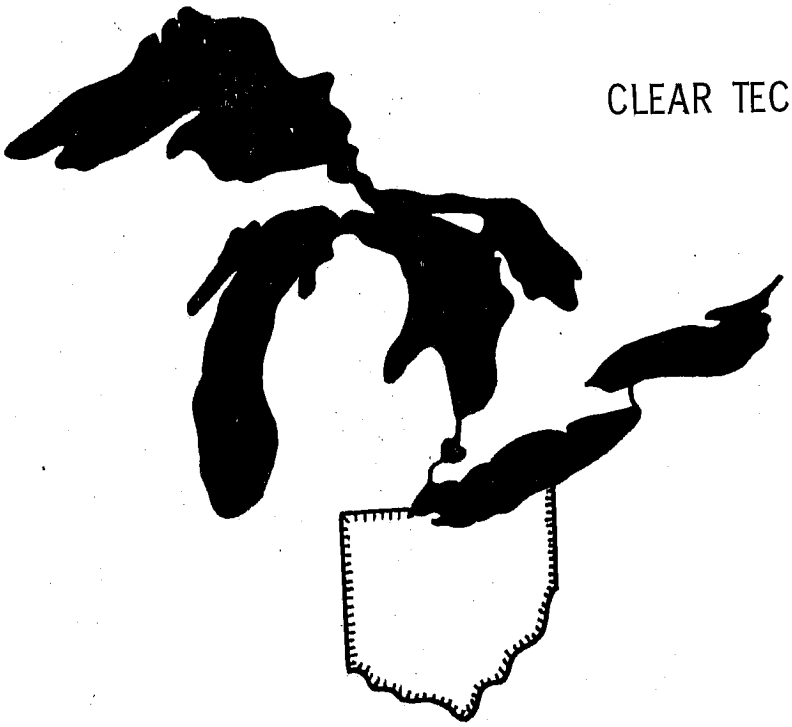

CLEAR TECHNICAL REPORT NO. 109

# 1978 NEARSHORE SURVEILLANCE PROGRAM FOR WESTERN LAKE ERIE

## Preliminary Summary


by

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# 1978 NEARSHORE SURVEILLANCE PROGRAM FOR WESTERN LAKE ERIE

## Introduction

The nearshore zone of Lake Erie is where the greatest interaction between water quality and water users take place. These waters are the source of all water for public and industrial water supply. It is the site of virtually all recreational use and it is the most important area for the propagation and support of all aquatic life forms. With the exception of that portion of atmospheric deposition falling on the main body of the lake, the nearshore zone is the recipient of most waste input. For this reason, these waters are the first to show signs of degradation and are the first indicators of progress in abating pollution.

The Center for Lake Erie Area Research (CLEAR) and the Water Resources Center (WRC) at The Ohio State University undertook an extensive study of the nearshore waters of western Lake Erie in 1978. Seventy seven (77) stations (Figures 1 and 2) were visited on three consecutive days (weather permitting) during each of four cruises (Appendix 1-3):

| | | | |
|---|---|---|---|
| Cruise 1 | April 14-29 (104-119) | Cruise 3 | August 23-Sept. 11 (235-254) |
| Cruise 2 | June 26-July 12 (177-193) | Cruise 4 | October 3-17 (276-290) |

Approximately 75 water quality and 30 sediment quality parameters were measured at these stations. The following report summarizes the preliminary results of this study. Several key parameters are discussed and measurements which exceed IJC objectives are documented. The study plan for this program was developed by the Lake Erie Work Group of the Surveillance Subcommittee, Great Lakes Water Quality Board, International Joint Commission. The surveillance program was sponsored by a grant from the Great Lakes National Program, U.S. Environmental Protection Agency, Region V.

## Ammonia

Ammonia ($NH_4$-N) concentrations in nearshore waters of western Lake Erie (Michigan and Ohio waters from the mouth of the Detroit River to Old Woman Creek) ranged from 0.0 µg/l to 1231.0 µg/l during the period April to October 1978. Inshore stations (nearshore stations nearest the shore) yielded a mean concentration of 96.5 µg/l while offshore stations (nearshore stations farthest from the shore) had a mean concentration of 74.9 µg/l. The mean value for all nearshore stations during the study period was 84.0 µg/l. In general the Maumee River dominated the release of ammonia to the Western Basin. Concentration along the Maumee Bay reach of shoreline averaged twice the concentration of the remaining shore reaches within the study area (185.9 vs. 81.6 µg/l). The highest ammonia values were also obtained near the mouth of the Maumee River and at times were over twice the IJC objectives. A secondary area of high concentrations was noted during April and June in the vicinity of the South Passage.

presumably the result of Maumee River flow exiting the basin. Concentrations in this region also exceeded the IJC objectives. Seasonally, ammonia concentrations showed a consistent decrease from April (183.4 µg/l) to October (19.1 µg/l) throughout the study area.

## Soluble Reactive Phosphorus

Soluble reactive phosphorus (SRP) concentrations in the nearshore waters of western Lake Erie (Michigan and Ohio waters from the mouth of the Detroit River to Old Woman Creek) ranged from 0.0 µg/l to 111.7 µg/l during the period April to October 1978. Inshore stations yielded a mean concentration of 18.0 µg/l while offshore stations had a mean value of 14.4 µg/l. The mean concentration for all nearshore stations during the study period was 15.8 µg/l.

Figure 3 demonstrates the predominance of the Maumee River on phosphorus loading to western Lake Erie. It also shows the relatively higher concentrations found in the inshore waters as compared to offshore values. Lesser peaks in SRP concentration were also observed for the Detroit/Huron River mouths, River Raisin Sandusky Bay and Huron River (Ohio). As with ammonia, high concentrations of SRP were noted in the South Passage, presumably the result of Maumee River flow exiting the basin. Seasonally, SRP showed a consistent decrease from April (38.8 µg/l) to October (6.2 µg/l). This decrease is particularly well exhibited in Maumee Bay (Figure 4 ). The dispersion that occurs as materials move from the Maumee River into Maumee Bay and western Lake Erie is also displayed in Figure 4 .

## Silica

Silica (dissolved reactive) concentrations in nearshore waters of western Lake Erie (Michigan and Ohio waters from the mouth of the Detroit River to Old Woman Creek) ranged from 0.0 µg/l to 9,650 µg/l during the period April to October 1978. Inshore stations yielded a mean concentration of 1,488 µg/l, while offshore stations had a mean value of 1,284 µg/l. The mean level for all nearshore stations during the study period was 1,329 µg/l.

The highest concentrations of silica were observed in the western half of Sandusky Bay (annual average in excess of 5,000 µg/l). The next highest levels were found in Maumee Bay (annual average over 2,000 µg/l). Silica, a major nutrient for diatoms, showed a distinct seasonal trend by consistently decreasing in concentration from April (3081 µg/l) to June (1395 µg/l) to August (578 µg/l) to October (262 µg/l) throughout the study area.

## Chlorophyll

Chlorophyll a concentrations (corrected for pheophytin) in the nearshore waters of western Lake Erie ranged between 0.04 µg/l and 207 µg/l during Cruises 1 and 2 (April and June, 1978). In April, inshore stations averaged 12.29 while offshore stations were 5.19 µg/l. The average chlorophyll a concentration rose from 11.10 µg/l in April to 32.15 µg/l in June.

The areas of lowest concentration (< 10 µg/l) during June were located along the Ohio shore west of Locust Point to East Harbor and Huron harbor. The areas of highest concentration (> 100 µg/l) were found along the Michigan shore between Brest Bay and Maumee Bay, within the outer part of Maumee Bay and east to Magee Marsh, and Sandusky Bay. These areas correlate well with areas of high phytoplankton species diversity (Figure 10).

## Turbidity

Turbidity values for the nearshore waters of western Lake Erie (Michigan and Ohio from the mouth of the Detroit River to Old Woman Creek) ranged from 2.0 to 122.0 NTU during the period April to October 1978. Inshore stations yielded a mean reading of 26.5 NTU, while offshore stations had a mean value of 15.6 NTU. The mean level for all nearshore stations during the study period was 19.8 NTU.

The most turbid waters, on an annual basis, were observed in western Sandusky Bay and along the Ohio shore near Crane Creek. Both of these areas are subject to extensive resuspension of bottom sediments by wave action. Turbidity shows distinct seasonal patterns which appear to be related to tributary discharges and the intensity of wave action in the nearshore area. Spring runoff and storms (Figure 5 ) account for the high turbidity values in April (41.4 NTU). Calmer weather in June (Figure 6 ) and August resulted in turbidity values of 17.0 and 10.0, respectively. The greater intensity of fall storms resulted in an average value of 21.8 NTU in October.

## Heterotrophic Bacteria

The total heterotrophic bacteria populations of the nearshore waters of western Lake Erie ranged from 13 cells/ml to $1.66 \times 10^6$ cells/ml during the period April to October 1978. Inshore stations yielded a yearly average of $2.2 \times 10^4$ cell/ml while offshore stations had a mean count of $4.9 \times 10^4$ cells/ml. The mean population density for all nearshore stations during the study period was $2.3 \times 10^4$ cells/ml. Seasonal trends indicate that the offshore populations were highest in the spring and that the inshore stations were highest during the summer and fall:

| Cruise | Cells/ml | |
|---|---|---|
| | Inshore Population Density | Offshore Population Density |
| 1-April | $7.4 \times 10^4$ | $1.9 \times 10^5$ |
| 2-June | $3.1 \times 10^3$ | $4.0 \times 10^2$ |
| 3-August | $9.4 \times 10^3$ | $4.5 \times 10^3$ |
| 4-October | $3.6 \times 10^3$ | $4.9 \times 10^2$ |

The reach of Michigan shoreline from the Detroit River Mouth to Brest Bay (inshore stations) contained the highest population density of heterotrophic bacteria. The mean inshore population for this reach was over 6 times greater than the inshore population for the remainder of the study area ($8.1 \times 10^4$ as compared to $1.3 \times 10^4$). A general decline in population density throughout the study area was noted for April ($8.4 \times 10^4$ cells/ml) to October ($1.4 \times 10^3$ cells/ml).

## Fecal Coliform Bacteria

The Ohio Environmental Protection Agency and the Michigan Department of Natural Resources have established a water quality standard of 200 cells/100 ml as the maximum allowable concentration of fecal coliform bacteria in water used for body contact. Figures 7 and 8 indicate the 27 stations where this concentration was exceeded at least once during the period April to October 1978. The highest populations were observed along the Michigan shore south of the Detroit River and River Raisin and in the Ohio waters of the Maumee River, along the shore east and west of the Portage River, in eastern Sandusky Bay and at the mouth of the Huron River. Offshore populations were generally low except for south of the Detroit River mouth and Maumee Bay. The fecal coliform bacteria populations of the nearshore waters of western Lake Erie ranged from 0 cells/100 mls to $2.3 \times 10^4$ cells/100 mls during the period April to October 1978.

## Macrobenthic Organisms

The benthos populations of the nearshore waters of western Lake Erie are dominated by annelid worms of the class Oligochaeta and dipteran larvae of the family Chironomidae. Populations ranged from 95 to 26,592 organisms per square meter. The highest populations, in order of decreasing abundance, were observed in 1) Maumee Bay, 2) Huron River discharge area, 3) South Passage off Port Clinton, 4) Sandusky Bay mouth and 5) Michigan nearshore south of Detroit River mouth. All of these areas contained populations in excess of 3,000 organisms per square meter. Sedimentary deposits consisting of detritus, soft mud and fine sand yielded the highest populations. Rock, coarse sand and gravel, and glacial till bottoms yielded low benthic populations. Benthic organisms were approximately 3.4 times more abundant at stations subject to recent dredging than those outside of shipping channels.

