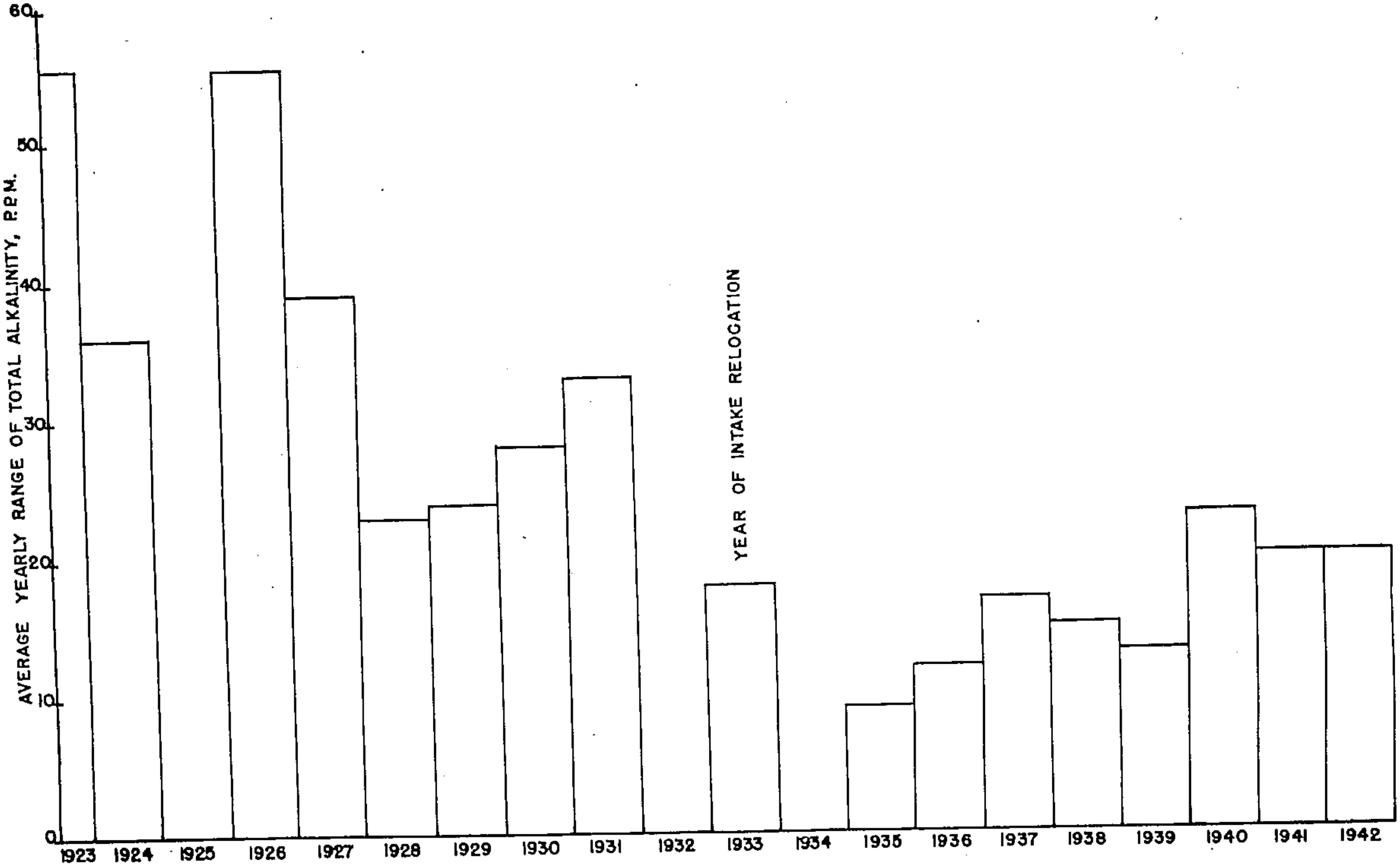
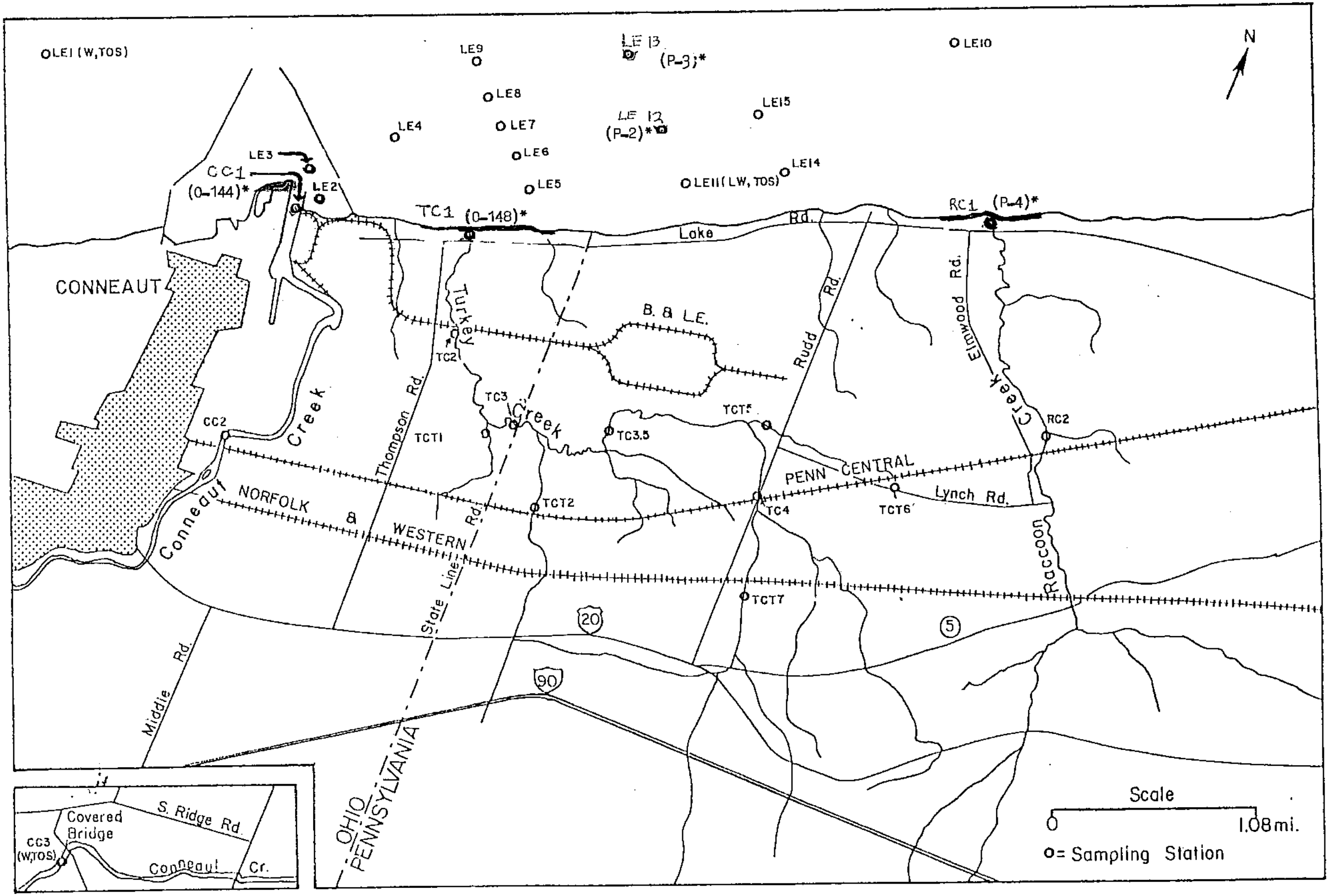


Fig. 62. Average yearly ranges of total alkalinity before and after change of intake location at Conneaut.

SOURCE: Powers, C.F., et al. 1959. Exploration of collateral data potentially applicable to Great Lakes hydrography and fisheries. Final report. Great Lakes Research Inst., Univ. Mich., Ann Arbor. 164 p.

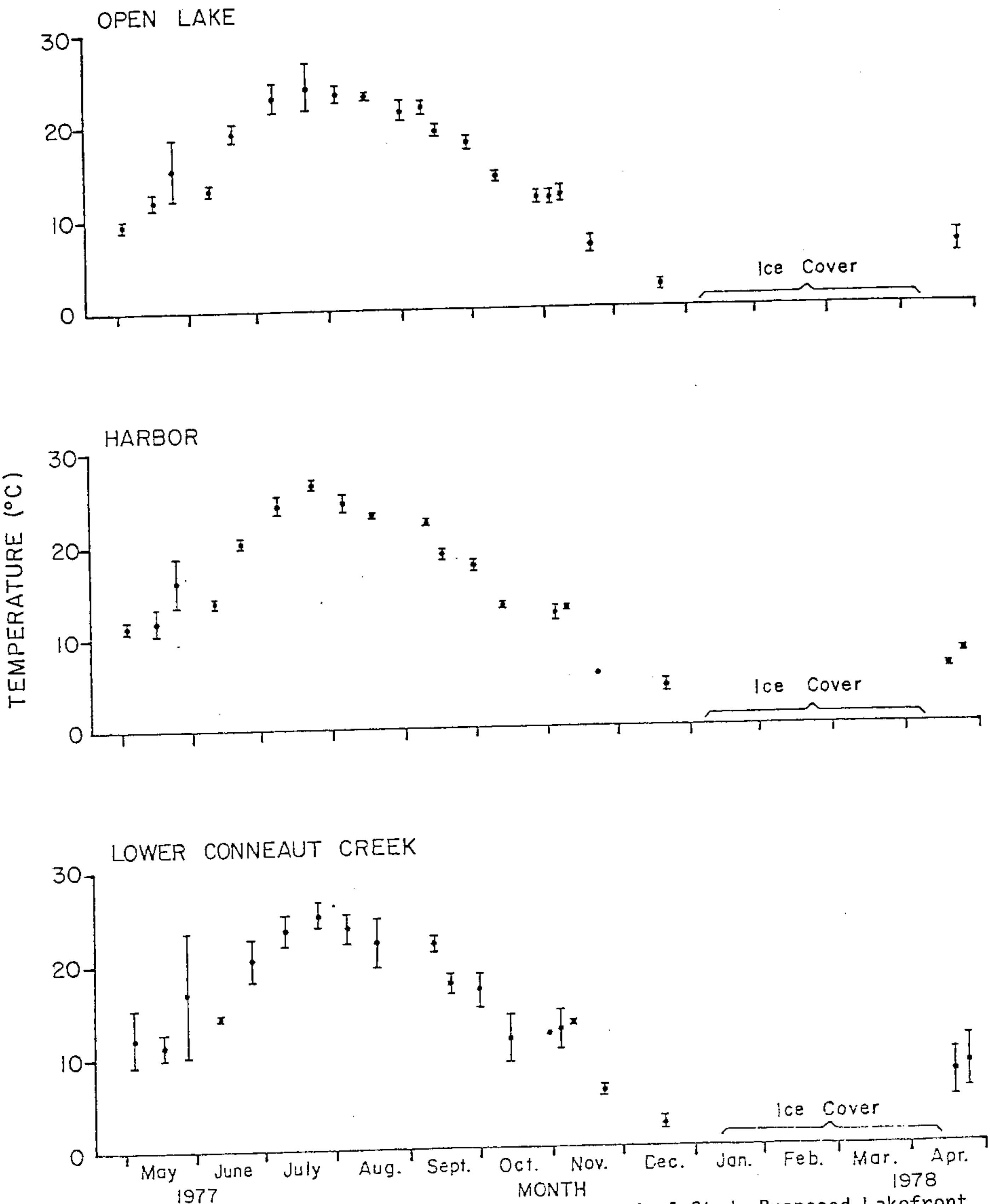
Figure 63. Map of Stream and Lake Water Chemistry Sampling Stations at the Proposed U. S. Steel Lakefront Plant Site, Conneaut, Ohio.



* Nearshore Master Plan Station Number

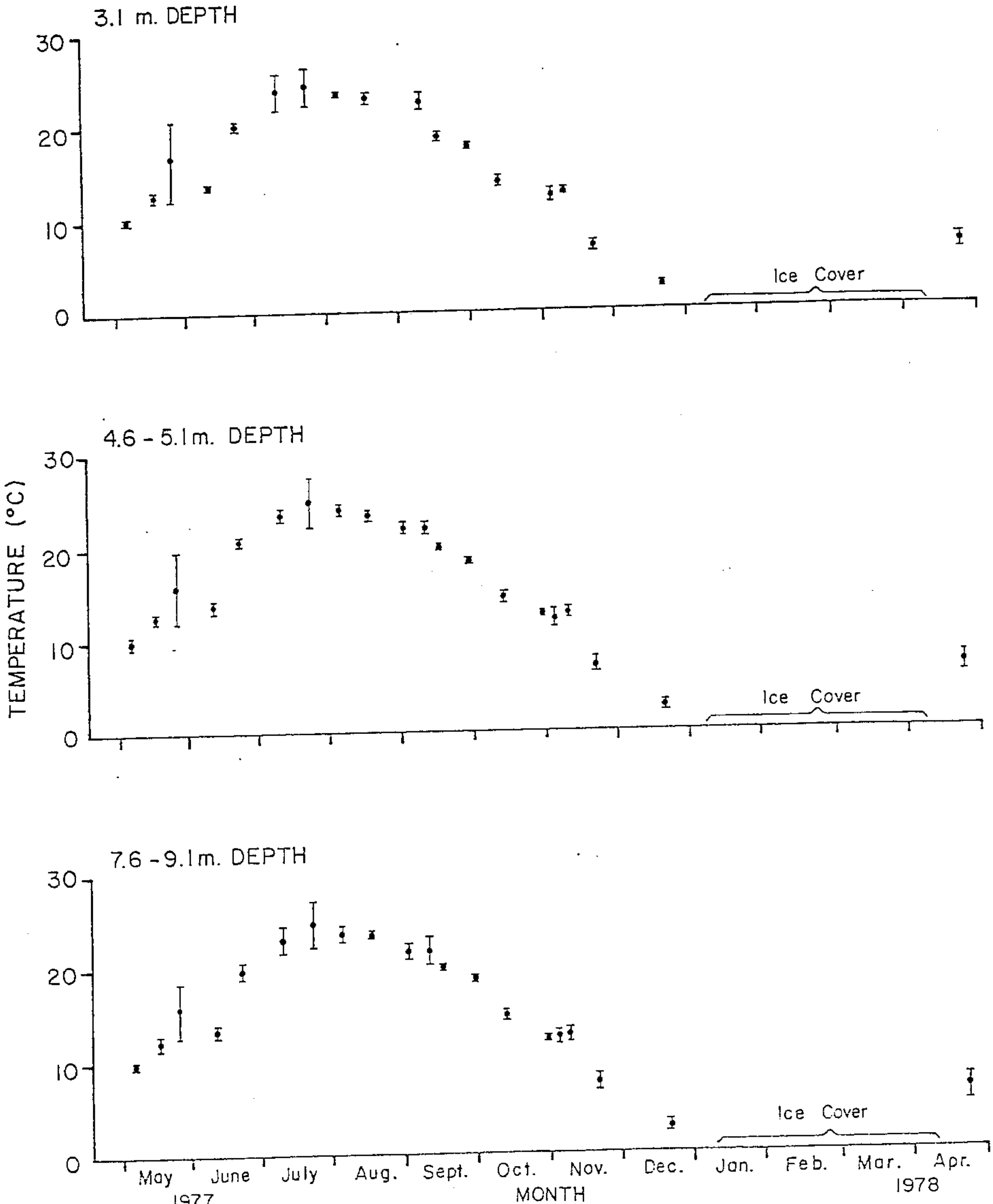
SOURCE: Aquatic Ecology Associates, Inc. 1978. Ecological Study Proposed Lakefront Plant Site, Conneaut, Oh. Preliminary Final Draft Report.

FIGURE 64. Mean Temperature in Lake Erie and Lower Conneaut Creek near the Proposed U. S. Steel Lakefront Plant Site, Conneaut, Ohio, May 2, 1977 through April 24, 1978. (Horizontal lines represent two standard deviations plus and minus from the mean.)



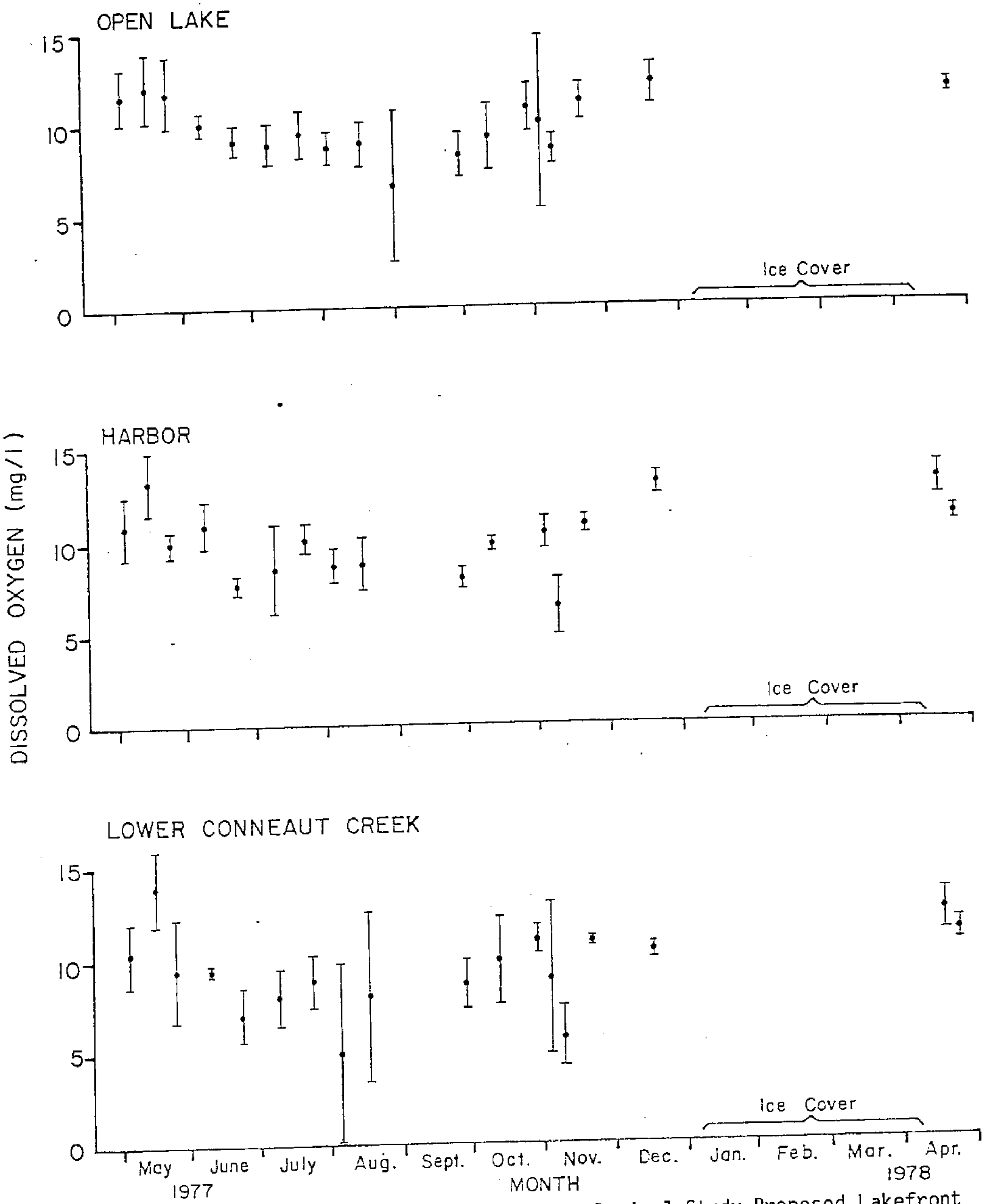
SOURCE: Aquatic Ecology Associates, Inc. 1978. Ecological Study Proposed Lakefront Plant Site, Conneaut, Ohio. Preliminary Final Draft Report.

FIGURE 65. Mean Temperature at the 3.1, 4.6 - 5.1, and 7.6 - 9.1 m Depth Stations in Lake Erie near the Proposed U. S. Steel Lakefront Plant Site, Conneaut, Ohio, May 2, 1977 through April 24, 1978. (Horizontal lines represent two standard deviations plus and minus from the mean.)



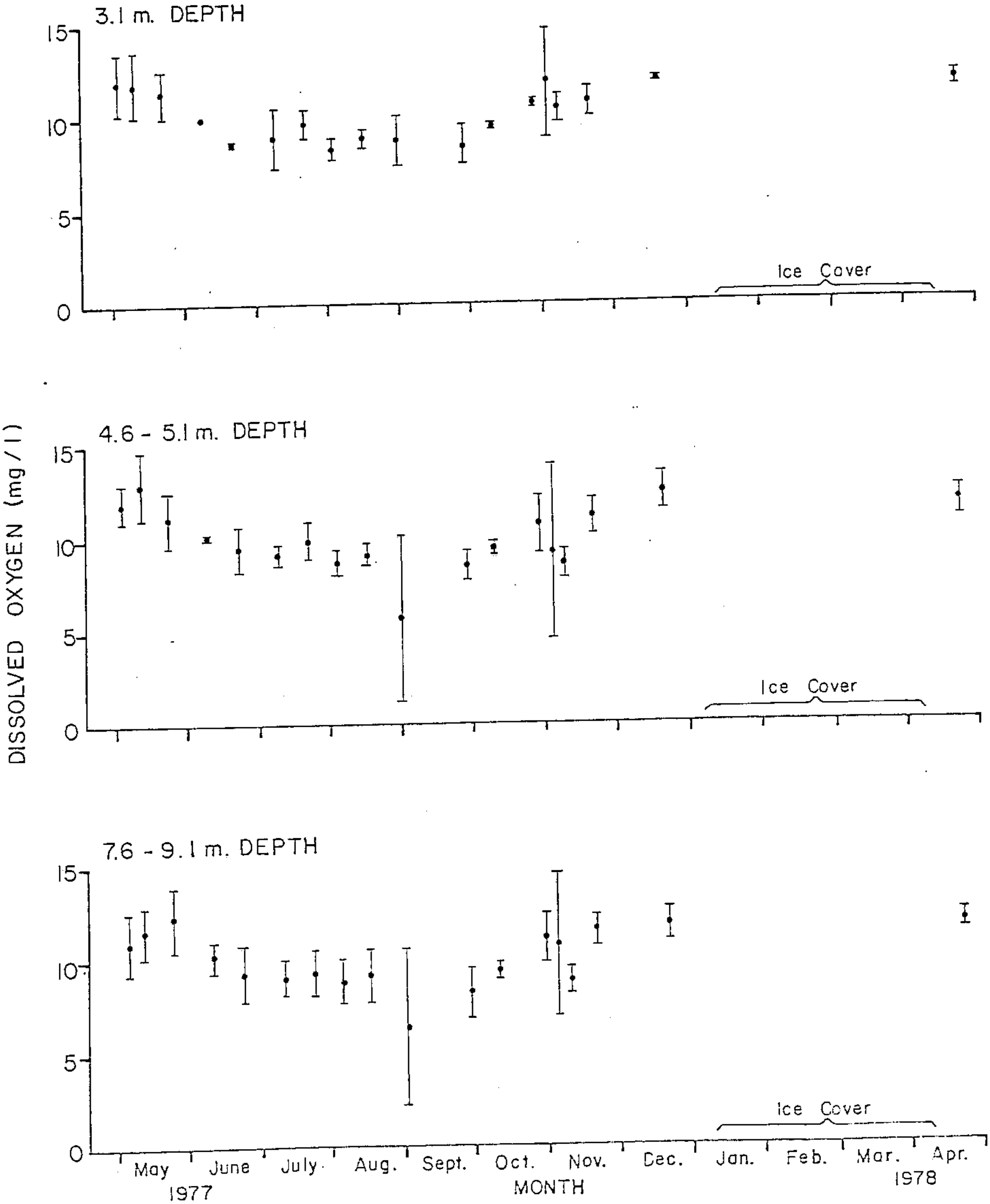
SOURCE: Aquatic Ecology Associates, Inc. 1978. Ecological Study Proposed Lakefront Plant Site, Conneaut, Ohio. Preliminary Final Draft Report.

FIGURE 66. Mean Dissolved Oxygen Levels in Lake Erie and Lower Conneaut Creek near the Proposed U. S. Steel Lakefront Plant Site, Conneaut, Ohio, May 2, 1977 through April 24, 1978. (Horizontal lines represent two standard deviations plus and minus from the mean.)



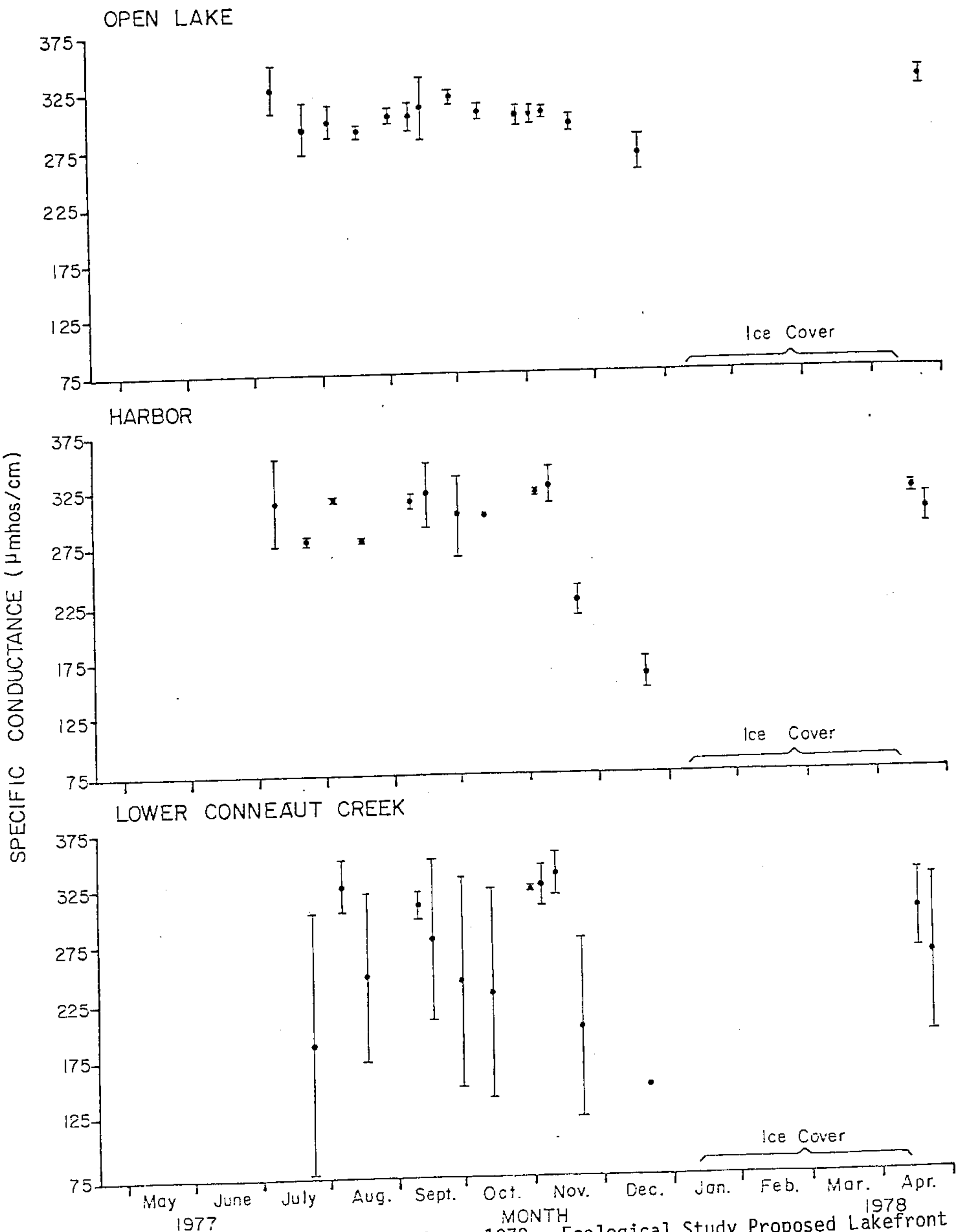
SOURCE: Aquatic Ecology Associates, Inc. 1978. Ecological Study Proposed Lakefront Plant Site, Conneaut, Ohio. Preliminary Final Draft Report.

FIGURE 67. Mean Dissolved Oxygen Levels at the 3.1, 4.6 - 5.1, and 7.6 - 9.1 m Depth Stations in Lake Erie near the Proposed U. S. Steel Lakefront Plant Site, Conneaut, Ohio, May 2, 1977 through April 24, 1978. (Horizontal lines represent two standard deviations plus and minus from the mean.)



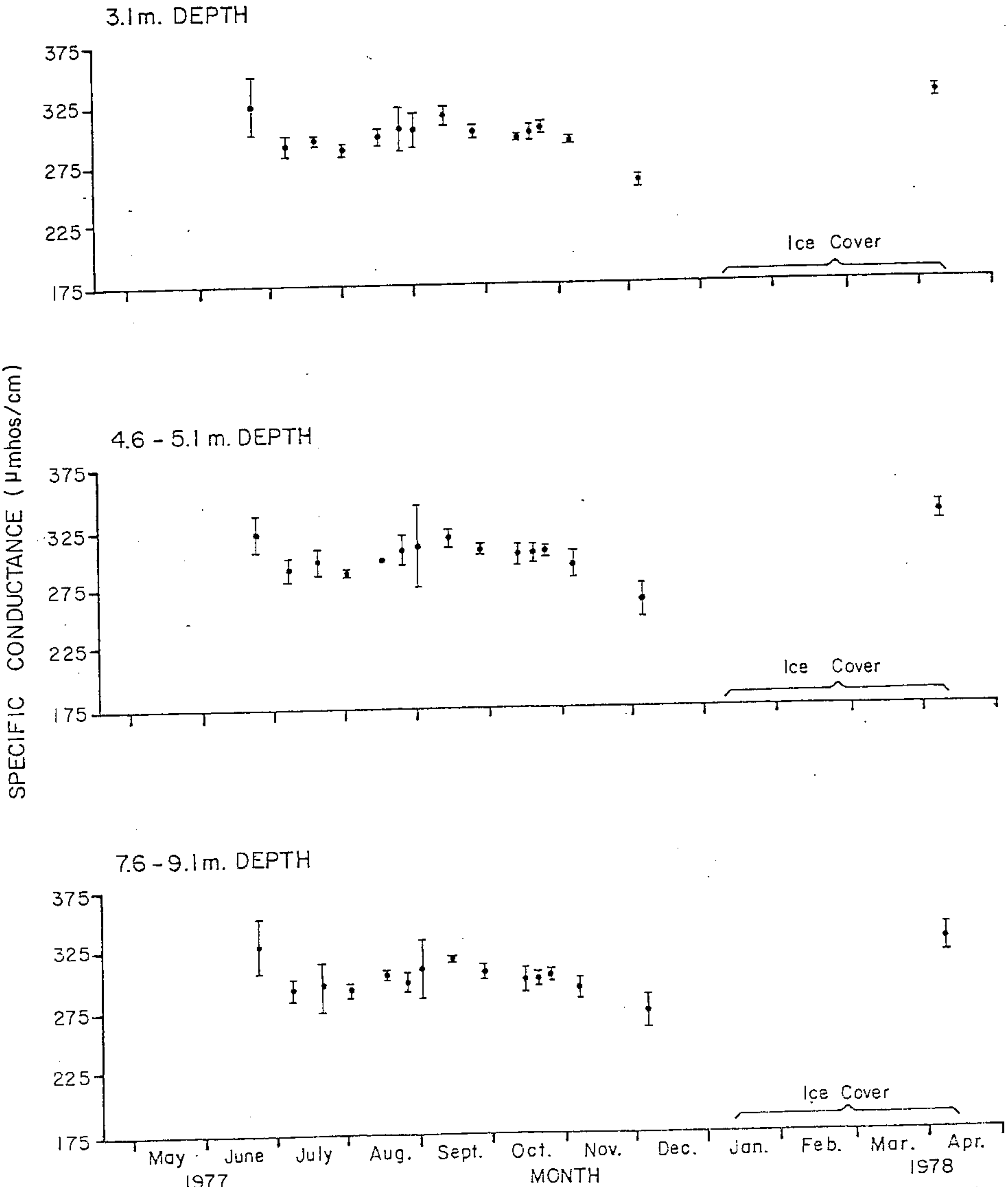
SOURCE: Aquatic Ecology Associates, Inc. 1978. Ecological Study Proposed Lakefront Plant Site, Conneaut, Ohio. Preliminary Final Draft Report.

FIGURE 68. Mean Specific Conductance in Lake Erie and Lower Conneaut Creek near the Prosed U. S. Steel Lakefront Plant Site, Conneaut, Ohio, July 5, 1977 through April 24, 1978. (Horizontal lines represent two standard deviations plus and minus from the mean.)



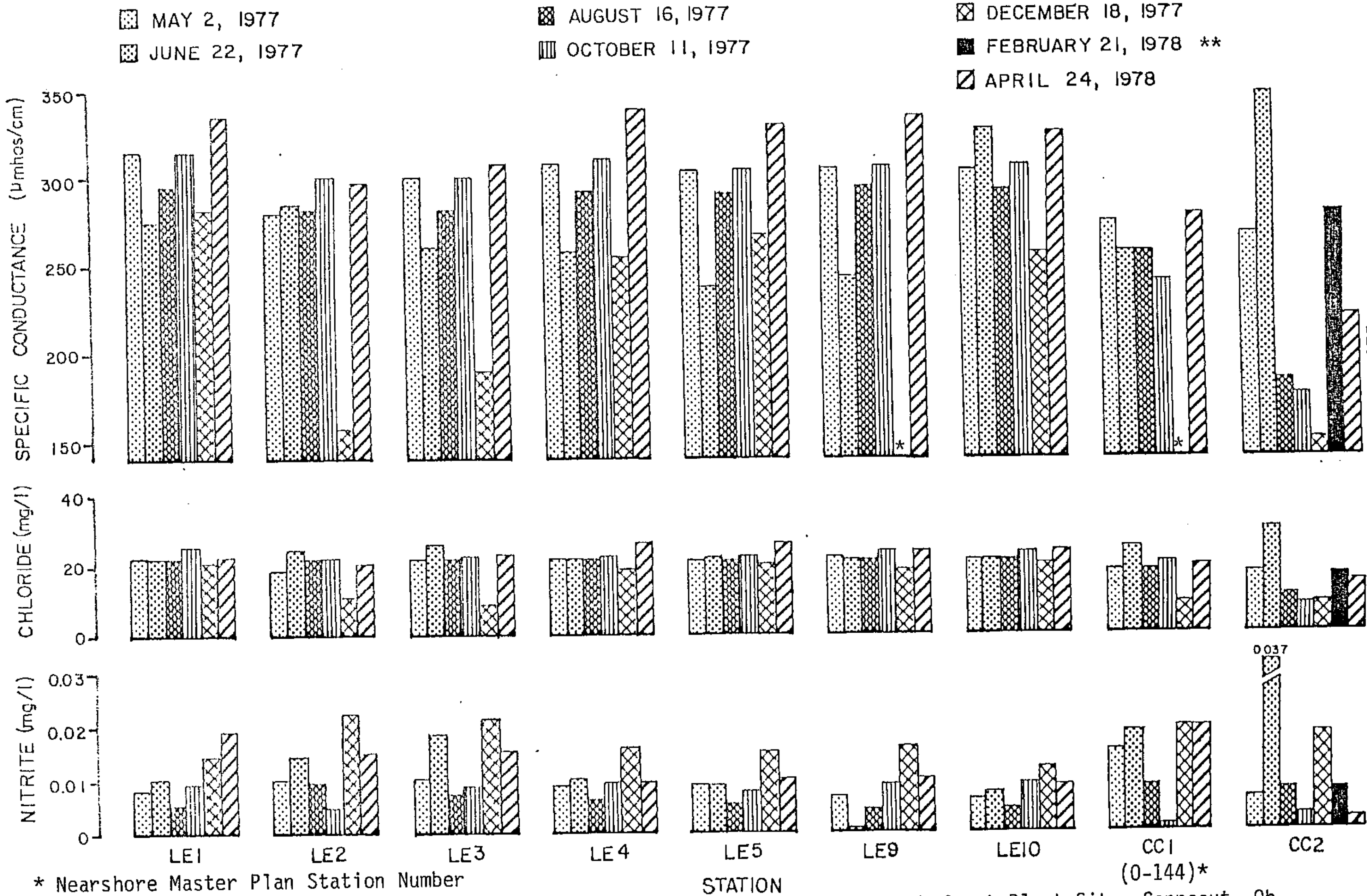
SOURCE: Aquatic Ecology Associates, Inc. 1978. Ecological Study Proposed Lakefront Plant Site, Conneaut, Ohio. Preliminary Final Draft Report.

FIGURE 69. Mean Specific Conductance at the 3.1, 4.6 - 5.1, and 7.6 - 9.1 m Depth Stations in Lake Erie near the Proposed U. S. Steel Lakefront Plant Site, Conneaut, Ohio, July 5, 1977 through April 24, 1978. (Horizontal lines represent two standard deviations plus and minus from the mean.)



SOURCE: Aquatic Ecology Associates, Inc. 1978. Ecological Study Proposed Lakefront Plant Site, Conneaut, Ohio. Preliminary Final Draft Report.

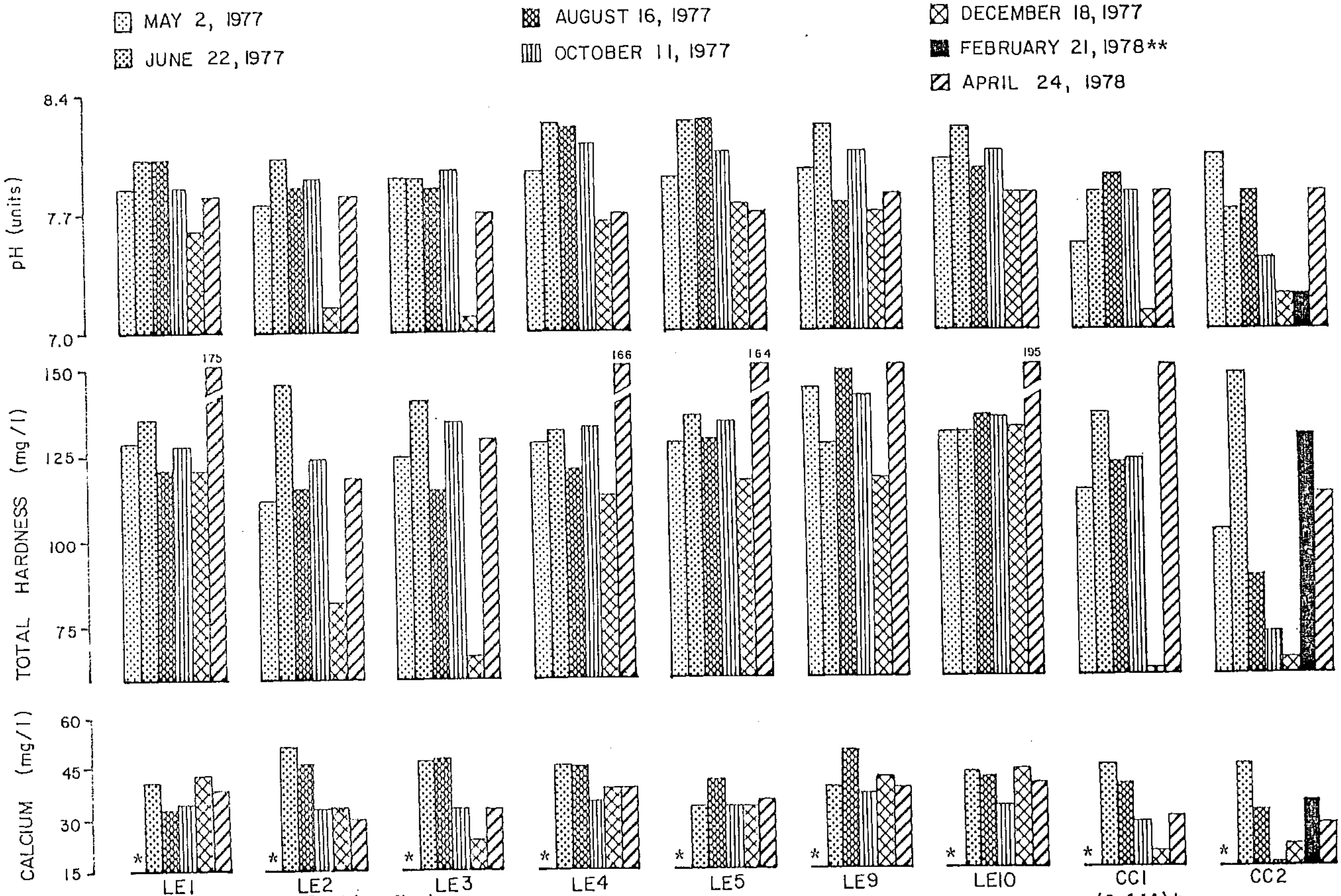
FIGURE 70. Specific Conductance, Chloride, and Nitrite in Lake Erie (LE) and Lower Conneaut Creek (CC) near the Proposed U.S. Steel Lakefront Plant Site, Conneaut, Ohio, May 1977 through April 1978. (Values represent the mean of surface and bottom samples; *Parameter not determined at this station; **Stations LE1 through LE10 and CC1 were not sampled.)



* Nearshore Master Plan Station Number

SOURCE: Aquatic Ecology Associates, Inc. 1978. Ecological Study Proposed Lakefront Plant Site, Conneaut, Oh. Preliminary Final Draft Report.

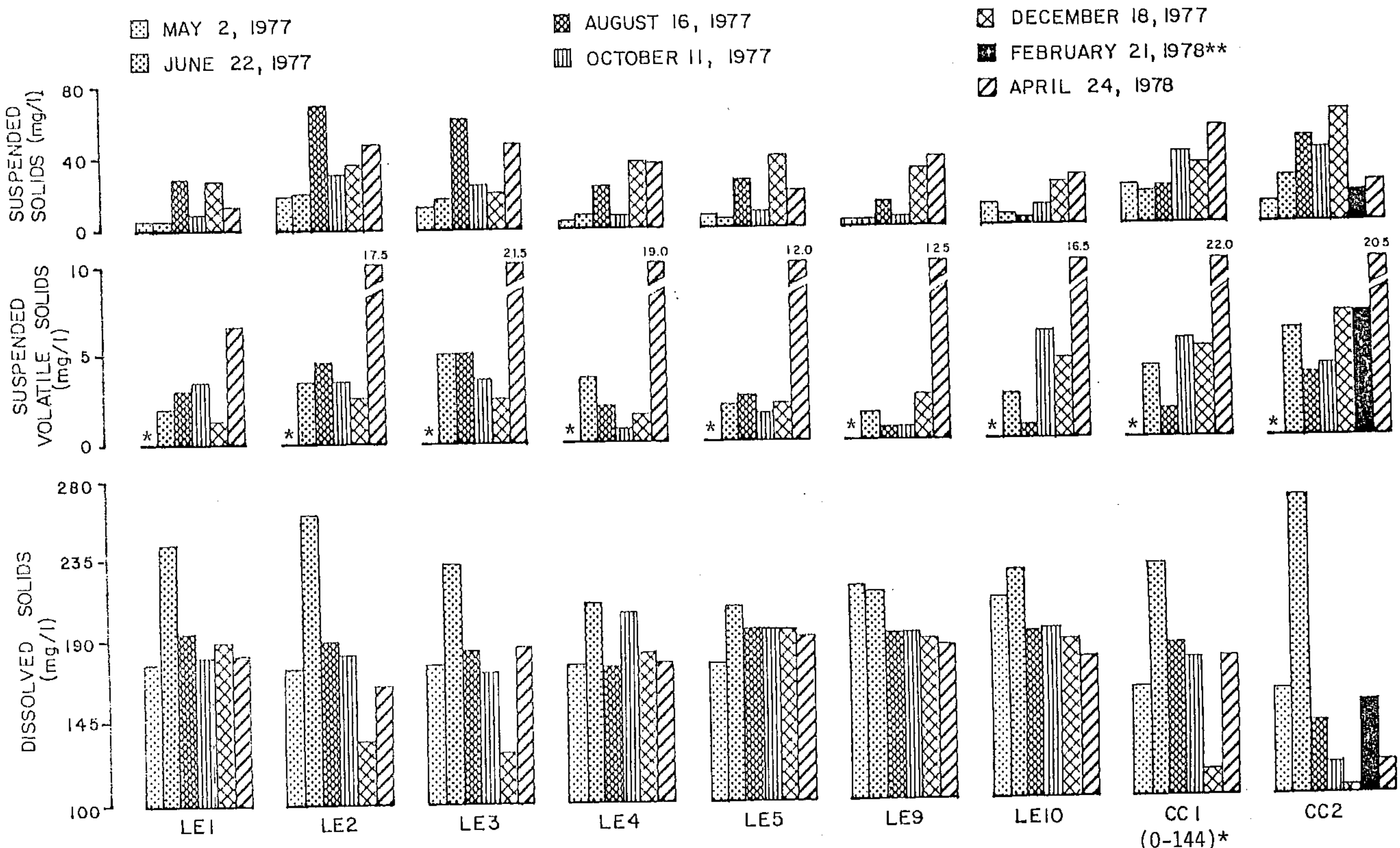
FIGURE 71. pH, Total Hardness, and Calcium in Lake Erie (LE) and Lower Conneaut Creek (CC) near the Proposed U. S. Steel Lakefront Plant Site, Conneaut, Ohio, May 1977 through April 1978. (Values represent the mean of surface and bottom samples; *Parameters not determined on this date; ** Stations LE1 through LE10 and CC1 were not sampled.)



* Nearshore Master Plan Station Number

SOURCE: Aquatic Ecology Associates, Inc. 1978. Ecological Study Proposed Lakefront Plant Site, Conneaut, Oh. Preliminary Final Draft Report

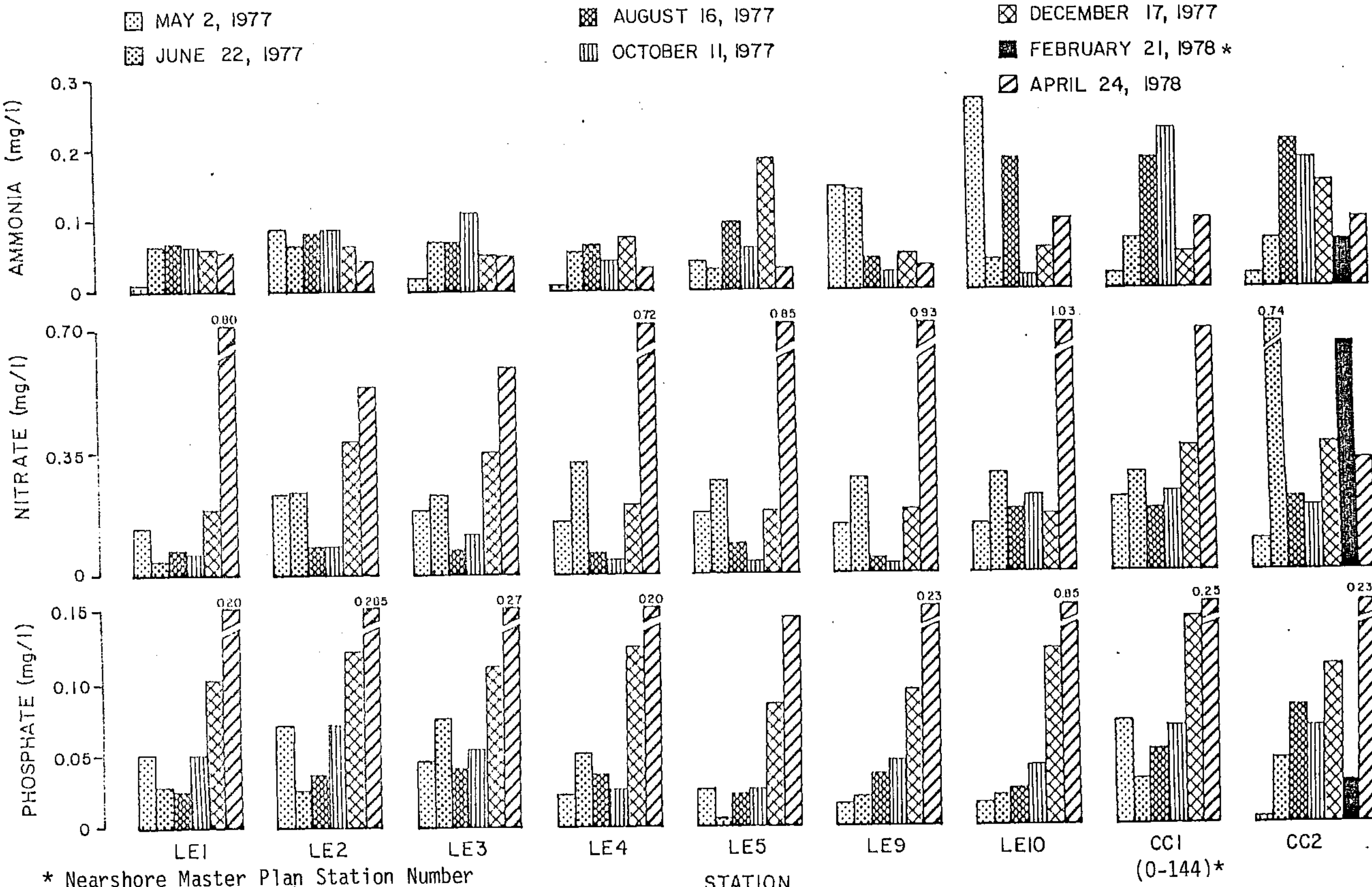
FIGURE 72. Suspended Solids, Suspended Volatile Solids, and Dissolved Solids in Lake Erie (LE) and Lower Conneaut Creek (CC) near the Proposed U.S. Steel Lakefront Plant Site, Conneaut, Ohio, May 1977 through April 1978. (Values represent the mean of surface and bottom samples; *Parameter not determined at this station; **Stations LE1 through LE10 and CC1 were not sampled.)



* Nearshore Master Plan Station Number

SOURCE: Aquatic Ecology Associates, Inc. 1978. Ecological Study Proposed Lakefront Plant Site, Conneaut, Oh. Preliminary Final Draft Report.

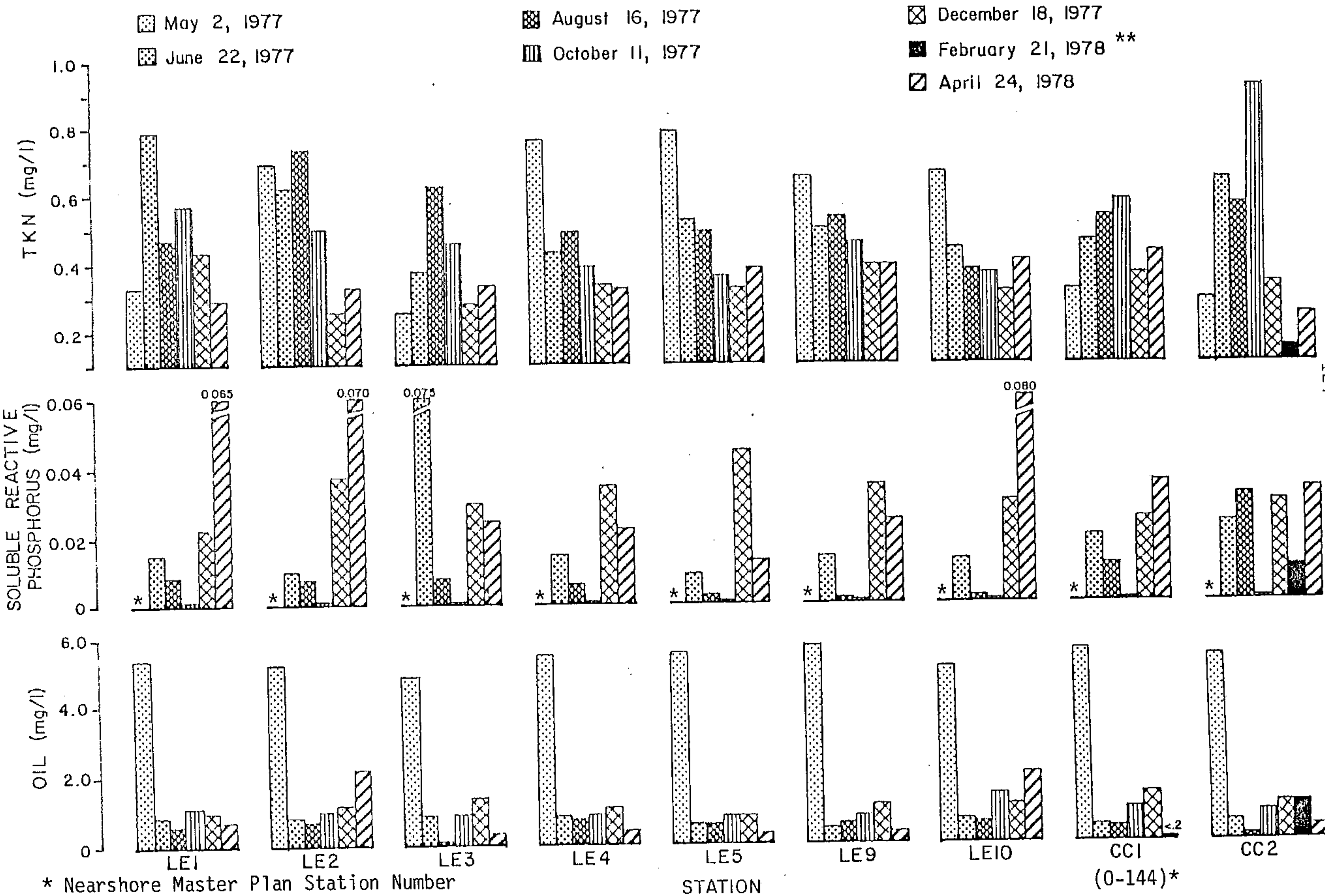
FIGURE 73. Ammonia, Nitrate, and Phosphate in Lake Erie (LE) and Lower Conneaut Creek (CC) near the Proposed U. S. Steel Lakefront Plant Site, Conneaut, Ohio, May 1977 through April 1978. (Values represent the mean of surface and bottom samples; *stations LE1 through LE10 and CC1 were not sampled.)



* Nearshore Master Plan Station Number

SOURCE: Aquatic Ecology Associates, Inc. 1978. Ecological Study Proposed Lakefront Plant Site, Conneaut, Oh. Preliminary Final Draft Report.

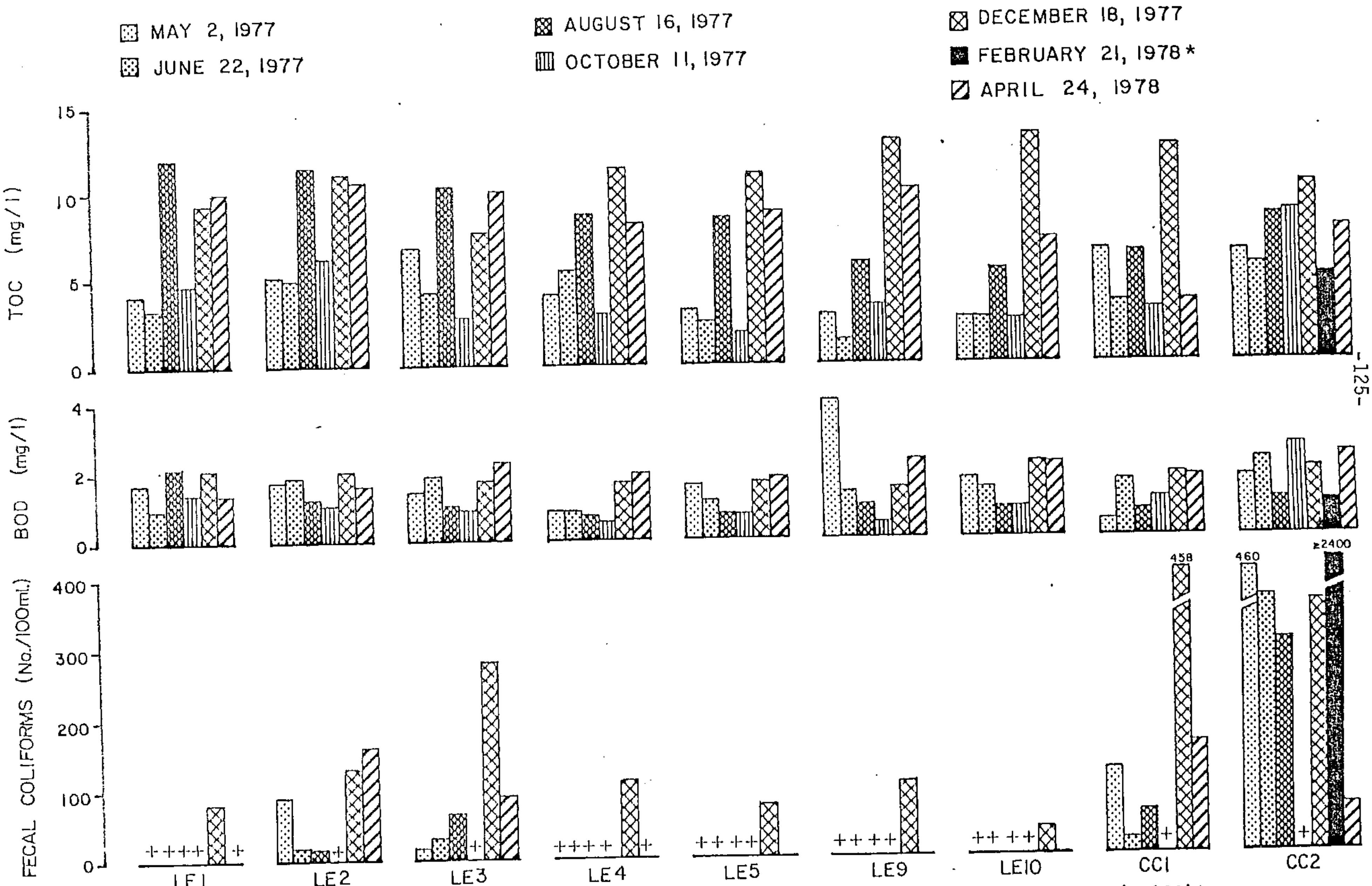
FIGURE 74. TKN, Soluble Reactive Phosphorus, and Oil in Lake Erie (LE) and Lower Conneaut Creek (CC) near the Proposed U. S. Steel Lakefront Plant Site, Conneaut, Ohio, May 1977 through April 1978. (Values represent the mean of surface and bottom samples; *parameter not determined for this date; **stations LE1 through LE10 and CC1 were not sampled.)



* Nearshore Master Plan Station Number

SOURCE: Aquatic Ecology Associates, Inc. 1978. Ecological Study Proposed Lakefront Plant Site, Conneaut, Oh. Preliminary Final Draft Report.

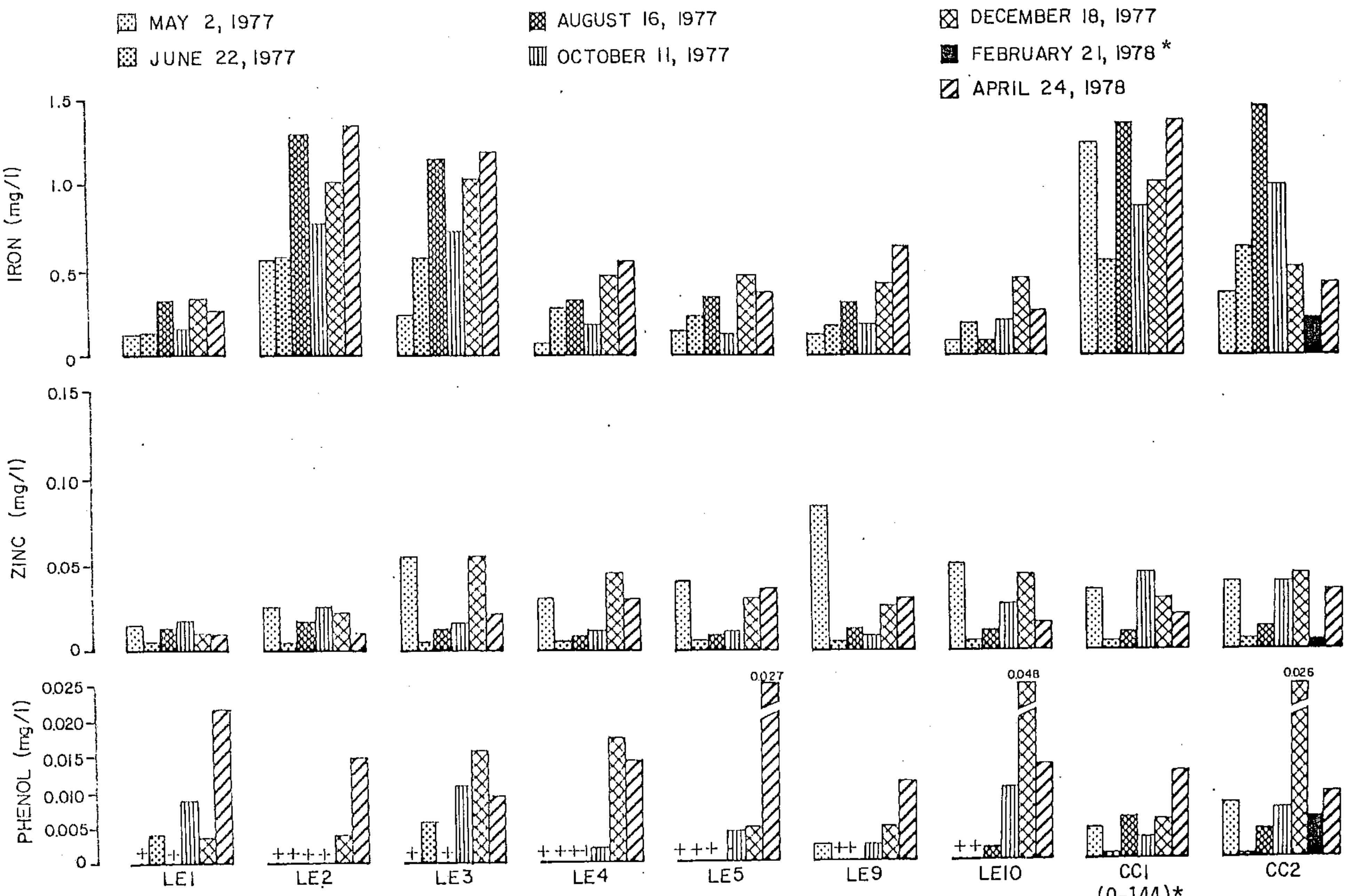
FIGURE 75. TOC, BOD, and Fecal Coliforms in Lake Erie (LE) and Lower Conneaut Creek (CC) near the Proposed U. S. Steel Lakefront Plant Site, Conneaut, Ohio, May 1977 through April 1978. (Values represent the mean of surface and bottom samples; *stations LE1 through LE10 and CC1 were not sampled; + Fecal Coliforms <10/100 ml.)



* Nearshore Master Plan Station Number

SOURCE: Aquatic Ecology Associates, Inc. 1978. Ecological Study Proposed Lakefront Plant Site, Conneaut, Oh. Preliminary Final Draft Report.

FIGURE 76. Iron, Zinc, and Phenol in Lake Erie (LE) and Lower Conneaut Creek (CC) near the Proposed U. S. Steel Lakefront Plant Site, Conneaut, Ohio, May 1977 through April 1978. (Values represent the mean of surface and bottom samples; *stations LE1 through LE10 and CC1 were not samples; + Phenol <.001 mg/l.)



* Nearshore Master Plan Station Number

SOURCE: Aquatic Ecology Associates, Inc. 1978. Ecological Study Proposed Lakefront Plant Site, Conneaut, Oh. Preliminary Final Draft Report.

Erie, Pa.

The purpose of this discussion is to summarize the limited number of water quality studies conducted in the vicinity of Erie, Pa. A surface water survey was conducted in Erie Harbor in 1929 (Fish, et al., 1960). The results of this early effort are depicted in Fig. 77. Using data collected in 1929, average monthly alkalinity, turbidity and temperature values of measurements taken at the Erie municipal water intake are compared in Tables 30 and 31 with average main lake values and average values of selected main lake stations bordering the southern nearshore zone. Alkalinity values from the intake were slightly lower than the other average values. Turbidity values at the intake definitely exceeded offshore values. The selected stations were apparently influenced by more turbid nearshore water. The range of values of water quality parameters measured in the harbor and main lake during 1963-1964 are presented in Table 32. Harbor values largely fall within the range of main lake values, indicating relatively good quality water. Similar data collected at the Erie water intake during 1973-1974 is summarized in Table 33. Comparison of mean values at the intake (Table 33) and in the eastern central basin (Table 29), respectively, for conductivity, dissolved oxygen, ammonia nitrogen and total phosphorus indicates better quality water at the intake than for the eastern portion of the Central Basin as a whole.

A more comprehensive study of water quality in Presque Isle Bay and adjacent Lake Erie during 1973-1974 indicated only a few localized water quality problem areas (Browne, 1975). Although overall water quality was considered good (Tables 34,35), low dissolved oxygen was observed consistently near Mill Creek and degraded water was observed in the marina area of the bay as well as in Lake Erie near the Hammermill Paper Company (Table 36). The cause of degraded water quality in the latter area is apparently due to wastewater discharges from the paper facility (Browne, loc. cit.). The prevailing eastward longshore current transports highly colored water at least as far as Fourmile Creek (Table 37).

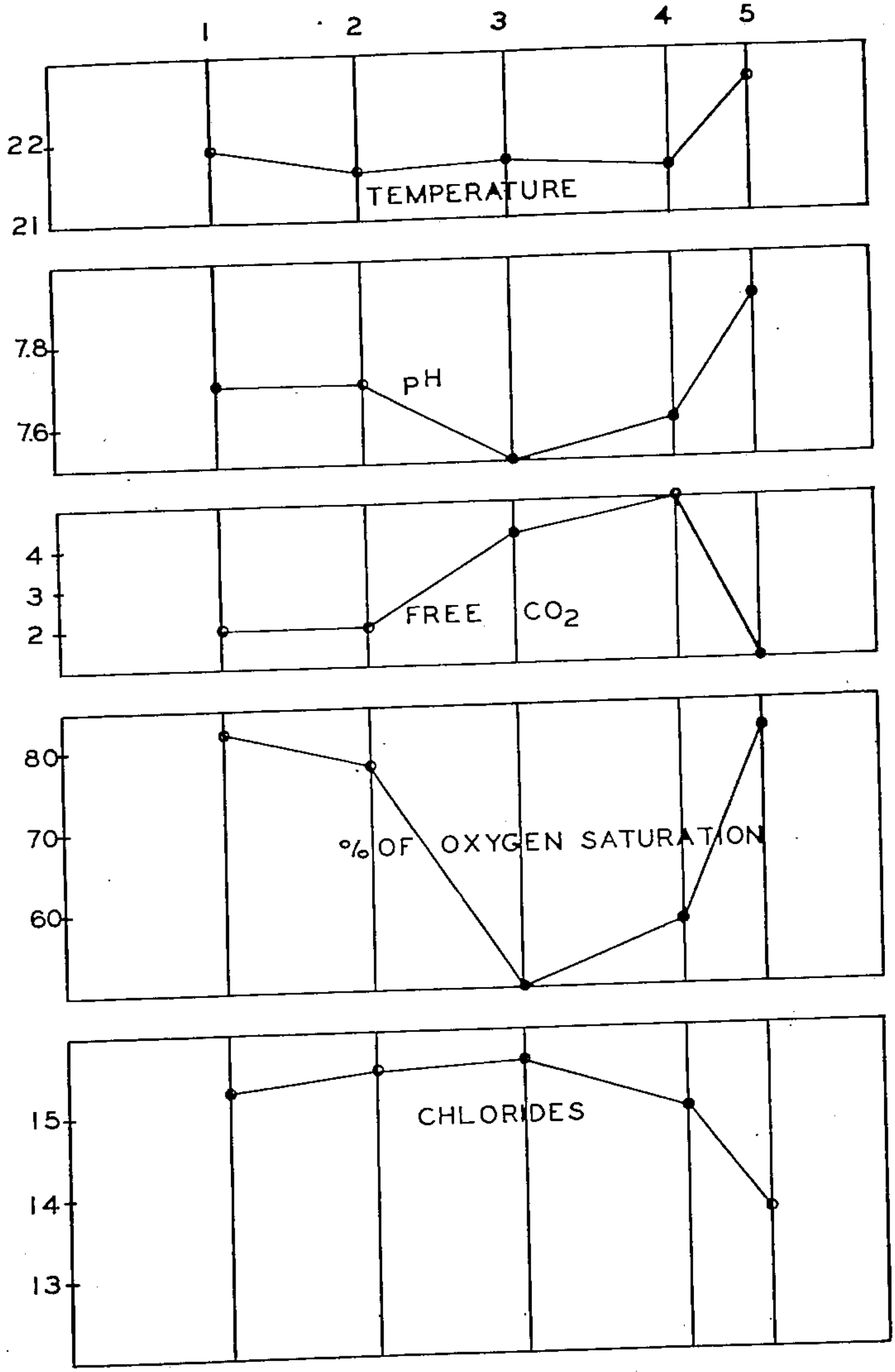


Figure 77 --Surface waters of Erie Harbor August 10 and 13, 1929.

SOURCE: Fish, C.J., et al. 1960. Spec. Scient. Rept.-Fish No. 334. USF&WS. 198 p.

TABLE 30

COMPARISON OF NEARSHORE AND OFFSHORE AVERAGE ALKALINITY AND TURBIDITY MEASUREMENTS TAKEN IN THE CENTRAL BASIN - 1929

	All Stations[1]			Selected Stations[1]			Erie Waterworks (P-16)*
	Surface	Bottom	Surface and Bottom	Surface	Bottom	Surface and Bottom	
Alkalinity							
June	99	97.5	98	95	94	95	92
July	101	98	99.5	96	95	95	92
Aug.	97	96.5	97	97	95.5	96	93
Sept.	98	98	98	97.5	99	98	93
Turbidity							
June	4	6	5	9	11	10	12
July	3	6	5	5	6	5	10
Aug.	2	5	4	5	6	6	16
Sept.	4	5.5	5	7	7	7	20

[1] Fish, C.J., et al. 1960. USF&WS Spec. Scient. Rept.-Fish No. 334

TABLE 31

COMPARISON OF NEARSHORE AND OFFSHORE AVERAGE TEMPERATURE MEASUREMENTS TAKEN IN THE CENTRAL BASIN - 1929

Month	Temperature, °C				
	All Stations[1]		Selected Stations[1]		Erie Waterworks (P-16)*
	Surface	10 Meters	Surface	10 Meters	
May	8.4	6.6	9.8	7.8	11.7
June	17.6	13.2	18.0	14.5	17.4
July	20.2	17.7	21.6	19.1	21.6
Aug.	20.9	20.0	21.4	20.7	21.8
Sept.	19.4	19.4	19.7	19.6	20.3

[1] Fish, C.J., et al. 1960. USF&WS Spec. Scient. Rept.-Fish No. 334

* Nearshore Master Plan Station Number

SOURCE: Powers, C.F., et al. 1959. Exploration of Collateral Data Potentially Applicable to Great Lakes Hydrography and Fisheries. Final Report. Great Lakes Research Inst., Univ. of Michigan, Ann Arbor. 164 p.

TABLE 32

SUMMARY OF WATER QUALITY MEASUREMENTS TAKEN
IN ERIE (Pa.) HARBOR AND LAKE ERIE, 1963-1964

Parameter	Erie Harbor[a]	Main Lake[b] Central Basin		Main Lake[b] Eastern Basin		Whole[b] Lake
	Range	Range	Average	Range	Average	Average
Temperature	16-19	-	-	-	-	-
pH (std uts)	7.3-8.1	-	-	-	-	-
Conductivity (μmhos/cm)	330-360	260-353	300	284-328	301	298.9
Dissolved Solids (mg/l)	180-290	137-239	178	150-233	179	177.6
Total Solids (mg/l)	200-290	159-218	185	167-240	188	185.8
Chlorides (mg/l)	26-38	19-46	24	21-31	24	23.9
Sulfate (mg/l)	26-44	-	-	-	-	-
Ammonia-Nitrogen (mg/l)	0.12-0.23	0.00-0.39	0.09	0.00-0.32	0.09	0.09
Nitrate-Nitrogen (mg/l)	0.07-0.14	0.00-0.84	0.09	0.01-0.85	0.09	0.09
Organic Nitrogen (mg/l)	0.30-0.59	-	0.25	-	0.24	0.25
Total Nitrogen (mg/l)	0.66-0.80	0.07-1.30	0.43	0.10-1.18	0.42	0.44
Soluable Phosphorus (mg/l)	0.01-0.03	0.00-0.07	0.01	0.00-0.04	0.01	0.011
Alkalinity (mg/l)	90-96	71-130	97	59-134	99	-

Sources: [a] Lake Erie Environmental Summary

[b] Proceedings, Pollution of Lake Erie and Its Tributaries

TABLE 33

SUMMARY OF WATER QUALITY MEASUREMENTS TAKEN
AT THE ERIE (PA.) WATER INTAKE [1], 1973-1974

Parameter	Jan. 2-Nov. 30/1973		Jan. 1-Dec. 18/1974	
	Range	Mean	Range	Mean
Turbidity (JTU)	0.5-86	12.3	0.5-67	11
Conductivity µmhos/cm at 25°C	190-334	253.8	-	-
Dissolved Oxygen (mg/l)	6.6-14.6	10.6	3.6-15.3	11.1
pH (std uts)	7.6-8.6	8	7.6-8.3	7.9
COD	5.0-14.7	9.1	7.4-17	10.5
Alkalinity (mg/l as $CaCO_3$)	8.9-96.0	87.5	0.0-94.5	85.5
Ammonia-Nitrogen (mg/l)	0.02-0.24	0.09	0.01-0.190	0.065
Total Phosphorus (mg/l)	0.04-0.1	0.07	0.02-0.09	0.05
Chloride (mg/l)	24-32	27.4	20-33	26
Sulfate (mg/l)	11.0-N.A.	26.5	15-27	18.8
Total Hardness (mg/l)	-	-	116-137	125

[1] Approximately 1.6 km offshore

Source: STORET

TABLE 34

SUMMARY OF WATER QUALITY MEASUREMENTS TAKEN IN PRESQUE ISLE BAY ABOUT 200ft. FROM THE SOUTH SHORE, SEPTEMBER 1973 TO JUNE 1974

CONSTITUENTS	Station 4 (P-21)* Mean	Range
pH	7.7	7.2-8.1
Alkalinity mg/l	96	93-104
Color Units	8	1-15
Total Solids mg/l	215	198-240
Suspended Solids mg/l	6	4-8
Biological Oxygen Demand mg/l	7.3	1.0-12.0
Ammonia as N mg/l	0.13	0.03-0.31
Nitrite as N mg/l	0.05	0.01-0.13
Nitrate as N mg/l	0.51	0.02-1.60
Organic Nitrogen as N mg/l	0.15	0.06-0.25
Total Kjeldahl Nitrogen as N mg/l	0.27	0.11-0.56
Dissolved Orthophosphate as P mg/l	0.01	0.00-0.02
Total Dissolved Phosphorus as P mg/l	0.04	0.01-0.07
Total Phosphorus as P mg/l	0.07	0.02-0.13
Total Organic Carbon mg/l	10	0-13
Iron as Fe µg/l	315	100-464
Copper as Cu µg/l	4	0-134
Lead as Pb µg/l	7	2-12
Zinc as Zn µg/l	18	0.65
Cadmium as Cd µg/l	3.7	0.01-10
Chromium as Cr µg/l	31	0-74
Aluminum as Al µg/l	256	180-318
Mercury as Hg µg/l	3	0.1-8.3

* Nearshore Master Plan Station Number

SOURCE: Browne, F.X. 1975. USEPA Rept. No.EPA-905/9-74-015. p. 41

TABLE 35

SUMMARY OF WATER QUALITY MEASUREMENTS DIRECTLY EAST OF CHANNEL LEADING FROM PRESQUE ISLE BAY TO LAKE ERIE, SEPTEMBER 1973 TO JUNE 1974

CONSTITUENTS	Station 7 (P-22)* Mean	Range
pH	7.7	7.1-8.0
Alkalinity mg/l	107	87-188
Color Units	7	3-15
Total Solids mg/l	200	189-210
Suspended Solids mg/l	7	5-10
Biological Oxygen Demand mg/l	6.0	0-17.0
Ammonia as N mg/l	0.08	0.01-0.27
Nitrite as N mg/l	0.08	0.01-0.33
Nitrate as N mg/l	0.31	0.01-1.30
Organic Nitrogen as N mg/l	0.21	0.05-0.40
Total Kjeldahl Nitrogen as N mg/l	0.29	0.05-0.57
Dissolved Orthophosphate as P mg/l	0.01	0.00-0.02
Total Dissolved Phosphorus as P mg/l	0.02	0.00-0.04
Total Phosphorus as P mg/l	0.08	0.02-0.23
Total Organic Carbon mg/l	9	0-11
Iron as Fe μg/l	317	100-564
Copper as Cu μg/l	4	018
Lead as Pb μg/l	8	2-16
Zinc as Zn μg/l	13	0-52
Cadmium as Cd μg/l	3.0	0.02-10
Chromium as Cr μg/l	9	0-24
Aluminum as Al μg/l	305	150-490
Mercury as Hg μg/l	2	0.1-7.4

* Nearshore Master Plan Station Number

SOURCE: Browne, F.X. 1975. USEPA Rept. No.EPA-905/9-74-015. p. 44

TABLE 36

SUMMARY OF WATER QUALITY MEASUREMENTS TAKEN IN THE VICINITY OF CITY OF ERIE AND HAMMERMILL PAPER COMPANY DISCHARGES FROM SEPTEMBER 1973 TO JUNE 1974

CONSTITUENTS	Mean	Range
pH	7.6	7.1-8.0
Alkalinity mg/l	109	87-188
Color Units	6	4-10
Total Solids mg/l	198	187-207
Suspended Solids mg/l	6	4-10
Biological Oxygen Demand mg/l	6.6	2.0-15.0
Ammonia as N mg/l	0.16	0.03-0.51
Nitrite as N mg/l	0.05	0.01-0.15
Nitrate as N mg/l	0.48	0.02-1.10
Organic Nitrogen as N mg/l	0.16	0.03-0.33
Total Kjeldahl Nitrogen as N mg/l	0.34	0.11-0.84
Dissolved Orthophosphate as P mg/l	0.01	0.00-0.02
Total Dissolved Phosphorus as P mg/l	0.02	0.00-0.03
Total Phosphorus as P mg/l	0.09	0.02-0.20
Total Organic Carbon mg/l	10	0-12
Iron as Fe μg/l	283	100-614
Copper as Cu μg/l	2	0-8
Lead as Pb μg/l	8	2-21
Zinc as Zn μg/l	4	0-12
Cadmium as Cd μg/l	2.7	0.02-10
Chromium as Cr μg/l	20	0-54
Aluminum as Al μg/l	236	50-477
Mercury as Hg μg/l	2	0.1-3.8

SOURCE: Browne, F.X. 1975. USEPA Rept. No.EPA-905/9-74-015. p. 46

TABLE 37

SUMMARY OF WATER QUALITY MEASUREMENTS TAKEN ABOUT 200 ft. OFFSHORE OF THE CONFLUENCE OF FOURMILE CREEK AND LAKE ERIE FROM SEPTEMBER 1973 TO JUNE 1974

CONSTITUENTS	Mean	Range
pH	7.6	7.1-7.9
Alkalinity mg/l	114	91-186
Color Units	35	30-40
Total Solids mg/l	237	213-298
Suspended Solids mg/l	11	3-17
Biological Oxygen Demand mg/l	10.4	5.0-14.0
Ammonia as N mg/l	0.08	0.01-0.28
Nitrite as N mg/l	0.08	0.01-0.24
Nitrate as N mg/l	0.49	0.01-1.30
Organic Nitrogen as N mg/l	0.48	0.05-1.19
Total Kjeldahl Nitrogen as N mg/l	0.57	0.05-1.47
Dissolved Orthophosphate as P mg/l	0.01	0.00-0.02
Total Dissolved Phosphorus as P mg/l	0.02	0.00-0.03
Total Phosphorus as P mg/l	0.07	0.02-0.20
Total Organic Carbon mg/l	17	0-21
Iron as Fe μg/l	334	120-580
Copper as Cu μg/l	3	0-9
Lead as Pb μg/l	8	2-18
Zinc as Zn μg/l	14	0-39
Cadmium as Cd μg/l	2.9	0.02-10
Chromium as Cr μg/l	10	0-32
Aluminum as Al μg/l	469	160-930
Mercury as Hg μg/l	4	0.1-8.9

SOURCE: Browne, F.X. 1975. USEPA Rept. No.EPA-905/9-74-015. p. 47

Buffalo, N.Y.

The earliest study in the vicinity of Buffalo was a bacteriological one sponsored by the IJC (1918). In its summary, the report of this effort stated ".... the bulk of the pollution in the river, and due to the discharge of sewage therein, is confined to the marginal water of the country in which it originates ". A more extensive effort was conducted in 1929 (Fish, et al., 1960 . The results of a surface water survey in Buffalo Harbor is presented in Figure 78. Using data collected during the 1929 study, average monthly alkalinity, turbidity and temperature values of measurements taken at the Woodlawn municipal water intake are compared in Tables 38 and 39 with average main lake values and average values of selected main lake stations bordering the southern nearshore zone. Alkalinity values from the intake were slightly lower than the other average values. Turbidity values at the intake exceeded the other values only in September.

A water quality study was conducted within a ten mile radius of Buffalo between 1948 and 1949 (IJC, 1951). In the study area, the 30-foot contour is uniformly about a mile offshore. The lake bottom slopes gently to 60 ft within the 10 mile radius. In 1948, the character and extent of water quality measurements differed materially from the earlier IJC survey (1918). Overall, water quality parameters measured routinely were not found to be sufficiently indicative to denote the trends or paths of pollution. The chloride content in this portion of the lake was about 20 mg/l. Similarly, the average alkalinity value was 95 mg/l and the pH value was 7.8. Average BOD values were low, ranging from 0 to 26 mg/l. Dissolved oxygen measurements showed little reduction from saturation levels. In the main lake portion of the Eastern Basin coliform bacteria averaged less than 10/100 ml, phenol values averaged about 1 ppb and turbidity values ranged from 1 to 4 mg/l.

Measurements made along the U.S. shore, south of Buffalo Harbor, showed the impact of both sewage and industrial outfalls. At stations along the shoreline, coliform bacteria numbers ranged from 430 to 240,000/100 ml with 11,000,000/100 ml as the maximum value recorded. Phenol measurements along the shoreline were relatively high. The maximum nearshore phenol value recorded was 200 μg/l. Offshore 2500 feet, coliform and phenol values were substantially lower: coliforms ranged from 43 to 390. Coliform bacteria numbers ranged from less than 1 to 16/100 ml and phenol values averaged about 1 μg/l along the Canadian shoreline. In summary, the general trend of both coliform and phenol results indicated that high concentrations were normally confined to a relatively narrow path, i.e. the nearshore zone, along the U.S. shoreline. The evidence accumulated by the study (IJC, 1951) indicated the zone of high concentration of coliforms and phenol widens during storm periods. An undertow along the east shore, such as accompanies strong southwesterly winds or a seiche, would tend to spread nearshore water into the main lake. Very little recent data and few recent reports were available for review. Available water intake records and the vast majority of STORET data is limited to Michigan, Ohio and Pennsylvania waters. Inquiries for New York State data brought little return. Measurements recorded at the Buffalo and Sturgeon point water intakes from 1969 to 1972 are summarized in Table 40.

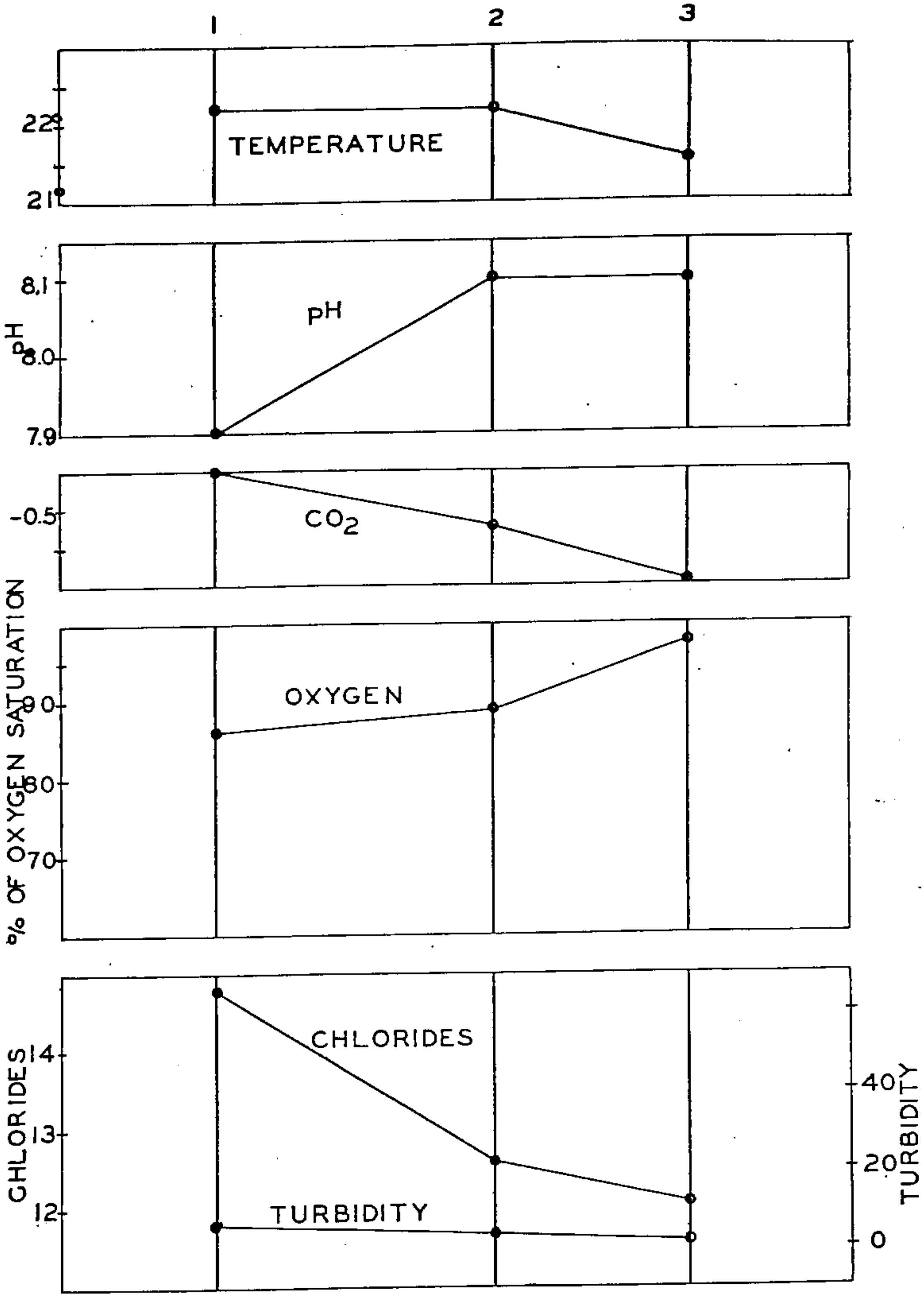


Figure 78 --Gradation of Buffalo Harbor waters from Black Rock Canal to Intake Canal. 1929

SOURCE: Fish, C.J., et al. 1960. Spec. Scient. Rept.-Fish No. 334. USF&WS. 198 p.

TABLE 38

COMPARISON OF NEARSHORE AND OFFSHORE AVERAGE ALKALINITY AND TURBIDITY MEASUREMENTS TAKEN IN THE EASTERN BASIN - 1929

	All Stations[1]			Selected Stations[1]			Woodlawn Waterworks
	Surface	Bottom	Surface and Bottom	Surface	Bottom	Surface and Bottom	
Alkalinity							
June	100	98	99.5	96	95	96	93
July	99	98	99	98	97	97.5	90
Aug.	98	97	97.5	98	97	97	91
Sept.	98.5	98.5	98	98	97	98	99
Turbidity							
June	13	16	14	14.5	15	15	13
July	6	20	13	8	9	8	7
Aug.	4.5	13	9	6	7	6.5	8
Sept.	0.5	8	4.5	0.6	1	1	13

[1] Fish, C.J., et al. 1960. USF&WS Spec. Scient. Rept.-Fish No. 334

TABLE 39

COMPARISON OF NEARSHORE AND OFFSHORE AVERAGE TEMPERATURE MEASUREMENTS TAKKEN IN THE EASTERN BASIN - 1929

Month	Temperature, °C						Woodlawn Waterworks
	All Stations[1]			Selected Stations[1]			
	Surface	10 Meters	Bottom	Surface	10 Meters	Bottom	
June	13	11	8	12	---	12	17
July	19	17	12	20	---	18	20
Aug.	20	18	14	21	---	20	18
Sept.	21	20	16	21	---	20	15

[1] Fish, C.J., et al. 1960. USF&WS Spec. Scient. Rept.-Fish No. 334

SOURCE: Powers, C.F., et al. 1959. Exploration of Collateral Data Potentially Applicable to Great Lakes Hydrography and Fisheries. Final Report. Great Lakes Research Inst., Univ. of Michigan, Ann Arbor. 164 p.

TABLE 40

SUMMARY OF MEAN WATER QUALITY MEASUREMENTS TAKEN IN THE NEARSHORE ZONE OF THE EASTERN BASIN, 1970-1975

PARAMETER / STATION	4 mile NE Barcalona N.Y.	Sturgeon Pt. Water Intake N-23	Buffalo N-40	Buffalo N-40
DATE :	Apr-Oct 1975	Jan/70-Dec/72	Jan/70-Dec/71	Jan/70-Dec/72
Turbidity Mean JTU	-	7.4	7.4	8.4
Turbidity Std. dev.	-	6.5	13.3	14.8
Conductivity Mean µmhos/cm	305	290	301.7	11.2
Conductivity Std. dev.	7	41.4	33.7	2.8
Diss. Oxygen Mean mg/l	11.0	11.1	10.9	11.2
Diss. Oxygen Std. dev.	1.8	2.5	2.5	2,8
pH Mean STD uts.	8.7	-	8.1	8.2
pH Std. dev.	0.1	-	-	0.2
Total Alkalinity Mean as $CaCO_2$ mg/l	-	95.2	99.3	90.8
Total Alkalinity Std. dev.	-	8.6	14.7	5.5
Chloride Mean mg/l	24.2	25.5	25.7	26.5
Chloride Std. dev.	3.4	1.5	1.2	2.4
SO_4 Mean mg/l	-	23.8	-	26.6
SO_4 Std. dev.	-	1.3	-	6.6
Total Hardness Mean mg/l	-	136	-	128
Total Hardness Std. dev.	-	10.5	-	6.7
Total Residue Mean mg/l	-	229	224	232
Total Residue Std. dev.	-	61.2	59	33
NH_3-N Mean mg/l	-	0.112	0.072	0.049
NH_3-N Std. dev.	-	0.105	0.068	0.059

SOURCE: STORET

Early Areal Information (Pre-1929)

The preceeding discussions were confined to presentation and discussion of summarized data collected after 1928. Data collected from several nearshore areas prior to 1929 is presented in Table 41. Data collected in 1873-1874 (Table 42) and 1887 (Table 43) in the vicinity of Cleveland indicates water quality offshore was better than that measured within the first mile of the shoreline.

Several studies have presented estimates of selected parameters for the main lake (Tables 44-48). Comparison of pre-1929 estimates (Tables 44-48) with measurements in the nearshore zone (Table 41) indicates calcium values were lower in the Detroit River than main lake estimates. Nearshore calcium values at Buffalo were similar to main lake estimates. Main lake chloride level in 1900 was estimated at 9 mg/l. Chloride values measures during the same approximate time period at Ashtabula, Erie and Buffalo were lower than the main lake estimate. The remaining nearshore values are too scattered to allow other nearshore/main lake comparisons.

TABLE 41.

CHEMICAL ANALYSES, LAKE ERIE WATER, PPM

Analyses of 1854 and 1882 have been reduced from hypothetical combinations.

	Detroit River			Ashtabula	Off Erie	Buffalo	Off Ashtabula	Off Conneaut	Off Fairport	Cleveland			
	1854[a]	1882[a]	1897[a]	1901[b]	1901-03[c]	1906-07[d]	31 Jan. 1925[e]	31 Jan. 1925[e]	4 Feb. 1925[e]	1928[f]	1929[f]	1930[f]	1937[f]
Alkalinity					98.8	98.*	105	75 (?)	105.				
Silica	5.0	7.2				5.9							
Iron	3.9					0.07				0.61	0.64	0.79	0.37
Calcium	20.	26.4	23.			31.							
Magnesium		7.4				7.6						9.3	9.5
Sodium plus potassium	3.7					6.5							
Carbonate						3.1							
Bicarbonate				110.		114.							
Sulphate	6.6	4.6				13.							
Nitrate				0.1	0.09	0.3	0.06	0.21	0.04				
Chloride		7.5		5.1	6.4	8.7	15.	7.	42.				
Total solids	98.1	117.1	108.	159.	144.	133.	160.	140.	235.				

	Cleveland										Port Stanley, Ont.	Lorain	Erie
	1938[f]	1939[f]	1940[f]	1941[f]	1942[f]	1943[f]	1944[f]	1946[f]	1947[f]	1948[f]	1948-49[g]	1950-52[h]	1956[i]
Alkalinity												91.*	90.
Silica											1.3	1.9	1.5
Iron	0.44	0.42	0.34	0.29	0.42						0.02	0.04	0.1
Calcium											38.	36.	36.
Magnesium	9.2	9.1	8.6	8.7	8.8	8.7	9.1	8.9	8.5	8.6	7.7	8.5	8.9
Sodium plus potassium											9.2	9.5	8.7
Carbonate											0.4	8.0	
Bicarbonate											107.	113.	152.**
Sulphate											42.4	25.	23.
Nitrate											1.14	1.2	0.4
Chloride											17.8	18.	20.
Total solids											174.	165.	171.