## Phytoplankton and Zooplankton

The phytoplankton population in the nearshore waters of western Lake Erie was dominated by centric diatoms during Cruise 1 (April 1978), except for Sandusky where green and blue-green algae were more prevalent. By June (Cruise 2) diatoms had diminished in importance; green and blue-green algae were the most prevalent form. In western Sandusky Bay blue-greens were dominant and more numerous than at any other reach in the study area. The lack of diatoms may account for the high dissolved silica concentrations in the bay. Cryptomonads were only noted in high numbers in eastern Sandusky Bay and Maumee Bay but they never dominated the algal population. Phytoplankton species diversity range from 0 taxa to 69 taxa during the April and June cruises (Figures 9 and 10). The highest diversity was noted near the Detroit River mouth, Michigan shore north of Maumee Bay, Ohio shore southeast of Maumee Bay, and Ohio shore east of Sandusky (all exceeded 50 taxa). The lowest diversity was observed at the mouth of the Maumee River, eastern Maumee Bay, western Sandusky Bay and at the mouth of the Huron River (none exceeded 10 taxa). In general, phytoplankton diversity appears to be influenced by turbidity; stations with high levels of

suspended solids, particularly near the mouth of the Maumee and Sandusky Rivers, have few species while stations with high clarity have higher diversity (Figures 11 and 12 ).

Spring zooplankton populations in the nearshore waters of western Lake Erie were dominated by rotifers, particularly of the genus Notholca (cold water form) and Synchaeta. Copepods were present in moderate numbers and cladocerans formed only a minor part of the population. Species diversity ranged from a low of 14 taxa in western Sandusky Bay to a high of 35 taxa along the Ohio shore east of Maumee Bay. In general, offshore species diversity was higher (24 taxa) when compared with the inshore stations (20 taxa). Diversity for zooplankton species was much more uniform throughout the study area (Figure 13) than the diversity exhibited by phytoplankton species (Figures 9 and 10).

## Toxic Substances

The presence of toxic substances in the water, including 10 pesticides, PCB, and 12 metals, was determined at selected nearshore stations. Preliminary results show trace amounts (ppt range) of pesticides; confirmation of concentrations for each compound is underway at this time. PCB was not detected in any samples at concentrations above the 0.01 detection limits.

Nearly one third of the stations (23) showed significant high values for several of the total metals in the water samples. These stations are concentrated in seven reaches: 1) Maumee Bay, 2) near the mouth of the Detroit River, 3) near Monroe, Michigan, 4) Locust Point, 5) near the mouth of the Portage River, 6) at the west end of Sandusky Bay, 7) near Huron, Ohio. The high values of total metals in Maumee Bay suggest that most of the contribution to the total metals analyses comes from the suspended sediment. All metals except mercury, lead, and nickel reflect this trend. Above average concentrations of lead, iron, manganese, mercury, and copper were observed at the mouth of the Detroit River. Scattered high values of zinc, nickel, lead, iron, copper and chromium extend as far south as Stony Point.

Discharge from the River Raisin at Monroe, Michigan, shows high values for zinc, lead, chromium, nickel, iron, manganese and copper. The stations in the vicinity of Locust Point show above average amounts of zinc, iron, manganese, vanadium, chromium, and cadmium. To the southeast of Locust Point the stations near the mouth of the Portage River show above average concentrations of zinc, iron, manganese, chromium, and cadmium. The maximum concentration detected for nine of the metals is shown on Table 6 .

## IJC Objectives

The 1978 agreement between Canada and the United States of America on Great Lakes water quality, established objectives for Lake Erie water quality. International Joint Commission has the responsibility of overseeing the implementation of the objectives. In addition, the Ohio Environmental Protection Agency and the Michigan Department of Natural Resources have developed water quality standards for Lake Erie. The water quality objectives and standards established by these agencies are listed on Table 2 (only those parameters which were investigated during the present study are listed).

A preliminary search of the station data showed that a number of IJC and State objectives and standards were exceeded during the period April to October 1978. Tables 2, 3, 4, and 5 indicate violations for dissolved oxygen, conductivity, total phosphorus and ammonia, respectively. Depression of DO levels below 6.0 and 4.0 mg/l occurred only during cruises 2 and 3 (late June thru early September). The most persistent areas of depression were found along the Michigan shore between Swan Creek and the River Raisin, Maumee Bay, the Ohio shore near the Locust Point to Sandusky Bay and all of the stations of Huron harbor. Conductivity exceeded the established limits at 44 stations (57%) within the study area. Almost all of the inshore and bay stations violated the standards, while nearly all of the offshore stations were below the established limits. Total phosphorus concentrations in the nearshore waters exceeded point source discharge objectives in the vicinity of Maumee Bay during each cruise and at one station east of Sandusky Bay during Cruise 1. Ammonia violations were noted in South Passage during Cruise 1 and in Maumee Bay during Cruises 2 and 3; no violations were detected for Cruise 4.

Other parameters which exceeded objectives or standards included pH, chloride, several trace metals (Fe, Cu, Mn, Cd, Zn, Hg, Cr and Ni), phenol, and fecal coliforms. Hydrogen-ion concentration exceeded 9 pH units at numerous stations, particularly during periods of high phytoplankton production. Chloride exceeded Michigan DNR standards at one station (55.4 mg/l) near Stony Point. Trace metals (Table 6) were high at the mouth of the Detroit River, Maumee Bay, the west end of Sandusky Bay and near the mouths of the other important tributaries. Phenol exceeded IJC objectives at one station in Sandusky Bay, near the mouth of Mill Creek. No violations were detected for sulfate, fluoride and cyanide.

## Historical Water Quality Trends

Ohio State University initiated nearshore water quality studies at Locust Point in July 1972. Over the past seven years most parameters have shown typical seasonal trends with only small variations from year to year. Trends for eight water quality parameters from July 1972 through November 1978 are shown on Figures 14, 15 and 16. Temperature and dissolved oxygen show normal seasonal trends for each year with only minor variations from one year to the next or over the entire period. DO appears to have undergone more depletion in 1976 and 1977 than in previous years or in 1978. Hydrogen-ion concentration (pH) and alkalinity remained fairly stable over the period. Transparency, turbidity, phosphorus and conductivity have shown some radical variations which are

probably due to storms and dredging activities that have disturbed the bottom sediments. Phosphorus levels were low in 1977 and 1978, 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 during the past seven years.

# TABLES

TABLE 1

WATER QUALITY OBJECTIVES AND STANDARDS

FOR WESTERN LAKE ERIE

| Parameter | IJC (1978) WATER QUALITY Objectives | OHIO EPA (1978) WATER QUALITY STANDARDS | | MICHIGAN DNR (1973) WATER QUALITY STANDARDS |
|---|---|---|---|---|
| | | Lake Erie | Excepted Areas | Lake Erie |
| Dissolved Oxygen | 6.0 mg/l | 6.0 mg/l | 4.0 mg/l | 6.0 mg/l; 7 mg/l (P) |
| pH | 6.5-9.0 | 6.5-9.0 | 6.5-9.0 | 6.7-8.5 |
| Total Dissolved Solids | 200 mg/l | 200 mg/l | 1500 mg/l | 200 mg/l |
| Conductivity | 308 µmhos/cm | 320 µmhos/cm | 2400 µmhos/cm | - |
| Total Phosphorus | 0.5 mg/l (1) | 1 mg/l (1) | 1 mg/l (1) | - |
| Total Ammonia | 500 µg/l ($NH_3$) | 6.5 mg/l (N) | 13 mg/l (N) | - |
| Nitrate | - | 10 mg/l | - | - |
| Nitrite | - | } 100 mg/l | } 100 mg/l | - |
| Chloride | - | 250 mg/l | - | 50 mg/l (2) |
| Fluoride | 1200 µg/l | 1800 µg/l | 2000 µg/l | - |
| Sulfate | - | 250 µg/l | - | - |
| Cadmium (Total) | 0.2 µg/l | 1.2 µg/l | 12 µg/l | 12 µg/l (P) |
| Chromium (Total) | 50 µg/l | 50 µg/l | 100 µg/l | 100 µg/l (P) |
| Copper (Total) | 5 µg/l | 5 µg/l | 10 µg/l | - |
| Iron (Total) | 300 µg/l | 300 µg/l (dissol.) 1000 µg/l | 1000 µg/l | 300 µg/l (P) |
| Lead (Total) | 25 µg/l | 30 µg/l | 30 µg/l | 30 µg/l (P) |
| Manganese | - | 50 µg/l | - | - |
| Nickel (Total) | 25 µg/l | 25 µg/l | 200 µg/l | - |
| Zinc (Total) | 30 µg/l | 30 µg/l | 55 µg/l | - |
| Arsenic | 50 µg/l | 50 µg/l | 100 µg/l | 100 µg/l (P) |
| Mercury (Total) | 0.2 µg/l (Dissol.) | 0.2 µg/l | 0.2 µg/l | .05 µg/l (P) |
| Selenium (Total) | 10 µg/l | 10 µg/l | 50 µg/l | - |
| Cyanide | — | 25 µg/l | 25 µg/l | 5 µg/l (P) |
| Phenol | 1 µg/l | 1 µg/l | 10 µg/l | - |
| Fecal Coliforms | - | 200/100 ml | - | 200/100 ml (3) 1000/100 ml (4) |
| PCB | 0.1 mg/l (5) | | | |

(1) point source discharges
(2) monthly average
(3) total body contact
(4) other waters
(P) proposed
(5) fish tissues

TABLE 2

DISSOLVED OXYGEN VIOLATION SUMMARY

Stations exceeding IJC 1978 Objectives and Michigan DNR standards of 6.0 mg/l and Ohio EPA 1978 standards for Lake Erie normal areas of 6.0 mg/l and excepted areas of 4.0 mg/l

| | Cruise 2 | | | Cruise 3 | | |
|---|---|---|---|---|---|---|
| Station No. | Run 1 | Run 2 | Run 3 | Run 1 | Run 2 | Run 3 |
| M5 -B | | | | < 6.0 | | < 6.0 |
| M6 -B | | | | < 6.0 | | |
| M12-B | | < 6.0 | < 6.0 | | | |
| M13-B | | | < 6.0 | | | |
| M14-B | | | < 6.0 | | | |
| M15-B | | | < 6.0 | | | < 6.0 |
| M19-B | | | < 4.0 | < 4.0 | < 4.0 | < 4.0 |
| 02 -01 * | < 4.0 | < 6.0 | < 4.0 | < 4.0 | < 4.0 | < 4.0 |
| 02 -B * | < 4.0 | < 6.0 | < 6.0 | | | |
| 03 -01 * | < 4.0 | | | | | |
| 03 -B * | < 4.0 | < 6.0 | | | | |
| 06 -B | < 6.0 | | | | | |
| 07 -B | < 6.0 | | | < 6.0 | | |
| 08 -01 * | | | | < 6.0 | | |
| 011-B | | | | | | |
| 017-B * | < 6.0 | | | | | |
| 024-B | < 6.0 | | | | | |
| 025-B | < 6.0 | | | | | |
| 027-B | | < 6.0 | | | | |
| 028-B | | < 6.0 | | | | |
| 036-B | < 6.0 | < 6.0 | < 6.0 | | | |
| 039-B | | | | < 4.0 | | <6.0 |
| 044-01 * | | | | | | <6.0 |
| 044-B * | < 6.0 | | < 6.0 | < 6.0 | < 6.0 | <6.0 |
| 045-B | | | | | | <4.0 |
| 046-B | | | | < 4.0 | < 4.0 | |
| 047-B | < 6.0 | | | < 4.0 | < 4.0 | <4.0 |
| 049-B | | | | | < 6.0 | <4.0 |
| 050-B | < 6.0 | | | < 4.0 | | |

Legend

M - Michigan
O - Ohio
5 - Station no.
01 - 1 meter below water surface
B - 1 meter above lake bottom
* Ohio EPA excepted area

Note: No DO levels exceeding IJC Objectives or State standards were observed during Cruises 1 and 4.