*Calculated or back-calculated (**) by method of Palmer (1911).
[a]From U. S. Geol. Surv. Water-Supply Paper No. 31.
[b]Ashtabula, low pressure data, pp. 164-5 in Foulk (1925).
[c]From U. S. Geol. Surv. Water-Supply and Irrigation Paper No. 161.
[d]From U. S. Geol. Surv. Water-Supply Paper 236, also in U. S. Geol. Surv., Prof. Paper 135.
[e]Personal communication, U. S. Engineer Office, Buffalo, N. Y., to U. S. Fish and Wildlife Service, Ann Arbor. Ammonia fractions, nitrite, BOD also given. Single samples only.
[f]Data of the Division and Baldwin water plants at Cleveland, collected by the present contract. Yearly averages derived from monthly averages at the plants.
[g]Average of 12 monthly samples throughout the year, from Thomas (1954), pp. 26-29.
[h]Average of numerous samples throughout the year at the Lorain water plant, from Lake Erie Pollution Survey. Supplement (1953).
[i]From Ninetieth Annual Report of the City of Erie.

SOURCE: Powers, C.F. et al. 1959. Exploration of Collateral Data Potentially Applicable to Great Lakes Hydrography and Fisheries. Final Rept. Great Lakes Research Inst., Univ. of Michigan, Ann Arbor. 164 p.

Table 42. WATER QUALITY OF LAKE ERIE IN 1873-1874
(mg/1)

Station[a]	Date	Total solids	Suspended matter
1	November, 1873	240	131
2	November, 1874	110	12

a Station 1. Lake Erie, 400 feet offshore and one mile west of the Cuyahoga River.
Station 2. Lake Erie, 6,200 feet lakeward of Station 1.

Table 43. WATER QUALITY OF LAKE ERIE IN 1887
(mg/1)

Distance offshore	Total ammonia	Chloride	Total solids	Oxygen consumed[a]
0.5 miles	.223	1.95	141.1	4.65
1.0 miles	.207	1.80	137.3	4.68
1.5 miles	.207	1.78	133.2	4.54
2.0 miles	.201	1.74	130.6	4.40
10.0 miles	.200	1.30	121.9	4.42
15.0 miles	.119	1.60	104.6	3.85

a A type of chemical oxygen demand test.

SOURCE: Garlauskas, A.B. 1974. USEPA Rept. No. EPA-905/9-74-005. 158 p.

Table 44. Natural background concentration and 1850 concentration of the five major ions in Lake Erie. (mg/l)

Ion	Natural Background Concentrations[1]	1850 Concentrations[2]
Calcium	31	30 - 31
Chloride	9	7 - 8
Sodium and Potassium	6.8	7 - 7.5
Sulfate	13	14 - 14.5
Total Dissolved Solids	144	140

[1]GLBC Framework Study, Appendix 4, 1972.

[2]Chawla (1971).

Table 45. Concentrations of the major ions for pre-1820, 1850, and 1900 for Lake Erie.

Ion	Concentration (mg/l)		
	pre - 1820	1850	1900
Calcium	31	31	31
Chloride	4 - 5	7 - 8	9
Sodium and Potassium	7	7 - 7.5	7.5
Sulfate	13	14 - 14.5	15
Total Dissolved Solids	110 - 120	140	141

Table 46. Revised estimates of concentrations of the major ions and total dissolved solids in Lake Erie prior to 1820.

Ion	Concentration (mg/l)
Calcium	31
Chloride	4 - 5
Sodium and Potassium	7
Sulfate	13
Total Dissolved Solids	110 - 120

SOURCE: Dalton, Dalton, Little, Newport. 1975. Great Lakes Region Assessment Study, Interim Report. Vol. I. National Commission on Water Quality, Washington, D.C. 230 p.

Table 47. Major ion concentrations in Lake Erie for 1900 to 1940 (Beeton, 1965).

Ion	Concentration (mg/l)	
	1900	1940
Calcium	31	35
Chloride	9	16.5
Sodium and Potassium	7.5	8
Sulfate	15	21
Total Dissolved Solids	141	162

Table 48. Concentrations of the major ions in Lake Erie for 1940 and 1970.

Ion	Concentration (mg/l)	
	1940[1]	1970[2]
Calcium	35	38
Chloride	16.5	26.5
Sodium and Potassium	8	13.5
Sulfate	21	25.5
Total Dissolved Solids	162	205

[1]Beeton (1965)
[2]Chawla (1971)

SOURCE: Dalton, Dalton, Little, Newport. 1975. Great Lakes Region Assessment Study, Interim Report. Vol. I. National Commission on Water Quality, Washington, D.C. 230 p.

NEARSHORE/OFFSHORE COMPARATIVE STUDIES

Monitoring programs providing comparative data were initiated in the 1960's. Main lake monitoring cruises were conducted in 1963-1964 and 1967-1968. Nearshore data collected during the 1963-1964 period is summarized in Table 49. Main lake data collected during this period is depicted in summary form in Figure 79. Nearshore data was not collected during the comparable period of the main lake monitoring cruises conducted in 1967-1968. Data collected at municipal water intakes during 1965-1966 is summarized in Table 50. Nutrient data from a 1966-1967 nearshore monitoring effort is summarized in Table 51. The results of the 1963-1964 and 1967-1968 main lake programs are summarized and percent change in parameters are noted in Table 52. An extensive municipal intake monitoring program was initiated in March, 1968 by the Ohio Dept. of Health and the FWPCA. The program was subsequently expanded to include intakes in Pennsylvania and the State of New York (Gedeon and Wilson, 1972). Summary data from the main lake monitoring program of 1967-1968 is compared with similar data from the municipal intake monitoring program conducted in 1968-1969 in Tables 53-59. Results of the 1968-1969 water intake program are analyzed graphically in Appendix B. The results of main lake monitoring cruises conducted in 1973, 1974, and 1975 are summarized in graphic form in Appendix C.

1963-1964 Main Lake and Nearshore Results (FWPCA, 1968)

During the winter months, water temperature was nearly uniform throughout the lake. During the spring and to a lesser extent during the early summer, the water within a mile of shore was warmer due to warmer tributary inputs and southwest winds pushing warm surface waters toward the south shore. The greatest differential occurred along the south shore of the Central Basin. This effect was less apparent in the Eastern Basin due to fewer tributaries and deeper nearshore water. Water temperature along the north shore did not vary greatly from the main lake temperature at any time of the year. Temperature is important in controlling water movements in the nearshore zone. In spring and early summer, density barriers may confine nearshore water along the south shore.

Biochemical oxidation proceeds at an increased rate with an increase in water temperature. Increased oxidation rates combined with lower oxygen solubility at higher temperatures results in significant oxygen depletion in harbor areas and at the mouths of tributaries where quantities of oxygen demanding compounds accumulate. Highest biochemical oxygen demand (BOD) measurements were recorded in Sandusky Bay (average - 3.8 mg/l), Erie (average - 3.3 mg/l), Ashtabula (average - 3.3 mg/l), Lorain and Cleveland harbors. Five-day BOD values decreased rapidly in samples taken further offshore. Outside of the harbor areas, the Michigan shore and Maumee Bay, BOD values were low, 1 mg/l or less. The highest chemical oxygen demand (COD) values were recorded near the south shore.

The range of conductivity and dissolved solid values were greatest in the Western Basin. Values recorded for these parameters increased further eastward. The lowest dissolved solids values were recorded in the mid-channel plume of the Detroit River (110 mg/l). Dissolved solids values in Sandusky Bay exceeded 700 mg/l and bottom values recorded in Fairport Harbor exceeded 3000 mg/l. Dissolved solids in the Central and Eastern Basin portions of the main lake averaged 180 mg/l. Concentrations of potassium measured in Michigan waters (4 mg/l) and Sandusky Bay (average - 2.6 mg/l) indicated large sources in each respective area. High concentrations of calcium (average - 65 mg/l) were measured in Sandusky Bay. Sandusky Bay apparently received large quantities of magnesium (average - 22 mg/l) and sulfate (average - 127 mg/l) as well. The study concluded that the nearshore zone from Detroit to Toledo received large quantities of sulfate. Average sulfate levels in the main lake ranged from 17.7 mg/l in the Western Basin to 23.4 mg/l in the Eastern Basin.

During the study period, average chloride values in the main lake ranged from a low of 21.3 mg/l in the Western Basin to 24.5 mg/l and 24.4 mg/l in the Central and Eastern Basins, respectively. Nearshore chloride values were much higher. Along the west shore of the Detroit River and along the Michigan shoreline, values frequently exceeded 40 mg/l. The data indicated most Western Basin chlorides originate with Michigan sources. The lowest chloride value was recorded from the mid-channel plume of the Detroit River. Harbor areas in Ohio exhibited chloride concentrations averaging in excess of 30 mg/l. The highest levels, up to 350 mg/l in surface water and 3500 mg/l in bottom water, were recorded from Fairport Harbor. A permanent density stratification was noted in the vicinity of the harbor.

Of the nutrient (nitrite-nitrogen, nitrate-nitrogen, organic nitrogen, soluble and total phosphorus) parameters, nearshore values for soluble phosphorus were generally higher than main lake values in the vicinity of tributaries and harbors. Average values in the main lake ranged from 0.032 mg/l in the Western Basin to 0.010 mg/l in both the Central and Eastern Basins. Values in Maumee Bay averaged 0.027 mg/l during the survey. Concentrations measured along the Michigan shoreline were commonly in excess of 0.066 mg/l. Relatively high levels were recorded in Sandusky Bay (0.056 mg/l) and Lorain Harbor (0.037 mg/l).

1967-1969 Main Lake and Nearshore Results (Hartley and Potos, 1971) (Appendix B)

Although the main lake sampling period and the nearshore data collection period were 1 year apart, the data were assumed to be comparable for report purposes. In general, nearshore water temperatures rise more slowly along the Central Basin shoreline than along the Western Basin shoreline. Early spring was characterized by consistently higher percentages of oxygen saturation while summer was characterized by the lowest. Dissolved oxygen concentrations were apparently related to phytoplankton populations, particularly diatoms. In areas not affected by the incursions of hypolimnetic water, low oxygen concentrations in nearshore areas were attributed to chemical deoxygenation from resuspended sediments following storm events. Low dissolved oxygen values recorded during the summer months were associated with lower chemical oxygen demand (COD) measurements while higher dissolved oxygen values recorded in the fall and winter were associated with relatively higher COD.

Nearshore ammonia-nitrogen values averaged about 200 μg/l in the Western Basin and about 150 μg/l in the Central Basin. In the Western Basin, nearshore values were highest, over 400 μg/l, in December and January and lowest in mid-November, less than 100 μg/l. In the main lake portion of the Western Basin, the highest values, over 200 μg/l, were recorded in the summer and the lowest values, about 100 μg/l, were recorded in the spring and fall. Nearshore values recorded in the Central Basin were consistent, varying around the average value. Average values recorded in the Central Basin portion of the main lake ranged from 100 to 150 μg/l. Values in the latter portion of the lake were apparently lowest during the winter months. Since short-term nearshore dispersion of ammonia was considered minimal, the study concluded that sediments are an important source of ammonia in the main lake.

Seasonal changes in nitrate-nitrogen values were apparent in both nearshore and main lake data. Nearshore values in the Western Basin averaged 1200 μg/l in the early spring, dropped to 400 μg/l at the end of April, rose to about 800 μg/l in early July, and subsequently dropped to near zero in early fall. In late fall concentrations began to rise and exceeded 2500 μg/l by mid-January. In the main lake portion of the Western Basin, average values in the spring ranged from 500 μg/l in the westernmost stations to about 200 μg/l in the easternmost stations. Lowest values for this portion of the main lake were recorded in the summer, about 50 μg/l. A remarkable rise occurred in the winter to an average value of about 600 μg/l.

Nearshore nitrate-nitrogen values in the Central Basin were highest in the late winter, 600 μg/l or more, and lowest in the late summer, 0 to 50 μg/l. During the winter, nearshore values ranged from a high value over 800 μg/l at Sandusky to less than 200 μg/l at Conneaut. In the spring, the highest value, 600 μg/l, was recorded at the Mentor municipal intake. Nitrate-nitrogen values in the summer and fall months averaged less than 200 μg/l. During the winter months, values recorded in the main lake portion of the Central Basin ranged from 350 μg/l at the westernmost stations to 50 μg/l at the center of the basin. The highest value in this portion of the lake, 400 μg/l, was recorded during the spring. Values recorded during the summer and fall months were uniformly low, less than 50 μg/l.

Generally, nearshore values exceeded main lake values by a factor of two. Both nearshore and main lake values were progressively lower from west to east. Values in excess of 1500 μg/l recorded in the nearshore of the Western Basin were attributed to tributary inputs, introduction of interstitial ammonia during sediment resuspension with subsequent conversion to nitrate and low nutrient utilization by limited algal populations. A conspicuous drop in nitrate-nitrogen concentrations in the spring was correlated with high densities of algae. Low concentrations, 200 μg/l or less, in the summer and fall were attributed to uptake by algae.

Organic-nitrogen values in the nearshore of the Western Basin averaged 400 μg/l in the fall and approximately 700 μg/l during the winter, spring and summer. Average values computed for the main lake portion of the Western Basin ranged from 300 µg/l in the fall and winter to about 350 µg/l in the spring and summer. Average values of nearshore station measurements in the Central Basin ranged from a low of less than 200 µg/l in November to a high of 500 µg/l in the spring. Values recorded in the main lake portion of the Central Basin averaged 300 µg/l throughout the year. Organic-nitrogen values, which often reflect biological productivity, did not correlate with algal numbers.

At any one place in the lake, soluble phosphorus measurements were remarkably uniform during the spring, summer and fall. In general, soluble phosphorus values decreased progressively from nearshore to offshore and from west to east. The average value computed from measurements taken at water intakes in the Western Basin was 50 µg/l. The average value for the Central Basin was 30 µg/l. The main lake portion of the Western Basin averaged 30 µg/l. Stations in the main lake portion of the Central Basin averaged 15 µg/l. Soluble phosphorus measurements at the water intakes more than doubled during the winter season. A similar increase was noted in the main lake portion of the Western Basin. The increase in values measured during the winter months was attributed to tributary input, nearshore sediment resuspension, limited dispersion and low utilization by algae.

A definite seasonal pattern was not discerned in particulate phosphorus values. Average values from the nearshore water intakes of the Western Basin ranged from 30 µg/l in the spring to approximately 50 µg/l during the summer, fall and winter. Throughout the year, average values from the main lake portion of the Western Basin ranged from 10 to 15 µg/l. Average values from the nearshore water intakes of the Central Basin were similar to values computed for the nearshore of the Western Basin. Average values from the main lake portion of the Central Basin ranged from 20 µg/l in the spring and summer to 40 µg/l in the fall and winter. The distribution of particulate phosphorus throughout the year and at any one time in the nearshore was termed erratic. The erratic nature of the nearshore distribution was attributed to variability in localized runoff inputs and sediment resuspension during storm events.

The results of the nearshore/main lake comparisons reviewed above must be used with caution. Comparing main lake data from one year with nearshore data collected the following year at municipal water intakes is not without hazard. The use of average values for each portion of the lake helps damp out but certainly does not eliminate year to year differences. The main lake study would have benefited from an increased frequency of sampling and a more extensive sampling pattern.

<u>1973-1975 Main Lake Nutrient Assessment Program (CLEAR/Ohio State University)</u>

The range and mean values of measurements recorded at selected main lake stations bordering the nearshore zone of the U.S. and Canadian shorelines as well as selected offshore main lake stations are presented graphically in Appendix C. In each graph the stations are ordered in a west to east series. The stations labelled as nearshore ones ranged from two to 16 km offshore. These stations were located considerably further offshore than corresponding municipal water intakes, the only exceptions being the Cleveland intakes.

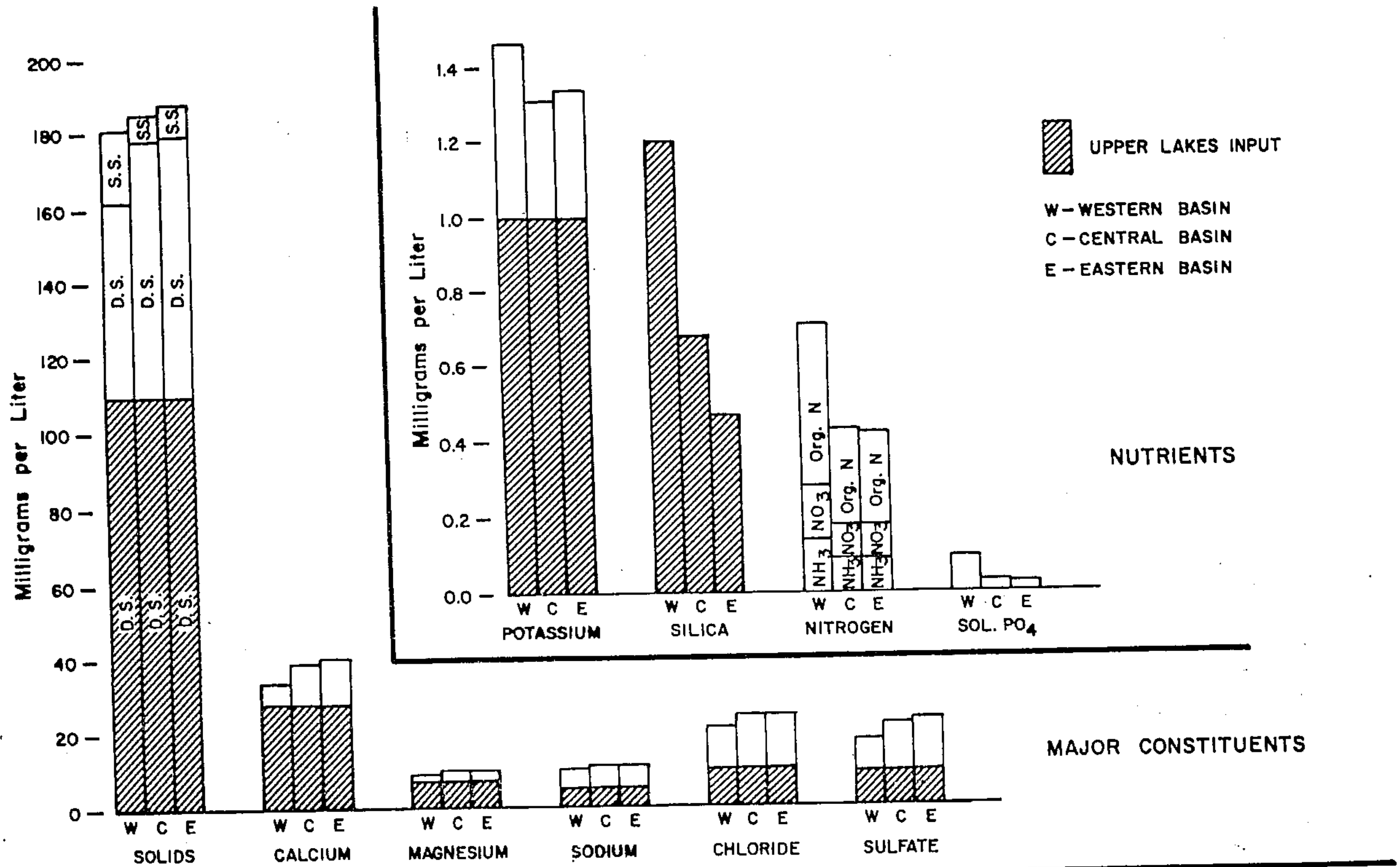
These nearshore stations are, in fact, main lake sampling points. However, the influence of nearshore water is apparent in higher means and ranges of conductivity measurements at nearshore stations relative to offshore stations along the southern portion of the lake.

TABLE 49

WATER QUALITY-NEARSHORE AND HARBORS
(mg/l or µmhos/cm)

Parameter	Michigan waters of Lake Erie		Maumee Bay		Sandusky Bay		Lorain Harbor		Cleveland Harbor		Fairport Harbor		Ashtabula Harbor		Erie Harbor	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Cond (25°C)			280	460	256	800	300	340	--		330	5920	--		330	360
DS			200	290	190	680	160	230	180	370	180	6000	170	230	180	290
TS			200	350	210	760	170	270	180	680	190	6100	180	250	200	290
Chlor.	27	82	20	32	16	32	19	25	14	88	--		24	42	26	38
Sol PO_4	.05	.20	.02	.19	.02	.17	.02	.11	--		--		.02	.06	.01	.03
SO_4			--		25	256	27	37	--		--		--		26	44
SiO_2			0.6	1.7	0.3	5.9	.40	1.10	--		--		--		.3	.5
K			1.4	2.6	1.2	4.0	1.3	2.2	--		--		--		1.4	1.9
Mg			12	18	10	38	9	11	--		--		--		9	9
Ca			35	42	38	114	34	38	--		--		--		42	47
Na			12	20	10	16	10	13	--		--		--		17	21
ABS	<.025		.05	.15	.05	.20	.05	.15	--		--		--		.07	.14
Alk	78	157	86	120	87	120	.88	99	81	130	90	110	94	100	90	96
pH	8.4	9.2	7.4	9.7	7.5	9.1	7.5	8.7	6.7	9.5	7.1	8.7	8.2	8.5	7.3	8.1
Temp			21	25	23	26	24	25	16	21	23	29	15	17	16	19
DO%S			60	95	65	115	80	95	70	95	80	130	95	110	Avg.	60%
BOD			1.5	4.0	2.1	6.3	1.0	2.3	--		--		2.0	5.6	Avg.	3.3
COD			12	53	13	42	10	28	8	22	8	12	7	11	Avg.	24
Phenol	0.0	0.058	--		--		--		--				--			
Total N			.82	3.45	.82	3.50	.50	4.20	--						.66	.80
Org N	0.20	0.30	.07	1.33	.53	2.30	.01	1.10	--				.29	.49	.30	.59
Amm N	0.20	0.30	.30	1.80			.12	.90	--				.03	1.55	.12	.23
Nit N	0.11	0.91	.00	.80	.01	1.80	00	2.90	--						.07	.14

SOURCE: Lake Erie Environmental Summary. 1963-1964.



CHEMISTRY OF LAKE ERIE WATER IN WESTERN, CENTRAL AND EASTERN BASINS, 1963-1964

FIGURE 79.

SOURCE: Lake Erie Environmental Summary, 1963-1964. 1968. FWPCA, Great Lakes Region. 170 p.

TABLE 50. **Summary of Lake Erie Water Quality at Municipal Waterworks Intakes (July 1965–June 1966)**

	Toledo		Oregon		Port Clinton		Marblehead		Sandusky	
Intake's Distance from shore (ft.)	10,000		5,200		1,000		300		2,500	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Total solids (mg/l)	167	282	128	211	168	282	190	246	193	265
Alkalinity as $CaCO_3$ (mg/l)	72	140	34	166	76	165	89	160	91	113
pH	7.6	8.9	7.9	8.8	7.4	8.4	7.2	8.0	7.7	8.5
Chlorides (mg/l)	15	36	22	23	16	26	22	24	11	21
Turbidity-units	5	148	4	98	25	300	1	160	5	1,560
Nitrates as NO_3 (mg/l)	0.5	1.0	1.5	---	0.1	2.5	0.2	2.0	0	1.5
Hardness as $CaCO_3$ (mg/l)	103	234	108	300	100	306	138	216	138	166
Coliforms/100 ml; daily	10	2,400	12	24,000	280	24,000	314	11,000	14	2,400
Coliforms/100 ml; yearly average[1]	111	---	449	---	2,460	---	1,209	---	160	---
Percent of time monthly coliform average > 5,000/100 ml[1]	0	---	0	---	8.3	---	0	---	0	---
No. days coliforms > 5,000/100 ml	0	---	6	---	37	---	1	---	0	---
No. days coliforms > 20,000/100 ml	0	---	3	---	6	---	0	---	0	---

	Crown		Division		Cleveland Baldwin		Nottingham		Lake Co. West Plant (Mentor)	
Intake's Distance from shore (ft.)	7,800		21,000		21,000		18,000		1,900	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Total solids (mg/l)	170	220	168	212	183	215	187	218	320	384
Alkalinity as $CaCO_3$ (mg/l)	83	104	77	100	87	95	66	98	77	107
pH	7.4	8.6	7.4	8.5	7.5	8.6	7.5	8.4	7.2	8.6
Chlorides (mg/l)	19	28	16	30	21	27	20	28	No data	
Turbidity-units	2	190	1	100	1	76	1	111	4	529
Nitrates as NO_3 (mg/l)	0	0.5	0	0.5	0	1.0	1.0	0.5	No data	
Hardness as $CaCO_3$ (mg/l)	118	133	122	130	120	128	120	132	119	203
Coliforms/100 ml; daily	27	12,000	61	8,200	3	11,000	3	11,000	372	240,000
Coliforms/100 ml; yearly average[1]	563	---	417	---	244	---	202	---	8,020	---
Percent of time monthly coliform average > 5,000/100 ml[1]	0	---	0	---	0	---	0	---	41.7	---
No. days coliforms > 5,000/100 ml	11	---	3	---	1	---	1	---	75	---
No. days coliforms > 20,000/100 ml	0	---	0	---	0	---	0	---	35	---

	Huron		Vermilion		Elyria		Lorain		Avon Lake	
Intake's Distance from shore (ft.)	2,100		1,500		1,200		2,000		1,900	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Total solids (mg/l)	186	245	171	266	168	305	178	286	194	234
Alkalinity as $CaCO_3$ (mg/l)	84	107	90	100	86	108	80	99	80	98
pH	7.7	8.2	7.2	8.4	7.6	8.5	7.8	8.7	7.3	8.4
Chlorides (mg/l)	15	30	15	25	16	17	16	27	21	26
Turbidity-units	5	200	20	100	10	180	1	140	4	130
Nitrates as NO_3 (mg/l)	0	3.0	0	0.7	0.1	0.2	0.1	2.5	0	1.0
Hardness as $CaCO_3$ (mg/l)	114	140	100	150	124	138	116	138	114	146
Coliforms/100 ml; daily	21	2,400	80	4,600	161	24,000	38	110,000	230	27,000
Coliforms/100 ml; yearly average[1]	200	---	876	---	1,416	---	3,673	---	1,897	---
Percent of time monthly coliform average > 5,000/100 ml[1]	0	---	0	---	0	---	33.3	---	8.3	---
No. days coliforms > 5,000/100 ml	0	---	0	---	24	---	43	---	47	---
No. days coliforms > 20,000/100 ml	0	---	0	---	5	---	18	---	2	---

	Painesville		Fairport		Lake Co. East Plant (Madison)		Ashtabula		Conneaut	
Intake's Distance from shore (ft.)	3,800		1,000		2,000		1,500		1,500	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Total solids (mg/l)	214	400	219	274	271	500	192	217	210	230
Alkalinity as $CaCO_3$ (mg/l)	65	106	65	98	60	100	87	110	90	120
pH	7.0	8.8	7.3	9.08	7.2	8.4	7.7	8.2	7.5	7.8
Chlorides (mg/l)	22	43	24	38	25	54	21	30	21	33
Turbidity-units	5	400	10	168	4	250	5	260	3	110
Nitrates as NO_3 (mg/l)	0	1.0	0	3.5	0	2.0	0	1.0	0.2	2.0
Hardness as $CaCO_3$ (mg/l)	116	264	99	162	121	183	130	148	126	134
Coliforms/100 ml; daily	56	110,000	47	11,000	314	24,000	27	9,600	44	24,000
Coliforms/100 ml; yearly average[1]	3,426	---	1,832	---	1,209	---	359	---	620	---
Percent of time monthly coliform average > 5,000/100 ml[1]	16.7	---	8.3	---	0	---	0	---	0	---
No. days coliforms > 5,000/100 ml	42	---	4	---	11	---	3	---	0	---
No. days coliforms > 20,000/100 ml	11	---	0	---	1	---	0	---	0	---

[1]Arithmetical Average

SOURCE: Great Lakes Basin Framework Study, Appendix 7. Water Quality. Great Lakes Basin Commission, Ann Arbor, Mich. 228 p.

TABLE 51

RANGE OF AVERAGE CONCENTRATIONS OF NUTRIENTS IN THE NEARSHORE ZONE OF THE WESTERN, CENTRAL AND EASTERN BASIN OF LAKE ERIE, 1966-1967

	U.S.			CANADA		
	Western	Central	Eastern	Western	Central	Eastern
1966 PO_4-P µg/l	15-100	-	-	15-30	5-15	5-25
1967 PO_4-P µg/l	20-100	-	-	15-30	10-15	10-15
1966 Total P µg/l	50-400	-	20-60	40-70	20-40	20-30
1967 Total P µg/l	40-190	-	20-70	30-60	20-30	20-30
1967 NO_3-N µg/l	20-100	-	30-50	80-100	20-50	10-30
1967 NH_3-N µg/l	50-100	-	20-70	40-80	30-50	20-50
1967 NO_2+NO_3 µg/l	10-60	-	2-4	10	3-12	3-8

SOURCE: Pollution of Lake Erie. Vol. 2. 1969. IJC Rept. 68-80 p.

TABLE 52

WATER CHEMISTRY COMPARISONS 1963-64 - 1967-68
(CLEVELAND PROGRAM OFFICE DATA)

		Western Basin			%	Central Basin			%	Eastern Basin			%	Total
		max.	min.	avg.	Change	max.	min.	avg.	Change	max.	min.	avg.	Change	Lake Avg.
Conductivity	1963-64	364	196	272		353	260	300		328	284	301		298.9
	1967-68	370	238	285	+4.8	330	283	312	+3.7	333	310	318	+5.6	312.6
Dissolved Solids	1963-64	220	110	162		239	137	178		233	150	179		177.6
	1967-68	247	135	170	+4.9	283	147	196	+10.1	297	138	204	+14.0	197.3
Total Solids	1963-64	250	140	181		218	159	185		240	167	188		185.8
	1967-68	356	149	188	+3.9	307	153	202	+9.2	308	175	220	+17.0	207.1
Chlorides	1963-64	34	10	21		46	19	24		31	21	24		23.9
	1967-68	26	10	19	-9.5	29	19	23	-4.2	28	24	25	+4.2	23.4
Silica	1963-64	5.0	0.3	1.20		9.6	0.2	0.68		3.5	0.2	0.47		0.64
	1967-68	1.87	0.43	1.06	-11.7	0.98	0.15	0.37	-45.6	0.72	0.18	0.37	-21.2	0.40
Soluble Phosphorus	1963-64	0.33	0.00	0.03		0.07	0.00	0.01		0.04	0.00	0.01		0.011
	1967-68	0.10	0.01	0.04	+33.3*	0.03	0.00	0.02	+100.0*	0.02	0.01	0.01	0.0	0.018
Total Phosphorus	1963-64	--	--	--		--	--	--		--	--	--		
	1967-68	0.19	0.02	0.06		0.05	0.01	0.02		0.08	0.01	0.02		0.022
Total Nitrogen	1963-64	2.66	0.17	0.71		1.30	0.07	0.43		1.18	0.10	0.42		0.44
	1967-68	1.98	0.27	0.74	+4.2	0.95	0.28	0.47	+9.3	0.75	0.30	0.47	+11.9	0.48
Organic Nitrogen	1963-64			0.36				0.25				0.24		0.25
	1967-68	0.71	0.07	0.37	+2.3	0.78	0.12	0.32	+28.0*	0.55	0.21	0.34	+41.6*	0.33

TABLE 52 CON'T.

(CON'T) WATER CHEMISTRY COMPARISONS 1963-64 - 1967-68
(CLEVELAND PROGRAM OFFICE DATA)

		Western Basin			%	Central Basin			%	Eastern Basin			%	Total
		max.	min.	avg.	Change	max.	min.	avg.	Change	max.	min.	avg.	Change	Lake Avg.
Ammonia Nitrogen	1963-64	0.77	0.01	0.16		0.39	0.00	0.09		0.32	0.00	0.09		0.09
	1967-68	0.56	0.04	0.17	+6.3	0.21	0.02	0.10	9.0	0.17	0.04	0.07	-22.2	0.09
Nitrate Nitrogen	1963-64	1.50	0.02	0.12		0.84	0.00	0.09		0.85	0.01	0.09		0.09
	1967-68	0.96	0.01	0.20	66.7*	0.43	0.00	0.05	-44.4	0.16	0.00	0.06	-33.3	0.06
Chemical Oxygen Demand	1963-64	29.0	1.1	10.4		16.0	3.1	7.1		27.0	4.7	7.4		7.36
	1967-68	18.9	5.5	9.8	-5.8	11.9	5.2	8.6	+21.1*	11.0	6.1	8.2	+10.8	8.53
5-Day Biochemical Oxygen Demand	1963-64	--	--	--		--	--	--		--	--	--		
	1967-68	4.1	0.4	1.7		2.7	0.0	1.0		2.5	0.2	1.2		1.10
Alkalinity	1963-64	240	57	99		130	71	97		134	59	99		
	1967-68	105	75	90	-9.9	102	92	96	-1.0	109	92	98	-1.0	96.3
Eh	1963-64	--	--	--		--	--	--		--	--	--		
	1967-68	560	474	511		612	354	470		444	324	385		445
pH	1963-64													
	1967-68	8.8	7.6	8.3		8.9	7.7	8.4		8.7	7.5	8.3		8.36

* Eliminated from average to insure statistical validity.

SOURCE: Proceedings, Pollution of Lake Erie and Its Tributaries, F.W.P.C.A., Dept. Interior, Cleveland, Ohio.

Terlecky, et al. 1975. USEPA Rept. No. EPA-905/9-74-008

TABLE 53

AVERAGE SEASONAL CONCENTRATIONS OF NITRATE NITROGEN IN VARIOUS SECTORS OF THE WESTERN BASIN OF LAKE ERIE (µg/l)

May 1967 - March 1969

Season	Maumee Bay	Southern Nearshore	Mid-basin	Northeast sector (outlet)
Winter	1,500	1,700	600	350
Spring	800	800	300	200
Summer	<50	250	75	<50
Fall	100	200	175	175

TABLE 54

AVERAGE SEASONAL CONCENTRATIONS OF NITRATE NITROGEN IN VARIOUS SECTORS OF THE CENTRAL BASIN OF LAKE ERIE (µg/l)

May 1967 - March 1969

Season	Southwest Nearshore	Southeast Nearshore	Western Midlake	Eastern Midlake
Winter	600	250	250	-
Spring	600	400	200	<50
Summer	100	150	<50	<50
Fall	100	175	<50	<50

SOURCE: Hartley, R. P. and C. P. Potos. 1971. Algal-Temperature-Nutrient Relationships and Distribution in Lake Erie - 1968. USEPA Water Quality Office, Region V - Lake Erie Basin. 87 p.

TABLE 55

AVERAGE SEASONAL CONCENTRATIONS OF ORGANIC NITROGEN IN VARIOUS SECTORS OF THE WESTERN BASIN OF LAKE ERIE (μg/l)

May 1967 - March 1969

Season	Maumee Bay	Southern Nearshore	Mid-basin	Northeast sector (outlet)
Winter	500	750	300	250
Spring	550	700	350	400
Summer	500	650	400	250
Fall	500	400	250	250

TABLE 56

AVERAGE SEASONAL CONCENTRATIONS OF ORGANIC NITROGEN IN VARIOUS SECTORS OF THE CENTRAL BASIN OF LAKE ERIE (μg/l)

May 1967 - March 1969

Season	Southwest Nearshore	Southeast Nearshore	Western Midlake	Eastern Midlake
Winter	400	300	300	-
Spring	600	450	250	300
Summer	450	500	300	350
Fall	350	350	250	250

SOURCE: Hartley, R. P. and C. P. Potos. 1971. Algal-Temperature-Nutrient Relationships and Distribution in Lake Erie - 1968. USEPA Water Quality Office, Region V - Lake Erie Basin. 87 p.

TABLE 57

AVERAGE SEASONAL CONCENTRATIONS OF SOLUBLE PHOSPHORUS (As P) IN VARIOUS SECTORS OF THE CENTRAL BASIN OF LAKE ERIE (μg/l)

May 1967 - March 1969

Season	Southwest Nearshore	Southeast Nearshore	Western Midlake	Eastern Midlake
Winter	80	55	25	-
Spring	30	25	10	15
Summer	35	25	15	10
Fall	30	30	20	15

TABLE 58

AVERAGE SEASONAL CONCENTRATIONS OF PARTICULATE PHOSPHORUS (As P) IN VARIOUS SECTORS OF THE CENTRAL BASIN OF LAKE ERIE (μg/l)

May 1967 - March 1969

Season	Southwest Nearshore	Southeast Nearshore	Western Midlake	Eastern Midlake
Winter	50	35	10	-
Spring	15	20	10	5
Summer	20	20	5	<5
Fall	50	50	5	5

SOURCE: Hartley, R. P. and C. P. Potos. 1971. Algal-Temperature-Nutrient Relationships and Distribution in Lake Erie - 1968. USEPA Water Quality Office, Region V - Lake Erie Basin. 87 p.

TABLE 59

AVERAGE SEASONAL CONCENTRATIONS OF SOLUBLE PHOSPHORUS (As P) IN VARIOUS SECTORS OF THE WESTERN BASIN OF LAKE ERIE (μg/l)

May 1967 - March 1969

Season	Maumee Bay	Southern Nearshore	Mid-basin	Northeast sector (outlet)
Winter	110	150	55	20
Spring	25	50	25	20
Summer	95	50	40	20
Fall	90	50	30	20

TABLE 60

AVERAGE SEASONAL CONCENTRATIONS OF PARTICULATE PHOSPHORUS (As P) IN VARIOUS SECTORS OF THE WESTERN BASIN OF LAKE ERIE (μg/l)

May 1967 - March 1969

Season	Maumee Bay	Southern Nearshore	Mid-basin	Northeast sector (outlet)
Winter	45	50	30	20
Spring	55	30	25	10
Summer	40	55	15	20
Fall	70	50	15	20

SOURCE: Hartley, R. P. and C. P. Potos. 1971. Algal-Temperature-Nutrient Relationships and Distribution in Lake Erie - 1968. USEPA Water Quality Office, Region V - Lake Erie Basin. 87 p.

THE NEARSHORE ZONE

The bottom of the Western Basin slopes gently out from shore to the 24-ft contour on its western and southern sides. The 24-ft contour is only one-half to two miles offshore on the north shore compared to the five to ten mile distances common along the western and southern shorelines. Beyond the 24-ft contour, the bottom of the Western Basin is relatively flat. Beach, bank and nearshore erosion is common around the basin. Erosion problems are especially severe along the Maumee Bay shoreline (Herdendorf, et al., 1977).

The 30-ft contour is one-half to two miles offshore in the Central and Eastern Basins. Beyond the 30-ft contour in both portions of the lake, the lake bottom slopes to increasingly greater depths. The north and south shores are generally characterized by eroding banks composed of lake sediments and/or glacial till. Rock bluffs occur along portions of the northern and southern shores. Streams are small contributors of sediments in the Central and Eastern Basins compared with that of the Detroit and Maumee Rivers in the Western Basin. The sediment load of the Maumee River represents 37% of the total sediment load to the lake.

The characteristics and extent of the nearshore zone are determined, in part, by currents and runoff inputs. The currents which disperse and relocate suspended or dissolved materials may be quite different between offshore and nearshore water during quiet weather periods due to the effects of bottom topography and density-related boundary conditions. In contrast, wind driven currents are the fastest and most variable in direction for the large-scale movement of water. Storm events may widely disperse nearshore waters.

The generalized circulation pattern in the U.S. waters of the lake shows an eastward flow along the south shore. Currents in the Western Basin are dominated by the inflow of the Detroit River. An eddy effect along the western side of the Detroit River inflow between Stony Point, Mich. and Maumee Bay tends to partially retain input materials, leading to higher concentrations of water quality-related constituents in this area (Lake Erie Environmental Summary, 1968).

Density-related currents are the most apparent and probably have their greatest importance in the nearshore zone. With the exception of the peak inputs of the major tributaries, density differences in the spring and early summer along the south shore serve to prevent lateral dispersion of warmer, solids-laden nearshore water. Tributary inputs in the spring and fall frequently establish non-compensating density currents which carry offshore into the main lake. Inputs can override lake water in the spring when tributary waters are warmer. The opposite can be true in the fall. This phenomena has been best demonstrated in the Toledo navigation channel. During the summer months, the bulk of the drainage from the Central Basin is surface water moving along the south shore. The density stratification accompanying the thermocline confines inputs from tributaries and from the south shore of the Western Basin to the epilimnion in the nearshore zone. Although not the persistent feature apparent during the summer months in the Central Basin, the surface movement along the south shore of the Eastern Basin is predominantly to the east.

Runoff is another apparent determinant of the characteristics and extent of the nearshore zone. Inspection of municipal water intake records indicated that increased runoff from tributary streams during wet years serves to increase the variability of several parameters. Intakes located farthest from shore were the least affected. Agreement between more nearshore and more offshore measurements was least apparent during years of substantially increased runoff. During dry years, the data recorded at intakes nearest to shore reflect decreased variability. The decreased variability reflects decreased fluctuations accompanying decreased runoffs (Powers, et al., 1959).

Relative to the main lake, nearshore water quality is characterized by higher mean values of most parameters (see Areal Analysis) and a considerably wider range of variability in measurements of each respective parameter. In a study of water quality data collected over a 12 year period (1940-1952) at the five municipal water intakes in the Central Basin least affected by local tributary inputs, Powers, et al., (1959) concluded that a wide range of variability is the hallmark of nearshore water quality measurements. Curves relating variability of total alkalinity (Figure 80) and turbidity (Figure 81). to intake depth at the five intakes approximated the distance-from-shore curves. Both curves reflect smaller variability with greater depth and witn greater distance from shore. Distance from shore and depth of intake are not mutually-independent variables. Of the two, distance from shore is the more important variable explaining the lesser variability observed with increasing distance offshore.

Higher mean values and wider ranges of variability of water quality measurements serve as effective criteria for delineating the extent of the nearshore zone in the U.S. waters of Lake Erie. Used in concert with these criteria, water depth serves as a useful criterion in selected portions of the lake. Water depth alone is a relatively simplistic, although sometimes effective, criterion. Application of these criteria to data and analyses of Central Basin and Eastern Basin water quality is less complex than its application to that of the Western Basin. In the former portions of the lake, distinctly higher mean values and wider ranges of values, relative to main lake values in each respective basin, are often evident within 1 to 1.5 kilometers of the shoreline. Four or more kilometers offshore, the means and ranges of measurements more closely resemble values recorded in the main lake. The inconsistencies common to boundary zones are apparent in values recorded one to four kilometers offshore. During or shortly after storm events and during periods of peak runoff, the characteristic qualities of nearshore water quality are measurable at greater distances and noticeably influence main lake monitoring stations bordering the south shore of the lake.

The shallow and semi-confined nature of the Western Basin combined with the influence of the Detroit and Maumee Rivers makes delineation of the nearshore zone in this portion of the lake more complex. Measurements in the main lake portion of the Western Basin often approximate measurements made at inshore stations in the Central Basin: this observation leads to the dubiously logical conclusion that the entire Western Basin should be considered within the limits of the nearshore zone. The input of high quality upper lakes water in the mid-channel plume of the Detroit River makes such an easy generalization impossible. Relative to values recorded in the main lake portion of the Western Basin, values measured within one kilometer of the south shore, throughout Maumee Bay including a 13 to 18 kilometer portion of the Toledo navigation channel and within three kilometers of the western shore satisfy nearshore criteria. An inconsistent boundary zone such as occurs in the Central Basin is much less evident. The dominant and variable effect of the Detroit River in this portion of the lake limits other generalizations.

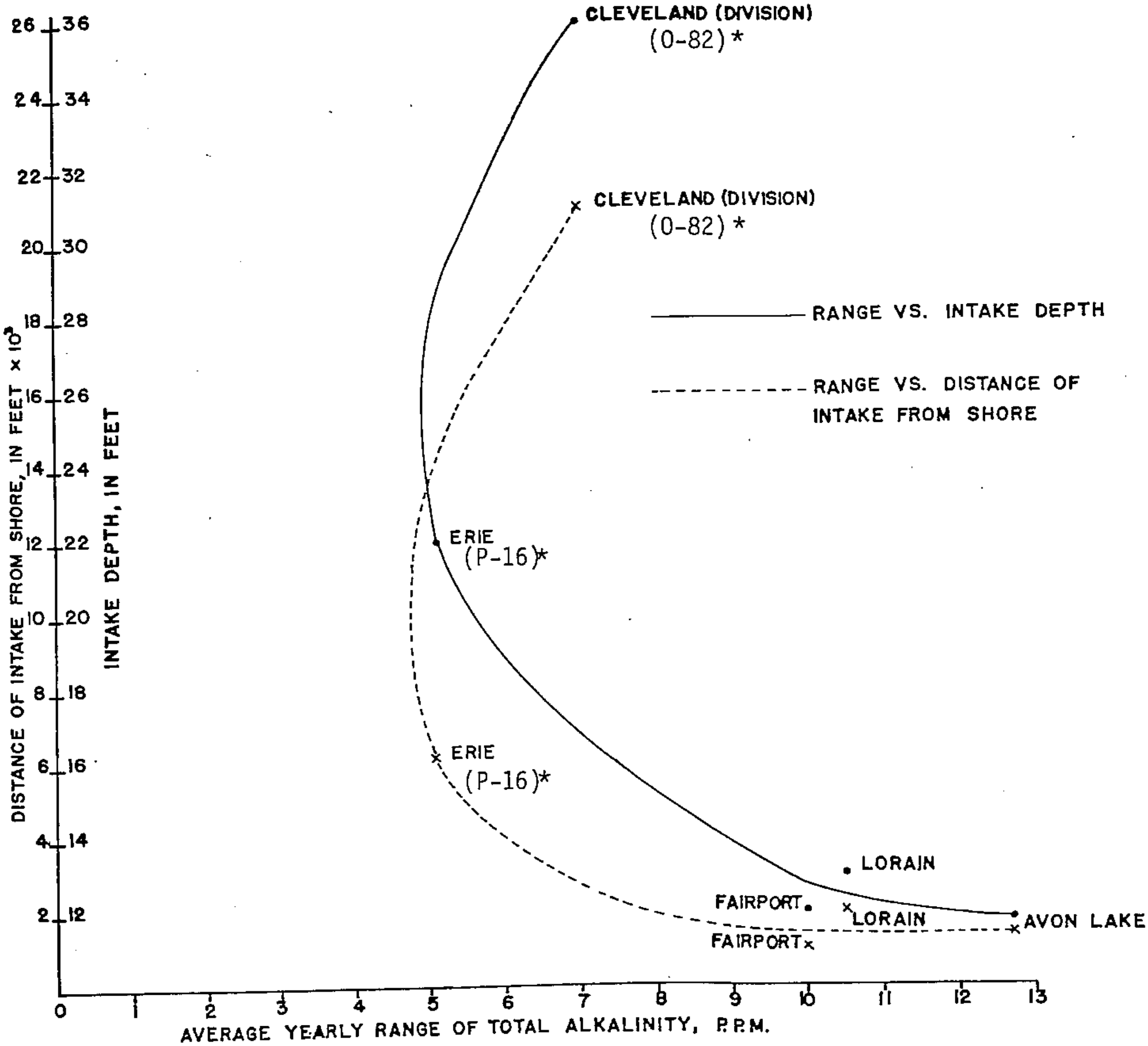


Fig. 80. Average yearly range of total alkalinity vs. distance from shore and depth of intake, at Cleveland, Erie, Lorain, Fairport, and Avon Lake.

* Nearshore Master Plan Station Number

SOURCE: Powers, C.F., et al. 1959. Exploration of Collateral data potentially applicable to Great Lakes hydrography and Fisheries. Final report. Great Lakes Research Inst., Univ. Mich., Ann Arbor. 164 p.

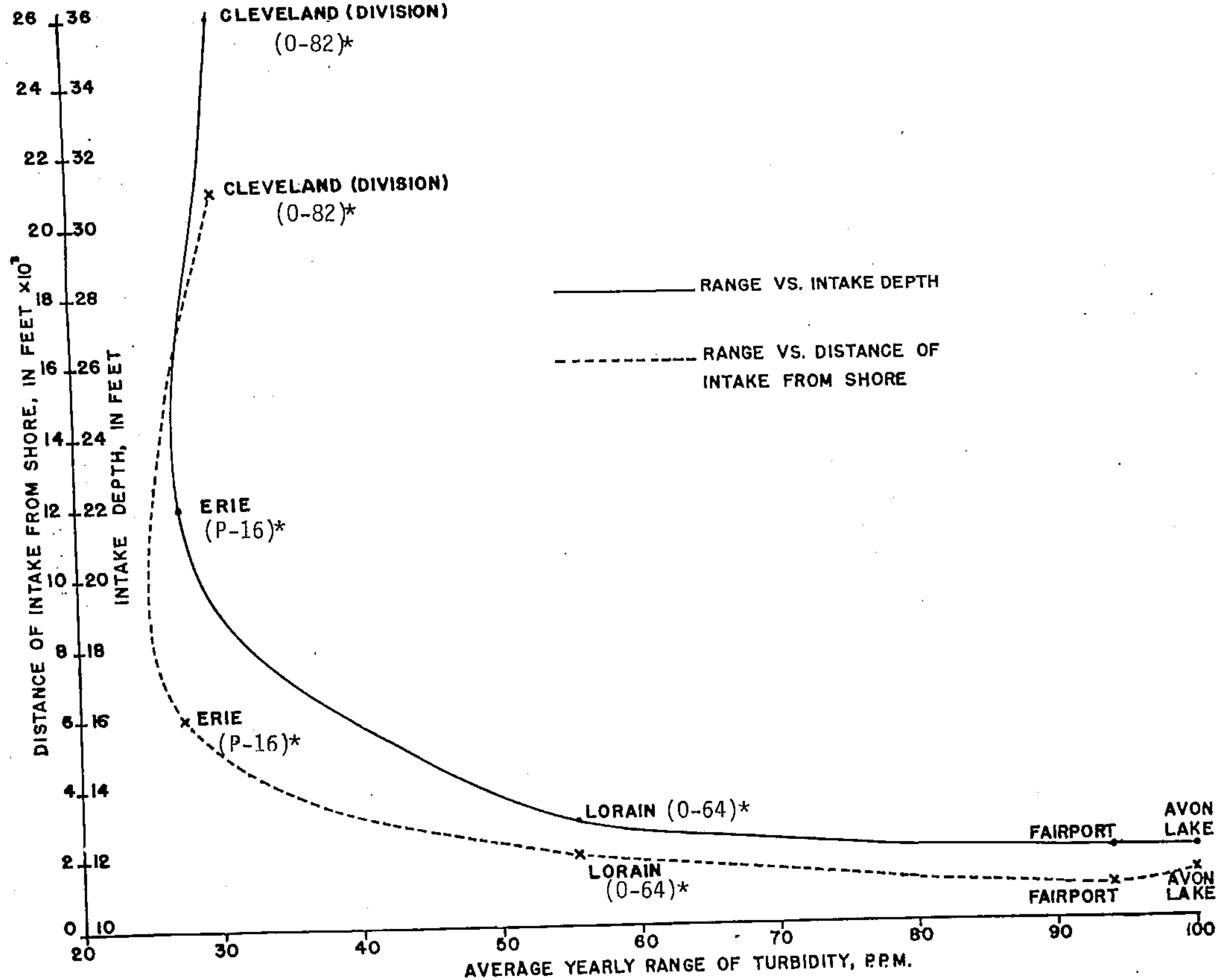


Fig. 81. Average yearly range of turbidity vs. distance from shore and depth of intake, at Cleveland, Erie, Lorain, Fairport, and Avon Lake.

*Nearshore Master Plan Station Number

SOURCE: Powers, C.F., et al. 1959. Exploration of collateral data potentially applicable to Great Lakes hydrography and fisheries. Final report. Great Lakes Research Inst., Univ. Mich., Ann Arbor. 164 p.

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APPENDIX A

EXISTING OR PROPOSED WATER QUALITY OBJECTIVES

1. SPECIFIC OBJECTIVES

   a) Microbiology: The geometric mean of not less than five samples taken over not more than a thirty-day period should not exceed 1,000/100 millilitres total coliforms, nor 200/100 millilitres fecal coliforms. Waters used for body contact recreation activities should be substantially free from bacteria, fungi, or viruses that may produce enteric disorders or eye, ear, nose, throat and skin infections or other human diseases and infections.

   b) Dissolved oxygen: In the Connecting Channels and in the upper waters of the Lakes, the dissolved oxygen level should be not less than 6.0 milligrams per litre at any time; in hypolimnetic waters, it should be not less than necessary for the support of fishlife, particularly cold water species.

   c) Total Dissolved Solids: In Lake Erie, Lake Ontario and the International Section of the St. Lawrence River, the level of total dissolved solids should not exceed 200 milligrams per litre. In the St. Clair River, Lake St. Clair, the Detroit River and the Niagara River, the level should be consistent with maintaining the levels of total dissolved solids in Lake Erie and Lake Ontario at not to exceed 200 milligrams per litre. In the remaining boundary waters, pending further study, the level of total dissolved solids should not exceed present levels.

   d) Taste and Odour: Taste, Odour and Tainting Substances

      1) Raw public water supply sources should be essentially free from objectionable taste and odour for aesthetic reasons.

      2) Levels of phenolic compounds should not exceed 0.001 milligm/l in raw public water supplies to protect against taste and odour in domestic water.

      3) Substances entering the water as a result of human activity that cause tainting of edible aquatic organisms should not be present in concentrations which will lower the acceptability of these organisms as determined by organoleptic tests.

   e) pH: Values of pH should not be outside the range of 6.5 to 9.0 nor should discharges change the pH at the boundary of a designated mixing zone more than 0.5 units from the ambient level.

   f) Iron: Levels should not exceed 0.3 milligm/l.

   g) Phosphorus: Concentrations should be limited to the extent necessary to prevent nuisance growths of algae, weeds and slimes that are or may become injurious to any beneficial water use.

h) Radio Activity: under review

2. INTERIM OBJECTIVES

a) Temperature: There should be no change that would adversely affect any local or general use of these waters.

b) Mercury and other Toxic Heavy Metals

i) Arsenic. Not to exceed 50 microgms/l in unfiltered water sample.
ii) Cadmium. Not to exceed 0.2 microgms/l in unfiltered water sample.
iii) Chromium. Not to exceed 50 microgms/l in unfiltered water sample.
iv) Lead. Not to exceed 10 microgms/l in unfiltered water sample - (Lake Superior).
Not to exceed 20 microgms/l in unfiltered water sample - (Lake Huron).
Not to exceed 25 microgms/l in unfiltered water sample - (Other Great Lakes).
v) Mercury. Total Hg in filtered water sample not to exceed 0.2 microgm/l. Total Hg in whole fish not to exceed 0.5 microgm/g (wet weight basis).
vi) Selenium. Not to exceed 10 microgms/l in unfiltered water sample.
vii) Zinc. Not to exceed 30 microgms/l in unfiltered water sample.

c) Persistent Organic Contaminants: Materials toxic or harmful to humans, animal or aquatic life should be substantially absent.

Pesticides

i) ALDRIN/DIELDRIN. Sum of concentrations in water not to exceed 0.001 microgm/l limit. Sum of concentration in edible portion of fish not to exceed 0.3 microgm/gm.
ii) CHLORDANE. Concentrations in water not to exceed 0.06 microgm/l.
iii) DDT and metabolites. In water, sum of concentrations not to exceed 0.003 microgm/l. In whole fish (wet weight basis), sum not to exceed 1.0 microgm/gm.
iv) ENDRIN. In water, not to exceed 0.002 microgm/l. In edible portion of fish, not to exceed 0.3 microgm/gm.
v) HEPTACHLOR & HEPTACHLOR OXIDE. In water not to exceed 0.001 microgm/l. In edible portion of fish, sum not to exceed 0.3 microgm/gm.
vi) LINDANE. Concentrations not to exceed 0.01 microgm/l in water. Concentrations not to exceed 0.3 microgm/l in edible portions of fish.
vii) METHOXYCHLOR. Concentrations not to exceed 0.04 microgm/l in water.
viii) TOXAPHENE. In water, concentrations not to exceed 0.008 microgm/l.

Other Toxic Persistent Compounds

i) PHTHALIC ACID ESTERS

Concentrations of dibutyl phthalate not to exceed 4.0 microgms/l in water.
Concentrations of di (2-ethyl hexyl) phthalate not to exceed 0.6 microgms/l.
Other phthalic acid esters, concentrations not to exceed 0.2 microgm/l.

ii) POLYCHLORINATED BIPHENYLS (PCBs)

Concentrations of total PCB in fish tissue (whole body, wet weight) not to exceed 0.1 microgm/gm.

iii) OTHER ORGANIC CONTAMINANTS

For others, levels of which are not specified but which can be demonstrated to be persistent and likely to be toxic, concentrations in water or organisms should be substantially absent or less than the detection level by best methodology available.

d) Settleable and Suspended Materials. Waters should be free from substances attributable to municipal, industrial or other discharges resulting from activity that will settle to form putrescent or otherwise objectionable sludge deposits or that will alter the value of the Secchi disk depth by more than 10%.

e) Oil, Petrochemicals and Immiscible Substances. Oil and petrochemicals should not be present in concentrations that: 1) can be detected as visible film, sheen or discoloration on the surface; 2) can be detected by odour; 3) can cause tainting of fish or edible invertebrates; 4) can form deposits on shorelines and bottom sediments that are detectable by sight or odour, or deleterious to resident aquatic organisms.

3. NON-DEGRADATION

Notwithstanding the adoption of specific water quality objectives, all reasonable and practicable measures shall be taken in accordance with paragraph 4 of article III of the agreement to maintain the levels of water quality existing at the date of entry into force of the agreement in those areas of the boundary waters of the Great Lakes System where such water quality is better than that prescribed by the specific water quality objectives.

4. SAMPLING DATA.

The Parties agree that the determination of compliance with specific objectives shall be based on statistically valid sampling data.

5. MIXING ZONES

A mixing zone is an area contiguous to a point source, where exceptions to water quality objectives and conditions otherwise applicable to the receiving waterbody may be granted. Thus, a mixing zone represents a loss of value. The following guidelines should be used in the designation of mixing zones.

1. Specific water quality objectives and conditions applicable to the receiving waterbody should be met at the boundary of mixing zones.

2. The size, shape, and exact location of a mixing zone should be specified so that the discharger and the regulatory agency know the bounds. The size should be minimized to the greatest possible degree.

3. Limitations on mixing zones should be established by the responsible regulatory agency on a case-by-case basis, where "Case" refers to local considerations and the waterbody as a whole, or segment of the waterbody.

4. Existing biological, chemical, physical and hydrological conditions should be known when considering location of a new mixing zone or limitations on an existing one.

5. Areas of extraordinary value should be designated off-limits for mixing zones.

6. When designing conditions to protect specific organisms it is necessary to know that the organisms would normally inhabit the area within the mixing zone. Zones of passage should be assured either by location or design of conditions within mixing zones. Mixing zones should not form a barrier to migratory routes of aquatic species or interfere with biological communities or populations of important species to a degree which is damaging to the ecosystem, or diminish other beneficial uses disproportionately.

7. No conditions within the mixing zone should be permitted which are either (a) rapidly lethal to important aquatic life conditions which result in sudden fish kills and mortality of organisms passing through the mixing zone; or (b) which cause irreversible responses which could result in detrimental pest-exposure effects; or (c) which result in bioconcentration of toxic materials which are harmful to the organism or its consumer.

8. Concentrations of toxic materials at any point in the mixing zone where important species are physically capable of residing should not exceed the 24-to-96-hour LC_{50}.

9. Many of the general water quality objectives should apply to discharge-related materials within mixing zones. The zones should be free of:

   a) Objectionable deposits;

   b) Unsightly or deleterious amounts of flotsam, debris, oil, scum, and other floating matter;

   c) Substances producing objectionable color, odour, taste or turbidity;

   d) Substances and conditions or combinations thereof at levels which produce aquatic life in nuisance quantities that interfere with other uses.

10. Mixing zones may overlap unless the combined effects exceed the conditions set forth in other guidelines.

11. Municipal and other water supply intakes and recreational areas should

not be in mixing zones as a general condition, but local knowledge of the effluent characteristics and the type of discharge associated with the zone could allow such a mixture of uses.

6. LOCALIZED AREAS

There will be other restricted, localized areas, such as harbours, where existing conditions such as land drainage and land use will prevent the objectives from being met at least over the short term; such areas, however, should be identified specifically and as early as possible by the responsible regulatory agencies and should be kept to a minimum. Pollution from such areas shall not contribute to the violation of the water quality objectives in the waters of the other Party. The International Joint Commission shall be notified of the identification of such localized areas, in accordance with Article VIII.

7. CONSULTATION

Specific objectives for arsenic, cadmium, chromium, lead, mercury, oil, some organic chemicals, phenols, selenium, and zinc now exist. Objectives for ammonia, copper, cyanide and nickel have been drafted. Objectives for barium, chloride and sulfate have been studied but none are being recommended. These (the latter) are part of the constituents in the Total Dissolved Solids group.

i) Fluoride. Concentrations of total fluoride in unfiltered water sample not to exceed 1.2 milligm/l.

ii) Organic Compounds. General Objective.

Concentrations of unspecified, non-persistent pesticides should not exceed 0.05 of the median lethal concentrations in a 96 hr test for any sensitive local species.

- Diazinon. Concentrations in unfiltered water sample not to exceed 0.08 microgm/l.
- Unspecified non-persistent toxic substances and complex effluents of municipal, industrial or origin should not be present in concentrations which exceed 0.05 of the median lethal concentrations (96 hr LC_{50}) for any sensitive local species to protect aquatic life.
- Asbestos. Asbestos should be kept at the lowest practicable levels and in any event should be controlled to the extent necessary to prevent harmful effects on health.

SOURCES: 1. New and Revised Specific Water Quality Objectives Proposed for the 1972 Agreement Between the United States and Canada on Great Lakes Water Quality by the Great Lakes Water Quality Board. 1976. International Joint Commission. United States and Canada.

2. New and Revised Great Lakes Water Quality Objectives. Vol. I. 1977. International Joint Commission. Canada and United States.

APPENDIX B

APPENDIX B

LIST OF TABLES AND FIGURES

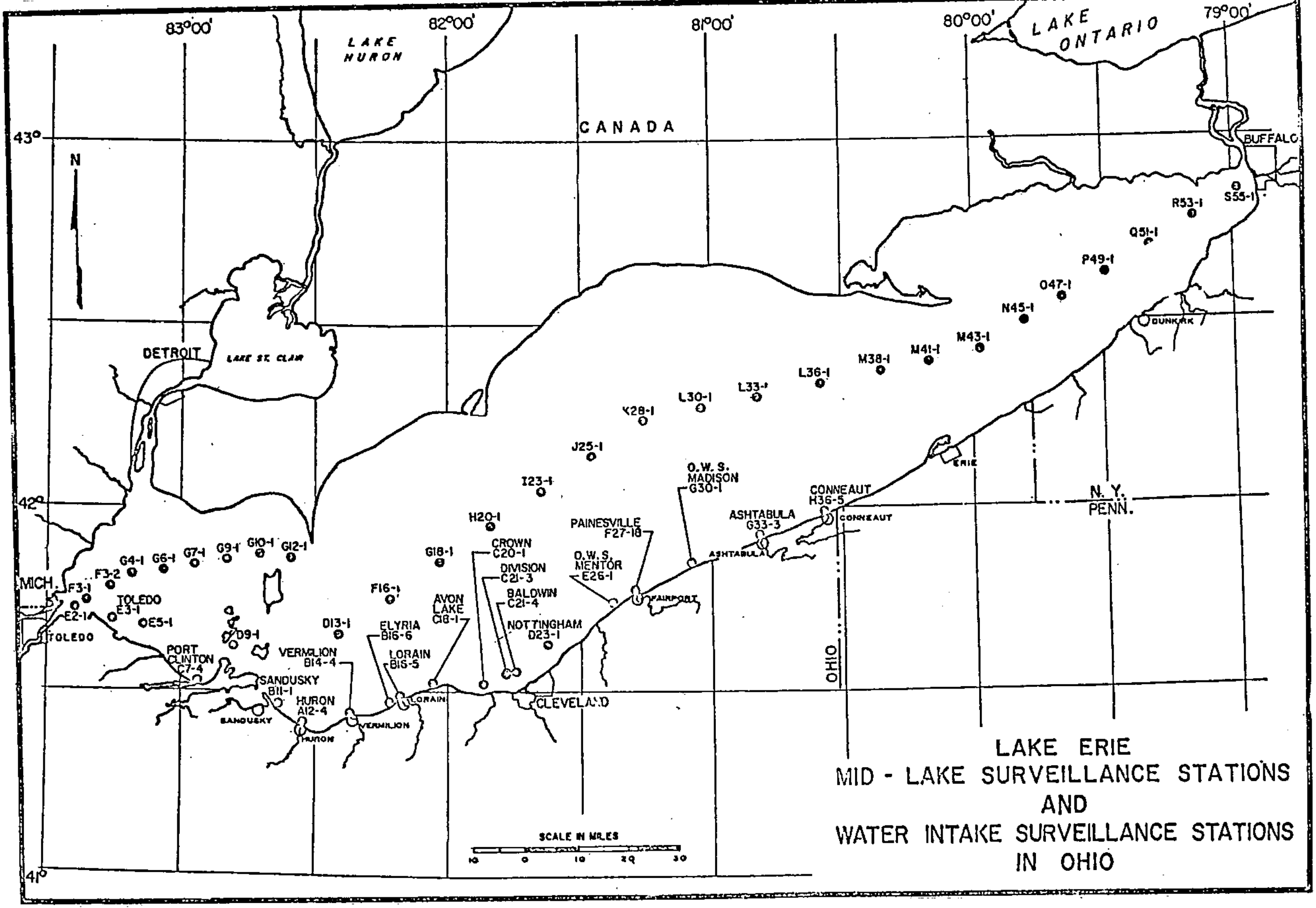

FIGURE B-1

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algae-Temperature-Nutrient relationships and distribution in Lake Erie. USEPA Region V Water Quality Office, Lake Erie Basin. 87 p.

TABLE B-2

SUMMARY OF WATER INTAKE PHYSICAL DATA

Location Number	Intake	Latitude	Longitude	Total** Depth (ft.)	Intake** Depth (ft.)	Intake Line Diameter (In.)	Intake Line Type	Distance from shore (ft.)	%WA	%WB
E3-1	Toledo	41°42'00"	83°15'32"	17	10±5	108	C	11,000	50	50
C7-4	Port Clinton	41°31'22"	82°56'21"	8	4	30	C	2,000	75	25
B11-1	Sandusky	41°27'51"	82°38'50"	21	16	42	S	2,900	100	0
A12-4	Huron	41°24'23"	82°33'24"	15	10	36	C	2,100	100	0
B14-4	Vermilion	41°25'42"	82°22'09"	11	7	18	S	1,200	100	0
B16-6	Elyria	41°27'26"	82°13'15"	20	11	42	I	1,200	100	0
B16-5	Lorain	41°28'21"	82°11'41"	24	11	48	I	1,100	95	5
C18-1	Avon Lake	41°30'46"	82°02'36"	21	18	36	C	2,000	100	0
C20-1	Cleveland-Crown	41°31'08"	81°52'46"	44	19*	96	C	13,000	100	0
C21-3	Cleveland-Division	41°32'50"	81°45'50"	50	34	120	C	20,000	100	0
C21-4	Cleveland-Baldwin	41°32'54"	81°45'02"	47	17±9	108	C	17,000	50	50
D23-1	Cleve.-Nottingham	41°37'05"	81°37'02"	49	38	120	C	18,000	100	0
E26-1	O.W.S. - Mentor	41°43'34"	81°22'05"	17	14	36	C	2,000	100	0
F27-18	Painesville	41°45'24"	81°17'53"	11	6	24	I	1,100	50	50
G30-1	O.W.S. - Madison	41°50'00"	81°04'38"	20	16	24	I	1,800	95	5
G33-3	Ashtabula	41°54'30"	80°48'38"	23	20	30	C	1,600	95	5
H36-5	Conneaut	41°57'54"	80°34'38"	19	13	24	I	2,000	100	0

Notes:

* Depth of Intake as of 9/17/68. Previous depth was 34 feet.
** All depths referred to mean low water level (568.6 feet).

Abbreviations:

C - Concrete
I - Iron
S - Steel
%WA - Percent of raw water from above center line of inlet port.
%WB - Percent of raw water from below center line of inlet port.

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algal-Temperature-Nutrient Relationships and Distribution in Lake Erie-1968 USEPA Water Quality Office, Region V - Lake Erie Basin. 87 p.

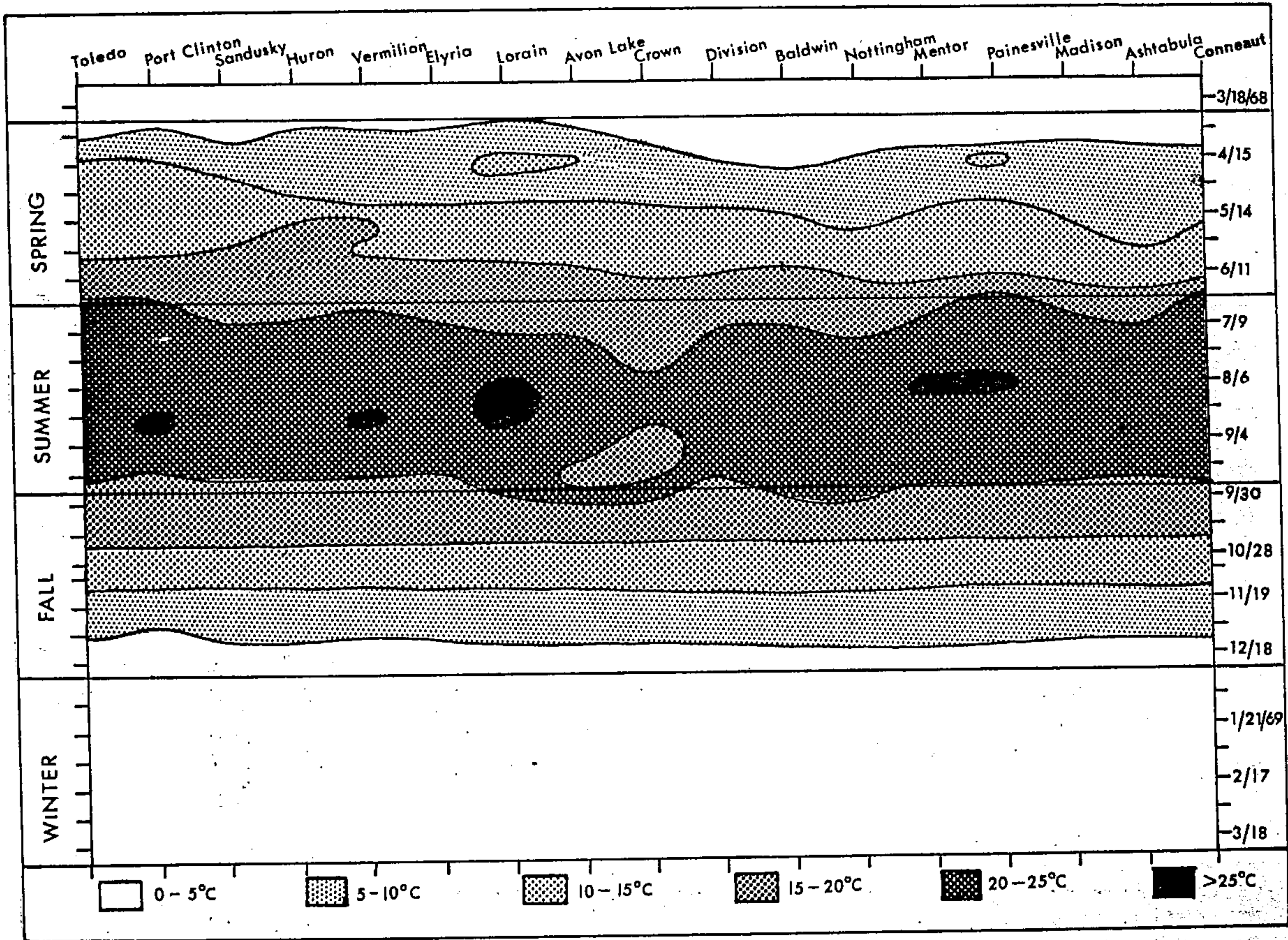

FIGURE B-3 **Nearshore Temperature Distribution in Lake Erie 1968-1969**

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algae-Temperature-Nutrient relationships and distribution in Lake Erie. USEPA Region V Water Quality Office, Lake Erie Basin. 87 p.

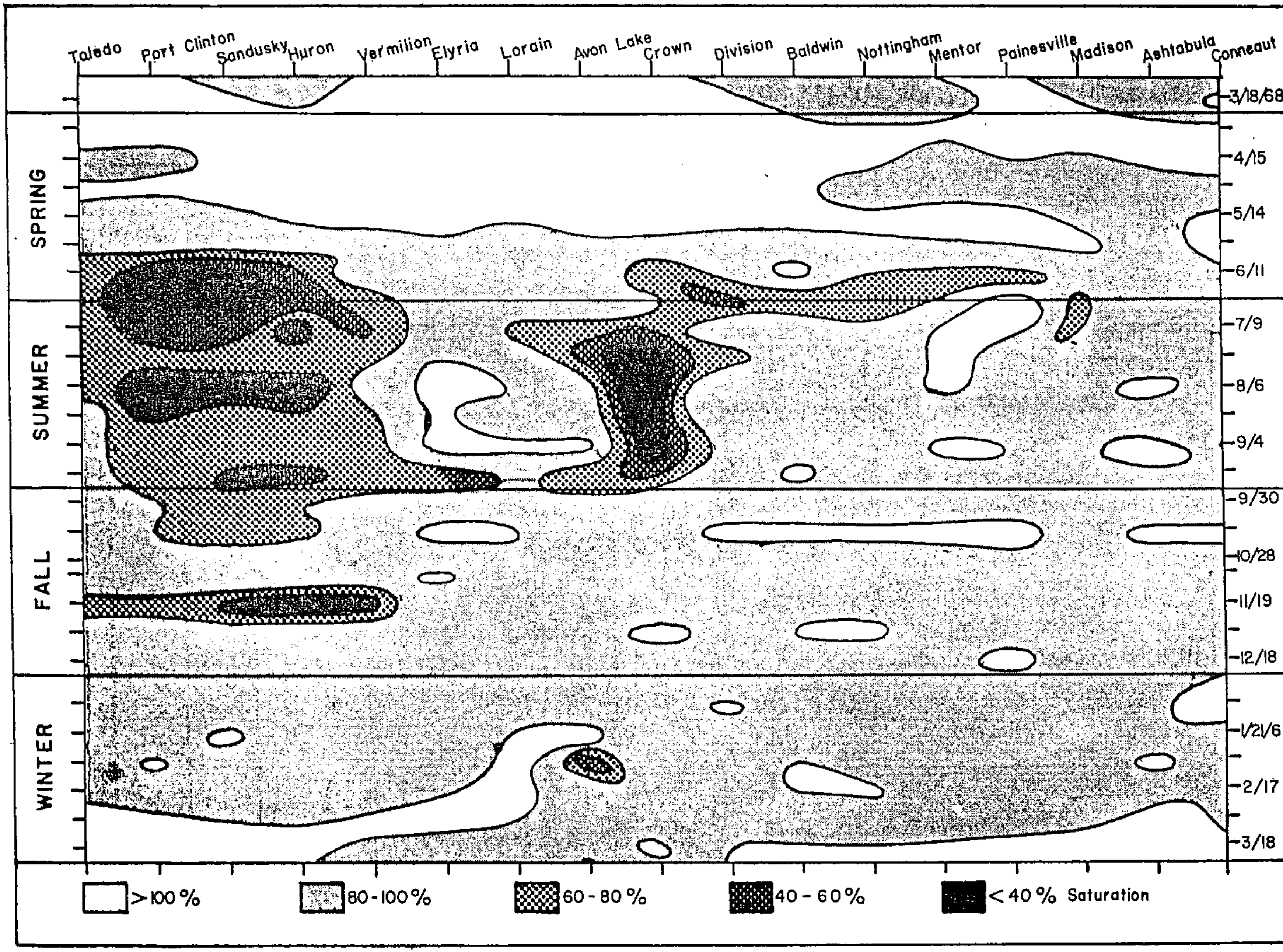

FIGURE B-4 **Nearshore Dissolved Oxygen Distribution in Lake Erie 1968 - 1969**

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algae-Temperature-Nutrient relationships and distribution in Lake Erie. USEPA Region V Water Quality Office, Lake Erie Basin. 87 p.

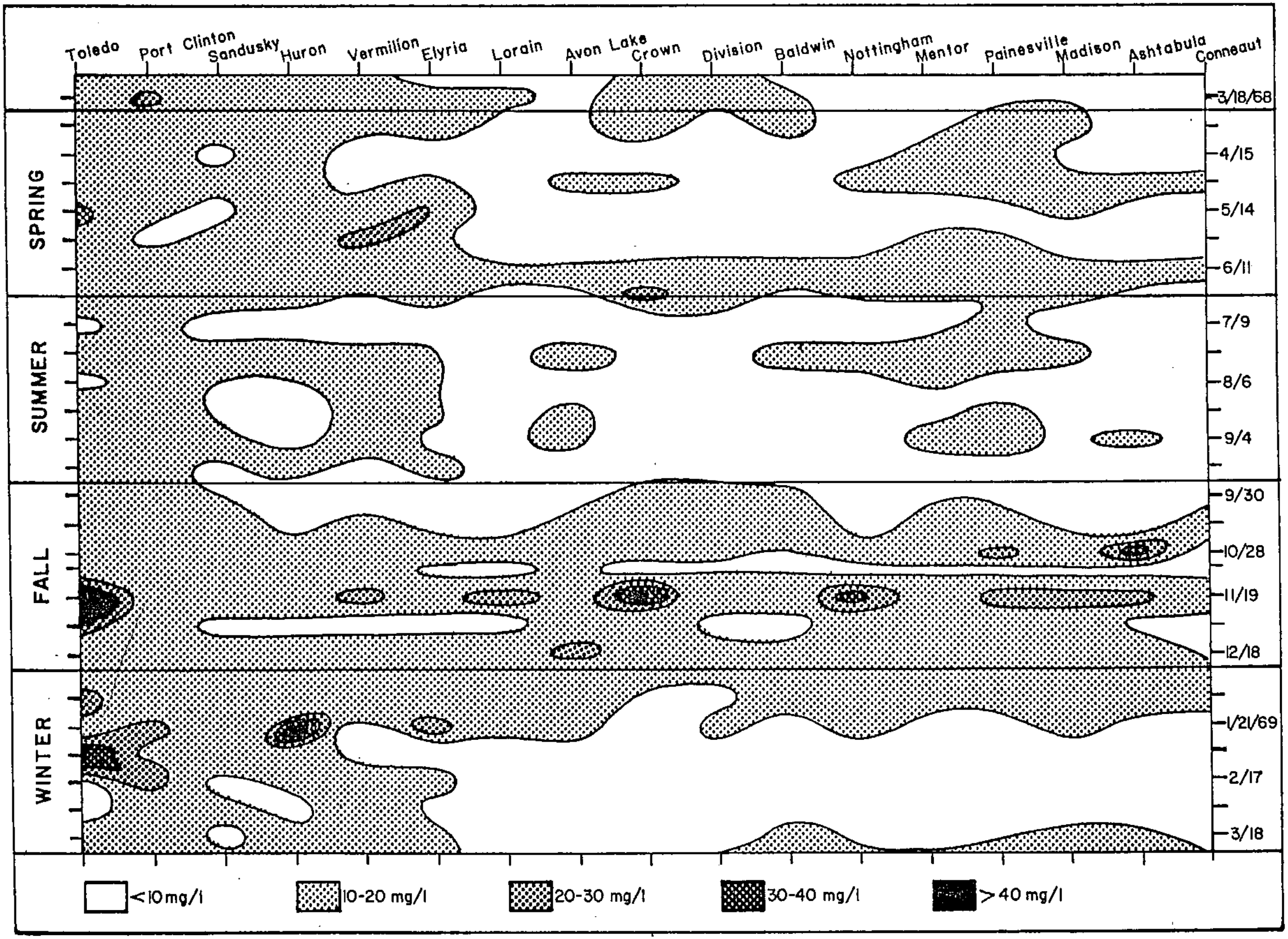

FIGURE B-5 **Nearshore COD Distribution in Lake Erie 1968-1969**

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algae-Temperature-Nutrient relationships and distribution in Lake Erie. USEPA Region V Water Quality Office, Lake Erie Basin. 87 p.

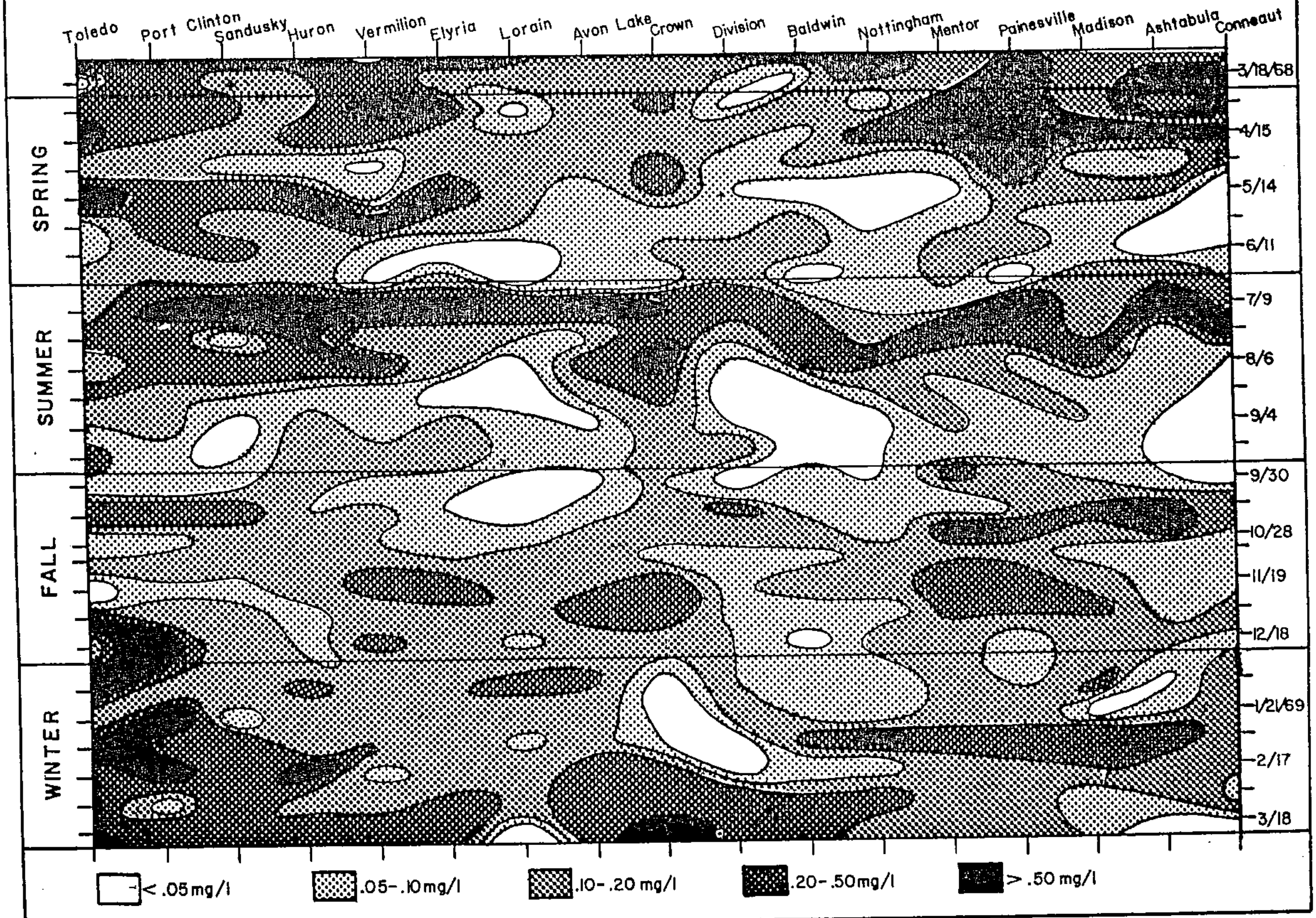

FIGURE B-6 **Nearshore Ammonia Nitrogen Distribution in Lake Erie 1968 - 1969**

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algae-Temperature-Nutrient relationships and distribution in Lake Erie. USEPA Region V Water Quality Office, Lake Erie Basin. 87 p.

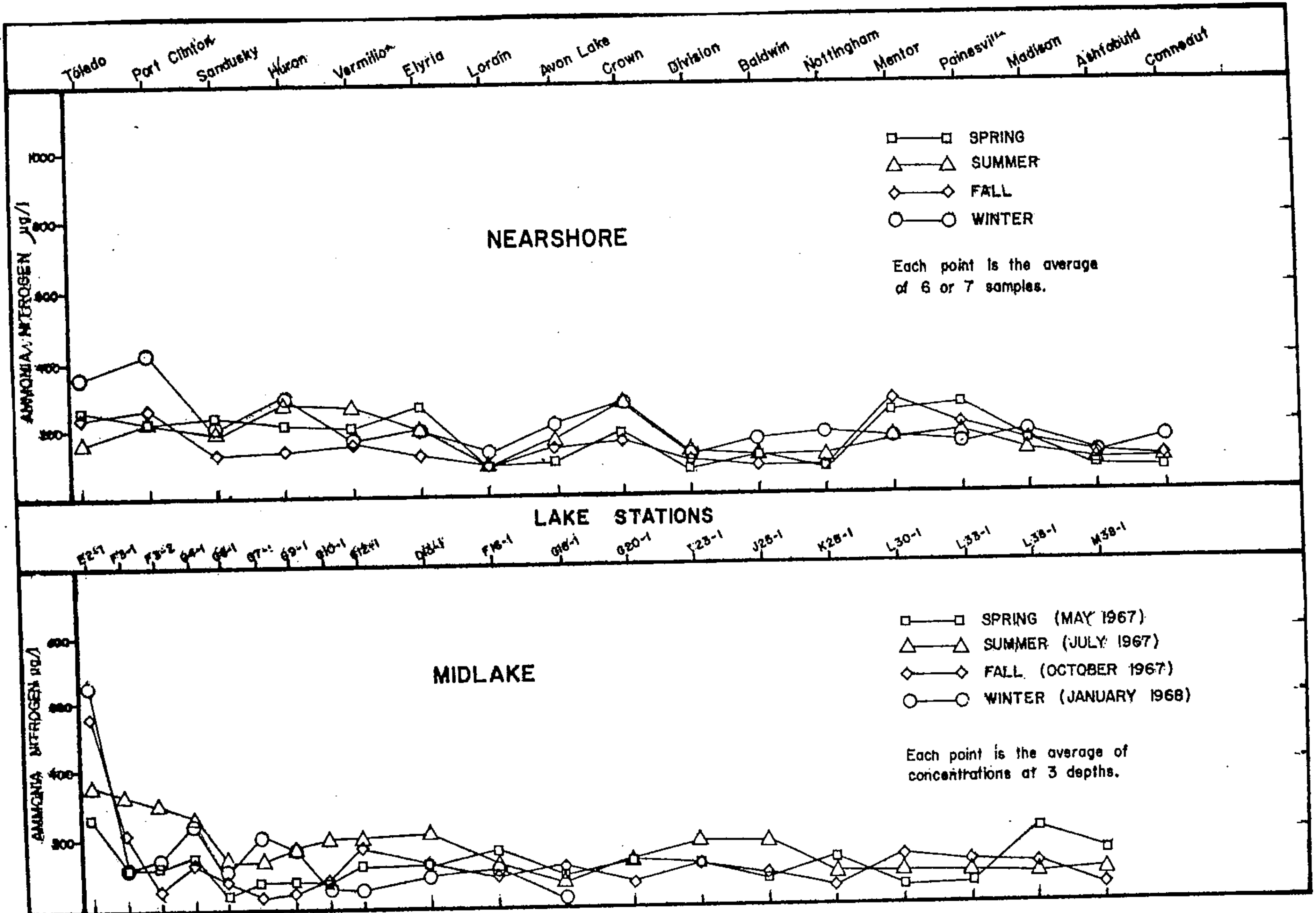

FIGURE B-7

Nearshore and Midlake Seasonal Distribution of Ammonia Nitrogen

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algae-Temperature-Nutrient relationships and distribution in Lake Erie. USEPA Region V Water Quality Office, Lake Erie Basin. 87 p.

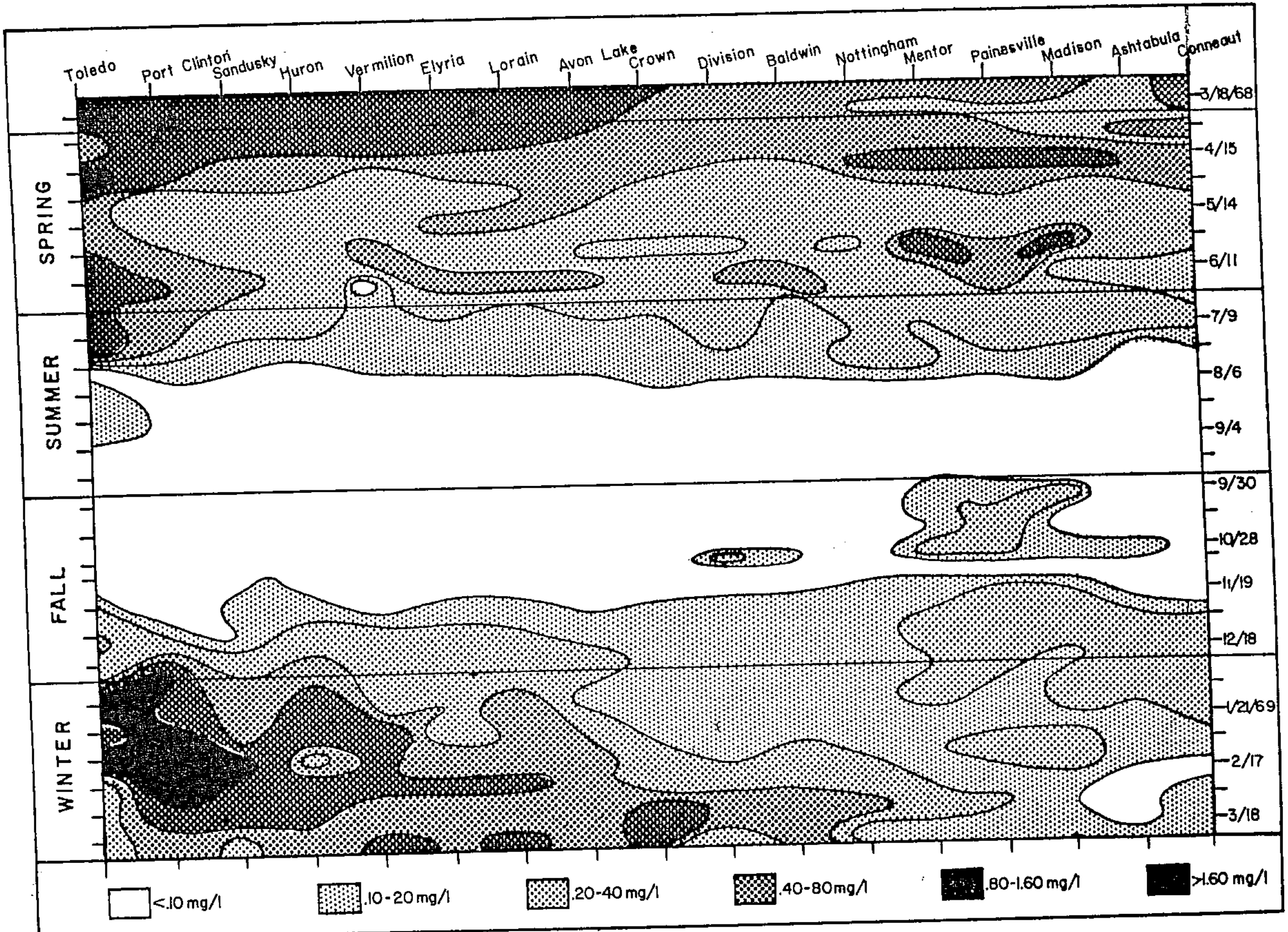

FIGURE B-8 **Nearshore Nitrate Nitrogen Distribution in Lake Erie 1968 - 1969**

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algae-Temperature-Nutrient relationships and distribution in Lake Erie. USEPA Region V Water Quality Office, Lake Erie Basin. 87 p.

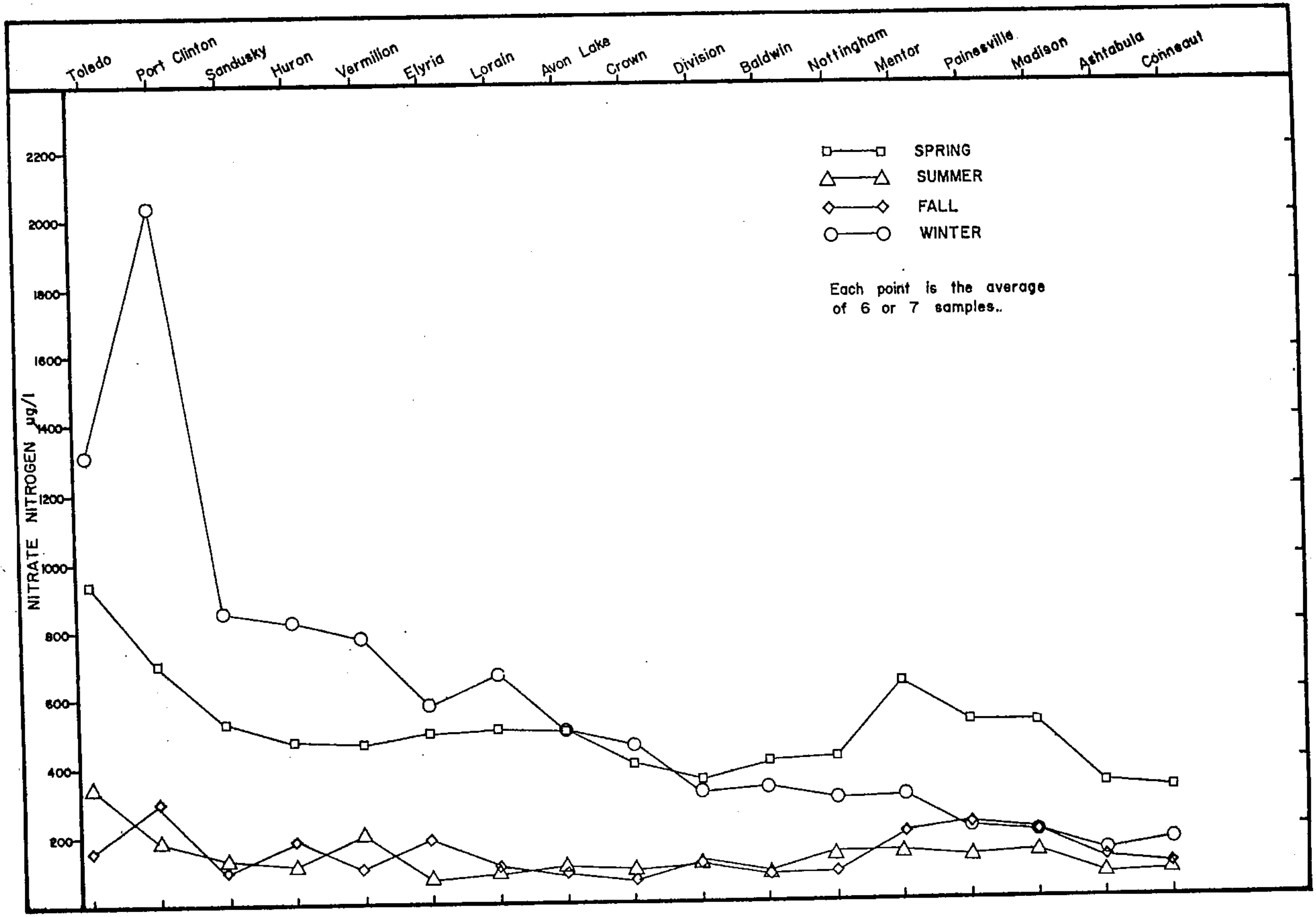

FIGURE B-9

Nearshore Seasonal Distribution of Nitrate Nitrogen

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algae-Temperature-Nutrient relationships and distribution in Lake Erie. USEPA Region V Water Quality Office, Lake Erie Basin. 87 p.