TABLE 3

CONDUCTIVITY VIOLATION SUMMARY (CRUISES 1-4)

Stations that exceeded IJC objectives of 308 μmhos/cm and Ohio EPA and Michigan DNR standards for normal areas of Lake at 320 μmhos/cm and excepted areas at 2400 μmhos/cm.

| Station # | > 308 | > 320 | > 2400 |
|---|---|---|---|
| M1 | X | X | |
| M2 | X | X | |
| M4 | X | | |
| M7 | X | X | |
| M10 | X | X | |
| M11 | X | X | |
| M12 | X | X | |
| M16 | X | X | |
| M17 | X | X | |
| M18 | X | | |
| M22 | X | X | |
| M23 | X | X | |
| M24 | X | X | |
| M25 | X | X | |
| M26 | X | X | |
| M27 | X | X | |
| 01* | X | X | |
| 02* | X | X | |
| 03* | X | X | |
| 04* | X | X | |
| 05 | X | X | |
| 06 | X | X | |
| 08* | X | X | |
| 09* | X | X | |
| 010* | X | X | |
| 011 | X | X | |
| 012 | X | X | |
| 013 | X | X | |
| 014 | X | X | |
| 021* | X | | |
| 022 | X | | |
| 023* | X | | |
| 026 | X | | |
| 029* | X | X | |
| 030* | X | X | |
| 031* | X | X | |
| 032* | X | X | |
| 033* | X | X | |
| 034* | X | X | |
| 035* | X | X | |
| 037 | X | X | |
| 040 | X | | |
| 041 | X | | |
| 044* | X | | |

* Ohio EPA excepted area

TABLE 4

TOTAL PHOSPHORUS VIOLATION SUMMARY

Stations exceeding IJC 1978 Objectives
and Ohio EPA Standards for point source discharges

| Station | 500 µg/l | 1000 µg/l | Station | 500 µg/l | 1000 µg/l |
|---|---|---|---|---|---|
| Cruise 1 | | | Cruise 3 | | |
| 02-01 | 624.4 | | M27-01 | 502.0 | |
| 02-01 | 616.4 | | Cruise 4 | | |
| 02-B | | 1030.4 | 010-01 | 502.3 | |
| 03-B | 592.8 | | | | |
| 03-B | 661.2 | | | | |
| 06-B | 617.6 | | | | |
| 08-01 | 618.4 | | | | |
| 08-01 | 540.8 | | | | |
| 011-B | 524.0 | | | | |
| 012-01 | 874.0 | | | | |
| 042-B | 644.4 | | | | |
| Cruise 2 | | | | | |
| M27 -01 | 774.8 | | | | |
| M27 -01 | 658.4 | | | | |
| 01-01 | 535.2 | | | | |
| 02-01 | 581.6 | | | | |
| 03-B | 628.1 | | | | |
| 04-01 | 626.0 | | | | |
| 08-01 | 574.0 | | | | |

TABLE 5

AMMONIA VIOLATION SUMMARY

Stations exceeding IJC Objectives of 500 µg/l

| Station | Value | |
|---|---|---|
| Cruise 1 | | |
| 025-01 | 503.0 | |
| Cruise 2 | | |
| 01-01 | 1231.0 | |
| | Run 1 | Run 2 |
| 02-01 | 575.5 | 598.5 |
| 02-B | 918.5 | 542.5 |
| 03-01 | 521.0 | |
| 03-B | 540.0 | |
| 08-01 | 1175.7 | |
| 09-01 | 571.0 | |
| Cruise 3 | | |
| M1-01 | 608.4 | |
| 02-01 | 643.9 | |
| 02-B | 501.4 | |
| Cruise 4 | | |
| no violations | | |

TABLE 6

TOTAL METALS THAT EXCEEDED THE MOST LENIENT

LAKE ERIE WATER QUALITY STANDARDS EXISTING IN 1978

Concentrations in µg/l

| | Cd | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|
| Cruise No. | 4 | 4 | 4 | 1 | 2 | 1 | 1 | 1 | 1 |
| Standard | 12 | 100 | 10 | 1000 | 0.2 | 50 | 200 | 30 | 55 |
| Max. Conc. | 38 | 197 | 192 | 3965 | 0.25 | 265 | 230 | 13.4 | 230 |
| M1 | | | x | | | | | | |
| M2 | | x | x | x | | x | | | |
| M3 | | | x | | | | | | |
| M4 | | | x | x | | | | | |
| M5 | | | x | | | | | | |
| M6 | x | | x | | | | | | x |
| M7 | | | x | | | | | | x |
| M8 | x | | x | | | | | | x |
| M9 | | | x | | | | | | |
| M10 | x | | x | | | | | | x |
| M11 | | | x | | | | | | x |
| M12 | | x | x | | | | | | x |
| M13 | | | x | | | | | | x |
| M14 | x | | x | | | | | | x |
| M15 | | | x | | | | | | x |
| M16 | | x | x | x | | x | | | x |
| M17 | | x | x | x | | x | | | x |
| M18 | x | | x | x | | | | | x |
| M19 | x | | x | | | | | | x |
| M20 | | | | | | | | | x |
| M21 | | x | x | | | | | | x |
| M22 | | | | | | | | | x |
| M23 | | x | | | | | | | |
| M24 | x | | | | | | | | |
| M25 | x | x | x | | | | | | x |
| M26 | | | | | | | | | x |
| M27 | | | | x | | x | | | |
| 01 | | x | | x | | x | | | |
| 02 | x | x | | x | | x | | | |
| 03 | | | | x | | x | | | x |
| 04 | | x | | x | | x | | | |
| 05 | | x | | x | | x | | | |
| 06 | | x | | | | | | | |
| 07 | x | | x | x | | x | | | |
| 08 | | x | x | x | | x | | | |
| 09 | | x | x | x | | x | | | |
| 010 | | | | | | | | | |

TABLE 6 (Con't.)

TOTAL METALS THAT EXCEEDED THE MOST LENIENT

LAKE ERIE WATER QUALITY STANDARDS EXISTING IN 1978

Concentrations in µg/l

| | Cd | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|
| Cruise No. | 4 | 4 | 4 | 1 | 2 | 1 | 1 | 1 | 1 |
| Standard | 12 | 100 | 10 | 1000 | 0.2 | 50 | 200 | 30 | 55 |
| 010. | | x | x | x | | x | | | |
| 011 | | | | x | | x | | | |
| 012 | | x | | x | | x | | | |
| 013 | | | | x | | x | | | |
| 014 | | x | | | | | | | |
| 015 | | x | | x | | x | | | |
| 016 | | x | | x | | x | | | |
| 017 | | | x | x | | x | | | |
| 018 | | | x | x | | x | | | |
| 019 | | x | | x | | | | | x |
| 020 | | x | | x | | x | | | |
| 021 | x | x | | x | | x | | | |
| 022 | | x | | x | | x | | | |
| 023 | | x | | x | | x | | | |
| 024 | x | | x | x | x | | | | |
| 025 | | | x | x | | x | | | x |
| 026 | x | x | x | x | | x | | | |
| 027 | | | | x | | | | | x |
| 028 | | | x | | | x | | | |
| 029 | | | | x | | x | | | |
| 030 | | x | | x | x | x | x | | x |
| 031 | | x | x | | | | | | |
| 032 | | x | x | x | x | | | | x |
| 033 | x | x | | | x | | | | |
| 034 | | | | x | | | | | |
| 036 | | x | | x | | | | | |
| 037 | | | x | x | | x | | | |
| 039 | x | | | | | | | | |
| 041 | x | | | | | | | | |
| 042 | x | | | | | | | | |
| 043 | x | | | | | | | | |
| 044 | | | x | x | | x | | | |
| 046 | | | | | | | | | x |
| 047 | | | x | | x | | | | |
| 048 | | | | | x | | | | |

# FIGURES

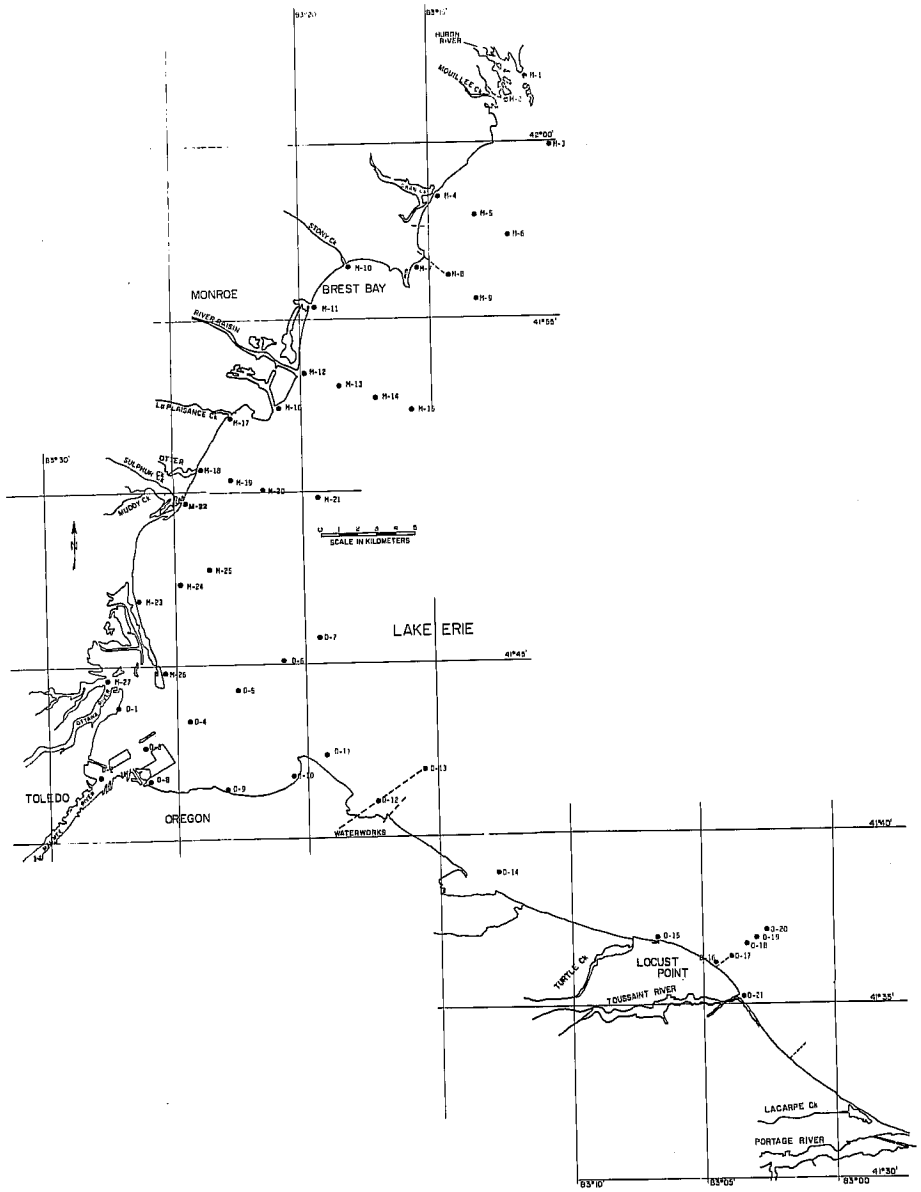



FIGURE 1. NEARSHORE STATION LOCATION MAP FOR WESTERN LAKE ERIE (WEST HALF)

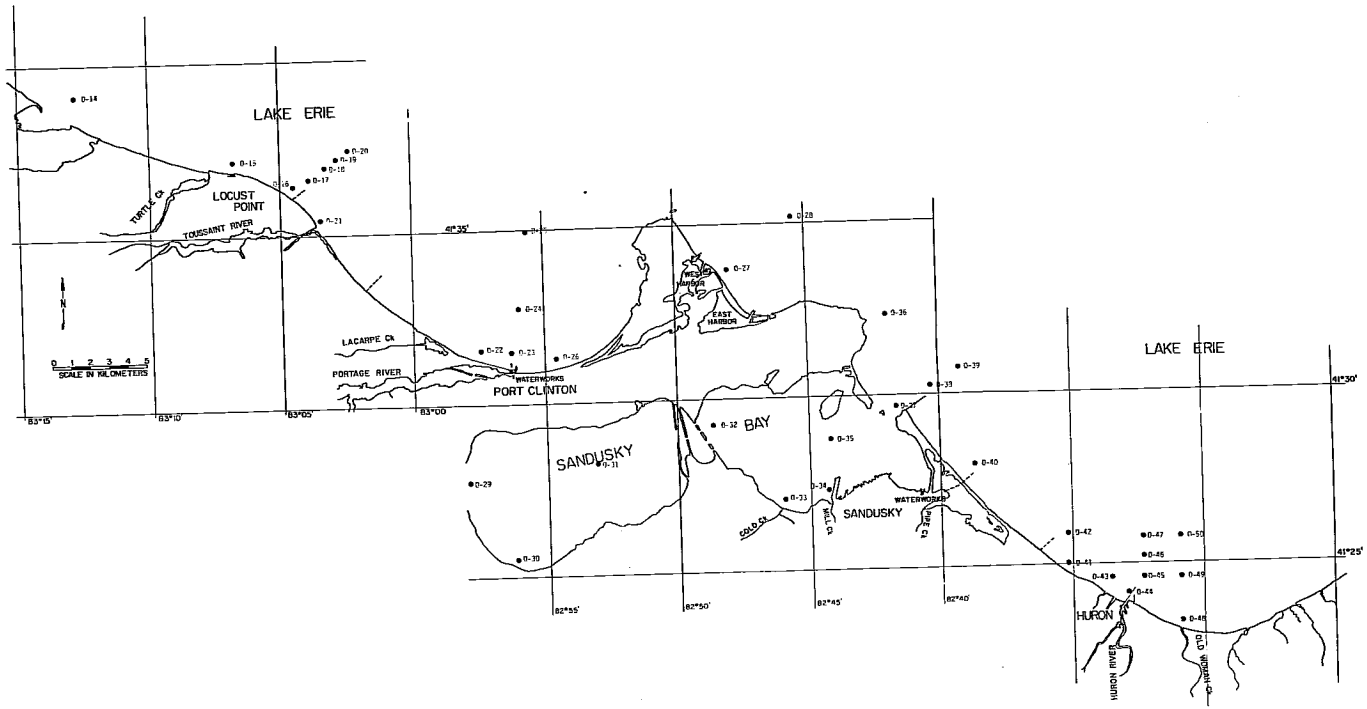



FIGURE 2. NEARSHORE STATION LOCATION MAP FOR WESTERN LAKE ERIE (EAST HALF)