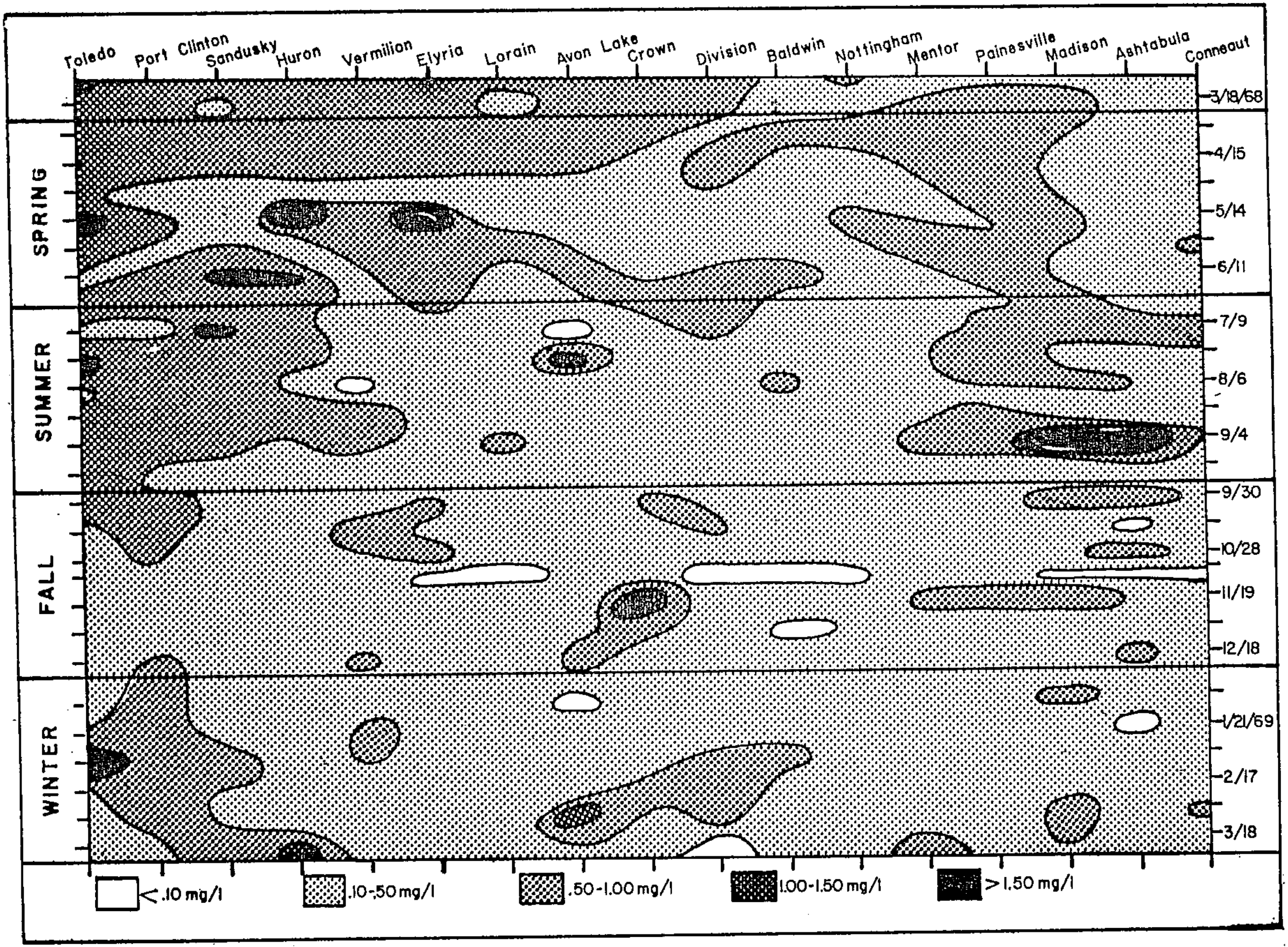

FIGURE B-10 **Nearshore Organic Nitrogen Distribution 1968 - 1969**

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algae-Temperature-Nutrient relationships and distribution in Lake Erie. USEPA Region V Water Quality Office, Lake Erie Basin. 87 p.

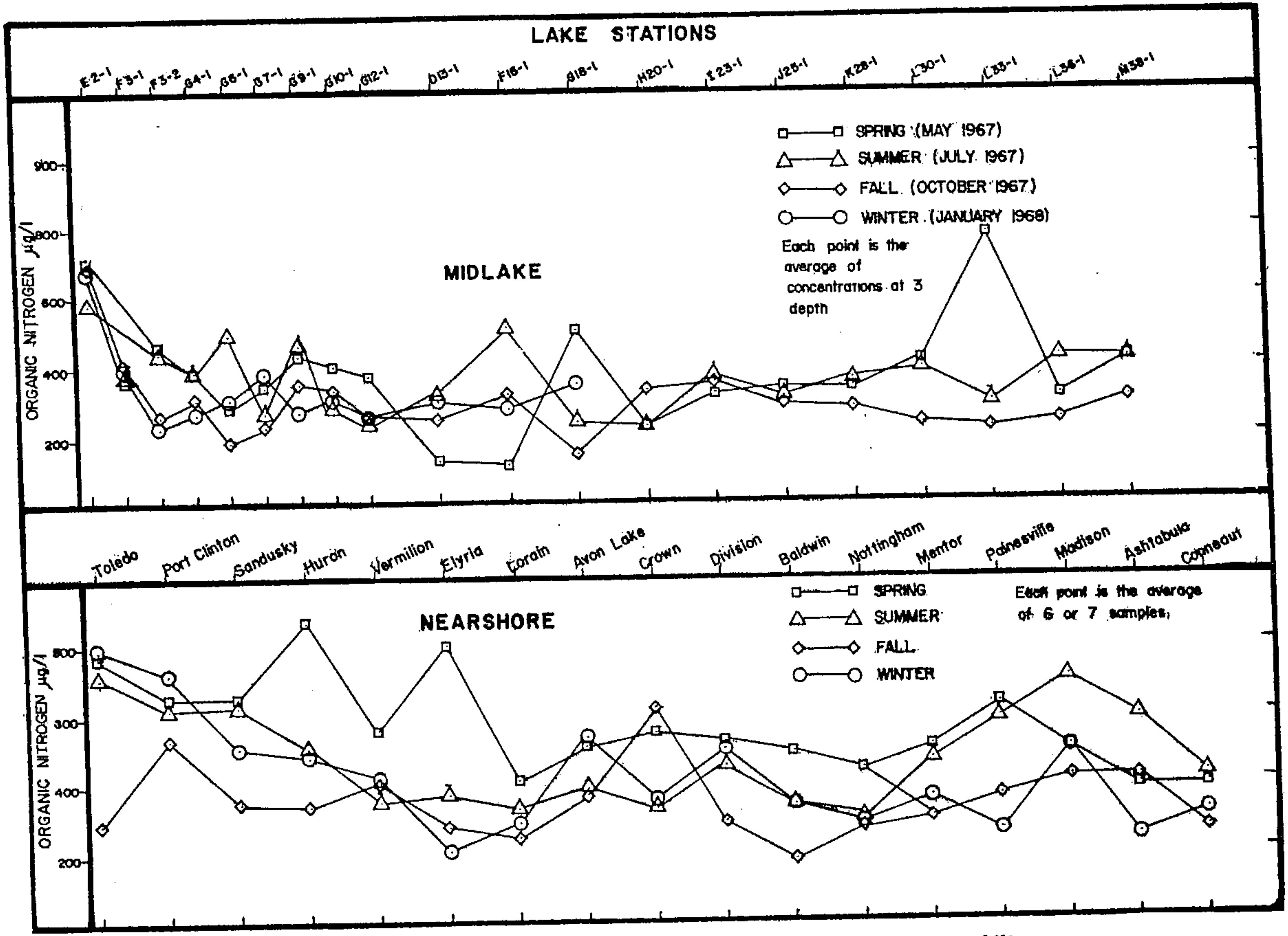

FIGURE B-11 **Midlake and Nearshore Seasonal Distribution of Organic Nitrogen**

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algae-Temperature-Nutrient relationships and distribution in Lake Erie. USEPA Region V Water Quality Office, Lake Erie Basin. 87 p.

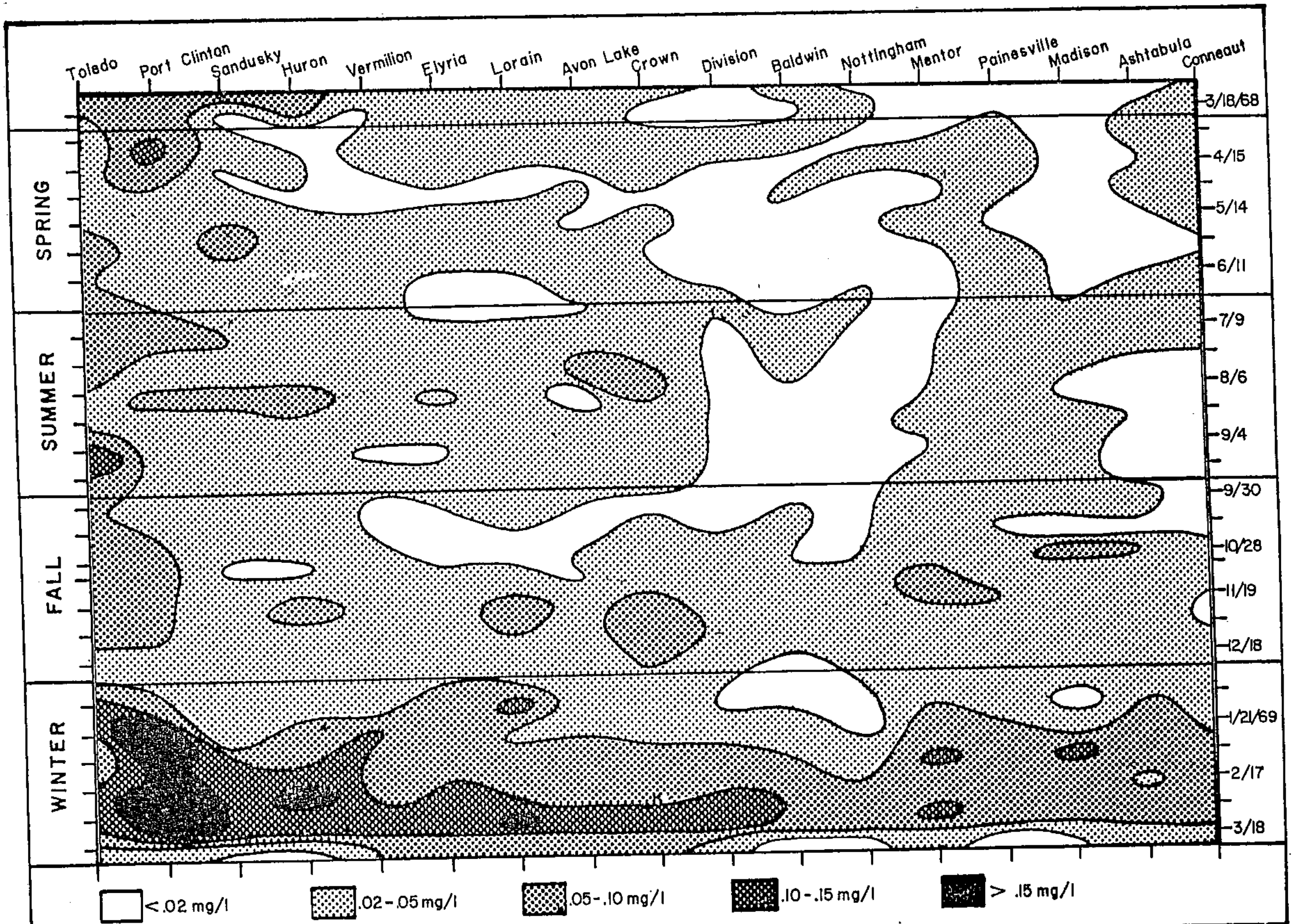

FIGURE B-12 **Nearshore Soluble Phosphorus Distribution in Lake Erie 1968 - 1969**

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algae-Temperature-Nutrient relationships and distribution in Lake Erie. USEPA Region V Water Quality Office, Lake Erie Basin. 87 p.

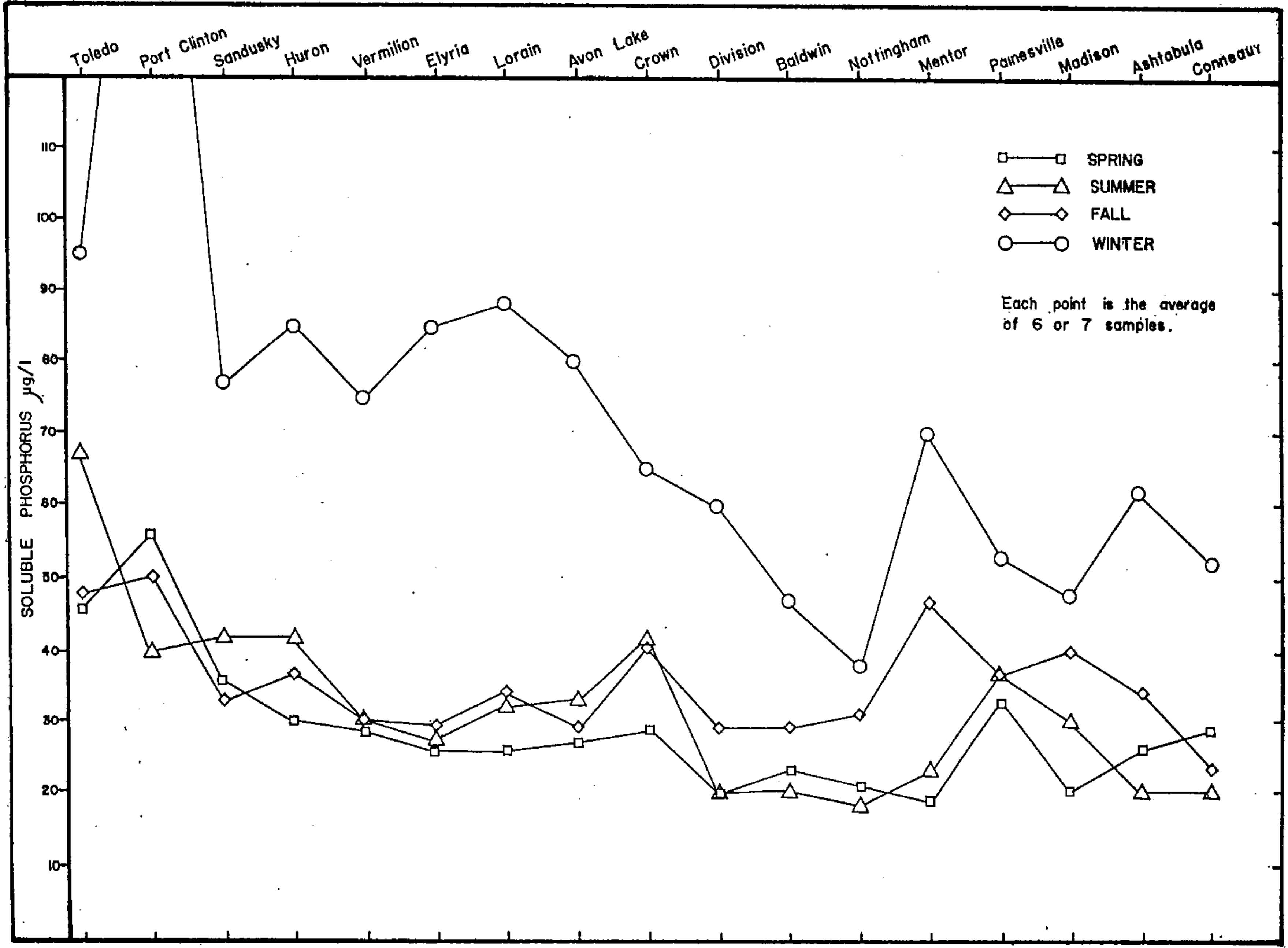

FIGURE B-13 **Nearshore Seasonal Distribution of Soluble Phosphorus**

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algae-Temperature-Nutrient relationships and distribution in Lake Erie. USEPA Region V Water Quality Office, Lake Erie Basin. 87 p.

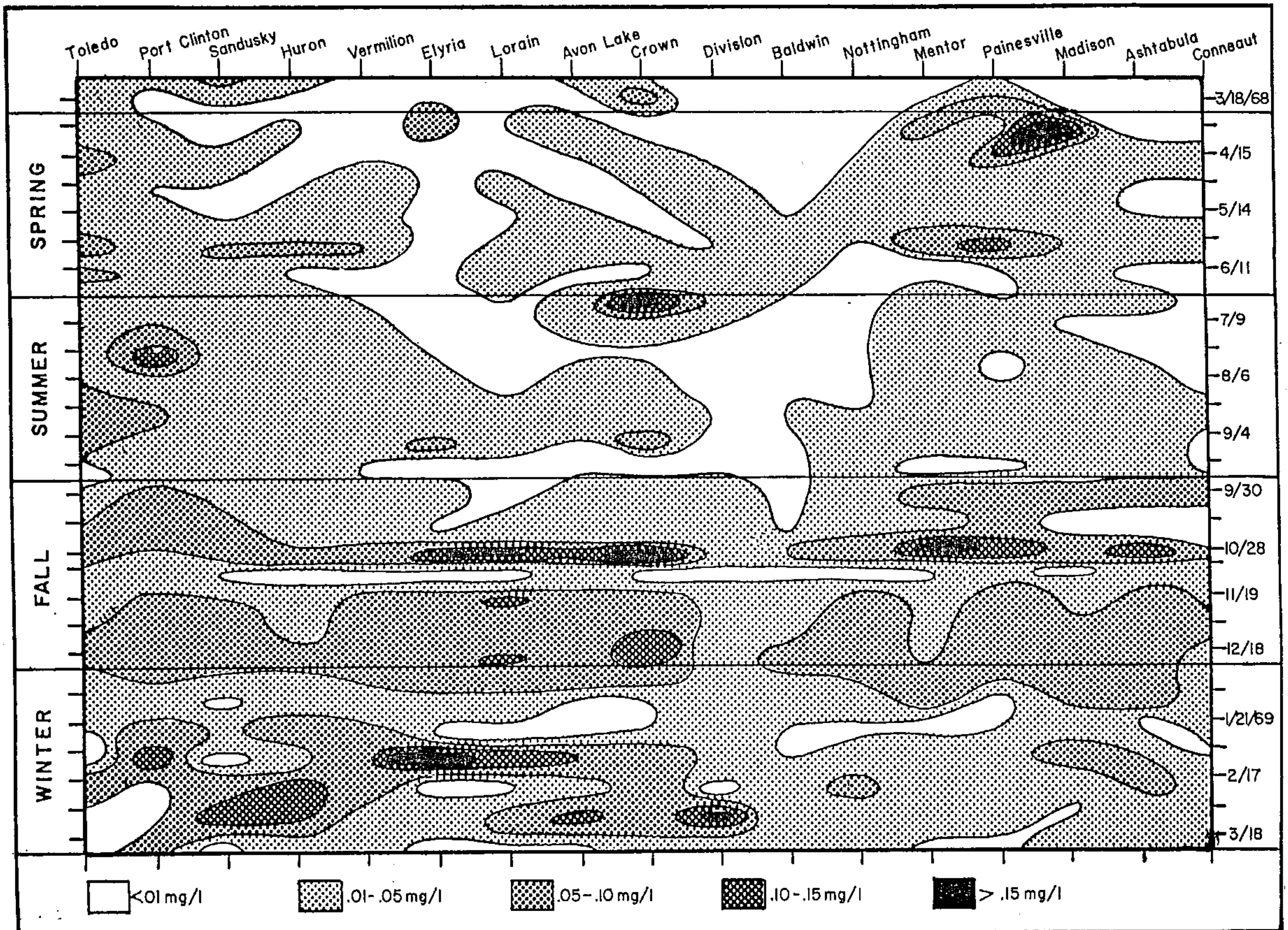

FIGURE B-14 **Nearshore Particulate Phosphorus Distribution in Lake Erie 1968 - 1969**

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algae-Temperature-Nutrient relationships and distribution in Lake Erie. USEPA Region V Water Quality Office, Lake Erie Basin. 87 p.

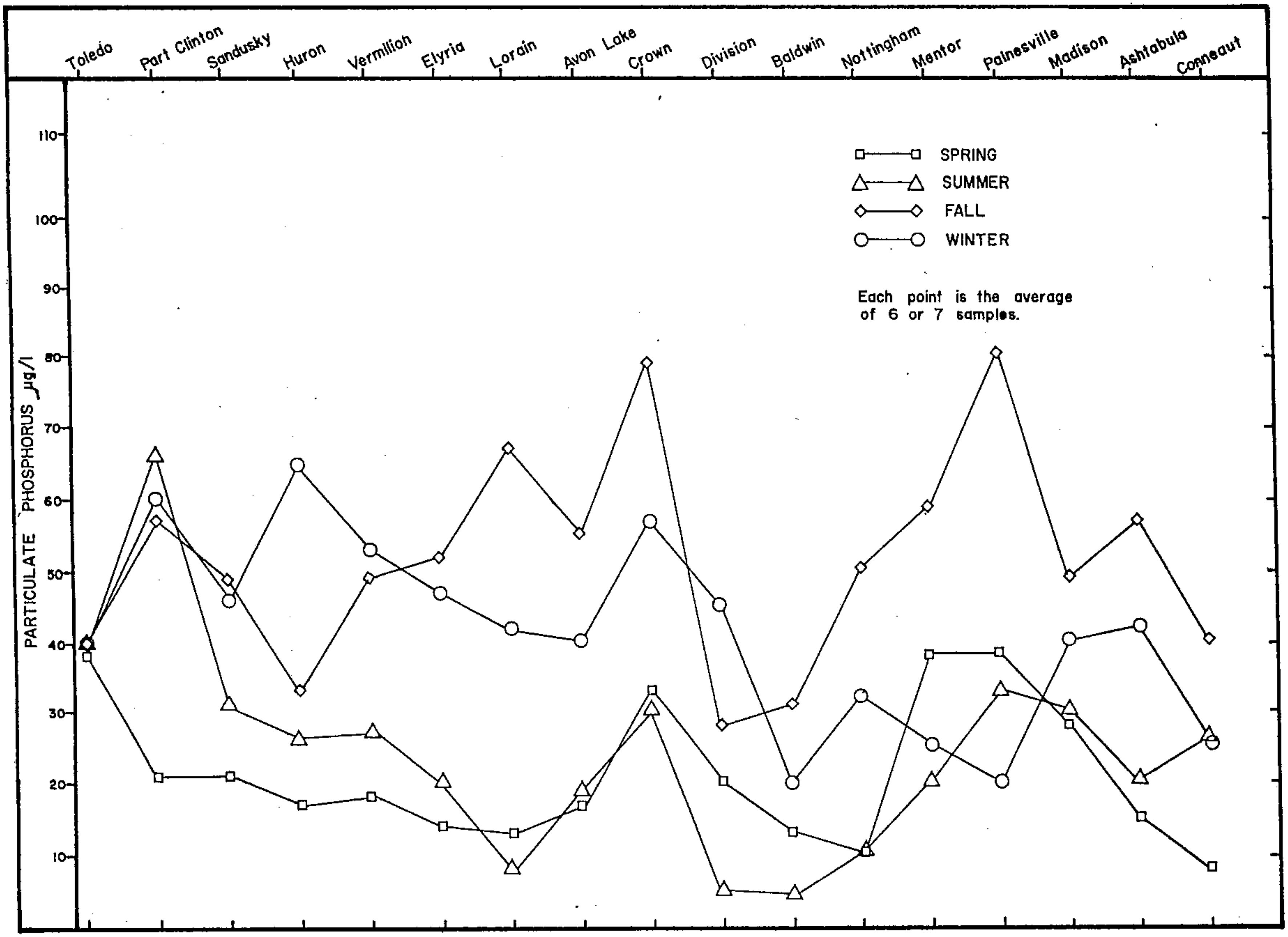

FIGURE B-15 **Nearshore Seasonal Distribution of Particulate Phosphorus**

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algae-Temperature-Nutrient relationships and distribution in Lake Erie. USEPA Region V Water Quality Office, Lake Erie Basin. 87 p.

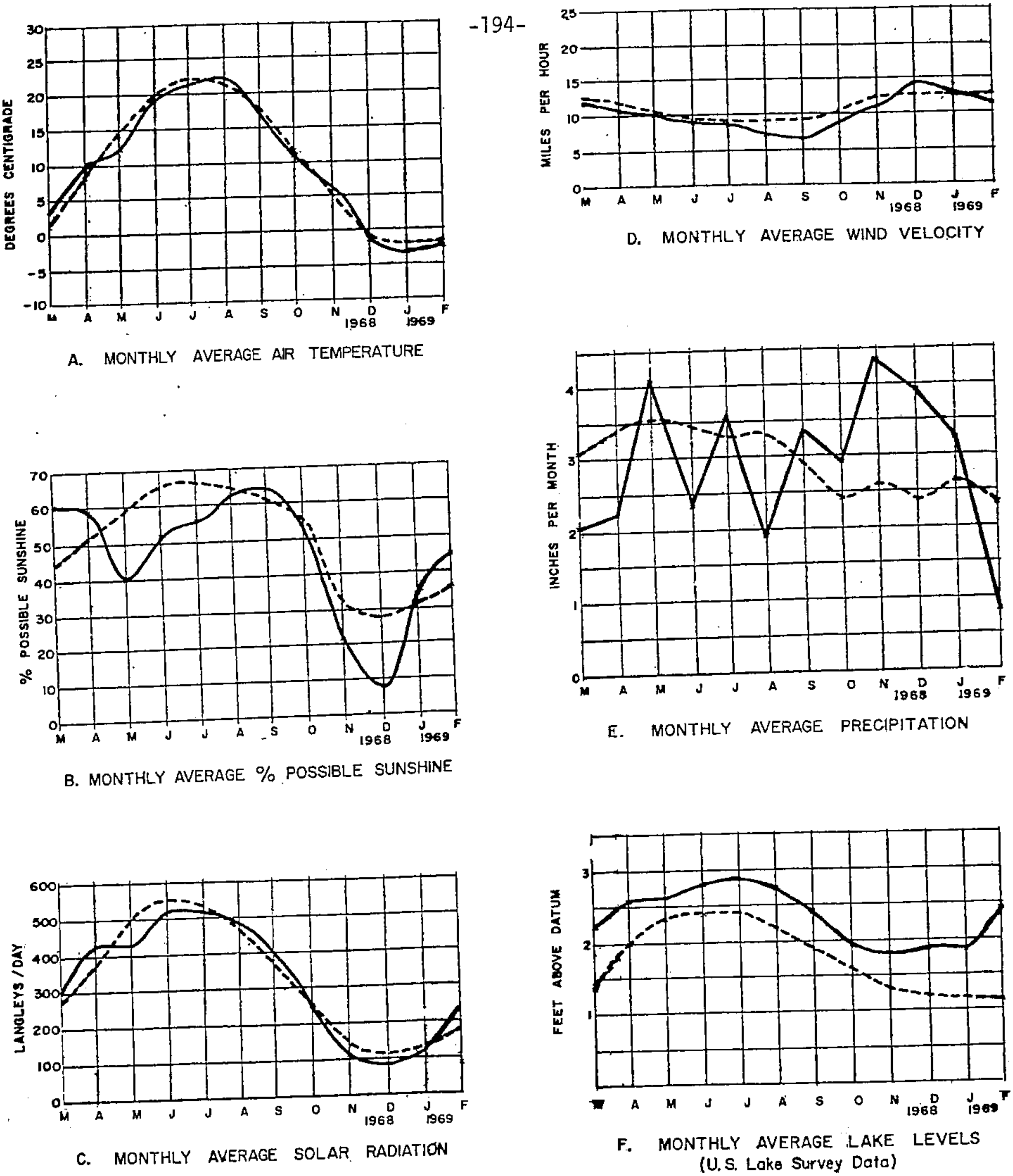

FIG. B-16 MONTHLY AVERAGES OF VARIOUS PHYSICAL FACTORS AFFECTING LAKE ERIE.
All data from U. S. Weather Bureau at Cleveland unless otherwise noted.
Dashed lines - longterm average. Solid lines - 1968-69.

SOURCE: Hartley, R.P. and C.P. Potos. 1971. Algae-Temperature-Nutrient relationships and distribution in Lake Erie. USEPA Region V Water Quality Office, Lake Erie Basin. 87 p.

APPENDIX C

APPENDIX C

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APPENDIX C CONTINUED

LIST OF TABLES AND FIGURES

FIGURE C-1.

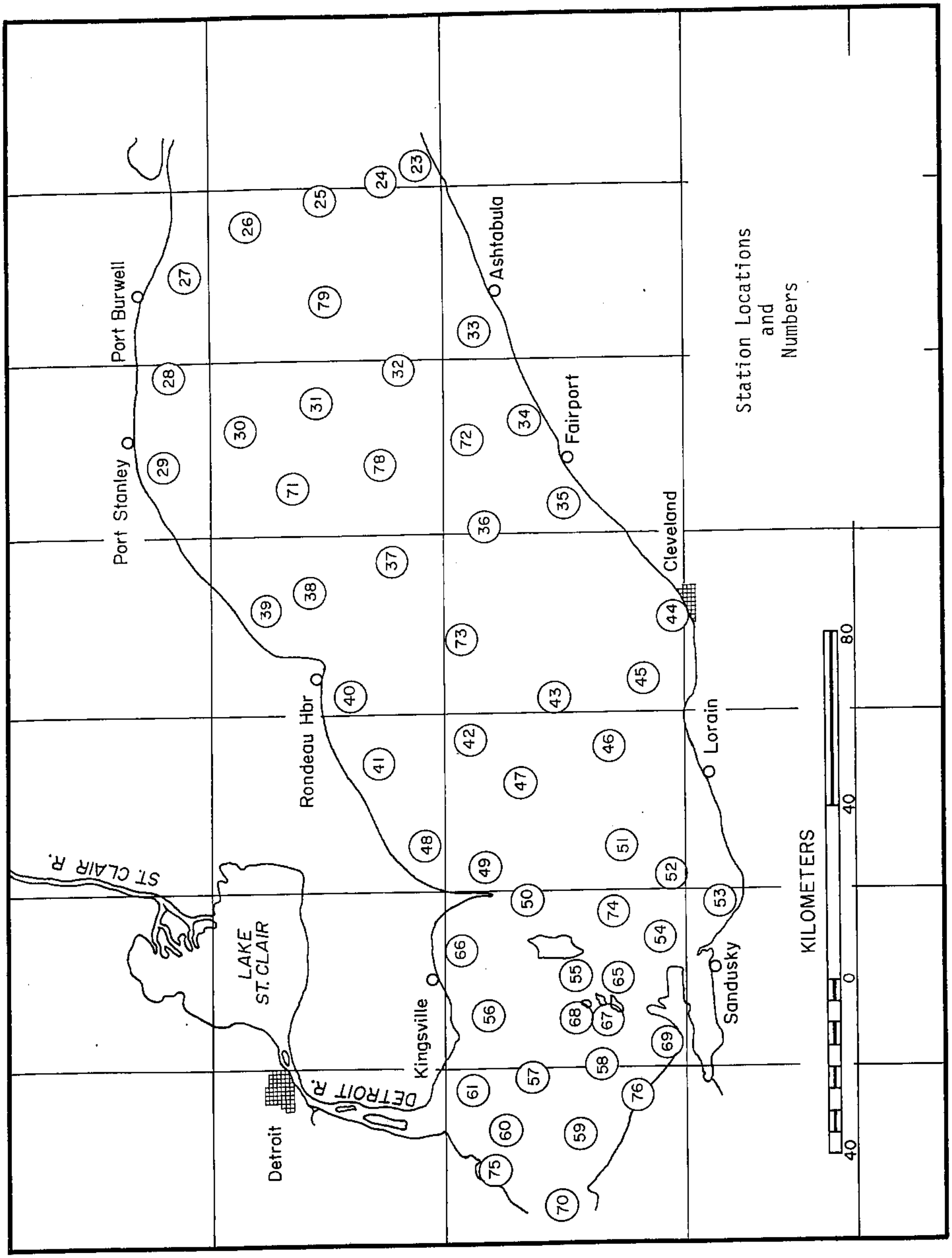
Station Locations
and
Numbers
Port Burwell
Port Stanley
Rondeau Hbr
Kingsville
Detroit
LAKE
ST. CLAIR
ST. CLAIR R.
DETROIT R.
Ashtabula
Fairport
Cleveland
Lorain
Sandusky
KILOMETERS
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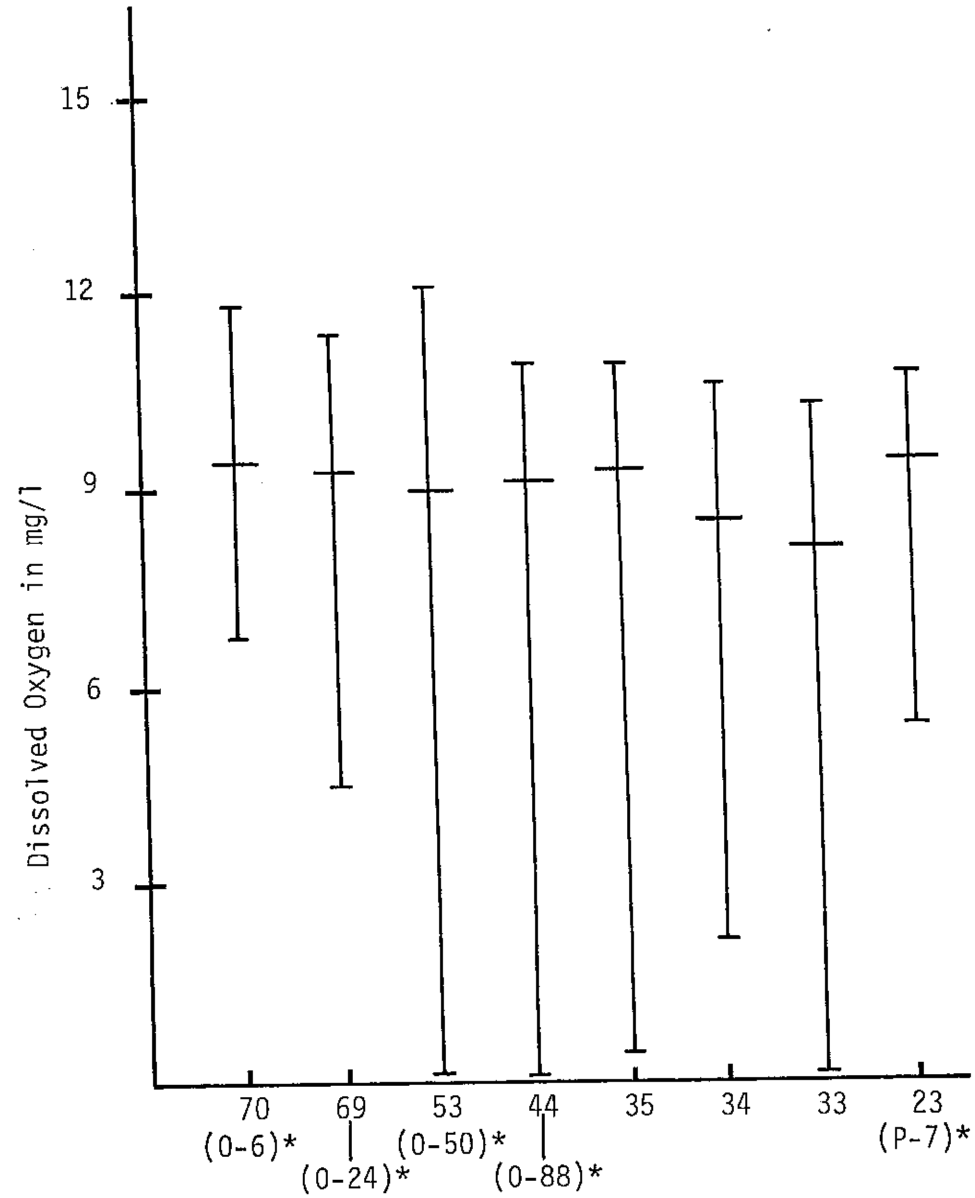
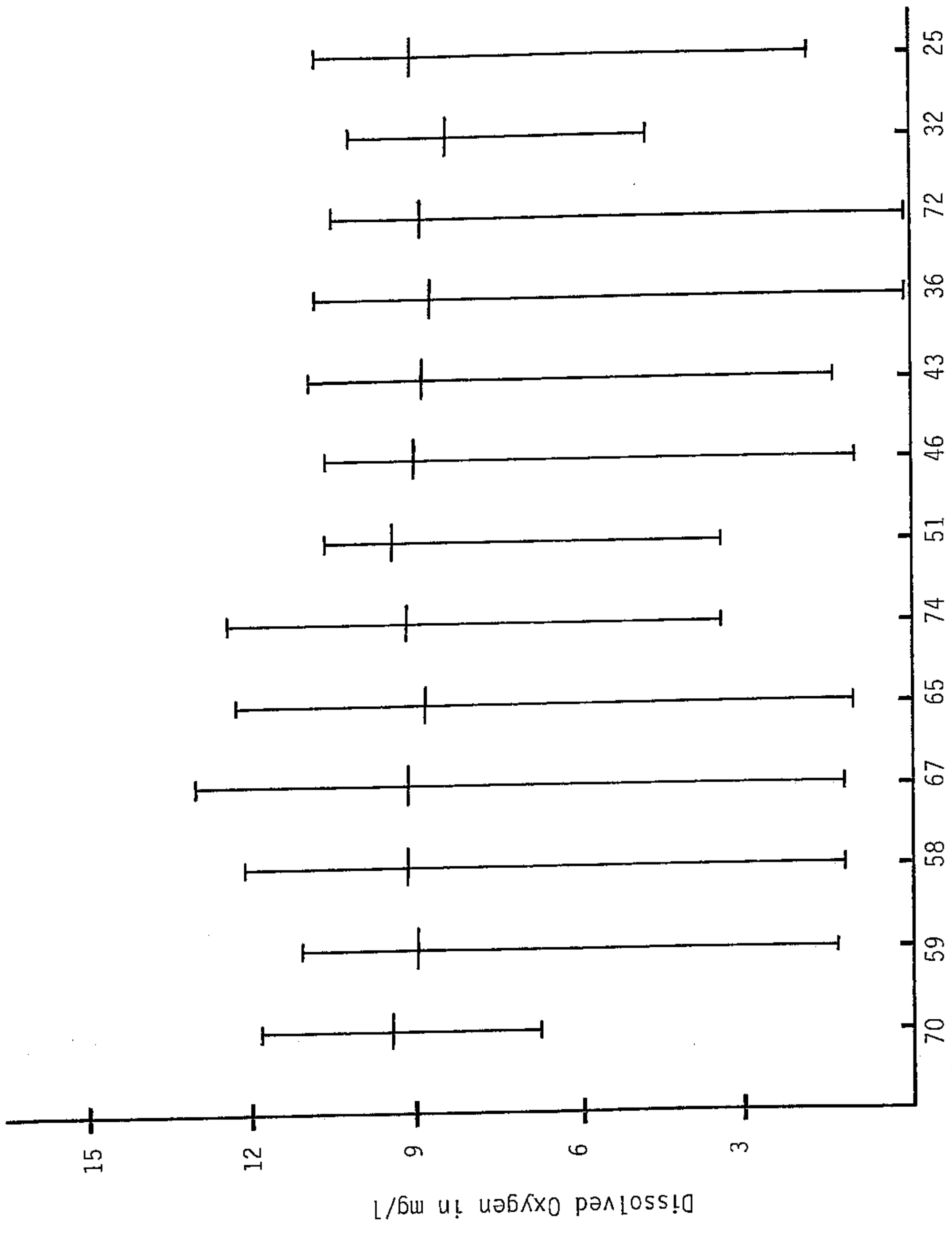
FIGURE C-2.
1973 South Nearshore - Dissolved Oxygen



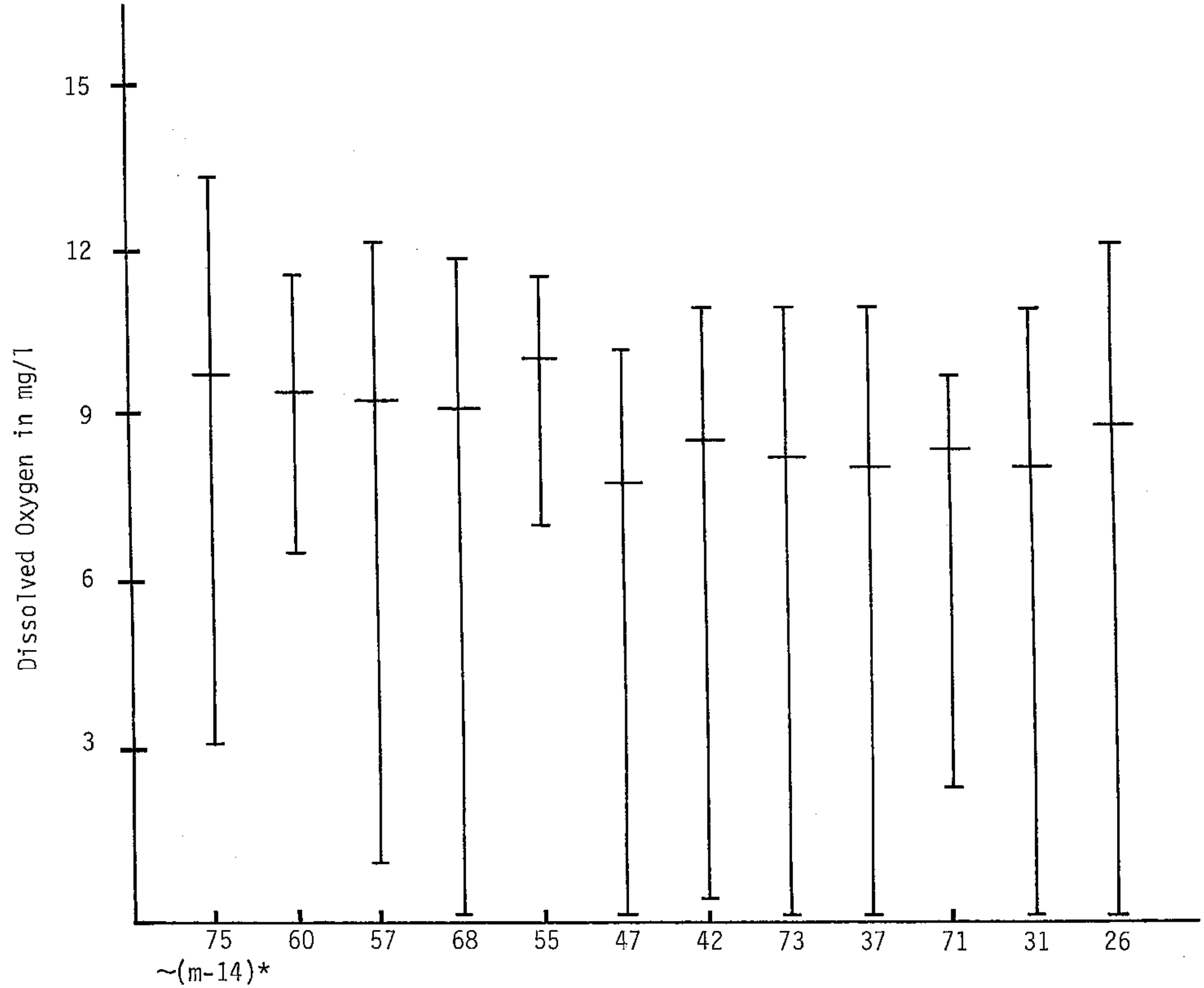
* Master Plan Station Numbers

FIGURE C-3.
1973 South Offshore - Dissolved Oxygen



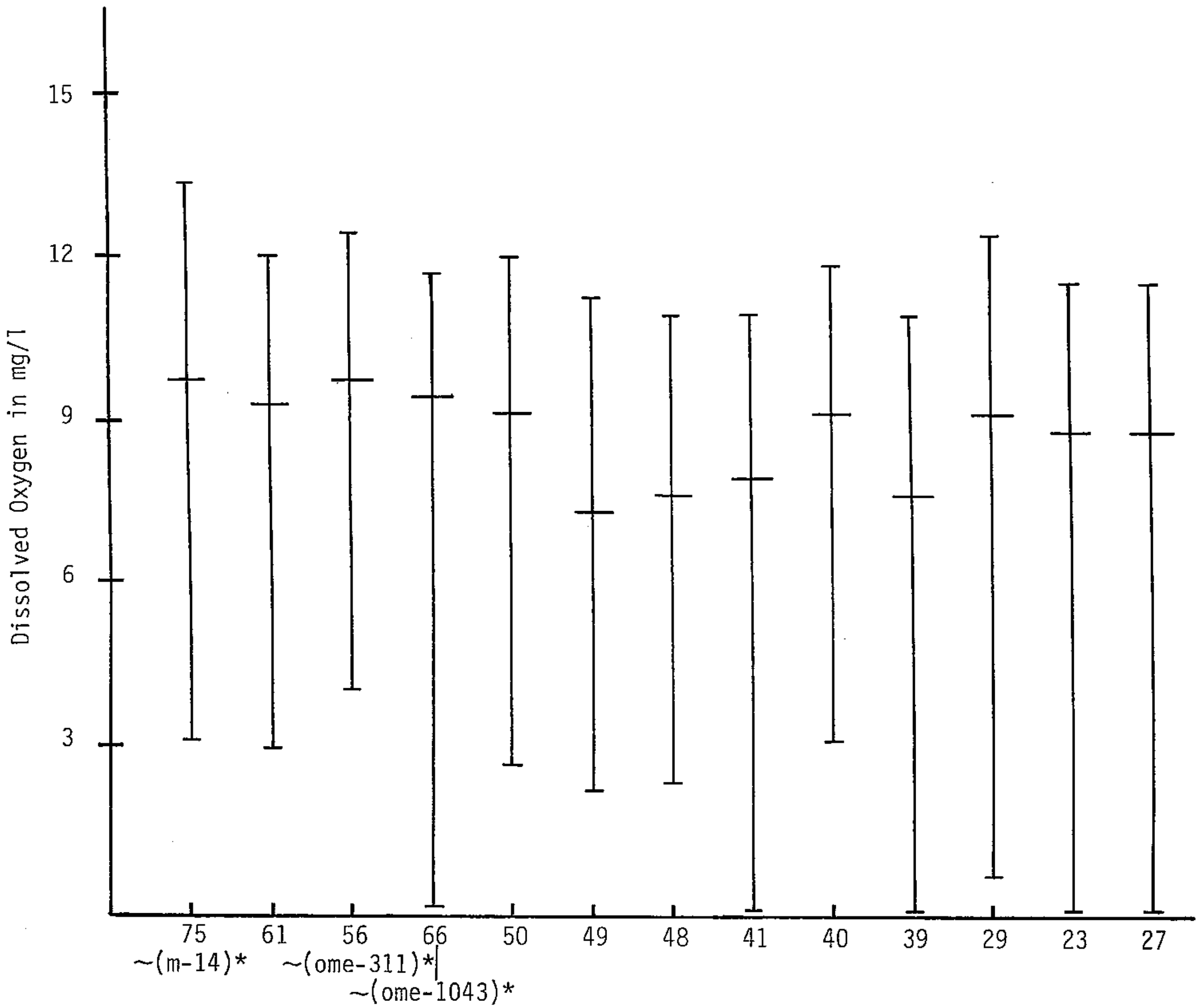
* Master Plan Station Numbers

FIGURE C-4.
1973 North Offshore - Dissolved Oxygen



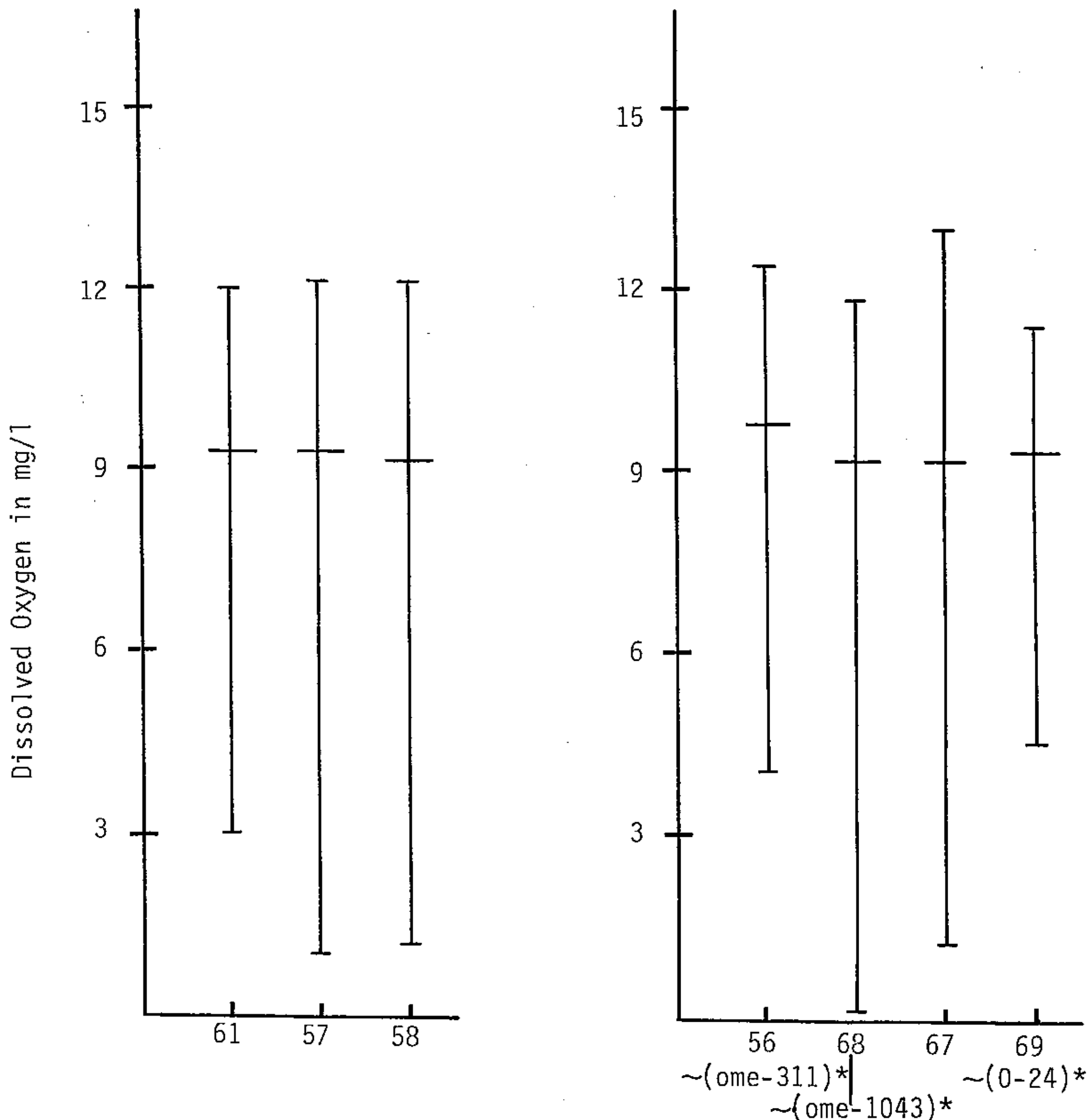
* Master Plan Station Numbers

FIGURE C-5.
1973 North Nearshore - Dissolved Oxygen



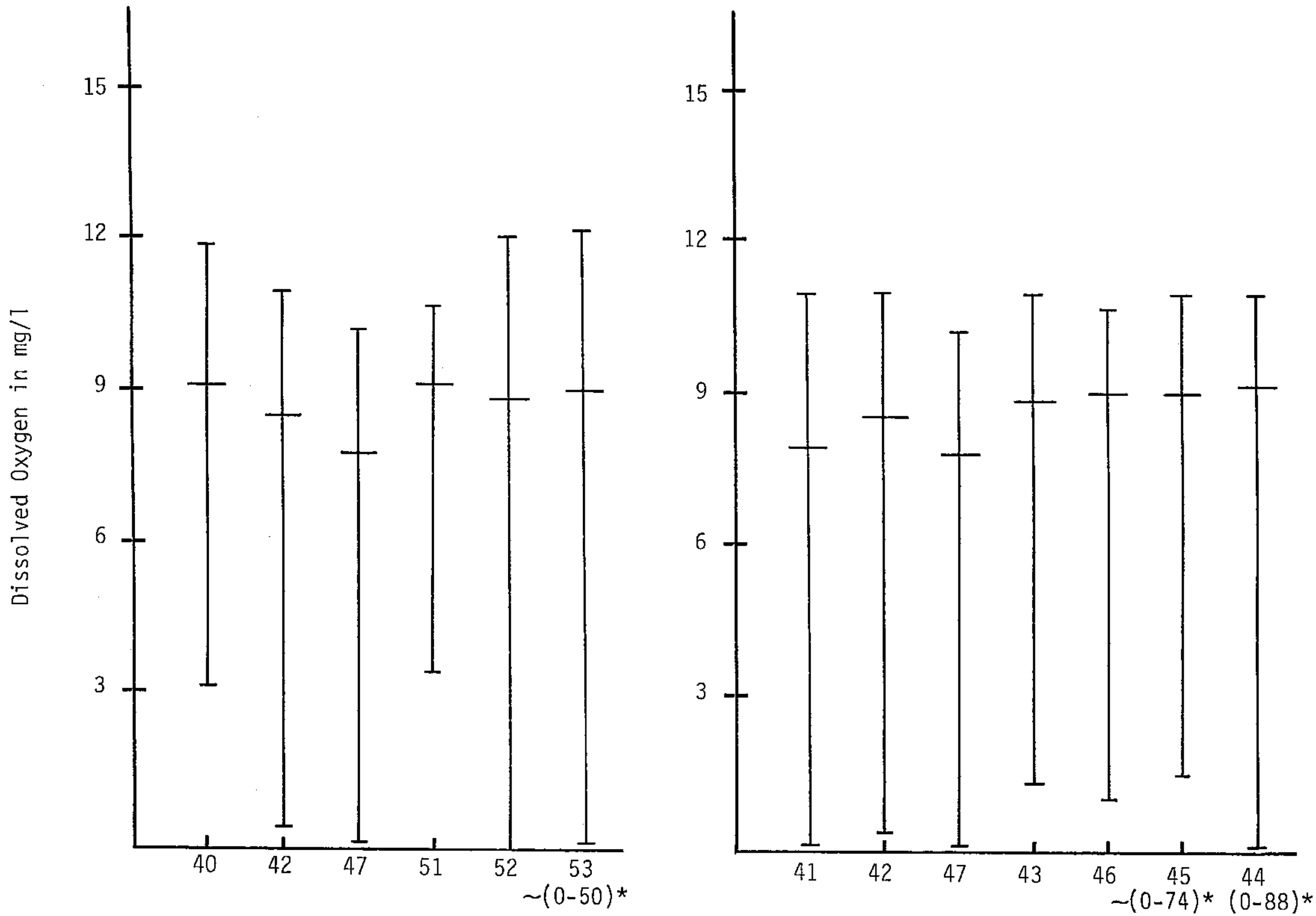
* Master Plan Station Numbers

FIGURE C-6.
1973 West Basin Transects - Dissolved Oxygen



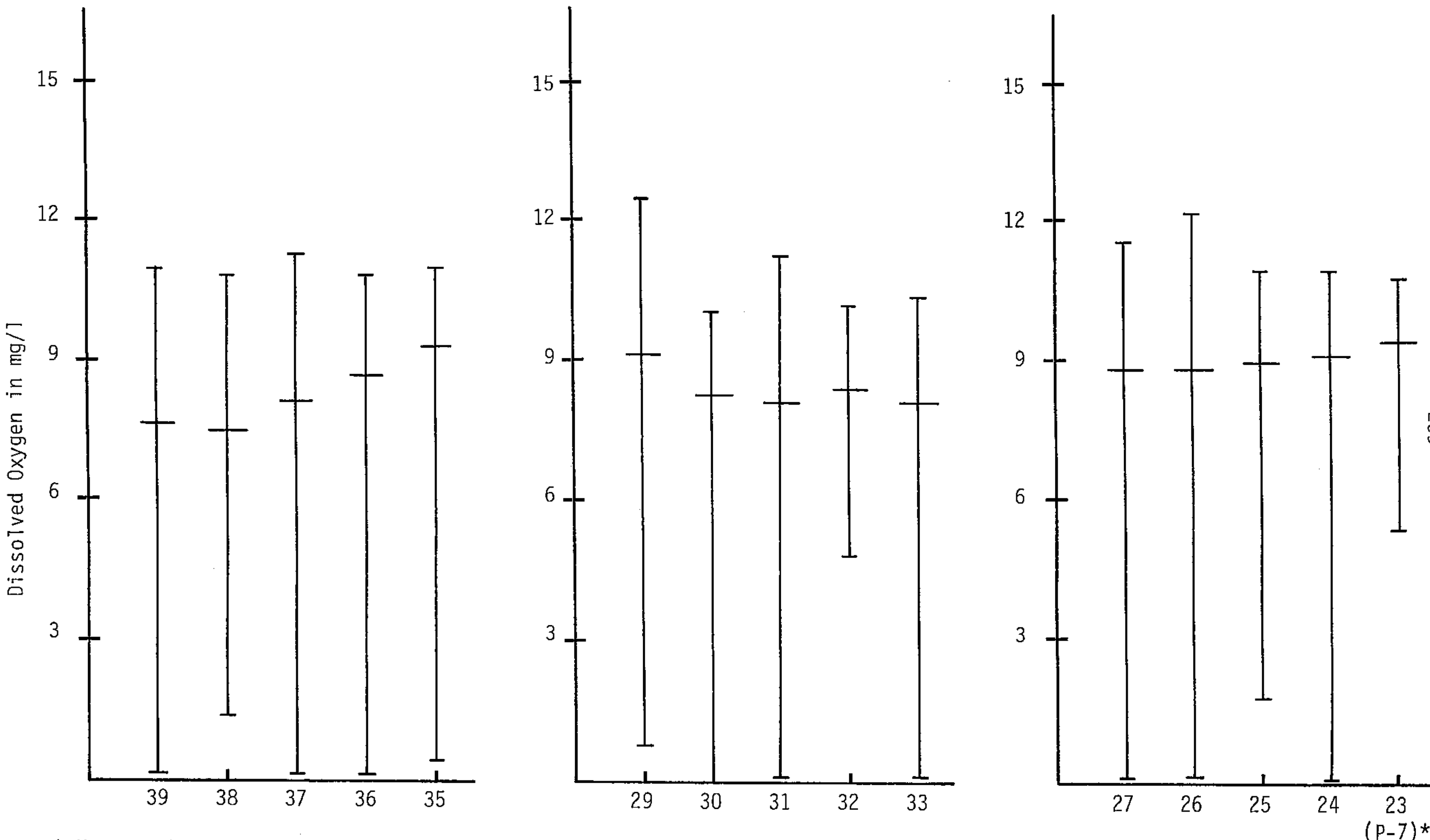
* Master Plan Station Numbers

FIGURE C-7.
1973 West Central Basin - Dissolved Oxygen



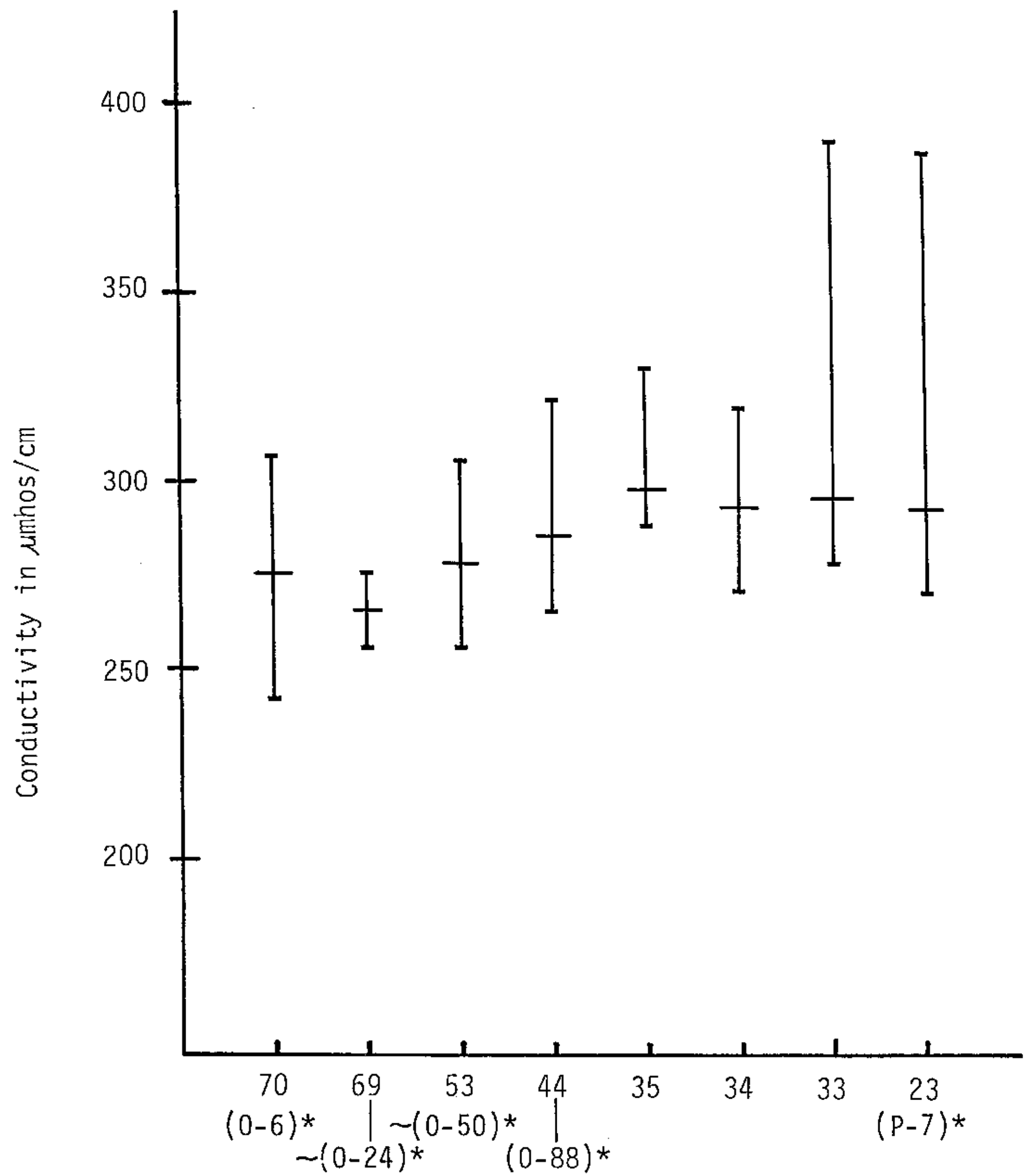
* Master Plan Station Numbers

FIGURE C-8.
1973 East Central Basin Transects - Dissolved Oxygen



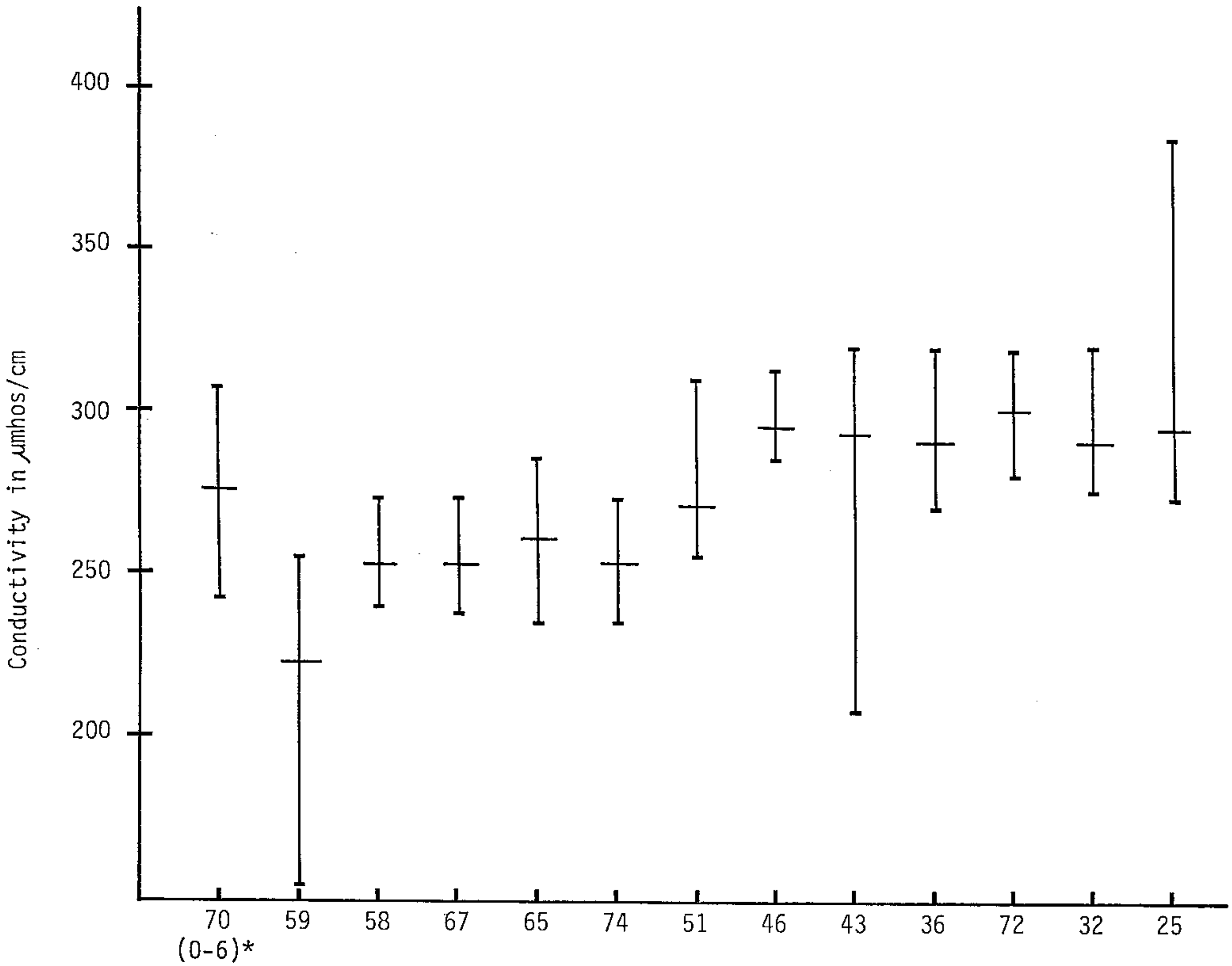
* Master Plan Station Numbers

FIGURE C-9.
1973 South Nearshore - Conductivity



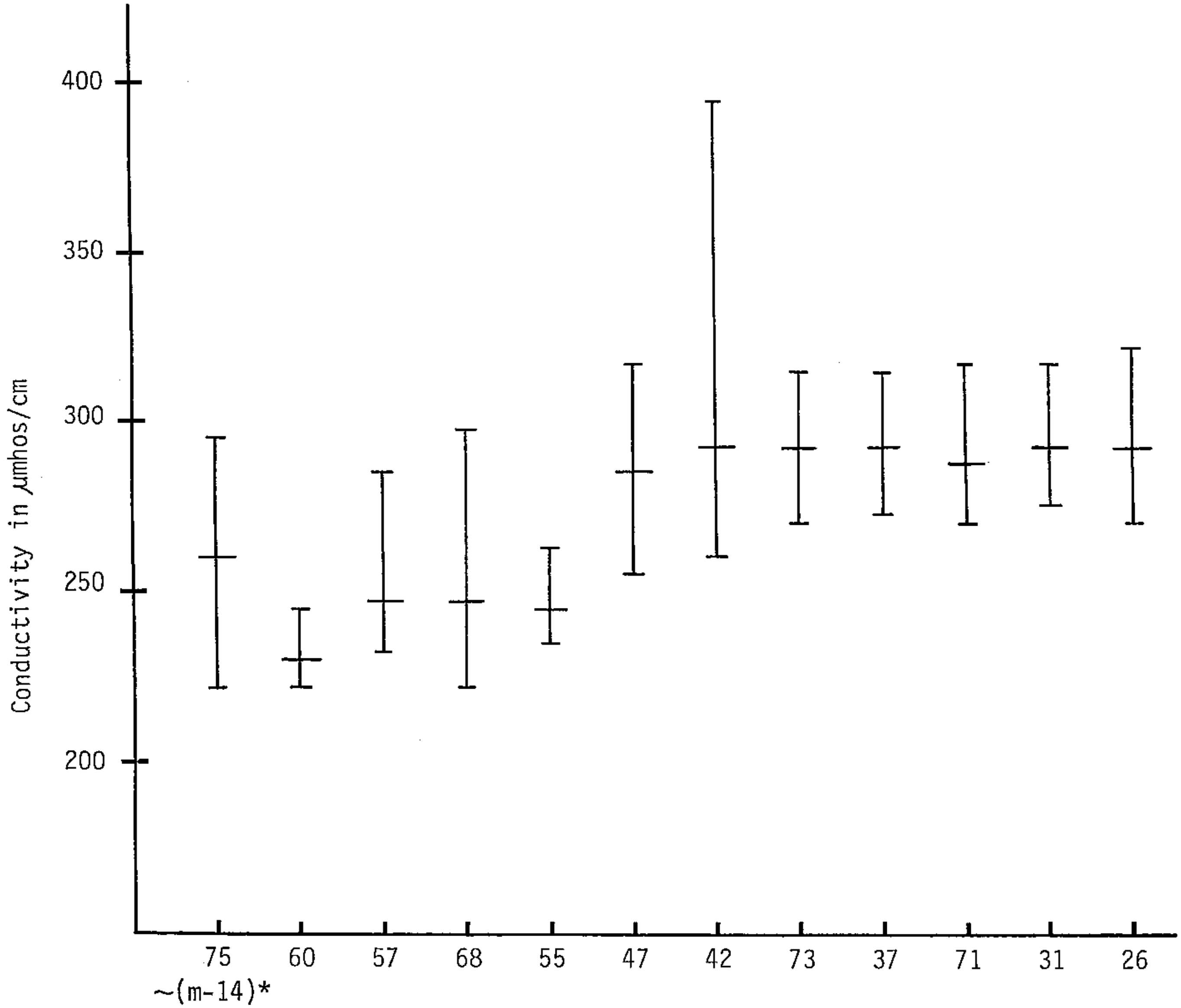
* Master Plan Station Numbers

FIGURE C-10·
1973 South Offshore - Conductivity



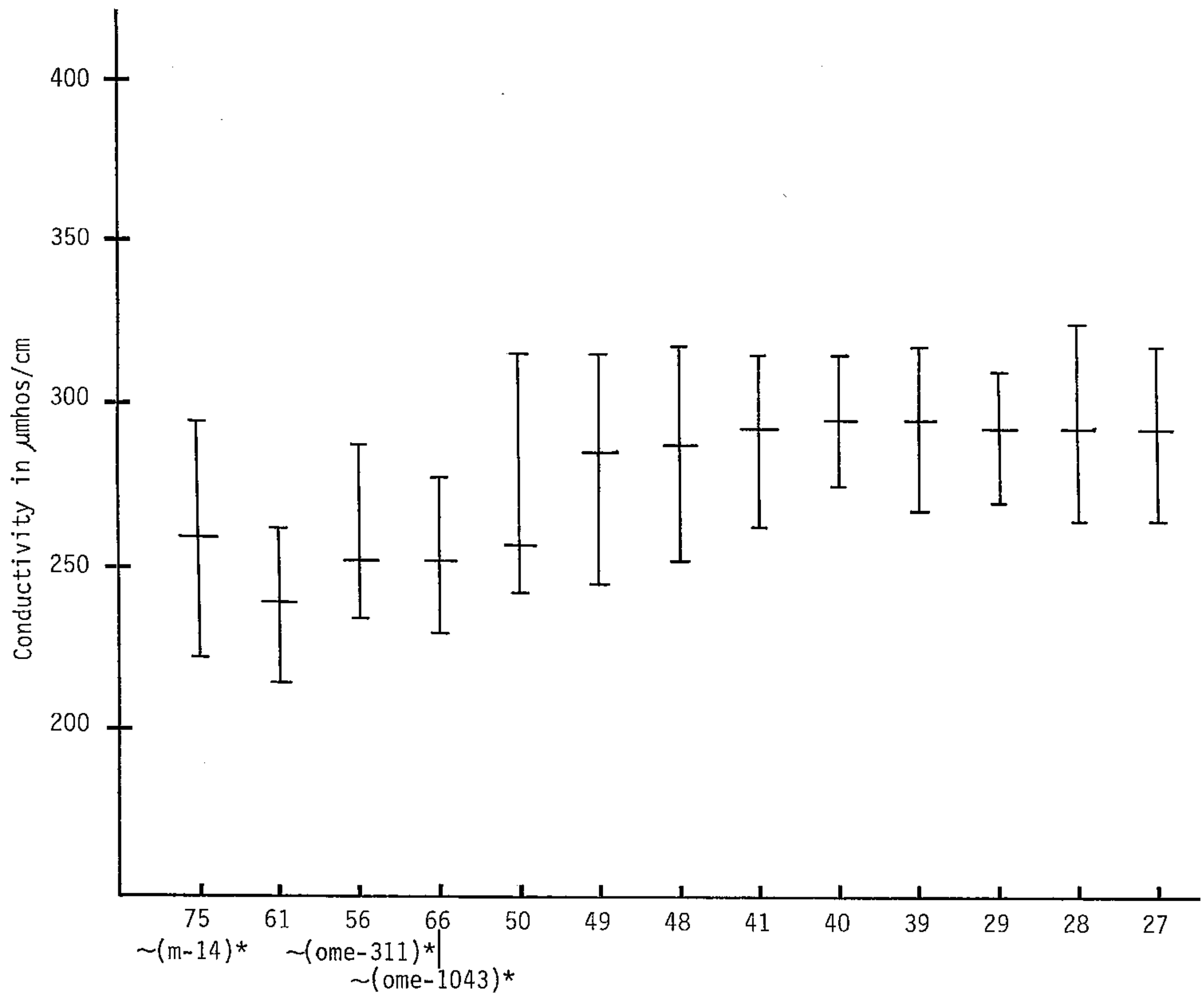
* Master Plan Station Numbers

FIGURE C-11.
1973 North Offshore - Conductivity



* Master Plan Station Numbers

FIGURE C-12.
1973 North Nearshore - Conductivity



* Master Plan Station Numbers

FIGURE C-13.
1973 West Basin Transects - Conductivity

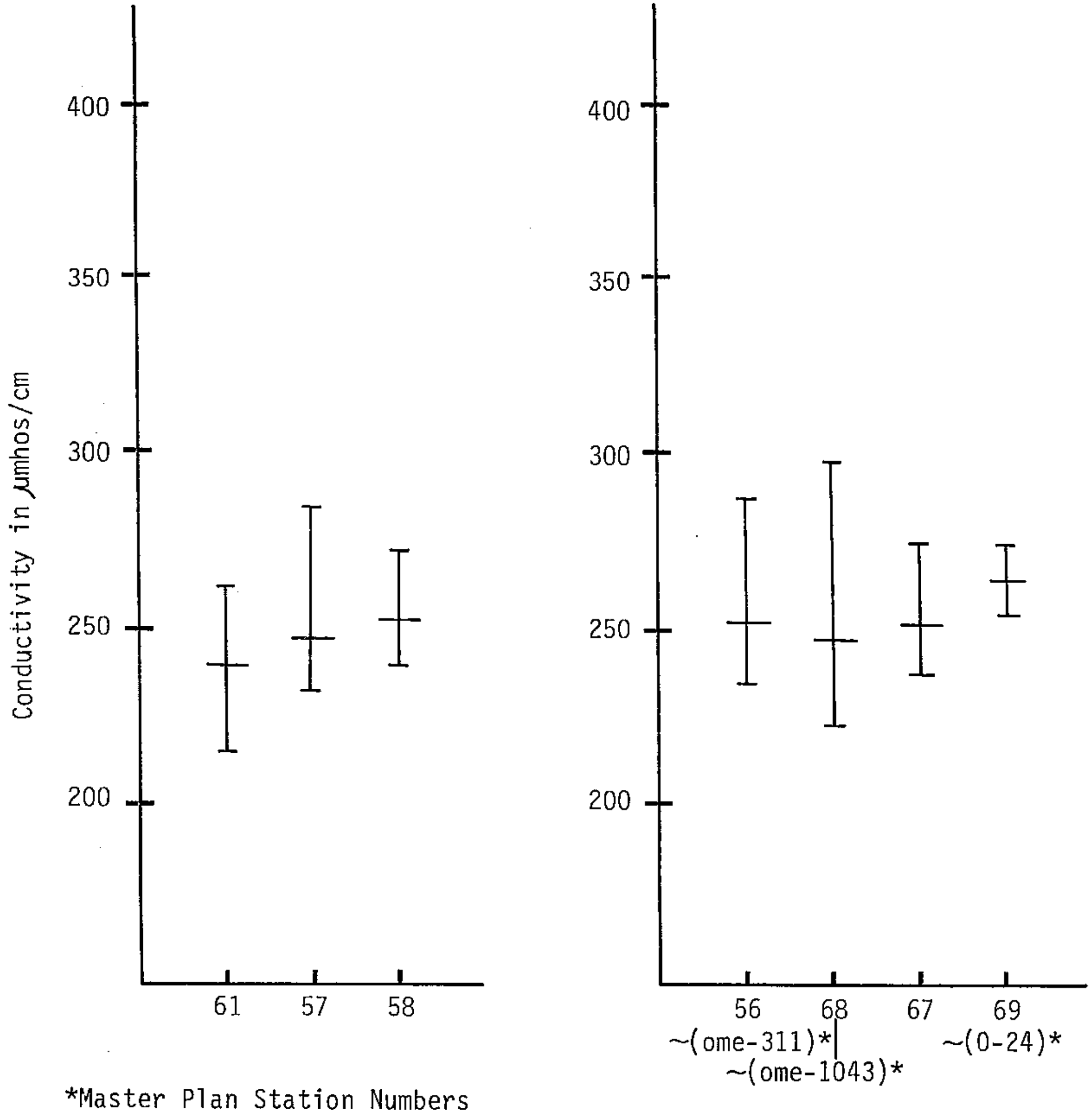
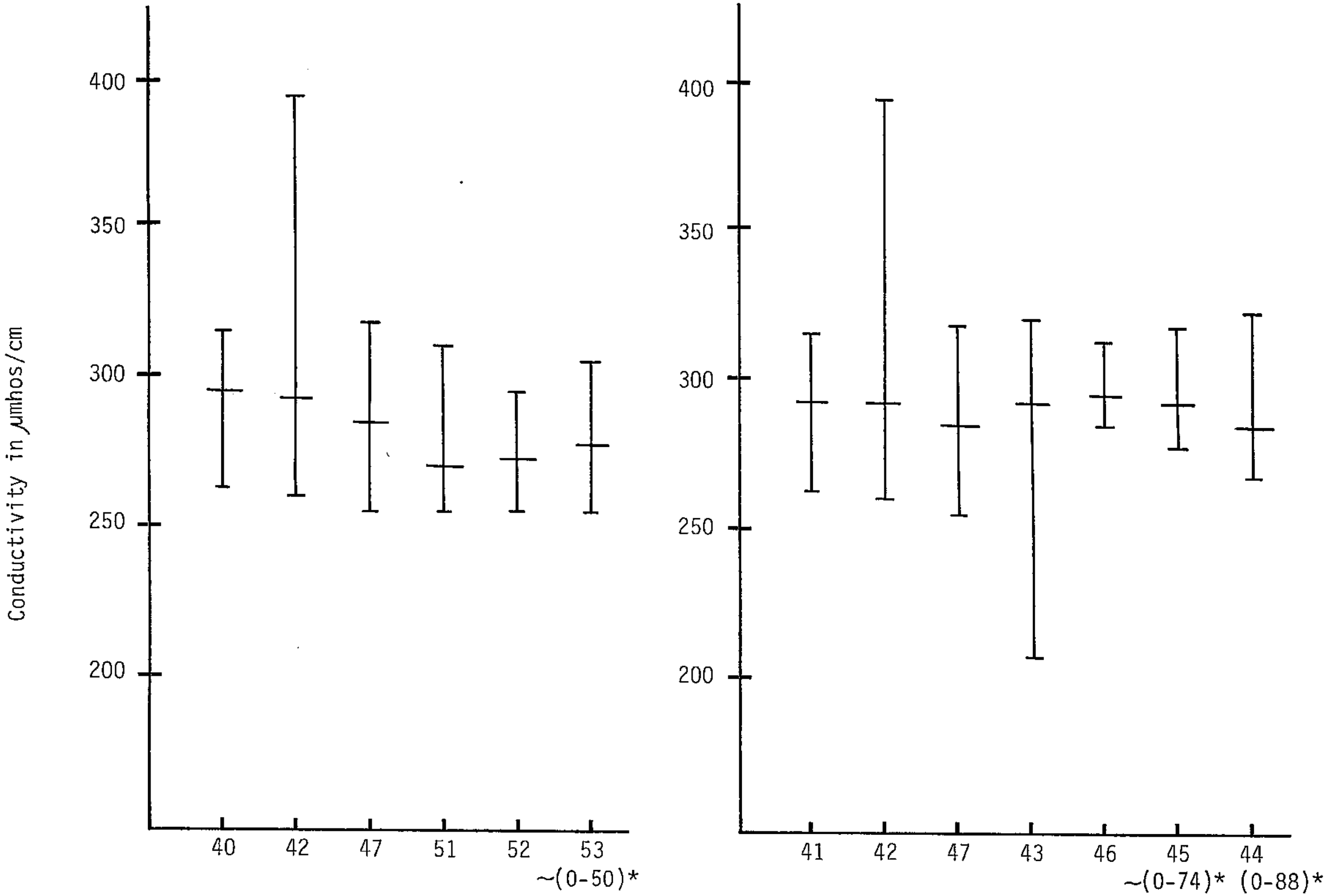
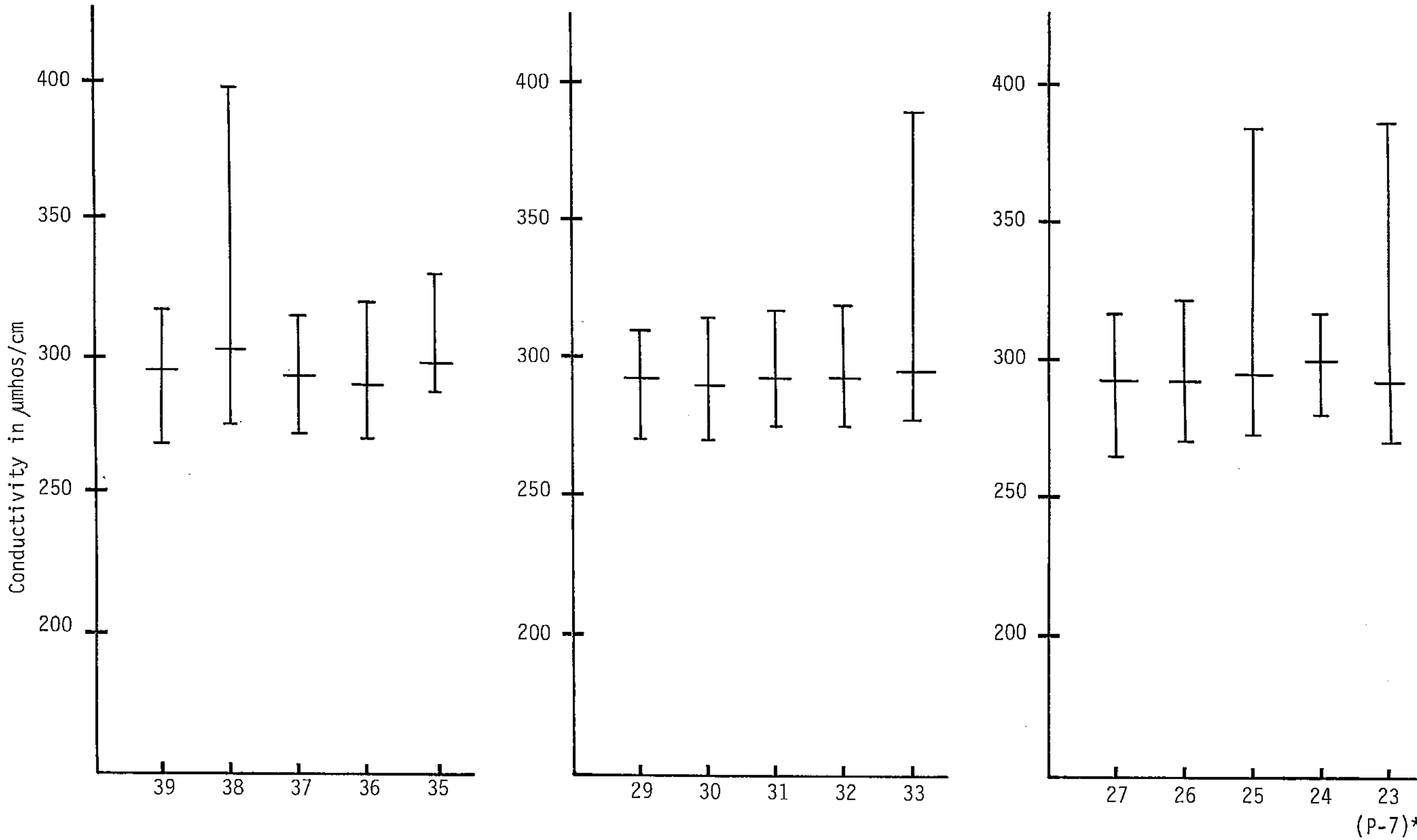


FIGURE C-14.
1973 West Central Basin - Conductivity



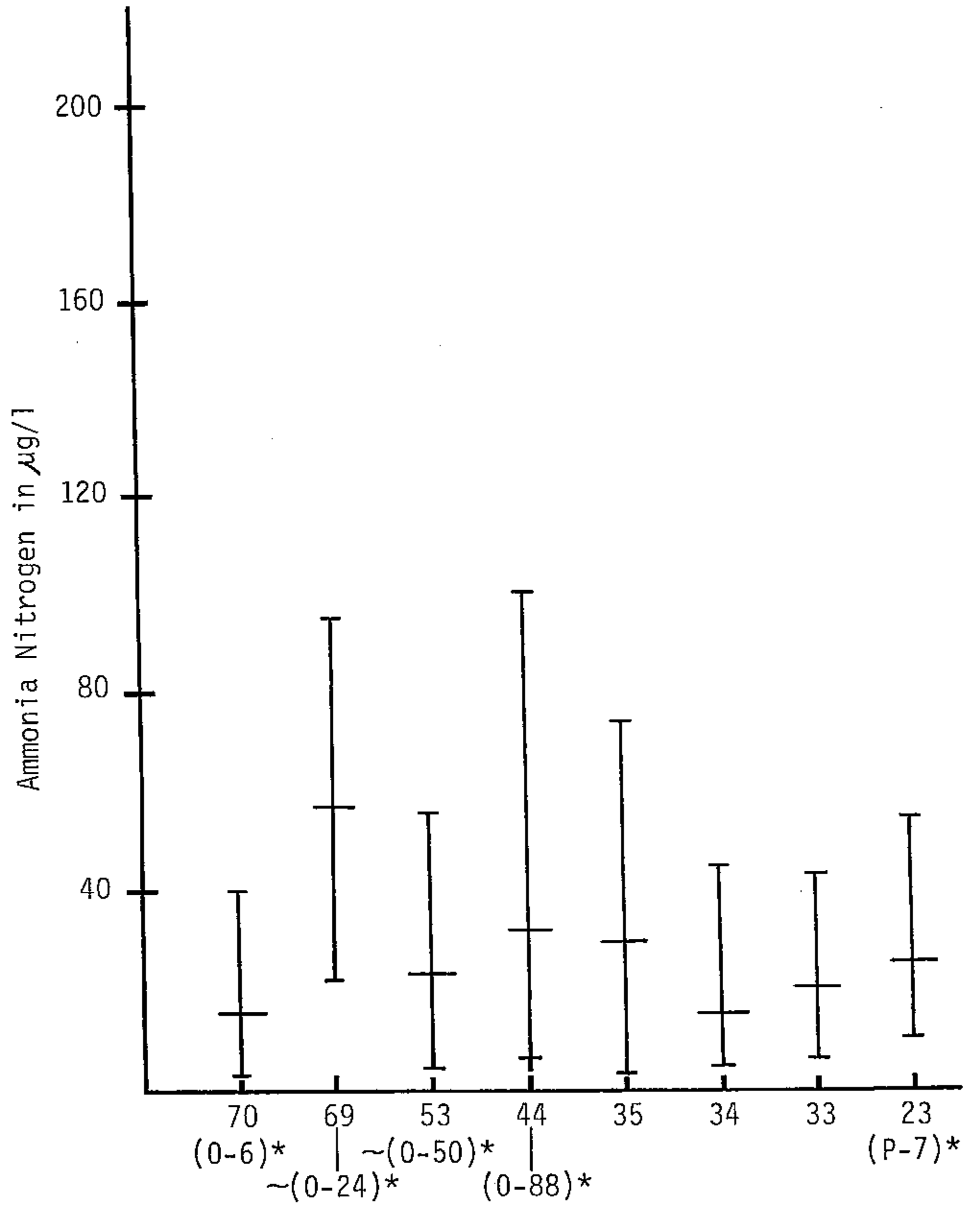
* Master Plan Station Numbers

FIGURE C-15.
1973 East Central Basin Transects - Conductivity



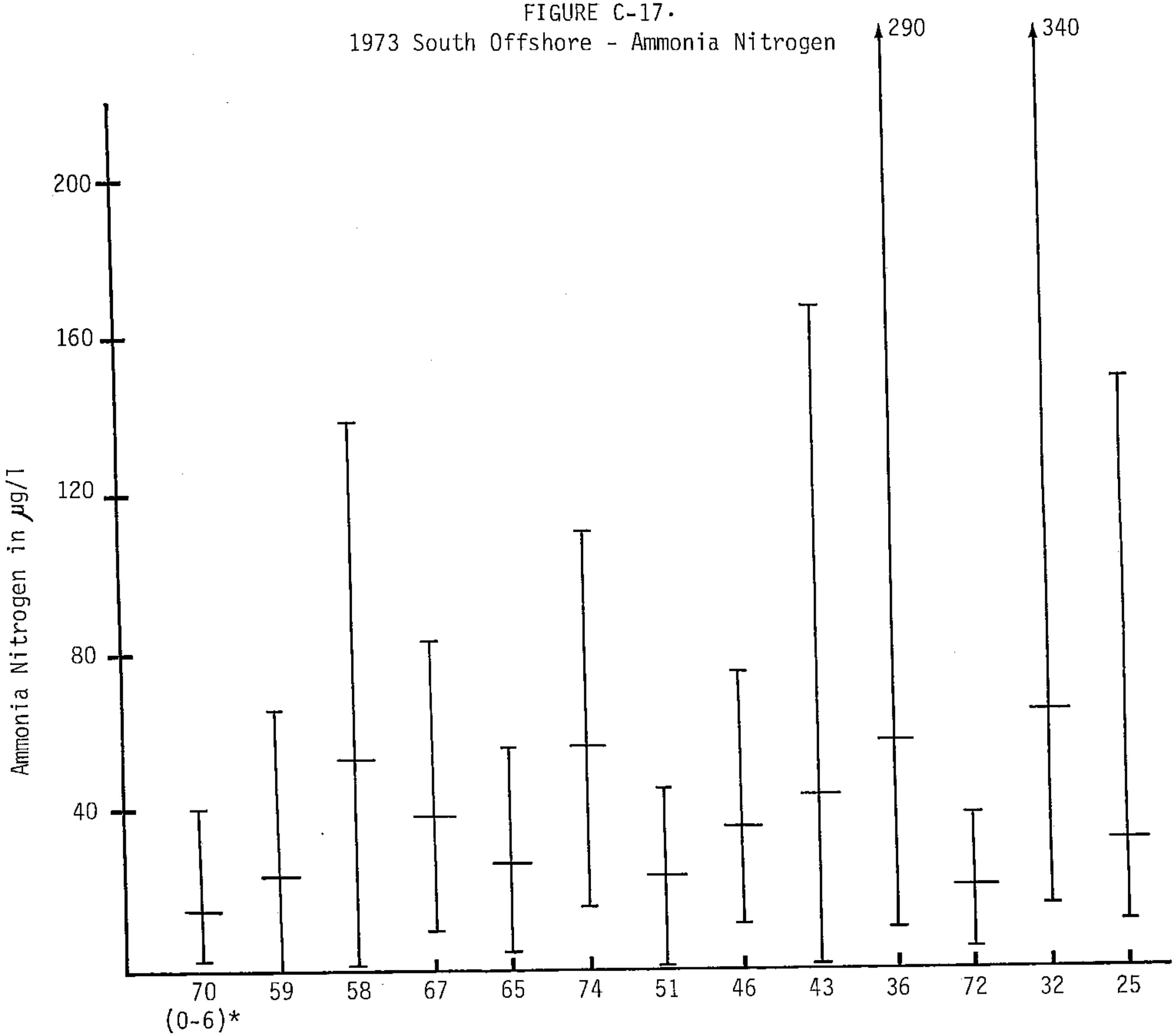
* Master Plan Station Numbers

FIGURE C-16.
1973 South Nearshore - Ammonia Nitrogen



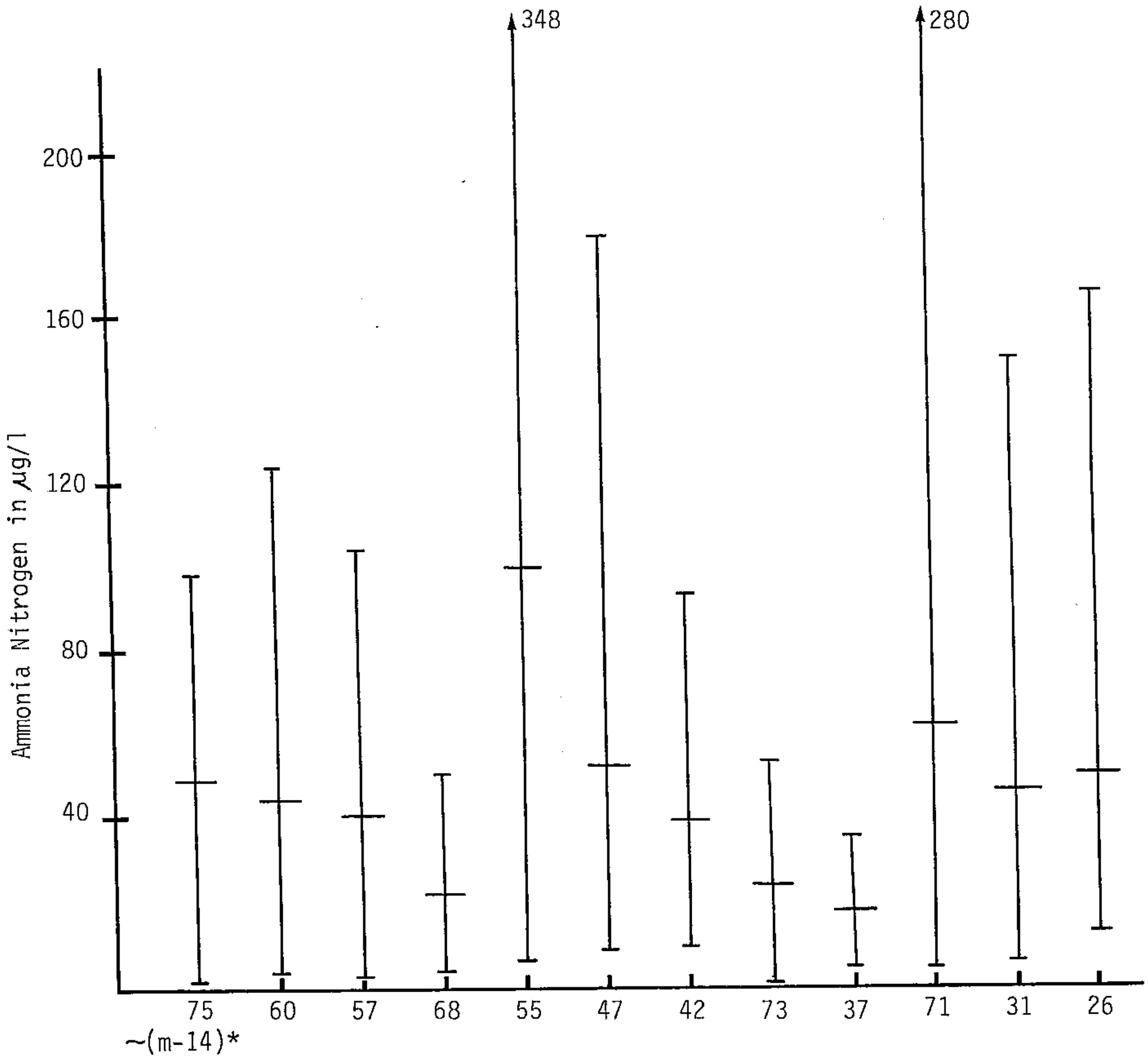
* Master Plan Station Numbers

FIGURE C-17.
1973 South Offshore - Ammonia Nitrogen



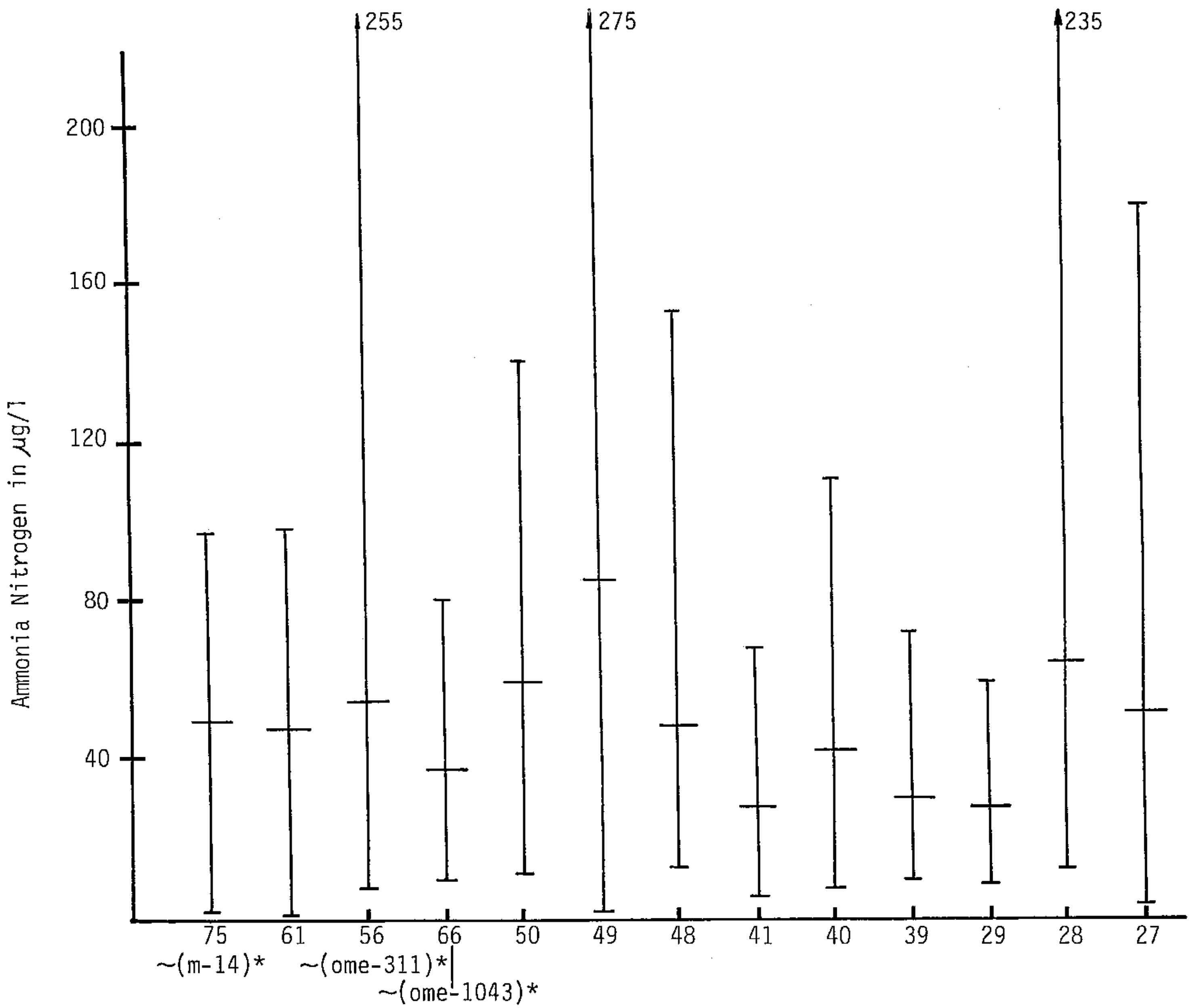
* Master Plan Station Numbers

FIGURE C-18.
1973 North Offshore - Ammonia Nitrogen



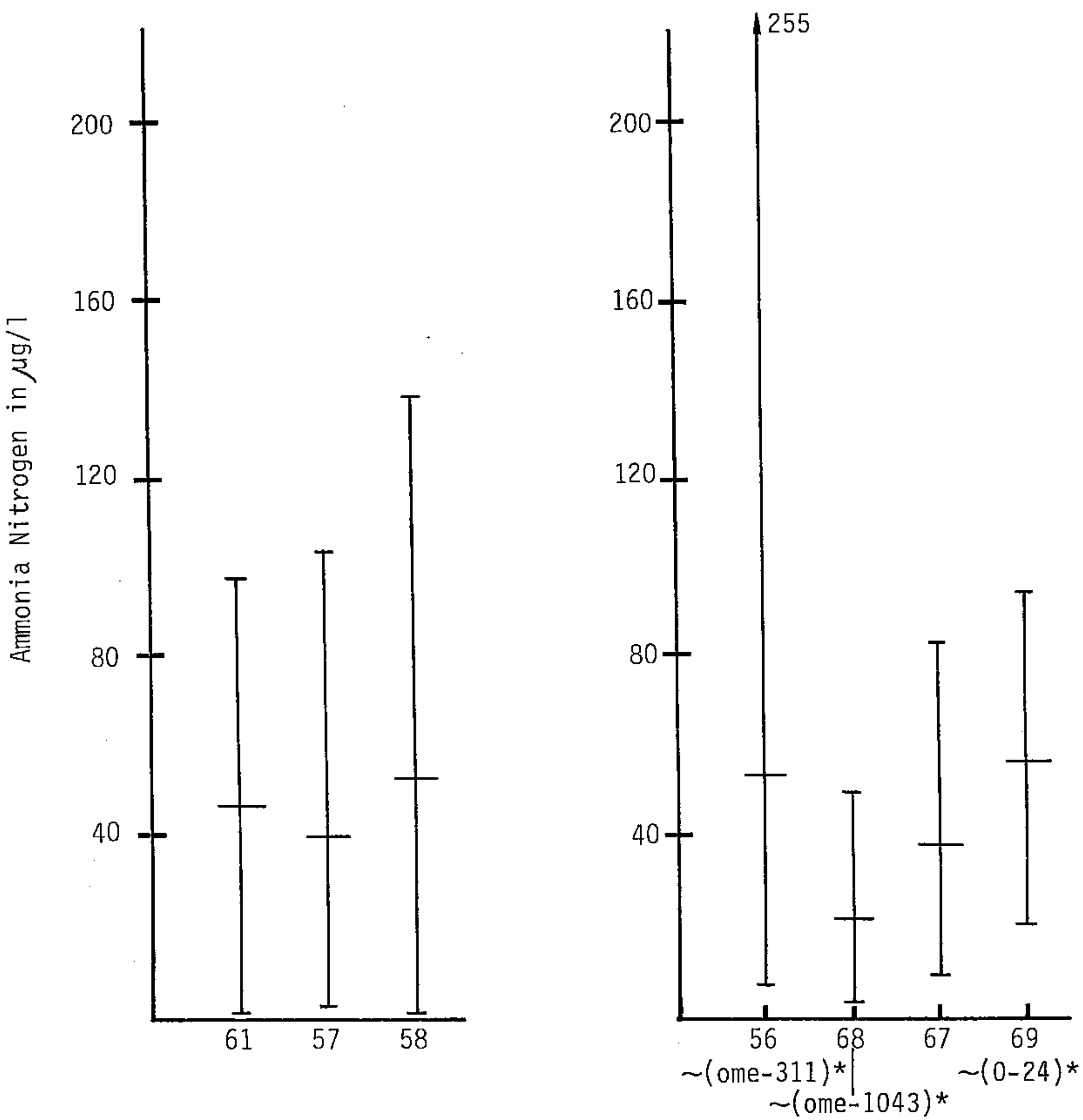
* Master Plan Station Numbers

FIGURE C-19.
1973 North Nearshore - Ammonia Nitrogen



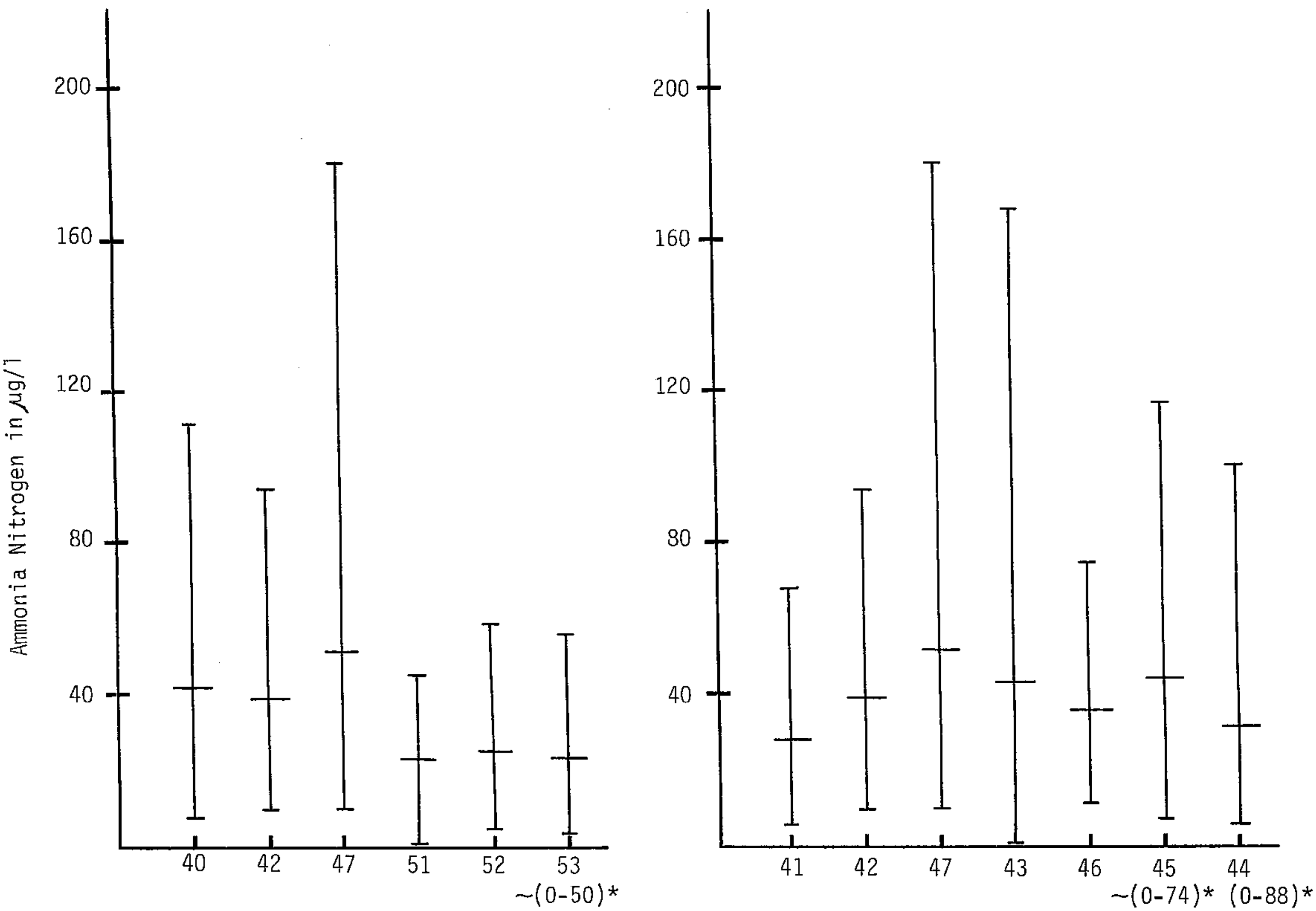
* Master Plan Station Numbers

FIGURE C-20.
1973 Western Basin Transects - Ammonia Nitrogen



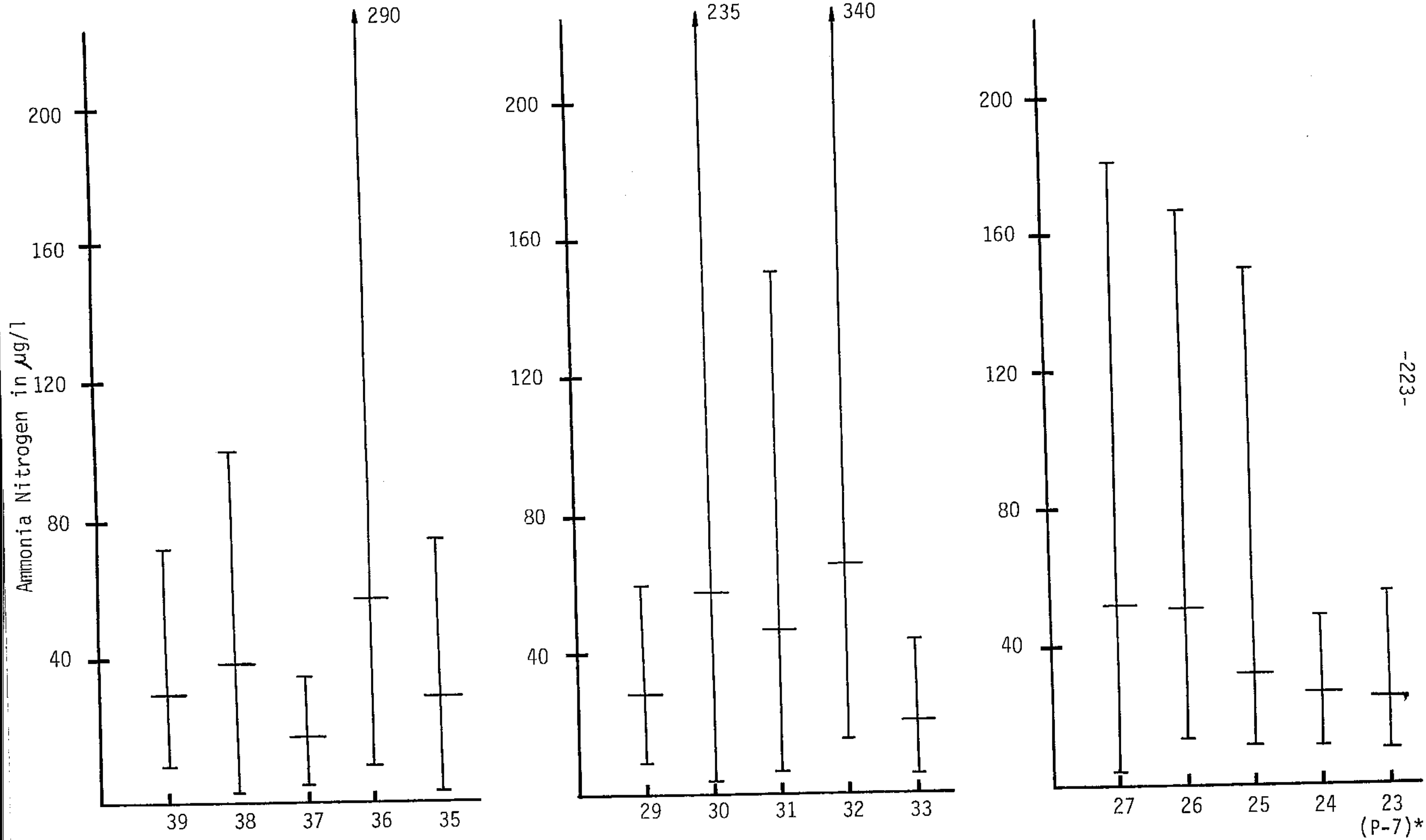
* Master Plan Station Numbers

FIGURE C-21.
1973 West Central Basin Transects - Ammonia Nitrogen



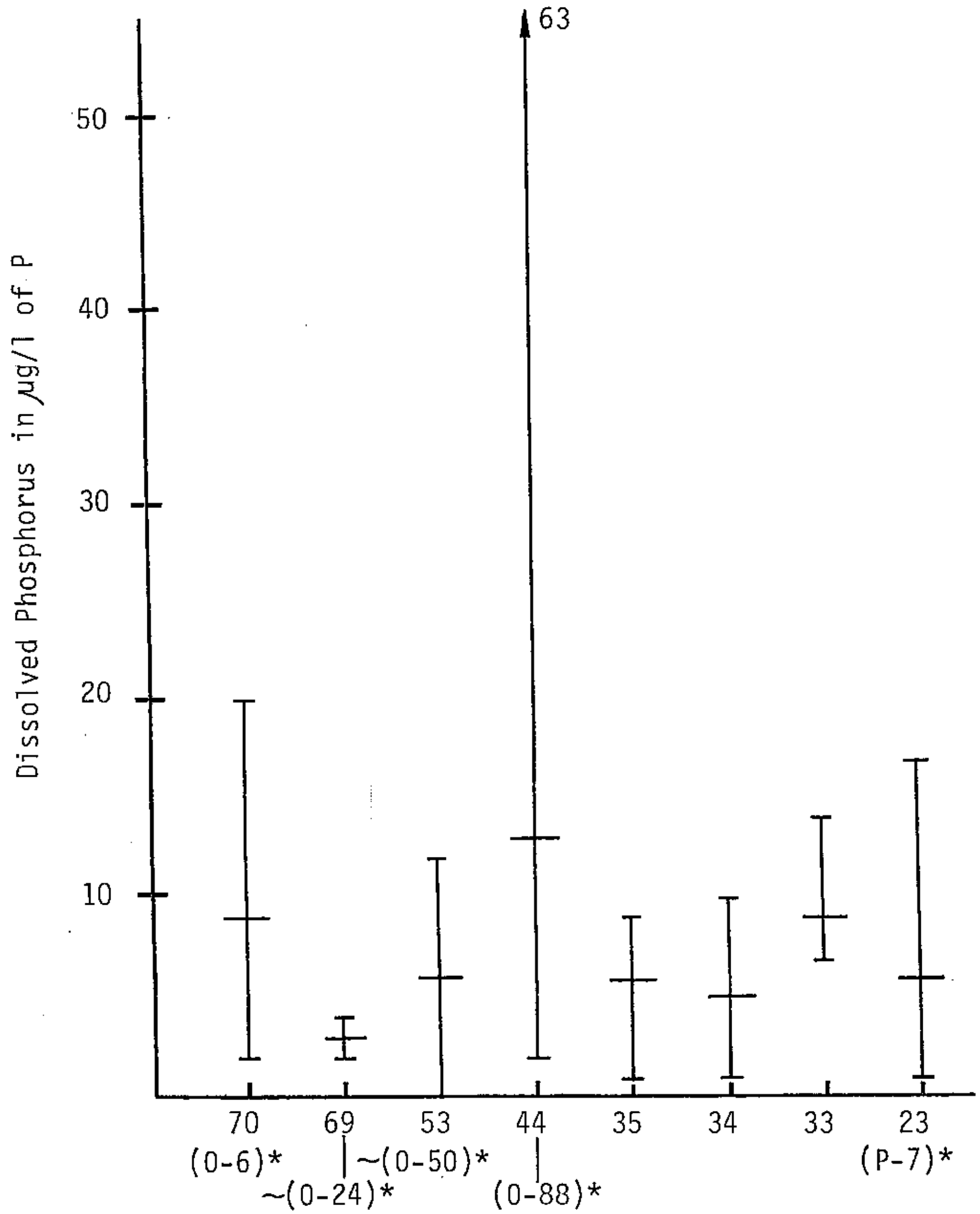
* Master Plan Station Numbers

FIGURE C-22.
1973 East Central Basin Transects - Ammonia Nitrogen



* Master Plan Station Numbers

FIGURE C-23.
1973 South Nearshore - Dissolved Phosphorus



* Master Plan Station Numbers

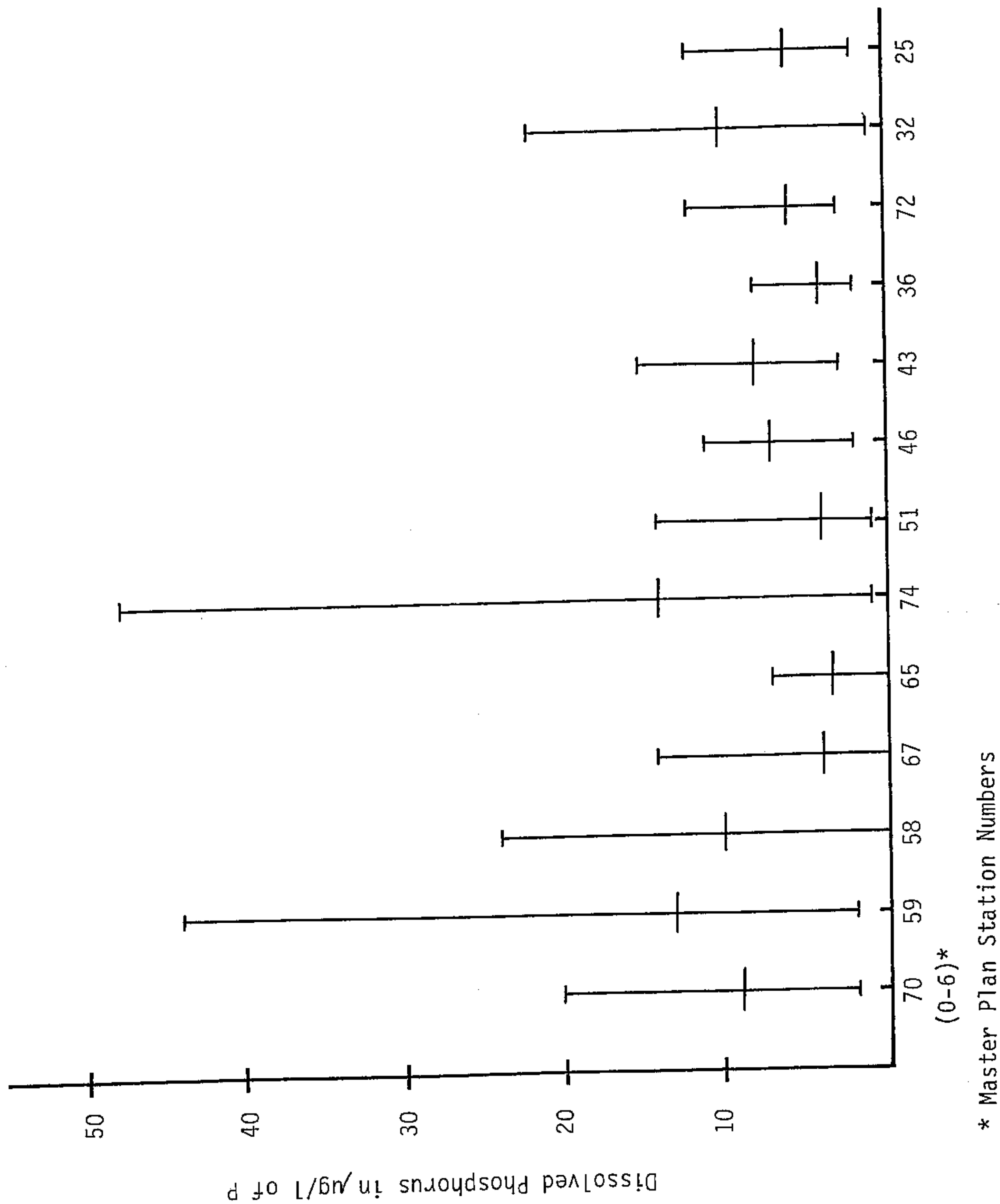
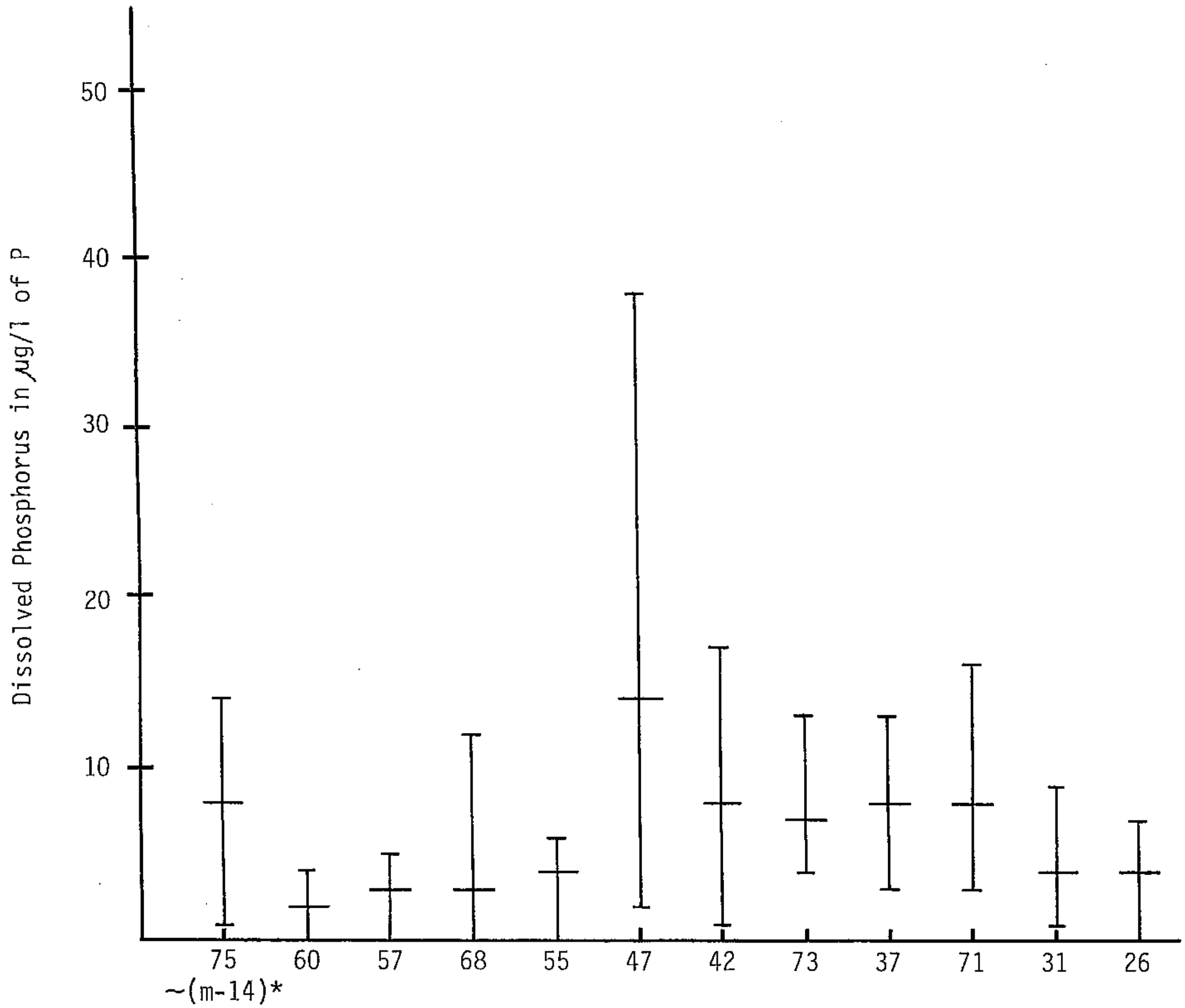


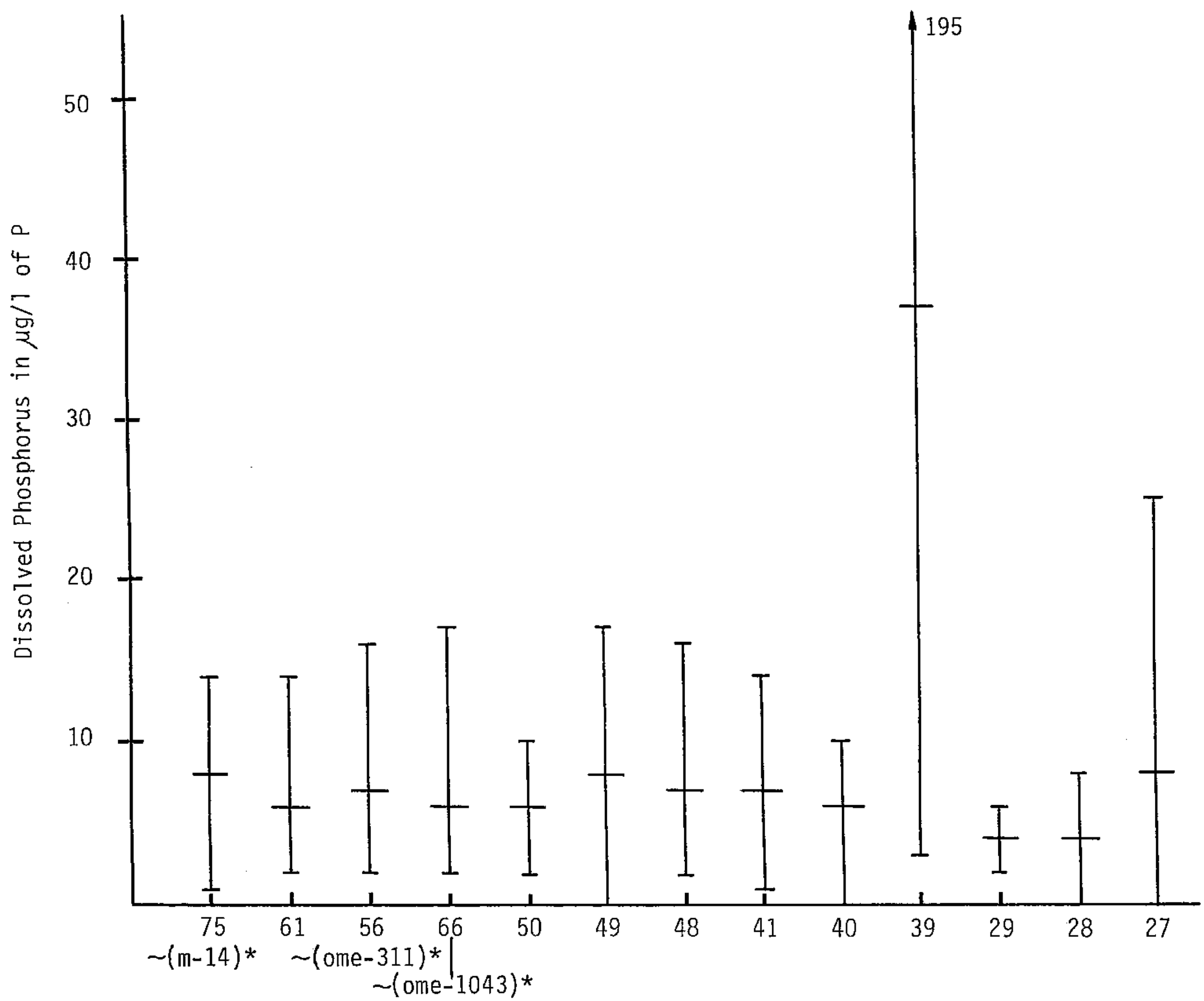
FIGURE C-24.
1973 South Offshore - Dissolved Phosphorus

FIGURE C-25.
1973 North Offshore - Dissolved Phosphorus



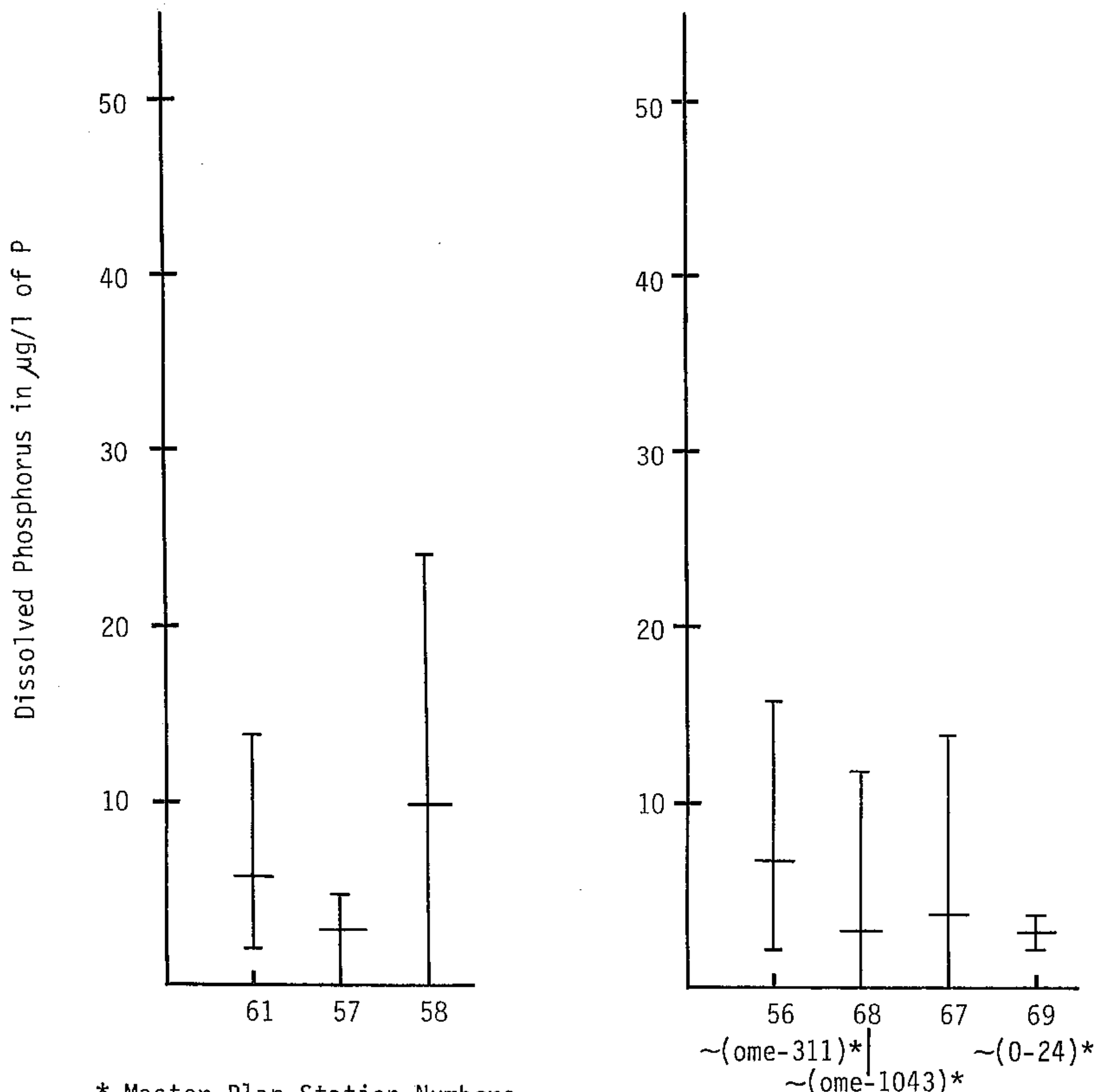
* Master Plan Station Numbers

FIGURE C-26.
1973 North Nearshore - Dissolved Phosphorus



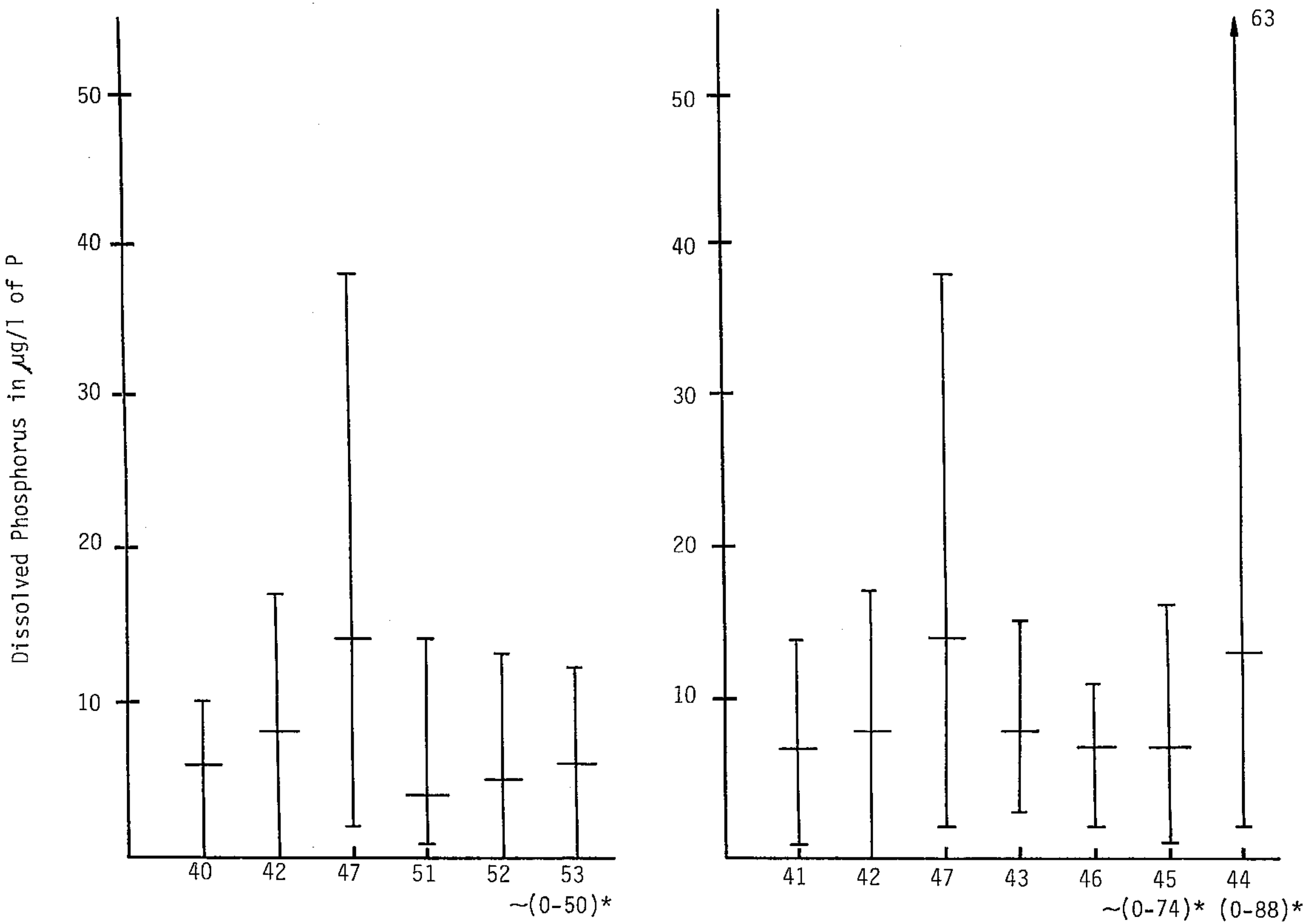
* Master Plan Station Numbers

FIGURE C-27.
1973 West Basin Transects - Dissolved Phosphorus



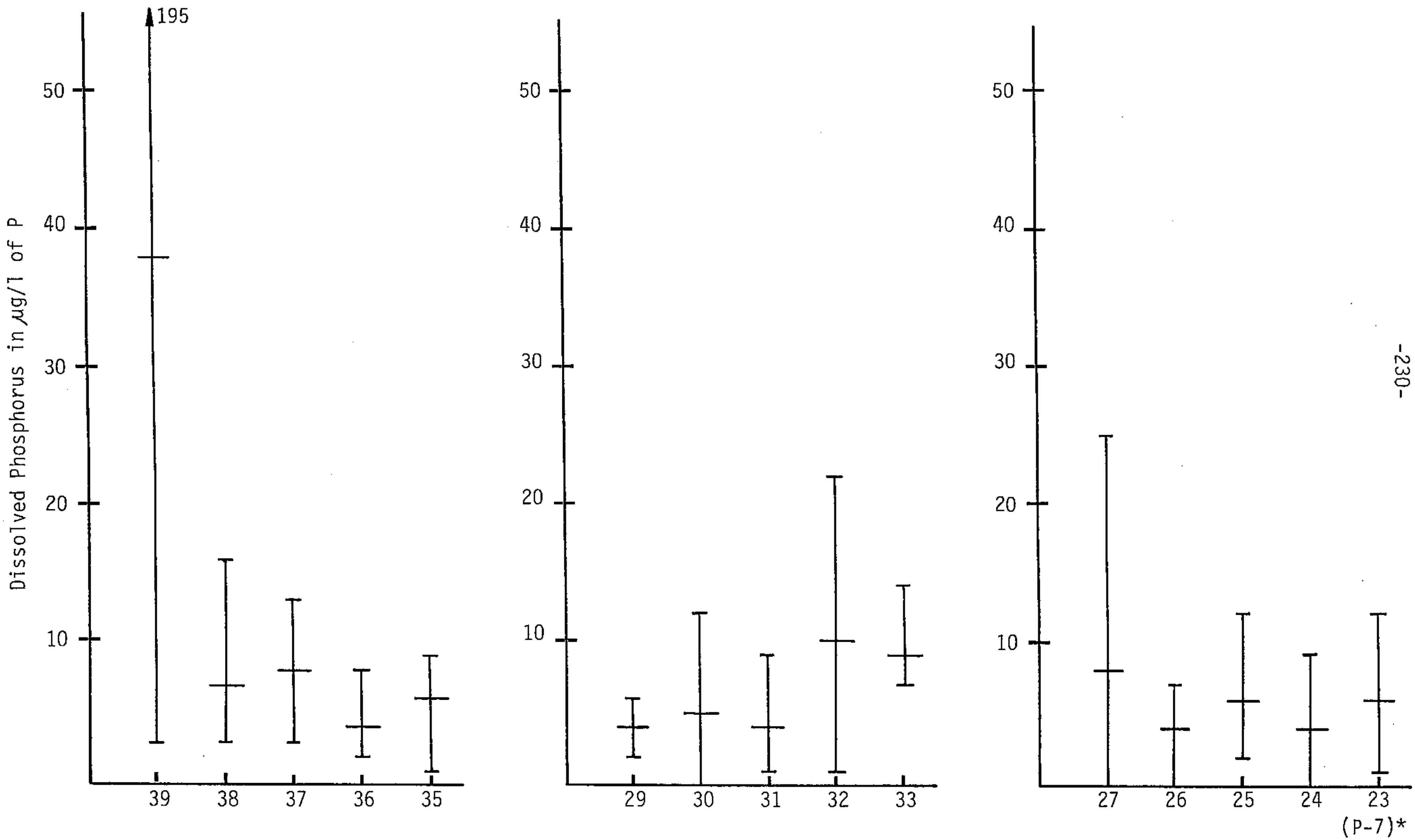
* Master Plan Station Numbers

FIGURE C-28.
1973 West Central Basin Transects - Dissolved Phosphorus



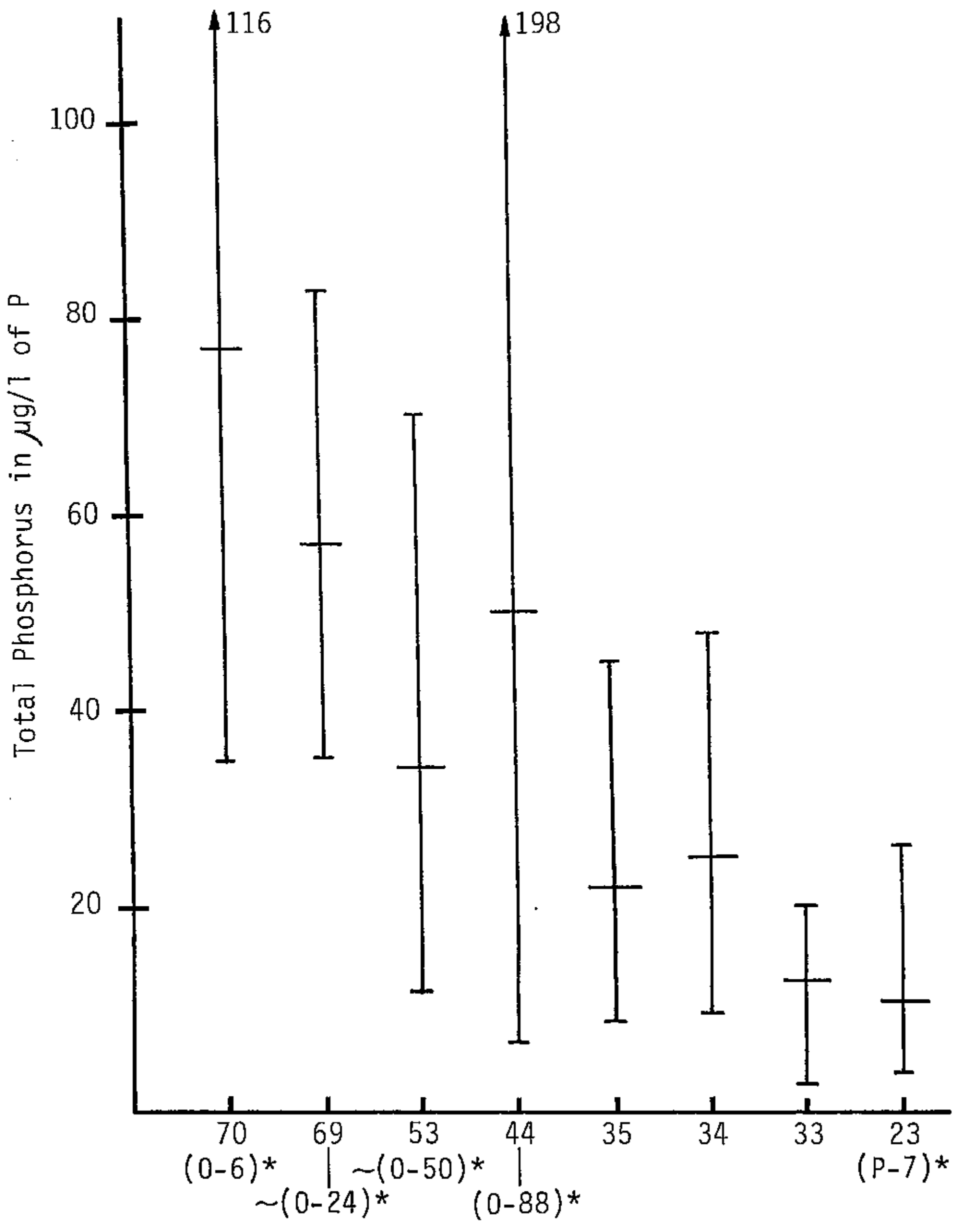
* Master Plan Station Numbers

FIGURE C-29.
1973 East Central Basin Transects - Dissolved Phosphorus



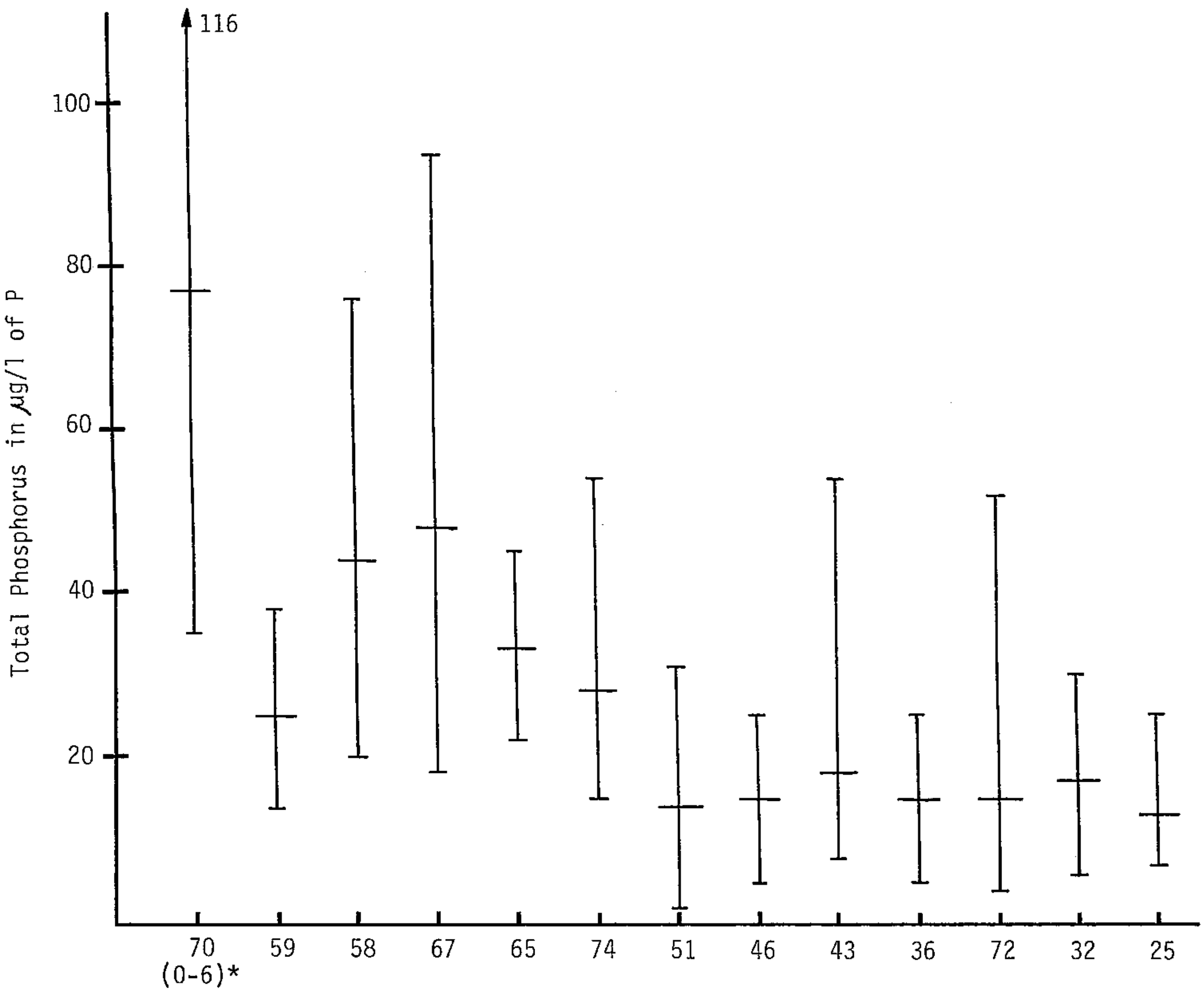
* Master Plan Station Numbers

FIGURE C-30.
1973 South Nearshore - Total Phosphorus



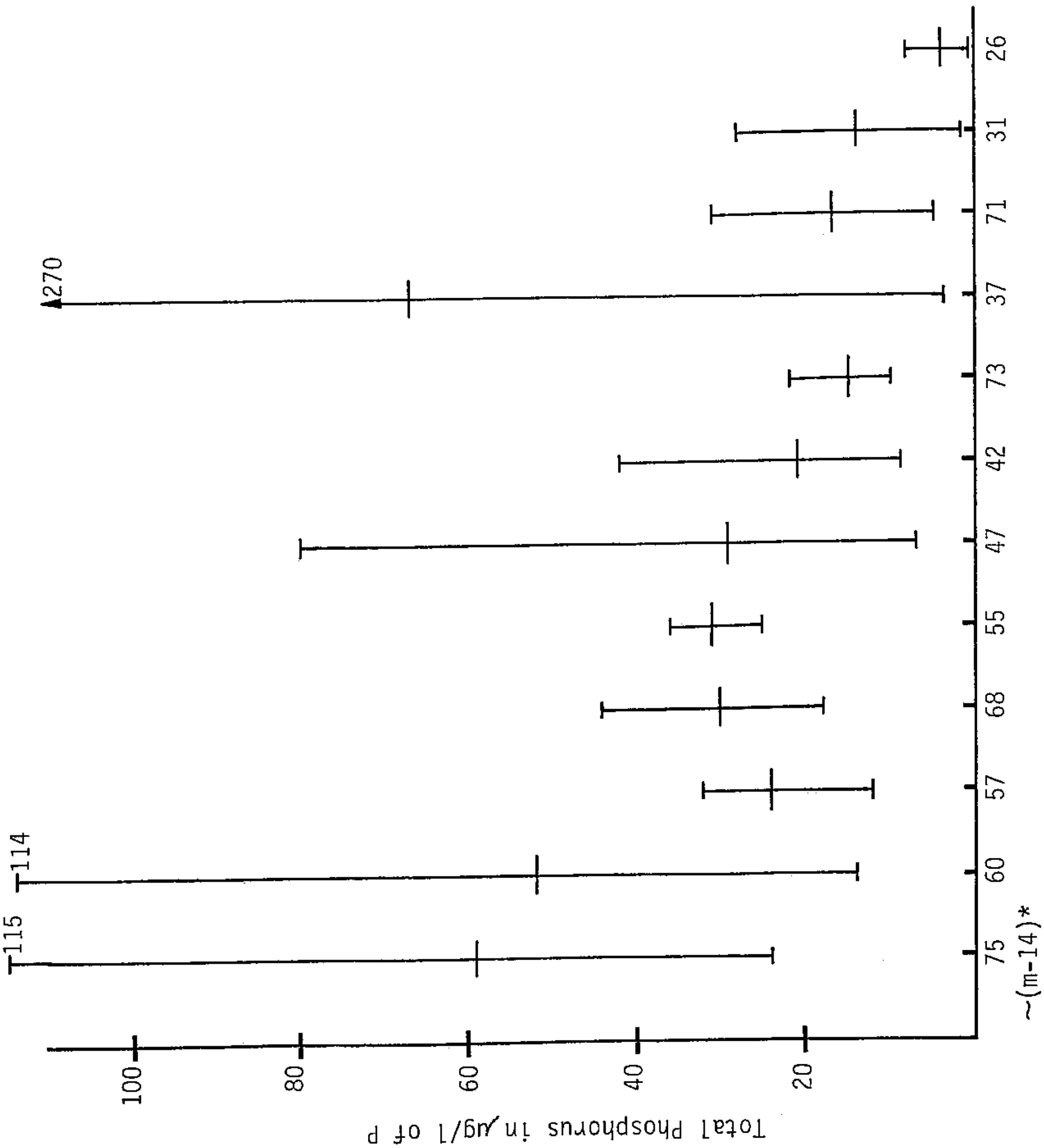
* Master Plan Station Numbers

FIGURE C-31.
1973 South Offshore - Total Phosphorus



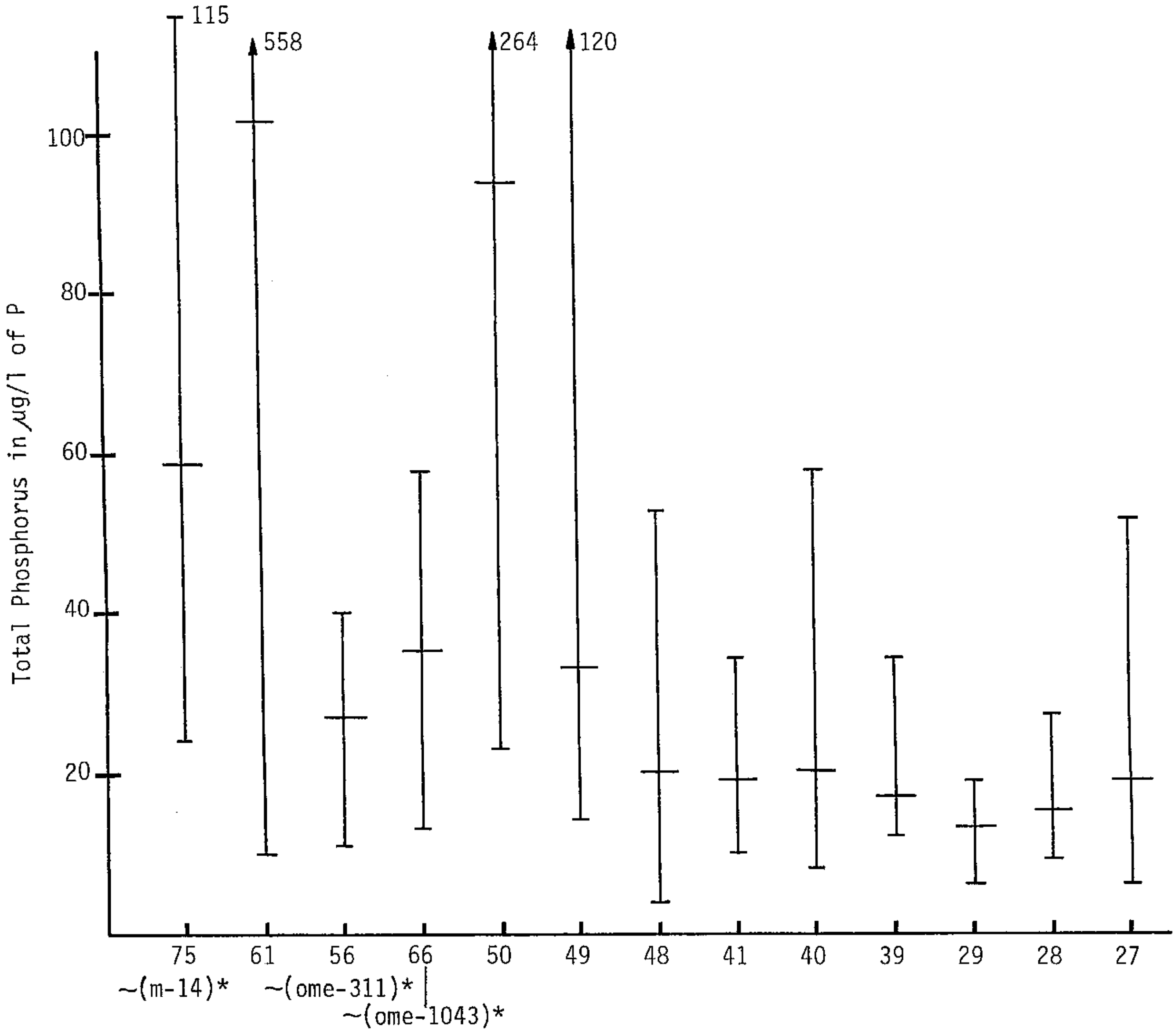
* Master Plan Station Numbers

FIGURE C-32.
1973 North Offshore - Total Phosphorus



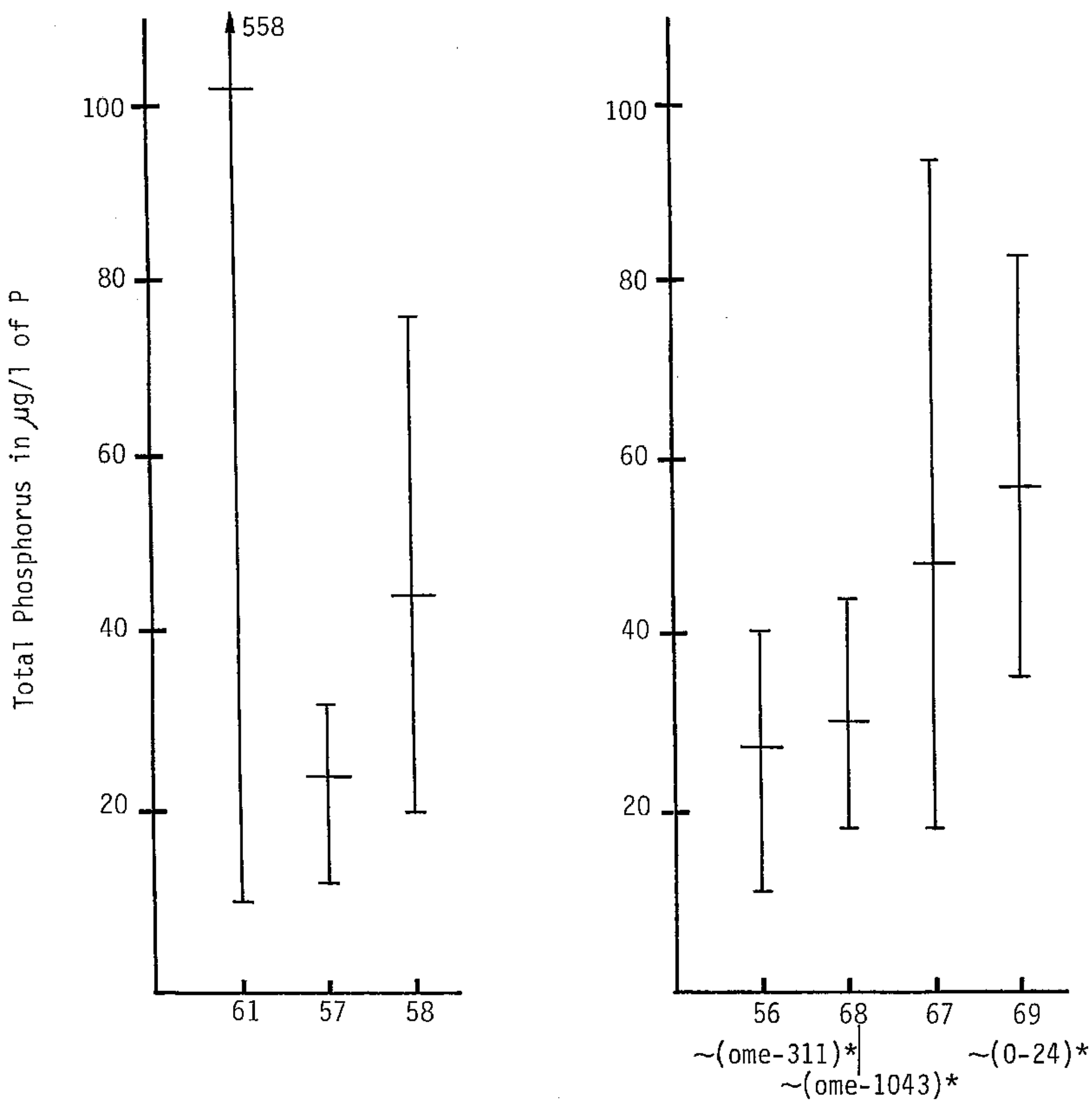
* Master Plan Station Numbers

FIGURE C-33.
1973 North Nearshore - Total Phosphorus



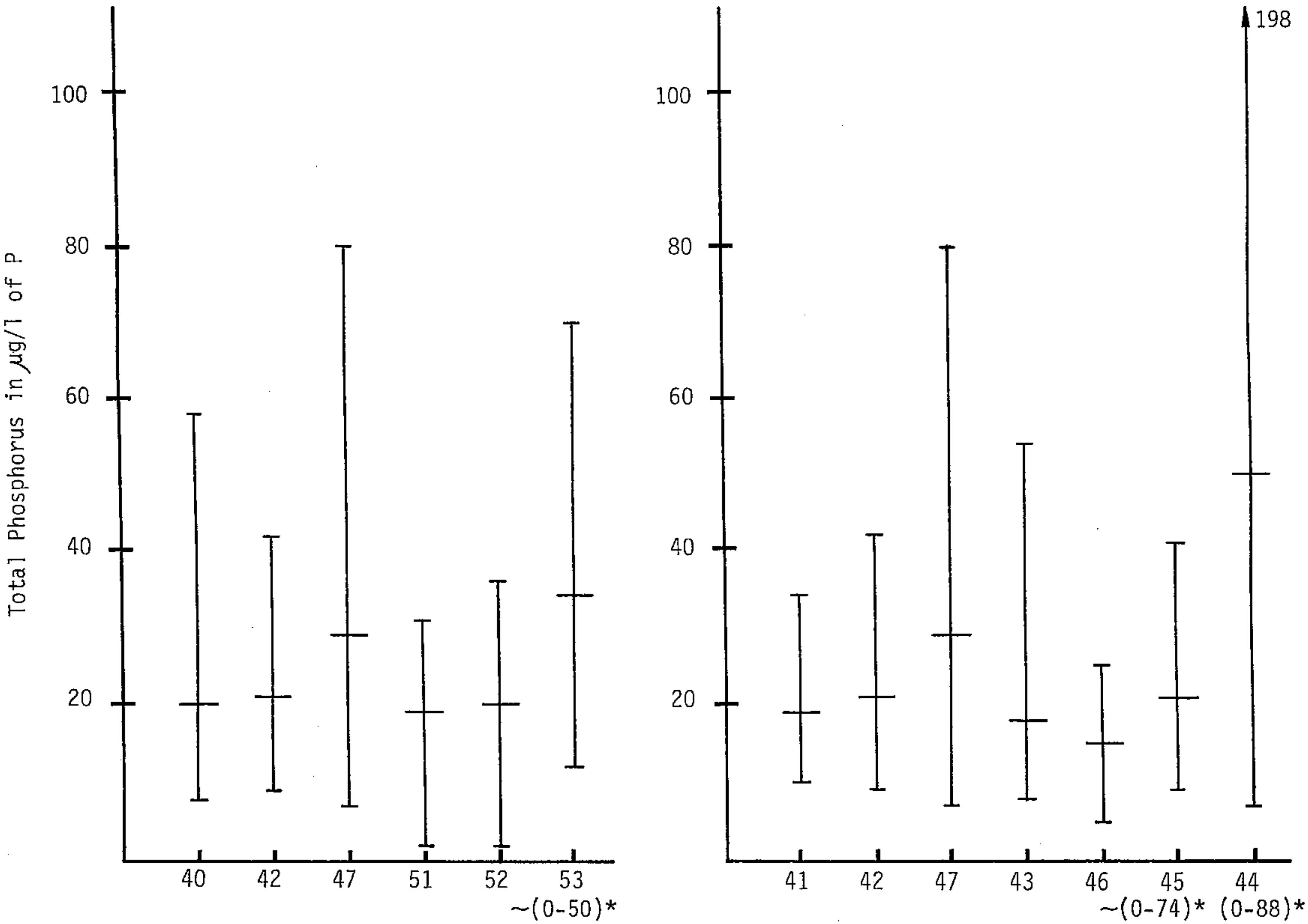
* Master Plan Station Numbers

FIGURE C-34.
1973 Western Basin Transects - Total Phosphorus



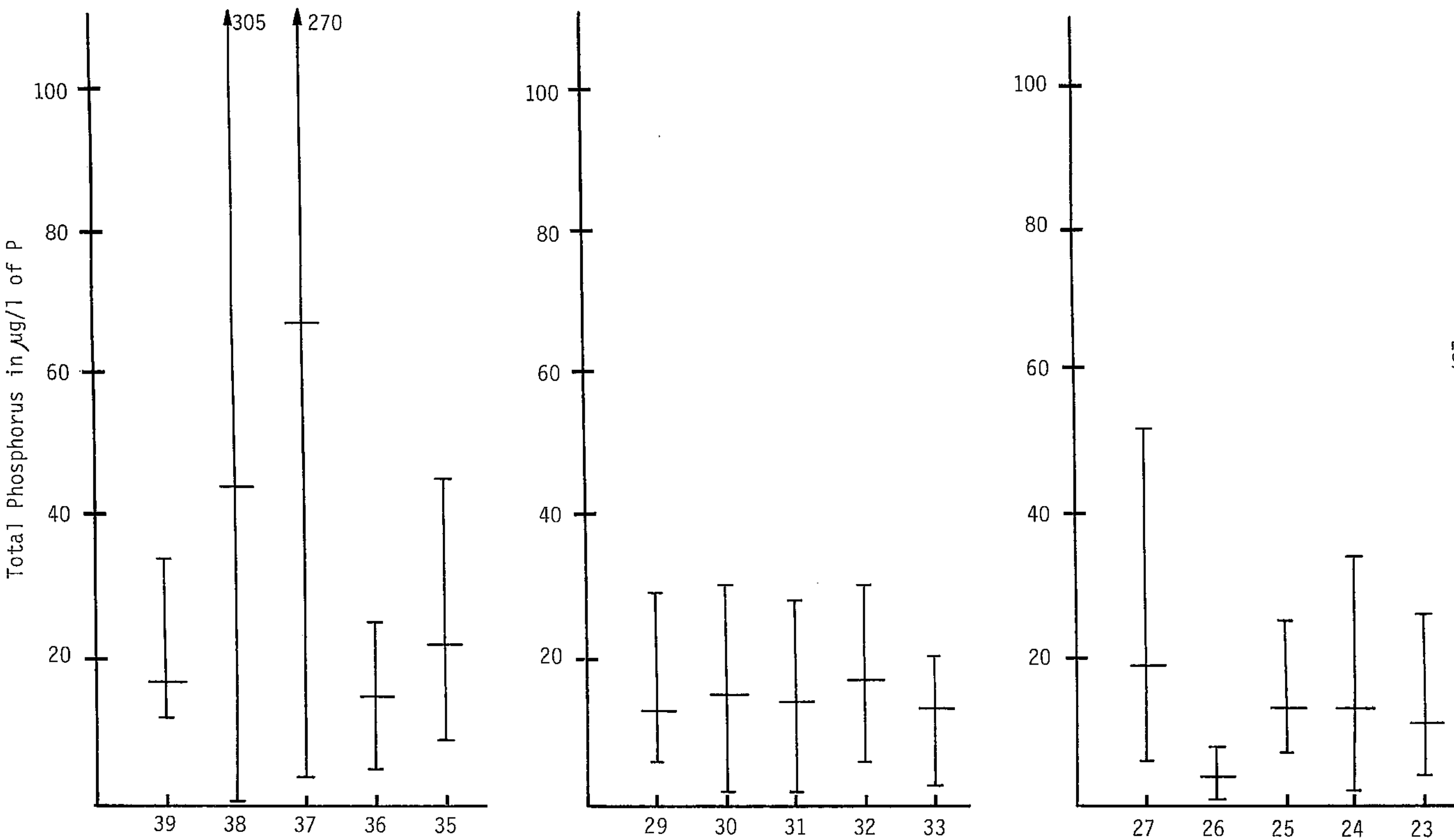
* Master Plan Station Numbers

FIGURE C-35.
1973 West Central Basin Transects - Total Phosphorus



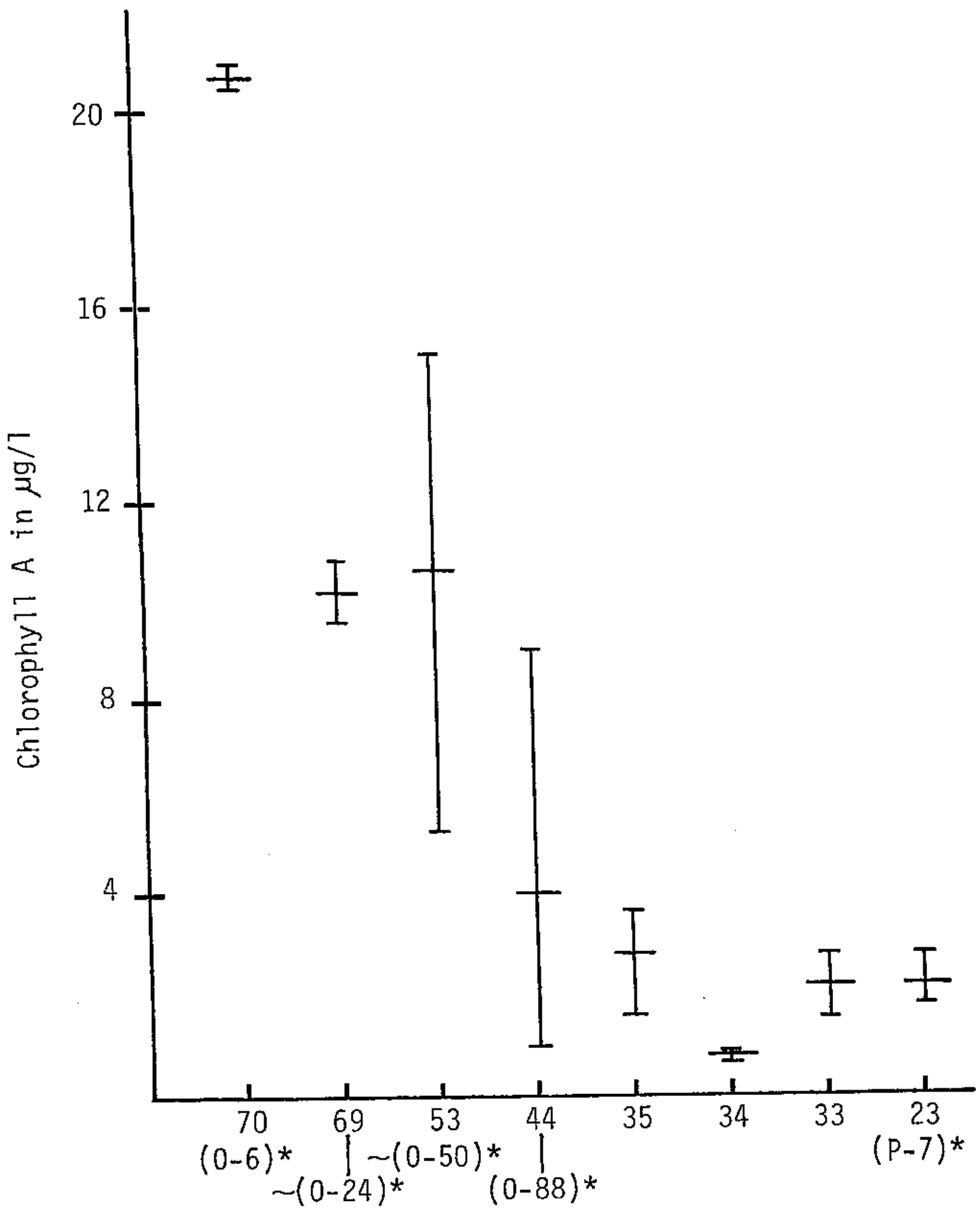
* Master Plan Station Numbers

FIGURE C-36.
1973 East Central Basin Transects - Total Phosphorus



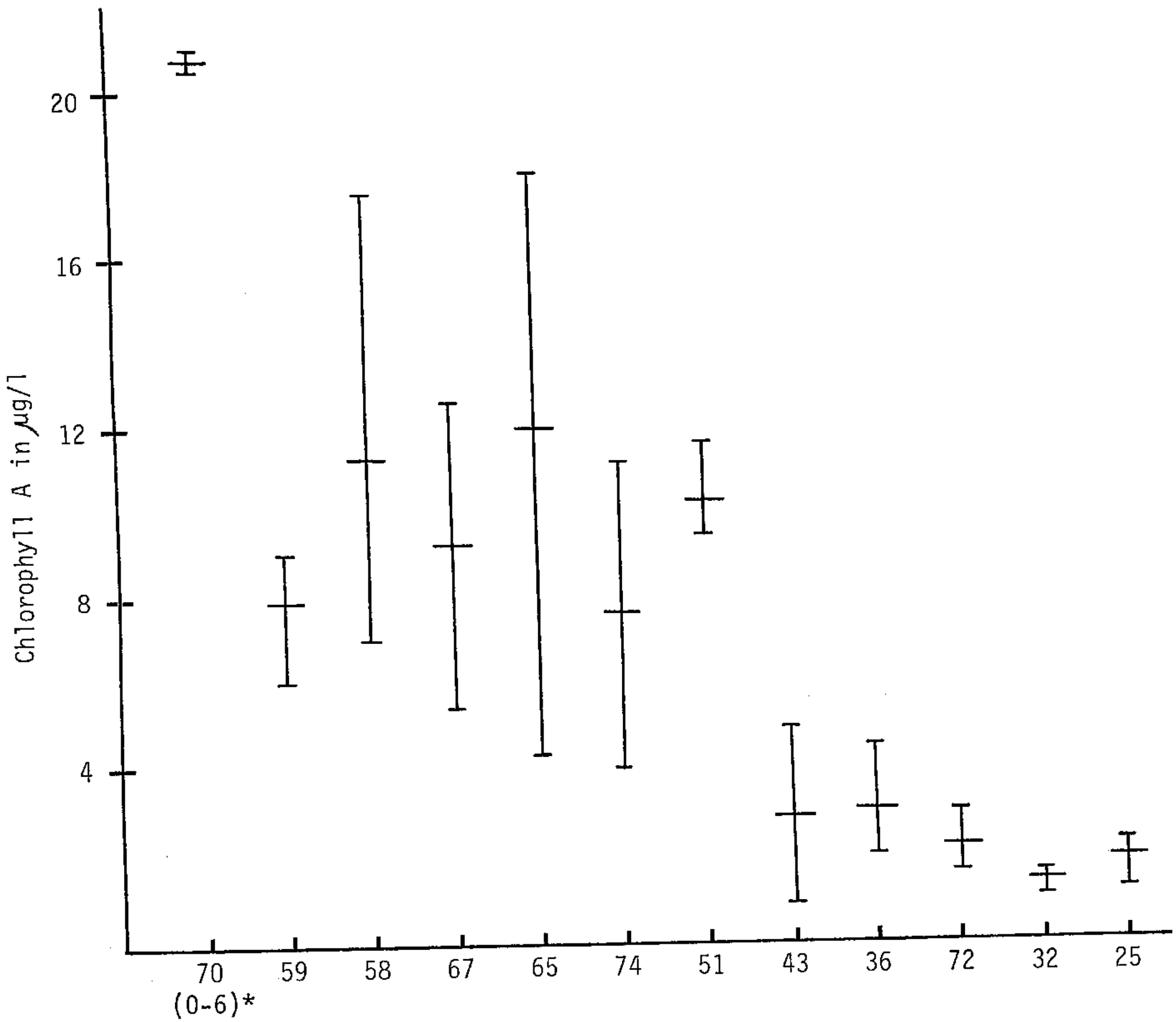
* Master Plan Station Numbers

FIGURE C-37.
1973 South Nearshore - Chlorophyll A



* Master Plan Station Numbers

FIGURE C-38.
1973 South Offshore - Chlorophyll A



* Master Plan Station Numbers

FIGURE C-39.
1973 North Offshore - Chlorophyll A

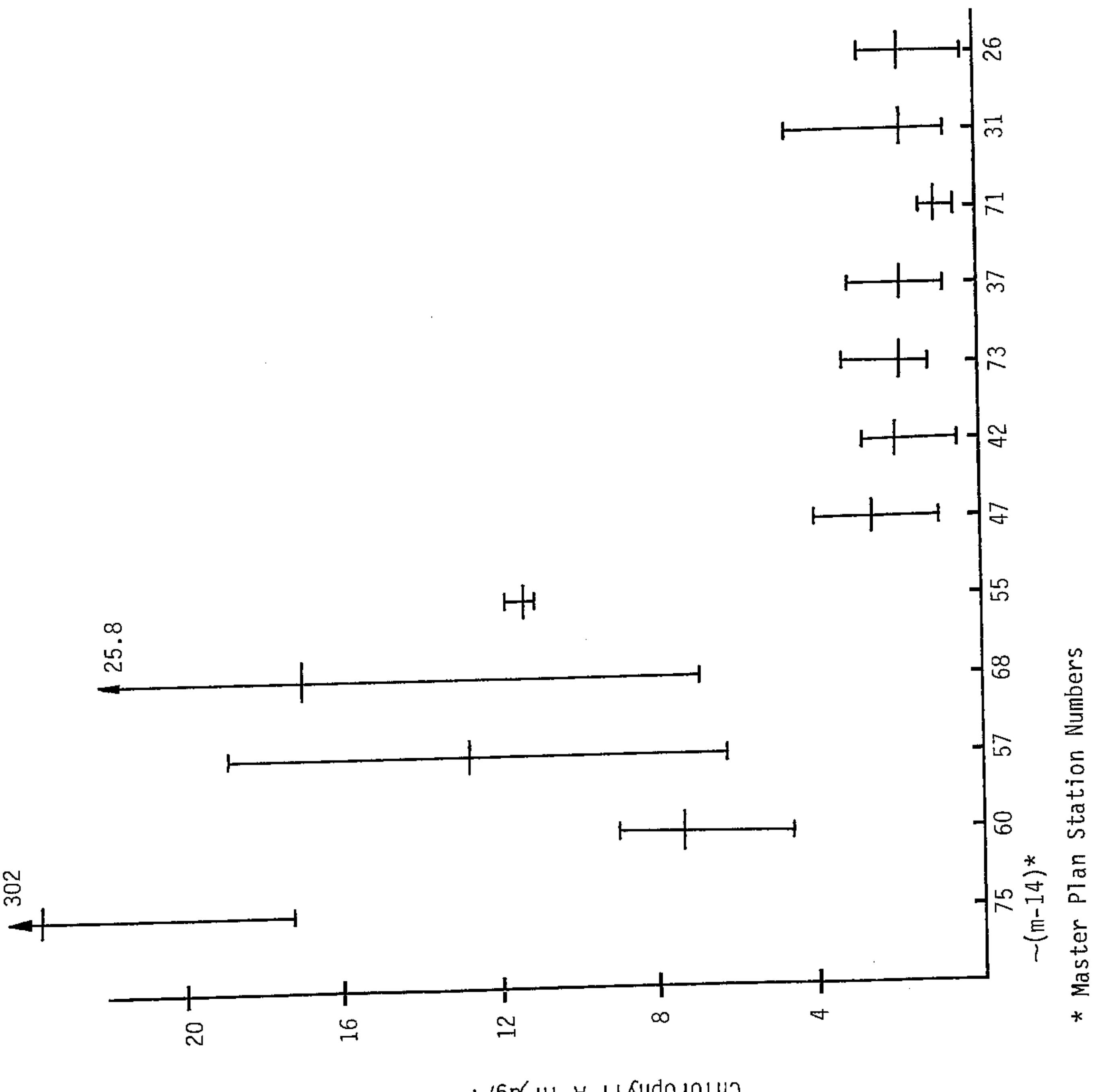
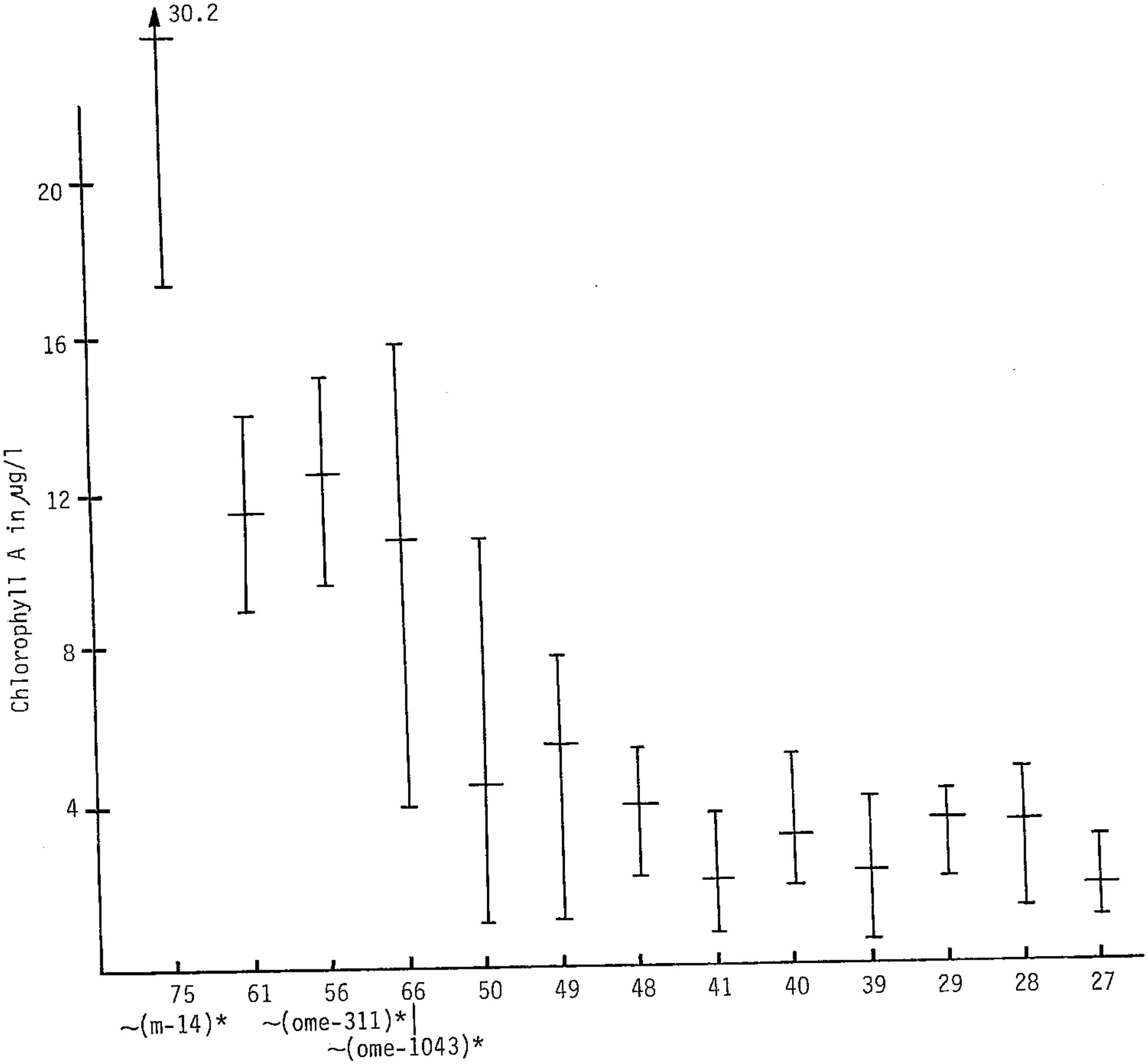
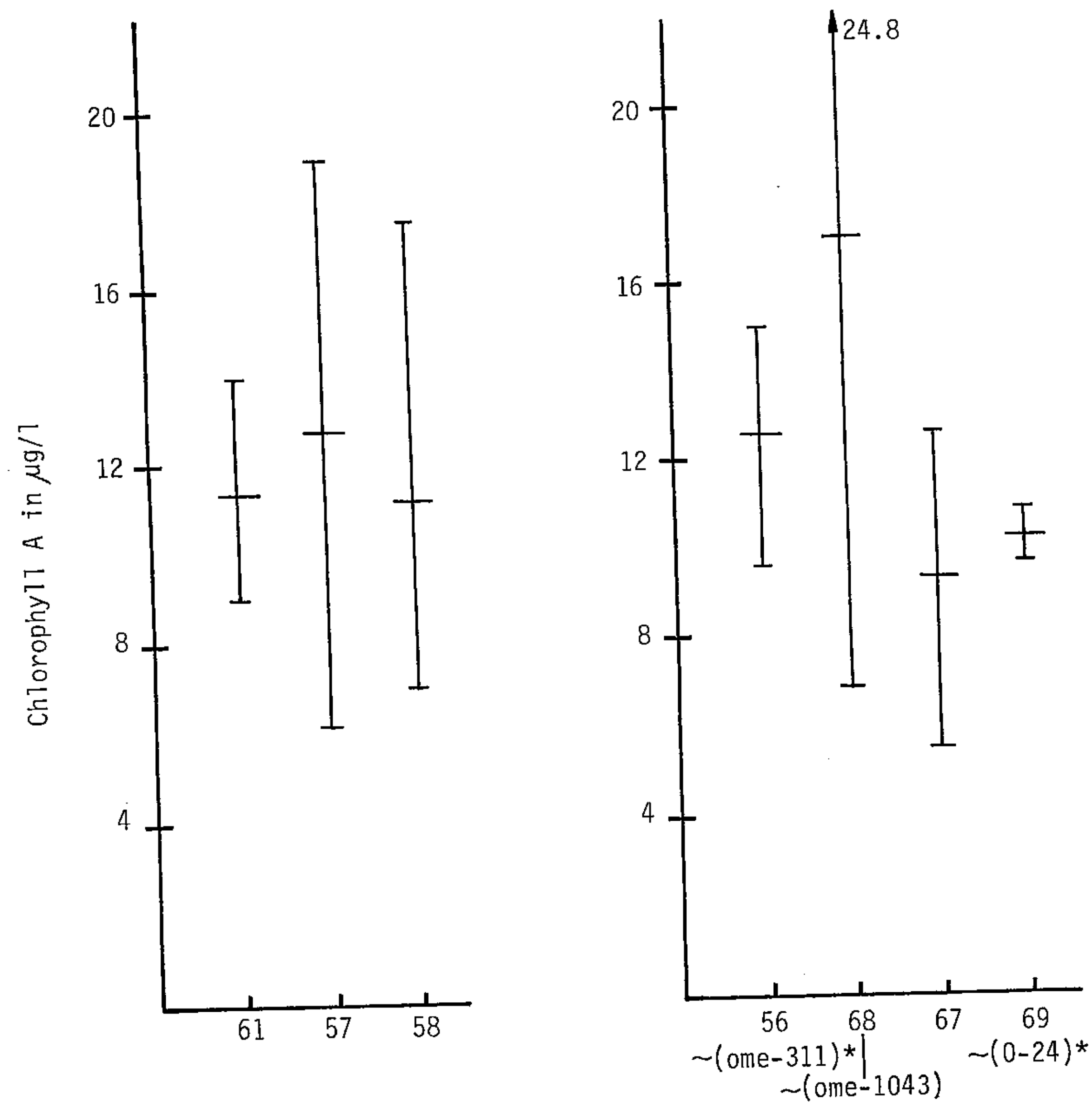