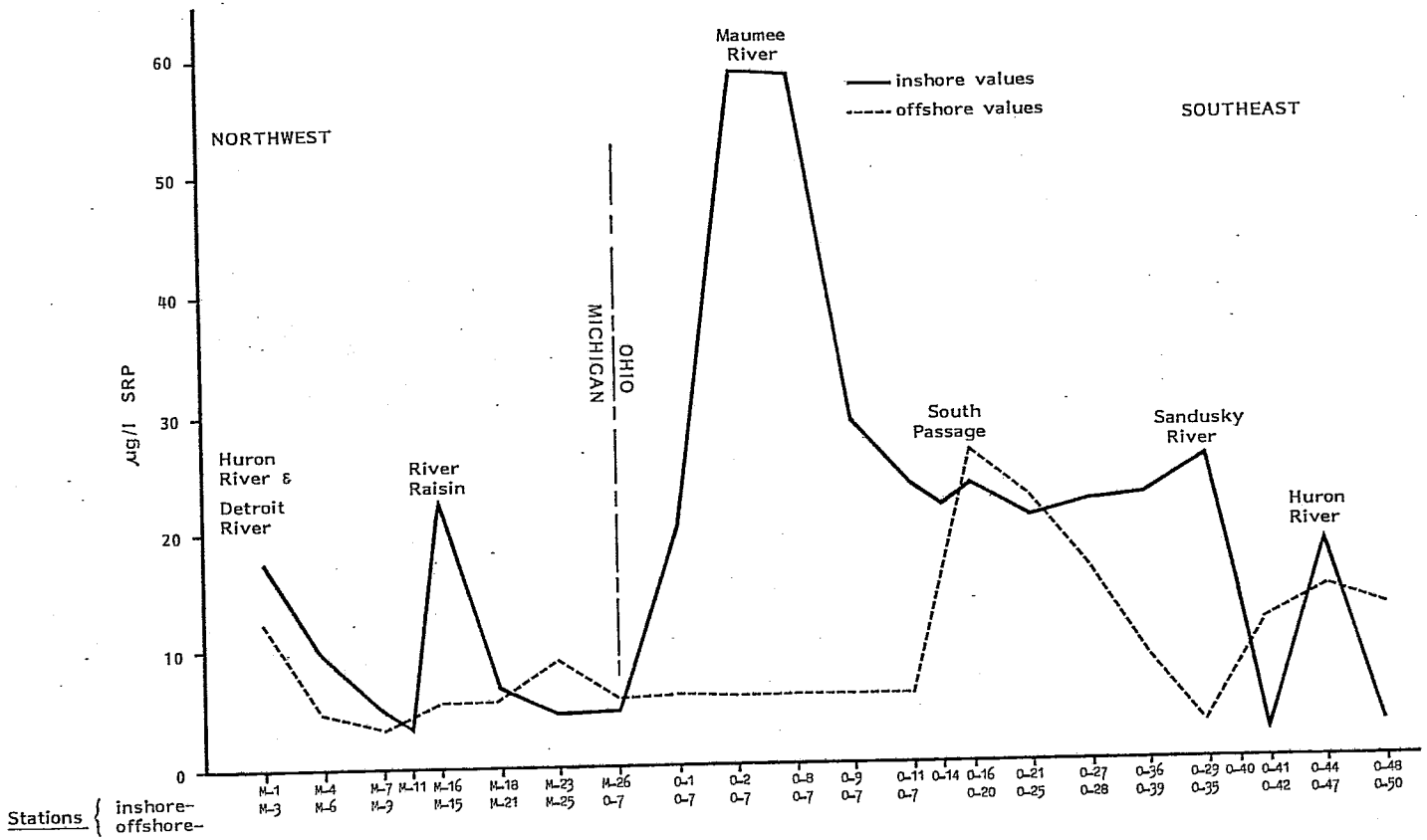



FIGURE 3. ANNUAL AVERAGE SOLUBLE REACTIVE PHOSPHORUS SURFACE CONCENTRATIONS FOR INSHORE AND OFFSHORE STATIONS (1978).

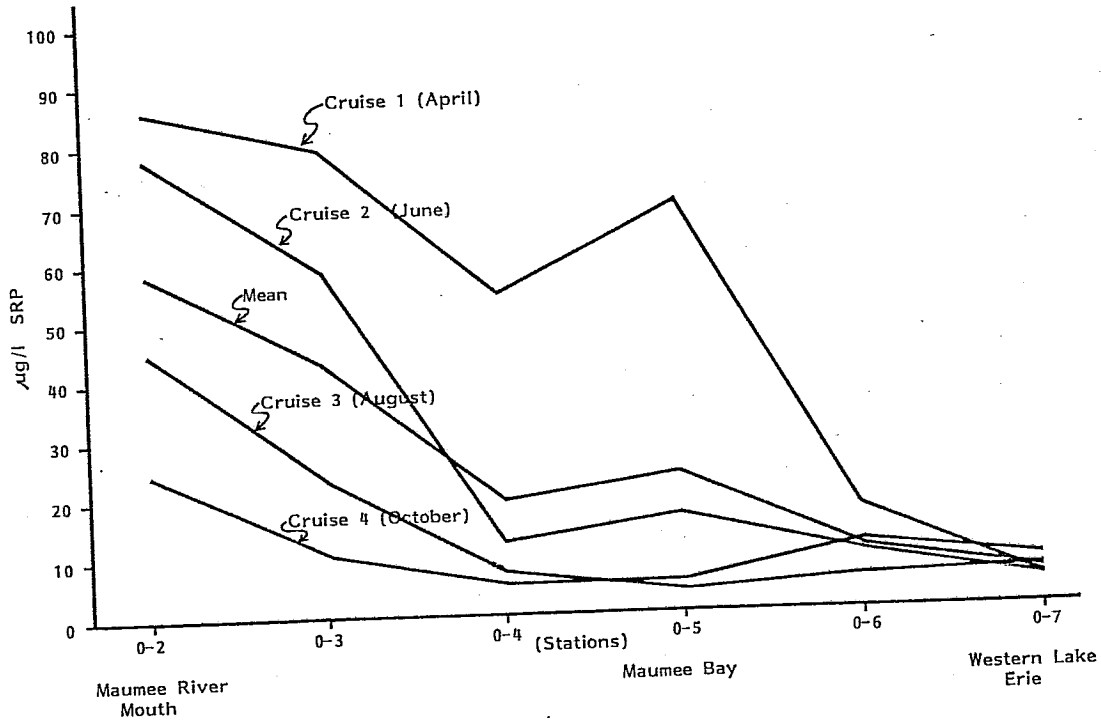



FIGURE 4. SEASONAL DECLINE IN SOLUBLE REACTIVE PHOSPHORUS FROM THE MAUMEE RIVER THRU MAUMEE BAY (1978).

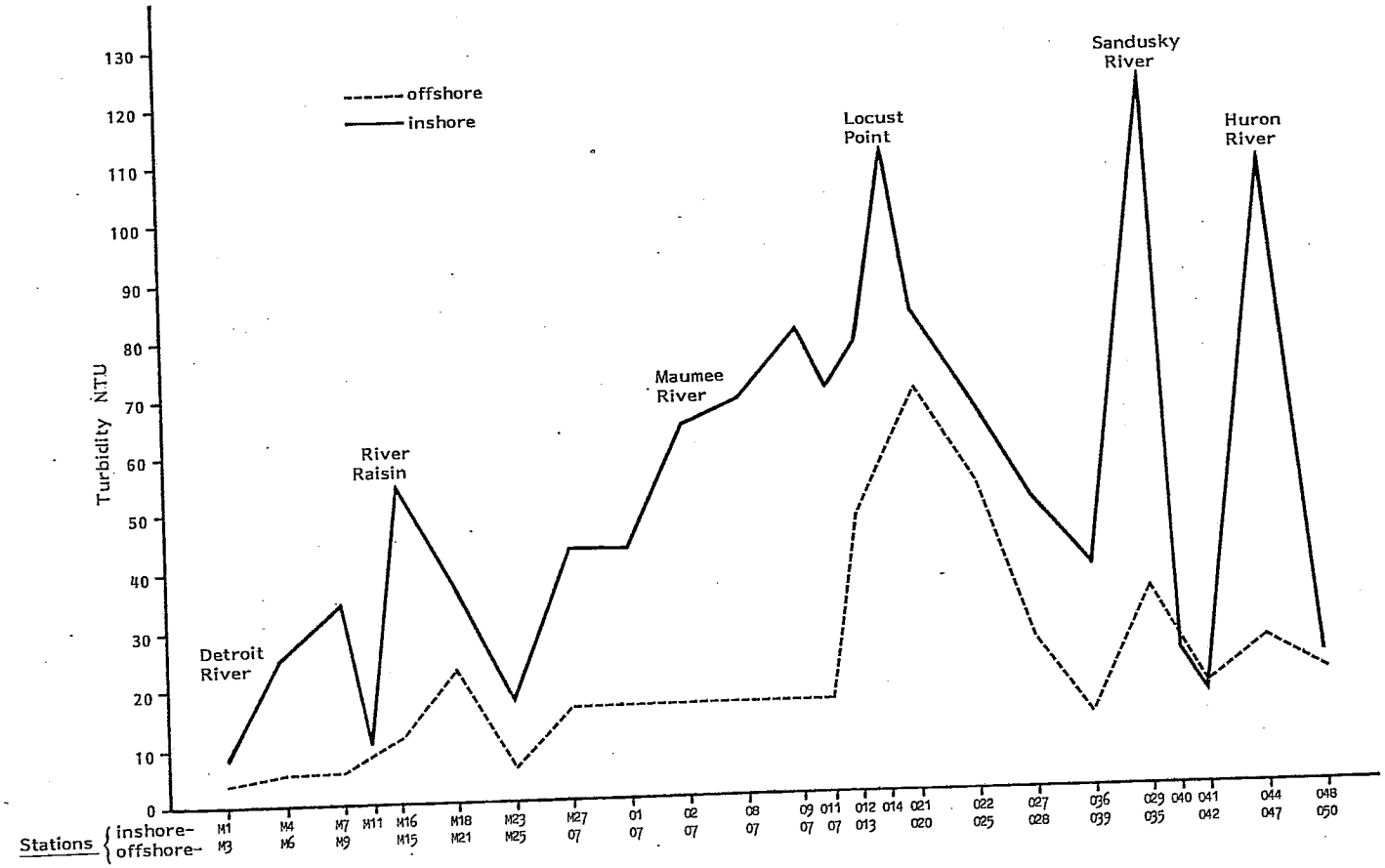



FIGURE 5. INSHORE - OFFSHORE TURBIDITY FOR WESTERN LAKE ERIE - CRUISE 1 (APRIL 1978)

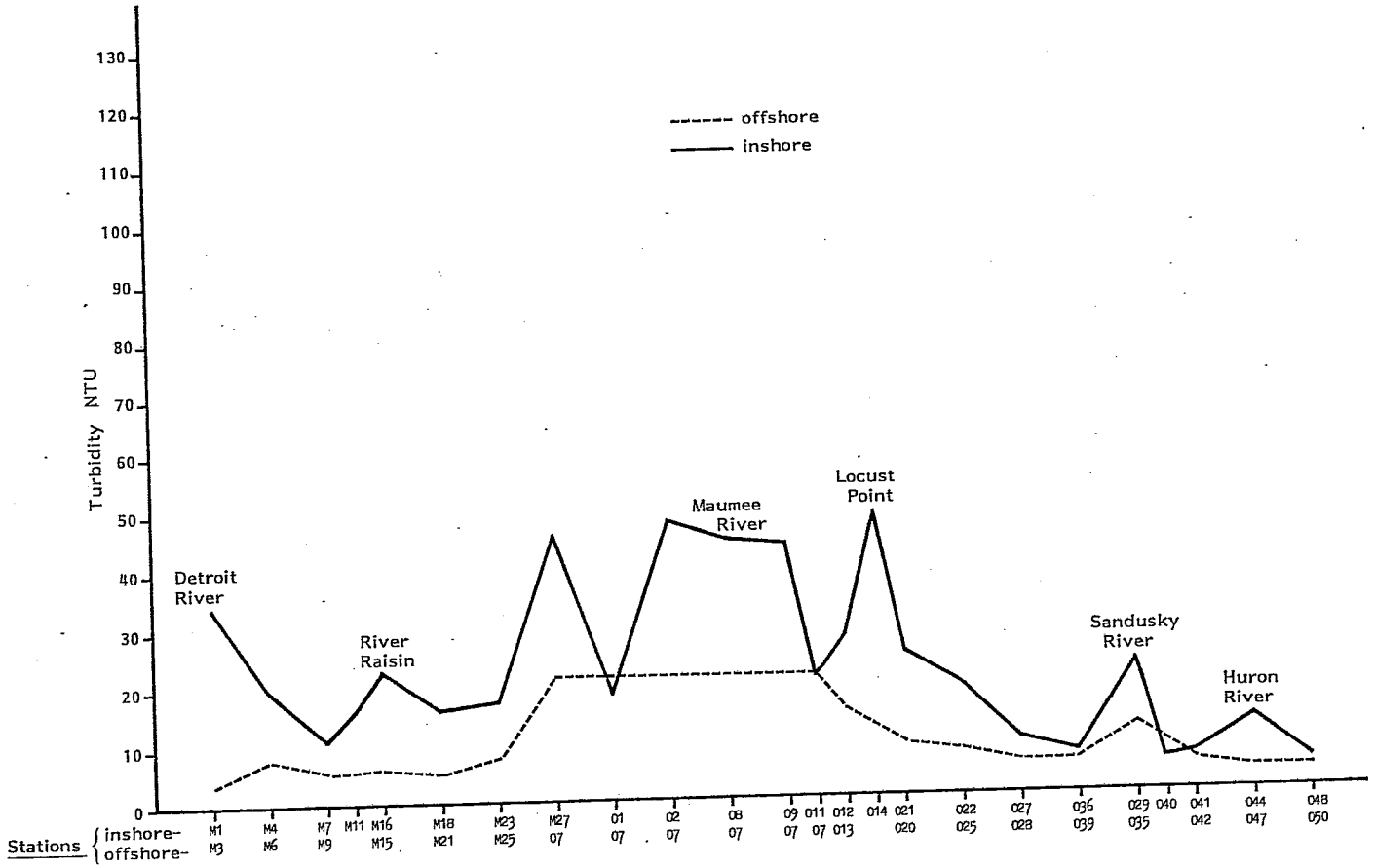



FIGURE 6. INSHORE - OFFSHORE TURBIDITY FOR WESTERN LAKE ERIE - CRUISE 2 (JUNE 1978)

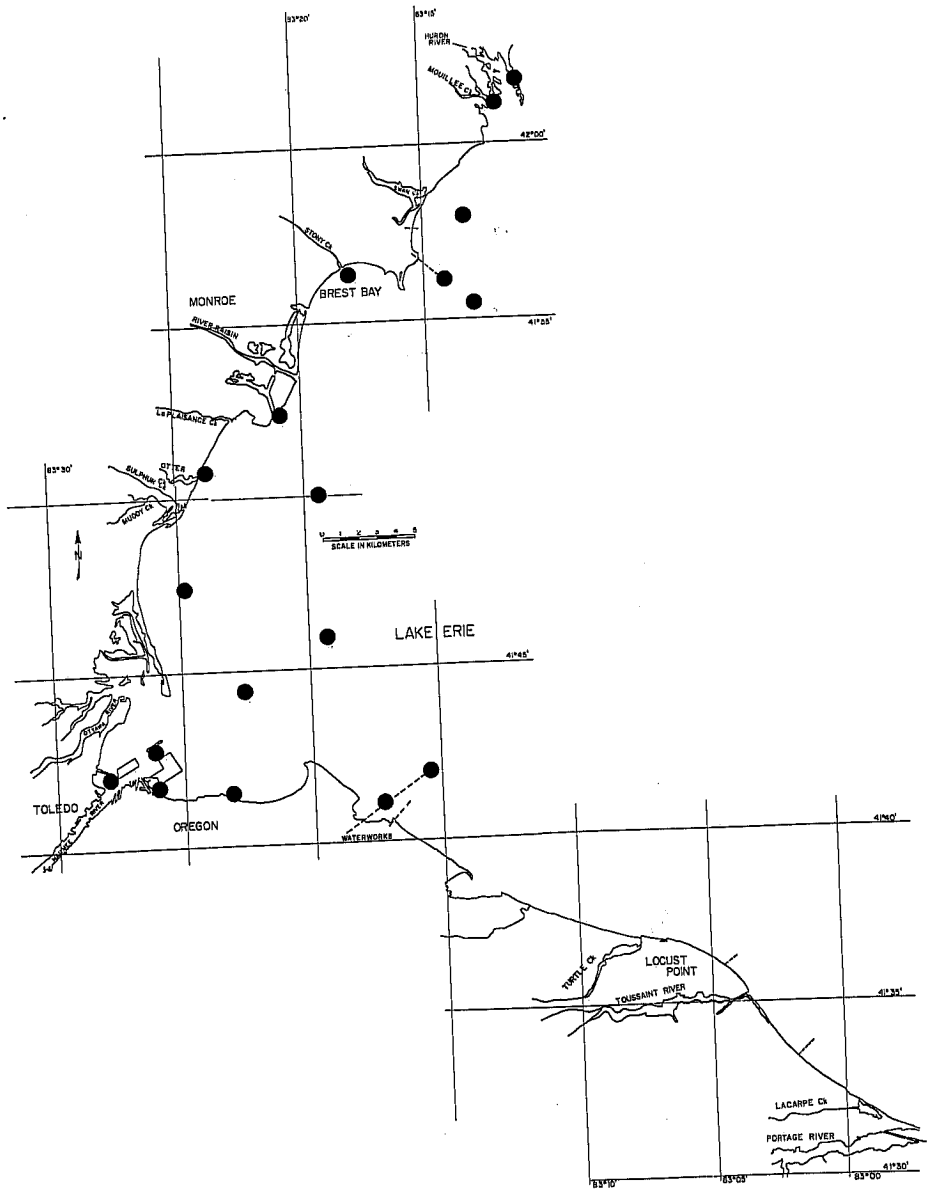



FIGURE 7. STATIONS WITH FECAL COLIFORM COUNTS OVER 200 CELLS/100 ml IN WESTERN LAKE ERIE (WEST HALF)

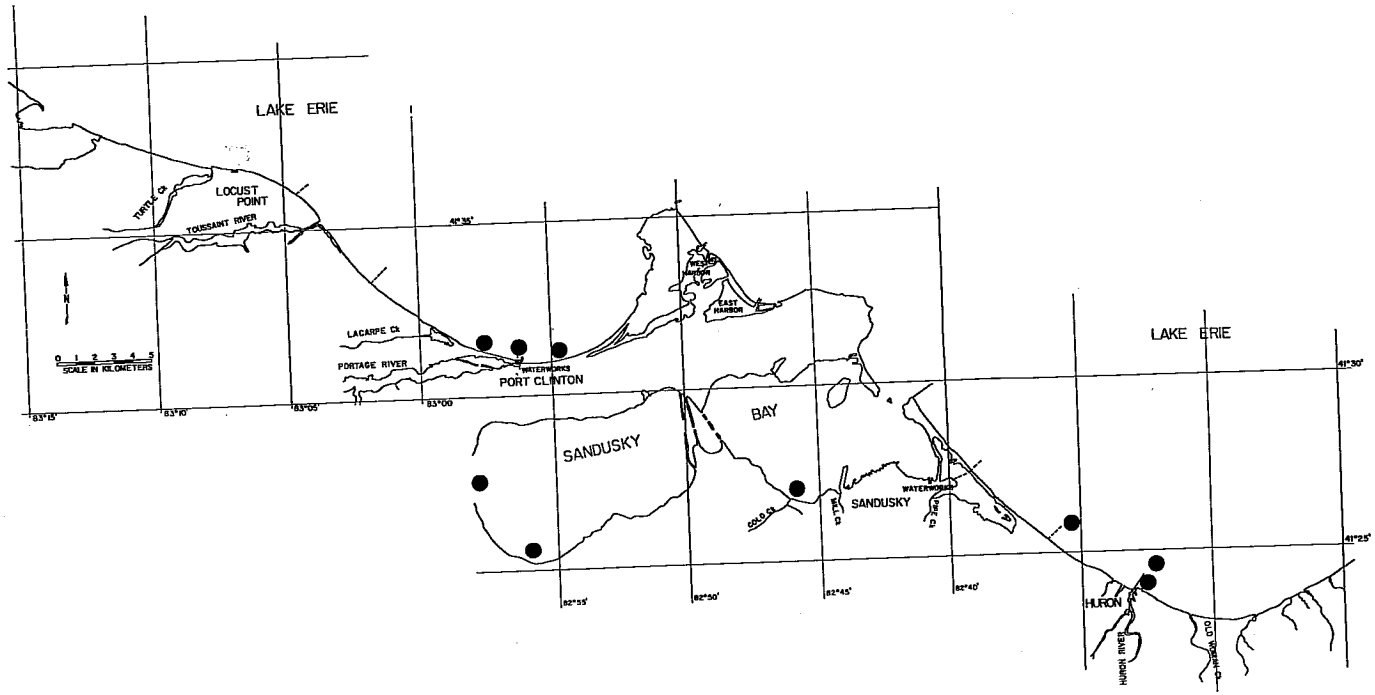



FIGURE 8. STATIONS WITH FECAL COLIFORM COUNTS OVER 200 CELLS/100ml IN WESTERN LAKE ERIE (EAST HALF)