FIGURE C-40.
1973 North Nearshore - Chlorophyll A



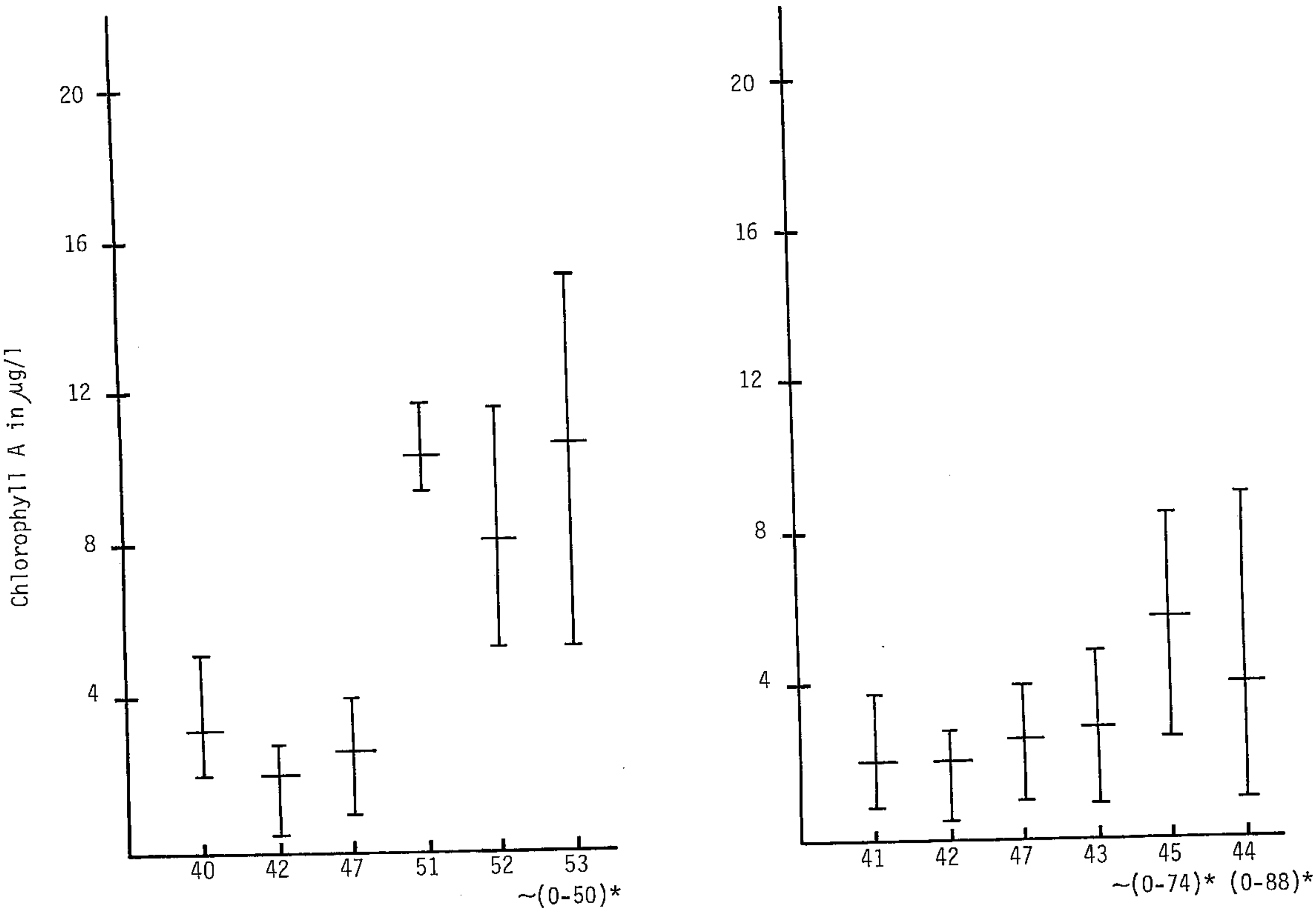
* Master Plan Station Numbers

FIGURE C-41.
1973 West Basin Transects - Chlorophyll A



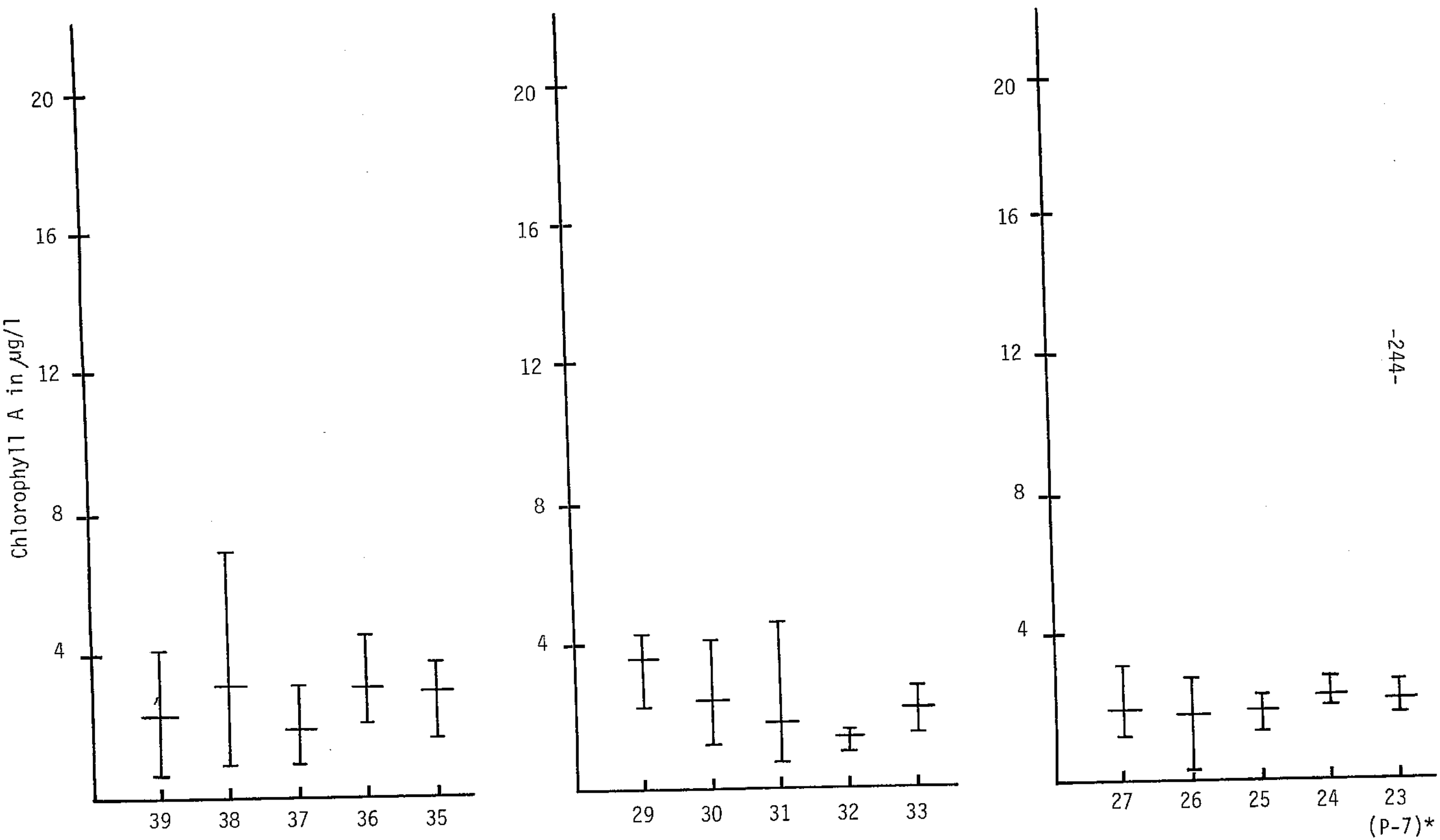
* Master Plan Station Numbers

FIGURE C-42.
1973 West Central Basin Transects - Chlorophyll A



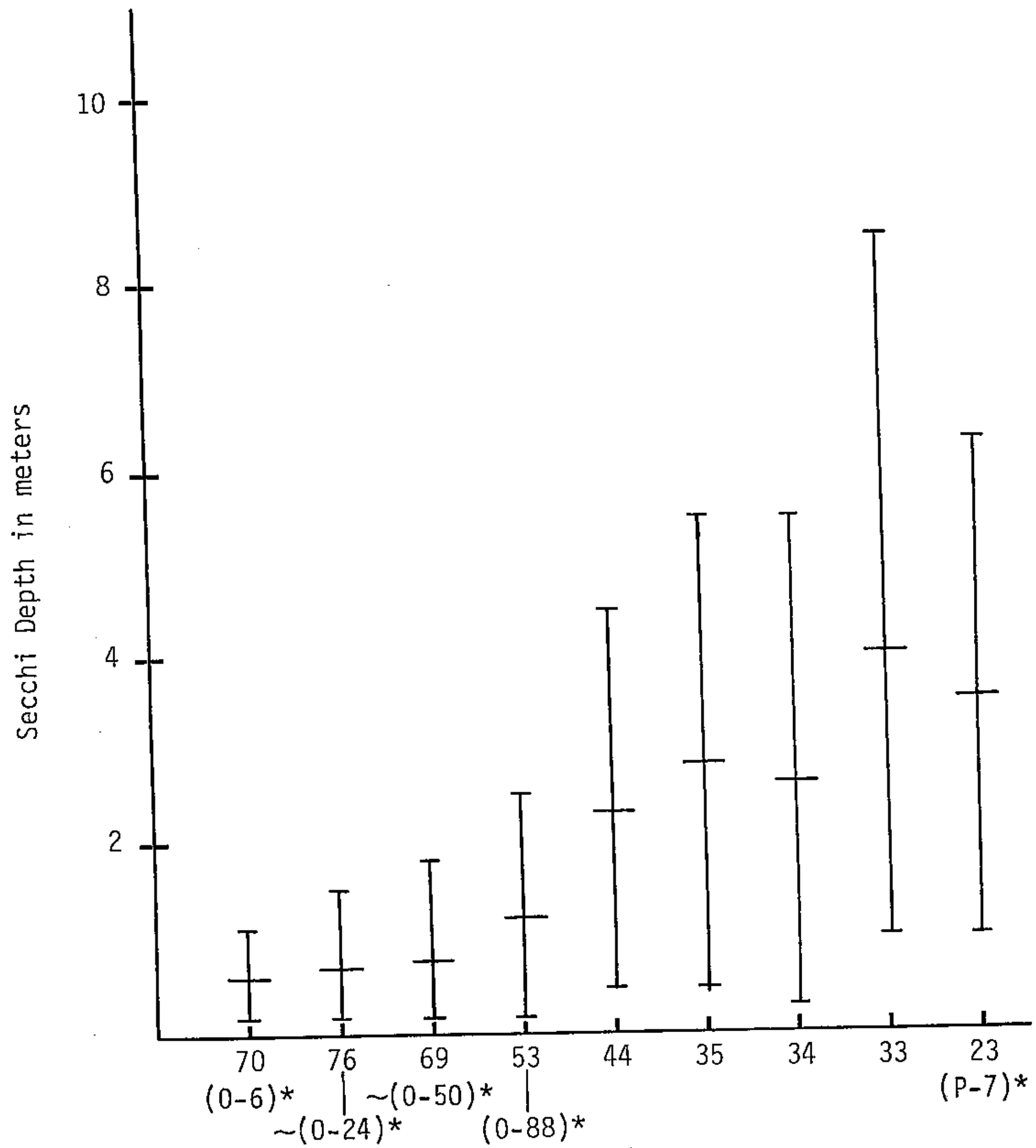
* Master Plan Station Numbers

FIGURE C-43.
1973 East Central Basin Transects - Chlorophyll A



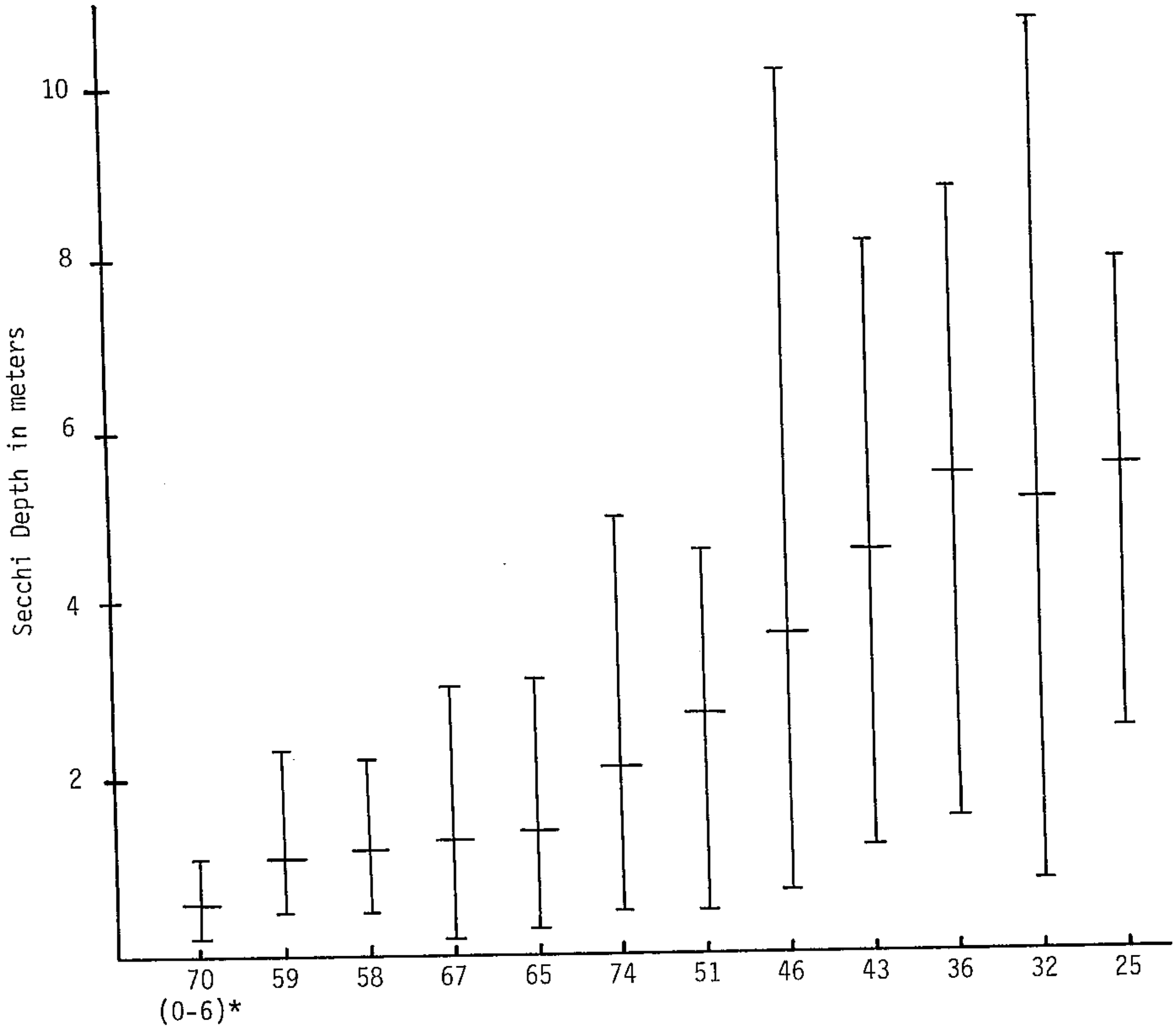
* Master Plan Station Numbers

FIGURE C-44.
1974 South Nearshore Transparency



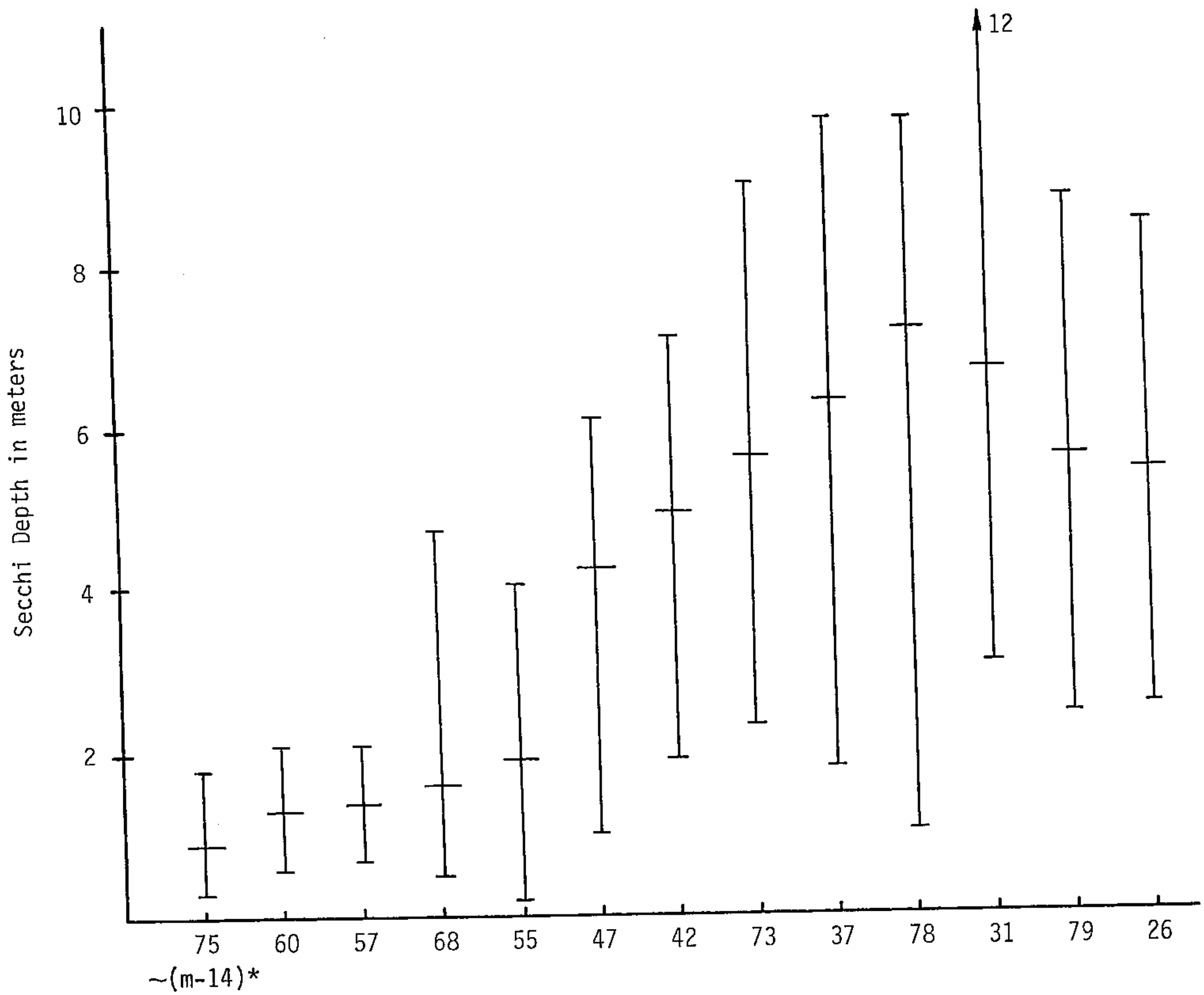
* Master Plan Station Numbers

FIGURE C-45.
1974 South Offshore Transparency



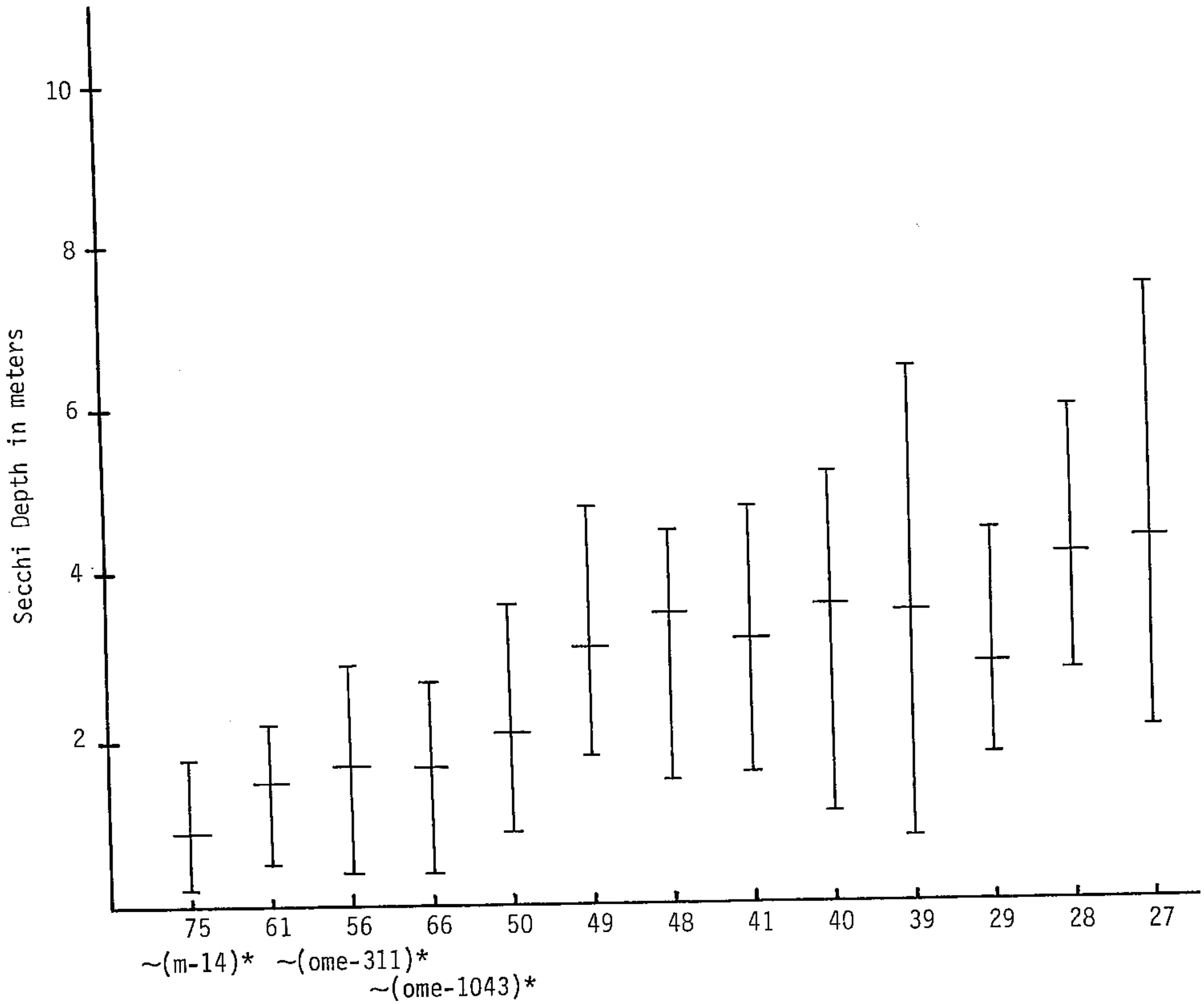
* Master Plan Station Numbers

FIGURE C-46.
1974 North Offshore Transparency



* Master Plan Station Numbers

FIGURE C-47.
1974 North Nearshore Transparency



* Master Plan Station Numbers

FIGURE C-48.
1974 Western Basin Transects - Transparency

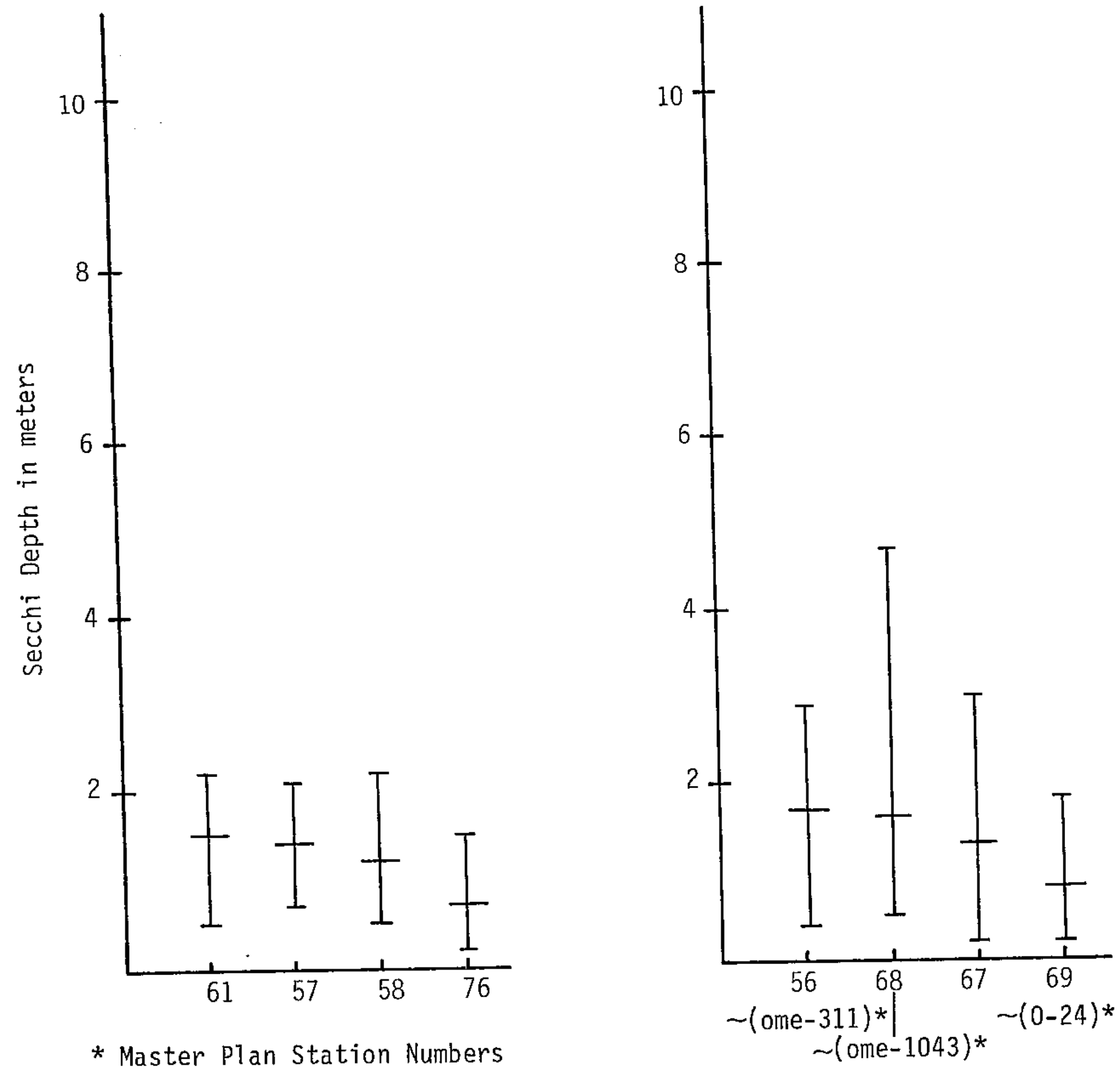
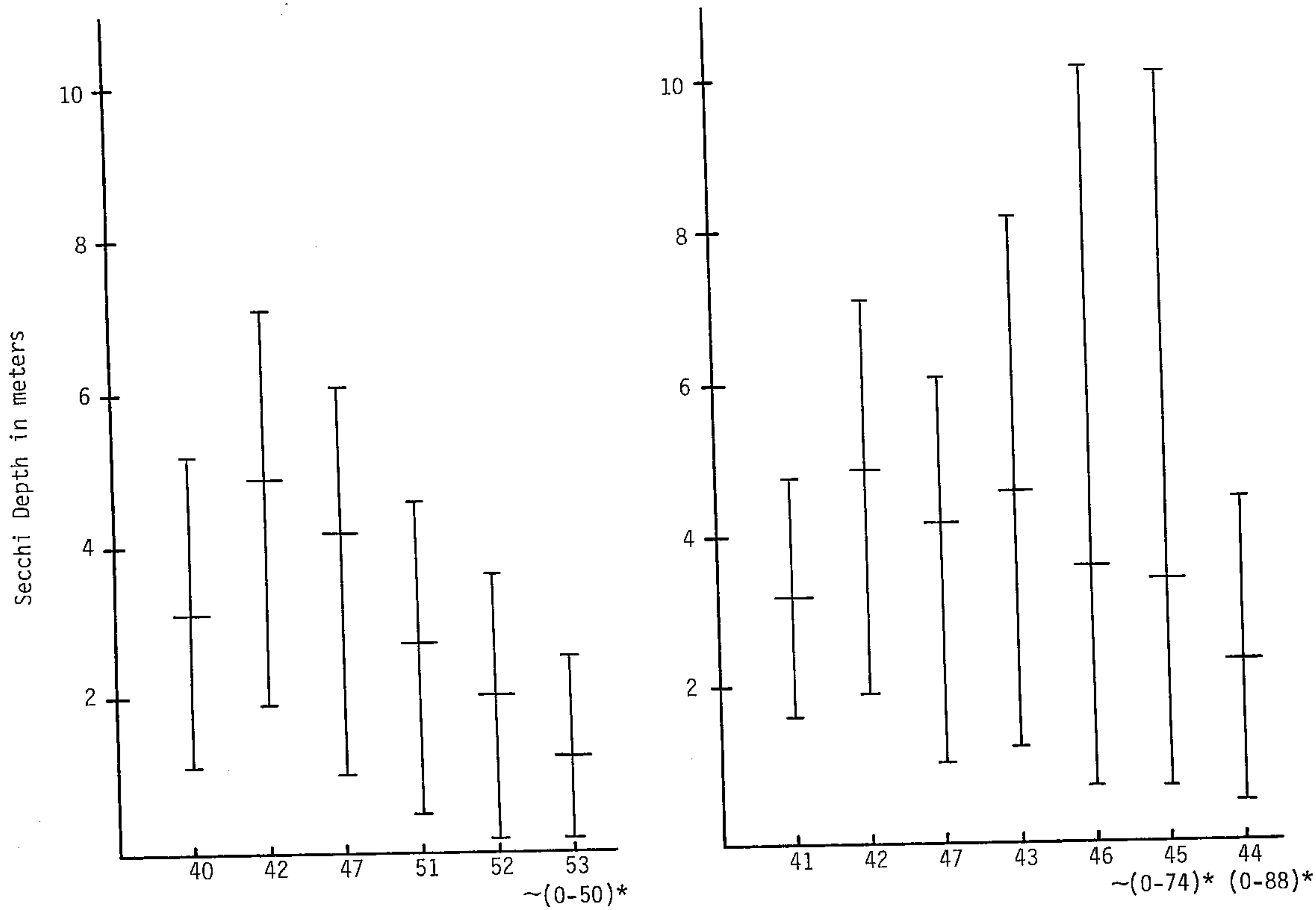
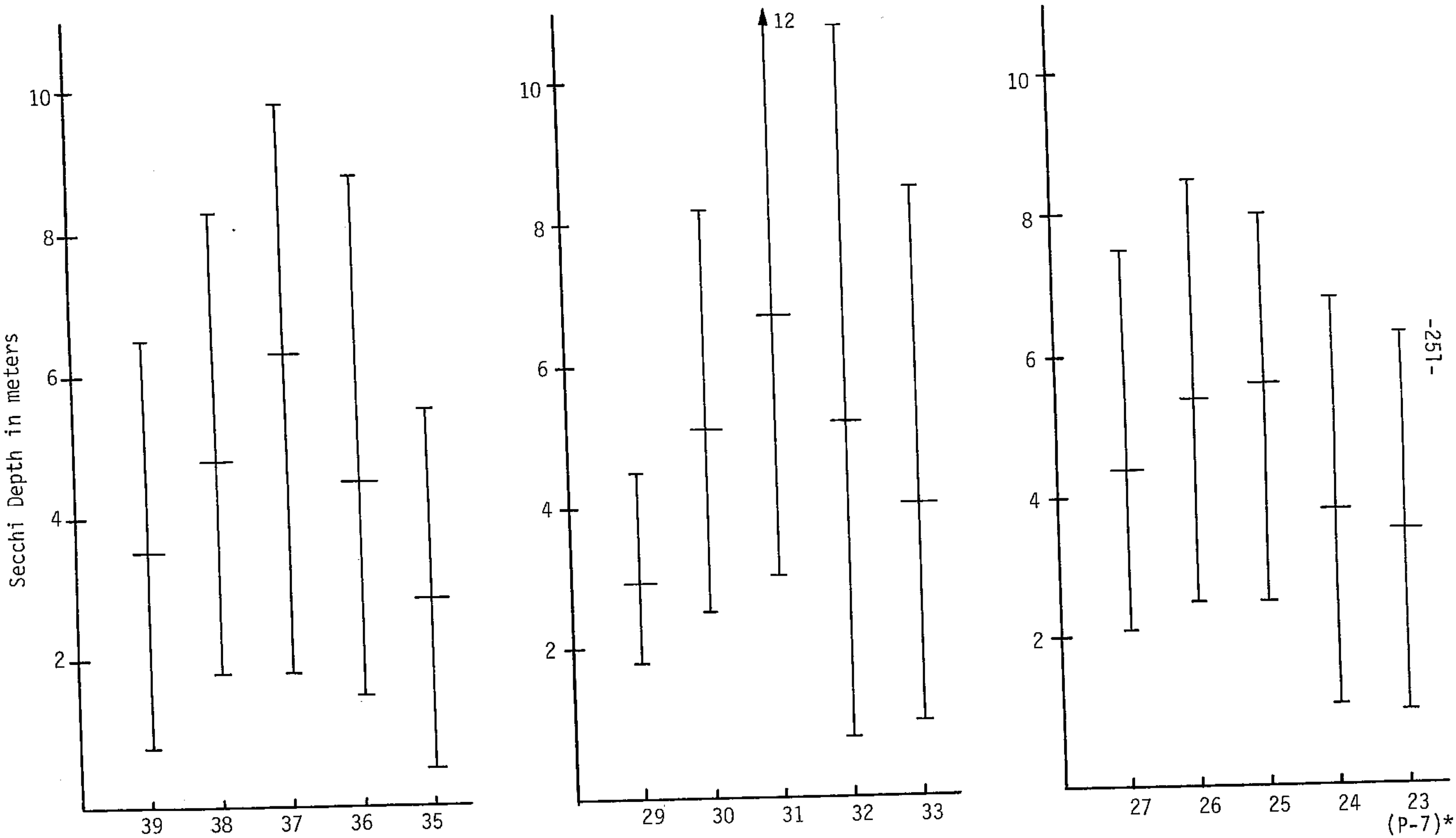


FIGURE C-49.
1974 Western Central Basin Transects - Transparency



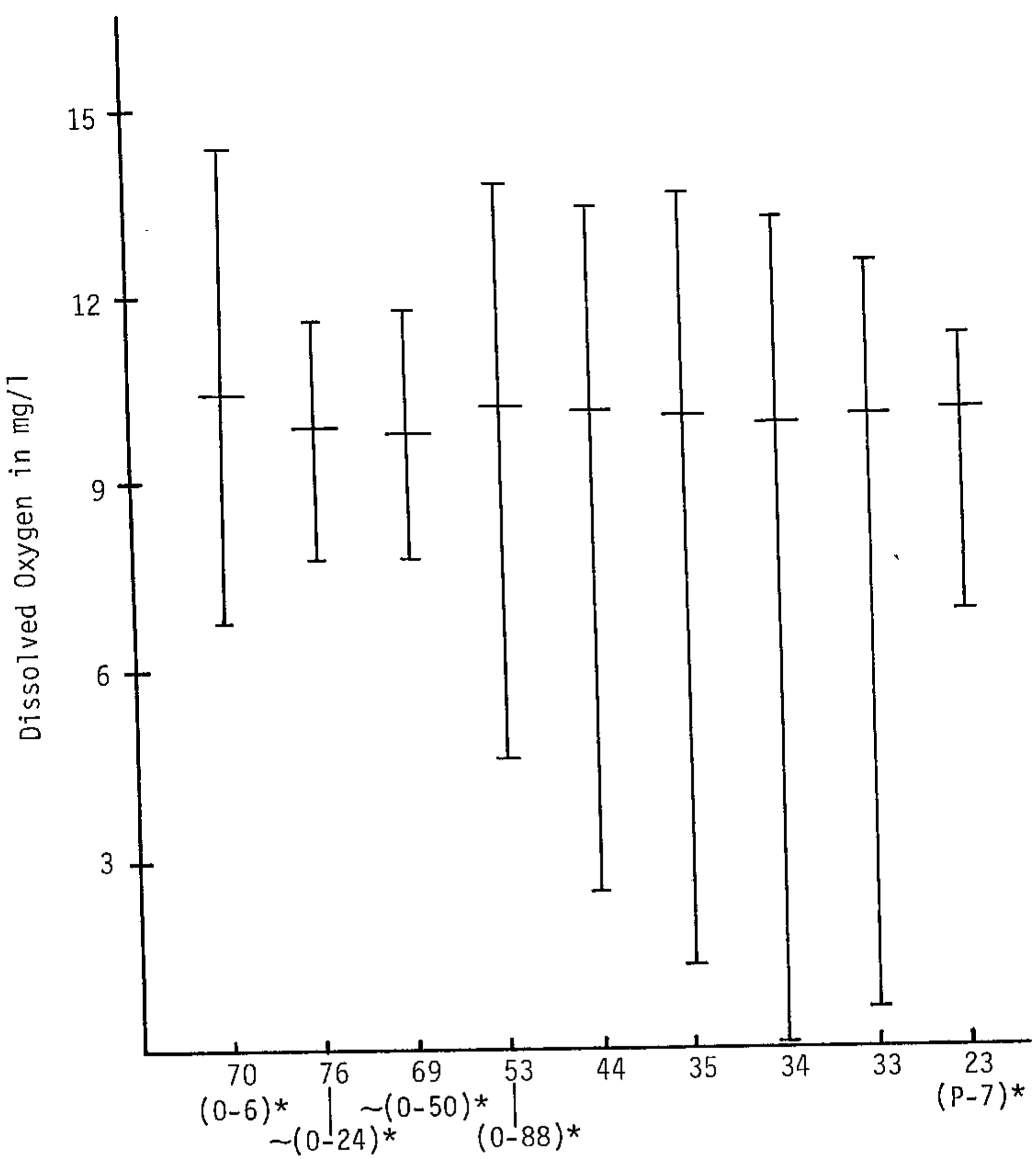
* Master Plan Station Numbers

FIGURE C-50.
1974 Eastern Central Basin Transects - Transparency



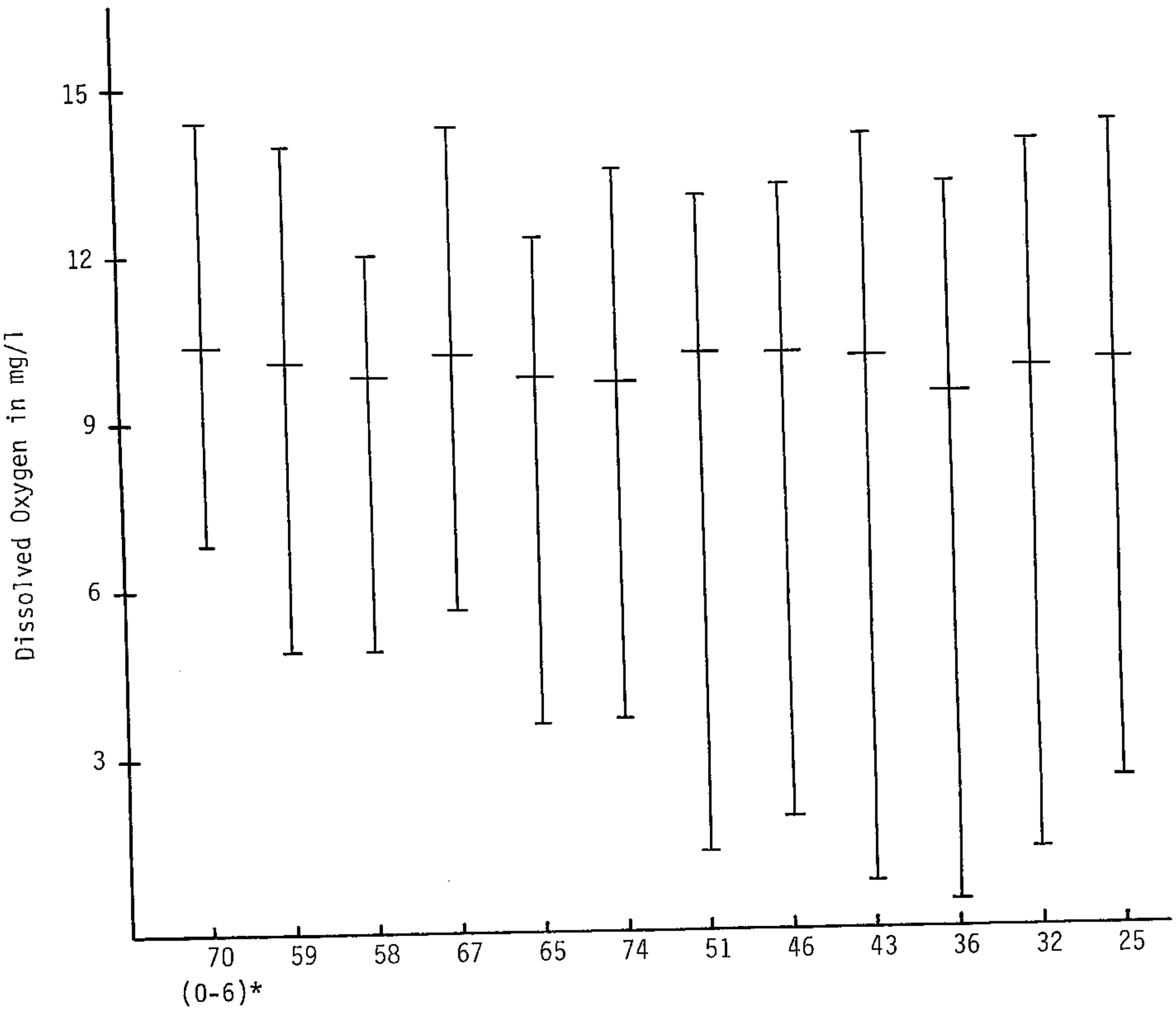
* Master Plan Station Numbers

FIGURE C-51.
1974 South Nearshore Dissolved Oxygen



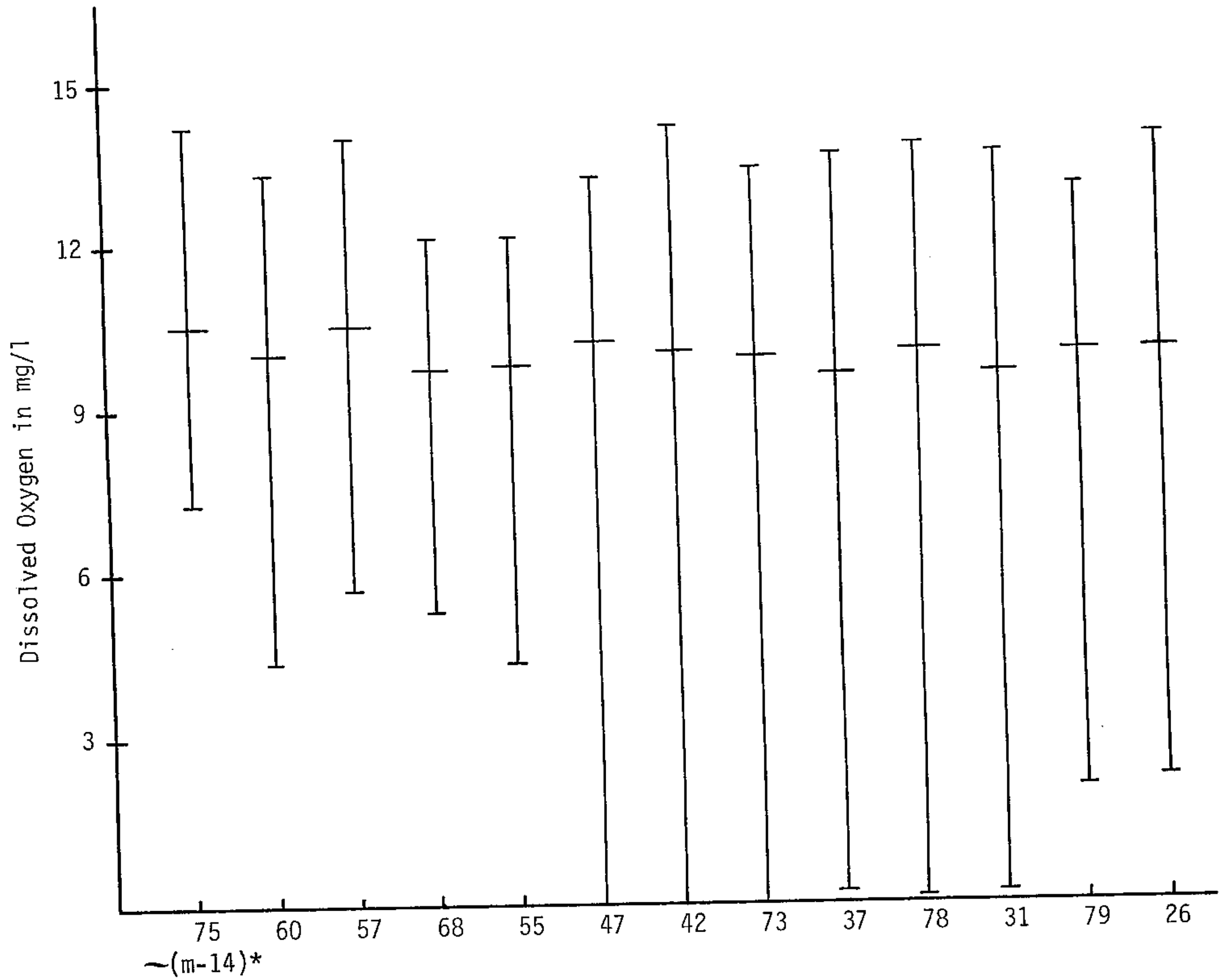
* Master Plan Station Numbers

FIGURE C-52.
1974 South Offshore Dissolved Oxygen



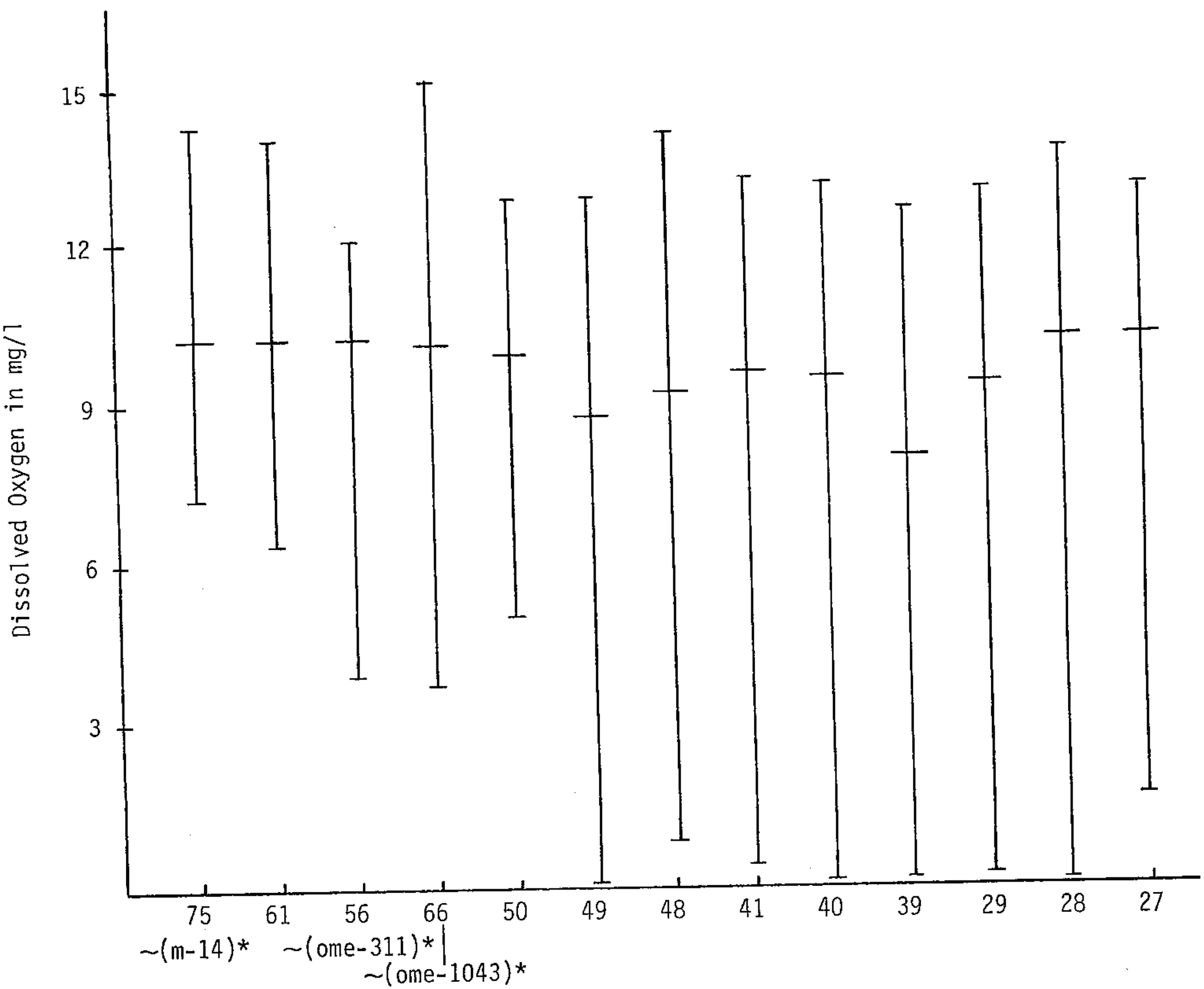
* Master Plan Station Numbers

FIGURE C-53.
1974 North Offshore Dissolved Oxygen



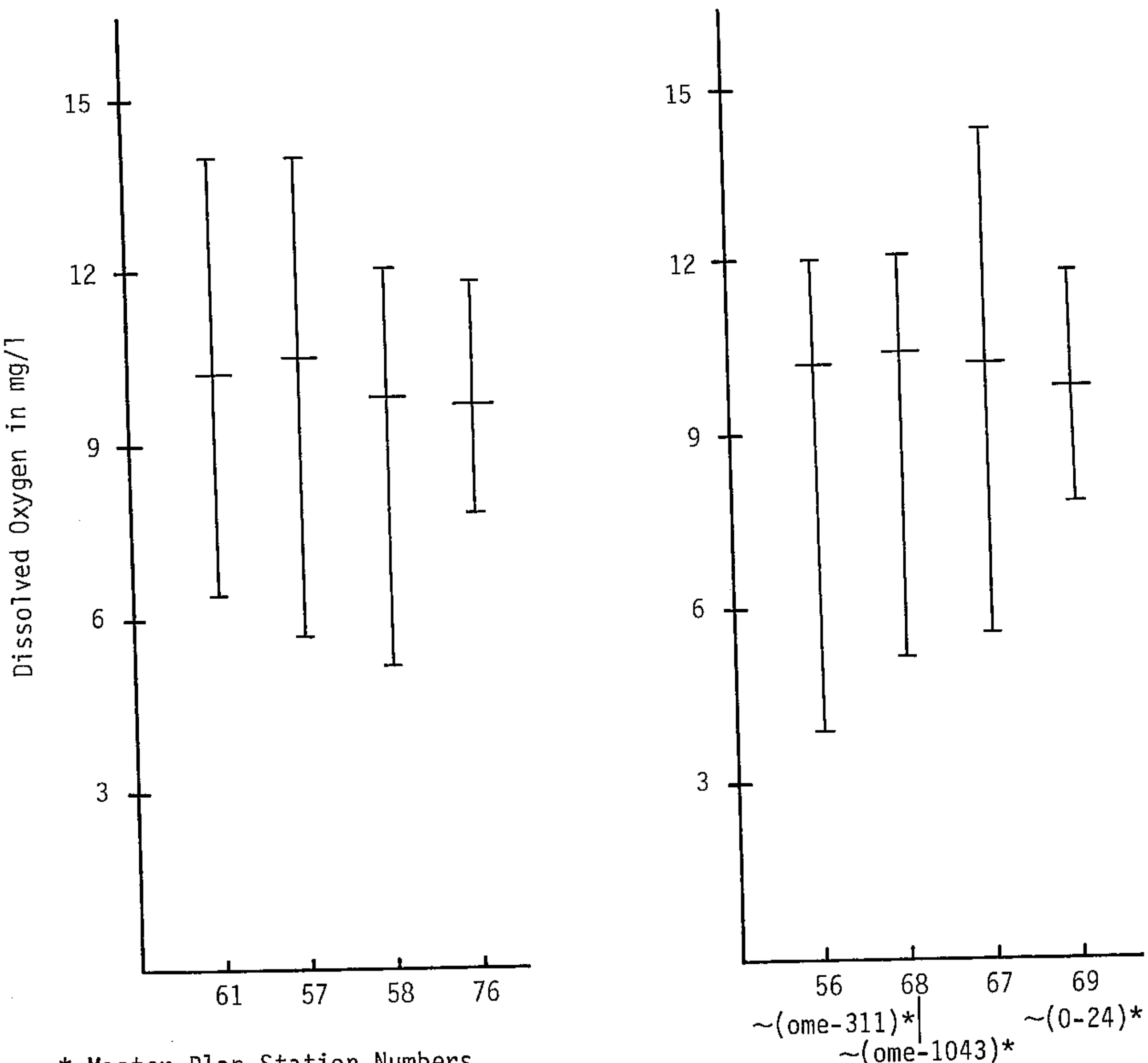
* Master Plan Station Numbers

FIGURE C-54.
1974 North Nearshore Dissolved Oxygen



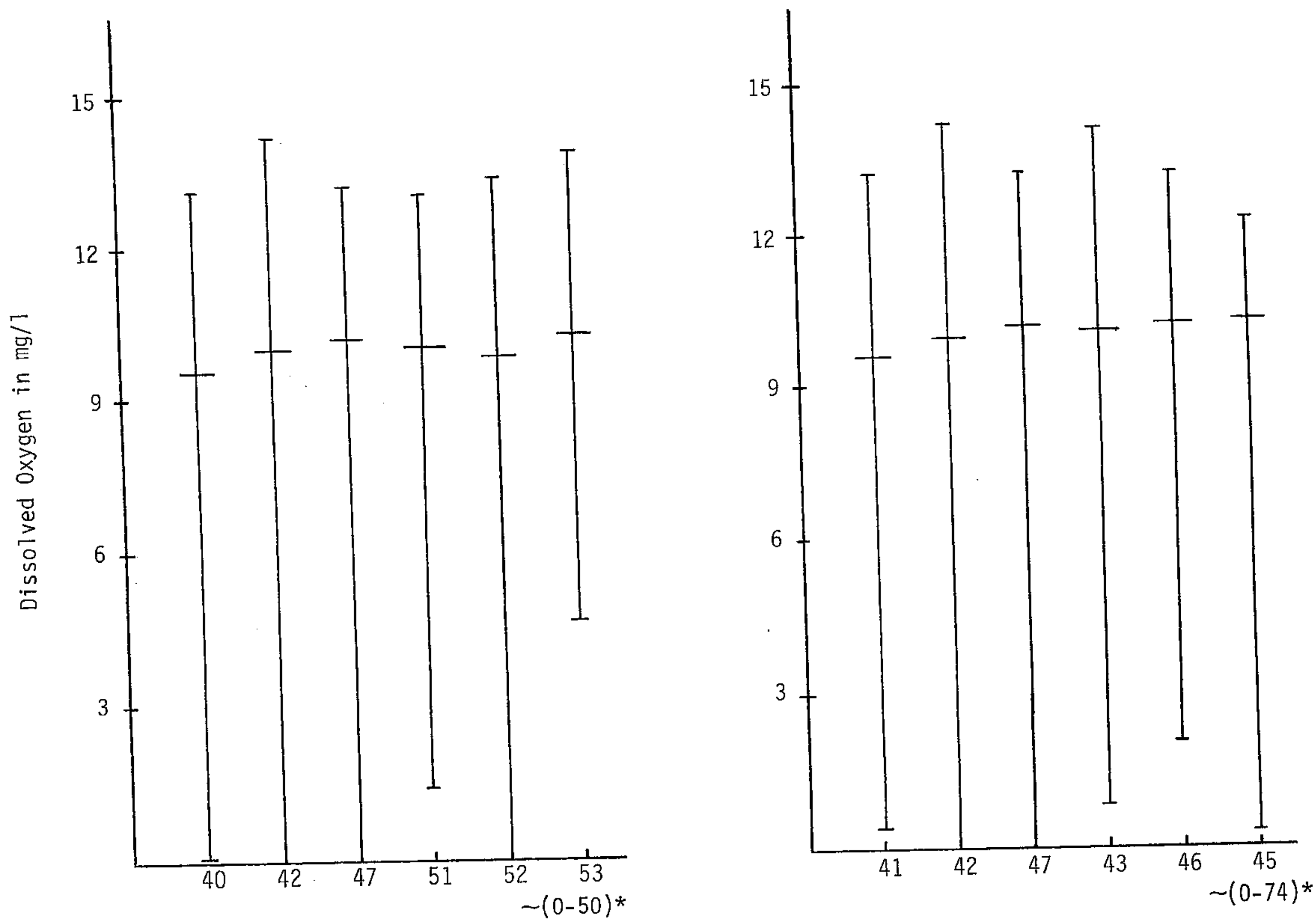
* Master Plan Station Numbers

FIGURE C-55.
1974 Western Basin Transects - Dissolved Oxygen



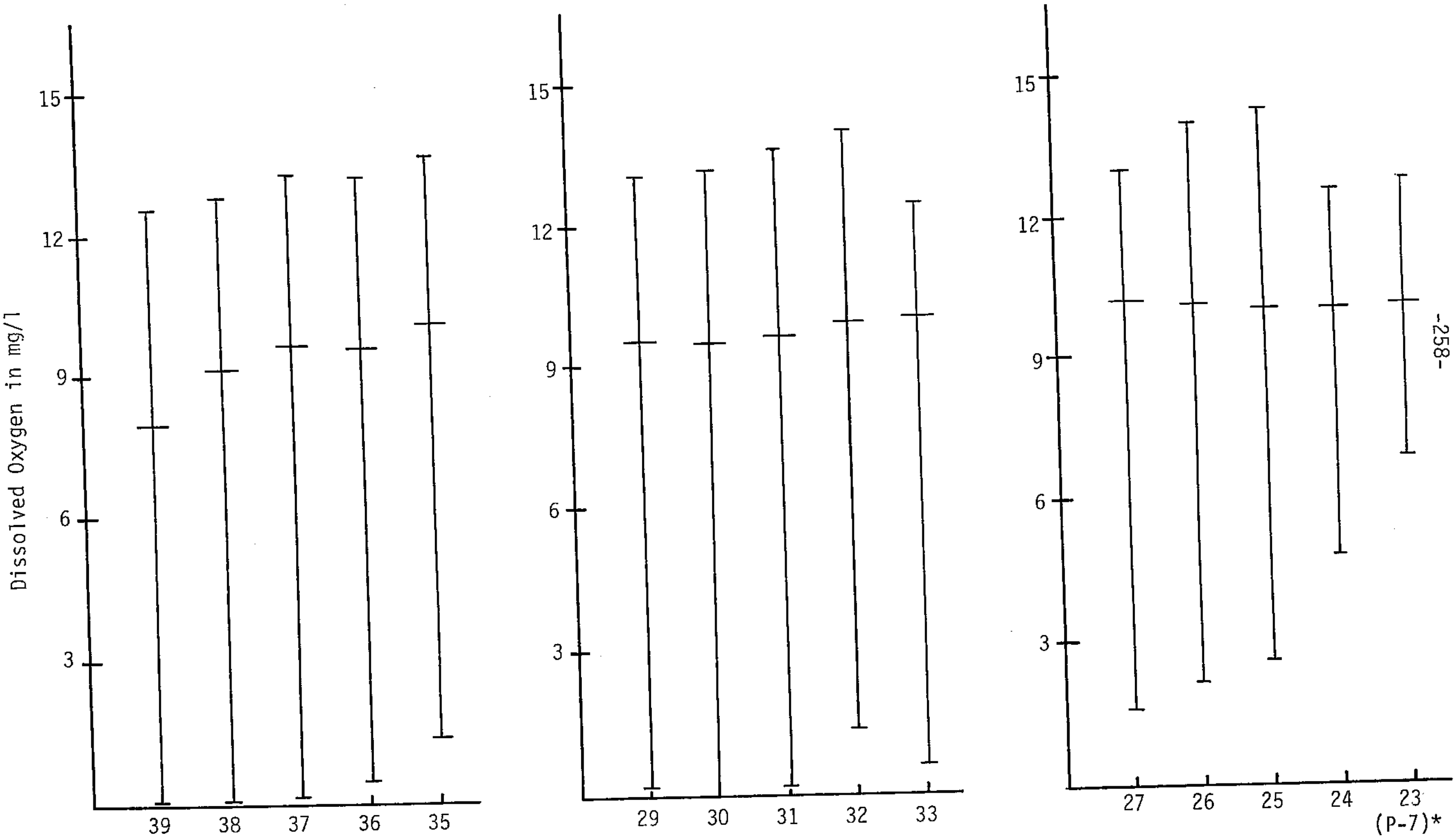
* Master Plan Station Numbers

FIGURE C-56.
1974 West Central Basin Transects - Dissolved Oxygen



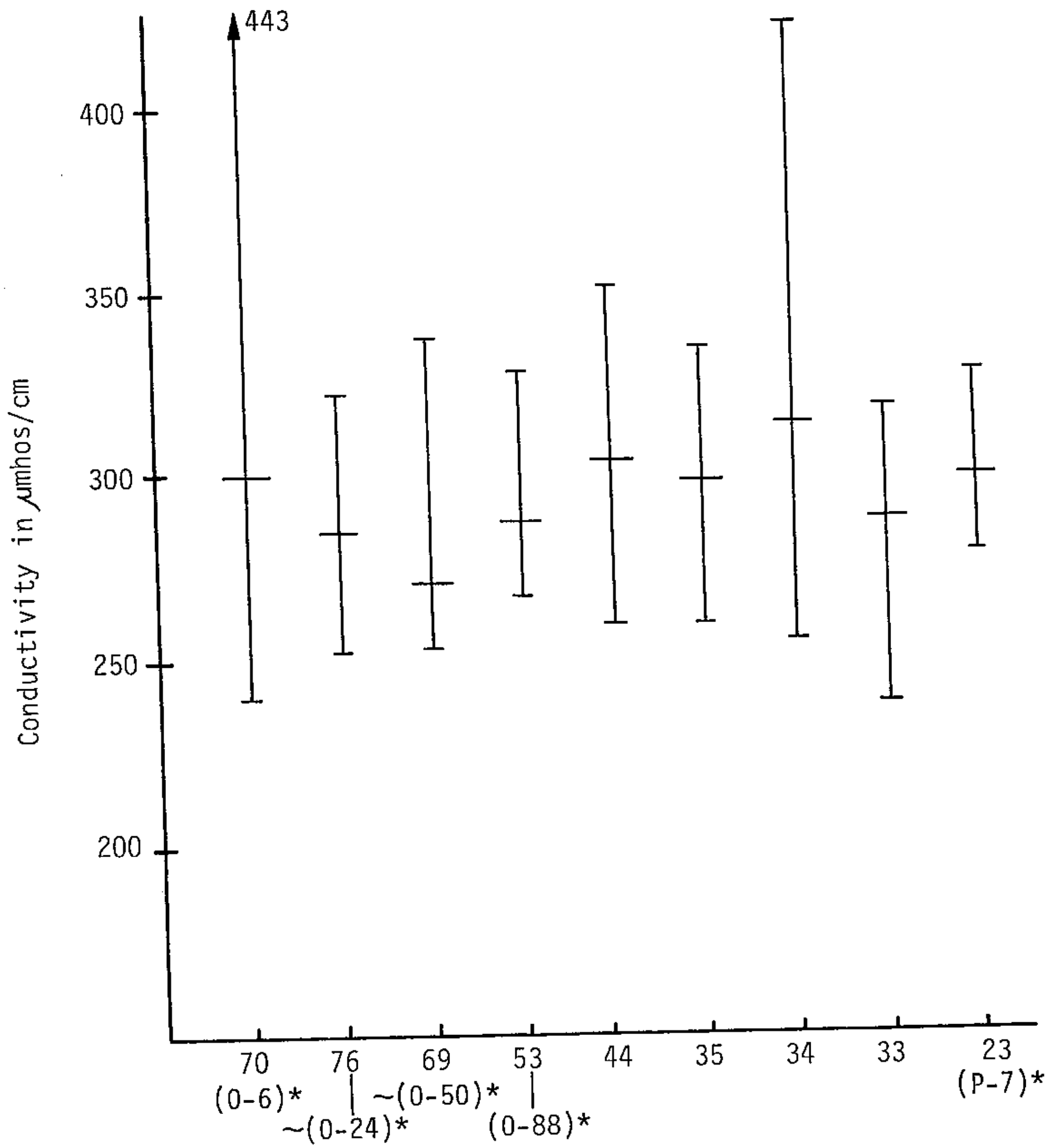
* Master Plan Station Numbers

FIGURE C-57.
1974 East Central Basin Transects - Dissolved Oxygen



* Master Plan Station Numbers

FIGURE C-58.
1974 South Nearshore Conductivity



* Master Plan Station Numbers

FIGURE C-59.
1974 South Offshore Conductivity

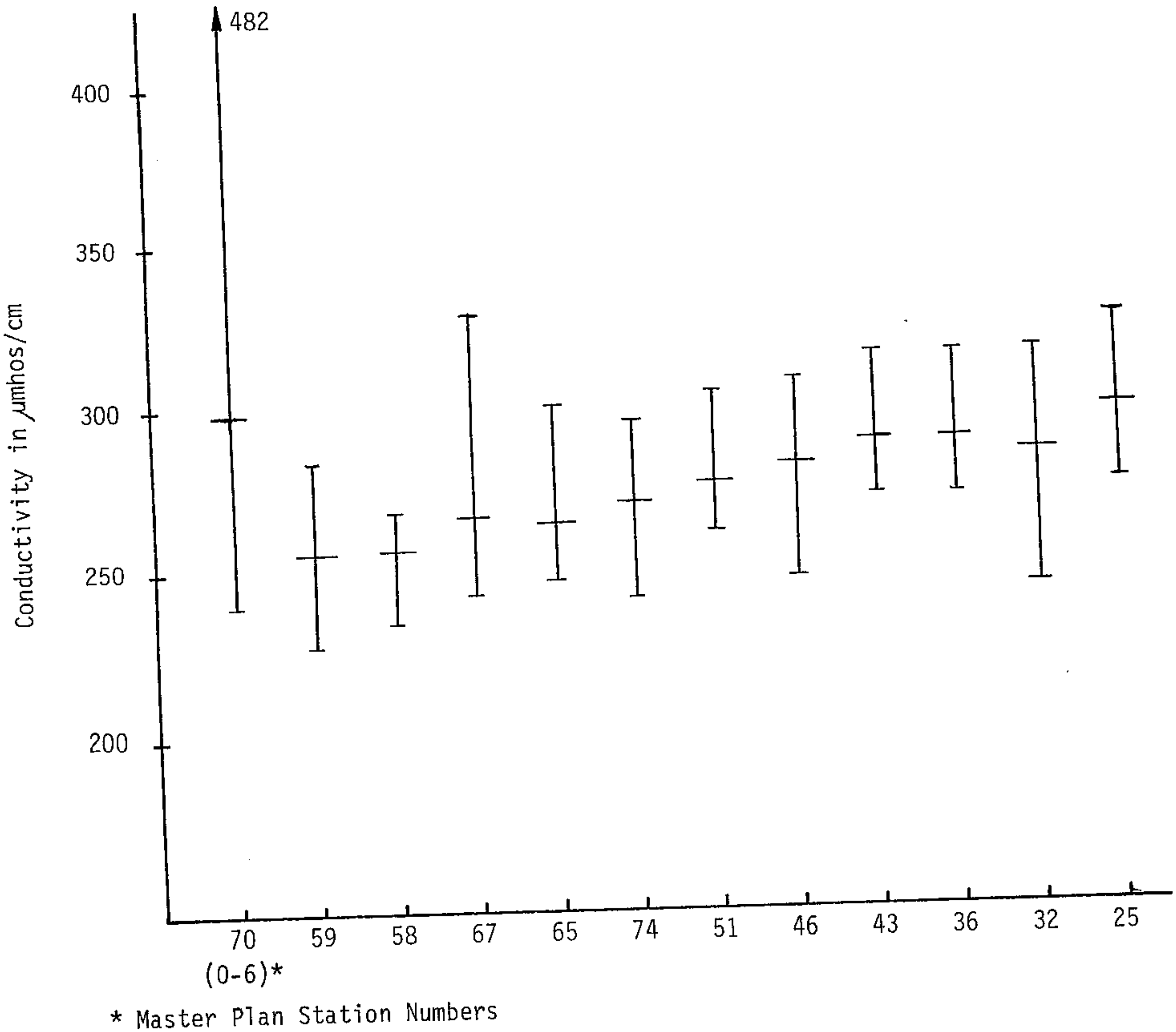
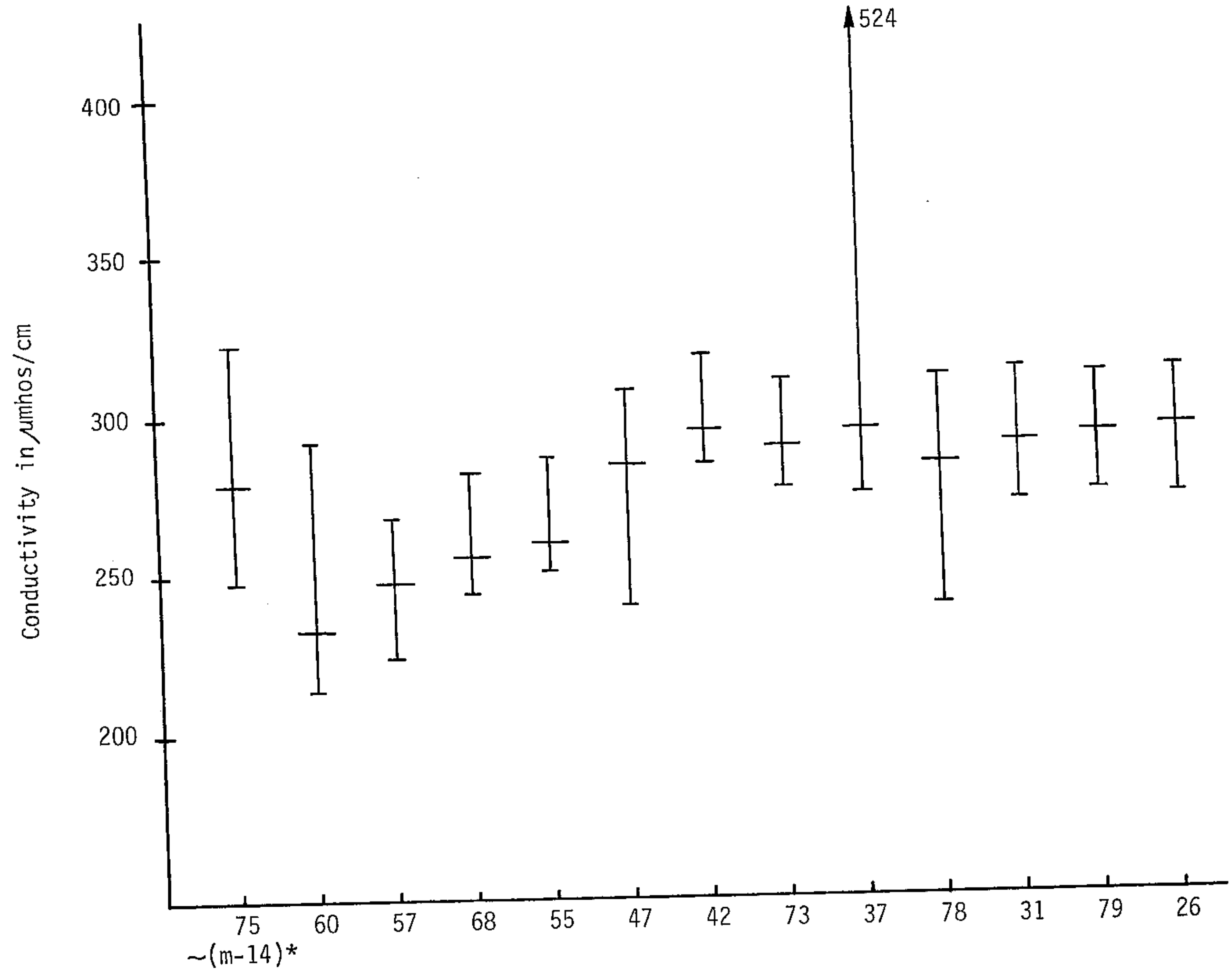
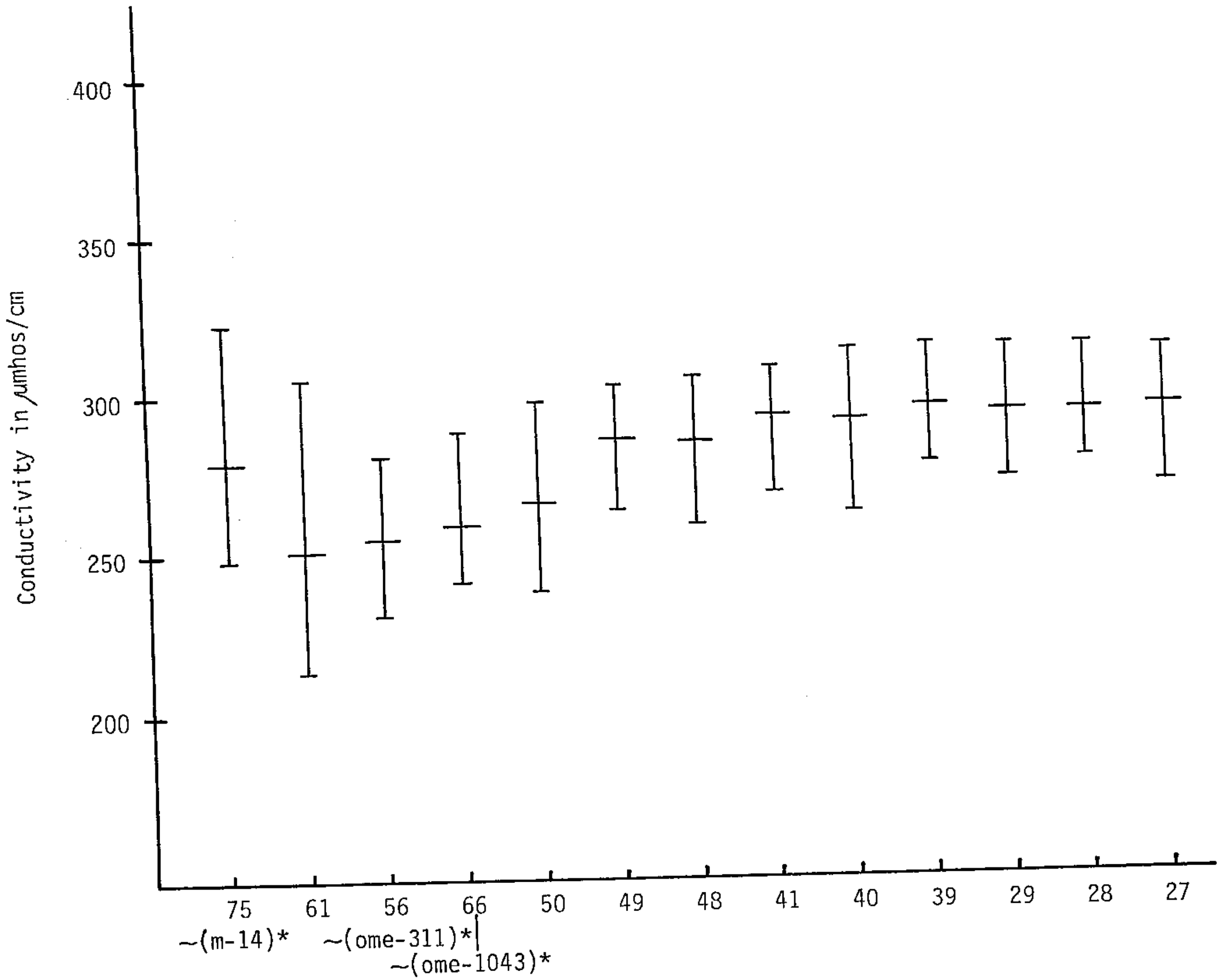


FIGURE C-60.
1974 North Offshore Conductivity



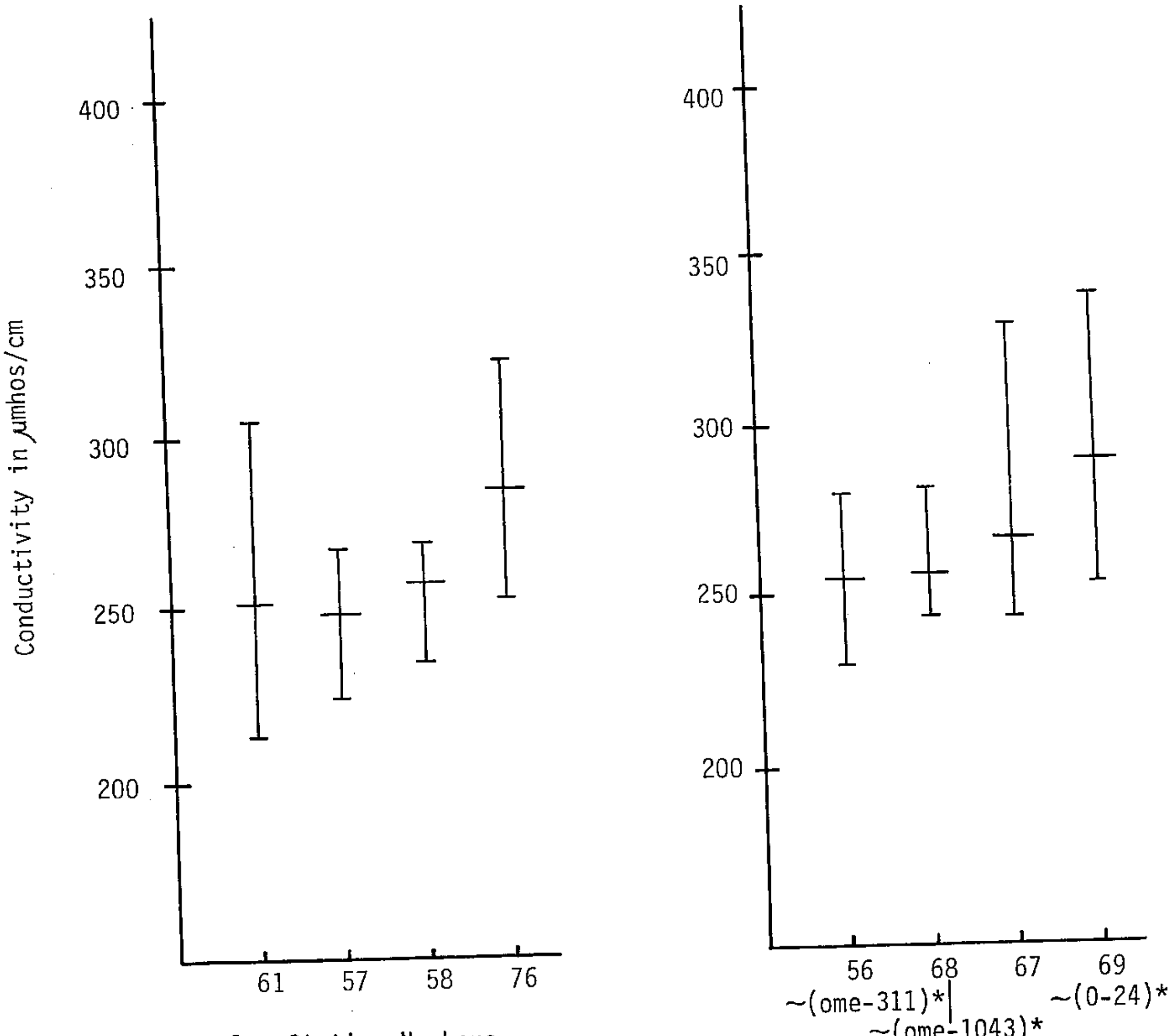
* Master Plan Station Numbers

FIGURE C-61.
1974 North Nearshore Conductivity



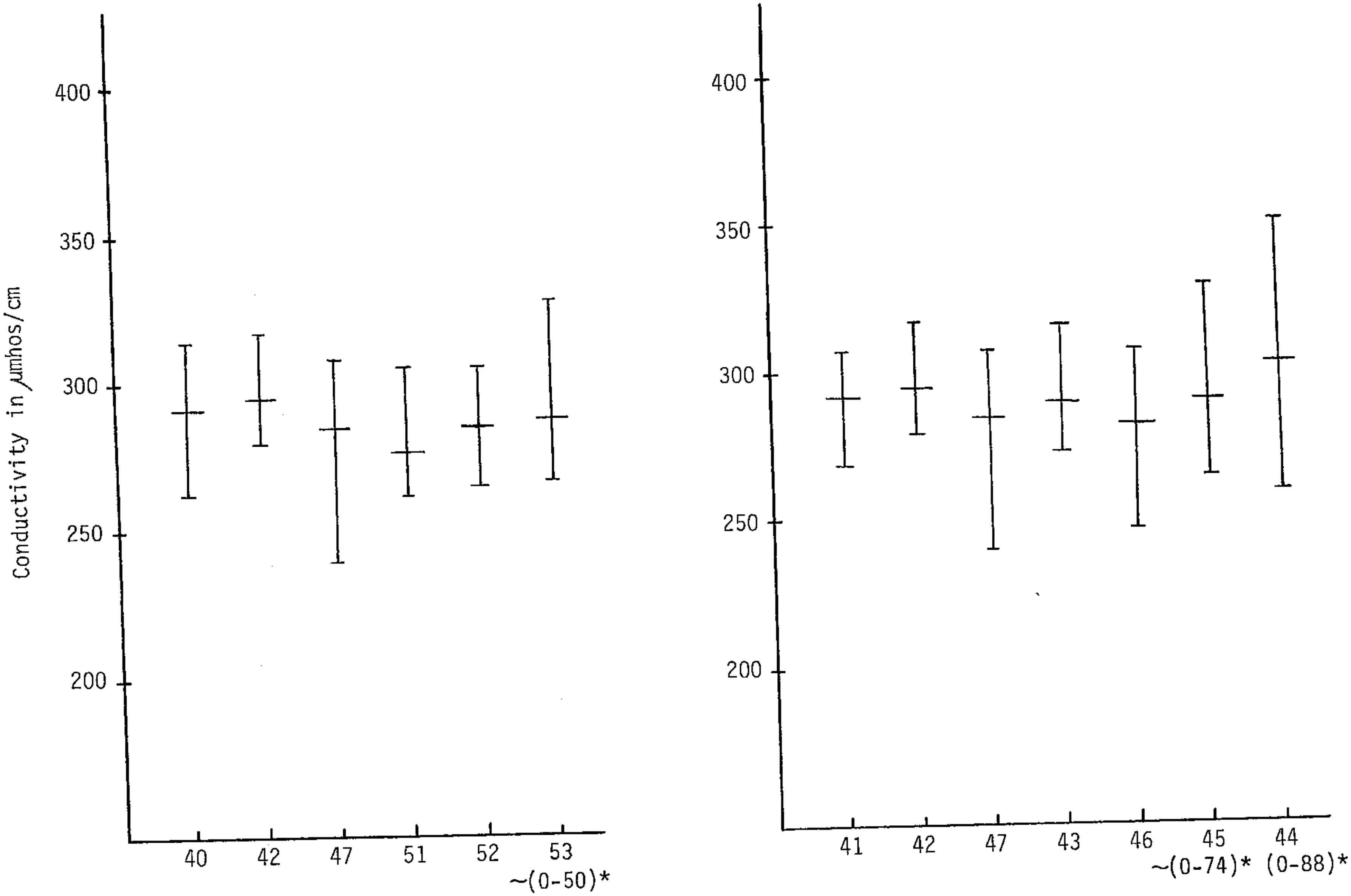
* Master Plan Station Numbers

FIGURE C-62.
1974 Western Basin Transects - Conductivity



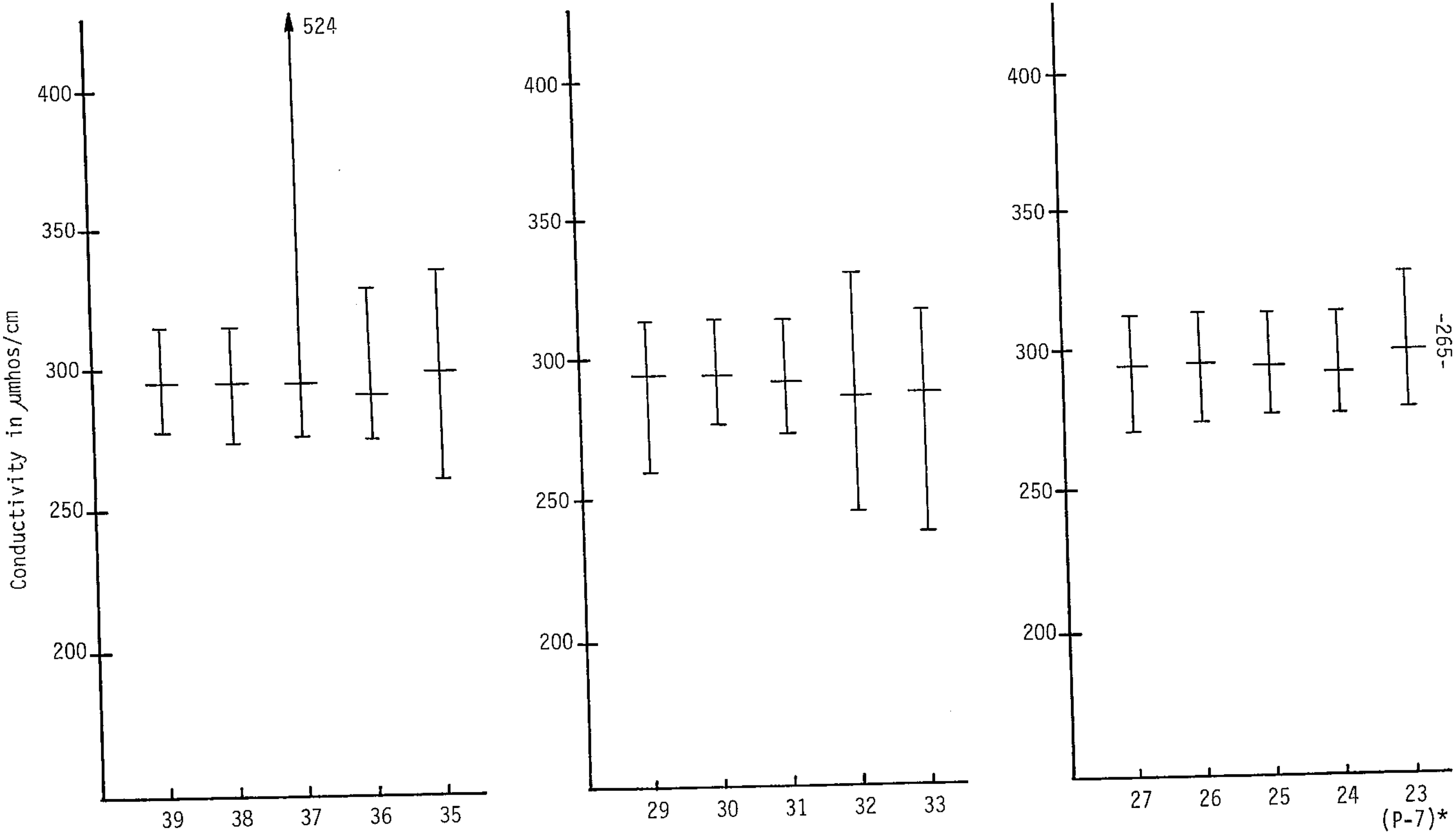
* Master Plan Station Numbers

FIGURE C-63.
1974 West Central Basin Transects - Conductivity



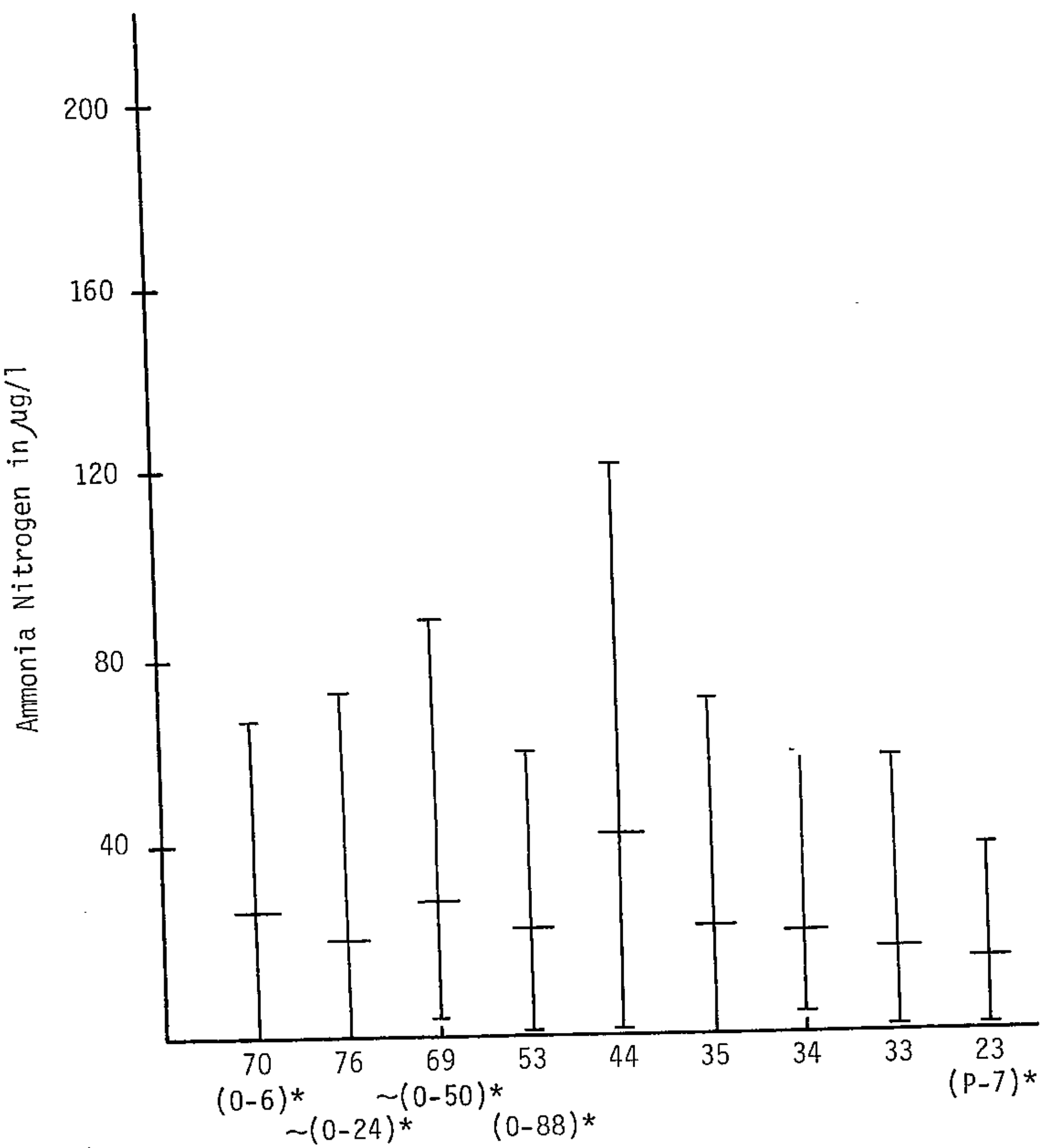
* Master Plan Station Numbers

FIGURE C-64.
1974 East Central Basin Transects - Conductivity



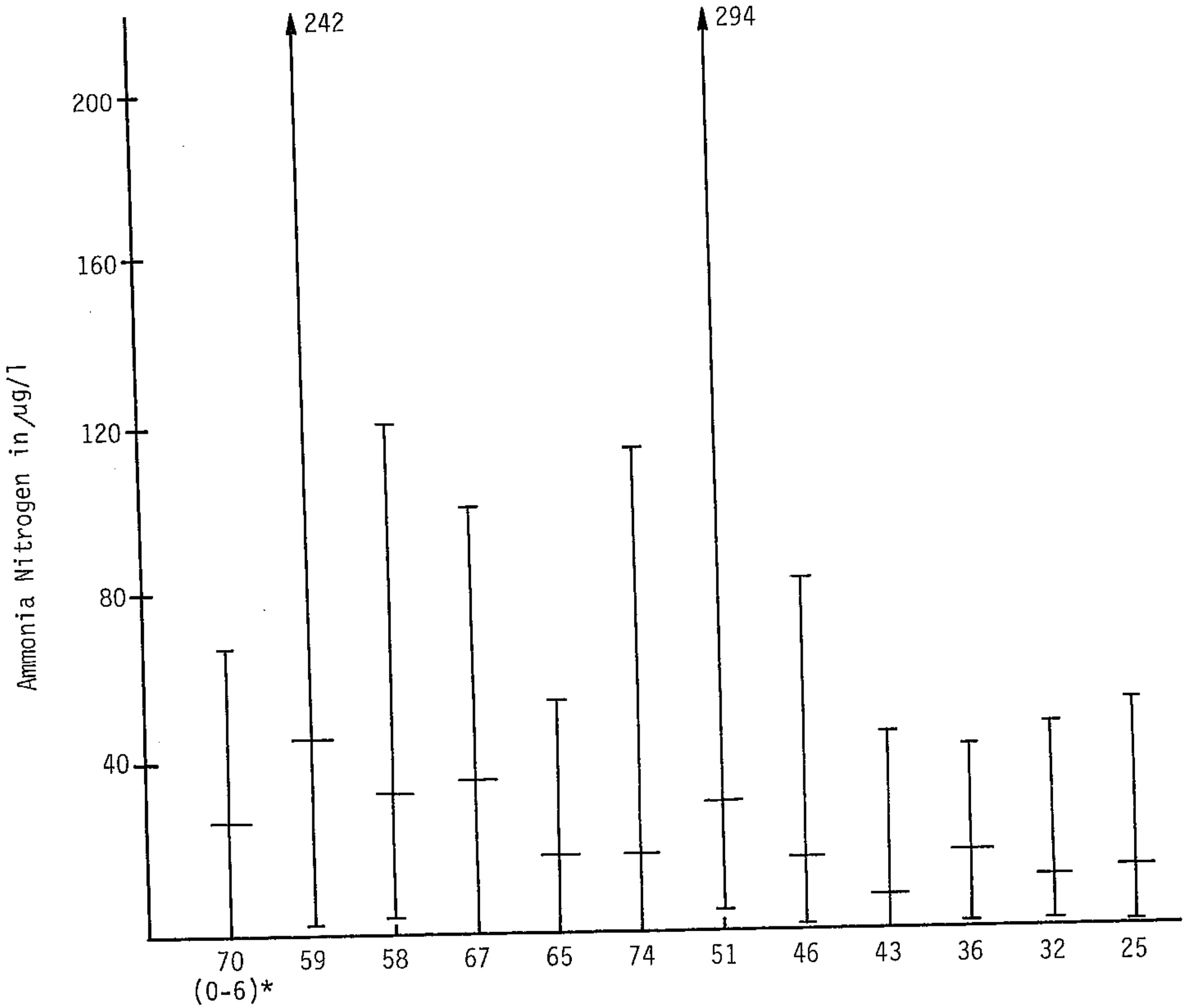
* Master Plan Station Numbers

FIGURE C-65.
1974 South Nearshore Ammonia Nitrogen



* Master Plan Station Numbers

FIGURE C-66.
1974 South Offshore Ammonia Nitrogen



* Master Plan Station Numbers

FIGURE C-67.
1974 North Offshore Ammonia Nitrogen

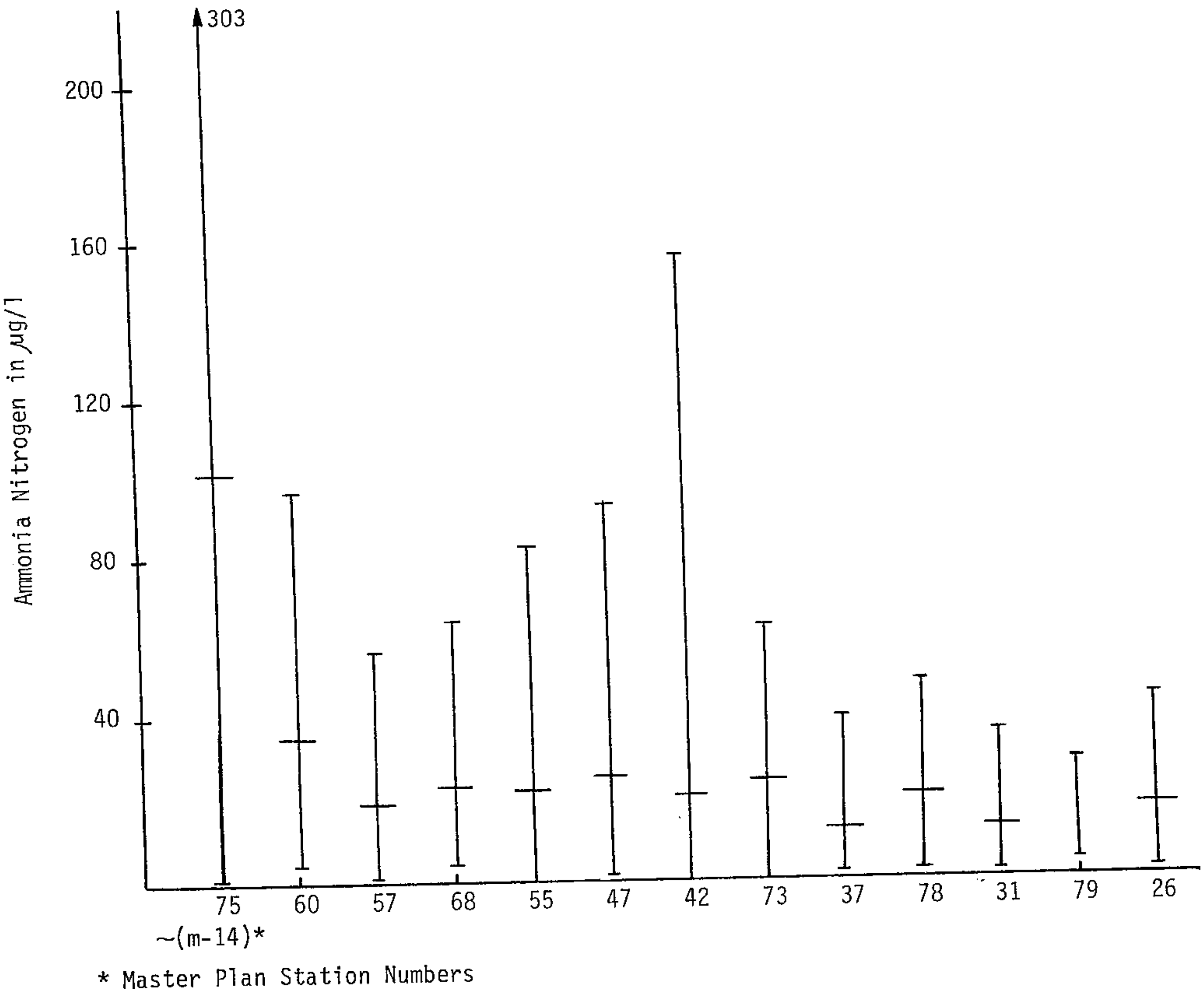
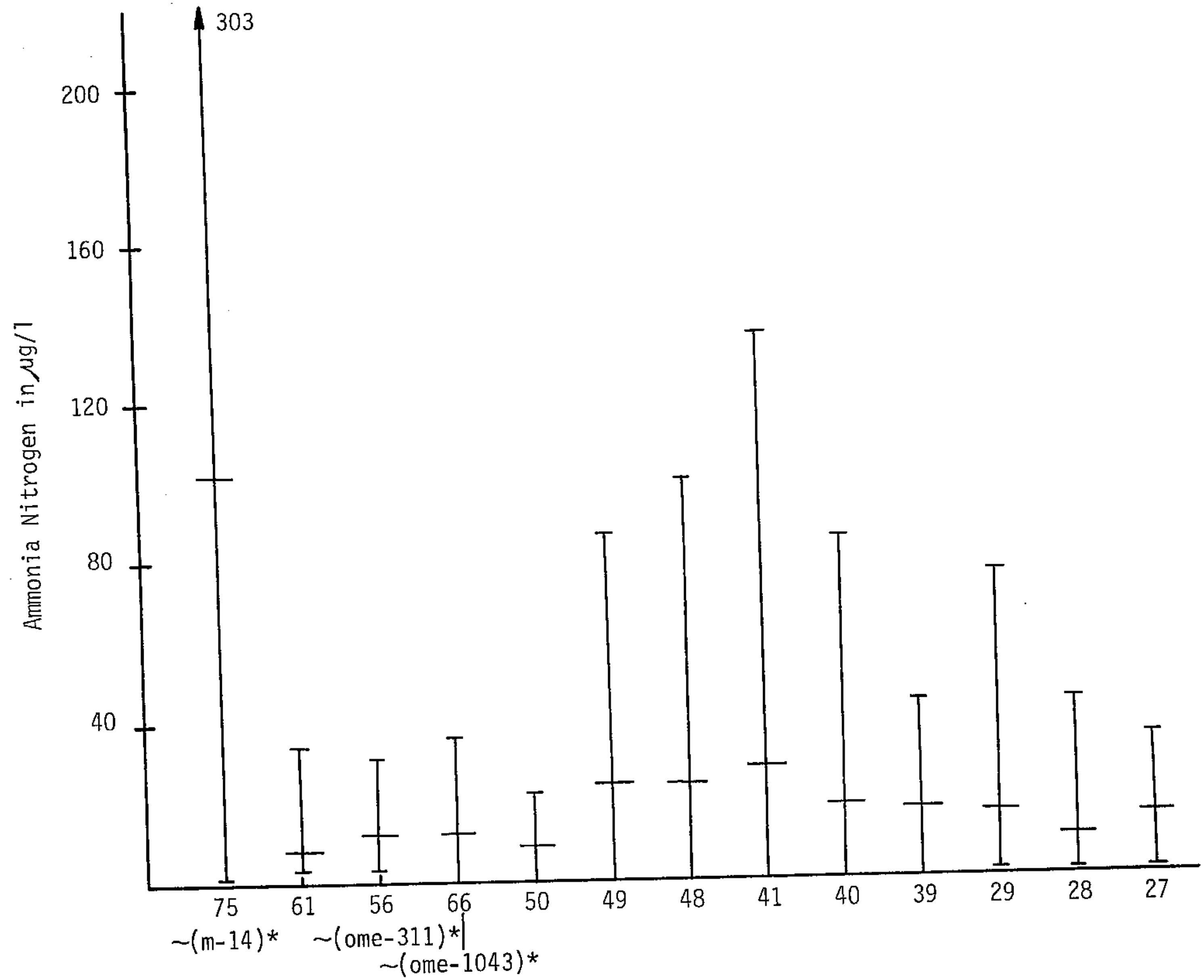