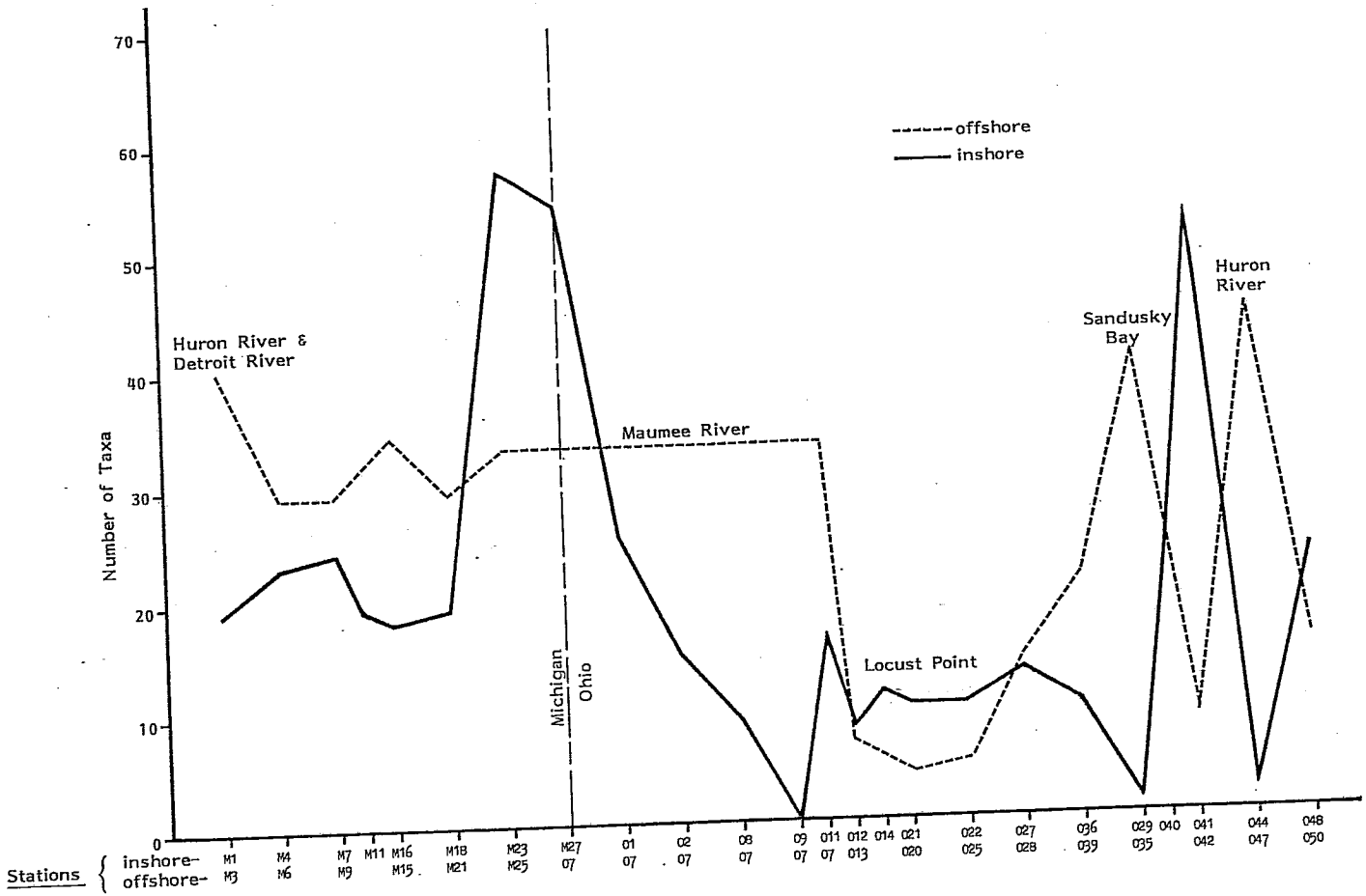



FIGURE 9. INSHORE - OFFSHORE PHYTOPLANKTON SPECIES DIVERSITY FOR WESTERN LAKE ERIE - CRUISE 1 (APRIL 1978)

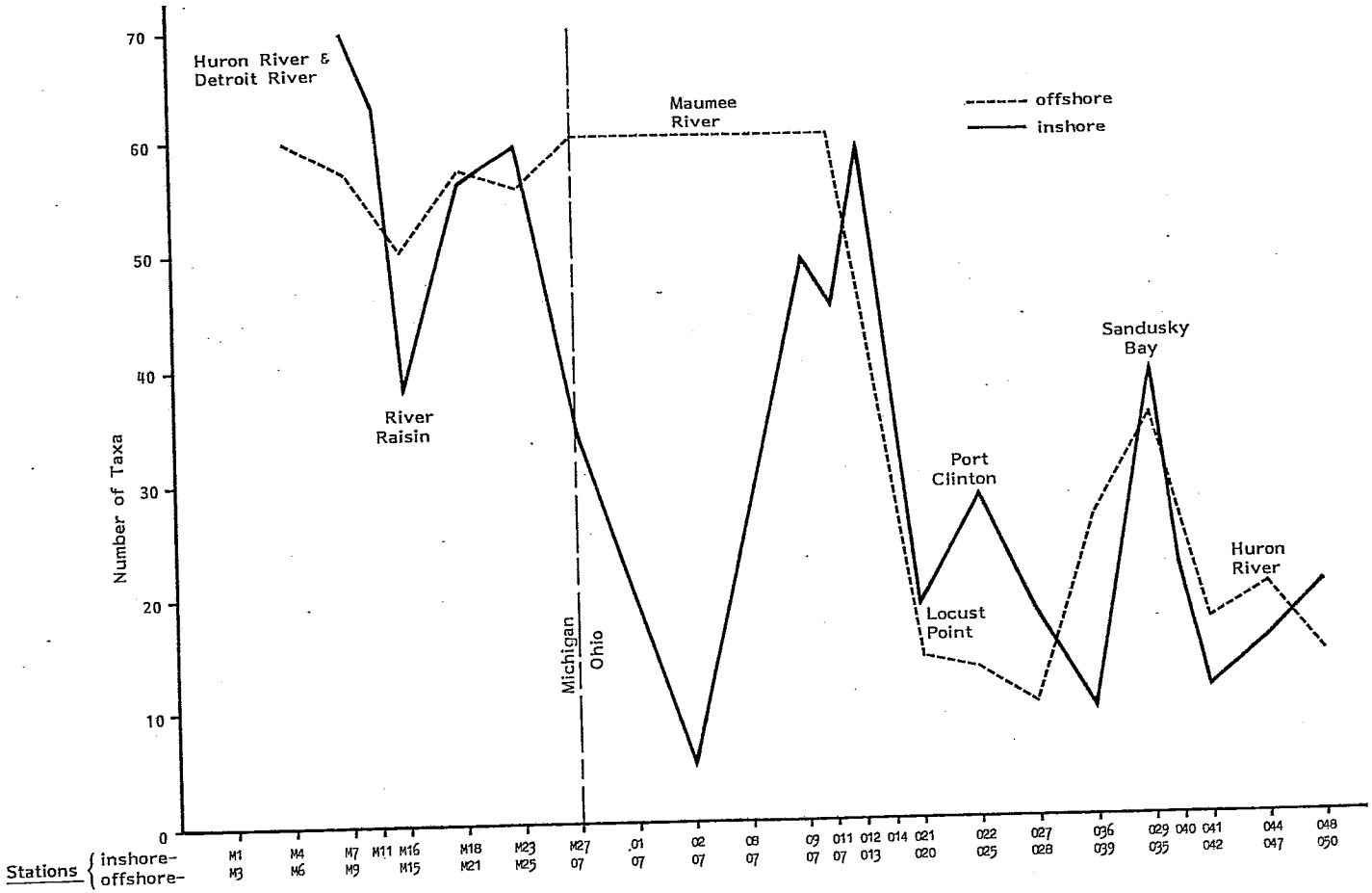



FIGURE 10. INSHORE - OFFSHORE PHYTOPLANKTON SPECIES DIVERSITY FOR WESTERN LAKE ERIE - CRUISE 2 (JUNE 1978)

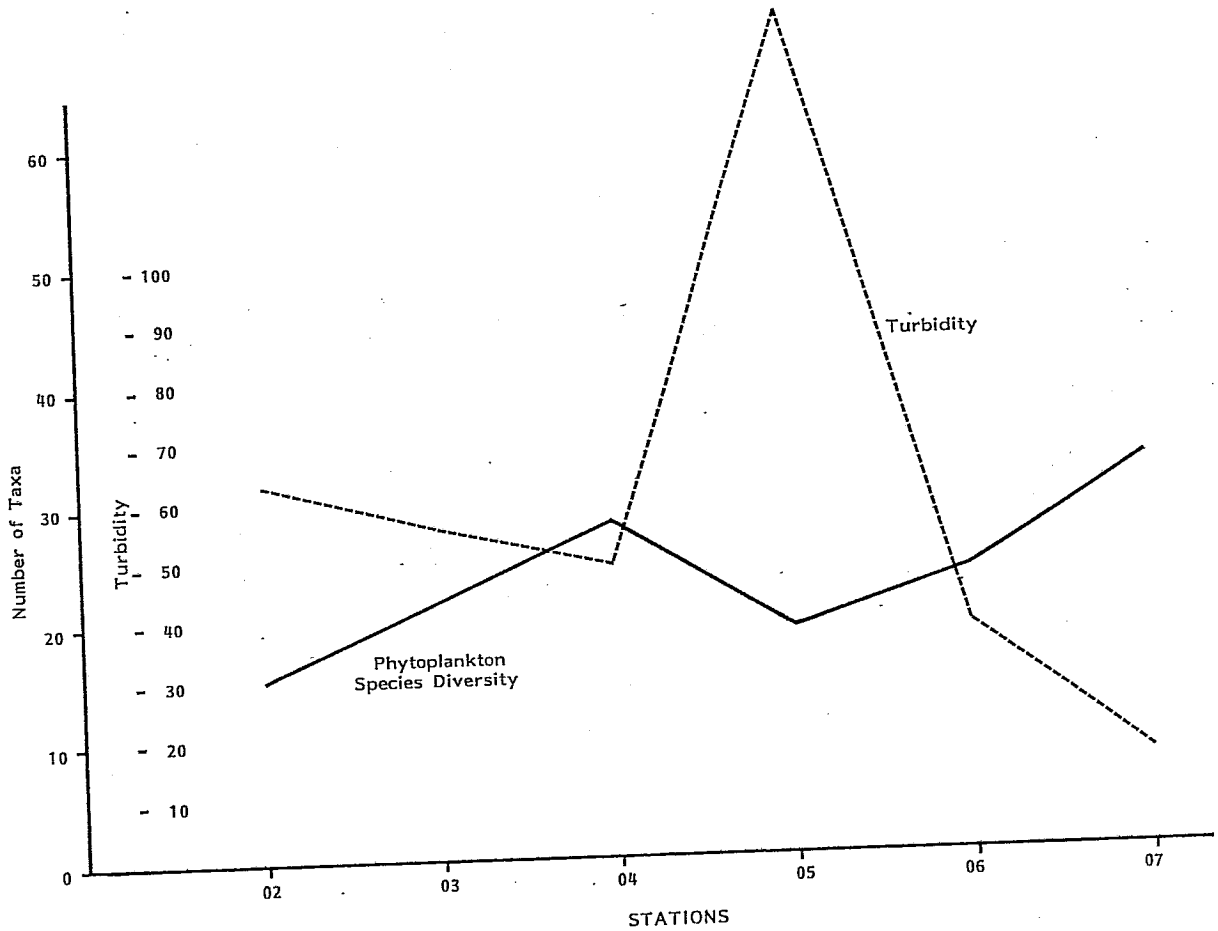



FIGURE 11. NEARSHORE PHYTOPLANKTON SPECIES DIVERSITY AND TURBIDITY: MAUMEE BAY TRANSECT - CRUISE 1 (APRIL 1978)

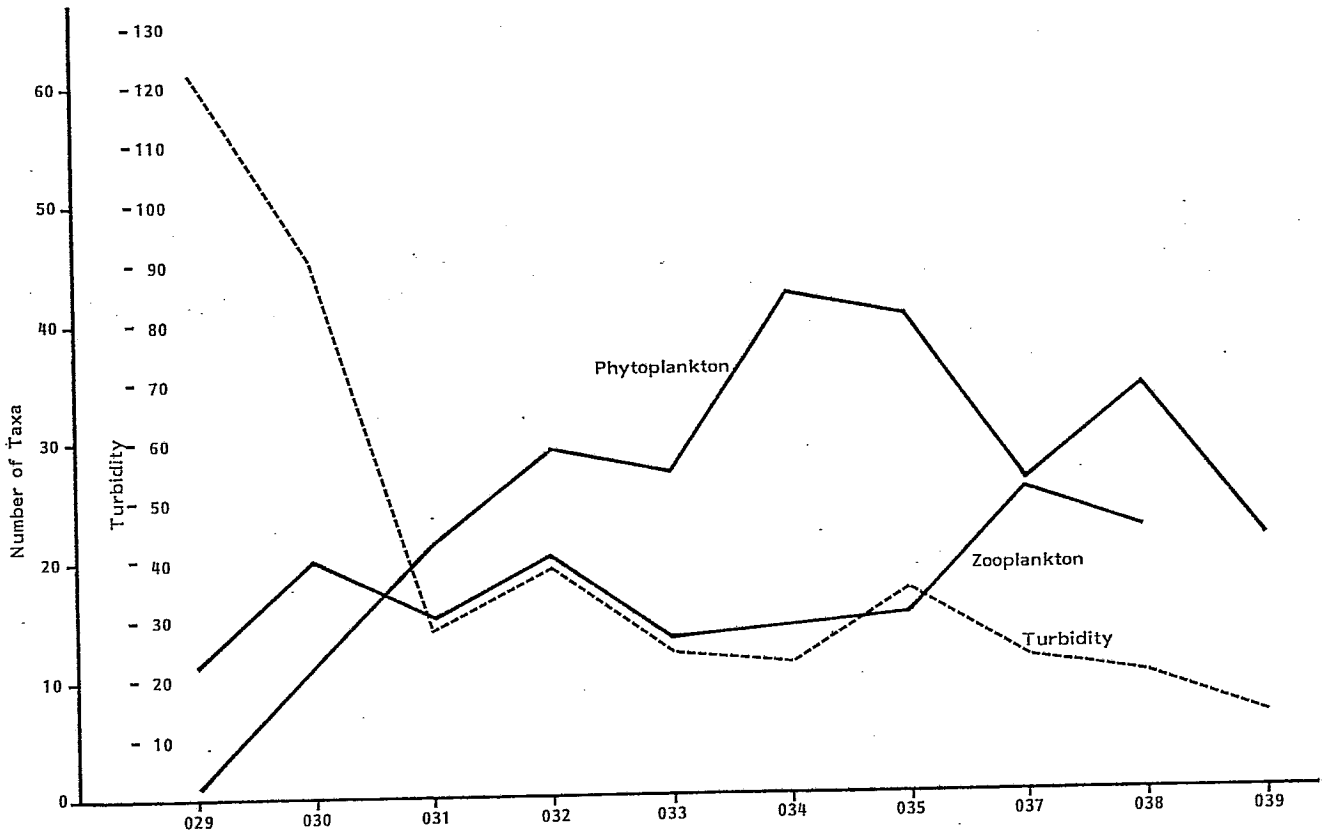



FIGURE 12. NEARSHORE PHYTOPLANKTON AND ZOOPLANKTON SPECIES DIVERSITY AND TURBIDITY : SANDUSKY BAY TRANSECT - CRUISE 1 (APRIL 1978)