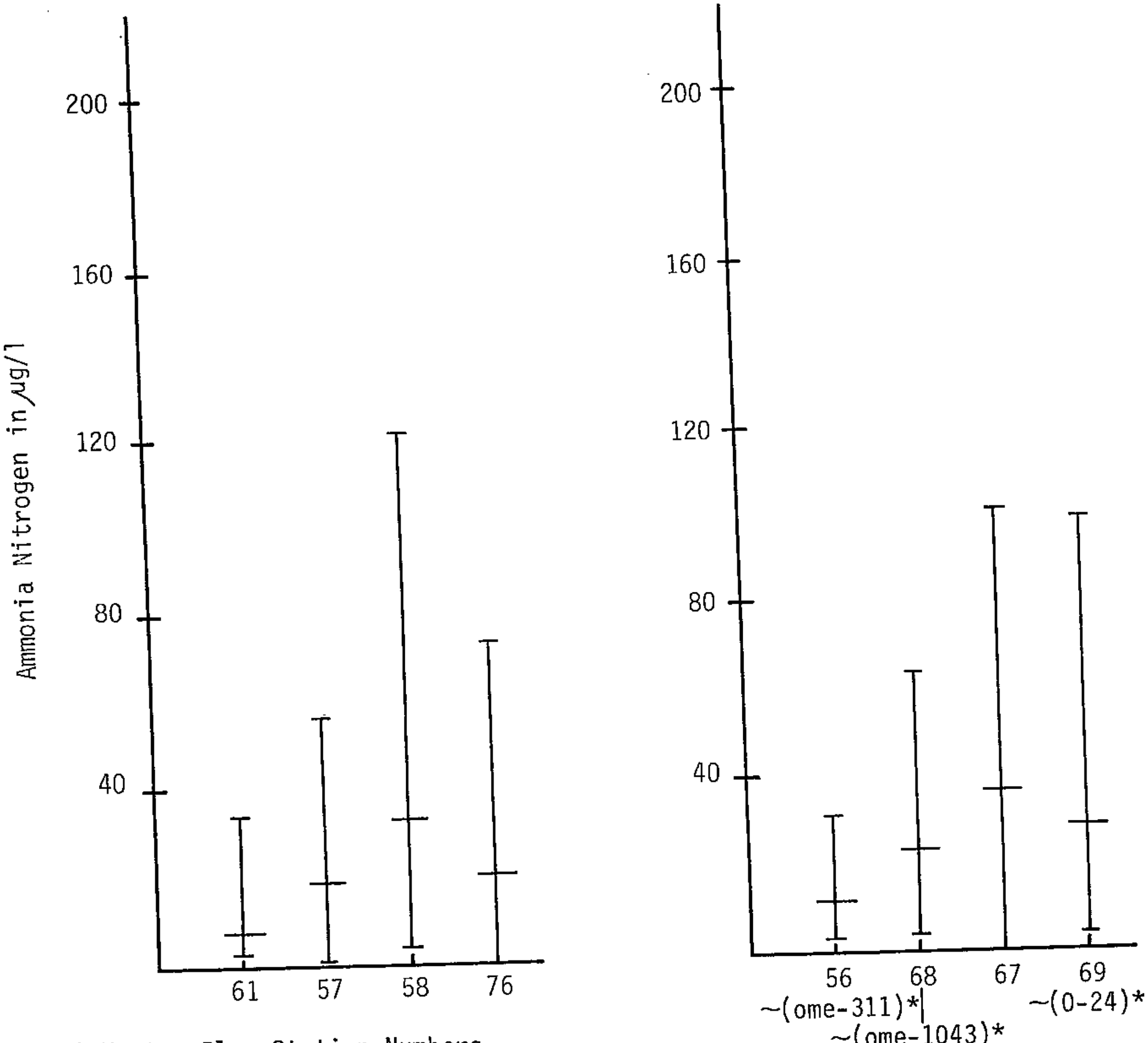
FIGURE C-68.
1974 North Nearshore Ammonia Nitrogen



* Master Plan Station Numbers

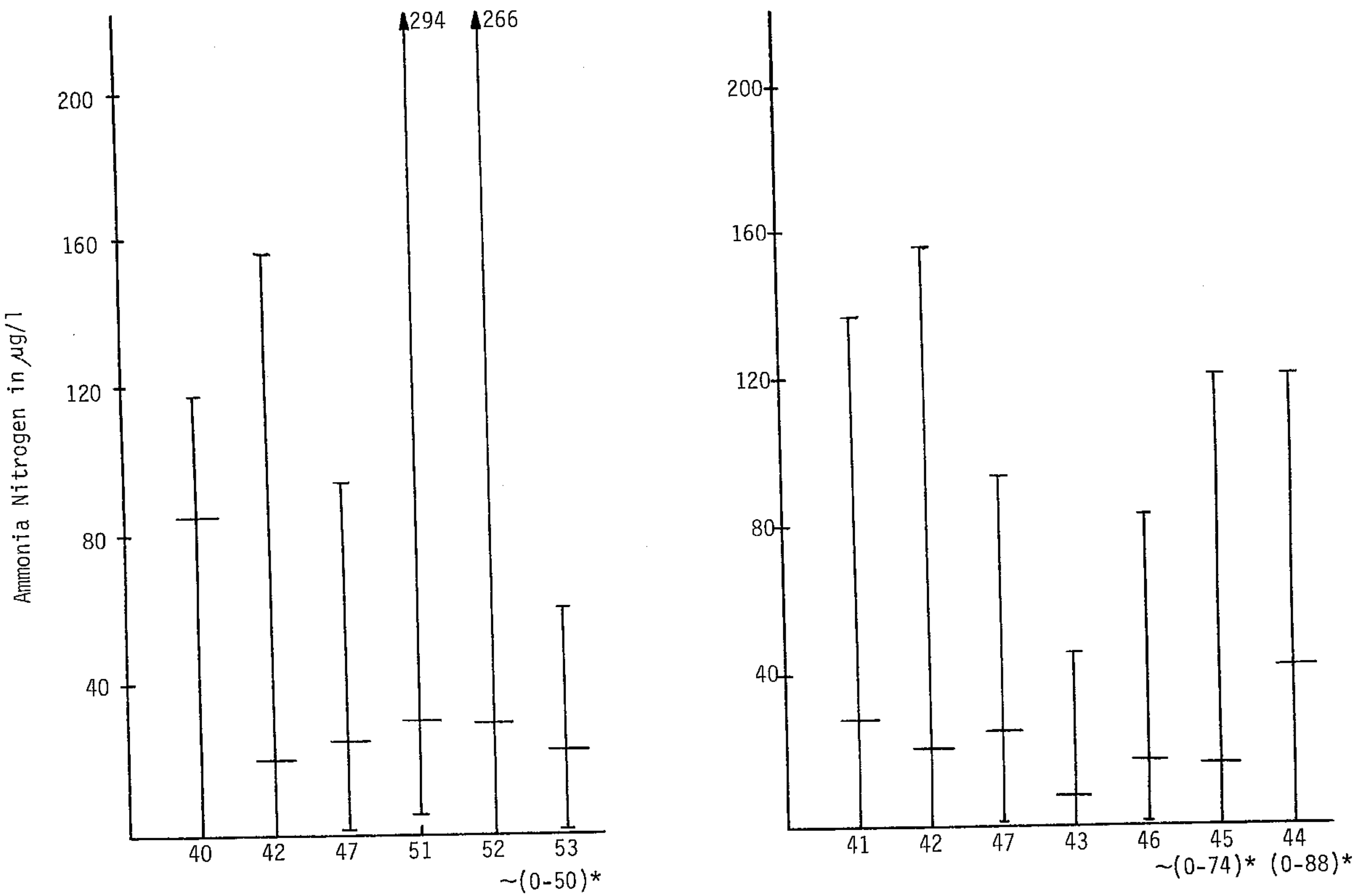
FIGURE C-69.

1974 Western Basin Transects - Ammonia Nitrogen



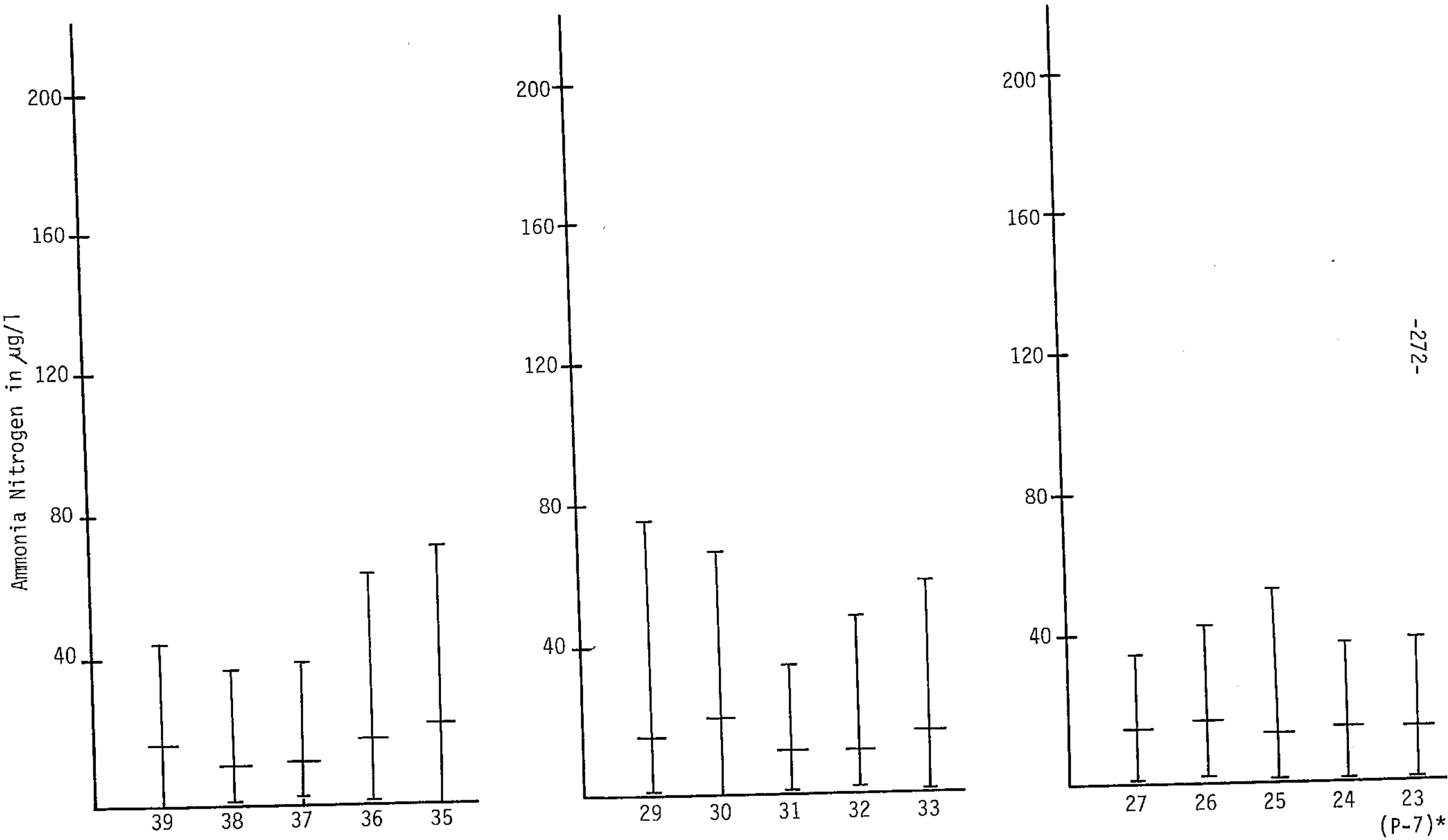
* Master Plan Station Numbers

FIGURE C-70.
1974 West Central Basin Transects - Ammonia Nitrogen



* Master Plan Station Numbers

FIGURE C-71.
1974 East Central Basin Transects - Ammonia Nitrogen



* Master Plan Station Numbers

FIGURE C-72.
1974 South Nearshore Dissolved Phosphorus

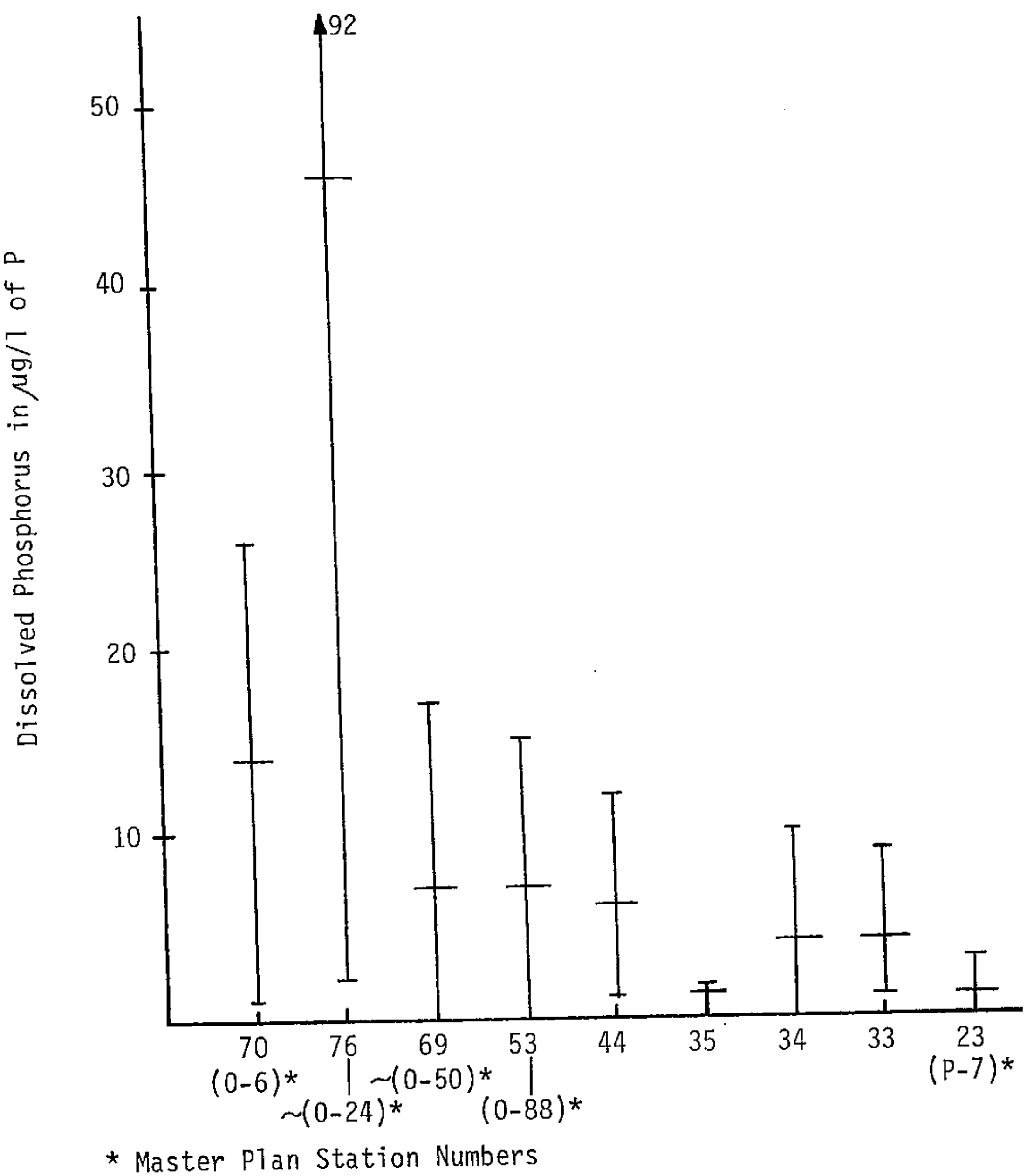
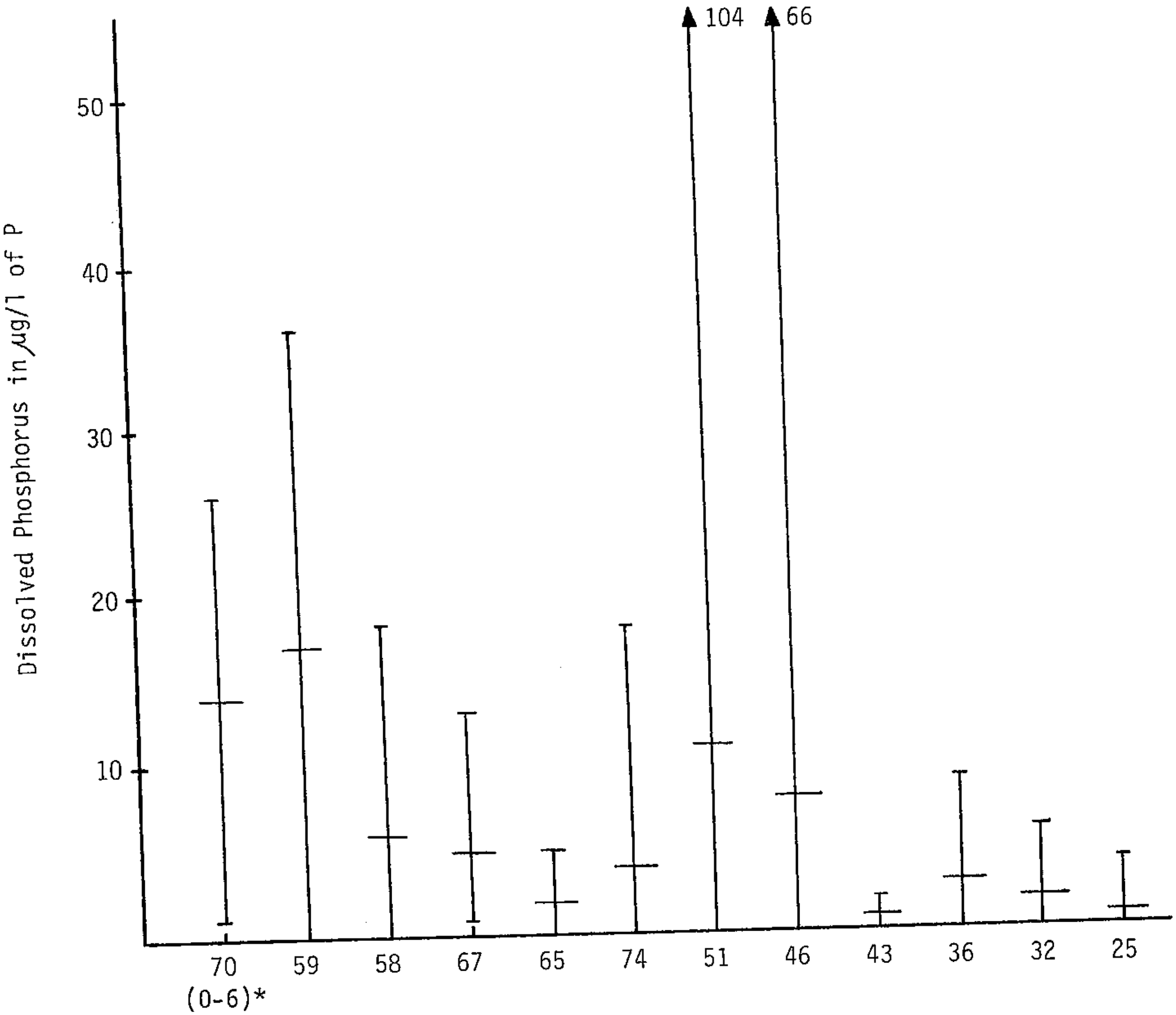
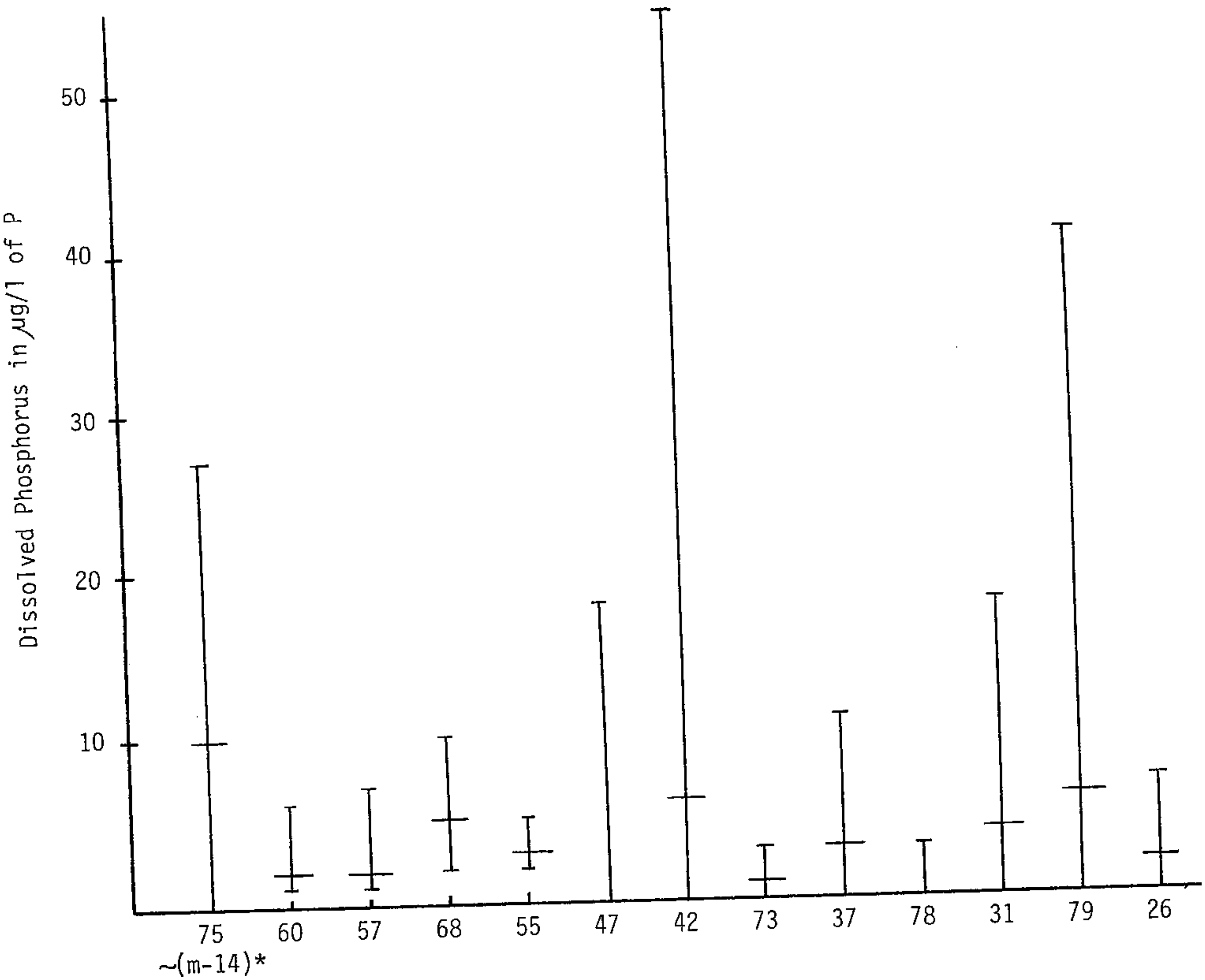


FIGURE C-73.
1974 South Offshore Dissolved Phosphorus



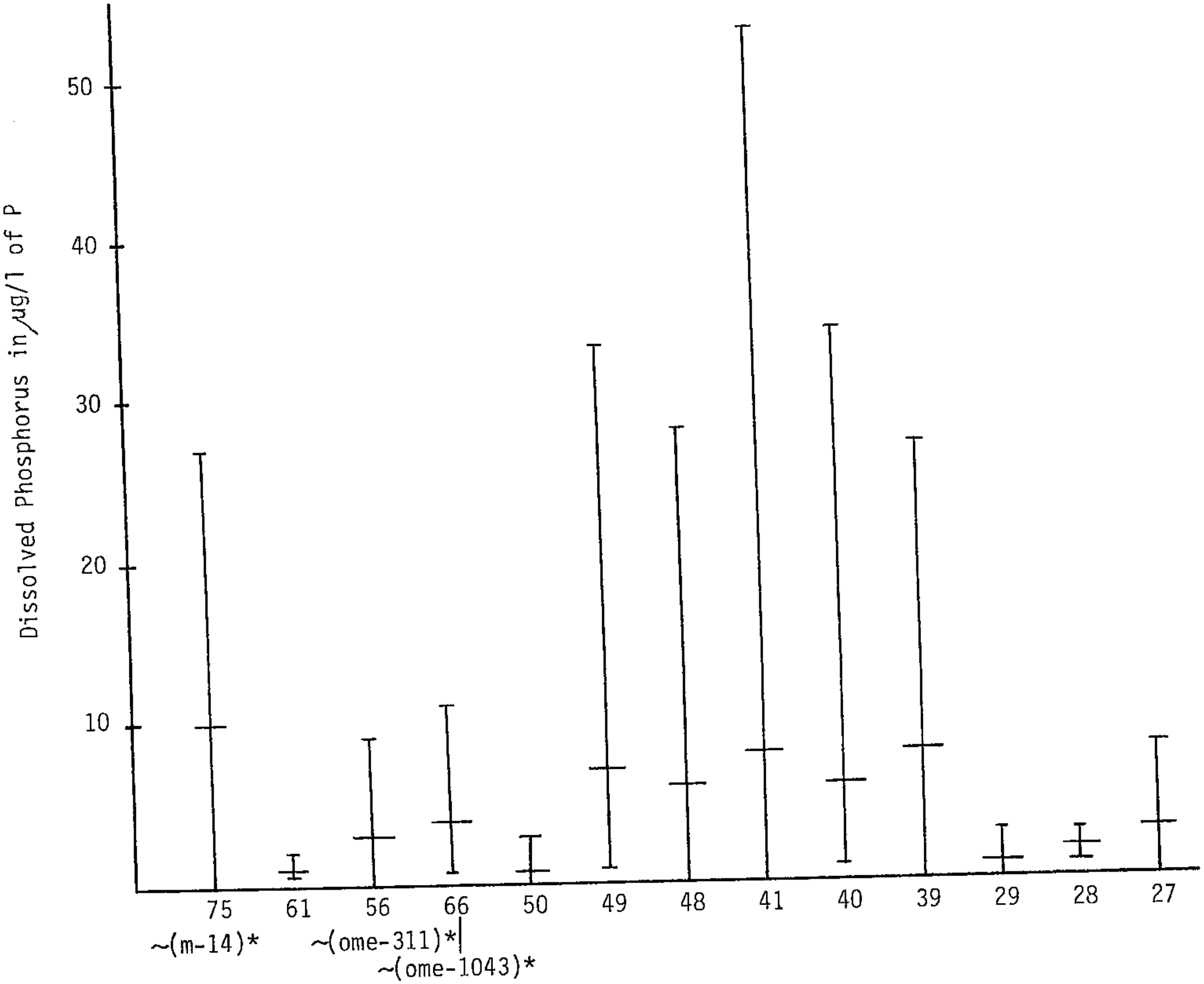
* Master Plan Station Numbers

FIGURE C-74.
1974 North Offshore Dissolved Phosphorus



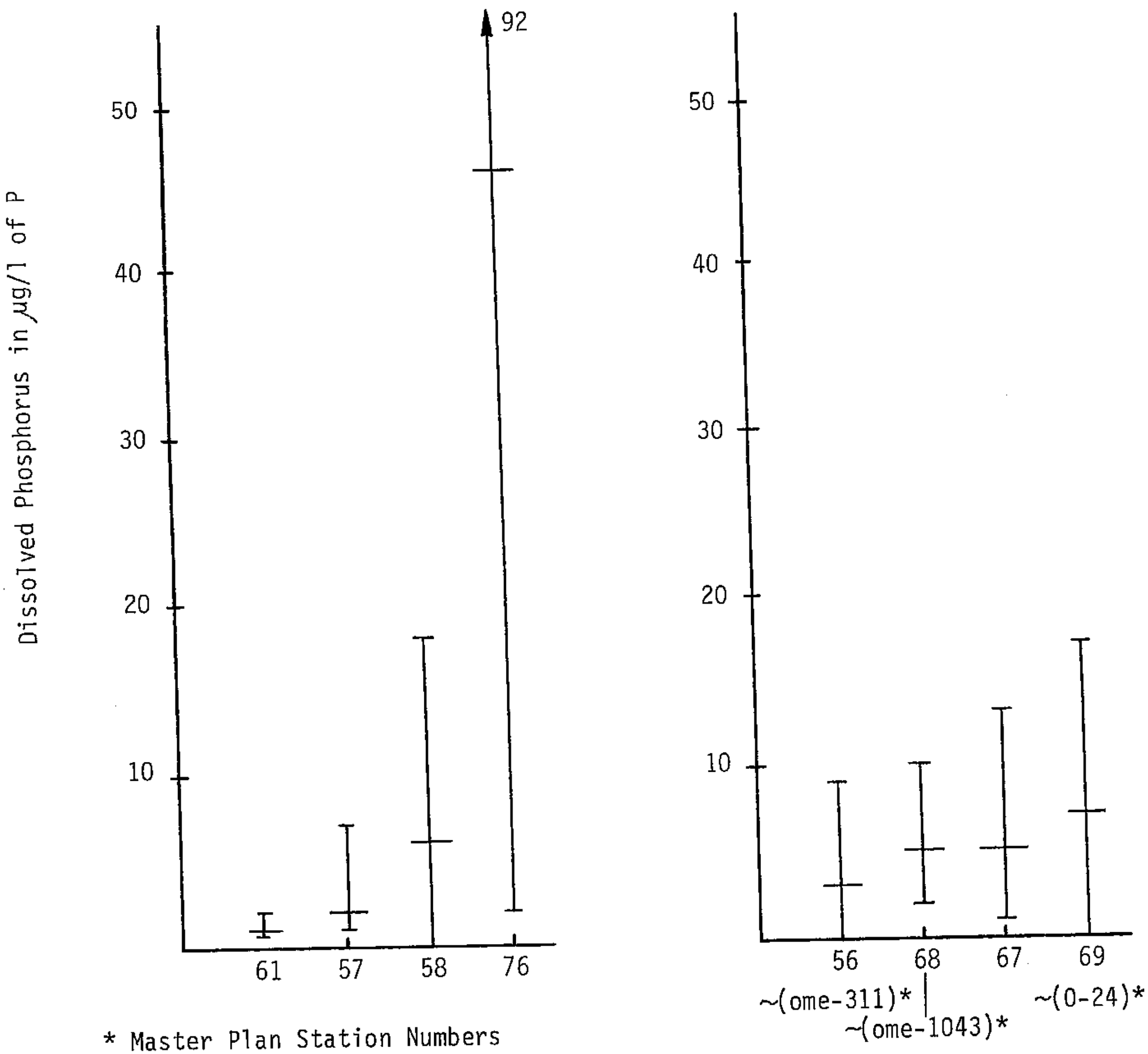
* Master Plan Station Numbers

FIGURE C-75.
1974 North Nearshore Dissolved Phosphorus



* Master Plan Station Numbers

FIGURE C-76.
1974 Western Basin Transects - Dissolved Phosphorus



* Master Plan Station Numbers

FIGURE C-77.
1974 West Central Basin Transects - Dissolved Phosphorus

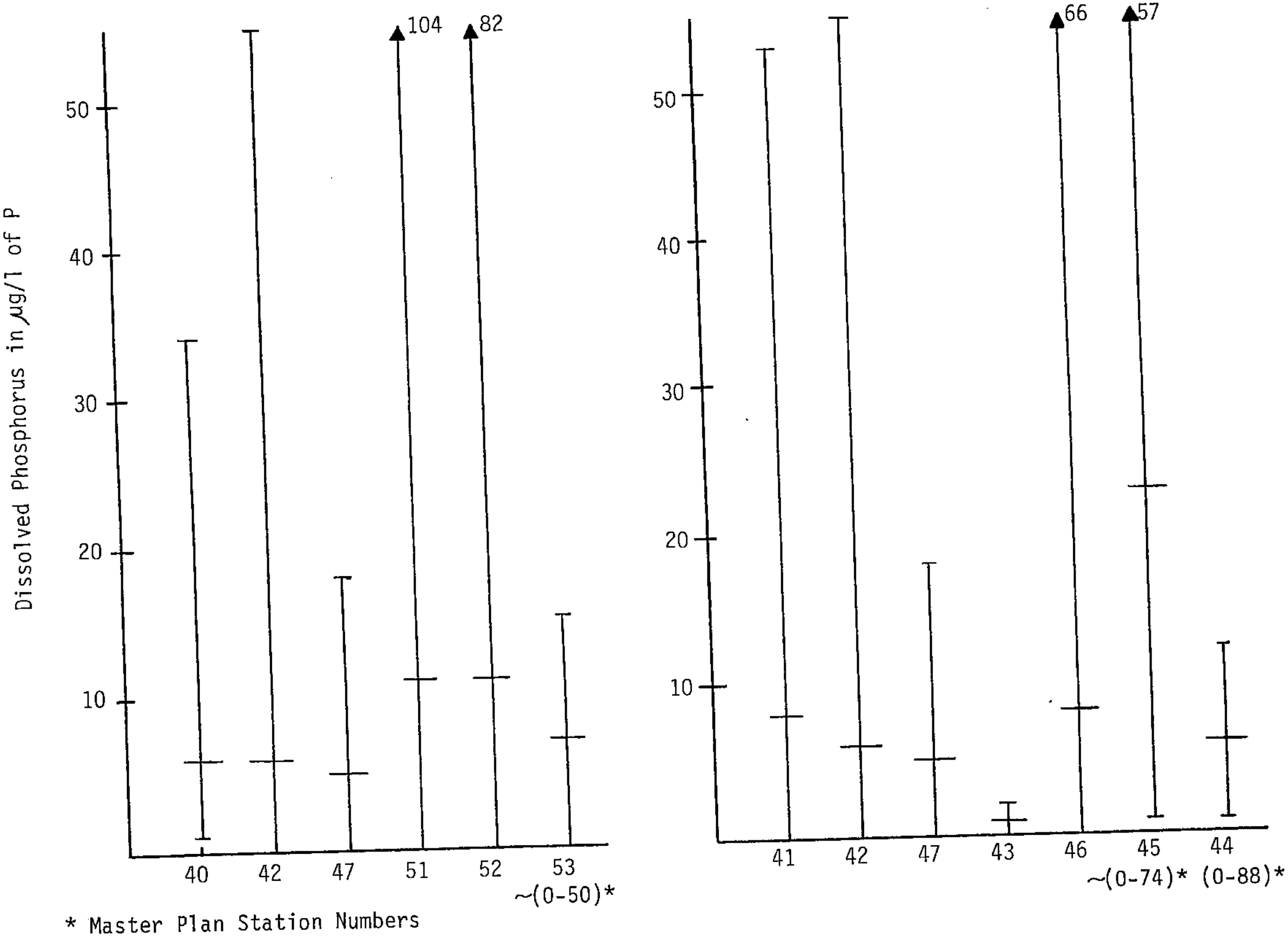
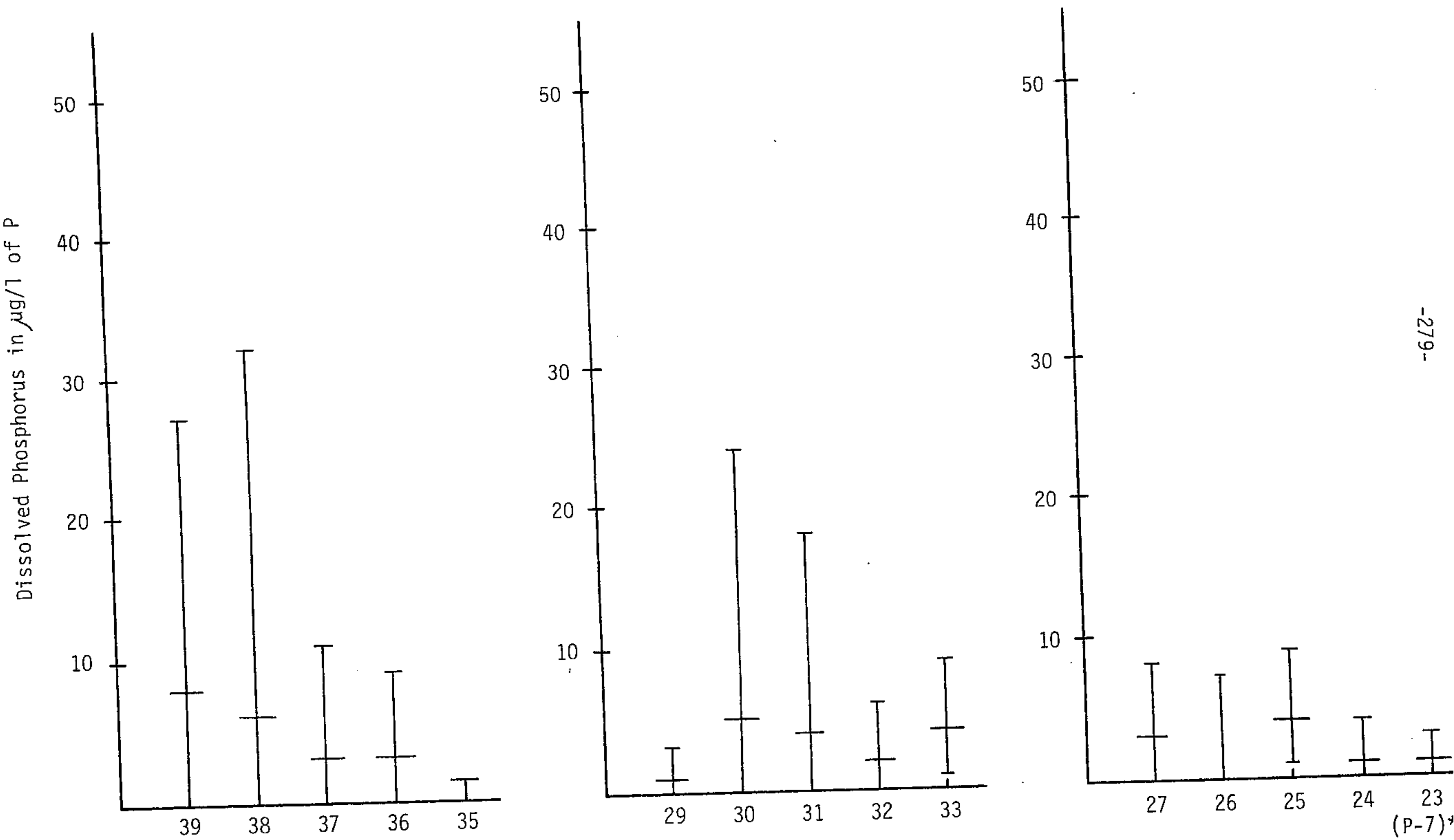


FIGURE C-78.
1974 East Central Basin Transects - Dissolved Phosphorus



* Master Plan Station Numbers

FIGURE C-79.
1974 South Nearshore Total Phosphorus

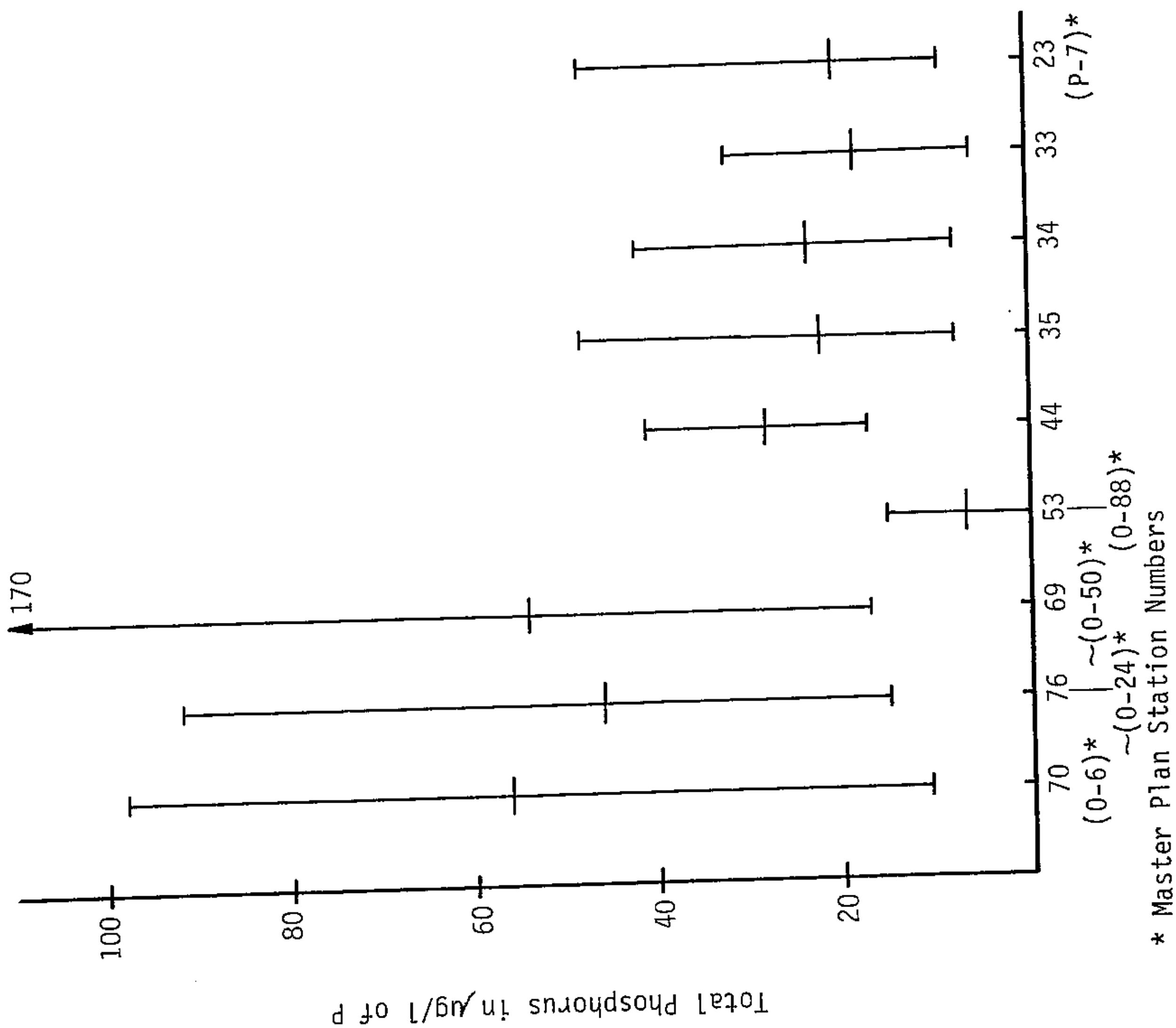


FIGURE C-80.
1974 South Offshore Total Phosphorus

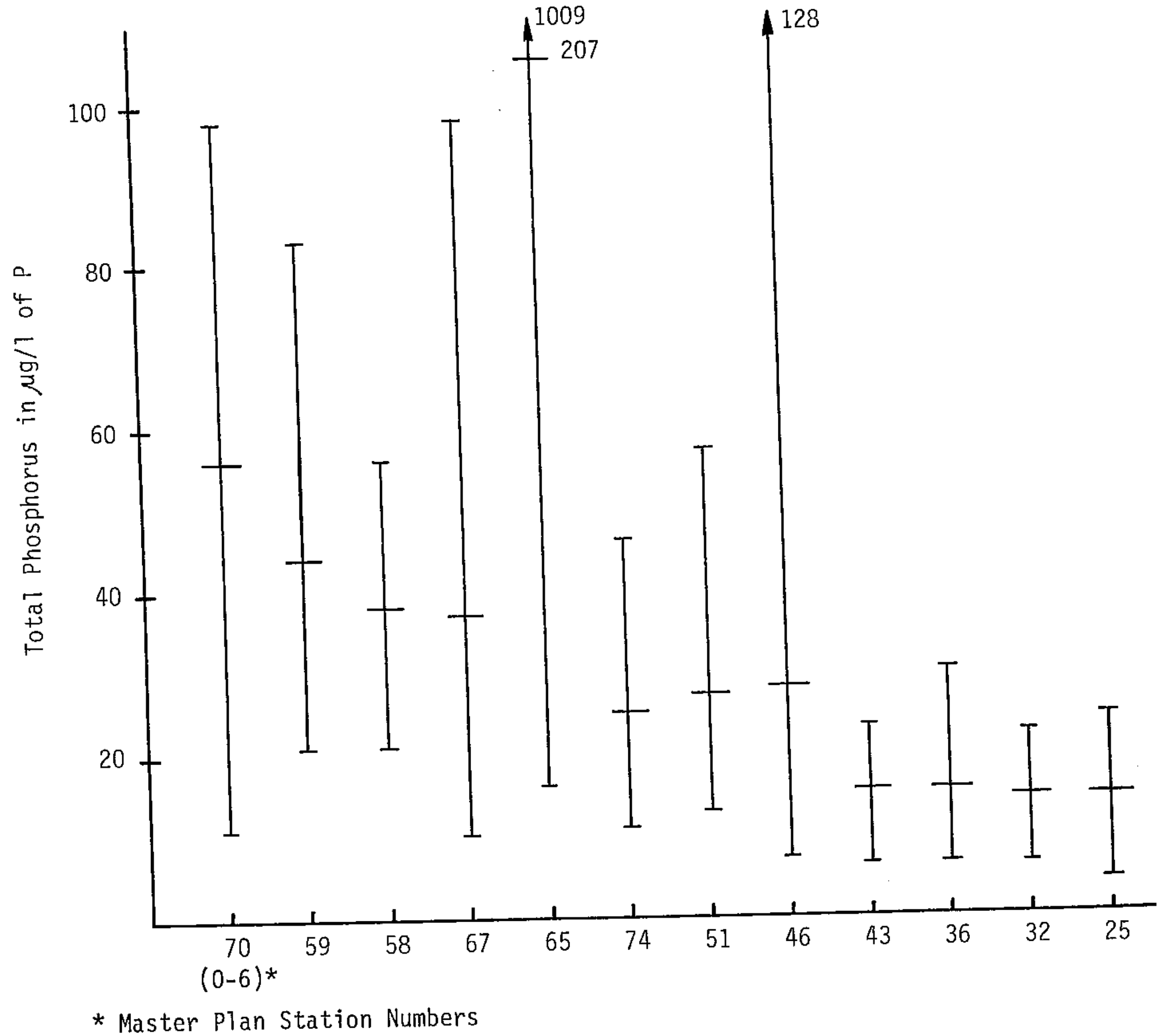


FIGURE C-81.
1974 North Offshore Total Phosphorus

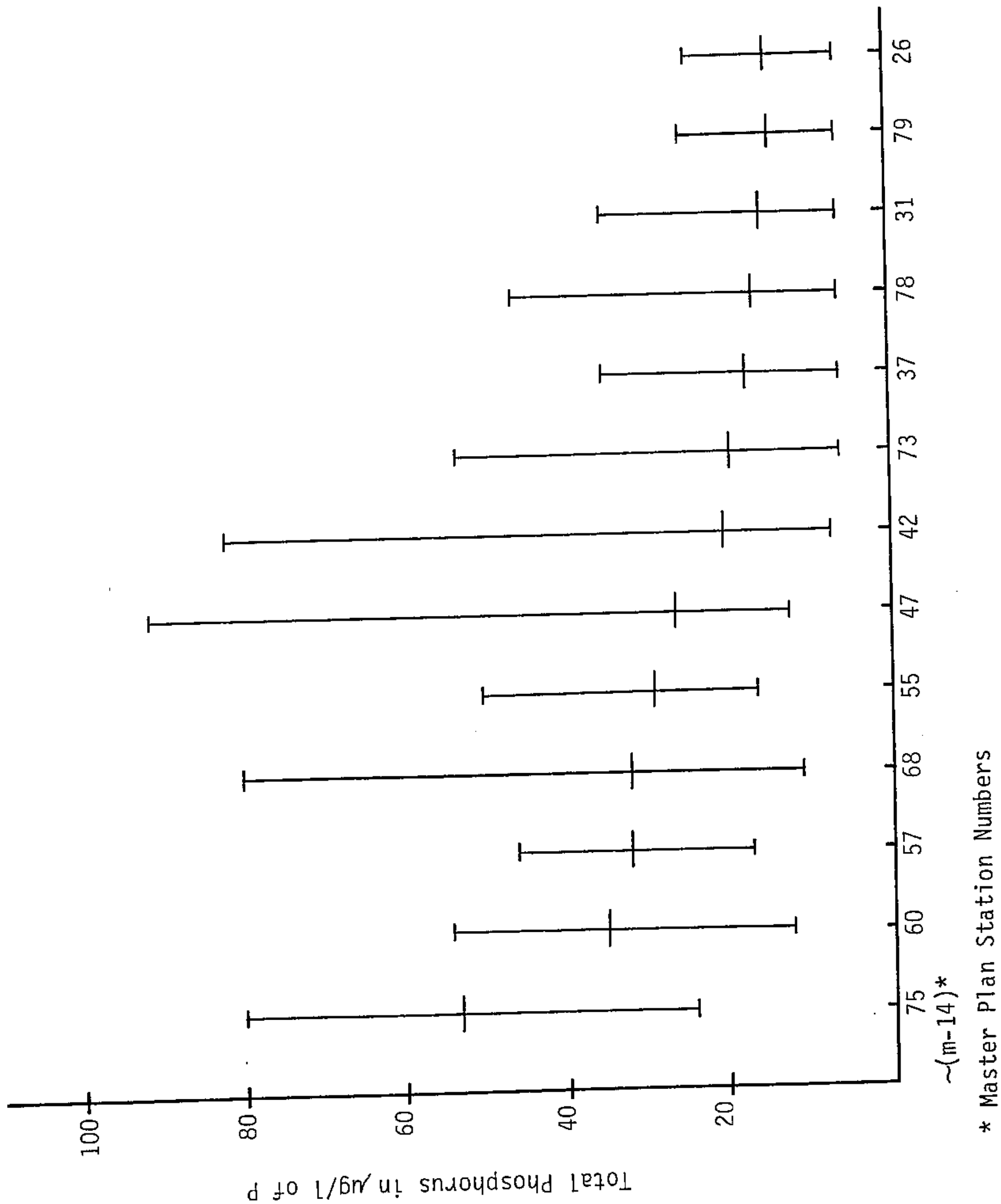
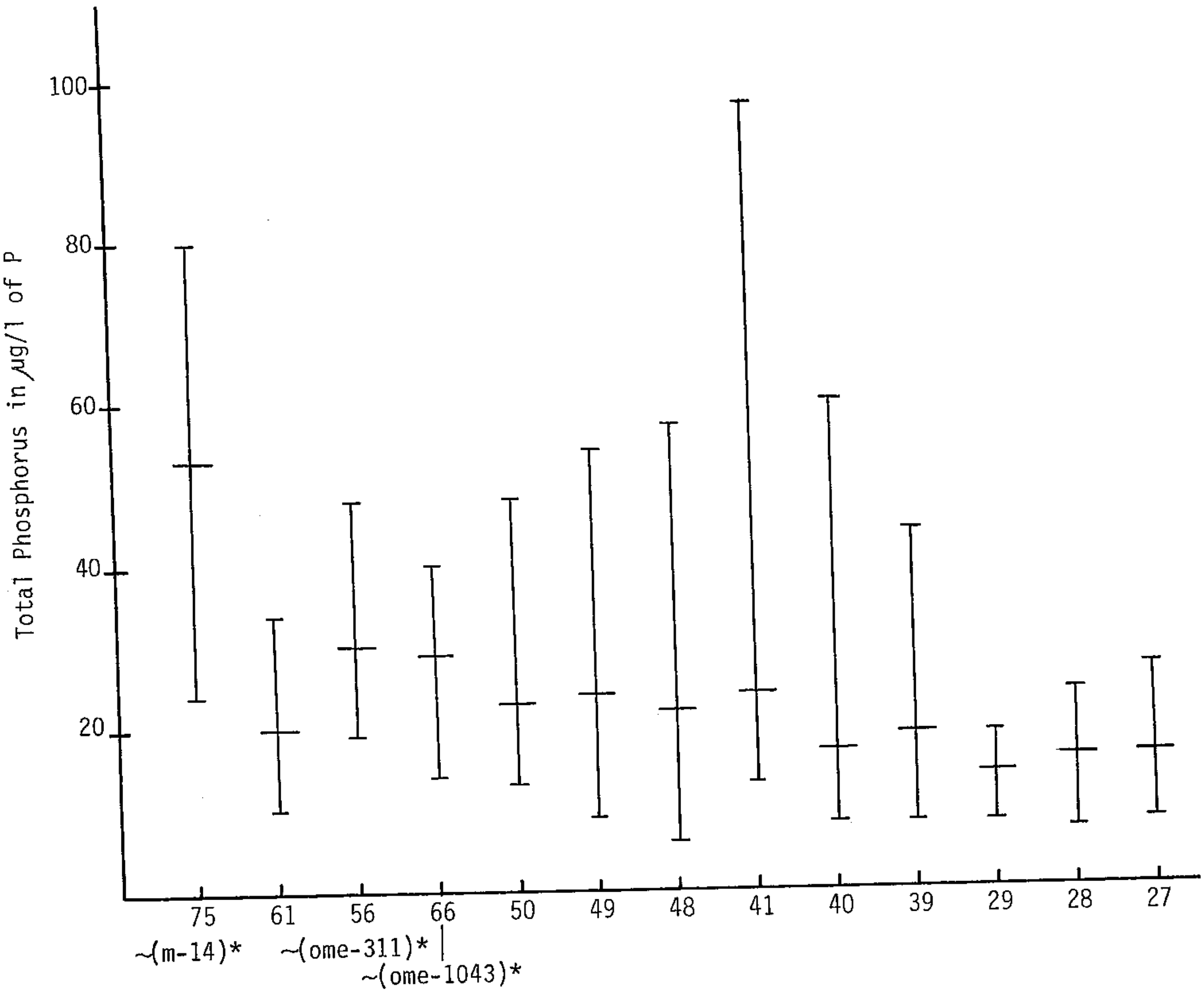


FIGURE C-82.
1974 North Nearshore Total Phosphorus



* Master Plan Station Numbers

FIGURE C-83.
1974 Western Basin Transects - Total Phosphorus

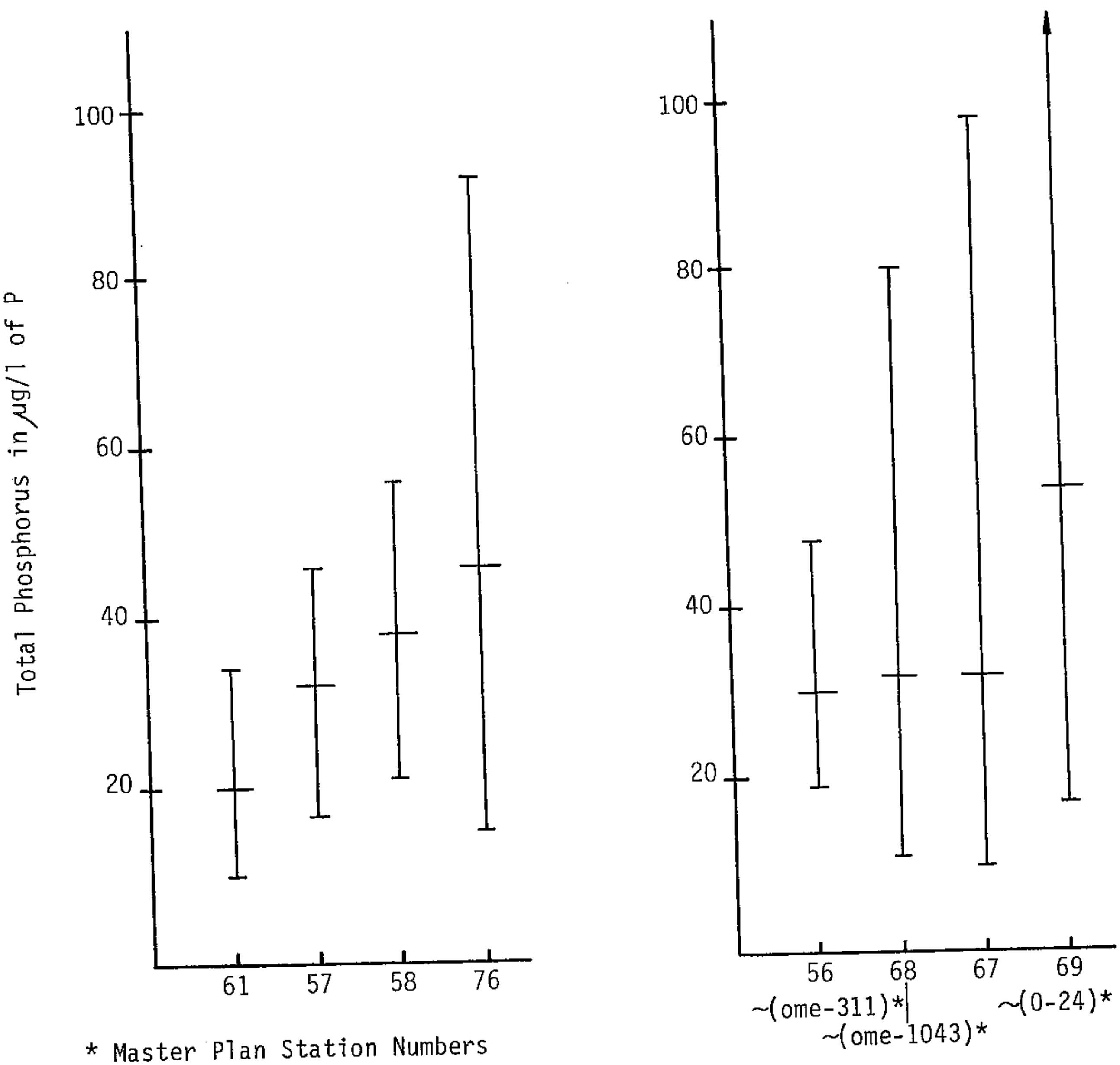
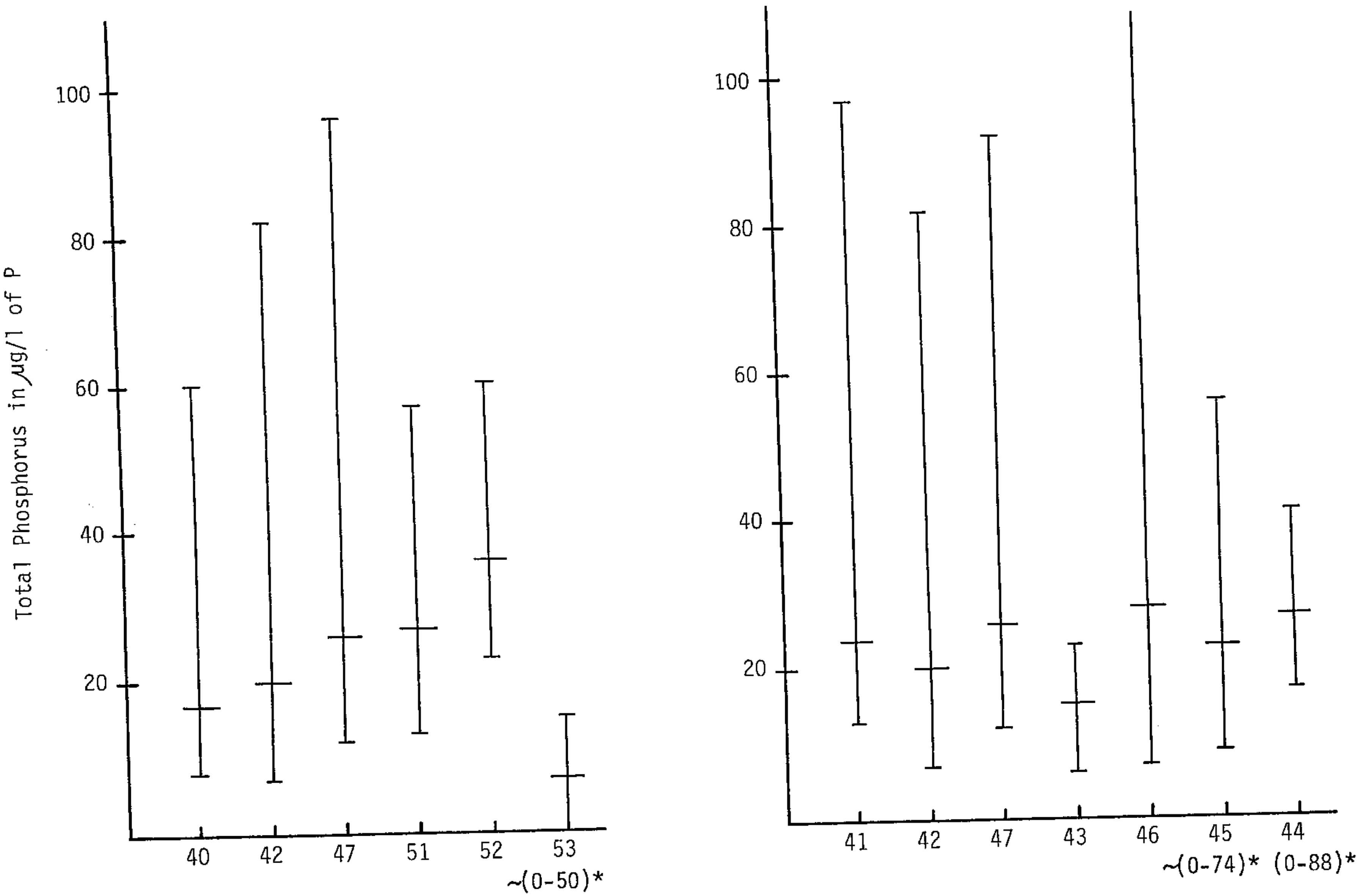
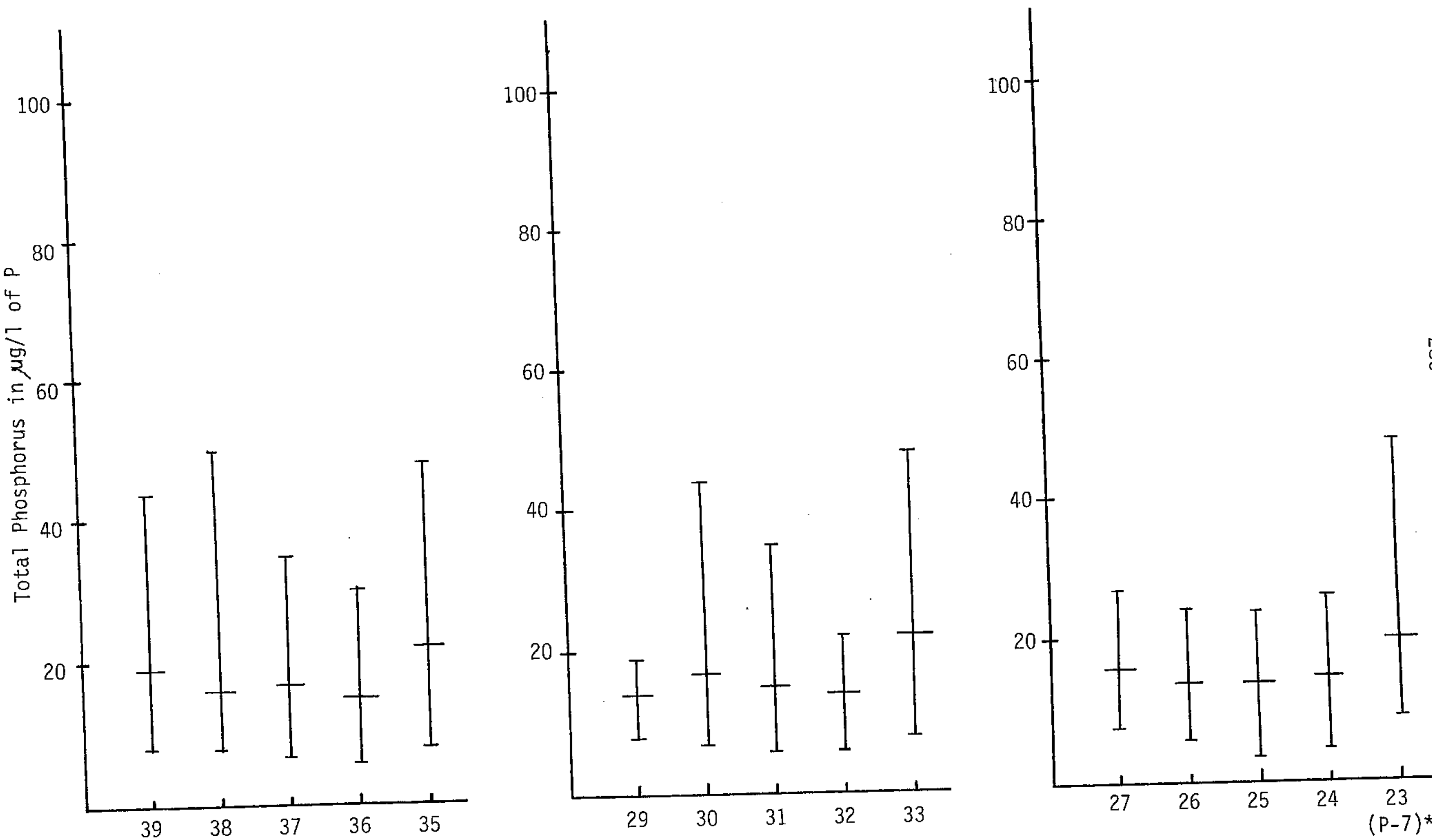


FIGURE C-84.
1974 West Central Basin Transects - Total Phosphorus



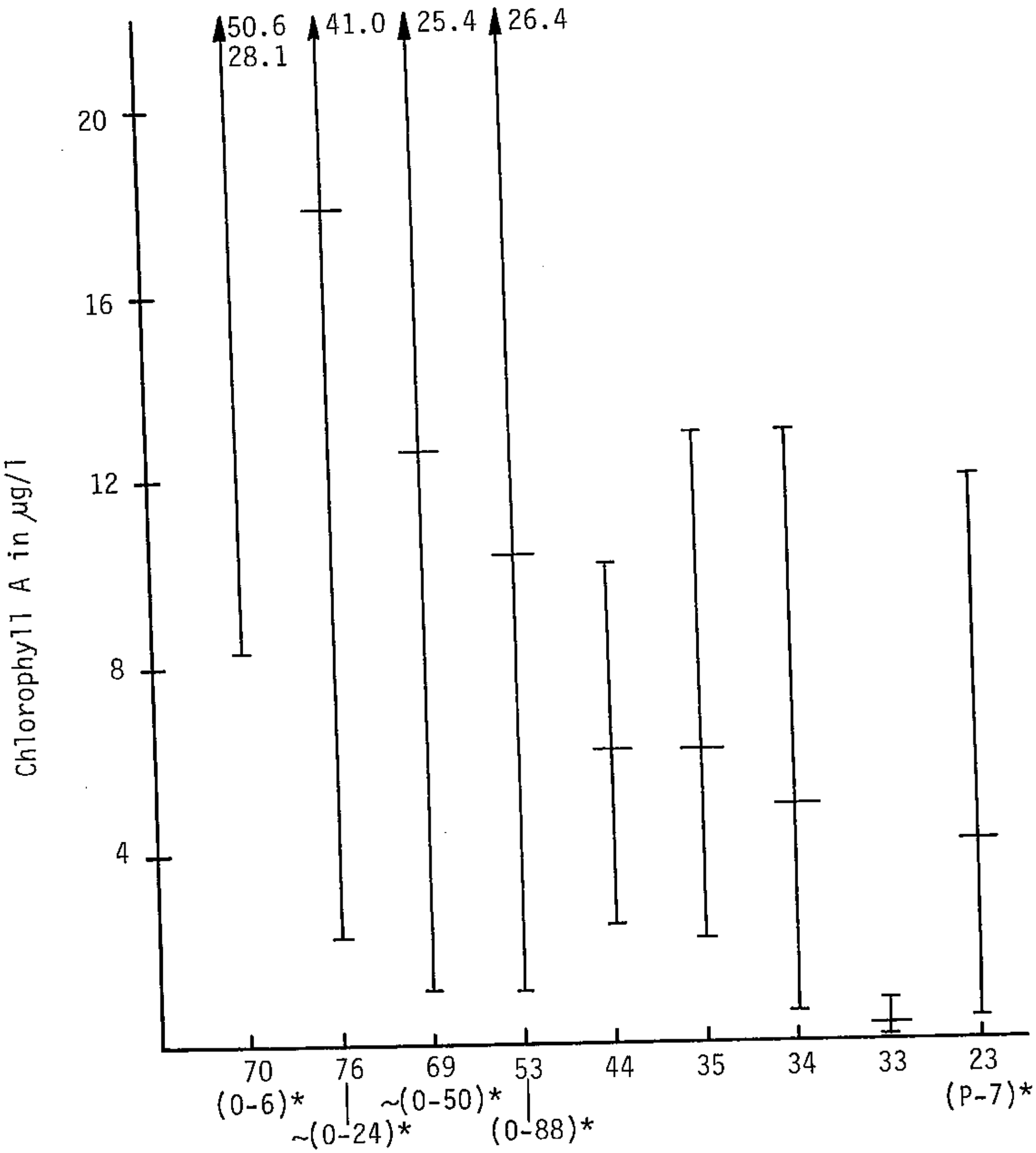
* Master Plan Station Numbers

FIGURE C-85.
1974 East Central Basin Transects - Total Phosphorus



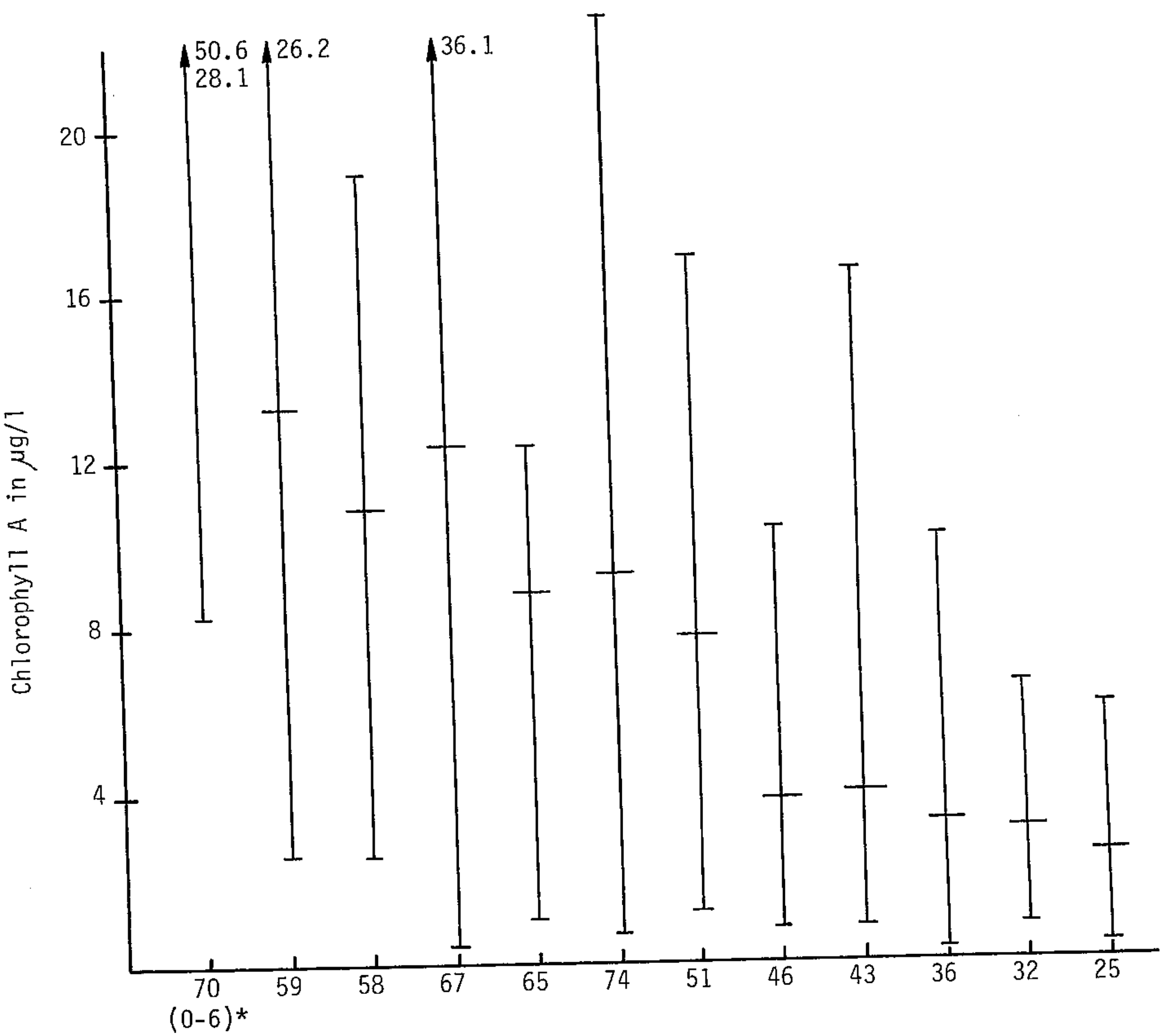
* Master Plan Station Numbers

FIGURE C-86.
1974 South Nearshore Chlorophyll A



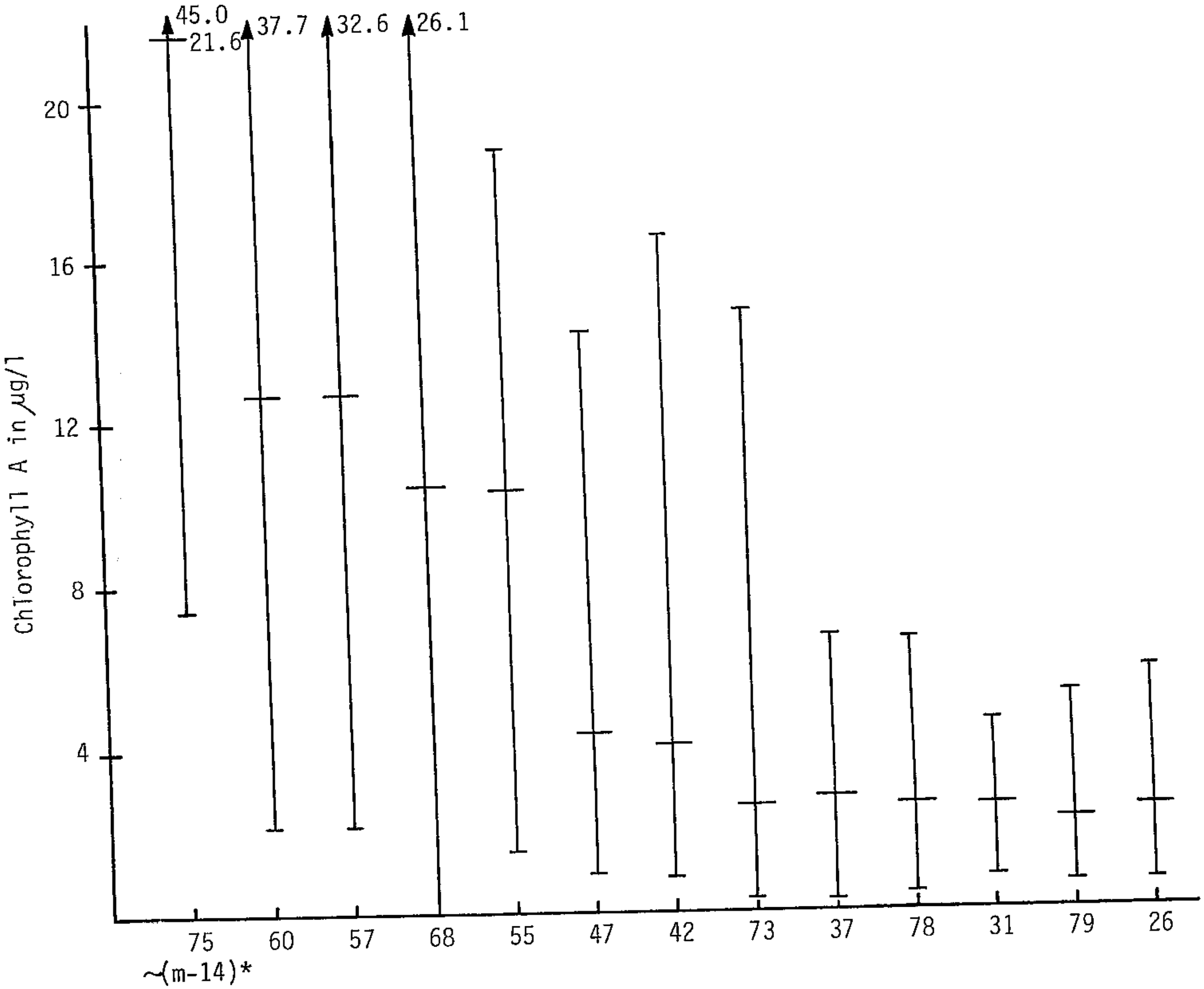
* Master Plan Station Numbers

FIGURE C-87.
1974 South Offshore Chlorophyll A



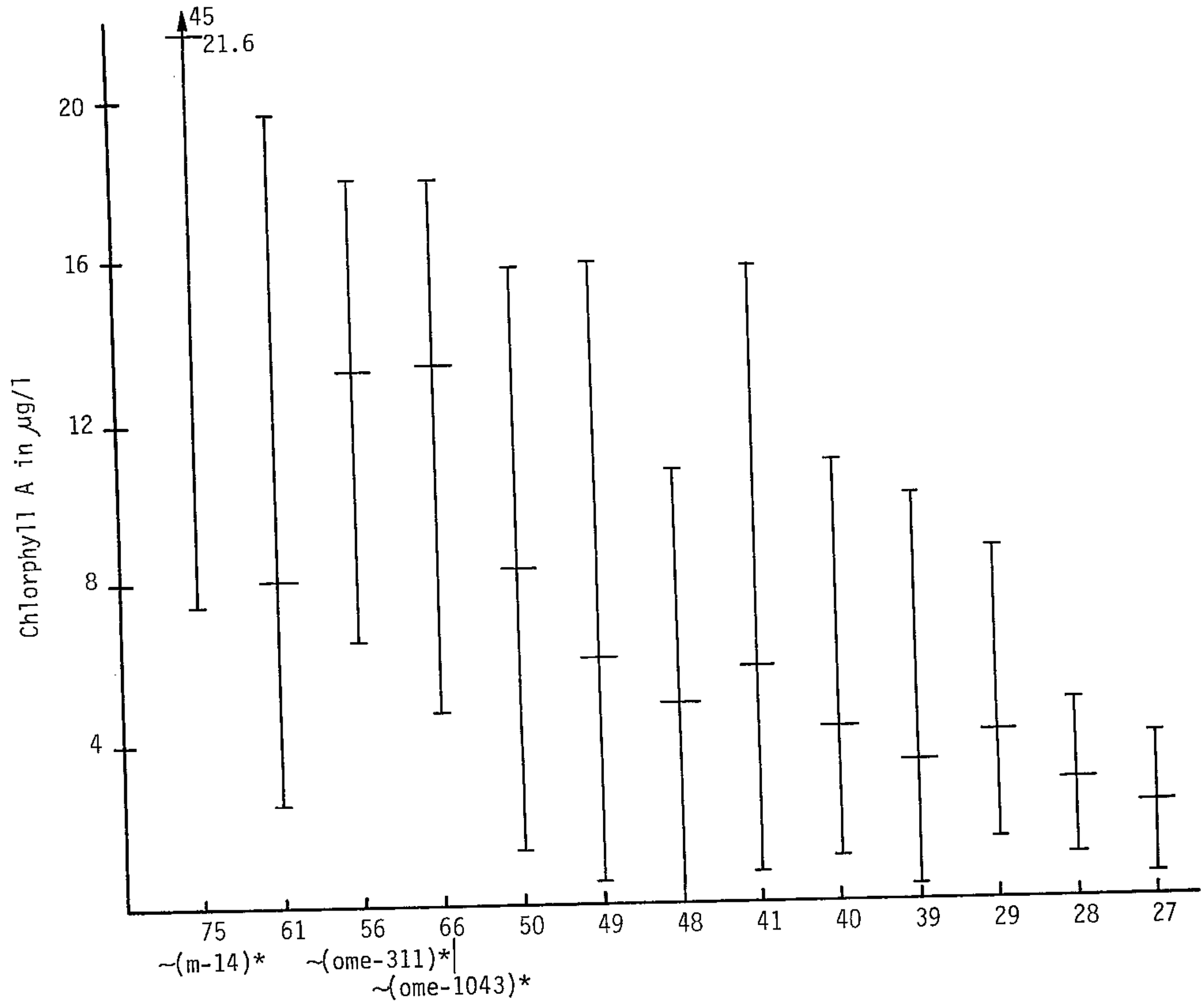
* Master Plan Station Numbers

FIGURE C-88.
1974 North Offshore Chlorophyll A



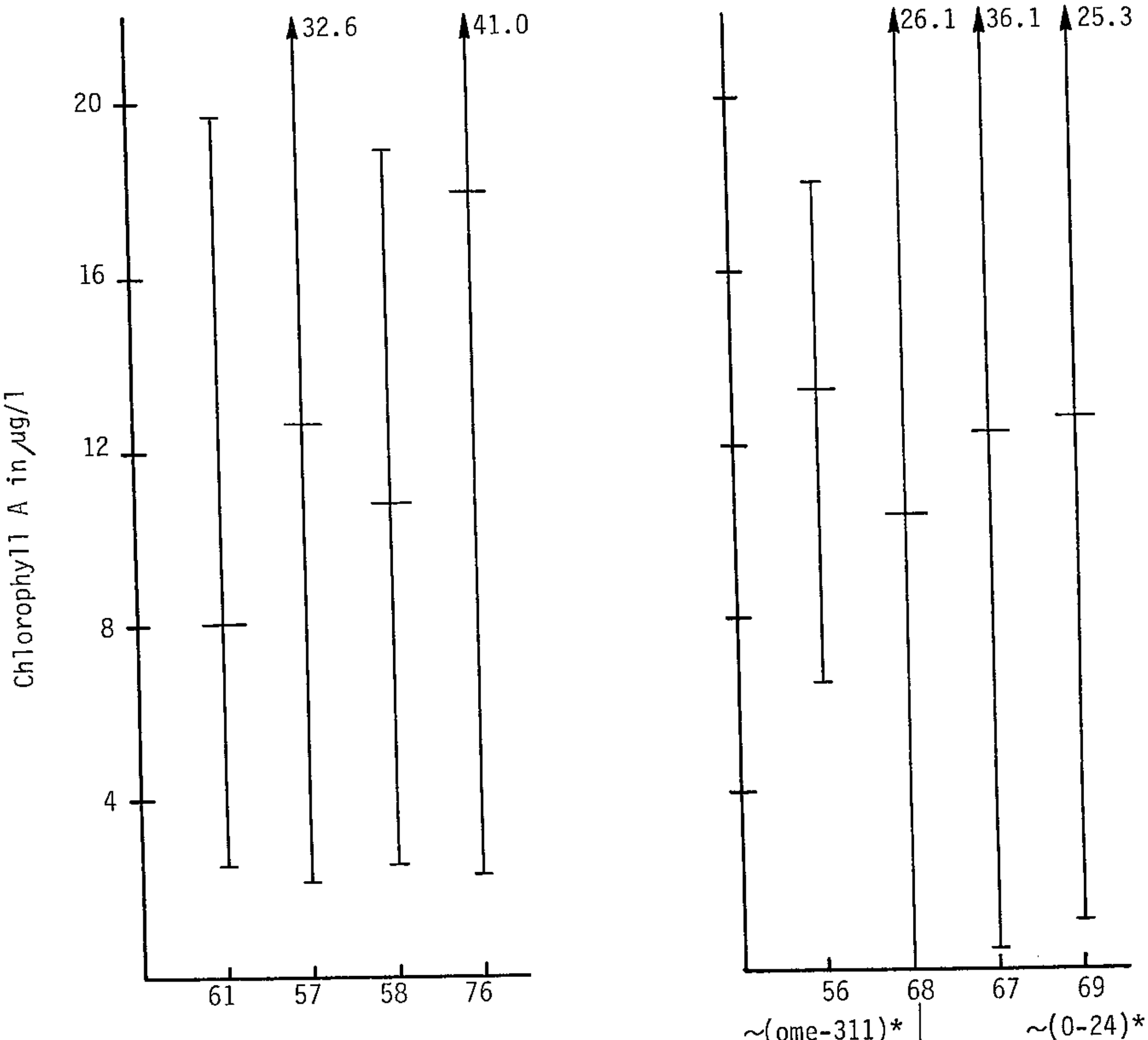
* Master Plan Station Numbers

FIGURE C-89.
1974 North Nearshore Chlorophyll A



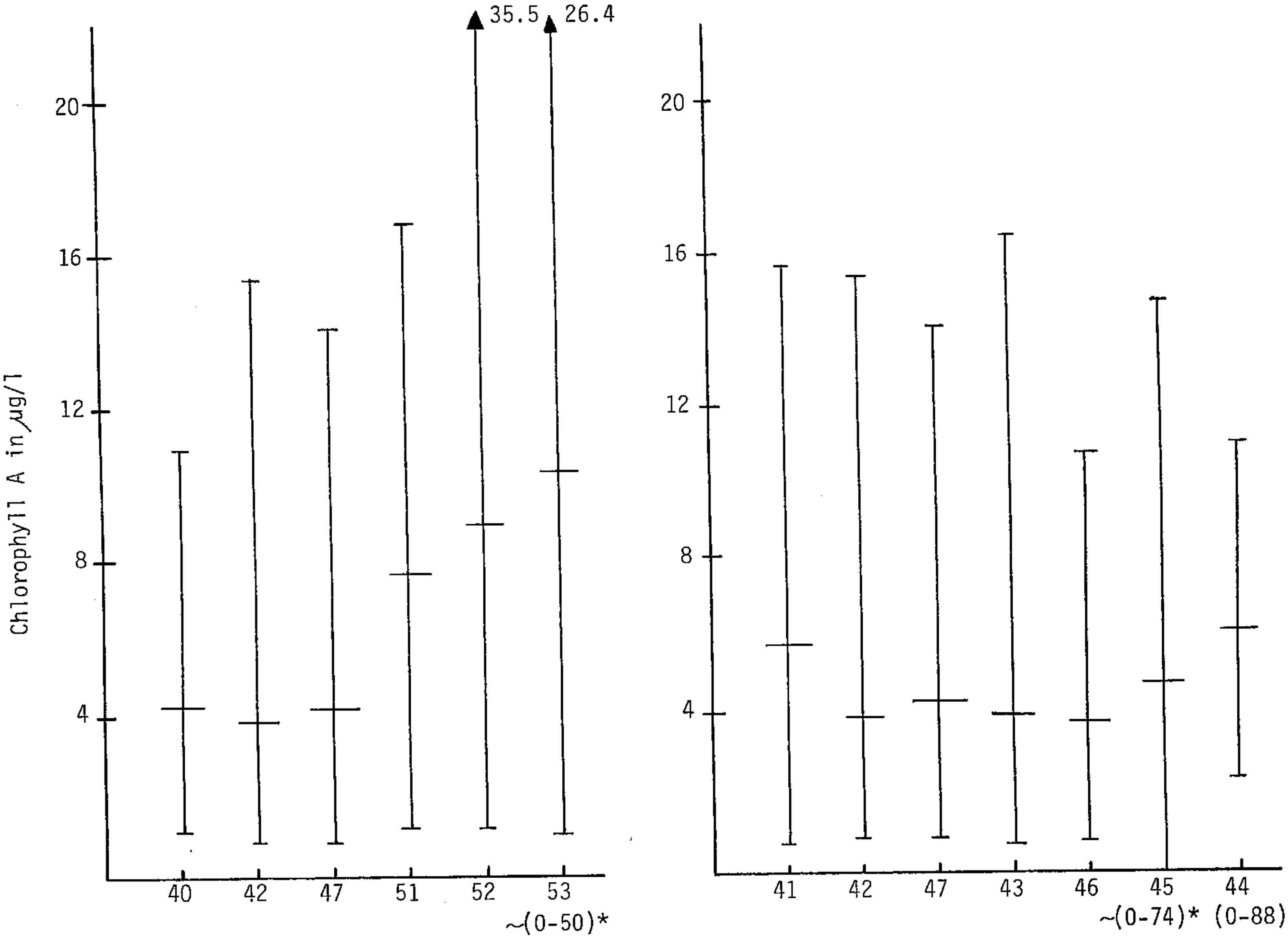
* Master Plan Station Numbers

FIGURE C-90.
1974 Western Basin Transects - Chlorophyll A



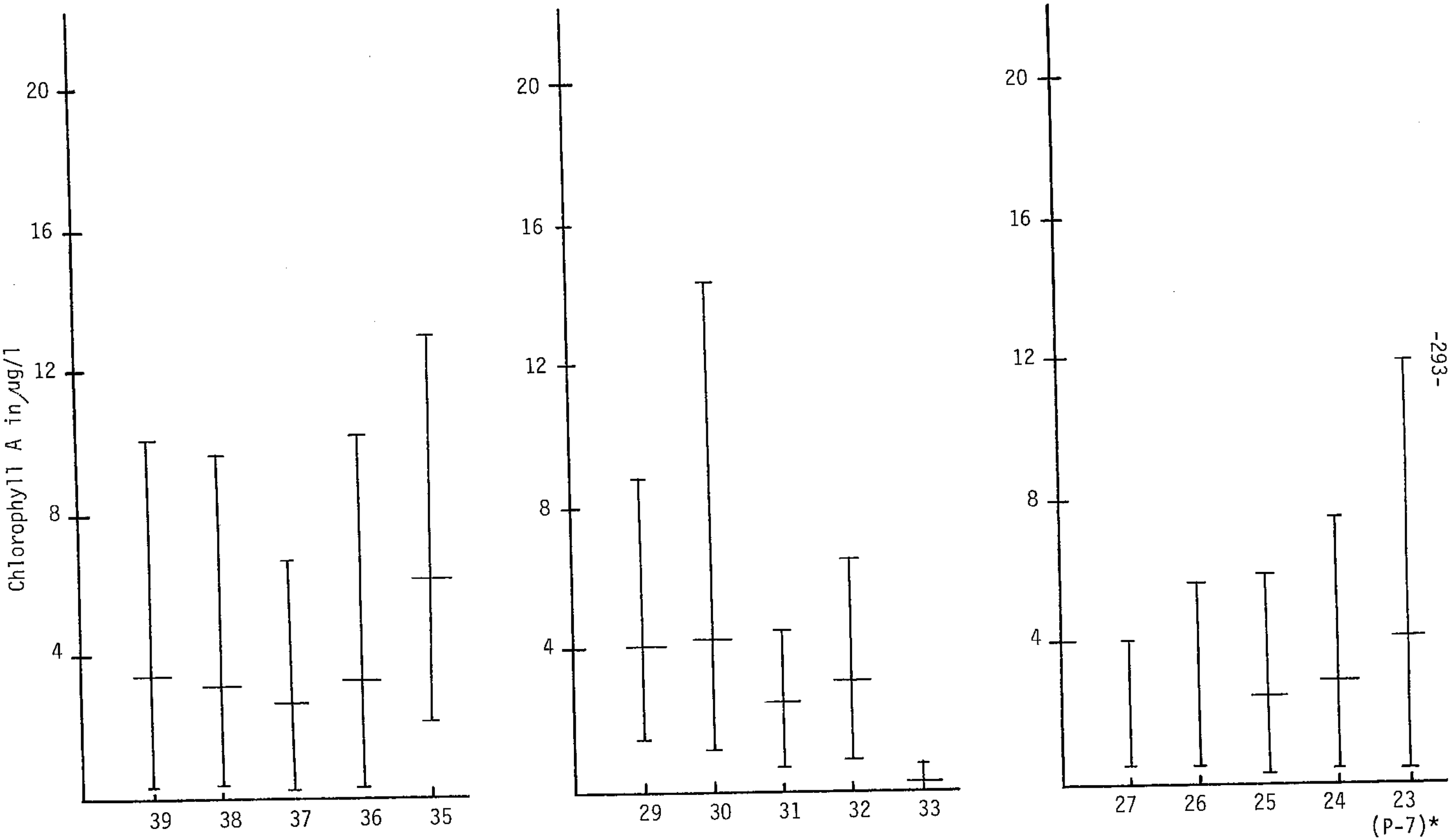
* Master Plan Station Numbers

FIGURE C-91.
1974 West Central Basin Transects - Chlorophyll A



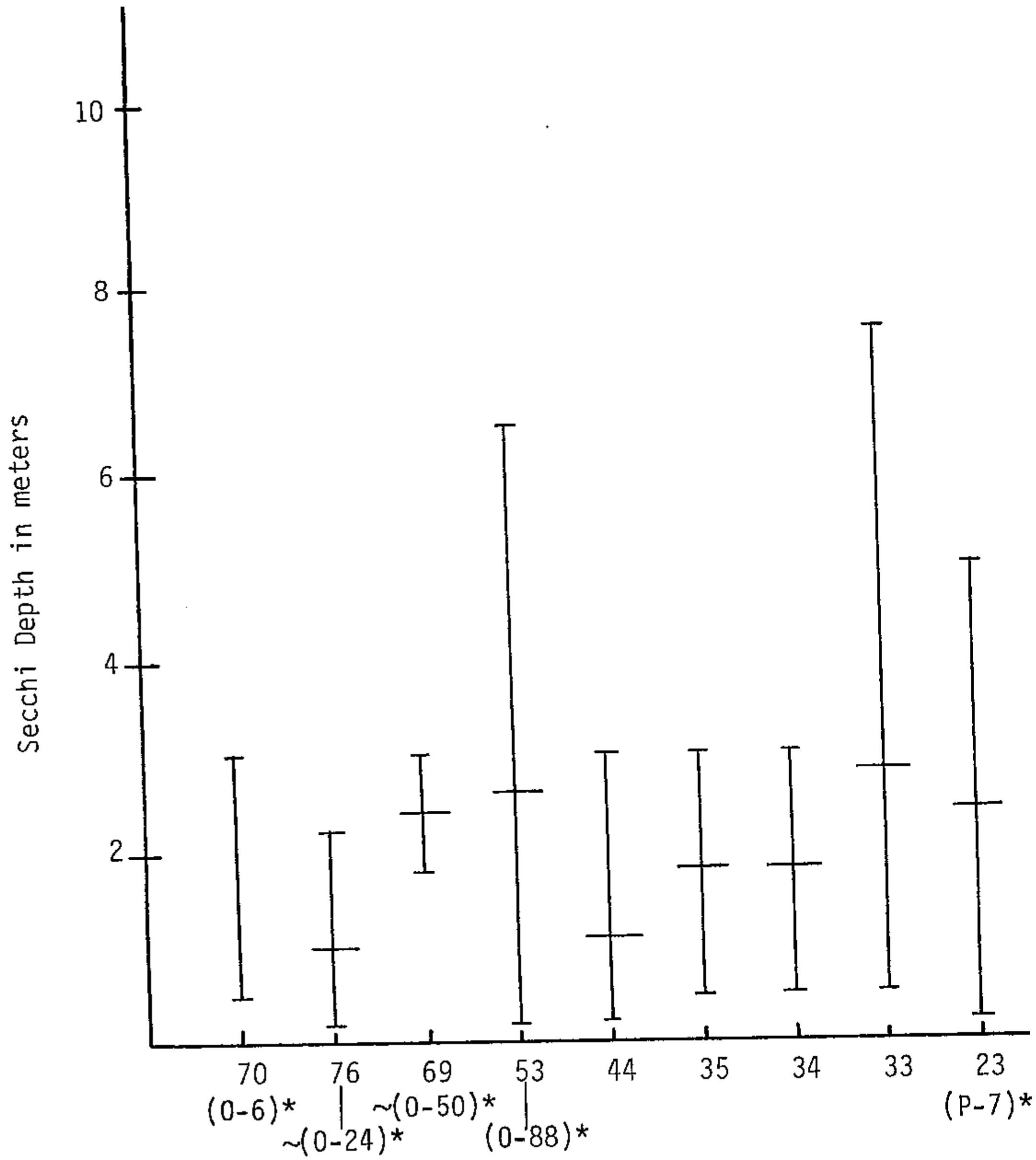
* Master Plan Station Numbers

FIGURE C-92.
1974 East Central Basin Transects - Chlorophyll A



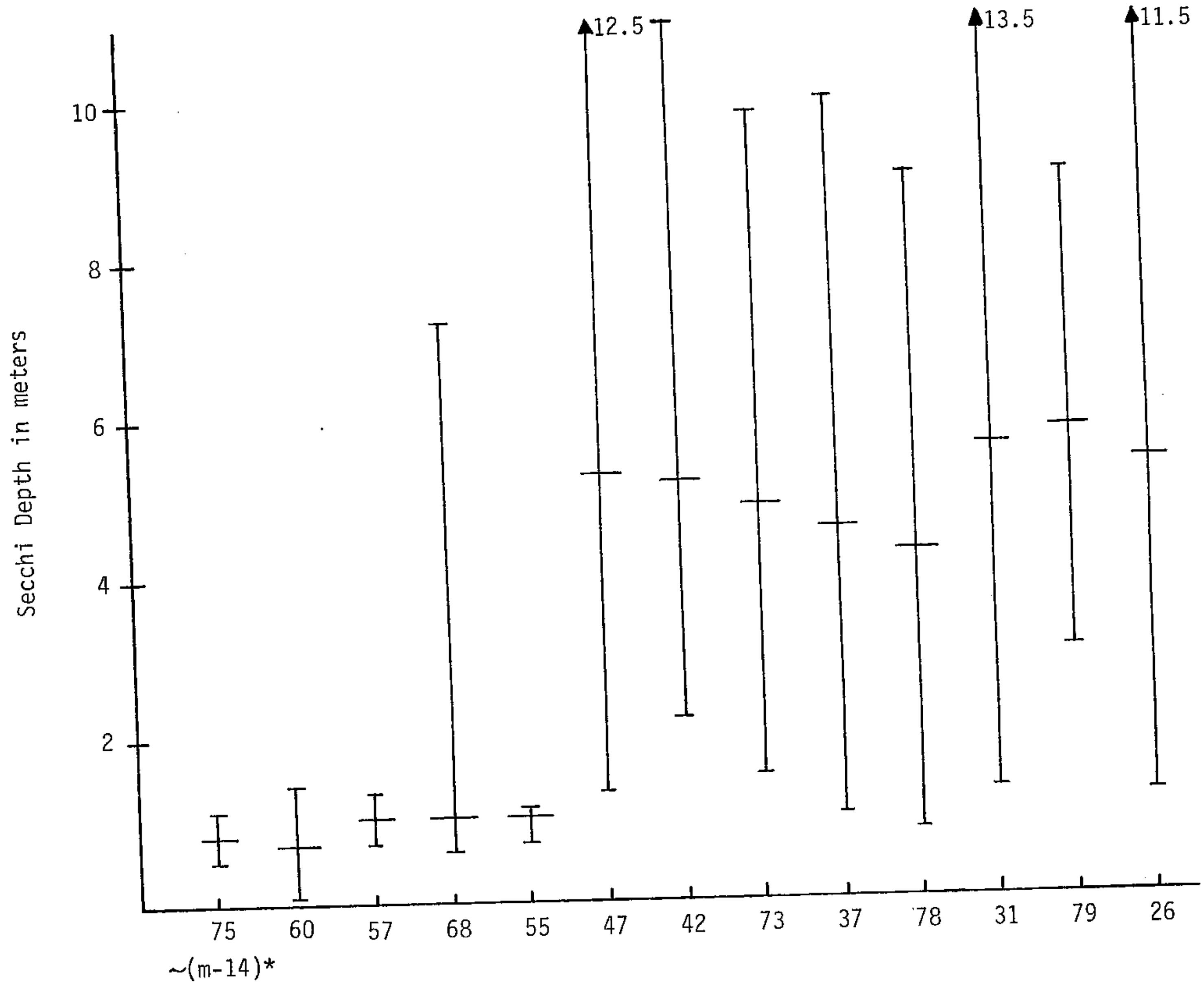
* Master Plan Station Numbers

FIGURE C-93.
1975 South Nearshore - Transparency



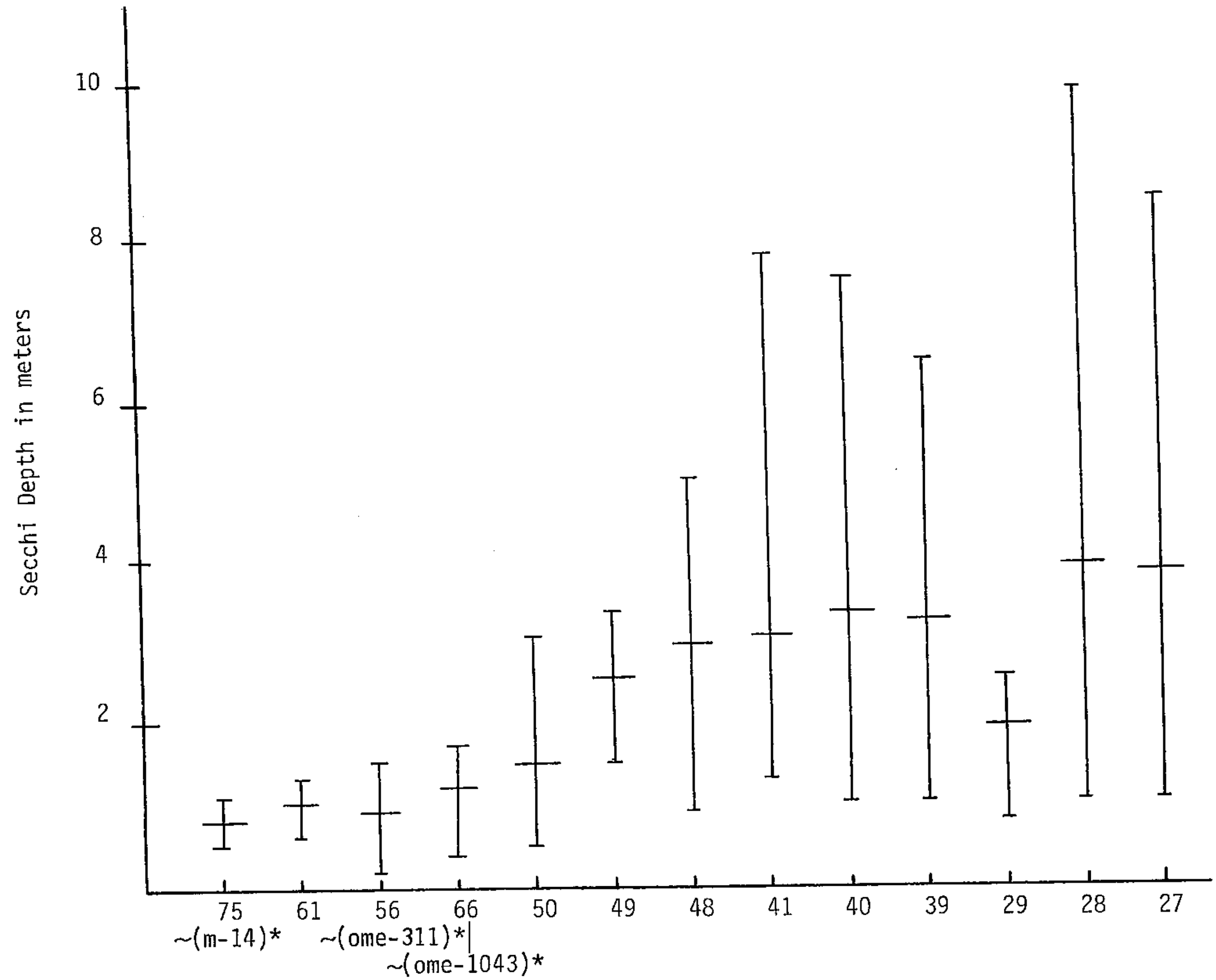
* Master Plan Station Numbers

FIGURE C-95.
1975 North Offshore - Transparency



* Master Plan Station Numbers

FIGURE C-96.
1975 North Nearshore - Transparency



* Master Plan Station Numbers

FIGURE C-97.
1975 Western Basin Transects - Transparency

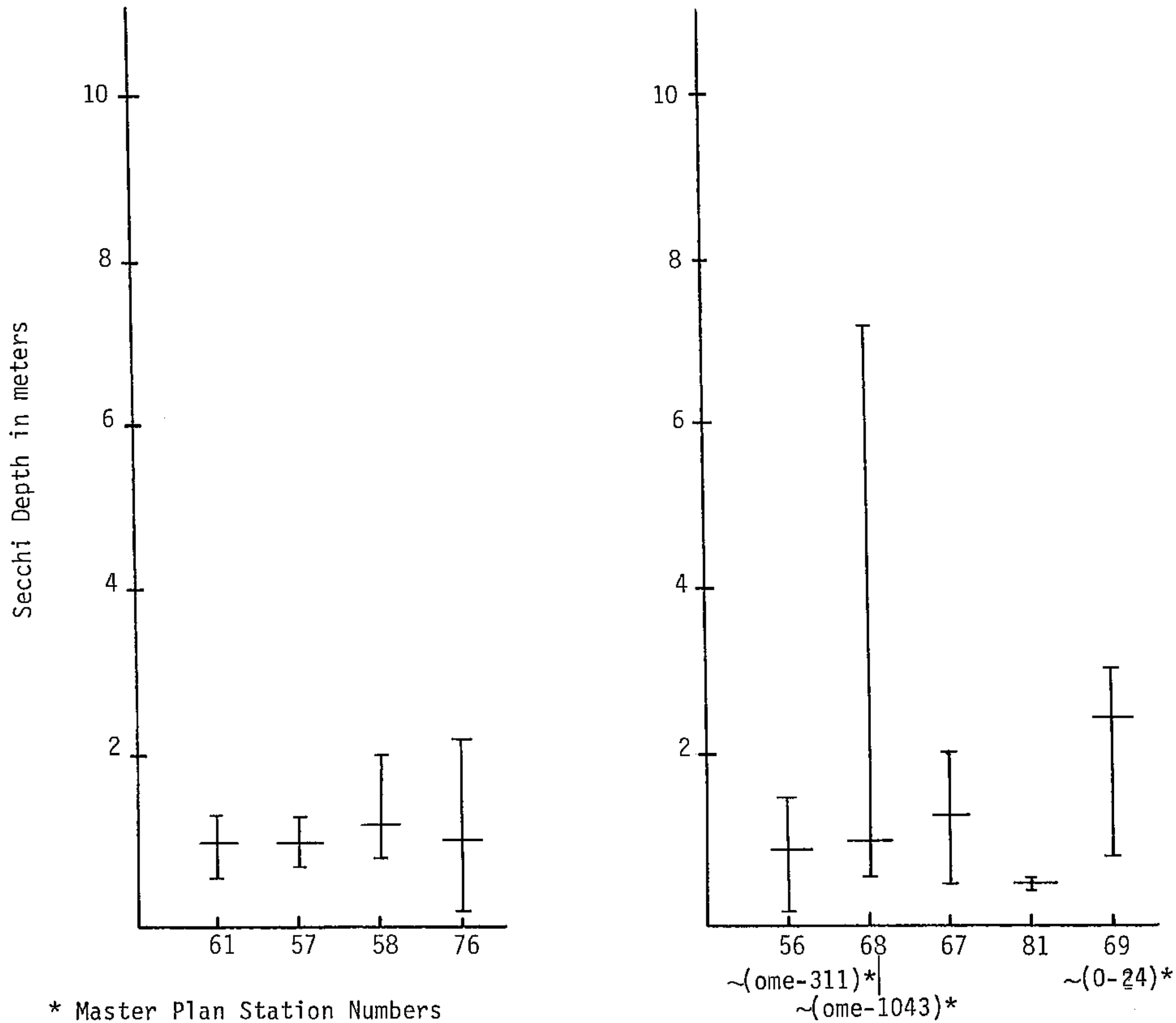
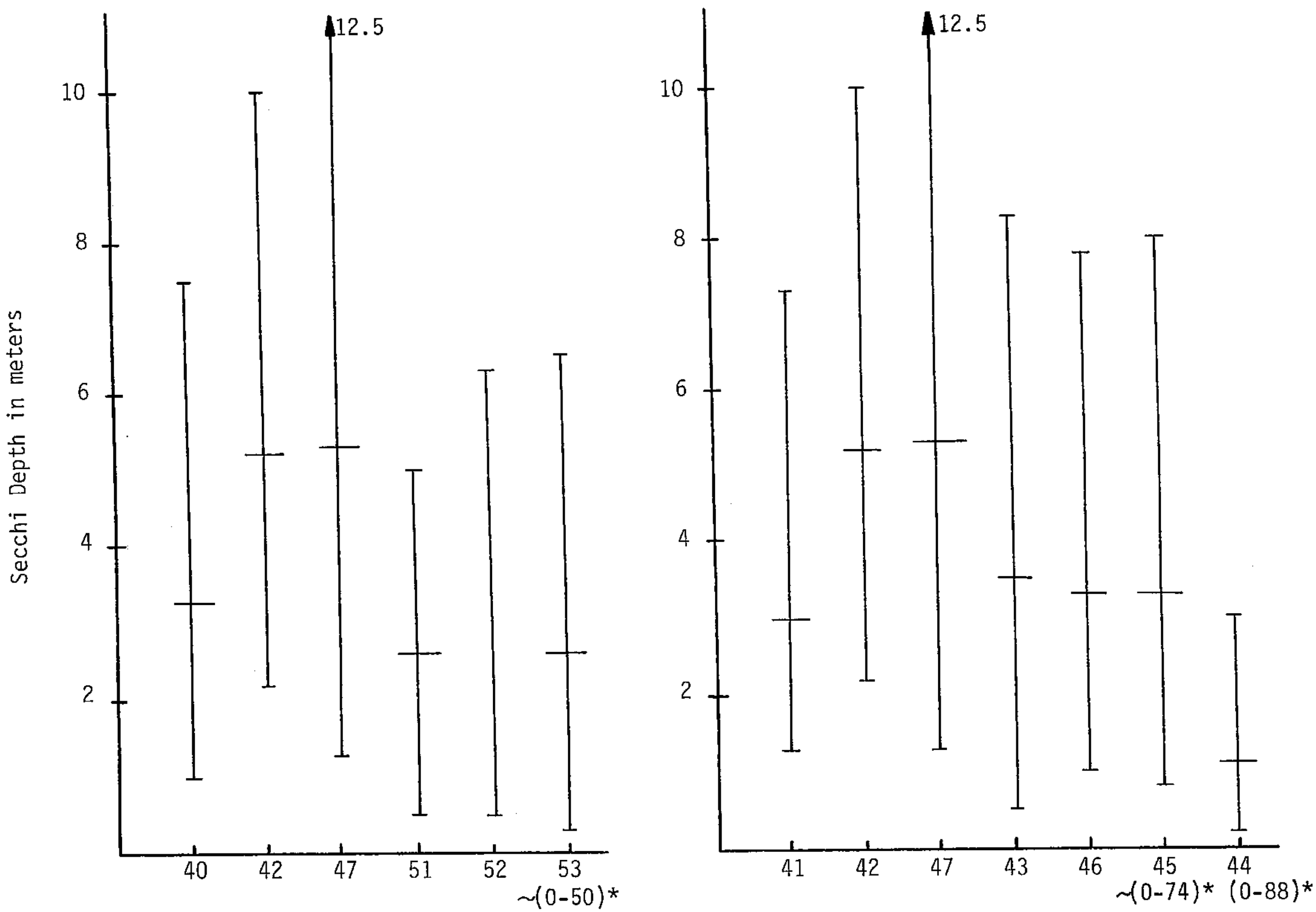
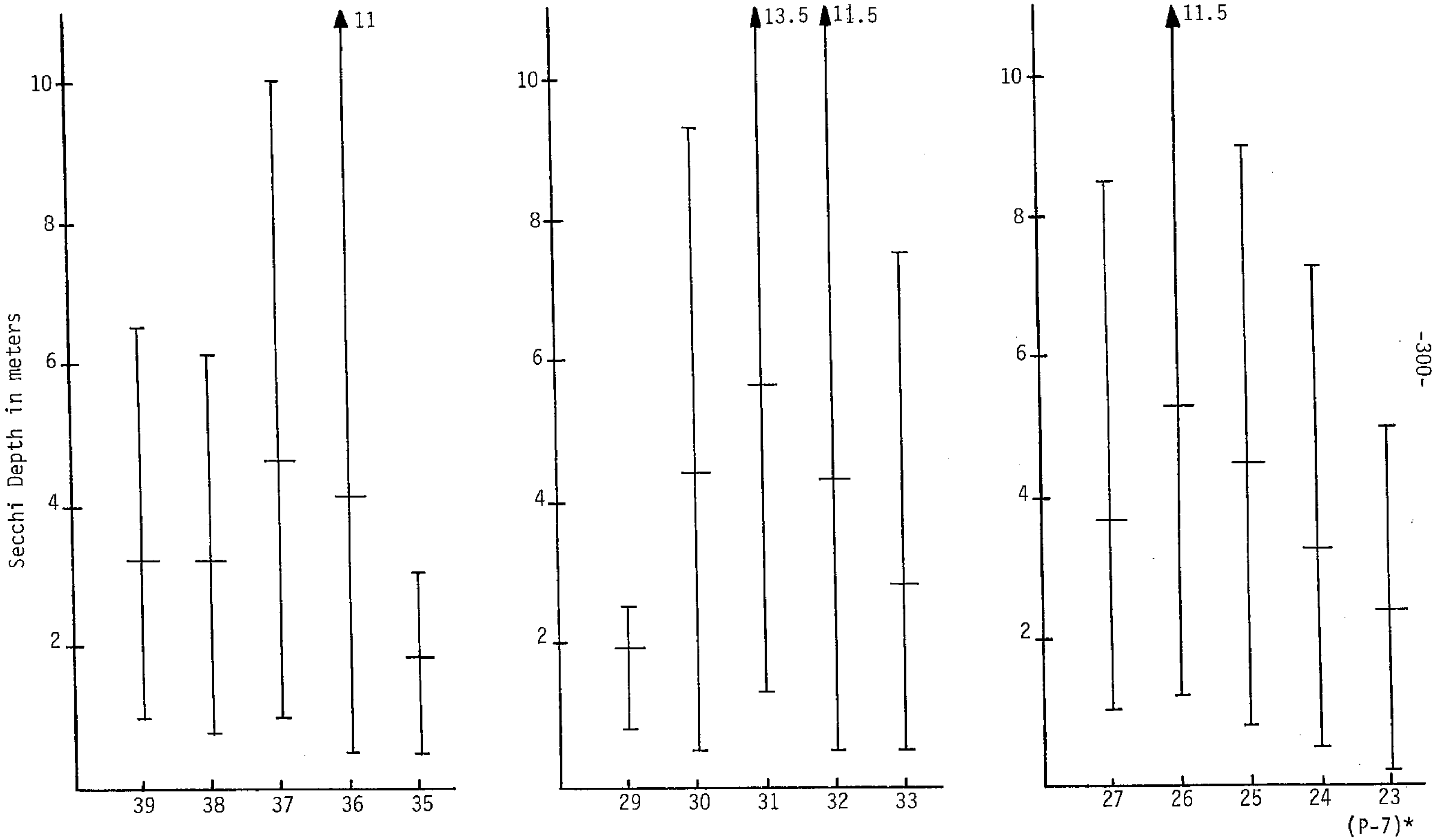


FIGURE C-98.
1975 West Central Basin Transects - Transparency



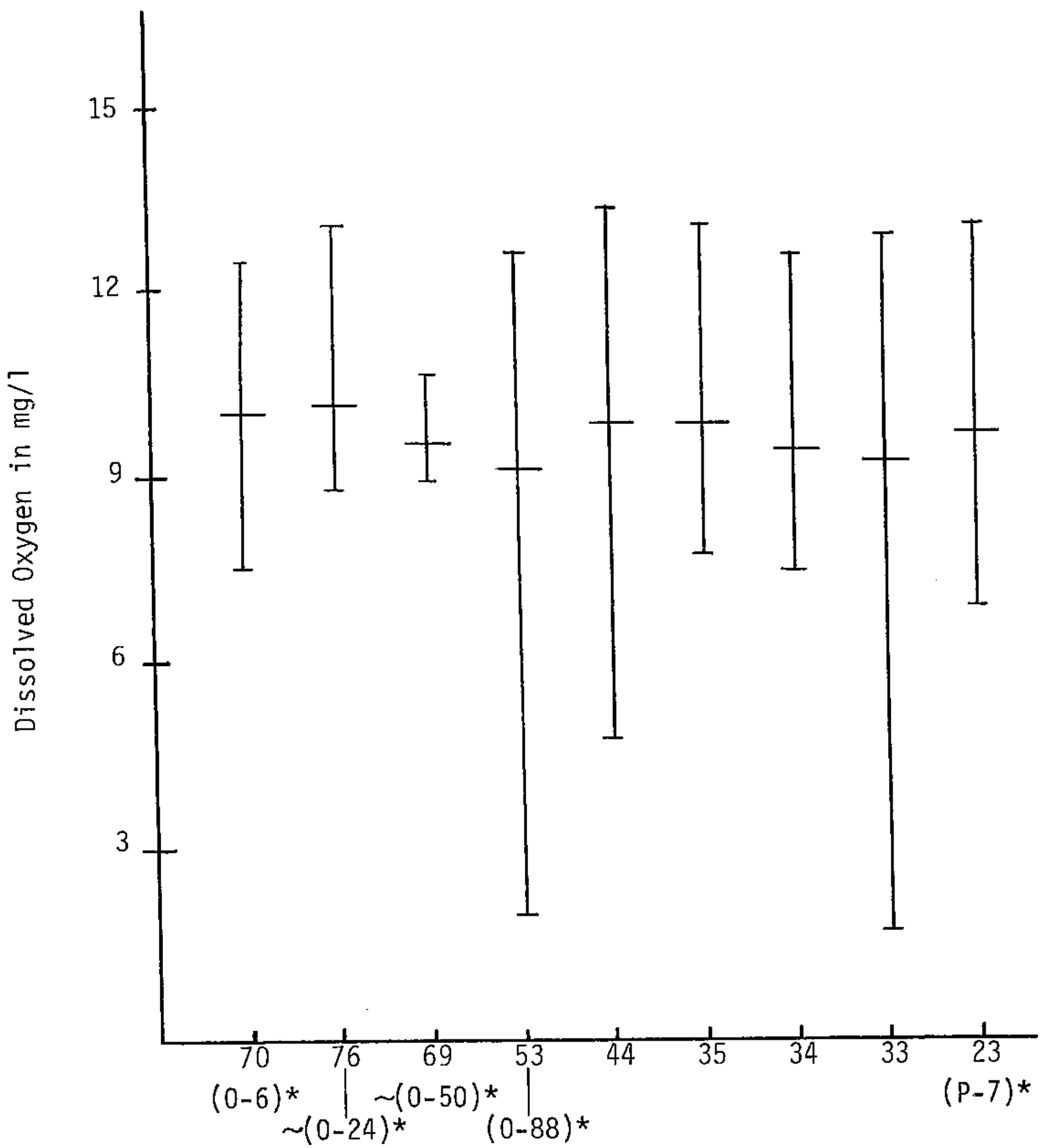
* Master Plan Station Numbers

FIGURE C-99.
1975 East Central Basin Transects - Transparency



* Master Plan Station Numbers

FIGURE C-100.
1975 South Nearshore - Dissolved Oxygen



* Master Plan Station Numbers

FIGURE C-101.
1975 South Offshore - Dissolved Oxygen

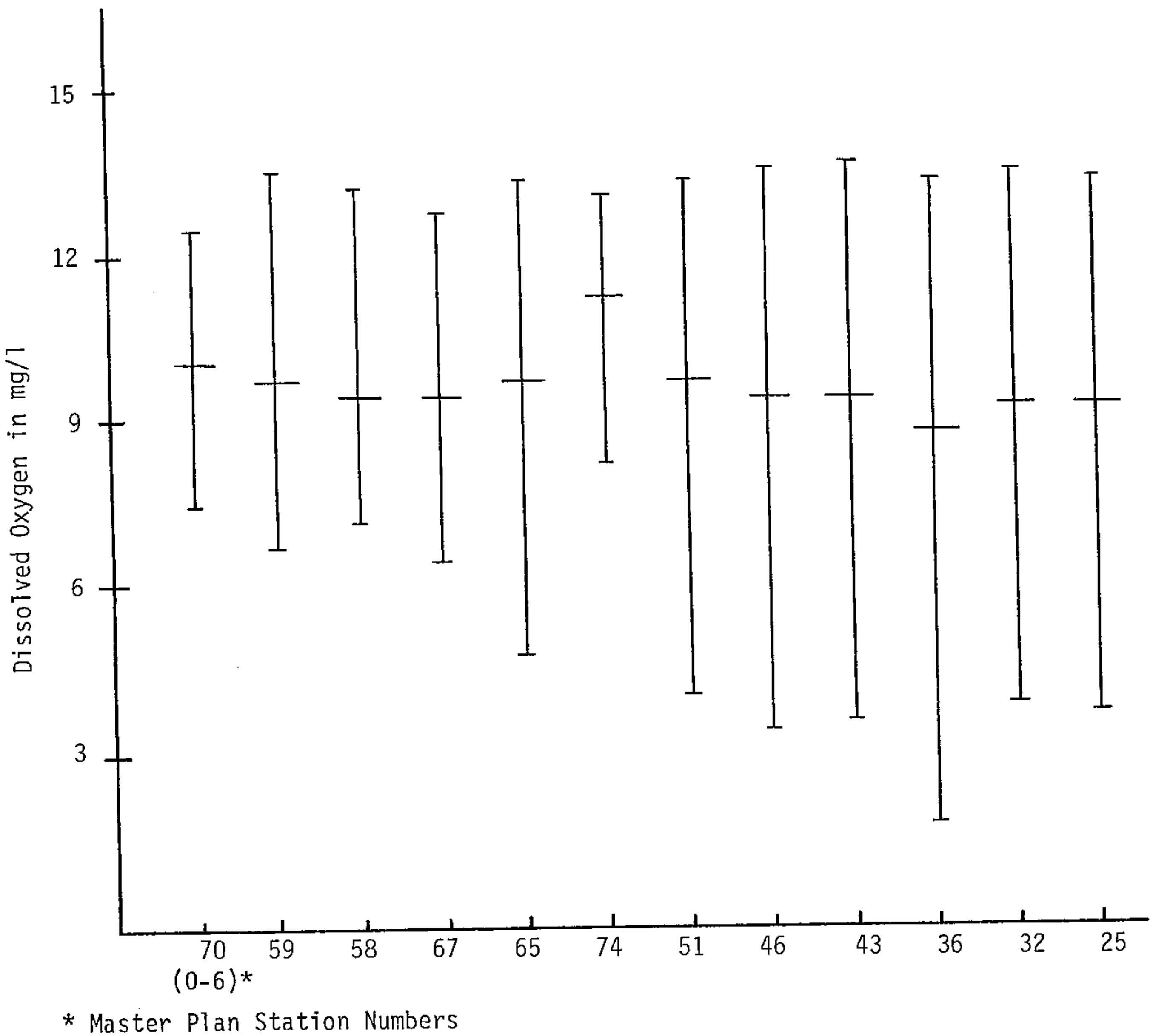
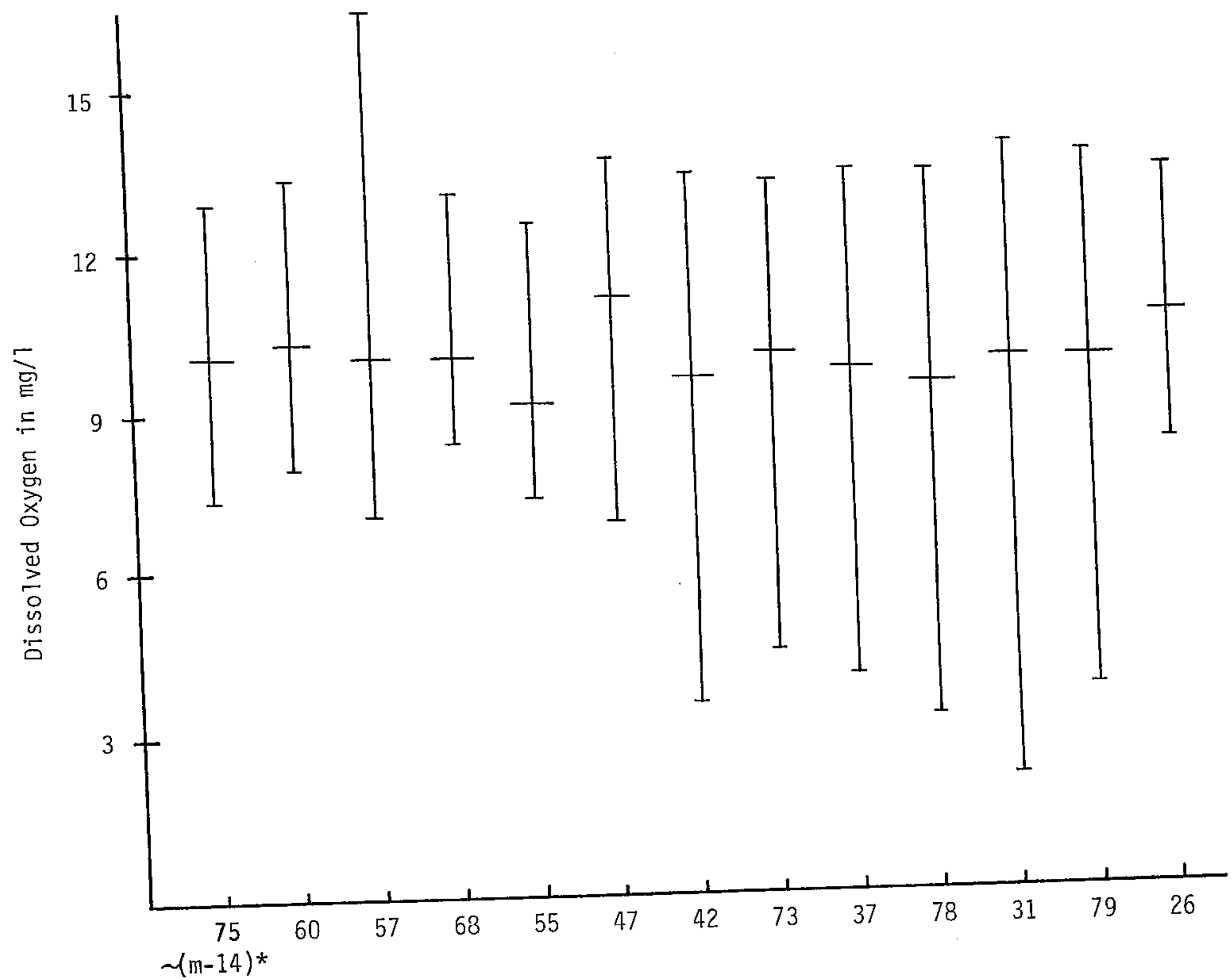
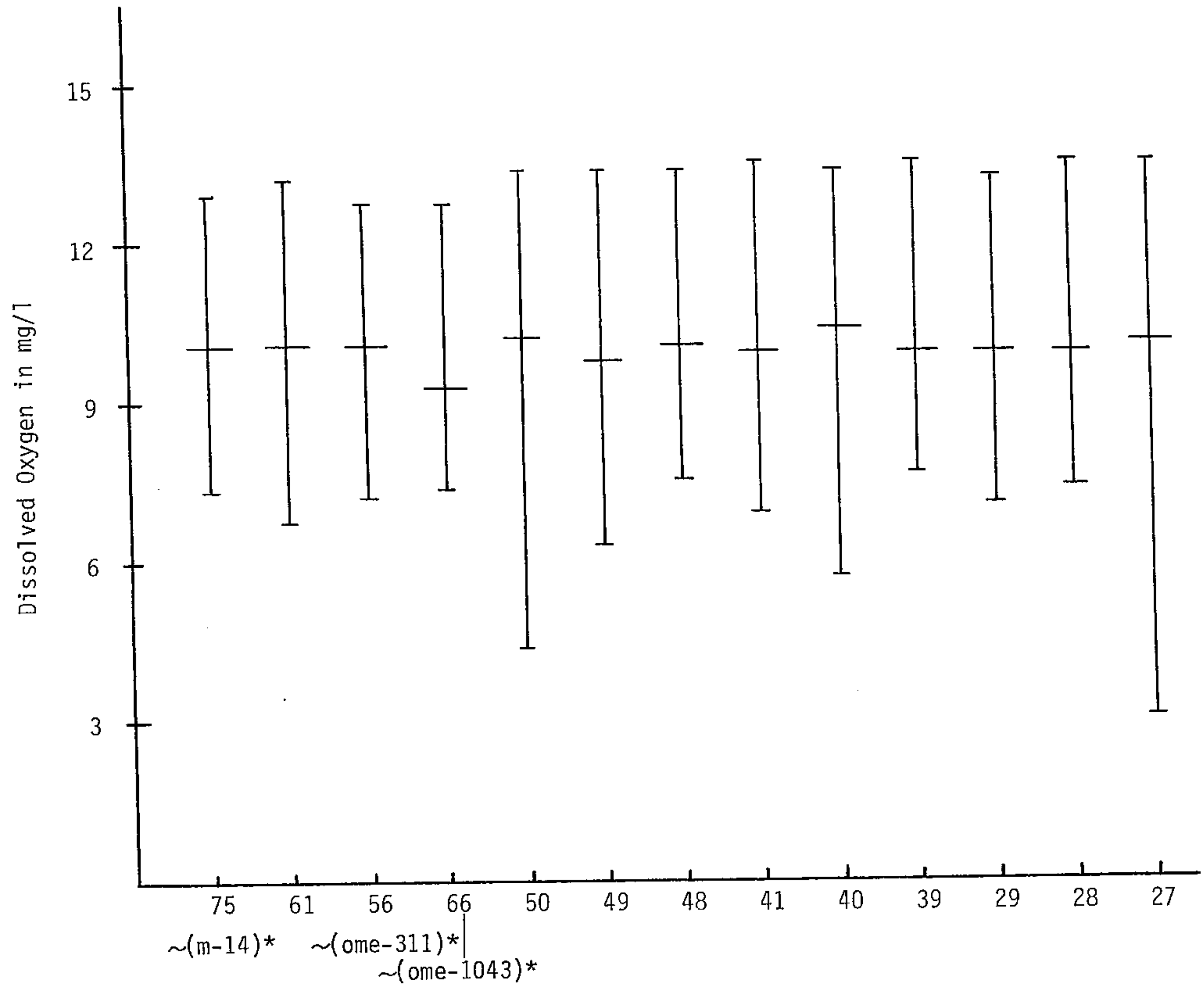


FIGURE C-102.
1975 North Offshore - Dissolved Oxygen



* Master Plan Station Numbers

FIGURE C-103.
1975 North Nearshore - Dissolved Oxygen



* Master Plan Station Numbers

FIGURE C-104.
1975 Western Basin Transects - Dissolved Oxygen

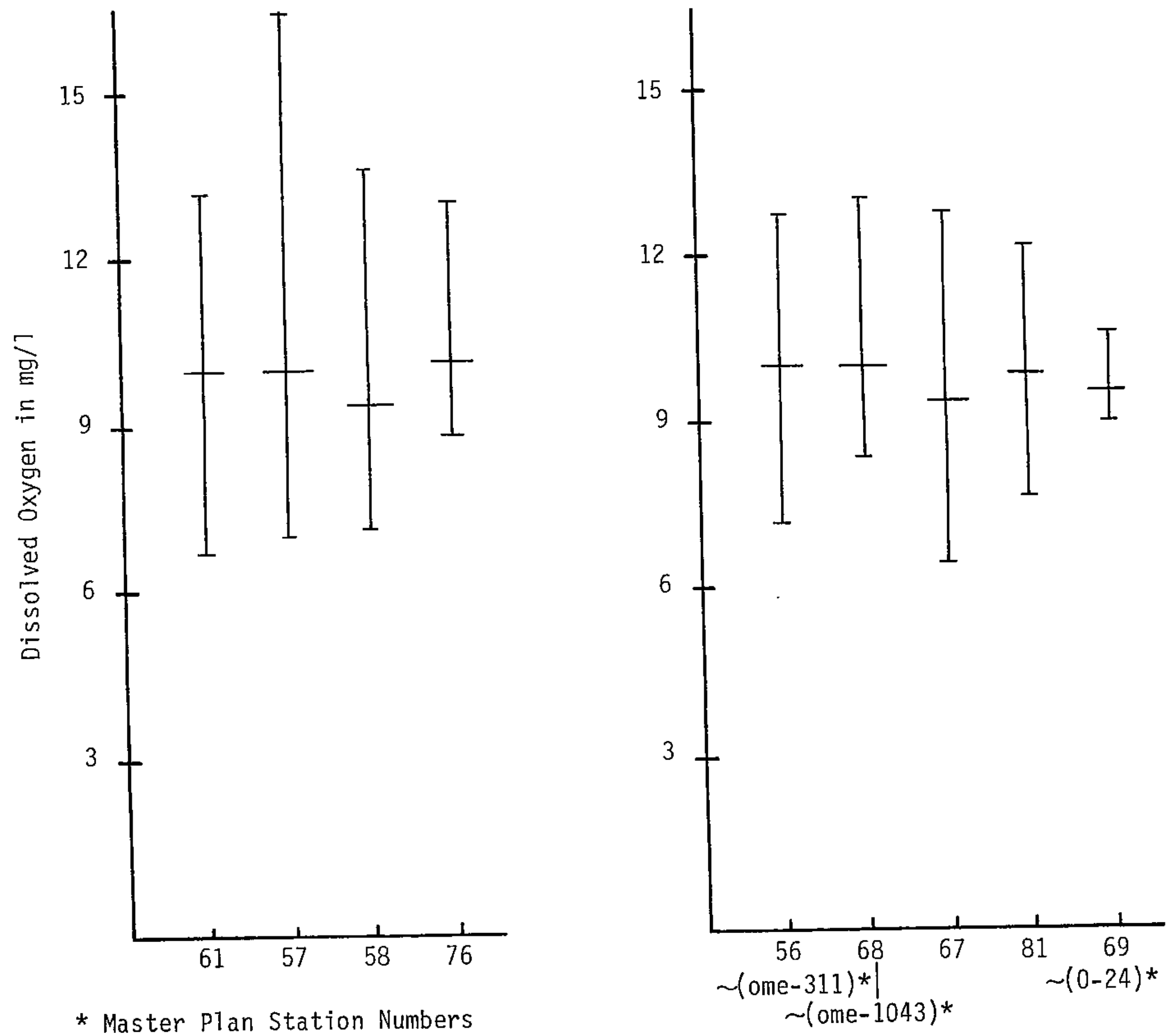
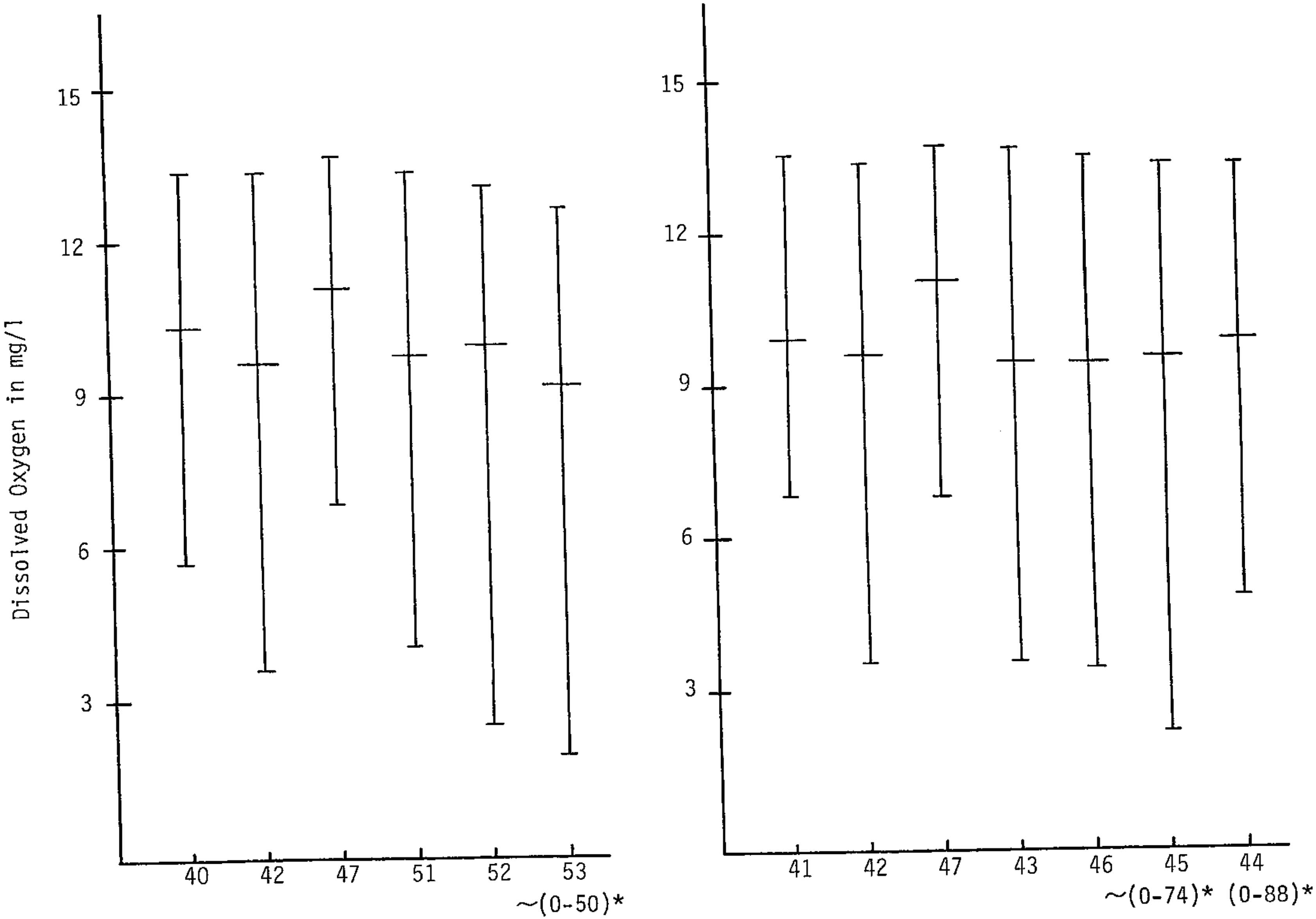
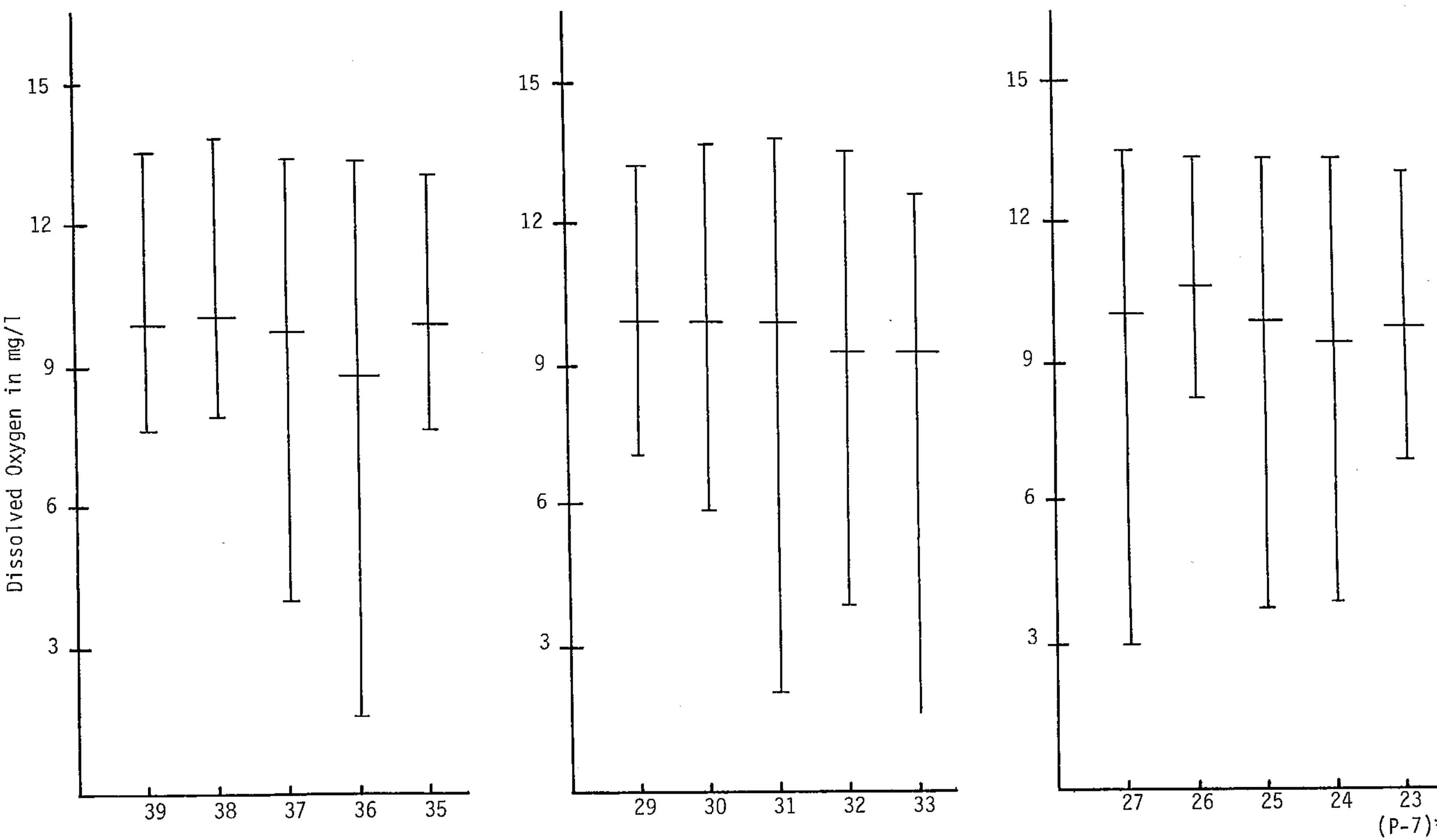


FIGURE C-105.
1975 West Central Basin Transects - Dissolved Oxygen



* Master Plan Station Numbers

FIGURE C-106.
1975 East Central Basin Transects - Dissolved Oxygen



* Master Plan Station Numbers

FIGURE C-107.
1975 South Nearshore - Conductivity

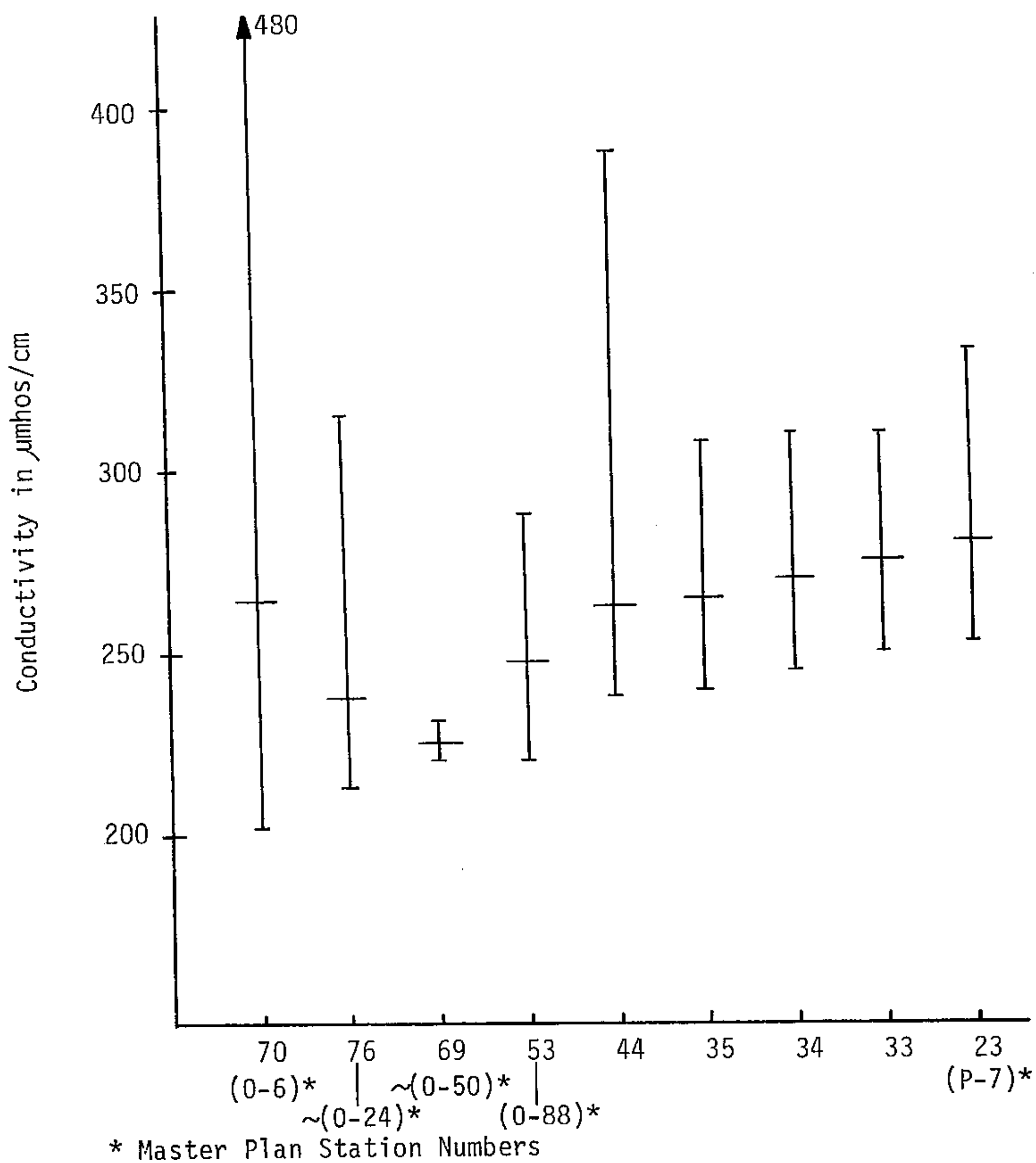


FIGURE C-108.
1975 South Offshore - Conductivity

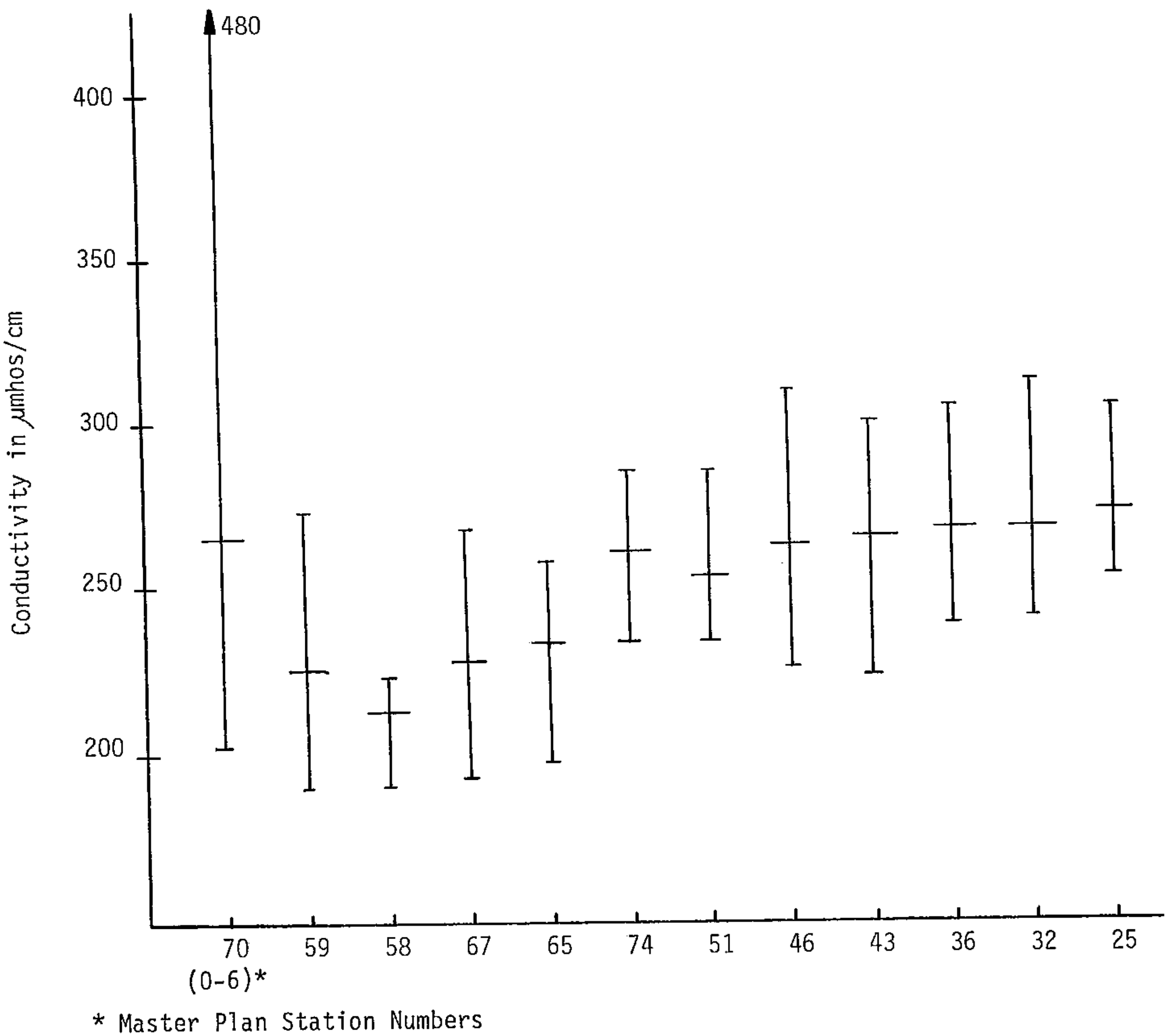
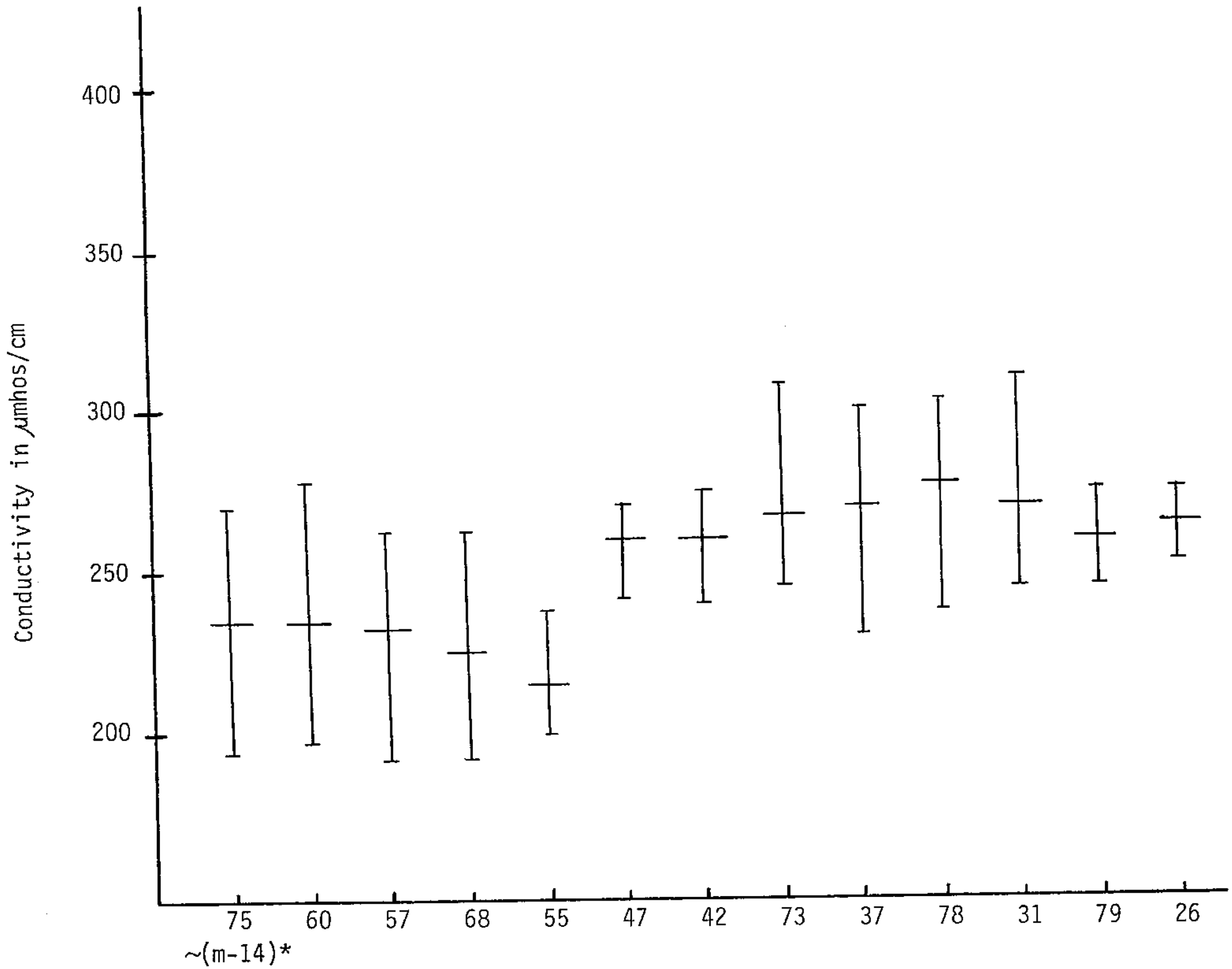
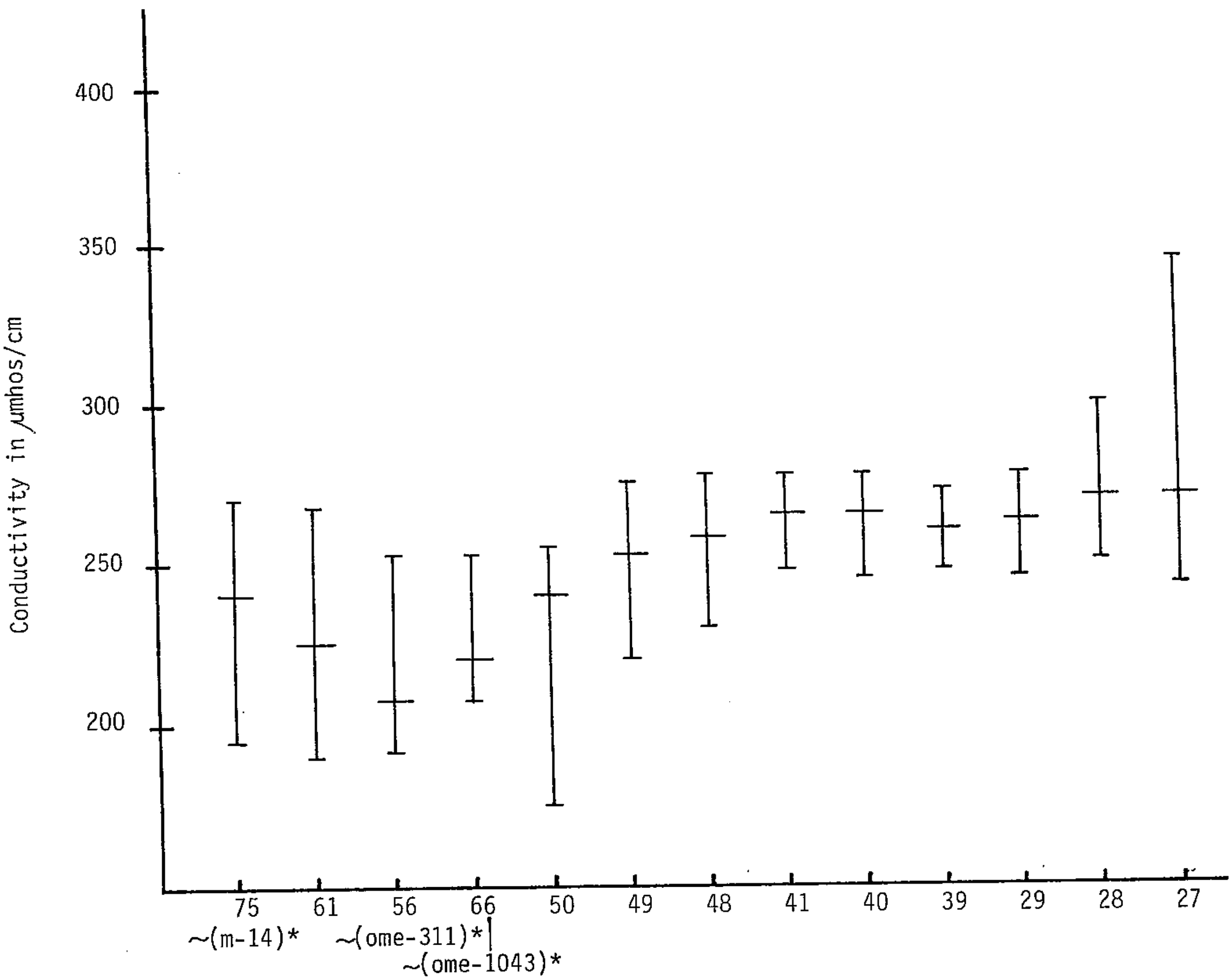


FIGURE C-109.
1975 North Offshore - Conductivity



* Master Plan Station Numbers

FIGURE C-110.
1975 North Nearshore - Conductivity



* Master Plan Station Number

FIGURE C-111.
1975 Western Basin Transects - Conductivity

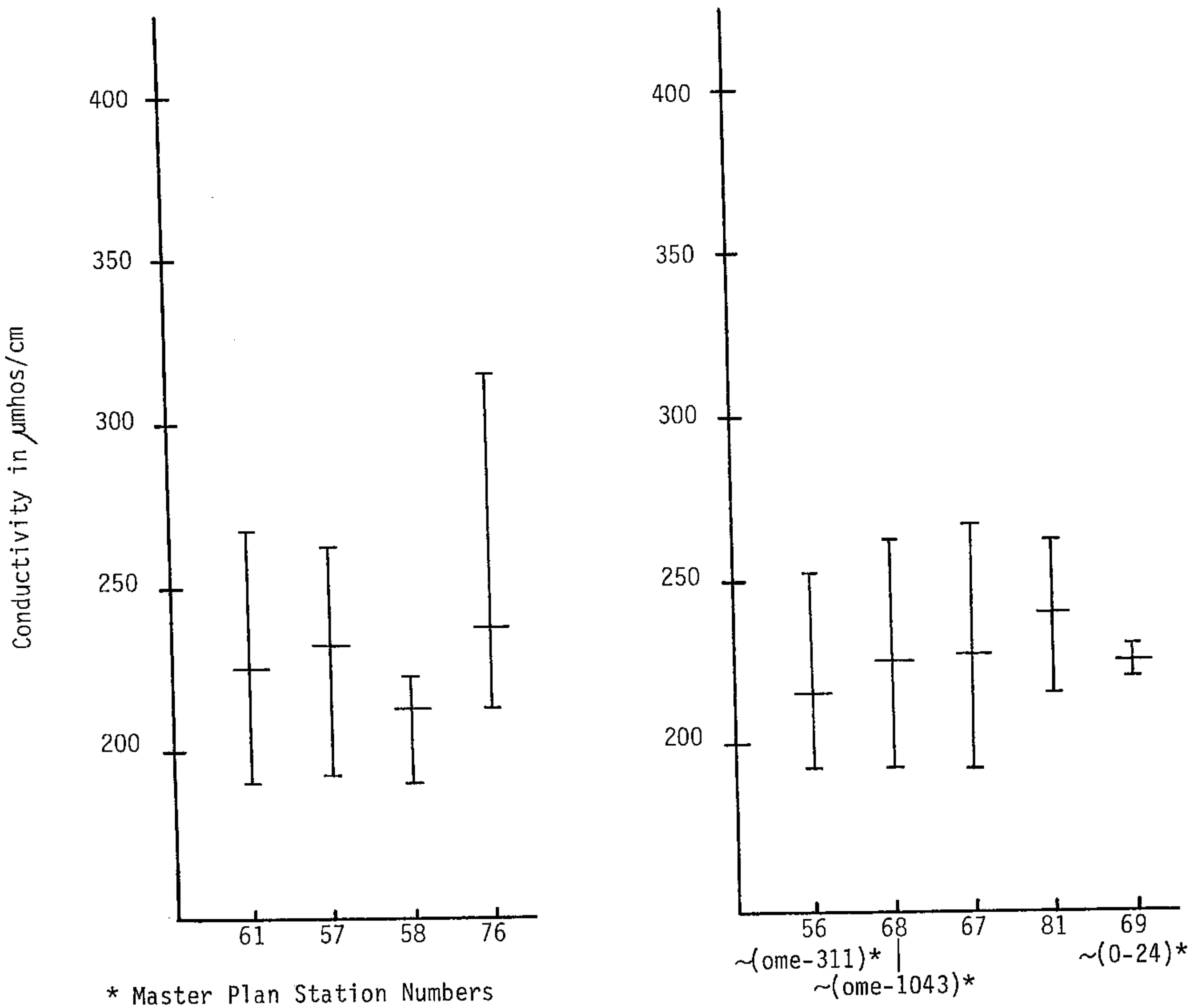
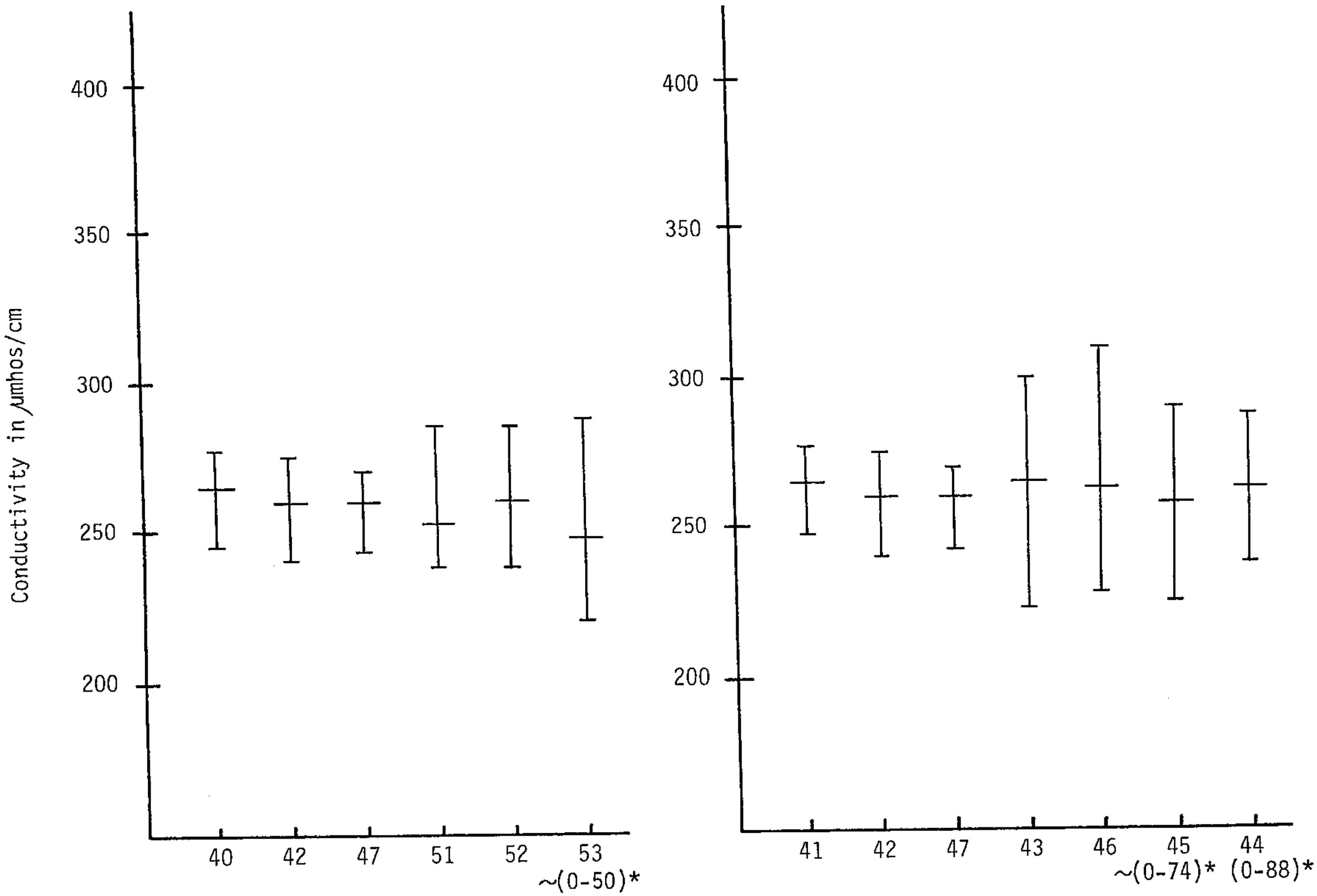
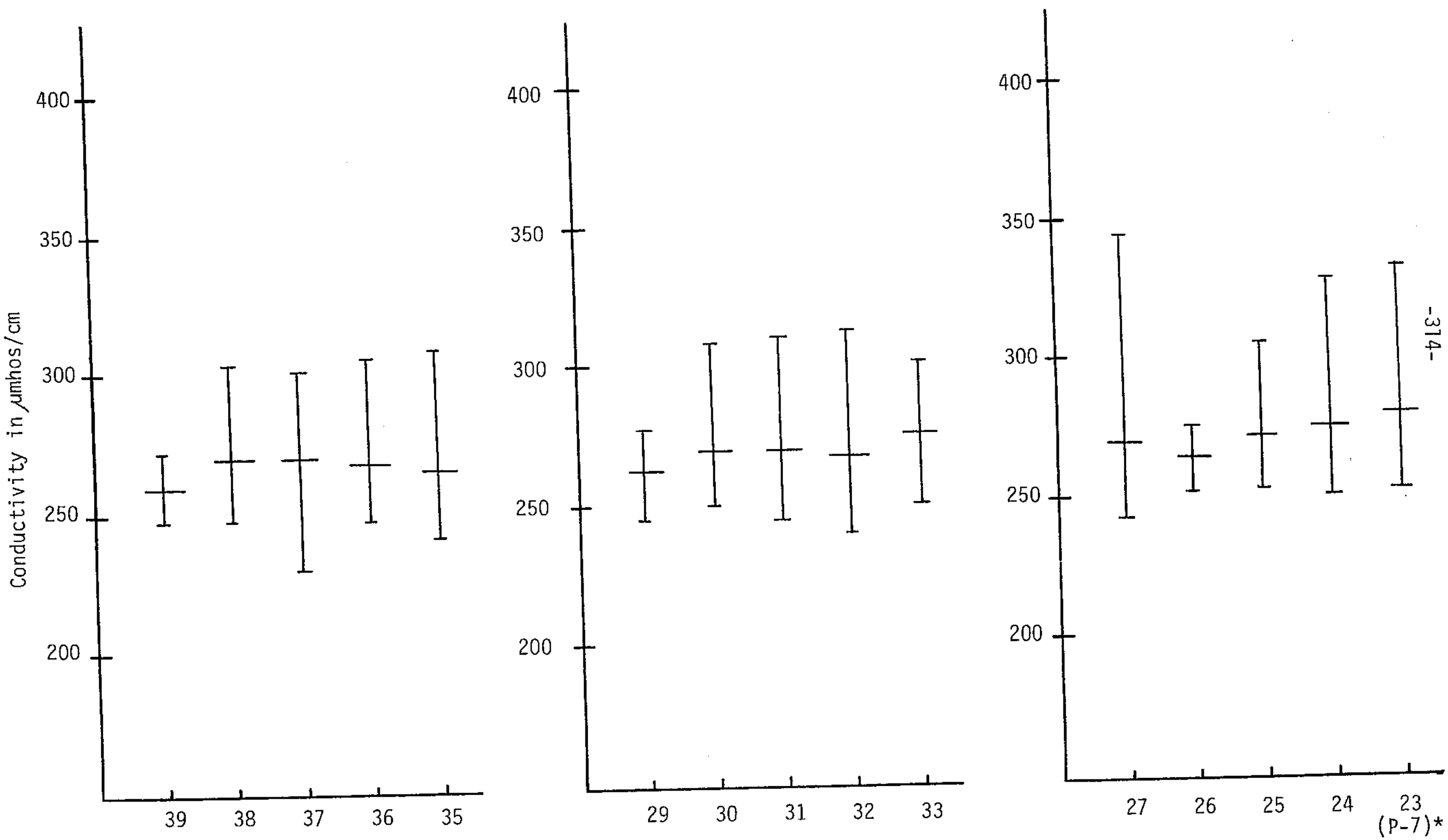


FIGURE C-112.
1975 West Central Basin Transects - Conductivity



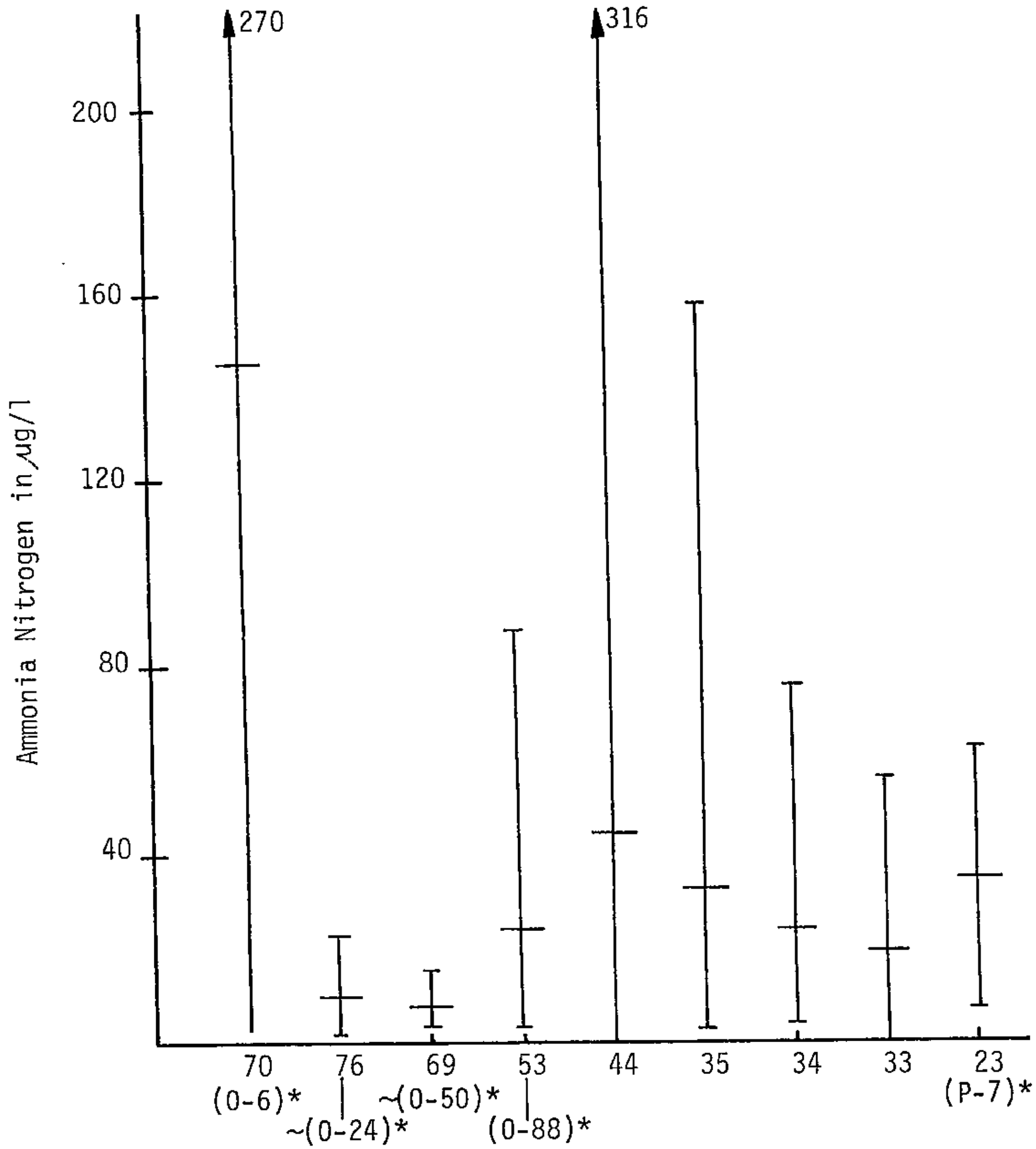
* Master Plan Station Numbers

FIGURE C-113.
1975 East Central Basin Transects - Conductivity



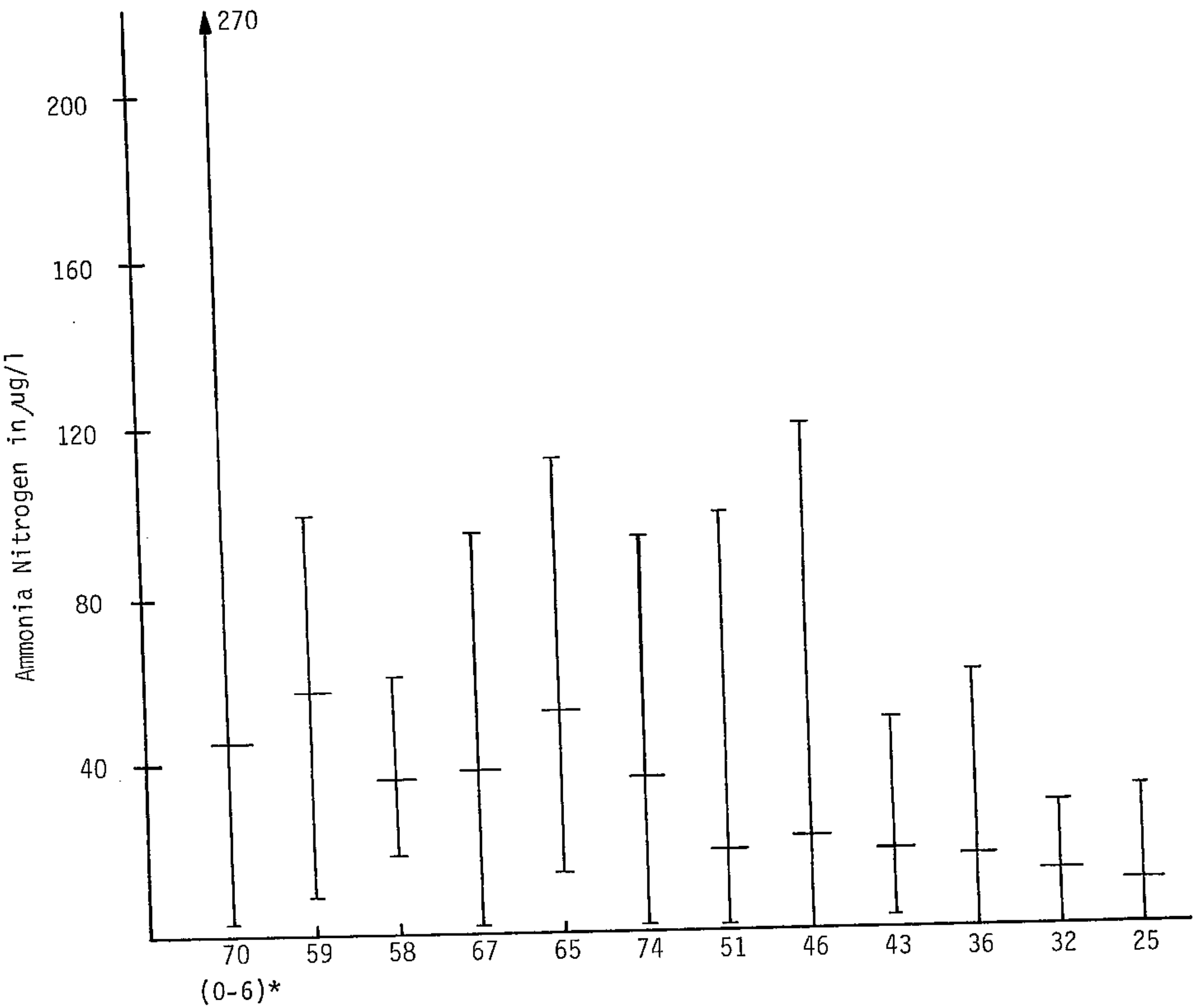
* Master Plan Station Numbers

FIGURE C-114.
1975 South Nearshore - Ammonia Nitrogen



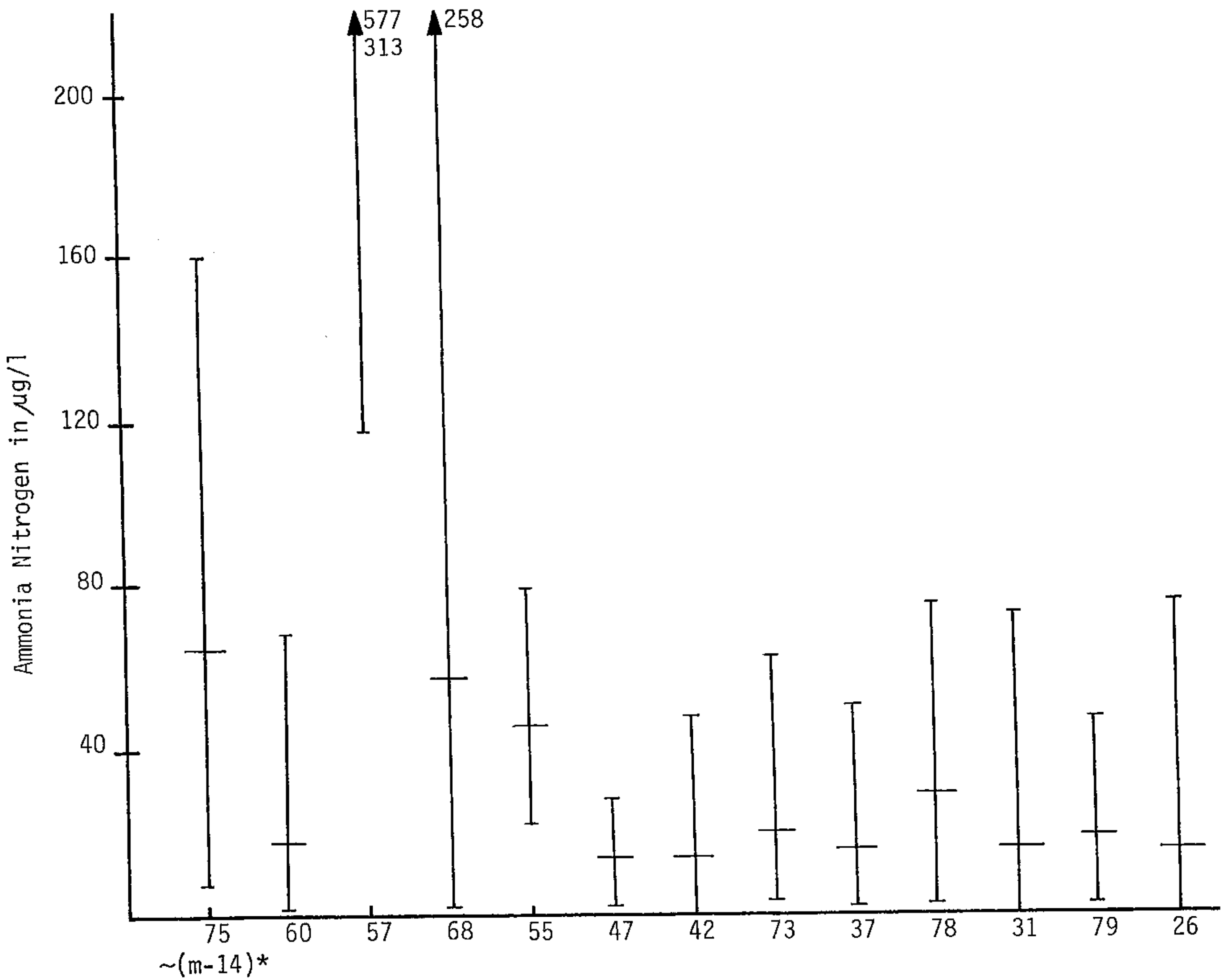
* Master Plan Station Numbers

FIGURE C-115.
1975 South Offshore - Ammonia Nitrogen



* Master Plan Station Numbers

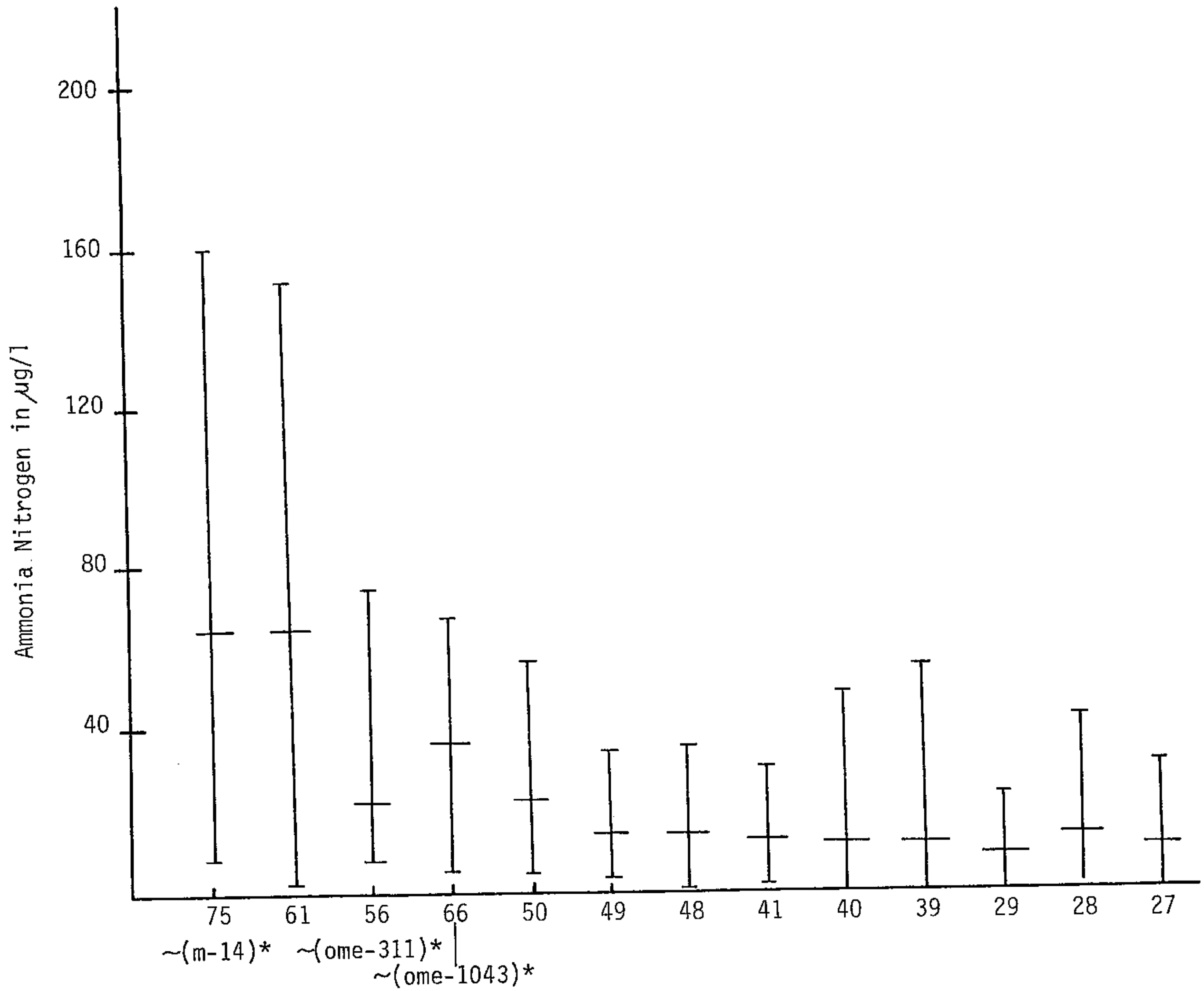
FIGURE C-116.
1975 North Offshore - Ammonia Nitrogen



* Master Plan Station Numbers

FIGURE C-117.