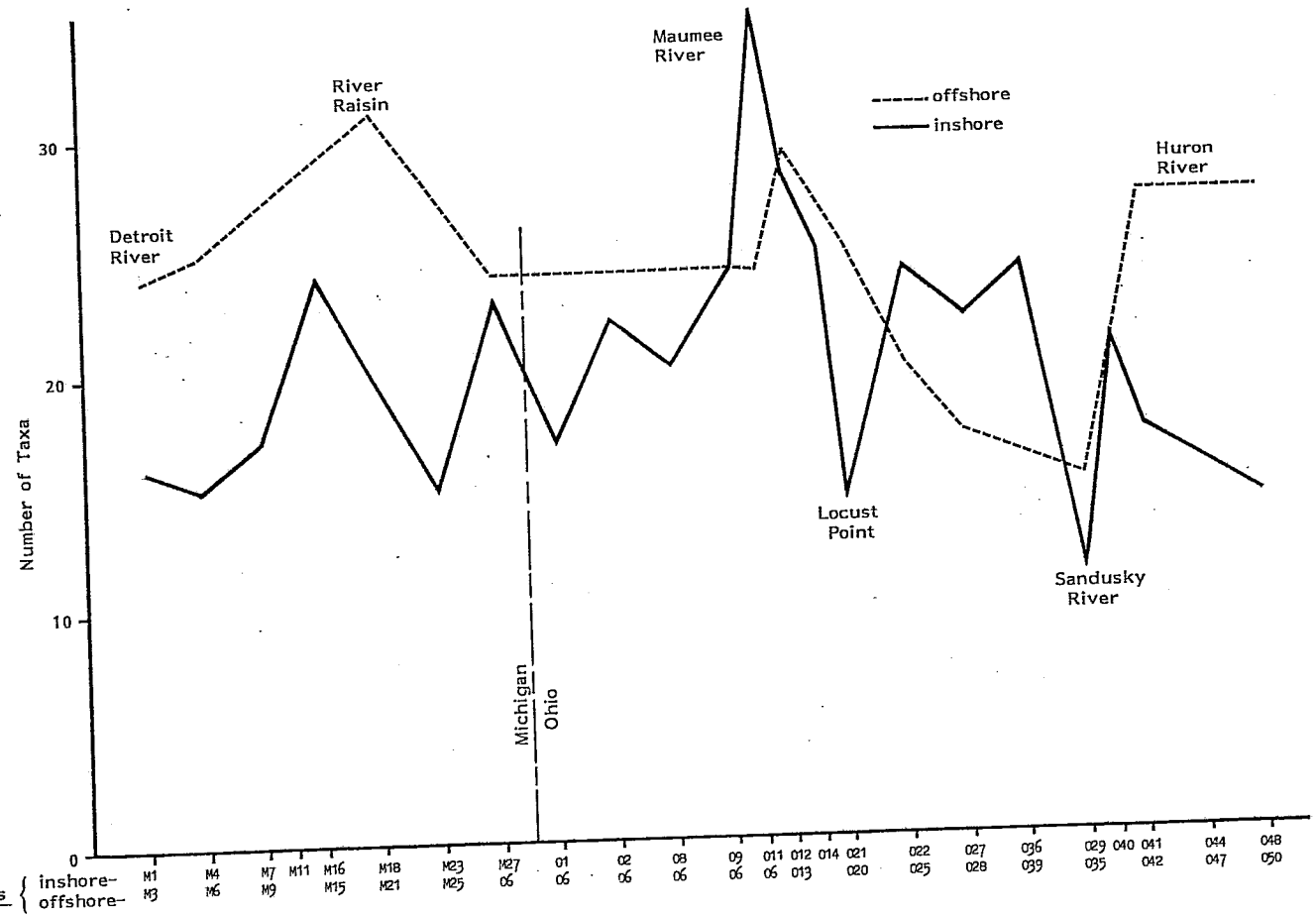



FIGURE 13. INSHORE - OFFSHORE ZOOPLANKTON SPECIES DIVERSITY FOR WESTERN LAKE ERIE - CRUISE 1 (APRIL 1978)

FIGURE 14. TRENDS IN MEAN MONTHLY TEMPERATURE, DISSOLVED OXYGEN, AND HYDROGEN ION MEASUREMENTS FOR LAKE ERIE AT LOCUST POINT FOR THE PERIOD 1972-1978.

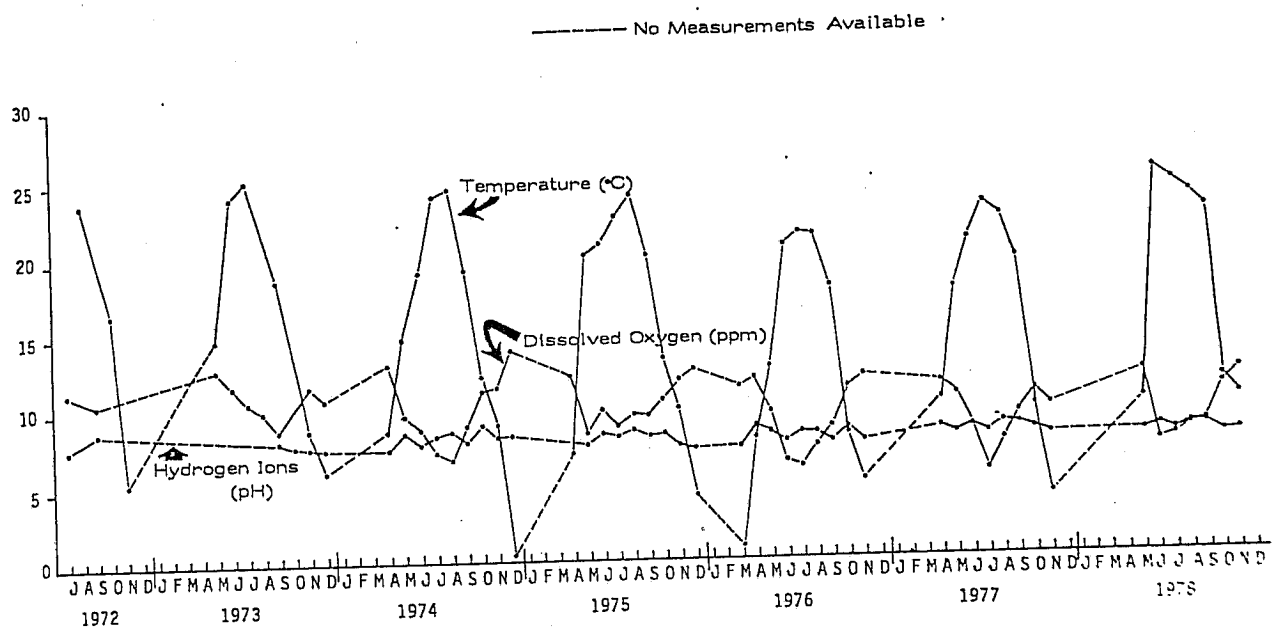



FIGURE 15. TRENDS IN MEAN MONTHLY CONDUCTIVITY, ALKALINITY AND TURBIDITY MEASUREMENTS FOR LAKE ERIE AT LOCUST POINT FOR THE PERIOD 1972-1978.

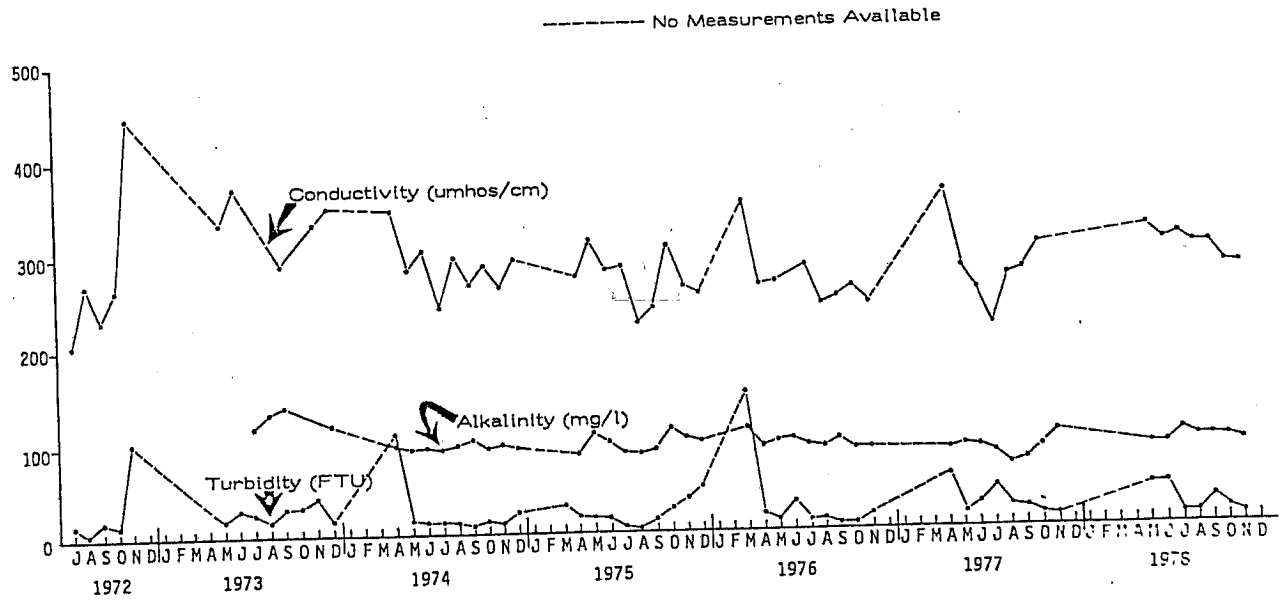
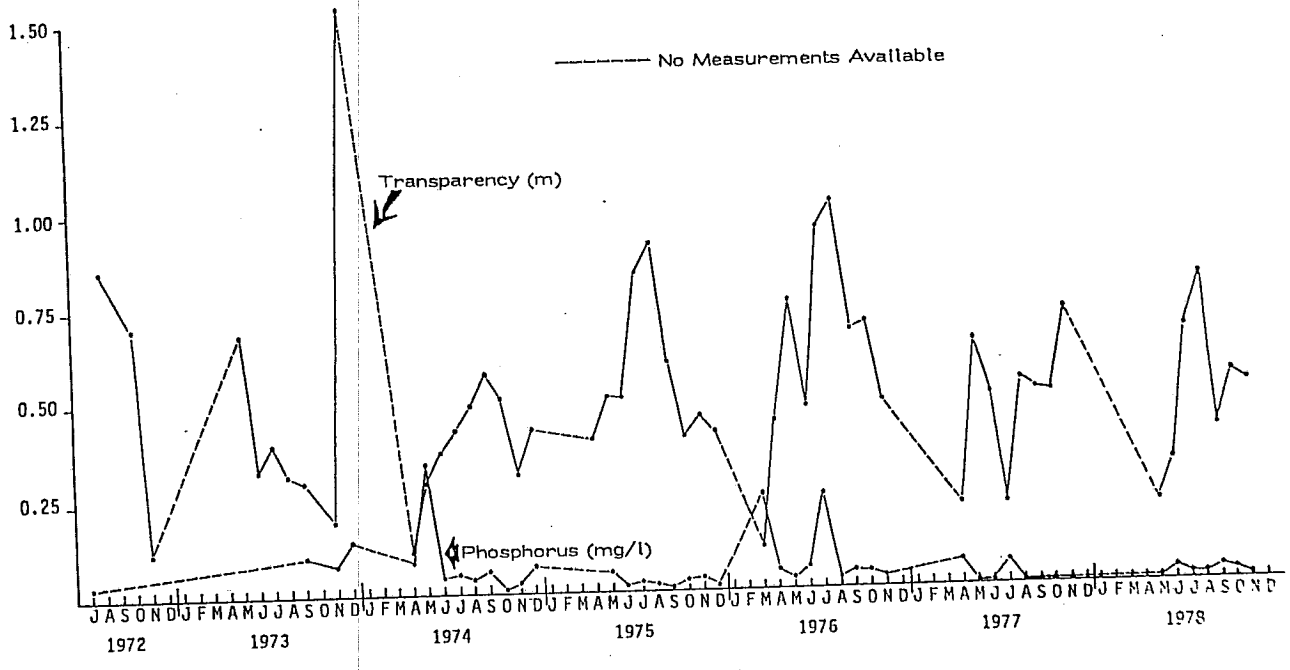