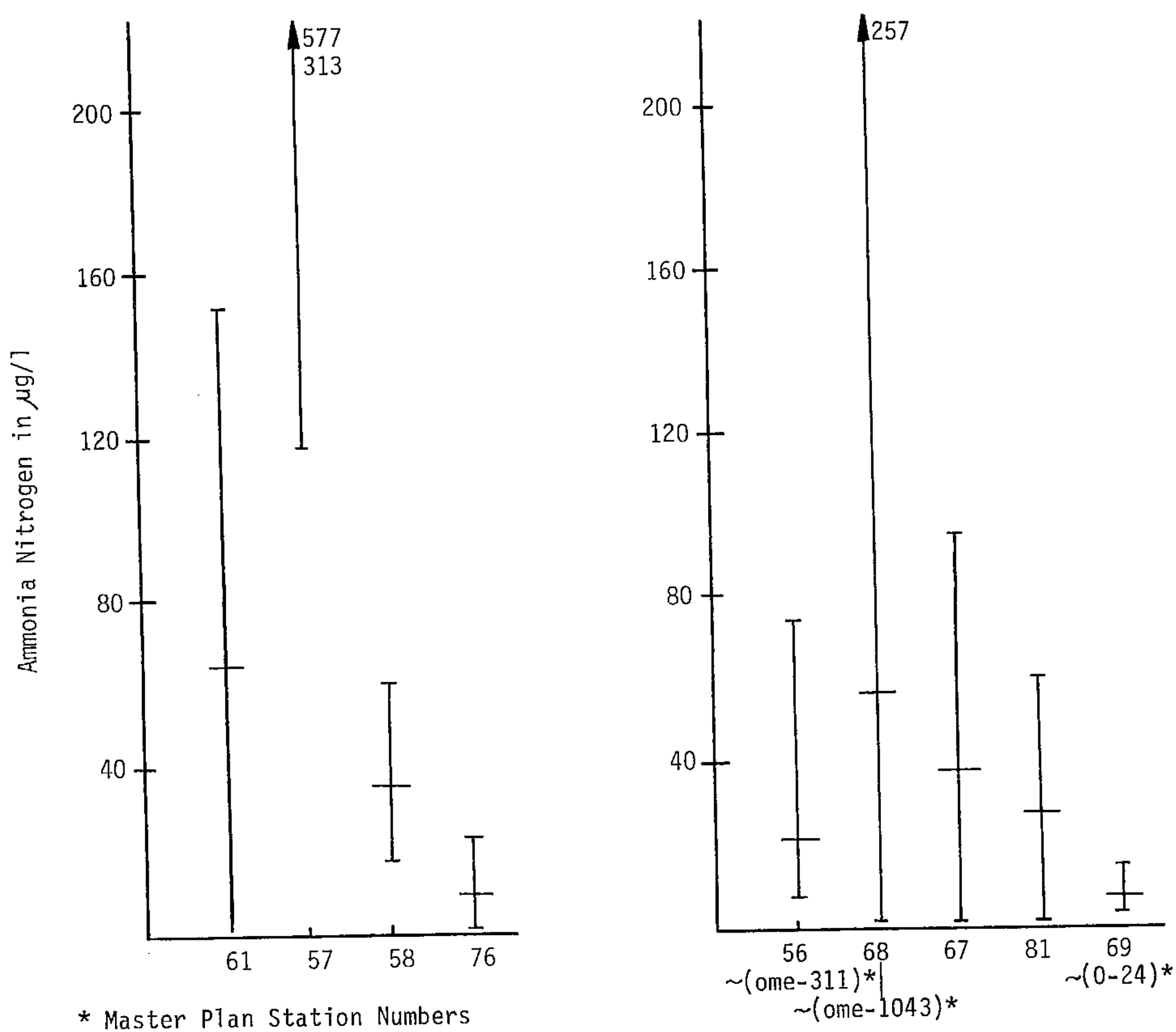
1975 North Nearshore - Ammonia Nitrogen



* Master Plan Station Numbers

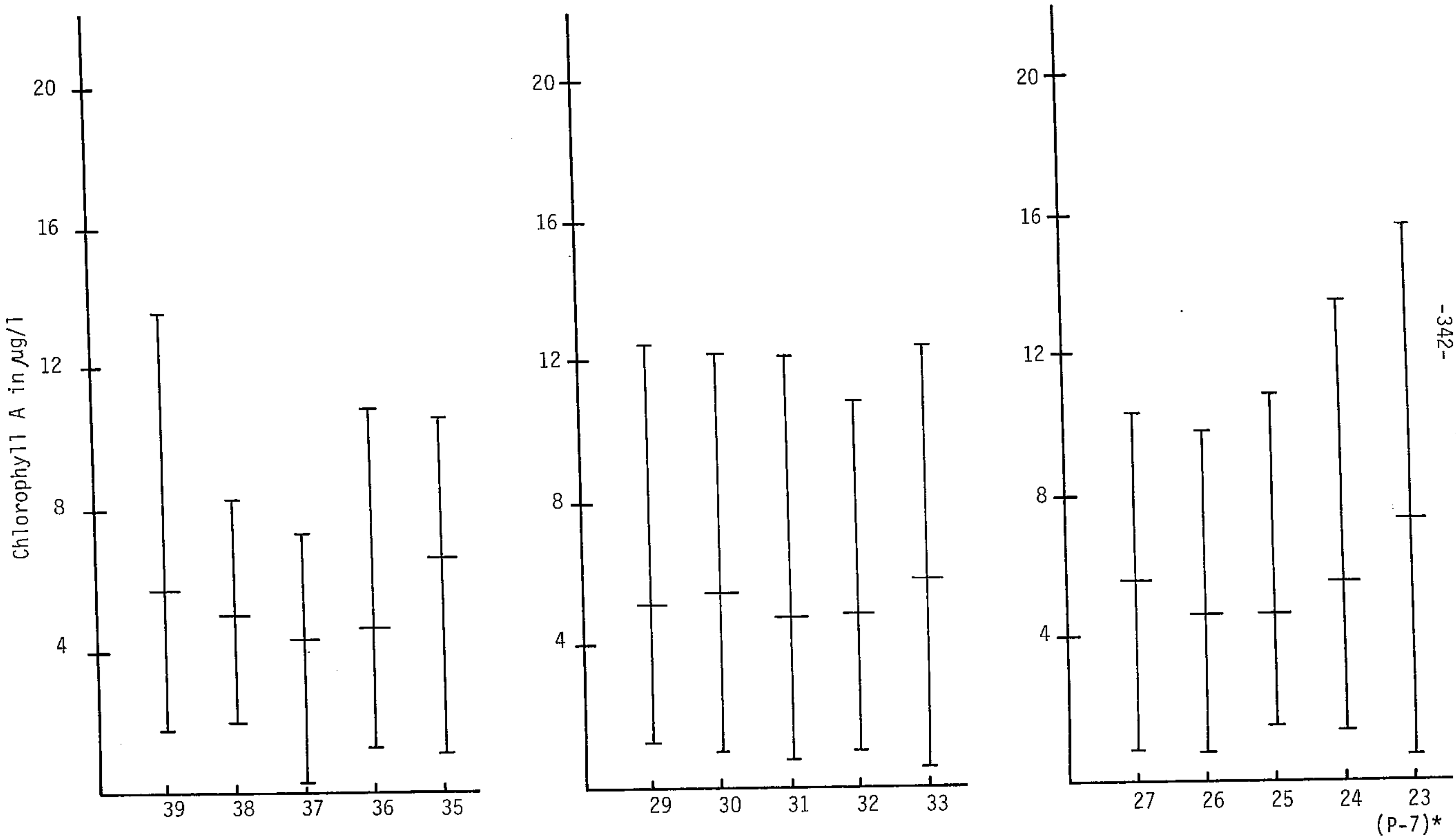
FIGURE C-118.

1975 Western Basin Transects - Ammonia Nitrogen



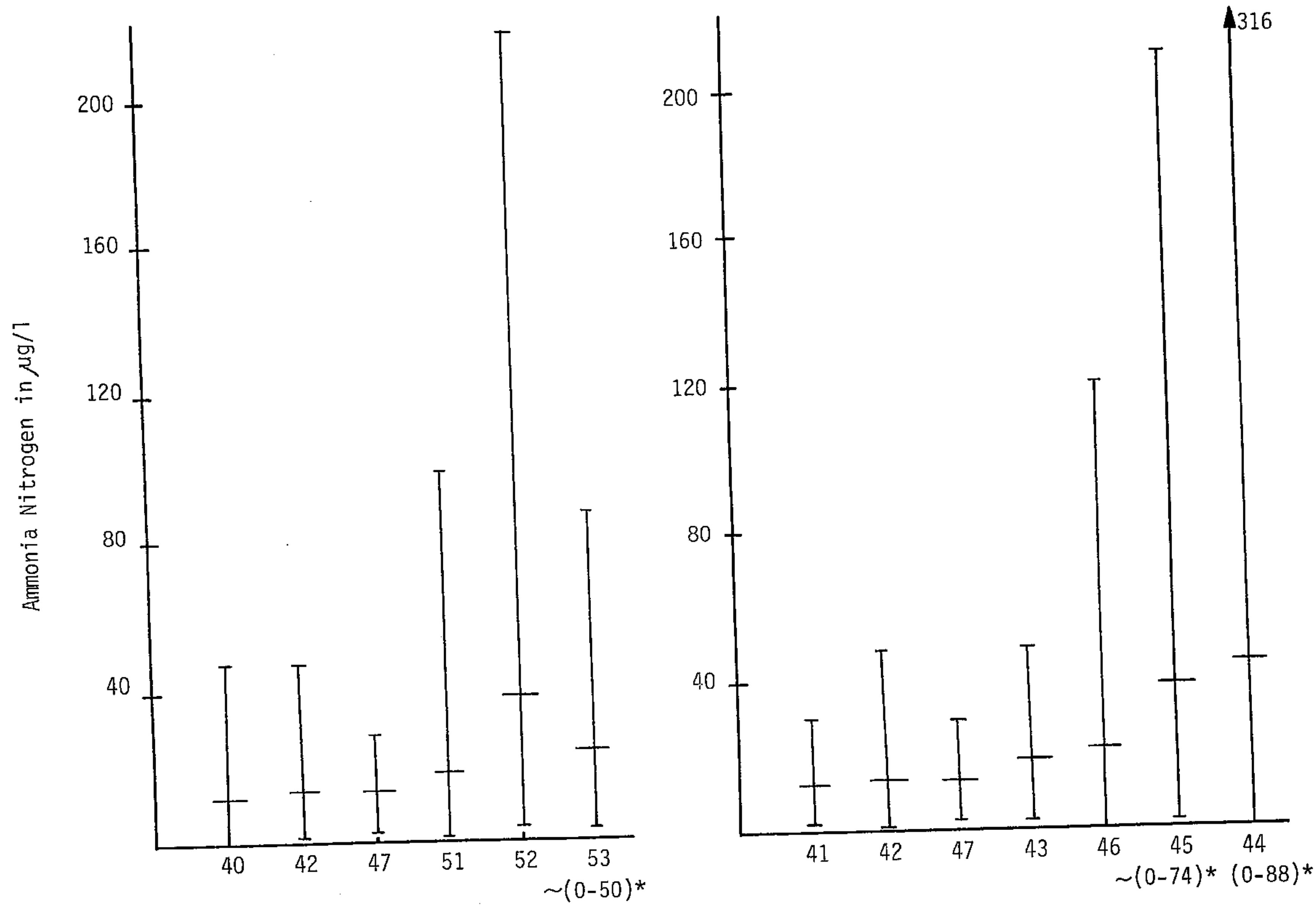
* Master Plan Station Numbers

FIGURE C-141.
1975 East Central Basin Transects - Chlorophyll A



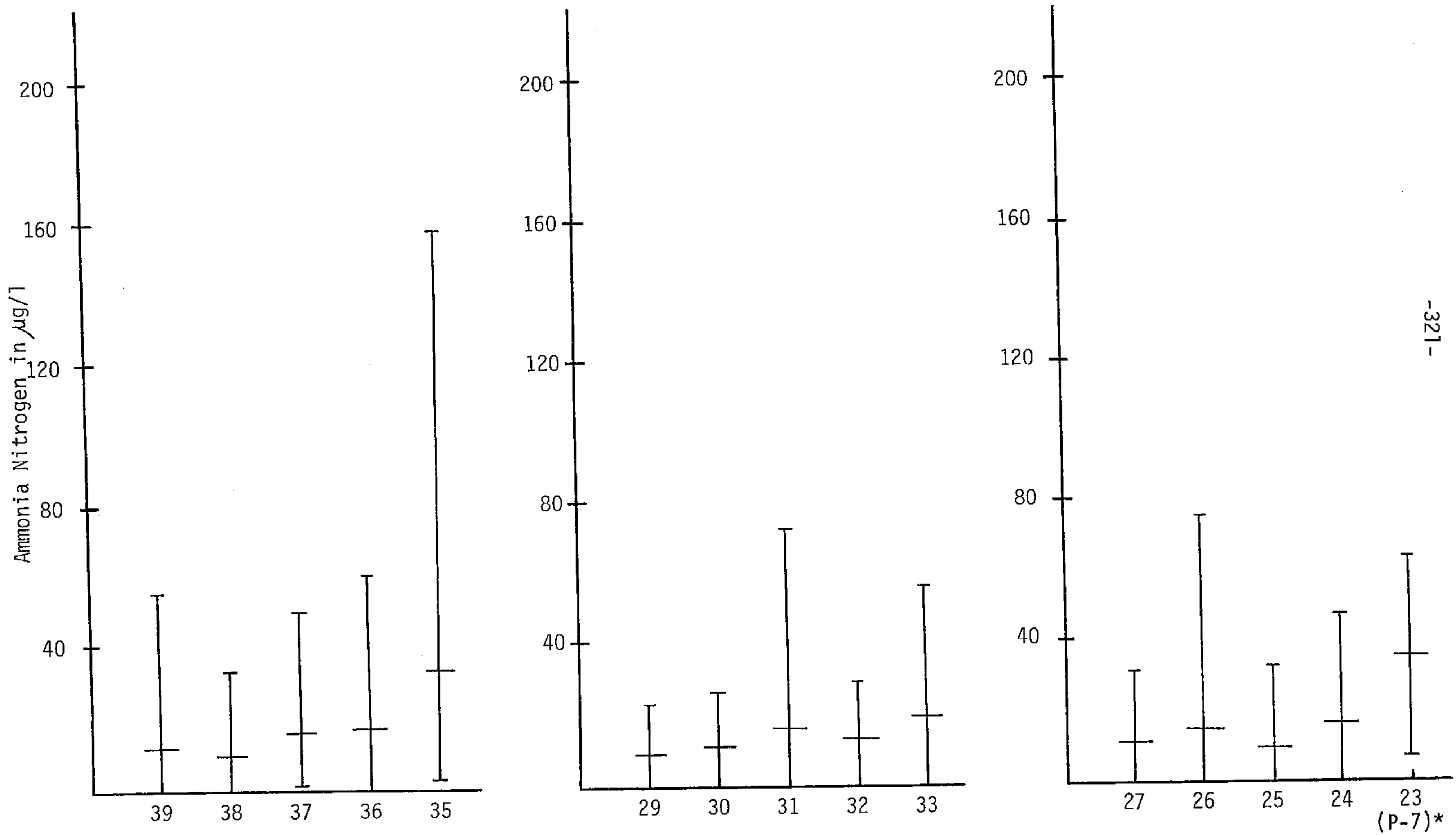
* Master Plan Station Numbers

FIGURE C-119.
1975 West Central Basin Transects - Ammonia Nitrogen



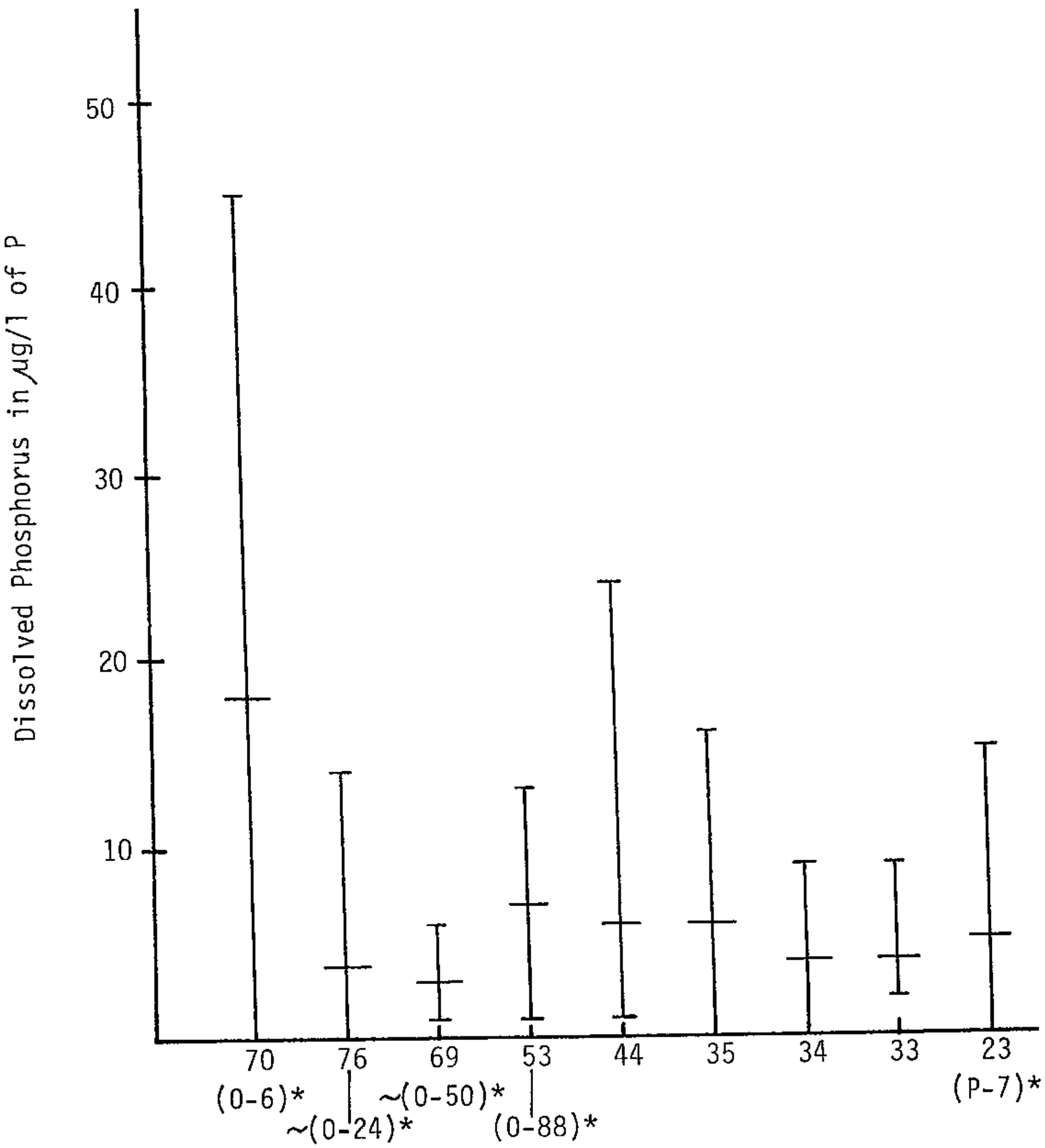
* Master Plan Station Numbers

FIGURE C-120.
1975 East Central Basin Transects - Ammonia Nitrogen



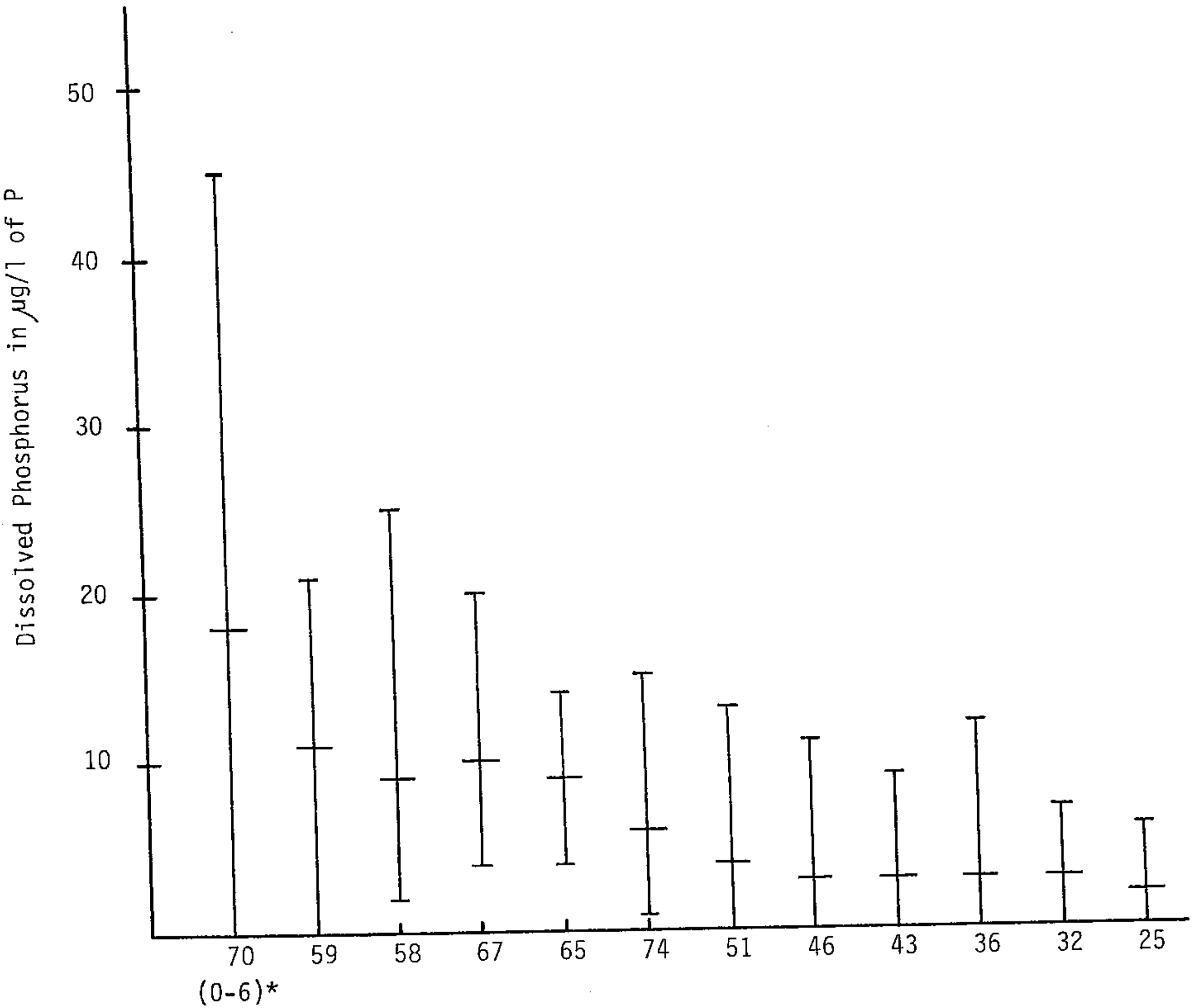
* Master Plan Station Numbers

FIGURE C-121.
1975 South Nearshore - Dissolved Phosphorus



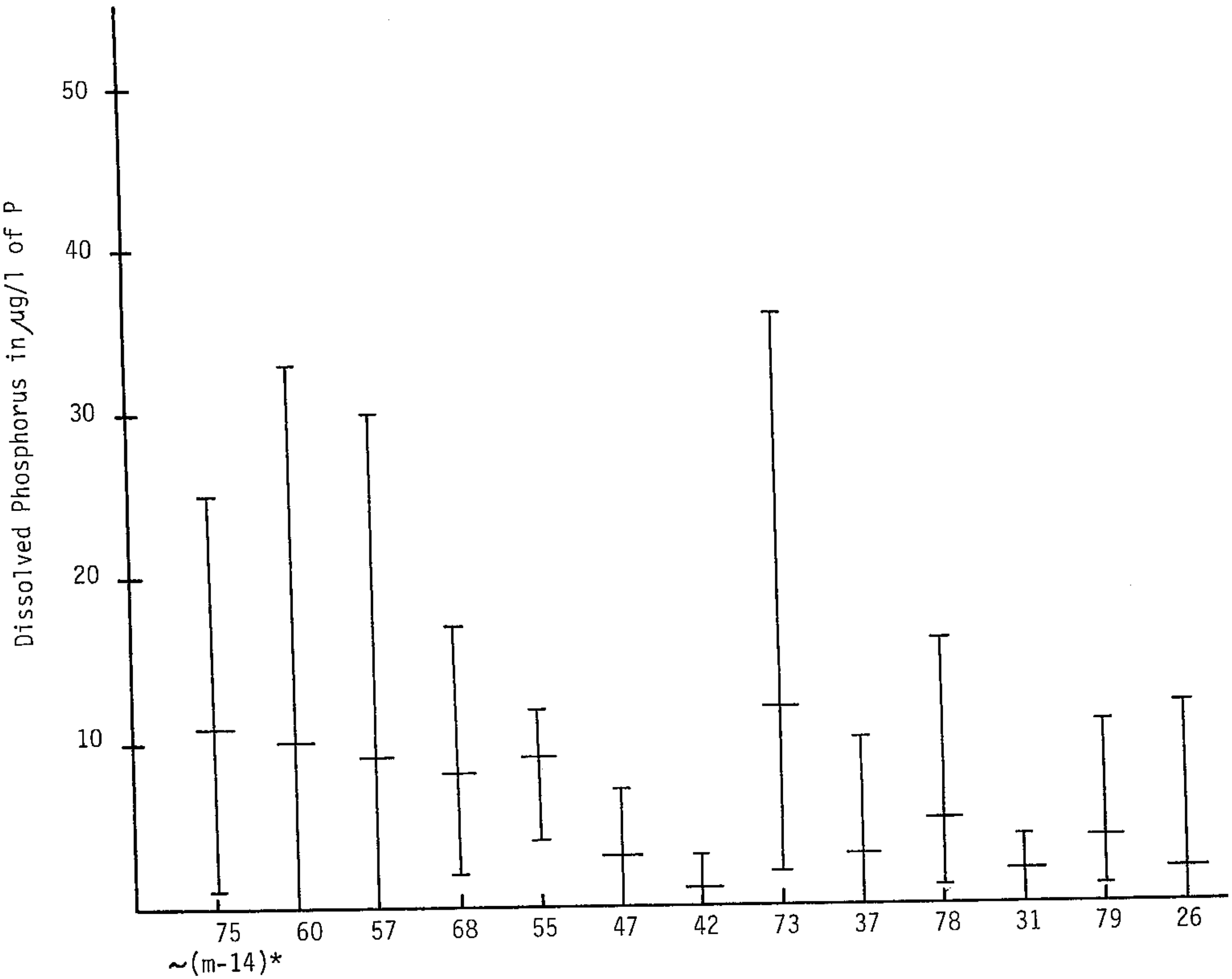
* Master Plan Station Numbers

FIGURE C-122.
1975 South Offshore - Dissolved Phosphorus



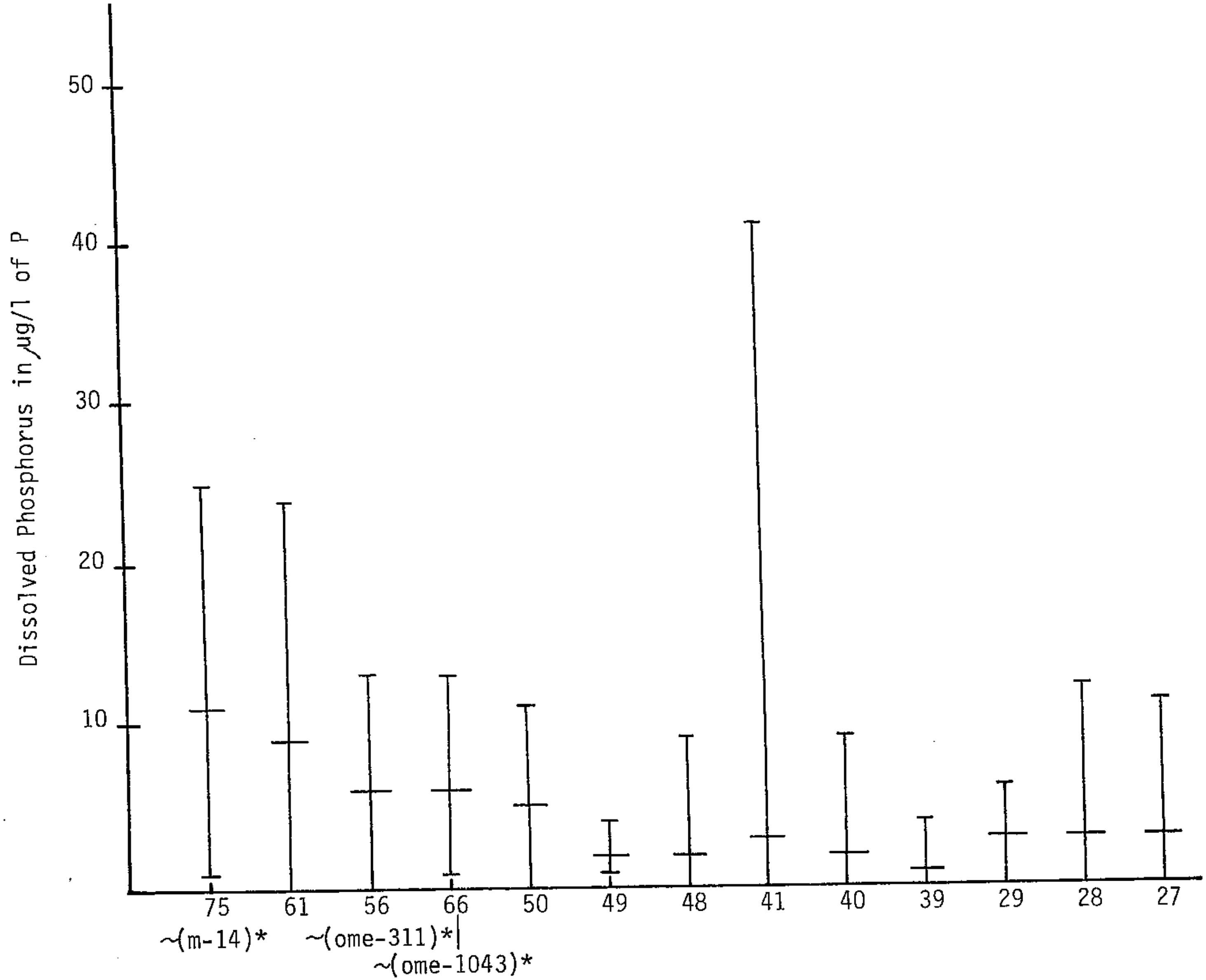
* Master Plan Station Numbers

FIGURE C-123.
1975 North Offshore - Dissolved Phosphorus



* Master Plan Station Numbers

FIGURE C-124.
1975 North Nearshore - Dissolved Phosphorus



* Master Plan Station Numbers

FIGURE C-125.
1975 Western Basin Transects - Dissolved Phosphorus

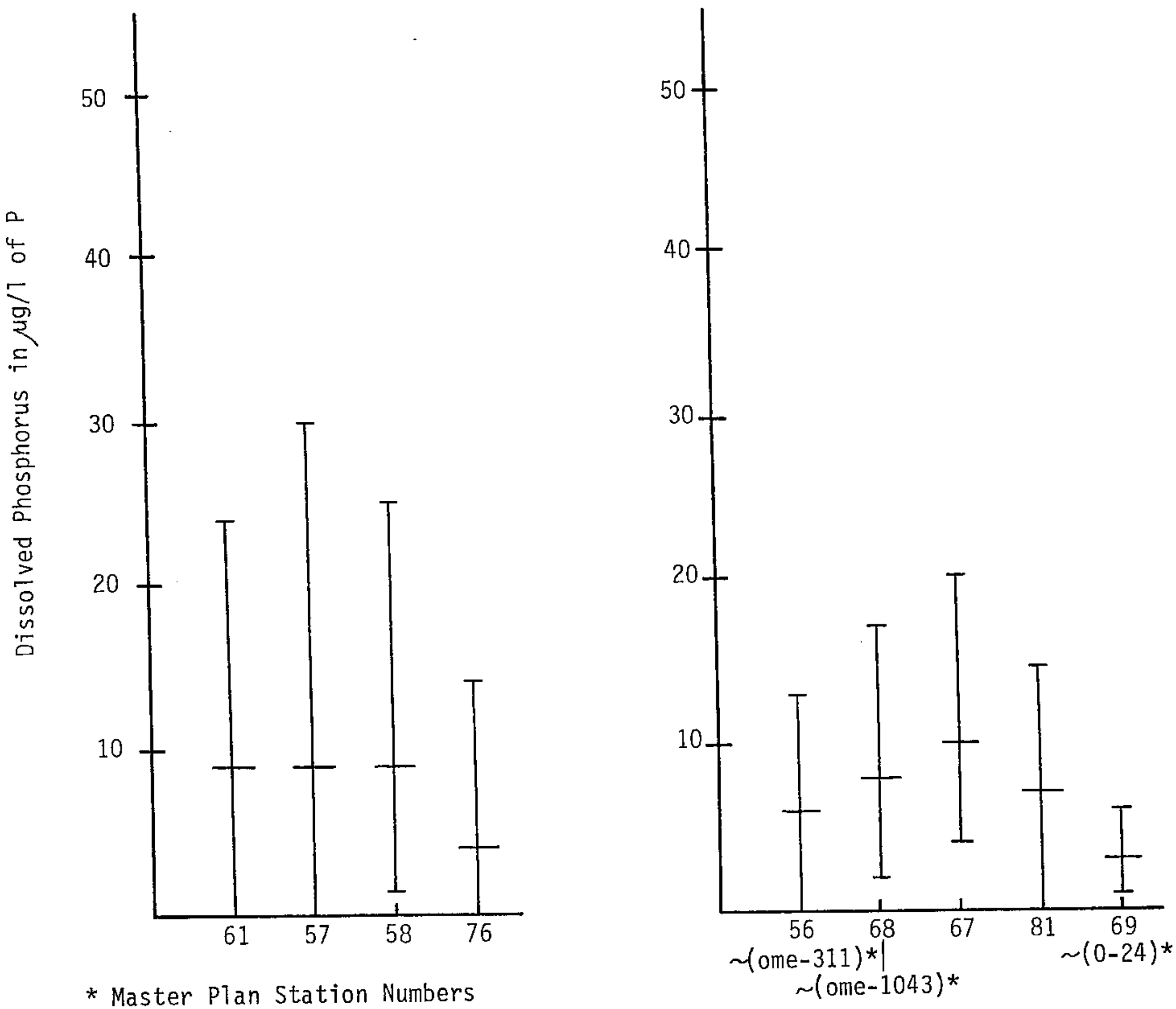
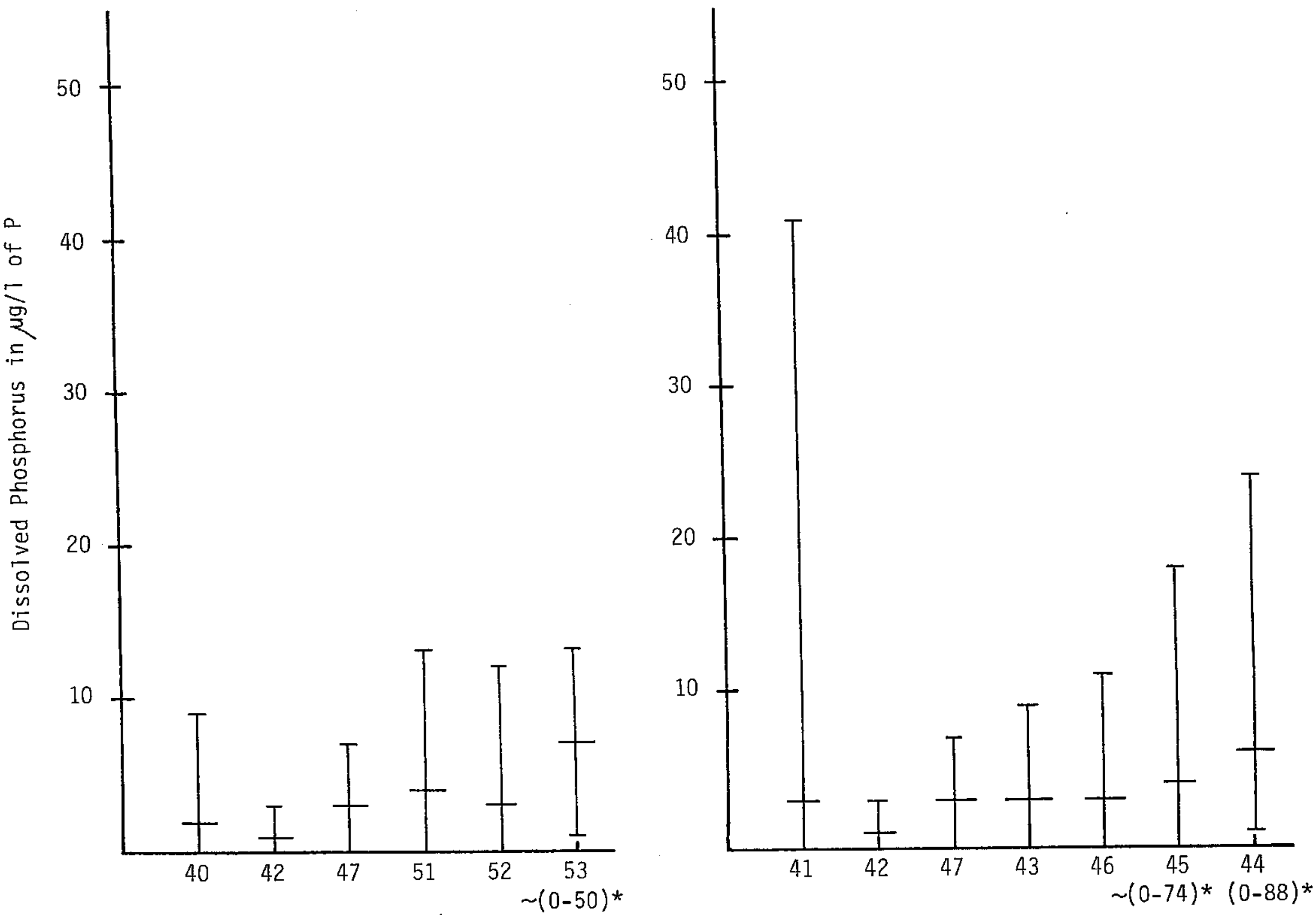
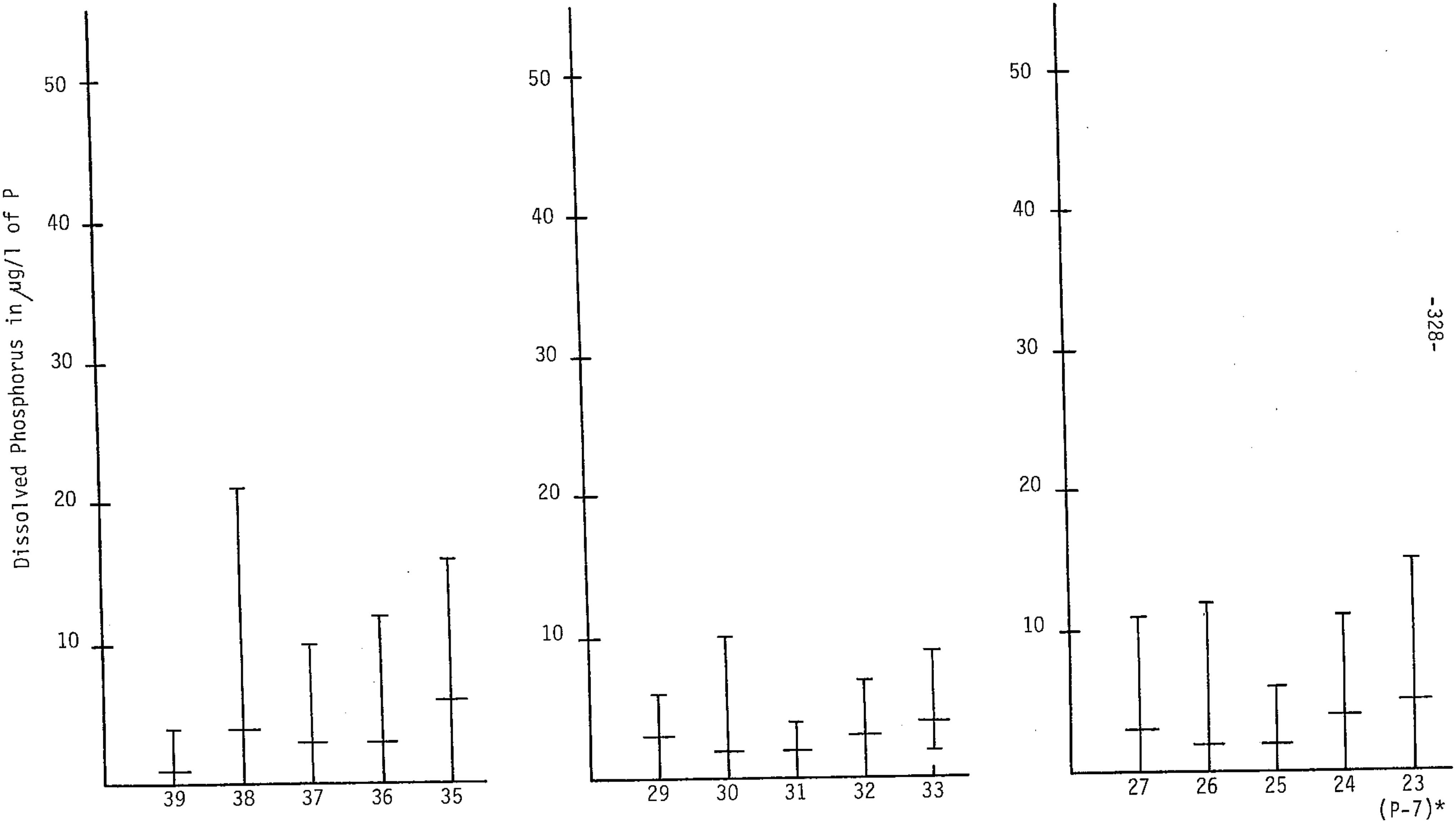


FIGURE C-126.
1975 West Central Basin Transects - Dissolved Phosphorus



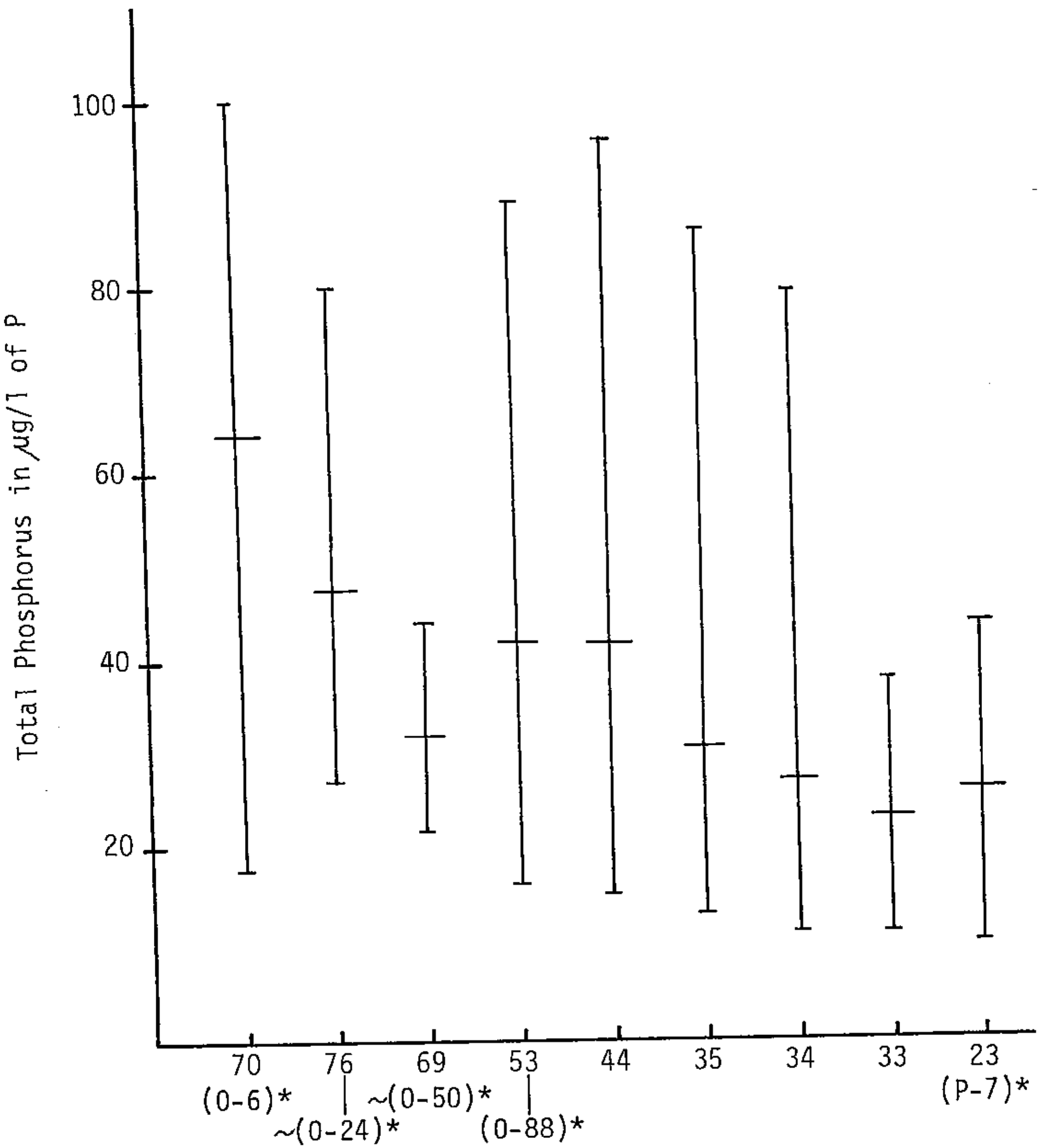
* Master Plan Station Numbers

FIGURE C-127.
1975 East Central Basin Transects - Dissolved Phosphorus



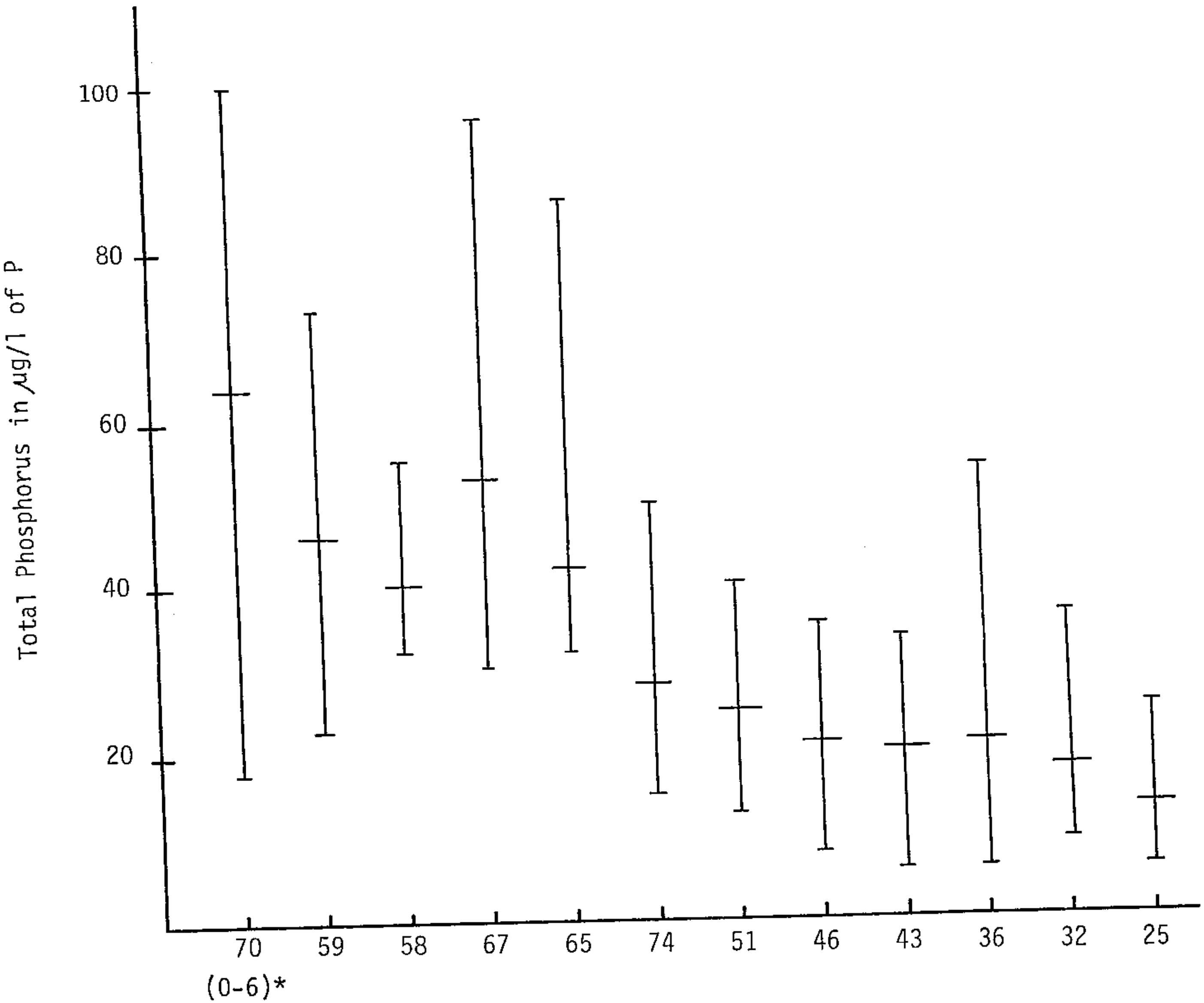
* Master Plan Station Numbers

FIGURE C-128.
1975 South Nearshore - Total Phosphorus



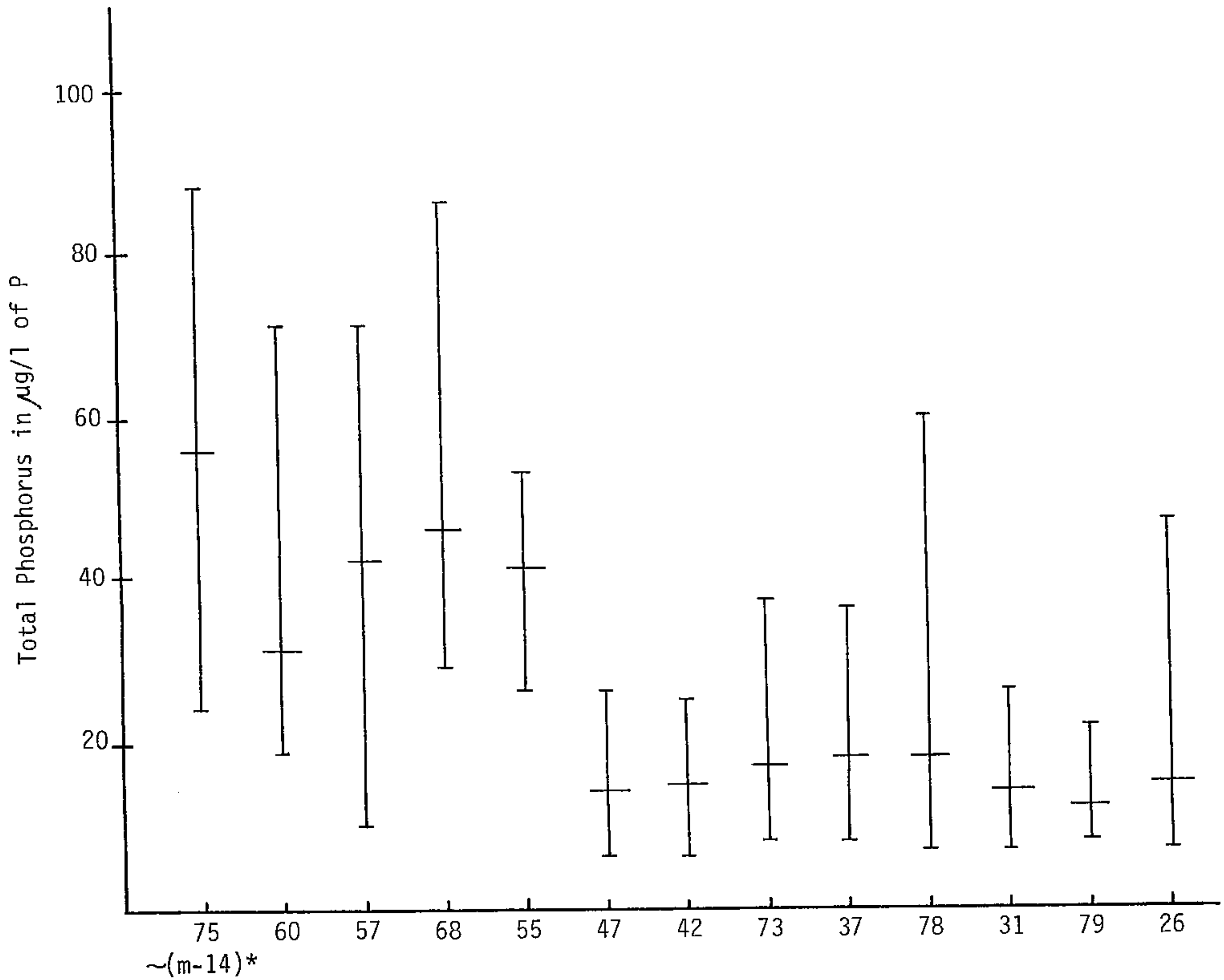
* Master Plan Station Numbers

FIGURE C-129.
1975 South Offshore - Total Phosphorus



* Master Plan Station Numbers

FIGURE C-130.
1975 North Offshore - Total Phosphorus



* Master Plan Station Numbers

FIGURE C-131.
1975 North Nearshore - Total Phosphorus

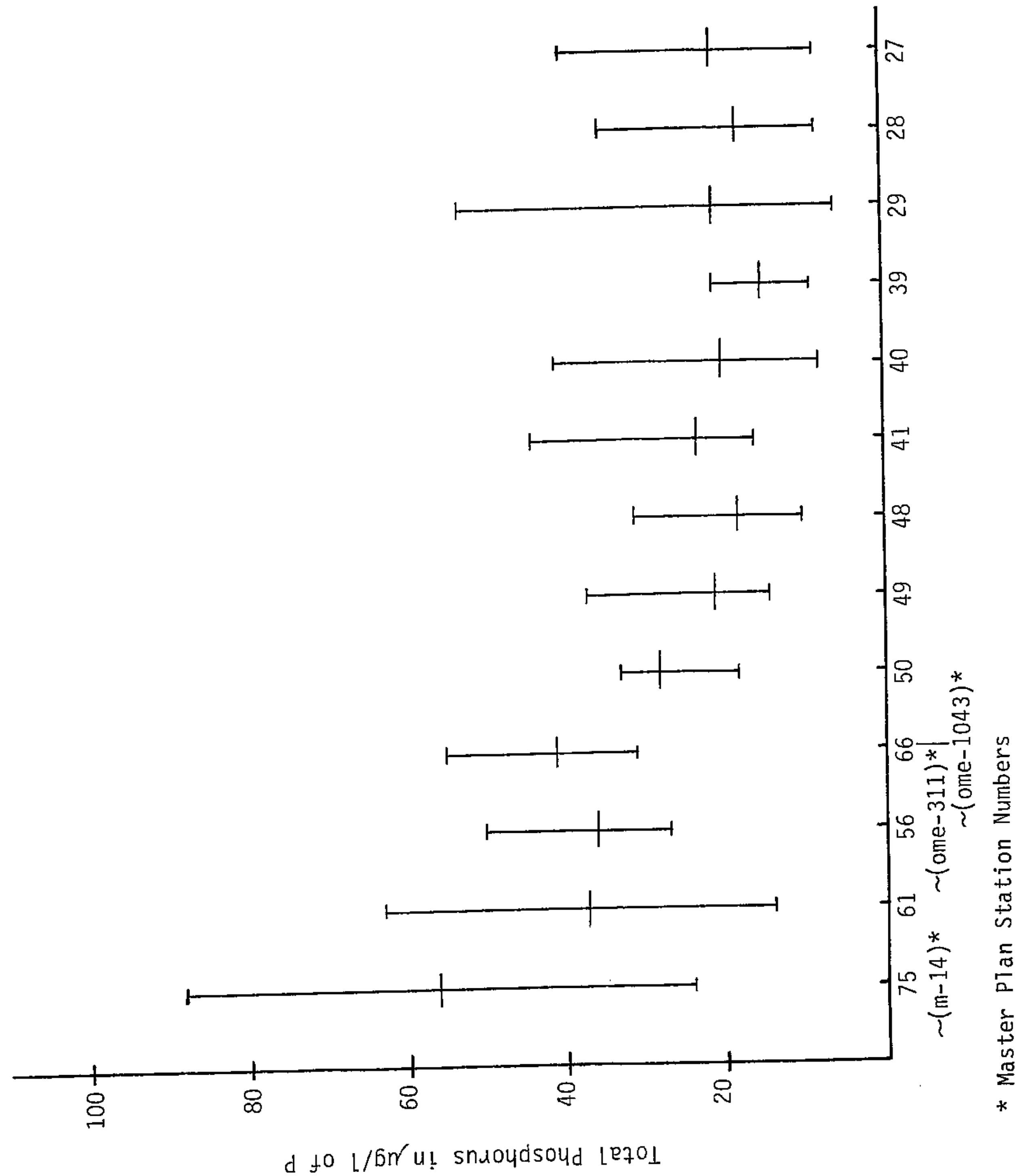
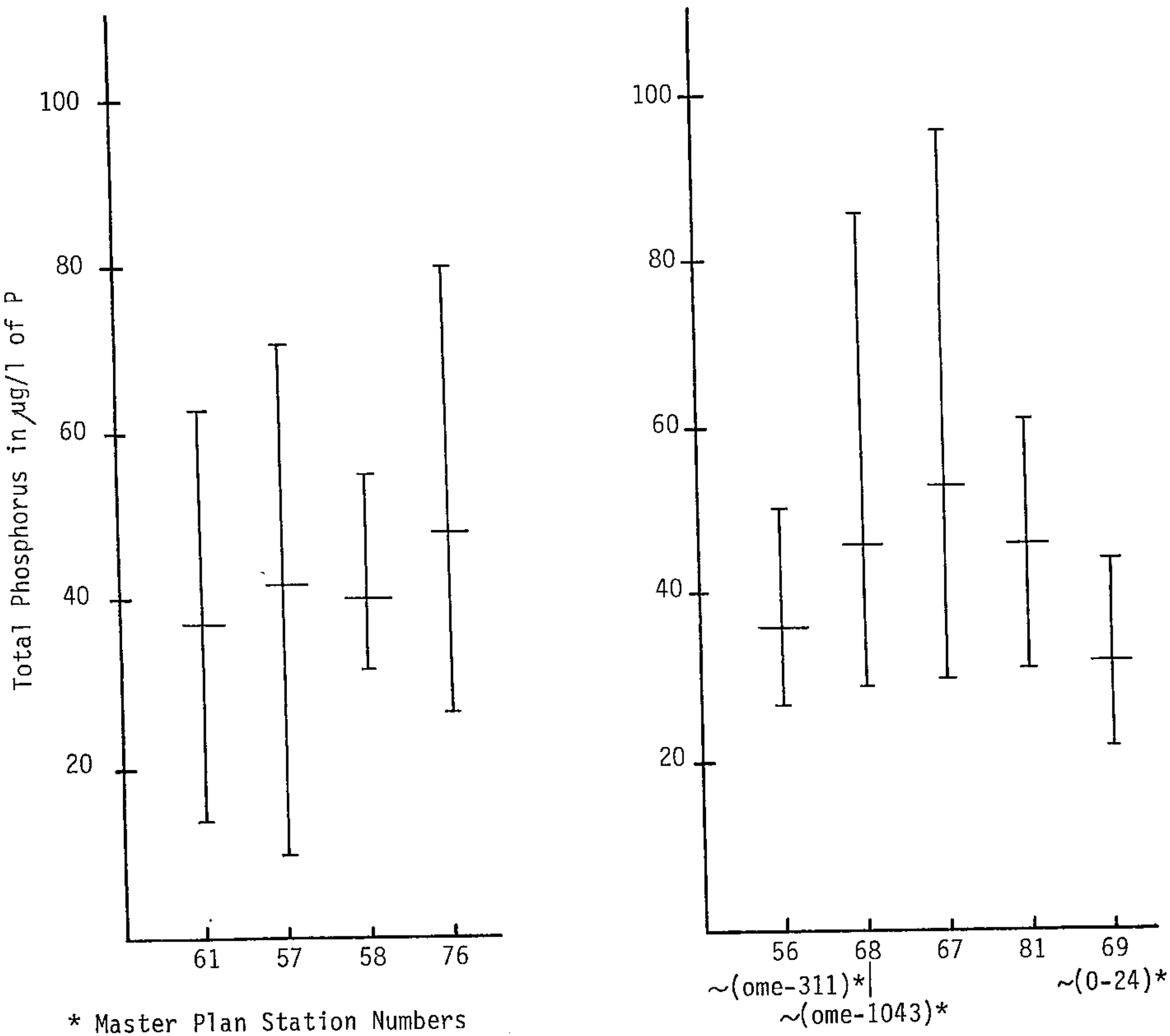


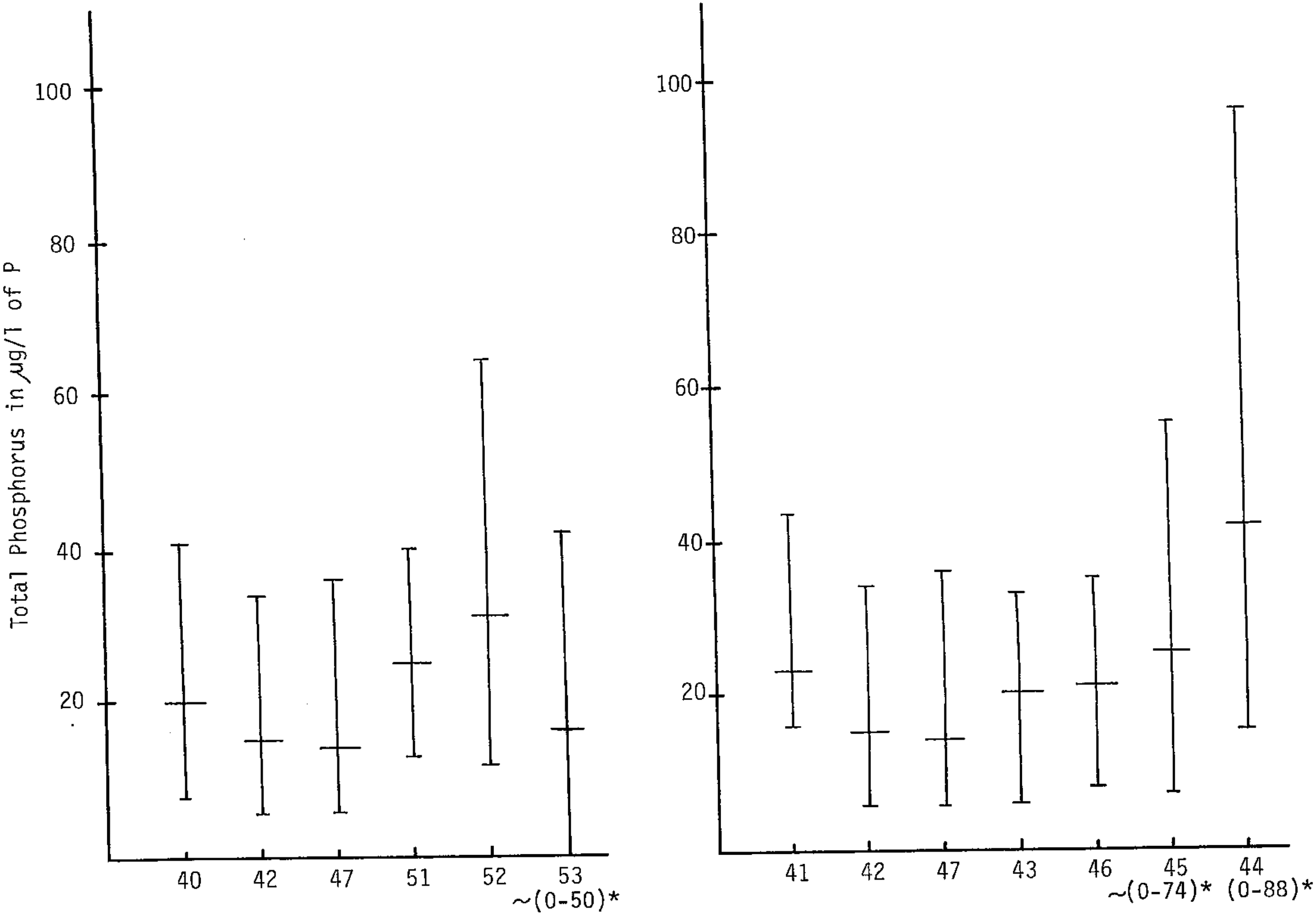
FIGURE C-132.
1975 Western Basin Transects - Total Phosphorus



* Master Plan Station Numbers

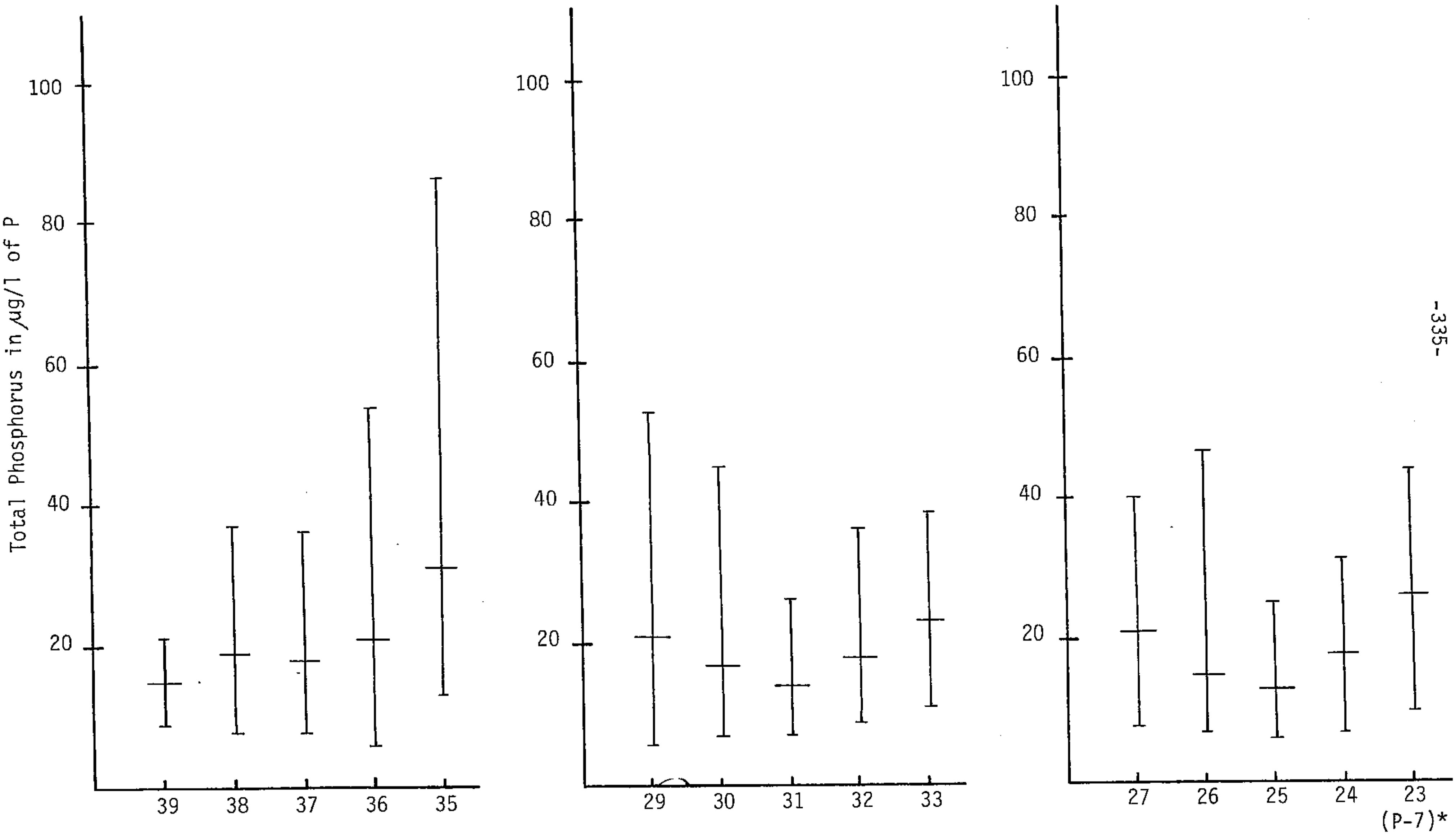
FIGURE C-133.

1975 West Central Basin Transects - Total Phosphorus



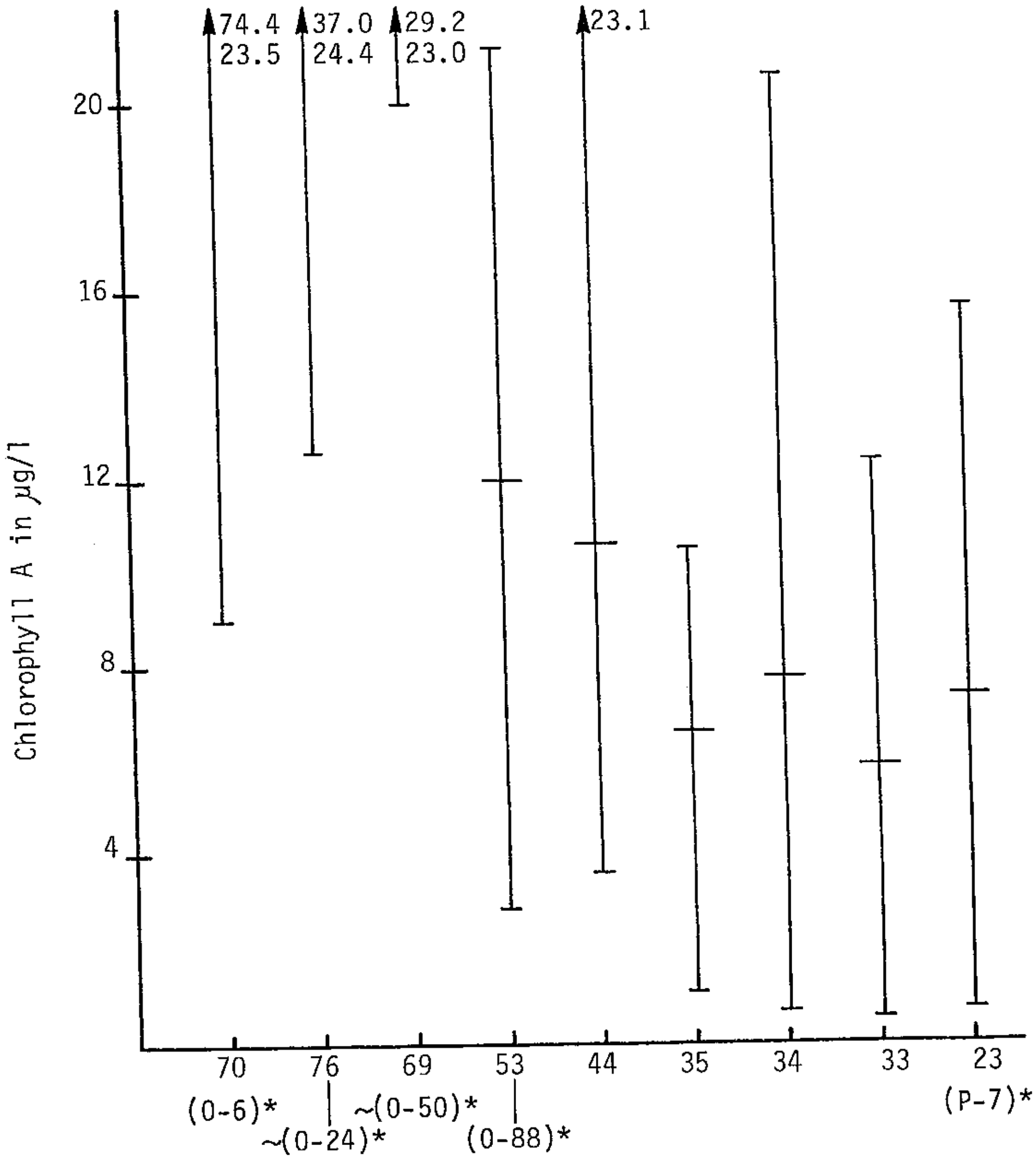
* Master Plan Station Numbers

FIGURE C-134.
1975 East Central Basin Transects - Total Phosphorus



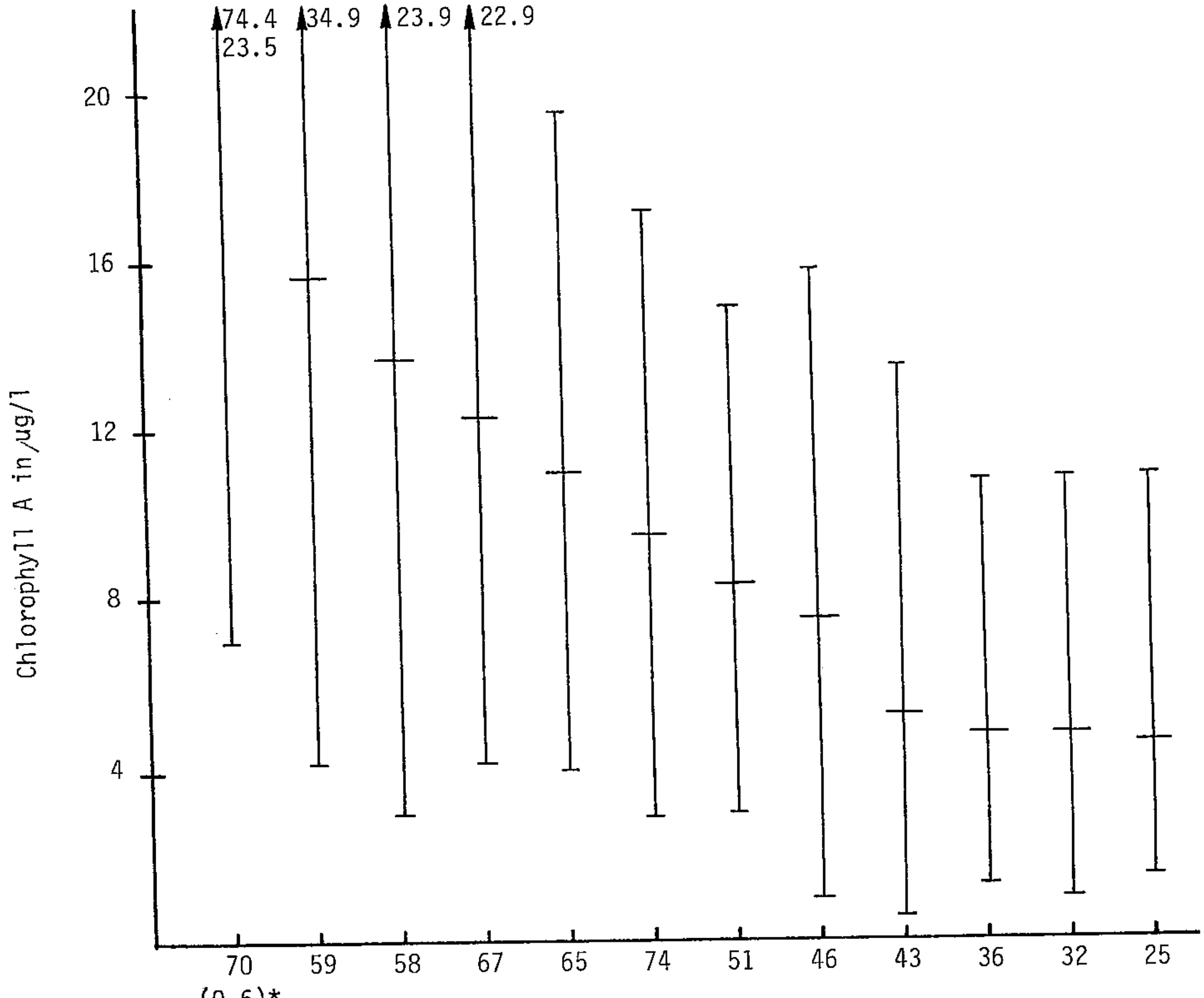
* Master Plan Station Numbers

FIGURE C-135.
1975 South Nearshore - Chlorophyll A



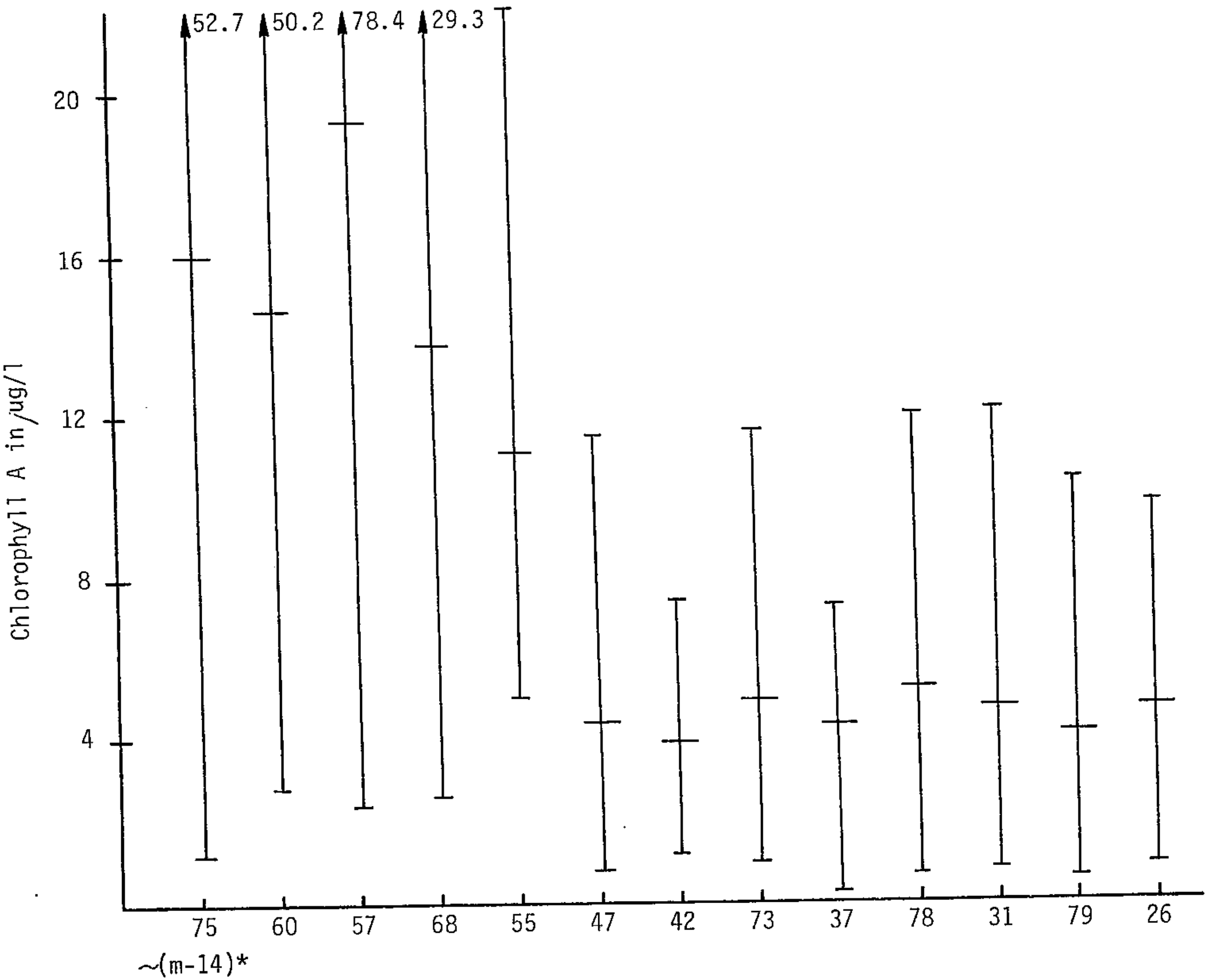
* Master Plan Station Numbers

FIGURE C-136.
1975 South Offshore - Chlorophyll A



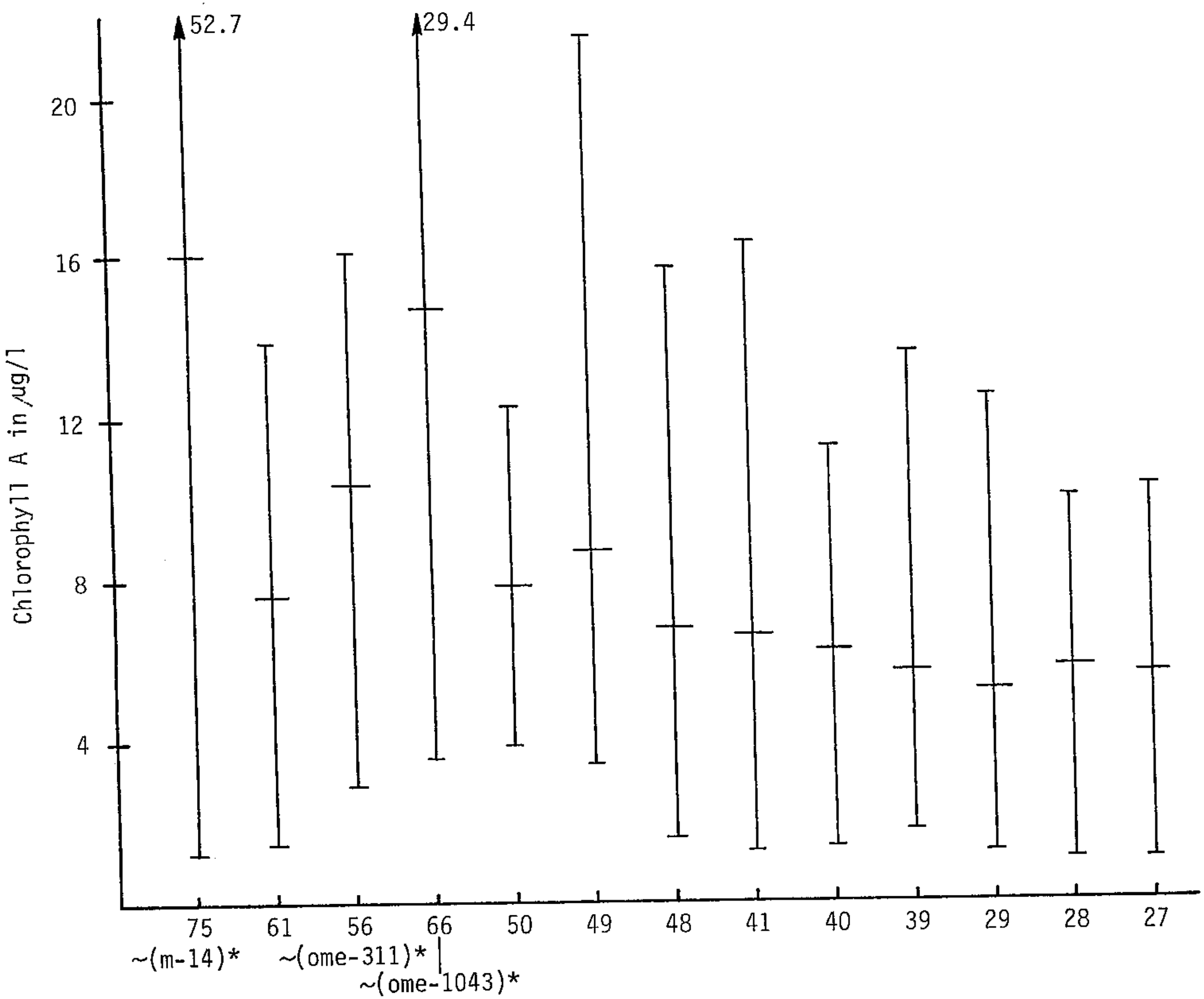
* Master Plan Station Numbers

FIGURE C-137.
1975 North Offshore - Chlorophyll A



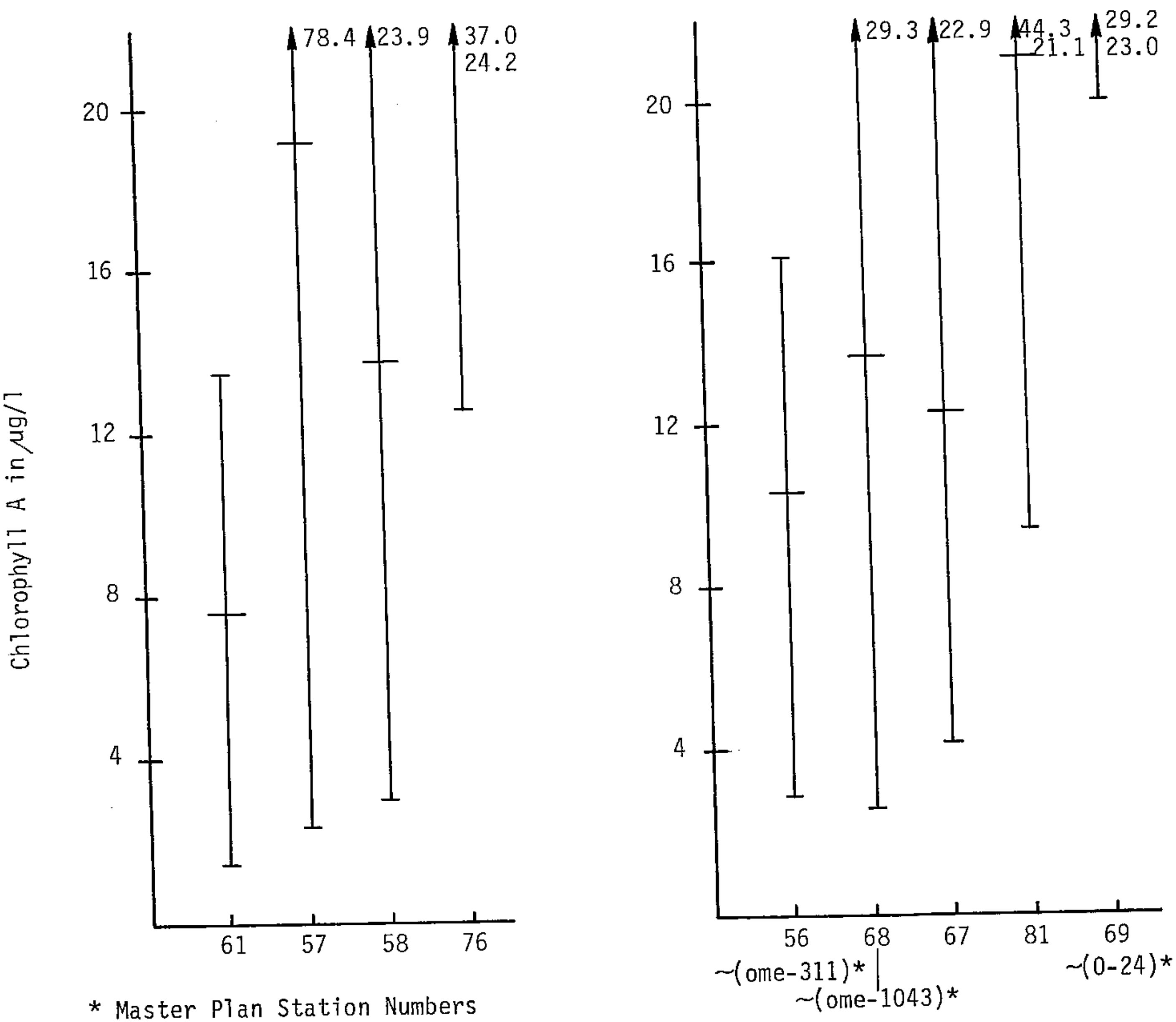
* Master Plan Station Numbers

FIGURE C-138.
1975 North Nearshore - Chlorophyll A



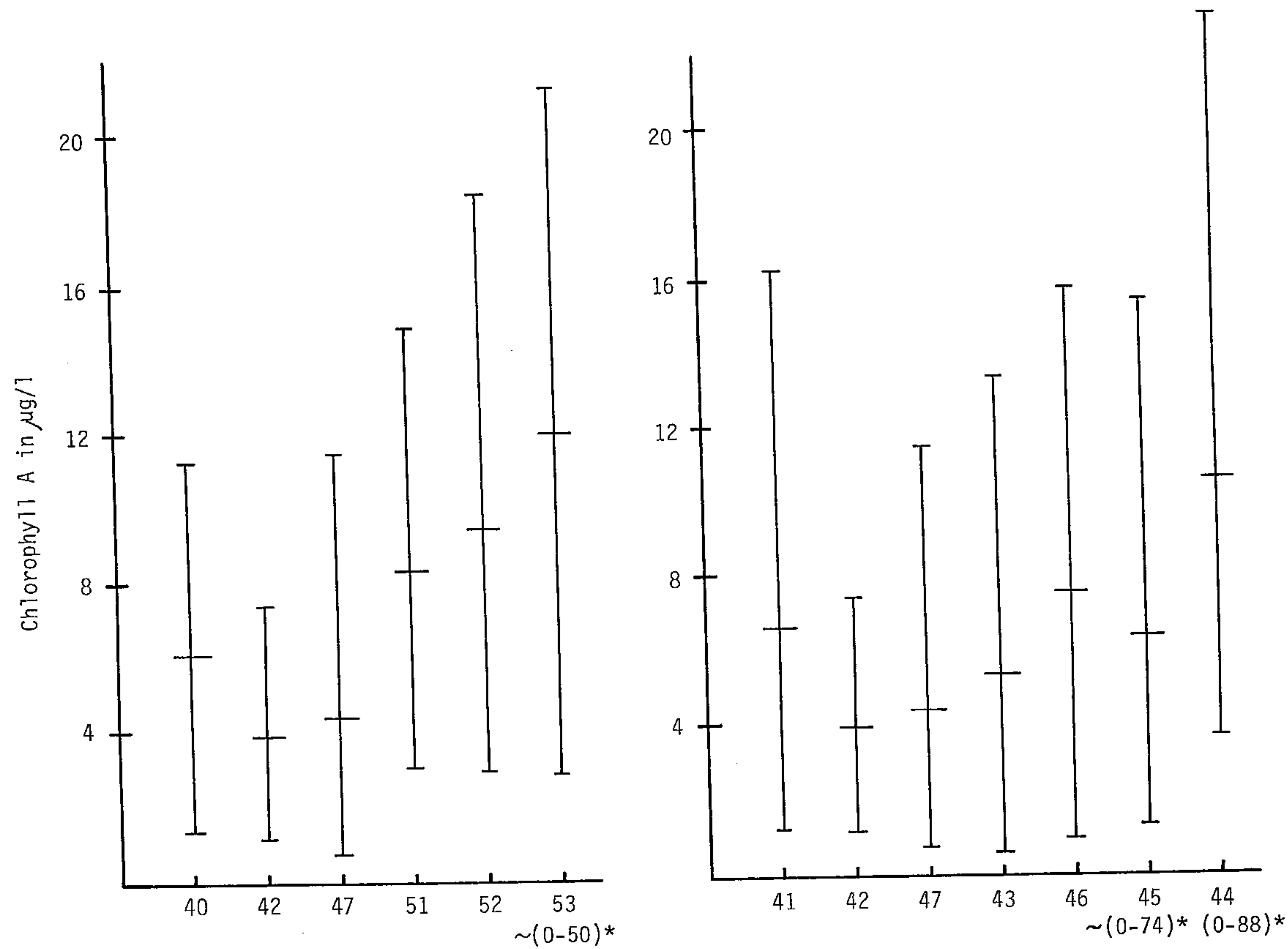
* Master Plan Station Numbers

FIGURE C-139.
1975 Western Basin Transects - Chlorophyll A



* Master Plan Station Numbers

FIGURE C-140.
1975 West Central Basin Transects - Chlorophyll A



* Master Plan Station Numbers