FIGURE 16. TRENDS IN MEAN MONTHLY TRANSPARENCY AND PHOSPHORUS MEASUREMENTS FOR LAKE ERIE AT LOCUST POINT FOR THE PERIOD 1972-1978.



# APPENDIX

APPENDIX 1

LAKE ERIE NEARSHORE SURVEILLANCE STATIONS
WESTERN SECTION

| Station No. | Latitude (°N) | Longitude (°W) | Depth (ft) | No. of samples | Problem area | Remarks |
|---|---|---|---|---|---|---|
| M-1 | 42°01.8' | 83°11.5' | 2 | 1 | | |
| M-2 | 42°01.0' | 83°12.0' | 1 | 1 | | |
| M-3 | 41°59.9' | 83°10.5' | 9 | 1 | | |
| M-4 | 41°58.5' | 83°14.6' | 6 | 1 | | |
| M-5 | 41°58.2' | 83°13.1' | 17 | 2 | | |
| M-6 | 41°57.7' | 83°11.7' | 18 | 2 | | |
| M-7 | 41°56.5' | 83°15.5' | 6 | 1 | | |
| M-8 | 41°56.2' | 83°14.3' | 20 | 2 | | |
| M-9 | 41°55.8' | 83°13.0' | 24 | 2 | | |
| M-10 | 41°56.4' | 83°18.1' | 6 | 1 | | |
| M-11 | 41°55.4' | 83°19.4' | 6 | 1 | | |
| M-12 | 41°53.4' | 83°19.9' | 24 | 2 | X | River Raisin |
| M-13 | 41°53.2' | 83°19.2' | 24 | 2 | | |
| M-14 | 41°52.8' | 83°17.8' | 24 | 2 | | |
| M-15 | 41°52.5' | 83°16.4' | 22 | 2 | | |
| M-16 | 41°52.4' | 83°20.9' | 1 | 1 | X | Monroe Discharge |
| M-17 | 41°52.1' | 83°22.7' | 6 | 1 | | |
| M-18 | 41°50.7' | 83°23.8' | 2 | 1 | | |
| M-19 | 41°50.4' | 83°22.2' | 11 | 2 | | |
| M-20 | 41°50.0' | 83°20.8' | 15 | 2 | | |
| M-21 | 41°49.7' | 83°19.5' | 17 | 2 | | |
| M-22 | 41°49.7' | 83°24.5' | 6 | 1 | | |
| M-23 | 41°46.4' | 83°26.2' | 1 | 1 | | |
| M-24 | 41°47.1' | 83°24.8' | 12 | 2 | | |
| M-25 | 41°47.9' | 83°23.0' | 15 | 2 | | |
| M-26 | 41°44.9' | 83°25.5' | 2 | 1 | | |
| M-27 | 41°44.6' | 83°27.6' | 2 | 1 | | |
| 0-1 | 41°44.0' | 83°27.2' | 2 | 1 | X | Maumee Bay |
| 0-2 | 41°41.8' | 83°28.0' | 28 | 2 | X | Maumee Bay |
| 0-3 | 41°42.7' | 83°26.2' | 28 | 2 | X | Toledo channel |
| 0-4 | 41°43.5' | 83°24.3' | 28 | 2 | X | Toledo channel |
| 0-5 | 41°44.3' | 83°22.6' | 28 | 2 | | |
| 0-6 | 41°45.2' | 83°20.8' | 28 | 2 | | |
| 0-7 | 41°46.0' | 83°19.0' | 28 | 2 | | |
| 0-8 | 41°42.7' | 83°26.0' | 1 | 1 | X | Maumee Bay |
| 0-9 | 41°41.4' | 83°22.6' | 1 | 1 | | |
| 0-10 | 41°41.9' | 83°20.5' | 1 | 1 | | |
| 0-11 | 41°42.5' | 83°18.4' | 12 | 2 | | |
| 0-12 | 41°41.1' | 83°16.7' | 8 | 1 | | |
| 0-13 | 41°42.0' | 83°15.5' | 17 | 2 | | |
| 0-14 | 41°38.7' | 83°13.2' | 6 | 1 | | |
| 0-15 | 41°36.9' | 83°06.2' | 2 | 1 | | |

APPENDIX 1 (Con't)

LAKE ERIE NEARSHORE SURVEILLANCE STATIONS
WESTERN SECTION

| Station No. | Latitude (°N) | Longitude (°W) | Depth (ft) | No. of samples | Problem area | Remarks |
|---|---|---|---|---|---|---|
| 0-16 | 41°36.2' | 83°04.6' | 3 | 1 | | |
| 0-17 | 41°36.4' | 83°04.1' | 8 | 1 | | |
| 0-18 | 41°36.7' | 83°03.6' | 12 | 2 | | |
| 0-19 | 41°37.1' | 83°03.0' | 14 | 2 | | |
| 0-20 | 41°37.4' | 83°02.4' | 15 | 2 | | |
| 0-21 | 41°35.2' | 83°03.6' | 2 | 1 | | |
| 0-22 | 41°31.4' | 82°57.5' | 5 | 1 | | |
| 0-23 | 41°31.4' | 82°56.4' | 8 | 1 | | |
| 0-24 | 41°32.3' | 82°56.1' | 12 | 2 | | |
| 0-25 | 41°34.5' | 82°56.0' | 20 | 2 | | |
| 0-26 | 41°31.2' | 82°54.7' | 6 | 1 | | |
| 0-27 | 41°33.4' | 82°47.8' | 20 | 2 | | |
| 0-28 | 41°34.8' | 82°45.6' | 6 | 1 | | |
| 0-29 | 41°27.7' | 82°57.9' | 2 | 1 | | |
| 0-30 | 41°25.4' | 82°55.9' | 1 | 1 | | |
| 0-31 | 41°28.0' | 82°53.0' | 5 | 1 | | |
| 0-32 | 41°29.0' | 82°48.6' | 3 | 1 | | |
| 0-33 | 41°27.0' | 82°46.0' | 3 | 1 | | |
| 0-34 | 41°27.2' | 82°44.4' | 3 | 1 | x | Sandusky Bay |
| 0-35 | 41°28.5' | 82°44.3' | 8 | 1 | | |
| 0-36 | 41°32.0' | 82°42.2' | 22 | 2 | | |
| 0-37 | 41°29.5' | 82°41.8' | 26 | 2 | | |
| 0-38 | 41°30.0' | 82°40.5' | 26 | 2 | | |
| 0-39 | 41°30.8' | 82°38.6' | 32 | 2 | | |
| 0-40 | 41°27.8' | 82°38.6' | 18 | 2 | | |
| 0-41 | 41°24.7' | 82°35.1' | 6 | 1 | | |
| 0-42 | 41°25.6' | 82°35.1' | 24 | 2 | | |
| 0-43 | 41°24.3' | 82°33.4' | 10 | 1 | | |
| 0-44 | 41°24.0' | 82°32.9' | 26 | 2 | | |
| 0-45 | 41°24.5' | 82°32.2' | 26 | 2 | | |
| 0-46 | 41°25.5' | 82°32.2' | 28 | 2 | | |
| 0-47 | 41°25.6' | 82°32.2' | 30 | 2 | | |
| 0-48 | 41°23.1' | 82°30.7' | 6 | 1 | | |
| 0-49 | 41°24.5' | 82°30.7' | 28 | 2 | | |
| 0-50 | 41°25.6' | 82°30.7' | 35 | 2 | | |
| 77 | | | | 116 | 8 | TOTALS |

APPENDIX 2

NEARSHORE REACHES AND STATIONS

FOR WESTERN LAKE ERIE: MICHIGAN AND OHIO

| REACH NO. | LOCATION | STATIONS | | |
|---|---|---|---|---|
| | | Nearshore | Inshore | Offshore |
| 1 | Detroit River to Brest Bay | M-1 thru M-11 | M-1, 2, 4, 7, 10 and 11 | M-3, 6 and 9 |
| 2 | Brest Bay to Maumee Bay | M-11 thru M-25 | M-11, 12, 16, 17, 18, 22 and 23 | M-15, 21 and 25 |
| 3 | Maumee Bay | M-23 thru M-27; O-1 thru O-13 | M-23, 26 and 27; O-1, 2, 8, 9, 10, 11 and 12 | M-25; O-7 and 13 |
| 4 | Maumee Bay to Toussaint River | O-12 thru O-21 | O-12, 14, 15, 16 and 21 | O-13 and 21 |
| 5 | Toussaint River to Sandusky Bay | O-21 thru O-28 | O-21, 22, 23, 26 and 27 | O-25 and 28 |
| 6 | Sandusky Bay | O-27 thru O-40 | O-27,29,30,33, 34,36,37, and 40 | O-28, 31, 32, 35 and 39 |
| 7 | Sandusky Bay to Old Woman Creek | O-40 thru O-50 | O-40, 41, 43 44 and 48 | O-42, 47 and 50 |

APPENDIX 3

TRANSECTS WITHIN NEARSHORE REACHES

OF WESTERN LAKE ERIE: MICHIGAN AND OHIO

| CROSS-SECTION NO. | REACH NO. | STATIONS IN TRANSECT | LOCATION | DIRECTION |
|---|---|---|---|---|
| 1 | 1 | M-1, 3, 6 and 9 | Detroit River Mouth to Stony Point | North to South |
| 2 | 2 | M-16, 20, 25, 24 and 23 | River Raisin mouth to Woodtick Pen. | North to South |
| 3 | 3 | O-2, 3, 4, 5, 6 and 7 | Maumee River Mouth and Bay | Southwest to Northeast |
| 4 | 4 | O-21, 16, 17, 18, 19 and 20 | Locust Point | South to North |
| 5 | 5 | O-23, 24 and 25 | Portage River Mouth | South to North |
| 6 | 6 | O-29, 31, 32, 35, 37, 38 and 39 | Sandusky Bay | West to East |
| 7 | 7 | O-44, 45, 46 and 47 | Huron River Mouth | South to North |
| Inshore | 1-7 | M-1, 4, 7, 11, 16, 18, 23, 26 and 27; O-1, 2, 8, 9, 10, 11, 12, 14, 16, 21, 27, 36, 29, 40, 41, 44 and 48 | Detroit River Mouth to Maumee Bay to Old Woman Creek | Northeast to Southwest to Southeast |
| Offshore | 1-7 | M-3, 6, 9, 13, 15, 21 and 25; O-7, 20, 25, 28, 39, 35, 42, 47 and 50 | Detroit River Mouth to Maumee Bay to Old Woman Creek | Northeast to Southwest to Southeast |